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Coupled hydrologic and hydraulic modeling of Upper Niger River Basin

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The Upper Niger Basin is located in Western Africa, flowing from Guinea Highlands towards the Sahel region. In this area lies the seasonally inundated Niger Inland Delta, which supports important environmental services such as habitats for wildlife, climate and flood regulation, as well as large fishery and agricultural areas. In this study, we present the application of MGB-IPH large scale hydrologic and hydrodynamic model for the Upper Niger Basin, totaling c.a. 650,000 km^2 and set up until the city of Niamey in Niger. The model couples hydrological vertical balance and runoff generation with hydrodynamic flood wave propagation, by allowing infiltration from floodplains into soil column as well as representing backwater effects and floodplain storage throughout flat areas such as the Inland Delta. The model is forced with TRMM 3B42 daily precipitation and Climate Research Unit (CRU) climatology for the period 2000-2010, and was calibrated against in-situ discharge gauges and validated with in-situ water level, remotely sensed estimations of flooded areas (classification of MODIS imagery) and satellite altimetry (JASON-2 mission). Model results show good predictions for calibrated daily discharge and validated water level and altimetry at stations both upstream and downstream of the delta (Nash-Sutcliffe Efficiency>0.7 for all stations), as well as for flooded areas within the delta region (ENS=0.5; r^2=0.8), allowing a good representation of flooding dynamics basinwide and simulation of flooding behavior of both perennial (e.g., Niger main stem) and ephemeral rivers (e.g., Niger Red Flood tributaries in Sahel). Coupling between hydrology and hydrodynamic processes indicates an important feedback between floodplain and soil water storage that allows high evapotranspiration rates even after the flood passage around the inner delta area. Also, representation of water retention in floodplain channels and distributaries in the inner delta (e.g., Diaka river distributary) is fundamental for the correct representation of the flood wave attenuation in Niger main stem. Improvements could be made in terms of floods propagation across the basin –through parameters such as Manning's roughness and section depth and width–using the comparison with satellite altimetry data, for instance. Finally, such coupled hydrologic and hydrodynamic models prove to be an important tool for integrated evaluation of hydrological processes in such ungauged, large scale floodplain areas. Possible uses of the model involve the assessment of different scenarios of anthropic alteration, e.g., the effects of reservoirs implementation and climate and land use changes.