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Spatial and serial clustering of extreme European winter windstorms and their large scale drivers

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Winter windstorms are amongst the most dangerous and destructive natural hazards in Europe. In order to better comprehend these extreme events, particularly the driving mechanisms, their variability in space and time is examined. Windstorm trajectories are extracted from 6-hourly wind speed data of the core winter season (DJF) via the objective WTRACK wind tracking algorithm.

The spatial clustering is carried out by a probabilistic clustering technique (Gaussian mixture models) which is applied to the windstorm trajectories identified in retrospective seasonal forecast data (ECMWF System 4 covering the years 1983-2014). The 51 ensemble members allow the construction of a broad statistical event base of (artificial) extreme storms. Three spatial clusters (SW to NE, W to E and NW to SE progression) can be identified. All three clusters have particulate individual features in terms of intensity, duration or celerity.

Serial clustering and large scale drivers of winter windstorms are analysed by developing a statistical model relating the winter windstorm counts to known teleconnection patterns in Europe (e.g. North Atlantic Oscillation (NAO), Scandinavian Pattern (SCA)...). The model is established using a step-wise AIC approach which is applied to annual windstorm counts and large scale indices retrieved from the ERA 20C reanalysis. Significant large scale drivers responsible for the inter-annual variability of storms are identified and compared on a regional as well as on grid box level. Additional to the SCA and the NAO which are found to be the key drivers for serial clustering for most regions in the European domain, for example Northern Hemispheric sea ice cover appears as an important driver for the Mediterranean region. The developed statistical model is able to estimate (with satisfactory skill) whether a season is positively or negatively clustered, especially for the British Isles and Scandinavia.