US Army Corps of Engineers®

## Urban Flood Demonstration Program

# More Efficient Optimization and Uncertainty Assessment of Hydrologic Model Parameters

**Products**

The principal product for this work unit is a Markov Chain Monte Carlo sampler entitled the Shuffled Complex Evolution Metropolis algorithm Function Approximation (SCEM-FA). SCEM-FA is a modification to the original SCEM-UA algorithm (Vrugt et al. 2003). It employs function approximation methods to improve the overall efficiency of SCEM-UA. To comprehensively demonstrate the efficiency gains that can be achieved with the SCEM-FA development efforts to date, all the while maintaining consistency with respect to convergence (assessed by comparing lower order statistics and also a visual comparison of the marginal posterior parameter probability distributions), 30 unique instances of SCEM-UA and SCEM-FA were each employed to infer the posterior distribution of 13 Sacramento soil moisture accounting (SAC-SMA) hydrologic model parameters using data from the Leaf River watershed near Collins, MS. An additional brief report succinctly summarizes how to interface SCEM-FA with a given local forward model.

Vrugt, J.A., Gupta, H.V., Bouten, W., and Sorooshian, S. 2003. A shuffled complex evolution metropolis algorithm for optimization and uncertainty assessment of hydrologic model parameters. *Water Resources Research* 39 (8), doi:10.1029/2002WR001642.

**Benefits**

Uncertainty analysis supports, among others, the following important activities:

1. Model comparison and selection.
2. Identification of the best water management strategies that reflect the likelihood of outcomes.
3. Data collection aimed at improving hydrologic predictions and water management.
4. Regionalization and extrapolation of hydrologic parameters to ungauged basins.

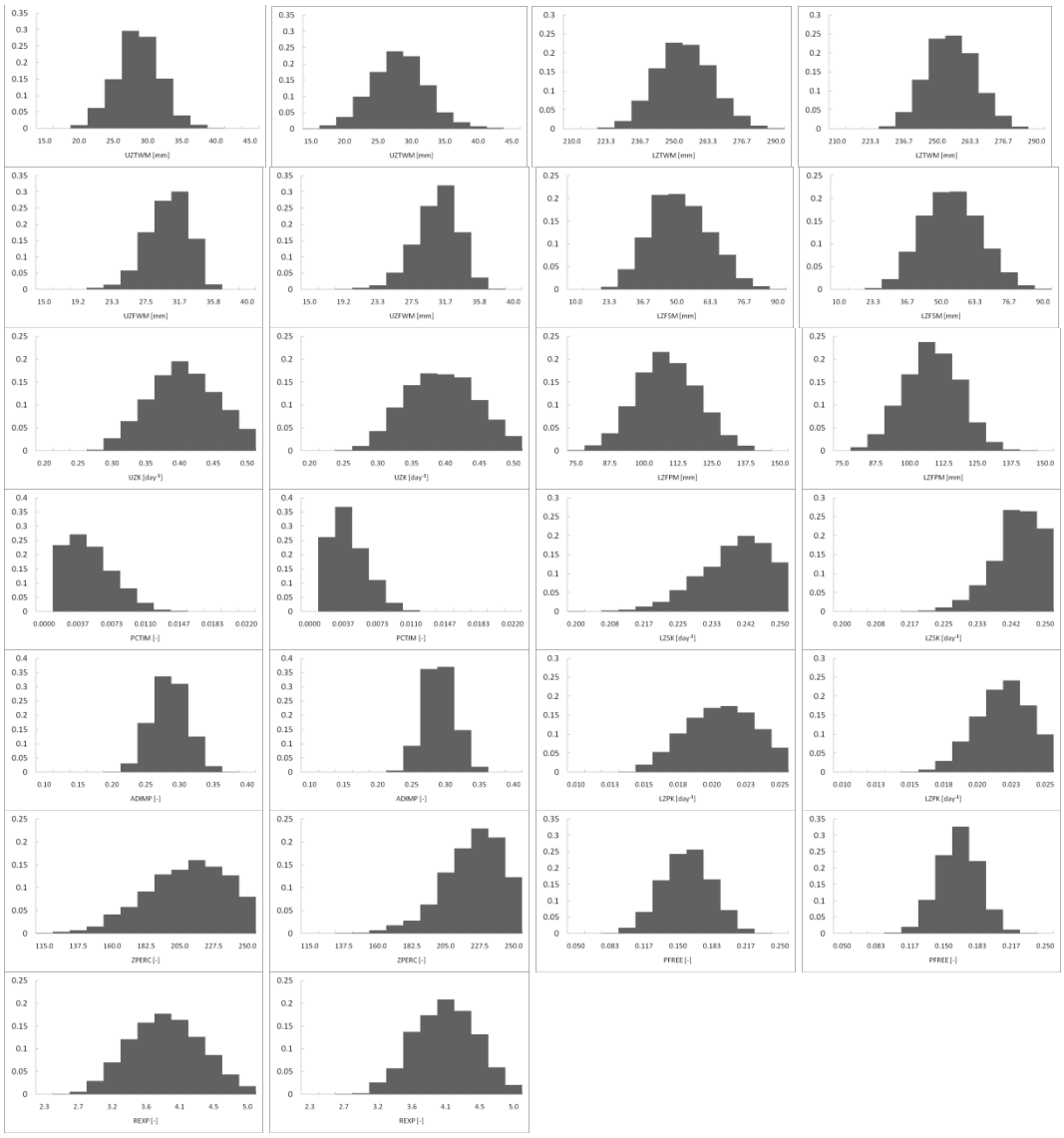
An important consideration in assessing the performance of model calibration software is that of run time. Minimizing the number of hydrologic model runs required during the calibration process is nearly always important, but particularly when the objective function landscape contains multiple local minima or hydrologic model run times are high. Minimizing the number of required model runs is one of the primary factors driving the research and development activities encapsulated in this work unit, such that the resulting optimization and uncertainty tool(s) are more compatible with the computationally expensive physics-based models that are becoming more commonly used within the practice community. Based on a summary of 30 random trials, SCEM-FA was able to infer, effectively, the same posterior probability distribution for 13 SAC-SMA hydrologic model parameters as that of SCEM-UA with an average 21 percent savings in total forward model calls.

**Issue**

While important for the many practical reasons already mentioned, it is computationally expensive to obtain a realistic assessment of hydrologic model uncertainty. Recent ERDC research and development activity has demonstrated the capacity to significantly improve upon the efficiency of native model calibration algorithms using function approximation methods.

**Description**

SCEM-FA is a modified version of the Markov Chain Monte Carlo sampler SCEM-UA. It is more efficient than the native SCEM-UA algorithm, through employment of function approximation, while effectively inferring the posterior parameter distribution of model parameters and also the most likely parameters within this high probability density region.




The posterior marginal probability density distributions for each of the SAC-SMA model parameters inferred for the Leaf River watershed using the samples generated with the SCEM-UA (1st and 3rd columns) and SCEM-FA (2nd and 4th columns) algorithms.

**Sponsor**

Urban Flood Damage Reduction and Channel Restoration Development and Demonstration Program for Arid and Semi-Arid Regions (UFDP)

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