

20th Century Temperatures of Palestine: Variability, Trend and the Global Warming (1901-2000)

***Dr. Ahmed K.A. El-Kadi**

E.mail: Kadi@iugaza.edu

*Department of Geography, Islamic University of Gaza,
Gaza Strip, Palestine.

20th Century Temperatures of Palestine: Variability, Trend and the Global Warming (1901-2000)

Dr. Ahmed K.A. El-Kadi

Abstract

Historical temperature data of Palestine in the 20th century have been analysed using time series analysis to detect the warming and cooling phases. Linear regression analysis was used to identify the signs and the magnitude of the temperatures trends. Linear correlation coefficient is used to identify the strength of the relationships of the temperature with time. The warming of the first and last decades is a general feature of the monthly, seasonal and annual temperature. The strongest positive trend of 1.2°C/100 years was found in summer and spring, while autumn and winter were warmed by 0.32°C and 0.95°C/100 years respectively. The annual temperature of the last century (1901-2000) was warmed by 0.9°C. The strongest warming trend was found in the next half of the last century, particularly from around 1970s/mid1980s onward. Annual temperature was significantly warmed by 1.1°C from 1980 onward. Seasonal warming trend from mid 1980s onward was 1.1°C for both Summer and Autumn, and 0.5°C to 0.7°C for Spring and Winter respectively. T-test was applied to validate the statistical significance of the mean temperature differences between 1901-1950 and 1951-2000. Monthly, seasonal and annual temperatures in 1951-2000 showed positive and statistically significant differences, except for a few months. There was gradual decreasing trend/cooling for February and March from 1970s onward.

Keywords: Palestine, Temperature, Trends, Variability, Warming, Climatic Change.

درجات حرارة فلسطين في القرن العشرين: التباين، الاتجاه و التسخين الحراري العالمي (1901-2000)

د. أحمد القاضي

الملخص:

يناقش البحث درجات حرارة فلسطين خلال القرن الماضي (1901-2000) لبيان ظاهرة الاحتباس الحراري. استخدم تحليل السلاسل الزمنية لبيان منحنيات الفترات الدافئة و الباردة. التحليل الخطي للبيانات استخدم لبيان إشارة ومقدار درجات الحرارة. معامل الارتباط الخطي استخدم لبيان قوة الارتباط مع الزمن. ولقد أوضح البحث أن العقود الثلاثة الأولى و الأخيرة من القرن الماضي تميزت باتجاه متزايد في درجة الحرارة. أعظم رفع حراري موجب وجد في كل من الصيف والربيع بمقدار $+1.2^{\circ}\text{C}/\text{م}$ / 100 عام بينما الخريف والشتاء فقد ارتفعت حرارتهما بمقدار $+0.3^{\circ}\text{C}$ و $+0.9^{\circ}\text{C}/\text{م}$ / 100 عام. درجات حرارة فلسطين للفترة كلها ارتفعت بمقدار 0.9°C م. أكبر رفع حراري وجد منذ أواخر السبعينيات وكان على أشده منذ منتصف الثمانينيات ولاحقاً. ولتوضيح ذلك قسمت البيانات إلي فترتين متساويتين وتم اختبار فرق درجات الحرارة بين 1901-1950 و 1951-2000 باستخدام اختبار ستودنت ت. درجات الحرارة الشهرية والفصلية والسنوية للنصف الأخير من القرن الماضي بينت اختلاف موجب ومميز إحصائياً باستثناء بعض الشهور. فبراير ومارس اظهرا اتجاهاً نحو الانخفاض الحراري والتبريد منذ السبعينيات ولاحقاً. ولقد تبين أن درجات الحرارة قد ارتفعت بشدة متزايدة منذ منتصف الثمانينيات ولاحقاً من القرن الماضي.

مصطلحات أساسية: درجة الحرارة، التباين، الاتجاهات، التسخين الحراري، التغير المناخي.

Introduction

From 1901 an equivalent global warming of 0.57°C has occurred with an uncertainty of 0.17°C (Folland, et al., 2002), and by about 0.2-0.3°C over the last 40 years (Bertrand and Van Ypersele, 2002) The warming from 1970s to 2000 was globally synchronous especially over the Northern Hemisphere in winter and spring (Folland, et al., 2001). The recent trends are receiving much attention in the global warming debate (Jones and Hulme, 1996). Human-induced climatic change and changes in climatic variability continue to be major global issues not only for the present generation, but also for future generations (Turkes, et al., 2002).

In the last decades of the last century, there has been great scientific attention and awareness of the climatic change that has taken place in different parts of the globe. The threat of global warming has activated investigation of trends in meteorological parameters in different spatial and temporal scales. It is obvious that even if global warming exists, then it does not take place uniformly everywhere and at any time (Keevallik, 2003). There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activity, and both the temperature and the sea-level are projected to continue rise throughout the twenty-first century (Griggs and Noguer, 2002, and Allen, 2002).

The recent warming, according to the results of wider range of research, can be related to different factors, such as continuing increase of greenhouse

gases concentration (Jones, et al., 1986) (Palutikof, et al., 1994) (Haigh, 2002) (Allen, 2002) (Bertrand and van Ypersele, 2002) (Zhao and Pitman, 2002) (Voss, and Roeckne, 2002) (Moberg, et al., 2003) and (Pitman, 2003). Urbanization (Hughes and Balling, 1996) (Choi, et al., 2003) (Brandsma, et al., 2003) (Englehart and Douglas, 2003) and (Turkes, et al., 2002). Atmospheric circulation change (Mote, 1998) (Tomozeiu, et al., 2002) (Brunetti, et al., 2002) (Jung and Stephenson, 2003) (Gimeno, et al., 2003) and (Domonkos, et al., 2003); to an increase in aerosol loading and modifications of the Sun's radiant energy output (Bertrand and Van Ypersele, 2002); to land surface change (Zhao and Pitman, 2002) (Pitman, 2003) and (Wang, et al., 2003). Abrupt ozone depletion occurred in the early 1980s, and the 1966-99 showed ~60% ozone reduction in the lower stratosphere (Krzyscin, 2002). These are the well known internal and external forcing mechanisms due to the internal natural variability or to human activity. The mankind induced changes that are now progressively emerging from the natural variability of the climate system and the global warming could accelerate as the greenhouse gases forcing agent begins to dominate over all other external driven climate forces. (Bertrand and Van Ypersele, 2002).

It has been documented that the atmospheric concentration of trace gases such as carbon dioxide have experienced a dramatic increase over the last century (Yue and Wang, 2002), and have led to an increase of 0.4 to 0.6°C in the mean global temperature (Jones, et al., 1986).

The Observed Impacts of Global Warming

If global climate change is a real phenomenon, its change should be first detected and most clearly revealed in the behaviour of the extreme climatic events (Przybylak, 2000). There have been wider and different impacts of global warming on the earth environments. Global warming is very likely to have an impact upon the global hydrological cycle, changing in extremes of climatic events, flood, drought episode, intensive rainfall events and cyclonic devastations.

During the last few years an increasing number of studies have revealed a lengthening of the growing season across the Northern Hemisphere that is related to air temperature increases, and the potential risk of frost damage in spring may decrease (Menzel, et al., 2003); a higher probability of flood conditions in a warmer climate (Voss and Roeckner, 2002), and the lengthened foliage period of trees in the recent decades (Menzel, et al., 2003). The strongest and most frequent subtropical air advection occurred over the North Atlantic-European regions during 1990s (Krzyscin, 2002). New England ice-out date has become significantly earlier (Hodgkins, et al., 2002). Large snow depth was less frequent in the 1980s-1990s, and the mean snow depth was significantly decreased from early 1980s towards the end of the last century, indicating that heavy winter precipitation, to an increasing degree, fell in the form of rain instead of snow (Latarnser and Schneebeli, 2003). There was a linear declining in the Arctic sea-ice covers and a retreat of the glaciers in the recent

decades (Singarayer, et al., 2006, Serreze and Francis, 2006 and Comiso, 2006). Bamzai (2003) concluded that the snow onset and snowmelt day-of-year in the Northern Hemisphere are shown to have considerable interannual variability and the number of snow-free days in a year has increased over the period 1967-2000, the increase arising primarily due to a trend in early snowmelt day-of-year in recent decades.

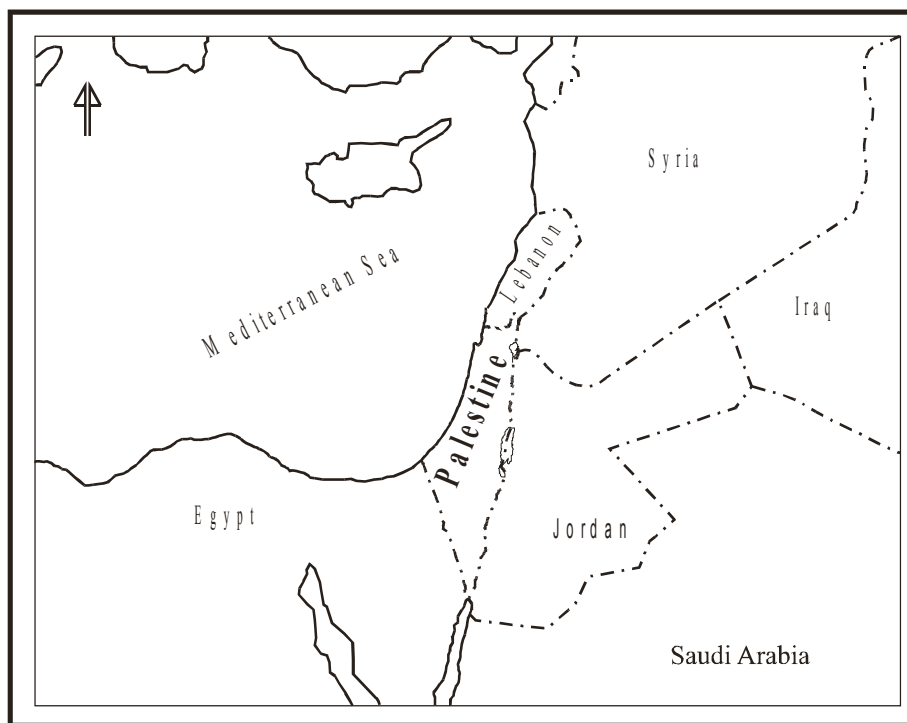
In different parts of the world there has been evidence of decreasing cold events and increasing of warm extremes (Menzel, et al., 2003 and Domonkos, et al., 2003), an increasing extreme intensity of high precipitation and high probability of flood conditions in a warmer climate (Fowler and Kilsby, 2003, Griffiths, et al., 2003 and Voss Roeckner, 2002). There is also a lengthening of frost-free periods in the last few decades (Menzel, et al, 2003), and there is a statistically significant decrease of snow fall days in the Swiss Alps after 1970 onwards (Latarnser and Schneebeli, 2003).

Palestine and the Mediterranean

The Mediterranean region lies on an area of a great climatic interest. It is influenced by some of the most relevant mechanisms influencing the global climate system. It marks a transitional zone between the deserts of North Africa, which are situated within the arid zone of the subtropical high, and central and northern Europe, which is influenced by westerly flow during the whole year. The Mediterranean region is exposed to Siberian high pressure, the Southern Oscillation, the North Atlantic Oscillation

and the Mediterranean Oscillation (Luterbacher and Xoplaki, 2003). The Eastern Mediterranean Basin is subjected to competing and seasonal influences from Southern Asia, Central Africa and Siberia (Reddaway and Bigg, 1996).

Palestine located in the Eastern Mediterranean basin between latitude $34^{\circ}15' - 35^{\circ}40'N$ and longitude $29^{\circ}30' - 33^{\circ}15' E$. It is characterized by Mediterranean type of climate (see Map 1).



Map 1. Location of Palestine

The major synoptic systems that prevail over the Eastern Mediterranean during summer are the Azores subtropical anticyclone and the southwest Asian heat. In summer season, the region experiences warm and dry conditions linked to the presence of a strong high-pressure ridge extending eastwards from the Azores subtropical anticyclone (Lolis, et al., 2002). Mediterranean winter season is characterized by cyclonic disturbances and low mean sea-level pressure with higher values in the east associated with

extension of the Siberian anticyclone.

Palestine is normally incorporated as part of the atmospheric analysis of the whole European and the Middle East (Kutiel and Kay, 1992), or as part of the whole European Mediterranean sector (Sahsamanoglou and Makrogiannis, 1992) (Makrogiannis and Sahsamanoglou, 1992) (Palutikof, et al., 1994) (Reddaway and Bigg, 1996) (Lolis, et al., 2002) (Klein Tank, et al., 2002) and (Garcia, et al., 2003).

Kutiel and Key (1992) discussed variations of summer atmospheric circulation in the Eastern Mediterranean in the period 1951-1971, and linked these to variations of summer climate. They found a decreasing pressure of the subtropical high pressure belt over the Sahara Desert (Garcia, et al., 2003) and applied two methods to analyze the predictability of temperature over the greater Mediterranean area. (Makrogiannis and Sahsamanoğlu, 1992) studied the trends of mean monthly temperature at the 1000/500hPa layer for the period 1945-1988 in the area 30-70°N and 30°W-40°E, they found that most of the area is characterized by a positive trend. The mean temperature of surface/500hPa layer over the Mediterranean exhibited a positive trend due to horizontal thermal advection and adiabatic warming. (Hasanean, 2004) investigated the spatial and temporal variability of Egypt winter temperature stations in 1901-2000. He found a remarkable upward trend in the last twenty years.

Most stations in the Central Mediterranean area showed very clear cooling or relative stability trends from at least the early 1950s to about the mid-1970s, followed by a strong warming trends since 1976 (Pirazzoli and Tomasin, 2003). (Palutikof, et al., 1994) used four general circulation models to estimate scenarios of the Mediterranean potential evapotranspiration per 1°C rise in global mean temperature caused by the enhanced greenhouse effects. The largest change and the greatest variability are found in summer with the greatest increase.

Data and Methodology

The aim of the research is to detect the variation of Palestine temperature in the last century, and to show whether it was affected by the recent warming conditions that have been taking place in different parts of the globe in the last century.

Temperature is a continuous variable and in most regions it tends to be normally distributed (Jones and Hulme, 1996). It is also apparent that the length of the series and its start and end dates are critical in determining whether trends can be detected. So it is easier to detect trends in long time series. Monthly, seasonal and annual averages of Palestine historical temperature data (1901-2000), were obtained from Climatic Research Unit, University of East Anglia, UK. The temperature data is a gridded data of high spatial and temporal resolution that are also continuous over the space time domain of interest (New, et al 2000), at a 0.5 degree latitude by 0.5 degree longitude grids resolution over the area (Mitchell, et al., 2004).

Kernel smoothing method is used to study temperature variations with time (Brazdil, et al., 1996) and (El-Kadi, 2007). In estimating linear regression line, we have used the simple least squares solution with time as the independent variable and the temperature as the dependent variable (Turkes, et al., 1996).

Least square linear regression equations were used repeatedly in climatic research. As examples; it has been used to detect warming/cooling rates (Turkes, et al., 2002), to detect climatic change

(Hodgkins, et al., 2002), to investigate the temperature records (Box, 2002) and to identify linear models for estimating average temperatures (Moberg, et al., 2003).

The coefficient of regression is multiplied by the number of years to indicate the magnitude of change over the period (Box, 2002). The temperature record (1901-2000) was then divided into two equal subgroups and the T-Test of the difference of the mean temperature between 1901-1950 and 1951-2000 was applied to evaluate the significance of the change in the temperature. The correlation coefficient between temperature and time was also calculated.

Discussion

Monthly Temperatures

In this section we investigated the trend and variability of the monthly mean temperature of Palestine in the last century. The monthly time series

are shown in Figure (1). The monthly average temperature of the two periods, their differences and the significance level of the T-test are shown in Table (1). The monthly linear trends of 1901-2000 and their significance levels are listed in Table (2).

January was characterized by a warming trend from the beginning to around mid 1950s, followed by a weaker cooling trend to around early 1980s. From then after there was a warming trend (Figure 1).

In January negative trends were observed in the Eastern Mediterranean in the period 1945-1988 (Makrogiannis and Sahsamanoğlu, 1992). The mean of 1901-1950 was warmer by 1.27°C. The T-test of the difference of the mean is significant at 0.006 (Table 1). A significant positive linear trend of +1.2°C at 0.01 was found in the whole period of the last century (Table 2).

Months	Average Temperature		Difference. Warming(+)Cooling(-)	T-Test Significance level
	1901-1950	1951-2000		
January	10.78	11.51	+1.27	0.006
February	11.64	12.24	+0.6	0.05
March	13.8	14.2	+0.4	No sig.
April	17.31	18.13	+0.82	0.002
May	21.2	21.42	+0.25	No sig.
June	23.6	24.32	+0.72	0.001
July	25.6	26.15	+0.55	0.01
August	26.17	26.59	+0.42	0.02
September	24.7	24.9	+0.2	No sig.
October	22.06	22.11	+0.05	No sig.
November	17.54	17.26	-0.28	No sig.
December	12.77	13.04	+0.27	No sig.

Table 1. Average monthly temperature of the two sub-periods, the average differences and the significance level of the T-test between the two periods (1951-2000 minus 1901-1950).. The + and – marked the warming and the cooling of the last period in reference to the first. (No sig.= no significant differences)

February shows a relatively stable condition around the average temperature throughout the whole series, with a general tendency to be cooler from mid 1970s onward (Figure 1). The latter period is warmer by 0.6°C. The T-test of the difference between the two periods is significant at 0.05 (Table 1). No significant trend was detected in the whole period (Table 2). February negative linear trend from 1970 was -0.57, but it is not statistically significant.

March shows similar pattern to February, with no significant trend found in the last century. The later period

is warmer by +0.4°C., however non significant differences do exist (Table 1). There was a gradual decrease of temperature from around 1970s to the end of the last century in both February and March (Figure 1).

Negative non significant linear trend of -0.98 was found from 1970 onward. Linear trend of +0.55°C was found in the whole period, but it was not statistically significant (Table 2).

April shows a warm period from the start to the end of the last century, interspersed by relative stability from early 1940s to early 1970s. This started to increase strongly from then onward (Figure 1). Linear trend of +1.85°C in the whole period was significant at 0.001 (Table 2). The latter period 1951-2000 was warmer by +0.82°C. The T-Test of the difference of the means was significant at 0.002 level of significance (Table 1).

Table 2. Linear trend of monthly temperature and the significance (sig.) level for the period 1901-2000.

Linear Trend of 1901-2000		
Months	Trend +/-	Significance Level
January	+1.2	0.01
February	+0.73	No sig.
March	+0.55	No sig.
April	+1.85	0.001
May	+1.12	0.01
June	+1.53	0.001
July	+1.24	0.001
August	+0.85	0.01
September	+0.46	No sig.
October	+0.25	No sig.
November	0.16	No sig.
December	+0.47	No sig.

May was characterized by a warm period from 1900s to mid-1930s, which decreased from then to early 1980s (Figure 1). Strong warming commenced from early 1980s onward with a trend of 1.9°C significance at 0.03. Linear positive trend of $+1.12^{\circ}\text{C}$ in the whole period was significant at 0.01 (Table 2). The latter period was warmer by 0.25°C (Table 1). No statistical differences exist between the two periods.

June showed a strong warming trend throughout the whole period, interspersed by a general cooling from mid 1960s to early 1980s, from then it later became warmer, especially from mid 1980s onwards (Figure 1). A positive trend of 1.32°C from 1980 onward was significant at 0.001. A positive linear trend of 1.53°C in the whole period was significant at 0.001 (Table 2). The means of the two periods were 23.60 and 24.32°C respectively. The later period is warmer by $+0.72^{\circ}\text{C}$, which is highly significant at 0.001 level of significance (Table 1).

July showed a similar pattern to June with much strong warming from mid 1970s onward (Figure 1). The linear trend of 1.24°C for the whole period was significant at 0.001 (Table 2). The latter period is warmer by 0.55°C , which is significant at 0.01 (Table 1). The positive trend of 1.61°C from 1980 onward was significant at 0.01

August was warm from 1900s to mid 1950s followed by much stronger cooling to mid 1970s and followed by strong warming trend from then after (Figure 1). August showed an overall warming trend from the beginning to the end of the last century. Linear trend of $+0.85^{\circ}\text{C}$ in the whole period was** something ***significant at 0.01 (Table 2). The cold from late 1960s to mid1980s in August was not predicted in the previous months.

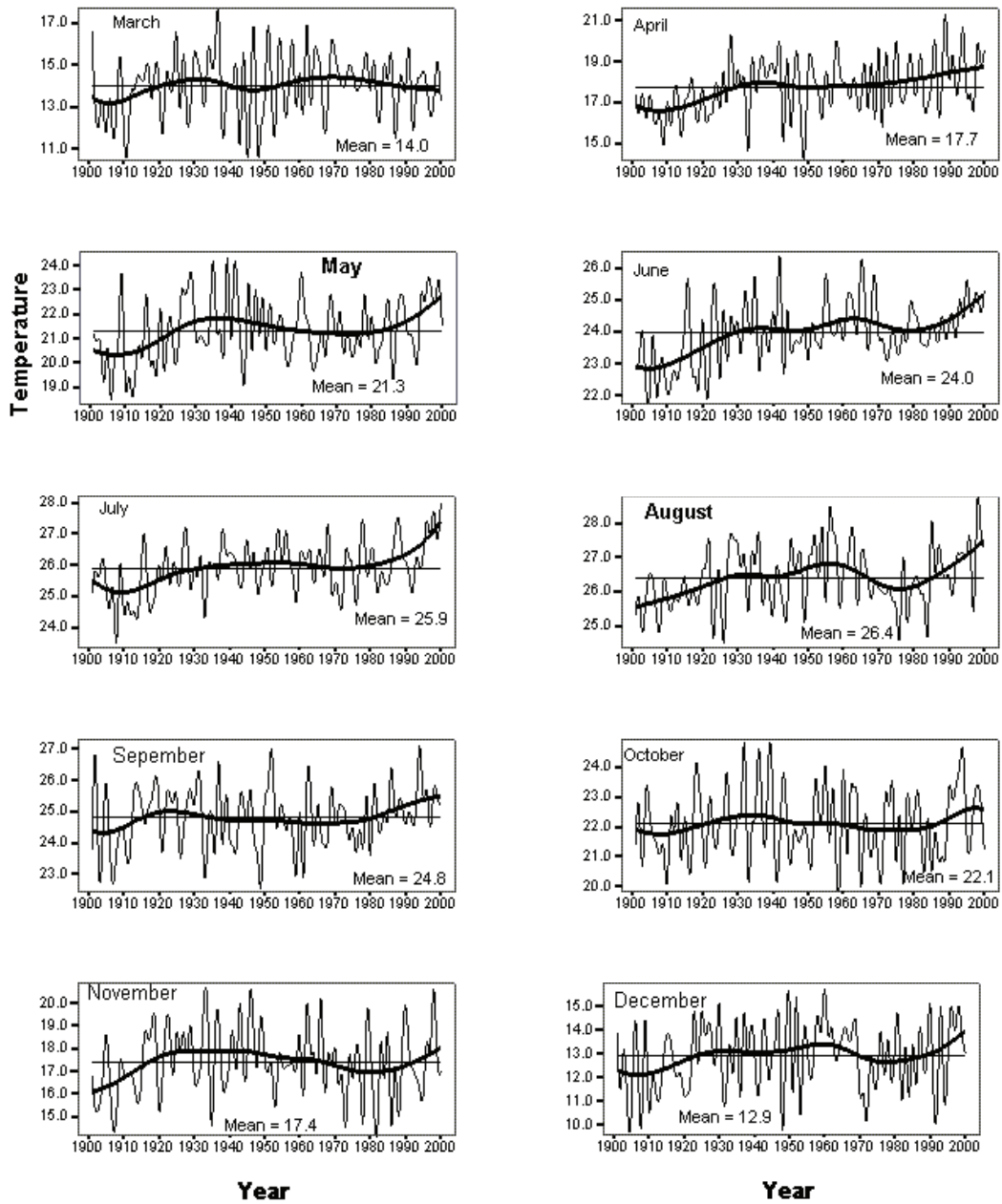


Figure 1. Actual and smooth curves of the monthly mean temperature for Palestine (1901-2000)

The warming from mid 1940s to mid 1960s was only evident in January, June and August. The later period was warmer by 0.42°C. The difference is significant at 0.02 level of significance (Table 1). The linear trend of +1.49°C from 1980 onward was significant at 0.03.

September showed different characteristics. It was relatively warm to mid 1920s, and then stationary around the average from mid 1920s to early 1980s, with warming trend from mid 1980s onwards (Figure 1). A warming trend of 0.86°C was found from 1980 onward. The linear trend of September in the last century was not significant (Table 2). The later period was warmer by 0.2°C, thus no significant difference exists between the two sub-periods (Table 1).

October shows a similar characteristic pattern to September (Figure 1). No statistically significant linear trend was evident in the last century (Table 2). A trend of 1.1°C was found from 1980s onward. At the same time no statistically significant difference existed between the two sub-periods (Table 1).

November showed a similar characteristic pattern to September and October. Warm prevailed from 1900s to late 1920s, declined to mid 1980s and from then after the temperature increased (Figure 1). A warming trend of +1.6°C was found from 1980 onward. The coldness from 1920s to mid 1980s was also evident in August, October and December. The linear trend was not significant in the whole period (Table 2). It is interesting to find that the period 1951-2000 was cooler than the 1900-1951 by -0.28°C (Table 1),

however, it is without statistical significant differences (Table 1). The negative trend of 1951-2000 relative to 1901-1950 was not predicted in the previous months.

December shows similar characteristic patterns to November with weak warming conditions from mid 1960s to 1980s (Figure 1). No statistical significance trend was found in the whole century (Table 2). The means of the two periods were 12.77 and 13.04°C respectively. The later period was warmer by 0.27°C, but it was not statistically significant (Table 1). An insignificant linear trend of +0.7°C was detected from mid 1980 onward.

September, October, November and December show cooling similarities from around mid 1930s to the early 1980s, while from mid 1980s onward the warming prevails with varying starting years.

The monthly temperatures show similar characteristic patterns of warming in the early and in the last recent decades, but with different endings. The ending periods ranged from 1920s in some months to 1930s in others. Temperature trends are not necessarily the same for different months, decreasing or increasing (Menzel, et al., 2003). A relatively continuous cold trend characterized the months of May, July, September, October and November.

Seasonal Patterns

In the last decades of the last century, strong warming prevailed with different starting decades. The warming started from 1960s/1970s, but it was stronger from around 1980s onwards (Figure 2).

Winter warming trends continue from 1900s to late 1960s, and then decreased to mid 1980s. Warming was then initiated from then to the end of the last century (Figure 2). Winter months in the period 1976-1999, were characterized by rapid warming (Klein Tank, 2002). The means of the two periods were 11.74 and 12.24°C respectively (Table 3). The later period was warmer by 0.5°C, which is statistically significant at 0.02. Linear warming trend of +0.95°C in the whole period was significant at 0.01 (Table 4).

The significant positive trend of surface air temperature over the Mediterranean, due to winter season is related to an increase of up to 6 hPa/50 years in the pressure data over Europe (Brunetti, et al., 2002), and the winter warming is accompanied by an increase

in the number of warm-spell days (Klein Tank, 2002). The correlation coefficient of winter with time was +0.25 which is significant at 0.01 level of significance.

Spring shows a warming tendency over the whole period (Figure 2). Spring is generally characterized by strong warming from the start to mid 1930s, which relatively decreased from mid 1930s to early 1950s. Warming was then resumed to the end of the last century (Figure 2).

Linear trend of +1.18°C in the whole period was significant at 0.001 (Table 4). The later period was warmer by 0.51°C (Table 3). The difference was statistically significant at 0.01.

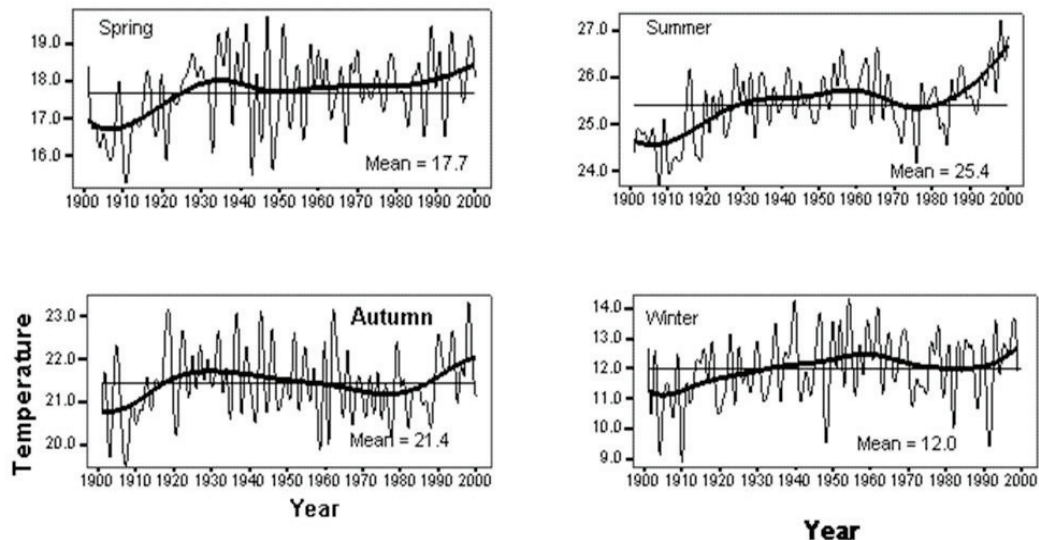


Figure 2. Trends of seasonal mean temperature for Palestine (1901-2000).

Spring is characterized by warm conditions and a southwesterly upper-level flow over the Eastern Mediterranean, whereas wet spring is likely characterized by cooler than average conditions brought on by an anomalous upper-level flow from the European continent and a mean westerly flow lower in the troposphere (Touchan, et al., 2003) Spring warmed by 0.3°C in 1971-2000 relative to the long-term average of 1901-2000.

Spring correlation with time is +0.36 which is significant at 0.001 level of significance. The linear trend indicates that spring was warmed by 1.2°C/100 years, which was significant at 0.001 (Table 4).

Summer season is characterized by a strong warming trend from the start to the end of the last century, interspersed by a weak temperature decline/cold period from 1960s to late 1970s (Figure 2). The warming trend was stronger in the most recent decades from mid 1980s to 2000.

Table 3. Seasonal and annual average temperatures of 1901-1950 and 1951-2000, the difference between the two periods and the significance level.

Seasons	Average Temperature		Difference. Warming(+) Cooling(-)	T-Test Significant level
	1901-1950	1951-2000		
Winter	11.74	12.24	+0.5	0.02
Spring	17.43	17.94	+0.51	0.01
Summer	25.14	26.68	+1.54	0.001
Autumn	21.43	21.42	-0.01	No sig.
Annual	18.94	19.32	+0.38	0.01

From 1975 a linear trend of 1.6°C was significant at 0.001. The summer climate change over the Eastern Mediterranean is likely to be the only local manifestation of a much wider scale, long-term adjustment,

The linear trend of +1.2°C in the whole period was significant at 0.001 (Table 4). The positive trend of 1.49°C from 1980 onward was significant at 0.002. The means of 1901-1950 and 1951-2000 were 25.14 and 26.68°C respectively. The later period is warmer by 1.54°C, this is the highest warming so far, and it is significant at 0.001 (Table 4). The period from mid 1980s to late 1990s was warmer by 0.6°C relative to the long term mean of 1901-2000. Summer mean temperatures have tended to increase at most stations in Turkey (Turkes, et al., 2002).

Summer correlation with time is +0.52 which is statistically significant at 0.000 level of significance. The linear trend showed that, the summer warming in the 1901-2000 amounted to 1.2°C/100 years (Table 4). The trends from the 1950s through the 1970s were towards a more temperate summer climate in the Eastern Mediterranean (Kutiel and Kay, 1992).

of the tropical circulation (Reddaway and Bigg, 1996), and in the period 1970-1988 during summer, there was a positive trend in most of the region with a maximum of 0.5°C/10 years.

Autumn warmed to mid 1930s, decreased to about mid 1970s. The warming started strongly from then onward (Figure 3). The linear trend indicates that autumn warming in the 1901-2000 is estimated to $0.3^{\circ}\text{C}/100$ years (Table 4) and was not significant. The decreasing trend from 1950 to 1980s in autumn temperature, and the warming after, was detected in Turkish Autumn temperatures (Turkes, et al., 2002). At

the same time no statistical significant difference existed between the two sub-periods (Table 3).

(Kleinberg and Moberg, 2003) reported that in Sweden after around 1940 there was a strong cooling trend until about 1970. The same results may be shown in Autumn, September, October, November, April and May in Palestine (see Figures 1 and 2). Meanwhile a positive trend of 1.18°C from 1980 onward was significant at 0.01.

Table 4. Seasonal and annual linear trends for the period 1901-2000 and the level of significance.

Linear Trend of 1901-2000		
Seasons	Trend +/-	Significance level
Winter	+0.95	0.01
Spring	+1.18	0.001
Summer	+1.2	0.001
Autumn	+0.3	No sig.
Annual	+0.9	0.01

Annual Pattern

The annual trend showed strong warming from the early century to late 1950s. This was followed by a decreased trend from early 1960s to early 1980s. From then after, a strong warming trend started (Figure 3). The Northern Hemisphere experienced cooling from 1964 to 1975 (Turkes, et al., 2002). In the annual temperature (Figure 3), it is noteworthy to see that the warmest year was 2000, and the warmest years have all occurred in the last 10 years 1990-2000. This is also seen in both the Northern Hemisphere and global temperatures discussed by (Folland, et al., 2002). In much of Europe the recent decades have

been approximately the warmest of the instrumental period. There has been an increasing warm extreme since 1990s (IPCC, 2007).

The means of the 1901-1950 and 1951-2000 were 18.94 and 19.32°C . The latter period was warmer by 0.38°C . The difference is significant at 0.01 level of significance (Table 3). A positive trend of 1.1°C was found from 1980 onward and significant at 0.002.

Annual correlation with time is $+0.42$ which is significant at 0.001 level of significance. The linear trend indicates that the annual warming of 1901-2000 is estimated to $0.9^{\circ}\text{C}/100$ years and was significant at 0.01 (Table 4).

(Jung, et al., 2002), examined South Korean temperatures since 1954, found a warming trend at a rate of 0.23°C per decade⁻¹ in the past four to five decades in the last century and there has been an abrupt increase since mid-1980s.

(Marshall, et al., 2002) examined Antarctic Peninsula troposphere temperature changes, and found statistically significant warming of 1.0 to 1.4°C in 1956-1999. There was a quite large rise in the mean seasonal and annual air temperatures in the Arctic from mid 1990s, the last 5 years being the warmest since 1950, by 1.0°C above the 1950-1990 average (Przybylak, 2002).

However, it can be concluded that the annual temperature pattern is characterized by a consistent rise of temperature throughout the whole series (Figure 3).

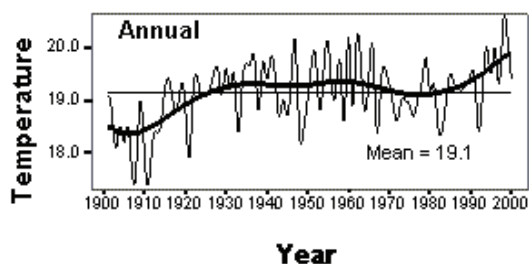


Figure 3. Trend of annual mean temperature for Palestine (1901-2000).

Palestine Temperature (1901-2000) and the 20th Century Warming

The monthly temperature variability and changes in Palestine showed consistent features of the strong warming that started in the last decades of the last century. The months indicate different starts and endings of the warming prior to

or around 1980s. The magnitudes of the trends are different in different months. The warming of the first decades of the last century is evident in all months. The warming was intensified from about 1980s, which is similar and consistent with those observed in the global temperature and in different countries around the world. The cold period was found generally in the mid periods of the last century in the seasonal patterns, similar to the monthly curves.

It can be said that the warming trend started from the early century to around mid 1930s in the seasonal patterns, with relative coldness to around 1970s in summer, autumn and winter. The warming was strongly intensified from around 1980s onward, mostly stronger in the summer season (Figure 2). A similar period of winter warming and cooling was found in Egypt winter temperature (see Hasanean, 2004).

Seasonal average temperature showed warming trends in the last decades of the last century and the warming was stronger from 1980s onward.

The annual temperature patterns indicate a warmness trend from the start of the last century to the mid 1950s (Figure 3), similar to the summer and winter patterns. Then it weakly declined to the around early 1980s, as noticed in the seasonal patterns of summer, autumn and winter. The relative decline of this period was indicated in other climatic researches in the Eastern Mediterranean area (Repapis and Philandras, 1988) (Metaxas, et al., 1991) (Sahsamanoglou and Makrogiannis, 1992) and (Reddaway

and Bigg, 1996). The trend of warming then intensified from around 1980s to the end of the last century, consistent with the seasonal patterns.

Most researches dealing with temperature change and variability indicated a warming climate, but with different trends and magnitudes. Most stations in Italy show very clear cooling or relative stability trends from at least the early 1950s to about the mid 1970s, followed by a strong warming trend since 1976 (Pirazzoli, and Tomasin, 2003).

Using a least-square linear regression the significant warming trends of Turkey annual temperature rates between 0.07 and 0.34°C (Turkes, et al., 2002) and during the 1980-1990s, we had the highest global mean annual temperature. (Gil-Alana, 2003) analyzed Central England temperature for the period 1659-2001, and found that the temperature warmed by about 0.25°C per century. Most researches had detected a turning point of temperature change or jump in the 1980s followed by an abrupt increasing of temperature in global scale or in regional ones (see Figures 2 and 3).

(Brazdil, et al., 1996) reported that the existence of change points signals two significant different means during 1951-1990. The change point around 1987 can signal important warming intensification of the 1980s to early 1990s, well recognized in most central European temperature series. Another change point appears in many series around 1965. Similar characteristic patterns are also observed in Palestine (Figures 2 and 3).

(Turkes, et al., 2002) examined

Turkish stations temperature in different regions during 1929-1999, and concluded that a statistically significant warming was detected with varying starting and ending periods. At some stations the trend is found in the late 1950s and early 1950s, and in many of them the significant warming begins immediately after early 1960s or in the early mid 1970s to the end of the last century, with significant positive trends in Turkish Mediterranean region.

The most consistent feature of the analysis of southwest North America temperature was the post-1970s warming trends (Englehart and Douglas, 2003). Domonkos, et al., (2003) discussed extreme temperature events in South-Central Europe during the period 1901-1998. The rate of the temperature mean over South-Central Europe was more than 1.5°C/100 years for the whole period and was more than 4°C/100 year in the last 50 years. Most of Europe experienced an increase in temperature of about 0.6°C, on average, in the 20th century and the period 1976-1999 displayed an intensive warming over most of Europe, the increase of annual mean was between 0.25-0.5°C (IPCC, 2001).

South Africa mean temperature was warmed by 1.13°C over the period 1885-1993, and the most rapid warming was from 1970 onward (Hughes and Balling, 1996). Hong Kong temperature was rising by about 0.15°C in the period 1947-1999 (Ding, et al., 2002). (Choi, et al., 2003) found that the increasing trends in the annual mean temperature of South Korea in the period 1968-1999 resulted from persistent positive anomalies since the

late 1980s, which increased more quickly after 1980s (Jung, et al., 2002). The late winter early spring air temperature warming of New England since 1850 has increased by about 1.5°C (Hodgkins, et al., 2002).

The 1990s are likely to have been the warmest decade of the past 1000 years over the Northern Hemisphere as a whole (Folland, et al., 2002). The onset of climatic change in the North Atlantic and the European sector was identified in the decade 1981-1990. Started in the early 1970s (Werner, et al., 2000), a significant part of this warming is likely due to anthropogenic emissions of greenhouse gases (Moberg, et al., 2003) and (IPCC, 2007).

(Klingbjør and Moberg, 2003), concluded that the warming trend of Sweden annual temperature observed between 1802 and 2001 is 1.97°C in the whole period, and all the four seasons show a warming trend throughout the series. The warming was then set again from 1970s to the end of the series. Advection of temperature suggests that changes in circulation induce a warming on the low and mid troposphere and a cooling in the upper atmosphere has been enhanced in the last 40 years, 1958-1998, consistent with the greenhouse warming (Gimeno, et al., 2003).

The rate of global and hemispheric warming in land-surface atmospheric temperatures from 1976 to 2000 was about twice as fast, but inter-annually more variable, than that for the period from 1910 to 1945 (Houghton, et al., 2001). The negative phase of the SST in the Eastern

Mediterranean in the last 40 years is associated with prevailing westerlies over the whole Mediterranean. This leads to the formation of depressions over the Central Mediterranean causing warm advection over the Eastern Mediterranean parts (Lolis, et al., 2002). Indeed, prior to about 1930 the solar and volcanic activity were the major forces of the climate systems. These two forces are clearly unable to induce the rapid warming observed after 1970. The resurgence of volcanic activity combined with a decreasing solar output allows one to offset and overcome the greenhouse warming signal during some years. In this way we can easily explain the cooling trend exhibited in the Northern Hemisphere during the period from 1950s through to the early 1970s (as shown in the annual Figure of Palestine), and the rapid warming after 1970s is the response to accelerate greenhouse warming and slower rate of increase in cooling from sulphate aerosols (Bertrand and van Ypersele, 2002). Model simulation of the temperature responses to natural and anthropogenic forces indicated that the first century warming was naturally induced, whereas the most recent warming of the last century was the response to the increase level of the greenhouse gases (IPCC, 2001), (Bertrand and van Ypersele, 2002) and (Károly and Wu, 2005). The analysis of Greenland historical temperature 1873-2001 (Box, 2002), indicated a general period of warming from 1984 to 2001, and cooling from 1955 to 1984, while over 1991-2000 statistically significant warming of 2-4°C was observed in western Greenland, and 1.1°C in the ice sheet summit.

(Leite and Peixoto, 1996), found a general trend of 0.6°C warming over Portugal during 1856-1994, and the 1980s-1990s were the most warming decades in the record. Kysely (2002) discussed heat waves of Czech Republic using daily temperatures of the period 1901-1997. The heat waves showed two maxima in the 1940s to early 1950s and in the 1990s. In the 1980s and 1990s unusually hot summer recurred over continents of the Northern Hemisphere mid-latitude and severe heat waves occurred in the 1990s in Prague.

The warming of Palestine in the whole period of analysis (1901-2000) is consistent with various researches outlined above. Moreover the strongest warming of the globe and of different countries and regions is also in accord with Palestine temperature. However, regional differences may exist. However, it must be noted that different periods of investigation strongly influence the resulting trends (Brazdil, et al., 1996).

Conclusion

In most months, the temperature was relatively cold from around 1930s to late 1970s/early 1980s, whereas from early/mid 1980s onwards the temperature increased steadily and warming prevailed.

Annual temperature has increased by 0.9°C in the last century and warmed by 1.1°C, from 1980 onward. Seasonal patterns are characterized by positive trends in the whole series. The trends ranged from 1.2°C for spring and summer to 0.29°C and 0.95°C for autumn and winter respectively. The seasonal trends

except autumn were significant at 0.01 or more (Figure 2).

The warming trend was particularly obvious from around 1980s and the warmest period of the last century was clustered in the 1990s.

It is interesting to note that the monthly, and particularly the seasonal and annual time series of the temperature of Palestine showed similar patterns to the Global and Northern Hemisphere temperature trends discussed by Parker and Alexander (2001, 2002) and Horton, et al., (2003). However, regional temperature trends over a few decades can be strongly influenced by regional variability in the climate system and can depart from a global average (IPCC., 2001).

It is difficult to achieve attribution of all or parts of a climate change to a specific cause, due to uncertainties in natural internal variability and in the histories and magnitude of natural and human-induced climate forces, so that many possible force combinations could yield the same curve of observed global and hemispheric mean temperature change (Bertrand and van Ypersele, 2002).

In the light of new evidence and taking into account the remaining uncertainties, most of the observed warming over the last 50 years is likely to be due to the increase in greenhouse gas concentrations (Houghton, et al., 2001) and (IPCC., 2007), whereas the early century warming is usually regarded as a manifestation of the natural effects (Meehl, 2004) and (IPCC, 2007), and recent climatic change could not be explained by natural variability alone and was consistent with

the response to anthropogenic forces (Hegerl, 2006). The well-known warming from mid 1980s onward was manifested in the temperature of Palestine. From mid 1980s, the annual temperature was warmed by 0.8°C, whereas summer and autumn warmed by 1.1°C. Spring and winter warming trends were 0.53°C and 0.7°C respectively. This confirmed that

the warming from mid1980s was faster than any time before within the 20th century.

Therefore, the results of this paper confirmed that the patterns of trends of Palestine temperature are consistent to those documented in the Global and regional temperature in the last century.

References:

- Allen, M. «Climate of the Twentieth Century: Detection of Change and Attribution of Causes.» *Weather* 57 (2002): 296-303.
- Bamazi, A. S. «Relationship Between Snow Cover Variability and Arctic Oscillation Index on a Hierarchy of Time Scales.» *International Journal of Climatology* 23 (2003): 131-142.
- Bertrand, C. and J.-P. Van Ypersele J.-P. «Transient Climate Simulation Forced by Natural and Anthropogenic Climate Forcing. *International Journal of Climatology.*» 22 (2002): 623-648.
- Box, J. E. «Survey of Greenland Instrumental Temperature Records: 1873-2001.» *International Journal of Climatology* 22 (2002): 1829-1847.
- Brandsma, T. Konnen, G. P and Wessels, H. R. A. «Empirical Estimation of the Effects of Urban Heat Advection on the Temperature series of De Bilt (The Netherlands).» *International Journal of Climatology* 23 (2003): 829-845.
- Brazdil, R. Budikova, M. Auer, I. Bohm, R. Cegnar, T. Fasko, P. Lapin, M. Gajic-Capka, M. Zaninovic, K Koleva. E. Nienzwiedz, T. Ustrnul, Z. Szalai, S. and Weber, R. O. «Trends of the Maximum Daily Temperatures in the Central and Southeastern Europe.» *International Journal of Climatology* 16 (1996): 765-782.
- Brunetti, M. Maugeri, M. Nanni, T. «Atmospheric Circulation and Precipitation in Italy for the Last 50 Years.» *International Journal of Climatology* 22 (2002): 1455-1471.
- Choi, Y. Jung, H-S., Nam, K-Y. and Kwon, W-T. «Adjusting Urban Bias in the Regional Mean Surface Temperature Series of South Korea, 1968-99.» *International Journal of Climatology*, 23 (2003): 577-591.
- Comiso, J. C. «Arctic Warming Signals from Satellite Observations.» *Weather* 61 (2006): 70-76.
- Ding, X. Zheng, D. and Yang, S. «Variations of the Surface Temperature in Hong Kong during the Last Century.» *International Journal of Climatology*, 22 (2002): 715- 730.
- Domonkos, P., Kysely, J., Piotrowics, K. Petrovic P. and Likso, T. «Variability of Extreme Temperature Events in South-Central Europe During the 20th century and its Relationship with Large-Scale Circulation.» *International Journal of Climatology* 23 (2003): 987-010.
- El-Kadi, A. K. A. «20th Century Rainfall of Palestine: Variability and Trends (1901-2000).» *Bulletin of the Egyptian Geographical Society* 80 (2007): 99-113.
- Englehart, P. and Douglas. A. V. «Urbanization and Seasonal Temperature Trends:

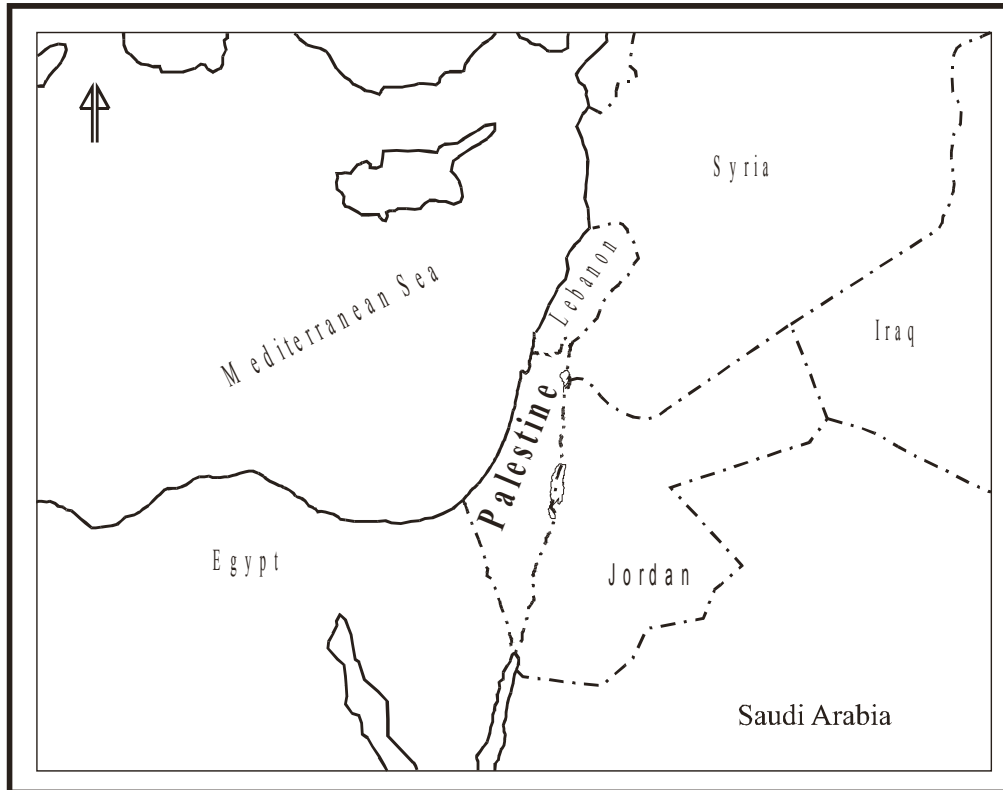
- Observational Evidence from a Data-Sparse Part of North America.» *International Journal of Climatology* 23 (2003): 1253-1263
- Folland, C. K., Karl, T. R., Christy, J. R., Clarke, R. A., Gruza, G. V., Jouzel, J., Mann, M. E., Overlemans, J., Salinger, M. J. and Wang, S.-W. «Observed Climate Variability and Change.» In *Climate Change. The Scientific Basis. Contribution of the Working Group 1 to the Third Assessment Report of the Intergovernmental Panel on Climate Change*, edited by Houghton, et al., Cambridge University Press, UK. 2001.
 - Folland, C. K. Karl. T. R. and Salinger, M. J. «Observed Climate Variability and Change.» *Weather* 57 (2002): 269-278
 - Fowler, H. J. and Kilsby, C. G. «A regional Frequency Analysis of United Kingdom Extreme Rainfall from 1961 to 2000.» *International Journal of Climatology* 23 (2003): 1313-1334.
 - Garcia, R. Munoz, T. Hernandez, E. Ribera, P. and Gimeno, L. «Temperature Predictability in the Great Mediterranean Area.» *Theoretical and Applied Climatology* 75 (2003): 179-187.
 - Gil-Alana, L. A. «An Application of Fractional Integration to a Long Temperature Series.» *International Journal of Climatology* 23 (2003): 1699-1710
 - Gimeno, L. Vidal, O. Nieto, R. Torre, L. D. Garcia, R. Hernandez, E. Bojariu, R. Ribera, P. an Gallego, D. «Impact of the Extratropical Dynamical Modes Upon Tropospheric Temperature Using an Approach Based on Advection of Temperature.» *International Journal of Climatology*, 23 (2003): 399-404.
 - Griffiths, G. M. Salinger, M. J. and Leleu, I. «Trends in Extreme Daily Rainfall Across the South Pacific and Relationship to the South Pacific Convergence Zone.» *International Journal of Climatology*, 23 (2003): 847-869.
 - Griggs, D. and Noguer, M. «Climatic change 2001, The Scientific Basis. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climatic Change.» *Weather* 57 (2002): 267- 269.
 - Haigh, J. «Radiative Forcing of Climate Change.» *Weather* 57 (2002): 278-283.
 - Hasanean, H.M. «Wintertime Surface Temperature in Egypt in Relation to the Associated Atmospheric Circulation.» *International Journal of Climatology*, 24 (2004): 985-999.
 - Hegerl, G.C. Karl, T.R. Allen, M. Bindoff, N.L. Gilletti, N. Karoly, D. Zhang, X. and Zwiers, F. «Climate Change Detection and Attribution: Beyond Mean Temperature Signals.» *Journal of Climate-Special Section* 19 (2006): 5058-5077.
 - Hodgkins, G. A. James II, I. C. and Huntington, T. G. «Historical Changes in Lake

- Ice-Out Dates as Indicators of Climatic Change in New England, 1850-2000.» *International Journal of Climatology* 22 (2002): 1819-1827.
- Horton, E. B. Parker, D. E. and Alexander, L. V. «Global and Regional Climate.» *Weather* 58 (2003): 324-336.
 - Houghton, J. T. Ding, Y. Griggs, D. J. Noguer, M. van der Linden, P. J. Da, X. Maskel, K. and Johnson. «Observed Climate Variability and Change» in *Climate Change. The Scientific Basis. Contribution of the Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change*, edited by Houghton, J. T. et al., Cambridge University Press, UK. 2001
 - Hughes, W. S. and Balling, JR. R. C. «Urban Influence on South African Temperature Trends.» *International Journal of Climatology* 16 (1996): 935-940.
 - IPCC. «Climate Change: The Scientific Basis.» Cambridge University Press, UK. 2001
 - IPCC. «Climate Change: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change». edited by Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. 2007.
 - Jones, P. D, and Hulme, M. «Calculating Regional Climatic Time series for Temperature and precipitation: Methods and Illustrations.» *International Journal of Climatology*, 16 (1996): 361-377
 - Jones, P. D. Raper, S. C. B. Bradley, R. S., Diaz, H. F., Kelly, P. M., Wigley, T. M. L. «Northern Hemisphere Surface Air Temperature Variations: 1851-1984.» *Journal of Climate and Applied Meteorology* 25 (1986): 161-179.
 - Jung, H-S., Choi, Y., Oh, J-H. Lim, G-H. «Recent Trends in Temperature and Precipitation over South Korea.» *International Journal of Climatology* 22 (2002): 1327-1337.
 - Jung, M. M. and Stephenson, D. B. «Mediated and Direct Effects of the North Atlantic Ocean on Winter Temperature in Northwest Europe.» *International Journal of Climatology* 23 (2003): 245-261.
 - Karoly, D. and Wu, Q. «Detection of Regional Surface Temperature Trends.» *Journal of Climate* 18 (2005): 4337-4343.
 - Keevallik, S. «Changes in Spring Weather Conditions and Atmospheric Circulation in Estonia (1955-95).» *International Journal of Climatology* 23 (2003): 263-270.
 - Klein Tank, A. M. G., Wijngaard, J.B. Konnen, G. B. Bohm, R. Demaree, G. Gocheva, A. Mileta, M. Pashiardis, S. Hejkrlik, L. Kern-Hansen, C. Heino, R. Bessemoulin,. Muller-Westermeier, G. Tzanakou, M. SZalai, S. Palsdottir, T.

- Fitzgerald, D. Rubin, S. Capaldo, M. Maugeri, M. Leitass, A. Bukantis, A. Aberfeld, R. Van Engelen, A. F. V. Forland, E. Mielus, M. Coelho, F. Mares, C. Razuvaen, V. Nieplova, E. Cegnar, T. Antonio Lopez, J. Dahlstrom, B. Moberg, A. Kirchhofer, W. Ceylan, A. Pachaliuk, O. Elexander, L. V. and Petrovic, P. «Daily Dataset of 20th Century Surface Air Temperature and Precipitation Series for the European Climate Assessment.» *International Journal of Climatology* 22 (2002): 1441-1453.
- Klingbjør, P and Moberg, A. «A Composite Monthly Temperature Record from Torendalen in Northern Sweden 1802-2002.» *International Journal of Climatology* 23 (2003): 1465-1494.
 - Krzyscin, J. W. «Long-Term Changes in Ozone Mini-Hole Event frequency over the Northern Hemisphere Derived from Ground-Based Measurements.» *International Journal of Climatology* 22 (2002): 1425-1439.
 - Kutiel, H. and Kay, P. A. «Recent Variations in 700hPa Geopotential Heights in Summer over Europe and the Middle East, and their Influence on other Meteorological Factors.» *Theoretical and Applied Climatology* 46 (1992): 99-108.
 - Kysely, J. «Temporal Fluctuations in Heat Waves at Prague-Klementinum, the Czech Republic, from 1901-97, and their Relationship to atmospheric Circulation.» *International Journal of Climatology* 22 (2002): 33-50.
 - Laternser, M. and Schneebeli, M. «Long-term Snow Climate Trends of the Swiss Alps (1931-1999).» *International Journal of Climatology* 23 (2003): 733-750.
 - Leite, S. M. and Peixoto, J. P. «The Autoregressive Model of Climatological Time Series: An Application to the Longest Time series in Portugal.» *International Journal of Climatology* 6 (1996): 1165-1173
 - Lolis, C. J. Bartzokas, A. and Katsoulis, B. D. «Spatial and Temporal 850hPa Air Temperature and Sea-Surface Temperature Covariances in the Mediterranean Region and Their Connection to Atmospheric Circulation.» *International Journal of Climatology* 22 (2002): 663-676.
 - Luterbacher, J. and Xoplaki, E. «500-year Winter Temperature and Precipitation Variability over Mediterranean area and its Connection to the Large-scale Atmospheric Circulation.» in *Mediterranean Climate*, 133-153. edited by Bolle, H-J. Berlin Heidelberg: Springer-Verlag, 2003.
 - Makrogiannis, T. J and Sahsamanoglou, T. J. «Analysis of Mean Temperature Variations at the 1000/500hPa Layer over Europe, 1945-1988.» *Theoretical and Applied Climatology* 45 (1992): 193-200.
 - Marshall, G. Lagun, V. and Lachlan-Cope, A. «Changes in Arctic Peninsula Tropospheric temperatures from 1956 to 1999: A Synthesis of Observations and Reanalysis data.» *International Journal of Climatology* 22 (2002): 291-310.

- Meehl, G.A. Washington, W.M. Ammann, C.M. Arblaster, J.M. Wigley, T.M.L. and Tebaldi, C. «Combinations of Natural and Anthropogenic Forcings in Twentieth-Century Climate.» *Journal of Climate* 17 (2004): 3721-3727.
- Menzel, A. Jakobi, G. Ahas, R. Scheifinger, H. and Estrella, N. «Variations of the Climatological Growing Season (1951-2000) in Germany Compared with other Countries.» *International Journal of Climatology* 23 (2003): 793-812.
- Metaxas, D. A., Bartzokas, A. and Vibras, A.. «Temperature Fluctuation in the Mediterranean Area during the Last 120 Years.» *International Journal of Climatology* 11 (1991): 897-908.
- Mitchell, T.D. Carter, T.R. Jones, P.D. Hulme, M. and New, M. «A Comprehensive Set of High-Resolution Grids of Monthly Climate for Europe and the Globe: The Observed Record (1901-2000) and 16 Scenarios (2001-2100)». Tyndall Centre Working Paper (2004): No 55.
- Moberg, A. Alexandersson, H. Bergstrom, H. and Jones, P. D. «Were Southern Swedish Summer Temperatures Before 1860 As Warm As Measured?.» *International Journal of Climatology* 23 (2003): 1459-1521.
- Mote, T. L. «Mid-Tropospheric Circulation and Surface Melt on the Greenland Ice Sheet. Part I: Atmospheric Teleconnections.» *International Journal of Climatology* 18 (1998): 111-129.
- New, M. Hulme, M. and Jones, P. «Representing Twentieth-Century Space-Time Climate Variability. Part II: Development of 1901-96 Monthly Grids of Terrestrial Surface Climate.» *Journal of Climate* 13 (2000): 2217-2238.
- Palutikof, J. P. Goodess, C. M. and Guo, X. «Climate Change: Potential Evapotranspiration and Moisture Availability in the Mediterranean Basin.» *International Journal of Climatology* 14 (1994): 853-869.
- Parker, D.E. and Alexander, L. V. «Global and Regional Climate in 2000.» *Weather* 56 (2001): 255-267.
- Parker, D. E. and Alexander, L. V. «Global and Regional Climate in 2001.» *Weather* 57 (2002): 328-340.
- Pirazzoli, P. A. and Tomasin, A. «Recent Near-Surface Wind Changes in the Central Mediterranean and Adriatic Areas.» *International Journal of Climatology* 23 (2003): 963-973.
- Pitman, A. J. «The Evolution of, and Revolution in, Land Surface Schemes Designed for Climate Models.» *International Journal of Climatology* 23 (2003): 479-510.
- Przybylak, R. «Changes in Seasonal and Annual High-frequency Air Temperature Variability in the Arctic from 1951 to 1990.» *International Journal of Climatology* 22 (2002): 1017-1032

- Reddaway, J. M. and Bigg, G. R. «Climatic Change over the Mediterranean and Links to the more General Atmospheric Circulation.» *International Journal of Climatology* 16 (1996): 651-661.
- Repapis, C. C. and Philandras, C. M. «A note on the Air Temperature trends of the last 100 Years as Evident in the Eastern Mediterranean time series.» *Theoretical and applied Climatology*, 39 (1988): 93-97.
- Sahsamanoglou, H. S. and Makrogiannis, T. J. «Temperature trends over the Mediterranean region, 1950-88.» *Theoretical and Applied Climatology* 45 (1992): 183-192.
- Serreze, M. C. and Francis, J. A. «The Arctic on the Fast Track of Change.» *Weather* 61 (2006): 65-69.
- Singarayer, J. S. Bamber, J. L. and Valeds, P. J. «Twenty-First-Century Climate Impacts from a Declining Arctic Sea Ice Cover.» *Journal of Climate-Special Section* 19 (2006): 1109-1125.
- Tomozeiu, R. Busuioc, A. Stefan, S.. «Changes in Seasonal Mean Maximum Air Temperature in Romania and their Connection with Large-Scale Circulation.» *International Journal of Climatology* 22 (2002): 12181-1196.
- Touchan, R. Carfin, G. M. Meko, A.M. Funkhouser, G. Erkan, N. Hughes, M. K. and Wallin, B.S. «Preliminary Reconstructions of Spring Precipitation in Southwestern Turkey from Tree-Ring Width.» *International Journal of Climatology* 23 (2003): 157-171.
- Turkes, M. Sumer, U. M. and Kilic, G. «Observed Changes in Maximum and Minimum Temperatures in Turkey.» *International Journal of Climatology* 16 (1996): 463-477
- Turkes, M. Sumer, U. M. and Demir, I. «Re-Evaluation of Trends and Changes in Mean, Maximum and Minimum Temperatures of Turkey for the Period 1929-1999.» *International Journal of Climatology* 22 (2002): 947-977.
- Voss, R. May, W. and Roeckner, E. «Enhanced Resolution Modeling Study on Anthropogenic Climate: Changes in Extremes of the Hydrological Cycle.» *International Journal of Climatology* 22 (2002): 755-777
- Wang, H. Pitman, A. J. Zhao, M. and Leemanas, R. «The impact of Land-cover Modification on the June Meteorology of China since 1700. Simulated Using a Regional Climate Model.» *International Journal of Climatology* 23 (2003): 511-527.
- Werner, P.C. Gerstengarbe F. W. Fraedrich, K. Oesterle, H. «Recent Climatic Change in the North Atlantic/European Sector.» *International Journal of Climatology* 20 (2000): 643-471.
- Zhao, M. and Pitman, A.J. «The Regional Scale Impact of Land Cover Change Simulated With a Climate Model.» *International Journal of Climatology* 22 (2002): 271-290.



Map 1. Location of Palestine