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Simulation of a Hail Event Set for Central Europe

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Since 1980, severe thunderstorms have caused nearly USD 3 billion in damages annually in Europe. Hailstorms account for a significant portion of thunderstorm-related losses, yet the climatological aspects of large hail are not well understood. While the European Severe Weather Database (ESWD) contains the most comprehensive archive of hail observations in Europe, spatial and temporal inhomogeneities and discontinuities preclude the database from being used to create a representative long-term hail climatology. We therefore propose a method to generate a hail event set for Central Europe by: 1) objectively identifying recent hail swaths from high-resolution radar data, and 2) combining the identified hail swath properties with a probabilistic convective hazard model and ESWD hail observations to simulate individual hailstorms. Such a hail event set will facilitate the evaluation of the climatological aspects of large hail and time-dependent changes in the frequency of hailstorms. In addition, the hail event set will be combined with exposure and vulnerability data to produce detailed loss estimates and better understand the risk of large hail in Europe.

Hail swaths occurring in Germany over a 4-year period (2015–2018) were identified using the vertically integrated ice (VII) product from the Deutscher Wetterdienst (DWD). Specifically, we isolated continuous regions where 6-hour accumulated VII satisfied a minimum intensity (25 kg m^{-3}) criterion, and then used Python image processing to generate hail swath ellipses and analyze their spatial characteristics. Next, for each 6-hour interval during the 1979–2018 period, we applied the convective hazard model to ERA-Interim reanalysis data to simulate the occurrence/non-occurrence of hail in each reanalysis grid cell. If hail was simulated in a given grid cell, we also predicted the number of hail swaths in the grid cell during the 6-hour period. For each hail swath, we simulated the length, area, and orientation based on the spatial properties of the previously identified hail swaths. In addition, we simulated the maximum hail diameter based on the statistical distributions of observed hail diameter under various instability and deep-layer shear scenarios.

Results from the VII hail detection algorithm suggest that large hail in Germany occurs primarily after 12 UTC, with a maximum frequency during the afternoon and early evening (12–18 UTC). While the majority of identified hail swaths affected areas less than 100 km^2, hail swaths exceeding 500 km^2 were not especially uncommon. Hail swaths generally followed trajectories between 225° (southwest-to-northeast) and 315° (northwest-to-southeast) and were typically associated with right-moving thunderstorm cells when the synoptic-scale environment was moderately-to-strongly sheared. The simulated hail swaths exhibit a meridional gradient in the predicted frequency of large hail, with the lowest frequencies near the North and Baltic Seas, and the highest frequencies over the eastern Alps. The number of simulated hail cases peaks in July and August, whereas large hail as reported in the ESWD is most prevalent between May and July.