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Dynamical S2S meteorological forecasts for hydrology: can they do better than good old climatology-based ensembles?

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Climatology-based forecasts, or Extended Streamflow Predictions (ESP), are a common operational standard for long term hydrological forecasting. There exist a long-standing idea that, when it comes to predicting events months or even weeks in advance, dynamical meteorological forecasts have no more skill than climatology. However, this belief rests on a strong assumption of stationarity, which may not hold in a changing climate and should be challenged.

Considering the efforts deployed to improve atmospheric models and forecasts, perhaps it would be good to give them a chance? The hypothesis we wanted to verify in this research is that «reservoir inflow forecasts based on dynamic meteorological forecasts have better predictive skill than ESP». Here, « better » means more skillful than ESP according to ensemble-specific metrics such as the CRPS and the ROC score.

In order to verify this hypothesis, we consider ten watersheds managed by Hydro-Québec (HQ). HQ is Quebec's main hydro-power producer and those 10 watersheds are thus economically important. Currently, HQ sub-divides the complete forecasting horizon in three distinct periods (short, medium and long term). The medium term forecasts are ESP. For both the short and medium term, the hydrological model is HSAMI, a conceptual lumped model with a daily time step.

We first reproduce HQ's ESP by providing HSAMI with 64 meteorological scenarios which consist in the observed meteorology (total precipitation, minimum and maximum temperature) from the last 64 years. Then, we provide HSAMI with two types of meteorological forecasts issued by the ECMWF. First, the 30-day ahead forecasts retrieved from the global S2S database. Second, the first 30 days of the 7-month ahead forecasts from the recently released SEAS5. In all cases we concentrate on the 1995-2014 period.

We first show that, although raw meteorological forecasts exhibit biases, they can be corrected using a simple linear scaling. We then show that, although the skill of dynamical meteorological forecasts rapidly decreases after the first few days (7 to 20, depending on variable and watershed), they have a better discrimination capacity than climatology. Unsurprisingly, the former have a smaller spread than the latter, and they also reproduce seasonal variability better for all variables. Regarding inflow forecasting, our experiment also points out limitations and biases attributable to HSAMI. Time aggregated values, such as inflow volume over one month, are forecasted with more precision (less spread for equal accuracy) when using dynamical meteorological forecasts compared to ESP.

Our initial hypothesis is only partly true: while dynamical meteorological forecasts encouragingly display some skill at the watershed scale and for 1-month ahead inflow forecasting, there is still a lot of room for improvement and we provide insights on directions for future work.