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High resolution radar-rain gauge data merging for urban hydrology: current practice and beyond

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In this work a thorough test is conducted of radar-rain gauge merging techniques at urban scales, under different climatological conditions and rain gauge density scenarios. The aim is to provide guidance regarding the suitability and application of merging methods at urban scales, which is lacking at present. The test is conducted based upon two pilot locations, i.e. the cities of Edinburgh (254 km̂2) and Birmingham (431 km̂2), for which a total of 96 and 84 tipping bucket rain gauges were respectively available, alongside radar QPEs, dense runoff records and urban drainage models.
Three merging techniques, namely Mean Field Bias (MFB) adjustment, kriging with external (KED) and Bayesian (BAY) combination, were selected for testing on grounds of performance and common use. They were initially tested as they were originally formulated and as they are reportedly commonly applied using typically available radar and rain gauge data. Afterwards, they were tested in combination with two special treatments which were identified as having the potential to improve merging applicability for urban hydrology: (1) reduction of temporal sampling errors in radar QPEs through temporal interpolation and (2) singularity-based decomposition of radar QPEs prior to merging. These treatments ultimately aim at improving the consistency between radar and rain gauge records, which has been identified as the chief factor affecting merging performance and is particularly challenging at the fine spatial-temporal resolutions required for urban applications. The main findings of this study are the following:
- All merging methods were found to improve the applicability of radar QPEs for urban hydrological applications, but the degree of improvement they provide and the added value of radar information vary for each merging method and are also a function of climatological conditions and rain gauge density scenarios.
- Overall, KED displayed the best performance, with BAY being a close second and MFB providing the smallest improvements upon radar QPEs. However, as compared to BAY, KED performance is more sensitive to rain gauge density and to the ability of rain gauges to sample critical features of the rainfall field. By incorporating more information from radar than KED, BAY is less sensitive to rain gauge density and to poor rain gauge predictability and proved able to provide a good representation of convective cells even in cases in which gauges completely missed such structures.
- Based on the findings of this study, it is recommended that KED be used when gauge densities are relatively high (of the order of 30 km2 per gauge or higher) and/or when the quality of radar QPEs is known to be very poor, in which case it is desirable to rely more upon rain gauge records. For low rain gauge density situations and QPEs of reasonable quality (as is the case in most of EU), BAY may be a more appropriate choice. MFB should be the last choice; however, it is better than no correction at all.
- The two special treatments under consideration successfully improved overall merging performance at the spatial-temporal resolutions required for urban hydrology, with benefits being particularly evident at low rain gauge density conditions.