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Analysis of the ambient air temperature database measured at Beer Sheva, Israel with regard to the global climate change theses

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Abstract

The initiative for this study was the declaration by the NOAA National Centers for Environmental Information (2024) that the year 2023 was the warmest year since global records began in 1850 at 1.18°C above the 20th century average of 13.9°C. The report also found that the months June through December in 2023 ranked as the warmest such month on record. The month of July 2023 was declared the warmest of all months on record. In fact, the months July, August and September during 2023 were all above the long-term averages. The aim of this study was to ascertain to what extent this was true with regard to our region of the globe, viz., the Middle East. First of all, a trend analysis was performed on a database consisting of the average hourly ambient air temperature measurements for Beer Sheva from August 1988 through December 2025 during the diurnal (06:00-18:00), nocturnal (18:00-06:00) and daily (24 hour) time intervals. Positive monthly trends were detected throughout the year for all time intervals, with the possible exception of the month of October. The largest trends, during all time intervals, were in January, February, March and December between 0.85 and 0.72°C/decade. The database of the ambient air temperature measurements for Beer Sheva between August 1988 and December 2025 was then truncated in order to perform an intercomparison between one consisting of data between January 2023-December 2025 with a second database consisting of data between August 1988-December 2022. Multiple intercomparisons were performed between the two databases and they, in general, support the validity of the global climate change theses for this region of the globe.

Keywords Ambient Air Temperature; Global Climate Change; Daily Temperature Trends; Diurnal; Nocturnal; Daily; Daily Temperature Range.

1. Introduction

In recent years global climate change, especially what is termed “global warming” (a misnomer; it’s extreme temperatures, both high and low), has become a topic of widespread interest to the general public and especially to the scientific community. The increase of the frequency and intensity of extreme weather conditions have been observed since around 1950 (Climate Change) and these include heatwaves, droughts and floods, which have significant adverse effects on the environment [1]. A number of studies published in the 1980’s (e.g., Jones et.al., [2–4]; Jones [5]; Hansen and Lebedeff [6, 7]) reported that the global surface temperature had increased between 0.3 and 0.6°C during the time interval between the mid-nineteenth century to the 1980’s.

Ben-Gai, et al. [8] studied the trend patterns of maximum and minimum surface temperatures monitored at 40 Israeli meteorological stations during the time period between 1964 and 1994. They observed well pronounced seasonal trends; viz., a cooling trend of both maximum and minimum temperatures during the cool season and a warming trend during the warm season. They also observed a distinctly decreasing trend in the diurnal temperature range of -0.05°C/decade and -0.26°C/decade in the summer and winter, respectfully.

Zhang et al. [9] concluded based upon data measured between 1950 and 2003 collected from 52 meteorological station located in 15 countries. i.e., Armenia, Azerbaijan, Bahrain, Cyprus, Georgia, Iran, Iraq, Israel, Jordan, Kuwait, Oman, Qatar, Saudi Arabia, Syria and Turkey, that statistically significant, spatially coherent positive trends in temperature indices were indicated for this region. They also found statistically significant trends with regard to both maximum and minimum temperatures.

Stanhill and Cohen [10] analyzed the maximum, minimum, mean and diurnal temperature trends in Israel between 1967 and 2003. They observed significant differences between different regions of Israel. They merged the data from three sites in Israel, i.e., Jerusalem, Bet Dagan and the Dead Sea, during the time period 1967-2003 and found an increasing trend of +0.27°C/decade, +0.33°C/decade and +0.30°C/decade for the maximum, minimum and mean temperatures, respectively.

Yoseph et al. [11] reported a study based upon data from 34 Israeli stations monitoring temperature during the time interval between 1950 and 2017 that examined temporal changes in climate extremes. They observed spatially coherent warming trends between 1950-2017 that became more distinct during the time interval 1988-2017. Sharp upward trends were observed since 1985. The annual maximum and minimum temperatures exhibited similar increasing trends of ~+0.55°C/decade, whereas during the winter a significant increase was detected for both parameters, viz., 0.7 and 0.4°C/decade, respectively.

Almazroui [12] studied the changes in average temperature and temperature extremes in Saudi Arabia using a database consisting of measurements performed between 1978-2019. The results of the analysis indicated an increase in both temperature trends and extremes in the time period 2000-2019 relative to that observed during 1978-1999. During the period 1978- 2019 the minimum temperature increased by 0.64°C/decade whereas the maximum increased by 0.60°C/decade.

Ayala, et al. [13] studied the increases in the annual, seasonal and daily temperatures measured in Puerto Rico during the time interval 1970-2024. They observed that the island has been experiencing an increase in the frequency of extremely warm days, which are causing significant environmental and socio-economic impacts. The study was based upon measurements performed at 12 sites on the island during this time interval and how it relates to climate change. The island has experienced significant warming during this time interval, with increases in minimum temperatures, especially during the summer and nighttime hours. The frequency of extreme heat events has also increased across nearly all stations in different areas of the island.

We reported previously upon our monitoring of the daily ambient air temperature between 1988 and

2019 at Beer Sheva, Israel (Kudish and Evseev [14]). The database was analyzed with regard to the existence of possible trends in the diurnal (06:00-18:00), nocturnal (18:00-06:00) and daily (24 hour) time intervals.

The incentive for this study, viz., the expansion of our previous study (Kudish and Evseev [14]), was the fact that: (1) the year 2023 had been declared an extreme temperature year (NOAA [15]) and 2) the year 2024 was the warmest year since global records began in 1850, viz., 1.29°C above the 20th century average of 13.9°C (NOAA [16]). Consequently, the database in the present study has been expanded to include the measurements through December 2025 and to ascertain to what extent the global climate change theses has affected our local environment.

2. Data Monitoring

This study is based upon the measurements recorded at the Solar Energy Laboratory's meteorological station located in Beer Sheva on the main campus of the Ben-Gurion University of the Negev (31°15'N, 34°45'E, 315m, m.s.l.) between August 1988 and December 2025. Beer Sheva is situated at the northern edge of the semi-arid Negev region of Israel. A data-logger, Campbell Scientific Instruments, model CR10, scans the measuring instruments every 10 seconds and stores the data as 10-minute averages. The data are reported on an hourly basis as the average of the 6 10-minute averages. The data are downloaded periodically from the data-logger to a computer in the Solar Energy Laboratory via modem. This station is part of the national network of meteorological stations overseen by the Israel Meteorological Service.

3. Results and Data Analysis

The average monthly diurnal, nocturnal and daily ambient air temperatures monitored in Beer Sheva between August 1988 and December 2025 are reported in Table 1. The maximum monthly average diurnal, nocturnal and daily values are 30.1°C (July and August), 24.1°C (August) and 27.1°C (August). The corresponding minimum monthly average values are 14.0°C, 10.7°C and 12.4°C, respectively, all in January.

A trend analysis, utilizing the Mann-Kendall Test (Mann [17], Kendall [18] and Gilbert [19]), was then performed on this database with regard to diurnal, nocturnal and daily ambient air temperatures. The results of this analysis are presented in Table 2 in terms of the corresponding p value and trend, i.e., °C/decade, where the criterion for defining a trend as statistically significant is a p value < 0.05. It is observed from this analysis that a positive trend exists throughout the year for all monthly diurnal, nocturnal and daily ambient air temperatures with exception of the month of October. The diurnal temperature trend varies between a maximum of 0.85°C/decade during January to a minimum of 0.47°C/decade in May. The nocturnal temperature trend varies between 0.69°C/decade during February and 0.50°C/decade during May. The daily temperature trend exhibits a maximum during February, 0.77°C/decade, and a minimum during May, 0.48°C/decade. It should also be noted that larger trends for all time intervals occur in the winter months (January and February), whereas the lower trends occur in the warmer months (May).

Table 1: Average monthly diurnal, nocturnal and daily air temperatures between August 1988 and December 2025 for Beer Sheva.

		Diurnal[1]	Nocturnal[2]	Daily[3]			Diurnal[1]	Nocturnal[2]	Daily[3]
January	Months	35	35	35	**July**	Months	37	37	37
	Average	14.0	10.7	12.4		Average	30.1	23.9	27.0
	Stdev	1.6	1.3	1.4		Stdev	1.0	0.9	0.9
February	Months	36	36	36	**August**	Months	38	38	38
	Average	14.9	11.2	13.1		Average	30.1	24.1	27.1
	Stdev	1.7	1.4	1.5		Stdev	0.9	0.9	0.9
March	Months	37	37	37	**September**	Months	36	36	36
	Average	18.0	13.3	15.6		Average	28.3	22.6	25.5
	Stdev	9.1	1.6	1.8		Stdev	0.9	0.9	0.9
April	Months	37	37	37	**October**	Months	37	37	37
	Average	22.1	16.3	19.2		Average	25.4	20.3	22.8
	Stdev	2.0	1.5	1.7		Stdev	1.2	1.1	1.1
May	Months	36	36	36	**November**	Months	38	38	38
	Average	26.1	19.4	22.8		Average	20.7	16.4	18.5
	Stdev	1.1	1.0	1.0		Stdev	1.5	1.3	1.4
June	Months	36	36	36	**December**	Months	38	38	38
	Average	28.6	21.8	25.2		Average	16.0	12.3	14.1
	Stdev	1.0	0.9	0.9		Stdev	1.6	1.4	1.5

[1] Diurnal: 06:00-18:00
[2] Nocturnal: 18:00-06:00
[3] Daily: 00:00-24:00

The next phase of this study was to determine the extent to which the average monthly temperatures monitored during the time interval January 2023 through December 2025 were in agreement/diverged with the original database after extraction of these data, viz., January 2023 through December 2025. This was accomplished by an inter-comparison of the monthly average diurnal, nocturnal and daily monthly values for the time interval January 2023 through December 2025 and the corresponding values for the time interval August 1988 through December 2022. The degree of similarity/deviation between the two average monthly values was based upon the difference, i.e., $\Delta = T_{23-25} - T_{Avg}$, relative to the standard deviation of the 1988-2022 average value, viz., D/Stdev. We have assumed that a value of D/Stdev $\geq$ 2 is indicative of a significant deviation between the two monthly average values. The results of this analysis are reported in Table 3 and it should be noted that there is no data for February 2023 due to a malfunction of the data-logger. It is apparent from Table 3 that only June, for all time intervals, and August, diurnal time interval, fulfill this criterion, viz., D/Stdev $\geq$ 2.

Table 2: Diurnal, nocturnal and daily air temperatures monthly trend analysis between August 1988 and Decembef 2025 for Beer Sheva based upon the Mann-Kendall test and slope analysis.

Month	**Diurnal**		**Nocturnal**		**Daily**	
	p-value	°C/decade	p-value	°C/decade	p-value	°C/decade
January	**0.000**	0.85	**0.000**	0.60	**0.001**	0.72
February	**0.001**	0.83	**0.001**	0.69	**0.001**	0.77
March	**0.006**	0.80	**0.005**	0.66	**0.006**	0.73
April	**0.027**	0.69	**0.012**	0.56	**0.019**	0.63
May	**0.005**	0.47	**0.002**	0.50	**0.002**	0.48
June	**0.002**	0.49	**0.000**	0.55	**0.000**	0.52
July	**0.000**	0.65	**0.000**	0.59	**0.000**	0.61
August	**0.000**	0.48	**0.000**	0.59	**0.000**	0.53
September	**0.000**	0.67	**0.000**	0.66	**0.000**	0.64
October	0.056	0.34	0.076	0.30	0.057	0.32
November	**0.010**	0.55	**0.006**	0.58	**0.007**	0.53
December	**0.004**	0.69	**0.004**	0.58	**0.002**	0.75

A similar analysis, i.e., inter-comparison, was also performed on the average monthly minimum and maximum hourly temperatures and the daily temperature ranges (DTR) between August 1988 and December 2022 and corresponding average values between January 2023 and December 2025. The monthly average hourly maximum and minimum temperatures were greater throughout the years between January 2023 and December 2025 with the exception of the month of February, viz., Δ = -0.4°C, with regard to the maximum and February and May, viz., Δ = = -0.5°C, for the minimum cf., Table 4. The difference exceeded 2°C during January, June, July and November with regard to the maximum viz., 2.8, 2.9, 2.4and 2.4°C, respectively. In the case of the monthly average hourly minimum temperatures the differences were smaller; the largest difference being 1.6°C during August. In general, the data reported in Table 4 appears to support the global warming theses to some degree.

The next step was to determine if there was any significant deviation between the two databases regarding monthly maximum and minimum daily ambient temperatures. Once again, a value of Δ =/Stdev ≥ 2 was indicative of a significant deviation. Only in the case of the maximum ambient temperatures during the months June and July was this criterion fulfilled, viz, Table 4. The differences in the Daily Temperature Range (DTR) between the two databases was also investigated and the largest difference was 5.1°C during November; the remaining months were all within -0.3 and 2.0°C.

An intercomparison was performed on the now two databases, viz., August 1988-December 2022 and January 2023- December 2025, with regard to the average monthly diurnal, nocturnal and daily ambient temperatures and daily temperature ranges. The results of this analysis are reported in Table 5. The daily temperature range (DTR) reported in Table 5 refers to the difference in the average daily diurnal and nocturnal ambient air temperatures. The monthly DTR values are quite similar throughout the year, c.f., ΔDTR1. A similar intercomparison was performed on the daily time interval data and is reported in Table 5, c.f., Δ =(Daily)2. In this case the differences are somewhat greater; with the exception of February, May and October.

Table 3: Analysis of average monthly diurnal, nocturnal and daily ambient temperatures between 2023-2025 relative to those recorded between August 1988 and December 2022 for Beer Sheva.

Month	**Parameter**	Diurnal	Nocturnal	Daily	**Month**	**Parameter**	Diurnal	Nocturnal	Daily
January	**Average**	13.9	10.6	12.2	**July**	**Average**	29.9	23.7	26.8
1990-2022	**Stdev**	1.6	1.3	1.4	**1989-2022**	**Stdev**	0.8	0.8	0.8
	2023-25$_{avg}$	15.7	11.6	13.7		**2023-25**$_{avg}$	32.3	25.3	28.8
	$\Delta = T_{23-25} - T_{Avg}$	1.8	1.0	1.5		$\Delta = T_{23-25} - T_{Avg}$	2.4	1.6	2.0
	Δ/Stdev	1.13	0.77	1.07		**Δ/Stdev**	3.0	2.0	2.5
February	**Average**	15.0	11.2	13.1	**August**	**Average**	29.9	24.0	27.0
1989-2022	**Stdev**	1.7	1.4	1.5	**1988-2022**	**Stdev**	0.8	0.9	0.8
	2024-25$_{avg}$	14.6	10.6	12.6		**2023-25**$_{avg}$	31.5	25.2	28.4
	$\Delta = T_{24-25} - T_{Avg}$	-0.4	-0.6	-0.5		$\Delta = T_{23-25} - T_{Avg}$	1.6	1.2	1.4
	Δ/Stdev					**Δ/Stdev**	2.0	1.33	1.75
March	**Average**	17.9	13.3	15.6	**September**	**Average**	28.2	22.5	25.4
1989-2022	**Stdev**	2.0	1.6	1.8	**1988-2022**	**Stdev**	0.9	0.9	0.9
	2023-25$_{avg}$	19.0	13.9	16.5		**2023-25**$_{avg}$	29.7	23.4	26.5
	$\Delta = T_{23-25} - T_{Avg}$	1.1	0.6	0.9		$\Delta = T_{23-25} - T_{Avg}$	1.5	0.9	1.1
	Δ/Stdev	0.55	0.37	0.50		**Δ/Stdev**	1.67	1.0	1.22
April	**Average**	22.0	16.2	19.1	**October**	**Average**	25.3	20.2	22.8
1989-2022	**Stdev**	2.1	1.5	1.8	**1988-2022**	**Stdev**	1.2	1.1	1.1
	2023-25$_{avg}$	22.5	16.8	19.7		**2023-25**$_{avg}$	26.3	20.4	23.3
	$\Delta = T_{23-25} - T_{Avg}$	0.5	0.6	0.6		$\Delta = T_{23-25} - T_{Avg}$	1.0	0.2	0.5
	Δ/Stdev	0.24	0.40	0.33		**Δ/Stdev**	0.83	0.18	0.45
May	**Average**	26.1	19.4	22.8	**November**	**Average**	20.6	16.3	18.5
1989-2022	**Stdev**	1.1	1.1	1.1	**1988-2022**	**Stdev**	1.4	1.3	1.3
	2023-25$_{avg}$	26.5	19.3	22.9		**2023-25**$_{avg}$	22.4	17.3	19.9
	$\Delta = T_{23-25} - T_{Avg}$	0.4	-0.1	0.1		$\Delta = T_{23-25} - T_{Avg}$	1.8	1.0	1.4
	Δ/Stdev	0.36		0.09		**Δ/Stdev**	1.29	0.77	1.08
June	**Average**	28.4	21.8	25.1	**December**	**Average**	16.0	12.4	14.2
1989-2022	**Stdev**	0.9	0.8	0.8	**1989-2022**	**Stdev**	1.6	1.3	1.5
	2023-25$_{avg}$	30.1	22.8	26.5		**2023-25**$_{avg}$	17.3	13.1	15.2
	$\Delta = T_{23-25} - T_{Avg}$	1.7	1.0	1.4		$\Delta = T_{23-25} - T_{Avg}$	1.3	0.7	1.0
	Δ/Stdev	1.89	1.25	1.75		**Δ/Stdev**	0.81	0.54	0.67

Table 4: Inter-comparison of the monthly average minimum and maximum daily temperature range (DTR) between August 1988 and December 2022 and the corresponding average values between January 2023 and December 2025 for Beer Sheva.

Month	Min_{avg}	Stdev	$T_{2023/25}$	$T_{2023/25}-T_{avg}$	ΔT/Stdev	Max_{avg}	Stdev	$T_{2023/25}$	$T_{2023/25}-T_{avg}$	ΔT/Stdev	DTR_{avg}	$DTR_{2023/25}$	ΔDTR
January	8.9	1.2	9.9	1.0	0.83	16.6	1.8	19.4	2.8	1.55	7.7	9.5	1.8
February	9.5	1.4	9.0	-0.5	-0.36	17.7	1.9	17.3	-0.4	-0.21	8.2	8.3	0.1
March	11.4	1.6	12.0	0.6	0.38	20.9	2.1	22.1	1.2	0.57	9.5	10.1	0.6
April	14.2	1.5	15.2	1.0	0.67	25.4	2.3	26.1	0.7	0.30	11.2	10.9	-0.3
May	17.4	1.2	16.9	-0.5	-0.42	29.5	1.2	30.3	0.8	0.67	12.1	13.4	1.3
June	19.6	0.9	20.5	0.9	1.00	31.9	0.9	34.8	2.9	3.22	12.3	14.3	2.0
July	21.6	0.9	22.9	1.3	1.44	33.6	0.8	36.0	2.4	3.00	12.0	13.1	1.1
August	21.8	1.0	23.4	1.6	1.60	33.7	0.9	35.3	1.6	1.78	11.9	11.9	0.0
September	20.4	1.1	21.1	0.7	0.64	31.9	0.9	33.5	1.6	1.78	11.5	12.4	0.9
October	18.2	1.3	18.5	0.3	0.23	28.8	1.3	29.9	1.1	0.85	10.6	11.4	0.8
November	14.5	1.3	11.8	-2.7	-2.08	23.7	1.7	26.1	2.4	1.41	9.2	14.3	5.1
December	10.7	1.3	10.8	0.1	0.08	18.9	1.8	19.0	0.1	0.06	8.2	8.2	0.0

$\Delta = T_{2023/25} - T_{Avg}$

Table 5: Inter-comparison of average monthly diurnal, nocturnal, daily ambient temperatures and daily temperature ranges (DTR) between August 1988 and December 2023 relative to those between January 2023 and December 2025.

August 1988-December 2022					January 2023-October 2025						
Month-Average	Diurnal	Nocturnal	Daily	DTR	Month-Average	Diurnal	Nocturnal	Daily	DTR	ΔDTR[1]	Δ(Daily)[2]
January	13.9	10.6	12.3	3.3	January	15.7	11.6	13.7	4.1	0.8	1.4
February	15.0	11.2	13.1	3.8	February	14.6	10.6	12.6	4.0	0.2	-0.5
March	17.9	13.3	15.6	4.6	March	19.0	13.9	16.5	5.1	0.5	0.9
April	22.0	16.2	19.1	5.8	April	22.5	16.8	19.7	5.7	-0.1	0.6
May	26.1	19.4	22.8	6.7	May	26.5	19.3	22.9	7.2	0.5	0.1
June	28.4	21.8	25.1	6.6	June	30.1	22.8	26.5	7.3	0.7	1.4
July	29.9	23.7	26.8	6.2	July	32.3	25.3	28.8	7.0	0.8	2.0
August	29.9	24.0	27.0	5.9	August	31.5	25.2	28.4	6.3	0.4	1.4
Septemeber	28.2	22.5	25.4	5.7	Septemeber	29.7	23.4	26.5	6.3	0.6	1.1
October	25.3	20.2	22.8	5.1	October	26.3	20.4	23.3	5.9	0.8	0.5
November	20.6	16.3	18.5	4.3	November	22.4	17.3	19.9	5.1	0.8	1.4
December	16.0	12.4	14.2	3.6	December	17.3	13.1	15.2	4.2	0.6	1.0

[1] **ΔDTR: DTR(January 2023- December 2025) - DTR(August 1988-December 2022)**

[2] **Δ(Daily): Daily((January 2023- December 2025) - Daily(August 1988-December 2022)**

4. Conclusions

The initiative for this study was the declaration by the NOAA National Centers for Environmental Information (2024) that the year 2023 was the warmest year since global records began in 1850 at 1.18°C above the 20th century average of 13.9°C (NOAA [15]). The report also found that the months June through December in 2023 ranked as the warmest such month on record. In addition, the month of July 2023 was declared the warmest of all months on record. In fact, the months July, August and September during 2023 were all above the long-term averages.

The purpose of this study was to ascertain to what extent this was true with regard to our region of the globe. In order to accomplish this a database of ambient air temperature measurements for Beer Sheva was truncated in order to perform an inter-comparison between a database consisting of data between January 2023- December 2025 with a second database consisting data between August 1988-December 2022. The original, untruncated database exhibited a positive trend throughout the year, with the possible exception of the month of October (viz., during all time intervals. The results of an intercomparison between the average monthly diurnal, nocturnal and daily ambient air temperatures between the two databases indicated that diurnal temperatures during the warmer months, June, July, August and September were higher and varied between a maximum of 2.4°C during July and a minimum of 1.5°C during September. A Δ/Stdev ≥ 2 indicative of a significant deviation between two monthly average values was observed for July during all time intervals and in August during the diurnal time interval. The results of an intercomparison of the monthly average hourly maximum and minimum temperatures between the two databases also support the general theses of global warming, viz., they were greater throughout the years between January 2023 and October 2025 with the exception of the month of February, viz., Δ = -0.4°C, with regard to the maximum and with the exception February and May, viz., Δ = -0.5°C, for the minimum. The results of the intercomparison of the daily temperature range (DTR) and the daily time interval temperatures between the two databases also, in general, support the global climate change theses with the exception of April in DTR and February in daily.

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