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Using time-varying global sensitivity analysis to understand the importance of different uncertainty sources in hydrological modelling

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Simulations from environmental models are affected by potentially large uncertainties stemming from various sources, including model parameters and observational uncertainty in the input/output data. Understanding the relative importance of such sources of uncertainty is essential to support model calibration, validation and diagnostic evaluation, and to prioritize efforts for uncertainty reduction. Global Sensitivity Analysis (GSA) provides the theoretical framework and the numerical tools to gain this understanding. However, in traditional applications of GSA, model outputs are an aggregation of the full set of simulated variables. This aggregation of propagated uncertainties prior to GSA may lead to a significant loss of information and may cover up local behaviour that could be of great interest. In this work, we propose a time-varying version of a recently developed density-based GSA method, called PAWN, as a viable option to reduce this loss of information. We apply our approach to a medium-complexity hydrological model in order to address two questions: [1] Can we distinguish between the relative importance of parameter uncertainty versus data uncertainty in time? [2] Do these influences change in catchments with different characteristics? The results present the first quantitative investigation on the relative importance of parameter and data uncertainty across time. They also provide a demonstration of the value of time-varying GSA to investigate the propagation of uncertainty through numerical models and therefore guide additional data collection needs and model calibration/assessment.