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Uncertainty in the relationship between flow and parameters in models of pollutant transport

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Fluorescent dye-tracer studies are usually performed under steady-state flow conditions. However, the model parameters, estimated using the tracer data, depend on the discharges. This paper investigates uncertainties in the relationship between discharges and parameters of a transient storage (TS) and an aggregated dead zone (ADZ) models. We apply a Bayesian statistical approach to derive the cumulative distribution of a range of model parameters conditioned on discharges. The data consist of eighteen tracer concentration profiles taken at different flow values at two cross-sections from the Murray Burn, a stream flowing through the Heriot-Watt University Campus at Riccarton in Edinburgh, Scotland.

A number of studies have been reported of the dependence of TS and ADZ model parameters on discharge but there are very few studies on the uncertainty related to that parameterization, which is the aim of this work. As the TS model is purely deterministic and the ADZ model is stochastic, different approaches are required to estimate the uncertainty in the dependence of their parameters on flow. The Generalised Likelihood Uncertainty Estimation (GLUE) approach is suitable for the deterministic models and is therefore applied to the TS model. The method applies Monte Carlo sampling of parameter space used in multiple simulations of a deterministic transient storage model. The relationship between model parameters and flow has the form of a nonlinear regression model based on multiple random realizations of the deterministic transport model. The parameterization of that relationship and its introduction into the TS model allow for the conditioning of parameter estimates and as a result, also model predictions on the whole set of available observations. In the case of the ADZ model, the approach is based on Monte Carlo sampling of ADZ model parameters, taking into account heteroscedastic variance of the observations and estimates of the covariance of the model parameters obtained during the model calibration stage. The parameterization obtained is validated using the experiments not applied during the estimation. The estimated uncertainty in the dependence of both TS model and ADZ model parameters on flow shows large increase with flow values. This indicates that smaller time steps for tracer sampling should be used for larger flows. However, in the case of the ADZ model, that increase of uncertainty in parameter values does not significantly influence the uncertainty in the estimated mean travel time.