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Statistical prediction of seasonal discharge in Central Asia for water resources management: development of a generic (pre-)operational modeling tool

Heiko Apel (1), Azamat Baimaganbetov (2), Olga Kalashnikova (3), Nadejda Gavrilenko (4), Zharkinay Abdykerimova (5), Marina Agalhanova (6), Lars Gerlitz (1), Katy Unger-Shayesteh (1), Sergiy Vorogushyn (1), and Abror Gafurov (1)

(1) GFZ German Research Center for Geoscience, Section 5.4 Hydrology, Potsdam, Germany (hapel@gfz-potsdam.de), (2) Hydro-Meteorological Service of Kazakhstan, Almaty, Kazakhstan, (3) CAIAG Central Asian Institute for Applied Geoscience, Bishkek, Kyrgyzstan, (4) Hydro-Meteorological Service of Uzbekistan, Tashkent, Uzbekistan, (5) Hydro-Meteorological Service of Kyrgyzstan, Bishkek, Kyrgyzstan, (6) Hydro-Meteorological Service of Turkmenistan, Ashgabat, Turkmenistan

The semi-arid regions of Central Asia crucially depend on the water resources supplied by the mountainous areas of the Tien-Shan and Pamirs. During the summer months the snow and glacier melt dominated river discharge originating in the mountains provides the main water resource available for agricultural production, but also for storage in reservoirs for energy generation during the winter months. Thus a reliable seasonal forecast of the water resources is crucial for a sustainable management and planning of water resources. In fact, seasonal forecasts are mandatory tasks of all national hydro-meteorological services in the region. In order to support the operational seasonal forecast procedures of hydromet services, this study aims at the development of a generic tool for deriving statistical forecast models of seasonal river discharge. The generic model is kept as simple as possible in order to be driven by available hydrological and meteorological data, and be applicable for all catchments with their often limited data availability in the region. As snowmelt dominates summer runoff, the main meteorological predictors for the forecast models are monthly values of winter precipitation and temperature as recorded by climatological stations in the catchments. These data sets are accompanied by snow cover predictors derived from the operational ModSnow tool, which provides cloud free snow cover data for the selected catchments based on MODIS satellite images. In addition to the meteorological data antecedent streamflow is used as a predictor variable. This basic predictor set was further extended by multi-monthly means of the individual predictors, as well as composites of the predictors. Forecast models are derived based on these predictors as linear combinations of up to 3 or 4 predictors. A user selectable number of best models according to pre-defined performance criteria is extracted automatically by the developed model fitting algorithm, which includes a test for robustness by a leave-one-out cross validation. Based on the cross validation the predictive uncertainty was quantified for every prediction model. According to the official procedures of the hydromet services forecasts of the mean seasonal discharge of the period April to September are derived every month starting from January until June. The application of the model for several catchments in Central Asia - ranging from small to the largest rivers – for the period 2000-2015 provided skillful forecasts for most catchments already in January. The skill of the prediction increased every month, with R2 values often in the range 0.8 – 0.9 in April just before the prediction period. The forecasts further improve in the following months, most likely due to the integration of spring precipitation, which is not included in the predictors before May, or spring discharge, which contains indicative information for the overall seasonal discharge. In summary, the proposed generic automatic forecast model development tool provides robust predictions for seasonal water availability in Central Asia, which will be tested against the official forecasts in the upcoming years, with the vision of eventual operational implementation.