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Modelling total phosphorous and nitrate using a water-age-based approach

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Abstract: Total phosphorous (TP) and nitrate are important stream contaminants. They vary strongly in response to climatic, hydrologic, and other drivers and are affected by different flow paths. Water travel time distributions carry information that can potentially provide a basis for modelling the dynamics of nitrate and TP in a manner that accounts for differences in travel times and flow paths through catchments. In this study, we use a travel time model coupled with age-concentration relationships to simulate nitrate and TP concentrations in the Duck River, Tasmania, Australia.

A modified version of the Tran-SAS model was used with time varying storage selection functions. It was calibrated against high frequency electrical conductivity (EC) observations to estimate the travel time distributions (TTDs) of water through the catchment (Riazi, Western, & Bende-Michl, 2022). EC was simulated using these TTDs and an age-based EC relationship. Concentrations of TP and nitrate were then modelled using the water TTDs coupled with age-concentration relationships for TP and nitrate calibrated and validated against high-frequency TP and nitrate observations for 2 years during 2008–2010.

It was initially hypothesised that the age-concentration relationships for nitrate and TP could be temporally fixed with the seasonal variation in residence time distribution capturing any seasonality in nutrient behaviour. The models performed moderately under this hypothesis; however, residual analysis clearly demonstrated seasonal declines in event TP and nitrate concentrations across the high flow season. Simulations were markedly improved by using different source concentrations – one for the early high flow season and the other for the remainder of the year. Both Nash-Sutcliffe Efficiency and the combined seasonal and event dynamics of nitrate and TP markedly improved as a result.

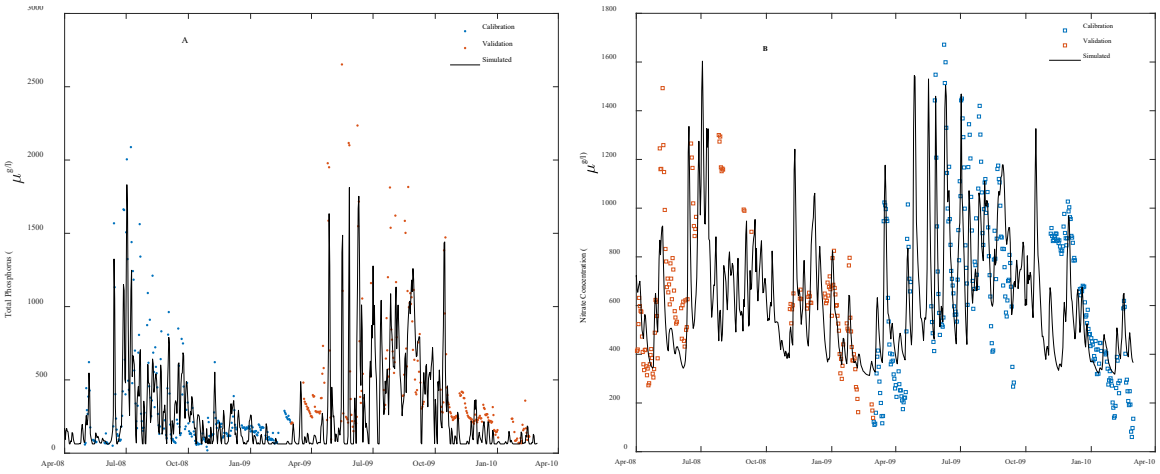

Figure 1. Simulated and observed time series of (A) total phosphorous and (B) nitrate for Duck River with the age-based solute model during calibration (blue dots) and validation (red dots)

REFERENCES

Riazi, Z., Western, A. W., Bende-Michl, U. 2022. Modelling electrical conductivity variation using a travel time distribution approach in the Duck River catchment, Australia. Hydrological Processes, e14721.

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