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Global Warming: A Study of the Gaza Temperature Variations in the Period 1976-1995

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التسخين الحراري العالمي: دراسة التغيير في درجات حرارة غزه للفترة 1995-1976

ملخـص: فـي العقود الأخيرة تنامي الاهتمام بالتسخين السريع الذي يحدث في كل العالم، وخاصة في نصف الكرة الشمالي.لقد تم اختبار متوسط درجه الحرارة و متوسط درجه الحرارة العظمى و الصغرى والمـدى الحراري لمدينة غزة، حيث تم استخدام درجات الحرارة اليومية للفترة من 1976 إلى 1995 لمناقشـة التغيـير في درجات حرارة غزة. و لقد بينت النتائج تغيرات واضحة في درجات الحرارة. وبالنسـبة لمتوسـط درجة الحرارة فقد أظهر اتجاه متزايد في ارتفاع درجه الحرارة في معظم الشهور والفصول وفى الفترة الزمنية كلها. وبالنسبة لنمط درجه الحرارة العظمي فلم يظهر تغير علي اتجاهها. أمـا التغيـير فقد كان مميزاً في تناقص المدى الحراري الشهري و الفصلي و السنوي للفترة كلها. أما درجـات الحـرارة الصغرى فقد بينت نمطاُ متزايد الارتفاع في درجات الحرارة كما هو معروفٌ في المناطق المختلفة من العالم. و حيث إنه لم يوجد تغيير في درجات الحرارة العظمى، فإن هذا يبين النمط المشـهور و المعروف لتزايد ارتفاع درجه الحرارة الصغرى.إن التسخين الحراري ظهر أكثر وضوحاُ وتميزاً منذ منتصف الثمانينيات و لاحقاً.

Abstract: In the last decades there has been a growing concern of the rapid warming that took place in the whole world and in different parts, particularly in the Northern Hemisphere. The mean temperature,the maximum, minimum and temperature range of Gaza have been investigated. The daily data from 1976 to 1995 have been used to discuss temperature change in Gaza. The results show clear temperature change. The mean temperature shows an upward trends for most months, seasons, and in the whole periods of analysis. The patterns of maximum temperature remain generally unchanged. The most pronouncd change was illustrated by a well defined downward trends of the monthly, seasonal and annual temperature ranges. Since there was no change in the maximum temperature, the patterns confirmed the well known increase values of the minimum temperature. The warmimg was mostly pronounced from mid-1980$_s$ onwards.

Key words: Temperature, Climate Change, Global Warming, Gaza, Palestine.

Introduction

Numerous studies have confirmed that our climate is changing. An increasing evidence, especially in the last four decades, has confirmed an increase in the global mean temperature. Global warming is usually related to increasing concenteration of atmospheric greenhouse gases (Jones et al, 1986, Bradely et al, 1987, Schonwise and Malcher, 1987, Wigley and Jones 1987, Parker, 1989, Weber, 1990, Rowntree, 1998, and Viner, et al, (2000), atmospheric circulation changes (Kozuchowski, 1993 and Bartzokas et al 1994), urbanization (Hughes and Balling, 1996, Kadioglu, 1997), changes in cloud covers and types (Hanson, 1991, Coley and Jonas, 1999), solar variability (Haigh 2000), volcanic europtions such as El Chichon in 1982 and Mt. Pinatubo in 1991 (Parker et al. 2000). Such changes are mostly refered to as enternal and external mechanisms or anthropogenic and non-anthropogenic factors. Therefore, there is a need to characterize the climate in (Gaza/Palestine), and to know how this existing climate may change in the future when subject to both natural and human-induced climate forcing (Hulme et al, 1995).

The rise in the observed global mean temperature during the 20th century was between 0.6 and 0.7^{o}C, and the two main periods of warming were 1910-45 and from 1976 onward (Viner, et al 2000). The overall global warming at the surface has been estimated at 0.6^{o}C since 1861 with 95% confidence limits of $\pm$ 0.2^{o}C (Parker et al, 2000).

The analyses of hemispheric and global historical temperature by different time series methods showed an increasing trends in the last half of the 20th century, most prounouned from the 1980$_{s,}$ particularly in the Northern Hemisphere (Jones and Hulme,1996).

Gorden (1992) analysed the Northern and Southern Hemisphere surface temperature, using the trend line of the linear regression and found out that the Northern hemisphere cooled between the1940$_{s}$ and the 1970$_{s,}$ with maximum warming trend in winter and minimum in summer. The mean temperature of the 1000-500 hpa exhibits a trend of cooling in the 1960s and a continuous warming after 1970 in the area 90^{o}E-110^{o}E and 40^{o}N-55^{o}N, and since 1970 there was a continuous decrease and a weakining of the Siberian anticyclone in this area (Sahsamanoglouu et al 1991).

The whole Mediterranean region is vulnerable to climate change, particulatly through the effects on water balance, the implication of agriculture, domestic and industrial water supply (Palutikof, et al 1994). Many researches have revealed a significant changes in the Mediterranean climate since the middle of the 20th centuary. Reddaway and Bigg (1996), showed a significant changes in the east-west pressure gradient, an increase in the northerly wind over the eastern Meditterranean basin in summer, and a general rise in the summer sea level pressure across the whole Mediterranean basin. The analysis of the land temperature and sea level pressure around the Mediterranean for the period (1951-1985) for the grid pointd 20^{o}N-45^{o}N, 10^{o}W-90^{o}E showed that the South Asian monsoonal low deepend and centred further east during this period which resulted in steepening of the pressure gradient across the entire eastern Mediterranean (Sahsamanoglou et al 1991).

Most of the Mediteranean area showed a decline in the temperature during 1960-1970s (Sahsamanoglou and Makrogiannis, 1992), which was most pronounced in the eastern part of the Mediterranean in the period 1951-1985. Whereas in the the southeastern area of the Mediterranean, the declining temperature occurred during the period 1940-1960 (Repapis, and Philandras, 1988)

Turkes et al (1996), Kadioglu (1997) discussed Turkish temperature, and Bartzokas et al (1994) analyzed the Mediterranean Sea surface temperature. For the eastern Midetrranean, they found downward trends in the 1950s, an upward trend in the early 1960s, and then a decrease until the late 1970s. These results were attributed to local circulation changes, with stronger and more frequent northerly wind.

This study is an additional contribution to investigate the climate change and global warming in the area. It is based on the analysis of mean, minimum and temperature ranges of Gaza in the period from 1976-1995. Gaza is characterized by a Mediterranean climate, with long hot dry summer caused by eastward extension of the Azores high pressure and a mild wet winter resulted from a peneteration of mid-latitude depressions accompanied by westerly wind moving eastward over the Mediterranean basin.

Concept and Definition of Global Warming

The global warming is a term used by scientists to indicate an increase in the global temperature. This increase of temperature may be related to different factors (see above), but it is now widley eccepted that this global warming may be a result of increasing greenhouse concentration. The greenhouse gases, such as: Carbon dioxide, Methan and water vapour play a dominant role in global warming, particularly the unusuall increasing concentration of Carbon dioxide. They act as a blanket to counteract the longwave radiations emitted from the earth surface forcing it back to the land surface, thus, increasing the earth temperature, and producing the greenhouse effets. The distruction of the Ozone in the upper atmosphere by Chlorofluorocarbons will permit additional ultraviolet radiation to reach the earth surface, consequently increasing the thermal state and the temperature of the lower troposphere.

Data Collection and Manipulation

Temperatures and their spatial and temporal variabilities continue to be examined extensively by climatologists for evidence of large-scale climatic change. Daily data are available for the period 1976-1995. The daily data was subtracted from the official documents of the Gaza climatological station. The data was stored in the computer and then was checked for possible writing mistakes. Gaza station is located on the coastal plain of the

southeastern basin of the Mediterranean with height of about 12 meters above the mean Sea level. The station is exposed to wind from south to the north, and the nearest buildings are about 100 meters eastward from the station. Therefore, it is exposed well to the atmospheric conditions.
Daily mean was calculated from the maximum and minimum temperature which produced a series of 7300 days, with only three missing days. From this daily series the monthly, seasonal, and annual means were calculated. Daily series of the temperature range were calculated as the differences between the maximum and minimum temperatures. The monthly, seasonal, and annual averages of the temperature ranges were calculated from averages of maximum and minimum temperature for each month, season, and for each year respectively.

Metheodology

Climate time series are best produced by using anomaly or standardized anomaly values rather than the raw values (Jones and Hulme, 1996). However, Willmott and Robinson (1995) reported that actual temperature is more informative than anomaly field in that it represents mor fully the thermal state of the near-surface temperature. Therefore, the actual temperature was used. Temperature is a continuous variable and in most regions of the world monthly mean temperature as well as monthly mean maximum or minimum temperature tend to be normally distributed (Jones and Hulme, 1996).
Linear correlation coefficient was used to identify the significant relationships between temperatures and the time (1976-1995). To reduce the amount of discussion, only those who showed a significant relationships were discussed. Since the results of analysing the maximum temperature did not show a significant relationships; therefor, their results were not presented. Only maximum temperatures in September and autumn show a significant correlation, the latter reflects the effect of September.
A global warming mainly taking the form of increases in minimum temperaure could be considered more informative than a one associated with marked increases in maximum temperature (Lockwood, 1998). The results of non-significant trends of the maximum temperature were found in Portugal, Turkey and Cuba (Leite and Peixoto, 1996, Kadioglue, 1997, and Naranjo-Diaz, and Centela, 1998).
Kernal smoothing and linear regression methods were used here to identify trends with time (Brazdil et al 1996). The directions of change (+/-) and their significant relationships were calculated. Since their signs and statistical significants were similar to the results of the correlation methods, they are not introduced. Moreover, the direction of the trends may read off

directly from the regression equations written in the Figures for each month, season, and year. The statistical significant of the changes was also calculated, but since the level of significant showed identical values to the correlation cofficients, they are not introduced. The cooling and warming periods in the Figures may be identified, simply by noting the direction of the smooth curve in the Figures. When the smooth curve is above/below the long-term average, indicated by the horizontal line in the Figures, for each respective month, season, and year, the warming/cooling of that period was identified.

Mann-Whitney U test is a valuable alternative test to the Student t test. The U test was used to test the difference of the annual temperatures between 1976-1985 and 1986-1995.

Discussion

Mean Temperature

Table (1) shows the results of the correlation between the mean temperatures and the time (1976-1995), were most of the them displayed a positive relationships. A highly significant correlation coefficient was found in June, July, August, September, October, summer, autumn and annual values. Figure (1) shows the monthly mean time series. All the Figures show a warming trends, particularly June, July, August, September and October. The warming was intensified from around mid-1980s onward where the smooth curves surpass their respective long-term averages (i.e solid horizontal line). The calculated U value of Mann-Whitney test is significant at 0.05. Therefor the warming of 1986-1996 by 0.5^{o}C, relative to the 1976-1985, was a real climatological fact. Tomozeiu et al (2002), discussed the temperature of Romaina in the period 1922-1998, and found a significant upward shift in the temperature from 1985 onward.

Figure (2) shows the seasonal and annual trends. The warm periods were intensified from around mid-1980s. Summer cooling trends prior to 1985 were detected in the surface temperature in the eastern Mediterranean, which was characterized by pronounced strength of the northwesterly wind over the eastrn basin caused by deepining and eastward movement of the South Asian monsoonal low (Reddaway and Bigg, 1996). Winter and spring show similar warm period from mid-1980s to early 1990s, but a non significant relationship exited. Reddaway and Bigg (1996), concluded that, winter trends in temperature and pressure showed less statistical significant relationship than in summer, which is likely to be due to winter high interannual variability mascking any real time trend. Jones and Hulme (1996), showed an upward trend from 1980s, mostly pronounced in the

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Northern Hemisphere, which support the upward trends of the mean temperature in Gaza from mid-1980s onward (see Figures 1 and 2).

Leite and Peixoto (1996), found a well defined warming in the 1980s and early 1990s in Portugal, and the warmimg of the 1980s and 1990s were unusual, and they were the warmest since 1856 in Portugal. Moreover, Brazdil et al (1996) and Komusco (1998) found a siginal of important warming intensification in the late 1980s, continued in the early 1990s in Central Euorope and in Turkey, respectively. Weber (1990), found a remarkable increase of the temperature gradient over the Middle East.

Holden and Adamson (2002) analysed the Moor House (UK) temperature during 1931-2000, they found prominent warming trends in 1980_s and 1990s, and the frequency of frost and the number of days with snow lying on the ground was dramatically reduced. Hughes and Balling (1996) found that much of the warming in South Africa temperature occurred in the most recent three decades.

The increase of the mean annual temperature in Gaza was about 0.4^oC from 1976-1995, which is approximately similar to the global values. Weber (1997), also found a warmimg trend of 0.76^o in the latitude $25\text{-}35^oN$, and a rapid temperature rise in the middle latitudes which took place in the late 1970_s and in the late 1980_s, and concluded that, the episode of the mid-latitude warming in the late 1980_s appeared as an interesting event embedded in the global temperature environment.

	Mean Temperature	Minimum temperature	Temperature Range
January	0.165	0.246	-0.303
	0.487	0.295	0.194
February	-0.096	-0.057	-0.145
	0.687	0.810	0.542
March	0.108	0.252	-0.522*
	0.651	0.283	0.018
April	0.097	0.247	-0.391
	0.684	0.293	0.089
May	0.215	0.443	-0.511*
	0.362	0.051	0.021
June	0.593**	0.706**	-0.487*
	0.006	0.000	0.029
July	0.496*	0.584**	-0.432
	0.026	0.007	0.057
August	0.581**	0.618**	-0.489*
	0.007	0.004	0.029
Septemb	0.785**	0.799**	-0.569**
er	0.000	0.000	0.009
October	0.541*	0.595**	-0.435
	0.014	0.006	0.055
Novemb	0.112	0.226	-0.564**
er	0.607	0.339	0.010
Decembe	0.093	0.187	-0.350
r	0.697	0.431	0.130
Winter	0.090	0.213	-0.399
	0.707	0.368	0.081
Spring	0.187	0.393	-0.623**
	0.431	0.086	0.003
Summer	0.662**	0.747**	-0.528**
	0.001	0.000	0.017
Autumn	0.704**	0.752**	-0.625**
	0.001	0.000	0.003
Annual	0.607**	0.733**	-0.659**
	0.005	0.000	0.002

Table 1. Pearson's correlation coefficient of monthly, seasonal, annual temperatures and the time (1976-1995). Note that * and ** denotes a correlation coefficient significant at 0.05 and 0.01 or higher respectively.

Changed temperature over the Mediterranan was related to a small change of the circulation (Sahsamanoglou and Makrogiannis, 1992), and to the increased influnce of westerly flow over the Levant and eastern Mediterranean basin (Kozuchowski, 1993), which basically were increases from north to south in the period 1983-1988 (Sarroni, et al 1996).
Moreover the warming of the 1980s was not just a surface phenomenon over Europe (Makrogiannis and Sahsamanoglou 1992), but there were more wider ones.

Minimum Temperature

The relationships of June, July, August, September, October, summer, autumn, and annual values of mimimum temperature are highly positively correlated with time (Table 1). This means that the minimumn temperature has a positive and upward trends within the time period under investigation. However, there were a non significant relatioships in some months and seasons (Table 1). Brazdil et al (1996) found statistically increasing trends in minimum temperature of most regions in Central Euorpe, and Onate and Pou (1996) found positive trends in minimum temperature in some stations in Spain. Mann (2001), examined the climate during the past millennium, and concluded that the year 1998 and the decade of the 1990s are probably the warmest decade and year respectively of the millennium.
Figures (3 and 4) illustrated this relationship of the increasing positive directions of the minimum temperatures, with stronger warming intensities in June, July, August, September, October, autumn, summer and the annual values all display warming trends from 1976 to 1995. Similar warming of the trends also shown in the other months and seasons, but unfortunately without significant relationships. The annual Figure shows a very clear upward trend from 1976-1995 (see Figure 4).
Naranjo-Diaz, and Centela (1998) found that the warmest periods in Cuba were in the 1980s and mid-1990s, which were mainly due to a very significant positive trend in the minimum temperatuer. The lowest and highest mean minimum temperatures in Gaza during 1976-1995, occurred in 1983 and 1994 respectively, while in spring, the coldest years were in 1983, 1987 and 1992; moreover, the warming had intensified since 1980s. Similar results have been found in Turkey (Turkes et al 1996 and Kadioglu, 1997). The mean minimum temperature of the decade 1986-1995 was warmer by 0.7^{o}C relative to 1976-1985. The Mann-Whitney U test between the two periods was sgnificant at the 0.01.The trend of the mean annual minimumn temperature was 0.06^{o}C/year (see Figure 4), and the increase was 1.2^{o}C from 1976 to 1995.

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Temperature Ranges

Table (1) shows an overall negative correlation coefficient with time. The months of March, May, June, August, September and November the relationships are statistically significant. The seasonal (except winter) and annual values show highly strong negative relationships with time. Winter season and its months also don't show significant relaionships with time, even they show the negative signs of correlation coefficent.

Figure (5) shows the monthly temperature ranges. Most of the Figuers show decreasing trends from 1976-1995, even the months with nonsignificant correlations display declining trends. Some stations in Spain show similar decreases in the temperature range. A significant decrease of temperature range was found in mid-Switzerland (winter, spring and annual), Germany (spring), and the Czech Republic in the annual series (Bradzil, et al 1996), and in South Africa (Hughes and Balling, 1996).

However, for the whole area of Central and southeastern Europe there was insignificant trends in the temperature ranges (Bradzil et al 1996), and in some stations in Spain (Onate and Pou, 1996). Temperature ranges apparently decreases over almost all regions of Turkey in all seasons (Turkes et al 1996).

Figure (6) shows a downward trends of the seasonal and annual temperatures ranges. The mean annual temperature range was 8.6^{o}C in 1976 decreased to 7.0^{o}C in 1996 which was nearly about 1.6^{o}C/20 years. Naranjo-Diaz, and Centela (1998) reported a decrease in the mean temperature range of almost 2^{o}C in Cuba. The mean annual temperature range decreased by 0.5^{o}C in 1986-1995 relative to 1976-1985. The Mann-Whitney U test of the difference between the two periods is significant at 0.01.

Conclusion

Mean temperature in Gaza showed an upward trends in most of the months. This upward trends was very clear in the seasonal Figures, especially in autumn, spring and summer (Figure 2). The increase intensified in the mid-1980s onwards. Similarly, there was warming in the Northern Hemisphere, and in different regions, such as Portugal, Turkey and Moor Houes (UK). The annual warming may be estimated to be 0.04^{o}C/year, which is amounted to about 0.4^{o}C from 1976 to1995: This warming is close to the estimated values of the Northern Hemisphere global warming. The projected rises in the mean temperature for the years 2005, 2010, and 2015 would be 0.72^{o}C and 0.92^{o}C and 1.12^{o}C respectively.

Minimum temperature has a significant increase direction from June to October and in spring, summer and autumn. The annual minimum temperature shows a significant upwards patterns from 1976 to 1995, mostly

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intensified from mid-1980s onward. The mean annual minimum temperature was 15.4°C in 1976, increased to 16.6°C in 1995. The trends of the annual minimum temperature were 0.06°C/year. This increase is estimated to be 1.2°C from 1976-1995. Summer temperature increased from 20.4°C in 1976 to 22.4°C in 1995, which is almost about 2°C in 1967-1995 (see Figures 3 and 4).

Temperature ranges show the well-documented decrease patterns. The monthly, seasonal, and annual mean temperature ranges showed a negative correlation and decreasing trends with time. The annual temperature ranges decrease by about 1.6°C from 1976 to1995.

The Mann-Whitney U test of the temperature differences between 1976-1985 and 1986-1995 were statistically significant at 0.01.

The patterns of the maximum termperature remain unchanged over Gaza, as well as different parts of the world, except in September and autumn for 1967-1996.

Since the station is located in the upwind of the Gaza city, the effects of urbanization in the temperature change can be rulled out. Other factors should be discussed in the future such as the well known effects of increasing concenteration of CO_2, and atmospheric circulation changes. Unfortunatly, non of these measurments are available in Gaza at the present time. The global warming that took place in different parts of the globe appears to be real and is reflected in the warming of Gaza. This warming in Gaza intensified in mid-1980s to 1995, as it could be noticed in the rest of the world.

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