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Coupled water, isotope and DOC flux simulations in a tropical monsoon catchment

Damien Maher (1), Christian Birkel (2), Clement Duvert (3), Alicia Correa (2), Niels C. Munksgaard (3), and Lindsay B. Hutley (3)

(1) Southern Cross Geoscience, Southern Cross University, Lismore, Australia., (2) Department of Geography, University of Costa Rica, 2060 San José, Costa Rica., (3) Research Institute for the Environment and Livelihoods, Charles Darwin University, Darwin, Australia.

The tropics are characterized by a much larger rate of change and dynamics compared to temperate climates, particularly in the seasonally-dry tropics. Yet, our understanding of how these systems process water and solutes remains limited. In this study, we attempt to gain a more detailed understanding of water, stable water isotope and dissolved organic carbon (DOC) transport, storage and mixing in a 126-km2 catchment of northern Australia. The river has relatively detailed hydrometric monitoring that we paired with water stable isotopes and carbon tracer sampling from 2015 to 2018. Based on previous work on the catchment's water sources contributing to streamflow, we developed a coupled, tracer-aided, conceptual rainfall-runoff model that simultaneously calculates water, isotope and DOC processes at a daily scale. The model set up is spatially semi-distributed in a way that accounts for the marked distinction of savanna woodland and riparian wetland ecosystems. These ecosystems correspond to landscape units and are directly related to the likely dominant hydrological processes. Furthermore, we temporally tracked the incoming and outgoing fluxes deriving information on the age of water in fluxes and storages. The model was independently tested against groundwater levels for internal consistency, and we used tritium dating to constrain the older water model estimates. The model was well capable to reproduce the observed streamflow, stream isotope and stream DOC data with KGE values greater than 0.8 for all three variables. Using three different data sources for calibration seemed to have reduced the overall parameter uncertainty by constraining the parameter space of plausible solutions. We, therefore, have developed an internally consistent and relatively parsimonious model that matches the extreme seasonal variability. Such variability caused by a climatically-driven switching on and off of flow pathways contributing to the perennial river. The latter hydrological connectivity was modulated by a deep karst aquifer system that continuously contributed water to maintain relatively stable river flows during the dry season. However, isotopic evidence suggests that the aquifer was preferentially recharged only during the biggest storm events of the wet season. Simulated DOC exports averaged 2 t C km-2 yr-1 and were mostly generated (up to 90%) by the hydraulically-active riparian wetlands during the short wet season. We conclude that coupled simulation of water and biogeochemistry is necessary to generate an integral picture of catchment functioning, particularly in the tropics. This work may lay the foundation to develop scenarios of future change in a region highly sensitive to climate change.