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Identifying river channel characteristics of the Niger Inner Delta from altimeter data

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To date, much flood inundation research has focused on the simulation of hydrodynamics within a framework where detailed river and floodplain bathymetry is used to construct a physically-based numerical model. This framework is fundamentally limited in scale by the lack of observed river bathymetry for most of the world's rivers and wetlands. To simulate floodplain inundation across large spatial scales requires a different approach that will need to estimate bathymetry and friction as reach averaged components of the hydraulic model, using remotely observable variables such as water level and channel width. This research presents a model where the river channel depth, shape and friction can be described by three physically meaningful but continuous parameters. We attempt to estimate these parameters using satellite altimeter data from a test site along ∼1000 km of the River Niger, Mali.

For calibration the model was split into 1, 2 or 3 reaches and we used a DEM at 2 arcminutes or ∼4 km. River and fl¬oodplain dynamics were simulated from 2002 to 2009, with each simulation taking ∼2.5 minutes. Each reach had two parameters if assumed rectangular and three if the cross-section shape was allowed to change. Therefore there were between two and nine parameters to calibrate, depending on the number of reaches and parameters. Infl¬ow boundary conditions were based on gauge observations. Water surface elevation observations were available from ICEsat and Envisat altimeters, with parameters estimated from these using a Gauss-Marquardt-Levenberg method, with an objective function where observations were weighted given an estimate of their uncertainty.

A twinned calibration experiment indicated that the information content of the data was sufficient to identify the parameters in an error free model and that the gradient based optimise was capable of finding the minimum of the objective function. Simulated levels were most sensitive to model friction and became more so with distance downstream due to the effect of friction on wave speed.

When calibrated, simulated water surface elevation RMS error to ICEsat data was less than 0.75 m for two reaches and less than 0.6 m for three reaches, which is less than half the RMS error of a previous model where channel depth was based on hydraulic geometry. Simulations of downstream discharge (wave propagation) were most accurate when there was only one globally applied friction parameter, but many reaches with different depths and shapes. The reason for this may be that reach frictions tended to interact with each other and depth in order to more accurately fit the level data, resulting in a wide range of effective friction values. The model was much less sensitive to channel shape than the other parameters. However, models that could adjust channel shape had less variability in their expected friction between reaches, and this parameter may help avoid physically unrealistic friction parameters.