Hydrologic Modelling in Non-Stationary Catchments: A Data Assimilation Approach

S. Pathiraja[a], L.A. Marshall[a] and A. Sharma[a]

[a] *School of Civil and Environmental Engineering, The University of New South Wales, Sydney*
Email: s.pathiraja@student.unsw.edu.au

Abstract: Hydrologic modeling is commonly predicated on the assumption that past conditions are representative of future conditions. However, changes to catchment characteristics (eg. Urbanisation), as well as the role of model parameters in pooling together scale effects and other unresolved model processes can easily violate this assumption. These issues raise a number of questions - can a single model and/or set of model parameters adequately represent a catchment's runoff response? Is it possible to design a modelling framework that can adequately represent catchment processes now and in the future? An appreciation of catchment non-stationarity is critical to answering these questions, however this has been given little consideration in the past. Typically a single hydrologic model is adopted, along with a pseudo optimal parameter set which is assumed to be adequate outside the period of calibration/validation.

We present a novel method for dealing with catchment non stationarity that allows model parameterisations to evolve in time through a Data Assimilation framework. Data Assimilation allows model simulations to be dynamically adjusted according to real time observations and the assumed error characteristics of both. The popular Ensemble Kalman Filter (EnKF) along with the Probability Distributed Model (PDM), a lumped conceptual hydrologic model are applied in a synthetic case study. It is shown that careful consideration of the artificial parameter evolution step is critical for non-stationary parameter estimation. Two commonly used artificial parameter evolution techniques, the kernel smoother with location shrinkage and the standard kernel smoother, are considered and found to be problematic when parameters exhibit temporal variability. This is demonstrated in Figure 1a) and 1b), where the time varying structure of PDM parameters is poorly represented.

A new hierarchical EnKF approach is presented which provides an improved prior parameter distribution by updating the parameter evolution process. Figure 1c) shows that the temporal nature of parameters is well represented with this approach, particularly in comparison to estimates from the traditional parameter evolution techniques. This method provides a general framework for establishing dynamically evolving models that will be particularly useful for rapidly changing catchments.

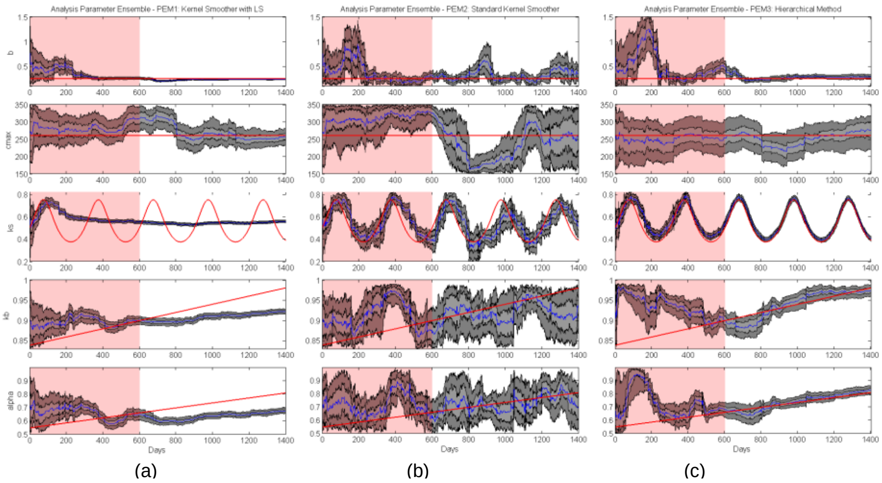

Figure 1. Estimates of the five PDM parameters over 1400 days using the EnKF and a) Kernel Smoother with Location Shrinkage; b) Standard Kernel Smoother; c) Hierarchical Method. The blue line indicates the ensemble mean whilst the shaded areas indicate the $25^{th}/75^{th}$ and 5^{th} / 95^{th} percentiles. The red line indicates the true parameter at each time.

Keywords: *Data Assimilation, Ensemble Kalman Filter, Non-stationarity, Parameter estimation*