



Detection of temperature trends within the course of the year using “shifting subseasons”

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Recent global warming has not been ubiquitous – there are seasons, regions, and time periods with clearly discernible zero or downward air temperature trends. Regions that are not warming or are even cooling – also known as “warming holes” – have been previously detected mainly in autumn in the second half of the 20th century in large parts of North America as well as in Central and Eastern Europe. Daily maximum and minimum temperature (TX and TN, respectively) and daily temperature range (DTR) at 136 stations in Europe during the period 1961–2000 are employed to precisely locate the seasonal and subseasonal trends within the course of the year. Linear trends are calculated for moving “subseasons” of differing lengths (10, 20, 30, 60, and 90 days), each shifted by one day. Cluster analysis of the annual course of “shifting trends” reveals relatively well-defined regions with similar trend behavior. Over most of Europe, the observed warming is greatest in winter, and the highest trend magnitudes are reached by TN in Eastern Europe. Two regions stand out: in Iceland and the Eastern Mediterranean, the trends during the year are weak, positive in summer and mostly negative in winter, reaching statistical significance at only few stations. Significant autumn cooling centered on mid-November was found in Eastern and Southeastern Europe for both TX and TN; in many other regions trends are close to zero in the same period. Other clearly non-warming (or even cooling) periods occur in Western and Central Europe in February, April, and late June. Trends of DTR are largely inconclusive and no general picture can be drawn. Our results suggest that using different time scales, apart from the conventional three-month seasons or common months, is highly desirable for a proper location of trends within the course of the year.