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Severe Thunderstorm Evaluation and Predictability in Climate Models (STEPCLIM)

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Meteorological hazards associated with severe thunderstorms (e.g., hail, tornadoes, high winds, and flash flooding) pose a major threat to human life and property. According to Munich Re Group, severe thunderstorms cause approximately € billion in damages annually in Europe. Recent studies suggest that the frequency of extreme weather events will likely increase throughout the twenty-first century in midlatitude regions. However, the predictability of severe thunderstorms on seasonal-to-decadal timescales is not well understood. Furthermore, the limited spatial and temporal resolution of present-day climate models prohibits the explicit simulation of mesoscale convection and resultant hazards. To address these issues, the STEPCLIM project aims to: 1) apply probabilistic convective hazard models to decadal hindcast simulations from the MiKlip prediction system, and 2) evaluate and correct biases in the predicted frequency of thunderstorms and individual convective hazards.

The convective hazard models employ additive logistic regression to estimate the probability of lightning and specific hazards (i.e. hail $\geq$ 2 cm and wind $\geq$ 25 m/s) based on the values of parameters relevant to severe weather (e.g., tropospheric moisture, instability, and wind shear). The models were developed using parameters derived from ERA-Interim reanalysis, lightning data from the European Cooperation for Lightning Detection (EUCLID), and hazard reports from the European Severe Weather Database (ESWD) during the 2008–2016 period. After optimizing the models, mean annual probabilities of lightning, large hail, and severe wind were computed for ERA-Interim reanalysis, the uninitialized Baseline0 simulations, and the Baseline1 decadal hindcasts over the European domain (25° N, 20° W – 75° N, 40° E). We selected the 1979–2013 period for evaluation and therefore considered all decadal hindcasts initialized between 1978 and 2004. In general, the decadal hindcast predictions achieve improved forecast skill relative to the uninitialized simulations over much of continental Europe. Both the uninitialized simulations and the decadal hindcasts exhibit large positive mean bias and negative conditional bias throughout the study domain. To improve the decadal hindcast predictions, we also applied a climate forecast recalibration method that adjusts the lead-year-dependent unconditional bias (i.e. drift), initialization-year-dependent bias (i.e. trend), conditional bias, and ensemble spread. The recalibration yielded considerable increases in forecast skill, driven primarily by large reductions in the magnitude of the conditional bias, and to a lesser extent, by increases in the anomaly correlation.