Trends in Indices of Daily Temperature and Precipitation Extremes in Europe, 1946–99

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ABSTRACT

Trends in indices of climate extremes are studied on the basis of daily series of temperature and precipitation observations from more than 100 meteorological stations in Europe. The period is 1946–99, a warming episode. Averaged over all stations, the indices of temperature extremes indicate ''symmetric'' warming of the cold and warm tails of the distributions of daily minimum and maximum temperature in this period. However, ''asymmetry'' is found for the trends if the period is split into two subperiods. For the 1946–75 subperiod, an episode of slight cooling, the annual number of warm extremes decreases, but the annual number of cold extremes does not increase. This implies a reduction in temperature variability. For the 1976–99 subperiod, an episode of pronounced warming, the annual number of warm extremes increases 2 times faster than expected from the corresponding decrease in the number of cold extremes. This implies an increase in temperature variability, which is mainly due to stagnation in the warming of the cold extremes.

For precipitation, all Europe-average indices of wet extremes increase in the 1946–99 period, although the spatial coherence of the trends is low. At stations where the annual amount increases, the index that represents the fraction of the annual amount due to very wet days gives a signal of disproportionate large changes in the extremes. At stations with a decreasing annual amount, there is no such amplified response of the extremes.

The indices of temperature and precipitation extremes in this study were selected from the list of climate change indices recommended by the World Meteorological Organization–Commission for Climatology (WMO–CCL) and the Research Programme on Climate Variability and Predictability (CLIVAR). The selected indices are expressions of events with return periods of 5–60 days. This means that the annual number of events is sufficiently large to allow for meaningful trend analysis in ~50 yr time series. Although the selected indices refer to events that may be called ''soft'' climate extremes, these indices have clear impact relevance.

1. Introduction

Surface air temperatures in most European regions have increased during the twentieth century (Houghton et al. 2001). In line with the characteristics of global temperature rise (Jones et al. 1999b; Karl et al. 2000), the European rate of change has been highest in the last quarter of the century (Klein Tank et al. 2002). The warming is projected to continue and is likely to be accompanied by changes in extreme weather and climate events (Houghton et al. 2001). Yet, little is known quantitatively about the nature of these changes. In this context, it is relevant to learn how the past warming affected the occurrence of temperature extremes, or whether the past warming was accompanied by detectable changes in precipitation extremes. Studies on these issues are receiving increased attention in the last few years (Easterling et al. 2000; Meehl et al. 2000).

Although changes in extreme temperature and precipitation events have been analyzed for individual European countries and stations (see, e.g., Forland et al. 1998; Tuomenvirta et al. 2000; Moberg et al. 2000; Brunetti et al. 2000; Osborn et al. 2000; Yan et al. 2002), a coherent picture for Europe as a whole is lacking. The main reason is the limited spatial coverage of the high time-resolution European datasets used in such studies. The second reason is that until recently no accepted standardization existed in the definitions of climate extremes, which has made it difficult to compare the results of different studies. This situation has changed now. The objective of the present study is to investigate the trends in some of the recently defined (Peterson et al. 2001) indices of temperature and precipitation extremes using the European Climate Assessment (ECA) daily dataset (Klein Tank et al. 2002).

The indices of temperature and precipitation extremes considered in the present study were selected

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