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Considering changing temporal structures in the construction of scenario-neutral runoff response surfaces

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Climate change impact studies are usually based on traditional top-down approaches in which post-processed climate model data serves as input into some kind of impact model. Parallel to these traditional approaches, scenario-neutral bottom-up approaches have been developed as an alternative methodology which assesses the intrinsic vulnerability of a system towards climate change. Such bottom-approaches perform a sensitivity analysis of an impact model towards systematically 'user-defined' changes in the climate system and summarize its response in a two-dimensional matrix: the response surface. The climate change signal is obtained by perturbing observed time series, which serve as inputs into the impact models. The impact model is then run with all possible combinations of perturbed input data series and the result of each combination (i.e. the impact) is plotted as one single realization (i.e. one pixel) of possible climate change impacts over the two dimensional domain. Although the complexity of existing perturbation methods varies, the temporal structure (i.e. the seasonal- and day-to-day-variability) of these time series often remains the same, which is critical, in particular for the simulations of extremes.

In this study, we present standardized response surfaces (SRS) that are based on impact simulations using both perturbed climate observations and projections which are scaled to a common domain. We apply this approach within the field of hydrology and estimate different aspects of runoff response, covering mean runoff as well as extremes like low flows and floods in a Nordic catchment with a mixed snowmelt/rainfall regime. Climate observations and projections from eight GCM-RCM combinations, downscaled by two different methods, are used for the perturbation which results in 17 different SRS. A series of linear regression- and linear mixed-effects models is applied to quantify the different effects of perturbing the climate input data and of the varying temporal structures which are contained in the climate projection data. Results suggest that the effect of the temporal structure is critical for runoff response estimation in terms of low flows and floods (at least 20% influence) and negligible for mean runoff. Our results confirm and quantify the crucial effect of the perturbation set-up in bottom-up approaches and contribute to the discussion about the validity of general change factor approaches.