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A sequential assimilation strategy to improve short- and long-term forecasts in a hydropower application

Juliane Mai (1), Richard Arsenault (2), Bryan Tolson (1), Marco Latraverse (3), and Kenjy Demeester (3)

(1) University of Waterloo, Engineering, Civil & Env. Engineering, Waterloo, ON, Canada (juliane.mai@uwaterloo.ca), (2) École de technologie supérieure, Dépt. de génie de la construction, Montreal, QC, Canada, (3) Rio Tinto, Aluminium division, Jonquière, QC, Canada

Hydropower producers rely on hydrologic models and reliable forecasts of incoming water volumes to operate power plants and dams efficiently. These models are parameterized and, as such, are mere approximations of the real hydrologic system. Hence, initial states of the model might not always match the current states of the system after more than a few days of open-loop simulations. An analyst therefore usually adjusts model states or input variables such that the model meets the current states of the system. The automatized version of this process is called data assimilation. The short-term impacts of such adjustments are mostly predictable while long-term effects are harder to foresee. The performance of the assimilation is measured by comparing the improvement of forecasts compared to an open-loop simulation where no adjustment is applied.

We will present a new strategy to update states of the operational hydrologic model CEQUEAU used by Rio Tinto to manage and operate 5 reservoirs and 7 hydroelectric generating stations in Quebec and British Columbia (Canada). The states and variables that will be adjusted are based on a rule framework that selects the states/variables based on the current meteorological conditions and the system state. This specific set of parameters is then calibrated to find an optimal setting to match the initial states. This is to mimic the analysts daily manual procedure before he/she issues a forecast. The optimal adjustment is then used to issue a forecast. Then the whole process is repeated for the next day. The current adjusted model setup is used as model initial state, the set of parameters is picked for this day's meteorological and system conditions, these parameters are calibrated to match the model initial state with the observed state. This method is applied for the 64-year period in which meteorological and stream flow data are available. This results in about 23,500 sequential calibration experiments and forecasts. The performance of the forecast after initial state assimilation is evaluated for the short term (3 days), intermediate (14 days), and long-term (180 days) and compared to the open-loop base run. The long-term impacts (180 days) are added to determine for the first time the impact of analysts choices in, e.g., the winter period on the performance during summer.

The experiment is repeated for 4 head catchments in the region of Saguenay–Lac-Saint-Jean (Quebec, Canada). Several rule frameworks of which states/variables are going to be adjusted under which conditions are tested. This is the first attempt to fully mimic the daily operations of the forecasting analysts at RioTinto to reduce the long-term impacts of manual adjustments and opens the door to providing a fully automated and reproducible framework for evaluating the value of hydrological forecasts.