Recent Changes of the Diurnal Temperature Extremes in Jordan

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Abstract

The monthly mean minimum and maximum temperatures in the period 1961-1996 were analyzed at six stations located in the main geographical regions of Jordan. It is found that the seasonal mean of maximum temperatures decreased in all seasons at all stations, with most noticeable at Aqaba, Ruwashed, and Amman. The seasonal mean of minimum temperatures increased in all seasons except winter in Deir Alla, Amman, Irbid, and Ruwashed, which are located in the northern part of Jordan; while decreased at Aqaba and Ma'an in all seasons except spring. The annual mean temperature decreased at all stations except Amman, where urbanization and industrialization in the area enhance the greenhouse effect by raising the nighttime temperatures.

Introduction

Clouds, aerosols, and the pollution of greenhouse gases (mainlyCarbon Dioxide) in the atmosphere slow down the escape of the terrestrial long-wave radiation to space. This effect is mostly noticeable at night because of the low heat capacity of the land and the absence of the solar radiation. This may cause the increase of diurnal minimum temperature, and then decreases the diurnal temperature range. Changes of the maximum temperature also are influenced by many factors affecting the sunshine duration such as pollution, water vapor and cloud cover. It has been noticed that the global average temperature has risen by about 0.5 ^{o}C in the last 100 years. Scientists believe that this warming is due to the increasing Carbon Dioxide concentration in the atmosphere, urbanization, and natural causes (Lindzen, 1990 and Linacre, 1992).

This paper is concerned with examining the changes of daily minimum (nighttime) versus the daily maximum (daytime) temperatures in Jordan, which affect the daily temperature range (maximum-minimum). This can narrow the possible causes of temperature change and help in estimating its impact on society.

Data and Methodology:

Monthly mean minimum and maximum temperatures at six stations were selected because all of them have data span from 1961 to 1996. This period of record chosen for the analysis were selected so that at least two stations would be located in the main geographical regions of Jordan, and there would be no missing observations in the database (Table 1 and Fig.1). All data were obtained from the Meteorological Department of Jordan.

Seasonal averages of maximum and minimum temperatures and the range were computed for all stations. The seasonal changes of temperatures are represented by linear trends expressed in/^{o}C. The change of the annual mean of minimum and maximum temperatures, weighted 9-point binomial filter, and linear trends are shown in graphs. Correlations between the seasonal temperature range and the diurnal extremes were computed; and standard tests of statistical significance were performed on all results.

Results and Discussion:

The temperature in Jordan varies seasonally and spatially due to the differences of geographical characteristics in the country. Table 2 shows the seasonal means of maxima, minima and the temperature ranges in 6 stations distributed in the three distinguished regions of Jordan. In the Rift Vally region, the average temperature is 24.1. ^{o}C in Aqaba and 23.6 ^{o}C in Deir Alla. In Aqaba, the mean maxima fluctuate between 21.3 C degrees in winter and 38.8 ^{o}C in summer, while the mean minima fluctuate between 9.6 ^{o}C in winter and 24.4 ^{o}C in summer

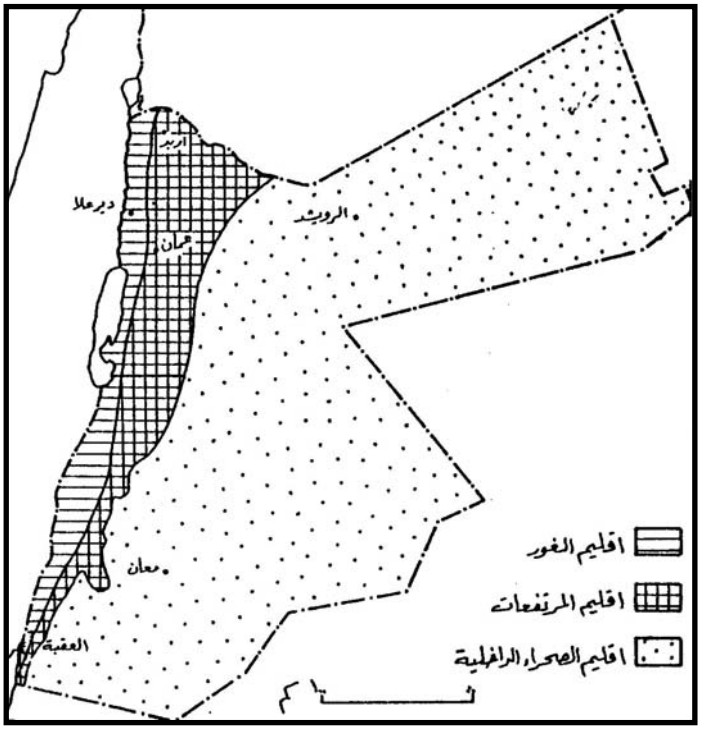
Table 1

Elevation and location of the stations selected for the analysis

Station	Latitude(N)		Longitude(E)		Elevation(m)	Regional Location
Deir Alla	32^{o}	13`	35^{o}	37`	-224	Rift Valley
Aqaba	29^{o}	33`	35^{o}	00`	51	Rift Valley
Amman	31^{o}	59`	35^{o}	59`	766	Eastern Hills
Irbid	32^{o}	33`	35^{o}	51`	616	Eastern Hills
Ruwashed	32^{o}	30`	38^{o}	12`	683	Desert
Ma’an	30^{o}	10`	35^{o}	47`	1069	Desert

From: Meteorological Department of Jordan

Fig. 1: The geographical distribution of stations and regions in



Jordan

Table 2

The mean seasonal of maximm, minimum, range, and the coefficient of variations (second line) from 1961 to 1996

	Deir Alla	Aqaba	Amman	Irbid	Ruwashed	Ma'an
Max: summer	38.1 1.6	38.8 2.1	31.5 3.5	30.6 3.3	36.5 2.7	33.5 2.4
Autumn	32 2.6	32 3.1	25.7 4.4	25.4 3.2	28.1 3.9	26.6 3.7
Winter	19.6 5.6	21.3 5.3	13.2 9.9	13.7 8.8	14.9 10.2	14.6 9.4
Spring	28.7 3.3	30.3 2.5	22.3 4.6	21.8 4.5	25.5 3.9	23.9 4.1
Min: summer	23 2.3	24.4 2.2	17.8 4.7	18.6 2.6	19 3.4	16.6 4.8
Autumn	20.2 3.9	19.3 3.7	12.7 7.9	14.3 4.8	12.6 6.5	11.3 7.3
Winter	11.2 6.7	9.6 7.9	3.9 23.9	5.3 17.3	2.9 32.9	2.4 37.9
Spring	15.4 4.9	16.7 4.3	9.4 11.4	10.5 8.5	10.6 6.9	9.3 9.1
Rang: summer	15.1 5.2	14.4 3.9	13.8 9.7	12 7.7	17.5 5.6	16.9 3.1
Autumn	11.9 7.5	12.7 5.1	13 11.4	11.2 8.3	15.5 7.7	15.3 4.6
Winter	8.4 9.5	11.7 5.7	9.3 12.6	8.4 9.1	12 8.1	12.2 6.6
Spring	13.3 7.1	13.6 4.8	12.8 10.3	11.4 8.3	14.8 7.1	14.7 4.5

Summer: Jun, Jul, Aug; Autumn: Sep, Oct, Nov;
Winter: Dec, Jan, Feb; Spring: Mar, Apr, May;

In the Eastern Hills region the mean temperature is 17.1 ^{o}C in Amman, and 17.6 ^{o}C in Irbid. In Amman, the mean maxima fluctuate between 13.2 ^{o}C in winter to 31.5 ^{o}C in summer, while the mean minima fluctuate from 3.9 ^{o}C in winter to 17.8 ^{o}C in summer. The Derest region has a continental climate with a wide range of temperature, ranges are higher than that of the other two regions. In summer, the mean maxima rise up to 36.5 ^{o}C in Ruwashed and 33.5 ^{o}C in Ma'an, with mean minima of 19 ^{o}C and 16.6 ^{o}C in Ruwashed and Ma'an, respectively.

The variability of the mean minimum temperatures are larger than that of the mean maximum temperatures. The coefficient of variation of the mean minima in winter is 23.9 in Amman, 37.9 in Ma'an, and 32.9 in Ruwashed, while it is 9.9, 9.4, and 10.2 for the mean maxima in the same stations, receptively.

Results of the analysis are shown also in table 3 and fig.2, over the study period 1961-1993 the mean maximum temperatures decreased in all seasons at all stations, with most noticeable and significant in Aqaba, Amman, and Ruwashed; the changes are less significant in Ma'an and Deir Alla. This probably attributed to the decrease of irradiance due to the increase of cloud cover and precipitation (Shehadeh, 1990).

The mean minimum temperatures increased in all seasons except in winter at Deir Alla, Amman, Irbid, and Ruwashed; all of these stations are located in the northern part of the country which are affected mostly by the cold air masses during winter.

Table 3

Linear trends of the mean seasonal temperatures in ^{o}C percent over the period 1961-1996

	Deir Alla	Aqaba	Amman	Irbid	Ruwashed	Ma'an
Max: winter	-4.3b	-6.9a	-6.1a	-4.3b	-7.1a	-4.3c
Spring	-0.5	-1.9	-3.5b	-2.5	-3.3b	-0.5
Summer	-2.3b	-3.4b	-5.3a	-4.4a	-3.8b	-2.1
Autumn	-2.3	-4.7a	-4.7a	-1.9	-3.6b	-0.7
Annual	-2.3b	-4.2a	-4.9a	-3.3a	-4.4a	-1.8
Min: winter	-0.1	-2.6b	+2.1	-0.2	-2.2	-3.6b
Spring	+2.8b	+1.6	+6.9a	+3.8a	+3.1a	+0.3
Summer	+1.1	-0.1	+5.9a	+1.2	+3.7a	-1.7
Autumn	+2.2	-0.4	+7.7a	+3.6a	+3.0b	-0.1
Annual	+1.5c	-0.4	+5.6a	+2.1a	+1.9b	-1.3
Range: winter	-4.2a	-4.3a	-8.2a	-4.0a	-4.9a	-0.7
Spring	-3.4b	-3.5a	-10.3a	-6.3a	-6.4a	-0.8
Summer	-3.4a	-3.2a	-11.2a	-5.5a	-7.5a	-0.5
Autumn	-4.5a	-4.3a	-12.4a	-5.5a	-6.7a	-0.6
Annual	-3.8a	-3.8a	-10.5a	-5.4a	-6.4a	-0.6
Annual mean	-0.4	-2.3a	+0.4	-0.6	-1.3	-1.6

a: trend significantly (α =0.01) different from 0 ^{o}C ;

b: trend significantly (α =0.05) different from 0 ^{o}C;

c: trend significantly (α =0.10) different from 0 ^{o}C .

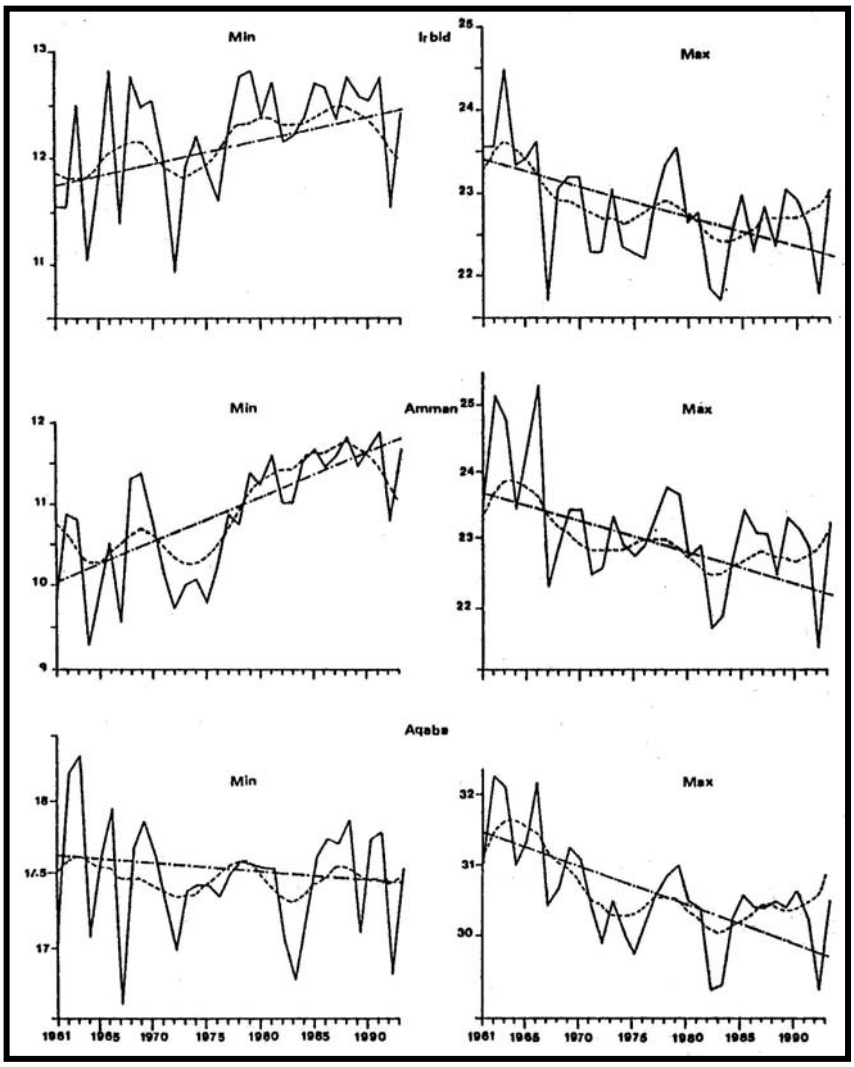


Fig.2: Variations of the mean annual maximum and minimum temperatures, in C degrees **(** ___) ; 9 point binomial filter (----); linear trend (-.-.-) since 1961 to 1996.

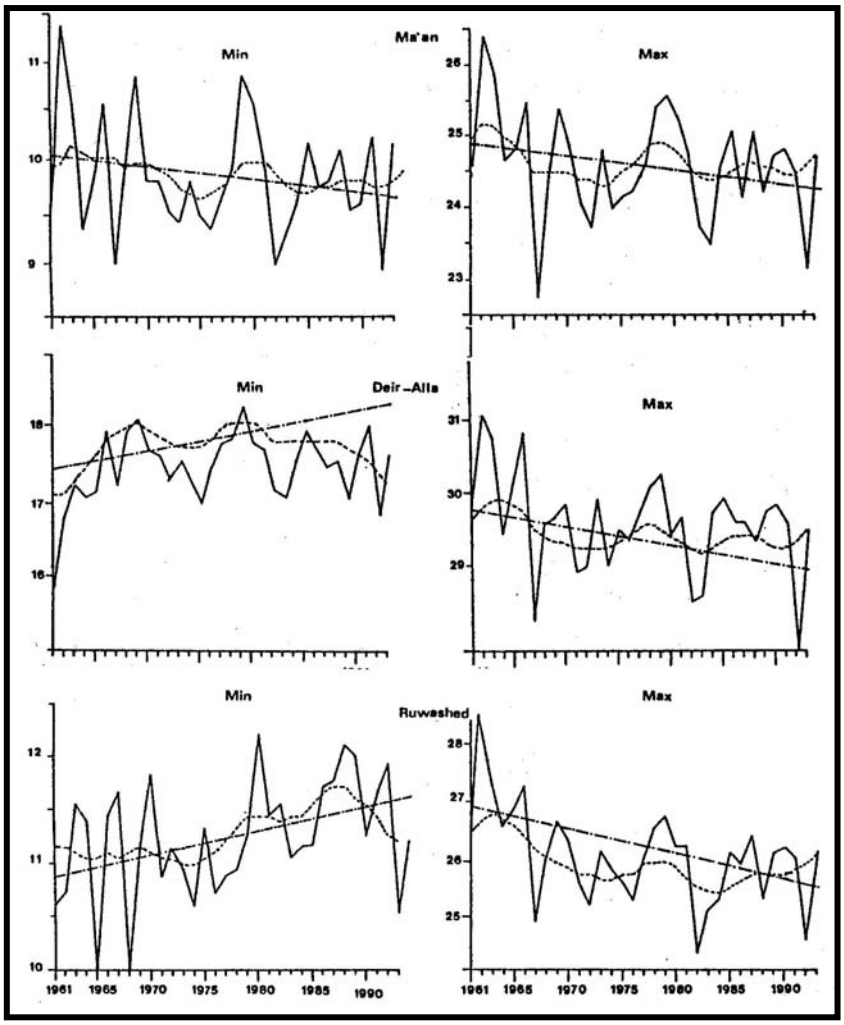


Fig. 2: continued

In contrast the mean minima decreased at Aqaba and Ma'an in all seasons except in spring, probably due to the impact of the Khamasin conditions during spring on the southern part of the country. The mean minima decreased also in winter in all stations except in Amman, because of urbanization and pollution that enhance the greenhouse effect in Amman. (Jones, et. Al., 1990).

As a result, the diurnal temperature ranges between the daily extremes decreased substantially in all seasons at all stations, and it is most pronounced in Amman. Most of the results have statistical significance except in Ma'an.

The mean annual maxima decreased in all stations. In contrast, the mean minima, representing mostly the nighttime and sunrise temperatures, increased at Deir Alla, Amman, Irbid, and Ruwshed; and decreased in Aqaba and Ma'an. Large year -to-year oscillations of maximum and minimum temperatures are imposed over the linear trends and 9-point binomial filter in fig.2. It is important to indicate that the annual mean temperatures decreased in all stations except in Amman which experienced a little increase.

The correlations between the mean seasonal range and the diurnal temperature extremes show that the decrease of the mean range in Aqaba and Ma'an are due to the decrease of both the mean minima and maxima; while in the other stations are due to both: the decrease of the mean maxima, and the increase of the mean minima. Generally, the negative correlations between the range and the temperature extremes have more statistical significant than positive correlations especially in stations located in arid climate that are Ma'an, Aqaba, and Ruwashed.

Conclusion:

Natural and human factors have accumulative impact on climate. One of these factors pollution, such as the increase of sulfur and carbon dioxide concentration in the atmosphere which enhance the increase of the minimum temperature. Some of the warming in Amman is due to the increase of minimum temperatures (which is stronger than the decrease of the maximum temperatures) due to the effect of the greenhouse gases which absorb most of the long-wave terrestrial radiation.

The decrease of maximum temperatures in all stations can't be explained by pollution alone, other factors must have contributed to the trend. The increase of precipitation in the last decades results from the increase of water vapor and cloud cover in the atmosphere causing the decrease of the sunshine duration; this would cause the decrease of maximum temperatures. (Henderson – sellers, 1986).

The changes of maximum temperatures are most pronounced and have a substantial effect on the cooling trend in all stations except in Amman which experienced little warming. The cooling trend in the other stations probably due to both the decrease of the mean maxima and the increase of the mean minima. Ma'an that is located in the arid region experienced little changes, with no statistical significance.

We have a little understanding of the causes of the different changes of maximum and minimum temperatures. The decrease of the diurnal temperature range is a fundamental characteristic of recent climate variations over much of the Northern Hemisphere landmass (Karl, et al., 1984). Extremes on both ends of the daily temperatures are beneficial for most human activities. For example, changes of the diurnal extreme temperatures have impact on the growing season, which would influence the distribution of cultivated crops in the country. So it is very important to study and understand the impact of many factors in the future such as the effect of pollution and urbanization on climate.

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