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High-resolution hydrological seasonal forecasting for water resources management over Europe

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To support the decision-making process at the seasonal time scale, hydrological forecasts with a high temporal and spatial resolution are required to provide the necessary level of information for water managers. The Copernicus Climate Change Service (C3S) aims to provide climate-derived information for improved decision making regarding mitigation and adaptation strategies in Europe at seasonal to multi-decadal timescales. In the water sector, two demonstration contracts were funded: i) EDgE: Sectorial Climate Impact Indicators: End to End Demonstrator for Improved Decision Making in Europe and ii) SWICCA: Service for Water Indicators for Climate Adaptation.

In this study, we performed an extensive seasonal hydrological model inter-comparison for 617 European river basins. We inter-compared the seasonal hydrological forecasts from a suite of six hydrological models over Europe, which were available through SWICCA and EDgE, as well as the existing European Flood Awareness System (EFAS) service. The six hydrological models (VIC, Noah-MP, mHM, PCR-GLOBWB, E-HYPE and LISFLOOD) are forced with the same dynamical seasonal climate forecasts from ECMWF-S4. Ensemble Streamflow Prediction (ESP), which only makes use of meteorological observations, is used as a benchmark forecast for the comparison. In total 15 years of monthly seasonal forecasts (of up to 6-month lead time) have been compared to the corresponding model specific reference simulations. Finally, these models are validated against daily streamflow observations to check the general model performance over Europe.

We find that there is a significant difference in the seasonal performance of the models; where hydrological models with a longer internal memory (i.e. PCR-GLOBWB, E-HYPE, and LISFLOOD) provide more skillful ESP forecasts. The impact of dynamical forcing is limited for these models, whilst models which have less storage included in their structure (i.e. mHM, Noah-MP, and VIC) tend to significantly benefit from the use of dynamical forcings. Validation results show that mHM and E-HYPE exhibit the best performance over Europe, whilst these models show a strongly contrasting seasonal forecasting skill. We find that there is a strong correlation between the skill in ESP forecasts and the auto-correlation of the model simulated streamflow, where high auto-correlation (i.e. longer memory) leads to better ESP forecasts. The largest forecast improvements are found for southern Europe, whilst the snow-dominated regions in northern Europe lead to the strongest discrepancies between the different models. Therefore, differences in process representation lead to large differences in the seasonal streamflow forecasts.

In conclusion, we find that hydrological model setup and structure have a strong impact on the seasonal predictability of discharge over Europe. This study clearly highlights that seasonal hydrological model inter-comparisons yield valuable information on the hydrological predictability and the impact of model setup and parameterization on seasonal forecasts. Finally, we observe that the added value of including dynamical climate forecasts is largely model dependent, a finding which could have implications for future multi-model hydrological seasonal forecast systems.