Geophysical Research Abstracts
Vol. 12, EGU2010-11850, 2010
EGU General Assembly 2010


# Sequential Processing of Data: The Future of Inverse Modeling and Parameter Estimation? (Outstanding Young Scientist Lecture)

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Several recent contributions to the hydrologic literature have demonstrated an inability of standard model evaluation criteria to adequately distinguish between different parameter sets and competing model structures, particulary when dealing with highly complex environmental models and significant structural error. The widespread approach to model evaluation that summarizes the mismatch, $\mathbf{E}_n = \{e_k; k = 1, \ldots, n\} = \mathbf{Y}_n - \tilde{\mathbf{Y}}_n$ between $n$ model predictions, $\mathbf{Y}_n$ and corresponding observations, $\tilde{\mathbf{Y}}_n$ in a single aggregated measure of length of the residuals, $F$ not only introduces equifinality but also complicates parameter estimation. Here we introduce the Differential Evolution Particle Filter (DEPF) to better reconcile models with observations. Our method uses sequential likelihood updating to provide a recursive mapping of $\{e_1, \ldots, e_n\} \Rightarrow F$. As main building block DEPF uses the DREAM adaptive MCMC scheme presented in Vrugt et al. (2008, 2009). Two illustrative case studies using conceptual hydrologic modeling show that DEPF (1) requires far fewer particles than conventional Sequential Monte Carlo approaches to work well in practice, (2) maintains adequate particle diversity during all stages of filter evolution, (3) provides important insights into the information content of discharge data and non-stationarity of hydrologic model parameters, and (4) is embarrassingly parallel and therefore designed to solve computationally demanding hydrologic models. Our DEPF code follows the formal Bayesian paradigm, yet readily accommodates informal likelihood functions or signature indices if those better represent the salient features of the data and simulation model.