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Interactive comment on "Dissolved organic carbon (DOC) in Arctic ground ice" *by* M. Fritz et al.

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Reply to Anonymous Referee No.1

We are grateful for the review and acknowledge your comments and suggestions. You will find all replies or changes that have been made below. Reviewer comments are cited in italic font.

Best regards,
Michael Fritz

(on behalf of the co-authors)

Title: *I recommend a little more info. How about: "The chemical composition and fate of organic carbon (DOC) in Arctic ground ice"*

We would like to keep the original title as it is concise and meaningful to us. We do not present the chemical composition of DOC.

Abstract:
Line 4: *The "their" is confusing. I think you mean "Permafrost" but the previous sentence ends with info on nutrients so it seems like that is what "their" refers to.*

Replaced by "permafrost".

Line 9: *"using biogeochemical data"*

Changed accordingly.

Line 17: *just a curiosity: why refer to snow melt as "pristine" and not just as "snowmelt"?*

In the course of the discussion we come back to this point, because ion-poor (i.e. pristine) snowmelt is able to leach inorganic and organic matter.

Line 20: *Perhaps start the "In the yedoma" with "We found that in the Yedoma..."*

Changed accordingly.

Lines 22-25: *This is the first time particulate OC is mentioned and it is a main focus of this last sentence. I recommend introducing some of the POC results, data, etc, to set this up. Maybe one sentence to do that?*

The abstract might not be the right chapter to extend the explanation on POC stock/relevance, because our manuscript does not rely on POC data. More information on the size and relevance of permafrost OC pools, also in comparison with DOC data in this study, is given in the following parts of the manuscript: p.79 L. 23ff, p.80 L. 7ff., p.89 L. 5ff., p91 L. 23ff.

Page 80: Line 7: *"several studies have shed light"*

Changed accordingly.

Page 82: Line 10: *"It is" is vague. The previous sentence covers a lot of topics so you have to be more specific.*

changed into: "DOC in intrasedimental ice is, however,. . ."

Page 83: *The Section title has "component" but line 25 has "components". Be consistent.*

Component!! Changed accordingly.

Page 85:
Line 10: *do the "mean concentrations" refer to DIC? If so then state that for clarity.*

DIC added.

Line 12-13: *the sentence that starts with "It is obvious" is unnecessary. Move the "Basal glacier ice" sentence to the end of the previous paragraph.*

Changed accordingly.

Page 86: Line 20: *"those with more of a continental"*

Changed accordingly.

Page 89: Line 26: *"sources that have been"*

Changed accordingly.

Page 90:
Line 4: *"into frost cracks"?*

There is no need to change anything because the text already reads this way.

Line 7: *Unless any of the "leachable components" are close to saturation in other*

precipitation/ water courses (which is highly unlikely) the "initial purity" of the snow is irrelevant. I recommend removing this sentence.

Dou et al. (2008) have shown that the ionic and chemical composition of the solvent plays a role in the ability and strength to leach DOC from permafrost. Therefore, we would like to keep the sentence.

Line 8-10: *The "Snow melt feeding" sentence: See previous comment and:*
1) There are a ton of papers on the age and lability of the DOC in rivers at melt and some suggest this surface flow (ie at snow melt) has bioavailable C. So it is not necessary that the bioavailable C has from lower down in the soil column.
2) As the spring snow melt waters trickle downward toward the ice wedges they interact with basal soil material (frozen or not) and this could leaches out carbon.
3) Also- since wedges take thousands of years to form and the location of their upper surface likely changes with time there are plenty of spatial and temporal ways that deeper soil pore waters can get integrated into the wedge ice.
I recommend some of these ideas be introduced or discussed. The fact that the snow has little ionic strength is not a potential reason for this. And I agree the waters at snow melt start at the surface but they do trickle downward and are not likely frozen until the following winter so there is ample time for subsequent waters, interacting with a deeper active layer, could incorporate deeper carbon.

Above the discussed paragraph we added the following information: "As the spring snow melt waters trickle downward toward the ice wedges they interact with the basal soil material leaching out carbon. Also, since wedges may take thousands of years to form and the location of their upper surface changes with time, there are plenty of spatial and temporal ways that deeper soil pore waters can get integrated into the wedge ice."

Pages 89-90: *Somewhere in here or elsewhere (?) it is worth noting the potential mineral weathering signature to which their samples provide context. For example- could*

the major cations and bicarbonate could be used to decipher silicate versus carbonate weathering. Since carbonate weathering occurs more rapidly with silicate weathering (particularly where "fresh" mineral surfaces are available) their study might be able to use this to identify where in the active layer some compounds are sourced? They could explore a few quick ternary diagrams of Ca, Mg, and Na+K and of SO4, HCO3, and Cl. I suspect there will be some unique trends and if/where the signatures are more carbonate based they could be able to decipher the location in the soil column? IE the "fresh" mineral surfaces are likely toward the base of the active layer (exposed to weathering the least amount of time on an annual basis). Caveat: the marine localities may have a swamped HCO3 and Cl signal so it is possible that this will not work. But I recommend they make the plots to explore it. This is in no way a requirement by me for acceptance, etc. Just that they have a unique data set and I am trying to see if there is more info that can be teased from it.

These are very good points. Unfortunately, we are not aware of any indices, based on the major ion composition in ground ice, to discuss the strength of silicate versus carbonate weathering in permafrost. A detailed study of the solid and liquid mineral composition along depth profiles would be necessary. With such an approach one could determine which layers are prone to leaching and at what depth/age of the deposits does the leaching/weathering happen. For now, we have only dealt with ground ice but not with the whole permafrost systems in a holistic approach.

Page 92: Line 20: *"while deposition occurred"*

Changed into "during deposition" as reviewer 2 recommended.

Page 93: Line 20: *I do not like use of the word "overproportionally" I am sorry I cannot provide a better word to use but it has a lot of chemical and physical connotations and I am not sure it is clear enough. Perhaps keep it but then provide what is being "overproportionally" loaded?*

We deleted the word.

Table 2 and discussion in the text: *Are there any data from non-thermokarst ponds? Or perhaps find it in the literature? It would be good for a comparison in this Table and for the study because thermokarst ponds likely have an outsized amount of mineral weathering (ie ions), and carbon (ie leaching from exposed blocks of soil and degraded permafrost). As such, comparing to non-thermokarst ponds could help identify whether there are significant differences?*

The purpose of showing the data on modern surface water was to get an idea about the magnitudes of DOC concentrations we are dealing with. Now, the reader knows that they are comparable. Further reading is recommended to Walter Anthony et al. (2014) where they show more data on DOC in Yedoma and non-Yedoma bottom lake water in eastern Siberia near Cherskii. We do not want to speculate here about the processes why lakes in different geological and catchment settings have different hydrochemical characteristics. On page 91 we also discuss that runoff into lakes and rivers might be already degraded by microbial communities and photochemical reactions in contrast to ground ice. As the focus of this paper is on ground ice we try to keep the presented information as close as possible to our manuscript goals.

Interactive comment on The Cryosphere Discuss., 9, 77, 2015.