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Seasonal ensemble forecast of snowmelt inflow into a large reservoir: ESP-based vs. WG-based approach

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An approach to seasonal ensemble forecast of snowmelt runoff was developed and applied for forecasting lateral water inflow into the Cheboksary Reservoir (the watershed area is 374,000 km2) located in the middle Volga River basin, Russia. The approach combines a physically-based semi-distributed hydrological model ECOMAG forced with ensembles of future weather scenarios for a specified lead-time of the forecast. The ECOMAG model describes processes of snow accumulation and melt, soil freezing and thawing, water infiltration into unfrozen and frozen soil, evapotranspiration, thermal and water regime of soil, overland, subsurface and channel flow. The hydrological model was forced using daily meteorological variables (precipitation, air temperature, and air humidity) taken from the available observation data prior to the forecast date. Using these datasets, the initial watershed state (primarily, spatial distribution of snow water equivalent, soil moisture content and soil freezing depth) as well as the initial river channel state were simulated by the model. Results from these spin-up simulations were routinely controlled by comparing them with observations from snow and agricultural surveys and streamflow observations. To assign ensemble of weather scenarios for the forecast lead-time (up to 6 months ahead in this study), two approaches were applied: (1) the historical, observed daily weather scenarios were utilized which assumed to be representative of possible future weather conditions (similarly to the widely-used Ensemble Streamflow Prediction, ESP, approach); and (2) the artificial daily weather patterns were Monte-Carlo-simulated by a stochastic weather generator (Weather Generator-based, WG-based, approach). Fifty observed and 1000 synthetic weather scenarios were constructed for each of the approaches, respectively. Being forced by the assigned ensembles of weather patterns for the forecast lead time, the ECOMAG model produced ensembles of daily inflow into the Cheboksary Reservoir.
Using the developed approach, hindcasts were produced for 35 seasons (1982 through 2016) and the statistical properties of the obtained ensembles of runoff characteristics (inflow volume, peak discharge, duration of high/low inflow) were evaluated. The median forecast traces were analyzed using the traditional Nash-and-Sutcliffe criterion while the distribution-oriented verification measures were utilized to assess the probabilistic information contained in both forecast approaches.
An evolution of the forecast uncertainty reduction, expressed as forecast efficiency, over various consequent forecast issue dates and lead time was evaluated. We analyzed the Nash-Sutcliffe efficiency of inflow hindcasts for the period 1982 to 2016 starting from March 1st with 15 days frequency for lead-time of 1 to 6 months. This resulted in the forecast efficiency matrix with issue dates versus lead-time that allows for predictability identification of the basin. The matrixes were constructed and compared for the ESP-based and the WG-based approaches.