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TREND ANALYSIS OF PRECIPITATION IN HATAY

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Abstract

The efforts for understanding climate and its trend which affect human life directly or indirectly, has been moved to a different dimension depend on advances and increasing in knowledge and technology. Turkey has a delicate position of climate change could occur in the short and long term. Therefore, the responses of the regions to climate change are formed by the ratio of this sensitivity. In this study monthly, seasonal and annual rainfall meteorological data (1970-2011) of Hatay, Antakya, Dörtyol, Samandağ and Iskenderun were used. The trend of precipitation has tried to understand by using Coefficient of variation, Mann- Kendall Trend Analysis and Linear Regression models. According to the results, the least annually variation of precipitation occurred in Iskenderun (16%), on the other hand the highest variation occurred in Antakya (26%). The results of Trend analysis show that all stations annual precipitation values increased. As a result of trend analysis has been observed that is an increase of precipitation values of all stations. However, all stations have been found insignificant at the 95% confidence interval except Iskenderun's station. According to the linear trend analysis results, the maximum increase in annual precipitation occurred in Samandağ (19, 4%) and the least occurred in Antakya (5, 15%).

Keywords: Trend Analysis, Hatay, Precipitation.

1. Introduction

Climate exhibiting a dynamic structure have two types of variances including short and long-term (Gardner et al., 1996; Karabulut and Cosun, 2009). The Short term variance refers to the difference between the annual measurement of any climatic element and its average of many years. The long term variance refers to an apparent increase or decrease occured at average of many years of any climatic element. In Turkey,particularly Mediterranean region, where the study area included in , has been located in a risky region, at which short or long term climatic variabilities can be experienced(Turkes et al., 2002; Xoplaki, 2002).

One of the greatest influences of global climatic variances occurs on rainfalls, while this climatic variances leads to drought in some areas due to the lack of rainfall, on the other hand,flood and spates can occur as a result of excessive railfall in some areas as well (Turkes et al., 2002). The most prominent features of the Mediterranean climate type are the significant differences between summer and winter seasons in terms of climatic conditions and the high relative variability of the climatic elements, particularly rainfalls in the years that followed(Karabulut and Cosun, 2009; Olgen, 2010).While thevariability of annualrainfall is between13.8% and 35.6% in Turkey (Turkes, 2006).Kocman (1993), pointed out that the places whererainfall variability of coefficient is between 20 and 25% have constituted a major part in Turkey. According to the Olgen's opinion(2010), this variability ratio is 25% for the Mediterranean region, where the study area is located in. There are many publications,in which the relationship of the variability of rainfall with various atmospheric emissions has been investigated(Turkes and Erlat, 2003; Philandras et al., 2011; Karakoc and Tagil, 2014; Topuz et al., 2014).It was revealed that the winter months in particular, has been associated with different degrees of other atmospheric emissions (Turkes, 1998),especially North Atlantic Oscillation (NAO) as well. (Erlat, 2002; Turkes and Erlat, 2005; Yetmen, 2006; Turkes and Erlat, 2006; Turkes, 2010; Saris et al., 2010; Karakoc and Tagil, 2014).

Although climate have many elements, especially temperature and rainfall parameters are the variables that are most commonly used in climate trend analysis (Karabulut and Cosun, 2009).As well as the studies, in which these variables were discussed together, are available (Lazaro et al., 2001; Turkes et al., 2002; Turkes et al., 2008; Jain and Kumar, 2012; Donat et al., 2013),the studies, in which only the variable of rainfall (Githui et al., 2002; Cicek, 2003; Feidas et al., 2007; Karabulut et al., 2008) was used, are also available.

When the studies in regard to rainfall, whichis the most changeable parameter in terms of time and space among the climatic elements, were analysed from the point of Turkey,it has been noticed that a decrease in annual rainfalltrend has been experienced in general; dry spells have increased after the year 1970 in terms of both number and intensity (Turkes, 1996).It was revealed that the annual rainfall values of a major part of subtropical lands comprising especially Mediterranean basin, have approximately decreased in the ratio of 3% every ten years (Turkes, 2007).In this study,with the intent of identifying the effects of variations of rainfalls in Turkey on a local scale; monthly, seasonal and annual rainfall trends in the time period between the year 1970 and 2011 in Hatay province were analysed.

2. Study Area

Study area includes Hatay province which is the southernmost of Turkey. It is surrounded by the Mediterranean from the west, Syria from south and east (Figure 1).

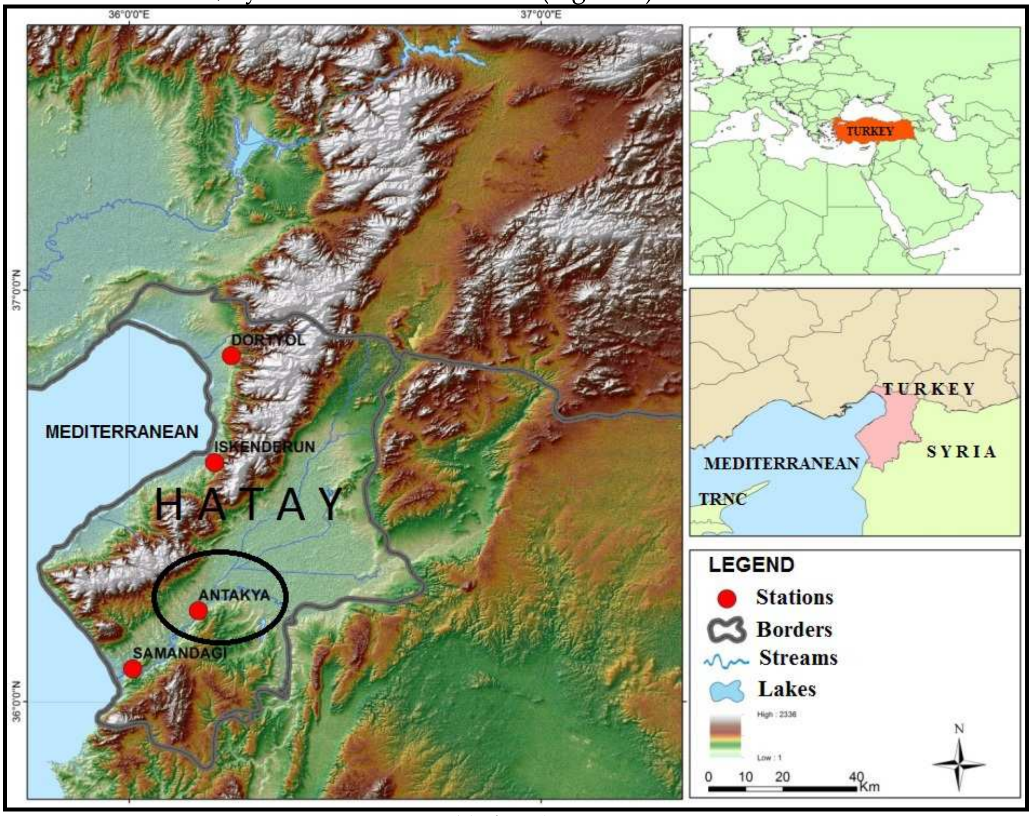

Figure 1: Field of Study Location Map

In Antakya, in general, Mediterranean climate type which is dry and hot in summers and warm and rainy in winter, is observed (Korkmaz and Faki, 2009). However, there is a differentiation among the meteorological measurement stations due to topographical reasons (Aytac and Semenderoglu, 2014). Amanus Mountains serve such as a barrier between the internal parts and the mild effects of the Mediterranean. While annual temperature averages vary between 15^{o}C and 20^{o}C the annual average of precipitations vary between 562 mm and 1216 mm. Precipitations are concentrated commonly in winter period and July and August are the months with highest temperature (Korkmaz 2008a; Korkmaz, 2009; Karatas and Korkmaz, 2012).

The field of study is included in the Mediterranean precipitation zone which is one of the Turkey's precipitation zones which are formed by Turkes and Tatli (2011) by using spectral clustering method. The precipitations in the region in general are influenced by Mediterranean basin originated frontal low pressure systems and Azore high pressure systems (Turkes and Tatli, 2011).

According to Thornthwaite method Antakya has semi-humid, mesothermal third degree climatic characteristics with overwhelming lack of water in summer and close to maritime conditions (C2 B'3 s2 b'3), (Korkmaz, 2009). Antakya has humid climate properties according to De Martonne and Gottman annual drought index which is based on the relation between the temperature and precipitation (value: 20.84), and Erinc annual precipitation index value (value: 48.23).

3. Material And Method

Samandag, Antakya, İskenderun and Dortyol's meteorological stations data, having observer durations over 30 years, were used in this study (Table 1).

Table 1: The meteorological stations, of which data were used

Station No	Station Name	Latitude (K)	Longitude (D)	Altitude	Recording Period
17372	Antakya	K 36° 12' 00''	D 36° 10' 34''	100 m	1970-2011
17962	Dortyol	K 36° 51' 21''	D 36° 13' 20''	28 m	1970-2011
17370	Iskenderun	K 36° 35' 12''	D 36° 10' 21''	3,5 m	1970-2011
17986	Samandag	K 36° 04' 56''	D 35° 59' 57''	4 m	1970-2011

In the study at first the descriptive statistics of data were calculated. Descriptive statistics are used to describe the basic features of the data in a study generally. They can provide simple summaries about the data set. Together with simple graphics analysis, they form the basis of virtually every quantitative analysis of data. After the descriptive statistics of the data were carried out, the uniformity test was carried out through Thom test (Karabulut and Cosun, 2009; Karabulut, 2012; Karakoc and Tagil, 2014). Thom test is a non parametric test measuring the variance that associates with the arithmetic mean of the series. It is used to test if any extreme situation occurs(randomness) during the emergence of the the events. Each data in the series are seperated into the sets according to being smaller or larger than the median specified. In a serie with a total of n elements; each consecutive data or data group, smaller or larger than the mean, constitutes a set.The important thing is the number of sets (R) (Tecer et al., 2004). According to the analysis results performed through Thom test; the annual rainfall values measured at all stations were identified to be homogeneous in the significance range of 95% (Table 2). As well as Antalya have the greatest values with regard to mean, maximum and minimum rainfall amounts, it has the greatest values among the stations with regard to standard deviation and range as well. (Table 2).

Table 2: Descriptive Statistics of The Stations Used Rainfall's Data and Homogeneity Test Results (*Thom Test: -1,68 < Z < +1,96; %95 homogeneous in 95%confidence interval)

Stations	Measurement Year	Average Rainfall	Standard Deviation	Minimum Rainfall	Maximum Rainfall	*Thom	Lowness	Deviancy	Range
Dortyol	42	939,1	182,37	619	1304	0	-0,789	0,016	685
Antakya	42	1088,45	287,01	609	1957	0,06	0,924	0,789	1348
Samandag	42	895,62	201,18	466	1307	1,24	-0,214	0,171	841
Iskenderun	42	720,21	121,07	480	1009	0,31	0,102	0,199	529

Another method used in the study is Mann–Kendall Test.This non parametric test is a special application of the Kendall's test known as Tau (Saris, 2006; Karabulut, 2009). In this method, the median values are arranged from lower towards larger and significance of this arrangement is important. The series arranged according to time (X1,X2……..Xn) are independent of time and according to the H0 hypothesis, they are smilar scattered random variables. According to the alternative hypothesis H1 ($k \neq j$) and $n \geq k, j$ (n, record length of data), the distribution of consecutive Xk and Xj data aren't similar in the serie and there is a linear trend in the serie (Karabulut et al., 2008). This method is practical because of that it can tolerate the lack of data and not necessitate compliance of the data with the normal distribution. Advantages of the test are practicability, essentialness on the arrangement of data and elimination effect on serial correlation (Partal, 2003; Saris, 2006; Karabulut, 2012).

In addition, linear regression model was used in the analysis of data. In this model, the relationship between time and rainfall are measured and the level of the relationship between two variables was intented to be revealed. Besides, this method allows not only observing a linear trend but also making a prediction (Sahinler, 2000; Saris, 2006; Karabulut and Cosun, 2009; Karabulut, 2012).

Another method used in the study is coefficient of variation method. This method allows direct comparison of spread of two random variables, Xj-Xi, and helps explaining the states of homogeneous or hetorejen. The standard deviations of the series compared are defined as a percentage of the mean of their own group (Ayday and Yersel, 1992; Karabulut and Cosun, 2009; Olgen, 2010).

4. Findings And Discussion

In this study, through which trend analysis of rainfalls at Hatay is targeted to be understood; the maximum rainfall at the stations,of which data were analysed,was received at Antakya, the minimum rainfall was received at Iskenderun (Table 2). The seasonal movement of air masses and frontal movements and topography were considered as the reason of this differentiation between stations. (Karatas, 2010; Karabulut, 2012; Aytacand Semenderoglu, 2014). The trend analysis of the rainfalls at Hatay was firstly performed with Mann-Kendall method, which is a nonparametric test (Table 3).

Table 3: Mann-Kendall Trend Analysis Results (*90%,** 95% confidence interval)

Months and Seasons	MK Trend Values			
	Dortyol	Antakya	Samandag	Iskenderun
January	0,38	0,16	0,12	1,38
February	1,63	1,24	1,95	1,56
March	-0,16	0,38	-0,87	-0,21
April	1,04	0,27	-0,78	0,47
May	-0,08	-0,10	0,39	0,48
June	0,39	-0,35	-0,02	0,39
July	0,76	-0,65	-0,89	-0,73
August	-0,92	-1,18	0,50	0,29
September	1,41	2,31**	1,63	2,37**
October	0,43	-1,57	0,62	-0,93
November	0,23	0,14	0,77	0,27
December	-0,55	0,23	0,62	0,30
Annual	1,87*	0,83	1,46	2,07**
Spring	0,27	0,18	-0,83	0,56
Summer	0,96	-1,08	0,01	0,14
Autumn	1,43	0,12	2,05**	1,03
Winter	0,66	0,67	0,77	1,83*

Accordingly,it is seen that the annual trends incline to increase and the statistically significant increases especially were experienced at stations of Iskenderun (95%) and Dortyol stations (90%) (Table 3). Regarding seasonal rainfalls; statistically non-significant increases and decreases at the 90% confidence interval have been experienced in spring and summer seasons. However, increase trend is statistically significant at 90% confidence interval in winter rainfalls at Iskenderun, and also at 95% confidence interval in autumn rainfalls at Samandag. This result,in other words, the increase in autumn rainfalls match up with the results of climate trend analysis performed at Mediterranean region (Ramos, 2001, Turkes et al., 2007; Karabulut and Cosun, 2009).Regarding monthly rainfalls, month of September draws attention in particular.In regard to the stations located at Antakya and Iskenderun, a statistically significant increase trend at 95% confidence interval was identified in September. In the other months of the year, statistically insignificant increases and decreases at 90% confidence interval was identified in every 4 stations (Table 3).It is beneficial to evaluate the findings of the study in two ways. While the risk of drought doesn't occur in terms of agricultural activities that have been carried out intensively at the region (Korkmaz 2008b), especially Amik's plain; it should be taken into consideration that an unexpected rainfall according to the results of trend analysis might cause serious problems as in the case of airport flood (Korkmaz and Karatas, 2013) occured in the months of January, March of the year 2012.

The result of Sen's slope analysis,which is other nonparametric test and allows making a prediction, (Karabulut et al., 2008) pointed out that the greatest increase in annual rainfalls was identified at Dortyol as 202 mm and the smallest increase was identified at Antakya as 92 mm within a total of 42 years (Table 4). An increase in trend was identified in allseasons ofthe stations except for seasons of spring at Samandag and of summer at Antakya. The greatest increase trend was identified in autumn at Dortyol and Samandag and inwinter seasons at Antakya and Iskenderun.

Table 4: Sen's slope Anaysis and The Resuts of Linear Regression Model

DORTYOL				ANTAKYA		
	Sen's slope (42 years)	Linear (42 years)			Sen's slope (42years)	Linear (42 years)
Annual	202,86	143,84		**Annual**	92,4	56,03
Spring	18,06	36,58		**Spring**	17,22	20,32
Summer	22,26	34,47		**Summer**	-12,18	41,44
Autumn	99,12	79,12		**Autumn**	7,98	16,54
Winter	31,92	26,59		**Winter**	73,08	60,61
SAMANDAG				**ISKENDERUN**		
	Sen's slope (42years)	Linear (42 years)			Sen's slope (42years)	Linear (42 years)
Annual	168,23	170,54		Annual	110,42	126,14
Spring	-32,45	-63,84		Spring	17,68	14,72

Summer	0,17	23,61		Summer	4,76	-2,52
Autumn	127,49	138,60		Autumn	38,33	38,98
Winter	60,38	72,16		Winter	88,88	74,95

According to the linear regression model; the greatest increase in the annual rainfall was identified at Samandag as 170 mm (19.4%), the lowest increase was identified at Antakya as 56 mm (% 5,15) with in a total of 42 years. (Figure 2). With respect to the seasonal rainfalls, increase trends was identified except for spring season at Samandag and summer season at Iskenderun (Table 4, Figure 2). It is remarkable that according to the linear regression model performed, the annual rainfall showed a tendency to increase at all stations within the period of 42 years; but this increase was identified as lowest with 56 mm at Antakya, where annual rainfall was identified as the greatest with 1088 mm.

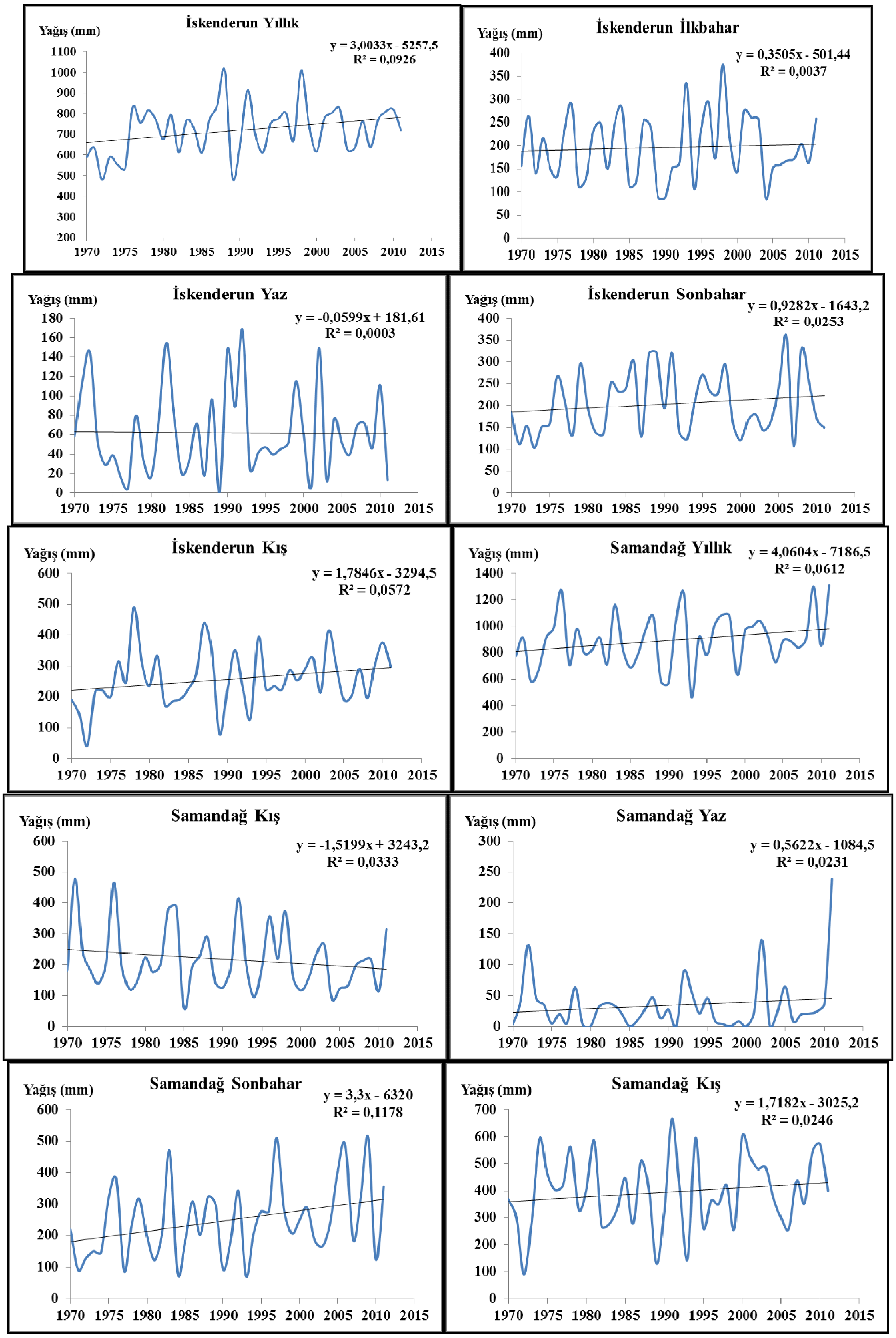

Figure 2. Graphs of linear regression model

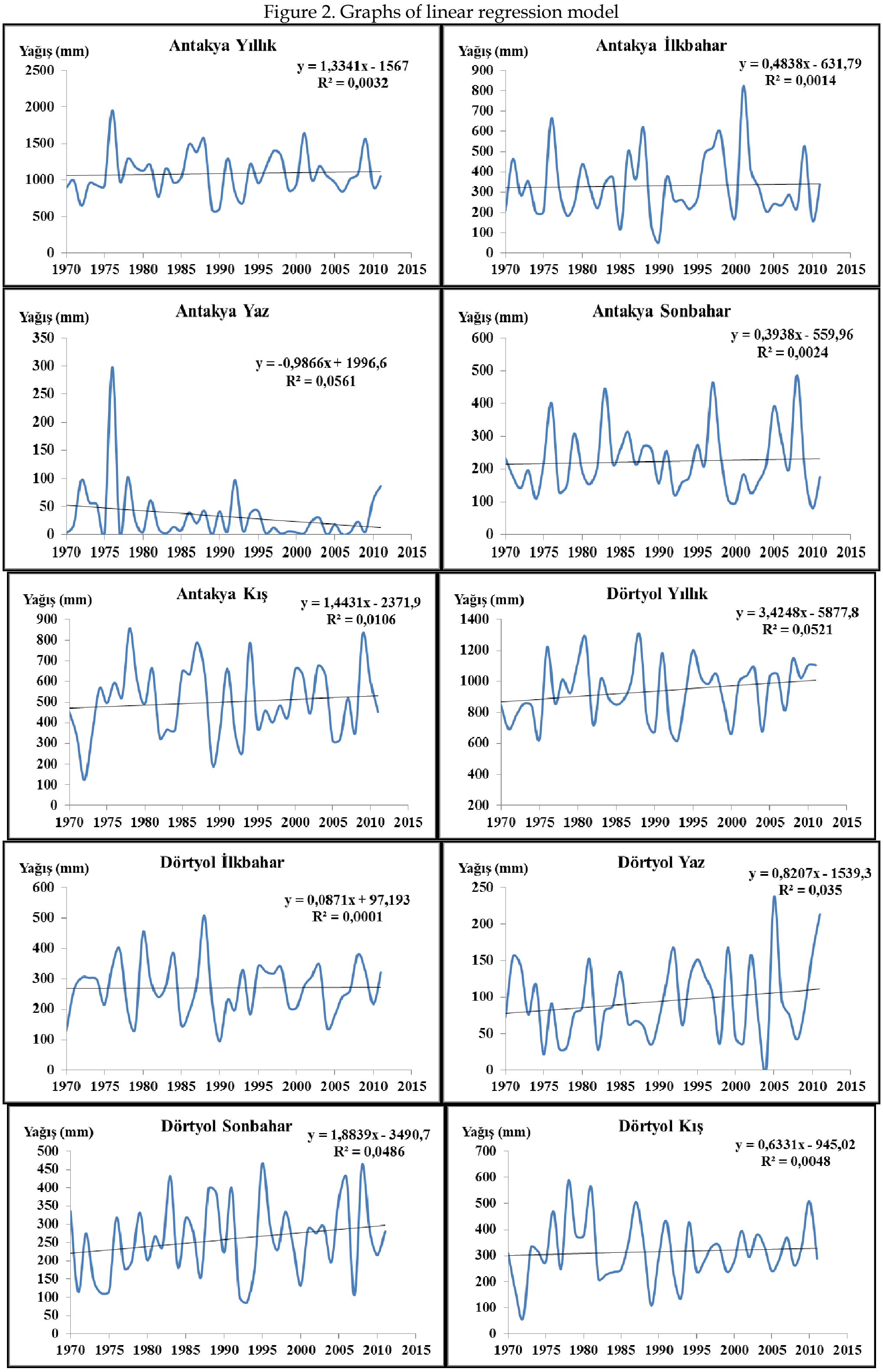

Figure 2. Graphs of linear regression model(continued).

The greatest rainfall was identified as 170 mm at Samandag, where annual rainfall was identified as 895 mm (Table 4, Figure 2). When evaluated in terms of seasonal, an increase of 138 mm draws attention in the autumn season at Samandag. The decrease in rainfalls in spring season of the same station is also important. The increase identified in winter rainfalls at Iskenderun and Samandag stations are above 70 mm. As well as increase trends were identified at all stations except for Iskenderun station in summer rainfalls, this value was the greatest at Antakya with 41 mm (Table 4).

It is seen according to the method of coefficient of variability that regarding annual rainfalls at Hatay, the greatest variability was identified at Antakya, the lowest variability was identified at Iskenderun (Table 5). With respect to the seasonal rainfalls, the greatest variability was identified in summer seasons, the lowest variability was identified in winter seasons. However it is seen that the greatest variability in autumn rainfalls was identified at Samandag stations, the lowest variability was identified at Iskenderun stations(Table 5). The fact of that the differences of variabilities between the stations resulted in minimum values in winter seasons might imply that they were affected from the common frontal movements. But the fact of that the variability values of winter seasons resulted in greater values implies that the winter rainfalls are critically important in terms of drought(Olgen, 2010). In addition, as well as identifying the heterogeneity or homogeneity properties of the rainfall distribution, these values reveal the relative situations of the stations(Karabulut and Cosun, 2009).In other words,In regard to 4 stations,of which data were analysed, Iskendurun has relatively more homogeneity structure,Antakya has more heterogeneity structure as well (Table 5).

Table 5. The Coefficient of Variability(CV) Analysis Result Table

Stations	Annual	Spring	Summer	Autumn	Winter
Dortyol	19,61	32,76	57,05	40,45	35,53
Antakya	26,47	48,24	155,94	43,85	34,33
Samandag	22,49	46,88	131,48	47,46	34,05
İskenderun	16,81	36,06	72,05	35,04	35,54

Conclusion And Recommendations

It was revealed that the coefficient of variability of annual rainfalls was lower on the coastal area and greater at the interior areas as well between the years 1970 and 2011 in Hatay (Olgen, 2010).It was revealed according to the linear regression model that the increase in annual rainfalls was greater on coastal areas, lower at the interior areas; moreover, similar results were identified with Sen's slope ve Mann-Kendall trend analysis.The increase in annual rainfalls differs from the other studies performed in respect of trend. Because the presence of a negative trend in other studies (Turkes et al., 2007; Karabulut and Cosun, 2009) wasn't determined. An increase trend in annual rainfall amount of all stations wasdetermined in the study.

When seasonal variability evaluated,it was revealed that the greatest variability resulted in summer season as well as the lowest variability resulted in winter season and in additon, the difference of variability between stations resulted in minimum value in winter season and resulted in maximum valuein summer season as well(Olgen, 2010). An increase in rainfall amount especially in autumn season was identified at every 4 stations,of which data were analysed. Particularly the increase in regard to Samandag is remarkable.According to the Sen's slope trend analysis, an increase of 124 mm and according to the linear trend analysis, an increase of 138 mm resulted within the period of 42 years in autumn season at Samandag.According the results of Mann-Kendall'strend analysis,the increase trend resulted at Samandag is significant at 99% confidence interval. While the increase trends were identified at all stations in winter season, the largest increase was experienced in Iskenderun. This increase in winter rainfalls at Iskendurun is significant at 95% confidence interval and an increase of 88 mm was determined according to the Sen's slope analysis and an increase of 74 mm was determined according to the linear regression model.It was pointed out in the other studies that the decrease in annual rainfalls was associated particularly with decrease in the winter seasons (Karabulut and Cosun, 2009).In this study, an increase trend was identified in winter rainfalls at all stations.Even though the decrease in spring season at Samandag was statistically insignificant at 90% confidence interval, it is important because of great increase in autumn season. When we evaluate the results on a montly basis, the month of September attracts the attention. A statistically significant trend increase was identified at 95% confidence interval in the month of September at Antakya and Iskenderun stations. This increase occured in autumn season match up with both previously performed studies with regional nature (Ramos, 2001) and Turkey-wide rainfall trend analysis studies (Turkes et al., 2007; Karabulut and Cosun, 2009) in terms of the variations of seasonal rainfalls.

In conclusion, it is beneficial to evaluate the findings of the study in two ways.While the risk of drought doesn'toccur in terms of agricultural activities that have been carried out intensively at the region (Korkmaz 2008b), especially Amik's plain;it should be taken into consideration that an unexpected rainfall according to the results of trend analysis might cause serious problems as in the case of airport flood (Korkmaz and Karatas, 2013) occured in the months of January, March of the year 2012. Through performing the regional detailed analysis of intensity and frequency changes of rainfalls resulted from global climate variations, it is beneficial to take the necessary measures against the risk of flood and spates. Such studies should be cared in terms of the potential consequences and regional effects of global climate changes and the strategic action plans should be prepared in the direction of these studies.

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