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End-to-end flood risk assessment: a coupled model cascade with uncertainty estimation

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This paper proposes a framework for an 'End-to-End' flood risk assessment strategy: the creation of a coupled system of models to allow continuous simulation methodology to be used to predict the magnitude and simulate the effects of high return period flood events. The scheme brings together the best in current thinking on reduced complexity modelling to formulate an efficient, process-based methodology which meets the needs of today's flood mitigation strategies.

Several factors provide the motivation to improve on conventional methods of flood risk assessment. Recent evidence of non-stationarity in the flood generation process suggests that a process-based model of catchment behaviour is required to replace the traditional 'curve-fitting' approach to flood frequency analysis. Further, it is no longer sufficient to limit the procedure to prediction of discharge; a distributed model of floodplain inundation based on sound hydraulic principles must be integrated into the analysis in order to support today's 'soft engineering' solutions to flood risk.

In order to achieve these aims, three component models were developed: a stochastic rainfall model, a rainfall-runoff model and a floodplain inundation model. The process-based technique of continuous simulation is employed to allow direct analysis of flow characteristics, using simulated rainfall series produced by the first model to drive the rainfall-runoff model and thereby produce continuous discharge simulation. Direct analysis of flow regime is then possible, which in turn provides the boundary conditions for the inundation model. This takes the form of a 2d raster storage cell

model which benefits from airborne laser altimetry (LIDAR) mapping of floodplain topography to allow high resolution simulation of floodplain inundation. Improvements in efficiency through the use of sub-grid scale information are explored.

The model chain is subject to stochasticity and parameter uncertainty, and hence the variables used to pass data between models are also uncertain. Therefore, in order to produce robust estimates of flood risk, uncertainties must be propagated through the chain. It is also important that their effects be quantified in terms of variables relevant to the end user such as spatial inundation extent or number of properties flooded. Methods to allow the propagation and quantification of uncertainty form, while retaining computational efficiency, are discussed.

Results from an experimental application are considered in terms of their implications for successful floodplain management, and compared against the deterministic methodology more commonly in use for flood risk assessment applications. The provenance of predictive uncertainty is also considered in order to identify those areas where future effort in terms of data collection or model refinement might best be directed in order to narrow prediction bounds and produce a more precise forecast.