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Interactive comment on "Radiocarbon Measurements of Ecosystem Respiration and Soil Pore-Space CO_2 in Utqiaġvik (Barrow), Alaska" *by* Lydia J. S. Vaughn and Margaret S. Torn

Anonymous Referee #1

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General comments: Overall quality & discussion of the paper. This manuscript presents a unique and important dataset of ïĄĎ 14C-CO2 soil and ecosystem respiration from a high-latitude polygonal tundra site. The data are important because they provide insight to the stability of old permafrost C and the conditions under which old permafrost C stocks could be released to the atmosphere. Overall the paper is well written although I think that it would be helpful to have more background about the ecosystem and context for why the different polygonal tundra features might affect ïĄĎ 14C-CO2. Specifically, what might explain some of the ïĄĎ 14C differences shown in Figure 1 and 2? If thaw depth does not explain the differences, is there anything else that might? Moisture, vegetation type, organic soil content, amount of cryotrubation?

The respired and profile ïĄĎ 14C measurements are a very nice complement to each other because they really let us understand production vs. release mechanisms for soil C. One challenge with the profile data is that we don't know the time scale over which the old 14C has accumulated. There could be lots of really old 14C because of slow diffusion rates and high accumulation. For example (Lee et al. 2010) measure very high Co2 concentrations deep in the soil profile and attribute this to low diffusion rates rather than high production rates. Of course this is difficult to solve and perhaps under steady-state assumption the accumulated CO2 is constantly being produced and diffusing out of the soil profile, and the 14C reflects the decomposability of old C and therefore it's eventual release to the atmosphere. Perhaps the authors could add 1-2 sentences about this, simply to point out some of the complexities with interpreting the data. A few additional comments below point out a few places where more consistent data presentation would make the manuscript more reader friendly and reduce some confusion that I encountered. Beyond that, I think this manuscript documents an important and interesting data set and should be published.

Data and code could be accessed with the DOI and links provided!

Specific comments: Individual questions & issues, and technical comments

Overall data presentation: Year/month is inconsistent. Sometimes month is reported with year, sometimes without. For example, figure 1 ignores years, while figure 4 explicitly represents years. That's confusing. How important do the authors think that year is? Can year be left out?

Table & Figure comments: Can a seasonal Reco flux rate figure be added?

Tables: The tables are tough to read. Could some of the environmental data be summarized in a figure and the tables moved to the supplement? As I understand it all the CO2 flux data is shown in figures so the tables aren't critical for the reader to understand the patterns.

Figure 2: Is the data the same as in Figure 1, September? It looks different. . .. Flat has 14C<0 in Figure 1 and >0 in Figure 2

Figure 3: Can the month in the legend be written as a month name (ie: July, September)? That would be much easier to read.

Figure 4: Can the legend be Flat2-Center-August 2012, Flat4 Center July 2013, etc? Would be easier to read. Even if there is no overall temporal and spatial pattern could the lines in the figure be systematically grouped? One colour for each location, and a different symbol+line type for early/late months? It might be conceptually helpful to have a horizontal line at 0cm to indicate the soil surface, and perhaps put the chamber flux data at +2cm?

Line-by-line minor comments: Page 1: Line 29-30: Cite Bond-Lamberty soil respiration database paper?

Line 34: something is missing in the end of the sentence, the grammar/tense is wrong: 'heterotrophic decomposition of soil carbon that cycles on broad range of timescales'

Page 2: Line 5: 'thaw depth' is not an obvious variable here without introducing permafrost? To some extent thaw depth is captured by soil temperature. Perhaps 'soil C pool' would be useful to add? Or maybe 'permafrost state'?

Line 6: what does 'such variations' refer to?

Line 7: the jump from environmental controls to use or availability of soil C substrate pools is a bit unclear. I think clarifying whether 'such variations' refers to 14C or variation in environmental factors would help. I suggest explicitly naming the variation that is meant, rather than 'such variations'.

Line 11: parameters of what?

Line 17: consider also citing (Elberling et al. 2013, Schädel et al. 2013)

Line 21-22: something is missing from this sentence

Line 24: (Schuur et al. 2009, Nowinski et al. 2010) ?

Line 26: It would be helpful to explain, in a few sentences, what polygonal tundra is, why it's important, and what unique features it has (eg: drained vs saturated microsites, C accumulation, temperature regimes). (Ping et al. 2015) might be a useful reference. This is mentioned in the methods, and I think it would be worth a brief mention in the introduction too.

Page 3:

Line 17: chamber height? Or volume?

Line 19-20: Oh, I see. I would move this sentence one earlier.

Page 5: Line 3: what is the mean 13C value of these samples? Is it possible that this 13C value largely represents autotrophic respiration, rather than soil respiration? My guess would be that the chambers with rapid CO2 accumulation and the highest Co2 concentrations have high plant respiration.

Line 10: This is a good idea for dual filtering criteria. I like it.

Page 7:

Line 25: is the data in figure 2 a subset of figure 1? The patterns between polygons in September look different in the two figures, and I can't understand why.

Line 30: profiles of what?

Line 32: I feel this needs a little more elaboration: 'At the scale of individual profiles seasonal variations in ïĄĎ 14C Reco correspond with changes in thaw', that's inferred from seasonal pattern of ïĄĎ 14C Reco decreasing as thaw exposes deeper parts of the soil profile? In contrast, across sites, there is no correlation between thaw and ïĄĎ 14C Reco.

Page 8: Line 6: I think this should be reworded to something like: 'As a result, old,

slow-cycling C from deep Reco comprises a large percentage of the total C flux only when autototrophic and surface soil (or fast-cycling) contributions are low. I think that might be a more accurate generalization, rather than old soil contributions being high when Reco rates are low, because there could be a number of reasons for low Reco rates like overall low plant&microbial activity, which might not affect the ïĄĎ 14C.

Line 18 -24: That's really interesting! Line 19: Should this be 'Figure 4'??

Line 24: The reason why cryoturbation may explain the more positive ïĄĎ 14C at depth may only be obvious to people familiar with permafrost dynamics? One sentence would be sufficient to say that cryoturbation can transport large chunks of surface/organic material deeper into the profile.

Page 10: Line 5: But these slow cycling contributions might be missed when measuring surface ïĄĎ 14C fluxes alone?

Line 14: the distinction between newly thaw and historical annual thaw might be very difficult for people without an Arctic/permafrost background to understand. Perhaps elaborate a little what this means and why it matters. Newly thawed does not refer to new C, it is newly exposed old C, I think that's a very permafrost-specific concept.

References

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