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Changes in annual temperature and precipitation extremes in the Carpathians since AD 1961

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The Carpathians are the largest, longest, most twisted and fragmented segment of the Alpine system, stretching between latitudes 44°N and 50°N, and longitudes 17°E and 27°E. This European mountain range is a climatically transitional region between major atmospheric circulation source areas of the Atlantic Ocean, Mediterranean Sea and continental Europe. The region is a European biodiversity hotspot, containing over one third of all European plant species. It is acknowledged that the mountain regions are particularly sensitive and vulnerable to climate change than any other regions located at the same latitudes. Observational studies on the variability and trends of extreme events suggest an overall consensus towards a significant increase in the frequency, duration and intensity of warm extremes in most of these regions, including the Carpathians.

15 core indices, defined by the Expert Team on Climate Change Detection and Indices (ETCCDI), were computed in order to investigate the changes in annual temperature and precipitation extremes, based on their known relevance for the infrastructure, human health and tourism activities in these mountains. The indices were computed from gridded daily datasets of minimum and maximum temperature and precipitation at 0.1° resolution (∼10 km), available online within the framework of the project CarpatClim (www.carpatclim-eu.org) for the period 1961-2010. Changes in the annual temperature and precipitation extremes in the last five decades have been identified with the Mann-Kendall non-parametric trend test, at the 90% significance level (two-tail test).

The results show decreasing trends in cold-related thermal indices, especially in the number of frost days, and increasing trends in warm-related ones. No consistent trend in precipitation extremes has been found. There is a generally uniform signal of significant increasing trends in the frequency of summer days across the Carpathians, with no obvious differences between high and low elevation areas. The positive shift in the upper tail of summer maximum temperature distribution largely explains the intensification of this signal after mid 1980s or early 1990s, over extended areas within the Carpathian region. The changes in the occurrence of tropical nights are substantial only in low elevation areas (below 700 m) located outside the Carpathian Mountains, which are particularly exposed to persistent and intense warm spells in summer. The Warm Spell Duration Index is increasing over 60% of the area, showing a coherent pattern related rather to geographical position than to elevation. The shifts in the lower end of minimum temperature distribution suggest a lower frequency of extreme cold conditions, favouring an extended increase in the probability of warmer winter temperatures. The areas experiencing significant decreases of cold spell duration are rather scattered across the region.

The trend patterns are consistent over the region (there are no mixed trends for a given index). Regional differences in climate extreme trends within the Carpathian region are related to altitude, rather than latitude. The (annual) East Atlantic pattern shows strong correlations with the warm-related indices. Our results are in agreement with previous studies on precipitation and temperature extremes in the region.

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