



## **Operational value of ensemble streamflow forecasts for hydropower production: A Canadian case study**

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Ensemble and probabilistic forecasts have many advantages over deterministic ones, both in meteorology and hydrology (e.g. Krzysztofowicz, 2001). Mainly, they inform the user on the uncertainty linked to the forecast. It has been brought to attention that such additional information could lead to improved decision making (e.g. Wilks and Hamill, 1995; Mylne, 2002; Roulin, 2007), but very few studies concentrate on operational situations involving the use of such forecasts. In addition, many authors have demonstrated that ensemble forecasts outperform deterministic forecasts in terms of performance (e.g. Jaun et al., 2005; Velazquez et al., 2009; Laio and Tamea, 2007). However, such performance is mostly assessed on the basis of numerical scoring rules, which compare the forecasts to the observations, and seldom in terms of management gains.

The proposed case study adopts an operational point of view, on the basis that a novel forecasting system has value only if it leads to increase monetary and societal gains (e.g. Murphy, 1994; Laio and Tamea, 2007). More specifically, Environment Canada operational ensemble precipitation forecasts are used to drive the HYDROTEL distributed hydrological model (Fortin et al., 1995), calibrated on the Gatineau watershed located in Québec, Canada. The resulting hydrological ensemble forecasts are then incorporated into Hydro-Québec SOHO stochastic management optimization tool that automatically search for optimal operation decisions for the all reservoirs and hydropower plants located on the basin.

The timeline of the study is the fall season of year 2003. This period is especially relevant because of high precipitations that nearly caused a major spill, and forced the preventive evacuation of a portion of the population located near one of the dams. We show that the use of the ensemble forecasts would have reduced the occurrence of spills and flooding, which is of particular importance for dams located in populous area, and increased hydropower production.

The ensemble precipitation forecasts extend from March 1<sup>st</sup> of 2002 to December 31<sup>st</sup> of 2003. They were obtained using two atmospheric models, SEF (8 members plus the control deterministic forecast) and GEM (8 members). The corresponding deterministic precipitation forecast issued by SEF model is also used within HYDROTEL in order to compare ensemble streamflow forecasts with their deterministic counterparts. Although this study does not incorporate all the sources of uncertainty, precipitation is certainly the most important input for hydrological modeling and conveys a great portion of the total uncertainty.

### **References:**

Fortin, J.P., Moussa, R., Bocquillon, C. and Villeneuve, J.P. 1995: HYDROTEL, un modèle hydrologique distribué pouvant bénéficier des données fournies par la télédétection et les systèmes d'information géographique, *Revue des Sciences de l'Eau*, **8**(1), 94-124.

Jaun, S., Ahrens, B., Walser, A., Ewen, T. and Schaer, C. 2008: A probabilistic view on the August 2005 floods in the upper Rhine catchment, *Natural Hazards and Earth System Sciences*, **8** (2), 281-291.

- Krzysztofowicz, R. 2001: The case for probabilistic forecasting in hydrology, *Journal of Hydrology*, **249**, 2-9.
- Murphy, A.H. 1994: Assessing the economic value of weather forecasts: An overview of methods, results and issues, *Meteorological Applications*, **1**, 69-73.
- Mylne, K.R. 2002: Decision-Making from probability forecasts based on forecast value, *Meteorological Applications*, **9**, 307-315.
- Laio, F. and Tamea, S. 2007: Verification tools for probabilistic forecasts of continuous hydrological variables, *Hydrology and Earth System Sciences*, **11**, 1267-1277.
- Roulin, E. 2007: Skill and relative economic value of medium-range hydrological ensemble predictions, *Hydrology and Earth System Sciences*, **11**, 725-737.
- Velazquez, J.-A., Petit, T., Lavoie, A., Boucher, M.-A., Turcotte, R., Fortin, V. and Anctil, F. 2009: An evaluation of the Canadian global meteorological ensemble prediction system for short-term hydrological forecasting, *Hydrology and Earth System Sciences*, **13**(11), 2221-2231.
- Wilks, D.S. and Hamill, T.M. 1995: Potential economic value of ensemble-based surface weather forecasts, *Monthly Weather Review*, **123**(12), 3565-3575.