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On the use of remote sensing-derived river width and water level in hydraulic flood forecast models

Stefania Grimaldi, Yuan Li, Jeffrey Walker, and Valentijn Pauwels
Department of Civil Engineering, Monash University, Clayton, Victoria, Australia (stefania.grimaldi@monash.edu)

Riverine flooding is one of the most frequent and destructive natural disasters worldwide. An accurate and reliable flood forecast can provide vital information for water and land management, and emergency response. Hydraulic models are used to compute water level and velocity in the river network, and when the storage capacity of the river is exceeded, in the floodplain. Accurate modelling of river flow dynamics is essential to reliably simulate floodplain inundation. Bathymetric data are thus critical to for hydraulic model application. However, it is impossible to measure river bathymetry along the entire river length, especially in large basins. Where channel geometry is unknown, channel shape, depth, and friction can be estimated through calibration, but different parameter sets can often match the model to the observed data equally well generating an equifinality problem. Moreover, channel shape, depth, and friction affect the wave propagation in rather different ways. Without the structural correction provided by channel shape and depth, the calibrated effective values can lead to spurious nonphysical effects. Conversely, an approximated knowledge of river bathymetry can provide a more robust model setup.

In this study a numerical experiment was conducted to investigate the use of remote sensing (RS)-derived observations of river width, inundation extent and water level for the implementation and error diagnosis of hydraulic flood forecast models. Specifically, the LISFLOOD-FP hydraulic model was used to simulate a hypothetical flood event in a meandering reach of the Clarence River (Australia). A high resolution model simulation based on accurate bathymetric field data was used to benchmark coarser model simulations based on simplified river geometries. These simplified river geometries were derived from a combination of RS-derived river width data, globally available empirical formulations, and a limited number of measurements. A methodology was proposed for the parsimonious, yet effective representation of geometrical variability. Such a preliminary assessment has the potential to reduce the uncertainty of an ill-posed problem and support RS-based data assimilation of upcoming SAR altimetry satellite missions (e.g. CryoSat-2, Sentinel-3 and SWOT).

Moreover, in this numerical experiment, distributed water levels derived from a synthetic RS observation, acquired as early as 24 hours before the flood peak at the input point of a short river reach, were found useful in diagnosing errors in the model implementation. Clearly, there are limitations to extrapolating the findings of this study to other flood events and other catchments, with further testing required. Furthermore, in a real case scenario, the impact of uncertainties in RS-derived observations on the use of this data for the diagnosis of errors in model implementation has to be carefully evaluated. Nevertheless, this study showed (i) the importance of structural correction by an adequate representation of channel geometric variability, (ii) the use of RS data for model implementation, and (iii) the potential benefit of acquiring satellite images at the early stages of a flood event to improve floodplain forecasting skill.