Geophysical Research Abstracts
Vol. 16, EGU2014-429, 2014
EGU General Assembly 2014

Reduction of forecast uncertainty in the context of hydropower production: a case study for two catchment in Lac-St-Jean, Canada

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This research focuses on the improvement of streamflow forecasts for two subcatchments in the Lac-St-Jean area, a northern part of the province of Quebec in Canada. Those two subcatchments, named Manouane and Passes-Dangereuses, are part of a bigger system, which comprises many reservoirs and six hydropower plants. This system is managed by Rio Tinto Alcan, an aluminium producer who needs this energy for its processes. Optimal management of the hydropower plants highly depends on the reliability of the inflow forecasts to the reservoirs and also on the reliability of observed streamflow. The latter are not directly measured, but rather deduced from the computation of a water balance. This water balance includes streamflow computation based on rating curves for river sections and upstream reservoirs and a modelling process using CEQUEAU hydrological model (Morin et al., 1981). In addition, mostly during the winter, the model has to account for a transfer of water from Lac Manouane reservoir to Passes-Dangereuses through Bonnard channel. Winter flow though Bonnard channel is controlled by a spillway, and represented in CEQUEAU by a transfer function and a fixed time delay (2 days). However, it is suspected that the evacuation function, as it is currently computed, is inaccurate.

The main objective of this work is to reduce predictive uncertainty for Lac Manouane and Passes-Dangereuses catchment, for the one-day ahead horizon. This objective is twofold. First, the uncertainty related to the parameterization of the hydrological model had never been evaluated. It was to be investigated whether it is better to spatialize the calibration of the hydrological model. In its actual form, the calibration of the hydrological model CEQUEAU (Morin et al., 1981) is based exclusively on the downstream outflow. There is, however, intermediate streamflow measurements data available for an intermediate location. Our study shows that calibrating the model using streamflows for both locations (intermediate location and downstream) leads to improved forecasts, as measured by the Nash-Sutcliffe efficiency criterion. The parameter sets thus determined best represent the phenomena of exchange and runoff in the watershed.

Second, this study aims at reducing the uncertainty associated to the evacuation function for the Bonnard channel as well as the time delay related to this transfer. Instead of using a fixed 2-day time delay for the transfer, it was attempted to represent the channel in the hydrological model CEQUEAU and compute the time delay from this model. The results show that hydrological modelling does not improve the results and that the 2-day time delay is adequate, especially for first days of opening and few days after closure of the gate. In addition, this research shows that the evacuation function of Bonnard spillway is inexact for large streamflows. It is considered the main source of uncertainty for the prediction of inflows to the reservoirs. We also show that the evacuated streamflows can be successfully corrected by hydrological modelling.

This case study shows that a careful revision of the inflow forecasting process for those important watersheds can help reduce predictive uncertainty. Although the application is specific to the Lac-St-Jean area, we believe that our experience could serve other users and water managers with similar issues regarding inflow uncertainty.

Reference

Morin, G., J.-P. Fortin, J.-P. Lardeau, W. Sochanska and S. Paquette. 1981. Modèle CEQUEAU : Manuel d'utilisation. Rapport de recherche no R-93, INRS-Eau, Sainte-Foy