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Testing geostatistical methods to combine radar and rain gauges for precipitation mapping in a mountainous region

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There is an increasing demand for accurate mapping of precipitation at a spatial resolution of kilometers. Radar and rain gauges – the two main precipitation measurement systems – exhibit complementary strengths and weaknesses. Radar offers high spatial and temporal resolution but lacks accuracy of absolute values, whereas rain gauges provide accurate values at their specific point location but suffer from poor spatial representativeness. Methods of geostatistical mapping have been proposed to combine radar and rain gauge data for quantitative precipitation estimation (QPE). The aim is to combine the respective strengths and compensate for the respective weaknesses of the two observation platforms. Several studies have demonstrated the potential of these methods over topography of moderate complexity, but their performance remains unclear for high-mountain regions where rainfall patterns are complex, the representativeness of rain gauge measurements is limited and radar observations are obstructed. In this study we examine the potential and limitations of two frequently used geostatistical mapping methods for the territory of Switzerland, where the mountain chain of the Alps poses particular challenges to QPE. The two geostatistical methods explored are kriging with external drift (KED) using radar as drift variable and ordinary kriging of radar errors (OKRE). The radar data is a composite from three C-band radars using a constant Z-R relationship, advanced correction processings for visibility, ground clutter and beam shielding and a climatological bias adjustment. The rain gauge data originates from an automatic network with a typical inter-station distance of 25 km. Both combination methods are applied to a set of case examples representing typical rainfall situations in the Alps with their inherent challenges at daily and hourly time resolution. The quality of precipitation estimates is assessed by several skill scores calculated from cross validation errors at gauge locations. These scores assess different characteristics such as bias, distinction between dry and wet areas (HK, SLEEPS), accuracy of values at wet locations (SCATTER) and overall performance (RMSE, MAD). Special attention is paid to the subject of appropriate case-dependent transformation of variables in order to fulfill model assumptions.

Our analyses show that geostatistical merging techniques can provide significant added value compared to pure radar and pure rain gauge data – also in mountainous terrain. Yet, the high a-priori quality of the radar product may have been essential for the good performance of methods. The comparison between the two combination methods shows better results in general for KED, the more flexible of the two methods. However, there are features, such as the differentiation between wet and dry areas (HK), and situations, such as small isolated convective cells, where OKRE outperforms KED. Our discussion conveys interesting insights into the potential and limitations of the two analyzed methods and leads to suggestions for further improvements of combination techniques.