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Extreme seasonal shifts in water and carbon sources to a wet-dry tropical river

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In regions with extreme climatic seasonality, the riverine export of carbon is expected to be driven by changes in connectivity between source areas and rivers. Yet we lack a thorough understanding of the relative contributions of each water source (e.g. wetlands, shallow soils, deep aquifers) to the dissolved carbon flux, and of the way these contributions vary with seasonal changes in flow regime. Here we assess the temporal variations in dissolved inorganic carbon (DIC) fluxes in a wet-dry tropical river of northern Australia, using weekly to monthly measurements of electrical conductivity, DIC and its carbon isotopic ratio ($\delta^{13}C_{DIC}$), as well as the isotopes of water (δD, δ^{18}O and ^{3}H), over a two-year period. We use linear mixing models integrated into a Bayesian framework to determine the relative contributions of stormflow, saturation areas, shallow groundwater and a deep carbonate aquifer to river fluxes, which we relate to water ages using lumped models fitted to isotopic time-series. Our results suggest extreme shifts in water and associated carbon sources between the wet and dry seasons. During the wet season, most DIC was transported by young water sources (< 1 year) originating mainly from saturation areas (52–82%) and stormflow (13–40%). This DIC was of biogenic origin (mean $\delta^{13}C_{DIC}$ –18‰). As rainfall ceased, the drainage of floodplains and wetlands occurred until all saturation areas either dried out or became disconnected from the river network. From this stage, river flow decreased substantially and the remaining DIC was nearly entirely conveyed via deeper, older water sources (20–40 years) from the underlying carbonate formation (85–95%). This DIC had a likely geogenic origin (mean $\delta^{13}C_{DIC}$ –14‰). Because of the disproportionately high flows during the wet season, the flux of DIC was larger during that period, an indication of the prevalence of biogenic carbon to the total DIC flux in this system. Our findings illustrate the need to consider dominant water flowpaths, as well as their changing patterns of connectivity, if we are to inform carbon fluxes across catchments. This work also suggests that carbon inputs to rivers need to be systematically partitioned between biogenic and geogenic sources, as this is an important consideration when evaluating the strength of soil carbon sinks.