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Singularity-sensitive merging of radar and raingauge rainfall data

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Traditionally, urban hydrological applications relied mainly upon rain gauge data as input as these provide accurate point rainfall estimates near the ground surface. However, they cannot capture the spatial variability of rainfall, which has a significant impact on the urban hydrological system and thus on the modelling of urban pluvial flooding. Thanks to the development of radar technology, weather radar has been playing an increasingly important role in urban hydrology. Radars can survey large areas and better capture the spatial variability of the rainfall, thus improving the short term predictability of rainfall and flooding. However, the accuracy of radar measurements is in general insufficient, particularly in the case of extreme rainfall magnitudes. This has a tremendous effect on the subsequent hydraulic model outputs.

In order to improve the accuracy of radar rainfall estimates while preserving their spatial description of rainfall fields, it is possible to dynamically adjust them based on rain gauge measurements. Studies on this subject have been carried out over the last few years, though most of them focus on the hydrological applications at large scales. A couple of recent research works have examined the applicability of these adjustment techniques to urban-scale hydrological applications and concluded that these techniques can effectively reduce rainfall bias, thus leading to improvements in the reproduction of hydraulic outputs (Wang et al., 2013). However, underestimation of storm peaks can still be seen after adjustment and this is particularly significant in the case of small drainage areas and for extreme rainfall magnitudes. This may be due to the fact that the underlying adjustment techniques, mainly based upon Gaussian approximations, cannot properly cope with the non-normality observed in urban scale applications.

With the purpose of improving this aspect, a methodology has been developed which identifies the local extremes or ‘singularities’ of radar rainfall fields and preserves them throughout the merging process (Wang and Onof, 2013). Singularities are defined through the fact that the areal average rainfall increases as a power function when the area decreases (Cheng et al., 1994). In the proposed methodology singularities are first identified and extracted from the radar rainfall field. The resulting non-singular radar field is then used in the merging process and the singularities are subsequently and proportionally added back to the final reconstructed rainfall field. A full-scale testing of this methodology in an urban area in the UK has been conducted and the result suggests that the original Bayesian data merging technique (Todini, 2001) could be effectively improved by incorporating this singularity analysis.

References

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