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The Generalized Uncertainty Estimation and Sensitivity analysis Scheme (GUESS) for performing sensitivity analyses with discrete model input factors

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Integrated environmental system models are often applied to assess the impacts of natural and human-induced system changes (e.g. climate change or land use change) on water balance components, nutrient loads and other environment variables. To draw well-informed conclusions from the modelled outputs, an in-depth knowledge of the sensitivities (and respective uncertainties) of the model input factors (i.e. climate data, land use data or parameters) and their interactions is essential. Several methods for undertaking sensitivity analyses are available with multiple applications in environmental modelling, however the focus of the majority of applications is on the model parameters. System changes (such as climate or land use change) are gaining importance and are typically represented by discrete states through scenarios or storylines that ideally cover a wide range of plausible future outcomes and also influence multiple processes in the environmental model setup.

With the Generalized Uncertainty Estimation and Sensitivity analysis Scheme (GUESS) we propose a scheme to flexibly implement discrete model input factors, expressed as different building blocks of an environmental model, into a global sensitivity analysis. So far, we provide a seamless integration of the model input factors related to the eco-hydrological model Soil and Water Assessment Tool (SWAT) into the Scheme, and offer various methods to undertake a sensitivity analysis. For two Austrian catchments we present an application of GUESS involving multiple discrete model input factors. Both catchment case studies assess the impacts on the SWAT-simulated variables of discharge and nitrate-N when the following model input factors were varied: future climate change; land use change; urban point sources; the SWAT model setup; and the parametrization of the model setup.

Both case study analyses showed similar patterns of the input factor sensitivities for both variables of discharge and nitrate-N. Overall, the case studies strongly emphasize the importance of considering a wide range of climate change scenarios, as the majority of analyzed variables showed the strongest response to the input factor of climate, in particular when the processes were driven by precipitation. A similarly important finding was related to the model parametrization. For evaluations that used low flow criteria and also nitrate-N concentrations, the model parametrization showed the most significant sensitivity. The urban point source scenarios only had an impact on the nitrate-N loads and only when industrial emitters were present. The different SWAT model setups and in particular the land use scenarios had little to no effect on the analyzed variables of discharge and nitrate-N. In the present context, the GUESS framework focuses on the implementation of the SWAT model for the sensitivity analysis, however the GUESS framework is theoretically feasible for any other model application.