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Long-term variability of the thunderstorm and hail potential in Europe

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Severe thunderstorms and associated hazardous weather events such as hail frequently cause considerable damage to buildings, crops, and automobiles, resulting in large monetary costs in many parts of Europe and the world. To relate single extreme hail events to the historic context and to estimate their return periods and possible trends related to climate change, long-term statistics of hail events are required. Due to the local-scale nature of hail and a lack of suitable observation systems, however, hailstorms are not captured reliably and comprehensively for a long period of time. In view of this fact, different proxies (indirect climate data) obtained from sounding stations and regional climate models can be used to infer the probability and intensity of thunderstorms or hailstorms. In contrast to direct observational data, such proxies are available homogeneously over a long time period. The aim of the study is to investigate the potential for severe thunderstorms and their changes over past decades.

Statistical analyses of sounding data show that the convective potential over the past 20 – 30 years has significantly increased over large parts of Central Europe, making severe thunderstorms more likely. A similar picture results from analyses of weather types that are most likely associated with damaging hailstorms. These weather patterns have increased, even if only slightly but nevertheless statistically significantly, in the time period from 1971 to 2000.

To improve the diagnostics of hail events in regional climate models, a logistic hail model has been developed by means of a multivariate analysis method. The model is based on a combination of appropriate hail-relevant meteorological parameters. The output of the model is a new index that estimates the potential of the atmosphere for hailstorm development, referred to as potential hail index (PHI). Applied to a high-resolved reanalysis run for Europe driven by NCEP/NCAR1, long-term changes of the PHI for 60 years (1951–2010) show large annual and multiannual variability. The trends are mostly positive in the western parts and negative to the east. However, due to the large temporal variability, the trends are not significant at most of the grid points. Furthermore, it becomes clear that the environmental conditions that favor the formation of hailstorms prevail in larger areas. This finding suggests that, despite the local-scale nature of convective storms, the ambient conditions favoring these events are mainly controlled by large-scale circulation patterns and mechanisms. This result is important to estimate the convective potential of the atmosphere in case of single events.