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Global Sensitivity Analysis of Environmental Models: Convergence, Robustness and Validation

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Global Sensitivity Analysis aims to characterize the impact that variations in model input factors (e.g. the parameters) have on the model output (e.g. simulated streamflow). In sampling-based Global Sensitivity Analysis, the sample size has to be chosen carefully in order to obtain reliable sensitivity estimates while spending computational resources efficiently. Furthermore, insensitive parameters are typically identified through the definition of a screening threshold: the theoretical value of their sensitivity index is zero but in a sampling-base framework they regularly take non-zero values. There is little guidance available for these two steps in environmental modelling though. The objective of the present study is to support modellers in making appropriate choices, regarding both sample size and screening threshold, so that a robust sensitivity analysis can be implemented.

We performed sensitivity analysis for the parameters of three hydrological models with increasing level of complexity (Hymod, HBV and SWAT), and tested three widely used sensitivity analysis methods (Elementary Effect Test or method of Morris, Regional Sensitivity Analysis, and Variance-Based Sensitivity Analysis). We defined criteria based on a bootstrap approach to assess three different types of convergence: the convergence of the value of the sensitivity indices, of the ranking (the ordering among the parameters) and of the screening (the identification of the insensitive parameters). We investigated the screening threshold through the definition of a validation procedure. The results showed that full convergence of the value of the sensitivity indices is not necessarily needed to rank or to screen the model input factors. Furthermore, typical values of the sample sizes that are reported in the literature can be well below the sample sizes that actually ensure convergence of ranking and screening.