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Secular cold winter extremes in Europe - A study by means of daily climate indices, based on a high-quality station-based dataset

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European winter temperatures are largely characterized by strong year-to-year and larger-scale variability. Distinctively warmer conditions – compared to previous centuries – were observed since the late 1980s, leading to a number of record-warm winters (e.g., 2007 and 2016). Nevertheless, comparatively cold winters and severe cold spells still occur regionally, as recently observed from 2009 to 2013. In 2017, parts of south-eastern Europe experienced their coldest January since 1954. A pronounced cold spell during the first part of January extended from north-western Russia down to the eastern Mediterranean, resulting in wide-spread extreme low temperatures, regionally the lowest since several decades. Analysing thermal characteristics and spatial distribution of severe (historical) winters – using early instrumental data – helps expanding and consolidating our knowledge of past weather extremes, as well as judging the severity of recent phenomena.

We compile, assess and evaluate a long-term, spatially widespread and well-distributed, high-quality meteorological data set in daily resolution to investigate the evolution of extremely low European winter temperatures. Hereby we focus on a large collective of threshold- and percentile-based indices, calculated from daily maximum and minimum temperatures. Our dataset covers most parts of Europe. It is essentially based on a homogenized version of daily extreme temperatures of the station-based ECA&D dataset, completed by homogenized data of additional sources. Most time series cover the 20th and part of the 19th century, with few exceptions already starting during the 18th century.

We analyse the spatio-temporal distribution of cold winters since the beginning of observations, as well as time series of regional area averages starting in the 19th century. Clustering into regions with similar average winter temperatures and standard deviations helps distinguishing a small collective of regions with comparable winter characteristics in most indices. Relationships with atmospheric circulation are investigated using various indices of the North-Atlantic Oscillation.