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Geostatistical Approach for Spatial Interpolation of Meteorological Data

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ABSTRACT

Meteorological data are used in many studies, especially in planning, disaster management, water resources management, hydrology, agriculture and environment. Analyzing changes in meteorological variables is very important to understand a climate system and minimize the adverse effects of the climate changes. One of the main issues in meteorological analysis is the interpolation of spatial data. In recent years, with the developments in Geographical Information System (GIS) technology, the statistical methods have been integrated with GIS and geostatistical methods have constituted a strong alternative to deterministic methods in the interpolation and analysis of the spatial data. In this study; spatial distribution of precipitation and temperature of the Aegean Region in Turkey for years 1975, 1980, 1985, 1990, 1995, 2000, 2005 and 2010 were obtained by the Ordinary Kriging method which is one of the geostatistical interpolation methods, the changes realized in 5-year periods were determined and the results were statistically examined using cell and multivariate statistics. The results of this study show that it is necessary to pay attention to climate change in the precipitation regime of the Aegean Region. This study also demonstrates the usefulness of the geostatistical approach in meteorological studies.

Key words: geostatistical interpolation, geographic information system, ordinary kriging, meteorological data.

INTRODUCTION

Measurement and evaluation of the spatially distributed meteorological data have become important in connection with climate-change impact studies, determination of water budgets at different temporal and spatial scales, as well as validation of atmospheric and hydrological models. Meteorological data are usually available from a limited number of meteorological stations (Hofierka et al. 2002), mostly because it is not economically and technically possible to obtain meteorological data throughout the entire surface. For this reason, spatial interpolation of the meteorological variables obtained from the certain sample points is performed in order to create a model for the entire surface.

Spatial interpolation is the procedure of estimating the value of unsampled points using existing observations (Waters 1997). Methods for spatial interpolation can be classified into two main categories

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as deterministic and geostatistical (Burrough and McDonnell 1998, Matthews 2002). Deterministic interpolation techniques calculate the values of unsampled points and create surfaces from measured points, based on either the extent of similarity or the degree of smoothing (Matthews 2002). Deterministic methods do not use probability theory (Waters 1997). Geostatistical interpolation techniques use the statistical properties of the measured points, quantify the spatial autocorrelation among the measured points and account for the spatial configuration of the sample points around the estimation location (Matthews 2002).

Kriging is a geostatistical technique for optimal spatial estimation (Waller and Gotway 2004). Kriging provides a solution to the problem of estimation based on a continuous model of stochastic spatial variation and takes the variogram model (Webster and Oliver 2007). Today, with the developments in computer and Geographical Information System (GIS) technologies, the statistical methods have been integrated with GIS and the geostatistical methods have constituted a strong alternative to deterministic methods in the interpolation of the spatial data. In addition, statistical methods to analyze the interpolated layers have allowed a better understanding of the changes occurred in the specific time period.

Climate change is one of the biggest threats for the entire globe (Kropp 2015). Climate changes affect the natural balance of the earth and ecosystems and whole life is disrupted (National Academy of Sciences 2009) Climate change is most often measured by changes in primary climate variables, such as temperature and precipitation. These variables are the main drivers of climate changes (Sheffield and Wood 2012). For this reason, to understand and monitor the changes and their causes and effects accurately, changes should be determined both spatially and quantitatively and the results should be evaluated in detail.

In this study it is aimed to investigate the spatial distribution of precipitation and temperature of the Aegean Region in Turkey for years 1975, 1980, 1985, 1990, 1995, 2000, 2005 and 2010 by the Ordinary Kriging method and statistically examine the results using cell statistics and multivariate statistics to understand the changes. This study demonstrates the usefulness of the geostatistical approach for both interpolation of meteorological data and analysis and comparison of the results.

MATERIALS AND METHODS

The Aegean Region is one of Turkey's seven geographical regions. It is surrounded by the Aegean Sea on the west and takes its name from the Aegean Sea (Ozcaglar 2014). In this study, the area comprising eight provinces located in the Aegean Region has been analyzed. The total area is approximately 90,000 km^2 (Figure 1). The coastal areas of the Aegean Region has a Mediterranean climate. The effects of the Mediterranean climate extend up to 100-150 km inland from the coast. In coastal areas, winters are mild and summers are very hot and dry. The interior side of the region is affected by the continental climate (Sensoy et al. 2008).

In the present study, the time series of monthly precipitation and temperature data from 98 meteorological stations for the years 1975, 1980, 1985, 1990, 1995, 2000, 2005 and 2010 were used. Spatial distributions of the stations are shown in Figure 1. The geospatial interpolation of temperature and precipitation data and all statistical analyses of the precipitation and temperature layers were performed using ArcGIS 10.0 software (Esri, Redlands, CA). The method of creating an estimation surface layer with the Ordinary Kriging is explained in Section "Creating An Estimation Surface Layer with the Ordinary Kriging" and statistical analyses of layers is presented in Section "Statistical Analyses of Layers".

Figure 1 - The location of the study area (The Aegean Region, Turkey) and spatial distributions of the meteorological stations.

CREATING AN ESTIMATION SURFACE LAYER WITH THE ORDINARY KRIGING

Estimation with the Kriging interpolation method has a two-step process: *(i) fitting a model:* creation of the variograms and covariance functions to estimate the statistical dependence (spatial autocorrelation) values that depend on the model of autocorrelation and *(ii) making an estimation:* estimation of the unknown values (ESRI 2014a).

The first step in the Ordinary Kriging is to create a semivariogram from the scatter point set to be interpolated. A semivariogram consists of *(i) an empirical semivariogram* (experimental variogram) and *(ii) a model semivariogram* (GMS User Manuel 2012). Semivariogram is a mathematical model of the semivariance as a function of *lag* and displays the statistical correlation of nearby points (Prasad et al. 2007). Spatial autocorrelation (means feature similarity) is based on both feature locations and feature values simultaneously (not only based on feature locations or attribute values alone). Given a set of features and an associated attribute, it evaluates whether the pattern expressed is clustered, dispersed, or random (Matthews 2002). Empirical semivariogram, computed by (Eq.1) for all pairs of locations separated by distance h (ESRI 2014a):

$$\text{Semivariogram (distance h)} = 0.5 * \text{average}[(\text{value at location i} - \text{value at location j})^2] \quad (1)$$

The formula involves calculating the difference squared between the values of the paired locations. Figure 2 shows the pairing of one point (the red point) with all other measured locations. This process continues for each measured point (ESRI 2014a).

Often, each pair of locations has a unique distance, and there are often many pairs of points. To plot all pairs quickly becomes unmanageable. Instead of plotting each pair, the pairs are grouped into *lag bins*. The empirical semivariogram is a graph of the averaged semivariogram values on the y-axis and the distance (or *lag*) on the x-axis (Figure 3) (ESRI 2014a).

When two locations are close to each other (far left on the x-axis of the semivariogram cloud), then they are expected to be similar (low on the y-axis of the semivariogram cloud) (ESRI 2014a, Prasad et al. 2007). *"As pairs of locations become farther apart (moving to the right on the x-axis of the semivariogram cloud), they should become more dissimilar and have a higher squared difference (moving up on the y-axis of the semivariogram cloud)"* (ESRI 2014a).

Once the empirical variogram is obtained, the next step is to define a model semivariogram (GMS User Manuel 2012). Semivariogram modeling is a main step between spatial description and spatial estimation. The empirical semivariogram provides information on the spatial autocorrelation of datasets, however does not supply information for all possible directions and distances. For this reason, it is necessary to fit

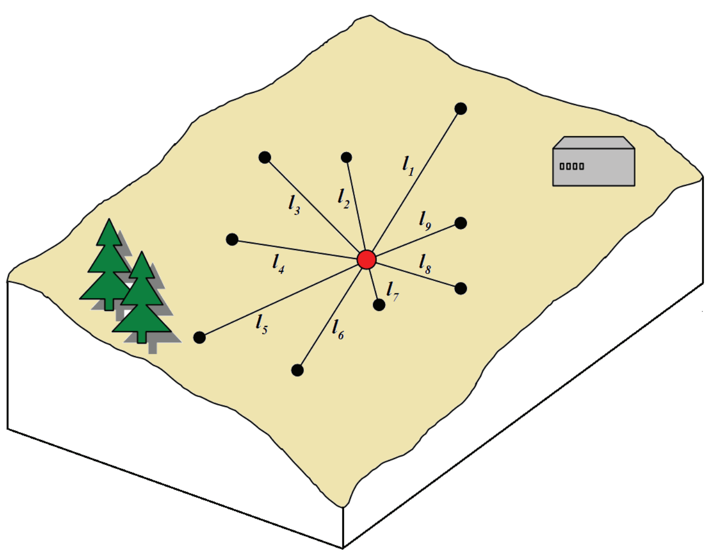

Figure 2 - Calculation of the difference squared between the paired locations.

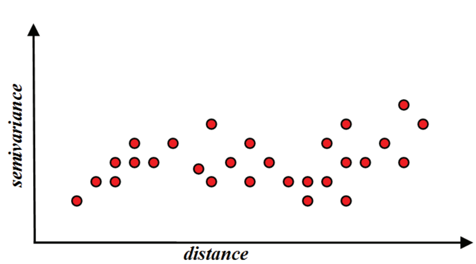

Figure 3 - Empirical semivariogram graph example.

a model (a continuous function or curve) to the empirical semivariogram (ESRI 2014a). There are many semivariogram models. Some of the most common are linear, circular, spherical, exponential, and Gaussian model (Li and Heap 2008). The selected model influences the estimation of the unknown values and each model is designed to fit different types of phenomena more accurately (ESRI 2014a).

Once the model variogram is obtained, it is used to calculate the weights used in Kriging (GMS User Manuel 2012). The basic equation used in the Ordinary Kriging is as (Eq.2) (ESRI 2014a, GMS User Manuel 2012, Borga and Vizzaccaro 1996):

$$\hat{Z}(s_0) = \sum_{i=1}^{N} \lambda_i Z(s_i) \tag{2}$$

Where;

$Z(s_i)$: the measured value at the ith location

λ_i : an unknown weight for the measured value at the ith location

(s_0) : the estimation location

N: the number of measured values

With Kriging method, the value $\hat{Z}(s_0)$ at the point s_0, where the true unknown value is $Z(s_0)$, is estimated by a linear combination of the values at N surrounding data points (Borga and Vizzaccaro 1996).

In the Ordinary Kriging, the weight, λ_i, depends on a fitted model to the measured points, the distance to the estimation point, and the spatial relationships among the measured values around the estimation location (ESRI 2014a) and the Kriging weights are calculated by minimizing the variance (Li and Heap 2008). The Ordinary Kriging is the most widely used Kriging method (Wackernagel 2003) and this method assumes that the data set has a stationary variance but also a non-stationary mean value within the search radius. The Ordinary Kriging is highly reliable and recommended for most data sets (Vertical Mapper User Guide 2008).

STATISTICAL ANALYSES OF LAYERS

CELL STATISTICS

In a local function, the value at each location on the output raster is a function of the input values at that location. When computing a local function, input rasters can be combined and a statistic can be calculated. In ArcGIS software, several cell statistics can be calculated for raster layers: *(i) MEAN:* Calculates the mean (average) of the inputs, *(ii) MAXIMUM:* Determines the maximum (largest value) of the inputs, *(iii) MEDIAN:* Calculates the median of the inputs, *(iv) MINIMUM:* Determines the minimum (smallest value) of the inputs, *(v) RANGE:* Calculates the range (difference between largest and smallest value) of the inputs, *(vi) STD:* Calculates the standard deviation of the inputs (ESRI 2014b).

Multivariate Statistics

The multivariate statistics allow exploration of relationships between many different data layers or types of attributes. In band collection function, main statistical measures (minimum, maximum, mean and standard deviation) can be calculated for every layer and in addition to these standard statistics, the covariance and correlation matrices can also be determined (ESRI 2014b).

RESULTS AND DISCUSSION

The time series of monthly precipitation and temperature data for the years 1975, 1980, 1985, 1990, 1995, 2000, 2005 and 2010 were used for preparing spatial distribution layers of precipitation and temperature of the Aegean Region, Turkey. The Ordinary Kriging interpolation was applied for each month and a total of 192 interpolations were performed (96 for precipitation and 96 for temperature) and grid layers with 250-meter pixel size were formed. The Ordinary Kriging interpolation results of the precipitation and temperature data for January are shown in Figures 4 and 5, respectively.

Based on the multivariate statistics (band collection), spatial analyses were applied for the monthly precipitation and temperature layer series which calculated by the Ordinary Kriging. Table I (for precipitation) and Table II (for temperature) represent the main statistics, including the minimum, maximum, mean and standard deviation values. In addition, the correlation coefficients were calculated with these analyses (Tables III and IV).

When examining Table I, it was seen that the highest *"average precipitation"* and the highest *"precipitation"* values were in December 1990. Table II shows that both highest *"average temperature"* and highest *"temperature"* values were in August 2010.

According to Table III, correlation coefficients for precipitation are between -0.04847 and 0.92382 for January, 0.18609 and 0.92908 for February, -0.57255 and 0.74793 for March, -0.43776 and 0.76531 for April, -0.62850 and 0.86128 for May, -0.26385 and 0.79177 for June, -0.22994 and 0.74375 for July, 0.01302 and 0.80480 for August, -0.20455 and 0.69922 for September, -0.68396 and 0.74704 for October,

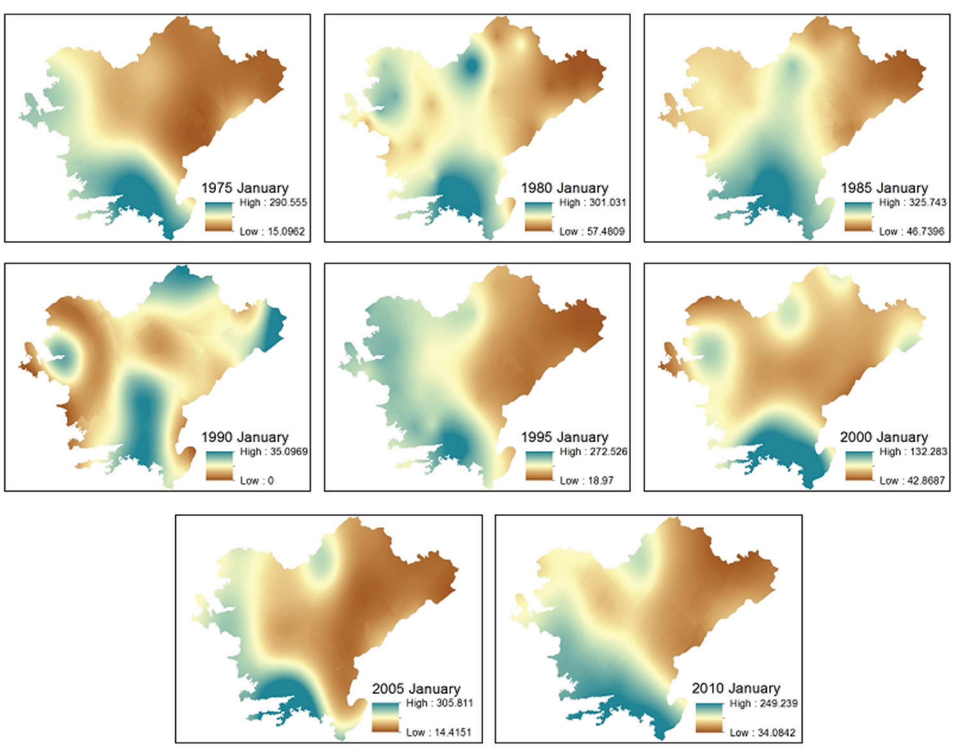

Figure 4 - The Ordinary Kriging interpolation results of the precipitation data for the month of January (For the years of 1975, 1980, 1985, 1990, 1995, 2000, 2005, and 2010).

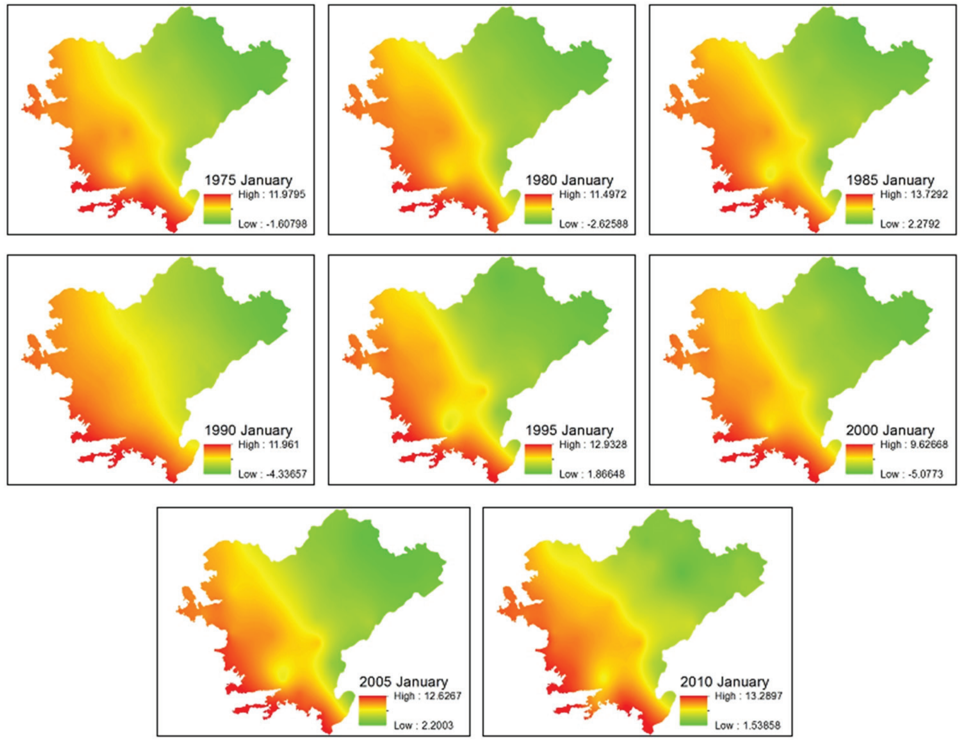

Figure 5 - The Ordinary Kriging interpolation results of the temperature data for the month of January (For the years of 1975, 1980, 1985, 1990, 1995, 2000, 2005, and 2010).

0.29150 and 0.85486 for November, 0.22520 and 0.90808 for December. According to Table IV, correlation coefficients for temperature are between 0.95152 and 0.99524 for January, 0.95804 and 0.99591 for February, 0.91016 and 0.99459 for March, 0.94823 and 0.99361 for April, 0.96744 and 0.99414 for May, 0.94961 and 0.99084 for June, 0.93391 and 0.99041 for July, 0.94175 and 0.99293 for August, 0.96714 and 0.99254 for September, 0.97214 and 0.99542 for October, 0.93409 and 0.99328 for November, 0.96537 and 0.99665 for December.

Correlations above 0.80 generally are accepted as high correlations. Correlations between 0.50 and 0.80 are usually considered as medium (moderate) correlations and correlations below 0.50 are typically regarded as low correlations (Wang et al. 1990). Accordingly, very high correlation values were observed between temperature values of years 1975, 1980, 1985, 1990, 1995, 2000, 2005 and 2010 for all months (Table IV). But, the correlations between layers of precipitation were examined, both high and low correlation values were observed. For precipitation layers, the highest correlation was observed between the year of 1975 and 2010 for January; 2005 and 2010 for February; 1985 and 1995 for March; 2005 and 2010 for April; 1990 and 2000 for May; 1990 and 1995 for June; 1975 and 2010 for July; 1975 and 2000 for August; 1980 and 2000 for September; 2000 and 2010 for October; 2005 and 2010 for November; 1980 and 1990 for December.

By calculating cell statistics, a statistic for each cell in an output raster can be calculated based on the values of multiple input rasters (ESRI 2014b). In this study; maximum, minimum, mean, median, range and standard deviation layers were produced by using precipitation and temperature layers for years 1975, 1980, 1985, 1990, 1995, 2000, 2005 and 2010 for all months. Totally 144 statistical layers were obtained

TABLE I

Main statistics for precipitation layers (Minimum, Maximum, Mean, Standard deviation).

STATISTICS of INDIVIDUAL LAYERS - PRECIPITATION											
Layer(Year)		**MIN**	**MAX**	**MEAN**	**STD**	**Layer(Year)**		**MIN**	**MAX**	**MEAN**	**STD**
January	**1975**	15.0962	290.5551	105.2915	68.9066	**July**	**1975**	0.0000	11.4688	3.8647	3.2307
	1980	57.4809	301.0310	144.8527	41.7206		**1980**	0.0000	6.4559	1.5206	0.9994
	1985	46.7396	325.7432	160.8042	58.6881		**1985**	0.0000	7.6697	0.7246	0.7361
	1990	0.0000	35.0969	12.1264	5.1998		**1990**	0.0000	39.4809	5.0383	5.5698
	1995	18.9700	272.5263	120.9055	59.4265		**1995**	0.0000	189.5152	34.9476	30.6981
	2000	42.8687	132.2835	69.6099	16.4874		**2000**	0.0000	23.2685	3.9946	4.4414
	2005	14.4151	305.8113	70.4621	46.7614		**2005**	0.0000	85.0155	24.6473	19.6237
	2010	34.0842	249.2391	114.5032	48.2253		**2010**	0.0173	12.8247	5.7179	3.1505
February	**1975**	35.9389	164.3231	58.1565	23.4616	**August**	**1975**	0.0000	66.0855	12.1734	13.2959
	1980	11.4949	100.1111	35.0220	14.2885		**1980**	0.0000	29.5959	4.3619	5.3946
	1985	29.6399	149.1992	73.9867	26.1003		**1985**	0.0000	41.5747	10.0517	7.4810
	1990	7.0911	143.2509	49.7590	25.1979		**1990**	0.4801	67.0008	10.8518	7.5046
	1995	6.6114	117.6134	27.3189	15.0847		**1995**	0.2385	16.9660	7.1374	3.8129
	2000	49.3334	109.7159	86.5541	15.9437		**2000**	0.0000	26.2174	6.2557	5.7277
	2005	18.2838	330.9904	117.0124	68.6871		**2005**	0.4208	17.9898	8.6525	4.3138
	2010	47.3964	343.1137	151.4875	62.9992		**2010**	0.0000	20.6179	7.7861	5.9152
March	**1975**	26.2257	107.8506	64.0406	15.5155	**September**	**1975**	0.0000	49.7015	10.9055	10.0935
	1980	49.5541	159.2850	95.6635	22.8128		**1980**	0.0000	55.4421	16.4988	14.7347
	1985	27.8837	106.6610	59.4646	17.9716		**1985**	0.0000	6.5261	1.9362	1.3202
	1990	6.9016	39.8629	23.6062	5.8286		**1990**	1.4236	38.1317	20.5715	8.0680
	1995	61.6728	222.2994	126.3867	33.2200		**1995**	0.0000	46.1658	17.5078	11.7651
	2000	38.4527	143.0037	88.8729	20.7716		**2000**	0.0000	22.9868	5.9550	5.8907
	2005	33.6981	117.8575	79.2205	15.7518		**2005**	4.7207	35.6864	15.2393	6.0027
	2010	2.0541	66.2231	30.9691	13.4006		**2010**	22.0556	44.4905	33.0731	4.0500
April	**1975**	18.2819	98.7922	51.6425	12.2515	**October**	**1975**	9.5328	90.6642	33.0401	13.0100
	1980	29.4372	69.5153	47.0104	7.3046		**1980**	4.3897	46.2036	22.3987	9.1381
	1985	2.0838	44.1912	19.7078	9.1412		**1985**	11.1300	151.5788	42.3043	26.9946
	1990	19.9863	90.5741	54.8812	12.3692		**1990**	7.2120	42.6564	24.6231	8.0837
	1995	18.1657	89.0869	51.9969	14.4514		**1995**	6.0607	56.4756	34.5488	14.9560
	2000	26.9695	152.4105	85.1713	26.0013		**2000**	3.6411	98.6216	34.3385	19.8806
	2005	15.9945	90.1445	39.7732	13.9404		**2005**	11.2323	121.7506	33.1998	17.9017
	2010	9.5546	83.4186	37.2400	14.8342		**2010**	49.5620	311.1042	116.5370	49.2287
May	**1975**	39.9216	119.2508	71.7452	17.9338	**November**	**1975**	39.6952	239.7979	112.4898	38.7931
	1980	10.6646	77.5801	36.4267	10.0239		**1980**	31.0222	174.3634	93.1593	26.5030
	1985	1.4462	92.5336	33.3793	9.2920		**1985**	28.2310	180.9006	85.0800	32.2572
	1990	0.0000	62.5613	23.3644	13.0269		**1990**	13.8738	74.1966	32.1743	11.6332
	1995	0.0000	76.9429	27.1503	9.6845		**1995**	31.6046	177.6392	88.1167	27.7271
	2000	1.0087	79.3443	31.0651	20.8717		**2000**	1.8513	201.2959	54.5331	44.2754
	2005	6.2719	83.2165	44.0559	17.0640		**2005**	43.2833	254.8676	114.4541	41.6780
	2010	12.1662	46.3693	26.6590	6.6865		**2010**	8.2926	51.3080	28.8157	9.8915
June	**1975**	15.4860	100.2484	50.0390	17.3824	**December**	**1975**	39.7735	188.7916	88.9672	25.1946
	1980	0.0000	80.8975	24.9794	12.4476		**1980**	28.2021	296.8829	147.5694	61.1975
	1985	0.0000	45.2143	16.5010	11.0090		**1985**	19.9052	135.5423	51.3575	16.5321
	1990	0.0000	54.2057	20.5578	14.1597		**1990**	43.9064	361.6299	165.4436	71.0610
	1995	0.0021	47.5019	9.5297	10.6071		**1995**	24.6129	165.1980	71.9208	30.6091
	2000	0.0000	37.4081	11.7682	8.3772		**2000**	14.4990	329.9915	52.2345	36.1115
	2005	0.3222	58.3159	27.5195	12.8268		**2005**	11.9330	203.2546	65.3737	31.7432
	2010	0.7233	141.3197	55.6312	24.9145		**2010**	59.0785	231.4372	119.4989	34.7257

TABLE II

Main statistics for temperature layers (Minimum, Maximum, Mean, Standard deviation).

STATISTICS of INDIVIDUAL LAYERS - TEMPERATURE											
Layer(Year)		**MIN**	**MAX**	**MEAN**	**STD**	**Layer(Year)**		**MIN**	**MAX**	**MEAN**	**STD**
January	**1975**	-1.6080	11.9795	3.7326	3.1861	**July**	**1975**	20.8040	28.7429	25.1050	2.1311
	1980	-2.6259	11.4972	3.0345	3.4320		**1980**	21.6467	29.0423	25.5491	1.7273
	1985	2.2792	13.7292	7.0922	2.9161		**1985**	18.8785	28.5773	24.1568	2.6798
	1990	-4.3366	11.9610	2.5856	3.4689		**1990**	20.9858	29.3868	25.8605	2.2016
	1995	1.8665	12.9328	6.2080	2.7793		**1995**	19.5084	29.1838	24.6306	2.9346
	2000	-5.0773	9.6267	1.1922	3.7585		**2000**	22.6168	30.2668	27.1807	2.0244
	2005	2.2003	12.6267	6.3250	2.6454		**2005**	21.7852	29.3529	26.1972	2.1397
	2010	1.5386	13.2897	6.6969	2.7832		**2010**	21.6157	30.2688	26.5241	2.1923
February	**1975**	-0.4336	11.9043	4.1513	3.0501	**August**	**1975**	20.1038	27.2521	23.9362	1.9830
	1980	-0.3540	11.8185	4.6182	2.9815		**1980**	20.3963	28.3603	24.5688	2.0282
	1985	-4.1206	10.0607	1.7981	3.7145		**1985**	21.4755	28.3776	25.3309	1.8210
	1990	0.0275	12.6155	5.6012	3.1362		**1990**	19.6488	27.6955	24.3883	2.2268
	1995	3.9147	13.8931	7.8196	2.5229		**1995**	20.3723	28.2541	24.5760	2.0307
	2000	-1.8539	11.9216	4.6025	3.3023		**2000**	20.0756	28.9870	25.3378	2.4911
	2005	1.0839	11.0291	5.1357	2.7220		**2005**	22.1073	28.9807	26.0388	1.9475
	2010	4.8857	14.0768	8.8109	2.4160		**2010**	25.2166	30.3014	28.1310	1.5564
March	**1975**	6.6072	15.0204	10.1282	2.2135	**September**	**1975**	16.5458	26.1924	20.8361	2.7081
	1980	3.7778	13.6001	7.4684	2.5244		**1980**	14.3647	24.4542	19.1395	2.5351
	1985	1.5080	13.6020	7.9737	2.9179		**1985**	15.2840	25.1916	20.5854	2.4419
	1990	5.8160	14.7953	9.8410	2.4662		**1990**	15.4788	25.2687	19.8176	2.4584
	1995	4.9791	14.0615	8.4624	2.4898		**1995**	17.0612	25.4172	21.0791	2.1735
	2000	3.4803	12.7911	7.1545	2.6171		**2000**	16.3220	25.8142	21.1166	2.4484
	2005	5.0723	13.9870	8.8848	2.4185		**2005**	16.4752	25.7482	20.7710	2.5786
	2010	5.8425	16.4715	10.4517	2.3320		**2010**	18.3427	25.9256	21.7630	2.1259
April	**1975**	11.4027	17.6734	13.9034	1.7218	**October**	**1975**	11.0174	21.0976	14.8899	2.6129
	1980	8.4474	15.4275	11.4915	2.0839		**1980**	12.3536	21.1985	16.2249	2.3637
	1985	10.4556	17.2842	13.9654	2.0125		**1985**	8.7044	19.1918	13.0156	2.5467
	1990	9.9327	17.4434	13.1470	2.2247		**1990**	11.7813	21.7325	16.0564	2.4525
	1995	8.2844	15.9269	11.5358	2.2356		**1995**	9.2743	19.8509	13.8540	2.5798
	2000	11.7082	17.5848	14.3388	1.8857		**2000**	10.5590	20.9450	14.9599	2.6980
	2005	9.9162	17.1927	13.1155	2.1300		**2005**	9.7082	20.0835	13.8896	2.6384
	2010	9.9424	18.6159	13.8762	2.4406		**2010**	10.2576	21.7663	14.9154	2.9379
May	**1975**	13.7103	20.7852	17.0399	2.3309	**November**	**1975**	5.2976	16.6203	9.3378	2.6591
	1980	14.1786	20.2122	16.8566	1.7605		**1980**	7.4070	18.1094	11.4330	2.6440
	1985	15.8079	22.5850	19.2854	2.1122		**1985**	8.4017	18.0259	12.0326	2.3988
	1990	13.3384	21.6440	17.3523	2.5074		**1990**	7.6179	18.0775	12.0642	2.6051
	1995	15.4864	21.1762	18.3836	1.6126		**1995**	1.5022	13.8388	6.7709	3.0380
	2000	13.9277	22.0098	18.0709	2.5511		**2000**	7.1828	18.5339	11.8420	2.5075
	2005	14.9138	21.6488	18.4084	2.1777		**2005**	5.1913	15.7904	9.1067	2.5619
	2010	14.5255	22.5254	19.3349	2.2301		**2010**	9.6838	19.5951	13.9344	2.3800
June	**1975**	17.7122	24.6564	21.2720	2.2485	**December**	**1975**	-3.2787	13.1689	3.8009	3.8370
	1980	18.1593	25.9312	21.7894	2.0464		**1980**	2.1513	13.9154	6.7185	2.9002
	1985	18.0790	26.3428	22.1907	2.3044		**1985**	2.0959	14.5184	6.6195	3.0085
	1990	17.3079	25.9777	21.8186	2.6735		**1990**	2.4093	14.2393	7.3080	3.0477
	1995	19.8111	27.7873	24.1458	2.4046		**1995**	1.0647	14.7638	7.1749	3.1052
	2000	18.0133	27.5768	23.1268	2.8309		**2000**	1.3021	14.4294	6.5028	3.1720
	2005	17.8073	25.9265	22.0558	2.4529		**2005**	3.0349	13.6756	7.2157	2.8025
	2010	18.0412	26.3838	22.1602	2.4779		**2010**	5.2619	15.6738	9.0097	2.6403

TABLE III

Correlation matrix for precipitation layers.

CORRELATION MATRIX (Precipitation-January)								
Layer(Year)	**1975**	**1980**	**1985**	**1990**	**1995**	**2000**	**2005**	**2010**
1975	1.00000	0.78846	0.78386	0.12940	0.87703	0.75682	0.77189	0.92382
1980	0.78846	1.00000	0.86062	0.17125	0.81056	0.69908	0.65659	0.77735
1985	0.78386	0.86062	1.00000	0.16711	0.69942	0.63916	0.60556	0.81675
1990	0.12940	0.17125	0.16711	1.00000	-0.04847	0.39700	0.01441	0.06176
1995	0.87703	0.81056	0.69942	-0.04847	1.00000	0.55791	0.78129	0.86215
2000	0.75682	0.69908	0.63916	0.39700	0.55791	1.00000	0.61256	0.74714
2005	0.77189	0.65659	0.60556	0.01441	0.78129	0.61256	1.00000	0.81718
2010	0.92382	0.77735	0.81675	0.06176	0.86215	0.74714	0.81718	1.00000
CORRELATION MATRIX (Precipitation-February)								
Layer(Year)	**1975**	**1980**	**1985**	**1990**	**1995**	**2000**	**2005**	**2010**
1975	1.00000	0.77978	0.71037	0.75465	0.78511	0.32408	0.62331	0.59694
1980	0.77978	1.00000	0.70680	0.65260	0.75107	0.18609	0.51814	0.44678
1985	0.71037	0.70680	1.00000	0.67623	0.59647	0.25324	0.33989	0.25617
1990	0.75465	0.65260	0.67623	1.00000	0.79150	0.64538	0.84264	0.77847
1995	0.78511	0.75107	0.59647	0.79150	1.00000	0.50060	0.71130	0.68328
2000	0.32408	0.18609	0.25324	0.64538	0.50060	1.00000	0.53958	0.66191
2005	0.62331	0.51814	0.33989	0.84264	0.71130	0.53958	1.00000	0.92908
2010	0.59694	0.44678	0.25617	0.77847	0.68328	0.66191	0.92908	1.00000
CORRELATION MATRIX (Precipitation-March)								
Layer(Year)	**1975**	**1980**	**1985**	**1990**	**1995**	**2000**	**2005**	**2010**
1975	1.00000	0.43577	0.43600	0.54000	0.42494	0.60580	0.65125	0.24777
1980	0.43577	1.00000	0.48775	0.59721	0.63492	0.69036	0.10031	-0.57255
1985	0.43600	0.48775	1.00000	0.24778	0.74793	0.23000	-0.00553	-0.38343
1990	0.54000	0.59721	0.24778	1.00000	0.34694	0.57528	0.44113	0.00851
1995	0.42494	0.63492	0.74793	0.34694	1.00000	0.51069	-0.00559	-0.43359
2000	0.60580	0.69036	0.23000	0.57528	0.51069	1.00000	0.39025	-0.20299
2005	0.65125	0.10031	-0.00553	0.44113	-0.00559	0.39025	1.00000	0.61318
2010	0.24777	-0.57255	-0.38343	0.00851	-0.43359	-0.20299	0.61318	1.00000
CORRELATION MATRIX (Precipitation-April)								
Layer(Year)	**1975**	**1980**	**1985**	**1990**	**1995**	**2000**	**2005**	**2010**
1975	1.00000	0.04649	-0.29210	0.22152	0.08140	-0.09371	-0.43776	-0.29386
1980	0.04649	1.00000	0.20565	0.08084	0.25487	-0.06780	0.46926	0.44613
1985	-0.29210	0.20565	1.00000	0.11292	0.31988	0.64021	0.74893	0.63354
1990	0.22152	0.08084	0.11292	1.00000	0.53602	0.27626	-0.03302	-0.19927
1995	0.08140	0.25487	0.31988	0.53602	1.00000	0.62172	0.26567	-0.06769
2000	-0.09371	-0.06780	0.64021	0.27626	0.62172	1.00000	0.33247	0.06834
2005	-0.43776	0.46926	0.74893	-0.03302	0.26567	0.33247	1.00000	0.76531
2010	-0.29386	0.44613	0.63354	-0.19927	-0.06769	0.06834	0.76531	1.00000
CORRELATION MATRIX (Precipitation-May)								
Layer(Year)	**1975**	**1980**	**1985**	**1990**	**1995**	**2000**	**2005**	**2010**
1975	1.00000	0.00014	0.51378	0.40567	0.04118	0.58152	-0.03261	-0.35965
1980	0.00014	1.00000	-0.14016	0.09716	0.11290	0.16423	-0.14988	-0.11414
1985	0.51378	-0.14016	1.00000	-0.22438	-0.12253	-0.13165	-0.22834	0.13157
1990	0.40567	0.09716	-0.22438	1.00000	0.28300	0.86128	0.64427	-0.51083
1995	0.04118	0.11290	-0.12253	0.28300	1.00000	0.19170	0.21629	0.00804
2000	0.58152	0.16423	-0.13165	0.86128	0.19170	1.00000	0.29651	-0.62850
2005	-0.03261	-0.14988	-0.22834	0.64427	0.21629	0.29651	1.00000	0.05753
2010	-0.35965	-0.11414	0.13157	-0.51083	0.00804	-0.62850	0.05753	1.00000

TABLE III (continuation)

CORRELATION MATRIX (Precipitation-June)								
Layer(Year)	**1975**	**1980**	**1985**	**1990**	**1995**	**2000**	**2005**	**2010**
1975	1.00000	0.20265	0.20593	0.28976	0.32791	0.31104	0.10884	-0.22344
1980	0.20265	1.00000	-0.25895	0.25642	-0.01494	-0.26385	0.30535	0.13046
1985	0.20593	-0.25895	1.00000	0.61296	0.63628	0.78552	0.42126	0.32951
1990	0.28976	0.25642	0.61296	1.00000	0.79177	0.60613	0.66090	0.48602
1995	0.32791	-0.01494	0.63628	0.79177	1.00000	0.76352	0.57111	0.30044
2000	0.31104	-0.26385	0.78552	0.60613	0.76352	1.00000	0.27430	0.25948
2005	0.10884	0.30535	0.42126	0.66090	0.57111	0.27430	1.00000	0.48441
2010	-0.22344	0.13046	0.32951	0.48602	0.30044	0.25948	0.48441	1.00000
CORRELATION MATRIX (Precipitation-July)								
Layer(Year)	**1975**	**1980**	**1985**	**1990**	**1995**	**2000**	**2005**	**2010**
1975	1.00000	0.22850	-0.22994	0.71580	0.46294	0.37854	0.62662	0.74375
1980	0.22850	1.00000	0.20738	0.21785	0.23528	0.29285	0.10786	0.54332
1985	-0.22994	0.20738	1.00000	0.11996	0.04063	0.20946	0.10074	0.05492
1990	0.71580	0.21785	0.11996	1.00000	0.29884	0.37246	0.57299	0.65655
1995	0.46294	0.23528	0.04063	0.29884	1.00000	0.04565	0.39870	0.56466
2000	0.37854	0.29285	0.20946	0.37246	0.04565	1.00000	0.55639	0.27101
2005	0.62662	0.10786	0.10074	0.57299	0.39870	0.55639	1.00000	0.40386
2010	0.74375	0.54332	0.05492	0.65655	0.56466	0.27101	0.40386	1.00000
CORRELATION MATRIX (Precipitation-August)								
Layer(Year)	**1975**	**1980**	**1985**	**1990**	**1995**	**2000**	**2005**	**2010**
1975	1.00000	0.62665	0.45484	0.33267	0.52327	0.80480	0.47424	0.60626
1980	0.62665	1.00000	0.63235	0.23099	0.34192	0.67653	0.49201	0.68952
1985	0.45484	0.63235	1.00000	0.27238	0.49517	0.47897	0.36196	0.71590
1990	0.33267	0.23099	0.27238	1.00000	0.11132	0.34003	0.01302	0.18870
1995	0.52327	0.34192	0.49517	0.11132	1.00000	0.35925	0.67713	0.59460
2000	0.80480	0.67653	0.47897	0.34003	0.35925	1.00000	0.51379	0.66336
2005	0.47424	0.49201	0.36196	0.01302	0.67713	0.51379	1.00000	0.55531
2010	0.60626	0.68952	0.71590	0.18870	0.59460	0.66336	0.55531	1.00000
CORRELATION MATRIX (Precipitation-September)								
Layer(Year)	**1975**	**1980**	**1985**	**1990**	**1995**	**2000**	**2005**	**2010**
1975	1.00000	0.37163	0.19678	0.59756	0.53491	0.04033	0.02862	0.39440
1980	0.37163	1.00000	0.57914	0.66755	-0.08048	0.69922	0.38872	0.20890
1985	0.19678	0.57914	1.00000	0.36662	-0.10389	0.58103	0.36137	0.23253
1990	0.59756	0.66755	0.36662	1.00000	0.37907	0.41984	0.03516	0.24139
1995	0.53491	-0.08048	-0.10389	0.37907	1.00000	-0.20455	-0.19451	0.65751
2000	0.04033	0.69922	0.58103	0.41984	-0.20455	1.00000	0.52987	0.17506
2005	0.02862	0.38872	0.36137	0.03516	-0.19451	0.52987	1.00000	0.31895
2010	0.39440	0.20890	0.23253	0.24139	0.65751	0.17506	0.31895	1.00000
CORRELATION MATRIX (Precipitation-October)								
Layer(Year)	**1975**	**1980**	**1985**	**1990**	**1995**	**2000**	**2005**	**2010**
1975	1.00000	0.06983	0.66618	-0.34307	-0.21368	0.26494	0.62937	0.25635
1980	0.06983	1.00000	0.49524	0.12709	0.66087	-0.57686	0.44764	-0.60944
1985	0.66618	0.49524	1.00000	-0.08372	0.13923	0.01497	0.61832	-0.06324
1990	-0.34307	0.12709	-0.08372	1.00000	0.50000	-0.16595	-0.20978	-0.04511
1995	-0.21368	0.66087	0.13923	0.50000	1.00000	-0.68396	0.06114	-0.63589
2000	0.26494	-0.57686	0.01497	-0.16595	-0.68396	1.00000	-0.10283	0.74704
2005	0.62937	0.44764	0.61832	-0.20978	0.06114	-0.10283	1.00000	-0.27208
2010	0.25635	-0.60944	-0.06324	-0.04511	-0.63589	0.74704	-0.27208	1.00000

TABLE III (continuation)

CORRELATION MATRIX (Precipitation-November)								
Layer(Year)	**1975**	**1980**	**1985**	**1990**	**1995**	**2000**	**2005**	**2010**
1975	1.00000	0.79762	0.65602	0.45331	0.41620	0.62822	0.79794	0.72336
1980	0.79762	1.00000	0.77541	0.57684	0.59180	0.52085	0.72144	0.68886
1985	0.65602	0.77541	1.00000	0.63039	0.56208	0.64761	0.72962	0.73200
1990	0.45331	0.57684	0.63039	1.00000	0.34262	0.47725	0.34958	0.29150
1995	0.41620	0.59180	0.56208	0.34262	1.00000	0.45066	0.43236	0.34430
2000	0.62822	0.52085	0.64761	0.47725	0.45066	1.00000	0.64668	0.55346
2005	0.79794	0.72144	0.72962	0.34958	0.43236	0.64668	1.00000	0.85486
2010	0.72336	0.68886	0.73200	0.29150	0.34430	0.55346	0.85486	1.00000
CORRELATION MATRIX (Precipitation-December)								
Layer(Year)	**1975**	**1980**	**1985**	**1990**	**1995**	**2000**	**2005**	**2010**
1975	1.00000	0.79379	0.25259	0.81574	0.78905	0.50197	0.86966	0.64845
1980	0.79379	1.00000	0.31704	0.90808	0.90569	0.39818	0.78649	0.80757
1985	0.25259	0.31704	1.00000	0.22520	0.48945	0.76838	0.31490	0.26742
1990	0.81574	0.90808	0.22520	1.00000	0.85097	0.42111	0.74077	0.78907
1995	0.78905	0.90569	0.48945	0.85097	1.00000	0.56697	0.77087	0.77156
2000	0.50197	0.39818	0.76838	0.42111	0.56697	1.00000	0.52801	0.38538
2005	0.86966	0.78649	0.31490	0.74077	0.77087	0.52801	1.00000	0.65563
2010	0.64845	0.80757	0.26742	0.78907	0.77156	0.38538	0.65563	1.00000

TABLE IV
Correlation matrix for temperature layers.

CORRELATION MATRIX (Temperature-January)								
Layer(Year)	**1975**	**1980**	**1985**	**1990**	**1995**	**2000**	**2005**	**2010**
1975	1.00000	0.99001	0.98543	0.99064	0.98531	0.99384	0.99098	0.97266
1980	0.99001	1.00000	0.99524	0.98171	0.99200	0.99217	0.99463	0.97417
1985	0.98543	0.99524	1.00000	0.97166	0.99482	0.98869	0.99503	0.97539
1990	0.99064	0.98171	0.97166	1.00000	0.97136	0.98582	0.97629	0.95152
1995	0.98531	0.99200	0.99482	0.97136	1.00000	0.98977	0.99353	0.97975
2000	0.99384	0.99217	0.98869	0.98582	0.98977	1.00000	0.99041	0.97014
2005	0.99098	0.99463	0.99503	0.97629	0.99353	0.99041	1.00000	0.98280
2010	0.97266	0.97417	0.97539	0.95152	0.97975	0.97014	0.98280	1.00000
CORRELATION MATRIX (Temperature-February)								
Layer(Year)	**1975**	**1980**	**1985**	**1990**	**1995**	**2000**	**2005**	**2010**
1975	1.00000	0.99420	0.99281	0.98748	0.98275	0.96240	0.98388	0.97305
1980	0.99420	1.00000	0.99591	0.99286	0.98342	0.97515	0.98280	0.96708
1985	0.99281	0.99591	1.00000	0.99162	0.98447	0.97700	0.98697	0.97381
1990	0.98748	0.99286	0.99162	1.00000	0.98965	0.98378	0.98806	0.97410
1995	0.98275	0.98342	0.98447	0.98965	1.00000	0.98594	0.98194	0.98254
2000	0.96240	0.97515	0.97700	0.98378	0.98594	1.00000	0.96256	0.95804
2005	0.98388	0.98280	0.98697	0.98806	0.98194	0.96256	1.00000	0.98685
2010	0.97305	0.96708	0.97381	0.97410	0.98254	0.95804	0.98685	1.00000
CORRELATION MATRIX (Temperature-March)								
Layer(Year)	**1975**	**1980**	**1985**	**1990**	**1995**	**2000**	**2005**	**2010**
1975	1.00000	0.96776	0.93293	0.96541	0.98026	0.97802	0.96322	0.91016
1980	0.96776	1.00000	0.97682	0.97817	0.98798	0.98687	0.99252	0.96439
1985	0.93293	0.97682	1.00000	0.97683	0.95402	0.95607	0.96738	0.93709
1990	0.96541	0.97817	0.97683	1.00000	0.97132	0.97380	0.97428	0.93204
1995	0.98026	0.98798	0.95402	0.97132	1.00000	0.99459	0.98740	0.93968
2000	0.97802	0.98687	0.95607	0.97380	0.99459	1.00000	0.98191	0.93228
2005	0.96322	0.99252	0.96738	0.97428	0.98740	0.98191	1.00000	0.96909
2010	0.91016	0.96439	0.93709	0.93204	0.93968	0.93228	0.96909	1.00000

TABLE IV (continuation)

CORRELATION MATRIX (Temperature-April)								
Layer(Year)	**1975**	**1980**	**1985**	**1990**	**1995**	**2000**	**2005**	**2010**
1975	1.00000	0.97750	0.97998	0.97378	0.97661	0.96197	0.96881	0.94823
1980	0.97750	1.00000	0.98631	0.98860	0.99361	0.96976	0.98274	0.97421
1985	0.97998	0.98631	1.00000	0.98679	0.98503	0.97772	0.98419	0.96170
1990	0.97378	0.98860	0.98679	1.00000	0.99253	0.98757	0.99332	0.98398
1995	0.97661	0.99361	0.98503	0.99253	1.00000	0.97755	0.98891	0.97271
2000	0.96197	0.96976	0.97772	0.98757	0.97755	1.00000	0.98612	0.96112
2005	0.96881	0.98274	0.98419	0.99332	0.98891	0.98612	1.00000	0.97864
2010	0.94823	0.97421	0.96170	0.98398	0.97271	0.96112	0.97864	1.00000
CORRELATION MATRIX (Temperature-May)								
Layer(Year)	**1975**	**1980**	**1985**	**1990**	**1995**	**2000**	**2005**	**2010**
1975	1.00000	0.98754	0.99057	0.97503	0.96946	0.98393	0.98151	0.97436
1980	0.98754	1.00000	0.99004	0.97957	0.98300	0.98179	0.98569	0.97928
1985	0.99057	0.99004	1.00000	0.97169	0.98487	0.97795	0.97774	0.97943
1990	0.97503	0.97957	0.97169	1.00000	0.97585	0.99414	0.98976	0.96744
1995	0.96946	0.98300	0.98487	0.97585	1.00000	0.97536	0.97691	0.97110
2000	0.98393	0.98179	0.97795	0.99414	0.97536	1.00000	0.98905	0.97046
2005	0.98151	0.98569	0.97774	0.98976	0.97691	0.98905	1.00000	0.96891
2010	0.97436	0.97928	0.97943	0.96744	0.97110	0.97046	0.96891	1.00000
CORRELATION MATRIX (Temperature-June)								
Layer(Year)	**1975**	**1980**	**1985**	**1990**	**1995**	**2000**	**2005**	**2010**
1975	1.00000	0.95346	0.98094	0.97460	0.97601	0.97138	0.96753	0.97943
1980	0.95346	1.00000	0.98204	0.98186	0.95395	0.97538	0.98243	0.94961
1985	0.98094	0.98204	1.00000	0.99084	0.97684	0.99073	0.99018	0.97364
1990	0.97460	0.98186	0.99084	1.00000	0.98152	0.98635	0.98838	0.97215
1995	0.97601	0.95395	0.97684	0.98152	1.00000	0.96700	0.96597	0.95207
2000	0.97138	0.97538	0.99073	0.98635	0.96700	1.00000	0.98993	0.96894
2005	0.96753	0.98243	0.99018	0.98838	0.96597	0.98993	1.00000	0.96989
2010	0.97943	0.94961	0.97364	0.97215	0.95207	0.96894	0.96989	1.00000
CORRELATION MATRIX (Temperature-July)								
Layer(Year)	**1975**	**1980**	**1985**	**1990**	**1995**	**2000**	**2005**	**2010**
1975	1.00000	0.97647	0.98897	0.99041	0.97678	0.98756	0.98871	0.97928
1980	0.97647	1.00000	0.96587	0.97782	0.93391	0.96840	0.96744	0.95022
1985	0.98897	0.96587	1.00000	0.98248	0.98509	0.97307	0.98407	0.97415
1990	0.99041	0.97782	0.98248	1.00000	0.95961	0.98519	0.98069	0.97109
1995	0.97678	0.93391	0.98509	0.95961	1.00000	0.96299	0.98156	0.96335
2000	0.98756	0.96840	0.97307	0.98519	0.96299	1.00000	0.98577	0.96678
2005	0.98871	0.96744	0.98407	0.98069	0.98156	0.98577	1.00000	0.96754
2010	0.97928	0.95022	0.97415	0.97109	0.96335	0.96678	0.96754	1.00000
CORRELATION MATRIX (Temperature-August)								
Layer(Year)	**1975**	**1980**	**1985**	**1990**	**1995**	**2000**	**2005**	**2010**
1975	1.00000	0.98710	0.98710	0.98982	0.98119	0.98817	0.98214	0.96580
1980	0.98710	1.00000	0.98525	0.98710	0.97927	0.98774	0.97624	0.95483
1985	0.98710	0.98525	1.00000	0.98983	0.98460	0.99000	0.98436	0.95388
1990	0.98982	0.98710	0.98983	1.00000	0.98274	0.99293	0.98298	0.96703
1995	0.98119	0.97927	0.98460	0.98274	1.00000	0.98346	0.98776	0.94175
2000	0.98817	0.98774	0.99000	0.99293	0.98346	1.00000	0.99239	0.97248
2005	0.98214	0.97624	0.98436	0.98298	0.98776	0.99239	1.00000	0.96056
2010	0.96580	0.95483	0.95388	0.96703	0.94175	0.97248	0.96056	1.00000

TABLE IV (continuation)

CORRELATION MATRIX (Temperature-September)

Layer(Year)	1975	1980	1985	1990	1995	2000	2005	2010
1975	1.00000	0.98432	0.98128	0.98609	0.97975	0.98318	0.98589	0.99125
1980	0.98432	1.00000	0.99155	0.98712	0.98378	0.98371	0.97888	0.97036
1985	0.98128	0.99155	1.00000	0.98127	0.97791	0.98163	0.97309	0.96714
1990	0.98609	0.98712	0.98127	1.00000	0.98041	0.97355	0.97007	0.98024
1995	0.97975	0.98378	0.97791	0.98041	1.00000	0.99027	0.98815	0.96733
2000	0.98318	0.98371	0.98163	0.97355	0.99027	1.00000	0.99254	0.97132
2005	0.98589	0.97888	0.97309	0.97007	0.98815	0.99254	1.00000	0.97438
2010	0.99125	0.97036	0.96714	0.98024	0.96733	0.97132	0.97438	1.00000

CORRELATION MATRIX (Temperature-October)

Layer(Year)	1975	1980	1985	1990	1995	2000	2005	2010
1975	1.00000	0.98886	0.99071	0.98472	0.99004	0.99062	0.99542	0.98544
1980	0.98886	1.00000	0.97972	0.98269	0.98005	0.98243	0.98307	0.97214
1985	0.99071	0.97972	1.00000	0.98881	0.99341	0.99234	0.98544	0.97534
1990	0.98472	0.98269	0.98881	1.00000	0.98608	0.98709	0.97632	0.97474
1995	0.99004	0.98005	0.99341	0.98608	1.00000	0.99196	0.98567	0.97342
2000	0.99062	0.98243	0.99234	0.98709	0.99196	1.00000	0.98698	0.98191
2005	0.99542	0.98307	0.98544	0.97632	0.98567	0.98698	1.00000	0.98408
2010	0.98544	0.97214	0.97534	0.97474	0.97342	0.98191	0.98408	1.00000

CORRELATION MATRIX (Temperature-November)

Layer(Year)	1975	1980	1985	1990	1995	2000	2005	2010
1975	1.00000	0.98838	0.99165	0.97041	0.98973	0.96630	0.99328	0.94459
1980	0.98838	1.00000	0.98876	0.98825	0.97959	0.97029	0.98830	0.96251
1985	0.99165	0.98876	1.00000	0.97865	0.98934	0.97822	0.98729	0.95602
1990	0.97041	0.98825	0.97865	1.00000	0.95958	0.97309	0.97731	0.97502
1995	0.98973	0.97959	0.98934	0.95958	1.00000	0.96471	0.98812	0.93409
2000	0.96630	0.97029	0.97822	0.97309	0.96471	1.00000	0.96795	0.96403
2005	0.99328	0.98830	0.98729	0.97731	0.98812	0.96795	1.00000	0.95475
2010	0.94459	0.96251	0.95602	0.97502	0.93409	0.96403	0.95475	1.00000

CORRELATION MATRIX (Temperature-December)

Layer(Year)	1975	1980	1985	1990	1995	2000	2005	2010
1975	1.00000	0.98203	0.98128	0.98008	0.98588	0.98097	0.96599	0.96537
1980	0.98203	1.00000	0.99205	0.99665	0.98918	0.99443	0.99171	0.97762
1985	0.98128	0.99205	1.00000	0.98926	0.98818	0.99459	0.98883	0.98108
1990	0.98008	0.99665	0.98926	1.00000	0.98819	0.99248	0.99313	0.98019
1995	0.98588	0.98918	0.98818	0.98819	1.00000	0.98769	0.98406	0.98327
2000	0.98097	0.99443	0.99459	0.99248	0.98769	1.00000	0.98867	0.97993
2005	0.96599	0.99171	0.98883	0.99313	0.98406	0.98867	1.00000	0.98158
2010	0.96537	0.97762	0.98108	0.98019	0.98327	0.97993	0.98158	1.00000

(72 for precipitation and 72 for temperature). Figures 6 and 7 show the cell statistics of the precipitation and temperature for the month of January.

Here, range layers give the most important information. Range layers indicate the difference between the largest and the smallest value of the inputs. When examining the range layers, it was understood that the month with largest changes is January for precipitation and November for temperature.

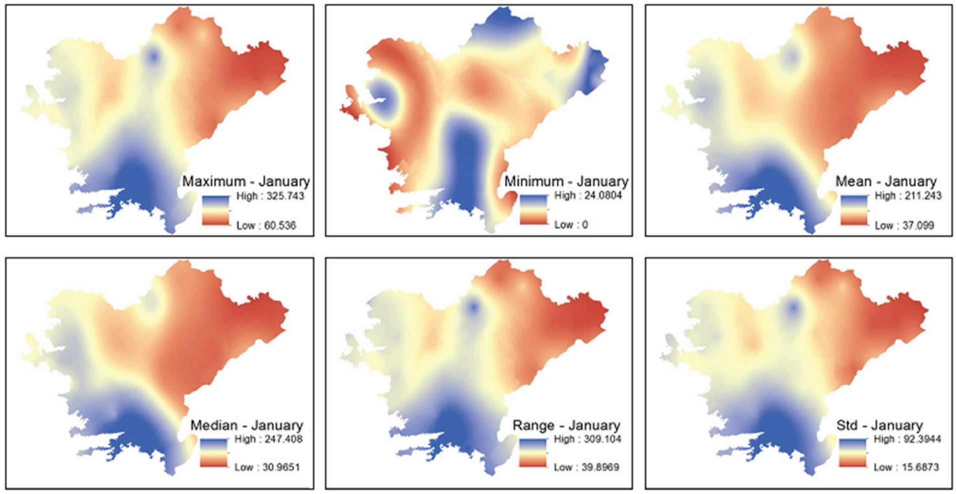

Figure 6 - Cell statistics of the precipitation for the month of January.

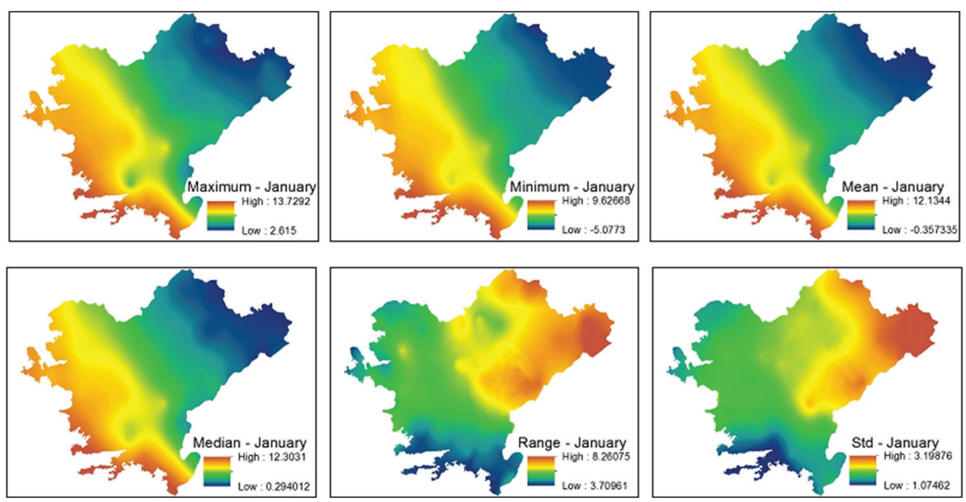

Figure 7 - Cell statistics of the temperature for the month of January.

CONCLUSIONS

Meteorological data are required in many fields such as environment, agriculture and management of natural disasters where spatial data are used. But meteorological data are generally available from a limited number of stations. For this reason, interpolation techniques are used to obtain complete surface information. In recent years, depending on the technological developments in computer and GIS, geostatistical methods are used in order to determine the spatial distribution of meteorological data and the Ordinary Kriging method is nowadays a preferable option in the literature. Unlike the deterministic methods, geostatistical interpolation techniques also utilize the statistical properties of the measured points. In geostatistical techniques the autocorrelation among the measured points is determined and spatial configuration of the sampling points around the estimation point is taken into consideration.

In this study, spatial distributions of precipitation and temperature of the Aegean Region in Turkey for years 1975, 1980, 1985, 1990, 1995, 2000, 2005 and 2010 in 5-year periods were determined by the Ordinary

Kriging method. The time series of monthly precipitation and temperature data from 98 meteorological stations were used for the Ordinary Kriging. To evaluate and interpret the results, multivariate statistics (band collection) and cell statistics were applied for the monthly precipitation and temperature layer series. The results revealed that a significant change in precipitation regime in the Aegean Region was occurred. It is necessary to pay attention to this change because of multiple environmental effects of the climate changes. In the following studies, prediction of the future trends and determination of the effects of these changes on nature and human health are required.

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