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Predicting Low Flow Conditions from Climatic Indices - Indicator-Based Modeling for Climate Change Impact Assessment

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In the face of climate change, the assessment of future hydrological regimes has become indispensable in the field of water resources management. Investigation of potential change is vital for proper planning, especially with regard to hydrological extremes. Commonly, projection of future streamflow is done applying process-based hydrological models, using climate model data as input, whose complex model structures generally require excessive amounts of time and effort for set-up and computation. This study aims at identifying practical alternatives to the employment of sophisticated models by considering simpler, yet sufficiently accurate methods for modeling rainfall-runoff relations with regard to hydrological extremes. The focus is thereby put on the prediction of low flow periods, which are, in contrast to flood events, characterized by extended durations and spatial dimensions. The models to be established in this study base on indicators, which characterize both meteorological and hydrological conditions within dry periods. This approach makes direct use of the coupling between atmospheric driving forces and streamflow response with the underlying presumption that low-precipitation and high-evaporation periods result in diminished flow, implying that relationships exist between the properties of both meteorological and hydrological events (duration, volume, severity etc.). Eventually, optimal combinations of meteorological indicators are sought that are suitable to predict various low flow characteristics with satisfactory accuracy.

Two approaches for model specification are tested: a) multiple linear regression, and b) Fuzzy logic. The data used for this study are daily time series of mean discharge obtained from 294 gauges with variable record length situated in the federal state of Lower Saxony, Germany, as well as interpolated climate variables available for a period from 1951 to 2011. After extraction of a variety of indicators from the available discharge and climate time series on a bi-annual basis, regression and Fuzzy models are fit. Fitting is done in two variations: locally at each of the watersheds in the study area, and regionally, yielding one specific model expression for the entire study area. Models for the individual stations perform well using only the meteorological indicators as predictor variables, while the regional models require the additional input of catchment descriptors to account for the variability of the rainfall-runoff translation processes between the catchments.