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From real-time monitoring to climate studies in the Congo basin: role of spatial hydrology and remote sensing datasets

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The Congo River Basin (CRB), located in the central region of Africa, is of particular importance for regional and global climate and carbon studies. Being the second largest river basin after the Amazon, it is also the one with the most free-flowing rivers. However, despite these important characteristics, it has not attracted as much attention among the scientific communities as the Amazon Basin or other large tropical rivers in the world. Because of the lack of comprehensive and maintained in situ data networks over time, large-scale monitoring of hydroclimatic variables has not been properly conducted. In this context, near real-time observations of the CRB, such as water surface elevation (WSE) and river discharge, as well as understanding the impacts of climate change in a spatiotemporally distributed manner across the basin present a major challenge. In the last few years, however, the scientific community, supported by the leading operational organism in the CRB (the CICOS), has worked on applying innovative tools, from hydrological and hydrodynamic modeling to the use of space data, to improve this monitoring and understanding of hydrological processes.

Our work illustrates how space Earth Observation (EO) datasets used jointly with a hydrological model improve both near-real-time monitoring and past-period revisiting (from 1980). First, we built and validated an extensive database on long-term time series of water levels (WL) from satellite altimetry using a comprehensive unprecedented *in situ* database (root mean square error varying between 10 cm to 75 cm). Crossing this database with the Global Inundation Extent from Multi-Satellites (*GIEMS*) database, we analyzed the normal behavior of surface water in the CRB, and worked towards understanding the genesis of recent extreme events. The observations

permitted to highlight the different travel time of waters from one to three months depending on its origin, and to discriminate the relative contribution of southern and northern sub-basins to the first and second peaks at the outlet of the basin Kinshasa/Brazzaville station. These datasets are then used to calibrate/validate the setting of a large-scale hydrologic and hydrodynamic model, the MGB model, in which lakes representation parameters are tuned using all the aforementioned databases and the long term CHIRPS precipitation product. In terms of discharge estimates, the model run resulted in an average KGE efficiency index value of 0.84 and 0.71 for the calibration (2001-2020) and validation (1981-2000) periods respectively.

When included within a scheduler, this model run validated by space EO datasets now permits the inference of discharge and depths all over the basin in real-time. In addition, data assimilation techniques applied to ingest remote sensing datasets, into the MGB model, improves such real-time estimates. Long term modeling also provides a new look and understanding on recent hydrological extreme events that occurred in the CRB, and permits analyzing the impact of recent global and regional climate change on freshwater in one of the most free-flowing watersheds.