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Analysis of turbidity time series data from the Lunan Water catchment, Scotland, using Hidden Markov methods

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In-situ turbidity was calibrated for assessing sediment and P transport [1;2] across several streams in the Lunan Water Catchment, Angus, Scotland. This has shown that turbidity sensors can improve temporal knowledge of river mass loads, and calibrations were improved by splitting rising and falling hydrograph periods. Calibrations for one stream or catchment were not transferable to a neighbouring catchment, and this suggests that we need to do more “data mining” to identify when fine sediments, more heavily enriched with adsorbed P, are being transported. This should help improve transferability of calibrations. One possible approach to this is to use a latent Markovian process to classify the data into hidden states, and relate these to time-dependent triggers for transport of fine sediment such as enhanced erosion of fine cohesive particles at high flows, or enhanced mobilisation of fines by raindrop impact at high intensities. This Bayesian modelling approach allows the analysis of non-linear and non-stationary time series with an auto-regressive component. The method uses a probabilistic framework to assign each observation to a ‘hidden state’ that could then be linked to different controlling factors or processes.

A Markov switching autoregressive model [3] was tested on one stream to analyse a time series of turbidity data. We started the analysis by performing model choice, that is by selecting the values of the autoregressive order p and the number of hidden states m. The pair (m; p) was selected by means of the Bayesian Information Criterion (BIC) and the best model was that with m=3 and p=5, as it was associated with the highest penalised likelihood . After that, given the best model, we performed parameter estimation (including the sequence of the hidden states) and the fitting of the series. Having three hidden states means that the observations can be classified into three groups that, in this case, can be ordered according to increasing levels of variability.

We are now seeking a physical interpretation of the hidden states, which could be transferable between sites. Characteristics of flow, rainfall and sediment/water quality in the differing states are under investigation. The next step of the analysis will be the application of the same methodology to another Burn in the same catchment, where replicate turbidity measurements occur, with autosampling providing a wider range of co-variates (particle size distribution, suspended solids, chemistry) to see if the model suggests concurrence of the three states for each replicate. A univariate analysis on the replicate series will be performed first, and then a multivariate analysis by using Markov switching vector autoregressive models under development.

1. Dunn S. M. et al. (2014) Recent trends in water quality in an agricultural catchment in Eastern Scotland: elucidating the roles of hydrology and land use. DOI:101039/c3em00698k
2. Stutter, M.I. et al. (2017) Evaluating the use of in-situ turbidity measurements to quantify fluvial sediment and phosphorus concentrations and fluxes in agricultural streams. https://doi.org/10.1016/j.scitotenv.2017.07.013.
3. Birkel, C. et al. (2012). A new approach to simulating stream isotope dynamics using Markov switching autoregressive models. DOI: 10.1016/j.advwatres.2012.05.013