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Coupling large scale hydrologic-reservoir-hydraulic models for impact studies in data sparse regions

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As hydraulic modelling moves to increasingly large spatial domains it has become essential to take reservoirs and their operations into account. Large-scale hydrological models have been including reservoirs for at least the past two decades, yet they cannot explicitly model the variations in spatial extent of reservoirs, and many reservoirs operations in hydrological models are not undertaken during the run-time operation. This requires a hydraulic model, yet to-date no continental scale hydraulic model has directly simulated reservoirs and their operations.
In addition to the need to include reservoirs and their operations in hydraulic models as they move to global coverage, there is also a need to link such models to large scale hydrology models or land surface schemes. This is especially true for Africa where the number of river gauges has consistently declined since the middle of the twentieth century.
In this study we address these two major issues by developing: 1) a coupling methodology for the VIC large-scale hydrological model and the LISFLOOD-FP hydraulic model, and 2) a reservoir module for the LISFLOOD-FP model, which currently includes four sets of reservoir operating rules taken from the major large-scale hydrological models.
The Volta Basin, West Africa, was chosen to demonstrate the capability of the modelling framework as it is a large river basin (∼400,000 km2) and contains the largest man-made lake in terms of area (8,482 km2), Lake Volta, created by the Akosombo dam. Lake Volta also experiences a seasonal variation in water levels of between two and six metres that creates a dynamic shoreline. In this study, we first run our coupled VIC and LISFLOOD-FP model without explicitly modelling Lake Volta and then compare these results with those from model runs where the dam operations and Lake Volta are included. The results show that we are able to obtain variation in the Lake Volta water levels and that including the dam operations and Lake Volta has significant impacts on the water levels across the domain.