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Hail hazard assessment: A new approach

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Severe hailstorms that occur almost exclusively in the summer months carry a high risk for buildings, vehicles, and crops. In the federal state of Baden-Württemberg in Southwest Germany, nearly 40% of the total damage to buildings between 1986 and 2008 are related to large hail, with the mean annual loss amounting to almost EUR 50 million. Single extreme events with a low probability of occurrence, however, exhibit a damage potential that by far exceeds the mean annual loss. Due to the high risk potential associated with large hail, comprehensive information about the local probability of occurrence is essential for loss prevention and risk management purposes. This is a big challenge, because convection-related weather phenomena like hail with a typical horizontal extent of several hundred meters only usually are not captured accurately and uniquely by a single observation system.

A new method for the assessment of the hail hazard in high spatial resolution will be presented. By applying a cell tracking algorithm to 2D and 3D radar data, individual tracks of severe hailstorms are detected. To close the gap between radar reflectivity measured at a certain level in the atmosphere and hail occurrence on the ground, insurance loss data were additionally used. This approach will be complemented by tracks derived from lightning data. From the combination of the different data sets, hail streaks that are related to damage to vulnerable structures can be identified. These streaks are projected on a 10×10 km^2 grid in order to quantify hail track density. By statistical modelling of extremes, a cumulative distribution function (generalized Pareto distribution) is estimated, which relates radar reflectivity and probability of occurrence.

First results are available for a test region in Southwest Germany for a period between 1997 and 2007, where all data sets are available. The results reveal a high spatial variability in track density. Lowest probabilities are found over the rolling terrain in the north as well as over the elevated terrain of Black Forest and Swabian Jura. Between the two mountain ridges, the probability of hail streaks to occur is highest. Considering not only the number but also the intensity of severe thunderstorms in terms of radar reflectivity for specific return periods, does not substantially change the spatial distribution of the hail patterns. The highest intensities are well correlated with the highest track densities. Again, the lowest values occur over the mountains of Black Forest and Swabian Jura. Based on a conceptual approach, it is discussed how the spatial differences in hail activity can be explained plausibly by pre-convective low Froude number flow ($Fr < 1$) around the mountains, which causes downstream horizontal convergence. Also flow deviation at the upstream border of the Swabian Jura, indicated by a sharp gradient of the hail streaks, may facilitate the formation of a convergence zone in this area.