

## General comments

The paper "Vegetation Influence and Environmental Controls on Greenhouse Gas Fluxes from a Drained Thermokarst Lake in the Western Canadian Arctic" by June Skeeter et al. reports CO<sub>2</sub> and CH<sub>4</sub> flux measurements from a permafrost tundra site in Western Canada. Eddy covariance and chamber flux measurements were taken during the growing season 2016, and analysed accounting for the spatial variability of vegetation cover. Statistical gap-filling and an analysis of the environmental controls of the fluxes is performed using artificial neural networks. I think the chosen methods are properly applied and explained. The results are presented clearly and the conclusions are supported by the results. Also, the paper is very well written.

Given the remote and rather special site location, this study should be very valuable for the arctic carbon flux community. As the flux time series collected in your study may be used and referred to in future studies, it would be nice if you could present the time series in a more raw format than you do in Figure 2. For example, a plot of the 30-minute flux time series would help to understand the character of the data. This is also relevant, because I guess the performance and output of your NNs could be susceptible to noise or outliers in the EC time series.

[Responses]

We changed Fig 2 to show the half hourly  $F_{CO_2}$  and  $F_{CH_4}$  observations, along with the  $NEE_{NN}$  and  $NME_{NN}$ .

Also, several of your results (cf. Line 221 and Line 342) are based on extrapolations into parts of the parameter space where the flux response could be governed by processes not captured in your NNs. Perhaps these statistical uncertainties could be discussed.

[Responses]

We added a sentence at the end of section 2.5.1 discussing the impact of calculating ER by extrapolation and its impact on the confidence of ER estimates relative to NEE [Lines 265-267]. We refer the reader to Appendix A for details on the calculation of confidence intervals around NN outputs [Lines 501 -521]. We also added a sentence to section 4.3 noting that projecting to Sedge = 100% is well outside of parameter space [Lines 433-434].

I understand there is little research from DTLB sites, but it would be good in your discussion to relate your findings to those from other tundra sites with (and without) thermokarst. In this discussion, it would be good to elaborate further on the peculiarities of the artificial draining performed at your site. Given the title of this paper, readers will probably expect more of these aspects discussed.

[Responses]

We split the results into two separate sections "results" (Section 3) and "discussion" (Section 4). In section 4.1 we discuss NEE and NME observations at Illisarvik relative to natural shrub vs. sedge-dominated DTLB to highlight the differences among these environments rather than attempt to fully contrast Illisarvik to a myriad of arctic tundra types/sites. These comparisons are always challenging given different years, time periods within a year, instrumentation, and data presentation. However, we believe we make a strong argument that shrub vs. sedge-dominated DTLB have the potential to differ and Illisarvik differs in particular from all other DTLB in its low methane emissions. (Table 4). We now further highlight the important implications of vegetation succession on CO<sub>2</sub> and CH<sub>4</sub> fluxes at our site in the discussion section 4.3 "Future Trajectories". This is one of the key messages associated with DTLBs – they undergo relatively rapid vegetation change over a number of decades that will influence their C budgets.

## Specific comments

**Line 16: "During the study period". Please be more specific here, because the upscaled average fluxes you mention in lines 18 and 20/21 don't tell much if you don't know the study period.**

[Responses]

Changed wording to "peak growing season" Line 16

**Line 24: Your abstract lacks a broader conclusion**

[Responses]

We added another sentence to make a broader conclusion about plant succession and Illisarvik's carbon balance, Lines 25-26

**Line 100: Could the grazing have a measurable effect on e.g. NEE? It could be a point to add to your discussion.**

[Responses]

Good point, we added a few words to mention that grazing may have affected GHG Fluxes [Lines 121-122]. It is possible that grazing had some impact, but we cannot answer this based on the data collected. According to images from a fish eye camera mounted on the tripod (taken at 5-minute intervals), the animals spent about an hour gazing within the footprint of the eddy-covariance tower. In other areas of the basin where they stayed for longer, there was definitely a more significant impact. They were only spotted within the footprint the morning of July 12th. In addition to the fish eye camera images, we were present at the field site during the full campaign and observed the reindeer's movements.

**Line 116: You discarded a sector because its flow could be disturbed by the tower. But did you see this effect in any of your quality checks? Maybe it's not necessary to discard this data.**

[Responses]

It is standard practice to discard winds affected in the wake of the tower and sensor head. We have added a reference to Aubinet et al., 2012 to support this choice. During light winds, windspeeds can be reduced as much as 50% in the wake of a tower/instrument mount and turbulent eddies are artificially created, significantly violating the assumptions that go into eddy-covariance flux calculations. We oriented the tower such that this wind sector was the least frequent (according to climatology from Tuktoyaktuk). It only resulted in 6.7% (86 of 1279) half hourly observations being discarded.

**Line 146: Maybe be more specific about the Python modules you used, otherwise this sentence adds very little to the understanding of your analysis.**

[Responses]

We removed this portion of the manuscript. Most of the code was written specifically for the project by the first author, the footprint model of Kljun et al. 2015 is available in multiple programming languages, and we mention the python module for the neural networks on Line 243 and discuss the procedures in more in the appendix.

**Line 182: Shouldn't there be five times more vials than flux estimates, if you used 5 gas samples per flux measurement?**

[Responses]

Yes, that is correct. The sentence has been corrected [Lines 202-203]. The '681 flux measurements' referred to the three different gas fluxes each measurement produced (CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O). For clarity, we have removed this number (681) and we now only refer to CO<sub>2</sub> and CH<sub>4</sub> flux measurements (see also reply to reviewer #1)

**Line 292: "Random forest regression tree". Did you use only one decision tree, or the ensemble mean of several?**

[Responses]

It was the ensemble mean of 100 trees. We removed this from the text however. In retrospect, it was beyond the scope/point of the paper. Discussing the choices made for the random forest (RF) analysis would have required a new section in the methods. But since we didn't use it in the results (beyond this one comparison), this didn't seem necessary. Instead, we added a paragraph to the appendix [Lines 522-532] discussing why we RF weren't the best choice for this analysis and we added Figure A2 to support this.

**Line 296: Maybe refer to an equation defining alpha.**

[Responses]

Alpha in this context is analogous to the minimum of the first derivative of the neural network output; which was calculated numerically. We added a new equation (Eq. 5) in section 2.5.1 [Line 258] to show a light response curve and clarified section 3.3 to better describe this [Line 332-334].

#### **Technical corrections**

**Line 75: Did you really mean 100 m, or maybe km?**

[Responses]

Yes, the antient basin, is just 100m to the south, it can be seen in Figure 1a (labeled 6b) and 1c in the top left of the drone image.

**Lines 302/303: Pa, with a capital P Line 310: "both"?**

[Responses]

Corrected, we also decided to use kPa instead

**Please check and correct the names of your references in the text, as several have spelling mistakes ("Whalen and Reedburgh", "Merbould", "Meyer-Smith")**

[Responses]

Thank you. We corrected these spelling mistakes.

**Figure 3b: Can you add a little bit of horizontal white space between the the Sedge plot and the rest? I think this could prevent confusion and make it clear that the y-axis for this box has a different scale**

[Responses]

We added the requested horizontal space and put "Sedge" into a separate subplot of the same figure.