Modelling electrical conductivity variation using a travel time distribution approach

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Abstract

Water quality dynamics depend strongly on hydrologic flow paths and transit time within catchments. In this paper we use a travel time tracking method to simulate stream salinity (as measured by electrical conductivity) in the Duck River catchment, NW Tasmania, Australia. The approach couples the StorAge transit time modelling approach with two different approaches to model electrical conductivity. The first assumes the catchment has a cyclic salt balance (rainfall source, stream flow sink) that is in dynamic equilibrium and evapoconcentration of salt is the only process changing concentration. The second assumes that the salinity of water in catchment storages is a function of water age in those stores, without explicitly simulating salt mass balance processes. The paper compares these alternate approaches in terms of salinity simulation, simulated stream water age distributions, and simulated storage age distributions. Both salinity simulation approaches reproduce stream salinity with high fidelity under calibration and perform well under validation. The simulations using the age-related solute concentration approach produce less biased results and thus high model efficiencies for validation periods. This approach also produces more consistent model parameter estimates between periods. There are systematic differences in the resultant age distributions between models, particularly for the solute balance based simulations where parameters (catchment storage size) changed more between calibration periods. The effect of time varying versus static storage selection functions are compared, with clear evidence that time varying storage selection functions with parameters linked to catchment conditions (flow) are essential for adequate simulation of event concentration dynamics.

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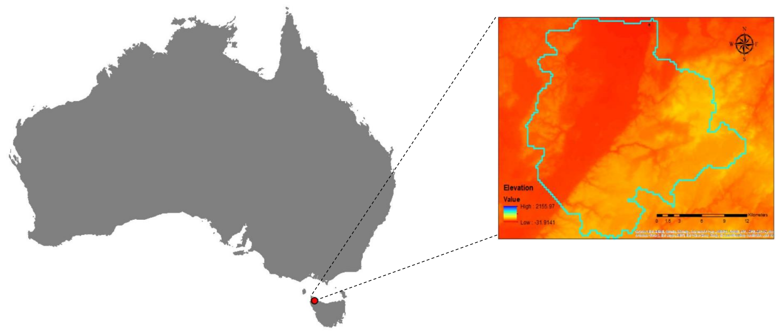

Figure 1: The Duck River catchment in north-west Tasmania, Australia.

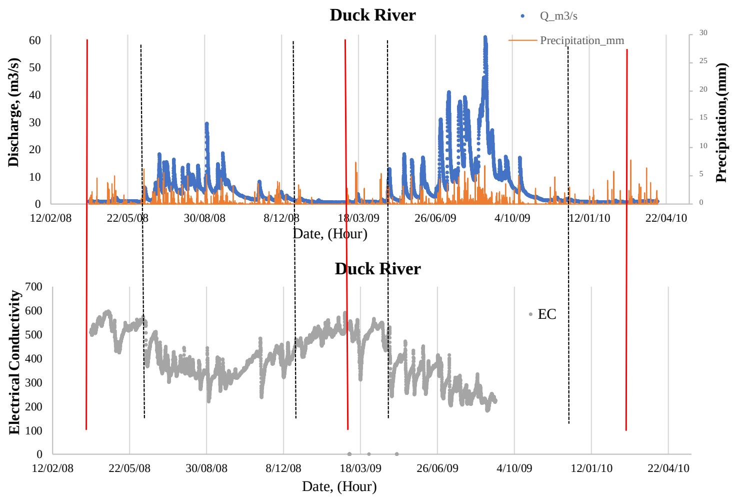

Figure 2: Hydrological and Electrical conductivity data time series during the 2-year monitoring period from 2/4/2008 to 31/3/2010.

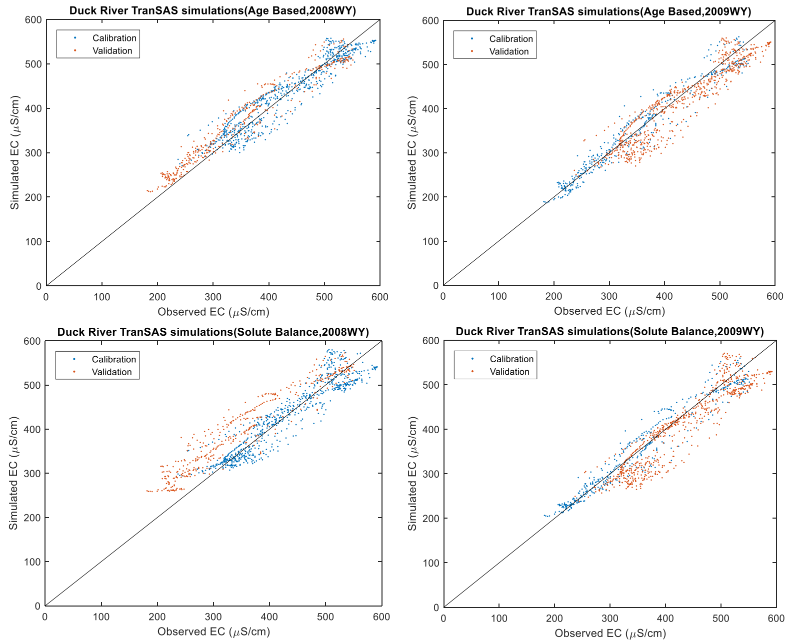

Figure 3: Scatter plot of observation and simulated EC data during two calibration (blue dots) and validations (red dots) for age-based and solute balance concentration model, 2008WY and 2009WY.

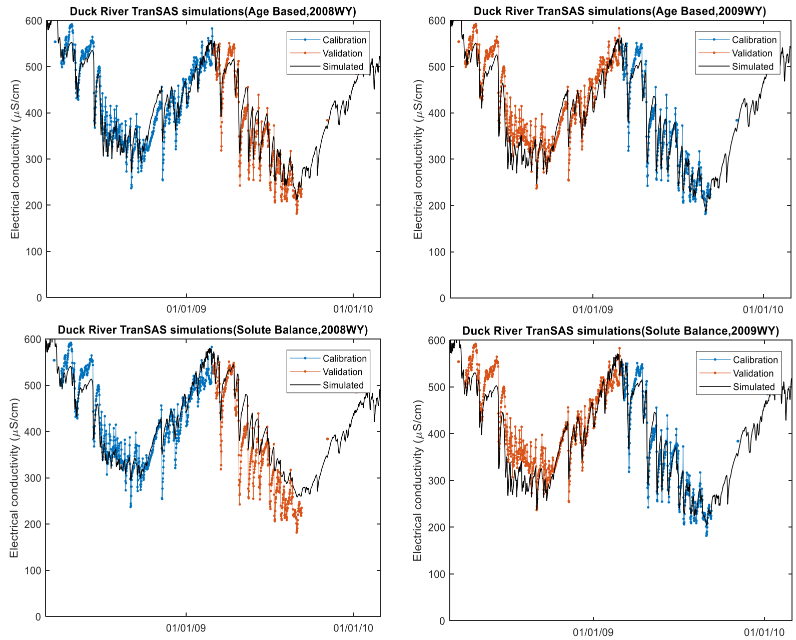

Figure 4: Time series of EC observed and simulated (continues black line) data during two calibration (blue line) and validation (red line) periods for age-based and solute balance concentration models, for 2008WY and 2009WY.

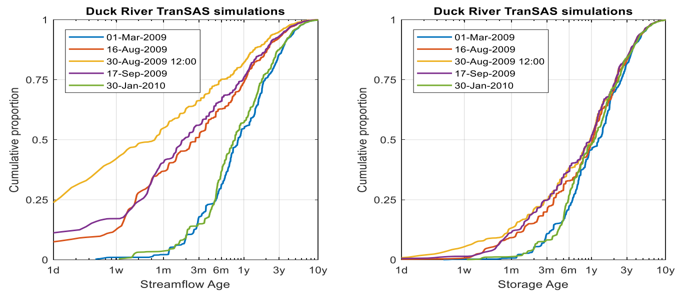

Figure 5: Water travel time distribution in the stream (left plot) and water residence time distributions for the age-based model (right plot) on 01 Mar (end low flow), 16 Aug (event start), 30 Aug (event peak), 17 Sep (event end), and 30 Jan 2010 (start low flow).

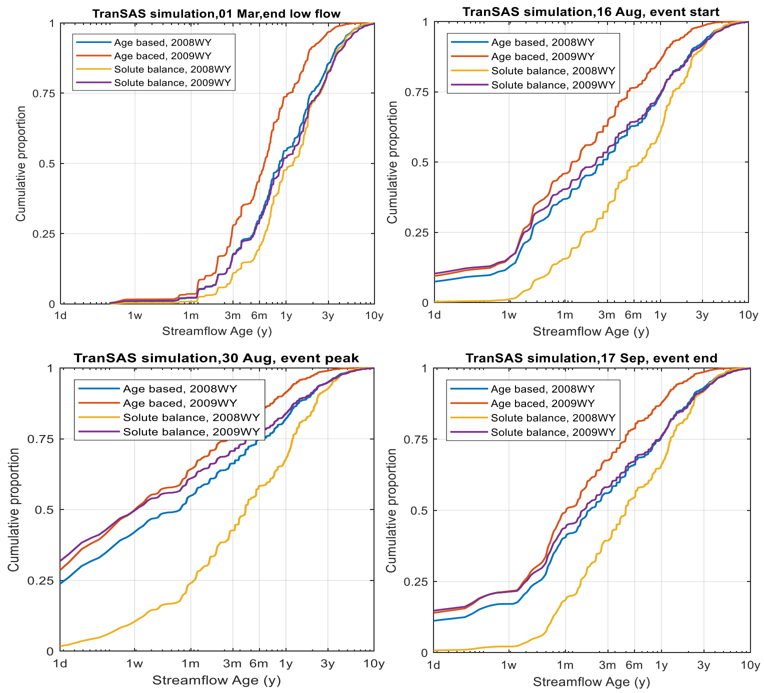

Figure 6: Water travel time distribution in the stream based on two concentration models in the calibration period of 2008WY for specified days: a) 01 Mar, end low flow, b) 16 Aug, event start, c) 30 Aug, event peak, and d) 17 Sep, event end.

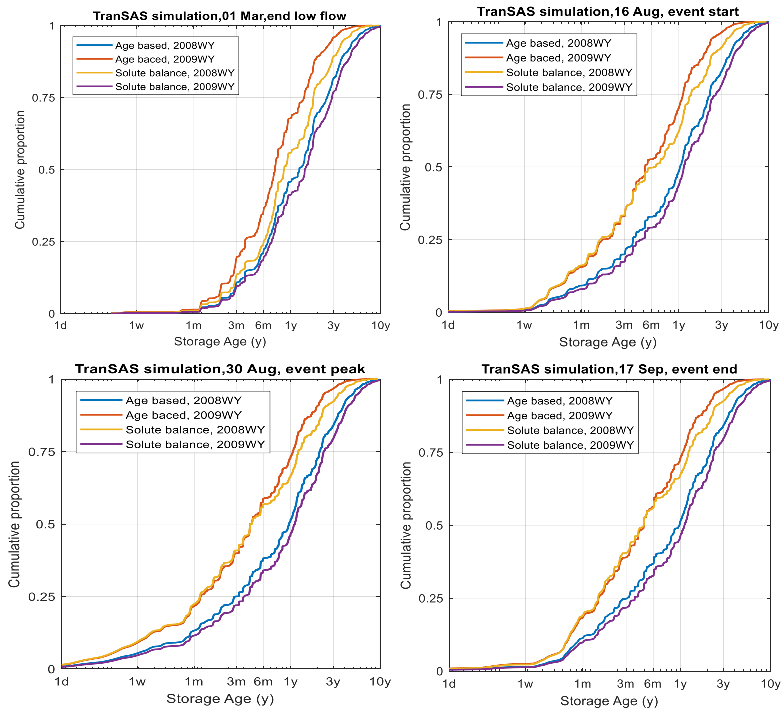

Figure 7: Water residence time distribution in the storage based on two concentration models in the calibration period of 2008WY for specified days: a) 01 Mar, end low flow, b) 16 Aug, event start, c) 30 Aug, event peak, and d) 17 Sep, event end.

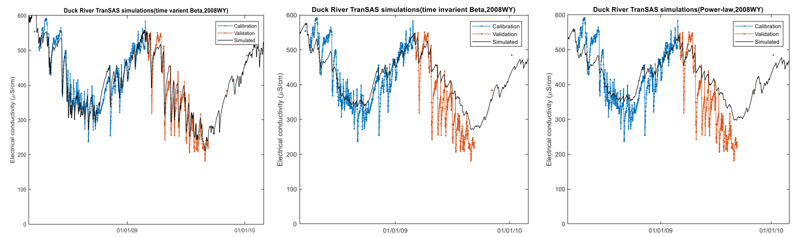

Figure 8: Time series of EC observed and simulated EC using a) time-variant beta, b) power-law, and c) time-invariant SAS functions for the age-based model calibrated for 2008/3/1-2009/3/1.

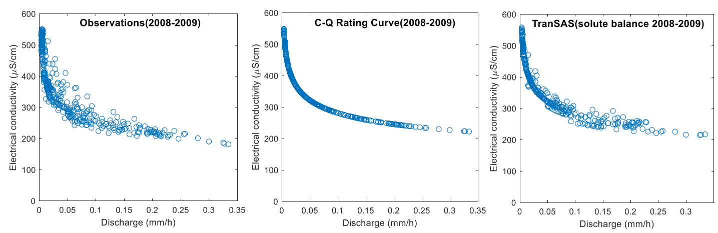

Figure 9: EC and discharge corrolations in the Age-based 2008WY scenarion. Observed data related to 2009 WY, the concentraiton-discharge rating curve fitted to 2008WY and simulated EC concentration by tran-SAS for duration of 2009 WY.