İSTANBUL TECHNICAL UNIVERSITY ★ INSTITUTE OF ENERGY

EVALUATION OF TURKEY'S GEOTHERMAL POTENTIAL: DEVELOPMENT OF TURKEY'S SUBSURFACE TEMPERATURE MAPS USING INTERPOLATION TECHNIQUES

M.Sc. Thesis by
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Programme : **Energy Sciences and Technologies**

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MAY 2009

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Date of submission : **04 May 2009**
Date of defence examination: **01 June 2009**

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MAY 2009

FOREWORD

First of all, I have special thanks go to Ass. Prof. Dr. Metin Mıhçakan and Prof. Dr. Metin İlkışık for their generosity. My study is mainly constructed on their studies and their data sets.

I would also like to thank my advisor Prof. Dr. Abdurrahman Satman and E. Didem Korkmaz Başel for their encouraging advices, their comments on the manuscript and making me question scientific background of the study on every level. Thanks to Pelin Çivisöken for technical help on printing this thesis.

Very special thanks go to my family, for their support mentally and financially during all my study years and showing me the value of hard work.

May 2009

Mehmet Kağan Çakın
Petroleum and Natural Gas Engineer

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ABBREVIATIONS

IDW **:** Inverse Distance Weighting
GIS **:** Geographic Information Systems
PE **:** Prediction Errors
NST **:** Normal Score Transformation
ASE **:** Average Standard Error
RMS **:** Root Mean Square
RMSS **:** Root Mean Square Standardized

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ÖZET

TÜRKİYE'NİN JEOTERMAL POTANSİYELİNİN DEĞERLENDİRİLMESİ: ENTERPOLASYON TEKNİKLERİ KULLANILARAK TÜRKİYE'NİN YERALTI SICAKLIK HARİTALARININ OLUŞTURULMASI

Bu çalışmada Türkiye'nin yeraltı sıcaklık haritası jeoistatistik yaklaşımlar (Ters Uzaklık Ağırlıklı Arakestirim Tekniği ve Kriging) kullanılarak oluşturulmuştur. Bu yaklaşımlarda iki ana veri grubu kullanılmıştır.

İlk olarak veri gruplarında bulunan jeotermal gradyan (^{o}C/100 m) ve ısı akısı (mW/m2) değerleri -500 m deki sıcaklık (^{o}C) değerlerine dönüştürülüp kullanıma uygun hale getirilmişlerdir. -500 m deki sıcaklık değerlerinin alınmasının sebebi -50 m ye kadar olan topografik etkilerin engellenilmesinin istenmesidir.

İkincil olarak, bu iki veri grubu, Arc Map yazılımının Jeoistatistiksel Analiz paketi kullanılarak istatiksel analizler yapılarak irdelenmiş, veri dönüşüm teknikleri ile şekillendirilmiştir. Böylece, iki veri grubunun birbiriyle ilişkisi incelenebilmiş ve göreceli olarak gerçeği yansıtma eğilimleri gözlenebilmiştir. Ayrıca, yapılan uygulamaların doğruluk dereceleri ve Türkiye'nin jeolojik eğilimleri gözetilerek farklı yaklaşımlar kullanılmıştır. Bu şekilde, Türkiye'nin yeraltı sıcaklık haritası oluşturulmuştur.

Son olarak, derin kuyu verilerinin çoğunlukla Trakya ve Güneydoğu Bölgelerinde bulunmasından dolayı aynı çalışma bu bölgelerde yerel olarak yapılmıştır. Bu sayede, sadece derin kuyu verilerini kullanarak –1000 m Güneydoğu Anadolu ve Trakya Bölgelerinin yeraltı sıcaklık dağılım haritalarının oluşturulmuş ve değerlendirilmiştir.

Bu çalışma yapılırken tahmin hata değişkenleri gösterge değişkeni olarak kullanılmıştır. Bu sayede, yaklaşımın doğruluğu test edilirken, model değişkenleri kontrol edilmiş ve diğer uygulamalarla karşılaştırılmıştır.

SUMMARY

EVALUATION OF TURKEY’S GEOTHERMAL POTENTIAL: DEVELOPMENT OF TURKEY’S SUBSURFACE TEMPERATURE MAPS USING INTERPOLATION TECHNIQUES

In this study, Turkey’s geothermal map was created with two geostatistical approaches: Inverse Distance Weighting (IDW) and Kriging. These two approaches are fed from two main datasets. First of all, the data sets having geothermal gradient values ($^oC/100$ m) and heat flow values ($mW/^{m2}$) were reformed into temperature (^oC) values at -500 m. To eliminate the topographical effects on temperature gradient that can be effective down to -50 m, the deeper level (-500 m) was chosen.
Secondly, by using Geostatistical Analysis package of ArcMap software, two datasets, which were analyzed statistically, shaped with Data Transformations and Declustering to prepare data for kriging interpolation. Thus, the correlation between different backgrounded data sets is investigated and relatively their tendency to real world tested. Finally, considering the sensitivity of applications and Turkey’s geological trends, by using Inverse Distance Weighting, Kriging and Co-kriging Interpolation techniques, Turkey’s geothermal maps representing different approaches are constructed. In this construction process, best approach is chosen by considering iteratively optimized values of Prediction Error (PE) values.
In addition, same methodology is locally applied on deep well temperature data in which clustered on specific regions (Southeast Anatolia and Thrace Regions). Temperature distribution local maps of these regions are constructed and determined for –1000 m considering dominated deeper well data.
In this study, Prediction Error values are used as indicator parameters. In this way, while testing accuracy of the applications, modeling parameters can be controlled and applications can be compared with each other.

1 INTRODUCTION

By the reinforcements of financial circumstances and technological progress, in recent years, demand and abilities for analyzing and modeling of geological structures have improved dramatically. In these examining processes understanding and determining parameter behaviors are prior and crucial. Among these parameters, temperature is one of the most operative ones with its "indicator" properties. Consequently, determining temperature distribution along a region gives important hints about geological aspect, which is also functional for examining energy and raw resources and seismic behaviors.

Likewise, for earth sciences, because of their complexity, collecting data as much as possible is necessary and compulsory to characterize the temperature distribution beyond analytical approaches. Accordingly, nowadays, multiple researches are basically focused on temperature data collection methods with the aim of mapping geothermal distribution. But in mapping, the data are never entirely enough to define the distribution along the region. By considering the data distribution and positioning of the data in space, correlation between the data, the data sets, and their accuracy, data may constitute the siluet of the picture. Consequently, the siluet, which is an engineering approach, is the combination of geological trends (the trends of other parameters that affects temperature), with standardized geostatistical models.

1.1 Purpose of the Study

In this study Turkey's and two regions of Turkey (Thrace and Southeastern Anatolia) subsurface temperature distribution maps were constructed by using revised data and improved software. The aim of this project is to make a different approach by combining datasets having different backgrounds on determining of geothermal potential of Turkey.

Therefore, the accuracy and quality of different backgrounded data can be tested and importance and functionality of geostatistical methods in geo-sciences may be revealed and emphasized. Moreover, this research is made inherently to be a reference on earth sciences along the same path for studies in Turkey.

1.2 Literature Survey

In recent years, a number of researches have examined regional geothermal distribution. Studies are mainly focused on two parts: data collection and mapping with interpolation techniques. According to having and using facilities and methods for data collection; geophysical, geochemical, geological and well temperature aspects are considered. Mapping is the approaching part of researches having optimum results. Different interpolations can be chosen for desirable approach.

Studies can also be found from using data sets coming from different backgrounds aiming to explain same purposes or to test correlation between each other. Kriging and co-kriging are suitable tools for dispersed outlandish along a volume. Most of these studies are applied to identify contamination of region by indirect measurements. Jang and Liu [5], Yalçın [10], Romney [8] and Zawadsky [11] are good examples of those kriging and co-kriging applications having datasets with different parameters, amounts and measurements. Because, geothermal distribution is emerged as a combination of fluid dynamics and tectonic structures having complex dispersion character that looks suitable to be tested with Kriging.

There have been several studies done on temperature gradient distribution and heat flux mapping of Turkey. Recently Mıhçakan et al [6]. and İlkışık [4] made wide researches focused on collecting data. Besides, Mıhçakan et al [6]. also used kriging interpolation for surface generation to create Turkey‘s geothermal temperature gradient distribution map.

1.3 Concepts used in Arc GIS

Arc GIS is the name of geographic information systems (GIS) commercial software package produced by software development company ESRI[1]. For this study, Arc Map Geostatistical Analyst of Arc GIS software package is used for mapping, data and geostatistical analysis. Methodology used in the software for this study is shown below (Figure 1.1) in the diagram and explained in detail in Appendix A:

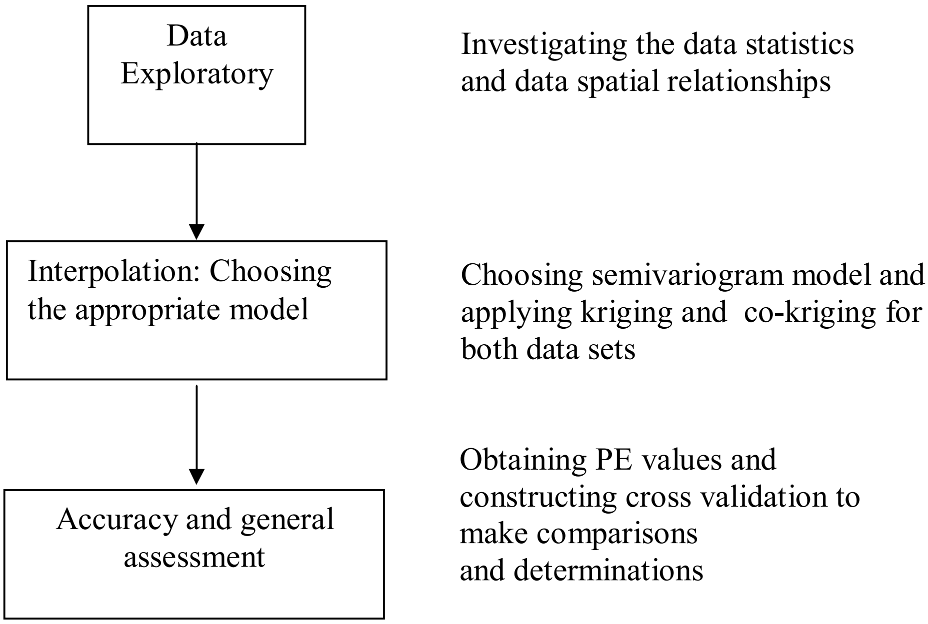


Figure 1.1: Diagram of Kriging Application.

2 DATA EXPLORATORY

2.1 Data Collection

2.1.1 Data Set 1

During this study, data in temperature values (^{o}C) at -500 m are chosen and examined. They are divided into two groups by considering their references and generation processes for data analysis and mapping. First data set, which is also called Data Set 1 (Table B.1) in this study, was collected from petroleum, natural gas and geothermal wells and processed in Mıhçakan et al [6]. and Taşçı [9]. The second one was constituted in İlkışık's study [4] which is based on geochemical analysis methods for determining geothermal gradients. In this study, this data set is called Data Set 2 (Table B.2).

Nonetheless, all chosen data were converted into temperature values at -500 m depth from measured temperature values at their measurement depths. Surface depth z1 is taken as 0 m. In addition, the surface temperature value is assumed to be 15 ^{o}C in average. Using surface temperature and deep well bore temperatures, geothermal gradient values are calculated (Equation 2.1). Then with the chosen depth (in this case - 500 m), subsurface temperature values are obtained.

$$dT / dz = (T_2 - T_1) / (z_2 - z_1) \quad \textbf{(2.1)}$$

where:

T_1 : Surface temperature (^{o}C)

T_2 : Measured temperature (^{o}C)

z_1 : Surface (m)

z_2 : Measurement depth (m)

dT / dz : Geothermal gradient ($^{o}C/m$)

While Data Set 1 was constructed, data taken from same petroleum or natural gas fields, have temperature values with varying depths. Thus, representative well bore temperatures from wells of fields are chosen by using best fit curve approach.

The data set with mostly deep temperature values and not having been affected from surface inconsistencies is very important for accuracy and margin of measurement error. However, considering the fact that most of the petroleum and natural gas fields are found in southeast and northwest of Turkey, the data have an irregular dispersion (Figure 2.1). Most of the Data Set 1 values are clustered in those regions. Thus, in later cases those regions will be analyzed locally. Furthermore, when determining together with the petroleum and natural gas fields' data, measured data from geothermal fields display marginal values on statistical distribution curves. With the help of geostatistical analysis and another data set, those disadvantages for well done interpolation are aimed to be smoothed.

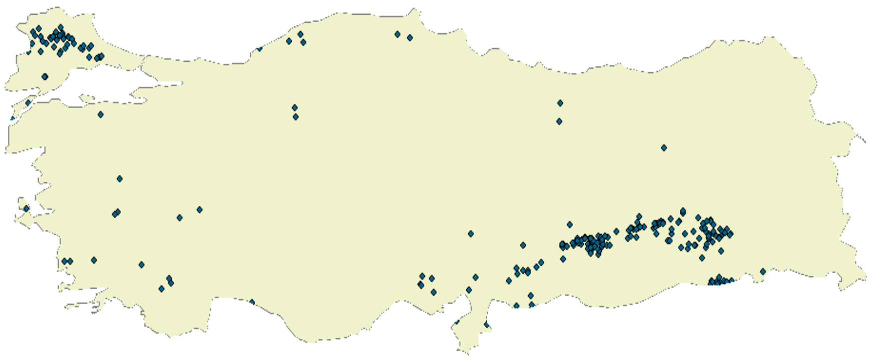


Figure 2.1: The Dispersion of Data Set 1 throughout Turkey.

2.1.2 Data Set 2

This data set is collected and processed by İlkışık [4]. Unlike Data Set 1, in Data Set 2, the data are obtained by Silica Geochemical Method. In this method, basically, the amounts of silicate in thermal waters taken from wells are examined and heat flux values are obtained. Geothermal gradient values which are used for calculating -500 m temperature values are obtained from surface temperature To (^{o}C), heat flux q (Wm^{-2}), geological structure's heat conductivity values K (Wm-1C-1) and depth z (m) by using Fourier's Law (Equation 2.2) and Bullard's Method (Equation 2.3). Accordingly, by these formulations temperature values at - 500 m can be obtained. K value is assumed to be 3 Wm^{-1}K^{-1} along earth crust. [4]

$$q = - K (dT/dz) \quad \textbf{(2.2)}$$

$$T(z) = To + q. \Sigma (\Delta zi/Ki) \quad \textbf{(2.3)}$$

The Data Set 2 is distributed relatively homogenously along Turkey Map (Figure 2.2). However, the data mostly taken from shallow water wells, and consequently, heat flux values are unguarded against topographical effects such as underground water behavior. While calculating deep temperature values, increase of deviation from reality will be considered.

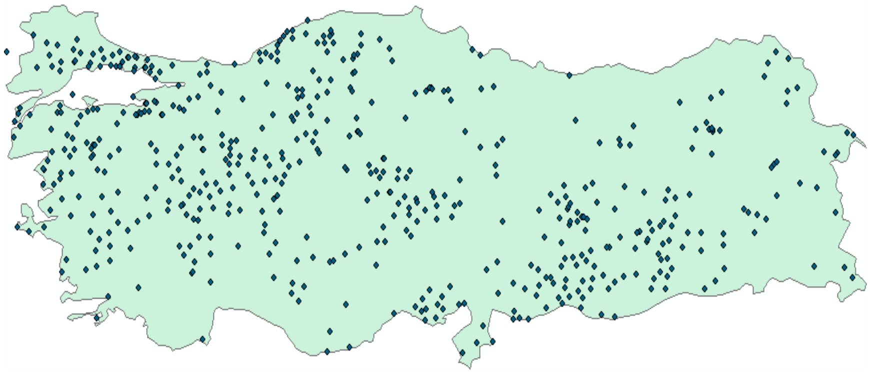


Figure 2.2: The Dispersion of Data Set 2 throughout Turkey.

3 SPATIAL DATA ANALYSIS

3.1 Data Analysis

3.1.1 Data Set 1

As mentioned before and shown in Figure 2.1, the data are clustered mostly in the north-western and south-eastern regions of Turkey. There is a clear disconnection between these data clusters, which is caused by lack of data. So, data in clusters have their own variations which are correlated with each other (auto-correlation). Non-uniform data collection is expected to ruin the shape of histogram curve of Data Set 1, excluding the effects of geological and instrumental deviations on measurements of data values. Besides, in comparison with dyed columns in histogram and dyed points in map, effects of outliers, which represent data having very high or low values, and effects of deviations from the body of distribution are mostly observed from data on geothermal fields in Aegean Region (Figure 3.1). The existence of outliers causes deviations from body distribution in interpolation applications. This outlier effect can be seen in Figure 3.2. The table on the upper right corner gives number of data points (count), minimum, maximum, median and standard deviation and other relevant statistical properties of Data Set. But in this case, outliers mostly have geothermal origin and so, could not be ignored. In the applications, outliers were accounted as much as possible.

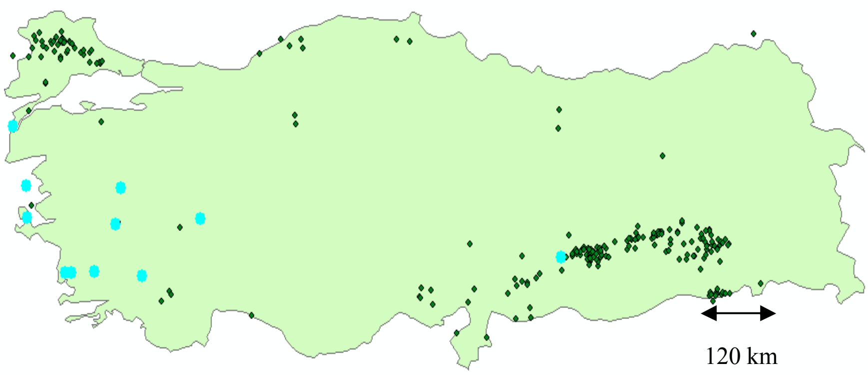


Figure 3.1: Outliers in Data Set 1 dispersed along Turkey map.

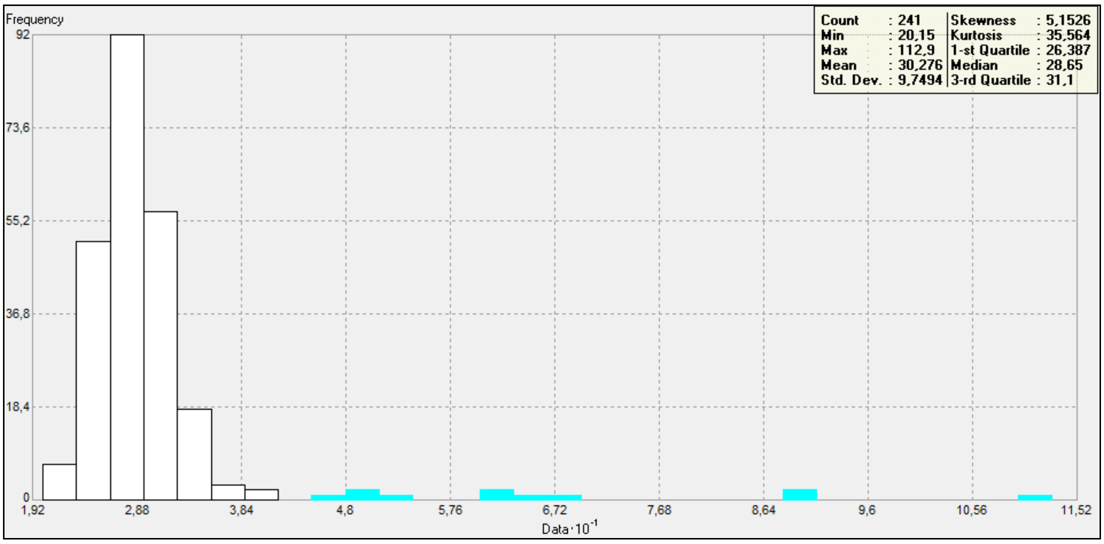


Figure 3.2: Histogram of Data Set 1.

3.1.2 Data Set 2

Data Set 2 is homogenously sparsed along the Turkey Map. Data are constructed left-skewed distribution. For a better kriging approach data should be normally distributed [8] (Figure 3.3). Accordingly, transformation is necessary.

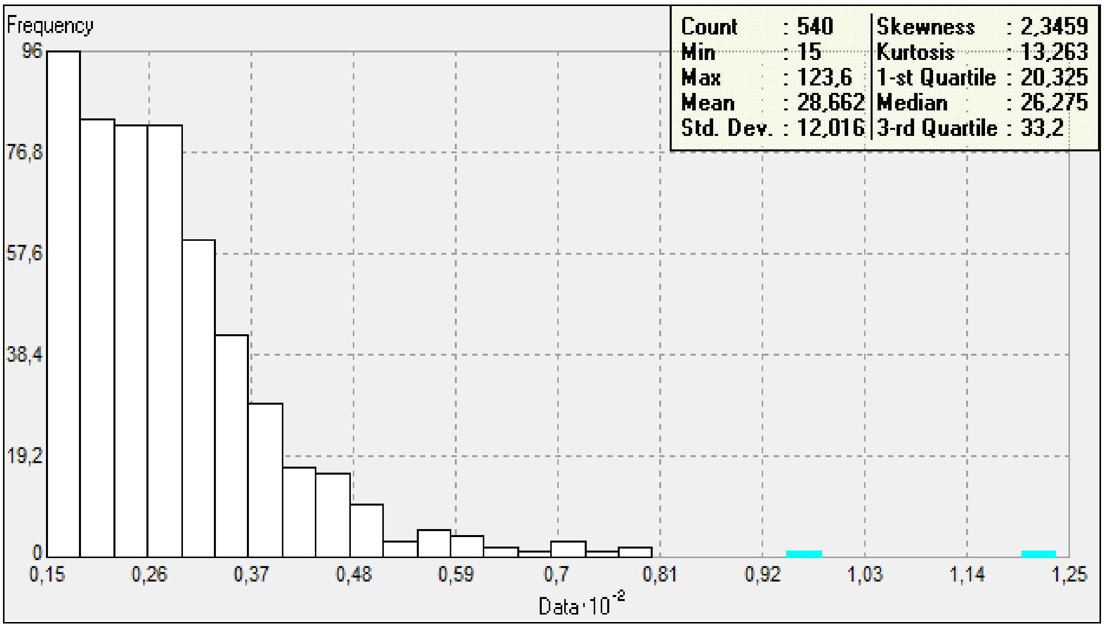


Figure 3.3: Histogram of Data Set 2.

3.2 IDW Interpolation on Turkey Map

3.2.1 Applying IDW on Data Set 1

In IDW, the map is created directly depending on Data Set 1 values without considering spatial relationships. Furthermore, to provide a continuous surface along the map, gap regions are examined and processed using Neighborhood Searching Method shown in Figure 3.4 (explained in detail in Appendix A-2). Especially, data in Central Anatolia Region are clearly missing. Eleven neighbors and one sector shape type are chosen by optimizing prediction error values. In addition, unitless power value that adjusts the raising proportion of the weight against inverse distance[9] is found 1 with the same optimization parameter values. On the upper right side of the Figure 3.4, neighborhood points are dyed, according to their weight degrees to affect a prediction location at the center of the circle.

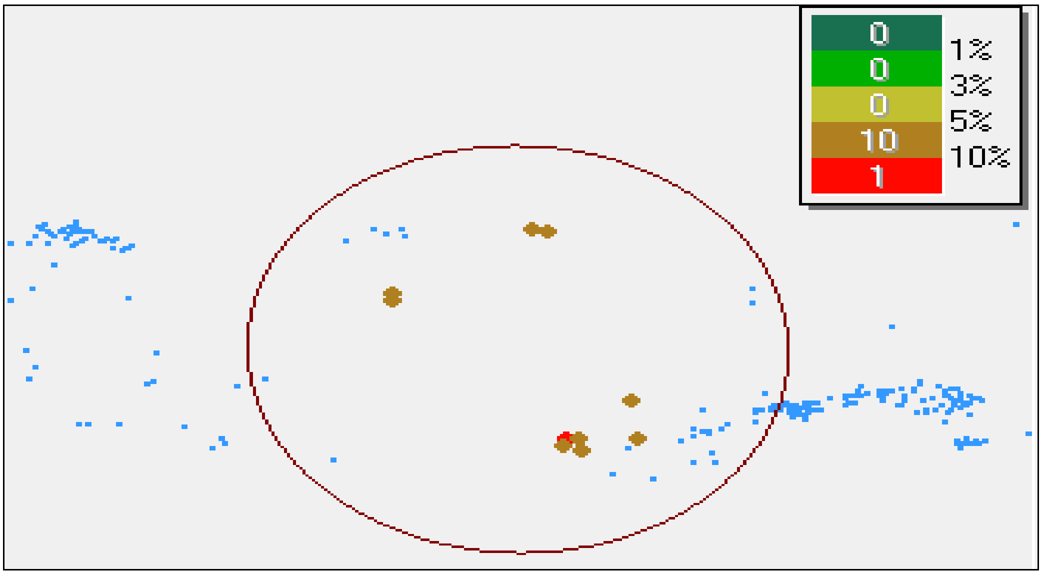
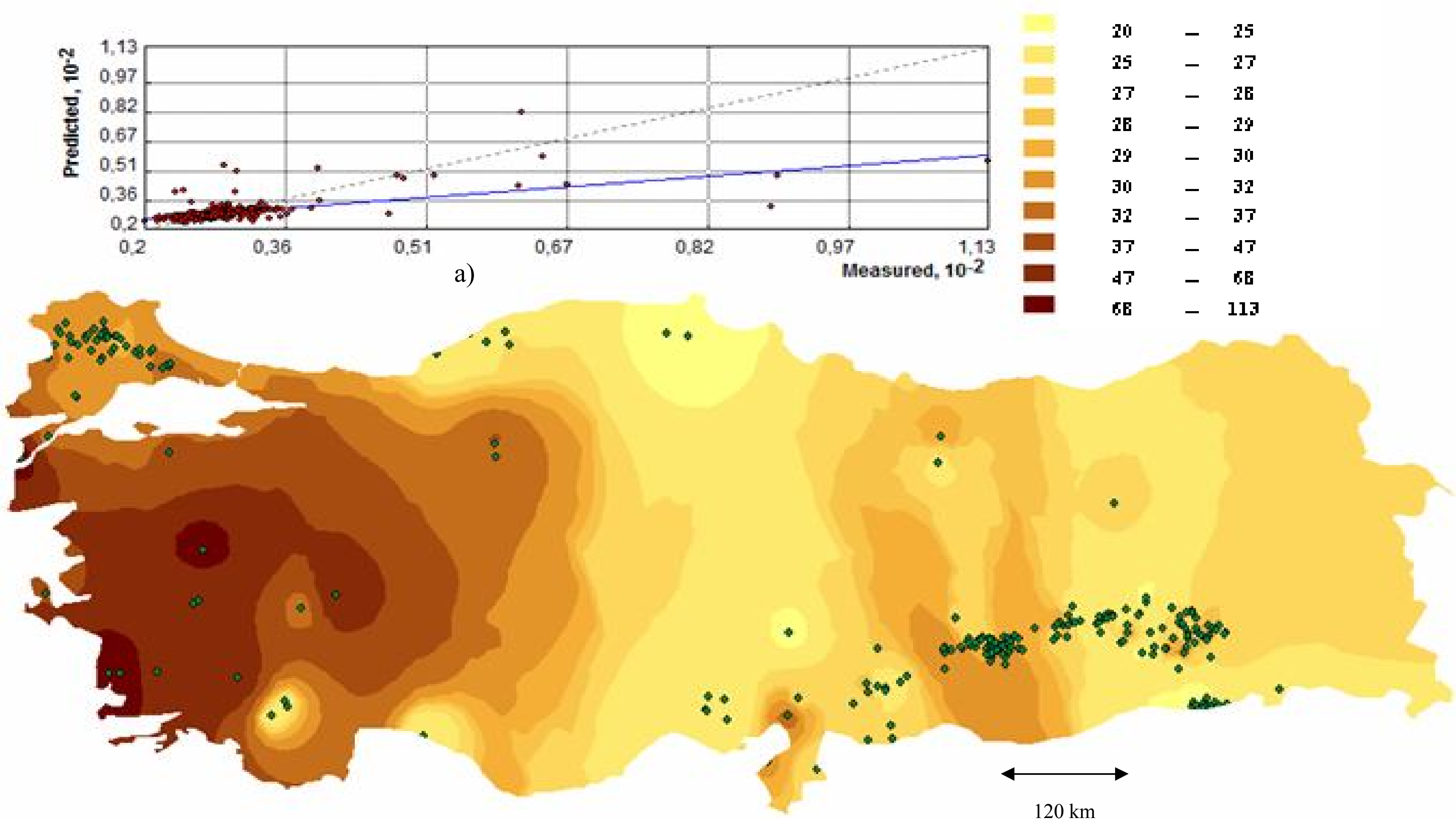


Figure 3.4: Application of Neighborhood Searching Model on IDW of Data Set1

After neighborhood searching, IDW interpolation generate temperature distribution map at -500 m as shown in Figure 3.5. The optimized prediction error values and comparison between measured data line and predicted data are shown in Figure 3.5 with their regression line having 0,361. x + 18,37 at the top of the map. Ideally, if the character of predicted data is similar to the measured ones, regression line would approach to 0,5 slope value. In this case, the regions, in which most of the data are gathered, look well matched. RMS value is found to be 7,389 that will be used as a comparison factor in later.



b)

Figure 3.5: a) Temperature Distribution Map (-500 m) using IDW Interpolation b) Cross-Validation of IDW for Data Set 1.

3.2.2 Applying Inverse Distance Weighting (IDW) on Data Set 2

Comparing to dispersion of Data Set 1, Data Set 2 does not have large gaps between data points. But, in the Central Anatolia Region there are more scarcely distributed points than other regions. Consequently, as in Data Set 1, neighborhood searching is necessarily applied in the middle of Turkey (Figure 3.6). 15 neighbors are used with four sector shape and 1 power value.

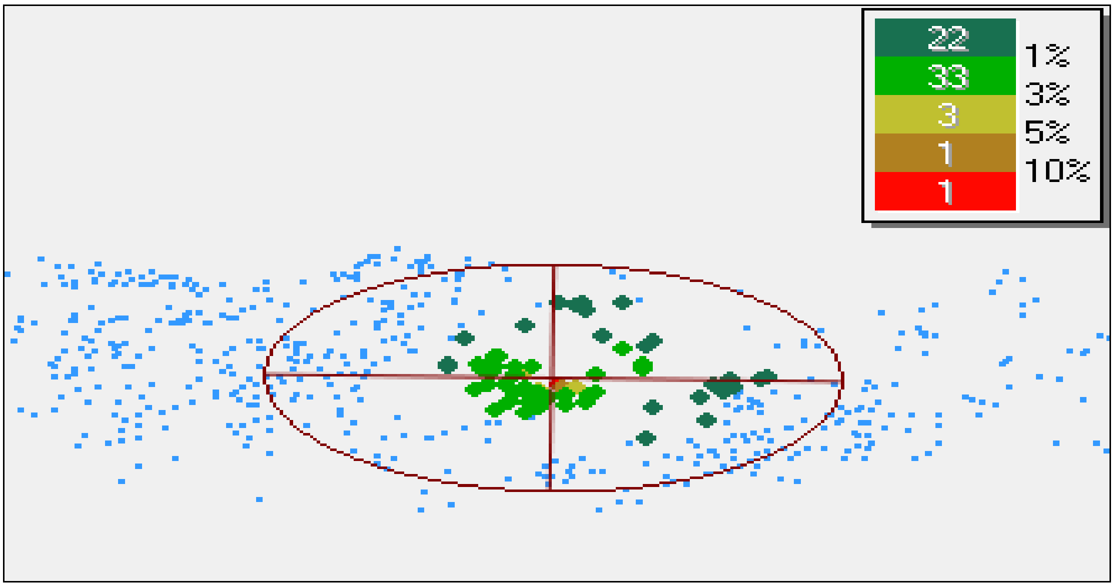


Figure 3.6: Neighborhood Searching of Data Set 2.

After neighborhood searching, IDW interpolation generates temperature distribution map at -500 m as shown in Figure 3.7. The optimized prediction error values and comparison between measured data line and predicted data with their regression line having 0,153 x + 23,906 are also shown in Figure 3.7 at the top of the map. RMS value is found 11,2. In this case, comparison with Data Set 1 is less satisfactory, due to smaller regression line slope and greater RMS value. Color scale intervals are chosen differently. Each data set is divided into color intervals considering their statistical distribution for better resolution.

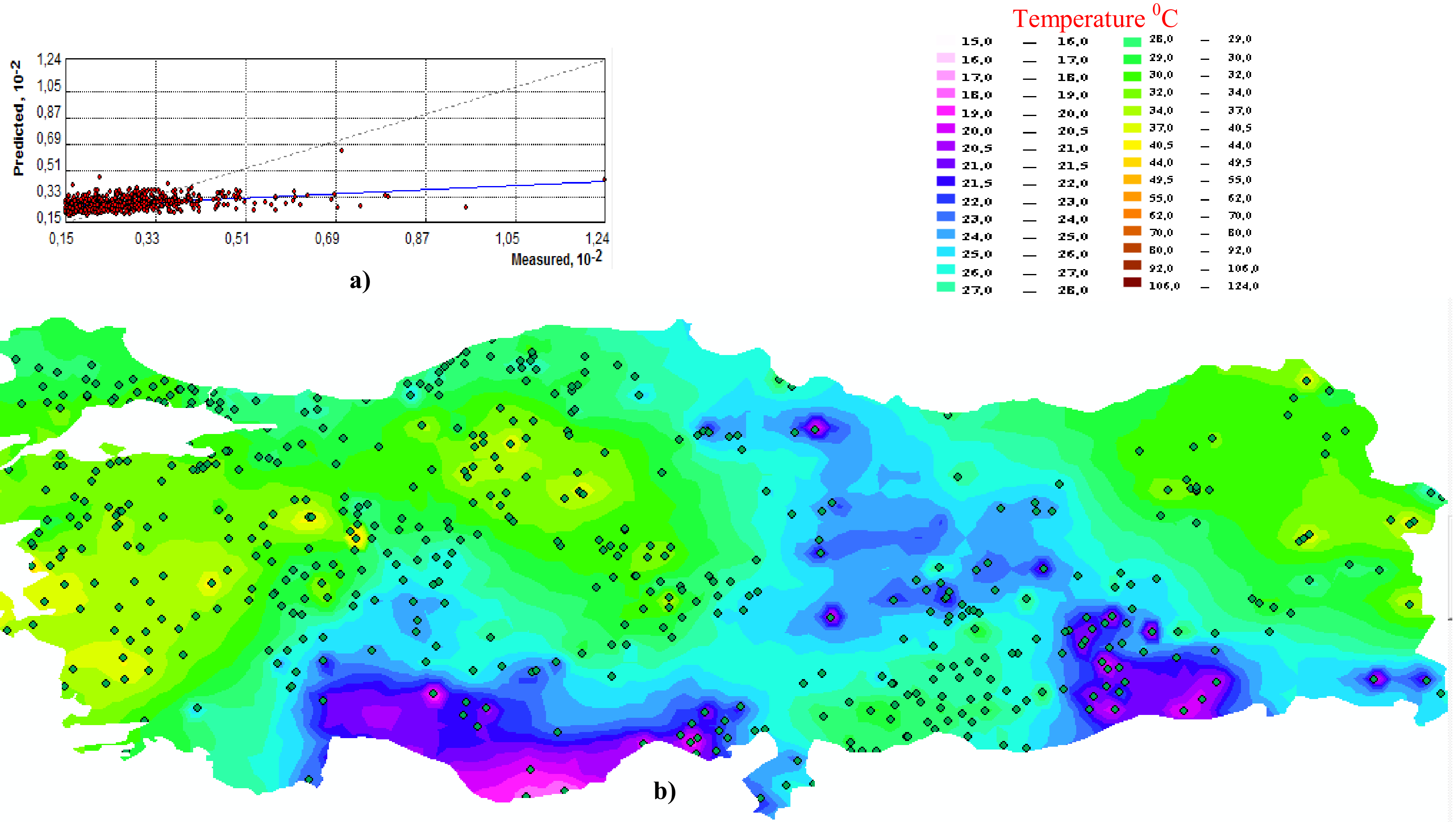


Figure 3.7: a) Temperature Distribution Map (-500 m) using IDW Interpolation
b) Cross-Validation of IDW for Data Set 2.

3.3 Kriging Interpolation

Spatial data analysis is based on designing semivariogram models. For semivariogram model like IDW, data should be examined statistically Normal Score Transformation (NST) and spatially with Declustering. Non-gaussian distributed and clustered data set are to be transformed into normally-distributed and more representatively-distributed data by declustering and NST. First of all, data set is to be shaped and then kriging process is applied with variogram analysis.

3.3.1 Applying Kriging with Data Set 1

Declustering for Data Set 1

In voronoi polygon map Clustering of Data Set 1 is shown. Areas are appointed to the data due to their clustering degree (explained in Appendix A-2). In Figure 3.8, clustering degree of data points are shown on the right side of the map by different colors. N is the number of data points in Data Set 1. The appointed area for each data point is propotionally created and classified.

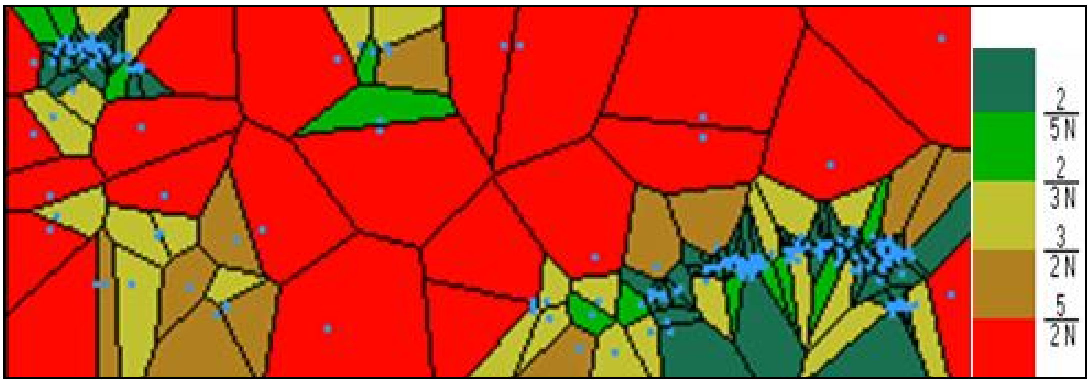


Figure 3.8: Voronoi Polygon Clustering Map of Turkey with Data Set 1.

At first look, Figure 3.8 may look confusing. Due to the structure of declustering in Arc GIS Software, data declustering is made considering the boundaries of Turkey Map as rectangle. However, clustered data and their covered regions due to their clustering degrees are shown successfully. According to this determination, interpolation is made more representatively to whole population.

Normal Score Transformation

Even if declustering method is useful for making data dispersed more regularly, it is not enough for successful application with kriging. Data should be normally distributed. Normal Score Transformation is chosen for this process and made the

Data Set 1 normally-distributed and ready for the semivariogram analysis and kriging.

Semivariogram Modelling

While obtaining model parameters, approaches are made iteratively according to reach better prediction error values (Table 3.1). Anisotropy should be examined with its effect zone (Major Range and Minor Range) and direction for a better approach. In this determination, the direction and the effect zone that represent most of the data and fit on the semivariogram model while having the better prediction error value are chosen and used. Anisotropy is examined on different directions shown in Figure 3.9 and Figure 3.10.

Table 3.1: Iteratively found semivariogram model parameters for Data Set 1.

Semivariogram Exponantial Model Parameters					
Anisotrophy Direction	**Major Range**	**Minor Range**	**Partial Sill**	**Lag Size**	**Nugget**
274.4	4.895	6	0.49586	1.3612	0.15705

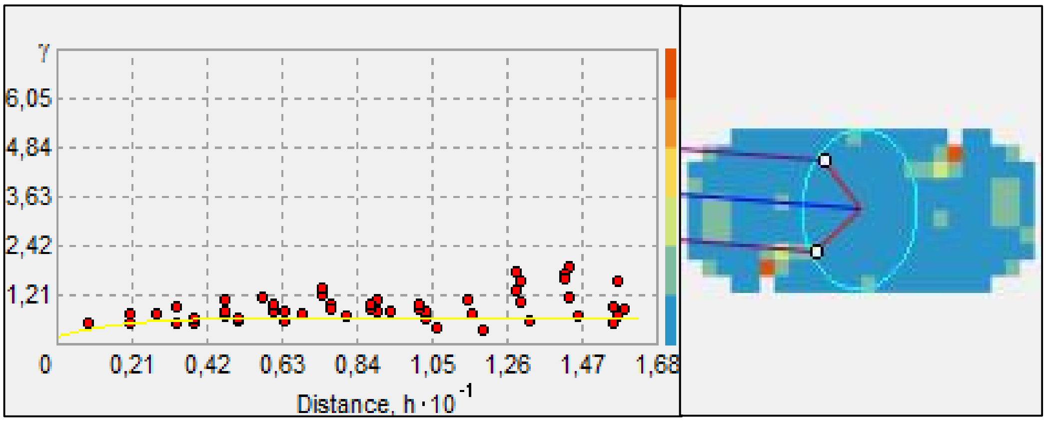


Figure 3.9: Examination of Anisotropy at 274.4 degree for Simple Kriging of Data Set 1.

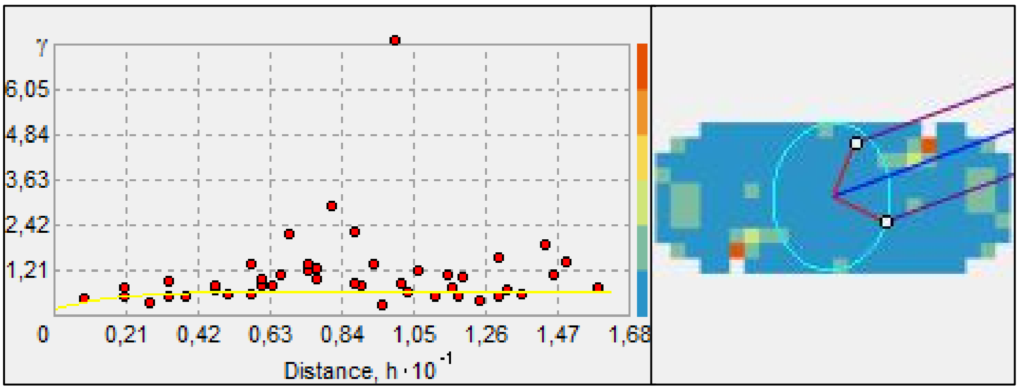


Figure 3.10: Examination of Anisotropy at 69.6 degree for Simple Kriging of Data Set 1.

Considering the anisotropy direction, exponential model of which the curve is settled on semivariogram clouds is preferred and convenient parameters for this model are obtained (Table 3.1). These values are found iteratively to reach the best prediction error values. Consequently final semivariogram model is constructed in Figure 3.11.

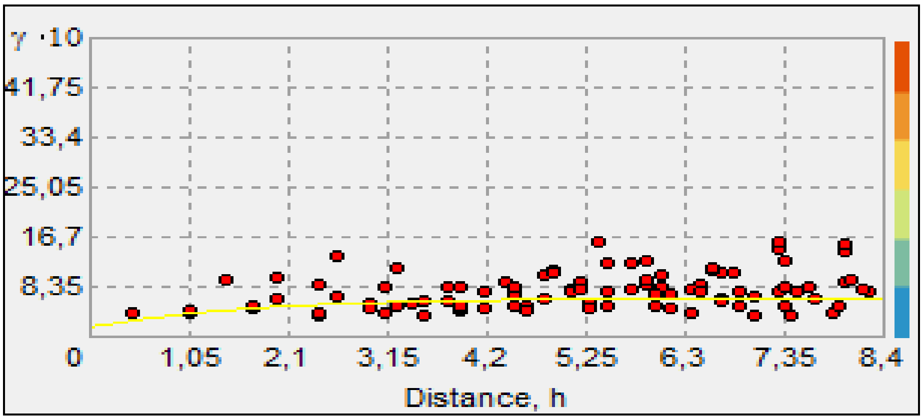


Figure 3.11: Semivariogram Model for Simple Kriging of Data Set 1.

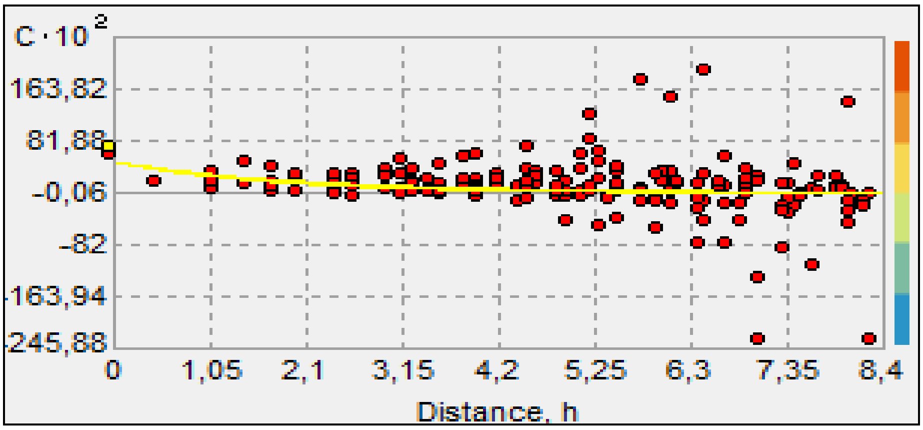


Figure 3.12: Covariance Model for Simple Kriging of Data Set 1.

Same relationship can also be observed on covariance cloud in Figure 3.12. Unlike semivariogram, auto-correlated points are gathered on 0 value of covariance function. Spatially weak related data are observed away from the smooth line that covariance model lies on. In some applications, even if those semivariogram and covariance data clouds have same basis, in reality one of them may be more useful for obtaining best fit model.

Neighborhood Searching in Kriging for Data Set 1

Final level before constructing the map is neighborhood searching. Neighborhood Searching is applied to a different region than the one applied in IDW (Figure 3.13). Once again, the decision is done by comparing Prediction Error (PE) values. Totally 16 points are chosen as neighbors on four sectors with 45 degree offset (15 neighbors each sector).

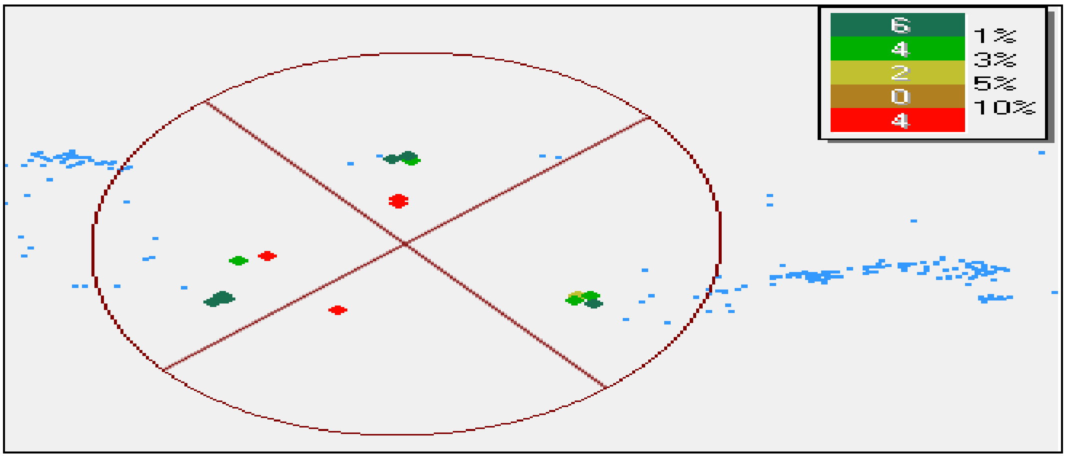


Figure 3.13: Neighbourhood Searching for Kriging of Data Set 1.

After Neighborhood Searching, Turkey's Geothermal Map at -500 m is constructed as shown in Figure 3.14. The optimized prediction error values and comparison between measured data line and predicted data with regression line having regression function 0,354 x + 18,927 are also shown in Figure 3.14 at the top of the map. Prediction Error Values such as Root Mean Square (RMS), Average Standard Error (ASE) Standardized RMS (RMSS) are shown in Table 3.2:

Table 3.2: PE Values of Kriging for Data Set 1.

RMS	ASE	RMSS
7.589	7.417	1.005

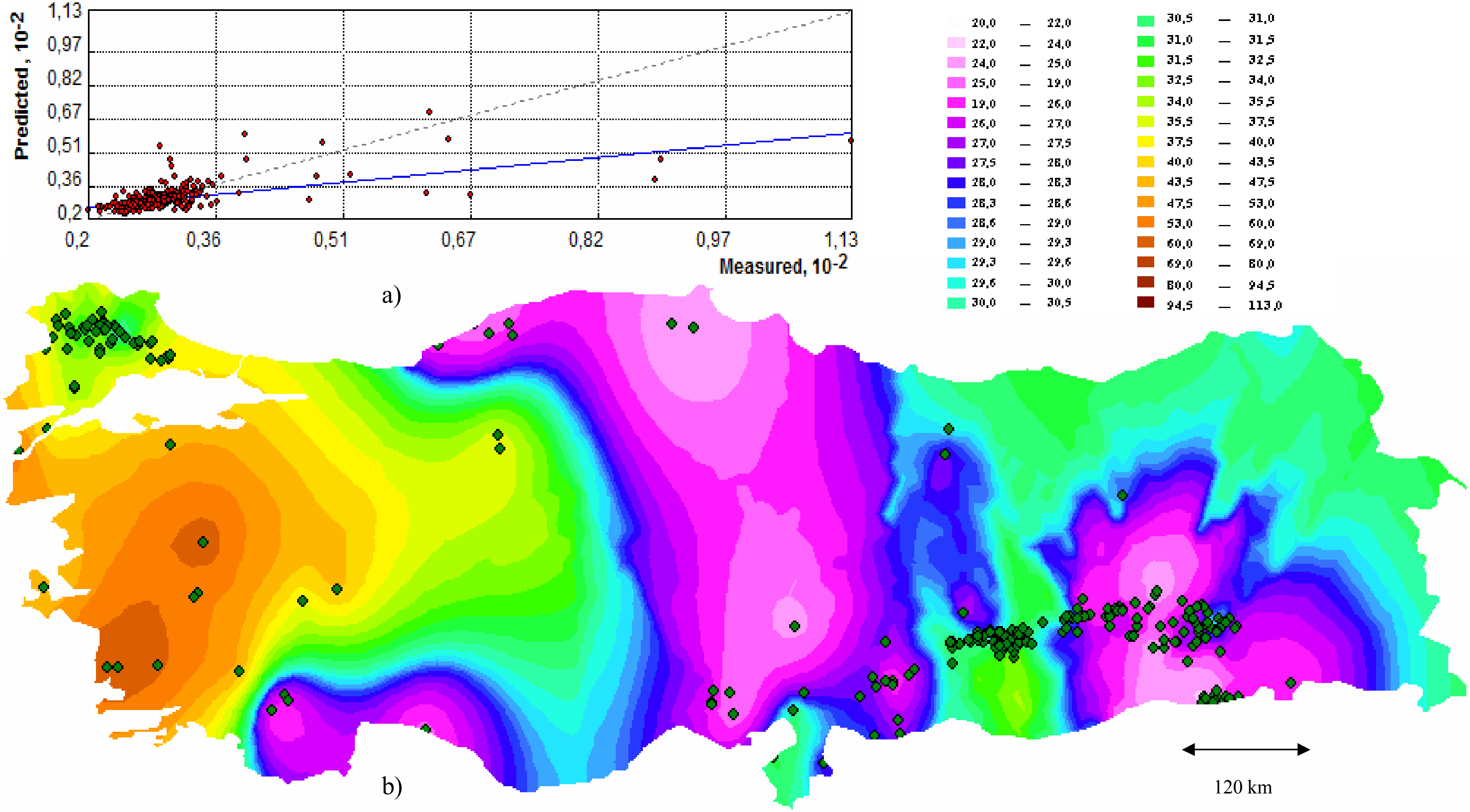


Figure 3.14: a) Temperature Distribution Map (-500m) using Kriging Interpolation and b) Cross-Validation of Kriging for Data Set 1.

3.3.2 Applying Kriging with Data Set 2

Declustering for Data Set 2

As mentioned before, for a successful kriging operation, data should be less clustered and have normally-distributed structure. Data Set 2 looks like dispersed homogenously but, data locations are mainly located on southeastern and northwestern parts of the country. In Figure 3.15, clusters are shown according to their densities and symbol N represents the amount of data points which is 540.

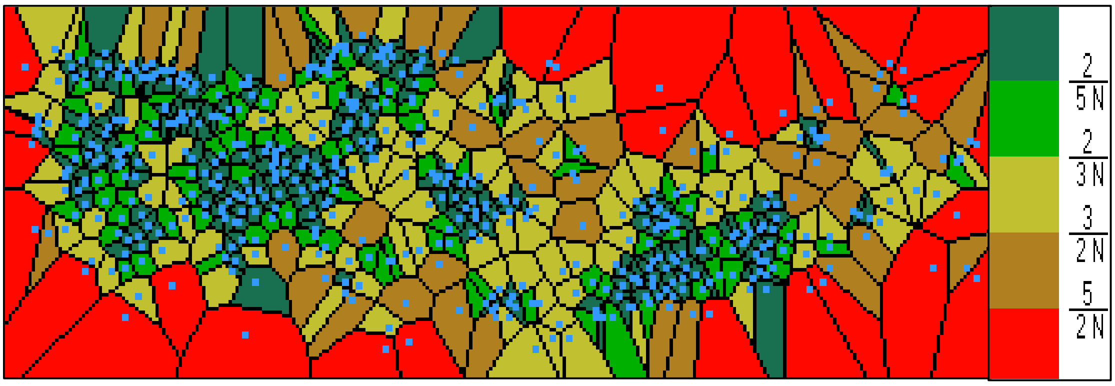


Figure 3.15: Declustering of Data Set 2 along Turkey Map for Kriging.

Semivariogram Analysis

With declustering, heterogeneous dispersion of the data is determined. Now, data should be fixed statistically. In this case, after iterations and comparisons according to PE Values, best transformation model is chosen as Normal Score Transformation. Anisotropy is examined on directions along 360° such as shown in Figure 3.16 and Figure 3.17 where points on 90° and 180° directions are chosen and showed for power of anisotropy on semivariogram graph. Then, model parameters are obtained iteratively to reach best PE values that are shown in Table 3.3.

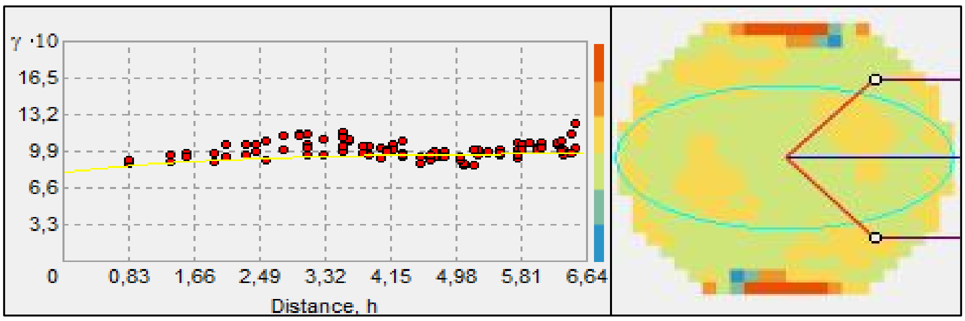


Figure 3.16: Examination of Anisotropy at 90 degree.

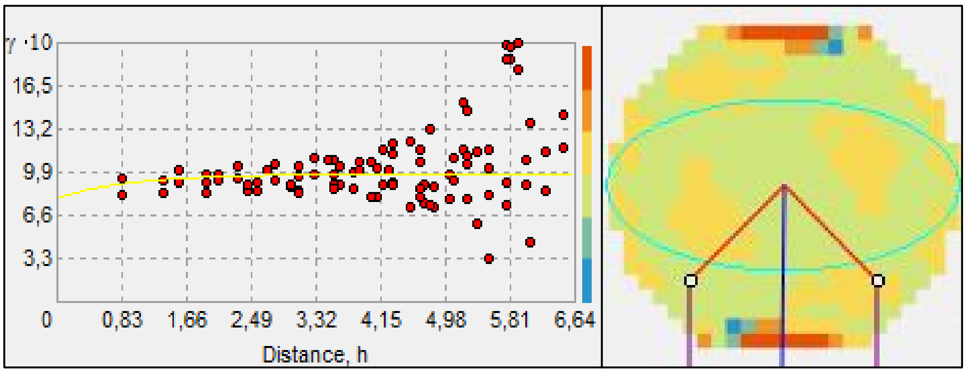


Figure 3.17: Examination of Anisotropy at 180 degree.

Table 3.3: Iteratively found semivariogram model parameters for Data Set 2.

Semivariogram Exponantial Model Parameters					
Anisotrophy Direction	**Major Range**	**Minor Range**	**Partial Sill**	**Lag Size**	**Nugget**
180	2.9	6	0.18255	0.5518	0.79532

Model parameters constructing semivariogram and covariance graphs are shown in Figure 3.18 and 3.19. In Figure 3.18, as shown in Figure 3.16, spatial relationship on north-south direction between data in Data Set 2 is decreasing.

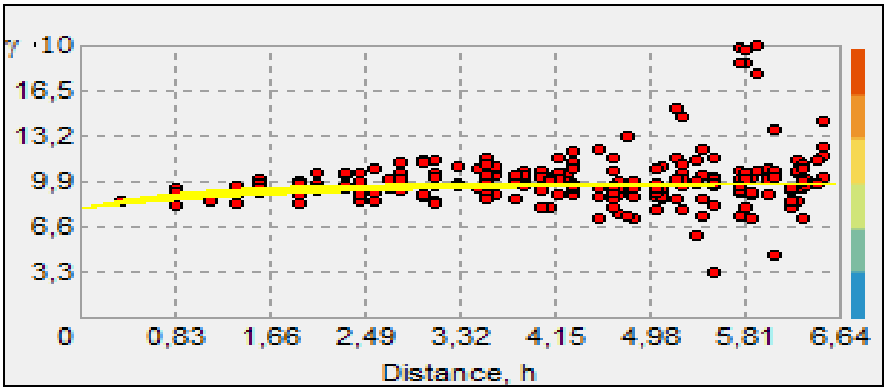


Figure 3.18: Semivariogram Model.

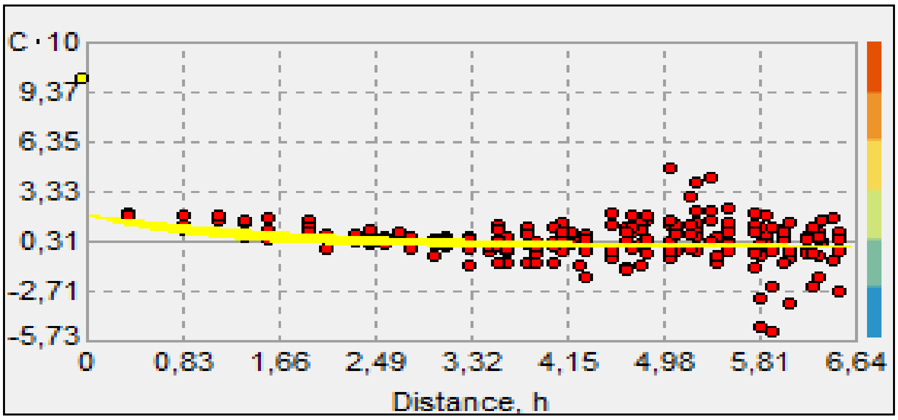


Figure 3.19: Covariance Model.

Neighborhood Searching in Kriging for Data Set 2

Final stage before constructing the map is neighborhood searching. Unlike IDW, in this application, neighborhood searching is decided to be done on northeastern part of Turkey (Figure 3.20). Once again, decision is made with PE values. A Total of 60 points are chosen as neighbors on four sectors with 45 degree offset (15 neighbors each sector).

After Neighborhood Searching, Turkey's Geothermal Map at -500 m is constructed as shown in Figure 3.21. The optimized prediction error values and comparison between measured data line and predicted data with their regression function 0.135 x + 24.364 are also shown at the top of the map in Figure 3.21. Prediction Error Values are shown in Table 3.4:

Table 3.4: Prediction Error Values of Kriging fot Data Set 2.

RMS	ASE	RMSS
11.37	11.06	1.059

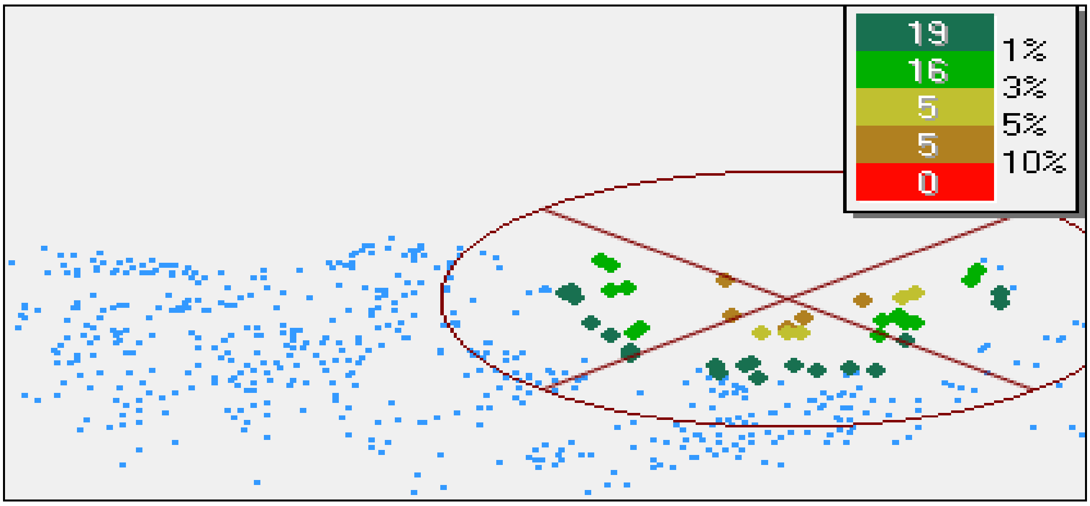


Figure 3.20: Neighbourhood Searching on Simple Kriging with Data Set 2.

3.3.3 Comparison of Simple Kriging of Data Set 1 and Data Set 2

In the previous pages, the physical and statistical advantages and disadvantages of data sets were discussed. Likewise, PE values are used again as main criteria to compare the succession of accomplished applications in this study for the datasets. In While Data Set 1, RMS/ASE is found to be 0,984; in Data Set 2 it is found to be 0,972. Considering the fact that ideal RMS/ASE should be 1, Simple Kriging of Data Set 1 is barely better than Simple Kriging of Data Set 2. The same trend can be observed on RMSS values such that RMSS of Data Set 1 is 1.005 and RMSS of Data Set 2 is 1.059.

In addition, cross validation results support better prediction error values of Data Set 1. This situation may be explained by the number of data. Because, while there are few data and large space as in example of Data Set 1, there will be less roughness affecting predicted data. This will help to show a better approach to the measured data.

3.4 Cokriging of Data Set 1 and Data Set 2

As mentioned in the beginning of the chapter, Data Set 1 contains reasonable data for deep temperature values with its measurement background. In addition, the PE values of kriging with Data Set 1 are better despite having lesser in number of data points. Thus, while predicting data secondary data set may smooth outlier effects and geostatistical deficiencies of primary data set. While applying co-kriging, Data Set 1 is a good choice to be the primary data set. Because second variable used in co-kriging is considered as auxiliary, neighborhood searching is similar to primary data set's kriging (Data Set 1). Semivariogram parameters are also chosen from Data Set 1 semivariogram model parameters (Figure 3.22).

Finally, after iterative processes are done with semivariogram parameters, PE values are constructed in Table 3.5. The new PE values such as (ASE, RMS and RMSS) are obviously better than Data Set 1 kriging application. Also, regression function that characterize deviation from measured data is found to be 0,396 x + 17,954 of which the slope is better than (closer to 0,5) 0,354 value of Data Set 1 kriging application. These results according to PE values show that co-kriging application is a better approach on creating -500 m geothermal distribution map (Figure 3.23).

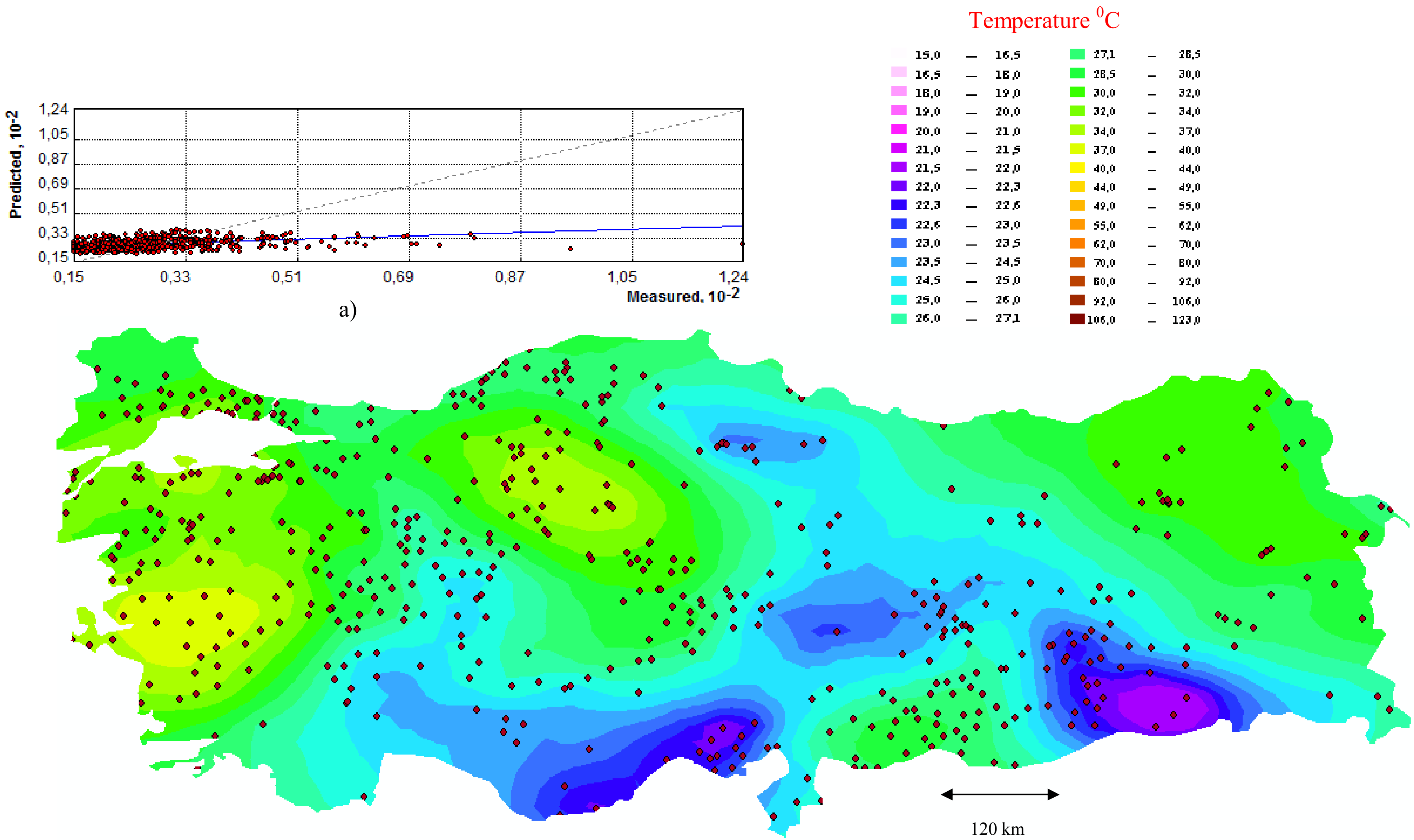


Figure 3.21: a) Temperature Distribution Map (-500m) using Kriging Interpolation and b) Cross-Validation of Kriging for Data Set 2.

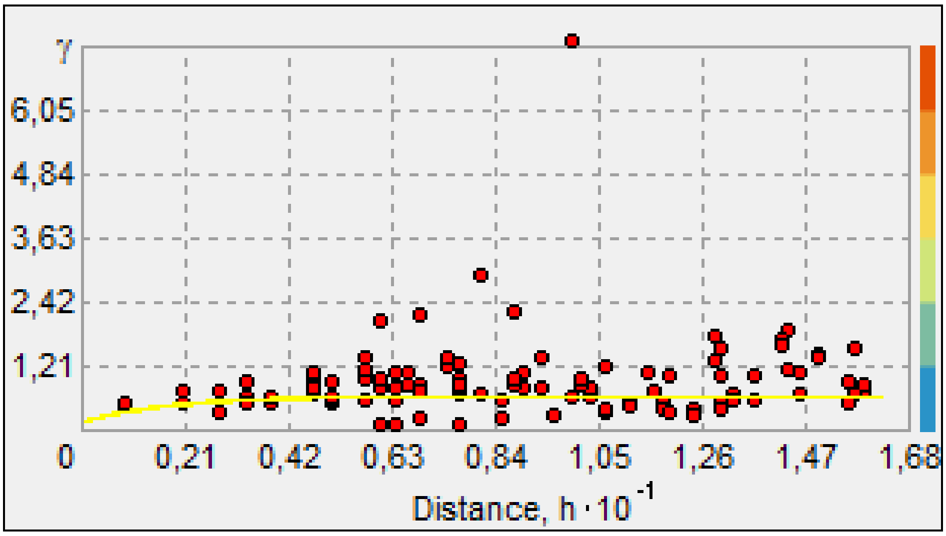


Figure 3.22: Semivariogram Modelling of Simple Cokriging (Data Set 1 and Data Set 2)

Table 3.5: Prediction Error Values of Co-Kriging

RMS	ASE	RMSS
7.451	7.478	1.02

As noticed in Figure 3.23, outlier effects of Data Set 1-based surface are smoothed by the Data Set 2 on Turkey Map. Also, locally, especially on geothermal regions, some temperature shifts can be observed between Data Set 1 kriging and co-kriging applications. For example, “Kızılcahamam” high temperature region is observed discretely from “Aegean” high temperature region by having more data values from Data set 2. But, even after combining datasets, measured data which are used for obtaining temperature values, may not be enough for local geo-temperature investigations. So, this final map could be useful just for analyzing general geothermal trends

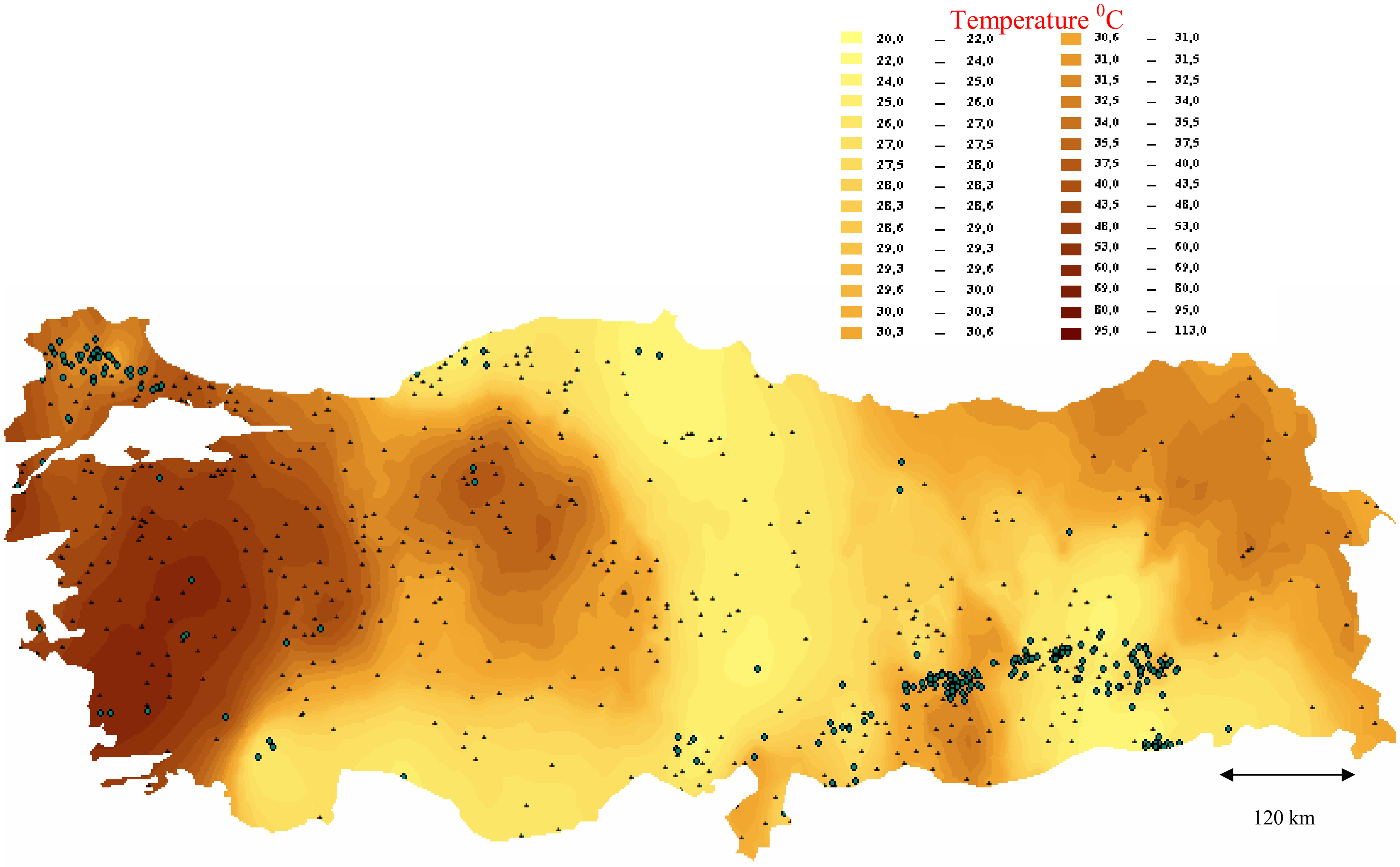


Figure 3.23: Temperature Distribution Map (-500m) using Cokriging Interpolation

4 LOCAL INVESTIGATION

In the second part of the study, regions (Thrace and Southeastern Anatolia) that have intensive data were investigated locally. This helps us to construct local geothermal maps in more detail and compare with the whole picture. However, because Data Set 2 are obtained from shallow well measurements and Data Set 1 values have sufficiently large number of data points and sparse homogeneously in selected regions, in this case, secondary (Data Set 2) data set will not be used.

4.1 Thrace Region

A total of 43 temperature data values (Appendix B-3) are selected and determined for the analysis of Thrace Region at -1000 m. These data are mostly collected from natural gas wells as well as few geothermal wells. In Figure 4.1, dispersion of wells along the Thrace Region can be seen.

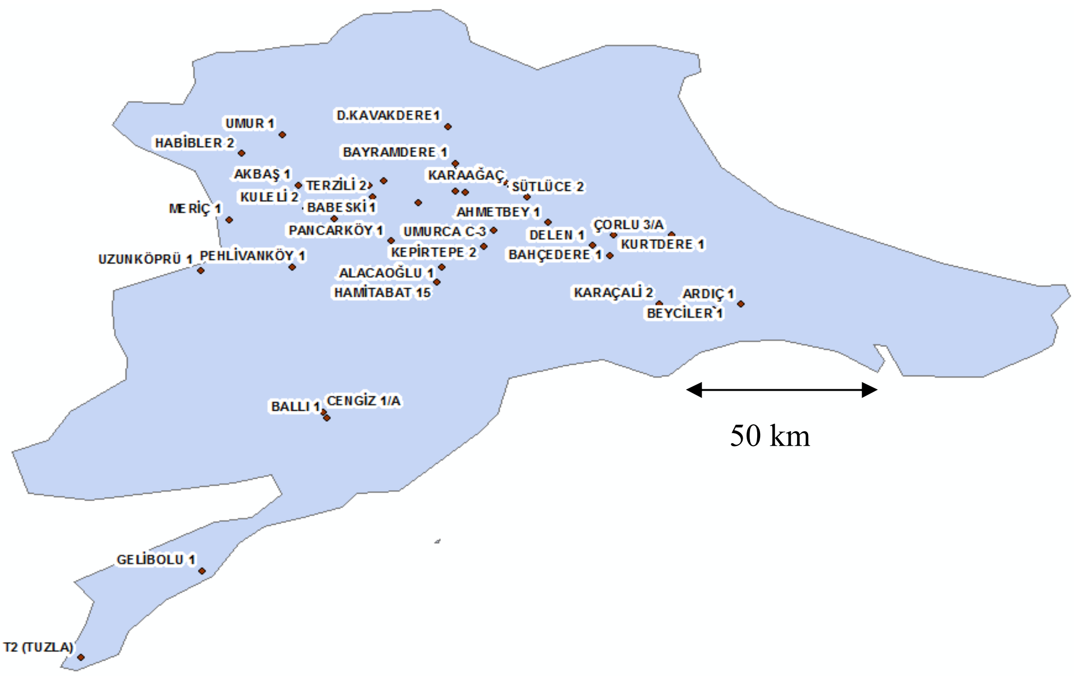


Figure 4.1: Data Locations on Thracian Region.

Only one high temperature data point, T2 (Tuzla), out of Data Set 1 is located in southwestern edge of the map. This is the only data that can be characterized as outlier. Rest of the data, mostly clustered to the center, form a better normally distributed histogram (Figure 4.2). Mean of temperature value is 64,682 ^{o}C with median 63 ^{o}C. That shows that very hot outlier, T2 (Tuzla) alone does not affect distribution statistically.

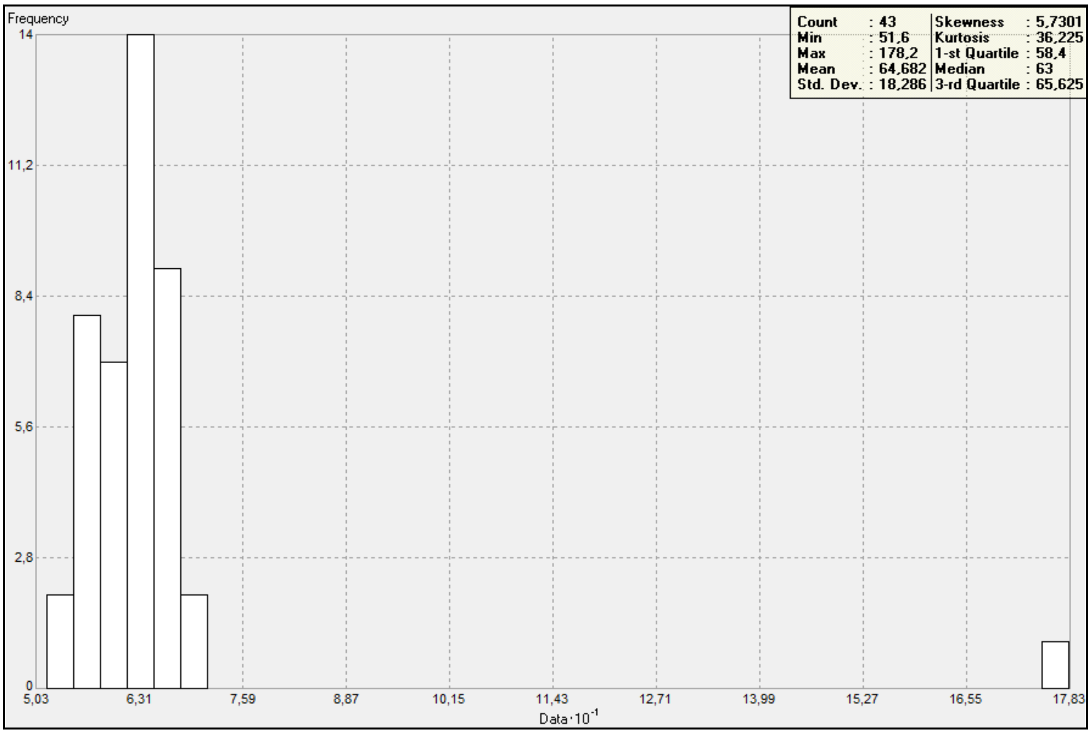


Figure 4.2: Histogram of Data Set 1 in Thracian Region.

4.1.1 IDW on Thrace Region

Applying IDW gives a general idea about temperature dispersion, but clustering along the map will probably hinder the understanding of the characterization of the distribution correctly. However, for comparing with kriging interpolations without smoothing, IDW is important. In Thrace Region, IDW for 43 data values is applied for 16 neighbors with four degrees offset. Regression function of line on cross validation of IDW is found to be 0,009 x + 61,247 (Figure 4.3). Here the small regression slope has direct and powerful effect of T2 (Tuzla) datum. Finally, IDW map of temperature distribution at -1000 m is shown in Figure 4.4 a.

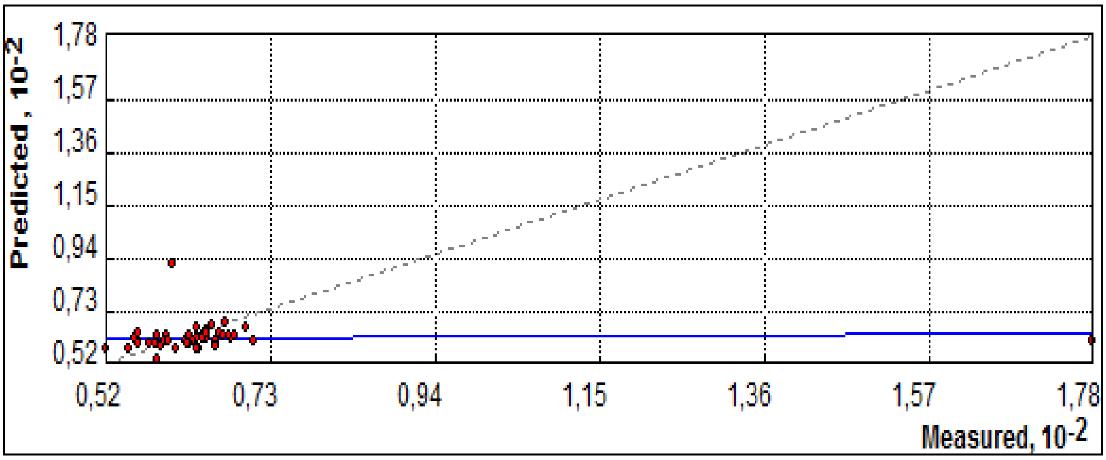


Figure 4.3: Cross-validation between predicted and measured data.

4.1.2 Kriging on Thrace Region

As mentioned in Appendix-1, normally distributed data are necessary for successfully applying kriging interpolation. So, in this case, also confirmed by iteratively optimized PE, no transformation and declustering are necessary. Same iterative methodology is used for covariance modeling, that is in this case more successful than semivariogram modeling, and the related parameters shown in Table 4.1 are determined. Resultant iteration PE values are also shown in Table 4.2.

Table 4.1: Iteratively found covariance model parameters for Thrace Region.

Covariance Exponantial Model Parameters					
Anisotrophy Direction	**Major Range**	**Minor Range**	**Partial Sill**	**Lag Size**	**Nugget**
88.4	1.7	1.4	14.124	0.148	312.47

Table 4.2: Prediction Error Values used for Kriging for Thrace Region

RMS	ASE	RMSS
17.98	18	0.9953

Finally, both IDW and kriging based temperature distribution maps at –1000 m are constructed as shown in Figure 4.4. Because most of the data values are close to each other and there is only one outlier, kriging map is very smooth and shows nearly average distributed surface. Most of the data are dominated by average of majority. On the other hand, despite of clustering behavior of data set, deviations can be observed or realized easier in IDW. Units of values in color scale table are in ^{o}C.

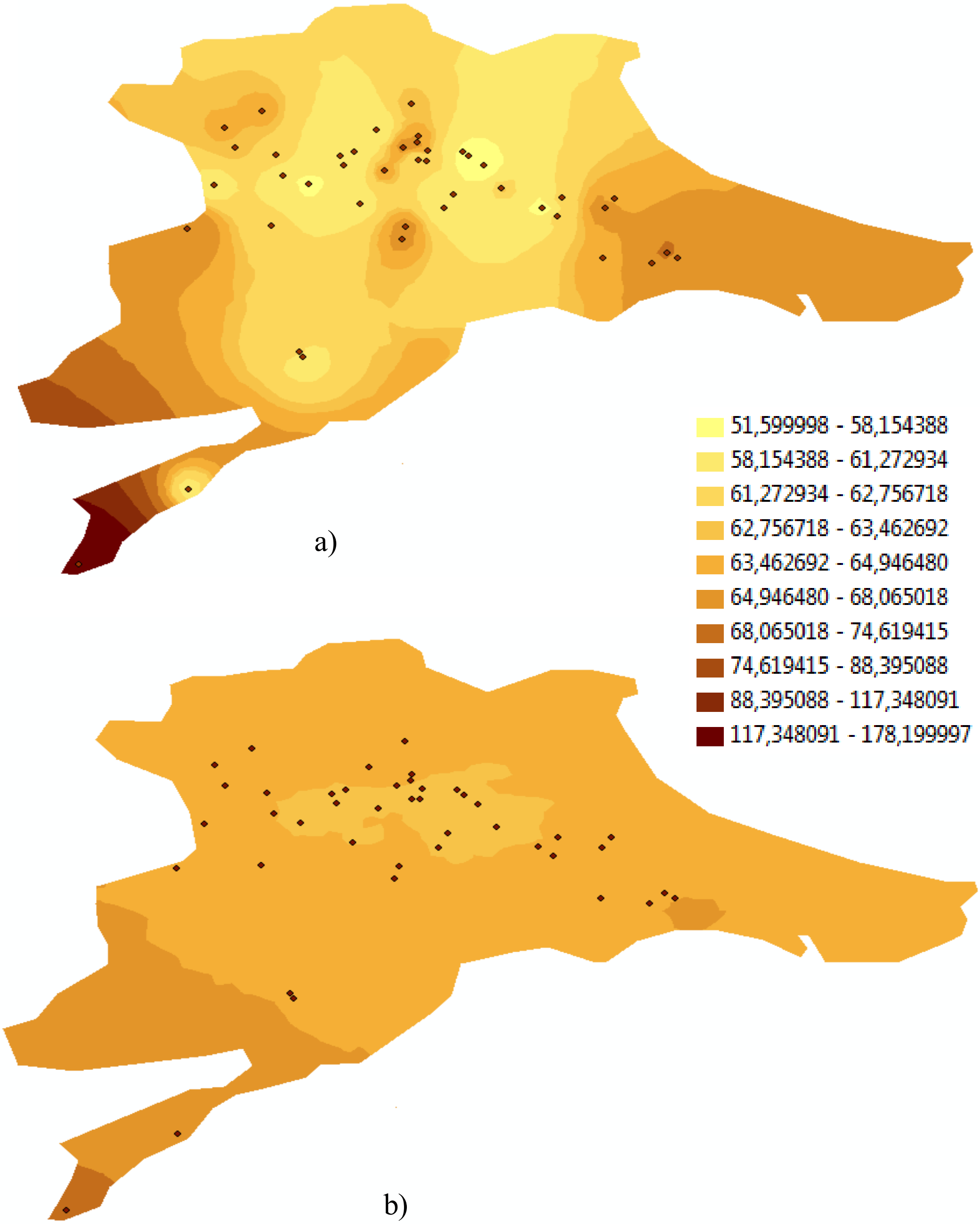


Figure 4.4: a) IDW map of -1000 m Temperature Distribution
b) Kriging Map of -1000 m Temperature Distribution of Thrace Region.

4.2 South-Eastern Anatolia Region

A total of 154 temperature data values (Appendix B-4) are selected and determined for the analysis of Southeastern Anatolia temperature values at -1000 m. These data are mostly collected from petroleum fields. In Figure 4.5, dispersion of wells along Southeastern Anatolia Region can be seen.

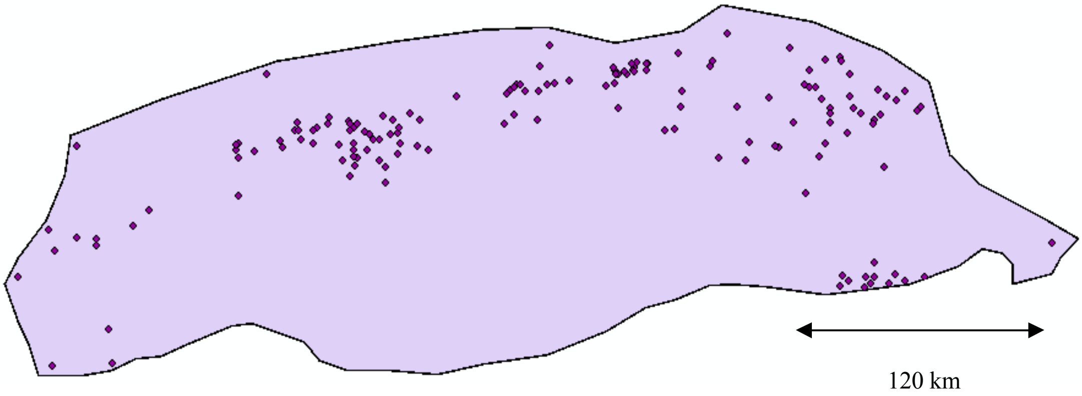


Figure 4.5: Data Locations sparsed along the Southeastern Region

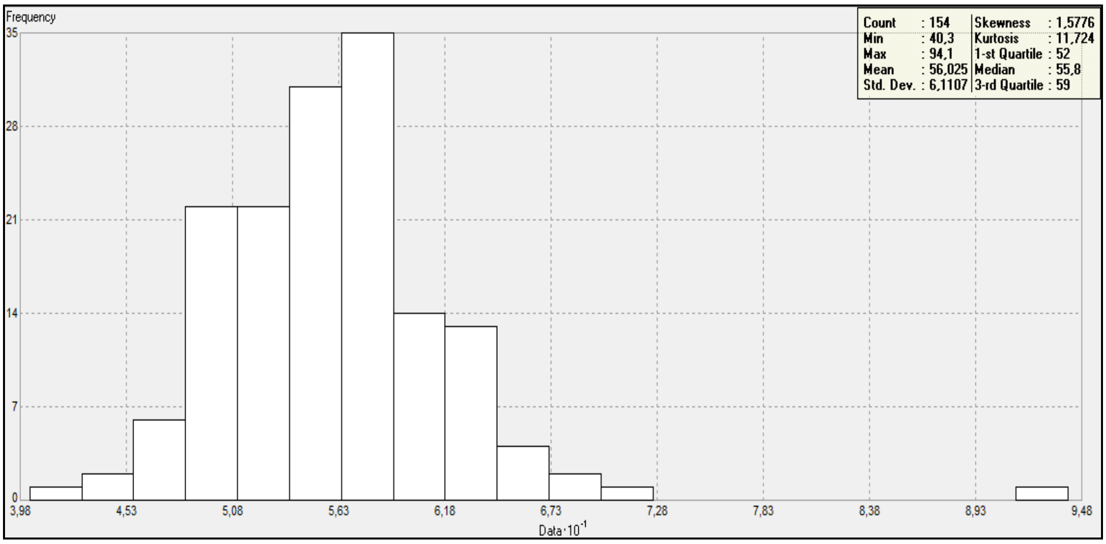


Figure 4.6: Histogram of South-eastern Region.

As shown in Figure 4.5 data are not sparsed homogeneously. Most of them gathered north and north-east. The empty regions will be filled by interpolation that will cause inevitable deviation from reality. Also shown in Figure 4.6, histogram of data looks like normally distributed. Mean temperature of data is 56,025 ^{o}C. Only Adıyaman 51 well is relatively hot (94,8 ^{o}C at -1000 m) and easily shows itself as an outlier.

4.2.1 IDW on Southeastern Anatolia Region

154 data values of IDW is applied for 18 neighbors with four degrees offset. Regression slope on Cross Validation of IDW having 0,34 x + 37,242 function is shown in Figure 4.7. Deviation from normality is the result of outlier (Adıyaman 51) However, comparing with T2 outlier in Thracian Region, Adıyaman 51 is closer to the rest of data in temperature value.

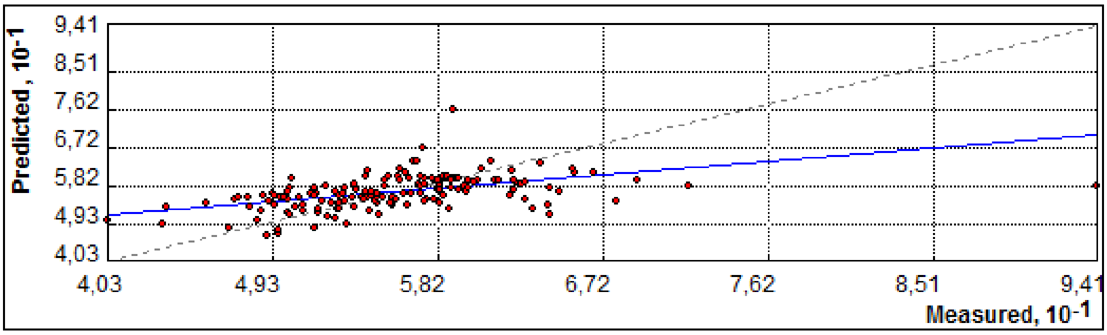


Figure 4.7: Cross-validation between predicted and measured data.

4.2.2 Kriging on South-Eastern Anatolia Region

In the covariance modeling, parameters in Table 4.3 are used. The resultant iteration PE values are shown in Table 4.4.

Table 4.3: Iteratively found covariance model parameters for Thrace Region.

Covariance Exponantial Model Parameters					
Anisotrophy Direction	**Major Range**	**Minor Range**	**Partial Sill**	**Lag Size**	**Nugget**
No Anisotrophy	1.514	-	9.349	0.24	27.75

Table 4.4: Prediction Error Values used for Kriging for South-eastern Region.

RMS	**ASE**	**RMSS**
5.501	5.56	0.9899

Finally, both IDW and kriging interpolation were employed ready for mapping temperature distribution at –1000 m. These maps are shown together in Figure 4.8.

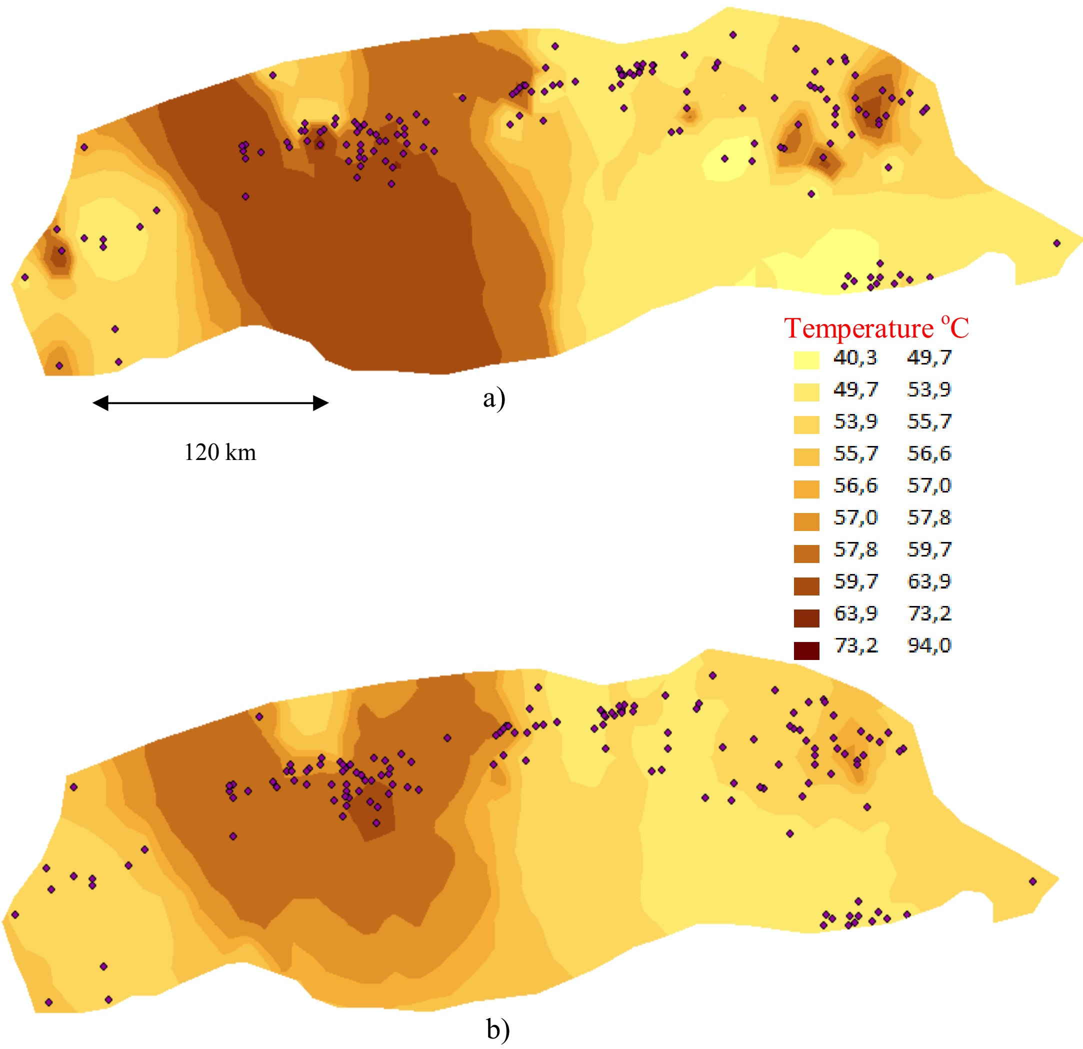


Figure 4.8: a) IDW map of -1000 m Temperature Distribution b) Kriging Map of -1000 m Temperature Distribution of South-eastern Anatolia Region

In Figure 4.8, on the left side of the map, most of the data are clustered around the boundaries of Adıyaman City. These data have higher temperature values comparing with the rest in the South-eastern Anatolia Region. Using kriging approach created interpolated surface more locally

5 CONCLUSIONS AND RECOMMENDATIONS

In this study, first of all, subsurface temperature distribution maps were prepared for Turkey. Two data sets are used, Data Set 1 consists of temperature values from deep wells and Data Set 2 consists of temperature data obtained from geochemical analysis of shallow wells. By using both of these data, IDW and Kriging maps are constructed for -500 m. Later, two datasets are used in co-kriging interpolation together to create combined temperature distribution maps. The effects supporting the main data set with a different backgrounded data set are observed and examined.

In addition, considering the fact that deep temperature data are clustered in Thrace Region and Southeastern Anatolia Region, local maps of these regions for -1000 m are also constructed. These maps are also constructed with IDW and kriging.

While making a model, there should be something to stand on for objectivity and comparison. In this case, all applications are essentially made based on iterative optimization of PE values.

In future studies, constraints should be considered for better approaches. This study had two main constraints: data properties and environment. Firstly, data are insufficient in number and poorly dispersed (inhomogeneous). Secondly, environment is smoothed to represent entire examining region. Topographical and geological affects are determined by taking average values that represent the entire environment. These constraints can be handled with more localized studies.

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APPENDIX A. GEOSTATISTICAL ANALYSIS

A.1. Methodology of Spatial Data Analysis Using ArcGIS TM Geostatistical Analyst

A.1.1. Data Exploratory

While creating a map with data sets, interpolations and estimations are very sensitive to outliers, measurement errors, quantity and dispersion of data in space. Thus, first of all, data should be analyzed and tested carefully. Following concepts will be applied in framework of the software for data exploratory.

i. General QQ Plot

General QQ Plot is a graphical technique, using the method of testing the similarities between two data set distributions. Quantile means the fraction or percentage of data values below the given value. For example, 0,3 quantile is the data value at which 30% of data fall below[1]. The QQ plot is formed by estimated quantiles from representative Data Set 1 at vertical axis versus estimated quantiles from representative Data Set 2 at horizontal axis (Figure A.1).

With the help of QQ plot, two data sets, which have different quantities, can be compared and many distributional aspects such as shifts in location, scale, changes in symmetry and the presence of outliers can be tested [7].

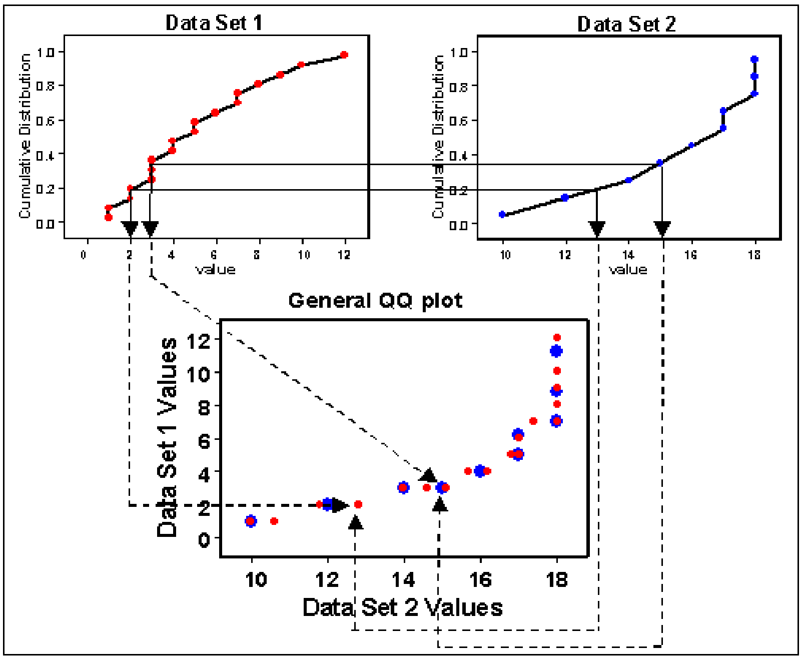

Figure A.1: The construction of QQ plot

ii. Data Transformations

Data Transformations are solutions for outliers and deviations from normal distribution. Especially when data sets are too small and skewed, these methods are used to prepare the data sets for the regression analysis and kriging. For a better kriging, the data can be assumed as linear, normal and homoscedastic [1]. These transformations basically are shown in Equation A.1 where Z(s) is the function of the real empirical cumulative distribution function and F(s) is the transformed cumulative distribution function, and T( ) represents transformation type function:

$$F(s) = T(Z(s)) \quad \text{(A.1)}$$

a. Log Transformation

When there is a left skewed-distributed data and outliers at localized regions, the log transformation helps to normalize the data and make variances more stable (Figure A.2 and Equation A.2).

$$F(s) = \ln(Z(s)) \quad \text{(A.2)}$$

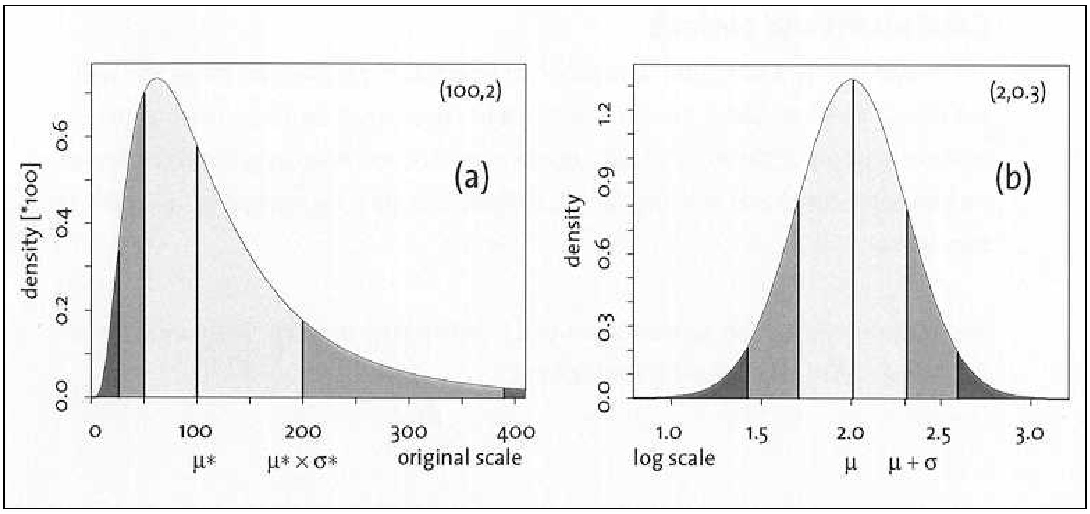

Figure A.2: a) lognormal data distribution along density scale and b) the data distribution after log transformation.

b. Normal Score Transformation (NST)

While determining values from lowest to highest, this transformation method ranks the data set and match with the equivalent ranks of normal distribution. The values taken from the normal distribution at that rank create transformation (Figure A.3). This method should be applied after trending considering the fact that determination of covariance and semivariogram is made on residuals followed by trend correction.[1] Unlike functional transformation, function of normal score is changing with each particular dataset.[1]

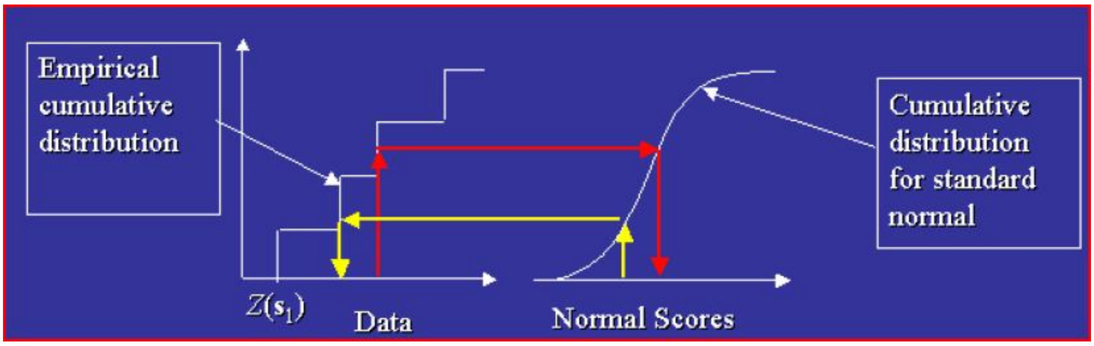

Figure A.3: Normal Score Transformation.[4]

iii. Declustering

The preferential data set should represent histogram of the whole population (real distribution), even if the preferential data set is spatially auto correlated, when there is clustering, the resulting histogram may not reflect the real histogram of the surface. The solution is to weight each data location in proportion to the area that locates which is called voronoi polygon declustering (Figure A.4). Data in densely sparsed areas receive less weight values and data in sparsely areas receive higher weight values.[1]

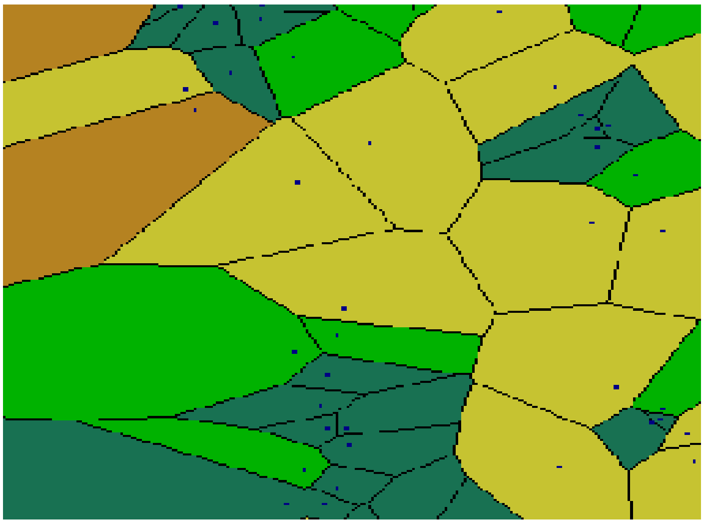

Figure A.4: Weighting data points in declustering.

With transformations and declustering, analyzing and shaping datasets are done by considering their statistical behaviors. Now it is time for determining spatial relationships of data prepared from statistical data analysis. This is generally called as spatial data analysis.

A.1.2. Spatial Data Anaysis

Data may be dispersed irregularly as shown in Figure A.5. Even if data are regularly dispersed, it is hard to determine correlation between data values and data locations by just looking at the map. Thus, the correlation should be done using spatial data analysis. The first stage of spatial data analysis is constructing the semivariogram graph.

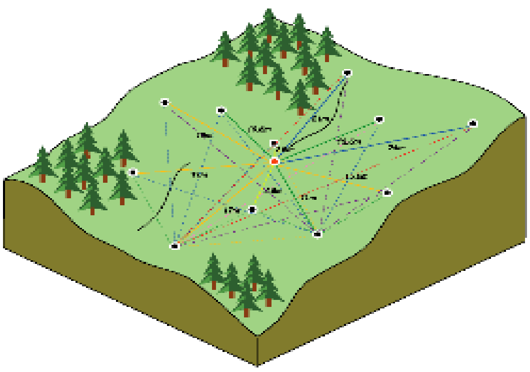

Figure A.5: Semivariogram scheme [1].

i. Semivariogram Function

When the distance between two data points increase, it is expected that the difference between data values increases or correlation between them decreases. This relationship is measured by semivariogram function. Semivariogram function examines the nature and structure of dissimilarities between the data dispersed along the map[7]. Semivariogram function, γ is a function of lag distance (h) between each possible data pair (Eq. A.3) and variance of data quality values (Eq. A.4 and A.5), which is also half of the variogram function. In semivariogram, it is ideally expected that while the lag distance increases, difference between data values tends to increase and vice versa (Figure A.6).

$$\gamma(h) = 0.5 * \mathrm{var}(z(x_i) - z(x_j)) \quad (A.3)$$

where;

z : distribution function of data set along space

xi,xj : coordinate parameters

$$\mathrm{var}(z(x_i) - z(x_j)) = \frac{1}{N(h)} \sum_{i,j \in N(h)} (z(x_i) - z(x_j))^2 \quad (A.4)$$

$$N(h) = x_i - x_j \quad (A.5)$$

With Equation A.4, after constructing the empirical semivariogram graph, a representative analytical model should be chosen to use analytical formulas while constructing frameworks for the interpolation processes (such as kriging). Empirical semivariogram is not sufficient to represent possible directions and distances. The analytical approach roughly follows Figure A.6 and uses 4 main parameters while constructing the model. The parameters and their notations are mentioned below:

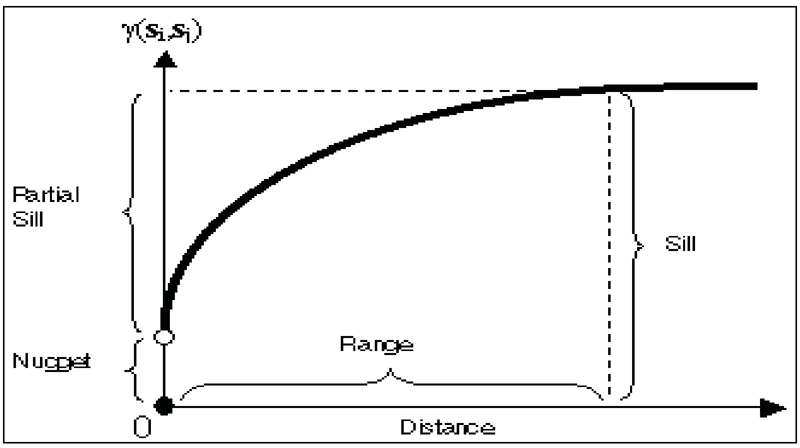

Figure A.6: Modelling of Semivariogram

Range *(r)* : Until reaching a point when lag distance increase, corresponding semivariogram value (dissimilarity) increase too. However at that point, increasing lag distance, semivariogram function value could not go up and reaches a plateau. The distance at which function reaches plateau is range. [7]

Sill (C) : is the semivariogram value where the function reaches range value.

Nugget (Co) : Theoretically, at zero lag distance, semivariogram value is expected to be zero. However, at very small lag distance values, the semivariogram function value corresponds to a nugget effect. When there are lots of data sources which have different values in a very small region or small lag intervals and measurements errors attribute to nugget effect. [1]

Partial Sill: is the distance between nugget and sill.

Models that are constructed to represent semivariogram of data, consist of 4 variables. Among them, exponential semivariogram analytical model is chosen and exhibited in Equation 2.6 as an example:

$$\gamma(h) = \begin{cases} 0 & \text{when} \quad h = 0 \\ C_0 + C\left[1 - \exp\left(-\frac{h}{r}\right)\right] & \text{when} \quad h > 0 \end{cases} \quad \text{(A.6)}$$

ii. Covariance Function

Covariance function is the similarity function of data in space. When two data are less similar it approaches to zero (Figure A.7). This function has the same aim with the semivariogram. Moreover estimation of covariance is similar to estimation of semivariogram but data mean, which usually may not be known but estimated, is required (Equation A.7). Therefore averting bias semivariogram is preferred as a default function in this study.

$$C(x_i, x_j) = \text{cov}(Z(x_i), Z(x_j)) \quad \text{(A.7)}$$

As also shown in Figure A.7, covariance model is characterized by the same 4 parameters (sill, lag distance, range and nugget) and the correlation between semivariogram and covariance can be formulized just by parameter sill (Equation A.8).

$$\gamma(x_i, x_j) = sill - C(x_i, x_j) \quad (A.8)$$

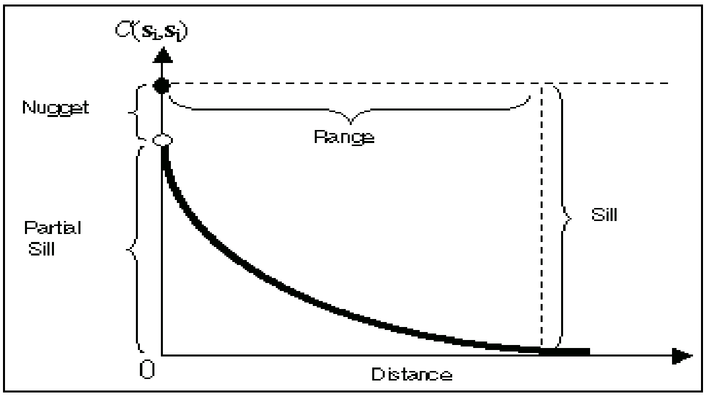

Figure A.7: Modelling of Covariance.

In semivariogram and covariance empirical graphs, the function values can be separated into groups by their direction and distance. This is called *binning* and useful for obtaining outliers, trends and anisotropy. The identification of relationships between points considering distances between each other and directions is called *autocorrelation*, which basically separates discrete or random statistical data from spatial data of geostatistics.

Moreover, the resolution of semivariogram graph is controlled by lags. Lags have two features to be edited: lag size and number of lags. Lag size is the size of a lag distance that is used to reduce the possible combinations. Number of Lags represents the number of adjacent cells in a straight horizontal or vertical line from the center to the edge of the figure. While lag size can be counted as size of cell, number of lags is number of cells [1].

iii. Interpolation Techniques

Interpolation techniques, used in spatial data interpretation, are basically separated into two groups: deterministic and kriging interpolation techniques. Deterministic Interpolation Techniques make surfaces from measured points considering similarities. On the other hand, kriging methods are using variography models and statistical relations among data points such as semivariogram models to explain the variation on the surface[7]. The most appropriate techniques for creating and comparing map should be considered due to aims and data characterization.

a. Inverse Distance Weighting (IDW)

Inverse Distance Weighting (IDW) is the simplest and exact deterministic interpolation method. It is very good on representing data, which makes it appropriate when comparing with other interpolation techniques to see deviations of assumptions and predictions. In IDW, a neighborhood about an interpolated point is identified and a weighted average is taken from the observation values within the neighborhood (Equation A.9). In Equation A.9, $Z(x_i)$ is the measured value at *i*th location where λ_i is a function of lag distance of data pairs, h_{io} is the lag distance between data point at origin and data points at neighborhood, x^o is the prediction location and N is the number of data points. The weights are a decreasing function of distance. In Arc GIS Geostatistical Package, the user has control over the mathematical form of the weighting function, the size of the neighborhood (expressed as a radius or a number of points). The controlling parameters process is based on considering reaching minimum root mean square prediction error (RMSPE) by iteration. Thus, IDW constructs bull eyes around data locations, while making no prediction errors and the data sets' marginal values considered and compared [1].

$$Z(x^0) = \sum_{i}^{N} \lambda_i Z(x_i) \qquad \text{(A.9)}$$

b. Kriging

Kriging is a stochastic interpolation method that estimates expected values in continuous surface. It uses semivariogram models produced from emprical data sets. Unlike IDW excluding distances between data pairs, in kriging, directional and statistical determinations of datasets are considered together while making predictions. Thereby, margin of error and approaching to reality can be tested. The general formula of the kriging is given by a weighted sum of the data (Equation A.10). This formula is similar with IDW method; however, weight parameter is not only related with distance of data values but also, semivariogram model. $Z(x_i)$ is the measured value at i th location, and μ is the trend value, where, x^o is the prediction location and N is the number of data points. Besides, the parameter λ_i is variogram function that differs kriging from other interpolation techniques.

$$Z(x^0) = \sum_{i}^{N} \lambda_i Z(x_i - \mu) \qquad \text{(A.10)}$$

c. Co-kriging

Co-kriging is an interpolation technique that allows better prediction of map data values according to kriging, while the secondary distribution is more intensely than the primary one[3]. When the measurement of the primary data set values may be difficult or expensive, co-kriging can greatly improve interpolation estimates without increasing the number of primary data set. The co-kriging is a linear combination of two data sets (Equation A.11) that naturally have the same basics with kriging method. Variance with the second variable becomes cross-variance. So, there are two more parameters coming from secondary data set. $Z(x_i)$ is the primary measured value and λ_i is primary weight for measured value at *i*th location, while $Y(x_j)$ is the secondary dataset's measured value and ψ_j is secondary weight for measured value at *i* th location. In addition, t for the measured value at the *i* -th location, x^o is the prediction location and N is the number of data points.

$$Z(x^0) = \sum_{i}^{N} \lambda_i Z(x_i) + \sum_{j}^{N} \psi_j Y(x_j) \tag{A.11}$$

d. Choosing Appropriate Kriging Method

$Z(x^o)$ distribution function, which is created by kriging, is decomposed for identifying the structure of distribution into two parts μ (x^o), for deterministic trends and ε (x^o), for random auto correlated errors (Equation A.11). Therefore, knowing the trend, μ (x^o) of the surface is not enough for exact predictions. Assumptions auto-correlation between errors, ε (x^o) should be made, which is formulated in semivariogram model (Equation A.12).

$$Z(x^0) = \mu(x^0) + \varepsilon(x^0) \tag{A.12}$$

According to obtaining the representative deterministic trend for the auto-correlated data which kriging method is to be used, is chosen. The chosen deterministic trend is expected to make mean of ε (x^o) values zero. If μ value is a known constant, simple kriging method named "Simple Kriging" is appropriate. When μ and $\varepsilon(x^o)$ values at the data locations are known exactly, auto-correlation provides better estimations[10] (Figure A.8).

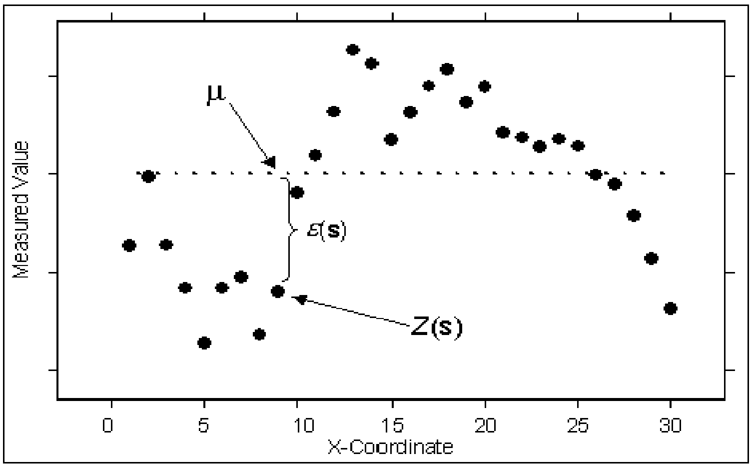

Figure A.8: Simple Kriging Method.

On the other hand, it is usually hard to know the exact trend. So, when the μ (x^o) trend is not known, a constant μ is assumed. This process is used in Ordinary Kriging. Besides, if a spatial-dependent μ (x^o) is preferred to be used, Universal Kriging could be chosen. In this study, assuming that there is known mean trend surface, Simple Kriging is used in applications. The assumption of exactly knowing deterministic trend μ may consider unrealistic. However, in a physically based model an assumed known trend makes sense [2]. In this study, datasets are examined by Simple Kriging.

In this study, Simple Co-kriging, which is multivariate version of simple kriging, is the type of kriging chosen on co-kriging application. Second variable is affecting the weight parameter of primary data set's kriging interpolation. Simple Co-kriging is using second variable affecting the weight of prediction value directly at the same location as shown as an example in Figure A.9. That's why second data set with more data is preferable.

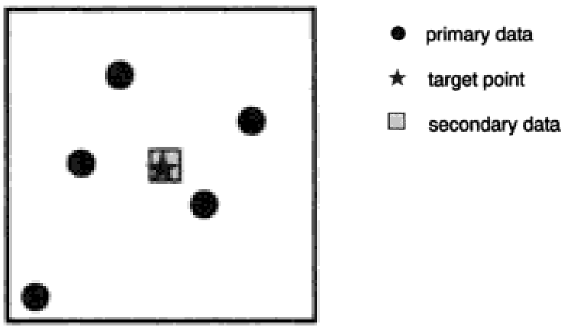

Figure A.9: Simple Co-kriging Neighbourhood with the secondary variable [3].

In Simple Co-kriging, the efficient application requires the result of a correlation coefficient without cross-covariance function, simplification that can only be meaningful for co regionalization models with proportionalities [3].

e. Neighborhood Searching

As having data clustered in some regions of physical surface, there can also be regions having none or slightly number of measured data. Consequently, regions having lack of data may cause confusion about continuity of physical surface. While creating the map, absence of data should be filled with predicted data. Those are the data created by kriging, considering data autocorrelation along the physical surface. In Arc GIS, Geostatistical Analyst package, while making new predictions for gap regions, to increase computational speed, the effect of distant locations can be eliminated and focused on the closer points. This option is called neighborhood searching. By this facility, the extent of predicted points by sector types in gap regions can be adjusted and the number of closer points (neighbors) that will affect the autocorrelation can be chosen. In this study, all parameters used in neighborhood searching are decided by optimization of prediction error values (Figure A.10).

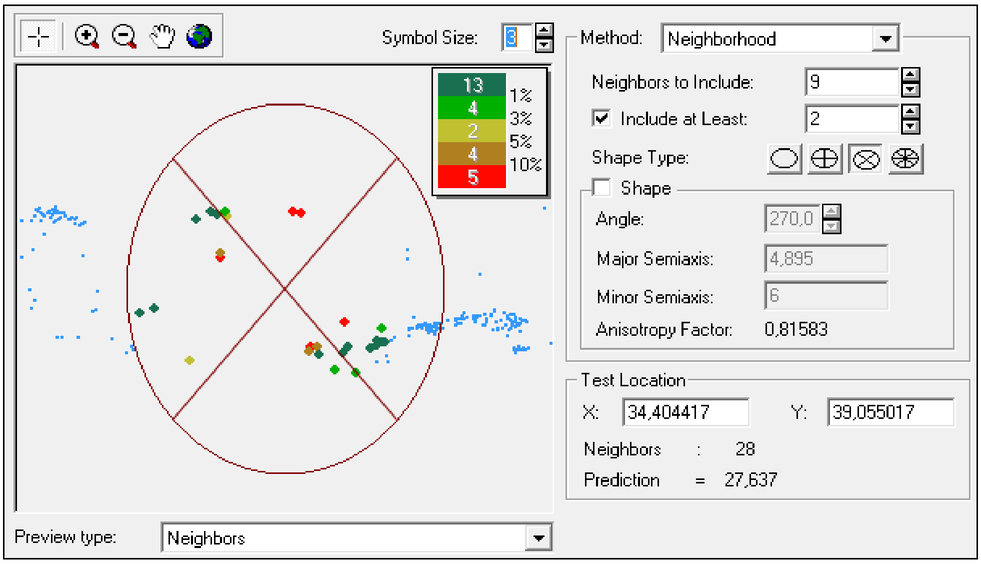

Figure A.10: Neighbourhood Searching Sample with control parameters in Arc GIS Geostatistical Analyst.

f. Accuracy

Parameters used in semivariogram modeling and neighborhood searching are obtained by considering two main factors. First of all, physical trends should be considered in data collection, measurement errors and modeling. Physical trends are forward factors and are shaped by geological aspects on data. Secondly, prediction error values and cross validation should be examined. However, prediction error values are used iteratively to obtain parameters until reaching best approach values. Error concepts used in this study are mentioned in Appendix A-2. For checking the goodness of the interpolation or semivariogram modeling several criteria and comparisons are used. In Table A.1 these criteria are shown:

Table A.1: Criteria used for prediction errors for accuracy check of applications.

Prediction Error Type	Better Approach
MPE, MSPE	→ 0
RMSPE	⬇ , → ASE
RMSSPE	→1

Cross-Validation is an accuracy tool that estimates the trends and autocorrelation models by processing all data [1]. It omits a data at a time and tries to predict the missing data by using the semivariogram and/or neighborhood models. The process is sustaining over and over again until all the data are predicted right after removing. At last, a line is constructed as in Figure A.11. If measured data values approach to the predicted ones, then slope would approach 1 value. Moreover, when there is no autocorrelation between data, the slope shows a horizontal line.

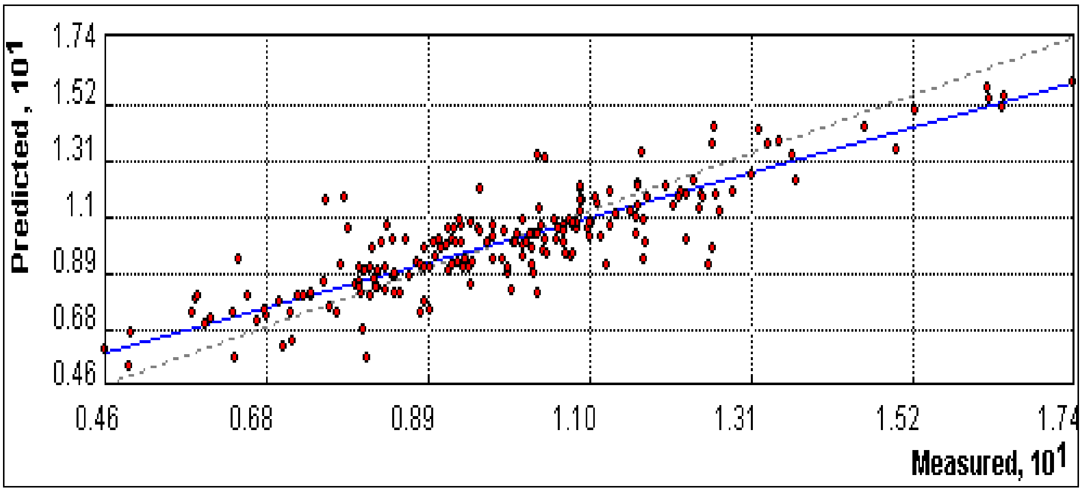

Figure A.11: Cross Validation Plot Example.

A.2 Prediction Error Formulations

s = Sample Standard Deviation

n = Size of the sample

$\hat{\varepsilon}_i$ = Prediction Error = Measured – Predicted

$\hat{\sigma}_i$ $\frac{s}{\sqrt{n}}$ (Standard error)

MPE $\frac{1}{n}\sum_{i=1}^{n}\varepsilon_i$ (Mean Prediction Error)

RMSPE $\sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(\varepsilon_i - \text{MPE})^2}$ (Root Mean Square Prediction Error)

$\hat{\varepsilon}_i = \frac{\varepsilon_i}{\hat{\sigma}_i}$ = Standardized prediction error

ASE $\frac{1}{n}\sum_{i=1}^{n}\hat{\sigma}_i$ = (Average Standard Error)

MSPE $\frac{1}{n}\sum_{i=1}^{n}\hat{\varepsilon}_i$ = (Mean Standardized Prediction error)

RMSSP $\sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(\hat{\varepsilon}_i - \text{MSPE})^2}$

(Root Mean Square Standardized Prediction Error)

APPENDIX B. DATASETS USED IN GEOSTATISTICAL ANALYSIS

Data Set 1in Table B.1 was collected from petroleum, natural gas and geothermal wells along Turkey and processed in Mıhçakan et al [6]. and Taşçı [9]. Nonetheless, all chosen data were converted (Equation 2.1) into temperature values at -500 m depth from measured temperature values at their measurement depths. Surface depth z_1 is taken as 0 m. In addition, the surface temperature value is assumed to be 15 ^oC in average.

Table B.1: Data Set 1

ID	Well Name	Latitude	Longitude	Temperature @500m
1	ABDÜLAZİZ 1	39,88	38,32	24,0
2	ADIYAMAN 51	38,21	37,79	47,1
3	AF1	30,32	38,45	61,4
4	AHMETBEY 1	27,59	41,44	31,7
5	AKBAŞ 1	26,87	41,56	31,5
6	AKÇELİ 1	38,76	37,82	29,1
7	AKKÖY 1	40,94	37,74	25,2
8	AKPINAR 5	38,83	37,90	31,2
9	AKYAR 2	35,12	37,09	24,8
10	ALACAOĞLU 1	27,28	41,30	33,4
11	ALAŞEHİR 1	28,54	38,39	39,3
12	ALÇIK 2	40,30	38,17	34,0
13	ALİAĞA	26,55	38,47	48,1
14	ALTINYAYLA 1A	29,48	37,01	23,6
15	ANBARCIK 101	40,79	37,75	21,8
16	ARABAN 2	37,66	37,41	26,7
17	ARAPLI 1	41,62	37,15	25,8
18	ARDAHAN 1	42,41	41,70	28,2
19	ARDIÇ 1	28,15	41,19	33,6
20	SALAVATLI 1	28,01	37,52	64,0
21	AŞKALE 1	40,42	39,55	29,3
22	B.AVİRAN 1A	40,35	38,23	27,9
23	BABESKİ 1	26,98	41,45	28,0
24	BAĞLICA 1	37,74	37,49	27,3
25	BAHÇEDERE 1	27,77	41,34	31,2
26	BAKACAK 1	38,84	37,71	27,8
27	BALLI 1	26,95	40,83	29,1
28	BARTIN 1	32,27	41,49	25,7
29	BATI FIRAT 9	38,92	37,87	30,8
30	BATI HAZRO 1	40,57	38,27	25,5

31	BATI KARABAĞ 1	37,46	37,34	24,1
32	BATI KOZLUCA 1	41,70	37,12	32,2
33	BATI MİGO 3	39,71	38,12	32,8
34	BATI RAMAN 257	41,11	37,80	28,6
35	BATI RAMAN 317	41,09	37,81	32,5
36	BAYRAMDERE 1	27,32	41,63	32,4
37	BAYRAMLI 1	26,24	41,31	36,4
38	BELAŞA 3/A	41,17	38,30	27,2
39	BEŞİKLİ 9	38,85	37,75	29,4
40	BEŞYAMAÇ 1	39,19	37,94	28,7
41	BEŞYOL 1	41,87	38,00	25,0
42	BEYBUNİ 1	40,34	38,20	27,9
43	BEYCİLER 1	28,12	41,21	34,9
44	BEYÇAYIR 1	41,39	38,00	27,5
45	BOĞAZ 1	39,39	38,06	28,7
46	BOYABAT 4	34,90	41,56	22,5
47	BUCAK 1	39,07	37,87	29,5
48	BUDAK 1	40,84	38,37	24,6
49	BÜYÜK ALAN 1	29,65	37,19	25,4
50	BÜYÜK YONCALI 1	27,92	41,37	34,1
51	CELALİYE 1	27,33	41,54	28,0
52	CENDERE 9	38,64	37,90	29,9
53	CENGİZ 1/A	26,94	40,85	31,9
54	CİLESİZ 1	41,58	37,15	20,2
55	COŞKUNSEL 2	38,82	37,89	29,2
56	CUMALAR 1	36,32	37,22	27,1
57	ÇAĞLA 1	39,00	37,63	30,4
58	ÇAMLIK 1	35,41	36,96	24,0
59	ÇAMURLU 102	41,60	37,12	24,8
60	ÇAYLARBAŞI 6	39,01	37,70	33,4
61	ÇELİKLİ 20	41,64	38,09	30,0
62	ÇEMBERLİTAŞ 8	37,35	37,81	28,5
63	ÇINARLI 1	40,84	38,42	21,6
64	ÇOBANPINAR 1	38,86	37,92	25,2
65	ÇORLU 3/A	27,95	41,40	31,8
66	D. MALADABİ 1	41,28	38,11	27,9
67	D.BÖLÜKYAYLA 1A	38,52	37,89	27,0
68	D.KAVAKDERE1	27,30	41,74	32,0
69	DEĞİRMENKÖY 2	28,07	41,17	32,7
70	DELEN 1	27,72	41,37	27,7
71	DEMRE 1	29,88	38,30	30,4
72	DEVEÇATAĞI 5	27,32	41,60	33,8
73	DİCLE 1	40,95	37,83	22,9
74	DİDAN 1	40,89	38,01	27,5
75	DİKMENTAŞ 1	38,84	37,82	28,1
76	DODAN 6/G	41,79	38,08	26,1
77	DOĞU BEŞİKLİ 8	38,97	37,73	31,2
78	DORUK 1	40,24	38,19	24,4
79	DUMRUL 2	40,33	38,19	26,9
80	EJ2 (SİMAV)	28,59	39,01	89,9

81	EKİNVEREN 1	34,62	41,60	24,0
82	ELBEYİ 1	38,77	37,74	30,3
83	ELBEYLİ 1	37,54	36,72	27,4
84	EMELCİK 1	35,16	37,24	30,7
85	ERBİN 1	41,85	37,99	27,6
86	EREĞLİ 1	31,63	41,35	25,5
87	ERTUĞRUL 1	27,47	41,57	29,2
88	EŞMELİ 1	39,07	37,77	34,6
89	FİLYOS 1	32,08	41,60	23,8
90	FOÇA 1	26,64	38,69	29,0
91	G. KAYAKÖY 1	40,25	38,00	26,5
92	G. SARICAK 5	40,25	38,17	25,9
93	G. ŞAHABAN 15	40,19	38,11	26,4
94	G.ADIYAMAN 7	38,22	37,75	29,6
95	G.KARAKUŞ 2	38,62	37,82	36,0
96	GARZAN 94	41,48	37,87	27,5
97	GEDİK 2	38,99	37,96	30,8
98	GEGENDERE 1	32,52	41,61	24,4
99	GELİBOLU 1	26,59	40,36	30,2
100	GERCÜŞ 2	41,26	37,57	23,8
101	GERMİK 20	41,39	37,93	24,7
102	GİLBAŞ 1	35,36	37,20	22,6
103	GİRMELİ 1	41,44	37,11	24,8
104	GÖKDERE 6	36,18	37,00	35,2
105	GÖRÜMLÜ 1	42,57	37,32	24,7
106	GÖZTEPE 1	41,52	37,01	26,4
107	GÜNEY AZIKLI 1	39,75	38,09	29,0
108	GÜNEY BAKÜK 1	41,45	37,16	21,7
109	GÜNEY DİNÇER 22	41,73	37,17	28,0
110	GÜNEY HAZRO 1	40,76	38,24	27,1
111	GÜNEY KINIK 1	38,46	37,80	27,7
112	GÜNGÖRMEZ 1	39,03	37,87	27,2
113	GÜRBÜZ 1	39,67	38,09	27,3
114	GÜVEN 1	38,94	37,84	29,3
115	GÜZELSU 2	38,89	37,88	30,0
116	HABİBLER 2	26,70	41,66	32,1
117	HAMİTABAT 15	27,27	41,26	33,2
118	HANÇERLİ 3	39,87	38,12	29,5
119	HAYAT 1	41,51	38,00	30,2
120	HİSTUR 1	38,71	37,95	25,7
121	HOSAN 1	39,83	38,21	27,4
122	İKİZCE5	38,84	37,79	31,5
123	İKİZTEPE SP3	41,57	37,10	23,5
124	İMAMKÖY(AYDIN)	27,51	37,51	61,8
125	İPEK1	41,67	37,71	25,8
126	İSKENDERUN 2	35,92	36,44	30,9
127	K. KARAKUŞ 6	38,62	37,89	28,8
128	K. OSMANCIK 1	27,36	41,58	31,2
129	K.ADIYAMAN 4	38,22	37,56	28,2

130	K1 DİKİLİ (BERGAMA)	26,52	39,04	52,2
131	KALDIRIM 1	39,82	37,94	28,7
132	KARAAĞAÇ	27,49	41,55	25,8
133	KARAALİ 3	41,06	38,05	26,9
134	KARABAĞ 1	41,69	38,06	28,8
135	KARACAOĞLAN 1	27,07	41,56	30,4
136	KARAÇALİ 2	27,92	41,19	32,3
137	KARADUT 1	38,81	37,93	28,7
138	KARAGÖL 1	37,36	37,35	23,7
139	KARAKUŞ 9	38,55	37,84	29,2
140	KARAKUYU 1	35,14	37,07	27,6
141	KARAPINAR 1	39,64	37,92	26,4
142	KARTALTEPE 1	38,37	38,17	26,9
143	KARTALTEPE 8	38,17	40,36	29,8
144	KASTEL 6	40,59	38,01	31,8
145	KAVAKDERE 3	27,28	41,59	33,9
146	KAYABAĞLAR 1	41,65	37,97	27,7
147	KAYADİBİ 1	41,44	38,26	26,6
148	KAYAKÖY 3	40,29	38,18	28,7
149	KAYAYOLU 1	40,59	38,09	25,9
150	KEPİRTEPE 2	27,41	41,37	29,4
151	SEYHAMAMI (KIZILCAHAMAM)	32,39	40,27	38,6
152	KIRCAOĞLU 1	36,57	36,37	26,1
153	KIRKLARELİ 1	27,19	41,65	27,7
154	KIRTEPE 1	39,99	38,14	26,3
155	KIZILDERE	29,06	37,46	66,8
156	KIZKAPANI 1	37,24	37,29	32,2
157	KOZLUK 2	41,49	38,17	28,3
158	KULECİK 1	37,04	37,15	26,7
159	KULELİ 2	26,89	41,49	29,6
160	KUMRULAR 4	27,22	41,50	32,9
161	KURTALAN 1	41,55	37,97	32,2
162	KURTDERE 1	27,78	41,40	31,1
163	KUZEY ABALAR 1	26,74	41,59	31,7
164	KUZEY EŞMELİ 1	39,09	37,82	28,3
165	KUZEY HALOF	38,54	37,93	25,2
166	KUZEY KARADUT 1	39,05	37,94	29,4
167	KUZEY KAYA 1	37,46	37,31	26,7
168	KUZEY MAĞRİP 2	41,62	37,94	28,2
169	KUZEY MİGO 3	39,72	38,12	30,6
170	KUZEY PİRİN 1	38,31	37,79	32,0
171	MAĞRİP 52	41,62	37,92	30,0
172	MALABADİ 1	41,25	38,12	27,9
173	MANAVGAT 1	31,46	36,77	24,6
174	MEHMETDERE 1	40,41	38,22	25,5
175	MEHMETDERE 7	40,40	38,22	26,2
176	MERİÇ 1	26,67	41,45	29,7
177	MH 1/B (MELİKŞAH)	32,41	40,12	33,0
178	MİYADİN 1	39,91	38,12	25,1

179	MOLLACA 1	40,50	37,89	27,3
180	MUTLU 1	38,54	37,89	29,1
181	NARLI 1	37,21	37,39	29,2
182	NASRETTİN 1	38,82	37,66	31,3
183	NAZAR 1	41,39	37,97	27,5
184	O. SUNGURLU 2	38,82	37,92	29,2
185	OCAKLI 1	41,78	37,14	25,4
186	OLUKLU 3	38,22	37,82	28,5
187	OYLUKTAŞ 1	41,49	38,06	29,5
188	ÖMERBEYLİ 6 (GERMENCİK)	27,37	37,51	112,9
189	ÖRDEKLİ 1	39,18	37,81	29,5
190	ÖZGÜNER 1	41,62	37,22	24,3
191	ÖZPINAR 1	36,21	38,01	23,3
192	PANCARKÖY 1	27,14	41,38	29,9
193	PAPUR 1	41,44	38,24	28,4
194	PEHLİVANKÖY 1	26,85	41,30	31,0
195	PİYANKO 4	38,98	37,84	30,7
196	RAMAN 234	41,32	37,76	31,6
197	SARICAK 9	40,24	38,17	25,1
198	SARIK 2	39,66	38,07	29,2
199	SARIKAYA 2	38,70	37,92	26,5
200	SARIKIZ 1	28,47	38,36	48,7
201	SEYMEN 2	28,17	40,16	39,5
202	SEZGİN 1	41,36	37,82	27,4
203	SİLVANKA 7	41,34	38,05	28,8
204	SİNEKLİ 1	28,18	41,22	30,7
205	SİVRİTEPE 1	40,24	38,12	25,3
206	SOĞUKTEPE 1	39,69	38,11	32,9
207	SÜTLÜCE 2	27,53	41,52	27,3
208	ŞELMO 104	41,28	38,19	29,2
209	ŞERBETLİ 2	38,14	40,04	26,4
210	T2 (TUZLA)	26,24	40,09	89,1
211	TALAN 1	41,36	38,24	24,4
212	TAŞKAPI 1	39,08	37,90	31,6
213	TAŞLIK 1	38,91	37,79	29,8
214	TELHASAN 1	41,49	37,13	24,5
215	TEPECİK 1	40,22	38,20	26,4
216	TERZİLİ 2	27,09	41,52	28,6
217	TOKARİS 2	38,83	37,76	29,7
218	TUĞRUL 1	40,32	38,22	24,9
219	TURA 1	41,19	37,93	29,3
220	TÜMAY 1	38,44	37,84	29,8
221	TÜTÜN 1	41,74	38,04	31,1
222	ULAŞ 4	39,82	38,09	25,8
223	ULUS 1	32,57	41,46	29,0
224	UMUR 1	26,82	41,72	32,4
225	UMURCA 2	29,69	37,12	27,7
226	UMURCA C-3	27,44	41,42	28,0
227	UZUNÇAYIR 1	41,31	38,10	24,7

228	UZUNKÖPRÜ 1	26,58	41,29	35,3
229	UZUNPINAR 1	39,14	37,98	31,2
230	ÜÇTAŞ 1	39,69	37,97	27,2
231	ÜZÜMCÜK 1A	39,24	37,79	28,4
232	VARINCA 1	40,74	38,21	27,9
233	YAKACIK 1	37,52	36,89	27,7
234	YANANKÖY 2	37,22	36,71	28,9
235	YASİNCE 1	40,55	37,89	25,1
236	YAYIK 2	40,34	38,18	26,0
237	YENİKÖY 8	40,40	38,19	26,5
238	YENİMAHALLE 1	27,12	41,57	29,1
239	YEŞİLGÖL 1	27,35	41,54	32,9
240	YOLAÇAN 1	41,89	37,15	25,9
241	ZEY 1	38,21	37,82	28,8

Data Set in Table B.2 is collected and processed by İlkışık [4]. Unlike Data Set 1, in Data Set 2, the data are obtained by Silica Geochemical Method. In this method, basically, the amounts of silicate in thermal waters taken from wells are examined and heat flux values are obtained.

Table B.2: Data Set 2

ID	Well Name	Latitude	Longitude	Temperature @500m
1	19 Mayıs Üniver.	36,23	41,33	31,0
2	Aa.şehirören	34,42	41,36	25,0
3	Aaydogmus	30,25	38,08	16,0
4	Abditolu	32,75	37,73	23,7
5	Abıde	29,31	38,94	46,7
6	Acıağaç	32,85	41,45	20,2
7	Afyon	30,48	38,78	53,3
8	Agzıkara	30,56	38,59	47,8
9	Ağacık	26,94	39,40	18,4
10	Ağayeri	26,93	41,46	31,5
11	Ağıllı	34,52	38,46	36,0
12	Ağın	38,71	38,94	22,9
13	Ahatlar	32,41	40,49	30,0
14	Ahiboz	32,84	39,60	34,0
15	Ahmetli	39,88	38,19	15,5
16	Ak Petrol	41,41	39,96	29,0
17	Akbaba	29,12	41,16	24,5
18	Akçakale	39,35	36,71	28,6
19	Akçakoca	31,04	41,08	23,2
20	Akçal	27,54	39,60	28,5
21	Akçavakıf	33,57	40,68	39,5
22	Akfırat	29,40	40,94	24,1
23	Akharım	29,33	40,42	21,5
24	Akıncı	37,27	36,68	20,5
25	Akkoç	36,43	40,66	22,0

26	Akkoyunlu	30,06	37,93	20,6
27	Akköy	35,02	38,35	23,0
28	Akman	34,32	38,01	16,0
29	Akoren	30,42	38,99	16,6
30	Akpınar	36,40	39,64	20,5
31	Akyazı	35,77	40,45	22,0
32	Alabancı	28,91	38,36	31,0
33	Alaca	41,23	37,85	15,7
34	Alacaatlı	28,04	39,25	28,6
35	Alacabük	31,72	41,27	24,0
36	Alahıdır	27,93	38,47	31,8
37	Alçıtepe	26,23	40,09	42,0
38	Aleyinli	35,85	38,62	16,7
39	Alınca	39,53	37,41	38,3
40	Alifakı	34,99	36,88	24,9
41	Alihan	38,70	38,20	57,5
42	Alpı	32,60	41,61	25,5
43	Altunelma	36,89	38,35	16,0
44	An.Lisesi	27,93	39,68	32,5
45	Argıthanı	31,69	38,30	22,6
46	Armutlu	28,82	40,52	28,4
47	Armutlu	28,82	40,51	38,0
48	As.Vet.	29,11	40,40	19,3
49	As.Vet.	29,09	40,39	41,9
50	Asarağaç Mah.	36,40	41,23	28,5
51	Atışalanı	28,09	41,04	28,0
52	Atlı	40,14	37,19	17,1
53	Avdan	32,30	37,28	18,2
54	Avdan	32,52	40,54	47,5
55	Aydınlar	31,57	41,28	26,8
56	Aydınlı	31,70	39,06	37,7
57	Aydınoğlu	36,06	36,94	28,0
58	Aynalı	39,46	38,08	32,9
59	Azımlı	27,63	38,78	30,9
60	B.Burnağıl	34,59	39,09	61,0
61	B.Çamlıca Tep.	29,07	41,03	19,0
62	B.haşlama	33,12	37,66	17,8
63	B.Kılıçlı	28,18	41,17	36,3
64	B.oba	32,03	38,53	19,2
65	B.yanık	30,44	41,09	29,0
66	Bacak	41,24	38,16	42,0
67	Bademlı	28,08	38,05	25,9
68	Bağlıca	38,74	38,39	24,5
69	Bakırcılar	32,98	41,56	26,5
70	Balaban	38,31	38,57	18,6
72	Balcı	27,59	40,05	27,0
73	Ballı	33,72	39,92	49,5
74	Ballışeyh	33,74	39,91	40,5
75	Bandırma	27,94	40,30	27,8
76	Bardat	33,11	36,45	19,5

77	Başkaya	37,68	38,56	17,7
78	Başören	31,60	41,13	17,1
79	Başören	31,87	40,20	22,5
80	Bayır	28,02	36,68	25,7
81	Bayramlı	39,09	37,43	20,2
82	Belediye	37,46	36,67	24,5
83	Belenli	38,73	37,67	26,5
84	Belisırma	34,29	38,26	47,1
85	Belli	40,82	37,91	34,2
86	Belpınar	36,07	39,92	22,5
87	Bergama	27,21	39,09	26,3
88	Besıktepe	26,87	39,25	35,9
89	Beyagac	28,93	37,21	15,7
90	Beyaztepe	39,35	37,30	20,1
91	Beydili	37,67	37,51	26,5
92	Beykısla	30,84	39,43	16,8
93	Beyler	39,56	38,95	19,0
94	Bıga	27,16	40,25	28,5
95	Bingöl	40,52	38,90	27,5
96	Boğaköy	35,71	40,63	19,8
97	Bolalan	42,45	38,47	41,5
98	Boyacılar	30,67	40,26	16,6
99	Boyalı	28,13	38,79	34,7
100	Boyallı	32,28	40,17	57,5
101	Bozan	31,07	39,76	17,6
102	Bozburun	38,33	38,60	16,9
103	Bozca	35,00	38,74	20,5
104	Böğrek	40,19	37,36	18,6
105	Bulutluçeşme	26,84	39,28	17,7
106	Bulutoğlu	36,78	37,65	28,5
107	Büyükeceli	33,55	36,17	15,8
108	By.Bıyıklı	33,48	39,25	36,5
109	Carık	27,83	40,26	37,2
110	Celıloglu	30,13	38,39	22,5
111	Cıgıltepe	30,27	38,57	32,5
112	Cınar	38,18	37,58	17,5
113	Cumalı	29,93	40,29	26,2
114	Ç.Pınar	29,98	38,48	21,9
115	Çalıköy	26,06	41,29	29,5
116	Çalıslar	30,04	38,81	23,2
117	Çalkaya	33,15	41,61	19,0
118	Çaltı	32,55	37,22	18,4
119	Çamkoy	28,50	39,61	20,9
120	Çamlıca	29,08	41,03	21,2
121	Çanakçı	32,08	39,45	25,5
122	Çank.İl Jand.	33,60	40,62	22,0
123	Çardaklı	33,14	40,81	34,5
124	Çat	34,61	38,66	23,5
125	Çataloluk	28,49	38,86	45,7
126	Çatalpınar	35,58	36,83	25,3

127	Çatalyazı	33,63	41,18	16,8
128	Çatkuyu	30,28	38,87	16,9
129	Çavdarlı	34,88	38,10	25,1
130	Çavuşköy	27,24	40,24	33,2
131	Çayırbaşı	42,62	40,87	35,5
132	Çayırhisar	27,91	39,62	35,0
133	Çaytepe	40,59	38,27	28,9
134	Çayyuzu	28,00	37,85	69,3
135	Çebekoğlu	37,95	37,39	29,1
136	Çendık	30,16	37,66	24,3
137	Çerkes	32,89	40,80	50,3
138	Çesnı	28,48	38,33	79,5
139	Çıftlıkkoy	26,29	38,25	46,8
140	Çiçekli	35,30	37,16	15,0
141	Çiller	34,13	37,60	26,1
142	Çimento Fab.	34,98	40,57	41,0
143	Çobanlı	42,70	41,10	26,5
144	Çoğullu	32,20	40,71	20,3
145	Çolaklı	38,53	38,36	24,5
146	Çomak	38,36	37,06	32,8
147	Çorlu-1	27,88	41,10	28,6
148	Çöçelli	37,12	37,28	16,5
149	Çukuraluç	34,47	41,13	15,3
150	Çukurhısar	30,30	39,82	35,3
151	Çukurkuyu	34,14	38,00	31,8
152	Dargeçit	41,73	37,54	15,1
153	Darıca	29,87	39,64	40,0
154	Ddavulga	31,42	39,01	16,5
155	Dedeler	35,56	37,06	23,8
156	Dedepınar	35,48	36,92	16,2
157	Değirmen	39,81	37,44	16,0
158	Demırlı	33,97	39,32	31,0
159	Demırtas	29,06	40,27	21,5
160	Demirkapı	33,46	36,91	26,5
161	Denızkoy	26,85	38,99	80,2
162	Derbent	31,00	38,94	27,5
163	Derbent	31,92	37,98	23,9
164	Dereköy	40,66	38,76	22,5
165	Deresenek	31,16	38,56	22,1
166	Dicle	40,10	38,34	17,3
167	Doganlar	27,50	39,79	15,7
168	Dogruca	28,04	40,30	68,7
169	Doğanhisar	31,68	38,17	22,3
170	Doğantepe	35,61	40,61	24,5
171	Doğuçanakçı	40,39	37,97	21,7
172	Doğumevi	42,27	38,52	40,6
173	Dudullu	29,22	41,04	25,0
174	Durak	44,54	37,39	27,5
175	Duraklı	44,37	37,56	20,0
176	Duraklı Yay.	43,34	40,68	24,5

177	Dülük	37,38	37,18	45,5
178	Düzce	41,31	37,18	16,2
179	Düzenli	39,21	37,19	27,9
180	Ekinci	38,82	37,85	33,5
181	Ekinlikada	27,49	40,55	30,6
182	Elbaşı	35,96	38,67	21,0
183	Elçiler	33,79	41,61	28,0
184	Elibüyük	38,48	40,11	31,5
185	Elmaağaç	32,27	37,12	26,9
186	Elmacık	30,09	37,47	24,5
187	Emınekın	31,12	39,34	19,2
188	Erikli	38,01	37,28	27,6
189	Ertugrul	28,92	40,20	37,5
190	Es.Kılıç	42,86	41,30	46,0
191	Esatlar	29,60	39,34	34,3
192	Esentepe	32,03	41,48	26,9
193	Eskakoren	31,32	39,16	16,5
194	Eskiyapar	34,77	40,15	28,0
195	Eycellı	28,31	37,93	29,7
196	Eyerce	29,82	40,33	25,0
197	Fındıklı	30,44	40,94	25,7
198	Fındıklı	30,43	40,94	23,0
199	Fosfat İş.	40,34	37,49	21,8
200	Gap İd.	38,82	37,18	34,4
201	Gaybiyan	40,41	38,36	18,5
202	Gayda	42,40	38,17	23,9
203	Gebeler	32,51	40,63	20,0
204	Gedik	32,45	39,39	21,5
205	Gerce	34,79	39,11	49,5
206	Geyikli	26,20	39,81	42,0
207	Gollu	34,29	39,44	22,5
208	Göbekli	38,54	37,14	22,8
209	Göbü	32,29	41,52	30,6
210	Göçeruşağı	38,24	38,97	36,0
211	Gödel	33,71	41,26	34,1
212	Gökçebağ	32,32	40,10	41,0
213	Gökçebel	35,33	40,67	19,5
214	Göktepe	40,36	37,69	18,8
215	Göktürk	28,89	41,19	28,5
216	Gölcük	29,81	40,71	22,6
217	Göllü	34,30	39,45	24,0
218	Gölpınarı	39,46	39,68	26,4
219	Gönen	27,66	40,18	47,5
220	Gözlühöyük	36,79	37,11	42,0
221	Gumuskol	29,17	38,46	39,9
222	Gumuskoy	29,76	39,50	32,7
223	Gunbası	32,71	40,21	49,0
224	Gunelı	30,95	39,73	17,8
225	Güllü	38,11	37,04	27,2
226	Gülören	39,06	36,74	28,8

227	Gültepe	36,47	36,54	15,2
228	Gümüşlü	38,37	38,66	20,5
229	Günören	41,55	37,32	16,1
230	Güntaşı	39,35	38,58	32,8
231	Gürbüzler	31,96	41,13	27,9
232	Gürle	29,29	40,43	59,6
233	Güzelce	28,45	41,05	32,0
234	Güzelcehisar	32,19	41,64	34,4
235	H.m.uşağı	33,93	38,72	23,2
236	Hacıhasan	33,05	40,59	25,6
237	Hacıhasan	32,74	39,74	45,5
238	Hacılar	35,46	38,62	21,0
239	Hacılar	38,28	37,35	21,6
240	Hacisungur	27,05	41,04	39,0
241	Hadim	32,44	36,98	21,2
242	Halıller	28,28	38,16	38,4
243	Halıören	40,04	38,00	15,7
244	Hallaçlı	28,11	41,33	29,0
245	Hamurkesen	38,85	37,36	28,1
246	Hamurkoy	30,13	38,93	19,1
247	Hanmağra	38,90	37,58	30,4
248	Hanpazarı	40,54	38,02	31,5
249	Hanyıkığı	33,44	37,79	19,6
250	Hasanaslan	33,05	40,11	31,2
251	Hasanoğlu	37,85	37,38	24,0
252	Havran	27,04	39,57	16,9
253	Haydarkulu	38,53	38,51	27,5
254	Haydarlı	37,52	37,60	18,5
255	Hayırbey	36,78	39,67	25,0
256	Hkhısar	31,71	39,47	31,3
257	Hocahacip	33,64	41,24	36,4
258	Horozlu	30,50	40,72	27,0
259	Ilgarlı	39,01	39,71	22,3
260	Ilgaz	33,63	40,92	15,7
261	Ilıca	32,23	39,31	26,5
262	Ilıca	41,11	39,95	62,0
263	Ilıca	41,11	39,95	40,5
264	Ilıca	33,13	41,66	53,0
265	Isıklar	29,86	39,05	18,7
266	Işıkören	30,93	39,63	21,1
267	İbrahimpaşa	34,85	38,59	62,5
268	İbrahimşehir	37,63	37,07	41,0
269	İgdır	29,93	37,77	19,5
270	İğciler	32,07	39,55	30,5
271	İkizköy	38,26	37,21	32,5
272	İmısehır	30,76	39,68	15,6
273	İncirtepe	40,50	37,71	19,2
274	İnecik	27,21	40,96	40,5
275	İnegöl	29,44	40,20	37,3
276	İnkaya	27,94	39,51	40,0

277	İnonu	30,14	39,82	21,3
278	İntepe	26,34	40,02	47,1
279	İski Arş.Tes.	29,30	40,83	28,5
280	İski Sos.Tes.	28,32	41,06	37,5
281	J.Bl.Kom.	41,45	40,49	25,1
282	J.İkm.M.Kom.	29,19	40,94	26,0
283	Jandarma	33,73	39,91	35,7
284	K.Belen	27,26	38,75	50,3
285	K.Karıştıran	27,52	41,33	25,0
286	K.Köseler	27,97	39,67	31,0
287	K.Sanayi	43,40	39,01	18,2
288	Kabakça	28,37	41,23	34,0
289	Kadıkoy	30,92	38,64	31,7
290	Kale	33,41	41,15	27,5
291	Kale	34,52	36,77	17,3
292	Kale	33,67	40,95	30,0
293	Kalkantepe	38,95	38,69	23,4
294	Kandamıs-1	27,23	41,12	22,1
295	Kapaklı	33,19	41,45	15,4
296	Kapı	35,19	36,64	21,6
297	Kapıkaya	39,23	37,90	36,5
298	Karaağaç	32,39	37,68	38,5
299	Karaağaç	28,58	41,12	35,0
300	Karaağaç	30,73	38,89	38,7
301	Karaarkac	34,62	39,25	34,0
302	Karaburun	44,21	39,55	22,0
303	Karacaoren	34,28	39,22	34,3
304	Karadın	29,81	39,26	19,0
305	Karagöz	38,35	38,29	16,0
306	Karahan	38,14	38,41	26,2
307	Karahüyük	34,42	38,87	33,0
308	Karakol Bah.	40,07	38,05	27,3
309	Karakurt	34,02	39,19	33,8
310	Karakuyu	29,11	38,77	61,3
311	Karakuyu	35,14	37,02	22,0
312	Karaman	32,62	41,83	34,6
313	Karamürsel	34,04	40,41	40,0
314	Karapürçek-1	26,98	41,23	25,3
315	Karavelet	41,48	39,92	31,5
316	Kargılı	28,01	37,58	46,0
317	Karlık	29,60	38,70	35,1
318	Kars	43,11	40,61	23,5
319	Kast.Khz bl.	33,79	41,41	32,0
320	Kayabeyi	43,14	41,18	19,0
321	Kayakent	31,80	39,32	22,0
322	Kayapa	27,44	39,49	30,0
323	Kaygısuz	40,33	38,28	16,1
324	Kayı	30,51	37,80	18,0
325	Kaymakamlık	38,62	37,78	32,5
326	Kaymaz	30,27	40,91	23,9

327	Kaymaz	31,15	39,49	21,0
328	Kazıklı	29,16	40,26	30,0
329	Kazıktepe	40,29	37,79	15,3
330	Kç.Bıyıklı	33,45	39,29	31,5
331	Kefeli	35,13	36,79	18,5
332	Keklik Kayası	39,44	39,78	19,0
333	Kemer	35,36	38,87	15,2
334	Kepeneklı	27,54	41,11	26,3
335	Kerimli	36,54	37,52	21,5
336	Kesik	35,44	36,68	22,4
337	Khasan	31,96	38,80	25,5
338	Khz Bak Evi	35,46	38,40	16,7
339	Khz Bak Evi	34,87	39,23	27,5
340	Khz Bak. Evi	38,27	38,78	21,5
341	Khz Sos.Tes.	40,46	37,19	18,2
342	Kırlangıc	33,78	39,88	61,2
343	Kısırm	28,85	41,22	28,1
344	Kıte	28,88	40,20	31,0
345	Kıyıcak	38,63	38,43	37,0
346	Kızılavlu	28,33	38,54	36,8
347	Kızılay	30,33	39,61	123,6
348	Kızılca	34,12	39,24	20,0
349	Kızılca	41,03	39,62	27,0
350	Kızılhöyük	36,76	39,16	18,5
351	Kiran	40,45	38,72	36,0
352	Kirazlı	41,67	40,59	39,0
353	Kite	28,87	40,20	28,0
354	Kocabahçe	43,10	40,39	36,0
355	Koltaş	38,20	36,94	20,4
356	Konaklı Belediy.	35,22	40,62	16,2
357	Koprucek	29,33	39,34	29,0
358	Koren	29,83	37,93	27,9
359	Korucak	41,48	39,95	16,5
360	Koyunağılı	31,64	39,97	26,8
361	Kozluca	30,11	37,49	24,5
362	Kurfallı	27,08	38,99	28,0
363	Kurse	28,07	39,77	30,0
364	Kurşunlu	29,11	40,40	31,4
365	Kurtalan	41,71	37,94	19,1
366	Kurtlugelik	33,11	41,56	19,5
367	Kurtpınar	35,93	36,92	26,1
368	Kuruca	41,47	39,53	21,0
369	Kurucuova	38,17	37,99	17,3
370	Kuruyaka	42,77	39,29	24,1
371	Kuscular	32,85	40,52	57,5
372	Kusura	30,24	38,38	25,9
373	Kuşaklı	36,67	36,27	25,6
374	Kuşsarayı	38,67	38,44	16,9
375	Kuştepe	38,42	37,74	16,0
376	Kuyucak	31,12	37,93	20,3

377	Kuyucakm	28,27	37,06	26,5
378	Kuzuören	30,91	39,18	19,1
379	Kuzviran	30,63	39,01	36,8
380	Küçükşapçı	27,32	39,61	16,7
381	Leylekli	31,52	38,82	18,2
382	Lınyıt	28,60	40,25	21,7
383	Lice	40,67	38,45	23,7
384	Linyitleri	28,96	40,25	27,6
385	M.K.Paşa	28,47	40,05	31,0
386	Mahmatlı	32,89	39,55	31,0
387	Mahmutlu	39,99	38,86	19,6
388	Maliköy	32,39	39,78	34,5
389	Mavıkent	30,33	36,32	22,5
390	Mazıköy	34,85	38,47	41,5
391	Mecıdıye	29,69	40,36	20,0
392	Merkez	26,31	40,23	33,0
393	Merkez	28,85	41,03	35,5
394	Merkez	37,95	38,82	22,5
395	Merkez	34,78	38,21	32,5
396	Mesudıye	30,93	39,51	23,7
397	Mmaltepe-1	26,71	41,02	25,1
398	mtayardım	32,80	39,90	23,5
399	Mudurnu	31,21	40,48	33,0
400	Musalla	38,26	37,72	49,5
401	Müsellim	27,55	41,13	38,0
402	Naneli	38,60	36,85	17,3
403	Nıtrosan	33,54	39,84	31,6
404	O.Sanayı	34,21	39,12	22,0
405	Oduncular	42,17	38,57	20,7
406	Okcular	29,20	39,70	21,3
407	Orhanıye	30,89	38,49	18,3
408	Ortakcı	28,75	37,88	29,3
409	Osmaniye	30,92	39,34	95,7
410	Ovacık	26,86	38,25	33,9
411	Ovacık	27,81	39,72	42,1
412	Oycalı yay.mah	33,05	41,30	35,5
413	Oymaağaç	35,40	38,79	37,5
414	Öncüpınar	37,13	36,67	36,0
415	Örenci	38,85	39,02	16,0
416	Örtülüce	27,21	40,37	28,7
417	Öz.Harekat	41,35	40,06	19,5
418	Pamukova	30,05	40,48	20,0
419	Panlı	34,75	38,79	15,2
420	Pasinler	41,64	39,94	29,0
421	Pazarkaya	31,63	38,54	17,7
422	Pazarköy	27,38	39,86	40,4
423	Pazaryolu	40,76	40,42	39,5
424	Pınarbaşı	37,66	37,51	28,5
425	Pınarbaşı	38,38	38,36	19,7
426	Pınarbaşı	35,29	40,68	15,2

427	Pınarlı	28,31	37,68	48,0
428	Pürsünler	28,20	39,22	26,8
429	Sallar	32,74	40,96	37,2
430	Salmanbeyli	35,22	36,83	17,0
431	Salmanlar	29,57	38,56	33,8
432	Samanpazarı	30,75	40,59	37,5
433	Sapcıdede	29,33	39,59	33,5
434	Sapça	31,96	41,42	17,5
435	Saray	44,16	38,51	56,5
436	Saray	44,16	39,51	74,5
437	Saraycık	31,74	40,75	55,3
438	Sarıcalar	27,48	39,20	29,5
439	Sarıcalar	32,61	38,09	33,8
440	Sarıköy	31,80	37,79	29,1
441	Sarımsaklı T.İş.	27,17	41,41	23,5
442	Savuca	27,36	37,70	46,5
443	Sazlıpınar	33,19	37,68	17,1
444	Selımıye	27,90	39,47	63,8
445	Selımıye	28,69	38,20	30,2
446	Selman	40,17	38,20	15,1
447	Senırkent	30,51	38,09	18,5
448	Serenli	39,76	40,02	18,0
449	Seyrek	27,01	38,55	37,2
450	Seyyar	38,65	37,04	26,2
451	Sıvrıhısar	31,45	39,44	23,8
452	Sivas H.alanı	36,90	39,78	18,0
453	Sofular	35,02	38,68	21,5
454	Soguksu	29,45	40,20	25,8
455	Söğüt	37,80	38,08	18,7
456	ssk	29,00	40,22	45,0
457	Subaşı	35,19	38,55	32,5
458	Sulakyurt	33,70	40,15	32,5
459	Susuz	40,93	38,17	16,6
460	Sutaşı	36,01	36,08	17,0
461	Sükyan	40,97	38,83	16,0
462	Süphan	42,89	38,81	16,9
463	Sütlüce	27,59	41,50	24,5
464	T.Sökmen	36,33	36,25	29,9
465	Tanıktepe	43,92	39,56	34,0
466	Tarlacık	40,58	37,54	19,9
467	Tasoluk	28,70	41,20	28,0
468	Taşağıl	31,89	37,39	17,9
469	Taşk.Jüt İp.Fb.	34,20	41,50	31,0
470	Taşoluk	28,72	41,20	33,0
471	Tayakadın	26,64	41,58	20,5
472	Tekeköy	29,67	41,06	22,5
474	Tekmen	33,05	36,10	16,2
475	Tellioğlu	31,84	41,21	45,7
476	Tepekoy	30,33	39,21	24,4
477	Tepeköy	34,44	38,87	46,0

478	Tepeönü	42,83	39,34	49,5
479	Terken	35,35	40,66	16,8
480	Terzialan	27,02	39,95	35,3
481	Tıgem	32,12	39,15	18,5
482	Topluca	32,30	41,66	20,7
483	Topraklı	42,66	38,40	24,7
484	Tozluca	39,16	37,90	17,3
485	Turfallar	28,30	39,48	37,0
486	Turgutlu	30,23	40,51	40,5
487	Turkobası	28,52	41,04	28,2
488	Turnalı	32,39	40,23	25,3
489	Tülmen	38,64	37,32	25,7
490	Türkmenli	27,85	41,05	33,0
491	Tütenocak	41,72	38,15	27,3
492	Tüyler	41,47	39,97	70,0
493	Ugurlua	32,66	40,35	31,0
494	Ugurlub	30,51	37,31	17,3
495	Ulupınar	34,15	38,85	21,0
496	Un Fab. Yanı	35,79	38,44	22,5
497	Uzgur	38,36	40,88	29,5
498	Uzuntepe	38,50	37,59	27,5
499	Üçdut	35,75	37,23	15,1
500	Üçgöl	37,69	37,25	30,0
501	Üzümlü	39,67	39,68	20,5
502	Vakıflar-1	27,66	41,27	27,3
503	Velıkoy	27,94	41,26	23,7
504	Y.Armutcuk	29,67	39,12	22,6
505	Y.Çiftlik	44,56	39,86	16,3
506	Y.Hacıosmanoğlu	31,92	39,09	17,2
507	Y.Kırıklar	27,24	39,19	39,8
508	Y.Kulecik	42,89	39,38	50,0
509	Y.Topraklı	44,43	39,90	16,2
510	Yağmur	40,50	37,41	25,3
511	Yahyalı	35,95	39,07	29,0
512	Yakakayı	30,77	39,86	17,6
513	Yamaç	33,75	37,90	45,3
514	Yapıldak	26,55	40,20	18,7
515	Yapracık	32,60	39,87	30,5
516	Yassıören	31,96	41,29	18,7
517	Yassıpınar	36,73	39,32	25,5
518	Yavaşlı	31,89	38,75	21,9
519	Yazıtepe	29,90	38,65	24,8
520	Yazıtepe	29,87	38,63	27,7
521	Yazlık	28,52	41,30	37,5
522	Yenısofca	30,36	39,61	70,7
523	Yeniköy	39,79	37,89	20,3
524	Yeniyurt	37,14	36,79	33,0
525	Yenmıs	27,46	38,46	32,4
526	Yeşerti	37,84	36,85	27,0
527	Yeşerti	37,85	36,85	37,0

528	Yeşilköy	32,10	41,56	27,8
529	Yeşilpınar	38,09	38,69	23,0
530	Yeşilyurt	28,84	40,97	26,0
531	Yeşilyurt	35,62	38,80	23,5
532	Yk.Karlı	33,00	41,46	20,2
533	Yolagzı	26,34	40,32	33,3
534	Yoldere	36,69	40,70	15,8
535	Yorguc	27,05	41,04	27,0
536	Yumaklı	43,77	38,94	22,5
537	Yurtkur	43,71	37,57	17,5
538	Yusufdere	27,88	38,18	33,2
539	Yuzukbası	32,07	39,01	17,5
540	Yüksel	39,83	38,17	28,1
541	Yünlüyaylası	32,39	40,63	42,4
542	Zeyköy	31,49	39,59	30,9
543	Zeytınelı	26,53	38,19	29,5

Data set of Thrace Region in Table B.3 is from the data dispersed in Thrace Region of Data Set 1.

Table B.3: Data set of Thrace Region

ID	Well Name	Latitude	Longitude	Temperature @1000m
1	T2 (TUZLA)	26,23733333	40,08733333	178,2
2	UZUNKÖPRÜ 1	26,58468333	41,29225	70,6
3	GELİBOLU 1	26,58966667	40,35766667	60,3
4	MERİÇ 1	26,67032	41,45013167	59,4
5	HABİBLER 2	26,70296667	41,657	64,2
6	KUZEY ABALAR 1	26,73918333	41,58741667	63,4
7	UMUR 1	26,823	41,71681667	64,7
8	PEHLİVANKÖY 1	26,8519	41,30358333	62
9	AKBAŞ 1	26,86823333	41,55911667	63
10	KULELİ 2	26,89196667	41,48611667	59,2
11	CENGİZ 1/A	26,94226667	40,85256667	63,7
12	BALLI 1	26,95306667	40,83475	58,2
13	BABESKİ 1	26,975	41,45358333	55,9
14	KARACAOĞLAN 1	27,07425	41,55633333	60,7
15	TERZİLİ 2	27,08623333	41,52345	57,2
16	YENİMAHALLE 1	27,11776667	41,57231667	58,1
17	PANCARKÖY 1	27,13963333	41,38455	59,7
18	KIRKLARELİ 1	27,18995	41,65063833	55,3
19	KUMRULAR 4	27,21768333	41,5045	65,7
20	HAMİTABAT 15	27,272	41,25653333	66,3
21	KAVAKDERE 3	27,27625	41,58671667	67,8
22	ALACAOĞLU 1	27,28363	41,30269333	66,7
23	D.KAVAKDERE1	27,30283333	41,742	64

ID	Well Name	Latitude	Longitude	Temperature @1000m
24	DEVEÇATAĞI 5	27,32006667	41,60423333	67,6
25	BAYRAMDERE 1	27,32456667	41,62621667	64,7
26	CELALİYE 1	27,32541667	41,53983333	55,9
27	YEŞİLGÖL 1	27,352	41,53708333	65,8
28	K. OSMANCIK 1	27,35695	41,57645	62,3
29	KEPİRTEPE 2	27,40715	41,36693333	58,7
30	UMURCA C-3	27,4368	41,41751333	55,9
31	ERTUĞRUL 1	27,4675	41,56921667	58,3
32	KARAAĞAÇ	27,48766667	41,55405	51,6
33	SÜTLÜCE 2	27,53386667	41,52058333	54,6
34	AHMETBEY 1	27,592575	41,44123333	63,33
35	DELEN 1	27,721865	41,36993167	55,3
36	BAHÇEDERE 1	27,77133333	41,33821667	62,3
37	KURTDERE 1	27,78423333	41,40483333	62,2
38	KARAÇALİ 2	27,9179	41,18876667	64,5
39	BÜYÜK YONCALI 1	27,923755	41,36732667	68,2
40	ÇORLU 3/A	27,95311167	41,40205333	63,5
41	DEĞİRMENKÖY 2	28,07234167	41,16979833	65,4
42	BEYCİLER 1	28,12178667	41,20608333	69,8
43	ARDIÇ 1	28,15455	41,18731667	67,1

Data set of Thrace Region in Table B.4 is from the data dispersed in Southeastern Anatolia Region of Data Set 1.

Table B.4: Data set of Southeastern Anatolia Region

ID	Well Name	Latitude	Longitude	Temperature @1000m
1	ABDÜLAZİZ 1	39,88463333	38,31690833	48
2	ADIYAMAN 51	38,20686667	37,78891667	94,1
3	AKÇELİ 1	38,759905	37,817865	58,1
4	AKKÖY 1	40,935995	37,738125	50,3
5	AKPINAR 5	38,83403333	37,90336667	62,4
6	ALÇIK 2	40,30036667	38,17035	68
7	ANBARCIK 101	40,7925	37,75233333	43,6
8	ARABAN 2	37,65586667	37,40806667	53,3
9	ARAPLI 1	41,6235	37,1523	51,6
10	B.AVİRAN 1A	40,35266667	38,22583333	55,8
11	BAĞLICA 1	37,74251667	37,486785	54,5
12	BAKACAK 1	38,84123333	37,70963333	55,6
13	BATI FIRAT 9	38,92005	37,87016667	61,6
14	BATI HAZRO 1	40,57405667	38,27306667	51
15	BATI KARABAĞ 1	37,45956	37,34272833	48,1
16	BATI KOZLUCA 1	41,70366667	37,12216667	64,4
17	BATI MİGO 3	39,708465	38,117805	65,6

ID	Well Name	Latitude	Longitude	Temperature @1000m
18	BATI RAMAN 257	41,10866667	37,80286667	57,2
19	BATI RAMAN 317	41,08960333	37,80709667	64,9
20	BELAŞA 3/A	41,17146667	38,30386667	54,3
21	BEŞİKLİ 9	38,85491667	37,75266667	58,7
22	BEŞYAMAÇ 1	39,19056667	37,9376	57,4
23	BEŞYOL 1	41,87293167	38,004705	50
24	BEYBUNİ 1	40,33831667	38,20196667	55,8
25	BEYÇAYIR 1	41,388965	38,00213	55
26	BOĞAZ 1	39,38721667	38,05818333	57,3
27	BUCAK 1	39,071565	37,87188667	59
28	BUDAK 1	40,8355	38,374	49,1
29	CENDERE 9	38,63903333	37,9	59,8
30	CİLESİZ 1	41,57553333	37,15235	40,3
31	COŞKUNSEL 2	38,81875	37,8857	58,3
32	ÇAĞLA 1	39,00395	37,62568333	60,7
33	ÇAMURLU 102	41,60461	37,11837	49,6
34	ÇAYLARBAŞI 6	39,00854667	37,70390167	66,8
35	ÇELİKLİ 20	41,64098333	38,09153333	60
36	ÇEMBERLİTAŞ 8	37,35458333	37,80761667	56,9
37	ÇOBANPINAR 1	38,85898833	37,91967333	50,4
38	D. MALADABİ 1	41,27655	38,1065	55,7
39	D.BÖLÜKYAYLA 1A	38,51833667	37,89016667	53,9
40	DİCLE 1	40,95128333	37,82628333	45,7
41	DİDAN 1	40,88549	38,00755333	55
42	DİKMENTAŞ 1	38,83873333	37,82128333	56,2
43	DODAN 6/G	41,787	38,08386667	52,2
44	DOĞU BEŞİKLİ 8	38,97141667	37,73491667	62,3
45	DORUK 1	40,23533333	38,18913333	48,7
46	DUMRUL 2	40,33383333	38,19066667	53,8
47	ELBEYİ 1	38,77413333	37,73793167	60,5
48	ELBEYLİ 1	37,54287333	36,72402833	54,7
49	ERBİN 1	41,85295	37,98745	55,1
50	EŞMELİ 1	39,06933333	37,77316667	69,2
51	G. KAYAKÖY 1	40,25003333	38,00238333	53
52	G. SARICAK 5	40,253	38,1685	51,8
53	G. ŞAHABAN 15	40,18908333	38,10858333	52,8
54	G.ADIYAMAN 7	38,22266667	37,75283333	59,1
55	G.KARAKUŞ 2	38,62146667	37,8232	71,9
56	GARZAN 94	41,47633333	37,87228333	55
57	GEDİK 2	38,99116667	37,95855	61,6
58	GERCÜŞ 2	41,25621667	37,57306667	47,5
59	GERMİK 20	41,38553333	37,92503333	49,4
60	GİRMELİ 1	41,43671667	37,10526667	49,6

ID	Well Name	Latitude	Longitude	Temperature @1000m
61	GÖRÜMLÜ 1	42,5715	37,32433333	49,4
62	GÜNEY AZIKLI 1	39,75425	38,08683333	58
63	GÜNEY BAKÜK 1	41,45273333	37,15715	43,3
64	GÜNEY DİNÇER 22	41,73383333	37,16808333	56
65	GÜNEY HAZRO 1	40,75536667	38,2358	54,2
66	GÜNEY KINIK 1	38,4589	37,80488333	55,4
67	GÜNGÖRMEZ 1	39,03333333	37,8715	54,4
68	GÜRBÜZ 1	39,67294833	38,08802333	54,5
69	GÜVEN 1	38,9391	37,83991667	58,6
70	GÜZELSU 2	38,89241667	37,88446667	60
71	HANÇERLİ 3	39,87077333	38,118015	58,9
72	HAYAT 1	41,50936667	38,00056667	60,3
73	HİSTUR 1	38,70711667	37,95408333	51,4
74	HOSAN 1	39,8345	38,20633333	54,7
75	İKİZCE5	38,83773333	37,7873	62,9
76	İKİZTEPE SP3	41,57213333	37,10191667	47
77	İPEK1	41,67191667	37,70643333	51,6
78	K. KARAKUŞ 6	38,62111667	37,88673333	57,6
79	K.ADIYAMAN 4	38,22175	37,55911667	56,3
80	KALDIRIM 1	39,819805	37,94227667	57,4
81	KARAALİ 3	41,0571	38,05405	53,7
82	KARABAĞ 1	41,68895	38,05691667	57,6
83	KARADUT 1	38,8085	37,93383333	57,3
84	KARAGÖL 1	37,35742667	37,35071	47,3
85	KARAKUŞ 9	38,55371667	37,8399	58,4
86	KARAPINAR 1	39,64218333	37,923	52,7
87	KARTALTEPE 1	38,36931667	38,16828333	53,8
88	KASTEL 6	40,588815	38,00515167	63,5
89	KAYABAĞLAR 1	41,65486667	37,96811667	55,4
90	KAYADİBİ 1	41,43566667	38,25731667	53,2
91	KAYAKÖY 3	40,28553	38,18396167	57,4
92	KAYAYOLU 1	40,59	38,08533333	51,7
93	KIRTEPE 1	39,9885	38,13816667	52,5
94	KIZKAPANI 1	37,23653333	37,28561667	64,3
95	KOZLUK 2	41,49036833	38,17009833	56,5
96	KULECİK 1	37,04093167	37,15437833	53,3
97	KURTALAN 1	41,55292167	37,97464667	64,4
98	KUZEY EŞMELİ 1	39,08813333	37,82425	56,6
99	KUZEY HALOF	38,5371	37,92581667	50,3
100	KUZEY KARADUT 1	39,04833333	37,94099833	58,8
101	KUZEY KAYA 1	37,45936667	37,30805	53,4
102	KUZEY MAĞRİP 2	41,621095	37,94233167	56,3
103	KUZEY MİGO 3	39,72493333	38,1192	61,2

ID	Well Name	Latitude	Longitude	Temperature @1000m
104	KUZEY PİRİN 1	38,30733333	37,7855	63,9
105	MAĞRİP 52	41,61838333	37,9227	59,9
106	MALABADİ 1	41,25138333	38,1168	55,8
107	MEHMETDERE 1	40,40833333	38,22008333	51
108	MEHMETDERE 7	40,40491667	38,22028333	52,3
109	MİYADİN 1	39,90865	38,12441667	50,2
110	MOLLACA 1	40,50404167	37,8862	54,6
111	MUTLU 1	38,5409	37,88836667	58,1
112	NARLI 1	37,20691667	37,39291667	58,3
113	NASRETTİN 1	38,81816667	37,656	62,6
114	NAZAR 1	41,38648333	37,97283333	54,9
115	O. SUNGURLU 2	38,81886667	37,92295	58,4
116	OCAKLI 1	41,7845	37,13728333	50,8
117	OLUKLU 3	38,22163333	37,8228	57
118	OYLUKTAŞ 1	41,4921	38,05536667	59
119	ÖRDEKLİ 1	39,17583333	37,80736667	59
120	ÖZGÜNER 1	41,62338333	37,22476667	48,5
121	PAPUR 1	41,443165	38,23835833	56,7
122	PİYANKO 4	38,97526667	37,842	61,4
123	RAMAN 234	41,3237	37,75858333	63,1
124	SARICAK 9	40,24066667	38,173	50,2
125	SARIK 2	39,65635	38,07243333	58,4
126	SARIKAYA 2	38,70091667	37,92203333	52,9
127	SEZGİN 1	41,357465	37,82454667	54,7
128	SİLVANKA 7	41,3388	38,04778333	57,6
129	SİVRİTEPE 1	40,23535	38,123	50,6
130	SOĞUKTEPE 1	39,69225	38,10693333	65,8
131	ŞELMO 104	41,275735	38,18949833	58,4
132	TALAN 1	41,35666667	38,2414	48,8
133	TAŞKAPI 1	39,07628333	37,90421667	63,1
134	TAŞLIK 1	38,90945	37,78795	59,5
135	TELHASAN 1	41,48546667	37,13416667	49
136	TEPECİK 1	40,22408333	38,20228333	52,7
137	TOKARİS 2	38,83471667	37,75843333	59,3
138	TUĞRUL 1	40,32333333	38,21895	49,7
139	TURA 1	41,18903333	37,92513333	58,6
140	TÜMAY 1	38,44225	37,8363	59,5
141	TÜTÜN 1	41,73991667	38,03708333	62,2
142	ULAŞ 4	39,82475	38,08706667	51,6
143	UZUNÇAYIR 1	41,30871667	38,10208333	49,3
144	UZUNPINAR 1	39,1384	37,9751	62,4
145	ÜÇTAŞ 1	39,69255	37,96691667	54,4
146	ÜZÜMCÜK 1A	39,23615	37,79149	56,8

ID	Well Name	Latitude	Longitude	Temperature @1000m
147	VARINCA 1	40,74225	38,20875	55,8
148	YAKACIK 1	37,52220167	36,89301167	55,3
149	YANANKÖY 2	37,22228333	36,707035	57,7
150	YASİNCE 1	40,55233333	37,89226667	50,2
151	YAYIK 2	40,33593333	38,18446667	52
152	YENİKÖY 8	40,40251667	38,19073333	52,9
153	YOLAÇAN 1	41,891125	37,15482167	51,8
154	ZEY 1	38,20516667	37,81721667	57,5

RESUME

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