Identifying changes in catchment phosphorus load – a parsimonious model for a small agricultural catchment

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1. Diffuse pollution – the challenge of prediction

Understanding and modelling of phosphorus (P) dynamics in order to inform successful mitigation requires both long-term data, to capture inter-annual variability, and high temporal resolution data, to capture high frequency dynamics. Most process-based nutrient transfer models require many more parameters than are available from observations.

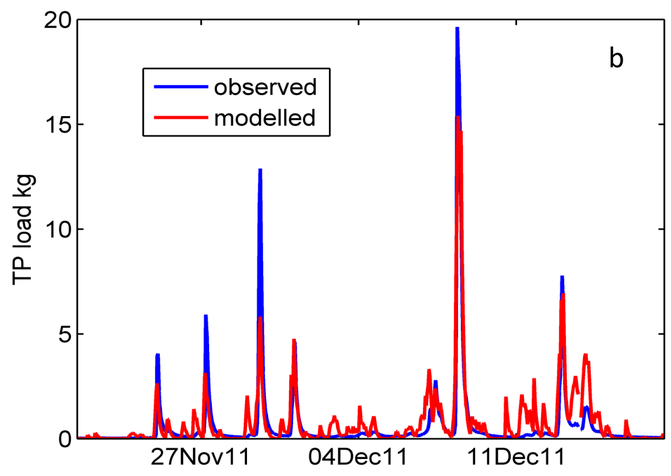
Figure 1. Overland flow in the River Eden basin, carrying sediment and nutrients

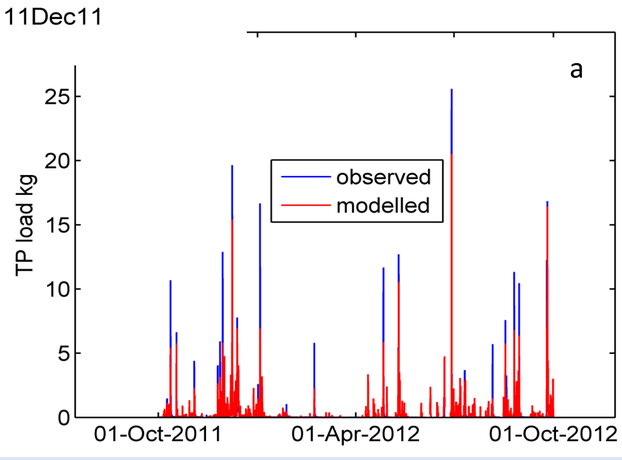
2. A parsimonious model for P transfer

A simple linear transfer function model with a non-linear rainfall input was used to relate observed rainfall with monitored total phosphorus (TP) load in the Newby Beck catchment (12.5km^2) in the River Eden basin, UK (Figure 2).

Figure 2. Location of the Newby Beck catchment, UK Grid ref. NY600213

By using a non-linear rainfall input, based on antecedent conditions in the catchment, the model captured the bigger influence of large rainfall events.





For the hydrological year 2011/12, the model (only 4 parameters in total) explained 79% of the variance in the TP load (Figure 3).

Figure 3. Observed and modelled TP loads for Newby Beck using a linear model with non-linear rainfall input for (a) hydrological year 2011/12 and (b) expanded view of part of year .

3. The effect of inter-annual variability on TP load

Hourly time series of rainfall, representing present day conditions with the range of inter-annual variability (Figure 4) from the UKCP09 Weather Generator (Jones et al. 2010) were used as input to the rainfall-TP model. The inter-annual variability in rainfall had a far greater influence on the annual TP load than the non-linearity in rainfall (Figure 5).

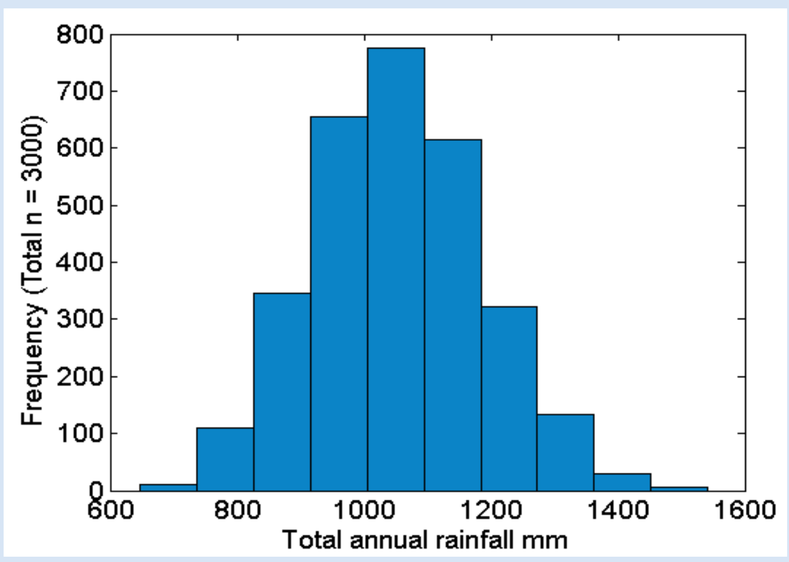


Figure 4 (above). Distribution of total annual rainfall from UKCP09 Weather Generator for present day conditions at Newby Beck, showing inter-annual variability

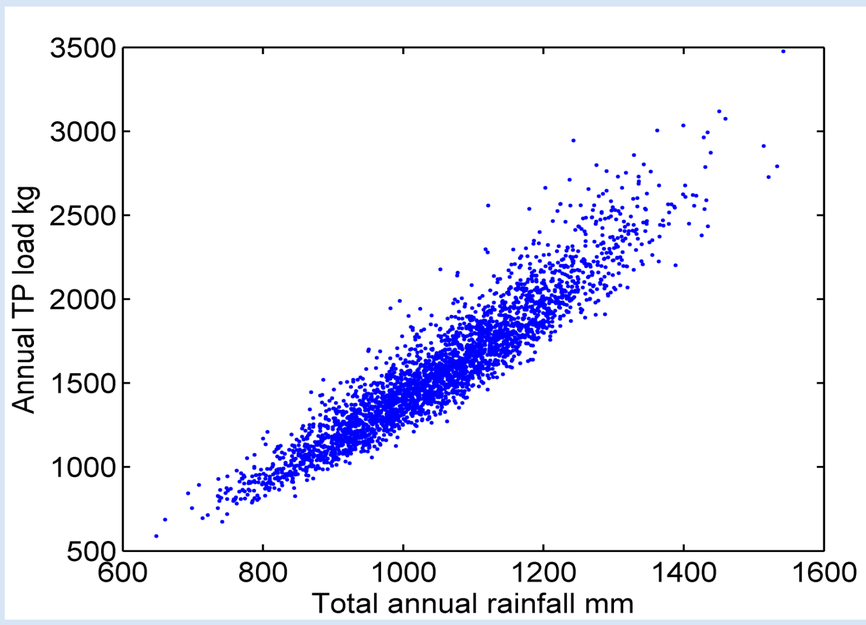


Figure 5 (right). Modelled annual TP load in Newby Beck against total annual rainfall from UKCP09 Weather Generator (n = 3000 years)

4. Conclusions

- A non-linear rainfall input with a linear transfer function model explained 79% of the variance in the TP load at Newby Beck
- The inter-annual variability in rainfall is much larger than the effects of non-linear rainfall input and may mask the effects of mitigation measures
- A simple model, with small parameter uncertainty, may help to separate effects of weather from other land management variables

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Reference:

Jones, P., Harpham, C., Kilsby, C.G., Glenis, V. and Burton, A., 2010. UK Climate Projections science report: Projections of future daily climate for the UK from the Weather Generator, Met Office, UK