Relationship between atmospheric blocking and thunderstorm activity over western and central Europe

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Overview
Severe thunderstorms and associated hazardous weather extremes such as heavy precipitation or hail frequently cause considerable damage to buildings, crops, and automobiles in many parts of Europe and the world. Despite the high relevance to questions regarding trends of such events caused by climate change, the role of large-scale mechanisms on the persistence or the natural variability behind them is not yet well understood. For example, a first case study indicates a connection between blocking and thunderstorm activity (Piper et al., 2016).

Data basis
- Lightening detection system BLTIS (part of EURAD)
- Time period: 2001 – 2014 (May to August)
- Dichotomous variable “thunderstorm day” (TD): TD is defined if at least five cloud-to-ground flashers were registered within a 10 x 10 km² grid point per day.

Blocking Data
- Based on ERA-Interim reanalysis data (1° x 1°)
- Time period: 2001 – 2014 (May to August)
- Methodology of Schreiber et al. (2004): Persistent negative upper-level potential vorticity (PV) anomalies
- Summer blocking criterion: ~1 pvu

Methodological approach
- Task: Identifying relevant regions over the North Atlantic and European sector, where blocking is related to thunderstorms over Europe
- Method: Odds Ratio (OR) (see Matthews et al., 2012; Mohr et al., 2016)
- Calculation of changes in the odds ratio between blocking data (1° x 1° grid) and thunderstorm data (converted to the same 1° x 1° grid, resulting in 132 grid points, cf. Fig. 1 black line)

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Relation between blocking & thunderstorms
- Fig. 1: Changes in the odds ratio, where blocking in an area (cf. Fig. 2) over the eastern part of the North Atlantic (ND) or (a) over the Baltic Sea (BS) influences the thunderstorm activity over western and central Europe. The blue color indicates a decrease in the odds by 50% and red color indicates an increase (e.g., a value of 2 means a doubling of the odds).

Conclusions
- Two regimes were identified, where blocking affects the probability of thunderstorm days over western and central Europe. One is located over the eastern part of the North Atlantic (convective-inhibiting conditions) and one over the Baltic Sea (convective-favoring conditions).
- The anticyclonic circulation of a blocking ridge over the eastern part of the North Atlantic leads to northwardly to northwestwardly advection of dry and stable air masses on the eastern flank of the block. In contrast, the southerly to southwesterly advection of warm, moist and unstable air masses from the Mediterranean on the western flank of a blocking system over the Baltic Sea results in preferably convection-favoring conditions (cf., Piper et al., 2019).
- Both blocking situations are generally associated with weak vertical wind speeds at mid-tropospheric levels and weak wind shear. As a consequence, thunderstorms related to atmospheric blocking over the Baltic Sea tend to be on average less organized. However, days with high wind shear values between 20 and 30 m/s are also observed during blocking over the Baltic Sea (around 10%).

Environmental conditions during blocking
- Fig. 6: Anomaly composites during blocking over the Baltic Sea (left) and over the North Atlantic (right).

References