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Simulation of present and future discharges at the Nile River upstream Lake Nasser

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The objective of this study is to simulate present and future discharges at the Nile River upstream Lake Nasser. For this purpose a rainfall-runoff model (HBV) is integrated in an existing model which describes the water distribution in the upper Nile (RIBASIM-NILE). RIBASIM-NILE can be used to describe effects of developments upstream the High Aswan Dam on Nile discharges, with the focus on Lake Nasser inflows. The combination of the two models is referred to as the Nile Hydrological Simulation Model (NHSM).

To assess the performance of NHSM in simulating discharges under the present climate it is forced by observed rainfall and potential evapotranspiration for the period 1961-2000. The first 20 years are used for model calibration and the second 20 years for model validation. To simulate future discharges, NHSM meteorological forcing is derived from simulated series by three Global Circulation Models (GCMs) under two SRES emission scenarios. Bias from GCM simulations is removed by a correction of rainfall and evapotranspiration to the observed 1961-1990 mean monthly climatology. The performance of NHSM-GCM combinations in simulating the present climate is assessed by comparison of observed and simulated mean monthly discharges and interannual variability. Finally, NHSM-GCM simulations under the two SRES scenarios are used to describe the 2065 and 2100 hydro-climates.

Results of NHSM calibration and validation are satisfying on the scale of the main tributaries; the White Nile draining the Great Lakes district and the Blue Nile and Atbara River draining the Ethiopian Highlands. However, especially in sub-catchments of the White Nile performance is considerably lower ranging from a poor representation of discharge peaks to a structural underestimation of discharges. Although some poor results are related to errors in model forcing, others are related to NHSM. It is expected that performance will increase when improvements are made in the description of rainfall-runoff processes in HBV and the representation of lakes and swamps in RIBASIM-NILE. The performance of NHSM-GCM combinations in simulating 1961-1990 discharges is low. Uncorrected meteorological forcing derived from GCM simulations shows a high bias compared to the observed climatology. After bias correction the spatio-temporal representation of observed meteorological forcing is insufficient, especially for rainfall. This is revealed when actual evapotranspiration simulations by NHSM with observed and simulated meteorological forcing are compared. NHSM-GCM simulations for 2065 and 2100 result in a large uncertainty in future climate and discharges. Although this uncertainty can be found in previous studies as well, some peculiar results cannot be explained. More detailed research on the performance of the used GCMs in representing the local climate is required to increase the predictive value within satisfactory limits.

Further research is recommended to improve the NHSM performance on sub-catchment scale by improving the quality of the meteorological forcing, changing the spatial discretisation of HBV, improving the representation of river-lake dynamics in RIBASIM-NILE and executing an integrated calibration of HBV and RIBASIM-NILE. Future meteorological forcing series can be improved by refining the methods to downscale GCM simulations to the required spatial scale. NHSM can then be used to assess the impact of river basin management strategies and socio-economic developments in the Nile basin under changing climate conditions.