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Statistical prediction of seasonal discharge in the Naryn basin for water resources planning in Central Asia

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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 water of the rivers originating in the mountains provides the only water resource available for agricultural production but also for water collection in reservoirs for energy production in 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 national hydro-meteorological services in the region. Thus this study aims at a statistical forecast of the seasonal water availability, whereas the focus is put on the usage of freely available data in order to facilitate an operational use without data access limitations. The study takes the Naryn basin as a test case, at which outlet the Toktogul reservoir stores the discharge of the Naryn River. As most of the water originates form snow and glacier melt, a statistical forecast model should use data sets that can serve as proxy data for the snow masses and snow water equivalent in late spring, which essentially determines the bulk of the seasonal discharge. CRU climate data describing the precipitation and temperature in the basin during winter and spring was used as base information, which was complemented by MODIS snow cover data processed through ModSnow tool, discharge during the spring and also GRACE gravimetry anomalies. For the construction of linear forecast models monthly as well as multi-monthly means over the period January to April were used to predict the seasonal mean discharge of May-September at the station Uchterek. An automatic model selection was performed in multiple steps, whereas the best models were selected according to several performance measures and their robustness in a leave-one-out cross validation. It could be shown that the seasonal discharge can be predicted with exceptionally high skill reaching explained variances of 86% in the cross validation using ModSnow processed snow cover data and CRU temperature and precipitation data, i.e. freely available data only. Using antecedent discharge information from the Uchterek station over the period January to April the skill can be improved even further. Also the addition of latest EGSIEM GRACE products can improve this skill to > 90% explained variance by replacing the CRU temperature data in the forecast model. From all variables the ModSnow processed MODIS snow cover data proved to be the most important predictor. However, although the prediction models proved to be robust in the cross validation, it has to be mentioned that the models are based on a limited time spanning the period 2000-2012 only. Nevertheless it is believed that the models are reliable, as this time period shows a high variability in seasonal water availability spanning from exceptionally dry to wet years. In summary, the developed forecast model may be a valuable complementary tool for the seasonal discharge prediction in Central Asia for water resources planning, that does not suffer from limited data access required for other forecast methods.