

CLIMATE CHANGE: MONTHLY PATTERNS OF MINIMUM TEMPERATURES AND THEIR CHANGE

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Abstract:

Climate change, in other word global warming, is one of the most serious environmental, economic, and social threats that this world faces. A change in the Earth's surface temperature also leads to increase in extreme events as well as extreme temperatures. Climate is the average weather conditions experienced in a particular place over a long period. The standard averaging period is 30 years but other periods may be used depending on the purpose. Climate also includes statistics other than the average, such as the magnitudes of day-to-day, month to month or year-to-year variations. Temperature is analysed with its mean, maximum and minimum values as climate and meteorological aspects. And also temperature has got an oscillation depending on time scale. In this study, it is intend to analysis monthly distributions pattern of minimum temperatures. For this purpose daily minimum temperature values are used from eight stations data with periods of 1971 to 2015 from Turkish State Meteorological Service which are Sarıyer, Sinop, Rize, Aydın, Ankara, Kars, Anamur and Hakkari. Extreme values of minimum temperatures are determined for 1971 to 2015 period, 1971 to 2000 period and 1981 to 2010 period. To determine monthly distribution patterns, it is calculated daily anomalies for each periods according to monthly mean values of extreme minimum temperatures of 1981 and 2010 period. As a result, probability of occurring minimum temperature or maximum temperature in certain time interval in a month may show a pattern in month. Moreover, the pattern is compatible with folk calendar and also the pattern is inclined to change with increasing temperature trend due to climate change. The minimum temperatures have increased with a different number of days according to different months after 1981. These figures changes from 1 day in March to 25 days in August.

Keywords: Temperature, Maximum, Monthly pattern, Climate change, Folk calendar.

INTRODUCTION

Climate change, in other word global warming, is one of the most serious environmental, economic, and social threats that this world faces. There are many assessments to monitor climate and to estimate climate variability over many regions and also globally by national and international institutions. A change in the Earth's surface temperature also leads to increase in extreme events as well as extreme temperatures.

Climate is the average weather conditions experienced in a particular place over a long period. Climatological normals are averages for consecutive periods of 30 years which are calculated from climatological data (Demircan et al. 2013; Demircan et al., 2014 [a],[b],[c],[d], Demircan et al., 2017 [a], [b]). Using climate normals are very important tool to provide a standard base for preparing global assessment and climate monitoring studies. The reference period of Climate; 1961-1990, 1971-2000 and 1981-2010 as climate normals are used by scientists, national climate services and international institutions and organizations in international, national and regional-based climate monitoring, climate trends, climate change and climate modelling studies.

Climate also includes statistics other than the average, such as the magnitudes of day-to-day, month to month or year-to-year variations. Temperature is one of the climate parameters and is most interested by the public and the sectors. The temperature is related to the solar energy which, in turn, is absorbed by the Earth's surface and heats the Earth's surface and then the Earth emits it as long wave radiation through the atmosphere into space and determines the climate and weather of the Earth. Greenhouse gases absorbs long wave radiation, thereby trapping and holding heat in the atmosphere. As a result of this, global temperature increases while amount of greenhouse gases increase. Temperature change occurs depending on the factors such as The Earth's rotation around its own axis and Sun, sun radiation and duration, latitude, altitude, distance to water sources, vegetation cover. At the same

time it is a continuous climate parameter on the topography. Temperature is analysed with its mean, maximum and minimum values as climate and meteorological aspects. And also temperature has got an oscillation depending on time scale.

DATA AND METHODS

Daily minimum temperature values are used from eight stations data with periods of 1971 to 2015 from Turkish State Meteorological Service which are Saryyer, Sinop, Rize, Aydın, Ankara, Kars, Anamur and Hakkari. Stations are selected as surrounding the Turkey and also according to direction of air masses which are entering to the Turkey. Extreme values of minimum temperatures are determined for 1971 to 2015 period, 1971 to 2000 period and 1981 to 2010 period from station’s daily minimum temperatures data. Monthly mean minimum temperatures are calculated from extreme minimum temperatures of 1981-2010 period. Differences are calculated between daily extreme minimum temperatures of 1971-2000, 1981-2010 and 1971-2015 periods and monthly mean minimum temperatures of 1981-2010 period. Difference graphics are prepared per every months and every stations (Fig.1). Monthly distribution patterns are determined from difference values of 1971-2000 period. Changing in minimum temperatures are determined by comparing of difference values of 1971-2000 period and difference values of other two periods.

APPLICATION AND RESULTS

If the difference values are negative it is accepted as cold and if they are positive accepted as warm. Difference graphics show a pattern that some weeks are cold and some weeks are warm for the 1971-2000, 1981-2000 and 1971-2015 periods as summary (Fig.1). In generally difference values are equal for all periods. For this reason we can expect to occur a heatwave or cold wave according to warm or cold periods of the month as a probabilistic method. By the way, in some days values of 1981-2010 and 1971-2015 periods are bigger or smaller than 1971-2000 period’s values which shows changing in climate.

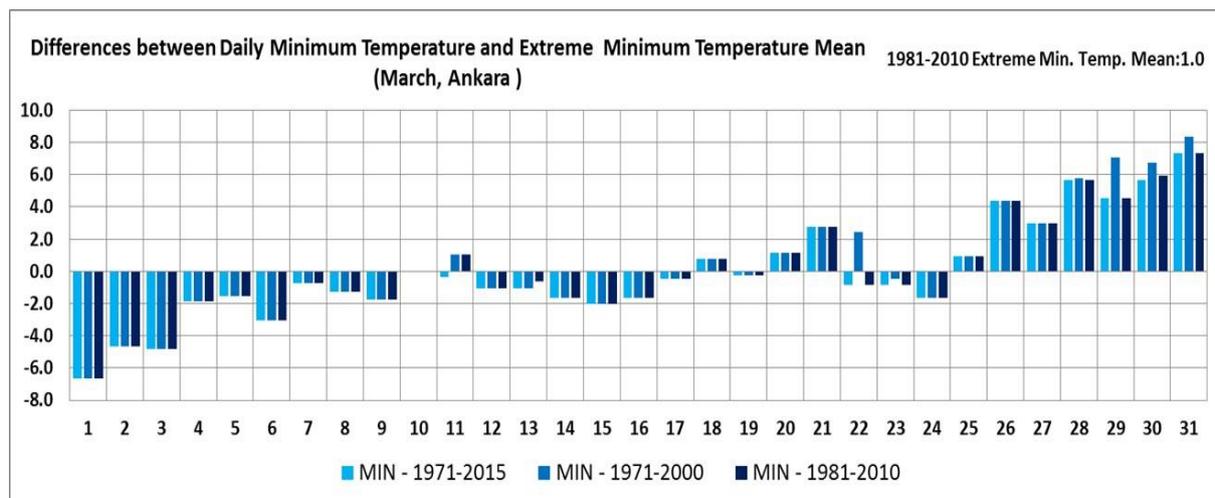


Figure 1. Differences between daily minimum temperature and extreme minimum temperature mean

We are using data sets and graphics and preparing a summary figure (Fig.3) to show monthly pattern and its change in all stations and months together. In this manner, regional and temporal compatibility could easily be seen. In the figure, daily minimum temperatures pattern according to 1971-2000 period are shown as red for warm differences and blue for cold differences. Change in pattern according to 1981-2010 and 1971-2015 periods are shown with figures (▲) for increase and (▼) for decrease. In here increasing's meaning is daily extreme minimum temperature is higher than 1971-2000 period’s value, in other term is warmer than 1971-2000 period’s value and decreasing's meaning is vice versa. The number of increasing, decreasing and no changing days are showed in tables 1 to 12 for each month. The maximum, mean and minimum differences values from mean of 1981-2010 daily extreme minimum temperature are also showed for three periods. Minimum difference value is indicated bottom point of pattern and maximum difference value is indicated top point of pattern. Mean difference value is indicate mean of daily difference values of month.

Daily extreme minimum temperatures were increased 9 to 16 days and decreased 1 to 11 days in January according to stations (Table 1; Fig. 2). The most increase is seen in two stations which are Ankara and Kars. While minimum difference between monthly mean and daily minimum temperature was -7.8°C in 1971-2000 period, it was

increased to -5.5°C in 1981-2010 period in Ankara. In generally it is about 0.5 to 2°C increase in all stations in January is assumed one of the colder months.

Table 1. Daily extra minimum temperatures changes in January.

Stations	Months	Increasing	Decreasing	No changing	1971-2015			1971-2000			1981-2010		
					Differences from Mean of			1981-2010 Daily Extreme			Temperatures (MDET)		
					Maks.	Min.	Mean	Maks.	Min.	Mean	Maks.	Min.	MDET
SARIYER	January	10	11	10	1.7	-6.9	-1.0	2.3	-6.9	-0.4	3.1	-3.9	-2.9
SINOP		11	8	12	2.1	-3.2	-0.8	2.1	-3.2	-0.5	2.1	-3.2	-1.3
RIZE		11	9	11	1.2	-3.6	-0.8	1.8	-3.6	-0.4	1.6	-2.8	-1.8
AYDIN		9	11	11	1.2	-3.4	-0.9	1.6	-3.4	-0.5	2.0	-2.2	-2.6
ANKARA		16	5	10	2.4	-7.8	-2.0	2.4	-7.8	-1.6	3.4	-5.5	-13.4
KARS		16	5	10	1.9	-8.4	-1.8	2.2	-8.4	-1.5	4.0	-3.6	-28.2
ANAMUR		11	1	19	1.0	-2.0	-0.3	2.0	-2.0	-0.3	1.6	-2.0	2.9
HAKKARI		12	8	11	2.4	-5.5	-0.6	2.8	-3.5	-0.2	2.8	-5.5	-17.9

Daily extreme minimum temperatures were increased 3 to 19 days and decreased 4 to 7 days in February according to stations (Table 2; Fig. 2). The most increase is seen in Kars. While minimum difference between monthly mean and daily minimum temperature was -5.8°C in 1971-2000 period, it was increased to -4.9°C in 1981-2010 period in Kars. Minimum difference values are equal for 1971-2000 and 1981-2010 periods due to cold wave occurred in 1985 between 19 to 23 February in Saryyer, Sinop, Aydin, Ankara, Anamur and in 1984 between 17 to 28 February in Rize and in 1997 between 6 to 11 February in Hakkari.

Table 2. Daily extra minimum temperatures changes in February.

Stations	Months	Increasing	Decreasing	No changing	1971-2015			1971-2000			1981-2010		
					Differences from Mean of			1981-2010 Daily Extreme			Temperatures (MDET)		
					Maks.	Min.	Mean	Maks.	Min.	Mean	Maks.	Min.	MDET
SARIYER	February	6	5	20	1.7	-4.1	-0.4	2.4	-4.1	0.0	3.0	-4.1	-4.3
SINOP		6	4	21	2.0	-4.6	-0.5	2.0	-4.6	-0.3	2.7	-4.6	-2.9
RIZE		3	4	24	2.6	-3.6	-0.3	3.2	-3.6	0.0	2.6	-3.6	-2.8
AYDIN		4	4	23	1.8	-1.8	-0.3	1.9	-1.8	0.0	1.8	-1.8	-3.4
ANKARA		12	5	14	4.6	-7.6	-1.3	5.9	-7.6	-0.9	4.6	-7.6	-13.9
KARS		19	0	12	2.1	-5.8	-2.5	2.1	-5.8	-2.5	3.3	-4.9	-27.3
ANAMUR		3	7	21	1.8	-2.6	-0.2	2.6	-2.6	0.0	2.0	-2.6	1.8
HAKKARI		6	4	21	3.5	-4.8	-0.4	5.3	-4.8	-0.2	4.8	-4.8	-17.9

Daily extreme minimum temperatures were increased 1 to 6 days and decreased 4 to 13 days in March according to stations (Table 3; Fig. 2). The most increase is seen in Kars. While minimum difference between monthly mean and daily minimum temperature was -7.4°C in 1971-2000 period, it was increased to -6.4°C in 1981-2010 period in Kars. Minimum difference values are equal for 1971-2000 and 1981-2010 periods due to cold wave occurred in 1985 between 1 and 13 March in generally.

Table 3. Daily extra minimum temperatures changes in March.

Stations	Months	Increasing	Decreasing	No changing	1971-2015			1971-2000			1981-2010		
					Differences from Mean of			1981-2010 Daily Extreme			Temperatures (MDET)		
					Maks.	Min.	Mean	Maks.	Min.	Mean	Maks.	Min.	MDET
SARIYER	March	3	10	18	3.0	-4.0	-0.1	5.0	-4.0	0.3	3.0	-4.0	-1.8
SINOP		2	7	22	3.1	-4.4	-0.1	4.0	-4.4	0.2	4.2	-4.4	-0.4
RIZE		0	13	18	2.2	-4.3	-0.1	4.0	-4.3	0.4	2.5	-4.3	-1.8
AYDIN		6	6	19	3.7	-4.4	-0.3	4.8	-4.4	-0.1	4.4	-4.4	-0.6
ANKARA		1	7	23	7.4	-6.6	-0.1	8.4	-6.6	0.2	7.4	-6.6	1.0
KARS		5	4	22	7.3	-7.4	-0.5	13.6	-7.4	0.5	8.8	-6.4	-22.8
ANAMUR		3	4	24	3.4	-2.5	-0.1	3.4	-2.5	0.0	3.4	-2.5	4.5
HAKKARI		1	5	25	5.2	-7.0	0.0	6.0	-7.0	0.3	5.2	-7.0	-12.0

Daily extreme minimum temperatures were increased 2 to 10 days and decreased 4 to 12 days in April according to stations (Table 4; Fig. 2). The most increase is seen in Anamur. While minimum difference between monthly mean and daily minimum temperature was -1.7 , -2.4 , -5.7 , -5.1 and -3.9°C in 1971-2000 period, it was decreased to -2.3 , -5.4 , -6.8 , -10.3 and -5.7°C in 1981-2010 period in Saryyer, Rize Ankara, Kars and Hakkari, respectively. Minimum difference values decrease in these stations due to cold wave in first week of April in 2003. The results suggest that there could be a cooling trend for April.

Table 4. Daily extra minimum temperatures changes in April.

Stations	Months	Increasing	Decreasing	No changing	1971-2015			1971-2000			1981-2010		
					Differences from Mean of			1981-2010 Daily Extreme			Temperatures (MDET)		
					Maks.	Min.	Mean	Maks.	Min.	Mean	Maks.	Min.	MDET
SARIYER	April	3	6	22	2.4	-2.3	-0.2	2.4	-1.7	0.1	2.6	-2.3	2.4
SINOP		2	7	22	2.5	-3.0	-0.2	2.5	-3.0	0.2	2.5	-3.0	3.5
RIZE		7	9	15	2.2	-5.4	-0.4	3.2	-2.4	0.0	2.2	-5.4	2.6
AYDIN		8	4	19	2.6	-4.4	-0.4	2.6	-4.4	-0.2	3.4	-4.4	3.6
ANKARA		8	5	18	4.9	-6.8	-0.5	4.9	-5.7	-0.2	4.9	-6.8	8.4
KARS		6	12	13	3.8	-10.3	-0.9	4.1	-5.1	0.0	5.0	-10.3	-8.1
ANAMUR		10	0	21	2.3	-4.3	-0.4	2.3	-4.3	-0.4	2.7	-4.3	7.9
HAKKARI		7	8	16	3.8	-5.7	-0.4	4.4	-3.9	0.0	5.2	-5.7	-2.4

Daily extreme minimum temperatures were increased 1 to 8 days and decreased 4 to 9 days in May according to stations (Table 5; Fig. 2). The most increase is seen in Hakkari. The results suggest that there could be a cooling trend for May.

Table 5. Daily extra minimum temperatures changes in May.

Stations	Months	Increasing	Decreasing	No changing	1971-2015			1971-2000			1981-2010		
					Differences from Mean of 1981-2010 Daily Extreme Temperatures (MDET)								
					Maks.	Min.	Mean	Maks.	Min.	Mean	Maks.	Min.	MDET
SARIYER	May	7	5	19	3.0	-4.6	-0.3	3.0	-4.6	-0.2	3.0	-4.6	7.6
SINOP		2	4	25	3.2	-9.3	-0.6	3.2	-3.8	-0.2	3.2	-3.8	8.6
RIZE		5	5	21	3.5	-8.8	-0.6	3.5	-3.9	-0.1	3.7	-3.9	8.1
AYDIN		1	4	26	2.0	-4.0	-0.2	2.6	-4.0	-0.1	2.0	-4.0	8.6
ANKARA		3	4	24	4.7	-7.4	-0.1	4.7	-7.4	0.0	4.7	-7.4	12.6
KARS		5	9	17	2.8	-3.7	-0.4	5.3	-3.7	0.3	3.5	-3.7	-2.3
ANAMUR		7	4	20	3.0	-3.2	-0.4	3.0	-3.2	-0.3	3.0	-3.2	11.8
HAKKARI		8	7	16	4.3	-4.1	-0.4	4.3	-4.1	-0.1	5.3	-4.1	3.7

Daily extreme minimum temperatures were increased 5 to 19 days and decreased 1 to 7 days in June according to stations (Table 6; Fig. 2). The most increase is seen in Anamur. While minimum difference between monthly mean and daily minimum temperature was -4.4, -2.8, -4.5 and -3.7°C in 1971-2000 period, it was increased to -2.6, -2.5, -3.0 and -2.8°C in 1981-2010 period in Sinop, Rize, Anamur and Hakkari, respectively.

Table 6. Daily extra minimum temperatures changes in June.

Stations	Months	Increasing	Decreasing	No changing	1971-2015			1971-2000			1981-2010		
					Differences from Mean of 1981-2010 Daily Extreme Temperatures (MDET)								
					Maks.	Min.	Mean	Maks.	Min.	Mean	Maks.	Min.	MDET
SARIYER	June	11	5	15	2.5	-4.0	-0.5	2.9	-4.0	-0.4	2.5	-4.0	12.5
SINOP		11	1	19	1.6	-4.4	-0.5	1.6	-4.4	-0.5	3.2	-2.6	13.2
RIZE		9	6	16	2.1	-2.8	-0.4	2.5	-2.8	-0.2	2.3	-2.5	12.5
AYDIN		5	2	24	2.1	-5.3	-0.3	2.2	-5.3	-0.3	2.2	-5.3	13.7
ANKARA		6	4	21	3.2	-4.4	-0.1	3.8	-4.4	0.1	5.5	-4.4	8.4
KARS		12	7	12	2.8	-4.2	-0.5	2.8	-4.2	-0.2	2.8	-4.2	1.4
ANAMUR		19	0	12	2.0	-4.5	-1.1	2.0	-4.5	-1.1	2.5	-3.0	16.7
HAKKARI		12	3	16	3.3	-3.7	-0.6	3.3	-3.7	-0.5	3.3	-2.8	9.1

Daily extreme minimum temperatures were increased 6 to 21 days and decreased 1 to 9 days in July according to stations (Table 7; Fig. 2). The most increase is seen in Anamur. While minimum difference between monthly mean and daily minimum temperature was -2.3, -2.8, and -3.2°C in 1971-2000 period, it was increased to -2.2, -2.6, and -2.5°C in 1981-2010 period in Sinop, Aydin and Anamur, respectively. It was decreased -2.8 and -2.0°C to -3.4 and -3.6°C in Kars and Hakkari, respectively.

Table 7. Daily extra minimum temperatures changes in July.

Stations	Months	Increasing	Decreasing	No changing	1971-2015			1971-2000			1981-2010		
					Differences from Mean of 1981-2010 Daily Extreme Temperatures (MDET)								
					Maks.	Min.	Mean	Maks.	Min.	Mean	Maks.	Min.	MDET
SARIYER	July	13	3	15	1.4	-3.2	-0.5	1.4	-3.2	-0.5	2.8	-3.2	15.2
SINOP		8	1	22	1.7	-2.3	-0.3	1.7	-2.3	-0.3	2.1	-2.2	15.9
RIZE		11	1	19	1.3	-3.7	-0.6	1.3	-3.7	-0.6	2.9	-3.7	15.7
AYDIN		11	3	17	1.8	-2.8	-0.7	2.0	-2.8	-0.5	2.6	-2.6	16.2
ANKARA		6	4	21	2.7	-4.0	-0.3	2.8	-4.0	0.0	3.4	-4.0	22.2
KARS		14	9	8	3.4	-3.4	-0.6	3.6	-2.8	-0.3	3.5	-3.4	4.6
ANAMUR		21	0	10	0.8	-3.2	-0.9	0.8	-3.2	-0.9	1.6	-2.5	19.4
HAKKARI		8	7	16	1.9	-3.6	-0.3	2.2	-2.0	-0.2	2.4	-3.6	13.6

Daily extreme minimum temperatures were increased 3 to 25 days and decreased 1 to 8 days in August according to stations (Table 8; Fig. 2). The most increase is seen in Anamur. While minimum difference between monthly mean and daily minimum temperature was -2.0, -2.7, and -3.7°C in 1971-2000 period, it was increased to -1.7, -2.1, and -2.0°C in 1981-2010 period in Sinop, Aydin and Anamur, respectively.

Table 8. Daily extra minimum temperatures changes in August.

Stations	Months	Increasing	Decreasing	No changing	1971-2015			1971-2000			1981-2010		
					Differences from Mean of 1981-2010 Daily Extreme Temperatures (MDET)								
					Maks.	Min.	Mean	Maks.	Min.	Mean	Maks.	Min.	MDET
SARIYER	August	13	1	17	1.2	-3.0	-0.7	1.2	-3.0	-0.6	2.8	-3.0	15.8
SINOP		10	4	17	1.3	-2.3	-0.3	1.5	-2.0	-0.2	1.3	-1.7	16.5
RIZE		8	3	20	1.0	-2.0	-0.2	1.6	-2.0	-0.2	1.9	-2.0	15.8
AYDIN		15	2	14	1.2	-2.7	-0.7	1.2	-2.7	-0.6	2.1	-2.1	16.4
ANKARA		10	0	21	3.1	-3.9	-0.4	3.1	-3.9	-0.4	3.1	-3.9	22.9
KARS		9	8	14	1.8	-2.7	-0.4	2.7	-2.7	0.0	3.7	-2.7	4.3
ANAMUR		25	1	5	0.9	-3.7	-1.6	0.9	-3.7	-1.6	2.0	-2.0	19.5
HAKKARI		3	4	24	2.9	-3.4	-0.2	2.9	-3.4	0.0	2.9	-3.4	13.1

Daily extreme minimum temperatures were increased 3 to 19 days and decreased 2 to 11 days in September according to stations (Table 9; Fig. 2). The most increase is seen in Anamur. While minimum difference between monthly mean and daily minimum temperature was -2.8, -6.3 and -4.3°C in 1971-2000 period, it was increased to

-2.2, -3.5, and -2.3°C in 1981-2010 period in Aydın, Ankara and Anamur, respectively. It was decreased -3.5°C to -3.9°C in Kars.

Table 9. Daily extra minimum temperatures changes in September.

Stations	Months	Increasing	Decreasing	No changing	1971-2015			1971-2000			1981-2010		
					Differences from Mean of 1981-2010 Daily Extreme Temperatures (MDET)			Differences from Mean of 1981-2010 Daily Extreme Temperatures (MDET)			Differences from Mean of 1981-2010 Daily Extreme Temperatures (MDET)		
					Maks.	Min.	Mean	Maks.	Min.	Mean	Maks.	Min.	MDET
SARIYER	September	9	7	15	2.5	-4.8	-0.5	2.8	-2.4	-0.2	2.5	-2.4	11.9
SINOP		7	8	16	2.9	-5.0	-0.4	3.5	-5.0	-0.1	3.1	-5.0	12.7
RIZE		7	2	22	3.9	-3.2	-0.1	3.9	-3.2	-0.1	3.9	-3.2	12.4
AYDIN		14	4	13	2.5	-4.2	-0.8	2.5	-2.8	-0.6	2.8	-2.2	11.8
ANKARA		5	11	15	3.7	-6.7	-0.4	4.7	-6.3	0.1	3.7	-3.5	8.4
KARS		3	10	18	5.4	-3.9	-0.4	5.4	-3.5	0.0	5.4	-3.9	-0.3
ANAMUR		19	4	8	1.6	-4.3	-1.1	1.6	-4.3	-1.0	2.3	-2.3	16.9
HAKKARI		8	3	20	4.8	-4.5	-0.4	4.8	-4.5	-0.3	5.0	-4.5	8.8

Daily extreme minimum temperatures were increased 1 to 15 days and decreased 2 to 11 days in October according to stations (Table 10; Fig. 2). The most increase is seen in Sinop. While minimum difference between monthly mean and daily minimum temperature was -4.4, -9.5 and -4.9°C in 1971-2000 period, it was increased to -4.0, -3.7, and -4.7°C in 1981-2010 period in Saryyer, Kars and Anamur, respectively. It was decreased -3.8°C to -4.0 °C in Sinop.

Table 10. Daily extra minimum temperatures changes in October.

Stations	Months	Increasing	Decreasing	No changing	1971-2015			1971-2000			1981-2010		
					Differences from Mean of 1981-2010 Daily Extreme Temperatures (MDET)			Differences from Mean of 1981-2010 Daily Extreme Temperatures (MDET)			Differences from Mean of 1981-2010 Daily Extreme Temperatures (MDET)		
					Maks.	Min.	Mean	Maks.	Min.	Mean	Maks.	Min.	MDET
SARIYER	October	8	17	6	2.2	-4.4	-1.5	2.3	-4.4	-0.7	3.2	-4.0	7.8
SINOP		15	8	8	2.0	-4.4	-1.2	2.2	-3.8	-0.8	2.0	-4.4	8.6
RIZE		12	8	11	1.8	-4.7	-1.0	2.5	-4.7	-0.8	2.9	-4.7	7.9
AYDIN		8	8	15	2.3	-4.7	-1.1	3.1	-4.7	-0.7	4.4	-4.7	6.7
ANKARA		7	9	15	3.9	-5.6	-0.9	5.4	-5.6	-0.1	5.4	-5.6	10.8
KARS		14	3	14	3.3	-9.5	-1.5	3.3	-9.5	-1.5	3.7	-3.7	-6.3
ANAMUR		15	10	6	1.4	-4.9	-1.4	1.6	-4.9	-1.0	1.7	-4.7	13.1
HAKKARI		1	6	24	3.6	-4.9	-0.1	4.6	-4.9	0.1	4.6	-4.9	1.8

Daily extreme minimum temperatures were increased 3 to 9 days and decreased 4 to 7 days in November according to stations (Table 11; Fig. 2). The most increase is seen in Hakkari. While minimum difference between monthly mean and daily minimum temperature was -5.4°C in 1971-2000 period, it was increased to -5.2°C in 1981-2010 period in Ankara. It was decreased -1.8°C to -2.0 °C in Rize.

Table 11. Daily extra minimum temperatures changes in November.

Stations	Months	Increasing	Decreasing	No changing	1971-2015			1971-2000			1981-2010		
					Differences from Mean of 1981-2010 Daily Extreme Temperatures (MDET)			Differences from Mean of 1981-2010 Daily Extreme Temperatures (MDET)			Differences from Mean of 1981-2010 Daily Extreme Temperatures (MDET)		
					Maks.	Min.	Mean	Maks.	Min.	Mean	Maks.	Min.	MDET
SARIYER	November	6	6	19	2.2	-2.8	-0.4	3.3	-2.8	0.0	4.4	-2.8	1.4
SINOP		4	7	20	2.2	-3.1	-0.3	2.3	-3.1	-0.2	4.7	-3.1	2.7
RIZE		7	6	18	2.3	-2.0	-0.2	2.3	-1.8	0.0	3.4	-2.0	2.4
AYDIN		5	5	21	4.4	-2.4	-0.3	4.6	-2.4	0.0	4.4	-2.4	0.4
ANKARA		3	6	22	3.3	-5.4	-0.4	4.0	-5.4	-0.2	4.4	-5.2	2.2
KARS		8	6	17	5.9	-13.1	-2.2	7.1	-13.1	-1.5	9.1	-13.1	-16.3
ANAMUR		7	4	20	2.7	-5.0	-0.4	3.7	-5.0	-0.2	3.3	-5.0	7.3
HAKKARI		9	5	17	6.6	-7.4	-0.4	6.6	-7.4	-0.1	6.6	-7.4	-7.6

Daily extreme minimum temperatures were increased 1 to 9 days and decreased 5 to 17 days in December according to stations (Table 12; Fig. 2). The most increase is seen in Ankara. While minimum difference between monthly mean and daily minimum temperature was -1.8°C in 1971-2000 period, it was increased to -1.9°C in 1981-2010 period in Aydın. It was decreased -2.6 and -4.5°C to -3.4 and -5.1°C in Rize and Kars, respectively. The results suggest that there could be a cooling trend for December.

Table 12. Daily extra minimum temperatures changes in December.

Stations	Months	Increasing	Decreasing	No changing	1971-2015			1971-2000			1981-2010		
					Differences from Mean of 1981-2010 Daily Extreme Temperatures (MDET)			Differences from Mean of 1981-2010 Daily Extreme Temperatures (MDET)			Differences from Mean of 1981-2010 Daily Extreme Temperatures (MDET)		
					Maks.	Min.	Mean	Maks.	Min.	Mean	Maks.	Min.	MDET
SARIYER	December	7	9	15	1.7	-2.8	-0.4	1.7	-2.8	-0.1	2.4	-2.8	-1.0
SINOP		3	17	11	1.3	-2.5	-0.2	2.7	-2.5	0.6	2.3	-2.5	0.3
RIZE		1	12	18	2.2	-3.4	-0.2	2.6	-2.6	0.1	2.6	-3.4	-0.6
AYDIN		4	6	21	1.7	-1.9	-0.2	1.7	-1.8	0.0	1.9	-1.9	-1.9
ANKARA		9	11	11	2.1	-5.5	-0.9	2.1	-3.6	-0.5	5.1	-3.6	-1.5
KARS		4	12	15	6.9	-5.1	-0.3	6.9	-4.5	0.5	6.9	-5.1	-25.3
ANAMUR		6	5	20	2.2	-3.3	-0.5	2.2	-3.3	-0.3	2.2	-3.3	4.5
HAKKARI		5	9	17	5.5	-5.3	-0.5	5.5	-5.3	-0.1	5.5	-5.3	-16.0

Extreme minimum temperatures were increased 9 to 16 days in January, 3-19 days in February, 1 to 6 days in March, 2 to 10 days in April, 1 to 8 days in May, 5 to 19 days in June, 8 to 21 in July, 3 to 25 days in August, in 3 to 19 days in September, 1 to 15 days in October, 3 to 9 days in November and 1 to 9 days in December since the year 1981. Extreme minimum temperatures were decreased 1 to 11 days in January, 0-7 days in February, 4 to 13

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days in March, 0 to 12 days in April, 4 to 9 days in May, 0 to 7 days in June, 0 to 9 in July, 0 to 8 days in August, in 2 to 11 days in September, 3 to 17 days in October, 4 to 7 days in November and 5 to 17 days in December since the year 1981.

CONCLUSIONS AND RECOMMENDATIONS

We've investigate daily extreme minimum temperature for its pattern and change with 8 stations which are located east to west and south to north in Turkey. Daily distribution of daily extreme minimum temperatures in a month shows a pattern which reflects warm and cold periods. Moreover, in generally stations monthly patterns are very similarly even though they are located in different geography. Additionally, this monthly pattern, warm and cold days, are generally compatible with public calendar which is familiar for Turkish people and based on long time public experience and knowledge on climate.

Demircan et al. (2017) concluded that extreme maximum temperatures shows a pattern in month and also this pattern shows probability of occurring maximum temperature in certain time interval in a month. Moreover, the pattern is compatible with folk calendar and also the pattern is inclined to change with increasing temperature trend due to climate change. They found an increase in daily extreme temperature about 12-23 days and a decrease about 1-6 days in all months. Furthermore monthly patterns are compatible with occurring heatwaves in 2015 and February 2016.

Extreme minimum temperatures are increased about 1 to 25 days and decreasing 1 to 17 days in months. Number of increasing days are more than decreasing days. Respectively, station's mean increasing and decreasing days are 12 and 7 in January, 7 and 4 days in February, 3 and 7 in March, 6 and 6 in April, 4 and 5 in May, 10 and 3 in June, 11 and 3 in July, 11 and 3 in August, 9 to 6 in September, 10 and 8 in October, 6 and 6 in November and 4 to 10 in December. The results suggest that there is a changing temperature pattern of months. While January, February, July, August, September and October are warming, March, April, May, June and December are cooling. This suggests needs to deeply researches on changing trends of these months separately. On the other hand these changing are signals of the new pattern. It is assumed that until new patterns are occurred by climate change, numbers and severity of extreme events are also increased rather than our familiar climate conditions.

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