**Hydrology and
Earth System
Sciences
Discussions**

Interactive comment on "Investigating the relationship between subsurface hydrology and dissolved carbon fluxes for a sub-arctic catchment" *by* S. W. Lyon et al.

Anonymous Referee #1

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GENERAL COMMENTS The study by S.W. Lyon et al. reports DOC and DIC fluxes through a sub-arctic catchment in Sweden, and investigates the effects of using spatially distributed or mean advective solute travel times to calculate catchment-scale dissolved carbon fluxes. The methodological comparison/sensitivity analysis is interesting. The paper addresses the issue that, in practice, catchment scale C fluxes must often be estimated for sites with limited data availability, gives a good example of possibilities to deal with this issue based on different assumptions and points out the consequences of these. In contrast to earlier studies in Sweden, which reported a dominance of DOC, the authors found that DOC and DIC fluxes were comparable in magnitude in their studied catchment. The study should be of interest for HESS

readers. The study is concisely presented, the figures and tables are largely accurate and clear, the methodology appears accurate and the abstract and discussion are mostly well written. However, the introduction can be significantly improved by shortening and rechecking the structure. The methodological description needs revision as well, it should be more concise in some parts and shortened. Also the result section needs revision to e.g. exclude repetition of methodological aspects. Working on these 3 sections will significantly improve the presentation of this manuscript with its interesting topic and discussion. Below, I am giving specific suggestions of where and how to improve and shorten the manuscript.

SPECIFIC COMMENTS P1680/L14: What is the hypothesis of your study? Please include.

P1681/L17: Please improve the structure of your site description. I suggest to e.g. move the part on soil thickness (P1681/L7ff) upwards, immediately following your initial statement on soil development. Please give some general climatological information (e.g. mean annual temperature, annual precipitation). Has the soil type been determined, in this or in earlier studies at the same site? What do you want to express with the sentence which mentions hydraulic conductivities for other soil types (may not be necessary)? Please give the unit of the effective porosity (cm^3 cm-3?) - This porosity value seems rather small?

P1682/L18: Is there a literature reference for equations (1) and (2)? Please define all variables of the equations and give the units.

P1682/L22: It is difficult to understand how exactly you validate your flow partition estimates with eqs. (1) and (2). Please improve the explanation.

P1683/L14ff: The explanation for α is currently rather complicated, it only became clear to me when I read the result section. Please improve this paragraph.

P1683/L20ff: The paragraph explaining your eq. (4) should be improved, e.g. give the

variables of the equations in the order that they appear in the equations. It may be sufficient to state that you calculate the travel time through the deep domain similarly to eq. 4 (delete eq. 5). P1684/L17: What is an 'accumulated area treshold'? Please explain for readers that are not familiar with this approach.

P1684/L26: What does this sentence mean, 'the measurements are in agreement with estimates made using the techniques...'? How do you adjust the hydraulic properties? Please rephrase such that it becomes unambiguously clear what you measured, what you calculated and how you make your quality check and validation.

P1686/L1-6: It is not necessary to repeat eqs. 6-8 for DIC (i.e. eqs. 9-11). Please shorten and only mention that the calculations are conducted similarly as for DIC, or rewrite the notation of the respective equations in a more general way using DC as subscript (dissolved carbon, which is DOC or DIC); Figure 2: Please improve your legend: What are the grey dots in (a), which part of the hydrograph is the deep and shallow contribution? Please make a note in the legend of why there is no measure of uncertainty in (b).

P1688/L4ff: You might add that DIC concentrations were usually larger than DOC concentrations. Please be more concise in your description of seasonality: For DOC, concentrations are small prior to spring thaw, show a peak immediately following spring thaw and decline towards late summer. I am not convinced that DIC shows the opposite seasonality to DOC, as for Sept/Oct you don't have DOC data and during summer the pattern of DIC and DOC is similar. Your average values (means?) are influenced by the high values during spring thaw. For DOC and DIC (both measured concentrations and flow-weighted concentrations) please give means plus minus standard errors as well as the median to provide the reader with more detailed information; Table 1: Please give measures of uncertainty (e.g. standard errors) for all your data, if not possible give a note why. I think the units are more precise (unambiguous) if you add carbon to all of them, i.e. mg C m-3 and so on. It might be useful to separate the table into measured values and estimated/calculated values so this aspect is clear from only

looking at the table. Suggest to sort the table such that the values that need to be compared (e.g. release rates based on spatially distributed travel times vs. release rates based on lumped travel time, Section 4.2) are given directly below each other.

P1689/L26: Please improve your final sentence of the section (there are some limitations, which are typical to hydrological models and in your study unavoidable because of limited data availability).

TECHNICAL CORRECTIONS Suggest to exclude 'Investigating' from the title

P1678/L7: 'In this study, we determined...'

P1678/L9: Please improve the structure of the sentence.

P1678/L12: 'We demonstrate the importance to correctly represent...'

P1678/L14: The expression 'relative balance' is not so nice (use e.g. the fluxes were comparable in magnitude). You can delete 'For the sub-arctic catchment considered in this study'. This balance could shift... (i.e. delete 'between DOC and DIC fluxes as it is already clear).

P1678/L21: 'permafrost warming and thawing'

P1678/L23: please sort the references chronologically

P1678/L25: 'The terrestrial freshwater cycle in the arctic...'

P1679/L9: '...to the surface water system; In addition, permafrost degradation may result in DOC release'

P1679/L11: suggest to replace 'Counter to this' with a better expression

P1679/L13: suggest to rephrase, e.g.: 'Deeper groundwater flow depths would also likely increase DIC formation due to weathering. Such shifts...would have consequences for the global...Increased DIC concentrations could enhance respiration rates in the surface water system, which would impose a positive feedback'

P1679/L21: suggest to delete 'due to climatic changes at northern latitudes' (not necessary)

P1679/L23: suggest to delete 'physical'

P1679/L24: 'In order to predict the fates of solutes, the transport time of water and solutes along the diverse flow pathways through a catchment must be quantified'

P1680/L2: suggest to rephrase, e.g.: 'As hydrological mass transport remains poorly investigated at northern latitudes, an empirical identification of the main solute sources and transport pathways is difficult. One option is to estimate the distributions of solute travel times along different flow and transport pathways through catchments using physical modeling approaches'

P1680/L9: suggest to rephrase, e.g.: 'In this study, we simulated solute travel times based on long-term data from the sub-arctic Swedish Abiskojokken catchment. Our objective was to determine water flow and mass transport effects on the present-day release rates of dissolved carbon from the subsurface landscape to the surface water system.' The last sentence of this paragraph is not necessary (can be deleted).

P1680/L10: suggest to write 'a modeling approach based on solute travel times'

P1680/L17: 'We conducted our study in the sub-arctic 566 km^2 Abiskojokken catchment in northern Sweden, which ranges in elevation...'

P1680/L24: shallow soil and deeper soil (instead of thin and thick)

P1681/L14: suggest to shorten, e.g.: 'Stream water alkalinity at the outlet of Abiskojokken was determined monthly from 1978 through 2008. (...) The annual water flow volume averaged 4.5*10ˆ8 m^3 (1918-2007; Lyon et al., 2009). Daily stream flows are available through (...). During mid-April to mid July and September to October 2008, stream samples were manually collected each week at the outlet of the Abiskojokken catchment. DOC concentrations were analyzed for the first sampling campaign... (n=22). DIC concentrations were calculated for both sampling campaigns... (n=30)'

P1682/L1: Please give city and country of manufacturer (Shimadzu)

P1682/L4: Suggest to delete 'relevant'

P1682/L2: What is PHREEQCI (becomes only clear if one reads the reference list)

P1682/L7: suggest to delete 'long-term' before hydrograph (suggest to delete that throughout the MS and only write hydrograph)

P1682/L12: flow domain freezes, and

P1682/L22: 'We can compare the Qsh and Qd values which we derived from the hydrograph separation...'

P1684/L15: 'We used the...to define'

P1684/L18: suggest to rephrase, e.g.: 'As the groundwater level and slope may be relatively unaffected by small-scale variations in surface elevation (Darracq), the hydraulic gradient...Hillslopes were delineated...as described in...'

P1685/L15: Even though it is trivial, please add the unit for theta and also for As (in line 22)

P1686/L10-16: Please shorten (using the catchment-average travel times gives you the homogeneous release rates, and additionally using the catchment-average flow velocity gives you the homogeneous mass fluxes). The last sentence (This is similar to assuming...) may not be necessary.

P1686/L21: First sentence of section 3.1 is not necessary, as you described it in your methods section.

P1686/L23: please give the standard error of your estimate (52% ±?)

P1687/L8: The first, second and third sentence of section 3.2 are not necessary as you described this in the methodology. Please only refer to your figure 3 and give your estimates of the aquifer thicknesses.

P1687/L18-23: Rather discussion then results; legend of Figure 4: The spatially distributed travel times are given in Fig. 3 not 2.

P1687/L23-26: Please include this into your methodology and delete here.

P1687/L26: Please give standard error with your mean.

P1688/L28/29: Discussion, not result.

P1688/L5: In your figure 4 it looks as if your highest DOC-concentration was prior to May? Please clarify.

P1688/L13ff: This is methodology (Using these flow-weighted...). Please delete and only refer to your results in Table 1

P1688/L21: The verb 'invoke' is not fitting in this context.

P1689/L3: Suggest to delete 'physically' before meaningful.

P1689/L4: 'invoking' does not fit in this context.

P1689/L18: suggest to write 'this type of information could and should be used'

P1689/L20: Suggest to delete 'for Abiskojokken' (statement is valid in general)

P1689/L22: 'it was possible to constrain'

P1690/L5: with observed aquifer depths in deposits (what deposit are you talking about? Please me more specific). How close is the catchment studied in Smedberg et al. 2006 to the Abiskijokken catchment?

P1690/L10-15: You can shorten this section by revising these 3 sentences (from 'Further, the mean advective travel time' to 'near the Abiskojokken catchment') and combining them.

P1690/L19: Suggest to use other expression than 'relative balance' e.g. the DIC and DOC fluxes were comparable in magnitude

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P1690/L21: Please delete this sentence (already written in the results).

P1690/L24: 'a direct connection with wetlands'

P1690/L28: Suggest to move the sentence concerning the study for Sweden forward, just after your statement that your finding differs from many other northern landscapes.

P1691/L8: Are you talking about model representations of the interactions in your final sentence? Please make this clearer.

P1691/L14: 'will generally lead to' or 'led to' (I guess the latter is appropriate in your case)

P1691/L16: 'was underestimated'

P1692/L20: 'This may lead to'; please improve this final sentence of section 4.3