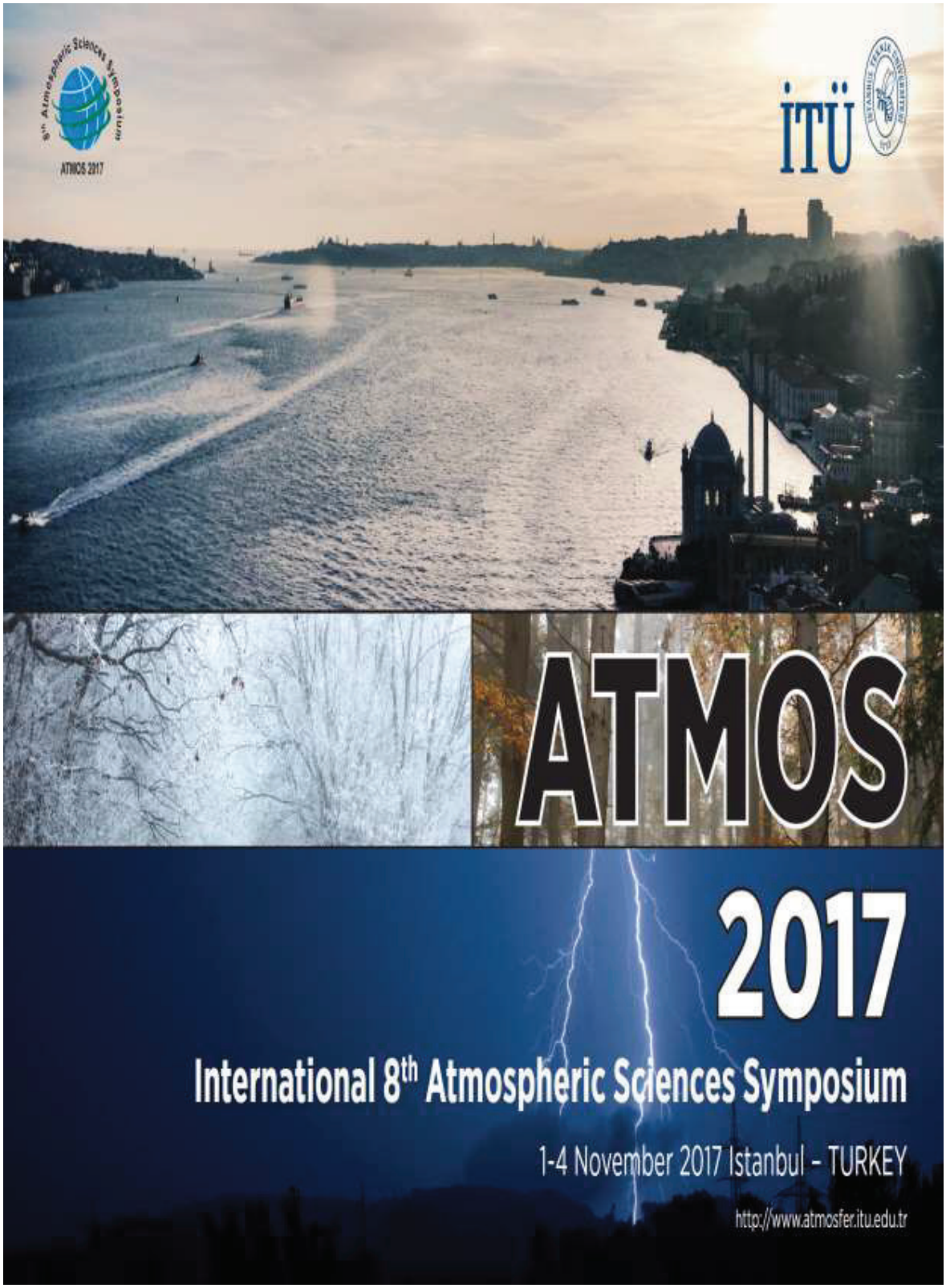
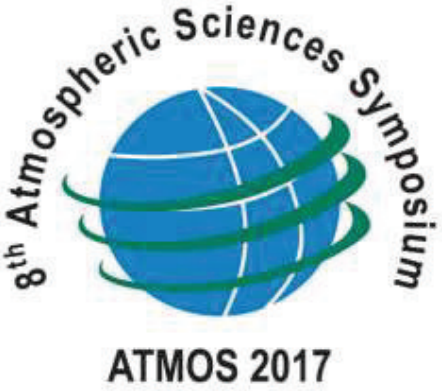

ATMOS
2017
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8th Atmospheric Sciences Symposium
ATMOS 2017

PREFACE

This 8th Atmospheric Sciences Symposium; ATMOS2017 built upon the series that began at Istanbul Technical University, Department of Meteorological Engineering in 1981. Subsequent meetings have been held in 1991; 2003; 2008; 2011; 2013 and 2015 in Istanbul, Turkey.

And it is not just enough to produce scientific data for people but it is also necessary to process the data and share the results of those data as a source for students and a starting point for all researchers, users and policy makers, it is a treasure for mankind.

We are very greatful and thankful to all the valuable researchers, session chairs and all participants who have contributed to ATMOS2017 from all around the world, whose valuable contributions made this event possible.

This e-Proceedings present a collection of 112 papers presented at the Symposium. The main themes covered in the Symposium include;

Agricultural and Forest Meteorology
Air Pollution and Modeling
Air Quality and Modeling
Air-Sea Interactions
Atmospheric Boundary Layer
Atmospheric Dynamics
Atmospheric Environment
Atmospheric Physics
Atmospheric Radiation
Aviation Meteorology
Biometeorology, Medical Meteorology
Causes of Climate Change
Chaos and Non-Linear Dynamics
Climate Change Impacts
Climate Change and Modeling
Climatology
Data Analysis
Extreme Weather Events (flood, storm, avalanche, drought …)
Hydrology and Hydrometeorology
Maritime Meteorology
Meteorological Disasters
Micrometeorology, Mesometeorology
Numerical Waether Prediction
Physics of Cloud and Precipitation
Remote Sensing in Atmospheric Sciences
Renewable Energy Sources
Solar and Wind Energy
Stratospheric Ozone
Solar and Climate System Interaction
Transportation Meteorology
Upper Atmosphere, Ionosphere
Magnetospheric Physics
Urbanisation Meteorology
Water Resources and Management
Weather Analysis, Prediction and Modeling

We would like to thank Rectorate of Istanbul Technical University and the Deanship of Faculty of Aeronautics and Astronautics for supporting ATMOS2017. We would like to express our appreciation to Organizing Committee Members, Steering Committee Members and Scientific Committee Members for their precious support. Last but not least we would like to thank Turkish State Meteorological Service, Union of Chambers of Turkish Engineers and Architects; Chamber of Meteorological Engineers for their valuable support.

Editors

Dr. Orhan ŞEN - Dr. Ceyhan KAHYA
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DETECTING CLIMATE-CHANGE FROM A SEASONAL PERSPECTIVE OVER TURKEY

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ABSTRACT

This study suggests a seasonal perspective to detect climate change. For this purpose, the Mann-Kendall (MK) trend method was applied to the seasonal values of maximum, minimum, average temperatures and precipitation totals of Turkey. To see the advantages of using seasonal-scale perspective, the results were also compared with those obtained from annual values, since several important traces of the climate change may be masked due to the smoothed annual data. In the study, the MK-trend test calculations were made by writing a source code of Fortran 95, and the homogeneity in data values was checked by a toolbox of the so called "Climtrends" written in R-language. In addition to being homogeneous of the data, the meteorological stations with less than 7% ratio of the missing records were selected. One of the important results is that the trends masked in the annual data, undoubtedly become clear in the seasonal-scale domain. In the study, another important result is the negative trend-patterns obtained from the precipitation series overlap the same areas of the several river-basins of Turkey, where the agricultural activities are so intense. In addition to global warming, determining the possible trends in the minimum temperatures under the influence of physical geographical factors observed in the southern coast of the country and the rain-shadows contribution to the precipitations in the north-east areas of the country are such important results of this study. This is the fact that an increasing of water demand due to increasing of the population is a very important problem needs to be solved by the policy makers.

Keywords: *Climate-Change, Mann-Kendall, Season, Trend, Turkey*

INTRODUCTION

Trends seen in slow components of temperature and precipitation values could be assessed as evidences of the climate change. Particularly, rainfall or water has been attracting so much from the past to present day. From the date of the Sumerians to present day, water has been perceived as an operable commodity. Due to the negative effects of climate-change on fresh water sources, our water related problems are becoming an inevitable spiral. In short, water crises are likely to emerge in many parts of the world in near future.

In this study, the MK-trend test was applied to detect a significant increase (or a decrease) in the slow components of the temperatures and precipitation values between 1970 and 2014 over Turkey. The country is located in the eastern Mediterranean basin, and mainly influenced from the westerly winds of the pressure disturbances especially in winter. There is a very humid region located in the northern coast of the country, where the precipitation shadows are also visible. Besides the fact that three sides of the country are covered by seas and mountainous over the eastern parts are cold and snowy in winter, and the summers are dry and hot. In other words, the typical real Mediterranean climate prevails in the country (Tatli and Dalfes, 2016). Since the southeastern region of the country is the hottest and moisture-poor place, the additional problem for agricultural activities could be overcome by the construction of various hydraulic power plants and dams. On the other hand, the Marmara Region, which is the most industrial region located in the north-west of the country has the most populous population, and therefore the demand for fresh-water have increased over time leads hydro-meteorological and environmental problems. One way to monitor these problems is to run a general circulation

model (GCM) linked to various socio-economic scenarios (Tatli *et al*., 2004, 2005; Tatli, 2015; IPCC, 2013). Another way is to have a look at the near past climate. The important issue in this context is the climate-change rather its natural variability. Correspondingly, one of the easy methods to detect climate change is finding trends in the variables, especially in temperature and precipitation values.

If one looks at the literature one many find studies on this topic. Some of them are summarized as: Partal and Kahya (2006) have applied Mann-Kendall-Sen to determine trend in the annual precipitation values over Turkey. Norrant and Douguédroit (2006) have investigated the identification of linear trends in monthly, seasonal and annual timescales in the Mediterranean. Jentsch *et al*. (2007) have underlined the evidences of the "event-based", not the "trend-based". Sousa *et al.* (2011) have analysed the trends and extremes of the drought indices throughout in the Mediterranean by using the average monthly precipitation and the Palmer Drought Severity Index (PDSI) during the 20th century. Tatli (2015) has suggested the Hurst exponent for determining the persistence of meteorological drought and using it in combination with the trends and jumps. Iqbal *et al.* (2016) have a recent study of changes in the maximum and minimum temperatures in Pakistan. Colombani *et al*. (2016) have found a relationship between the trend of heavy metal release and climate change. Chattopadhyay and Edwards (2016) have studied to determine the long-term trends in annual precipitation and mean annual air temperature for the state of Kentucky. Shi *et al.* (2016) have investigated the potential effects of climate change on energy demand in the household sector by determining the trends of heating and cooling days in China.

METHODS AND DATA

Data

In this study, the data set of monthly total precipitation and average temperature, maximum, minimum temperature values of the 212 meteorological stations belonging to the Turkish State Meteorological Service was used for the period 1970-2014. In addition, the homogeneity of the data was checked by cross applying the Pettit (Pettitt, 1979), Standard Normal Homogeneity (SNHT) (Alexandersson, 1986) and von Neumann ratio (Von Neumann, 1941) tests with the help of a statistical toolbox written in R-language of the so called "Statistical Methods for Climate Sciences (Climtrends)" (Gama, 2016). A confidence level of 95% was chosen while employing the tests. Consequently, in addition to homogenous stations and the number of stations with an incomplete-data ratio of less than 7% were chosen. Wijngaard *et al.* (2003) have studied the homogeneity characteristics of the climate series over Europe that one may find more detailed information of the corresponding tests in their study.

Mann-Kendall Trend Test

The Mann-Kendall trend (MK) test was first suggested by Mann (1945), and later it has been enhanced by Kendall (1975) and Hirsch *et al*. (1991). The application steps of the MK test follow as:

$$\left.\begin{array}{l} \mathrm{H}_0 : \text{There is no trend in the series} \\ \mathrm{H}_a : \text{There is a trend in the series} \end{array}\right\} \quad (1)$$

To assess the null hypothesis, a required quantity of the test, *s*, is calculated by

$$s = \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \mathrm{sgn}(x_j - x_i) \quad (2)$$

Where *sgn* indicates the abbreviation of the Signum (or Sign) function. Let $x, y \in \mathbf{R}$, the sgn function is defined by

$$\operatorname{sgn}(x-y)=\begin{cases}1, & \text{if } x>y\\ 0, & \text{if } x=y\\ -1, & \text{if } x<y\end{cases} \quad (3)$$

The average of the statistic, $\bar{s}$, is assumed to be zero and follows the normal probability distribution, and its variance of σ^2 is acquired by

$$\sigma^2=\frac{N(N-1)(2N+5)-\sum_{i=1}^{p}h_i(i)(i-1)(2i+5)}{18} \quad (4)$$

Here, h_i, represents the number of ties up to sample *i,* and the test-statistic is calculated as follows,

$$Z=\begin{cases}\dfrac{s-1}{\sigma^2}, & \text{for } s>0\\ 0, & \text{for } s=0\\ \dfrac{s+1}{\sigma^2}, & \text{for } s<0\end{cases} \quad (5)$$

The probability density function of the Z also follows the standard normal distribution. If *Z* is greater than the critical value of $Z_{1-\alpha/2}$ then the alternative hypothesis, H_a, is accepted by a statistical significance level of $1-\alpha/2$, where "α" is generally taken as 0.01, 0.05 and 0.1.

RESULTS AND DISCUSSION

The results of the MK-trend analysis were transferred to the related Geographic Information Systems (GIS) program for shaping the patterns of trends in the climatic variables over the country. The unmarked areas indicate that there are no significant trends while the "+" and "-" signs on the maps show statistically significant trends in these areas, respectively. In this section, at first, the maps obtained from the annual data shown in Fig.1 were interpreted, and later the maps of the seasonal data were analysed.

Annual Patterns

Thus, the trend patterns of the annual mean temperatures are given in Fig.1a. As seen in this figure, the significant positive trends show a significant distribution across the northern, western and southern coasts of the country, as well as the ignificant positive trends are also observed on the southern part of Eastern Anatolia, one of the most mountainous regions of the country. Like the mean temperatures, the minimum temperatures have significant positive trends observed on the southern and southern-western regions of the country, which are distributed along the coasts of the country adjacent to the sea. Certainly, the changes seen in the minimum temperatures usually represent the local-climate conditions.

The very interesting patterns those given in Figure 1.d are seen in the trends obtained from the annual precipitation totals. As can be seen in this figure, there are two trend patterns of decreasing in the precipitations around the eastern Marmara and Van Lake. On the other hand, there is an increase in the precipitation throughout the belt of Agri-Ardahan-Artvin of the Eastern Anatolia, as well as in the coastal region of the Middle-Black Sea.

Seasonal Patterns

Spring

We have provided a collection of information about the geographic distribution of the trends from the annual data, but we are now detecting that the distribution of trends in the seasonal variables have been changed in a great deal. If we take each of the variables one by one, the

positive trends of the annual mean-temperatures as given in Fig.1a, previously were seen in the Mid-Black Sea and the entire Marmara region.

However, in the new situation as shown in Figure 2a, the positive trends of the mean-temperatures are only observed over the coasts of the south Aegean and Mediterranean seas of the country. Since the tourism activities in this region are very important, the possible changes in the climate are of great importance, as well as this region is known a centre of producing industry of the citrus-fruits and orangeries. Accordingly, the positive trends of the temperature values in these regions would also affect the population of the diversity of living species, perhaps it will lead to occurrence of possible proliferation of the new pests.

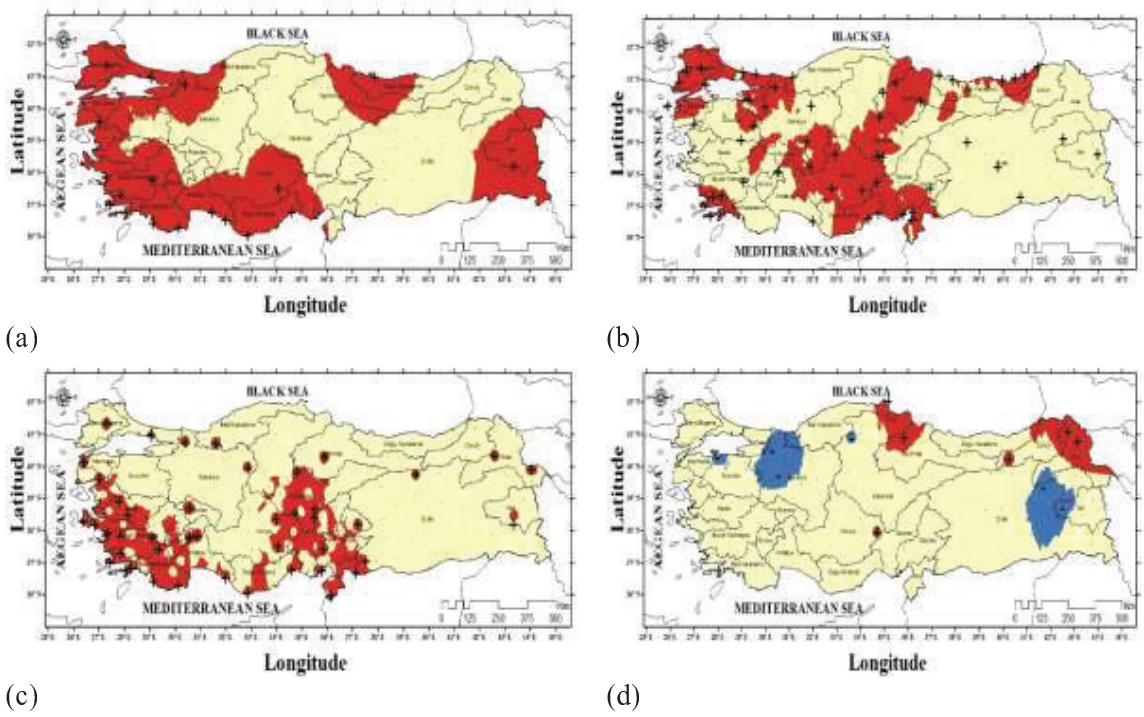


Figure 1. Spatial distributions of MK-trend in the annual data: Average temperature (a); Maximum temperature (b); Minimum temperature (c); and Total precipitation (d).

Similar situations are observed in the trends of the maximum temperatures as given in Fig.2b. As we can see from this figure that, the positive trends are observed on the entire Thrace region (except the west parts), the South-eastern Anatolia and Eastern Anatolia regions. Furthermore, a similar a positive trend pattern is also observed over the city of Konya and its surrounding. The grain production is very rich in Konya, but the underground water resources be so poor. When we examine the patterns of the minimum temperature as given in Fig.2c, they seem the patterns of those previously observed in the annual minimum-temperatures. However, the positive trends now are scattering over the coasts of the southern and southern Aegean of the country, are much more intense. This density is partly because of global warming, as well as the local-climate effects. In recent years, on these territories, it is a fact that summers have started early. This situation feels itself with the positive trend patterns observed in the minimum temperatures as seen in Fig.2c. When we look at the patterns at both maximum and minimum temperatures, we can see the significant positive trends in Istanbul, which is the most populous and financial city of the country. These positive trends, which are absorbed both in the annual and spring seasons, are the result of “urbanization” in Istanbul, i.e., the "heat island" reality.

Indeed, with the global warming, early precipitations are expected to increase due to acceleration of evaporation rate in the hydrologic cycle. However, this situation cannot be generalized. The negative trends of the spring rainfalls as given in Fig.2d are observed over the areas where the amount of agricultural produce being very economically important. Only on the north-eastern part of the country, the precipitations have a positive trend on a narrow-band area, which is influenced by the northly moist-cool air.

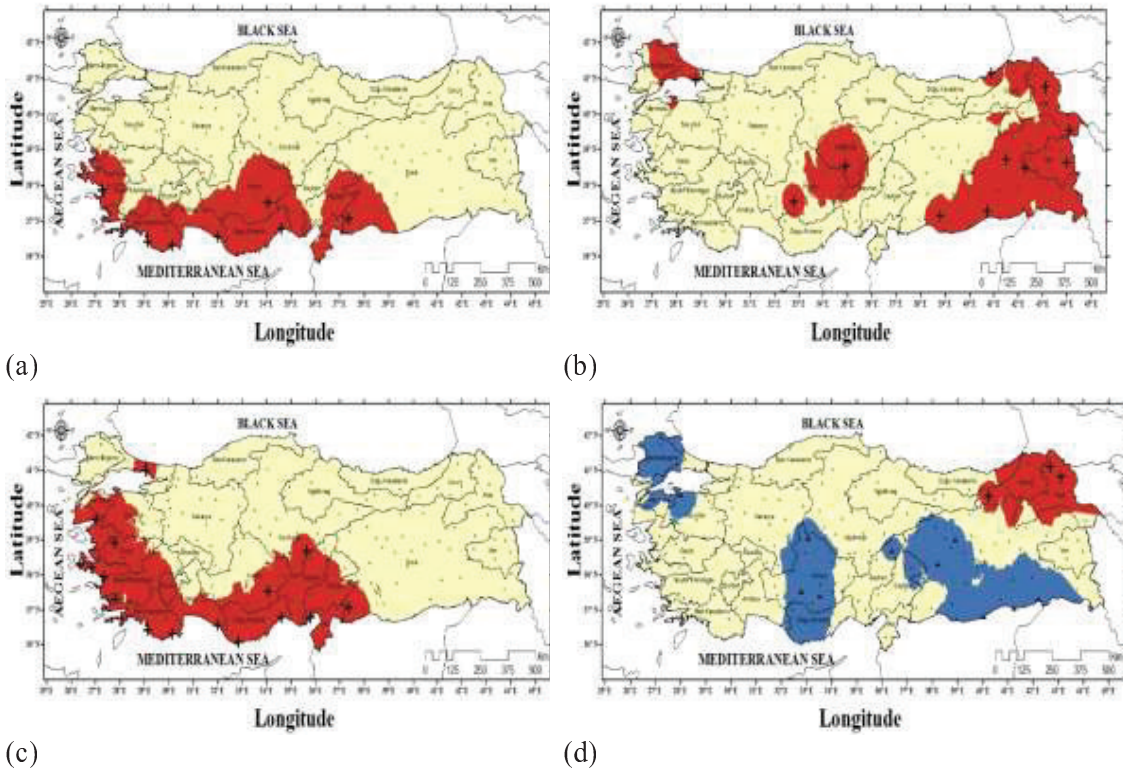


Figure 2. Spatial distributions of MK-trend in the spring: Average temperature (a); Maximum temperature (b); Minimum temperature (c); and Total precipitation (d).

Winter

As shown in Fig.3a, the positive trends in the mean temperatures of winter months have a pattern which is extending from the southern parts to north-eastern regions of the country. In other regions, there is an increase in the average-temperatures predominantly in some large cities. The global warming is felt much more in the southern regions; interestingly in the mountainous regions, several positive trends are seen in the places with high altitude and very cold weather can turn this into a more pleasant and comfortable region. On the contrary, the southern regions could be affected negatively. The increase in the winter average-temperatures may affect the snowfall in mountainous areas, so shortening the period of snow-cover on surface might have increased the frequency of extreme events such as various erosion and floods. It is obvious that many land-studies are needed to determine how living creatures adapting to the climatic conditions in that region and their diversity react to the new situation. The trends of the maximum temperature for the winter months are given in Fig.3b. This figure is very important in terms of revealing the gravity of the event. Because of the nature of the true Mediterranean climate, the winters must be cold and wet. In addition, a new study by Tatli and Dalfes (2016) have showed that the Holdridge based classification of the vegetation-types seen in the southern part of the country tended to resemble the tropical ones, and a shifting from the dominant cold-step vegetation structure to the warm-step vegetation, particularly in the inner regions of the country. This study clearly supports their work.

The trend patterns of the minimum temperatures are shown in Fig.3c, there are several significant positive trends of those predominantly seen in the eastern and southern of the central Anatolia, and southern parts of the Aegean. When the minimum temperatures and average-maximum temperatures are compared, we cannot see dominant trends except for the high mountainous and a narrow band area in the south-eastern Mediterranean Sea. Therefore, we can arrive at a conclusion that the minimum temperatures that reflect the characteristics of local effects are not effective in winter, but rather the effect of global (or regional) climate. One reason for not seeing the certain positive trends in the northern regions of the country in winter, we can link these conditions seen in these regions to the effects of the cold weather blowing by the Siberian high pressure and Arctic Oscillations bringing the cold air of North Pole (Cohen *et al*., 2001).

When we examine the winter precipitation, we observe that a decrease and increase in the precipitation values over the narrow areas (Fig.3d), in contrast to the trends observed in the temperatures. Likewise, there are positive trends seen in the precipitations only in a few narrow areas of the country such as north-east, middle and western parts of the Black Sea basin, because the northly air is fed with moisture and leaves much rainfall over there.

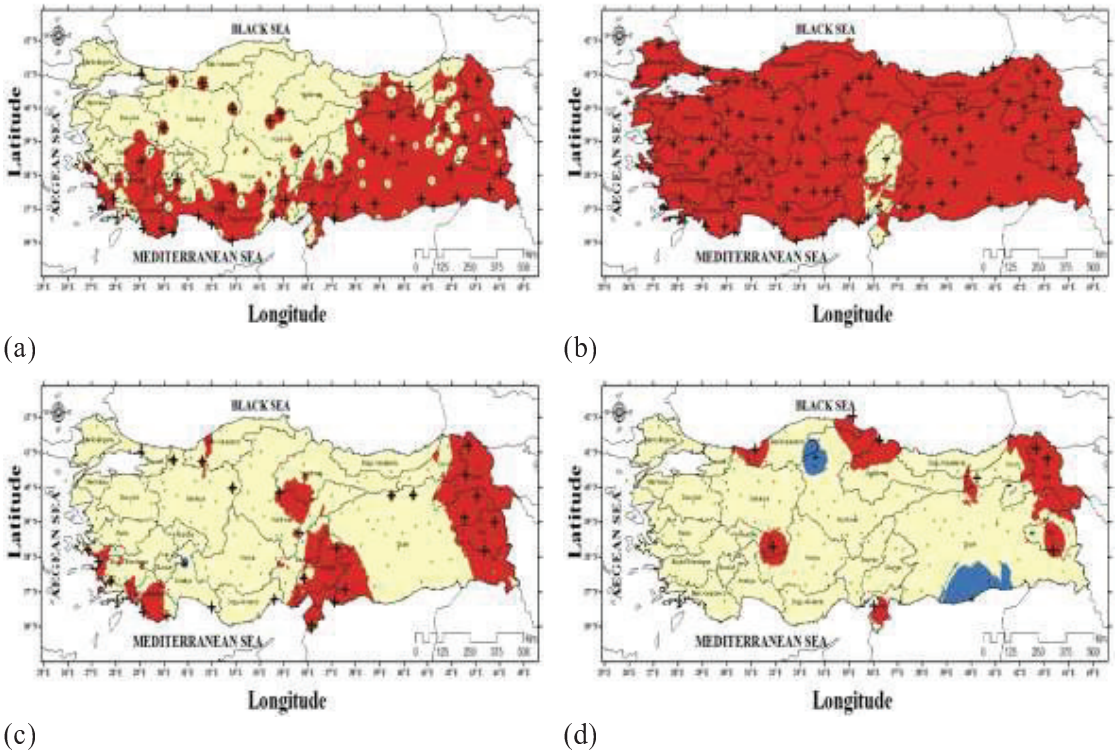


Figure 3. Spatial distributions of MK-trend in the winter: Average temperature (a); Maximum temperature (b); Minimum temperature (c); and Total Precipitation (d).

Autumn

When we look at the trends of the autumn temperatures and precipitation as given in Fig.4, we observe the typical local-climate effects. In no map, we have examined before, we have not found climate situations that reflect such local characteristics. There is a positive trend pattern in the warmest region of the country experienced the temperatures over the southern areas of the sea-coasts of the Mediterranean (Fig.4a).

Similarly, a positive trend of the maximum temperatures is seen in the eastern Black Sea region. Since this region of the country has rainy in all seasons, the released heat energy after rainfalls (Fig.4b) may have increased the temperatures.

The physical quantity that best describes the local effects is the minimum temperature (Fig. 4c). As can be seen, starting from the Central Anatolia region of the country, positive trends are detected in all the southern and western regions near the sea. A negative trend appears in the southern and round region between the south and the west positive trends.

As seen in Fig.4d, a negative trend of the precipitations is observed in the region, which is slightly in the west of the middle Black Sea basin. There is a positively contradictory pattern located to the south of this pattern.

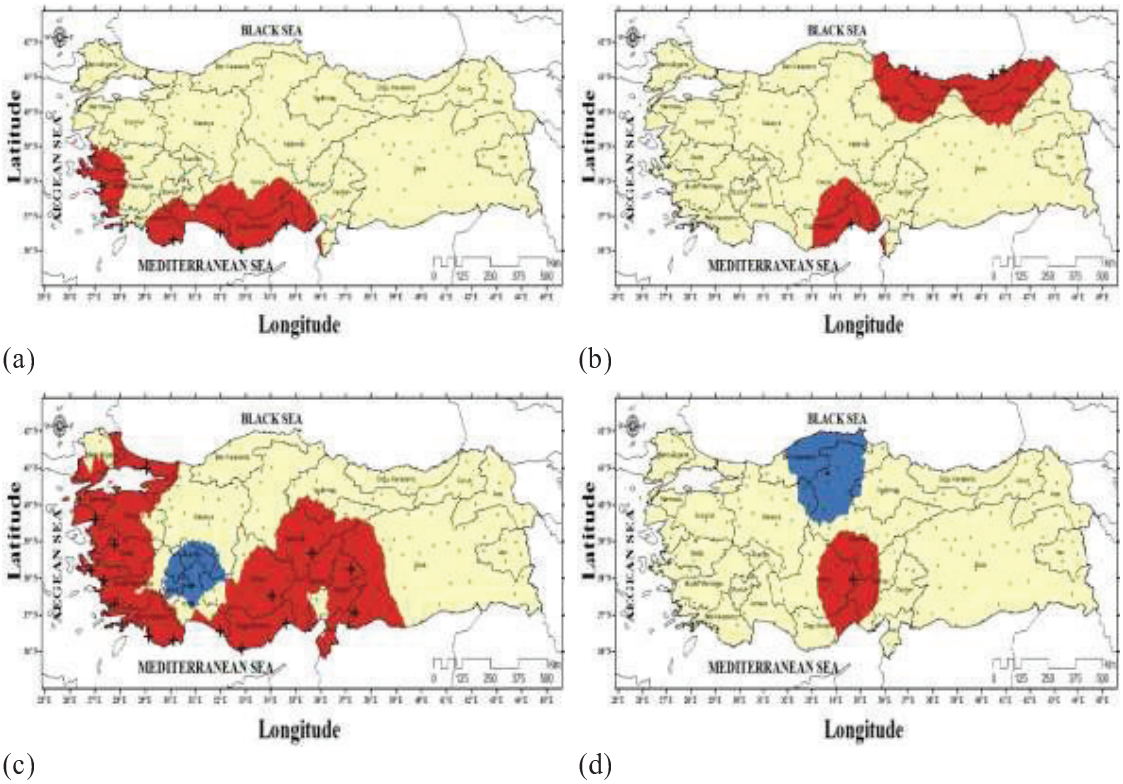


Figure 4. Spatial distributions of MK-trend in the autumn: Average temperature (a); Maximum temperature (b); Minimum temperature (c); and Total Precipitation (d).

Summer

When all types of temperature given in Fig.5abc are examined, positive temperature trends are observed in all areas except a few local points. Those local spots are probably preventing it from getting too warming due to its high altitude. In the summer season, global warming is the most felt. One of the negative conditions brought about by the warming is the increase of wild forest fires because of the increase of the drought. In the north Aegean, a decrease in summer precipitation is striking. In this case, as we have underlined previously, possible wild forest fires in this region are expected.

Likewise, although there is a positive trend due to sudden summer precipitation in the south-east region of the country, it is negligible in terms of the amount of precipitation observed there. Similarly, there is an increase in the summer-precipitation over an area of the north-east

part of the country. One of the reasons of this trend may be the rain-shadows observed there. In the summer, as seen in Fig.5abc, the country seems to be burning in a circle of fire. The most basic physical reason for these positive trends of the temperatures is, of course, the moving of the Inter Tropical Convergence Zone (ITCZ) to the northern regions, and the centre of the Asian low pressure, and the African temperatures brought by the Arabic low are such examples.

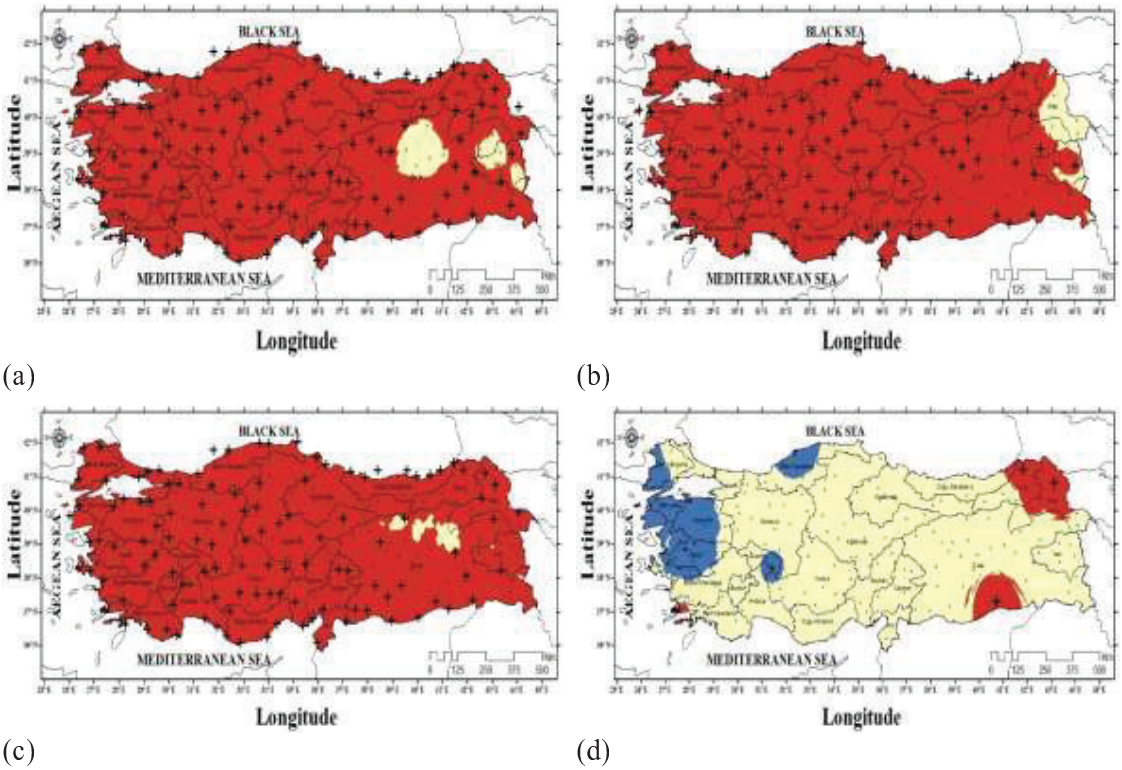


Figure 5. Spatial distributions of MK-trend in summer: Average temperature (a); Maximum temperature (b); Minimum temperature (c); and Total Precipitation (d).

CONCLUSIONS

These positive trends seen in the temperatures may cause more health problems as it will lead to an increase in the frequency of heat waves. When seasonal and annual trends are compared, a lot of detailed information and masked patterns have become much more transparent. In a large country like Turkey, where Mediterranean climate prevails, every season has produced its own patterns and many different classes of temperature and precipitation have emerged. The most important reasons for these differences are the physical geographical factors in the region concerned, that is, the most important in the minimum temperatures and partly in the rainfall are these geographical factors. On the other hand, the temperature values have been significantly increased due to the influence of the Arabic Low (an extension of the Monsoon Low), as well as the Central Asian Low, one of the large-scale pressure systems, because of global warming. Considering the method applied in this study, it consists of only a simple trend analysis which is quite simple and not complicated. However, the results of our study are not lower in the quality than those of the most complex methods. For example, the climate models that are very expensive in time-money gives only very smoothed information, indeed not the forecast, since the projections are not forecasts as in the daily weather forecasting. As a result, this work presents a photograph of the Turkey climate at a seasonal scale. As open points of this study, the results are not compared with the results of the previous studies in the literature. This is particularly preferred because it involves many differences from the quality of the data

used in the studies. For example, the preferred method of interpolation may create different maps. Secondly, since the length of data considered may change the results of the applied statistical method, the comparisons may lead the study to the wrong direction.

For future work in this topic, for example, for hydrological purposes, it may be advisable to examine possible trends of the rivers. It is possible to investigate the effects of these changes, for example, on the amount of agricultural production. Or it can be investigated whether there will be a positive contribution to tourism activities or not.

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