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Verification of flood wave arrival time predictions using remote sensing-derived water levels

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Two-dimensional (2-D) hydraulic models are used for the prediction of floodplain inundation spatio-temporal patterns to improve flood risk estimation, and support emergency and land management. Accurate model calibration is pivotal to enable adequate representation of flood dynamics and requires the comparison between model predictions and observed data.

Remote sensing (RS) observations of inundation extent and water level allow model evaluation at a large number of locations in the floodplain, providing opportunities for a thorough understanding of inundation dynamics. However, RS instruments provide information at a snapshot in time and so the existing performance metrics generally compare model results and observations at the acquisition time. Nevertheless, explicitly differentiating between model parameterizations which underpredict or overpredict the flood wave arrival time is valuable to assess models' predictive skill.

In 2-D hydraulic models, roughness values are considered to be the most important parameters controlling the flow characteristics and so they are used for model calibration. Although RS-derived spatially distributed information allows the tuning of a large number of spatially distributed roughness values, the calibration framework must enable parameter identifiability while avoiding overfitting and equifinality problems. Another challenge affecting the calibration exercise is the computational burden of 2D-hydraulic models, which generally hampers the application of frameworks requiring a large number of model realizations.

This presentation introduces a novel framework for the calibration of 2D hydraulic models. Specifically, the calibration framework was designed to (1) make exclusive use of RS-derived observations and consequently enable model calibration in ungauged catchments; (2) allow discriminating between underprediction and overprediction of flood wave arrival time; (3) identify a parameter configuration which is robust for different flood events; and (4) require a limited number of model realizations.

A novel performance metric, the Space-Time-Score, is therefore proposed to compare modelled and observed water level and discriminate between underestimation and overestimation of flood wave arrival time, with binary performance metrics used to compare modelled and observed inundation extents. These performance metrics allow quantifying the capability of different parameter sets to reproduce the observed data. A novel set of river roughness values is then computed to minimise the discrepancy between model results and observations.

The 2011 and the 2013 flood events in the Clarence catchment (Australia) were used as test cases. The 2D hydraulic model was LISFLOOD-FP; available remote sensing data included both Synthetic Aperture Radar and optical acquisitions. Gauged data were used as an independent validation dataset and demonstrated the effectiveness of the proposed framework to identify a spatially distributed parameter set which is robust for different flood events.

Despite the promising results of this initial testing, it is imperative to underline that the proposed framework was designed to minimise the discrepancies between model results and observations. Consequently, RS accuracy, timing and spatial coverage are expected to affect the performance of the calibration. For this reason, extensive further testing is essential to investigate the impacts of RS features on the effectiveness of the proposed methodology for a number of catchments with different morphologies and flooding dynamics.