Summary

In this study, trends of annual and seasonal surface air temperature time series were examined for 20 stations in Greece for the period 1955–2001, and satellite data for the period 1980–2001. Two statistical tests based on the least square method and one based on the Mann-Kendall test, which is also capable of detecting the starting year of possible climatic discontinuities or changes, were used for the analysis. Greece, in general, shows a cooling trend in winter for the period 1955–2001, whereas, summer shows an overall warming trend, however, neither is statistically significant. As a result, the overall trend of the annual values is nearly zero. Comparison with corresponding trends in the Northern Hemisphere (NH) shows that temperatures in Greece do not follow the intense warming trends. Satellite data indicate a remarkable warming trend in mean annual, winter and summer in Greece for the period 1980–2001, and a slight warming trend in annual, spring and autumn for the NH. Comparison with the respective trends detected in the surface air temperature for the same period (1980–2001) shows they match each other quite well in both Greece and the NH. The relationship between temperature variability in Greece and atmospheric circulation was also examined using correlation analysis with three circulation indices: the well-known North Atlantic Oscillation Index (NAOI), a Mediterranean Oscillation Index (MOI) and a new Mediterranean Circulation Index (MCI). The MOI and MCI indices show the most interesting correlation with winter temperatures in Greece. The behaviour of pressure and the height of the 500hPa surface over the Mediterranean region supports these results.

1. Introduction

Analysis of air temperature data at global scales with respect to climate change indicates a 0.4°C to 0.8°C rise since 1860 (IPCC, 2001). Warming since the mid-1970s has been particularly rapid with all eight of the warmest years on record occurring since 1983 (WMO, 1997; CRU, 1997). The 1990s are quite likely to have been the warmest decade of the millennium in the Northern Hemisphere (NH) while 1998 is likely to have been the warmest year (IPCC, 2001). In particular, summer temperatures in the NH during recent decades have been the warmest in at least six centuries. The average temperature near the surface of the Earth in 1999 was the 5th highest so far recorded, an estimated 0.33°C higher than the 1961–90 average (IPCC, 2001). In spite
of ongoing research on climate change conducted by various international agencies and universities, the question of whether rising global mean air temperatures is caused either by increasing emissions of greenhouse gases to the atmosphere or by natural variability of climate has not been answered satisfactorily.

In terms of analysis of satellite temperature data a very slight warming trend since 1979, has been observed in the lower troposphere, but not to the extent shown by surface observations. Major anomalies due to volcanic eruptions like Pinatubo, and ocean current phenomena like El Nino, are detected but overall the trend is near zero, about 0.04 degrees Celsius warming per decade for the 23-year period, 1979–2001 (Spencer, 2002).

Although regional differences are relatively high, most of Europe has experienced rising temperatures of about 0.8°C during the 20th century (IPCC, 1996; IPCC, 2001). Analysis of surface air temperature observed at stations located in all regions of the Mediterranean basin, indicates similar patterns to the global or and hemispheric scale; namely a cooling during the period 1955–1975 and a strong warming during the 1980s and the first half of the 1990s (Piervitali et al., 1997). However, the east–west Mediterranean difference in air and sea surface temperature trends is distinctive. Most of the studies concerning air temperature in the Mediterranean discern a positive trend in the western Mediterranean for the period 1950–1990, and a negative trend in the eastern Mediterranean for the same period (Parker et al., 1994; Sahsamanoglou and Makrogiannis, 1992; Nicholls et al., 1996), which reinforces the concept of a Mediterranean Oscillation between the western and eastern parts of the basin (Kutiel and Maheras, 1998). The large-scale circulation, however, has been found to play an important role in temperature variability in the Mediterranean. Cullen and de Menocal (2000) detected a connection between the North Atlantic sector and the southeastern Mediterranean, which is the easternmost limit of the North Atlantic Oscillation influence on Mediterranean climate.

Regional climate variations, however, have regional features that often do not match those of the globe as a whole. Greece’s orography and location in the eastern Mediterranean basin imply strong influence from the local circulation. For this reason the analysis of temperature changes in this region may be suitable to identify such differences. Indeed, Greece is differentiated from the rest of Europe in that air temperature shows a slight negative trend over the 20th century (IPCC, 1996; Mitchell and Hulme, 2000; Giles and Flocas, 1984; Retalis et al., 1998). An overall cooling trend was detected in the study of Proedrou et al. (1997) for the majority of Greek stations in winter over the entire period, 1951–1993. The same cooling trend was also recognized for the mean annual and summer values, although a reverse warming trend was detected around the mid-1970s at several stations. According to a more recent study by Luterbacher et al. (2000), winter temperatures in Greece present a cooling trend during the period 1957–1997. The 1970s has been the coldest decade of the 20th century in Greece (Giles and Flocas, 1984; Makrogiannis et al., 1998).

Many papers have been published dealing with global scale climate, this paper, however, deals with a regional scale investigation, referring specifically to Greece. The few published studies on trend analysis of air temperature in the area of Greece are based either on a single test or on extended time series of temperature for a limited number of stations. The primary aim of this study is to examine the trends of the mean annual and seasonal air temperature time series for all the available stations in Greece (20), for the longest common time period with homogenous temperature data (1955–2001), using three statistical tests. Taking into account the size of Greece and the even spatial distribution of the 20 stations, this sample may be considered as sufficient to also account for the local differences. The study also describes trend analysis of lower tropospheric temperature data from satellite measurements for the period 1980–2001 for Greece. A comparison with the corresponding trends in the NH is performed in order to examine whether trends observed in surface based and satellite temperature measurements in Greece match the overall warming trend detected at the hemispheric scale.

The secondary objective of this study is to detect regional and large-scale mechanisms which are responsible for the temperature trends around Greece. Local changes in meteorological