We appreciate the review by Referee #1 and are grateful for her/his helpful comments, which will certainly improve the manuscript. In the following, we will address the general and the specific comments and explain our intended changes.

General comments

This study assesses the controls on the export of dissolved organic carbon (DOC) using high frequency discharge and DOC times series datasets across nested watersheds with contrasting topography. Specifically, the authors focus on event-scale export patterns across four events with generally similar event size, but contrasting antecedent hydrologic conditions.

While the results contribute to our general understanding of DOC export behavior and possible controls, this manuscript can benefit from major revisions that focus on a few areas: (1) clarity – the data in this manuscript is extensive, which while useful, makes it very difficult to follow the Results and Discussion sections. The manuscript would benefit from re-writing certain sections of the manuscript to make the event descriptions and comparisons more clear – see specific comments below for more details. (2) The role of seasonality. While one of the major findings is that events in May and September behaved differently, even though event size was similar. However, the authors do not discuss the role of seasonality in their hierarchy of controlling factors. This seems to miss an important biological control on DOC availability.

There are a range of other specific comments outlined below. Once the authors address these major revisions, I believe the manuscript may be suitable for publication in HESS.

We agree that the data is extensive and therefore some sections might be hard to follow. We will revise the sections mentioned to enhance the clarity of the manuscript according to the comments provided and agree that the manuscript will greatly benefit from this.

Moreover, we agree with both referees that the role of seasonality is an important point. As biological activity is strongly influenced by temperature, DOC production is expected to be higher during the summer months often leading to an increased DOC export. However, this effect seems to be offset at our study site by the pronounced drought period inhibiting hydrological connectivity. We will discuss this in more detail in the revised manuscript.

Specific comments

L65- 67 – In addition to event-scale dynamics not being linear or having hysteretic loops, they also often do not mirror annual scale dynamics. Here is a recently published paper that discuss differences in event-scale vs annual scale c-Q relationships that may be relevant for this study:

Fazekas, H. M., Wymore, A. S., & McDowell, W. H. (2020). Dissolved organic carbon and nitrate concentrationâ€ • discharge behavior across scales: Land use, excursions, and misclassification. *Water Resources Research*, *56*, e2019WR027028. https://doi.org/10.1029/2019WR027028

Thank you for this recommendation. We will add a sentence about the difficulty of gaining information about annual processes through composite hysteretic loops.

Introduction – the knowledge gap for this study is not well explained. The authors state in L 87-89 the main goal of the study, but don’t give necessary motivation leading up to this as to why this is needed. The paragraphs leading up to this are largely explaining what our community knows about about DOC-Q relationships, but don't address the gaps.

We will further elaborate the knowledge gap for this study. The setting in the National Park allows us to investigate DOC export mechanisms in a region with little anthropogenic influence, which is important against the background of rising DOC concentrations in freshwater systems. There are few studies focusing on the influence of topography on the DOC mobilization mechanisms. Another aspect of increasing importance is the possible impact of climate change and, associated therewith, prolonged drought periods on DOC export.

Description of events – While four events is not that many, it is difficult to keep track of which event is which and how the responses across the watersheds vary. I strongly recommend the authors think about a way to describe these events besides using their dates. For example, could the authors order them by driest (antecedent-wise) to wettest?

We reflected on several options to describe the four events. However, we are of the opinion that the current description using the event dates is useful as we discuss not only the antecedent conditions but also event size, which would be missing if ordering them by driest to wettest. As all events happened at another time of the year, every month is used only once, which prevents confusion. We argue that an order by antecedent conditions would not necessarily make it easier to follow which event is which.

Figure 1 – How were the blue streams in this map determined?

The location of the streams was derived from a DEM with a resolution of 5m. We show all tributaries with a Strahler stream order number > 2.

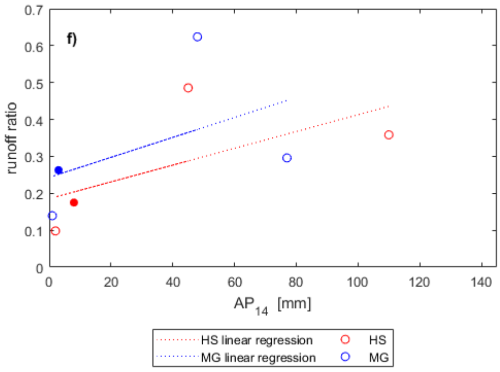
L 164-165 – To understand the antecedent hydrologic conditions of the four events, it would be helpful if the authors provide antecedent groundwater levels, or the cumulative precipitation from the water year, or some additional information to help the reader understand the context of the event within range of hydrologic conditions that occur in this watershed. Otherwise, there is no clear rationale for why these four events were chosen to represent c-Q dynamics at this site.

We have provided antecedent groundwater levels in Figure 3. In order to clarify the rationale for the selection of the four events, we will refer to Figure 3 earlier in the text in the end of section 2.1. additionally to section 3.1. We will rename section 3.1. to "Hydrological preconditions and discharge behavior" to better summarize the content of the section.

Section 3.3 – This section is extremely hard to follow as written. It is different to understand the differences between all the events at the two different locations. I recommend the authors re-write this section to more clearly introduce the event characteristics.

We are not sure if the referee is really referring to section 3.3. We suppose she/he is referring to section 3.1., where we introduce the event characteristics. We will rewrite this section and better incorporate the groundwater level data as also suggested by Referee #2.

Figure 4 – Have the authors considered calculating runoff ratios? These are good indicators of how much precipitation translates to discharge each event and can help explain c-Q patterns. Further, are the linear regressions necessary? There are so few points, what do the regressions add?



We will add the plot of runoff ratio vs. AP_{14} to Figure 4. We see that Q generation increases with increasing antecedent wetness, which supports our general argument that hydrological connectivity is of importance for Q generation. We will add further explanations to section 3.1. and take up the arguments in the discussion. We are aware that it is difficult to interpret the linear regressions in its original sense due to the low sample size. However, we are of the opinion that they help to recognize a general trend more easily and will therefore not remove them.

Figure 5 – What are the time units on precipitation? Is this precipitation per 15 minutes? Further, it would be helpful for comparison between watersheds, since the watershed sizes are different, to have the discharge area normalized for these analyses.

The precipitation unit in Figure 5 is mm/hr, which we will add to the figure. We will also change discharge to area normalized discharge in mm/h in this figure.

Figure 5 – continued – it is difficult to see the event dynamics in each sub-plot. The authors should consider shortening the x-axis time interval that is displayed to allow readers an opportunity to really see the event specific dynamics.

We will shorten the x-axis to a time interval of 14 days prior to the event, which corresponds to the used AP_{14}. This will allow the reader to both see the event specific dynamics in more detail and at the same time be aware of the hydrological preconditions of the event.

Figure 6- Could the authors include an identifier of the antecedent conditions or total P associated with each event? This could go in the upper right corner of each subplot.

Thank you for this helpful suggestion, which we will include in the next version of the figure.

Figure 6 continued – While the caption describes what the color gradient refers to, it would be helpful if the authors include a legend/scale bar. Therefore, the reader would know what color is related to the peak of the event, for example. Otherwise the color gradient only helps identify the start and end of the event.

As suggested by Referee #2 we will add arrows to facilitate the interpretation of the hysteresis loops. However, we will refrain from adding a color gradient as this will add a lot of additional information to the figure, which can be seen without the color gradient as well. The peak of the event, for instance, corresponds to the highest Q value.

L 285 – Can the authors provide more detail about how this 0.32 is calculated? Is this dividing the watershed area between the two watersheds? I do not believe this is described in the Methods section, and for clarity I recommend including this analysis explanation in the Methods section.

When comparing the contribution of different sub-catchments to total Q and DOC export, we assume an equal area contribution of all catchment parts. The calculation of the area ratio is as follows: areaMG/areaHS = 1.1 km^2/3.5km^2 = 0.31. Therefore, we use the value 0.31 as a benchmark. We will add a sentence to the end of section 2.3. explaining the calculation and adjust the value to 0.31 as we show rounded numbers for the catchment area.

L 305-307 – The authors should back up this statement regarding the relationship between watershed area and event response with literature that has shown this pattern as well. For example, are there studies that have looked at transit time distributions as a function of watershed area? This may help support your argument that water must travel further, and thus takes longer, to reach the watershed outlet.

We will add references supporting our statement.

L 309-311 – The transmissivity feedback concept is relevant in all soils, thus it is unclear why the authors invoke this as a particularly important process in the lower watershed.

We agree that the generally declining saturated hydraulic conductivity in soils could potentially evoke a non-linear increase in lateral subsurface flow in most soils. However, a precondition for this to happen is that the upper soil layers can fully saturate during an event, which usually requires shallow groundwater tables that can quickly rise into the upper soil layers. Such conditions typically exist in flat riparian areas with large TWIs as we only find them in the lower part of our studied catchment. We will add a clarifying sentence to section 4.1.

L 318-320 – Recent work by Michael Rinderer exploring the role of topography on groundwater levels in geographically proximal locations to this study may provide some support for the mechanisms discussed in this section.

We thank you for this valuable suggestion and will include it in section 4.1.

Section 4.1 – Is it possible that there is more groundwater recharge in the lower catchment; that is, as water is transported from a topographic steep landscape to a low gradient landscape, could there be water lost to recharge groundwater at that transition? This could explain why the upper catchment is contributing more flow and DOC relative to the downstream catchment. Alternatively, is it possible that the upper catchment is dominated by shallow stormflow contributions, while the lower catchment is dominated by slower moving deeper groundwater contributions? I believe both of these mechanisms are suggested in the Zimmer and McGlynn (2018) paper cited in this section.

We thank the referee for these valuable suggestions. We do think that both mechanisms could be of importance in the catchment. We also investigated possible groundwater gains or losses along the stream using tracer experiments and radon data. The data indicate that exchange with groundwater is especially important in the lower part of the catchment. However, we decided not to include this data as it is beyond the scope of this study. Nevertheless, we will include the suggestions into section 4.1. and discuss the possibilities of groundwater recharge and contributions in more detail

L 400-404 – There is no mention of the timing of events within this hierarchy of controlling factors. Certainly conditions in biological activity, temperature, etc that vary by season play an important role in DOC export. The authors even discuss this in the previous paragraph. However, it is not mentioned in this concluding paragraph, which seems to therefore miss a critical controlling factor.

As mentioned above we will explain the influence of seasonality in more detail and will include this information in the concluding paragraph as suggested.

Technical comments

L 3627 – Is Drake et al 2018 related to the previous sentence? If so, I would recommend moving the citation up a sentence.

As the citation is related to both sentences, we decided to merge the sentences.

L 55-56 – Put "e.g. precipitation" in parentheses.

We will add the parentheses as suggested.

L 196 – should "(1990 and 2010)" be "(1990-2010)"?

Yes, thank you. We will change this.

L 197 – should "compared to 1600 mm" be "compared to long-term average of 1600 mm"?

Yes, we will add this.

L 315 – Missing Figure reference

We will correct this.

Katharina Blaurock

On behalf of all co-authors