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The Operation of the Grand Ethiopian Renaissance Dam under Future Climate Scenarios

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Abstract

The Grand Ethiopian Renaissance Dam (GERD) at the outlet of the Upper Blue Nile (UBN) basin in Ethiopia will be the largest dam in Africa when completed. The inflow to the dam represents about 60% of the discharge to the main Nile river. While Ethiopia in general contributes 85% of the Nile flow (measured at High Aswan), it only withdraws 3-4 % of the total annual flow. The highlands of the UBN have the potential for significant hydropower and irrigation, with spatially varying temperature and precipitation over the basin. The Ethiopian government is constructing GERD since 2011, to meet the increasing demand for electricity and water, which has arisen controversies of water share among the three riparian countries, Ethiopia, Sudan, and Egypt. In this study, we deployed a physically-based hydrological model (Coupled Routing and Excess STorage; CREST) to investigate the impact of future climate projection on the basin hydrology. CREST was tested in a prior study and was demonstrated to perform well in terms of ET and discharge simulation in the UBN basin and that the modeling framework can be applied to predict reservoir inflow volume. We used sub-daily resolution climate projection data (3-hourly by 50 km) from Rossby Centre regional atmospheric model, RCA4, which is forced by the Model for Interdisciplinary Research On Climate (MIROC5) global circulation model. We used 1981-2010 as the baseline period and analysed future projections within the three windows (2011-2040, 2041-2070, and 2071-2100). Compared to the baseline period, climate projections in UBN exhibit around +9% increment of the annual total precipitation and 1.8 to 4.2 ℃ overall increment of temperature. As a result, the annual flow at El Diem outlet of UBN (close to the GERD) could increase between 24% and 63%. Considering different annual release scenarios to the downstream countries and the simulated projected inflow to the GERD, we estimated the probable filling time of the reservoir and analysed the hydropower generation of the dam in the various future time windows. The findings of the study will help understand how the dam operation can be planned for future climate extremes as well as the negotiation among the three counties regarding release amounts.

Keywords: GERD, CREST Model, Upper Blue Nile Basin, Climate prediction, Global Circulation Model, Blue Nile River flow prediction

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