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Drone-based hail observations and the retrieval of the hail size distribution after a supercell passage in summer 2021 in Switzerland

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Hail is a major threat connected to severe thunderstorms and an estimation of the hail size is important to issue warnings for the public. Radar real-time products exist that estimate the size of the expected hail. For the verification of such products, ground based observations are necessary. Automatic hail sensors, as available within the Swiss hail network, can provide information about hail diameters observed on the ground. Unfortunately, due to the small size of these sensors (e.g. 0.2 m^2) the estimation of the hail size distribution (HSD) can have large uncertainties. To overcome this issue, aerial drone-based 2D orthophotos can be analyzed by using state-of-the-art custom trained AI-object detection models to identify hail stones in the images and to estimate the HSD.

A large right moving supercell with a lifespan of more than 6 hours crossed the midlands of Switzerland from south west in the afternoon of 20th June 2021. The hail swath of this classical supercell was intercepted near Entlebuch and aerial images of the hail on the ground were taken by a DJI Matrice 300RTK drone immediately after the storm has passed. The drone was equipped with a 50 megapixels full frame camera. The average ground sampling distance is 1.5 mm per pixel, which is set by the mounted camera objective with a focal length of 35 mm and a flight altitude of 12 m above ground level.

A 2D orthomosaic model of the survey area (soccer field) is created based on 116 captured images during the first drone mapping flight. The orthomosaic covers an area of about 750 m^2 and is then used to detect hail by using a region-based Convolutional Neural Network (Mask R-CNN) model. First, we characterize the hail sizes based on the individual hail segmentation masks resulting from the model detections and investigate the performance with respect to manual hail annotations from experts that are used as validation and test data sets. We present the final obtained HSD from more than 18000 hail stones (D_{max} = 39 mm, D_{med} = 9 mm) and compare it with nearby automatic hail sensor observations and weather radar based hail products like MESHS (Maximum Expected Severe Hail Size). Furthermore, we provide first insights into hail melting processes that can be inferred from the information retrieved from a total of 5 subsequent flights performed with the drone within about 20 minutes after the passage of the supercell.