Geophysical Research Abstracts
Vol. 21, EGU2019-1024, 2019
EGU General Assembly 2019

Efficient cascade modelling of nature-based solutions scaled to larger catchments to model extremes taking account of uncertainties

Barry Hankin (1,2), Ann Kretzschmar (2), Trevor Page (2), Nick Chappell (2), Rob Lamb (2,4), Keith Beven (2), Gemma Coxon (3), and Jim Freer (3)

(1) JBA Consulting, Environmental Modelling, Warrington, United Kingdom (barry.hankin@jbaconsulting.com), (2) LEC, Lancaster University, UK, (3) Geography, University of Bristol, (4) JBA Trust

This study presents ensemble distributed modelling of nature-based measures using a cascade of rainfall-runoff (Dynamic Topmodel) and fast 2d inundation models (JFlow or HEC-RAS 2d). The approach is first applied to model an extreme event in a small upland catchment (15km2), and then scaled up to a larger catchment (210km2). Both catchments are in Cumbria, UK, and have a range of on-going distributed nature-based measures including river restoration, leaky barriers, peat restoration, floodplain tree planting and storage, for which we wish to explore the impacts at the catchment-scale.

Advances in fully-distributed whole-catchment hydrodynamic modelling have been made using direct rainfall and losses models (e.g. Hankin et al, 2017a, 2017b), largely due to the rapid advances in GPU parallel processing and numerical schemes such as JFlow (Lamb et al., 2009). However, this has partly been at the expense of full representation of the hydrological processes on the hillslope, where different nature-based measures such as tree-planting or reduced grazing, can give rise to distributed changes in infiltration, re-infiltration, wet canopy evaporation, and attenuation of overland flows. These processes lead to a surface-subsurface interaction of flows that we now aim to put back into the modelling where they are significant, whilst retaining the 2d hydrodynamics to represent the complex flows around channel and floodplains. These areas are being increasingly targeted for other types of nature based approaches such as leaky barriers, seeking to increase instream and floodplain attenuation.

A cascade approach is demonstrated where Dynamic Topmodel is used generate inflow hydrographs along reaches within the 2d domain of either JFlow or HEC-RAS2d, which then simulates the 2d hydrodynamics of the channel and floodplain. This has been shown to give strong results at the small-scale, 15 km2 catchment with 12 km of watercourse, in terms of model performance at the flow gauge and generates realistic depth grids for the extreme (November 2009) event modelled. We then scale-up to a catchment an order of magnitude larger (210km2, 72km watercourse), within which a range of nature-based measures are being proposed through community-led projects. We explore the effectiveness of the approach considering Limits of Acceptability based on local knowledge from communities at risk, model performance measures, and comparisons with existing spatial risk data. We demonstrate the benefits of an efficient fully distributed hydrological-hydraulics platform, which we think is required to represent many distributed nature-based schemes designed to slow, store and infiltrate flood waters, and integrate their effects on flood risk reduction at the catchment-scale.

Our aim is to quantify how many distributed nature-based measures influence risk-reduction at the catchment-scale whilst being honest about the uncertainties to help with targeting and decision making.