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A new implementation of the PAWN method to perform density-based sensitivity analysis from a generic sample

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In a previous study we introduced a novel density-based method for global sensitivity analysis, called PAWN. The advantage of density-based methods over more established variance-based ones is that they are also suitable when variance is not an adequate measure of uncertainty, for example when the output distribution is highly-skewed or multi-modal. The advantage of PAWN over other density-based methods is that it characterises output distributions via their cumulative distribution functions instead of their probability density functions, which makes numerical approximation of PAWN sensitivity indices easy and robust. However, one of the limitations of the numerical approximation procedure proposed in our previous study is that it relies on a tailored sampling strategy of the input variability space, and hence it could so far not be applied to a generic dataset of input-output samples. Such extra effort needed in producing PAWN sensitivity indices is common to other density-based methods and may be one of the reasons that have limited their uptake as a complement to variance-based ones. Furthermore, the tailored sampling strategy used by PAWN requires defining three tuning parameters whose choice can be confusing for the user.

In this study, we present an alternative approximation procedure that tackles both issues by being applicable to a generic input-output dataset while requiring only one tuning parameter (the number of conditioning points n). We test this approximation strategy on a benchmark function and on a complex hydrological model (the Soil Water Assessment Tool, SWAT, in a set-up that includes 50 uncertain parameters). Results show that the PAWN sensitivity indices estimated with the new approximation procedure from a generic dataset are very similar to the ones provided by the original approximation procedure. Furthermore, sensitivity indices are stable at reasonably low sample sizes and robust against the choice of the tuning parameter n. Hence, we recommend using the new approximation procedure for estimating the PAWN sensitivity indices to reduce the subjectivity of set-up choices and to allow for application to generic datasets. The latter aspect is particularly important because it enables the integration of PAWN into a multi-method approach to global sensitivity analysis, which we would recommend as best practice to validate the conclusions drawn from individual GSA methods.