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Model Variable Augmentation MVA for Online Diagnostic Assessment of Sensitivity Analysis Results

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Sensitivity analysis are gaining more and more attraction in the environmental modeling community to either reduce the complexity of the model by identifying dominant processes or parameters. Reducing the complexity does help to decrease the runtime of the model or increase the efficiency of a model calibration since only a fewer number of parameters need to be considered. Sensitivity analyses also play an important role in the model development as they can identify weak parameterizations in case model outputs are overly-sensitive or not sensitive at all to a given parameter.

However, the convergence and quality control of sensitivity results is rarely checked. If any, bootstrapping of the sensitivity results is used to determine the reliability of the estimated indexes. Bootstrapping, however, might as well become computationally expensive in case of large model outputs and a high number of bootstraps required.

We, therefore, present a Model Variable Augmentation (MVA) approach to check the convergence of sensitivity indexes without performing any additional model runs. MVA is therefore supplementing the original model with dummy parameters of known properties and that are used to draw conclusions on the reliability of the other "original" model parameters' sensitivities. This technique is method- and model-independent. It can be applied either during the sensitivity analysis (SA) or afterwards. The latter case enables the checking of already processed sensitivity indexes. MVA has exactly one control variable, which represents the confidence level of the user.

The method is applied to two widely used, global SA methods: the variance-based Sobol' method (Sobol' 1993) and the moment-independent PAWN method (Pianosi & Wagener 2015). It is first scrutinized using 12 analytical benchmark functions (Cuntz & Mai et al. 2015) where the true indexes of the Sobol' index are known. The method is then used to quality-check already published sensitivity results of the hydrologic model mHM (Cuntz & Mai et al. 2015).

Several results and conclusions can be drawn from this study: 1) This proof of principle shows that the method reliably determines the uncertainty of the SA results when different budgets are used for the SA considering various confidence levels of the users. 2) The quality of sensitivity indexes derived by the Sobol' and PAWN method are comparable when the same budget of model evaluations is used. 3) MVA provides a threshold for screening parameters that are not informative enough to be considered in subsequent analyses. 4) The number of correctly identified informative parameters is higher than without using MVA for all test functions used. 5) MVA provides a framework to more reliably rank parameters since parameters with indistinguishable sensitivities are identified. 6) MVA is a particularly attractive alternative to bootstrapping when computationally expensive models limit total model runs to levels that make bootstrapping analyses inappropriate.