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Efficient incorporation of channel cross-section geometry uncertainty into regional and global scale flood models

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This work explores the challenge of representing structural differences in river channel cross-section geometry for regional to global scale river hydraulic models and the effect this can have on simulations of flood wave dynamics. Classically, channel geometry is defined using data, yet at larger scales the necessary information and model structures do not exist to take this approach. We therefore propose a fundamentally different approach where the structural uncertainty in channel geometry is represented using a simple parameterization and that can then be estimated through calibration or data assimilation. We first outline the development of a computationally efficient numerical scheme to represent generalised channel shapes using a single parameter, which is then validated using a simple straight channel test case and shown to predict wetted perimeter to within 2% for the channels tested. An application to the River Severn, UK and Niger Inner Delta, Mali are also presented, along with an analysis of model sensitivity to channel shape, depth and friction. The channel shape parameter was shown to improve model simulations of river level, particularly for more physically plausible channel roughness and depth parameter ranges. Calibrating channel Manning's coefficient in a rectangular channel provided similar water level simulation accuracy in terms of Nash-Sutcliffe efficiency to a model where friction and shape or depth were calibrated. However, the calibrated Manning coefficient in the rectangular channel model was greater by 0.015-0.02 than the more complex channel shape and this erroneously slowed wave propagation times through the 30 km reach by 1.4 hours (17%). Even a poor estimate of channel shape resulted in more physically realistic calibration of channel Manning's coefficient and channel depth. On the River Niger, where the river depth and shape are unknown, we calibrate depth, shape and friction using ICEsat data for a number of reaches. Including the shape parameter led to little improvement in simulation accuracy. However, friction and depth were more consistent from reach to reach when the shape parameter was included. Therefore, for large scale models applied in data sparse areas, calibrating channel depth and/or shape may be preferable to assuming a rectangular geometry and calibrating friction alone if sufficient data on level dynamics is available.