

## CLIMATIC TRENDS IN THE EASTERN BLACK SEA REGION, TURKEY

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### Abstract

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A study was conducted in order to determine certain pre-tests parameters (covering time-span of 1970-2012) of monthly mean, maximum and minimum temperatures and relative humidity and precipitation in the Eastern Black Sea region of Turkey and results interpreted considering engineering and agricultural works. Mann-Kendall and Sequential Mann-Kendall tests were employed to determine likely trends in the region using a software. Result of this work interpreted considering increasing effects of high temperatures crop water requirements on agricultural productivity.

**Keywords:** Climatic changes, monthly temperatures, relative humidity, precipitation

## DOĞU KARADENİZ BÖLGESİNDE (TÜRKİYE) İKLİMSEL EĞİLİMLER

### Özet

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Bu çalışmada, Doğu Karadeniz bölgesinin aylık maksimum, minimum ve ortalama sıcaklıklar ile oransal nem ve yağış verilerindeki eğilimleri bazı ön testlerle 1970-2012 yılları için analiz edilmiştir. Elde edilen bulgular tarımsal ve mühendislik çalışmaları açısından yorumlanmıştır. Bölgedeki olası eğilimler Mann-Kendall ve Ardışık Mann-Kendall testleri paket program kullanılarak saptanmıştır. Bulgulara göre saptanan sıcaklık artışlarının bitki su tüketimini artıracığı şeklinde yorumlanmıştır.

**Anahtar Kelimeler:** İklim değişiklikleri, aylık sıcaklıklar, oransal nem, yağış

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## **1. INTRODUCTION**

In the recent years, climatic change or trends in climatic parameters have been analyzed by many researcher and their results get more attention than ever. Global warming and/or irregularities in rainfall regimes have been affected many people directly or indirectly. Although this effect somehow was reasonable in northern parts of world, southern people suffer from negative effects of this changes i.e. high temperature, dryness, floods. In agricultural view, rising requirements of irrigation water, existence of new insects or diseases and resulting low agricultural yields is the main problem of human nutrition perspective.

Aim of this study is to determine likely trends of certain climatic parameters (rainfall, relative humidity, mean, maximum and minimum temperatures) in the eastern black sea region (Ordu, Giresun, Trabzon, Rize and Artvin stations) covering period 1970 to 2012 using nonparametric approaches.

## **2. MATERIALS AND METHODS**

The Eastern Black Sea Region is located in the northeastern part of Turkey. Monthly data (rainfall, relative humidity, mean maximum and minimum temperatures) recorded from 1970 to 2012 was used in the investigation for Ordu, Giresun, Trabzon, Rize and Artvin meteorological stations. Data quality control was made by General Directorate of Turkish Meteorological Affairs. However, missing data, less than 5% for whole record period, were completed using as the mean of preceding and following month's data.

A Mann-Kendall (MK) trend tests were employed in order to detect likely trend component and magnitude in meteorological data series. Additionally, a nonparametric Sequential Mann-Kendall (SMK) trend test was used in order to expose trend behaviors of certain climatic series over the years. The trend test was first developed by Kendall et al (1938), and then some extended versions came up later. The basic idea behind this procedure is usage of rank of value instead of observed magnitude in contrast to parametric methods. Especially, the Sequential Mann Kendall trend test is useful providing starting an ending time of likely trend component in the series (Sneyers 1990; Tonkaz et al 2003).

## **3. RESULTS AND DISCUSSIONS**

Trend test results indicated that meteorological series in the Eastern Black Sea Region has significant upward or downward trend components for each station in certain months (Tab. 1).

**Table 1.** Mann-Kendall trend results including test statistics

Months	Stations										
	Ordu		Giresun		Trabzon		Rize		Artvin		
	Test Z	Sign.	Test Z	Sign.	Test Z	Sign.	Test Z	Sign.	Test Z	Sign.	
<b>Rainfall</b>	January	1,883776	+	1,18266		1,61167		0,14652		0,39769	
	February	1,454773		1,45		1,06		1,00		0,65	
	March	2,417645	*	1,19		1,79	+	1,53		2,02	*
	April	0,041862		-0,42		1,20		0,65		-0,09	
	May	1,077997		0,40		0,74		-0,33		0,00	
	June	-0,01047		0,20		0,02		1,32		-0,30	
	July	-0,58606		0,57		0,09		0,57		2,79	**
	August	-1,04654		-1,38		-0,86		-0,06		2,31	*
	September	0,648856		0,06		-0,27		1,26		0,32	
	October	0,136058		1,32		2,20	*	1,15		1,42	
	November	1,140793		0,49		-0,06		-0,29		0,05	
	December	-2,01994	*	-1,25		-1,58		-0,48		-2,08	*
<b>Relative humidity</b>	January	-2,01054	*	-1,66428	+	1,45515		1,76914	+	-1,29785	
	February	-1,08		-1,33		2,85	**	3,61	***	-1,25	
	March	-2,85	**	-2,25	*	0,76		1,12		-1,07	
	April	-3,12	**	-1,29		2,04	*	2,38	*	-0,77	
	May	-3,58	***	-2,25	*	1,08		0,63		-2,64	**
	June	-3,36	***	-1,89	+	1,21		0,67		-3,22	**
	July	-3,96	***	-2,06	*	1,24		-0,25		-3,18	**
	August	-4,23	***	-2,31	*	1,43		-0,39		-3,19	**
	September	-3,79	***	-2,94	**	0,00		-0,22		-3,09	**
	October	-2,68	**	-1,94	+	2,44	*	1,49		-1,07	
	November	-0,68		-1,19		1,35		2,43	*	-1,50	
	December	-2,67	**	-2,53	*	1,88	+	1,73	+	-2,90	**
<b>Mean temperature</b>	January	1,29952		0,74385		0,18854		1,23573		1,05753	
	February	-0,20		-0,74		-0,74		-0,48		-0,22	
	March	0,93		0,22		-0,12		0,04		-0,67	
	April	-0,04		-0,68		-0,69		-0,76		-1,07	
	May	1,72	+	0,59		1,19		1,47		0,44	
	June	3,86	***	1,75	+	3,51	***	3,27	**	1,90	+
	July	4,53	***	2,92	**	3,90	***	3,87	***	2,64	**
	August	5,21	***	3,98	***	4,56	***	5,13	***	3,78	***
	September	4,08	***	2,26	*	3,30	***	3,51	***	2,24	*
	October	3,10	**	1,81	+	2,22	*	3,32	***	2,15	*
	November	0,87		0,54		-0,47		1,24		0,60	
	December	1,98	*	1,67	+	1,46		2,08	*	1,93	+

+: suspectable, \*: significant at the level of 5%, \*\*: significant at the level 1%, \*\*\*: significant at the level of 0.1 %

Cont.

Months		Stations									
		Ordu		Giresun		Trabzon		Rize		Artvin	
		Test Z	Sign.	Test Z	Sign.	Test Z	Sign.	Test Z	Sign.	Test Z	Sign.
Maximum temperature	January	1,15170		0,24081		0,48164		0,76474		0,48194	
	February	0,13		-0,65		-0,10		0,22		0,24	
	March	0,47		-0,45		-0,15		1,05		-0,97	
	April	-1,59		-1,92	+	-0,49		-0,49		-1,15	
	May	1,54		-0,04		1,42		0,20		0,54	
	June	1,97	*	-1,04		0,99		0,82		0,53	
	July	3,65	***	0,94		1,79	+	2,65	**	1,01	
	August	4,71	***	0,20		4,12	***	4,07	***	1,82	+
	September	3,35	***	-0,37		2,11	*	2,91	**	0,54	
	October	0,25		-0,02		1,27		1,43		1,96	+
	November	0,63		-0,91		-1,03		1,08		0,52	
	December	1,94	+	1,20		1,87	+	2,51	*	0,75	
Months		Ordu		Giresun		Trabzon		Rize		Artvin	
Minimum temperature	January	0,20955		0,19908		0,20946		0,25139		0,5863	
	February	0,36		-0,09		-0,50		-0,14		0,72	
	March	1,79	+	1,19		0,29		0,23		-0,17	
	April	0,32		0,08		-0,74		-0,61		-0,71	
	May	0,81		-0,03		-0,01		0,08		0,65	
	June	1,24		0,20		0,90		1,00		1,00	
	July	3,44	***	2,20	*	0,83		1,36		1,83	+
	August	4,58	***	3,60	***	4,03	***	3,87	***	3,30	***
	September	2,57	*	1,56		2,23	*	2,17	*	2,46	*
	October	3,23	**	2,12	*	1,82	+	2,89	**	2,27	*
	November	1,48		1,14		-0,15		0,23		0,36	
	December	1,14		0,91		1,05		0,52		0,61	

+: suspectable

\*: significant at the level of 5%

\*\* : significant at the level 1%

\*\*\*: significant at the level of 0.1

%

### Mann-Kendall test results

**Rainfall** series showed significant declining or rising trends across the region. Artvin station was found the trendiest series among the analyzed series. Similar result reported by Türkeş (1999)

that he analyzed and interpreted Turkey's rainfall series. Giresun and Rize stations have not any significant trend components for any months.

**Relative humidity** series showed downward trend in Ordu, Giresun and Artvin stations. Ordu station has significant downward trend components for all months except February and November months. In contrast to Ordu, Giresun and Artvin stations, trend direction was positive in Trabzon station where February, April and October months have significant trends.

**Mean temperature** series also indicated mostly positive trends for all months in the study area. It is remarkable that there were upward significant or suspicious trend components in June, July, August, September and October for all station across the region.

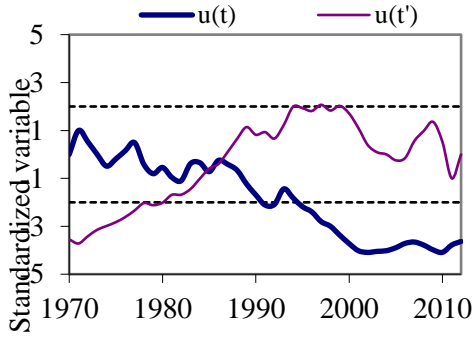
**Maximum temperature** series behaved a little bit differently from mean temperature series that there were no significant increasing or decreasing trend component in Giresun and Artvin stations. However, it was not go unnoticed that increasing significant trends was dominated in remaining station in some summer months.

**Minimum temperature** series gave similar result with mean temperature series that a positive increasing trends is predominant in summer and early fall seasons. There were no significant downward trend components in the series. Finding of this work is parallel to Türkeş et al (2002) that they reported increasing trends components in minimum temperature series.

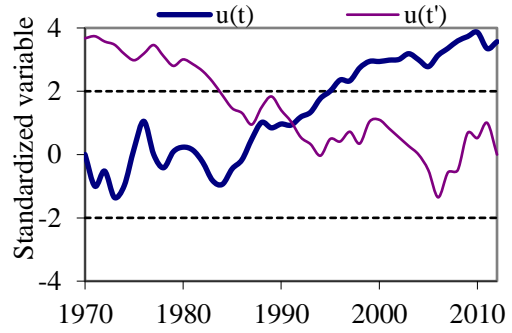
#### **Sequential Mann-Kendall test results**

Sequential Mann-Kendall test results were supported Mann-Kendall test results in most of the stations. SMK results indicated that rainfall series have not significant trend components in the analyzed stations (Fig. 1).

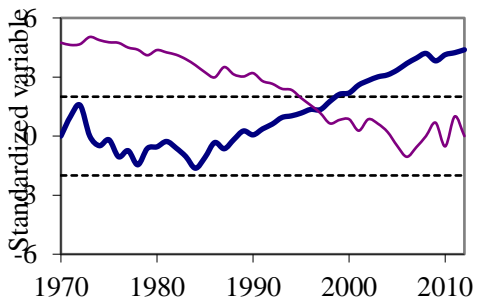
A significant upward trend was detected starting from 1990's in relative humidity series in Trabzon and Rize station. On the contrary, a significant declining trend was detected starting from 1990's and 2000's in Ordu and Artvin stations, respectively. Mean temperature series showed a rising trend behavior all stations starting from around 2000's. Similarly, maximum temperature series showed a significant upward starting from late 1990's or early 2000's in the station of Ordu, Trabzon and Rize. Again, an increasing trend stands out all stations starting from about 2000's.



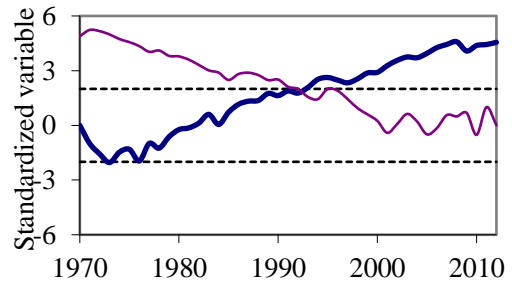
Relative humidity of Ordu station, May



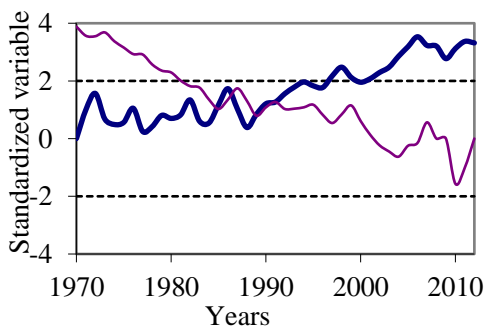
Relative humidity of Rize station, February



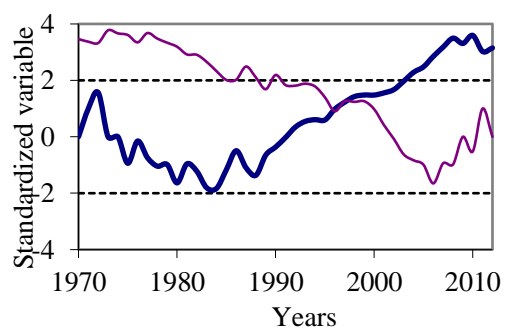
Mean temperature of Trabzon station, August



Maximum temperature of Ordu station, August



Minimum temperature of Giresun station, August



Minimum temperature of Artvin station, August

**Figure 1.** Sequential Mann-Kendall test results of climatic variables of Eastern Black Sea region, Turkey

#### **4. CONCLUSIONS**

Findings of this work indicated that there were significant upward trend components in the temperature series over the study area. In the region, a traditional rain-fed mono-culture hazelnut production takes place over the years. Since, irrigation practices strictly restricted in the region, modern irrigation techniques must apply to provide increasing plant water consumption. On the other hand, all station take place in the center of cities, a heat island Tayanç et al (1997); Tonkaz et al (2007) effect may accelerate increasing trend in the area especially in temperature series. Increasing temperature affects relative humidity negatively. Further studies or new rural meteorological stations establishment is needed to handle to solve this paradox.

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