Geophysical Research Abstracts
Vol. 17, EGU2015-997, 2015
EGU General Assembly 2015

Global sensitivity analysis of a SWAT model: comparison of the variance-based and moment-independent approaches

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Uncertainty in parameters is a well-known reason of model output uncertainty which, undermines model reliability and restricts model application. A large number of parameters, in addition to the lack of data, limits calibration efficiency and also leads to higher parameter uncertainty. Global Sensitivity Analysis (GSA) is a set of mathematical techniques that provides quantitative information about the contribution of different sources of uncertainties (e.g. model parameters) to the model output uncertainty. Therefore, identifying influential and non-influential parameters using GSA can improve model calibration efficiency and consequently reduce model uncertainty.

In this paper, moment-independent density-based GSA methods that consider the entire model output distribution – i.e. Probability Density Function (PDF) or Cumulative Distribution Function (CDF) - are compared with the widely-used variance-based method and their differences are discussed. Moreover, the effect of model output definition on parameter ranking results is investigated using Nash-Sutcliffe Efficiency (NSE) and model bias as example outputs. To this end, 26 flow parameters of a SWAT model of the River Zenne (Belgium) are analysed. In order to assess the robustness of the sensitivity indices, bootstrapping is applied and 95% confidence intervals are estimated. The results show that, although the variance-based method is easy to implement and interpret, it provides wider confidence intervals, especially for non-influential parameters, compared to the density-based methods. Therefore, density-based methods may be a useful complement to variance-based methods for identifying non-influential parameters.