Analyzing and modelling severe hail events over Austria based on radar data and the metastatistical extreme value distribution

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Hail is a dangerous and devastating phenomenon associated with severe thunderstorms. Knowledge about the occurrence and extreme values of severe hail plays an important role, not only for economy and daily life, but also for engineering and insurances. Only three-dimensional radar data allow for a comprehensive, area-wide indirect estimation of hail events and hail size. By analyzing the vertical storm structure, parameters like the maximum estimated hail size (MEHS) and, in comparison with hail damage reports, a probability of hail (POH) can be derived. Since both parameters are highly sensitive to changes in the radar adjustments, the radar archive at GeoSphere Austria was reprocessed using the Austrian Thunderstorm Nowcasting Tool A-TNT and quality controlled MEHS values were calibrated by hail reports to observed hail sizes. The new and comprehensive MEHS archive, now reaching back to 2009, is analyzed for maximum observed hail sizes and frequencies of observed hail events.

Despite the reprocessing of GeoSphere Austria hail parameters, the available data set is still relatively small, making the calculation of return levels of severe hail events challenging. Based on this sparse data the application of classical extreme value theory, such as Block-Maxima or Peak over Threshold might be invalid. Instead, we use a version of the metastatistical extreme value distribution (MEVD), which was shown to work reasonably well in the context of extreme precipitation events, even with a rather small number of available years used for the estimation in comparison to the recurrence time. More precisely, we make an assumption about the underlying probability distribution of the daily maximum POH values. The parameters of the distribution are then modeled as smooth functions of the day of the year and the year of observation, thus employing the framework of generalized additive models for location, scale and shape (GAMLSS). Furthermore, we add topographic information (longitude, latitude, altitude) to our model, resulting in a full spatiotemporal model across the whole domain of Austria, from which the return values of the POH, respectively MEHS are calculated. This framework allows for the incorporation of an arbitrary number of additional covariables, as long as they are available on the same grid as the desired output. To illustrate this we use the information of daily precipitation extremes to enrich the model with additional atmospheric information.