Defining cold extremes: methodological peculiarities and their impact on the research results

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Cold extremes defined as days with extremely cold temperature can have adverse impacts on human, natural and industrial systems. These systems are sensitive to the frequency of such events, whose severity increases with their intensity and size of the affected area. Unlike summer hot extremes, the occurrence of winter cold extremes in Europe along with their long-term variances is not very well understood.

There is no universal definition of a temperature extreme, hence a large number of different indices can be found in literature. Vast majority of climatology studies assume that an air temperature is "extremely cold" when it does not reach a certain percentile-based threshold value. However, different research teams use different percentiles, which are calculated in a variety of ways, e.g. using various temperature metrics and baseline periods.

Our previous study concerning various methods of percentile calculation in summer hot extremes analysis for Europe has shown, that the selection of criteria is the key to further analysis. The differences in the geographic patterns of frequencies and trends are considerable if the percentile have been calculated using different approaches. On the other hand, initial research regarding winter cold extremes in Europe has revealed additional methodological issues which are particularly relevant in winter. This fact encouraged us to undertake the following study.

The aim of this study is therefore to assess the impact of different methods of percentile calculation on winter cold extremes analysis for Europe. The study is based on daily maximum (TX) and minimum (TN) temperatures for winter (DJF) obtained from the E-OBS dataset with a spatial resolution of $0.5°$. Patterns and trends of frequency, intensity and spatial extent of extremely cold days are investigated. The period of 1961/62–2016/17 is considered with a closer look at the most recent events.

Days with an extremely cold temperature are determined at each grid point using TX and TN. Those days are identified using percentile-based thresholds of varying severity (10th, 5th and 1st percentiles) which are computed using different approaches, i.e. seasonal and monthly values and values calculated for each calendar day using moving window of varying size. The thresholds are defined for commonly used baseline periods: 1961–1990, 1971-2000 and 1981–2010. Severity of a cold extreme is characterized by the cumulative temperature excess below the corresponding threshold for the total area affected.

The study demonstrates that the choice of a method of percentile calculation is critically important to the resulting analysis of patterns and trends of cold days. The obtained results enable to show strengths and weaknesses of considered approaches. The study reveals that different methodological issues related to percentile calculation are significant depending if summer or winter is considered.