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Reconstruction of monthly streamflow indices from two centuries of HISTALP-DATA

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Long term data records are a basic requirement to assess climate change impacts on stream flows. While records of daily streamflow in Austria start only in the second half of the 20th century, monthly temperature and rainfall records are available since 1801 from the HISTALP-data set. In this paper we investigate the performance of linear statistical models to reconstruct monthly streamflow indices from the HISTALP-data, with a focus on dry (mean to low flow) conditions. The study is based on a comprehensive Austrian stream flow data set, and streamflow records from 1976 - 2003 are used to calibrate the models.

For linking stream flow with rainfall and temperature we use SPI, PDSI and similar meteorological drought indices as independent variables in our models. The Standardised Precipitation Index (SPI) is a well known index for monitoring dry spells in precipitation. The Palmer Drought Severity Index (PDSI) connects monthly rainfall and temperature records with a simple soil model to a useful drought monitoring tool which takes the soil moisture balance into account.

The model selection focuses on (i) regional dependency structures influenced by catchment conditions, (ii) seasonality issues, especially occurrences of low flow events, (iii) taking advantage of interactions in process-memory mentioned below while (iv) avoiding overfitting. A stratified analysis is performed to assess the predictive performance of the reconstructions for various flow conditions ranging from mean to low flows.

Exploration of process-memory by means of auto-correlation functions (ACF) and cross-correlation functions (CCF) between meteorological and stream flow indices show significant cross-correlation at lag 0 (i.e. correlation) and lag 1 to 3 month. A possible reason could be the lack of knowledge about groundwater storage capacities of PDSI's soil model. Prediction of streamflow indices from SPI or PDSI by linear models can take advantage of this lag 1-3 correlations by using them as explanatory variables.

The results of the stratified analysis indicate that reconstruction performs notably well for mean flow which constitutes the upper limit of low flow discharges. More extreme low flow indices, such as Q95 prove much harder to predict and seem to need much more knowledge about storage capacities and other soil related variables. Models taking strong focus on seasonality and medium term drought severity outperform simpler ones in all quality criteria used (AIC, BIC, R^2). Depending on the area, separate modelling for small PDSI value proofed useful. Our models helped to get a much better understanding between meteorological drought indices and streamflow drought. Trustworthy reconstructions could be provided for parts of Austria.