Modelling the impact of intermittent flow on leaf litter processing in river networks

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Abstract

Streams and rivers are increasingly recognized as landscape-scale bioreactors that metabolize terrestrially sourced organic matter to carbon dioxide during transport to the oceans. This role of rivers is intimately tied to their flow regime that governs residence times of organic matter in river networks, shapes the evolution of organic matter chemistry and further reactivity through fractional progression of decomposition, and ultimately controls the amount of carbon dioxide and reduced carbon exported to the atmosphere and the oceans, respectively. For rivers, climate change means hydrological change and future flow regimes will likely be more extreme, encompassing flash floods and phases of drought. Indeed, in intermittent rivers, whose flow ceases at some point in time or space, dynamics of leaf litter decomposition are known to include phases of aquatic decomposition during normal flow, mostly accumulation of material in phases without low or no flow, and pronounced transport during high flow events typical for the onset of wet phases. Here, we explore the consequences of flow regimes of increasing intermittency for the decomposition of leaf litter at the scale of entire river networks. Our in-silico approach rests on a model that integrates seasonal litter accumulation and decomposition during dry or wet state of a particular river reach with transport dynamics through a dendritic river network. Decomposition modulates chemistry of decomposing leaves, which is captured by an evolving reactivity continuum with consequences for later, potentially further downstream decomposition. Both the total amount of organic matter

exported from a specific river size in the network and its quality (i.e. reactivity) show predictable responses to alteration of flow as could be caused by climate change, for instance. Of crucial importance is how synchronous phenology of leaf litter fall is with times of drought or higher flow – this translates to a challenge for climate models as well as future river ecosystems. Our study provides mechanisms that could be incorporated into models of riverine carbon dynamics and testable predictions for future empirical studies.