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Temporal diagnostic analysis of the SWAT model to detect dominant periods of poor model performance

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Hydrological models generally include thresholds and non-linearities, such as snow-rain-temperature thresholds, non-linear reservoirs, infiltration thresholds and the like. When relating observed variables to modelling results, formal methods often calculate performance metrics over long periods, reporting model performance with only few numbers. Such approaches are not well suited to compare dominating processes between reality and model and to better understand when thresholds and non-linearities are driving model results. We present a combination of two temporally resolved model diagnostic tools to answer when a model is performing (not so) well and what the dominant processes are during these periods. We look at the temporal dynamics of parameter sensitivities and model performance to answer this question.

For this, the eco-hydrological SWAT model is applied in the Treene lowland catchment in Northern Germany. As a first step, temporal dynamics of parameter sensitivities are analyzed using the Fourier Amplitude Sensitivity test (FAST). The sensitivities of the eight model parameters investigated show strong temporal variations. High sensitivities were detected for two groundwater (GW_DELAY, ALPHA_BF) and one evaporation parameters (ESCO) most of the time. The periods of high parameter sensitivity can be related to different phases of the hydrograph with dominances of the groundwater parameters in the recession phases and of ESCO in baseflow and resaturation periods. Surface runoff parameters show high parameter sensitivities in phases of a precipitation event in combination with high soil water contents. The dominant parameters give indication for the controlling processes during a given period for the hydrological catchment.

The second step included the temporal analysis of model performance. For each time step, model performance was characterized with a “finger print” consisting of a large set of performance measures. These finger prints were clustered into four reoccurring patterns of typical model performance, which can be related to different phases of the hydrograph. Overall, the baseflow cluster has the lowest performance.

By combining the periods with poor model performance with the dominant model components during these phases, the groundwater module was detected as the model part with the highest potential for model improvements. The detection of dominant processes in periods of poor model performance enhances the understanding of the SWAT model. Based on this, concepts how to improve the SWAT model structure for the application in German lowland catchment are derived.