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To what extend do seasonal hydrological forecasts benefit from improved meteorological forcing – a case study applying ECMWF SEAS5 forecasts to the Rhine basin

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In autumn 2017 ECMWF launched the fifth generation of its seasonal prediction system SEAS5, which offers various improvements compared to the previous version System 4 (SEAS4), like the integration of updated and more complex model components, an increase of spatial resolution etc. Noticeably forecast skill improvements of SEAS5 are reported, e.g. for El Niño / La Niña events, Artic Sea Ice or near-surface temperature in the northern hemisphere. An improved meteorological predictability is also good news for seasonal hydrological predictions relying on these predictions as boundary conditions. Although seasonal hydrological forecasts depend on an adequate estimation of the initial state (e.g. soil moisture, groundwater storage etc.), numerous studies prove that in many European regions seasonal flow forecast skill is largely dominated by the climatological forcing. At least this is true for monthly to seasonal flow forecasts along the German stretches of the international waterways of the Rhine, Danube and Elbe rivers, which are currently developed at the German Federal Institute of Hydrology (BfG) to support the operation of waterway transport, as well as anticipatory waterway and harbour management. Therefore the questions at hand are: (i) how do the climate model improvements of SEAS5 propagate through the hydrological model chain, and (ii) could the aforementioned climate model improvements enhance the skill and (economic) value of seasonal flow forecasts in central Europe, too?

We will address these questions using the example of the River Rhine basin situated in the heart of Europe. The semi-distributed HBV-model for the Rhine catchment is applied in hindcast-mode for the period 1981-2016, for which (re-)forecasts of SEAS5 and SEAS4 are available. In order to evaluate the impact of an improved meteorological boundary on the regional to local seasonal flow forecasts with a lead-time up to 7 months, the HBV-model is forced with three different inputs: SEAS4, SEAS5 and ERA-Interim reanalysis. The latter one is required to generate a simulated flow reference, which allows excluding hydrological model uncertainty from forecast skill evaluation, and to set-up the Ensemble streamflow predictions approach (ESP) as additional forecast reference. Furthermore ERA-Interim is applied for bias correcting the raw climate model outputs – still a necessary evil step when forcing regional hydrological models with global model outputs. Considering different basin scales and flow regimes within the Rhine basin differences in seasonal flow forecast skill for the different forecast set-ups will be evaluated using common deterministic and probabilistic performance indicators. In this context particular attention is paid to the effect of different bias correction methods on predictability using SEAS4 and SEAS5 as forcing.

For the River Rhine itself, Europe's most important inland waterway, the concept of relative economic value is applied for the prediction of relevant flood and low flow thresholds. These results will be used in the context of the ongoing H2020-project IMPREX in order to answer the question on how improved hydro-meteorological and hydrological forecast products increase the operating efficiency and strategic management of the European transportation sector with special focus on the 'wet' mode of transport.