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Interactive comment on "Carbon dynamics and changing winter conditions: a review of current understanding and future research directions" *by* M. Haei and H. Laudon

Anonymous Referee #2

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General comments: Ecosystems which experience long or deep winters also tend to contain large standing stocks of organic carbon, mostly in soils. Climate warming, especially at high latitudes, is expected to be more pronounced in winter than in summer, and there is potential for significant impacts of winter warming on long-term ecosystem function and carbon dynamics. The subject matter of this review is therefore timely and important, and one which would be of significant interest to BG readers.

I think the authors are correct in saying that winter processes have been understudied, and this ms does present a useful collation of the available research. However, at present, there is little in the way of synthesis and the presentation is lacking. The text jumps back and forth between different processes and ecosystems with no clear

development of ideas or arguments.

Part of the problem is that the review is presented as Methods, Results and Discussion sections. No new data are presented (there is no meta-analysis) which is perfectly OK, but then it doesn't make sense to me to have a methods and results section – the results section mostly just lists the results of previously published papers and isn't necessary (but do summarise the results of the literature search e.g. search terms, numbers of papers published on each topic etc.).

The ms would be significantly improved, and would have much greater impact, if instead it was structured around describing the important concepts and/or processes which govern C cycling responses to winter conditions (for example main sections on "Projected winter climate change" or "Mechanisms of DOC export from soils" etc). Each section would then explain the concept or process, how it works, why it is important, what the main uncertainties are etc. This has partially been done in places, e.g. section 4.1, and I really like figure 2. However, the take home messages from the literature need to be much more strongly emphasised, and some substantive conclusions provided at the end of the manuscript (over and above highlighting the need for more research).

In general the language should be more precise and specific – there are quite a few instances where the authors make ambiguous statements. I've given examples below so it is clear what I'm talking about, but I haven't made exhaustive minor edits because I expect the text will have to change substantially to address the issues above.

A recent review of the effects of thawing on soil gas fluxes should be cited (Kim et al. 2012)

Specific comments:

Introduction P. 15764 L. 23-26: This information on terrestrial C stocks in "northern ecosystems" needs to be more specific – how are you defining northern ecosystems?

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I would suggest giving values for carbon stocks. There are also more recent relevant estimates of terrestrial C stocks than those available in Hobbie et al 2000 (e.g. (Hugelius et al. 2014))

Results P. 15768 L. 16-17. Sentence beginning “Most field and laboratory studies. . .” Do you mean an increase in DOC in the soil solution? Or delivery of DOC to the aquatic system? Does “field studies” include long-term observational data? It is also not clear what the increased DOC is in response to. Are you referring to increased severity of freezing or the effect of a single freeze thaw event compared to unfrozen conditions? The following sentences go into details, but the meaning of the first sentence of the paragraph should be clear.

Discussion P15773 L.22-24.This is another example of a general statement which is ambiguous. The clause “showing that cold soils and soil frost generally enhance organic carbon concentrations” could mean any number of different things; enhanced organic C concentrations in soils, in soil pore water, in streams etc. I’m also not sure that all available/relevant studies on carbon in both organic and inorganic forms have been included (e.g. Bokhorst et al. 2008; Nowinski et al. 2010; Grogan 2012)

References Bokhorst, S., Bjerke, J.W., Bowles, F.W., Melillo, J., Callaghan, T. V. & Phoenix, G.K. (2008) Impacts of extreme winter warming in the sub-Arctic: growing season responses of dwarf shrub heathland. Global Change Biology, 1–10.

Grogan, P. (2012) Cold Season Respiration Across a Low Arctic Landscape: the Influence of Vegetation Type, Snow Depth, and Interannual Climatic Variation. Arctic, Antarctic, and Alpine Research, 44, 446–456.

Hugelius, G., Strauss, J., Zubrzycki, S., Harden, J.W., Schuur, E. a. G., Ping, C.L., Schirrmeister, L., Grosse, G., Michaelson, G.J., Koven, C.D., O’Donnell, J. a., Elberling, B., Mishra, U., Camill, P., Yu, Z., Palmtag, J. & Kuhry, P. (2014) Estimated stocks of circumpolar permafrost carbon with quantified uncertainty ranges and identified data gaps. Biogeosciences, 11, 6573–6593.

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Kim, D.G., Vargas, R., Bond-Lamberty, B. & Turetsky, M.R. (2012) Effects of soil rewetting and thawing on soil gas fluxes: A review of current literature and suggestions for future research. Biogeosciences, 9, 2459–2483.

Nowinski, N.S., Taneva, L., Trumbore, S.E. & Welker, J.M. (2010) Decomposition of old organic matter as a result of deeper active layers in a snow depth manipulation experiment. Oecologia, 163, 785–792.

Interactive comment on Biogeosciences Discuss., 12, 15763, 2015.