How will the occurrence of extreme weather events in Greece, change by the end of the 21st century?

This information sheet is one in a series describing how the frequency and intensity of extreme weather events may change by the end of the 21st century in response to global warming. The regional information presented here was obtained using state-of-the-art climate modeling and regional downscaling techniques developed during the STARDEX European Union-funded research project. These methods and the STARDEX approach are described in an accompanying overview information sheet.

Climate of the Greek region

Greece is located in the Eastern Mediterranean basin in the south Balkans. Its climate is highly diverse because of the complex terrain, together with the strong continental and maritime influences. A large mountain range dominates the western side of the country, while the eastern and southern side consists of low altitude areas and islands (Figure 1).

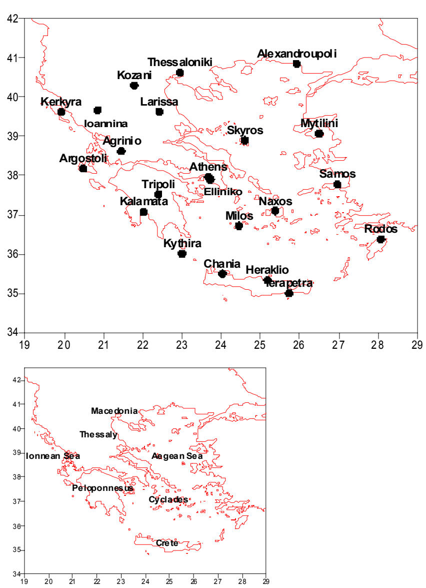

Figure 1:.Geographical distribution of the Greek stations.

The maximum of precipitation is found in the western part of the country mainly resulting from the moist air advection from west and the orographic uplift mechanisms due to the Pindos chain and the mountains of

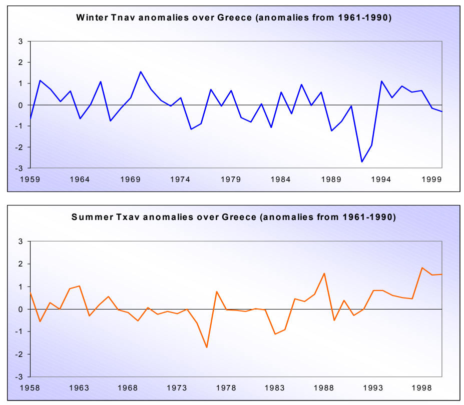

Figure 2. Time series of winter minimum temperature and summer maximum temperature anomalies for the period 1958-2000, averaged over the 20 Greek stations

the Peloponnese. A second maximum is found over the eastern Greek islands principally due to large-scale moisture advection. The spatial distribution of temperature could be considered more uniform but the relief and the distance from the sea influence the temperature conditions of each region. A pronounced significant trend to drier winter climate has occurred in the eastern Mediterranean area, especially over Greece for the period 1961-1990. A decrease of mean winter precipitation around 60mm for the same period was also found. Furthermore, in accordance with the trend in the mean, negative significant trends in annual, winter and autumn precipitation totals over Greece during the period 1958-1997 were observed. Concerning temperatures a small decrease for the period 1958-2000 is observed for the minimum winter temperature anomalies, while the summer maximum temperatures show a small increasing trend which is more intense in the last decade (Figure 2).

Past changes in extremes

Apart from the changes in the mean precipitation and temperature conditions in the Greek area, changes were also observed in the extreme precipitation and temperature events. The 90th percentile of precipitation, on an annual basis, presents a decreasing trend for the whole Greek area except for the central Aegean Sea and Athens. In wintertime, its trend appears to have a similar distribution to the annual one. In three stations, two island (Skyros and Rodos) and one continental (Tripoli), the decreasing trends were found to be statistical significant. During the autumn period, there are decreasing and increasing trends depending on the station location. Only two of these stations present statistically significant results (Figure 3a, b). For the maximum dry spells, both for winter and summer the computed trends were increasing in the majority of the stations (Figure 4a,

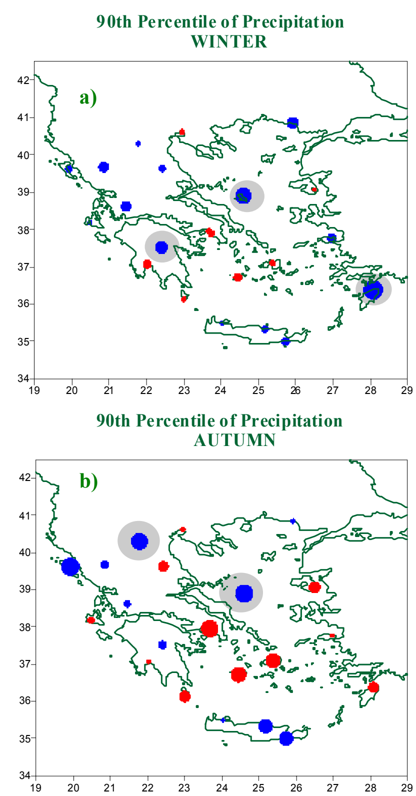

Figure 3. Winter and autumn trends of the 90th precipitation percentile for the Greek area. The red circles are the positive trends and the blue the negative ones. The shaded trends are the statistically significant ones.

b). The annual 90th percentile of maximum temperature increased during the period 1958-2000 almost for the whole Greek area. The increasing maximum summer temperatures can explain this positive trend, although the maximum winter temperatures present a statistically significant decrease. On the contrary, annual minimum temperatures present a decreasing trend, which is statistically significant in central and southwestern Greece.

Future changes in extremes

The above results imply that the frequency and the intensity of the extreme temperatures and precipitation changed during the last century in Greece. A crucial question can be addressed "Will these extreme events (drought, heat waves or storms) be more frequent in the future?" It is necessary to analyze in a more extensive way the extreme events in the future, not just using the raw data of the GCM but also the results derived from statistical downscaling methods – see the overview information sheet.

Concerning the extreme temperature

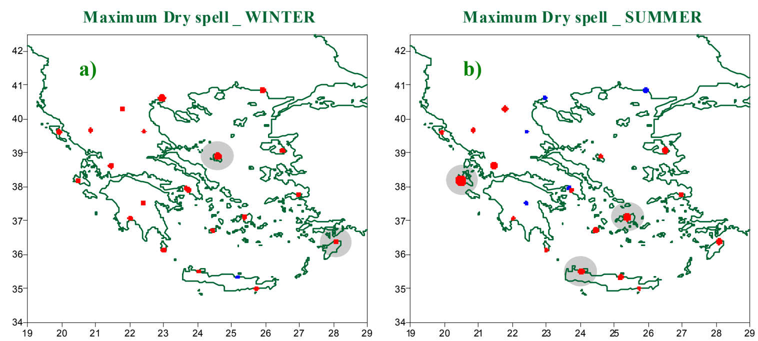

Figure 4. Winter and summer trends of the maximum dry spells for the Greek area, 1958-2000. The red circles are the positive trends and the blue the negative ones. The shaded trends are the statistical significant ones

conditions for the future period 2070-2100, the downscaled A2 HadAM3P scenario projects a rather warmer climate for the Greek area since both the 10th winter minimum temperature percentile (Tnq10) and the 90th summer maximum temperature percentile (Txq90) present higher values – the increase is more obvious for the extreme maximum temperatures – in comparison to the present day conditions. According to the B2 scenario, a small increase is predicted for the winter Tnq10 but the values are lower than the ones in the A2 scenario. The B2 summers are expected to be warmer (warmer extreme summer events) compared to todays conditions. This increase is almost the same as that predicted from the A2 scenario (Figure 5).

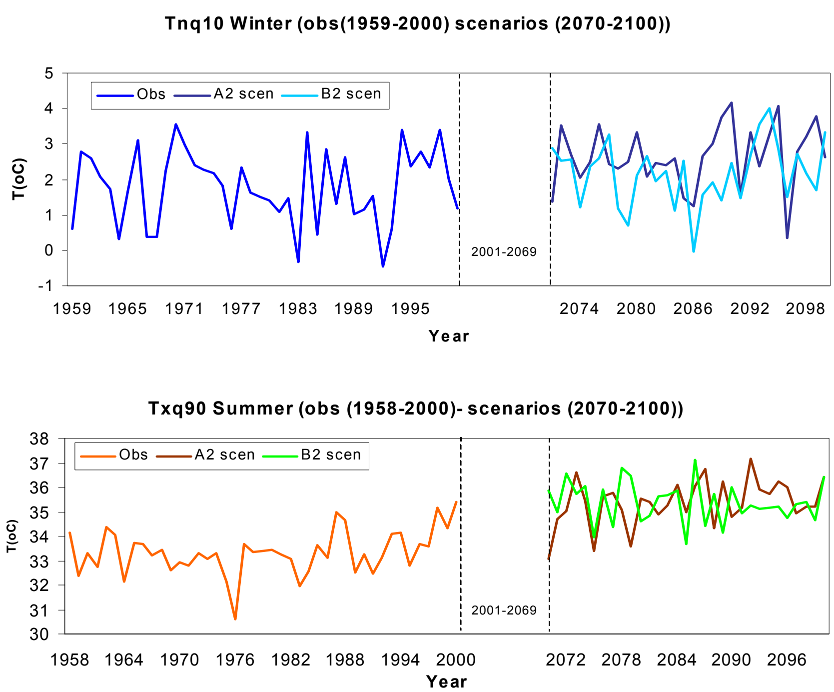

Figure 5. Time series of future winter 10th minimum temperature percentile (cold-day threshold) and future summer 90th maximum temperature percentile (hot-day threshold) based on the A2 and B2 scenarios for the period 2070-2100

In the case of extreme precipitation events (90th percentile), both the future scenarios show an increase in the extreme precipitation amounts for winter in central continental Greece and in a part of the Aegean Sea (mainly in the southern Aegean Sea in the B2 scenario). In the rest of the country, the extreme precipitation events will decrease (Figure 6 a1, b1). As regards autumn, the A2 scenario presents a decrease in the extreme rainfall totals mainly in central and southeastern Aegean Sea. According to B2 scenario this decrease characterizes a larger part of the Greek region in comparison to A2 scenario (Figure 6 c1, d1).

The analysis of the behaviour of the winter maximum dry spells for the future period 2070-2100 shows that both scenarios predict an increase of this parameter (drier conditions) in almost the whole Greek area. The only exceptions are the northwestern parts (A2) and the southern parts (B2) where the maximum dry spells are expected to decrease (Figure 6 a2, b2). A significant increase is also predicted during the summer months, especially according to the B2 scenario. Only in a few limited areas, the maximum dry spells are projected to decrease (Figure 6 c2, d2).

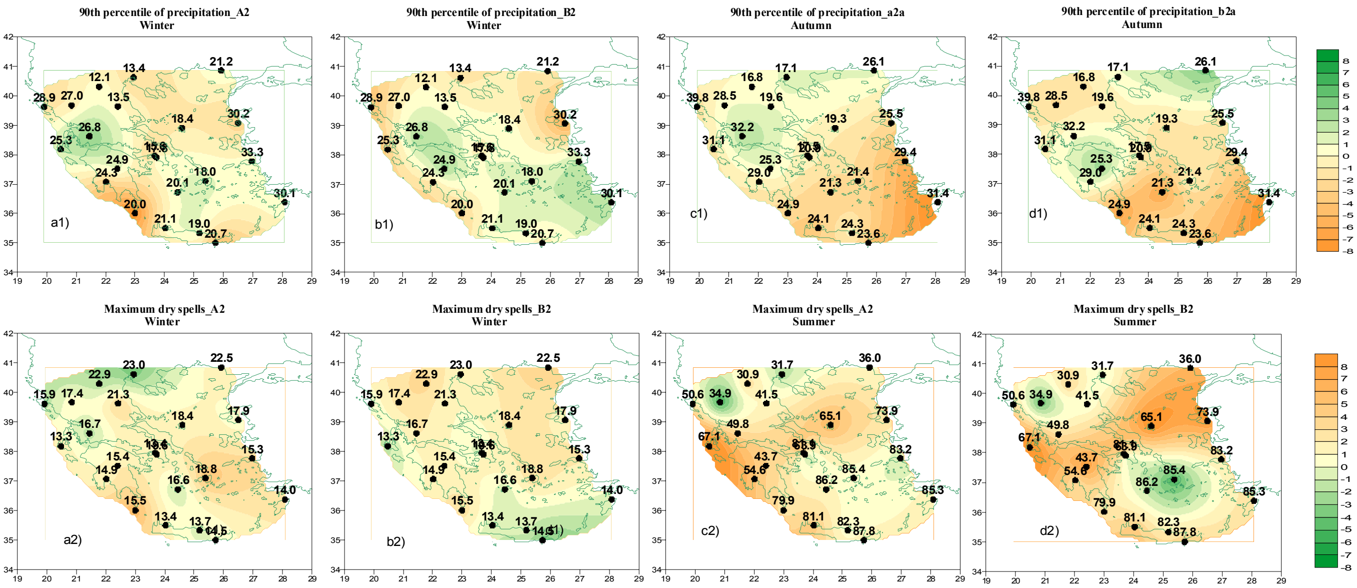

Figure 6. The spatial distribution of the differences of the 90th precipitation percentile and maximum dry spells for the scenarios (A2 and B2). The values of each station represent the mean value of 90th precipitation percentile and maximum dry spells for the period 1958-2000. The colored contours show the differences between the scenarios and the observed values

Impacts

The past changes in extreme events have had serious impacts on many aspects of human activity, agriculture, environmental, socio-economic, tourism. Although, Greece did not experience the "very hot" summer of 2003 as other parts of Europe, damages were also caused in Greece from other extreme events. According to data published from the Hellenic Agricultural Insurance Organization of Greece, the economic losses from heavy precipitation, floods and extreme winds were over 180 million Euros in 2002.

Many extreme events occurred in the past few years, in Greece:

- 19-29 July 1987: Heatwave occured during this period. According to the Greek Ministry of Health this heatwave resulted in 1280 deaths, of which 1115 were in Athens and the remaining 195 were in the rest of Greece, including 96 in Thessaloniki (Giles and Balafoutis, 1990; Giles et al., 1990).
- 10/12/2001: Very low temperatures were observed in the whole Greek region. Heavy snowfall was observed even in the centre of the capital, Athens (Figure 7).
- 21/1/2003: The heavy and intense rainfall on the eastern Aegean islands resulted in floods and damages in inhabited areas (Figure 8).

Figure 7. Heavy snowfall in the center of Athens (10/12/2001)

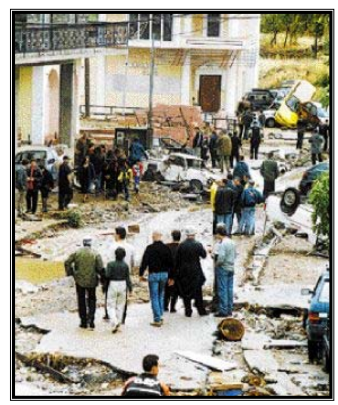

Figure 8. Damages from the heavy rainfall in eastern Aegean islands (21/1/2003)

References and further reading

Giles BD, Balafoutis C (1990). The Greek heatwaves of 1987 and 1988. *Int. J. Climatol.*, **10**: 505-517.

Giles BD, Balafoutis C, Maheras P (1990). Too hot for comfort: the heat waves in Greece in 1987 and 1988. *Int. J. Biometeorol*, 34: 98-104.

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