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Interactive comment on "Environmental controls on ecosystem-scale cold season methane and carbon dioxide fluxes in an Arctic tundra ecosystem" *by* Dean Howard et al.

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The authors wish to thank the anonymous reviewer for their time and for their constructive comments regarding the manuscript. We believe this feedback has had a large, positive impact on the outcome of the current manuscript. We present below the reviewer's comments, along with our responses and any changes made to the manuscript or supporting information in bullets. Line numbers correspond to the new version of the manuscript submitted along with these responses. Any changes made to the manuscript/SI are marked in blue within the respective document.

Reviewer 2: The paper "Environmental controls on ecosystem-scale cold season

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Discussion paper

methane and carbon dioxide fluxes in an Arctic tundra ecosystem" by Howard et al. presents new year-round measurements and analysis of methane and carbon dioxide fluxes and environmental variables in an under sampled ecosystem type. Through well-reasoned and well-written description, the authors differentiate the impacts of soil temperature on microbial activity in the upper and lower portions of the active soil profile, specifically highlighting the role that unfrozen deep layer soil can have on the total methane emissions in Arctic tundra. This is an important insight, supported by in-situ data, that is worthy of rapid publication in Biogeosciences and may significantly impact future understanding of this system in a changing climate.

Specific minor comments and suggestions follow below:

1. The laboratory study in lines 43-46 seems a bit old to be the only one mentioned. Have there now been any more recent studies of these relationships? Perhaps the incubation studies on page 11 could be integrated into this introduction?

- The newest reference we could find that considered both rates of methanotrophy and methanogenesis (Schipper et al., 2014; doi: 10.1111/gcb.12596) is a development of thermodynamic theory that was applied to the Dunfield et al. (1993) data. Unfortunately, the references on page 11 refer to only one process or the other.

- No changes made.

2. The additional measurements are clearly useful to have. More emphasis could be added at the end of the introduction relating to what sets this study location apart from those in Zona et al. 2016.

- As suggested, we added some additional discussion here relating to expansion of year-round data sets in different study locations.

- Included in line 56: “(four on coastal plains and tundra dominated by sedges, grasses, and mosses within the northern coastal region surrounding Utqiaġvik and one over tussock-sedge dwarf-shrub, moss tundra at Ivotuk on the North Slope of the Brooks Range, Walker et al., 2005),”
- Included in line 70: “expand our coverage of year-round methane and carbon dioxide exchange data sets across different bioclimates and landscapes, as well as”

3. Is the gap-filling in line 133 applied with daily value for days with at least some PAR< 5? This is a bit unclear.

- We agree that this was a little unclear, thank you. The gap filling was actually applied on the half-hourly data and we have included information to explain this in the text.
- Included in line 155: “half-hourly”

4. The large range cited for the wet sedge tundra site in line 227 is a result of a changing state at this location, rather than the representative variability of wet sedge itself.

- We have added some additional discussion to reflect this point.
- Included in line 265: “The low end of the range of values quoted for wet sedge tundra (2 g C m^{-2} h^{-1}, Euskirchen, et al., 2012) is based on a period when active season deposition largely balanced cold season emission; Euskirchen et al. (2017) report in their longer-term study of this wet sedge site a trend towards larger annual net emission values that are largely attributed to increasing cold season emission, with little trend seen for active season deposition. They note an

increase in September–December carbon dioxide emission of 1.34 g C m^{-2} for each additional day of zero curtain (freezing season) length. Here, the observed difference was much larger, with an additional 126 g C m^{-2} loss observed in Year 1 over a 10 day longer freezing season (Table 2)."

5. Additional discussion could be added after line 400 relating to what happens to the methane flux in the case that high VWC soil freezes. Does frozen water present in the soil inhibit the gas transfer upward from the methanogens?

- This is a good point and related to another that Reviewer 1 had regarding soil pore gas concentrations. In addition to the inclusion of soil pore gas measurements and the surrounding discussion, we have expanded the discussion at this point to refer specifically to diffusion inhibition.
- Included in line 458: "Evidence of this reduced oxygen diffusivity, as well as inhibition of gas diffusion through the soil profile, can be seen in the soil pore gas measurements in Fig. S3, where melting ice in the Year 2 thawing season resulted in a sharp decrease in soil pore oxygen concentration, as well as a build-up of methane and carbon dioxide concentrations in the upper 40 cm. Flooding of the sample inlets unfortunately precluded the collection of any such evidence in the Year 1 thawing season. Decreased gas diffusivity during these periods likely contributed to a suppression of the methane flux, which were amongst the lowest seen throughout the year (leaf group 6 in Fig. 3)."

6. Perhaps toward the end of section 3.5 point out the importance of additional soil temperature information to improving gridded products, which are needed to fully quantify regional to pan-Arctic scale carbon fluxes.

- We are not overly familiar with such gridded products, but we tried. . .

- Included in line 507: “This is particularly important for large-scale soil monitoring networks such as the Soil Climate Analysis Network (SCAN), the outputs from which are important for enabling gridded modelling products for quantifying regional-scale carbon fluxes.”

7. Could the letter labels from Figure 2 be added to their appropriate time positions in Figure 1? This would better link the data during the description sections.

- They sure can!
- Included letters in Figure 1 and altered caption.

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