Developing a seamless medium- to long-range flow forecast to improve the prediction of hydropower generation in Brazil

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The management of water resources is of great importance for many human activities, especially in the operational context of the Brazilian electricity sector, where we have a predominance of hydroelectric generation. In this context, streamflow forecasts are the main source of information for the optimization of the electric system. This presentation focuses on a series of steps developed to deal with uncertainties in the forecasts and obtain reliable flow predictions. The aim is to develop and evaluate a chain of data and models for medium- to long-range hydrometeorological forecasting (several days to months ahead), which can be used to forecast hydroelectric production in Brazil. The study is based on 41 river basins, which represent 30 hydroelectric plants in South America.

We first investigated the uncertainty in the observed precipitation from the TRMM_MERGE and CPC datasets. A spatial trend was found, with TRMM-MERGE precipitation values higher than those of the CPC dataset when moving towards north and west in the study area. Based on the observed uncertainties, we evaluated a combination of these two data sources. Observed discharges were used to quantify precipitation uncertainties and to weight the blending, while discharges obtained from hydrological modeling were used to validate the final precipitation product.

We then considered three sets of ensemble daily forecasts from the European Centre for Medium-Range Weather Forecasts (ECMWF): (i) seasonal precipitation forecasts (SEAS5, up to 7 months of forecast horizon; hindcast period 1981 – 2016); (ii) extended-range forecasts (S2S, up to 46 days of forecast horizon; on-the-fly hindcast for the past 20 years of the forecast period 2015 – 2021), and (iii) medium-range forecasts (EPS, up to 15 days of forecast horizon; fixed hindcast for the period 2006 – 2021). We evaluated the performance of two bias correction methods (QM - Quantile Mapping and LS - Linear Scaling) when applied to SEAS5 seasonal forecasts. The results showed that the errors observed in the raw forecasts are more dependent on the month of the year than on the forecast horizon, with systematic overestimation (underestimation) during the rainy (dry) season for most of the river basins. The QM method showed better performance and was applied to the S2S and the EPS forecasts to identify the best strategy when it comes to use the on-the-fly hindcast from S2S or the fixed hindcast from EPS. For this purpose, the parameters for the QM correction were first calculated at each S2S initialization (every 15 days), generating an on-the-fly correction, which depends only on the forecast horizon. These parameters were then used to correct the EPS medium-range forecasts (initialized every day). The results obtained were equal to or better than the results obtained with the parameters calculated with the fixed hindcast from the EPS. The on-the-fly correction is advantageous as it does not need a long time series of reforecasts to calibrate the bias correction parameters, which allows to better follow the evolution of meteorological models.

In order to build a seamless precipitation forecasting system, we evaluated several coupling methods. The member-by-member method showed equivalent performance when compared to more sophisticated methods, but with the advantage of not requiring intense mathematical efforts or data manipulation. The seamless forecasts were then applied to a hydrological modelling framework, where two techniques were evaluated to deal with the uncertainty of the hydrological forecasts: (i) the assimilation of streamflow data in real time, and (ii) the application of an autoregressive output-error correction to adjust the model output (final streamflow predictions). These techniques improved the performance of the forecasts, especially in the first two months of the forecast horizon.

Finally, the streamflow forecasts were applied to predict the production of hydroelectric energy in the Brazilian electric system. The results showed a good performance of the forecasting system, which was able to predict when the production would be above or below the average production for the most distant forecast horizons. The work developed proposes a tool that has great potential to be applied in the planning of the hydroelectric operation in Brazil, which can contribute to the optimization of the operation of the electrical system and the management of the use of water stored in the reservoirs.

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