

## Co-occurrence of hail and heavy precipitation in Switzerland

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The co-occurrence of hail and heavy rainfall has the potential to lead to an increase in damages. For example, a dense cover of hail may clog drainage systems, consequently creating a situation favoring flooding by subsequent rain. In this exploratory study, we investigate this phenomenon of co-occurring precipitation types, first in a case study of the 28th of June 2021 in Switzerland, a day with substantial damages caused by convective storms, before following up with an analysis of the whole convective season of 2021.

For the co-occurrence analysis, we require data with high temporal and spatial resolution and good spatial coverage, which is challenging in the complex alpine topography. For both hail and rain, we use datasets produced by the Swiss weather radar network, which consists of five c-band radars at altitudes between 900 – 3000 m. Further, the rain dataset is created using rain gauge data to improve the accuracy of the radar-based rain estimates.

The case study showed that hail and rainfall co-occurred in large areas, with 88 % of the co-occurrence areas experiencing extreme rainfall within 10 minutes of each other. The proximity, large impact area, and high cumulative amount of rainfall after the hail likely contributed to the costly damages of the 28 June 2021 hail event. Further, the seasonal analysis has shown that the cumulative amount of rain after the first hail detection is significantly higher than before. However, these results are not homogeneous in space or time but exhibit regional variation. Additionally, we find that the co-occurrence of hail and rain is impacted by the estimated maximum hail size as well as by the presence of cold fronts. Finally, we also explore the reliability and limitations of using radar data for the estimation of both hail and rain, e.g. addressing the challenge of errors in radar rainfall estimates arising from the presence of hail stones.