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River flow and inundation in African river systems: results from a new pan-African land-surface model validated against Earth observations

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The role of surface-water flooding in controlling fluxes of water and carbon between the land and the atmosphere is increasingly recognized in studies of the Earth system. Simultaneous advances in remote earth observation and large-scale land-surface and hydrological modeling promise improvements in our ability to understand these linkages, and suggest that improvements in prediction of river flow and inundation extents may result. Here we present an analysis of newly-available observational estimates of surface water inundation obtained through satellite Earth observation with results from simulations produced by using the Joint UK Land Environment Simulator (JULES) land-surface model operating at 0.5 degree resolution over the African continent. The model was forced with meteorological input from the WATCH Forcing Data for the period 1981-2001 and sensitivity to various model configurations and parameter settings were tested. Both the PDM and TOPMODEL sub-grid scale runoff generation schemes were tested for parameter sensitivities, with the evaluation focussing on simulated river discharge in sub-catchments of the Congo, Nile, Niger, Orange, Okavango and Zambezi rivers. It was found that whilst the water balance in each of the catchments can be simulated with acceptable accuracy, the individual responses of each river vary between model configurations so that there is no single runoff parameterization scheme or parameter values that yields optimal results across all catchments. We trace these differences to the model's representation of sub-surface flow and make some suggestions to improve the performance of large-scale land-surface models for use in similar applications. These findings suggest that the use of Earth observation data together with improved models of large-scale hydrology have the potential to improve our ability to predict surface-water flooding and to develop our understanding of the role of flooding in driving components of the water and carbon cycles.