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# A simple model for wide area hydraulic modelling in data sparse areas.

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The simulation of wave propagation, level and discharge in large rivers systems at continental or global scales, for applications ranging from regional flood risk assessment to climate change impacts, requires computationally efficient hydraulic models that can be applied to locations where limited or no ground based data are available. Many existing global or large scale river routing schemes use kinematic or simpler wave models, which although computationally efficient, are unable to simulate backwatering and floodplain interactions that are key controllers of wave propagation in many large rivers. Diffusive wave models are often suggested as a more physically based alternative, however the lack of inertia in the scheme leads to long simulation times due to the very low slopes in large rivers.

We present a Cartesian grid two-dimensional hydraulic model with a parameterised sub-grid scale representation of the 1D channel network that can be build entirely from remotely sensed data. For both channel and floodplain flows the model simulates a simplified shallow water wave (diffusion and inertia) using an explicit finite difference scheme, which was chosen because of its computational efficiency relative to both explicit diffusive and full shallow water wave models.

The model was applied to an 800 km reach of the River Niger that includes the complex waterways and lakes of the Niger Inland Delta in Mali. This site has the advantage of having no or low vegetation cover and hence SRTM represents (close to) bare earth floodplain elevations. Floodplain elevation was defined at 1 km resolution from SRTM data to reduce pixel-to-pixel noise, while the widths of main rivers and floodplain channels were estimated from Landsat imagery. The channel bed was defined as a depth from the adjacent floodplain from hydraulic geometry principles using a power law relationship between channel width and depth. This was first approximated from empirical data from a range of other sites then refined through model calibration using observations of water surface elevation between 2003 and 2008 from the ICEsat laser altimeter.

The sub-grid model had a RMSE of 1.24 m to 155 observations of water levels taken over six years from 2003-2008 at 24 virtual gauging stations. Wave propagation was also assessed against a gauge towards the downstream end of the river. The model was used to demonstrate that both the channel network (including the connectivity provided by floodplain channels) and floodplain storage are necessary to simulate the correct wave propagation. The RMSE for a model without sub-grid channels (e.g. a 2D model) was 6.25 m, while a model of the sub-grid channel network without floodplain storage (e.g. a 1D model) had a RMSE of 1.81 m. Wave propagation was substantially slower than that observed by the gauge network in the 2D model and faster in the 1D model. The calibration of the sub-grid channel model from the available remotely sensed data sets and prospects for assimilating data with the model on un-gauged rivers were also evaluated.