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Spatial-temporal rainfall input resolution requirements for urban drainage modelling: a multi-storm, multi-catchment investigation

Susana Ochoa-Rodriguez (1), Li-Pen Wang (2), Auguste Gires (3), Rui Pina (1), Ricardo Reinoso-Rondinel (4), Guendalina Bruni (5), Abdellah Ichiba (3), Santiago Gaitan (5), Elena Cristiano (5), Johan van Assel (6), Stefan Kroll (6), Damian Murlà-Tuyls (2), Daniel Schertzer (3), Ioulia Tchiguirinskaia (3), Patrick Willems (2), Christian Onof (1), and Marie-Claire ten Veldhuis (5)

(1) Imperial College London, Urban Water Research Group, Civil and Environmental Engineering, London, United Kingdom, (2) Hydraulics Laboratory, KU Leuven, Leuven, Belgium, (3) Laboratoire Eau Environnement et Systèmes Urbains (LEESU), École des PontsParisTech, Paris, France, (4) Department of Geosciences and Remote Sensing, Faculty of Civil Engineering and Geosciences, Delft University of Technology, Delft, The Netherlands, (5) Department of Water Management, Faculty of Civil Engineering and Geosciences, Delft University of Technology, Delft, the Netherlands, (6) Aquafin NV, Aartselaar, Belgium

Urban hydrological applications require high resolution precipitation and catchment information in order to well represent the spatial variability, fast runoff processes and short response times of urban catchments. Although fast progress has been made over the last few decades in high resolution measurement of rainfall at urban scales, including increasing use of weather radars, the resolution of the currently available rainfall estimates (typically 1 x 1 km2 in space and 5 min in time) may still be too coarse to meet the stringent spatial-temporal scales characteristic of urban catchments. In addition, current evidence is still insufficient to provide a concrete answer regarding rainfall input resolution requirements of urban hydrological applications. With the aim of providing further evidence in this regard, in the framework of the EU Interreg RainGain project a collaborative study was conducted which investigated the impact of rainfall estimates for a range of spatial and temporal resolution combinations on the outputs of operational semi distributed models of seven urban catchments in North-West Europe. Nine storm events measured by a dual polarimetric X-band weather radar, located in the Cabauw Experimental Site for Atmospheric Research (CESAR) of the Netherlands, were selected for analysis. Based on the original radar estimates, at 100 m and 1 min resolutions, 15 different combinations of coarser spatial and temporal resolutions, up to 3000 m and 10 min, were generated. These estimates were applied to the hydraulic models of the urban catchments, all of which have similar size (between 3 and 8 km2), but different morphological, hydrological and hydraulic characteristics. When doing so, methodologies for standardising model outputs and making results comparable were implemented. Results were analysed in the light of storm and catchment characteristics. Three main features were observed in the results: (1) the impact of rainfall input resolution decreases as catchment drainage area increases; (2) in general, the variation in temporal resolution of rainfall inputs affects hydrodynamic model results more strongly than variations in spatial resolution; (3) there is a strong interaction between the spatial and temporal resolution of rainfall input estimates and in order to avoid losing relevant information from the rainfall fields, the two resolutions must be in agreement with each other. Based on these results, initial models to quantify the impact of rainfall input resolution as a function of catchment size and spatial-temporal characteristics of storms are proposed and discussed.