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Comment on esd-2021-44

Anonymous Referee #1

Referee comment on "Spatiotemporal patterns and drivers of terrestrial dissolved organic carbon (DOC) leaching into the European river network" by Céline Gommet et al., Earth Syst. Dynam. Discuss., <https://doi.org/10.5194/esd-2021-44-RC1>, 2021

Review of the manuscript: 'Spatio-temporal patterns and drivers of terrestrial dissolved organic carbon (DOC) leaching to the European river network' by Celine Gommet and colleagues.

The manuscript addresses a significant topic that is interesting for different scientific communities studying the turnover of carbon in terrestrial and aquatic environments. As the authors also state in their introduction, OC loss from rivers has not traditionally been considered in terrestrial ecosystem budgets. It is therefore to be welcomed that this study makes a contribution to a cross-system synthesis. The manuscript is well written and presentation is clear. I comment from the perspective of an aquatic ecologist and question whether the model includes the relevant parameters for riverine DOC transport and whether the significant processes are reasonably represented. I recommend revision of the paper, addressing the points raised below. If the authors can address the listed issues in the manuscript, it would make the article interesting to a wider readership.

1. OC in the soil is represented by four different litter and three different SOC pools with different turnover rates. The SOC is subdivided into active, slow and passive pools (Figure 1). I understand that such a complex model is needed to describe the turnover of OC in the soil. However, one can critically question whether NPP and the amount of SOC in the catchment are significant criteria in determining how much DOC enters the river (see statement line 401). The proportion of DOC export relative to terrestrial NPP is low (on average 0.6%, line 630), but highly variable (~0.02% to 2%) and strongly related to runoff (Figure 12). This seems to suggest that NPP is likely not the rate limiting step and that hydrology is the key factor governing the transport of DOC to the stream, as also mentioned in the manuscript (lines 645-647). I would like to see a sensitivity analysis added to show how much the variability of the modeled parameters NPP, SOC, and pore water DOC as well as the input parameters determines the final result and if the parameters are significant. The multiple regression (equation 13) makes a step in this direction. But it would be more convincing if NPP was tested independently, not as a ratio DOC leaching / NPP.

2. It is well documented that the near-stream (riparian) areas are the main source areas of stream DOC (Inamdar and Mitchell 2006, Grabs et al. 2012), while large parts of the catchment remain hydrologically disconnected from the stream during most of the time. The upslope areas will be connected to the stream only occasionally during events (Stieglitz et al. 2003, Ocampo et al. 2006). In line with this, field investigations showed that the largest part of the DOC flux originated from only a few decimeters thick organic soil layer in the riparian wetland zones (Ledesma et al. 2015), which are near-infinite sources of DOC (Raymond and Hopkinson 2003). With this in mind, it seems questionable to assume the entire watershed as the source of the DOC in the model. It would be interesting here to see what the authors' views are on this issue. Should future models focus on riparian zones?

3. Figure 5 shows that DOC pore water concentrations decrease nonlinearly with depth, which is a reasonable result. However, the DOC in the topsoil was overestimated by 100% compared to reference sites. This can be a problem as the annual DOC exports are largely generated during events, when groundwater tables are high and the OC-rich topsoil layers become the main source of water and DOC to the stream (lines 590-595). The transmissivity feedback predicts that lateral hydraulic conductivities increase nonlinearly with increasing distance from the soil surface (Kendall et al. 1999, Bishop et al. 2004). Are there different lateral hydraulic conductivities assumed for different soil layers to connect the pore water DOC with the stream? In addition to Figure 5, I recommend including a graph showing the relationship between discharge and predicted DOC concentration in the stream. Typically, DOC concentration increases exponentially with discharge.

4. In the late 1980's the DOC concentrations started to increase in many European streams and rivers. Often the concentrations have doubled over the last decades. As possible causes a decrease of soil pH and ionic strength leading to a higher solubility of DOC (Monteith et al. 2007) and a decreasing stability of iron minerals and an accompanying release of formerly adsorbed OC are discussed (Ekström et al. 2016, Musolff et al. 2017). Is the model sensitive to the parameters discussed?

5. Application of manure was included (lines 216-226). Is there observational evidence that manure can contribute to stream DOC, except for cases when manure was applied on frozen ground or snow? On the other hand, discharge from wastewater treatment plants was not considered as a carbon source (lines 93-94). This can be questioned as the DOC concentrations in wastewater effluent are as high as in the streams (Griffith et al 2009) and, in contrast to manure this source is directly released to the stream. For the Sacramento River, Sickman et al. 2007 estimated that urban sources contributed 20% to total OC discharge. It can be assumed that wastewater-derived OC is also significant in other rivers with densely populated catchment areas.

Further comments

DOC is also produced by autochthonous photosynthesis in the stream. How important can production be compared to the terrestrial DOC modeled here. Or can we assume that the DOC is readily available and therefore most of it is quickly decomposed in the river itself?

If the manuscript aims to provide an estimation of riverine organic carbon transport, particulate organic carbon (POC) cannot be ignored. Compared to DOC, concentrations are smaller, typically ranging between 10% and 30%. May briefly discuss the potential contribution of POC to OC flux.

Figure 9: DOC export is the product of DOC concentration and discharge. What is the variability of DOC concentration compared to the variability of discharge? Figure 9 suggests that the exports largely depend on discharges. Would a similar result be obtained if a mean constant DOC release were assumed?

Table 1: May briefly explain 'topographic index' and the context of 'Floodplains and swamps'.

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