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Monthly to seasonal low flow prediction: statistical versus dynamical models

Monica Ionita-Scholz (1,2), Bastian Klein (3), Dennis Meissner (3), and Silke Rademacher (3)

(1) Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research, Paleoclimate Dynamics, Bremerhaven, Germany (monica.ionita@awi.de), (2) MARUM – Center for Marine Environmental Sciences, University of Bremen, Bremen, Germany, (3) Federal Institute of Hydrology, Koblenz, Germany

While the societal and economical impacts of floods are well documented and assessable, the impacts of lows flows are less studied and sometimes overlooked. For example, over the western part of Europe, due to intense inland waterway transportation, the economical loses due to low flows are often similar compared to the ones due to floods. In general, the low flow aspect has the tendency to be underestimated by the scientific community. One of the best examples in this respect is the facts that at European level most of the countries have an (early) flood alert system, but in many cases no real information regarding the development, evolution and impacts of droughts. Low flows, occurring during dry periods, may result in several types of problems to society and economy: e.g. lack of water for drinking, irrigation, industrial use and power production, deterioration of water quality, inland waterway transport, agriculture, tourism, issuing and renewing waste disposal permits, and for assessing the impact of prolonged drought on aquatic ecosystems. As such, the ever-increasing demand on water resources calls for better a management, understanding and prediction of the water deficit situation and for more reliable and extended studies regarding the evolution of the low flow situations.

In order to find an optimized monthly to seasonal forecast procedure for the German waterways, the Federal Institute of Hydrology (BfG) is exploring multiple approaches at the moment. On the one hand, based on the operational short- to medium-range forecasting chain, existing hydrological models are forced with two different hydro-meteorological inputs: (i) resampled historical meteorology generated by the Ensemble Streamflow Prediction approach and (ii) ensemble (re-) forecasts of ECMWF's global coupled ocean-atmosphere general circulation model, which have to be downscaled and bias corrected before feeding the hydrological models. As a second approach BfG evaluates in cooperation with the Alfred Wegener Institute a purely statistical scheme to generate streamflow forecasts for several months ahead. Instead of directly using teleconnection indices (e.g. NAO, AO) the idea is to identify regions with stable teleconnections between different global climate information (e.g. sea surface temperature, geopotential height etc.) and streamflow at different gauges relevant for inland waterway transport. So-called stability (correlation) maps are generated showing regions where streamflow and climate variable from previous months are significantly correlated in a 21 (31) years moving window. Finally, the optimal forecast model is established based on a multiple regression analysis of the stable predictors.

We will present current results of the aforementioned approaches with focus on the River Rhine (being one of the world's most frequented waterways and the backbone of the European inland waterway network) and the Elbe River. Overall, our analysis reveals the existence of a valuable predictability of the low flows at monthly and seasonal time scales, a result that may be useful to water resources management. Given that all predictors used in the models are available at the end of each month, the forecast scheme can be used operationally to predict extreme events and to provide early warnings for upcoming low flows.