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Climate change impact assessment on floodplain dynamics in the upper Zambezi using a process-based distributed modelling approach

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Current projections of climate and socio-economic development indicate that both will have a significant impact on hydrological processes and available water resources in southern Africa. As such, the identification and quantification of these impacts is necessary so as to be able to develop sustainable adaptation strategies related to integrated land and water resources management (ILWRM). The present research quantifies the potential impacts of climate change on annual floods and water resources in a large southern African watershed, the Luanginga River basin (~33000 km^2), which is a tributary of the Upper Zambezi River ranging from the Angolan highlands to the Barotse floodplain. The catchment is characterized by an annual flow regime and extensive wetland areas, which are especially sensitive to changes in hydrological conditions.
The climate change assessment undertaken in the present research consisted of the application of the process-based distributed hydrological model J2000-(Flood) using a daily time step. The applied floodplain simulation extension, characterized as a conceptual and easily transferable approach that is simultaneously not overly data- and resource-intensive, as well as easily parameterizable, was developed with the goal of simulating wetland inundation within the model. In order to provide a spatial basis for model validation, the inundated area was determined using the Desert Flood Index, which was generated from a time series of 14 Landsat image mosaics.
With regards to runoff dynamics at the catchment outlet, good results were achieved for calibration (1959-1968; E2 0.81) and validation (1981-2003; E2 0.75). Analyzing the spatial pattern indicates an accurate simulation of the inundation in the main floodplain for most years. Considering the elevation uncertainty inherent to the digital elevation model, as well as data sparsity in terms of both time-series length and station presence and location, the results are deemed satisfactory.
Overall, the model is able to accurately represent the annual flood regime of the system, and thus too, to address the potential effect of various climate change scenarios on the hydrological processes in the watershed. Under the RCP 8.5 scenario, using input data from the EC-Earth and ECHAM models, following a process of downscaling using the REMO model and bias correction, the model results revealed a substantial decrease in runoff generation (39%), flood extent (35%), and groundwater recharge (32%) as being very likely. The changes presented by these models are mainly associated with a substantial temperature rise of about 5°C, leading to a strong increase in evapotranspiration being projected by the end of the century. This decrease in water quantity would damage the wetland ecosystem and signify increased risk to the people living in the region, many of whom depend upon this highly productive ecosystem for their livelihoods.