Geophysical Research Abstracts
Vol. 17, EGU2015-434, 2015
EGU General Assembly 2015


# How does higher frequency monitoring data affect the calibration of a process-based water quality model?

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Process-based catchment water quality models are increasingly used as tools to inform land management. However, for such models to be reliable they need to be well calibrated and shown to reproduce key catchment processes. Calibration can be challenging for process-based models, which tend to be complex and highly parameterised. Calibrating a large number of parameters generally requires a large amount of monitoring data, spanning all hydrochemical conditions. However, regulatory agencies and research organisations generally only sample at a fortnightly or monthly frequency, even in well-studied catchments, often missing peak flow events. The primary aim of this study was therefore to investigate how the quality and uncertainty of model simulations produced by a process-based, semi-distributed catchment model, INCA-P (the INtegrated CAtchment model of Phosphorus dynamics), were improved by calibration to higher frequency water chemistry data. Two model calibrations were carried out for a small rural Scottish catchment: one using 18 months of daily total dissolved phosphorus (TDP) concentration data, another using a fortnightly dataset derived from the daily data. To aid comparability, calibrations were carried out automatically using the Markov Chain Monte Carlo – DiffeRential Evolution Adaptive Metropolis (MCMC-DREAM) algorithm.

Calibration to daily data resulted in improved simulation of peak TDP concentrations and improved model performance statistics. Parameter-related uncertainty in simulated TDP was large when fortnightly data was used for calibration, with a 95% credible interval of 26 $\mu$g/l. This uncertainty is comparable in size to the difference between Water Framework Directive (WFD) chemical status classes, and would therefore make it difficult to use this calibration to predict shifts in WFD status. The 95% credible interval reduced markedly with the higher frequency monitoring data, to 6 $\mu$g/l. The number of parameters that could be reliably auto-calibrated was lower for the fortnightly data, with a physically unrealistic TDP simulation being produced when too many parameters were allowed to vary during model calibration. Parameters should not therefore be varied spatially for models such as INCA-P unless there is solid evidence that this is appropriate, or there is a real need to do so for the model to fulfil its purpose.

This study highlights the potential pitfalls of using low frequency timeseries of observed water quality to calibrate complex process-based models. For reliable model calibrations to be produced, monitoring programmes need to be designed which capture system variability, in particular nutrient dynamics during high flow events. In addition, there is a need for simpler models, so that all model parameters can be included in auto-calibration and uncertainty analysis, and to reduce the data needs during calibration.