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# Significant trends, underlying processes and indicators - the validation of hydrological change

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Changes in hydrological processes are often complex and involve modifications in several components of the water cycle at different scales in space and in time. While statistical methods provide an exploratory approach, the plausibility of significant changes in the hydrological system depends on whether underlying processes can be identified and associated with such trends as well. For a meso-scale research basin, the Dreisam river basin (300 skm, Germany), a combined approach for the detection and validation of changes in hydrological processes has been tested. The combined approach involves ensemble time series analysis for the detection of trends by non-parametric Mann-Kendall tests including detrending and correction procedures for auto-correlation. Time series analysis was carried out on ensembles of water cycle components (precipitation, temperature, absolute atmospheric moisture, derived potential evaporation, runoff and its isotopic composition) in order to detect seasonal, scale and altitude dependent, synchronized changes in respective balances, processes and regimes. Process-oriented, physically-based modeling was then carried out in order to test the validity and plausibility of observed significant changes by corresponding sensitivity analysis. The results of hydrological modeling were re-analyzed by statistical methods in order to ascertain the significance of modeled results compared to original time series. Finally, the consistency of observed process changes with stable isotope signatures was ascertained. The combined approach yielded significant internal changes in snow-melt and recharge mechanisms as well as shifts in runoff regimes resulting from increased ambient temperature.