academicJournals

Vol. 5(9), pp. 541-556, September 2013
DOI: 10.5897/IJBC11.006
ISSN 2141-243X © 2013 Academic Journals
http://www.academicjournals.org/IJBC

International Journal of Biodiversity and Conservation

Full Length Research Paper

Variability and trends of air temperature and pressure at Port Said, Egypt, 1978-2008

Nabil, N. N. Saad[1]*, Sharaf El-Din S. H.[2] and Ebtessam E. E. Mohamed[1]

[1]National Institute of Oceanography and Fisheries, Alexandria, Egypt.
[2]Faculty of Science, Alexandria University, Egypt.

Accepted 15 July, 2013

The climatologically records of hourly surface air temperature and pressure collected at Port Said weather land stations during the period from 1978 to 2008 are used to study the long term variability of both parameters. January, December and February were considered the coldest months through the years of the whole period with occurrence of about 65.5, 13.8 and 20.7% values, respectively. In the opposite side, August is considered the hottest month with 82.8% occurrence through all the years while July represented the second hottest month with 17.2% occurrence values. July has a lowest value in pressure with percentage of occurrence 73.3% during the whole period. August advantage of the second grade with percentage of occurrence equal 23.3%. The months of highest values of pressure is distributed from November to March. December and January are considered as highest months of pressure values with percentage of occurrence equal 33.3 and 43.3%, respectively. The existence of any significant trends in the monthly, seasonally and annual patterns of temperature and pressure within the region were studied. Also, inter annual patterns of the surface temperature and pressure was explained by using spectral analysis. Finally, a discussion between the results detected at Alexandria and Port Said was done.

Key words: Port Said, Egypt, air temperature, atmospheric pressure, trend.

INTRODUCTION

Regional climate changes under global warming context are the most important motivations for the Mediterranean regional climate modelling. It is generally agreed that the Mediterranean region is one of the sensitive areas on Earth in the context of global climate change, due to its position at the border of the climatologically determined Hadley cell and the consequent transition character between two very different climate regimes in the North and in the South. The atmosphere over the Mediterranean Sea is subject to both subtropical and mid-latitude weather systems (Flocas, 1984). The surrounding continents also strongly regulate the marine climate in the basin. The Mediterranean climate is thus subject to vaned influences (Jenny and Grant, 1996). Although, this potentially causes it to be sensitive to remote forcing, it also means that competing factors make it difficult to disentangle cause from effect in climatic variation over the basin itself when such variation is not examined in a wider context.

Many scientists have revealed various changes to the Mediterranean climate since the middle of the present century. Repapis and Philandras (1988) show some evidence from land stations for declining temperatures over the south-eastern comer of the Mediterranean during the 1940, 1950 and early 1960s, and the north-eastern region during the 1960 and 1970s. Metaxas et al. (1991) and Sahsamanoglou and Makrogiannis (1992) show that this decrease during the 1960 and 1970s is found in Sea Surface Temperatures (SST) over the entire Mediterranean Sea, although, it was particularly pro-

*Corresponding author. E-mail: nabilelbatikhy@yahoo.com.

nounced in the eastern basin. This decrease is most pronounced in the period prior to 1976; since then some evidence of temperature increase was found, consistent with Repapis and Philandras (1988) and Metaxas et al. (1991). However, Bartzokas and Metaxas (1990) suggest that the increasing northerly wind over the eastern Mediterranean during this later period should have suppressed any temperature rise in this region.

Metaxas et al. (1991) also shows that this trend has been partially reversed during the 1980s west of Greece. The global air temperature data set of Jones has the temperatures of the eastern Mediterranean lower during the 1980s than the 1951 to 1980 average (Folland et al., 1990), and also shows different tendencies between the western and eastern basins.

In the framework of the French national programme GICC-Med. Water, two regionally-oriented atmospheric models, LMDZ-Med (developed in IPSL in Paris) and ARPEGE-Med (developed in Meteo-France in Toulouse), were used to study the Mediterranean climate change for the end of the 21st century (Laurent et al., 2006). Both models showed that temperature and salinity values increased at the end of the 21st century. Gaertner et al. (2007), using an ensemble of regional climate models found an increase in the extremes of tropical cyclone intensity over the Mediterranean Sea under a climate change scenario.

Port Said, situated largely on man-made land, the city was founded in 1859 by the builders of the Suez Canal on a low sandy strip separating the Mediterranean from Lake Manzala, Mud and sand dredged from the harbour and huge artificial stones capable of resisting saltwater action were added to the strip; its breakwaters were completed in 1868, a year before the canal was completed. Port Said geographically is isolated, situated on a low, sandy ground west of the Suez Canal and east of Lake Manzala. The city is situated on the Mediterranean Sea, and at the northern end of the Suez Canal.

The port is about 150 mile from Alexandria, Egypt. The port is situated a couple of miles west of the Port Suez bypass approach channel to the Suez Canal. The coastline in this area is unusually low and flat.

DATA COLLECTION AND QUALITY CONTROL

The datasets of monthly mean surface air temperature and pressure used in this study was collected at Port Said weather land stations during the period from 1978 to 2008. Data missing in some time and homogeneity in some months may occur due to several causes, some of which are related to changes in instrumentation and observation practices, and the others which relate to modification of the environmental condition of the site, such as rapid urbanization. Missed data within 2 or 3 h were linearly interpolated from upper and lower values.

All the hourly data have been assessed for homogeneity using the method described by FAO (1998). Monthly data have also been assessed for errors by identifying peaks exceeding three standard deviations.

MATERIALS AND METHODS

The climatologically records were subjected to several analyses, which included trend, spectral and correlation analyses. Trend analysis examined the existence of any significant trends in the monthly, seasonally and annual patterns of temperature and pressure within the period. Spectral analysis was used to delineate the interannual cycles that are dominant in the various temperature series. Correlation analysis was also used to investigate the potential association between any observed interannual anomalies in the surface air temperature patterns and anomalies in the pressure pattern that control the seasonal climate variability over the region. Several methods were used in the study to determine the existence of any significant trends in the year-to-year patterns of temperature and pressure over the area of study. The techniques used included graphical and statistical techniques. The graphical methods displayed the visual patterns of the mean interannual trends of the respective temperature and pressure records. A five-term moving average filter was used to smooth the interannual temperature trends. The most objective trend analyses in this study were however based on the analysis of variance approach and the nonparametric Spearman rank correlation statistic (Kendall et al., 1961).

Spectral analysis delinseated the major cycles in the interannual patterns of the temperature and pressure values over the region of study. Details of the maximum entropy method of spectral analysis that was used in this study may be found in Kendall et al. (1961) and Kay and Marple (1981) among others.

Observed temperature and pressure trends

A linear trend analysis for 1987 to 2008 over Port Said area was performed on two variables: air temperature and pressure. The air temperature and pressure anomalies analysis was done on each individual month of the winter (December, January and February) and summer (June, July and August). Spring and autumn months were also considered.

RESULTS AND DISCUSSION

Preface

The time series of the monthly mean of air temperature and air pressure values during the period from 1978 to 2008 are shown in Figures 1 and 2. The daily mean temperature values were fluctuated between 12.299 and 28.395°C. The lowest values were detected during January 1983 while the highest one during July, 2002. Ebtessam and Beltagy (2009) found that the minimum and maximum daily mean air temperature at Alexandria was 7.2 and 33.0°C during January 1981 and May 1970. Whatever, Hamed (1983) declared the minimum mean temperature of 13.7°C and the maximum mean temperature of 26.1°C during January. Hamed (1983) calculation was based on 30 years hourly data over the Southeastern

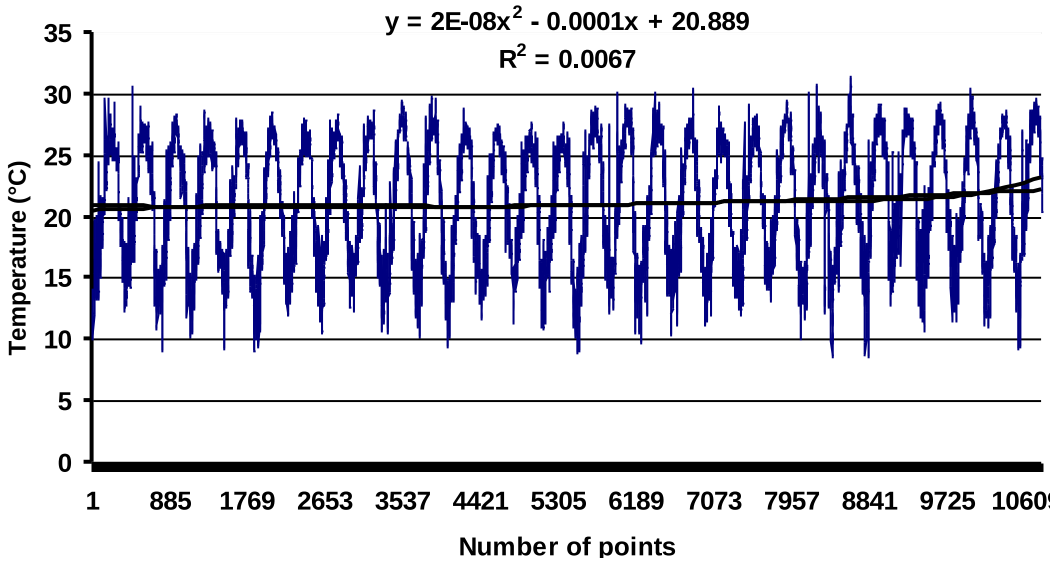

Figure 1. Time series of average daily temperature values during the period from 1978 to 2008.

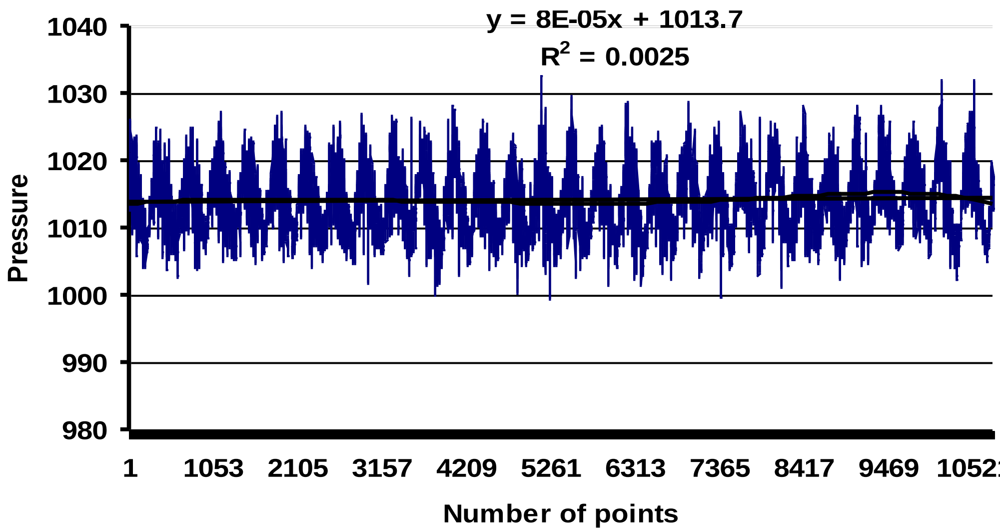

Figure 2. Time series of average daily pressure values during the period from 1978 to 2008.

of the Mediterranean in the period from 1951 to 1980. The pressure values were ranged from 1010.1 mb during July 2005 to 1023 mb during June 2007. There is a linear trend in the mean daily air temperature (Figure 1) which seems to represent a general trend of increase in air temperature with time. At pressure, the linear trend exists also with small evidence compared with temperature (Figure 2). The mean monthly values of air temperature and air pressure through all the period (Figures 3 and 4) declared that the highest values of temperature were detected at the warm seasons while the lowest values exists at cold seasons. This pattern was inversed completely in pressure. The high values were recorded at the cold seasons while the lowest values were detected at warm ones.

In general, January is considered the coldest month through the years of the whole period with occurrence of about 65.5% (Figure 5). Also, December and February is detected as coldest month with 13.8 and 20.7% values, respectively. In the opposite side, August is considered the hottest month with 82.8% occurrence through all the years (Figure 6) followed by July, represented the hottest month with 17.2% occurrence values. July has a lowest value in pressure with percentage of occurrence 73.3% during the whole period (Figure 7). August advantage was the second grade with percentage of occurrence

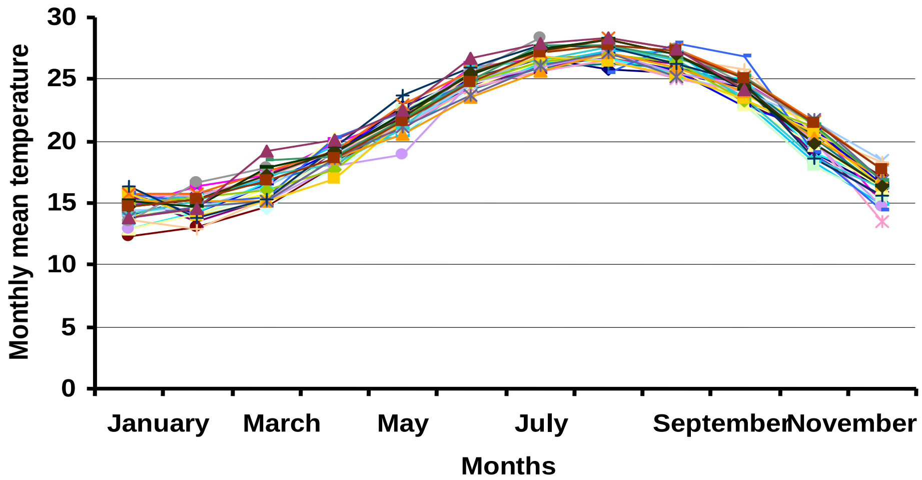

Figure 3. Mean monthly air temperature in the period from 1978 to 2008.

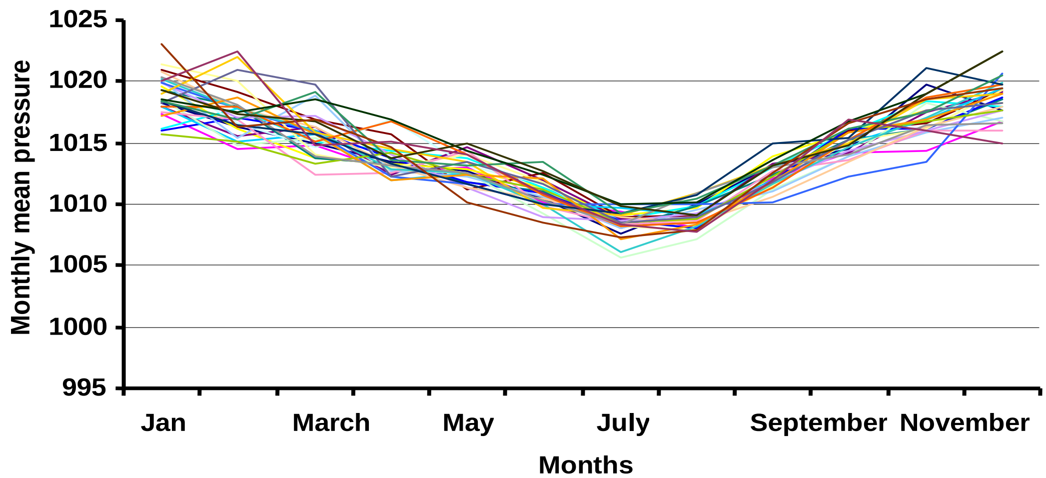

Figure 4. Mean monthly pressure in the period from 1978 to 2008.

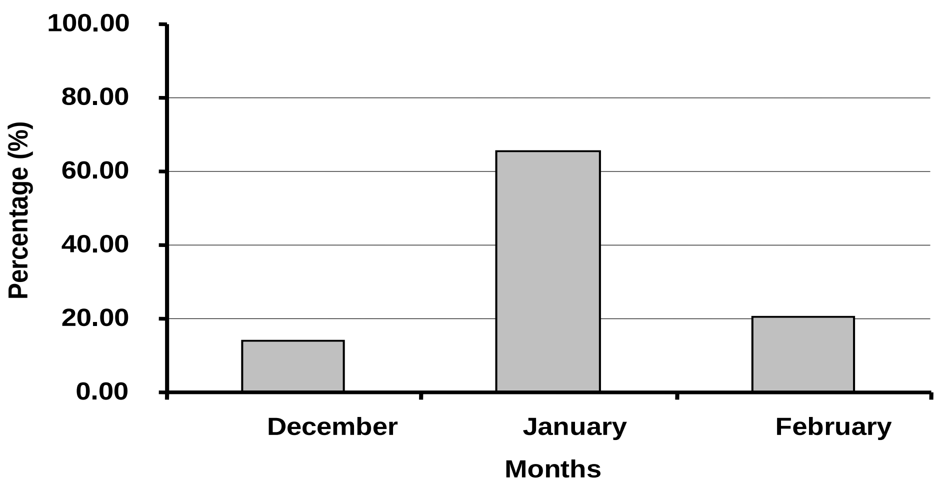

Figure 5. Percentage values of occurrence of lowest air temperature during the period from 1978 to 2008.

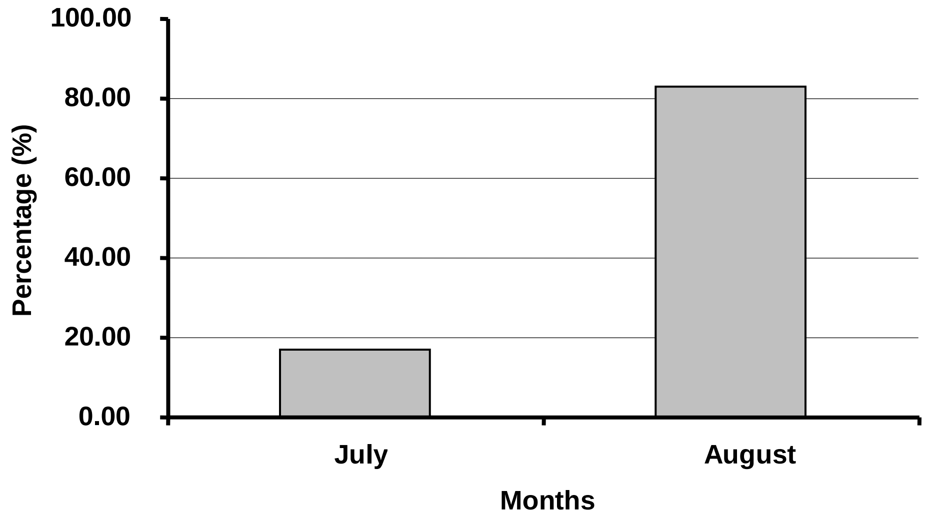

Figure 6. Percentage values of occurrence of the highest air temperature during the period from 1978 to 2008.

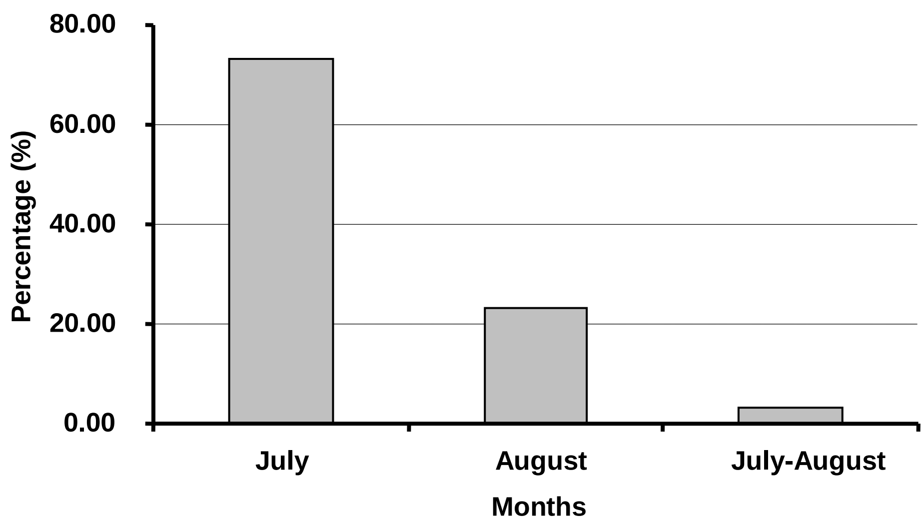

Figure 7. Percentage values of occurrence of the lowest values of pressure during the period from 1978 to 2008.

equal 23.3%. Figure 8 represents the highest percentage values during all the period. The months of highest values of pressure is distributed from November with percentage of occurrence 10% to March with percentage of occurrence equal 3.3%. December and January are considered as highest months of pressure values with percentage of occurrence equal 33.3 and 43.3%, respectively. Minimum, maximum and mean values of mean monthly air temperature and pressure are illustrated in Figures 9 and 10. The minimum values (12.299°C) of air temperature is detected during January 1983 and the maximum ones (28.395°C) is observed at July 2002. The minimum value of pressure (1005.6 mb) is detected at July 1988 while the maximum (1023.1 mb) is observed at January 2007.

Minimum, maximum and mean annual values of air temperature and pressure at Port Said area (Figures 11 and 12) declared a linear trends and warming evidence are existed in both parameters.

Monthly trends

The composite time series of monthly mean air temperature and pressure anomalies during the three months represent cold period (December, January and

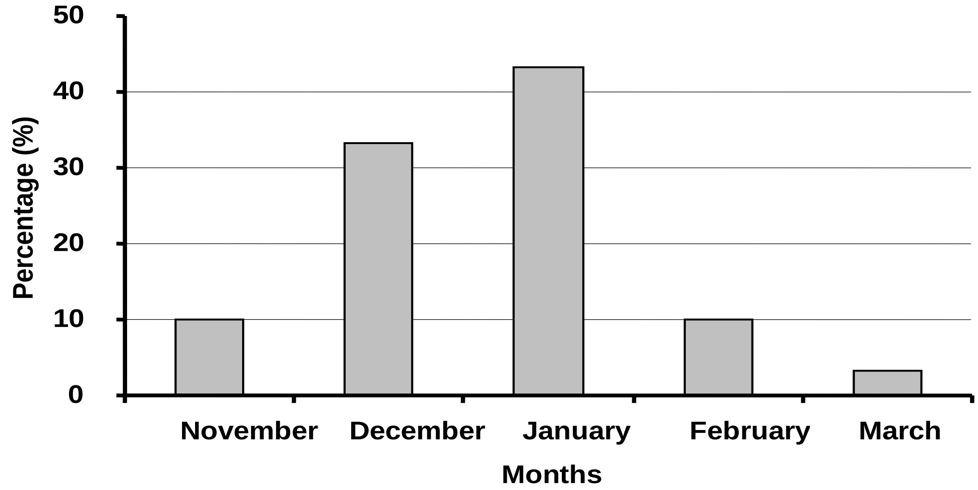

Figure 8. Percentage values of occurrence of the highest values of pressure during the period from 1978 to 2008.

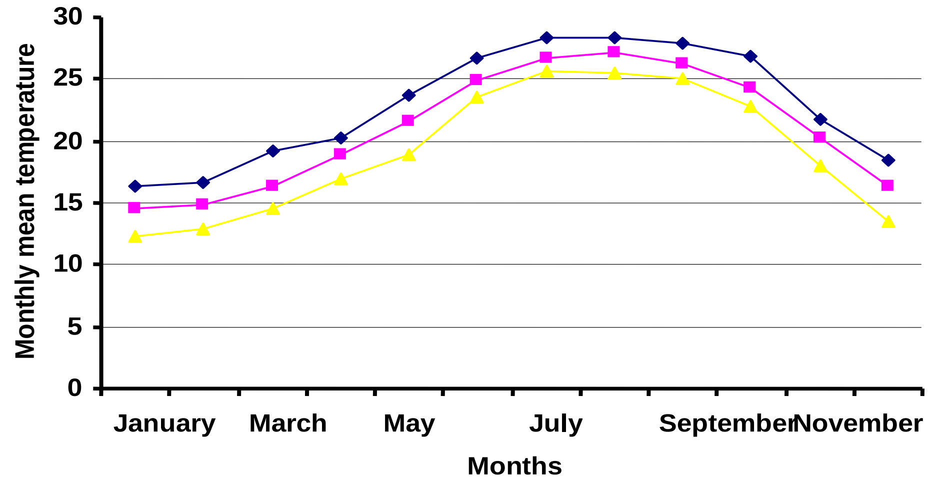

Figure 9. Maximum, minimum and mean of mean monthly air temperature in Port Said (1978-2008).

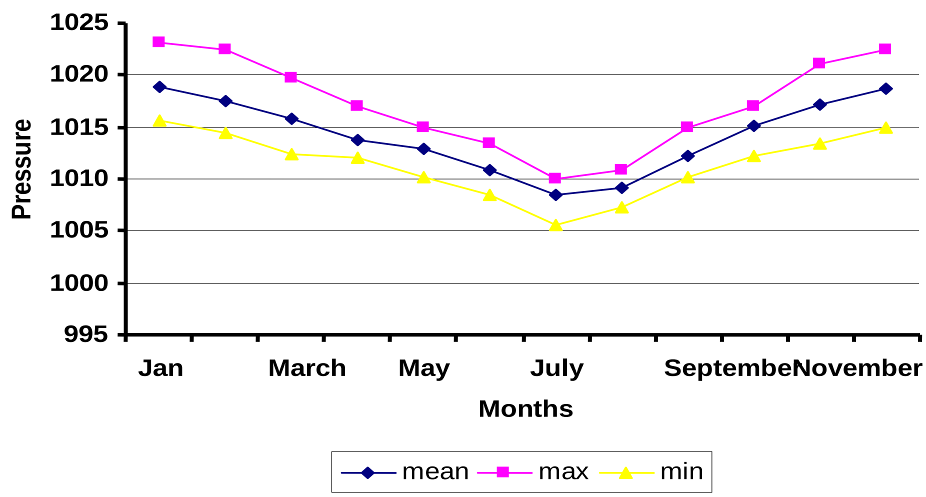

Figure 10. Maximum, minimum and mean of mean monthly air pressure in Port Said (1978-2008).

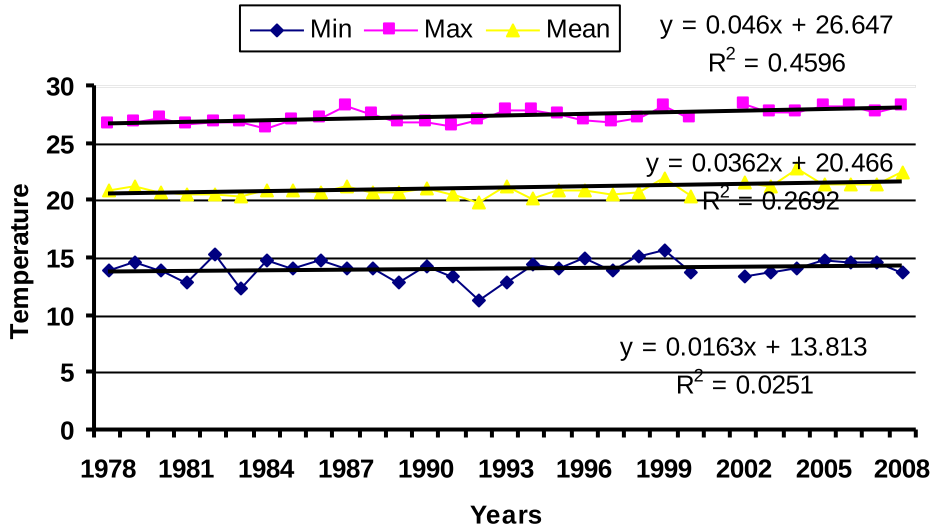

Figure 11. Minimum, maximum and mean annual values of air temperature at Port Said (1978-2008).

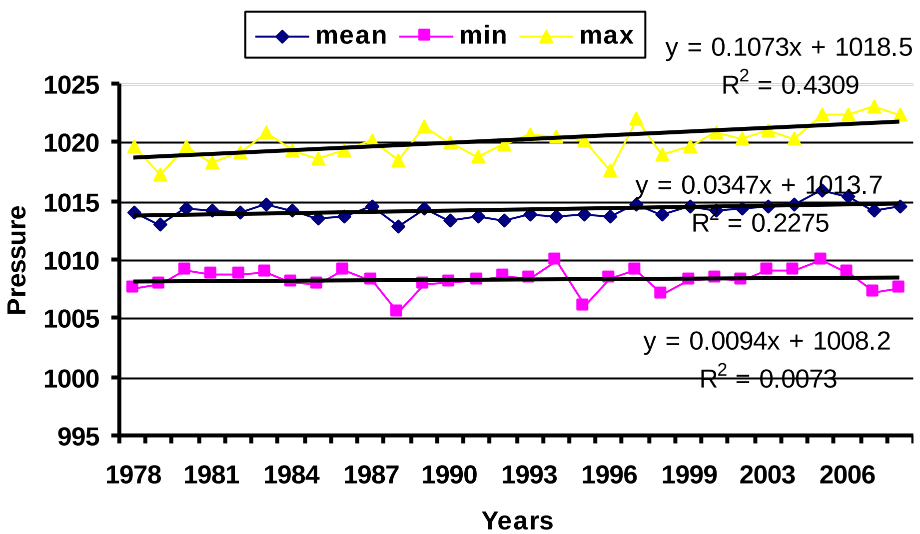

Figure 12. Minimum, maximum and mean annual values of pressure at Port Said (1978-2008).

February) are shown in Figure 13. It is clear that the time series of monthly mean air temperature anomaly at December appears to exhibit one negative (cold) and one positive (warm) period extended from 1978 to 1994 and from 1994 until 2008, respectively. During February, there is another positive period extended from 1983 to 1986. The warming rate of temperature for the period from 1978 to 2008 through December, January and February are equals 0.039, 0.010 and 0.001°C /30 year, respectively which mean that there is a significant increase in temperature at December and January more than February. The correlation coefficient satisfies the trend line equations of December and January are equal 0.638 and 0.653 which mean that 43 and 42% of their variance are in common. But at February, the line trend equation shows that only 23% of the variance is in common. The monthly mean pressure anomaly time series shows a one period of positive values through the whole period. The correlation coefficient appears a significant increasing from December to February. During spring (March, April and May), the time series of temperature anomaly (Figure 14) appeared one negative period until 1998 and positive one from 1998 until 2008. Two positive periods could be detected during April; one ended at 1992, the second period started at 1998 and still continuous until end of data. The line trend has a rapid

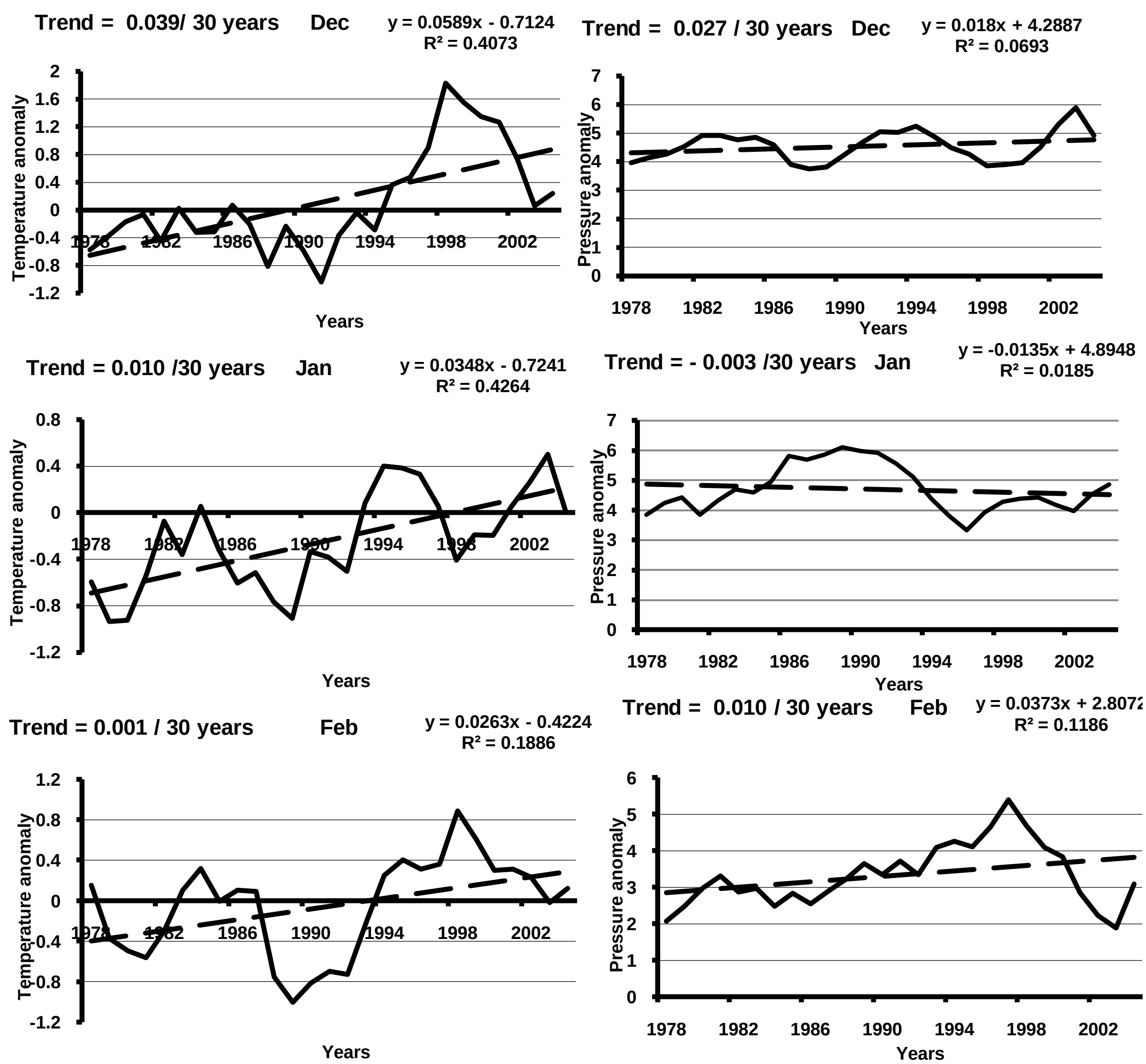

Figure 13. Monthly mean air temperature and pressure anomalies during the three months represent winter season (December, January and February).

increase during March and May while the increasing in temperature during April is negligible. March has a highest common variance of 45% followed by May 32% while April represents the lowest one.

The correlation coefficient related to trend line equation gives 0.673 and 0.566 for March and May, respectively. Through the series of pressure anomaly, one positive period can be observed during March and negative one appeared during April and May extended to the whole studied period. Also, March has the highest percentage of variance (38%) in common in comparison with the other two months. From Figure 15, summer season (June, July and August) appeared one negative and one positive period for the temperature anomaly through all the period. The positive one started from 1998 until the end of recording data. August has rapid trend of warming with values equal to 0.041/ 30 years followed by July by values of about 0.027/ 30 years. July and August have a percentage occurrence of 63 and 74% of variance. The correlation values gives a high values during July and August (0.792 and 0.863, respectively). One negative period extended from 1978 to 2008 appeared through the time series of pressure anomaly with trend line approximately horizontal through the three months. June represent the highest month of percentage of variance in common with 39% while August represents the lowest one. During September (Figure 16), in general, the time series of temperature anomaly shows the same pattern exists in the earlier months. A negative period is observed during the period between 1978 and 1998, and a positive period detected from 1998 and still exists to the end of the studied period. The positive period has a

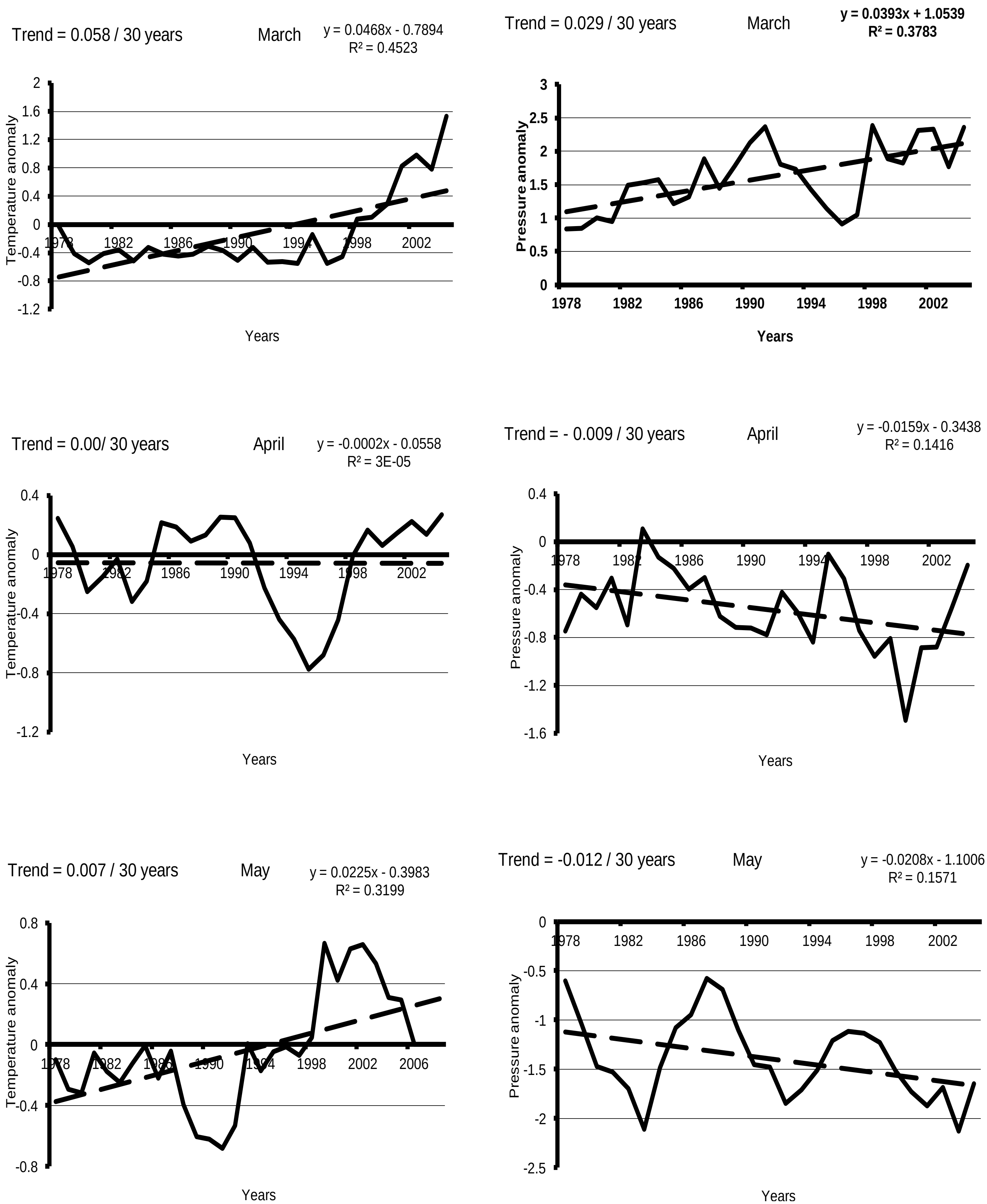

Figure 14. Monthly mean air temperature and pressure anomalies during the three months represent spring season (March, April and May).

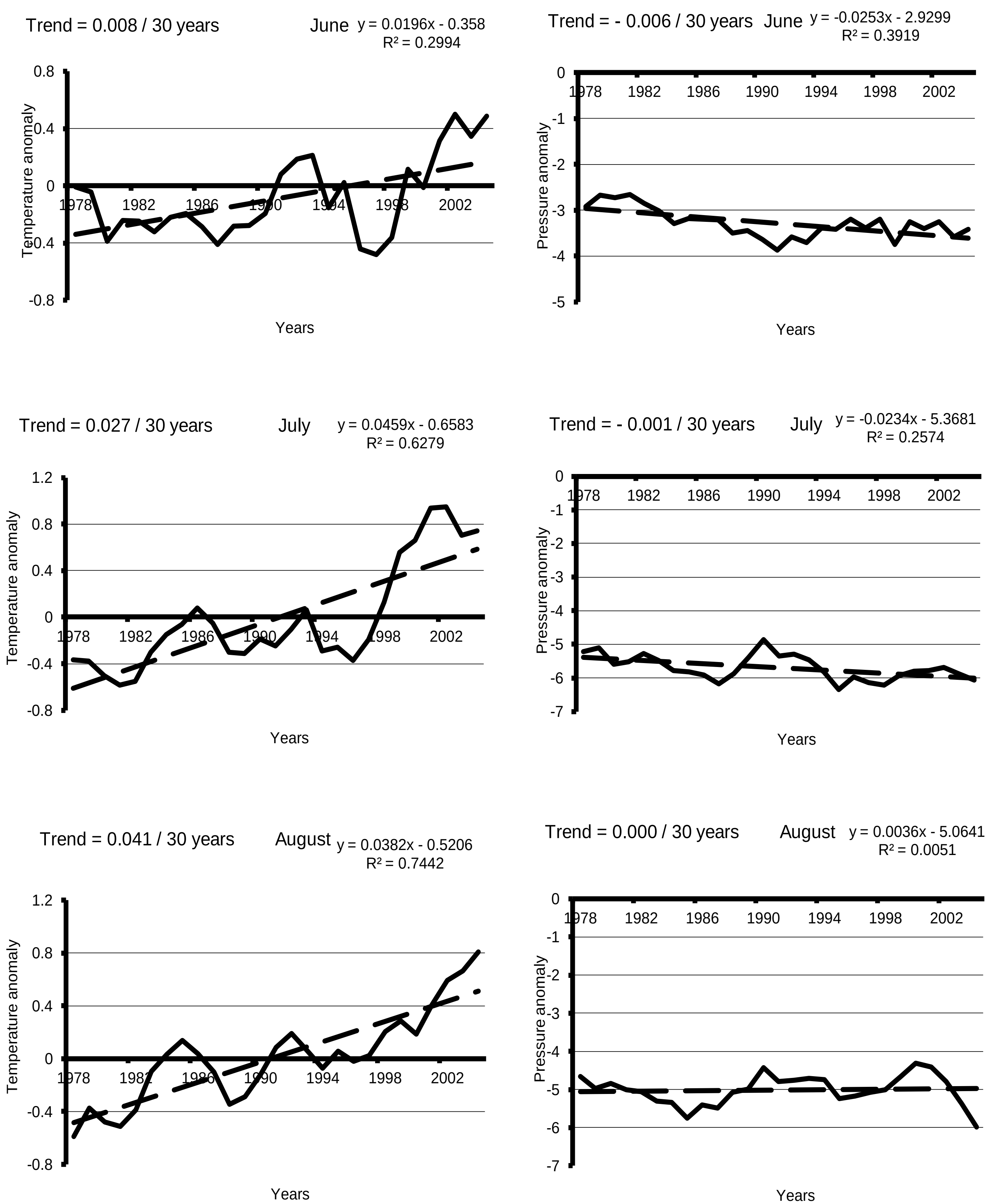

Figure 15. Monthly mean air temperature and pressure anomalies during the three months represent summer season (June, July and August).

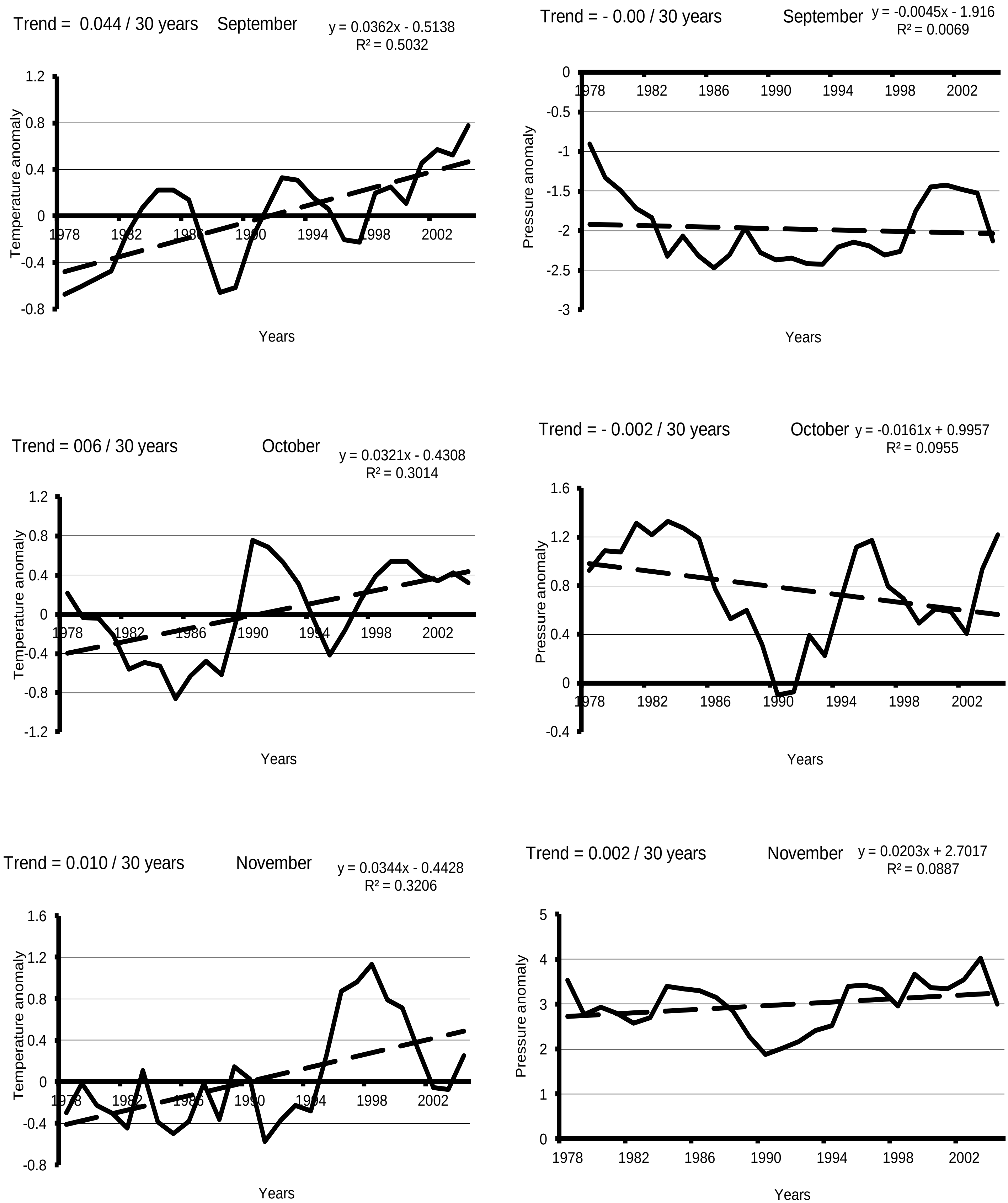

Figure 16. Monthly mean air temperature and pressure anomalies during the three months represent autumn season (September, November and December).

different start time during October and November; it started from 1990 and 1995, respectively and extended to the end of the period.

The trend line equation appears that variance is in common with percentage of about 50% during September while having 30 and 32% are existed through the other two months. The trend increase rapidly through September and November while it slows during November. Only in September, a negative period of pressure anomaly could be detected. This period extended to cover all the period. At both October and November, a positive one appeared clearly and extends to all period. October has the highest correlation in comparison to the other two months, while the trend values give a relatively constant values equal to zero during the three months. Figure 17 illustrate the average seasonally air temperature and pressure anomaly at Port Said during the period between 1978 and 2008. The seasonal differences in alternate warming period (from 1990 ~ 1998 to 2008) and cooling period (1978 to 1990 ~ 1998) are striking. For example, the warming was very rapid in spring and summer and rapid in winter, and was much weaker in autumn. Also, the warming period started at 1998 during both spring and summer and at 1994 during winter and 1990 during autumn. Autumn represent the highest season of variance in common with percentage of about 73% followed by summer with percentage equal 66% while spring has the lowest values (35%). The warming occurs over the four seasons, being greatest in summer (0.026). The rate was slightly lower during both spring and autumn (0.016 for both). The rate is considered as negligible during winter.

The seasonal difference in pressure anomaly revealed a nearly constant positive phase during winter and autumn. And a negative one existed during summer and spring through all the periods. The trend line gives negligible values during the four seasons. Also, summer season has the highest correlation (0.424) and spring represent the lowest one. The time series of the annual air temperature and pressure anomalies for the Port Said are shown in Figure 18. Strong rapid warming started clearly at 1998 for temperature and extended until the record end. This means that the average air temperature increase from 1998 till 2008. This result is coinciding with the conclusion obtained from Ebtessam and beltagy (2009) with one exception related to the start point of the positive period (1984). According to Hasanean and Abdel Baset (2006), there is positive trend value during the last 20 years and it was attributed not only to human activities but also to atmospheric circulation changes. The trend line has 0.024 /30 years with correlation coefficient equal 0.748. This small trend value of increasing temperature is not coincide with the rapid trend values obtained by Vinnikove et al. (1990), which reported that the northern hemisphere were warming at a rate 0f 0.5°C/100 year and warmed by about 0.71°C/100 year when using more recent data up to 2005. But it is disagreed with the value estimated by Ebtessam and Beltagy (2009) where it was -0.04/year with correlation coefficient equals 0.842. The cold period detected along the period begin from 1978 until 1998. The correlation coefficient shows that variance for average annual air temperature was in common with percentage of about 56%. The time series of pressure anomaly shows two positive periods 1978 and 1988 and the other started in 2000 till 2008. Between these two periods there is a negative one between 1988 and 2000.

For each decade period (1978 to 1987; 1988 to 1997 and 1998 to 2008), the monthly mean temperature anomaly is calculated relative to the mean of the study period 1978 to 2008. The obtained results are represented in Figure 19. It is clear that the period started from 1998 to 2008 considered as the rapid warming period in relative to the other two periods. The trend value at this period reached about (0.049/30 years). Also, we observed that at this period the correlation coefficient shows that the variance of air temperature was in common with percentage of about 75%. The time series of pressure anomaly show a negative trend values during the three periods.

Spectral analysis

In order to examine the inter-decadal fluctuation cycle of mean annual air temperature, the spectral analysis technique has been extensively used in many domains of meteorology and climatology. Among these studies which applying the spectral analysis of those done by many authors such as Kan and Teixeira (1990), Leite and Peixoto (1995), Echer et al. (2008), Fredolin and Al bahari (2009) and Joao and Solange (2009). The spectral analysis on of mean annual air temperature in Port Said gives that over the 31 year, the mean annual variability is mainly dominated by oscillations in low frequency time of 11.66, 3.89, 2.3, 1.66 and 0.75 year. The varying length of the 11-year cycle has been found to be strongly correlated with long-term variations of the northern hemisphere land surface air temperature since the beginning of systematic temperature variations from a global network that is, during the past 130 years (Lassen, 1995). This is related to sunspot cycle. According to Geerts and Linacre (www.das.uwyo.edu), there is a strong radial magnetic field within a sunspot, and the direction of the field reverses in alternate years within the leading sunspots of a group. So, the true sunspot cycle is 22.2 years.

There is also a superimposed fluctuation with a period of 3.89 and 2.3 months, that is, a quasi-biennial oscillation. These results are compatible with that obtained by Ebtessam and Beltagy (2009).

Conclusion

We examine air temperature and pressure data for the

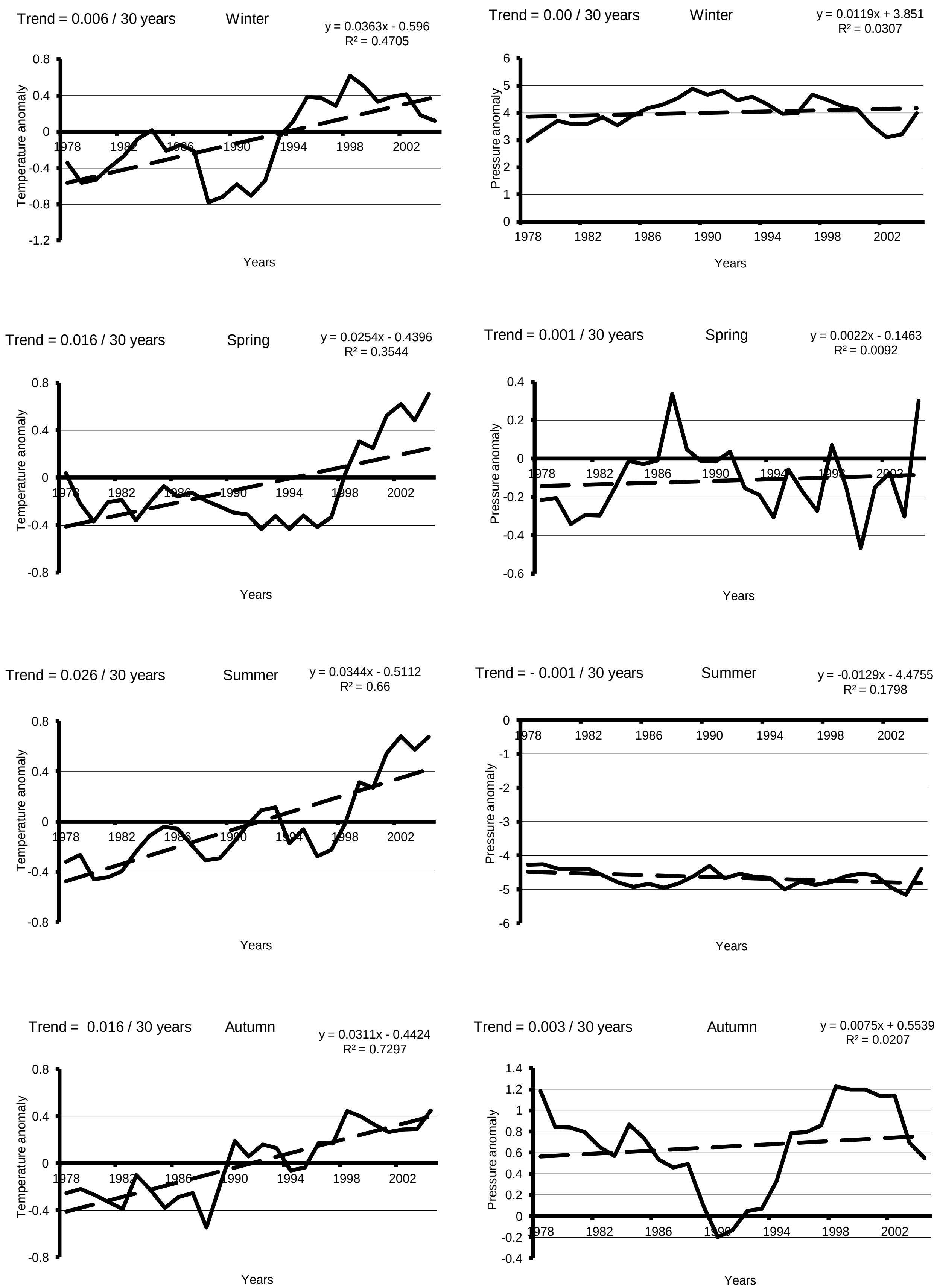

Figure 17. Seasonally mean air temperature and pressure anomalies during the different seasons.

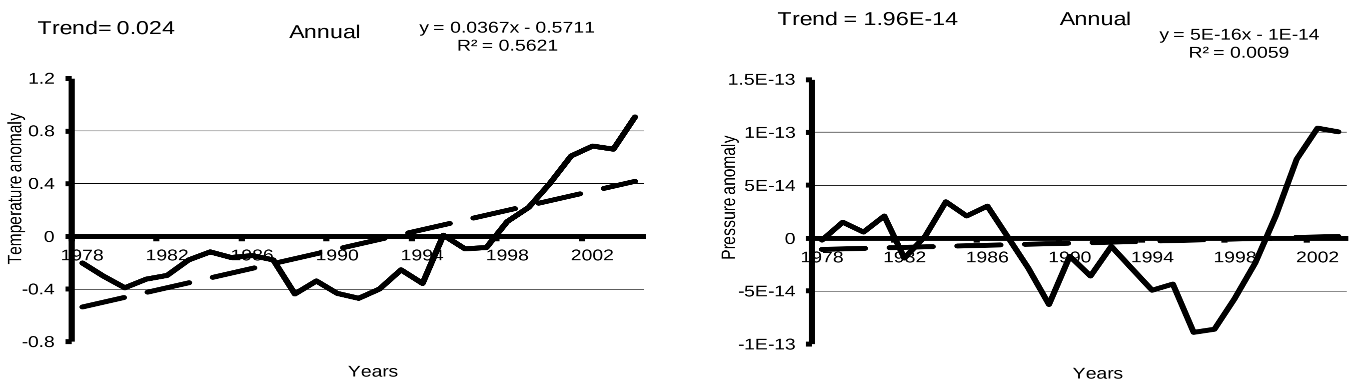

Figure 18. Annual mean air temperature and pressure anomalies.

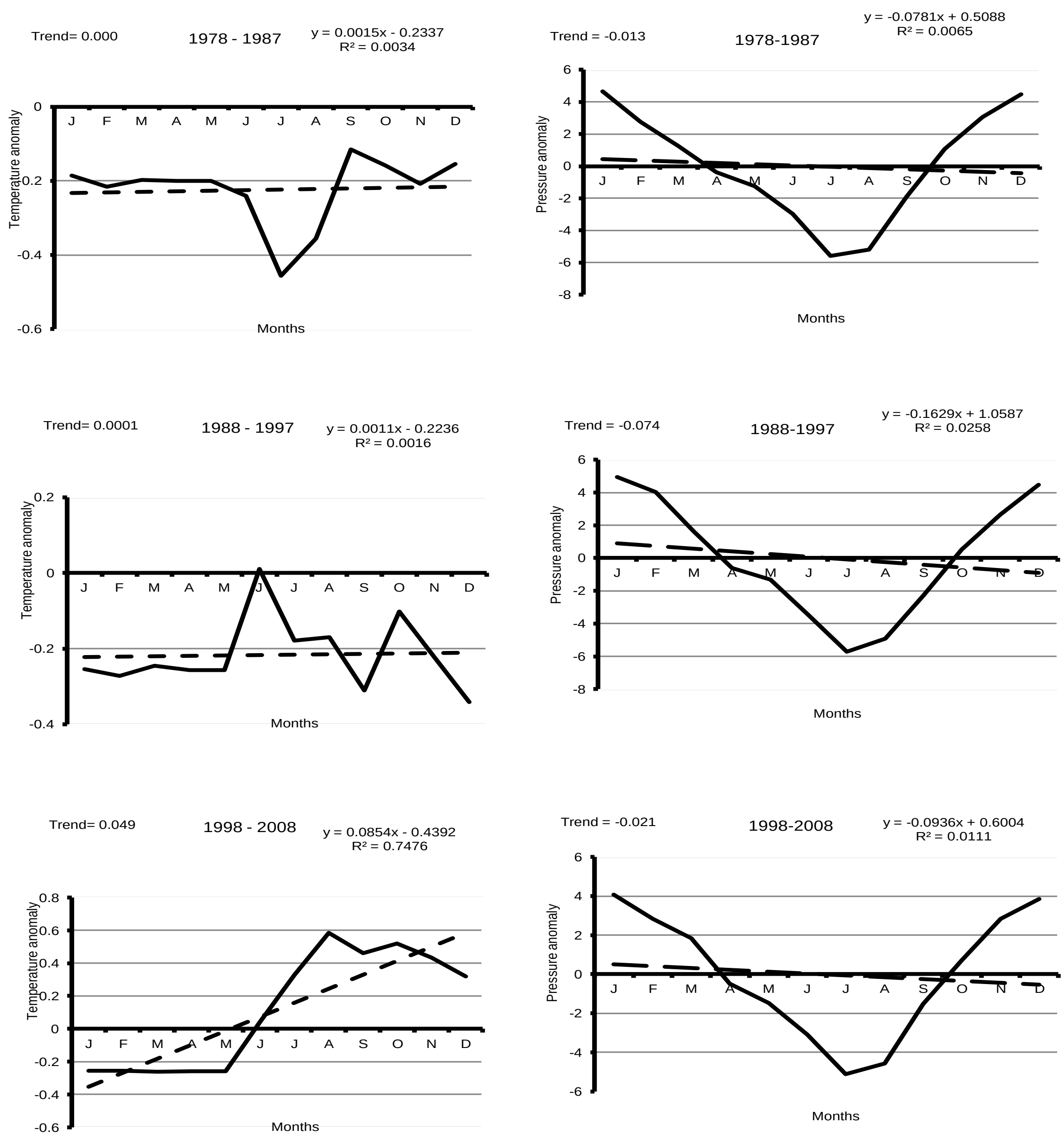

Figure 19. Decadal mean air temperature and pressure anomalies.

period of 1978 to 2008 using long-term records of hourly values from Port Said weather land stations. The mean daily values of temperature and pressure were fluctuated between 12.299 and 28.395°C and from 1010.1 to 1023 mb, respectively. There is a linear trend in the mean daily air temperature which seems to represent a general trend of increase in air temperature with time. At pressure, the linear trend was exists also with small evidence compared with temperature. January is considered the coldest month through the years of the whole period with occurrence of about 65.5%, while August is considered the hottest month with 82.8% occurrence through all the years. July has a lowest value in pressure with percentage of occurrence 73.3% during the whole period. The months of highest values of pressure is distributed from November with percentage of occurrence 10% to March with percentage of occurrence equal 3.3%. December and January are considered as highest months of pressure values with percentage of occurrence equal 33.3 and 43.3%, respectively. Minimum, maximum and mean annual values of air temperature and pressure at Port Said area, declared a linear trends and warming evidence are existed in both parameters. The maximum annual values declared more warming trends more than the minimum and mean annual values. Generally, two distinct periods are observed through the studied period.

A negative period is observed during 1978 and 1998, and the positive one detected from 1998 and still exists to the end of the data record. The end and the start point of the two periods are fluctuated from 1990 and 1995. In general, there is a trend of increasing in temperature values during all the months which agreed with the conclusion obtained from Ebtessam and Beltagy (2009). The trend value of temperature anomaly through December, January and February are equals 0.039, 0.010 and 0.001°C/30 years, respectively. There is a significant increase in temperature at December and January more than February with correlation coefficient equal 0.638 and 0.653 which mean that 43 and 42% of their variance are in common. The line trend has a rapid increase during March and May while the increasing in temperature during April is negligible. March has a highest common variance of 45% followed by May 32% while April represents the lowest one. August has rapid trend of warming with values equal to 0.041/ 30 years followed by July by values of about 0.027/ 30 years. July and August have a percentage occurrence of 63 and 74% of variance. Trend is increased rapidly through September and November while it shows lowering during November. These results have an agreement with Vinnikove et al. (1990) and Ebtessam and Beltagy (2009) in general but our result has a small trend values (0.193/100 years through March) in comparison to which reported by their results which says that the northern hemisphere was warming at a rate of 0.5°C / 100 years and 0.71°C/100 years, respectively. The seasonal differences in alternate warming period (from 1990 ~ 1998 to the present) and cooling period (1978 to 1990 ~ 1998) are striking. The warming was very rapid in spring and summer and weaker in winter, and was much weaker in autumn. Also, the warming period started at 1998 during both spring and summer and at 1994 during winter and 1990 during autumn.

The spectral analysis technique was applied on the mean annual air temperature data. The mean annual variability is mainly dominated by oscillation in low frequency time 11.66, 3.89, 2.3, 1.66 and 0.75 years. The 11.66 year cycle is related to sunspot activity.

REFERENCES

Bartzokas A, Metaxas DA (1990). 'Climatic fluctuations of temperature and air circulation in the Mediterranean', in Duplessey JC, Pons A and Fantechi R (eds), Proceedings of the Course on Climate and Global Change of the European School of Climatology and Natuml Hazards, Arles, European Commission, Luxembourg. pp. 279-298.

Gaertner MA, Jacob D, Gil V, Domínguez M, Padorno E, Sánchez E, and Castro M (2007). Tropical cyclones over the Mediterranean Sea in climate change simulations, Geophys. Res. Lett. 34:L14711, doi:10.1029/2007GL029977.

Ebtessam EEM, Beltagy AI (2009). Analysis of long-term air temperature in Alexandria. Egyp. J. Aquatic Res. 35(4): 461-474.

Echer E, Mariza E, Nordemann D, Rigozo J, Nivaor R (2008). Spectral analysis of global hemispheric averaged air temperature time series. 37th COSPAR Scientific Assembly. Held 13-20 July 2008, in Montereal, Canada. p. 784.

Fredolin TT, El-Bahari A (2009.) Enso information on precipitation and air temperature variability in Malaysia. www.ekomar.ukm.my/incomes2009-06-02.

Flocas AA (1984). 'The annual and seasonal distribution of fronts over central-southem Europe and the Mediterranean', 1 Climatol. 4:255-267.

Folland CK, Karl TR, Vinnikov KYA (1990). 'Observed climate variations and change', Houghton JT, Jenkins GJ and Ephram JJ (eds), Climate Change: the IPCC Scienrific Assessment, Cambridge University Press.

Geerts B, Linacre E Sunspots and climate. www.das.uwyo.edu

Hamed AA (1983). Atmospheric circulation over the south eastern of the Mediterranean sea in relation with weather conditions and wind waves along the Egyptian coast. Ph.D. thesis, Faculty of Science. Alexanderia University. p. 280.

Hasanean HM, Abdel Baset H (2006). Variability of summer temperature over Egypt. Int. J. Climatol. 26:1619-1634.

Jenny MR, Grant RB (1996). Climatic change over the Mediterranean and links to the more general atmospheric circulation international. J. Climatol. 16:651-461.

Joao S, Solange L (2009). Long-term variability of the temperature time series recorded in Lisbon. J. Appl. Statist. 36:323-337.

Kane RP, Teixeira NR (1990). Power spectrum analysis of the time series of annual mean surface air temperatures. Springer Netherland, vol. 17(1):121-130.

Kay SM, Marple SL (1981). Spectrum analysis: A modern perspective. Proc. IEEE, 69:1380-1419.

Kendall M, Stuart A, Ord JK (1961). The Advanced Theory of Statistics. Design and Analysis, and Time Series, Charles Griffin and Co. 3:780.

Lassen K, Friis-Christensen E (1995). Variabilty of the solar cycle length during the past five centuries and the apparent association with terrestrial climate. J. Atmos. Solar Terr. Phys. 57:835-845.

Laurent L, Alexandra B, Samuel S, Michel C (2006). Modelling

regional-scale climate change of the Mediterranean–"CLIVAR newsletter Exchanges", numéro 37(11):2.
Leite SM, Peixoto JP (1995). Spectral analysis of climatological series in Duero Basin. Theor. Appl. Climatol. 50(3-4):157-167.
Metaxas DA, Bartzokas A, Vibras A (1991). 'Temperature fluctuations in the Meditemean area during the last 120 years', Inf. 1 Climafol. 11:897-908.
Repapis CC, Philandras CM (1988). 'A note on the air temperature trends of the last 100 years as evidenced in the eastern Mediterranean time series', Them. Appl.Climafol. 39:93- 97.
Sahsamanoglou HS, Makrogiannis TJ (1992). 'Temperature trends over the Mediterranean region 1950-88', Theor Appl. Climatol. 45:183-192.
Vinnikove KY, Groisman P, Lugina, KM (1990). Emperical data on conterporary global climate change (temperature and precipitation). J. Clim. 3:662:677.