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Assessing forecast skill of a large scale 2D inundation model of the Lower Zambezi River with multiple satellite data sets

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With flood frequency likely to increase as a result of altered precipitation patterns triggered by climate change, there is a growing demand for more data and, at the same time, improved flood inundation modeling. The aim is to develop more reliable flood forecasting systems over large scales that account for errors and inconsistencies in observations, modeling, and output. Over the last few decades, there have been major advances in the fields of remote sensing, NWP, and flood inundation modeling. At the same time these research communities are attempting to roll out their products on a continental to global scale.
In a first attempt to bring together these research efforts on a very large scale, a two-dimensional flood model has been built for the Lower Zambezi River in southeast Africa covering an area similar to the size of the UK. This scale demands a different approach to traditional 2D model structuring and we have implemented a simplified version of the shallow water equations as developed in [1] and complemented this formulation with a sub-grid structure for simulating flows in a channel much smaller than the actual grid resolution of the model. This particular setup allows to model flood flows across two dimensions with efficient computational speeds but without losing out on channel resolution when moving to coarse model grids (1 km).

We coupled the hydrodynamic model with baseline and forecast simulations of daily flows from the VIC (variable infiltration capacity) macroscale hydrological model, which was forced with ERA-40 meteorological data and EPS forecasts, respectively. The modeling system was first calibrated and then applied to illustrate prediction performance for the February 2007 Mozambique floods. Although there are some local efforts in terms of flood forecasting in the Zambezi basin, according to WMO there is currently no integrated flood warning system in the basin, primarily due to poor communication facilities and limited exchange of information and data in real-time.

Furthermore, in these rather data poor regions of the world and at this type of scale, verification of flood modeling is realistically only feasible with wide swath or global mode remotely sensed imagery. The modeled water surface was first calibrated to within centimetres (mean bias of 0.017 m) using highly accurate water levels on the main channel from the ICESat laser altimeter. Forecast validation of the Zambezi model was then carried out using multiple satellite acquisitions of the flood area on different days, including AVHRR, Landsat and Formosat. Results show that satisfactory parameter values and performance as well as acceptable prediction skill can be achieved at a very large scale and using coarse grid resolutions; however in forecast mode, it is crucial to account for basin-wide hydrological response time when assessing lead time performances for flood event forecasting. Our findings also illustrate the importance and value of different satellite data sets that exist to assess model skill at very large scales and for areas where the collection of field data is usually impossible.

[1] Bates, P. D., Horritt, M. S., & Fewtrell, T. J. (2010). A simple inertial formulation of the shallow water equations for efficient two dimensional flood inundation modelling. Journal of Hydrology, 387, 33–45.