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Combined rainfall estimates from personal weather station and commercial microwave link data in Germany

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Rain gauges and weather radars are the default sources of rainfall information. Rainfall estimates from these sensors improve our understanding of the hydrological cycle and are vital for water-resource management, agriculture, urban planning, as well as for weather, climate, and hydrological modelling. Still, due to the high spatio-temporal variability of rainfall and the specific drawbacks of the individual rainfall sensors, the rainfall variability cannot be captured completely. In the last decade, the number and availability of opportunistic rainfall sensors increased rapidly. These sensors are initially not meant to measure rainfall for scientific or operational purposes, but, if processed carefully, can be used for these cases . Here we present an analysis of two years of data from two opportunistic rainfall sensors, namely personal weather stations (PWS) and commercial microwave links (CMLs). We evaluate the performance of rainfall maps derived from these sensors on different spatial and temporal scales in Germany.

The data from around 15000 PWS tipping bucket-style rain gauges from the Netatmo network were accessed via Netatmos API. The data from around 4000 CMLs, which can be used to derive rainfall estimates from the rain-induced attenuation of the CMLs' signal, were obtained from Ericsson. As both, PWS and CML data, can suffer from various error sources e.g. from unfavourable positioning and poor maintenance of PWS and from non-rain induced attenuation of the CMLs signal, we used a strict filtering routine. A total of seven gridded rainfall products were derived from different combinations of PWS, CML, and rain gauge data from the German Weather Service (DWD) with a geostatistical interpolation approach. This approach incorporates the uncertainty of the opportunistic sensors and the path-averaging characteristic of the CML observations.

To evaluate the resulting rainfall maps, we used three rain gauge data sets with different temporal and spatial scales covering the whole of Germany, the state of Rhineland-Palatinate and the city of Reutlingen, respectively. For all three reference data sets, rainfall maps from opportunistic sensors provided good agreement, with best results being derived from the combinations with PWS. Rainfall maps including CML data had the lowest bias. In a comparison with gauge adjusted radar products from the DWD, the radar products yielded better results than the rainfall maps from

opportunistic sensors for the country-wide comparison of daily rainfall sums, which was carried out using the DWD’s independent network of manual rain gauges. But for the hourly references covering Rhineland-Palatinate and Reutlingen, the rainfall maps derived from opportunistic sensors outperformed the radar products. These results highlight the capabilities of opportunistic rainfall sensors which could be used in many hydrometeorological applications.