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Estimating the hazard from extreme hail events across regional to local scales

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Hailstorms and associated hail stone sizes are a tricky atmospheric hazard to assess, because the processes leading to severe convective weather are complex and the spatiotemporal scales of the impacts are often small. The high natural variability of hail requires expensive high-resolution, area-covering measurements to establish robust statics. Weather radars help to achieve this, but despite growing data archives, records usually do not yet extend to climatological time scales (≥30y), and reference ground observations to calibrate hail algorithms are still fragmentary. Consequentially, there remain substantial uncertainties regarding the long-term hazard of hail. Nevertheless, stakeholders require estimates of return periods for preventive regulations or as input to downstream impact models, e.g., in the insurance and engineering sector.

In the project “Hail climatology Switzerland” MeteoSwiss partnered up with three federal offices, the insurance and engineering sectors to establish a common national reference of the occurrence of hail in Switzerland. The deliverables include developing return period maps of extreme hail events. However, the definition of such extremes varies across sectors. For example, stakeholders from damage prevention require impact probabilities of the largest hailstorm onto an average rooftop, whereas reinsurance stakeholders are interested in nation-wide worst-case events. Here we report on the approaches we took in deriving the frequencies of severe hail considering the different stakeholder demands and the challenges and uncertainties we thereby encountered.

Using newly reprocessed gridded radar hail data, we assess frequencies of observed hail occurrence in Switzerland over 19 years (2002-2020). We further developed a probabilistic hazard model using stochastic resampling of hailstorms, driven by large-scale environmental boundary conditions. In order to take a storm-object perspective on extremes, we isolate more than 40’000 individual hailstorm footprints. This allows us to consider local storm properties such as the distributions of hail stone sizes by storm area and duration. In addition, we identify region-dependent extreme storm properties, which is specifically relevant in the Alpine region, where high and complex topography creates sharp climatic gradients and results from other regions are often not easily transferable.

Results show that observed storm tracks vary strongly between years, and hail footprints vary substantially by storm type. Comparing our results obtained from the longest radar-based hail

record so far, we find that the spatial patterns of hail agree well with existing hazard maps derived, i.a., from damage claims. However, we also find that frequencies of local extreme hail stone sizes may have been underestimated in the past. This is further corroborated by a regionally aggregated comparative analysis of the radar record to historical records of very large hail in Switzerland over the past century.