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Reply on RC1

Anna Lupon et al.

Author comment on "Groundwater flow paths drive longitudinal patterns of stream dissolved organic carbon (DOC) concentrations in boreal landscapes" by Anna Lupon et al., Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2021-358-AC1, 2022

We thank both reviewers for their time and thoughtful reviews. We identified five overarching themes in the comments that we will address in the revised version of the manuscript.

- Improved context

We will improve the context of the study and highlight key knowledge gaps this work addresses in both the introduction and conclusions. Streams are not explicitly considered in the Earth System Models because fluxes of C transport, removal and emission in headwater streams are highly inaccurate (IPCC 2022). This uncertainty partly reflects the fact that DOC concentrations and cycling vary greatly at small spatial scales (i.e. meters to kilometers) (Lupon et al. 2019). Given that these fine-scale spatial heterogeneities can change global C fluxes by 15-folds (Rocher-Ros et al. 2019), resolving the factors that generate them is a top priority for better understanding the role of headwater streams in current and future global biogeochemical cycles.

Boreal landscapes store a large fraction of the Earth's organic solid C. DRIPs are widespread in boreal landscapes and may be a critical transport mechanism of C from terrestrial to aquatic systems. We hypothesized that DRIPs affect spatial patterns of stream DOC concentrations because they (i) supply terrestrially-derived DOC and (ii) fuel in-stream DOC mineralization. DRIPs (or zero-order streams) are well known for hydrologists, but rarely included in biogeochemical studies focusing on in-stream C cycling or fluxes (Briggs & Hare 2018). Our study addresses this knowledge gap and also explores how the relevance of DRIPs for DOC dynamics might depend on hydrological conditions.

- Improved structure

We will improve the overall structure of the manuscript to better highlight the key findings of the study. Improving the context of the study (point #1 above) will help focus the structure of the remaining sections; however, we will also make substantial revisions throughout to improve clarity. For example, we will provide more details on DRIPs (point #3 below) and improved explanation of model uncertainty (point #4 below). Importantly, we will better structure the key results around contrasting hydroclimatic conditions. Currently, all the sampling periods and modelling scenarios are presented together, which makes it difficult for readers. In the revised manuscript, we will structure the results and discussion around key comparisons focused on grouping hydroclimatic conditions, as well

as differing model structures. This systematic approach, with appropriate figures highlighting key comparisons, will improve the readability of the manuscript.

- Clarifications on DRIPs, drought, and passive pipe

In the revised manuscript we will provide better clarification about some concepts and terminology. For example, we will better define DRIPs using the approach by Ploum et al 2021. We will also include a map of DRIP locations following Leach et al 2017. We will also be explicit that our study covers both natural and artificial hydrological conditions (i.e., artificial drought/low-flow conditions). Both reviewers' also commented about our use of 'passive pipe' to describe potential in-stream DOC dynamics. We will revise these terms and use "active DOC processing" vs "passive DOC transport" as a way to describe stream biota interactions. We argue that the assumption of 'passive DOC transport' is still prevalent in the field of biogeochemistry (e.g., Raymond et al. 2016 Ecology, Mladenov et al. 2022 STOTEN; Manning et al. 2022 Freshwater Sciences).

- Improved accounting for model uncertainty

We have revised how we handle uncertainty in the stream DOC model used in this study. We have incorporated a more rigorous approach for propagating error through the model and its influence on downstream DOC estimates. In the revised manuscript we will provide a better explanation of this approach with a description of the model equations, assumptions and uncertainty estimates. The revised model does not change the key findings of the study, but does highlight outstanding knowledge gaps on our understanding of terrestrial-aquatic interactions on in-stream DOC dynamics. We will also provide more discussion about model structure, assumptions and uncertainty in the discussion. The revised context and manuscript structure (points #1 and #2 above), in addition to a better presentation of the model, will improve overall clarity of the study.

- Corrected grammar and spelling

Both reviewers noted a number of grammatical and spelling mistakes throughout the manuscript that impacted readability. We will revise these errors.

The key themes listed above address what we see as the main points made by the reviewers. When preparing our revised manuscript, we will address each of the reviewers' specific points listed.