Response to reviewer comments

We thank all reviewers for their constructive comments and are glad that both reviewers found our study interesting and suitable for publication in Biogeoscience after some revision. Below we list our detailed responses in blue.

Reviewer # 1

This paper presents spatial and temporal variability of TOC in soil water and ground-water in riparian zone of boreal forest. Then, the authors argued topographic effects on TOC concentration of soil and groundwater. Also, they discussed roles of spatiotemporal variability of TOC concentration in riparian zone in stream water TOC concentration. I consider that the dataset of this study is important and might be helpful to understand controlling factors of TOC concentration of surface water, soil water, and groundwater in forest ecosystems. I think that not only researchers in cold regions, but also other regions should be interested in this study. However, I have two major concerns about current version of this paper. So, I would like to suggest that the paper is worthy for publication in Biogeoscience, but several revisions are necessary.

Main points

1. Difference in TOC concentration and profile between till and sedimentary parts. The authors suggested that there were different controlling factors for TOC concentration between till and sedimentary parts. So the authors excluded data of sedimentary parts to conduct regression analysis for predicting TOC concentration (Fig. 7). While, the authors argued that TWI should control TOC concentration in till parts. I consider that there are some confusions and discrepancies. I would like to they argued both effects of material and topography simultaneously. For example, I feel that there were no significant differences in absolute concentration and profile of TOC between R15 (sedimentary part) and R1 and R9 (till part). Also, there were no significant differences in TWI. Moreover, as indicated by the authors, TOC concentration in R14 was surely very low, but there was no data for till part with similar large TWI. So, I think that it is very difficult to differentiate effects of material and topography on low TOC concentration in R14. According to Fig. 6c, I suspect that the TOC concentration exhibited the highest value, when the TWI was around 8. In spite of till part, large TWI sties, likes R10, showed relatively small TOC concentrations. Anyway, I would like to the authors conduct more detail and careful discussions about roles of material and topography.

Reply:

> This is a perceptive comment based on the material presented in the paper, and alerts us to the fact that we were influenced by data either not appearing in the paper, or only mentioned briefly. We agree with the reviewer in that it would be statistically impossible to make a clear distinction between riparian zones in the sedimentary parts and the ones in the till/ moraine part if one solely looks at the TOC concentrations. There are two factors we failed to clarify in the text that contribute to the conclusions we drew. First, before we established the dozen riparian soil solution sampling sites reported in this paper, we made a detailed soil survey of the

solid soil along the streams on some 380 transects with soils sampled at 0.5 m, 2m, 4m, 8m, 12m and 25m distances to the stream (Figure 1 in this reply).: These data showed that sedimentary riparian soils were mineral soils with no or only very shallow organic horizons while most till riparian soils had thick peat horizons (>= 30cm) (Figure 2 in this reply). We mentioned the difference between riparian zones in the introduction of the original manuscript (e.g., page 3, lines 12-14) and we refer to the survey in the discussion (original manuscript: page 19, lines 7-11). But these allusions did not adequately emphasize how much the sedimentary and till soils differ in the riparian zones. We also did not point out that in the selection of the dozen riparian soil solution sampling sites we did not try to get “representative” sedimentary sites, but rather used two of the three sedimentary sites to explore what looked to be interesting exceptions. For this reason we have not tried to build a model of the riparian soil solution in the sedimentary soils. We recognize that we need to do more to establish the basis for seeing the soil parent material (sediment or till) as a factor for riparian TOC in addition to the TWI. To clarify this, we have inserted the following sentence into the results part (original manuscript: page 14, line 26):

> “This observation is consistent with the results from a more detailed riparian soil survey (Blomberg, 2009) indicating that RZs in the sedimentary parts are predominantly mineral gley soils.”

We further inserted the following two sentences into the description of the study site (section 2.2):

> “Ten sites were placed in the till part, two in the sedimentary part and one site was placed at the transition between the till and the sedimentary part of the catchment. Placing the majority of the sites in the till part was motivated by a detailed riparian soil survey (Blomberg, 2009). Data from the survey showed that sedimentary riparian soils were mineral soils with no or only very shallow organic horizons while most till riparian soils had thick peat horizons (≥ 30 cm).”

We hope that this provides a more clear explanation why we focused in more detail on till soils than on sedimentary soils for estimating detailed riparian TOC exports. We will try to publish this detailed riparian soil survey of 380 transects in an upcoming paper, and hope that we do not need to use more material from this survey in the current paper.

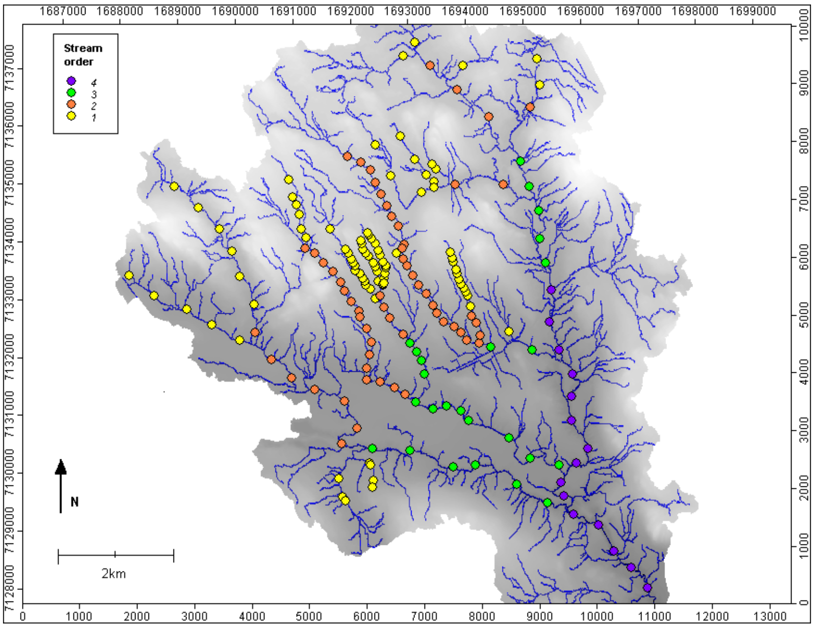

Figure 1: Location of soil transects mid-points (transects were surveyed on both stream sides) and of (intermittent and perennial) streams in the Krycklan catchment. Colors indicate Strahler stream orders (order 1 to 4). Stream orders were assigned based on the perennial stream network.

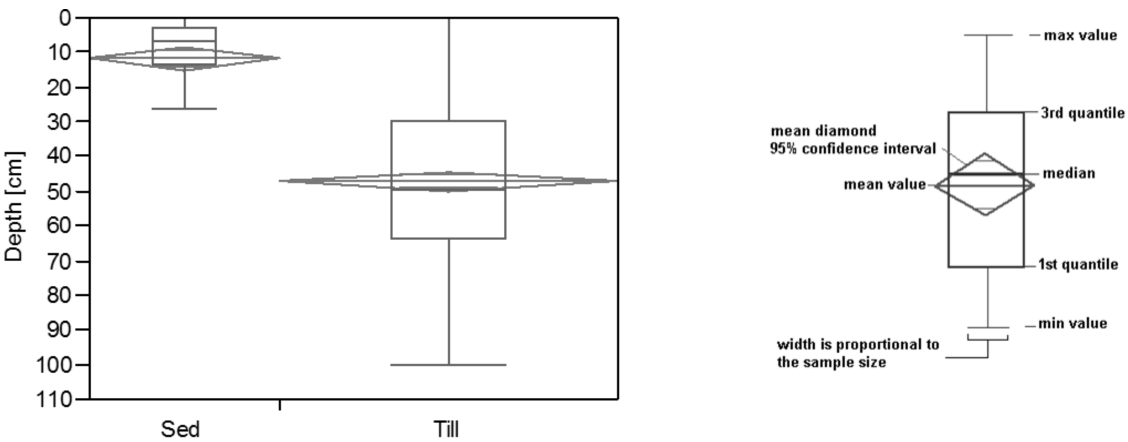

Figure 2: Depth distributions of organic material within 4 m distance to streams. The data set consists of 375 transects (4 soil sampling points at each transect) of which 135 were located in the sedimentary and 240 in the till (moraine) part of the catchment.

2. Temporal variability of TOC concentration and its relation to stream TOC. The authors argued temporal variability of TOC concentration and its relation to stream TOC concentration at the last paragraph of section 6, 1 and section 6.2), However, I consider that this parts were not directly related to the observation results of this study. I fell that several discussions, like effects of hydrologic connectivity, are very speculative and general. The authors showed only time-series data of TOC

concentration, TOC export rate and discharge in Fig. 5. Unfortunately, there were no time-series data of groundwater level, spatial variability of TOC concentration, hydrologic connectivity etc. If the authors want to discuss about temporal variability of stream water in detail, I would like to the authors add several time-series data and discuss more carefully.

Reply:

1) Discussion of implications for stream water TOC

We agree with the reviewer that there was room to improve the discussion by making a more careful distinction between direct interpretation of study results and the more hypothetical discussion of implications for stream water chemistry. We therefore changed the sentence on page 17 line 26. – page 18 line 3 (section 6.1) to stress more the hypothetical nature of the statement:

> "Differential mixing of riparian soil waters from different soil horizons as conceptualized in the RIM (Seibert et al., 2009) model is a mechanism that <u>could explain</u> some of the temporal variability of stream TOC concentrations observed in this and similar <u>catchments as presented by other authors (Köhler et al., 2009; Bishop et al., 2004)</u>."

Similarly, we pointed out that the results of this study do not prove the hypothesis that riparian zones (as conceptualized by the RIM model) generate much of the spatial variability in stream TOC (section 6.1):

> "And, indeed, there seemed to be sufficient spatial variation in RZ types <u>to explain some</u> of the spatial variation in stream TOC concentrations at Krycklan. While <u>the existence of different RZ types does not prove the RIM concept, it is a necessary prerequisite for upscaling RIM from single hillslopes or small headwaters to a spatially distributed representation of riparian TOC exports at the catchment scale</u>."

...and we also added the formulation "<u>can be</u>" to the sentence on page 18 lines 11-13 (section 6.1).

> "By the same token, the range of soil water TOC concentrations as well as the variety of concentration profile shapes and water table positions observed at the ROK sites (Figure 3) indicate that a single representative lumped conceptualization of chemistry or flow pathways in the RZ (e.g. Seibert et al., 2009; Bishop et al., 2004; Boyer et al., 1996; Köhler et al., 2009) <u>can be</u> inappropriate for predicting the spatio-temporal variability of stream TOC concentrations "

Furthermore we strengthened our argumentation by stressing that riparian zones which appear to be homogenous at first sight (but without actually having detailed TOC data) may turn out to be very heterogeneous in regard to TOC concentrations (section 6.1):

> "This appears to be true even when considering only the RZs in the till part of the Krycklan catchment (Figure 3), which one otherwise might easily and mistakenly think of as being rather

homogenous when one does not have the type of spatial detail in TOC concentration measurements that could be obtained with the ROK."

We also put more effort into highlighting our focus on riparian zones by linking the term "export" clearly to riparian zones (following the other reviewer's comments). We hope that with these more careful formulations readers be able to distinguish direct interpretation of our observations from the discussion of possible implications. We think that the latter more hypothetical discussion is valuable and necessary to place our results into a larger context. However, we also believe that adding more data from stream observations is out of the frame of this study which is already quite detailed.

2) Hydrological connectivity, spatial variability and TOC time-series

Hydrological connectivity

We use the term hydrological connectivity in the vertical sense, with the view that vertically layered soil horizons with different TOC concentrations become "connected" by vertically rising groundwater levels. This type of "vertical" soil-horizon-connectivity is different from a more "lateral" view on landscape-element-connectivity as for example used by Jencso et al. (2009). Since we also found a good relation between groundwater levels and stream flow (manuscript-figure 4) that varied relatively synchronously with streamflow (Figure 3 in this reply) we only presented streamflow conditions in manuscript-figure 5 as a 'global proxy' for groundwater table conditions. We had previously linked "connectivity to soil horizons" (see e.g., page 20, lines 16-19). However, to make the link between streamflow conditions and groundwater levels clearer, we changed the sentence on page 21 lines 1-4 (section 6.2) to:

"Variations of TOC exports from wet RZs were largely related to changes in soil water TOC concentrations while variations in TOC exports from humid RZs were related to changing groundwater tables (which were correlated to streamflow conditions as illustrated by figures 4 and 5) and varying soil water TOC concentrations.

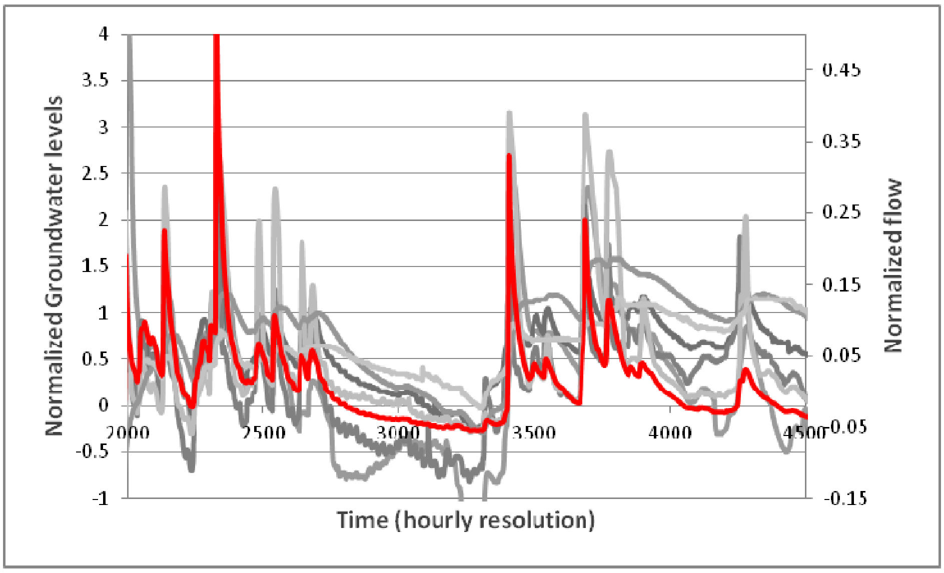

Figure 3: Time series of streamflow (red line) and riparian groundwater levels measured at the observatory. Groundwater levels and streamflow were normalized for better comparison. Overall streamflow and groundwater levels vary relatively synchronously although the relation differs between sites (which is accounted for by fitting groundwater-streamflow relations separately for each site).

We also removed a potentially unclear part (related to hydrological connectivity) from the sentence in the discussion section 6.1:

> "For this simple model to be scalable to entire stream networks, much the considerable spatial variability in stream TOC would need to derive from lateral exports from different types of RZs and wetlands along the stream network ~~together with their temporally varying hydrological connectivity to the stream~~."

3) Spatial variability and TOC –time-series

Given the effort and cost involved to obtain and analyze large number of soil water samples it is very difficult to obtain high-resolution data for riparian TOC profiles in both space and time. To our knowledge, this study is currently one of the most detailed investigations on temporal ***and*** spatial variations of riparian TOC concentrations and TOC exports from riparian zones. Adding stream related times series data is outside the scope of the study as we would like to keep the focus on the variability between different RZs. Still, we find it is valuable to place this detailed riparian study into a wider context by discussing the *potential* implications for stream water chemistry. However, we agree with both reviewers that there is a need for more careful formulations to (1) better differentiate between the discussion of *actual* and their *potential* implications for stream water chemistry as well as to (2) avoid over generalization of our observations. We addressed this by adding added two new paragraphs to the discussion section 6.2 including references to other papers that have focused on the time-series of stream DOC and adapting the conclusions. (Please see also our reply to reviewer #2)

New paragraph at the beginning of section 6.2:

"The RIM concept (Winterdahl et al., 2011b; Seibert et al., 2009) was used to calculate riparian TOC export rates. RIM only accounts for riparian TOC exported by lateral subsurface flows through a single, chemostatic soil profile. Consequently, other potential flow pathways (such as groundwater recharge to the streambed or overland flow) and biogeochemical processes during transport through the RZ were not taken into account. The effect of alternative flow pathways which could partially bypass the RZ was not assessed in detail, though other studies have confirmed the strong relationship between stream flow and riparian groundwater levels (Seibert et al., 2002). However, periods of potential overland flow as indicated by groundwater levels above surface were relatively limited at most ROK sites (Table 1). This also agrees with the transmissivity feedback mechanism (Bishop, 1991; Bishop et al., 2011), which implies that even during relatively high discharge conditions most runoff reaches the stream as shallow subsurface flow rather than as overland flow. That 1991 study also examined lateral versus vertical hydraulic gradients during stream events and concluded that on two till hillslopes in the vicinity of the ROK, upwelling groundwater is not a major factor as lateral subsurface flow is the dominant flow component. "

New paragraph at the end of section 6.2:

“It is noteworthy that TOC exported from the RZ, and in particular its labile fraction, might be subject to additional processes in the hyporheic zone. Although we hypothesize that much of the estimated lateral riparian TOC exports reaches the stream, a part of it might be metabolized in either the hyporheic zone or within the stream itself and transformed to dissolved inorganic carbon (DIC). The low rates of TOC breakdown relative to the short time that water spends in the largely shaded stream channel of the Krycklan streams (Wallin et al., 2010) and measured rates of TOC mineralization (Köhler et al., 2002) indicate, however, that only a few percent of the TOC will be mineralized in the stream. The rate of hyporheic processing of TOC has not, to our knowledge, been quantified in Fennoscandian streams, or been suggested to be a major factor in downstream patterns of TOC (Temnerud et al., 2007).”

Minor points

1) I cannot find Table 2.

   Reply: Thanks you for noticing this mistake. In fact there should be no “Table 2” in the text. We corrected this and replaced all occurrences of “Table 2” with “Table 1”.

2) I feel that several figures are too small.
   Reply: We re-arranged the subplots in figures 5 and 6 and hope that this will allow for increasing the size of subplots during typesetting / printing of the final draft.

Reviewer # 2

The authors describe the results of a study of the spatial variation of TOC concentrations and fluxes in subsurface waters of the riparian zone at the Krycklan catchment in northern Sweden. Overall, the paper is well organized, well written, and the methods and assumptions of the study appear to be reasonable. This is an excellent study of aspects of spatial variation of TOC in a well-studied riparian boreal catchment, and will make a nice addition to the literature on riparian biogeochemistry and relations to landscape geomorphology. The weakest part of the paper lies in a few places where overstatements are made and proper consideration and caution regarding the limitations of this data set and the modeling approach have not been made. But these are generally fairly minor concerns, and overall this is a strong paper.

Main points

1) Use of the term export – I believe that term export has very specific meaning in the catchment biogeochemistry literature, and refers to export of solute mass via streamflow. Here, the authors use this term somewhat inappropriately to describe what is essentially a modeled flux of TOC across a defined cross-sectional area. So, I much prefer the term flux here, not just as a personal word choice, but because there are many spatial considerations and potential processes that might change this TOC flux before it is exported from the catchment.
   Reply: We understand the reviewer’s concern about potential confusions. However, we think that the term “export” is relatively unambiguous when used in close conjunction with the source/ system boundary, which is the riparian zone in this study. Thus, to improve clarity, we used the term “flux” where appropriate but <u>added the key word “riparian” or “RZ” to any</u>

occurrence of the term "export" (including in the manuscript title) that was not already previously clearly linked to the RZ. We also complemented the discussion section by indicating that processes in the hyporheic zone could influence riparian TOC exports before they ultimately reach the outlet of the catchment. (Please see also our reply to Comment 3))

2) Additionally, there are transport pathways such as overland flow that are an important part of TOC export from riparian zones, yet were not considered in this study.

   Reply: Overland flow did not seem to occur often at our studied riparian study sites (see Table 1). We agree, however, that overland flow can play an important role and consequently added it (together with other alternative flow pathways) to the discussion (section 6.2) and conclusion (section 7).

New paragraph at the beginning of section 6.2:

"The RIM concept (Winterdahl et al., 2011b; Seibert et al., 2009) was used to calculate riparian TOC export rates. RIM only accounts for riparian TOC exported by lateral subsurface flows through a single, chemostatic soil profile. Consequently, other potential flow pathways (such as groundwater recharge to the streambed or overland flow) and biogeochemical processes during transport through the RZ were not taken into account. The effect of alternative flow pathways which could partially bypass the RZ was not assessed in detail, though other studies have confirmed the strong relationship between stream flow and riparian groundwater levels (Seibert et al., 2002). However, periods of potential overland flow as indicated by groundwater levels above surface were relatively limited at most ROK sites (Table 1). This also agrees with the transmissivity feedback mechanism (Bishop, 1991; Bishop et al., 2011), which implies that even during relatively high discharge conditions most runoff reaches the stream as shallow subsurface flow rather than as overland flow. That 1991 study also examined lateral versus vertical hydraulic gradients during stream events and concluded that on two till hillslopes in the vicinity of the ROK, upwelling groundwater is not a major factor as lateral subsurface flow is the dominant flow component. "

New sentence in the conclusion:

"The interplay of varying lateral flow pathways and heterogeneity of riparian zones can be expected to be similarly crucial for transport processes involving other key parameters of water quality such as nitrate or heavy metals. While lateral subsurface flow is the major transport pathway through the riparian zones of Krycklan, alternative pathways such as overland flow or groundwater recharge to streams can be more important in other catchments."

3) Furthermore, biogeochemical processes in the hyporheic zone as well as in the stream channel were not considered, and might alter TOC export as well.

Reply: We now mention potential effects of hyporheic processes on riparian TOC exports in a separate paragraph at the end of the discussion (section 6.2):

> "It is noteworthy that TOC exported from the RZ, and in particular its labile fraction, might be subject to additional processes in the hyporheic zone. Although we hypothesize that much of the estimated lateral riparian TOC exports reaches the stream, a part of it might be metabolized in either the hyporheic zone or within the stream itself and transformed to dissolved inorganic carbon (DIC). The low rates of TOC breakdown relative to the short time that water spends in the largely shaded stream channel of the Krycklan streams (Wallin et al., 2010) and measured rates of TOC mineralization (Köhler et al., 2002) indicate, however, that only a few percent of the TOC will be mineralized in the stream. The rate of hyporheic processing of TOC has not, to our knowledge, been quantified in Fennoscandian streams, or been suggested to be a major factor in downstream patterns of TOC (Temnerud et al., 2007)."

Furthermore, we added the hyporheic zone as one of the 'recipients' of riparian TOC exports into the first sentence of the introduction:

> Introduction:
> "Being located directly adjacent to streams, the riparian zone (RZ) is the last strip of land in contact with groundwater before it discharges into the stream network <u>or into the hyporheic zone</u>."

In-stream processing of TOC probably plays a minor role for catchment-scale exports in Krycklan due to short stream residence times, low water temperatures and mostly recalcitrant TOC. We added a corresponding sentence in a new paragraph at the end of section 6.2 (see also our reply to comment 4)).

"The low rates of TOC breakdown relative to the short time that water spends in the largely shaded stream channel of the Krycklan streams (Wallin et al., 2010) and measured rates of TOC mineralization (Köhler et al., 2002) indicate, however, that only a few percent of the TOC will be mineralized in the stream."

4) Secondly, this study did not really explore systematic lateral changes in TOC with distance from the stream channel, another factor that could change the flux from what was observed at the static points sampled here prior to stream export. These concerns are relevant to Section 6.2 of the Discussion as well as in the Conclusion Section at line 19.

Reply: We interpret this comment as raising a question about the influence of upslope water moving through the riparian zone during flow events. This has been explored in great detail along one transect through the riparian zone where we have over a decade of data from both upslope and riparian zone soil water (Winterdahl et al., 2011a). That detailed evaluation of the soil water pattern moving away from the stream, and its dynamics over time, has shown that there is little influence of the upslope water on the riparian DOC within a year, or even year to year. Therefore, we do not expect much change in lateral TOC export from the riparian zone as a result of upslope influences in the short term. We highlighted this also in a new paragraph in the beginning of discussion section 6.2. (Please see also our reply to Comment 5 immediately below))

New paragraph at the beginning of section 6.2:

"The RIM concept (Winterdahl et al., 2011b; Seibert et al., 2009) was used to calculate riparian TOC export rates. RIM only accounts for riparian TOC exported by lateral subsurface flows through a single, chemostatic soil profile. Consequently, other potential flow pathways (such as groundwater recharge to the streambed or overland flow) and biogeochemical processes during transport through the RZ were not taken into account. The effect of alternative flow pathways which could partially bypass the RZ was not assessed in detail, though other studies have confirmed the strong relationship between stream flow and riparian groundwater levels (Seibert et al., 2002). However, periods of potential overland flow as indicated by groundwater levels above surface were relatively limited at most ROK sites (Table 1). This also agrees with the transmissivity feedback mechanism (Bishop, 1991; Bishop et al., 2011), which implies that even during relatively high discharge conditions most runoff reaches the stream as shallow subsurface flow rather than as overland flow. That 1991 study also examined lateral versus vertical hydraulic gradients during stream events and concluded that on two till hillslopes in the vicinity of the ROK, upwelling groundwater is not a major factor as lateral subsurface flow is the dominant flow component. "

5) Assumption of only lateral flow in the riparian zone – The modeling approach applied here assumes all relevant flow is strictly lateral in the riparian zone. This is not necessarily a bad assumption, but there are many published studies that demonstrate upward flow of somewhat deeper groundwater, especially as one gets closer to the stream channel. And of course the classic conceptualization of groundwater – stream water interactions shows upward curving flow lines delivering water to the stream bed— so called "Tothian" flow if I remember correctly from hydrogeology class. It is important to remember that there are different combinations of mixing that could yield the concentrations and export of TOC measured in streams. Some combination of deeper groundwater with low TOC, shallow groundwater with high TOC as measured in this study, and finally overland flow from saturated areas that might have even greater TOC concentrations. Again, it is important to acknowledge here that you have a specific conceptualization of lateral shallow flow as being most important for transporting TOC to streams, and you have in this study ignored the upwelling into the stream of deeper groundwater, which may be part of a more complete understanding of stream TOC export.

Reply: We added the following part of a new paragraph in the beginning of the discussion section 6.2 to point out these other potential flow pathways:

"However, periods of potential overland flow as indicated by groundwater levels above surface were relatively limited at most ROK sites (Table 1). This also agrees with the transmissivity feedback mechanism (Bishop, 1991; Bishop et al., 2011), which implies that even during relatively high discharge conditions most runoff reaches the stream as shallow subsurface flow rather than as overland flow. That 1991 study also examined lateral versus vertical hydraulic gradients during stream events and concluded that on two till hillslopes in the vicinity of the ROK, upwelling groundwater is not a major factor as lateral subsurface flow is the dominant flow component."

6) The limits of a two-dimensional conceptualization – I agree that this work clearly shows much heterogeneity of TOC profiles with depth in subsurface water. The implications of this work are that models based on lumped representations of the riparian zone may be inaccurate as the authors' state. But it is important to remember that this study did not systematically explore the third dimension going from upland areas across the riparian zone towards the stream. In soils with abundant shallow organic matter as here, and lateral flow towards the stream, one would expect TOC to increase during transit. So, even though the work reported here is a great improvement in riparian spatial conceptualization, this other dimension towards the stream was not studied and may be another important consideration when modeling TOC in subsurface waters of riparian zones.

Reply: We agree that we do not consider the third dimension, i.e. the distance from the stream. The motivation for this simplification is the assumption that the riparian zone acts as a chemostat and basically resets the DOC in water coming from upslope. The incoming DOC is still of interest in a long-time perspective, but we focus on a shorter time perspective in this paper where the riparian zone controls DOC exports to the stream (i.e. the last meters before the stream) rather than the upslope areas (Cory et al., 2007).

Minor points

o Page 6, line 4 – not familiar with term "paludification" of soils here and throughout the text. Is this a well-known term for journal audience?

Reply: We reformulated the sentence on page 6 line 4 to clarify this term for readers who were not familiar with it, even though in certain traditions of geomorphology paludification is a standard term:

"Over the course of millennia, considerable amounts of organic matter were built up in boreal ecosystems (particularly in areas underlain by glacial till) through the formation of valley bottom peat soils and wetlands (paludification)."

We also omitted the word "paludified" in an earlier sentence (page 5, line 9 – 11) by changing the sentence to:

"Most streams have their headwaters in the till parts of the catchment where the combination of gentle topography and less permeable substrate has led to the formation of some small lakes, wetlands and hydromorphic riparian peat soils.."

o Page 12, line 26 – "Spearman" should be capitalized.

Reply: Done!

o Page 13, line 11 – sometimes minor predictor variables can be significant in multivariate regressions, even if these variables are not major standalone variables in bivariate regressions.

Reply: While we agree that also minor variables can be significant in multivariate regressions, we prefer to use only TWI for the sake of simplicity. To make this clear, we modified a sentence in the results section 5.3 (page 16, line 26) by adding "For simplicity," to its beginning:

"<u>For simplicity</u>, only TWI was selected for regression modeling since it correlated more with observed average TOC concentrations (rs = 0.67) than slope and laterally contributing area (rs= -0.65 and rs = 0.58 respectively)."

o Page 17, line 14 – need comma between scatter and points.

Reply: Done! Thanks -the comma makes it indeed much more readable.

o Page 21, line 9 – change "to" to "of" so would read vicinity "of" streams.

Reply: Done!

o Page 21, line 10 – slight changes might affect hyporheic dynamics short of the greater changes that might be expected with a full reversal of flow direction.

Reply: We added a paragraph at the end of the discussion in section 6.2 that highlights potential influences of processes in the hyporheic zone. (Please refer to our reply to Comment 3))

o Page 24, line 6 – lumped representations of riparian zones at catchment scale are probably inadequate, seems to be true at Krycklan, but can this statement be made as generalization? Supporting evidence from other studies?

Reply: We reformulated this statement by to:

"The marked heterogeneity of riparian zones also indicated that lumped representations of riparian zones at the catchment scale <u>can be</u> overly simplistic and highlights the need <u>both</u> for more distributed RZ representations <u>and more studies of variability in the riparian zone of other landscapes.</u>"

o Page 25, line 6 – should capitalize Minnesota.

Reply: Done! (Typo was caused by an issue with Endnote™)

o Page 25, line 15 – should capitalize Svartberget.

Reply: Done! (Typo was caused by an issue with Endnote™)

o Page 27, line 6 – should capitalize Fennoscandian.

Reply: Done! (Typo was caused by an issue with Endnote™)

o Page 30, line 10 – should capitalize Wisconsin.

Reply: Done! (Typo was caused by an issue with Endnote™)

o Page 30, line 15 – should capitalize “S”.

Reply: Done! (Typo was caused by an issue with Endnote™)

o Page 30, line 23 – should capitalize Swedish.

Reply: Done! (Typo was caused by an issue with Endnote™)

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