TREND ANALYSIS OF TEMPERATURE AND PRECIPITATION IN THE NORTHERN PART OF LIBYA

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I certify that in my opinion the thesis submitted by Mahmood Mohammed Mahmood SOLIMAN titled "TREND ANALYSIS OF TEMPERATURE AND PRECIPITATION DATA IN NORTHERN OF LIBYA" is fully adequate in scopeand in quality as a thesis forthe degree of PhD.

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ABSTRACT

The trend analysis is one of the important climate studies for detecting climate change in the short and long term. Climate change trend analysis can provide information on how climate has evolved to determine the changes and trends in climate elements over time. The importance of climate trend analysis studies is to estimate the risks of future climate changes based on current data and to try to avoid drought and lack of water resources by establishing sound scientific plans based on the results of these studies.

The scope of the research subject entitled “Trend Analysis of Temperatures and Precipitation data in Northern part of Libya” extends to analysis of 16 meteorological stations, 8 of which are coastal stations, which are Agdabia, Benghazi, Derna, Misurata, Sirte, Tobruk, Tripoli, Zwara. And 5 of them are desert stations, which are Ghadames, Ghariat, Hon, Jaghboub, Jalo, and 3 mountain stations are Alfataiah, NALUT and SHAHAT. In order to perform trend analysis, the data must be at least 30 years old. The data for current analysis in most of the stations comprises of 40 years, from 1971 to 2010, except for Alfataiah Station (1981-2010) and Tobruk Station (1984-2010).The necessary data comprising 40-year continuous data were collected from Libyan National Meteorological center climate & climate Change, Tripoli.

Microsoft Excel 2007 and IBM SPSS 23 program were used to organize the climate and other data and to create tables, graphs and figures for the data. Arc GIS 10.4 (Geography Information System) program was used to make the maps. Trend Analysis and Windows software and IBM SPSS 23 program were used to perform trends and other statistical analyzes. Descriptive statistics of the data were made in the statistical methods used within the scope of the study, Kolmogorov- Smirnov test for made normality distributions, and the data were not distributed normally. After the Kruskal-Wallis H test was used to determine the difference between the temperature and Precipitation, the correlation was determined using the Spearman Rho method for correlation analysis. For the trend analysis of 40-year temperature and precipitation data, trends directions were determined by Mann-Kendall, Spearman Rho, Sen test, Simple Linear Regression Analysis for temperatures.

In maximum temperatures, it is observed that there are warming at western stations of the study area during the spring season and in most stations in the summer, and Sirte, Agdabia, Jalo and Hon stations in autumn. The winter season showed no significant trends in the maximum temperatures. However, the general average temperatures of the maximum temperatures have shown warming in all stations except for stations near Green Mountain and Zwara station in the west. In minimum temperatures, it is observed that there are warming at all stations in summer, except for Shahat station. In spring, while in the autumn season, all stations showed warming except for stations located on a high elevation, such as Nalut, Ghadames and Shahat. The winter season has shown trends towards warming at stations of Jagboub, Alfataiah, and Agdabia, as for the annual average, it showed trends towards warming in some situations, such as Jaghboub, Alfataiah and Zwara. In average temperatures, most stations showed a tendency to warming.

There were relationships between the indicators of the North Atlantic Oscillation (positive and negative) and the increase trends in the autumn season in several years the most important of which was in September 1993 with the value (-3.18) and its impact reached several stations such as Al-FATAIAH, JAGHBOUB, JALO, TRIPOLI and DERNA in increasing and decreasing trends in temperatures and precipitation in deferent years.

The El Nino and La Nino phenomenon influenced temperature trends and precipitation in the region. The El Niño effect (very strong) in the 1982-1983 season caused the lowest temperatures in DERNA station and the maximum temperatures in ZWARA and JALO stations while the phenomenon of La Niño affected the trends of precipitation in some stations such as NALUT, SHAHAT, JAGHBOUB, TOBRUK, DERNA, JALO, and JAGHBOUB.Based on results of this study, appropriate plans and policies can be established to address current and future climate conditions, by which areas threatened by drought and water shortages can be identified.

Keywords: Temperature, Precipitation, Trend Analysis, Mann-Kendall, Spearman Trend Slope Test, Physical Geography.

ÖZET

Trend analizi, uzun vadede iklim değişikliğini tespit etmek için önemli iklim istatistik uygulamalarından biridir. İklim elemanlarının zaman serileri içerisindeki değişikliklerini ve eğilimlerini belirlemek iklimin nasıl değiştiği üzerine bir fikir verebilir. Zaman serileri içerisindeki iklim değişkenliklerinin iklim parametrelerinde artış ya da azalış eğilimi göstermesi, mevcut durumu tespit etmek kadar gelecek ile ilgili öngörü yapılabilmesine de yardımcı olmaktadır.

Araştırmanın kapsamını; "Kuzey Libya'da Sıcaklık ve Yağış Verilerinin Trend Analizi" oluşturmaktadır. Tezin amacını ise, araştırmaya dâhil edilen istasyonların (Agdabia, Bingazi, Derna, Misurata, Sirte, Tobruk, Trablus, Zwara, Ghadames, Ghariat, Hon, Jaghboub, Jalo, Alfataiah, Nalut ve Shahat) sıcaklık ve yağış verilerini değerlendirerek mevcut trendin eğilimlerini, boyutunu ve şiddetini belirlemek meydana getirmekedir. Karma araştırma modelinin kullanıldığı bu çalışmanın verileri Trablus'da bulunan Libya Ulusal Meteoroloji Merkezi İklim ve İklim Değişikliği biriminden elde edilmiştir.

Verilerin analizinde tablolar, grafikler ve şekiller oluşturmak için Microsoft Excel 2007, harita yapımı ve analizi için Arc GIS 10.4 programı, Trend analizi ve diğer istatistiksel işlemleri gerçekleştirmek için SPSS 23 programı kullanılmıştır. Sıcaklık ve yağış arasındaki farkı belirlemek için Kruskal-Wallis H testi uygulandıktan sonra korelasyon analizi için Spearman Rho yöntemi kullanılarak korelasyon belirlenmiştir. 40 yıllık sıcaklık ve yağış verilerinin trend analizi için eğilim yönleri Mann-Kendall, Spearman Rho, Sen testi, sıcaklıklar için basit doğrusal regresyon analizi ile belirlenmiştir.

Maksimum sıcaklıklarda, ilkbahar mevsiminde ve yaz aylarında çoğu istasyonda ve sonbaharda Sirte, Agdabia, Jalove Hon istasyonlarında çalışma alanının batı istasyonlarında ısınma olduğu görülmektedir. Kış mevsiminde maksimum sıcaklıklarda önemli eğilimler göstermemiştir. Bununla birlikte, maksimum sıcaklıkların genel ortalama sıcaklıkları, batıdaki Green Mountain ve Zwara istasyonu yakınlarındaki istasyonlar hariç tüm istasyonlarda ısınmayı göstermiştir.

Araştırmanın sonucunda minimum sıcaklıklarda, Shahat istasyonu hariç, yaz aylarında tüm istasyonlarda ısınma olduğu görülmektedir. İlkbaharda, tüm çöl istasyonları ısınma eğilimlerini gösterirken, sonbahar mevsiminde tüm istasyonlar Nalut, Ghadames ve Shahat gibi yükseltisi fazla olan istasyonlar dışında ısınma eğilimi göstermemektedir. Kış mevsimi, Jagboub, Alfataiah ve Agdabia istasyonlarında ısınmaya yönelik eğilimler göstermekte; yıllık ortalamada ise Jaghboub, Alfataiah ve Zwara gibi bazı stasyonlar ısınma eğilimleri göstermiştir. Ortalama sıcaklıklarda, çoğu istasyon her mevsim özellikle (1998-2001) arasında ısınma eğilimi göstermiştir. Isınma eğilimi, Trablus, Misurata, Bingazi gibi büyük nüfus merkezlerinin yakınında bulunan istasyonlarda ve Agdabia, Tobruk ve Sirte gibi petrol rafinerilerinin yakınında bulunan istasyonlarda görülmektedir.

Zwara, Trablus ve Tobruk istasyonları gibi bazı istasyonlar, yıllık yağış ortalamasında azalma eğilimleri gösterirken, diğer tüm istasyonların yağışında önemli bir eğilim göstermemiştir.

Kuzey Atlantik Salınımının göstergeleri (pozitif ve negatif) ile sonbahar mevsimindeki artış eğilimleri arasında en önemlisi (-3.18) değeri ile Eylül 1993'te olan ilişkiler bulunmaktadır ve onun etkisi AL-FATAIAH, JAGHBOUB, JALO, TRİPOLİ ve DERNA gibi çeşitli istasyonlara ulaşmıştır.

El Nino ve La Nino salınımları bölgedeki sıcaklık trendlerini ve yağışları etkilemiştir. 1982-1983 yıllarında El Niño etkisi (çok güçlü), DERNA istasyonundaki en düşük sıcaklıklara ve ZWARA ve JALO istasyonlarındaki maksimum sıcaklıklara neden olurken, la Niño salınımı NALUT, SHAHAT, JAGHBOUB, TOBRUK, DERNA, JALO ve JAGHBOUB gibi bazı istasyonlarda yağış trendlerini etkilemiştir.

Araştırmanın sonuçlarına göre Libya’daki iklim değişikliğinin olumsuz etkilerini ortadan kaldırmak veya azaltmak için düşük yağış ve artan sıcaklıkları etkileyen bazı tedbirler alınmalıdır. Bu tedbirlerin en önemlisi, su kaynakları yönetimi için planlar yapılmalı ve uygulanmalıdır.

Anahtar Kelimeler: Sıcaklık, Yağış, Trend Analizi, Mann-Kendall, Spearman Trend Eğilim Testi, Fiziki Coğrafya.

ARABIC ABSTRACT

المُلخص

تعد دراسة تحليل الاتجاهات واحدة من الدراسات المُناخية المهمة للكشف عن تغير المُناخ على المدى القريب والبعيد ، ويمكن أن يوفر تحليل المتغيرات المُناخية معلومات عن كيفية تطور المُناخ من خلال تحليل السلاسل الزمنية.

مجال البحث هو تحليل اتجاه درجات الحرارة وهطول الأمطار في القسم الشمالي من ليبيا ، لـ 16 محطة أرصاد جوية، منها 8 محطات ساحلية وهي أجدابيا وبنغازي ودرنة و مصراتة وسرت وطبرق وطرابلس و زوارة. و 5 منها محطات صحراوية هي غدامس ، و القريات ، وهون ، و الجغبوب ، و جالو ، و 3 محطات جبلية هي الفتائح و شحات و نالوت.

من أجل إجراء تحليل الاتجاهات على نحو معتبر علمياً، يجب ألّا تقل البيانات المُناخية عن 30 عامًا. كانت السلاسل الزمنية في معظم المحطات (40 عامًا) ، من 1971 إلى 2010، باستثناء محطة الفتائح فقد كانت مدة بياناتها (30 عاماً) من1981 إلى 2001، ومحطة طبرق (27 عاماً) من 1984إلى 2010، لذلك، هناك العديد من المحطات في منطقة الدراسة لم تُدرج في البحث، منها على سبيل المثال محطة ناصر و محطة يفرن و محطة الكفرة، حيث لا توجد سلسلة بيانات منتظمة يمكن الاعتماد عليها في تحليل الاتجاهات.

الغرض من هذه الدراسة هو تحليل اتجاهات بيانات درجات الحرارة و الأمطار للمحطات المشمولة في البحث والتعرف على الزيادة أو النقصان في تلك المحطات، و ذلك للمساهمة في إثراء المكتبة العلمية للمُناخ ، خاصة و إن دراسات تحليل اتجاهات المُناخ قليلة في ليبيا، حيث تكمن أهمية دراسة تحليل اتجاه المُناخ في التنبؤ بمخاطر التغيرات المُناخية المستقبلية، ومحاولة تجنب مشكلة الجفاف ونقص الموارد المائية و ترشيد استهلاكها، و يُعتقد أن البحث سوف يسهم في تحديد المناطق الجافة في شمال ليبيا، من أجل إعطاء رؤية مستقبلية لتطوير مشاريع المياه في ليبيا و التي من خلالها يمكن تحقيق التنمية الاقتصادية في البلاد.

تم الحصول على البيانات من المركز الوطني الليبي للأرصاد الجوية وتغير المُناخ، طرابلس. أُستخدم برنامج Microsoft Excel 2007 و برنامج IBM SPSS 23 لتنظيم البيانات المُناخية، ثم أُستخدم برنامج Arc GIS 10.4.(نظم المعلومات الجغرافية) لعمل الخرائط الطبيعية و المُناخية.

لإجراء تحليلات اتجاهية وإحصائية أخرى. أُجريت إحصاءات وصفية لبيانات IBM SPSS 23 استُخدم برنامج الحرارة و المطر. أُجريت اختبارات التوزيعات الطبيعية بواسطة اختبار Kolmogorov Smirnov حيث أشارت أغلب النتائج أن توزيع البيانات لم يتم بشكل طبيعي. أُستخدم اختبار Kruskal-Wallis لتحديد الفرق بين درجة الحرارة وهطول الأمطار، حُددت العلاقة بين البيانات باستخدام طريقة Spearman's Rho and Kendall's tau لتحليل الارتباط. و لتحليل الاتجاهات أُستخدمت اختبارات: Mann-Kendall, Spearman, Sen slope Trend analysis windows .

أعطت اختبارات تحليل الاتجاه عدة اتجاهات مختلفة، حيث لوحظ وجود ارتفاع في درجات الحرارة العظمى في المحطات الغربية لمنطقة الدراسة خلال فصل الربيع، وفي معظم المحطات في فصل الصيف، و محطات سرت و أجدابيا و جالو وهون في الخريف، ولم يظهر موسم الشتاء أي اتجاهات مهمة. ومع ذلك، فإن المعدل السنوي لدرجات الحرارة العظمى أظهر اتجاهات نحو الزيادة في جميع المحطات باستثناء المحطات القريبة من الجبل الأخضر بنغازي و الفتائح ومحطة زوارة في الغرب.في درجات الحرارة الصغرى لوحظ ارتفاع درجات الحرارة في جميع المحطات في فصل الصيف، باستثناء محطة شحات، في فصل الربيع، أظهرت جميع المحطات الصحراوية اتجاهات نحو الاحترار، و كذلك الحال في فصل الخريف أظهرت جميع المحطات زيادة في درجات الحرارة باستثناء المحطات الواقعة في مناطق مرتفعة فوق مستوى سطح البحر، أظهر فصل الشتاء اتجاهات نحو الاحترار في محطات الجغبوب و الفتائح و أجدابيا.في المعدل العام لدرجات الحرارة، أظهرت معظم المحطات ميلًا إلى الاحترار في جميع الفصول وأيضاً في المعدل السنوي، خاصة بين (1998-2010)، ويمكن ملاحظة هذا الاحترار في المحطات القريبة من المراكز السكانية الكبيرة مثل طرابلس و مصراتة و بنغازي. وكذلك المحطات الموجودة بالقرب من مصافي تكرير النفط مثل أجدابيا و طبرق و سرت.لم تُظهر جميع المحطات أي اتجاهات مهمة في هطول الأمطار، خاصة أن بعض المحطات أظهرت اتجاهات نحو الانخفاض في المعدلات السنوية لكميات الأمطار، مثل محطات زوارة و طرابلس و طبرق.

كانت هناك علاقات بين مؤشرات تذبذب شمال الأطلسي (إيجابية وسلبية) خاصة في موسم الخريف خلال عدة سنوات أهمها عام 1993، عندما كان المؤشر في سبتمبر (-3.18)، و لقد وصل تأثيره إلى العديد من المحطات مثل الفتائح و الجغبوب و جالو و طرابلس و درنة. و بالمقارنة بين نتائج الدراسة و نتائج تذبذب شمال الأطلسي لوحظ أن هناك علاقة بين اتجاهات (الزيادة والنقصان) في العديد من محطات منطقة الدراسة و يظهر الأثر واضحاً على درجات الحرارة وهطول الأمطار في مواسم و سنوات مختلفة. و لظاهرة El Niño تأثير ضعيف على اتجاهات درجات الحرارة وهطول الأمطار في المنطقة. في موسم 1982-1983 وصل تأثير النينيو إلى منطقة الدراسة عندما كان (قوي جدًا) و اقتصر أثره فقط على درجات الحرارة الصغرى في محطة درنة، و درجات الحرارة العظمى في محطات زوارة و جالو. في حين أن ظاهرة La Niño كان لها تأثير على اتجاهات هطول الأمطار في بعض المحطات مثل نالوت، و شحات، و الجغبوب، و طبرق، و درنة، و جالو.

استنادًا إلى التقييم الحقيقي للنتائج التي تم الحصول عليها من تحليل الاتجاهات، يمكن إنشاء خطط وسياسات مناسبة لمواجهة الظروف المُناخية الحالية والمستقبلية، من خلالها يمكن حصر المناطق المهددة بالجفاف و العجز المائي.

الكلمات الافتتاحية: درجة الحرارة، التساقط، تحليل الاتجاه، مان كيندال، سبيرمان، المُناخ، الجغرافيا الطبيعية.

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ABBREVIATIONS

Ap. : April
Aver. : Average
Ag. : August
Aut. : Autumn
°C : Celsius Temperature
CL : Control Limit
De. : December
E : East
ENSO : El Niño Southern Oscillation
GIS : Geography Information System
hPa : Hectopascal (Pressure Unit)
Fb. : February
IPCC : Intergovernmental Panel on Climate Change
Ja. : January
Jn. : June
Jl. : July
km : Kilometer
K-W : Kruskal Wallis
LCL : Lower Control Limit
LNMC : Libyan National Meteorological Centre
LSL : Lower Specification Limit
m : Meter
Mr. : March
Ma. : May
M-K : Mann-Kendall
Max. : Maximum
Min. : Minimum
mm : Millimeter
MO :Mediterranean Oscillation

N	: North
n	: Sample Size
NAO	: North Atlantic Oscillation
Nv.	: November
p	: Significance Level
Oc.	: October
r	: Coefficient of correlation
S	: South
SAO	: Southern Oscillation Index
Sp.	: September
SPI	: Standard Precipitation Index
SPSS	: Statistical Package for the Social Sciences
Spr.	: Spring
Std.	: Standard Deviation
Std.eva.	: Standard Deviation on Sample Size
Sum.	: Summer
UCL	: Upper Control Limit
USL	: Upper Specification Limit
U(t)-U'(t)	: Mann-Kendall Order Correlation Test
W	: West
WEMO	: Western Mediterranean Oscillation
Win.	: Winter
WMO	: World Meteorological Organization
Z	: Result of Mann Kendall & Spearman test

INTRODUCTION

The introduction part of thesis covers the subject of the research, purpose, sub-objectives, justification, importance, limitations, materials and methods and analysis of previous studies.

I. SUBJECT OF THE RESEARCH

The climate is one of the major physical elements on the earth that has become an important area of scientific research. The governments of many countries in the world have shown keen interest in climate change after the industrial revolution of the 19th century. Besides, the issue of global warming in recent decades has also increased the interest of scientists in climate research.

In general, climate change can be defined as a long-term and slow-developing changes with significant global and local impacts on climatic conditions of the world. These changes in climate during ice age and interglaciation period has great impact on climatic patterns in various regions of the world that influence the melting of glaciers, average temperature and amount of precipitation (Türkeş, 2001).

This implies that the portrayal of the climate patterns in a particular region must include an analysis of mean conditions of the seasonal cycle of the probability of extremes such as severe drought in the arid areas.

The most recent assessment conducted by Intergovernmental Panel on Climate Change (IPCC) has reported an increase in the mean surface temperature from 0.56 ^{0}C in 1906 to 0.92 ^{0}C in 2005 (IPCC, 2007). This increase is larger than what had been mentioned by previous IPCC report, which mentioned that global mean surface temperature has increased by approximately 0.3 ^{0}C to 0.6 ^{0}C from 1901-2000 (IPCC, 2001).

Climate changes in the past were entirely due to natural causes. However, the share of human activities in recent climate changes is much greater. The short-range climate changes, which are suggested to be the result of more human activities, are the subjects related to the phenomenon of global warming (Nişancı, 2007).

The climate which has a dynamic structure shows continuous variation in temporal and spatial scale, hence, a large part of the earth is subject to changes due to the nature of the climate in short or long periods. On the other hand, the idea of global climate change, which is expressed as the increase of global temperature and the change of rainfall pattern, has started to be accepted by the scientists due to the findings obtained in recent years (Karabulut, 2009).

Climate change has both positive and negative effects. These impacts influence human health and quality of life at greater extent with changes in water resources, natural ecosystems, agriculture, forestry, and fishing activities. The negative impact start dominating as the changes in the climate patterns increase (Demirci, and Karakuyu, 2002; Türkeş, 2012).

The elements of heat and precipitation are of the most important climatic elements that affect directly or indirectly other air elements such as evaporation, condensation, atmospheric pressure, etc. Any change in temperature or lack of rain can cause a change in the general that affects regional or even local climate. Temperature and precipitation that represents the main elements of climate have both spatial and temporal variability.

The oscillations in the temperature and precipitation parameters show evidence of the general characteristics of the climate and they are of great importance. Accordingly, recent studies on climate change have focused on the trend analysis of temperature and precipitation parameters. The studies revealed that during the period between 1850-2016, the year 2000 represented the hottest ten years on a global scale (Cosun, 2009 andTürkeş, 2012).

This definition of the climate as representative of conditions over several decades should, of course, not mask the fact that climate can change rapidly. Nevertheless, a substantial time interval is needed to observe a difference in climate between any two periods. In general, the less the difference between the two periods, the longer is the time needed to identify any changes in the climate between them with confidence.

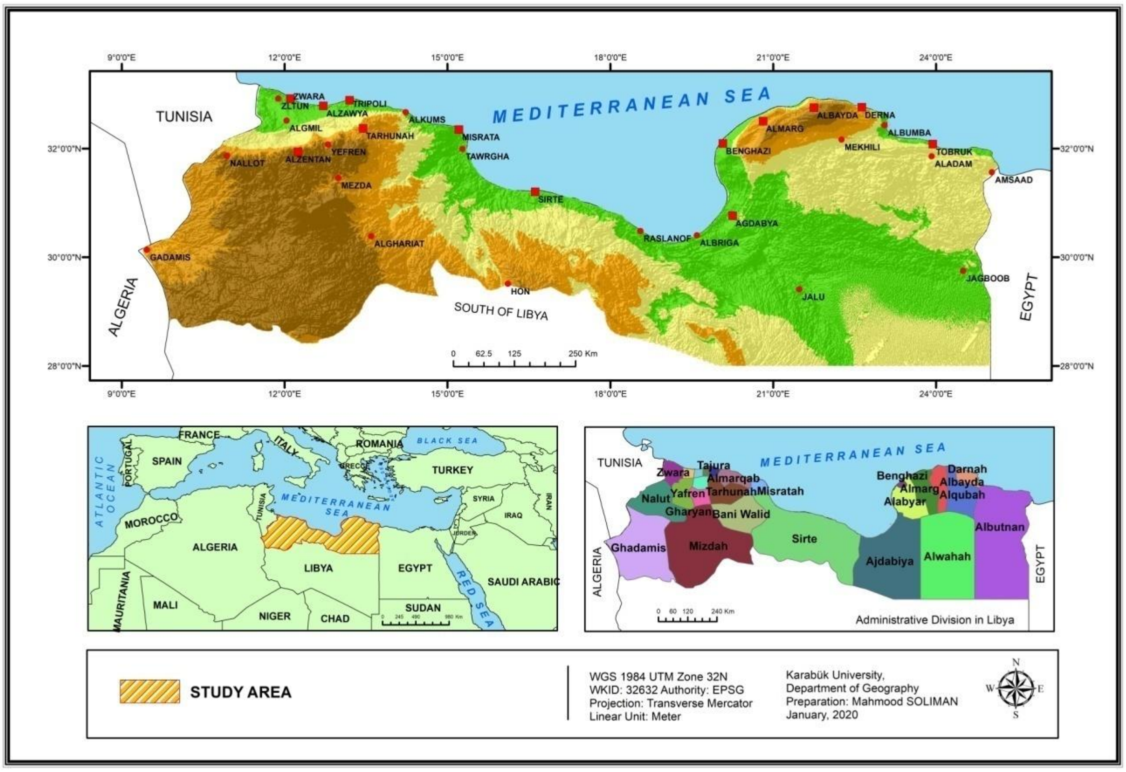
Following the World Meteorological Organization (WMO), a period of 30 years is the classical period for performing the statistics used to define climate. This is well adopted for studying climate of recent decades since it requires a reasonable amount of data while still providing a good sample of the different types of weather that can occur in a particular area.

However, when analyzing the most distant past, such as the last glacial maximum around 20.000 years ago, climatologists are often interested in varied characteristic of longer time intervals. Consequently, the 30-year period proposed by the WMO should be considered more as an indicator than a norm that must be followed in all cases (Brohan, 2006).

The analysis of previous literature has revealed that there is an absence of scientific studies regarding trend analysis of temperature and precipitation in Libya. Therefore, in present study the trend analysis was applied to temperature and precipitation data of north Libya from 16 meteorological stations for the period between 1971-2010, to identify general trends along with present and future climate predictions in the study area. Besides, the dimensions of climatic changes related to these climate parameters were determined in order to make accurate inferences about future situations on the climate. In this study, trend analysis was performed on temperature and precipitation parameters instead of evaluating all climatic parameters which best reflect the changes in climate with time.

The study area is located in North Africa in Libya extending from 28.00 to 33.10 latitudes in north and 09.20 to 25.00 longitude in the east. Mediterranean sea lies in the north, desert of Libya in the south, Tunisia and Algeria in the west and Egypt in the east of the study area. There is about 1900 km long coastline in the north of study area extending from Berdya gulf in the east to Ras Ajdir in the west.

The study area covers an area of about 538,495 square kilometers comprising two different regions. First region comprises coastline area, Green Mountain in Northeast, and West Mountain in northwest, while the second one is southern region which is a dry desert area making the largest part of the study area. This diversity and extension in the surface features resulted in a variety of climatic conditions prevailing in the region from semi-humid climate in the north and semi-arid climate in the center to the very-arid climate in the south.



Map 1. Location Map of Northern Libya

II. PURPOSE AND SUB-AIMS OF THE RESEARCH

Present research aims to identify the trend of temperature and precipitation data of long period and find the direction and dimensions of these trends. For this purpose, the following questions have been sought:

- ❖ What are the planetary and local factors affecting the climate of northern Libya?
- ❖ In which trends (increase/decrease) the trend has occurred in meteorological stations (Desert stations or Coast stations)?
- ❖ Which meteorological stations show strong trends and are these stations show changes in temperature and precipitation data?
- ❖ Is there any relationship between the temperatures and precipitationtrends in Libya and global climate change and climatic phenomena such as Atlantic oscillations and El Niño?

The study is based on one main axis to answer these questions that is concerned with descriptive and statistical analysis of temperatures and precipitation in the area.

A number of studies have recommended the study of trends for different climate variables (Nalley, 2012) to understand the relationship between human activities and climate. In the light of this, the main objective of this research is to analyze the trends that may exist in the time series of climatic variables. These parameters serve as good indicators of how the climate has evolved as the studies on climate change indicate an increase in patterns of temperature and precipitation experienced in different parts of the world. Therefore, information about the impacts of climate change on the spatiotemporal characteristics of temperature and precipitation is required to understand the effects of climate change on scarcity of water resources in region.

III. SIGNIFICANCE AND LIMITATIONS OF THE RESEARCH

The subject of the study is important because it is the first study that provides a clearer understanding of climatic trends in Libya with such extent the obtained results are thought to provide an important contribution to the development of climate plans and policies.

Climatic characteristics, climate change and trends have a very decisive influence on human activities and ecosystems. These effects are mostly manifested by temperature and precipitation elements. This issue demonstrates the necessity of the subject taken in the study and shows the importance of taking the basis of temperature and precipitation data for trend analysis. Besides, it is also important to analyze the trends of heat and rain in the region to identify the causes of drought and how to treat them by sound scientific methods as the study area suffers from the problem of water shortage and the spread of drought in agricultural land.

During the course of research, some difficulties were encountered in terms of accuracy of the results of the study. In order to carry out the trend analysis which constitutes the subject of the research, there is a need for at least 30 years of temperature and precipitation data continuously. While the number of meteorological stations in North Libya is more than the number of stations included in the study, all of these stations were not included in the study. This is because some stations did not have long-year data and data sets containing long years did not show uninterrupted measurements and in some cases the data for 5 years or more were not taken consecutively in these stations. Besides, the most important difficulties faced during the research were the lack of sources and references of climate.

IV. RESEARCH HYPOTHESIS

The hypotheses created within the scope of the research are as follows:

H_0: Observation sequences of North of Libya temperatures (mean, average maximum and average minimum) show trends.

H_a: Observation sequences of the North of Libya temperatures (mean, average maximum and average minimum) do not show any trend.

H_0: Observation sequences for the precipitation of the North of Libya show a trend.

H_a: Observation sequences of the precipitation of the North of Libya do not show any trend.

H_0: There is a relationship between Temperatures and Precipitation trends, Atlantic oscillations, and El Niño.

H_a: There isn't a relationship between Temperatures and Precipitation trends, Atlantic oscillations, and El Niño.

V. MATERIALS AND METHODS OF THE RESEARCH

Within the scope of the research, a detailed literature review was conducted including local and international sources of information. In light of the literature, features and characteristics of physical geography were determined as they have an influence on climatic properties and necessary preliminary works were made about the evaluation processes of the programs, methods, and analyses used in the trend analysis. Following actions were taken after collection of secondary data of climate obtained from the Libyan National Meteorological Office, The steps regarding the organization and evaluation of the scattered data are given below:

- ❖ Monthly and long-year average and total values of temperature, solar duration, humidity, precipitation, pressure and wind velocity were calculated with Microsoft Excel 2007 program. Tables and graphs were created through this program to visualize these numerical data including solar radiation, temperature, atmospheric pressure, wind directions, humidity, evaporation, clouds, precipitation, SPI index, and all classifications of climate.

- ❖ The Excel (QI Macros) was used to extract the standard deviations of temperature and precipitation variables and graphs were made.
- ❖ IBM SPSS 20 program was used in creating selective statistics, analysis of data distribution, determination of differences and correlation analysis. In the determination of the distribution of data Kolmogorov-Smirnov, Mann-Whitney U for the difference and Spearman Rho test for correlation analysis were used.
- ❖ SPSS 20 program was used to determine the homogeneity of variances on temperature and precipitation data and Kruskal-Wallis H test was preferred.
- ❖ Trend values of temperature and precipitation data were determined using Trend Analysis for Windows program. Microsoft Word 2007 program was used to table these values.
- ❖ Simple linear regression analyses for temperature and precipitation data were performed on the IBM SPSS 20 program and results were visualized by graphs on Microsoft Excel 2007 program.
- ❖ Mann-Kendall-rank correlation graphs were created on the Microsoft Excel 2007 program using the u(t)-u'(t) values obtained from the Trend Analysis for Windows software.
- ❖ App of XmR Trend Control Chart in Excel (QI Macros) was used to identify the trends of maximum and minor temperatures and general averages for seasons, and years, and also was used to identify the monthly and annual precipitation trends.
- ❖ The tabulation of the values obtained from these formulas and the creation was carried out via Microsoft Excel 2007.
- ❖ Mapping was done through GIS program (Arc map 10.3).

* **Climate Data,** consists of a groups of time series, a simple model of data in a time series is to view each observation as being the realization of a random variable made up of a trend through time, (one or more) seasonal effects, and remaining effects that are not a function of time (Tamra et al., 2013).

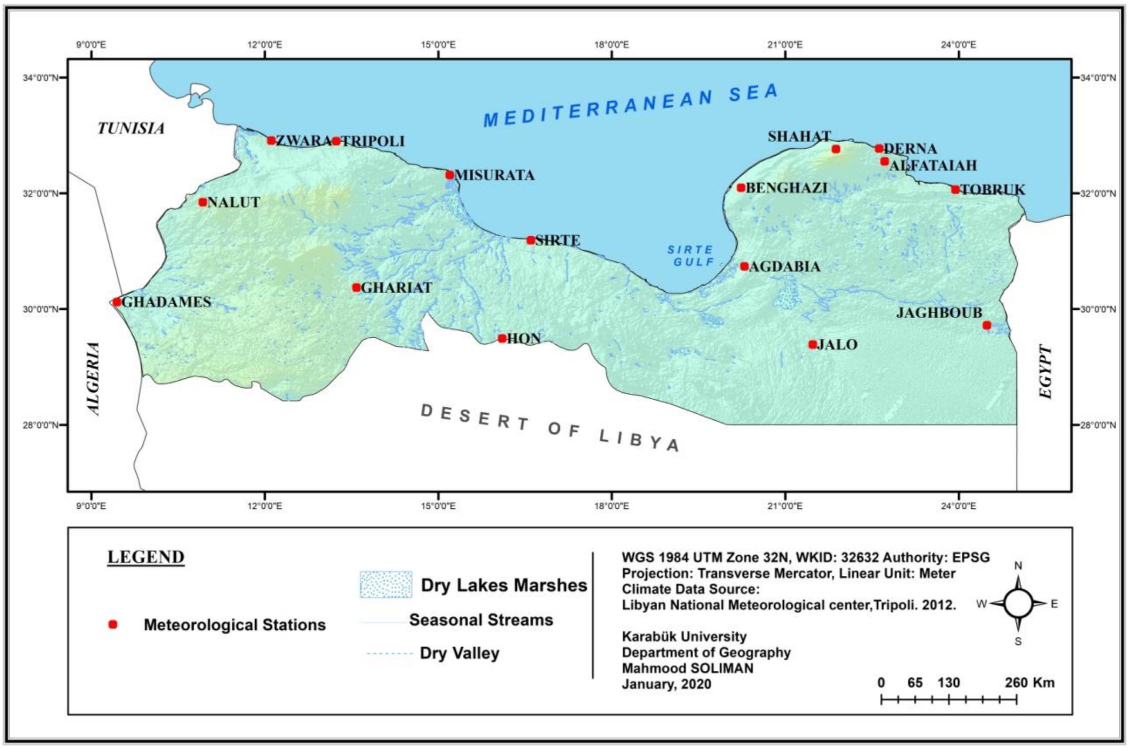
Climatic data for 16 synoptic stations across Libya were collected from the Libyan National Meteorological Centre (LNMC), for periods of 1971-2010 from 16 stations except for ALFATAIAH station 1981-2010 and TOBRUK station 1984-2010. as most of the meteorological stations of the study area stopped working at the beginning of

2011 due to the political circumstances of the country. The following table 1 and map2 show the geographical characteristics of the selected stations.

Table 1. **Geographical Information about Meteorological Stations**

NO	Station Code	Station Name	North Latitude	East Longitude	Elevation	Distance from sea	Monitoring Period
1	62055	AGDABIA	30.43	20.10	0.7	21	1971 - 2010
2	62115	ALFATAIAH	32.45	22.38	263	15	1981 - 2010
3	62053	BENGHAZI	32.05	20.16	129	13	1971 - 2010
4	62059	DERNA	32.47	22.35	26	0.6	1971 - 2010
5	62103	GHADAMES	30.08	09.30	357	400	1971 - 2010
6	62120	GHARIAT	30.23	13.35	497	254	1971 - 2010
7	62131	HON	29.07	15.57	263	230	1971 - 2010
8	62176	JAGHBOUB	29.45	24.32	0.2	247	1971 - 2010
9	62161	JALO	29.01	21.34	60	206	1971 - 2010
10	62016	MISURATA	32.19	15.03	32	0.2	1971 - 2010
11	62002	NALUT	31.52	10.59	640	160	1971 - 2010
12	62056	SHAHAT	32.49	21.51	621	11	1971 - 2010
13	62019	SIRTE	31.12	16.35	13	0.3	1971 - 2010
14	62062	TOBRUK	32.06	23.56	50	0.2	1984 - 2010
15	62010	TRIPOLI	32.40	13.09	81	3.2	1971 - 2010
16	62007	ZWARA	32.53	12.05	0.3	1.2	1971 - 2010

Source: Unpublished data from General Administration of Meteorology and Climate, Tripoli, Libya, 2012.



Map 2. Meteorological Station in Northern of Libya

- **Methods**

The following are the stages for the regulation and evaluation of the data. The longest observational periods of meteorological stations were first determined and the data sets were evaluated in this context.

- **Applied Statistical Methods**

Various statistical methods were used in the research. Firstly, descriptive statistics of the data were determined and then the distribution of the data was examined with the Kolmogorov-Smirnov test. Following this process, the data were subjected to the Kruskal Wallis H test to determine the homogeneity of the variances and whether there was a difference between the variables.

The difference between the average temperature and precipitation data was considered separately and the Mann Whitney U test was used for this. Limiting the number of groups to two required the use of the Mann Whitney test instead of Kruskal Wallis test. Correlation analysis was performed with Spearman Rho test on temperature and precipitation data before the trend analysis.

The normal distribution of the data and the lack of homogeneity necessitate the use of this method. Mann-Kendall and Spearman's Rho tests were used for the analysis of temperature and precipitation data. In the determination of trend start year, Mann-Kendall Order Correlation test statistic and Trend Linear Regression and Sen's Trend Slope tests were used (Yılmaz, 2018).

In the analysis of trend analysis, it is very important to obtain data containing long-term measurements and to determine the increase or decrease in trend of time series in terms of parametric and nonparametric methods (Gümüş, 2006).

It is possible to obtain better results with the use of parametric tests in cases where the data have a normal distribution and the variances are homogeneous. In non-parametric tests, the time series generally shows a non-normal distribution. Therefore, The use of nonparametric methods in the determination of the trend in the climatic data where continuous variables such as temperature and precipitation are concerned provides more accurate results than parametric methods (Yılmaz, 2018).

Within the scope of this study, descriptive statistics were performed primarily on average temperature and precipitation data. After descriptive statistics, Kolmogorov-Smirnov test was used to investigate the distribution of the data. Then, temperature and precipitation data were tested for Kruskal-Wallis H correlation analysis by Spearman Rho for the homogeneity of variance. The determination of the normal distribution of the data required the use of these methods. As a result of these stages, Mann-Kendall, Spearman's Rho, Sen-Trends and Mann-Kendall Correlation tests and Simple Linear regression analysis were applied to the data.

- **Kolmogorov-Smirnov**

It is a method used to investigate the normality of data. It is preferred when the group size is greater than 30. The evaluation of the test is carried out by comparing the obtained p value with the desired level of significance. If the group size is less than 30, the Shapiro-Walks test is suitable (Yılmaz, 2018).

- **Kruskal Wallis H Test**

In studies of climatic change, change types such as the form of sudden or step climatic fluctuation or periodicity, strong tendency and change in atmospheric or hydrological series, constitute the main alternatives of homogeneity. Some of the aforementioned types of change may reflect non-homogeneity. The observation records obtained from the applications performed on the data are often not homogeneous (Yılmaz, 2018; Türkeş, 2013).

In scientific studies, the data to be included in the research must be absolutely reliable. One of the ways to provide valid information on the reliability of the data is the quality control and homogeneity analysis for meteorological measurements. Climatologically data are not always homogeneous. Such data show occasional non-homogenous characteristics depending on urbanization, measuring instrument problems and station location change factors. However, when the discontinuities and values observed do not have a normal distribution, the precipitation parameter differs from many other meteorological parameters. Depending on the nature of the precipitation parameter, it is inconvenient to use the one-way variance test (ANOVA) in the homogeneity analysis of precipitation data. One-way variance test is applicable for cases where normal distribution is seen and the variances of the series are accepted as equal (Sönmez, 2007).

One way variance test is a parametric test. The Kruskal Wallis H test refers to the non-parametric response of the one-way analysis of variance where the samples exhibit independent irrelevant characteristics. An alternative non-parametric Kruskal Wallis H test is preferred when one-way analysis of variance is not possible. The assumptions adopted by the ANOVA test are invalid and when the number of groups to be compared exceeds two, the Kruskal Wallis test is applied. In the Kruskal Wallis analysis, first the values are sorted, the difference between the independent tools of the ranking values is compared and the difference between them is tested (Büyüköztürk, 2016).

The Kruskal Wallis H homogeneity test is performed on averages and variances to demonstrate the homogeneity of these values and reflects a non-parametric effective homogeneity test. In this homogeneity test, it is not possible to use original observations containing each of the analyzed sequences. In the Kruskal Wallis H homogeneity test, the sequence numbers of the total sequential sequence formed by ordering the original observations from small to large are used (Türkeş, 2013).

The following hypotheses were considered to test the homogeneity of the mean:

H_0: Group variances are homogeneous.
H_a: Group variances are not homogeneous.

- **Mann Whitney U-Test**

Mann-Whitney U test is used to determine whether the data of two non-related samples differ significantly from each other. In order to be able to apply this test, the dependent variable must be at least on the ranking scale and the observation results must be independent from each other. In the evaluation of the analysis, the total number of the values of the two groups is taken as the basis (Büyüköztürk, 2016 and İçel, 2009).

- **Mann-Kendall Test**

The statistical methods used to determine the degree and direction of the relationship between variables and the dependent and independent variables of the variables are defined as correlation. In this respect, Mann-Kendall and Spearman Rho tests are applied when the parametric Pearson Correlation test is not possible to use (Norrant, 2006;Karmeshu, 2012;Gozalan, 2019 andÖzbunar, 2019).

The Mann-Kendall test is one of the commonly used methods for determining the trend occurring in time series for study areas such as climatology and hydrology(Salamiet al., 2016). The Mann-Kendall test is a statistical method proposed by the World Meteorological Organization (WMO). In many studies on trend analysis, this method has demonstrated superiority among other methods used (Pielke, 2002 and Hendricks, 2015). The Mann-Kendall test statistic (S statistic) is formulated with the following equation (Bulutet al., 2006; Al-Tahir et al., 2010;Bonfils, 2012andKhomsiet al., 2016).

$$s = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} sgn\,(x_{j\_}x_i)$$

The S value in the equation shows almost normal distribution with the mean and variance values stated below in cases where n is greater than or equal to eight (n> 8). The value of n corresponds to the data length in the equation in years. If the value of n is greater than or equal to thirty (n ≥ 30) the z test approaches the t-test. The sign function is indicated by a sign data test performed on an (xj) data set, which is sorted by a set of (xi) and (xj)data as specified in the following equation (Özfidaner, 2007).

$$sign\,(x_{j\_}x_i) = \begin{Bmatrix} 1\,; & x_j > x_i \\ 0\,; & x_j = x_i \\ -1\,; & x_j < x_i \end{Bmatrix}$$

The variance determination of S is determined by the following equation:

$$Var(s) = \frac{n(n-1)(2n+5) - \sum_{i=1}^{p} t_i(t_i-1)(2t_i+\ 5)}{18}$$

In the above equation, the numbers of the relative groups in the data set are denoted by the value of p and the connected observations in a series i are indicated by the value of t. The use of the collection term shown in the equation only occurs if there is observation in the data.

The Z value that denotes the standardized Mann-Kendall test statistic can be calculated by the following equation (9) and under the assumption that there is no course in the series corresponding to the null hypothesis (H_0), it shows the standard normal distribution with a mean of zero and variance (Özfidaner, 2007).

$$Z = \begin{cases} \frac{s-1}{\sqrt{var\ (s)}} & ; s > o \\ 0 & ; s = o \\ \frac{s+1}{\sqrt{var\ (s)}} & ; s < 0 \end{cases}$$

Null-hypothesis is accepted when the 1-α/2 condition is satisfied, while Z is indicated by the plus (+). The Z value indicated by minus (-) reflects the decrease. Depending on the results of the Mann-Kendall test the corresponding value of Z value was determined as 1.96 for the two-way 95% confidence interval.

- **Mann-Kendall Correlation Coefficient**

The sequential analysis of the Mann-Kendall u (t) test sample value was used to determine the beginning of the trend in the observation sequences with significant trend and the point or points of change in the observation sequence (Türkeş, 2013 Yılmaz, 2018 and Gozalan 2019) and test results were shown graphically.

Test sample value t:

$$t = \sum_{i-1}^{n} n_i$$

The average of distribution function E (t):

$$E(t) = \frac{n(n-1)}{4}$$

and has variance (t):

$$var\ (t)\frac{n(n-1)(2n+5)}{72}$$

Equations are given. Test sample value u (t):

$$u(t) = \ [t - E(t)]/\sqrt{var\ (t)}$$

As shown in the equation, the null hypothesis is rejected for the large values of u (t) according to the bi-lateral shape. If the obtained u (t) value is significant at 95% or 99%, trend can be determined depending on whether u (t) is greater than or equal to 0.

If u (t)> 0, the trend is increasing, if u (t) <0, the trend is decreasing. The determination of the u(t') test sample value was also determined in a similar way to u(t') by applying the inverse of the current process performed in series (Yılmaz, 2018).

The successive analysis of the Mann-Kendall rank correlation test was used to graphically show the trends detected in the temperature and precipitation from the u(t) and u(t') test sample values. While the curves of u(t) and u(t') trend values on the charts intersect at one point, they provide evidence for the existence of a significant trend. The intersection of u(t) and u(t') several times indicates that there are no trends in the sequence. In order to determine the starting date of the trends in the direction of increase or decrease, attention is paid to the points where the u (t) and u (t') curves overlap (Papadimitrio, 1991).

- **Spearman's Rho Test**

The Rho test of Spearman is one of the tests to detect the correlation between two observation sequences. It is used because it has fast and simple application in determining the Simple Linear trend in observation series. The determination of R_{xy} which represents the sequence statistics, takes place from small to large, or from large to small. The r_s correlation coefficient symbolizes Spearman's Rho test statistic (Gümüş, 2006, Zarei, 2017 and Gozalan 2019).

Spearman's Relationship Coefficient:

$$\boldsymbol{r_s = 1 - 6\frac{[\sum_{i-1}^{n}(R(X_i - i)^2)]}{n^3 - n}}$$

The $r_s$distribution approach is normal when n> 30. Accordingly, normal distribution tables were used to determine r_s test statistic. The Z value corresponding to the test statistic of r_s is calculated by the following equation (Gümüş, 2006).

$$\boldsymbol{Z = r_s\sqrt{n-1}}$$

The higher Z value obtained as a result of the equation compared to the Z_α / 2 value shown in the standard normal distribution tables at the α significance level is the evidence for the existence of a trend towards increase or decrease.

In order to determine whether there is any tendency in the observation series included in the study, it is examined whether the sample value is significant or not. If the sample value is significant then the trend is calculated to be increased if $r_s > 0$ while trend decreases in the direction of decreasing if $r_s < 0$ (Türkeş, 2013).

- **Sen's Trend Slope Method**

Sen's trend slope method is a nonparametric statistical method which is used to determine the change of the slope in unit time in the case of determination of Simple Linear trend presence for time series. The lack of data in the time series does not constitute an obstacle to the implementation of this test. The size of the trend observed in the time series is calculated by the following formulas in the following order (Demirci, 2008, Karpouzos, 2010, Aziz, 2017 and Ay, 2017).

$$\boldsymbol{Q_i = \frac{x_{i-} x_k}{j - k}}$$

The Qi value corresponds to the data between x_i and x_k. (x_j), and (j)are values that were determined at the time, (x_k), and (k) are the time determined value, and (j) is the next time for the (k) time. N value is calculated by N= n(n - 1)/2 equation and the median values of N and $Q_i$are used to determine the trend of Sen (Polat, 2017 and Saplıoğlu, 2013).The N values of the Q_i are primarily sorted from small to large, and then the trend curve of Sen is calculated by the following equation:

$$\boldsymbol{Q = Q_{\left(\frac{n+1}{2}\right)}}$$

And if **N** is an even number, the amount of change of the slope in time series is calculated using the following formula:

$$\boldsymbol{Q = \frac{1}{2}\left(\frac{Q_n}{2} + \frac{Q_n + 2}{2}\right)}$$

- **Simple Linear Regression Analysis**

Simple linear regression analysis is a parametric method, assuming that the data is normally distributed. With this test, the relationship between the variables determined as X and Y is tried to be analyzed whether there is a linear trend (Cosun, 2008 and Şen, 2013).

The simple linear regression equation is established as y = ax + b, where a is constant in the simple linear regression equation that indicates the direction and amount of change. A positive value shows change in the direction of change, a negative value indicates that the change occurred in the direction of change. The fact that a is not far from zero shows that there is no change (Bulutet al., 2006).

In the regression analysis, the cause-effect relationship between two or more variables is examined in order to make predictions or to make inferences and this relationship is characterized by a regression model which is a mathematical modeling model (Yılmaz, 2018). It can be expressed in the model using the equation (Agresti, 2011):

$$\boldsymbol{E(Y|x) = B_0 + B_{1x}}$$

where E indicates a mean; Y |x, which indicates possible values of Y when x is restricted to some single value; B_0, is the intercept parameter, and B_1 is the slope parameter.

- **Statisticswithin the Constraints of Excel**URL:1**and Analyze data using the XmR Trend Control Chart in Excel with (QI Macros)**URL:2**.**

In the application of (QI Macros) run chart is used to study collected data for trends or patterns over a specific period of time. A run chart will help:

❖ Monitor data over time to detect trends.

❖ The Figures (Charts) is a record of a process over time.

❖ The vertical axis represents the process being measured precipitation. The horizontal axis represents the time units during which measurements are made.

❖ Middle of the chart is average or average, and here are the formulas used to calculate Figure:

UCL: mt + b + A2R

CL: mt + b

LCL: mt + b – A2R

The Charts calculates the fit of the data to the trend, As follows:
-R^2 gives the fit of the line to the trend. Greater than 0.80 is a good fit.
-Ryx is the linear correlation coefficient. Compare to probability for df = n -2.
-The slope is the positive or negative slope of the trend.
-Sigma is the estimated standard deviation of R bar/d2.
-Probability is a critical value for Ryx. If Ryx > Probability then a statistically significant correlation exists.

This sample format explains the above codes:

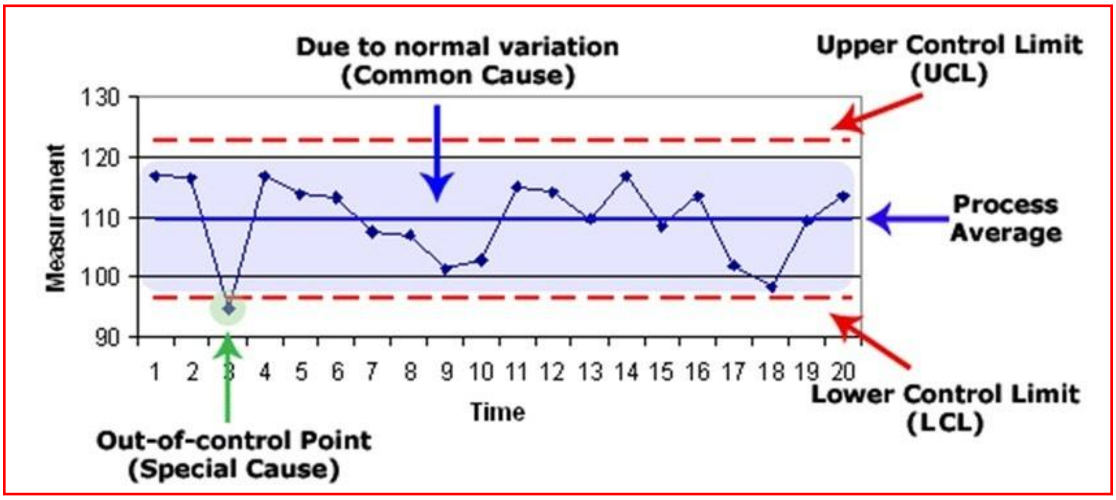


Figure 1. Explaining How to Extract Results from Trend Control Chart

Control Limits are used to determine if a data is stable or not. Control limits are the "key ingredient" that distinguish control charts from a simple line graph to the charts of trend analysis and are calculated from input data. The years and stations that did not show a trend through the upper and lower limit line of the precipitation are identified by positive control line and the negative control line (two red lines).

These four equations were applied to annual Precipitation Data, and equations are as follows:

(1) $$\boldsymbol{m} = \frac{\left[\sum tX - \left(\frac{(\sum t \sum X)}{k}\right)\right]}{\left[\sum t^2 - \left(\frac{(\sum t)}{k}\right)\right]}$$

(2) $$\boldsymbol{b} = \boldsymbol{X} - \boldsymbol{m}\frac{(\sum t_t)}{k}$$

(3) $$\boldsymbol{CL} = \boldsymbol{X_i} = \boldsymbol{mt} + \boldsymbol{b}$$

(4) $$\boldsymbol{R_{xy}} = \left(\sum t_i \sum X_i - ntX\right)(n-1)s_t s_x$$

- **Standard Precipitation Index (SPI)**

(McKeeet al., 1993) developed the Standardized Precipitation Index (SPI) which can be calculated at different time scales to monitor droughts in the different usable water resources. Due to its robustness it has already been widely used to study droughts in different regions like USA, (Hayes,1999), Italy (Bonaccorso,et al., 2003), and Turkey (Sönmezet al.,2005). Present study tries to identify the droughts locations in the northern half of Libya as lack of rainfall and its fluctuation has had a significant impact on the region.

The computation of SPI requires long-term data on precipitation to determine the probability distribution function which is then transformed to a normal distribution with mean zero and standard deviation of one. Thus, the values of SPI are expressed in standard deviations, positive SPI indicating greater than median precipitation and negative values indicating less than median precipitation (McKee et al., 1993).

The Standardized Precipitation Index (SPI) method converts the precipitation parameter into a single numerical value in order to define the drought of regions with different climates. This method is obtained by the following equation 1 by dividing the difference from the mean (Xi) to the standard deviation (σ) in a selected time period.

$$SPI = \frac{X_i - X_i^{Average}}{\sigma}$$

Table 2. Standardized Precipitation Index (SPI) Values

SPI Values	Drought Category
≥ 2	Very Heavy Rainy
1.50 ~ 1.99	Very Rainy
1.00 ~ 1.49	Moderate to Moderate
0.99 ~ 0	Normal
0 ~ -0.99	Close to Normal Drought
-1.00 ~ -1.49	Moderate-severe Drought
-1.50 ~ -1.99	Severe Drought
≤ - 2	Very Severe Drought

- **Climate Classification of ERINÇ**

Evaluating average temperatures when a region is considered wet or dry leads to incorrect results. For this reason, it is necessary to base the precipitation activity on the average maximum temperatures rather than the average temperatures. In the determination of Erinç precipitation activity, temperatures below 0 degree are excluded due to the fact that evaporation has not occurred.

It is possible to reach the right conclusions on Turkey's climatic conditions by using Erinç precipitation activity index (Erinç, 1996). For this reason, this index was utilized when the climate classification for North of Libya stations was carried out.

Turkish climate scientist Erinç developed the equation in 1965 to identify simple Bora drought index is as follows:

1. The annual drought index:

$$\mathbf{Im} = \frac{\mathbf{P}}{\mathbf{TOM}}$$

2. To find the monthly Drought Index:

$$\mathbf{Im} = \frac{\mathbf{12.P}}{\mathbf{tom}}$$

(P) it means amount precipitation in year or month, and (TOM) mean The average temperature in the year or month. And this table identifies climate rankings as a result of the previous equations. URL: 5

Table 3. Determining Drought Indicators in Erinç's Equation

Index value	Climate class	vegetation
From 8 small	Very Arid	Desert
8- 15	Arid	Desert Steppe
15- 23	Semi Arid	Steppe
23- 40	Semi Humidity	Dry Forest
40- 55	Humidity	Humidity Forest
From 55 upper	Very Humidity	Very Humidity Forest

Source: URL:2.

- **Climate Classification of L. EMBERGER (Coefficient of Thermal – Rain)**

There are two equations for Emberger, the first equation of the summer months is used for total amount of rain for months of June, July, and August with the highest temperature during these months. The second equation is used in annual average maximum temperature and the minimum temperature and average amount of rain in area (Neira, 2006). In the study area, the second equation will be used, because rainfall in the summer is almost completely absent. The equation is as follows:

$$Q = \frac{2000.P}{(M + m + 546.4)(M - m)}$$

The index of equation as follows:
Q = < 20 and P = < 300 mm = Very arid Mediterranean climate.
Q = 20–32 and P = 300- 400 mm = Arid Mediterranean climate.
Q = 32–63 and P = 400 – 600 mm = Semi arid Mediterranean climate.
Q = 63–98 and P = 600 – 800 mm = Mediterranean climate little rain.
Q = > 98 and P = > 1000 mm = Mediterranean rainy climate.

Q = Coefficient of thermal rain.

P = Total annual rain.

M = Average maximum temperature.

m = Average minimum temperature.

2000 = Constant No.

- **Index of JOHANSSON for Continental Climate and Oceanity Climate**

The climatic equations of the Continental and Oceanity are important in the study area. The study area comprises of two geographically different regions. One region has continental climate (Desert) while the other region possesses marine climate that include the coastal area of the Mediterranean Sea. Therefore, the Johnson equation will be used to determine the difference between Continental and Oceanity areas.

The Johansson Continentality Index is used for the climatic classification between continental and oceanic climates. The index is calculated by the following formula (Toroset al., 2008).

$$\boldsymbol{Jc} = \frac{\mathbf{1.7}\boldsymbol{E}}{\boldsymbol{Sinf}} - 20.4$$

The index of equation as follows:
O - 33 Oceanity climate.
34 - 66 Continental climate.
67 - 100 very Continental climate.

Where E is the annual range of monthly mean air temperatures, in (°C), (difference between the maximum and minimum monthly mean air temperatures) and Sin f is the latitude of the stations. The value of the annual difference of maximum and minimum air temperature is used to determine the Continentality of the climate. The climate is characterized as marine when k varies between 0 and 33, as continental when k varies between 34 and 66, and exceptionally continental when k varies between 67 and 100.

- **Index of KERNER for Continental Climate and Oceanity Climate**

Kerner was motivated by the fact that in marine climates the spring months are colder than the autumn months which led to formulation of the Thermodynamic fraction (Baltas, 2007).

$$\boldsymbol{K_1} = \frac{\mathbf{100}\ (\boldsymbol{To} - \boldsymbol{Ta})}{\boldsymbol{E}}$$

Where T_o and T_a are the October and April mean values of air temperatures, respectively. E is the annual range of monthly mean air Temperatures in (°C). Small or negative values of k1 imply a continental climate, while larger ones imply Oceanity, More specifically, in the present study, when the Kerner Oceanity is higher than 10 the climate is characterized as an oceanic. The following table and graph shows the branches of the equation and the values in Study areas.

VI. PREVIOUS STUDIES

Some related studies to the subject of research are given below:

Table 4. Some Studies in the Scope of Trend Analysis

Researcher Name and Year	The Topic	Method
Papadimitrio(1991)	Some Statistical Characteristics of Air Temperature Variations at Four Mediterranean Stations	Mann-Kendall Pattern Correlation Test
Pielke (2002)	Evaluating regional and local trends in temperature: an example from eastern Colorado, USA.	Mann-Kendall's test
Çiçek (2003)	The Statistical Analysis of Precipitation in Ankara	Wald-Wolfowitz Serial Correlation, and Mann-Kendall
Norrant (2006)	Monthly and Daily Precipitation Trends in The Mediterranean (1950-2000)	Mann-Kendall's test
Cosun (2008)	Climate Change Trend Analysis in Kahramanmaraş Province	Mann- Kendall Test and Linear Regression test
İçel(2009)	Trend Analysis for Temperatures and Precipitation in Eastern Coast of Mediterranean in Turkey	ANOVA, and Mann-Whitney U
Karpouzos(2010)	Trend Analysis of Precipitation Data in Pieria Region (Greece)	Mann-Kendall and Sen's Slope
Al-Tahir(2010)	Statistical properties of the Temperature, Relative Humidity, and Solar Radiation in the Blue Nile-Eastern Sudan Region	Mann-Kendall's test
Bahadır (2011)	Determination of Seasonal Changes of Rainfall in Trabzon and Rize with Marginal and Matrix Methods and Trend Analysis	ARIMA
Nalley (2012)	Trend Analysis of Temperatures and Precipitation Data Over Southern Ontario and Quebec Using The Discrete Wavelet Transform, Master Thesis, McGill University, France.	Mann-Kendall Trend test, and Discrete Wavelet Transform (DWT) Applications on Different Time Series.
Karabulut(2012)	Trend Analysis of Extreme Maximum and Minimum Temperatures in the Eastern Mediterranean	Mann-Kendall and Linear Regression Analysis
Karmeshu (2012)	Trend Detection in Annual Temperature & Precipitation Using the Mann Kendall test – A Case Study to Assess Climate Change on Select States in the Northeastern United States.	Mann-Kendall' test

Researcher Name and Year	The Topic	Method
Bonfils (2012)	Trend Analysis of the Mean Annual Temperature in Rwanda during the Last Fifty Years	Mann-Kendall' test
Al-Kenawy (2012)	Trend and Variability of Surface Air Temperature in North-Eastern Spain (1920–2006)	Mann-Kendall' test
Şen (2013)	Trend Analysis of Temperatures Precipitation Data in Isparta, in Turkey, Master Thesis, in Suleyman Demirel University, Turkey.	Mann-Kendall, Spearman's Rho, and Simple Linear Regression Analysis
Ageena (2013)	Trend and Patterns in the climate of Libya	Standard Error Bars, Mann-Kendall, Sen's slope
Saplıoğlu (2013)	Trend Analysis of Black Sea Region Rainfall Series	Mann-Kendall test, Sen's Slope test
Hendricks (2015)	Spatial Precipitation Trends and Effects of Climate Change on Hawaiian Aquifer	The Mann-Kendall and Sen's Slope test
Oliveira (2015)	Trend Analysis of Extreme Precipitation in Sub Regions of Northeast Brazil	Mann-Kendall' test
Dwayne (2016)	Long-Term Trend Analysis of Precipitation and Air temperature for Kentucky, United States, Department of Biology and Agricultural Engineering, University of Kentucky, Lexington, USA.	Mann-Kendall Trend test, and The test statistic t_{n1}, t_{n2}
Khomsi(2016)	Regional Impacts of Global change: seasonal Trends in Extreme Rainfall, run-off, and Temperature in two contrasting regions of Morocco	Mann-Kendall's test
Salami (2016)	Trend Analysis of Hydro-meteorological variables in the Coastal Area of Lagos "using Mann-Kendall's test and Standard Anomaly Index Methods"	Mann-Kendall's test, and Standard Anomaly Index Methods (SAI)
Aziz (2017)	Trend analysis in observed and projected precipitation and mean Temperature over the Black Volta Basin, West Africa	Mann-Kendall's test, and Sen's Slope

Researcher Name and Year	The Topic	Method
Zarei (2017)	Impact of Land Use Change on Precipitation and Temperature Trends in an Arid Environments	Mann-Kendall, and Spearman's Rho tests
Ay (2017)	Trend Analysis of Monthly Total Rainfall and Monthly Mean Air Temperature Variables of Yozgat in Turkey	Mann-Kendall's test, and Sen's Slope
Polat (2017)	Climate Characteristics and Trend Analysis of Long-Term Temperature and Precipitation Data in Rize in Turkey.	Mann-Kendall and Sen's Slope tests
Yılmaz (2018)	Trend Analysis of Temperature and Precipitation Data in Western Black Sea	Mann-Kendall, Spearman's Rho, and Sen's Slope tests
Nia(2018)	Trend in Temperatures average as A parameter to Quantify in Climatology in North of Algeria (1973- 2015)	Mann-Kendall's Test
Gedefaw(2018)	Innovative Trend Analysis of Annual and Seasonal Rainfall Variability in Amhara Regional State, Ethiopia	Mann-Kendall' test, and Innovative Trend Analysis Method (ITAM)
Gozalan (2019)	Comparative trend analysis of temperature and humidity parameters at surface, 850, 700 and 500 hPa pressure levels: Case of Turkey	Mann-Kendall, Spearman's Rho, and Sen's Slope tests
Özbunar (2019)	Trend analysis of Temperature Parameters of Florya, Sarıyer, Kumköy and Şile (Istanbul) Stations	Mann-Kendall, Spearman's Rho, and Sen's Slope tests
Nashwan(2019)	Unidirectional trends in annual and seasonal climate and extremes in Egypt	Mann-Kendall's Test

I. CHAPTER

CHARACTERISTICS OF PHYSICAL GEOGRAPHY

1.1. Geological Properties of Northern Libya

The geological regions of northern Libya consist of several sedimentary basins and high plateaus interspersed with several cracks, Most part of the study area consists of the Sahara desert which has old geological properties with the exception of the narrow Mediterranean coastal strip and mountain ranges to the south (Al-meselaty, 1995). The sedimentary layer that forms the surface of the desert is found everywhere on the bedrock of continent of Africa. The bedrock appears on the surface in some places due to the removal of sedimentary formations by erosion.

Chemical sedimentary rocks are found in humid coastal areas such as Green Mountain and Benghazi plain, where chemical sedimentary rocks are either dissolved in water directly, with calcium bicarbonate, ferrous, dolomite, etc. It occurs when the substances precipitate or when these dissolved substances change and replace others. The saturation of the water to the solution it carries causes the solution to precipitate. Some organisms also contribute to sedimentation (Coşkun, 2019).

The areas associated to different geological periods can be classified as follows:

1.1.1. Paleozoic

Most of the early Paleozoic formations are concentrated in the south of Libya that are found in the south-west and southern edge of the study area in Hamada Hemra. Some of the Nubian sandstone formations belong to this early Paleozoic period. At the beginning of Silurian and Carboniferous periods, the sea covered large parts of the southern boundary of the study area (Sharaf, 1971), and sandstone rocks are widely visible in those areas (Al-meselaty, 1995).

1.1.2. Mesozoic

In the northwest of Libya, the Mesozoic formations of Triassic and Jurassic periods are concentrated in limited places. Triassic formations are found at the base of Western Mountain which are limestone rocks of amorphous or thick and deep in form. Triassic and Jurassic rocks has disappeared in northern Libya under the layers of the newer rocks, however, re-emerging in Tunisia on a large scale (Sharaf, 1971). In the east, the Cretaceous rocks appear in many areas of the Green Mountain, especially Marawah, and in deep valleys such as the Bakur Valley near Tukera.

The Cretaceous rocks appear on the surface only in limited patches on the surface of the Green Mountain in the region of JARDES and ALMEHAJIR located southwest of ALBIDA. Although these formations disappear in the eastern part of the study area, they reappear widely in the Egyptian Western Desert around Libya-Egypt border. Moreover, there are a lot of limestone of the Eocene near south-east (Sharaf, 1971).

1.1.3. Cenozoic (Tertiary and Quaternary)

The rocks of Miocene are the basis of the bedrock of the Green Mountain and plateaus that are extending south of the green mountain. These rocks appear in the deep valleys, which are white limestone rocks and mixed in the Sirte plains with clay and sand rocks and sometimes mixed with Oligocene and Eocenen rocks south of areas Sirte and Agdabia. Most of the Miocene rocks Include north-eastern plateaus in the study area as Albutnan plateau. These rocks continue to extend westward forming the vast areas of the steppes south of the SIRTE plains and disappear completely in the northwestern regions of Libya (Sharaf, 1971).

Quaternary formations include sedimentation of Quaternary formations include sedimentation of alluriel, colluriel, some dune formations near coastline area, and Mediterranean sea which is still accumulating at present. The most important of these formations is the sedimentary soil in the valleys of the mountains and their estuaries such as the red soil formations found in the valleys of the Green Mountain and the western mountains during Pleistocene period.

It is known that sometimes in the Quaternary period, the deserts of Libya had received a lot of rain and were rich by river valleys. However, sand and quartz are covering vast areas of Libya desert like the rest of Great Desert in present configurations of quaternary period (Sharaf, 1971). The coastal sand dunes and rocky hills were formed by the cohesion of mostly limestone sand along the Libyan coast. During this period, the saline soils formed that accumulated in the Marshes areas near the oases such as the JAGHBOUB oasis (Sharaf, 1971).

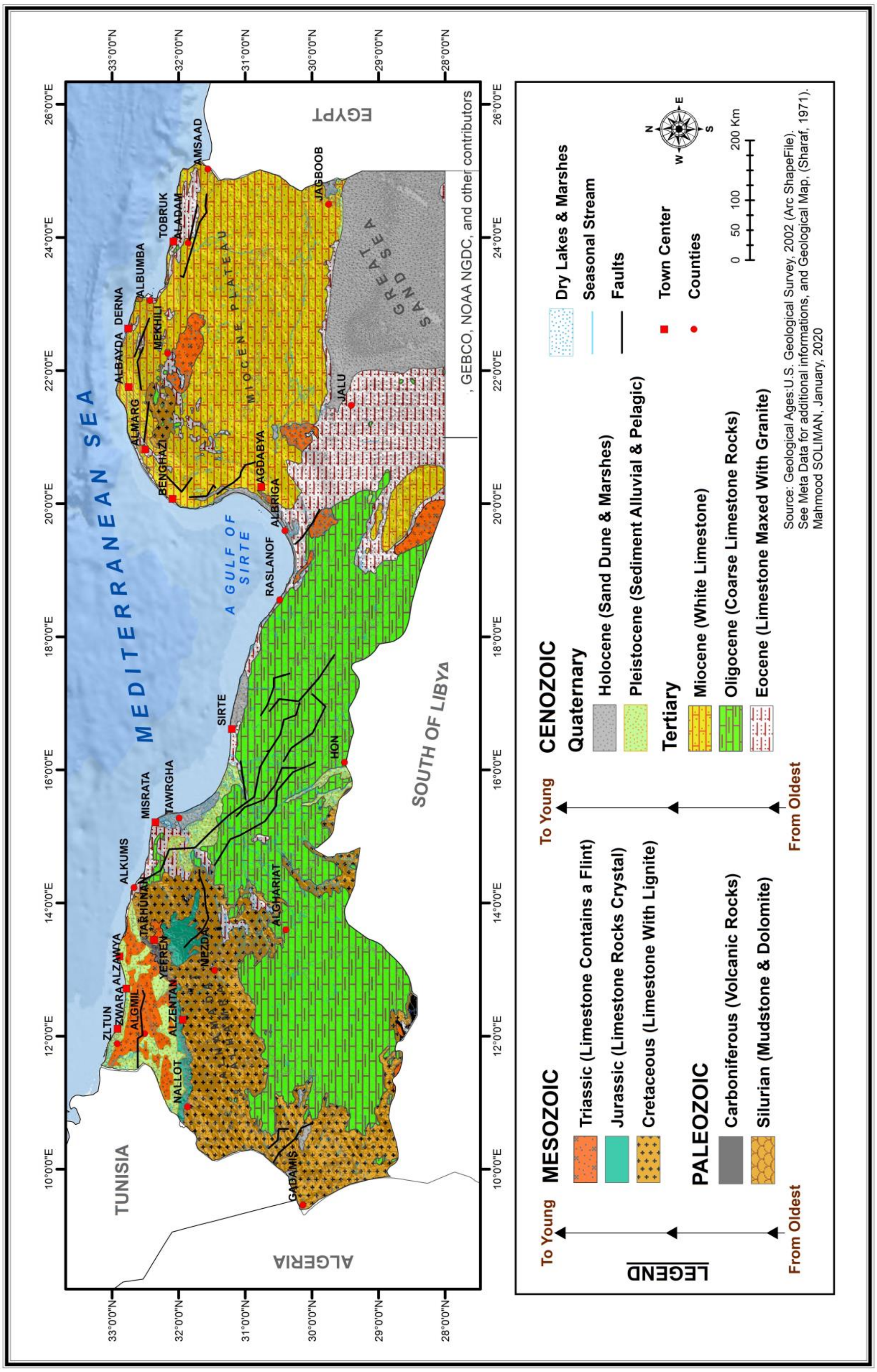
Generally, Paleozoic rocks and Mesozoic continental deposits occupy the greater part of southern Libya south of lat 28° N. Mesozoic sedimentary rocks form the Hamada al l;Iamra' plateau of northwest Libya and are largely covered by a thin veneer of early Tertiary sedimentary rocks. Other Tertiary rocks occupy almost all the central and northeastern part of the country and smaller areas in south-central Libya. The narrow coastal plains arc generally mantled by Quaternary deposits; a third of the country is covered by sand dunes and gravel plains (William, 1970).

The following table 5 summarizes the geological time scale experienced by the study area and the excavations that confirm this in its areas:

Table 5. The Geological Time Scale in Northern Libya

Era	Period	Epoch	The important of Configurations	Millions Years
Cenozoic	Quaternary	Holocene	Continenetal sands in Desert, Beach sands, Solonchaks	0.2 - 1
		Pleistocene	Dunes Sands, Red Soil,Saline soil in oases	1.8- 3
	Tertiary	Miocene	Limestone rocksin most of study area, and some times mixed with Clay Sand rocks in Sirte	11- 23
		Oligocene	Rough Limestone rocks in center and, and southwest of study area	24-33
		Eocene	Precise white limestone rocks in most east of study area in Green Mountain and Albutnan	41- 50
Misozoic	Cretaceous		Limestone rocks with Lignite in West Mountain	100-150
	Jurassic		Limestone rocks with crystal in West Mountain and Green Mountain,	160-200
	Triassic		Limestone contains a Flint in West Mountain and some areas in east , and south of Sirte gulf	206-248
Paleozoic	Carboniferous		Vocanic rocks in south center of study area	300-350
	Silurian		Mudstone and Dolomite in Southwest of study area	420

Based on: (Sharaf, 1971 and Al-meselaty, 1995).



Map 3. Geological Map for Northern of Libya

Source: Geological Ages: U.S. Geological Survey, 2002 (Arc Shape File), Projection: World Robinson. See Meta Data for additional information, And Geological Map in (Sharaf, 1971), p. 18.

1.2. Properties of Geomorphology

Looking at the Physical map, the region can be divided into three main types of the surface:

1.2.1. North Mountains

The northern highlands are divided into two main sections separated by the Gulf of Sirte, which are as follows:

1.2.1.1. Green Mountain

It is a plateau with a length of 300 kilometers from east to west that comprises mostly limestone and in many places this plateau descends toward the sea. The Green Mountain consists of three terraces one of which is 280 meters high and represented by the forest covered city. The second one is 600 meters high which is represented by the village of Sidi al-Hamri the south of Al-Bayda city. The third one is 860 meters high where the Al-Bida city is located. The Green Mountain has three main edges:

*First edge is the longest and lowest in altitude. It comprised of the area between Sosa town and Al-Hilal head with an average elevation of 300 m. The first edge begins directly after the end of the narrow coastal plain.

*Second edge begins after the end of the first edge which has the highest altitude with an elevation ranging between 420-600 meters above sea level. The surface of this edge appears in the form of simple hills.

*Third edge is the highest top in the Green Mountain with the highest elevation at Sidi al-Hamri area that is about 860 m above sea level (Alheram, 1995).

The limestone formations that make up the Green Mountain are reflected in the general shape of the water drainage network. From Green Mountain, a large group of river valleys descend to the north and flow into the sea (Johnson, 1973) such as Kouf, Mahboul, Atharoun, Naqa, Derna valleys.

In the south, however, after the Water Splitting Line, there are many valleys that are poured into the desert, ending in swamps which are called Blatat, such as Samalus valley, Ramle valley, and others.

1.2.1.2. Western's Mountain

This mountain has several names such as Nefusa Mountain, Geryan Mountain and TerhonaMountain.The peaks of the western mountain extend from the borders of Tunisia in the west to Alkums city in the east, and from A-Jufara plain in the north, to Alhamad plateau in the south. The maximum elevation of the West Mountain at the city of Geryan is 750 m above sea level.

Most of the western mountain consists of limestone rocks. However, there are some small areas, such as the Abu Qanush area, basaltic rocks are also present along with limestone rocks that cover most of this mountain,. In the north of West Mountain, there are a large network of valleys. These valleys descend in different directions due to the general decline in gradient that include Ghazwan valley, Jarjir valley, Maimon valley, Bani Walid valley and other small valleys (Alheram, 1995).

1.2.2. Coastal Plains and Coastal Landforms

A group of coastal plains is also found between the mountains and the sea or between the desert and the sea. In general, these plains represent a very small area in Libya that does not exceed more than 5% of total area of the country. These plains run parallel to the Mediterranean shores in the form of narrow strip and exceed towards the northern mountainous region of the Mediterranean sea. These plains are in the form of a tighten place between the Albutnan plateau and Mediterranean sea and many areas in Green Mountain. The most important of these plains are Benghazi plain, Sirte plains, Aljafarah plain and eastern lowlands. These plains have many coastal valleys through which the water is poured into the sea during rainy season in the winter., These plains can be briefly described as follows:

1.2.2.1. Benghazi Plain

The plain of Benghazi appears in the shape of a triangle whose head is located in the north widening in the south and gradually interfering with the Sirte plains in the west.The Benghazi plain’s elevation isn't exceeding 100 meters until the western slopes of Green Mountain appear where the plain meets those slopes at the river valleys that flow into the sea such as the Bakour Valley in the north.The plain is covered with unique Quaternary sediments consisting of red sedimentary soils which are transported by river valleys of Green Mountain to Benghazi plain (Alheram, 1995).

In Benghazi plain, there are many large marshes, such as Bu Jarrar, and Birses marshes which are separated along the coast by white sands.Some rocky beaches appear in the plain of Benghazi especially in the areas near of the Green Mountain.

1.2.2.2. Aljafarah Plain

It is one of the largest coastal plains in Libya with an area of more than 17,000 square kilometers (Alheram, 1995). It extends from the Alkoms city in the east to the West Mountain in the west.

The coastline of the plain is characterized by a straight line with the exception of some estuaries of valleys where the Jafara plain cuts many valleys pouring their water into the sea during the winter including Al-Majinin, Al-Hira and other valleys. In some areas, the rocky hills rise abruptly causing a difference in the degree of the slope towards the sea (Alheram, 1995).

1.2.2.3. Sirte Plain

This area includes all the plains surrounding the Gulf of Sirte between the Alburj head in the west and the town of Al-Zwaitina in the east. However, it is difficult to determine the southern boundary of the Sirte plain because the surface of the plain gradually increases as it moves away from the coast due to absence of any natural obstacles. It is just like a large arc of about 750 km in length and extends south to 30°S latitude, the Sirte plains are characterized by their low sandy beaches. As a result of the expansion of the surface of the plain and its low altitude from the surrounding areas, it became a huge basin where many large valleys such as Zmzm Valley are found. Besides, many salt marshes such as Tawargha marsh are also found in the Sirte plain (Alheram, 1995).

1.2.3. Plateaus

The most important plateaus which can be explained are the plateau of Al-Butnan and Defna and Al-Hamada:

1.2.3.1. Al-Butnan and Defna

It is a rectangular plateau with an average elevation of 200 meters above sea level stretching, from the Bumba Gulf in the west to the Libyan-Egyptian border in the east at a distance about 220 km to the northern border of the eastern Libyan desert. Many of the valleys that flow into the Mediterranean Sea descend from this plateau.

However, the southern side of this plateau gradually descends towards the desert. Most of the plateau formations consist of limestone (Sharaf, 1971).

1.2.3.2. Al-Hamada Alhamra

This is located in the southwest of the study area and extends to Tunisian and Algerian lands in the west while bordered to the east by the Jufra oasis. The surface of the plateau consists of sandy rocks. A number of river valleys emerged from this plateau heading towards the Gulf of Sirte, Ghadames area and some valleys are heading Alshatiy valley in the south of the study area. Moreover, some shallow basins are also found in the Hamada plateau, which receives floods from the northern river valleys during the rainy season (Alheram, 1995).

1.2.4. Karstic Land Forms

The karst phenomenon is widespread in many places of the study area, the most important of which are the limestone caves, karst drilling, the corridors and the red limestone soil on the surface of the green mountain. Besides, large carbon formations and multi-directional cracks serve as large reservoir for rainwater that falls heavily in the winter. The surface karstic drilling spread in the plain of Benghazi. The limestone base on the surface is directly separated by a thin layer of red soil resulting from karst erosion (Alheram, 1995).

1.2.5. Arid Region Land Forms

In general, the desert of Libya represents about 90% of the total area of the lands in the country. The desert stretches from the mountainous regions and Sirte Gulf in the north to the southern boundary of the country.

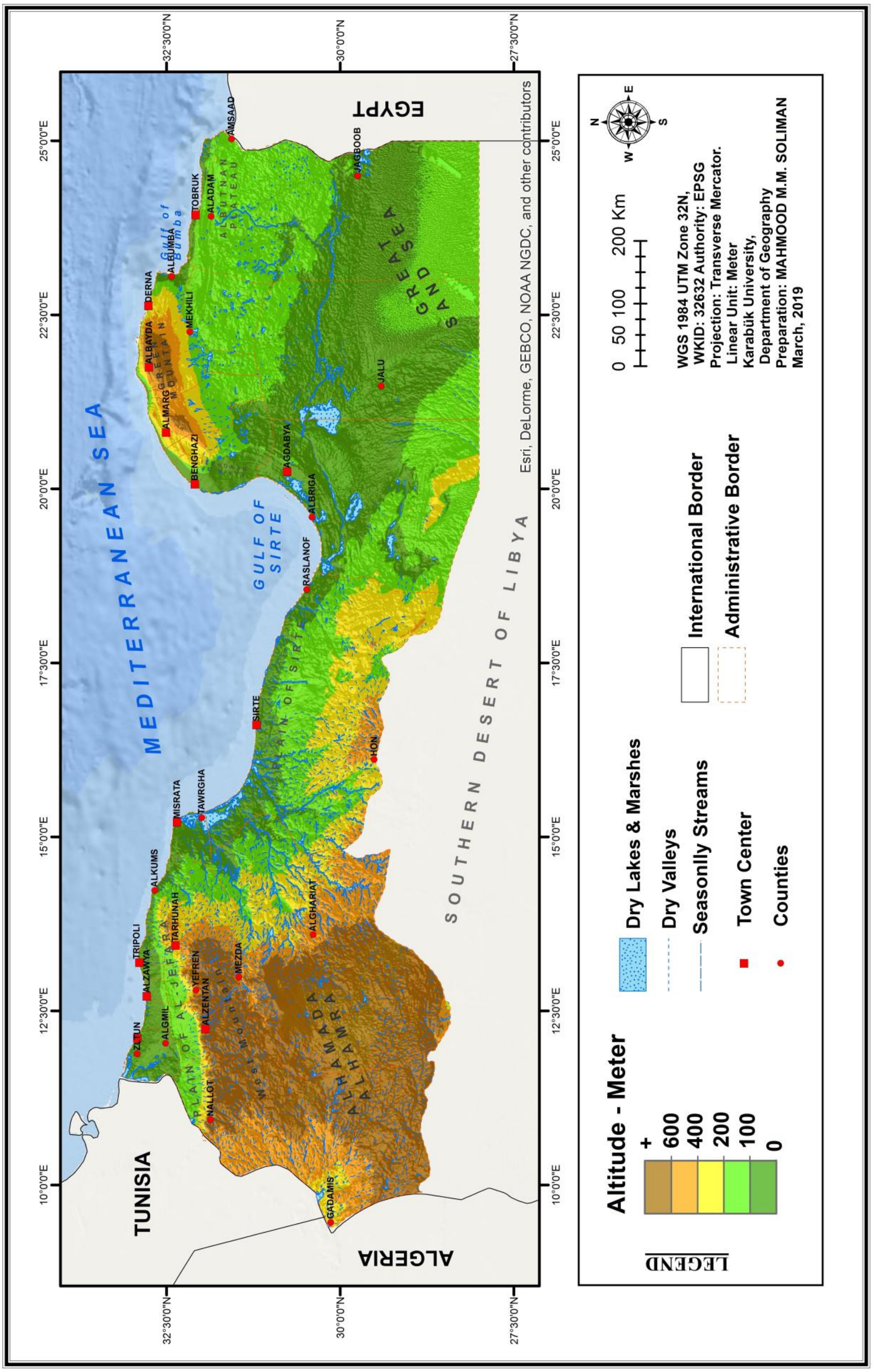
It is the part of Great Desert Sahara in the North Africa which is considered as the world's drier region. The Libyan desert contains large underground plains covered with sand at different heights.

Besides, small hills are also found over the surface of the desert in different forms such as Shahid Sahrawi. These small hills are found isolated or in groups in different shapes and forms like cones and columns. These different forms and shapes are associated to the erosion of ancient plateaus. Many of these forms exist in the Jaghboub and Jalo oasis.

❖ Great Sand Sea

The sand covers a vast area in the south of the study area which constitutes flat surface areas. The sand in the south-east of the study area is called the Great Sand Sea, a vast area that lies between the latitudes of 26°to 28.5°N and 24°to 30°Wlongitudes. It is characterized with big sand dunes which correspond to the direction of wind (Alheram, 1995).

There are many oases as Jaghboub, Jalo, Hon, Ghadames and others which are located within the boundaries of the study area in the south. These oases are depressions extending along latitude 29°N and characterized by the abundance of shallow lakes, salt marshes, isolated hills, and dry valleys. The reason for the emergence of these oases is related to various erosion factors that have been exposed through its long geological history (Sharaf, 1971).



Map 4. The Physical Map of Northern Libya

1.3. Climate of North Libya

Since the topic of the thesis is related to climatology, the subject of climate is not mentioned in this section. The climate of North Libya Sea Department is given in the next chapter.

1.4. Properties of Hydrography

1.4.1. Surface Water

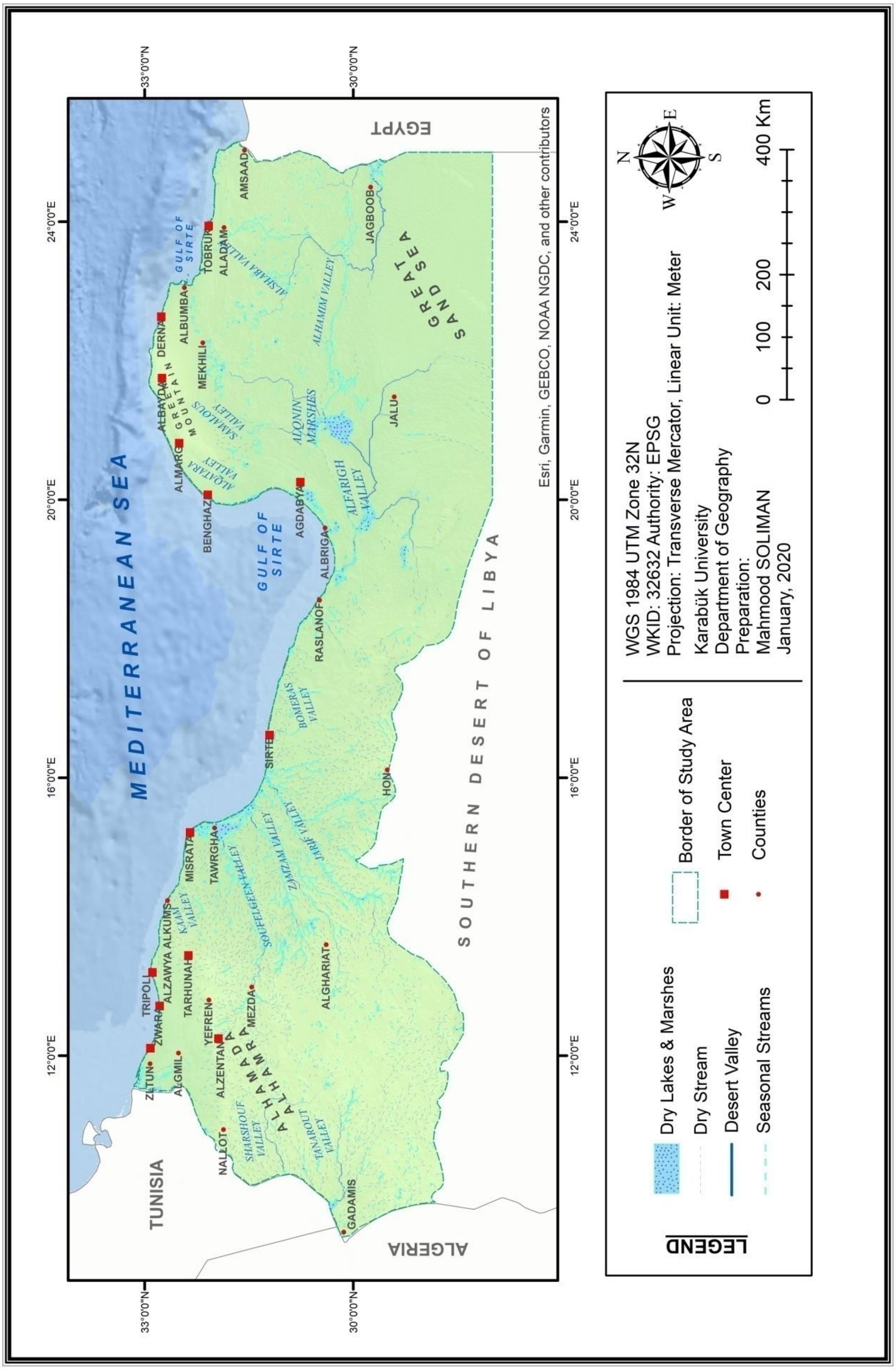
The surface water depends entirely on rainwater that flows on the surface of the earth in the valley and coastal plains or seeps down into the pores of the surface soils where the plants live directly. The average annual runoff of the seasonal river valleys in the coast of Libya is about 285 million m^3/year; of which about 110 million$m^3$of water is borne by the valleys sloping north of the western mountain, 20 million m^3/year in central region of Sirte and Aljefara, about 90 million m^3/year in Green Mountain area and 65 million m^3/year is distributed over other coastal areas such as Al-Betnan plateau and West Coast (General Information Authority, Statistical Book, 2007).

1.4.2. Groundwater

Renewable groundwater is concentrated in the plain areas such as the Jaffara plain, the Benghazi plain and the Misurata region. This water has been produced by collecting rainwater through dams that were established on the coastal valleys such as Al-Qatara valley dam, Derna valley dam, Kaam dam, Al-Mjinin dam, and others. Non-renewable groundwater is found stable in the desert in the south of the study area. it is a large underground reservoir that has been storing water for millions of years. Besides, karst water reservoirs are also found in many areas of Green Mountain. These are aquifers which are called karstic groundwater.

The characteristic of water is dense in limestone rocks as the limestone increases the proportion of salt and calcium carbonate. The water dissolves the rock and makes water channels, karst caves, lagoons and tributary tables inside the surface. These features are filled with water as whole or in part resulting in the formation of waterfalls in many areas of the Green Mountain region, such as the Derna waterfall, Ain Dabbousia, Ain Marara and others.

A shortage of water sources is observed despite the large extent of study area. Even if it is available in some areas, the scarcity prevails because of natural factors like lack of rainfall, high temperatures, and high evaporation rates. Besides, the mountainous areas don't benefit from the amount of rain falling in the winter because most of the rainwater seeps into the ground through the cracks of the karst and some part penetrates deep into the ground while very little water appears in the form of small waterfalls. It is concluded from the previous map which shows the dry and seasonal waterways in northern Libya that these river valleys do not contain any water for many years. Sometimes, sudden rain falls around which produces strong floods of water going directly towards the Mediterranean sea. However, this water cannot be used and often causes Environmental and Economic problems in the areas from which they originate.



Map 5. Hydrography of North Libya

1.5. Properties of Soils (Parent Material and Components)

The parent material of the soil is divided into two parts that are the residual material of the remaining bedrock consisting Igneous rocks, Sedimentary rocks or Metamorphic rocks which is a source of local soil due to the mechanical weathering activity in dry and semi-arid areas while the second part is comprised of transported materials that consist of all the Libyan soils.

Soil formation reveals not only the geographic properties such as climate, topography, parent material and vegetation but also geomorphic process like erosion and sedimentation conditions of an area. Paleosols are indicator of past climate changes and formed long periods ago that do not have relationship in their chemical and physical characteristics to the present-day climate or vegetation (Atalay, 2013/a).

The systems for classification of the field have been formed by developed countries in order to make the best of existing natural sources against increasing population with Industrial Revolution. For instance; local planning made by America of 1930s, the studies of "Land Use Survey" made by England in 1922, the report of "SCOTT" published in 1941 explained the use of natural environ-ment and how it should be used (Coskun 2016).In general, soils in northern Libya are divided into two main sections which are the coastal soils and the desert soils. There are many types of classifications of soils around the world including biological, physical, chemical, and other classifications (Eswaran, 2002).

The soils in the study area can be classified into three main classes depending on the Factor-genetic of classification that Zonal, Intra-zonal, and Azonal soils.

1.5.1. Zonal Soils

These soils result from the maximum effect of climate and living vegetation upon parent material in areas extremes of weathering prevails. and where the landscape and climate have been stable for long time (Eswaran, 2002).

1.5.1.1.Terra Rossa

Red soil covers a large part of the green mountain in the region of Al-Marj and region of Al-Fataiah, and Benghazi Plain, it is muddy, calcareous, with calcium carbonate and its high ability to conserve water, filtration rate is 4 centimeter/ hour (Gefli, 1972).

1.5.1.2. Arid Steppes Soil

This spreads in most of the southern regions of Green Mountain and Benghazi plain, Western Mountain, and Albutnan plateau. Besides, this soilis also found in the transitional area between the mountains and the desert where very little amounts of rainfall happens.

1.5.1.3. Rocky Desert Soil

In the more arid parts of the Libya Desert, surfaces of some soils are covered by a layer of small stones interlocked, it is characterized by poverty in the necessary nutrients such as nitrogen, phosphorous and potassium, as well as its low ability to retain moisture, it is Incoherent soil, mixed with gravel and stones, and often exposed to air erosion.

1.5.1.4. Brown Arid Soil

These soils cover large areas of northern Libya especially in the desert and semi-desert areas which are composed of different originals under a dry-hot climate that leads to a lack of vegetation cover except desert grasses or shrubs. Besides, the amounts of rain are also not enough to wash dissolved salts, gypsum and calcium carbonate. This type of soil is widely distributed in the northern, central and eastern region, it is characterized by a low percentage of organic matter and nitrogen, as well as high carbonates, salinity, and alkalinity, and this soil suffers from the problem of dismantlement by winds.

1.5.1.5. Reddish Brown Arid Soil

It is a widespread soil in the Jufara plain and in Benghazi plain. The origin of this soil is due to the desert sands with a limited effect of silt, and the carbonate with a percentage of salt and gypsum (Export, 1978).

1.5.2. Intra-Zonal Soils

Reflect the dominance of single local factor, such as parent rock or extreme of drainage, as they are not related to general climatic controls, they are not found in zones (Nalley, 2002), including the following types:

1.5.2.1.Saline Soils, (Marshy soils)

This is widespread in many areas on the coastline, and is particularly prevalent between the Libyan-Tunisian border in the west and the Sirte plains in the east, between Taourgha and Sirte, and continues in some northern parts of the Benghazi plain (Export, 1978). Another type of saline soil is located to the south of the Green Mountain where rainwater accumulates, such as the Al-Belet region south of the Green Mountain, where evaporation increases due to high temperature, which helps to raise the poetic water to the surface of the soil, which it evaporates and leaves salts in the surface layer of soil, to form a salt crust (Abu-Khashim, 1995).

1.5.2.2.Rendzina Soil

Is a black soil whose spread is related to the wet climate in regions Al-Bida, Al-Quba, Labraq, and the southern part of Al-Marj plain, these is characterized by muddy soil, poor drainage, and cracks in the dry season and little Calcium carbonate and nitrogen, and the ratio of acidity between the simple and the average and despite the lack of nutrients, but it compensates using phosphoric fertilizers (Export, 1978).

1.5.3. Azonal Soils

Incomplete soils, have a more recent origin and occur where soil-forming processes have had insufficient time to operate fully, as a consequence, these soils usually showing just the characteristics of their origin, there is two types in the study area, it spreads in all coastal valleys and some and in some desert basins.

1.5.3.1. Sedimentary Soil (Fluvisols)

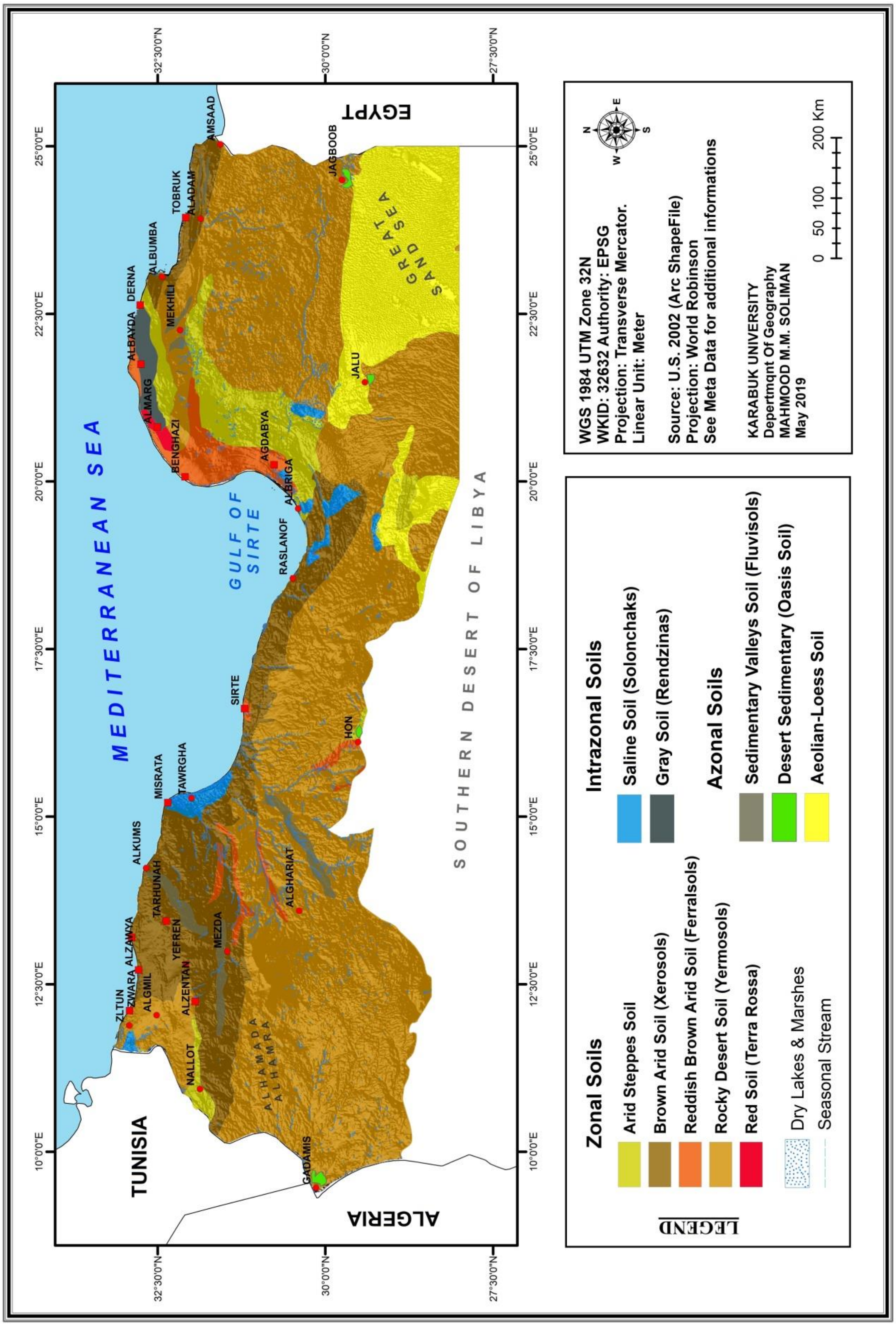
This type is prevalent in valleys, and its distribution is related to the water drainage system. It is spread in different parts of the study area, especially in the valleys that cut the Green Mountain, and Western Mountain. and Al-Sagayef area in Al-Batnan in eastern of the study area, and mixed with gravel and rocks, and contain sufficient amounts of potassium, and a little of phosphorus (Abu-Khashim, 1995).

1.5.3.2. Desert Sedimentary (Oasis Soil)

Located in the bottoms of the southern valleys (Oasis) it is caused by the deposition of materials by the wind at different periods of time. They contain varying amounts of gravel, consisting of sand and gravel mixed with clay, and spread in Jaghboub, Jalo, Ghadames areas.

1.5.3.3. Aeolian-Loess Soil

This type includes sand dunes that is disassembled sand moving from one place to other by wind. , This type of soil is characterized by high salinity and poor essential nutrients with inability to retain moisture. This type of soil is home to some plants that circumvent the drought such as cactus. It also includes Continental Sands covering vast areas of the study area, especially the southern regions such as Hamada Alhamra. It also includes sedimentary soils in the lowlands, such as oases and southern valleys Areas, as Aljufra, Ghariat, and Hon.



Map 6. Soil Map of North Libya

1.6. Properties of Vegetation in North Libya

Except for some northern regions like Green Mountain or Western Mountain. Or some transitional areas between the mountains and the desert and between the coast and the desert. There are oak trees, peat and pine in the Green Mountain due to amount of rainfall exceeding (500 mm).

On other side are the transition areas between the coast and the mountain, on the other the deserts are very common. The dry desert climate is characterized by drought-tolerant plants and thorny weeds, such as cacti. But it disappears when you see the sand. These are some plant species growing in different regions of Libya are as follows:*Arbutupavarii*,*Ceratonia, silique*, *Cistus salvifolius*, *Juniperusphoenicea, Cupressus sempervirens*, *Myrtuscommunis, Pinus halepensis, Pistacialentiscus* and*Quercus coccifera*(Ali, 2015). In general, the number of natural plant species in Libya is estimated at 1750 species (Jafri, 1972 and Elgadi, 1986).

Some important plant species will be addressed in the study area, and important vegetation in Green Mountain and other areas, and it is worth mentioning that the western area of the study area is completely devoid of forests due to topographic and climatic factors (Sharaf, 1971).

- ***Cupressus sempervirens***, the most important areas of growth are the Lemloda area, and around city of Al-Bayda and Al-Kouf Valley, It is the highest mountain area and the most rainy about (400 -600 mm) in the years.
- ***Pinus halepensis,*** it grows in the northeast of the Green Mountain, on the valleys of the coastal region between Karsa in the east and Sousa in the west. The best places to grow this species are naturally protected areas from strong winds.
- ***Arbutus unedo,***in Libya local name is (Shemary) these trees are characterized by their fruits, which resemble red berries. They are short shrubs that grow in many parts of the Green Mountain, where rain is abundant and often mixed with cypress trees.
- ***Quercus sp.***it broad-leafed trees that grow in many deep valleys of the Green Mountain, as Al-Loleb valley, Zaza Valley, and ZaweatMesaud, and it requires deep soils and available water.

❖ ***Olea europaea*****(Olives),** natural olive, it is due to ancient Greek or Roman origins, and there is the largest gatherings of this kind in the region of Ghraib, and it grow in the region of Mertoba and Um-Alrezem in east of Green Mountain.

❖ ***Ceratoniasiliqua,***carob trees grow in many area in Green Mountain, including the middle plateau of the mountain, along the middle coast, where the soil is replenished and water is available. It is usually found in the form of scattered trees, and is rarely found in large gatherings, which is an evergreen plant, the height of the tree ranges between (10 - 20 meters).

❖ ***Pistaciaatlantica,***the local name is Al-Batoum, where the Al-Batoum forests are located in most parts of Green Mountain and to the north of the city of Benghazi until to Tukera, and this tree help used to protect the soil.

And grow in oases some natural plant like TamarixAphylla that grows in the desert oases (Abu-Khasim, 1995), a tree with an existing trunk, sometimes branching from the base near the surface of the earth. This shrub is spread in the oasis of Jalo, and is particularly grows in sandy and saline soil, and like other oases in the deserts of the world, the Libyan oases are famous for palm trees, where natural palm trees grow on the edges of the salt lakes as Almelfa Lake in Jaghboub oasis.

In different areas of the study area, there are many types of grasses, which depend on the amount of rain and the distribution of soil, including seasonal growth during the spring, and what permanent growth and flourishes during the rainy season, there is no doubt that weeds are one of the most widespread plants in Libya, especially the seasonal grasses that grow after the fall of rain, there are different species, the most important of which is the grass that grows in disassembled soil, as Albelooz that is spread in the northwest plain of the study area in Al-Shahal.

In the agricultural areas, grasses that grow next to agricultural crops such as Zaghlil, Chrysanthemum, and Anemones are scattered. It is worth mentioning that these weeds grow next to agricultural fields that are planted on rain water, such as wheat and barley. There are also grasses has different names, such as Shiyh, Alhlfaa, Mothnan, Aljell and kandul, and other species with many local names, in the west and east of study area.

***Human Impact on Vegetation:**

Many of human activities occurred in Green Mountaın area as result of increase of development activities and growth of population. The investigations were many searces out to study the flora and vegetation composition of coastal region of AL-jabal AL-akhdar area and the effects of human impacts on the vegetation composition.

The results in (Al-shatshat, 2014) showed that 104 plant species belonging to 37 families were found. On the family level, both Fabaceae and Asteraceae were the major plant families in the area with 16 and 15 species, respectively. The annuals form the huge number of the plants(64.4%), while other life forms of the biological spectrum appeared in different percentages. Negative interactions between human activities (land abuse, charcoal burning, overgrazing…etc.) and vegetation were noticed among the study site.

Forest ecosystems that exist within the terrestrial ecosystems are one of the seriously important resources for the life of living organisms. Natural, cultural and economic functions of forest products and services are inarguable. As well as these functions, natural foods that are obtained from forests like fruit, mushrooms and leaves pose a supplementary food especially for poor sections of the society living in rural areas.

Countries have to produce serious policies in order to prevent rural population living in the forest areas from migrating to urban areas, and to increase the income resources. Agricultural forest activities are among important policies that are made for the people living in rural areas. Opening proper forest areas for agricultural activities without damaging the natural tissue is in fact the activity that will make the existing areas of a country become more economic and functional (Coşkun al., 2017).

II.CHAPTER

CLIMATE CHARACTERISTICS

This section covers general climatic characteristics and factors affecting the climate of the region such as solar radiation, temperature, atmospheric pressure and wind, humidity and evaporation and condensation and precipitation.

2.1. Effect of Physical Factors on Climate

2.1.1. Planetary Factors

Thissection contains global or regional factors that impact on climate of the study area, including air masses, depressions, effect of the Mediterranean Sea, and global pressure centers.

2.1.1.1. Geographical Location

The most important natural influences on the climate in any region of the world is the absolute and geographical location. The region has been subjected to many natural impacts on the climate due to it vast geographical extension. In absolute location, the latitudes determine the angle of the solar radiation which in turn determines the temperature of the place on the earth's surface. In the study area, two distinct climatic regions are determined that are; the coastal area of Libya in the north with wet climatic characteristics and dry desert area in the south.

The study area is located within five latitudes resulting in large differences in the temperature of and thus leads to differences in atmospheric pressure systems and affects the type of climate prevailing.

The geographical location has a significant impact on the climate of the region which further influences the land use patterns. In the study area, the southern part is more strongly influenced by the geographical location in terms of climate as Libya desert constitutes the largest part of this area.

- **Relationship Between (Temperature & Precipitation) and Latitude**

A positive correlation was found between latitudes and the average temperatures in the study areas shown in the following (Figure 2).

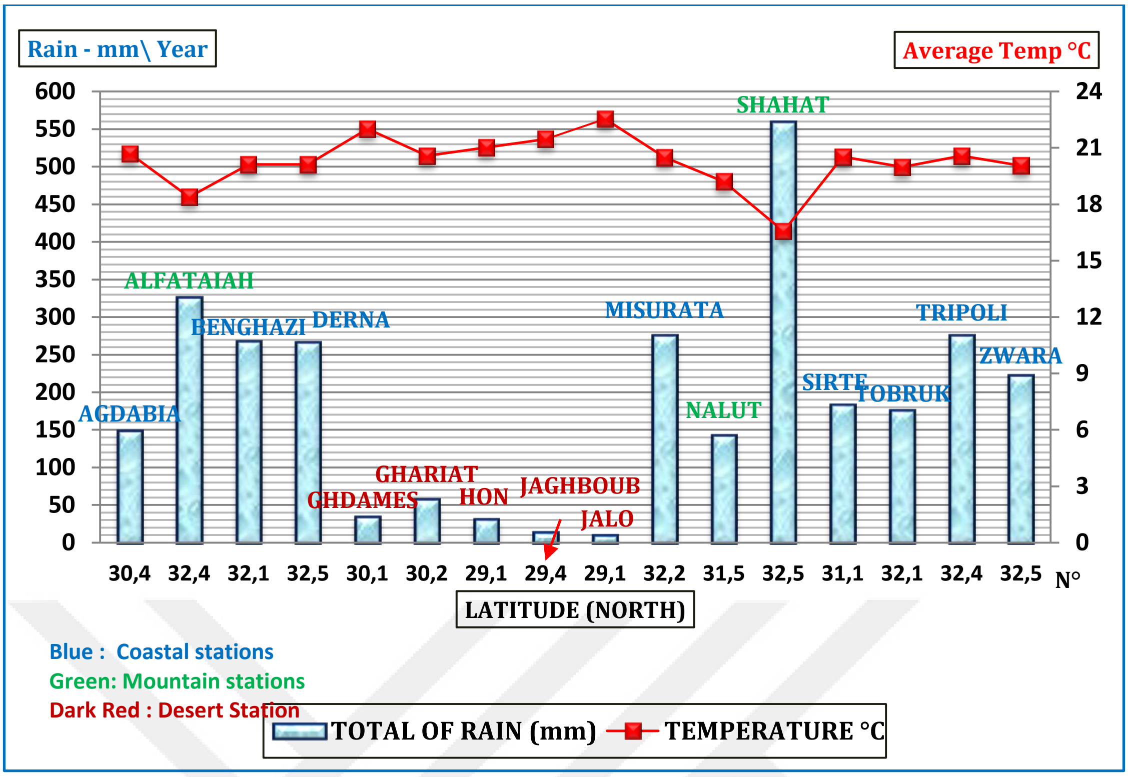


Figure 2. Relationship Between (Temperatures &Precipitation) and Latitude (1971-2010)

From the figure 2, the following facts can be found:

- The stations located within the circle of the width of the latitude 29,30°N, shows increase in the general rates of temperature and decrease in rain while at some stations there is no rain. This is at stations of JALO, JAGHBOUB, HON, GHADAMES, GHARIAT, and AGDABIA station, these are desert's stations.

- Temperature ranges from (16 °C) in SHAHAT to (21°C) in AGDABIA and the rain ranges from (150 mm) in NALOT to (538 mm) at SHAHAT, at the stations located on the latitude of (31, 32 °N) including BENGHAZI, DERNA, ALFATAIAH, SHAHAT, SIRTE, TOBRUK, TRIPOLI, ZWARA, NALUT, and MISURATA. These facts confirm that Latitudes are an important factor that directly affects climate elements in the study area. It is worth noting that there are many natural factors that work to stop the effect of the astronomical location factor on the climate, including the elevation and affect of Aspects, for example, the DERNA, SHAHAT and ZWARA stations are located on the same latitude (32.5 °N), and the average of rainfall at SHAHAT Station reaches more from (538 mm) its elevation 621 m., and in DERNA station annual average rainfall is (260 mm), ZWARA station the average of rainfall didn’t exceed (222 mm), its elevation only 1m above level sea in ZWARA, and elevation of DERNA (26 m).

2.1.1.2. Air Masses and Fronts

The area of northern Libya is affected by many types of air masses the most important of which:

*Continental Tropical (cT), the region is affected by the warm air coming from the Sahara which is concentrated on North Africa desert produces tropical air which is characterized by dryness throughout the year, this air mass is responsible for extreme heat in summer and tends to cold in the winter. The cold air is felt especially at the end of the spring and early autumn when rushing in the form of wind of Qubly at the front of air depressions (Al-Darat, 2004).

*Continental Polar air (cP), its cold air that reaches the north of the study area in the Winter coming from Russia and eastern of Europe, when passing through the warmer Mediterranean Sea, its temperature increases relatively.

*Maritime Tropical (mT), when the air mass remains on the Mediterranean Sea for a long time, it modify the air in the Mediterranean Sea, from dry air to moist air, and orbital air mass turns into a moderate air mass, affecting the climate of the study area in the summer.

*Maritime Polar air (mP), humid cold air coming from northwest of Europe across France and Italy, This cold air meets the warm air over the Mediterranean Sea and leads to heavy rains in some areas of coast in study area, such as Green Mountain and Western Mountain (Map 7).

Fronts,the northern region of Libya is affected by several warm and cold fronts, and the type of front depends on the movement of air. Is it cooler than the surface or is it warmer than it? The cold front advances the warm air along its fold to occupy a place occupied by the cold air, and the opposite occurs on the cold front.And a hurricane arises on the surface of the front for many reasons, including mountain ranges, and severe thermal variation between surface and Mediternnean Sea, and strong winds usually occur and the appearance of masses of cumulative clouds on the horizon, and a decrease in temperature on coastal areas, and this may be accompanied Heavy rains fall on mountainous areas, such as the Green Mountain region.

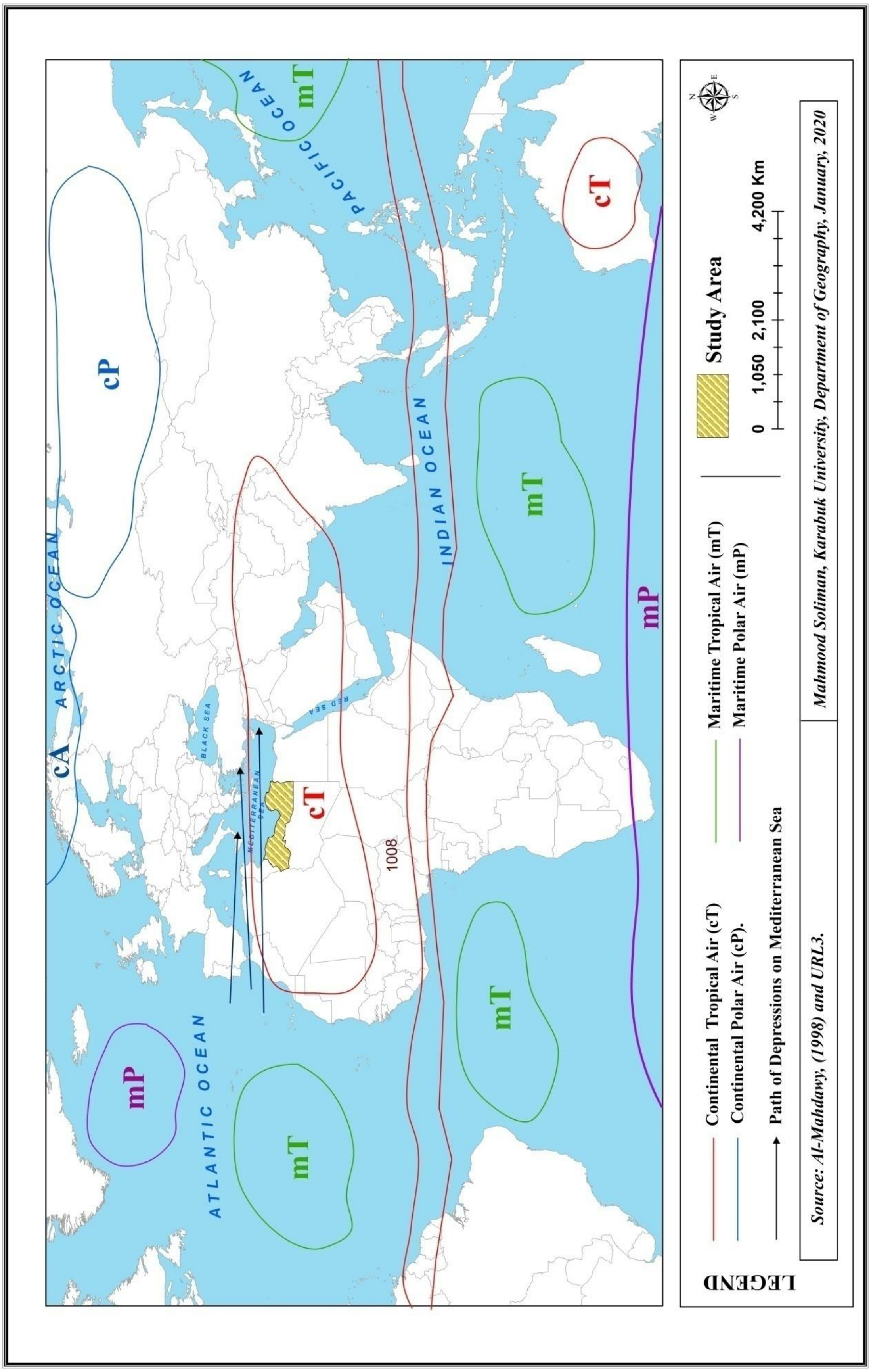
There are maritime and ocean masses which are formed in the areas of high pressure without the orbital movement and formed over the Mediterranean Sea in the summer. These air masses have moderate warm air and high relative humidity. As Atlantic ocean is relatively cooler than Mediterranean during the spring and autumn seasons, this air mass moves to the east and affects the study area. However, wind from the north helps decreasing the temperature of the mass and sometimes caused the fall of a small amount of rain. The impact of fronts on the climate of study area is very limited. The tropical front is does not cause any effect on precipitation in the region and only forms some medium and high clouds, this front is weak on the surface and is usually accompanied by the so-called current (Jet Stream) at the upper levels of the atmosphere which changes its location from one season to another.

2.1.1.3. Depressions

The cyclones have affected the climate of the study area in several ways. The region lies within the Mediterranean region, where these depressions move over all seasons and affect the climate to a large extent causing sudden changes in the climate due to very fast winds. These depressions are accompied with heavy rain and thunderstorms and other weather fluctuations affecting the Mediterranean coast like sudden increase in temperatures in the winter (Map 7).

These air depressions causes rainy season in spring and winter through moist westerly wind system in the study area (Sharaf, 1971).These depressions also move from north to south and vice versa and follow the movement of the sun. These are often found in winter and spring and disappear in the summer. In the summer, they appear at the beginning or near the end of the season and there is no effect of the depressions in the area during this season. In the season of autumn, the depressions cause the autumn rains to begin. The Mediterranean Sea in the winter consists of a range of relatively low pressure area due to the warmth of its water compared to the south of the study area. The southern area is subject to the high-pressure range of the Azores which extends over the Sahara Desert and continues to extend eastward. In the summer, the Azores high pressure moves to the north extending its part of over the

Mediterranean Sea to the north of the Libyan coast. The Sahara is part of a large range of low-pressure areas which is attracted by the north and north-west winds blowing to the north of study area throughout the summer months.



Map 7. Air Masses And Depressions Around The Study Area

Sourc: (Al-Mahdawy, 1998 and URL3).

2.1.2. Geographical Factors

2.1.2.1. Effect Mediterranean Sea and Desert

The great differences between the desert and ocean climate have profound impact on the climatic characteristics of those areas in terms of temperatures, amount of rainfall, humidity, and evaporation. The desert has a high annual temperatures as the incoming solar energy is relatively constant throughout the year. The temperature cycles of a given region reflect the net energy gains and losses in a given time period. The temperature of an area decreases when energy losses surpass energy gains and vice versa (Ackerman, 2012).

The length of Libyan coast on the Mediterranean Sea is about 1900 km. The impact of sea on the climate varies from one place to another because of the different stations of the surface and the shape of the coast. In general, many coastal areas in northern Libya are characterized by moderate temperature in the summer because of the sea breeze while in some coastal areas the sea breeze reaches 40 km inwards.The sea breeze usually activates during the day after 2:00 or 3:00 pm when there is maximum air temperature, it helps to regularize the temperature and humidity.The highest summer temperature in most of the coastal meteorological stations reaches (28 °C) with (80 %) relative humidity. These are the characteristics of the marine climate. In contrast, the maximum temperature at the southern stations reaches (32 °C) while relative humidity does not exceed (60 %) which shows the characteristics of a continental climate.

2.1.2.2. Impact of Mountains and Direction of Coastline

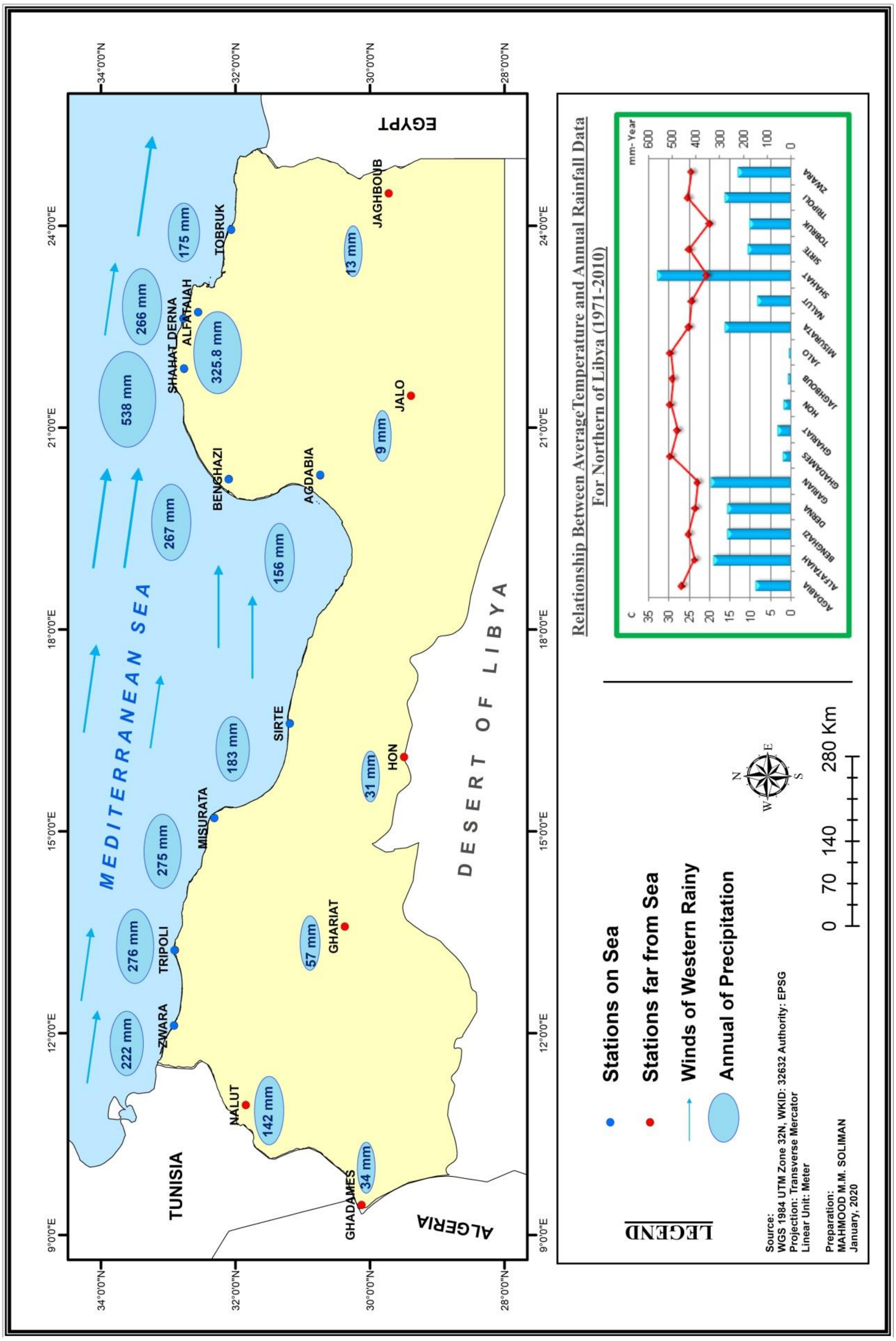
The impact of Mountains on climate is evident in mountainous areas such as the Green Mountain and the Western Mountain with more humid climate. Green Mountain, with a maximum elevation of about 880 meters comprises of a plateau facing towards the Mediterranean Sea. The temperature is mild during the summer and becomes low in winter.

Green mountains receive amounts of rain up to (538 mm) in SHAHAT**.** Similarly, Western Mountain are also prevailed by moderate temperatures in the summer and low temperatures in winter. Coastal areas within the study area are characterized by high temperatures and high relative humidity with no high rainfall. Sirte region has a general temperature of (20 ^{0}C) where rainfall does not exceed more than (200mm). while in MISURATAaverage temperature is (21 °C) and the average rainfall is (275 mm). The general average temperature in Tripoli, where the plain of Al-Jafara lies, is (21 °C) and with precipitation of (276 mm).Coastal areas of the study area are characterized by high temperatures and high relative humidity, and little rainfall. SIRTE region has an average temperature of 20 degrees Celsius while the rainfall does not exceed more than (200 mm). In MISURATAregion, the average temperature is (21 °C) and the average rainfall is (275 mm). The general average temperature is (21 °C) and the rainfall rate is (276 mm) in Tripoli, where lies the plain of Jafara at the top of triangle.

2.1.2.3. Coastline Direction

The map 7 shows the impact of coastline direction on heat and rain at some station, such as SHAHAT station which is 621 meters high facing towards the rainy west wind and has annual rainfall of (556 mm). There are many stations receiving large amounts of rain because of facing the western winds of rain such as TRIPOLI station (276 mm), BENGHAZI station (267 mm), MISURATA station (275 mm), ALFATAIAH (326 mm) station, and DERNA station (266 mm). These stations are affected by the factors of elevation and direction of coastline towards the rainy wind. Al-Batnan plateau lies in the east with an average elevation of less than 200 meters and its coast take a south-easterly & north-west direction from Bumba gulf area to the Ghazala gulf area and then takes a south-easterly direction up to Ras-Almelh. The effect of this trend is clear on the western wind which results in a shortage of rainfall during the season.

In TOBRUK region the annual rainfall rate is only (178 mm) while in contrast the BENGHAZI region receives annual rainfall of (249 mm). The reason for the increase in the amount of rain in Benghazi is because of the direction of coastline facing towards the rainy western winds as the coast of Benghazi plain takes a northeastern – southwest direction. It is noted from the map 7 that the GHADAMES station, which is about 400 km away from the sea, has a rainfall of 34 mm, while GHARIAT station to the west of it has a rain rate of (57 mm) and it is 254 km from the Mediterranean coast.Moreover, there are other natural factors that may cause a decrease in the amount of rain, such as the rise above sea level, and distance from the Mediterranean sea.



Map 7. The Relationship Between Direction of Coastline and Precipitation

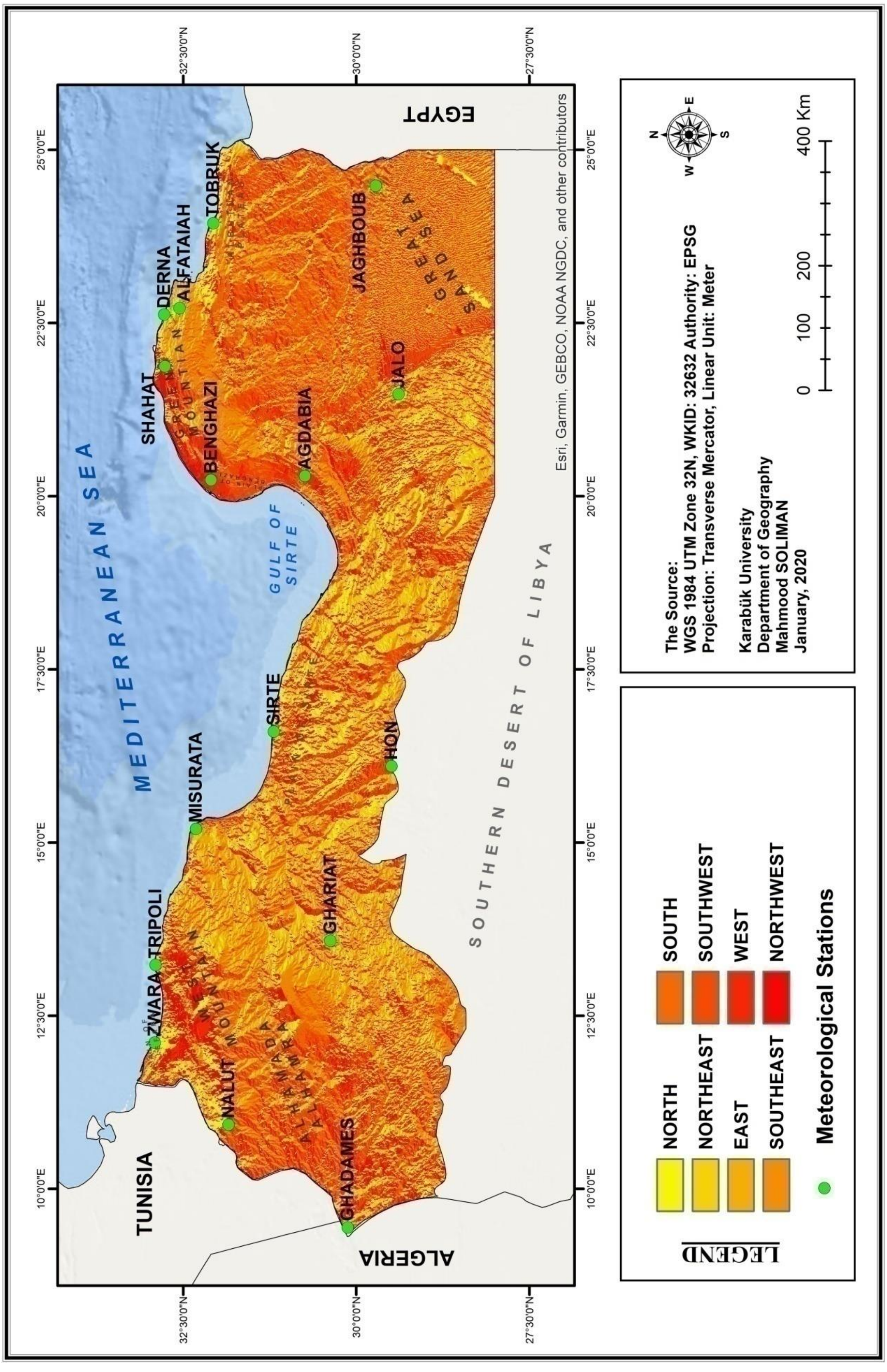
2.1.2.4. Aspects

The northern mountains (the Green mountain and the Western mountain) have different surfaces than the rest of the surface of the study area. This different surface has a significant impact on temperature and precipitation as well as the amount of low solar radiation. These mountains contain semi humid areas while in low elevated coastal areas and the southern desert, the amount of precipitation is relatively low and solar radiation is high. This is evident from the aspects map.

In coastal areas facing towards the Mediterranean sea, solar radiation is less intense, but these areas are characterized by high relative humidity. The rate of difference in daily temperature is leass as compared to the southern desert regions which show dry climate due to the strength of solar radiation. In many places, the sunshine remains up to (14 hours\day). This will be demonstrated by the study of solar radiation at the stations of those areas.

The slopes of the green mountain, at SHAHAT Station facing north show characteristics of humid climate due to the high amount of precipitation and the low amount of radiation., The southern lands have semi-arid climatic conditions due to the decrease in precipitation and increase in solar radiation. However, the western mountain troughs remain in the shadow of rain, corresponding to the hottest and arid areas within the boundaries of the section in west of the study area at NALUT Station, it is because the distance from the sea is an important factor on direction of solar radiation.

The map 8 shows the mountains of northwest and northeast areas which are towards north solar radiation directions.



Map 8. Aspects Map for Sun Trends in Northern of Libya

***Calculation of Correlation between some Geographical Factors and Climate Elements (Temperature and Precipitation)**

A correlation coefficient was used to find the relation between temperature and elevation from sea level, and between temperature and distance between meteorological stations and the Mediterranean coast, as well as amount of precipitation. The results are presented in the following table:

Table 6. Relationship Between Geographical Factors and Some Climate Elements

NO	Station Name	North latitude	East Longitude	Coefficient Correlation of Temperature			
				Elevation Above Sea Level	Average Temperature By (°C)	Distance From Sea- Km	Average Temperature By (°C)
1	AGDABIA	30.43	20.10	0.7	20.70	21	20.70
2	ALFATAIAH	32.45	22.38	263	18.39	15	18.39
3	BENGHAZI	32.05	20.16	129	20.13	13	20.13
4	DERNA	32.47	22.35	26	20.13	0.6	20.13
5	GHADAMES	30.08	09.30	357	22.02	400	22.02
6	GHARIAT	30.23	13.35	497	20.58	254	20.58
7	HON	29.07	15.57	263	21.03	230	21.03
8	JAGHBOUB	29.45	24.32	- 1	21.47	247	21.47
9	JALO	29.01	21.34	60	22.54	206	22.54
10	MISURATA	32.19	15.03	32	20.50	0.2	20.50
11	NALUT	31.52	10.59	640	19.21	160	19.21
12	SHAHAT	32.49	21.51	621	16.57	11	16.57
13	SIRTE	31.12	16.35	13	20.53	0.3	20.53
14	TOBRUK	32.06	23.56	50	19.98	0.2	19.98
15	TRIPOLI	32.40	13.09	81	20.58	3.2	20.58
16	ZWARA	32.53	12.05	0.3	20.06	1.2	20.06
Result &Calculation:-				R = -0.502 High Negative Correlation		R = 0.541 Positive Correlation	

NO	Station Name	North latitude	East Longitude	Coefficient Correlation of Precipitation			
				Elevation Above Sea Level	Total Annual Precipitation By mm	Distance From Sea- Km	Total Annual Precipitation By mm
1	AGDABIA	30.43	20.10	0.7	148.8	21	148.8
2	ALFATAIAH	32.45	22.38	263	326	15	326
3	BENGHAZI	32.05	20.16	129	267.4	13	267.4
4	DERNA	32.47	22.35	26	266.5	0.6	266.5
5	GHADAMES	30.08	09.30	357	34.3	400	34.3
6	GHARIAT	30.23	13.35	497	57.3	254	57.3
7	HON	29.07	15.57	263	31.3	230	31.3
8	JAGHBOUB	29.45	24.32	- 1	13.6	247	13.6
9	JALO	29.01	21.34	60	9.6	206	9.6
10	MISURATA	32.19	15.03	32	275.7	0.2	275.7
11	NALUT	31.52	10.59	640	142.6	160	142.6
12	SHAHAT	32.49	21.51	621	559.9	11	559.9
13	SIRTE	31.12	16.35	13	183.5	0.3	183.5
14	TOBRUK	32.06	23.56	50	175.7	0.2	175.7
15	TRIPOLI	32.40	13.09	81	275.9	3.2	275.9
16	ZWARA	32.53	12.05	0.3	222.8	1.2	222.8
Result &Calculation:-				R = 0.185 Positive Correlation		R = -0.735 High Negative Correlation	

The Source: Depending on: Libyan National Meteorological center climate & Climate Change, Tripoli. 2012.

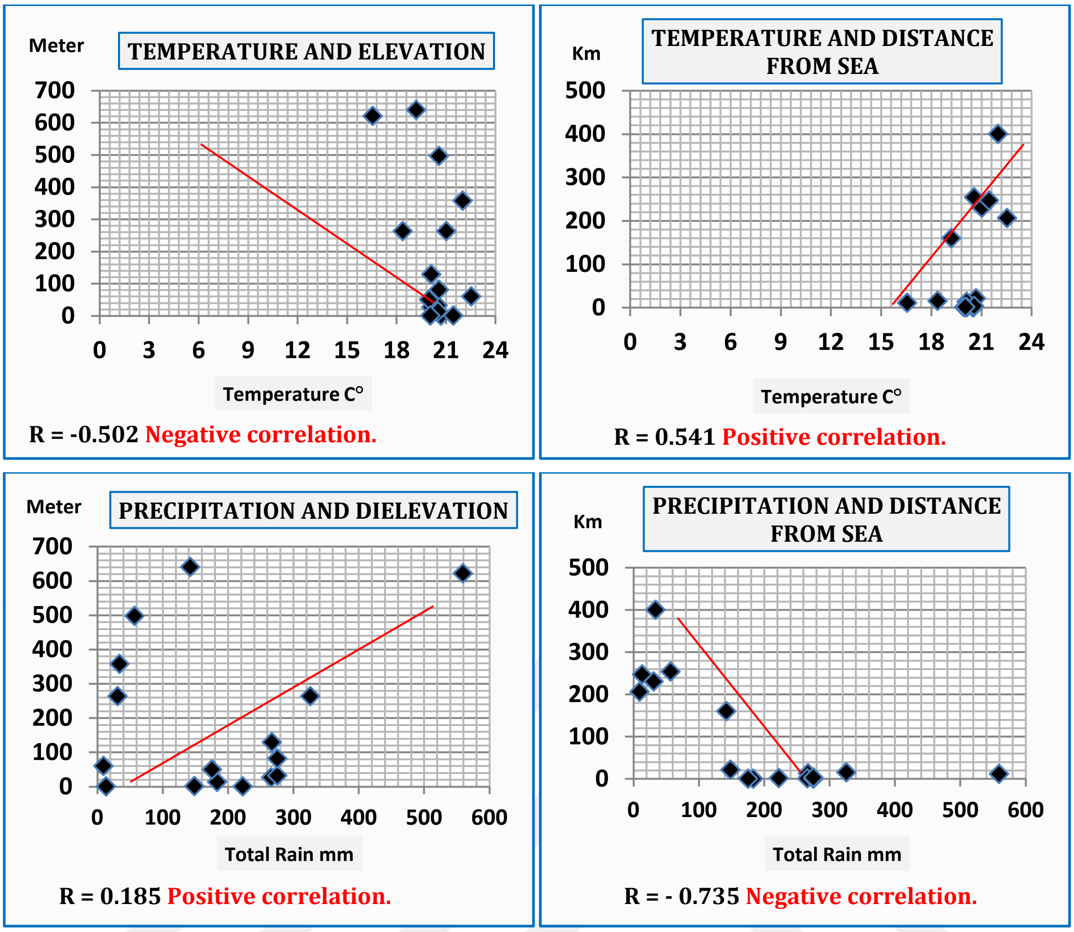


Figure3. Relations Between (Temperature and Precipitation) With some Physical Factors (1971-2010)

From table 6 and figure 3 following facts can be inferred:

❖ The coefficient of correlation between the general mean temperature and elevation of sea level is (-0.502). This is a moderate negative correlation which means there is a tendency for high X variable (Temperatures) scores to go with low Y variable (Elevation) scores (and vice versa).

❖ The results of the coefficient of correlation between temperature and distance from the sea is (0.541). This is a moderate positive correlation, so there is a positive relation between location of stations in terms of proximity or dimension from the sea and temperature.

❖ The coefficient of correlation between the annual rate of rainfall and elevation is (0.185), it gives a positive but relatively weak indicator. This showed that the surface manifestations affect the amounts of rainfall in some stations of the study area, in addition to other factors such the direction of coastline.The impact of the distance from the sea on the amounts of rainfall has a very negative effect (-0.735) but naturally, desert areas receive less rain than coastal areas.

❖ Graphical Relations Between (Temperature and Precipitation) With Some Physical Factors

a. The Relationship Between Temperature and (Elevation) Altitude

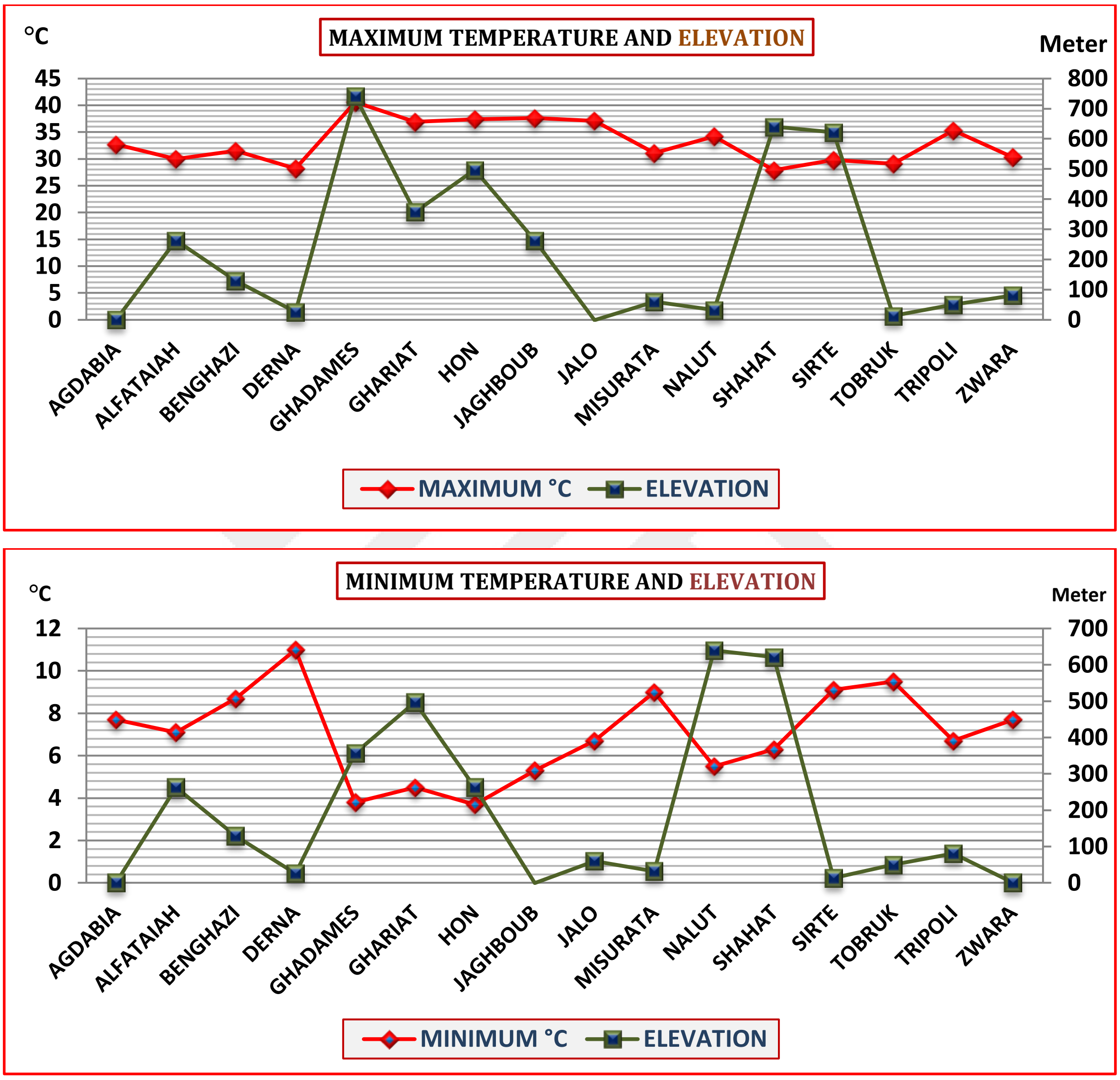


Figure 3. Relationship between Temperatures and Elevation (1971-2010)

In figure 4 it was found that the elevation factor has an effect on the temperature in the study area, especially at the stations near the coast of the sea. The stations which are located far from the sea are affected by the continental conditions. For example, NALUT station is located on 670 m with maximum temperature of (25 °C) and SHAHAT station is located on 690 m with maximum temperature of (22°C). This does not apply to the GHADAMES station, which has elevation of 750 m located in the Desert where the overall average maximum temperature exceeds (30 °C).

b. Relationship Between Distance from Sea and Temperature

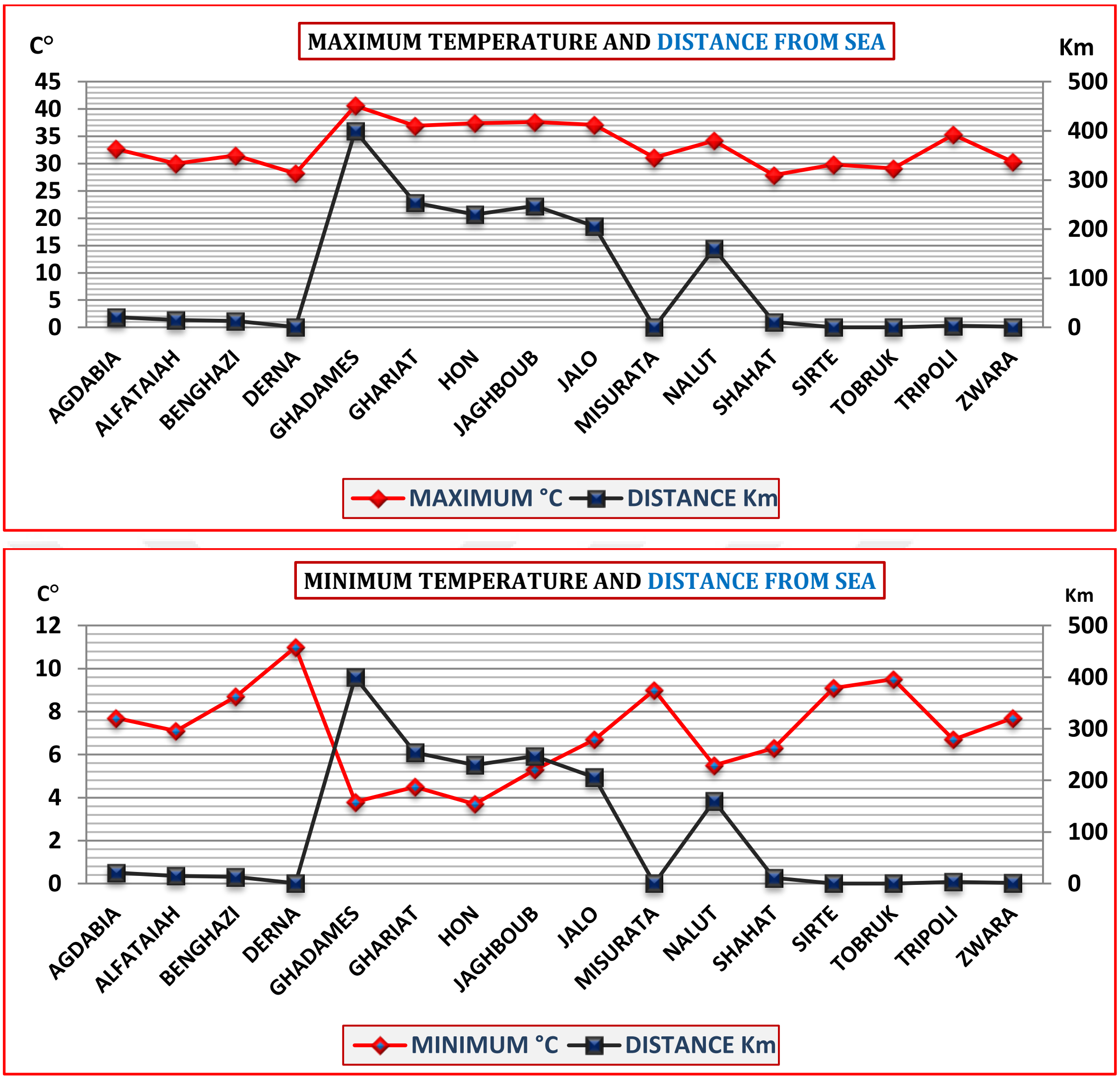


Figure 4. Relationship between Temperatures and Distance from sea (1971-2010)

In figure 5 there is a clear correlation between distance from sea and the temperature in the stations of the study area. The stations on the coast have relatively low temperature as compared to the stations located away from the coast. This is evident in the GHADAMES station, where the maximum temperature is (42 °C) as its distance from the coast is approximately 450 km. Similarly, the minimum temperature of that station is (4 °C) in the winter. These conditions are associated with the extremely arid climate. However, the temperature in the stations on the coast is moderate. It is noticed at the coastal stations that the difference between the maximum and the minimum temperature is very little in contrast to the thermal range in desert stations which exceeds (30 °C) at some stations (Figure 5).

c. Relationship Between Elevation and Precipitation

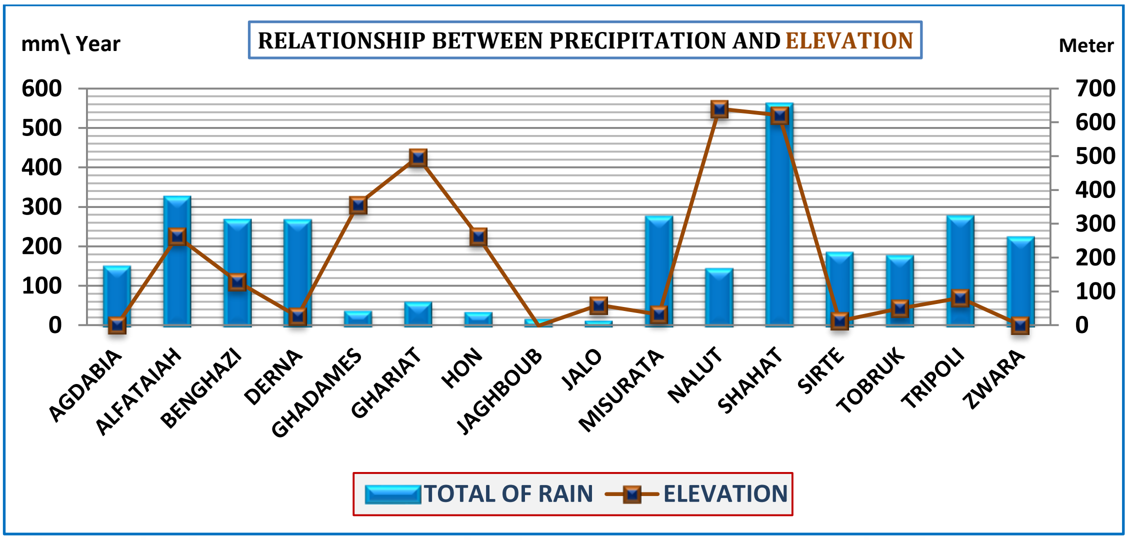


Figure 5. Relationship between Precipitation and Elevation (1971-2010)

From the figure 6 it is possible to observe the effect of the increase in rainfall quantities at several stations, most notably the SHAHAT station, ALFATAIAH station. However, the amount of rainfall is very low GHADAMES station despite of its high elevation because of its location in the desert area while other stations have not much elevation above sea level.

d. Relationship Between Distance from Sea and Precipitation

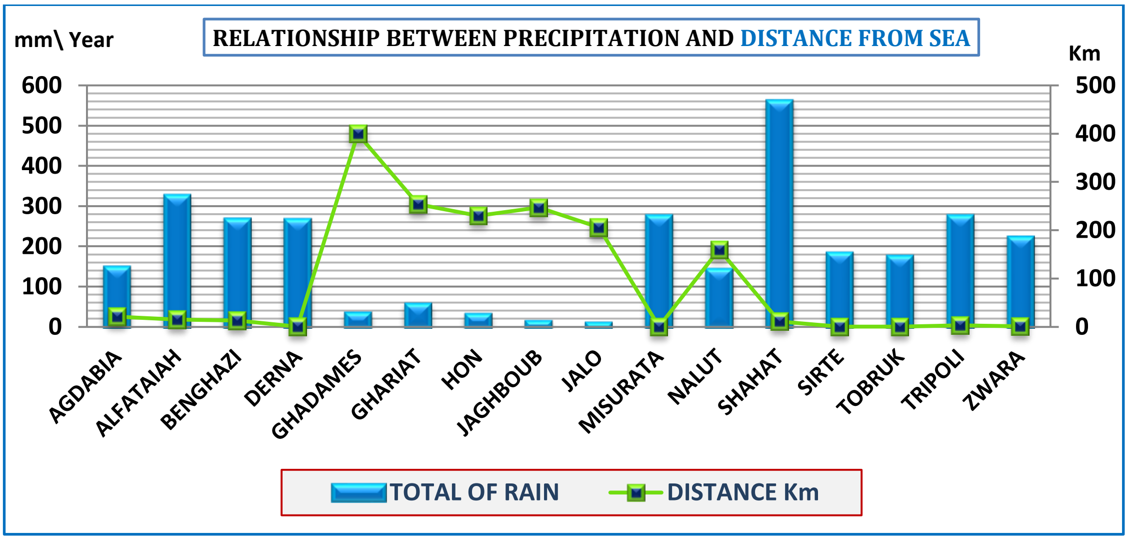


Figure 6. Relationship between Precipitation and Distance from sea (1971-2010)

It is noticeable from figure 7 that areas on the coast receive large amounts of rain while the areas away from the coast get very little rain and almost no rain is received in areas that are far away from the coast. This is evident at the stations of DERNA, TRIPOLI, ZUARA, MISURATA, TOBRUK and SIRTE.

2.2. Elements of Climate

2.2.1. Solar Radiation

The number of hours of sunshine are associated with several factors of which the most important is mathematical location (Latitude). The study area is within the latitudinal range that gets long hours of sunshine, especially in the summer due to the length of the day. as sun rays focuses directly on the Tropic of Cancer. The sun reaches the northern part of Libya at an angle that makes it receive a large amount of solar radiation. The color of the soil affects the receiving of the amount of solar radiation. Most of the soil of the region is characterized by light color except in some northern and coastal mountain regions. In the southward direction, the soil becomes white and white drier until reaching the Great Sand Sea where white sandy soil dominates.

The cloudiness of sky affects the duration of the sunlight during the daytime. The day may be short or long and the sun is not very bright for hours. The cloudy days are less sunny than the non-cloudy days which are affected by several climatic factors including the effect of the sea. The increase of fog and snow during the winter in coastal areas reduces the daily brightness, while the desert areas of the inner region receives increased sunshine as the sky is clear and free of clouds. The hours of sunshine at the stations of the study area were monitored at different periods and the minimum number of years was used. The monthly and seasonal averages of the sunshine hours are given as follows Table 7.

Table 7. The Mean Monthly & Annual Duration of Sunshine Hours- Day (1971-2010)

NO	Station Name	Months												Annual
		Ja.	Fb.	Mr.	Ap.	Ma.	Jn.	Jl.	Ag.	Sp.	Oc.	Nv.	De.	Average
1	AGDABIA	6.7	7.7	8.4	9.0	10.1	11.4	12.1	11.7	10.1	8.9	7.8	6.1	**9.1**
2	ALFATAIAH	5.7	6.6	7.7	9.1	10.3	11.9	12.3	11.7	9.9	8.5	7.0	5.8	**8.9**
3	BENGHAZI	5.8	6.8	7.9	8.8	10.3	11.5	12.2	11.7	9.9	8.5	7.0	5.6	**8.8**
4	DERNA	5.1	6.1	7.0	8.0	9.6	10.9	11.0	10.5	9.0	7.6	6.3	5.1	**8.0**
5	GHADAMES	8.1	8.6	8.7	9.5	10.2	11.0	12.1	11.5	9.5	8.7	8.4	7.8	**9.5**
6	GHARIAT	7.6	8.1	8.3	8.8	10.3	10.4	12.0	11.3	9.0	8.3	8.1	7.3	**9.1**
7	HON	7.6	8.5	8.5	9.0	9.8	11.2	12.1	11.8	10.1	8.9	8.3	7.5	**9.4**
8	JAGHBOUB	8.1	8.8	9.4	10.2	11.2	12.5	12.8	12.2	10.8	10.0	9.0	8.2	**10.2**
9	JALO	7.6	8.4	9.2	9.5	10.6	11.9	12.6	11.9	10.4	9.5	8.8	7.9	**9.8**
10	MISURATA	6.4	7.4	7.8	8.5	9.5	10.6	11.8	11.2	9.1	7.8	7.1	6.2	**8.6**
11	NALUT	7.0	8.1	8.4	9.1	10.1	10.9	12.0	11.3	9.2	8.2	7.6	6.9	**9.0**
12	SHAHAT	5.5	7.1	7.3	8.8	10.5	12.7	12.3	11.5	9.7	8.5	6.7	4.7	**8.7**
13	SIRTE	6.6	7.6	8.1	8.5	9.4	10.9	11.9	11.4	9.6	8.2	7.2	6.4	**8.8**
14	TOBRUK	5.9	6.8	7.9	8.5	9.8	11.0	11.8	11.3	9.8	8.3	7.1	5.6	**8.6**
15	TRIPOLI	5.9	7.0	7.9	8.8	9.9	11.0	12.0	11.4	9.1	7.5	6.5	5.6	**8.5**
16	ZWARA	6.4	7.2	7.6	7.9	8.7	9.5	11.2	10.7	8.5	7.6	7.0	5.9	**8.2**

The Source: Depending on: Libyan National Meteorological center climate & climate Change, Tripoli. 2012.

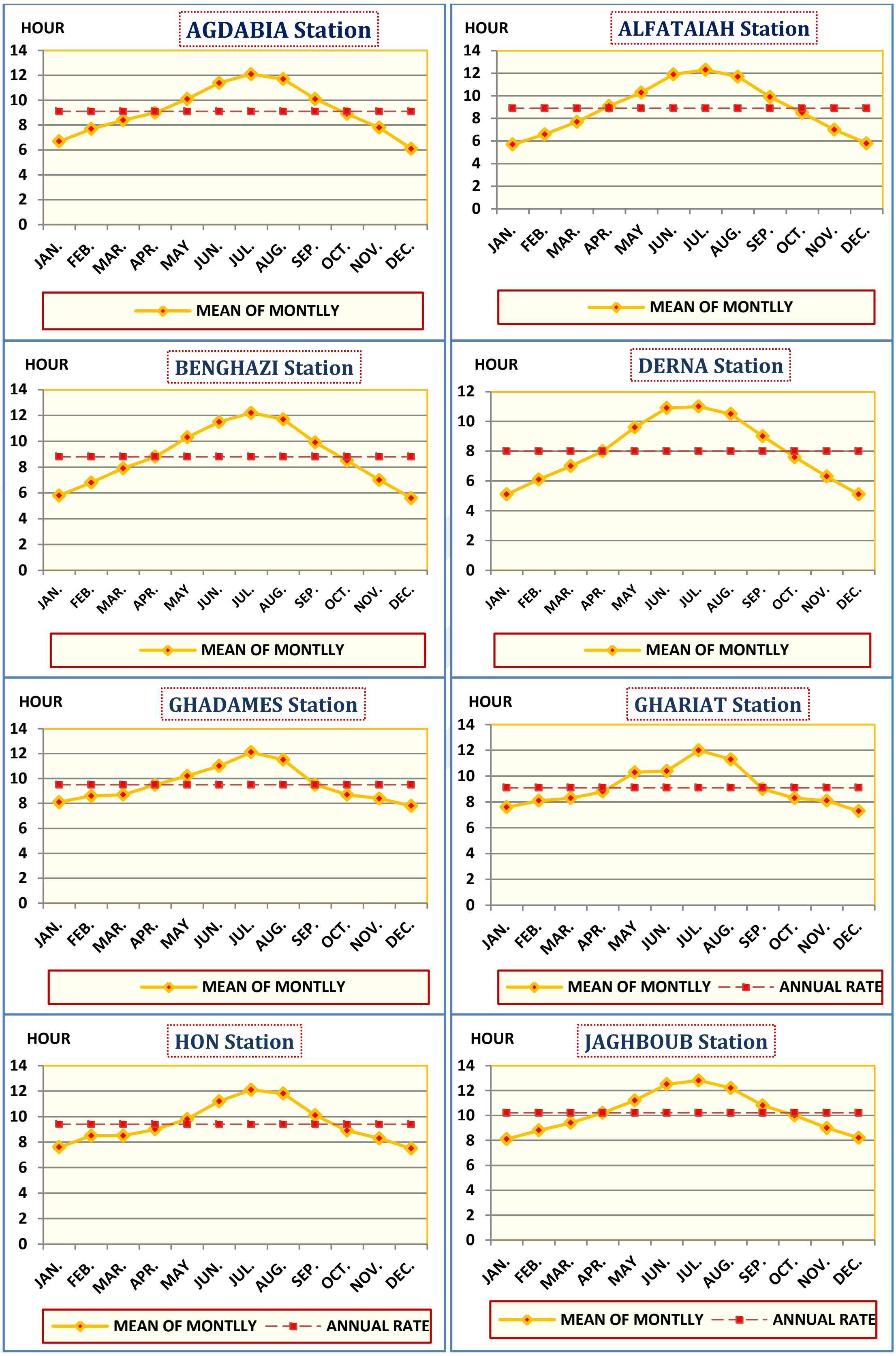


Figure 7. The Mean of Monthly & Annual Duration of Sunshine (Hours\ Day) at AGDABIA, ALFATAIAH, BENGHAZI, DERNA, GHADAMES, GHARIAT, HON, and JAGHBOUB stations for Period (1971-2010)

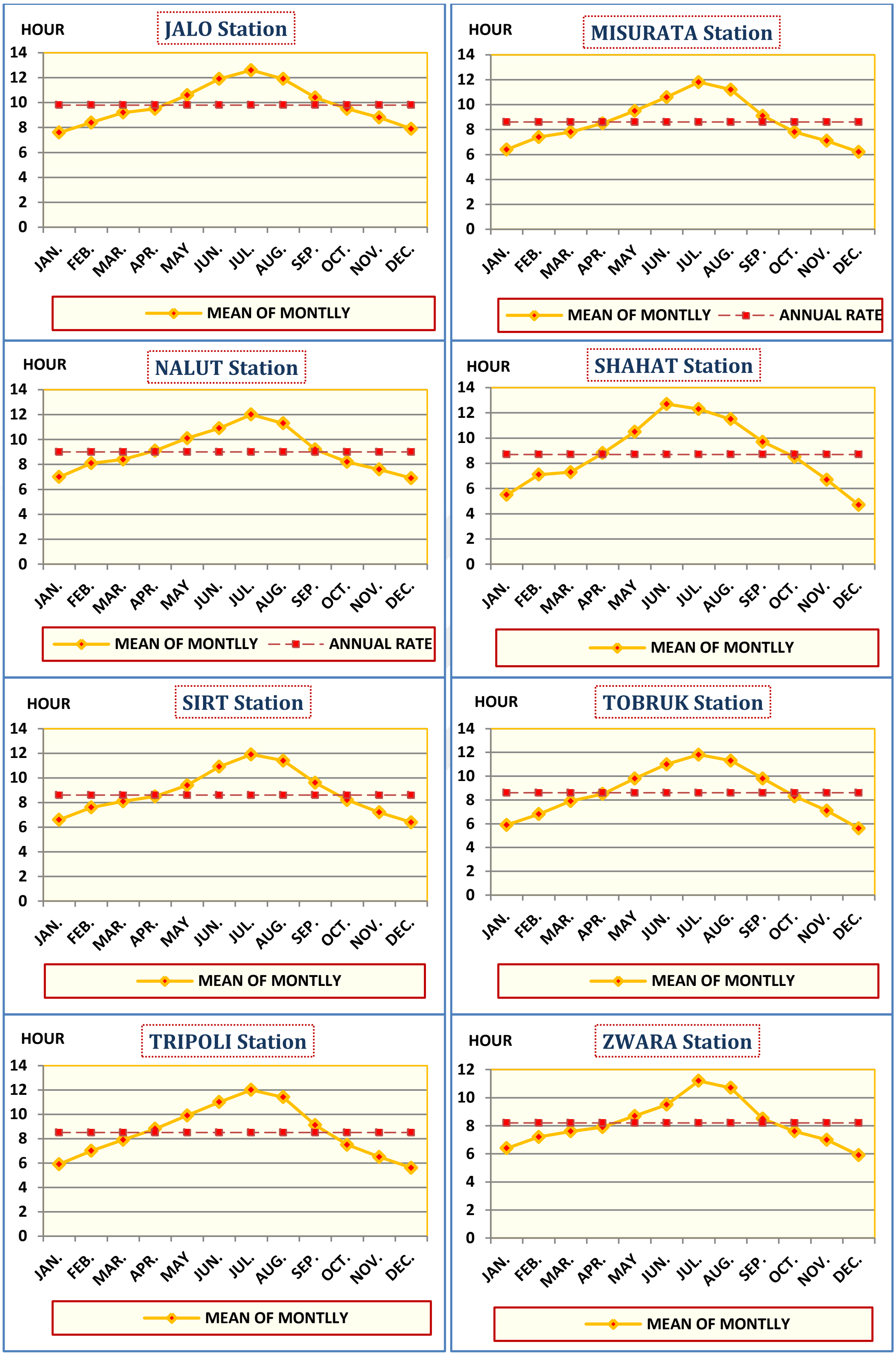


Figure 8. The Mean Monthly & Annual Duration of Sunshine (Hours\ Day) at JALO, MISURATA, NALUT, SHAHAT, SIRTE, TOBRUK, TRIPOLI, and ZWARA stations for Period (1971-2010)

Table 8. Average Seasonally of Duration of Sunshine (Hours\ Day) (1971-2010)

NO	Station Name	Seasons			
		Spring	Summer	Autumn	Winter
1	AGDABIA	9.17	11.73	8.93	6.83
2	ALFATAIAH	9.03	11.97	8.47	6.03
3	BENGHAZI	9.00	11.80	8.47	6.07
4	DERNA	8.20	10.80	7.63	5.43
5	GHADAMES	9.47	11.53	8.87	8.17
6	GHARIAT	9.13	11.23	8.47	7.67
7	HON	9.10	11.70	9.10	7.87
8	JAGHBOUB	10.27	12.50	9.93	8.37
9	JALO	9.77	12.13	9.57	7.97
10	MISURATA	8.60	11.20	8.00	6.67
11	NALUT	9.20	11.40	8.33	7.33
12	SHAHAT	8.87	12.17	8.30	5.77
13	SIRTE	8.67	11.40	8.33	6.87
14	TOBRUK	8.73	11.37	8.40	6.10
15	TRIPOLI	8.87	11.47	7.70	6.17
16	ZWARA	8.07	10.47	7.70	6.50

The Source: Depending on: Libyan National Meteorological center climate & climate Change, Tripoli. 2012.

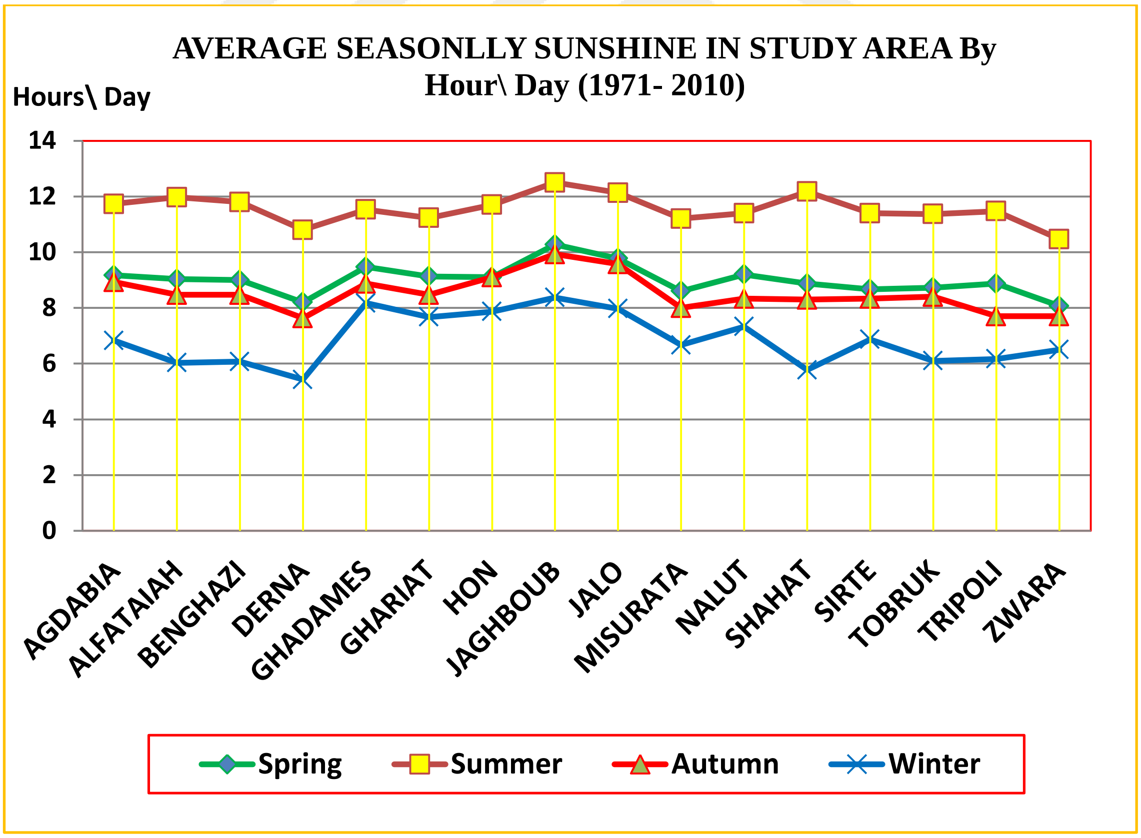
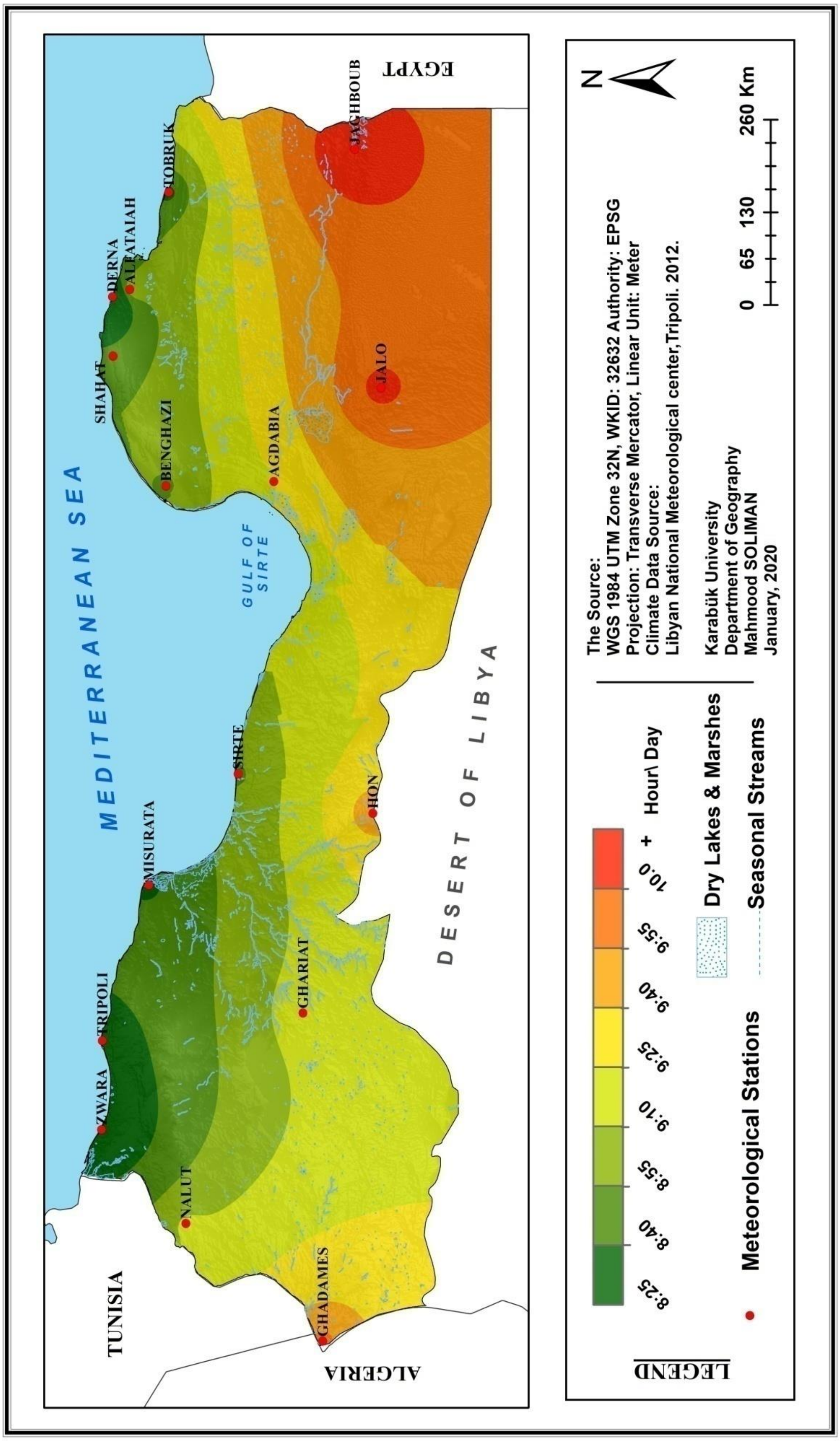


Figure 9. Average Seasonally of Duration of Sunshine (Hours\ Day) for Period (1971-2010)



Map 9. The Annual Duration of Sunshine (Hours\ Day) for Period (1971-2010)

From table 7, 8, figures 8, 9, 10and map 10for average monthly and annual duration of sunshine, and show the hours of sunshine in northern Libya vary from one station to another and from one month to the next. In general, desert stations show increase in average hours of sunshine because of their distance from the coast and the lack of clouds and the long days especially in the Summer months. On the other hand, the hours of sunshine at stations near the coast vary monthly due to natural factors, the most important of which is the elevation from sea level. For example, the average time of sunshine at JAGHBOUB station in July was (12.8 hours/ day), the highest in the region, followed by the JALO station (12.6 hours/ day) and the (12.3 hours/ day).

In the Winter months, the hours of sunshine decrease significantly at the coastal stations like SHAHAT Station (5.5 hours/ day) in January, BENGHAZI (5.7 hours / day), TOBRUK and TRIPOLI (5.9 hours/ day). At desert stations, the hours of sunshine in January ranged between (8.1 hours/ day), at JAGHBOUB and GHADAMES stations, (7.6 hours/ day) at JALO and HON stations.

There is a slight difference between the stations of the study area in terms of general average of the sunlight hours. The highest rates appeared in the station JAGHBOUB located in the south-east of the study area where the general average of the brightness of the sun is (10.2 hours/ day) because of its flat ground and white sandy soil free of plants . JALO station to the west of JAGHBOUB has average sunlight of (9.8 hours/ day) and is almost located on the same latitude of JAGHBOUB station, and it is desert station, so there is convergence in the average of duration of sunshine.

At DERNA Station, the average sunshine is of (8 hours/ day) that is the lowest, this is due to the occurrence of the station under the green mountain. The city of DERNA is located in the Derna valley, which obscures the sun in its sunrise and sunset (Map 8).The overall rate of sunshine at ZWARA station is about (8.2 hours/ day), TOBRUK (8.6 hours/ day), SIRTE (8.8 hours/ day) and at MISURATA station (8.6 hours/ day).

Here, it can be said that desert stations are higher in terms of sun sunshine duration than coastal stations because of the low percentage of clouds. It may be short or long day and the sun is not bright while fog and bristle affect significantly the hours of sunshine.

2.2.2. Temperatures (Maximum, Minimum and Average)

Table 9. The Monthly and Annual Maximum Temperatures (°C) (1971-2010)

NO	Station Name	Months												Annual Average
		Ja.	Fb.	Mr.	Ap.	Ma.	Jn.	Jl.	Ag.	Sp.	Oc.	Nv.	De.	
1	AGDABIA	17.9	19.3	22.3	26.6	30.5	33.5	32.7	33.3	32.6	29.4	24.1	19.5	26.81
2	ALFATAIAH	16.4	16.1	19.7	22.7	26.0	28.6	30.0	30.1	28.9	26.1	22.3	18.0	23.74
3	BENGHAZI	16.6	17.5	20.2	24.5	28.6	31.6	31.5	32.1	30.8	27.8	22.8	18.3	25.19
4	DERNA	17.3	17.8	19.3	21.6	24.2	27.1	28.2	29.1	28.3	26.2	22.8	19.1	23.42
5	GHADAMES	17.5	20.5	24.7	29.6	34.8	39.8	40.6	40.1	36.7	30.7	24.0	18.4	29.78
6	GHARIAT	17.0	19.2	23.3	28.0	32.3	36.4	36.9	36.9	34.4	29.1	22.9	18.2	27.88
7	HON	18.8	21.2	24.9	30.0	33.9	37.8	37.4	37.2	35.4	30.8	24.9	20.0	29.36
8	JAGHBOUB	19.0	21.0	24.5	29.4	33.7	37.0	37.6	37.2	34.7	30.5	24.9	20.2	29.14
9	JALO	19.8	21.9	25.4	30.2	34.1	37.5	37.1	37.0	35.2	31.1	25.4	21.1	29.65
10	MISURATA	17.9	19.0	20.5	23.1	26.3	29.7	31.1	32.2	31.0	28.0	23.6	19.3	25.14
11	NALUT	13.6	16.2	19.4	23.8	28.4	32.7	34.2	34.5	31.2	25.9	20.0	14.9	24.57
12	SHAHAT	12.5	13.2	15.6	19.7	24.0	27.5	27.9	28.1	26.1	22.8	18.4	14.2	20.83
13	SIRTE	18.2	19.4	21.3	23.6	26.2	28.7	29.8	30.8	30.4	28.2	24.1	19.8	25.04
14	TOBRUK	17.5	18.0	20.0	22.7	24.8	27.6	29.1	29.7	29.1	26.6	23.0	19.3	23.95
15	TRIPOLI	17.4	19.2	22.0	26.0	30.2	34.1	35.3	36.0	33.5	29.1	23.5	18.8	27.09
16	ZWARA	17.6	19.1	20.5	22.5	25.2	28.0	30.3	31.7	30.4	27.6	23.4	19.0	24.61

The Source: Depending on: Libyan National Meteorological center climate & climate Change, Tripoli. 2012.

Table 10. The Monthly and Annual Minimum Temperatures (°C) (1971-2010)

NO	Station Name	Months												Annual Average
		Ja.	Fb.	Mr.	Ap.	Ma.	Jn.	Jl.	Ag.	Sp.	Oc.	Nv.	De.	
1	AGDABIA	7.7	8.3	10.3	13.5	16.8	19.6	20.2	20.6	19.5	16.6	12.4	9.1	14.55
2	ALFATAIAH	7.1	6.9	7.7	10.3	13.6	17.5	20.7	21.6	19.0	15.6	11.6	8.6	13.35
3	BENGHAZI	8.7	8.7	10.0	13.1	16.5	19.7	20.8	21.4	20.1	17.3	13.6	10.3	15.02
4	DERNA	11.0	11.1	12.0	14.1	16.7	20.3	22.8	23.6	22.3	19.3	15.8	12.6	16.80
5	GHADAMES	3.8	5.9	9.4	14.0	18.4	22.5	23.2	23.0	20.9	15.8	9.4	4.8	14.26
6	GHARIAT	4.5	5.6	8.6	12.1	16.3	19.8	20.7	21.0	19.6	15.4	9.7	5.5	13.23
7	HON	3.7	5.0	8.1	12.4	16.3	19.6	19.7	19.9	18.8	14.8	8.9	4.8	12.67
8	JAGHBOUB	5.3	6.3	9.2	13.0	16.9	19.9	20.8	21.2	19.5	15.9	10.6	6.4	13.75
9	JALO	6.7	7.8	10.7	14.9	18.9	22.2	22.7	22.9	21.1	17.0	11.7	7.9	15.38
10	MISURATA	9.0	9.6	11.3	13.8	16.6	19.9	22.0	22.9	21.9	18.8	14.1	10.3	15.85
11	NALUT	5.5	6.8	9.0	12.1	15.9	19.6	21.5	21.9	19.9	15.9	10.9	6.6	13.80
12	SHAHAT	6.3	6.2	7.4	9.8	13.2	16.6	18.1	18.7	17.1	14.6	11.0	7.9	12.24
13	SIRTE	9.1	9.8	11.7	14.2	17.0	20.0	21.9	22.7	21.7	18.9	14.3	10.4	15.98
14	TOBRUK	9.5	9.5	11.1	13.4	16.7	20.2	22.5	23.4	22.1	18.6	14.6	10.8	16.03
15	TRIPOLI	6.7	7.0	9.0	12.0	15.8	19.4	20.4	21.3	20.2	16.7	11.8	8.0	14.03
16	ZWARA	7.7	8.7	10.9	13.7	17.0	20.3	22.4	23.3	22.0	18.1	12.7	8.7	15.46

The Source: Depending on: Libyan National Meteorological center climate & climate Change, Tripoli. 2012.

Table 11. The Monthly and Annual Average Temperature (°C) (1971-2010)

NO	Station Name	Months												Annual Average
		Ja.	Fb.	Mr.	Ap.	Ma.	Jn.	Jl.	Ag.	Sp.	Oc.	Nv.	De.	
1	AGDABIA	12.8	13.8	16.3	20.0	23.7	26.6	26.5	27.0	26.1	23.0	18.3	14.3	20.70
2	ALFATAIAH	11.9	11.5	12.8	16.4	19.7	23.3	25.1	25.7	23.8	20.6	16.7	13.2	18.39
3	BENGHAZI	12.7	13.1	15.1	18.9	22.6	25.6	26.2	26.8	25.5	22.6	18.2	14.3	20.13
4	DERNA	14.2	14.5	15.6	17.9	20.5	23.7	25.6	26.4	25.3	22.8	19.3	15.8	20.13
5	GHADAMES	10.7	13.2	17.0	21.8	26.6	31.2	31.8	31.6	28.8	23.2	16.7	11.6	22.02
6	GHARIAT	10.8	12.4	16.0	20.1	24.4	28.2	28.7	28.9	27.0	22.3	16.3	11.9	20.58
7	HON	11.3	13.1	16.5	21.2	25.0	28.7	28.6	28.6	27.1	22.8	16.9	12.5	21.03
8	JAGHBOUB	12.2	13.7	16.8	21.3	25.2	28.5	29.3	29.2	27.1	23.2	17.8	13.3	21.47
9	JALO	13.3	14.9	18.1	22.5	26.5	29.9	29.9	29.9	28.2	24.1	18.6	14.6	22.54
10	MISURATA	13.4	14.3	15.9	18.4	21.5	24.8	26.6	27.6	26.4	23.4	18.9	14.8	20.50
11	NALUT	9.6	11.5	14.2	18.0	22.2	26.2	27.9	28.3	25.5	20.9	15.4	10.8	19.21
12	SHAHAT	9.4	9.8	11.5	14.8	18.6	22.1	23.0	23.4	21.7	18.7	14.7	11.1	16.57
13	SIRTE	13.7	14.6	16.5	18.9	21.6	24.4	25.9	26.8	26.1	23.6	19.2	15.1	20.53
14	TOBRUK	13.5	13.8	15.5	17.9	20.8	23.9	25.8	26.6	25.6	22.6	18.8	15.0	19.98
15	TRIPOLI	12.1	13.1	15.5	19.0	23.0	26.8	27.9	28.6	26.9	22.9	17.7	13.4	20.58
16	ZWARA	12.7	13.9	15.7	18.1	21.1	24.2	26.4	27.5	26.2	22.9	18.1	13.9	20.06

The Source: Depending on: Libyan National Meteorological center climate & climate Change, Tripoli. 2012.

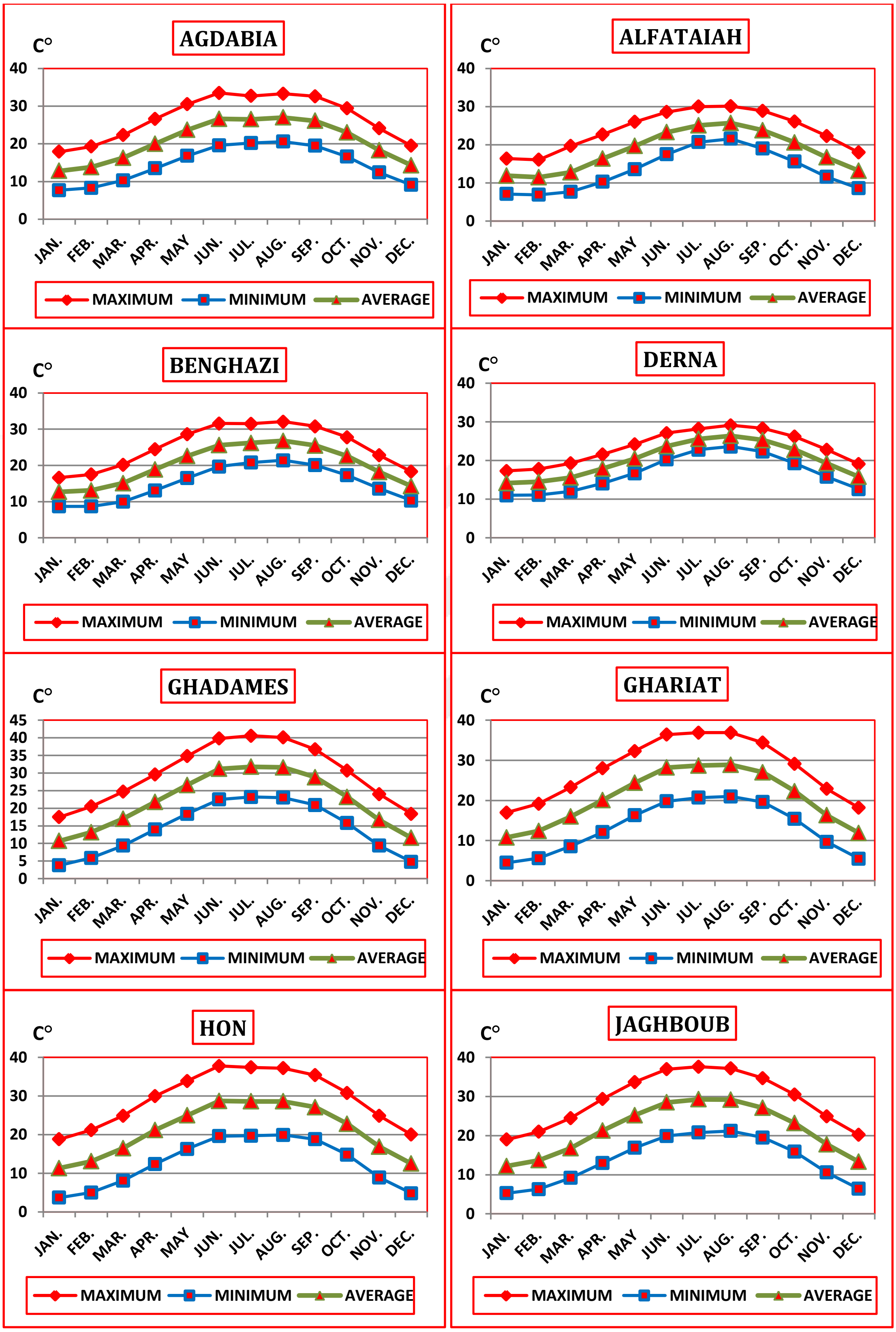


Figure 10. Maximum, Minimum and Average Temperatures at AGDABIA, ALFATAIAH, BENGHAZI, DERNA, GHADAMES, GHARIAT, HON and JAGHBOUB stations for Period (1971-2010)

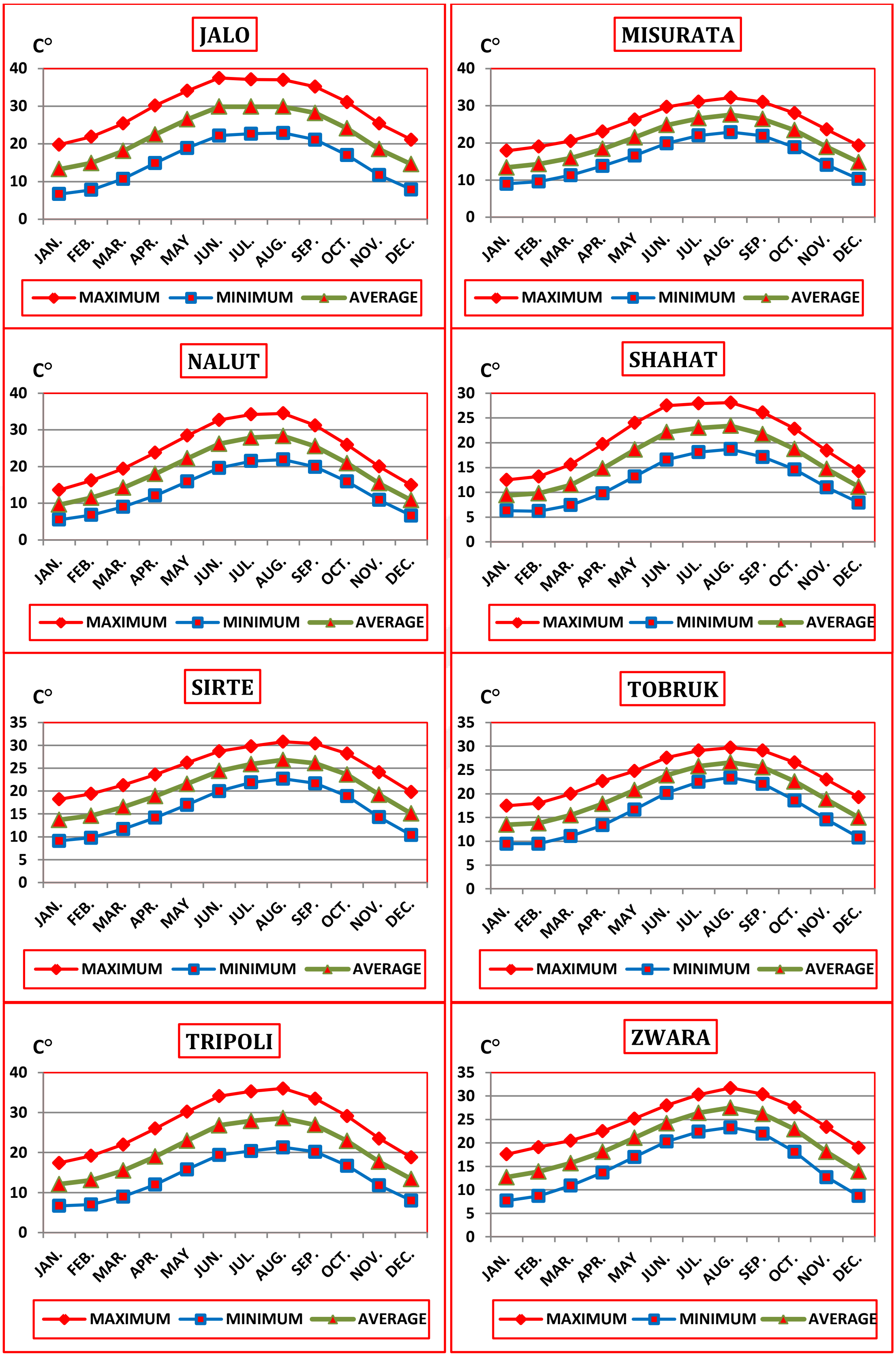
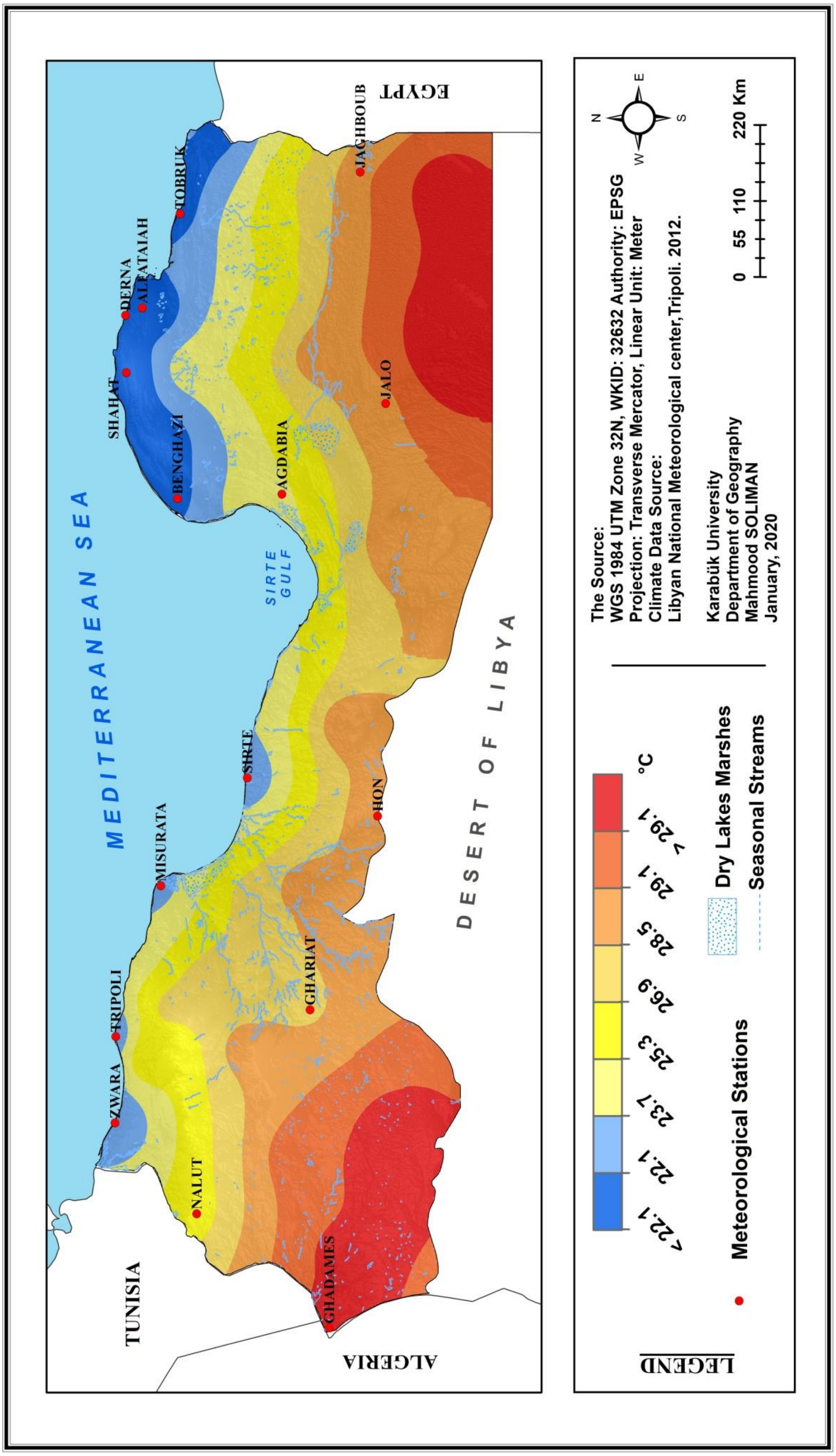
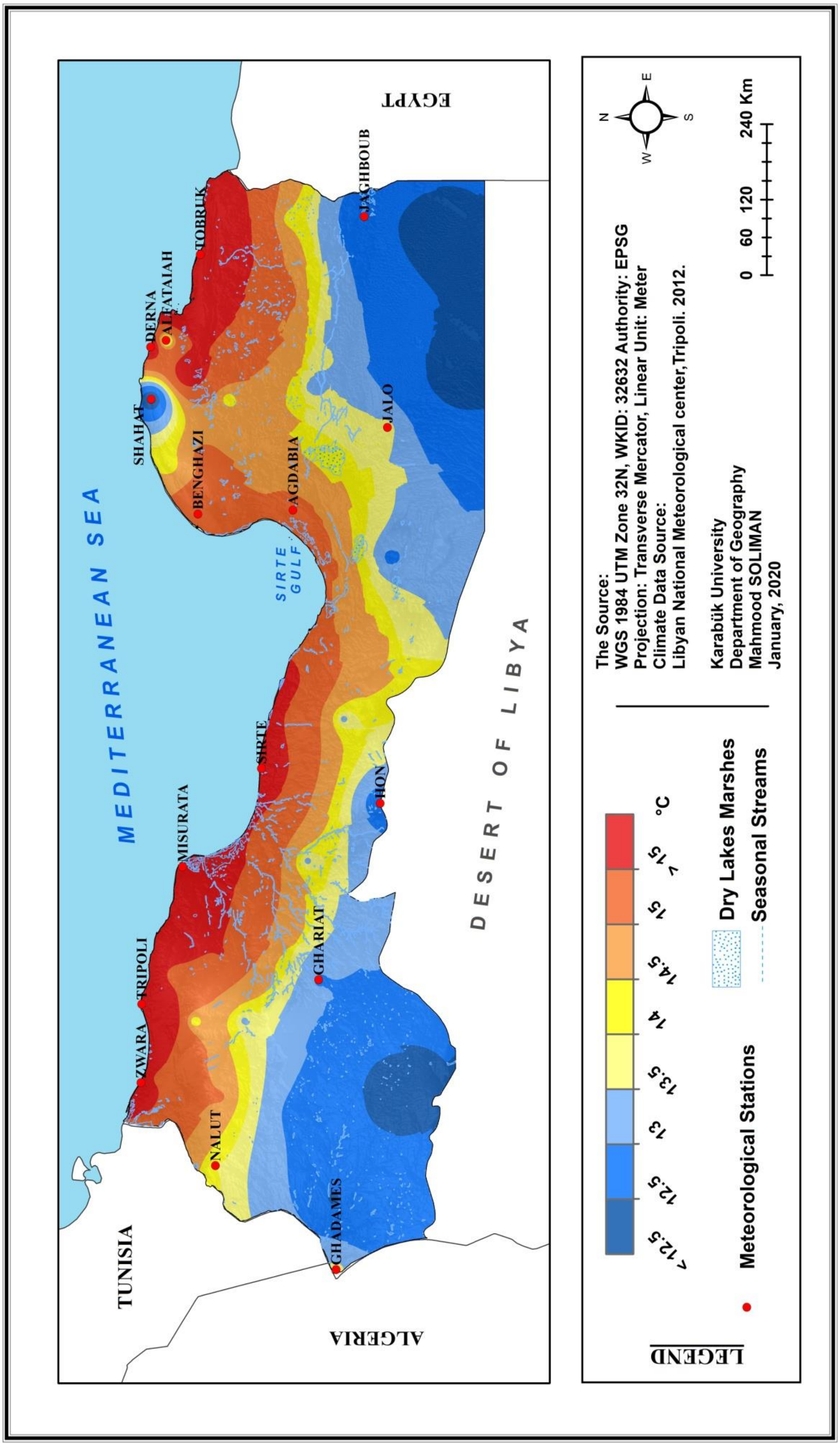


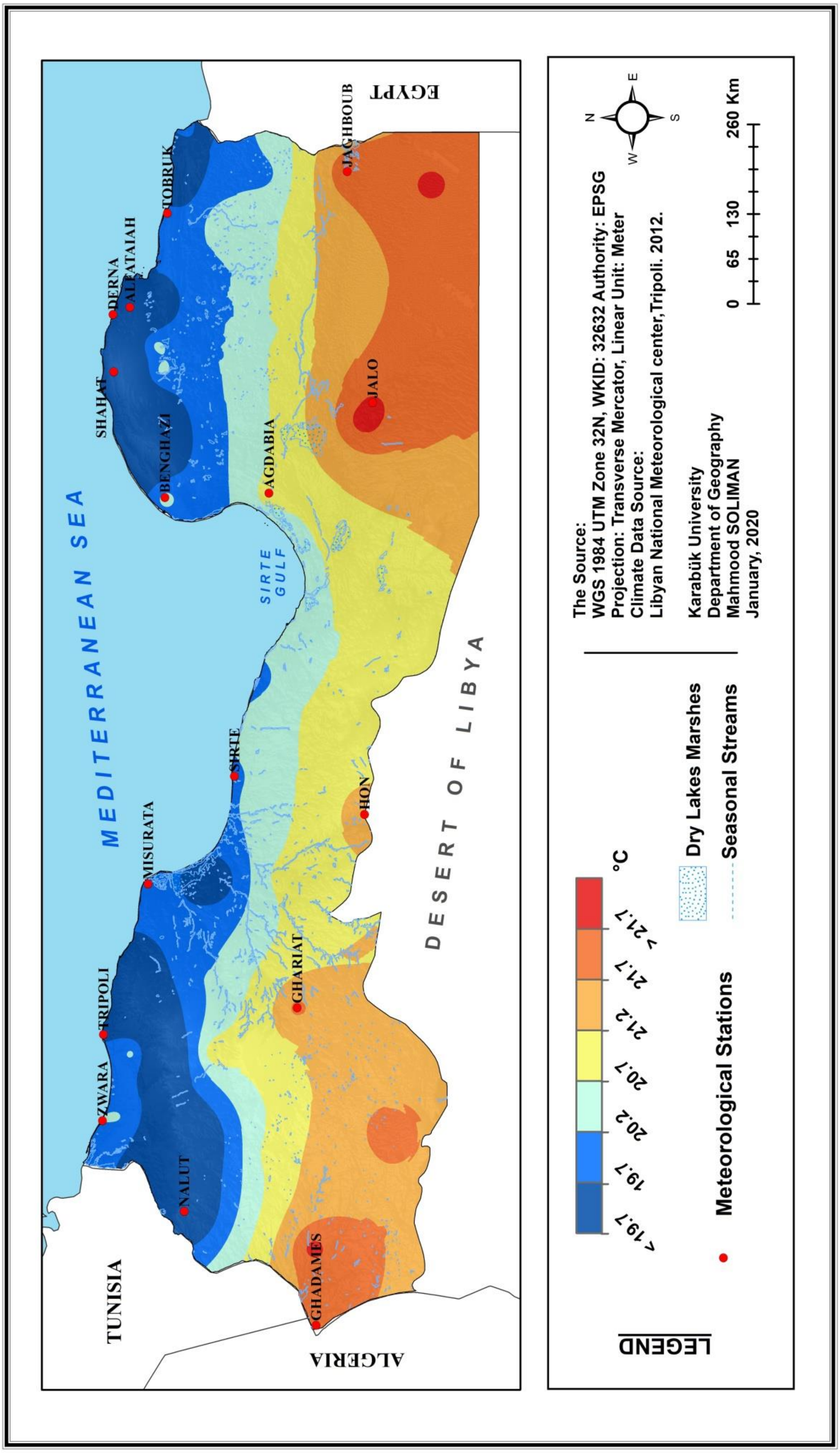
Figure 11. Maximum, Minimum and Average Temperatures (°C) at JALO, MISURATA, NALUT, SHAHAT, SIRTE, TOBRUK, TRIPOLI and ZWARA stations for Period (1971-2010)



Map 10. The Annual Maximum Temperatures (°C) for Period (1971-2010)



Map 11. The Annual Minimum Temperatures (°C) for Period (1971-2010)



Map 12. The Annual Average Temperatures (°C) for Period (1971-2010)

Through the tables 9, 10, 11, figures 11, 12 and maps (10, 11, 12), following results can be inferred.

There is a difference between the temperature from one station to another and from month to month when calculating and evaluating the monthly average and the annual average temperature in the stations of the study area. The desert stations record high values in temperature because of the distance from the sea and arid climate (The continental climate). On the other hand, the stations on the Mediterranean sea show average low temperatures around the year. For example, GHADAMES station reached the maximum temperatures in July to (40.6 °C), in contrast to the ZWARA station which is located in north on the Mediterranean sea where average temperature in July is (30.3 °C) . Similarly, July temperature at JAGHBOUB station is (37.6 °C) in contrast to (29.8 °C) at TOBRUK station in the north on the Mediterranean sea.

This is the difference between the continental and marine climate. It is noticed from the tables, figures, and previous maps that most stations are located on Mediterranean Sea show moderate temperatures while, on the contrary, the stations far from the sea are characterized by extremes of temperature.

Besides, the elevation has also a significant impact on temperature. The stations located on higher altitude are characterized by low average temperatures in the winter months as is evident at stations of SHAHAT in Green Mountains. and NALUT in the Western Mountain. The stations recorded the lowest temperature at SHAHAT station in January as (12.5 °C), and here the altitude plays a large role in determining the temperature.

As for the minimum temperatures, the difference between stations can be observed from month to month. Desert stations have low winter temperatures in January at GHADAMES (3.8 °C), HON (3.7 °C), GHARIAT (4.5 °C) and JAGHBOUB (5.3 °C).

This shows the extreme desert climate. In the stations located in the north of the study area, the minimum temperature varies according to the height of the station. For example, in January, the station of SHAHAT in Green Mountain (6.3 °C), at Derna (11 °C) and at MISURATA (9 °C) and at AGDABIA the minimum temperature in January is (7.7 °C). During the summer months, the average temperature in all the stations of the study area (coastal and desert) rises and increases in the desert stations, reaching at

(22.7 °C), (23 °C) and (25.2 °C) in July and HON (19.9 °C). At the coastal stations the temperatures reached at Tobruk (22.5 °C), TRIPOLI to (20.4 °C), Sirte to (21.9 °C), BENGHAZI to (20.8 °C) and ALFATAIAH to (20.7 °C). In general, the lowest temperature in the study area was recorded at desert stations because of drought and frost during the winter at night.

Naturally, the minimum temperatures were lower during the winter season, wherein some stations it reached to (4.8 °C) at GHADAMES, (5.2 °C) at GHARIAT, while the lowest in winter reached to (11.5 °C) at DERNA, (9.7 °C) at SIRTE, (9.9 °C) at TOBRUK, and (9.6 °C) at MISURATA. In the spring, the temperature ranged between (10.5 °C) at ALFATAIAH and (14.8 °C) at JALO stations.

There are several factors that can affect the relative increase of the minor degrees in the spring, the most important of which is the hot dry southern winds blowing in many desert and coastal stations.

In the autumn, the lowest temperatures range from (14.1 °C) at HON, and (19.1 °C) at DERNA, both the two mountain stations, at TRIPOLI the temperature is (16.2°C) and at ZWARA it is (17.6 °C). The air cycle begins to prepare the winter climate in this period, the autumn usually begins in the middle of October in the desert areas and during the end of September in coastal areas.

In the summer, the minimum temperatures in the desert stations rise and remain moderate in the coastal stations. The temperature at JALO and GHADAMES desert stations are (22.6 °C), and (22.9 °C) respectively and at the coastal stations of TOBRUK and SIRTE, it is (22.0 °C) and (21.5 °C) respectively. This confirms the stability of summer temperatures during the night at most desert and coastal areas in the study area.

As for the general average temperature, the lowest recorded temperature is (16.5 °C) at SHAHAT station because of several factors like its proximity to the sea and elevation up to 621 m above sea level. and despite the rise of NALUT station 640 meters above sea level, The general average temperature of NALUT station is (19.2 °C) despite it elevation of 640 meters perhaps due to the distance from the sea which is 160 Km from the Mediterranean Sea. The highest overall temperature was recorded at JALO station which is (22.5 °C).

Table 12. The Average Seasonally of Temperatures (°C) (1971-2010)

NO	Station Name	Maximum Temperatures				Minimum Temperatures				Average Temperature			
		Spr.	Sum.	Aut.	Win.	Spr.	Sum.	Aut.	Win.	Spr.	Sum.	Aut.	Win.
1	AGDABIA	26.47	33.17	28.70	18.90	13.53	20.13	16.17	8.37	20.00	26.65	22.44	13.64
2	ALFATAIAH	22.80	29.57	25.77	16.83	10.53	19.93	15.40	7.53	16.67	24.75	20.59	12.18
3	BENGHAZI	24.43	31.73	27.13	17.47	13.20	20.63	17.00	9.23	18.82	26.18	22.07	13.35
4	DERNA	21.70	28.13	25.77	18.07	14.27	22.23	19.13	11.57	17.99	25.18	22.45	14.82
5	GHADAMES	29.70	40.17	30.47	18.80	13.93	22.90	15.37	4.83	21.82	31.54	22.92	11.82
6	GHARIAT	27.87	36.73	28.80	18.13	12.33	20.50	14.90	5.20	20.10	28.62	21.85	11.67
7	HON	29.60	37.47	30.37	20.00	12.27	19.73	14.17	4.50	20.94	28.60	22.27	12.25
8	JAGHBOUB	29.20	37.27	30.03	20.07	13.03	20.63	15.33	6.00	21.12	28.95	22.68	13.04
9	JALO	29.90	37.20	30.57	20.93	14.83	22.60	16.60	7.47	22.37	29.90	23.59	14.20
10	MISURATA	23.30	31.00	27.53	18.73	13.90	21.60	18.27	9.63	18.60	26.30	22.90	14.18
11	NALUT	23.87	33.80	25.70	14.90	12.33	21.00	15.57	6.30	18.10	27.40	20.64	10.60
12	SHAHAT	19.77	27.83	22.43	13.30	10.13	17.80	14.23	6.80	14.95	22.82	18.33	10.05
13	SIRTE	23.70	29.77	27.57	19.13	14.30	21.53	18.30	9.77	19.00	25.65	22.94	14.45
14	TOBRUK	22.50	28.80	26.23	18.27	13.73	22.03	18.43	9.93	18.12	25.42	22.33	14.10
15	TRIPOLI	26.07	35.13	28.70	18.47	12.27	20.37	16.23	7.23	19.17	27.75	22.47	12.85
16	ZWARA	22.73	30.00	27.13	18.57	13.87	22.00	17.60	8.37	18.30	26.00	22.37	13.47

The Source: Depending on: Libyan National Meteorological center climate & climate Change, Tripoli. 2012.

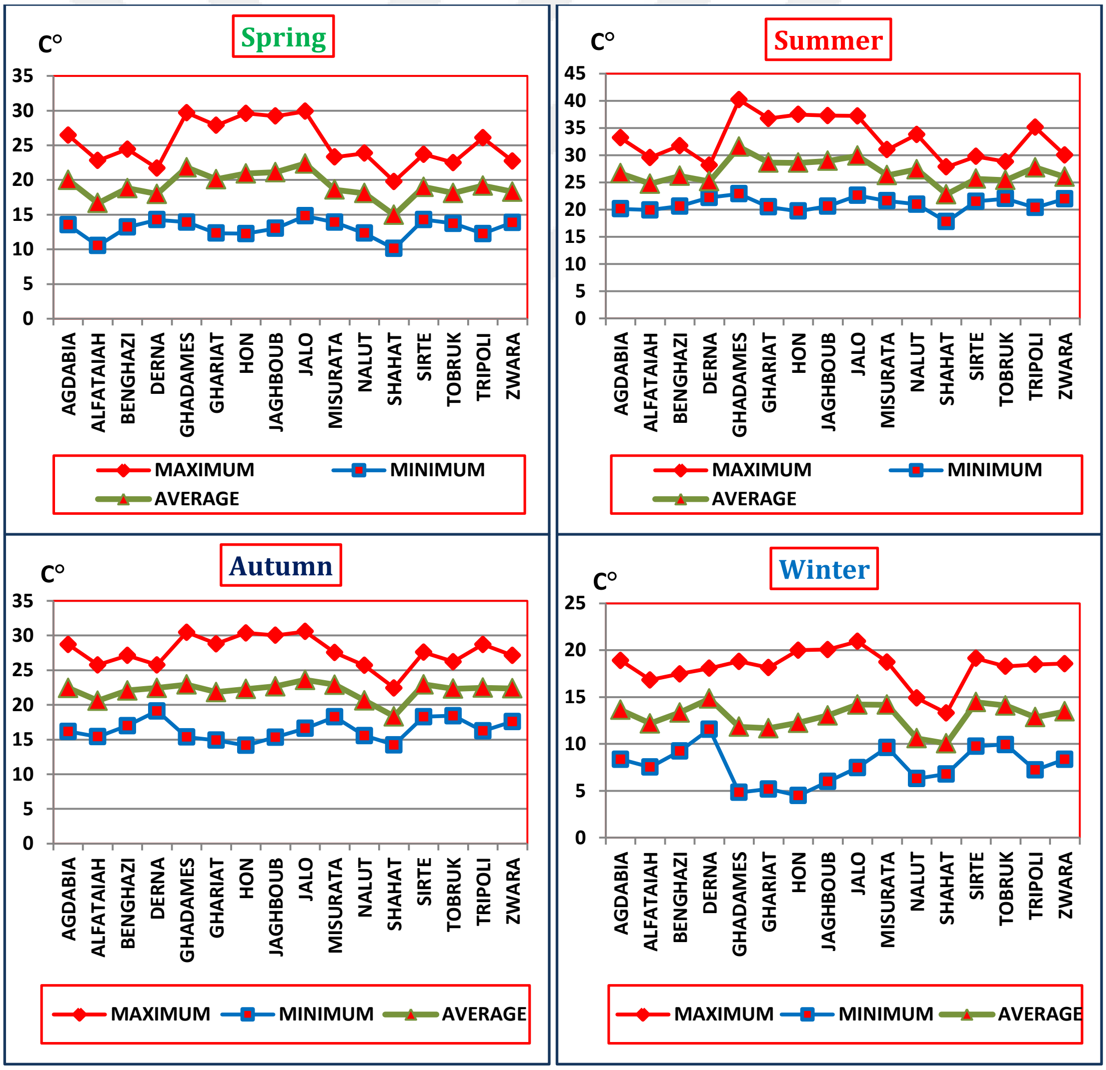


Figure 12. The Average Seasonally of Temperatures (°C) for Period (1971-2010)

Through the tables 12 and figure 13, following results can be inferred:

Maximum temperatures in the study area vary from one season to another and from station to another. In the spring, temperatures range between (19.7 °C) at SHAHAT and (29.6 °C) at HON. Desert temperatures rise and decrease gradually by distance from the sea and elevation. In the summer, the maximum temperature reaches (40.1 °C) at GHADAMES and it is also high in the desert areas. In autumn season is almost equal in most areas except for some stations that have high temperature values such as JAGHBOUB, JALO, HON, and GHADAMES stations, all of which are desert stations. In the winter, the maximum temperatures in all the stations of the study area drop below (20 °C). The temperature drops to (13.3 °C) at SHAHAT station and remains moderate in coastal stations such as BENGHAZI (17.4°C), DERNA (18.1 °C), SIRTE (19.1 °C), TOBRUK and ZWARA (18.4 °C).

Minimum temperatures, in the spring of temperatures range between (10.1 °C) at SHAHAT and (12.2 °C) at HON. Desert temperatures rise and decrease gradually by distance from the sea and elevation. In the summer, the minimum temperature reaches (4.5 °C) at GHADAMES, at JALO (7.4 °C), at HON (4.5 °C), and at GHARIAT (5.2 °C), and it is also low in the desert areas. In coastal stations, minimum temperatures rise more than desert stations, for example at TOBRUK (9.9 °C) and at JAGHBOUB (6.0 °C) in winter, the difference between the two stations is JAGHBOUB station is 250 km from the sea coast, while TOBRUK station is located on coast.

The average temperatures of the stations in the study area vary from one season to the next, with the average of (20.7 °C) at AGDABIA, (18.4 °C) at ALFATAIAH, (20.1 °C) at BENGHAZI, (20.1 °C) at DERNA, (22.0 °C) at GHADAMES , (20.6 °C) at GHARIAT, (21.0 °C) at HON, (21.4 °C) at JAGHBOUB , (22.5 °C) at JALO (Which is highest in study area), (20.5 °C) at MISURATA, (19.2 °C) at NALUT, (16.5 °C) in SHAHAT (Which is the lowest in the region), (20.5 °C) at SIRTE , (19.9 °C) at TOBRUK , (20.5 °C) at TRIPOLI and (20.1 °C) at ZWARA.

The figures shown as follows illustrate the relationship between the maximum and minimum temperatures and the general average temperature in the study area. The high temperatures in the Summer months and the moderation in Spring and Autumn and decline of temperature in the Winter is expressed in these illustrations

❖ Extreme Maximum and Minimum Temperatures

Table 13. The Extreme Maximum Temperature (°C) (1971-2010)

NO	Station Name	Months												EXTREME MAXIMUM
		Ja.	Fb.	Mr.	Ap.	Ma.	Jn.	Jl.	Ag.	Sp.	Oc.	Nv.	De.	
1	AGDABIA	27.9	36.7	39.0	42.3	47.4	47.0	45.3	47.2	44.5	41.2	37.8	32.5	47.4
2	ALFATAIAH	26.2	32.0	35.2	40.8	40.4	44.8	41.9	44.1	42.0	38.7	34.3	29.5	44.8
3	BENGHAZI	26.3	31.7	38.0	39.9	44.8	45.6	42.4	44.0	42.1	38.5	37.2	31.0	45.6
4	DERNA	22.4	25.2	29.6	33.9	36.1	36.7	32.3	33.7	35.1	33.6	29.0	24.2	36.7
5	GHADAMES	31.8	35.0	39.0	45.7	46.8	50.6	49.0	49.8	45.2	45.8	38.0	33.0	50.6
6	GHARIAT	30.5	34.5	36.5	42.5	44.0	45.9	46.5	46.0	45.0	40.4	37.0	30.0	46.5
7	HON	31.5	38.3	40.0	43.5	47.2	48.0	46.8	46.7	46.0	42.9	38.5	34.2	48.0
8	JAGHBOUB	31.7	37.0	40.0	45.5	47.5	47.9	48.0	46.1	44.5	40.0	36.0	30.5	48.0
9	JALO	35.0	38.6	43.0	44.0	49.1	48.0	46.8	48.0	45.5	43.5	39.4	33.3	49.1
10	MISURATA	29.8	36.1	39.3	42.2	45.1	47.6	47.5	50.6	45.0	40.9	36.7	32.4	47.6
11	NALUT	27.5	32.7	35.6	39.4	41.4	44.0	45.0	44.0	41.7	39.0	33.6	27.8	45.0
12	SHAHAT	25.4	26.7	34.0	36.0	42.0	41.4	40.6	40.6	39.0	36.0	33.9	29.2	42.0
13	SIRTE	31.9	37.2	40.8	43.5	46.2	47.8	47.0	48.5	45.5	42.0	39.4	32.0	48.5
14	TOBRUK	27.0	34.5	38.5	42.0	42.4	45.7	44.7	39.0	42.6	38.5	35.0	29.8	45.7
15	TRIPOLI	32.0	36.2	40.0	44.0	46.7	48.4	48.3	49.1	47.2	44.5	39.0	32.1	49.1
16	ZWARA	32.0	38.6	41.7	41.7	45.5	50.2	48.3	53.0	47.8	43.0	39.0	32.5	53.0

The Source: Depending on: Libyan National Meteorological center climate & climate Change, Tripoli. 2012.

Table 14. The Extreme Minimum Temperatures (°C) (1971-2010)

NO	Station Name	Months												EXTREME MINIMUM
		Ja.	Fb.	Mr.	Ap.	Ma.	Jn.	Jl.	Ag.	Sp.	Oc.	Nv.	De.	
1	AGDABIA	0.0	0.2	2.8	3.9	6.4	10.4	13.3	13.9	11.7	8.0	3.6	1.9	0.0
2	ALFATAIAH	1.0	-0.5	-1.5	1.3	4.0	8.8	9.0	10.0	8.5	5.8	2.9	2.2	-1.5
3	BENGHAZI	1.7	1.7	0.6	3.9	6.1	10.0	14.8	12.0	10.0	9.0	5.6	3.9	0.6
4	DERNA	7.8	7.7	8.2	10.1	13.2	16.7	20.2	21.4	19.2	15.3	12.0	9.2	7.7
5	GHADAMES	-6.9	-8.0	-2.6	2.2	6.0	12.0	10.8	14.6	11.2	1.4	-2.0	-5.0	-8.0
6	GHARIAT	-4.2	-3.6	-3.0	2.3	4.5	10.0	11.0	13.5	10.5	5.0	0.3	-3.6	-4.2
7	HON	-6.9	-5.6	-3.9	0.0	5.2	9.9	11.7	10.0	10.0	4.0	-1.7	-6.0	-6.9
8	JAGHBOUB	-3.0	-1.0	1.0	2.0	4.4	13.0	13.9	13.9	9.4	7.5	0.0	-1.1	-3.0
9	JALO	-2.8	-0.6	1.6	5.6	9.5	13.4	16.6	16.7	12.2	7.8	0.6	0.0	-2.8
10	MISURATA	0.0	1.7	2.5	3.9	9.0	11.6	14.6	16.0	15.0	9.4	4.9	1.6	0.0
11	NALUT	-3.3	-3.9	-0.5	2.4	4.4	9.5	12.8	13.2	11.5	5.2	1.0	-2.0	-3.9
12	SHAHAT	-1.8	-1.1	0.0	1.1	5.0	9.0	12.4	12.5	10.5	5.0	4.0	1.5	-1.8
13	SIRTE	1.0	1.7	3.9	5.0	7.5	10.0	13.0	16.1	14.4	7.5	5.0	3.2	1.0
14	TOBRUK	2.8	4.0	3.3	4.5	4.8	12.0	11.0	15.4	11.8	10.5	6.6	4.5	2.8
15	TRIPOLI	-0.9	-0.6	0.6	1.8	5.0	10.0	9.0	13.9	11.8	5.4	2.8	-1.3	-1.3
16	ZWARA	-1.1	-0.6	1.0	3.9	7.5	11.0	10.0	15.6	13.0	5.0	1.1	-1.0	-1.1

The Source: Depending on, Libyan National Meteorological center climate & climate Change, Tripoli. 2012.

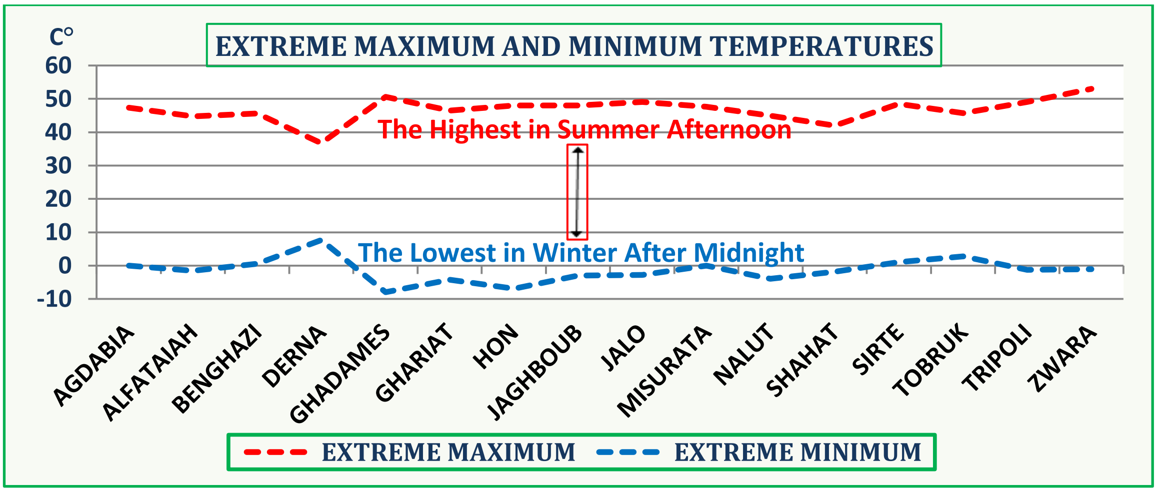


Figure 13. Extreme (Maximum& Minimum) Temperatures (°C) (1971-2010)

From the tables 13, 14 and figure 14 in view of the highest and lowest recorded temperature values during the observation periods, the highest (Extreme Maximum) temperature recorded at ZWARA station which was (53 °C), GHADAMES (50.6 °C), JALO (49.1 °C), AGDABIA (47.4 °C), HON and JAGHBOUB (48 °C), GHARIAT (46.5 °C), TOBRUK (45.7 °C), SIRTE (48.5 °C), and Tripoli (49.1 °C), it is noteworthy that historically recorded highest temperature was (57.7 °C) in southern TRIPOLI in 1922. The lowest observed temperature were at GHADAMES (- 8 °C) and HON (-6.9 °C).

It is observed that, temperatures are reduced at high rates in the winter in the areas far from the sea, The stations near the sea have the lowest temperatures between (7.7 °C) at DERNA and (0 °C) at AGDABIA.

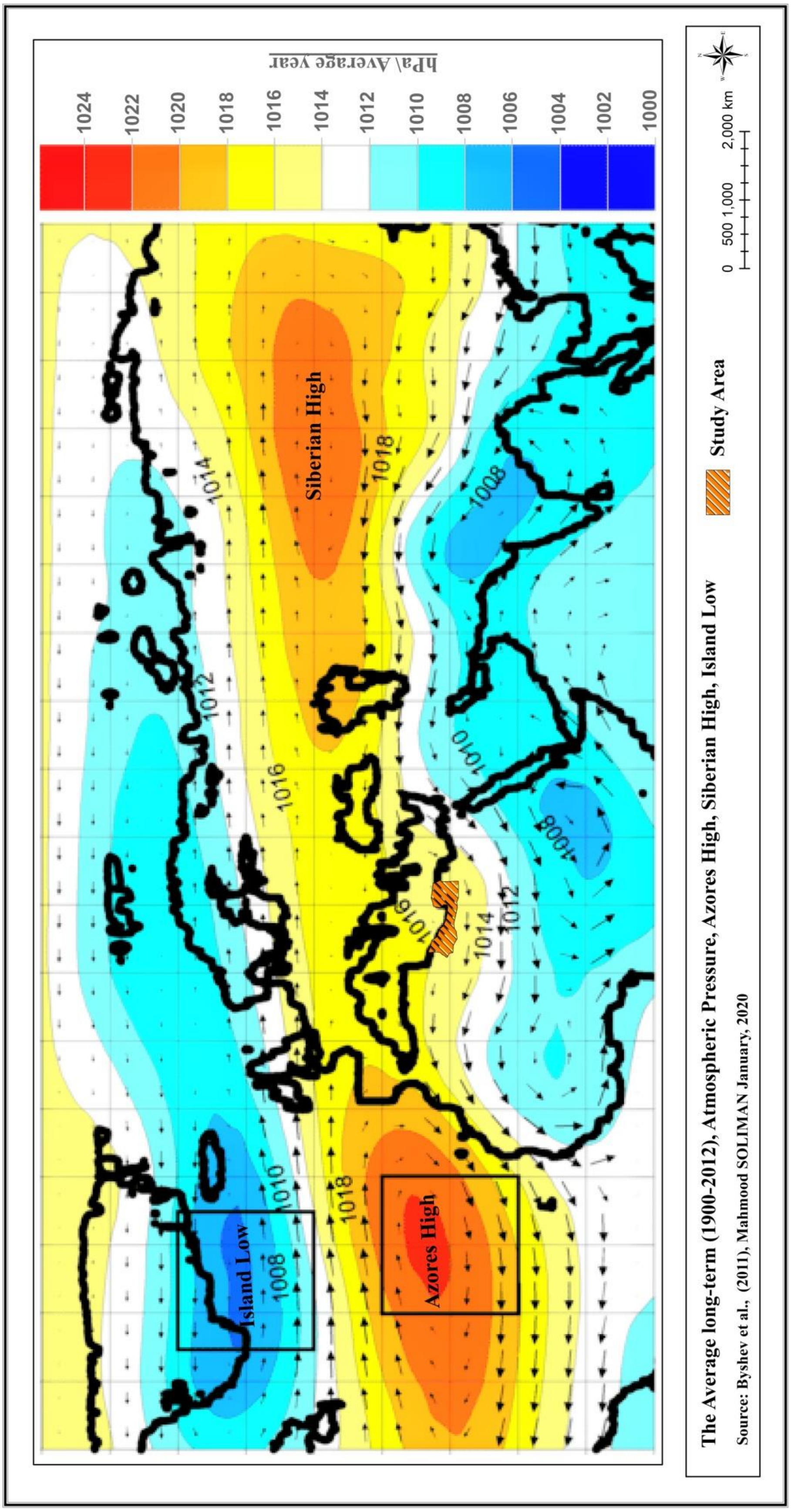
From the above, it can be seen that there are several factors that have an effect on the temperature in the stations of the study area, the most important of which is nearness to the Mediterranean Sea, the altitude above the sea level and the location of the latitudes for all stations in the study area.

2.2.3. Atmospheric Pressure and Wind

2.2.3.1. Atmospheric Pressure

Winds are known to be the result of variations in atmospheric pressure zones. Temperature controls the distribution of atmospheric pressure zones on the Earth's surface. During the winter, Icelandic low pressure and high Azurian pressure move slightly to the south by 5 -10 degrees in north. The desert region is an extension of the high (Azurian and Asian) pressure. From this great range of high pressure, the northerly and dry northerly winds are spreading towards the tropical low pressure in the south of Equator. Sometimes, the trade winds give up their control over the northern limbs to leave open the western wind and rain drops to invade the region in the winter months (Soliman, 2010)The Mediterranean turns into a center of relatively low pressure because of its warm water and moisture. The upper wind currents, especially the jet currents, play an important role in activating them and directing them to the east and northeast.

In the summer, the Azurian high pressure zone moves to the north and extends from an arm centered in the Mediterranean Sea.



Map 13. General Average Distribution of Atmospheric in The world (1900-2012)

As a result of the orthogonal rays of the sun over the course of the tropic of cancer and the high temperature of the dry land, a low-pressure zone stretches over North Africa. The north of Libya is generally under the influence of northern winds. These winds help to temper the temperatures on the coasts. In the spring, the passage of the front windshield (linked to the mid-east-west air drops) is accompanied by the flow of the continental tropical air mass to the north. The hot winds blowing in the north of Libya from the east and southeast to south and southwest bring severe drought-laden dust. During the autumn season, the air depressions begin to rise over the Mediterranean sea.

The winds at the top of these depressions are south-west and southwards coming from the desert carrying continental dry air (tribal winds). When the hurricane passes through the back of these depressions, (North and Northwesterly), the wind coming from a cold area becomes saturated with moisture from the warm sea water and therefore it is responsible for the rains that fall on the north of the study area during the fall and winter (Amgailey, 2009). Following tables and figures show the average pressure, wind direction and speed recorded in the stations in the study area.

Table 15. The Average Monthly and Annual of Air Pressure (hPa) (1971-2010)

NO	Station Name	Months												Annual (hPa)
		Ja.	Fb.	Mr.	Ap.	Ma.	Jn.	Jl.	Ag.	Sp.	Oc.	Nv.	De.	
1	AGDABIA	1019.6	1018.7	1016.7	1014.5	1014.2	1014.3	1013.4	1013.4	1015.5	1017.1	1018.8	1019.4	1016.30
2	ALFATAIAH	1003.3	1002.2	1000.6	998.7	999.1	999.2	998.9	998.7	1000.5	1001.8	1003.3	1003.1	1000.78
3	BENGHAZI	1018.9	1018.0	1016.6	1014.5	1014.4	1014.5	1013.6	1013.6	1015.7	1017.1	1018.1	1018.6	1016.13
4	DERNA	1018.1	1017.2	1016.1	1014.6	1014.6	1014.3	1012.6	1012.6	1015.2	1016.9	1017.9	1018.0	1015.68
5	GHADAMES	979.8	978.0	975.3	972.3	972.3	972.6	973.6	973.4	974.4	976.0	978.2	979.0	975.41
6	GHARIAT	962.0	960.5	959.0	956.8	957.4	958.4	958.8	958.6	959.6	960.6	961.7	962.2	959.63
7	HON	988.5	987.3	985.0	982.7	982.9	983.2	983.4	983.3	984.7	986.1	987.3	988.5	985.24
8	JAGHBOUB	1020.0	1019.9	1016.7	1013.7	1012.8	1011.7	1009.8	1010.2	1013.1	1016.2	1018.4	1019.9	1015.20
9	JALO	1015.4	1013.9	1011.7	1008.8	1008.5	1008.3	1007.4	1007.6	1009.9	1012.0	1014.2	1015.0	1011.06
10	MISURATA	998.4	1015.4	1013.8	1011.4	994.1	1012.3	1012.2	1012.1	1013.2	1014.1	1015.3	1015.8	1010.68
11	NALUT	947.5	946.2	944.5	942.7	943.7	944.7	945.6	945.4	946.1	946.5	946.8	947.1	945.57
12	SHAHAT	941.8	940.6	940.0	939.5	939.9	940.7	939.7	939.4	941.6	942.8	943.4	943.1	941.04
13	SIRTE	1017.7	1016.3	1014.4	1012.1	1012.6	1012.7	1012.7	1012.4	1013.7	1014.8	1016.3	1017.1	1014.40
14	TOBRUK	988.6	994.2	991.6	992.0	993.0	997.0	997.5	998.2	998.3	996.7	998.3	997.0	995.20
15	TRIPOLI	1010.2	1008.6	1006.8	1004.2	1004.6	1005.0	1005.5	1005.0	1006.2	1007.2	1008.6	1009.4	1006.78
16	ZWARA	1019.3	1017.7	1015.8	1013.1	1013.5	1014.0	1014.3	1013.9	1015.0	1016.0	1017.4	1018.3	1015.69

The Source: Depending on Libyan National Meteorological center climate & climate Change, Tripoli. 2012.

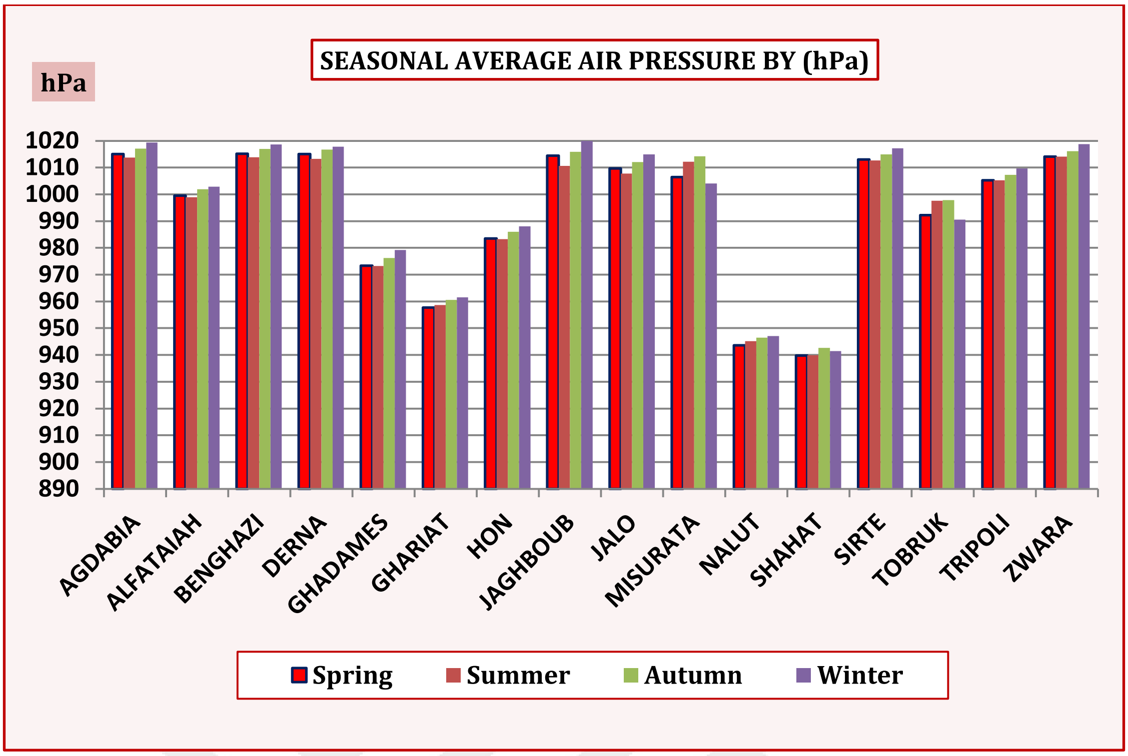


Figure 14. The Seasonally Air Pressure (hPa)in Meteorological Stations (1971-2010)

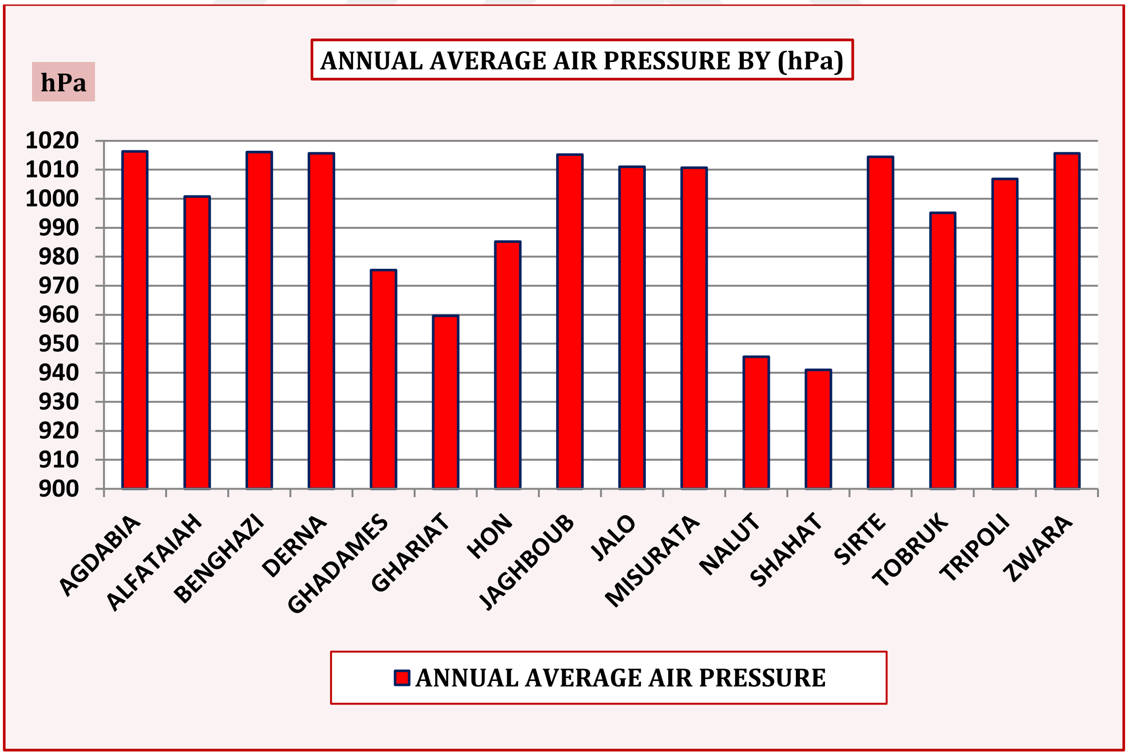
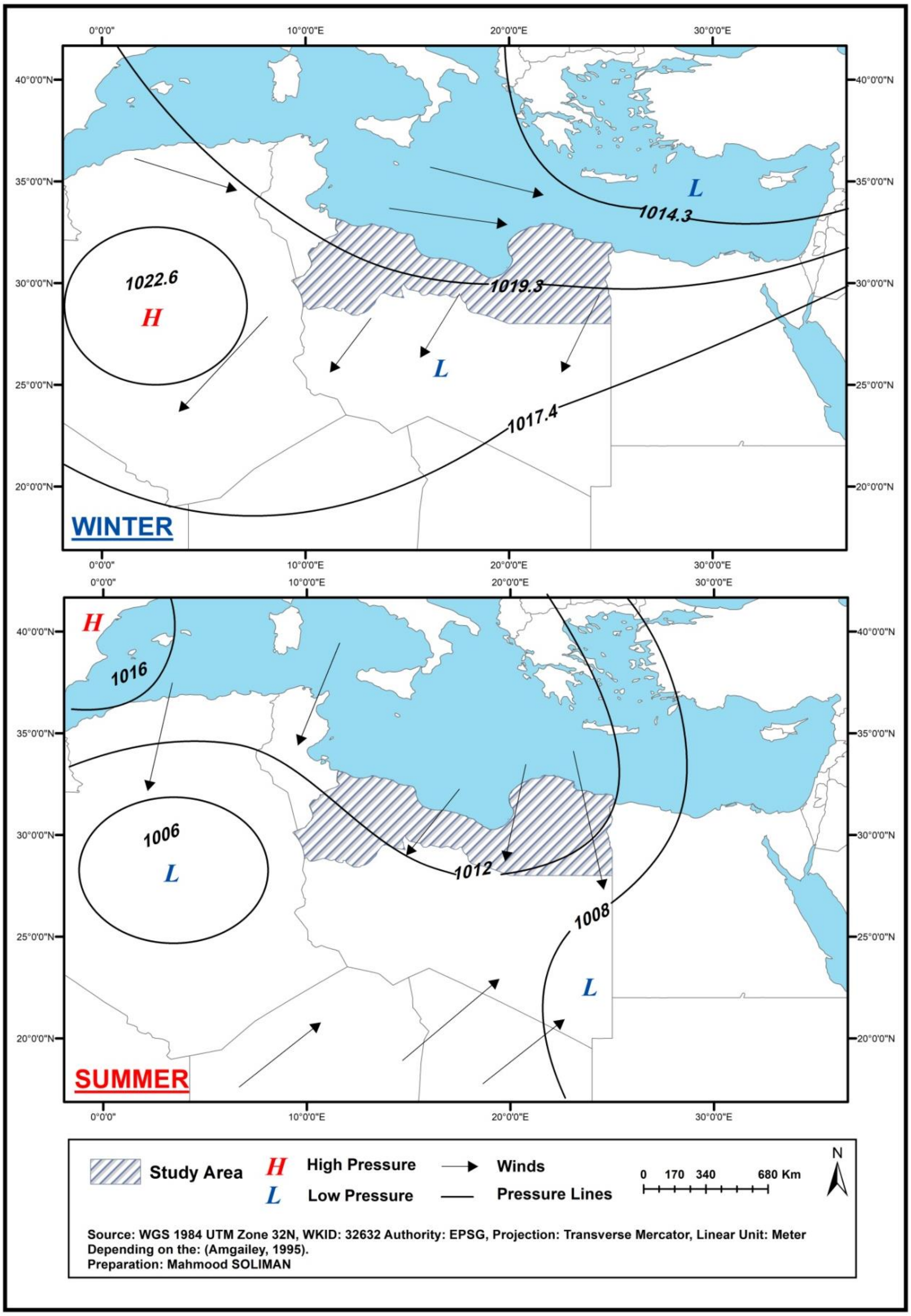


Figure 15. The Average Annual Air Pressure (hPa) in Meteorological Stations(1971-2010)



Map 14. General Average Distribution of Atmospheric Pressure Around Study Area For Winter And Summer

Table 15, figure 15, 16 and map 13 show that the atmospheric pressure zones in the study area vary from monthly and from station to station. For example, at AGDABIA station, atmospheric pressure in January, February, November, and December were between (1018.8 and 1019.6 hPa). These values are lower in March, April, May, June, and October, possibly because of the low temperature during the cold months. There is an inverse relationship between temperature and atmospheric pressure, and in July and August, September and October the atmospheric pressure ranges between (1013.4 and 1015.5 hPa).This relative decrease in atmospheric pressure can be observed in the results of the winds directions and their speed at the station. At ALFATAIAH station which is located about 300 meters above sea level, the atmospheric pressure value of (1003.3 hPa) is the highest recorded value in January due to the relative rise in sea level. In the rest of the months it ranges between (998.7 hPa) to (1001.8 hPa), while the average rate of air pressure at ALFATAIAH station is (1000.78 hPa).

BENGHAZI station located on the Mediterranean Sea coast has higher atmospheric pressure during the winter months, reaching up to (1018.9 hPa) in January, (1018.0 hPa) in February and (1018.6 hPa) in December. In Summer months, the rate of atmospheric pressure is relatively high in coastal stations not exceeding 100 meters above sea level such as DERNA (1015.6 hPa), TOBRUK (995.2 hPa), MISURATA (1010.6 hPa), Sirte (1014.4 hPa) and ZWARA (1015.7 hPa). The atmospheric pressure in high stations such as the SHAHAT station and NALUT station is low as the annual rates of atmospheric pressure did not exceed more than (941.1 hPa) at SHAHAT and (945.6 hPa) at NALUT. The dessert stations differ from one station to another in terms of pressure. At JAGHBOUB station, the average annual air pressure was (1015.2 hPa), at Jalo (1011.1 hPa), at GHADAMES (975.4 hPa), at HON (985.2 hPa) and at GHARIAT (959.6 hPa). The values of atmospheric pressure increase during the winter months and decrease during the summer months.

In general, the highest average pressure values were observed in months of July, August, and September while the lowest mean pressure values were observed in months of January, February December, and November. It is found that the most important factors controlling atmospheric pressure are temperature and elevation which is evident from the difference between the atmospheric pressure values of the SHAHAT and DERNA stations.

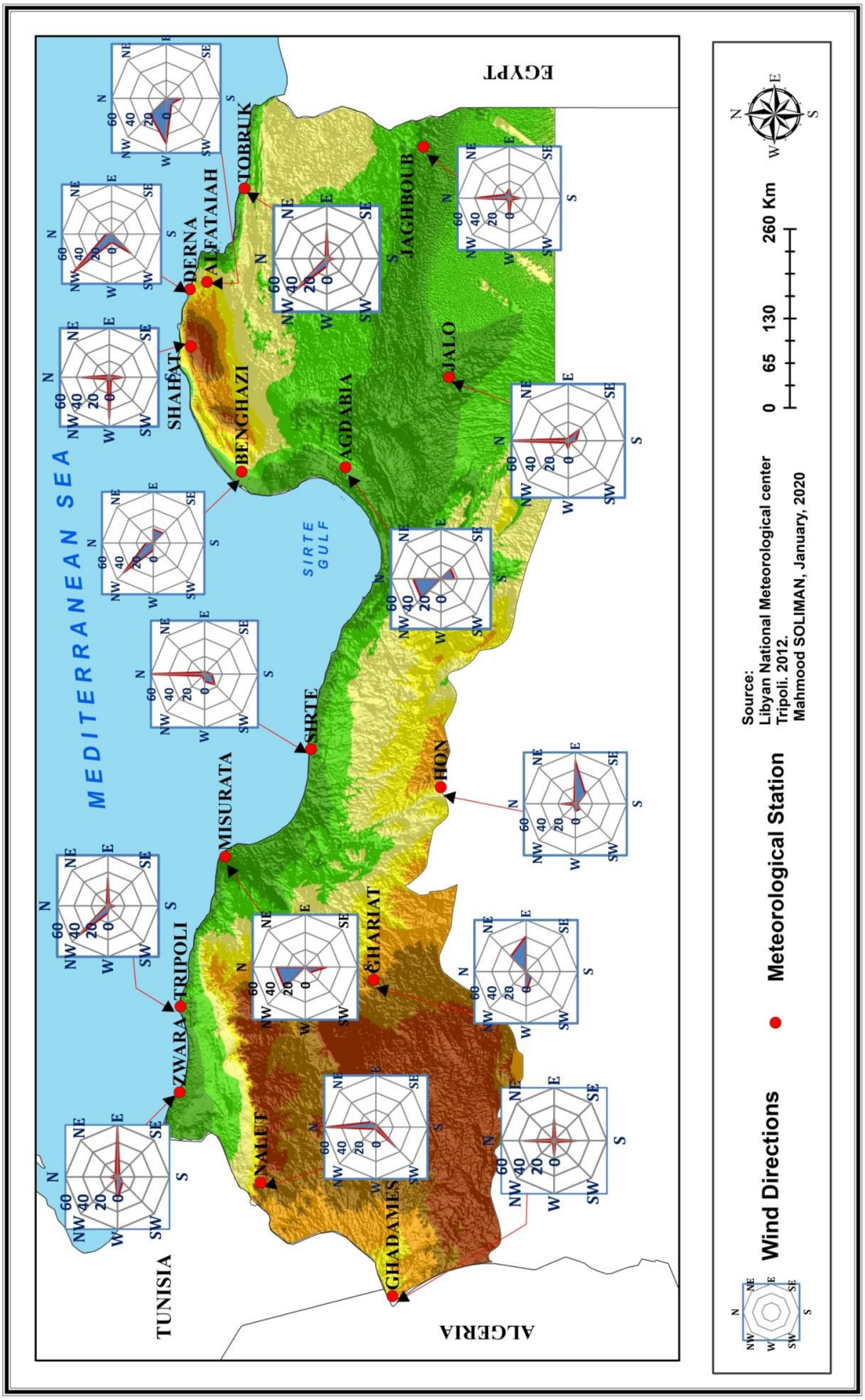
2.2.3.2. Wind Directions, in general, the trends of wind fluctuation vary according to the atmospheric pressure centers around the meteorological stations. It is possible that the prevailing trend of wind is to the north more often on a station if the pressure value is low in northern region than in that station and around it.

Table 16. Average Monthly and Annual of Prevailing Wind Direction in Meteorological Stations (By 0 - 360° & Directions) (1971-2010)

NO	Station Name	Months											
		Ja.	Fb.	Mr.	Ap.	Ma.	Jn.	Jl.	Ag.	Sp.	Oc.	Nv.	De.
1	AGDABIA	150	310	130	330	310	350	350	340	340	310	170	170
		SE	NW	SE	NW	NW	N	N	N	N	NW	S	S
2	ALFATAIAH	220	300	270	290	290	290	290	290	330	290	200	190
		SW	NW	W	W	W	W	W	W	NW	NW	S	S
3	BENGHAZI	100	330	110	260	330	330	330	330	350	330	150	150
		E	NW	E	W	NW	NW	NW	NW	N	NW	SE	SE
4	DERNA	220	220	310	330	310	330	310	330	330	330	210	220
		SW	SW	NW	NW	NW	NW	NW	NW	NW	NW	SW	SW
5	GHADAMES	170	170	350	260	260	080	080	080	350	020	170	350
		S	S	N	W	W	E	E	E	N	N	S	N
6	GHARIAT	260	260	080	080	060	080	060	060	080	210	080	260
		W	W	E	E	NE	E	NE	NE	E	SW	E	W
7	HON	240	120	120	110	110	110	350	350	110	110	110	290
		SW	SE	SE	E	E	E	N	N	E	E	E	W
8	JAGHBOUB	260	350	260	350	170	350	350	350	350	350	260	260
		W	N	W	N	N	N	N	N	N	N	W	W
9	JALO	170	350	350	350	350	350	350	350	350	135	135	260
		S	N	N	N	N	N	N	N	N	SE	SE	W
10	MISURATA	240	350	330	330	330	020	350	350	330	170	170	190
		SW	N	NW	NW	NW	N	N	N	NW	S	S	S
11	NALUT	240	240	350	350	350	350	040	350	350	350	240	240
		SW	SW	N	N	N	N	NE	N	N	N	SW	SW
12	SHAHAT	290	260	260	350	290	350	350	290	350	170	170	260
		W	W	W	N	W	N	N	W	N	S	S	W
13	SIRTE	220	220	350	350	350	350	350	350	350	350	170	260
		SW	SW	N	N	N	N	N	N	N	N	S	W
14	TOBRUK	260	330	080	080	080	330	330	330	330	330	080	170
		W	NW	E	E	E	NW	NW	NW	NW	NW	E	S
15	TRIPOLI	240	240	240	150	080	060	080	020	080	080	240	240
		SW	SW	SW	SE	E	NE	E	N	E	E	SW	SW
16	ZWARA	260	260	350	080	080	080	100	070	100	070	240	280
		W	W	N	E	E	E	E	E	E	E	SW	W

The Source: Depending on: Libyan National Meteorological center climate & climate Change, Tripoli. 2012.

From table 15 it is clear that there is a difference between wind direction from one station to another and from one month to another. Following forms illustrate this variation from one station to another.



Map 15. Average Percentage Wind Directions (Wind Roses) in Meteorological stations (1971-2010)

The above diagrams describe table 16 and map 14 the following facts; directions of wind at AGDABIA station mostly in the summer months are towards north (33.3 %) and north west (33.3 %), in November and December, south (16.6 %) and in January and March from southeast (16.6 %), while the rest of the directions are very low. The wind at ALFATAIAH station blows from the West (50 %) from March to August and the wind blows from Northwest (25 %) during February and beginning of the autumn season in September and October. Wind blows from south (16.6 %) especially in November and December and South-West (8.6 %) in January only, at BENGHAZI station, the Northwest wind blows most of the summer months by (50 %), which is the prevailing wind at the station. In January and March, it flows from direction of East by (16.4 %) and South East by (16.4 %). In November and December, the wind blows from north while in September, only by (8.6 %) of the total wind directions on the station.

At DERNA station, the wind blows from two directions by a small percentages only and doesn't blow from other directions. The most important direction is north-west (66.6 %) of the total wind direction on the station from March to October, followed by the south-west (33.4 %) in January and February and November and December, at GADAMES station, the percentage of wind blowing from the north is (33.4 %) in March, September, October, and December. From the east (25 %) in summer months, and from the south (25 %) in January and February and November, and from the West (16.6 %) in April and May, and other directions are distributed in very few percentages.

At GHARIAT, The wind blows from a direction of the east (41.4 %) in the months of March, April, June, and September, and the north-east (25 %) in the months of May, July and August and (25 %) during the winter months, and the south-west (8.6 %) in October. As for HON station, the prevailing direction of wind blowing from the east (50 %) in April, May, June, September, October, and November, followed by the South East (16.6 %) in February and March, June and July, and the rest are distributed on the south and south-west. There are two directions at JAGHBOUB station, the first is the north direction, where (75 %) of the wind direction is found in the station is from February to October, the second is from west by (25 %) in January, November, and December. at JALO station from the north (66.6 %) from February to September, followed by the South East (16.6 %) in October and November, and the West (8.4 %) in December and South (8.4 %) in January only.

At MISURATA station, the percentage of winds from the north reaches 33.3% during the summer months, north west (33.3 %) during the spring months, and the south (25 %) during October, November, and December, and from west just in January (8.4 %), at NALUT station the percentage of wind blowing from the north reaches (58.3 %) during the months of March, April, May, June, August, September and October, south-west (33.3 %) in the winter months, at SHAHAT station the wind blows from the west in January, February, March, May, August and December by (50 %), north by (33.3 %) in April, June, July and September and southwest by (16.7 %) in October and November, while the rest of the directions have very low percentages, at the SIRTE station, the wind blows from the north in the month of October by (66.6 %), south-west by (16.6 %) in January and February from the south by (8.4 %) in November only, and from the West by (8.4 %) in December only, at TOBRUK, the largest percentage of wind blows from the north west (50 %) in February June, July, August, September and October followed by the east (33.2 %) in the spring month, west by (8.4 %) in January, and south by (8.4 %) in December.

At TRIPOLI station, the percentage of wind blowing from the south west is (41.8 %) in the winter months, from the east (33.3 %) in the months of May, July, September and October, and from the south-east in April by (8.3 %) , North-east (8.3 %) in June and north in August (8.3 %). At ZWARA station, the wind blows from the east, starting from April to October by (58.4 %), from the west direction by (25 %) in the winter months, from the north by (8.3 %) in March only and southwest (8.3 %) just in November. In should be noted that the general rates of wind trends do not necessarily mean that these trends are always permanent and true. Wind may blow from several destinations in one day and preliminary data show that there are many trends that will be ignored if the monthly average of a long period of time is calculated as in some stations may reach to 60 years. Therefore, it is necessary to focus on preliminary data for their importance in determining wind trends lost in arithmetic averages. For example, at JAGHBOUB station, there are only two directions for the wind (North, and West), while in the raw data there are many wind directions but only a few appear in the general average.

2.2.3.3. Wind Speed

Wind speed varies from one place to another because of the difference in the amount of atmospheric pressure from one place to another and from one season to another. Winds move from high-pressure to low pressure. The higher the values of high-pressure centers, wind speed is also greater. Following table and figures show the general average of wind speeds in meteorological stations in the study area.

Table 17. The Average Monthly and Annual Wind Speed by (Knots)[1](1971-2010)

NO	Station Name	Months												Annual SPEED (Knots)
		Ja.	Fb.	Mr.	Ap.	Ma.	Jn.	Jl.	Ag.	Sp.	Oc.	Nv.	De.	
1	AGDABIA	4.9	5.8	6.8	7.5	7.0	6.5	6.6	6.0	5.4	5.1	4.5	4.8	5.91
2	ALFATAIAH	9.4	10.5	10.4	11.3	10.4	11.3	12.9	12.4	10.2	9.0	9.4	9.4	10.55
3	BENGHAZI	9.3	9.8	10.7	11.7	11.4	11.0	11.0	10.3	9.5	9.4	9.1	9.5	10.23
4	DERNA	12.7	13.0	12.6	12.0	10.4	11.4	14.3	13.9	11.2	10.0	11.4	12.9	12.15
5	GHADAMES	7.2	7.7	9.4	10.3	10.6	10.5	9.5	8.7	9.0	7.9	6.8	6.9	8.71
6	GHARIAT	8.1	8.3	8.8	8.9	8.3	7.6	6.2	5.9	6.4	6.5	6.7	7.4	7.43
7	HON	7.1	7.7	8.8	9.8	9.5	8.9	7.8	7.3	7.3	7.0	6.3	6.6	7.84
8	JAGHBOUB	5.5	6.2	7.1	7.5	7.2	7.2	7.1	6.6	5.7	5.0	4.3	4.8	6.18
9	JALO	6.2	6.8	7.7	8.4	7.6	6.9	7.3	6.5	5.7	5.3	5.1	5.9	6.62
10	MISURATA	8.6	8.6	9.6	9.5	8.7	7.9	6.8	6.4	7.0	7.0	7.2	8.1	7.95
11	NALUT	9.5	9.4	9.7	10.1	9.7	9.7	8.2	7.9	8.3	7.8	8.0	9.6	8.99
12	SHAHAT	11.3	11.4	11.1	10.7	8.3	7.0	6.5	6.4	6.3	7.9	9.9	11.6	9.03
13	SIRTE	8.6	8.8	9.3	9.5	8.6	7.7	7.0	6.9	7.4	7.8	7.8	8.5	8.16
14	TOBRUK	9.3	10.2	9.8	9.7	8.7	8.9	10.6	10.4	8.6	7.3	8.5	9.5	9.29
15	TRIPOLI	6.8	6.8	7.4	8.3	8.6	8.5	7.2	7.0	7.3	6.5	6.1	6.7	7.27
16	ZWARA	7.8	7.9	9.0	9.6	9.1	8.8	7.8	8.0	8.5	7.7	6.9	7.3	8.20

The Source: Depending on: Libyan National Meteorological center climate & climate Change, Tripoli. 2012

These figures showed the difference in wind speed between station and another:

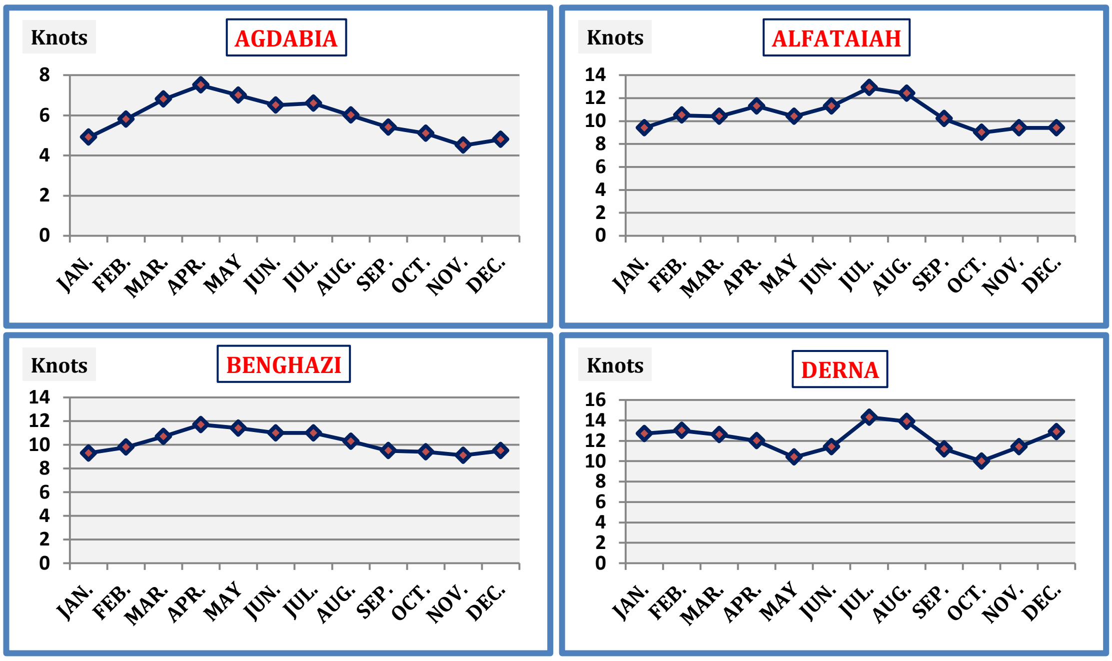


Figure 16. The Average Monthly and Annual of Wind Speed by (Knots) (1971-2010)

[1]1 knots = 1.852 km\ hour, for example; the wind speed in station of AGDABIA in January 4.9 knots = 4.9\1.852 = 9.07 km in hour.

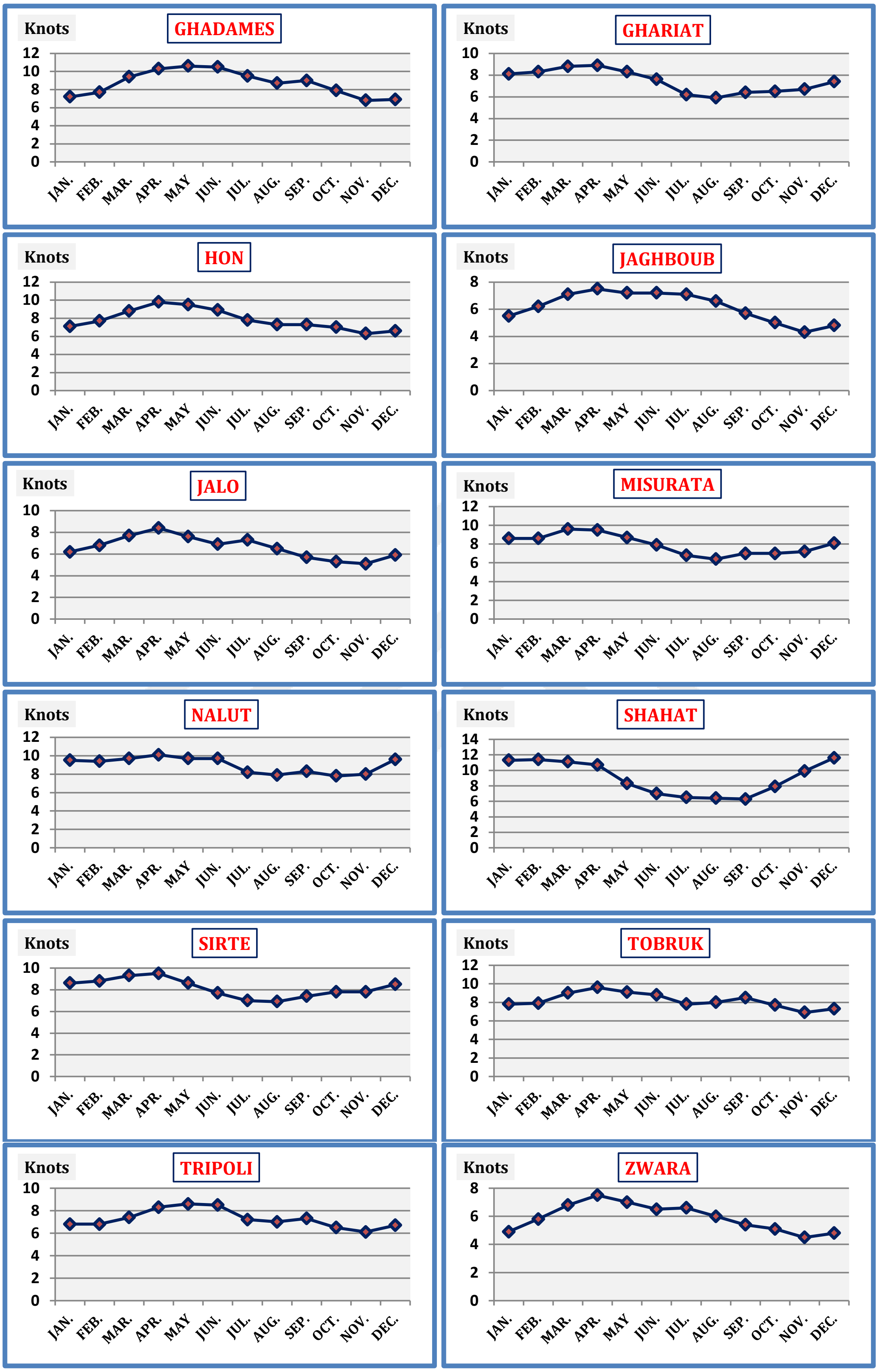


Figure 17. The Average Monthly and Annual of Wind Speed by (Knots) (1971-2010)

Through the previous table 17 and figures 17, 18 it was observed that wind speed decreases in the summer months in all stations of the study area. The speed of wind at stations of ALFATAIAH, BENGHAZI and DERNA increases due to the geographic location of these three stations which are located facing towards western winds during the winter months.

Wind speed increases during spring months at most stations in the study area due to low pressure zone over most of North Libya.Wind speed reachesto (10 knots/ hour) at TOBRUK station during April, at ZWARA station (7.5 knots/ hour) in April and at SIRTE station (9 knots/ hour) in same month.It is possible to say that duringl spring months all stations of the study area have recorded increased wind speed, especially in April which is an increase of up to (30 %) as compared to other months.

The summer months are characterized by low wind speed, ranging from (5-7 knots/ hour) in many stations of the study area, except of DERNA station. This is because of the balance of atmospheric pressure prevailing in the region during months of summer.

The autumn months are different from one station to the other in terms of wind speed. Wind speed reaches up tp (10 knots/ hour) at ALFATAIAH, (5 knots/ hour) at AGDABIA, (6 knots/ hour) at TRIPOLI and (8-9 knots\ hour) at BENGHAZI.

The maximum wind speed recorded at DERNA station was (14.3 knots/ hour) during the month of July.The lowest wind speed during the monitoring period at Al-Jaghbub station was (4.3 knots/ hour) during November.The highest general average of wind speed in stations of study area was recorded at DERNA station which was (12.15 knots/ hour) and (10.55 knots/ hour) at ALFATAIAH station.The lowest general average of wind speed recorded at AGDABIA station which was (5.91 knots/ hour), (6.18 knots/ hour) at JAGHBOUB and (6.62 knots/ hour) at JALO station.

2.2.4. Humidity and Precipitation

2.2.4.1. Relative Humidity

The ratio of the amount of water vapor in the air to the amount of water vapor in saturated water is expressed as relative humidity and is expressed in % (Atalay, 2013).Relative humidity depends on the amount of water vapor in the air and its temperature. Relative humidity increases with increased rates of evaporation or decrease in temperature. Relative humidity on the ground is higher in winter than in summer, and unlike water bodies where relative humidity is higher in summer than in winter (Soliman, 2010). Therefore, the difference in the nature of the relative humidity distribution in stations of the study area can be explained on this basis.

The humidity in the atmosphere depends on the amount of air contained in the water vapor and its temperature. The relative humidity increases with increasing evaporation rates or low temperature and the relative humidity over the land is higher in winter than in the summer.

The relative humidity in coastal meteorological stations is higher in the summer and winter and therefore, the difference in the nature of the distribution of relative humidity between the stations of the study area can be explained on this basis.

The stations affected by mountain climate vary where rates of relative humidity differ monthly and seasonally. These differences can be seen in the following table, figure, and map.

Table 18. Annual and Monthly Average Relative Humidity (%) (1971-2010)

NO	Station Name	Months												Annual Average
		Ja.	Fb.	Mr.	Ap.	Ma.	Jn.	Jl.	Ag.	Sp.	Oc.	Nv.	De.	
1	AGDABIA	70.7	65.8	59.5	53.1	51.1	52.3	62.8	63.3	60.1	60.3	65.3	69.5	61.15
2	ALFATAIAH	74.4	72.5	68.8	60.5	58.3	58.3	64.8	67.0	68.8	67.2	67.0	73.1	66.73
3	BENGHAZI	76.1	73.0	67.0	58.2	54.8	55.6	64.9	65.6	63.2	64.2	68.8	73.9	65.44
4	DERNA	71.8	69.5	68.6	68.4	71.5	72.5	74.9	74.4	73.3	70.9	68.7	69.5	71.17
5	GHADAMES	51.2	42.4	36.2	29.0	26.4	22.8	22.1	24.4	30.0	37.8	45.3	52.2	34.98
6	GHARIAT	63.0	55.0	51.5	46.8	43.6	41.8	44.0	45.0	50.5	55.3	58.9	62.0	51.45
7	HON	58.2	52.6	47.6	41.7	38.6	36.9	41.5	43.6	45.3	51.1	55.5	57.7	47.53
8	JAGHBOUB	61.1	55.9	48.8	41.4	37.9	38.1	41.6	43.7	47.4	52.5	58.0	62.2	49.05
9	JALO	56.1	50.2	45.5	38.6	34.4	33.8	38.4	39.8	42.2	46.7	52.6	57.3	44.63
10	MISURATA	71.5	69.7	69.9	69.6	70.2	71.3	73.1	72.2	71.7	71.1	69.6	69.6	70.80
11	NALUT	60.8	53.5	51.0	47.3	43.6	41.5	40.9	43.5	50.4	54.9	56.8	60.6	50.40
12	SHAHAT	78.5	74.8	71.7	63.6	57.1	56.1	66.6	69.4	70.6	71.3	73.7	77.2	69.22
13	SIRTE	69.7	67.8	67.8	67.6	70.8	73.5	76.4	75.3	73.8	70.9	67.9	68.0	70.73
14	TOBRUK	70.7	68.3	68.0	67.8	72.1	74.5	76.9	77.8	72.5	70.3	68.9	69.0	71.40
15	TRIPOLI	70.4	66.7	64.4	59.3	54.2	52.5	55.5	56.9	60.9	64.0	66.2	69.0	61.67
16	ZWARA	71.3	69.6	72.1	72.6	74.9	76.0	76.7	75.5	74.4	72.7	69.4	70.6	72.98

The Source: Depending on: Libyan National Meteorological center climate & climate Change, Tripoli. 2012.

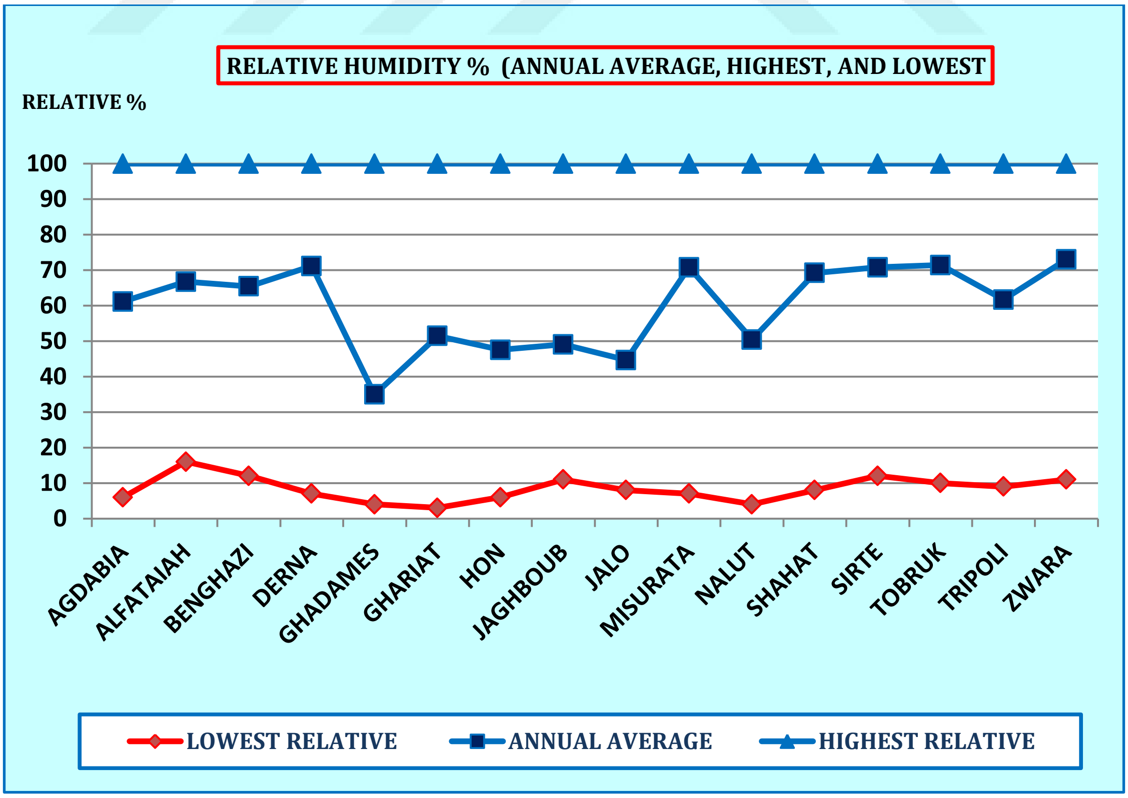
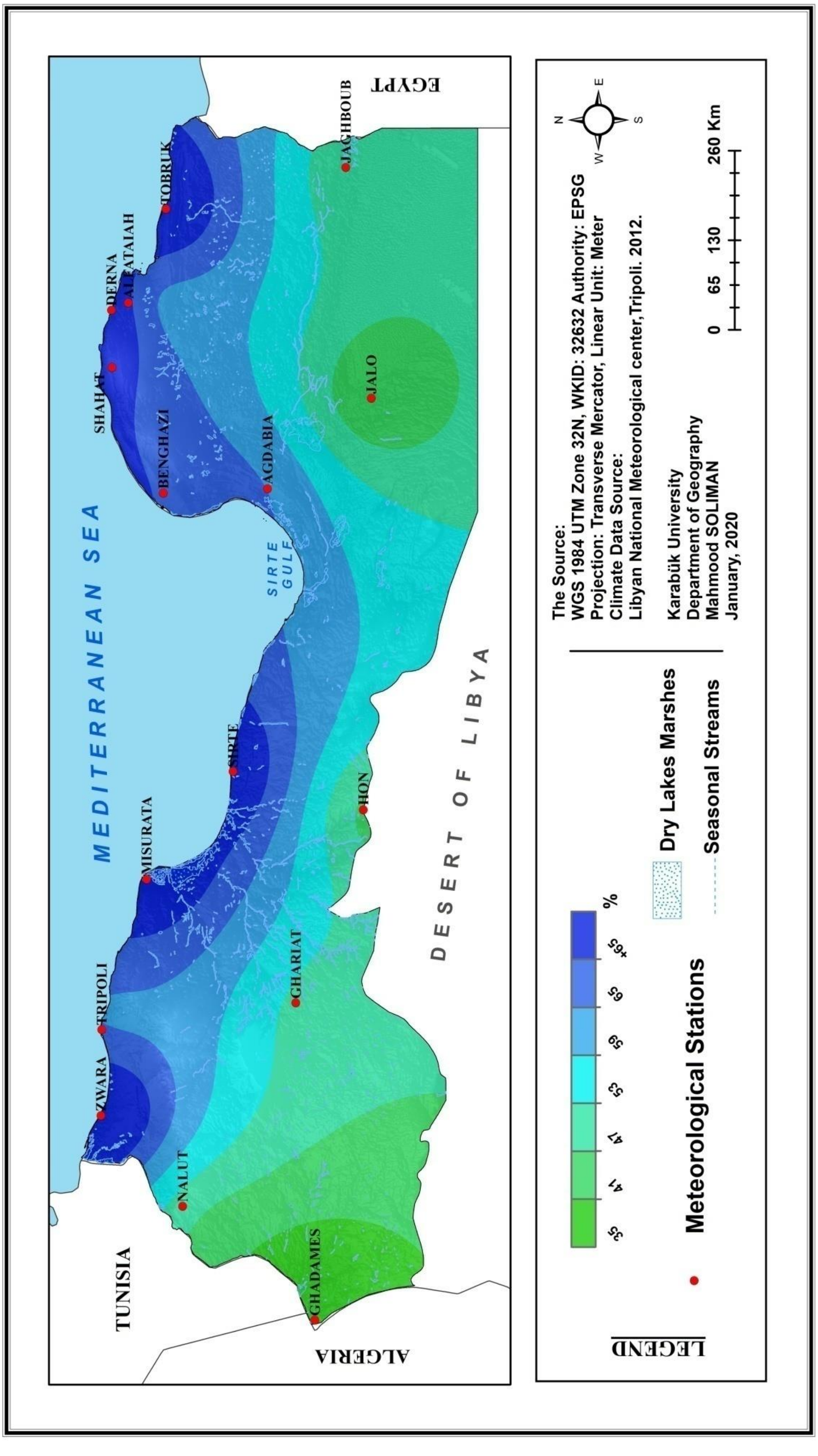


Figure 18. Average Relative Humidity (%) for Annual, Highest, Lowest (1971-2010)



Map 16. The Annual Average of Relative Humidity (%) for Period (1971-2010)

In table 18, figure 19 and map 13 the average relative humidity in the region varies according to the months and seasons of the year depending on the absolute and relative location. The most important factors affecting relative humidity are the vegetation the and distance or proximity to the sea. The closer the stations are to the sea, the higher the relative humidity is. The data obtained from different stations of the study area which is described in the above-mentioned tables and maps show several important findings discussed below.

The highest average humidity was recorded at the SHAHAT station that was (78.5 %) during the winter months in general and particularly in January, because of the density of vegetation in the region and due to rainfall that falls in large quantities, leading to saturation of the atmosphere with water vapor. This figure is further followed by BENGHAZI station with (76.1 %), DERNA with (71.8 %), ZWARA with (71.3 %) and MISURATA with (71.5 %) of relative humidity. On the other hand, the average relative humidity in desert stations in the month of January was (51.2 %) in GHADAMES, (56.1 %) in JALO and (58.2 %) in Hon. At some low-lying coastal stations, the average relative humidity is only (69.7 %) at SIRTE station and (70.7 %) in TOBRUK, at NALUT, despite its elevation of 640 meters, the average relative humidity in January is (60.8 %) due to the its distance from the sea which is more than 160 km. It is noticeable that the semi-desert GHARIAT station has average relative humidity of (63 %) in January.

The average Relative Humidity in DERNA in the month of July is (74.9%), in Sirte (76.4 %), at TOBRUK (76.9 %) and at ZWARA (76.7 %). This is due to the increased amount of evaporation from the sea during the summer season. As for desert stations, the average relative humidity in July at GHADAMES is (22.1 %), at JALO (38.4 %) at JAGHBOUB, (47.5 %) at HON (36.9 %), and at GHARIAT (44 %). This is because of the distance from the sea and the extreme desert climate.

The annual rate of relative humidity recorded different values from one station to another. For instance the annual average humidity was (73 %) at ZWARA station, which is the highest annual rate in the study area.

It is followed by (71.4 %) at TOBRUK, (71.2 %) at DERNA, (70.8 %) at MISURATA, (70.7 %) at SIRTE, (61.15 %) at AGDABIA, (65.44 %) at BENGHAZI, (70.8 %) at MISURATA, (61.67 %) at TRIPOLI and (66.73 %) at ALFATAIAH.

Therefore, relative humidity do not reduce more than (70 %) in most coastal stations and this shows the characteristics of the wet and semi-wet marine climate. In contrast, the desert stations do not exceed the relative humidity of more (50 %) for example relative humidity found at GHADAMES is (34.9 %), at HON (47.5 %), at JAGHBOUB (49 %), and at JALO (44.6 %).

The stations which are located at highest elevation are characterized as moderate in relative humidity in most months of the year. For example, the general average relative humidity in months of the Summer at SHAHAT station is (69.2 %) which is (66.6 %) in July. On the other hand, in the DERNA station which is located on the Mediterranean coast, the relative humidity in July is (74.9 %).

It can be observed from the tables 18 and 19, which describe the highest and lowest recorded relative humidity, that all the stations in the study area recorded (100 %) relative humidity values in all months of the year except for two stations GHADAMES and JALO. However, (0 %) relative humidity was recorded at Benghazi station in May which appears to be extreme. Moreover, desert stations recorded the lowest values of relative humidity as (1 %) while coastal stations recorded between (3 %) and (7 %).

In general, the relative humidity in the stations of the study area varies according to geographical location and elevation from sea level. Relative humidity is high in the coastal stations in the summer while desert stations have relatively low relative humidity especially in the summer. However, mountain stations are characterized by moderate relative humidity in most months of the year. As for stations that are located in areas with dense vegetation, such as SHAHAT, ALFATAIAH and DERNA Stations, due to Evapotranspiration from plants, they increase the rates of relative humidity during the winter season, and are moderate during the summer season.

2.2.4.2. Evaporation

One of the most important factors affecting evaporation are hot air, that can carry more moisture than cold air as dry air can absorb more moisture than wet air, and nature of the surface. Evaporation rates are higher in the desert inland areas which far away from the impact of the sea. Therefore, the record highest evaporation rates in the region in the summer are found in the desert stations which are the hottest and most dry. This is because of several factors including length of sunshine, high temperature, lack of cloud cover and absence of plant cover which reduces the speed of air. On the other hand, the relative humidity on the coast stations increases as a result of low evaporation rates.

Table 19. Total Average (Monthly and Annual) of Evaporation (Pich by mm) in Meteorological Stations (1971-2010)

NO	Station Name	Months												Annual Total
		Ja.	Fb.	Mr.	Ap.	Ma.	Jn.	Jl.	Ag.	Sp.	Oc.	Nv.	De.	
1	AGDABIA	105.4	173.6	192.2	255.0	297.6	297.0	254.2	238.7	234.0	204.6	144.0	114.7	2511.0
2	ALFATAIAH	127.1	148.4	164.3	207.0	226.3	255.0	275.9	248.0	207.0	195.3	174.0	142.6	2370.9
3	BENGHAZI	108.5	159.6	176.7	249.0	288.3	273.0	213.9	210.8	216.0	207.7	153.0	124.0	2380.5
4	DERNA	161.2	159.6	176.7	186.0	179.8	186.0	198.4	189.1	174.0	182.9	180.0	182.9	2156.6
5	GHADAMES	192.2	347.2	384.4	498.0	604.5	666.0	675.8	644.8	531.0	399.9	252.0	189.1	5384.9
6	GHARIAT	161.2	249.2	275.9	315.0	368.9	414.0	372.0	365.8	303.0	238.7	189.0	158.1	3410.8
7	HON	170.5	280.0	310.0	390.0	465.0	471.0	427.8	399.9	357.0	291.4	207.0	173.6	3943.2
8	JAGHBOUB	136.4	215.6	238.7	318.0	384.4	387.0	387.5	341.0	282.0	223.2	162.0	127.1	3202.9
9	JALO	133.3	212.8	235.6	291.0	325.5	357.0	356.5	331.7	294.0	220.1	141.0	130.2	3028.7
10	MISURATA	145.7	156.8	173.6	183.0	198.4	189.0	176.7	186.0	189.0	186.0	180.0	164.3	2128.5
11	NALUT	158.1	218.4	241.8	285.0	350.3	375.0	393.7	372.0	297.0	244.9	204.0	170.5	3310.7
12	SHAHAT	55.8	114.8	127.1	174.0	182.9	213.0	182.9	139.5	132.0	127.1	114.0	80.6	1643.7
13	SIRTE	148.8	170.8	189.1	204.0	189.1	168.0	161.2	173.6	183.0	192.2	177.0	164.3	2121.1
14	TOBRUK	120.9	128.8	142.6	153.0	139.5	141.0	136.4	142.6	153.0	151.9	135.0	136.4	1681.1
15	TRIPOLI	124.0	165.2	182.9	201.0	220.1	237.0	217.0	229.4	219.0	207.7	162.0	133.3	2298.6
16	ZWARA	130.2	134.4	148.8	153.0	145.7	135.0	142.6	155.0	165.0	170.5	156.0	142.6	1778.8

The Source: Depending on: Libyan National Meteorological center climate & climate Change, Tripoli. 2012.

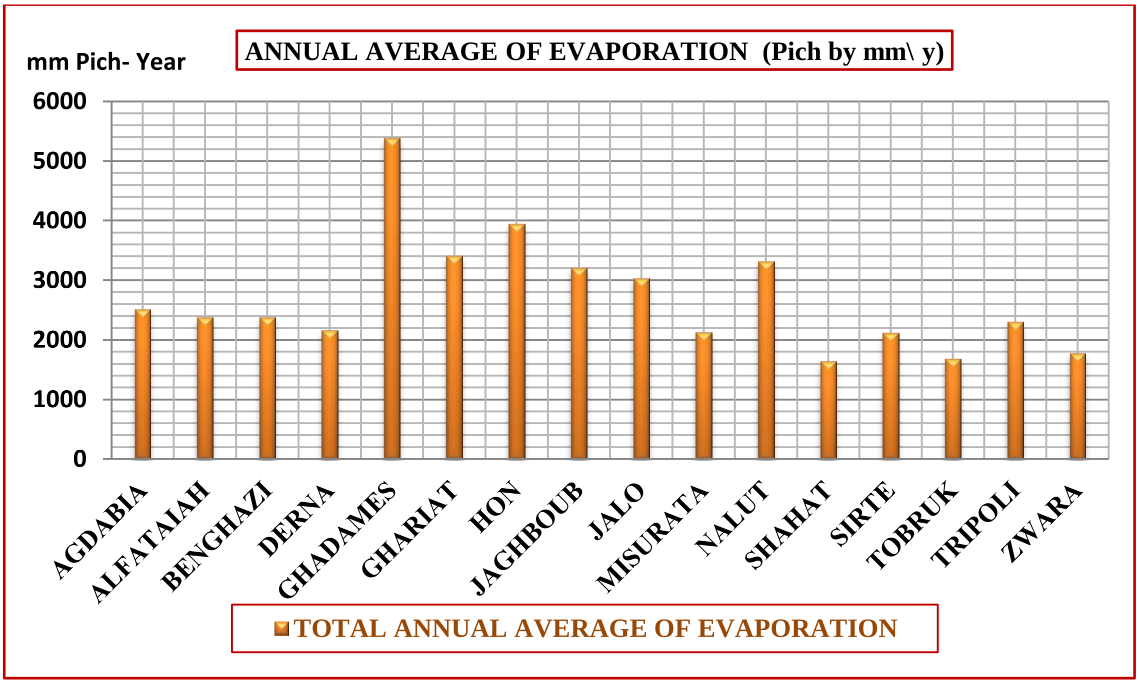
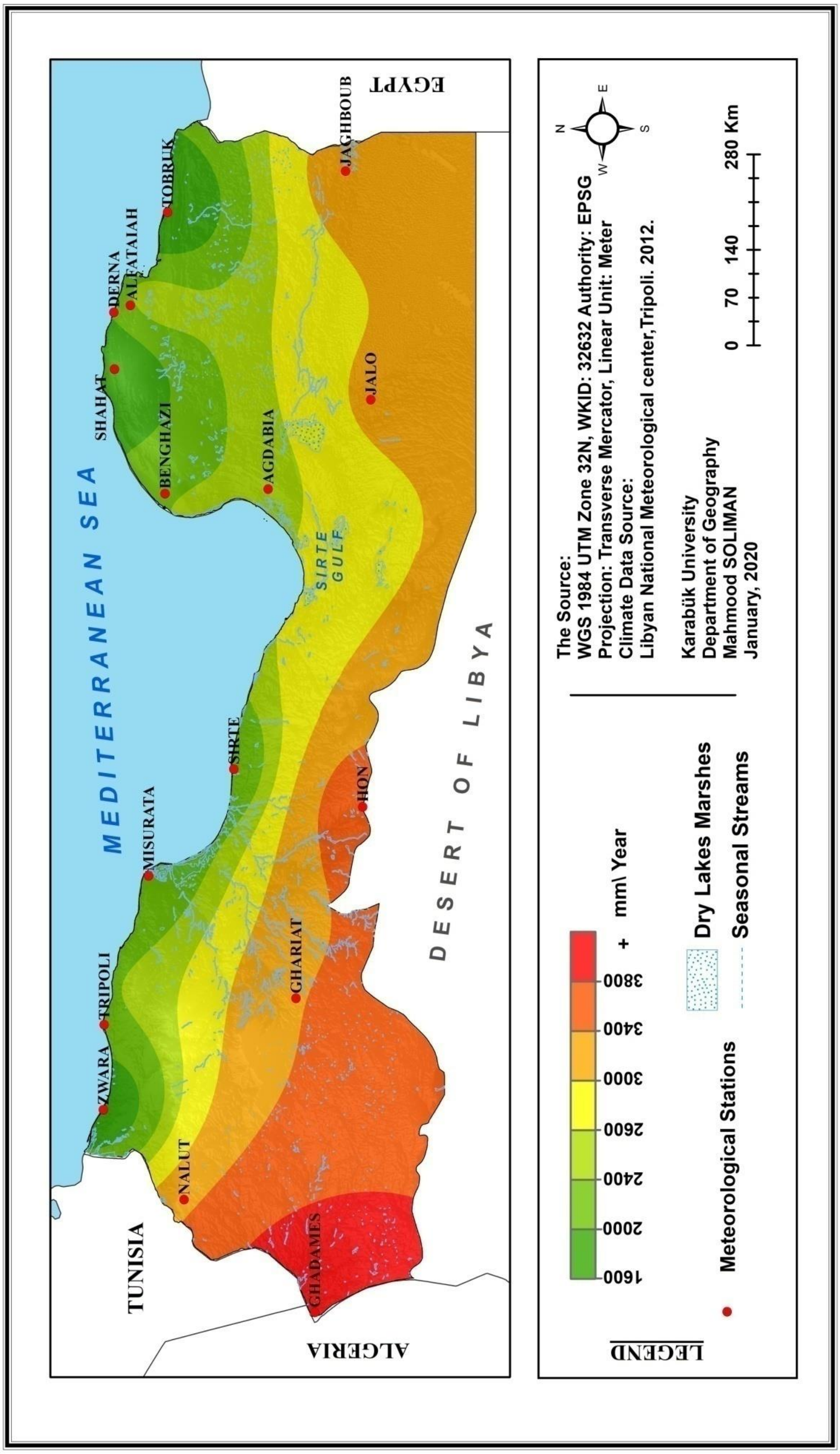


Figure 19. Total Average Annual of Evaporation (Pich mm) in Meteorological Stations (1971-2010)



Map 17. The Annual Average of Evaporation (mm\ year) by Pich Tube (1971-2010)

The values of evaporation differ from one station to another and from one season to another, and the difference appears clear during the summer, and here will be presented June as a reliable model to know the difference in the evaporation values from one station to another.As shown in the table 19, figure 20 and map 18 the desert stations are found with recorded high values in evaporation, especially in the summer months (June), at GHADAMES station, evaporation rates reached (660 mm/month) in June, equivalent to (5384.9 mm/ year), followed by HON Station with (471 mm/ month) equivalent to (471 mm/ month), AGDABIA with (297 mm\month) Equivalent to (2511mm/ year), GHARIAT station with (9.18 mm/ day) equivalent to (275 mm/ Month), JAGHBOUB with (387 mm/ month) equivalent to (3202.9 mm/ year) and JALO station with (356.5 mm/ month) equivalent to (3028.7 mm/ year), Thus, desert stations have higher values of evaporation significantly due to above-mentioned reasons.

In coastal stations such as TOBRUK station, the evaporation rate reaches to (168 mm/ month) equivalent to (1681 mm/ year), at ZWARA to (135 mm/ month) equivalent to (1778.8 mm/ year), at DERNA to (186 mm/ month) equivalent to (2156.6 mm/ year), at SIRTE to (213 mm/ month) equivalent to (2121.1 mm/ year) at TRIPOLI to (237 mm/ month) equivalent to (2298.6 mm/ year), at ALFATAIAH to (255 mm/ day) Equivalent to (2370.9 mm/ year) at SHAHAT station to (213 mm/ month) equivalent to (1643 mm/ year), this is the lowest rate recorded during the monitoring period, due to the location of the SHAHAT Station in an area with dense vegetation, which helps to the transpiration throughout the year, which in turn works to reduce the rates of evaporation. and at BENGHAZI station to (2730 mm/ month) equivalent to (2380 mm/ year). The difference in evaporation values between coastal and desert stations is very clear by looking at evaporation maps.

It can be noted that there is a significant difference between the evaporation values on the coast and the values of evaporation in the desert. For example, at JAGBOUB station, the evaporation values were (387 mm/ month) in June while at TOBRUK station located 280 km North of JAGHBOUB station on the Mediterranean, the evaporation values in the same month were (141 mm/ month). This is the difference between humid marine climate (Ocean Climate) and desert (Continental climate).

❖ **Relationship between Relative Humidity and Evaporation**

High evaporation rates and low humidity in desert and low evaporation rates and high humidity in coastal meteorological stations in the study area can be explained as illustrated in the following figure:

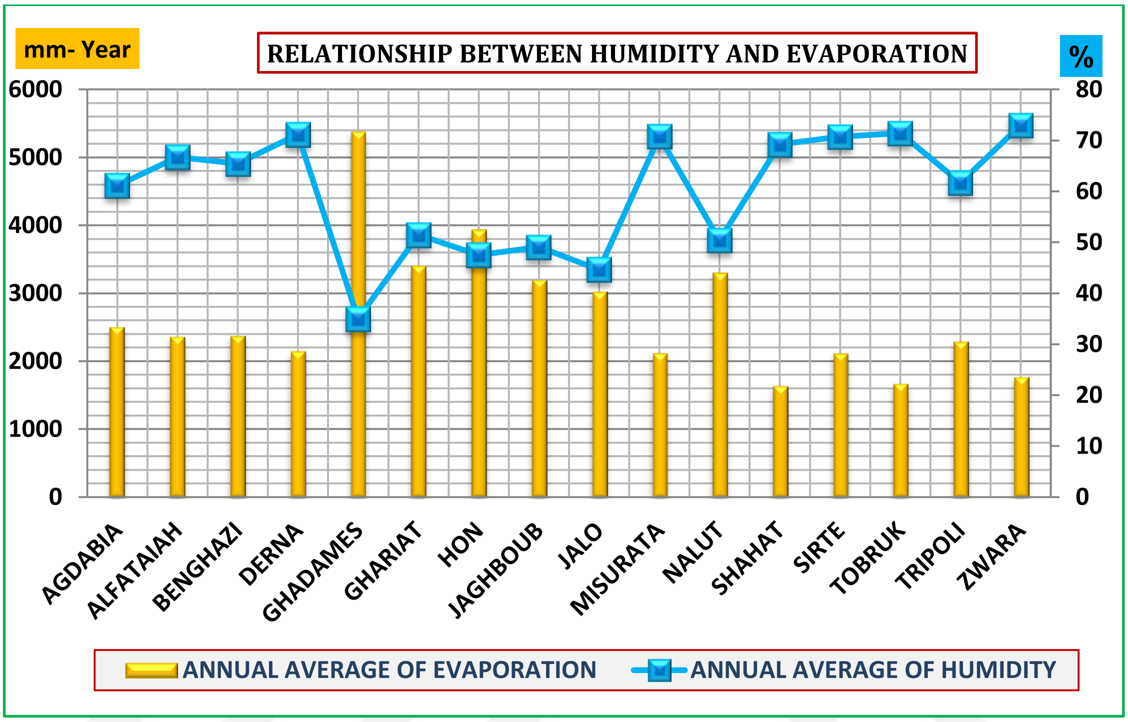


Figure 20. Relationship Between Humidity and Evaporation (1971-2010)

Through figure 21 it is known that relative humidity is amount of water vapor present in air expressed as a percentage of the amount needed for saturation at the same temperature. Evaporation takes place as long as the air has not reached saturation, and the rate of evaporation depends on the amount of difference between the actual humidity of the air and its relative humidity when it becomes fully saturated and is 100 % (Abu-Alata, 1985). For example, air with a relative humidity of 30 % is more suitable for evaporation activity than air with a relative humidity of 40 %. Evaporation activity decreases as relative humidity approaches 100 % maximum. At this stage the evaporation stops completely. Climatologist Vissman noted that evaporation is due to the effect of solar radiation, temperature, and wind speed, as well as of the surface where evaporation takes place (Vissman, 1972). The relationship between these variables can be seen in previous figure, especially in desert stations.

2.2.4.3. Clouds

This part includes the study of clouds as a source of all types of precipitation especially rain in the study area. Although it is not necessary that presence of clouds always causes rainfall. The presence of clouds is not only important of rainfall but also for the amount of solar radiation. Amount of clouds is based on the assumption of dividing the sky into eight sections and calculating the numbers of sections covered by the clouds. The following table 20 and figure 22 show the quantities of clouds at meteorological stations in study area:

Table 20. The Average Monthly and Annual Cloud Amount bay (Oktas) in Meteorological Stations (1971-2010)

NO	Station Name	Months												Annual Average
		Ja.	Fb.	Mr.	Ap.	Ma.	Jn.	Jl.	Ag.	Sp.	Oc.	Nv.	De.	
1	AGDABIA	3.3	2.9	2.6	2.5	2.2	0.9	0.4	0.4	0.9	1.9	2.6	3.2	1.98
2	ALFATAIAH	5.4	5.1	4.5	4.0	3.3	1.8	1.7	2.1	3.0	3.8	4.8	5.1	3.72
3	BENGHAZI	4.4	4.1	3.7	3.4	3.0	1.7	1.4	1.4	1.9	3.0	3.7	4.3	3.00
4	DERNA	4.5	4.3	3.9	3.4	2.8	1.5	1.3	1.6	2.5	3.4	4.0	4.4	3.13
5	GHADAMES	1.8	1.8	1.8	2.0	2.0	1.4	0.4	0.5	1.8	1.9	2.0	2.0	1.62
6	GHARIAT	2.2	2.0	1.9	2.1	2.3	1.4	0.3	0.5	1.5	2.1	2.0	2.1	1.70
7	HON	2.4	2.2	2.0	2.3	2.3	1.1	0.3	0.4	1.3	2.0	2.1	2.3	1.73
8	JAGHBOUB	2.4	2.2	2.0	2.0	1.7	0.5	0.3	0.3	0.5	1.3	2.0	2.3	1.46
9	JALO	2.0	1.8	1.6	1.7	1.7	0.5	0.2	0.1	0.4	1.1	1.6	2.0	1.23
10	MISURATA	3.7	3.4	3.3	3.2	2.9	1.9	1.2	1.2	2.2	3.1	3.4	3.7	2.77
11	NALUT	2.6	2.5	2.5	2.6	2.4	1.7	0.7	0.8	1.9	2.6	2.5	2.6	2.12
12	SHAHAT	5.0	4.8	4.4	3.8	3.1	2.1	2.5	3.0	3.5	3.9	4.4	4.8	3.78
13	SIRTE	3.5	3.2	3.1	3.0	2.9	1.9	1.5	1.5	2.1	3.0	3.3	3.5	2.71
14	TOBRUK	4.0	3.6	3.3	2.8	2.7	1.8	1.6	1.8	2.1	2.8	3.5	3.8	2.82
15	TRIPOLI	3.6	3.3	3.3	3.2	2.9	2.0	0.8	0.9	2.2	3.0	3.4	3.6	2.68
16	ZWARA	3.2	3.0	3.0	3.1	2.7	1.9	0.9	1.0	2.1	3.0	3.2	3.3	2.53

The Source: Depending on: Libyan National Meteorological center climate & climate Change, Tripoli. 2012.

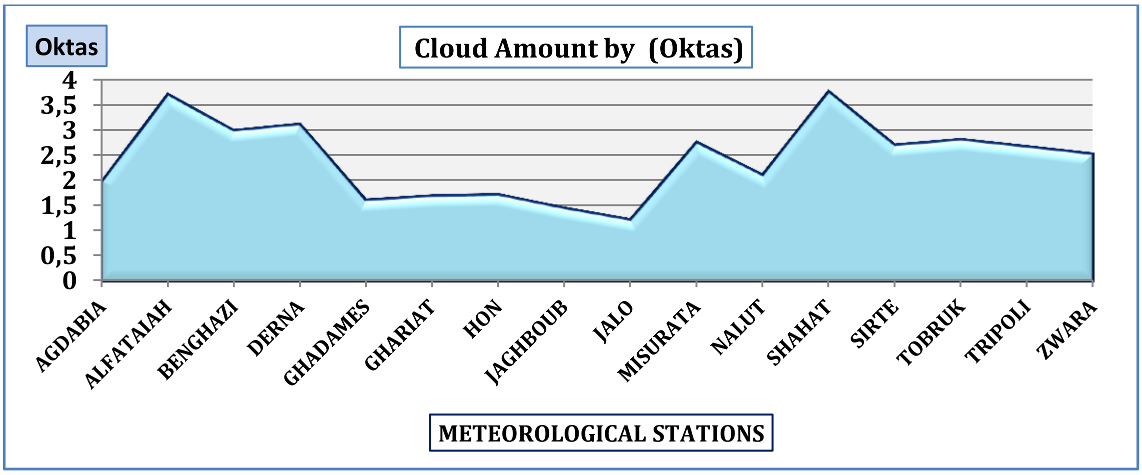


Figure 21. The Average Monthly and Annual Cloud Amount bay (Oktas) in Meteorological Stations (1971-2010)

Several factors are found responsible for this situation including increasing condensation from the sea surface and elevation. When the clouds penetrate the desert, they quickly disappear because of the lack of condensation due to increased amount of dry air in the desert and the distance from the sea. In particular, many of the clouds are associated with the air depressions above the Mediterranean from west to east. It is worth mentioning that many types of clouds are closely related with air depressions that move on the Mediterranean from west to east.

2.2.4.4. Precipitation

2.2.4.4.a. Monthly and Annual Distribution of Precipitation

Table 21. Annual and Monthly Rainfall (mm) For Period (1971-2010)

Station Name	Months												Annual Average
	Ja.	Fb.	Mr.	Ap.	Ma.	Jn.	Jl.	Ag.	Sp.	Oc.	Nv.	De.	
AGDABIA	38.7	22.3	12.1	3.8	1.2	0.1	0.0	0.0	1.8	9.8	21.5	44.8	**156.15**
ALFATAIAH	85.6	49.0	30.7	9.7	8.6	0.6	0.2	0.2	4.3	25.3	31.3	80.2	**325.8**
BENGHAZI	59.8	45.1	26.7	6.7	3.1	0.2	0.0	0.3	3.4	18.7	37.5	63.5	**265.0**
DERNA	60.5	41.9	22.2	8.2	5.1	1.1	0.0	0.3	3.7	27.6	29.0	59.5	**259.0**
GHADAMES	6.6	5.7	6.9	3.1	2.2	0.4	0.0	0.3	1.9	3.0	2.0	4.4	**36.5**
GHARIAT	9.5	4.3	7.4	3.0	4.9	1.0	0.3	0.2	3.6	8.9	7.1	5.9	**56.2**
HON	5.1	3.3	3.9	3.2	3.0	0.6	0.0	0.0	1.6	4.2	4.3	2.7	**31.8**
JAGHBOUB	3.5	3.4	3.5	1.0	0.4	0.0	0.0	0.0	0.4	0.1	0.6	3.2	**16.1**
JALO	2.0	2.0	1.6	0.9	0.4	0.0	0.0	0.0	0.1	1.3	0.3	1.1	**9.6**
MISURATA	53.7	28.7	24.1	10.2	3.6	1.2	0.0	0.5	11.6	32.5	56.9	57.9	**280.9**
NALUT	16.7	20.5	27.8	14.0	13.6	2.1	0.1	0.2	5.9	20.6	14.2	19.0	**154.7**
SHAHAT	112.6	89.9	64.9	26.1	7.6	0.4	0.7	1.1	8.6	45.1	67.0	114.4	**538.4**
SIRTE	41.7	23.8	16.8	4.4	3.4	0.7	0.0	0.2	10.3	28.4	24.6	45.5	**199.8**
TOBRUK	45.1	32.2	13.2	3.9	6.3	0.0	0.0	0.0	1.8	13.7	19.7	39.8	**175.8**
TRIPOLI	56.5	33.9	28.9	15.1	5.6	0.5	0.1	0.2	9.1	33.0	41.3	48.5	**272.7**
ZWARA	40.1	23.9	18.9	11.0	5.9	0.6	0.0	1.1	11.9	31.9	41.6	48.6	**235.6**

The Source: Depending on: Libyan National Meteorological center climate & climate Change, Tripoli. 2012.

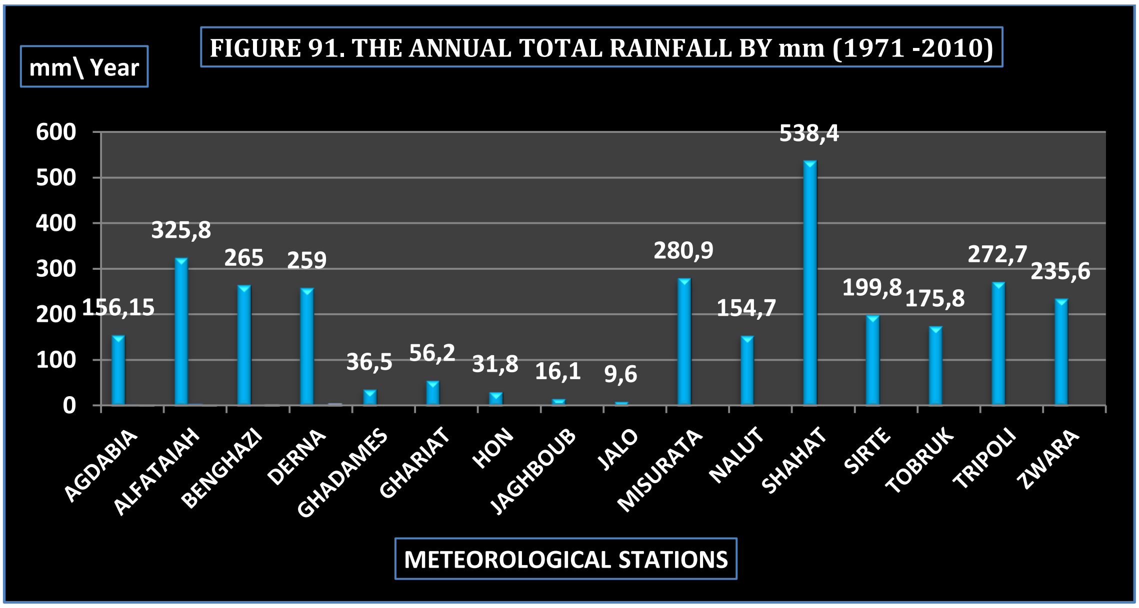
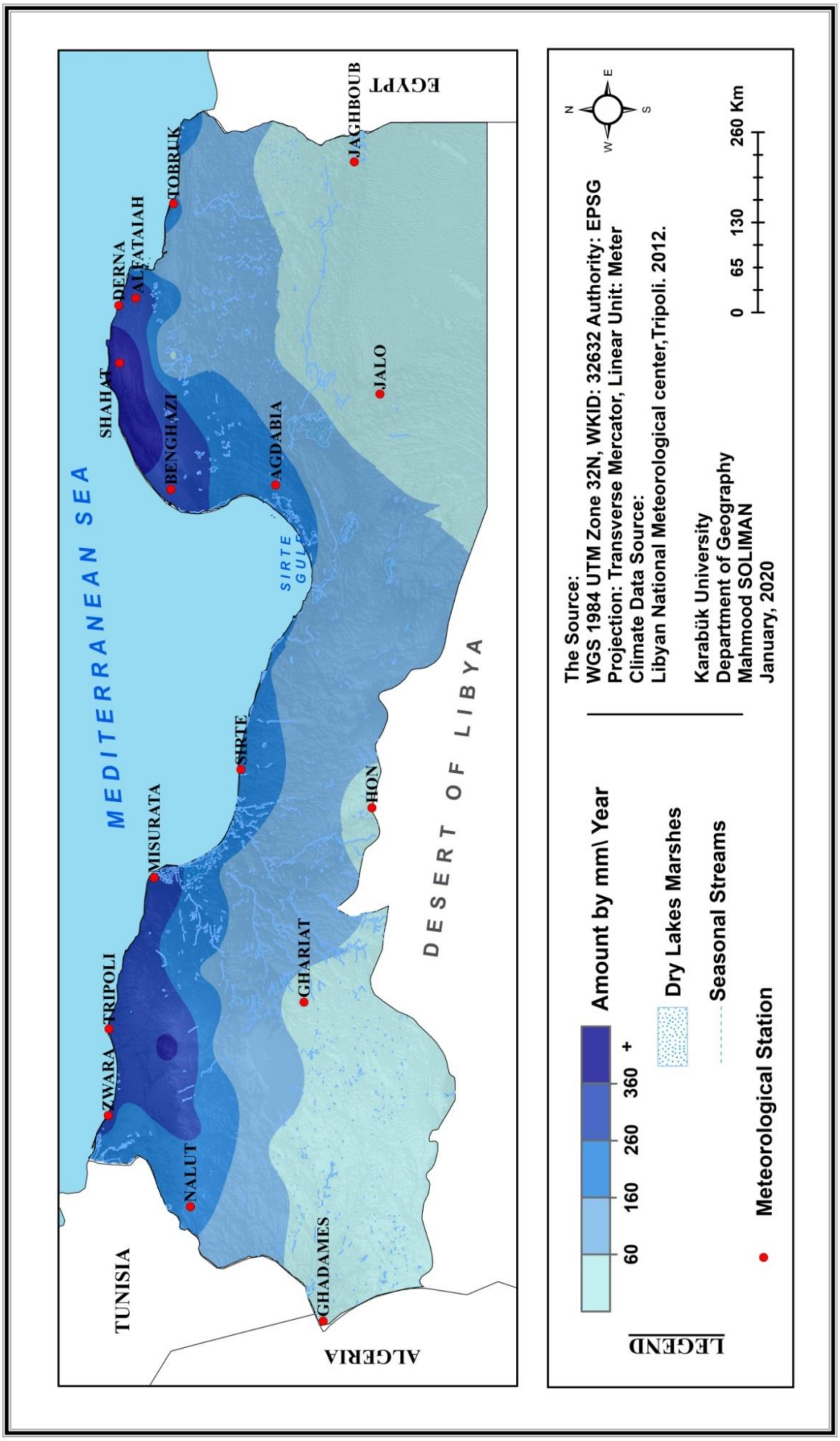


Figure 22. Average Annual Rainfall (mm) in Meteorological Stations (1971-2010)



Map 18. The Average Annual of Rainfall in Northern of Libya (1971-2010)

In table 21, figure 23 and map 19 the average annual rainfall rate in coastal stations is between (148 mm) at AGDABIA station and (559.9 mm) at SHAHAT station in Green Mountain. Such a contrasting difference between the two stations is due to several natural factors of which elevation is the most important, at TOBRUK, which is located on the Mediterranean Sea, the annual rainfall is (175.7 mm). This lower rate is due to the location of Tobruk station under the rain shadow of the Green Mountain, which receives the highest amount of rainfall in Libya.

The amount of rainfall in the Al-Fataiah which is located on the eastern border of Green Mountain reaches an annual average of (326 mm) followed by BENGHAZI with (267.4 mm), DERNA with (266.5 mm), MISURATA with (275.7 mm) (in the center of northern Libya), SIRTE with (183.5 mm), TRIPOLI with (275.9 mm) and ZWARA with (222.8 mm). Coastal stations are likely to receive significant amounts of rain.Desert stations located in the south of the study area receive few or no rainfall with annual rates ranging from only (9 mm) at JALO station to (57.3 mm) at GHARIAT station. This is because of extreme desert climate prevailing in these areas.The tables, figures, and maps showing amounts of precipitation are given below.

- **Amounts of Monthly Rainfall in Stations**

The amount of rainfall varies monthly and seasonally in the study area. The winter months are the most rainy months in the study area, followed by the months of autumn and spring season while the amount of rainfall in the summer is very scarce. This can be seen in the following figures:

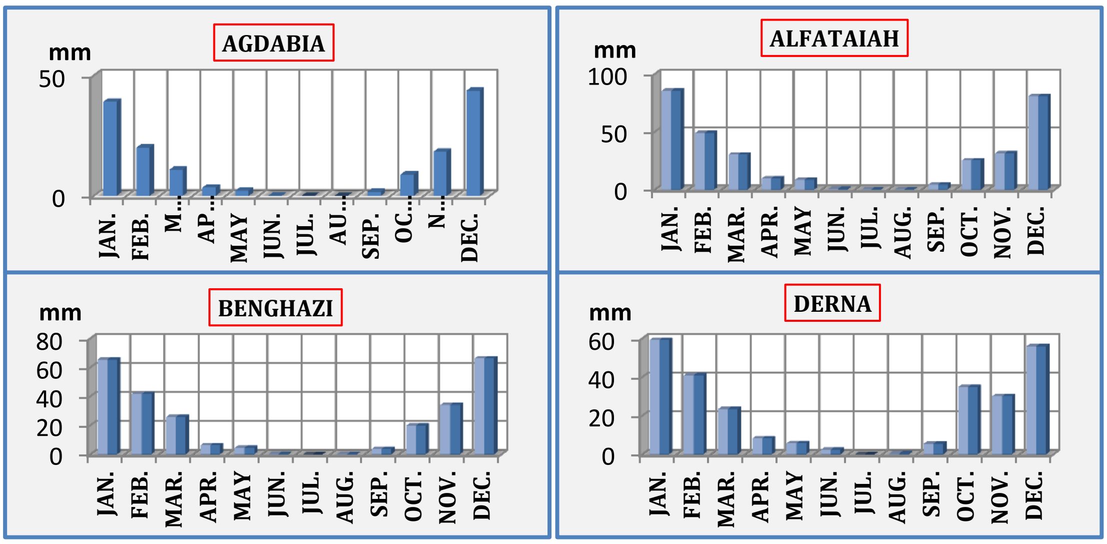


Figure 23. Amounts of Monthly Rainfall in Meteorological Stations (1971-2010)

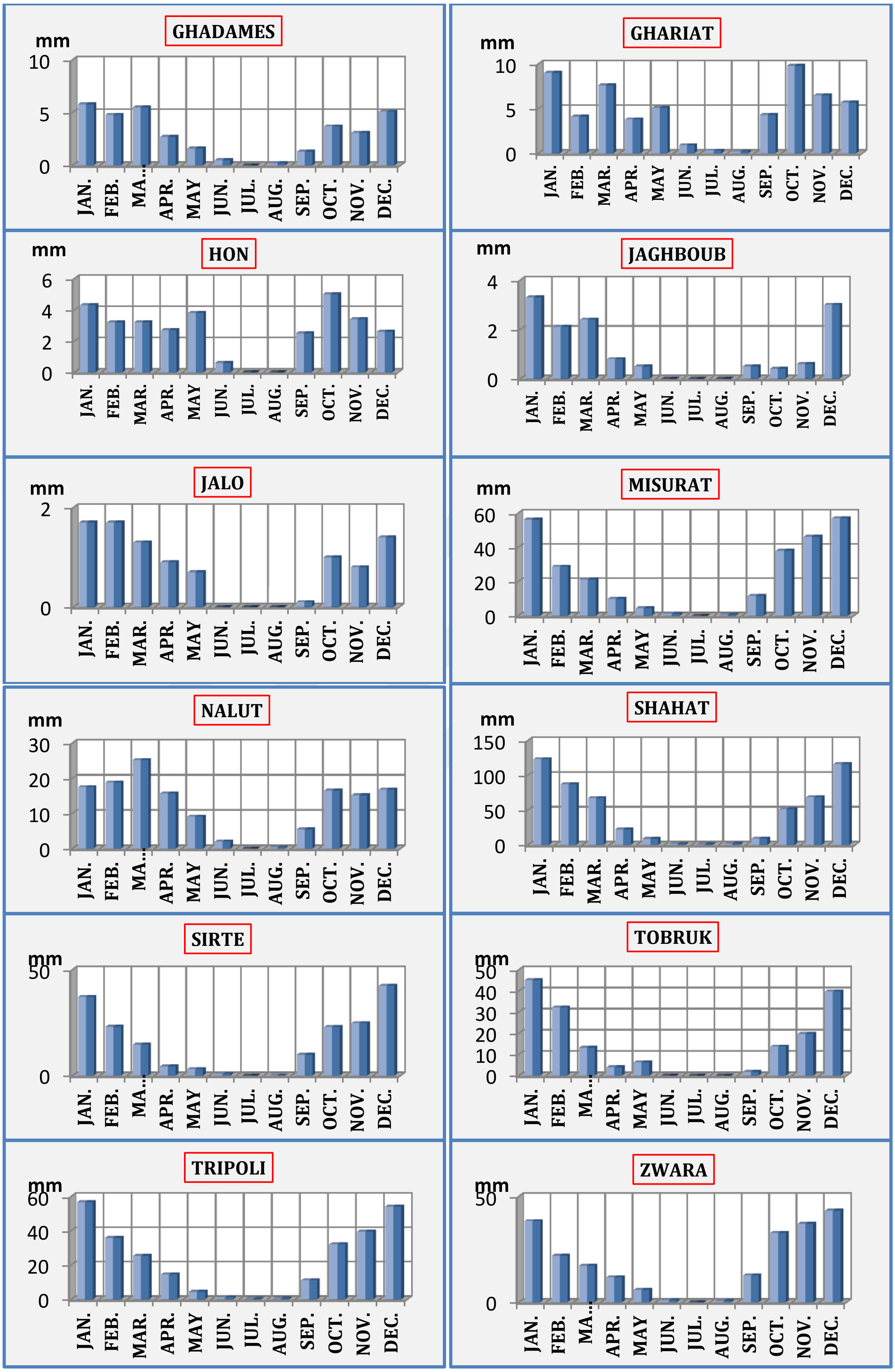


Figure 24. Amounts of Monthly Rainfall in Meteorological Stations (1971-2010)

The above mentioned table and the figures 24, 25 show the amounts of monthly precipitation in stations of the study area. It is found that the month of January receives the largest amount of rainfall in all the stations. The highest amount of rainfall in January is received by SHAHAT which was (123.5 mm) with (22 %) of annual rate that falls on the station followed by the ALFATAIAH (85.6 mm) with (26 %) of annual rate, BENGHAZI (65.4 mm) with (24.4 %), and MISURATA (56.4 mm) with (20.4 %). In December, the rainfall reaches (116.6 mm) in SHAHAT with an annual rate of (20 %) followed by ALFATAIAH about (80.9 mm) with (24.8 %), BENGHAZI (66.2 mm) with an annual rate of (24 %), at DERNA (56 mm) with (21 %), TRIPOLI (54.2 mm) with annual rate of (19.6 %) and AGDABIA (39.2 mm) with annual rate of (26.3 %). The month of February is characterized by a relative increase in precipitation as compared to rest of months after January and December. In the month of March, the amount of rain at SHAHAT station reaches (67.4 mm), followed by BENGHAZI station with (25.7 mm), TRIPOLI with (25.4 mm) and NALUT with (25.2 mm).

Rainfall in November falls on several stations including TRIPOLI with (39.6 mm), and MISURATA with (36.3 mm). Rainfall is observed in several stations in the month of October the most important of which is SHAHAT station with (51.6 mm) MISURATA with (38.1 mm), TRIPOLI station with (32.1 mm) and ALFATAIAH with (25.3 mm). The rest of the year in the coastal stations is less rainy in the spring months, especially April and May and rainfall is very rare in the summer months. In the desert stations, it can be said that the rain is rare in all months, except for the station of GHARIAT, which does not exceed more than (57.3 mm) per year.

In terms of precipitation, indeed, north side of the coast is more important because it faces the direct western rain winds. This area stretches from TRIPOLI in the west to MISURATA in the east and the from Benghazi in the west to DERNA in the east. The rain map shows that there are two main areas of rain in northern Libya that are TRIPOLI in the west with (279.5 mm/years), and SHAHAT in the east with (559 mm/year). Both of these stations are located at (32°.56 N) latitudes. However, the elevation is the main reason for the difference between rainfall at TRIPOLI and SHAHAT stations. It is evident that the slopes of the green mountain extending near the coast in the eastern part of the study area are high in altitude than the adjacent plains of BENGHAZI and BATNAN Plateau.

However, the distribution of rain on the Green Mountain depends on several natural factors including elevation, proximity or distance from the sea, and the direction of the slopes of the mountains relative to the direction of rain winds.In particular, it was observed that the northern and western slopes were rainier than the southern and eastern slopes due to the fact that the rain winds often blow from the north and the north-west. This is evident in the SHAHAT station, which faces these winds directly.

On the other hand, the plains behind these slopes do not receive enough rain, and most of them possess dry and semi-dry climates with poor vegetation increased desert appearance. AGDABIA station, which is far away from the coast, receives (148 mm/year) of rainfall while JALO station, which is located 200 km south of AGDABIA, receives not more than (9 mm/year). This shows a significant decrease in amount of rainfall in Jalo station. The stations located in the shadow of rain Green Mountain such as the Tobruk station, do not get large amounts of rain exceeding not more than (178 mm/year), at SIRTE station the annual rainfall rate is (183 mm/year), while at HON station which is located in the south of the Sirte station at a distance of 250 km, the annual rate of rainfall is only (31.8 mm/year). This example also applies to the western section of the study area, especially to TRIPOLI and NALUT.

2.2.4.4.b. Seasonally Distribution of Precipitation

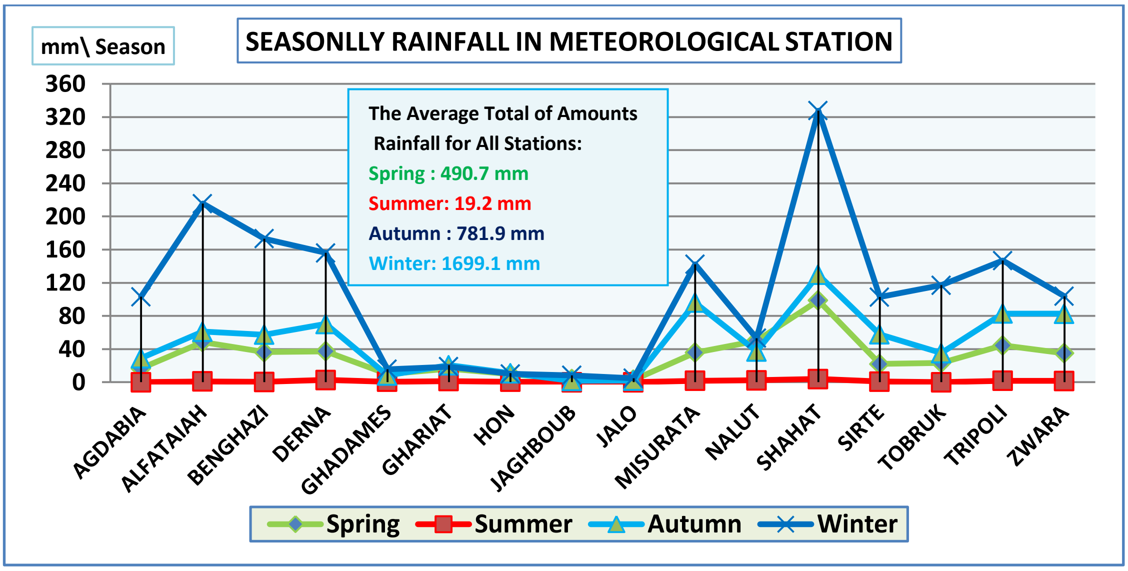


Figure 25. Amount Seasonally Rainfall (mm) in Meteorological Stations (1971-2010)

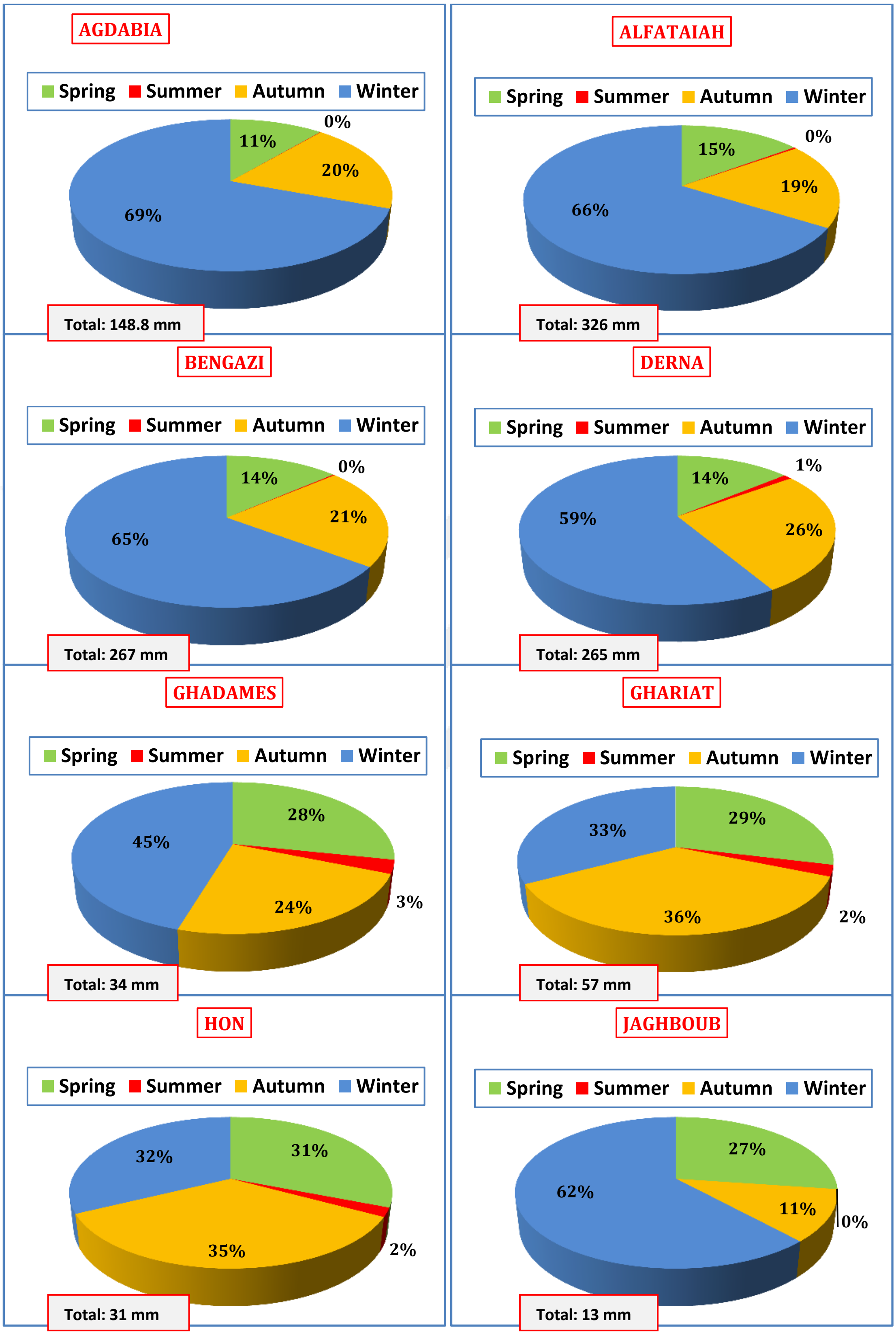


Figure 26. Relative Distribution of Precipitation Amounts Over The seasons in AGDABIA, ALFATAIAH, BENGHAZI, DERNA, GHADAMES, GHARIAT, HON and JAGHBOUB Stations (1971-2010)

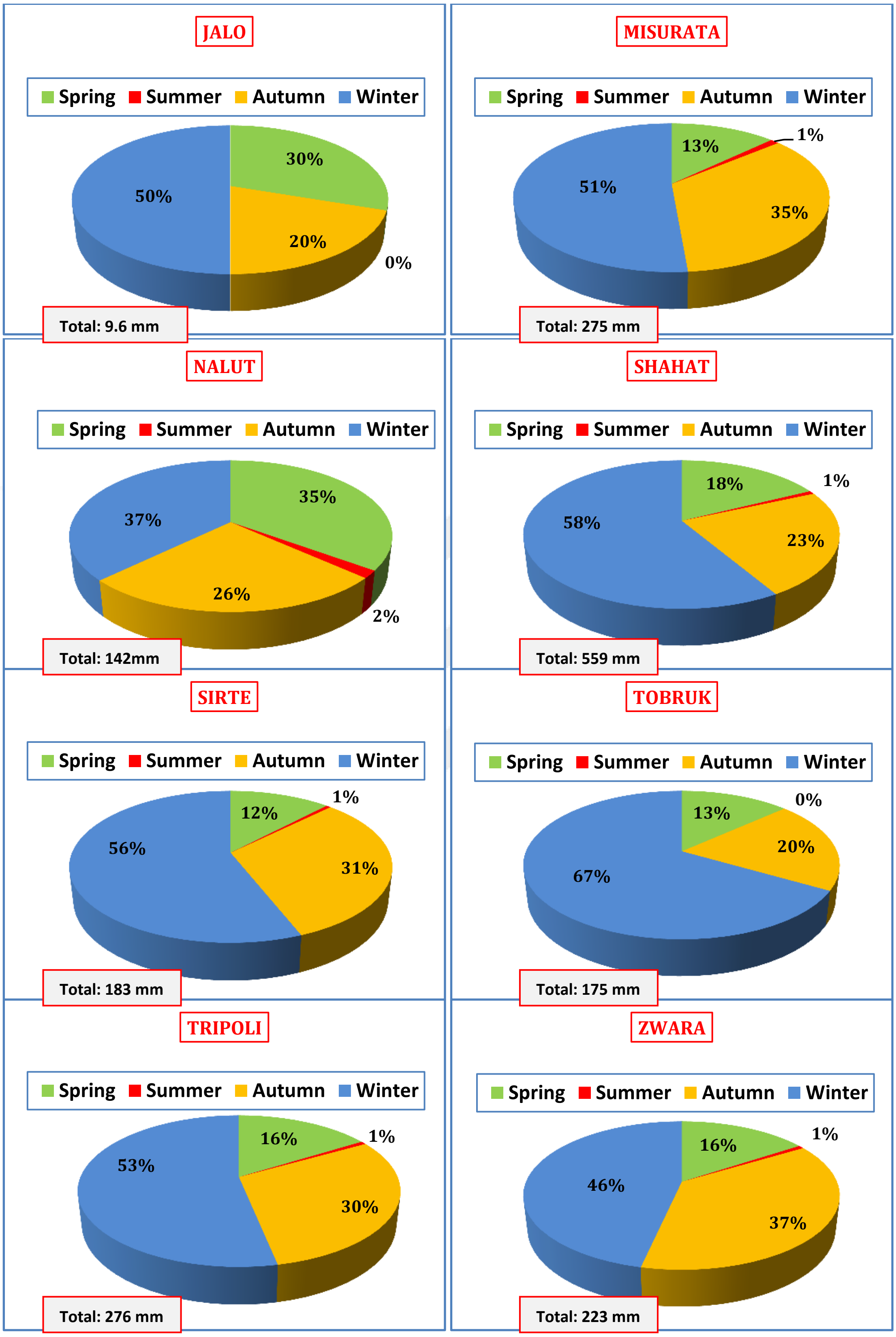


Figure 27. Relative Distribution of Precipitation Amounts Over The seasons in JALO, MISURATA, NALUT, SHAHAT, SIRTE, TOBRUK, TRIPOLI and ZWARA Stations (1971-2010)

From the figures 26, 27 and 28 can be inferred that rainfall in the study area is limited to the winter months, at AGDABIA station, which has a rainfall of (148 mm\year), the rainfall in winter is (103 mm) which is (69 %) of the annual average followed by ALFATAIAH station with (326 mm) which is (66 %) of the annual rainfall, BENGHAZI with (64 %) and DERNA with (58 %) of annual rainfall. The desert areas receive very little amount of rain which falls in the winter, at MISURATA rainfall amounts in winter were (142.3 mm) with (51 %) of annual amount followed by SHAHAT with (58 %) and TOBRUK with (66.8 %).

The winter season is followed by the spring season which is characterized by increased rainfall. For example, at NALUT Station, the amount of rain in the winter is almost equal to the amount of rain in the spring where the amount of rain in the spring was (50 mm). This is because the station is located far west of the study area and penetrating slightly inward the sea with high elevation. This location expose the station them to the rainy wind blowing in the spring months which can be observed by looking at wind directions during the Spring season, at SHAHAT (the rainiest in the study area) the amount of rainfall in the spring reaches (98.7 mm) which is (17.6 %) of the annual rainfall while at TRIPOLI the amount of rain in the spring is (44.5 mm) which is (16 %) of the amount of annual rainfall.

In the autumn season, rainfall varies from one station to other. The stations which receives much amount of rainfall are SHAHAT with (129.6 mm) which is (23 %) of annual rainfall followed by TRIPOLI with (82.8 mm) which is (30 %) of annual, ZWARA with (82.6 mm) which is (37 %), BENGHAZI with (57.4 mm) which is (21 %) of annual rainfall.

Very little rainfall drops in the summer months like (4 mm) at SHAHT, (2.3 mm) at DERNA and (2.3 mm) at NALUT. It is noteworthy that the summer season is the driest season which greatly affects the climatic conditions prevailing in the study area. It is noted that the amount of rain in Summer doesn't appear in the relative distribution of rain in the stations of the study area, and even if it appears is in a very small proportion.

2.2.4.4.c. Number of Rainy Days

Table 22. Average Monthly of Number of Rainy Days, in Meteorological Stations(1971-2010)

NO	Station Name	Months												Annual No. of Rainy Days
		Ja.	Fb.	Mr.	Ap.	Ma.	Jn.	Jl.	Ag.	Sp.	Oc.	Nv.	De.	
1	AGDABIA	8.5	5.3	3.7	1.5	0.9	0.2	0.0	0.0	0.5	2.3	4.2	8.2	35.3
2	ALFATAIAH	11.4	10.2	6.1	2.9	1.9	0.4	0.1	0.1	1.9	4.6	6.5	11.1	57.21
3	BENGHAZI	12.4	8.9	6.4	2.6	1.7	0.2	0.0	0.1	1.2	4.4	7.0	11.7	56.6
4	DERNA	10.5	8.4	6.0	2.8	1.8	0.3	0.0	0.2	1.2	4.7	6.0	9.5	51.4
5	GHADAMES	1.2	1.3	1.4	0.9	0.7	0.3	0.1	0.1	0.5	1.0	0.8	1.6	9.9
6	GHARIAT	1.7	1.1	1.3	0.9	1.1	0.4	0.1	0.1	1.0	1.6	0.9	1.3	11.28
7	HON	1.7	1.4	1.3	0.7	1.2	0.3	0.0	0.1	0.6	1.4	0.8	1.1	10.6
8	JAGHBOUB	1.4	0.9	1.0	0.5	0.4	0.1	0.0	0.0	0.1	0.3	0.4	1.3	6.18
9	JALO	1.0	0.9	0.7	0.4	0.3	0.0	0.0	0.0	0.1	0.4	0.4	0.7	4.76
10	MISURATA	9.2	6.1	4.6	2.5	1.3	0.7	0.0	0.2	2.3	5.4	6.7	8.9	47.91
11	NALUT	4.0	3.0	3.0	2.5	1.6	0.7	0.1	0.2	1.5	2.8	2.6	3.6	25.35
12	SHAHAT	14.6	12.1	9.2	4.5	2.2	0.4	0.4	0.3	2.5	6.7	9.5	13.4	75.61
13	SIRTE	7.1	4.4	3.3	1.6	1.3	0.6	0.0	0.1	1.3	3.8	4.5	6.6	34.71
14	TOBRUK	7.3	5.6	3.4	1.0	1.0	0.1	0.0	0.0	0.5	2.5	3.1	6.0	30.44
15	TRIPOLI	8.4	5.8	5.1	3.2	1.6	0.4	0.1	0.1	2.0	4.9	6.0	8.0	45.6
16	ZWARA	5.9	4.0	3.6	2.5	1.4	0.5	0.1	0.2	2.2	4.2	5.0	6.2	35.57

The Source: Depending on: Libyan National Meteorological center climate & climate Change, Tripoli. 2012.

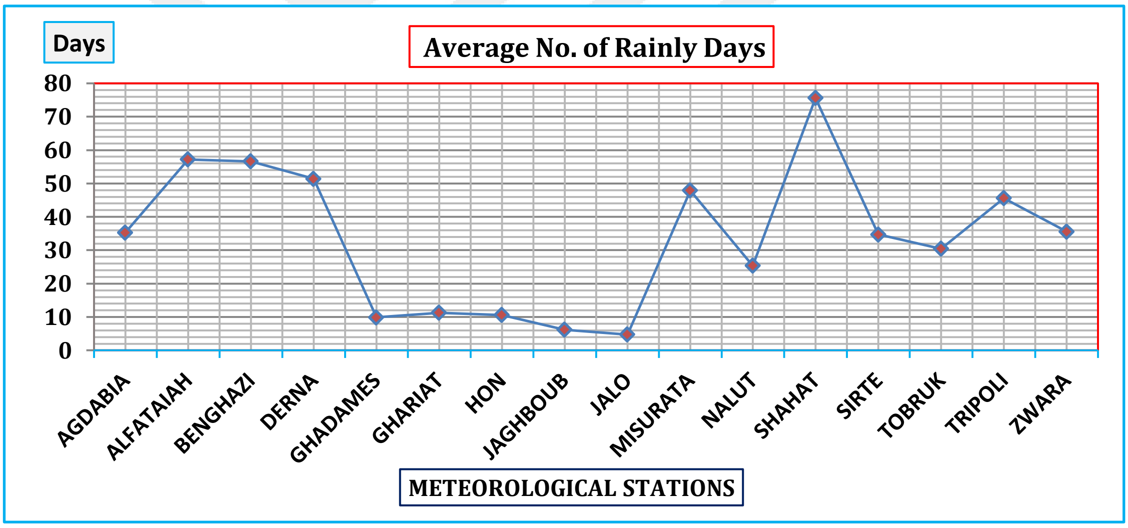


Figure 28. Average Monthly of Number of Rainy Days, in Meteorological Stations (1971-2010)

Rain is concentrated in the winter months of January, February, and December, and the number of rain days increases in stations receiving large amounts of rain such as the SHAHAT station, where the number of rainy days is (75 days) followed by ALFATAIAH (57 days), BENGHAZI (56 days), DERNA (51 days), MISURATA (48 days), and at TRIPOLI (45 days). It is worth mentioning that the amount of rain is not related to the number of rainy days. Sometimes, large amount of rain falls in one hour while sometimes, rain continues full day in small quantities. This will be explained in the next table for the largest amount of rain falling in a day.

2.2.4.4.d. The Maximum Rainfall in Day

Table 23. The Maximum Rainfall in Day (mm) in Meteorological Stations (1971-2010)

NO	Station Name	Months												MAX mm\ Day
		Ja.	Fb.	Mr.	Ap.	Ma.	Jn.	Jl.	Ag.	Sp.	Oc.	Nv.	De.	
1	AGDABIA	42.5	30.0	21.0	18.5	47.7	2.5	0.2	0.0	19.0	67.0	38.2	73.0	**73.0**
2	ALFATAIAH	196.0	47.0	35.0	35.0	19.8	4.0	2.8	5.3	24.0	65.0	47.3	65.0	**196.0**
3	BENGHAZI	48.0	33.9	43.1	19.2	22.1	5.9	0.5	6.4	36.0	36.8	108.7	53.4	**108.7**
4	DERNA	105.7	51.6	44.4	29.1	23.0	53.7	0.7	11.4	61.0	145.7	86.7	72.5	**145.7**
5	GHADAMES	3.3	3.3	4.6	2.7	1.7	0.3	0.0	0.2	1.5	2.6	1.5	2.4	**4.6**
6	GHARIAT	54.0	16.0	31.7	20.0	25.4	6.0	11.0	4.0	26.0	42.0	41.0	27.0	**54.0**
7	HON	28.4	23.6	15.7	33.0	21.4	11.0	0.0	1.3	19.7	42.7	39.6	15.6	**42.7**
8	JAGHBOUB	18.0	23.1	24.0	10.3	11.2	2.0	0.0	0.0	13.0	9.6	8.3	30.0	**30.0**
9	JALO	15.0	14.0	11.1	10.0	18.5	0.2	0.0	0.0	2.2	16.3	13.0	19.8	**19.8**
10	MISURATA	93.9	41.9	68.7	28.3	33.7	9.4	0.7	10.6	46.2	78.0	104.0	82.0	**104.0**
11	NALUT	8.2	10.1	14.0	11.1	6.7	1.9	0.0	0.3	4.0	11.0	8.7	9.8	**14.0**
12	SHAHAT	84.5	67.5	86.5	65.3	37.4	19.5	13.6	42.1	41.5	103.3	89.0	86.5	**103.3**
13	SIRTE	51.8	54.8	41.5	13.3	14.3	9.0	1.3	6.0	76.6	99.2	53.5	51.5	**99.2**
14	TOBRUK	41.2	77.7	21.0	13.4	60.0	0.7	0.0	0.0	10.0	36.0	76.0	54.7	**77.7**
15	TRIPOLI	67.7	52.8	52.7	83.0	34.0	14.7	8.2	21.4	87.8	130.2	126.5	69.6	**130.2**
16	ZWARA	71.0	65.4	53.0	56.0	65.8	17.0	0.8	10.0	72.5	78.5	90.1	76.5	**90.1**

The Source: Depending on: Libyan National Meteorological center climate & climate Change, Tripoli. 2012.

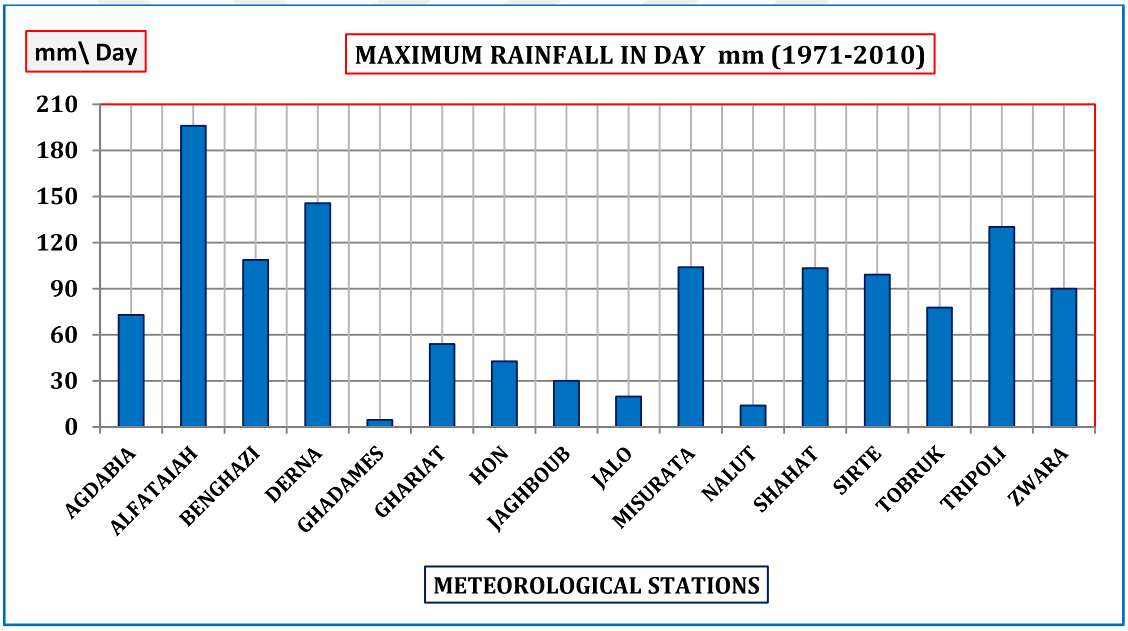


Figure 29. The Maximum Rainfall in Day (mm) in Meteorological Stations (1971-2010)

From table 23 and figure 30 the heaviest rainfall was found at ALFATAIAH station (196 mm/ Day) in January 1990 followed by DERNA station (145 mm/ Day) in October 1959, TRIPOLI station (130.2 mm/ Day) in October 1986, BENGHAZI station (108 mm/ Day) in November 1979,In MISURATA (104 mm/ Day) in November 1990, SHAHAT (103.2 mm/ Day) in October 1954, SIRTE (99.2 mm/ Day) in October 1973, (90.1 mm/ Day) in November 1984, TOBRUK (77.7 mm/Day) in February 1997 and at AGDABIA (73 mm/ Day) in December 2002. The heaviest rainfall in the desert stations was recorded at GHARIAT in the month of October 1986 followed by JAGHBOUB (30 mm/ Day) in December 1988, and JALO (19.8 mm / Day). The lowest rainfall in one day was recorded at GHADAMES Station (4.6 mm/ Day) only. NALUT station which is classified as a high mountain station, never exceeded the largest amount of rainfall in one day more than (14 mm/ Day).

2.2.4.4.e.Annual Average Values and Change Coefficients of Precipitation

The difference between the quantities of rainfall in terms of the heaviest and the lowest value**,** has been given below:

Table 24. Calculation of Annual General Rainfall Variables in Meteorological Stations of Study Area (1971- 2010)

Station Name	Annual Average mm	Annual Maximum Rainfall			Annual Minimum Rainfall			Amplitude of Change mm	General Std.Eva
		Rainfall mm	Difference With G.Average	%	Rainfall mm	Difference With G.Average	%		
AGDABIA	156.1	351.1 (1991)	+ 195.0	124.9	80.1 (2010)	-76.0	48.6	271.0	66.9
ALFATAIAH	325.8	572.1 (1991)	+ 246.3	75.5	142.3 (1999)	- 183.5	56.3	429.8	95.4
BENGHAZI	265.0	464.8 (1978)	+ 199.8	75.3	157.8 (1980)	- 107.2	40.4	307.0	76.0
DERNA	259.0	405.2 (1995)	+ 146.2	56.4	134.7 (1999)	- 124.3	47.9	270.5	66.1
GHADAMES	36.5	204.8 (1976)	+ 168.3	461.1	2.6 (1981)	- 33.9	92.8	202.2	35.2
GHARIAT	56.2	150.7 (2008)	+ 94.5	168.1	8.4 (2009)	- 47.8	85.1	142.3	36.8
HON	31.8	161.2 (1990)	+ 129.4	406.9	3.7 (1974)	- 28.1	88.3	157.5	30.0
JAGHBOUB	16.1	90.4 (1988)	+ 74.3	461.4	0.2 (1989)	- 90.2	560.2	90.2	16.9
JALO	9.6	39.2 (2006)	+ 29.6	308.3	0.0 (1996)	- 9.6	100.0	39.2	10.2
MISURATA	280.9	461.9 (1991)	+ 181.0	64.4	145.9 (1989)	- 135.0	48.0	316.0	84.4
NALUT	154.7	568.8 (1976)	+ 414.1	267.6	37.0 (1981)	- 117.7	76.1	531.8	92.0
SHAHAT	538.4	834.8 (1991)	+ 296.4	55.1	391.8 (1980)	- 146.6	27.2	443.0	107.0
SIRTE	199.8	423.8 (1991)	+ 224.0	112.1	103.1 (2004)	- 96.7	48.3	320.7	70.8
TOBRUK	175.8	265.8 (1988)	+ 90.0	51.2	72.6 (1999)	- 103.2	58.7	193.2	53.5
TRIPOLI	272.7	468.8 (1995)	+ 196.1	71.9	117.4 (2009)	- 155.3	56.9	396.2	95.9
ZWARA	235.6	453.6 (1984)	+ 218.0	92.5	40.1 (1981)	- 195.5	82.9	413.5	95.2

The Source: Depending on: Libyan National Meteorological center climate & climate Change, Tripoli. 2012.

These facts graphically represented as follows:

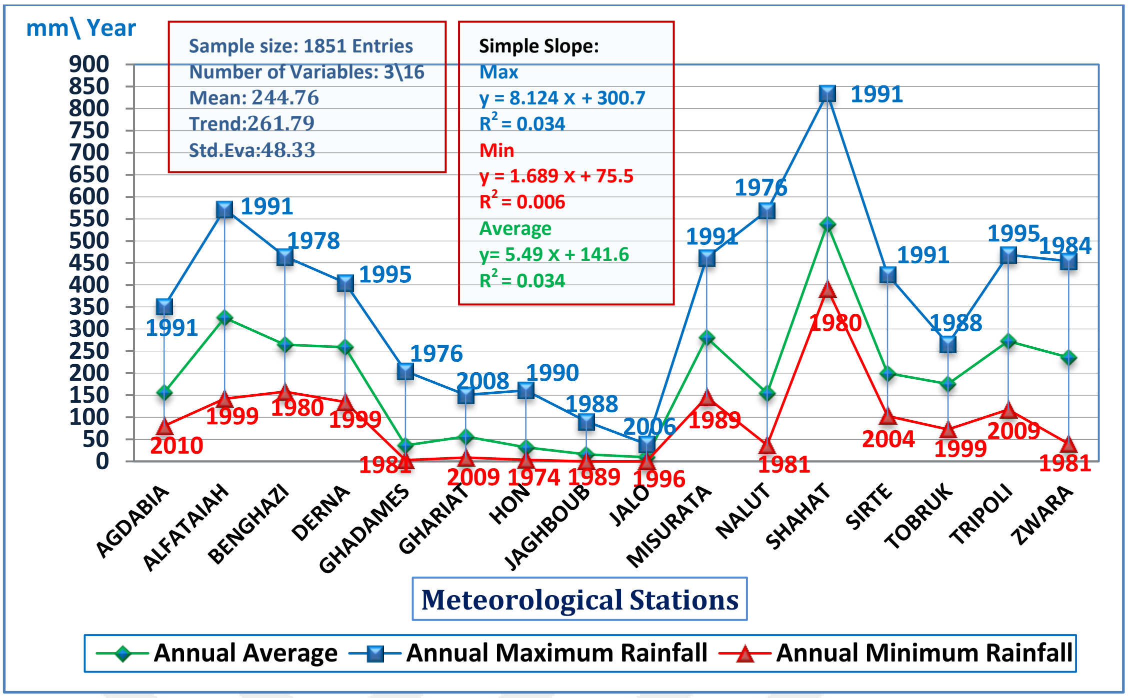


Figure 30. Analysis Of Statistically For Annual General Rainfall Variables in Meteorological Stations Of Study Area (1971- 2010)

The above mentioned table 24 and figure 31 show that 1991 was the most rainy years in stations of the study area. For example AGDABIA station received (351.1 mm) of rainfall with an annual average of (156.1 mm) followed by ALFATAIAH with (572.1 mm) with annual average of (325.8 mm), at SHAHAT (834 mm) with annual average of (538.4 mm), at MISURATA station (461 mm) with annual average of (280.9 mm) and SIRTE station (423.8 mm) with annual average of (199.8 mm). Thus, the quantity that fell in 1991 is the largest rainfall in past 40 years. The quantity of rain in some stations also varies from year to year. For example, at BENGHAZI station the largest quantity of rainfall was received in 1978 (464 mm), and its average was (265 mm) followed by DERNA station in 1995 (405 mm) with average (259 mm) and NALUT Station in 1976 (568 mm) with average (154.7 mm).

The lowest rainy years are 2010 for AGDABIA Station (80 mm), 1999 for ALFATAIAH Station (142 mm), 1980 for BENGHAZI Station (157 mm), 1999 for DERNA Station (134 mm), 1980 for SHAHAT station (391 mm), 2004 in for SIRTE station 102 mm), 1999 for TOBRUK station (72 mm), 2009 for TRIPOLI station (117 mm) and 1981 for ZWARA station (40 mm).The desert stations receive few rain except in Ghadames station where the amount of rain reached in 1976 to (204 mm).

2.3. Some Classification of Climate in Study Area

2.3.1. SPI Index For Annual of Rain

Table 25 Results of Standard Precipitation Index (SPI) for Annual of Rain (1971-2010)

Years	Stations							
	AGDABIA	ALFATAIAH	BENGHAZI	DERNA	GHADAMES	GHARAIAT	HON	JAGHBOUB
1971	-0.36	-	0.77	-0.50	-0.71	-0.57	-0.69	-0.58
1972	-0.54	-	-0.97	-0.31	-0.70	0.24	1.95	0.75
1973	-0.38	-	-0.64	-0.59	-0.75	-1.20	-0.94	-0.79
1974	0.24	-	1.09	-0.41	1.08	-0.05	-0.94	-0.83
1975	-0.22	-	-0.99	-0.33	-0.38	1.28	-0.15	0.04
1976	0.36	-	-0.19	0.03	4.78	2.09	0.50	-0.24
1977	-0.16	-	0.45	-1.16	-0.40	-0.52	-0.81	-0.76
1978	0.10	-	2.63	1.34	-0.34	0.21	-0.51	-0.28
1979	-0.99	-	0.39	-0.23	-0.21	-0.68	-0.31	-0.05
1980	-0.93	-	-1.41	-1.22	-0.79	1.05	0.24	0.44
1981	1.96	-0.55	2.21	-0.62	-0.96	-1.02	-0.91	-0.27
1982	-0.67	-0.67	0.31	-1.33	0.51	-0.11	0.82	0.17
1983	0.97	-0.06	0.51	0.23	-0.72	-0.96	-0.18	-0.34
1984	-0.32	-1.43	-0.36	0.00	-0.48	-0.94	0.89	0.05
1985	-0.60	-0.02	-0.51	0.37	-0.24	-0.97	-0.90	0.76
1986	1.06	-0.81	0.10	0.12	-0.46	0.57	2.09	-0.21
1987	-0.46	-0.08	-0.79	-0.42	-0.57	-0.11	-0.54	-0.33
1988	0.14	1.76	0.64	2.06	-0.16	1.52	-0.16	4.40
1989	-0.89	-0.13	0.01	0.13	-0.26	-0.64	0.18	-0.94
1990	-1.09	0.66	-1.12	0.38	1.79	1.01	4.31	0.35
1991	2.91	2.58	2.57	1.83	0.03	1.17	-0.18	2.28
1992	-1.01	0.06	-0.78	0.08	-0.67	-1.13	-0.35	-0.55
1993	-0.98	0.61	-0.52	-0.70	-0.95	-0.11	0.32	0.76
1994	2.23	-0.51	1.28	1.27	-0.01	1.09	0.31	-0.01
1995	-0.23	0.97	0.81	2.21	0.04	-0.88	-0.20	1.21
1996	0.20	0.02	-0.08	0.85	-0.57	0.04	0.30	-0.67
1997	0.10	-0.26	0.04	0.35	-0.55	-0.73	0.29	-0.61
1998	1.44	1.01	0.51	2.05	-0.16	-0.55	-0.61	-0.15
1999	-0.58	-1.92	-1.17	-1.88	0.33	-0.44	-0.60	0.60
2000	-0.73	-0.64	-0.88	-0.93	-0.13	-1.01	0.45	1.25
2001	1.97	0.93	-0.05	0.86	-0.94	-0.99	-0.88	-0.82
2002	0.97	-1.36	0.18	-1.17	-0.34	-0.27	-0.54	-0.72
2003	0.53	-0.63	0.82	-0.98	0.95	-0.36	0.27	-0.71
2004	-0.61	0.26	-0.55	-0.47	0.25	-0.26	-0.84	-0.84
2005	-0.38	0.09	0.08	-0.15	0.18	0.68	-0.10	-0.74
2006	-0.50	-0.23	-0.84	0.27	0.59	2.15	0.31	-0.77
2007	-0.54	-0.32	-0.63	0.05	0.28	-0.13	-0.82	0.34
2008	-1.09	0.97	-1.31	1.02	1.33	2.57	0.21	-0.11
2009	0.25	-1.60	-0.40	-0.87	0.35	-1.30	-0.83	-0.82
2010	-1.14	1.29	-1.22	-1.21	0.03	0.26	-0.45	-0.36

The Source: Depending on: Libyan National Meteorological center climate & climate Change, Tripoli. 2012.

Figure 26. Results of Standard Precipitation Index (SPI) for Annual of Rain (1971-2010)

Years	Stations							
	JALO	MISURATA	NALUT	SHAHAT	SIRTE	TOBRUK	TRIPOLI	ZWARA
1971	-0.47	0.12	-0.82	-0.39	-0.53	-	0.55	-0.16
1972	1.37	-0.10	1.58	0.16	-0.38	-	0.83	0.26
1973	-0.58	0.03	-1.08	-0.91	2.31	-	0.76	0.15
1974	-0.90	-0.28	0.55	-0.56	0.15	-	1.20	1.86
1975	-0.12	-0.52	-0.07	-1.05	0.05	-	0.31	0.74
1976	0.63	0.57	4.50	0.64	0.26	-	1.88	2.23
1977	-0.75	-1.06	-0.58	1.14	0.75	-	0.62	-0.45
1978	1.75	1.32	-0.87	1.57	1.94	-	0.40	1.28
1979	-0.60	-0.28	0.69	0.03	-0.82	-	0.14	0.64
1980	0.51	0.78	0.11	-1.37	0.22	-	2.02	-0.30
1981	0.11	0.97	-1.28	1.75	0.62	-	0.02	-1.99
1982	-0.48	0.31	0.78	-1.20	-0.91	-	1.23	0.76
1983	-0.05	-0.60	-0.10	1.07	0.34	-	0.31	-0.49
1984	0.90	0.70	-0.20	-0.70	-1.36	0.44	1.47	2.36
1985	-0.60	-0.73	0.31	0.72	-0.85	-0.01	-0.69	-0.67
1986	-0.54	1.77	0.33	-0.53	1.83	1.44	2.03	1.69
1987	-0.67	-1.25	0.15	0.19	-0.69	-0.22	-1.00	0.28
1988	-0.57	1.00	-0.01	1.57	-0.07	1.68	-0.32	1.38
1989	-0.57	-1.60	-0.72	0.28	-0.52	-0.36	-0.73	-0.83
1990	-0.76	1.20	0.33	-1.20	-1.15	-0.08	-0.56	0.13
1991	1.90	2.14	0.75	2.77	3.16	0.99	-0.38	-0.68
1992	-0.57	-1.59	-0.13	-0.78	-1.20	0.52	-1.55	-1.37
1993	-0.79	-1.35	-0.52	-0.89	0.30	-0.01	-1.44	-0.13
1994	-0.65	0.09	-0.21	1.12	0.81	0.78	-0.22	-0.45
1995	1.73	2.05	2.00	-0.23	-0.11	-0.91	2.04	0.97
1996	-0.94	-0.50	0.10	-0.49	-0.67	-0.40	-0.22	-0.50
1997	-0.84	-0.34	-0.44	0.35	0.41	1.53	-0.35	0.72
1998	0.26	-0.31	-0.26	0.39	-0.06	0.27	-0.51	-0.27
1999	-0.16	-0.77	-0.42	-1.33	-0.25	-1.93	-0.14	0.13
2000	1.52	-0.79	-0.11	-0.62	-0.48	0.23	-1.31	-0.86
2001	-0.88	0.71	-0.92	0.73	0.27	-0.41	-0.89	-1.09
2002	-0.63	-0.92	-0.22	-1.11	-0.63	-1.31	-0.01	0.92
2003	-0.77	1.18	-0.02	0.99	0.08	-0.43	-0.31	0.23
2004	-0.88	-0.37	-0.52	0.03	-1.37	-0.66	-0.65	-0.60
2005	-0.15	-0.94	-0.17	0.78	-0.09	1.34	-0.74	-0.69
2006	2.90	0.34	-0.16	-1.14	0.51	-0.27	-0.17	0.27
2007	0.52	0.32	-0.33	-0.10	-1.20	1.43	-0.45	0.16
2008	1.87	0.95	0.26	-0.67	0.72	-0.67	-0.27	-0.72
2009	-0.52	-0.72	-1.08	0.12	-0.46	-1.93	-1.62	-0.86
2010	-0.74	-1.55	-1.22	-1.17	-0.93	-1.03	-1.28	-1.43

The Source: Depending on: Libyan National Meteorological center climate & climate Change, Tripoli. 2012.

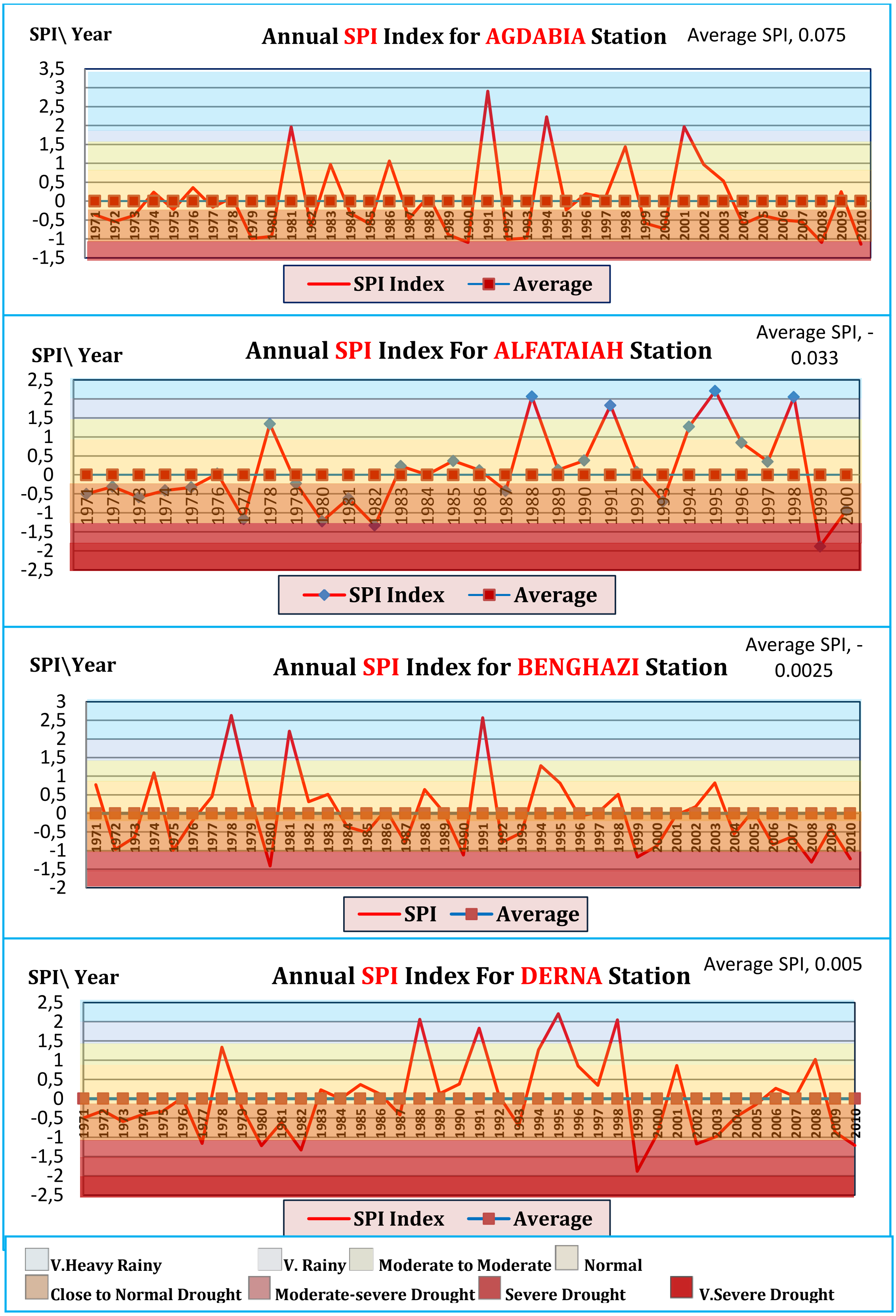


Figure 31. Results of Standard Precipitation Index (SPI) for Annual of Rain in AGDABIA, ALFATAIAH, BENGHAZI and DERNA stations(1971-2010)

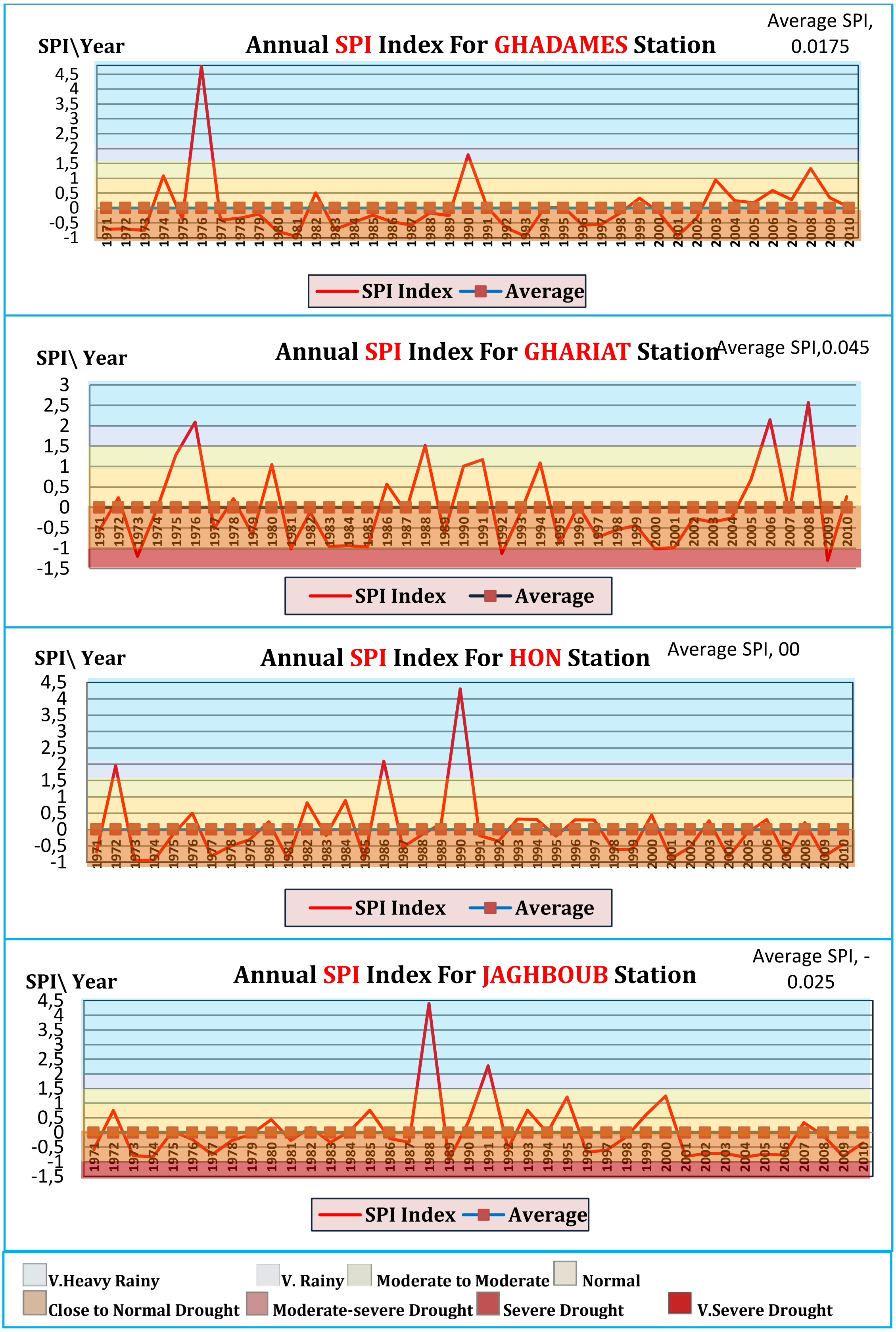


Figure 32. Results of Standard Precipitation Index (SPI) for Annual of Rain in GHADAMES, GHARIAT, HON and JAGHBOUB stations (1971-2010)

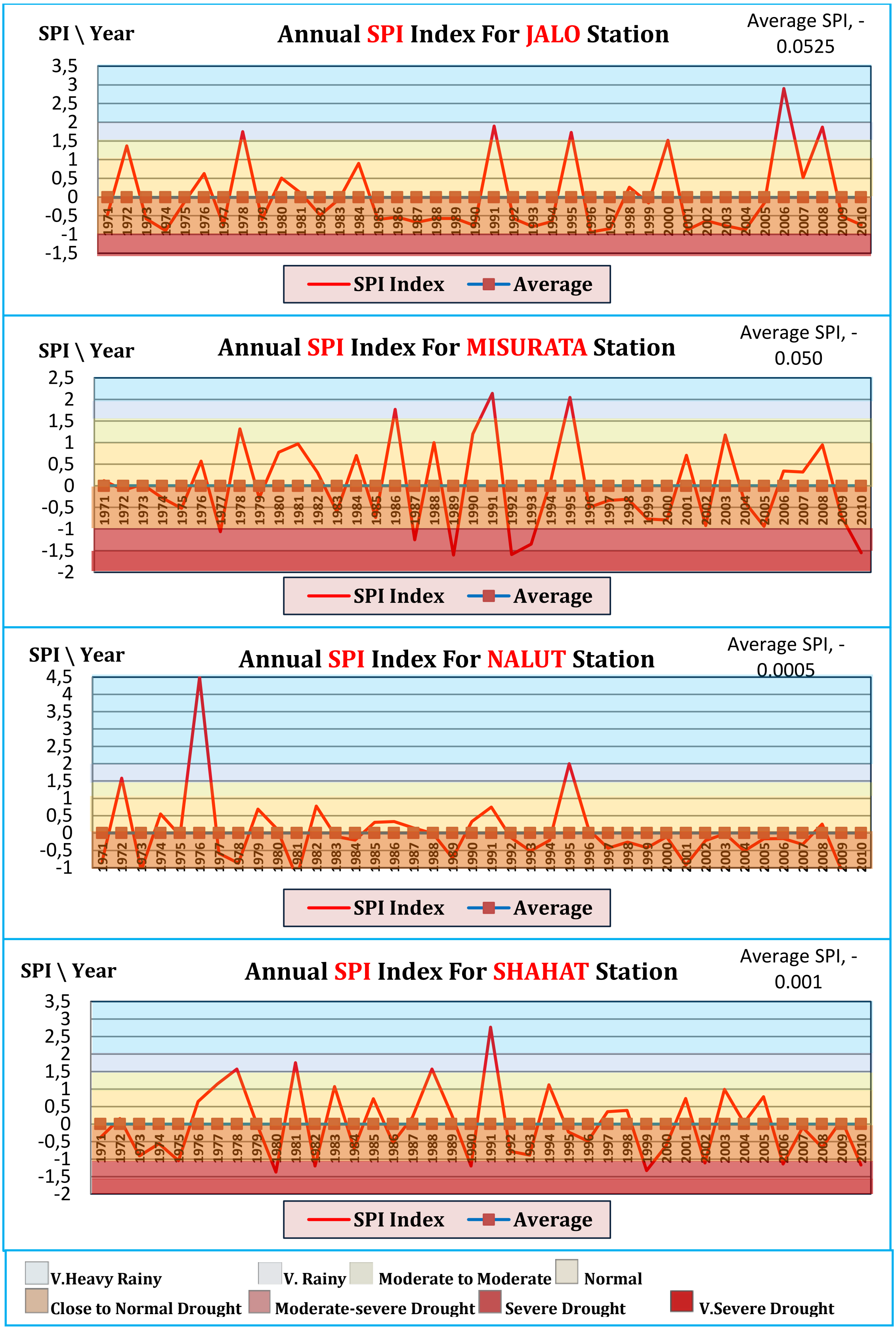


Figure 33. Results of Standard Precipitation Index (SPI) for Annual of Rain in JALO, MISURATA, NALUT and SHAHAT stations(1971-2010)

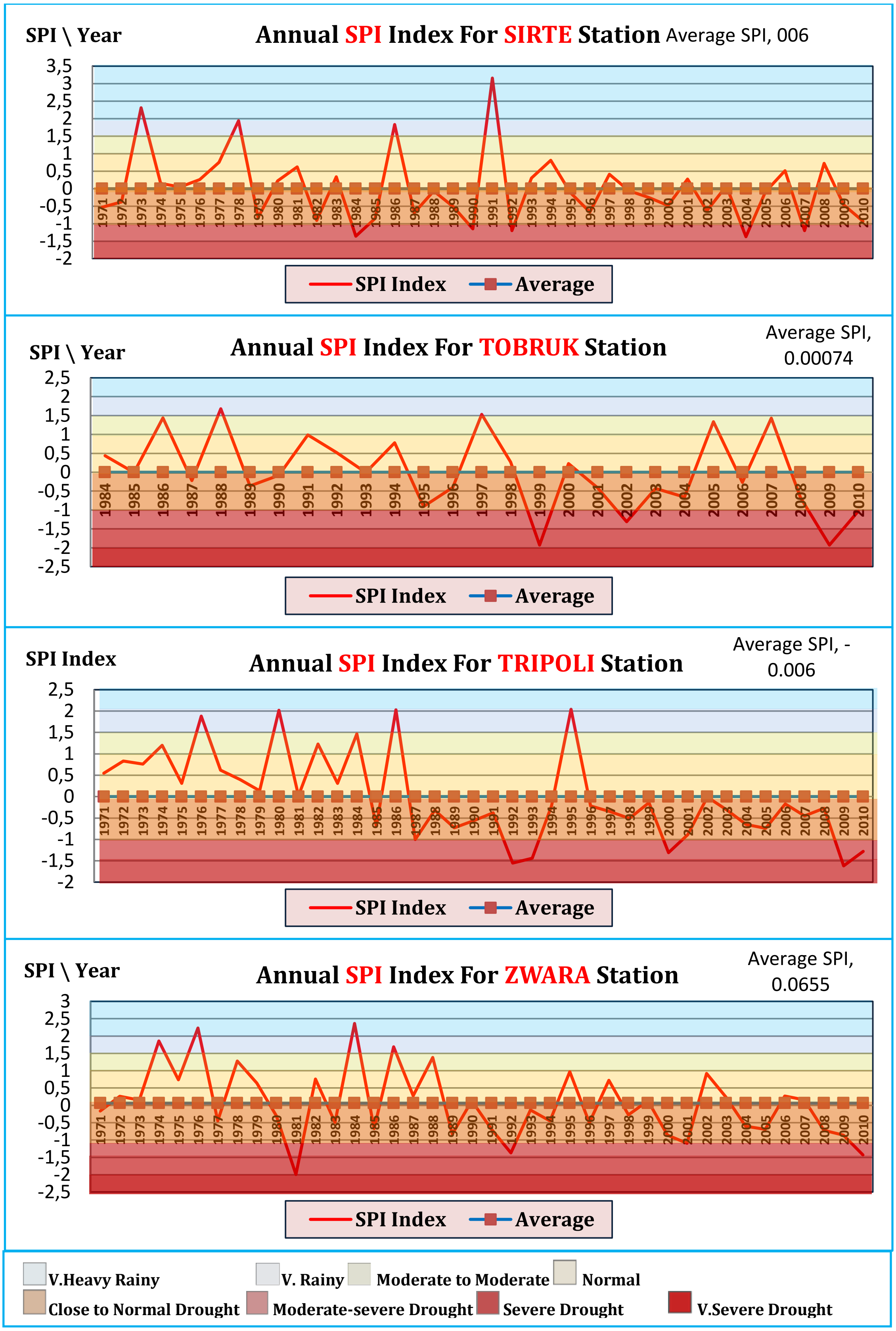


Figure 34. Results of Standard Precipitation Index (SPI) for Annual of Rain in SIRTE, TOBRUK, TRIPOLI and ZWARA station(1971-2010)

Table 27. Average SPI Index in Seasons for Meteorological Stations

Station	SPI Index For Seasons			
	Spring	Summer	Autumn	Winter
AGDABIA	0.20	-0.05	-0.06	-0.10
ALFATAIAH	-0.03	0.02	-0.06	-0.05
BENGHAZI	-0.02	-0.05	-0.01	-0.05
DERNA	0.00	0.03	0.03	0.21
GHADAMES	-0.02	-0.05	-0.02	0.00
GHARIAT	0.00	0.01	0.01	0.03
HON	-0.01	-0.08	0.01	0.02
JAGHBOUB	0.00	0.02	0.00	-0.06
JALO	0.07	0.01	0.00	-0.01
MISURATA	0.01	0.00	-0.04	-0.01
NALUT	0.00	-0.01	-0.02	0.48
SHAHAT	-0.01	0.05	0.06	0.45
SIRTE	0.02	-0.02	-0.02	-0.02
TOBRUK	0.04	0.02	0.04	0.02
TRIPOLI	0.08	-0.01	0.00	-0.02
ZWARA	0.01	-0.05	-0.01	-0.02

The Source: Depending on: Libyan National Meteorological center climate & climate Change, Tripoli. 2012.

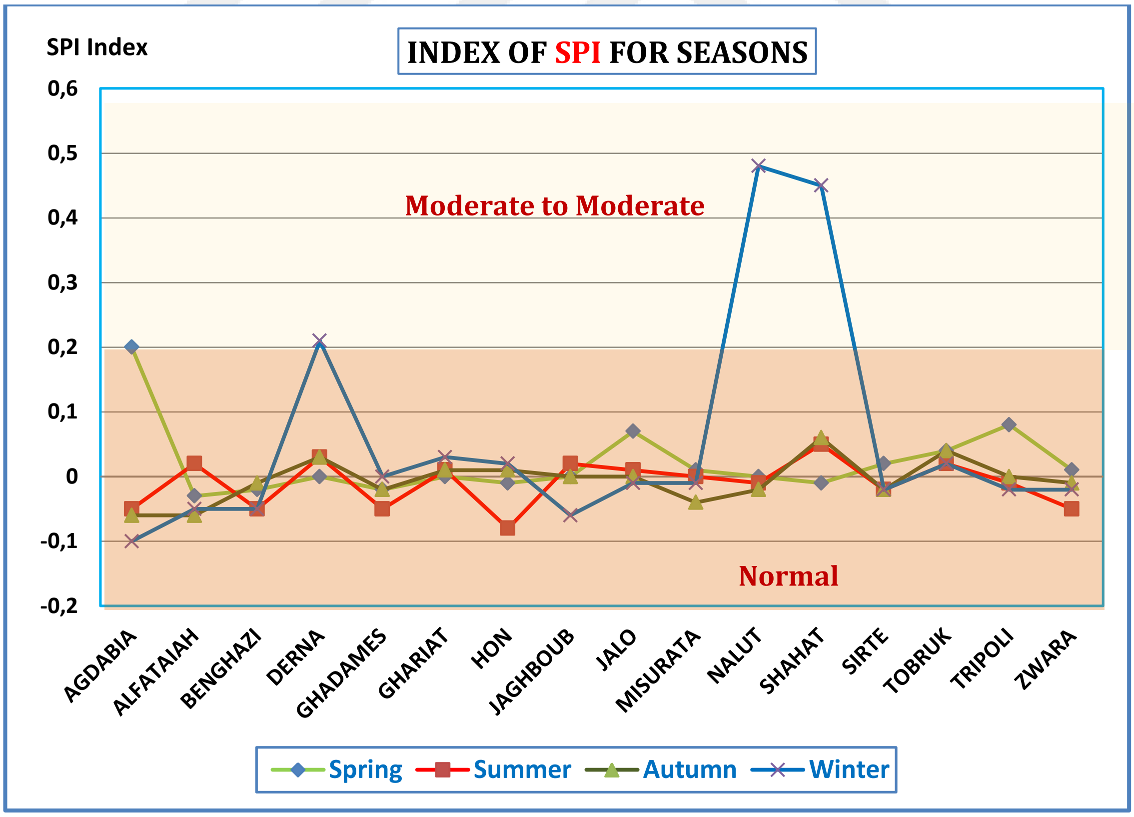
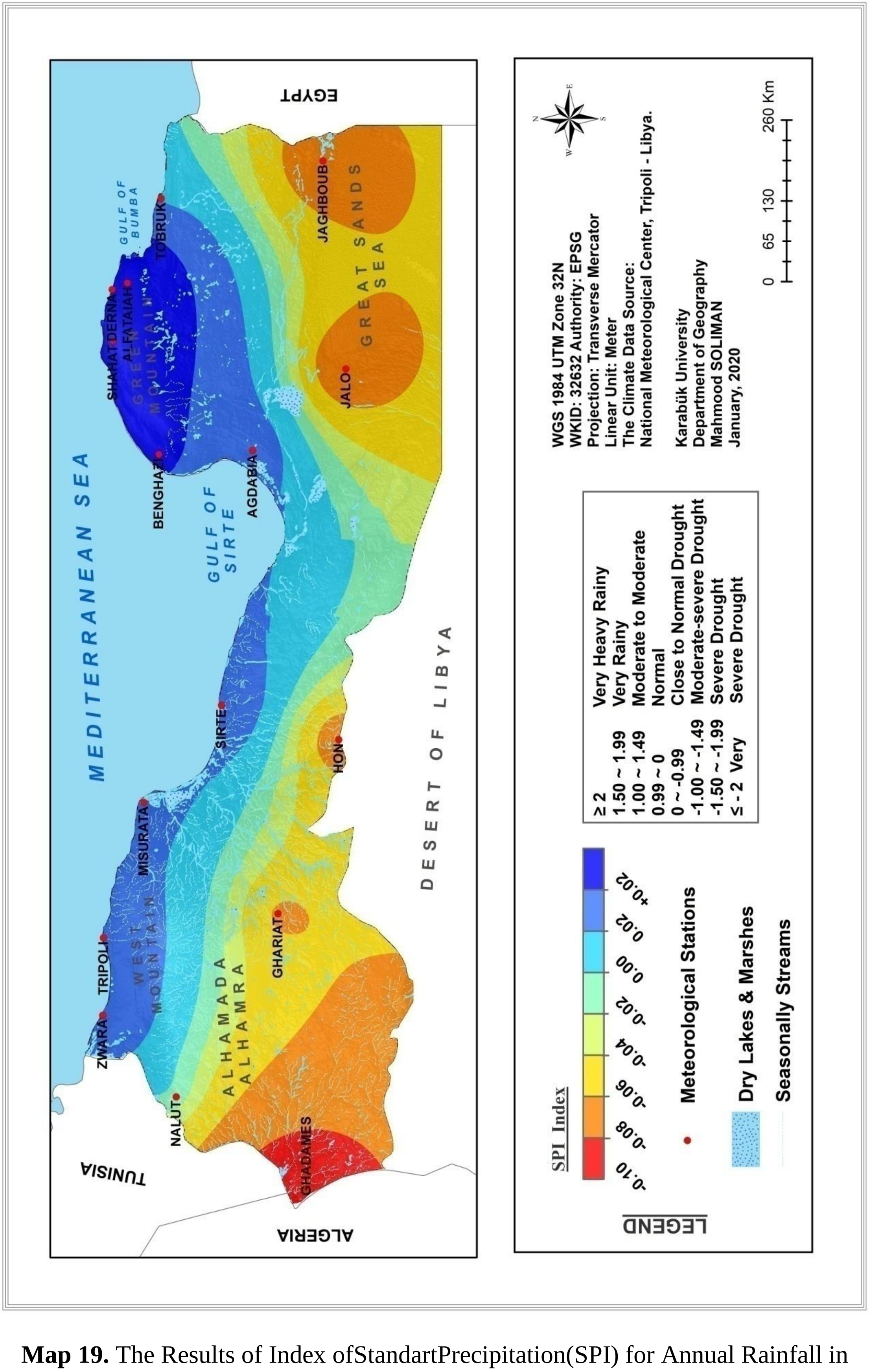


Figure 35. Average SPI Index in Seasons for Meteorological Stations (1971-2010)



Map 19. The Results of Index ofStandartPrecipitation(SPI) for Annual Rainfall in Northern of Libya (1971-2010)

Through tables 25, 26, 27, figures 32, 33, 34, 35, 36 and map 20 it can be said that index SPI described well the drought areas conditions by applying the index (SPI) on the stations of northern Libya.This is done by establishing the onset, the ending, and the severity levels of drought in the study area during the meteorological periods (1971-2010).

All the precipitation data were converted to Index of (SPI). All the chosen precipitation stations exhibit good data quality in coastal stations, and great fluctuation in desert stations.According to the main criterion for selection, the raw data for each year are the only ones that can be relied upon in this index (Christos, 2011), especially in the stations where rainfall fluctuates from year to year.It was considered that raw data may be more appropriate to represent natural drought conditions (extreme minimum values).

Figures of the precipitation over time were made for all years for 16 stations in order to visualize the time series data and to serve an ad hoc quality control of the precipitation values.

The SPI values ranged between (Severe Drought) at ALFATAIAH Station in 1999 and (Very Heavy Rainy) in 1991, as the amount of rain in those years was (572 mm) at ALFATAIAH and (258.3 mm) at GHADAMES. This indicates that the annual rainfall affects the result of the SPI index. Similarly, the index was high in 1988 (Very Heavy Rainy) at JAGHBOUB station showing it is very rainy as the amount of rain was (90.4 mm) that year. Besides, due to the extreme fluctuation in the rainfall on the desert stations such as HON and GHARIAT, it is possible to observe the general increase in these stations, as the fall of large quantities of rain may be in one day only which in turn raises the annual rainfall. Therefore, it may not be useful to depict rare precipitation, maybe once during the monitoring period.

In JALO station, the index is relatively moderate due to the lack of rain, and generally it is Moderate-severe Drought,it was supposed to be in a very arid climate and the reason for this result is the difference in the amount of rainfall in some years with the general average of rain, at MISURATA station, the index is affected by fluctuating rainfall. The highest index reached (2.14) in 1991 (Very Heavy Rainy) and (-1.59) in 1992 (Severe Drought) while the general average is (0.000) which is

(Normal). NALUT station index reached to (4.5) (Very Heavy Rainy) in 1976, and was (-1.28) in 1981 (Moderate-severe Drought), and remained constant for the rest of the years by average (0.000) which is (Normal).

For TRIPOLI station, the index in 1980 was (2.20) as very Heavy Rainy and (-1.62) in 2009 as Severe Drought. For TOBRUK station the SPI values ranged between (-1.93) in 1999 and 2009 and (1.68) in 1988. The other coastal stations the index values ranged at SIRTE station between (3.16) in 1991 and (-1.36) in 2004 and ZWARA between (2.23) in 1976 and (-1.99) in 1981 .

In general, it is found that the year1991 was one of the most humid years in the eastern part of the study area. In contrast, however, 1999 was one of the driest years in the region. Moreover, in the west of study area, 1976 was very rainy while 1981 was found very arid. The general stability of the SPI indicator can be observed in many years and stations, and this indicates the stability of the annual rainfall rate with the general average (0.000) which was (normal).

As for the seasons of the year, the indicators differed from one station to another due to above mentioned reasons. Therefore, the amount of rainfall in winter varies with the general average of precipitation. The index was high in the mountain stations of SHAHAT and NALUT. In summer, (SPI) index shows negative values for most stations because of little rainfall. Similar findings were observed in case of spring and autumn. The results of seasons can be more accurately identified by the map (12).

Overall, SPI described well the drought conditions in Libya, the indicator established the onset, the ending, and the severity levels of exceptional drought events and its climate conditions. The spatial SPI visualization provided a stakeholder-oriented tool for immediate drought categorization. At the same time, it could depict drought conditions all over the north of Libyan territory incorporating the most vulnerable insular environments except Green Mountain which is represented by the ALFATAIAH and SHAHAT stations.

2.3.2. Climate Classification of Erinç

Table 28. The Results Monthly and Annual of Climate Classification of Erinç for Period (1971-2010)

NO	STATION NAME	Ja.	Fb.	Mr.	Ap.	Ma.	Jn.	Jl.	Ag.	Sp.	Oc.	Nv.	De.	General Classi.
		MONTHS												
1	AGDABIA	26.2	12.4	5.8	1.5	0.8	0	0	0	0.6	3.6	9.1	26.9	5.5
		SH	A	VA	VA	VA	VA	VA	VA	VA	VA	A	SH	VA
2	ALFATAIAH	62.6	36.5	18.4	5.1	3.9	0.2	0.1	0.1	1.7	11.6	16.9	53.9	13.7
		VH	SH	SA	VA	VA	VA	VA	VA	VA	A	SA	H	A
3	BENGHAZI	47.2	28.5	15.2	3.0	1.8	0.1	0	0	1.4	8.5	17.9	43.4	10.6
		H	SH	SA	VA	VA	VA	VA	VA	VA	A	SA	H	A
4	DERNA	41.0	27.5	14.5	4.5	2.8	1.0	0	0.1	2.3	15.9	15.8	35.2	1.2
		H	SH	A	VA	VA	VA	VA	VA	VA	SA	SA	SH	VA
5	GHADAMES	3.9	2.8	2.6	1.1	0.5	0.1	0	0	0.4	1.4	1.5	3.3	1.1
		VA	VA	VA	VA	VA	VA	VA	VA	VA	VA	VA	VA	VA
6	GHARIAT	6.3	2.5	3.9	1.6	1.9	0.2	0.1	0	1.5	4.0	3.4	3.7	2.0
		VA	VA	VA	VA	VA	VA	VA	VA	VA	VA	VA	VA	VA
7	HON	2.7	1.8	1.5	1.0	0.2	0	0	0	0.8	1.9	1.6	1.5	1.0
		VA	VA	VA	VA	VA	VA	VA	VA	VA	VA	VA	VA	VA
8	JAGHBOUB	2.8	1.2	1.2	0.3	0.2	0	0	0	0.2	0.1	0.3	1.8	0.4
		VA	VA	VA	VA	VA	VA	VA	VA	VA	VA	VA	VA	VA
9	JALO	1.0	0.9	0.6	0.3	0.2	0	0	0	0	0.3	0.3	1.7	0.3
		VA	VA	VA	VA	VA	VA	VA	VA	VA	VA	VA	VA	VA
10	MISURATA	49.7	18.1	12.4	5.2	2.0	0.4	0	0.2	4.5	16.3	23.5	35.5	10.9
		H	SA	A	VA	VA	VA	VA	VA	VA	SA	SH	SH	A
11	NALUT	15.4	13.9	15.6	7.9	3.8	0.7	0	0.1	2.1	7.6	9.1	13.5	5.8
		SA	A	SA	VA	VA	VA	VA	VA	VA	VA	A	A	VA
12	SHAHAT	118.5	79.5	51.8	13.6	4.4	0.5	0.3	0.8	4.2	27.1	44.8	98.5	26.9
		VH	VH	H	VA	VA	VA	VA	VA	VA	SH	H	VH	SH
13	SIRTE	24.5	14.3	8.2	2.2	1.4	0.3	0	0	3.9	9.7	12.3	25.7	7.3
		SH	A	A	VA	VA	VA	VA	VA	VA	A	A	SH	VA
14	TOBRUK	30.9	21.4	7.9	2.0	3.0	0	0	0	0.7	6.1	10.3	24.7	7.4
		SH	SA	VA	VA	VA	VA	VA	VA	VA	VA	A	SH	VA
15	TRIPOLI	39.1	22.4	13.8	6.7	1.8	0.4	0	0.2	4.0	13.2	20.2	34.6	10.1
		SH	SA	A	VA	VA	VA	VA	VA	VA	A	SA	SH	A
16	ZWARA	26.2	13.8	10.1	6.3	2.8	0.4	0	0.2	5.0	14.1	19.0	27.3	9.0
		SH	A	A	VA	VA	VA	VA	VA	VA	A	SA	SH	A

The Source: Depending on: Libyan National Meteorological center climate & climate Change, Tripoli. 2012.

Table 29. The Results Seasonally and Annual of Climate Classification of Erinç for Period (1971-2010)

NO	STATION NAME	SEASONS			
		Spring	Summer	Autumn	Winter
1	AGDABIA	2.7	0	4.4	21.3
		Very Arid	Very Arid	Very Arid	Semi Arid
2	ALFATAIAH	9.1	0.1	10.0	51.0
		Arid	Very Arid	Very Arid	Humidity
3	BENGHAZI	6.7	0	9.2	39.7
		Very Arid	Very Arid	Arid	Semi Humidity
4	DERNA	7.2	0.3	11.3	34.5
		Very Arid	Very Arid	Arid	Semi Humidity
5	GHADAMES	1.4	0	1.1	3.3
		Very Arid	Very Arid	Very Arid	Very Arid
6	GHARIAT	2.4	0.1	2.9	4.1
		Very Arid	Very Arid	Very Arid	Very Arid
7	HON	0.9	0	1.4	2.0
		Very Arid	Very Arid	Very Arid	Very Arid
8	JAGHBOUB	0.6	0	0.2	1.9
		Very Arid	Very Arid	Very Arid	Very Arid
9	JALO	0.4	0	0.2	1.2
		Very Arid	Very Arid	Very Arid	Very Arid
10	MISURATA	6.5	0.2	14.8	34.4
		Very Arid	Very Arid	Arid	Semi Humidity
11	NALUT	9.1	0.3	6.3	14.2
		Arid	Very Arid	Very Arid	Arid
12	SHAHAT	23.2	0.5	25.4	98.8
		Semi Humidity	Very Arid	Semi Humidity	Very Humidity
13	SIRTE	3.9	0.1	8.6	21.5
		Very Arid	Very Arid	Arid	Semi Arid
14	TOBRUK	4.3	0	5.7	25.6
		Very Arid	Very Arid	Very Arid	Semi Humidity
15	TRIPOLI	7.4	0.2	12.4	32.0
		Very Arid	Very Arid	Arid	Semi Humidity
16	ZWARA	6.4	0.2	12.7	22.4
		Very Arid	Very Arid	Arid	Semi Arid

The Source: Depending on: Libyan National Meteorological center climate & climate Change, Tripoli. 2012.

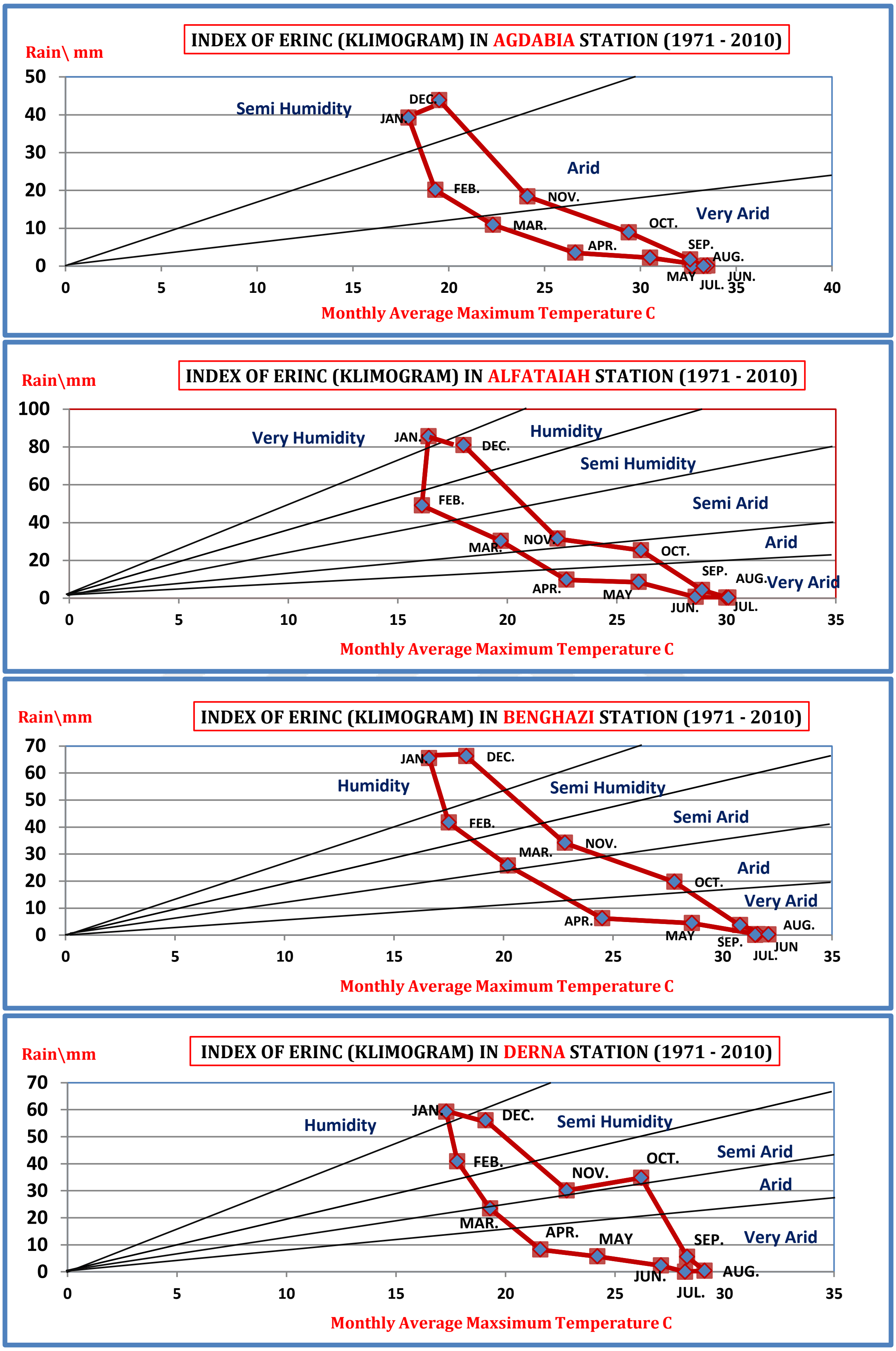


Figure 36. Index of Erinç(Klimograms) in AGDABIA, ALFATAIAH, BENGHAZIand DERNA stations (1971-2010)

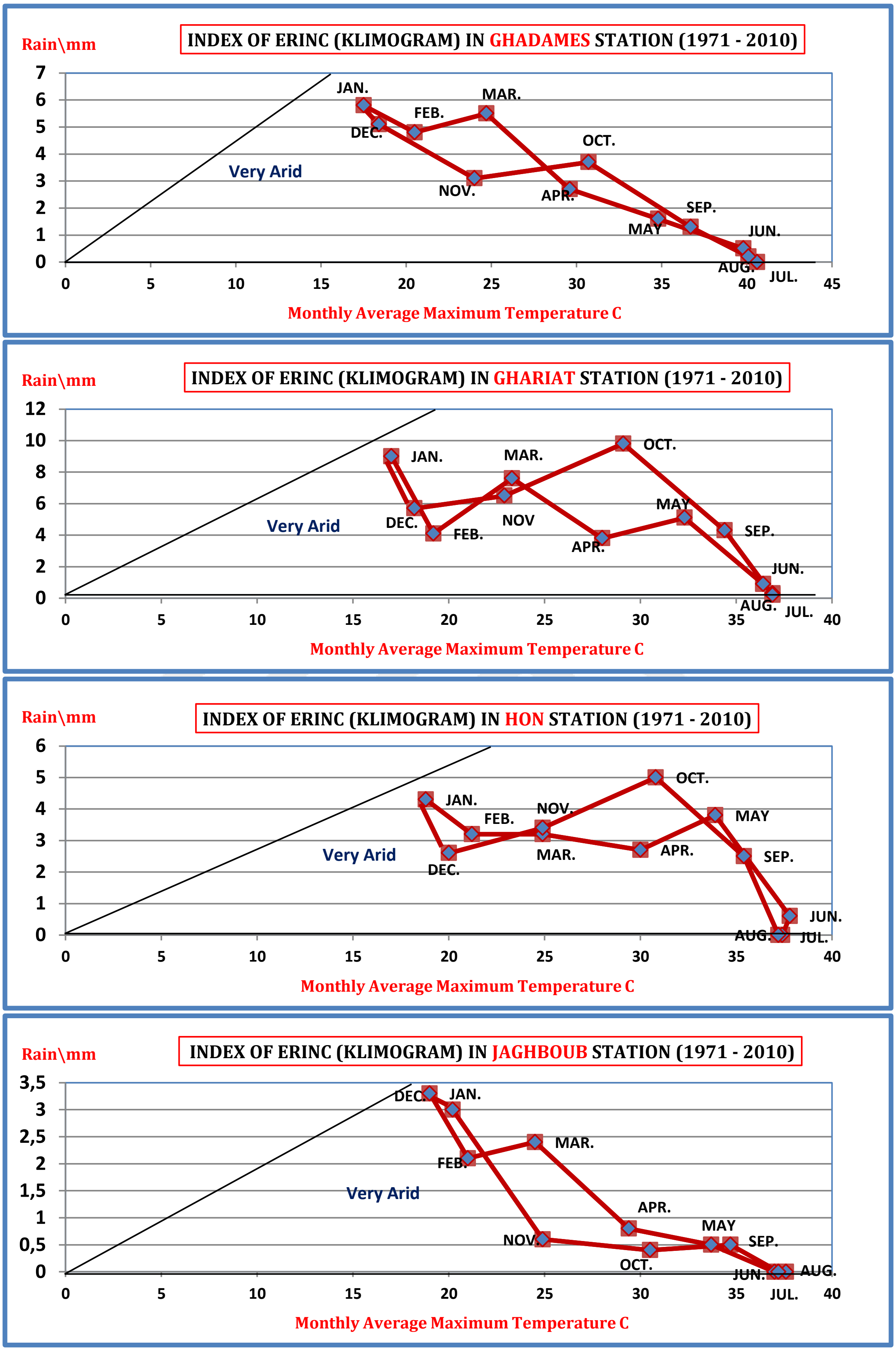


Figure 37. Index of Erinç (Klimograms) in GHADAMEA, GHARIAT, HON and JAGHBOUB stations (1971-2010)

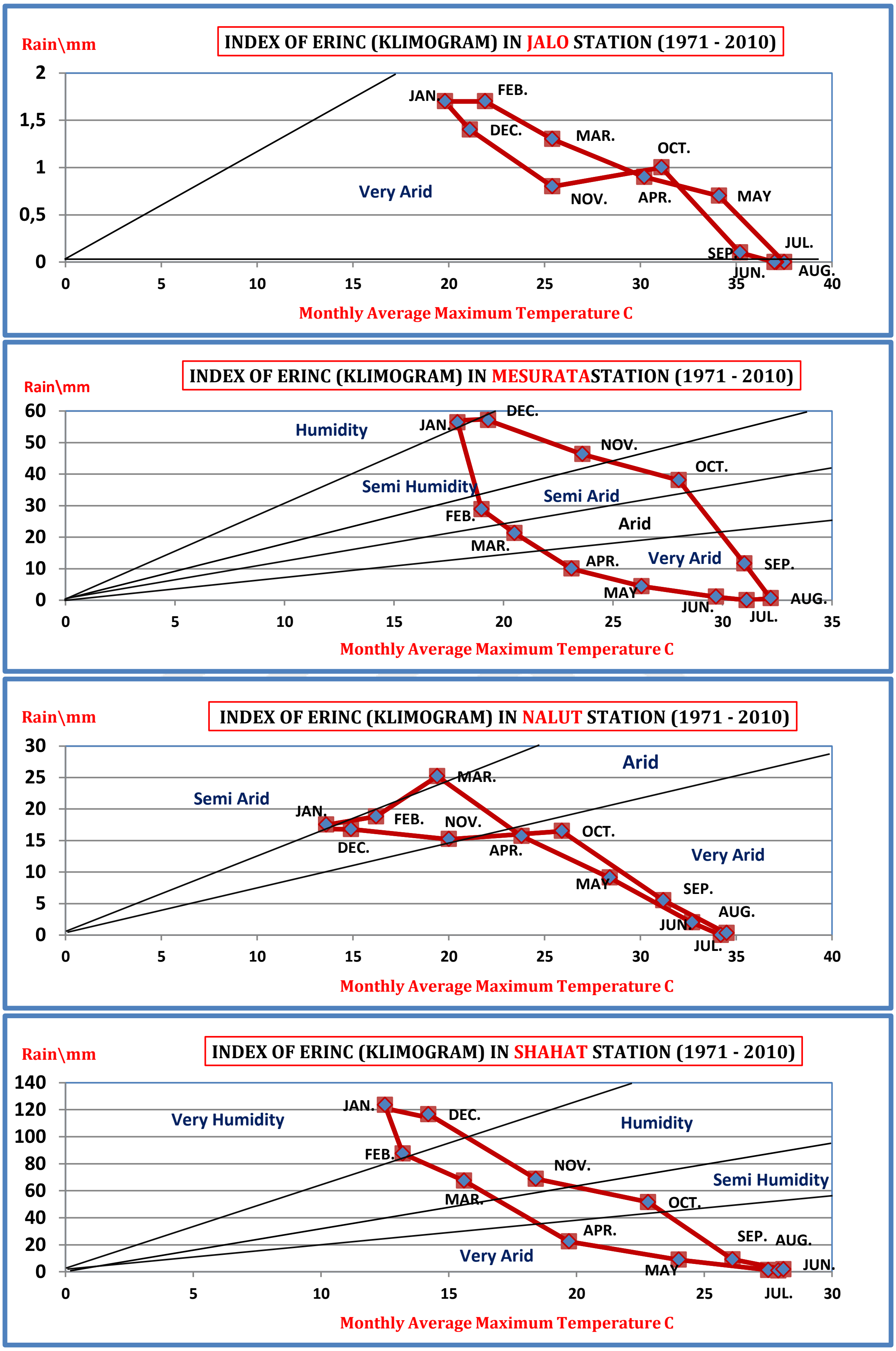


Figure 38. Index of Erinç(Klimograms) in JALO, MISURATA, NALUT and SHAHAT stations (1971-2010)

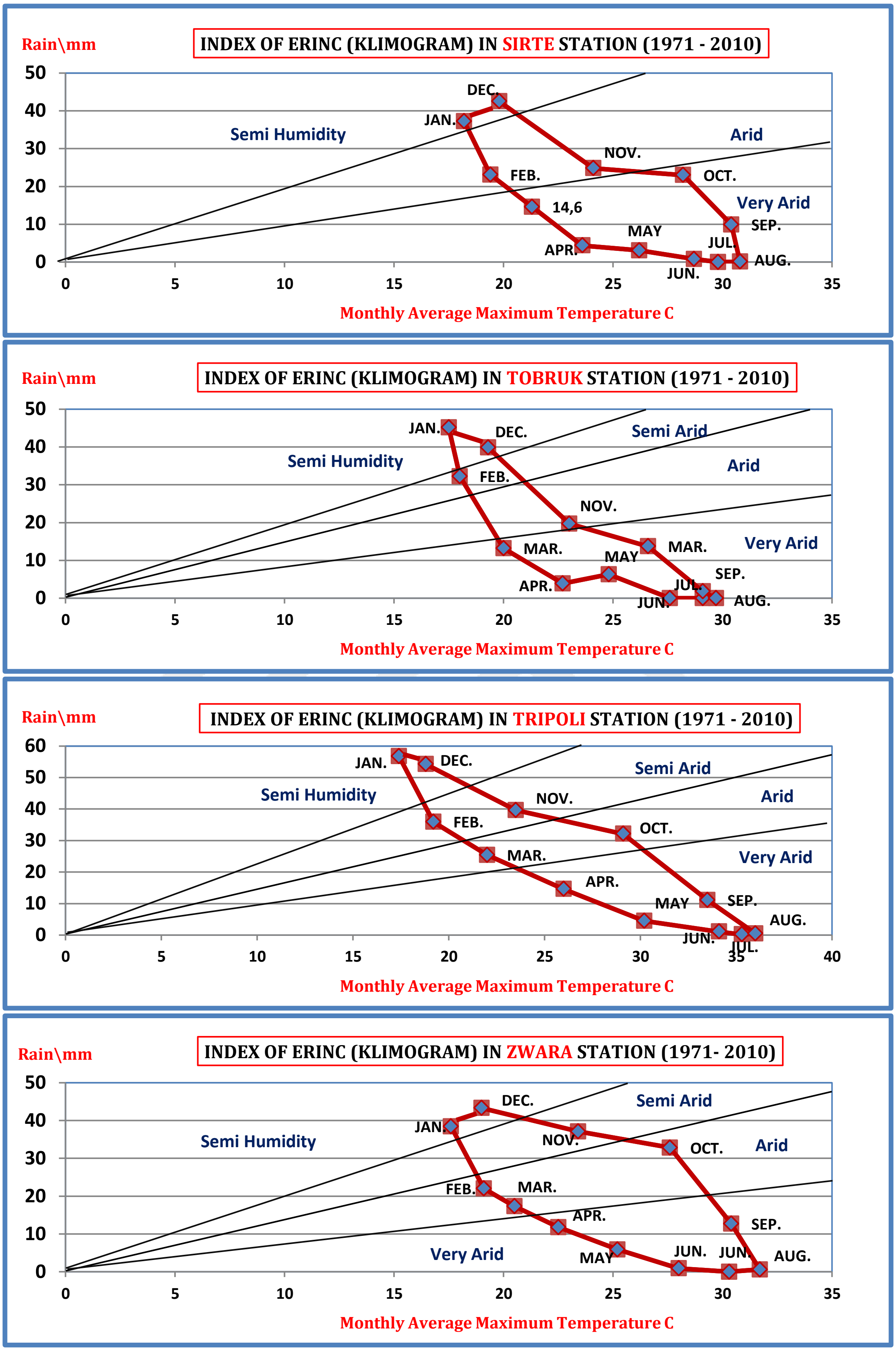
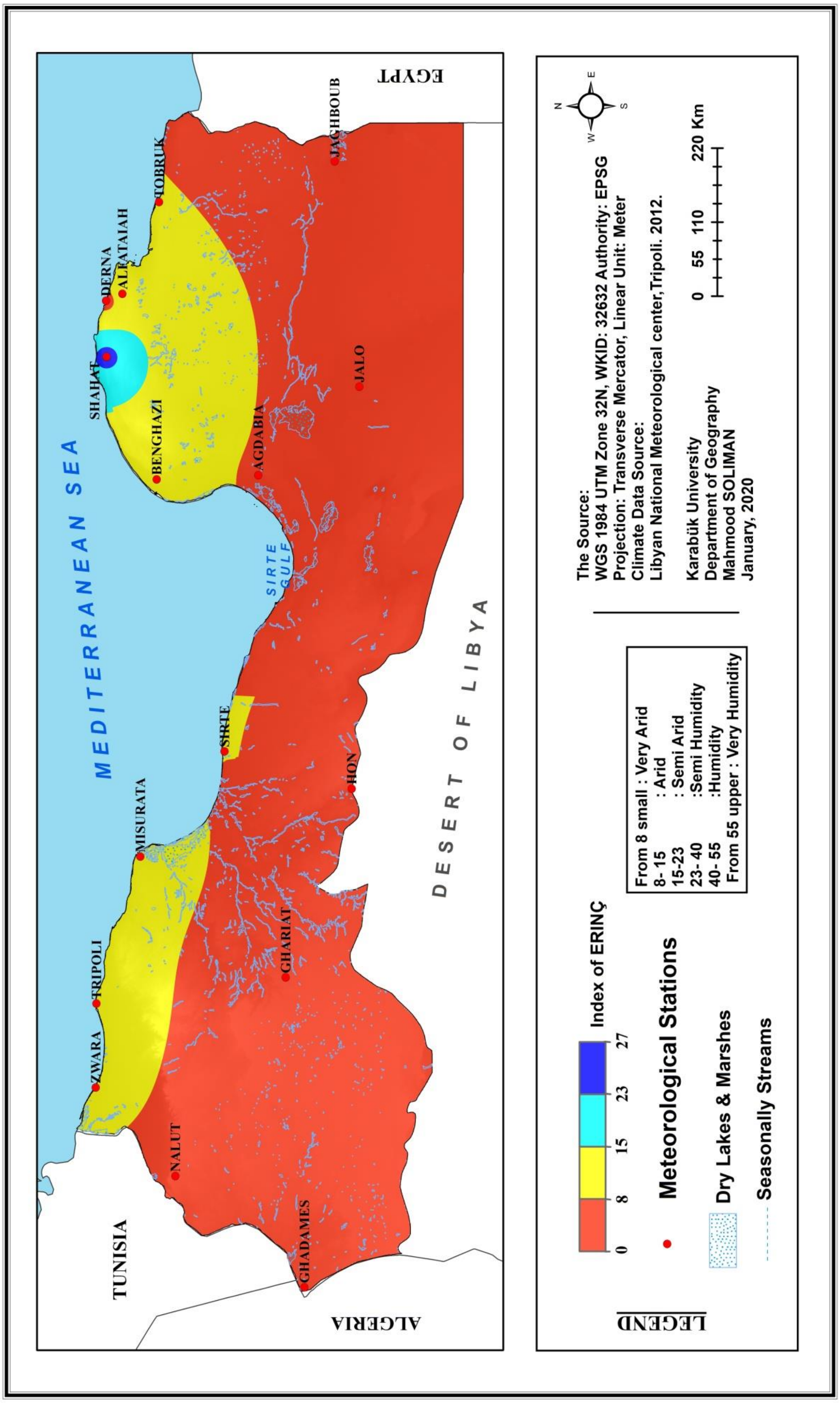


Figure 39. Index of Erinç (Klimograms) in SIRTE, TOBRUK, TRIPOLI and ZWARA stations (1971-2010)



Map 20. Results of Classification of Erinç in Northern of Libya (1971-2010)

From tables 28, 29, figures 37, 38,39, 40 and map 17 shows index ofErinç showed that most of the stations in the study area fall within the dry range, especially the stations that do not receive sufficient amounts of rain., Besides, the summer months were classified in a very dry climate in all stations.

The most important result that was inferred by this classification was that SHAHAT station was the largest wet station in the region due to heavy rain during the winter. The months of January, February, and December were very humid which exceed the average of 98 months in the Erinç standard.

On the other hand, the summer months were classified in a very arid climate because of the lack of rain in those months. The only humid month of spring months is March which is followed by the months of drought until the fall. The month of October is the semi-humid while November is humid.

At ALFATAIAH station, January and December were very humid, February was Semi Humid, and the dry months continued until December.

It can be said that the dry period extends from March to November and the wet period includes January, February, and December. in most of stations except for desert stations. The five desert stations were severely dehydrated during the summer months of the year.

2.3.3. Climate Classification of L. EMBERGER(Coefficient of Thermal – Rain)

When applying this equation to meteorological stations in study area, the results were as follows: AGDABIA 20.2, ALFATAIAH 48.7, BENGHAZI 39.9, DERNA 52.9, GHADAMES 3.1 ,GHARIAT 6.1, HON 3.2, JAGHBOUB 1.4, JALO 1.1, MISURATA: 42.5, NALUT 16.9, SHAHAT 86.6, SIRTE 30.2, TOBRUK 30.6, TRIPOLI 32.7 and ZWARA 33.7.

The higher values of coastal and mountain stations can be observed due to the increase in the amount of rainfall, for example at SHAHAT (559 mm) plant which was the result of classification (86.6, Mediterranean climate little rain) andALFATAIAH (48.7, Semi-arid Mediterranean climate)), And the desert stations were very dry, the results of equation 6.1 did not exceed.

The following figure 41 and map 22 showed the distribution of meteorological stations according to equation (Coefficient of Thermal & Rain).

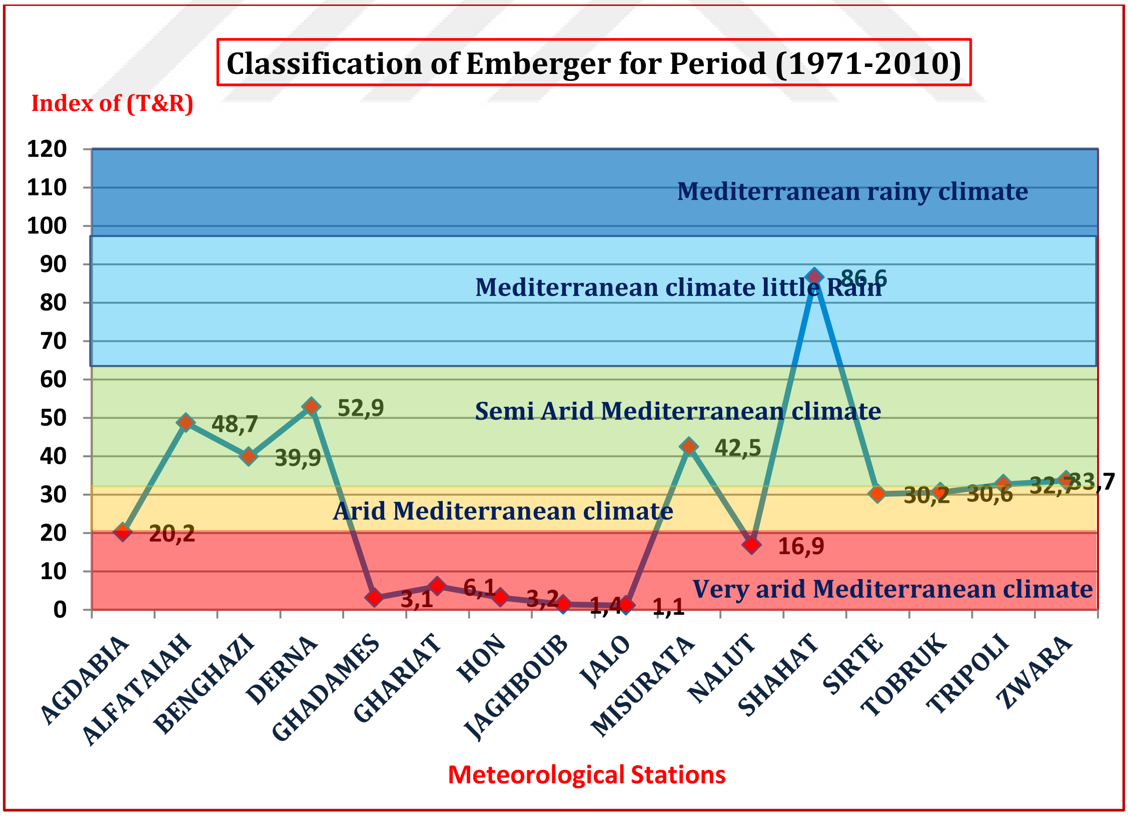
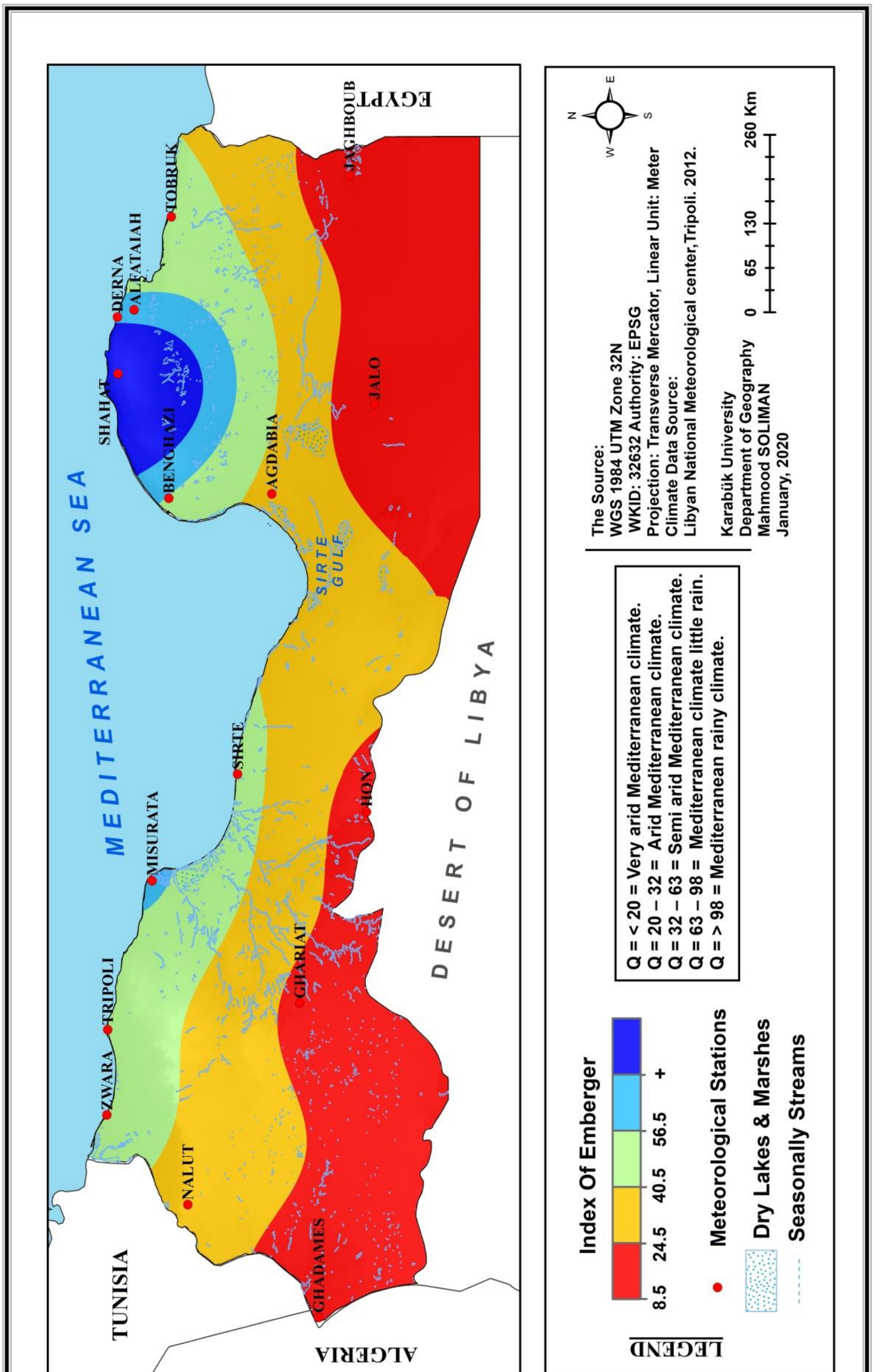


Figure 40. Classification of Emberger in Northern of Libya (1971-2010)



Map 21. Results of Classification of Emberger in Northern of Libya (1971-2010)

2.3.4. Index of Johansson for Continental Climate and Oceanity Climate

The following table and figure showed the branches of the equation and the values in study areas:

Table 30. Results Equation of Johansson in Meteorological Stations (1971-2010)

No	STATION NAME	Maximum °C	Minimum °C	Amplitude	Latitude	Sin *f*	J. C	Climate Type
1	AGDABIA	33.5	7.7	25.8	30° N	0.5000	46.9	Continental
2	ALFATAIAH	30.1	7.1	23.0	32° N	0.5299	35.2	Continental
3	BENGHAZI	31.6	8.7	22.9	32° N	0.5299	34.9	Continental
4	DERNA	29.1	11.0	18.1	32° N	0.5299	19.5	Oceanity
5	GHADAMES	40.6	3.8	36.8	30° N	0.5000	84.3	V. Continental
6	GHARIAT	36.9	4.5	32.4	30° N	0.5000	69.3	V. Continental
7	HON	37.8	3.7	34.1	28° N	0.4695	80.0	V. Continental
8	JAGHBOUB	37.6	5.3	32.3	29° N	0.4848	71.1	V. Continental
9	JALO	37.5	6.7	30.8	29° N	0.4848	67.9	V. Continental
10	MISURATA	32.2	9.0	23.2	32° N	0.5299	35.9	Continental
11	NALUT	34.5	5.5	29.0	31° N	0.5150	56.1	Continental
12	SHAHAT	28.1	6.3	21.8	32° N	0.5299	31.4	Oceanity
13	SIRTE	30.8	9.1	24.1	31° N	0.5150	39.9	Continental
14	TOBRUK	29.7	9.5	20.2	32° N	0.5299	26.3	Oceanity
15	TRIPOLI	36.0	6.7	29.3	32° N	0.5299	49.2	Continental
16	ZWARA	31.7	7.7	24.0	32° N	0.5299	38.4	Continental

The Source: Depending on: Libyan National Meteorological center climate & climate Change, Tripoli. 2012. And, (Toros et al., **2008).**

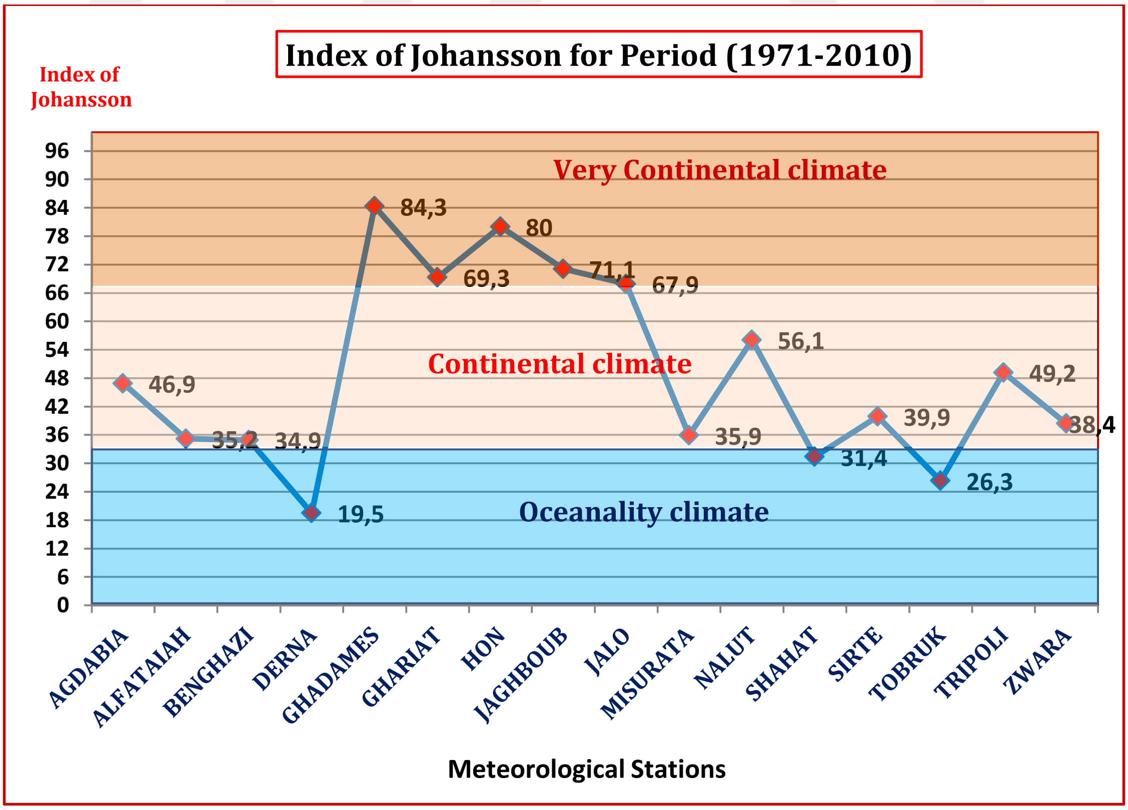
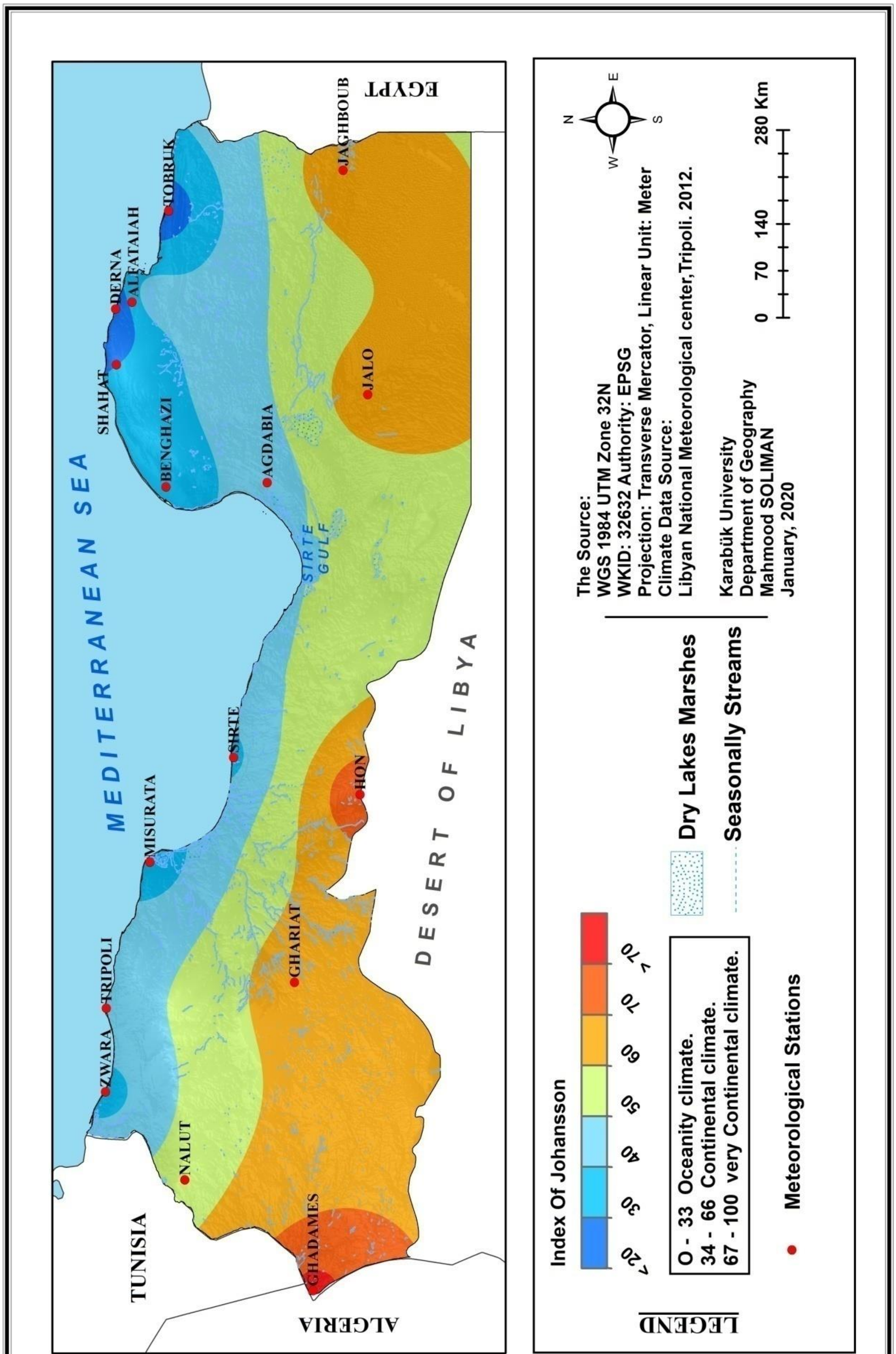


Figure 41. Results Equation of Johansson in Northern of Libya (1971-2010)



Map 22. Results Equation of Johansson in Northern of Libya (1971-2010)

The above mentioned table 30, figure 42 and map 23 can identify important results from the Johansson Index:

Johansson Continentality index gives reasonable results for North Libya. The index values are found in between 19.5 at DERNA to30.1 at SHAHAT over the coastal areas and from 67.9 at JALO to 84.3 at GADAMES over the whole inner continental regions.

The Johansson index and the average temperature distribution over Libya has been compared in Figure and Map as expected that the Continentality effect is increased by the distance from coastal areas. Continentality effect particularly is the maximum in southern regions of Libya. It is clearly seen that Continentality effect shows difference in amplitude between coastal and inland areas. The results of Johansson index show that there is strong effect of the Mediterranean Sea in the coastal areas. because of the mild temperatures in these areas.

Therefore, the amplitude is found low. Besides, the mathematical location has also an impact as going towards the south. An increase in the Johansson index values is noted such as at DERNA on 32°N (Sin f: 0.5299), Johansson index value was (19.5) which is lowest value of the index in North Libya. In contrast at GHADAMES on 30N° (Sin f: 0.5000) Johansson index value was (84.3) which is highest value of the index in North Libya.

2.3.5. Index of Kerner for Continental Climate and Oceanity Climate

The following table and figure show the branches of the equation and the values:

Table 31. Results Equation of Kerner in Meteorological Stations (1971-2010)

No	STATION NAME	T April °C	T October °C	E; Amplitude °C	K_1	Climate type
1	AGDABIA	20.0	23.0	14.2	21.1	Oceanity
2	ALFATAIAH	16.4	20.6	13.8	30.4	Oceanity
3	BENGHAZI	18.9	22.6	14.1	26.2	Oceanity
4	DERNA	17.9	22.8	12.2	40.1	Oceanity
5	GHADAMES	21.8	23.2	21.1	6.6	Continental
6	GHARIAT	20.1	21.7	18.1	8.8	Continental
7	HON	21.2	22.8	15.8	5.6	Continental
8	JAGHBOUB	22.3	23.2	17.1	9.8	Continental
9	JALO	22.5	24.1	16.6	9.6	Continental
10	MISURATA	18.4	23.4	14.2	35.2	Oceanity
11	NALUT	18.0	20.9	18.7	15.5	Oceanity
12	SHAHAT	14.8	18.7	14.0	27.8	Oceanity
13	SIRTE	18.9	23.6	13.1	35.8	Oceanity
14	TOBRUK	17.9	22.6	13.1	35.9	Oceanity
15	TRIPOLI	19.0	22.9	16.5	23.6	Oceanity
16	ZWARA	18.1	22.9	14.8	32.4	Oceanity

The Source: Depending on: Libyan National Meteorological center climate & climate Change, Tripoli. 2012.

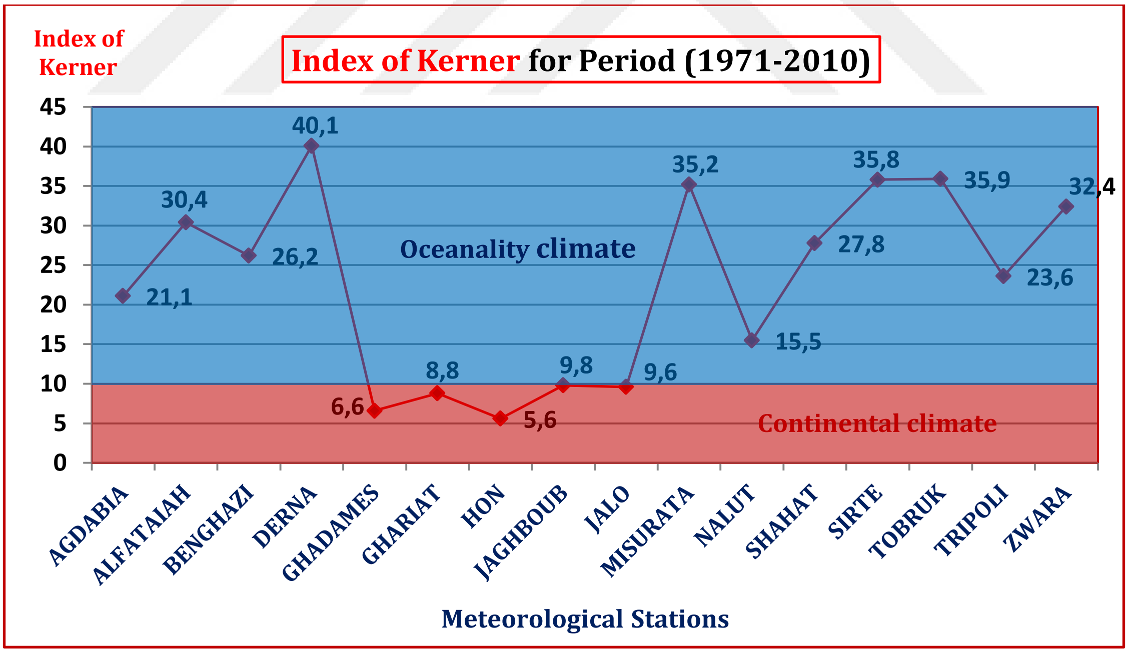
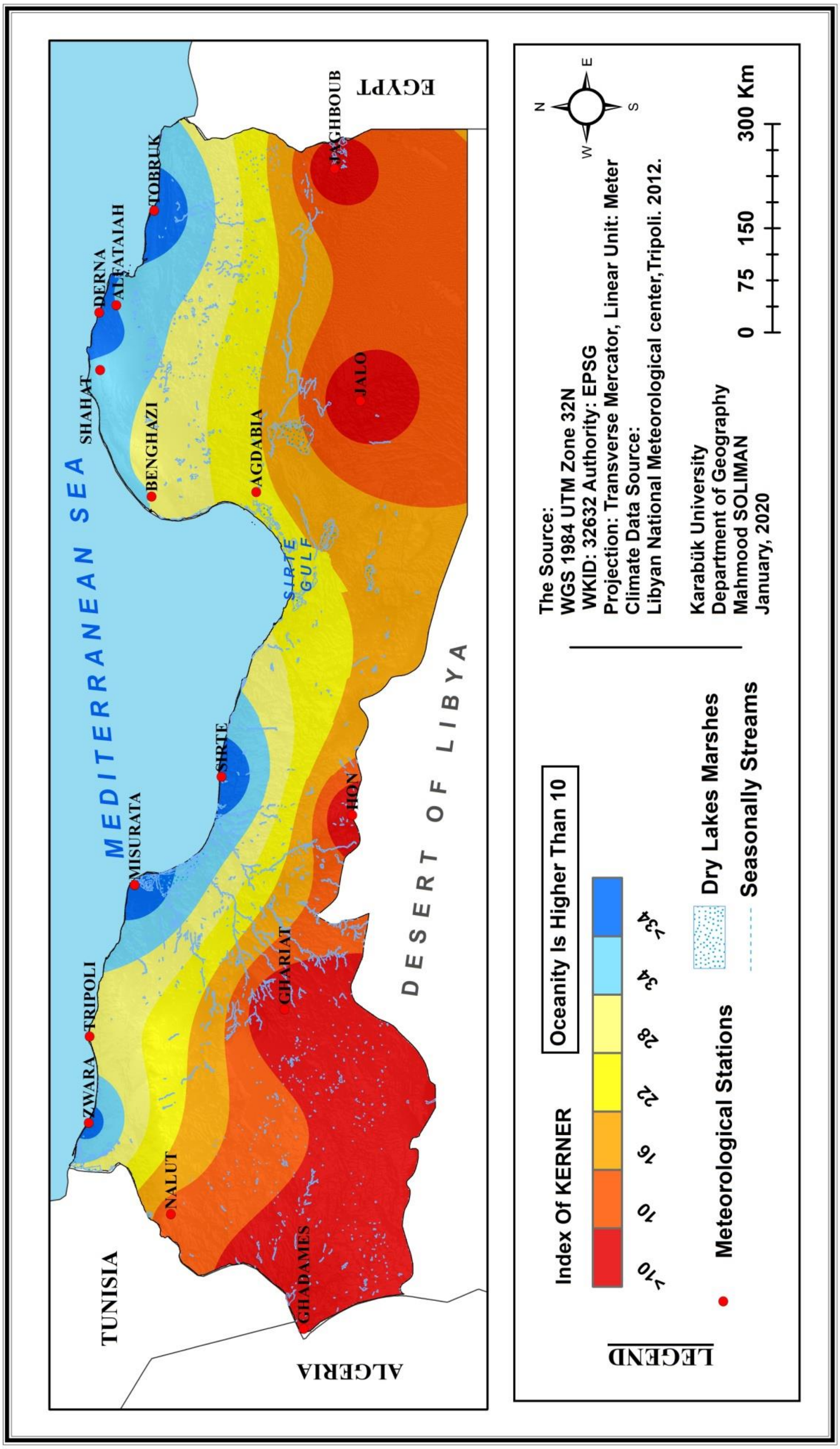


Figure 42. Continental Climate and Oceanity Climate for Kerner (1971-2010)

The Kerner index shows that the Ocean climate is concentrated in all stations near the Mediterranean Sea coast while the Continental climate prevails in the desert stations except for the JAGHBOUB station. However, the result (K_1= 11.1) is close to continental climate values which is a relatively correct result (Table 31 and Figure 43).



Map 23. Index of Kerner for Continental Climate and Oceanity Climate (1971-2010)

❖ Correlation Coefficient Between the two indicators (Johansson & Kerner)

The correlation coefficient between the equations shows very negative relationship between the results:

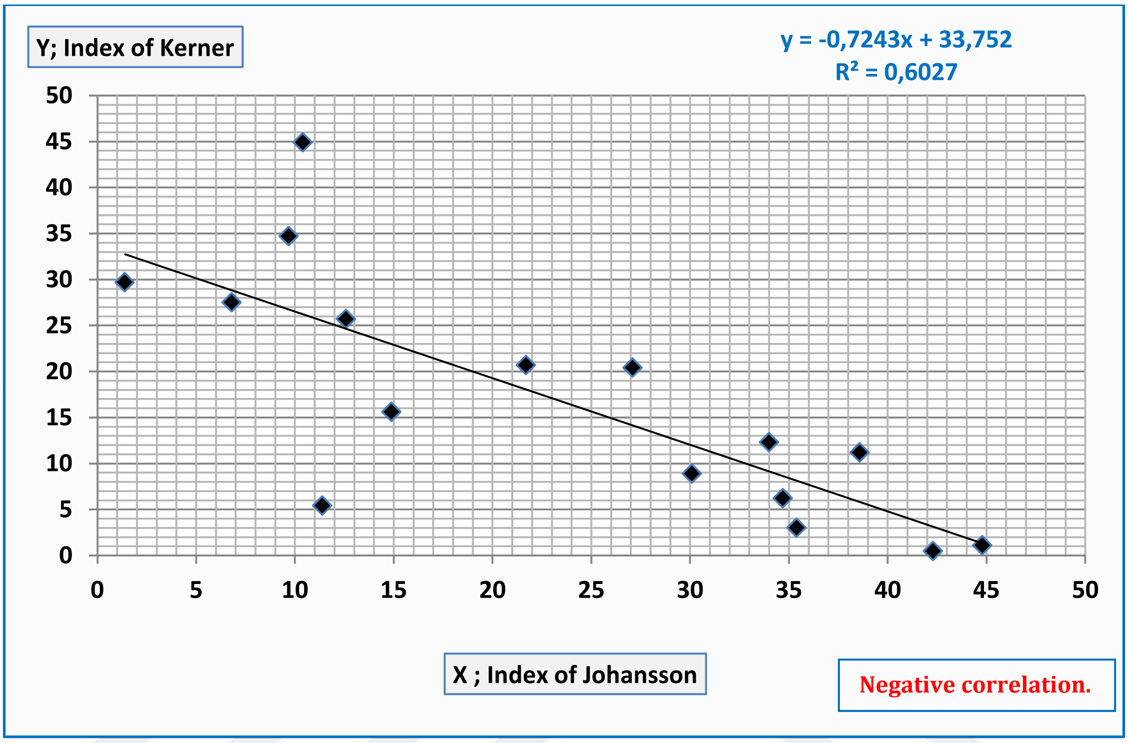


Figure 43. Correlation Between Indices of Johansson and Kerner (1971-2010)

Kerner index gave results close to Johnson index keeping in view the tables, figures and map, we can compare the results of the coastal stations and the internal stations in two indexes of Johansson and Kerner.

There isn't a significant correlation between Johansson and Kerner indices. Furthermore, in spite of an acceptable difference between distribution of the temperature patterns with Kerner Index variations do not support the desert patterns as only April and October data were used. However, that doesn't mean that there isn't a matching in the results as we use different standards between the equations. For example, in Johansson index, climate is characterized as marine when index varies between 0 and 33 while in Kerner index Ocean climate is Larger than 10 (Figure 44).

III. CHAPTER

DESCRIPTIVE STATISTICS AND DISTRIBUTION OF TEMPERATURE AND PRECIPITATION DATA

Descriptive statistics are found to be useful to obtain valuable conclusions in analysis of large amount of climatic data of certain period of time. Since statistical assessments are valuable for the analysis when data are processed by one season or even narrower interval of time. Otherwise, the variability exceeds the threshold of 30% which means there is lack of homogeneity and statistical analysis has no significance for the considered data (Borradaile, 2003).

This chapter will examine the statistical analysis of annual, seasonal and monthly temperatures and rainfall data of selected meteorological stations in the study area.

The chapter includes the analysis of standard deviations of the maximum and minimum values and general average of temperatures. The analyses can be summarized in following points:

- Descriptive statistics for temperature and precipitation data, in this analysis monthly averages, mode, median, standard deviation, dispersion, sigma, and other statistical processes were made.
- Investigation of data distribution, normal distribution of seasonal and annual temperature and precipitation variables using was calculated by Kolmogorov-Smirnov test.
- Homogeneity of variances, Kruskal-Wallis and Mann-Whitney tests for homogeneity performed for seasonal and annual temperatures and precipitation variables.
- Correlation analysis, Spearman's Rho and Kendall's tests to determine the relationship between temperatures and precipitation were perfumed.

3.1. Descriptive Statistics and Distributions of Temperature Data

The following tables and figures[(2)] show the results of statistical analyzes of maximum, minimum and average temperatures for selected years in stations of the study area:

Table 32. The Descriptive Statistics and Distributions of Annual Temperature in AGDABIA Station for Period (1971-2010)

Years	Annual Maximum Temperature °C			Annual Minimum Temperature °C			Annual Average Temperature °C		
	Mean	Median	Standard Deviation	Mean	Median	Standard Deviation	Mean	Median	Standard Deviation
1971	26.4	27.6	5.8	13.7	14.0	4.6	20.1	20.8	5.2
1972	27.0	27.3	6.6	14.3	15.3	5.6	20.7	21.4	6.0
1973	26.7	27.6	6.4	14.0	14.1	4.9	20.3	20.9	5.6
1974	26.6	28.7	6.2	14.2	15.0	4.7	20.5	21.9	5.4
1975	26.2	27.6	5.6	13.9	14.6	4.4	20.0	21.1	5.0
1976	26.4	27.6	6.4	14.1	15.0	4.9	20.3	21.4	5.6
1977	27.1	26.0	6.7	14.5	13.9	5.2	20.8	20.0	5.9
1978	26.6	27.0	5.7	14.4	15.1	4.3	20.5	21.1	5.0
1979	27.3	28.1	5.6	14.5	14.4	4.7	20.9	21.3	5.1
1980	26.6	27.8	6.1	13.6	14.2	4.7	20.1	21.0	5.4
1981	26.8	29.0	6.8	14.2	15.1	5.0	20.5	22.1	5.9
1982	26.7	27.9	6.4	13.8	14.4	5.2	20.3	21.2	5.8
1983	26.5	27.7	6.2	13.8	14.5	4.7	20.2	21.0	5.4
1984	26.9	27.8	6.4	13.9	14.2	4.9	20.4	21.0	5.7
1985	27.0	27.1	5.6	14.1	13.5	4.2	20.6	20.3	4.9
1986	26.4	27.4	5.9	14.3	14.3	5.0	20.4	21.0	5.4
1987	26.8	26.6	6.1	14.1	13.8	5.0	20.5	20.2	5.6
1988	27.4	28.4	7.0	15.4	14.8	5.8	21.4	21.6	6.4
1989	27.4	28.8	6.0	14.7	15.6	5.3	21.1	22.2	5.7
1990	27.4	29.0	5.9	14.8	15.8	5.1	21.1	22.2	5.5
1991	26.7	28.2	6.2	14.9	15.4	5.2	20.8	21.8	5.7
1992	26.5	27.4	6.6	14.3	14.9	5.4	20.4	20.9	5.9
1993	27.2	28.4	6.3	14.7	15.7	5.3	21.0	21.9	5.8
1994	26.7	28.6	5.9	15.3	15.7	4.9	21.0	22.3	5.3
1995	27.5	26.5	7.1	15.3	14.4	6.4	21.4	20.5	6.7
1996	27.2	26.4	6.2	15.4	14.6	5.1	21.3	20.5	5.6
1997	27.0	27.3	6.5	14.7	15.0	5.8	20.9	21.2	6.1
1998	27.1	30.0	6.5	15.3	16.4	5.5	21.2	23.2	6.0
1999	28.1	29.4	6.5	15.7	16.0	5.7	21.9	22.8	6.0
2000	27.0	28.7	6.0	15.0	15.9	5.3	21.0	22.3	5.6
2001	27.5	27.8	6.0	15.8	15.9	5.2	21.7	21.9	5.5
2002	27.6	27.9	6.7	15.9	15.6	5.9	21.8	21.8	6.3
2003	27.4	28.3	6.5	16.1	16.3	5.9	21.8	22.1	6.2
2004	27.3	28.3	5.6	15.9	16.6	4.9	21.6	22.5	5.2
2005	27.2	28.3	6.3	15.7	15.5	5.4	21.5	22.0	5.8
2006	26.9	27.6	6.1	15.6	15.9	5.6	21.3	21.8	5.8
2007	27.4	28.2	5.8	16.4	16.0	5.9	22.0	22.1	5.8
2008	28.0	29.2	6.2	16.2	17.0	5.7	22.1	23.1	5.9
2009	27.5	28.2	5.7	16.3	16.1	5.2	21.9	22.3	5.4
2010	28.8	29.6	4.7	17.0	17.4	4.8	22.9	23.6	4.7
G.Average	27.10	27.98	6.17	14.90	15.20	5.18	21.00	21.61	5.65

The temperatures: Values are red: above average.
Values are blue: below average.

[2]In Figures, only the General average is entered. The (The columns Red), so there is a difference in Results of the statistical analysis of the years in detail, and the years in General Averages.

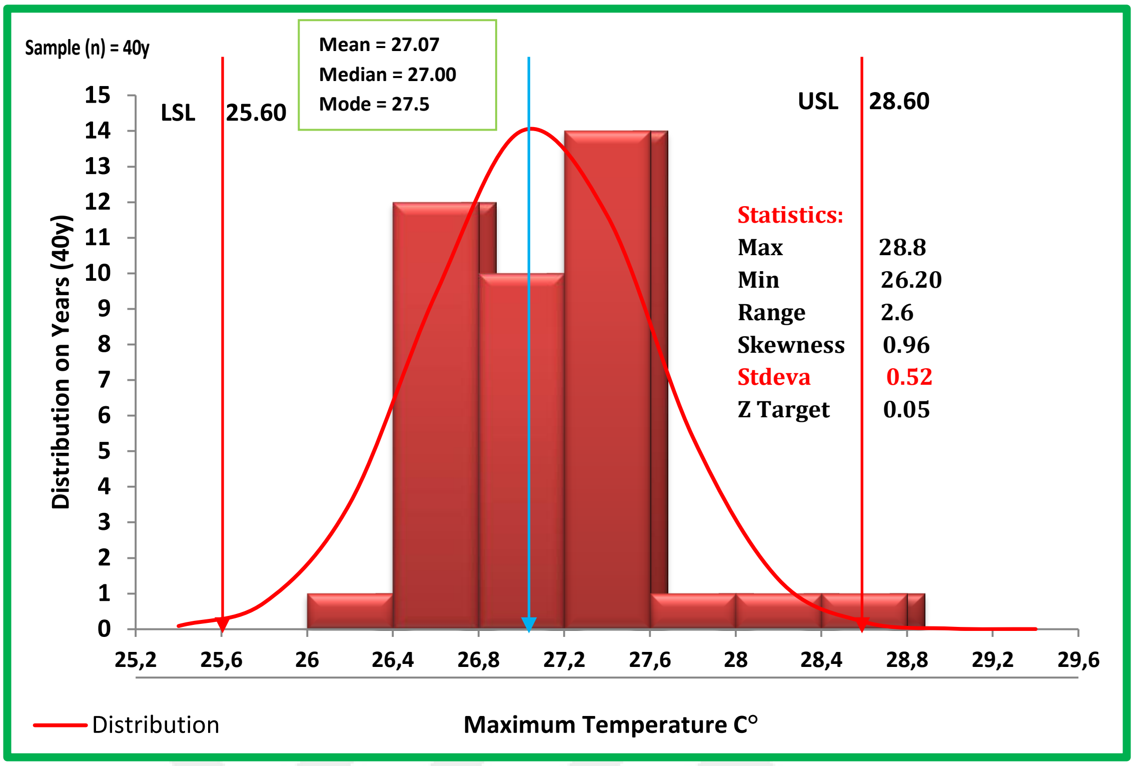


Figure 44. Statistics of Annual Maximum Temperature in AGDABIA Station for Period (1971-2010)

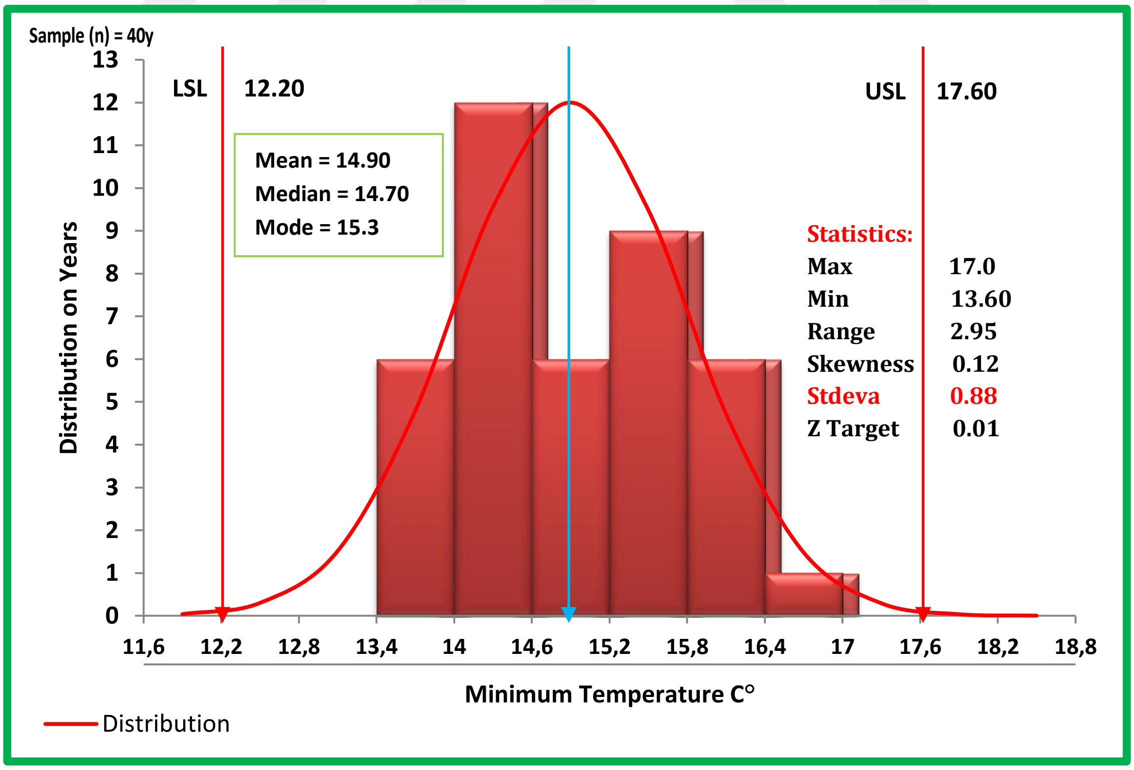


Figure 45. Statistics of Annual Minimum Temperature in AGDABIA Station for Period (1971-2010)

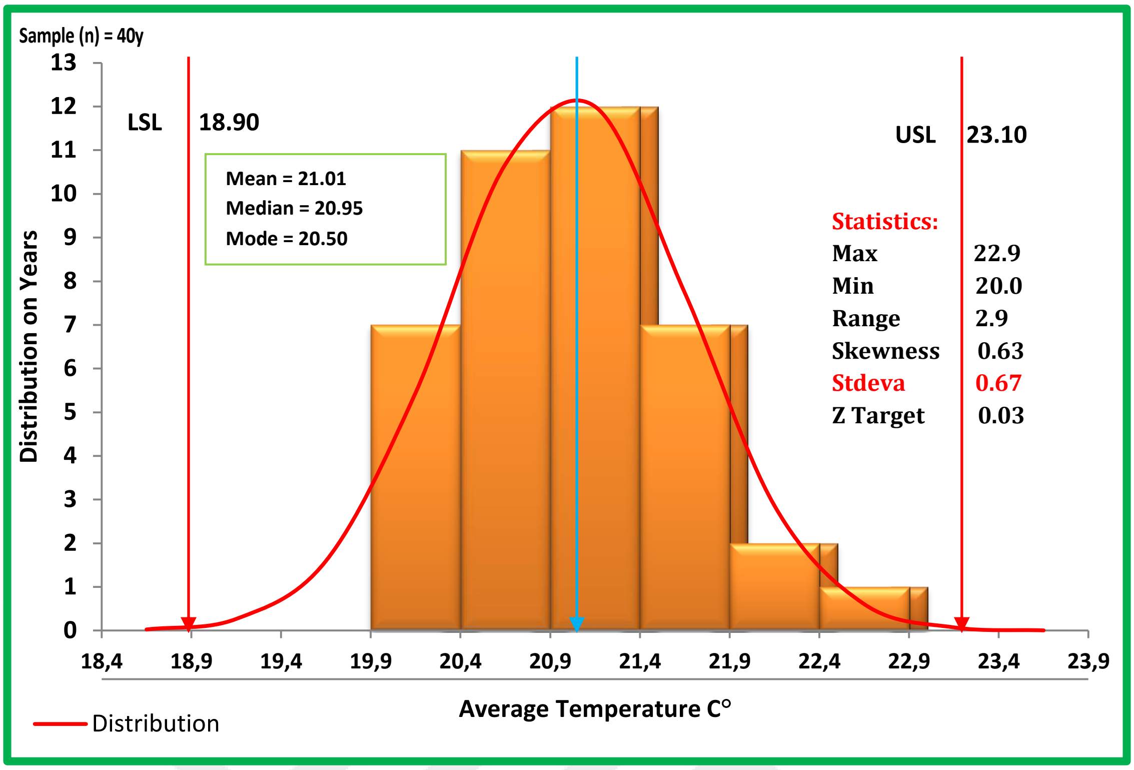


Figure 46. Statistics of Annual Average Temperature in AGDABIA Station for Period (1971-2010)

The table 32 increase in the maximum and minimum temperature in recent years at AGDABIA station. The above average temperatures are observed most of the selected years as from 1995 to 2010 indicating that there is a general trend towards warming during 15 consecutive years in the monitoring period. Figure 45 shows the of distribution of temperature over years. It is observed from the figure that maximum temperature (27.6 °C) encompasses14 years and maximum temperature (26.8 °C) is distributed to 11 years while the rest of temperatures were distributed on 9 years at temperature of (27.2 °C). Besides, temperatures of (26 °C), (27.6 °C), (28 °C), and (28.8 °C) are found for one year each.

The maximum of the standard deviation curve is found at point of temperature (27.07 °C) while th lowest point is at (25.6 °C). In figure 46 it is found that the minimum temperature of (14.6 °C) is the highest during 12 years. Temperature is found stable at (15.2 °C) over a period of 8 years, while the temperature (13.4, 15.2 and 16.4°C) are found stabilized over 6 years. The standard deviation curve reached to a limit of (14.9 °C). In the figure 47 the average temperature reached in distribution curve to (21.01 °C) and found stabilized. The curve is to the highest level at the right of the figure at (23.10 °C), and in left to lowest (18.9 °C).Temperatures are found distributed between 1, 2, 7, 10, and 11 years, started from (19.9 °C).

Table 33. The Descriptive Statistics and Distributions of Annual Temperature in ALFATAIAH Station for Period (1981-2010)

Years	Annual Maximum Temperature °C			Annual Minimum Temperature °C			Annual Average Temperature °C		
	Mean	Median	Standard Deviation	Mean	Median	Standard Deviation	Mean	Median	Standard Deviation
1981	22.9	22.5	5.8	13.2	12.0	5.9	18.0	17.1	5.7
1982	23.0	23.2	5.5	13.3	11.6	5.9	18.4	17.4	6.6
1983	22.4	23.3	5.3	12.8	12.4	5.1	16.8	17.7	6.7
1984	23.1	23.7	5.1	13.1	12.5	5.0	18.0	18.4	5.1
1985	23.0	23.4	4.7	13.3	12.9	5.0	18.2	17.8	4.8
1986	23.0	23.3	5.0	13.1	11.9	5.2	18.3	17.6	4.9
1987	22.7	22.0	5.4	13.2	13.0	5.8	18.0	17.8	5.6
1988	23.0	23.3	5.9	13.3	12.6	5.4	18.4	18.0	5.6
1989	22.7	24.0	5.5	13.0	12.1	5.1	17.8	18.4	5.2
1990	23.0	24.1	5.3	13.7	12.8	5.1	18.3	18.5	5.2
1991	22.8	22.9	5.7	13.3	12.5	5.4	18.1	17.7	5.5
1992	22.4	22.8	6.4	12.5	11.7	5.3	17.4	17.3	5.7
1993	23.4	23.9	5.8	12.8	12.5	5.3	18.1	18.2	5.5
1994	23.5	25.3	5.3	14.1	13.9	5.4	18.8	19.2	5.3
1995	23.3	21.3	5.9	12.7	11.8	5.6	18.0	16.9	5.6
1996	23.3	22.7	5.5	12.3	11.2	5.6	17.8	17.3	5.5
1997	23.3	23.9	5.4	12.1	11.2	5.1	17.7	17.5	5.2
1998	23.8	24.8	5.9	14.2	14.2	5.3	19.0	19.5	5.5
1999	25.2	27.1	8.7	13.6	13.8	6.1	19.1	19.9	5.7
2000	23.6	24.9	5.5	13.2	12.3	5.4	19.3	20.2	4.7
2001	24.2	24.3	5.3	14.0	12.7	5.9	18.8	17.6	5.5
2002	24.0	24.2	5.8	13.3	12.4	5.8	18.7	18.4	5.7
2003	23.7	24.5	6.1	14.2	12.7	6.2	19.0	18.6	6.1
2004	23.9	24.3	5.3	14.6	15.0	5.4	19.2	19.5	5.3
2005	23.4	23.3	5.5	13.2	12.7	5.5	18.3	18.3	5.5
2006	23.4	23.9	5.3	13.1	12.5	5.7	18.3	18.3	5.5
2007	24.0	24.1	5.3	13.9	13.5	5.4	19.0	18.8	5.3
2008	24.2	25.3	5.4	13.9	13.4	5.9	19.1	19.8	5.5
2009	23.8	23.7	4.7	13.8	13.2	5.4	18.8	18.2	5.0
2010	23.0	24.0	5.2	13.3	11.6	5.9	19.0	18.9	5.2
General Average	23.37	23.80	5.58	13.34	12.62	5.50	18.39	18.29	5.47

The temperatures: Values are red: above average.
Values are blue: below average.

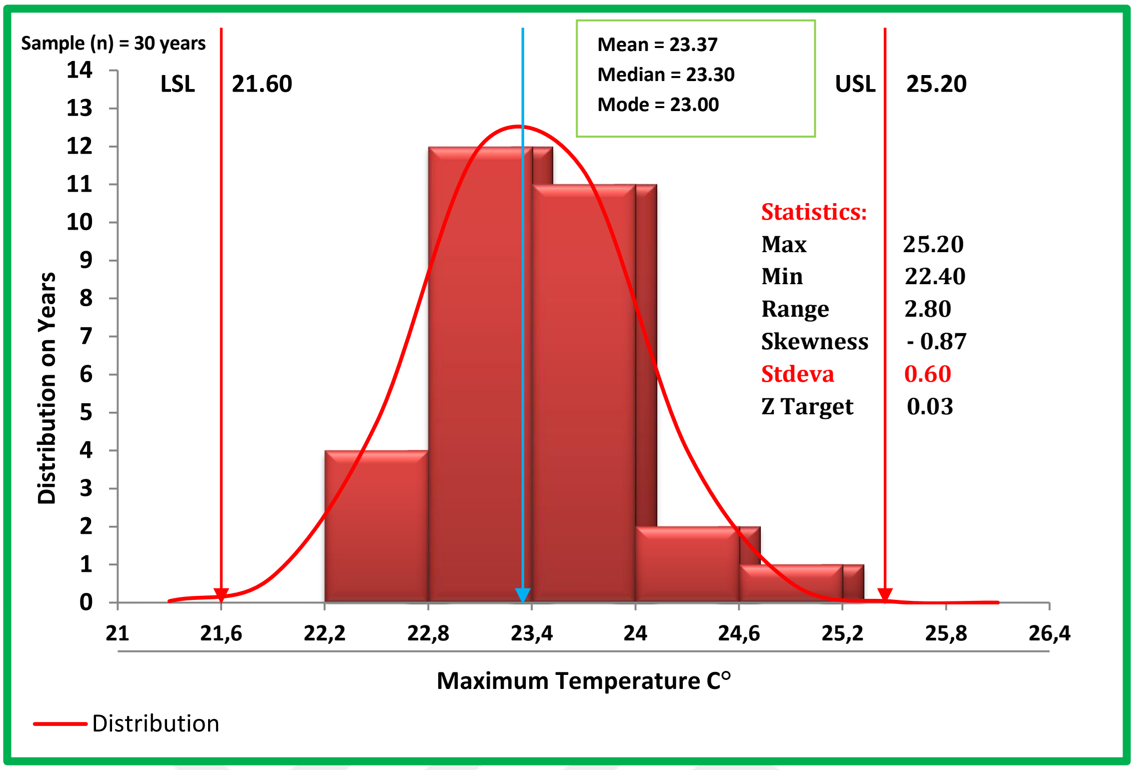


Figure 47. Statistics of Annual Maximum Temperature in ALFATAIAH Station for Period (1981-2010)

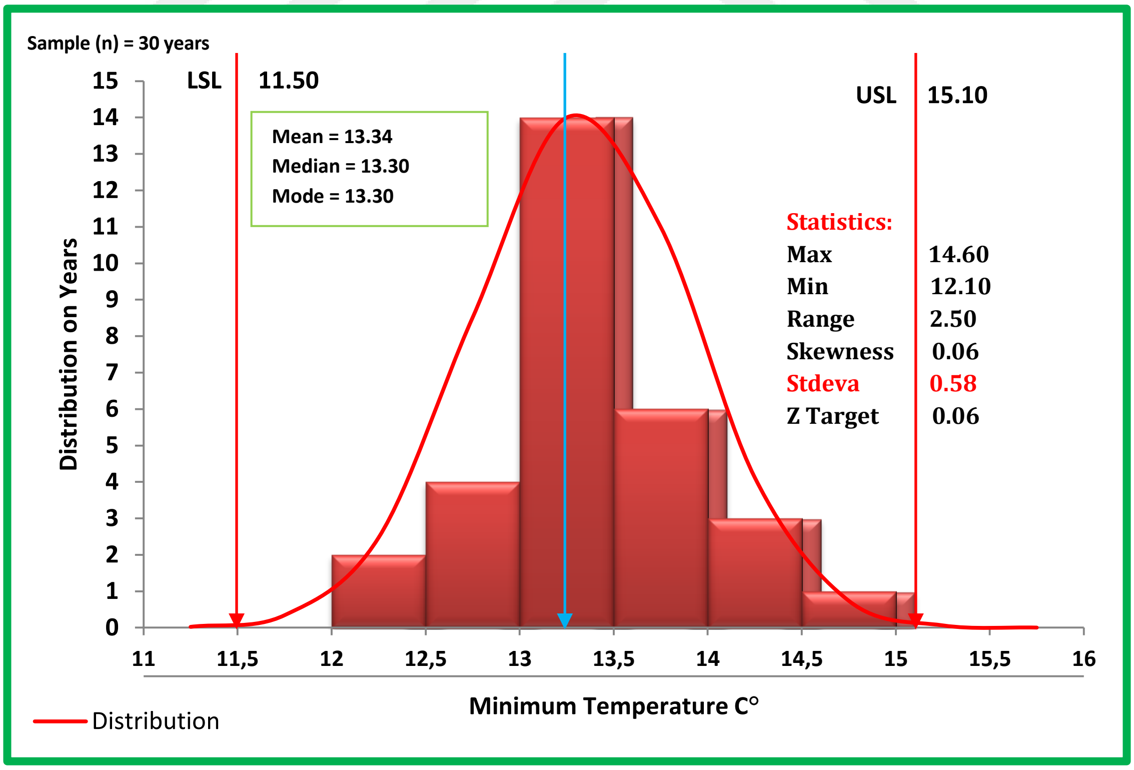


Figure 48. Statistics of Annual Minimum Temperature in ALFATAIAH Station for Period (1981-2010)

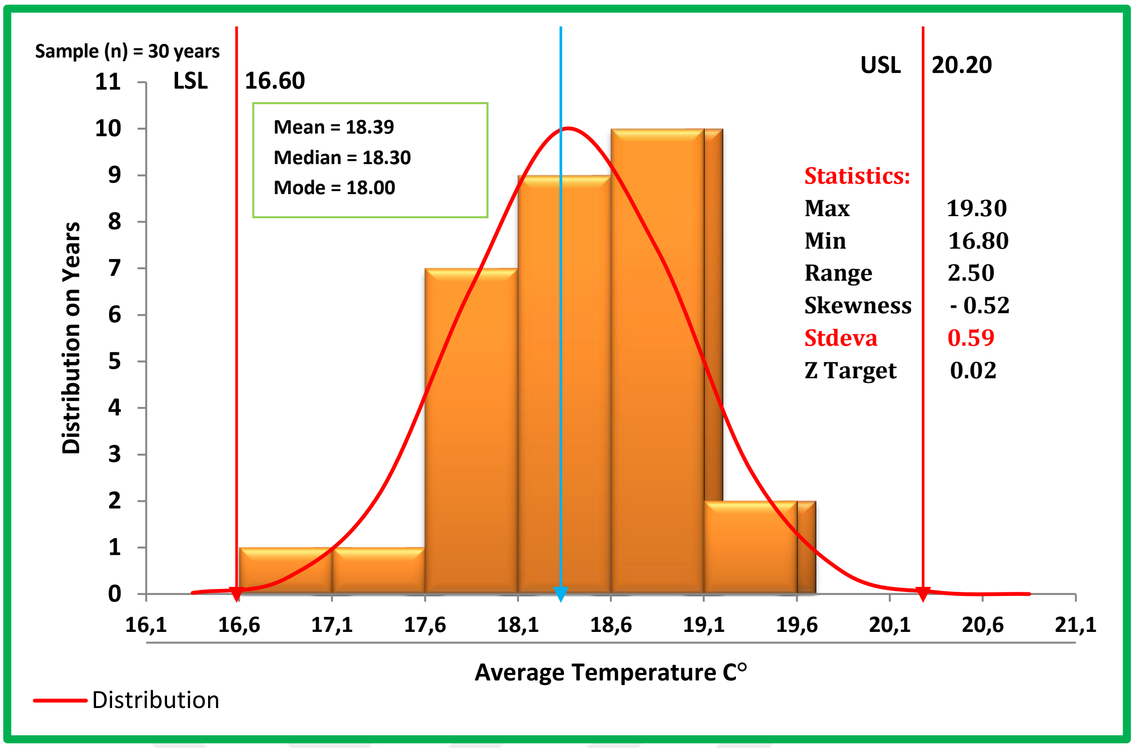


Figure 49. Statistics of Annual Average Temperature in ALFATAIAH Station for Period (1981-2010)

Table 33 shows an increase in the maximum and average temperature in recent years. at ALFATAIAH station. The temperature is found above average in most of years from 1998 to 2010 indicating that there is a general trend towards warming during 12 consecutive years in the monitoring period. However, the maximum temperatures do not show normal distribution over the monitoring years.

It is observed in figure 48 that the maximum temperature of (22.8 °C) spanned over 12 years, (23.4 °C) over11 years and the rest of temperatures were distributed as 4 years at temperatures of (22.2 °C), two years for (24 °C) and (28.8 °C) and one year for temperature (25.2 °C). The maximum of standard deviation curve is found at a point of (23.4 °C) and the lowest point at (21.6 °C). In figure 49 it is found that the minimum temperature (13 °C) is found highest during 14 years and the temperature remained stable on (13.5 °C) over a period of 5 years, while the temperature (12.5 °C) is found stabilized over 4 years. The temperatures are found distributed at one year at temperatures (16.6, 17.1 and 17.6 °C).The standard deviation curve reached to maximum limit of (14.6 °C). Figure 50 describes that the average temperature reached in distribution curve to (19.3 °C) and remained stabilized. The curve is to the highest level at the right of the figure at (20.2 °C) and in left to lowest (16.6 °C).

Table 34. The Descriptive Statistics and Distributions of Annual Temperature in BENGHAZI Station for Period (1971-2010)

Years	Annual Maximum Temperature °C			Annual Minimum Temperature °C			Annual Average Temperature °C		
	Mean	Median	Standard Deviation	Mean	Median	Standard Deviation	Mean	Median	Standard Deviation
1971	25.0	26.1	5.9	14.9	14.9	4.6	20.0	20.5	5.2
1972	25.6	25.6	6.3	15.2	15.2	5.2	20.4	20.6	5.7
1973	25.6	26.0	6.5	15.0	14.9	5.1	20.3	20.6	5.8
1974	25.8	27.4	6.2	15.1	15.1	4.9	20.4	21.3	5.6
1975	24.9	25.9	5.6	14.4	14.8	4.7	19.7	20.4	5.1
1976	24.8	26.1	6.1	14.7	15.0	4.9	19.7	20.6	5.5
1977	25.9	24.4	6.0	15.6	14.7	5.0	20.8	19.5	5.5
1978	24.9	25.4	5.9	14.8	15.2	4.3	19.9	20.3	5.1
1979	25.7	25.9	5.8	15.4	14.2	4.9	20.6	20.0	5.3
1980	25.1	26.4	6.2	14.9	15.4	4.7	20.0	20.9	5.4
1981	25.4	27.7	6.9	15.6	15.8	5.3	20.5	21.7	6.1
1982	25.6	25.9	7.0	15.2	14.8	5.2	20.5	20.5	6.1
1983	25.1	26.5	6.3	14.8	15.5	4.8	20.0	20.9	5.6
1984	24.8	25.8	6.0	15.0	16.0	4.9	19.9	20.9	5.4
1985	25.1	25.4	5.3	15.3	15.0	4.5	20.2	20.2	4.8
1986	24.8	25.3	5.5	15.0	14.6	4.9	19.9	20.0	5.2
1987	25.3	26.7	5.9	15.0	14.2	5.0	20.1	19.9	5.4
1988	25.4	25.8	7.1	16.1	15.9	5.5	20.8	20.9	6.3
1989	24.9	26.0	5.9	15.5	15.8	5.0	20.2	20.9	5.5
1990	24.8	26.1	5.6	15.8	16.6	4.8	20.3	21.1	5.2
1991	24.1	24.5	6.1	15.3	14.9	5.0	19.7	19.6	5.5
1992	24.1	24.6	6.5	15.0	15.2	5.3	19.6	19.9	5.9
1993	24.7	25.5	6.2	15.6	16.0	5.3	20.2	20.8	5.7
1994	24.4	26.2	5.7	16.0	15.6	4.9	20.2	21.1	5.2
1995	24.9	24.0	6.8	15.7	14.1	5.9	20.3	19.4	6.3
1996	24.6	23.9	6.0	15.4	14.9	5.1	20.0	19.3	5.6
1997	24.2	24.2	6.3	15.5	16.1	5.5	19.9	20.3	5.9
1998	24.6	27.2	6.5	16.3	17.2	5.3	20.5	22.3	5.9
1999	25.7	26.4	6.3	16.6	17.6	5.3	21.2	22.1	5.8
2000	24.9	26.2	5.9	16.2	17.3	4.9	20.6	21.7	5.4
2001	25.3	25.7	5.9	16.5	16.9	5.1	20.9	21.1	5.4
2002	25.0	24.7	6.0	16.5	16.4	5.3	20.7	20.5	5.7
2003	25.4	26.3	6.7	16.0	16.3	5.5	20.7	21.3	6.1
2004	25.4	26.2	5.6	15.4	15.3	4.5	20.4	20.8	5.0
2005	25.2	25.8	6.3	14.9	15.1	5.3	20.1	20.5	5.8
2006	25.1	25.6	6.0	14.7	14.4	5.1	19.9	20.2	5.5
2007	25.4	25.7	5.9	15.2	14.9	4.8	20.3	20.1	5.3
2008	25.8	26.6	6.1	15.4	16.0	5.3	20.6	21.3	5.6
2009	25.1	25.6	5.6	15.3	14.4	4.9	20.3	20.1	5.2
2010	26.3	27.0	4.9	15.9	15.9	4.5	21.2	21.5	4.7
General Average	25.12	25.81	6.08	15.42	15.45	5.03	20.29	20.64	5.53

The temperatures: Values are red: above average.
Values are blue: below average.

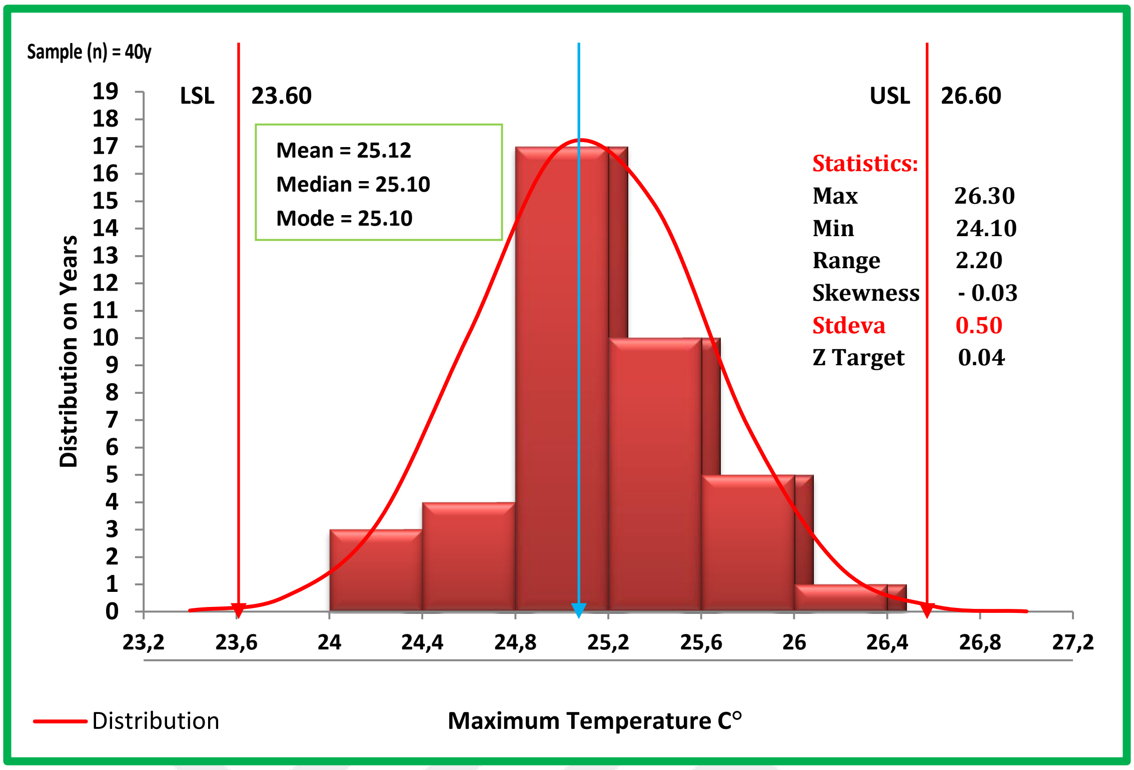


Figure 50. Statistics of Annual Maximum Temperature in BENGHAZI Station for Period (1971-2010)

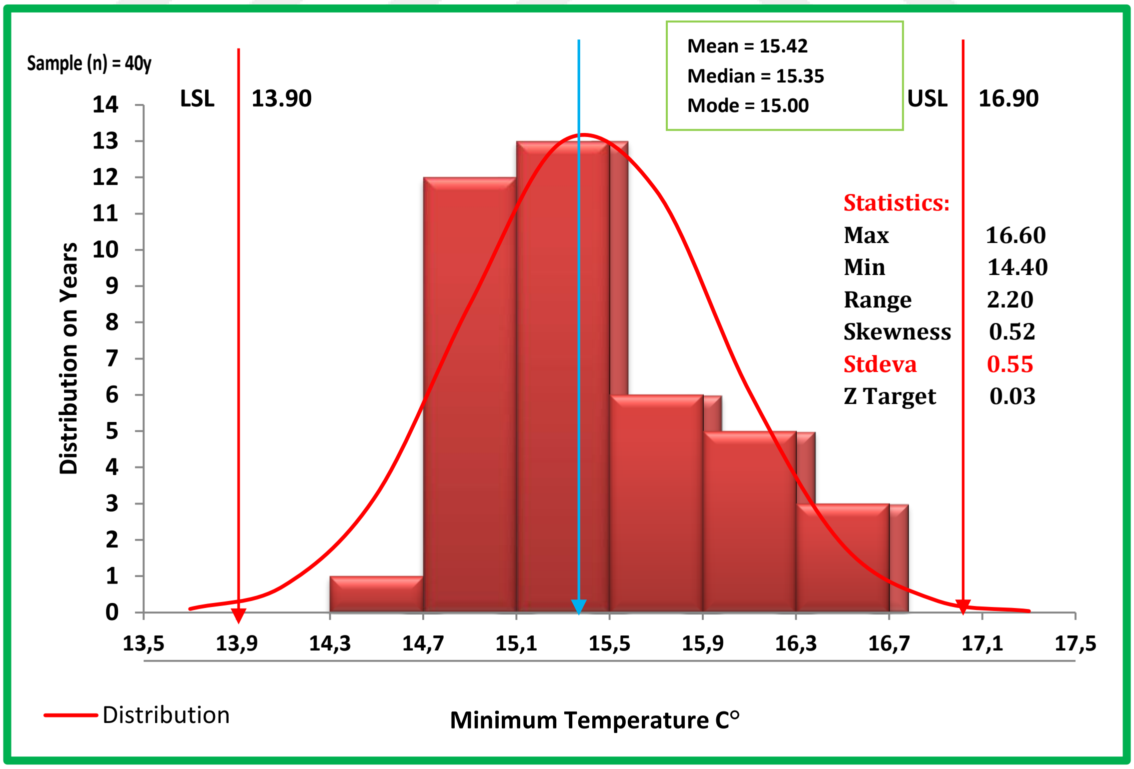


Figure 51. Statistics of Annual Minimum Temperature in BENGHAZI Station for Period (1971-2010)

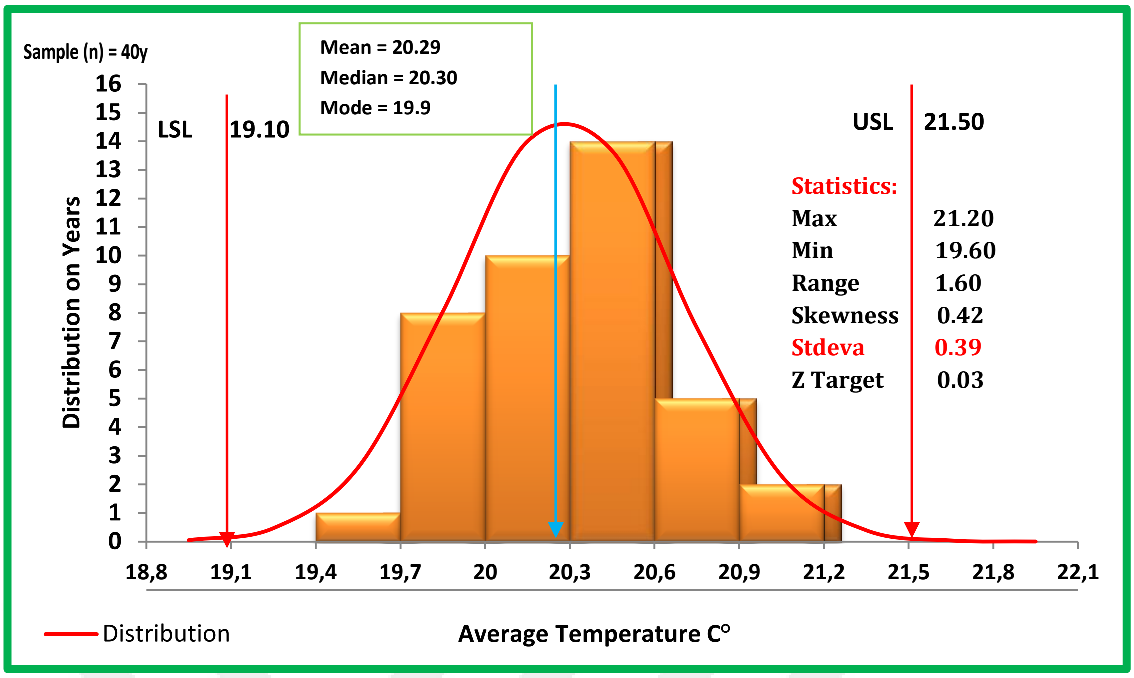


Figure 52. Statistics of Annual Average Temperature in BENGHAZI Station for Period (1971-2010)

Table 34 shows an increase in the average temperature in recent years at BENGHAZI station. It is found that the years with above average temperatures range from 1998 to 2010 indicating that there is a general trend towards warming during 12 consecutive years in the monitoring period.

It is observed in figure 51 that maximum temperature of (24.8 °C) spanned over16 years, temperature of (25.2 °C) over 9 years, while the rest of temperatures were distributed as 5 years at temperatures (25.6 °C), 4 years at (24.4 °C), 3 years at (24 °C) and one year for temperature (26 °C).The maximum standard deviation curve is found at a point of (25.1 °C) while the lowest point at (23.6 °C). In figure 52 the minimum temperature of (15.1 °C) is found the highest during 13 years while the temperature was stable on (14.7 °C) over a period of 12 years. Moreover, the temperature of (15.5 °C) is found stabilized over 6 years, (15.9 °C) over 5 years, (16.3 °C) over 3 years and (14.3 °C) for one year. Figure 53 shows the semi-normal distribution of average temperatures over the monitoring years. The temperatures were distributed as (20.3 to 20.6 °C) over 14 years, (20 °C) over 10 years, (19.7 °C) over 8 years, (20.6 °C) over 5 years, (20.9 °C) over 2 years and one years for (19.4 °C). The curve of distribution reached at (20.3 °C) and stabilized. The curve is found to the highest level at the right of the figure at (21.5 °C) and in left to lowest at (19.1 °C).

Table 35. The Descriptive Statistics and Distributions of Annual Temperature in DERNA Station for Period (1971-2010)

Years	Annual Maximum Temperature °C			Annual Minimum Temperature °C			Annual Average Temperature °C		
	Mean	Median	Standard Deviation	Mean	Median	Standard Deviation	Mean	Median	Standard Deviation
1971	23.6	23.8	4.2	16.6	16.6	4.5	20.1	20.2	4.3
1972	23.9	23.3	4.5	16.5	15.7	4.7	20.2	19.3	4.6
1973	23.6	23.3	4.3	16.5	15.6	4.9	20.0	19.4	4.6
1974	23.2	23.0	4.6	16.4	15.6	4.7	19.8	19.2	4.6
1975	22.9	23.8	4.2	16.3	16.1	4.6	19.6	20.0	4.3
1976	22.7	22.7	4.5	16.3	16.1	4.7	19.5	19.4	4.6
1977	23.7	24.1	4.1	16.8	16.5	4.4	20.2	20.6	4.3
1978	22.9	23.1	3.8	16.6	16.0	4.4	19.8	19.4	4.1
1979	23.6	22.4	4.3	16.7	15.3	4.2	20.2	18.9	4.2
1980	23.1	23.7	4.5	16.1	14.6	4.7	19.6	19.0	4.5
1981	23.3	22.6	4.7	17.2	16.3	5.1	20.3	19.3	4.9
1982	23.1	22.4	4.6	16.7	15.7	4.7	19.9	19.1	4.7
1983	22.7	23.5	4.6	16.2	16.3	4.9	19.5	20.0	4.8
1984	23.4	23.9	4.4	16.4	16.6	4.5	19.9	20.7	4.4
1985	23.6	24.1	3.9	16.7	16.6	4.4	20.2	20.5	4.1
1986	23.1	22.3	4.5	16.5	15.4	5.0	19.9	18.8	4.6
1987	22.9	22.5	4.7	16.3	15.4	4.9	19.6	19.0	4.8
1988	23.5	23.6	5.2	16.8	16.1	4.9	20.2	20.0	5.1
1989	23.2	23.9	4.8	16.7	16.6	4.6	20.0	20.2	4.7
1990	23.5	23.9	4.4	17.3	17.1	4.4	20.4	20.5	4.4
1991	23.0	22.9	4.7	16.8	16.1	4.7	19.9	19.5	4.7
1992	22.6	22.6	5.4	16.9	16.2	4.8	19.7	19.4	5.2
1993	23.1	23.5	4.7	16.8	16.7	5.1	20.0	20.1	4.8
1994	23.4	23.7	4.5	17.6	17.2	4.9	20.5	20.1	4.7
1995	23.1	22.0	4.8	17.1	15.5	5.1	20.1	18.7	4.9
1996	22.9	22.9	4.7	16.9	16.5	4.9	19.9	19.7	4.7
1997	22.9	23.7	4.6	17.0	16.8	4.8	19.9	20.2	4.7
1998	23.8	24.2	5.1	17.7	16.8	5.1	20.7	20.5	5.1
1999	23.8	24.9	4.8	18.0	18.5	5.3	20.9	21.7	5.0
2000	22.9	24.0	4.7	17.6	17.5	4.9	20.3	20.7	4.8
2001	23.7	23.9	4.6	18.1	17.4	4.9	21.1	20.7	4.6
2002	24.2	24.2	5.0	18.1	17.6	5.2	21.2	20.9	5.1
2003	24.0	24.3	5.5	18.3	17.8	5.6	21.1	21.1	5.5
2004	23.5	23.5	4.2	18.1	17.7	4.7	21.0	20.6	4.6
2005	23.4	23.6	4.7	17.8	17.6	5.2	20.6	20.6	4.9
2006	23.3	23.2	4.5	17.7	17.0	5.2	20.5	20.0	4.9
2007	23.4	23.7	4.8	17.2	16.5	4.7	20.5	20.1	4.6
2008	24.1	25.1	4.6	18.3	18.4	5.0	21.3	21.6	4.7
2009	23.8	22.8	4.3	18.2	17.7	4.9	21.0	20.3	4.6
2010	24.8	25.8	3.7	18.4	17.8	4.4	21.6	21.8	4.0
General Average	23.38	23.51	4.57	17.11	16.59	4.82	20.27	20.05	4.67

The temperatures: Values are red: above average.
Values are blue: below average.

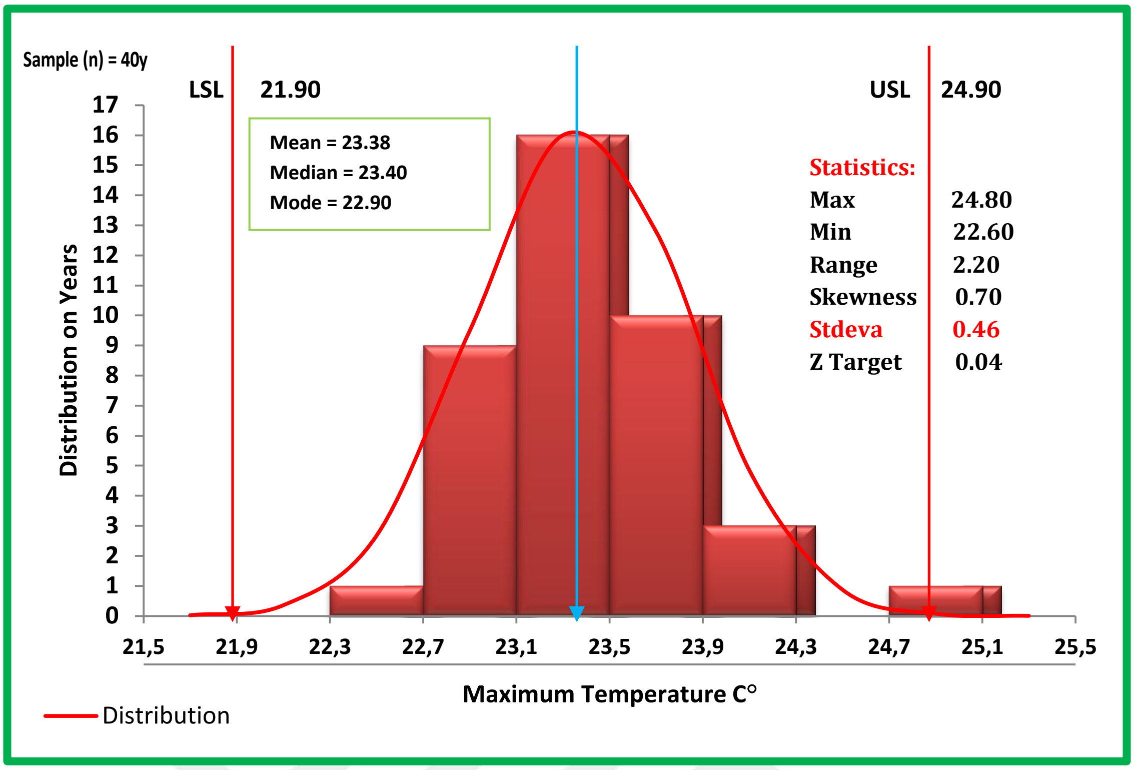


Figure 53. Statistics of Annual Maximum Temperature in DERNA Station for Period (1971-2010)

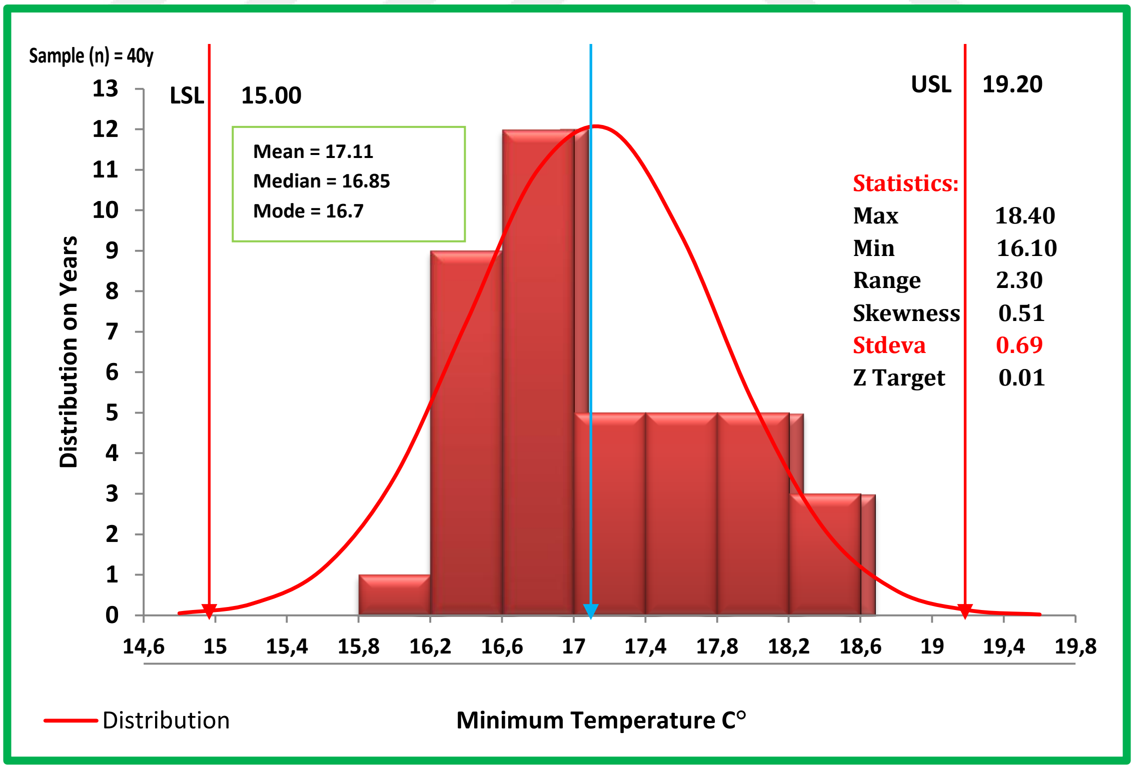


Figure 54. Statistics of Annual Minimum Temperature in DERNA Station for Period (1971-2010)

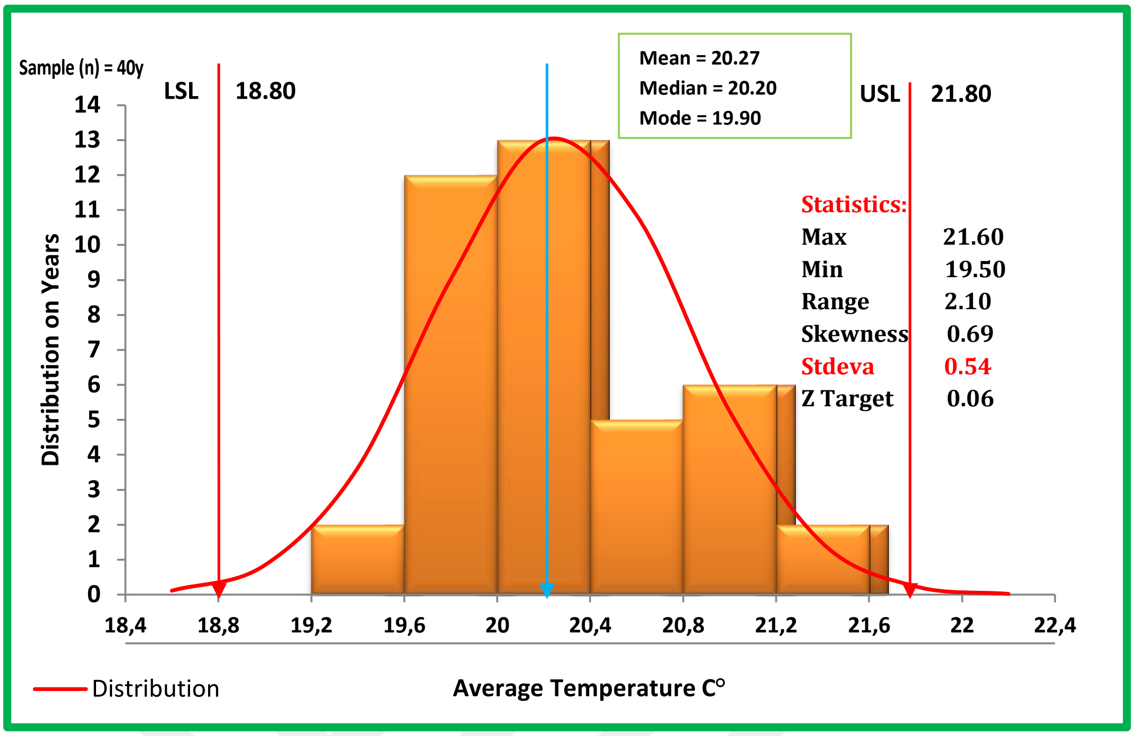


Figure 55. Statistics of Annual Average Temperature in DERNA Station for Period (1971-2010)

The table 35 shows an increase in the average temperature in recent years at DERNA station. Just like the above mentioned stations, the temperature was found above average for most of the years from 1998 to 2010 indicating that there is a general trend towards warming during 12 consecutive years in the monitoring period.

The maximum temperatures show semi-normal distribution over the monitoring years. It is observed in the figure 54 that maximum temperature of (23.1 °C) is distributed over 16 years and (23.5 °C) is distributed over 10 years while the rest of temperatures are distributed as (22.7 °C) over 9 years , (23.9 °C) over 3 years, (23.9 °C) over 3 years, and (22.3 °C) over one year. There is one extreme year in which the temperature rises to (24.7 °C). The maximum of standard deviation curve is found at a point of (25.1 °C) while the lowest point is at (23.6 °C). According to figure 55 the minimum temperature of (16.6 °C) is the highest during period of 12 years. The temperature has remained stable at (16.2 °C) over a period of 9 years, while the temperature over 15 years period is distributed at (17, 17.4, 17.8, 18.2 °C). The temperature of (18.2 °C) is found stabilized over 3 years and (15.9 °C) over 5 years. The average temperatures show semi-normal distribution in the figure 56 over the monitoring years. The temperatures are found distributed at (20 to 20.4 °C) over 13 years, (19.6v °C) over 12 years, (20.8 °C) over 6 years, (20.4 °C) over 5 years, (21.2 °C) over two year, and (19.2 °C) over two years. The distribution curve has reached at (20.2b°C) and stabilized. The curve is found to the highest level at the right of the figure at (21.8°C) and in left of figure to lowest at (18.8b°C).

Table 36. The Descriptive Statistics and Distributions of Annual Temperature in GHADAMES Station for Period (1971-2010)

Years	Annual Maximum Temperature °C			Annual Minimum Temperature °C			Annual Average Temperature °C		
	Mean	Median	Standard Deviation	Mean	Median	Standard Deviation	Mean	Median	Standard Deviation
1971	29.2	29.5	8.8	13.5	14.0	7.3	21.4	21.8	8.0
1972	29.8	28.5	9.0	13.9	13.9	7.9	21.9	21.2	8.4
1973	29.6	30.7	10.0	13.3	13.5	8.4	21.5	22.1	9.2
1974	28.7	28.7	8.9	12.2	13.6	7.2	20.5	21.2	8.0
1975	29.3	29.7	8.9	12.7	13.4	7.3	21.0	21.6	8.1
1976	28.3	28.9	9.4	12.9	14.0	7.3	20.6	21.5	8.3
1977	30.9	29.4	8.6	13.4	12.4	7.1	22.0	20.9	7.7
1978	29.5	28.7	8.3	13.4	12.9	6.6	21.5	20.8	7.4
1979	29.8	30.1	8.2	14.6	14.1	7.3	22.2	22.2	7.8
1980	30.2	29.9	8.9	14.0	14.2	7.7	22.2	21.9	8.3
1981	30.2	32.4	9.3	14.6	16.5	8.5	22.4	24.5	8.9
1982	29.4	30.3	9.4	14.4	15.9	7.8	21.9	23.1	8.6
1983	29.5	31.0	9.6	14.4	15.6	8.2	22.0	23.3	8.9
1984	29.3	29.4	9.0	14.3	14.9	7.8	21.8	22.2	8.3
1985	30.0	30.4	8.5	14.6	14.9	7.0	22.3	22.7	7.7
1986	29.1	30.3	9.0	14.3	15.7	7.8	21.7	23.0	8.4
1987	29.5	29.2	8.7	14.6	14.8	7.8	21.3	22.2	8.0
1988	30.3	32.1	9.4	15.8	17.1	8.2	23.1	24.6	8.8
1989	30.2	30.7	8.2	15.5	16.0	7.6	22.9	23.4	7.8
1990	30.2	32.0	9.0	16.1	18.0	7.5	23.2	25.1	8.2
1991	29.2	30.3	9.1	14.7	15.2	8.1	22.0	22.7	8.6
1992	29.2	29.5	8.4	14.6	14.9	7.3	21.9	22.2	7.9
1993	30.5	32.2	9.4	15.7	16.5	8.1	23.1	24.4	8.7
1994	30.1	29.4	8.4	14.9	15.2	7.3	22.5	22.3	7.8
1995	30.4	27.9	9.1	15.7	14.8	8.4	23.1	21.4	8.7
1996	30.2	28.9	8.2	15.8	14.2	7.4	23.0	21.6	7.8
1997	30.0	28.6	8.9	15.4	15.0	8.2	22.7	21.8	8.6
1998	29.8	31.1	9.1	15.1	16.6	8.5	22.5	23.9	8.9
1999	31.2	32.8	10.0	16.5	17.4	8.6	23.9	25.1	9.3
2000	30.4	31.1	8.5	15.3	16.9	7.8	22.9	24.0	8.2
2001	31.7	32.4	8.9	15.9	16.4	7.9	23.8	24.4	8.4
2002	31.0	30.3	8.9	15.5	15.1	8.3	23.3	22.7	8.6
2003	30.3	32.9	8.9	14.8	16.6	7.8	22.6	24.8	8.4
2004	30.1	31.6	8.2	14.7	16.2	7.1	22.4	23.9	7.6
2005	30.2	31.8	9.6	15.0	16.0	8.4	22.6	23.9	9.0
2006	30.1	32.3	9.2	15.0	16.6	7.8	22.6	24.4	8.5
2007	30.6	31.6	8.6	15.8	16.9	7.4	23.2	24.3	8.0
2008	30.3	31.1	9.3	16.2	17.7	7.9	22.5	24.3	7.9
2009	30.1	29.1	8.2	15.6	15.0	7.6	23.0	22.0	8.0
2010	29.5	29.1	8.9	14.6	14.9	7.3	23.0	21.6	7.8
General Average	29.95	30.40	8.92	14.73	15.34	7.74	22.35	22.88	8.29

The temperatures: Values are red: above average.
Values are blue: below average.

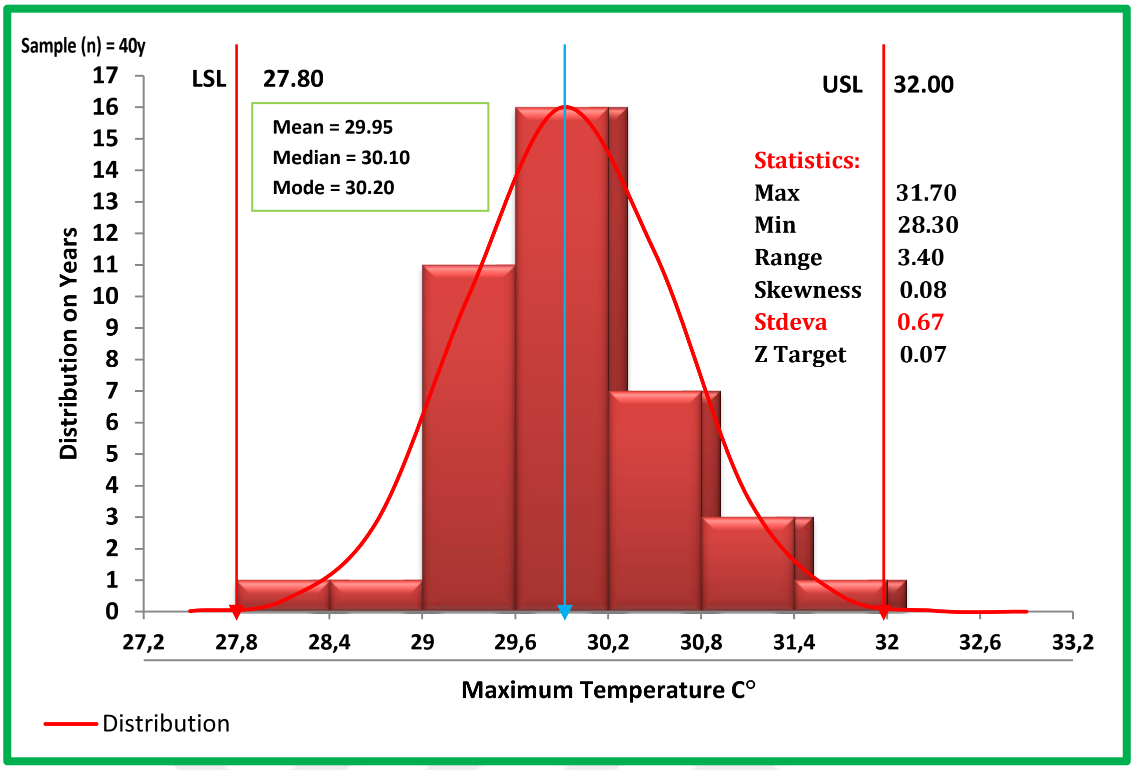


Figure 56. Statistics of Annual Maximum Temperature in GHADAMES Station for Period (1971-2010)

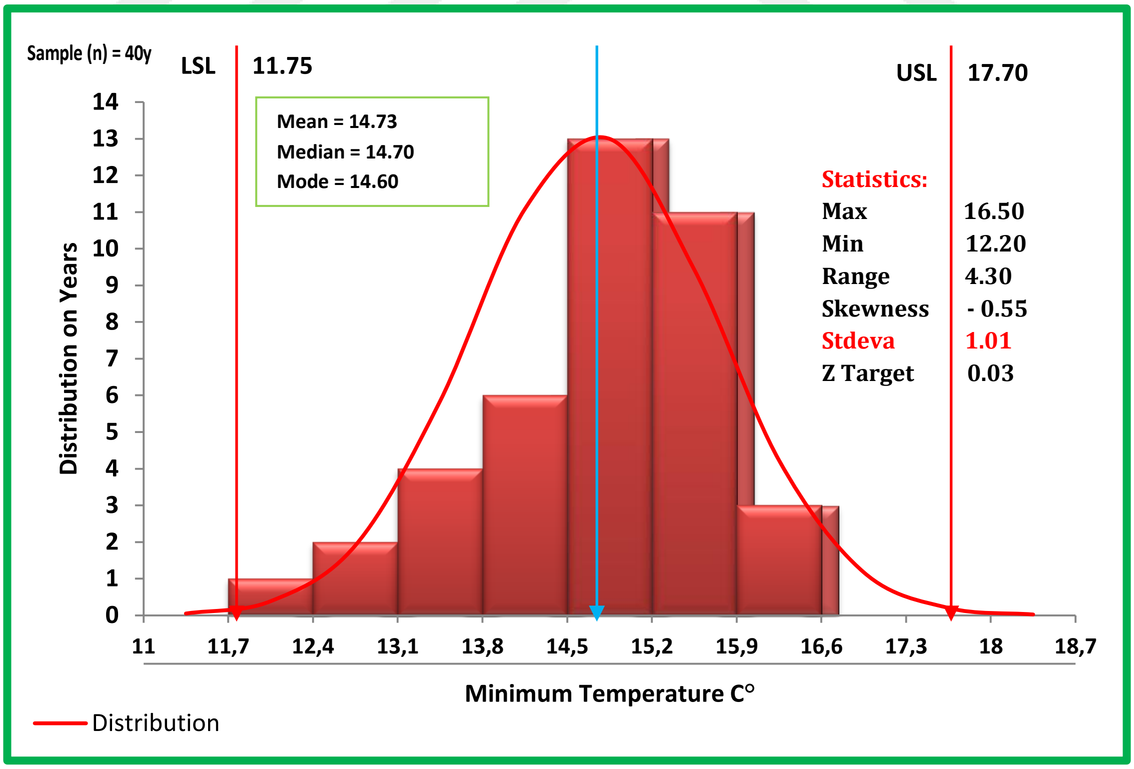


Figure 57. Statistics of Annual Minimum Temperature in GHADAMES Station for Period (1971-2010)

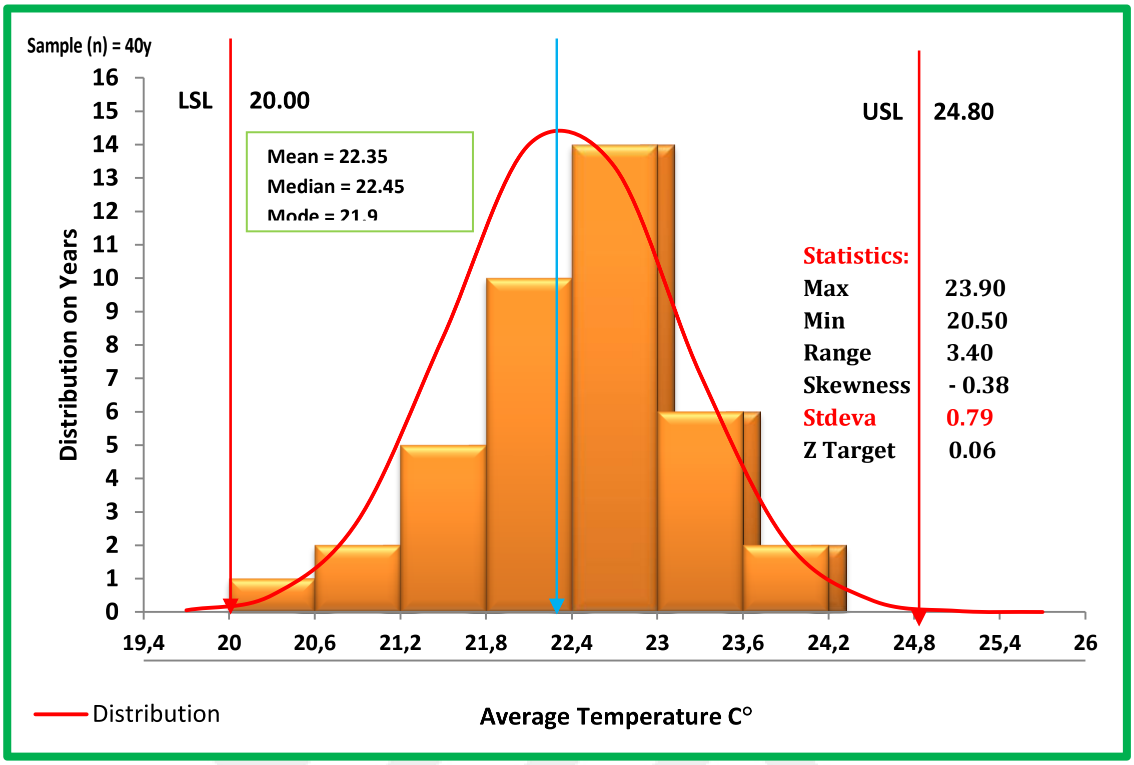


Figure 58. Statistics of Annual Average Temperature in GHADAMES Station for Period (1971-2010)

Table 36 shows an increase in temperatures to above average was from 1988 to 2010 (except for some years) at GHADAMES station indicating that there is a general trend towards warming during 22 consecutive years in the monitoring period.

The figure 57 of maximum temperatures shows a non-normal distribution over the monitoring years. It is observed that temperature of (29.6 °C) is distributed over 16 years temperature of (29 °C) is distributed over 11 years, temperature of (30.2 °C) is distributed on 11 years, temperature of (30.8 °C) over 3 years and temperatures (27.8 °C), (28.4 °C) and (31.4 °C) are distributed over one year.According to figure 58 the minimum temperatures show a non-normal distribution. The temperature of (14.5 °C) is found the highest which is distributed over13 years and stable at (15.2 °C) over a period of 11 years. The temperature of (13 °C) is found stabilized over 6 years, (13.1 °C) over 4 years, (12.4 °C) over two years and (11.7°C) over one year.

The average temperatures in the figure 59 are distributed as (22.4 °C) over 14 years, (21.8 °C) over 10 years, (23 °C) over 6 years, (21.2 °C) over 5 years, (23.6 °C), (20.6 °C) over two years and (20 °C) over one year. The distribution curve is found at

(22.3 °C) and stabilized. The curve is to the highest level at the right of the figure at (24.8 °C) and at left to lowest at (20 °C).

Table 37. The Descriptive Statistics and Distributions of Annual Temperature in GHARIAT Station for Period (1971-2010)

Years	Annual Maximum Temperature °C			Annual Minimum Temperature °C			Annual Average Temperature °C		
	Mean	Median	Standard Deviation	Mean	Median	Standard Deviation	Mean	Median	Standard Deviation
1971	27.3	27.6	7.6	10.8	11.8	6.6	19.0	19.7	7.0
1972	27.6	26.0	7.8	12.3	11.9	6.7	20.0	19.2	7.3
1973	27.6	28.6	8.1	11.4	11.5	6.6	19.6	20.1	7.3
1974	27.1	28.2	7.6	11.9	13.2	6.5	19.5	20.7	7.0
1975	27.4	28.0	7.7	12.3	13.0	5.9	19.9	20.5	6.8
1976	26.5	28.0	8.3	12.4	13.2	6.4	19.5	20.6	7.3
1977	28.6	25.7	7.5	12.3	10.9	6.4	20.7	18.3	7.3
1978	27.5	27.8	6.8	12.4	12.8	5.5	20.0	20.3	6.1
1979	28.4	30.2	6.9	13.0	12.6	5.9	20.7	21.5	6.4
1980	27.4	27.2	7.8	13.1	13.8	6.4	20.1	20.4	7.0
1981	28.0	29.5	8.1	12.5	14.2	6.4	20.2	21.9	7.2
1982	27.4	28.5	8.0	12.5	13.6	7.2	20.0	21.3	7.6
1983	27.5	28.7	8.2	12.8	14.0	6.9	20.1	21.3	7.5
1984	27.8	28.3	7.9	13.0	14.9	6.3	20.4	22.0	7.0
1985	28.0	28.2	7.2	13.0	13.0	6.1	20.6	20.6	6.7
1986	27.3	28.6	7.7	13.4	13.7	6.4	20.1	21.2	6.8
1987	27.9	28.2	7.7	15.8	16.9	6.3	21.6	21.5	6.9
1988	28.1	28.7	8.5	14.2	13.9	6.6	21.2	21.1	7.5
1989	27.9	27.3	7.1	14.5	14.6	5.7	21.0	20.8	6.9
1990	28.4	29.5	8.0	14.7	15.8	6.4	21.5	22.6	7.2
1991	27.7	27.5	7.7	13.8	13.2	6.7	20.8	20.3	7.2
1992	27.6	28.5	7.7	13.2	13.1	6.3	20.5	20.8	6.9
1993	28.2	30.4	8.5	13.8	14.5	6.5	21.0	22.4	7.5
1994	28.1	27.9	7.6	13.8	13.9	6.1	21.0	20.9	6.8
1995	28.5	26.4	8.0	13.7	13.6	7.2	21.1	20.0	7.6
1996	29.0	27.5	7.2	13.6	12.6	6.5	21.3	20.0	6.9
1997	28.8	27.8	8.2	13.8	13.3	7.0	21.2	20.6	7.7
1998	27.9	30.4	8.0	13.4	14.4	6.5	20.7	22.4	7.2
1999	28.9	30.5	8.4	14.6	14.9	7.1	21.8	23.0	7.8
2000	28.1	30.0	7.6	13.6	14.9	6.3	20.9	22.5	6.9
2001	29.1	29.9	7.5	13.6	14.0	6.5	21.4	22.0	6.9
2002	28.1	27.9	7.9	13.9	13.3	7.0	21.0	20.6	7.4
2003	28.0	30.1	8.2	14.8	15.0	6.9	21.4	22.5	7.5
2004	27.7	29.4	7.1	14.1	14.2	5.9	20.9	21.8	6.5
2005	27.6	29.0	7.9	14.4	14.8	6.8	21.0	22.0	7.3
2006	27.5	29.3	8.1	14.4	15.4	6.5	21.0	22.4	7.3
2007	27.7	29.3	7.1	13.9	14.0	6.1	21.0	21.7	6.8
2008	27.5	28.4	8.1	13.8	14.2	6.3	20.7	21.3	7.1
2009	27.8	27.9	7.1	13.6	13.3	6.2	20.8	20.9	6.6
2010	28.0	26.3	7.5	13.1	13.8	6.4	20.0	20.5	6.6
General Average	**27.89**	**28.43**	**7.75**	**13.38**	**13.74**	**6.45**	**20.63**	**21.11**	**7.08**

The temperatures: Values are red: above average.
Values are blue: below average.

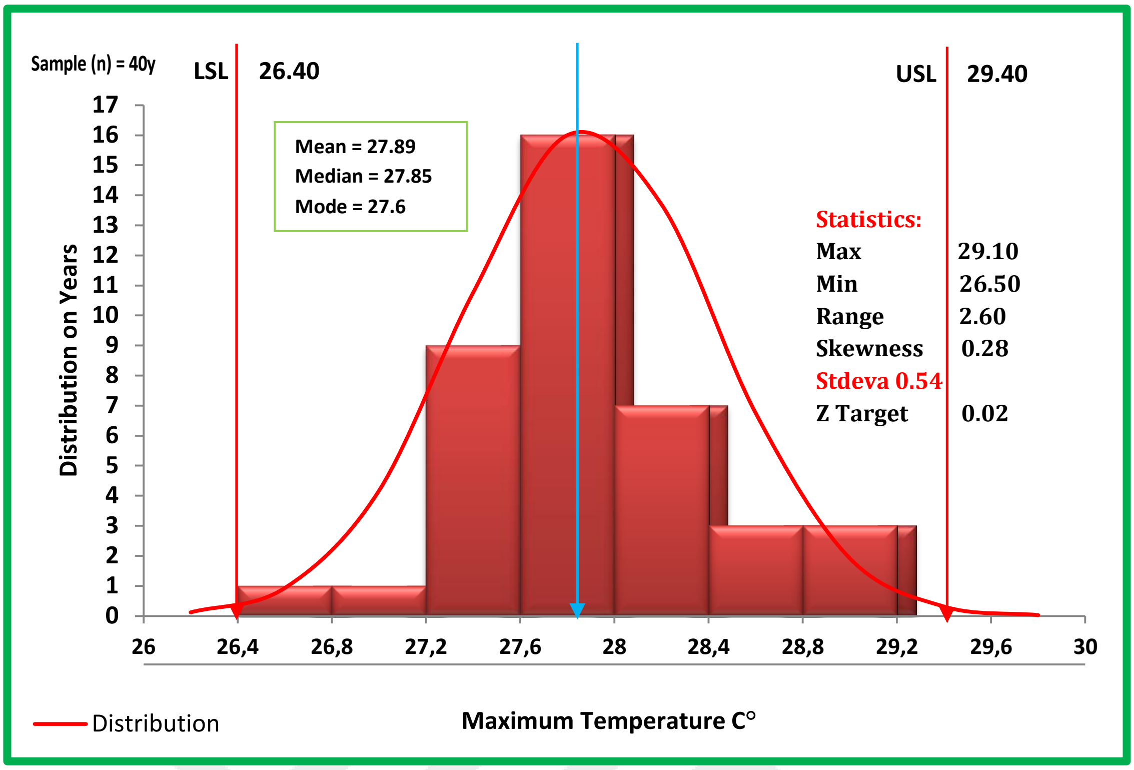


Figure 59. Statistics of Annual Maximum Temperature in GHARIAT Station for Period (1971-2010)

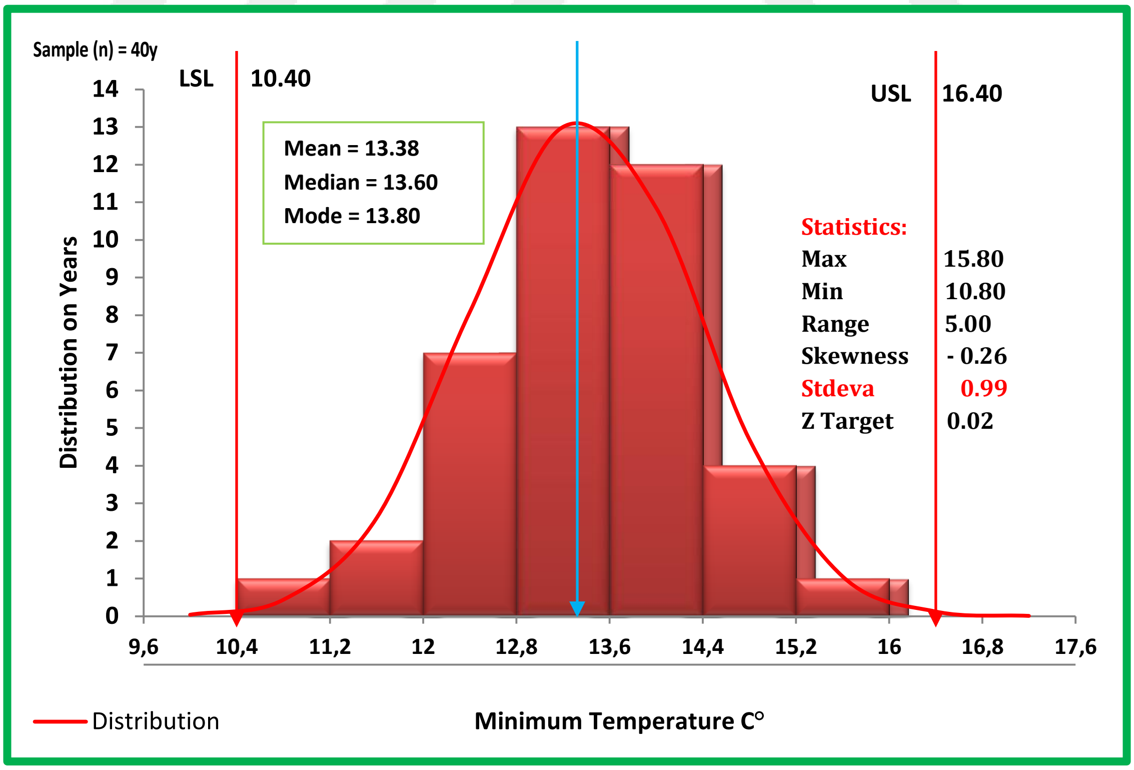


Figure 60. Statistics of Annual Minimum Temperature in GHARIAT Station for Period (1971-2010)

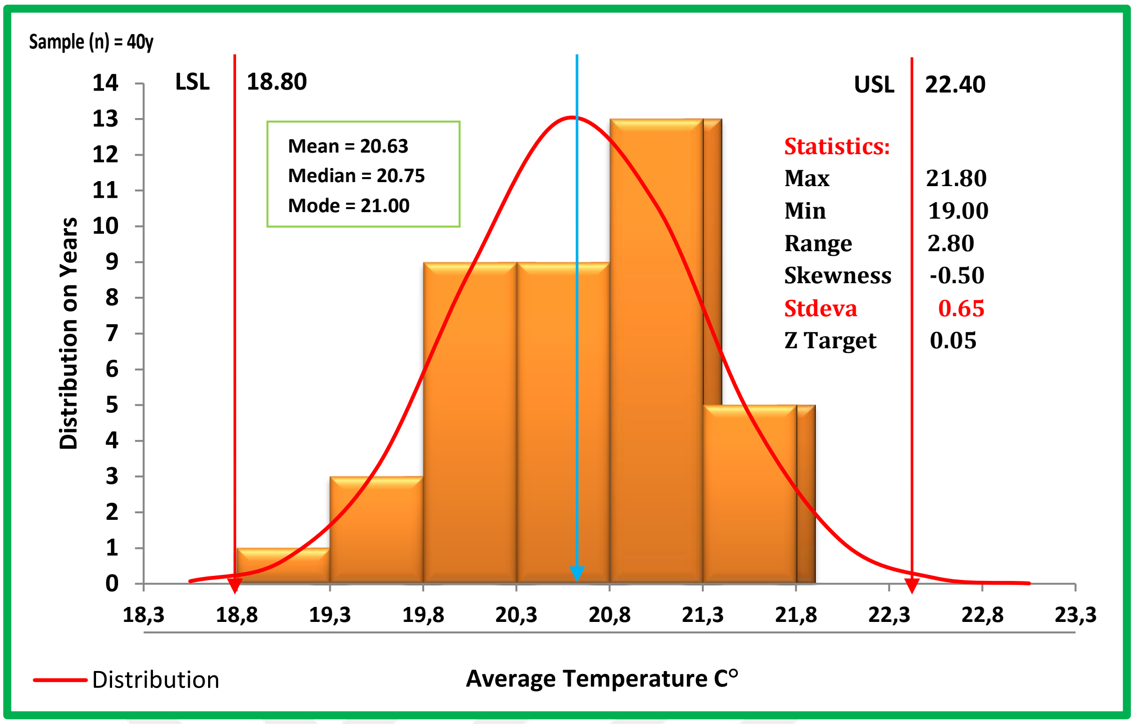


Figure 61. Statistics of Annual Average Temperature in GHARIAT Station for Period (1971-2010)

Table 37 shows that the maximum temperatures continued to rise above the average from 1993 to 2003 at GHARIAT station. Besides, the minimum temperatures also recorded a significant increase from 1986 to 2009. Therefore, a significant increase is observed in the general average of temperature from 1987 to 2009 indicating a trend towards warming during the last years of monitoring period.

The figure 60 shows a non-normal distribution for maximum temperatures over the monitoring years. It is observed that temperature of (27.6 °C) is distributed over 16 years, temperature of (27.2 °C) is distributed over 9 years, (28 °C) over 7 years, (28.4 °C) and (28.8 °C) over 3 years while (26.4 °C), (26.8 °C) are distributed over one year. According to figure 61 the minimum temperature of (12.8 °C) is the highest which was distributed over 13 years. The temperature is founds table at (13.6 °C) over a period of 12 years, temperatures of (12 to 12.8 °C) are found stabilized over 7 years, (14.4 °C) over 4 years, (12.4 °C) over two years, (11.2 to 12 °C) over two years and (10.4 °C) over one year. Te figure 62 Shows that average temperatures are distributed at (20.8 °C) over 13 years, (19.8, 20.3, and 20.8 °C) over 18 years, (21.3 to 21.8 °C) over 5 years, and (18.3 °C) over one year. The distribution curve is reached at (22.3°C) and found stabilized. The curve is to the highest level at the right of the figure at (24.8 °C) and its left to lowest at (20 °C).

Table 38. The Descriptive Statistics and Distributions of Annual Temperature in HON Station for Period (1971-2010)

Years	Annual Maximum Temperature °C			Annual Minimum Temperature °C			Annual Average Temperature °C		
	Mean	Median	Standard Deviation	Mean	Median	Standard Deviation	Mean	Median	Standard Deviation
1971	29.3	29.6	7.0	11.4	12.1	6.3	20.4	20.9	6.6
1972	29.5	28.6	7.6	12.6	13.9	7.1	21.1	21.3	7.3
1973	29.4	30.4	7.4	11.3	11.5	6.2	20.4	21.0	6.8
1974	29.1	31.5	7.6	11.6	13.6	6.5	20.3	22.7	7.0
1975	29.0	30.1	7.3	12.2	12.7	6.2	20.6	21.4	6.7
1976	28.4	30.6	7.9	12.5	13.7	6.4	20.5	22.2	7.1
1977	30.0	28.9	7.3	12.3	11.6	6.7	21.2	20.3	7.0
1978	29.5	30.2	6.3	12.5	13.9	5.5	21.0	22.1	5.9
1979	29.7	30.7	6.6	13.1	13.1	5.8	21.4	21.9	6.2
1980	29.2	29.2	7.2	12.6	13.7	6.4	20.9	22.0	6.7
1981	30.2	32.3	7.2	12.7	14.9	6.8	21.5	23.6	6.9
1982	29.1	31.2	7.4	12.6	14.5	6.6	21.0	22.8	6.9
1983	28.8	30.0	7.8	12.5	13.1	6.6	20.7	21.6	7.2
1984	29.2	30.3	7.7	12.9	14.3	6.9	21.0	22.3	7.3
1985	29.5	30.2	6.7	12.7	12.9	6.0	21.2	21.6	6.3
1986	28.8	30.2	7.5	13.0	14.7	6.7	20.9	22.5	7.0
1987	29.6	30.0	7.2	13.1	13.2	6.7	21.4	21.6	6.9
1988	30.0	31.1	8.3	13.7	14.5	6.8	21.9	22.8	7.5
1989	29.5	31.2	7.5	13.0	14.4	6.8	21.3	22.8	7.1
1990	29.3	31.2	7.5	13.6	15.1	6.3	21.4	23.2	6.9
1991	29.1	30.6	7.6	13.2	14.3	6.6	21.1	22.5	7.1
1992	28.8	30.4	7.4	13.2	14.0	6.5	21.0	22.3	6.9
1993	29.7	32.0	8.1	13.7	15.4	6.9	21.7	23.3	7.5
1994	29.5	30.3	7.2	13.4	14.2	6.0	21.5	22.3	6.5
1995	29.2	29.7	6.8	12.5	13.4	6.5	20.6	21.8	6.3
1996	30.4	29.4	7.0	12.4	11.2	6.7	21.4	20.4	6.8
1997	29.5	28.9	7.9	12.4	12.9	7.7	20.4	18.4	7.7
1998	29.8	32.5	8.0	13.9	15.5	7.4	21.9	24.0	7.6
1999	30.5	31.7	7.9	14.7	15.7	7.1	22.6	23.7	7.5
2000	29.5	32.7	7.7	14.0	16.6	6.6	21.7	24.7	7.1
2001	30.4	30.4	7.1	14.4	14.9	6.8	22.5	22.7	6.9
2002	30.0	29.8	8.0	14.1	14.6	7.1	22.1	22.2	7.6
2003	30.0	31.9	7.7	14.7	15.3	7.0	22.4	23.6	7.3
2004	29.6	31.7	6.9	14.4	15.1	5.9	22.0	23.4	6.4
2005	29.6	31.0	7.5	14.5	14.4	6.5	22.1	23.1	7.0
2006	29.6	31.1	7.6	14.6	15.6	6.5	22.1	23.4	7.0
2007	30.0	31.5	7.1	14.7	15.9	6.2	22.3	23.7	6.6
2008	30.0	31.4	7.8	15.3	16.1	6.6	22.7	23.7	7.1
2009	29.8	29.9	6.6	14.8	15.5	6.5	22.3	22.7	6.5
2010	31.4	31.5	5.7	15.9	17.0	6.0	23.7	24.3	5.8
General Average	**29.59**	**30.65**	**7.37**	**13.32**	**14.23**	**6.56**	**21.46**	**22.42**	**6.91**

The temperatures: Values are red: above average.
Values are blue: below average.

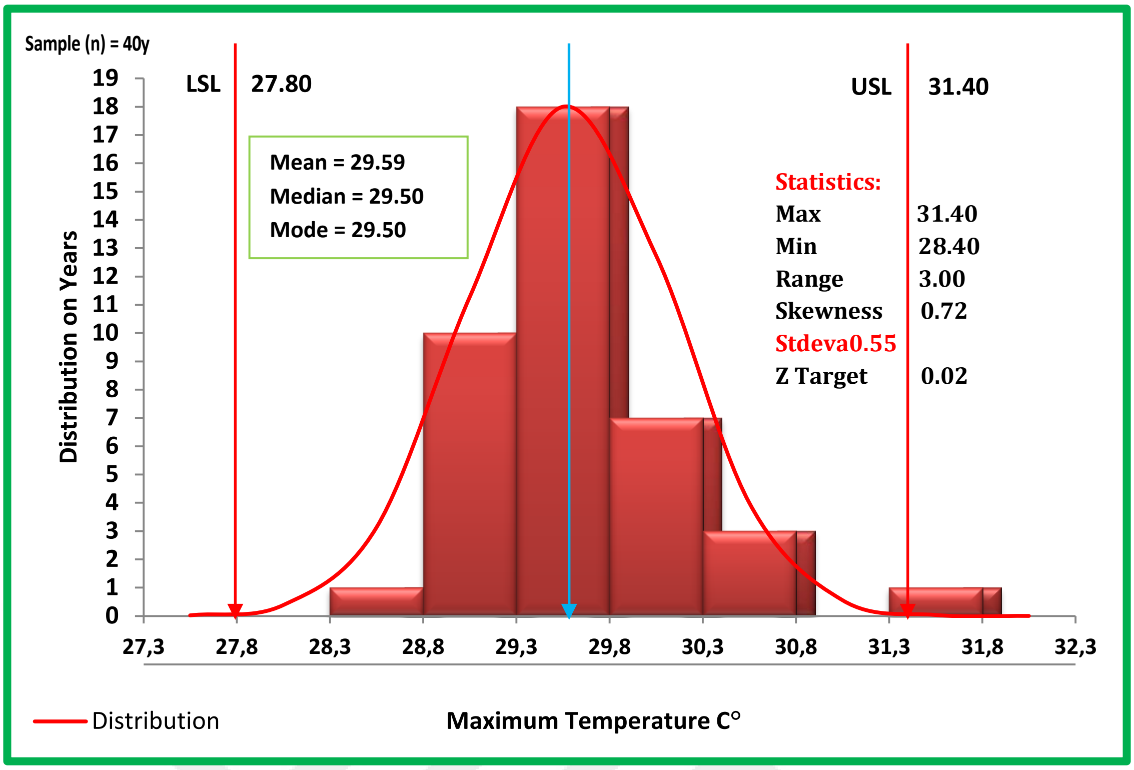


Figure 62. Statistics of Annual Maximum Temperature in HON Station for Period (1971-2010)

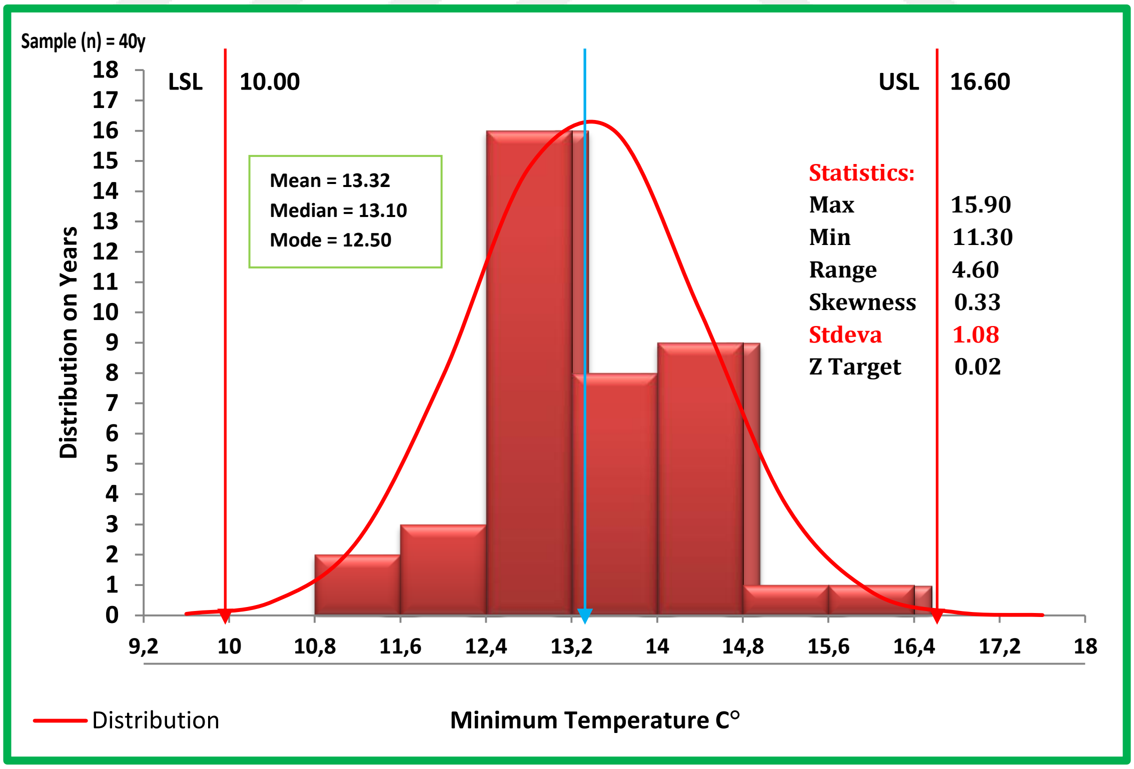


Figure 63. Statistics of Annual Minimum Temperature in HON Station for Period (1971-2010)

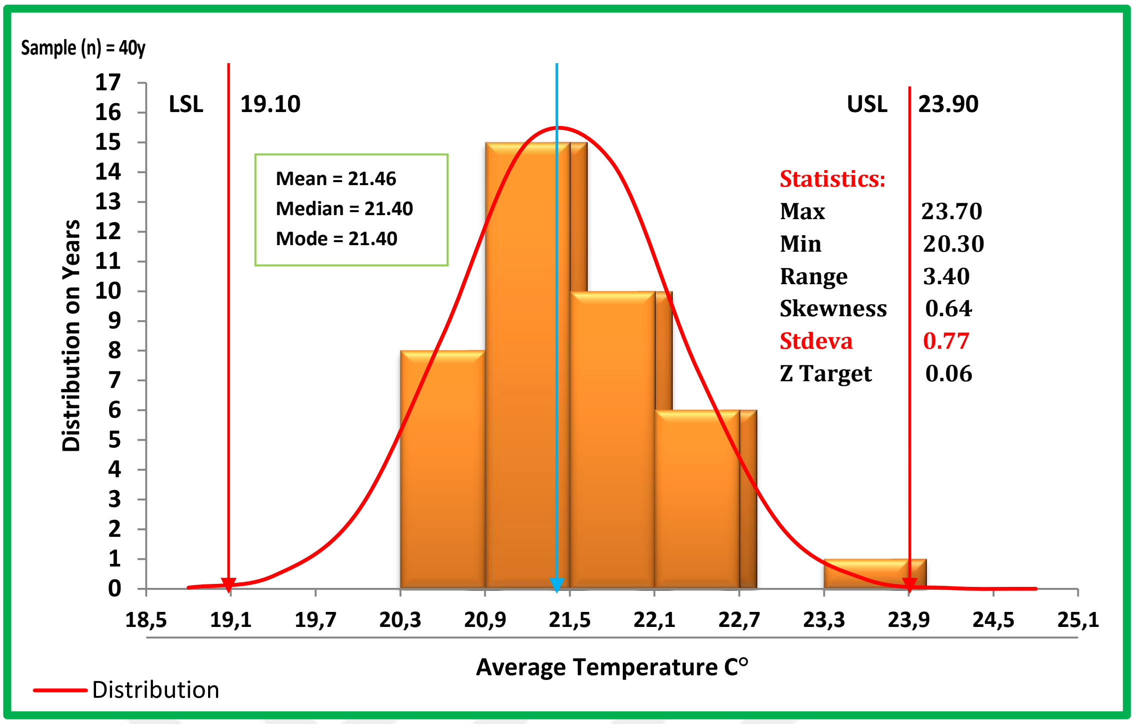


Figure 64. Statistics of Annual Average Temperature in HON Station for Period (1971-2010)

The data in the table 38 show that the maximum temperatures continued to rise above the average from 2001 to 2010 at HON station. Besides, the minimum temperatures recorded a significant increase from 1998 to 2010. Hence, a significant increase is observed in the general average from 1998 to 2010 indicating a trend towards warming during the last years of monitoring.

The figure 63 shows a non-normal distribution of maximum temperature over the monitoring years. It is observed that temperature of (29.3 °C) is distributed over 18 years, temperature of (28.8 °C) is distributed over 10 years, (29.8 °C) over 7 years, (30.3 °C) over3 years and (28.3 °C) over one year. Besides, (31.3 °C) is found as extreme temperature over one year from general distribution. In figure 64 it is found that the minimum temperatures of (12.4 °C) is the highest which is distributed over16 years. The temperature is found stable at (14 °C) over a period of 9 years, (13.2 °C) is found stabilized over 7 years, (11.6 °C) over 4 years, (12.4 °C) over 3 years, (11.2 °C) over two years and (15.6 °C) over one year. It is observed in the figure 65 that the average temperatures are distributed at (20.9 °C) over 15 years, (21.5, 22.2 °C) over10 years, (22.1 °C) over 18 years and (23.3 °C) over one year. The distribution curve is reached at (21.5 °C) and found stabilized. The curve is to the highest level at the right of the figure at (23.9 °C) and at left to lowest at (19.1 °C).

Table 39. The Descriptive Statistics and Distributions of Annual Temperature in JAGHBOUB Station for Period (1971-2010)

Years	Annual Maximum Temperature °C			Annual Minimum Temperature °C			Annual Average Temperature °C		
	Mean	Median	Standard Deviation	Mean	Median	Standard Deviation	Mean	Median	Standard Deviation
1971	28.9	28.7	6.6	13.4	13.3	5.8	21.2	21.0	6.2
1972	29.0	29.6	7.2	13.6	15.3	6.5	21.3	22.5	6.9
1973	28.7	29.1	7.0	13.1	13.6	6.2	21.0	21.4	6.6
1974	29.0	31.5	7.1	13.3	14.8	5.8	21.2	23.3	6.4
1975	28.6	30.1	6.7	12.9	13.7	5.7	20.8	21.9	6.2
1976	28.5	29.5	7.0	13.3	14.4	6.0	20.9	22.0	6.5
1977	29.3	28.4	7.3	12.9	12.5	6.6	21.1	20.4	6.9
1978	29.0	30.0	6.8	13.3	14.7	5.8	21.2	22.4	6.2
1979	29.2	30.6	6.5	13.9	15.2	6.1	21.6	22.9	6.3
1980	28.2	29.6	8.0	13.5	14.3	5.9	20.9	22.0	6.9
1981	28.9	31.8	7.5	13.9	16.2	6.5	21.4	24.3	7.0
1982	28.5	30.4	7.3	13.6	15.1	6.3	21.0	22.8	6.8
1983	28.2	28.9	7.2	13.2	13.4	6.2	20.7	21.2	6.7
1984	29.1	29.8	7.3	13.4	14.0	6.2	21.3	21.9	6.7
1985	29.0	28.8	6.8	14.0	13.3	5.6	21.5	21.1	6.1
1986	28.8	29.7	7.0	13.9	13.7	6.3	21.4	21.8	6.6
1987	28.8	28.3	7.0	12.9	12.9	6.5	20.9	20.2	6.7
1988	29.3	29.7	8.1	13.8	14.1	6.4	21.6	21.9	7.2
1989	29.2	30.7	7.7	12.6	13.8	6.2	20.9	22.2	6.9
1990	29.3	31.0	6.7	13.7	14.3	6.1	21.5	22.7	6.4
1991	28.9	31.0	7.3	14.0	14.9	6.1	21.5	23.0	6.7
1992	28.2	29.8	7.5	13.2	13.1	6.3	20.8	21.8	6.9
1993	29.3	31.4	7.4	14.0	14.5	5.9	21.7	23.0	6.6
1994	29.2	31.6	7.4	13.9	15.5	6.3	21.2	21.7	6.7
1995	29.6	28.5	8.0	13.9	13.4	6.9	21.8	21.2	7.4
1996	29.7	28.7	7.0	13.6	13.6	6.1	21.6	21.2	6.5
1997	29.2	28.5	7.4	13.0	13.5	6.3	21.1	21.0	6.8
1998	29.3	31.0	7.8	14.0	14.8	6.6	21.7	23.0	7.2
1999	29.8	30.8	7.4	14.3	15.2	6.4	22.1	23.0	6.8
2000	29.2	30.7	7.3	13.6	15.4	6.2	21.4	23.1	6.7
2001	30.2	29.7	7.1	14.2	14.8	6.6	22.2	22.3	6.8
2002	30.1	29.9	7.6	14.6	15.2	6.8	22.4	22.6	7.2
2003	30.0	31.8	7.4	14.3	15.2	6.7	22.5	25.0	7.1
2004	30.1	30.6	6.6	14.8	15.0	6.0	22.5	22.8	6.3
2005	29.8	29.8	6.9	14.7	15.3	6.1	22.3	22.6	6.5
2006	29.8	30.3	7.2	14.6	14.8	6.4	22.1	22.6	6.8
2007	29.7	30.2	7.0	15.0	15.5	6.3	22.4	22.9	6.7
2008	30.0	30.3	7.3	15.5	15.5	6.2	22.8	22.9	6.7
2009	29.7	30.6	6.7	15.1	15.8	6.2	22.4	23.4	6.4
2010	30.7	30.4	6.3	15.4	16.0	6.3	22.6	22.2	6.7
General Average	29.25	30.05	7.19	13.85	14.49	6.24	21.56	22.28	6.69

The temperatures: Values are red: above average.
Values are blue: below average.

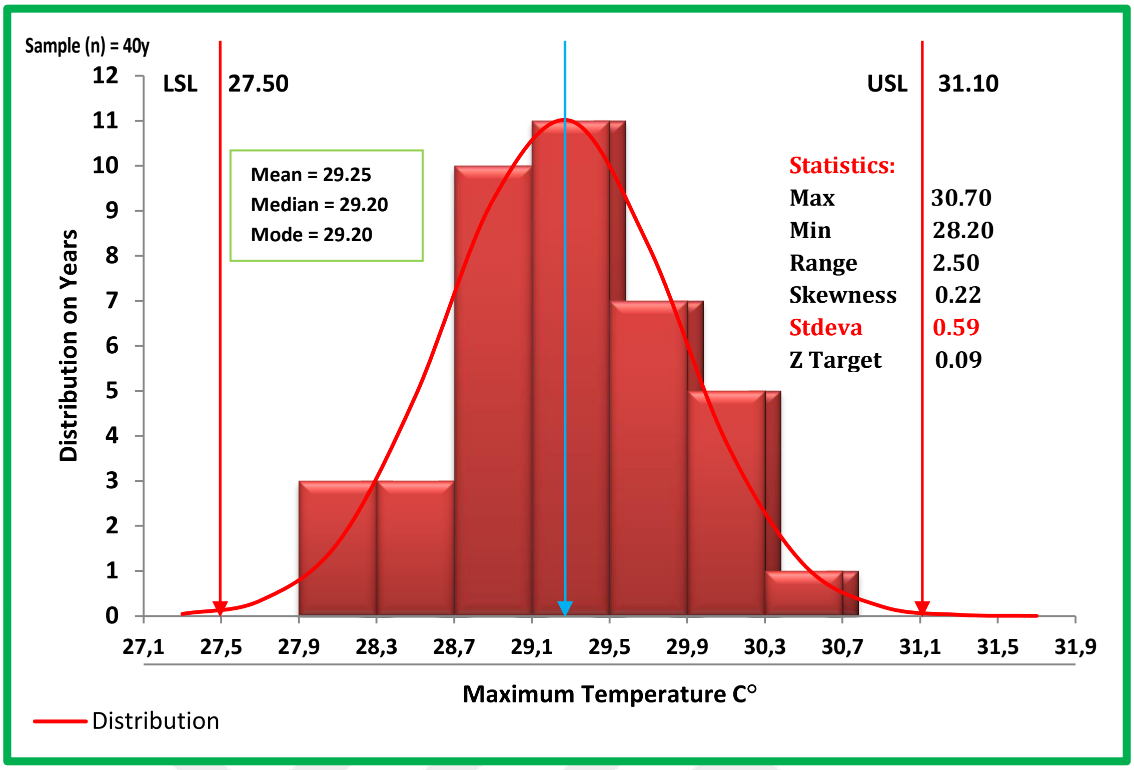


Figure 65. Statistics of Annual Maximum Temperature in JAGHBOUB Station for Period (1971-2010)

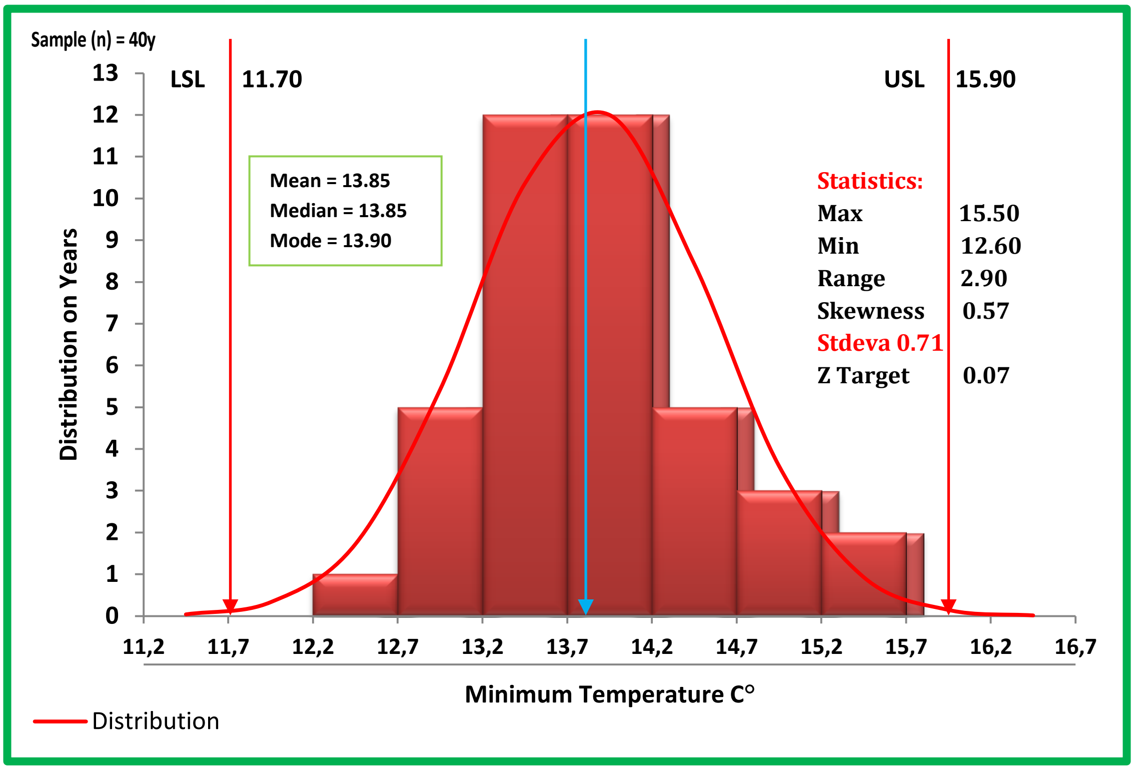


Figure 66. Statistics of Annual Minimum Temperature in JAGHBOUB Station for Period (1971-2010)

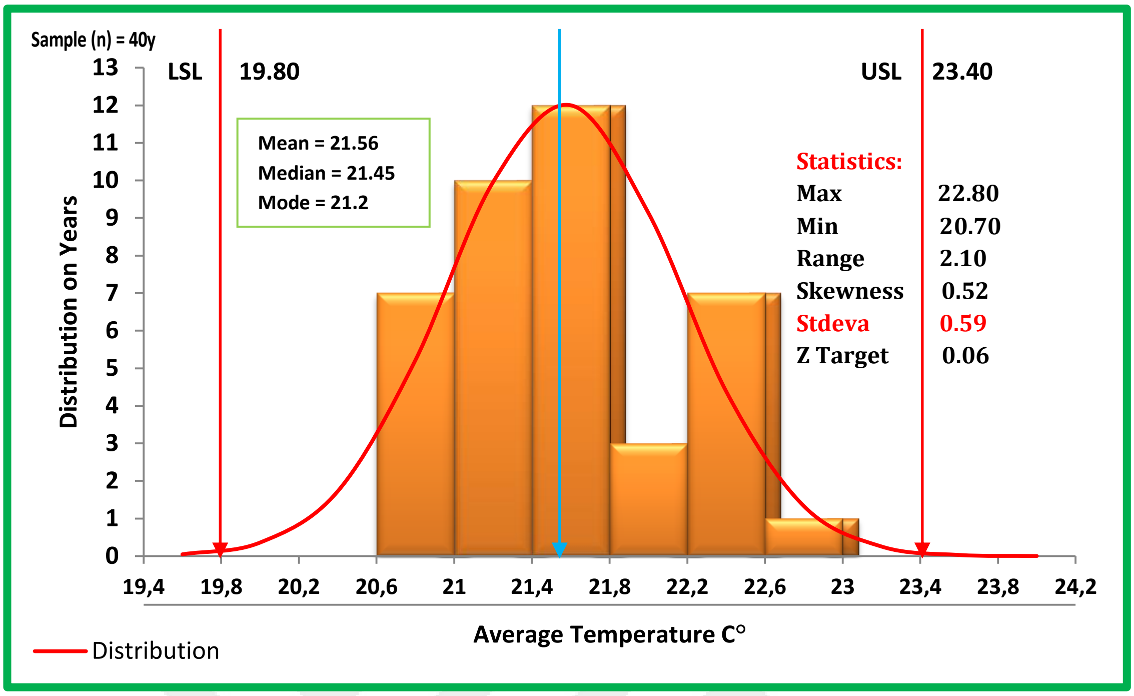


Figure 67. Statistics of Annual Average Temperature in JAGHBOUB Station for Period (1971-2010)

According to table 39 the maximum temperature, minimum temperature and average temperature continued to rise above the average from 2001 to 2010 at JAGHBOUB station. Moreover, and the minimum temperatures also recorded a significant increase from 1998 to 2010 indicating a trend towards warming during the last years of monitoring period.

The figure 66 shows a non-normal distribution of maximum temperature over the monitoring years. It is observed that temperature of (29.1 °C) is distributed over 11 years, temperature of (28.7 °C) is distributed over 10 years, (29.5 °C) over 7 years, (29.9 °C), over 5 years and (30.3 °C) over one years. Besides, the temperatures of (27.9 and 28.7 °C) are found distributed over 3 years. According to figure 67, the minimum temperatures of (13.2, and 13.7 °C) are the highest and distributed over12 years for each. The temperatures of (12.7 and 14.2 °C) are found stable over a period of 5 years for each, (12.7 °C) over 3 years, (15.2 °C) over 2 years and (12.2 °C) over one year. There is no data for extreme minimum temperatures.Thefigure 68 shows a non-normal distribution for average temperatures over the monitoring years. The temperature of (21.4 °C) is distributed over 12 years, (21 °C) over 10 years, (20.6 and 22.2 °C) over 7 years, (21.8 °C) over three years and (22.2 °C) over one year.

The distribution curve is reached at (21.56 °C) and stabilized. The curve is to the highest level at the right of the figure at (23.4 °C) and at left to lowest at (19.8 °C).

Table 40. The Descriptive Statistics and Distributions of Annual Temperature in JALO Station for Period (1971-2010)

Years	Annual Maximum Temperature °C			Annual Minimum Temperature °C			Annual Average Temperature °C		
	Mean	Median	Standard Deviation	Mean	Median	Standard Deviation	Mean	Median	Standard Deviation
1971	29.3	29.9	6.3	14.7	15.0	5.9	22.0	22.5	6.0
1972	29.7	30.1	7.2	15.7	17.2	6.6	22.7	23.6	6.9
1973	29.2	30.0	6.8	14.9	14.8	6.2	22.1	22.4	6.5
1974	29.4	32.6	6.8	14.6	16.4	5.8	22.1	24.5	6.3
1975	29.1	30.6	6.2	14.2	15.2	5.7	21.7	22.9	6.0
1976	29.0	30.4	7.0	15.1	15.8	6.2	22.1	23.1	6.6
1977	29.9	28.6	7.1	14.8	14.0	6.4	22.4	21.3	6.8
1978	29.5	30.1	6.2	15.0	16.2	5.6	22.3	23.2	5.9
1979	29.9	31.4	6.4	15.5	16.2	5.8	22.7	23.8	6.1
1980	29.2	30.4	6.8	15.1	16.0	5.9	22.2	23.2	6.4
1981	29.6	32.8	7.4	15.2	17.7	6.4	22.4	25.3	6.8
1982	29.0	30.7	7.1	14.6	16.4	6.6	21.8	23.6	6.8
1983	28.9	29.9	7.0	14.7	15.0	6.3	21.8	22.5	6.6
1984	29.3	29.9	7.0	14.7	15.2	6.4	22.1	22.6	6.7
1985	29.1	29.1	6.3	15.3	14.9	5.5	22.2	22.0	5.9
1986	29.1	29.9	6.7	15.2	15.8	6.3	22.1	22.9	6.5
1987	29.1	28.7	6.5	14.5	14.2	5.9	21.8	21.5	6.2
1988	29.9	30.2	7.6	15.1	14.9	6.5	22.5	22.6	7.0
1989	29.6	31.0	7.4	15.2	16.2	6.8	22.4	23.6	7.1
1990	29.4	31.5	6.6	15.5	16.2	6.2	22.5	23.9	6.4
1991	28.9	31.2	7.2	16.0	17.2	6.5	22.2	24.2	6.7
1992	28.6	29.9	7.3	15.3	16.0	6.5	22.0	23.2	6.8
1993	29.4	31.4	7.4	16.2	17.3	6.4	22.9	24.6	6.9
1994	29.3	31.1	7.1	16.3	17.4	6.2	22.7	24.3	6.4
1995	29.7	28.4	8.0	16.6	15.9	7.1	23.2	22.2	7.5
1996	29.8	28.8	6.9	15.9	14.6	6.4	22.8	21.7	6.6
1997	28.9	29.1	7.8	15.8	15.9	6.9	22.4	22.5	7.3
1998	29.8	32.1	7.5	16.3	17.3	6.8	23.1	24.7	7.1
1999	30.3	31.8	7.3	16.7	17.6	6.7	23.5	24.7	7.0
2000	29.2	31.4	7.1	15.6	17.0	6.3	22.4	24.2	6.7
2001	30.6	30.4	6.7	15.8	16.4	6.3	23.2	23.4	6.5
2002	30.2	30.5	7.6	16.0	16.4	6.9	23.2	23.5	7.2
2003	30.4	32.4	7.1	15.7	16.0	7.4	23.1	24.2	7.2
2004	30.2	30.9	6.5	15.9	15.8	6.0	23.1	23.4	6.2
2005	29.8	30.3	6.9	16.0	16.3	6.2	22.9	23.3	6.5
2006	29.7	30.6	7.2	16.1	16.1	6.6	22.9	23.4	6.9
2007	30.1	31.2	6.8	16.3	17.2	6.3	23.2	24.2	6.5
2008	30.2	31.5	7.3	16.8	17.1	6.5	23.5	24.3	6.8
2009	30.0	31.1	6.4	16.4	17.1	6.2	23.2	24.3	6.3
2010	31.6	32.3	5.5	17.6	18.4	6.1	24.6	25.6	5.8
General Average	29.60	30.61	6.95	15.57	16.16	6.33	22.60	23.42	6.61

The temperatures: Values are red: above average.
Values are blue: below average.

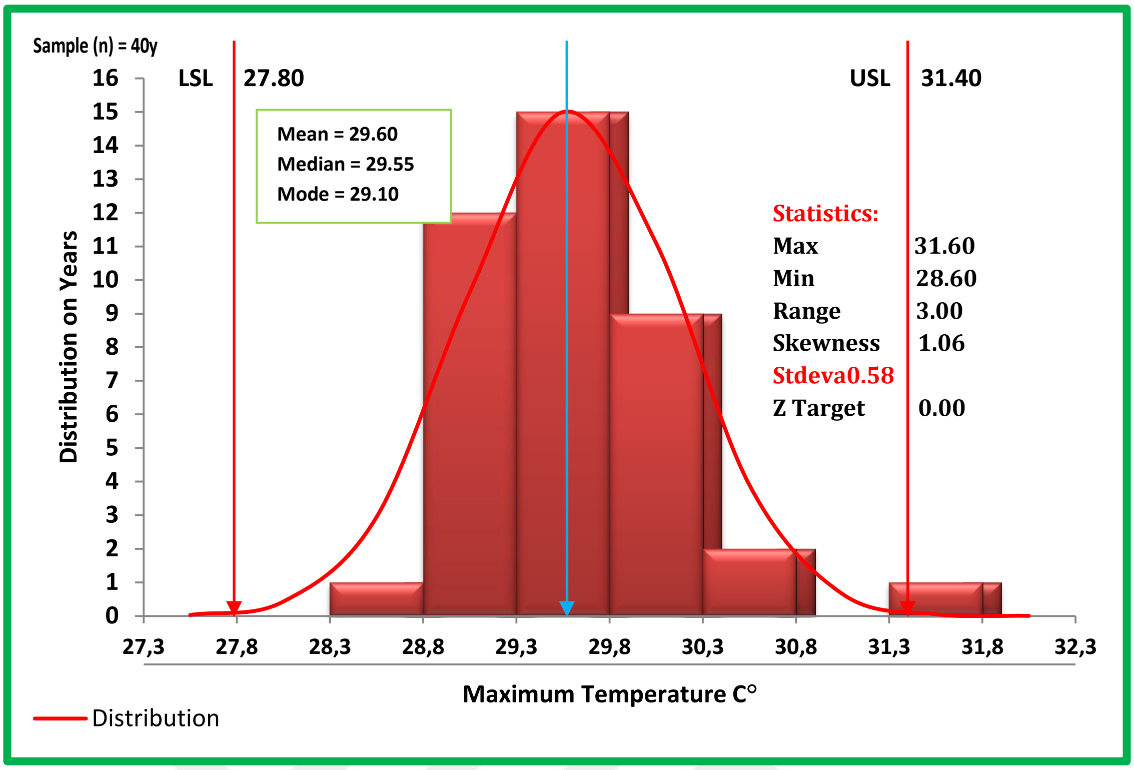


Figure 68. Statistics of Annual Maximum Temperature in JALO Station for Period (1971-2010)

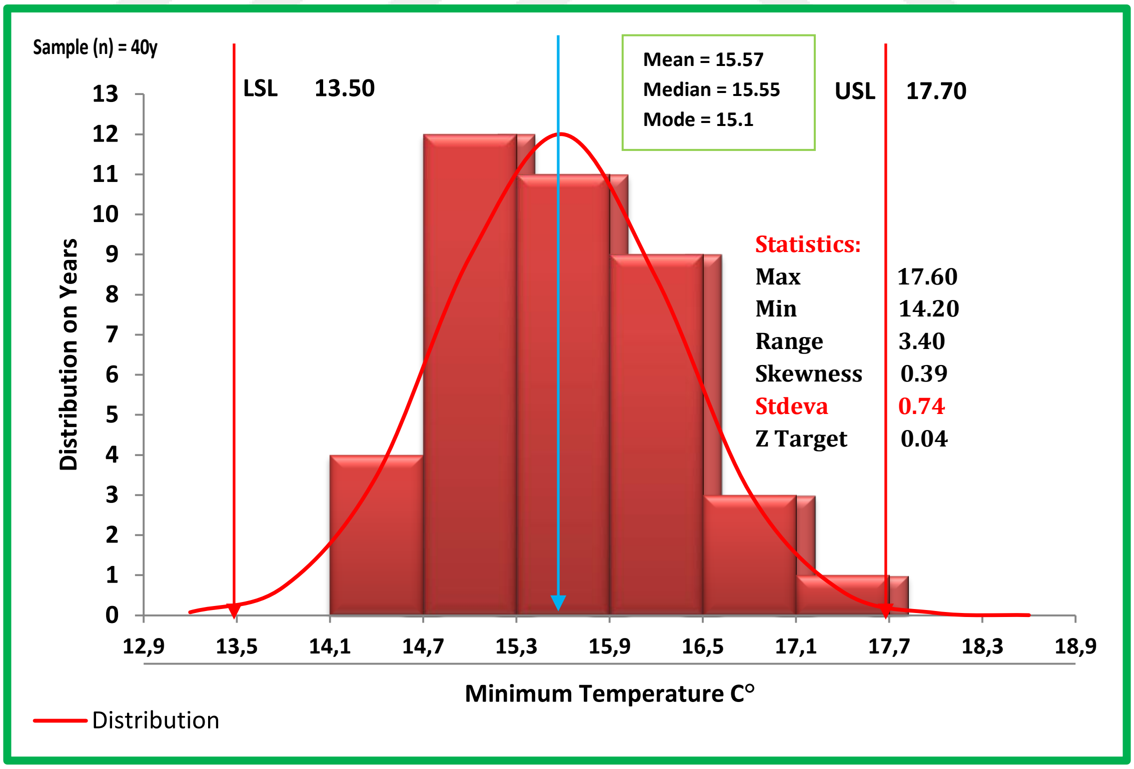


Figure 69. Statistics of Annual Minimum Temperature In JALO Station For Period (1971-2010)

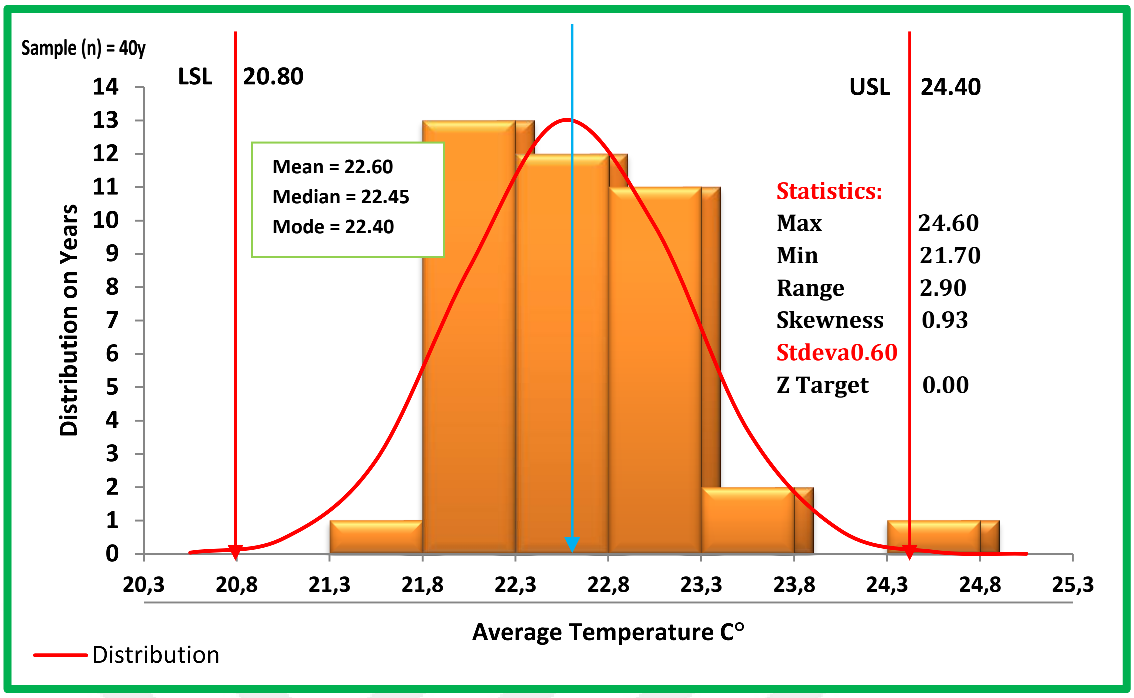


Figure 70. Statistics of Annual Average Temperature in JALO Station for Period (1971-2010)

The data presented in the table 40 show that the maximum temperatures continued to rise above the average from 2001 to 2010 at JALO station. Besides, the minimum temperatures also recorded a significant increase from 1993 to 2010 while a significant increase is also observed in the general average from 1993 to 2010 except for 1997, and 2000. This indicates a trend towards warming during the last years of monitoring period. The figure 69 shows a non-normal distribution for maximum temperatures over the monitoring years. It is observed that temperature of (29.3 °C) is distributed over 15 years, (28.8 °C) over 12 years, (29.8 °C) over 9 years, (30.3 °C) over 2 years and (28.8 °C) over one year. Moreover, (31.3 °C) is found as extreme temperature which is distributed over one year.

Figure 70 shows non-normal distribution for minimum temperatures, the temperature of (14.7 °C) is found the highest which is distributed over12 years, the temperature is found stable at (15.3 °C) over a period of 11 years, (15.9 °C) over 9 years, (14.1 °C) over 4 years, (16.5 °C) over 3 years and (17.1 °C) over one year. According to the figure 71, the average temperatures are distributed as the temperature of (21.8 °C) over 13 years, (22.3 °C) over 12 years, (22.8 °C) over 11 years and (23.3 °C) over two years. The distribution curve is reached at (20.8 °C) and found stabilized and the curve is to the highest level at the right of the figure at (24.4 °C) and at left to lowest at (21.3 °C).

Table 41. The Descriptive Statistics and Distributions of Annual Temperature in MISURATA Station for Period (1971-2010)

Years	Annual Maximum Temperature °C			Annual Minimum Temperature °C			Annual Average Temperature °C		
	Mean	Median	Standard Deviation	Mean	Median	Standard Deviation	Mean	Median	Standard Deviation
1971	24.2	24.7	5.1	15.4	15.6	5.1	19.8	20.3	5.1
1972	24.4	23.3	5.3	15.5	14.6	5.1	20.0	18.8	5.2
1973	24.8	24.5	6.1	15.4	15.2	5.5	20.1	19.9	5.8
1974	24.3	25.1	5.2	15.9	15.5	4.7	20.1	20.3	4.9
1975	24.4	24.5	5.0	15.5	14.7	5.0	19.9	19.5	5.0
1976	24.4	24.7	6.0	14.3	14.3	5.2	19.4	19.5	5.6
1977	26.3	25.7	5.1	14.2	14.3	5.0	20.3	20.1	5.0
1978	25.2	24.9	5.4	14.3	13.0	5.4	19.8	19.9	5.2
1979	24.2	22.4	4.7	14.3	13.1	4.5	19.3	17.7	4.6
1980	23.2	23.6	4.8	13.9	15.0	5.4	18.6	19.3	5.0
1981	24.2	24.5	5.7	15.2	14.6	5.4	19.7	19.5	5.5
1982	24.3	23.0	5.9	15.6	15.0	5.3	20.0	19.0	5.6
1983	23.7	24.2	5.3	15.2	15.5	5.3	19.4	19.9	5.3
1984	23.9	24.4	5.3	15.0	15.1	5.3	19.5	20.1	5.3
1985	24.7	25.5	4.6	15.1	15.0	4.7	19.9	20.3	4.6
1986	23.8	23.6	5.1	15.3	14.8	4.9	19.6	19.2	5.0
1987	24.5	22.9	5.4	15.9	14.9	5.3	20.2	18.9	5.4
1988	24.8	25.3	5.5	16.5	16.3	5.0	20.7	21.1	5.2
1989	25.0	25.4	5.0	16.4	15.6	4.8	20.7	20.5	4.9
1990	25.2	24.8	5.5	16.8	16.5	5.0	21.0	20.7	5.2
1991	24.5	23.9	5.6	16.0	14.8	5.0	20.3	19.4	5.3
1992	24.7	24.0	5.5	16.1	16.3	5.0	20.4	20.1	5.2
1993	25.1	25.3	5.6	16.4	16.2	5.1	20.8	20.8	5.3
1994	25.3	25.7	5.0	16.4	16.2	5.1	20.9	21.1	5.0
1995	25.1	23.7	5.5	16.0	14.5	5.8	20.6	19.7	5.6
1996	25.4	25.3	5.4	16.0	15.5	5.1	20.7	20.5	5.2
1997	25.2	25.0	6.0	16.3	15.6	5.5	20.8	20.3	5.7
1998	25.2	25.4	5.8	16.8	16.5	5.3	21.0	21.0	5.5
1999	26.0	27.1	6.1	17.3	17.5	5.6	21.6	22.2	5.8
2000	25.1	25.8	5.4	16.9	17.3	5.2	21.0	21.6	5.3
2001	26.1	26.4	5.3	17.3	17.3	5.3	21.7	21.8	5.3
2002	25.6	25.8	5.4	16.9	16.4	5.2	21.3	21.1	5.3
2003	25.6	25.2	6.1	17.4	16.8	5.9	21.5	21.0	6.0
2004	25.4	24.7	5.1	16.7	16.0	4.9	21.0	20.4	4.9
2005	25.0	25.7	5.7	16.6	16.3	5.7	20.8	21.0	5.7
2006	25.2	25.8	5.6	17.0	16.6	5.7	21.1	21.2	5.6
2007	25.2	24.3	5.3	17.2	16.8	5.1	21.2	20.3	5.2
2008	25.7	26.9	5.4	17.5	17.6	5.4	21.6	22.2	5.4
2009	25.1	23.6	4.8	17.0	16.0	5.3	20.9	19.8	5.2
2010	26.4	26.9	3.8	17.8	17.5	4.5	22.1	22.2	4.2
General Average	24.91	24.84	5.36	16.03	15.66	5.19	20.48	20.31	5.25

The temperatures: Values are red: above average.
Values are blue: below average.

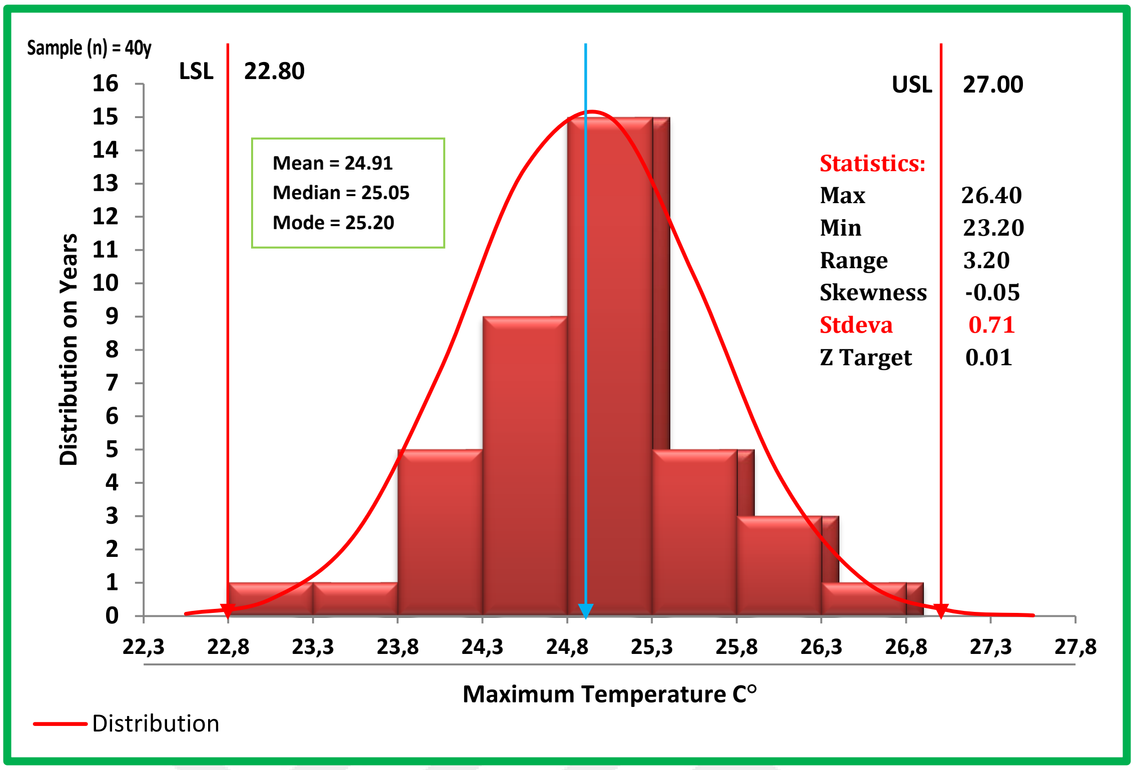


Figure 71. Statistics of Annual Maximum Temperature in MISURATA Station for Period (1971-2010)

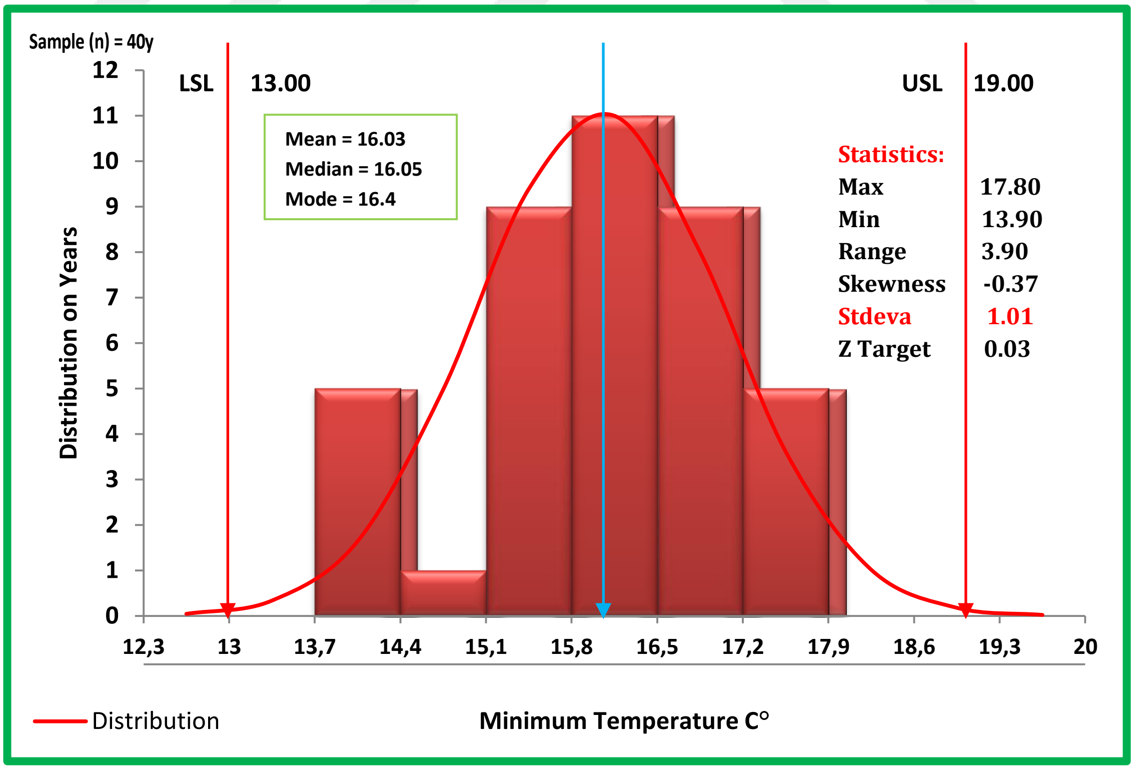


Figure 72. Statistics of Annual Minimum Temperature in MISURATA Station for Period (1971-2010)

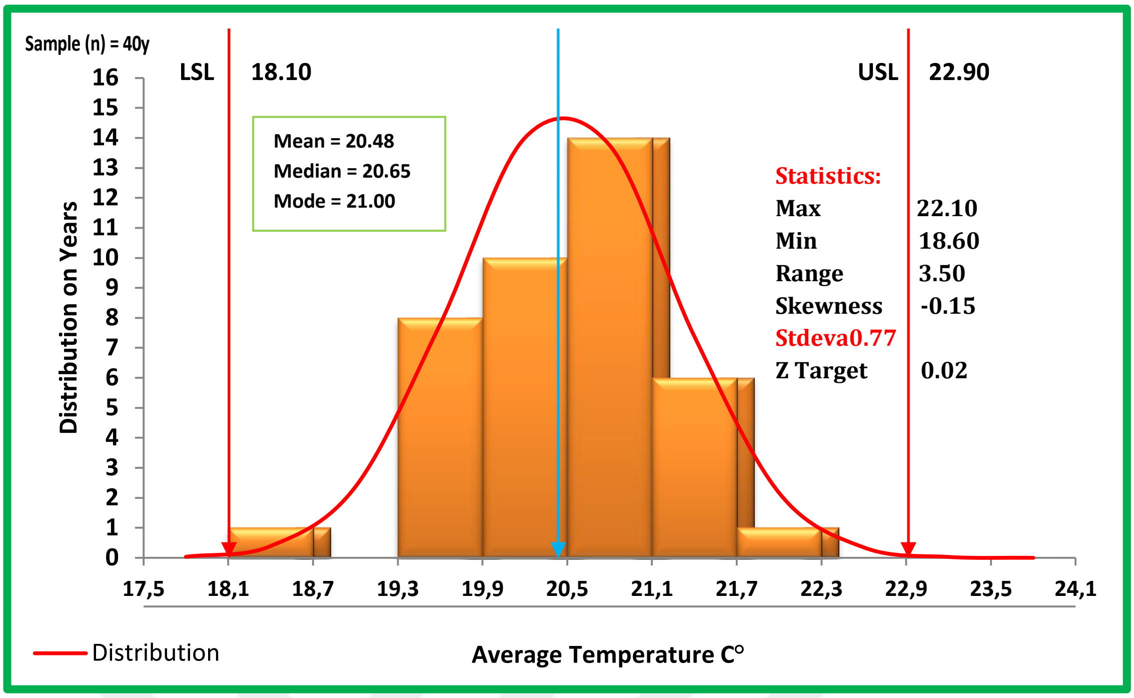


Figure 73. Statistics of Annual Average Temperature in MISURATA Station for Period (1971-2010)

The data presented in the table 41 show that the maximum temperatures continued to rise above the average at MISURATA station from 1993 to 2010. Besides, the minimum temperatures also recorded a significant increase from 1992 to 2010 except for two years of 1995, and 1996. Therefore, a significant increase is observed in the general average from 1993 to 2010 indicating a trend towards warming during the last years of monitoring period.

The figure 72 for maximum temperatures shows a semi-normal distribution over the monitoring years. It is observed that temperature of (24.8 °C) is distributed over 15 years, (23.8 °C) over 5 years, (25.3 °C) over 5 years, (25.8 °C) over 3 years and over one year for each of (22.8, 23.3 and 26.3 °C). There is no extreme data found in distribution. Thefigure 73 shows a not-normal distribution over the monitoring years for minimum temperatures. The temperature of (15.8 °C) is found the highest which is distributed over 11 years as stable, (15.1 and 16.5 °C) over a period of 9 years, (13.7 and 17.2 °C) over 5 years and (14.1 °C) over only one year. Non-normal distribution over the monitoring years for average temperatures is shown in figure 74. The temperature of (20.5 °C) is found distributed over 14 years, (19.9 °C) over 10 years, (19.3 °C) over 8 years, (21.1 °C) over 6 years and (21.7 °C) over one year. Besides, (18.1 °C) is found as extreme temperature spanning over one year. The distribution curve is found reaching at (20.5 °C) and stabilized. The curve is to the highest level at the right of the figure at (22.9 °C) and at left to lowest at (18.1 °C).

Table 42. The Descriptive Statistics and Distributions of Annual Temperature in NALUT Station for Period (1971-2010)

Years	Annual Maximum Temperature °C			Annual Minimum Temperature °C			Annual Average Temperature °C		
	Mean	Median	Standard Deviation	Mean	Median	Standard Deviation	Mean	Median	Standard Deviation
1971	24.0	24.0	8.2	13.2	13.4	6.4	18.6	18.7	7.2
1972	24.0	22.4	7.8	13.2	12.0	6.0	18.6	17.4	6.9
1973	24.2	25.0	8.9	13.0	12.7	7.1	18.7	19.0	8.0
1974	23.6	23.2	7.8	13.2	13.0	6.0	18.5	18.2	6.8
1975	24.2	24.2	8.1	13.4	13.1	5.8	18.8	18.8	6.9
1976	23.0	23.5	8.4	12.9	13.1	6.1	18.1	18.4	7.3
1977	25.9	24.6	7.4	14.2	13.3	5.7	20.0	18.8	6.6
1978	24.2	23.5	7.1	13.5	12.7	5.5	18.8	18.1	6.2
1979	24.2	23.4	7.1	13.8	12.1	5.8	19.1	17.6	6.4
1980	23.6	23.0	7.6	13.1	13.4	6.1	18.4	18.1	6.8
1981	24.7	26.6	8.1	14.0	15.6	6.4	19.4	21.2	7.2
1982	24.5	24.6	8.5	14.1	13.6	6.9	19.3	19.2	7.7
1983	24.2	24.7	8.2	13.6	14.2	6.3	18.9	19.5	7.2
1984	24.0	23.4	8.0	13.7	14.1	6.0	18.9	18.8	7.0
1985	24.4	24.3	7.5	14.2	14.5	5.8	19.4	19.3	6.6
1986	23.6	25.1	8.1	14.0	14.2	6.2	18.9	19.8	7.1
1987	24.9	25.7	8.1	14.8	13.6	6.6	19.9	19.7	7.3
1988	25.7	28.3	8.3	14.6	15.6	6.3	19.8	21.0	7.4
1989	24.9	24.4	7.8	14.9	15.1	5.8	19.9	19.9	6.6
1990	24.8	25.3	8.2	14.9	15.6	6.1	19.8	20.5	7.1
1991	23.7	22.8	7.7	13.7	11.9	6.2	18.7	17.3	6.9
1992	24.2	24.1	7.6	13.9	13.8	5.8	19.1	18.8	6.7
1993	24.7	27.0	8.5	13.9	13.8	6.0	19.3	20.4	7.2
1994	25.1	24.2	7.6	15.1	15.0	6.4	20.1	19.3	7.0
1995	24.7	22.6	8.0	13.1	11.5	5.8	18.9	17.1	6.9
1996	25.0	24.1	7.5	13.1	12.6	6.2	19.0	18.4	6.8
1997	25.3	23.8	8.3	14.2	13.6	6.8	19.7	18.5	7.5
1998	25.1	26.8	8.3	14.8	15.7	6.5	20.0	21.3	7.4
1999	26.3	27.5	9.1	15.7	16.6	7.4	21.0	22.1	8.2
2000	25.1	25.8	7.7	15.1	15.8	6.0	20.1	20.8	6.8
2001	26.2	27.6	7.7	15.0	14.9	6.0	20.6	21.3	6.8
2002	25.7	25.4	7.9	14.9	15.0	6.1	20.3	20.2	7.0
2003	25.4	27.3	8.5	14.9	15.1	7.2	20.2	21.2	7.9
2004	25.1	25.7	7.4	14.6	14.1	6.0	19.9	19.9	6.7
2005	24.9	26.0	8.6	14.3	14.7	6.8	19.6	20.5	7.7
2006	25.0	26.9	8.3	15.0	16.2	6.4	20.0	21.6	7.4
2007	25.5	26.0	7.8	14.9	15.0	5.7	20.2	20.7	6.7
2008	25.3	26.2	8.4	14.3	15.2	6.1	19.8	20.7	7.2
2009	25.1	24.4	7.6	14.1	13.1	6.6	19.7	19.0	7.1
2010	26.5	26.1	6.4	15.3	14.6	5.5	20.9	20.6	5.9
General Average	24.76	24.99	7.95	14.16	14.08	6.21	19.47	19.54	7.05

The temperatures: Values are red: above average.
Values are blue: below average.

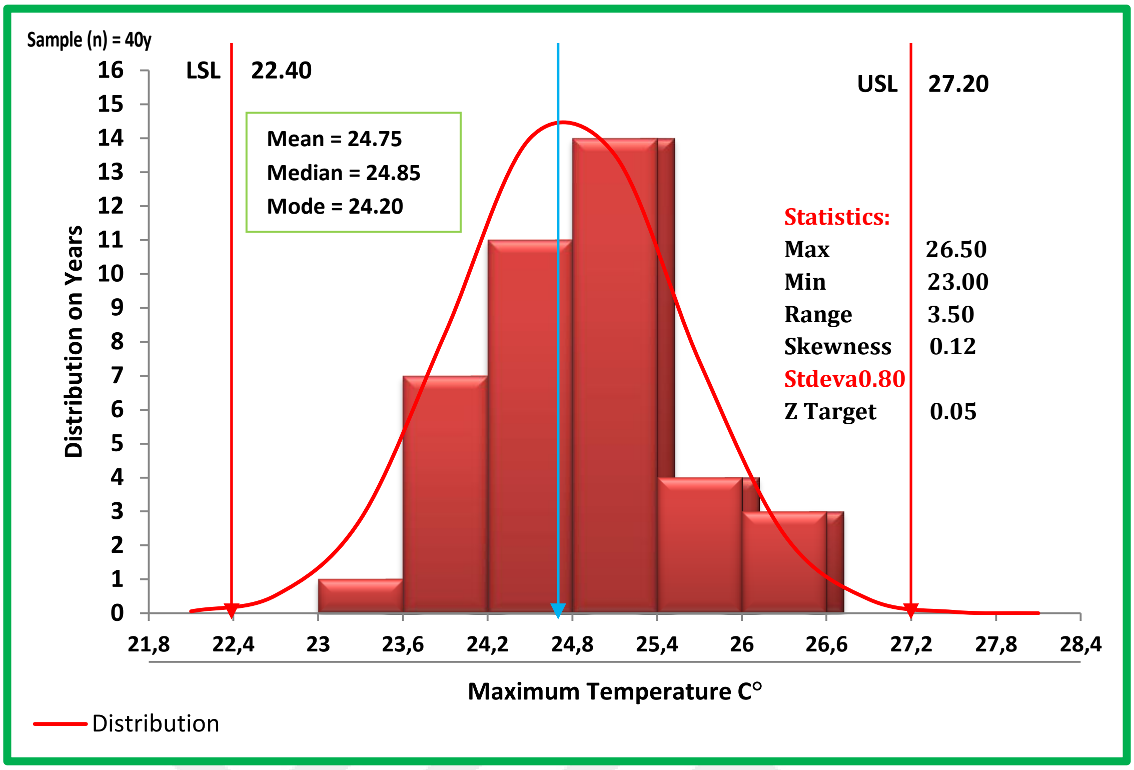


Figure 74. Statistics of Annual Maximum Temperature in NALUT Station for Period (1971-2010)

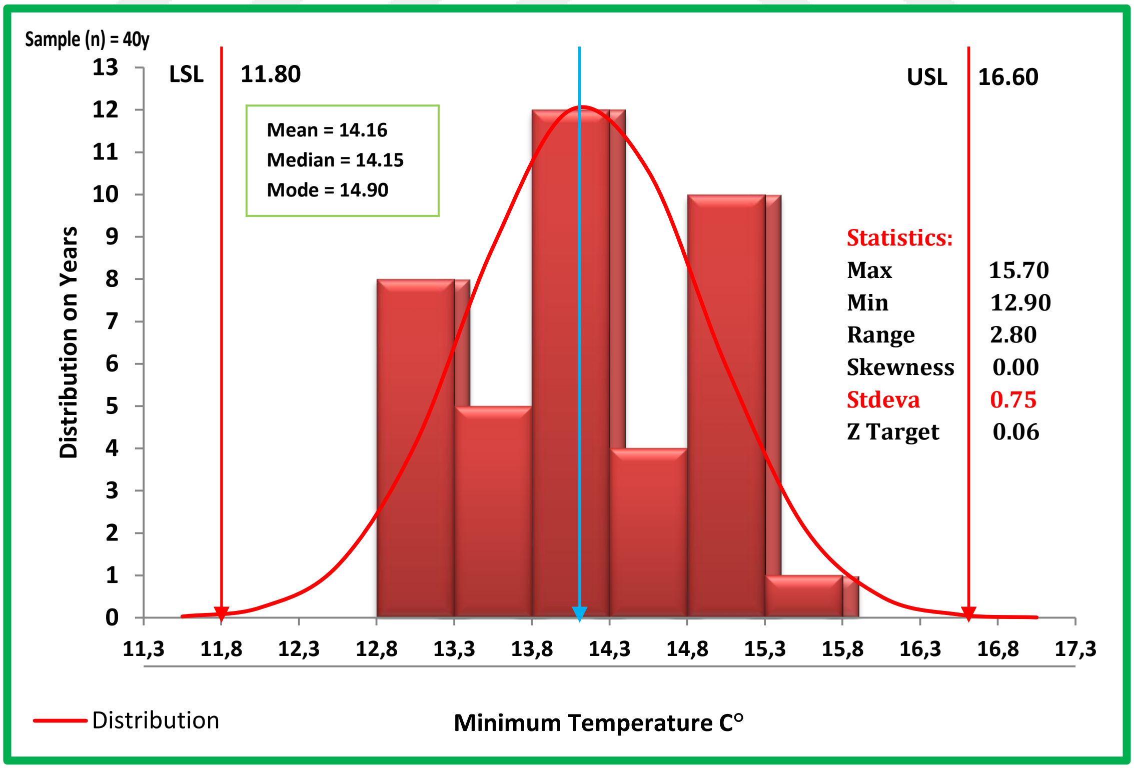


Figure 75. Statistics of Annual Minimum Temperature in NALUT Station for Period (1971-2010)

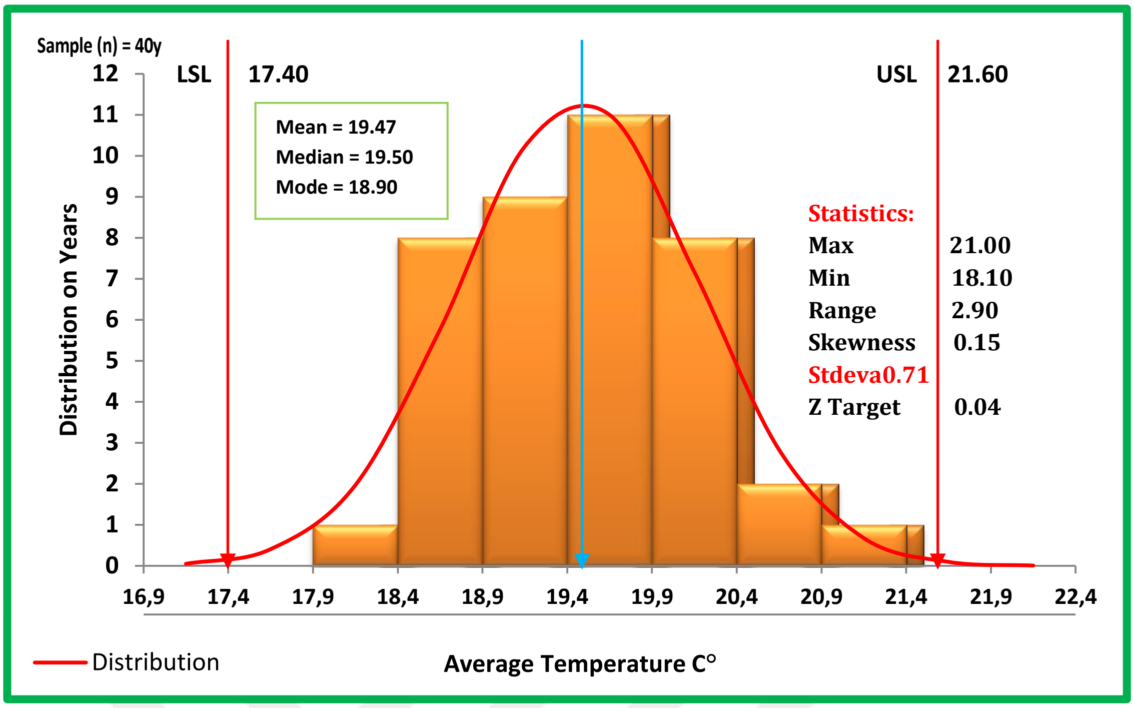


Figure 76. Statistics of Annual Average Temperature in NALUT Station for Period (1971-2010)

In table 42 NALUT station The data shown in table 43 describes that the maximum temperatures continued to rise above the average from 1996 to 2010. Moreover, the minimum temperatures also recorded a significant increase from 1997 to 2010. A significant increase is also observed in the general average from 1997 to 2010 except for the years 1997 and 2000 indicating a trend towards warming during the last years of monitoring.

The figure 75 shows a semi-normal distribution over the monitoring years for maximum temperatures. It is observed that temperature of (24.8 °C) is distributed over 14 years, (24.2 °C) over 11 years, (23.6 °C) over 7 years, (25.4 °C) over 4 years, (26 °C) over 3 year (23 °C) over one year. There is no extreme data found in the distribution. In figure 76, it is shown that for minimum temperatures a non-normal distribution over the monitoring years is present. The temperature of (13.8 °C) is the highest which is distributed over 12 years, (14.8 °C) over a period of 10 years, (12.8 °C) is stabilized over 8 years, (13.3 °C) over 5 years, (11.4 °C) over4 years and (15.3 °C) over only one year. Figure 77 shows on-normal distribution over the monitoring years for average temperatures. The temperature of (19.4 °C) is distributed over 11 years, (18.9 °C) over 9 years, (18.4 and 19.9 °C) over 8 years, (20.4 °C) over 2 years and (17.9 and 20.9 °C) over one year. No extreme temperature is found in the distribution. The distribution curve is reached at (19.4 °C) and stabilized. The curve is to the highest level at the right of the figure at (21.6 °C), and at left to lowest at (17.4 °C).

Table 43. The Descriptive Statistics and Distributions of Annual Temperature in SHAHAT Station for Period (1971-2010)

Years	Annual Maximum Temperature °C			Annual Minimum Temperature °C			Annual Average Temperature °C		
	Mean	Median	Standard Deviation	Mean	Median	Standard Deviation	Mean	Median	Standard Deviation
1971	21.4	21.5	6.3	11.7	11.5	4.4	16.6	16.5	5.3
1972	21.8	21.2	6.6	11.5	10.7	4.6	16.7	16.0	5.6
1973	21.4	21.2	6.2	11.7	11.2	4.8	16.6	16.4	5.4
1974	20.9	22.1	6.3	11.6	11.2	4.5	16.3	16.6	5.3
1975	20.8	21.1	5.8	11.8	12.0	4.3	16.3	16.7	5.0
1976	20.5	21.2	5.9	11.4	11.6	4.5	15.9	16.5	5.2
1977	21.4	20.2	5.7	11.6	11.2	4.6	16.5	15.7	5.0
1978	20.6	21.3	5.5	11.4	11.2	4.2	16.0	16.3	4.8
1979	21.3	21.4	5.7	11.9	10.7	4.6	16.7	15.8	5.1
1980	20.6	22.2	6.3	11.9	12.0	4.9	16.3	17.1	5.5
1981	20.7	22.1	6.4	11.8	11.6	5.0	16.3	16.9	5.6
1982	20.6	21.1	6.6	11.5	11.1	4.7	16.1	16.1	5.7
1983	20.0	21.0	6.0	11.7	12.5	4.8	15.9	16.4	5.4
1984	21.0	21.7	6.1	12.0	12.8	4.7	16.6	17.4	5.4
1985	21.1	20.8	5.3	12.4	12.3	4.4	16.7	16.4	5.0
1986	20.3	20.6	6.0	12.3	11.2	4.7	16.3	16.1	5.3
1987	20.5	20.6	6.2	12.4	12.0	5.2	16.5	16.3	5.7
1988	21.1	21.0	7.3	13.1	12.6	5.3	17.2	16.8	6.3
1989	20.7	22.1	6.3	12.9	13.5	4.7	16.8	17.8	5.5
1990	21.0	21.9	6.1	13.2	13.6	4.5	17.1	17.7	5.3
1991	20.4	20.5	6.5	12.7	12.0	5.0	16.6	16.1	5.7
1992	20.2	20.4	6.9	12.8	12.8	5.3	16.5	16.6	6.1
1993	21.0	21.8	6.6	13.4	13.7	5.3	17.2	17.6	5.9
1994	21.1	22.1	6.3	13.6	13.6	4.9	17.4	18.1	5.5
1995	21.1	18.8	6.7	13.9	11.9	5.8	17.3	15.2	6.0
1996	20.6	19.3	6.4	13.3	12.8	5.1	17.0	16.0	5.7
1997	20.4	20.3	6.5	13.1	13.4	5.2	16.8	17.0	5.8
1998	20.8	22.8	6.8	13.6	13.7	5.2	17.2	18.3	6.0
1999	21.4	21.6	6.5	13.9	14.9	5.3	17.7	18.3	5.9
2000	20.5	21.7	6.3	12.3	12.4	4.7	16.4	17.3	5.4
2001	21.2	21.0	6.2	12.5	12.3	4.9	16.9	16.8	5.5
2002	21.0	20.3	6.5	12.5	12.0	5.1	16.8	16.3	5.8
2003	20.7	21.7	6.9	12.5	11.8	5.6	16.6	16.8	6.2
2004	20.9	21.4	5.8	12.6	12.0	4.7	16.8	16.5	5.3
2005	20.4	20.2	6.3	11.5	11.6	5.1	16.0	15.7	5.6
2006	20.2	20.8	6.3	11.5	10.6	5.4	15.9	16.2	5.8
2007	21.1	21.3	6.7	12.1	12.2	4.7	16.7	16.7	5.7
2008	21.9	22.1	6.5	12.5	12.4	5.1	17.2	17.4	5.7
2009	21.3	21.9	5.9	12.7	12.3	4.8	17.0	16.6	5.3
2010	22.7	23.2	5.3	13.1	12.9	4.4	17.9	18.4	4.8
General Average	20.92	21.24	6.26	12.40	12.20	4.88	16.68	16.74	5.53

The temperatures: Values are red: above average.
Values are blue: below average.

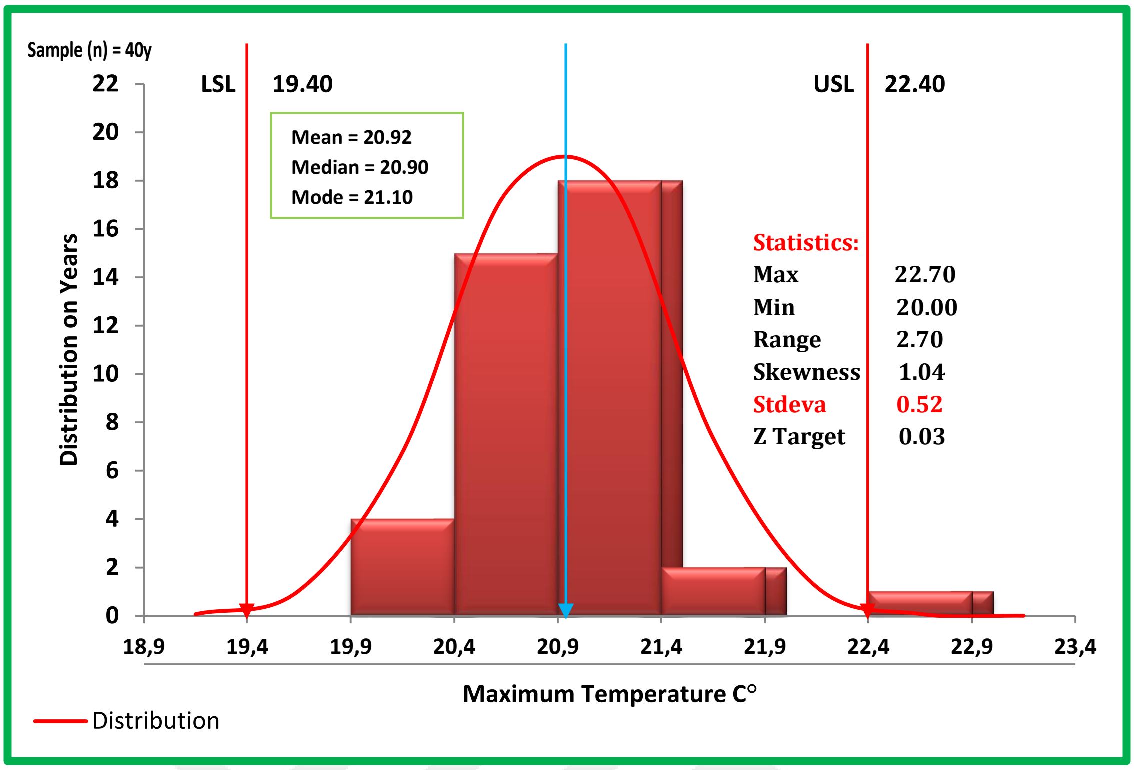


Figure 77. Statistics of Annual Maximum Temperature in SHAHAT Station for Period (1971-2010)

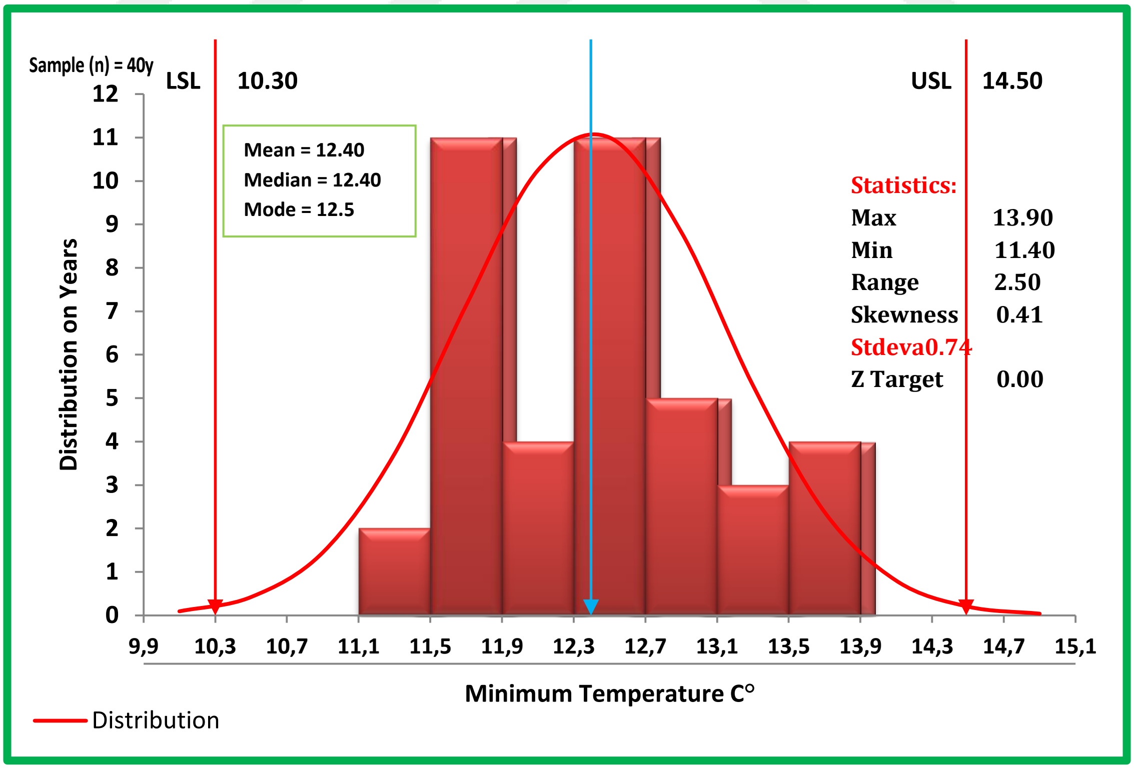


Figure 78. Statistics of Annual Minimum Temperature in SHAHAT Station for Period (1971-2010)

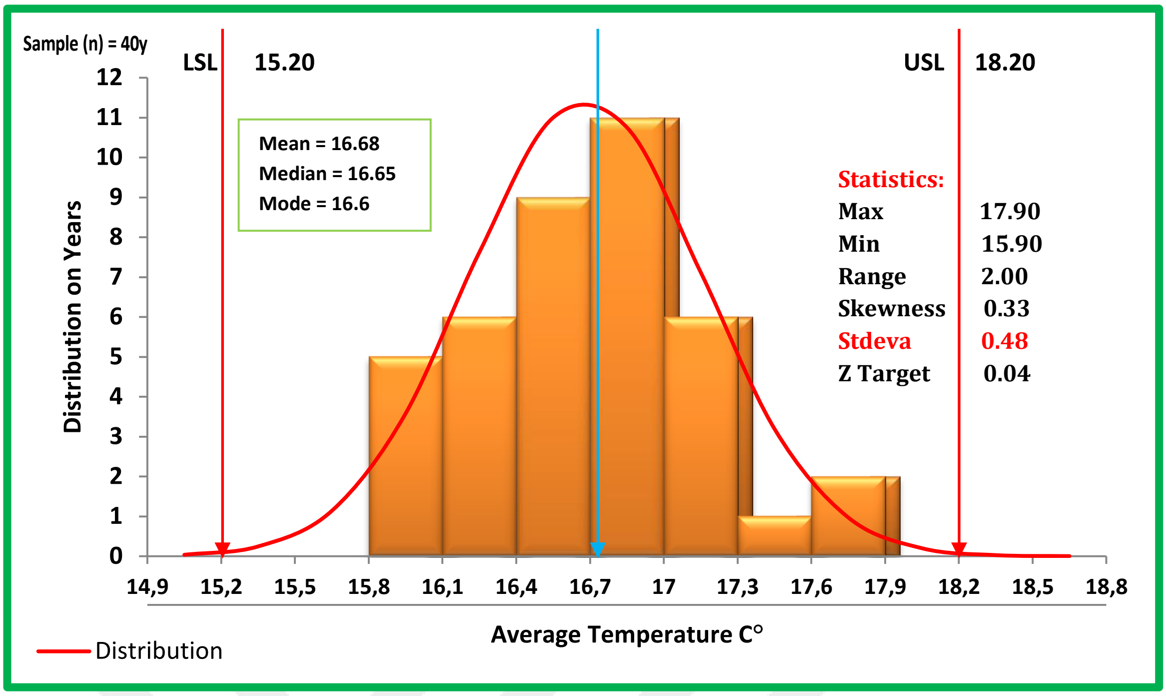


Figure 79. Statistics of Annual Average Temperature in SHAHAT Station for Period (1971-2010)

The data presented in the table 43 show that the maximum temperatures continued to rise above the average at SHAHAT station from 2007 to 2010. Besides, the minimum temperatures also recorded a significant increase from 2008 to 2010. Moreover, a significant increase is also observed in the general average from 2007 to 2010 indicating a trend towards warming during the last four years of monitoring period.

The figure 78 shows a non-normal distribution over the monitoring years for maximum temperatures. It is observed that the temperature of (20.9 °C) is distributed and stabilized over 18 years, (20.4 °C) over 14 years, (23.6 °C) over 7 years, (19.9 °C) over 4 years and (21.4 °C) over 2 years. The temperature of (22.4 °C) is found as an extreme in the distribution over one year. The figure 79 shows a non-normal distribution for minimum temperatures over the monitoring years. The temperatures of (11.5 and 12.7 °C) are found the highest that are distributed over 11 years, (12.7 °C) over a period of 5 years, (11.9 and 13.5 °C) over 4 years, (13.1 °C) over 3 years and (11.1 °C) over 2 years. No extreme temperature is found in the data in distribution. Semi-normal distribution over the monitoring years is observed in the figure 80 for average temperatures. The temperature of (16.7 °C) is distributed over 11 years, (16.4 °C) over 9 years, (16.1 and 17 °C) over 6 years, (15.8 °C) over 5 years, (17.6 °C) over

2 years and (17.3 °C) over one year. No extreme temperatures are observed. The distribution curve is reached at (16.7 °C) and found stabilized. The curve is to the highest level at the right of the figure at (18.2 °C) and at left to lowest at (15.2 °C).

Table 44. The Descriptive Statistics and Distributions of Annual Temperature in SIRTE Station for Period (1971-2010)

Years	Annual Maximum Temperature °C			Annual Minimum Temperature °C			Annual Average Temperature °C		
	Mean	Median	Standard Deviation	Mean	Median	Standard Deviation	Mean	Median	Standard Deviation
1971	25.0	25.7	4.5	15.6	15.8	4.9	20.3	21.0	4.7
1972	25.2	24.0	4.6	16.2	15.7	5.3	20.7	19.8	4.9
1973	24.8	25.0	5.3	15.7	15.5	5.7	20.3	20.3	5.4
1974	24.7	24.8	4.5	14.8	14.5	4.3	19.8	19.7	4.3
1975	24.4	24.9	4.5	15.9	16.4	4.5	20.2	20.3	4.4
1976	24.1	25.0	5.1	14.9	14.9	5.1	19.5	20.1	5.1
1977	25.7	25.3	4.5	15.9	15.7	4.9	20.8	20.6	4.7
1978	24.6	25.5	4.1	15.4	15.7	4.7	20.0	20.9	4.3
1979	25.0	23.8	4.2	16.0	14.9	4.6	20.5	19.3	4.3
1980	23.9	25.2	4.4	15.4	16.0	4.9	19.7	20.6	4.6
1981	24.1	24.4	5.2	16.0	15.9	5.7	20.1	20.2	5.4
1982	24.5	24.1	5.0	16.3	16.2	5.3	20.4	20.2	5.1
1983	23.8	24.7	4.8	15.9	16.5	5.0	19.9	20.7	4.9
1984	24.9	25.3	5.1	15.5	15.8	5.1	20.2	20.6	5.1
1985	25.4	26.3	4.2	16.2	16.1	4.5	20.8	21.2	4.3
1986	24.2	23.9	4.5	15.9	15.3	5.0	20.1	19.6	4.7
1987	24.9	24.2	4.5	16.1	15.4	4.9	20.5	19.8	4.7
1988	25.6	26.0	5.4	16.9	17.1	5.3	21.3	21.6	5.3
1989	25.5	26.4	4.6	16.8	17.0	4.9	21.2	21.7	4.7
1990	25.4	25.3	5.0	16.7	17.0	4.3	21.1	21.2	4.6
1991	24.9	24.4	5.2	15.7	14.8	4.8	20.4	19.6	5.0
1992	25.1	24.4	5.5	16.2	16.1	5.1	20.7	20.3	5.3
1993	24.9	25.7	5.3	16.9	17.4	5.2	20.9	21.5	5.2
1994	25.2	26.0	4.5	17.2	17.2	5.0	21.2	21.8	4.7
1995	25.6	24.6	5.3	16.6	15.5	5.6	21.1	20.3	5.4
1996	25.6	25.3	4.5	16.0	15.4	5.2	20.8	20.6	4.8
1997	25.1	24.9	5.3	15.8	14.8	5.6	20.4	19.9	5.4
1998	25.3	26.5	5.0	16.1	16.5	5.1	20.7	21.5	5.0
1999	25.2	27.2	6.2	15.2	15.9	6.0	20.2	21.5	6.0
2000	25.5	26.9	5.2	16.0	16.1	5.3	20.8	21.5	5.2
2001	26.4	26.5	4.7	16.2	16.6	5.4	21.3	21.9	5.0
2002	25.9	26.4	5.2	16.5	15.9	5.3	21.2	21.2	5.2
2003	25.6	25.3	5.6	17.1	16.3	6.5	21.4	20.8	6.0
2004	25.8	26.1	4.5	16.5	15.9	5.1	21.1	21.0	4.8
2005	25.5	26.1	5.1	16.5	16.2	5.2	21.1	21.0	5.1
2006	25.5	26.1	5.1	16.5	15.8	5.5	21.1	20.9	5.3
2007	26.0	25.2	4.9	17.1	16.5	5.1	21.6	20.7	5.0
2008	26.3	28.1	5.2	16.8	17.4	5.5	21.6	23.0	5.3
2009	26.1	24.9	4.3	16.9	16.0	5.5	21.5	20.5	4.9
2010	27.7	28.8	3.7	17.6	16.8	4.5	22.7	22.8	4.0
General Average	25.22	25.48	4.86	16.19	16.01	5.14	20.73	20.79	4.95

The temperatures: Values are red: above average.
Values are blue: below average.

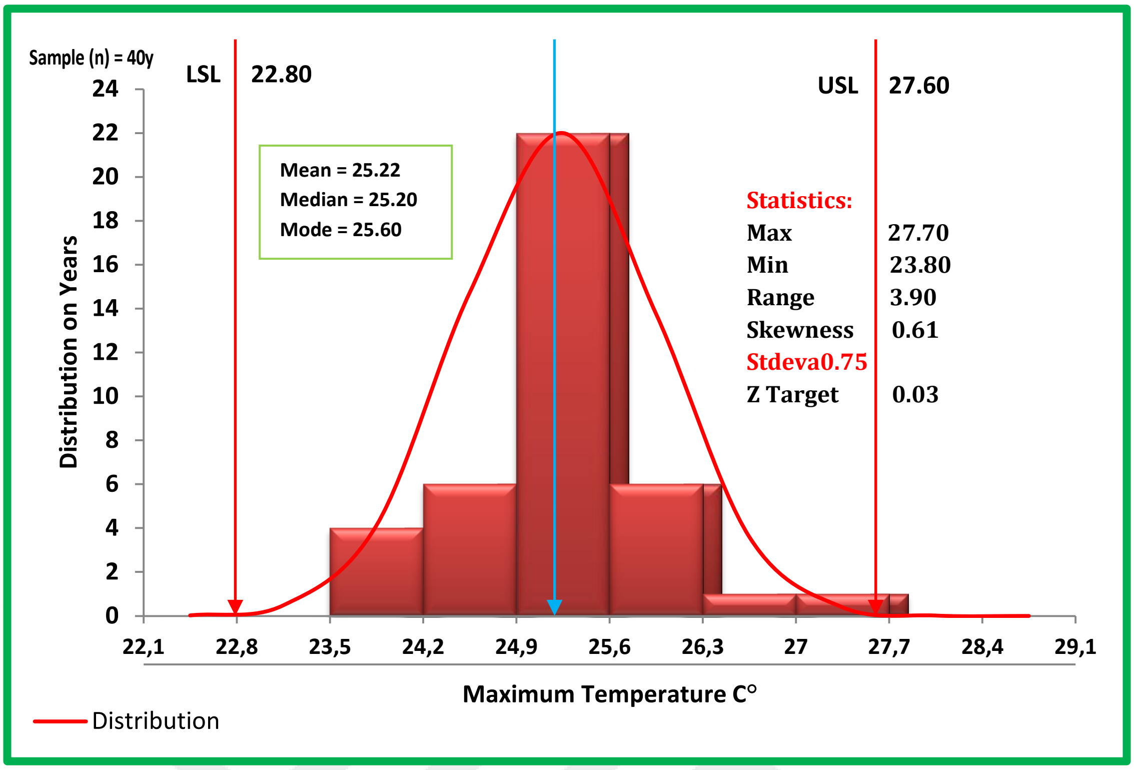


Figure 80. Statistics of Annual Maximum Temperature in SIRTE Station for Period (1971-2010)

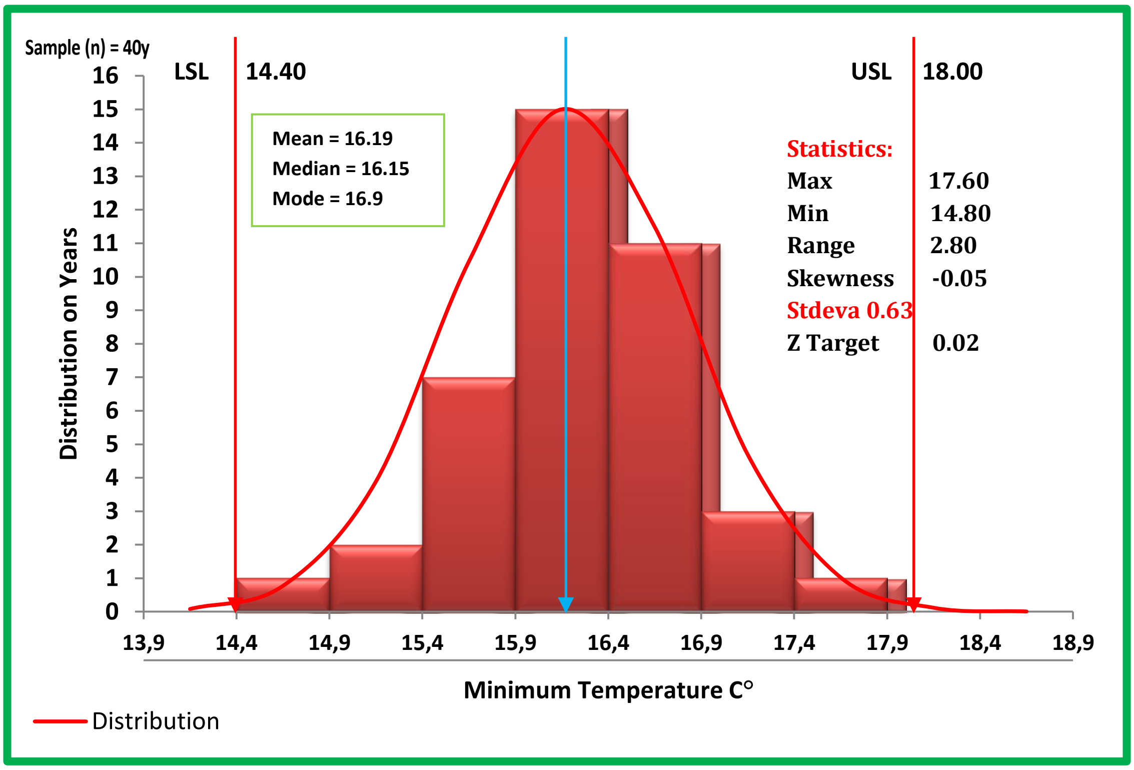


Figure 81. Statistics of Annual Minimum Temperature in SIRTE Station for Period (1971-2010)

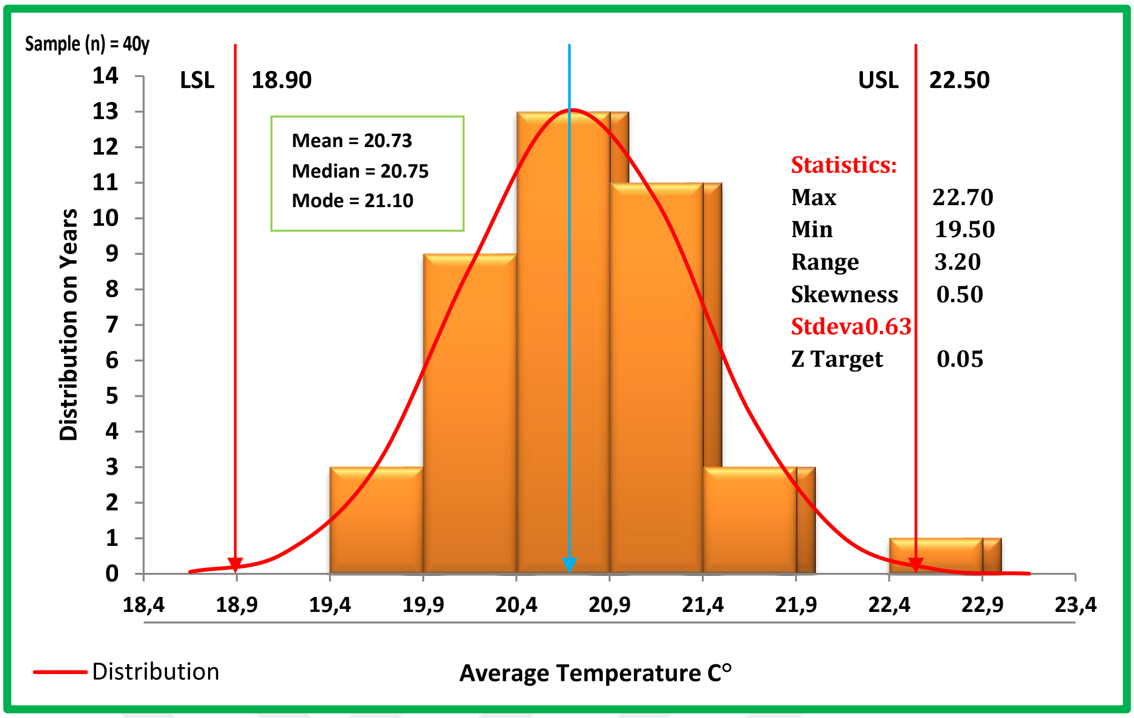


Figure 82. Statistics of Annual Average Temperature in SIRTE Station for Period (1971-2010)

The data described in the table 44 show that the maximum temperatures continued to rise above the average at SIRTE station from 2000 to 2010. Besides, the minimum temperatures recorded a significant increase from 2001 to 2010. Moreover, a significant increase is also observed in the general average from 2000 to 2010 indicating a trend towards warming during the last ten years of monitoring period.

The figure 81 shows a non-normal distribution for maximum temperatures over the monitoring years. It is observed that the temperature of (24.9 °C) is distributed over 22 years, (24.2 and 25.6°C) over 6 years, (23.5 °C) over 4 years and (26.3 and 27 °C) over one year. No extreme data is observed in the distribution.Thefigure 82 shows a semi-normal distribution for minimum temperatures over the monitoring years. The temperature of (15.9 °C) is found the highest distributed over 15 years, (16.4 °C) over a period of 11 years, (15.4 °C) over 7 years, (16.9 °C) over 3 years and (14.4 and 17.4 °C) over one year. Besides, no extreme data is found in the distribution. Semi-normal distribution over the monitoring years is shown in figure 83 for average temperatures. The temperature of (20.4 °C) is distributed over 13 years, (20.9 °C) over 11 years, (19.9 °C) over 9 years and (19.4 and 21.4 °C) over 3 years. Besides, (22.4 °C) is found as extreme temperature over one year.

The distribution curve is reached at (20.7 °C) and stabilized. The curve is to the highest level at the right of the figure at (22.5 °C) and at left to lowest at (18.9 °C).

Table 45. The Descriptive Statistics and Distributions of Annual Temperature in TOBRUK Station for Period (1984-2010)

Years	Annual Maximum Temperature °C			Annual Minimum Temperature °C			Annual Average Temperature °C		
	Mean	Median	Standard Deviation	Mean	Median	Standard Deviation	Mean	Median	Standard Deviation
1984	23.8	24.0	3.9	15.6	15.0	4.7	19.7	19.5	4.3
1985	23.8	24.2	4.0	15.9	15.5	4.8	19.9	19.7	4.3
1986	23.2	22.6	4.6	16.0	15.3	5.3	19.6	18.9	4.9
1987	23.2	23.3	4.6	15.8	14.6	5.4	19.5	19.0	5.0
1988	24.1	24.1	5.2	15.5	14.8	5.6	19.8	19.7	5.4
1989	23.6	24.6	4.7	15.5	15.2	5.0	19.6	19.9	4.8
1990	24.1	24.5	4.6	15.8	15.9	5.1	20.0	20.2	4.8
1991	23.6	23.7	4.8	15.5	15.2	4.9	19.6	19.4	4.9
1992	23.1	23.4	5.3	14.3	13.5	4.8	18.8	18.5	4.9
1993	23.7	24.0	4.9	15.4	15.2	5.3	19.6	19.6	5.1
1994	24.1	25.3	4.6	15.8	15.7	5.2	19.9	19.9	4.9
1995	24.0	23.6	4.7	15.2	14.3	5.5	19.2	18.1	5.5
1996	23.9	23.9	4.7	14.6	14.5	5.8	19.3	19.5	5.3
1997	24.1	24.9	4.6	15.2	16.0	5.7	19.6	20.8	5.1
1998	24.0	24.3	5.0	16.5	16.1	5.3	20.2	20.2	5.1
1999	24.4	25.4	4.6	16.4	16.6	5.6	20.4	21.0	5.1
2000	24.2	24.9	4.5	15.6	15.4	5.1	19.9	20.0	4.7
2001	25.0	25.3	4.1	15.7	15.6	6.2	20.4	20.2	5.1
2002	24.3	24.0	4.8	17.3	16.9	5.8	20.8	20.5	5.3
2003	23.8	24.1	5.0	16.8	17.3	5.1	20.3	20.7	5.0
2004	24.0	24.2	4.6	16.3	16.4	4.8	20.2	20.3	4.7
2005	23.8	24.1	4.8	16.9	16.6	5.3	20.3	20.5	5.1
2006	23.7	23.6	4.7	17.0	16.3	5.4	20.3	19.9	5.0
2007	24.3	24.2	4.6	17.4	16.7	5.1	20.9	20.5	4.9
2008	24.7	25.6	4.5	17.8	17.9	5.1	21.3	21.4	4.8
2009	24.5	23.4	4.2	17.1	16.5	5.6	20.8	20.0	4.9
2010	23.7	23.4	4.5	16.1	15.5	5.7	19.9	19.4	5.1
General Average	23.95	24.17	4.63	16.04	15.72	5.30	19.99	19.90	4.96

The temperatures: Values are red: above average.
Values are blue: below average.

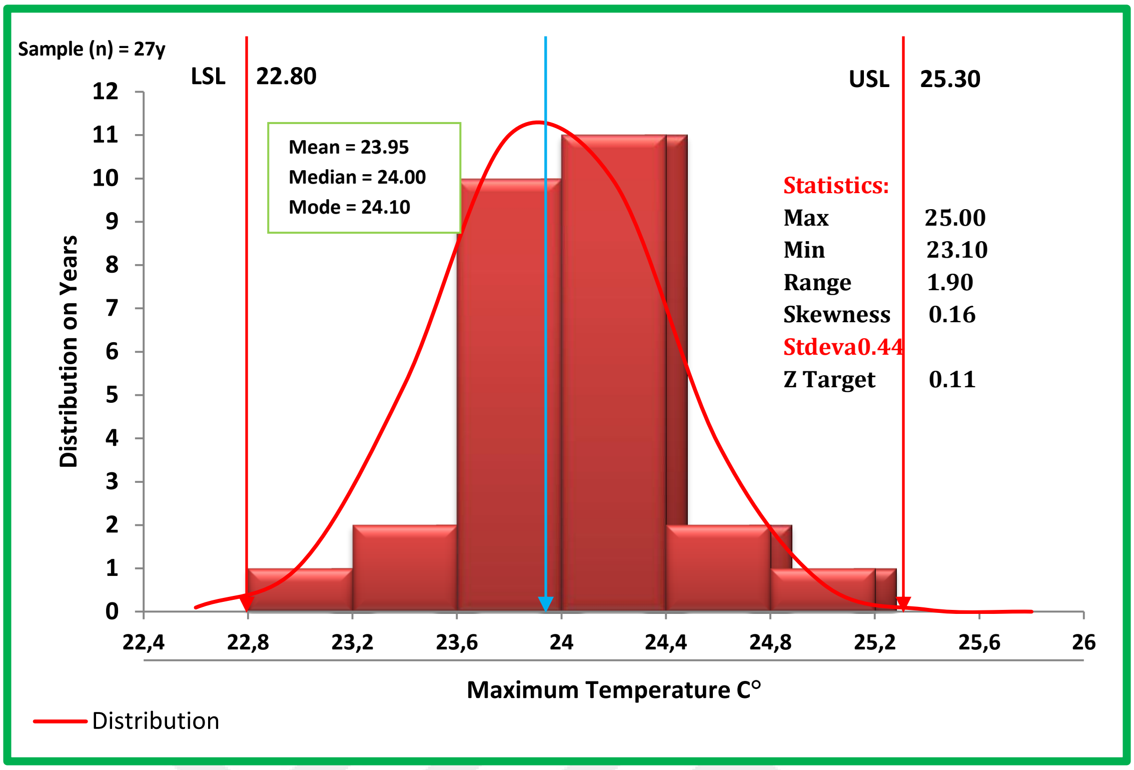


Figure 83. Statistics of Annual Maximum Temperature in TOBRUK Station for Period (1984-2010)

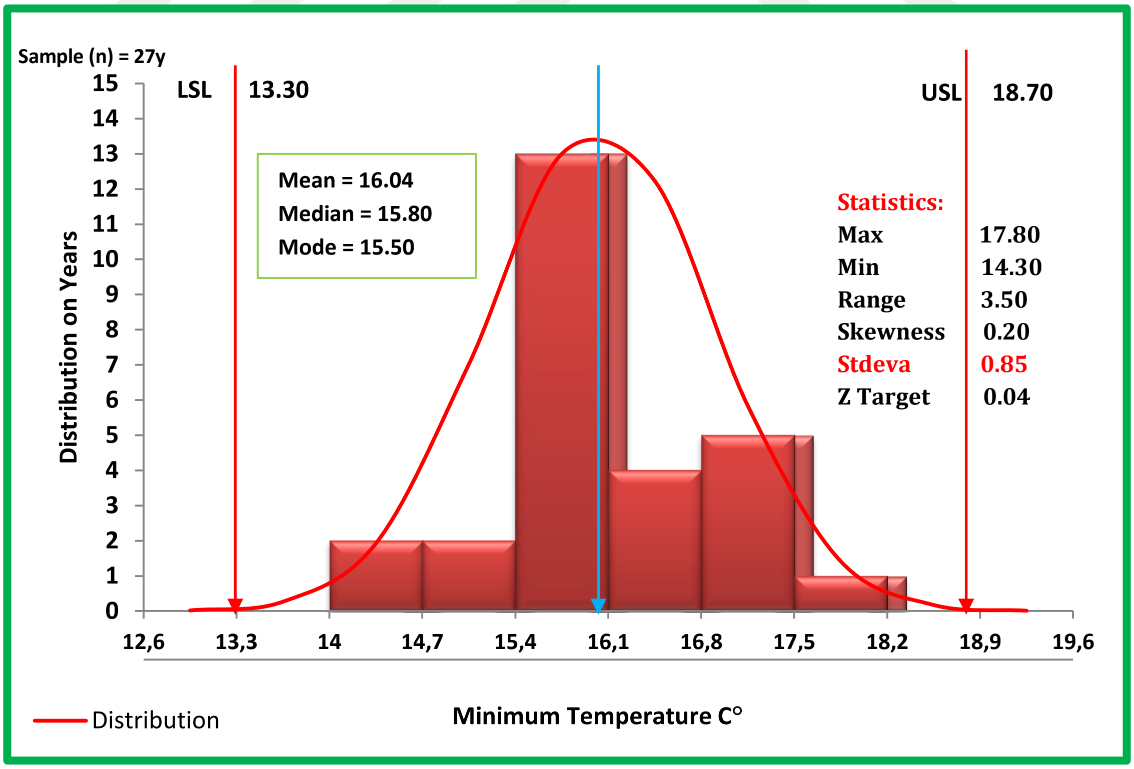


Figure 84. Statistics of Annual Minimum Temperature in TOBRUK Station for Period (1984-2010)

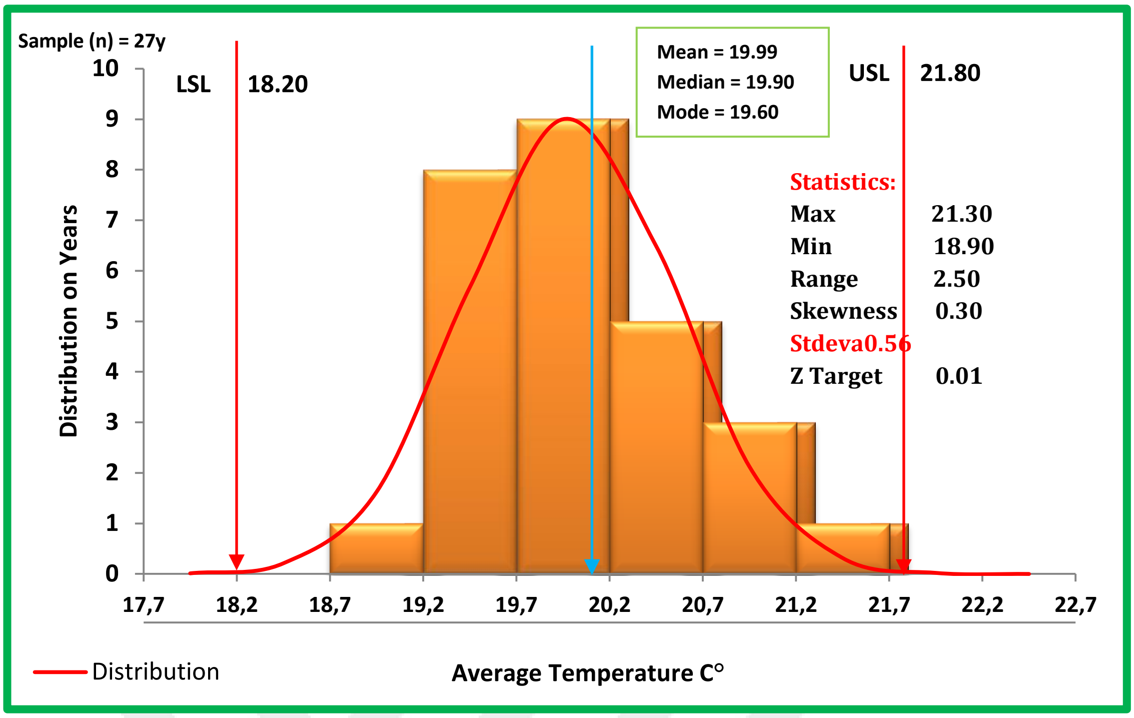


Figure 85. Statistics of Annual Average Temperature in TOBRUK Station for Period (1984-2010)

The data shown in the table 45 has revealed that the maximum temperatures continued to rise above the average at TOBRUK station in different periods from 1997 to 2002 and from 2007 to 2009. Besides, the minimum temperatures recorded a significant increase from 2002 to 2010. Moreover, a significant increase is also observed in the general average from 2001 to 2009 indicating a trend towards warming during the last years of monitoring period.

The figure 84shows a semi-normal distribution for maximum temperatures over the monitoring years. It is observed that the temperature of (24 °C) is distributed over 11 years, (23.6 °C) over 10 years, (23.2 and 24.4 °C) over two years and (22.8 and 24.8 °C) over one year. No extreme data is found in distribution. In figure 85 a non-normal distribution for minimum temperatures is shown over the monitoring years. The temperature of (15.4 °C) is found the highest which is distributed over 13 years, (16.8 °C) over a period of 5 years, (16.1 °C) over 4 years, (14.0 and 14.7 °C) over 2 years and (17.5°C) over one year. There is no extreme data observed in distribution. The figure 86shows a semi-normal distribution for average temperatures over the monitoring years. The temperature of (19.7 °C) is found distributed over 9 years, (19.2 °C) over 8 years, (20.2 °C) over3 years and (18.7 and 21.2 °C) over one year.

Besides, no extreme data is observed in the distribution. The distribution curve is reached at (19.99 °C) and stabilized. The curve is to the highest level at the right of the figure at (21.8 °C) and at left to lowest at (18.2 °C).

Table 46. The Descriptive Statistics and Distributions of Annual Temperature in TRIPOLI Station for Period (1971-2010)

Years	Annual Maximum Temperature °C			Annual Minimum Temperature °C			Annual Average Temperature °C		
	Mean	Median	Standard Deviation	Mean	Median	Standard Deviation	Mean	Median	Standard Deviation
1971	26.3	26.8	7.1	13.8	13.7	5.2	20.1	20.3	6.1
1972	26.6	25.3	6.8	14.1	13.0	5.8	20.4	19.3	6.3
1973	26.7	27.6	8.2	13.6	13.8	6.2	20.2	20.5	7.2
1974	26.1	26.0	7.0	13.3	13.3	5.1	19.7	20.0	6.0
1975	26.0	26.3	6.7	14.1	14.2	5.1	20.0	20.3	5.9
1976	25.5	26.0	7.2	14.1	14.1	5.6	19.8	20.2	6.4
1977	27.6	26.6	6.6	14.4	14.1	5.6	21.1	20.4	6.1
1978	26.5	26.5	6.2	13.7	13.7	5.0	20.1	20.1	5.5
1979	27.0	26.0	6.1	13.9	12.6	5.5	20.4	19.3	5.8
1980	26.3	26.1	6.6	12.9	13.8	5.7	19.6	20.4	6.1
1981	27.5	29.0	7.3	13.7	14.6	6.0	20.6	21.9	6.7
1982	27.8	27.8	7.7	14.3	13.8	6.1	21.1	20.8	6.9
1983	27.2	27.6	7.2	13.4	14.1	6.2	20.3	20.8	6.7
1984	27.5	27.5	7.0	13.1	13.3	5.8	20.3	20.4	6.4
1985	28.2	28.2	6.4	13.5	13.5	5.2	20.9	20.8	5.8
1986	26.7	28.1	7.0	13.8	13.3	5.5	20.2	20.7	6.2
1987	27.6	26.8	7.6	14.2	13.0	6.1	20.9	19.5	6.8
1988	27.6	28.8	7.5	14.8	15.2	5.7	21.2	22.0	6.6
1989	27.0	26.5	6.5	14.4	14.3	5.4	20.7	20.5	5.9
1990	27.4	27.6	7.2	15.2	15.3	5.6	21.3	21.5	6.4
1991	26.3	25.3	7.2	14.0	12.4	5.6	20.2	18.9	6.4
1992	26.8	26.0	7.1	13.6	13.5	5.3	20.3	19.7	6.3
1993	27.4	29.3	7.4	14.4	15.3	6.0	20.9	21.7	6.7
1994	27.3	26.7	6.8	14.9	15.2	5.8	21.1	21.0	6.2
1995	26.2	24.5	7.0	15.1	14.5	6.2	20.7	19.5	6.6
1996	26.6	25.9	6.6	15.2	13.9	5.6	20.9	19.9	6.1
1997	26.7	26.5	7.3	15.0	14.2	6.4	20.9	20.5	6.8
1998	27.3	29.0	7.5	14.4	15.3	6.2	20.9	22.4	6.8
1999	29.1	30.9	8.2	13.9	13.2	6.1	21.5	22.1	7.1
2000	27.7	28.7	6.7	13.5	14.7	6.3	20.6	21.4	6.4
2001	28.2	29.1	6.7	15.1	15.9	5.8	21.7	22.0	6.2
2002	28.2	28.5	7.3	14.6	14.7	6.5	21.4	21.6	6.8
2003	28.1	28.9	7.8	15.0	15.3	6.3	21.6	21.9	7.1
2004	28.0	27.9	6.7	14.6	14.6	5.3	21.4	21.3	5.9
2005	27.5	28.7	7.6	14.8	14.1	6.2	21.2	21.7	6.8
2006	27.7	29.3	7.5	14.8	15.3	5.9	21.2	22.5	6.6
2007	27.6	28.2	7.0	15.1	15.0	5.6	21.4	21.7	6.3
2008	28.0	29.6	7.7	14.6	15.3	6.4	21.3	22.6	6.9
2009	27.8	27.1	6.6	14.8	14.2	5.9	21.3	20.9	6.2
2010	28.6	28.4	5.5	15.8	15.8	5.2	22.2	22.2	5.3
General Average	27.26	27.49	7.05	14.29	14.23	5.78	20.79	20.88	6.38

The temperatures: Values are red: above average.
Values are blue: below average.

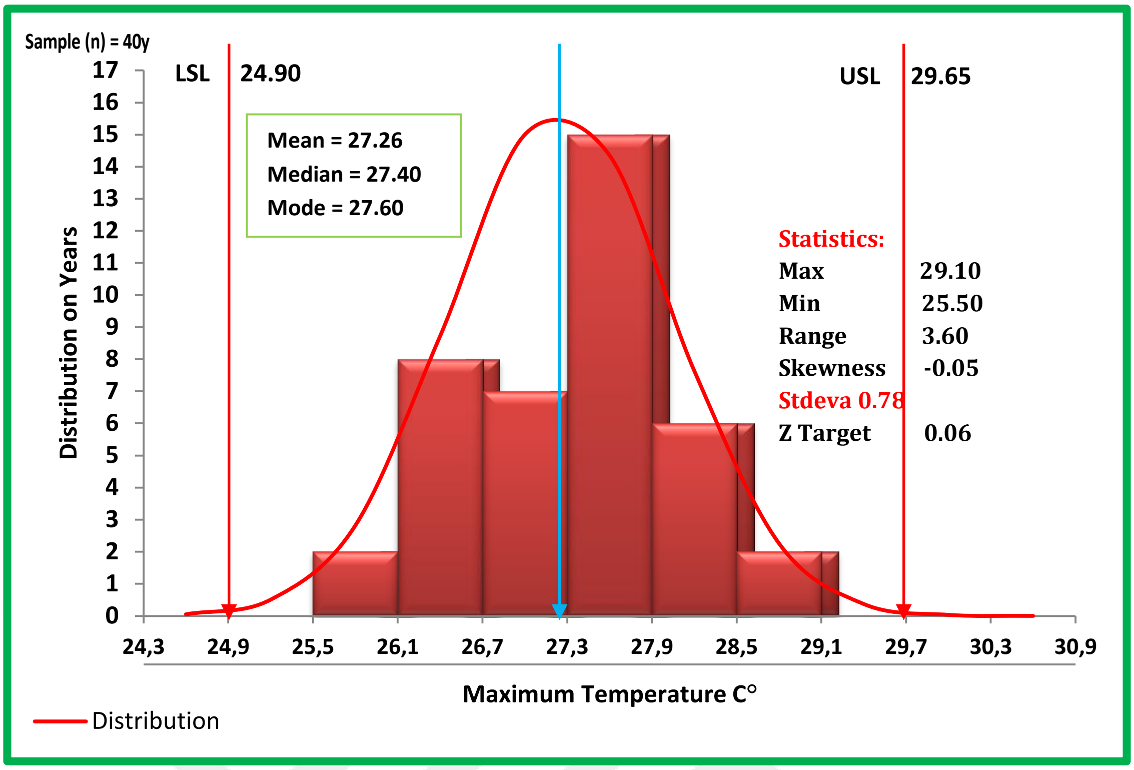


Figure 86. Statistics of Annual Maximum Temperature in TRIPOLI Station for Period (1984-2010)

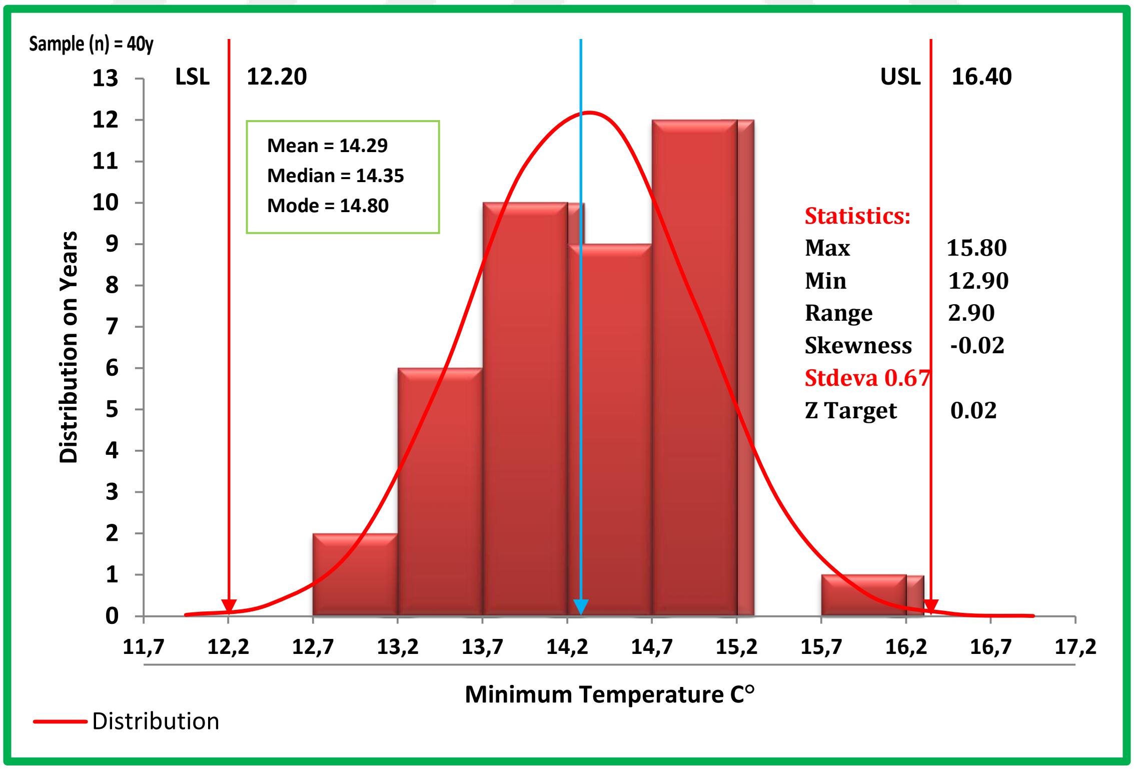


Figure 87. Statistics of Annual Minimum Temperature in TRIPOLI Station for Period (1984-2010)

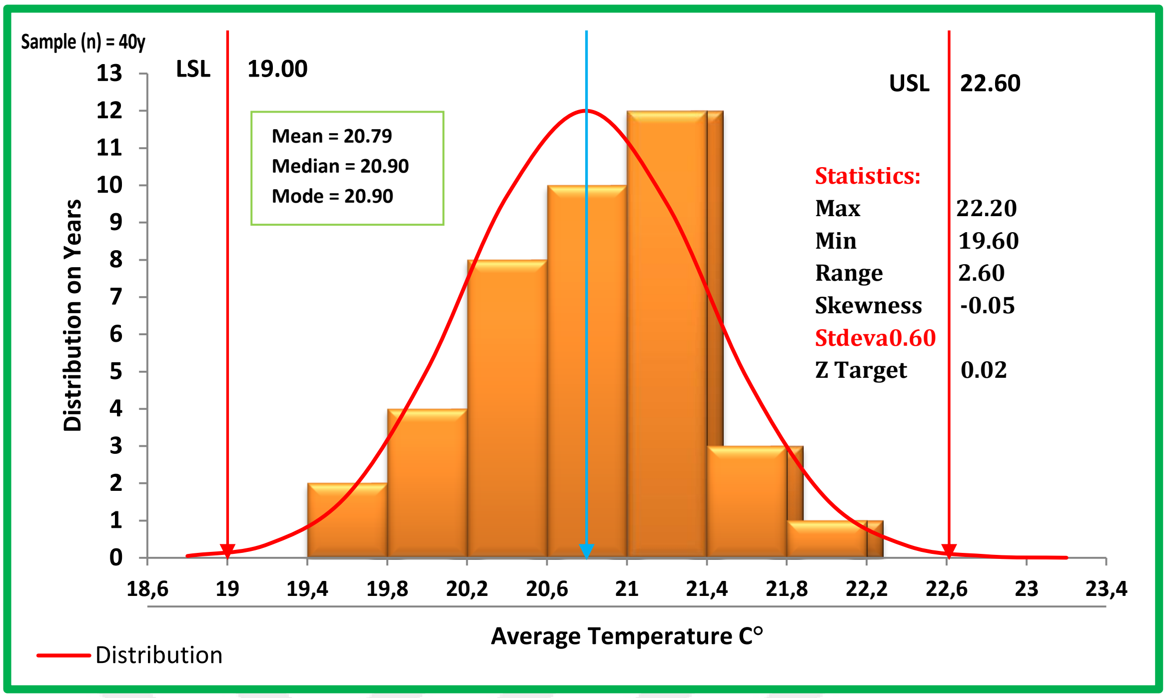


Figure 88. Statistics of Annual Average Temperature in TRIPOLI Station for Period (1984-2010)

Table 46 shows that the maximum temperatures continued to rise above the average at TRIPOLI station from 1998 to 2010. Moreover, the minimum temperatures recorded a significant increase from 2001 to 2010. Besides, a significant increase is also observed in the general average from 2001 to 2009 indicating a trend towards warming during the last years of monitoring period.

Asemi-normal distribution for maximum temperatures over the monitoring years is shown in figure 87. It is observed that the temperature of (27.3 °C) is distributed over 15 years, (26.1 °C) over 8 years, (26.7 °C) over 7 years, (27.9 °C) over 6 years and (25.5 and 28.5 °C) over one year. No extreme data is observed in the distribution. Thefigure 88 shows a non-normal distribution for minimum temperatures over the monitoring years. The temperature of (14.7 °C) is found the highest which is distributed over 12 years, (13.7 °C) over a period of 10 years, (14.2 °C) over 9 years and (12.7 °C) over 2 years. The temperature of (15.7 °C) is found as an extreme in the distribution over one year. The figure 79 shows a semi-normal distribution for average temperatures over the monitoring years. The temperature of (21 °C) is found distributed over 12 years, (20.6 °C) over 10 years, (20.2 °C) over 8 years, (19.8 °C) over 4 years, (21.4 °C) over 3 years, (19.4 °C) over two years and(21.8 °C) over one year. No extreme data is observed in the distribution. The distribution curve is reached at (20.79 °C) and stabilized. The curve is to the highest level at the right of the figure at (22.6 °C) and at left to lowest at (19 °C).

Table 47. The Descriptive Statistics and Distributions of Annual Temperature in ZWARA Station for Period (1971-2010)

Years	Annual Maximum Temperature °C			Annual Minimum Temperature °C			Annual Average Temperature °C		
	Mean	Median	Standard Deviation	Mean	Median	Standard Deviation	Mean	Median	Standard Deviation
1971	23.9	24.0	5.1	14.6	15.2	6.2	19.2	19.8	5.6
1972	23.9	24.3	4.7	15.1	15.0	6.0	19.5	19.1	5.2
1973	23.9	23.3	5.8	14.7	14.7	6.2	19.3	18.9	5.9
1974	24.0	24.1	4.7	14.7	15.0	5.7	19.3	19.6	5.1
1975	23.6	23.0	4.6	14.9	15.1	5.5	19.3	18.9	5.0
1976	23.2	22.1	4.9	15.0	15.1	5.8	19.1	18.6	5.3
1977	24.3	23.6	4.0	15.5	14.9	5.5	19.9	19.4	4.7
1978	23.9	24.1	4.2	15.0	14.7	5.3	19.5	19.4	4.7
1979	24.0	21.7	4.1	15.5	14.8	5.4	19.8	18.3	4.7
1980	23.4	23.6	4.6	14.8	15.2	5.8	19.1	19.4	5.2
1981	24.4	23.7	5.3	14.9	15.4	6.0	19.7	19.6	5.6
1982	24.7	22.6	5.7	15.2	14.7	5.7	20.0	18.6	5.6
1983	23.8	23.7	5.0	15.1	15.1	6.1	19.5	19.4	5.6
1984	24.3	25.4	5.2	15.2	15.4	6.0	19.7	20.7	5.6
1985	24.7	25.6	4.6	15.7	15.5	5.3	20.2	20.6	4.9
1986	23.7	23.4	4.8	15.8	15.7	5.7	19.8	19.6	5.2
1987	24.5	22.9	5.3	15.7	14.5	6.0	20.1	18.6	5.6
1988	24.7	25.5	5.1	16.2	16.9	5.7	20.5	21.3	5.4
1989	24.5	25.3	4.8	16.3	16.2	5.5	20.4	20.4	5.1
1990	25.0	24.4	5.5	16.8	16.6	5.8	20.9	20.5	5.6
1991	24.4	23.6	5.6	15.5	14.2	5.8	20.0	18.8	5.6
1992	24.7	23.5	5.2	15.5	14.9	5.6	20.1	19.3	5.4
1993	24.8	24.6	5.4	16.4	16.8	6.0	20.6	20.7	5.7
1994	25.4	25.1	5.0	16.4	16.3	6.0	20.9	20.7	5.5
1995	24.8	24.3	5.1	16.2	15.3	6.0	20.5	19.6	5.5
1996	25.7	25.5	4.9	16.2	15.4	5.5	21.0	20.4	5.2
1997	25.7	25.0	5.4	16.3	15.1	6.0	21.0	20.0	5.7
1998	25.2	25.2	5.4	16.4	16.6	6.1	20.8	21.0	5.7
1999	26.0	26.4	6.2	17.3	17.0	6.5	21.6	21.7	6.3
2000	25.5	25.9	5.1	16.3	17.3	5.9	21.0	21.6	5.5
2001	26.2	26.5	4.9	17.1	17.4	6.0	21.7	22.1	5.4
2002	25.9	26.6	5.0	16.6	16.7	6.0	21.3	21.5	5.5
2003	25.6	24.8	6.2	17.1	16.7	6.6	21.3	20.8	6.4
2004	24.8	24.0	4.6	17.0	16.6	5.4	20.9	20.3	5.0
2005	24.6	25.4	5.8	16.9	16.6	6.4	20.8	21.0	6.1
2006	25.0	25.6	5.4	17.3	17.4	5.9	21.2	21.5	5.6
2007	25.0	24.8	5.1	17.6	17.5	5.7	21.3	20.7	5.3
2008	24.9	25.6	5.1	17.5	17.4	6.0	21.2	21.6	5.5
2009	25.0	24.3	4.7	17.2	16.3	5.9	21.1	20.0	5.3
2010	25.5	25.8	3.8	17.8	17.6	5.2	21.7	21.4	4.5
General Average	24.68	24.47	5.05	16.03	15.87	5.84	20.37	20.14	5.41

The temperatures: Values are red: above average.
Values are blue: below average.

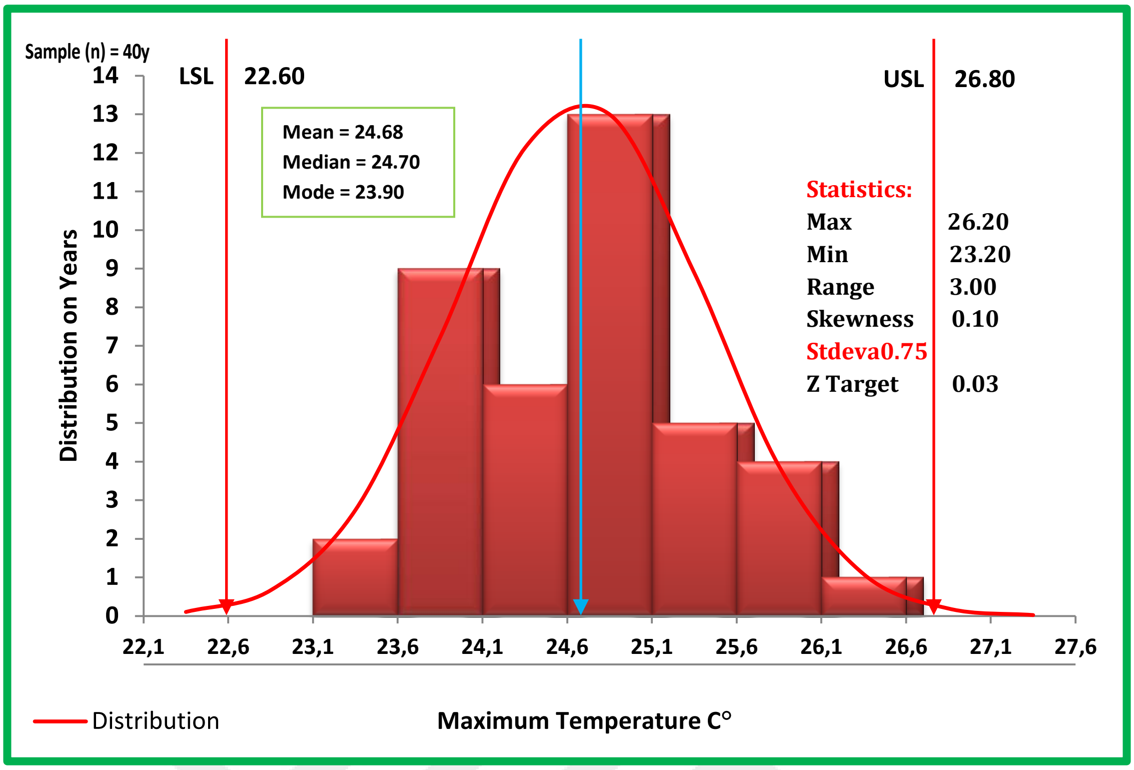


Figure 89. Statistics of Annual Maximum Temperature in ZWARA Station for Period (1971-2010)

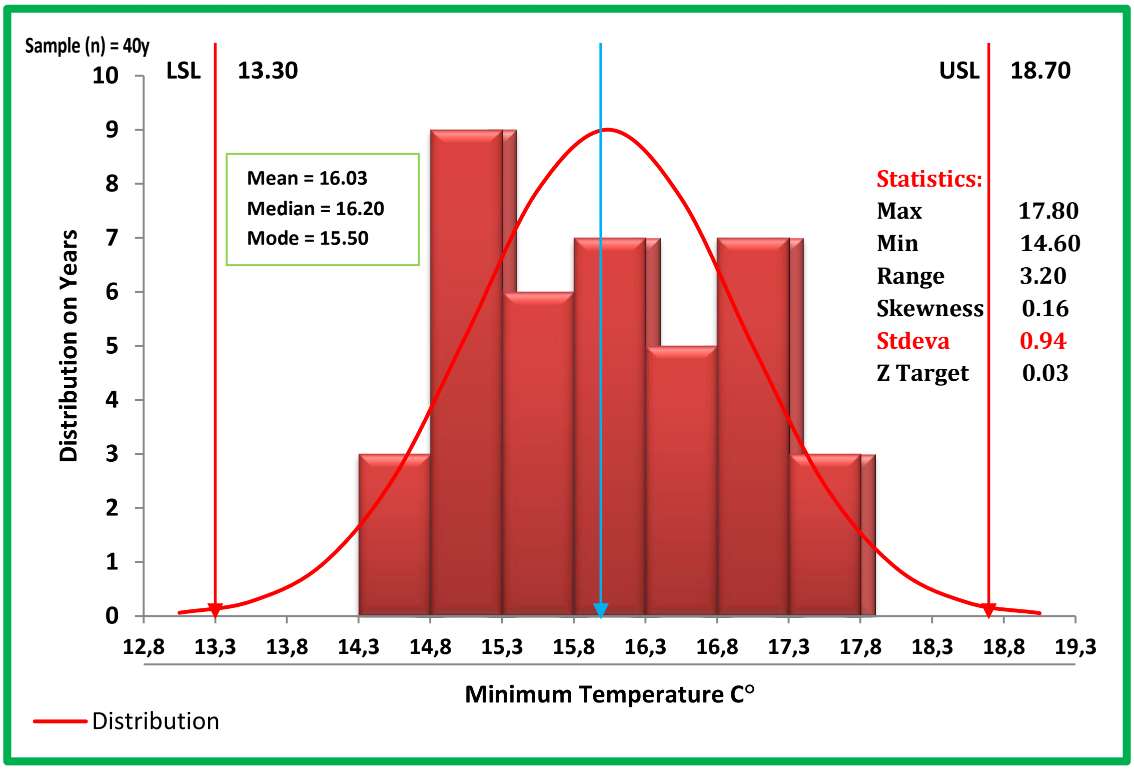


Figure 90. Statistics of Annual Minimum Temperature in ZWARA Station for Period (1971-2010)

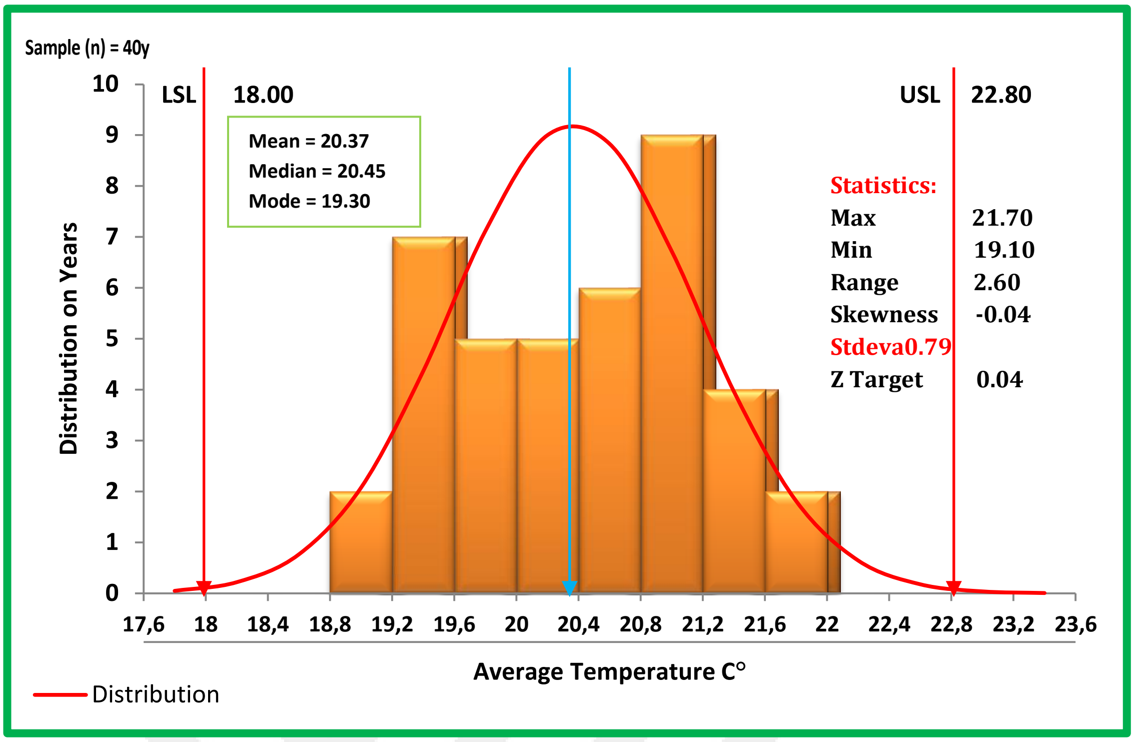


Figure 91. Statistics of Annual Average Temperature in ZWARA Station for Period (1971-2010)

The data in table 47 showlong-term warming above average in maximum temperatures at ZWARA station from 1992 to 2010. The minimum temperatures also recorded a significant increase from 1993 to 2010. Besides, a significant increase is also observed in the general average from 1993 to 2009 indicating a trend towards warming during the last years of monitoring period. The figure 90 shows a semi-normal distribution for maximum temperatures over the monitoring years.

It is observed that the temperature of (24.6 °C) is distributed over 13 years, (23.6 °C) over 9 years, (24.1 °C) over6 years, (25.1 °C) over 5 years, (25.6 °C) over 4 years, (23.1 °C) over two years and (26.1 °C) over one year. No extreme data is found in the distribution. In figure 91 a semi-normal distribution for minimum temperatures over the monitoring years is shown.

The temperature of (14.8 °C) is found the highest which is distributed over 9 years, (15.8 and 16.8 °C) over a period of 7 years, (15.3 °C) over 6 years, (16.3 °C) over 5 years and (14.3, and 17.3 °C) over 3 years. There are no extreme temperatures found in the distribution. The figure 92 shows a semi-normal distribution for average temperatures over the monitoring years. The temperature of (20.8 °C) is distributed over 9 years, (19.2 °C) over 7 years, (20.4 °C) over 6 years, (19.6 and 20 °C) over 5 years, (21.2 °C) over 4 years, (19.4 °C) over two years and (18.8 and 21.6 °C) over two years. There is no extreme data present in the distribution. The distribution curve is reached at (20.37 °C) and stabilized. The curve is to the highest level at the right of the figure at (22.8 °C) and at left to lowest at (18 °C).

Table 48. Descriptive Analysis of Distribution of Temperatures Data over the Monitoring Period(1971-2010)

Stations	Maximum Temperatures			Minimum Temperatures			Average Temperatures		
	Skewness	Range	Z Target	Skewness	Range	Z Target	Skewness	Range	Z Target
AGDABIA	0.96	2.60	0.05	0.12	2.95	0.01	0.63	2.90	0.03
ALFATAIAH	-0.87	2.80	0.03	0.06	2.50	0.06	-0.52	2.50	0.02
BENGHAZI	-0.03	2.20	0.04	0.52	2.20	0.03	0.42	1.60	0.03
DERNA	0.70	2.20	0.04	0.51	2.30	0.01	0.69	2.10	0.06
GHADAMES	0.08	3.40	0.07	-0.55	4.30	0.03	-0.38	3.40	0.06
GHARIAT	0.28	2.60	0.02	-0.26	5.00	0.02	-0.50	2.80	0.05
HON	0.72	3.00	0.02	0.33	4.60	0.02	0.64	3.40	0.06
JAGHBOUB	0.22	2.50	0.09	0.57	2.90	0.07	0.52	2.10	0.06
JALO	1.06	3.00	0.00	0.39	3.40	0.04	0.93	2.90	0.00
MISURATA	-0.05	3.20	0.01	-0.04	3.90	0.03	-0.15	3.50	0.02
NALUT	0.12	3.50	0.05	0.00	2.80	0.06	0.15	2.90	0.04
SHAHAT	1.04	2.70	0.03	0.41	2.50	0.00	0.33	2.00	0.04
SIRTE	0.61	3.90	0.03	-0.05	2.80	0.02	0.50	3.20	0.05
TOBRUK	0.16	1.90	0.11	0.20	3.50	0.04	0.30	2.50	0.01
TRIPOLI	-0.05	3.60	0.06	-0.02	2.90	0.02	-0.05	2.60	0.02
ZWARA	0.10	3.00	0.03	0.16	3.20	0.03	-0.04	2.60	0.04

Positive skewness: distribution asymmetric tail toward more positive values, and **Negative skewness**: distribution asymmetric tail toward more negative values.
Rang: The difference between the lowest and highest values.
Z Target = <**0.5**is desired (less than 1/2 standard deviation from target).

The following in table 48 is a statistical brief showed of some data distribution operations during observation periods in meteorological stations in the study area.

3.2. Descriptive Statistics and Distribution of Precipitation Data

The following Tables and Figures show the statistical analyzes of the annual amounts of rainfall in all the stations of the study area:

Table 49. Statistics of Rainfall Data in (mm) for Monthly and Annual in AGDABIAStation (1971-2010)

Years	Ja.	Fb.	Mr.	Ap.	Ma.	Jn.	Jl.	Ag.	Sp.	Oc.	Nv.	De.	Annual
1971	49.0	36.1	2.2	1.2	0.0	0.0	0.0	0.0	0.0	7.2	28.3	8.1	**132.1**
1972	43.1	7.7	8.4	36.5	0.8	0.0	0.0	0.0	0.0	10.1	0.5	12.9	**120.0**
1973	37.6	5.7	17.2	1.3	0.0	0.0	0.0	0.0	0.0	8.7	51.8	8.1	**130.4**
1974	34.7	11.3	14.0	0.2	0.0	0.0	0.0	0.0	0.5	4.8	22.0	84.6	**172.1**
1975	56.4	44.1	0.0	0.0	2.9	0.0	0.0	0.0	0.3	3.6	2.9	31.0	**141.2**
1976	86.5	9.8	15.4	0.2	0.8	0.6	0.0	0.0	0.0	6.8	55.0	5.0	**180.1**
1977	4.6	9.6	6.8	21.3	0.0	0.0	0.0	0.0	9.1	0.0	21.7	72.4	**145.5**
1978	60.4	49.5	19.5	2.4	0.0	0.0	0.0	0.0	0.0	22.2	3.9	5.2	**163.1**
1979	5.6	2.3	2.9	1.5	0.0	0.0	0.0	0.0	0.0	0.9	57.1	19.4	**89.7**
1980	10.6	28.3	6.0	0.3	1.6	0.0	0.0	0.0	0.0	3.2	0.0	43.6	**93.6**
1981	196.6	30.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.6	55.0	0.0	**287.1**
1982	9.4	14.1	19.3	9.3	2.7	0.0	0.0	0.0	0.0	2.3	19.0	35.1	**111.2**
1983	50.9	4.8	14.3	6.4	0.0	0.0	0.0	0.0	0.0	13.4	65.5	65.8	**221.1**
1984	30.4	11.1	17.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.2	54.2	**134.5**
1985	54.1	6.9	2.4	2.0	0.0	0.0	0.0	0.0	0.0	8.4	21.8	20.3	**115.9**
1986	45.5	15.5	22.6	0.0	0.0	0.0	0.0	0.0	35.5	47.7	6.8	53.7	**227.3**
1987	21.8	30.8	21.7	10.4	0.6	0.0	0.0	0.0	0.0	0.0	25.6	14.4	**125.3**
1988	37.5	35.8	18.8	0.7	0.0	0.0	0.0	0.0	0.0	0.7	0.9	71.0	**165.4**
1989	30.1	19.6	32.6	0.0	0.0	0.0	0.0	0.0	0.0	2.0	11.8	0.5	**96.6**
1990	14.9	15.9	0.0	1.5	18.3	0.0	0.0	0.0	0.0	0.0	10.1	22.6	**83.3**
1991	60.1	33.4	28.4	0.0	8.6	2.8	0.0	0.0	0.0	0.3	17.0	200.5	**351.1**
1992	5.1	28.0	2.7	5.0	0.1	0.0	0.0	0.0	0.0	0.0	34.6	12.8	**88.3**
1993	14.4	30.4	19.6	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	25.6	**90.4**
1994	88.2	5.8	0.5	21.5	1.0	0.0	0.0	0.0	0.0	68.9	37.1	82.5	**305.5**
1995	26.7	19.4	10.3	11.3	0.0	0.3	0.0	0.0	1.0	2.2	55.9	13.5	**140.6**
1996	27.0	36.8	25.8	2.7	0.0	0.0	0.0	0.0	8.0	37.1	9.8	22.1	**169.3**
1997	9.1	4.5	40.7	10.0	0.0	0.0	0.0	0.0	0.0	2.5	17.0	79.0	**162.8**
1998	44.4	8.0	50.6	0.5	0.0	0.0	0.0	0.0	0.0	9.0	2.2	137.8	**252.5**
1999	30.6	27.0	5.8	1.4	0.0	0.0	0.0	0.0	0.0	3.2	0.0	49.4	**117.4**
2000	44.2	17.4	0.0	0.0	1.2	0.0	0.0	0.0	0.0	0.8	13.1	30.3	**107.0**
2001	32.5	42.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	99.2	113.7	**287.9**
2002	25.3	43.7	11.4	0.0	0.0	0.0	0.0	0.0	12.1	1.2	27.1	100.4	**221.2**
2003	26.6	58.4	4.7	0.0	2.0	0.2	0.0	0.0	2.8	0.0	19.0	78.1	**191.8**
2004	24.1	1.3	6.6	0.1	0.0	0.0	0.0	0.0	0.0	0.0	7.6	75.5	**115.2**
2005	68.3	28.0	7.8	0.0	0.0	0.7	0.0	0.0	0.2	6.2	2.0	17.2	**130.4**
2006	27.1	34.0	4.9	0.0	0.4	0.0	0.0	0.0	0.0	19.9	17.8	18.8	**122.9**
2007	38.3	37.0	6.6	0.0	4.9	0.5	0.0	0.0	0.0	6.6	4.0	22.1	**120.0**
2008	31.8	14.3	5.9	0.0	2.5	0.0	0.0	0.0	0.0	0.8	0.0	28.1	**83.4**
2009	0.5	32.0	11.6	0.0	0.0	0.0	0.0	0.0	0.3	84.3	8.3	35.8	**172.8**
2010	44.4	0.1	0.0	3.2	0.0	0.0	0.0	0.0	0.4	3.9	8.9	19.2	**80.1**
Average	**38.7**	**22.3**	**12.1**	**3.8**	**1.2**	**0.1**	**0.0**	**0.0**	**1.8**	**9.8**	**21.5**	**44.8**	**156.15**
Median	32.1	19.5	8.1	0.4	0.0	0.0	0.0	0.0	0.0	3.2	17.0	29.2	133.30
Std.Eva	33.0	15.1	11.7	7.5	3.2	0.5	0.0	0.0	6.1	18.5	22.5	42.0	66.90

The rainfall: Values are blue: above average.
Values are red: below average.

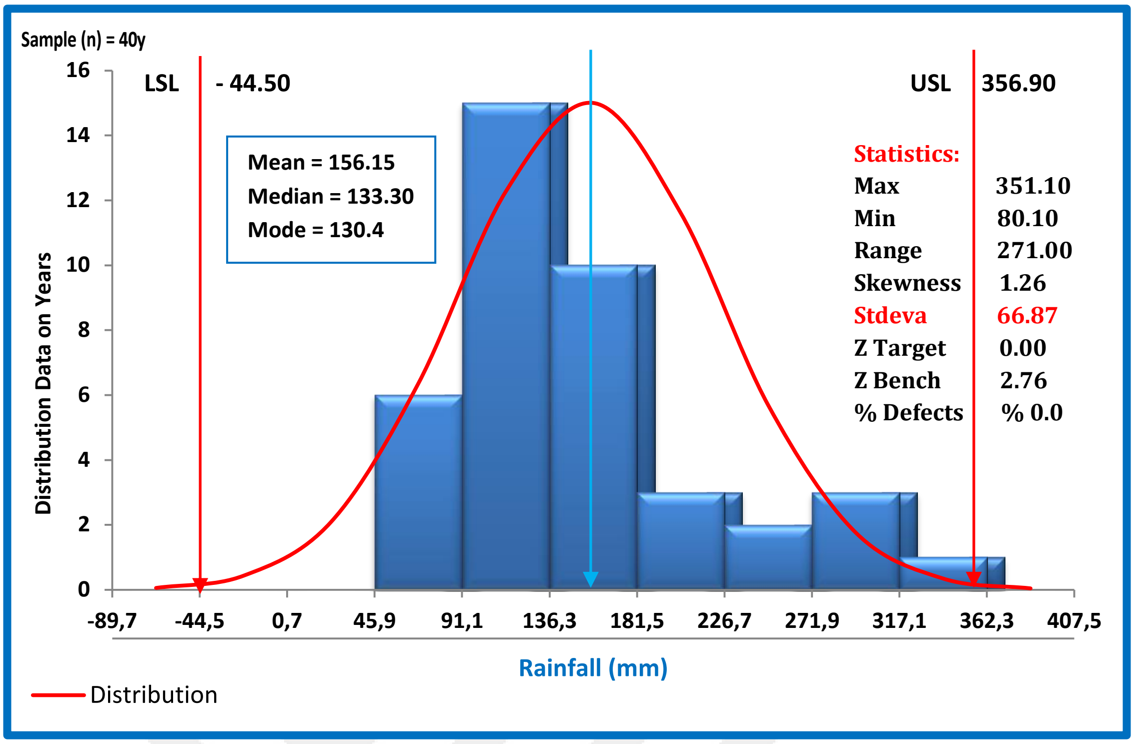


Figure 92. Descriptive Statistics on Rainfall Data By Years in AGDABIA Station For Period (1971-2010)

According to the data shown in table 49 and figure 93 significant annual and monthly fluctuation in rainfall is observed at AGDABIA station. It is found that the distribution of precipitation data over the period of monitoring years is non- normal. Some of the years show the amount rainfall above of annual average while in some years the amount of rainfall is shown below the annual average. The highest amount of rain is founding the year 1991 that is 351.1 mm/y and the lowest is in the year 2010 with 80.1 mm/y.

It is observed from the distribution of rainfall data over the years that the amount of rainfall varies in a period of 40 years. The amount of rainfall between (91 to 136.3 mm/y) distributed over 14 years, (136.3 to 181.5 mm/y) over 10 years, (45.9 to 91.1 mm/y) over 6 years, (181.5 to 226.7 and 271.9 to 317.1 mm/y) over3 years for each, (226.7 to 271.9 mm/y) over 2 years and (317.1 to 362.3 mm/y) is distributed over one year. The distribution curve is reached to an annual average of precipitation rate of (156.15/y) and found stabilized. The curve is to the highest level at the right of the figure at (356.9 mm/y), and at left to lowest at (- 44.5 mm/y). This indicates a significant decrease and fluctuation in precipitation from year to year.

Table 50. Statistics of Rainfall Data By (mm) for Monthly and Annual in ALFATAIAH Station (1971-2010)

Years	Ja.	Fb.	Mr.	Ap.	Ma.	Jn.	Jl.	Ag.	Sp.	Oc.	Nv.	De.	Annual
1981	111.5	48.8	41.0	0.0	0.0	0.8	0.0	0.0	0.0	28.1	41.8	1.0	273.0
1982	23.8	103.5	28.0	12.7	8.4	2.8	0.0	0.0	0.0	1.3	9.6	72.0	262.1
1983	128.6	61.0	9.7	12.8	10.2	0.0	0.0	0.0	7.6	36.5	42.0	12.1	320.5
1984	28.8	7.1	11.3	11.1	0.0	0.0	2.8	0.0	0.0	42.4	51.0	34.6	189.1
1985	59.6	44.0	19.6	1.3	4.7	0.0	0.0	0.0	1.3	50.5	4.1	139.0	324.1
1986	36.9	17.9	61.8	0.0	15.0	0.5	0.0	0.0	8.8	21.1	29.0	58.0	249.0
1987	63.5	6.7	91.2	56.3	11.0	0.0	0.0	0.0	0.0	1.2	33.7	54.3	317.9
1988	19.5	64.8	20.0	23.2	3.3	0.0	0.0	0.0	0.0	49.5	22.0	291.3	493.6
1989	116.0	51.6	39.8	0.0	0.0	2.3	0.0	0.0	0.0	25.4	41.2	37.0	313.3
1990	317.1	37.1	6.4	5.9	3.2	0.0	0.0	0.0	5.0	0.0	11.1	2.9	388.7
1991	68.3	42.7	11.7	11.1	31.0	2.0	0.0	0.0	2.5	4.8	74.6	323.4	572.1
1992	88.2	66.2	35.8	5.1	6.6	0.0	0.0	0.0	0.0	0.0	52.0	77.5	331.4
1993	249.3	33.7	14.3	0.0	15.3	0.0	0.0	0.0	0.2	19.3	21.1	31.1	384.3
1994	82.2	30.2	9.1	1.6	18.7	0.0	0.0	0.0	0.0	31.3	10.0	94.4	277.5
1995	20.5	70.4	32.7	43.4	9.5	0.3	0.0	0.0	2.0	118.2	93.7	27.9	418.6
1996	120.2	35.2	52.1	6.6	0.0	1.7	0.0	0.0	6.8	63.4	16.7	25.3	328.0
1997	89.8	69.0	39.8	9.8	0.7	0.0	0.0	0.0	6.2	23.9	34.6	27.0	300.8
1998	61.9	31.2	116.8	2.9	7.5	0.0	0.0	0.0	1.8	2.7	1.5	195.9	422.2
1999	41.3	9.2	28.0	5.5	0.8	0.0	0.0	1.5	10.8	2.5	9.4	33.3	142.3
2000	100.7	39.1	7.3	6.8	0.0	0.0	0.0	0.0	13.5	2.9	60.8	33.6	264.7
2001	63.2	23.7	8.0	13.0	17.8	0.0	0.0	0.0	0.0	14.4	54.1	220.6	414.8
2002	41.3	25.9	22.6	3.0	0.0	0.0	0.0	0.0	27.2	20.5	7.9	47.6	196.0
2003	28.1	70.6	85.9	7.2	0.0	2.8	0.0	0.0	0.3	0.0	19.3	51.2	265.4
2004	117.5	84.7	5.4	2.6	0.0	0.0	2.5	0.0	0.0	7.3	46.5	84.2	350.7
2005	86.7	64.2	56.3	5.0	0.4	0.0	0.7	5.3	3.5	6.2	28.2	77.8	334.3
2006	86.2	69.1	18.0	22.0	4.8	0.4	0.0	0.0	0.3	40.1	24.5	38.2	303.6
2007	94.8	50.4	3.8	0.5	46.1	4.9	0.0	0.0	12.6	13.5	20.2	48.9	295.7
2008	103.4	81.9	4.2	5.1	3.0	0.0	0.0	0.0	13.5	57.7	6.0	143.6	418.4
2009	8.7	53.2	15.5	3.0	9.0	0.0	0.0	0.0	1.9	31.2	21.3	29.0	172.8
2010	111.0	76.2	23.9	13.8	31.7	0.0	0.0	0.0	4.4	43.3	51.8	92.7	448.8
Average	**85.6**	**49.0**	**30.7**	**9.7**	**8.6**	**0.6**	**0.2**	**0.2**	**4.3**	**25.3**	**31.3**	**80.2**	**325.8**
Median	**84.2**	**49.6**	**21.3**	**5.7**	**4.8**	**0.0**	**0.0**	**0.0**	**1.9**	**20.8**	**26.4**	**50.1**	**319.2**
Std.Eva	**64.6**	**24.5**	**28.1**	**12.6**	**11.2**	**1.2**	**0.7**	**1.0**	**6.2**	**25.9**	**22.3**	**80.8**	**95.4**

The rainfall: Values are blue: above average.
Values are red: below average.

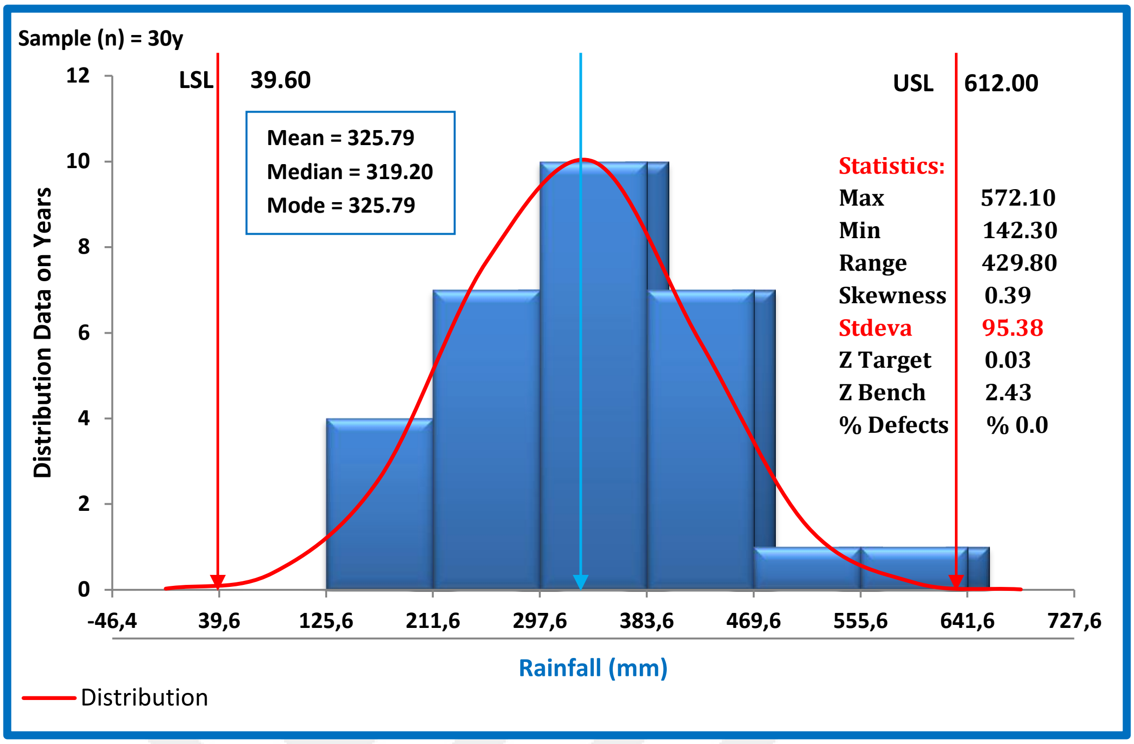


Figure 93. Descriptive Statistics on Rainfall Data By Years in ALFATAIAH Station For Period (1981-2010)

The data presented in the table 50 and depicted in figure 94 show the fluctuation in rainfall at ALFATAIAH station in some periods. It is observed that some of the year show the amount of rainfall above the annual average while amount of rainfall is found below of annual average in some years. The distribution of precipitation data over the period of monitoring years is found non- normal. The highest amount of rain is found in the year 1991 with rate of (572.1 mm/y) and the lowest in 2009 with rate of (172.8 mm/y).

Keeping in view the distribution of rainfall data, it is found that the amount of rain between (297.6 to 383.6 mm/y) is the most continuous which is distributed over 10 years followed by (211.6 to 297.6 mm/y and 383.6 to 469.6 mm/y) over 7 years for each, (125.6 to 211.6 mm/y) over 4 years, (469.6 to 555.6 and 555.6 to 641.6 mm/y) over one year for each. The distribution curve is reached to an annual average of precipitation rate of (325.79 mm/y) which is found stabilized. The curve is to the highest level at the right of the figure at (612 mm/y) and at left to lowest at (39.6 mm/y). This indicates an increase and fluctuation in precipitation in some years.

Table 51. Statistics of Rainfall Data By (mm) for Monthly and Annual in BENGHAZI Station (1971-2010)

Years	Ja.	Fb.	Mr.	Ap.	Ma.	Jn.	Jl.	Ag.	Sp.	Oc.	Nv.	De.	Annual
1971	81.3	134.8	12.0	5.1	0.0	0.0	0.0	0.0	8.4	9.0	34.5	38.1	323.2
1972	46.7	13.0	17.5	39.7	5.1	0.0	0.0	4.6	0.4	30.9	7.2	26.3	191.4
1973	37.6	42.4	33.7	4.2	0.0	0.0	0.0	0.0	0.8	34.0	44.7	19.1	216.5
1974	59.8	42.8	33.0	0.0	0.5	0.0	0.0	0.0	0.0	21.5	53.4	136.8	347.8
1975	78.9	33.2	4.8	16.0	0.5	0.0	0.0	0.0	0.0	8.8	6.1	41.8	190.1
1976	81.3	40.5	21.3	5.3	16.7	0.0	0.0	0.0	0.0	28.3	33.1	24.0	250.5
1977	12.0	11.2	1.6	47.5	0.0	0.0	0.0	0.0	18.1	0.0	32.4	176.7	299.5
1978	92.9	105.1	75.6	4.7	0.3	0.2	0.0	0.0	5.9	109.1	21.8	49.2	464.8
1979	52.9	22.1	11.5	7.5	0.5	0.0	0.0	0.0	0.8	3.9	141.8	53.7	294.7
1980	37.7	33.0	5.0	11.5	0.2	0.0	0.0	0.0	0.0	8.2	0.6	61.6	157.8
1981	176.6	97.0	2.1	0.3	1.0	0.0	0.0	0.0	0.4	10.0	126.1	19.2	432.7
1982	20.8	53.4	49.9	9.1	0.0	0.0	0.0	0.0	0.0	3.4	54.4	97.9	288.9
1983	57.2	26.8	22.7	1.3	0.3	0.1	0.0	0.0	1.1	53.4	55.2	86.0	304.1
1984	59.4	57.0	24.3	2.9	0.4	0.0	0.0	0.0	0.0	4.1	29.6	59.8	237.5
1985	72.6	23.0	1.7	0.7	1.7	0.0	0.0	0.0	0.4	18.4	27.3	80.6	226.4
1986	36.2	17.1	43.8	0.0	11.3	0.0	0.0	0.0	6.4	27.7	13.3	116.5	272.3
1987	24.5	27.0	60.5	4.0	0.0	0.0	0.0	0.0	5.0	5.6	60.9	17.6	205.1
1988	39.1	35.7	48.9	0.0	0.0	0.0	0.0	0.0	11.5	8.7	8.6	160.9	313.4
1989	62.7	28.6	112.5	0.0	0.1	0.0	0.0	0.0	0.0	19.1	19.9	22.5	265.4
1990	61.6	27.4	0.0	4.0	9.0	0.0	0.0	0.1	0.0	0.0	64.1	13.5	179.7
1991	63.3	57.6	17.3	12.6	9.7	0.3	0.0	6.4	0.0	1.0	57.7	234.7	460.6
1992	29.6	64.1	12.5	6.3	3.2	0.0	0.0	0.0	0.0	0.0	59.2	30.8	205.7
1993	71.0	76.1	26.4	0.0	3.0	0.0	0.0	0.0	0.2	0.0	22.4	26.3	225.4
1994	117.6	35.0	1.9	25.4	6.0	0.0	0.0	0.0	0.0	42.7	61.4	72.3	362.3
1995	107.1	55.3	13.6	6.7	1.0	0.0	0.0	0.0	3.4	51.7	40.6	47.3	326.7
1996	49.0	76.6	24.2	4.7	0.1	0.1	0.0	0.0	3.6	21.9	21.5	57.5	259.2
1997	49.1	35.7	32.9	17.1	1.0	0.0	0.0	0.0	0.3	24.6	39.7	67.5	267.9
1998	61.3	18.4	86.4	2.8	1.8	0.0	0.0	0.0	0.1	20.2	35.2	77.9	304.1
1999	56.0	11.9	39.8	2.8	1.8	0.0	0.0	0.0	11.2	9.5	22.3	21.0	176.3
2000	73.9	31.2	0.0	7.1	0.6	0.0	0.0	0.0	5.6	4.4	20.1	55.1	198
2001	46.9	90.8	2.0	1.2	2.1	0.0	0.0	0.0	0.0	7.2	40.5	70.8	323.2
2002	43.5	44.7	33.1	3.6	0.0	0.0	0.0	0.0	11.7	35.9	30.5	75.5	191.4
2003	63.4	83.2	37.1	3.8	13.5	4.3	0.0	0.0	1.9	3.0	9.6	107.2	216.5
2004	82.2	9.0	4.4	5.4	0.0	0.0	0.8	0.0	0.0	0.9	60.0	60.3	347.8
2005	91.1	28.2	65.4	1.8	0.0	1.3	0.0	0.0	2.4	6.9	22.4	51.8	190.1
2006	50.4	32.2	20.6	0.3	1.2	0.9	0.0	0.0	0.0	44.2	36.0	15.2	250.5
2007	31.8	48.7	37.8	0.0	24.6	0.1	0.0	0.0	0.0	8.8	7.6	57.7	299.5
2008	29.5	44.5	19.6	3.5	0.4	0.0	0.0	0.0	34.0	6.3	3.9	23.4	464.8
2009	27.4	84.2	9.9	0.2	5.2	0.0	0.0	0.0	3.6	39.9	5.6	58.3	294.7
2010	57.7	6.6	0.1	0.1	0.9	0.2	0.0	0.0	0.5	13.6	66.8	26.0	157.8
Average	**59.8**	**45.1**	**26.7**	**6.7**	**3.1**	**0.2**	**0.0**	**0.3**	**3.4**	**18.7**	**37.5**	**63.5**	**265.0**
Median	**57.5**	**35.7**	**21.0**	**3.9**	**0.8**	**0.0**	**0.0**	**0.0**	**0.4**	**9.3**	**32.8**	**56.3**	**260.4**
Std.Eva	**30.1**	**29.2**	**25.8**	**10.2**	**5.3**	**0.7**	**0.1**	**1.2**	**6.5**	**21.2**	**29.7**	**47.8**	**76.0**

The rainfall: Values are blue: above average.
Values are red: below average.

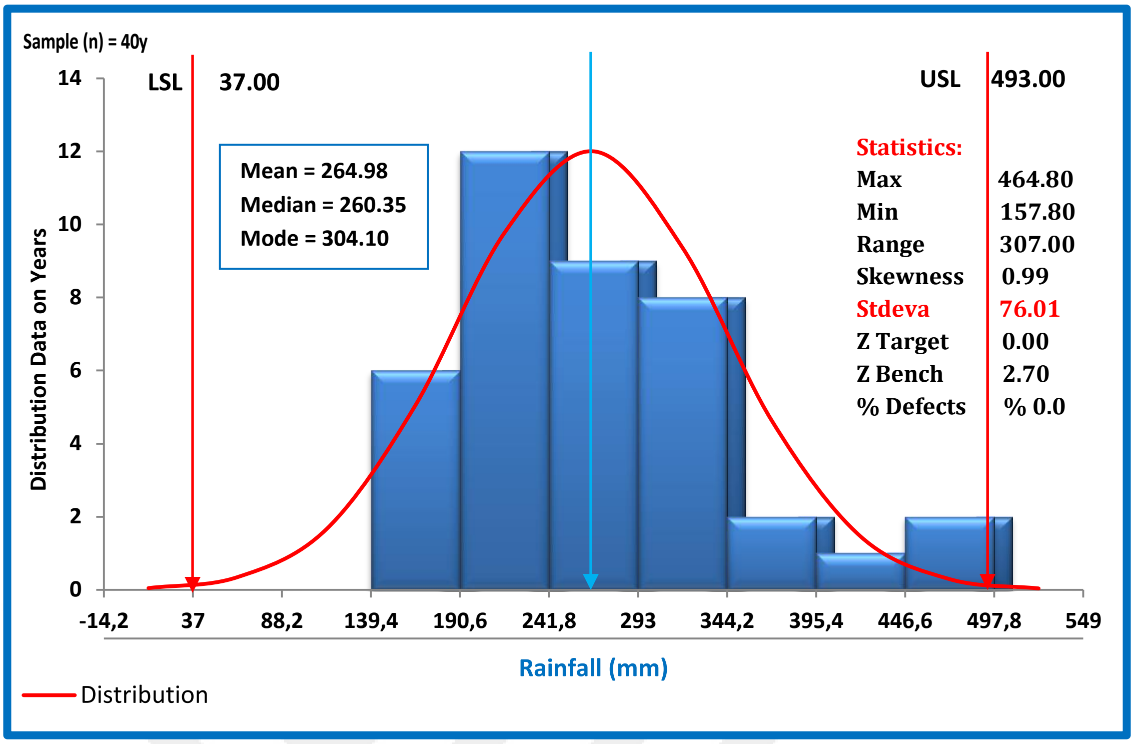


Figure 94. Descriptive Statistics on Rainfall Data By Years in BENGHAZI Station For Period (1971-2010)

The data provided in table 51 and depicted in figure 95 show fluctuation in rainfall in some periods at BENGHAZI station. It is observed that some of the years show the amount of rainfall above the annual average, while amount of rainfall is found below of annual average in some years. The distribution of precipitation data over the monitoring years is found non- normal The highest amount of rain is found in the year 1978 with rate of (464.8 mm/y) and the lowest in 2010 with rate of (157.8 mm/y).

It is observed that the amount of rain between (190.6 to 241.8 mm/y) is the most continuous throughout the selected years and distributed over12 years followed by (241.8 to 293 mm/y) distributed over 9 years, (293 to 344.2 mm/y) distributed over 7 years, (139.4 to 190.6 mm/y) distributed over 6 years, (344.2 to 395.4 and 446.6 to 497.8 mm/y) distributed over 2 years and (395.4 to 446.6 mm/y) over one yea. The distribution curve is reached to an annual average of precipitation rate of (264.98 mm/y) and found stabilized. The curve is to the highest level at the right of the figure at (493 mm/y) and at left to lowest at (37 mm/y) This indicates an increase and fluctuation in precipitation in some years.

Table 52. Statistics of Rainfall Data By (mm) for Monthly and Annual in DERNA Station (1971-2010)

Years	Ja.	Fb.	Mr.	Ap.	Ma.	Jn.	Jl.	Ag.	Sp.	Oc.	Nv.	De.	Annual
1971	52.2	50.9	7.3	13.6	2.4	0.0	0.0	0.0	7.6	11.9	48.4	31.6	225.9
1972	15.8	15.8	17.1	49.8	3.0	0.0	0.0	0.7	0.4	73.4	5.4	57.1	238.5
1973	38.7	22.1	60.3	2.8	3.8	0.0	0.0	0.0	0.0	51.0	33.0	8.5	220.2
1974	134.9	15.4	12.1	6.5	0.4	0.0	0.0	0.2	0.7	18.2	8.0	35.8	232.2
1975	59.7	34.1	7.1	18.2	9.5	0.8	0.0	0.0	1.2	40.6	8.0	57.7	236.9
1976	51.6	60.0	48.7	6.5	6.4	7.4	0.0	0.0	0.0	16.3	54.4	9.5	260.8
1977	38.4	7.9	17.3	8.6	0.1	0.0	0.0	0.0	14.9	1.3	4.2	89.4	182.1
1978	105.7	19.6	31.8	18.0	0.0	0.0	0.0	0.0	12.9	101.5	23.0	35.0	347.5
1979	28.7	51.3	7.5	5.9	0.0	16.8	0.0	0.0	0.0	54.9	27.0	51.9	244.0
1980	40.7	82.7	20.4	6.9	0.0	0.0	0.0	0.0	0.0	16.8	0.0	10.6	178.1
1981	78.2	52.6	0.0	0.0	6.1	0.0	0.0	0.0	0.0	29.3	47.7	4.1	218.0
1982	16.6	55.6	6.5	14.1	2.0	0.0	0.0	0.0	0.0	9.6	8.7	58.3	171.4
1983	95.5	51.2	2.7	4.4	2.8	3.4	0.0	0.0	5.2	25.5	64.9	18.6	274.2
1984	26.5	60.8	27.4	4.0	0.0	0.0	0.0	0.4	0.0	24.9	50.7	64.1	258.8
1985	54.0	27.7	14.2	4.5	8.9	0.0	0.0	0.0	0.0	46.6	5.0	122.4	283.3
1986	25.5	2.3	38.1	1.0	25.0	0.0	0.0	0.0	24.5	28.4	74.1	47.8	266.7
1987	43.7	2.7	75.0	37.5	0.0	0.0	0.0	0.0	0.0	2.0	27.1	43.4	231.4
1988	24.0	66.1	10.5	4.5	3.3	0.0	0.0	0.0	0.0	29.3	36.1	221.5	395.3
1989	108.8	32.4	29.6	0.0	0.0	0.1	0.0	0.0	0.0	8.7	46.5	41.2	267.3
1990	222.2	22.3	0.3	1.3	3.2	0.0	0.0	0.0	4.7	0.0	18.4	11.5	283.9
1991	38.2	38.3	4.0	2.2	13.2	0.5	0.0	0.3	2.2	11.0	44.3	225.5	379.7
1992	64.5	66.7	14.4	2.9	3.2	0.0	0.0	0.0	0.0	0.0	27.6	85.2	264.5
1993	64.5	47.1	20.0	0.0	12.4	0.0	0.0	0.0	2.7	27.7	14.0	24.5	212.9
1994	69.7	40.5	11.8	1.6	19.4	0.0	0.0	0.0	0.0	44.4	74.1	81.5	343.0
1995	13.2	86.8	26.0	38.4	1.0	0.2	0.0	0.0	0.4	116.3	70.6	52.3	405.2
1996	83.9	37.6	52.4	16.5	0.0	0.0	0.0	0.0	9.1	63.3	35.3	17.1	315.2
1997	77.1	64.6	29.8	12.7	0.0	0.0	0.0	0.0	3.8	13.4	45.0	35.6	282.0
1998	38.2	29.7	98.4	0.4	24.5	0.0	0.0	0.0	0.0	11.0	0.2	192.0	394.4
1999	49.6	8.1	9.5	1.7	0.0	0.0	0.0	0.0	6.0	5.4	11.9	42.5	134.7
2000	89.6	32.4	8.8	6.4	0.6	0.0	0.0	0.0	19.0	1.0	25.0	14.6	197.4
2001	51.2	18.5	2.6	5.2	0.0	0.0	0.0	0.0	0.0	17.3	72.6	148.2	225.9
2002	32.3	47.0	28.3	0.6	0.0	0.0	0.0	0.0	7.5	20.3	0.7	44.8	238.5
2003	20.4	71.3	58.3	2.9	1.3	4.0	0.0	0.0	0.0	0.0	5.9	29.9	220.2
2004	106.9	45.4	3.0	1.2	0.1	0.0	0.3	0.1	1.0	0.0	19.6	50.6	232.2
2005	79.9	58.6	40.5	0.0	0.0	0.0	0.0	1.8	0.5	3.8	5.5	58.3	236.9
2006	89.3	51.4	18.3	18.6	0.9	1.6	0.0	0.0	0.0	29.6	15.6	51.5	260.8
2007	59.4	56.7	6.6	1.2	40.1	8.3	0.0	8.0	4.1	13.1	25.5	39.0	182.1
2008	76.9	66.6	5.2	4.3	0.0	0.0	0.0	0.0	13.5	62.2	0.0	98.0	347.5
2009	9.9	62.4	9.6	1.4	10.3	0.0	0.0	0.0	2.0	59.0	20.5	26.7	244.0
2010	43.9	11.2	6.0	2.8	0.0	0.0	0.0	0.0	2.2	14.1	57.2	41.4	178.1
Average	**60.5**	**41.9**	**22.2**	**8.2**	**5.1**	**1.1**	**0.0**	**0.3**	**3.7**	**27.6**	**29.0**	**59.5**	**259.0**
Median	**51.9**	**46.2**	**14.3**	**4.4**	**1.2**	**0.0**	**0.0**	**0.0**	**0.6**	**17.8**	**25.3**	**44.1**	**253.9**
Std.Eva	**39.9**	**22.3**	**22.1**	**11.2**	**8.7**	**3.2**	**0.0**	**1.3**	**5.9**	**27.6**	**23.2**	**53.8**	**66.1**

The rainfall: Values are blue: above average.
Values are red: below average.

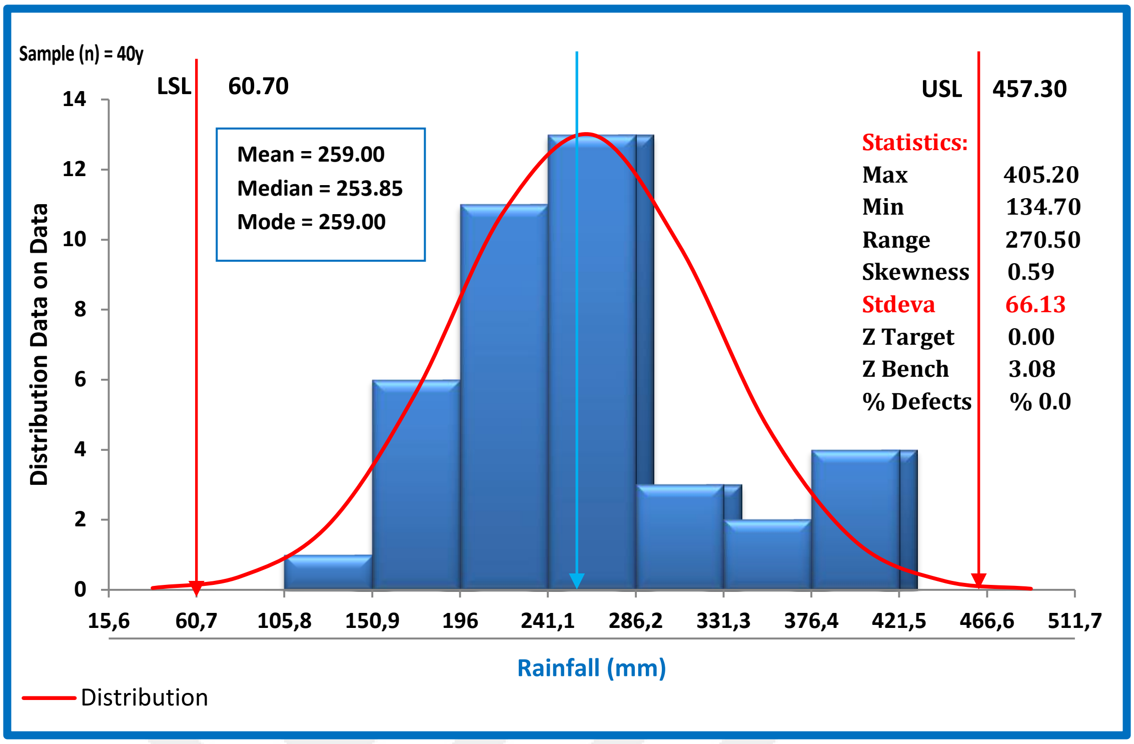


Figure 95. Descriptive Statistics on Rainfall Data By Years in DERNA Station For Period (1971-2010)

The table 52 and figure 96 show fluctuation in rainfall in some periods at DERNA station. It is observed that some of the year show the amount of rainfall above the annual average while amount of rainfall is found below of annual average in some years. The distribution of precipitation data over the monitoring years is found non-normal. The highest amount of rain is found in the year 1995 with rate of (405.2 mm/y) and the lowest in 1999 with rate of (134.7 mm/y).

It is observed that the amount of rain between (241.1 to 286.2 mm/y) is the most continuous which is distributed over 13 years followed by (196 to 241.1 mm/y) over 11 years, (150.9 to 196 mm/y) over 6 years, (376.4 to 421.5 mm/y) over 4 years, (286.2 to 331.3 mm/y), over 3 years, (331.3 to 376.4 mm/y) over 2 years and (105.8 to 150.9 mm/y) over one year. The, distribution curve is reached to an annual average of precipitation rate of (259 mm/y) and found stabilized. The curve is to the highest level at the right of the figure at (457.3 mm/y) and at left to lowest at (60.7 mm\y). This indicates an increase and fluctuation in precipitation in some years.

Table 53. Statistics of Rainfall Data By (mm) for Monthly and Annual in GHADAMES Station(1971-2010)

Years	Ja.	Fb.	Mr.	Ap.	Ma.	Jn.	Jl.	Ag.	Sp.	Oc.	Nv.	De.	Annual
1971	3.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.1	0.0	11.5
1972	0.0	0.0	0.0	1.0	4.5	0.0	0.0	0.0	0.0	2.8	0.0	3.7	12.0
1973	0.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0
1974	0.0	0.0	65.8	0.0	0.0	0.0	0.0	0.0	8.0	0.0	0.4	0.3	74.5
1975	0.0	15.9	0.3	0.0	1.0	0.0	0.0	0.0	0.0	0.0	3.0	3.0	23.2
1976	21.0	59.2	52.6	18.5	42.9	0.0	0.4	0.0	0.0	2.2	2.0	6.0	203.8
1977	0.0	0.0	0.0	18.0	0.0	0.0	0.0	0.0	4.0	0.5	0.0	0.0	22.5
1978	0.6	1.3	0.0	0.4	0.0	0.0	0.0	0.0	0.0	14.4	7.7	0.0	24.4
1979	7.4	3.4	8.1	4.3	0.0	0.0	0.0	0.0	5.0	0.7	0.2	0.0	29.1
1980	0.0	0.4	0.4	0.0	0.0	0.0	0.0	0.0	0.0	4.0	1.0	3.0	8.8
1981	0.0	1.2	0.0	0.8	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	2.6
1982	1.3	0.0	0.0	3.5	0.2	0.2	0.0	0.0	0.0	2.0	6.5	40.7	54.4
1983	0.2	4.4	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	11.0
1984	1.8	0.8	0.3	0.0	0.0	0.0	0.0	0.0	1.5	15.2	0.0	0.0	19.6
1985	14.0	0.0	0.8	6.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.0	28.1
1986	0.0	0.0	0.4	0.0	0.0	1.0	0.0	1.0	0.0	0.5	1.0	16.3	20.2
1987	0.0	0.0	0.5	0.0	0.0	0.0	0.0	7.9	0.0	2.2	3.9	2.0	16.5
1988	0.5	10.7	11.5	0.0	0.0	0.0	0.0	0.0	0.0	0.6	3.0	4.4	30.7
1989	0.0	15.0	1.0	0.0	0.0	0.9	0.3	0.0	0.0	0.0	8.0	2.0	27.2
1990	76.0	0.0	4.7	7.6	0.1	0.0	0.0	0.0	0.0	0.0	9.1	2.0	99.5
1991	25.0	0.0	0.0	0.0	4.7	0.8	0.0	0.0	0.5	2.0	0.0	4.5	37.5
1992	0.7	0.0	7.1	0.0	2.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	12.8
1993	0.0	3.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	3.1
1994	5.5	0.0	1.4	10.0	16.9	0.0	0.0	0.0	0.2	0.0	0.0	2.0	36.0
1995	6.0	0.0	1.4	11.0	0.0	0.0	0.0	0.0	1.0	17.0	0.0	1.5	37.9
1996	1.9	7.2	3.0	1.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6	16.3
1997	0.0	0.0	0.1	7.0	8.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	17.1
1998	0.0	0.0	13.0	0.0	0.4	10.9	0.0	0.0	1.8	1.6	0.0	3.0	30.7
1999	0.9	32.7	9.9	2.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	2.0	48.2
2000	0.0	8.0	0.0	0.0	3.1	0.0	0.0	0.0	0.0	20.7	0.0	0.0	31.8
2001	0.0	0.3	0.0	2.0	0.5	0.0	0.0	0.6	0.0	0.0	0.0	0.0	11.5
2002	0.0	3.3	0.0	6.3	0.5	0.0	0.0	0.0	0.4	6.1	7.8	0.0	12.0
2003	0.0	20.6	0.0	0.0	1.6	0.0	0.0	0.5	13.0	0.6	0.0	33.6	10.0
2004	16.7	0.0	12.0	2.1	0.0	0.0	0.0	0.0	0.0	0.0	5.8	8.7	74.5
2005	0.0	6.9	9.8	0.0	0.0	0.0	0.0	0.0	0.0	5.4	11.0	9.7	23.2
2006	29.1	22.8	0.6	0.3	0.0	0.0	0.0	0.0	3.1	0.7	0.0	0.8	204.1
2007	0.0	1.0	25.2	9.3	2.0	0.0	0.0	0.0	2.0	2.9	0.0	4.0	22.5
2008	44.8	0.0	0.0	4.0	0.0	0.0	0.0	0.0	30.3	0.0	0.2	4.0	24.4
2009	2.0	0.0	25.2	0.0	1.4	0.0	0.0	0.0	4.7	15.6	0.0	0.0	29.1
2010	3.8	0.2	21.2	8.6	0.1	0.0	0.0	0.0	0.0	0.1	0.0	3.4	8.8
Average	**6.6**	**5.7**	**6.9**	**3.1**	**2.2**	**0.4**	**0.0**	**0.3**	**1.9**	**3.0**	**2.0**	**4.4**	**36.5**
Median	**0.4**	**0.4**	**0.5**	**0.4**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.6**	**0.0**	**2.0**	**28.6**
Std.Eva	**14.9**	**11.5**	**14.0**	**4.8**	**7.3**	**1.7**	**0.1**	**1.3**	**5.3**	**5.5**	**3.2**	**8.4**	**35.2**

The rainfall: Values are blue: above average.
Values are red: below average.

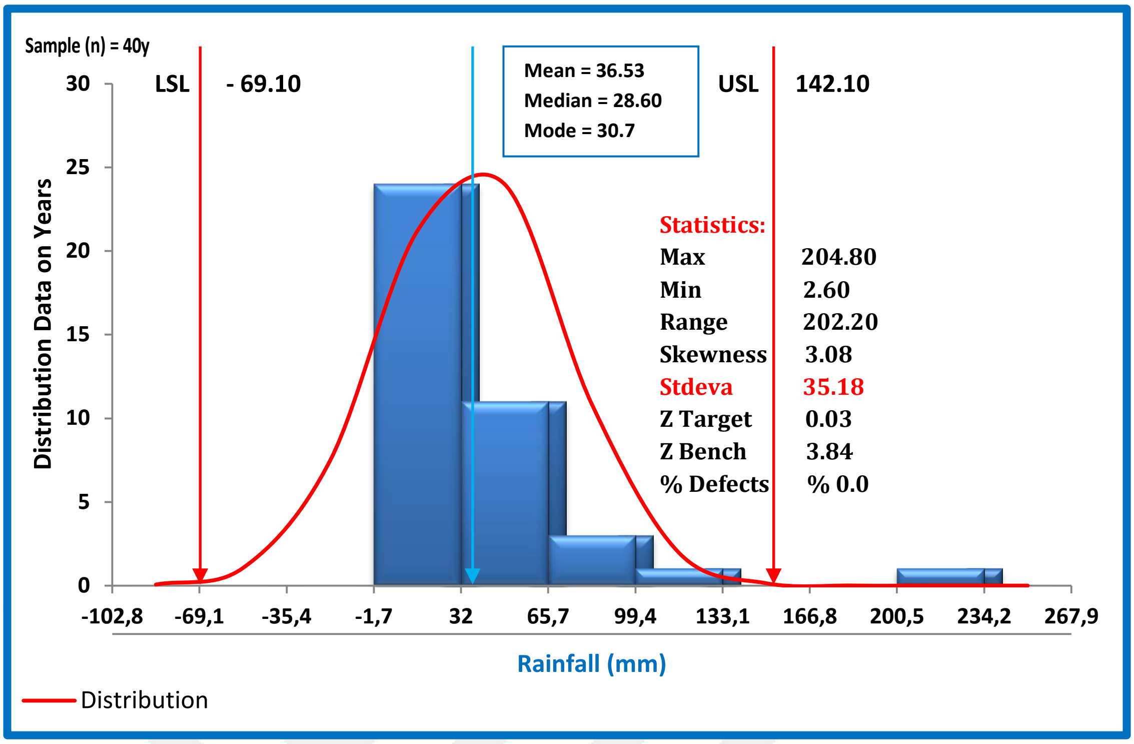


Figure 96. Descriptive Statistics on Rainfall Data By Years in GHADAMES Station For Period (1971-2010)

The data presented in table 53 and figure 97 show fluctuation in rainfall at GHADAMES station in some periods with lack of amount of rainfall due to its desert location. It is observed that some of the year show the amount of rainfall above the annual average while amount of rainfall is found below of annual average in some years. The distribution of precipitation data over the monitoring years is found non-normal The highest amount of rainfall is found in the year 2006 with rate of (204.1 mm/y) and the lowest in 1981with rate of (2.6 mm/y).

It is observed that most of the years have similar continuous amount of rainfall distribution. The amount of rainfall between (-1.7 to 32 mm/y) is the most continuous which is distributed over about 24 years. This indicates a severe shortage of rainfall in GHADAMES station. It is followed by (65.7 to 133.1 mm/y) distributed over two years. There is an extreme value of (200.5 to 234.2 mm/y) distributed over one year.

The distribution curve is reached to an annual average of precipitation rate of (36.53 mm/y) and found stabilized. The curve is to the highest level at the right of the figure at (142.1 mm/y) and at left to lowest at (-69.1 mm/y).This indicates a severe decrease and fluctuation in precipitation in some years.

Table 54. Statistics of Rainfall Data By (mm) for Monthly and Annual in GHARIAT Station (1971-2010)

Years	Ja.	Fb.	Mr.	Ap.	Ma.	Jn.	Jl.	Ag.	Sp.	Oc.	Nv.	De.	Annual
1971	2.5	6.5	0.0	0.0	6.9	0.0	0.0	0.0	19.5	0.0	0.0	0.0	35.4
1972	9.5	0.0	0.0	13.0	13.9	0.0	0.0	2.5	4.0	6.3	1.6	14.3	65.1
1973	0.6	10.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	11.9
1974	10.7	0.0	11.5	0.4	0.0	0.0	0.0	0.0	12.0	3.3	0.0	16.4	54.3
1975	22.5	8.6	0.0	0.0	0.9	8.8	0.0	0.0	0.0	0.0	0.0	62.5	103.3
1976	12.0	48.0	20.2	1.0	9.0	7.0	0.0	0.0	25.5	10.3	0.0	0.0	133.0
1977	1.0	0.0	0.0	17.0	0.4	0.0	0.0	0.0	9.7	3.0	4.2	1.6	36.9
1978	1.9	7.4	0.0	3.7	4.2	0.0	0.0	0.0	0.0	21.8	25.0	0.0	64.0
1979	0.0	3.0	9.0	0.0	3.0	4.0	0.0	4.0	7.0	0.0	1.0	0.0	31.0
1980	2.8	2.9	25.6	0.0	0.0	0.0	0.0	0.0	0.0	22.2	23.5	18.0	95.0
1981	2.0	6.8	0.0	0.0	0.0	4.0	0.0	0.0	0.0	6.0	0.0	0.0	18.8
1982	0.7	0.0	0.0	2.2	0.0	0.0	0.0	0.0	0.0	25.8	0.0	23.5	52.2
1983	16.1	0.0	0.0	0.0	0.0	2.2	0.0	0.0	0.0	0.7	0.0	2.0	21.0
1984	2.0	0.0	9.6	2.5	0.0	0.0	0.0	0.0	2.0	5.6	0.0	0.0	21.7
1985	0.0	0.0	10.4	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	8.2	20.6
1986	13.3	0.0	18.7	0.0	0.0	0.5	0.0	0.4	0.0	18.2	24.4	1.5	77.0
1987	0.0	2.4	5.0	0.0	0.0	0.0	0.0	0.0	12.6	0.0	23.5	8.5	52.0
1988	63.0	0.0	24.7	0.0	0.0	0.0	0.0	0.0	9.4	0.8	0.0	14.4	112.3
1989	0.7	4.1	0.0	2.9	1.6	2.5	0.0	0.0	2.0	0.0	4.0	15.0	32.8
1990	8.0	0.7	6.0	4.0	35.0	0.0	0.0	0.0	3.0	0.0	36.5	0.2	93.4
1991	13.6	0.0	1.6	0.0	59.7	0.0	2.0	0.0	2.5	0.0	0.0	19.7	99.1
1992	0.0	0.5	12.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	14.5
1993	14.7	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.5	0.0	52.2
1994	34.6	0.0	11.6	8.3	13.8	0.0	0.0	0.0	0.0	28.0	0.0	0.0	96.3
1995	0.0	5.1	0.7	0.0	0.0	0.0	0.0	0.0	0.0	15.9	0.0	2.0	23.7
1996	1.0	2.0	27.0	11.6	0.0	0.0	0.0	0.0	16.0	0.0	0.0	0.0	57.6
1997	5.0	0.0	0.0	8.5	4.0	0.0	0.0	0.0	2.0	9.7	0.0	0.0	29.2
1998	6.0	12.9	2.0	0.0	8.0	0.0	0.0	0.0	0.0	7.0	0.0	0.0	35.9
1999	0.0	10.1	2.0	10.0	0.0	0.0	0.0	0.0	2.0	9.0	7.0	0.0	40.1
2000	10.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.0	0.0	0.0	19.0
2001	16.0	0.6	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.6
2002	0.0	5.0	0.0	3.0	9.0	0.0	0.0	0.0	3.0	12.0	10.4	4.0	46.4
2003	2.0	2.2	20.0	5.5	0.0	0.0	0.0	0.0	4.1	4.0	0.0	5.0	42.8
2004	4.0	0.0	36.5	4.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	46.5
2005	1.0	8.0	1.0	0.0	0.0	6.4	0.0	0.0	0.0	54.0	10.0	1.0	81.4
2006	54.2	3.0	0.0	0.0	0.0	0.0	11.0	0.0	0.0	22.0	41.0	4.0	135.2
2007	0.0	0.0	35.5	0.0	5.0	0.0	0.0	0.0	0.0	0.0	6.0	5.0	51.5
2008	35.5	1.2	0.0	20.0	17.0	0.0	0.0	0.0	4.0	55.0	15.0	3.0	150.7
2009	0.1	0.0	3.6	0.0	0.8	0.0	0.0	0.0	3.9	0.0	0.0	0.0	8.4
2010	14.7	14.1	0.0	2.9	1.6	3.6	0.0	0.0	0.0	2.8	21.1	4.8	65.6
Average	9.5	4.3	7.4	3.0	4.9	1.0	0.3	0.2	3.6	8.9	7.1	5.9	56.2
Median	2.7	2.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	3.2	0.0	1.6	49.0
Std.Eva	14.5	8.1	10.6	5.0	11.2	2.2	1.8	0.7	6.0	13.4	11.6	11.3	36.8

The rainfall: Values are blue: above average.
Values are red: below average.

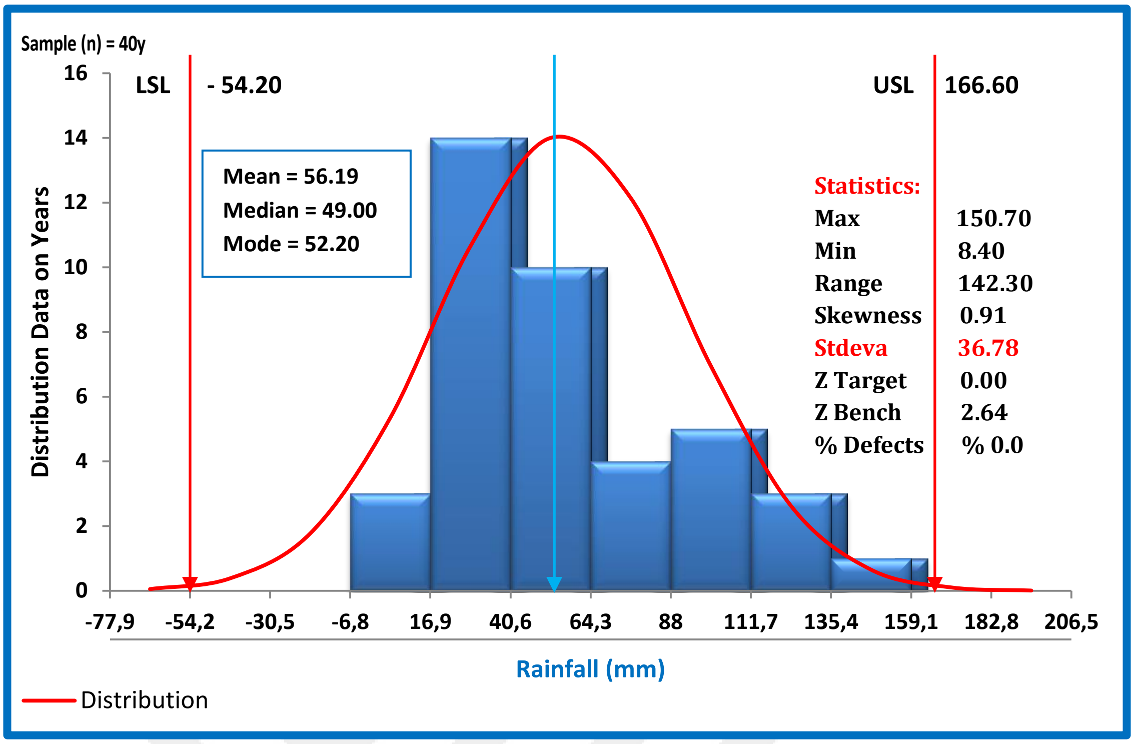


Figure 97. Descriptive Statistics on Rainfall Data By Years in GHARIAT Station For Period (1971-2010)

Table 54 and figure 98 show fluctuation in rainfall in some periods at GHARIAT station with lack of good amount of rain due to its desert location. It is observed that some of the year show the amount of rainfall above the annual average while amount of rainfall is found below of annual average in some years. The distribution of precipitation data over the monitoring years is found non- normal The highest amount of rain is found in the year 2008 with rate of (204.1 mm/y), and the lowest amount is found in 2009 with rate of (8.4 mm/y).

The most continuous amount of rainfall is (16.9 to 40.6 mm\yr) which is distributed over 14 years. This indicates a severe shortage of the rainfall in the area. The figure is followed by (40.6 to 64.3 mm/y) distributed over 10 years, (88 to 111.7 mm/y) over 5 years, (64.3 to 88 mm/y) over 4 years, (111.7 to 135.4 mm/y) over 3 years, (- 6.8 to 16.9 mm/y) over 3 years and (135.4 to 159.1 mm/y) over one year. The distribution curve is reached to an annual average of precipitation rate of (56.19 mm/y) and found stabilized. The curve is to the highest level at the right of the figure at (166.6 mm/y) and at left to lowest at (- 54.2 mm/y).This indicates severe decrease and fluctuation in precipitation in some years.

Table 55. Statistics of Rainfall Data By (mm) for Monthly and Annual in HON Station (1971-2010)

Years	Ja.	Fb.	Mr.	Ap.	Ma.	Jn.	Jl.	Ag.	Sp.	Oc.	Nv.	De.	Annual
1971	0.1	4.0	0.0	0.0	1.9	0.0	0.0	0.0	0.0	5.2	0.0	0.0	**11.2**
1972	0.6	0.0	0.7	34.4	15.3	0.3	0.0	0.0	6.1	29.9	0.0	2.9	**90.2**
1973	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.2	0.0	0.0	**3.7**
1974	0.0	0.0	2.4	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	**3.7**
1975	0.8	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.2	**27.3**
1976	6.0	15.3	7.3	0.0	8.2	0.2	0.0	0.0	9.8	0.1	0.0	0.0	**46.9**
1977	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.3	1.8	**7.6**
1978	0.5	4.9	0.0	7.3	0.0	0.0	0.0	0.0	0.0	2.5	1.3	0.0	**16.5**
1979	0.0	0.0	6.8	0.4	0.3	0.0	0.0	0.0	3.3	0.0	7.0	4.8	**22.6**
1980	2.9	4.5	24.9	0.0	0.7	0.0	0.0	0.0	0.0	0.0	3.9	2.2	**39.1**
1981	3.6	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	**4.4**
1982	3.9	3.6	2.8	1.8	15.9	0.0	0.0	0.0	0.0	22.6	0.0	5.8	**56.4**
1983	5.2	1.3	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.1	18.5	**26.4**
1984	0.1	24.8	26.1	0.0	1.2	0.0	0.0	0.0	0.0	1.0	0.4	5.0	**58.6**
1985	2.5	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	2.2	**4.9**
1986	0.3	3.5	11.1	0.0	0.0	0.0	0.0	0.0	0.0	67.4	12.3	0.0	**94.6**
1987	0.0	0.2	3.4	0.0	0.0	0.0	0.0	0.0	0.5	0.0	3.8	7.8	**15.7**
1988	19.3	0.3	5.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.1	2.1	**27.0**
1989	0.0	0.0	20.5	0.0	8.0	0.4	0.0	0.0	0.0	6.2	1.1	1.0	**37.2**
1990	9.1	2.7	0.0	7.6	33.0	0.0	0.0	0.0	0.0	0.0	108.8	0.0	**161.2**
1991	0.0	2.0	1.0	0.0	8.8	0.0	0.0	0.0	14.5	0.0	0.0	0.0	**26.3**
1992	13.0	0.9	6.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	**21.3**
1993	29.3	0.0	1.0	3.6	0.0	0.0	0.0	0.0	1.1	0.0	3.8	2.7	**41.5**
1994	13.8	0.0	4.1	13.6	4.9	0.0	0.0	0.0	0.0	3.8	0.0	0.9	**41.1**
1995	0.0	10.9	3.7	2.4	3.2	0.0	0.0	0.0	0.0	1.2	0.0	4.4	**25.8**
1996	4.7	1.8	12.8	21.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**40.9**
1997	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.1	18.0	0.0	1.6	**40.4**
1998	4.7	0.8	4.0	0.0	1.0	0.0	0.0	0.0	0.0	1.0	0.0	2.0	**13.5**
1999	0.2	1.5	0.0	0.0	4.8	0.0	0.0	0.0	6.2	0.0	0.0	1.0	**13.7**
2000	33.7	7.7	0.0	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.0	2.2	**45.3**
2001	0.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.4	0.0	0.0	**5.4**
2002	1.4	2.7	1.1	0.0	1.3	0.0	0.0	0.0	3.3	0.1	1.4	4.3	**15.6**
2003	1.8	15.8	0.6	20.5	0.0	0.4	0.0	0.0	0.0	0.8	0.0	0.0	**39.9**
2004	0.8	0.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.7	0.3	**6.5**
2005	0.2	7.4	0.4	0.0	0.3	19.1	0.0	0.0	0.0	1.3	0.0	0.0	**28.7**
2006	16.2	6.8	0.0	0.0	0.0	0.1	0.0	0.0	0.0	1.1	16.9	0.1	**41.2**
2007	0.0	0.0	3.3	3.8	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**7.2**
2008	24.6	2.0	0.0	0.5	10.5	0.0	0.0	0.0	0.0	0.0	0.0	0.5	**38.1**
2009	0.8	1.1	3.0	0.0	1.2	0.0	0.0	0.0	0.6	0.3	0.0	0.0	**7.0**
2010	0.0	0.0	0.0	8.2	0.0	0.2	0.0	0.0	0.0	0.3	0.1	9.4	**18.2**
Average	**5.1**	**3.3**	**3.9**	**3.2**	**3.0**	**0.6**	**0.0**	**0.0**	**1.6**	**4.2**	**4.3**	**2.7**	**31.8**
Median	**0.8**	**1.4**	**1.0**	**0.0**	**0.1**	**0.0**	**0.0**	**0.0**	**0.0**	**0.2**	**0.0**	**1.0**	**26.4**
Std.Eva	**8.5**	**5.2**	**6.6**	**7.3**	**6.4**	**3.0**	**0.0**	**0.0**	**4.1**	**12.1**	**17.3**	**4.9**	**30.0**

The rainfall: Values are blue: above average.
Values are red: below average.

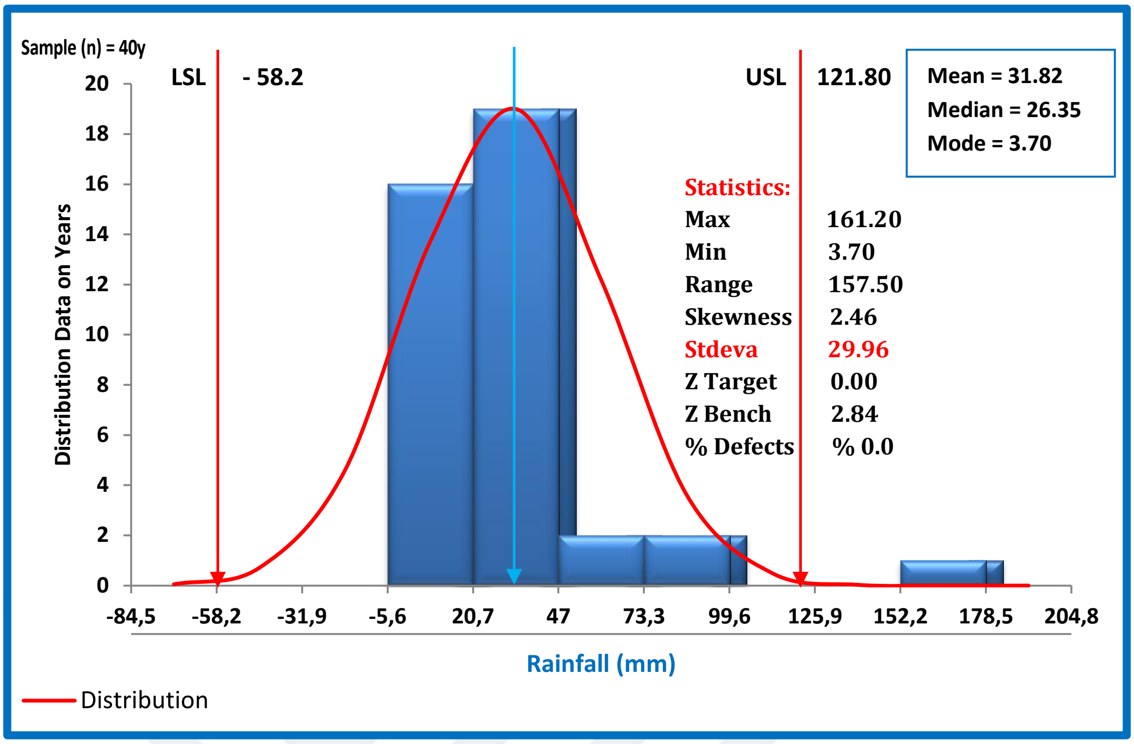


Figure 98. Descriptive Statistics on Rainfall Data By Years in HON Station For Period (1971-2010)

Table 55 and figure 99 show fluctuation in rainfall at HON station in some periods with lack of good amount of rain due to its desert location. It is observed that some of the year show the amount of rainfall above the annual average while amount of rainfall is found below of annual average in some years. The distribution of precipitation data over the monitoring years is found non- normal The highest amount of rain is found in the year 1990with rate of (161.2 mm/y) and the lowest amount in 1974with rate of (3.7 mm/y).

It is observed that the amount of rain between (20.7 to 47 mm/y) is the most continuous throughout the years and is distributed over 19 years. This indicates a severe shortage in amount rain at HON station. This is followed by (-5.6 to 20.7 mm/y) distributed over 16 years and (47 to 99.6 mm/y) over 4 years. An extreme value of (152.2 to 178.5 mm/y) is also observed in one year. The distribution curve is reached to an annual average of precipitation rate of (31.82 mm/y) and found stabilized. The curve is to the highest level at the right of the figure at (121.8 mm/y) and at left to lowest at (- 58.2 mm/y).This indicates severe decrease and fluctuation in precipitation in some years.

Table 56. Statistics of Rainfall Data By (mm) for Monthly and Annual in JAGHBOUB Station (1971-2010)

Years	Ja.	Fb.	Mr.	Ap.	Ma.	Jn.	Jl.	Ag.	Sp.	Oc.	Nv.	De.	Annual
1971	5.3	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.3
1972	6.8	0.0	0.0	22.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.8
1973	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.5	2.8
1974	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0
1975	0.0	15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	16.8
1976	2.0	0.0	5.0	5.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.1
1977	0.0	0.0	1.5	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	1.0	3.2
1978	5.0	0.0	1.0	3.6	0.0	0.0	0.0	0.0	0.0	0.2	0.0	1.6	11.4
1979	0.0	0.0	9.7	0.5	0.0	1.0	0.0	0.0	0.0	0.0	1.0	3.0	15.2
1980	2.0	8.2	6.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.3	23.5
1981	6.6	2.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	11.6
1982	0.0	8.0	10.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.0
1983	4.6	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	3.4	0.0	10.3
1984	0.0	9.0	8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	17.0
1985	6.6	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	17.4	29.0
1986	0.0	3.5	0.0	1.0	1.0	0.0	0.0	0.0	7.0	0.0	0.0	0.0	12.5
1987	0.0	0.0	5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	10.5
1988	23.4	0.1	31.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.6	90.4
1989	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.2
1990	0.5	11.0	1.3	0.1	0.2	0.0	0.0	0.0	0.0	0.0	8.9	0.0	22.0
1991	18.6	2.8	15.5	0.4	0.2	0.0	0.0	0.0	0.0	1.1	0.0	16.1	54.7
1992	0.0	2.2	3.0	0.5	0.1	0.0	0.0	0.0	0.0	0.0	0.0	1.0	6.8
1993	12.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.0	29.0
1994	6.3	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.4	4.3	4.5	16.0
1995	5.2	10.3	18.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	2.0	36.5
1996	0.2	0.3	2.2	1.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	4.7
1997	0.0	0.0	5.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	5.8
1998	0.0	1.9	0.3	0.0	3.0	0.0	0.0	0.0	0.0	0.0	1.1	7.3	13.6
1999	2.1	18.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.3	26.3
2000	8.2	26.4	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.3
2001	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	2.3
2002	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	4.0
2003	0.0	0.0	3.1	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.1
2004	0.6	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	1.0	1.9
2005	0.0	3.5	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	3.6
2006	0.0	2.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	3.1
2007	6.4	7.4	0.0	0.0	8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.8
2008	3.4	0.4	0.0	0.4	0.0	0.0	0.0	0.0	10.0	0.1	0.0	0.0	14.3
2009	0.3	0.0	0.9	0.1	0.3	0.0	0.0	0.0	0.1	0.3	0.0	0.3	2.3
2010	9.0	0.1	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	10.0
Average	3.5	3.4	3.5	1.0	0.4	0.0	0.0	0.0	0.4	0.1	0.6	3.2	16.1
Median	0.8	0.2	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	11.9
Std.Eva	5.2	5.9	6.2	3.6	1.3	0.2	0.0	0.0	1.9	0.4	1.7	6.8	16.9

The rainfall: Values are blue: above average.
Values are red: below average.

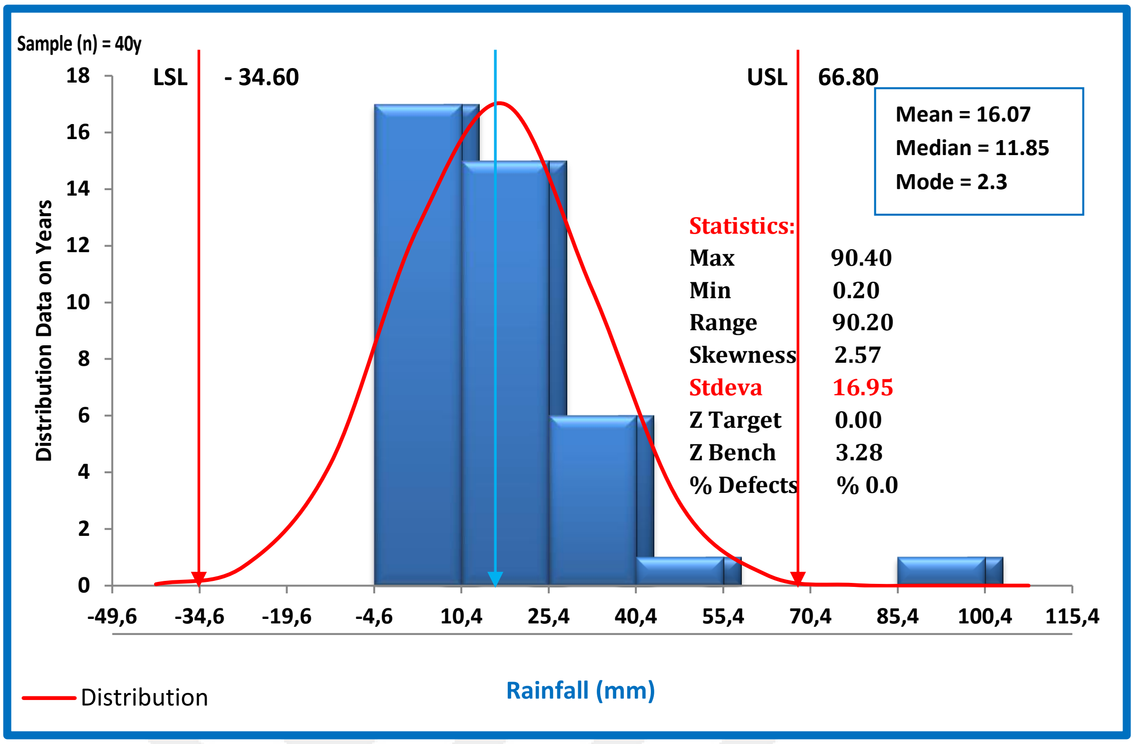


Figure 99. Descriptive Statistics on Rainfall Data By Years in JAGHBOUB Station For Period (1971-2010)

The data found in table 56 and figure 100 show fluctuation in rainfall at JAGHBOUB station in some periods with lack of good amount of rain due to its desert location. It is observed that some of the year show the amount of rainfall above the annual average while amount of rainfall is found below of annual average in some years. The distribution of precipitation data over the monitoring years is found non-normal The highest amount of rain is found in the year 1988 with rate of (90.4 mm/y) and the lowest amount in 2009 with rate of (0.2 mm/y).

Distribution of rainfall data has indicated that the amount of rain between (-4.6 to 10.4 mm/y) is the most continuous in selected years which distributed over 17 years. This indicates a severe shortage in amount rainfall in the area. The distribution is followed by (10.4 to 25.4 mm/y) over15 years, (25.4 to 40.4 mm/y) over 6 years and (40.4 to 55.4 mm/y) over one year., An extreme value of (85.4 to 100.4 mm/y) is also observed for one year. The distribution curve is reached to an annual average of precipitation rate of (16.07 mm/y) and found stabilized. The curve is to the highest level at the right of the figure at (66.8 mm/y) and at left to lowest at (-34.60 mm/y).This indicates high a decrease and fluctuation in precipitation in some years.

Table 57. Statistics of Rainfall Data By (mm) for Monthly and Annual in JALO Station (1971-2010)

Years	Ja.	Fb.	Mr.	Ap.	Ma.	Jn.	Jl.	Ag.	Sp.	Oc.	Nv.	De.	Annual
1971	2.8	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.8
1972	0.1	0.0	0.0	3.4	0.0	0.0	0.0	0.0	0.0	20.1	0.0	0.0	23.6
1973	3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	3.7
1974	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
1975	0.0	0.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	3.6	8.4
1976	3.5	3.7	0.0	5.7	0.0	0.0	0.0	0.0	0.0	2.0	1.1	0.0	16.0
1977	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	2.0
1978	1.0	0.0	0.0	4.0	0.0	0.0	0.0	0.0	0.0	19.5	3.0	0.0	27.5
1979	0.0	0.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	3.5
1980	0.4	10.0	3.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	14.8
1981	7.9	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	10.7
1982	0.9	0.6	1.6	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	4.7
1983	5.1	1.2	0.0	2.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.6	9.1
1984	0.3	0.0	17.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	18.8
1985	0.3	0.3	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	3.5
1986	0.0	0.7	1.0	0.0	0.7	0.0	0.0	0.0	1.3	0.2	0.2	0.0	4.1
1987	0.0	0.7	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.8
1988	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	3.8
1989	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.5	0.0	3.8
1990	1.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	1.8
1991	0.2	0.0	16.1	3.0	3.5	0.0	0.0	0.0	0.0	0.0	0.0	6.2	29.0
1992	0.8	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.8
1993	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	1.5
1994	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0
1995	0.0	18.0	8.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	27.2
1996	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1997	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	1.0
1998	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.0	12.3
1999	0.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	8.0
2000	6.7	18.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.1
2001	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6
2002	0.0	1.9	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	3.2
2003	0.7	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7
2004	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6
2005	0.0	0.3	1.2	0.0	0.0	0.0	0.0	0.0	0.0	6.3	0.0	0.3	8.1
2006	7.2	11.0	0.0	9.4	2.0	0.0	0.0	0.0	0.0	0.0	0.0	9.6	39.2
2007	13.8	0.1	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.9
2008	15.0	0.1	0.0	4.0	5.0	0.0	0.0	0.0	0.0	0.6	0.0	4.0	28.7
2009	0.3	1.0	1.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.3
2010	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	2.1
Average	2.0	2.0	1.6	0.9	0.4	0.0	0.0	0.0	0.1	1.3	0.3	1.1	9.6
Median	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2
Std.Eva	3.6	4.5	3.9	2.0	1.0	0.0	0.0	0.0	0.3	4.4	0.7	2.6	10.2

The rainfall: Values are blue: above average.
Values are red: below average.

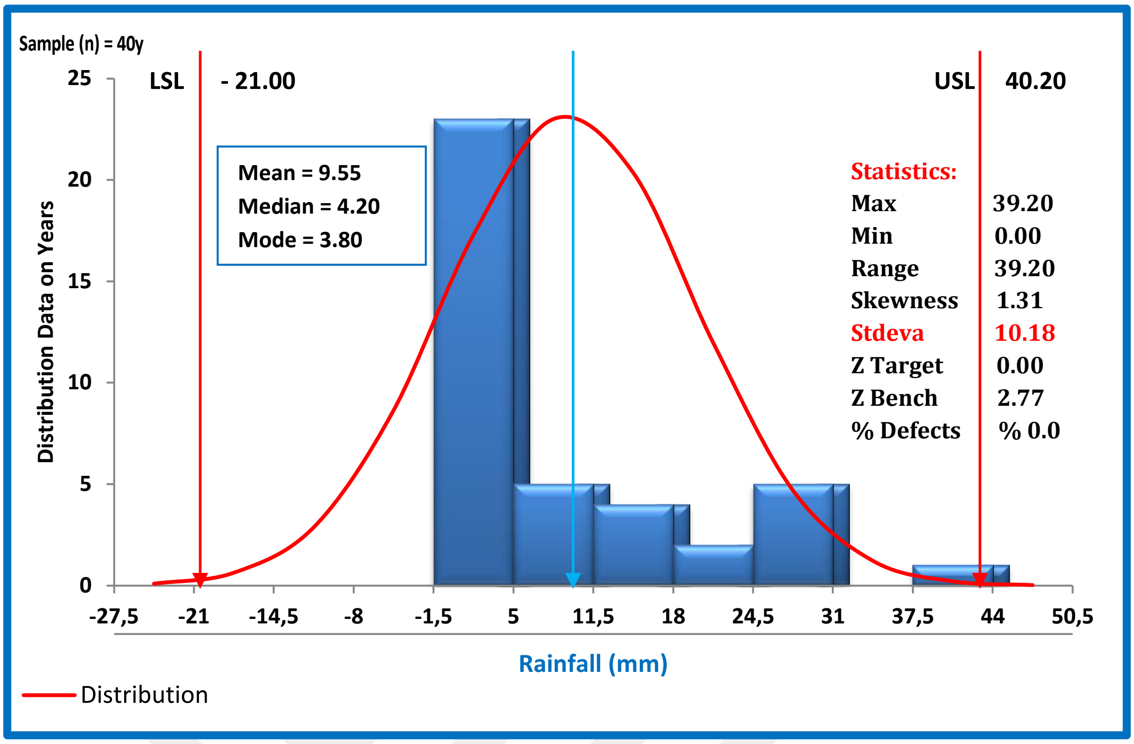


Figure 100. Descriptive Statistics on Rainfall Data By Years in JALO Station For Period (1971-2010)

Table 57 and figure 101 show fluctuation in rainfall at JALO station in some periods with lack of good amount of rain due to its desert location. It is observed that some of the year show the amount of rainfall above the annual average while amount of rainfall is found below of annual average in some years. The distribution of precipitation data over the monitoring years is found non- normal The highest amount of rain is found in 2006 with rate of (39.2 mm/y) and the lowest amount in 1996 with rate of (0 mm\yr.).

It is observed that the amount of rain between (-1.5 to 5 mm/y) is the most continuous and distributed over 23 years. This is an indication of severe shortage in amount of rainfall. The distribution of rainfall is followed by (5 to 11.5 mm/y) distributed over 5 years, (24.5 to 31 m\y) over 5 years, (11.5 to 18 m/\y) over 4 years and (18 to 24.5 mm/y) over 2 years. An extreme value of (37.5 to 44 mm/y)is also observed in one year. The distribution curve is reached to an annual average of precipitation rate of (9.55 mm/y) and found stabilized. The curve is to the highest level at the right of the figure at (40.2 mm/y) and at left to lowest at (-21 mm/y).This indicates high a decrease and fluctuation in precipitation in some years.

Table 58. Statistics of Rainfall Data By (mm) for Monthly and Annual in MISURATA Station(1971-2010)

Years	Ja.	Fb.	Mr.	Ap.	Ma.	Jn.	Jl.	Ag.	Sp.	Oc.	Nv.	De.	Annual
1971	70.3	70.4	7.5	4.1	12.4	0.0	0.0	0.0	5.4	69.6	25.5	26.1	291.3
1972	41.1	2.9	50.5	27.2	10.9	0.0	0.0	0.0	5.3	28.4	5.6	100.6	272.5
1973	51.9	20.8	24.6	10.6	0.0	0.0	0.0	0.0	4.0	56.8	104.9	9.5	283.1
1974	22.1	28.4	44.9	0.0	0.0	0.0	0.0	0.0	3.4	32.7	18.8	106.9	257.2
1975	68.7	40.0	10.7	0.0	0.4	2.0	0.0	0.0	0.0	13.4	26.6	75.4	237.2
1976	92.5	38.8	43.9	22.3	2.2	0.0	0.0	0.0	3.8	35.1	81.3	9.0	328.9
1977	20.7	3.2	2.7	9.7	0.0	0.0	0.0	0.0	53.7	0.0	9.3	92.4	191.7
1978	31.7	37.0	13.9	9.4	4.0	0.0	0.0	0.0	15.8	74.1	200.9	5.6	392.4
1979	18.4	24.7	41.1	10.8	0.0	2.9	0.0	0.0	55.0	1.0	82.0	21.2	257.1
1980	8.4	39.2	14.5	28.4	1.0	0.0	0.0	0.0	0.4	116.7	54.8	83.3	346.7
1981	206.8	27.7	7.1	2.6	0.0	0.0	0.0	0.0	0.0	14.7	102.1	1.6	362.6
1982	13.7	31.3	40.1	11.2	17.5	0.0	0.0	0.0	0.0	28.9	80.4	83.6	306.7
1983	51.4	4.9	7.4	0.6	0.0	1.3	0.0	0.0	0.0	28.5	93.9	42.4	230.4
1984	25.9	42.9	6.1	10.3	0.0	0.0	0.0	0.0	0.0	70.9	19.7	164.5	340.3
1985	29.4	0.8	19.2	0.8	2.8	0.0	0.0	0.0	9.4	12.9	8.7	135.3	219.3
1986	45.3	0.9	70.2	0.0	0.8	1.5	0.0	0.0	19.6	34.7	113.2	143.8	430.0
1987	29.9	15.6	11.0	6.0	0.0	0.0	0.0	6.5	3.1	0.0	72.9	30.7	175.7
1988	80.3	24.5	20.3	0.0	0.0	0.3	0.0	0.0	67.3	24.7	26.3	121.7	365.4
1989	32.8	23.0	24.9	0.0	1.7	0.0	0.0	0.0	12.7	31.3	17.6	1.9	145.9
1990	112.4	2.3	3.7	17.4	2.0	0.0	0.0	0.0	0.0	0.0	222.5	22.3	382.6
1991	103.3	40.7	18.7	24.4	27.4	9.8	0.0	0.0	18.8	9.5	42.2	167.1	461.9
1992	47.7	36.3	2.4	3.3	2.8	3.8	0.0	0.0	0.0	0.0	25.8	24.6	146.7
1993	25.0	56.5	11.8	8.3	0.0	0.0	0.0	0.0	0.0	4.7	14.5	45.8	166.6
1994	32.6	16.1	4.0	53.5	3.0	0.0	0.5	0.0	0.0	66.0	47.8	65.3	288.8
1995	215.0	27.2	14.7	2.3	0.0	4.6	0.0	5.6	1.9	136.3	42.4	4.0	454.0
1996	14.9	65.0	45.7	2.4	0.0	18.5	0.7	0.2	11.9	5.5	31.5	42.6	238.9
1997	16.4	26.7	27.1	12.3	0.0	0.8	0.0	0.5	22.7	26.8	29.4	89.3	252.0
1998	48.1	26.9	36.7	1.7	7.6	0.0	0.0	0.0	1.2	51.3	33.3	48.1	254.9
1999	40.7	35.7	14.8	0.1	0.2	0.0	0.0	0.0	3.8	44.0	30.5	46.2	216.0
2000	82.1	53.9	0.0	15.6	0.0	0.0	0.0	0.5	1.1	17.9	1.4	41.4	213.9
2001	15.7	48.8	3.9	8.3	2.1	0.0	0.0	0.0	0.6	2.1	198.6	60.8	340.9
2002	21.0	20.6	10.9	11.7	2.7	0.0	0.0	3.5	19.7	5.0	82.3	26.2	203.6
2003	50.6	18.6	49.2	2.4	0.0	0.0	0.0	3.3	54.6	0.2	125.7	76.2	380.8
2004	37.2	4.2	113.6	22.0	0.0	0.0	0.0	0.0	9.2	0.0	42.3	21.5	250.0
2005	64.9	9.6	20.9	1.4	0.0	0.3	0.0	0.0	1.0	14.5	12.2	76.4	201.2
2006	93.2	45.7	23.0	9.9	2.7	0.0	0.0	0.0	14.1	58.4	36.6	26.0	309.6
2007	25.4	55.0	74.2	16.0	1.3	0.6	0.0	0.0	4.6	63.8	26.6	40.0	307.5
2008	141.9	42.4	5.1	20.4	0.0	1.0	0.0	1.0	8.0	1.9	48.1	91.6	361.4
2009	4.9	36.3	11.0	0.9	36.8	0.0	0.0	0.0	18.3	97.1	6.3	8.7	220.3
2010	12.1	2.2	13.1	20.2	0.0	0.0	0.0	0.0	15.1	22.1	30.9	34.8	150.5
Average	**53.7**	**28.7**	**24.1**	**10.2**	**3.6**	**1.2**	**0.0**	**0.5**	**11.6**	**32.5**	**56.9**	**57.9**	**280.9**
Median	**39.0**	**27.5**	**14.8**	**8.9**	**0.3**	**0.0**	**0.0**	**0.0**	**4.3**	**25.8**	**35.0**	**44.2**	**264.9**
Std.Eva	**48.2**	**18.5**	**23.6**	**11.0**	**7.7**	**3.3**	**0.1**	**1.5**	**17.1**	**33.7**	**54.3**	**45.4**	**84.4**

The rainfall: Values are blue: above average.
Values are red: below average.

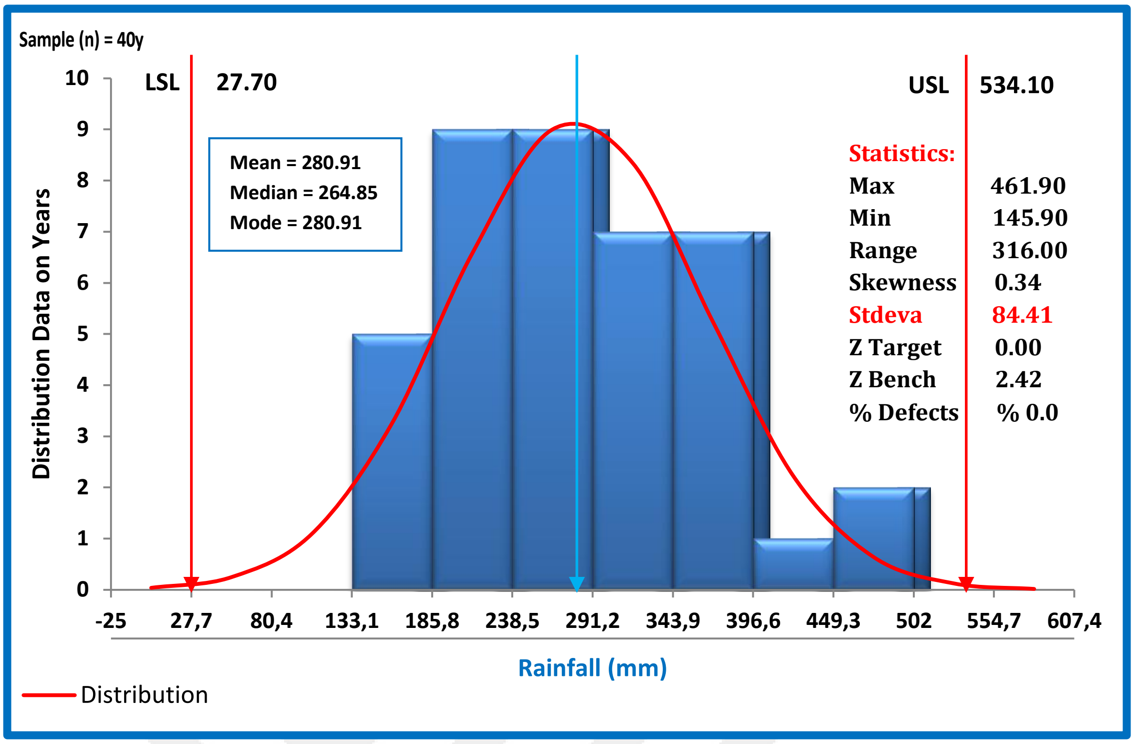


Figure 101. Descriptive Statistics on Rainfall Data By Years in MISURATA Station For Period (1971-2010)

Table 58 and figure 102 show fluctuation in rainfall at MISURATA station in some periods. It is observed that some of the year show the amount of rainfall above the annual average while amount of rainfall is found below of annual average in some years. The distribution of precipitation data over the monitoring years is found non-normal The highest amount of rain is found in the year 1991 with rate of (461.9 mm/y) and the lowest in 1989 with(145.9 mm/y).

Distribution of rainfall data on the years shows that the amount of rain between (185.8 to 291.2 mm/y) is the most continuous which is distributed over 18 years in two periods. This is followed by (291.2 to 396.6 mm/y) distributed over 14 years in two periods, (133.1 to 185.5 mm/y) distributed over 5 years, (449.3 to 502 mm/y) distributed over two years, (344.2 to 395.4 and 446.6 to 497.8 mm/y) distributed over 2 years and (396.6 to 449.3 mm/y) over one year. The distribution curve is reached an annual average of precipitation rate of (280.91 mm/y), and found stabilized. The curve is to the highest level at the right of the figure at (534.1 mm/y) and at left to lowest at (27.7 mm/y).This indicates an increase and fluctuation in precipitation in some years.

Table 59. Statistics of Rainfall Data By (mm) for Monthly and Annual in NALUT Station (1971-2010)

Years	Ja.	Fb.	Mr.	Ap.	Ma.	Jn.	Jl.	Ag.	Sp.	Oc.	Nv.	De.	Annual
1971	13.6	16.4	1.0	0.0	2.5	0.0	0.0	0.0	4.3	29.4	9.2	2.5	78.9
1972	18.6	20.7	26.4	44.5	159.9	0.0	0.0	0.6	11.7	0.3	0.4	16.8	299.9
1973	14.0	6.9	5.9	3.9	0.0	0.0	0.0	2.2	0.0	2.1	5.2	15.5	55.7
1974	5.0	3.6	55.8	5.6	0.0	0.2	0.0	0.0	3.4	111.7	4.2	16.0	205.5
1975	10.6	48.4	9.3	3.9	10.4	4.2	0.0	0.0	6.6	9.2	8.9	36.9	148.4
1976	71.3	81.9	251.9	24.7	107.1	0.0	0.0	0.0	0.0	2.6	16.6	12.7	568.8
1977	6.9	2.6	20.4	59.6	0.0	0.0	0.0	0.0	3.4	1.0	2.4	5.3	101.6
1978	15.8	22.2	1.0	0.0	7.1	0.0	0.0	0.0	0.0	10.3	18.6	0.0	75.0
1979	8.3	28.4	38.5	69.3	1.7	9.0	0.0	1.0	53.3	0.6	8.0	0.0	218.1
1980	3.7	10.5	38.5	16.2	0.0	0.0	0.0	0.0	1.6	9.8	53.2	31.6	165.1
1981	5.4	27.0	2.0	0.8	0.0	1.2	0.0	0.0	0.1	0.3	0.0	0.2	37.0
1982	21.0	16.5	12.7	81.9	0.7	0.0	0.0	0.0	0.8	46.0	13.3	33.4	226.3
1983	11.7	17.4	32.1	2.5	0.0	12.2	0.0	0.0	0.0	34.6	19.4	15.3	145.2
1984	17.3	0.0	17.9	0.5	0.0	0.0	0.0	0.0	0.0	52.9	4.9	42.6	136.1
1985	12.7	12.7	33.0	14.6	0.0	0.0	0.0	0.0	14.0	14.0	1.0	81.5	183.5
1986	3.6	0.0	66.4	3.1	1.0	6.0	0.0	0.0	0.1	14.4	85.9	4.7	185.2
1987	0.2	35.3	10.8	4.7	13.0	0.0	0.0	0.0	7.0	0.0	87.3	10.6	168.9
1988	10.2	1.0	41.1	0.0	0.0	0.0	0.0	0.0	6.0	0.0	62.8	32.3	153.4
1989	1.9	20.6	45.0	0.0	5.2	0.0	2.0	0.0	1.0	1.5	6.4	5.0	88.6
1990	107.2	0.0	2.7	3.1	49.0	0.0	0.0	0.0	0.0	0.0	21.5	1.7	185.2
1991	10.5	22.3	29.3	2.9	100.9	13.0	0.0	0.0	18.5	13.1	0.0	13.6	224.1
1992	37.5	2.0	74.6	0.0	13.0	0.0	0.0	0.0	0.0	0.0	0.0	15.2	142.3
1993	22.8	0.0	0.0	6.1	0.0	0.0	0.0	0.0	0.0	6.0	20.8	51.0	106.7
1994	19.0	2.0	13.0	70.0	15.0	0.0	0.0	0.0	4.0	6.1	2.1	4.3	135.5
1995	12.5	8.7	20.0	52.0	0.0	0.0	0.0	0.4	1.8	238.3	0.0	5.3	339.0
1996	6.1	108.0	27.4	1.3	0.0	14.1	0.0	0.0	2.0	0.0	4.0	1.1	164.0
1997	14.0	0.0	27.1	4.0	0.0	3.7	0.0	2.4	4.9	55.9	0.0	1.9	113.9
1998	8.5	8.6	56.9	0.5	20.2	4.3	0.0	0.0	6.3	5.6	0.5	19.0	130.4
1999	0.2	49.2	42.9	0.0	0.0	0.0	0.0	0.0	3.0	1.2	5.5	14.3	116.3
2000	7.5	28.4	1.3	0.1	10.3	3.0	0.0	0.0	0.1	94.1	0.0	0.0	144.8
2001	0.0	32.0	1.3	26.5	0.1	0.0	0.0	0.0	2.8	0.0	0.0	7.8	70.5
2002	3.3	85.4	0.1	6.2	1.4	0.0	0.0	0.9	4.0	15.6	14.8	2.4	134.1
2003	12.6	56.3	6.9	3.7	0.2	0.0	0.0	0.0	13.7	1.0	0.1	58.5	153.0
2004	18.5	0.0	58.7	3.0	0.0	0.0	0.0	0.0	0.0	0.0	13.3	13.4	106.9
2005	9.0	2.9	2.0	2.1	0.0	9.2	0.0	2.3	3.2	9.3	16.7	82.7	139.4
2006	39.9	28.1	0.0	18.9	7.2	0.0	0.1	0.0	0.0	17.6	11.0	16.8	139.6
2007	0.0	5.6	28.7	17.2	5.6	1.1	0.0	0.0	2.0	0.6	0.0	63.8	124.6
2008	71.1	7.9	0.3	0.2	0.1	0.0	0.0	0.1	34.9	15.1	25.7	23.1	178.5
2009	9.2	0.7	8.1	5.5	13.3	0.4	0.0	0.0	15.5	2.5	0.0	0.2	55.4
2010	5.6	0.0	0.0	2.6	0.7	1.7	0.0	0.0	4.2	0.8	25.6	1.3	42.5
Average	**16.7**	**20.5**	**27.8**	**14.0**	**13.6**	**2.1**	**0.1**	**0.2**	**5.9**	**20.6**	**14.2**	**19.0**	**154.7**
Median	**10.6**	**11.6**	**19.0**	**3.8**	**0.7**	**0.0**	**0.0**	**0.0**	**2.9**	**5.8**	**6.0**	**13.5**	**141.0**
Std.Eva	**21.6**	**25.6**	**42.0**	**22.3**	**33.5**	**4.0**	**0.3**	**0.6**	**10.3**	**43.3**	**21.6**	**22.0**	**92.0**

The rainfall: Values are blue: above average.
Values are red: below average.

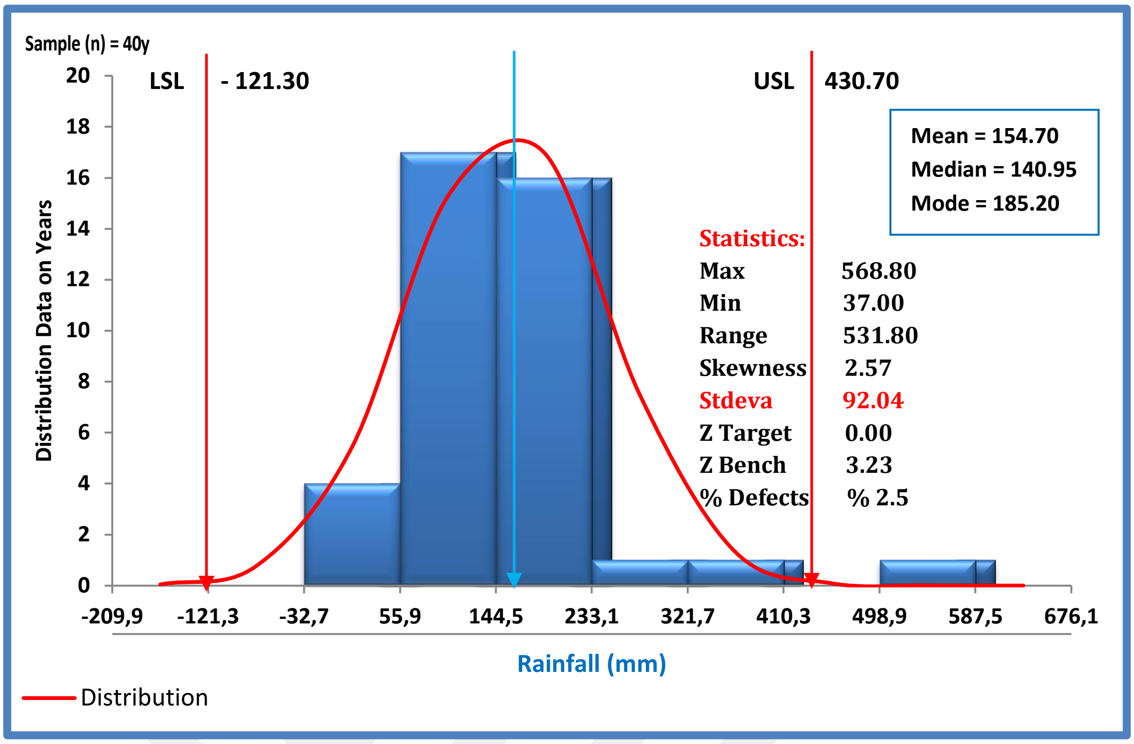


Figure 102. Descriptive Statistics on Rainfall Data By Years in NALUT Station For Period (1971-2010)

Table 59 and figure 103 show fluctuation in rainfall at NALUT station in some periods. It is observed that some of the year show the amount of rainfall above the annual average while amount of rainfall is found below of annual average in some years. The distribution of precipitation data over the monitoring years is found non-normal The highest amount of rain is found in the year 1976 with rate of (568.8 mm/y)and the lowest in 1981with (37 mm/y).

It is observed that the amount of rain between (66.8 to 144.6 mm/y) is the most continuous and distributed over 17 years. It is followed by (144.6 to 233.1 mm/y) distributed over 16 years in two periods, (-32.7 to 66.8 mm/y) distributed over 4 years and (233.1 to 410.3 mm/y) distributed over two years. An extreme value of (488.9 to 587.6 mm/y) is also observed for one year. The distribution curve is reached an annual average of precipitation rate of (154.7 mm/y) and found stabilized. The curve is to the highest level at the right of the figure at (430.7 mm/y) and at left to lowest at (-121.3 mm/y). This indicates a fluctuation in precipitation in many years.

Table 60. Statistics of Rainfall Data By (mm) for Monthly and Annual in SHAHAT Station (1971-2010)

Years	Ja.	Fb.	Mr.	Ap.	Ma.	Jn.	Jl.	Ag.	Sp.	Oc.	Nv.	De.	Annual
1971	98.9	131.8	23.9	32.8	1.7	0.0	0.7	0.0	22.8	41.1	110.4	32.5	496.6
1972	20.8	44.4	60.5	165.7	3.7	0.0	0.0	0.0	0.0	168.4	17.7	74.8	556.0
1973	74.9	97.8	76.6	32.8	1.7	0.0	0.0	0.0	0.9	76.3	48.6	31.8	441.4
1974	147.8	66.8	36.9	5.9	1.3	0.0	0.0	7.0	0.3	13.2	72.3	127.5	479.0
1975	152.4	55.6	7.2	37.2	1.0	1.2	0.0	0.4	2.2	37.6	24.5	106.3	425.6
1976	168.0	110.9	93.4	41.3	15.3	4.9	0.3	0.3	17.5	40.8	66.0	48.4	607.1
1977	83.7	19.3	17.3	81.0	1.6	0.0	0.0	0.0	66.4	16.3	17.4	357.2	660.2
1978	146.1	165.0	87.0	15.3	0.1	0.0	10.5	0.0	31.4	106.6	22.1	122.5	706.6
1979	60.3	121.8	22.3	22.4	3.3	1.2	0.0	0.0	1.0	89.4	76.9	143.5	542.1
1980	61.8	145.2	85.9	26.7	0.4	0.0	0.0	0.0	2.2	29.4	3.0	37.2	391.8
1981	332.1	152.2	15.2	2.2	15.6	0.8	0.3	0.0	0.0	7.7	146.3	52.9	725.3
1982	41.2	109.6	44.3	17.0	0.0	0.0	0.0	0.0	0.0	2.0	62.0	133.9	410.0
1983	168.0	68.2	104.3	25.5	6.9	0.0	0.0	13.5	17.0	46.8	139.4	62.9	652.5
1984	92.8	36.9	55.6	43.1	0.0	0.0	0.0	0.0	0.4	29.5	163.5	41.4	463.2
1985	148.1	144.4	71.3	21.0	13.5	0.0	0.0	0.5	0.1	91.7	38.0	87.2	615.8
1986	109.8	33.6	62.5	0.0	31.8	0.0	0.0	0.0	36.0	20.0	60.1	127.4	481.2
1987	81.9	57.8	163.4	61.9	0.0	0.0	0.0	0.0	0.0	2.6	74.0	117.6	559.2
1988	93.5	118.4	74.1	2.4	2.3	0.0	0.0	0.0	3.9	104.3	43.5	263.7	706.1
1989	119.0	63.6	230.1	0.0	2.7	4.3	0.0	0.0	2.4	40.2	71.4	35.1	568.8
1990	168.9	74.5	11.7	4.6	0.4	0.0	0.0	14.5	11.5	3.5	55.0	65.7	410.3
1991	93.7	107.0	16.2	24.2	24.6	0.0	0.6	0.0	2.9	17.3	113.5	434.8	834.8
1992	42.8	154.1	31.0	6.8	16.4	0.0	0.4	0.0	1.5	0.0	97.2	105.1	455.3
1993	189.3	47.1	65.9	0.4	9.6	0.0	0.0	0.0	15.3	48.9	26.3	40.1	442.9
1994	182.5	82.7	14.1	5.8	13.4	0.0	0.0	0.0	0.0	94.3	150.0	115.8	658.6
1995	78.0	42.7	59.5	40.2	0.0	0.0	0.0	0.0	4.5	145.1	110.1	34.2	514.3
1996	86.0	126.2	60.3	19.7	0.0	0.0	0.0	0.0	8.0	77.8	27.3	80.4	485.7
1997	93.2	116.5	107.7	29.8	0.0	0.0	0.0	0.0	4.2	55.1	99.0	70.8	576.3
1998	58.3	53.2	175.0	5.8	40.9	0.0	0.0	0.0	0.0	2.9	43.1	201.3	580.5
1999	97.0	26.4	80.3	14.1	1.1	0.0	0.0	2.7	10.4	63.1	13.6	87.9	396.6
2000	160.4	60.9	26.3	80.4	2.2	0.0	0.0	0.0	4.2	14.5	71.6	51.9	472.4
2001	58.0	71.2	4.8	12.0	17.5	0.0	0.0	0.0	0.0	3.5	128.2	321.6	616.8
2002	87.4	56.9	108.3	13.2	0.0	0.0	0.0	0.0	9.3	32.9	19.9	91.4	419.3
2003	79.8	151.7	193.3	39.4	4.9	4.1	0.0	0.0	6.1	0.0	49.6	115.2	644.1
2004	230.7	53.0	13.7	20.0	0.0	0.0	13.6	2.0	0.2	13.7	116.5	78.2	541.6
2005	211.8	69.4	96.8	22.9	0.0	0.0	1.8	3.2	24.0	12.9	77.7	101.8	622.3
2006	57.7	81.9	81.7	6.2	2.6	0.2	0.0	0.0	0.0	53.8	74.1	58.4	416.6
2007	112.0	122.5	36.8	2.0	31.3	0.0	0.0	0.3	3.0	53.9	31.7	134.1	527.6
2008	65.6	133.5	27.8	45.4	2.0	0.0	0.0	0.0	20.4	30.9	12.1	128.6	466.3
2009	65.3	182.7	24.7	8.0	33.7	0.0	0.0	0.0	14.4	82.1	25.2	115.3	551.4
2010	83.9	39.3	26.9	7.7	1.9	0.0	0.0	0.0	1.0	34.3	79.6	138.7	413.3
Average	112.6	89.9	64.9	26.1	7.6	0.4	0.7	1.1	8.6	45.1	67.0	114.4	538.4
Median	93.4	78.2	59.9	19.9	2.1	0.0	0.0	0.0	3.0	36.0	64.0	96.6	534.6
Std.Eva	61.2	43.9	52.9	30.4	11.0	1.2	2.7	3.3	13.2	40.7	43.0	89.0	107.0

The rainfall: Values are blue: above average.
Values are red: below average.

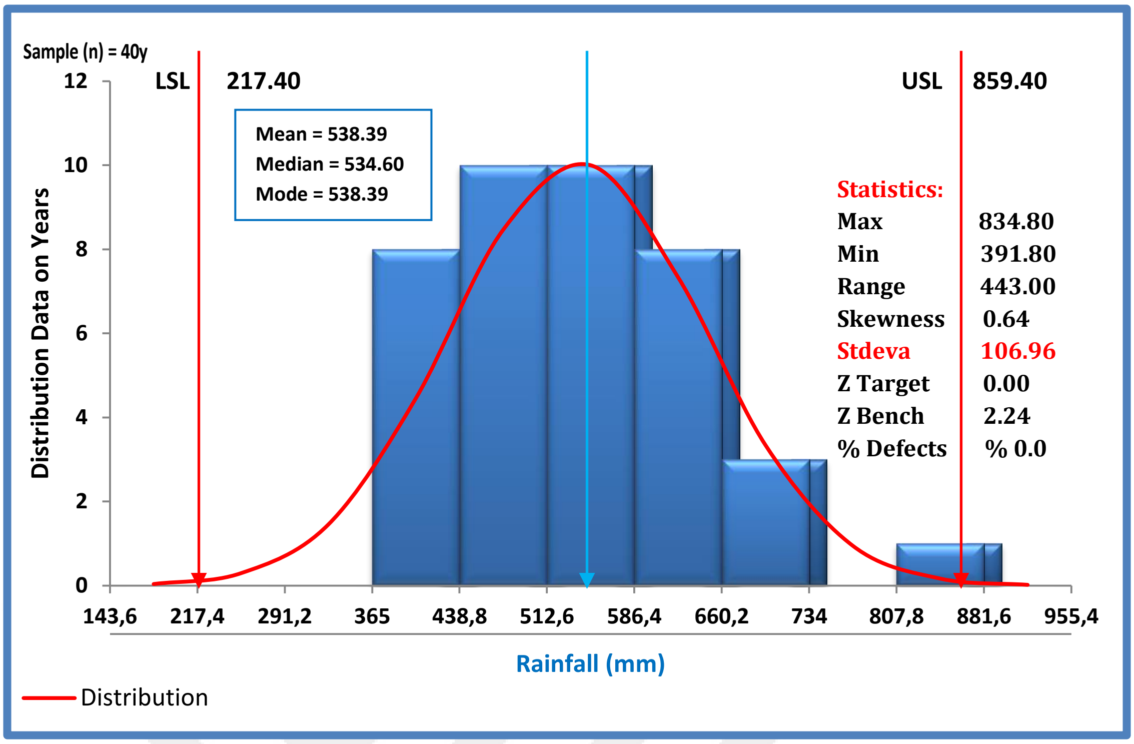


Figure 103. Descriptive Statistics on Rainfall Data By Years in SHAHAT Station For Period (1971-2010)

Table 60 and figure 104 show increase in rainfall at SHAHAT station in many periods. It is observed that some of the year show the amount of rainfall above the annual average while amount of rainfall is found below of annual average in some years. The distribution of precipitation data over the monitoring years is found semi-normal The highest amount of rain is found in 1991 with rate of (834.8 mm/y) and the lowest in 1980 with (391.8 mm/y).

It is observed that the amount of rain between (365 to 438.8 mm/y) is the most continuous and distributed over 8 years. It is followed by (438.8, 512.6 to 586.4 mm/y) distributed over 20 years in two periods, (586.4 to 660.2 mm/y) distributed over 8 years and (660.2 to 734 mm/y) distributed over 3 years. An extreme value of (807.8 to 881.6 mm/y) is also observed in one year. The distribution curve is reached an annual average of precipitation rate of (538.39 mm/y) and found stabilized. The curve is to the highest level at the right of the figure at (859.4 mm/y) and at left to lowest at (217.4 mm/y).This indicates a large in precipitation in many years.

Table 61. Statistics of Rainfall Data By (mm) for Monthly and Annual in SIRTE Station (1971-2010)

Years	Ja.	Fb.	Mr.	Ap.	Ma.	Jn.	Jl.	Ag.	Sp.	Oc.	Nv.	De.	Annual
1971	72.6	19.8	0.0	2.0	0.0	0.0	0.0	0.0	4.1	26.4	37.3	0.0	162.2
1972	6.0	4.0	0.0	3.5	5.7	0.0	0.0	0.0	0.0	105.5	0.0	48.2	172.9
1973	27.0	7.0	43.0	0.0	0.0	0.0	0.0	0.0	4.4	215.7	51.0	15.1	363.2
1974	28.0	0.0	11.0	0.0	0.0	0.0	0.0	0.0	13.7	0.0	21.7	136.3	210.7
1975	60.4	30.8	1.6	0.1	4.9	0.0	0.0	0.0	8.4	2.8	4.1	90.0	203.1
1976	58.4	14.8	18.8	9.3	2.1	0.0	0.0	0.0	0.0	44.2	70.7	0.0	218.3
1977	4.5	7.4	5.8	16.9	0.0	0.0	0.0	0.0	36.1	3.4	12.4	166.6	253.1
1978	54.4	53.7	35.3	27.3	0.1	0.0	0.0	0.0	27.9	81.1	52.9	4.7	337.4
1979	2.6	7.4	4.5	0.0	0.0	0.0	0.0	0.0	25.9	0.0	46.1	55.3	141.8
1980	3.2	25.1	6.9	1.6	4.7	0.0	0.0	0.0	0.0	42.2	0.0	131.7	215.4
1981	154.3	15.9	0.5	0.1	0.0	0.3	0.0	0.0	0.0	14.7	57.1	0.7	243.6
1982	9.8	9.2	23.8	12.8	0.7	0.0	0.0	0.0	0.0	29.0	6.1	43.9	135.3
1983	68.4	10.7	23.3	0.0	0.0	3.8	0.0	0.0	0.0	98.5	5.3	14.1	224.1
1984	11.0	13.8	8.4	0.0	0.0	0.0	0.0	0.7	5.0	5.2	15.2	44.2	103.5
1985	22.0	0.0	3.0	0.0	0.2	0.0	0.0	0.0	1.0	5.5	30.2	77.6	139.5
1986	20.5	0.0	57.7	0.0	0.4	2.7	0.0	0.0	104.5	32.5	74.5	36.4	329.2
1987	16.4	11.7	39.3	3.6	0.0	0.0	0.0	0.0	0.0	5.7	59.6	14.5	150.8
1988	33.8	4.8	27.5	0.0	0.0	0.0	0.0	0.0	8.3	34.1	25.3	61.1	194.9
1989	40.7	22.0	45.9	0.0	4.3	0.2	0.0	0.0	0.0	33.2	10.1	6.4	162.8
1990	50.8	13.3	3.6	3.9	22.3	0.0	0.0	0.0	0.0	0.0	17.4	7.0	118.3
1991	56.0	35.0	12.9	0.1	43.3	0.2	0.0	0.0	34.0	0.0	21.4	220.9	423.8
1992	32.7	30.8	2.6	0.0	2.2	1.2	0.0	0.0	0.0	0.0	36.9	8.3	114.7
1993	93.7	61.9	17.0	0.8	0.1	0.0	0.0	0.0	0.0	2.9	27.4	17.3	221.1
1994	49.0	2.0	2.0	5.7	7.8	0.0	0.0	0.0	0.0	28.4	62.2	100.4	257.5
1995	31.4	52.9	7.2	0.1	0.5	0.1	0.0	0.0	26.7	36.8	32.3	4.1	192.1
1996	29.1	20.4	36.0	6.5	0.6	8.6	0.0	0.0	7.0	14.5	23.0	6.6	152.3
1997	36.7	43.5	36.5	9.3	1.0	0.0	0.0	0.0	2.0	58.0	9.0	32.7	228.7
1998	19.0	49.0	68.7	3.1	5.1	0.1	0.0	0.0	1.0	4.0	9.0	36.3	195.3
1999	28.7	34.2	4.0	1.3	0.2	0.0	0.0	0.0	13.0	38.9	9.2	52.8	182.3
2000	107.5	45.3	0.0	0.0	0.0	0.0	0.0	0.0	2.0	2.6	0.0	8.2	165.6
2001	15.3	40.0	0.0	12.0	0.0	0.0	0.0	0.0	1.9	6.6	57.9	85.5	219.2
2002	58.6	31.9	7.4	7.7	2.0	0.0	0.0	0.0	32.6	6.1	2.0	6.6	154.9
2003	30.8	34.6	52.1	18.5	0.0	0.7	0.0	0.0	11.5	0.4	1.7	55.1	205.4
2004	32.0	9.0	26.2	0.0	4.0	0.2	0.0	0.0	2.1	0.0	9.0	20.6	103.1
2005	87.1	19.2	11.4	0.0	0.0	8.2	0.0	0.0	4.0	6.0	12.4	44.9	193.2
2006	82.6	44.2	2.0	4.5	0.0	0.2	1.6	0.0	0.8	42.1	30.8	27.0	235.8
2007	24.7	31.9	21.5	1.8	17.8	0.0	0.0	0.0	0.0	2.3	8.2	6.5	114.7
2008	65.0	60.4	0.0	17.3	0.5	0.0	0.0	0.0	0.5	28.5	1.9	76.6	250.7
2009	1.0	10.9	1.2	0.0	5.0	0.0	0.0	6.0	10.5	77.8	13.5	41.5	167.4
2010	41.1	21.6	4.2	4.7	2.4	0.0	0.0	0.0	24.1	2.3	18.7	14.7	133.8
Average	**41.7**	**23.8**	**16.8**	**4.4**	**3.4**	**0.7**	**0.0**	**0.2**	**10.3**	**28.4**	**24.6**	**45.5**	**199.8**
Median	**32.4**	**20.1**	**7.9**	**1.5**	**0.5**	**0.0**	**0.0**	**0.0**	**2.1**	**10.6**	**18.1**	**34.5**	**194.1**
Std.Eva	**32.2**	**17.8**	**18.4**	**6.5**	**7.9**	**1.9**	**0.3**	**1.0**	**18.8**	**41.3**	**21.7**	**49.6**	**70.8**

The rainfall: Values are blue: above average.
Values are red: below average.

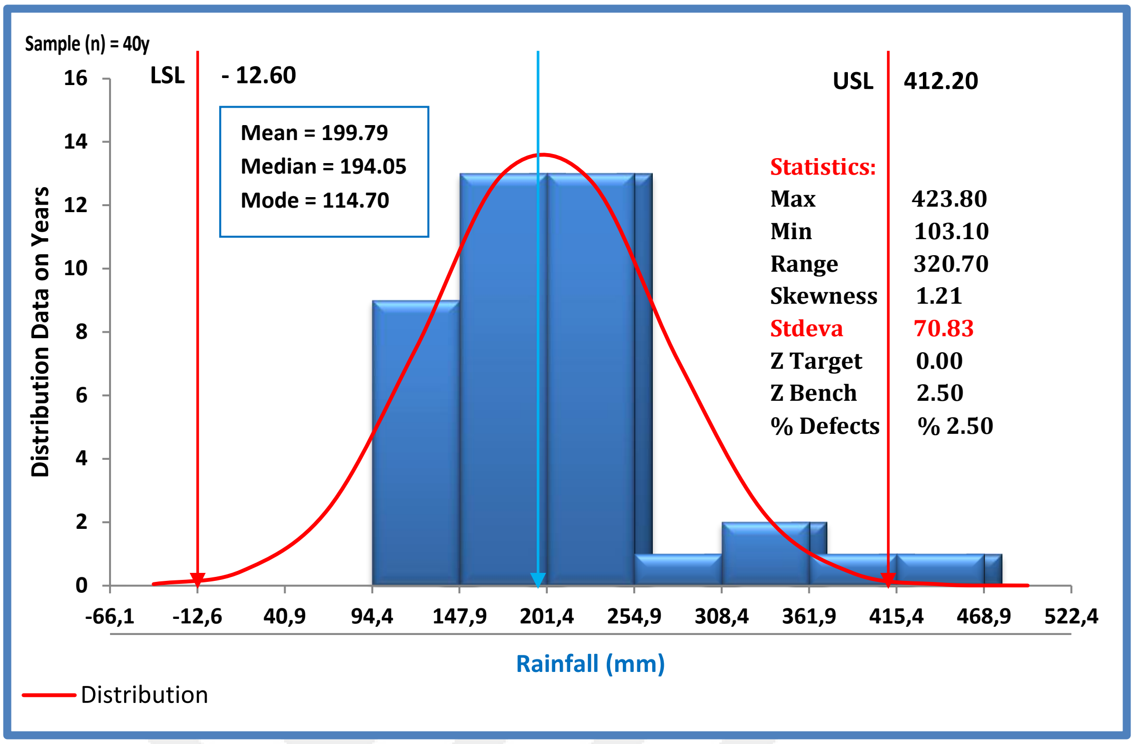


Figure 104. Descriptive Statistics on Rainfall Data By Years in SIRTE Station for Period (1971-2010)

Table 61 and figure 105 show fluctuation in rainfall at SIRTE station in some periods. It is observed that some of the year show the amount of rainfall above the annual average while amount of rainfall is found below of annual average in some years. The distribution of precipitation data over the monitoring years is found non-normal, the highest amount of rain is found in 1991 with rate of (423.8 mm/y) and the lowest in 2004 with (103.1 mm/y).

It is found that the amount of rain between (147.9 to 254.9 mm/y) is the most continuous and distributed over 26 years in two periods. It is followed by (94.4 to 17.9 mm/y) distributed over 9 years, (308.4 to 361.9 mm/y) distributed over 2 years and (254.9 to 308.4 mm/y), (361.9 to 415.4 mm/y), and (415.4 to 468.9 mm/y) all distributed over one year. No extreme values are found in SIRTE station. The distribution curve is reached an annual average of precipitation rate of (199.79 mm/y) and found stabilized. The curve is to the highest level at the right of the figure at (412.2 mm/y) and at left to lowest (-12.6 mm/y). This indicates a fluctuation in precipitation in many years.

Table 62. Statistics of Rainfall Data By (mm) for Monthly and Annual in TOBRUK Station (1971-2010)

Years	Ja.	Fb.	Mr.	Ap.	Ma.	Jn.	Jl.	Ag.	Sp.	Oc.	Nv.	De.	Annual
1984	31.2	33.5	31.9	4.4	2.3	0.0	0.0	0.0	0.0	27.7	29.8	38.6	199.4
1985	34.3	34.8	6.1	13.6	0.5	0.0	0.0	0.0	0.0	6.5	0.3	78.9	175.0
1986	27.0	23.6	21.0	0.0	3.3	0.0	0.0	0.0	17.0	9.4	133.6	18.1	253.0
1987	23.2	4.0	40.8	15.6	0.0	0.0	0.0	0.0	0.0	1.1	11.9	67.5	164.1
1988	54.3	83.8	6.5	4.0	0.0	0.0	0.0	0.0	0.0	10.1	4.2	102.9	265.8
1989	75.4	38.8	21.9	0.0	0.7	0.7	0.0	0.0	2.0	2.2	3.6	11.1	156.4
1990	77.7	24.3	22.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	14.6	32.0	171.6
1991	94.4	41.8	2.9	3.0	8.4	0.0	0.0	0.0	0.0	8.5	28.8	41.0	228.8
1992	76.3	44.0	7.2	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	75.2	203.7
1993	76.6	17.3	2.0	0.0	15.0	0.0	0.0	0.0	0.0	32.0	1.1	31.2	175.2
1994	46.5	1.0	3.0	0.0	21.5	0.0	0.0	0.0	0.0	42.2	91.5	12.0	217.7
1995	13.4	30.6	13.6	9.0	0.0	0.0	0.0	0.0	0.0	32.3	13.6	14.6	127.1
1996	45.5	7.3	18.7	2.0	0.0	0.0	0.0	0.0	0.0	59.9	19.8	1.3	154.5
1997	29.8	95.4	30.1	13.0	1.5	0.0	0.0	0.0	5.0	30.1	46.4	6.3	257.6
1998	32.3	20.4	42.6	0.0	24.4	0.0	0.0	0.0	0.0	7.1	0.6	62.7	190.1
1999	25.6	24.0	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.2	5.7	72.6
2000	89.8	29.7	0.3	10.0	0.1	0.0	0.0	0.0	7.3	0.1	28.0	22.7	188.0
2001	14.1	13.4	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	15.5	110.0	153.6
2002	57.0	1.0	0.6	9.0	0.0	0.0	0.0	0.0	8.2	14.8	1.0	14.0	105.6
2003	27.5	34.0	44.3	4.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	42.3	152.6
2004	45.6	46.5	6.6	7.0	0.6	0.0	0.0	0.0	0.0	0.0	7.3	27.0	140.6
2005	55.2	29.4	9.6	0.0	0.0	0.0	0.0	0.0	0.0	10.9	22.0	120.4	247.5
2006	71.0	48.2	2.7	0.0	2.0	0.0	0.0	0.0	0.0	8.0	3.3	26.1	161.3
2007	57.4	52.6	1.7	0.0	74.2	0.3	0.0	0.0	0.4	0.0	13.8	52.0	252.4
2008	24.1	23.0	0.8	3.4	1.0	0.0	0.0	0.0	0.0	41.0	0.0	46.9	140.2
2009	1.0	38.3	5.0	0.0	1.0	0.0	0.0	0.0	2.0	15.0	5.0	5.5	72.8
2010	10.4	29.8	12.3	6.0	14.2	0.0	0.0	0.0	6.0	11.3	21.2	9.3	120.5
Average	**45.1**	**32.2**	**13.2**	**3.9**	**6.3**	**0.0**	**0.0**	**0.0**	**1.8**	**13.7**	**19.7**	**39.8**	**175.8**
Median	**45.5**	**29.8**	**6.6**	**2.0**	**0.6**	**0.0**	**0.0**	**0.0**	**0.0**	**8.5**	**13.6**	**31.2**	**171.6**
Std.Eva	**25.8**	**21.7**	**14.0**	**4.8**	**15.2**	**0.1**	**0.0**	**0.0**	**3.9**	**16.2**	**29.8**	**33.8**	**53.5**

The rainfall: Values are blue: above average.
Values are red: below average.

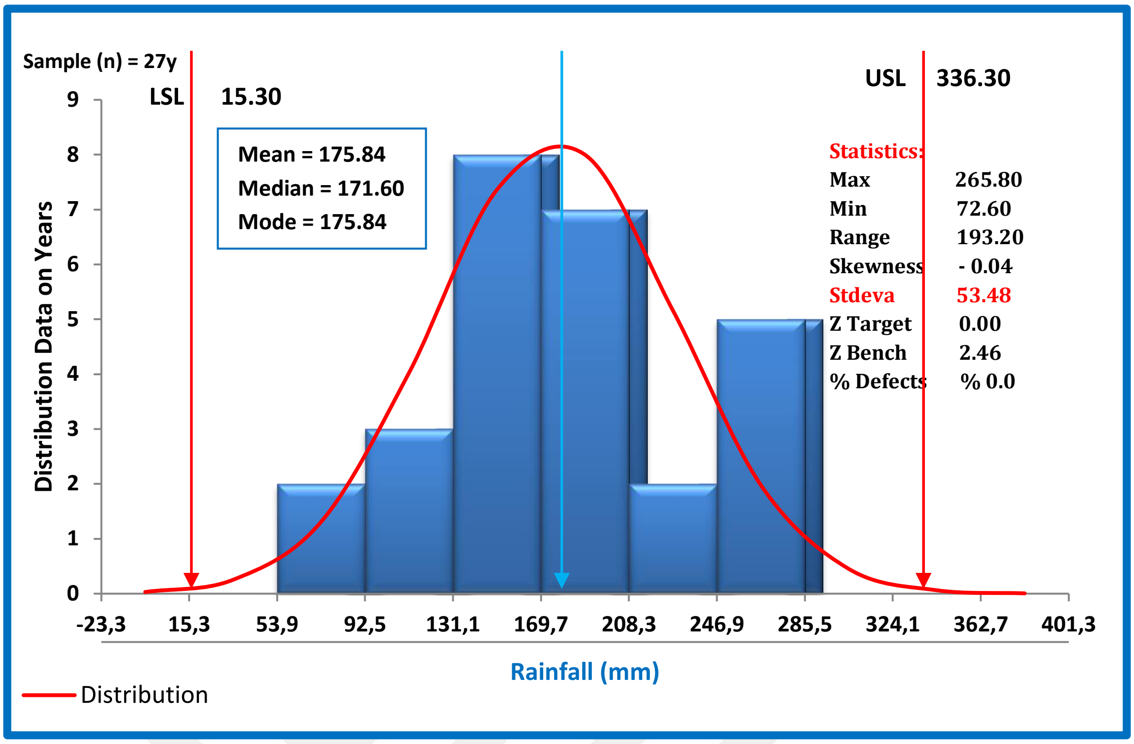


Figure 105. Descriptive Statistics on Rainfall Data By Years in TOBRUK Station for Period (1984-2010)

The data presented in table 62 and figure 106 show fluctuation in rainfall at TOBRUK station in some periods. It is observed that some of the year show the amount of rainfall above the annual average while amount of rainfall is found below of annual average in some years. The distribution of precipitation data over the monitoring years is found semi- normal, the highest amount of rain is found in 1988 with rate of (265.8 mm/y) and the lowest in 1999 with (72.6 mm/y).

It has been indicated that the amount of rain between (131.1 to 169.7 mm/y) is the most continuous which is distributed over 8 years. This is followed by (169.7 to 208.3 mm/y) distributed over 7 years, (246.9 to 285.5 mm/y) distributed over 5 years, (92.5 to 131.1 mm/y) over 3 years, (53.9 to 92.5 mm/y) and (208.3 to 246.9 mm/y) distributed over one year in two periods. No extreme value is found in TOBRUK station. The distribution curve is reached an annual average of precipitation (175.84 mm/y) and found stabilized. The curve is to the highest level at the right of the figure at (336.3 mm/y) and at left to lowest at (15.30 mm/y). This indicates a fluctuation in precipitation in many years with stability in the data in some periods.

Table 63. Statistics of Rainfall Data By (mm) for Monthly and Annual in TRIPOLI Station (1971-2010)

Years	Ja.	Fb.	Mr.	Ap.	Ma.	Jn.	Jl.	Ag.	Sp.	Oc.	Nv.	De.	Annual
1971	54.1	79.8	49.1	0.0	1.6	0.0	0.0	0.0	24.4	47.4	13.8	55.2	325.4
1972	43.6	14.3	88.1	54.3	25.7	0.0	0.0	0.0	1.4	91.6	0.0	33.0	352.0
1973	140.8	48.8	40.5	9.5	0.0	0.0	0.0	2.0	0.0	28.7	61.6	13.5	345.4
1974	44.3	51.7	100.4	23.0	0.0	0.0	0.0	0.0	6.5	59.1	55.0	48.2	388.2
1975	65.0	61.6	7.5	0.0	0.4	1.1	0.0	0.0	0.0	10.7	39.7	116.8	302.8
1976	107.9	41.8	91.0	41.2	52.6	0.0	0.0	0.0	2.9	73.0	28.8	14.0	453.2
1977	56.0	24.0	0.0	23.3	2.4	0.0	0.0	0.0	60.5	0.0	27.3	138.6	332.1
1978	37.8	58.2	22.0	0.8	12.6	0.0	0.0	1.0	0.0	77.8	97.7	3.3	311.2
1979	16.0	55.2	44.3	58.1	0.0	3.3	0.0	0.0	32.3	3.7	43.0	30.2	286.1
1980	2.8	15.0	30.9	21.6	3.1	0.0	0.0	0.0	0.0	135.9	154.8	102.0	466.1
1981	172.6	32.6	10.5	7.2	1.1	0.0	0.0	0.0	0.0	3.4	21.1	25.7	274.2
1982	100.7	70.3	57.5	13.3	0.1	0.0	0.0	0.0	0.6	37.2	53.5	57.5	390.7
1983	32.1	14.9	46.4	0.5	0.0	1.9	0.1	0.0	11.6	84.0	46.8	63.7	302.0
1984	65.9	51.1	6.1	14.0	2.0	0.0	0.0	0.0	0.0	78.8	58.9	136.5	413.3
1985	76.6	6.6	2.2	24.4	0.8	0.0	0.0	0.0	11.4	7.6	15.7	61.7	207.0
1986	31.7	2.5	27.3	0.0	2.2	1.2	0.8	0.0	16.5	167.8	117.3	99.7	467.0
1987	14.7	45.8	9.9	10.7	0.3	0.0	0.1	0.0	2.5	0.4	84.2	7.9	176.5
1988	86.2	6.2	18.5	1.2	0.0	0.3	0.0	0.0	16.3	0.0	20.8	92.7	242.2
1989	47.7	13.3	73.1	0.4	0.0	0.3	0.0	0.0	1.3	41.4	23.9	1.5	202.9
1990	81.0	2.3	8.3	37.0	18.8	0.0	1.0	0.0	0.0	0.0	45.9	24.3	218.6
1991	20.6	26.6	31.3	19.4	39.8	8.0	0.0	0.0	8.0	1.4	58.7	22.8	236.6
1992	12.4	27.6	30.5	8.9	8.4	0.0	0.0	0.0	0.0	3.0	22.0	11.1	123.9
1993	23.9	34.0	5.3	0.2	1.0	0.0	0.0	0.0	2.4	7.7	44.2	16.2	134.9
1994	44.3	5.3	5.8	94.2	7.2	0.0	0.0	0.0	0.2	35.1	24.8	34.8	251.7
1995	173.4	20.9	27.8	43.8	0.0	0.7	0.0	0.0	12.7	88.8	39.2	61.5	468.8
1996	24.3	92.9	44.3	7.4	0.0	0.0	0.0	0.0	11.4	13.6	33.9	23.6	251.4
1997	43.4	7.5	19.4	3.6	0.2	0.0	0.0	0.0	71.5	19.5	6.8	67.7	239.6
1998	33.0	28.0	48.1	3.6	14.4	0.7	0.0	0.0	0.0	14.7	42.6	38.4	223.5
1999	24.3	45.7	56.4	0.3	0.0	0.0	0.0	0.0	0.5	0.0	53.2	78.6	259.0
2000	23.4	86.7	7.0	2.0	2.6	0.0	0.0	0.0	0.0	18.2	0.2	6.7	146.8
2001	32.0	27.7	4.7	0.8	0.4	0.0	0.0	0.0	1.0	0.1	79.3	41.3	187.3
2002	10.5	40.8	7.7	10.0	1.5	0.0	0.0	1.2	12.1	27.4	133.6	26.9	271.7
2003	69.4	25.2	15.9	19.2	0.0	0.0	0.0	0.0	4.6	0.6	24.3	83.8	243.0
2004	58.8	2.6	61.8	18.0	0.0	0.0	0.0	0.0	7.3	0.0	23.8	38.1	210.4
2005	67.5	16.5	11.2	4.2	0.0	1.2	0.0	2.5	3.9	0.0	13.3	81.2	201.5
2006	125.2	51.4	0.7	5.5	11.7	0.0	2.8	0.4	10.2	17.7	15.2	15.6	256.4
2007	10.2	51.0	28.4	6.4	1.0	0.0	0.0	0.0	0.0	48.6	13.9	70.2	229.7
2008	117.6	50.7	0.3	0.0	0.9	0.0	0.0	0.0	9.1	1.4	5.0	62.0	247.0
2009	21.4	17.1	0.5	4.6	5.5	0.0	0.0	0.0	8.9	54.4	2.3	2.7	117.4
2010	45.1	0.2	15.1	13.0	7.2	1.0	0.0	0.0	11.8	19.0	7.6	29.7	149.7
Average	**56.5**	**33.9**	**28.9**	**15.1**	**5.6**	**0.5**	**0.1**	**0.2**	**9.1**	**33.0**	**41.3**	**48.5**	**272.7**
Median	**44.3**	**27.9**	**20.7**	**8.2**	**1.0**	**0.0**	**0.0**	**0.0**	**3.4**	**18.0**	**31.4**	**38.3**	**251.6**
Std.Eva	**43.1**	**24.5**	**27.0**	**19.9**	**11.1**	**1.4**	**0.5**	**0.5**	**15.2**	**40.2**	**35.9**	**36.8**	**95.9**

The rainfall: Values are blue: above average.
Values are red: below average.

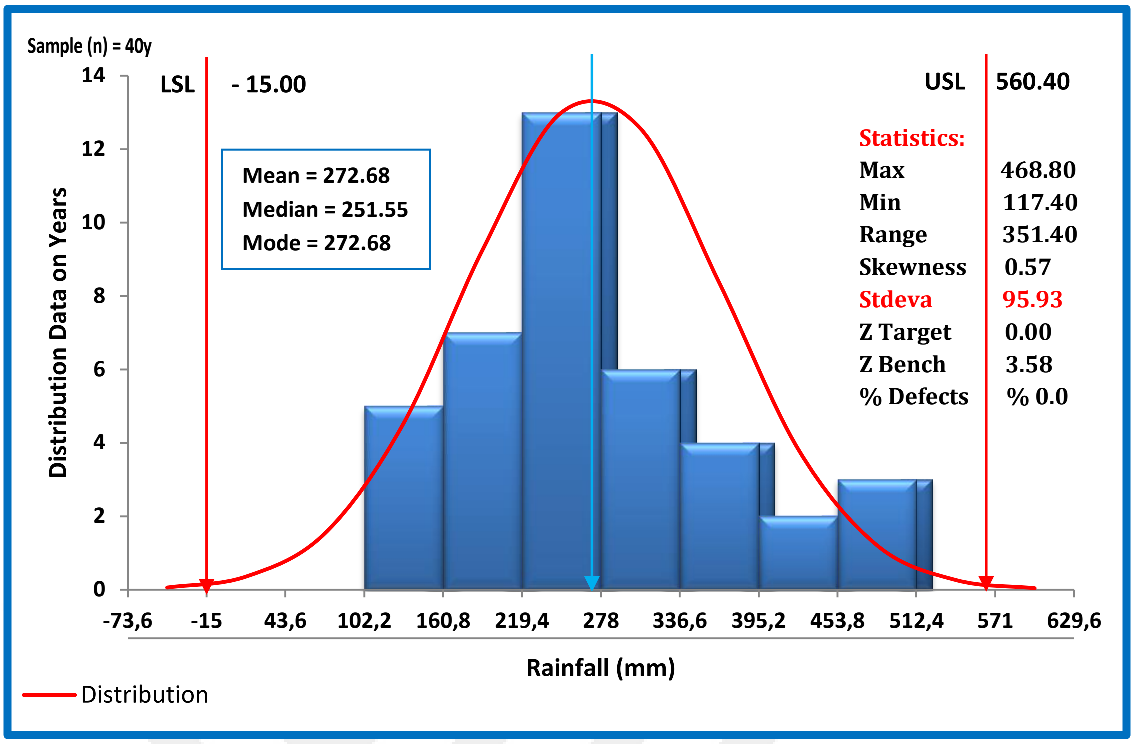


Figure 106. Descriptive Statistics on Rainfall Data By Years in TRIPOLI Station for Period (1971-2010)

The data found in the table 63 and figure 107 show fluctuation in rainfall at TRIPOLI station in some periods. The distribution of precipitation data over the monitoring years is found semi- normal The highest amount of rain is found in the year 1995 with the rate of (468.8 mm/y) and the lowest in 2009 with rate of (117.4 mm/y).

It is found that the amount of rain between (219.4 to 278 mm/y) is the most continuous which is distributed over 13 years. It is followed by (160.8 to 219.4 mm/y) distributed over 7 years, (278 to 336.6 mm/y) distributed over 6 years, (102.2 to 160.8 mm/y) over 5 years, (336.6 to 395.2 mm/y) distributed over 4 years, (453.8 to 512.4 mm/y) distributed over 3 year and (395.2 to 453.8 mm/y) distributed over two years. There is no extreme values found in TRIPOLI station. The distribution curve is reached an annual average of precipitation rate of (272.68 mm/y) and found stabilized. The curve is to the highest level at the right of the figure at (560.4 mm/y) and at left to lowest (-15 mm\y).This indicates a fluctuation in precipitation in many years with stability in the data in some periods.

Table 64. Statistics of Rainfall Data By (mm) for Monthly and Annual in ZWARA Station (1971-2010)

Years	Ja.	Fb.	Mr.	Ap.	Ma.	Jn.	Jl.	Ag.	Sp.	Oc.	Nv.	De.	Annual
1971	76.3	31.1	7.1	0.0	1.3	0.0	0.0	0.0	37.8	27.8	12.6	19.7	213.7
1972	25.5	16.4	53.2	45.4	17.6	0.0	0.0	0.0	2.6	11.3	0.0	82.5	254.5
1973	77.1	48.1	26.5	7.3	0.0	0.0	0.0	2.8	2.9	28.4	29.2	21.6	243.9
1974	29.0	41.2	56.7	8.1	0.0	0.0	0.8	0.0	1.3	87.8	29.5	151.6	406.0
1975	76.0	32.9	9.7	1.9	26.0	0.3	0.0	0.0	0.0	3.7	28.5	120.7	299.7
1976	97.2	63.4	79.6	19.2	73.4	0.0	0.0	0.0	12.2	45.4	45.8	5.2	441.4
1977	20.7	26.8	6.0	21.6	0.4	0.0	0.0	0.0	32.3	4.1	31.5	43.0	186.4
1978	22.4	7.2	5.7	0.0	0.8	2.2	0.0	2.7	0.0	129.4	181.1	0.0	351.5
1979	2.0	53.9	66.9	83.3	0.5	0.8	0.0	0.0	16.2	5.2	47.7	14.0	290.5
1980	1.8	7.0	14.3	15.0	4.0	0.0	0.0	0.5	23.9	64.0	11.6	58.4	200.5
1981	8.7	7.3	0.3	0.0	0.7	0.6	0.0	0.0	0.0	0.7	17.0	4.8	40.1
1982	33.7	2.2	12.9	10.9	0.6	0.0	0.0	0.0	3.2	164.7	23.1	50.7	302.0
1983	16.9	11.2	14.7	0.0	0.0	1.5	0.0	0.0	8.9	46.8	34.6	47.9	182.5
1984	54.9	8.8	7.4	1.5	0.0	0.0	0.0	0.0	0.3	103.9	121.4	155.4	453.6
1985	34.8	5.8	2.2	18.1	0.0	0.0	0.0	0.0	14.2	3.6	2.8	83.7	165.2
1986	20.8	0.2	2.4	1.4	1.2	0.0	0.7	0.0	37.2	125.5	144.3	56.7	390.4
1987	2.5	11.7	3.3	6.9	1.5	0.0	0.0	0.0	16.0	8.9	189.7	15.8	256.3
1988	39.3	2.8	7.0	0.0	0.0	2.3	0.0	6.0	57.7	1.9	71.8	171.5	360.3
1989	28.4	21.1	47.2	0.0	0.0	0.0	0.0	0.1	1.0	26.5	20.2	5.9	150.4
1990	149.7	1.6	5.9	7.4	0.8	0.0	0.0	0.0	1.8	0.0	69.5	5.0	241.7
1991	14.4	5.0	23.0	0.4	32.3	2.0	0.0	0.0	11.7	0.0	7.8	68.3	164.9
1992	12.5	9.6	16.1	0.0	15.1	0.0	0.0	0.0	0.0	0.0	8.7	37.1	99.1
1993	16.5	62.7	7.9	2.0	0.0	0.0	0.0	0.0	0.1	9.8	60.6	57.4	217.0
1994	57.2	6.5	7.9	56.6	1.3	0.0	0.0	0.0	0.0	26.2	13.0	17.9	186.6
1995	90.0	14.7	4.4	25.9	0.0	0.0	0.0	0.0	33.2	75.7	29.5	48.6	322.0
1996	7.8	72.8	53.0	3.6	0.2	1.3	0.0	0.0	10.6	1.4	27.5	3.9	182.1
1997	56.4	5.0	16.7	1.7	0.0	4.1	0.0	2.6	41.4	87.0	8.1	74.5	297.5
1998	53.0	29.3	26.3	1.9	5.2	3.3	0.0	0.0	3.4	0.6	39.6	41.4	204.0
1999	35.0	53.8	50.9	0.0	0.0	0.0	0.0	0.0	0.8	9.6	17.2	74.9	242.2
2000	46.8	64.1	0.8	0.2	6.9	0.0	0.0	0.0	2.0	26.6	0.0	0.1	147.5
2001	7.8	20.0	14.0	3.8	0.2	0.0	0.0	0.0	3.9	0.6	30.1	45.4	125.8
2002	8.6	88.2	0.7	19.1	0.6	0.0	0.0	0.0	15.0	31.1	135.3	18.1	316.7
2003	70.6	22.9	4.3	25.4	2.3	0.0	0.0	6.0	6.6	0.1	53.6	59.6	251.4
2004	46.8	8.0	43.2	4.9	1.7	0.0	0.0	0.0	2.9	0.0	32.7	32.3	172.5
2005	37.5	2.0	4.6	1.9	0.0	4.5	0.0	5.9	16.1	0.0	2.8	88.8	164.1
2006	126.2	23.0	0.0	5.7	16.1	0.0	0.0	18.4	3.5	22.5	10.9	29.1	255.4
2007	10.7	43.0	31.9	11.9	0.0	0.0	0.0	0.0	0.0	41.2	37.6	68.6	244.9
2008	38.1	20.5	3.1	0.6	2.3	0.2	0.0	0.0	14.3	0.0	32.5	49.3	160.9
2009	15.4	4.9	9.7	14.8	23.7	0.0	0.0	0.0	34.1	43.0	0.4	1.2	147.2
2010	34.2	0.7	6.7	11.6	1.2	0.0	0.0	0.0	8.2	11.1	5.2	14.2	93.1
Average	40.1	23.9	18.9	11.0	5.9	0.6	0.0	1.1	11.9	31.9	41.6	48.6	235.6
Median	34.0	15.6	8.8	4.4	0.8	0.0	0.0	0.0	5.3	11.2	29.4	44.2	229.4
Std.	34.0	23.3	20.9	17.1	13.6	1.2	0.2	3.3	14.4	41.9	47.8	43.3	95.2

The rainfall: Values are blue: above average.
Values are red: below average.

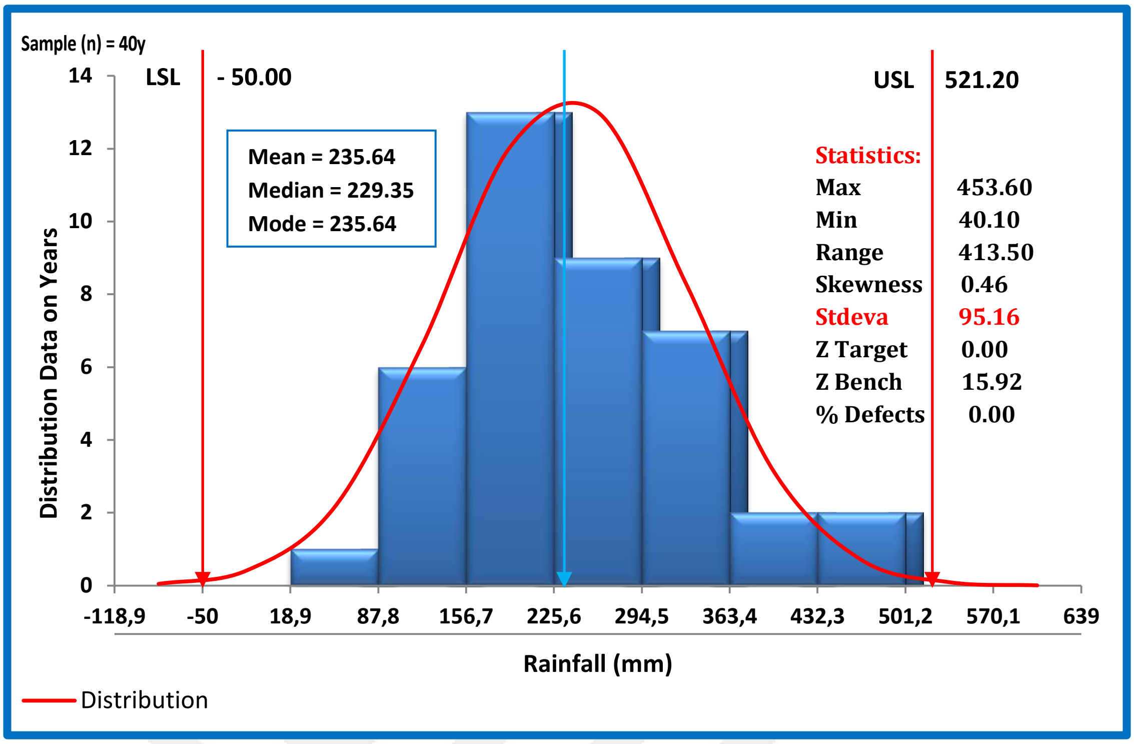


Figure 107. Descriptive Statistics on Rainfall Data By Years in ZWARA Station for Period (1971-2010)

Table 64 and figure 108 show fluctuation in rainfall at ZWARA station in some periods. It is observed that some of the year show the amount of rainfall above the annual average while amount of rainfall is found below of annual average in some years. The distribution of precipitation data over the monitoring years is found semi-normal, the highest amount of rain is found in the year 1984 with rate of (453.6 mm/y) and the lowest in 1981 with rate of (40.1 mm/y).

It is observed that the amount of rain between (156.7 to 225.6 mm/y) is the most continuous and distributed over 13 years. It is followed by (225.6 to 294.5 mm/y) distributed over 9 years, (294.5 to 363.4 mm/y) distributed over 7 years, (87.8 to 156.7 mm/y) over 6 years, (363.4 to 432.3 mm/y) and (432.3 to 501.2 mm/y) over two years in two periods and (18.9 to 87.8 mm/y) distributed over one year. No extreme value is found in ZWARA station. The distribution curve is reached an annual average of precipitation rate of (235.64 mm/y) and found stabilized. The curve is to the highest level at the right of the figure at (521.2 mm/y) and at left to lowest at (-50 mm\y). This indicates a fluctuation in precipitation in many years.

3.3. Statistical Investigation of Temperatures and Precipitation Data

3.3.1. Investigation of Data Distribution

The Kolmogorov-Smirnov test has been used to evaluate the suitability of climatic data for normal distribution. This test is used to calculate the normal or unnormal distribution of average maximum and average minimum temperatures and the number of data for precipitation variables greater than 40 years.

Table 65. Normal Distribution of Annual Temperature and Precipitation Variables (1971-2010)

Variables	Kolmogorov-Smirnov		
	n	Statistics	p >(alpha = 0.05)
Maximum Temperature °C	617	0.085	0,000
Minimum Temperature °C	617	0.032	0.200*
Average Temperature °C	617	0.101	0.000
Precipitation (mm)	617	0.112	0.000

H_0: p= >(alpha = 0.05).

The test results for the normal distribution of the annual data of the variables are given in table 65 The following hypotheses were established to test whether the data sets of average temperature, average maximum temperature andPrecipitationvalues are not normally distributed. Only the minimum temperatures are normal distribution.

H_0: 95% confidence level shows a normal distribution.

H_a: 95% confidence level does not show normal distribution.

The results obtained from the Kolmogorov-Smirnov test have determined that the average temperature, average maximum temperature and annual data of precipitation variables are not normally distributed. (p) values of the variables are less than 0.05 depending on the H_a hypothesis for all variables, H_a hypothesis is accepted.

The hypothesis H_0 is accepted only at minimum temperatures because the result of (p) was (0.200*).It is greater than 0.05.

Table 66. Normal Distribution (Kolmogorov-Smirnov)for Seasonally Temperature and Precipitation Variables in Meteorological Stations (1971-2010)

Variables	n	Spring		Summer		Autumn		Winter	
		Statistic	p	Statistic	p	Statistic	p	Statistic	p
Maximum Temperature	617	0.083	0.000	0.112	0.00	0.040	0.019	0.104	0.000
Minimum Temperature	617	0.081	0.000	0.037	0.43	0.041	0.015	0.039	0.023
Average Temperature	617	0.041	0.015	0.051	0.001	0.079	0.000	0.085	0.000
Precipitation	617	0.213	0.359	0.000	0.000	0.187	0.000	0.137	0.000

H_0: p= >(alpha = 0.05).

The table 66 shows the test results for the normal distribution for seasons variables. The last hypotheses were established to test the spring, summer, autumn, and winter seasons. The results obtained from the Kolmogorov-Smirnov test revealed that the maximum temperature, minimum temperature, average temperature, and precipitation variables are not normally distributed because (p) values of the variables are less than 0.05. Therefore, H_0 hypothesis is rejected for all variables and Ha hypothesis is accepted.

3.3.2.Homogeneity of Variances

The homogeneity of the variance of the variables was analyzed by nonparametric tests of Kruskal-Wallis and Mann-Whitney due to the lack of normal distribution of data.

3.3.2.1.Kruskal-Wallis

Table 67. Kruskal-Wallis Test Results for Seasonallyof Temperatures and Precipitation Variables (1971-2010)

Variables	Spring					Summer				
	n	Average Rank	Test Statistics			n	Average Rank	Test Statistics		
			Chi-Square	df	p			Chi-Square	df	p
Maximum T	617	44.51	0.505	1	0.00	617	268.75	2.139	1	0.00
Minimum T	617	43.55	0.000	1	0.00	617	267.10	0.149	1	0.00
Average T	617	44.47	0.429	1	0.00	617	268.47	1.635	1	0.00
Precipitation	617	32.90	0.625	1	0.01	617	18.07	1.055	1	0.02
Variables	**Autumn**					**Winter**				
	n	Average Rank	Test Statistics			n	Average Rank	Test Statistics		
			Chi-Square	df	p			Chi-Square	df	p
Maximum T	617	53.86	0.534	1	0.00	617	20.93	0.647	1	0.00
Minimum T	617	56.59	1.498	1	0.00	617	21.41	0.194	1	0.00
Average T	617	54.71	0.049	1	0.00	617	21.17	0.388	1	0.00
Precipitation	617	56.90	0.460	1	0.01	617	79.78	0.900	1	0.00

H_0 :p= >(alpha = 0.05).
The independent factor is Precipitation data.

Table 68. Kruskal-Wallis Test Results for Annual of Temperatures and Precipitation Variables (1971-2010)

Variables	n	Average Rank	Test Statistics		
			Chi-Square	df	p
Maximum Temperature	617	7.21	0.661	1	0.00
Minimum Temperature	617	6.43	0.007	1	0.00
Average Temperature	617	6.57	0.007	1	0.00
Precipitation	617	111.80	0.950	1	0.00

H_0 :p= >(alpha = 0.05).

The results of the test for the homogeneity of variance (Kruskal-Wallis) are given in tables 67 and 68 the following hypotheses were established to determine the homogeneity of the variances in the data sets of the annual average temperature, average maximum temperature, average minimum temperature, and precipitation variables:

H_0: 95% confidence level is homogeneous.

Ha: 95% confidence level is not homogeneous.

According to the results obtained from the Kruskal-Wallis test, the mean temperature, average maximum temperature, average minimum temperature and p-value of precipitation variables are found to be less than 0.05 (p = 0.000). Therefore, H_0 hypothesis is rejected and H_a hypothesis is accepted.

According to hypothesis H_a variances at 95% confidence level do not show homogeneous characteristics. It is observed from evaluation of seasonal results obtained from the Kruskal-Wallis test that the p values of the average temperature and precipitation variables of all seasons are less than 0.05 (p = 0.000). Therefore, H_0 hypothesis is rejected and H_a hypothesis is accepted for spring, summer, autumn and winter seasons, and also in annual averages. According to the hypothesis H_a, variances at 95% confidence level is based on seasonal data of variables that are not homogeneous. Mann-Whitney U test is used to determine whether there is any difference between the temperature and precipitation values. The existence of two independent groups necessitated the use of this test to determine the difference between the groups.

3.3.2.2.Mann-Whitney U

Table 69. Results Mann-Whitney Test for Seasonally of Temperatures and Precipitation Variables (1971-2010)

Variables	Spring					Summer				
	n	Average Rank	Test Statistics			n	Average Rank	Test Statistics		
			Mann-Whitney	Z	p			Mann-Whitney	Z	p
Maximum T / Precipitation	617	25.76	120.5	-0.344	0.00	617	211.57	659.5	-1.425	0.00
Minimum T / Precipitation	617	25.18	118.0	-0.418	0.00	617	212.49	1042.5	-0.018	0.00
Average T / Precipitation	617	25.67	124.5	-0.224	0.00	617	211.56	655.0	-1.441	0.00
Variables	**Autumn**					**Winter**				
	n	Average Rank	Test Statistics			n	Average Rank	Test Statistics		
			Mann-Whitney	Z	p			Mann-Whitney	Z	p
Maximum T / Precipitation	617	38.86	235.5	-0.168	0.00	617	7.55	19.5	-0.071	0.00
Minimum T / Precipitation	617	38.99	244.5	-0.009	0.00	617	7.90	16.0	-0.576	0.00
Average T / Precipitation	617	38.62	218.5	-0.470	0.00	617	7.90	16.5	-0.568	0.00

H_0 :p= >(alpha = 0.05).

Table 70. Results of Mann-Whitney Test for Annual of Temperatures and Precipitation Variables (1971-2010)

Variables	n	Average Rank	Test Statistics		
			Mann-Whitney	Z	p
Maximum Temperature Precipitation	617	2.50	0.00	-1.225	0.00
Minimum Temperature Precipitation	617	2.50	0.00	-1.225	0.00
Average Temperature Precipitation	617	2.50	0.00	-1.225	0.00

H_0 :p= >(alpha = 0.05).

The independent factor is Precipitation data.

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Tables 69, 70 show the results of the Mann-Whitney U test for temperatures and precipitation groups. The following hypotheses were established to determine the difference between groups:

H_0: There is no difference between groups.

H_a: There is a difference between the groups.

According to the results obtained from the test, there is no statistically significant difference between the groups. H_a hypothesis is accepted.

3.3.3. Correlation Analysis (Spearman's Rho, and Kendall's tau)

It is a quick and simple test to investigate the presence of a linear trend and is based on sequence statistics. This test is used to determine whether there is a significant correlation between the two-observation series. Sequence statistics R (x_i) is used from small to large or small to small. Although the data belonging to the variables were independent, non-parametric tests were preferred for the correlation analysis of meteorological stations since the data did not show normal distribution and the variances were not homogeneous. In this study Spearman's Rho and Kendall's tau tests for correlation analysis have been used.

The main variable was the general mean of precipitation in all stations of the study area. This variable was compared with the averages of maximum temperatures, minimum temperatures, and the general average annual temperatures.

The following hypotheses were formed within the scope of the analysis:

H_0: There is a relationship between rainfall and temperatures variables.

H_a: There is no relation between rainfall and temperature variables.

The results were as in following tables 71, 72 and 73.

Table 71. Results of Spearman's Rho &Kendall's tau Test for Relationship between Rainfall and Maximum Temperatures in Meteorological Stations (1971-2010)

Stations		Spearman's Rho					Kendall's tau				
		Spr.	Sum.	Aut.	Win	Annual	Spr.	Sum.	Aut.	Win	Annual
AGDABIA	r_s	-.045	-.101	-.328*	-.238	-.240	-.023	-.067	-.221*	-.171	-.167
	p	.784	.534	.039	.139	.135	.834	.551	.047	.128	.130
ALFATAIAH	r_s	-.049	-.016	-.094	-.404*	-.187	-.028	-.007	-.063	-.281*	-.141
	p	.796	.932	.623	.027	.322	.830	.957	.629	.032	.276
BENGHAZI	r_s	.076	.136	-.420**	-.084	-.129	.057	.105	-.312**	-.064	-.095
	p	.639	.403	.007	.605	.428	.607	.345	.005	.567	.388
DERNA	r_s	.100	.012	-.418**	-.151	-.221	.071	-.001	-.304**	-.105	-.154
	p	.541	.942	.007	.353	.171	.528	.991	.007	.350	.162
GHADAMES	r_s	-.053	-.151	.037	-.121	.016	-.021	-.099	.005	-.063	.023
	p	.747	.352	.822	.456	.922	.852	.375	.963	.568	.834
GHARIAT	r_s	-.038	-.139	-.172	-.390*	-.333*	-.025	-.099	-.110	-.275*	-.216
	p	.814	.391	.287	.013	.036	.824	.375	.327	.014	.050
HON	r_s	-.338*	-.384*	.196	-.089	-.303	-.231*	-.255*	.134	-.044	-.204
	p	.033	.014	.224	.585	.057	.037	.022	.229	.691	.067
JAGHBOUB	r_s	-.168	-.115	.011	-.432**	-.223	-.115	-.061	.009	-.307**	-.150
	p	.299	.480	.945	.005	.167	.304	.583	.935	.006	.173
JALO	r_s	.181	-.156	-.154	-.347*	-.182	.136	-.109	-.102	-.244*	-.120
	p	.263	.335	.342	.028	.261	.220	.332	.362	.030	.278
MISURATA	r_s	-.159	.023	-.254	-.211	-.182	-.118	.026	-.196	-.157	-.134
	p	.326	.888	.114	.190	.261	.288	.816	.078	.161	.225
NALUT	r_s	-.583**	-.274	-.189	-.192	-.444**	-.422**	-.203	-.142	-.140	-.309**
	p	.000	.087	.242	.235	.004	.000	.069	.203	.208	.005
SHAHAT	r_s	.139	-.246	-.348*	-.006	-.130	.090	-.169	-.250*	.001	-.089
	p	.392	.126	.028	.971	.423	.421	.132	.025	.991	.421
SIRTE	r_s	-.073	-.127	-.349*	-.237	-.320*	-.056	-.091	-.252*	-.171	-.199
	p	.655	.435	.027	.140	.044	.616	.414	.024	.126	.071
TOBRUK	r_s	.002	-.081	-.361	-.418*	-.303	-.020	-.065	-.279*	-.296*	-.200
	p	.992	.688	.065	.030	.124	.884	.645	.048	.033	.144
TRIPOLI	r_s	-.254	-.174	-.598**	-.239	-.515**	-.179	-.099	-.435**	-.183	-.358**
	p	.113	.282	.000	.137	.001	.107	.375	.000	.100	.001
ZWARA	r_s	-.233	-.105	-.367*	-.013	-.252	-.153	-.062	-.249*	.003	-.155
	p	.148	.518	.020	.937	.117	.168	.575	.025	.981	.159

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).
The independent factor is rPrecipitation data.

Table 71 shows the correlation test results for seasons maximum temperatures and precipitation variables on the basis of stations. On evaluation of results from correlation test in the spring season, it is found that no stations has a relation with the average temperature and rainfall values except for ALFATAIAH station.

In this case, H_0 hypothesis is rejected and H_a hypothesis is accepted. In the summer season however, maximum temperatures is found to be related with precipitation as temperatures were high and with very little rain. Hence, the hypothesis H_0 is accepted for the (AGDABIA, JAGHBOUB,TOBRUK, and ZWARA) stations and the H_a hypothesis is accepted for remaining stations, though remaining stations show the same rain data. It is found that no stations has a relation with the maximum temperature and rainfall values according to correlation test results in the autumn. In this case, H_0 hypothesis is rejected and H_a hypothesis is accepted. Besides, H_0 hypothesis is also rejected and H_a hypothesis is accepted in winter.

Table 72. Results of Spearman's Rho & Kendall's tau Test for Relationship between Rainfall and Minimum Temperatures in Meteorological Stations (1971-2010)

Stations		Spearman's Rho					Kendall's tau				
		Spr.	Sum.	Aut.	Win	Annual	Spr.	Sum.	Aut.	Win	Annual
AGDABIA	r_s	.996**	.754**	.837**	.914**	.709**	.989**	.581**	.654**	.750**	.515**
	p	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000
ALFATAIAH	r_s	.184	-.101	-.031	-.129	.052	.128	-.054	-.009	-.103	.018
	p	.331	.596	.869	.498	.784	.326	.680	.943	.431	.886
BENGHAZI	r_s	.097	.245	-.069	.078	.100	.068	.189	-.037	.073	.082
	p	.553	.128	.673	.632	.538	.544	.092	.744	.513	.456
DERNA	r_s	-.048	.014	-.157	-.030	.000	-.029	.016	-.108	-.014	.001
	p	.770	.930	.334	.852	1.000	.797	.888	.333	.898	.991
GHADAMES	r_s	.114	.059	.277	.159	.226	.095	.026	.218*	.120	.178
	p	.484	.718	.083	.328	.161	.394	.815	.050	.283	.108
GHARIAT	r_s	.102	.153	.199	.208	.211	.056	.097	.144	.163	.147
	p	.530	.346	.218	.197	.191	.616	.382	.195	.144	.184
HON	r_s	-.097	-.090	.234	-.129	.009	-.060	-.064	.151	-.110	.008
	p	.553	.579	.147	.426	.954	.591	.568	.172	.321	.944
JAGHBOUB	r_s	.072	-.046	-.035	.073	.070	.054	-.030	-.010	.047	.067
	p	.659	.779	.830	.653	.669	.632	.788	.926	.674	.544
JALO	r_s	.307	-.072	.016	-.059	.049	.216	-.057	.018	-.041	-.001
	p	.054	.657	.923	.717	.764	.054	.608	.870	.717	.991
MISURATA	r_s	-.063	-.169	-.209	-.112	-.069	-.027	-.120	-.152	-.069	-.045
	p	.699	.296	.195	.492	.672	.806	.283	.175	.529	.683
NALUT	r_s	-.275	-.313*	-.139	-.138	-.288	-.203	-.206	-.102	-.101	-.209
	p	.086	.049	.391	.395	.072	.069	.064	.362	.363	.057
SHAHAT	r_s	.029	.005	-.207	-.026	-.071	-.012	-.003	-.123	-.025	-.036
	p	.859	.973	.200	.873	.664	.916	.981	.268	.824	.744
SIRTE	r_s	-.214	-.016	-.183	-.326*	-.275	-.154	-.014	-.127	-.240*	-.193
	p	.184	.923	.257	.040	.085	.171	.898	.253	.032	.080
TOBRUK	r_s	-.232	-.365	-.418*	-.134	-.318	-.165	-.268	-.307*	-.110	-.223
	p	.245	.061	.030	.505	.106	.234	.054	.027	.427	.104
TRIPOLI	r_s	-.177	-.227	-.444**	-.257	-.371*	-.141	-.169	-.285*	-.186	-.282*
	p	.274	.159	.004	.109	.019	.207	.129	.011	.095	.010
ZWARA	r_s	-.311	-.225	-.377*	-.213	-.330*	-.220*	-.163	-.260*	-.169	-.232*
	p	.051	.162	.016	.187	.038	.050	.142	.019	.129	.035

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).
The independent factor is Precipitation data.

Table 72 shows the correlation test results for seasons minimum temperatures and rainfall variables. No relation between these two variables is found in any station in spring season except for JALO and SIRTE stations. The correlation value in JALO is (r_s = 0.046) (95%) which shows in termed ate relationship and in SIRTE station the value is (r_s = 0.028)which shows a weak relationship.

However, many stations show a relationship between these variables in the summer season. AGDABIA, ALFATAIAH, GHADAMES, HON, JAGHBOUB, MISURATA, SIRTE, and TRIPOLI stations show a strong relationship. Therefore, hypothesis H_0 is accepted and hypothesis H_a is rejected for these stations, while the rest of the stations accepted the hypothesis H_a and rejected the hypothesis H_0.

In autumn season, the relation between two variables of minimum temperature and rainfall is found only for three stations of GHADAMES, GHARIAT, and JAGHBOUB. For these stations the H_0 hypothesis is accepted while all the remaining stations do not accept the H_0.

Winter is found as a severe season for stations of the study area in terms of the relationship between the minimum temperature and the amount of rainfall. This is because winter is different in the rates of rain from year to year and desert stations have generally low temperatures. Correlation values of weak and medium were observed in stations of ALFATAIAH, BENGHAZI, DERNA, HON, JAGHBOUB, JALO, and TOBRUK. Therefore, hypothesis H_0 is accepted and the hypothesis H_a was rejected for these stations, while the rest of the stations accepted the hypothesis H_a and rejected the hypothesis H_0.

The correlation is found weak and positive at significance level of 95% in JAGHBOUB station. The decrease in the rain values and low temperature in winter are the basis of the positive directional relationship in these stations. As a result H_0 hypothesis is accepted for above stations while $H_a$hypothesis was accepted for all other stations.

Table 73. Results of Spearman's Rho & Kendall's tau Test for Relationship between Rainfall and Average Temperatures in Meteorological Stations (1971-2010)

Stations		Spearman					Kendall's tau				
		Spr.	Sum.	Aut.	Win	Annual	Spr.	Sum.	Aut.	Win	Annual
AGDABIA	r_s	.023	.008	-.235	-.022	-.071	.007	.000	-.152	-.022	-.055
	p	.888	.962	.144	.893	.663	.953	1.000	.172	.843	.616
ALFATAIAH	r_s	.067	-.087	-.102	-.326	-.081	.030	-.038	-.049	-.217	-.069
	p	.726	.649	.592	.079	.672	.816	.775	.707	.099	.592
BENGHAZI	r_s	.008	.169	-.297	-.055	-.022	.000	.143	-.205	-.039	-.021
	p	.962	.298	.063	.734	.892	.989	.203	.068	.726	.852
DERNA	r_s	-.008	-.008	.009	-.292	-.080	-.009	-.009	-.004	-.210	-.061
	p	.961	.961	.954	.068	.623	.935	.935	.972	.059	.590
GHADAMES	r_s	.066	-.068	.183	.037	.146	.059	-.055	.142	.017	.121
	p	.685	.678	.258	.822	.370	.599	.623	.200	.879	.273
GHARIAT	r_s	.016	.105	.067	-.093	-.021	.014	.063	.052	-.057	-.009
	p	.924	.520	.681	.566	.897	.898	.575	.641	.608	.935
HON	r_s	-.241	-.107	.214	-.292	-.101	-.171	-.078	.139	-.185	-.069
	p	.134	.510	.185	.067	.533	.126	.484	.211	.097	.529
JAGHBOUB	r_s	-.047	-.073	-.009	-.257	-.049	-.025	-.043	.012	-.185	-.021
	p	.774	.653	.955	.109	.765	.824	.700	.916	.099	.852
JALO	r_s	.176	-.099	-.111	-.222	-.097	.124	-.071	-.065	-.135	-.075
	p	.277	.545	.494	.169	.552	.267	.528	.566	.229	.499
MISURATA	r_s	-.131	-.053	-.198	-.260	-.167	-.082	-.034	-.142	-.196	-.107
	p	.420	.747	.220	.106	.303	.462	.761	.199	.080	.333
NALUT	r_s	-.430**	-.325*	-.175	-.147	-.378*	-.304**	-.233*	-.125	-.099	-.268*
	p	.006	.040	.280	.366	.016	.006	.037	.263	.375	.015
SHAHAT	r_s	.081	-.107	-.313*	.034	-.092	.039	-.071	-.218	.030	-.042
	p	.618	.510	.049	.836	.572	.726	.521	.051	.788	.701
SIRTE	r_s	-.132	-.047	-.294	-.357*	-.285	-.099	-.026	-.216	-.256*	-.183
	p	.416	.773	.066	.024	.075	.375	.815	.051	.022	.098
TOBRUK	r_s	-.147	-.277	-.472*	-.298	-.339	-.091	-.205	-.348*	-.218	-.223
	p	.465	.162	.013	.131	.084	.515	.138	.013	.120	.104
TRIPOLI	r_s	-.304	-.221	-.638**	-.258	-.522**	-.225*	-.149	-.437**	-.195	-.352**
	p	.057	.170	.000	.108	.001	.043	.180	.000	.080	.001
ZWARA	r_s	-.297	-.213	-.379*	-.165	-.324*	-.192	-.131	-.256*	-.135	-.230*
	p	.062	.186	.016	.309	.041	.084	.239	.021	.225	.037

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).
The independent factor is Precipitation data.

Table 73 shows the correlation test results for seasons general average temperatures and rainfall variables, the following facts can be found in the table:

ALFATAIAH and NALUT stations show relationship between the average temperature and rainfall values in spring while the rest of the stations do not show any relation between two variables the relationship is found strong in NALUT Station (r_s=0.485), in spring season.

There fore, H_0 hypothesis is accepted for ALFATAIAH and NALUT Stations, and H_a hypothesis was accepted for all other stations. For AGDABIA, GHADAMES, HON, JAGHBOUB, MISURATA, and SIRTE stations, a positive relationship was identified in summer season. In ALFATAIAH, TOBRUK, ZWARA stations also show good relationship. The correlation value is (r_s= 0.13) in TOBRUK, ZWARA stations and(r_s = 0.027) in ALFATAIAH station. Therefore, H_0 hypothesis is accepted for above Stations, and H_a hypothesis is accepted for the remaining stations.

In autumn there is no station that has a relationship between the variable of the general rate of heat and the variable of rain except the GHDAMES. Therefore, H_0 hypothesis is accepted for GHADAMES station and H_a hypothesis is accepted for all other stations. In the winter, it can be said that there is no relationship between the general rates of temperature and rainfall for all stations in the study area. The reform H_a hypothesis is accepted for all Stations.

IV. CHAPTER

TREND ANALYSIS FOR TEMPERATURESAND PRECIPITATION DATA

Trend analysis is a technique used to determine the relationship between two or more variables with a causal relationship by using a mathematical model called regression model in order to make predictions (Şahinler, 2000).

The Linear Regression test is a parametric test used to test whether a linear trend exists in the relationship between X and Y variables assuming that the data is normally distributed., The annual, seasonal and monthly linear trends of maximum, minimum and average temperatures have been analyzed in present study by creating the separate regression models. Thus, it can be easily observed that the values of temperature data have increased or decreased over long periods of time.

The trend analysis of meteorological time series data explains not only the direction of trends in positive or negative direction but also tells how the values fluctuate within different time scales of months, seasons, and years. In general, the use of average of time series data provides better representation of large-scale climatic processes of a region and it is easier to deal with one series of index (Kahya, 1993).

This chapter examines the trend analysis of maximum, minimum, and average of temperature and precipitation data. Several methods have been used to analyze the trend, of which the most important are the Mann-Kendall, Spearman Rho and Sen's slope tests.

4.1. Trend Analysis for Temperatures Data

4.1.1. Trend Analysis of Mann-Kendall, Spearman, and Sen's slope

Table 74. Results of Tests Analysis for Mann-Kendall, Spearman and Sen's slope for Temperatures (°C) Data in AGDABIA Station (1971-2010)

Variables	Mann-Kendall			Spearman's Rho			Sen's slope		
	Max.	Min.	Aver.	Max.	Min.	Aver.	Max.	Min.	Aver.
January	1.12	3.52	2.32	1.25	3.53	2.43	0.02	0.05	0.03
February	0.00	1.59	0.90	-0.08	1.56	0.94	0.00	0.02	0.02
March	1.31	2.05	1.23	1.42	2.30	1.37	0.02	0.03	0.02
April	0.40	1.56	0.95	0.49	1.77	1.08	0.01	0.02	0.01
May	-0.01	2.77	1.55	0.11	2.81	1.68	0.00	0.06	0.04
June	-0.76	3.28	1.59	-0.87	3.20	1.69	-0.01	0.06	0.03
July	1.71	2.34	1.97	1.74	2.36	2.11	0.03	0.10	0.07
August	2.94	1.79	2.01	2.92	2.33	2.82	0.04	0.11	0.08
September	3.16	2.83	2.85	3.19	3.48	3.00	0.06	0.11	0.08
October	1.48	2.49	1.67	1.51	3.85	1.80	0.04	0.08	0.06
November	2.96	4.29	3.68	2.86	4.07	3.61	0.07	0.08	0.07
December	1.73	2.21	2.53	1.99	2.95	2.72	0.03	0.02	0.04
Spring	0.74	2.82	2.24	0.79	3.03	2.43	0.01	0.04	0.02
Summer	1.52	2.23	2.85	1.64	2.29	2.96	0.02	0.10	0.06
Autumn	2.18	2.33	2.35	2.81	2.39	2.50	0.05	0.08	0.06
Winter	1.03	2.58	1.96	1.66	3.08	1.99	0.02	0.04	0.03
Annual	2.56	1.60	1.74	2.77	1.83	2.14	0.02	0.07	0.05

Red numbers 95% (a = 0.05) indicates the level of significance in the confidence interval.

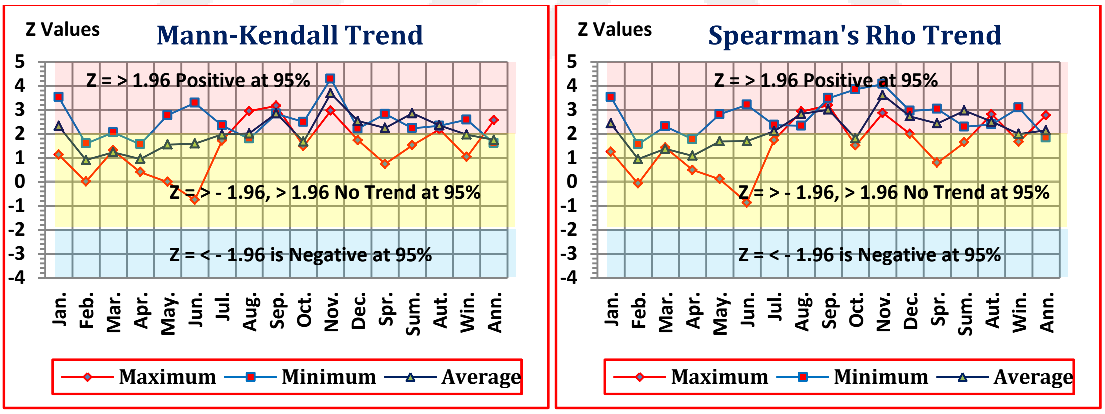


Figure 108. Results Tests of M-K, and Spearman's Rho for Temperatures Data at AGDABIA Station (1971-2010)

- **AGDABIA** station, the temperature data of the AGDABIA station show a tendency of increase in August and September. The strongest trend of increase is observed in the months of August and November maximum, minimum and average temperatures. However, in terms of maximum temperature the month of September has strong trend. Seasonally, spring, summer and autumn trend have shown an increased trend. The presence of trend has manifested itself on a seasonal basis during the summer and autumn seasons and is found increased. The increase trend in autumn is stronger than in the summer (Table 74 and Figure 109).

Table 75. Results of Tests Analysis for Mann-Kendall, Spearman and Sen's slope for Temperatures (°C) Data in ALFATAIAH Station (1981-2010)

Variables	Mann-Kendall			Spearman's Rho			Sen's slope		
	Max.	Min.	Aver.	Max.	Min.	Aver.	Max.	Min.	Aver.
January	1.57	0.47	1.66	1.31	0.39	1.71	0.05	0.01	0.04
February	0.66	-0.79	0.48	0.78	-0.75	0.55	0.01	-0.01	0.01
March	1.91	-0.23	2.25	1.93	-0.34	2.33	0.09	-0.01	0.07
April	0.59	0.90	0.79	0.78	0.91	1.02	0.02	0.02	0.02
May	1.18	0.48	1.49	1.35	0.62	1.58	0.04	0.01	0.04
June	1.25	1.54	1.00	1.21	1.74	0.88	0.03	0.03	0.02
July	1.05	1.26	1.28	2.55	1.63	1.48	0.06	0.04	0.05
August	0.51	1.84	2.29	1.77	2.13	2.54	0.05	0.04	0.08
September	2.73	1.90	3.24	2.69	2.07	3.37	0.06	0.04	0.06
October	0.52	2.50	0.57	0.63	2.45	0.47	0.02	0.07	0.03
November	1.90	0.98	1.68	2.12	0.88	1.86	0.06	0.03	0.04
December	1.00	0.84	1.11	0.93	0.94	1.09	0.03	0.02	0.02
Spring	1.09	0.61	1.18	1.29	0.54	1.34	0.04	0.02	0.02
Summer	2.02	1.78	1.82	2.15	2.02	2.10	0.04	0.04	0.04
Autumn	0.88	2.27	2.90	2.36	2.23	2.87	0.05	0.07	0.04
Winter	0.56	0.41	1.20	1.71	0.33	1.45	0.03	0.01	0.02
Annual	1.22	1.77	1.86	1.85	2.10	2.06	0.04	0.02	0.04

Red numbers 95% (a = 0.05) indicates the level of significance in the confidence interval.

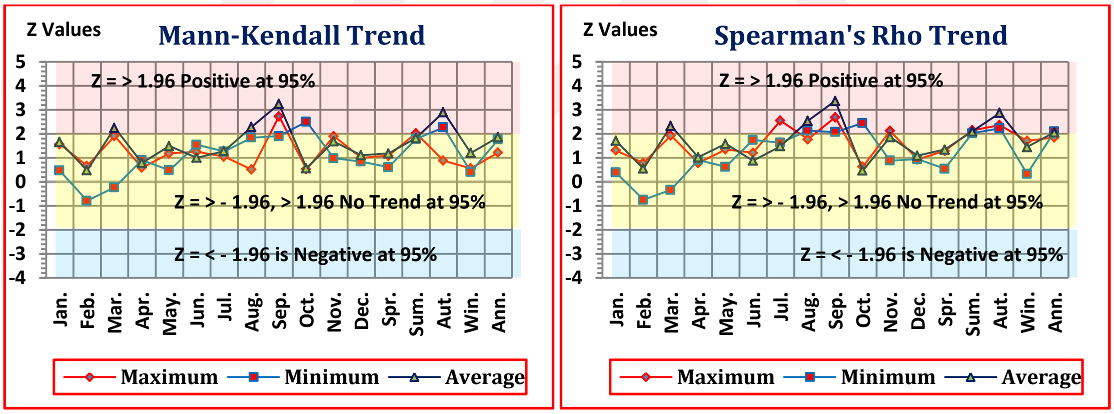


Figure 109. Results Tests of M-K, and Spearman's Rho for Temperatures Data at ALFATAIAH Station (1981-2010)

- **ALFATAIAH**station,there is an increased trend found in the month of September in terms of average and maximum temperatures. All other remaining months have not shown any trend in maximum temperatures. The months of March and August has shown a trend of increase in terms of average temperatures. The seasonal evaluation has shown that the increased trend in average and minimum temperatures are limited to summer and autumn seasons while maximum temperatures trends are constantly decreasing. The most pronounced downward trend is observed in the months of February, April, May, and June on a monthly and in winter on seasonal basis (Table 75 and Figure 110).

Table 76. Results of Tests Analysis for Mann-Kendall, Spearman and Sen's slope for Temperatures (°C) Data in BENGHAZI Station (1971-2010)

Variables	Mann-Kendall			Spearman's Rho			Sen's slope		
	Max.	Min.	Aver.	Max.	Min.	Aver.	Max.	Min.	Aver.
January	0.04	1.81	0.83	0.03	1.86	0.88	0.00	0.02	0.01
February	-1.19	0.48	-1.02	-1.35	0.49	-0.98	-0.02	0.01	-0.02
March	0.16	0.13	0.37	0.22	0.06	0.54	0.00	0.00	0.01
April	-1.00	-0.28	-0.68	-1.15	-0.18	-0.65	-0.02	0.00	-0.01
May	-0.72	0.85	-0.29	-0.94	0.94	-0.34	-0.02	0.01	-0.01
June	-2.17	-0.38	-1.38	-2.11	-0.37	-1.99	-0.05	-0.01	-0.03
July	0.33	0.82	1.27	0.25	2.46	1.33	0.01	0.04	0.02
August	0.35	2.23	1.82	0.55	2.45	2.09	0.00	0.04	0.03
September	0.84	2.01	2.12	0.90	2.02	2.18	0.01	0.04	0.03
October	0.13	0.65	0.70	0.14	1.08	0.83	0.00	0.03	0.02
November	2.06	1.67	2.80	2.02	1.98	2.71	0.04	0.05	0.05
December	1.03	3.05	2.25	0.96	2.99	2.22	0.01	0.04	0.03
Spring	-1.52	0.02	-0.42	-1.50	0.06	-0.31	-0.02	0.00	0.00
Summer	-0.57	2.31	0.90	-0.78	2.27	0.93	-0.01	0.02	0.01
Autumn	0.92	1.09	1.67	1.04	1.49	2.02	0.01	0.04	0.03
Winter	-0.34	1.96	1.38	-0.56	1.99	1.13	0.00	0.02	0.01
Annual	-0.36	1.21	1.72	-0.58	1.87	1.75	-0.01	0.02	0.01

Red numbers 95% (a = 0.05) indicates the level of significance in the confidence interval.

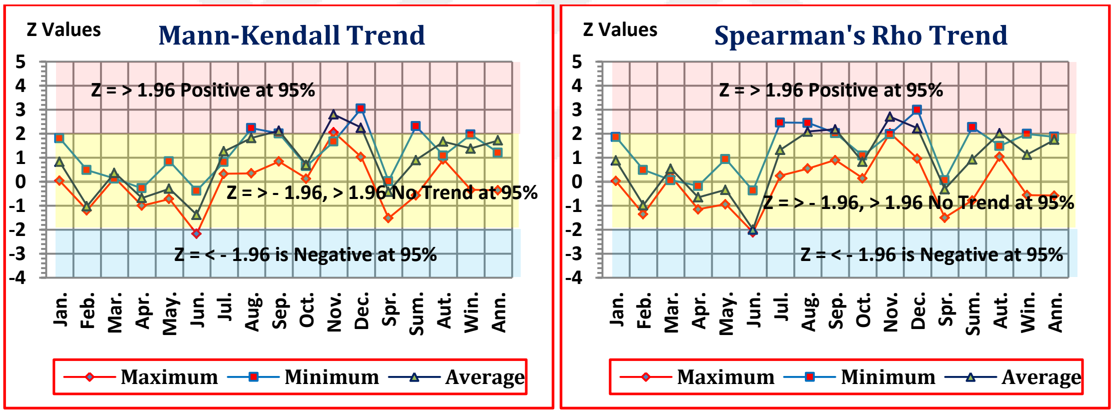


Figure 110. Results Tests of M-K, and Spearman's Rho for Temperatures Data at BENGHAZI Station (1971-2010)

- BENGHAZI station, most of the months in this station have not shown a good trend, with the exception of some months showing positive trends with minimum temperatures and averages such as August, September, October, November, and December. The most positive trend is found in November and December in terms of minimum and maximum temperatures. Seasonally, the summer and winter have shown a positive trend present in minimum temperature. However, this trend of increase is not valid at average maximum temperatures while the autumn has shown a positive trend in average temperature in Spearman's result (Table 76 and Figure 111).

Table 77. Results of Tests Analysis for Mann-Kendall, Spearman and Sen's slope for Temperatures (°C)Data in DERNA Station (1971-2010)

Variables	Mann-Kendall			Spearman's Rho			Sen's slope		
	Max.	Min.	Aver.	Max.	Min.	Aver.	Max.	Min.	Aver.
January	-0.07	3.97	1.53	-0.06	3.75	1.54	0.00	0.04	0.02
February	-1.10	2.05	-0.37	-1.07	2.08	-0.46	-0.02	0.03	-0.01
March	-0.22	2.71	-0.01	-0.09	2.77	1.54	0.00	0.02	0.02
April	-0.66	3.19	1.65	-0.96	3.30	1.63	-0.01	0.05	0.03
May	0.70	2.67	1.89	0.67	2.84	1.90	0.01	0.05	0.03
June	-0.08	2.86	2.10	-0.09	3.04	2.12	0.00	0.06	0.03
July	2.25	1.85	1.91	2.29	2.18	2.54	0.03	0.07	0.05
August	2.41	1.90	1.92	2.67	2.22	1.99	0.04	0.07	0.06
September	2.12	2.31	2.54	2.20	2.37	3.01	0.03	0.05	0.04
October	0.53	1.28	1.06	0.75	1.38	1.18	0.02	0.06	0.03
November	1.97	2.10	2.73	1.96	2.29	2.89	0.04	0.06	0.05
December	1.36	3.42	2.58	1.44	3.31	2.53	0.02	0.04	0.03
Spring	-0.41	2.79	2.10	-0.40	3.02	2.29	-0.01	0.03	0.02
Summer	2.31	1.95	2.23	2.41	2.22	2.29	0.02	0.06	0.02
Autumn	1.28	2.08	2.95	2.43	2.26	3.02	0.02	0.06	0.04
Winter	0.10	2.73	1.91	0.09	3.34	2.06	0.00	0.04	0.04
Annual	1.65	2.10	1.03	1.85	2.41	1.26	0.01	0.05	0.01

Red numbers 95% (a = 0.05) indicates the level of significance in the confidence interval.

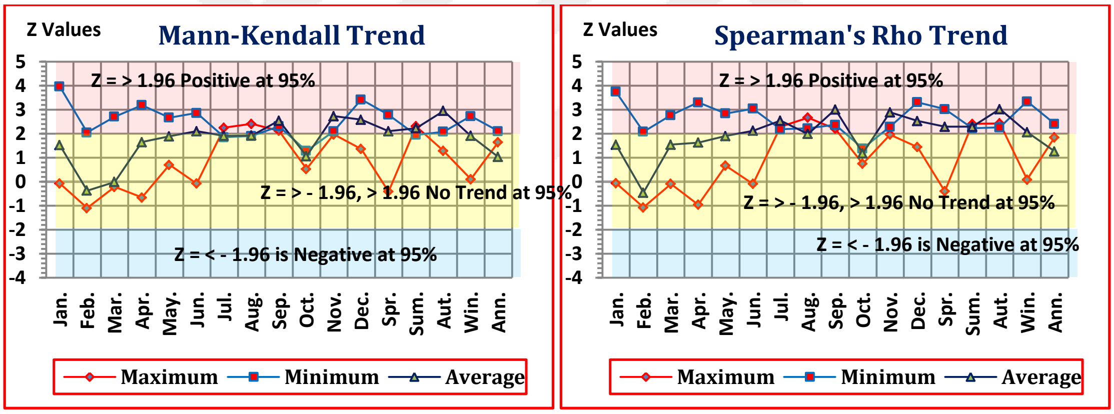


Figure 111. Results Tests of M-K, and Spearman's Rho for Temperatures Data at DERNA Station (1971-2010)

- **DERNA** station, the average, maximum and minimum temperatures at DERNA station are provided for all months and seasons. The months of July, August, and September have shown a positive trend in the maximum temperatures at DERNA station. Besides, a positive trend in average temperature in the months between June and December except October has also been observed Moreover, the month of January has shown a positive trend towards increase in minimum temperatures. Seasonally, the average, maximum and minimum temperatures in spring, summer, and autumn seasons have shown different trends. The strongest increased trend is found in the summer in maximum temperatures. The station has shown annual positive trend in minimum temperatures only (Table 77 and Figure 112).

Table 78. Results of Tests Analysis for Mann-Kendall, Spearman and Sen's slope for Temperatures (°C) Data in GHADAMESStation (1971-2010)

Variables	Mann-Kendall			Spearman's Rho			Sen's slope		
	Max.	Min.	Aver.	Max.	Min.	Aver.	Max.	Min.	Aver.
January	0.20	1.34	1.29	0.36	1.33	1.52	0.01	0.04	0.03
February	0.30	1.11	0.53	0.48	1.33	0.62	0.01	0.02	0.01
March	1.84	3.42	2.60	1.99	3.31	2.63	0.05	0.07	0.07
April	0.82	1.86	1.87	0.79	2.03	1.85	0.02	0.05	0.04
May	1.87	1.67	2.70	1.77	1.98	2.82	0.04	0.07	0.06
June	1.80	0.63	1.50	1.61	0.55	1.43	0.02	0.01	0.24
July	1.63	3.52	1.92	1.63	3.31	1.81	0.03	0.08	0.04
August	2.03	1.55	2.13	2.20	1.70	2.82	0.03	0.10	0.07
September	0.94	1.10	1.65	1.04	1.84	1.99	0.03	0.09	0.08
October	1.28	2.71	1.33	2.48	3.02	1.81	0.07	0.10	0.08
November	1.69	1.62	2.52	1.91	1.97	2.66	0.05	0.08	0.07
December	1.20	2.89	2.08	1.21	2.98	2.23	0.03	0.06	0.05
Spring	1.78	1.88	2.11	1.86	1.89	2.26	0.03	0.07	0.05
Summer	1.35	1.95	2.79	1.50	2.28	2.88	0.07	0.06	0.03
Autumn	0.91	1.03	1.20	1.57	1.41	1.77	0.05	0.08	0.07
Winter	1.57	1.71	1.45	1.39	1.76	1.98	0.03	0.04	0.03
Annual	2.08	0.94	1.74	2.20	1.18	1.99	0.03	0.06	0.04

Red numbers 95% (a = 0.05) indicates the level of significance in the confidence interval.

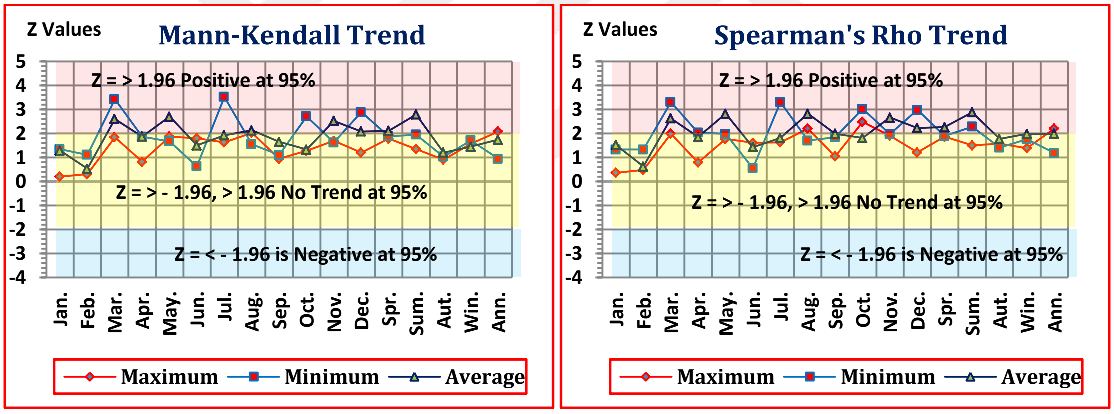


Figure 112. Results Tests of M-K, and Spearman's Rho for Temperatures Data in GHADAMES Station (1971-2010)

- GHADAMES station, the minimum temperatures in this station have shown a positive trend in March, July, October, and December. The trends in maximum temperatures are found increased in August while average temperatures have shown increased trend in May. Seasonally, the trend has increased in the average temperatures in spring and summer as observed by Mann-Kendall and Spearman's tests. The strongest seasonal trend in the summer season is found in average temperature. Annually, the maximum temperature has shown positive trend and average temperature has shown positive trend in Spearman's result (Table 78 and Figure 113).

Table 79. Results of Tests Analysis for Mann-Kendall, Spearman and Sen's slope for Temperatures (°C) Data in GHARIAT Station (1971-2010)

Variables	Mann-Kendall			Spearman's Rho			Sen's slope		
	Max.	Min.	Aver.	Max.	Min.	Aver.	Max.	Min.	Aver.
January	-0.54	1.85	1.32	-0.30	2.13	1.50	-0.01	0.06	0.03
February	-0.13	0.59	0.67	-0.18	1.03	0.67	0.00	0.04	0.02
March	1.25	1.82	1.89	1.40	1.92	1.87	0.03	0.04	0.04
April	0.35	1.76	1.76	0.38	1.94	1.75	0.01	0.03	0.02
May	0.16	1.46	0.84	0.27	1.49	0.94	0.00	0.03	0.02
June	-2.23	1.19	-0.92	-2.31	1.18	-1.05	-0.07	0.03	-0.02
July	0.58	1.48	1.99	0.41	1.56	1.99	0.01	0.07	0.05
August	1.25	1.61	1.26	1.84	1.95	1.85	0.05	0.09	0.06
September	2.43	1.96	1.89	2.27	2.57	2.23	0.05	0.07	0.06
October	0.41	1.77	0.80	0.67	2.22	1.69	0.05	0.08	0.06
November	2.05	2.25	1.09	2.30	2.34	1.74	0.05	0.09	0.06
December	-0.12	2.69	2.04	-0.18	2.60	1.97	-0.01	0.05	0.03
Spring	0.74	1.19	1.97	0.88	2.30	1.98	0.01	0.03	0.02
Summer	-0.14	1.74	2.38	-0.34	2.08	2.45	0.00	0.04	0.03
Autumn	1.17	1.34	1.21	1.23	2.04	1.35	0.05	0.08	0.06
Winter	0.01	1.51	1.22	0.04	1.95	1.66	0.00	0.05	0.03
Annual	1.98	0.63	1.33	2.16	1.44	1.87	0.01	0.06	0.04

Red numbers 95% (a = 0.05) indicates the level of significance in the confidence interval.

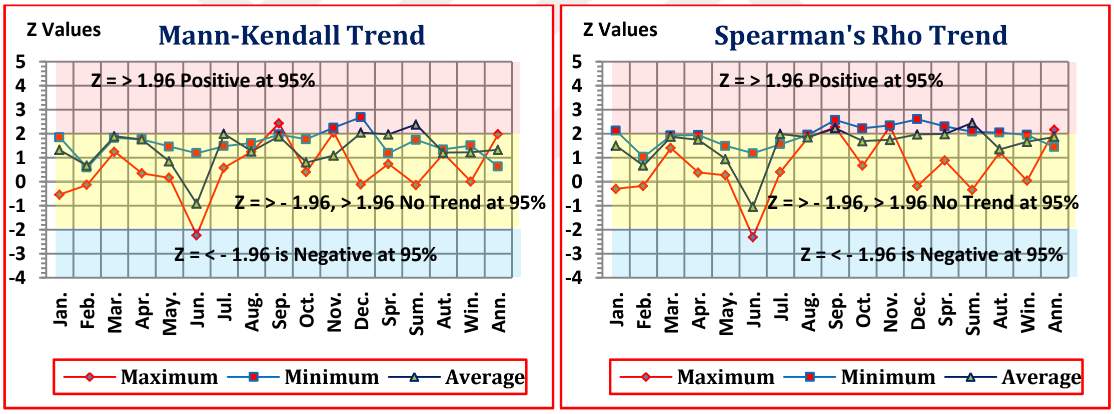


Figure 113. Results Tests of M-K, and Spearman's Rho for Temperatures Data at GHARIAT Station (1971-2010)

- GHARIAT station, in general, the station has not shown any clear trends in the tests for most months. However, the month of November has shown a positive trend in maximum and average temperatures while December has shown a positive trend in the average and minimum temperature. The month of July has shown a trend in the average temperatures only. Seasonally, spring and summer seasons has shown increased tends especially in average temperature, while annually, positive trend is observed only at maximum temperatures (Table 79 and Figure 114).

Table 80. Results of Tests for Mann-Kendall, Spearman and Sen's slope for Temperatures (°C) Data in HON Station (1971-2010)

Variables	Mann-Kendall			Spearman's Rho			Sen's slope		
	Max.	Min.	Aver.	Max.	Min.	Aver.	Max.	Min.	Aver.
January	-0.23	2.98	1.91	-0.12	3.05	1.98	-0.01	0.09	0.04
February	-1.04	1.83	1.01	-1.01	2.09	1.09	-0.02	0.05	0.02
March	1.29	2.79	2.19	1.31	2.84	2.31	0.03	0.06	0.06
April	1.35	2.71	1.54	1.30	2.74	1.73	0.02	0.05	0.03
May	0.28	1.84	1.91	0.58	1.88	2.15	0.01	0.05	0.03
June	-0.83	3.27	0.98	-0.93	3.19	0.96	-0.02	0.06	0.02
July	1.07	1.81	3.06	0.96	2.50	2.90	0.02	0.11	0.07
August	1.70	1.74	2.13	1.65	2.41	2.50	0.03	0.11	0.07
September	2.12	3.29	3.71	2.26	3.39	3.47	0.05	0.12	0.08
October	1.28	2.50	2.51	1.37	2.84	2.63	0.04	0.10	0.06
November	2.11	2.83	3.67	2.40	2.95	3.65	0.05	0.11	0.08
December	0.05	3.81	3.09	0.46	3.58	2.98	0.04	0.08	0.06
Spring	1.34	1.96	3.26	1.33	2.23	3.26	0.02	0.05	0.04
Summer	0.02	1.86	2.89	0.16	2.19	2.93	0.02	0.09	0.06
Autumn	3.93	2.59	2.38	3.79	2.69	2.67	0.05	0.10	0.07
Winter	0.27	1.86	2.14	0.30	2.28	2.20	0.00	0.08	0.04
Annual	2.06	1.26	2.25	2.31	1.47	2.46	0.02	0.08	0.05

Red numbers 95% (a = 0.05) indicates the level of significance in the confidence interval.

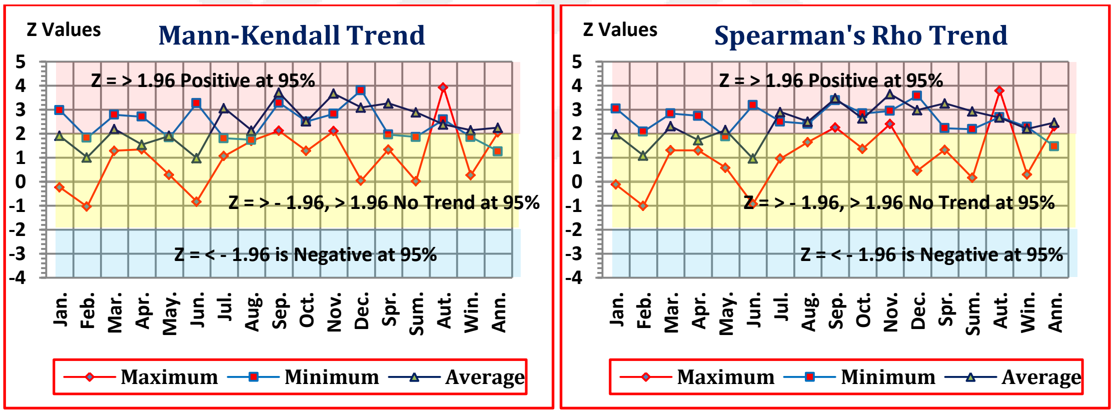


Figure 114. Results Tests of M-K, and Spearman's Rho for Temperatures Data at HON Station (1971-2010)

- HONstation, the above table has shown the presence of positive and strongest trend in the months of September and November in all the results of tests in HON station. However, many months with positive trends differ from one variable to another. For example, the month of March shows a positive trend in the minimum and average temperatures, June shows a positive trend in the minimum temperatures, January and March show a positive trend in the minimum and average temperatures. Seasonally, the autumn season has shown a positive in all tests' results followed by winter and summer in the minimum and average temperatures and spring in minimum and average temperatures. The general annual average shows a trend in all results except for maximum temperatures (Table 80 and Figure 115).

Table 81. Results of Tests Analysis for Mann-Kendall, Spearman and Sen's slope for Temperatures (°C) Data in JAGHBOUB Station (1971-2010)

Variables	Mann-Kendall			Spearman's Rho			Sen's slope		
	Max.	Min.	Aver.	Max.	Min.	Aver.	Max.	Min.	Aver.
January	1.79	2.56	3.29	1.91	2.44	3.11	0.03	0.04	0.04
February	0.41	2.25	1.52	0.78	2.30	1.44	0.02	0.03	0.02
March	1.25	0.98	0.77	1.28	1.23	0.97	0.04	0.02	0.02
April	1.13	1.68	1.32	1.24	1.59	1.36	0.03	0.03	0.02
May	0.30	1.95	1.12	0.54	1.98	1.15	0.01	0.03	0.02
June	1.84	2.82	2.62	1.92	2.78	2.56	0.02	0.05	0.04
July	1.77	2.71	2.08	2.46	3.18	2.45	0.05	0.06	0.05
August	2.89	2.47	2.38	3.09	2.69	2.64	0.06	0.08	0.07
September	1.86	2.61	2.32	2.14	3.01	2.54	0.06	0.08	0.07
October	0.89	2.73	1.42	0.98	2.77	1.38	0.02	0.05	0.03
November	3.27	1.98	3.10	3.25	2.55	3.13	0.06	0.06	0.05
December	3.28	2.48	2.99	3.47	2.66	2.97	0.04	0.03	0.04
Spring	1.60	2.46	1.54	1.60	2.39	1.61	0.02	0.03	0.02
Summer	2.98	2.78	3.00	3.13	3.04	3.25	0.05	0.06	0.05
Autumn	1.67	2.15	2.35	1.97	2.60	2.65	0.04	0.06	0.05
Winter	1.52	2.36	2.73	1.65	2.55	2.84	0.03	0.03	0.04
Annual	2.27	2.50	2.06	2.84	2.61	2.27	0.03	0.03	0.04

Red numbers 95% (a = 0.05) indicates the level of significance in the confidence interval.

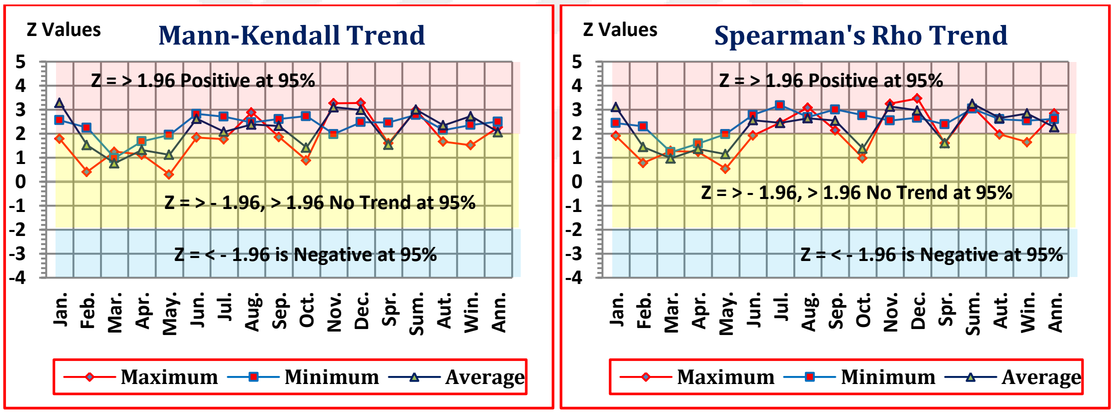


Figure 115. Results Tests of M-K, and Spearman's Rho for Temperatures Data at JAGHBOUB Station (1971-2010)

- JAGHBOUBstation,the temperature data of the JAGHBOUB station have shown an increased trend in June, July, August, and September. The month of August has strongest trend in terms of average, maximum, and minimum temperature. Seasonally, trend of summer is found the strongest increased trend. The presence of trend has manifested itself on a seasonal basis during the summer and autumn seasons and is found increased. The increasing trend in summer is stronger than in the autumn season. Generally, the annual trend is found positive in all variables (Table 81 and Figure 116).

Table 82. Results of Tests Analysis for Mann-Kendall, Spearman and Sen's slope for Temperatures (°C) Data in JALO Station (1971-2010)

Variables	Mann-Kendall			Spearman's Rho			Sen's slope		
	Max.	Min.	Aver.	Max.	Min.	Aver.	Max.	Min.	Aver.
January	0.44	3.03	1.63	0.51	3.02	1.70	0.01	0.04	0.03
February	-0.80	1.75	0.27	-0.92	1.95	0.44	-0.02	0.03	0.00
March	0.51	1.33	1.26	0.66	1.55	1.35	0.01	0.02	0.03
April	0.44	0.83	0.98	0.67	0.94	1.14	0.01	0.01	0.02
May	-0.42	1.32	0.55	-0.45	1.26	0.63	-0.01	0.03	0.01
June	0.43	2.88	1.80	0.57	2.96	1.81	0.01	0.05	0.03
July	2.43	2.35	2.23	2.36	2.71	2.86	0.04	0.08	0.06
August	2.30	2.08	2.67	2.41	2.19	3.07	0.06	0.08	0.07
September	2.40	2.13	2.42	2.74	2.22	2.74	0.08	0.09	0.08
October	0.96	2.20	2.30	0.87	2.51	2.30	0.03	0.07	0.04
November	1.42	2.23	2.24	1.39	2.49	2.29	0.03	0.04	0.04
December	2.37	2.08	3.06	2.42	2.31	3.23	0.04	0.04	0.04
Spring	0.09	1.82	1.54	0.15	2.00	1.61	0.00	0.02	0.02
Summer	3.02	2.71	2.77	3.04	2.91	3.16	0.04	0.07	0.05
Autumn	2.30	2.53	2.24	2.44	2.56	2.43	0.03	0.07	0.05
Winter	0.70	1.90	1.57	0.92	2.44	1.98	0.01	0.03	0.02
Annual	1.84	1.91	2.42	2.27	2.04	2.88	0.02	0.05	0.04

Red numbers 95% (a = 0.05) indicates the level of significance in the confidence interval.

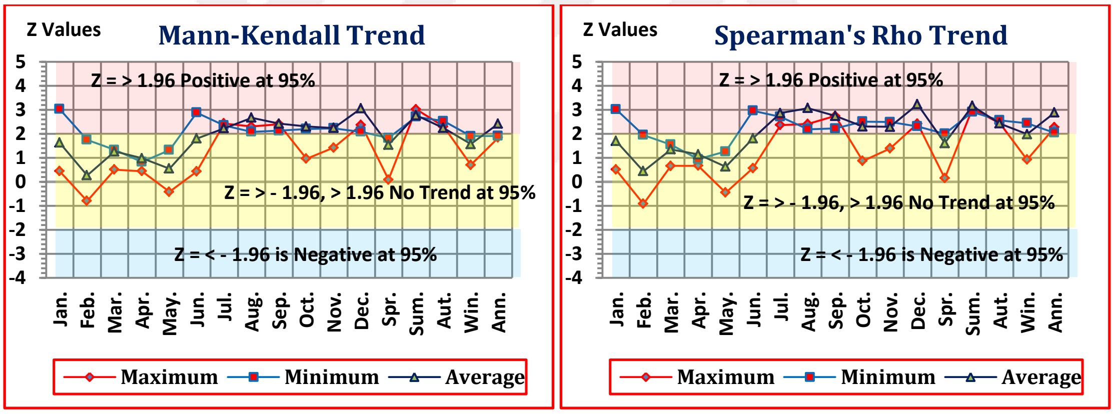


Figure 116. Results Tests of M-K, and Spearman's Rhofor Temperatures Data at JALO Station (1971-2010)

- JALOstation,the temperature data of the JALO station have shown an increased positive trend in July, August, and September in all variables. The month of September has shown strongest trend in terms of average, maximum, and minimum temperatures. Besides, December has also shown a positive trend in all variables. Seasonally, the summer and autumn have shown positive trend towards increase. The increasing trend in summer is stronger than in the autumn season. Generally, the annual trend is found positive in the results of Spearman (Table 82 and Figure 117).

Table 83. Results of Tests Analysis for Mann-Kendall, Spearman and Sen's slope for Temperatures (°C) Data in MISURATA Station (1971-2010)

Variables	Mann-Kendall			Spearman's Rho			Sen's slope		
	Max.	Min.	Aver.	Max.	Min.	Aver.	Max.	Min.	Aver.
January	0.99	2.61	3.08	1.15	2.93	2.92	0.02	0.07	0.05
February	0.60	3.02	1.32	0.62	3.21	1.32	0.01	0.04	0.02
March	2.23	2.47	2.65	2.18	2.90	2.62	0.04	0.06	0.04
April	2.44	2.49	3.10	2.40	2.76	3.03	0.04	0.06	0.05
May	1.18	2.23	2.40	1.18	2.78	2.59	0.03	0.07	0.05
June	1.21	2.32	2.17	1.12	2.88	2.15	0.04	0.07	0.04
July	2.24	2.30	2.30	2.16	2.47	2.46	0.05	0.08	0.07
August	1.69	1.89	2.25	2.02	2.37	2.70	0.04	0.08	0.06
September	1.12	2.66	1.80	1.32	2.91	2.30	0.02	0.08	0.05
October	1.77	1.89	1.65	2.26	2.39	3.02	0.07	0.06	0.08
November	3.14	2.54	2.37	3.20	2.62	2.48	0.06	0.09	0.07
December	1.85	2.88	2.81	1.88	3.18	3.17	0.04	0.06	0.04
Spring	2.31	2.25	2.61	2.25	2.64	2.82	0.04	0.06	0.05
Summer	0.92	2.37	1.62	1.24	2.59	2.08	0.03	0.08	0.05
Autumn	1.62	1.74	1.48	1.97	2.40	1.63	0.05	0.06	0.07
Winter	1.58	1.83	2.21	2.01	2.36	2.87	0.02	0.05	0.04
Annual	2.30	1.61	1.81	2.73	2.01	2.26	0.04	0.07	0.05

Red numbers 95% (a = 0.05) indicates the level of significance in the confidence interval.

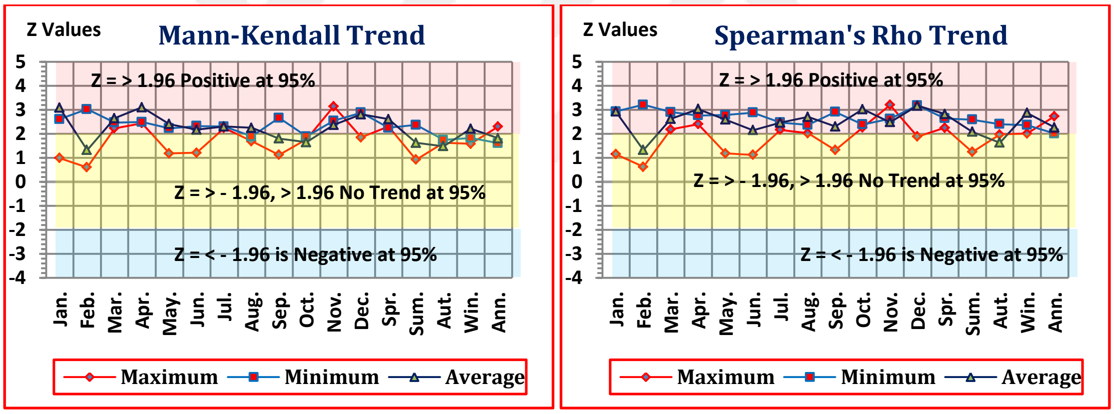


Figure 117. Results Tests of M-K, and Spearman's Rho for Temperatures Data at MISURATA Station (1971-2010)

- MISURATA station, there is presence of increased trend in most months and seasons, especially in minimum and average temperatures. The trend is found strong in March, April, July, and November in all variables. Spearman's results have shown a positive trend in all months and seasons in the minimum temperatures data. The month of May has shown a trend in minimum and average temperatures. Spring season has strongest positive trend in all variables. Besides, there was a good trend in Spearman's results for winter as well as in annual average temperature (Table 83 and Figure 118).

Table 84. Results of Tests Analysis for Mann-Kendall, Spearman and Sen's slope for Temperatures (°C) Data in NALUT Station (1971-2010)

Variables	Mann-Kendall			Spearman's Rho			Sen's slope		
	Max.	Min.	Aver.	Max.	Min.	Aver.	Max.	Min.	Aver.
January	0.93	1.77	1.33	1.00	1.80	1.40	0.03	0.03	0.02
February	0.00	0.16	-0.38	0.25	0.07	-0.32	0.00	0.00	-0.01
March	1.66	2.73	2.11	1.89	2.67	2.23	0.05	0.05	0.05
April	2.67	2.43	2.40	2.61	2.44	2.43	0.06	0.05	0.06
May	1.84	1.71	2.03	2.09	1.74	2.12	0.05	0.03	0.05
June	-0.23	2.01	0.79	-0.01	2.05	0.82	-0.01	0.03	0.01
July	2.11	1.96	2.11	1.91	1.97	2.05	0.05	0.04	0.05
August	1.98	2.70	2.35	1.99	2.91	2.39	0.04	0.06	0.05
September	1.60	1.21	1.77	1.81	1.42	2.02	0.04	0.04	0.04
October	2.49	1.57	1.56	2.55	2.13	1.98	0.08	0.08	0.08
November	2.66	1.52	3.03	2.70	2.01	3.05	0.07	0.07	0.07
December	1.01	1.75	1.26	1.03	1.69	1.29	0.03	0.03	0.03
Spring	2.89	2.42	2.40	2.95	2.74	2.63	0.06	0.05	0.05
Summer	2.55	2.25	3.02	2.65	2.29	3.04	0.04	0.04	0.04
Autumn	1.32	1.51	1.11	1.72	1.73	1.78	0.06	0.06	0.06
Winter	1.66	1.56	1.42	1.50	1.49	1.46	0.03	0.02	0.02
Annual	3.29	1.91	2.43	3.31	2.03	2.56	0.04	0.04	0.04

Red numbers 95% (a = 0.05) indicates the level of significance in the confidence interval.

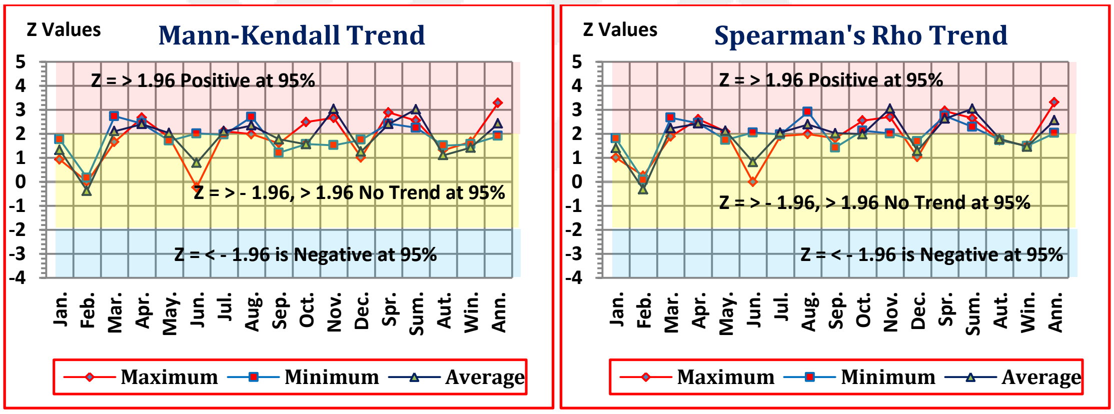


Figure 118. Results Tests of M-K, and Spearman's Rho for Temperatures Data at NALUT Station (1971-2010)

- NALUT station, the results of the test have shown a positive trend in April and August, March and July in the minimum and average temperatures. Besides, increased trend is also found in November in maximum and average temperatures. Seasonally, maximum, minimum, and average temperatures in spring and summer have shown positive increased trend while the autumn and winter seasons have shown no trends. The annual average has shown a trend at all temperatures (Table 84 and Figure 119).

Table 85. Results of Tests Analysis for Mann-Kendall, Spearman and Sen's slope for Temperatures (°C) Data in SHAHAT Station (1971-2010)

Variables	Mann-Kendall			Spearman's Rho			Sen's slope		
	Max.	Min.	Aver.	Max.	Min.	Aver.	Max.	Min.	Aver.
January	-0.96	1.78	0.51	-1.01	1.64	0.31	-0.02	0.03	0.01
February	-1.57	0.08	-1.12	-1.62	0.30	-1.10	-0.04	0.00	-0.02
March	-0.04	0.57	0.64	0.14	0.64	0.56	0.02	0.01	0.01
April	0.38	0.92	0.33	0.32	1.15	0.47	0.01	0.02	0.01
May	-0.33	0.73	0.06	-0.36	1.01	0.23	-0.01	0.01	0.00
June	-0.64	0.88	0.00	-0.53	1.09	0.26	-0.02	0.03	0.01
July	1.41	1.86	1.94	1.30	2.04	2.10	0.02	0.07	0.04
August	2.35	2.14	2.76	2.32	2.32	2.92	0.04	0.06	0.05
September	1.25	1.27	1.91	1.37	1.63	2.18	0.02	0.05	0.04
October	0.02	0.75	0.22	-0.06	1.02	0.56	0.00	0.03	0.02
November	1.07	1.55	2.17	1.14	1.68	2.21	0.02	0.05	0.04
December	-0.38	1.93	0.93	-0.33	2.03	0.99	-0.01	0.03	0.02
Spring	-0.21	1.28	0.53	-0.34	1.32	0.61	0.00	0.02	0.01
Summer	1.40	1.34	2.10	1.40	1.54	2.45	0.01	0.06	0.04
Autumn	0.71	0.85	1.23	0.76	1.08	1.50	0.01	0.04	0.03
Winter	-0.67	1.11	-0.13	-1.00	1.38	-0.08	-0.02	0.02	0.00
Annual	-0.12	1.67	2.08	-0.04	1.99	2.15	0.00	0.04	0.02

Red numbers 95% (a = 0.05) indicates the level of significance in the confidence interval.

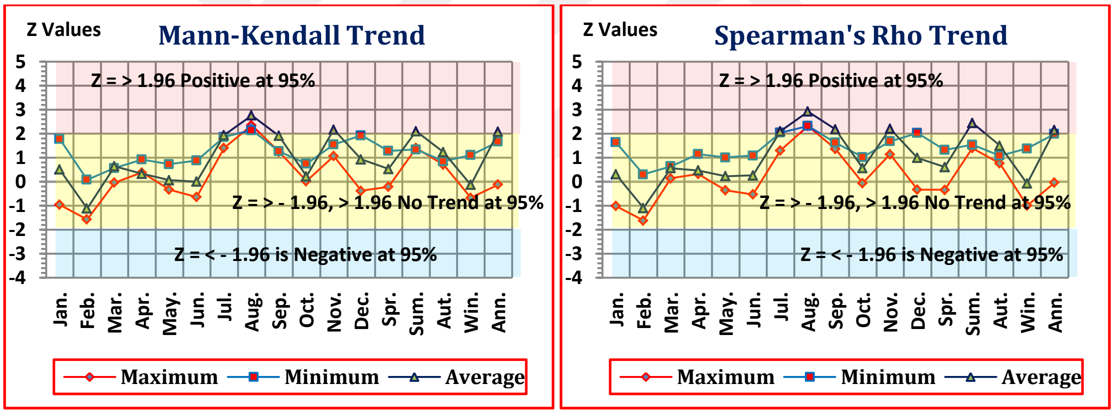


Figure 119. Results Tests of M-K, and Spearman's Rho for Temperatures Data at SHAHAT Station (1971-2010)

- **SHAHAT** station, in this station almost all months have not shown any trends except for the month of August which shows a positive increased trend in all variables. The Spearman's results has shown a positive trend in the minimum and average temperatures in July. Seasonally, the rest of the seasons have not shown any trend except for the summer, which shows a trend in the average temperature. The overall annual average has shown a positive trend only in the average temperatures (Table 85 and Figure 120).

Table 86. Results of Tests Analysis for Mann-Kendall, Spearman and Sen's slope for Temperatures (°C) Data in SIRTE Station (1971-2010)

Variables	Mann-Kendall			Spearman's Rho			Sen's slope		
	Max.	Min.	Aver.	Max.	Min.	Aver.	Max.	Min.	Aver.
January	0.93	2.15	1.20	1.01	2.17	1.27	0.02	0.03	0.02
February	0.23	0.37	-0.10	0.20	0.29	-0.14	0.00	0.01	0.00
March	2.10	1.58	1.61	2.11	1.58	1.70	0.05	0.02	0.02
April	2.29	0.89	1.73	2.37	0.86	1.86	0.04	0.01	0.02
May	1.46	1.60	1.70	1.47	1.75	1.83	0.04	0.02	0.03
June	0.23	1.74	0.84	0.24	1.66	0.90	0.01	0.02	0.01
July	2.38	3.69	2.37	2.42	3.61	2.87	0.07	0.06	0.07
August	3.84	2.03	2.41	3.76	2.20	2.57	0.05	0.06	0.05
September	1.96	2.47	2.54	2.09	2.64	2.73	0.06	0.05	0.06
October	2.03	1.09	1.96	2.58	1.35	2.28	0.08	0.04	0.06
November	3.72	2.45	3.28	3.55	2.41	3.20	0.08	0.04	0.05
December	2.10	1.62	2.09	2.17	1.72	2.20	0.03	0.02	0.03
Spring	2.09	1.91	2.06	2.09	1.91	2.14	0.04	0.02	0.02
Summer	3.92	2.46	2.49	3.80	2.95	3.06	0.05	0.05	0.05
Autumn	2.35	1.48	1.98	2.56	1.99	2.18	0.07	0.04	0.06
Winter	0.97	1.80	1.96	1.08	1.95	2.00	0.09	0.02	0.02
Annual	2.76	1.84	2.59	2.85	2.03	2.65	0.04	0.03	0.04

Red numbers 95% (a = 0.05) indicates the level of significance in the confidence interval.

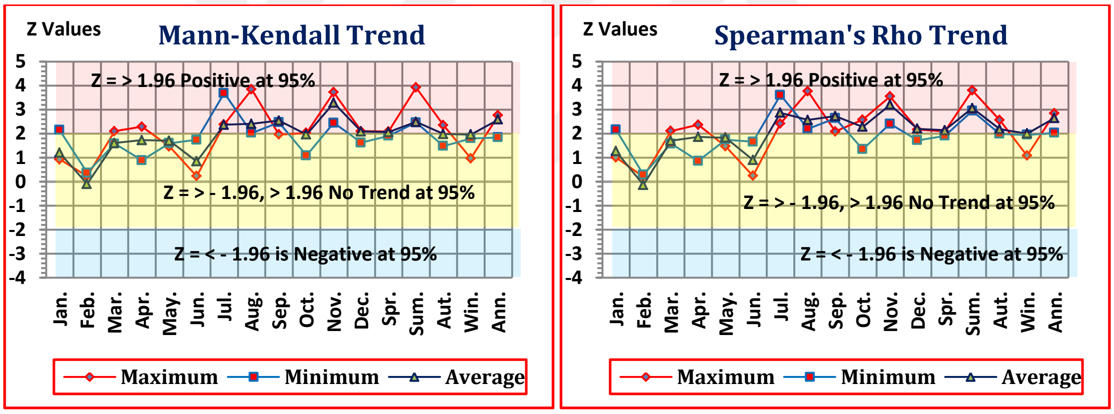


Figure 120. Results Tests of M-K, and Spearman's Rho for Temperatures Data at SIRTE Station (1971-2010)

- SIRTEstation,there is a positive trend found in July, August, and November, in the maximum, minimum, and average temperatures. The trend of increase are found strongest in July and August. Seasonally, spring, summer, and autumn have shown trend of increase, with the exception of the minimum temperatures in results of Mann-Kendall. Generally, the spring season shows positive trend towards an increase in minimum and average temperatures. The annual average has shown an increased trend. (Table 86 and Figure 121).

Table 87. Results of Tests Analysis for Mann-Kendall, Spearman and Sen's slope for Temperatures (°C) Data in TOBRUK Station (1984-2010)

Variables	Mann-Kendall			Spearman's Rho			Sen's slope		
	Max.	Min.	Aver.	Max.	Min.	Aver.	Max.	Min.	Aver.
January	0.33	1.32	0.82	0.24	1.27	0.72	0.01	0.04	0.02
February	0.13	0.58	0.69	0.19	0.74	0.79	0.00	0.01	0.01
March	0.79	1.06	1.19	0.67	1.27	1.29	0.03	0.07	0.03
April	-0.78	2.26	0.44	-0.63	2.23	0.47	-0.03	0.07	0.02
May	-0.06	1.76	1.69	-0.07	2.09	1.90	0.00	0.09	0.04
June	-0.75	2.12	1.49	-0.80	2.27	1.48	-0.02	0.09	0.03
July	3.16	1.63	1.90	3.00	1.81	2.26	0.06	0.07	0.06
August	1.15	0.75	1.19	1.39	1.33	2.01	0.05	0.06	0.06
September	1.49	1.26	3.13	1.80	2.35	3.11	0.04	0.09	0.06
October	0.42	1.28	0.97	0.85	2.05	1.47	0.05	0.10	0.06
November	0.98	2.44	1.98	1.02	2.61	2.05	0.03	0.06	0.08
December	1.90	2.15	2.61	1.82	2.02	2.71	0.06	0.07	0.06
Spring	-0.17	1.06	2.02	-0.33	1.77	1.75	-0.17	0.07	0.03
Summer	2.45	1.45	1.94	2.38	2.14	2.33	0.03	0.08	0.06
Autumn	0.64	1.37	1.76	2.06	1.97	2.07	0.04	0.09	0.07
Winter	0.53	0.86	2.12	1.02	1.14	2.37	0.01	0.04	0.04
Annual	1.68	0.97	1.41	1.99	1.20	1.98	0.03	0.07	0.05

Red numbers 95% (a = 0.05) indicates the level of significance in the confidence interval.

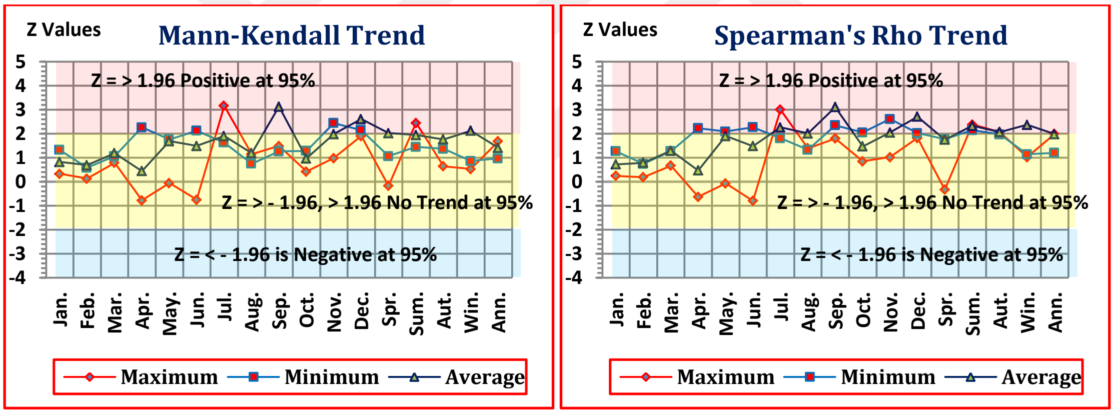


Figure 121. Results Tests of M-K, and Spearman's Rho for Temperatures Data at TOBRUK Station (1984-2010)

- **TOBRUK** station, an increasing trend has been found in the months of November and December in terms of minimum and average temperatures in the TOBRUK station. However, there is no trend at the maximum temperatures in all the months except July. Seasonally, trends are found only in the summer and autumn in all temperatures in Spearman's results. The trends in the direction of increase are seen to be the strongest in summer and autumn at Spearman's results, (Table 87 and Figure 122).

Table 88. Results of Tests Analysis for Mann-Kendall, Spearman and Sen's slope for Temperatures (°C) Data in TRIPOLI Station (1971-2010)

Variables	Mann-Kendall			Spearman's Rho			Sen's slope		
	Max.	Min.	Aver.	Max.	Min.	Aver.	Max.	Min.	Aver.
January	0.70	1.55	1.01	0.89	1.56	1.14	0.02	0.03	0.02
February	-0.26	-0.07	-0.06	-0.08	0.00	-0.11	-0.01	-0.07	0.00
March	1.50	0.39	1.60	1.89	0.59	1.73	0.05	0.01	0.03
April	1.77	1.51	2.53	2.00	1.52	2.51	0.05	0.02	0.05
May	1.98	2.42	2.09	1.98	2.55	2.23	0.05	0.04	0.04
June	0.96	1.74	1.35	0.91	1.77	1.20	0.02	0.03	0.03
July	1.99	3.10	2.78	1.86	3.01	2.63	0.06	0.07	0.06
August	1.79	1.74	1.79	2.04	2.13	2.40	0.05	0.06	0.06
September	1.25	1.89	1.94	1.30	2.52	2.03	0.03	0.05	0.04
October	1.60	2.80	1.69	1.98	2.96	1.90	0.09	0.05	0.07
November	3.34	2.73	2.59	3.31	2.86	2.79	0.07	0.05	0.05
December	1.16	2.09	1.53	0.93	2.19	1.57	0.03	0.03	0.03
Spring	2.37	2.60	3.22	2.61	2.73	3.16	0.05	0.03	0.04
Summer	2.32	2.18	2.50	2.45	2.92	3.03	0.04	0.05	0.04
Autumn	0.99	1.84	2.04	1.25	2.60	2.13	0.06	0.04	0.05
Winter	1.47	1.21	1.30	1.33	1.38	1.29	0.03	0.02	0.02
Annual	2.08	1.98	2.44	2.27	2.00	2.89	0.04	0.04	0.04

Red numbers 95% (a = 0.05) indicates the level of significance in the confidence interval.

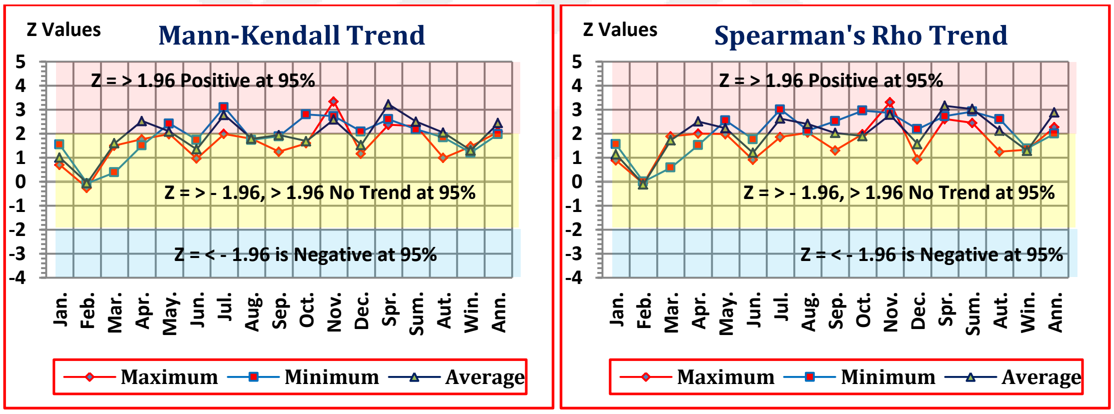


Figure 122. Results Tests of M-K, and Spearman's Rho for Temperatures Data at TRIPOLI Station (1971-2010)

- TRIPOLI station, the months of May and November have shown an increasing trend while the month of November shows the strongest.

In the seasons was strongest increases in Spring and summer have shown strongest positive trend while autumn has shown trend in average temperatures at Mann-Kendall result, and minimum and average at Spearman's results. The general annual average has shown positive trend in all variables (Table 88 and Figure 123).

Table 89. Results of Tests Analysis for Mann-Kendall, Spearman and Sen's slope for Temperatures (°C) Data in ZWARA Station (1971-2010)

Variables	Mann-Kendall			Spearman's Rho			Sen's slope		
	Max.	Min.	Aver.	Max.	Min.	Aver.	Max.	Min.	Aver.
January	0.77	3.64	2.65	0.75	3.62	2.57	0.01	0.07	0.05
February	-0.17	3.01	1.70	-0.11	2.89	1.71	0.00	0.05	0.04
March	2.13	2.59	2.89	2.05	3.26	3.90	0.03	0.07	0.05
April	3.03	2.48	2.96	2.71	3.45	3.37	0.06	0.05	0.06
May	2.23	2.92	2.43	3.17	3.05	3.78	0.06	0.06	0.06
June	1.83	2.53	2.84	1.90	3.43	3.43	0.03	0.05	0.04
July	2.35	2.54	2.70	2.41	3.02	3.43	0.06	0.09	0.07
August	2.32	2.08	2.06	2.45	2.51	2.56	0.07	0.08	0.08
September	1.13	2.25	1.74	1.68	2.90	2.07	0.05	0.09	0.04
October	1.94	2.15	2.10	2.29	3.35	2.31	0.07	0.10	0.07
November	1.98	1.79	1.80	2.43	2.48	2.24	0.07	0.04	0.06
December	1.28	2.71	2.87	1.35	3.31	2.93	0.03	0.07	0.06
Spring	2.63	3.73	2.88	2.64	4.06	3.65	0.05	0.06	0.06
Summer	2.27	2.07	2.54	2.81	3.01	3.07	0.06	0.08	0.06
Autumn	0.63	1.77	1.02	1.97	3.05	1.84	0.06	0.03	0.08
Winter	1.34	1.89	2.18	1.31	2.49	2.32	0.02	0.06	0.04
Annual	0.99	1.50	1.21	1.72	2.15	1.69	0.05	0.05	0.06

Red numbers 95%, (a = 0.05) indicates the level of significance in the confidence interval.

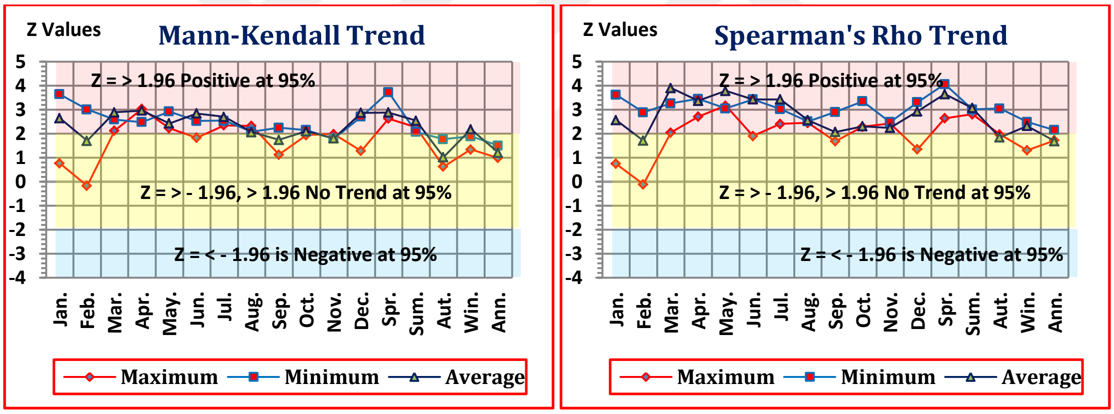


Figure 123. Results Tests of M-K, and Spearman's Rho for Temperatures Data at ZWARA Station (1971-2010)

- **ZWARA**station, an increasing trend has been shown in the maximum, minimum, and average temperatures in the months between March and November. June is the only month left in this range not showing any trend in maximum temperature.

However, increasing trend is found in terms of minimum temperatures in all months. According to seasonal evaluation, it is seen that trend in maximum, minimum, and average temperatures is limited to spring and summer. The most strongest positive upward trend is seen in August on monthly basis and seasonally ins Spring and summer. (Table 89 and Figure 124).

4.1.1.1. Evaluation on Maximum Temperatures Results

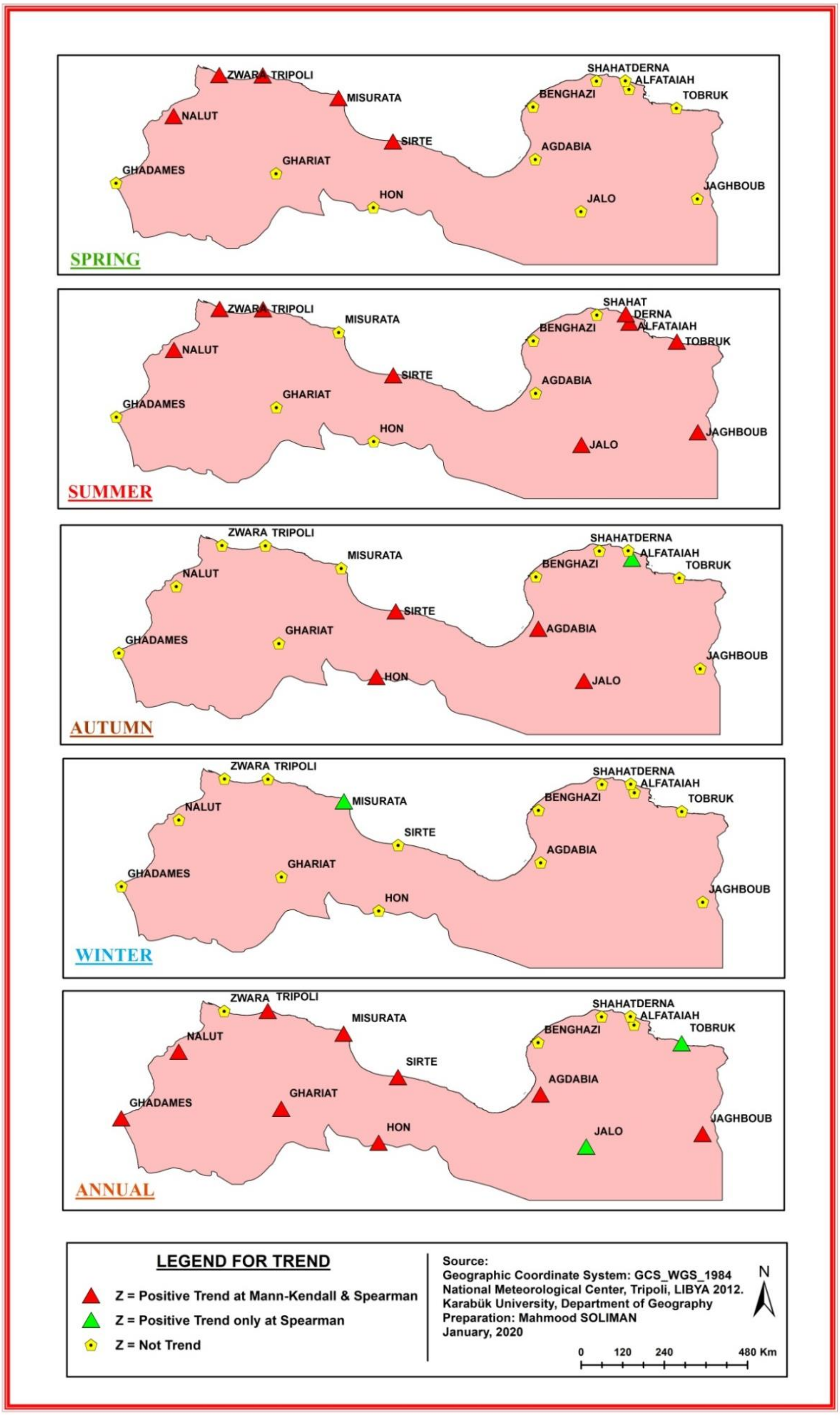
❖ **Mann-Kendall and Spearman's Rho Tests**

From the previous tables and figures following results can be inferred, at SIRTE station is noteworthy for a significant warming trend in all months except January, February, May, and September in terms of monthly maximum temperatures. JALO station has shown a strong trend in four months of July, August, September, and December in the Mann Kendall and Spearman tests.

According to Mann-Kendall test statistics, November has shown a strong trend in most stations such as AGDABIA, BENGHAZI, GHARIAT, HON, JAGHBOUB, MISURATA, NALUT, SIRTE, TRIPOLI and ZWARA. On the other hand, Spearman Rho test statistics has shown trend in August, September, November, and December in AGEDABIA station .However, it has shown no trend in December according to Mann Kendall test. According to the Mann-Kendall and Spearman Rho tests no significant trend of warming is found in all months in SHAHAT station except August. Besides, no trend has shown at ALFATAIAH station by Mann Kendall test except in September, while in the Spearman test the station has shown trend in the months of July, September, and November. GHARIAT station has also not shown any trend except in the months of September and November. It has been found that given decreasing trend in maximum temperatures is shown in the stations that are elevated from the sea level.

The results of the Mann Kendall test has shown trend in GHADAMES station only in August, while the Spearman Rho test has shown trend in August and October. AGDABIA, BENGHAZI, GHARIAT, HON, JALO, NALUT, SHAHAT, TOBRUK stations have shown significant decreasing trend on a monthly basis, especially in months of January, February, April, and June while a strong negative trend is found in GHARIAT station in June. It is observed that the months of January and February are not significant in showing trend towards an increase. No trend is found in these two months at all stations in results of Mann Kendall and Spearman Rho tests.

Seasonally, the stations of MISURATA, NALUT, SIRTE, TRIPOLI, and ZWARA show a trend towards warming in the spring, while the other stations do not show any increasing trend. The following map 25 summarizes all trends.



Map 24. Distribution Results of Mann Kendall & Spearman tests for Seasonally and Annual Maximum Temperatures (1971-2010)

In the **summer,** many stations show a trend towards warming because of the high temperature in the summer. The most important of these stations are ALFATAIAH, DERNA, JAGHBOUB, JALO, NALUT, SIRTE, TOBRUK, TRIPOLI, and ZWARA, while other stations do not show increasing trend. The results ranged from57 at BENGHAZI station to 1.52 at AGDABIA station.

In the season of **autumn,**an increased trend is observed in AGDABIA, JALO, and SIRTE only in terms of maximum temperature while there is no trend in other stations. It is noted that all the stations have shown no increased trends in the winter perhaps because of the relative decrease in temperature in most stations of the study area.

Results analysis of **annual maximum** temperatures at AGDABIA, GHADAMES, GHARIAT, HON, JAGHBOUB, MISURATA, NALUT, SIRTE, and TRIPOLI stations have shown significant increase at 95%, with strong trend at AGDABIA, HON, JAGHBOUB, MISURATA and NALUT stations, while ALFATAIAH, BENGHAZI, SHAHAT, TOBRUK, and ZWARA stations have shown no increasing trend.

- **Sen's Trend slope Test**

Almost all stations have shown an increasing trend when the maximum temperature data is evaluated annually. However, this increase does not indicate as significant increase. Besides, there are also minor exceptions in some stations during the spring such as BENGHAZI station where the test of Sen was given (-0.02), DERNA station (-0.01) and strongest negative trend In stations at TOBRUK station (-0.17).

As for the annual maximum temperatures, most of the stations have shown a positive trend, although the values do not reach more than (0.05) except in the ZWARA station. Some months have shown a negative trend in many stations like DERNA station in February (-0.02), BENGHAZI station in June (-0.05), GHARIAT station in June (-0.07), HON station in February (-0.04) and June (-0.02) and at TOBRUK station in April -0.03). It should be noted that some stations show values (0) in some months such as January, February, March, May and October.

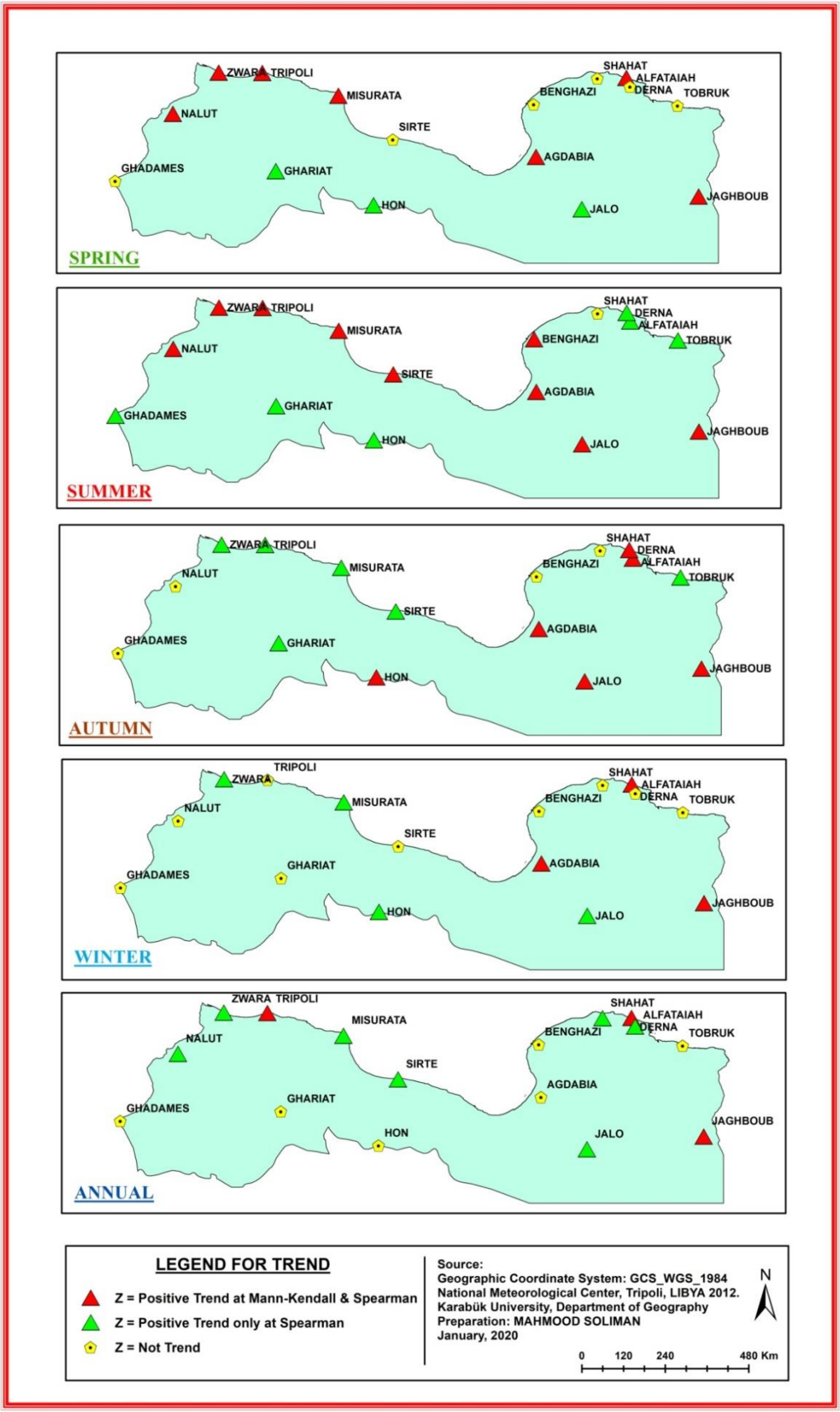
4.1.1.2. Evaluation of Minimum Temperatures Results

❖ **Mann-Kendall and Spearman's Rho Tests**

Generally, maximum temperatures show a stronger trend than minimum temperatures on monthly basis. AGDABIA station has shown a positive trend in almost all months in the results of the Mann Kendall and Spearman tests except for February, May, and August. The strongest trend is observed in November (4.29), January (3.52) and June (3.28). These trends are strong as compared to other outcomes in other stations.

According to the results of the Mann Kendall, ALFATAIAH station has not shown any trend in minimum temperature except in October. The results of Spearman Rho, on the other hand has shown a trend in August, September, and October with strongest of trend in September. Results of BENGHAZI station has shown difference between Mann Kendall and Spearman Rho test. The results of Mann Kendall show a trend in three months of August, September, and December, while Spearman's results show a five-month trend in July, August, September, November, and December. In the months of January to June, some stations such as DERNA and MISURATA stations show an increasing trend in both the Mann Kendall and Spearman test results.

An increasing trend is shown at GHADAMES station in 4 months of March, July, October, and December. On the other hand, Spearman Rho's test shows increasing trend in 7 months including April, May, and November. According to Spearman Rho test statistic, a meaningful increasing trend is evident at HON station in all months except for May while according to Mann Kendall test statistic, the trend is shown in all months except February, May, July, and August.It is observed that there is a significant increasing trend in January and February and from March to May non-significant cooling tendency at JAGBOUB station (according to Mann-Kendall test statistics).The results of Spearman show trends in all months except for March, and April while there is an increased trend in months from June to December. JALO station shows a trend towards warming in most months, and no trend is found in February, March, April and May. MISURATA Station shows a trend towards warming in all months, even if some months in the results of the Mann Kendall test do not show a trend, such as August and October.following map 27 summarizes all trends.



Map 25. Distribution Results of Mann Kendall & Spearman tests for Seasonally and Annual MinimumTemperatures (1971-2010)

NALUT station shows significant increasing trend in some months such as March, April, June, and August by Mann Kendall test statistics. However, Spearman test statistics show increased trend in other months as such July, September, and November. According to Mann-Kendall test statistics, all months except August show non-significant warming trendatSHAHAT station while Spearman test statistics show trend in July, August, and December. It is observed that there is a significant warming trend in July, August, September, and November at SIRTE station according to Mann-Kendall and Spearman tests statistics, the months of April, June, November, and December show a significant warming trend at TOBRUK according to Mann-Kendall test statistics. According to Mann-Kendall tests statistics TRIPOLI station shows a increasing trend in several months May, July and November. However, increasing trend is observed for months from July to December according to Spearman tests statistics. A significant warming trend is observed in all months at ZWARA station and there is no trend of decreasing.

In terms of seasonal and annual temperatures it is observed that in spring average minimum temperatures most stations show significant increasing trend with 95% significance level except ALFATAIAH, BENGHAZI, GHADAMES, SHAHAT and TOBRUK where no increasing trend is observed. The average minimum temperatures of summer has shown increasing trend at AGDABIA, ALFATAIAH, BENGHAZI, DERNA, HON, JAGHBOUB, JALO, MISURATA, NALUT, SIRTE, TOBRUK, TRIPOLI, and ZWARA stations. JAGBOUB, JALO, NALUT show strongest increasing trend. In the autumn season, a significant warming trend is observed in the stations of AGDABIA, ALFATAIAH, DERNA, HON, JAGHBOUB, and JALO. Among these stations, the increasing trend in JALO and JAGHBOUB is very clear while in SHAHAT and NALUT non-significant increasing trend is observed.

In the autumn season, no decreasing trend is observed in any of the two stations. Besides, some stations show a trend in autumn at Mann Kendall's test and show no trend at Spearman's test and vice versa. At the average minimum temperatures of the winter season, there is an increasing trend at AGDABIA, DERNA, JAGHBOUB, and BENGHAZI stations by 95%, while the trend in AGDABIA is strong. ALFATAIAH, GHADAMES, SHAHAT SIRTE, TOBRUK, TRIPOLI, and ZWARA stations show non-significant warming tendency within the winter season, while GHARIAT, HON, and JALO stations show a significant decreasing trend.

A significant warming trend is found at 95%,at AGDABIA, BENGHAZI, DERNA, JAGHBOUB, JALO, MISURATA, NALUT, SIRTE, TRIPOLI, and ZWARA stations in average annual minimum temperatures. The warming trend in JAGHBOUB station is strong, at ALFATAIAH, GHADAMES, GHARIAT, HON, SHAHAT, SIRTE, TOBRUK, and TRIPOLI stations there is trend of non-significant warming.

- **Sen's Trend slope Test**

As a result of the annual analysis of the annual minimum temperatures data in Sen's trend slope, the stations of AGDABIA, DERNA, GHADAMES, GHARIAT, HON, JALO, MISURATA, TOBRUK and ZWARA have shown a trend in (0.05) to (0.08). However, there are many stations that do not show any trend and the results are less than (0.05) at ALFATAIAH, BENGHAZI, JAGHBOUB, NALUT, SHAHAT, SIRTE and TRIPOLI stations.

The stations of DERNA, GHADAMES, GHARIAT, JAGHBOUB, and TOBRUK show a trend slope in all months except January, February, March, while ZWARA station shows the strongest trend in all months. ALFATAIAH station does not show any trend in all months. The strongest slope of trend is found at HON Station during September (0.12). Some stations show negative slope in some months and values are between (-.01 and -0.07) such as ALFATAIAH in February (-0.01), and March (-0.01), BENGHAZI in June (-0.01), and TRIPOLI station in February (-0.07).

It is observed that the trend is increasing in some stations in the spring season such as GHADAMES, HON, MISURATA, NALUT, TOBRUK, and ZWARA. The remaining stations show less than (0.05) value. In summer, AGDABIA station show strongest slope (0.10) and results show trend slope in most except ALFATAIAH, BENGHAZI, GHARIAT, and NALUT. In the autumn, all stations show a tendency towards positive trend (over 0.05) except BENGHAZI, SHAHAT, SIRTE, TRIPOLI, and ZWARA. In the winter, there is no trend in any stations except in four stations of GHARIAT, HON, MISURATA and ZWARA stations.

4.1.1.3. Evaluationof Average Temperatures Results

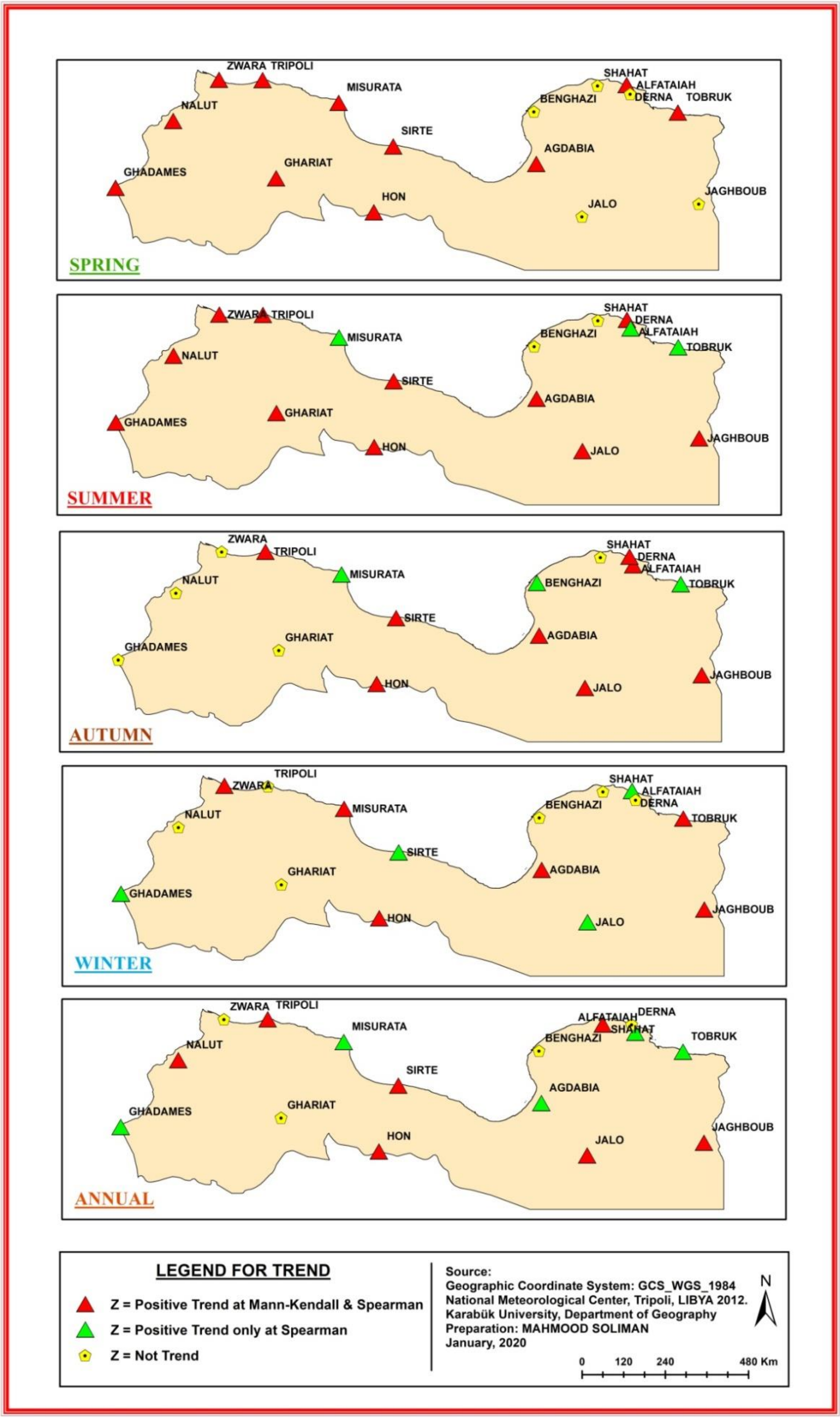
❖ **Mann-Kendall and Spearman's Rho Tests**

The results of the months differ from one station to another perhaps because of the different locations. It is observed that months from May to December are warming months in most stations except January and March, at AGDABIA and ALFATAIAH.

According to Mann-Kendall and Spearman tests statistics, several stations show a trend in June, July, August and September. At HON, JAGHBOUB, JALO and SIRTE stations strong trend is found from June and July to December. MISURATA Station is characterized by positive trend all months except in September and October. ZWARA station show positive trend according to Spearman tests statistics in all months except for February, at SHAHAT station, no trend is observed except in months of August and November. March shows the strongest trend in at ZWARA Station, with the test result (3.90) followed by HON (3.65) in November.

Seasonally, a significant trend is observed in average temperature in spring in most of the stations such as AGDABIA, DERNA, GHADAMES, GHARIAT, HON, and MISURATA., An increasing trend is observed at 95% significance level NALUT, SIRTE, TRIPOLI, and ZWARA in M-K and Spearman test statistics. However, ALFATAIAH, BENGHAZI, JAGBOUB, JALO, and SHAHAT stations are not significant in increasing trend. Considering the average temperature values of summer season, the presence of a warming trend at 95% significance level in all stations is noteworthy except for BENGHAZI station. JAGHBOUB, and JALO stations have shown high increasing trend.

In the autumn season, there is a significant increasing trend at AGDABIA, ALFATAIAH, HON, JAGHBOUB, JALO, SIRTE and TRIPOLI stations according to Mann Kendall and Spearman Tests Statistics, while BENGHAZI, and TOBRUK stations show trend in results of Spearman only. There are five stations which show no trend in autumn which are GHADAMES, GHARIAT, MISURATA, NALUT and SHAHAT .In the winter, five stations show a warming trend at Man Kendall and Spearman tests namely AGDABIA, HON, JAGHBOUB, MISURATA, TOBRUK, and ZWARA. Some stations such as GHADAMES, JALO, SIRTE stations have shown trend in the result of the Spearman test, and map 27 summarizes all trends.



Map 26. Distribution Results of Mann Kendall & Spearman tests for Seasonally and Annual Average Temperatures (1971-2010)

There are some stations that show no trend in the winter, most important of these stations are ALFATAIAH, BENGHAZI, GHARIAT, NALUT, SHAHAT, and TRIPOLI. It is determined that there was a significant increase in trend in annual average temperature values at 95% significance level in some stations, according to Mann-Kendall and Spearman tests statistics such as HON, JAGHBOUB, JALO, MISURATA, NALUT, SHAHAT, SIRTE and TRIPOLI stations. However, some stations only show trend according to Spearman test statistics such as AGDABIA, ALFATAIAH, GHADAMES and MISURATA stations. In annual average temperatures compared to the other stations, TRIPOLI station has a more significant warming trend (2.44 and 2,89). It is possible to say that urbanization is effective in this increasing trend in biggest of cities in Libya.

According to the address-based population registration data of 2006, a large part of the population of TRIPOLI live in cities, while city population is over one million. It can be stated that TRIPOLI has become a heat island compared to its surrounding, and SHAHAT station show significant decreasing trend (-1.0 at M-K, and -0.08 at Spearman). No other stations shows significant decreasing trend during the winter season.

❖ **Sen's Trend slope Test**

The presence of a non-significant trend is observed in some stations when the average temperature data are analyzed on an annual basis according to Sen's trend slope test, in the months of the spring season, decreasing trend has shown and these trends do not have a distinct character., This decreasing trend continues to exist over the months. BENGHAZI and SHAHAT stations have shown the trend towards decreasing in all months. In general, the dominance of the trends toward decline continues to exist over the months.

In addition, AGDABIA station shows trend from July to November, and ALFATAIAH station in March, July, August, and September. It should be noted that some stations do not show a seasonal trend in any season such as ALFATAIAH, BENGHAZI, DERNA and SHAHAT. Other stations show increasing trend especially in the summer and autumn such as AGDABIA GHADAMES and GHARIAT stations in autumn and in the summer HON, JAGHBOUB, JALO, MISURATA, TOBRUK, TRIPOLI and ZWARA stations. NALUT station shows a trend of increase in spring and autumn.

Trends in the direction of increase (Z ≥1.96) are shown by (+) in the above tables and the decreasing trends (Z≥ 1.96) are represented with the (-) sign. The fact that the Z value is between (-/+ 1.96), which is the critical value (H0) means that the hypothesis is accepted, and it indicates there is no trend, symbolized by (0).

Temperature data were then included in the Mann-Kendall test sequential analysis process, and the obtained U(t) and U'(t) values and the two-way confidence interval (+/1.96) were generated. With the evaluation of these charts, it is possible to have information about the start year in the presence/absence of trend. The following figures represent the trends of maximum, minimum, and general average temperatures in all stations during the seasons and the annual.

4.1.2. Mann-Kendall Correlation CoefficientU(t)-U'(t)

4.1.2.1. Graphs of M-K U(t)-U'(t) Results for Seasonally and Annual Maximum Temperatures (1971-2010)

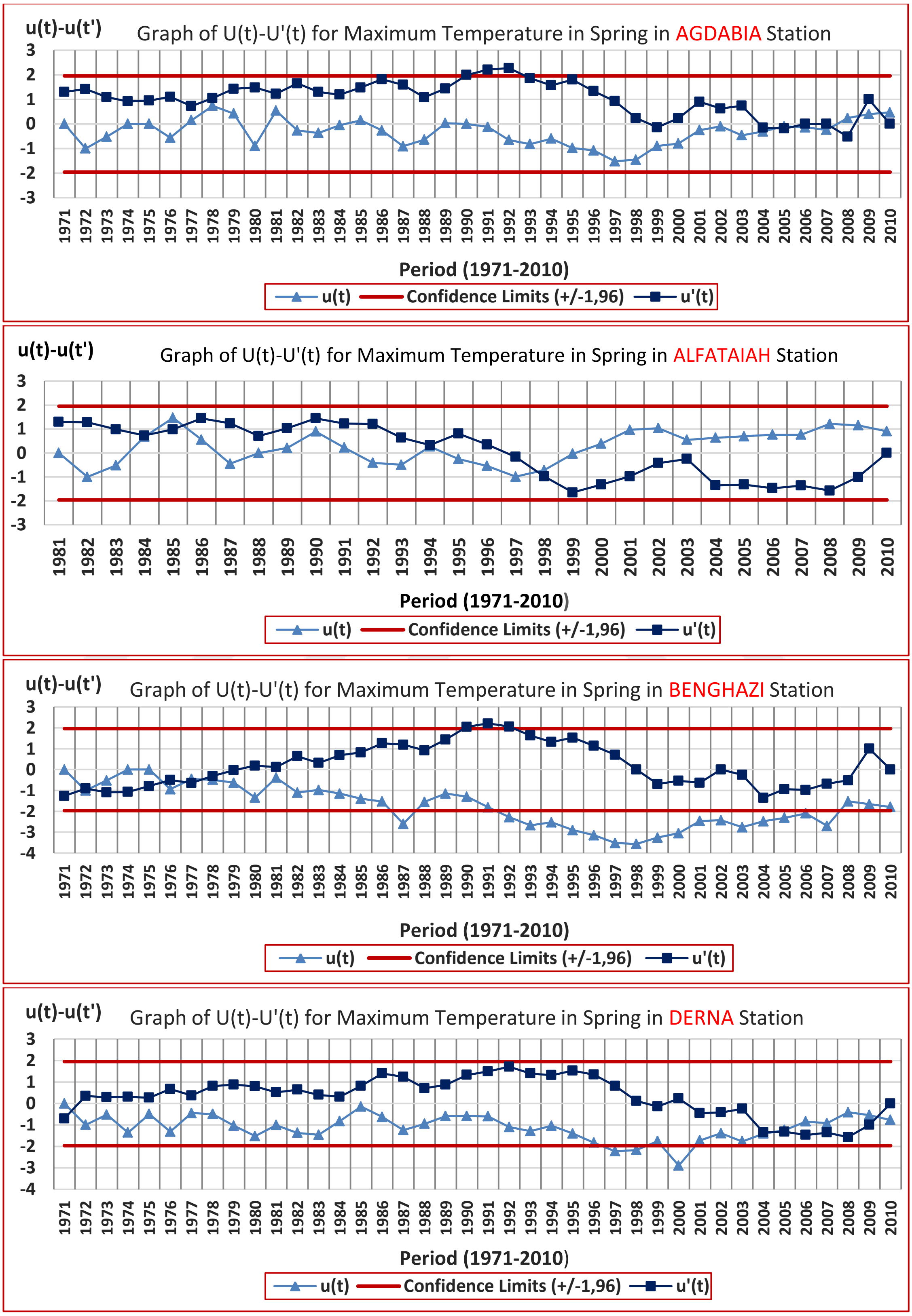


Figure 124. Graphs of M-K U(t)-U'(t) Results for Maximum Temperature in Spring in AGDABIA, ALFATAIAH, BENGHAZI and DERNA Stations

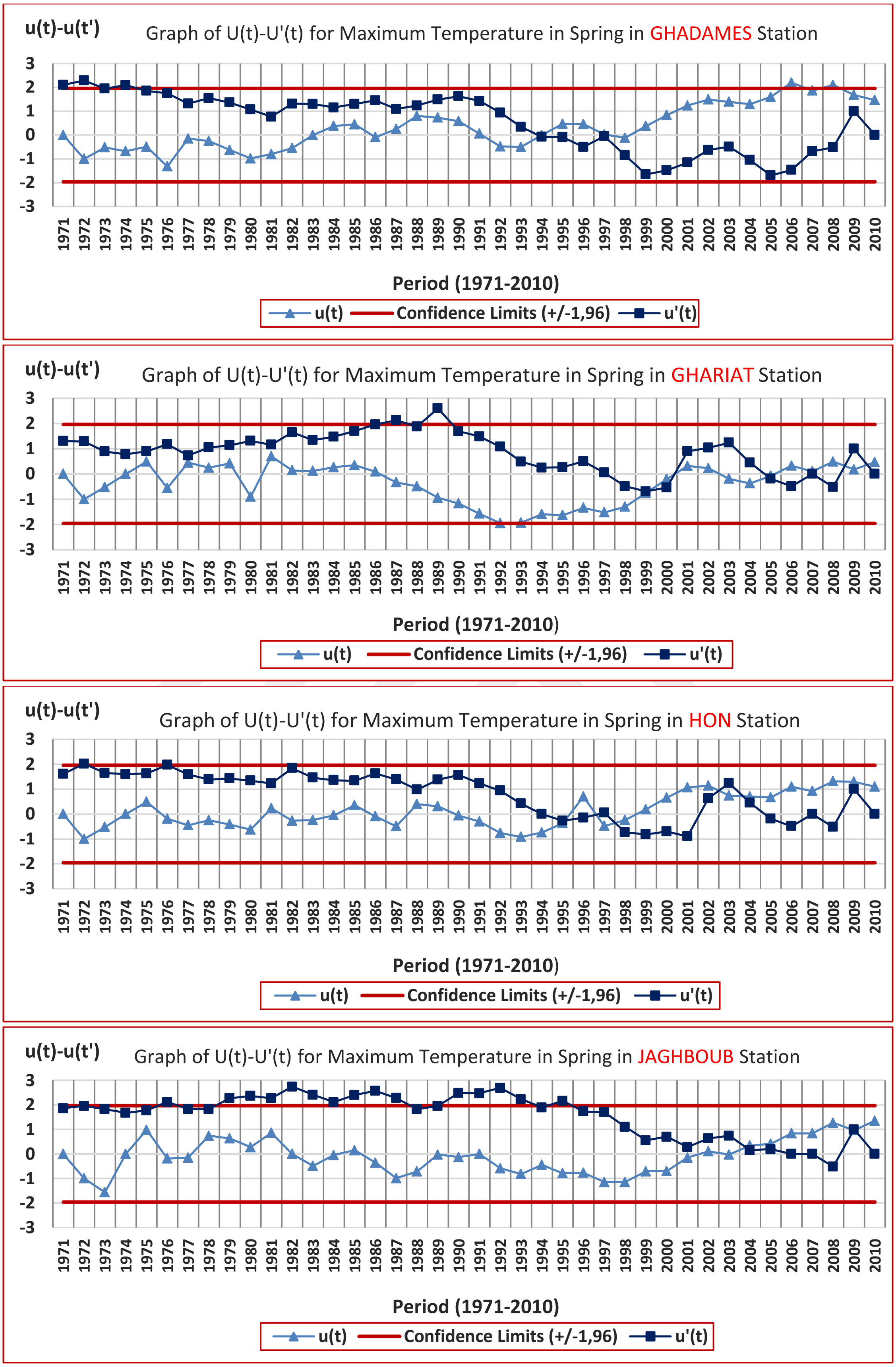


Figure 125. Graphs of M-K U(t)-U'(t) Results for Maximum Temperature in Spring in GHADAMES, GHARIAT, HON and JAGHBOUB Stations

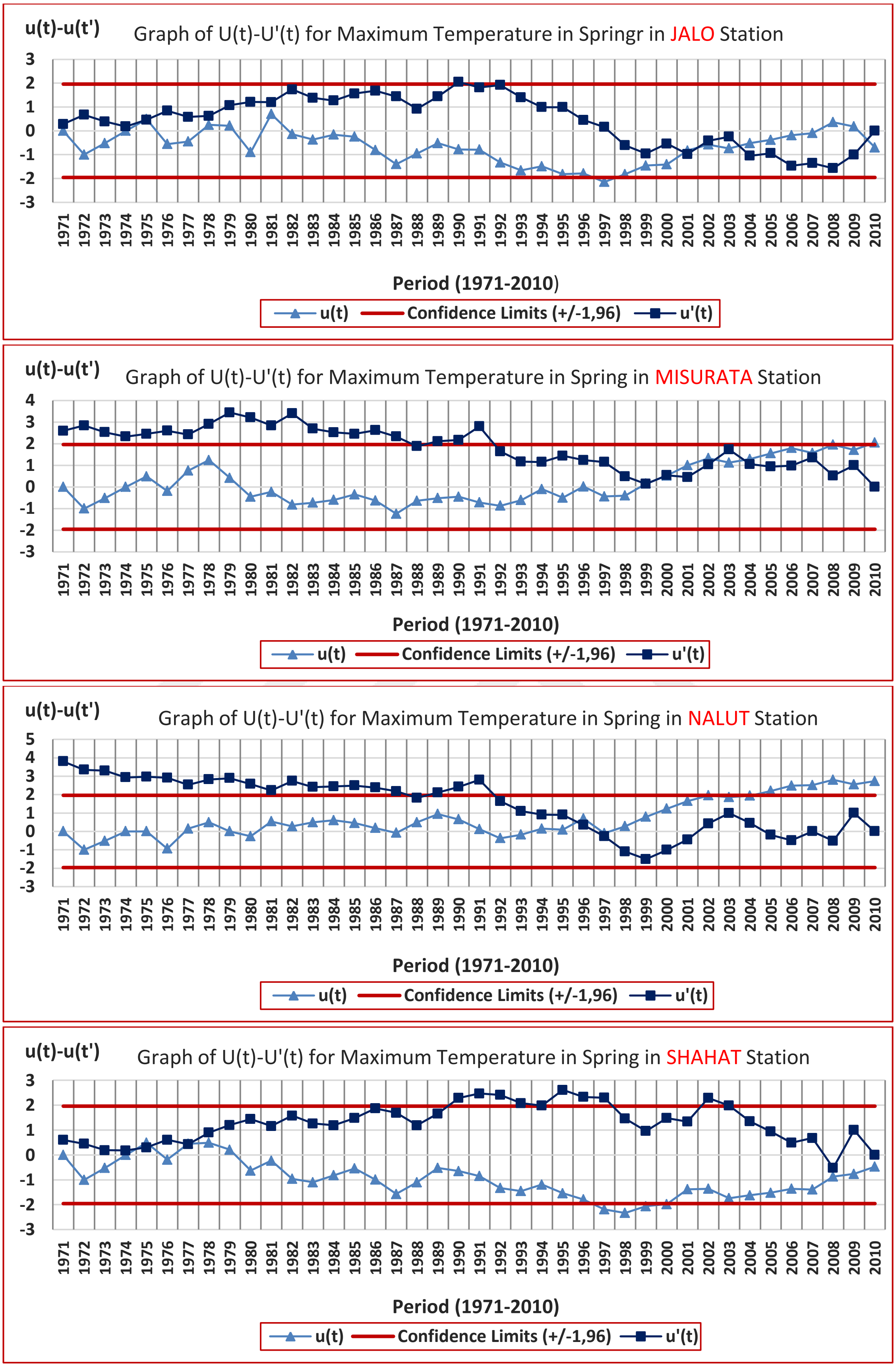


Figure 126. Graphs of M-K U(t)-U'(t) Results for Maximum Temperature in Spring in JALO, MISURATA, NALUT and SHAHAT Stations

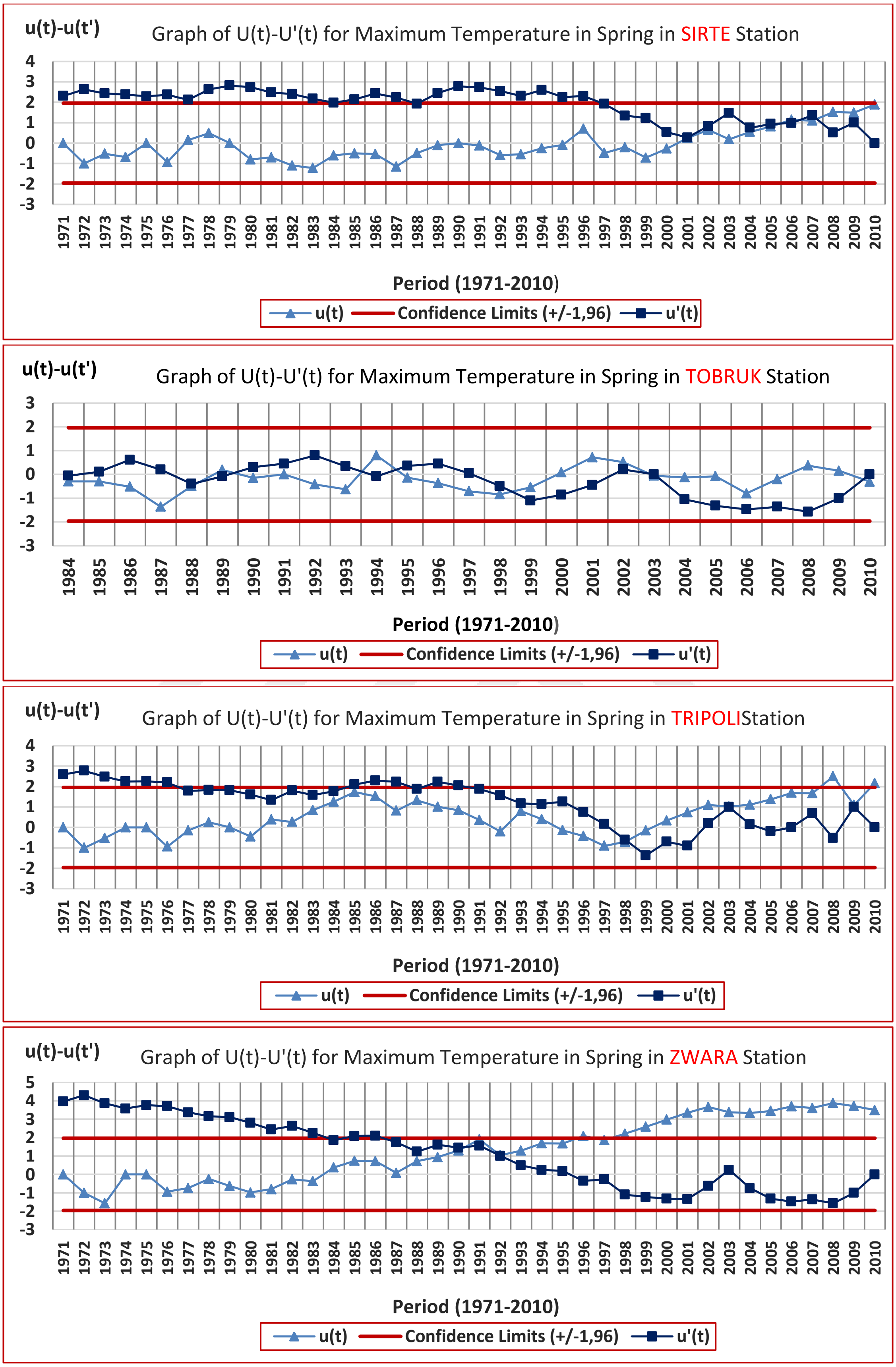


Figure 127. Graphs of M-K U(t)-U'(t) Results for Maximum Temperature in Spring in SIRTE, TOBRUK, TRIPOLI and ZWARA Stations

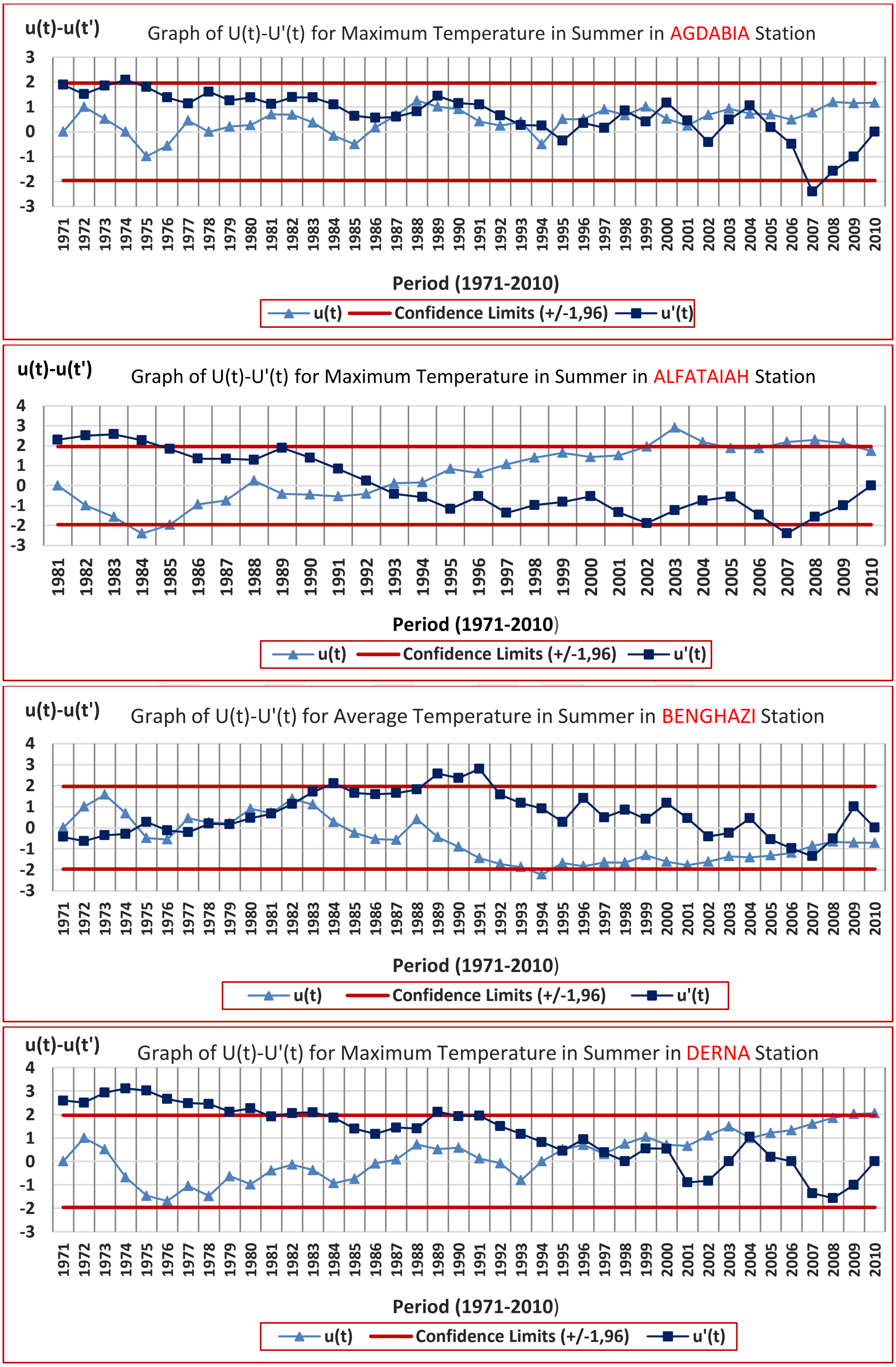


Figure 128. Graphs of M-K U(t)-U'(t) Results for Maximum Temperature in Summer in AGDABIA, ALFATAIAH, BENGHAZI and DERNA Stations

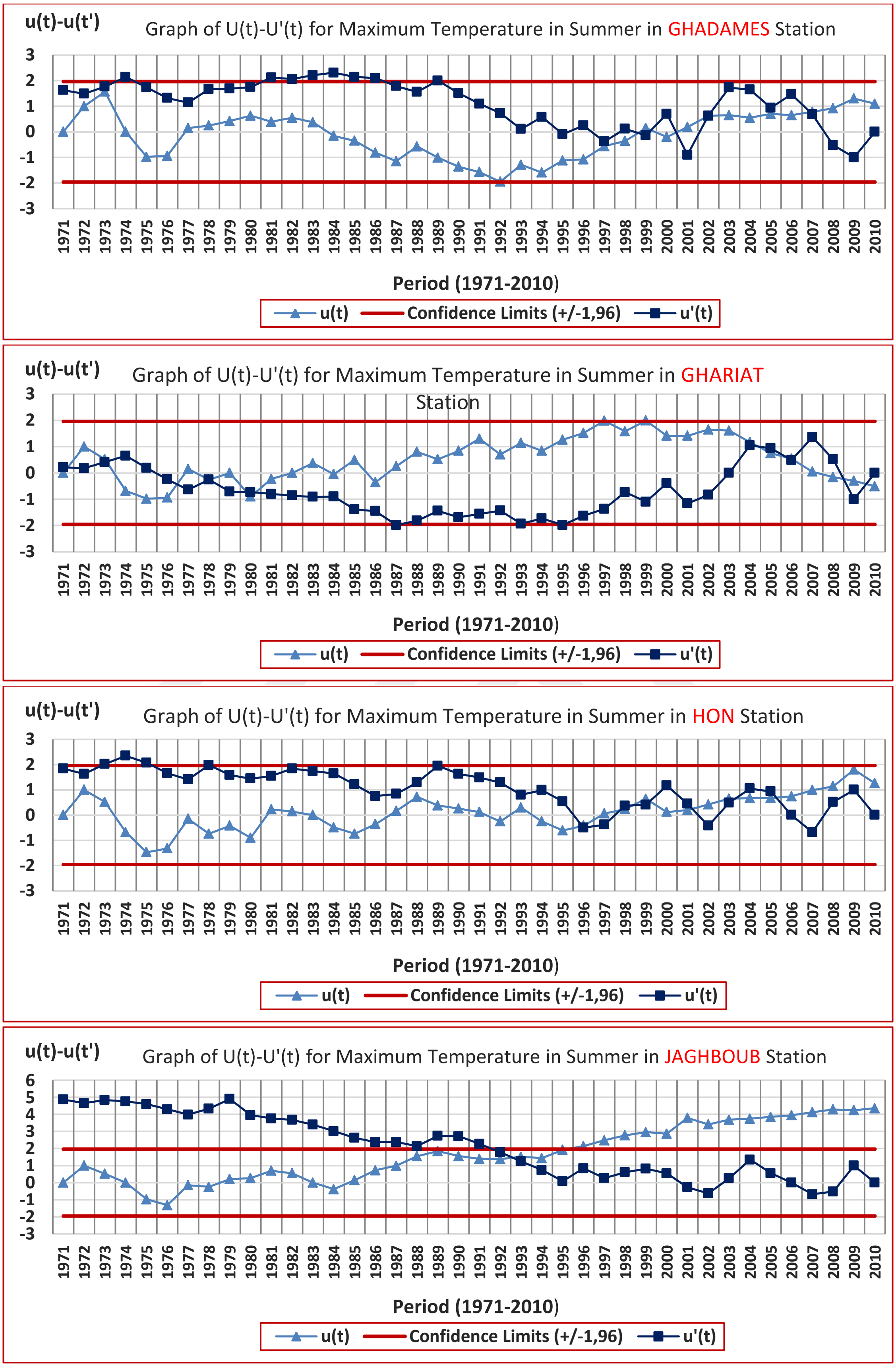


Figure 129. Graphs of M-K U(t)-U'(t) Results for Maximum Temperature in Summer in GHADAMES, GHARIAT, HON and JAGHBOUB Stations

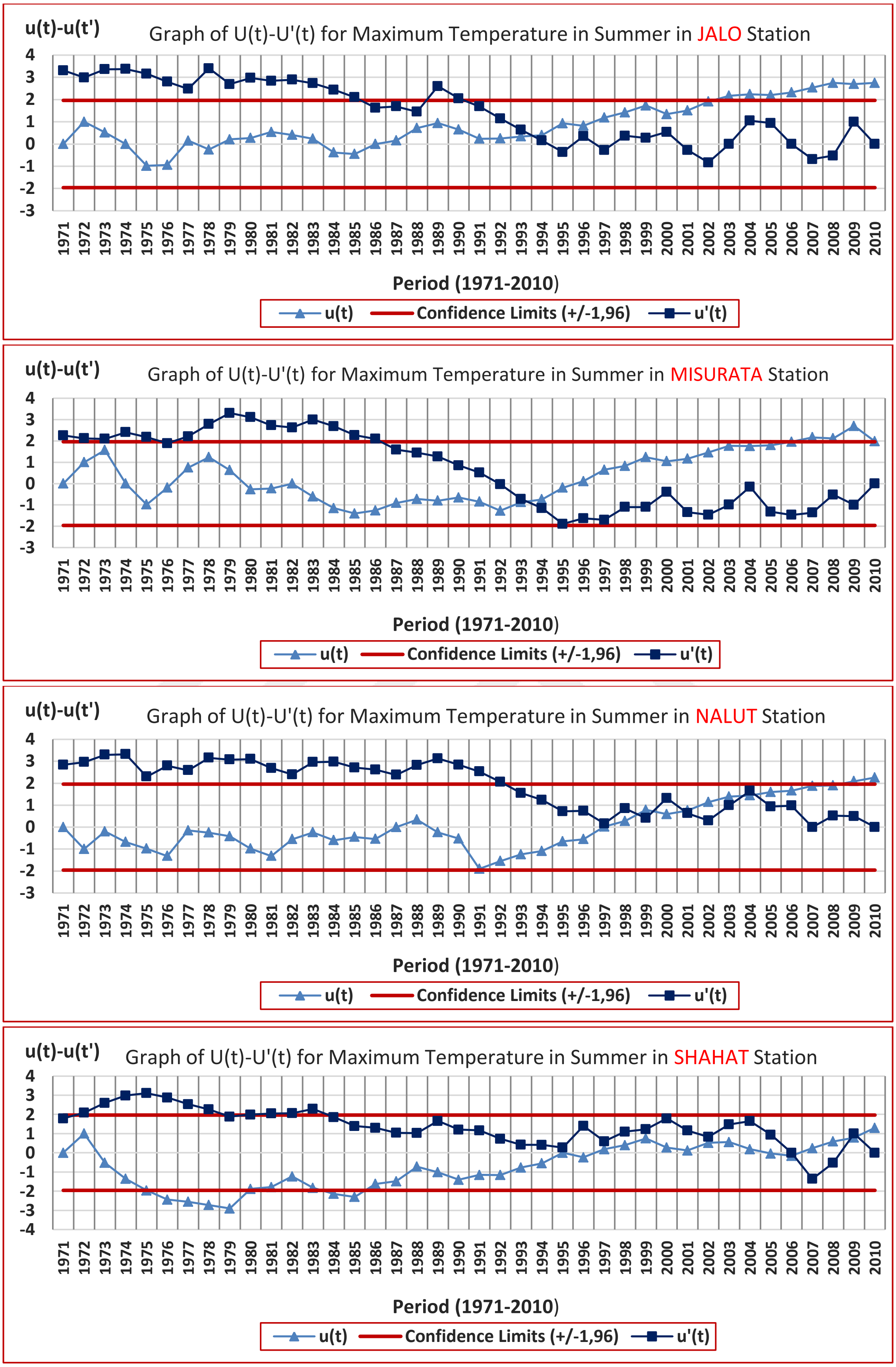


Figure 130. Graphs of M-K U(t)-U'(t) Results for Maximum Temperature in Summer in JALO, MISURATA, NALUT and SHAHAT Stations

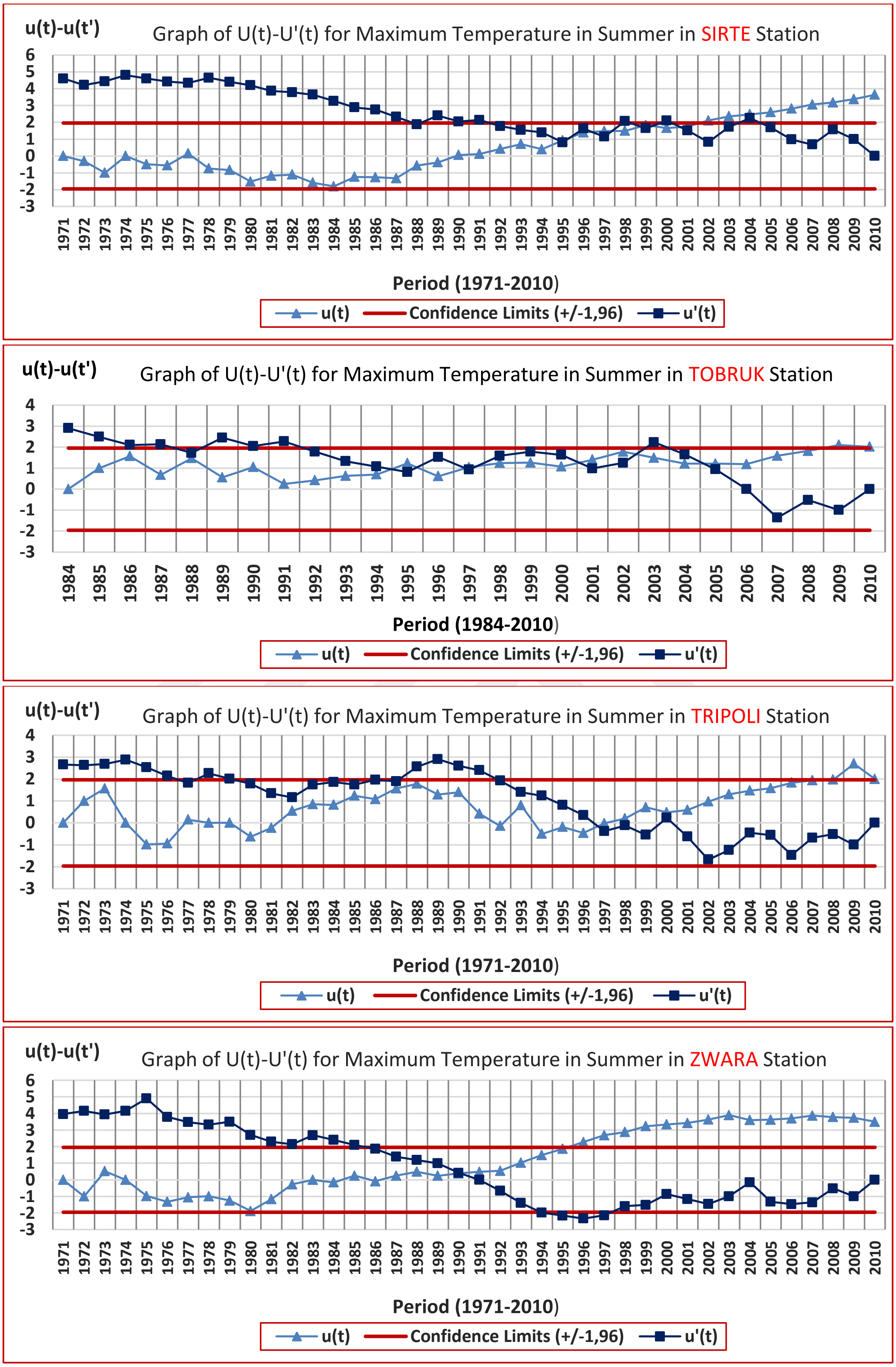
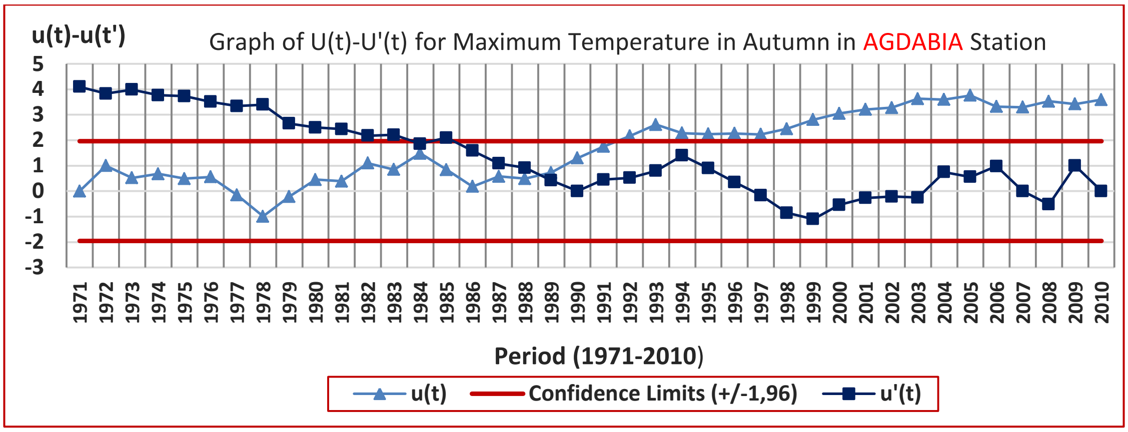
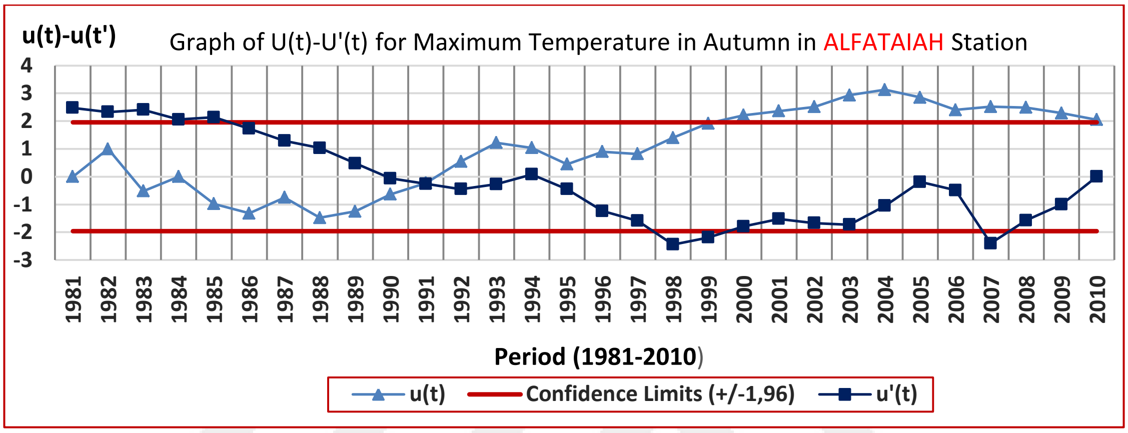
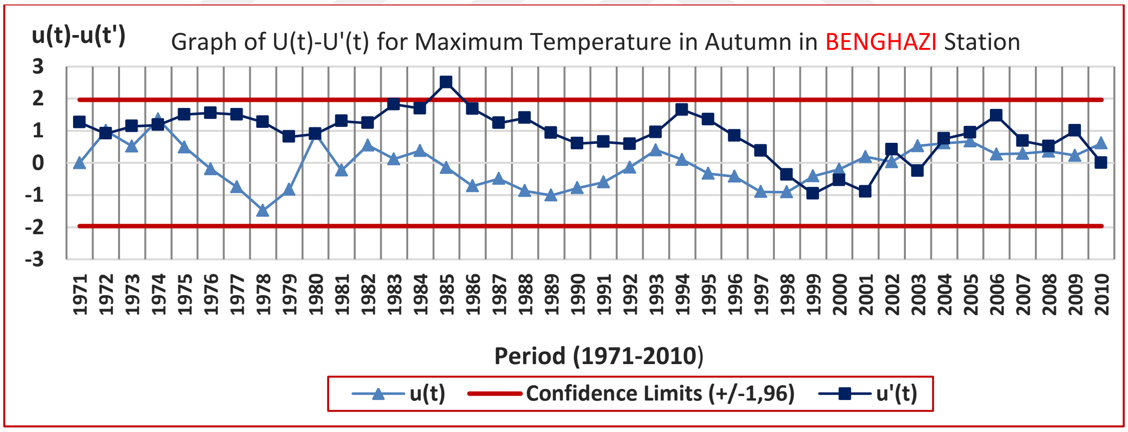


Figure 131. Graphs of M-K U(t)-U'(t) Results for Maximum Temperature in Summer in SIRTE, TOBRUK, TRIPOLI and ZWARA Stations







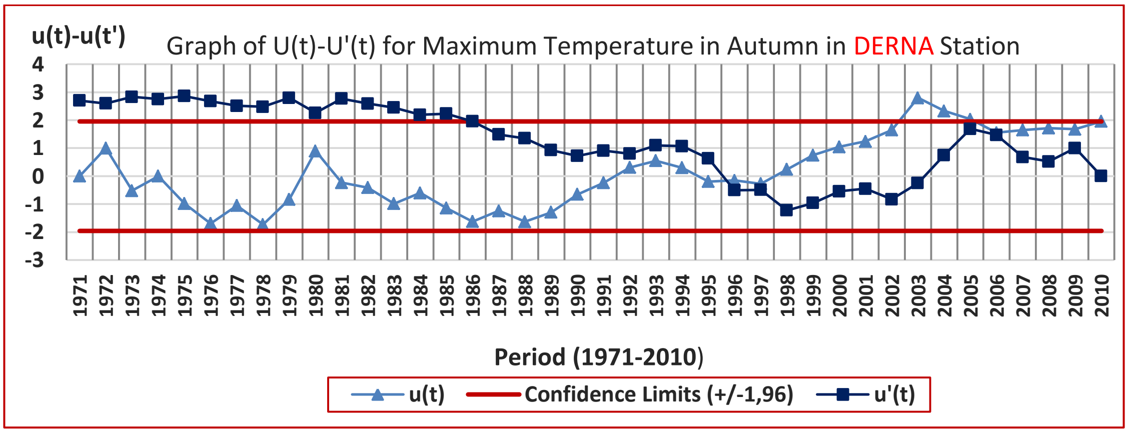


Figure 132. Graphs of M-K U(t)-U'(t) Results for Maximum Temperature in Autumnin AGDABIA, ALFATAIAH, BENGHAZI and DERNA Stations

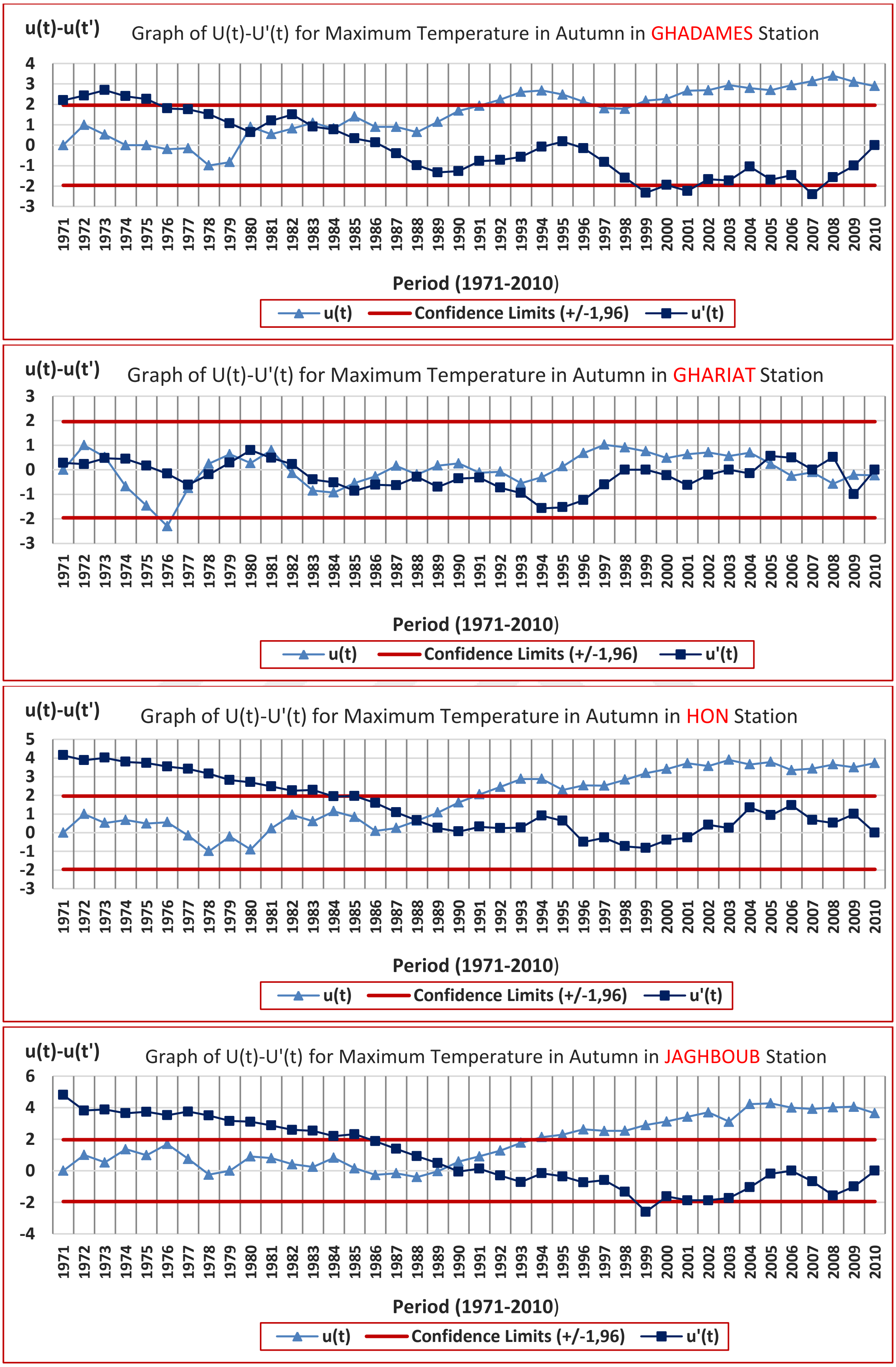


Figure 133. Graphs of M-K U(t)-U'(t) Results for Maximum Temperature in Autumnin GHADAMES, GHARIAT, HON and JAGHBOUB Stations

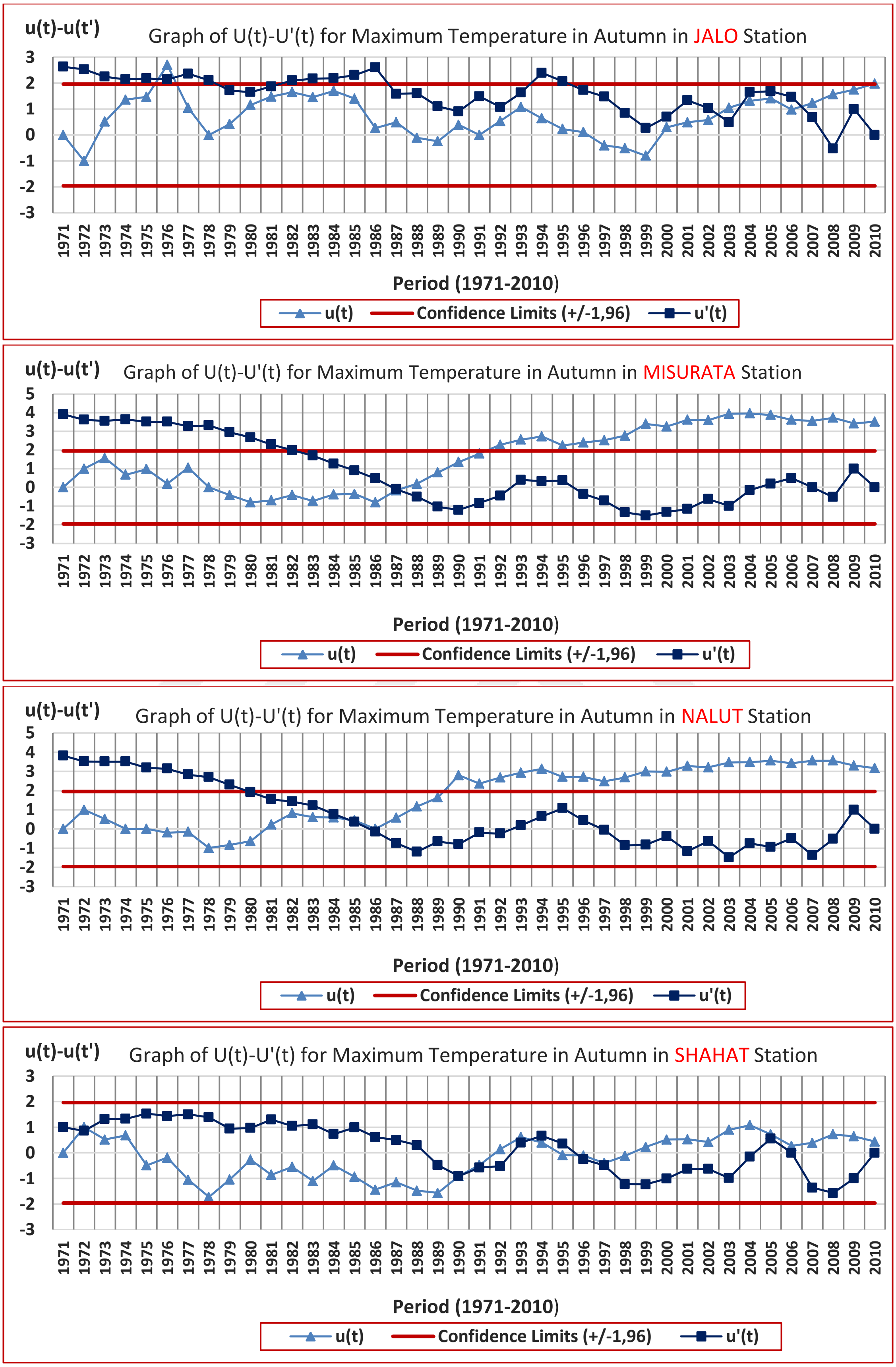


Figure 134. Graphs of M-K U(t)-U'(t) Results for Maximum Temperature in Autumn in JALO, MISURATA, NALUT and SHAHAT Stations

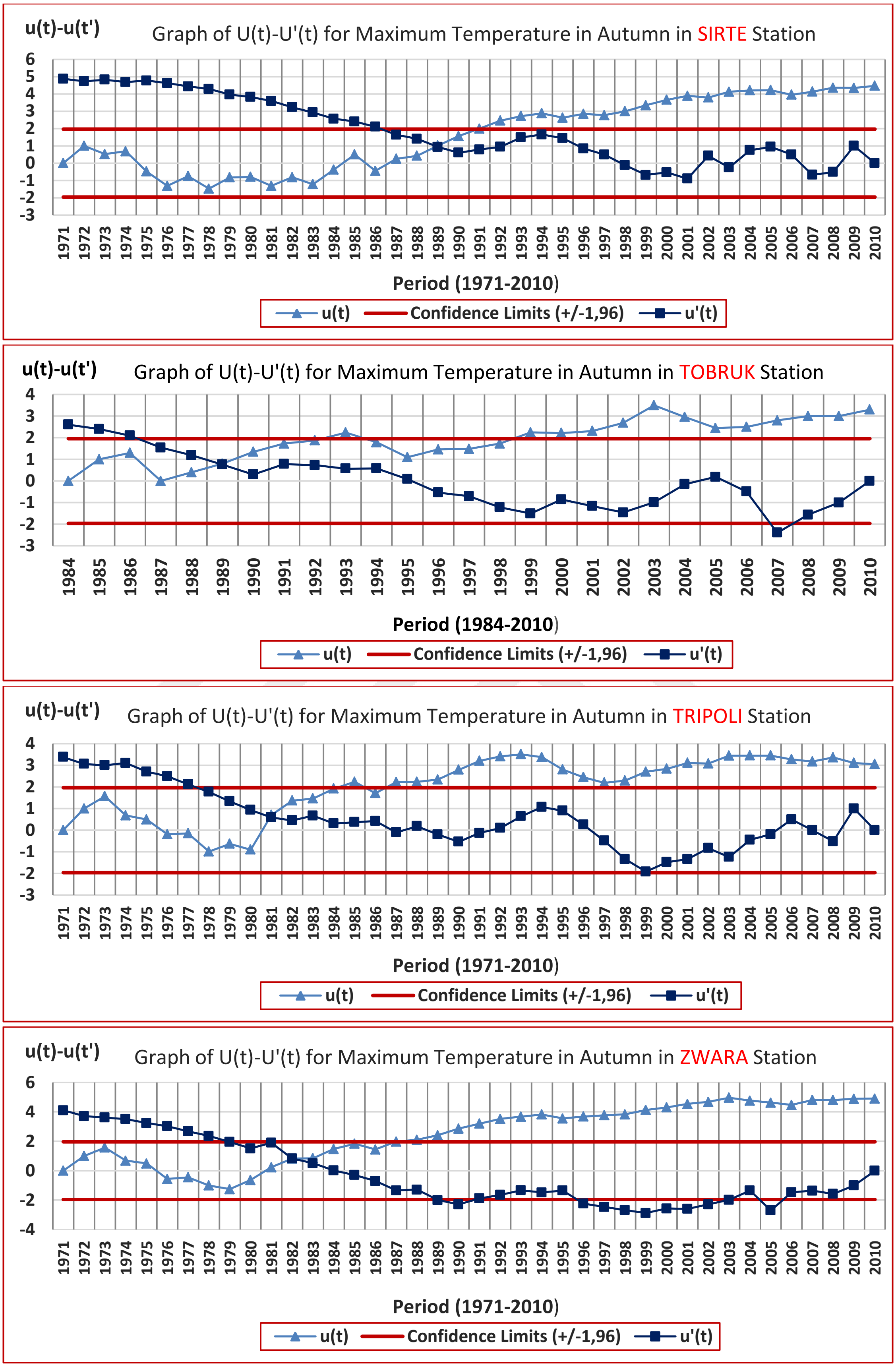


Figure 135. Graphs of M-K U(t)-U'(t) Results for Maximum Temperature in Autumn in SIRTE, TOBRUK, TRIPOLI and ZWARA Stations

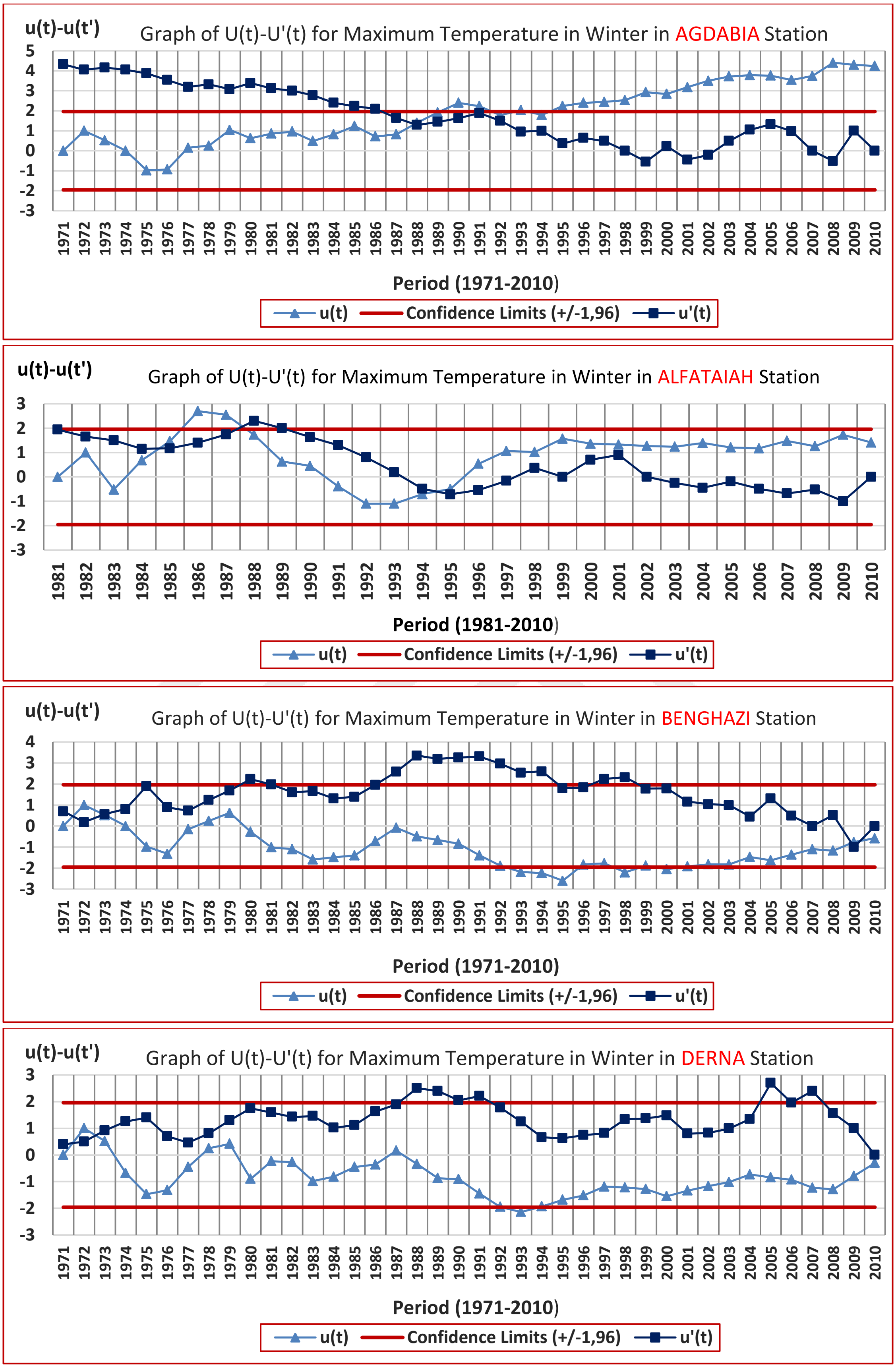


Figure 136. Graphs of M-K U(t)-U'(t) Results for Maximum Temperature in Winter in AGDABIA, ALFATAIAH, BENGHAZI and DERNA Stations

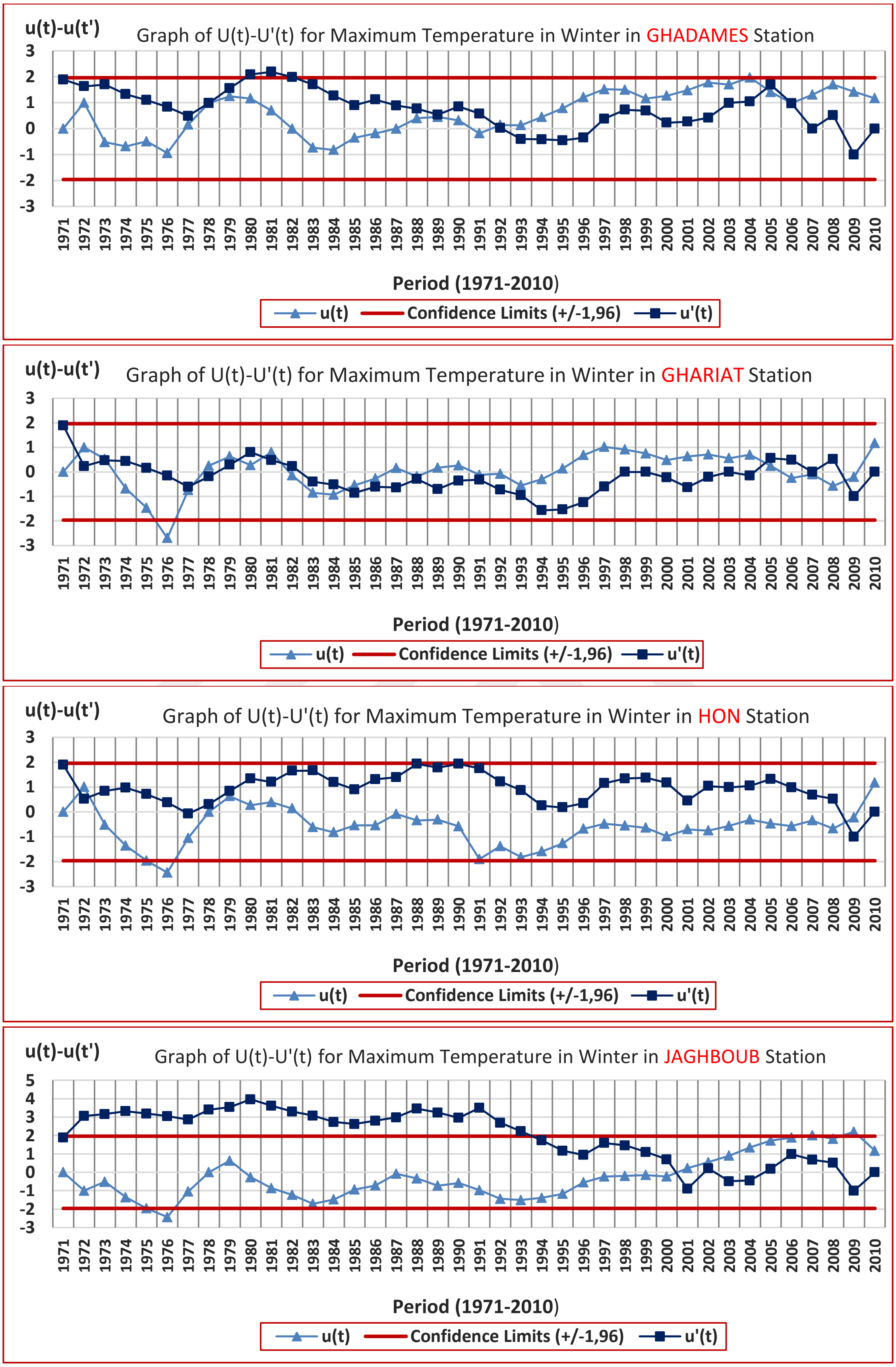


Figure 137. Graphs of M-K U(t)-U'(t) Results for Maximum Temperature in Winter in GHADAMES, GHARIAT, HON and JAGHBOUB Stations

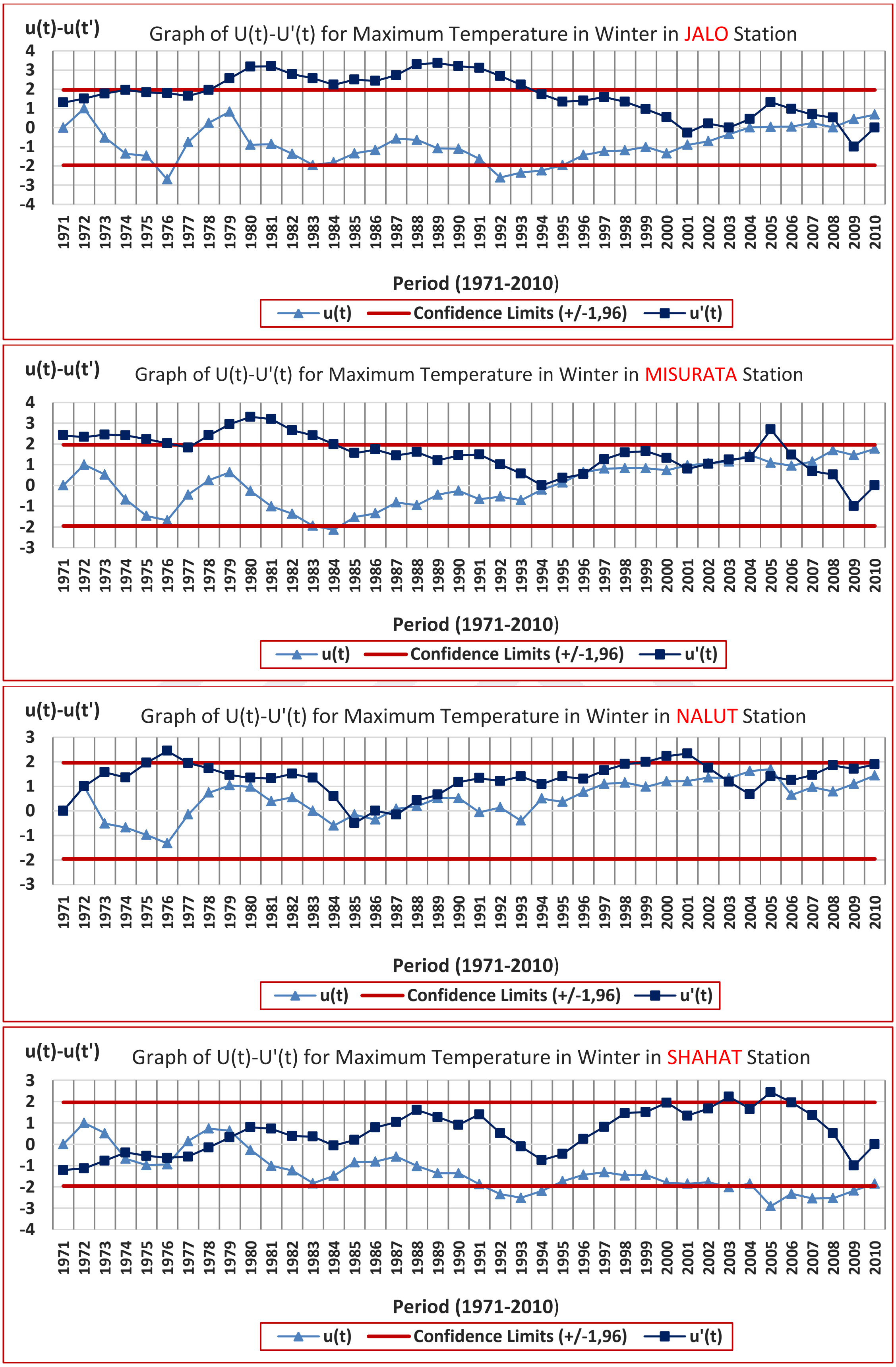


Figure 138. Graphs of M-K U(t)-U'(t) Results for Maximum Temperature in Winter in JALO, MISURATA, NALUT and SHAHAT Stations

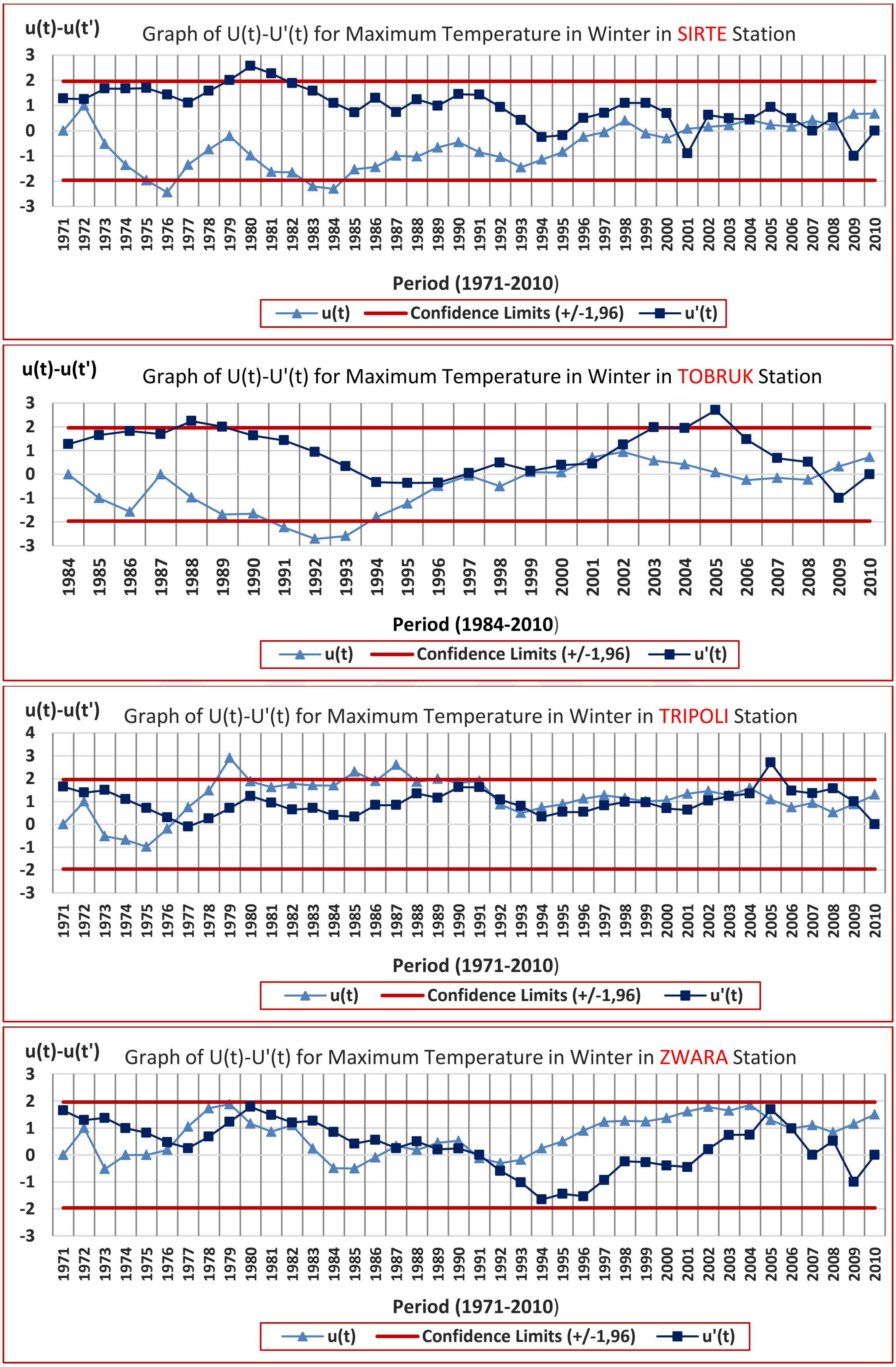


Figure 139. Graphs of M-K U(t)-U'(t) Results for Maximum Temperature in Winter in SIRTE, TOBRUK, TRIPOLI and ZWARA Stations

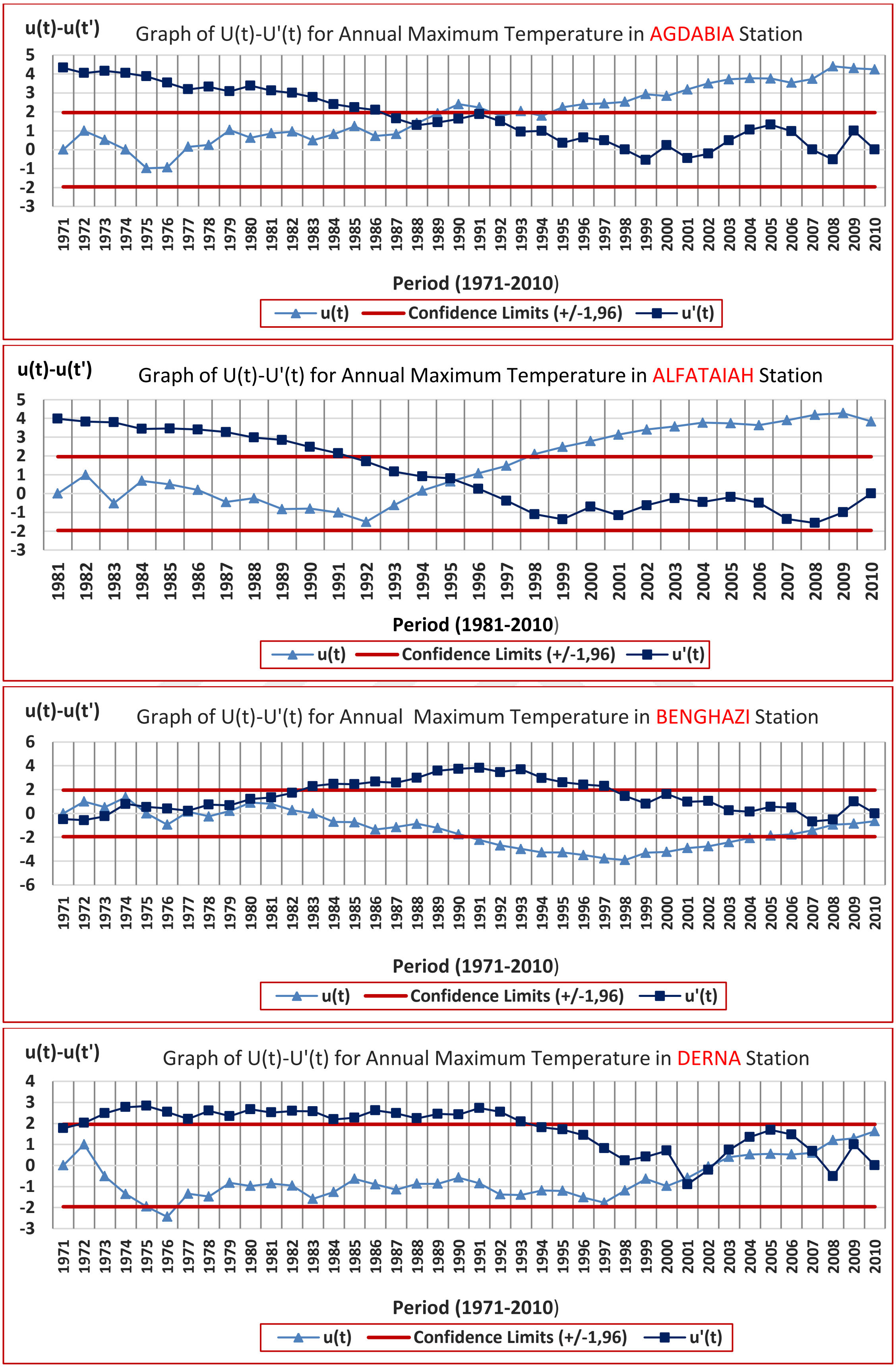


Figure 140. Graphs of M-K U(t)-U'(t) Results for Maximum Temperature in Annual in AGDABIA, ALFATAIAH, BENGHAZI and DERNA Stations

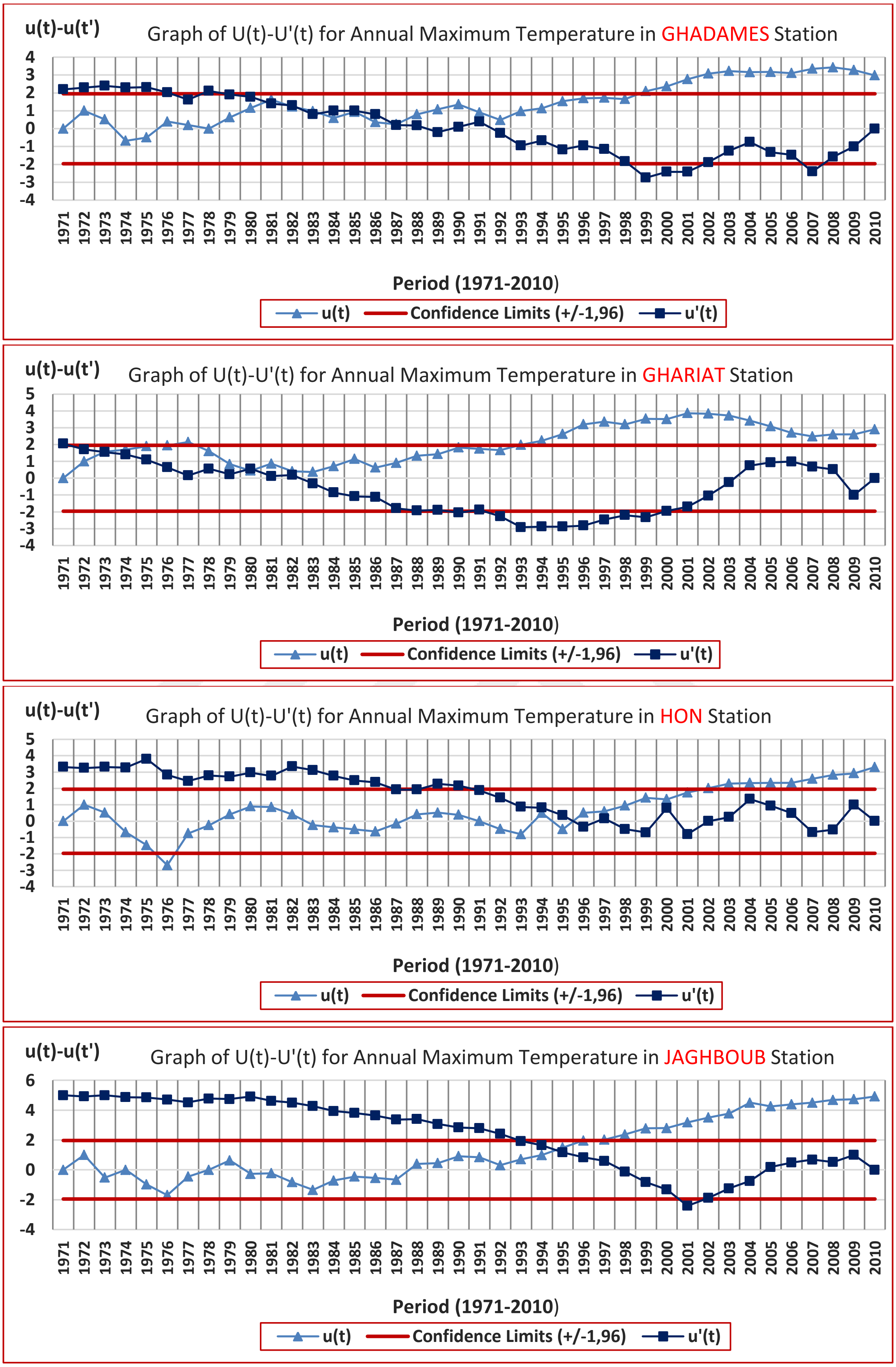
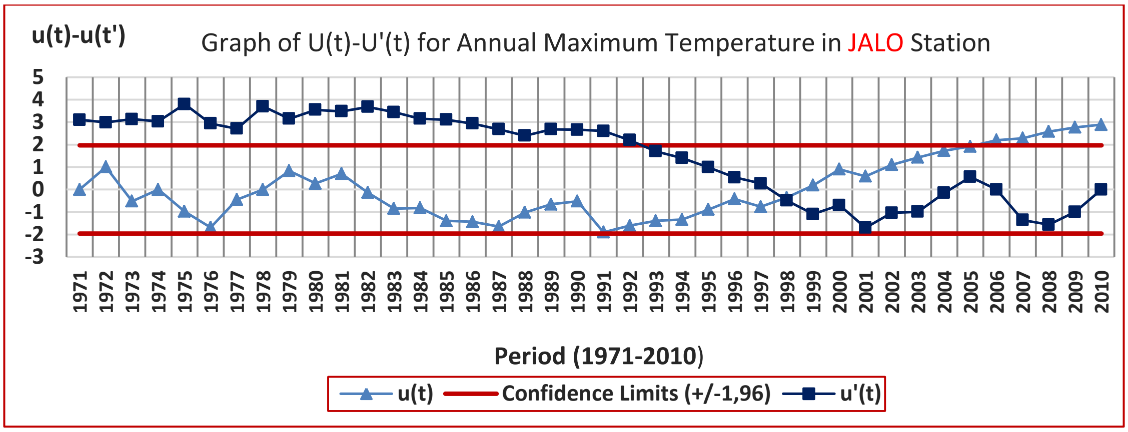
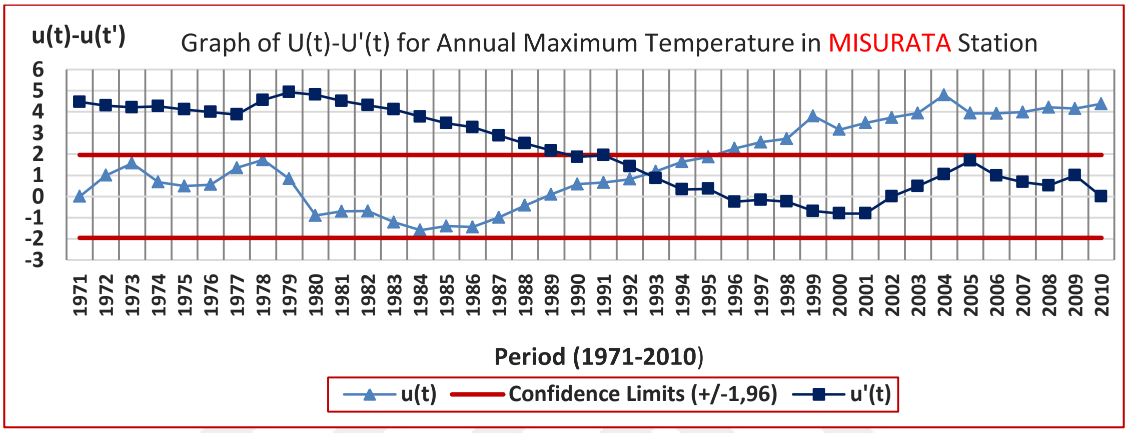
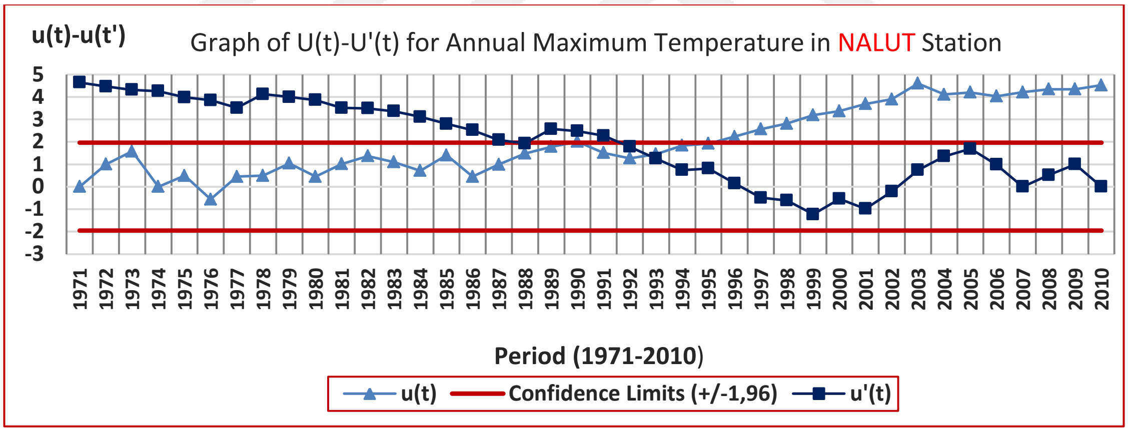


Figure 141. Graphs of M-K U(t)-U'(t) Results for Annual Maximum Temperature GHADAMES, GHARIAT, HON and JAGHBOUB Stations







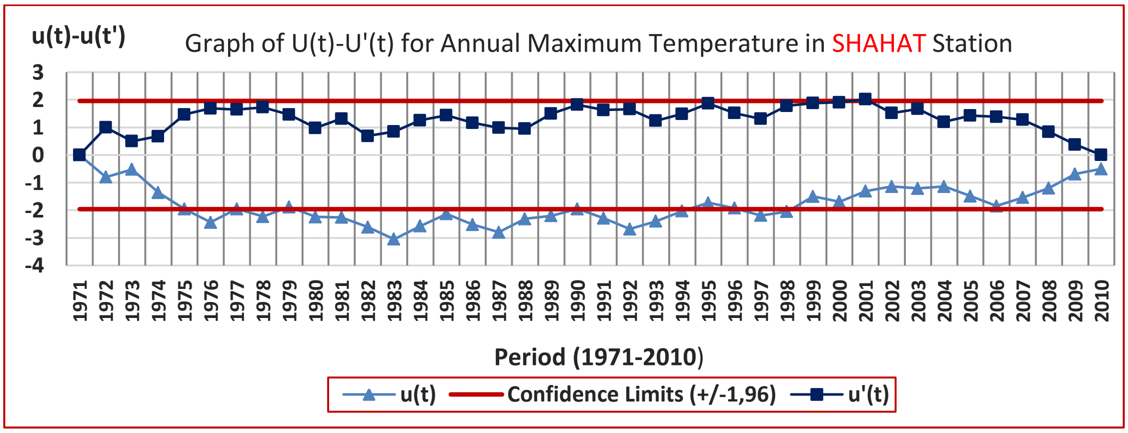
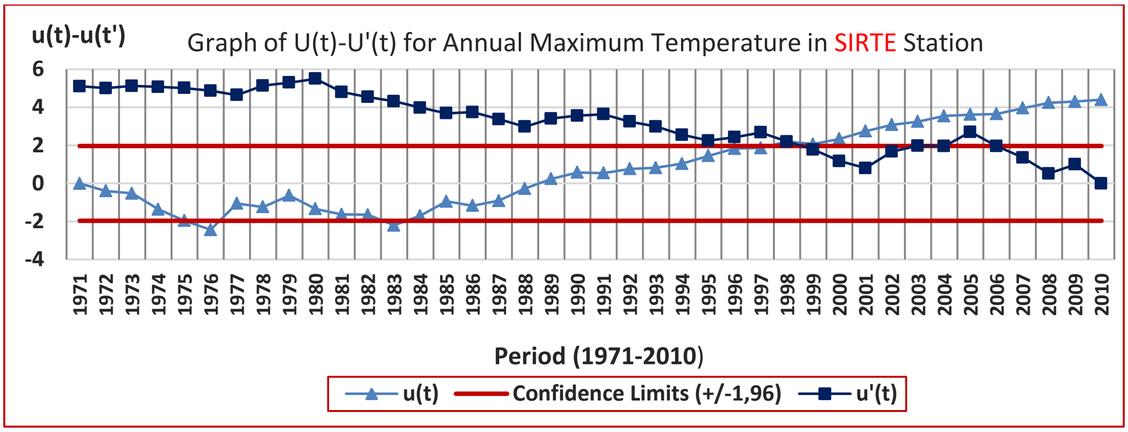
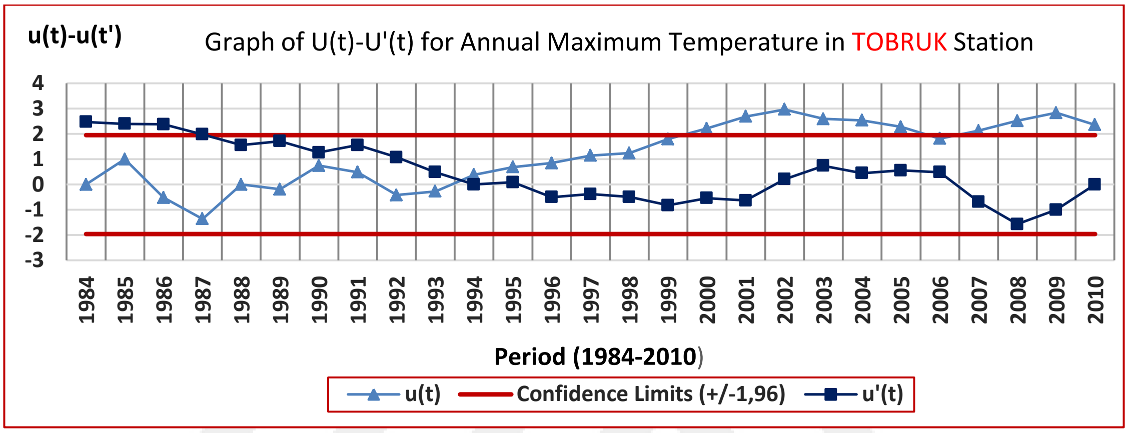
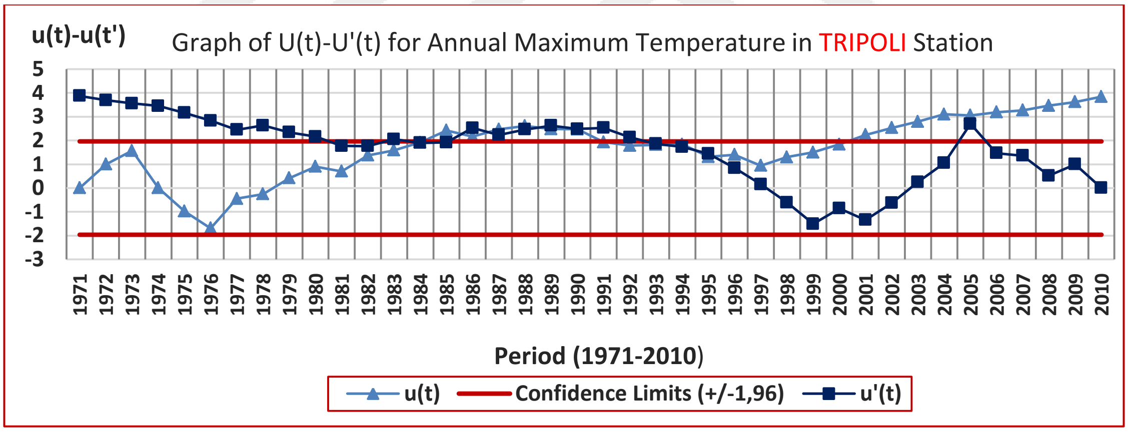


Figure 142. Graphs of M-K U(t)-U'(t) Results for Annual Maximum Temperature JALO, MISURATA, NALUT and SHAHAT Stations







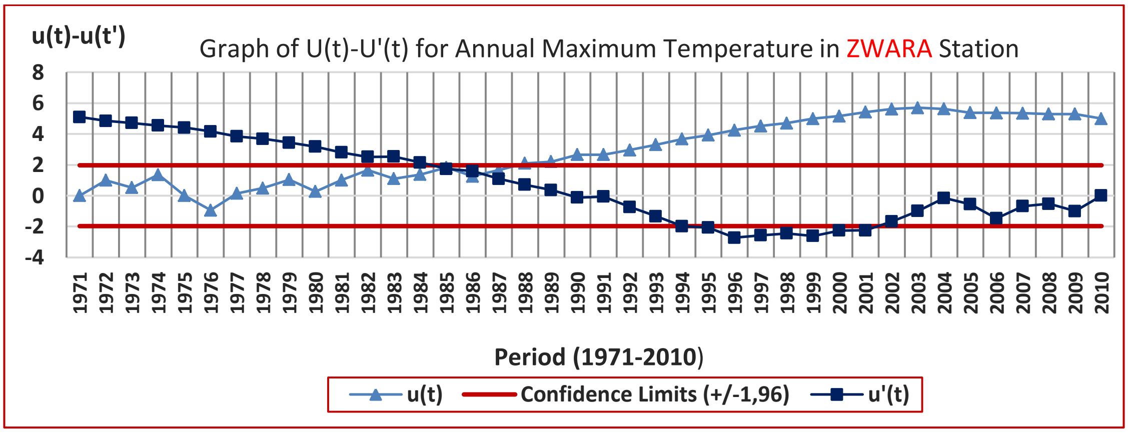
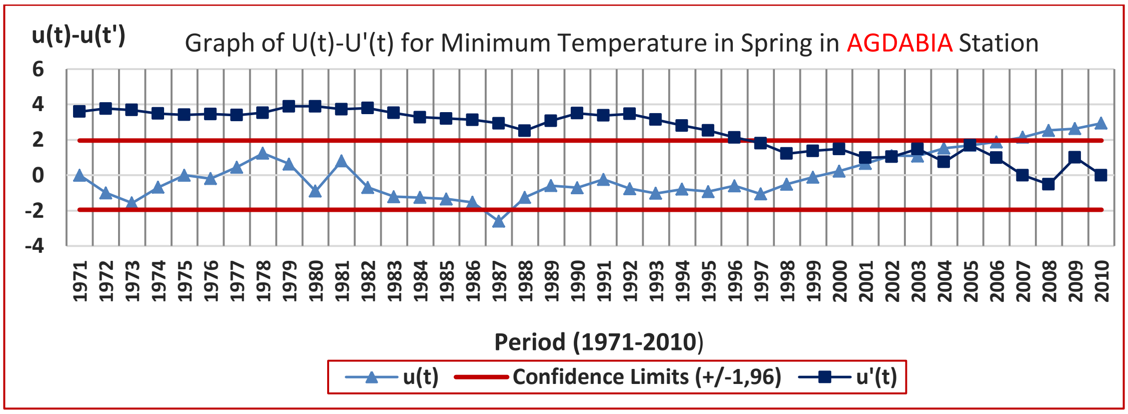
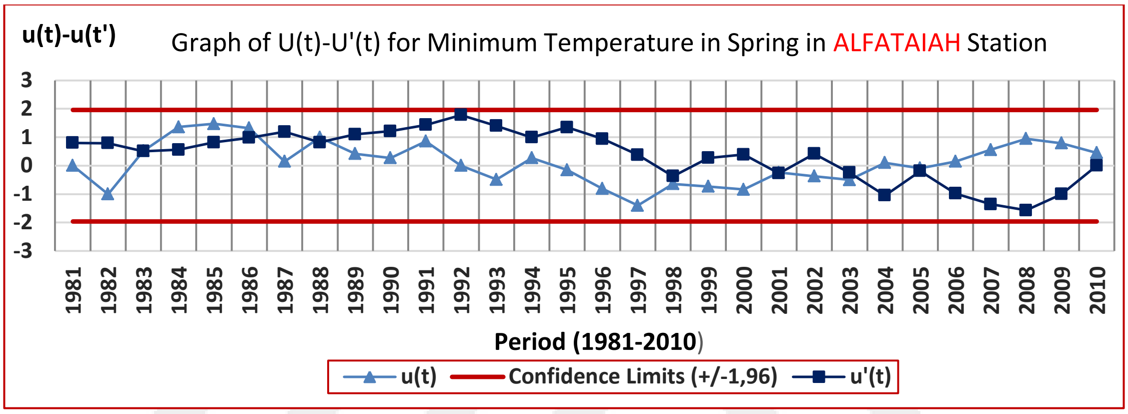
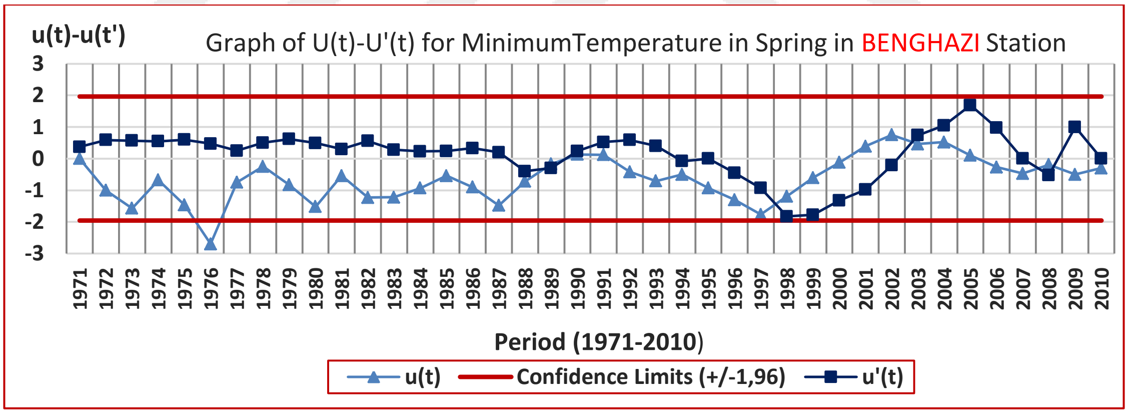


Figure 143. Graphs of M-K U(t)-U'(t) Results for Annual Maximum Temperature in SIRTE, TOBRUK, TRIPOLI and ZWARA Stations

4.1.2.2. Graphs of M-K U(t)-U'(t) Results for Seasonally and Annual Minimum Temperatures (1971-2010)







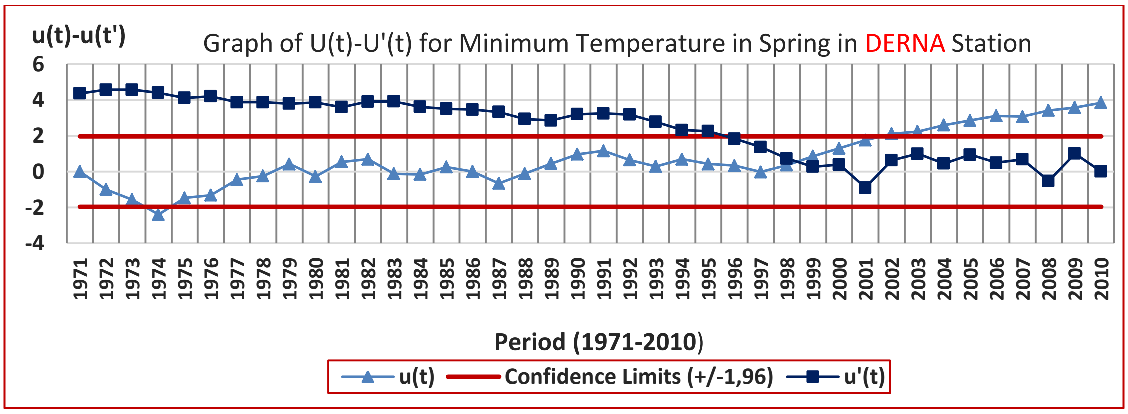
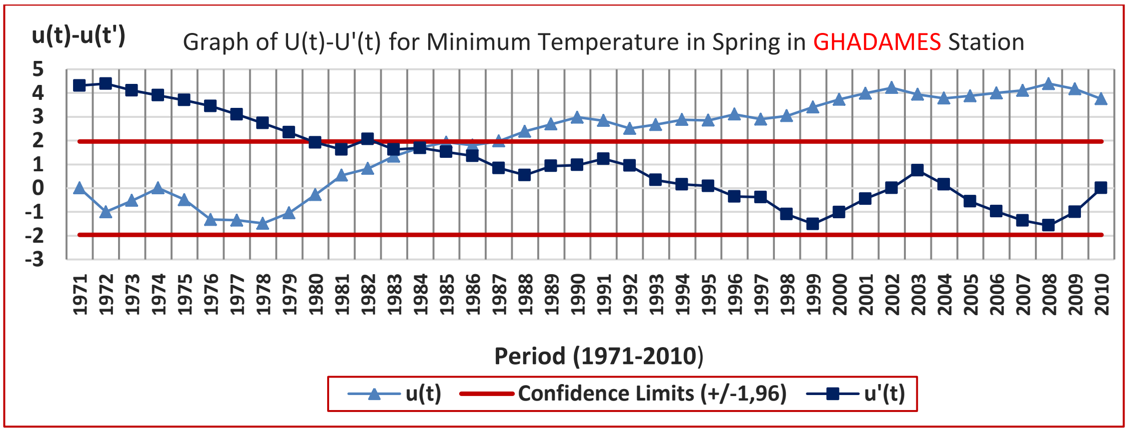
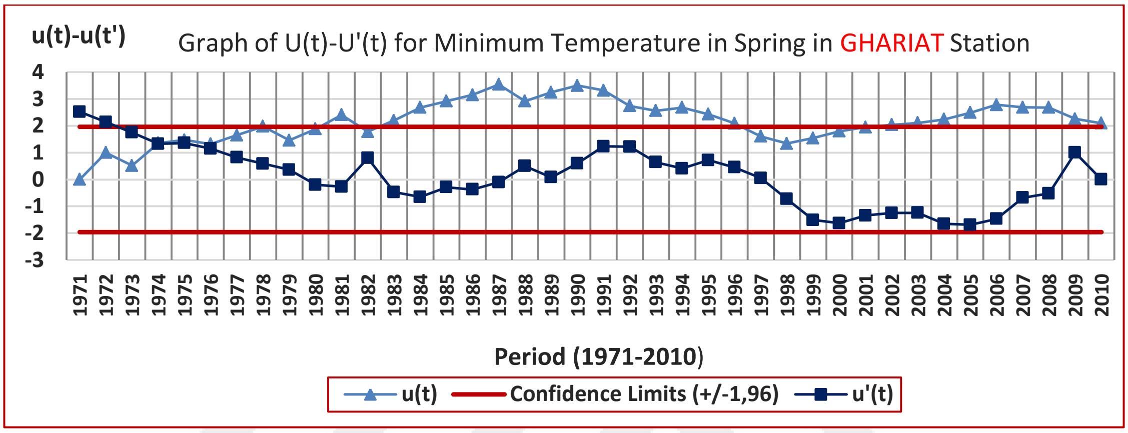
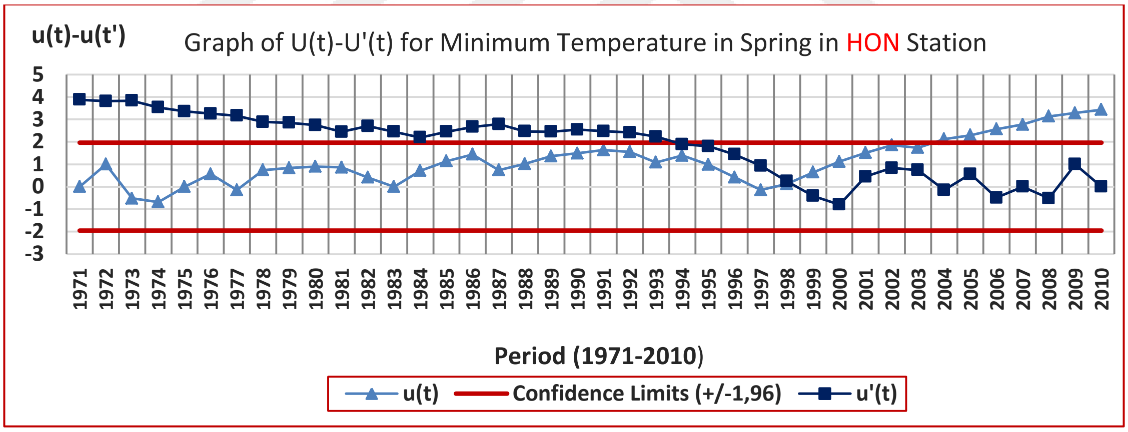


Figure 144. Graphs of M-K U(t)-U'(t) Results for Minimum Temperature in Spring in AGDABIA, ALFATAIAH, BENGHAZI and DERNA Stations







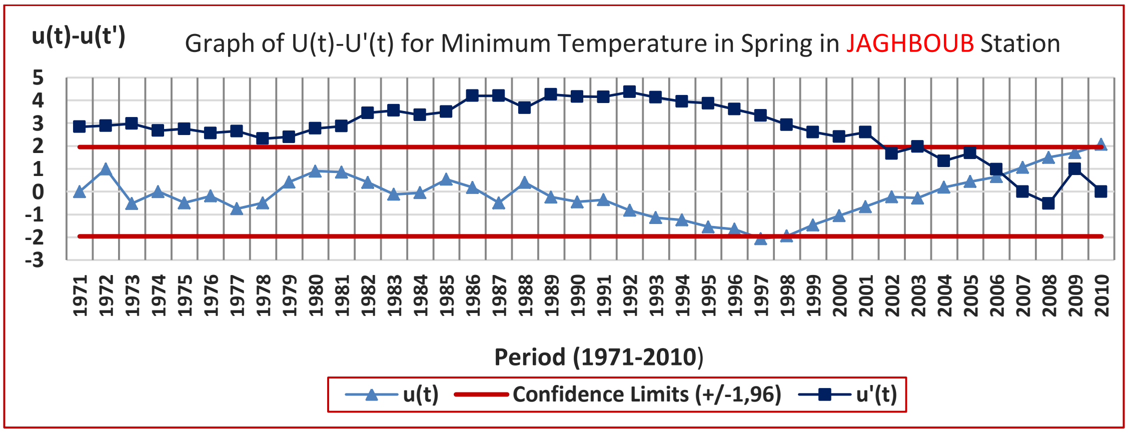


Figure 145. Graphs of M-K U(t)-U'(t) Results for Minimum Temperature in Spring in GHADAMES, GHARIAT, HON and JAGHBOUB Stations

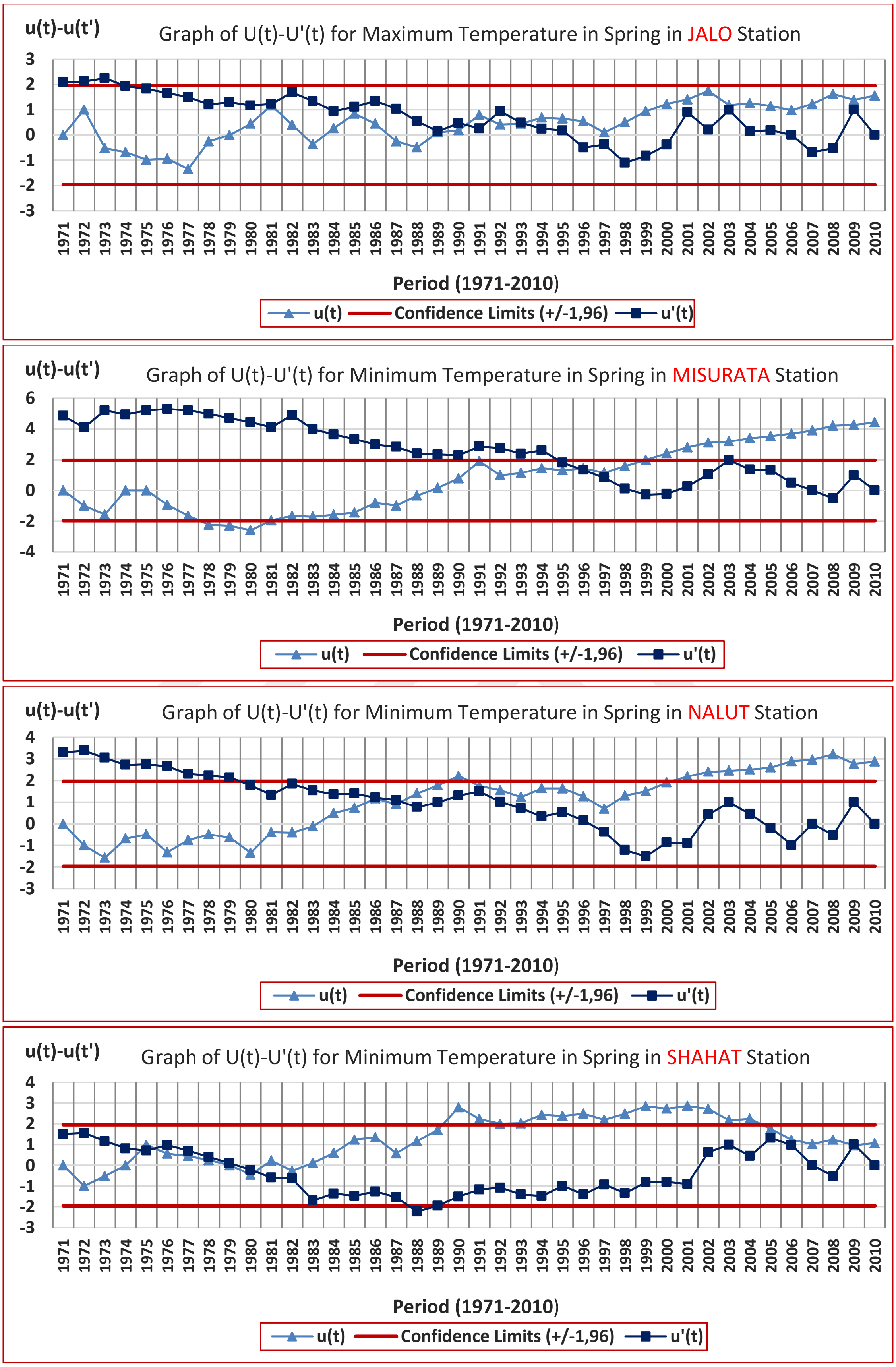


Figure 146. Graphs of M-K U(t)-U'(t) Results for Minimum Temperature in Spring in JALO, MISURATA, NALUT and SHAHAT Stations

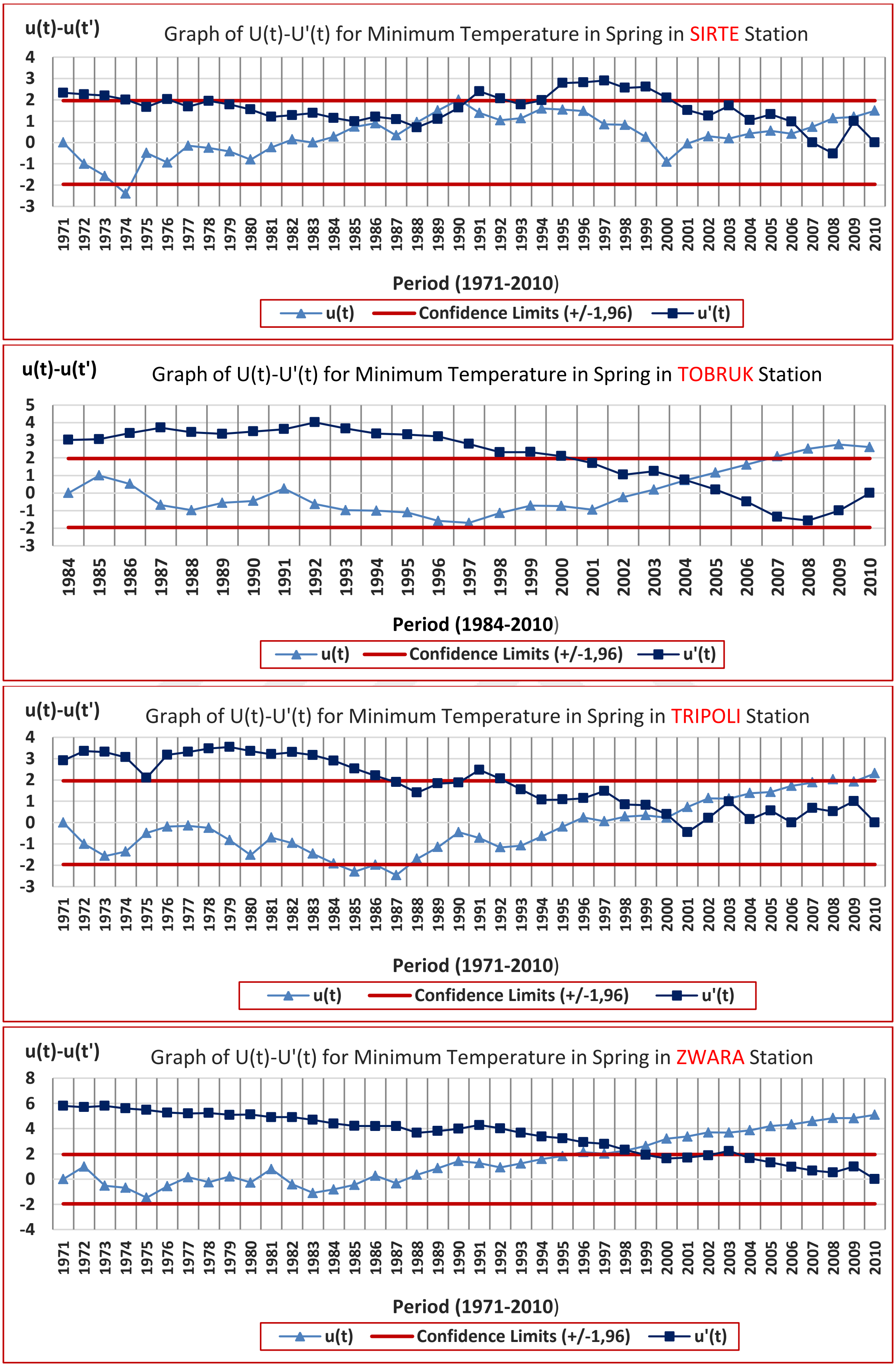


Figure 147. Graphs of M-K U(t)-U'(t) Results for Minimum Temperature in Spring in SIRTE, TOBRUK, TRIPOLI and ZWARA Stations

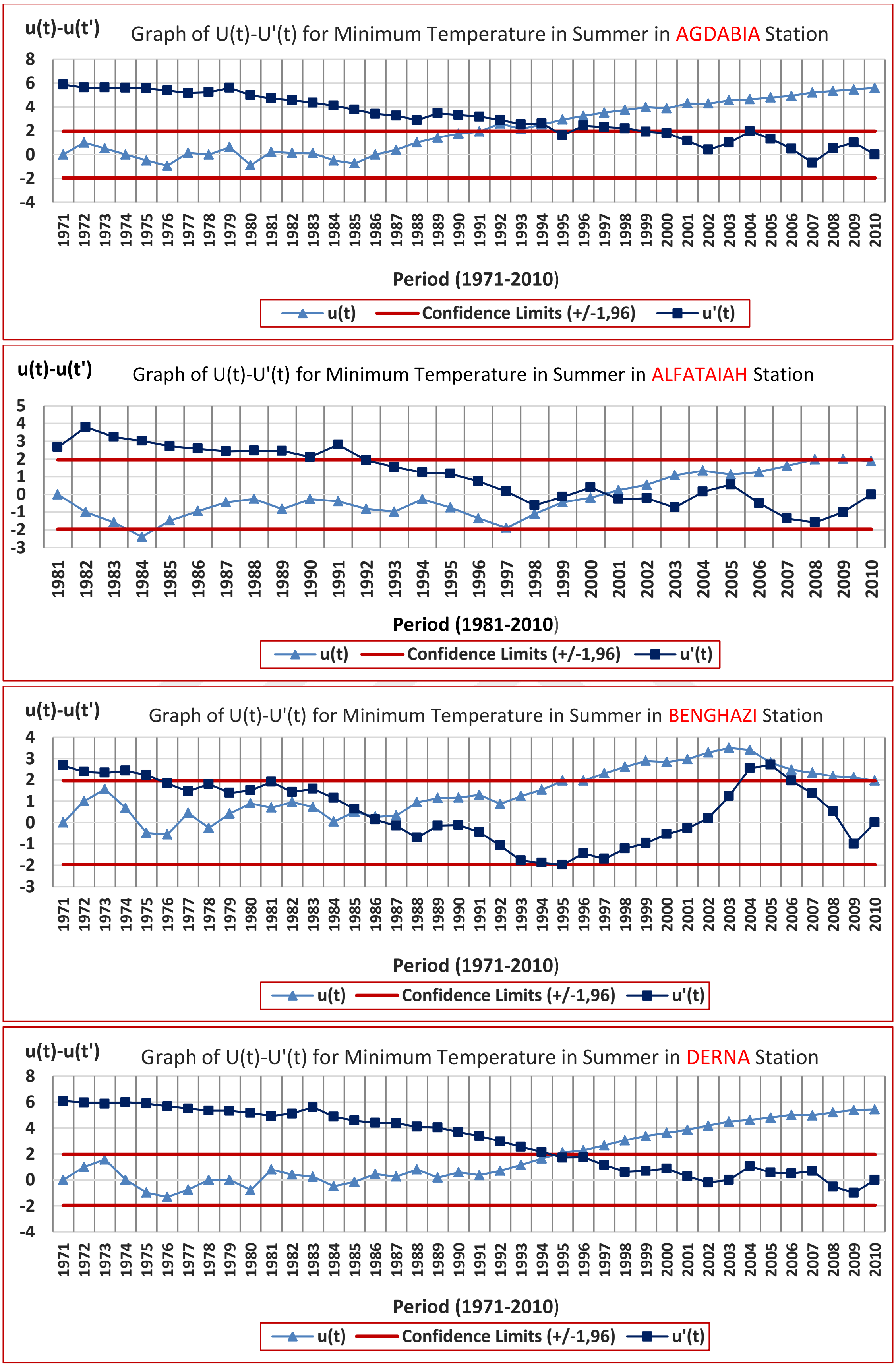


Figure 148. Graphs of M-K U(t)-U'(t) Results for Minimum Temperature in Summer in AGDABIA, ALFATAIAH, BENGHAZI and DERNA Stations

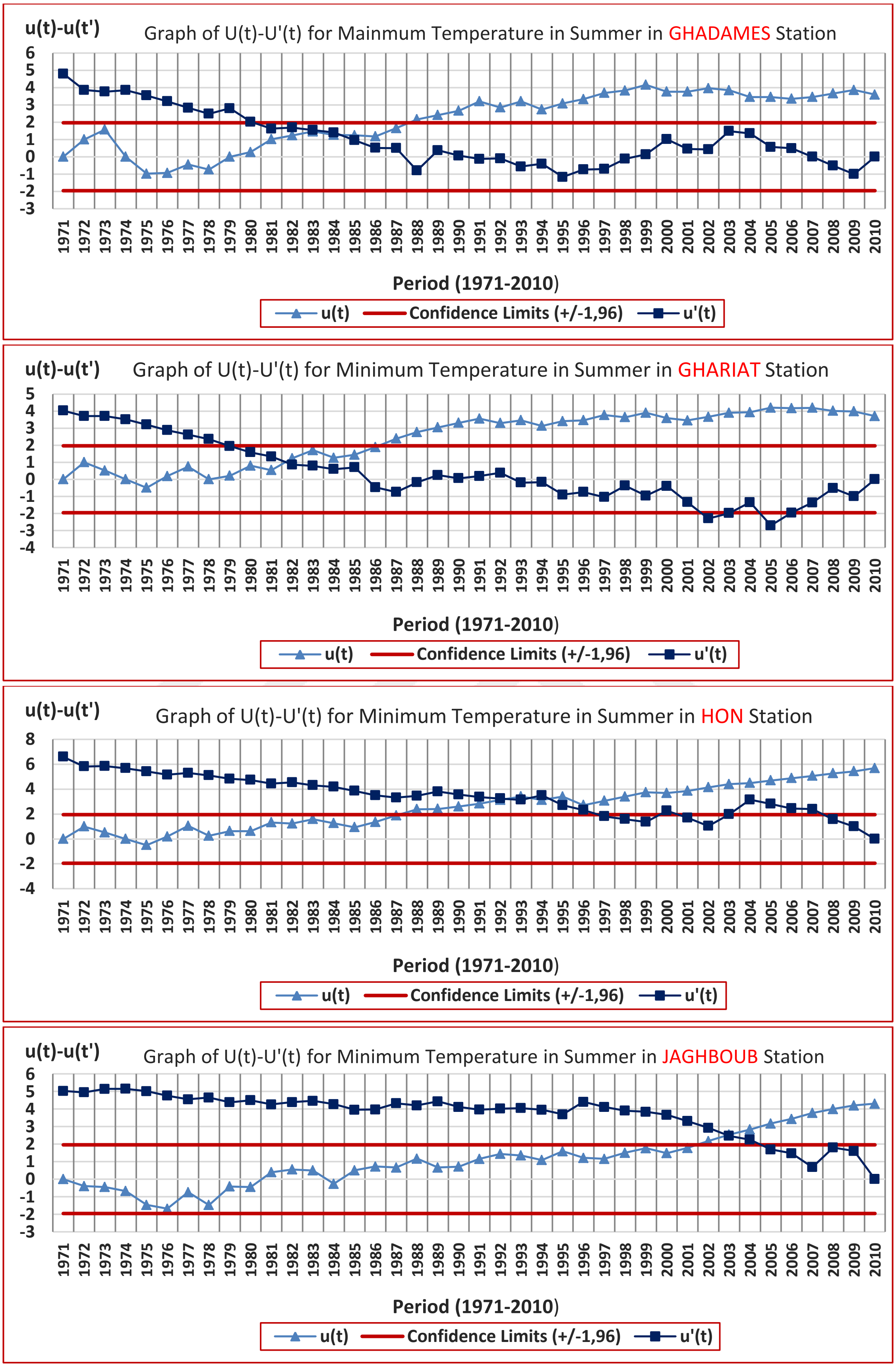


Figure 149. Graphs of M-K U(t)-U'(t) Results for Minimum Temperature in Summer in GHADAMES, GHARIAT, HON and JAGHBOUB Stations

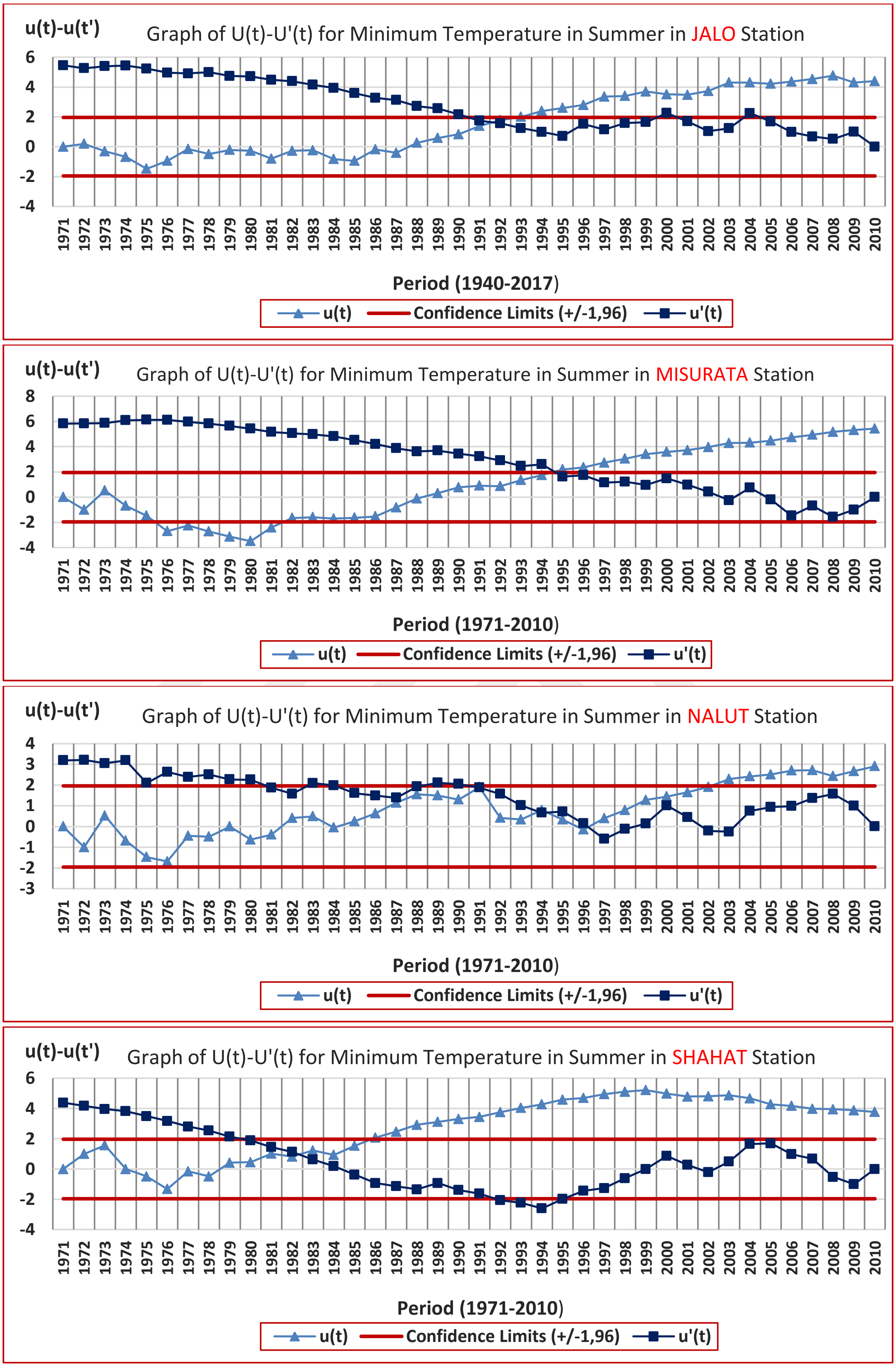


Figure 150. Graphs of M-K U(t)-U'(t) Results for Minimum Temperature in Summer in JALO, MISURATA, NALUT and SHAHAT Stations

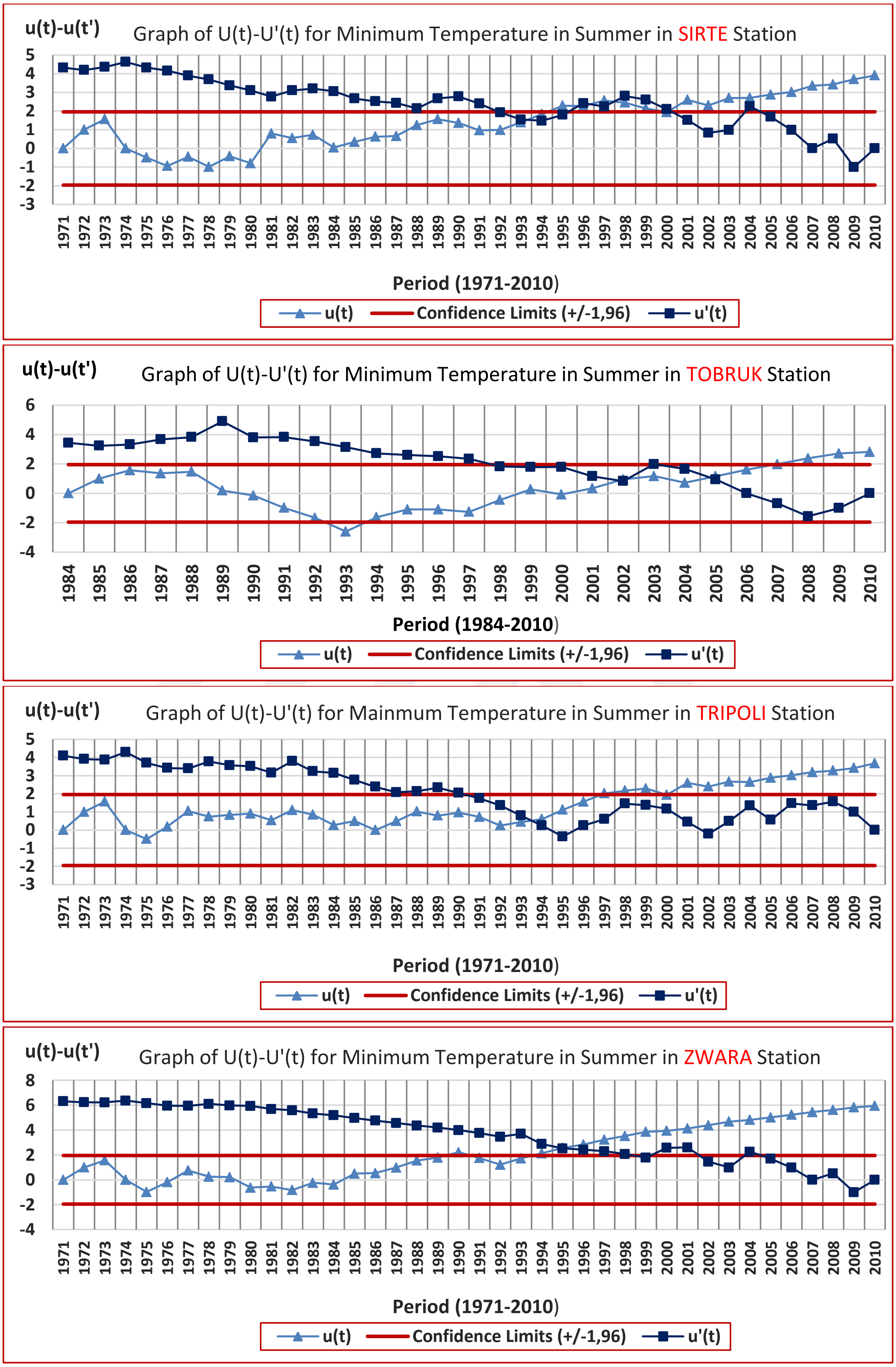
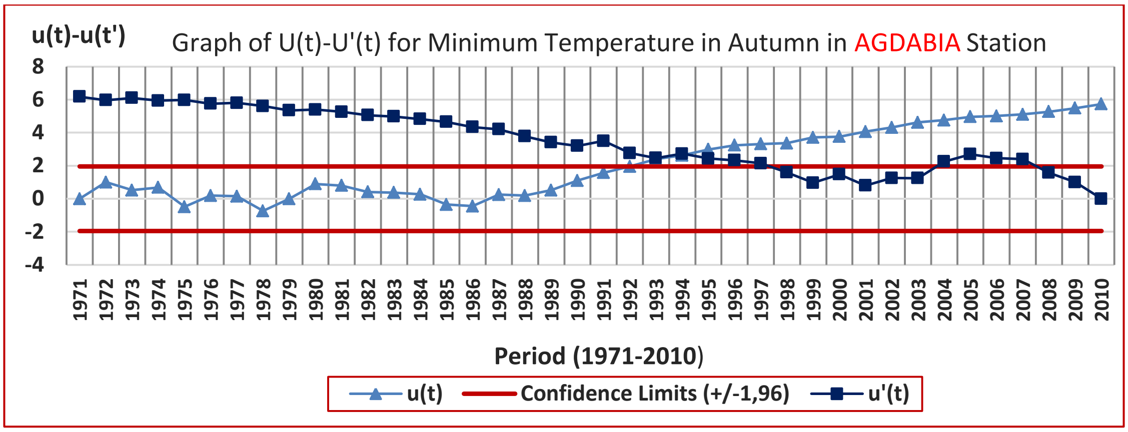
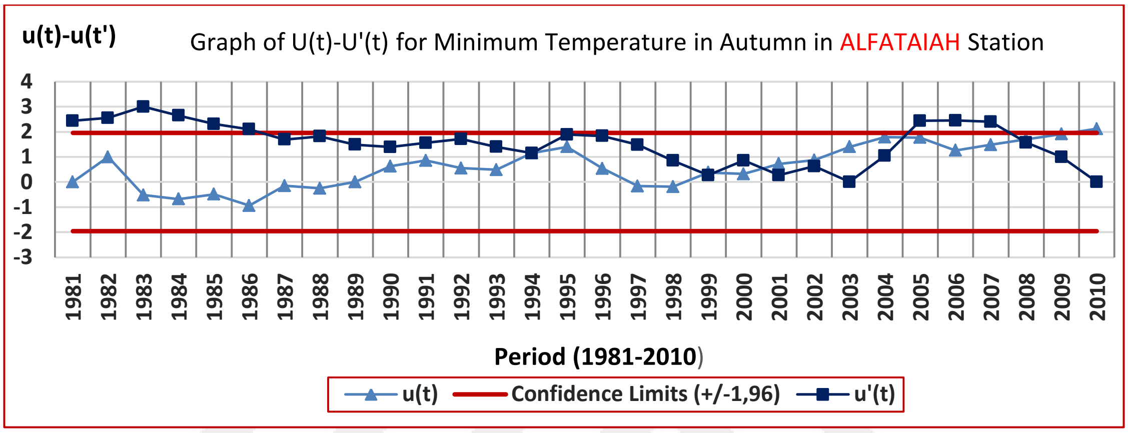
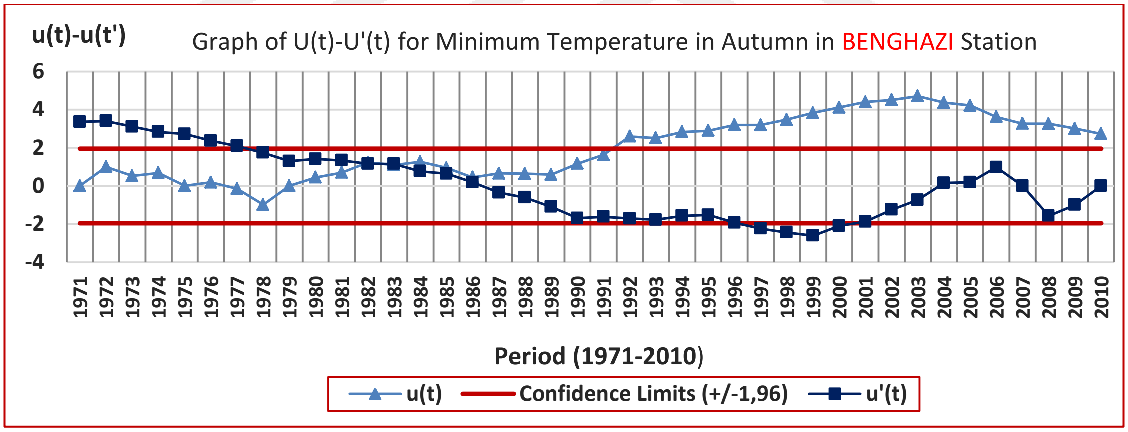


Figure 151. Graphs of M-K U(t)-U'(t) Results for Minimum Temperature in Summer in SIRTE, TOBRUK, TRIPOLI and ZWARA Stations







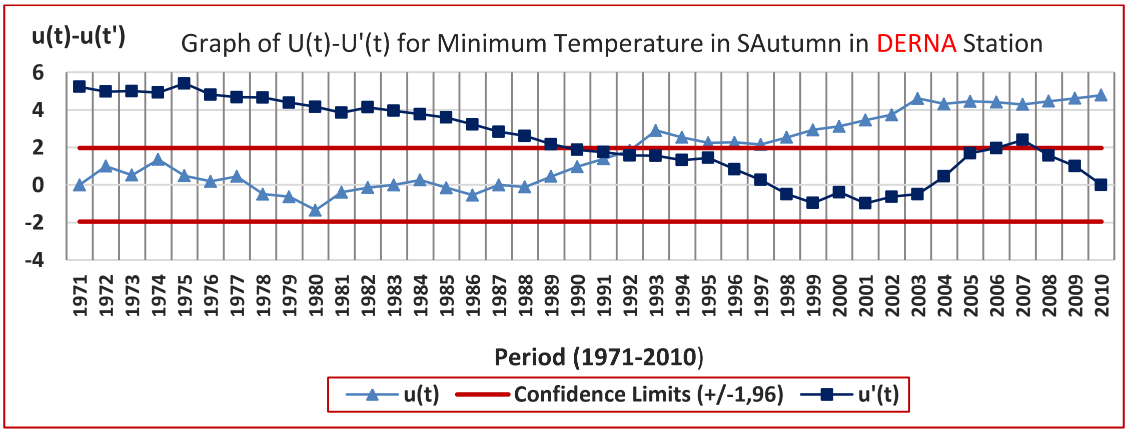


Figure 152. Graphs of M-K U(t)-U'(t) Results for Minimum Temperature in Autumn in AGDABIA, ALFATAIAH, BENGHAZI and DERNA Stations

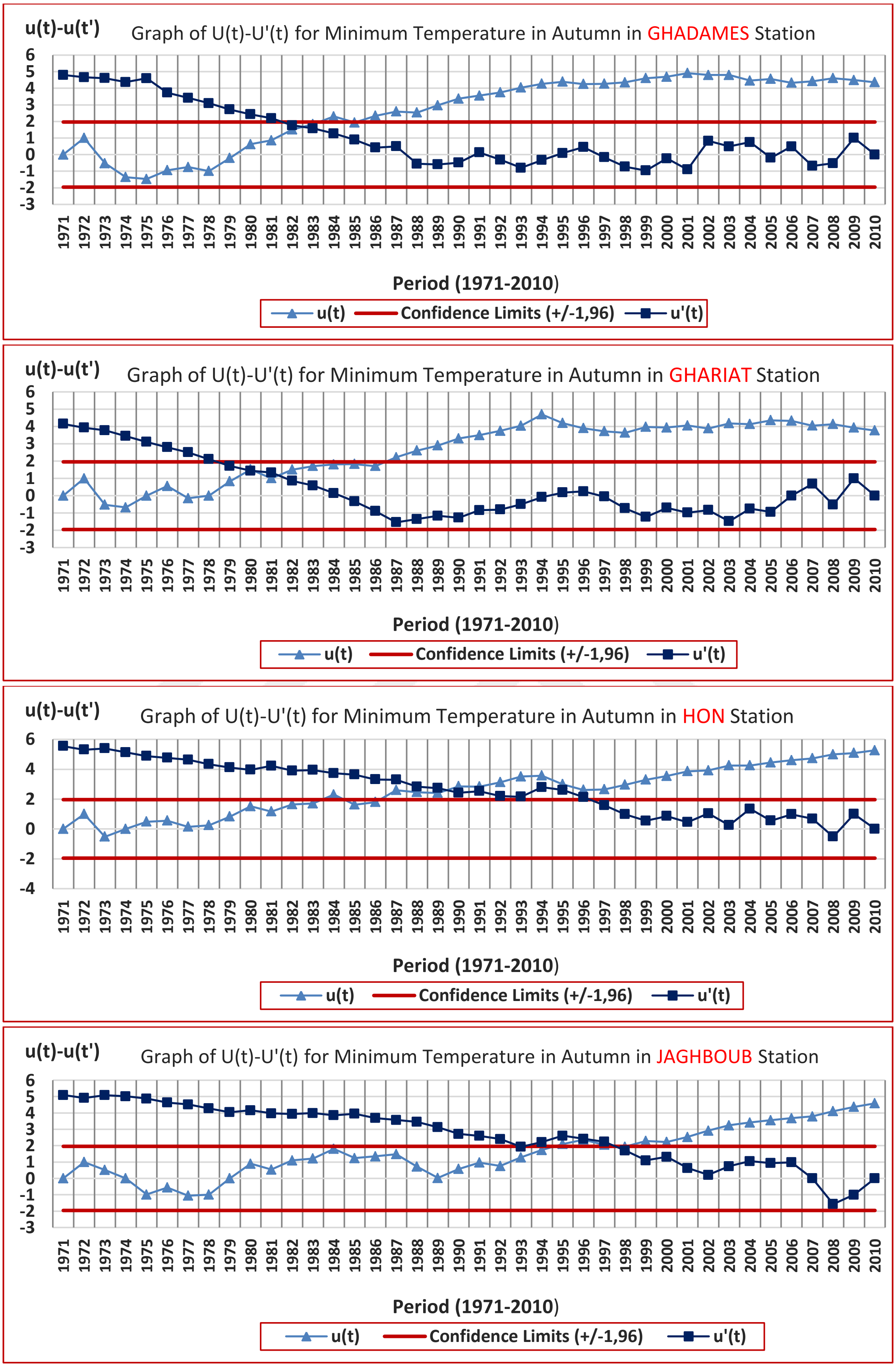
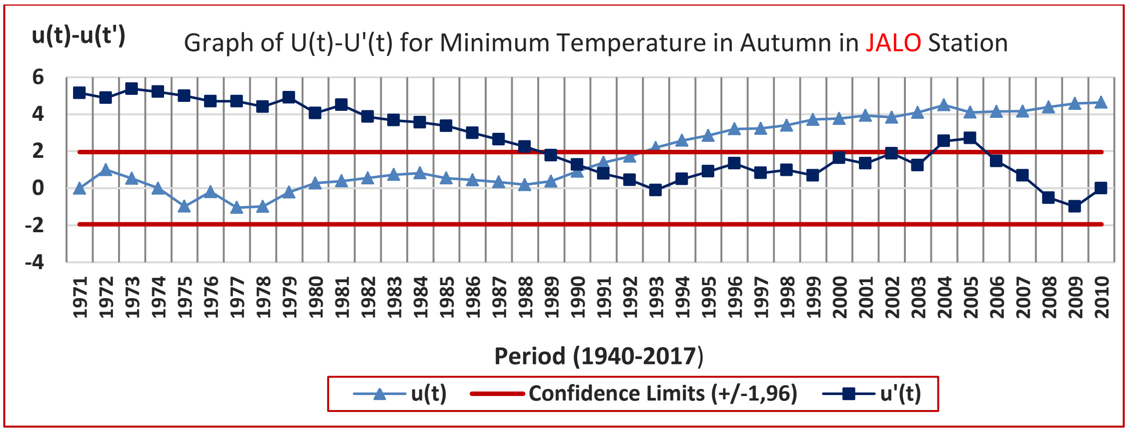
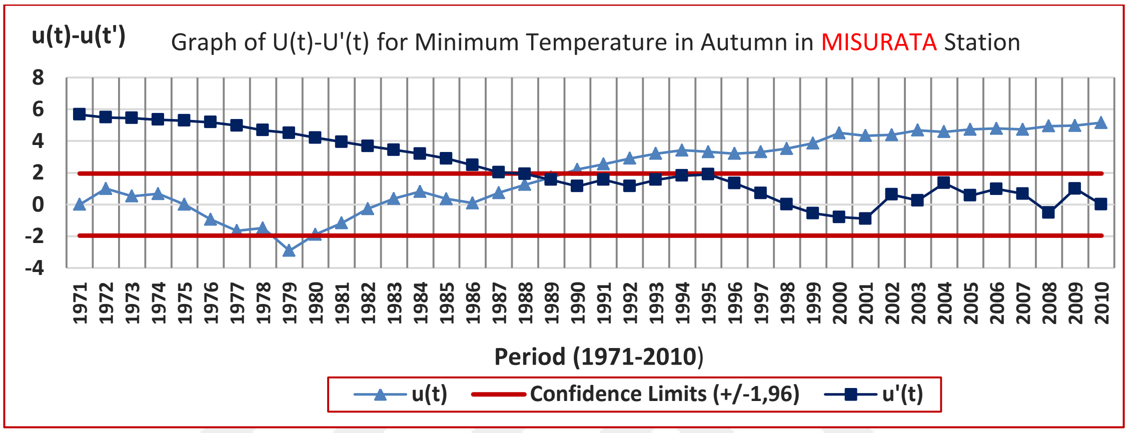
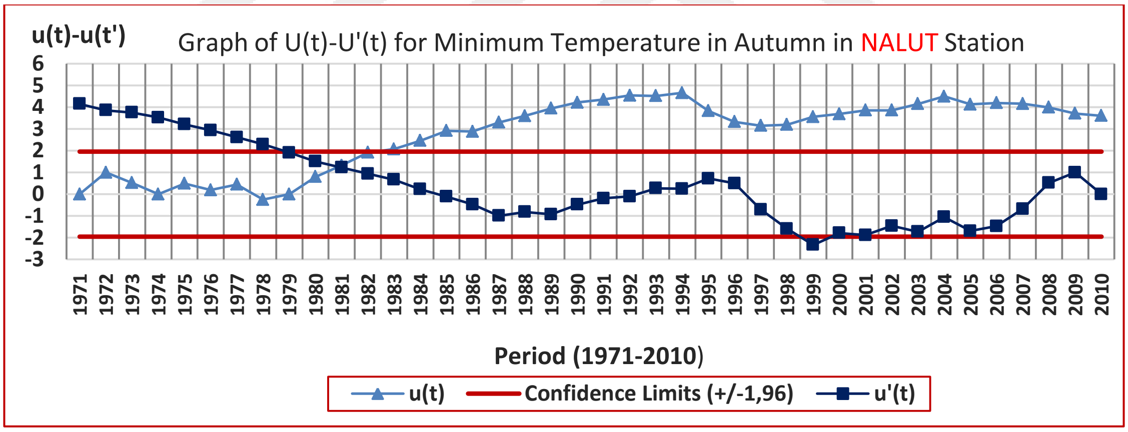


Figure 153. Graphs of M-K U(t)-U'(t) Results for Minimum Temperature in Autumn in GHADAMES, GHARIAT, HON and JAGHBOUB Stations







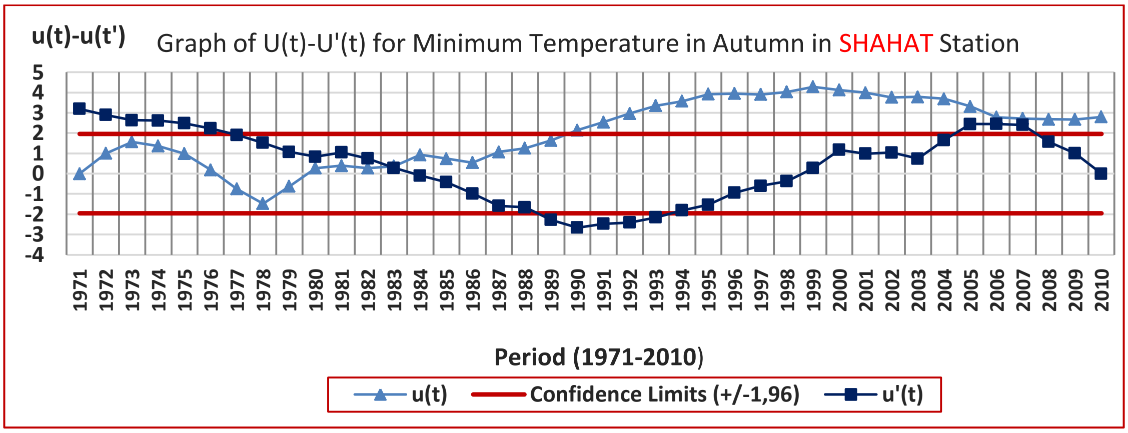


Figure 154. Graphs of M-K U(t)-U'(t) Results for Minimum Temperature in Autumn in JALO, MISURATA, NALUT and SHAHAT Stations

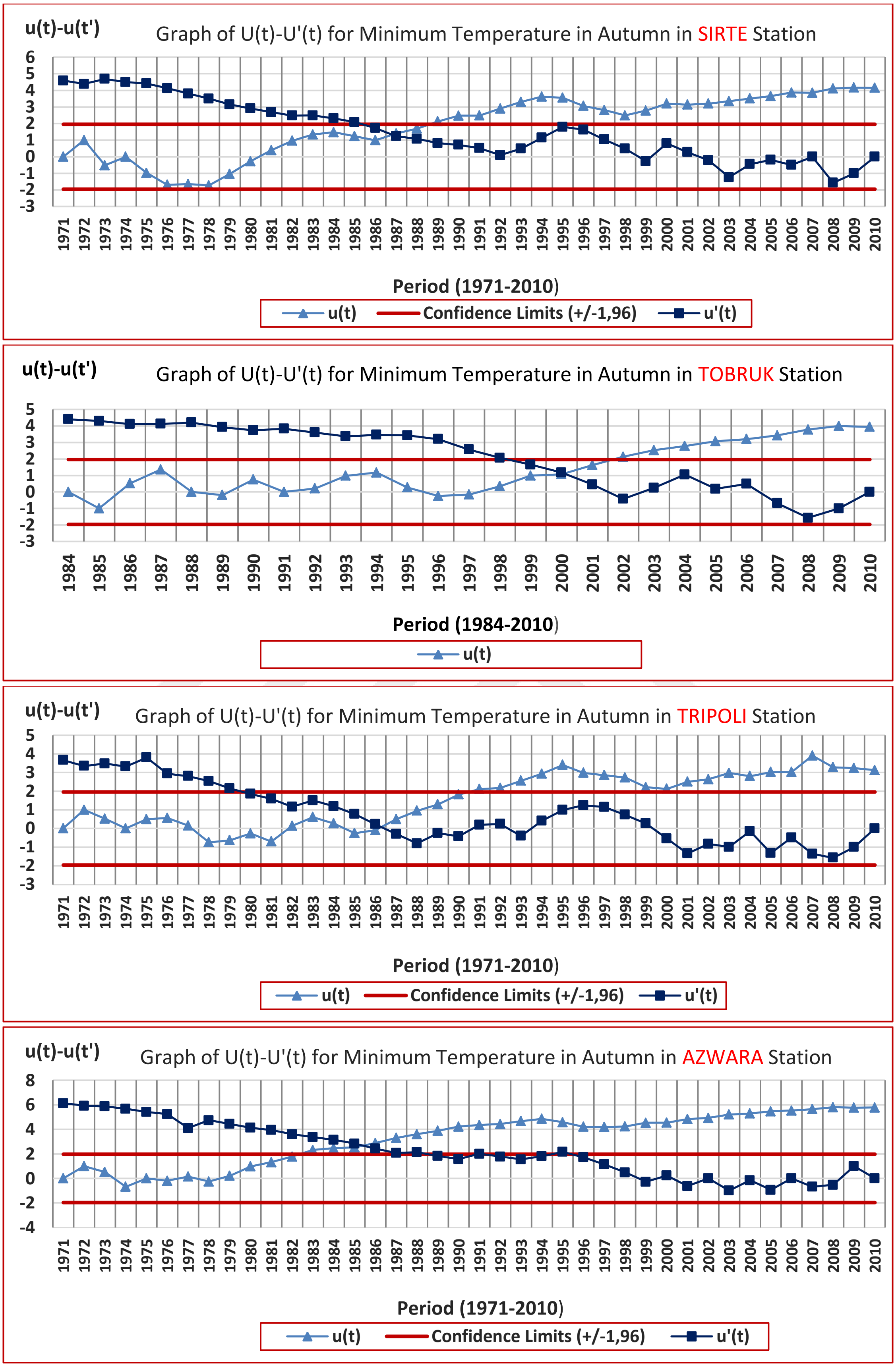


Figure 155. Graphs of M-K U(t)-U'(t) Results for Minimum Temperature in Autumn in SIRTE, TOBRUK, TRIPOLI and ZWARA Stations

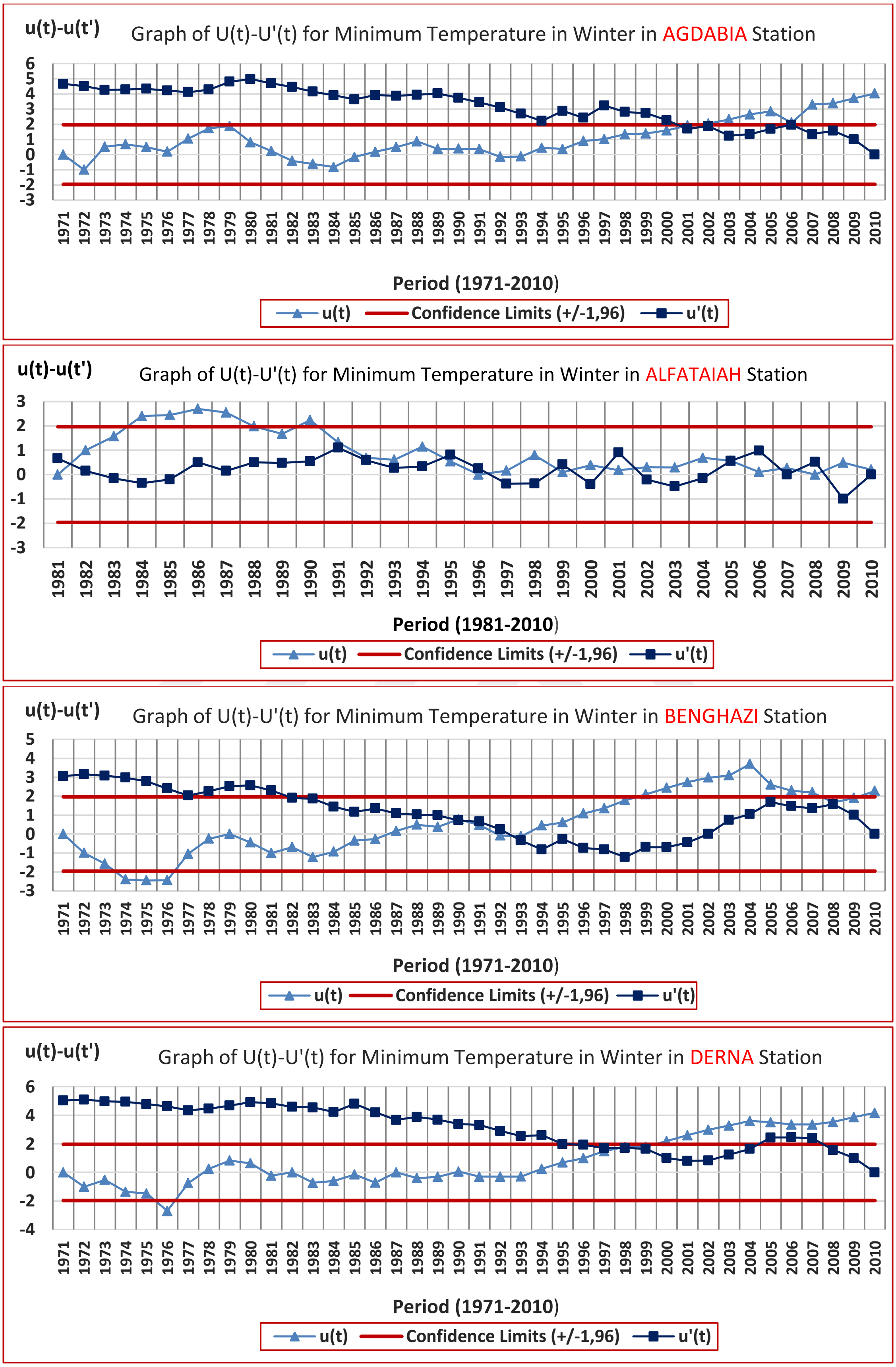


Figure 156. Graphs of M-K U(t)-U'(t) Results for Minimum Temperature in Winter in AGDABIA, ALFATAIAH, BENGHAZI and DERNA Stations

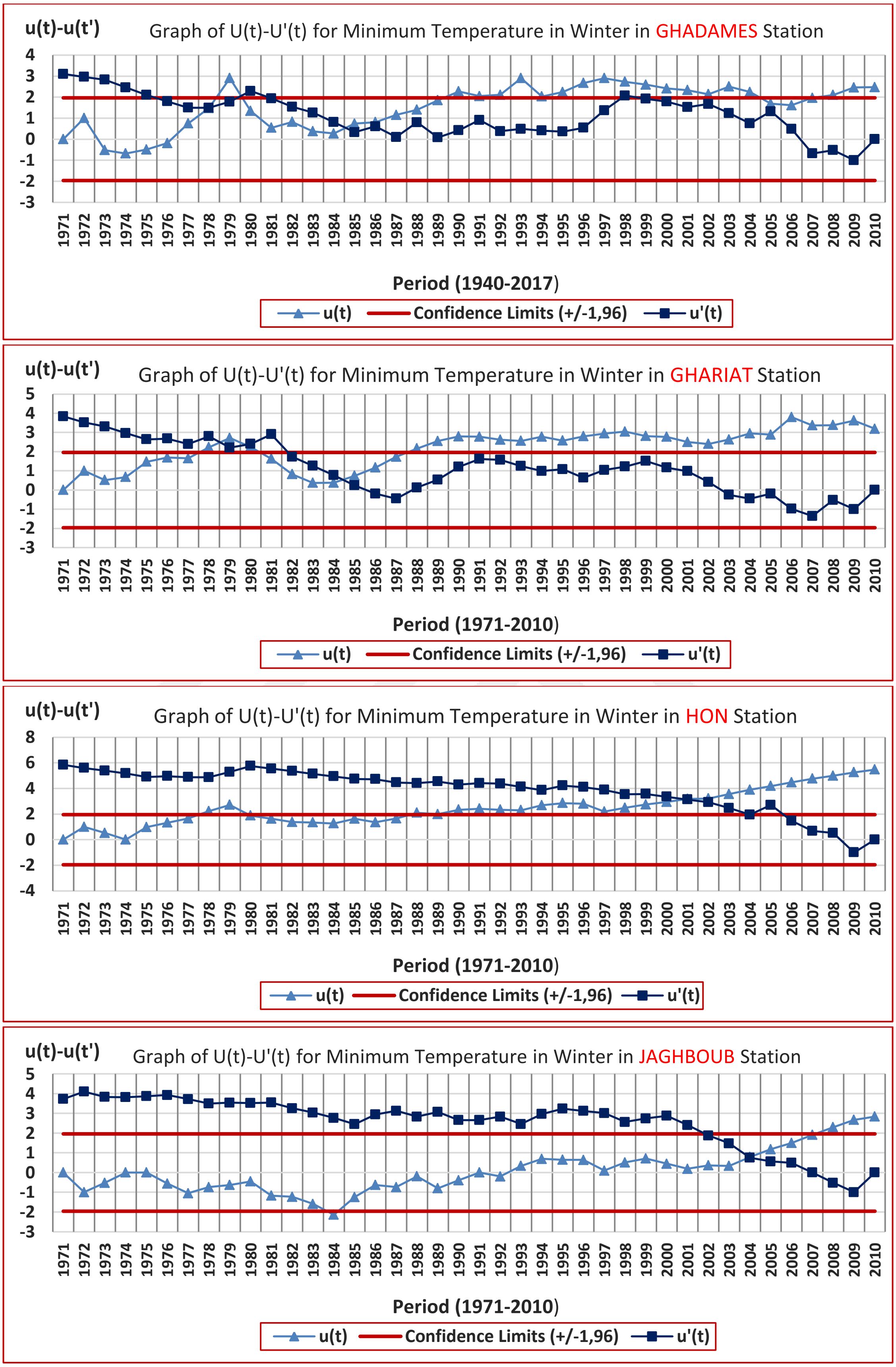


Figure 157. Graphs of M-K U(t)-U'(t) Results for Minimum Temperature in Winter in GHADAMES, GHARIAT HON and JAGHBOUB Stations

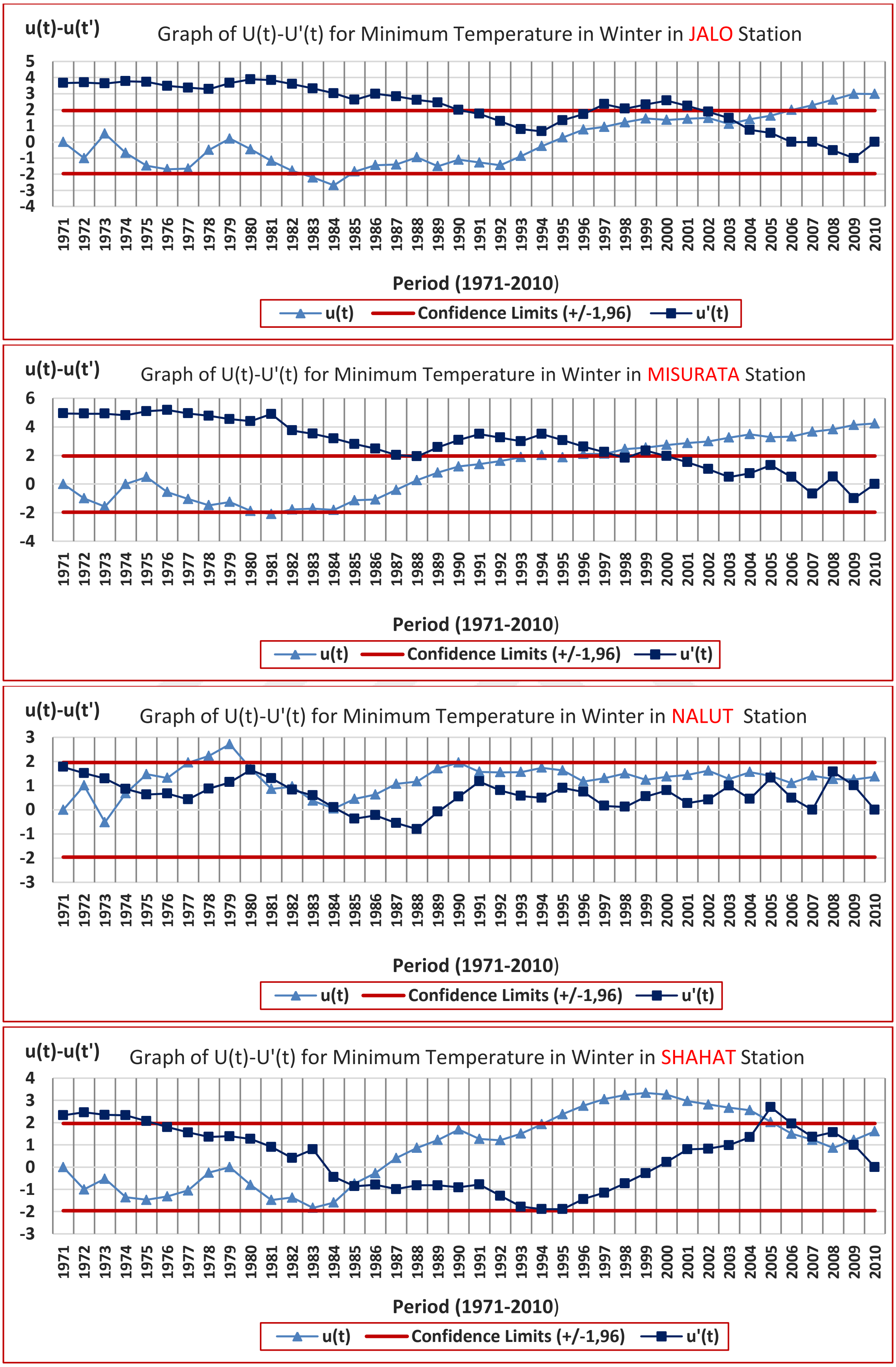


Figure 158. Graphs of M-K U(t)-U'(t) Results for Minimum Temperature in Winter in JALO, MISURATA, NALUT and SHAHAT Stations

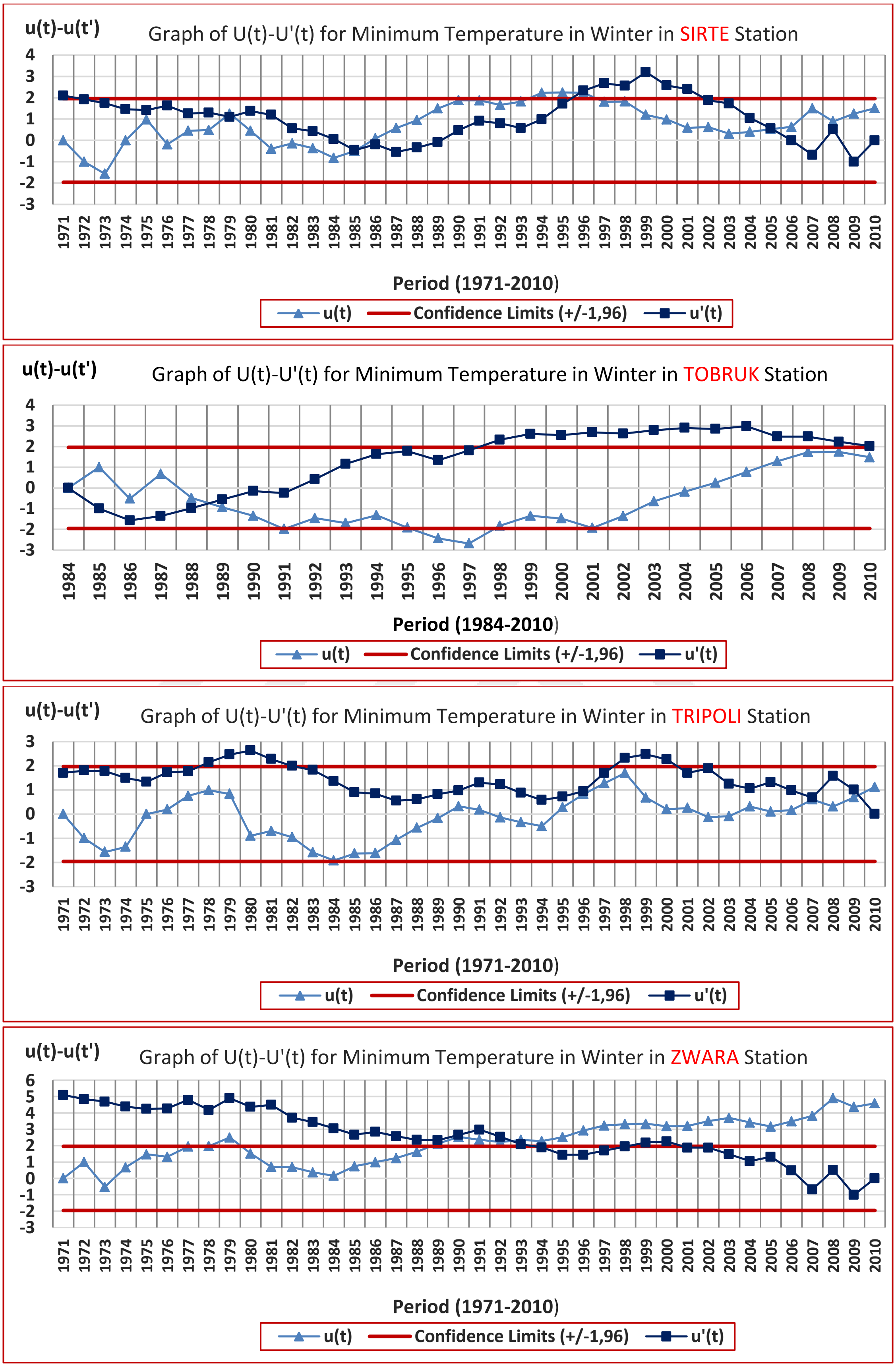


Figure 159. Graphs of M-K U(t)-U'(t) Results for Minimum Temperature in Winter in SIRTE, TOBRUK, TRIPOLI and ZWARA Stations

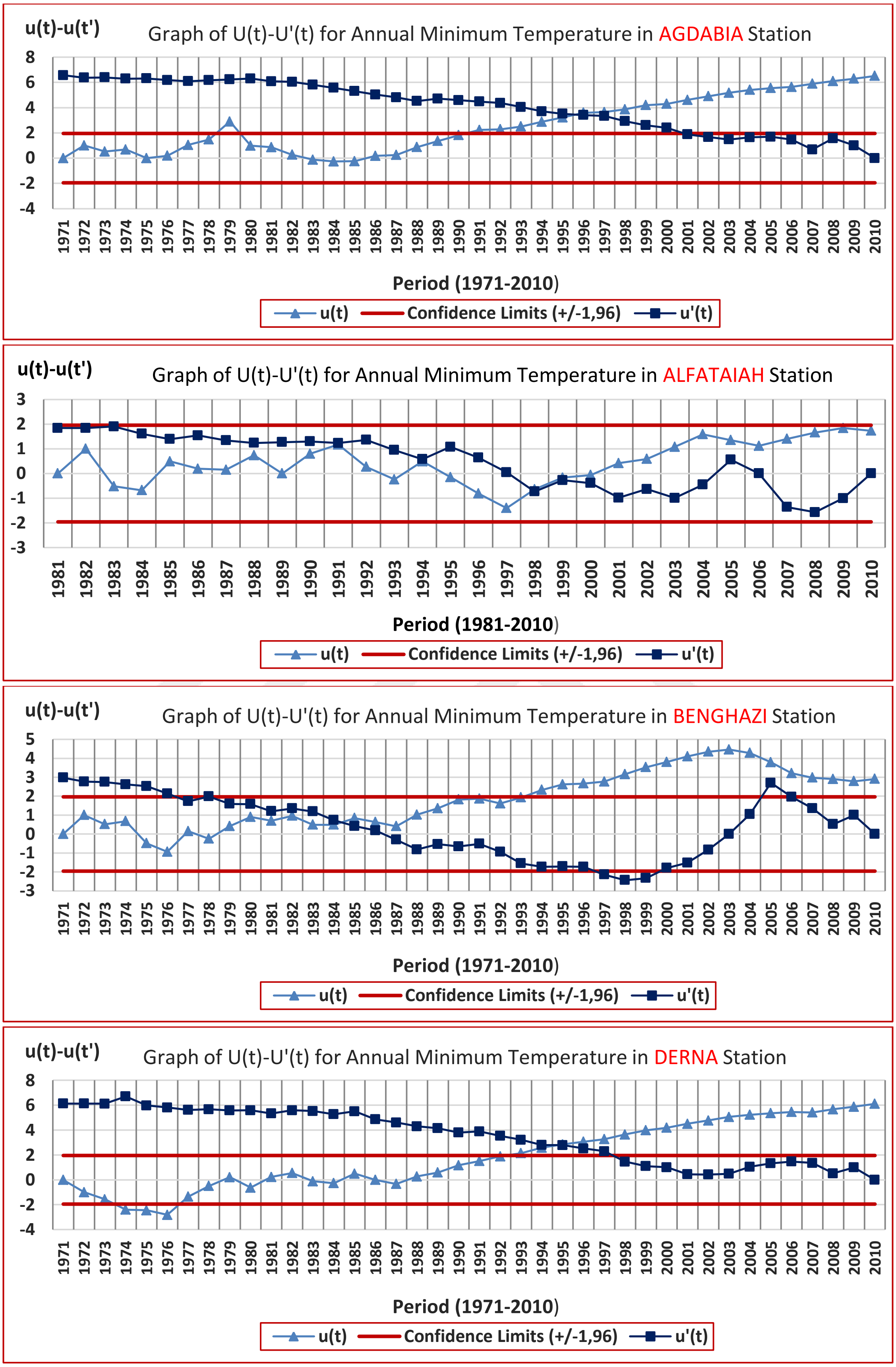


Figure 160. Graphs of M-K U(t)-U'(t) Results for Annual Minimum Temperature AGDABIA, ALFATAIAH, BENGHAZI and DERNA Stations

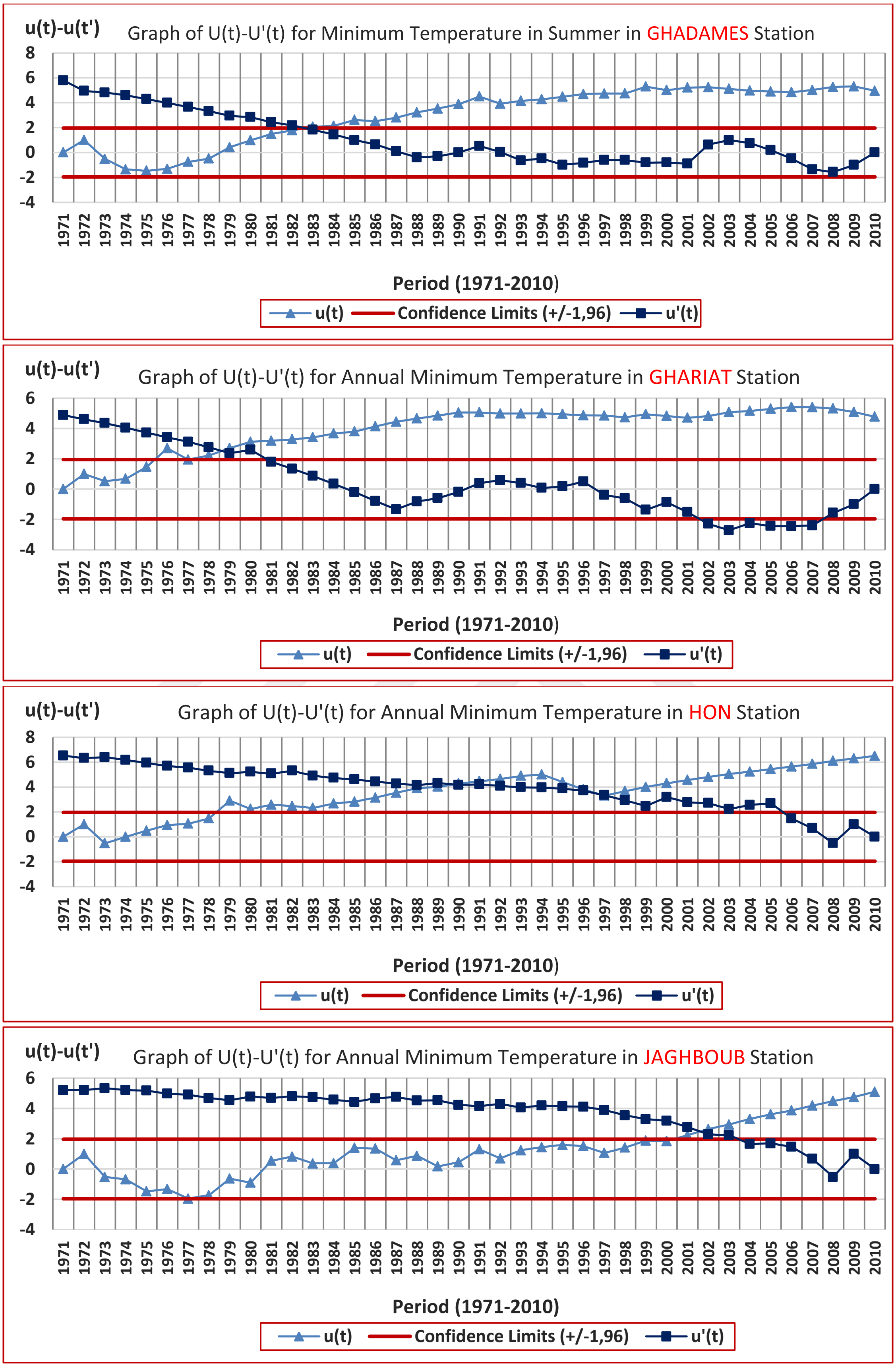


Figure 161. Graphs of M-K U(t)-U'(t) Results for Annual Minimum Temperature GHADAMES, GHARIAT, HON and JAGHBOUB Stations

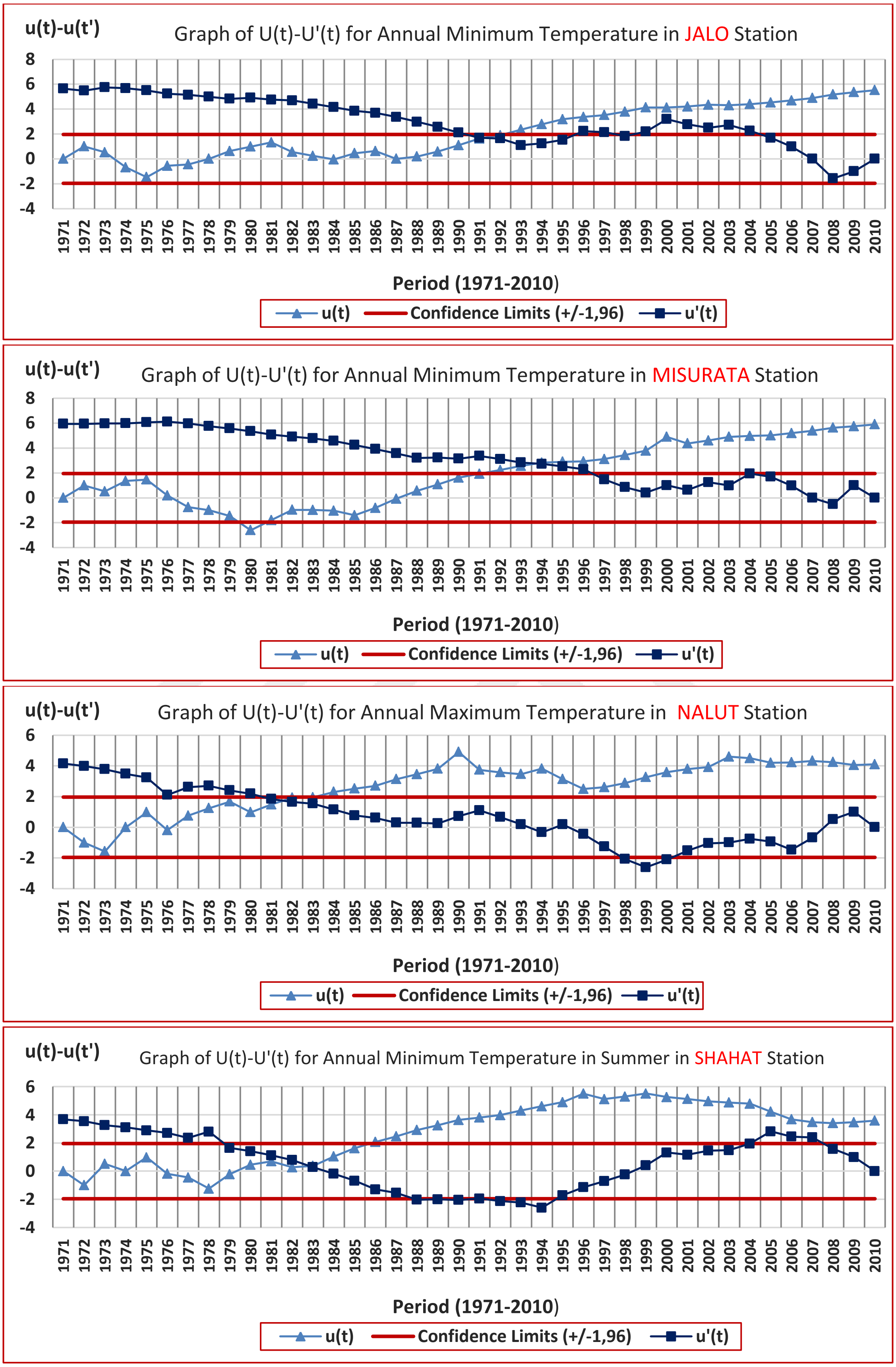


Figure 162. Graphs of M-K U(t)-U'(t) Results for Annual Minimum Temperature in JALO, MISURATA, NALUT and SHAHAT Stations

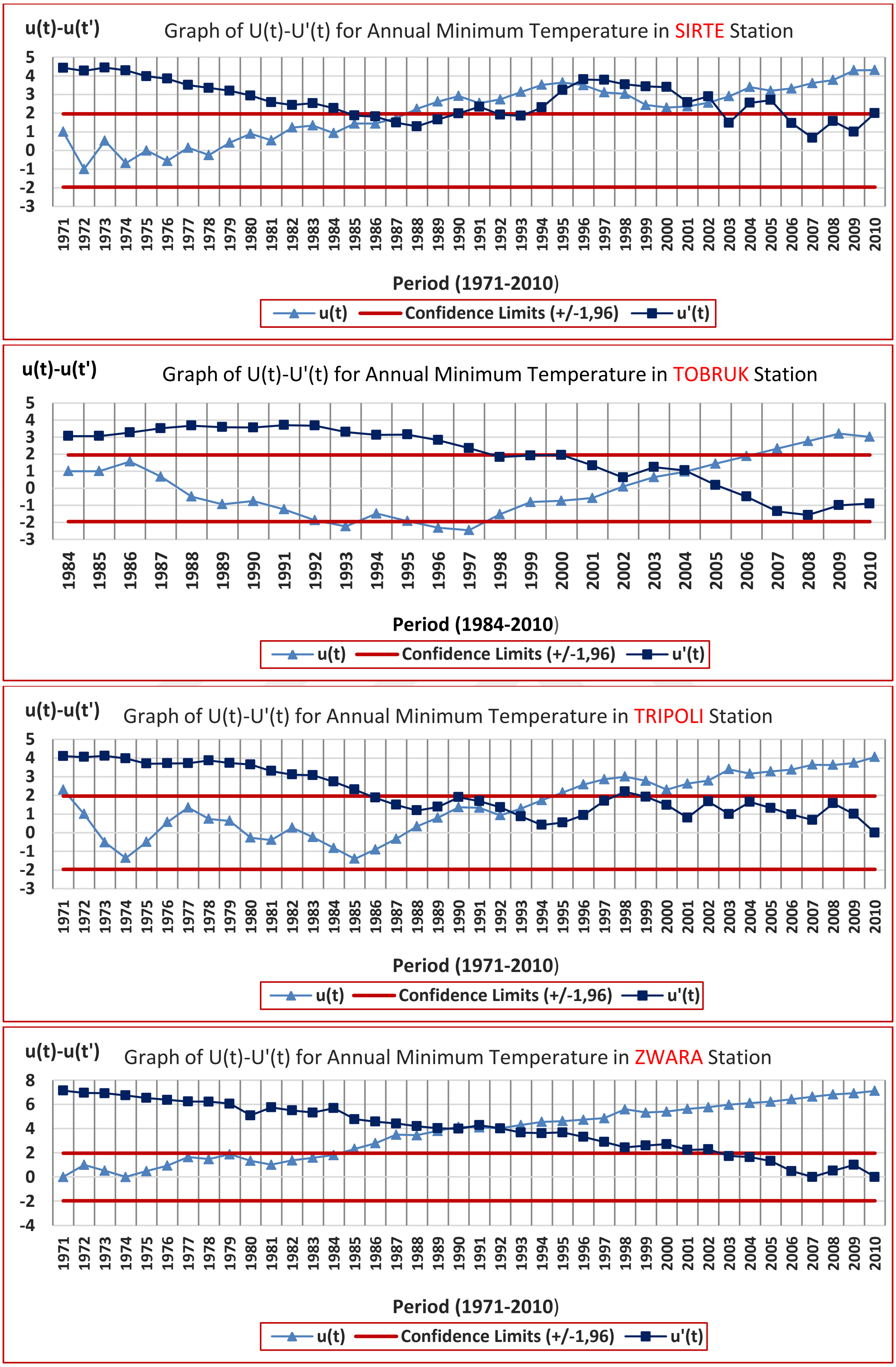


Figure 163. Graphs of M-K U(t)-U'(t) Results for Annual Minimum Temperature SIRTE, TOBRUK, TRIPOLI and ZWARA Stations

4.1.2.3.Graphs of M-K U(t)-U'(t) Results for Seasonally and Annual AverageTemperatures (1971-2010)

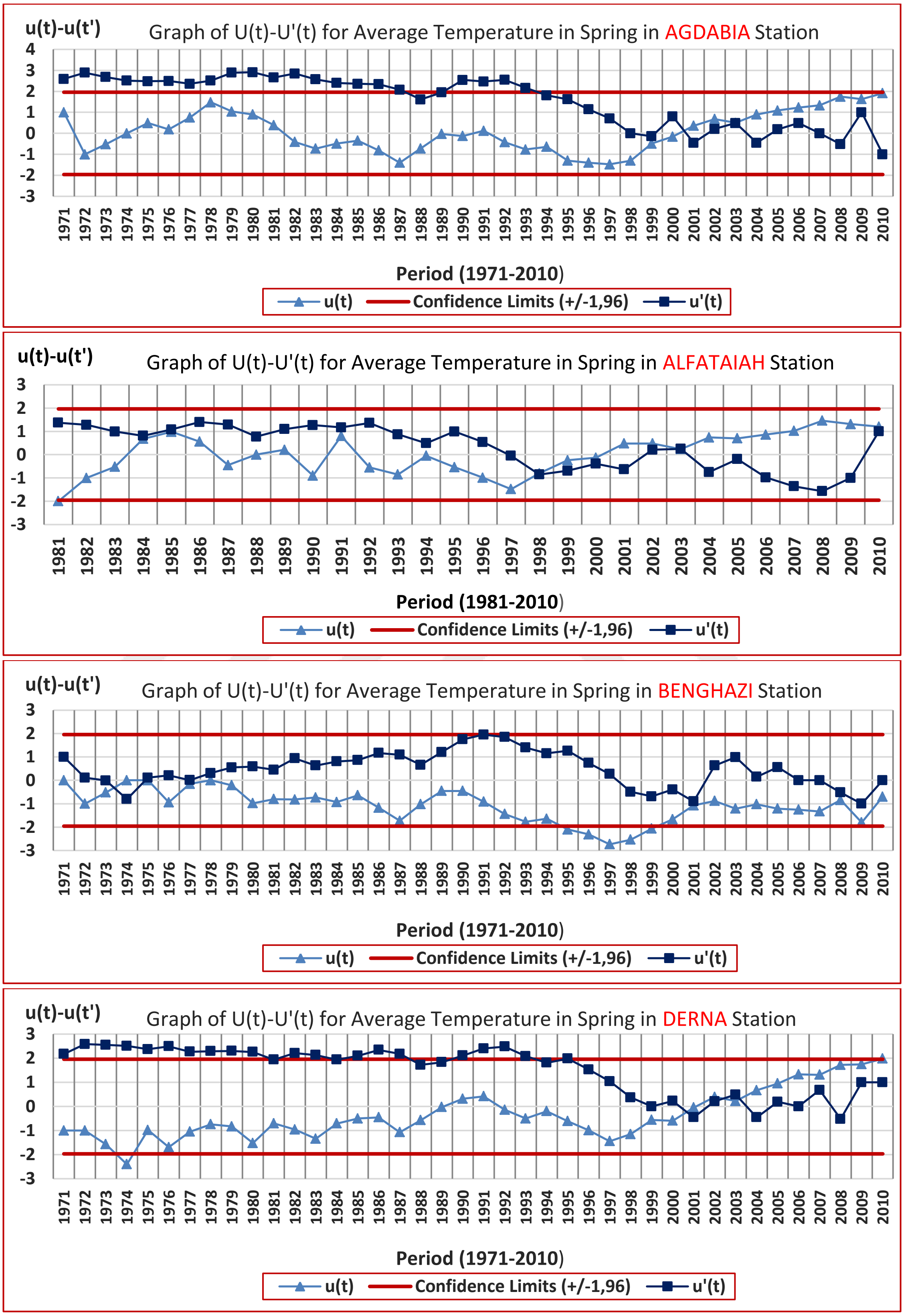


Figure 164. Graphs of M-K U(t)-U'(t) Results for Average Temperature in Spring in AGDABIA, ALFATAIAH, BENGHAZI and DERNA Stations

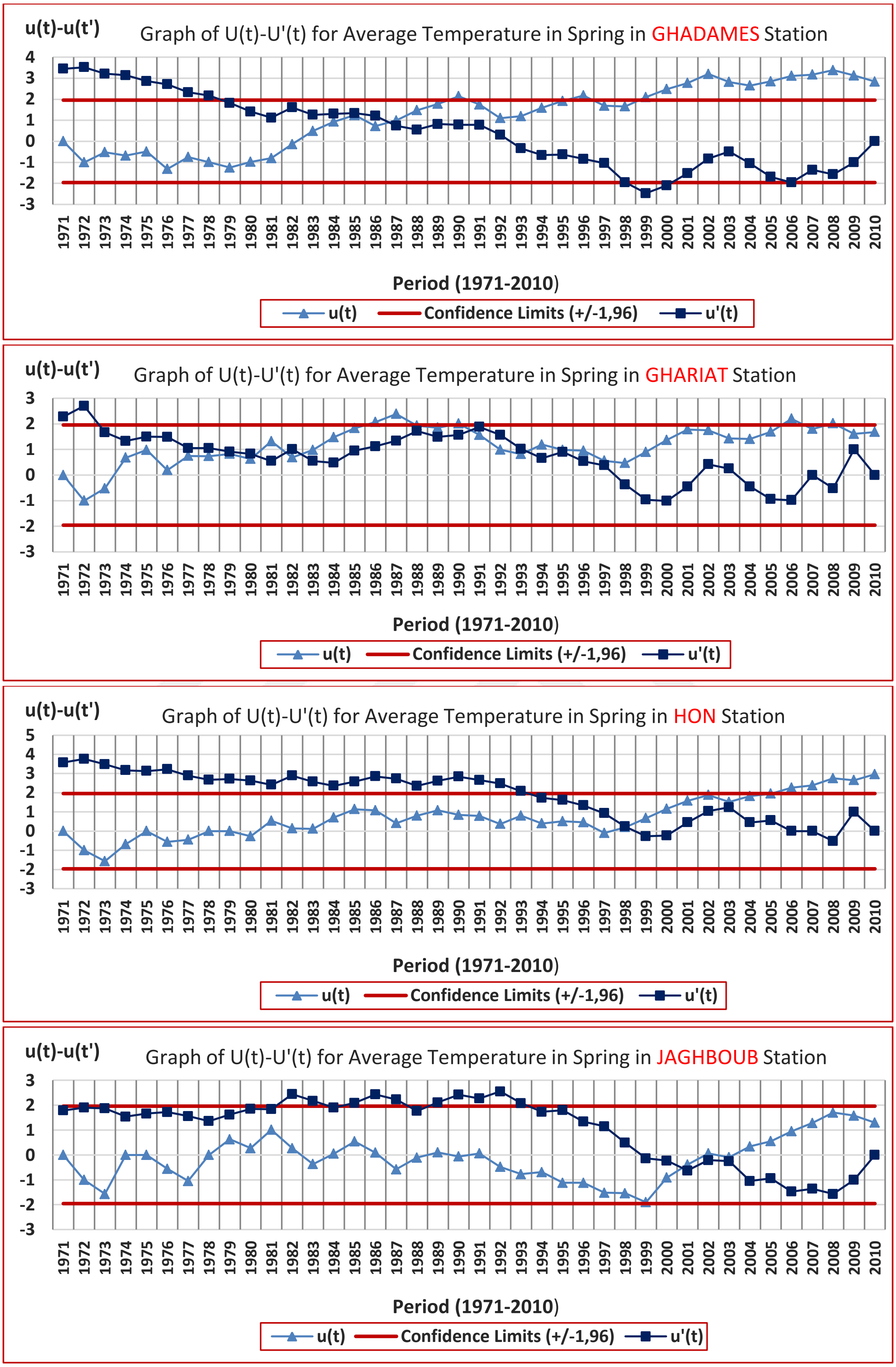


Figure 165. Graphs of M-K U(t)-U'(t) Results for Average Temperature in Spring in GHADAMES, GHARIAT, HON and JAGHBOUB Stations

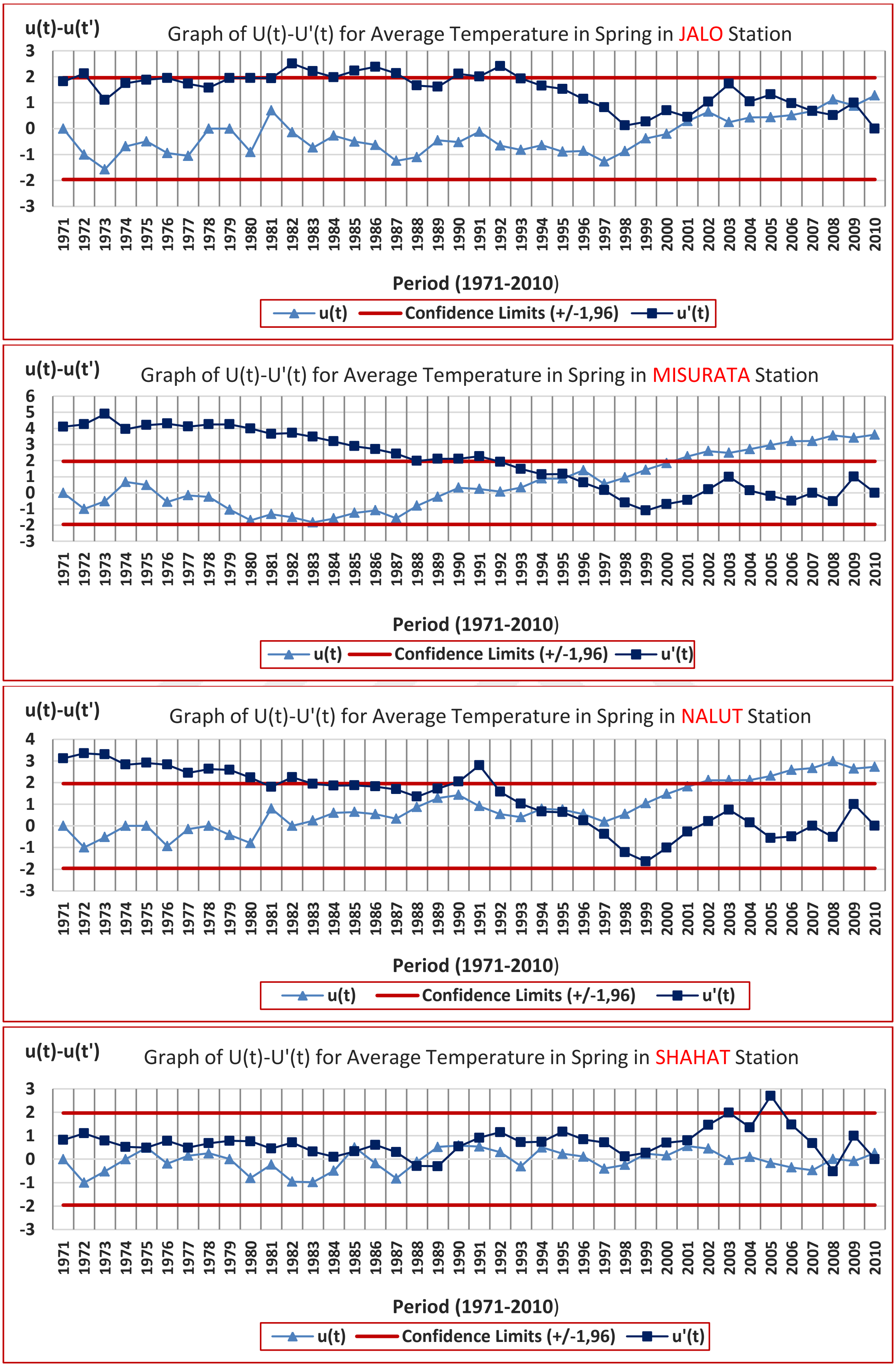


Figure 166. Graphs of M-K U(t)-U'(t) Results for Average Temperature in Spring in JALO, MISURATA, NALUT and SHAHAT Stations

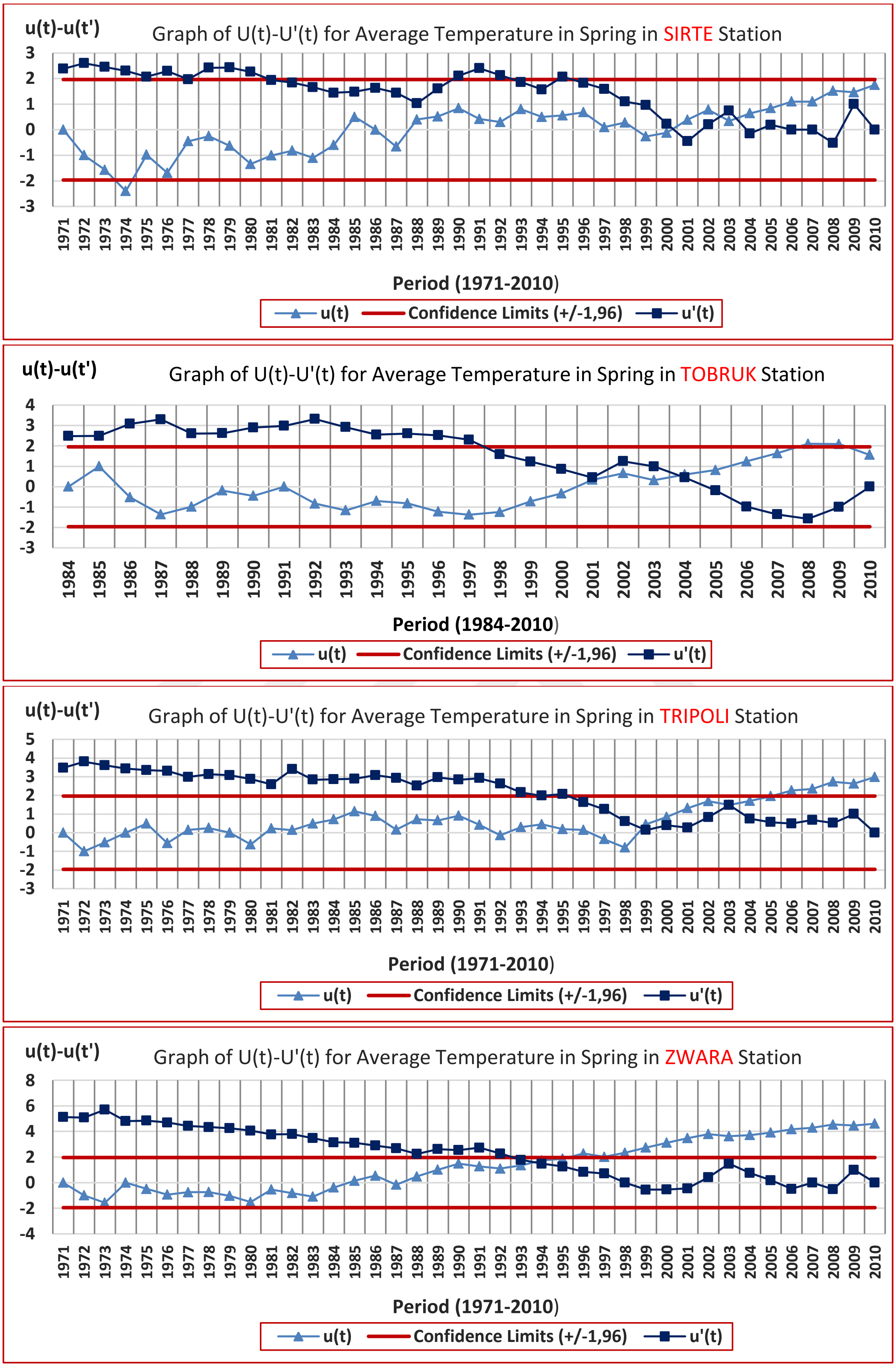


Figure 167. Graphs of M-K U(t)-U'(t) Results for Average Temperature in Spring in SIRTE, TOBRUK, TRIPOLI and ZWARA Stations

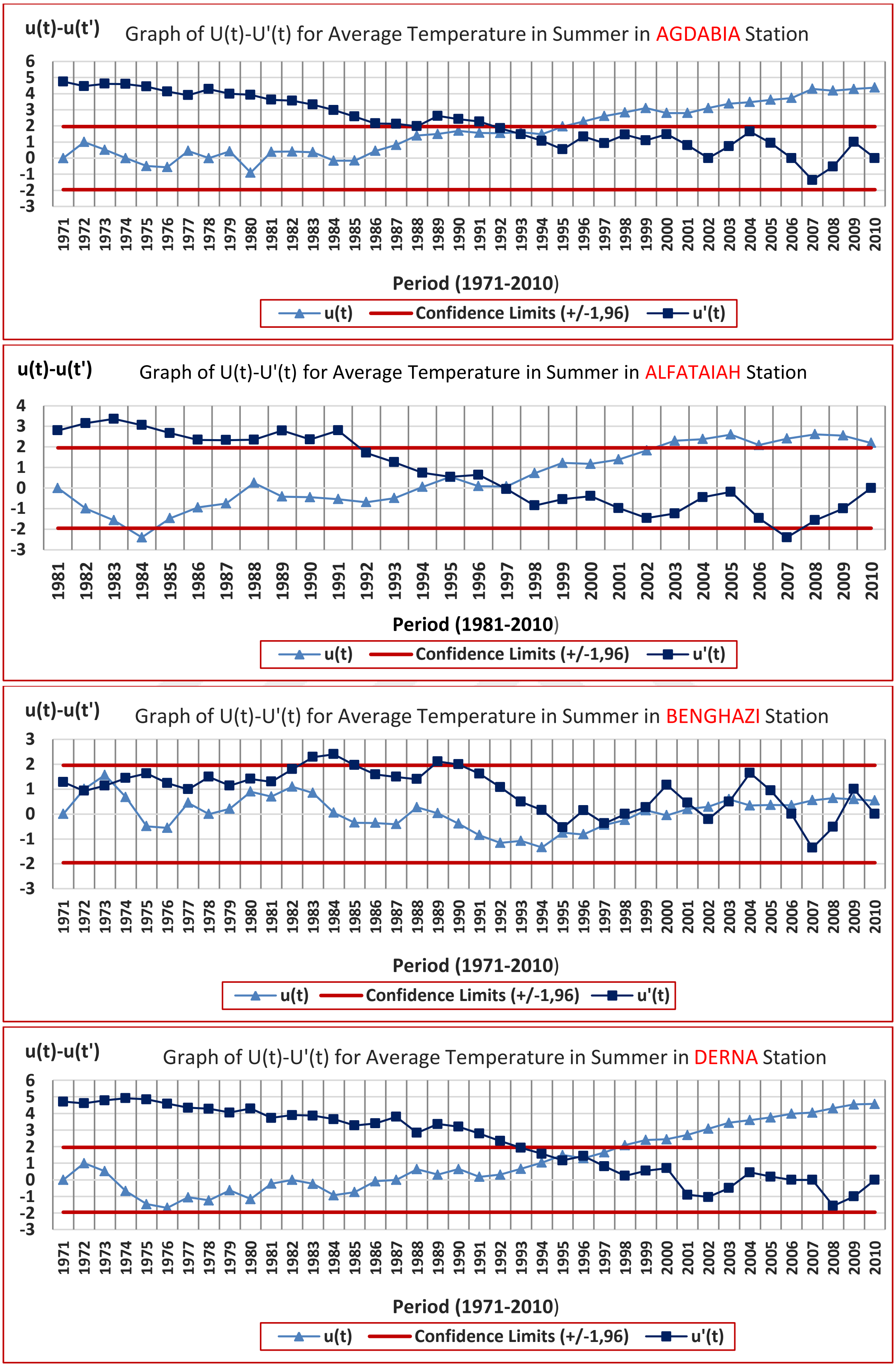


Figure 168. Graphs of M-K U(t)-U'(t) Results for Average Temperature in Summer in AGDABIA, ALFATAIAH, BENGHAZI and DERNA Stations

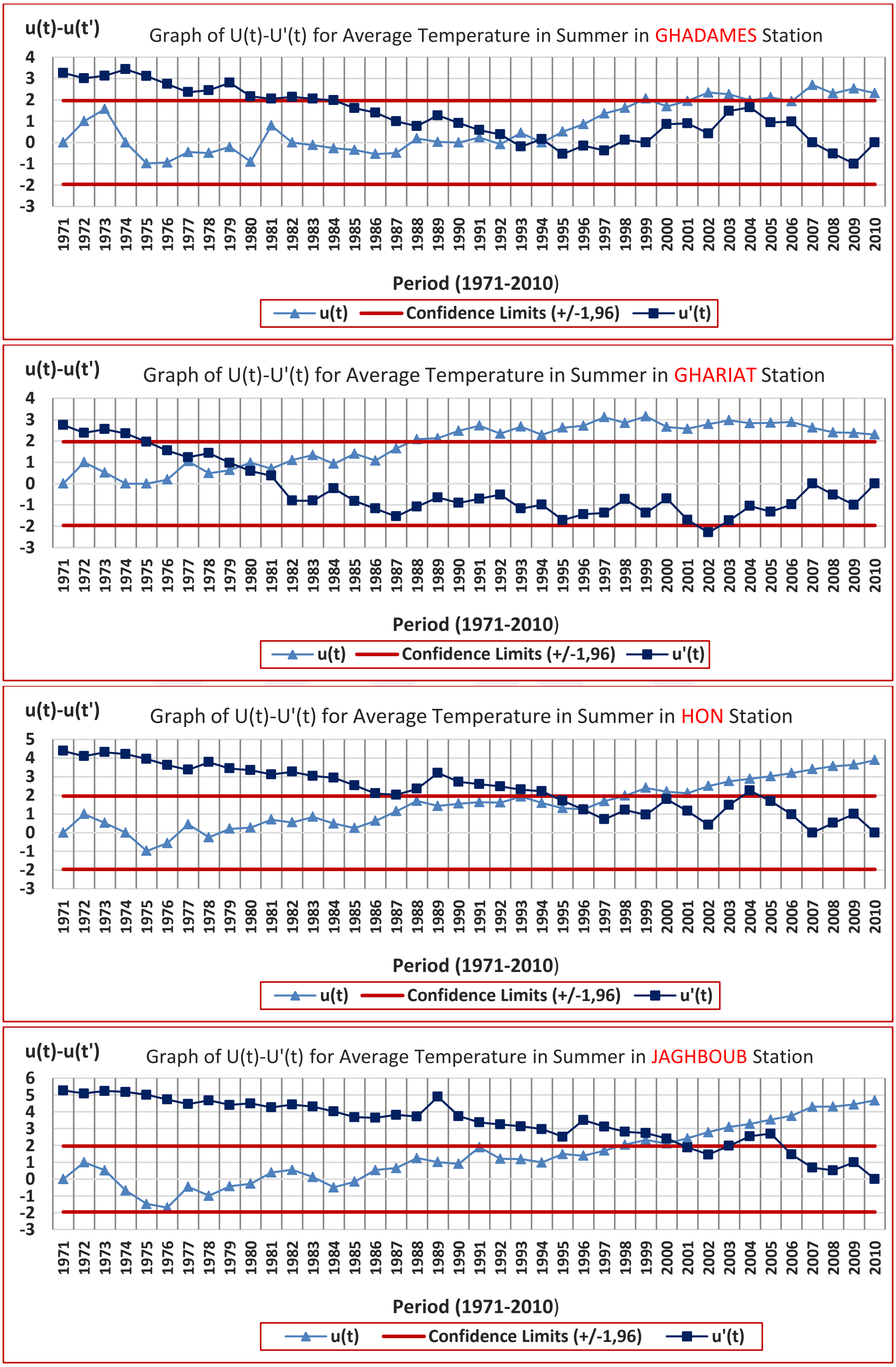


Figure 169. Graphs of M-K U(t)-U'(t) Results for Average Temperature in Summer in GHADAMES, GHARIAT, HON and JAGHBOUB Stations

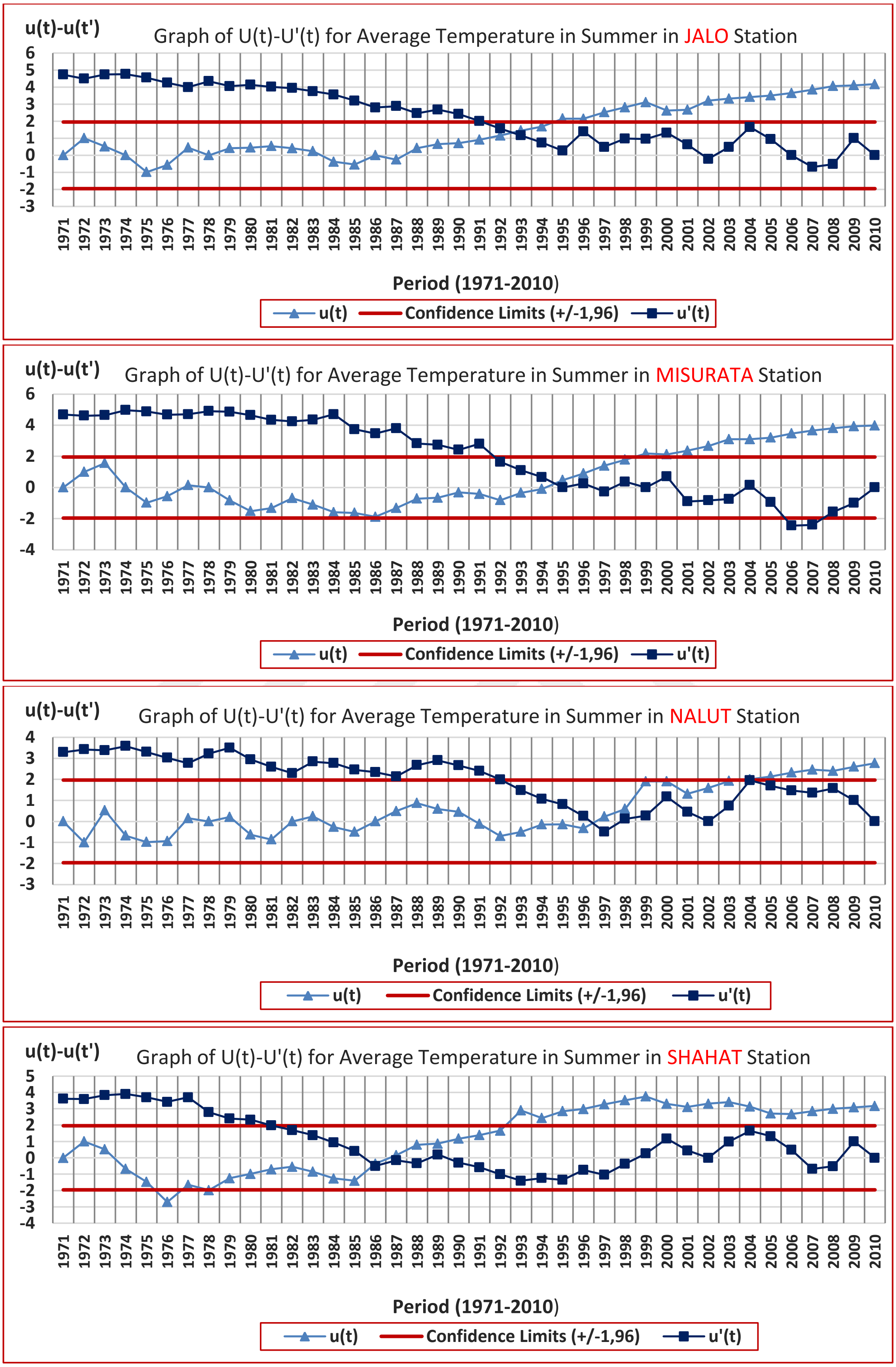


Figure 170. Graphs of M-K U(t)-U'(t) Results for Average Temperature in Summer in JALO, MISURATA, NALUT and SHAHAT Stations

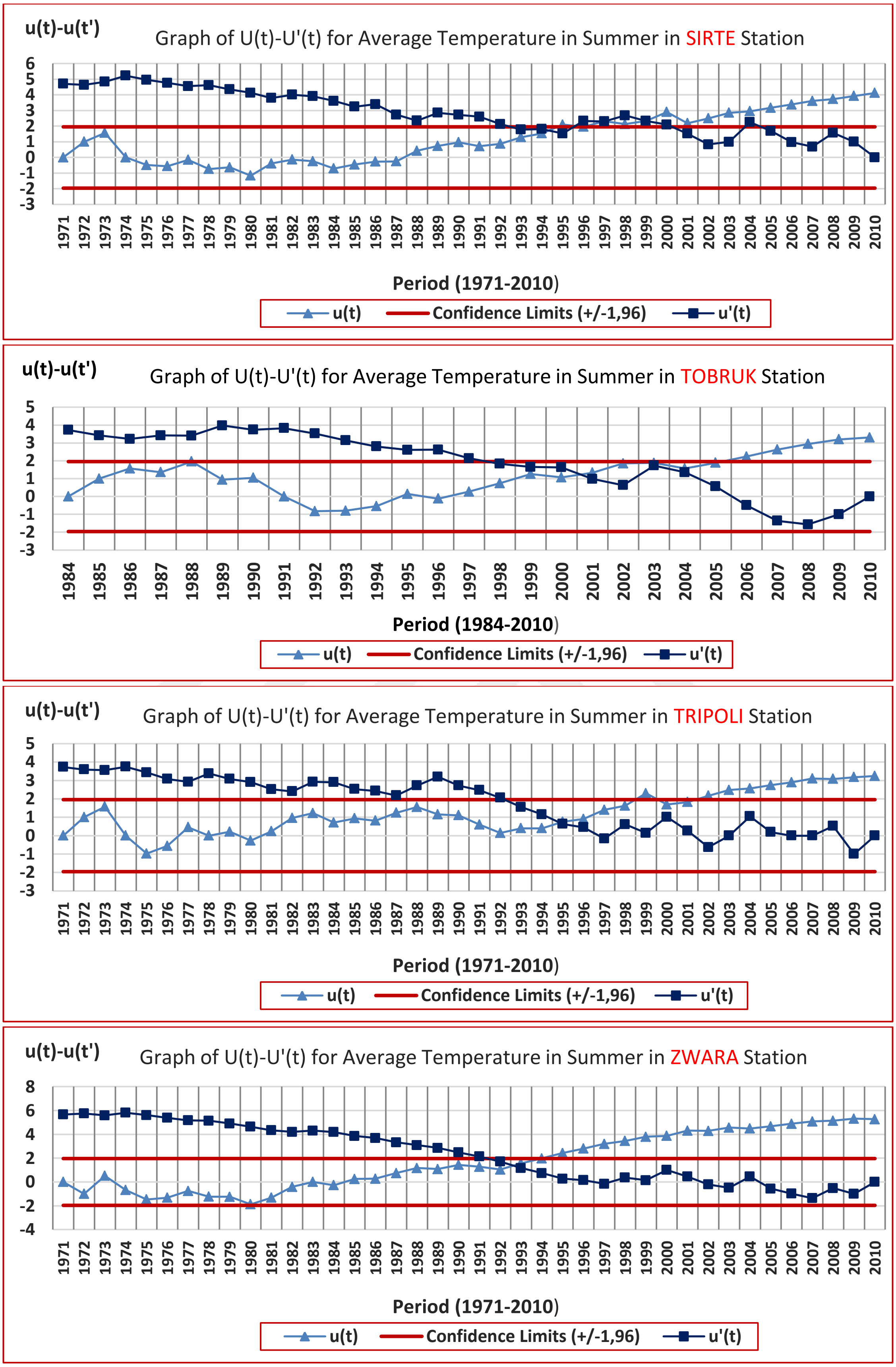


Figure 171. Graphs of M-K U(t)-U'(t) Results for Average Temperature in Summer in SIRTE, TOBRUK, TRIPOLI and ZWARA Stations

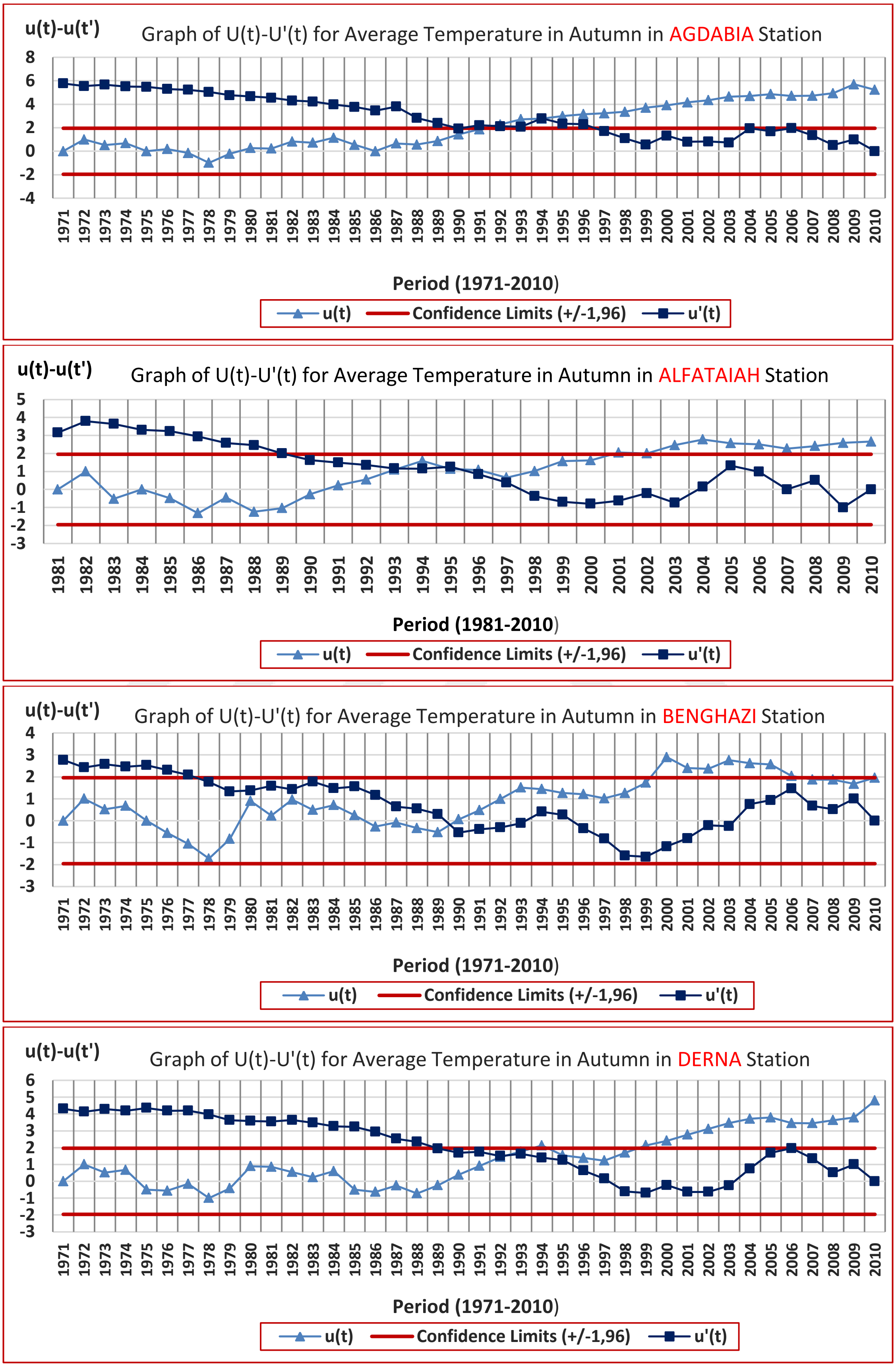


Figure 172. Graphs of M-K U(t)-U'(t) Results for Average Temperature in Autumn in AGDABIA, ALFATAIAH, BENGHAZI and DERNA Stations

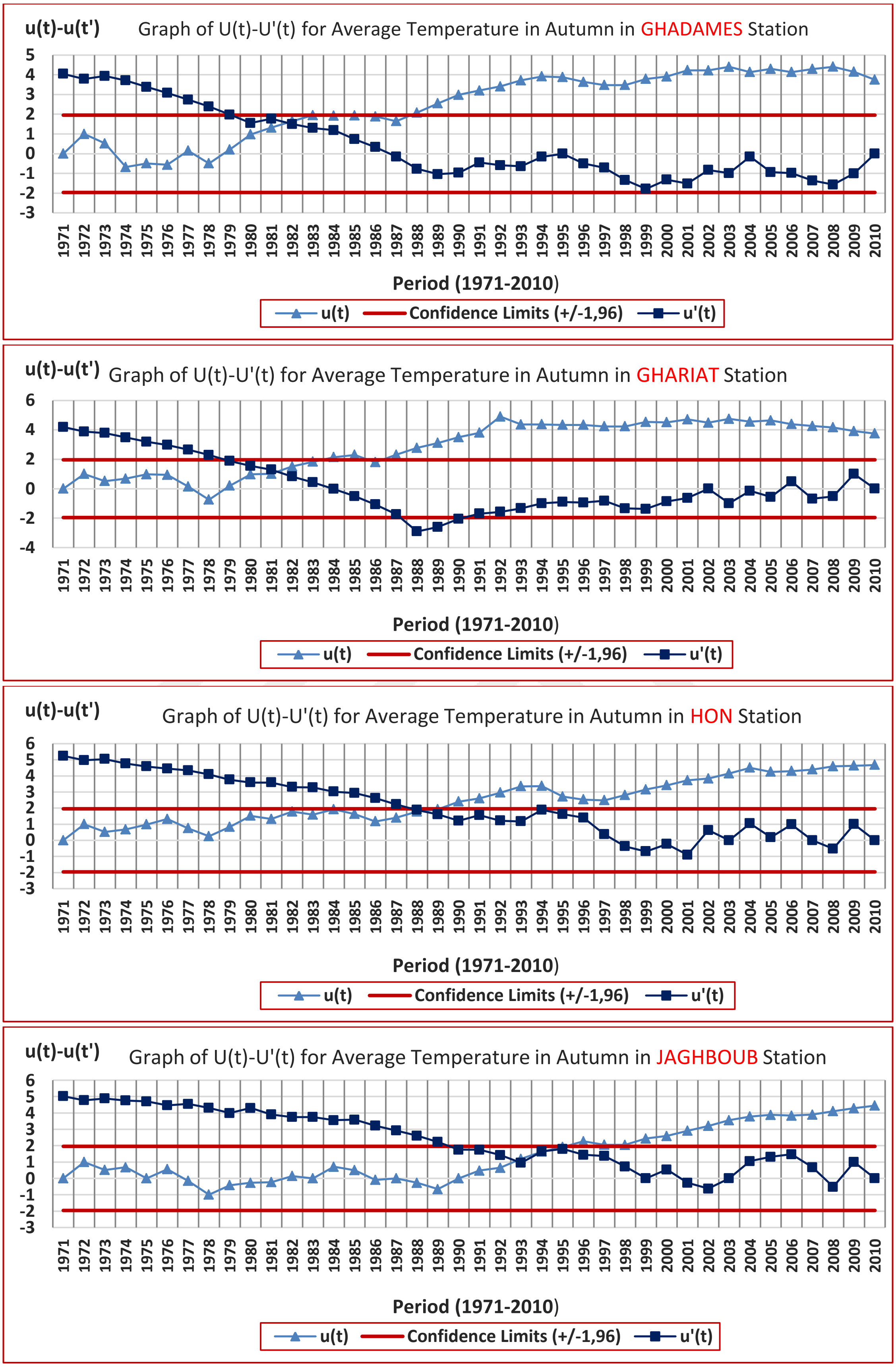


Figure 173. Graphs of M-K U(t)-U'(t) Results for Average Temperature in Autumn in GHADAMES, GHARIAT, HON and JAGHBOUB Stations

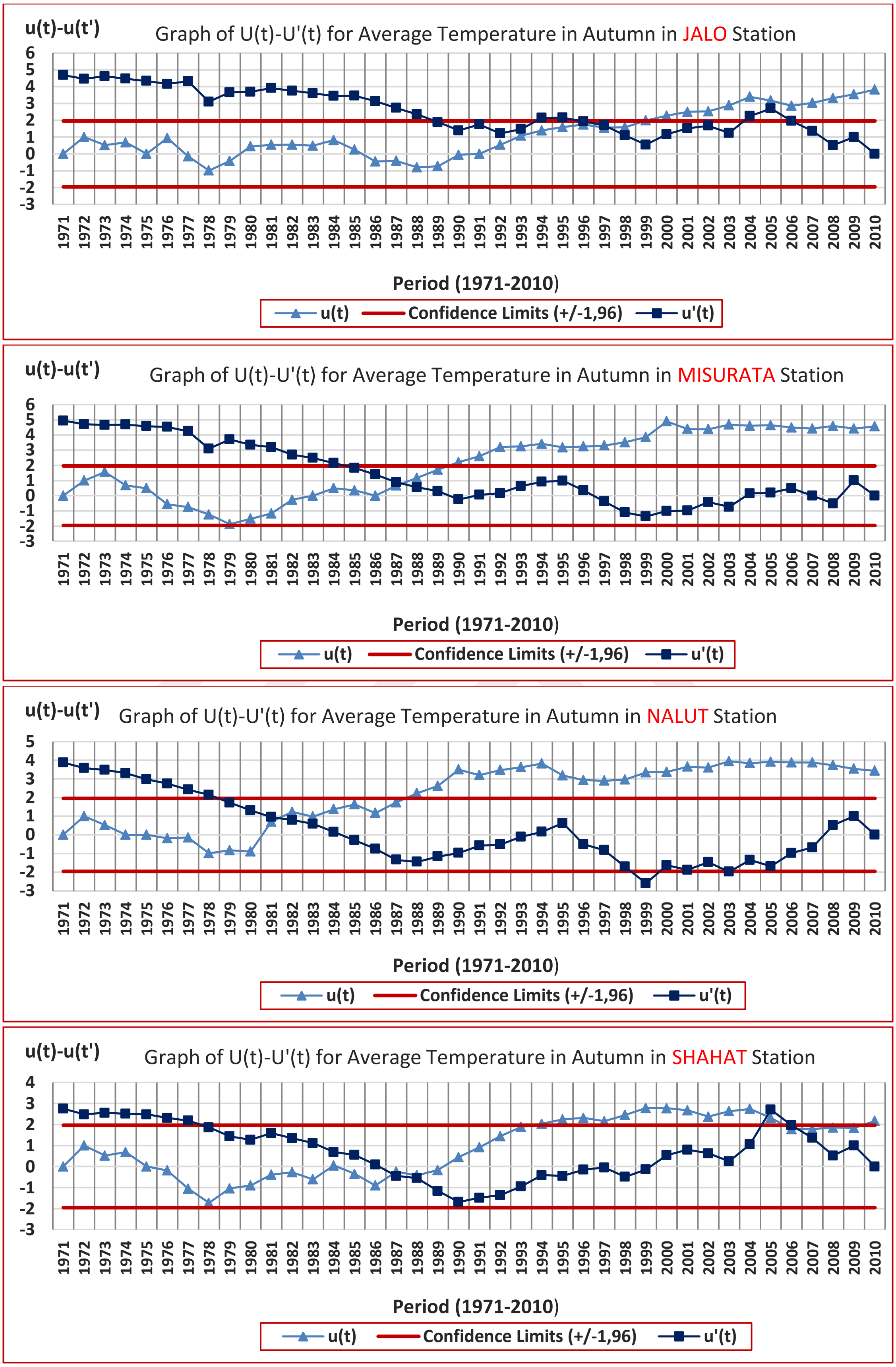


Figure 174. Graphs of M-K U(t)-U'(t) Results for Average Temperature in Autumn in JALO, MISURATA, NALUT and SHAHAT Stations

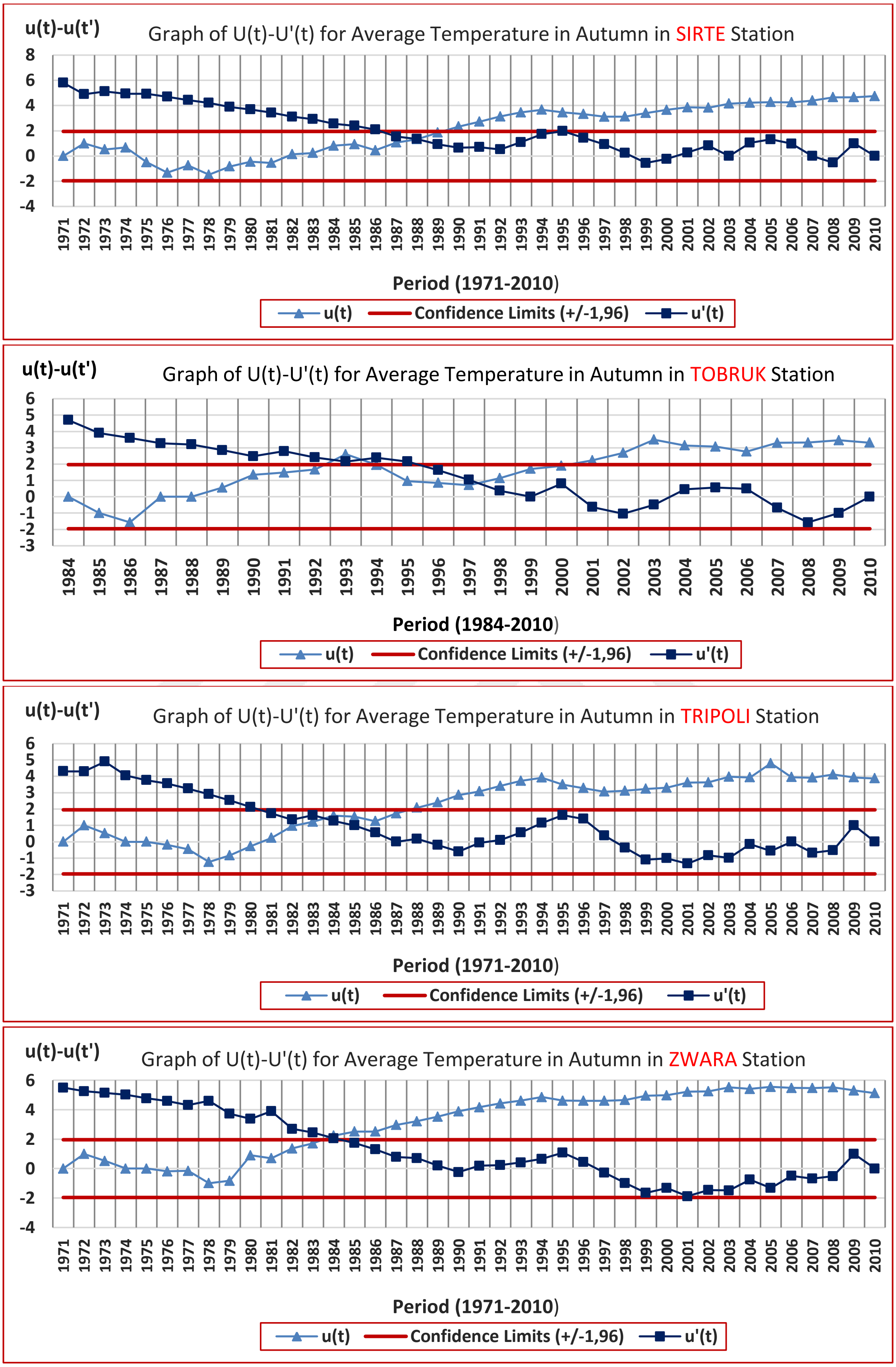


Figure 175. Graphs of M-K U(t)-U'(t) Results for Average Temperature in Autumn in SIRTE, TOBRUK, TRIPOLI and ZWARA Stations

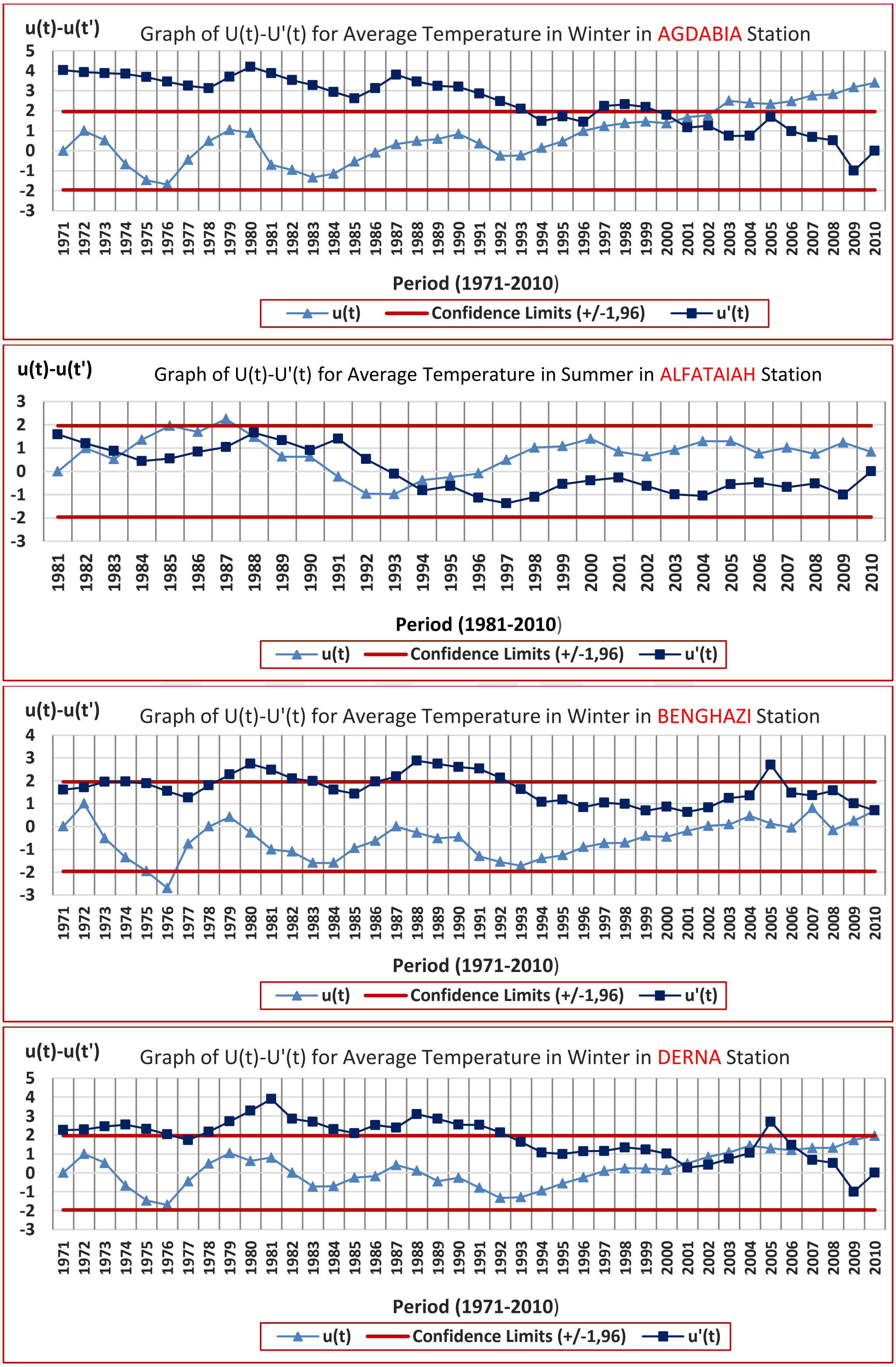


Figure 176. Graphs of M-K U(t)-U'(t) Results for Average Temperature in Winter in AGDABIA, ALFATAIAH, BENGHAZI and DERNA Stations

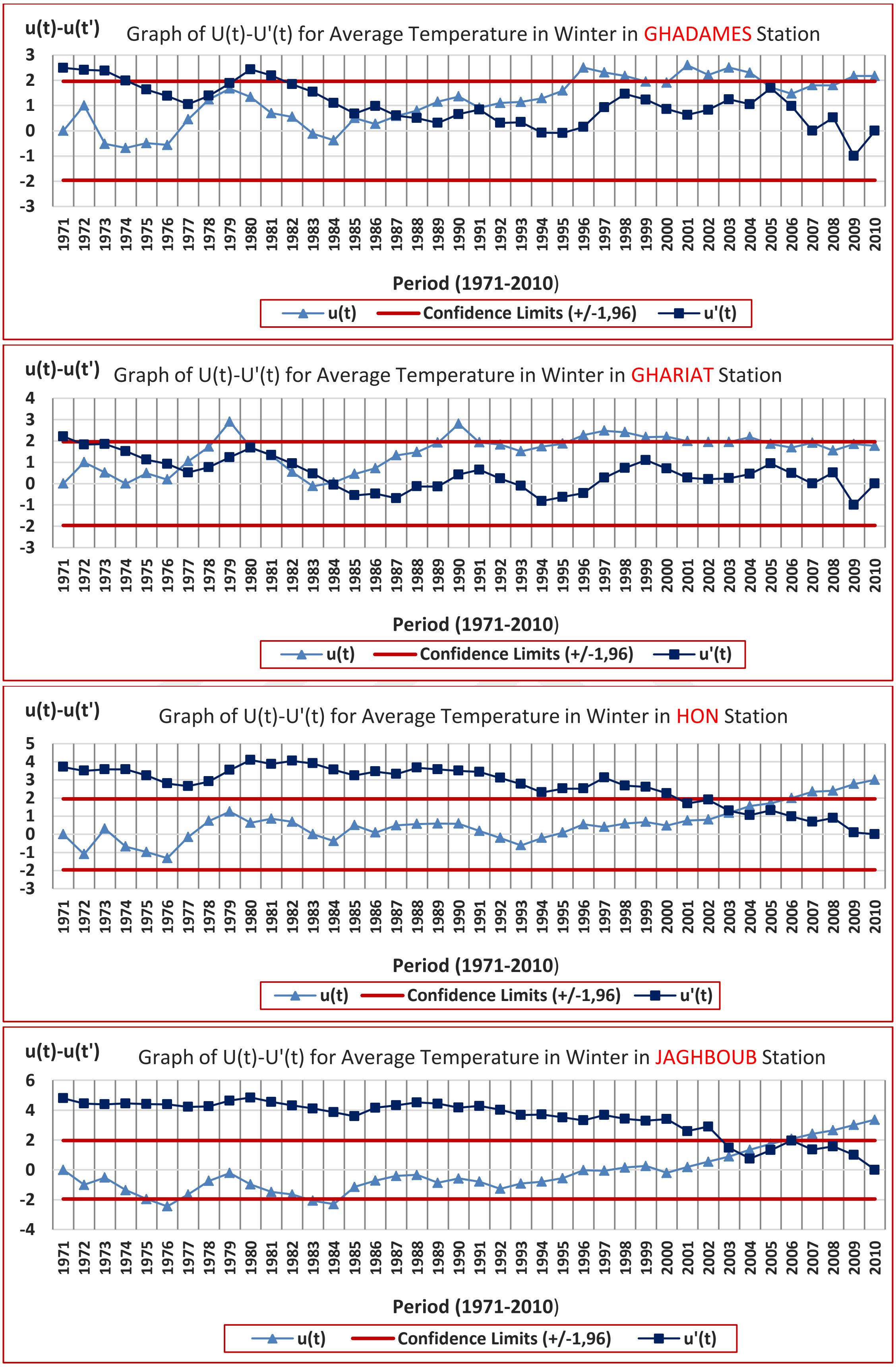


Figure 177. Graphs of M-K U(t)-U'(t) Results for Average Temperature in Winter in GHADAMES, GHARIAT, HON and JAGHBOUB Stations

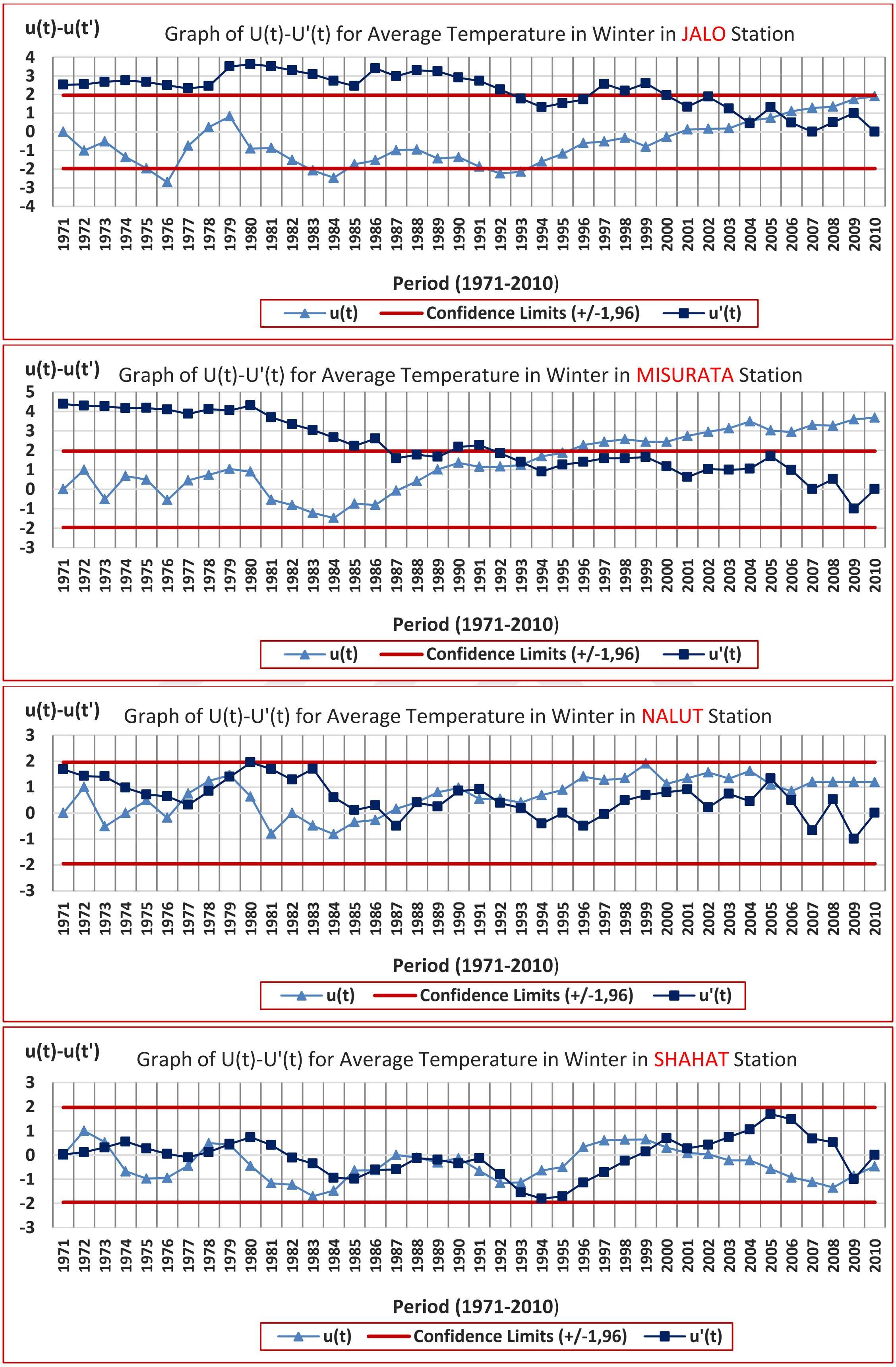


Figure 178. Graphs of M-K U(t)-U'(t) Results for Average Temperature in Winter in JALO, MISURATA, NALUT and SHAHAT Stations

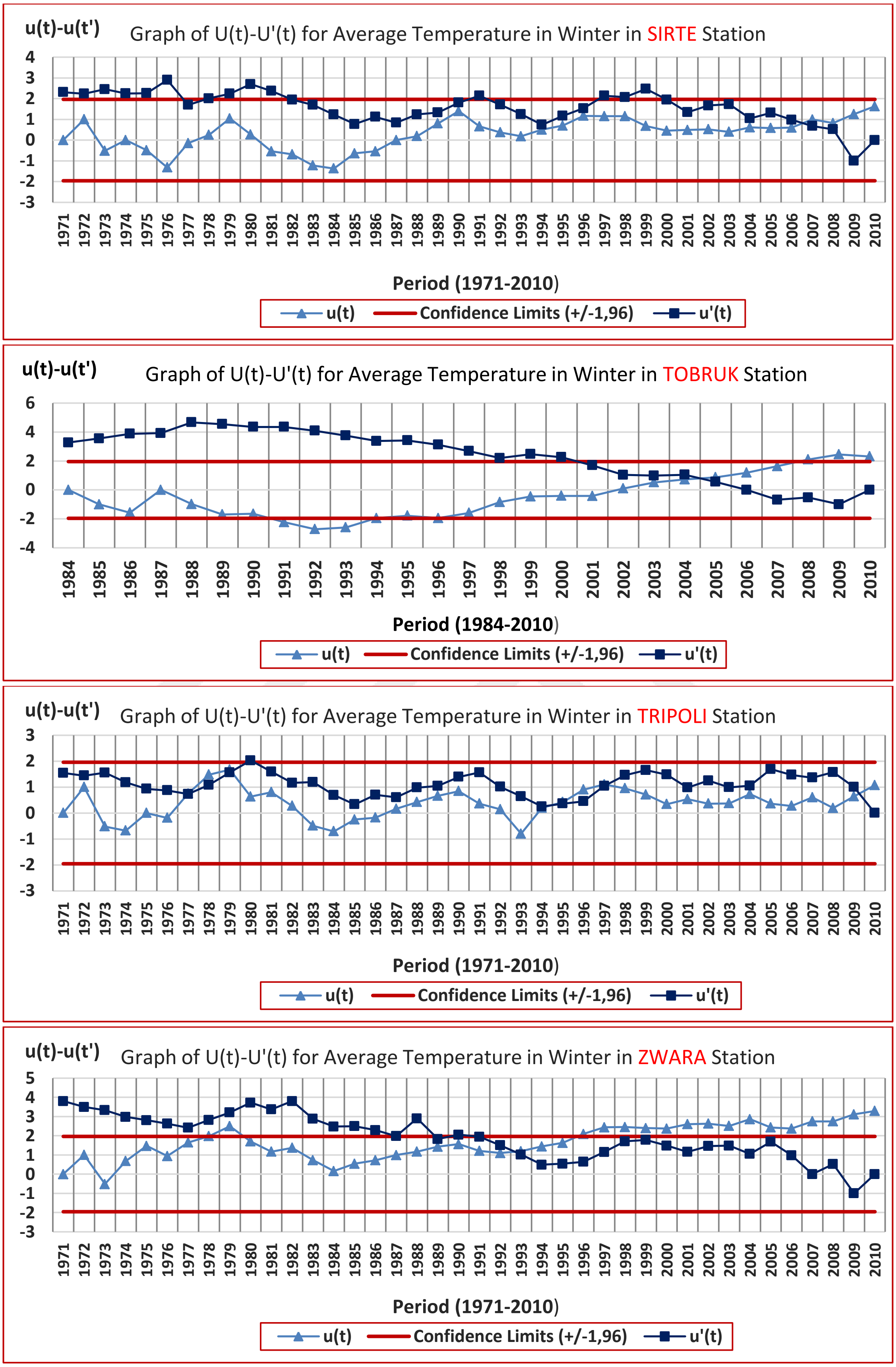


Figure 179. Graphs of M-K U(t)-U'(t) Results for Average Temperature in Winter in SIRTE, TOBRUK, TRIPOLI and ZWARA Stations

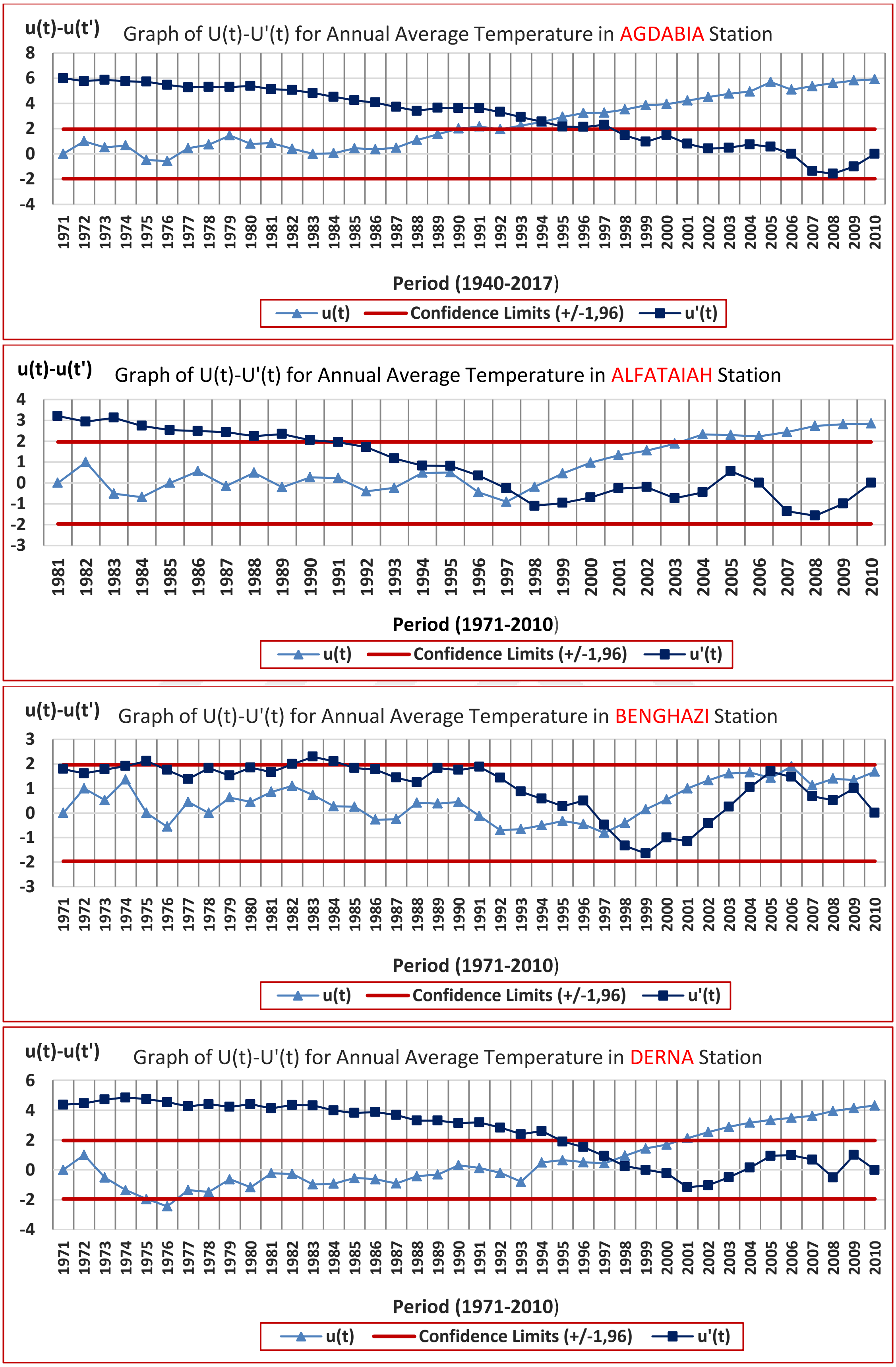
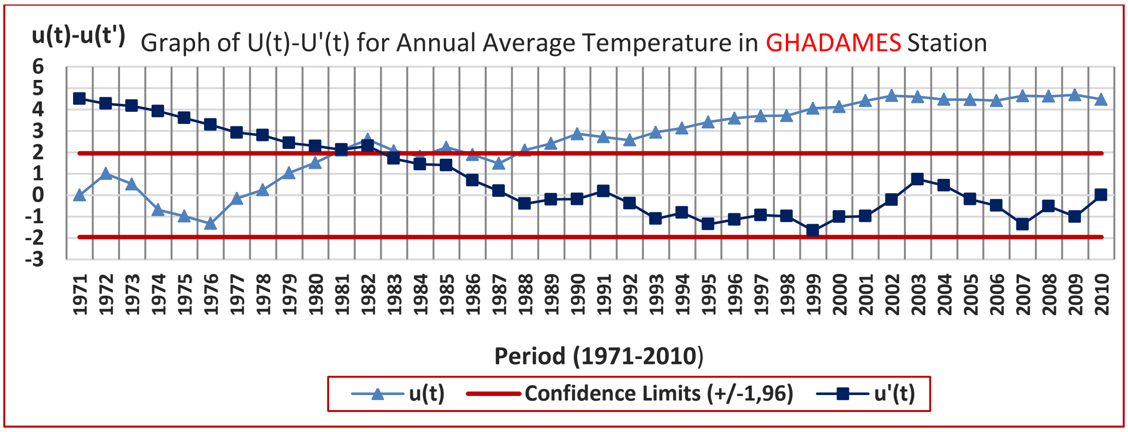
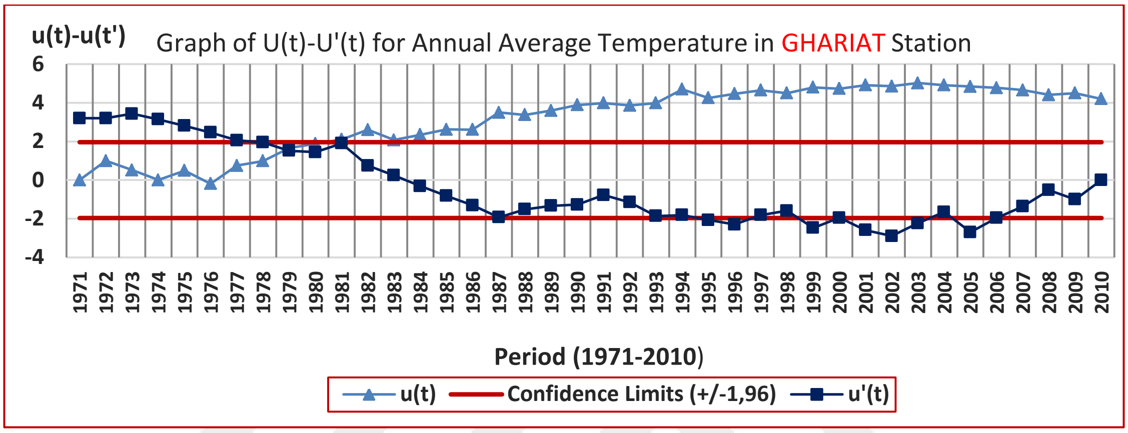
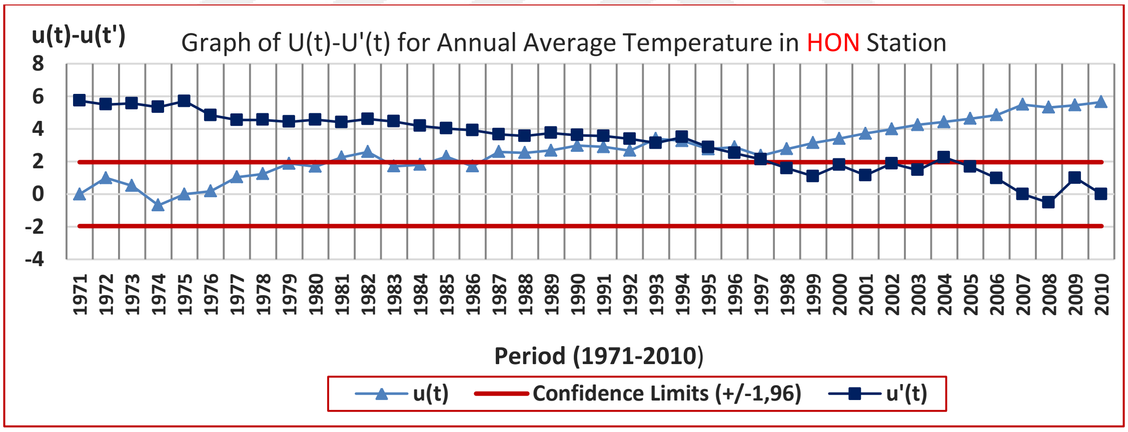


Figure 180. Graphs of M-K U(t)-U'(t) Results for Annual Average Temperature in AGDABIA, ALFATAIAH, BENGHAZI and DERNA Stations







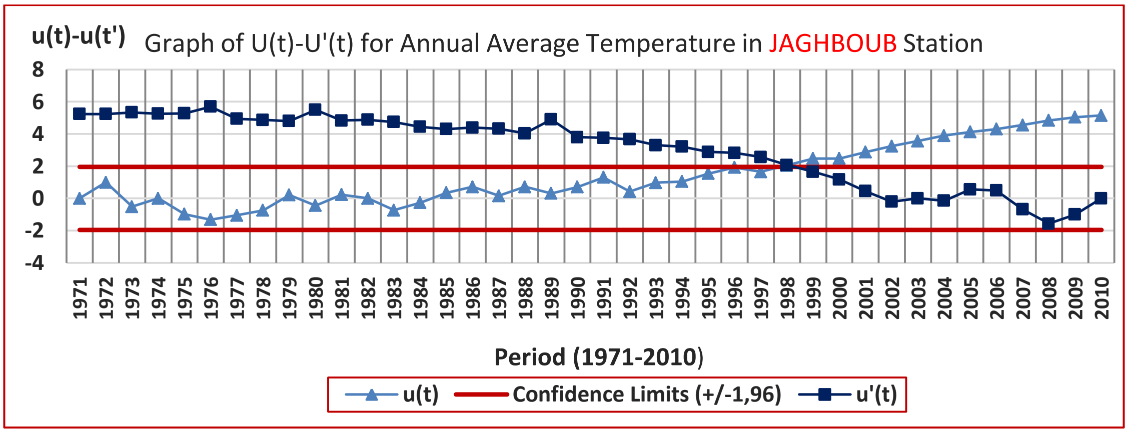


Figure 181. Graphs of M-K U(t)-U'(t) Results for Annual Average Temperature in GHADAMES, GHARIAT, HON and JAGHBOUB Stations

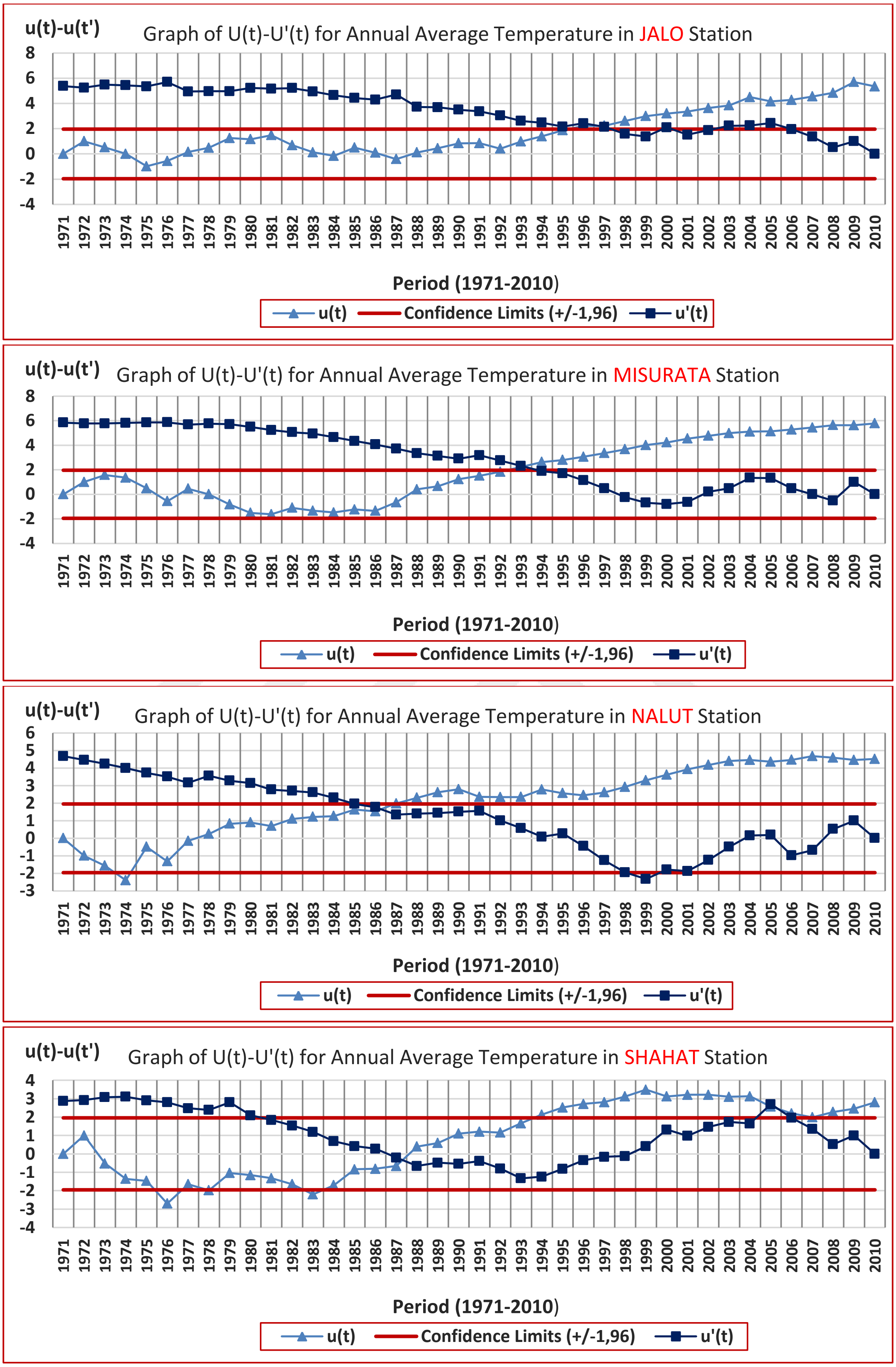
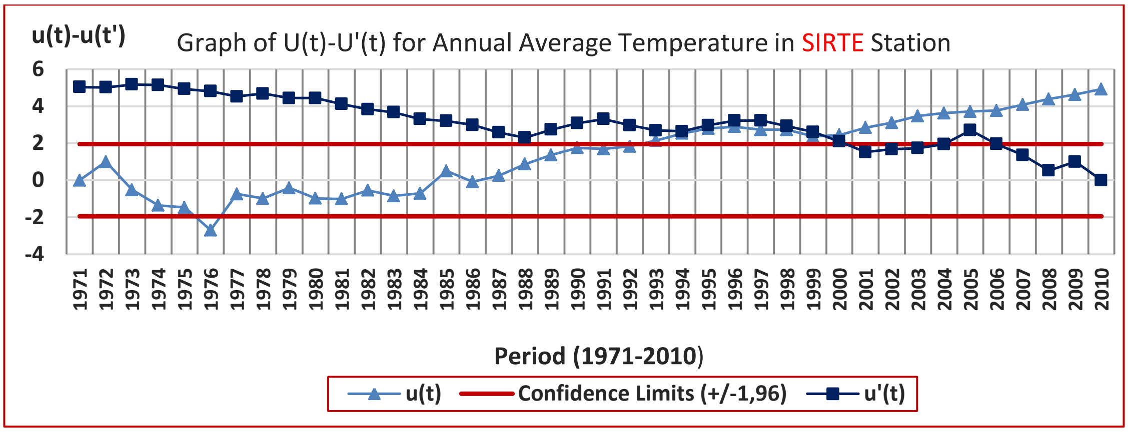
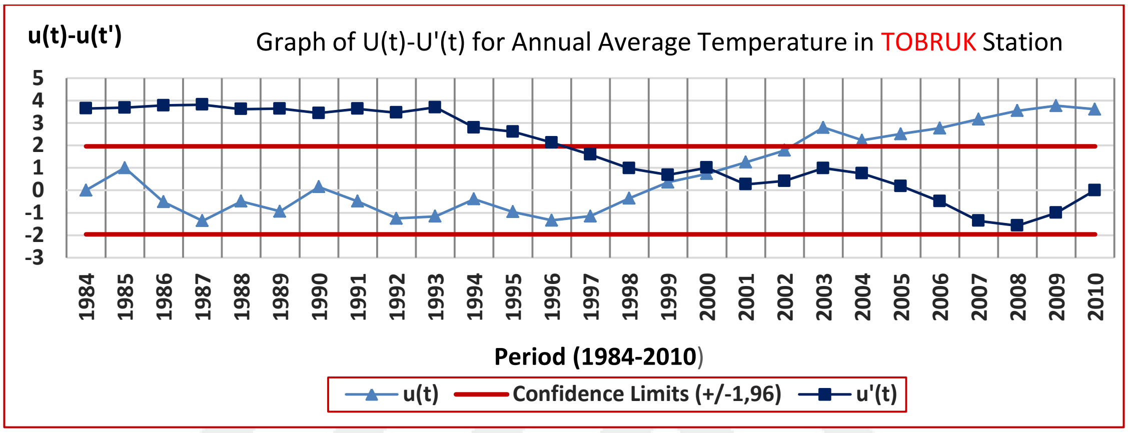
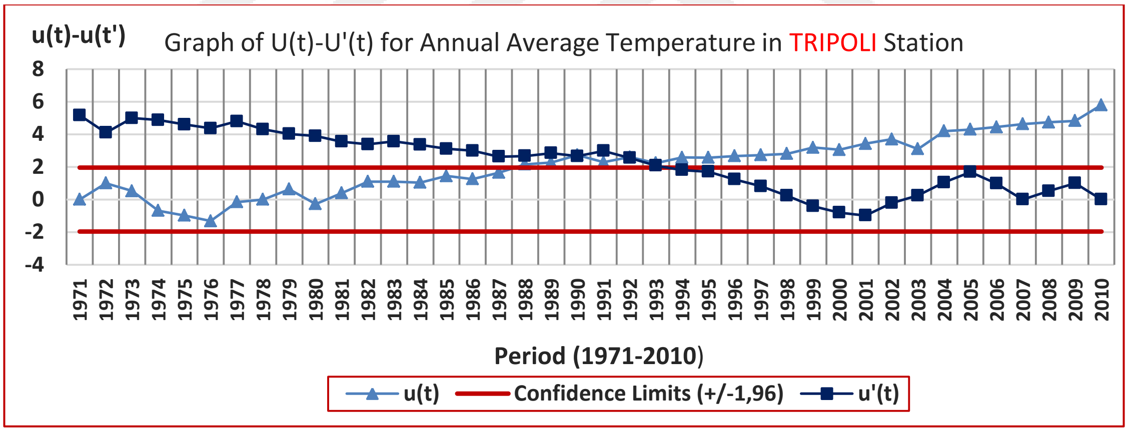


Figure 182. Graphs of M-K U(t)-U'(t) Results for Annual Average Temperature in JALO, MISURATA, NALUT and SHAHAT Stations







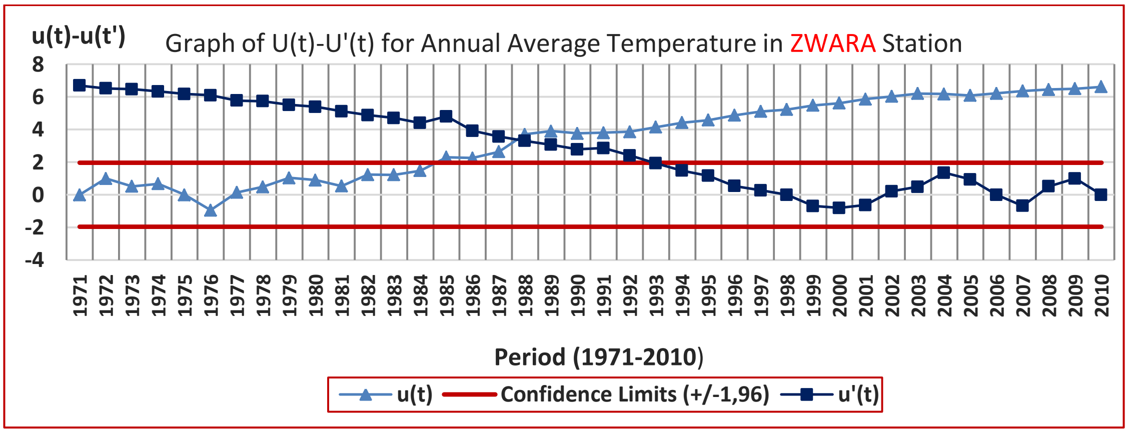


Figure 183. Graphs of M-K U(t)-U'(t) Results for Annual Average Temperature in SIRTE, TOBRUK, TRIPOLI and ZWARA Stations

4.1.2.4.Evaluation for Results of Mann-Kendall Embodiment Correlation U(t) -U (t') Tests of the Maximum, MinimumandAverageTemperatures Data

The results are to be assessed by indicating whether or not there is a trend, in the next tables because of the many graphs (Figures from 125 to 184).

-**Evaluation for Result of Maximum Temperature**

Table 90. Evaluation of Results of U(t), U(t') for Seasonally and Annul MaximumTemperatures Data

Stations	Spring	Summer	Autumn	Winter	Annual
AGDABIA	×	×	↑ (1989)	×	×
ALFATAIAH	×	↓ (1993)	↓ (1990)	×	↑ (1995)
BENGHAZI	×	×	×	×	×
DERNA	×	×	×	×	×
GHADAMES	×	×	×	×	×
GHARIAT	×	×	×	×	×
HON	×	×	↑ (1988)	×	×
JAGHBOUB	×	↑ (1993)	↑ (1989)	↓ (2002)	↑ (1995)
JALO	×	↑ (1993)	×	↑ (2008)	↑ (1998)
MISURATA	×	↑ (1993)	↓ (1987)	×	↑ (1993)
NALUT	×	×	×	×	↑ (1993)
SHAHAT	×	×	×	×	↑ (1971)
SIRTE	×	×	↑ (1989)	×	↑ (1998)
TOBRUK	×	×	↑ (1989)	×	↑ (1994)
TRIPOLI	×	×	↑ (1981)	×	×
ZWARA	×	↑ (1990)	↑ (1982)	×	×

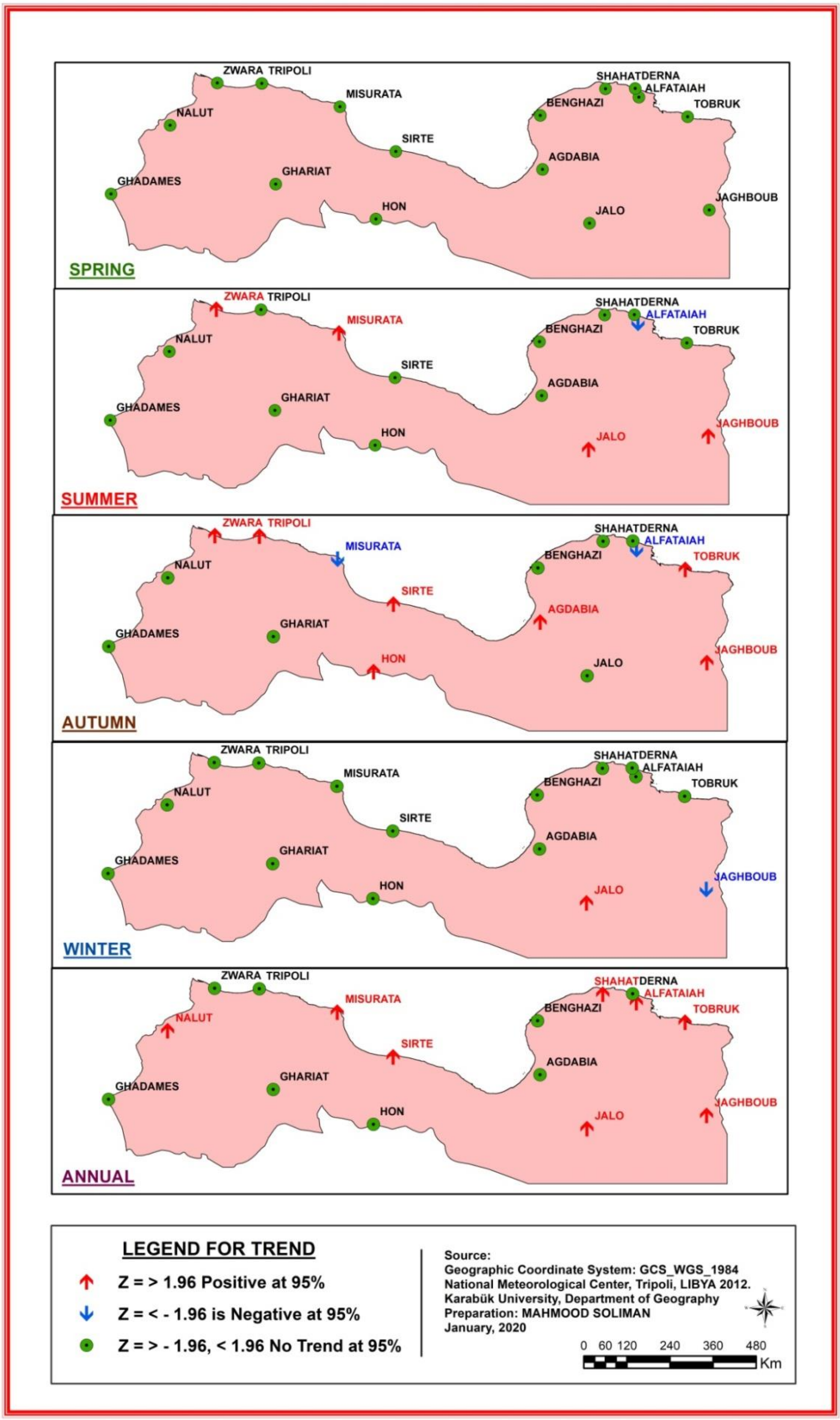
Table data based on the graphs of U(t), U(t').
↑= There is Positive Trend, ↓= There is Negative Trend, and ×= There isn't Trend.

Table 90 and The map 28 show the distribution of seasonally maximum temperature trends over the stations of the study area shows the following facts:

❖ **Spring,**there is no station showing any trend (Positive or Negative) in spring.

❖ **Summer,**there are five stations showing a trend in the summer season which are ALFATAIAH (negative Trend began in 1993), JAGHBOUB, JALO, MISURATA (positive trend began in 1993), and ZWARA (positive trend began in 1990).

❖ **Autumn,**many stations show an increasing trend in the autumn season four stations show beginning of positive trend positive trend in 1989 which are AGDABIA, JAGHBOUB, SIRTE, and TOBRUK. HON station shows an increase in trend (a positive trend began in 1988), TRIPOLI station (positive trend began in 1981) and ZWARA station (a positive trend in 1982). There are two stations that show a decrease in trend which are ALFATAIAH station (a negative trend began in 1991), and MISURATA station (a negative trend began in 1987). It is worth mentioning that the fall season shows most of trends during the monitoring period.



Map 27. Results of U(t), U(t') for Seasonally and Annul forAverageMaximumTemperatures (1971-2010)

❖ **Winter,**the trend is very decreasing at all stations except for two stations of JAGHBOUB station (negative trend began in 2002) and JALO station (a positive trend in 2008), while the intersection of curves in monitoring years is observed significantly.

❖ **Annual,**in the annual average temperatures, some stations show an increase in trend like ALFATAIAH station (positive trend began in 1995), JAGHBOUB station (positive trend began in 1995), JALO station (positive trend began in 1998), MISURATA station (positive trend began in 1993), NALUT station (positive trend began in 1993), SIRTE station (positive trend began in 1998), and TOBRUK station (positive trend began in 1994), (|Table 92 and Map 24).

***Evaluation for Result ofMinimumTemperature**

Table 91. Evaluation of Results of U(t), U(t') for Seasonally and Annul Minimum Temperatures Data

Stations	Spring	Summer	Autumn	Winter	Annual
AGDABIA	×	×	×	×	×
ALFATAIAH	×	×	×	×	×
BENGHAZI	×	×	×	×	×
DERNA	↑ (1999)	×	↑ (1992)	×	↑ (1983)
GHADAMES	×	×	×	×	×
GHARIAT	×	×	×	×	×
HON	↑ (1998)	↑ (2003)	×	×	×
JAGHBOUB	↑ (2006)	×	×	↑ (2004)	↑ (2002)
JALO	×	×	×	×	×
MISURATA	×	×	↑ (1989)	×	×
NALUT	×	×	↑ (1981)	×	×
SHAHAT	×	×	×	×	×
SIRTE	×	×	×	×	×
TOBRUK	↑ (2004)	×	↑ (2000)	×	↑ (2004)
TRIPOLI	×	↑ (1994)	↑ (1986)	×	×
ZWARA	↑ (1998)	×	×	×	×

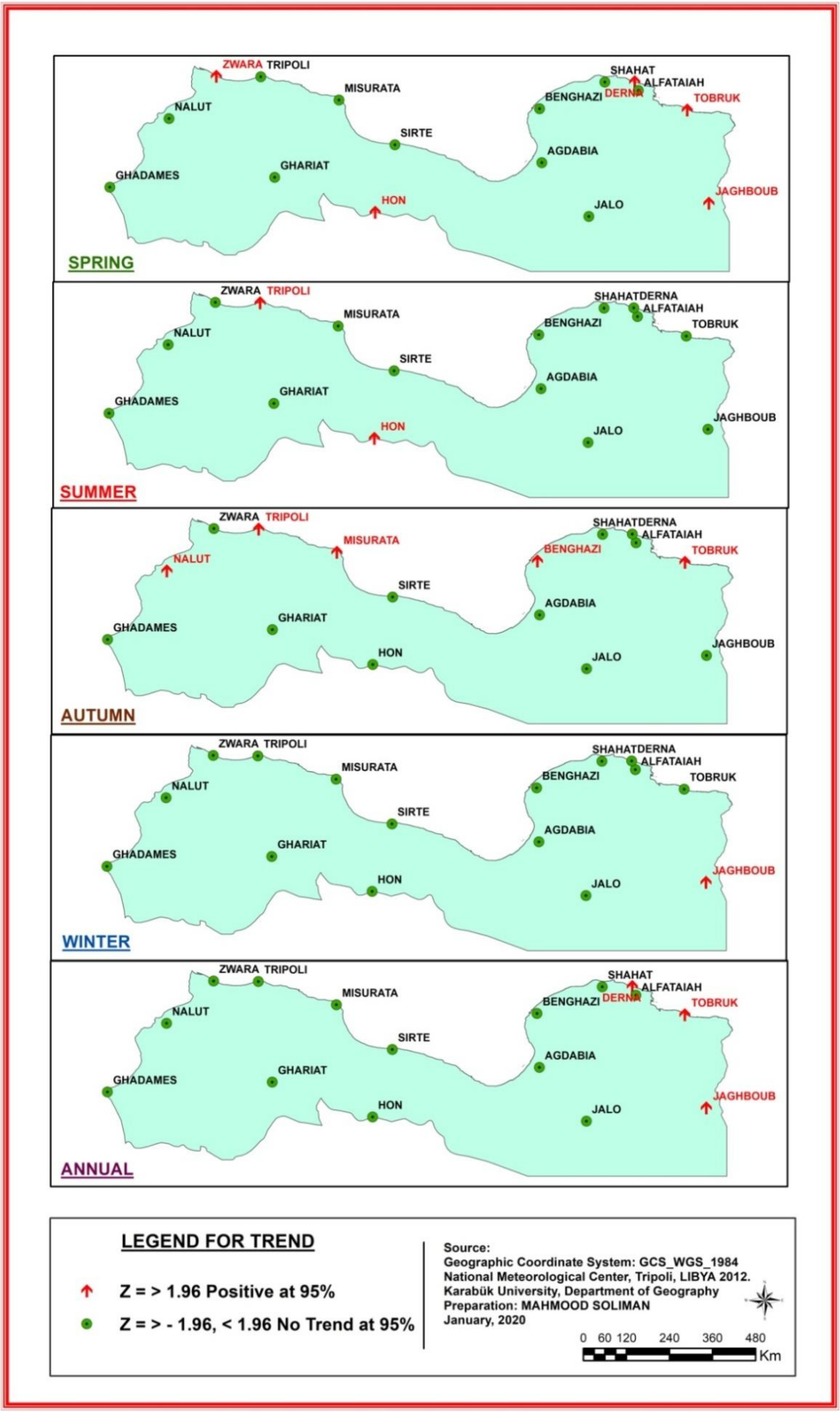
Table data based on the graphs of U(t), U(t').

↑= There is Positive Trend, ↓= There is Negative Trend, and ×= There isn't Trend.

Table 91 and the map 29 show the distribution of seasonally minimum temperature trends over the stations of the study area shows the following facts:

❖ **Spring,**there are five stations showing positive trend in spring which are DERNA (a positive trend of increase began in 1999), Hon (positive trend began in 1998), JAGHBOUB (positive trend began in 2006), TOBRUK (positive trend began in 2004) and ZWARA (positive trend began in 1998).

❖ **Summer,** only two stations show increase in trend in the summer season which are DERNA station (positive trend began in 2003) and ZWARA station (positive trend began in 1994).



Map 28. Results of U(t), U(t') for Seasonally and Annul forAverageMinimumTemperatures (1971-2010)

❖ **Autumn,** some stations show an increase in trend in the autumn season. There are five stations which show increasing trend which are DERNA station (positive trend in 1992), MISURATA station (positive trend in 1989), NALUT station (positive trend in 1981), TOBRUK station (positive trend in 2000) and TRIPOLI station (positive trend in 1986).

❖ **Winter,** only JAGHBOUB station shows positive trend in 2004 while the trend was very decreasing at all stations.

❖ **Annual,** in the annual average temperatures, only three stations show an increase in trend which are DERNA station (positive trend began in 1983), JAGHBOUB station (positive trend began in 2002) and TOBRUK station (positive trend began in 2004), (|Table 93 and Map 25).

-Evaluation for Result of Average Temperature

Table 92. Evaluation of Results of U(t), U(t') for Seasonally and Annul Average Temperatures Data

Stations	Spring	Summer	Autumn	Winter	Annual
AGDABIA	×	×	×	×	↑ (1994)
ALFATAIAH	×	×	×	×	×
BENGHAZI	×	×	×	↑ (2010)	×
DERNA	×	×	×	×	↑ (1997)
GHADAMES	×	×	↑ (1982)	×	×
GHARIAT	×	×	↑ (1981)	×	×
HON	×	×	×	×	×
JAGHBOUB	×	×	×	×	↑ (1998)
JALO	×	↑ (1993)	×	×	×
MISURATA	×	×	↑ (1987)	×	↑ (1993)
NALUT	×	×	×	×	×
SHAHAT	×	×	×	×	×
SIRTE	×	×	×	×	×
TOBRUK	×	×	×	×	×
TRIPOLI	×	×	×	×	×
ZWARA	↑ (1988)	↑ (1993)	↑ (1984)	×	×

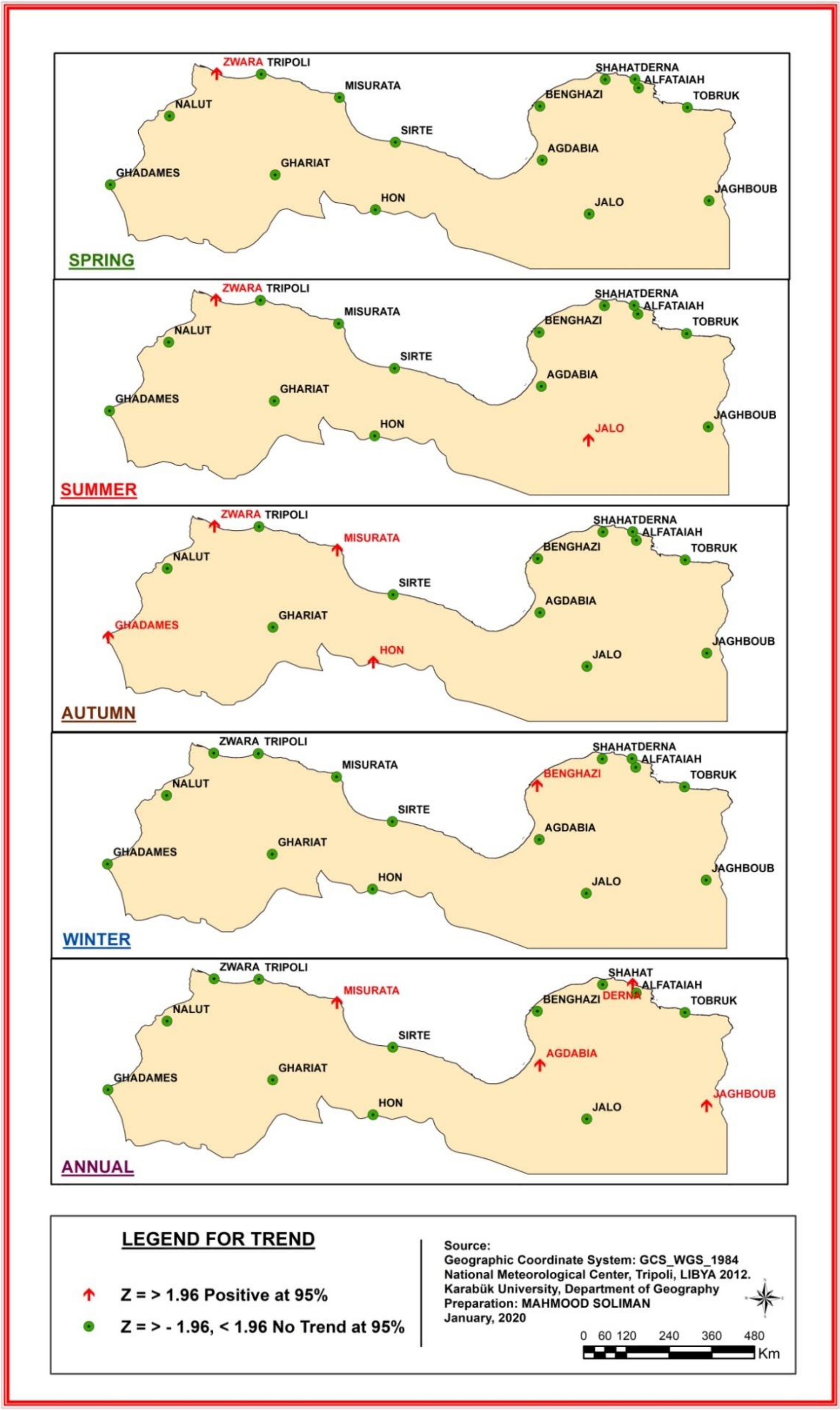
Table data based on the graphs of U(t), U(t').

↑= There is Positive Trend, ↓= There is Negative Trend, and ×= There isn't Trend.

Table 92and the map 30 show the distribution of seasonally minimum temperature trends over the stations of the study area shows the following facts:

❖ **Spring,**ZWARA station is the only station with a positive trend in 1988 in spring **Summer,** in summer, only two station show increase in trend (JALO, and ZWARA), the positive trend started in JALO and ZWARA stations in 1993 and in

❖ **Autumn,**there are four stations that show increase in trend in autumn season which are GHADAMES in (1982), GHARIAT in (1981), MISURATA in (1987), and ZWARA in (1984).



Map 29. Results of U(t), U(t') for Seasonally and Annul for Average Temperatures (1971-2010)

❖ **Winter,** only BENGHAZI station shows increase in trend in (2010),and all other stations do not show any trend in any of the monitoring years, indicating that the general trends of average temperatures in winter are very decreasing.

❖ **Annual,** there are four stations that show an increase in trend in the annual average temperatures which are AGDABIA station (positive trend began in 1994), DERNA station (positive trend began in 1997), JAGHBOUB station (positive trend began in 1998), and MISURATA station where positive trend started in (1993), (|Table 94 and Map 25).

4.1.3. Simple Linear Trend for Temperatures Data

4.1.3.1.Simple Linear Trend of Maximum Temperatures Data (1971-2010)

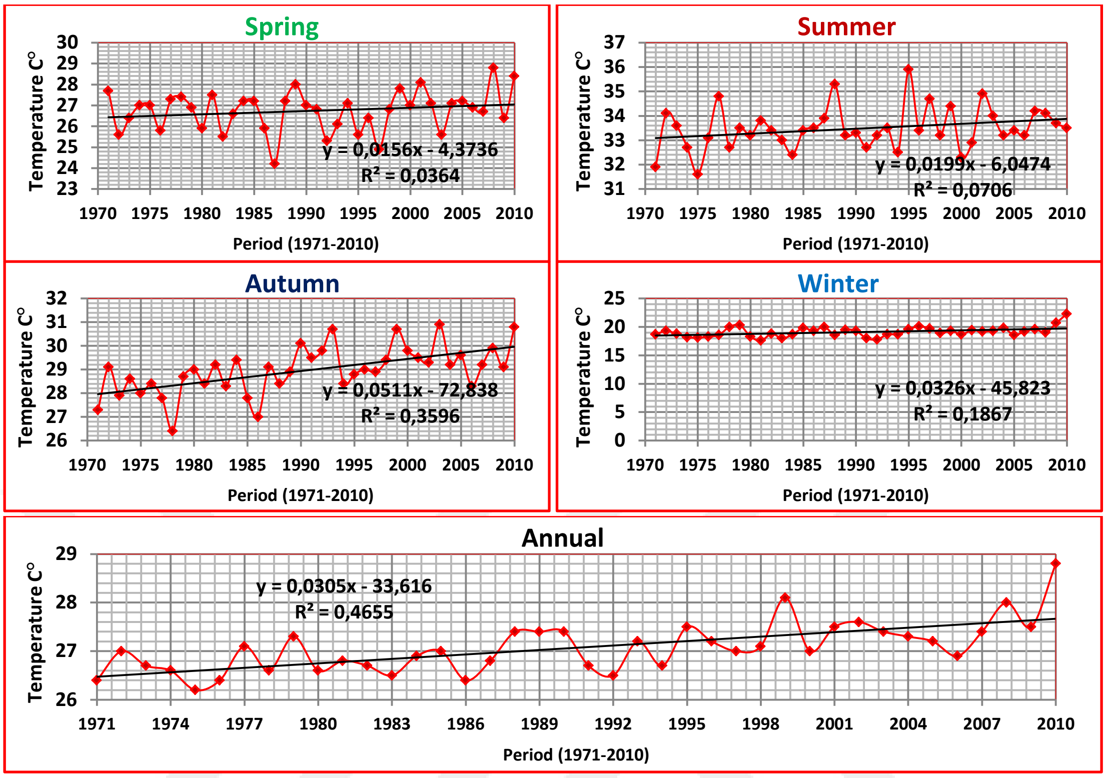


Figure 184. Simple Linear Trend Graphs of Seasonally and Annual Maximum Temperature in AGDABIA Station

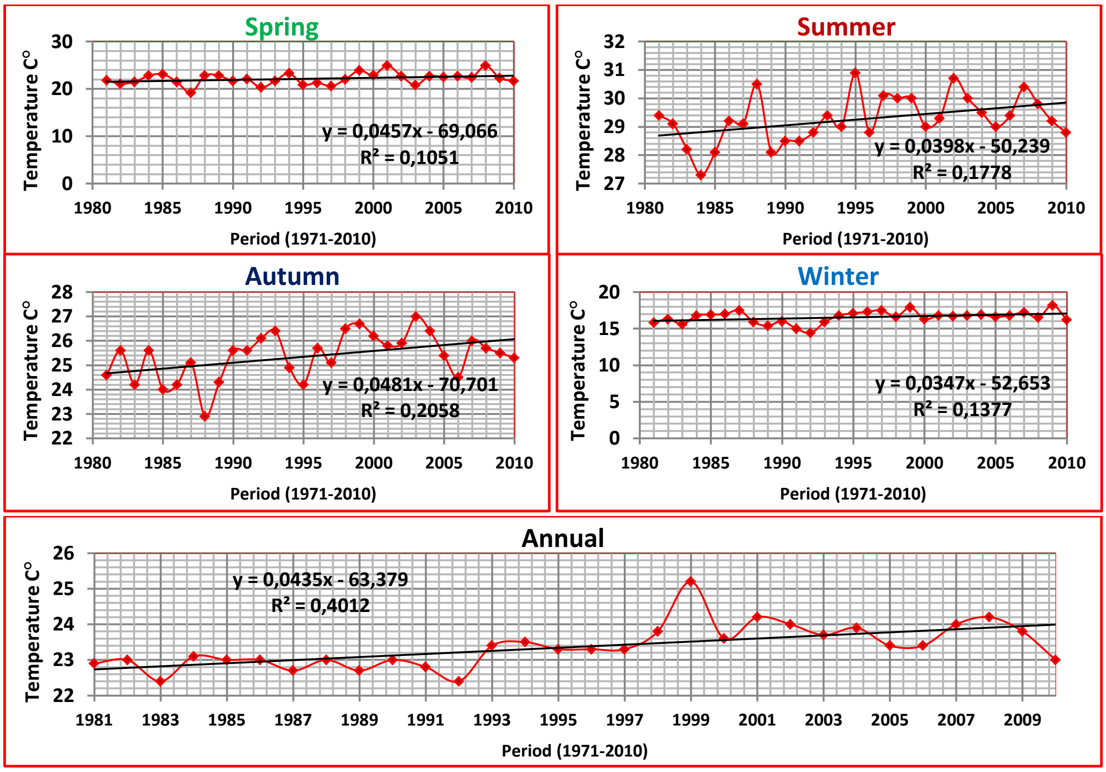


Figure 185. Simple Linear Trend Graphs of Seasonally and Annual Maximum Temperature in ALFATAIAH Station

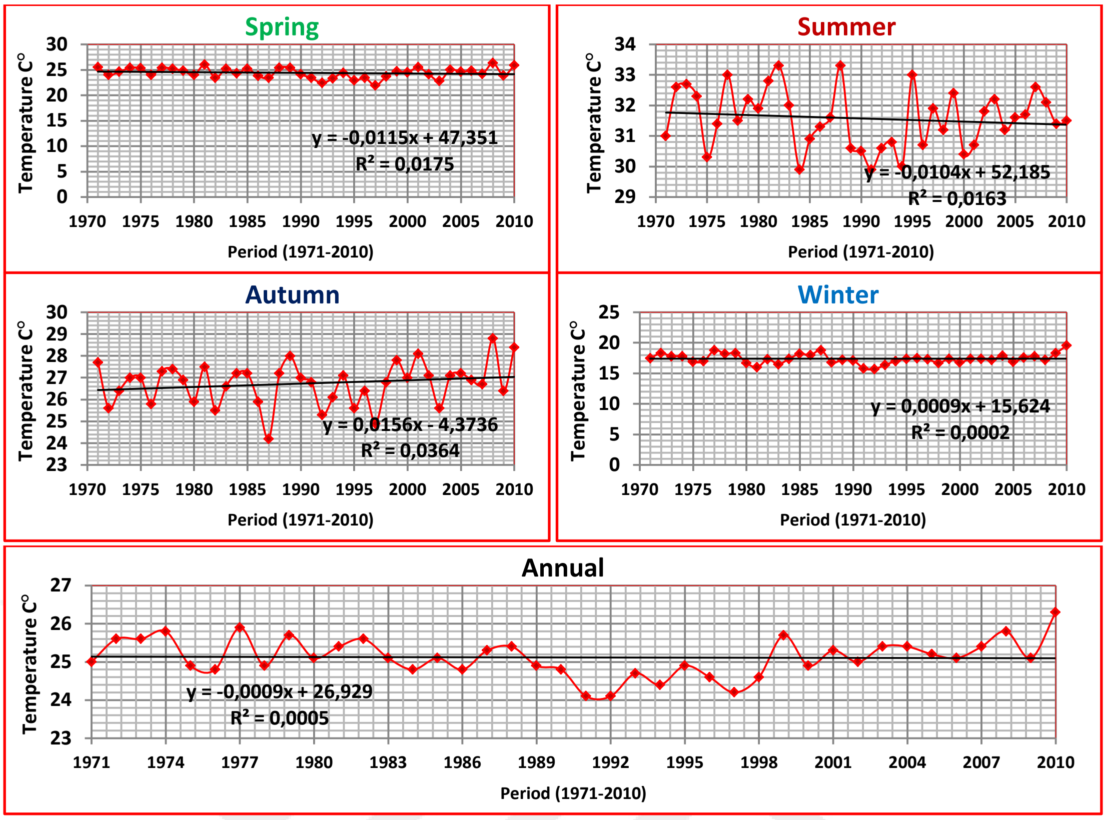


Figure 186. Simple Linear Trend Graphs of Seasonally and Annual Maximum Temperature in BENGHAZI Station

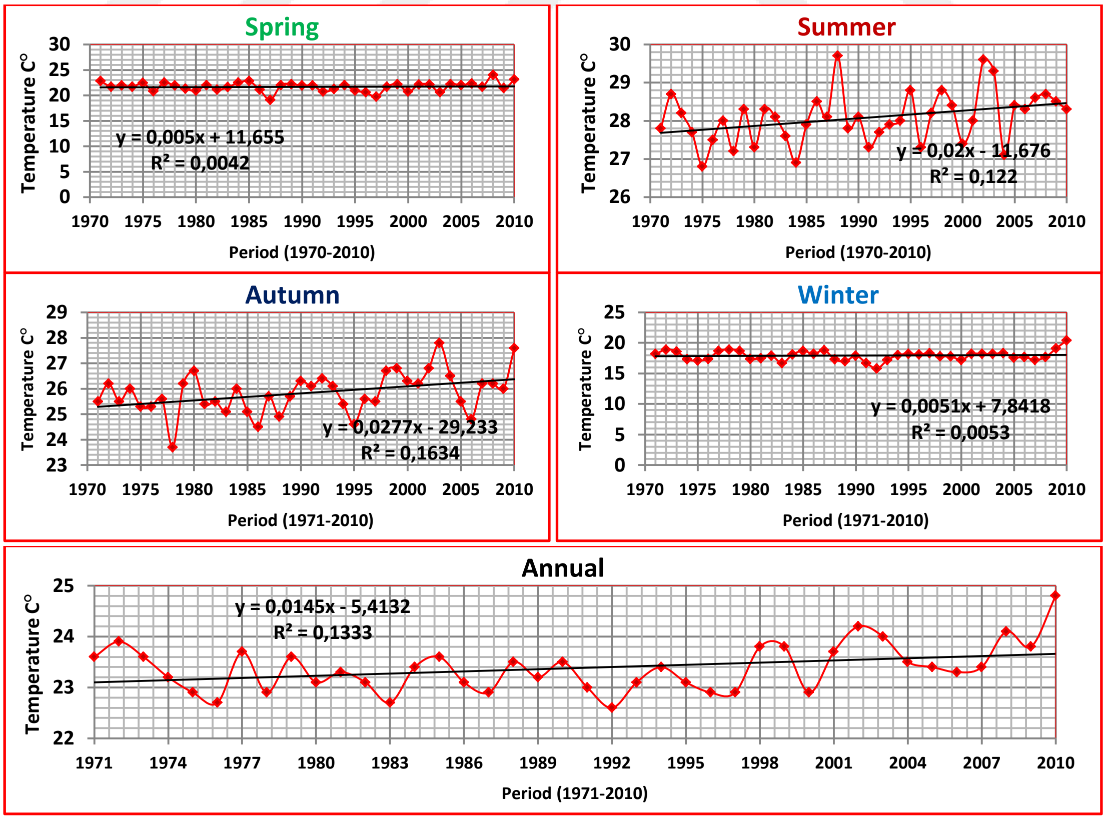


Figure 187. Simple Linear Trend Graphs of Seasonally and Annual Maximum Temperature in DERNA Station

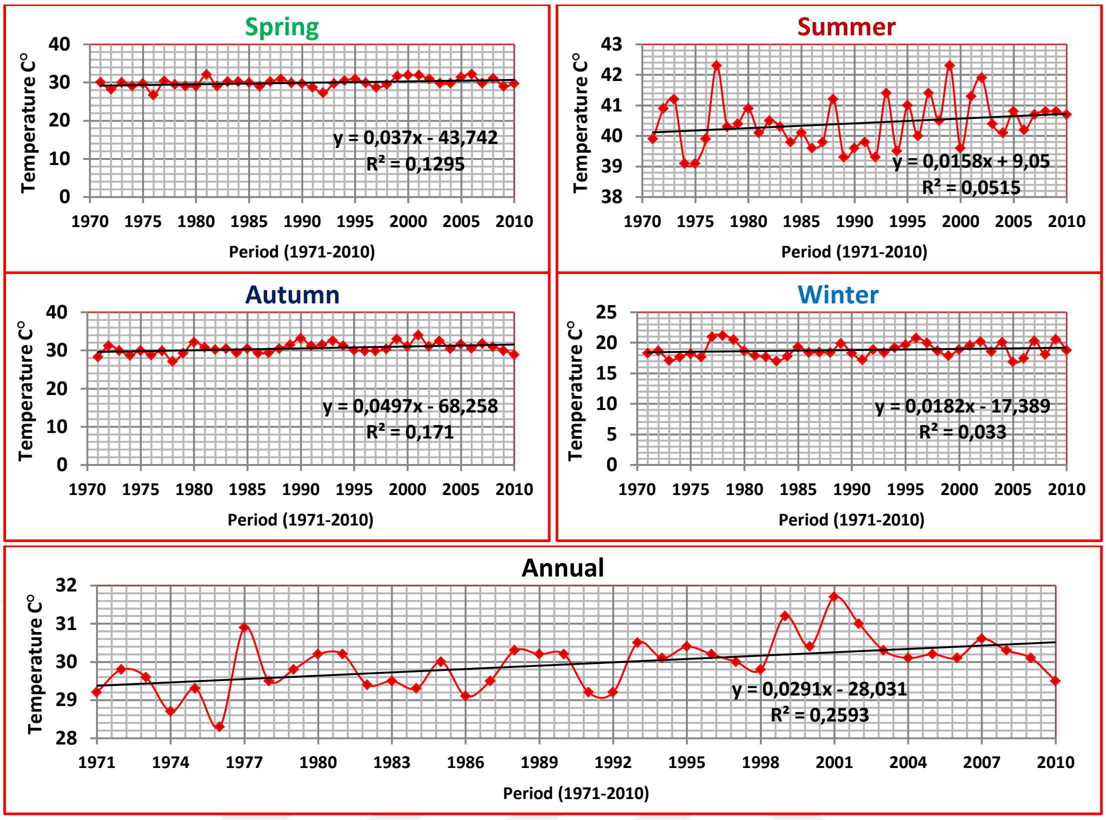


Figure 188. Simple Linear Trend Graphs of Seasonally and Annual Maximum Temperature in GHADAMES Station

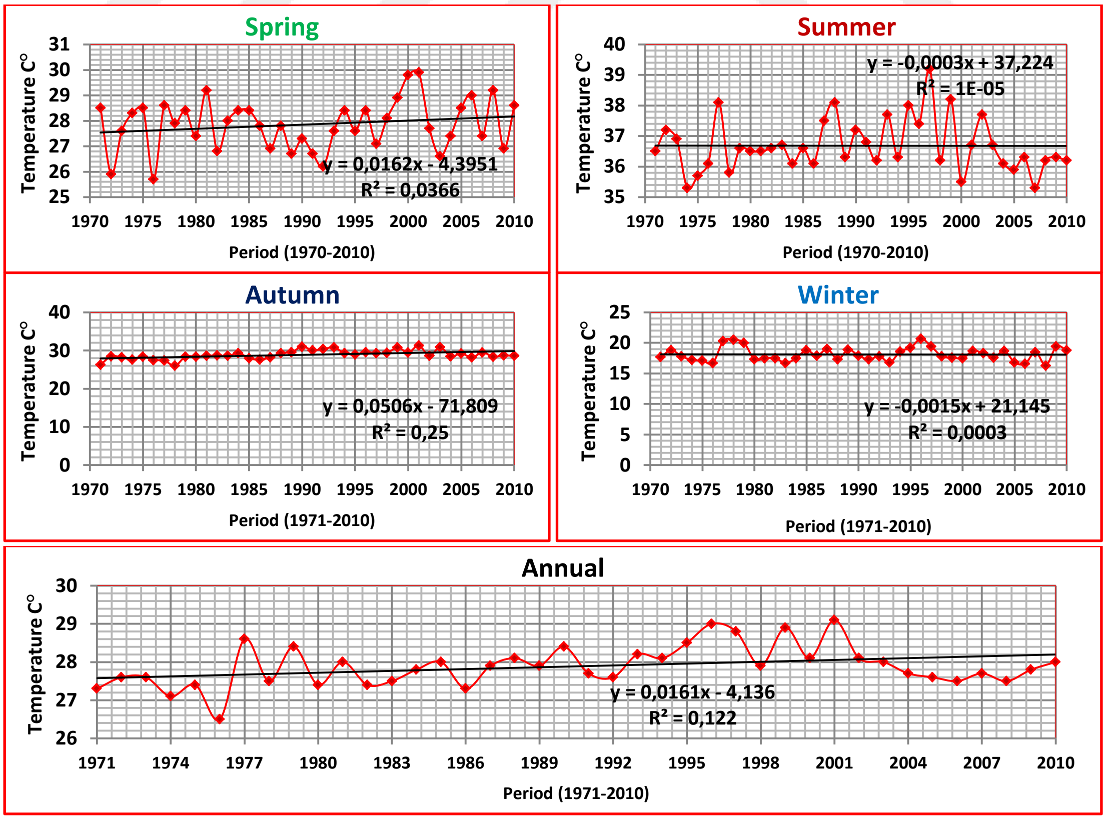


Figure 189. Simple Linear Trend Graphs of Seasonally and Annual Maximum Temperature in GHARIAT Station

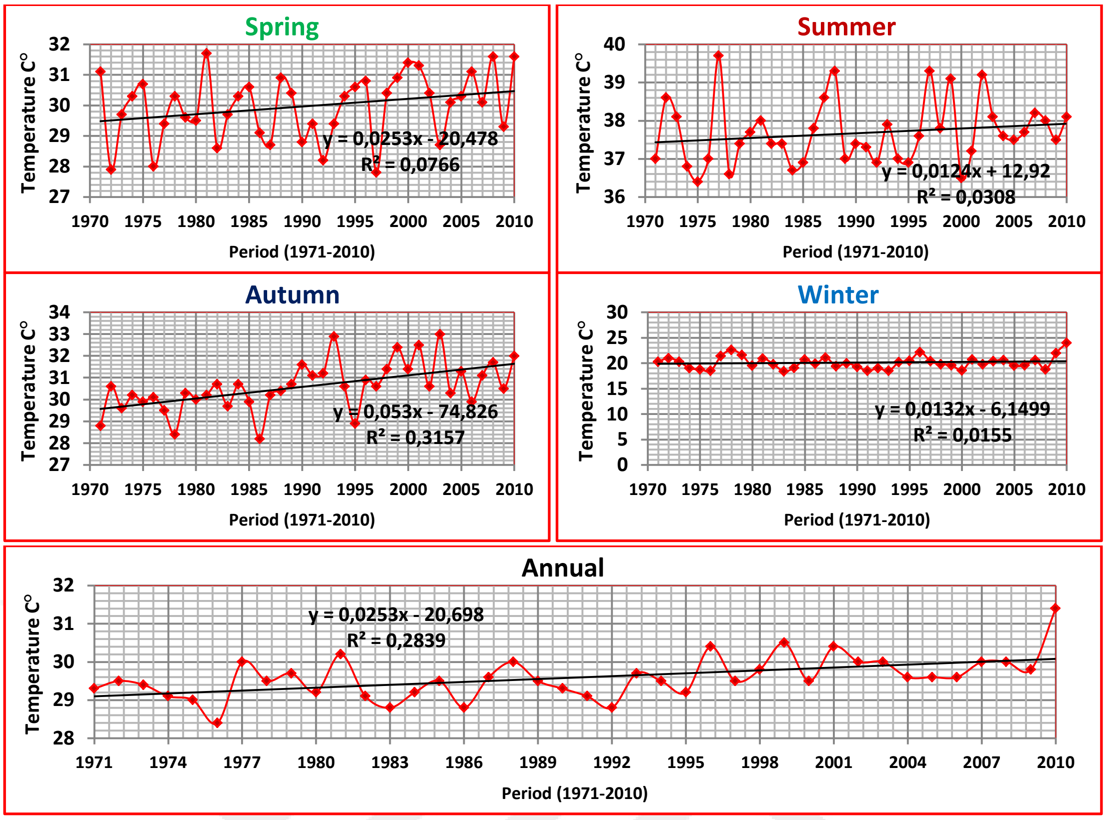


Figure 190. Simple Linear Trend Graphs of Seasonally and Annual Maximum Temperature in HON Station

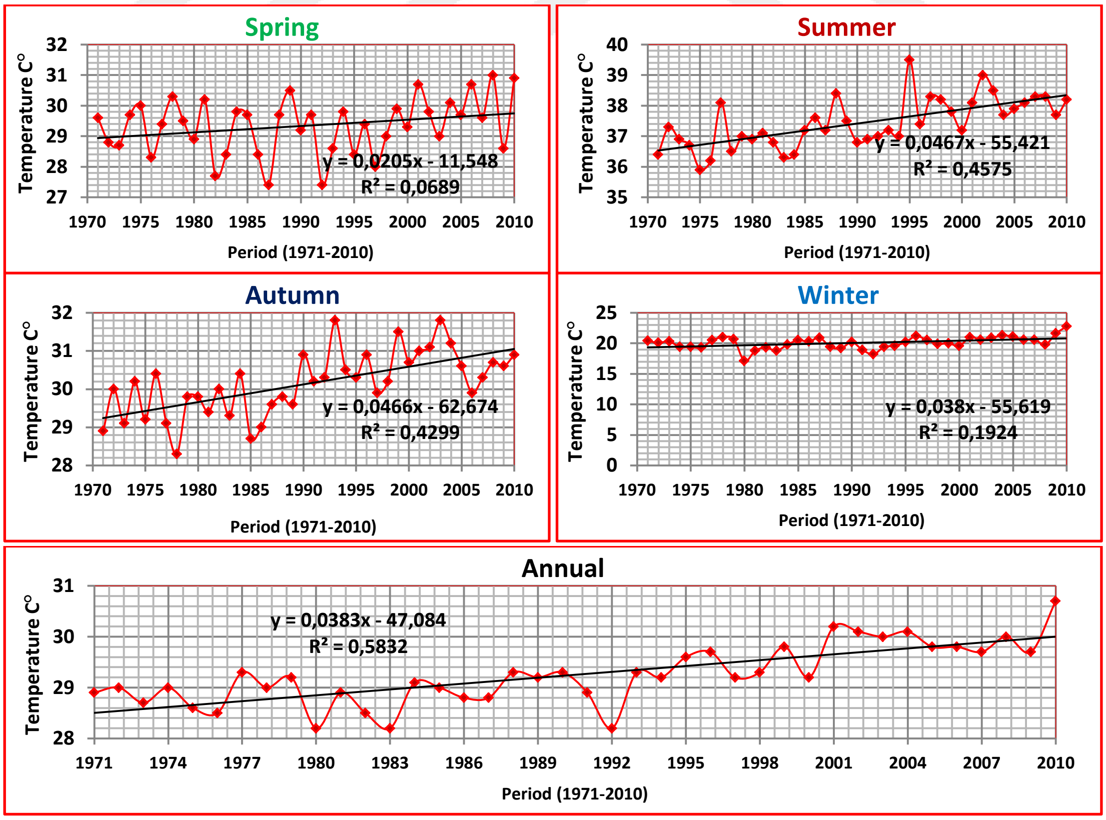


Figure 191. Simple Linear Trend Graphs of Seasonally and Annual Maximum Temperature in JAGHBOUB Station

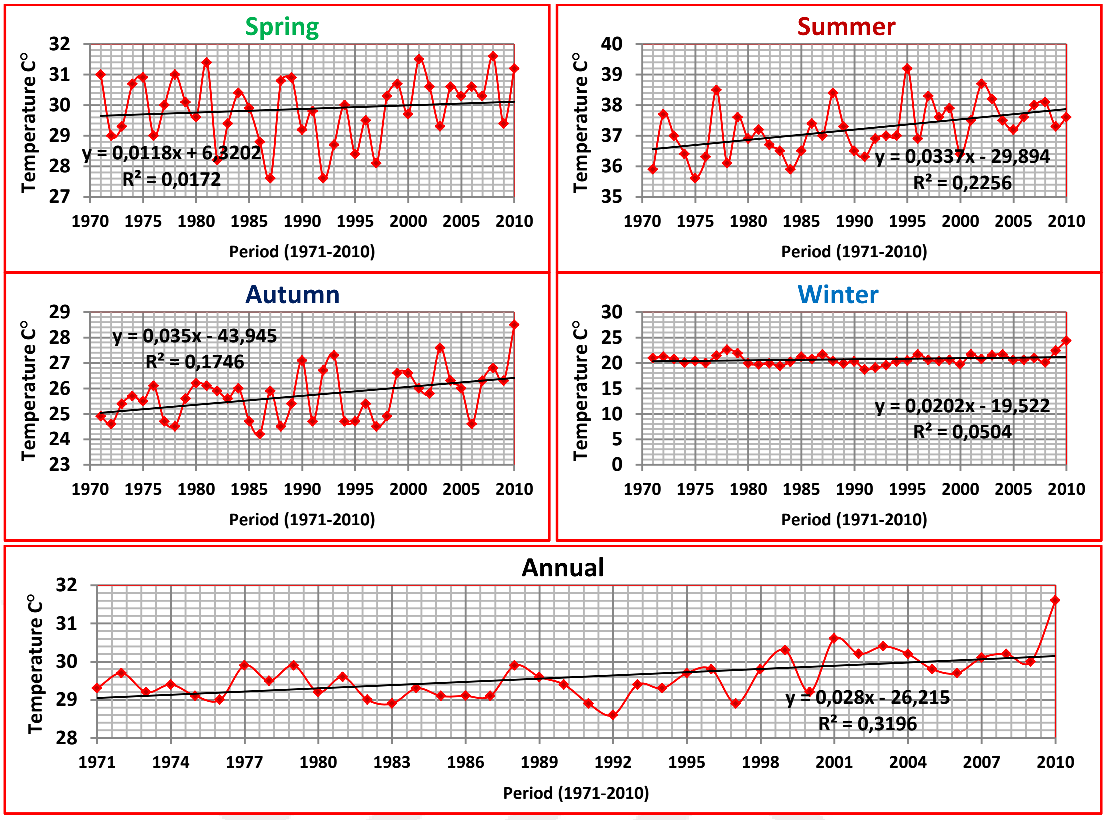


Figure 192. Simple Linear Trend Graphs of Seasonally and Annual Maximum Temperature in JALO Station

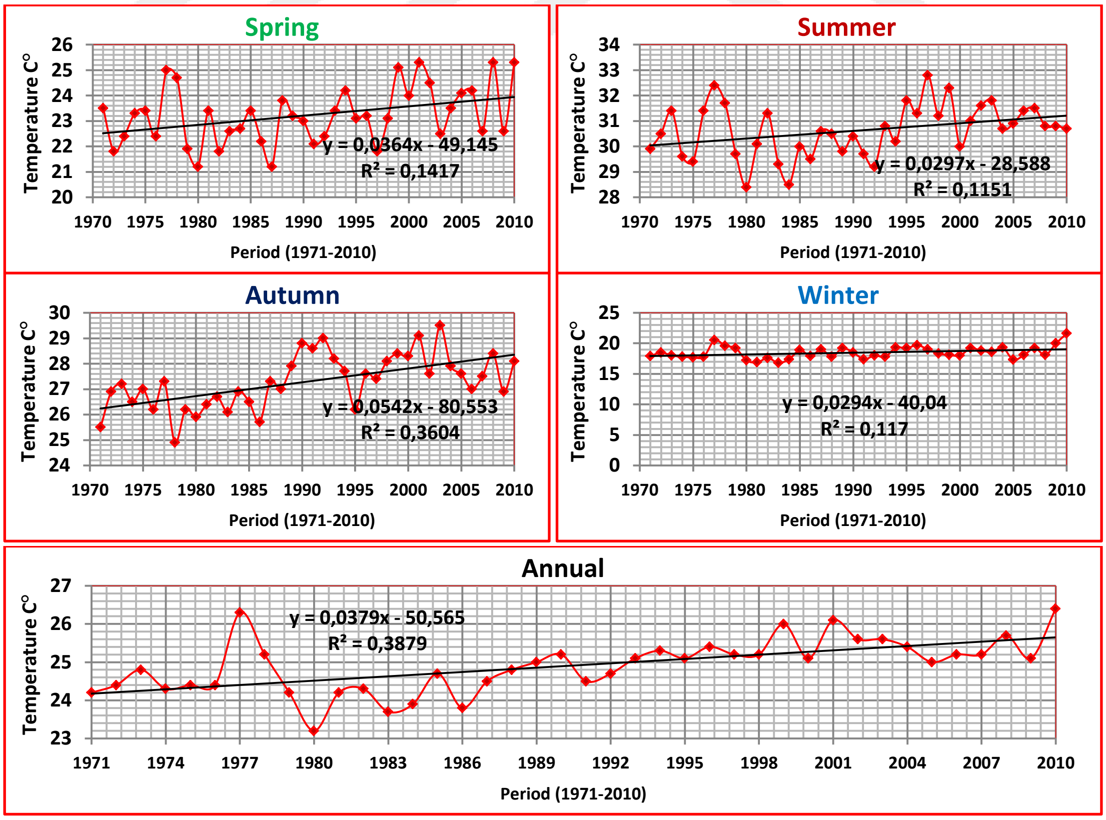


Figure 193. Simple Linear Trend Graphs of Seasonally and Annual Maximum Temperature in MISURATA Station

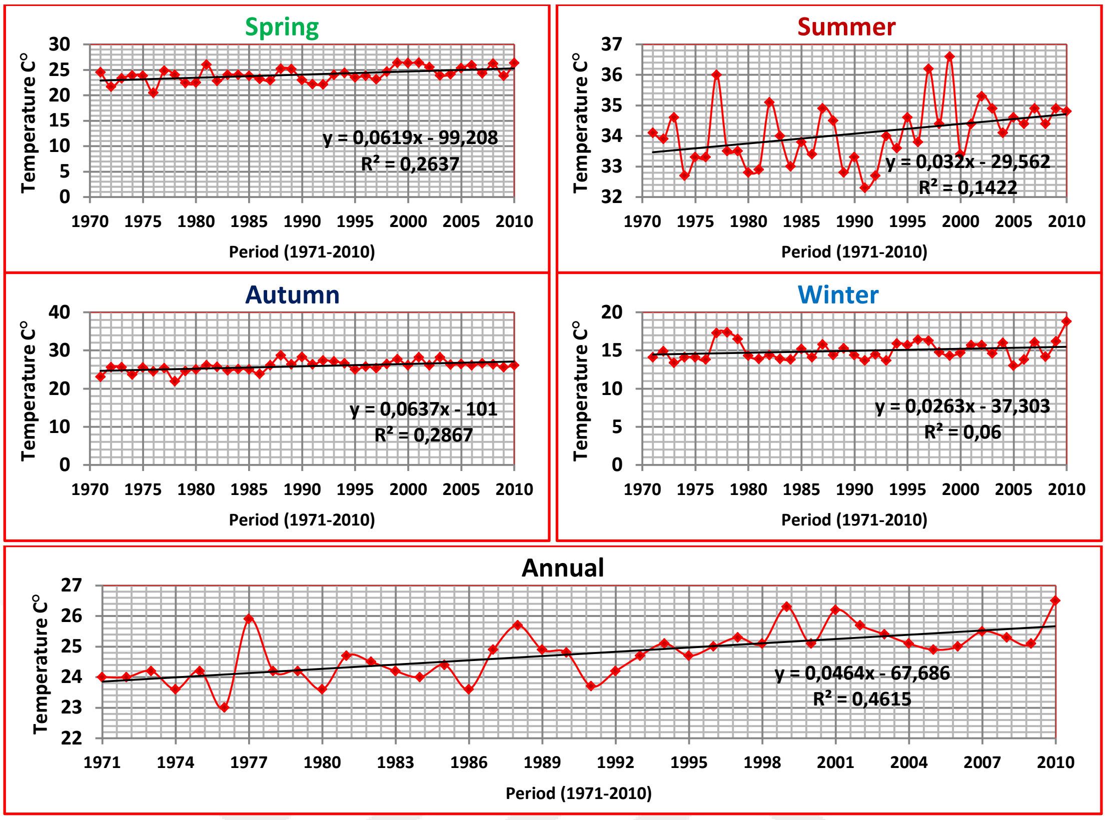


Figure 194. Simple Linear Trend Graphs of Seasonally and Annual Maximum Temperature in NALUT Station

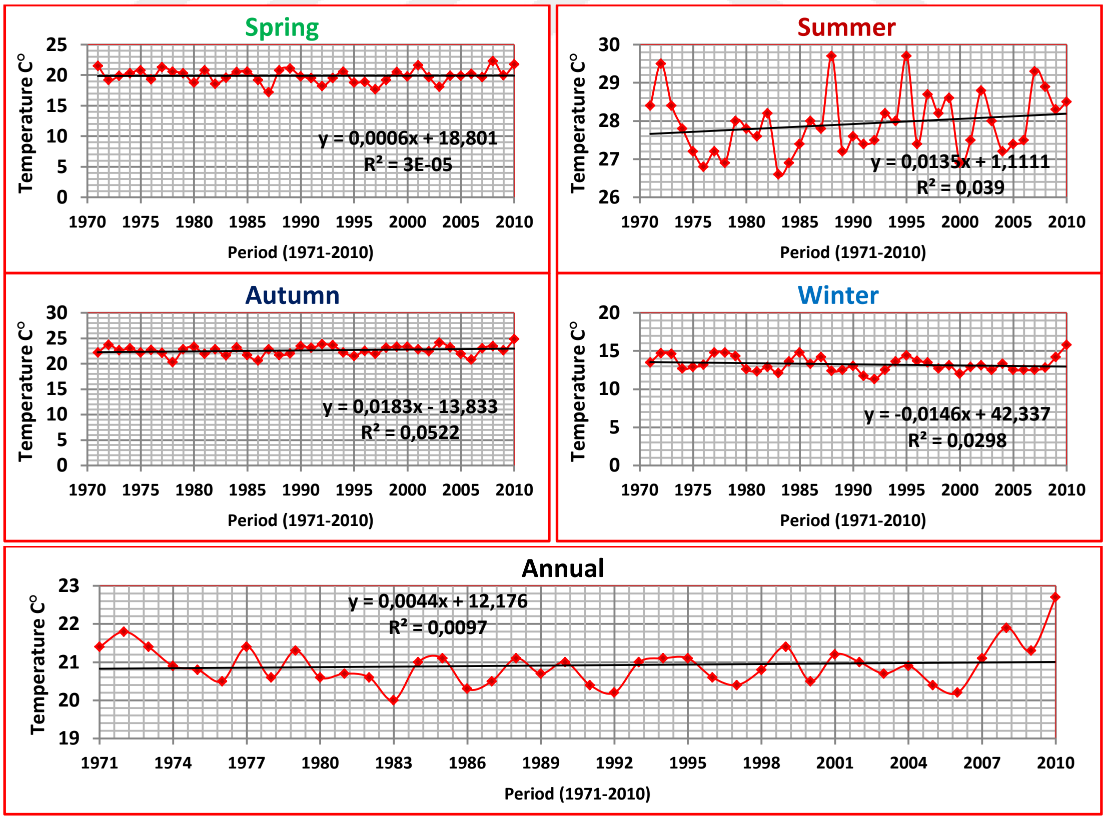


Figure 195. Simple Linear Trend Graphs of Seasonally and Annual Maximum Temperature in SHAHAT Station

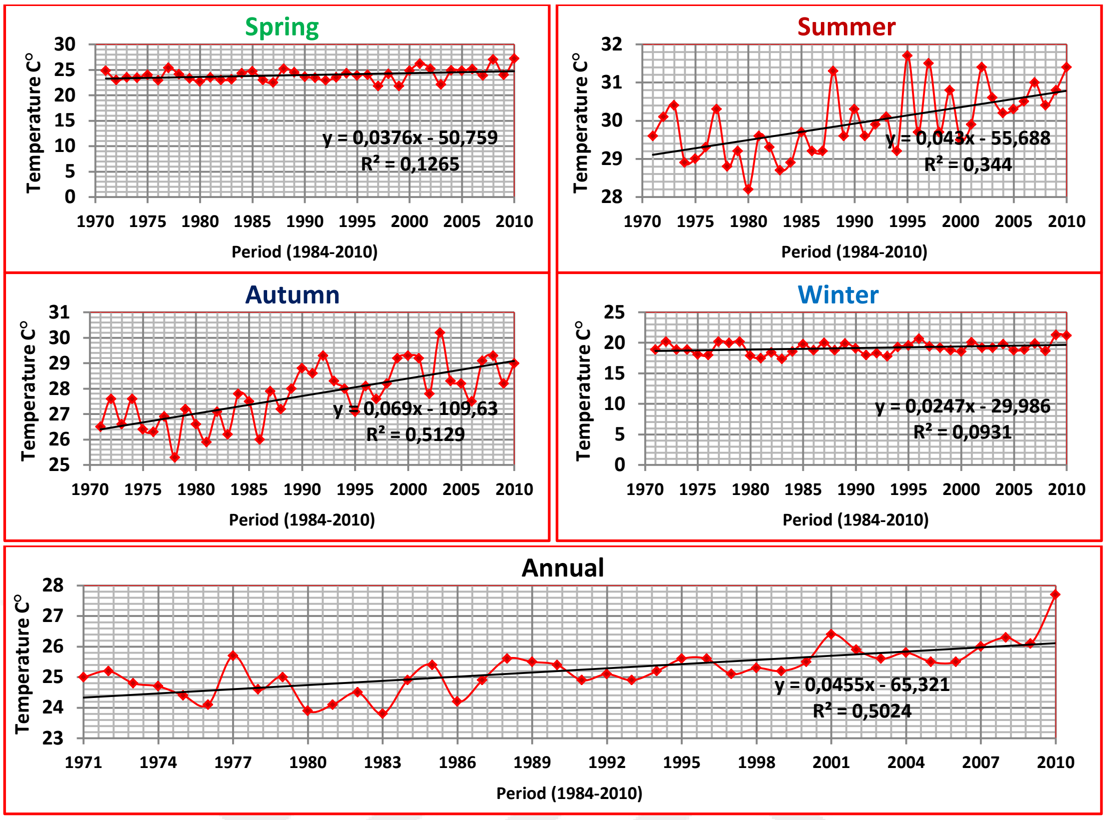


Figure 196. Simple Linear Trend Graphs of Seasonally and Annual Maximum Temperature in SIRTE Station

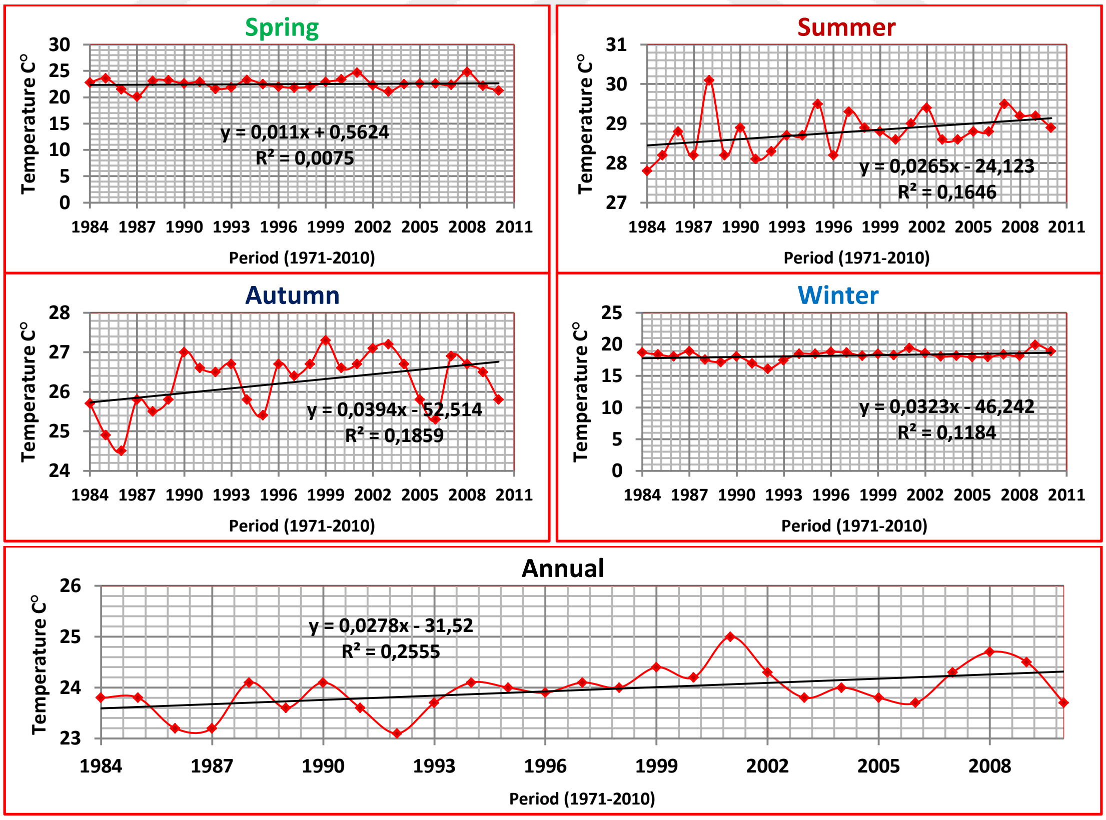


Figure 197. Simple Linear Trend Graphs of Seasonally and Annual Maximum Temperature in TOBRUK Station

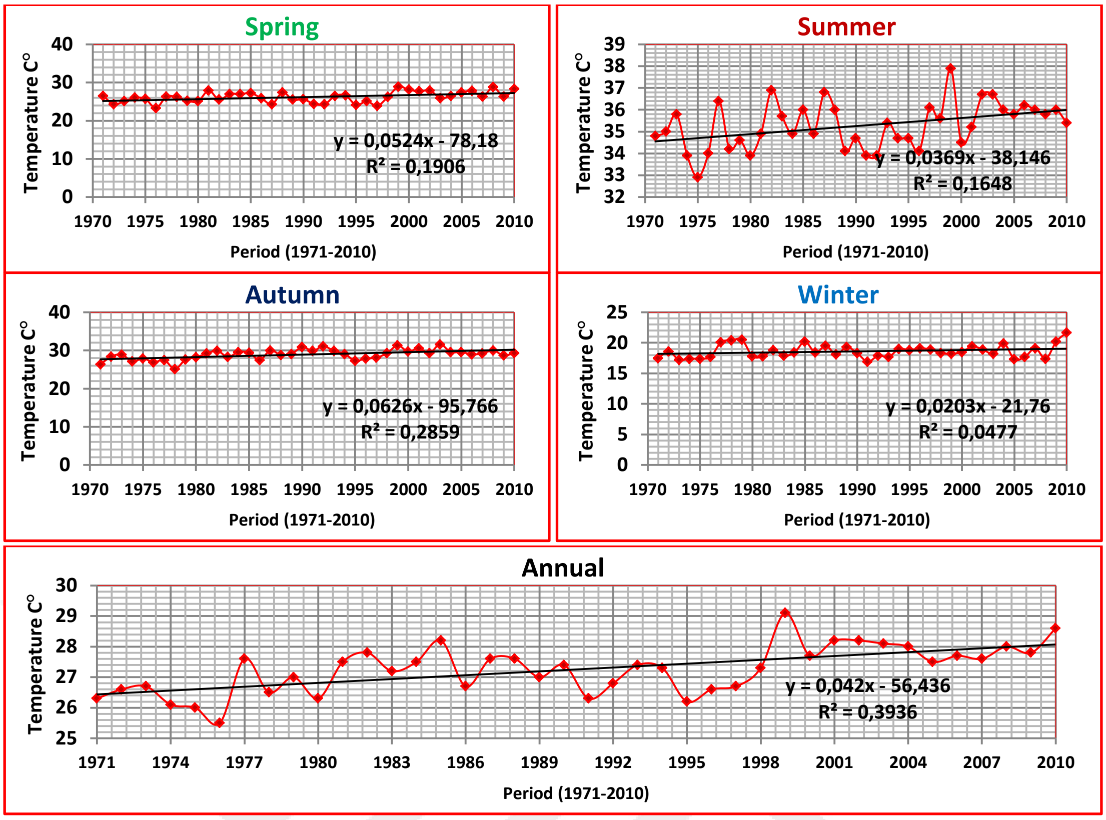


Figure 198. Simple Linear Trend Graphs of Seasonally and Annual Maximum Temperature in TRIPOLI Station

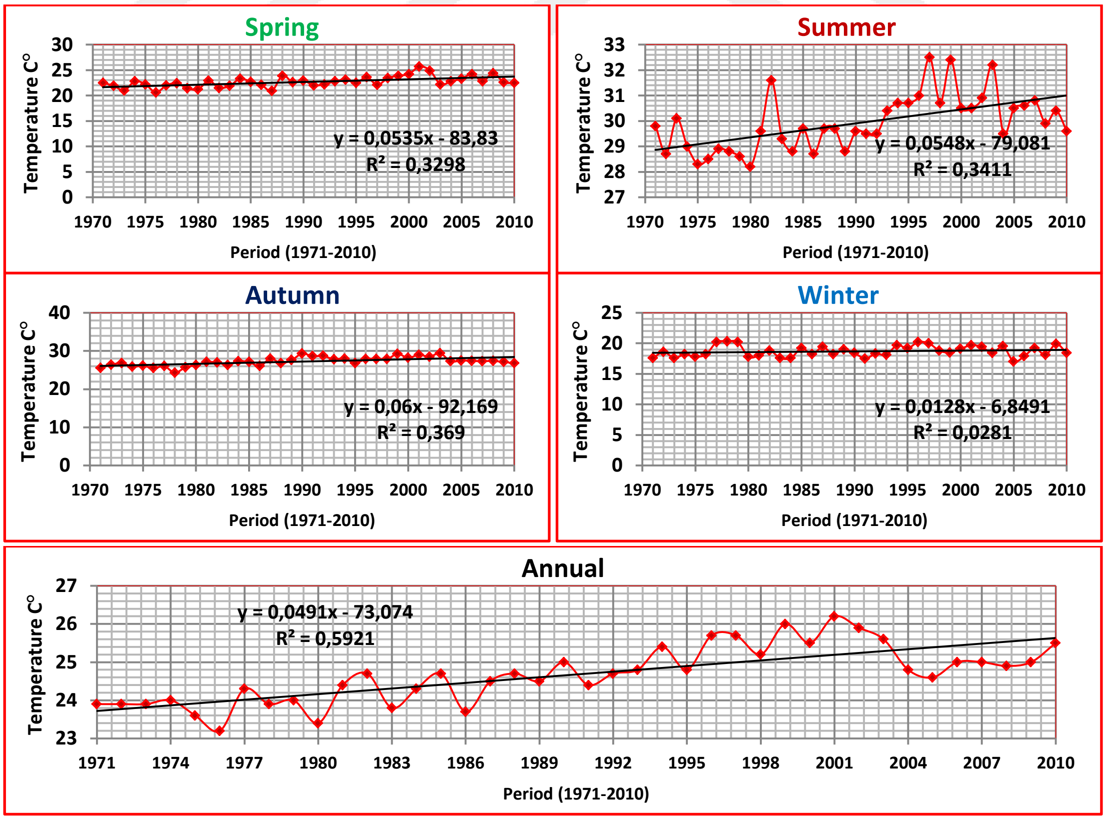


Figure 199. Simple Linear Trend Graphs of Seasonally and Annual Maximum and Annual Temperature in ZWARA Station

Table 93. Simple Linear Regression Analysis Results for Seasonally and Annual Maximum Temperatures in All Stations (1971-2010)

Stations	Spring	Summer	Autumn	Winter	Annual
AGDABIA	0.015	0.019	0.047	0.014	0.024
ALFATAIAH	0.045	0.039	0.048	0.034	0.041
BENGHAZI	-0.018	-0.010	0.016	-0.006	-0.004
DERNA	-0.002	0.019	0.024	0.005	0.011
GHADAMES	0.037	0.015	0.050	0.018	0.030
GHARIAT	0.016	-0.002	0.051	-0.001	0.015
HON	0.020	0.012	0.052	0.003	0.020
JAGHBOUB	0.020	0.046	0.041	0.030	0.035
JALO	0.004	0.033	0.027	0.009	0.021
MISURATA	0.036	0.029	0.054	0.022	0.035
NALUT	0.058	0.031	0.063	0.017	0.042
SHAHAT	-0.003	0.013	0.008	-0.020	0.000
SIRTE	0.037	0.043	0.069	0.017	0.042
TOBRUK	0.010	0.026	0.039	0.032	0.027
TRIPOLI	0.048	0.036	0.062	0.016	0.041
ZWARA	0.053	0.054	0.059	0.012	0.045

- Evaluation of Results Simple Linear Regression for Seasonally and Annual Maximum Temperature Data

When examining the trends that have occurred over the years in average maximum temperature values on a seasonal basis; in spring season there is not an increase in all stations except for NALUT station (0.058), and ZWARA station (0.053), it was observed that the results in the rest of the stations are approaching zero, either increase or decrease. If they did not show any trend during spring.

In summer, the only ZWARA station showed an upward trend (0.054), all stations were not shown an increase or decrease in trend.

Autumn is considered the most seasons increase in the trend, while 8 stations showed an upward trend, are; GHADAMES is (0.050), GHARIAT is (0.051), HON is (0.052), MISURATA is (0.054), NALUT is (0.063), SIRTE is (0.069), TRIPOLI is (0.062), and ZWARA is (0.059). Looking at the previous trend tests, it will be noted that the autumn season is characterized by the increasing trend the maximum temperature data for most stations.It was observed through the results that the winter and the general average annual maximum temperature were not showing any trend (increase or decrease)(Table 93dependent on figures 185 – 200).

4.1.3.2. Simple Linear Trend of Minimum Temperatures Data (1971-2010)

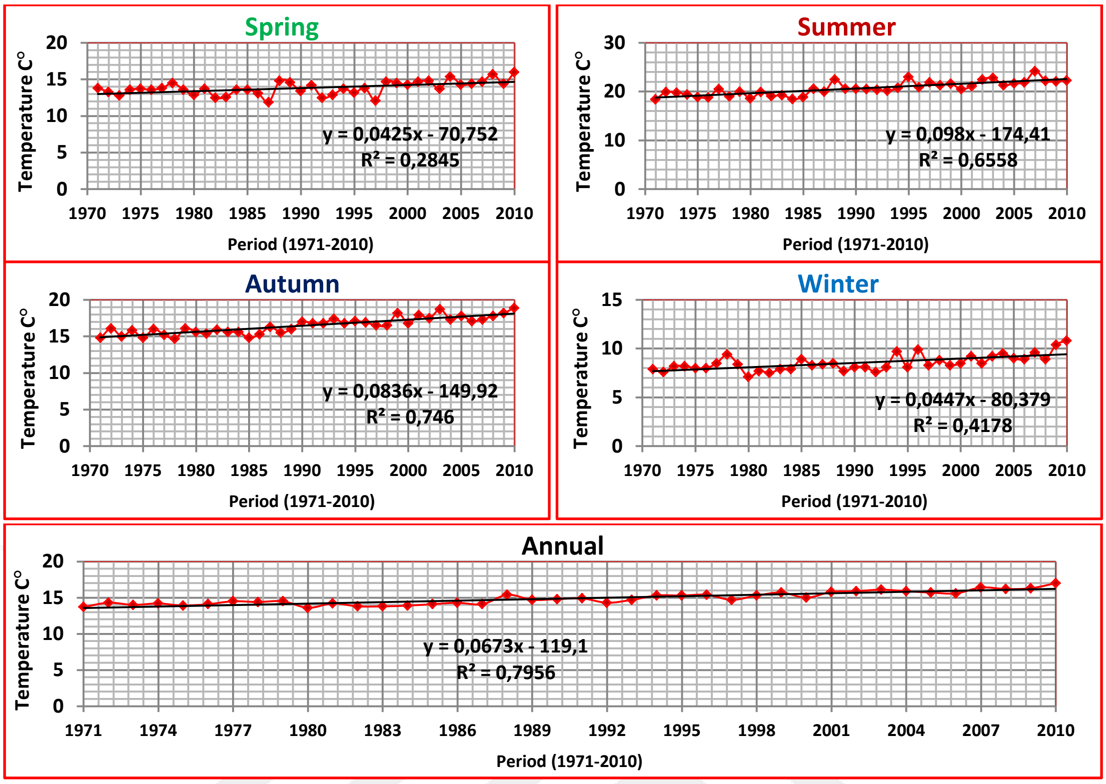


Figure 200. Simple Linear Trend Graphs of Seasonally and Annual Minimum Temperature in AGDABIA Station

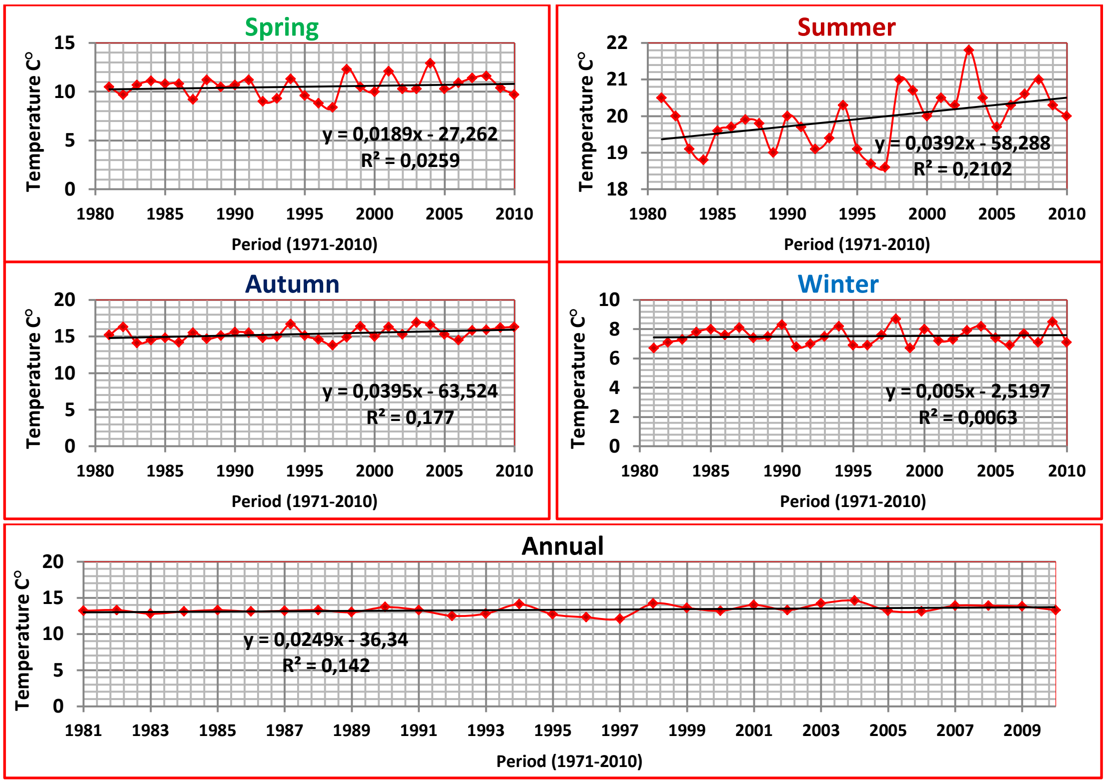


Figure 201. Simple Linear Trend Graphs of Seasonally and Annual Minimum Temperature in ALFATAIAH Station

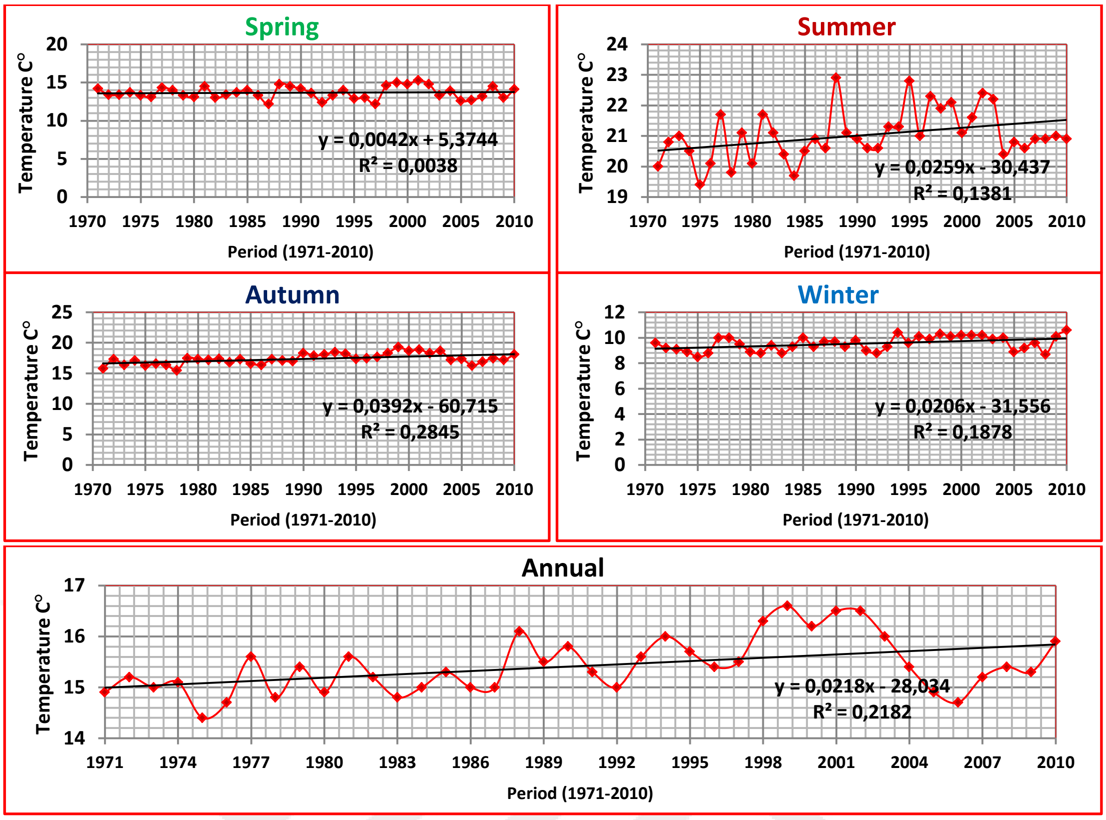


Figure 202. Simple Linear Trend Graphs of Seasonally and Annual Minimum Temperature in BENGHAZI Station

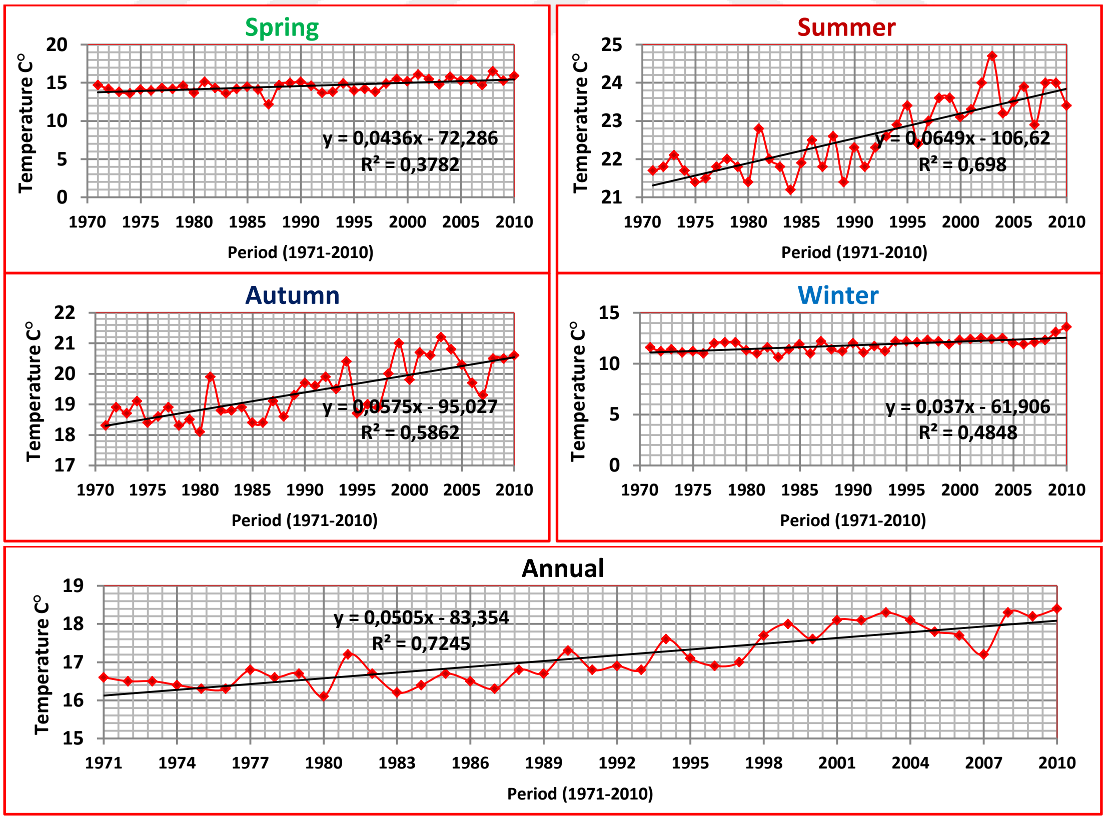


Figure 203. Simple Linear Trend Graphs of Seasonally and Annual MinimumTemperature in DERNA Station

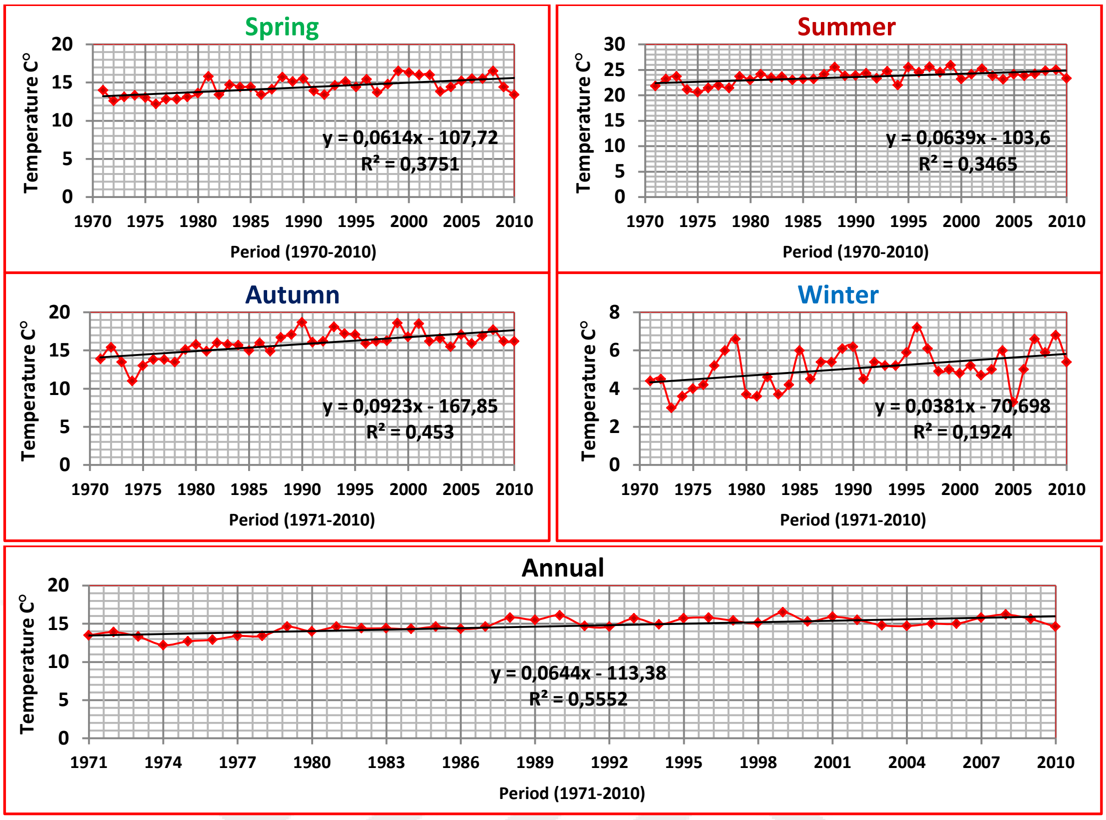


Figure 204. Simple Linear Trend Graphs of Seasonally and Annual Minimum Temperature in GHADAMES Station

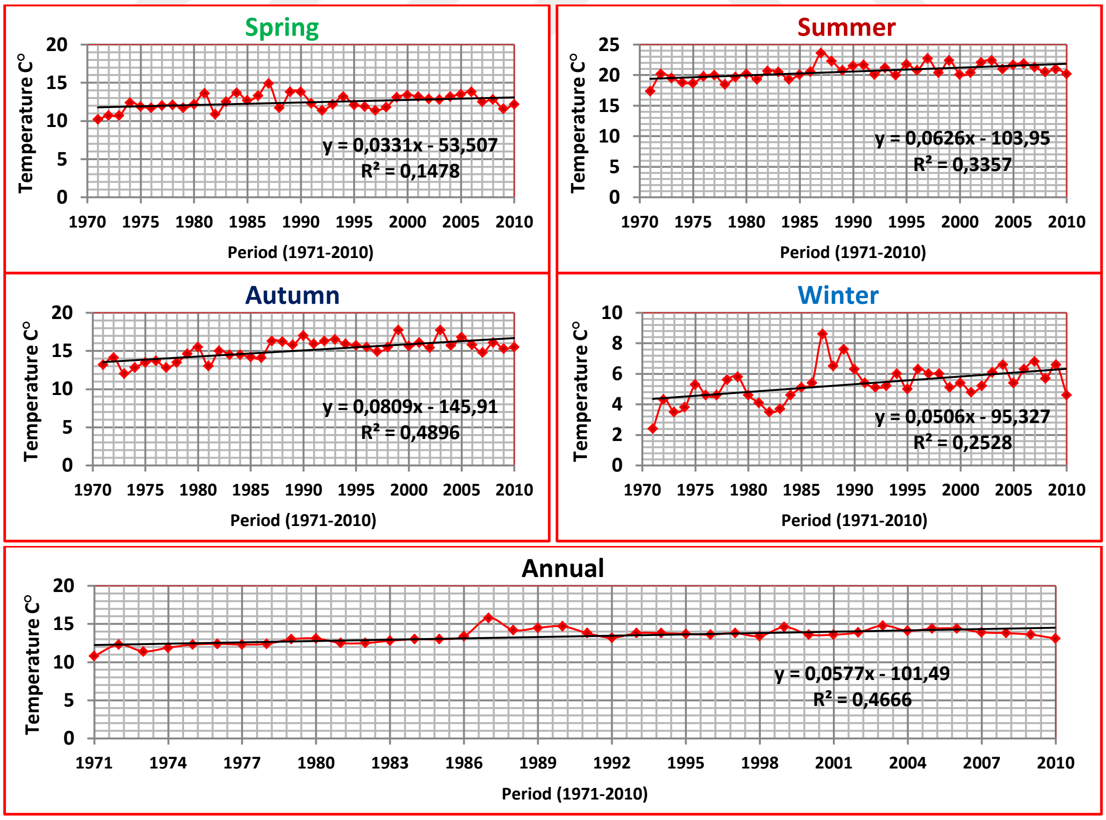


Figure 205. Simple Linear Trend Graphs of Seasonally and Annual Minimum Temperature in GHARIAT Station

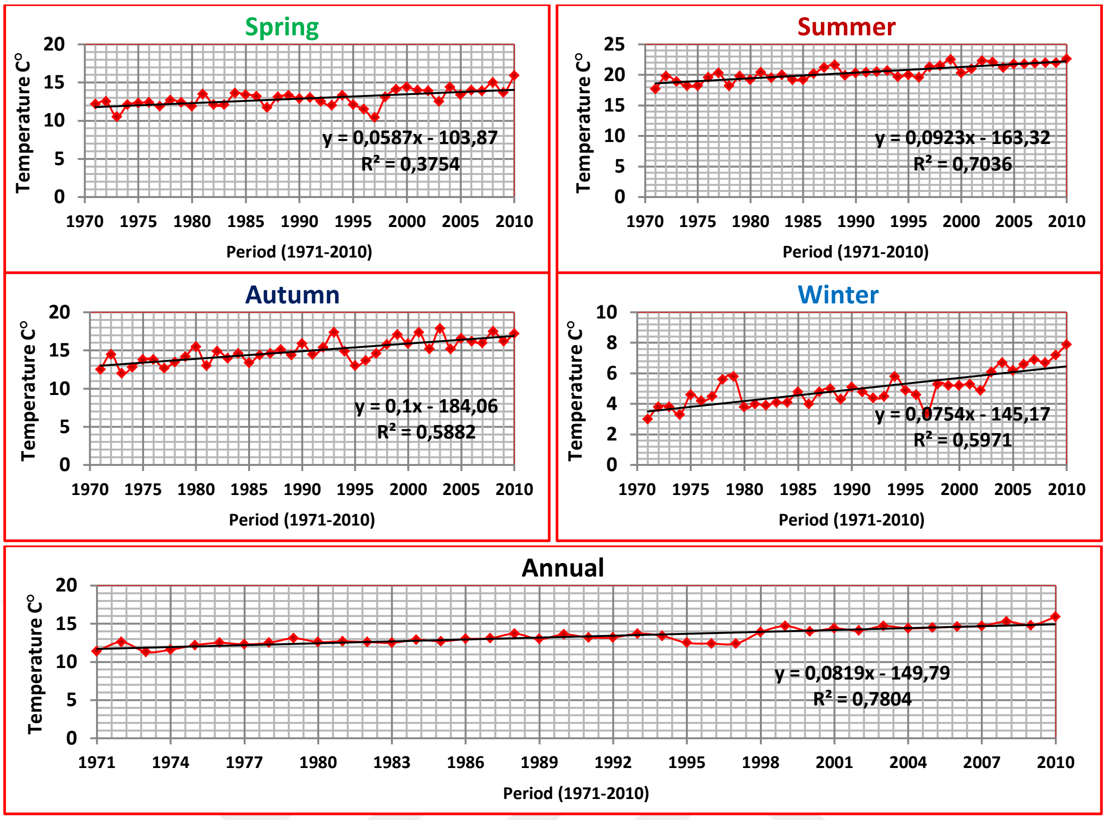


Figure 206. Simple Linear Trend Graphs of Seasonally and Annual Minimum Temperature in HON Station

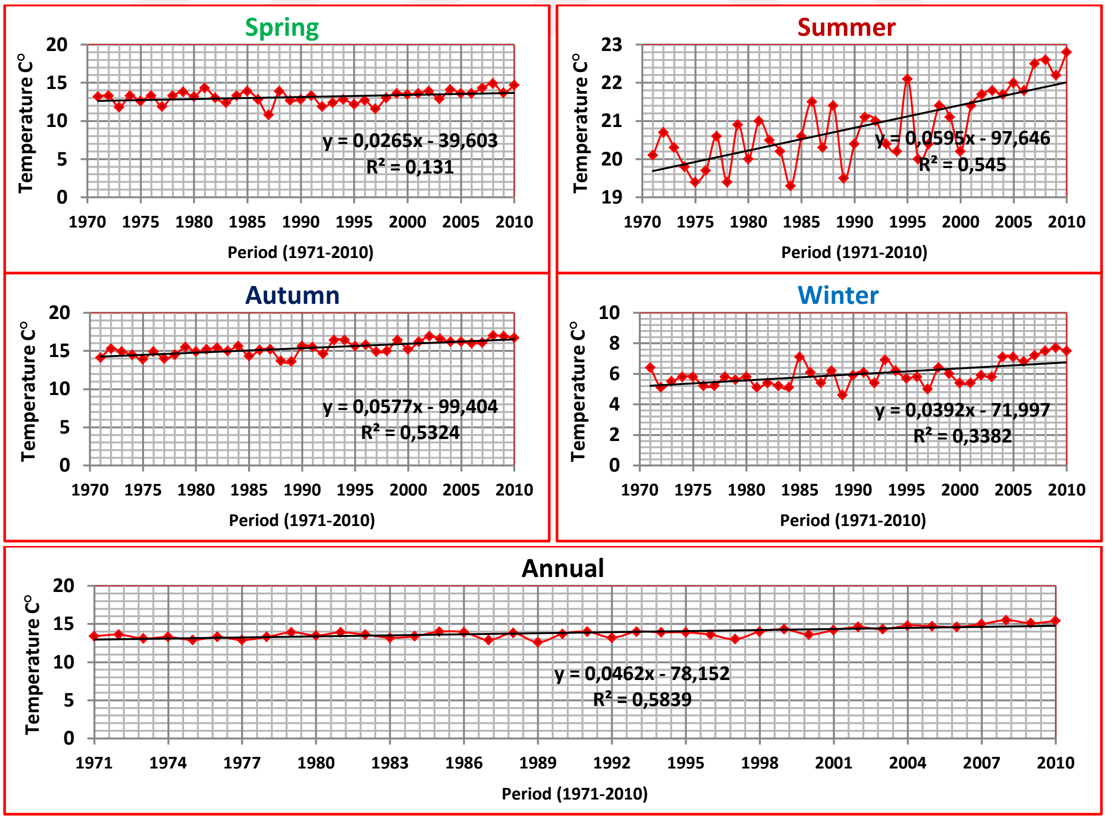


Figure 207. Simple Linear Trend Graphs of Seasonally and Annual Minimum Temperature in JAGHBOUB Station

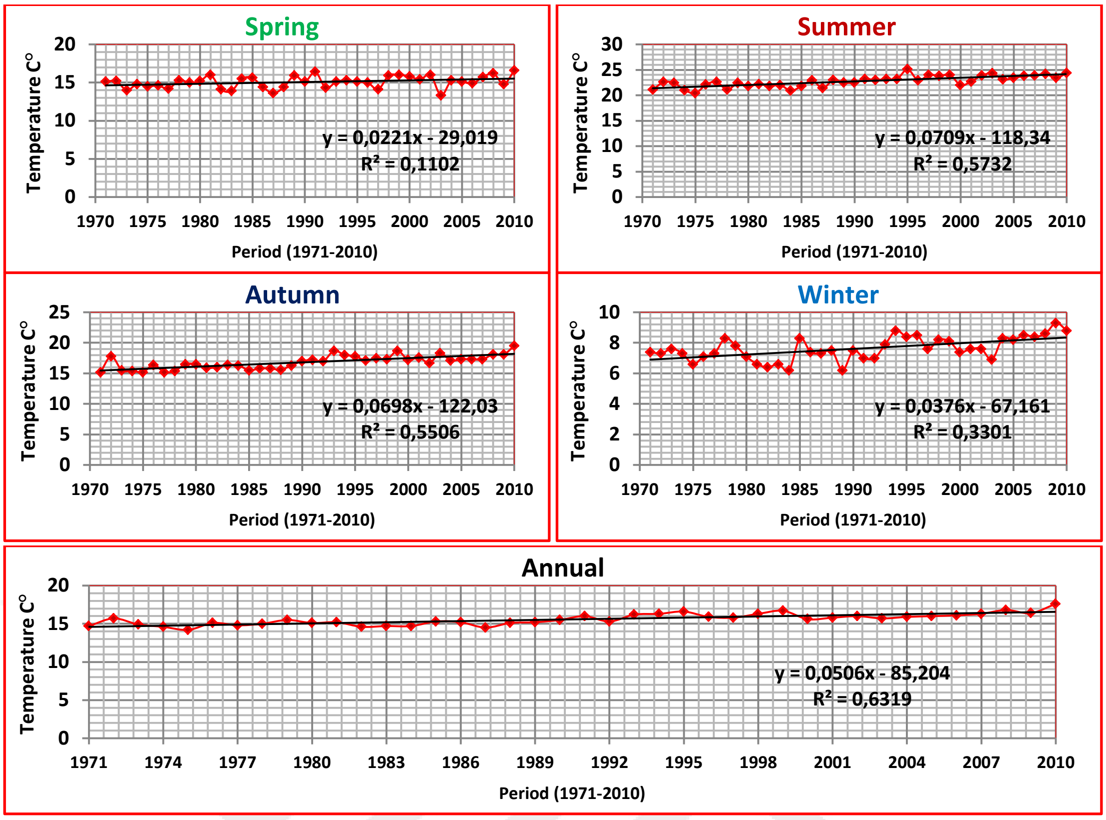


Figure 208. Simple Linear Trend Graphs of Seasonally and Annual Minimum Temperature in JALO Station

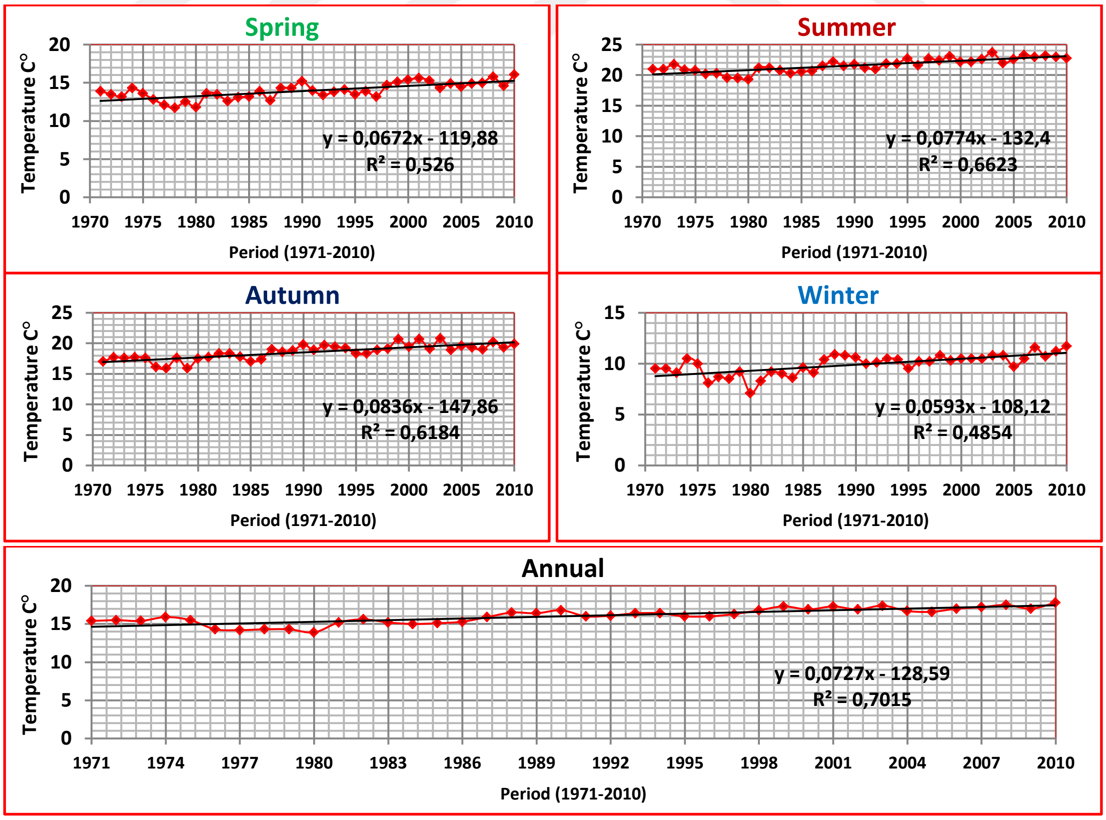


Figure 209. Simple Linear Trend Graphs of Seasonally and Annual Minimum Temperature in MISURATA Station

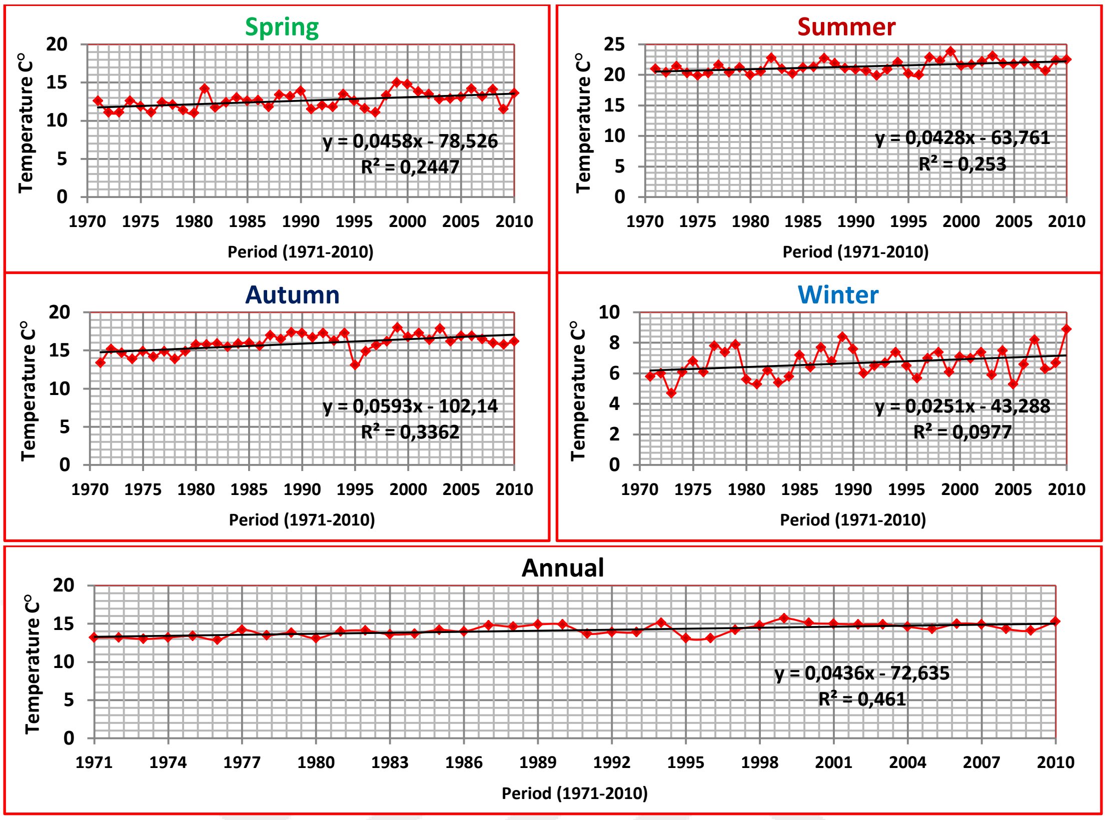


Figure 210. Simple Linear Trend Graphs of Seasonally and Annual Minimum Temperature in NALUT Station

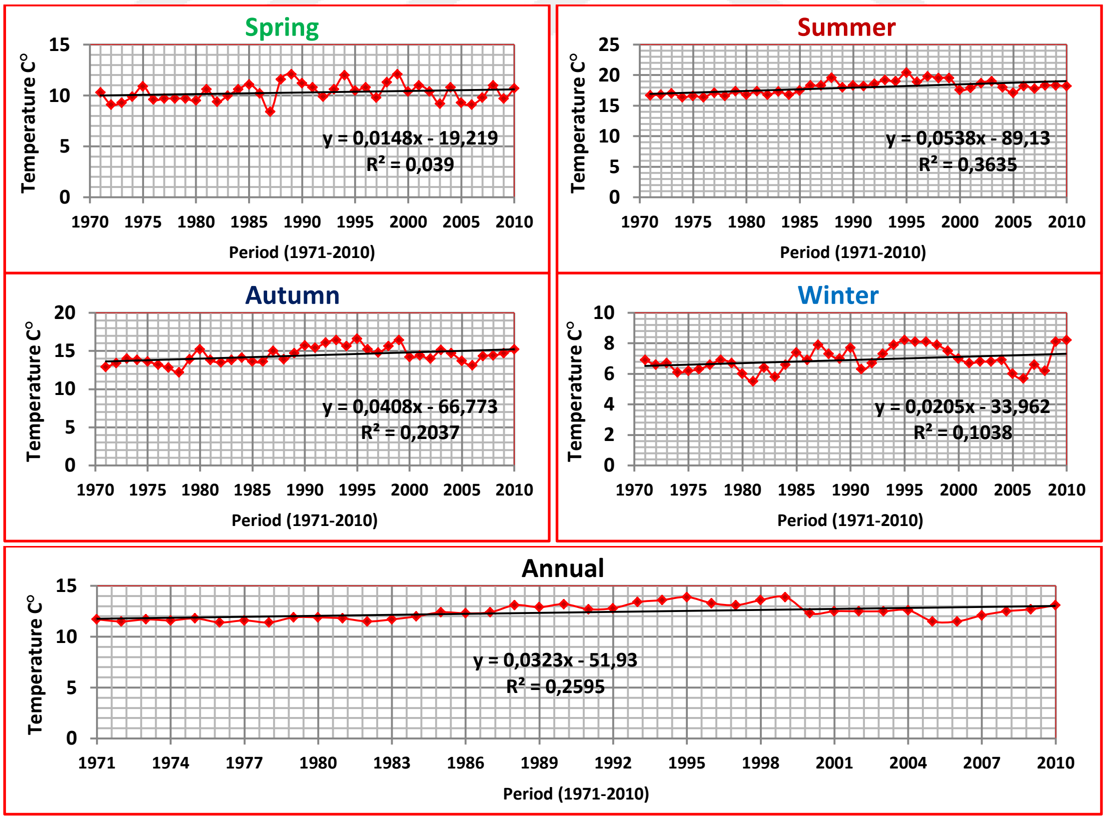


Figure 211. Simple Linear Trend Graphs of Seasonally and Annual Minimum Temperature in SHAHAT Station

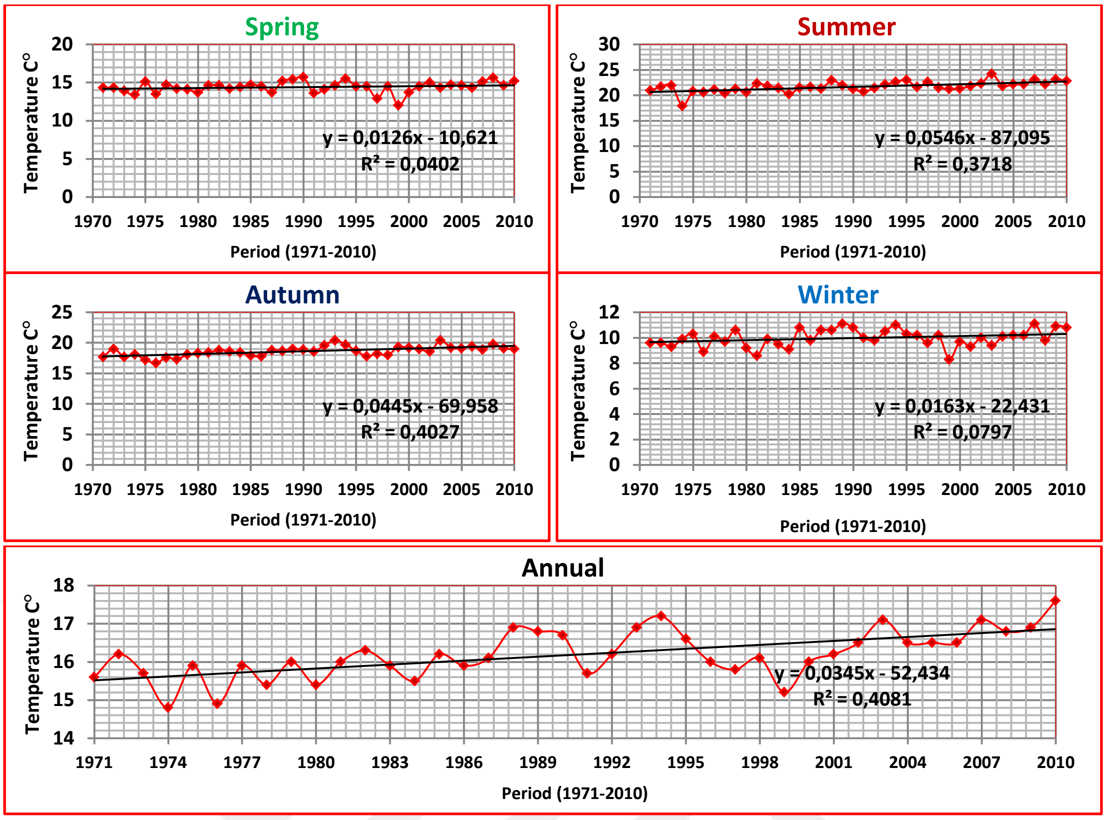


Figure 212. Simple Linear Trend Graphs of Seasonally and Annual Minimum Temperature in SIRTE Station

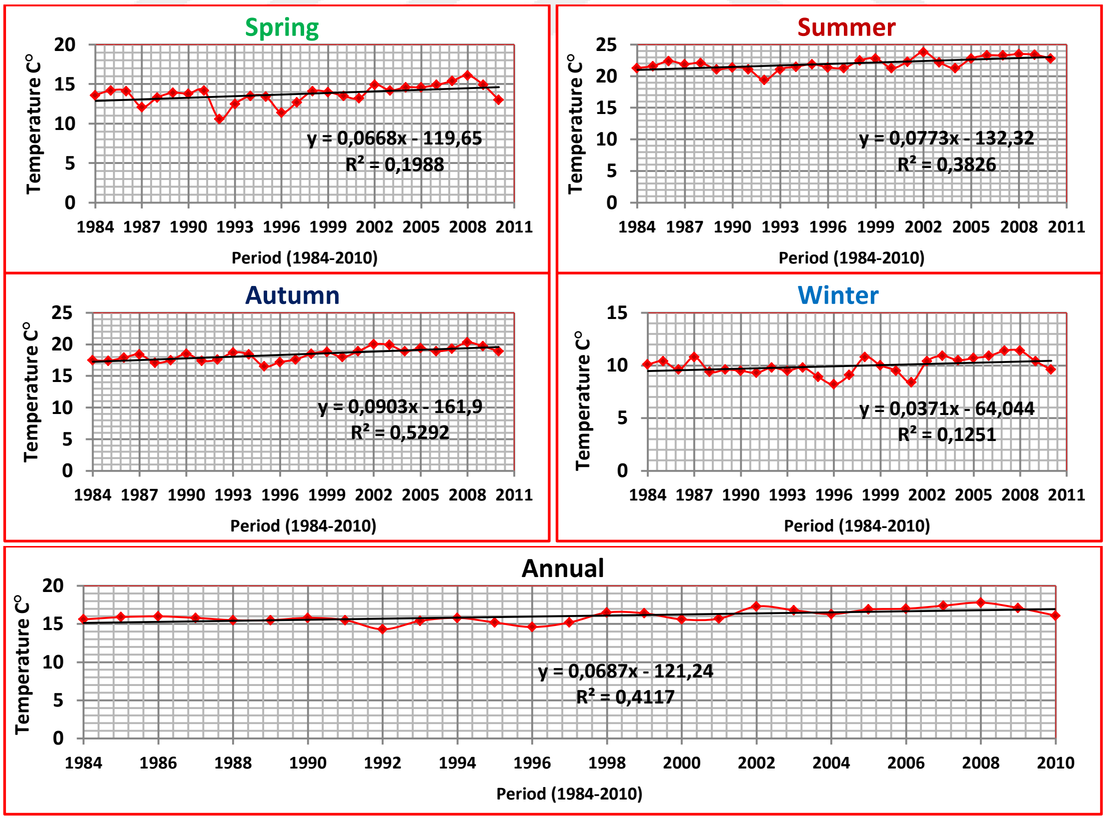


Figure 213. Simple Linear Trend Graphs of Seasonally and Annual Minimum Temperature in TOBRUK Station

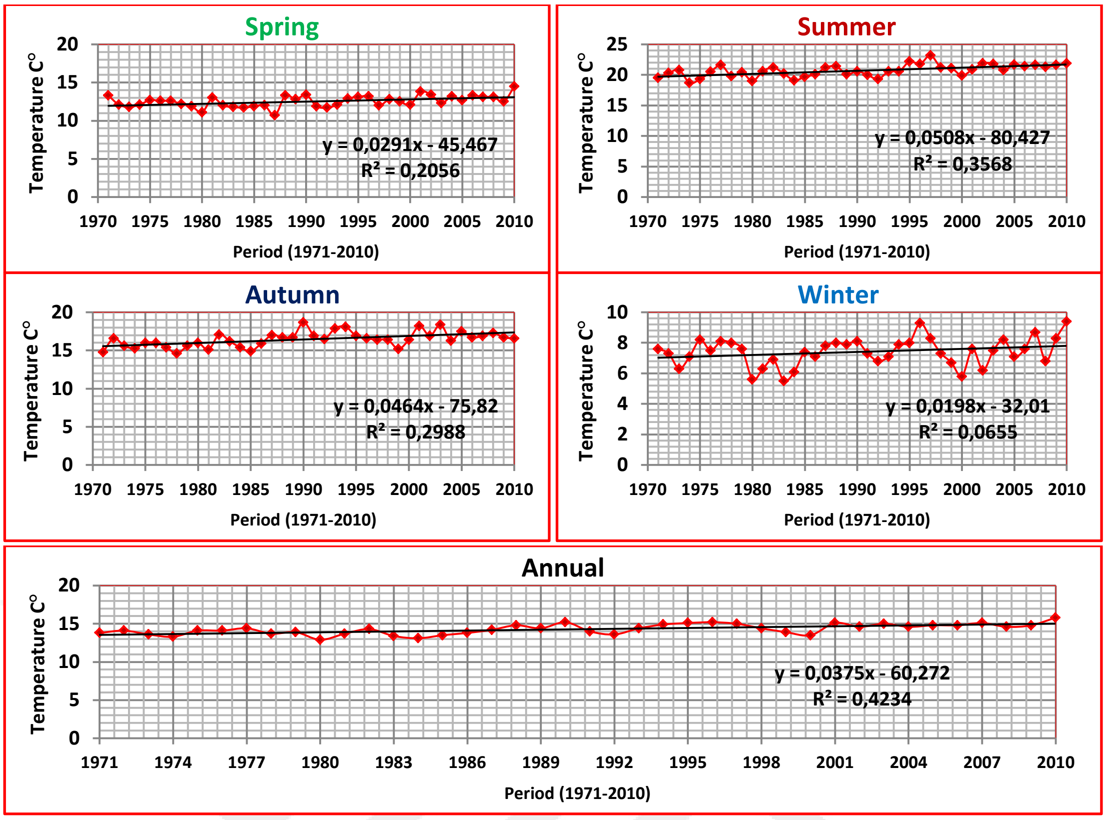


Figure 214. Simple Linear Trend Graphs of Seasonally and Annual MinimumTemperature in TRIPOLI Station

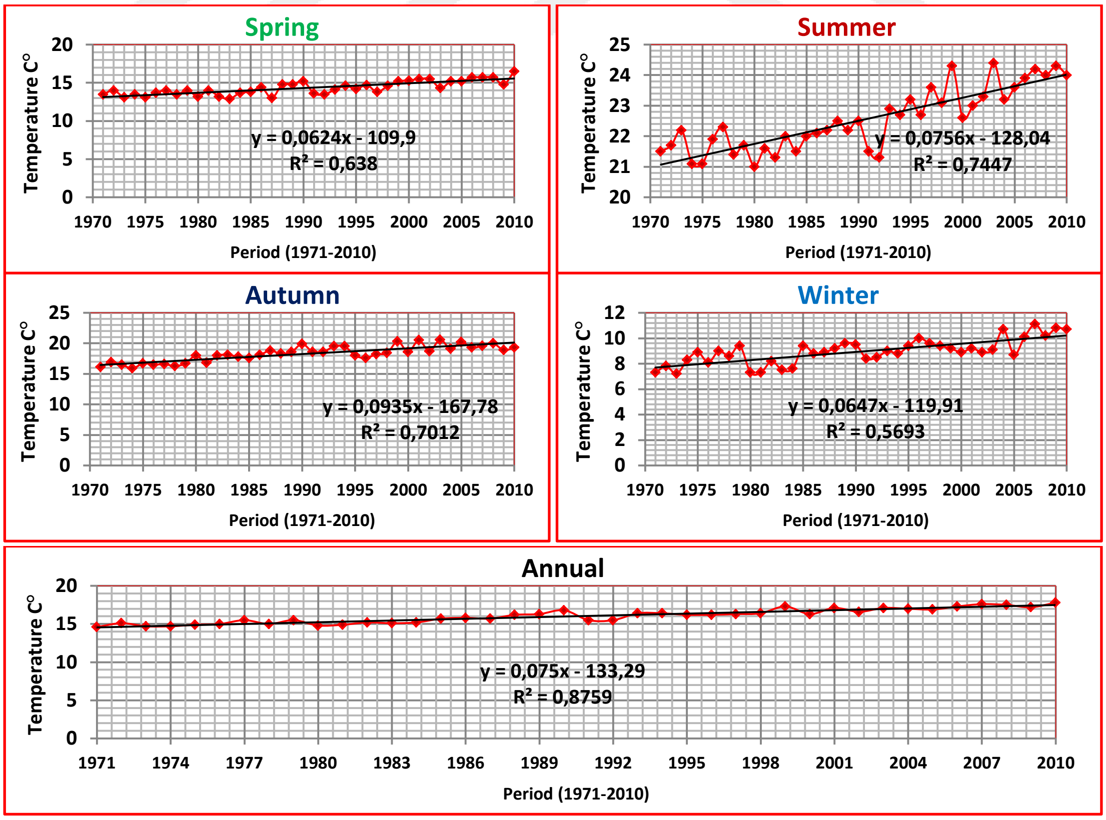


Figure 215. Simple Linear Trend Graphs of Seasonally and Annual Minimum Temperaturein ZWARA Station

Table 94. Simple Linear Regression Analysis Results for Seasonally and Annual Minimum Temperatures in All Stations (1971-2010)

Stations	Spring	Summer	Autumn	Winter	Annual
AGDABIA	0.038	0.098	0.083	0.044	0.065
ALFATAIAH	0.018	0.039	0.059	0.005	0.025
BENGHAZI	0.004	0.025	0.035	0.020	0.021
DERNA	0.043	0.064	0.057	0.037	0.050
GHADAMES	0.061	0.064	0.092	0.038	0.064
GHARIAT	0.033	0.062	0.080	0.050	0.057
HON	0.051	0.092	0.100	0.071	0.078
JAGHBOUB	0.026	0.059	0.057	0.035	0.044
JALO	0.018	0.070	0.062	0.033	0.046
MISURATA	0.077	0.083	0.055	0.070	0.044
NALUT	0.044	0.042	0.059	0.018	0.041
SHAHAT	0.014	0.053	0.051	0.020	0.032
SIRTE	0.012	0.054	0.050	0.016	0.032
TOBRUK	0.074	0.077	0.090	0.037	0.069
TRIPOLI	0.029	0.050	0.056	0.019	0.036
ZWARA	0.062	0.075	0.093	0.064	0.074

- Evaluation of Results Simple Linear Regression for Seasonally and Annual Minimum Temperature Data

When examining the trends in minimum temperature values over many years on a seasonal basis, it was observed that only five stations showed a trend towards an increase in spring, GHADAMES station (0.061), HON station (0.051), MISURATA station (0.077) is the highest trend, TOBRUK station (0.074), and ZWARA station (0.062). The rest of the stations did not show any trends, and all values were close to zero, indicating the stability of the minimum temperatures in most stations in spring season.

In summer season HON is the station where the increase is highest with (0.092), although there is an increase in most stations except for three stations ALFATAIAH, BENGHAZI, and NALUT. DERNA station showed an increasing trend was (0.064), also GHADAMES was (0.064), GHARIAT was (0.062), JAGHBOUB was (0.059), JALO was (0.070), MISURATA was (0.083), SHAHAT was (0.053), SIRTE was (0.054), TOBRUK was (0.077), TRIPOLI was (0.050), and ZWARA was (0.075).

These results indicate that there is a tendency towards warming in most stations and the trend is increasing in desert stations.

Except for BENGHAZI station, the autumn season is characterized by an increase in trend in all stations. The strongest trend was at HON Station (0.100), and ZWARA station (0.093), followed by GHADAMES station (0.092), then TOBRUK was (0.090), AGDABIA (0.083), JALO (0.062), NALUT and ALFATAIAH were (0.059), MISURATA (0.055), DERNA (0.057), TRIPOLI (0.056), SHAHAT (0.051), SIRTE (0.050), and GHARIAT (0.080).

The winter was not showed a trend in all stations except for four stations of GHARIAT, HON, MISURATA and ZWARA where they showed a positive trend towards increase.

Many stations showed a trend towards an increase in the annual average temperature data. HON station showed the strongest trend. It was (0.078), followed by ZWARA station (0.074), then TOBRUK station (0.069), AGDABIA station (0.065), GHADAMES station (0.064), GHARIAT station was (0.057), and finally DERNA station (0.050).

From the above, it is clear that there were two stations that showed a trend to increase in all seasons and annual minimum temperatures, HON desert station, and the coastal ZWARA station, and the biggest increase was in the autumn, followed by summer, then spring, and winter season (Table 94 dependent on figures 201 - 216).

4.1.3.3. Simple Linear Trend of Average Temperatures Data (1971-2010)

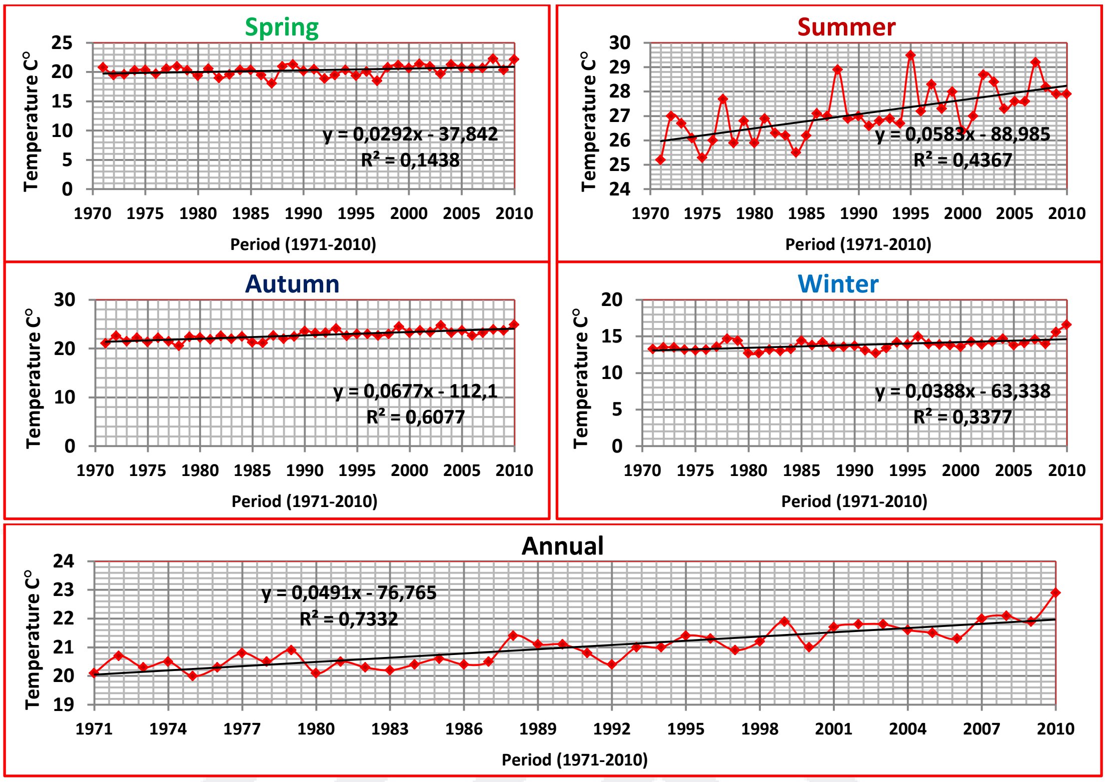


Figure 216. Simple Linear Trend Graphs of Seasonally and Annual Average Temperature in AGDABIA Station

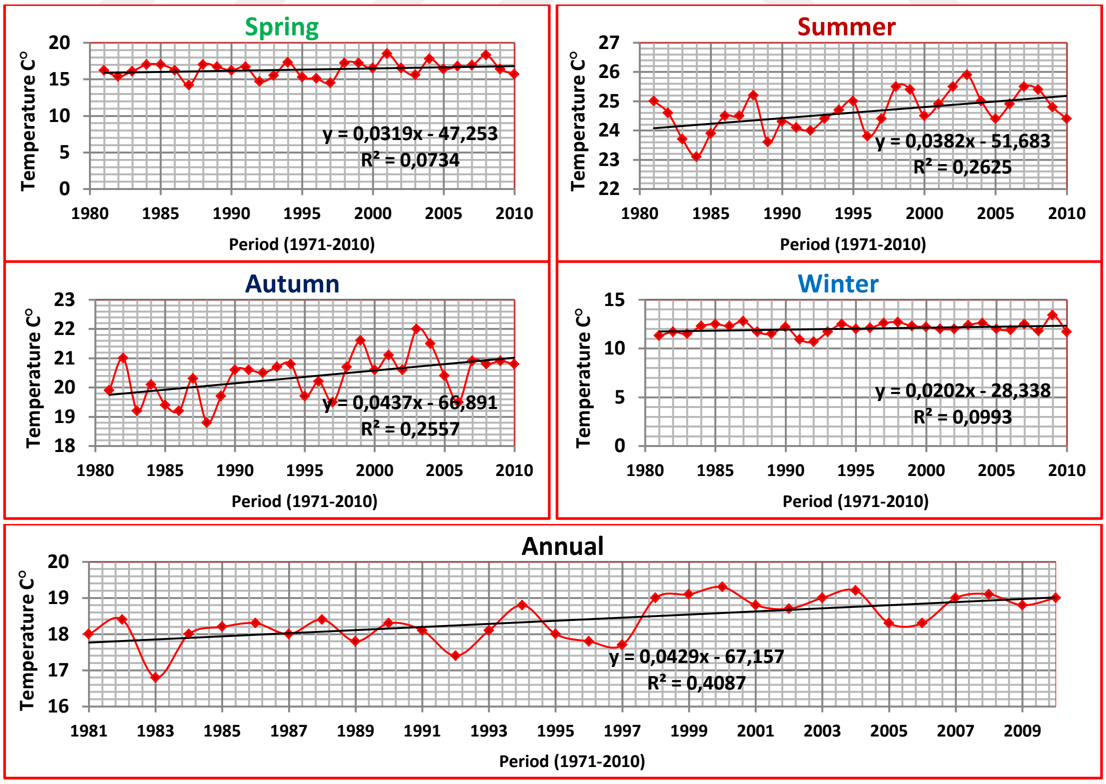


Figure 217. Simple Linear Trend Graphs of Seasonally and Annual Average Temperature in ALFATAIAH Station

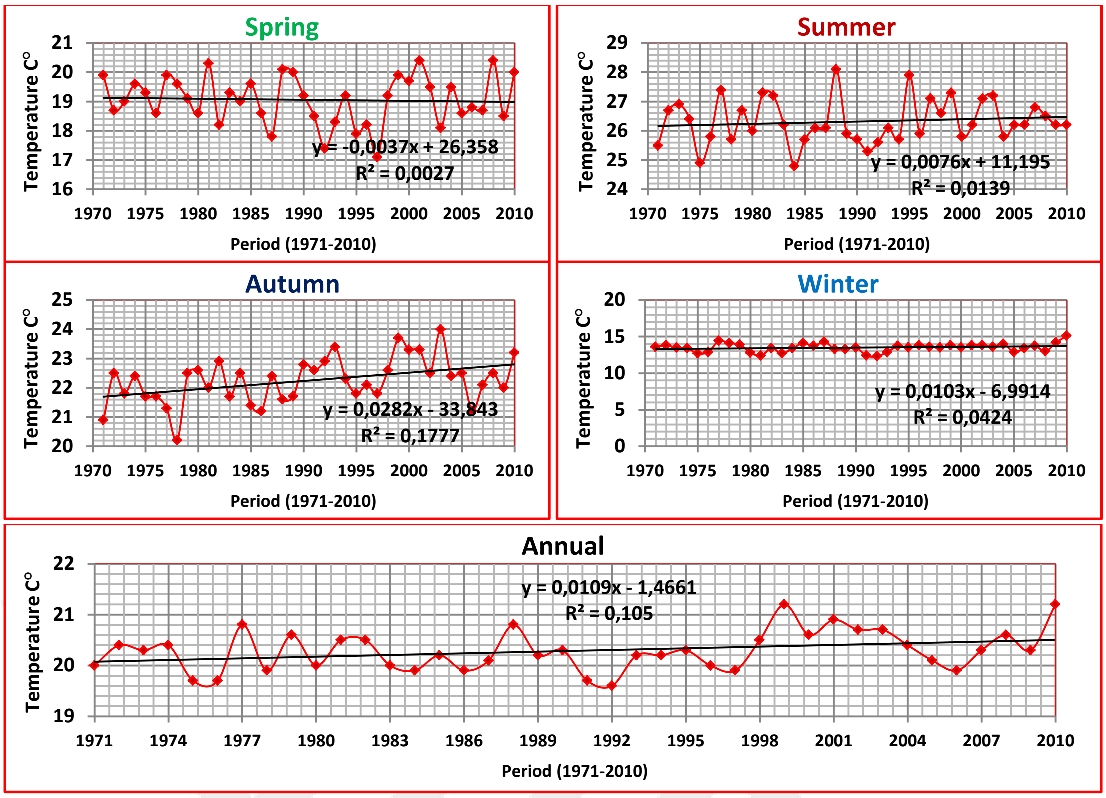


Figure 218. Simple Linear Trend Graphs of Seasonally and Annual Average Temperature in BENGHAZI Station

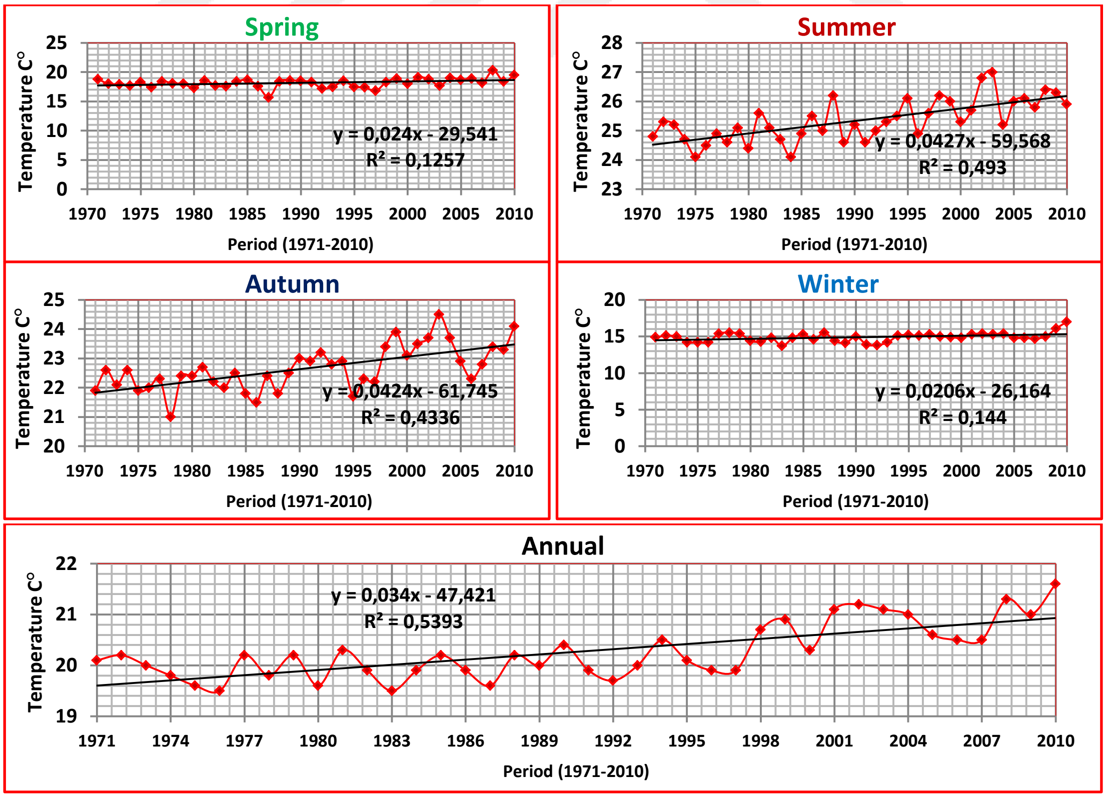


Figure 219. Simple Linear Trend Graphs of Seasonally and Annual Average Temperature in DERNA Station

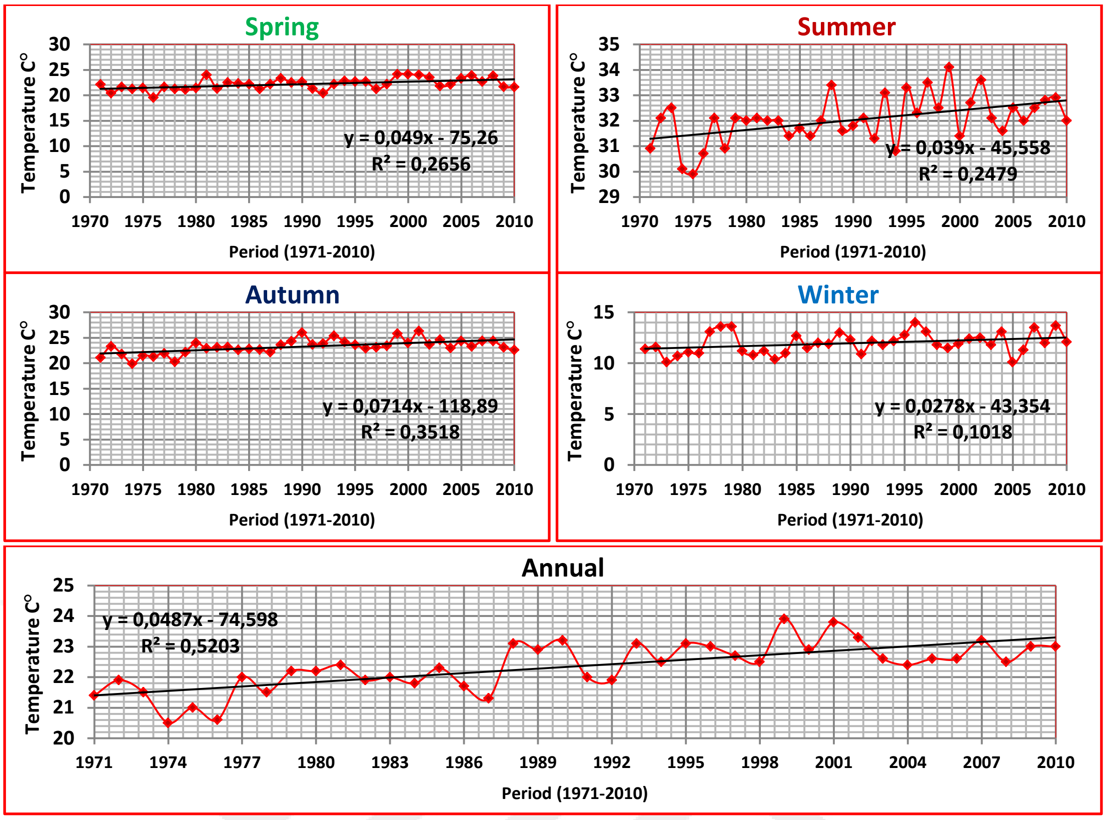


Figure 220. Simple Linear Trend Graphs of Seasonally and Annual Average Temperature in GHADAMES Station

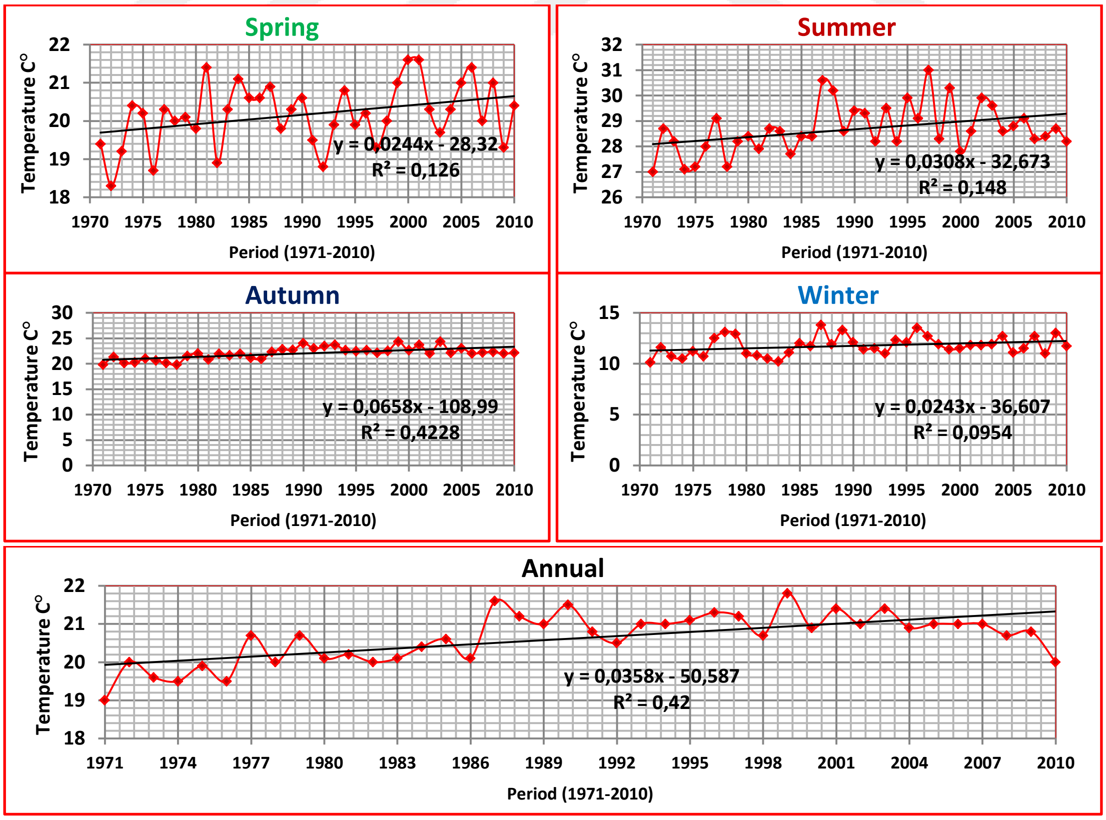


Figure 221. Simple Linear Trend Graphs of Seasonally and Annual Average Temperature in GHARIAT Station

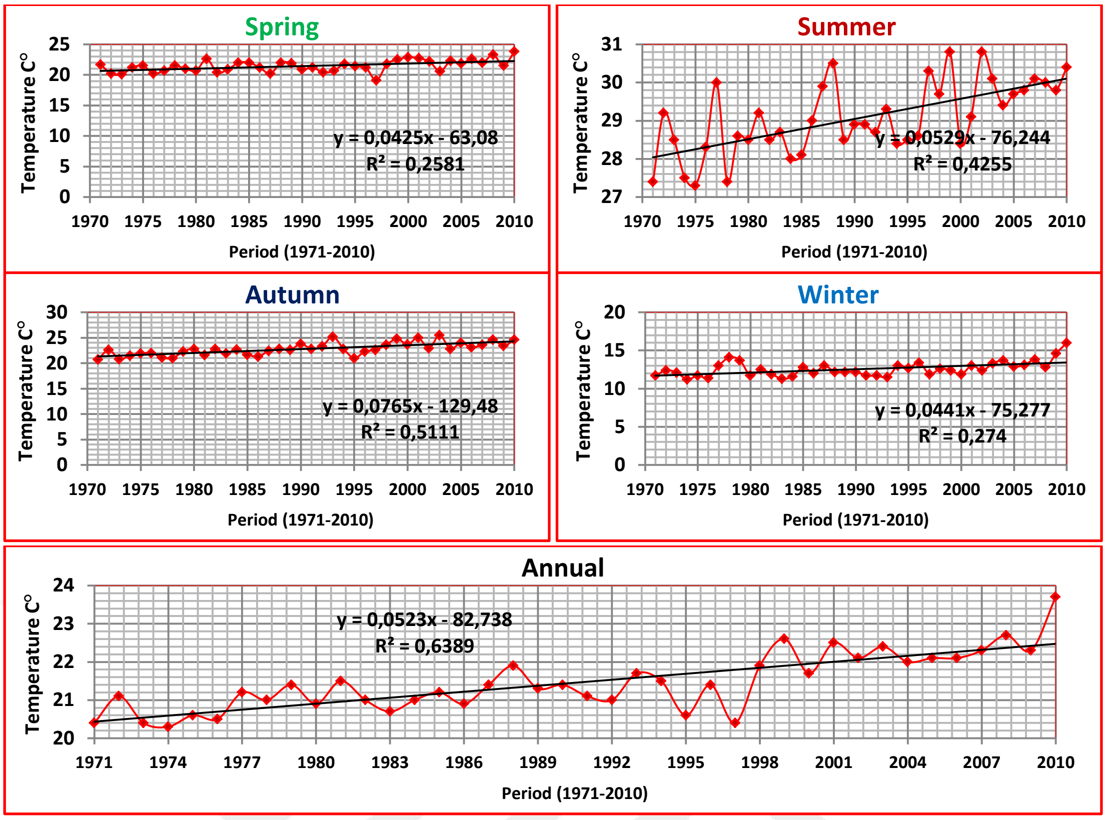


Figure 222. Simple Linear Trend Graphs of Seasonally and Annual Average Temperature in HON Station

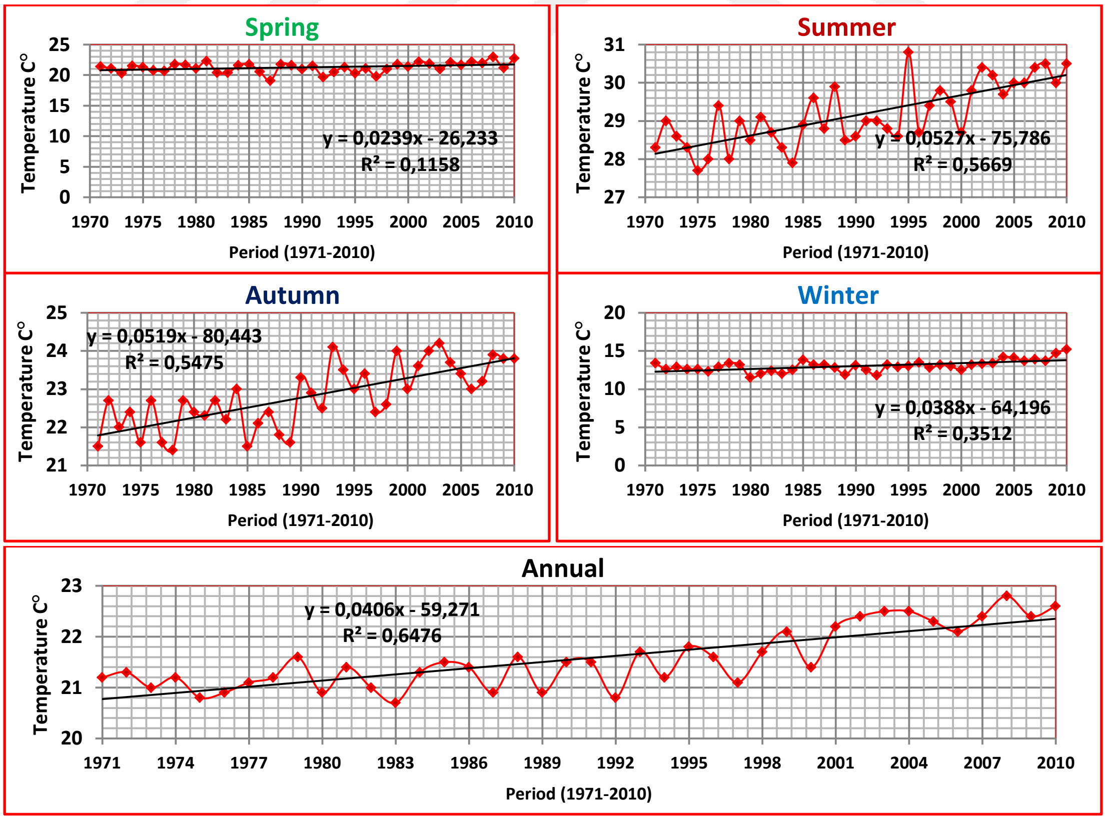


Figure 223. Simple Linear Trend Graphs of Seasonally and Annual Average Temperature in JAGHBOUB Station

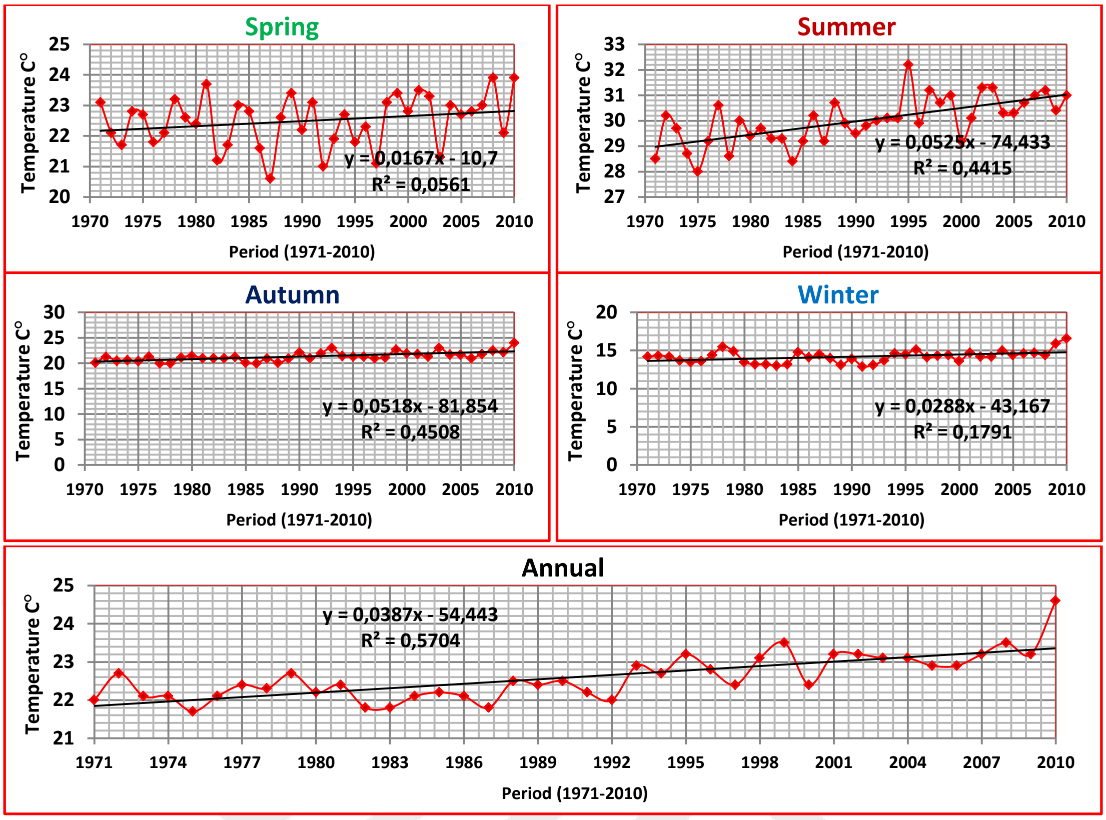


Figure 224. Simple Linear Trend Graphs of Seasonally and Annual Average Temperature in JALO Station

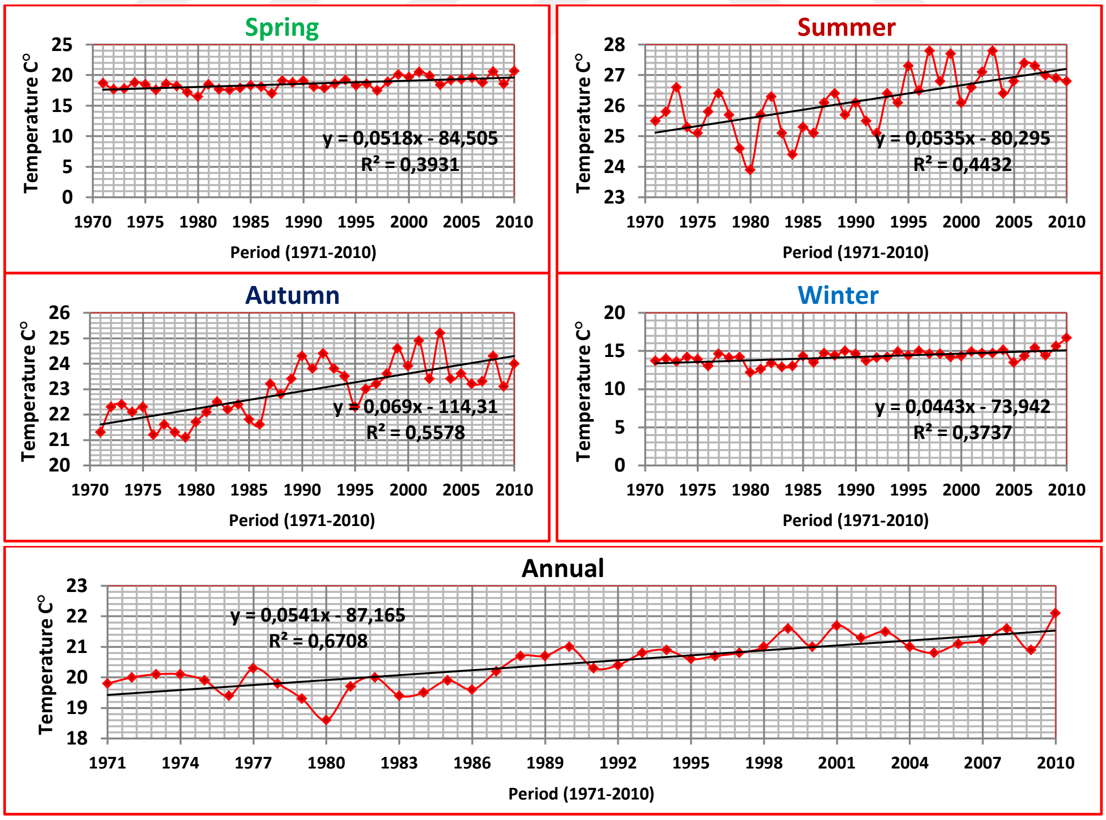


Figure 225. Simple Linear Trend Graphs of Seasonally and Annual Average Temperature in MISURATA Station

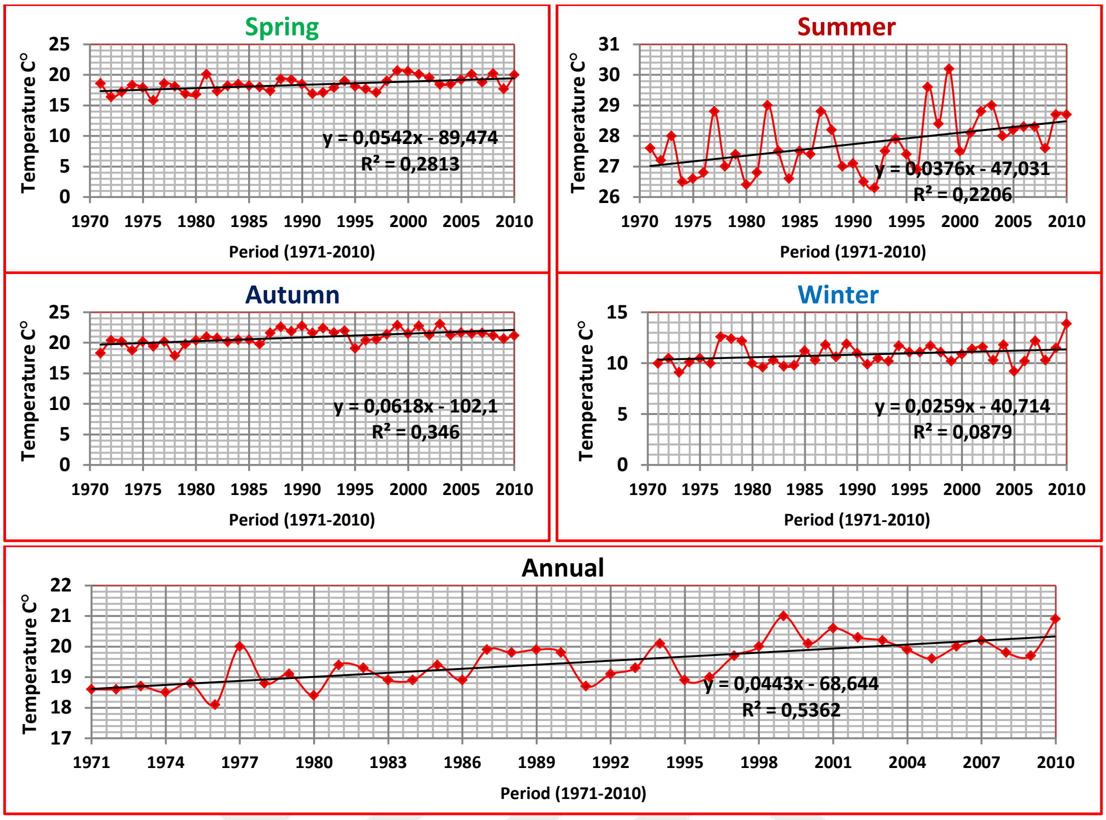


Figure 226. Simple Linear Trend Graphs of Seasonally and Annual Average Temperature in NALUT Station

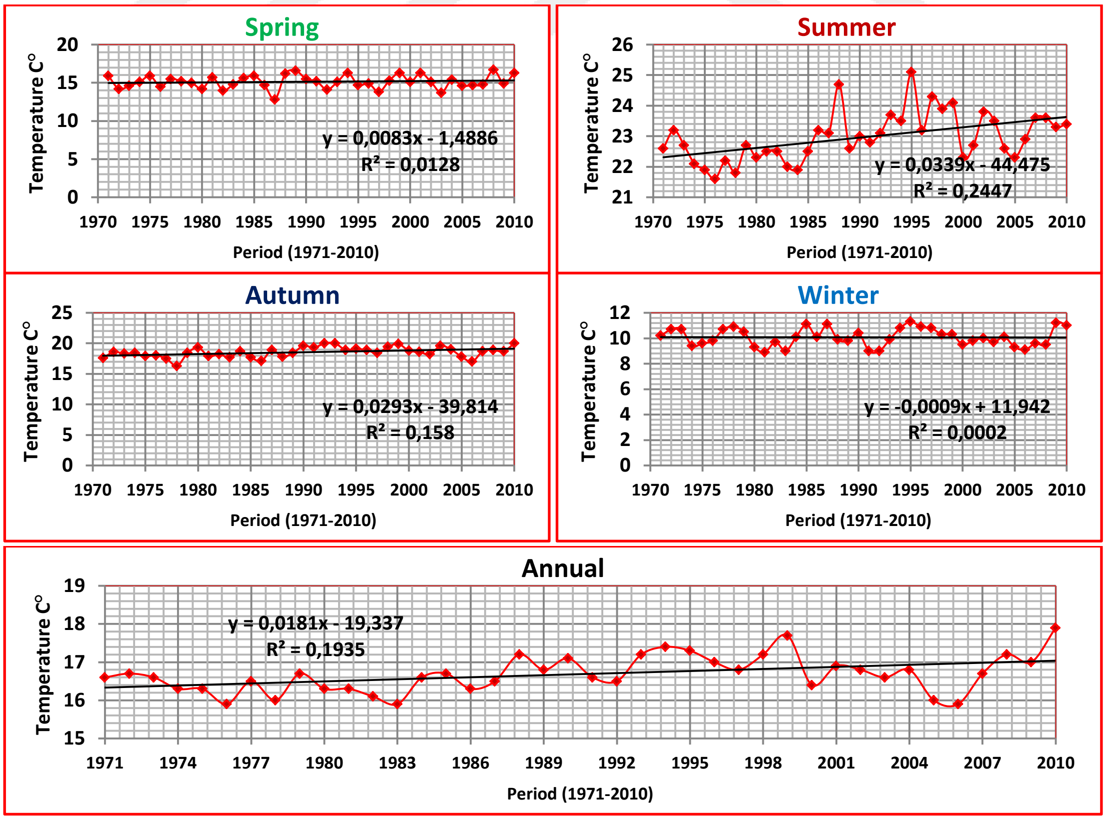


Figure 227. Simple Linear Trend Graphs of Seasonally and Annual Average Temperature in SHAHAT Station

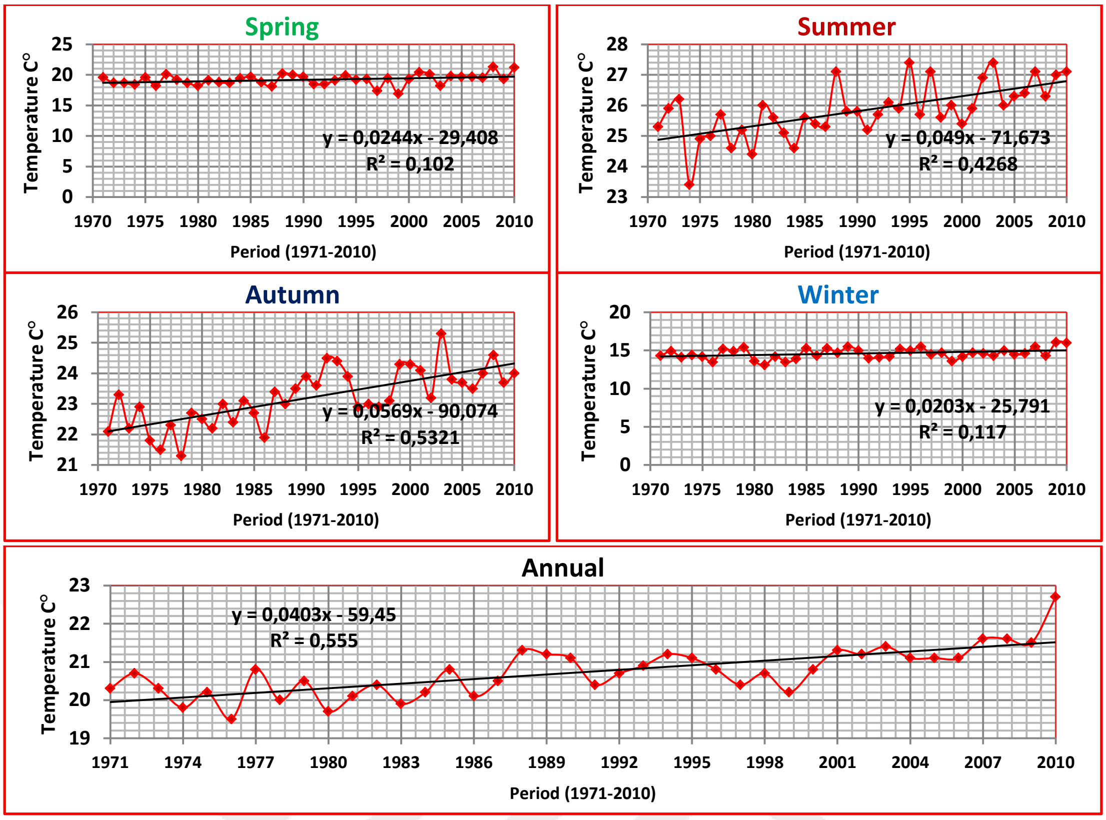


Figure 228. Simple Linear Trend Graphs of Seasonally and Annual Average Temperature in SIRTE Station

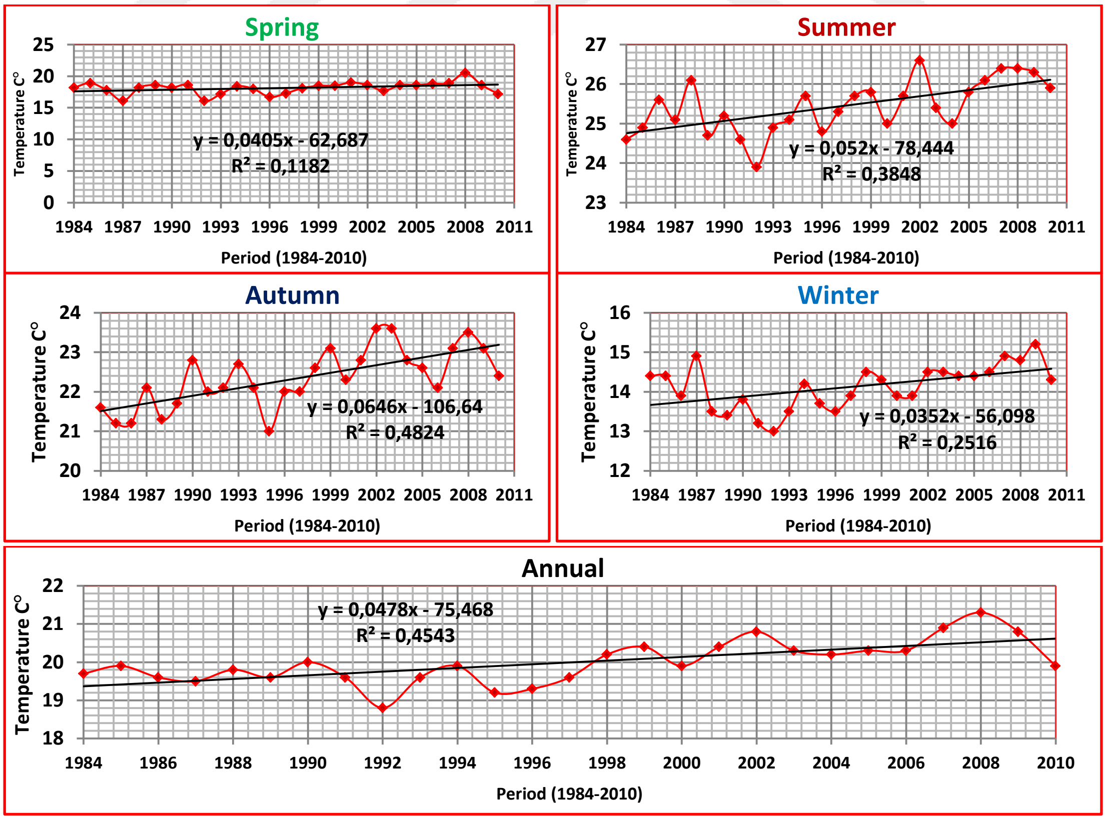


Figure 229. Simple Linear Trend Graphs of Seasonally and Annual Average Temperature in TOBRUK Station

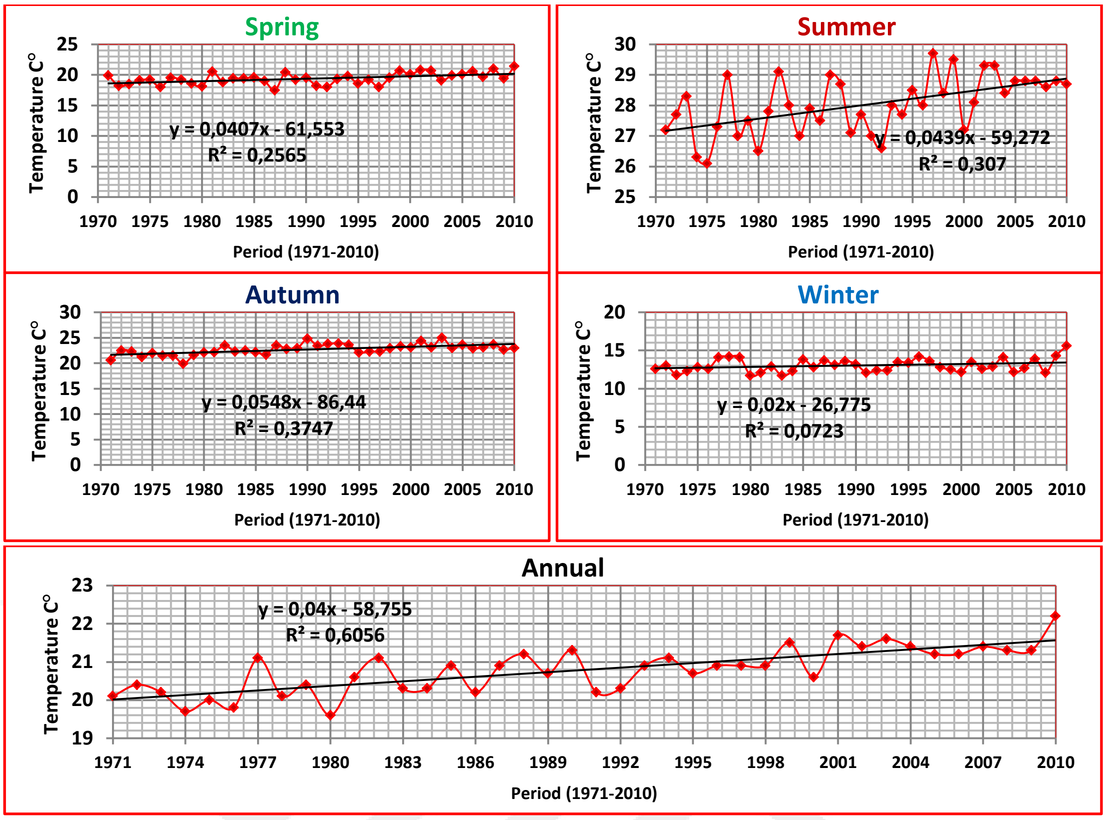


Figure 230. Simple Linear Trend Graphs of Seasonally and Annual Average Temperature in TRIPOLI Station

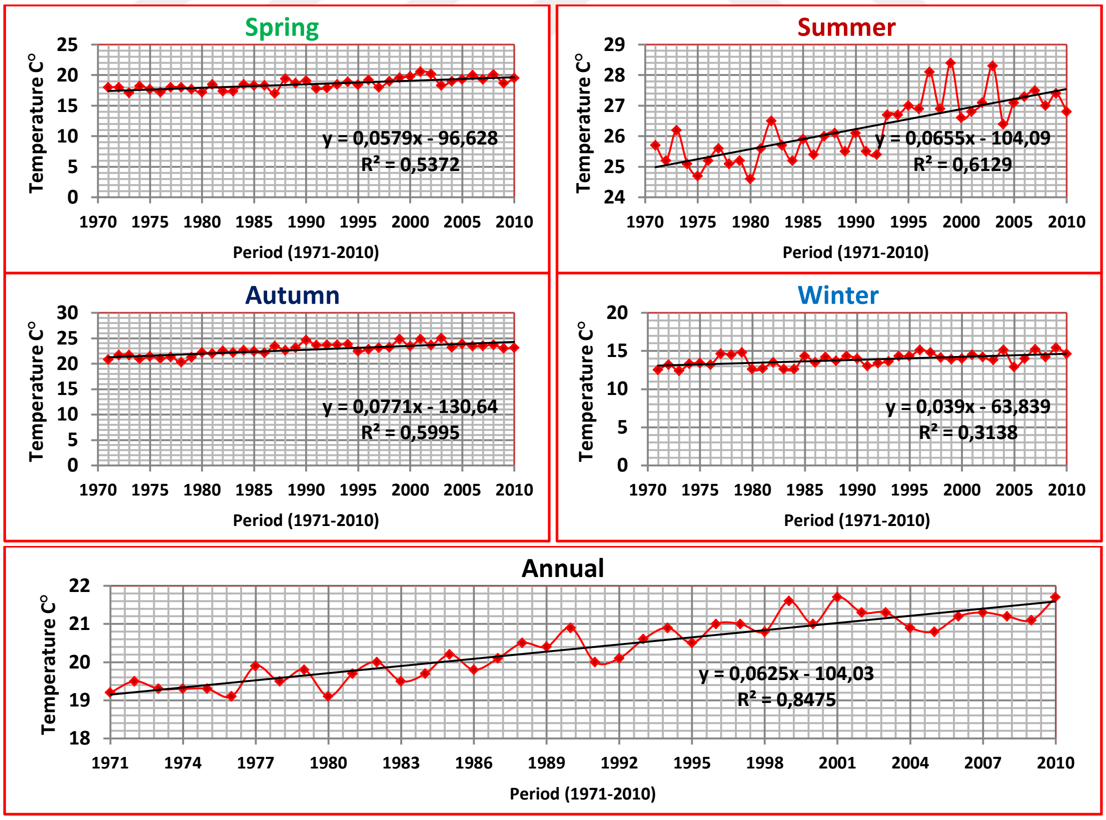


Figure 231. Simple Linear Trend Graphs of Seasonally and Annual Average Temperature in ZWARA Station

Table 95. Simple Linear Regression Analysis Results for Seasonally and Annual Average Temperatures in All Stations (1971-2010)

Stations	Spring	Summer	Autumn	Winter	Annual
AGDABIA	0.025	0.058	0.064	0.031	0.044
ALFATAIAH	0.031	0.038	0.043	0.020	0.040
BENGHAZI	-0.003	-0.007	0.028	0.010	0.009
DERNA	0.023	0.023	0.042	0.042	0.014
GHADAMES	0.048	0.038	0.071	0.027	0.047
GHARIAT	0.024	0.030	0.065	0.024	0.035
HON	0.038	0.052	0.072	0.036	0.050
JAGHBOUB	0.016	0.052	0.051	0.038	0.038
JALO	0.016	0.051	0.050	0.021	0.035
MISURATA	0.047	0.053	0.068	0.036	0.051
NALUT	0.050	0.037	0.061	0.014	0.040
SHAHAT	0.008	0.033	0.029	-0.009	0.017
SIRTE	0.020	0.048	0.056	0.019	0.036
TOBRUK	0.040	0.052	0.064	0.035	0.048
TRIPOLI	0.041	0.043	0.054	0.020	0.037
ZWARA	0.057	0.065	0.077	0.039	0.061

- Evaluation of Results Simple Linear Regression for Seasonally and Annual Average Temperature Data

When evaluation of the simple linear regression for the average of the minimum temperatures in the spring there was no trend in all stations, except for two stations that showed a tendency to increase, NALUT station (0.050), and ZWARA station (0.057).

In summer, many stations showed a trend toward increase. ZWARA station was the strongest (0.065), then AGDABIA station (0.058), MISURATA station was (0.053), then HON and JAGHBOUB stations were (0.052) and JALO station (0.051).

Except for four stations (ALFATAIAH, BENGHAZI, DERNA, and SHAHAT), all the stations in the autumn showed a trend towards to increase. The strongest trend was an increase in ZWARA station (0.077), then HON station (0.072), then GHADAMES station was (0.071), MISURATA station was (0.068), GHARIAT station was (0.065), TOBRUK and AGDABIA stations were (0.064), after that SIRTE, TRIPOLI, JAGHBOUB, JALO stations (0.056, 0.054, 0.051, 0.050).

The winter season did not show a trend in all stations, and the average annual temperature data showed a trend in three stations; HON station (0.050), MISURATA station (0.051) and station ZWARA (0.061)(Table 95 dependent on figures 217 - 232).

4.2.Trend Analysis for Precipitation Data

4.2.1. Trend Analysis of Mann-Kendall, Spearman and Sen's slope

Table 96. Results of Trend Analysis for Mann-Kendall, Spearman and Sen's slope for Precipitation Data in AGDABIA, ALFATAIAHStations(1971-2010)

Test's Type	AGDABIA			ALFATAIAH(1981-2010)		
	Mann-Kendall	Spearman's Rho	Sen's Slope	Mann-Kendall	Spearman's Rho	Sen's Slope
January	-0.98	-1.16	-0.05	0.37	0.21	0.04
February	1.05	0.89	0.26	1.43	1.57	0.09
March	-0.29	-0.70	-0.02	-1.11	-1.17	-0.07
April	-2.09	-2.09	-0.01	0.00	0.07	0.00
May	0.25	0.26	0.00	0.18	0.17	0.00
June	0.72	0.76	0.00	-0.71	-0.72	0.00
July	-0.77	-0.01	0.00	0.31	0.35	0.00
August	0.07	-0.01	0.00	1.08	1.10	0.00
September	0.92	0.94	0.00	2.20	2.12	0.06
October	-0.71	-0.69	-0.03	0.28	0.08	0.06
November	-1.63	-1.65	-0.07	-0.50	-0.46	-0.05
December	1.57	1.70	0.19	1.00	0.92	0.14
Spring	-0.87	-1.15	-0.07	0.00	0.07	0.00
Summer	1.21	1.22	0.00	-0.10	-0.08	0.00
Autumn	-1.18	-1.05	-0.10	-0.16	-0.21	-0.11
Winter	0.20	0.40	0.11	0.21	0.22	0.14
Annual	-0.48	-0.53	-0.20	0.50	0.49	0.21

Red (Positive) and Blue (Negative), at 95% (a = 0.05) indicates a level of significance in confidence interval.

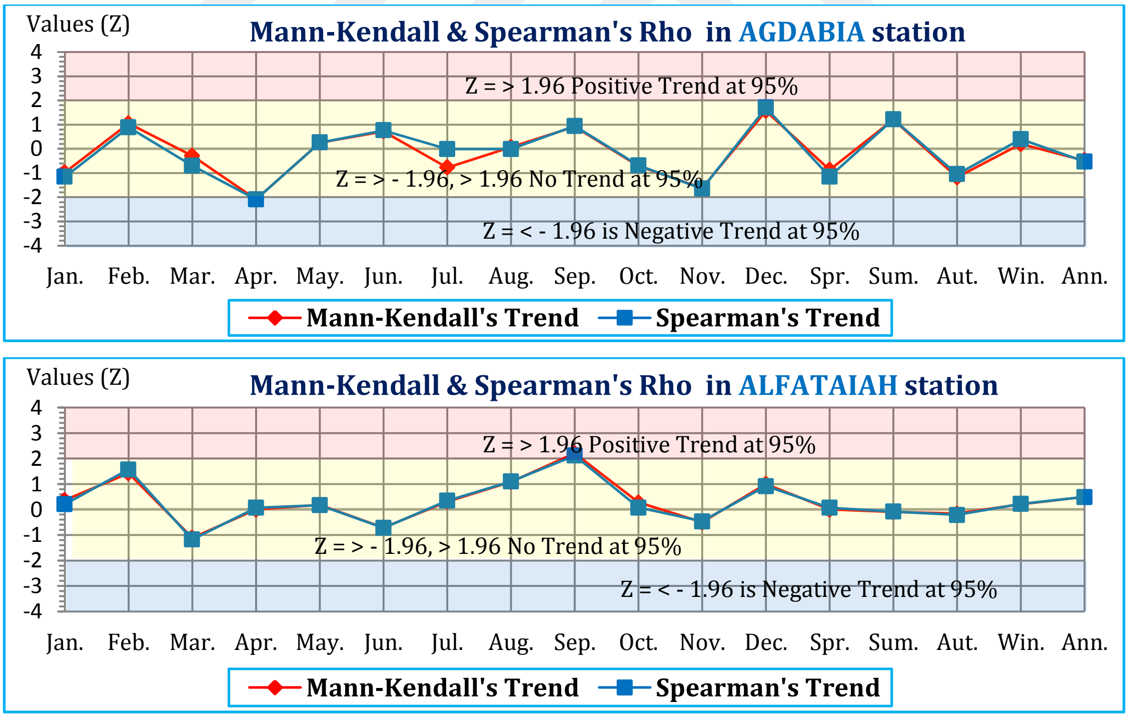


Figure 232. Mann-Kendall And Spearman's Trend for Precipitation in AGDABIA(1971-2010) and ALFATAIAHStation(1981-2010)

AGDABIAstation does not show any trend during all months of the year except in April a negative trend is found and ALFATAIAHstation shows a positive trend in September only (Table 96, Figure 233).

Table 97. Results of Trend Analysis for Mann-Kendall, Spearman and Sen's slope for Precipitation Data in BENGHAZI, and DERNAStations(1971-2010)

Station Name	**BENGHAZI**			**DERNA**		
Test's Type	**Mann-Kendall**	**Spearman's Rho**	**Sen's Slope**	**Mann-Kendall**	**Spearman's Rho**	**Sen's Slope**
January	-0.35	-0.44	-0.10	0.34	0.42	0.06
February	0.05	-0.09	0.05	1.47	1.41	0.09
March	0.02	-0.04	0.00	-0.43	-0.55	-0.06
April	-2.15	-2.03	-0.12	-2.50	-2.48	-0.17
May	1.28	1.40	0.02	-0.79	-0.86	0.00
June	2.08	2.19	0.00	0.00	-0.05	0.00
July	1.13	1.17	0.00	1.13	1.17	0.00
August	-0.90	-0.95	0.00	0.19	0.22	0.00
September	0.44	0.47	0.00	0.91	0.92	0.00
October	-0.47	-0.39	-0.02	-0.97	-1.21	-0.08
November	-0.79	-0.57	-0.06	-0.35	-0.37	-0.07
December	-0.07	-0.14	-0.04	0.91	0.92	0.07
Spring	-0.61	-0.68	-0.05	-0.79	-0.93	-0.06
Summer	1.59	1.66	0.00	-0.19	-0.24	0.00
Autumn	-0.83	-0.82	-0.11	-1.04	-1.04	-0.12
Winter	-1.14	-1.08	-0.27	1.42	1.53	0.09
Annual	-1.56	-1.46	-0.27	0.62	0.44	0.07

Red (Positive) and Blue (Negative),at 95% (a = 0.05) indicates a level of significance in confidence interval.

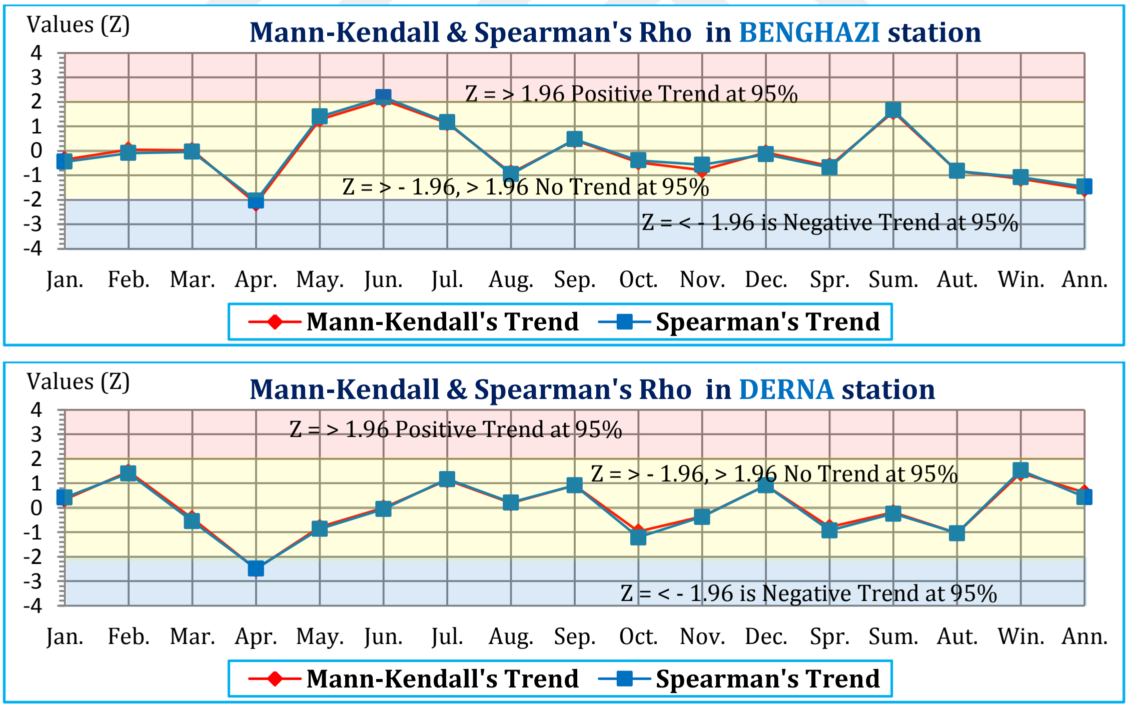


Figure 233. Mann-Kendall And Spearman's Trend for Precipitation in BENGHAZI and DERNAStations(1971-2010)

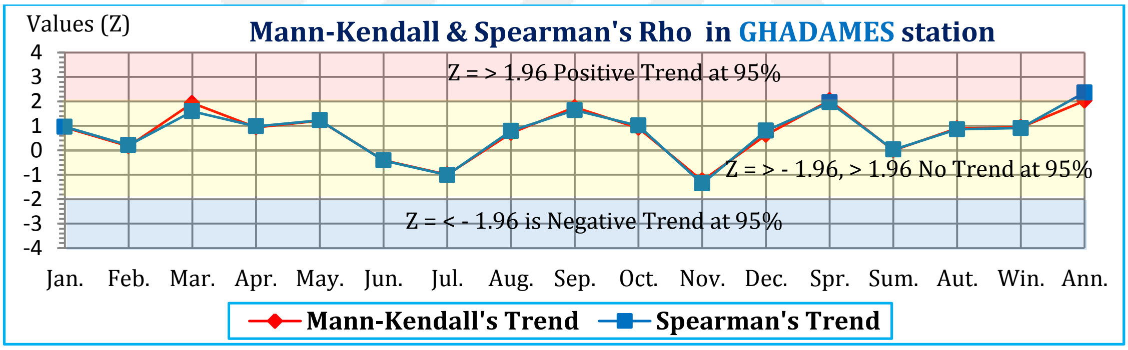
BENGHAZI station,there is a positive trend in June only and a negative trend in April, while the rest of months and seasons do not show any trends.

DERNA station, only negative trend in April is observed (Table 97, Figure 234).

Table 98. Results of Trend Analysis for Mann-Kendall, Spearman and Sen's slope for Precipitation Data in GHADAMES and GHARIAT Stations(1971-2010)

Station Name	GHADAMES			GHARIAT		
Test's Type	**Mann-Kendall**	**Spearman's Rho**	**Sen's Slope**	**Mann-Kendall**	**Spearman's Rho**	**Sen's Slope**
January	0.94	0.96	0.00	0.18	0.15	0.00
February	0.17	0.21	0.00	-0.10	-0.09	0.00
March	1.93	1.60	0.03	0.55	0.60	0.00
April	0.94	0.98	0.00	0.59	0.54	0.00
May	1.21	1.23	0.00	0.24	0.12	0.00
June	-0.41	-0.42	0.00	-1.20	-1.08	0.00
July	-0.99	-1.01	0.00	0.99	1.02	0.00
August	0.71	0.79	0.00	-1.77	-1.79	0.00
September	1.76	1.64	0.00	-1.35	-1.40	0.00
October	0.92	1.01	0.00	0.69	0.83	0.00
November	-1.24	-1.36	0.00	1.05	1.04	0.00
December	0.63	0.80	0.00	-0.77	-0.90	0.00
Spring	2.04	1.96	0.00	0.42	0.39	0.02
Summer	0.00	0.03	0.00	-1.04	-0.90	0.00
Autumn	0.90	0.86	0.01	0.23	0.43	0.04
Winter	0.94	0.91	0.01	-0.70	-0.65	0.02
Annual	2.03	2.36	0.06	0.21	0.12	0.01

Red (Positive) and Blue (Negative),at 95% (a = 0.05) indicates a level of significance in confidence interval.



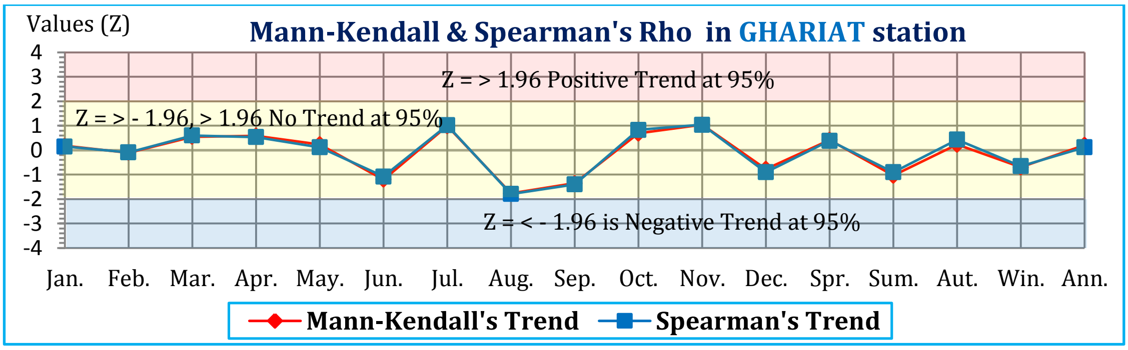


Figure 234. Mann-Kendall And Spearman's Trend for Precipitation in GHADAMES and GHARIAT Stations(1971-2010)

GHADAMES station the months do not show any trend while the spring season and the annual average show a positive trend.GHARIAT station no trends are shown (Table 98, Figure 235).

Table 99. Results of Trend Analysis for Mann-Kendall, Spearman and Sen's slope for Precipitation Data in HON and JAGHBOUB Stations(1971-2010)

Station Name	HON			JAGHBOUB		
Test's Type	**Mann-Kendall**	**Spearman's Rho**	**Sen's Slope**	**Mann-Kendall**	**Spearman's Rho**	**Sen**
January	0.66	0.70	0.01	0.11	0.17	0.00
February	0.40	0.49	0.00	0.80	0.87	0.00
March	-0.48	-0.37	0.00	-1.27	-1.37	0.00
April	0.69	0.64	0.00	-0.61	-0.59	0.00
May	-0.24	-0.22	0.00	1.74	1.77	0.00
June	-0.22	-0.39	0.00	0.77	0.78	0.00
July	0.00	0.00	0.00	-0.95	-0.60	0.00
August	-0.09	-0.06	0.00	-0.61	-0.42	0.00
September	-0.08	-0.09	0.00	1.56	1.61	0.00
October	-1.03	-1.02	0.00	0.44	0.43	0.00
November	-0.36	-0.39	0.00	-0.88	-0.91	0.00
December	-0.78	-0.62	0.00	0.17	0.28	0.00
Spring	-0.23	-0.25	0.00	-1.21	-1.25	-0.05
Summer	-0.01	-0.19	0.00	0.64	0.66	0.00
Autumn	-1.97	-1.99	-0.07	-0.24	-0.29	0.00
Winter	0.66	0.57	0.01	0.00	-0.15	0.00
Annual	-0.05	-0.03	-0.01	-0.80	-0.87	-0.02

Red (Positive) and Blue (Negative),at 95% (a = 0.05) indicates a level of significance in confidence interval.

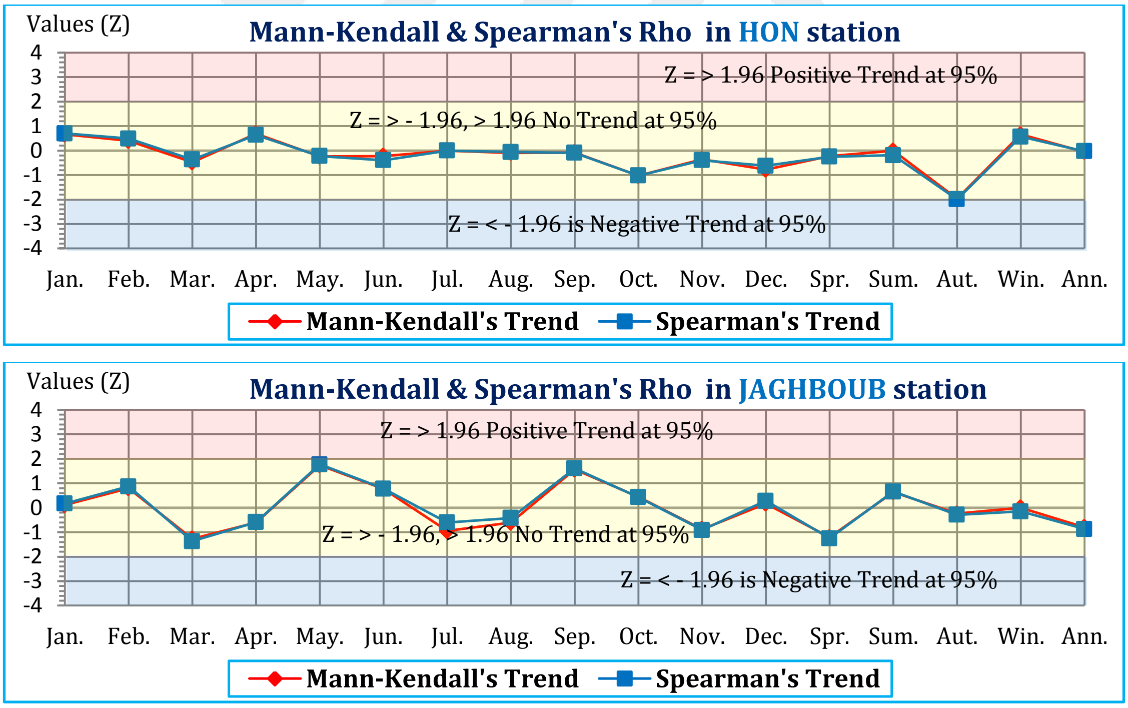


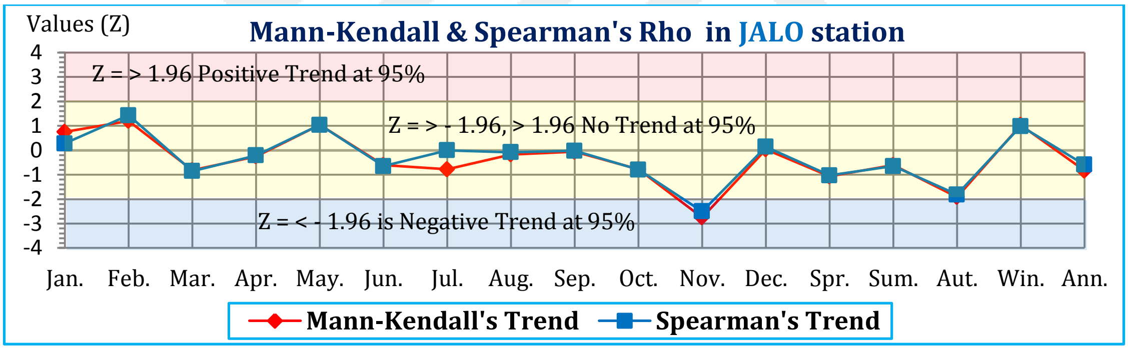
Figure 235. Mann-Kendall And Spearman's Trend for Precipitation in HON and JAGHBOUBStations(1971-2010)

HON station no trends are shown, also JAGHBOUB station no trends are shown (Table 99, Figure 236).

Table 100. Results of Trend Analysis for Mann-Kendall, Spearman and Sen's slope for Precipitation Data in JALO and MISURATAStations(1971-2010)

Station Name	JALO			MISURATA		
Test's Type	Mann-Kendall	Spearman's Rho	Sen's Slope	Mann-Kendall	Spearman's Rho	Sen's Slope
January	0.75	0.28	0.04	-0.29	-0.45	-0.13
February	1.20	1.43	0.00	0.37	0.43	0.12
March	-0.82	-0.85	0.00	-0.09	-0.09	-0.02
April	-0.25	-0.21	0.00	0.52	0.55	0.04
May	1.04	1.04	0.02	-0.47	-0.53	0.00
June	-0.61	-0.65	0.00	0.55	0.49	0.00
July	-0.78	0.00	0.00	0.56	0.56	0.00
August	-0.17	-0.08	0.00	2.04	2.08	0.00
September	-0.06	-0.02	0.00	0.91	1.01	0.05
October	-0.78	-0.79	0.00	-0.94	-0.89	-0.06
November	-2.75	-2.50	0.00	-0.47	-0.34	-0.07
December	0.04	0.14	0.00	-0.43	-0.48	-0.05
Spring	-1.07	-1.03	0.00	0.54	0.54	0.07
Summer	-0.61	-0.65	0.00	0.26	0.37	0.00
Autumn	-1.91	-1.81	0.00	-0.67	-0.73	-0.04
Winter	1.03	0.99	0.03	-0.94	-0.97	-0.08
Annual	-0.83	-0.59	0.00	-0.90	-0.95	-0.08

Red (Positive) and Blue (Negative),at 95% (a = 0.05) indicates a level of significance in confidence interval.



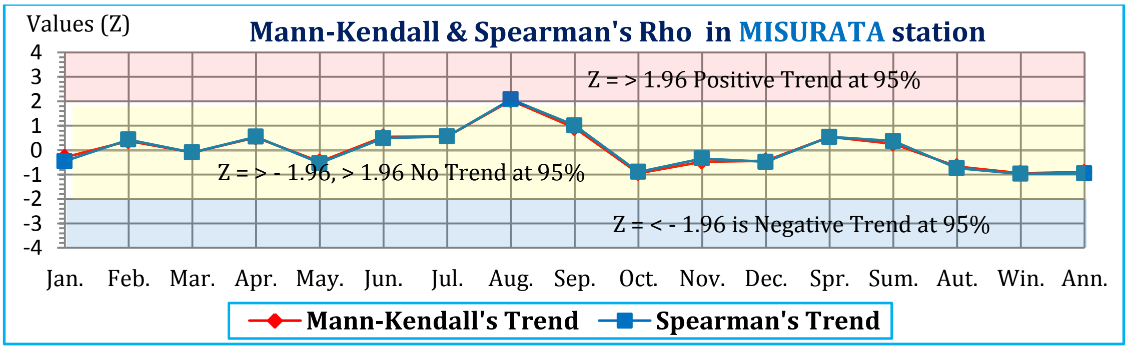


Figure 236. Mann-Kendall And Spearman's Trend for Precipitation in JALO and MISURATA Stations (1971-2010)

JALO station only negative trend in November is shown. MISURATA stationonly positive trend in August is shown (Table 100, Figure 237).

Table 101. Results of Trend Analysis for Mann-Kendall, Spearman and Sen's slope for Precipitation Data in NALUT and SHAHAT Stations(1971-2010)

Station Name	NALUT			SHAHAT		
Test's Type	**Mann-Kendall**	**Spearman's Rho**	**Sen's Slope**	**Mann-Kendall**	**Spearman's Rho**	**Sen's Slope**
January	-0.84	-0.77	-0.11	-0.37	-0.41	-0.10
February	-0.79	-0.81	-0.10	-0.06	-0.08	-0.06
March	-1.45	-1.60	-0.30	0.24	0.22	0.05
April	-0.67	-0.68	-0.04	-1.45	-1.58	0.00
May	0.05	0.03	0.00	0.32	0.49	0.00
June	0.71	0.77	0.00	-0.95	-0.95	0.00
July	0.81	0.84	0.00	-0.74	-0.71	0.00
August	0.18	0.20	0.00	-0.23	-0.23	0.00
September	0.78	0.72	0.01	0.35	0.27	0.00
October	-0.60	-0.59	-0.02	-0.76	-0.77	-0.02
November	-0.06	-0.82	-0.03	0.10	0.22	0.05
December	0.01	0.02	0.00	1.99	2.00	0.02
Spring	-1.91	-1.75	-0.10	-0.43	-0.44	-0.06
Summer	0.71	0.71	0.00	-1.07	-1.06	0.00
Autumn	-0.54	-0.61	-0.10	-1.49	-1.46	-0.06
Winter	0.58	0.41	0.19	-0.42	-0.40	-0.05
Annual	-1.72	-1.57	-0.16	-0.70	-0.61	-0.08

Red (Positive) and Blue (Negative),at 95%, (a = 0.05) indicates a level of significance in confidence interval.

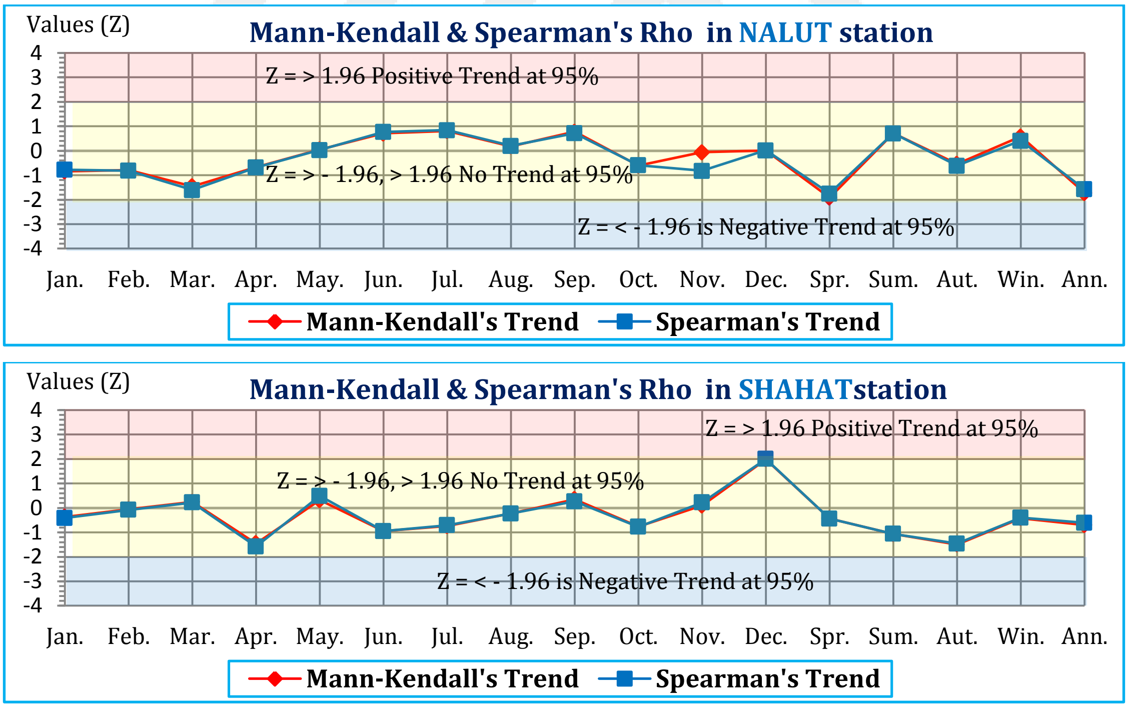


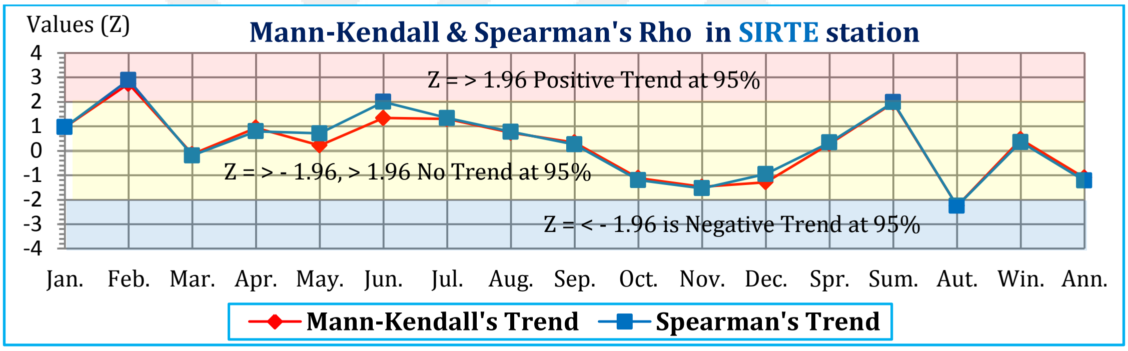
Figure 237. Mann-Kendall And Spearman's Trend for Precipitation in NALUTI and SHAHAT Stations (1971-2010)

NALUT stationno trends are shown., SHAHAT station only positive trend in December is shown (Table 101, Figure 238).

Table 102. Results of Trend Analysis for Mann-Kendall, Spearman and Sen's slope for Precipitation Data in SIRTE and TOBRUK Stations

Station Name	SIRTE			TOBRUK(1984-2010)		
Test's Type	**Mann-Kendall**	**Spearman's Rho**	**Sen's Slope**	**Mann-Kendall**	**Spearman's Rho**	**Sen's Slope**
January	0.97	0.97	0.04	-1.50	-1.41	-0.09
February	2.74	2.90	0.05	0.40	0.36	0.06
March	-0.14	-0.19	-0.01	-1.71	-2.40	-0.09
April	0.94	0.80	0.00	-0.74	-0.79	0.00
May	0.22	0.71	0.00	0.65	0.61	0.00
June	1.34	2.00	0.00	0.09	0.15	0.00
July	1.30	1.34	0.00	-0.58	-0.21	0.00
August	0.74	0.78	0.00	-0.42	-0.40	0.00
September	0.34	0.26	0.00	1.09	1.26	0.00
October	-1.11	-1.20	-0.09	0.18	-0.21	-0.01
November	-1.47	-1.53	-0.09	-0.77	-0.97	-0.08
December	-1.28	-0.95	-0.03	-0.88	-1.11	-0.10
Spring	0.29	0.34	0.07	-1.42	-1.77	-0.18
Summer	1.96	1.99	0.00	0.09	0.15	0.00
Autumn	-2.25	-2.25	-0.18	-0.15	-0.36	-0.02
Winter	0.47	0.36	0.08	-0.88	-1.18	-0.23
Annual	-1.10	-1.22	-0.13	-2.33	-2.85	-0.69

Red (Positive) and Blue (Negative),at95% (a = 0.05) indicates a level of significance in confidence interval.



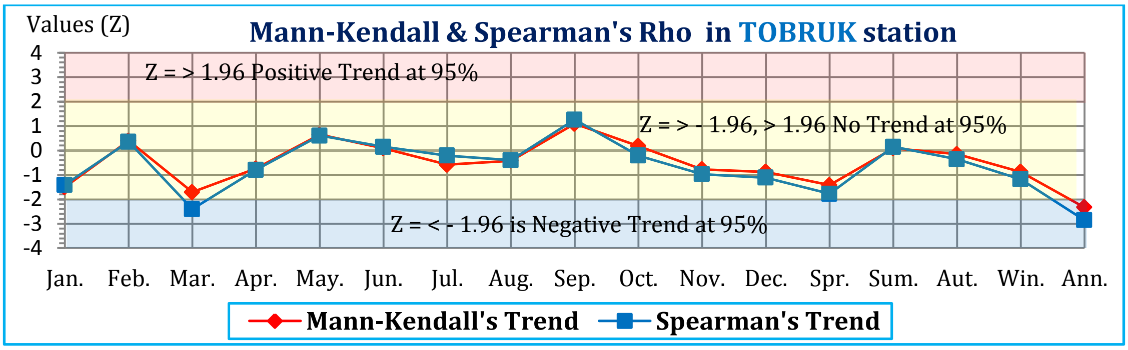


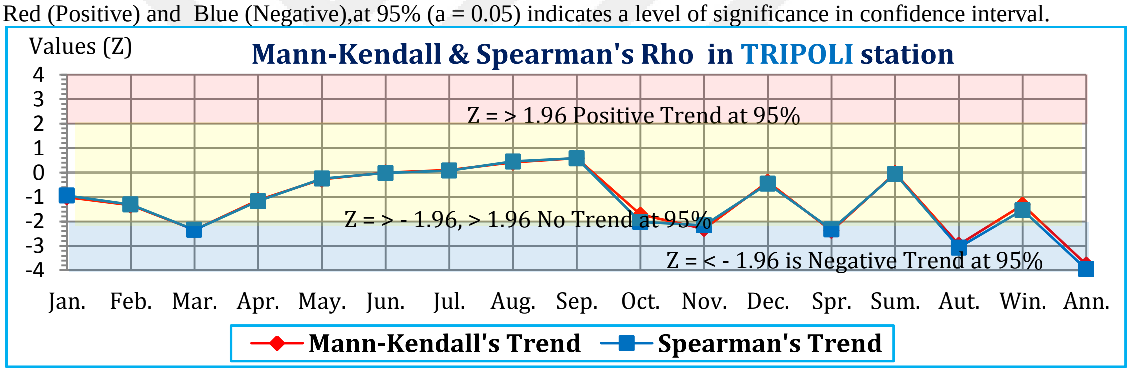
Figure 238. Mann-Kendall And Spearman's Trend for Precipitation in SIRTE Station (1971-2010) and TOBRUK Station (1984-2010)

SIRTEstation shows a positive trend in February and summer, positive trend in June in Spearman's results and shows a negative trend during the autumn.TOBRUKstation shows the negative trend only in March in result of Spearman, and shows positive trend in annual average (Table 102, Figure 239).

Table 103. Results of Trend Analysis for Mann-Kendall, Spearman and Sen's slope for Precipitation Data in TRIPOLI and ZWARAStations(1971-2010)

Station Name	**TRIPOLI**			**ZWARA**		
Test's Type	**Mann-Kendall**	**Spearman's Rho**	**Sen's Slope**	**Mann-Kendall**	**Spearman's Rho**	**Sen's Slope**
January	-1.01	-0.94	-0.09	-0.06	-0.02	-0.03
February	-1.34	-1.31	-0.10	-0.61	-0.64	-0.09
March	-2.35	-2.34	-0.06	-1.41	-1.57	-0.09
April	-1.13	-1.17	-0.07	0.16	0.05	0.00
May	-0.28	-0.25	0.00	0.27	0.21	0.00
June	0.00	-0.02	0.00	0.10	0.00	0.00
July	0.10	0.08	0.00	-1.30	-1.32	0.00
August	0.41	0.45	0.00	0.30	0.37	0.00
September	0.58	0.58	0.00	0.39	0.33	0.02
October	-1.72	-2.02	-0.13	-1.88	-1.97	-0.09
November	-2.30	-2.16	-0.30	-0.79	-0.81	-0.05
December	-0.38	-0.46	-0.09	-0.48	-0.52	-0.05
Spring	-2.38	-2.33	-0.22	-0.58	-0.63	-0.08
Summer	-0.03	-0.06	0.00	-0.13	-0.17	0.00
Autumn	-2.95	-3.07	-0.32	-1.35	-1.46	-0.17
Winter	-1.32	-1.54	-0.19	-0.61	-0.69	-0.11
Annual	-3.76	-3.95	-0.42	-2.57	-2.50	-0.41

Red (Positive) and Blue (Negative),at 95% (a = 0.05) indicates a level of significance in confidence interval.



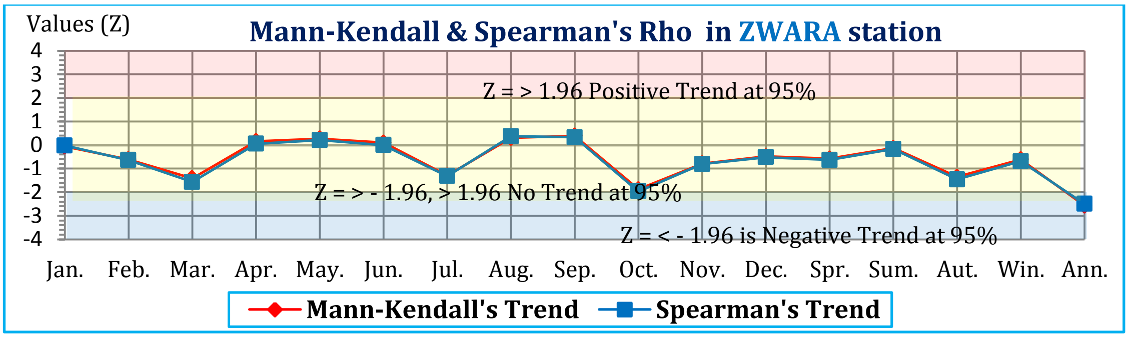


Figure 239. Mann-Kendall And Spearman's Trend for Precipitation in TRIPOLI and ZWARA Stations (1971-2010)

TRIPOLIstation shows negative trends in March, October and November, and shows a negative trend in the spring and in the annual precipitation.

ZWARAstation shows the negative trend only in November in result of Spearman, and shows positive trend in annual average (Table 103, Figure 240).

- **Evaluation of results of Precipitation Values**

It is possible to say that precipitation trends are almost completely absent in some stations by looking at the results of the Mann-Kendall, Spearman and Sen tests perhaps due to fluctuation of precipitation from year to year.

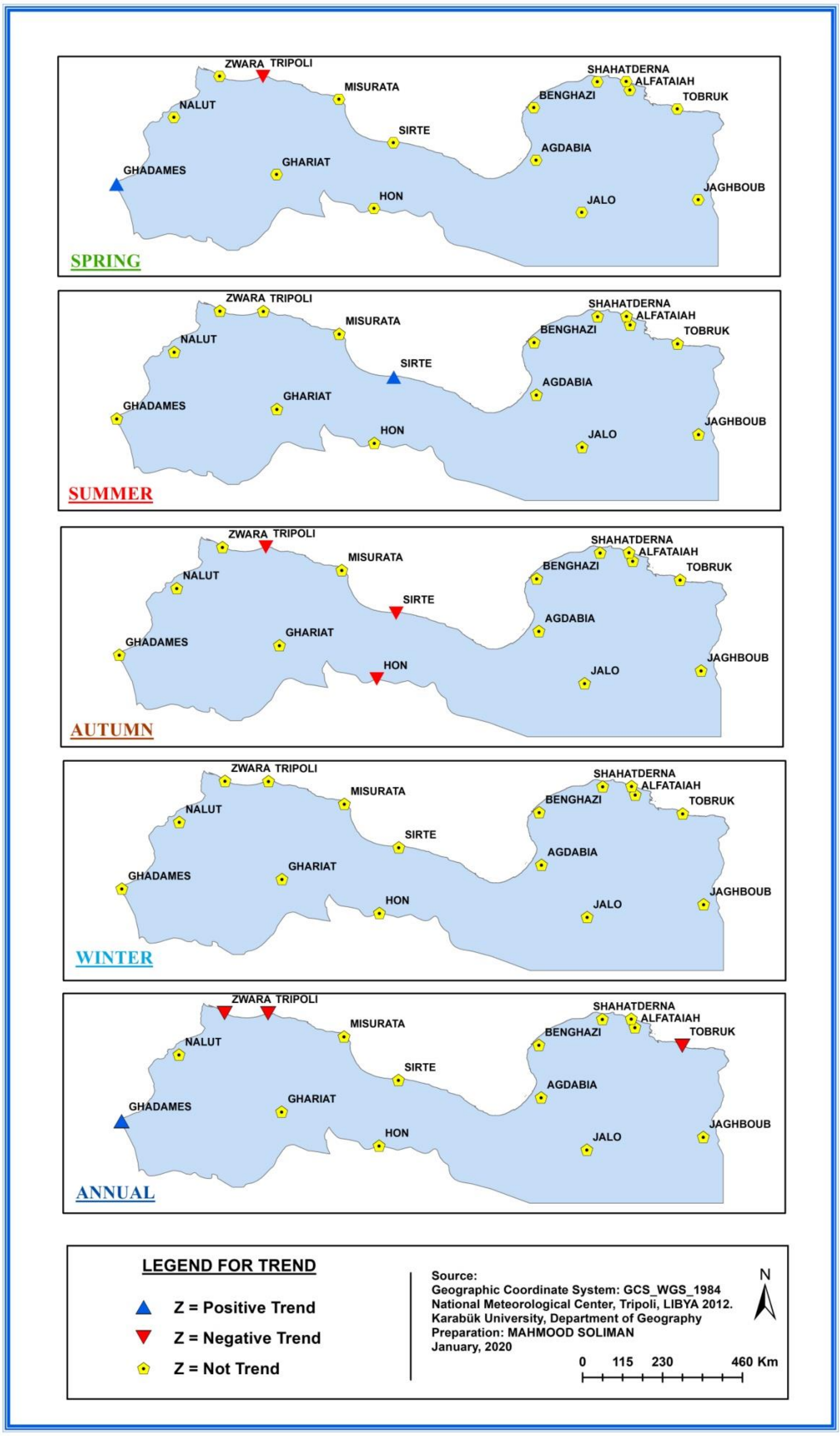
-Mann-Kendall and Spearman's Rho Tests

It is possible to say that all the stations in northern Libya gave weak trends in most months, whether positive or negative, perhaps due to the irregularity of precipitation on monthly, seasonally and annually basis. The comments can be summarized as follows.

It is found that the non-significant trends of increase or decrease prevail over the months when the rainfall data are evaluated on a monthly basis. Significant trends can also be seen in increasing or decreasing directions. SIRTE station shows increasing trend in February and June, MISURATA in August, and BENGHAZI in June, ALFATAIAH in September and SHAHAT in December. JALO station and most of desert stations show decreasing trend significantly such as GHARIAT station in November, HON station shows a negative trend in most of the months especially in August, and JAGHBOUB station.

TRIPOLI station shows a significant decrease in trend during the months of March and November. TOBRUK station shows a decrease in March in the result of Spearman Rho's test (-2.40). All the remaining stations have a decreasing trend. The decreasing trend is seen in DERNA in April (-2.50 in M-K and -2.48 in Spearman). The decreasing trend appears in April at three stations in results of M-K and Spearman with (-2.09 and -2.09) at AGDABIA, with (-2.15 and -2.03) at BENGHAZI and with (-2.50 and -2.48) at DERNA. Except for desert's stations, an upward trend in June, which does not have a significant significance, is evident throughout the stations.

Seasonally, in the spring season, there found generally significant increase in trends. These increasing trends are only significant in Tripoli and GHADAMES stations (according to Mann-Kendall and Spearman tests statistics). In other stations, most of the increasing trends seen in spring season are not significant. Besides, non-significant decreasing trend are also found at AGDABIA, BENGHAZI, DERNA, HON, JAGHBOUB, JALO, SHAHAT, TOBRUK, and ZWARA stations.



Map 30. Results of Mann-Kendall And Spearman's Trend for Precipitation in Meteorological Stations (1971-2010)

In summer,only SIRTE and TRIPOLI stations show a significant trend with a significant upward trend while other stations have no trend. Positive and negative trends have low ranges. That may be because of the lack of rain in the summer at all stations. In the autumn season, there is a significant decrease in trends only in three stations which are HON station, SIRTE station, and TRIPOLI station while most stations show non-significant decreasing trend. such as JALO, AGDABIA, ZWARA, DERNA and SHAHAT stations. Some desert stations show a non-significant increase in trend such as GHADAMES, and GHARIAT along with NALUT stations. Winter season shows decreasing trends. However, it is possible to see the stations that have a non-significant decreasing trend in winter. The stations that show a decreasing non-significant trend include TRIPOLI, TOBRUK, and BENGHAZI. The non-significant increasing trends are not found in any station except some desert station such as JALO and GHADAMES.

In analysis of annual rainfall, some stations show significant decreasing trend such as TRIPOLI, and ZWARA stations. In generala non-significant trend is observed in decreasing direction. From all stations in the study area, only GHADAMES station shows a significant increasing trend, according to Mann-Kendall and Spearman tests statistics (Map 31).

- Sen's Trend slope Test

The tests show that trend decreases in the direction of rainfall data. A decreasing trend has been determined in most of the stations for most of the months except for summer months. Moreover, significant decreasing trend is observed in BENGHAZI, AGDABIA, ALFATAIAH, DERNA, MISURATA, NALUT, SHAHAT, SIRTE, TOBRUK, TRIPOLI and ZWARA stations. Following are several results discussed:

Monthly, Many coastal stations show an increase in trend in five months of January, February, March, October, and November. However, these trends are non-significant. Some stations show an increase in trend in January, February, March (only in SHAHAT station), September and October.

The stations where the trend is shown in line with the increase consist of seven coastal stations, which are AGDABIA, ALFATAIAH, BENGHAZI, DERNA, MISURATA, SHAHAT, SIRTE, and TOBRUK.AGDABIA station shows an increase in trend only in February (0.26) and December (0.19). ALFATAIAH station in

February (0.09 mm) in September, October (0.06 mm) and December (0.14),BENGHAZI only in February (0.05), DERNA in January (0.06), February (0.09), and December(0.14), MISURATA only in February (0.12), SHAHAT in March (0.06) and November (0.05), SIRTE only in February (0.05) and TOBRUK shows an increase in trend only in February, (0.06).

Many coastal stations show a decrease in trend in five months which are January, February, March, October, and November but these trends are not important, AGDABIA station in January (-0.10 mm), and in November (-0.07 mm), ALFATAIAH station in March (-0.07 mm) and in November (-0.05 mm), BENGHAZI station in January (-0.10 mm) and November (-0.06 mm), MISURATA station in January (-0.13 mm), October (-0.06 mm) and November (-0.07 mm), NALUT station in January (-0.11mm), February (-0.11 mm), and March (-0.30 mm), SHAHAT station in January (-0.10 mm), and February (-0.06 mm), SIRTE station in October and November (-0.09 mm), and TOBRUK station in January, March (-0.09 mm) and November (-0.08 mm). TRIPOLI station shows a decrease in trend in seven months which are January (-0.09 mm), February (-0.10 mm), March (-0.06 mm), April (-0.07 mm), October (-0.13 mm), November (-0.30 mm), and December (-0.09 mm). ZWARA station shows a decrease in trend in five months which are February, March (-0.09), October (-0.09), November and December (-0.05).It should be noted that all the desert stations do not show any trends, whether positive or negative.

Seasonally, there is a significant trends at GHADAMES, AGDABIA, MISURATA, and SIRTE stations when the rainfall data are evaluated in the spring season,. Other stations do not show any positive trend and most stations show negative trends in all season, except for desert's stations of GHADAMES. The summer season does not show any trend at any station or in any month. In the winter, AGDABIA (0.11), ALFATAIAH (0.14), DERNA (0.09) and SIRTE (0.08)stations show a trend. Most stations show decreasing trends in autumn and winter. In the annual averages, there are not any positive trend except ALFATAIAH and DERNA stations.The following figures show the most different trends of precipitation, using Mann Kendall test U(t), and U(t').

4.2.2. Relative Correlation of Mann-Kendall U(t)-U'(t) Graphs for Precipitation Data (1971-2010)

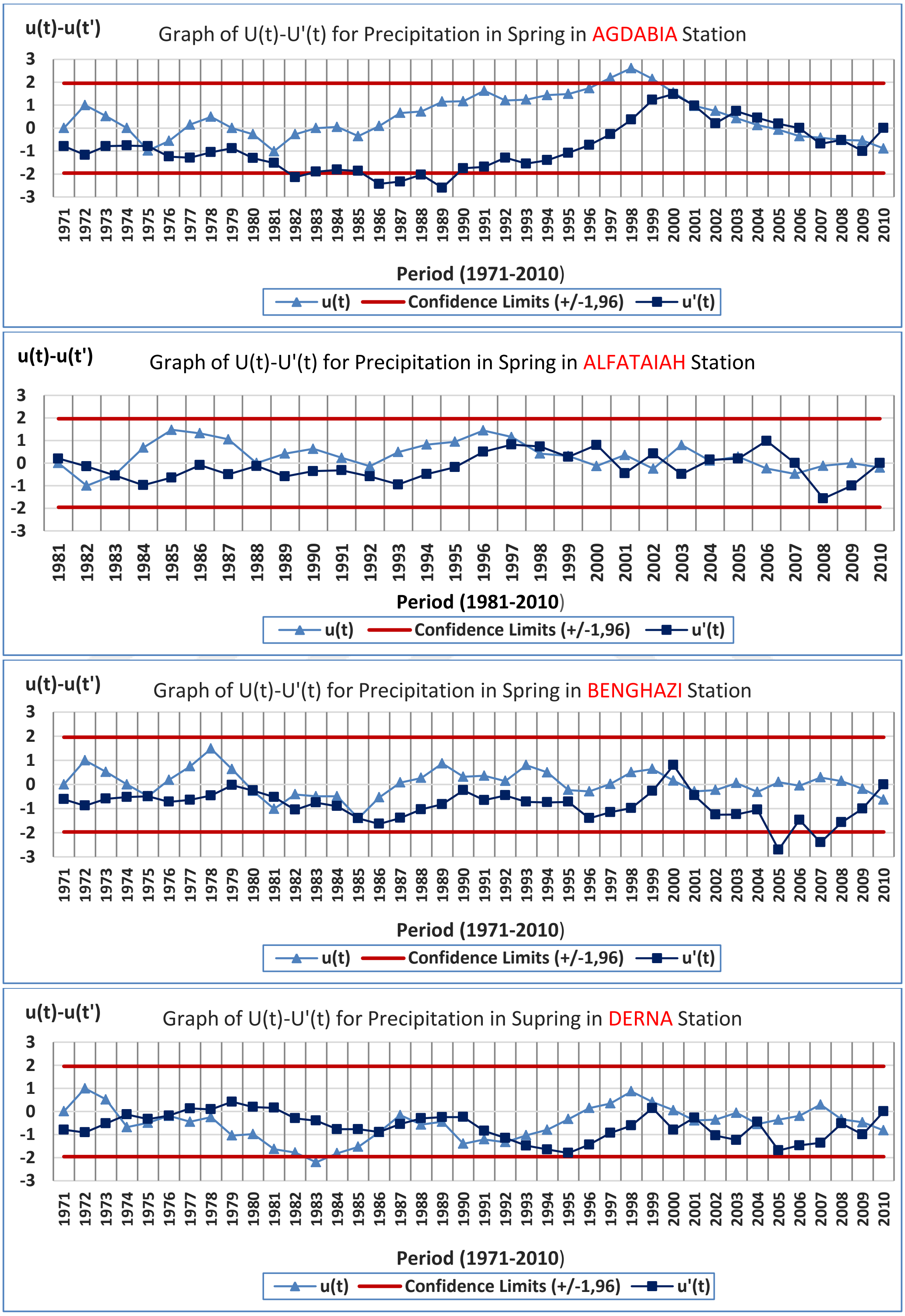
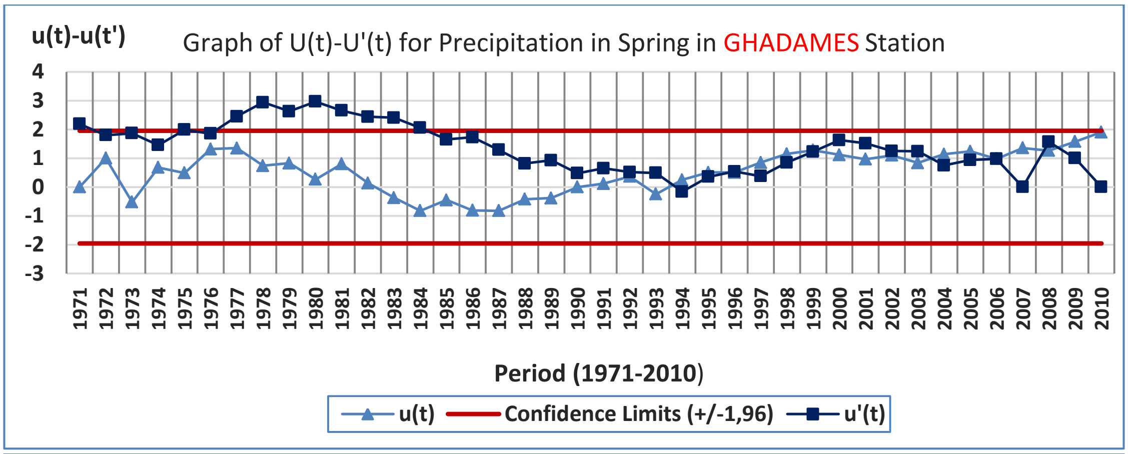
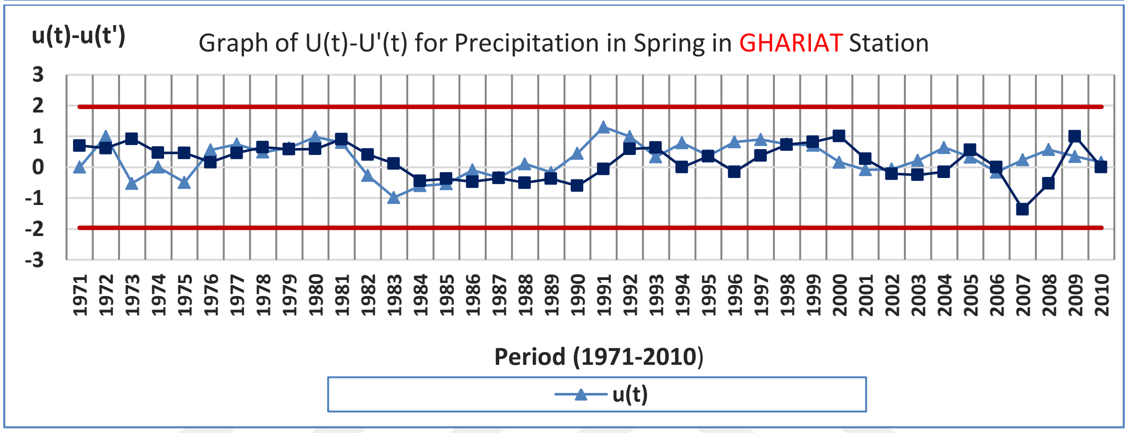
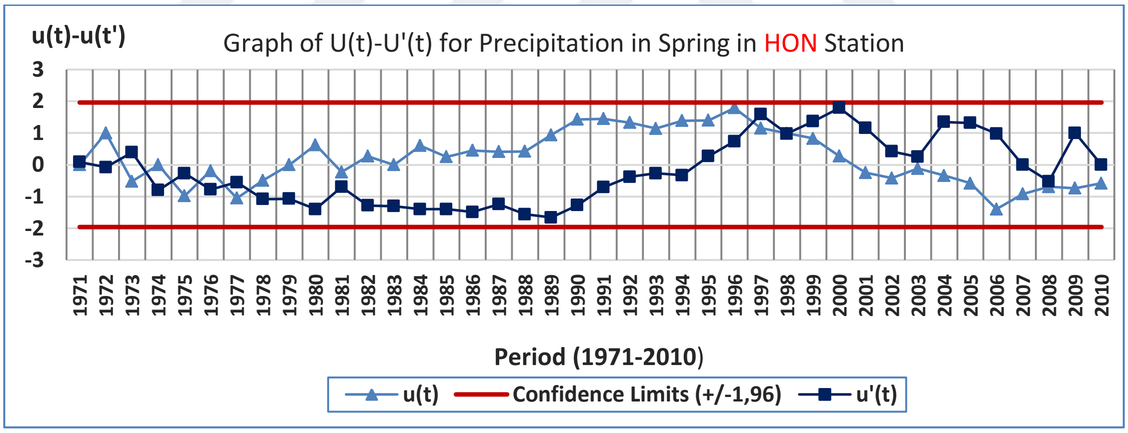


Figure 240. Graphs of M-K U(t)-U'(t) Results for Precipitation in Spring in AGDABIA, ALFATAIAH, BENGHAZI and DERNA Stations







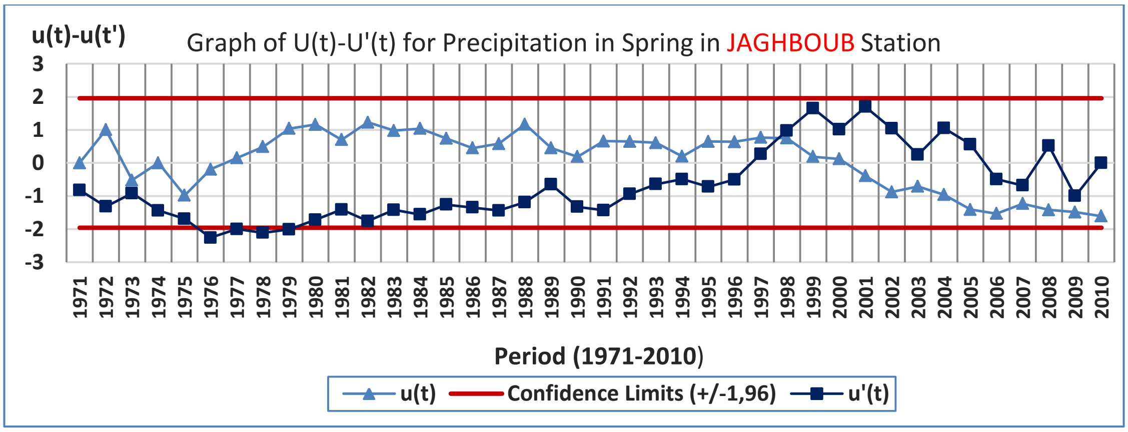


Figure 241. Graphs of M-K U(t)-U'(t) Results for Precipitation in Spring in GHADAMES, GHARIAT, HON and JAGHBOUB Stations

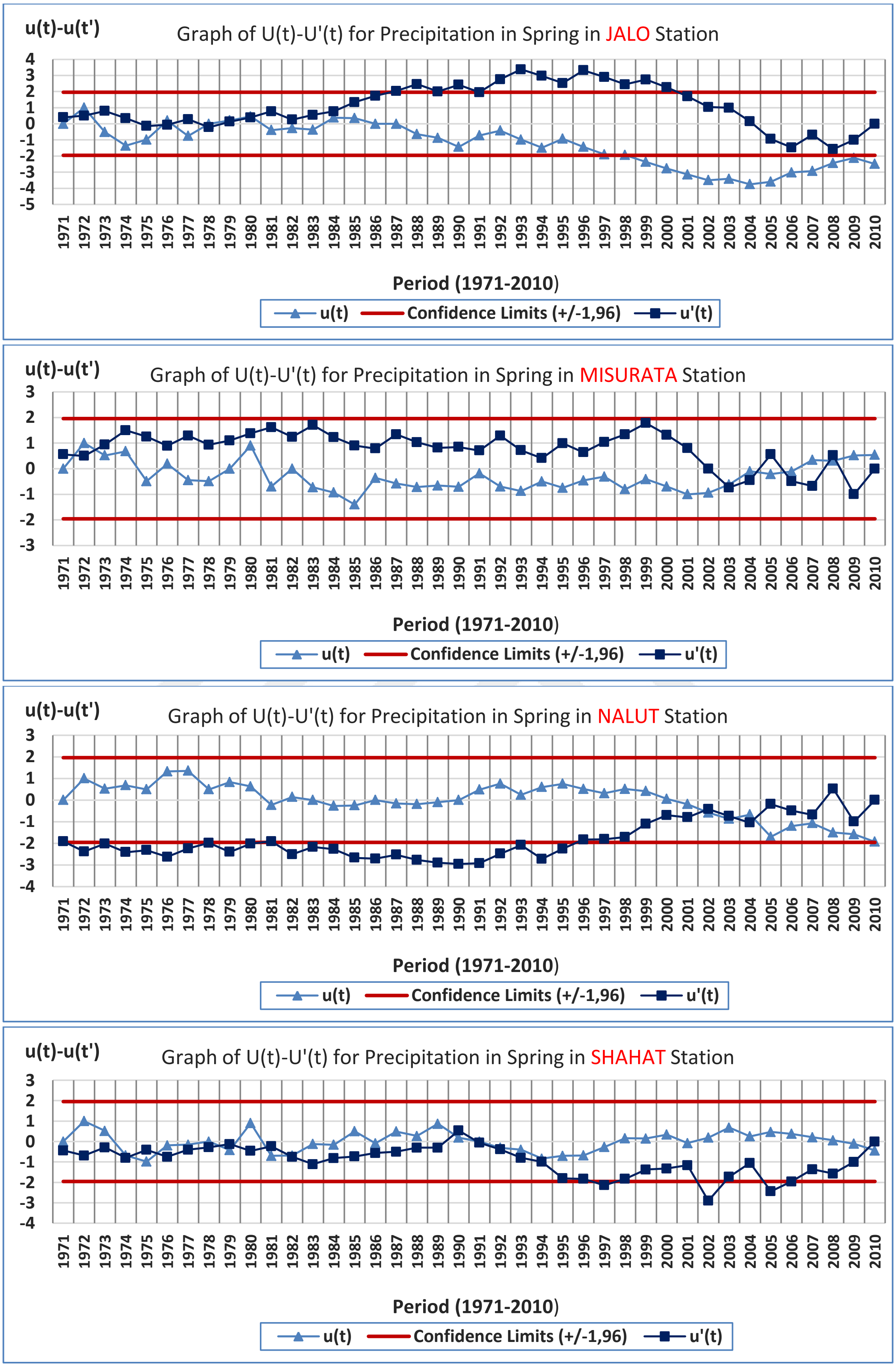


Figure 242. Graphs of M-K U(t)-U'(t) Results for Precipitation in Spring in JALO, MISURATA, NALUT and SHAHAT Stations

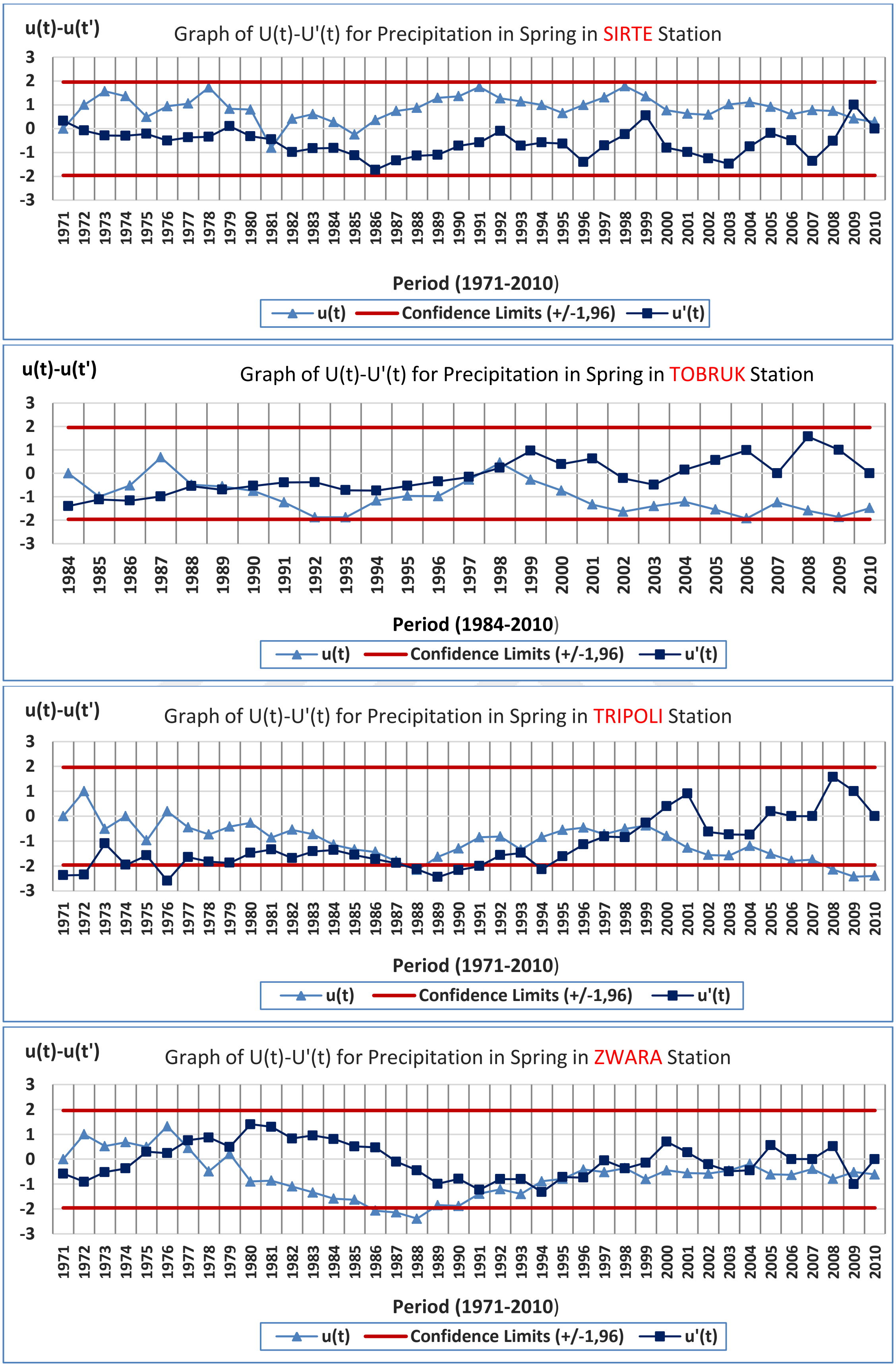


Figure 243. Graphs of M-K U(t)-U'(t) Results for Precipitation in Spring in SIRTE, TOBRUK, TRIPOLI and ZWARA Stations

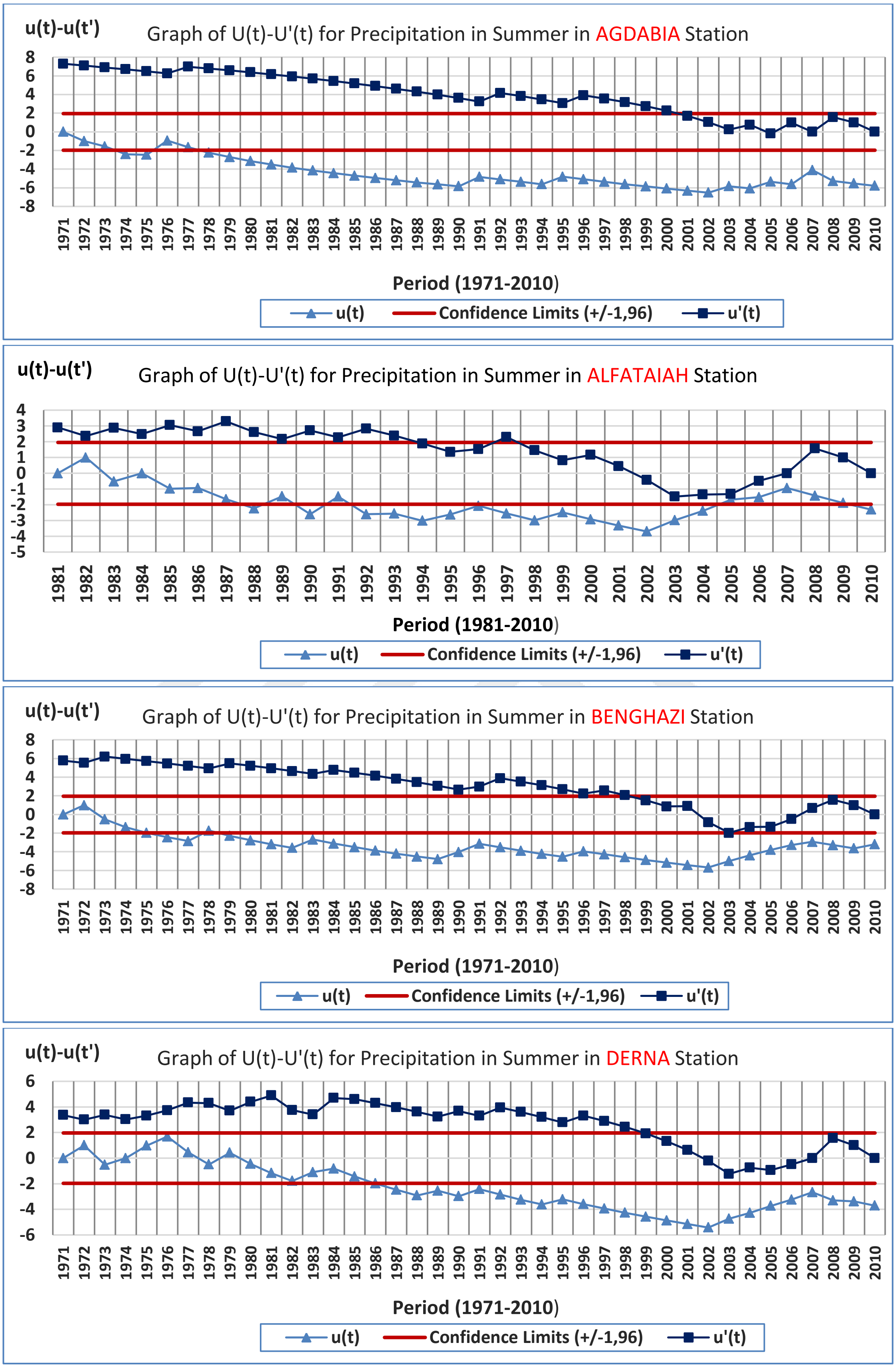
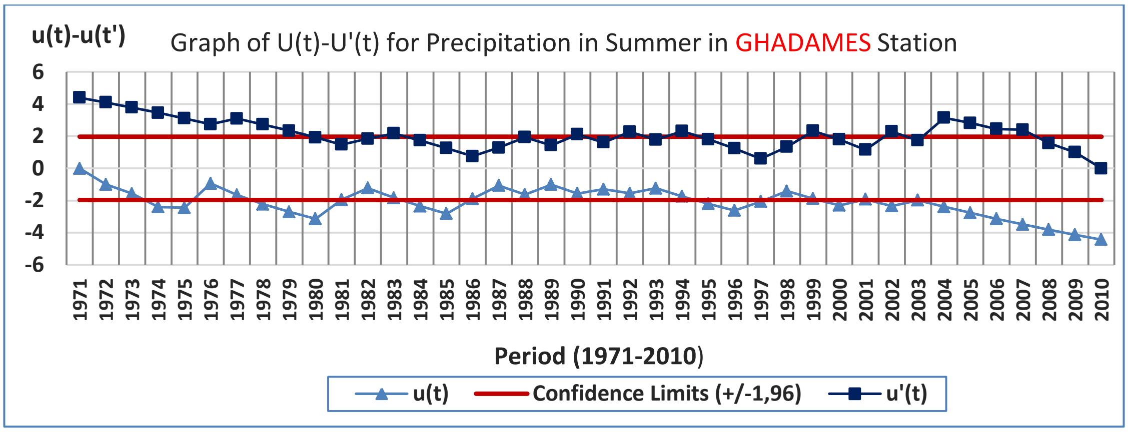
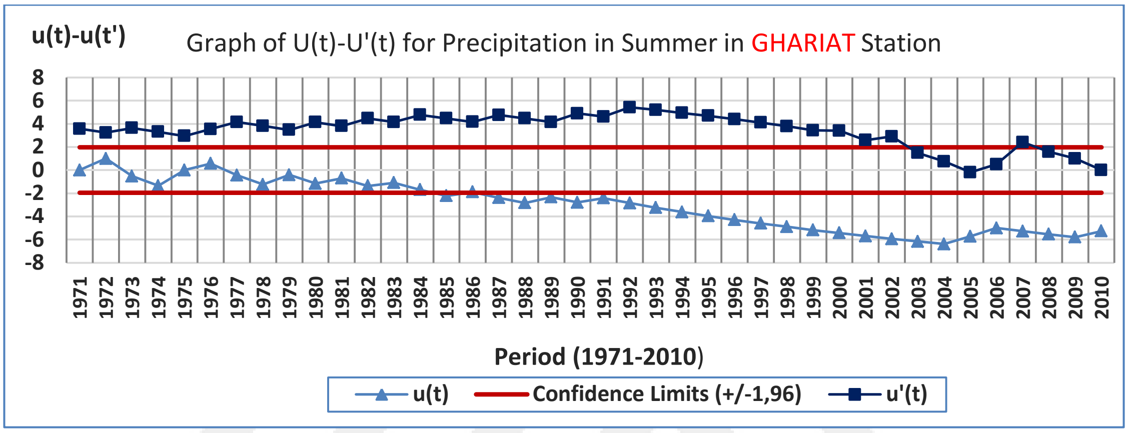
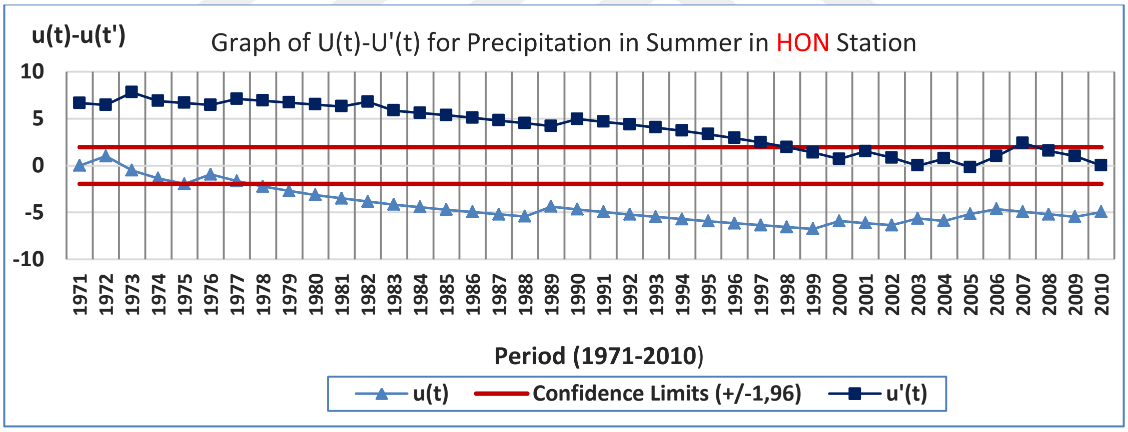


Figure 244. Graphs of M-K U(t)-U'(t) Results for Precipitation in Summer in AGDABIA, ALFATAIAH, BENGHAZI and DERNA Stations







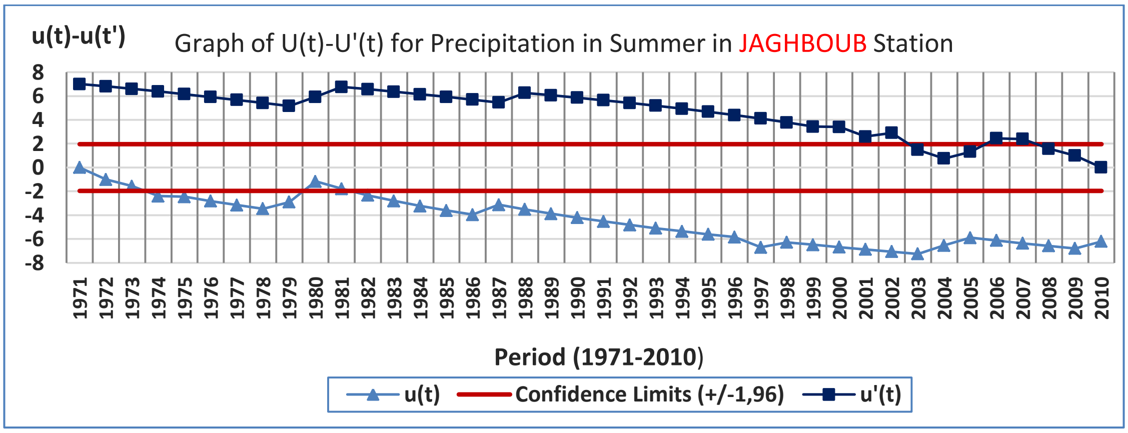


Figure 245. Graphs of M-K U(t)-U'(t) Results for Precipitation in Summer in GHADAMES, GHARIAT HON and JAGHBOUB Stations

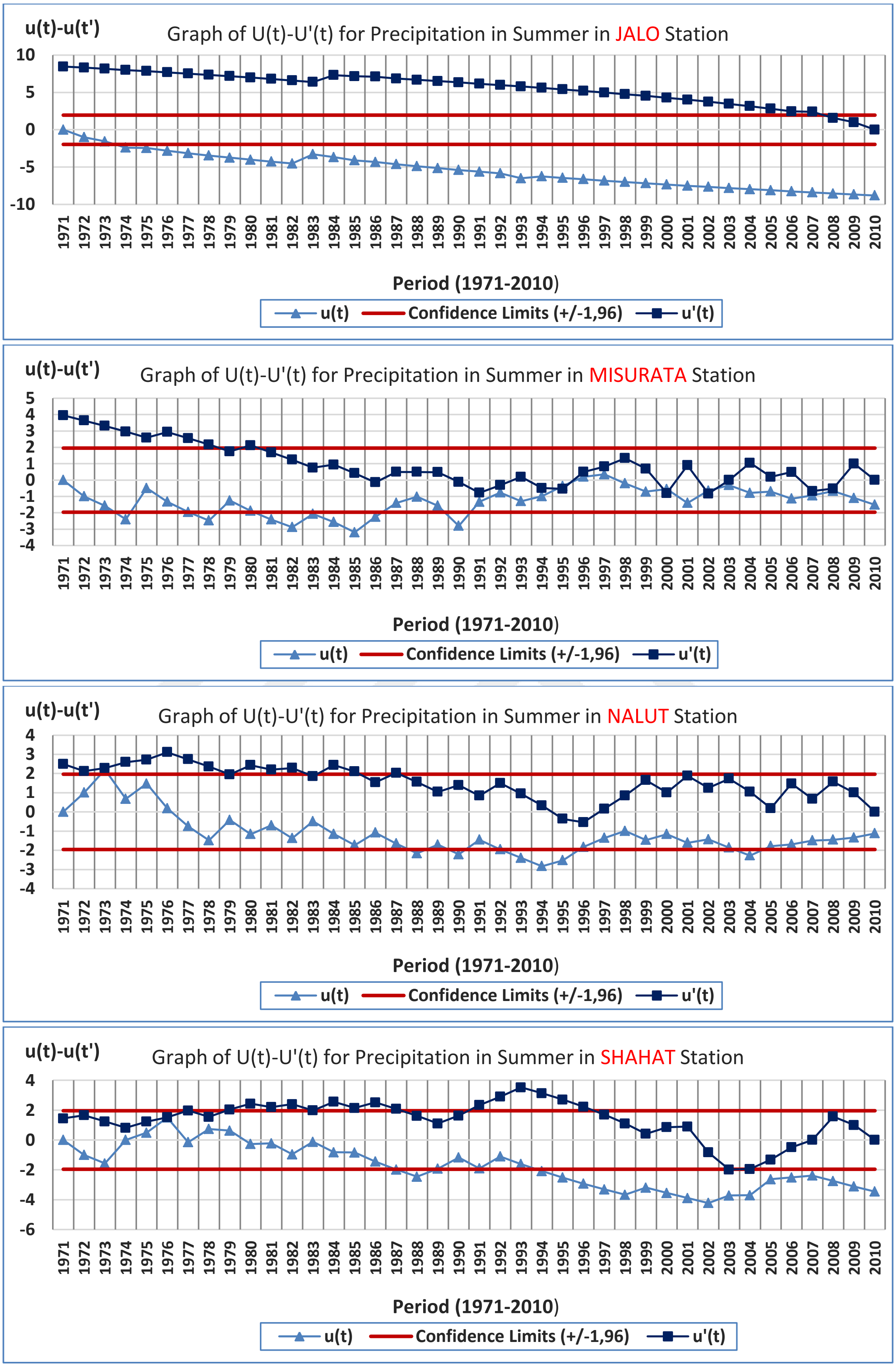


Figure 246. Graphs of M-K U(t)-U'(t) Results for Precipitation in Summer in JALO, MISURATA, NALUT and SHAHAT Stations

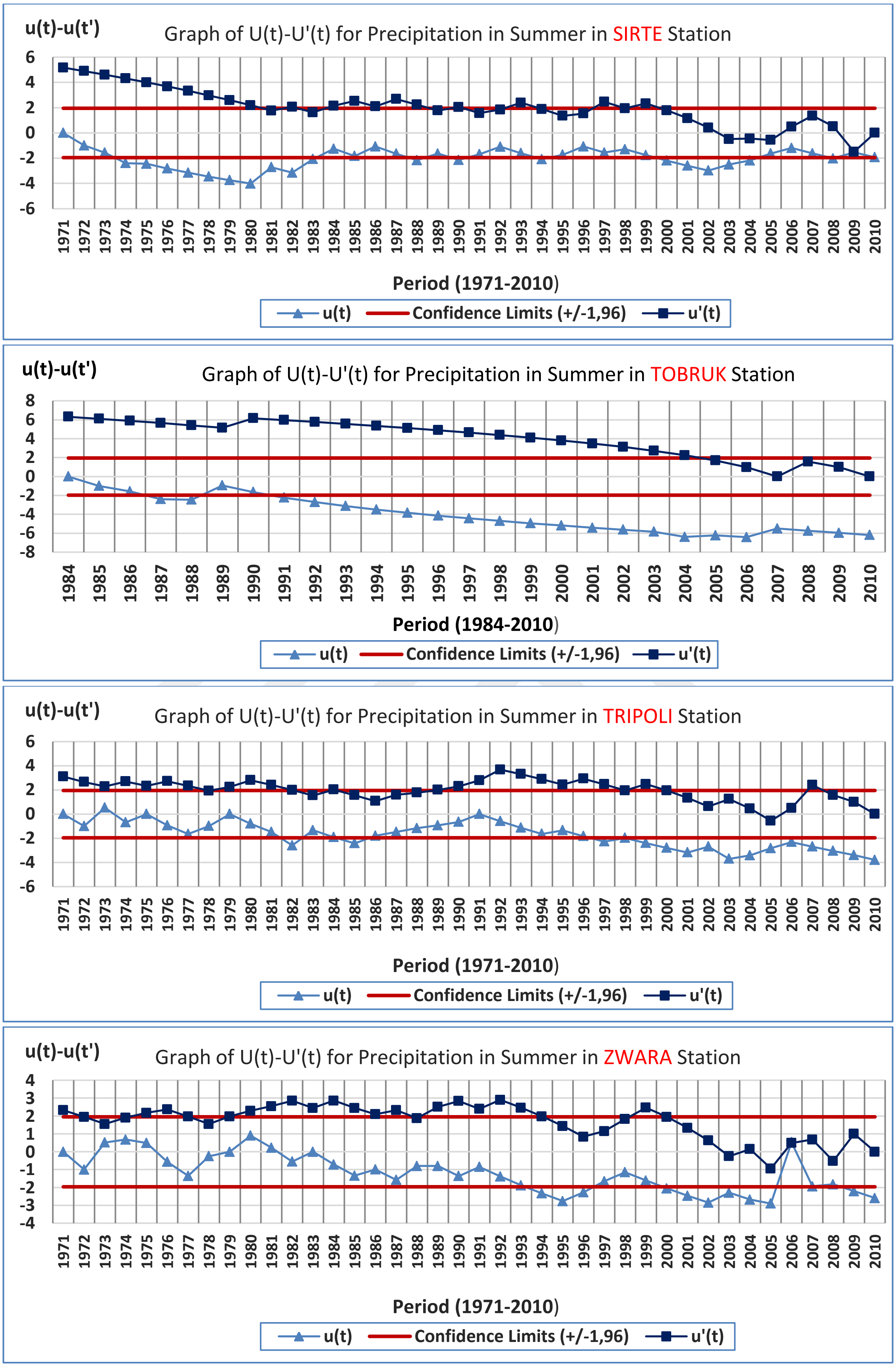


Figure 247. Graphs of M-K U(t)-U'(t) Results for Precipitation in Summer in SIRTE, TOBRUK, TRIPOLI and ZWARA Stations

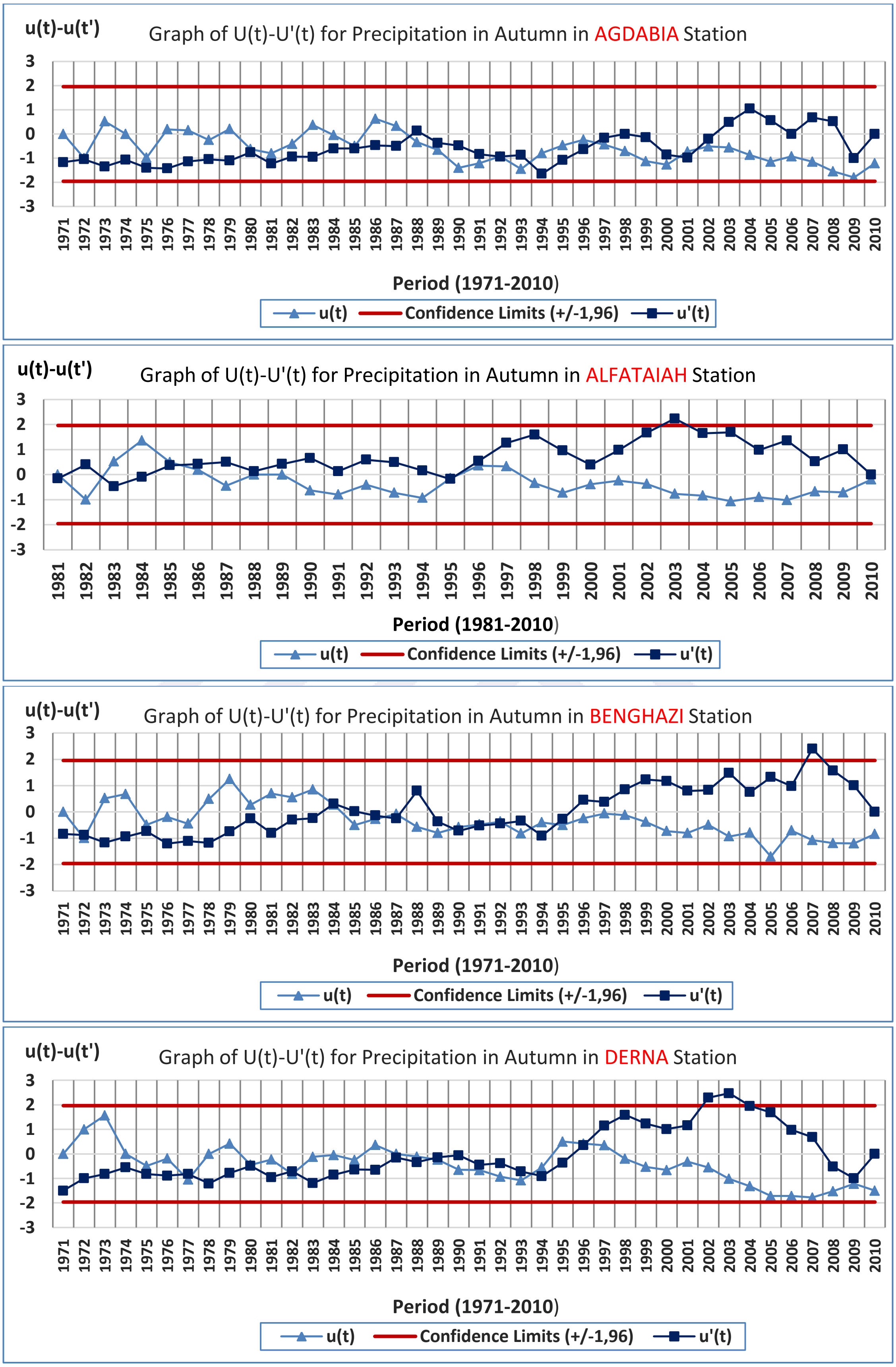


Figure 248. Graphs of M-K U(t)-U'(t) Results for Precipitation in Autumn in AGDABIA, ALFATAIAH, BENGHAZI and DERNA Stations

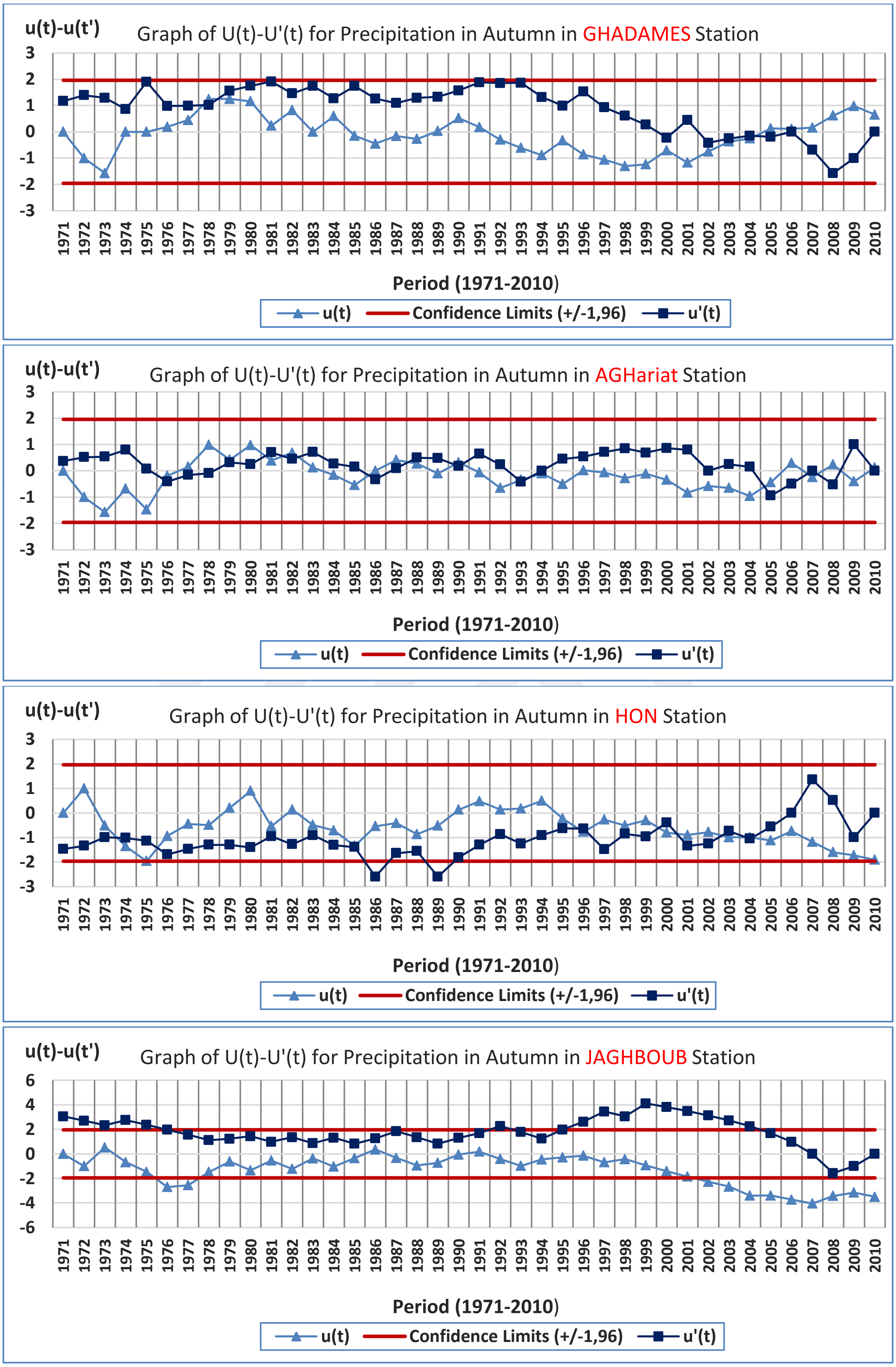


Figure 249. Graphs of M-K U(t)-U'(t) Results for Precipitation in Autumn in GHADAMES, GHARIAT, HON and JAGHBOUB Stations

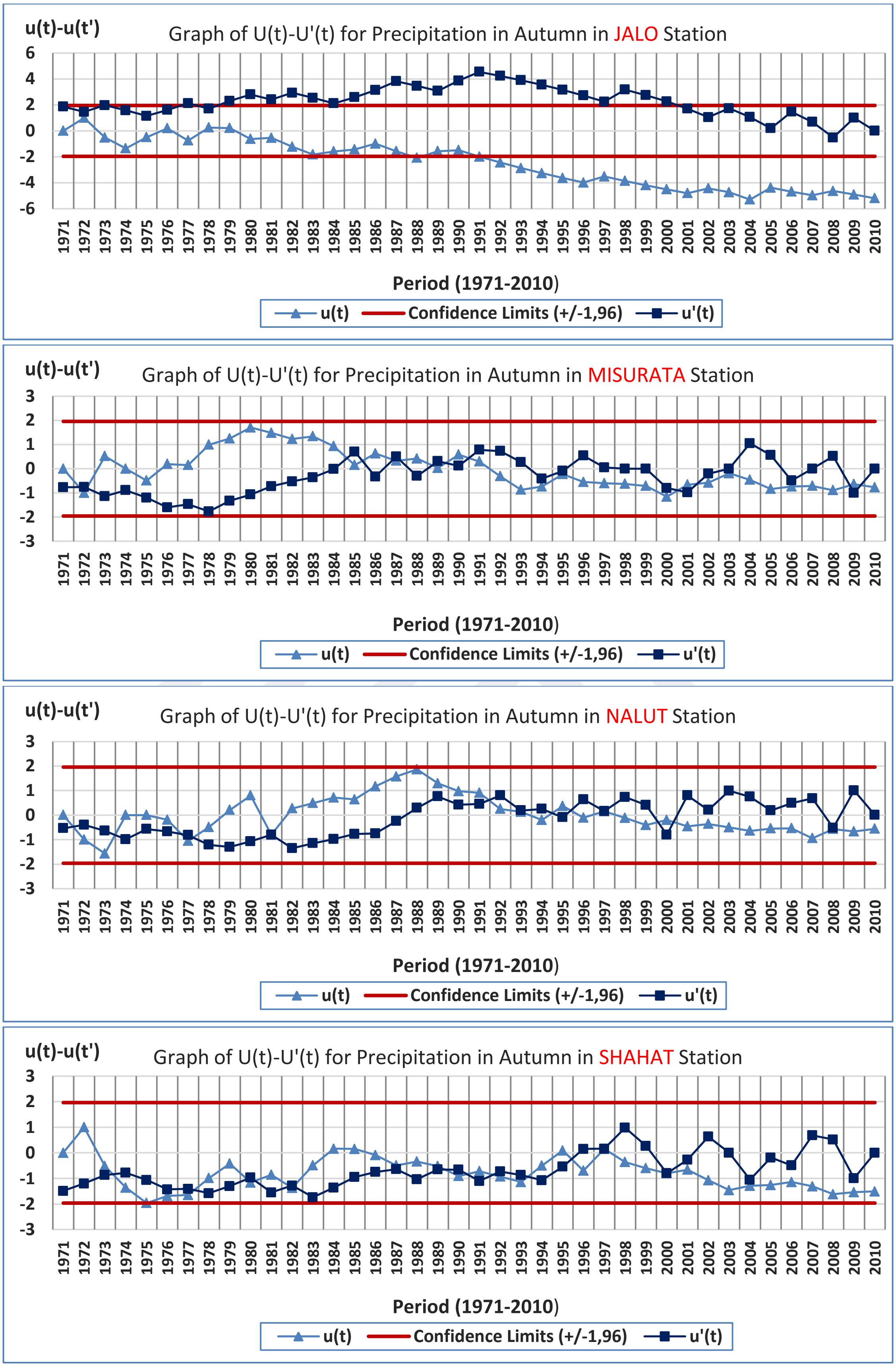
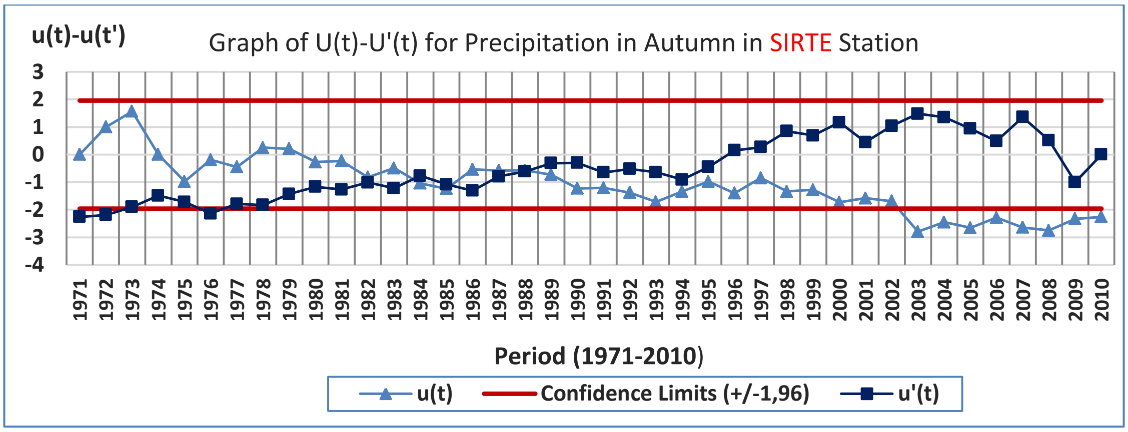
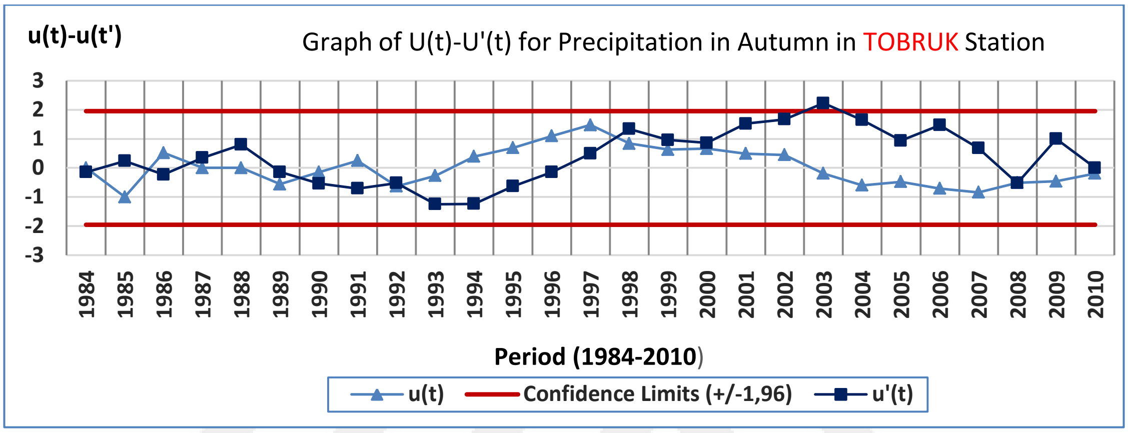
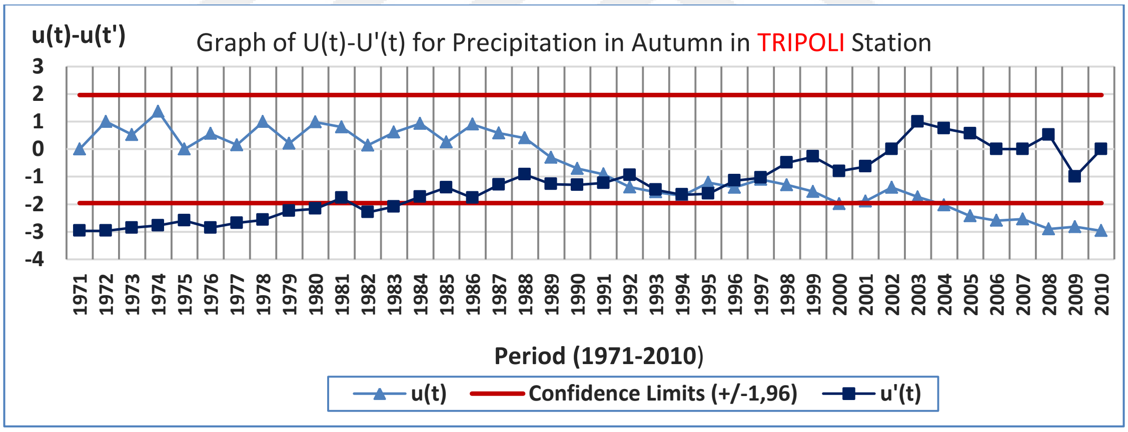


Figure 250. Graphs of M-K U(t)-U'(t) Results for Precipitation in Autumn in JALO, MISURATA, NALUT and SHAHAT Stations







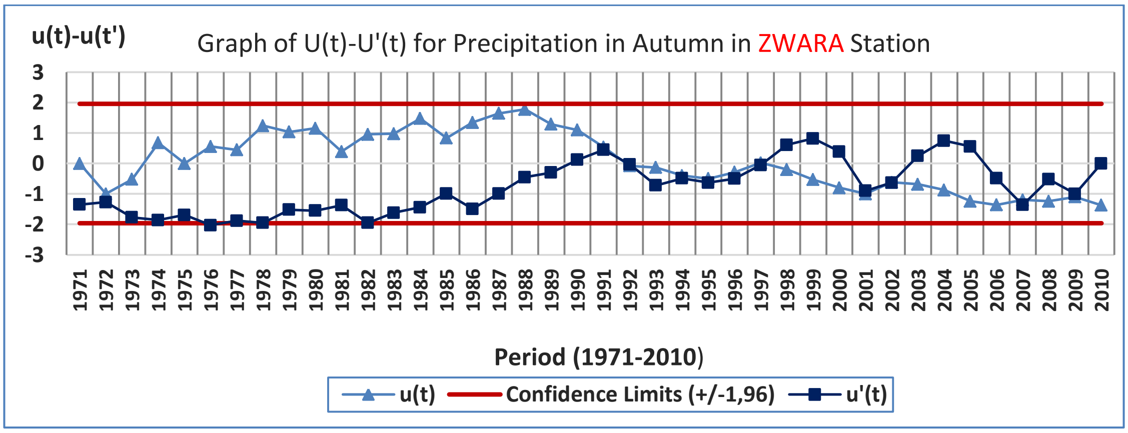


Figure 251. Graphs of M-K U(t)-U'(t) Results for Precipitation in Autumn in SIRTE, TOBRUK, TRIPOLI and ZWARA Stations

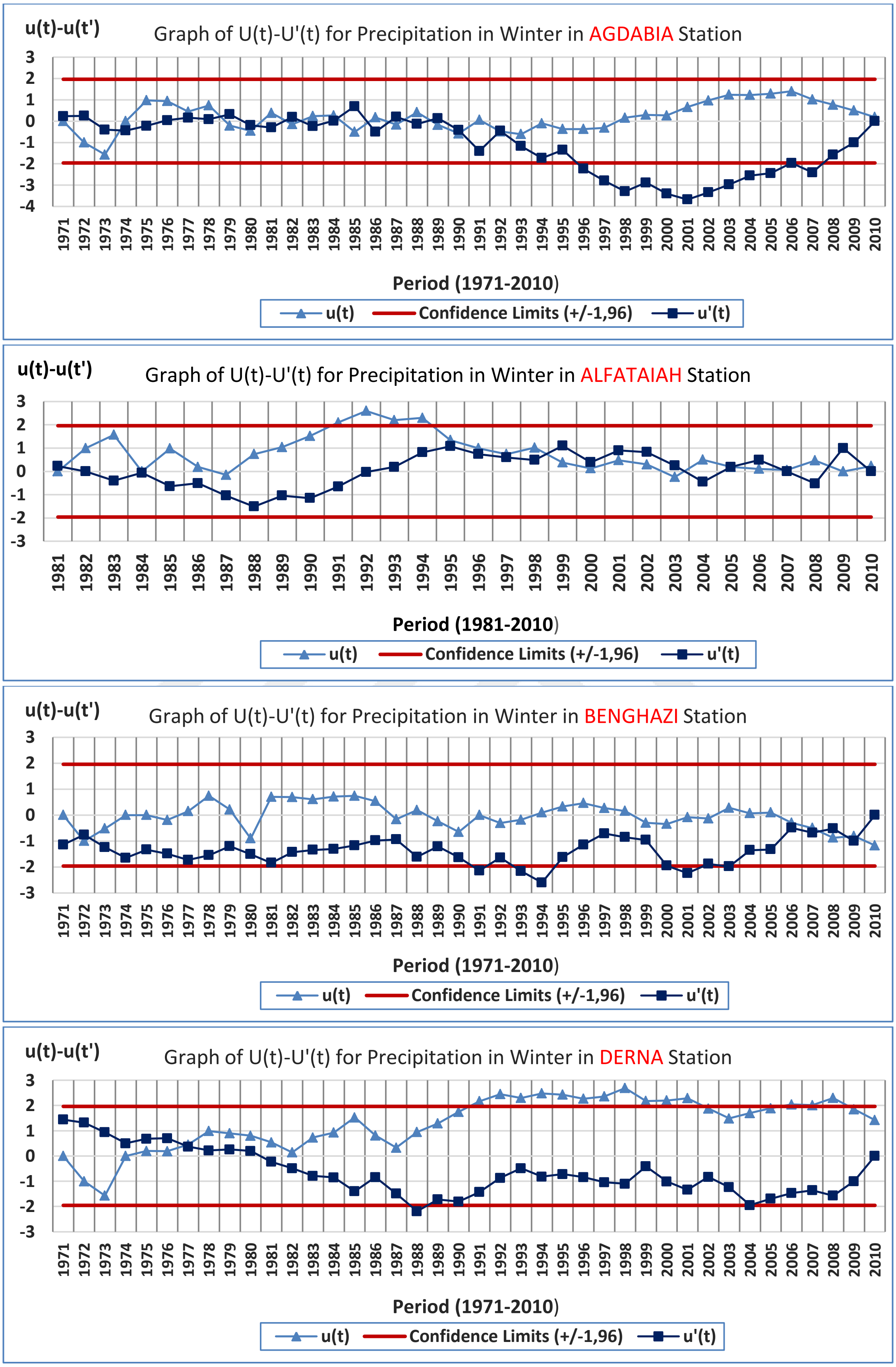


Figure 252. Graphs of M-K U(t)-U'(t) Results for Precipitation in Winter in AGDABIA, ALFATAIAH, BENGHAZI and DERNA Stations

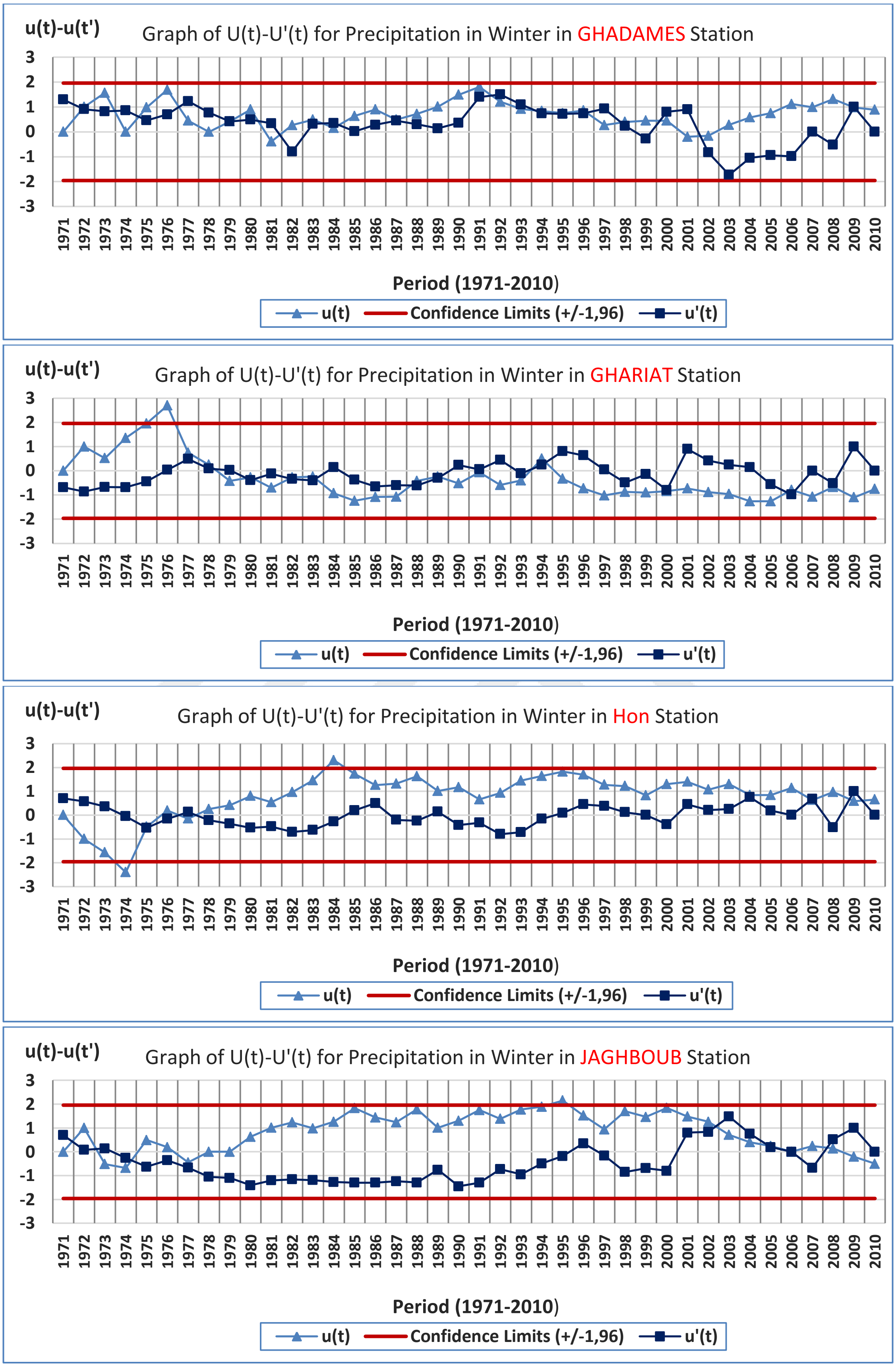


Figure 253. Graphs of M-K U(t)-U'(t) Results for Precipitation in Winter in GHADAMES, GHARIAT, HON and JAGHBOUB Stations

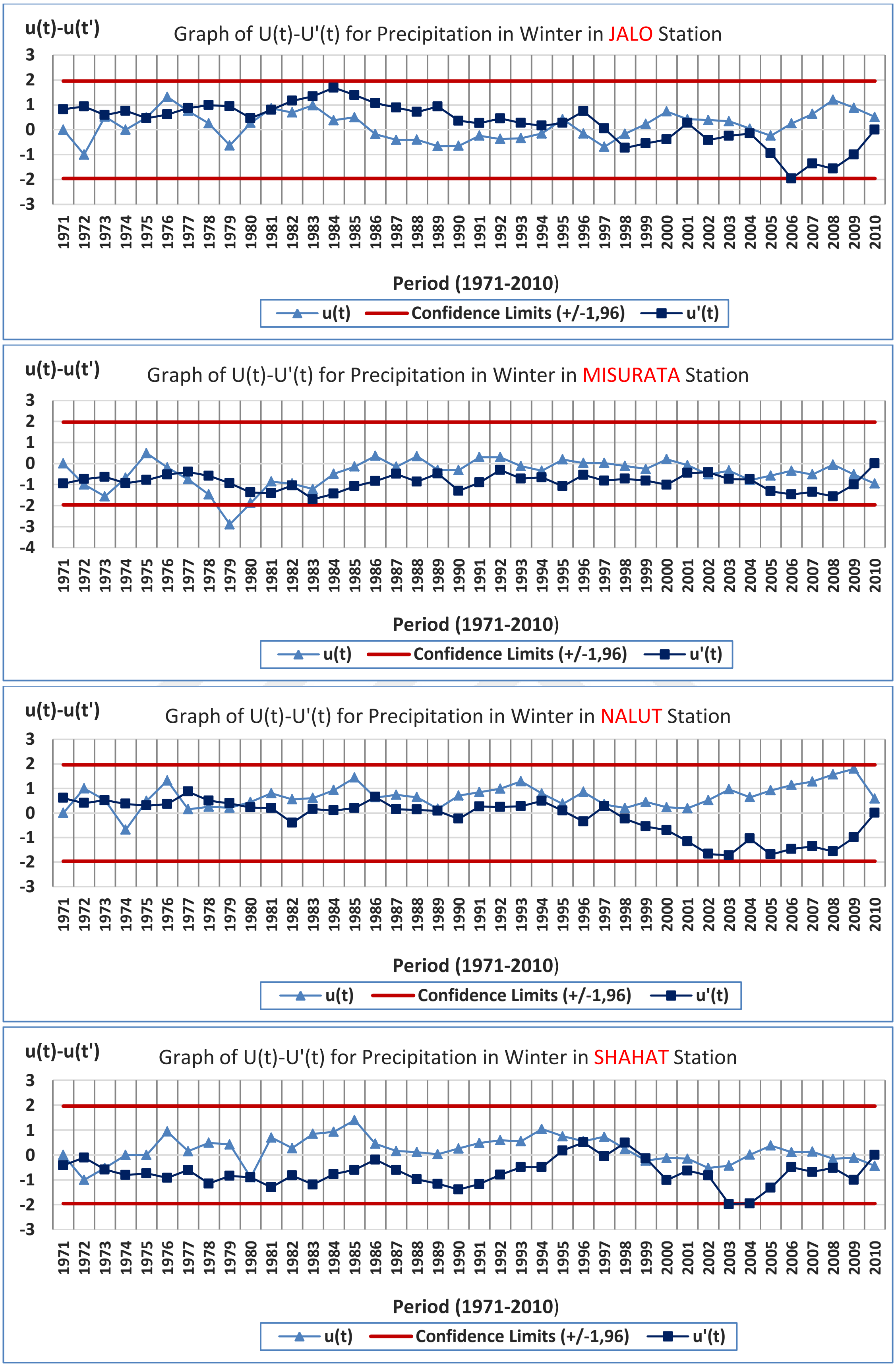


Figure 254. Graphs of M-K U(t)-U'(t) Results for Precipitation in Winter in JALO, MISURATA, NALUT and SHAHAT Stations

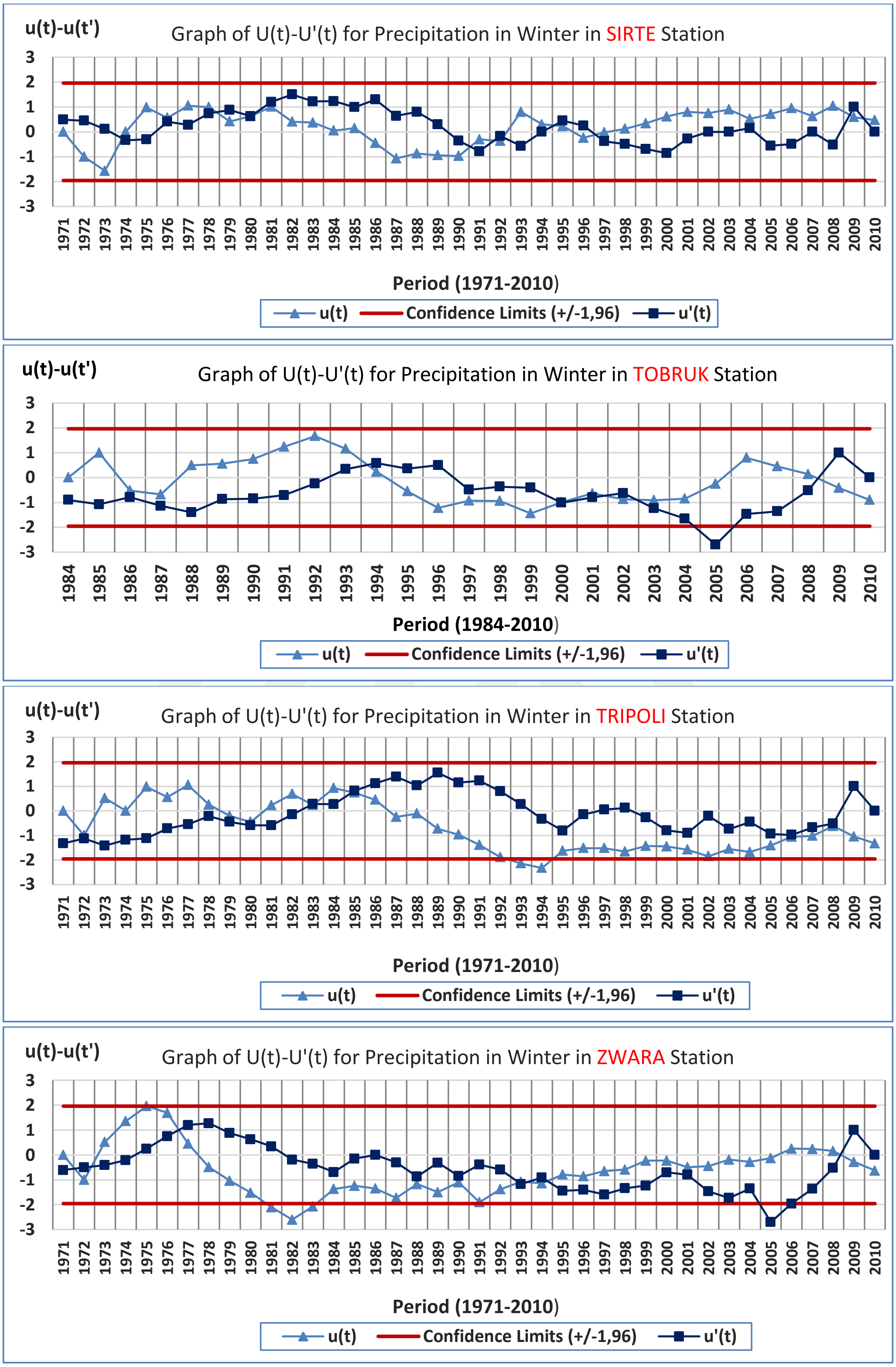


Figure 255. Graphs of M-K U(t)-U'(t) Results for Precipitation in Winter in SIRTE, TOBRUK, TRIPOLI and ZWARA Stations

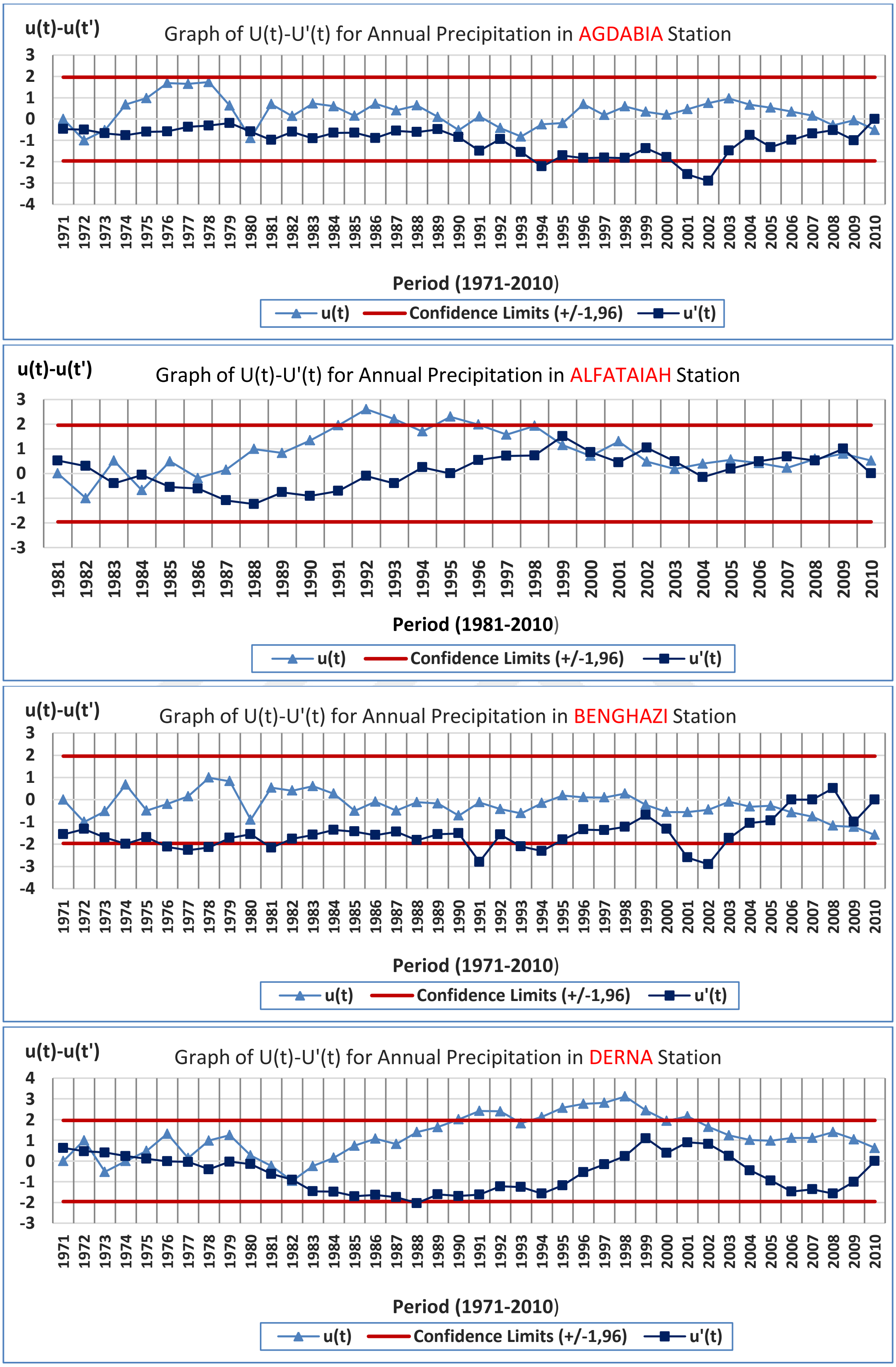
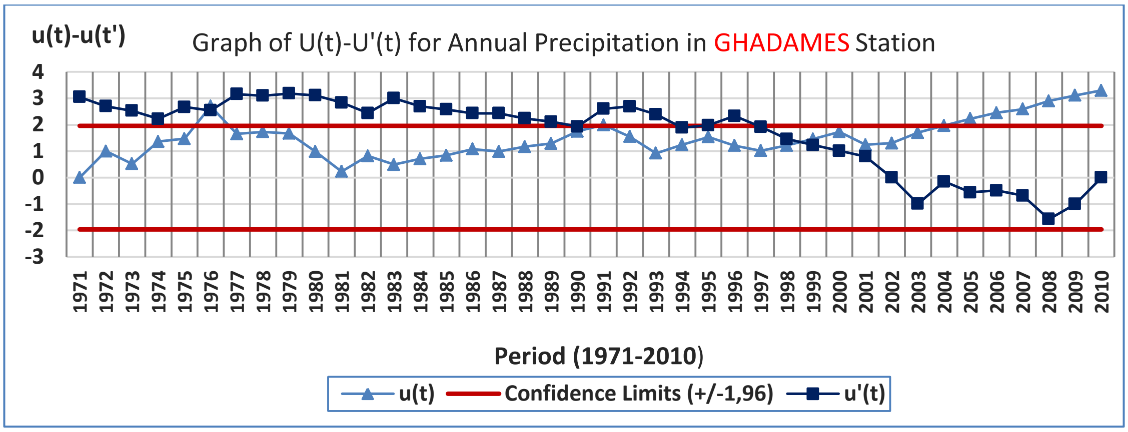
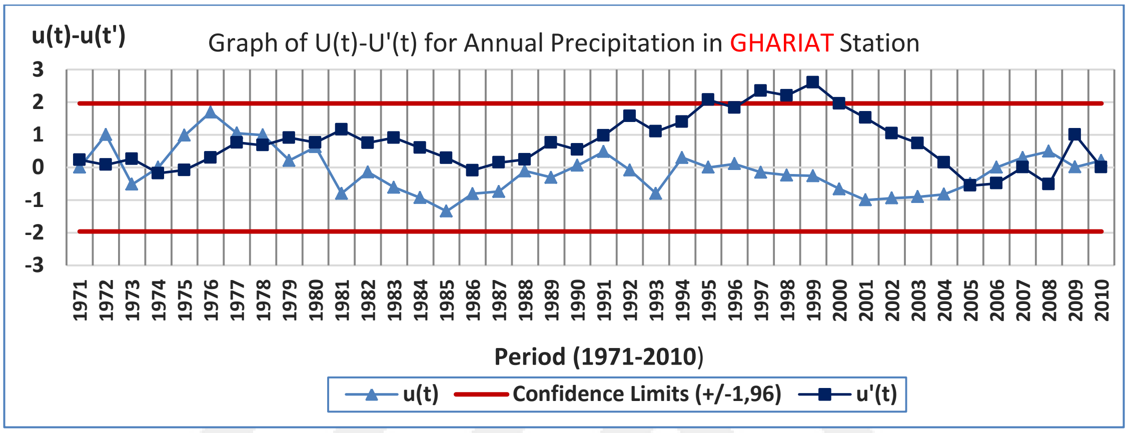
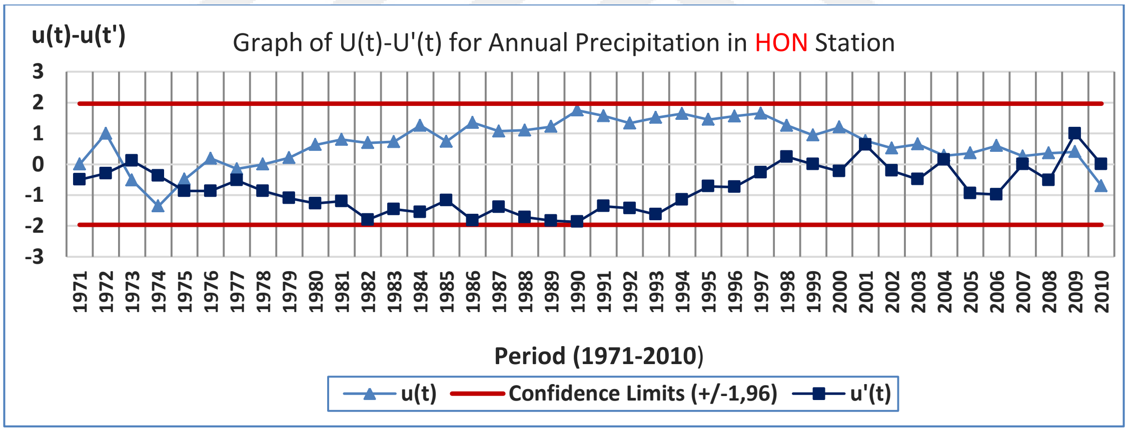


Figure 256. Graphs of M-K U(t)-U'(t) Results for Annual Precipitation in AGDABIA, ALFATAIAH, BENGHAZI and DERNA Stations







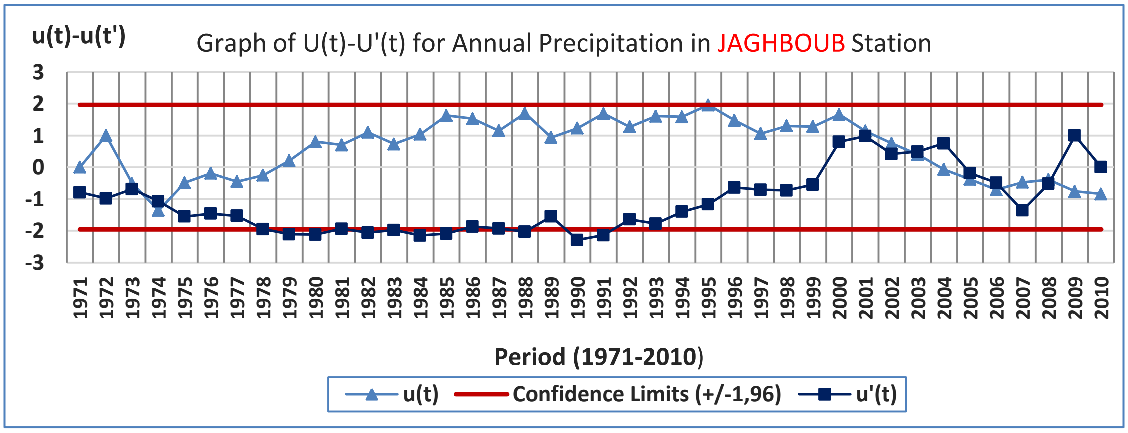


Figure 257. Graphs of M-K U(t)-U'(t) Results for Annual Precipitation in GHADAMES, GHARIAT, HON and JAGHBOUB Stations

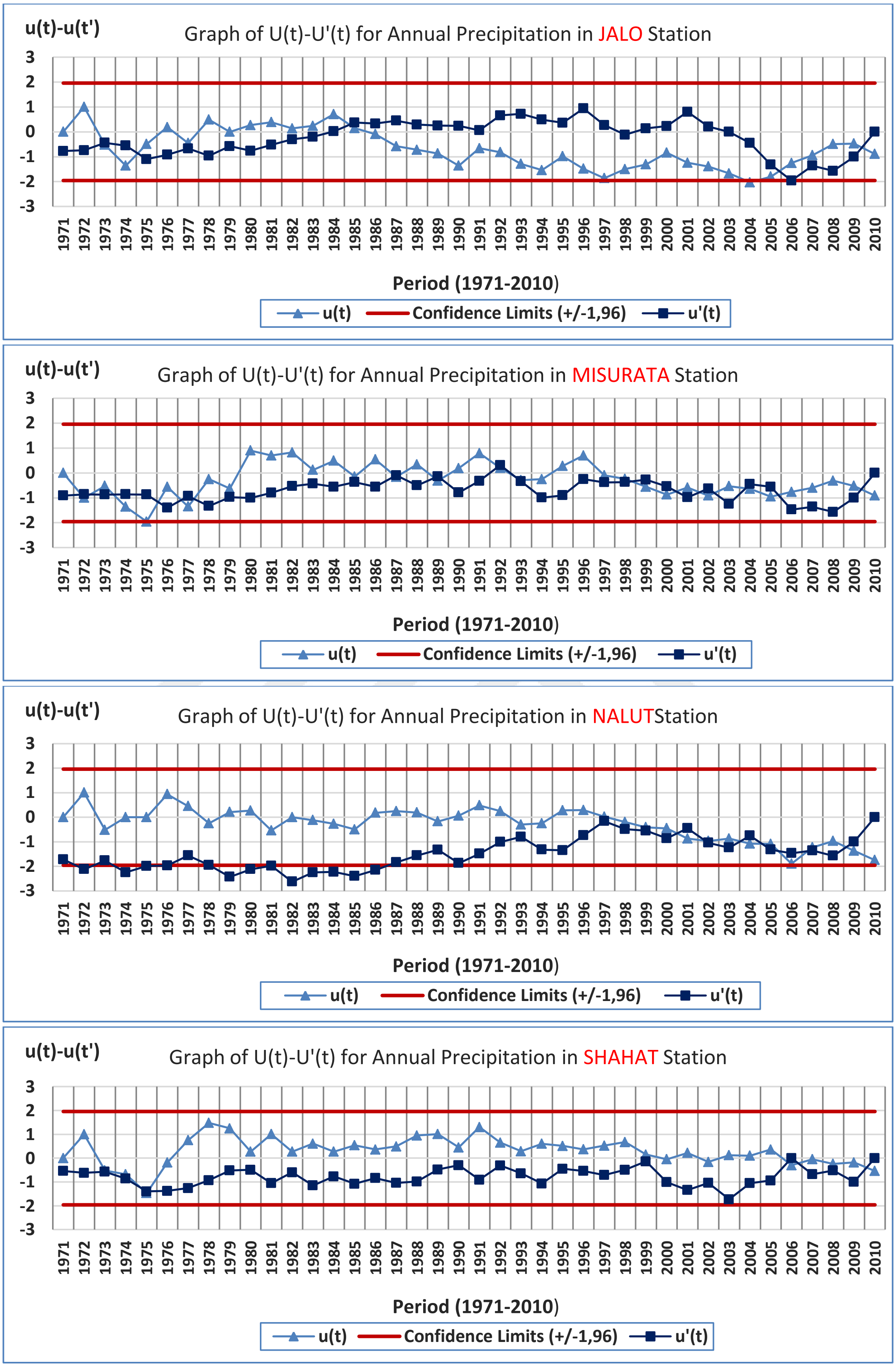


Figure 258. Graphs of M-K U(t)-U'(t) Results for Annual Precipitation in JALO, MISURATA, NALUT and SHAHAT Stations

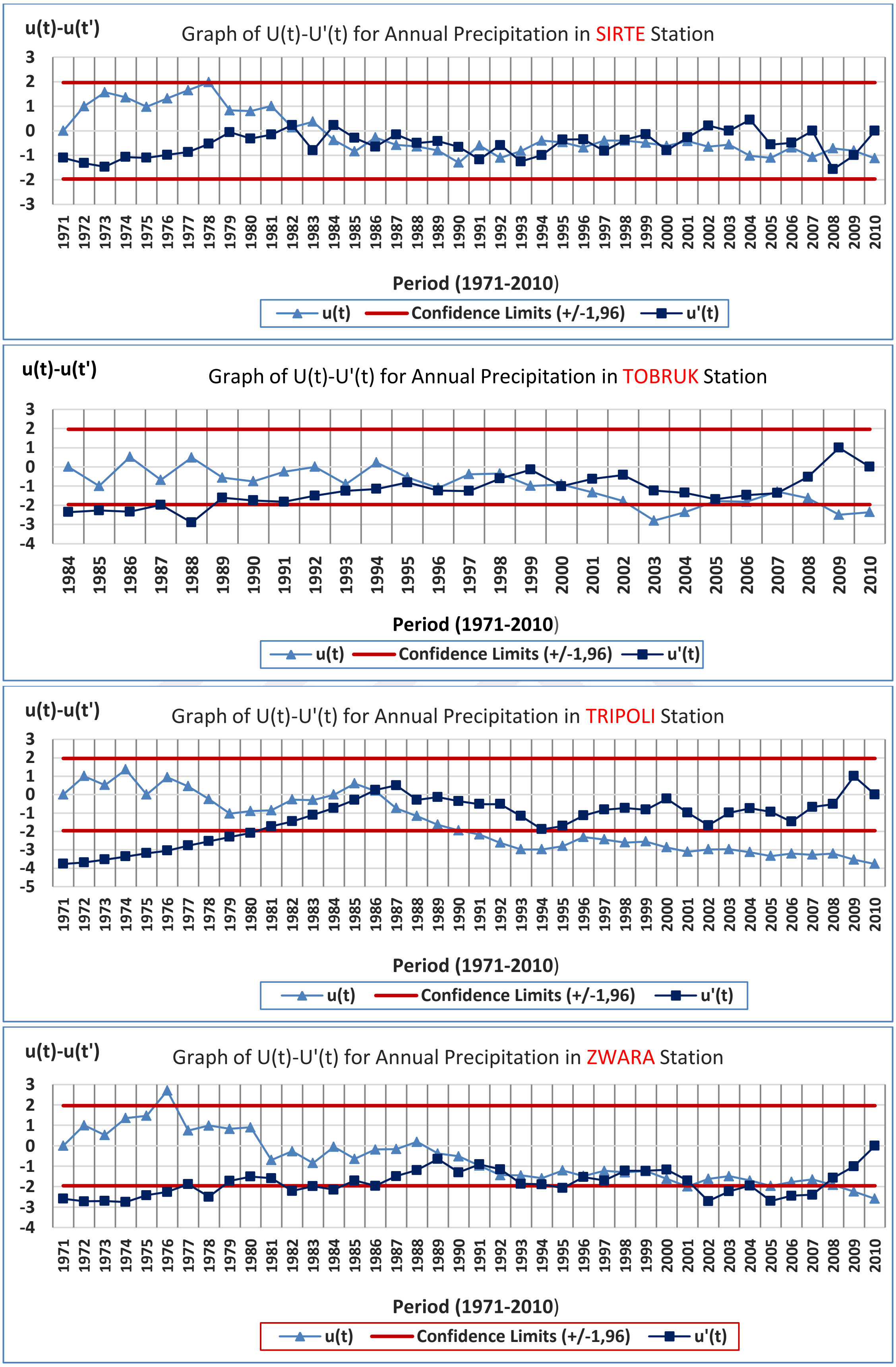


Figure 259. Graphs of M-K U(t)-U'(t) Results for Annual Precipitation in SIRTE, TOBRUK, TRIPOLI and ZWARA Stations

- **Evaluation of Results Correlation of Mann-Kendall U(t) -U'(t) Test of Seasonally and Annul Precipitation Data**

The general trends of precipitation were very few, and the percentage of trends were not reach 9% from all graphs of seasonal and annual, the reason maybe is not irregularity in amounts of rainfall.

Table 104. Evaluation of Results of U(t), U(t') for Seasonally and Annul Precipitation Data (1971-2010)

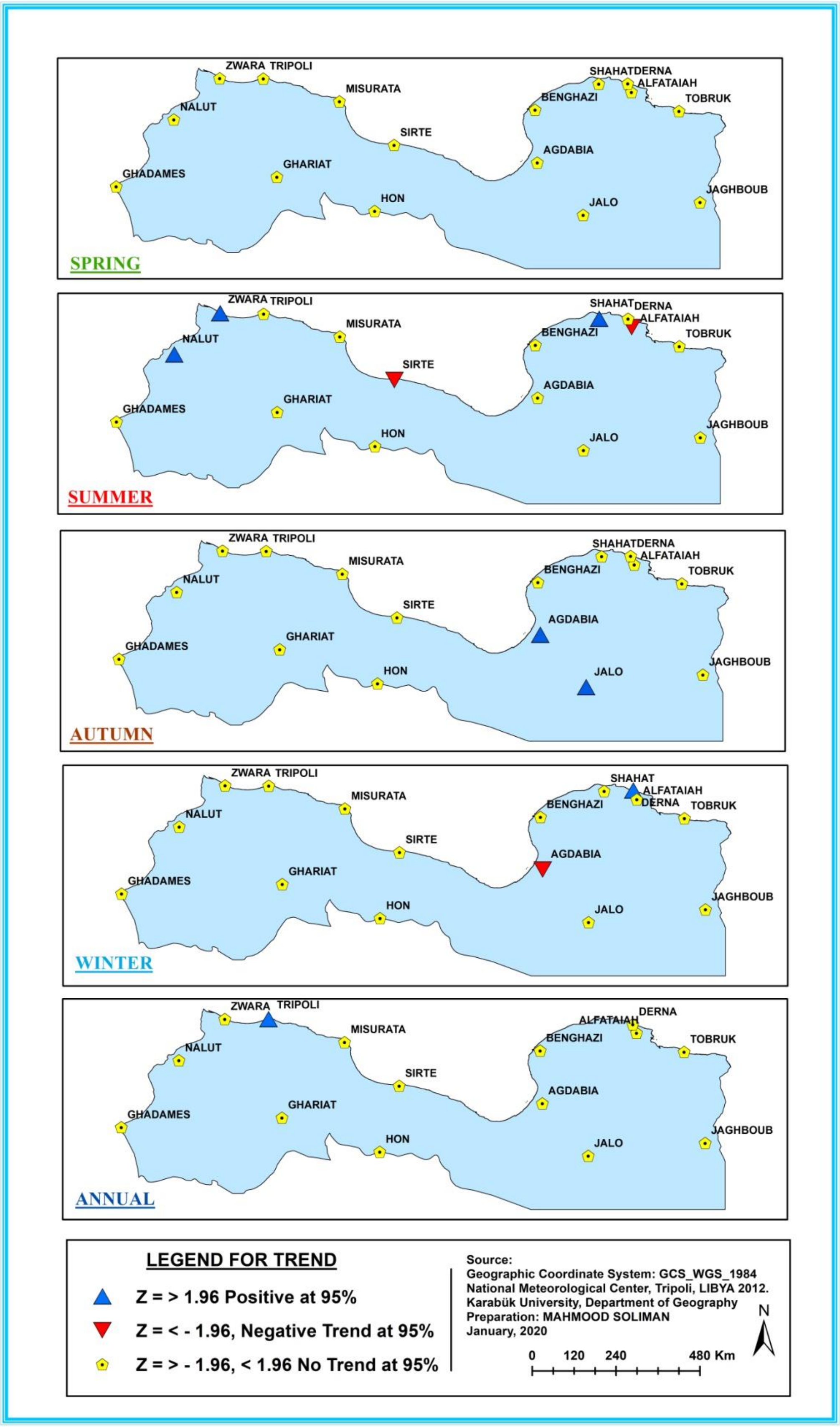
Stations	Spring	Summer	Autumn	Winter	Annual
AGDABIA	×	×	↑ (1989)	↓ (1991)	×
ALFATAIAH	×	↓ (2005)	×	×	×
BENGHAZI	×	×	×	×	×
DERNA	×	×	×	↑ (1977)	×
GHADAMES	×	×	×	×	×
GHARIAT	×	×	×	×	×
HON	×	×	×	×	×
JAGHBOUB	×	×	×	×	×
JALO	×	×	↑ (1972)	×	×
MISURATA	×	×	×	×	×
NALUT	×	↑ (1973)	×	×	×
SHAHAT	×	↑ (1976)	×	×	×
SIRTE	×	↓ (2009)	×	×	×
TOBRUK	×	×	×	×	×
TRIPOLI	×	×	×	×	↑ (1986)
ZWARA	×	↑ (2006)	×	×	×

Table data based on the graphs of U(t), U(t').

↑= There is Positive Trend, ↓= There is Negative Trend, and ×= There isn't Trend.

Table 104. and Map 32 show the following facts:

- **Precipitation in spring,**all stations do not show any trend in the monitoring period.
- **Precipitation in Summer,**some stations show different trends,at the ALFATAIH station the trend is decreasing started from (2005), at NALUT station the trend is increasing to increase started in (1973), at SHAHAT station the trend of precipitation began to increase from (1976), at SIRTE station trend started to decrease in (2009) and at ZWARA station the trend began to increase during (2006).
- **Precipitation in Autumn,**there are only two stations showing an upward trend, AGDABIA station in (1989) and JALO station in (1972).
- **Precipitation in Winter,**AGDABIA station shows a decrease in trend in (1991), and DRENA station shows a trend towards increase in (1977).
- **Precipitation in Annual,** there is only one station is TRIPOLI which shows a trend towards increase in (1986) (Table 104 depending on the figures 241- 260).



Map 31. Distribution of Results of U(t), U(t') for Seasonally and Annul of Precipitation (1971-2010)

4.2.3. Simple Linear Regression of PrecipitationData (1971-2010)

4.2.3.1. Simple Linear Regression for Seasonally Precipitation

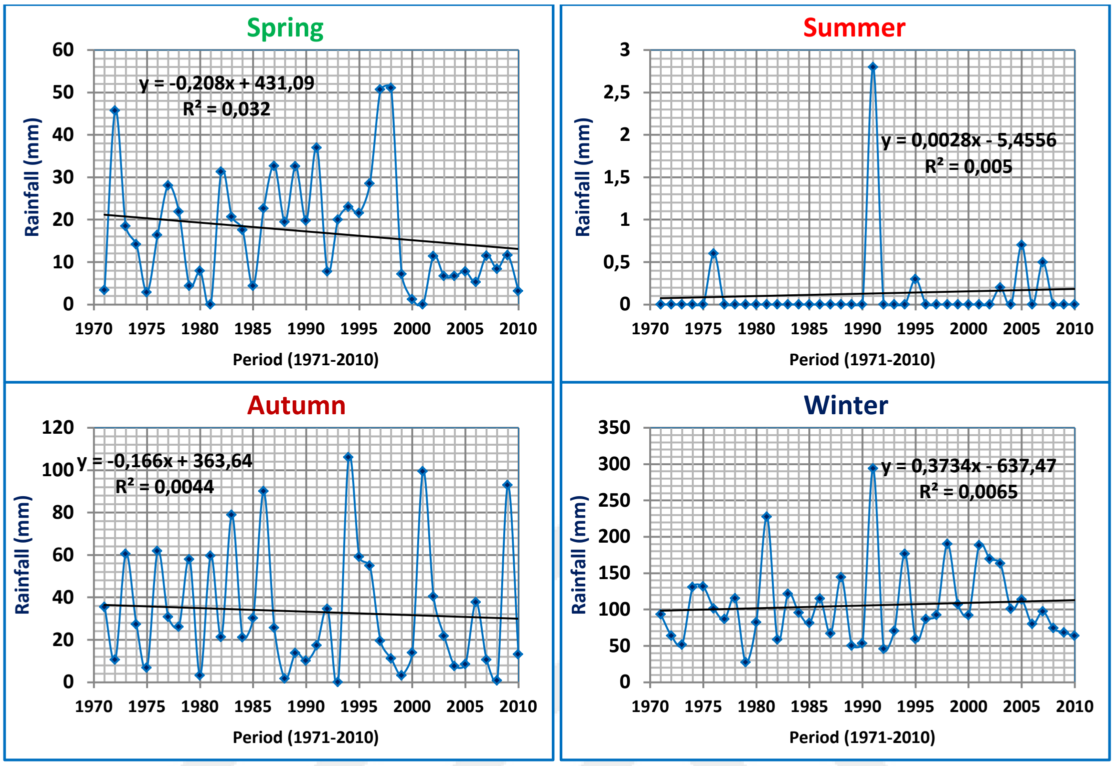


Figure 260. Simple Linear Trend Graphs of Seasonally Precipitation in AGDABIA Station (1971-2010)

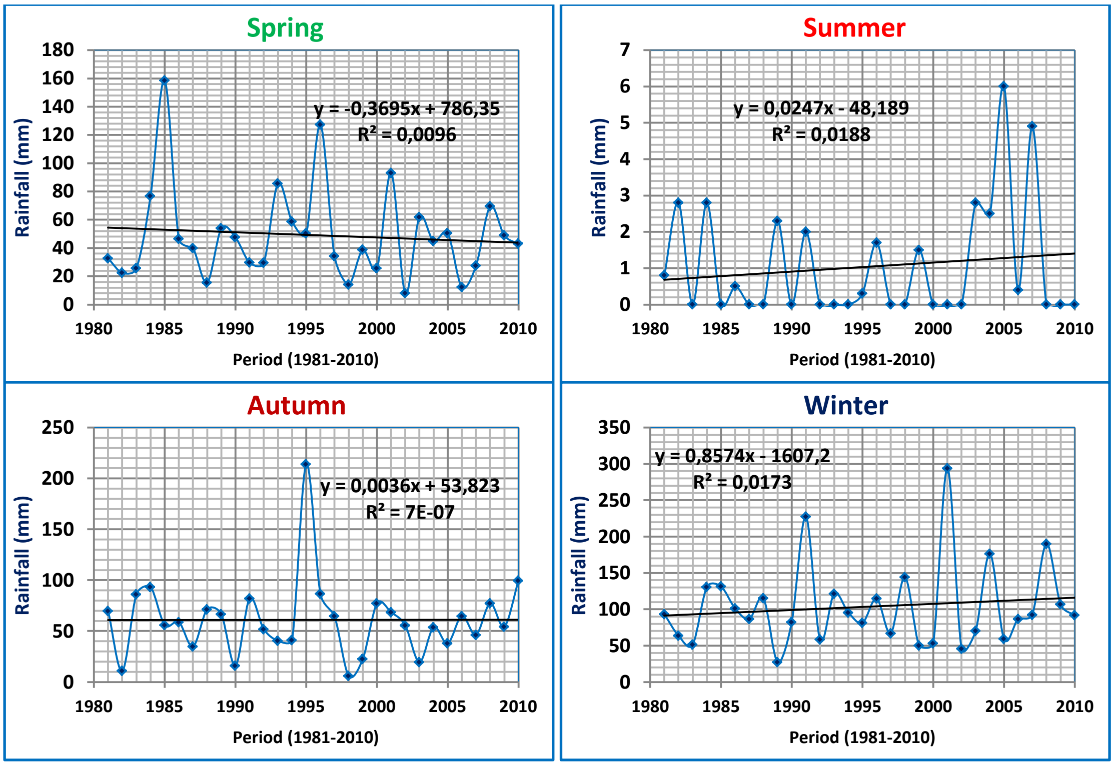


Figure 261. Simple Linear Trend Graphs of Seasonally Precipitation in ALFATAIAH Station (1981-2010)

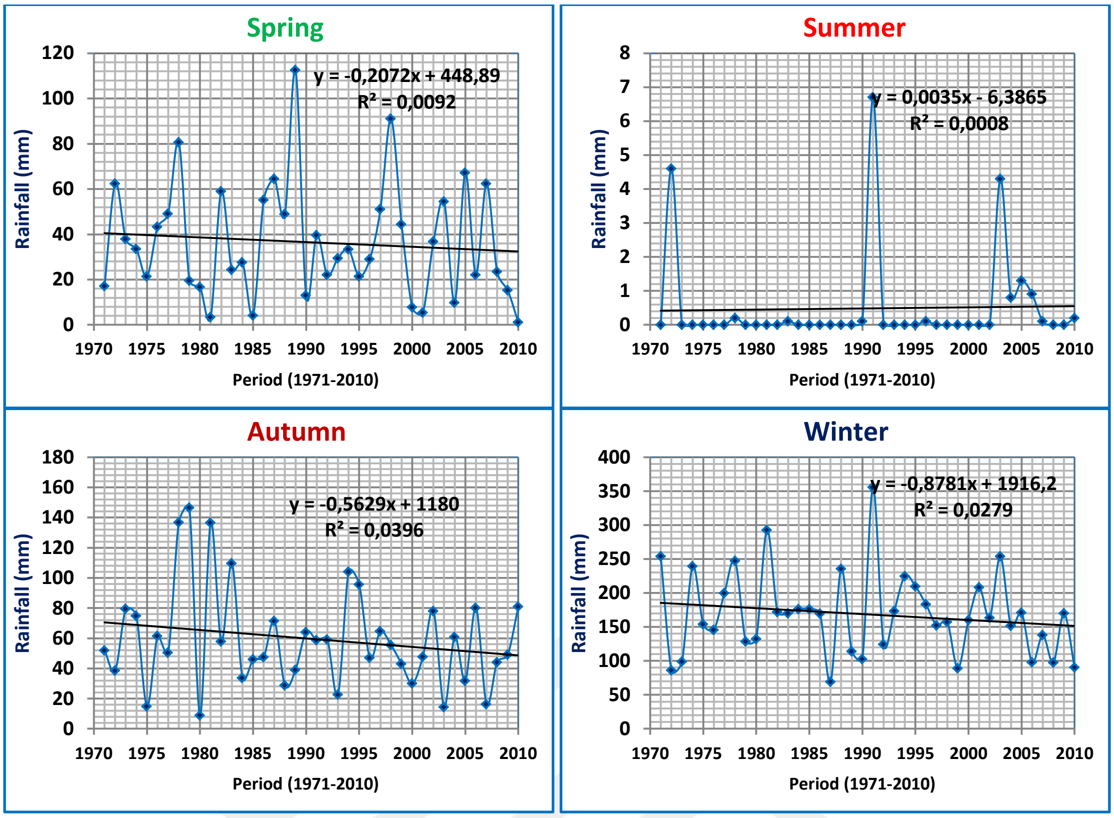


Figure 262. Simple Linear Trend Graphs of Seasonally Precipitation in BENGHAZI Station (1971-2010)

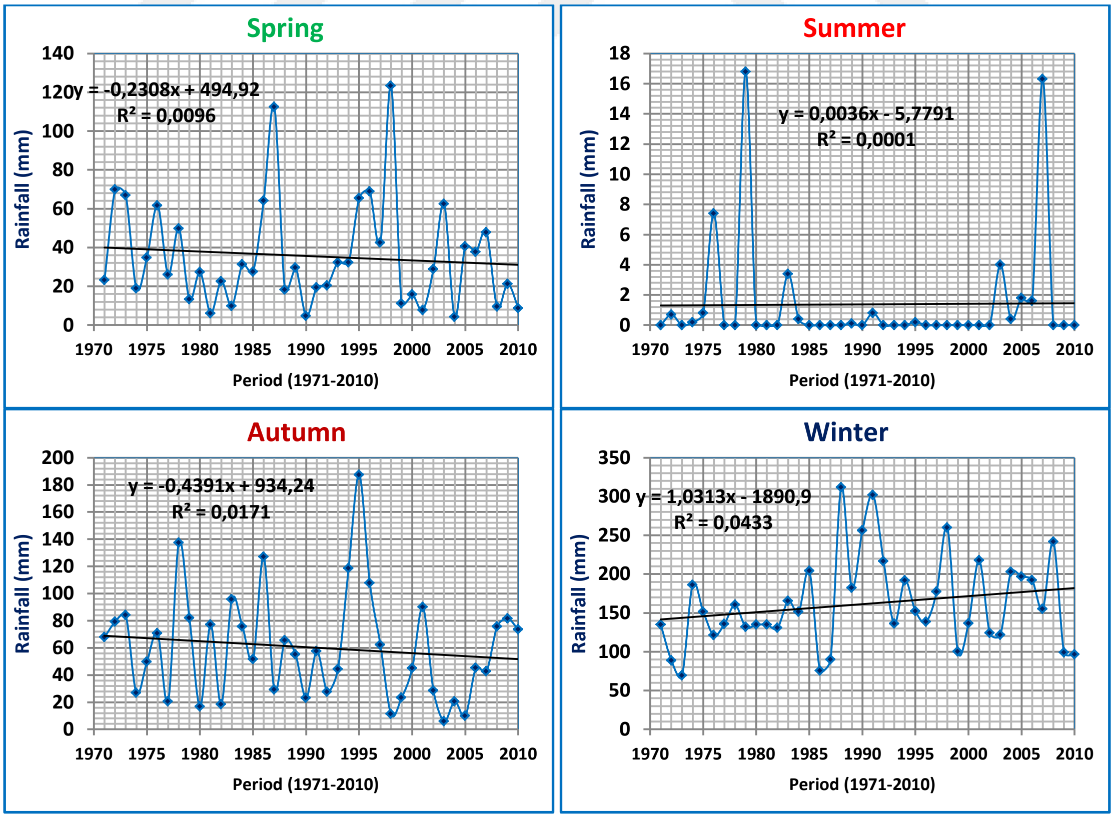


Figure 263. Simple Linear Trend Graphs of Seasonally Precipitation in DERNA Station (1971-2010)

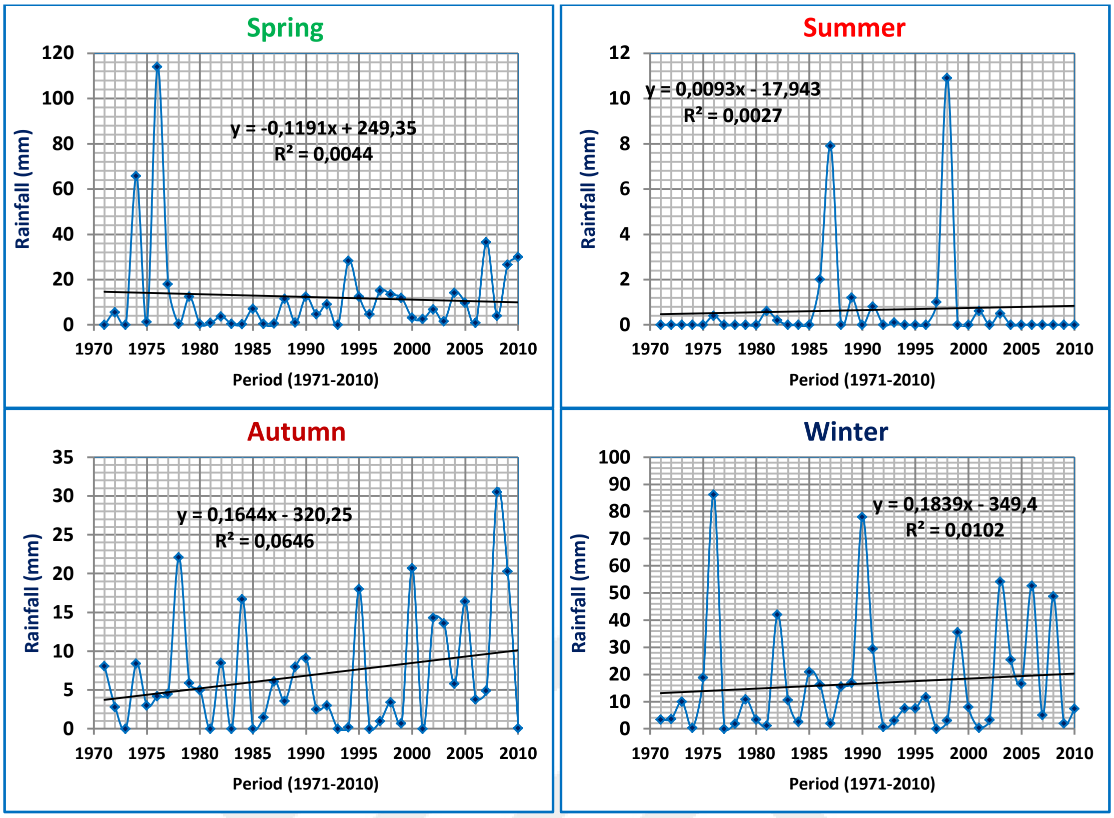


Figure 264. Simple Linear Trend Graphs of Seasonally Precipitation in GHADAMES Station (1971-2010)

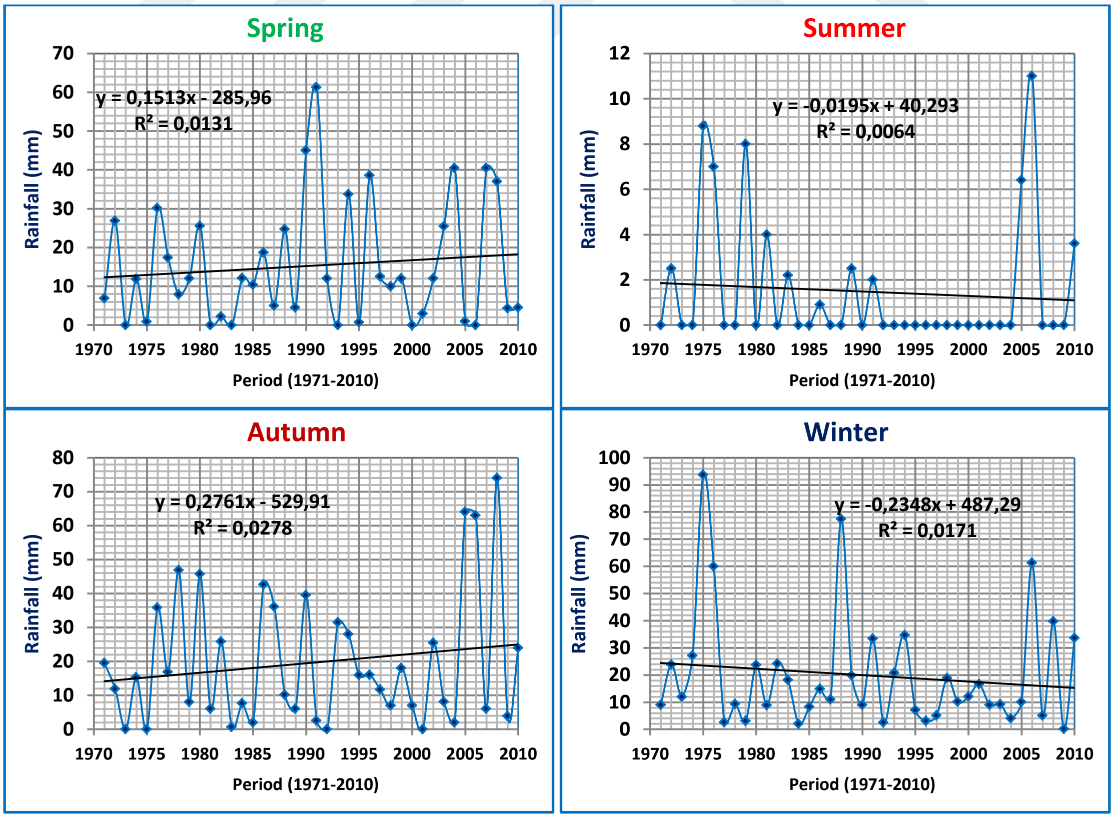


Figure 265. Simple Linear Trend Graphs of Seasonally Precipitation in GHARIAT Station (1971-2010)

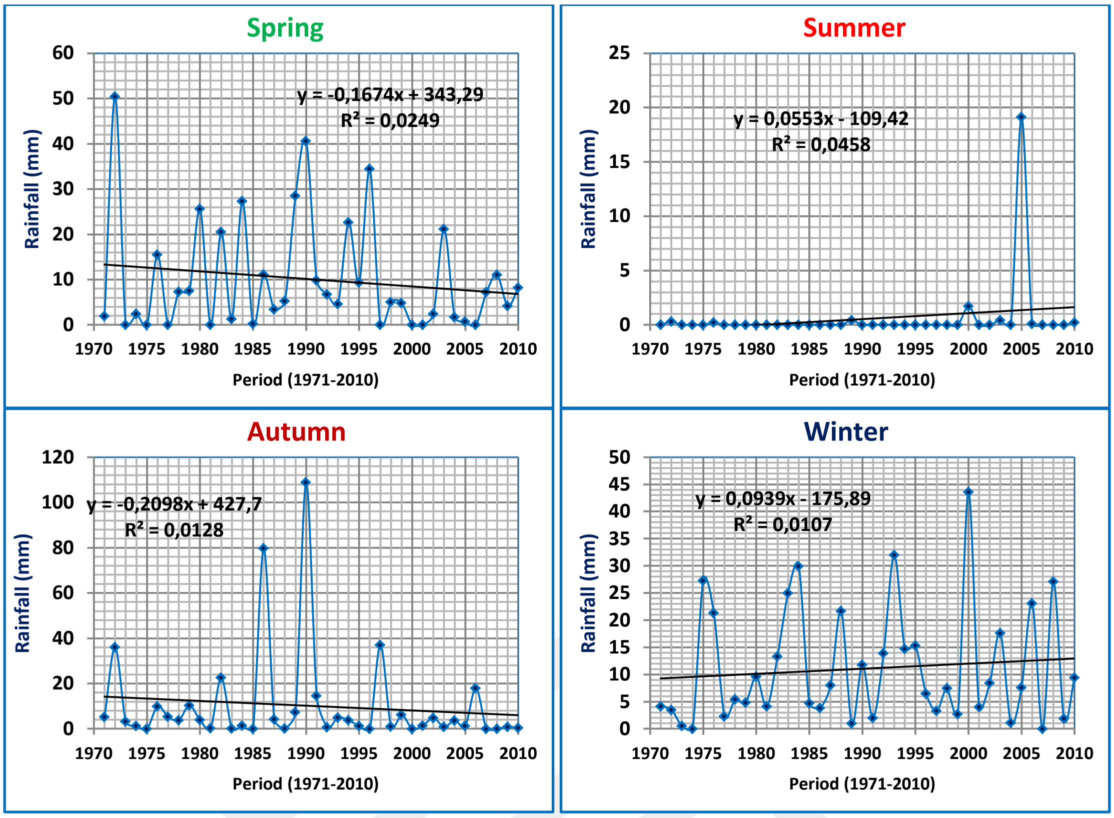


Figure 266. Simple Linear Trend Graphs of Seasonally Precipitation in HON Station (1971-2010)

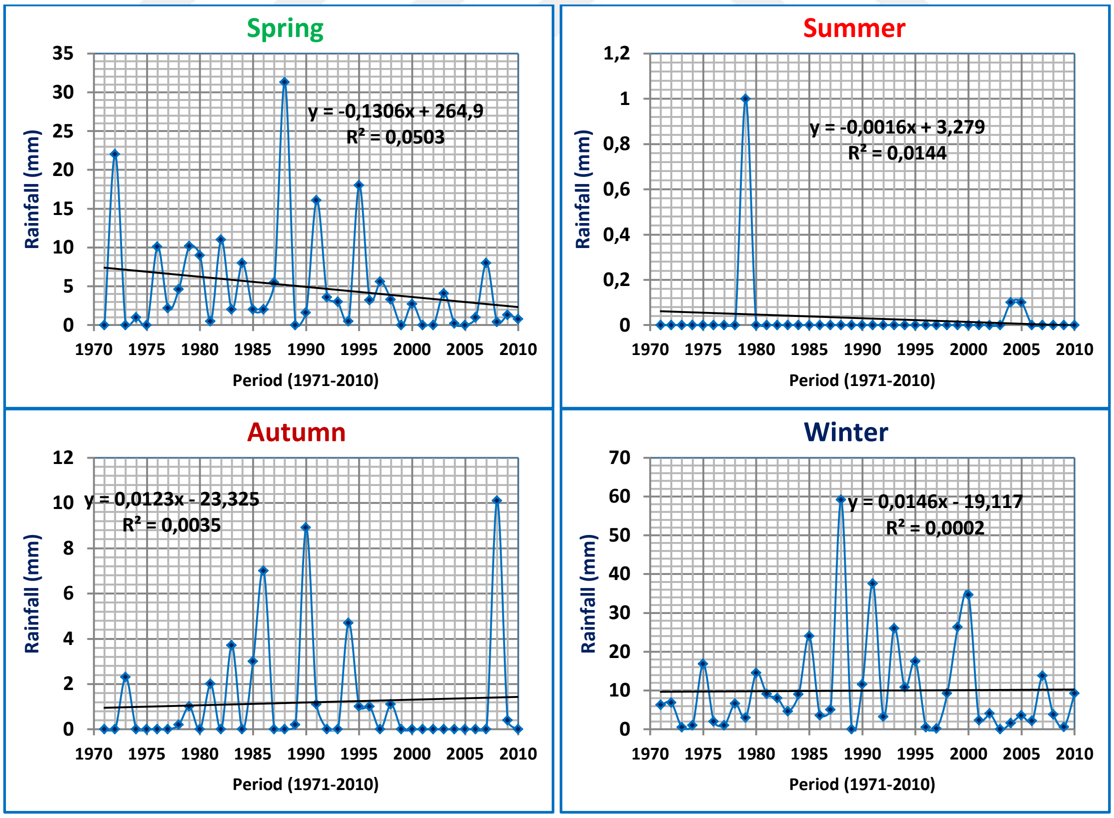


Figure 267. Simple Linear Trend Graphs of Seasonally Precipitation in JAGHBOUB Station (1971-2010)

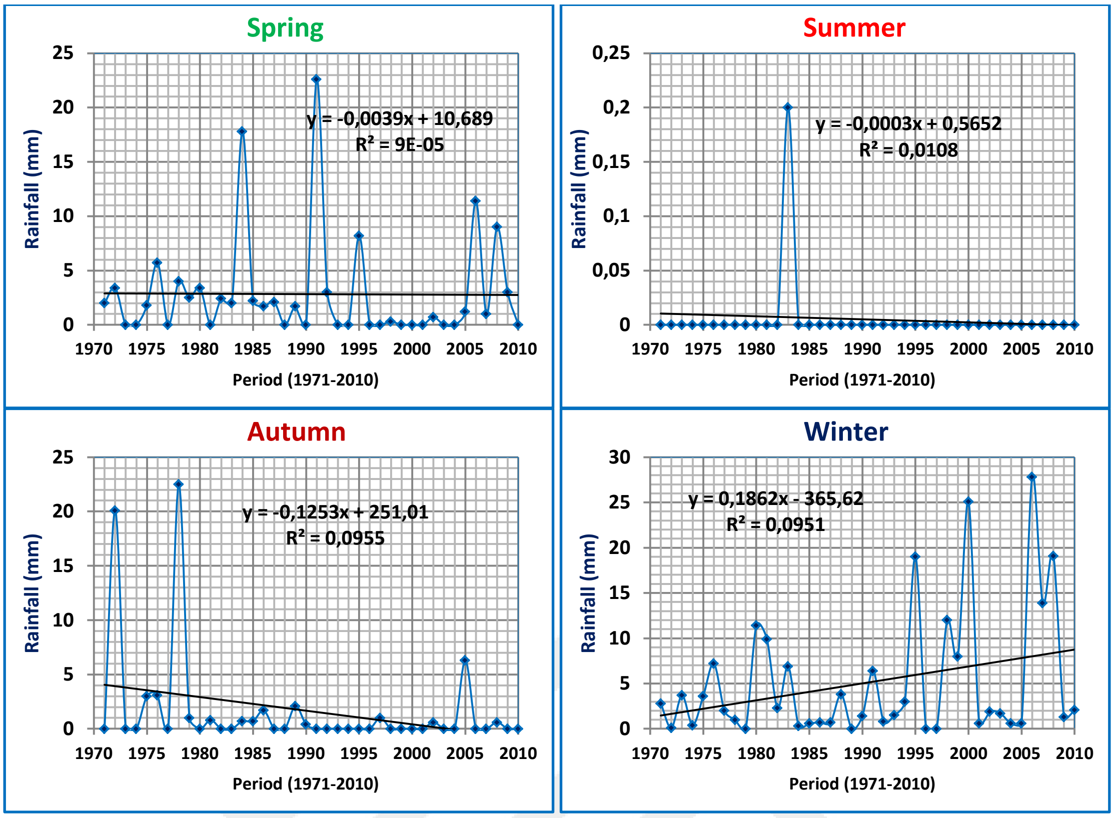


Figure 268. Simple Linear Trend Graphs of Seasonally Precipitationin JALO Station (1971-2010)

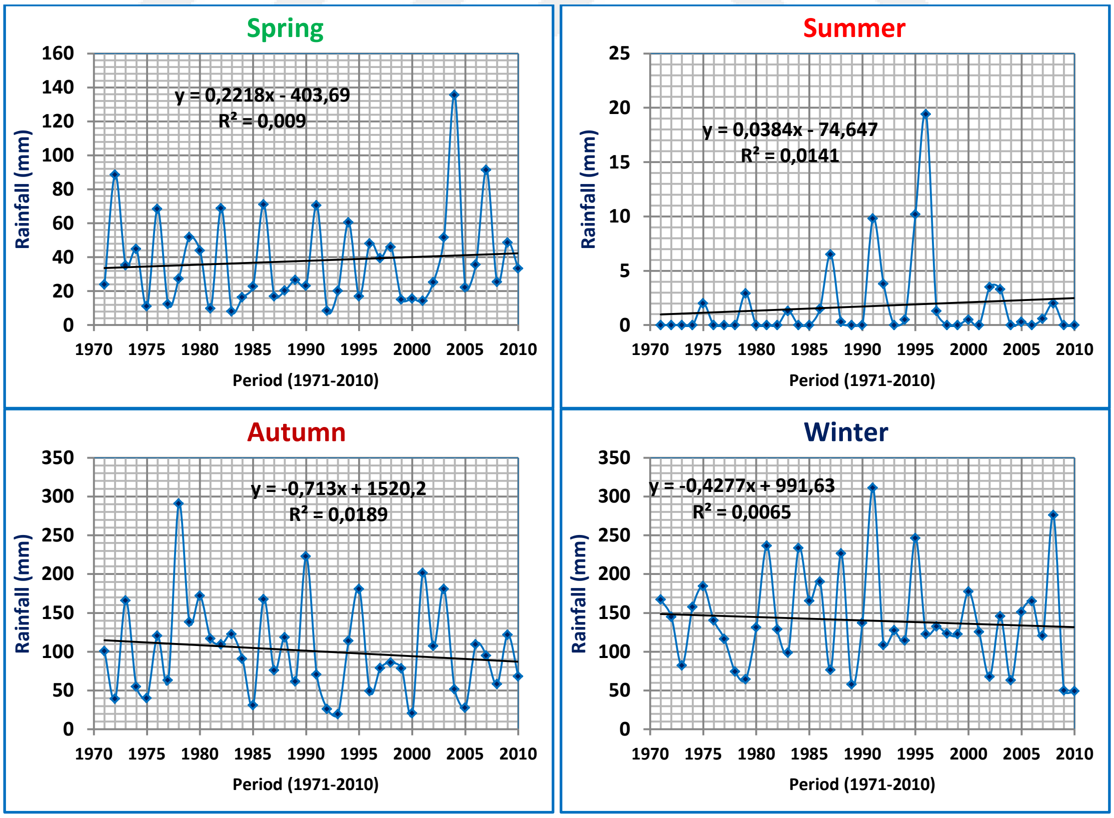


Figure 269. Simple Linear Trend Graphs of Seasonally Precipitationin MISURATA Station (1971-2010)

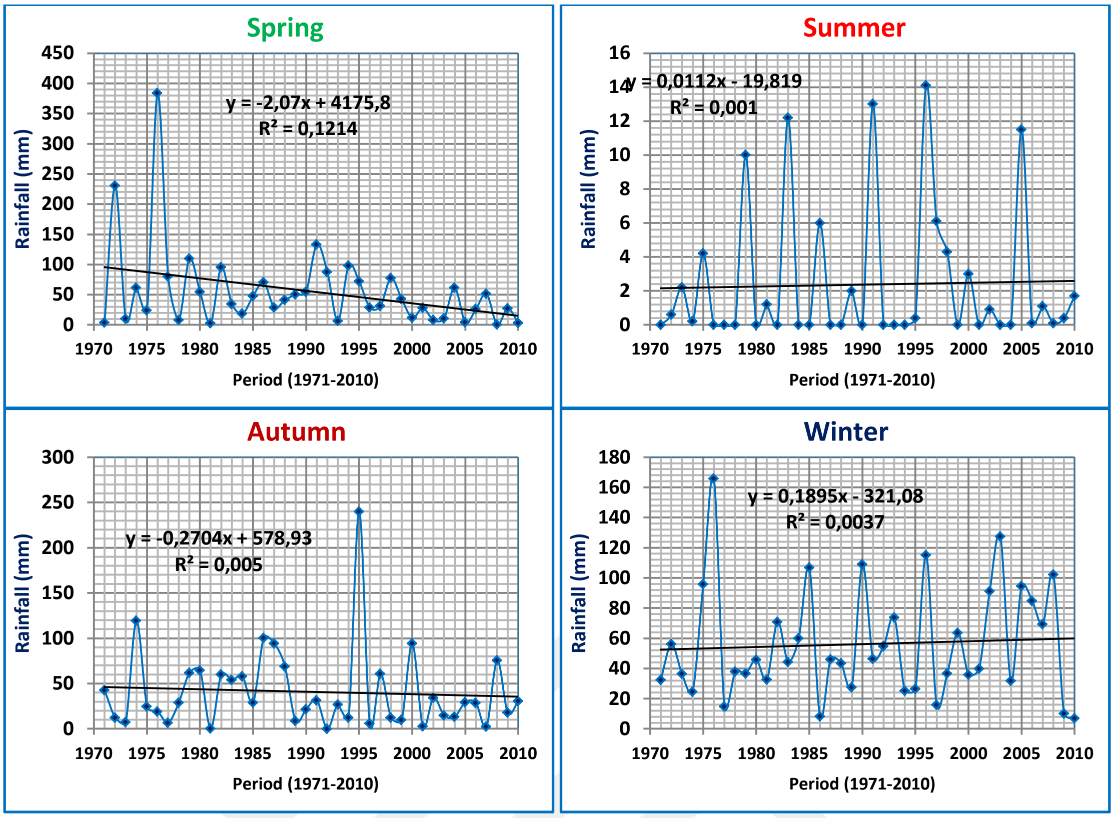


Figure 270. Simple Linear Trend Graphs of Seasonally Precipitationin NALUT Station (1971-2010)

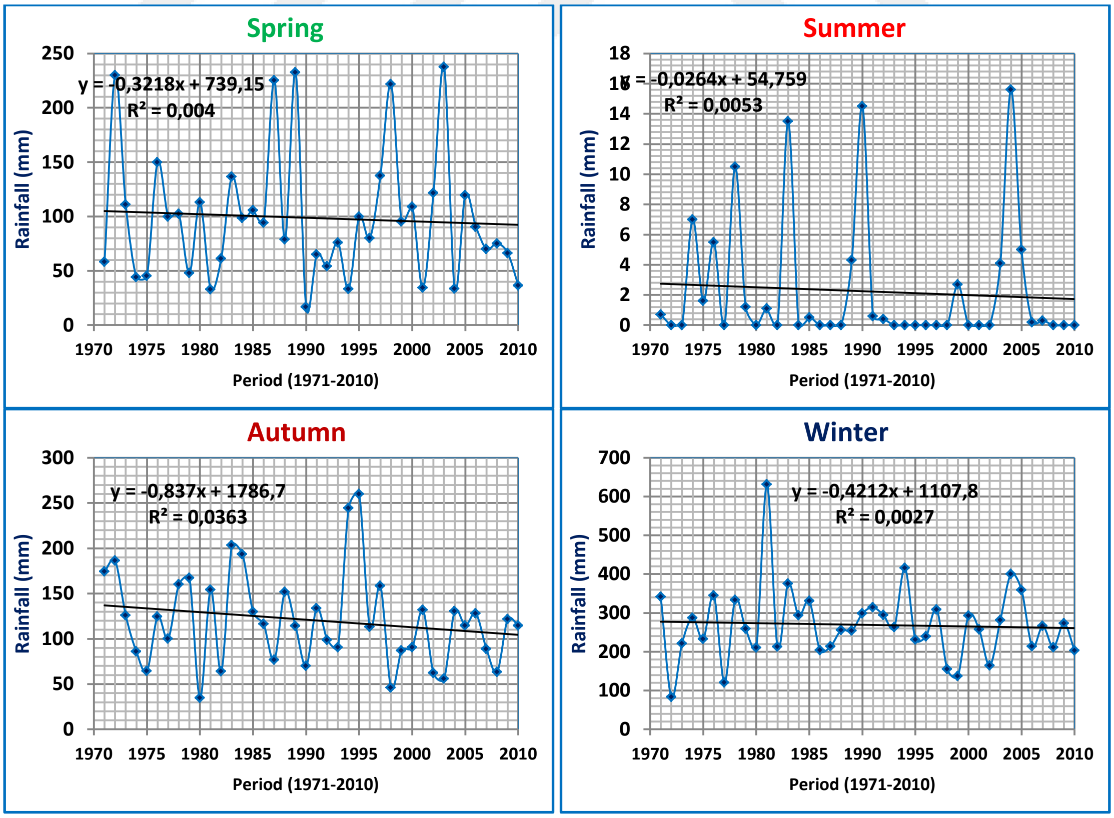


Figure 271. Simple Linear Trend Graphs of Seasonally Precipitation in SHAHAT Station (1971-2010)

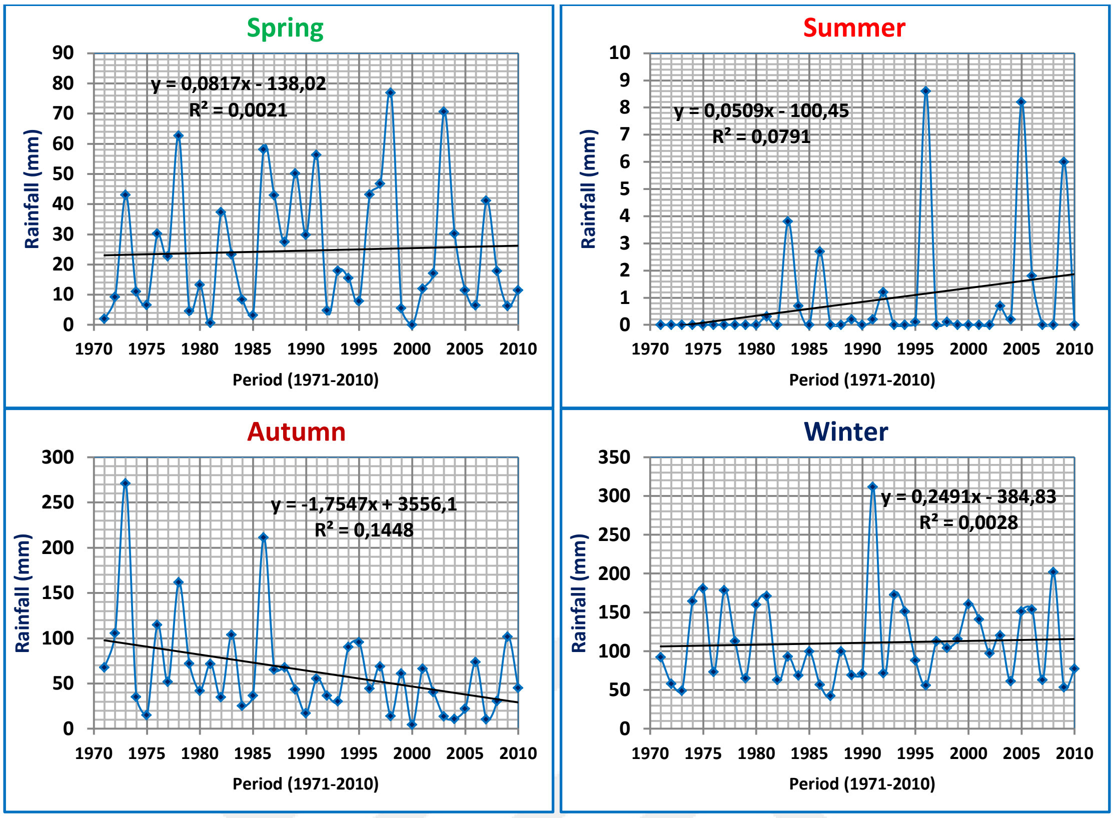


Figure 272. Simple Linear Trend Graphs of Seasonally Precipitation in SIRTE Station (1971-2010)

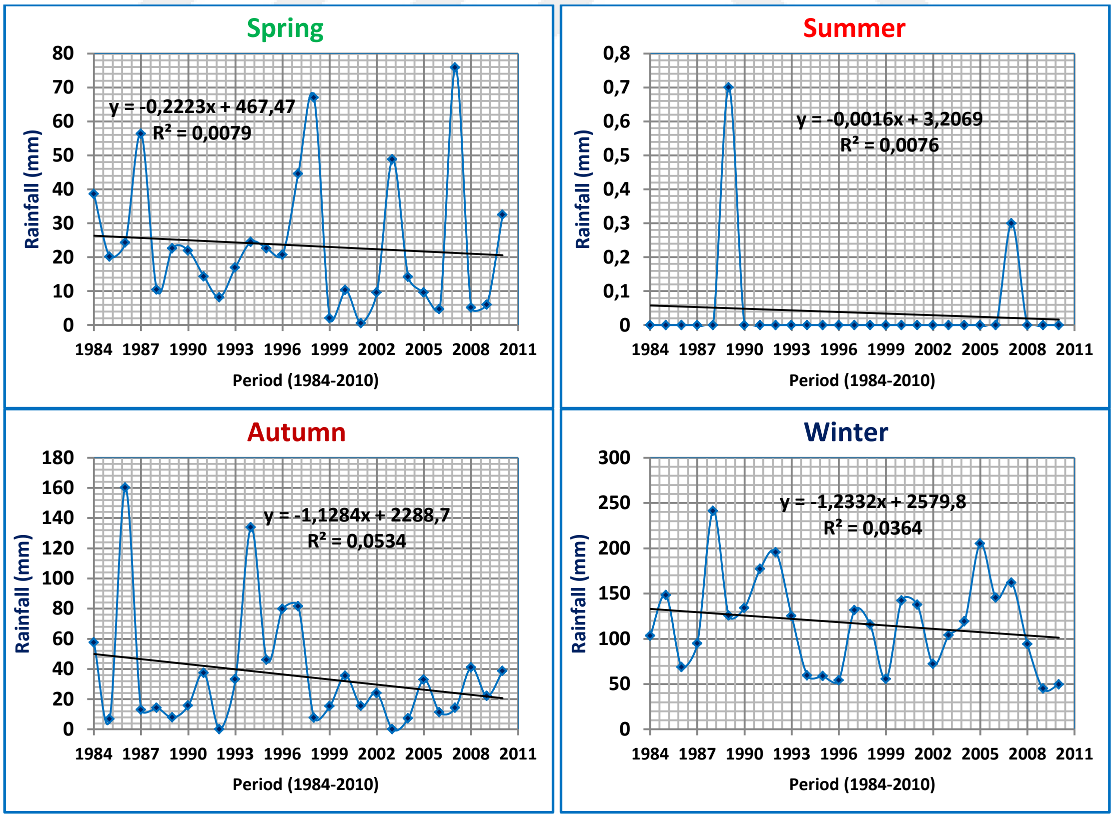


Figure 273. Simple Linear Trend Graphs of Seasonally Precipitation in TOBRUK Station (1984-2010)

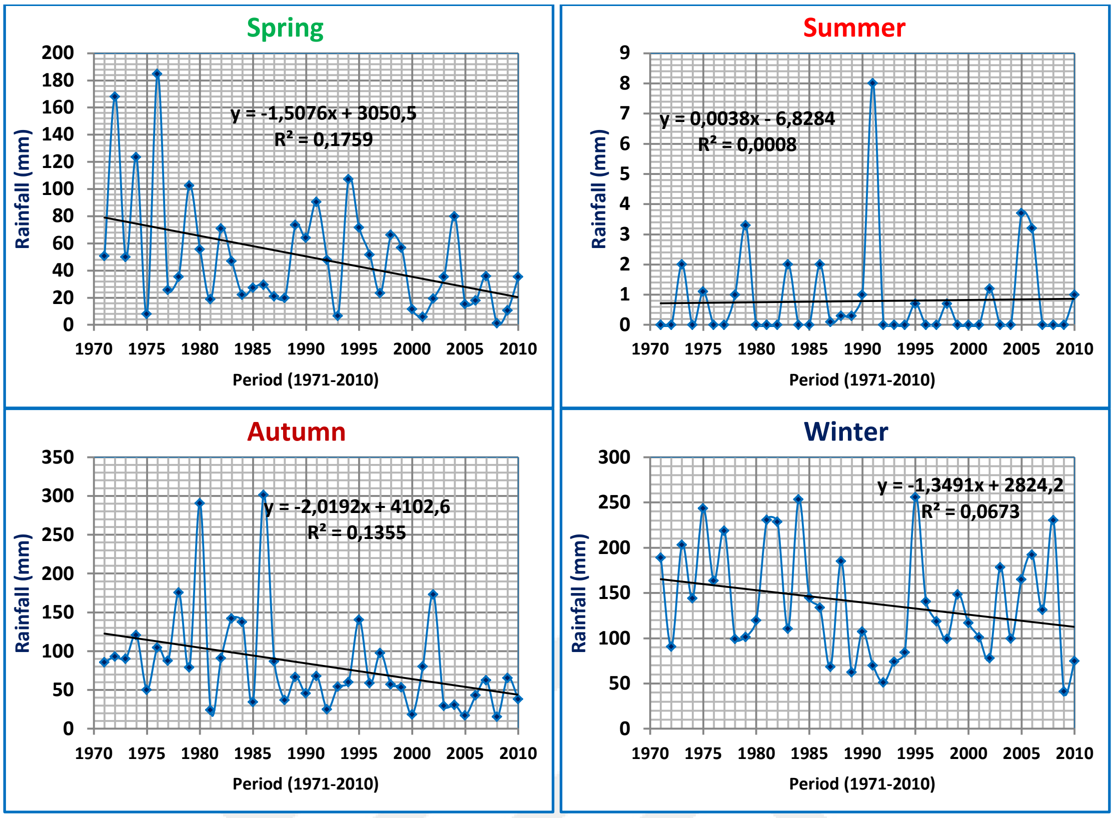


Figure 274. Simple Linear Trend Graphs of Seasonally Precipitation in TRIPOLI Station (1971-2010)

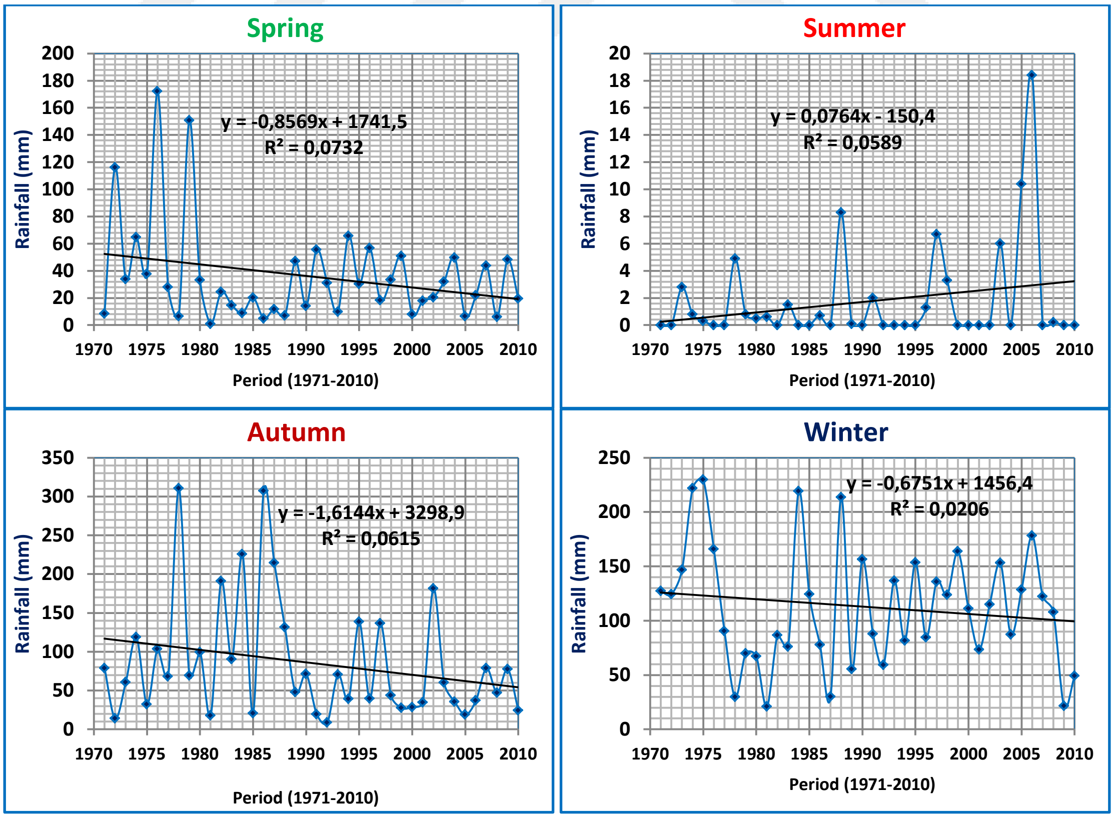


Figure 275. Simple Linear Trend Graphs of Seasonally Precipitation in ZWARA Station (1971-2010)

4.2.3.2. Simple Linear Regression for Annual Precipitation Data (1971-2010)

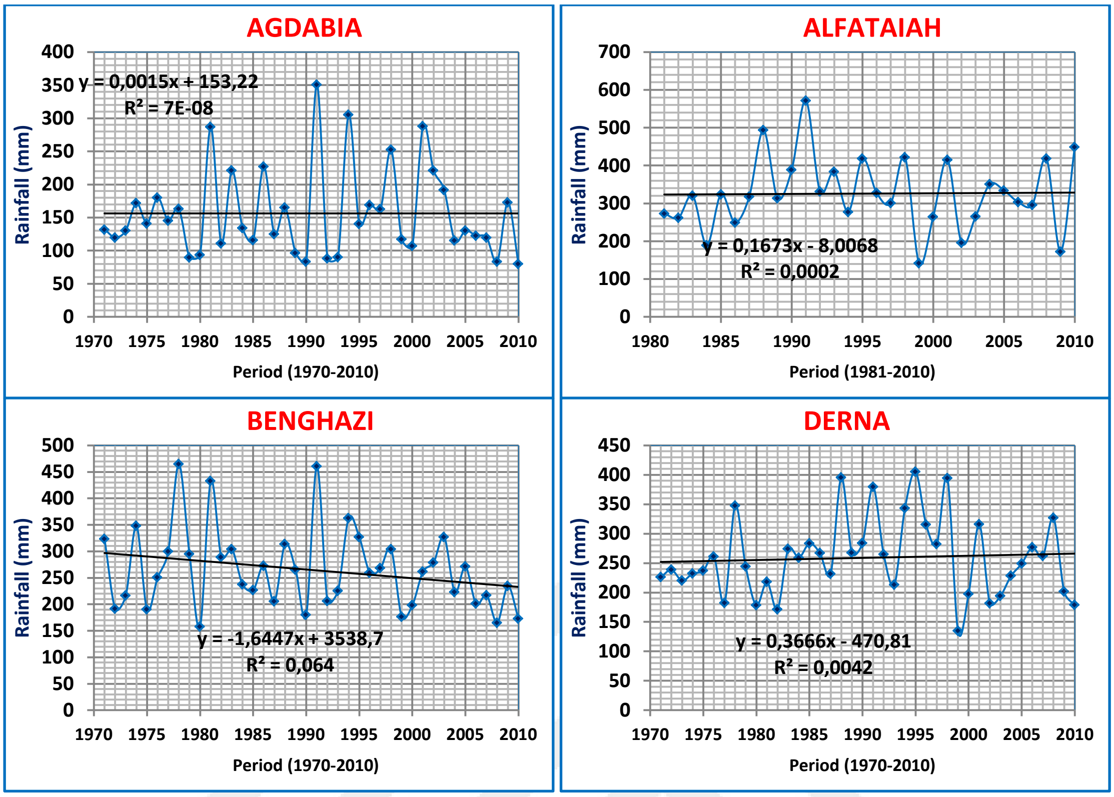


Figure 276. Simple Linear Trend Graphs of Annual Precipitation in AGDABIA, ALFATAIAH, BENGHAZI and DERNA Stations (1971-2010)

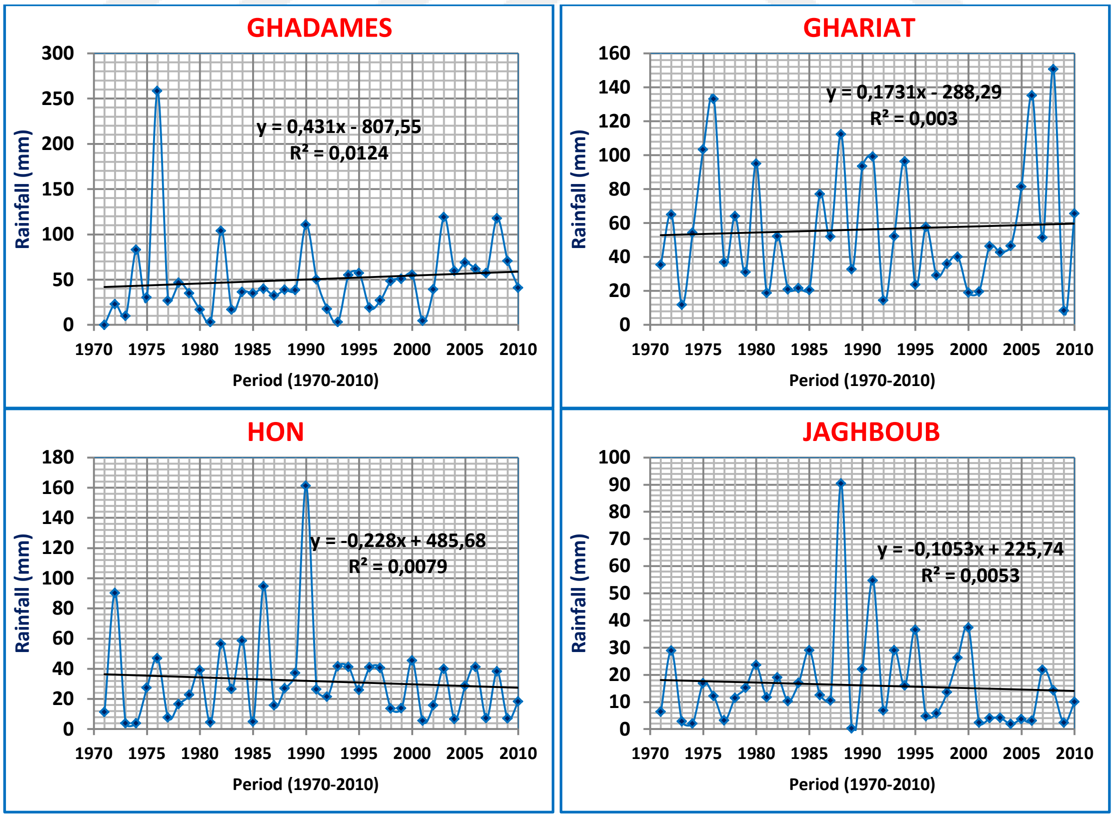


Figure 277. Simple Linear Trend Graphs of Precipitation in GHADAMES, GHARIAT, HON and JAGHBOUB Stations (1971-2010)

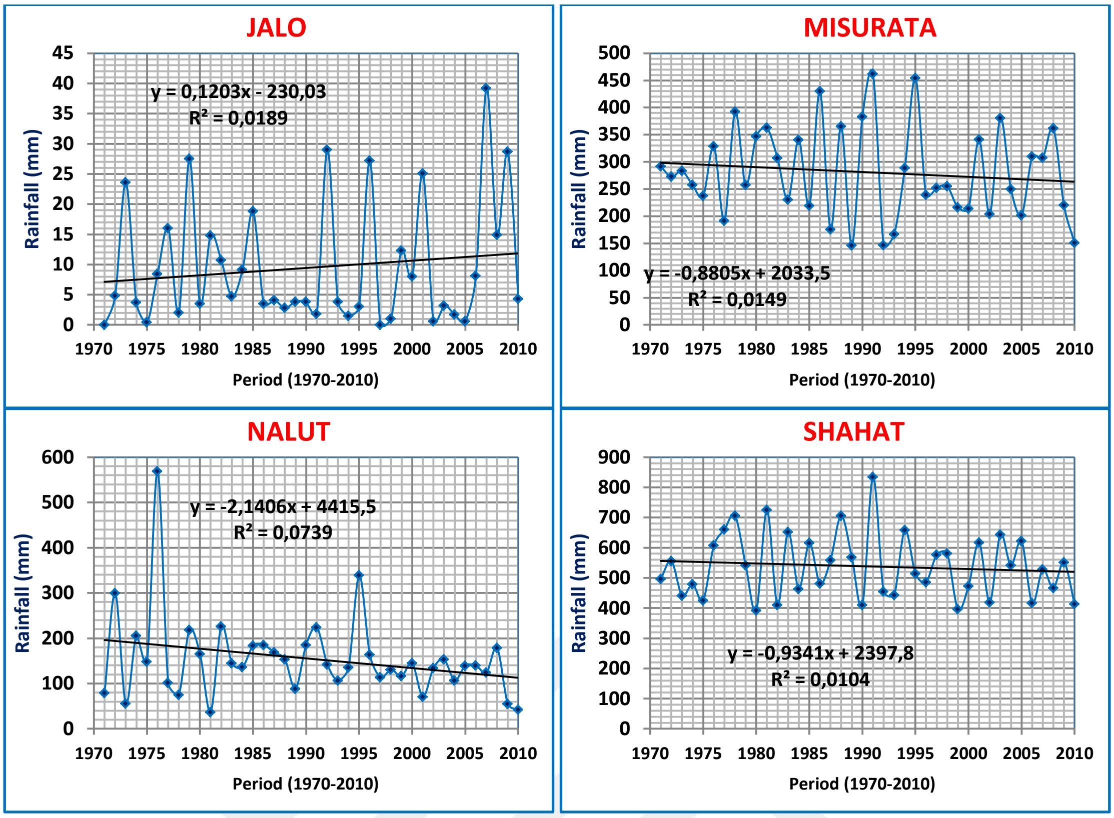


Figure 278. Simple Linear Trend Graphs of Annual Precipitation in JALO, MISURATA, NALUT and SHAHAT Stations (1971-2010)

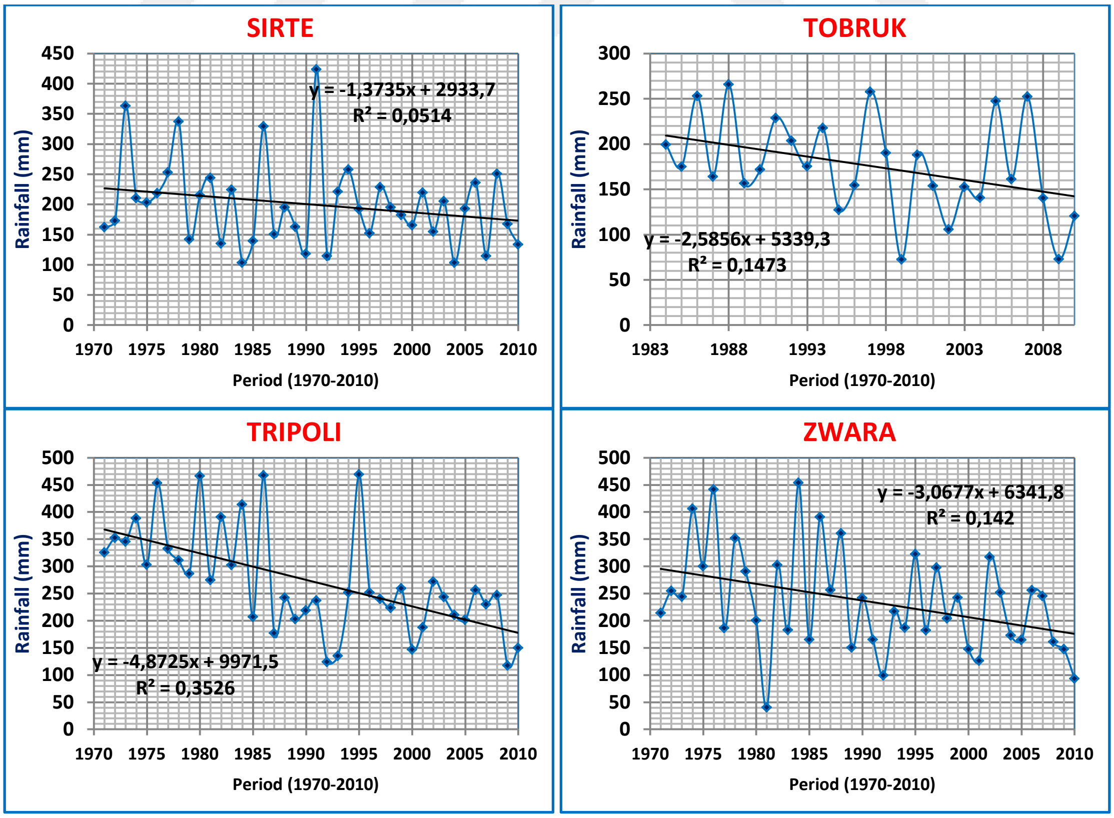


Figure 279. Simple Linear Trend Graphs of Annual Precipitationin SIRTE, TOBRUK, TRIPOLI and ZWARA Stations (1971-2010)

Table 105. Results of Simple Linear Regression Analysis for Seasonally and Annual Amount of Precipitation Data for All Stations (1971-2010)

Stations	Spring	Summer	Autumn	Winter	Annual
AGDABIA	-0.207	0.002	-0.166	0.373	0.001
ALFATAIAH	-0.369	0.024	0.003	0.411	0.167
BENGHAZI	-0.207	0.003	-0.562	-0.878	-1.644
DERNA	-0.230	0.003	-0.439	1.031	0.366
GHADAMES	-0.119	0.009	0.164	0.183	0.427
GHARIAT	0.151	-0.019	0.276	-0.234	0.173
HON	-0.167	0.055	-0.209	0.093	-0.228
JAGHBOUB	-0.130	-0.001	0.012	0.014	-0.105
JALO	-0.003	-0.002	-0.125	0.186	0.049
MISURATA	0.221	0.038	-0.712	-0.427	-0.880
NALUT	-2.070	0.011	-0.270	0.189	-2.140
SHAHAT	-0.321	-0.026	-0.836	-0.421	-0.934
SIRTE	0.081	0.051	-1.754	0.249	-1.373
TOBRUK	-0.222	-0.001	-1.128	-1.233	-2.585
TRIPOLI	-1.507	0.003	-2.019	-1.349	-4.872
ZWARA	-0.856	0.076	-1.614	-0.675	-3.067

- Evaluation of Results Simple Linear Regression for Seasonally and Annual Precipitation Data

When rainfall levels are evaluated at the stations of the study area in the seasons of the year, it can be said that there is a general tendency to decrease significantly, especially in the spring and autumn, and in the winter the trends were divided between increase and decrease. In Table 105 and above figures (from 261 to 280), several facts can be found about the simple regression equation as shown.

In spring season, most of the stations showed a decreasing trend, most notably AGDABIA Station (-0.208), ALFATAIAH Station (-0.369), BENGHAZI Station (-0.207), DERNA station (-0.230), GHADAMES Station (-0.119) (-0.167), JAGHBOUB (-0.130), NALUT (-2.070), the highest decrease in the results, SHAHAT (-0.321), TOBRUK (-0.222), TRIPOLI (-1.57), (-0.856). Only three stations showed a trend towards increase at GHARIAT station (0.151), MISURATA station (0.221) and SIRTE station (0.081). This may be due to the large fluctuation in rainfall in the spring between one year and another (Table 97).

This can be seen in the statistical tables in Chapter 3, where it was noted that there are years when rainfall exceeds the general average and the other is significantly less than the general average.

In summer, there was a lack of trends in all stations, except for positive trends shown by the stations of HON, SIRTE and ZWARA. This is due to the amount of rainfall that may be in just one day throughout the monitoring period, while the JALO station did not show any direction. In autumn, the coastal stations showed a significant negative trend.

The biggest trend was the decrease in the TRIPOLI station (-2.19), SIRTE station (-1.750), ZWARA station (-1.614), TOBRUK station (-1.128) Towards the increase such as GHADAMES station (0.164), GHARIAT station (0.276), JAGHBOUB (0.052), only ALFATAIAH station did not show any trend in autumn.

The winter season, showed different trends, some stations showed a trend towards increase, and the other decreases, while only one station did not show any trend and is the desert JAGHBOUB, the most important stations that showed a large trend towards the increase is the DERNA station (1.031) (0.411), AJDABIA station (0.373), SIRTE station (0.249), NALUT station (0.189), JALO station (0.186), GHADAMES station (0.183) and HON station was (0.093).

The stations that showed a decrease trend are the coastal stations, TRIPOLI station was (-1.349), TOBRUK station was (-1.233), BENGHAZI station (-0.878), ZWARA station (-0.675), MISURATA station was (-0.427), SHAHAT station was (-0.421), and only one station of desert stations, which is the station of GHARIAT, where it showed a trend of decreasing (-0.234).

Annual general average, The most important results that can be relied on by the simple linear regression equation are the results of the annual rainfall data, and because of the large fluctuation in the amounts of rainfall in the stations of the study area showed a significant difference in trends between coastal stations and desert stations, of course, a reflection of the prevailing natural factors, which are most important geographical location and proximity or distance from the sea. There are only four stations showing an increasing trend, ALFATAIAH station was (0.167), DERNA station was (0.366), GHADAMES station was (0.427), and GHARIAT station was

(0.173). Most of the stations showed a decreasing trend, TRIPOLI station was a large trend towards decreasing (-4.872), ZWARA station was (-3.067), TOBRUK station was (-2.585), NALUT station was (-2.140), BENGHAZI station was (-1.344), SIRTE station was (-1.373), SHAHAT station was (-0.934), MISURATA station was (-0.880), HON station was (-0.228), and JAGHBOUB station was (-0.105). And there were only two stations did not show any trend are AJDABIA and JALO.

4.2.4. Control's Models of Trend for Annual Precipitation Data (1971-2010)

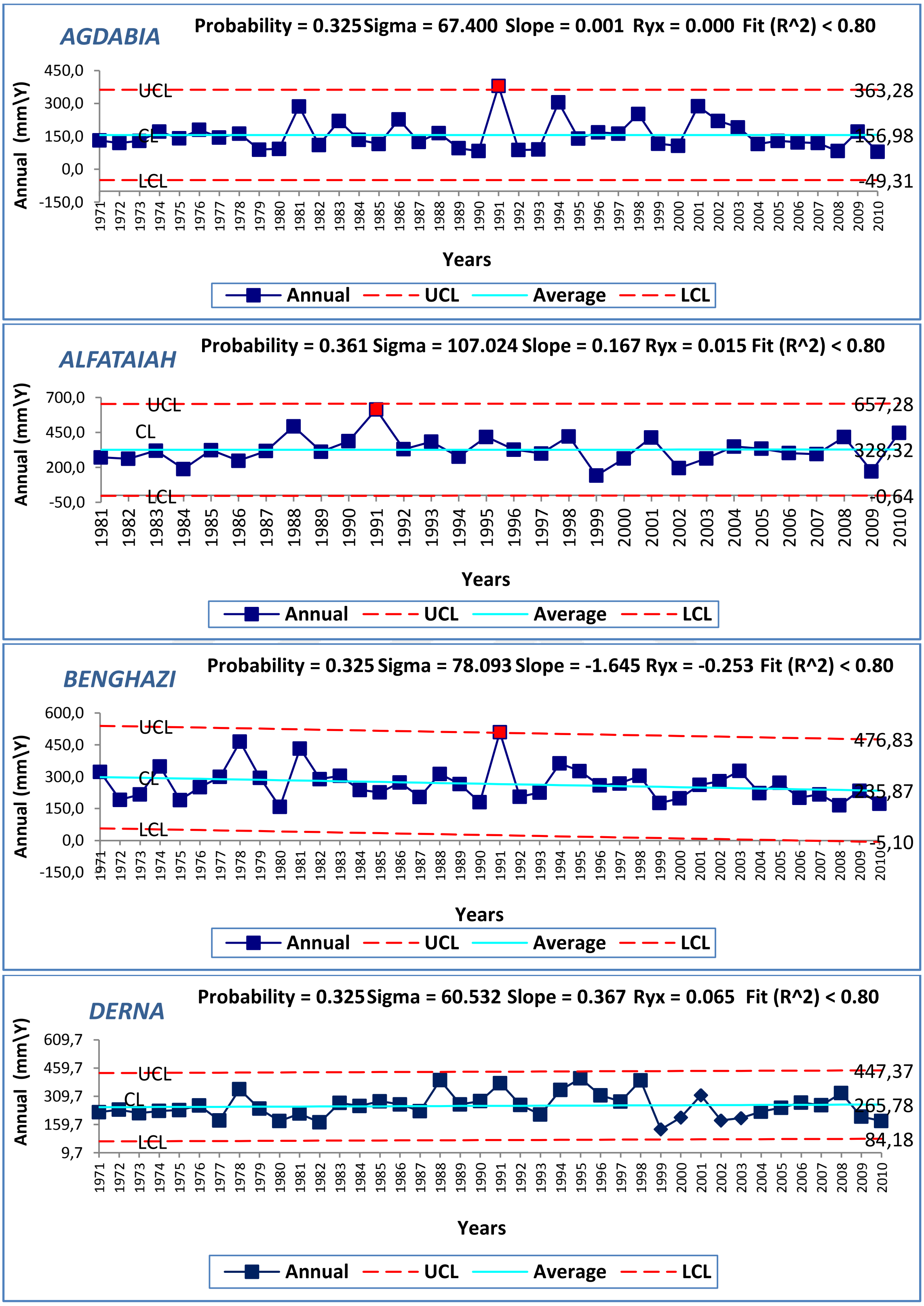
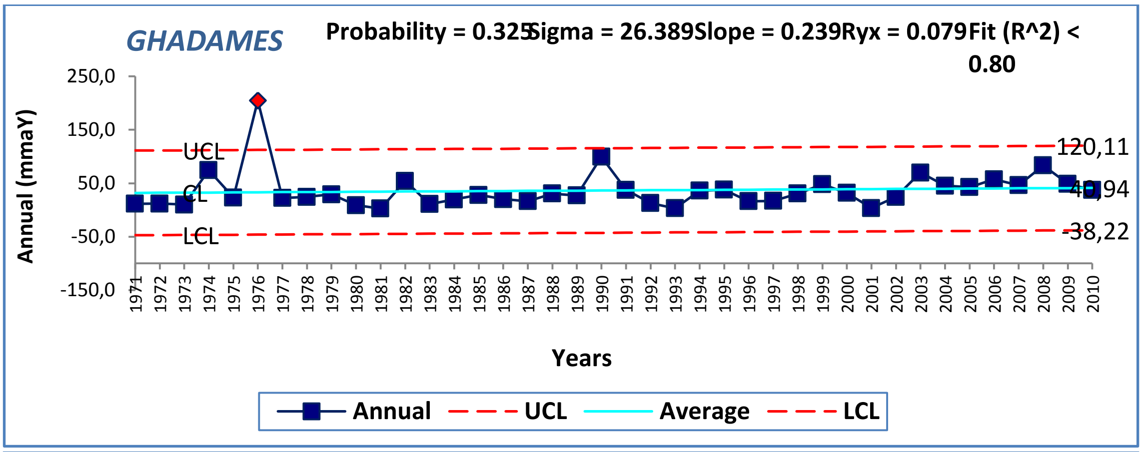
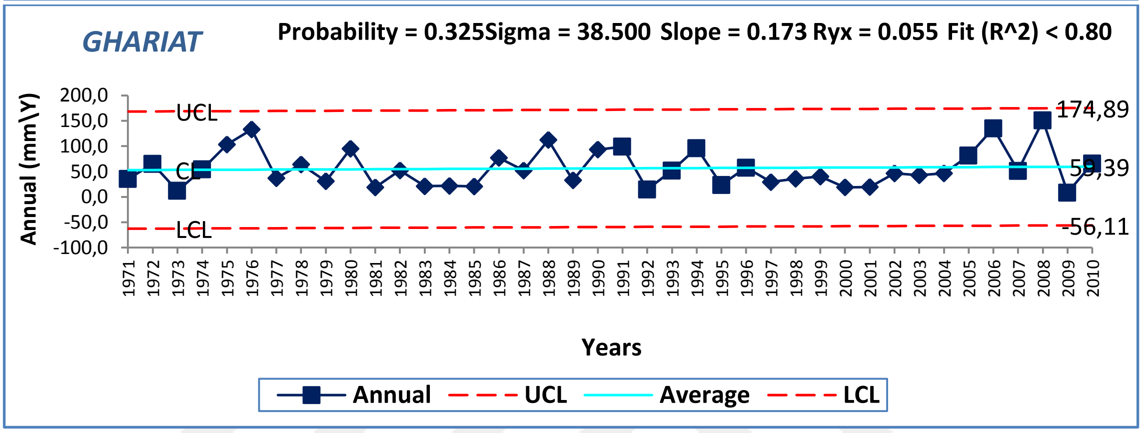
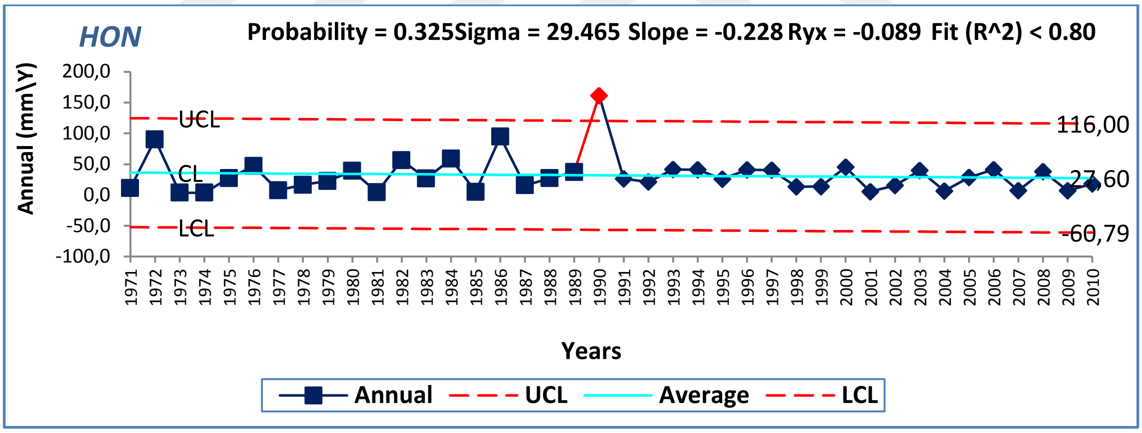


Figure 280. Charts Control's Model of Trend for Precipitation in AGDABIA, ALFATAIAH, BENGHAZI and DERNA Stations (1971-2010)







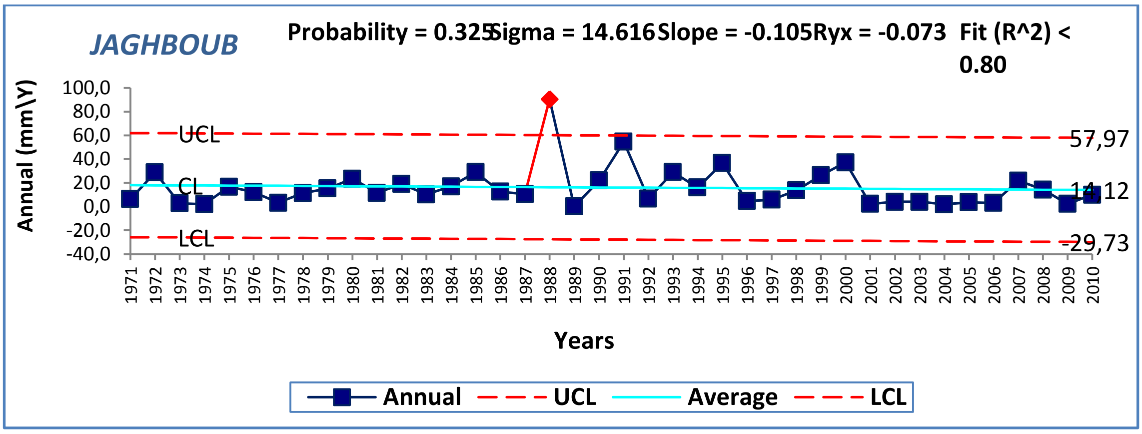


Figure 281. Charts Control's Model of Trend for Precipitation in GHADAMES, GHARIAT, HON and JAGHBOUB Stations (1971-2010)

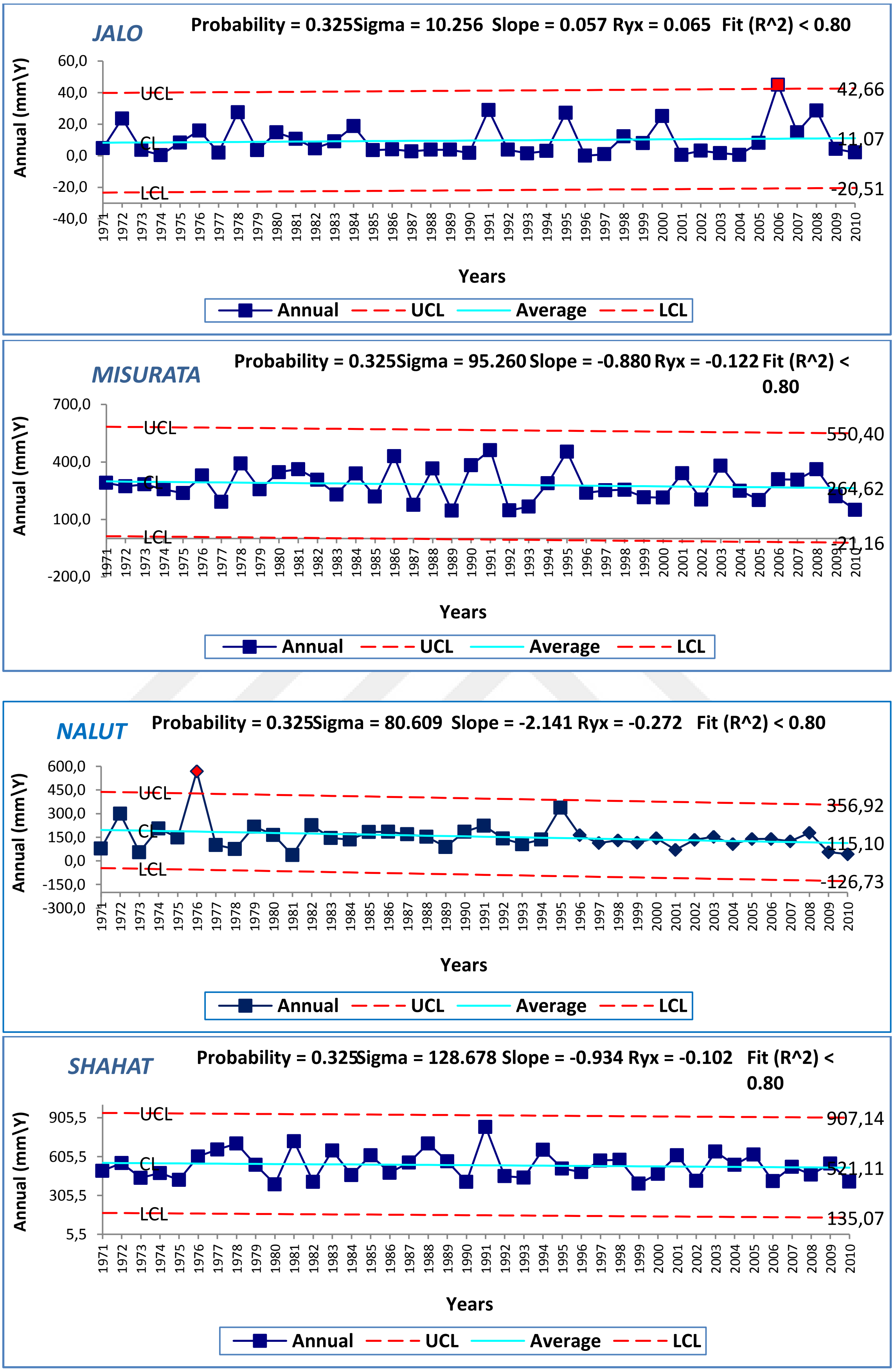


Figure 282. Charts Control's Model of Trend for Precipitation in JALO, MISURATA, NALUT and SHAHAT Stations (1971-2010)

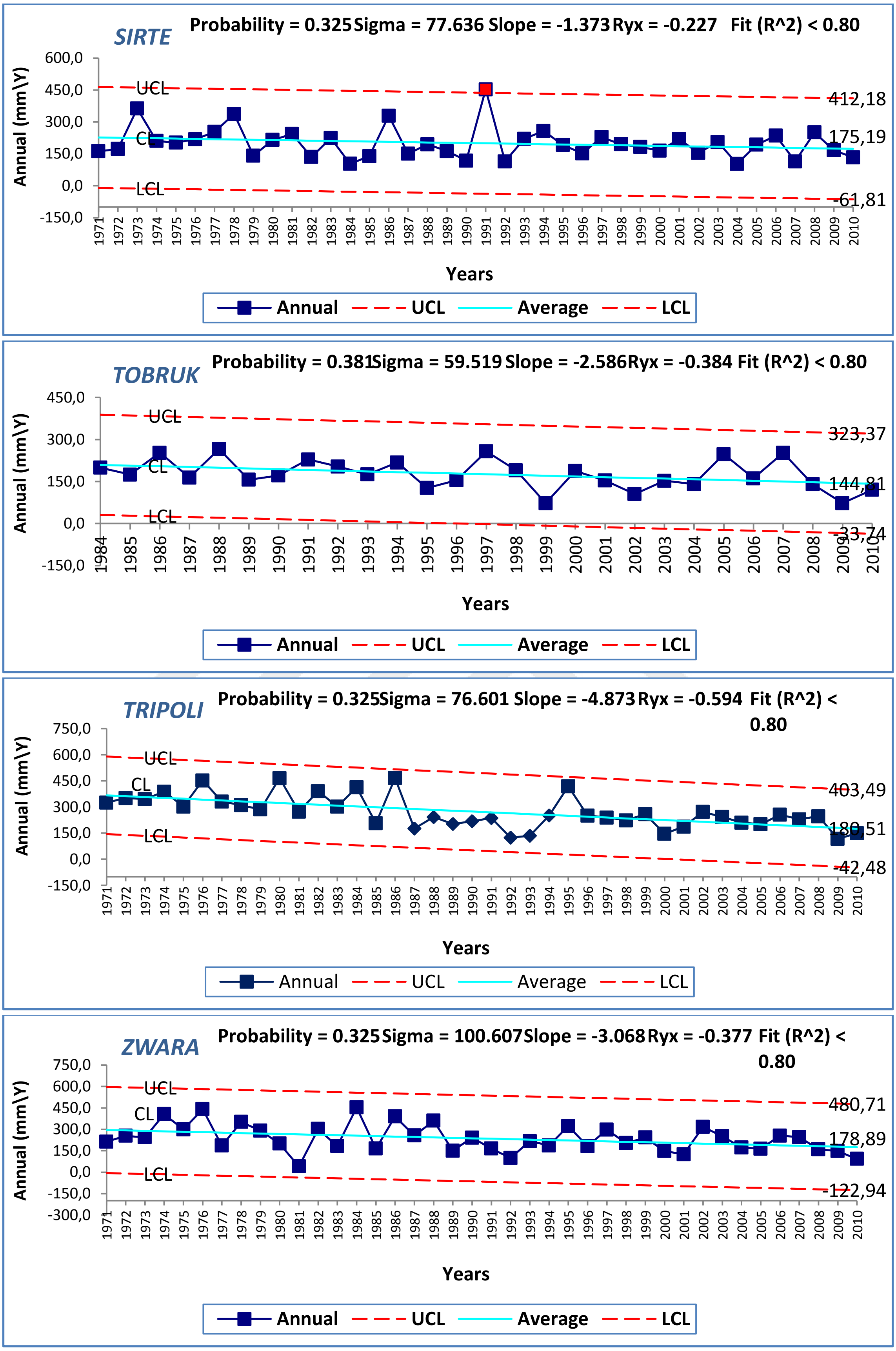


Figure 283. Charts Control's Model of Trend for Precipitation in SIRTE, TOBRUK, TRIPOLI and ZWARA Stations (1971-2010)

- Evaluation on Results of Charts Control's Models for Annual Precipitation Data

Stability process is reflected in relatively constant variation exhibited in Control Charts in previous graphs. Basically, the data fall within a band bounded by the control limits. If a process is stable, the likelihood of a point falling outside this band is so small that such an occurrence is taken as a signal of a special cause of variation.

In other words, something abnormal is occurring within the process of monitoring. The presence of unusual values provides evidence that the process is not in statistical control (Nelson, 1988) like a significant increase in the amount of rain in one year of the monitoring period or vice versa.

From figures 281, 282, 283 and 284the following facts can be found:

-AGDABIA station shows no trend in all years except for a positive trend in 1991, where the curve exceeds the upper control limit (UCL), precipitation average in 1991 was (351.1 mm/y) while the overall rainfall average during the monitoring period is (156. 15 mm/y).The upper control limit (UCL) reaches (363.28 mm/y), while the lower control limit (LCL) is reduced to (-49.31 mm/y). Not a single year shows a decreasing trend. The years show an increase and decrease (above and below) of the general average except for 1991.All years show normal variation which indicates that the data is under control. It is also observed that the value of Sigma reaches 67.4, Slope is 0.001, Ryx is 0.000, and Fit (R^2)is< 0.80.

-ALFATAIAH station shows no trend in all years except for a positive trend in 1991 where the curve exceeded the upper control limit (UCL), precipitation average in 1991 is (572.1 mm/y) while the overall rainfall average during the monitoring period is (325.8 mm/y). The upper control limit (UCL) reaches (657.28 mm/y, while the lower control limit (LCL) is reduced to (-0.64 mm/y). Not a single year shows a decreasing trend. The years show an increase and decrease (above and below) of the general average except for 1991.All years show normal variation which indicates that the data is under control. It is also observed that the value of Sigma reaches 107.024, Slope is 0.167, Ryx is 0.000, and Fit (R^2)is< 0.80.

-BENGHAZI station shows no trend in all years except for a positive trend in 1991 where the curve exceeded the upper control limit (UCL), precipitation in 1991 is

(460.6 mm/y), while the overall rainfall average during the monitoring period is (265 mm/y). The upper control limit (UCL) reaches (476.83 mm/y), while the lower control limit (LCL) is reduced to (-5.10 mm/y). Not a single year shows a decreasing trend. The years show an increase and decrease (above and below) of the general average, except for 1991.All years show normal variation, which indicates that the data is under control. It is observed that the value of Sigma reaches 78.093, Slope is - 1.645, Ryx is - 0.253, and Fit (R^2)is< 0.80.

-DERNA station shows no trend in all the years, the curve is not exceeded the upper control limit (UCL), while the overall rainfall average during the monitoring period is (259 mm/y).The upper control limit (UCL) reaches (447.37 mm/y), while the lower control limit (LCL) is reduced to (84.18 mm/y). Not a single year shows an increasing or decreasing trend. The years show an increase and decrease (above and below) of the general average on normal variation, which indicates that the data is under control. It is also observed that the value of Sigma reaches60.532, Slope is 0.367, Ryx is 0.065, and Fit (R^2)is < 0.80.

-GHADAMES station does not show any trend, except for a positive trend in 1976 , where the curve exceeded upper control limit (UCL), precipitation amount in 1976 is (203.8 mm/y), while the overall rainfall average during the monitoring period is (36.5 mm/y).The upper control limit (UCL) is reached (120.11 mm/y), while the lower control limit (LCL) is reduced to (-38.22 mm/y). Not a single year shows a decreasing trend. The years show an increase and decrease (above and below) of the general average, except for 1976.All years show normal variation, which indicates that the data is under control. It is also observed that the value of Sigma reaches 26.389, Slope is 0.239, Ryx is 0.079, and Fit (R^2)is< 0.80.

-GHARIAT station shows no trend in all the years, the curve is not exceeded the upper control limit (UCL), while the overall rainfall average during the monitoring period is (56.2 mm/y).The upper control limit (UCL) is reached (174.89 mm/y), while the lower control limit (LCL) is reduced to (-56.11 mm\y). Not a single year shows an increasing or decreasing trend. The years show an increase and decrease (above and below) of the general average on normal variation, which indicates that the data is under control. It is also observed that the value of Sigma reaches 38.5, Slope is 0.173, Ryx is 0.055, and Fit (R^2)is< 0.80.

-HON station shows no trend in all years, except for a positive trend in 1990, where the curve exceeded the upper control limit (UCL), precipitation amount in 1990 was (161.2 mm/y), while the overall rainfall average during the monitoring period is (31.8 mm/y). The upper control limit (UCL) is reached (116.00 mm/y), while the lower control limit (LCL) is reduced to (-60.79 mm/y). Not a single year shows a decreasing trend. The years show an increase and decrease (above and below) of the general average, except for 1990.All years showed normal variation, which indicates that the data is under control. It is also observed that the value of Sigma reaches 29.465, Slope is 0.173, Ryx is 0.055, and Fit (R^2)is< 0.80.

-JAGHBOUB station shows no trend in all years, except for a positive trend in 1988, where the curve exceeded the upper control limit (UCL), precipitation amount in 1988 is 90.4 mm, while the overall rainfall average during the monitoring period was (16.1 mm/y).The upper control limit (UCL) reaches (57.97 mm/y), while the lower control limit (LCL) is reduced to (-29.73 mm/y), and not any year shows a decreasing trend. The years show an increase and decrease (above and below) of the general average, except for 1988.All years showed normal variation, which indicates that the data under control. And it was observed that the value of Sigma reached 14.616, Slope was 0.105, Ryx was 0.073, and Fit (R^2) is< 0.80.

-JALO station shows no trend in all years, except for a positive trend in 2006, where the curve exceeded the upper control limit (UCL), precipitation amount in 2006 is (39.2 mm/y).The overall rainfall average during the monitoring period was only (9.6 mm/y), and the upper control limit (UCL) reached (42.66 mm/y), while the lower control limit (LCL) was reduced to (-20.51 mm/y), and not any year shows a decreasing trend. the years showed an increase and decrease (above and below) of the general average, except for 2006 all years showed normal variation, which indicates that the data under control. And it was observed that the value of Sigma reached 10.256, Slope was 0.057, Ryx was 0.065, and Fit (R^2) is< 0.80.

-MISURATA station showed no trend in all the years, the curve was not exceeded the upper control limit (UCL), while the overall rainfall average during the monitoring period was (280.9 mm\y), and upper control limit (UCL) reached (550.40 mm\y), while the lower control limit (LCL) reached reduced to (-21.16 mm\y), and not any year showed an increasing or decreasing trend. the years showed an increase and decrease (above and below) of the general average on normal variation, which indicates that the data under control. And it was observed that the value of Sigma reached 95.260, Slope was -0.880, Ryx was -0.122, and Fit (R^2) is < 0.80.

-NALUTstation showed no trend in all years, except for a positive trend in 1976, where the curve exceeded the upper control limit (UCL), precipitation amount in 1976 was (568.8 mm\y), while the overall rainfall average during the monitoring period was (154.7 mm\y), and the upper control limit (UCL) reached (356.92 mm\y), while the lower control limit (LCL) reached reduced to (-126.73 mm\y), and not any year showed a decreasing trend. the years showed an increase and decrease (above and below) of the general average, except for 1976 all years showed normal variation, which indicates that the data under control. And it was observed that the value of Sigma reached 80.609, Slope was -2.141, Ryx was -0.272, and Fit (R^2) is< 0.80.

-SHAHAT station showed no trend in all the years, the curve was not exceeded the upper control limit (UCL), while the overall rainfall average during the monitoring period was (538.4 mm\y), and upper control limit (UCL) reached (907.14 mm\y), while the lower control limit (LCL) reached reduced to (135.07 mm\y), and not any year showed an increasing or decreasing trend. the years showed an increase and decrease (above and below) of the general average on normal variation, which indicates that the data under control. And it was observed that the value of Sigma reached 128.678, Slope was -0.934, Ryx was -0.102, and Fit (R^2) is< 0.80.

-SIRTE station showed no trend in all years, except for a positive trend in 1991, where the curve exceeded the upper control limit (UCL), precipitation in 1991 was (423.8 mm\y), while the overall rainfall average during the monitoring period was (199.8 mm\y), and the upper control limit (UCL) reached (412.18 mm\y), while the lower control limit (LCL) was reduced to (-61.81 mm), and not any year showed a decreasing trend. the years showed an increase and decrease (above and below) of the general average, except for 1991 all years showed normal variation, which indicates that the data under control. And it was observed that the value of Sigma reached 77.636, Slope was -1.373, Ryx was -0.227, and Fit (R^2) is< 0.80.

-TOBRUK station shows no trend in all the years, the curve is not exceeded the upper control limit (UCL), while the overall rainfall average during the monitoring period was (175.8 mm/y), and upper control limit (UCL) reached (323.37 mm/y), while the lower control limit (LCL) reached reduced to (-33.74 mm/y). Not a single year shows an increasing or decreasing trend. The years show an increase and decrease (above and below) of the general average on normal variation, which indicates that the data under control. And it was observed that the value of Sigma reaches 59.519, Slope is -2.586, Ryx is -0.384, and Fit (R^2) is < 0.80.

-TRIPOLI station shows no trend in all the years, the curve is not exceeded the upper control limit (UCL), while the overall rainfall average during the monitoring period is (272.7 mm/y). The upper control limit (UCL) reaches (403.49 mm/y), while the lower control limit (LCL) is reduced to (-42.48 mm/y). Not a single year shows an increasing or decreasing trend. The years show an increase and decrease (above and below) of the general average on normal variation, which indicates that the data is under control. It is also observed that the value of Sigma reaches 76.601, Slope is -4.873, Ryx is -0.594, and Fit (R^2) is < 0.80.

-ZWARA station shows no trend in all the years, the curve is not exceeded the upper control limit (UCL), while the overall rainfall average during the monitoring period is (235.6 mm/y). The upper control limit (UCL) reaches (480.71 mm/y), while the lower control limit (LCL) is reduced to (-122.94 mm/y). Not a single year shows an increasing or decreasing trend. The years show an increase and decrease (above and below) of the general average on normal variation, which indicates that the data is under control. It is also observed that the value of Sigma reaches 100.607, Slope is -3.068, Ryx is -0.377, and Fit (R^2)is< 0.80.

V. CHAPTER

CONCLUSION

5.1. General Comments on Results

Present study has analyzed the trends of temperature and precipitation in selected locations of North Libya. The trend analysis of temperature data obtained from the 16 meteorological stations selected from almost all of North Libya over long period of time has been conducted in this research. Variability of maximum, minimum and mean average temperature as well as the extremes of temperature have been studied for the period between the years 1971 and 2010. Graphical distribution of data, measures of association and statistical trend detection methods have been applied to examine the long-term changes and trends of temperature in the study area (Chapter 3).

The results of temperature analysis for the period of 40 years (1971-2010) have revealed significant increases in maximum, minimum and mean average temperature. A significant annual change in temperature towards strong warming has been observed in the study area after the mid-1990s.Besides, rapid increases in temperature, almost doubling from the previous figure, during the period of last 12 years (1998-2010) have also been indicated (Tables 33 to 48).

The findings of present study, discussed in Chapter 3, have revealed that minimum temperature has rapidly increased at most of stations with a much higher rate (0.9 to1.3 °C) during the period of last 12 years (1998-2010). This is considerably faster than the (IPCC, 2007) global mean temperature increase of (0.74 °C) over the last 100 years.

Seasonal temperature data indicates that rapid increases in maximum temperature took place in autumn, summer and spring while the most rapid warming is observed in the summer and autumn. The results have revealed that minimum temperature, particularly mean seasonal average in minimum temperature, is characterized byhigher rates of increase compared to the maximum temperature with the highest rates of increase in the warm season (April-September). These trends in maximum, minimum and mean average temperature are in line with global, regional and local temperature trends since the late nineteenth century which show the most rapid increase since the mid-1970s (IPCC, 2007 and URL6).

The results of the study of variability in temporal and spatial precipitation in Libya for the period 1971-2010 are presented in Chapter 3. The data are analyzed using several graphical techniques, trend analysis, measures of association and statistical trend detection methods for sites in the study area.

The Green Mountain and Benghazi plain in the northeast, outside of the coastal region, have received some of the highest levels of precipitation in north of Libya. It is found that 15 % of the study area has received annual averages precipitation of 265 - 538 mm whereas about 85% of the study area at inland stations (Sahara) has received<50 mm of precipitation.

Northern region of Libya is frequently affected by low pressure (depressions) associated with a branch of the westerly jet stream (Amgailey, 1995; Zikrey 1998). These depressions are more frequent in winter with only 28% of the total annual depressions resulting in effective precipitation over Libya, seasonal and annual precipitation trends in Libya seem to be strongly affected by local factors including topography and land use. The coastal region is mainly affected by Mediterranean convection processes, apart from central coast region.

5.2. Comments on the Results of Planetary and Local Factors Affecting the Climate of Northern Libya

Chapter II discusses the relationships between planetary, regional, and local factors on the climate of the study area. The study area is affected by the dry continental air coming from central Africa which increases the temperatures in the summer. On the other hand, the cold air coming from Europe is responsible for the decrease in temperatures and rainfall in most coastal stations in the winter.

The coefficient of correlation between the general mean temperature and elevation of sea level is negative (-0.502),while the coefficient of correlation between temperature and distance from the sea is positive (0.541). Besides, the coefficient of correlation between the annual rate of rainfall and elevation shows a positive but relatively weak trend with the value of (0.185), while the impact of the distance from the sea on the amounts of rainfall shows very negative trend with a value of (-0.735).

The trends of temperature and precipitation are linked to the mathematical location (latitude) in some stations; however the effect of elevation and distance from the

Mediterranean seems much stronger which is noticed in figure (2).For example, the stations located within the latitude 29,30°N shows an increase in the general rates of temperature and decrease in rain, while in some stations, there is no rain. These characteristics are found in the stations of JALO, JAGHBOUB, HON, GHADAMES, GHARIAT, and AGDABIA station. It is observed that some stations are located at the same latitude, but they differ in climatic characteristics due to the elevation, distance from the sea, and this is evident in the stations of SHAHAT, ZWARA and DERNA.

Map 7 shows the effect of the direction of the mountains towards the coast on the annual rate of rainfall. The direction of the coast in parallel to the rain winds reduces the chances of rainfall, like in the stations of TOBRUK, ZWARA and SIRTE, while the stations facing to the rainy winds like BENGHAZI, MISRATA and SHAHAT receive a larger amount of rain.

5.3. Comments on the Results of Trend Analysis

In which trends (increase/decrease) the trend has occurred at meteorological stations (Desert stations or Coast stations) and which meteorological stations show strong trends and are these stations show changes in temperature and precipitation data?To answer the study questions, comments will be made on the results of the tests used in the third chapter, as follows:

***Mann-Kendall and Spearman**

Maximum temperatures, an upward trend of heat at the station of MISURATA, TRIPOLI and ZWARA is observed in spring season. This trend is assumed to be linked with the heating due to the blowing of the southern wind in the forefront of the air depressions that prevail in the late spring along the Libyan coast and presence of high-rise buildings in TRIPOLI and MISURATA.

A significant increase at most stations is indicated in the seasons of summer and autumn while a poor weak trend is identified in winter. The increase in the trend of temperature manystations such as MISURATA, AGDABIA, SIRTE, TRIPOLI, ZWARA associated to urban expansion and sprawl towards the natural margins of cities resulting in low wind speed and absorption of higher solar radiation. Moreover, an increase trend in the annual average temperature is also observed at most stations, except ALFATAIAH, BENGHAZI, DERNA, SHAHAT and ZWARA. This appears to be associated with observed increase in temperature during the last 12 years of monitoring period.

BENGHAZI and SHAHAT are the only two stations that have shown insignificant trends towards decreasing. The absolute and geographical along with the elevation of these stations are among the important factors that affect the trend since the station of SHAHAT is located at a height of 621 meters.

The findings obtained from the U(t)-U'(t) graphs have indicated that , many stations have shown positive trends in the summer starting from the year 1993.The stations such as ALFATAIAH, JAGHBOUB, JALO and MISURATA have started to show an increase in temperature during the 1990s. Addition , many stations such as AGDABIA, JAGHBOUB, SIRTE, TOBRUK, TRIPOLI and ZWARA have shown a positive trend in the autumn during 1980.Besides, most of the station have been observed to have positive trend in annual average temperature in 1990s.No trend is found in the seasons of spring and winter except at JAGBOUB station with a negative trend in 2002at JALO station with positive trend in 1989.

Minimum Temperatures, the annual rate of minimum temperature has shown a tendency to increase in the summer and autumn seasons while a weak trend is observed in spring and winter. Only the AGDABIA and JAGHBOUB stations have shown an upward trend at all the seasons. ALFATAIAH, DERNA, MISURATA and ZWARA station have shown an increase in trend during autumn. Most of the stations have shown no significant trend in the annual average of the minimum temperature except DERNA, JAGHBOUB and TRIPOLI stations.

The U(t)-U'(t) graphs show that there were positive trends towards the increase during the spring season at DERNA Station which started in 1999 followed by HON in 1998, JAGHBOUB in 2006, TOBRUK in 2004 and ZWARA in 1998. In the summer, only two stations have shown a positive trend which are HON in 2003 and TRIPOLI in 1994. Besides,some coastal stations have shown a positive trend in the autumn starting in 1986 at TRIPOLI Station, in 1989 at MISURATA Station, in 1992 at DERNA Station and in 2000 at TOBRUK Station. In the winter, only one station has shown a trend towards the increase starting in 2004. The annual average temperature has shown no trend in most of the stations except a positive trend at DERNA in 1983, I addition JAGHBOUB in 2002 and in TOBRUK in 2004.

Average temperatures, general increasing trend has been observed at the stations of MISURATA, SIRTE, TRIPOLI and ZWARA. This increasing trends linked with urbanization factors such as expansion of buildings at the expense of green spaces. These areas have turned into hot islands leading to an increase in the trends in the annual average temperature. Desert stations such as GHADAMES, HON, JAGHBOUB and JALO have shown an increasing trend the average annual temperature. This upward trend is associated to the increase in temperature during the summer in dry regions. Moreover, the mountain stations such as ALFATAIAH, SHAHAT and NALUT have also shown an increasing trend. This increase is thought to be associated with large amounts of solar radiation during the summer and lack of sufficient amount of cold air in the summer due to the altitude factor.

It is observed in U(t)-U'(t) graphs that most of the stations have not shown any trends in spring season except ZWARA station with a positive trend in 1988.In summer, JALO and ZWARA stations only have shown positive trend in 1993. In autumn, some stations have shown positive trend in 1980s. However, in winter, only BENGHAZI station has shown positive trend in 2010. Besides, four stations have also shown positive trend in average annual temperatures in 1990s that are AGDABIA, DERNA.

Precipitation, it has been observed that most of the stations have shown no trend towards the increase of precipitation in spring except GHADAMES station. This is, because of the fall of a large amount of rain in a short period leading to an increase in the quarterly average which results in an increase in trend. Besides, most of the stations has shown no or very weak trend in the summer except for is Sirte station. However, in autumn, a decreased trend has been observed in the stations of HON, SIRTE and TRIPOLI. Besides one station has shown a very negligible downward trend. The winter season has shown insignificant trends towards the increase and decrease in some stations such as TRIPOLI TOBRUK and BENGHAZI while some desert stations such as JALO, GHADAMES and HON have shown an insignificant upward trend.

Almost all of the stations have not shown any significant trend in the general average of precipitation except the upward trend shown only at GHADAMES station.

However, some stations have shown a significant decreasing trend like TRIPOLI, ZWARA, TOBRUK, SIRTE and NALUT.

It is noteworthy that Mann-Kendall and Spearman tests of trend are not feasible to measure the rainfall trends in the desert stations because of the seasonal and annual scarcity and fluctuation of rainfall. In the desert climate, a large amount of rain may fall in one day and the rain may not fall for many years.

***Sen's Trend Slope Test**

Maximum Temperatures, it has been observed that in most of the stations there is a trend towards increase of rainfall in the except BENGHAZI, DERNA, JAGHBOUB, JALO, SHAHAT and TOBRUK. The remaining stations have not shown any significant trends in the other seasons.

Minimum Temperatures, the trend is found increasing in the spring at stations of GHADAMES, HON, MISURATA, NALUT, TOBRUK and ZWARA, while other stations have not shown any meaningful trends. AGDABIA station has shown the strongest trend in the summer probably because of the presence of oil refineries and petrochemical industries located to the west of the city of AGDABIA in the regions of Al-Briga and Ras-Lanuf. The other stations have shown trends towards increase in minimum temperature such as BENGHAZI, GHARIAT and NALUT. In the autumn, all stations have shown trends towards increase except BENGHAZI, SHAHAT, SIRTE, TRIPOLI and ZWARA. Almost all stations have not shown any trend in winter except four stations of GHARIAT, HON, MISURATA and ZWARA. Only ZWARA station has shown a trend in annual minimum temperatures. Some stations have shown trends towards increase in annual minimum temperatures such as AGDABIA, HON, MISURATA, TOBRUK and ZWARA.

Average Temperatures, atrend towards increase in the temperature is observed at MISURATA station perhaps due to the presence of some heavy industries such as the iron and steel industry. Some of the stations have not shown any trend in any season while some stations have shown trends in the summer and autumn such as(HON, JAGHBOUB, JALO, TOBRUK and TRIPOLI. There is a trend towards increase at NALUT station during the spring and autumn.

Precipitation, MISURATA and SIRTE have shown important trends towards increase in the spring. The rest of the stations have not shown any important trends. Some stations have shown negative trends such as stations of TRIPOLI, TOBRUK and ZWARA, it should be noted that the trends observed in the seasonal and annual rainfall data are not as important as the temperature data. The basis of this argument is that the trends of precipitation are short term as opposed to temperature trends that are long-term.

*** Simple Linear Regression Results**

Maximum Temperatures, it is found that almost all stations have shown no significant trends when examining the trends that have occurred over the years in average maximum temperature values on a seasonal basis except NALUT and ZWARA stations. Besides, it is also observed that the results in the rest of the stations are approaching zero either increasing or decreasing during spring. In summer, only ZWARA station has shown an upward trend and no other station shown an increase or decrease in trend. Autumn is considered as the most important in increased trends during which8 stations have shown an upward trend that are GHADAMES, GHARIAT, HON, MISURATA, SIRTE, TRIPOLI and ZWARA. Looking at the previous trend tests, it will be noted that the autumn season is characterized by the increasing trend the maximum temperature data for most of the stations. It is observed through the results that in the winter, the general average annual maximum temperature have not shown any trend (increase or decrease).

Minimum Temperatures, it has been observed that only five stations have shown a trend towards an increase in the spring while examining the trends in minimum temperature values over many years on a seasonal basis that are GHADAMES, HON, MISURATA, TOBRUK and ZWARA. Other stations have not shown any trends indicating the stability of the minimum temperatures in most of the stations in spring season.

In summer season, HON station where the increase is highest, although there is an increase in most stations except for three stations of ALFATAIAH, BENGHAZI and NALUT.DERNA station has shown an increasing trend along with GHADAMES, GHARIAT, JAGHBOUB, JALO, MISURATA, SHAHAT, SIRTE, TOBRUK, TRIPOLI and ZWARA. These results indicate a tendency towards warming in most stations and the trend is also found increasing in desert stations except for BENGHAZI station. The autumn season is characterized by an increase in trend in all stations. The winter season has not shown any trend in all stations except for four stations of GHARIAT, HON, MISURATA and ZWARA with trend towards increase.

Many stations have shown a trend towards an increase in the annual average temperature data. HON station has shown the strongest trend, followed by ZWARA, TOBRUK, AGDABIA, GHADAMES, GHARIAT and DERNA.

Average Temperatures, the evaluation of the simple linear regression for the average of the minimum temperatures in the spring has shown no trend in almost all stations except for two stations of NALUT and ZWARA that show a tendency to increase. In summer, many stations have shown a trend toward increase. ZWARA station has shown the strongest followed by AGDABIA, MISURATA, HON, JAGHBOUB and JALO stations. Almost all the stations in the autumn have shown a trend towards increase except ALFATAIAH, BENGHAZI, DERNA and SHAHAT. The strongest trend towards increase is found at ZWARA, HON, GHADAMES, MISURATA, GHARIAT, TOBRUK and AGDABIA stations followed by SIRTE, TRIPOLI, JAGHBOUB and JALO. The winter season has not shown a trend in all stations. The average annual temperature has shown a trend in three stations of HON, MISURATA and ZWARA.

Precipitation, Most of the stations have shown a decreasing trend in annual average precipitation in most of the seasons except for winter. The most important results deducted from the simple linear regression equation are the results of the annual rainfall data as the large fluctuation in the amounts of rainfall in the stations of the study area have shown a significant difference in trends between coastal stations and desert stations. This reflects the importance of prevailing natural factors of geographical location and proximity or distance from the sea. There are only four stations that show an increasing trend which are ALFATAIAH, DERNA, GHADAMES and GHARIAT. Most of the stations have shown a decreasing trend such as TRIPOLI station with large trend towards decreasing followed by ZWARA, TOBRUK, NALUT, BENGHAZI, SIRTE, SHAHAT, MISURATA, HON and JAGHBOUB stations. Only two of AJDABIA and JALO have shown no trend.

***Results of Charts Control's Models for Annual Rainfall**

There no observed trend of increase or decrease in most stations except for AGDABIA, ALFATAIAH, BENGHAZI and SIRTE in 1991, GHADAMES in 1976, HON in 1990, JAGHBOUB in 1988 and JALO in 2006. This increase in trends may be due to the large amounts of rainfall during a short period of time in the year in which the increase occurred.

5.4. Relationships between Results of Thesis and (NAO and El Niño) and Causes of increases Temperature and potential causes of variability in northern Libyan Precipitation

Is there any relationship between the temperatures and precipitation trends in Libya and global climate change and climatic phenomena such as North Atlantic Oscillations (NAO) and El Niño?

The Pacific El Nino-Southern Oscillation (ENSO) and North Atlantic Oscillation (NAO) phenomena play an important role in interannual temperature variability in many regions throughout the world (Philander, 1990 and Hurrell, 1995). Significant effects are observed on the anomaly variability patterns of precipitation over the arid and semiarid regions of North Africa by the North Atlantic Oscillation (NAO), while the El-Nino of the Southern Oscillation (ENSO) is significantly affecting the variability over some regions in North Africa (Djomouet al., 2013).

***Relationships between Results of Thesis and (NAO)**

The North Atlantic Oscillation (NAO) is a large-scale mode of natural climate variability governing the path of Atlantic mid-latitude storm tracks and precipitation regimes in the Atlantic and Mediterranean sectors (Küçüket al.,2009).

Temperature variability can be associated to variations in large-scale atmospheric patterns represented by Eastern Atlantic and the Western Mediterranean Oscillations, resulting from increases in atmospheric circulation and anticyclone conditions in recent decades, which seem to play a significant role in explaining spatial and temporal variability of temperatures in the Mediterranean basin. Therefore, regional and local temperature trends can be strongly influenced by regional variability and changes in the climate system. In addition, It is believed that the volcanic eruptions can be responsible for changes (fall) in global annual average temperature by less than (1.0

°C) (Pidwirny,2004); this may explain why 1992 and 1993 were the coldest years in the 1990s with mean annual temperature in Libya potentially affected by the eruption of Mount Pinatubo.

To reveal the relation between Arctic Oscillation, North Atlantic Oscillation and temperature, precipitation regime of north Libya, With looking at values NAO in period (1971-2010) There was a weak relationship between the two variables in terms of results, except for three of the stations that showed a trend towards increasing the maximum temperatures during 1993, which are JAGBOUB, JALO and MISURATA stations, this corresponds to the positive indicator that was shown North Atlantic Oscillation in 1993.Table 103 and figure 300 show the relationships between the trends (increase and decrease) of maximum, minimum and average temperatures and the North Atlantic Volatility Index (negative and positive).

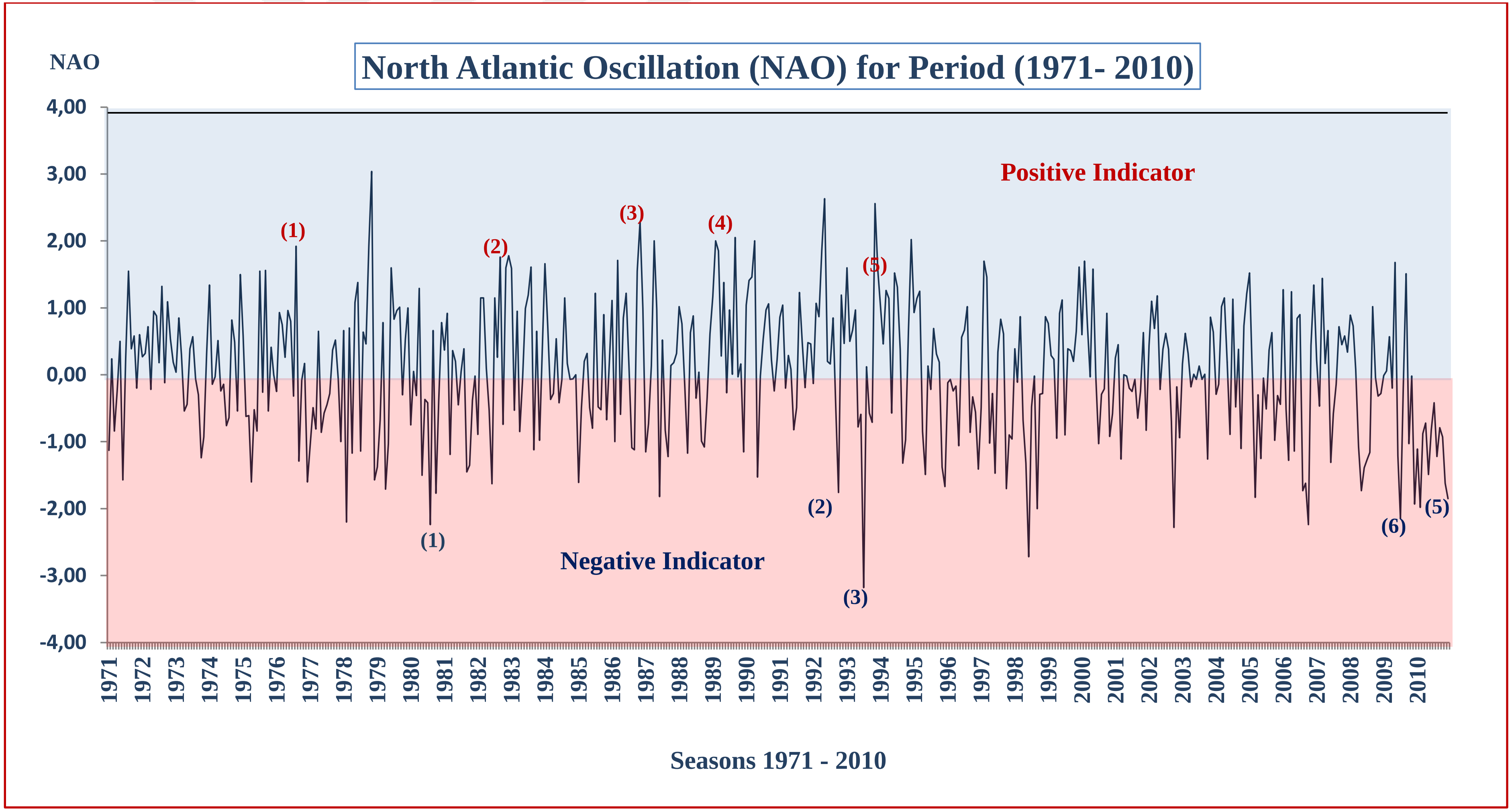
Table 106. The Relationship Between North Atlantic Oscillation Indicator and Trend Analysis Results for Seasonal and Annual

Stations	Maximum Temperatures				Minimum Temperatures				Average Temperatures				Precipitation			
	Spr.	Sum.	Aut.	Win.	Spr.	Sum.	Aut.	Win.	Spr.	Sum.	Aut.	Win.	Spr.	Sum.	Aut.	Win.
AGDABIA	×	×	↑ (1989) Sep. 2.05	×	×	×	×	×	×	×	×	×	×	×	↑ (1989) Sep. 2.05	↓ (1991)
ALFATAIAH	×	↓ (1993) Jul. -3.18	↓ (1990)	×	×	×	×	×	×	×	×	×	×	↓ (2005)	×	×
BENGHAZI	×	×	×	×	×	×	×	×	×	×	×	↑ (2010) Dec. -1.85	×	×	×	×
DERNA	×	×	×	×	↑ (1999)	×	↑ (1992) Oct. -1.68	×	×	×	×	×	×	×	×	↑ (1977)
GHADAMES	×	×	×	×	×	×	×	×	×	×	↑ (1982) Sep. 1.78	×	×	×	×	×
GHARIAT	×	×	×	×	×	×	×	×	×	×	↑ (1981) Sep. -1.45	×	×	×	×	×
HON	×	×	↑ (1988)	×	↑ (1998)	↑ (2003)	×	×	×	×	×	×	×	×	×	×
JAGHBOUB	×	↑ (1993) Jul. -3.18	↑ (1989) Sep. 2.05	↓ (2002)	↑ (2006)	×	×	↑ (2004)	×	×	×	×	×	×	×	×
JALO	×	↑ (1993) Jul. -3.18	×	↑ (2008)	×	×	×	×	×	↑ (1993) Jul. -3.18	×	×	×	×	↑ (1972)	×
MISURATA	×	↑ (1993) Jul. -3.18	↓ (1987)	×	×	×	↑ (1989) Sep. 2.05	×	×	×	↑ (1987)	×	×	×	×	×
NALUT	×	×	×	×	×	×	↑ (1981) Sep. -1.45	×	×	×	×	×	×	↑ (1973)	×	×
SHAHAT	×	×	×	×	×	×	×	×	×	×	×	×	×	↑ (1976) Aug. 1.92	×	×
SIRTE	×	×	↑ (1989) Sep. 2.05	×	×	×	×	×	×	×	×	×	×	↓ (2009) Jul. -2.15	×	×
TOBRUK	×	×	↑ (1989) Sep. 2.05	×	↑ (2004)	×	↑ (2000)	×	×	×	×	×	×	×	×	×
TRIPOLI	×	×	↑ (1981) Sep. -1.45	×	×	↑ (1994) Jun. 1.52	↑ (1986) Oct. 1.55	×	×	×	×	×	×	×	×	×
ZWARA	×	↑ (1990)	↑ (1982) Sep. 1.78	×	↑ (1998)	×	×	×	↑ (1988)	↑ (1993) Jul. -3.18	↑ (1984)	×	×	↑ (2006)	×	×

Source: Tables 92, 93, 94, 106 and URL4.

↑= There is Positive Trend, ↓= There is Negative Trend, and ×= There isn't Trend.

NAO =Positive Indicator
NAO =Negative Indicator
NAO = Weak Indicator



Source, student's work depending on URL4.

Figure 284. North Atlantic Oscillation for Period (1971 -2010)

Following conclusions can be reached through the table (106) and the figure (285):

- **Positive Indicators**

1. The effect of North Atlantic oscillation (NAO) on the increase in the trend of precipitation at SHAHAT station is observed in the summer 1976.
2. In autumn 1982, the effect on the increase in average temperature at GHADAMES and an increase in maximum temperature at ZWARA station was observed.
3. In autumn 1986, the effect was observed only on minimum temperatures in TRIPOLI station.
4. In autumn 1989,the effect on the maximum temperature was observed at AGDABIA, JAGHBOUB, SIRTE and TOBRUK stations, while on minimum temperatures at MISURATA station and there is an effect on the increased trend of precipitation at AGDABIA station in autumn.
5. In summer 1994, NAO affected only TRIPOLI station on minimum temperature.

- **Negative Indicators**

1. In autumn 1981, the effect of NAO at GHARIAT station on average temperature, at NALUT station on minimum temperature and at TRIPOLI station on maximum temperature was observed.
2. Autumn 1992 found the effect at DERNA station on minimum temperature.
3. There was a strong relationship between the (NAO) index and the maximum and average temperatures in several stations in summer 1993 including ALFATAIAH, JAGHBOUB, JALO and MISURATAon maximum temperatures, JALO and TRIPOLI on average temperature. It is worth noting that the index of (NAO) had reached (-3.18) this year.
4. In summer 2009, the effect was observed on the decreasing trend of precipitation in SIRTE station.
5. In summer 2010, theeffectwas observed on increasing average temperature at BENGHAZI station.

***Relationships between Results of Thesis and El Niño**

The Pacific El Nino-Southern Oscillation (ENSO) phenomena play a role in interannual temperature variability in many regions through the world (Hurrell, 1995),the El-Nino of the Southern Oscillation (ENSO) significantly affecting the variability over some regions in North Africa (Djomouet al., 2013).Events are defined as 5 consecutive overlapping 3-month periods at or above the +0.5o anomaly for warm (El Niño) events and at or below the -0.5 anomaly for cold (La Niña) events. The threshold is further broken down into Weak (with a 0.5 to 0.9 SST anomaly), Moderate (1.0 to 1.4), Strong (1.5 to 1.9) and Very Strong (≥ 2.0) events. For the purpose of this report for an event to be categorized as weak, moderate, strong or very strong (URL7, 2020).

- **El Niño**

1- In the season of 1972 – 1973, there was a very strong effect of El Nino, but it doesn’t affect the results of the study.

2- In the season of 1982 – 1983,avery strong effect was observed that might be related to the increasing trend in the minimum temperature in the autumn at DERNA station and on the maximum temperature in autumn at ZWARA station.

3- In the season of 1987 – 1988,a strong effect was observed that might be related to the increasing trend in maximum temperature in the autumn at HON station and increase in average temperature in spring at ZWARA station.

4- In the season of 1997 – 1998, a very strong effect was observed that might be related to the increasing trend in annual average temperatures in JALO and ZWARA stations.

5- In the season of 1997 – 1998, a very strong effect was observed that might be related to the increasing trend in annual average temperatures in JALO and ZWARA stations.

6- In the season of 2008 – 2009, a strong effect is observed but was not found associated with the results of the study.

- **La Niño**

1. In the season of 1973 – 1974, a strong effect was observed, which might be related to the increasing trend in the precipitation at NALUT station in summer.

2. In the season of 1975 – 1976,a strong effect was observed that might be related to the increase in precipitation trend at SHAHAT station in summer.

3. In the season of 1988 – 1989, a strong effect was observed that might be related with the increasing trend in maximum temperature in the autumn at AGDABIA, HON, JAGHBOUB, SIRTE and TOBRUK stations and on the minimum temperature in autumn at MISURATA station, while increase in precipitation trend in AGDABIA station in autumn.

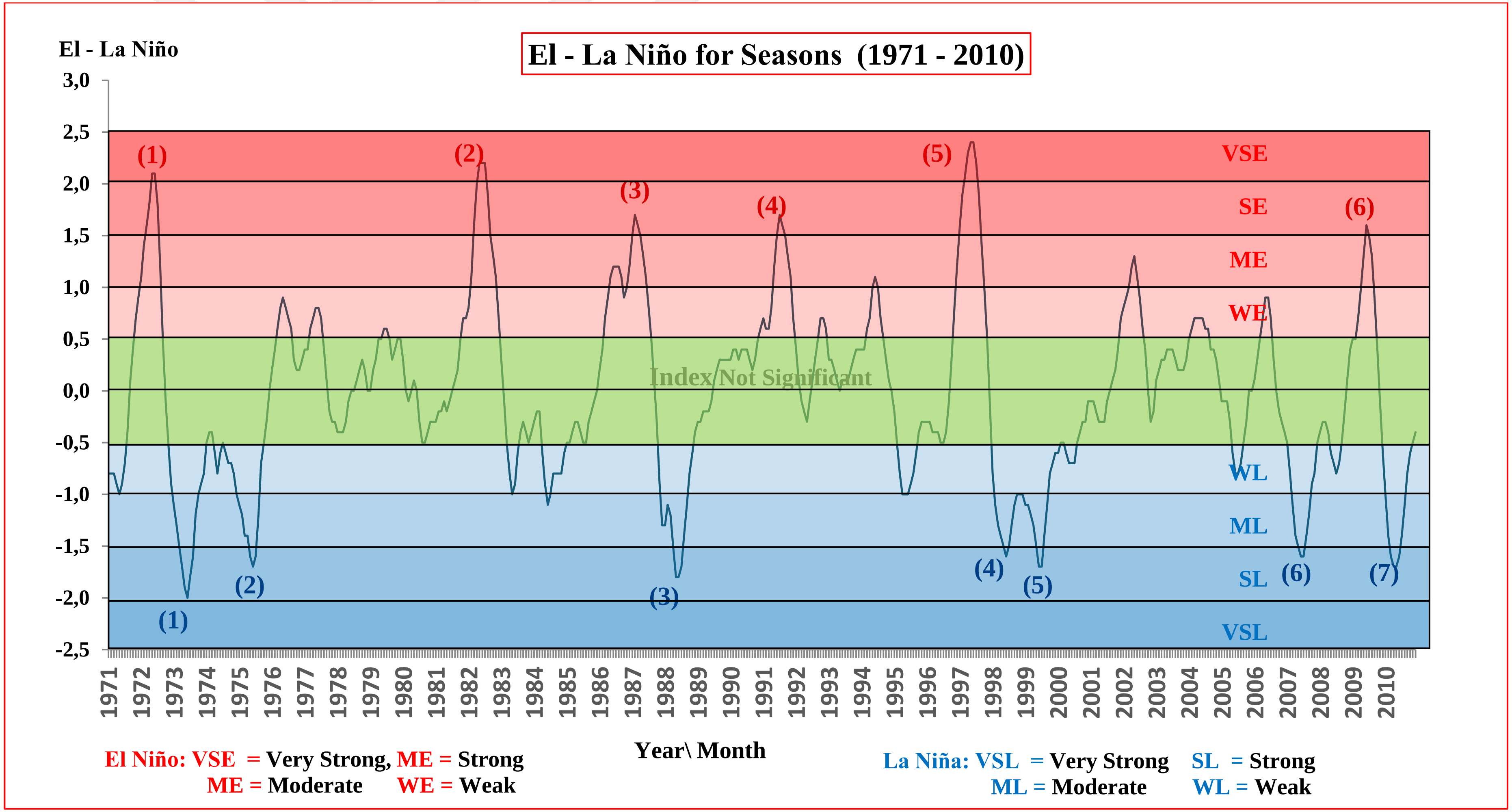
4. In the season 1998 – 1999, the El Nino index was very strong and the same result was found at DERNA, HON and ZWARA stations in the minimum temperatures during the spring season.

5. In the season 1999 – 2000, a strong effect was observed that might be related to the increasing trend in minimum temperatures in autumn in DERNA and TOBRUK station.

6. In the season of 2007 – 2008,a strong effect was observed that was related to the trend towards an increase in maximum temperatures in winter at JALO station.

7. In the season 2010 – 2011, there was only a trend towards an increase in average temperatures in winter at BENGHAZI station.

It is noted that in some years the El Nino indicators were strong but did not affect the trends of many stations and conversely, some stations showed strong trends in some years in which the El Nino indicators were weak (Tables 92, 93, 94, 106 and Figure 286).



Source, student's work depending on URL5.

Figure 285. El Niño & La Niño for Period (1971- 2010)

***Another Causes of increases Temperature and variability Precipitation in northern Libyan**

Increases Temperature, the interannual variability of temperature in the North Africa region is complex and controlled by many factors (Balas, 2007).Changes in the state of the climate system can occur due to natural reasons that are external (e.g. variation in the solar out puts and suns pots) and/or internal (e.g. atmospheric compositions, atmospheric-oceanic oscillations and volcanic activity). (Houghtonet al., 2001) has suggested that natural climate change factors probably increased during the first half of the 20th century. The reconstructions of climate during the 20th century indicate that the direct effect of variations in solar radiation over the last 10 decades was about 20-25% of the observed change while the rest were resulting from increases in greenhouse gases. (Pidwirny, 2004) has suggested that 1% change of solar output constant caused a change in equilibrium temperature of about (0.6 °C). (Joneset al., 2001) showed that the relationship between global annual temperature and sunspot number data over the 20th century is varied with changes in temperature which was higher during the first half of the 20th century (1901-1950) relative to the second half (1951-2000).

Overgrazing in semi-arid areas leads to increased rates of albedo (shortwave radiation as the fraction of the solar energy reflected from the earth back into space). The uncovered land have a greater irradiative heat loss than adjacent vegetated areas as it reflects more sunlight compared to the vegetated land in the forms of crops, grasses and trees (Barry, 1977). This situation leads to changes in climate which may further influence climatic parameters (temperature, precipitation).

According to the Technical Centre of Environmental Protection (TCEP, 1998), about half million ha were cleared during the period 1980-2000 in different regions in north of Libya (particularly around TRIPOLI, MISURATA and Green Mountain) for seasonal irrigated plantations. Regional urbanization and industrialization are also believed to be more influential on regional temperature than the global warming from 1951-2000 (Chung, 2004). However, the effects of urban heat islands on temperature and precipitation are found very weak in Libya.

Latitude, altitude and land–sea distribution are the main physical and geographical factors controlling temperature and they seem to play a noticeable role to explaining variability of temperature in Libya (Al-Jadide, 1985 and Ageena, 2002). The changing composition of the atmosphere, including greenhouse gases and aerosol content, is a major internal forcing mechanism of climate change.

In developed countries, carbon derivatives, sulfur derivatives, nitrogen derivatives and non methane volatile organic compounds emitted to the atmosphere by between years 2000 and 2007 showed a decline in the general total (Coşkun, 2011). Despite that, these countries still suffer from breakthroughs in the proportion of carbon dioxide, as is the case in the study area, the amounts of aerosols in the atmosphere produced by human activities can change the climate through changing the chemical and microphysical properties of clouds which absorb solar and infrared radiation. Total emissions of carbon dioxide (CO2) have sharply increased in Libya, particularly during the last 30 years (1980-2010), with an increase from 83,214,246 tons in 1980 to 133,452,660 tons in 2009, a probable function of the expanding petrochemical and oil production in the country over the period. A positive (high) correlation is found between emissions of CO2 and mean annual temperatures for the different regions, with values ranging from 0.36 to 0.84, with six cases exceeding 0.50. Some of the most rapid increases are observed in the sites near large oil fields and exports centers e.g. AGDABIA and ZWARA (Ageena, 2013).

No clear evidence about the relationships between population increase and temperature is observed through trend analysis. The study area includes the most populated cites, where 40% of Libya's people resided, with the total population of TRIPOLI (1,063,571), BENGHAZI (674,951) and MISURATA (543,129). Increasing emissions of CO_2 since the early 1970s have had a pronounced effect on temperature increases at some stations near oil refineries and petrochemical industries such as AGDABIA, SIRTE, and ZWARA.

Variability of Precipitation, global precipitation has increased significantly by approximately 2% during the 20th century (Folland, 2002). (Mosmannet al., 2004) haveidentified rates of increase between 7% and 12% for the areas lying between 30–85° N latitude and by about 2% for the areas lying between 0–55° S. On the other hand, a pattern of continuous aridity since the late 1960s has been observed over the western parts of North Africa and South of the Sahara since the 1980s which includes a large area of Libya (Folland, 2001 and Ageena, 2013). Is generally characterized by high temporal and spatial variability, which can partly be explained by changes in atmospheric circulation (Xoplakiet al., 2003). It is expected to affect fluctuations in the hydrological cycle including increases/decreases in precipitation, geographical distribution of precipitation and droughts. Relationships between precipitation indices for the different stations in North Africa (Morocco, Algeria, Tunisia, Libya and Egypt) and large scale atmospheric circulation patterns including the North Atlantic Oscillation (NAO), Western Mediterranean Oscillation (WEMO), Mediterranean Oscillation (MO), El Nino and Southern Oscillation (Tramblayet al., 2013andAgeena, 2013). He has identified decreases in total precipitation and wet days with an increase in the duration of dry periods (Meddi, 2010), has also identified a decrease in total annual precipitation in northwest Algeria after 1970 and related this to the El Nino Southern Oscillation (ENSO) index.

These findings are supported by (Al-Hamlyet al., 1998) as he has observed an increase in dry years after 1970 in Morocco and identified a relationship with positive NAO phases. The relationship between North Atlantic Oscillation (NAO), El Niño Southern Oscillation (ENSO), Southern Oscillation Index (SOI) and local precipitation are well studied (Philander, 1990; Hurrell, 1995; Jones et al., 1997; Houghton et al., 2001; McCarthy et al., 2001, andDjomou et al., 2013).

In general, changes of ENSO in recent decades are replicated in precipitation variations throughout the world, particularly over the tropics and sub-tropics regions (Houghton et al., 2001). (McCarthy et al., 2001) suggested that the NAO is the most responsible factor for inter-annual fluctuation in precipitation over the Northern Africa (Ageena, 2013). with high correlations for a few cities across Libya. In comparison, weakly negative links between SOI and annual and seasonal precipitation has been found at three cities in Libya (Ageena, 2013).Changes of temperature and its effect on air masses-movements and air pressure circulation are one of the important impacts on changes in global precipitation (Ritter, 2003). The study has revealed a number of results; which following are the most important No clear links between precipitation and temperature in north of Libya are identified with a mixture of negative and positive correlations while negative correlations only found at a small number of stations with 95% confidence level(Ageena, 2013).

5.5. Climatic Relations Between Some of Previous Studies in Mediterranean Basin and Results of Thesis

The results are also compared with the findings of previous studies over the last half of the 20th century which examined spatial and temporal variability in local and regional precipitation in Mediterranean sea and North Africa.

Analysis of mean average temperature data of 40 years (1971-2010) has shown significant increases (0.9 °C) with a doubling of the warming rate (1.7 °C) at most stations for the last 12 years (1998-2010 Tables from (33 to 48). As a result a rapid increase in annual maximum and minimum temperature is observed and the overall mean value shows upward trend. This finding agree with that of (Al-Kenawy, 2012) who has found that mean average temperature in north-eastern Spain is mostly increased during the period 1920-2006 resulted from the increase in maximum temperatures, especially in spring and summer.

Also study of (Philandraset al., 2008) identified decreasing trends since the early 1960s until the mid-1970s across Greece, they found that contribution of summer in increase annual averages temperatures is unquestionable, also (Domroes, 2005) have found negative trends in maximum temperature observed across Egypt for period (1971–2000), whine examination of annual average temperature for the study period (1971- 2010) an increase is identified which is statistically significant (95% confidence level) at most stations, this corroborates the concerns of rapid global warming and its impacts in this region. These results are consistent with previous regional and local research (Ben-Gaiet al., 1999 andDomroes,2005), which showed a significant increase in temperature of different regions across the Mediterranean basin.

In study in North of Algeria for period (1973- 2015), in most of the eight stations the study has brought to light an increase in average temperature monthly, seasonal, and annual average temperatures (Nia, 2018). and the study did not show the results of the trends of minimum and maximum temperatures, this increase is caused by an increase in the maximum temperature, and looking at the results of previous studies in that region, can be noted that increase in annual rate results from the increase in the maximum temperatures, and this is what is shown by a study (Ramos, 2006 and Al-Kenawy et al., 2012), who has found that temperatures in north-eastern Spain is mostly increased during the period 1920-2006 resulted from the increase in maximum temperature (North-eastern Spain).

(Nashwan, 2019),the results showed a large difference between the trends obtained using Mann Kendall test. the test showed increasing trends in maximum temperature and a number of minimum temperatureat stations of Egypt, but almost no change in rainfall and rainfall extremes.

(Maged, 2016), in Egypt, magnitude of climate change i s illustrated to increase over the period 1970– 2010, i.e. annual mean temperature increased from (0.98 °C) at Alexandria to (1.68°C) at Cairo. Seasonally, the highest warming trends were observed for summer temperatures and also increasing temperature trends detected with different magnitude in the remainder seasons. This research is the closest to the results of the study, because the time series was (1970 - 2010), as researchers used (Mann-Kendall) to trend analysis. Also at (Cosun, 2008), in Kahramanmaraş, Turkey, Mediterranean Sea region, have found most increase in maximum temperature, and average temperatures. However the results are not statistically significant because (p) value is higher than (Alfa) level.

(Fontaine, 2011), this study have identified a slight general increase in North Africa since the mid-90s with significant northward migrations of rainfall amounts. The findings are supported by (Yosefet al., 2009) who found an increased trend in total annual rainfall across Israel for the period 1950-2003. However, Al-Tantawi, 2005 identified positive trends (0.170 mm) in annual precipitation computed at most of study stations observed during the period 1971-2000, this result is not consistent with the results of study of (Meddi et al., 2010) which as they have observed decrease in total annual rainfall for the north-eastern Algeria after 1970.

In Europe (Moberg, 2005) they identified significant increasing precipitation trends over the 20th century in winter, based on about 80 stations situated in Central and Western Europe during the period 1901-1999, with low precipitation trends in summer.Afterwards (Boccolari, 2013) have found decreases in precipitation trend (-6.33 mm) over Modena in Italy during the 1831-2010. A general decreasing trend (-2.32) in mean annual precipitation for the 26 years (1979-2004) with increase in trend in parts of central and northern Greece have been identified by (Hatzianastassiou, 2008). Moreover, the (IPCC, 2007) report illustrated that the linear trends of rainfall decreases for 1900 to 2005 in western Africa.These findings are supported by (Meddi et al., 2010) as they have observed decrease in total annual rainfall for the north-eastern Algeria after 1970.

Negative precipitation evolution in the western parts of Northern Africa with no significant precipitation trends have been observed in central Tunisia Mediterranean , and the Mediterranean parts of Libya and Egypt, during the last decades (Schillinget al., 2012). During the 20th century, general decrease in total annual rainfall has been found in Turkey, and apparently during the 1930-1993, none of the decreasing trends in precipitation were found significant. About 19% of total stations showed a significant trend with majority of these trends are downward especially in Mediterranean Sea stations (Türkeş, 1996).

5.6. Recommendations

*****Work to increase the number synoptic stations, and improvements to data completeness, standard of stations and operating procedures along with regular training provision to operational station meteorologists is necessary to raise the efficiency and performance of Libyan meteorological stations.

*The statistical tests used in the study show that during the 40-year period, winter and autumn rains have a decreasing trend in coastal stations. Considering that rain waters are used for storage in soil and agricultural irrigation in dry seasons, the decrease in winter rainfall may cause problems in terms of agricultural area which are decreasing in the long run. Therefore, some measures should be taken to eliminate or reduce the negative impacts of climate change on our country which is reflected by the low rainfall, and increased temperatures. The most important of these measures is the establishment and implementation of plans for water resources management.

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CURRICULUM VITAE

Mahmood Soliman was born in 02-05-1975 at Tobruk city in the northeastern of Libya. He received his elementary education from Al-Manar School in Tobruk. He completed his middle school from Al Majd School, then the secondary education from Al-Bayan School in Kambut located in eastern of Tobruk. Then he moved to study at the ‘Higher Institute for Teacher Training’ in Tobruk in 1996,then he obtained his bachelor’s degree from the Faculty of Arts and Education, Department of Geography, Omar Al-Mukhtar University in the academic year 2001-2002. In November 2007, he moved to study master program at the Institute of Arab Research and Studies of the League of Arab States, Cairo, Egypt, and he obtained a master with an excellent grade in Department of Geography in October 2010. After that, he was appointed as a faculty member at Omar Al-Mukhtar University-Tobruk branch. In 2013, Omar Al-Mukhtar University and Libyan Ministry of Higher Education chosen him to study Ph.D. In Turkey in September 2013. Finally, in 08-01-2020 he completed hisdoctoratestudy at Karabük University, Department of Geography, specializing of Physical Geography.