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Sources of skill in forecasting North Atlantic winter storm activity in dynamical seasonal prediction models

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European winter storms are the natural hazard with the highest loss potential to society and economy in the mid-latitudes. Risk management could benefit from the availability of skilful prediction of storm risk on seasonal time scales. This study considers in how far current dynamical seasonal prediction models are capable of providing such information. It addresses three issues:
a) Which factors influence windstorm activity on seasonal timescales, and are therefore potential sources of predictability? b) How do these factors and related physical mechanisms compare between observations and dynamical seasonal prediction models? c) Do state-of-the-art seasonal prediction models successfully predict wintertime windstorm activity?
On the basis of observational and reanalysis data it is shown that anomalies in hemispheric-scale factors—such as sea surface temperatures and sea ice extent in the North Atlantic, continental snow cover extent, and the North Atlantic Oscillation—in late summer and autumn are statistically significantly linked with anomalous windstorm activity in the North Atlantic and European region in subsequent winter (i.e. with lead times of 4–6 months). Thus, they may be considered as potential sources of seasonal windstorm predictability. Possible physical mechanisms responsible for these relationships include the relation of hemispheric-scale factors to anomalies in growth factors of cyclones. In particular, specific anomalies of North Atlantic SST during late summer and autumn (resembling the so-called Horseshoe pattern) are persistent to winter and related to better growth conditions for cyclones (e.g., higher baroclinicity between Newfoundland and the British Isles), potentially leading to more intense or a higher number of windstorms.
The same relationships are evaluated in dynamical seasonal prediction models of the DEMETER and ENSEMBLES projects. Both August and November hindcasts are considered. Focussing on the North Atlantic SST–windstorm relationship, it is shown that SST anomalies are accompanied by physically consistent anomalies in growth factors of cyclones, in good agreement with observations. However, the persistence of the SST anomalies from summer to winter differs significantly between different models, and is generally weaker than in observations. The ability to retain the anomalous oceanic conditions from summer through winter in the models' ocean control run used to initialize the hindcasts is shown to be crucial. Some models retain anomalies, e.g., in ocean heat content, through winter and develop specific anomalies in SST, growth conditions of cyclones, and windstorm frequency. In other models, this information is lost in the model ocean control run from August to November.
Finally, the hindcasts are assessed in terms of predictive skill. It is shown that there are multi- and single-model ensembles with statistically significant skill, ranging from about 0.15–0.40. One specific model suite used at Météo France shows particularly high skill scores. Generally, models with the ability to reproduce the observed North Atlantic SST–windstorm relationship show higher skill. This is an indication that the state of the North Atlantic in summer and autumn is indeed a source of seasonal windstorm predictability.