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[1] Laboratory of Climatology and Atmospheric Environment, University of Athens, Athens, Greece
[2] Meteorological Institute, University of Freiburg, Freiburg, Germany

Variability of tropical days over Greece within the second half of the twentieth century

P. T. Nastos[1], A. P. Matzarakis[2]

With 10 Figures

Summary

Tropical days (TD) are defined as the days with a maximum air temperature greater than 30.0 °C. It is clear that the study of TD includes also the absolute maximum temperatures, which are of great interest for the description of a region's climate. These days are considered as very hot, and they particularly are of great importance not only for bioclimatology and applied sciences, but also for the individuals who are sensitive in the heat-stress. The regime of the TD in Greece is the focus of this study. The aim is to demonstrate their changes from decade to decade, for the time period 1960–2000. For this study, the Annual Number of Tropical Days (ANTD) recorded by each of the 26 meteorological stations of National Meteorological Service, which are uniformly distributed in the Hellenic peninsula, was calculated and analysed.

In terms of quantifying the conditions in a human-biometeorological manner, the thermal index Physiological Equivalent Temperature (PET) and the consecutive days for Athens have been included in this study.

The trends of the TD for each station were analysed through the Mann–Kendall technique, while the spatial distribution per decade reveals the regions with change (increase or decrease) in the ANTD during the examined period. Two characteristic periods of change for the ANTD appear in the majority of the meteorological stations in Greece. The first period (1955–1976) is determined by a negative trend, which is statistically significant (c.l. 95%), for adequate stations. In the period between 1976 and 2000, the increase in the ANTD and the maximum temperature exceed the corresponding maximum that appeared in the beginning of the 1950s for several of the examined meteorological stations.

The human-biometeorological analysis shows that the consecutive days of PET > 35 °C have had a positive trend in the last two decades of the last century.

1. Introduction

The rise in air temperature, as a result of the greenhouse effect, is the focus of current research from the local to global scale. This trend has been recorded in the 20th century and particularly in the last decade 1990–2000, which likewise was the warmest decade in the last century, while the year 1998 was the warmest year of the instrumental observation period since 1861. The global average surface temperature (the average of near surface air temperature over land, and sea surface temperature) has increased since 1861. Over the 20th century the increase has been 0.6 ± 0.2 °C (IPCC 2001; Jones et al. 2001). A recent study undertaken by Jones and Moberg (2003) presents an extensive revision of the Climatic Research Unit (CRU) land station temperature database

Correspondence: Dr. Panagiotis T. Nastos, Laboratory of Climatology and Atmospheric Environment, Department of Geography and Climatology, Faculty of Geology and Geoenvironment, University of Athens, Panepistimiopolis GR, 157 84 Athens, Greece, e-mail: nastos@geol.uoa.gr

that is used to produce a gridbox dataset of 5° latitude × 5° longitude temperature anomalies. Apart from the increase in station numbers compared to the earlier study in 1994 (Jones 1994), many station records have had their data replaced by newly homogenized series that have been produced by several recent studies. The rate of the annual global warming for land areas over the 1901–2000 period has been estimated by least squares to be 0.078 °C/decade (significant at the 99.9% level).

With respect to the air temperature pattern in the Mediterranean region, where Greece is located in the south-east, many climatologists have studied the temperature fluctuations and the trends (Repapis and Philandras 1988; Arseni-Papadimitriou and Maheras 1991; Metaxas et al. 1991; Hasanean 2001) and the relationships between air temperature and atmospheric circulation (Kutiel and Maheras 1998; Maheras et al. 1999).

The air temperature maxima for Athens have been studied many years ago by Eginitis (1907) and recently among others by Flocas and Angouridakis (1979), Bartzokas and Metaxas (1995), Philandras et al. (1999), Founda et al. (2004). Studies focussing on Greece have been carried out by Mariolopoulos (1938), Carapiperis (1954) and most recently by Giles and Flocas (1984), Balafoutis and Arseni-Papadimitriou (1992), Nastos (1995), Proedrou et al. (1997), Feidas et al. (2004) and Flocas et al. (2005).

The tropical days (defined as the days with the maximum air temperature greater than 30.0 °C) in Athens have been examined by Carapiperis (1959) and by Dikaiakos and Nastos (1991), who have incorporated not only the trends but also the climatic and bioclimatic variables associated with the regime of tropical days for the period 1891–1984. The tropical days (TD) in Athens, for the whole examination period, present a small positive trend, which does not exceed the 14 days for the whole period. However, an extended study about the variability and the spatial distribution of the TD in Greece for the second half of this century is still missing.

The present study examines the fluctuations and, more specifically, the trends of ANTD in Greece and also the spatial distribution of these days per decade. As a result, the TD change in Greece could be derived for the second half of the 20th century.

Furthermore, in order to assess the TD conditions in Greece in a humanbiometeorological manner, the thermal index "Physiological Equivalent Temperature" has been analysed for Hellenikon/Athens for the period 1955–2001 on a daily basis. Additionally, the consecutive days of TD have been compiled for the Station of Hellenikon/Athens in order to detect any heat stress conditions.

2. Data and methodology

During the period 1955–2000, the ANTD for each station were evaluated by taking into account the daily maximum air temperatures of a network of 26 stations of the National Meteorological Service, which cover the Greek region sufficiently.

The used data of these meteorological stations have been examined for homogeneity in the past (Proedrou et al. 1997; Lolis et al. 1999; Xoplaki et al. 2000; Feidas et al. 2004; Flocas et al. 2005), using mainly the Alexandersson test (1986). The Alexandersson test has the advantage over other homogeneity tests in providing information on the year of the possible shift in a station time series without using complex mathematics. The relatively homogeneity is tested by using nearby reference stations, with time series considered a-priori as homogeneous. The geographic distribution of the meteorological stations network is illustrated in Fig. 1.

With regards to the trends of the TD, the statistical method Mann–Kendall (Sneyers 1975; Chu et al. 1994) was applied to the time series of the ANTD for each station. According to this criterion, each term x_i $(i = 1, \ldots, N)$ is compared with all the sequences of the terms. If n_i is the number of terms which are bigger than x_i, then the following sum is calculated: $P = \sum_{i=1}^{N-1} n_i$ and in the process the statistical term: $t = \frac{4P}{N(N-1)} - 1$ is extracted. Afterwards, this statistical term is compared with the term: $(\tau)_t = 0 \pm 1.96\sqrt{\frac{4N+10}{9N(N-1)}}$, where 1.96 is the value for t in the probability point in the Normal distribution for the 95% confidence level. So long as $t > (\tau)_t$, the corresponding trend is statistically significant (c.l. 95%).

For the analysis of the spatial distribution of the ANTD trends in Greece, Kriging, which is the most appropriate method for mapping out isopleths (Nastos 1993), was used.

Fig. 1. Network of the meteorological stations

In order to take into consideration the thermal environment of humans in a appropriate way, it is necessary to use evaluation methods that

• deal with the atmospheric environment as a whole and not with single meteorological parameters,
• have a thermo-physiological importance.

Therefore, "simple complex indices" that have often been used in earlier publications, such as effective temperature or the equivalent temperature, do not meet the above criteria. The VDI-guideline 3787, part 2 (VDI 1998), recommends several methods for the assessment of the thermal component of the human climate, all of which are based on the human energy balance equation (Höppe 1984, 1993, 1999; Mayer 1993). The thermal index used in this study is called PET (Physiological Equivalent Temperature), which is based on the MEMI model (Höppe 1999). Other existing thermal indices like PMV (Fanger 1972; Jendritzky et al. 1990) and SET (Gagge et al. 1986) or OUT_SET* (De Dear and Pickup 2000; Spagnolo and De Dear 2003a, b) produce similar results. The calculations have been done by the use of the radiation and bioclimate RayMan model (Matzarakis et al. 1999, 2000), which is based on the VDI-guidelines 3787 and 3789 (VDI 1994, 1998).

3. Results and discussion

In order to detect the ANTD trend pattern in Greece, the ANTD trends for the second half of the twentieth century were estimated according to the Mann–Kendall test statistics. Based on the Kriging method, the spatial distribution of the ANTD trends is depicted in Fig. 2. Increasing ANTD trends that are mostly insignificant show a spatial concentration in the central parts of Greece. Significantly increased trends (c.l. 95%) are seen in three stations (National Observatory of Athens +0.41 TD/year, N. Philadelphia +0.66 TD/year and Tripolis +0.53 TD/year). The main cause of this pattern is probably the heat island effect due to the development of the cities in the recent decades (Philandras et al. 1999) rather than climatic change. On the other hand, significant negative trends (c.l. 95%) are observed in the southeastern part of Greece. According to a study by Turkes et al. (2002), the maximum summer temperatures for the period 1929–1999 show mostly insignificant negative trends for the central parts of the Marmara and Central Anatolia regions and the eastern Mediterranean sub-region. On the other hand, significant positive trends are found in the Aegean regions.

The ANTD time series, the corresponding nine years moving averages, the linear trends for two
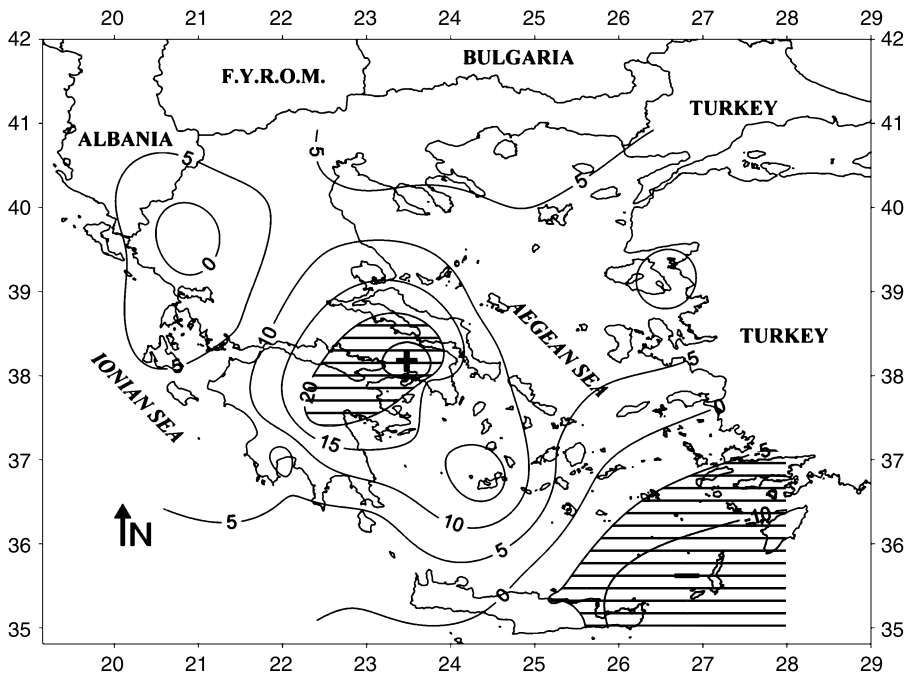
Fig. 2. Spatial distribution of the ANTD trends of 26 stations in Greece from the Mann–Kendall test statistic. Shading: statistically significant at the c.l. 95%

examined periods (1951–1976, 1976–2000), and the mean, mean + 2SD, mean − 2SD (SD: standard deviation) for 20 of the examined meteorological stations, are presented in Figs. 3 and 4. It is obvious, that in the early 1950s, the ANTD appear to be high for most of the meteorological stations in Greece. Then, a general decrease in the ANTD is observed, which leads to the minimum of the TD in 1976, a year, which is considered as the coldest year of last fifty-year period, for the region of Greece (Proedrou et al. 1997; Feidas et al. 2004). The only exception is the station of N. Philadelphia where the minimum did already appear in 1967. After 1976, the ANTD present a positive trend with various fluctuations until the end of the examined period in 2000. These results are consistent with the findings of Jones and Moberg (2003), who present an extensive revision of the Climatic Research Unit (CRU) land station temperature database. According to Jones and Moberg (2003) warming is not continuous but occurred mainly in two periods (about 1920–1945 and since 1975). Annual temperature series for the seven continents and the Arctic all show significant warming over the twentieth century, with significant (95%) warming for 1920–1944 for North America, the Arctic, Africa, and South America and all continents except Australia and the Antarctic since 1977. Cooling is significant during the intervening period (1945–1976) for North America, the Arctic, and Africa.

Based on the results from previous studies covering the whole Mediterranean basin and taking into account sea surface temperature (SST), Metaxas et al. (1991) detected a period of relative warming from 1910 to 1940, another cooling period from 1960 to 1970, and the onset of warming from 1980. They also noted that low SST in the eastern Mediterranean during the 1980s should be attributed to the increased frequency and strength of northerly winds in the region. Furthermore, Xoplaki et al. (2003) analysed the variability of the summer air temperature in the Mediterranean and its connection to the large-scale atmospheric circulation and SSTs. They found that in the Mediterranean region warmer summers characterised the 1950s, 1980s and 1990s and cooler summers were prevalent from the mid-1960s to the mid-1970s. A significant warming of 0.5 °C/decade is appeared in the period 1980–1999. The coolest periods in the Mediterranean region were the 1960s and 1970s, with the coolest year in 1976.

On a more local scale, Maugeri and Nanni (1998) analysed historic series of monthly mean temperatures from 27 Italian stations until 1993. They found that a positive trend, stronger at southern stations compared to northern stations, is apparent from 1920 to 1950, rather constant
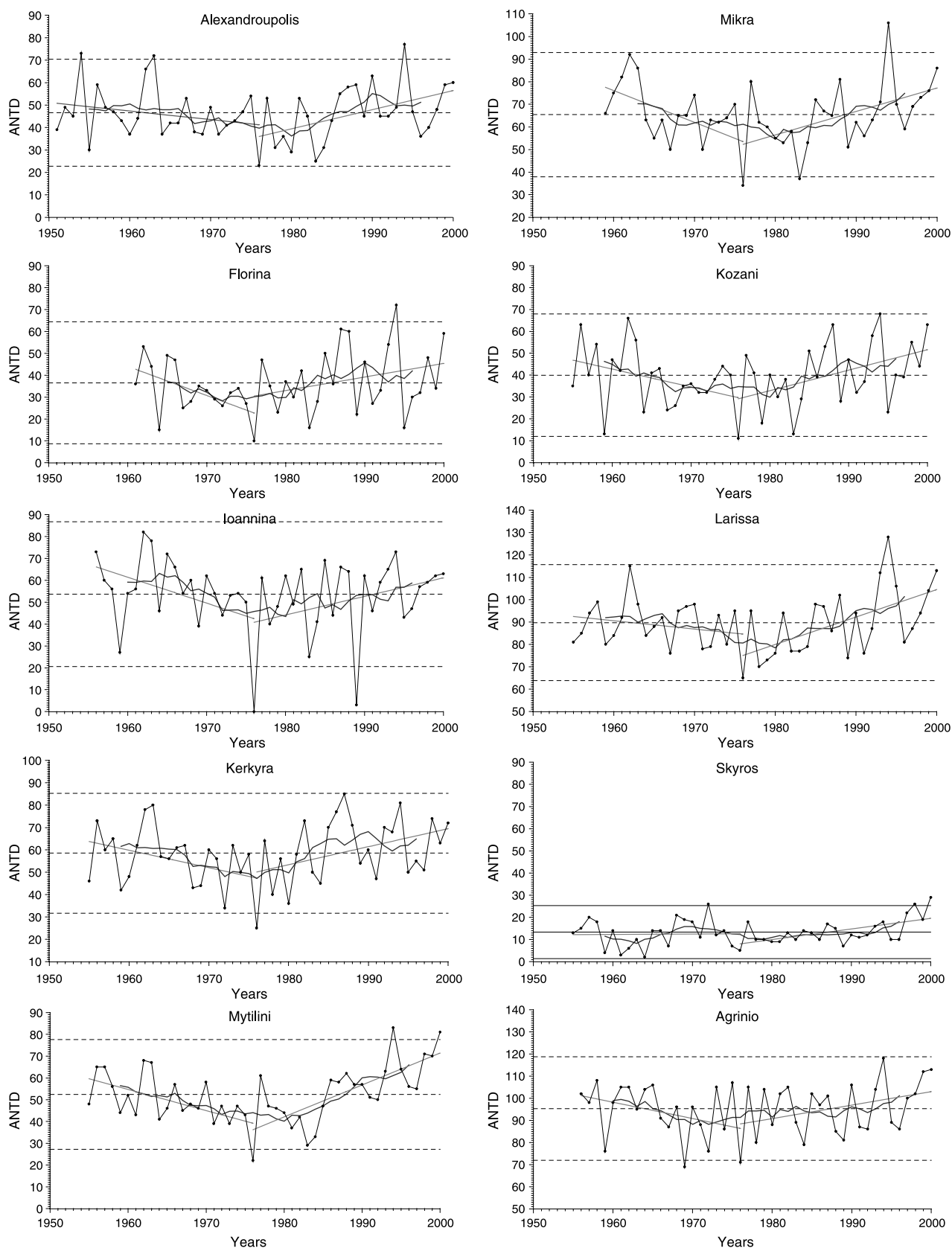
Fig. 3. Time series of ANTD of selected stations in Greece, along with 9-years moving average and linear trends for the two examined periods (solid lines) and the mean, mean + 2SD, mean − 2SD (dot lines)
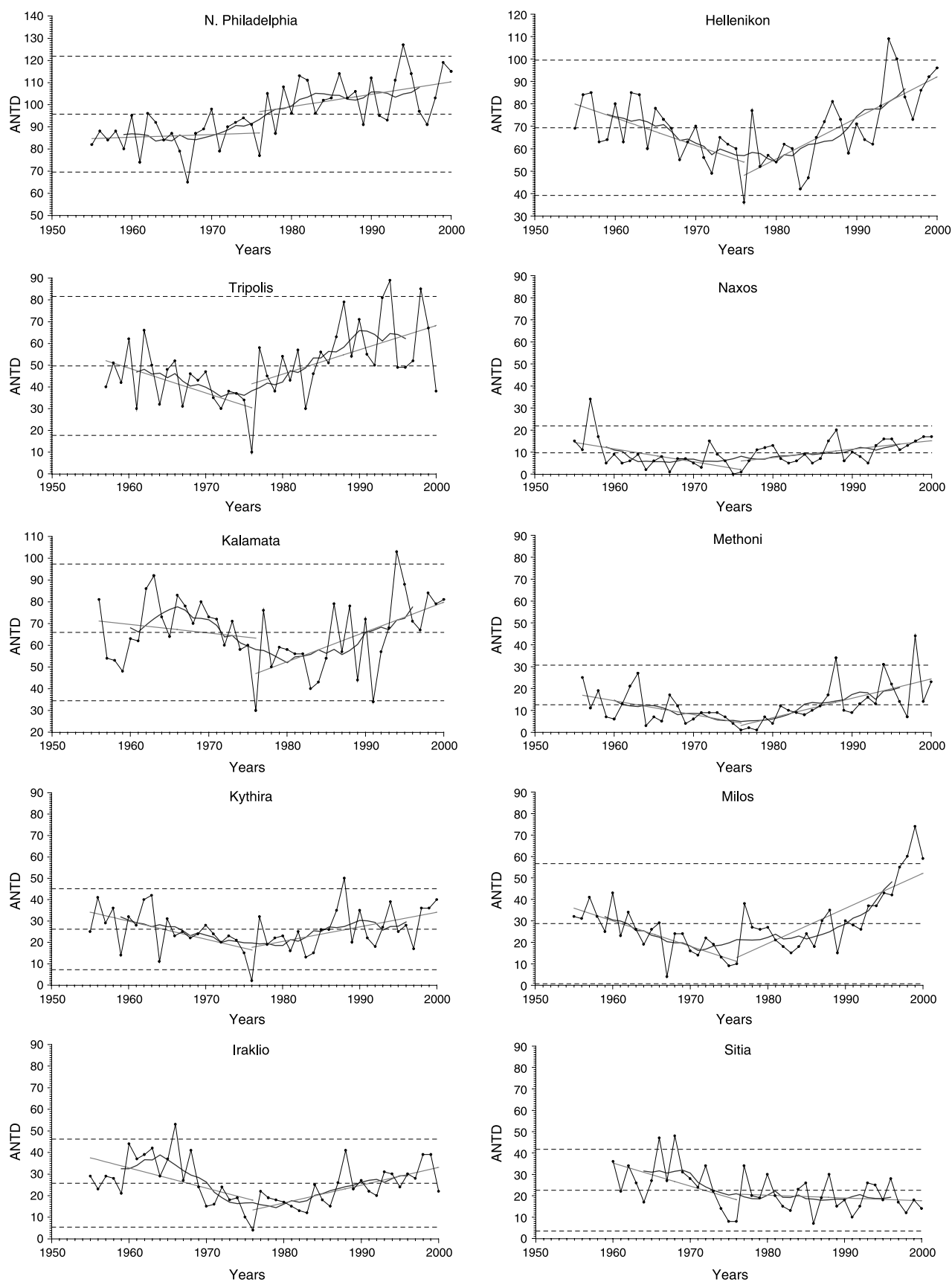
Fig. 4. Time series of ANTD of selected stations in Greece, along with 9-years moving average and linear trends for the two examined periods (solid lines) and the mean, mean + 2SD, mean − 2SD (dot lines)

Table 1. Results of the application of the Mann–Kendall test statistic to the ANTD time series

Stations	A′ period	t	Change per year	B′ period	t	Change per year
Athens National Observatory	1950–1976	−0.58*	−1.14	1976–2002	+0.39*	+1.17
Alexandroupolis	1951–1976	−0.19	−0.37	1976–2000	+0.33*	+0.82
Mikra	1959–1976	−0.36*	−1.33	1976–2000	+0.37*	+1.00
Florina	1961–1976	−0.38*	−1.25	1976–2000	+0.17	+0.59
Kozani	1955–1976	−0.22	−0.78	1976–2000	+0.28*	+0.90
Ioannina	1956–1976	−0.39*	−1.13	1976–2000	+0.19	+0.81
Larissa	1955–1976	−0.12	−0.36	1976–2000	+0.44*	+1.18
Kerkyra	1955–1976	−0.25	−0.74	1976–2000	+0.24	+0.77
Skyros	1955–1976	**	**	1976–2000	+0.35*	+0.46
Mytilini	1955–1976	−0.39*	−0.93	1976–2000	+0.49*	+1.41
Agrinio	1956–1969	−0.32	−1.04	1969–2000	+0.20	+0.51
N. Philadelphia	1955–1967	−0.20	−0.62	1967–2000	+0.44*	+0.80
Hellenikon	1955–1976	−0.50*	−1.18	1976–2000	+0.57*	+1.76
Tripolis	1957–1976	−0.37*	−1.08	1976–2000	+0.25	+1.07
Naxos	1955–1976	−0.43*	−0.56	1976–2000	+0.38	+0.37
Kalamata	1956–1976	−0.13	−0.37	1976–2000	+0.37*	+1.31
Methoni	1956–1976	−0.40*	−0.60	1976–2000	+0.54*	+0.85
Kythira	1955–1976	−0.47*	−0.81	1976–2000	+0.36*	+0.65
Milos	1955–1976	−0.64*	−1.13	1976–2000	+0.51*	+1.57
Iraklio	1955–1976	−0.40*	−0.89	1976–2000	+0.45*	+0.79
Sitia	1960–1976	−0.37*	−1.01	1976–2000	−0.17	−0.12

* Statistically significant trend (c.l. 95%)
** Successive positive and negative trends, not statistically significant (c.l. 95%)

from 1950 to 1985, with only a slight drop in the period 1970–1980. In the last 5–10 years of the study, temperature has begun to rise throughout the year. Likewise, Serra et al. (2001) suggested that monthly maximum temperatures show, within the significant band, an abrupt change in the early 1980s.

Furthermore, the maximum values of the time series of ANTD in the 1990s exceeded the corresponding maximum, which was established in the middle of the twentieth century, for adequate stations. The ANTD exceed the limit of mean + 2SD, which is a limit used for extreme conditions, for most of the stations during the last decade of the twentieth century. On the other hand, the ANTD are below the limit of mean − 2SD only in the year 1976, which was the coldest year of last fifty-year period in Greece (Figs. 3, 4). The change of the trend from decrease to increase during the 1970s is also reported by Proedrou et al. (1997), who studied the trends of the mean maximum and minimum air temperature for 25 stations of Greece during the period 1951–1993.

Table 1 shows the results of the analysis of the time series for TD using the Mann–Kendal test,

as well as the trends recorded within the two main periods of observed changes, 1955–1976 and 1976–2000. The t values, which are statistically significant (c.l. 95%), have been shaded and marked by an asterisk, so that the corresponding period is easily distinguishable.

For the first period, a statistically significant (c.l. 95%) negative trend of ANTD is observed, with an exception of some stations (Alexandroupoli, Kozani, Corfu, Larissa, Agrinio, N. Philadelphia, Kalamata) where the negative trend is not statistically significant. With regard to the station of Skyros, this period is characterised by successive positive and negative trends, while being not statistically significant. The negative trend of ANTD ranges from −1.33 TD/year in Mikra up to −0.56 TD/year in Naxos.

In the second period, a statistically significant (c.l. 95%) positive trend of ANTD is observed for the majority of the meteorological stations, with small exceptions as shown in Table 1. The peak values of the positive trends of ANTD range from +0.37 TD/year in Naxos up to +1.76 TD/year in Hellenikon. An exemption is the case of the Sitia station in south-eastern Greece, where the ANTD shows a decrease in both the two
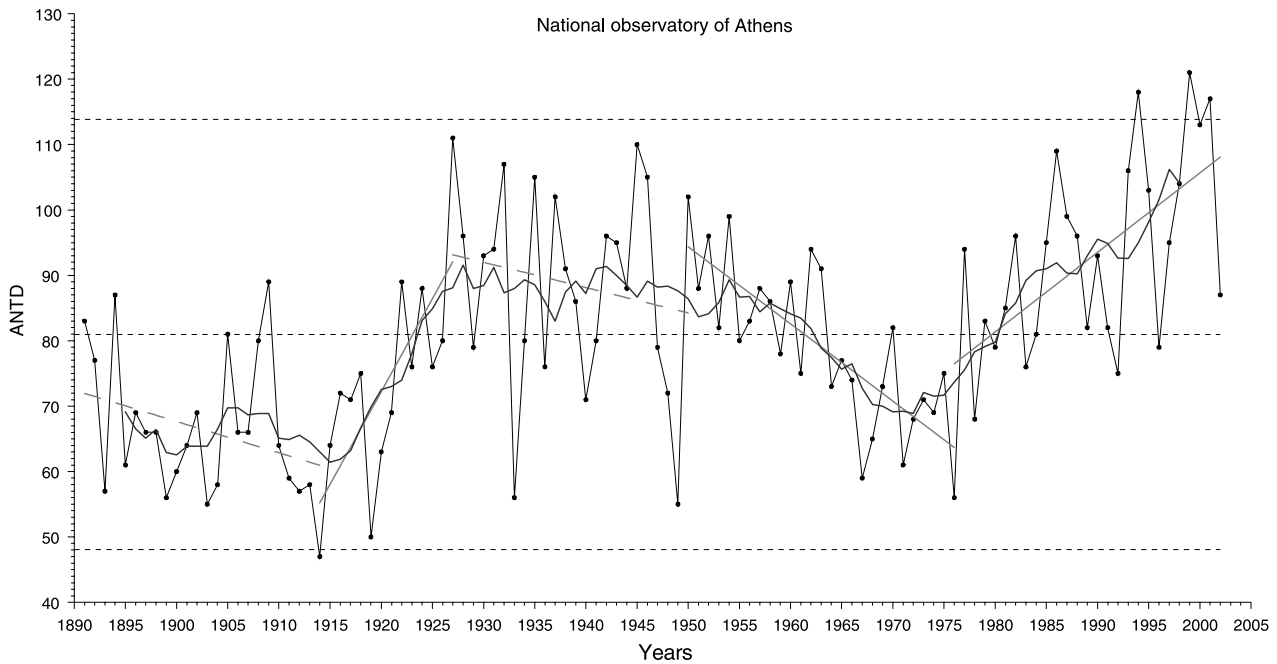
Fig. 5. Time series of ANTD, along with 9-years moving average and linear trends for the examined periods (solid lines represent statistically significant trends (c.l. 95%); dash lines represent not statistically significant trends) and the mean, mean + 2SD, mean − 2SD (dot lines), for the National Observatory of Athens during the period 1891–2002

aforementioned periods, but the trend is statistically significant (c.l. 95%) only in the period 1960–1976. The findings are consistent with these of other researchers, (Kutiel and Maheras 1998; Maheras et al. 1999; Turkes et al. 2002) who have investigated the air temperature regime over the Mediterranean basin.

Figure 5 shows the time series of the ANTD for the National Observatory of Athens, during the period 1891–2002, which is the longest and the most reliable in the Greek region. The ANTD time series present a negative trend that is not statistically significant (c.l. 95%) ending at a minimum in 1914. Then, an inversion to an increase trend is observed until 1927, which is statistically significant (c.l. 95%). The change rate of the ANTD is +2.63 TD/year. During the next two decades, the ANTD presents great variability, with a small negative trend which is not statistically significant (c.l. 95%). Nevertheless, since 1950, the characteristic negative trend, which is appeared all over Greece, is observable and results in a minimum in 1976, which, as it has been reported, was the coldest year of last fifty-year period. This negative trend is statistically significant (c.l. 95%) with a change rate of −1.14 TD/year. After that, this trend is reversed

into a statistically significant positive trend, (c.l. 95%), until the end of the examined period. It is remarkable that the ANTD in the last decade appeared to have exceeded the maximum values recorded in the middle of the twentieth century and have overcome the limit of mean + 2SD. These results are consistent with the findings of Founda et al. (2004), who found that the number of hot days as well as the frequency of occurrence and duration of warm events have significantly increased during the last decade. The change rate of the ANTD is −1.17 TD/year.

The Hellenikon station located at the headquarters of the Hellenic National Weather Service has been chosen to examine the persistence of the consecutive days of TD. Figure 6 shows the frequencies of consecutive days (three and higher) with $Ta_{max} > 30.0\,°C$ for the period 1955–2001, along with a 5th polynomial fitting. The amount of bars for each year represents the episodes with consecutive days and the number in the bars gives the length of the TD event. The episodes occur from 25th May to 4th October. The long episodes occur from the beginning of June and can also take place to the middle of the September. Since the 1980s there is an increasing amount of consecutive TD, which is higher than
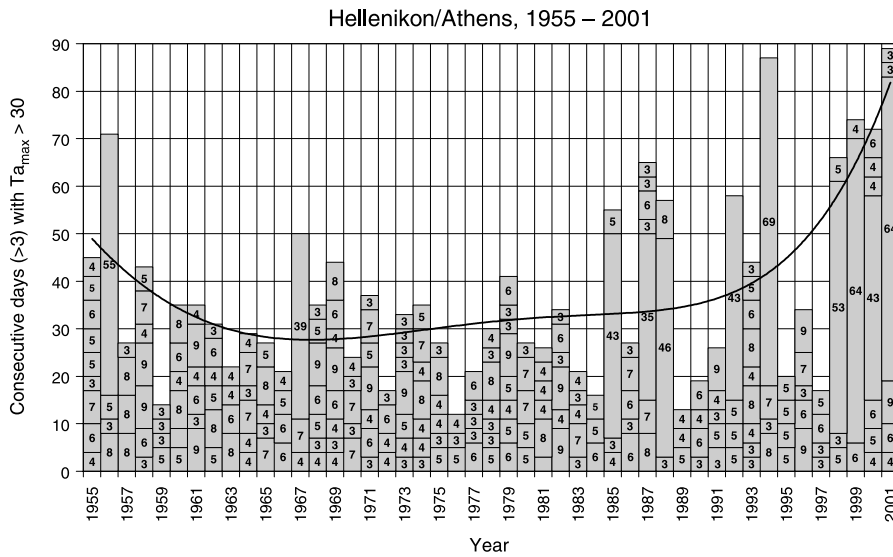
Fig. 6. Frequencies of consecutive days (three and more) with $Ta_{max} >$ 30.0 °C for Hellenikon/Athens during the period 1955–2001, along with the polynomial fitting

in the middle of the 20th century. More specifically, the amount of consecutive TD is increasing more rapidly than the amount of total TD. The duration per time period since the 1980s is increased compared to the previous decades. It has been noticed that there is a not statistically significant positive trend for the whole examined period. Nevertheless, there is also a negative not significant trend for the period 1955–1976, while the trend of the consecutive days for the period 1976–2001 is positive and statistically significant (c.l. 95%). The number of the episodes for the whole examined period presents a negative and statistically significant trend (c.l. 95%), but for the two examined subperiods there is no statistically significant trend.

In order to look at the change of the ANTD from decade to decade for the entire region of Greece, the spatial distribution of the ANTD is shown in Figs. 7 and 8. With regard to the first decade (1961–1970), the maxima of the TD are shown in the central continental Greece, while minima are observed in the central Aegean Sea and particularly in the Cyclades islands. This is because of the beneficial blow of the Etesians winds, which modify the maximum air temperatures and contribute to thermal comfort conditions.

Since the ancient times, every summer from June to September, a strong Monsoon-like system develops above the east Mediterranean Sea especially the Aegean Sea, where the high pressure is located in the North Balkans and the low in the Central Iraq. This system develops strong north–south directed winds, which blow

continuously with varying intensity. The annual recurrence and their persistence made the ancient Greeks to name them "Etesians" which in the Greek language means, annually recurrent (Mariolopoulos 1972). The TD range from 56 (Naxos) up to 954 (Agrinio) and follow mainly the meridian distribution, similar to that of the mean maximum air temperatures (Nastos 1995). In the second decade (1971–1980) the maxima of the TD are limited to small regions in continental Greece, while the minima are distributed in a larger region in the Aegean Sea. The TD range from 53 (Methoni) up to 919 (N. Philadelphia). The third decade (1981–1990) is characterised by an increase in the TD and also in the area of regions that enclose the maximum values. The maxima of the decade of the TD are found in vast areas of central Greece while the distribution of the minima is similar to that of the second decade. The station of N. Philadelphia presents 1051 TD while the station of Naxos hardly reaches 90 TD. The spatial distribution of the TD in the last decade (1991–2000) shows a similar pattern to that of the previous decade, with but the only difference being the maximum number of TD in these regions. The minima of the TD are limited to the southern region of the Aegean Sea and the south-eastern part of Crete Island. This is due to the reduced intensity of the Etesians winds. The TD oscillates from 131 in Naxos up to 1065 in N. Philadelphia.

Tropical days, as mentioned, are considered as very hot ($Ta_{max} >$ 30.0 °C), and they represent a good opportunity to detect and quantify heat
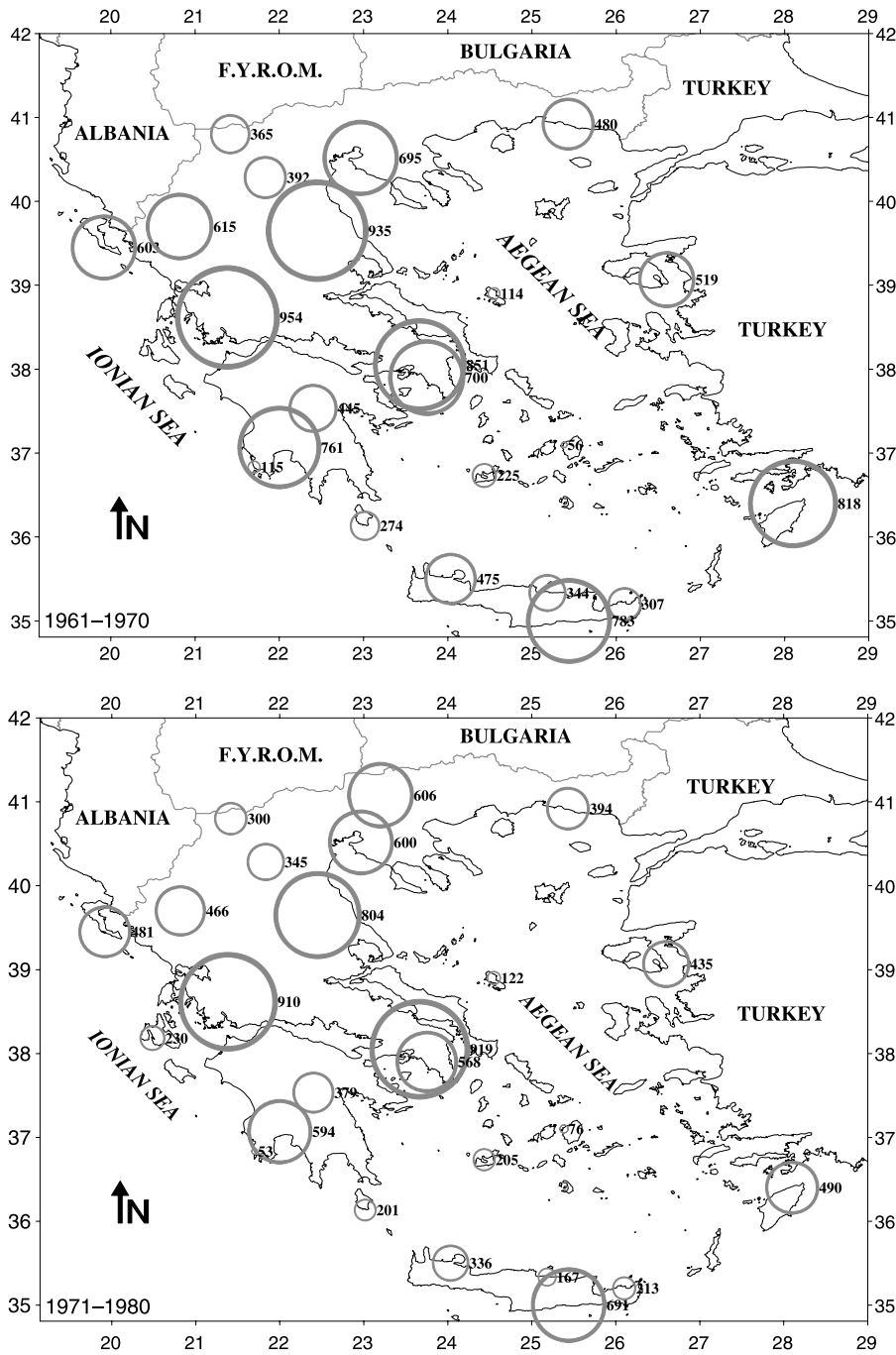
Fig. 7. Spatial distribution of the number of tropical days for the decade 1961–1970 (upper panel) and the decade 1971–1980 (lower panel)

stress conditions and the possible consequences for human health. Accordingly, we have evaluated the thermal index PET for Hellenikon station, which is based on the human energy balance, is considering thermo-physiology, and can be used for the assessment of the thermal environment of humans. Figure 9 shows the bioclimatic diagrams for PET in Athens for the period 1955–1976 (upper graph) and for the period 1977–2001 (lower graph) in order to exhibit variation in time. The

bars present in 10-days intervals the percentages of PET-Classes according to physiological strain after Matzarakis and Mayer (1997). Figure 9 shows that the period of occurrence of heat stress conditions (PET > 35) takes place from April to the end of September. The bioclimatic graphs show also the amount of days exceeding a threshold of a PET-value, along with the annual mean PET_a, the maximum PET_{max} and minimum PET_{min} for the two examined sub periods. The
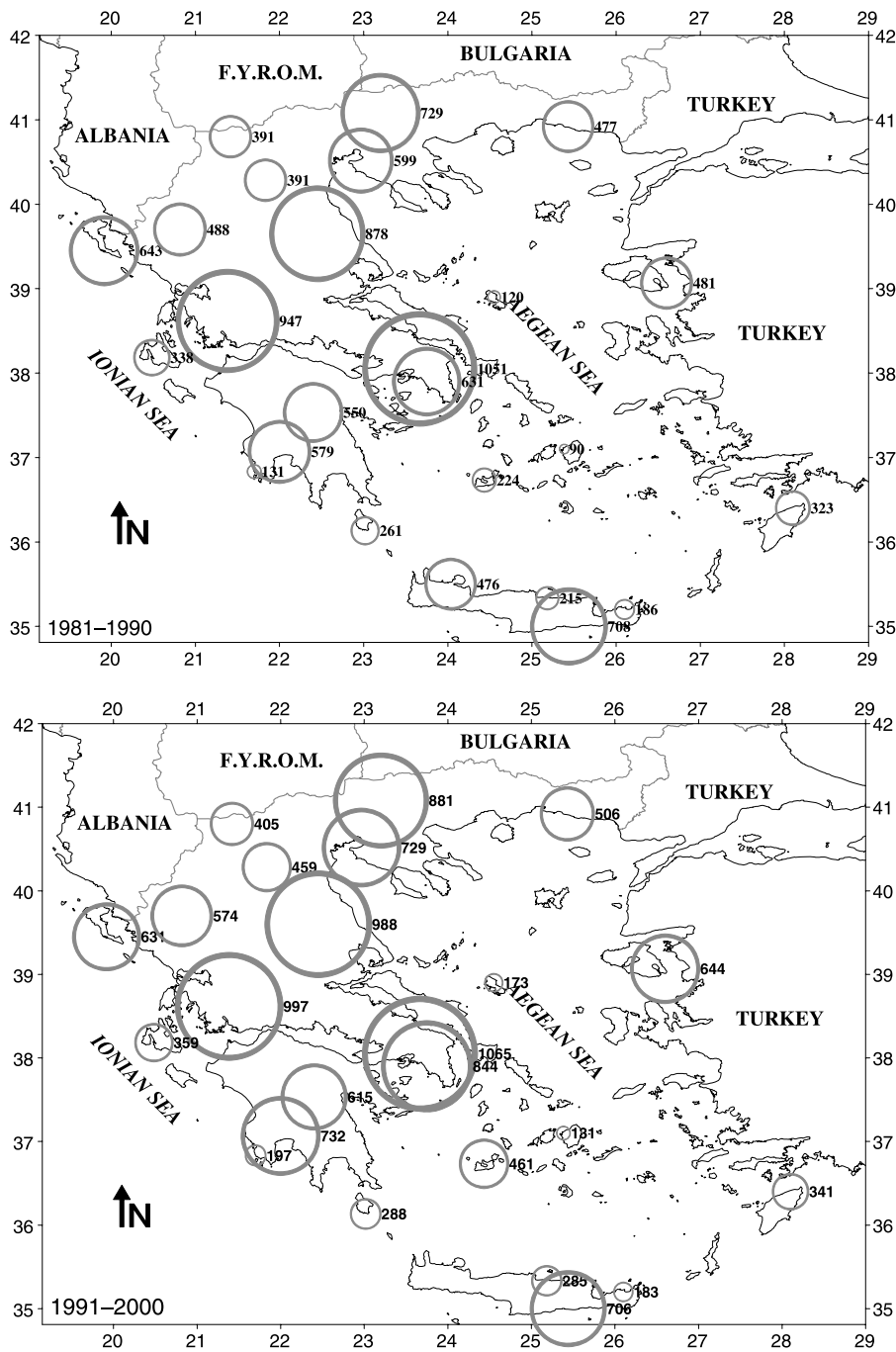
Fig. 8. Spatial distribution of the number of TD for the decade 1981–1990 (upper panel) and the decade 1991–2000 (lower panel)

amount of days with PET > 35 vary from 2 to 43 days with a mean of 21.0 days for the whole period 1955–2001.

Figure 10 shows the frequencies of consecutive days (three and higher) of PET > 35 °C for the period 1955–2001. The amount of bars for each year represents the episodes with consecutive days and the number in the bars indicate the length of the episodes. Additionally, the 5th polynomial fitting of the consecutive days with PET > 35 is included in the Fig. 10. Since the 1980s we have an increasing amount of days with PET > 35 °C, which are higher than in the middle of the 20th century. The consecutive days of PET > 35 are increasing rapidly in comparison to previous decades. The duration per specific episode since the middle of the 1990s has increased in comparison to the previous years.

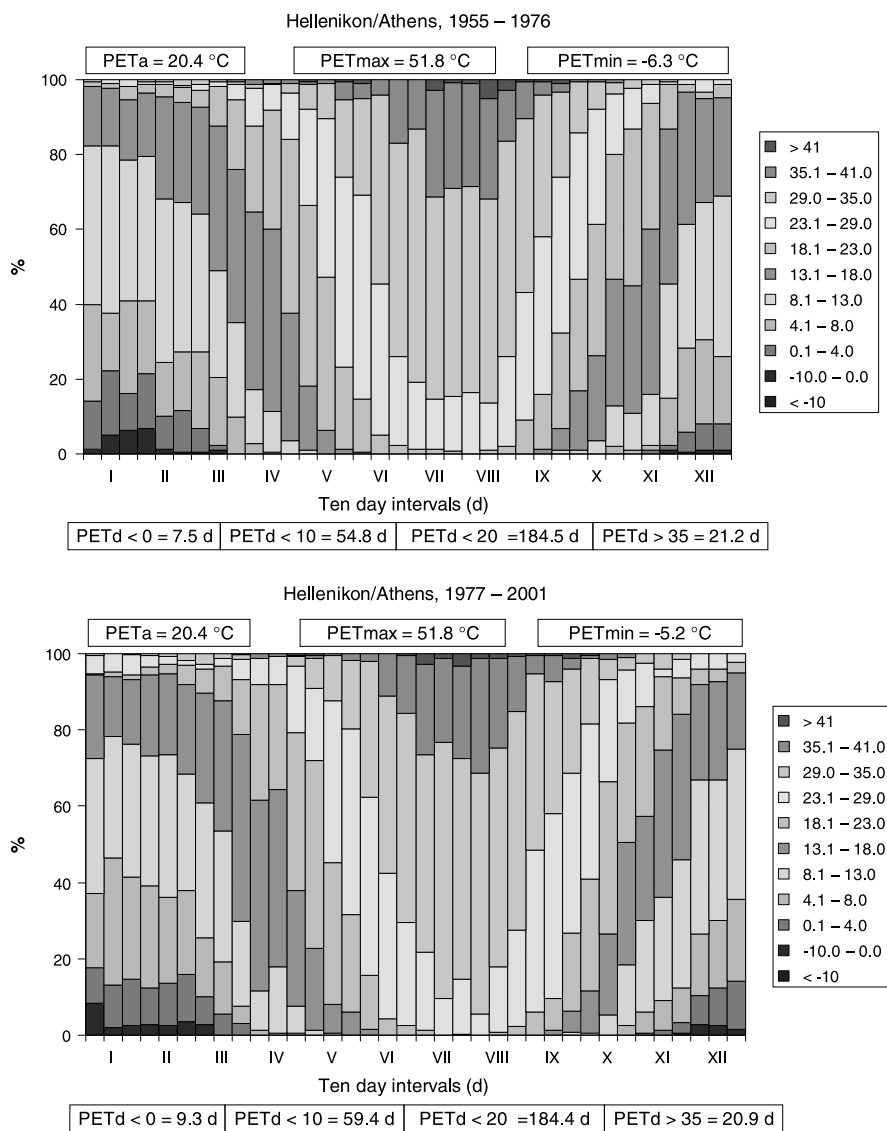With regards to the amount of days with PET > 35 °C, it is observed that there is a positive

Fig. 9. Bioclimate diagram (Physiological Equivalent Temperature) for Hellenikon/Athens during the periods 1955–1976 (upper graph) and 1977–2001 (lower graph)
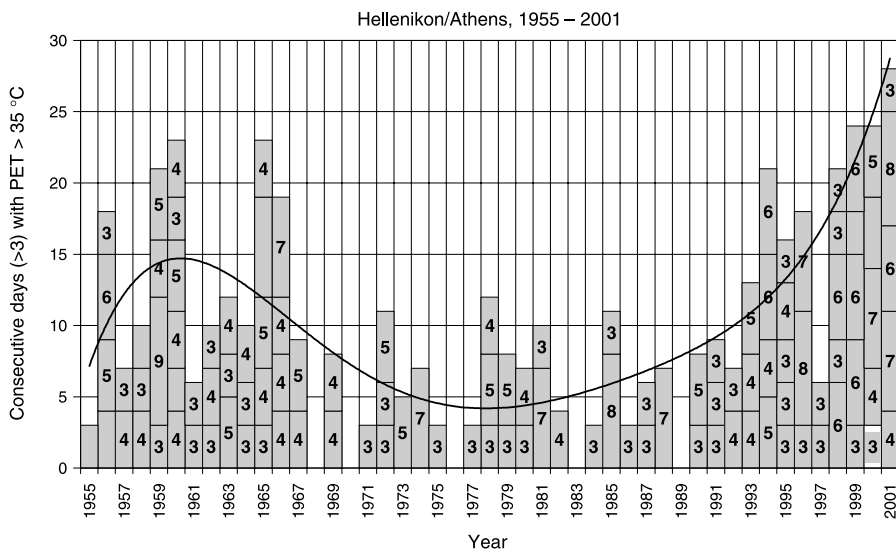

Fig. 10. Frequencies of consecutive days (three and more) with PET > 35 °C for Hellenikon/Athens during the period 1955–2001, along with the polynomial fitting

but not statistically significant trend for the whole examined period. Beside this, there is a negative and positive statistically significant trend at c.l. 95% for the two subperiods, respectively. Nevertheless, the number of the episodes for the whole examined period shows a positive but not statistically significant trend (c.l. 95%), the trends for the two examined subperiods are negative for the first and positive for the second period, both are statistically significant at c.l. 95%.

4. Conclusions

Positive trends of ANTD, although mostly insignificant, have appeared in the central parts of Greece during the second half of the twentieth century. Significantly positive trends (c.l. 95%) are established for three stations. On the other hand, significant negative trends (c.l. 95%) are observed in the south-eastern regions of Greece, which is consistent with the findings of other researchers for the eastern Mediterranean region.

The analysis of the ANTD variability over time showed two periods of change for the majority of the meteorological stations examined. The first (1955–1976) is characterised by a statistically significant negative trend (c.l. 95%) for most of the examined stations. The second period (1976–2000) shows statistically significant positive trends of ANTD (c.l. 95%). For some stations, the maximum temperature in the 1990s exceeds the maximum temperature of the 1950s. A physical explanation is the development of the Urban Heat Island (UHI) around the sites where the meteorological observations have been recorded. With respect to the National Observatory of Athens (NOA), the UHI appeared is attributed to the extensive building of Athens around NOA after the Second World War and the rapid increase of the population and the number of vehicles mainly after 1970. The urbanization effect in NOA refers mainly to maximum air temperature (an increase $\sim 2\,^{\circ}\text{C}$) and to the warmer seasons of the year (Philandras et al. 1999).

Concerning the spatial distribution of the number of TD, a change is observed from decade to decade. The maxima, which occur mainly in central Greece, increase, while they are simultaneously delimited in larger areas of the country for the last decade (1991–2000). Nevertheless, there is an exemption in the decade 1971–1980,

where the maxima are limited in small regions and do not encompass large parts of the country. The minima of the TD are limited to the central Aegean Sea and during the last decade they are found in the southern Aegean and in southeastern part of Crete Island and this is possibly due to the regime of the "Etesians", the northerly high summer winds established mainly during summer months over the Aegean Sea.

With regard to the consecutive days of the humanbiometeological thermal index PET for the Hellenikon station and the chosen threshold of PET > 35, which is correlated with extreme thermal stress conditions, we found that there is a positive but not significant (c.l. 95%) trend for the entire period. Furthermore, the trends for the two subperiods are statistically significant negative and positive, respectively (c.l. 95%). The occurrence of demanding conditions for the human body regarding consecutive days with PET > 35 lasts from the beginning of April until the end of September.

Further work concerning absolute minimum temperatures is needed, in order to describe better the extreme thermal stress conditions in Greece, especially during the last decade of the 20th century.

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