A Particle Filter for Efficient Recursive BATEA Analysis of Hydrological Models

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I hereby certify that the work embodied in this thesis contains a published paper/s/scholarly work of which I am a joint author. I have included as part of the thesis a written statement, endorsed by my supervisor, attesting to my contribution to the joint publication/s/scholarly work.

The publication/s/scholarly work consists of two conference papers, listed below.

Newman A., Kuczera G. and Kavetski D., (2012), 'Towards a Recursive Bayesian Total Error Analysis Framework', *34th Hydrology and Water Resources Symposium*, Sydney, Engineers Australia

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ABSTRACT

The Bayesian Total Error Analysis (BATEA) framework permits model calibration and prediction to be informed by estimates of data and model uncertainty, and allows assessment of the relative contribution of various sources of error to the total uncertainty within the conceptual hydrologic modelling system. However, full BATEA applications are presently limited to studies with relatively short record lengths. This is because batch calibration rapidly becomes computationally infeasible as the number of inferred input and/or model structural errors grows.

This thesis presents the development of a recursive implementation of the BATEA framework based on particle filtering techniques. Particle filtering techniques, traditionally used in automatic control and signal processing, are a group of sequential Monte Carlo methods which can be adapted to provide a robust recursive implementation of the BATEA framework within the non-linear and non-Gaussian conditions presented by conceptual hydrologic models. The particle filter developed in this thesis is designed to preserve the constraints and relationships between time-invariant parameters and latents which exist in most conceptual hydrologic models. This is achieved in a fully recursive manner through careful selection of appropriate Importance Sampling proposals, design and selection of Markov Chain Monte Carlo (MCMC) proposals which permit efficient regeneration of time-invariant parameters and the construction of an approximation to the Metropolis-Hasting acceptance probability which avoids the need for batch evaluation. The resulting particle filter is capable of efficiently performing an approximate recursive BATEA analysis for a conceptual hydrological model subject to observation, structural and parameter uncertainty with the parameters of both the error model and the hydrological model requiring inference. The performance of the approximate BATEA analysis technique is demonstrated with synthetic case studies ranging from well-posed to highly ill-posed problems and is shown to produce practically useful results at a small fraction of the computational effort required in batch calibration.