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Should we use seasonnal meteorological ensemble forecasts for hydrological forecasting? A case study for nordic watersheds in Canada.

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Hydro-electricity is a major source of energy for many countries throughout the world, including Canada. Long lead-time streamflow forecasts are all the more valuable as they help decision making and dam management. Different techniques exist for long-term hydrological forecasting. Perhaps the most well-known is 'Extended Streamflow Prediction' (ESP), which considers past meteorological scenarios as possible, often equiprobable, future scenarios. In the ESP framework, those past-observed meteorological scenarios (climatology) are used in turn as the inputs of a chosen hydrological model to produce ensemble forecasts (one member corresponding to each year in the available database). Many hydropower companies, including Hydro-Québec (province of Quebec, Canada) use variants of the above described ESP system operationally for long-term operation planning. The ESP system accounts for the hydrological initial conditions and for the natural variability of the meteorological variables. However, it cannot consider the current initial state of the atmosphere. Climate models can help remedy this drawback. In the context of a changing climate, dynamical forecasts issued from climate models seem to be an interesting avenue to improve upon the ESP method and could help hydropower companies to adapt their management practices to an evolving climate. Long-range forecasts from climate models can also be helpful for water management at locations where records of past meteorological conditions are short or nonexistent. In this study, we compare 7-month hydrological forecasts obtained from climate model outputs to an ESP system. The ESP system mimics the one used operationally at Hydro-Québec. The dynamical climate forecasts are produced by the European Center for Medium range Weather Forecasts (ECMWF) System4. Forecasts quality is assessed using numerical scores such as the Continuous Ranked Probability Score (CRPS) and the Ignorance score and also graphical tools such as the reliability diagram. This study covers 10 nordic watersheds. We show that forecast performance according to the CRPS varies with lead-time but also with the period of the year. The raw forecasts from the ECMWF System4 display important biases for both temperature and precipitation, which need to be corrected. The linear scaling method is used for this purpose and is found effective. Bias correction improves forecasts performance, especially during the summer when the precipitations are over-estimated. According to the CRPS, bias corrected forecasts from System4 show performances comparable to those of the ESP system. However, the Ignorance score, which penalizes the lack of calibration (under-dispersive forecasts in this case) more severely than the CRPS, provides a different outlook for the comparison of the two systems. In fact, according to the Ignorance score, the ESP system outperforms forecasts based on System4 in most cases. This illustrates that the joint use of several metrics is crucial to assess the quality of a forecasts system thoroughly. Globally, ESP provide reliable forecasts which can be over-dispersed whereas bias corrected ECMWF System4 forecasts are sharper but at the risk of missing events.