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Application of a conceptual rainfall-runoff model (HBV) in the Black Volta basin of Western Africa for CC impact assessment studies

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The Black Volta basin, located in the West of Africa is a very vital transboundary water resource which is shared by four (4) riparian countries. The Volta basin, including the Black Volta basin is the main source of hydropower for the sub-region. The climate of the area ranges from semi-arid (in the northern part) to sub-humid (in the southern part). The basin covers an area of about 150,000 km2 and spans from 7°N to 15°N and 5° 24‘W to 1°W.

Rainfall-runoff models are necessary and needed to predict water resources future development. And to investigate the water balance situations in the catchment, a lumped version of the conceptual HBV-IWS version (Hydrologiska Byrans Vattenbalansavdelning) hydrological model was applied to the study area. The input data (i.e. rainfall and temperature) were obtained from the Meteorological agencies in Ghana and Burkina Faso. Discharge measurements at two different locations were used to optimize the model parameters and to check the performance of the model.

In assessing how well the model performs, different optimization techniques ranging from Nash-Sutcliffe (NS), the logarithmic of the Nash-Sutcliffe (LogNS), the Nash-Sutcliffe with a bias constraint (NS-Bias) and the Kling-Gupta (KG) were used. The robust parameter estimation (ROPE) was used to generate and calibrate 10,000 best parameter sets in a computer framework with initially set model parameter ranges.

It is interesting to know that, the model performs well with an average NS of 0.75 and 0.6 for calibration and validation respectively. The performance also improves when a higher weight is given to the low-flows during the optimization. Results also show that the model reacts well to signals in that a split sampling of the data into dry and wet years used for calibration and validation and vice-versa yielded good results. The annual discharge cycle was subtracted from both the observed and modeled discharges and then the efficiency of the model was determined using the residual-discharges and the results were found to be encouraging.

Different climate simulations were used as input to the hydrological model to determine the impact of climate changes on the hydrological regime of the basin.