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Severe convective storms in Europe and their relation to large-scale mechanisms

Susanna Mohr (1,2), Michael Kunz (1,2), David Piper (1), Jan Wandel (1), Olivia Martius (3,4)

(1) Karlsruhe Institute of Technology (KIT), Institute of Meteorology and Climate Research (IMK-TRO), Karlsruhe, Germany (mohr@kit.edu), (2) Center for Disaster Management and Risk Reduction Technology (CEDIM), Karlsruhe, Germany, (3) Oeschger Centre for Climate Change Research and Institute of Geography, University of Bern, Bern, Switzerland, (4) Mobiliar Lab for Natural Risks, University of Bern, Bern, Switzerland

Severe convective storms (SCS) and associated hazardous weather extremes such as heavy precipitation or hail frequently cause considerable damage to buildings and infrastructures in many parts of Europe. Despite the high relevance of questions regarding trends of such events, the driving factors that influence the spatial and annual variability of SCS across Europe are still poorly understood.

Tackling this problem (including long-term and consistent information about the SCS occurrence), a specific weather type classification has been developed that investigated temporal and spatial variability of convective predisposition between 1958 and 2014 identifying potential drivers for convective days. Our results suggest a strong link between large-scale flow and air mass properties, such as stability or moisture, and local-scale thunderstorm activity. For example, while all over Central Europe the most prominent pattern is given by a southwesterly flow type over the respective area, distinct regional discrepancies regarding further favorable flow types are observed. The crucial role of large-scale flow is further studied by assessing the impact of northern hemisphere teleconnection patterns on the annual variability of SCS. It is found that positive phases of the North Atlantic Oscillation and the negative phases of the East Atlantic go along with a significant reduction of SCS in most of the investigated European regions, which can be explained by anomalies in the temperature and flow fields. Some secondary correlation (e.g.,Scandinavian pattern, sea surface temperature) have a significant impact on the SCS occurrence as well.

Furthermore, we established a relationship between the occurrence of atmospheric blocking over the eastern North Atlantic and northern Europe and the incidence of SCS in western and central Europe based on lightning data between 2001-2014. We found that the anticyclonic circulation of a block over the eastern part of the North Atlantic leads to a northerly to northwesterly advection of drier and more stable air masses at the eastern flank of the block (convection-inhibiting conditions). In addition, the environmental conditions tend to cause on average a large-scale subsidence of air masses above the investigation area. In contrast, the southerly to southwesterly advection of warm, moist and unstable air masses from the Mediterranean on the western flank of a block over the Baltic Sea results in convection-favoring conditions over Europe. It is interesting to note that both blocking situation are on average associated with weak wind shear. As a consequence, thunderstorms related to atmospheric blocking over the Baltic Sea are on average probably less organized.