

## Severe European winters in a secular perspective

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Temperature conditions during the winter time are substantially shaped by a strong year-to-year variability. European winters since the late 1980s – compared to previous decades and centuries – were mainly characterised by a high temperature level, including recent record-warm winters. Yet, comparably cold winters and severe cold spells still occur nowadays, like recently observed from 2009 to 2013 and in early 2017. Central England experienced its second coldest December since start of observations more than 350 years ago in 2010, and some of the lowest temperatures ever measured in northern Europe (below  $-50^{\circ}\text{C}$  in Lapland) were recorded in January 1999. Analysing thermal characteristics and spatial distribution of severe (historical) winters – using early instrumental data – helps expanding and consolidating our knowledge of past weather extremes.

This contribution presents efforts towards this direction. We focus on a) compiling and assessing a very long-term instrumental, spatially widespread and well-distributed, high-quality meteorological data set to b) investigate very cold winter temperatures in Europe from early measurements until today.

In a first step, we analyse the longest available time series of monthly temperature averages within Europe. Our dataset extends from the Nordic countries up to the Mediterranean and from the British Isles up to Russia. We utilise as much as possible homogenised times series in order to ensure reliable results. Homogenised data derive from the NORDHOM (Scandinavia) and HISTALP (greater alpine region) datasets or were obtained from national weather services and universities. Other (not specifically homogenised) data were derived from the ECA&D dataset or national institutions. The employed time series often start already during the 18th century, with Paris & Central England being the longest datasets (from 1659).

In a second step, daily temperature averages are involved. Only some of those series are homogenised, but those available are sufficiently distributed throughout Europe to ensure reliable results. Furthermore, the comparably dense network of long-term observations allows an appropriate quality checking within the network. Additionally, the large collective of homogenised monthly data enables assessing the quality of many daily series. Daily data are used to sum up negative values for the respective winter periods to create times series of “cold summations”, which are a good indicator for the severeness of winters in most parts of Europe. Additionally, days below certain thresholds may be counted or summed up.

Future work will include daily minimum and maximum temperatures, allowing calculating and applying an extensive set of climate indices, refining the work presented here.