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Parametrisation of initial conditions for seasonal stream flow forecasting in the Swiss Rhine basin

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Current climate forecast models show – to the best of our knowledge – low skill in forecasting climate variability in Central Europe at seasonal lead times. When it comes to seasonal stream flow forecasting, initial conditions thus play an important role. Here, initial conditions refer to the catchments moisture at the date of forecast, i.e. snow depth, stream flow and lake level, soil moisture content, and groundwater level.

The parametrisation of these initial conditions can take place at various spatial and temporal scales. Examples are the grid size of a distributed model or the time aggregation of predictors in statistical models. Therefore, the present study aims to investigate the extent to which the parametrisation of initial conditions at different spatial scales leads to differences in forecast errors. To do so, we conduct a forecast experiment for the Swiss Rhine at Basel, which covers parts of Germany, Austria, and Switzerland and is southerly bounded by the Alps. Seasonal mean stream flow is defined for the time aggregation of 30, 60, and 90 days and forecasted at 24 dates within the calendar year, i.e. at the 1st and 16th day of each month.

A regression model is employed due to the various anthropogenic effects on the basins hydrology, which often are not quantifiable but might be grasped by a simple black box model. Furthermore, the pool of candidate predictors consists of antecedent temperature, precipitation, and stream flow only. This pragmatic approach follows the fact that observations of variables relevant for hydrological storages are either scarce in space or time (soil moisture, groundwater level), restricted to certain seasons (snow depth), or regions (lake levels, snow depth).

For a systematic evaluation, we therefore focus on the comprehensive archives of meteorological observations and reanalyses to estimate the initial conditions via climate variability prior to the date of forecast. The experiment itself is based on four different approaches, whose differences in model skill were estimated within a rigorous cross-validation framework for the period 1982-2013:

1. The predictands are regressed on antecedent temperature, precipitation, and stream flow. Here, temperature and precipitation constitute basin averages out of the E-OBS gridded data set.
2. As in 1., but temperature and precipitation are used at the E-OBS grid scale (0.25 degree in longitude and latitude) without spatial averaging.
3. As in 1., but the regression model is applied to 66 gauged subcatchments of the Rhine basin. Forecasts for these subcatchments are then simply summed and upscaled to the area of the Rhine basin.
4. As in 3., but the forecasts at the subcatchment scale are additionally weighted in terms of hydrological representativeness of the corresponding subcatchment.