Session IPS105: Statistical inferential frameworks for environmental process models

Parametric Model Uncertainty at Decision-Relevant Scales to Inform Multi-Objective Stormwater Management with Green Infrastructure

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Abstract:

Spatially distributed ecohydrological models are used to simulate the impact of vegetation on hydrological and nutrient cycles, and resulting water quality and quantity metrics. These models are also used in stormwater management to optimize locations where green infrastructure (GI) could control runoff. However, at the fine spatial scales required for modeling GI performance, data are often limited relative to the thousands of parameters such physics-based models may require. This results in calibration for an ill-posed inverse problem, which could have proximate consequences if different, equifinal model parameterizations suggest different optimal GI sites and sizes. We present a framework for multi-objective spatial optimization of GI that is robust to this parametric uncertainty. GI portfolios are designed to minimize flooding, low flow intensification, and the cost of GI implementation. For this research, we employ the Regional Hydro-Ecological Simulation System (RHESSys) to model an exurban forested watershed in Maryland, USA. To evaluate our methodology, we set synthetic true values for the RHESSys model parameters and estimate them through calibration. We first use global parameter screening methods to select a parsimonious subset of parameters to calibrate. We then calibrate the model using a Bayesian framework to estimate the joint posterior distribution of parameters. The optimization then evaluates GI portfolios across a posterior probability-weighted sample of parameter sets in search of portfolios that are robust to parametric uncertainty. We compare the solutions obtained from the robust optimization to those obtained by optimizing to the estimated maximum *a posteriori* (MAP) parameter set and the synthetic true parameter set. While selected MAP and robust solutions both perform worse when evaluated on the true parameter set than on the parameter sets to which they were optimized, the performance of the robust solutions is closer to the optimal, illustrating the importance of considering parametric uncertainty in water system design.

Keywords: Global Sensitivity Analysis, Bayesian Inference, Spatially Distributed Model, Stormwater Management, Optimization