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A Novel Sampling Approach for Efficient and Robust Uncertainty and Sensitivity Analysis of Environmental Models

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Abstract: Modern environmental models are typically characterized by a large parameter/problem space and high computational demand. These two attributes impede effective implementation of sampling-based analysis such as sensitivity and uncertainty analysis, which require running these computationally intensive models many times to adequately explore and characterize the parameter/problem space. Therefore, developing efficient sampling strategies that scale with the size of the problem, computational budget, and users' needs is essential. In this study, we propose an efficient sequential sampling strategy, called Progressive Latin Hypercube Sampling (PLHS), which provides an increasingly improved coverage of the parameter space, while satisfying pre-specified requirements. As opposed to the common Latin hypercube sampling (LHS) approach that generates the entire sample set in one stage, PLHS generates a series of smaller sub-sets (also called 'slices') while: (1) each sub-set is Latin hypercube and achieves maximum stratification in any one-dimensional projection; (2) the progressive addition of sub-sets remains Latin hypercube; and as such (3) the entire sample set is Latin hypercube. Therefore, it has the capability to preserve the intended sampling properties throughout the sampling procedure. PLHS is deemed advantageous over the existing methods, particularly because it nearly avoids over- or under-sampling. Through multiple sampling-based analysis case studies, we show that PHLS has multiple advantages over the one-stage sample generation approaches, including improved convergence and stability of the analysis results with fewer model runs.

***Keywords**:* Sequential sampling; Computationally intensive simulation models; Uncertainty analysis; Sensitivity analysis; Optimal experimental design