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The effects of extreme hydrological events on the transport and reactivity of dissolved organic matter in a Mediterranean river

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Mediterranean rivers typically experience extreme hydrological conditions over an annual cycle, including floods in spring and autumn, and prolonged droughts in summer. This extreme hydrological variability translates into a high temporal dynamism in water residence times and river connectivity, both longitudinally (upstream/downstream) and laterally (stream/catchment). This has profound implications on the biogeochemical functioning of rivers and, more specifically, on the transport and reactivity of dissolved organic matter (DOM). A substantial body of theoretical work acknowledges a prominent role of hydrology on carbon cycling and DOM processing in streams; however, field evidence is still scarce.

In this study, we measured how the properties and reactivity of DOM along a river continuum changed over a gradient of 15 hydrological conditions, spanning from flood to drought. On each occasion, we measured DOM optical properties at 22 sites along the main stem of river Tordera (NE of Barcelona, Catalonia). Also, we performed a mass balance on 13 consecutive stream segments, for bulk dissolved organic carbon and for individual DOM fluorophores, on four contrasting hydrological conditions. Results demonstrate drastically distinctive patterns between flood, baseflow and drought conditions. During flood we observed a conservative transport of highly aromatic and humified DOM of terrestrial origin. By contrast, during baseflow DOM experienced a qualitative and quantitative transformation in the downstream direction. A terrestrially-derived aromatic character in the headwaters gradually shifted toward a protein-like dominated composition at downstream sites. This was due to an important in-stream generation of protein-like compounds at the lower parts of the river, as revealed by the mass-balance calculations. Finally, during drought, there was a maximal heterogeneity of DOM properties along the river course together with high retention rates.

Taken together, these results reveal that extremely opposite hydrological conditions lead to also extremely opposite biogeochemical interactions of DOM. Floods caused a nonreactive transport of terrestrial DOM and created chemically homogeneous longitudinal profiles. On the opposite conditions, drought favoured important in-stream DOM reactivity and enhanced a longitudinal diversity of DOM properties. All in all, this highlights the need to take into account the full hydrological variability in order to fully understand the role of DOM and carbon cycling in rivers.