RC1: 'Comment on bg-2021-308', Thomas Friborg, 27 Jan 2022 reply

Lindroth et al. Moist moss tundra on Kapp Linne, Svalbard is a net source of 1 CO2 and CH4 to the atmosphere.

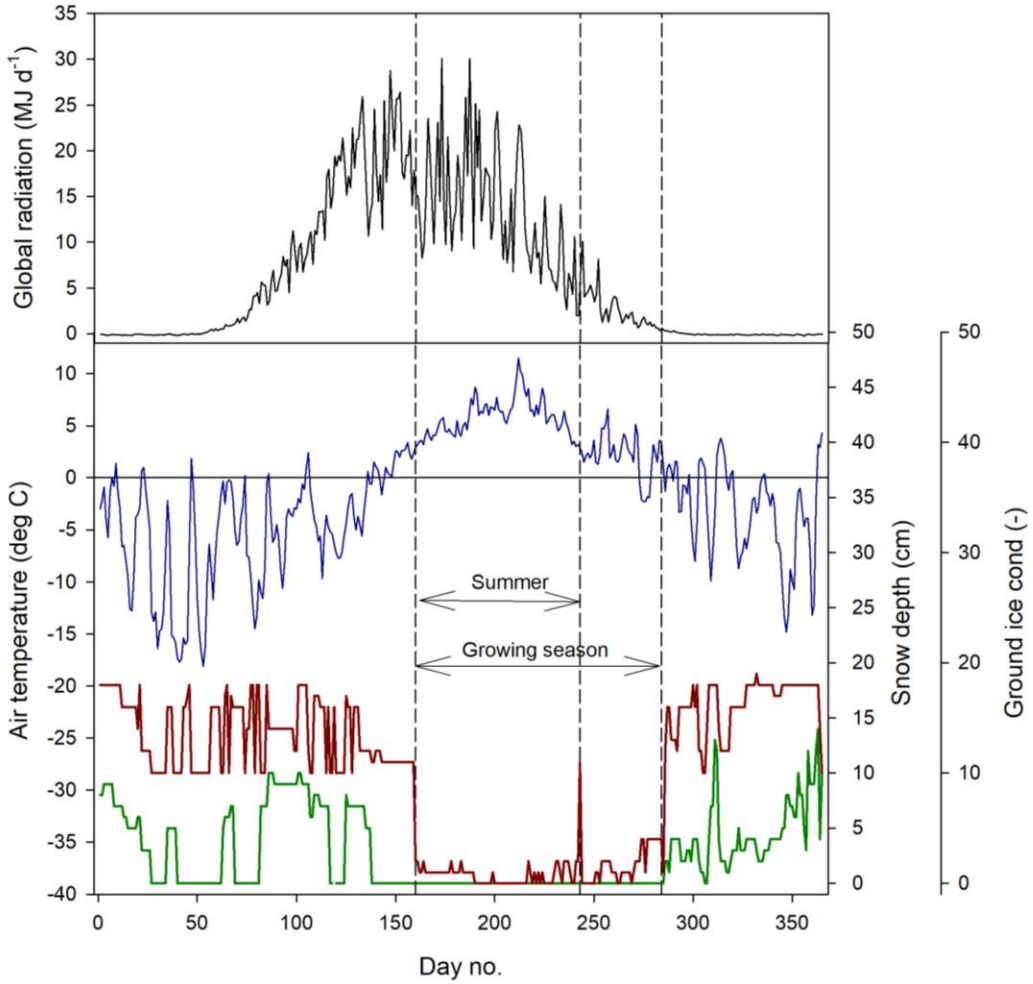
Overall:

The ms addresses GHG measurements from a very remote part of the World and in the high arctic. As pointed out in the introduction few trustworthy measurements are available from the high Artic area as a whole and especially full year estimates and measurements are rare. The ms is written in an unpretentious way and aim to fill a piece of the GHG puzzle of the Arctic ecosystems, where also seasonal observations can be appreciated. As such measurements from the summer (late June – mid September) 2015 are reported on and also used for an interpretation of the annual CO2 /CH4 GHG budget of this tundra landscape.

So far so good. When I despite this feel that the authors still need to do some work with this ms it is because I find that especially the interpretation is take a bit further than the data can justify. Even if several assumptions are made (which is fine) it is not clear to the reader why some of the figures look like they do or why e.g. there are uncertainty of some definitions (e.g. growing/summer season) which I find confusing and suboptimal for the further interpretation of the data. I was first puzzled by the way data was presented in fig. 8 where supposing half hourly observations are compiled into a bi-weekly plot, leaving a peculiar impression of the dynamics of summer season in this ecosystem. It also leaves you with the impression that the peak of the summer is missing. However, it was not until I downloaded the data (which the general reader will not do) that I discovered that a whole month of data from later July to late August is completely missing in the flux observations. This should be made very clear in text as well as a general improvement of the description of the data coverage, which is not apparent from the figures and is critical for the further interpretation of the data. Based on this it is difficult for the reader to have confidence in the annual flux estimates (despite assumptions made) when also the peak of summer is missing in observations.

Answer:

1. The reason why we chose to have two different definitions of growing season is because there is no standardized definition of growing season. We mention this in L 503. This is illustrated by e.g Oechel et al. (2014) which used five different definitions of growing season. But we also agree that we could be more explicit in our formulations and we suggest the following changes: We retain only one definition of growing season, the one based on permanence of snow cover and we are more explicit in the definition of 'summer' period which now does not include the first 8 days in June where there was a snow cover. Thus, summer is here defined as the period from 9 June to 31 August. Accordingly, we also changed Figure 2 (see below).



2. Concerning flux observations, we agree that we should have given more details about data coverage. However, the gapfilling of the missing data is made with a well-established and thoroughly tested tool (Wutzler et al. 2018) which is commonly used by the flux community and which we have confidence in. We added the following ". The total data coverage during this period was 47% with a longer break in the measurements between 28 July and 29 August."

3. Regarding comment about 'missing peak of summer season'. We agree that Fig. 8 does not give a good description of the dynamics of the system and we therefore suggest to remove Fig. 8 and instead show a figure of the diurnal course of NEE during each of the months June-September (new Fig. 8, see below). We also suggest to add a Fig. 9 showing the cumulative NEE during the growing season. It is obvious from these new figures that we did not 'miss' the peak of the summer season but that the high respiration and the relatively low GPP resulted in a very flat behavior of the season course (previous Fig. 8) when averaging was made over several 24 h cycles.

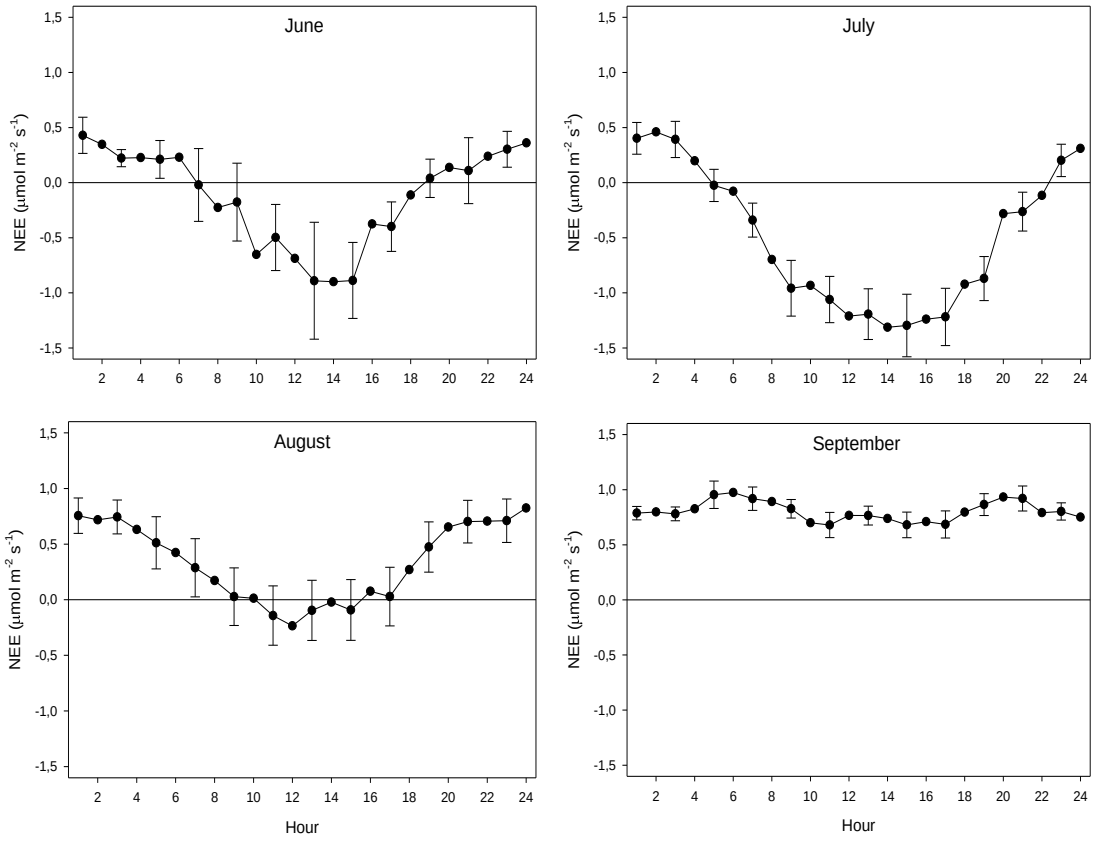


Figure 8. The mean monthly diurnal course of NEE during the period of eddy covariance measurements 25 June to 17 September. The error bars (only every 2nd is shown) are the 95% confidence interval.

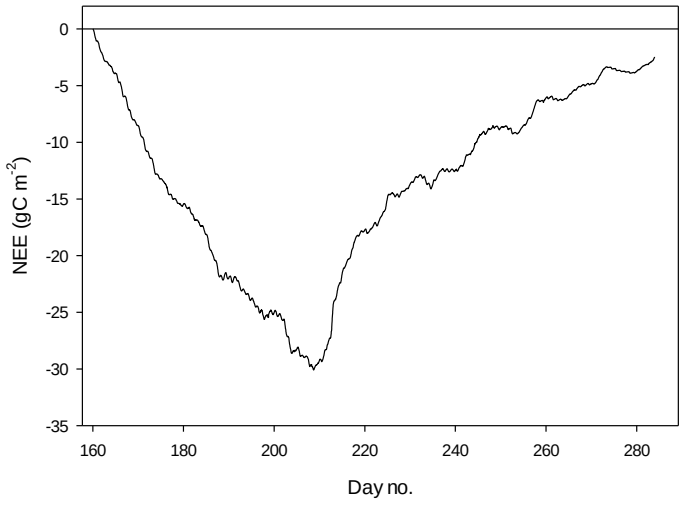


Figure 9. The cumulated half-hourly NEE during growing season.

It would therefore be my recommendation that the revised manuscript relied more on the direct comparison of the measured data and the observed balance in GHG effect during the summer season, and made less attempts to extrapolate these into annual values, which it is difficult to have any confidence in. The observed data are rare and look fine (those which are there) and the authors could avoid a lot of the uncertainty by having a focus on that and a more direct comparison with other seasonal measurements from the Arctic.

Answer: We agree that the winter extrapolation is uncertain and that a focus on growing season is better. Thanks to this comment we discovered an error in the spread sheet calculation of growing season estimate and since we also adjusted the summer period a little, our numbers changed for both for summer and for growing season. We include a new Table 2 with the correct numbers (see below).

Table 2. Summary of seasonal C-fluxes from Kapp Linne.

Period	Component	Value ($gC\ m^{-2}$)
Growing season	Reco	110.2
	GPP	-112.7
	NEE	-2.5
Summer	Reco	94.1
	GPP	-105.9
	NEE	-11.8

Specific:

L22: the numbers seems to contradict the conclusion L535

Answer: We have skipped the calculation of GWP values based on recommendation from another reviewer.

L74: other studies could be mentioned e.g. Jammet 2017- Year-round CH4 and CO2 flux dynamics in two contrasting freshwater ecosystems of the subarctic, Biogeosciences, 14, 5189–5216, 2017 https://doi.org/10.5194/bg-14-5189-2017

Answer: Thanks, we have added a reference but choose Jammet et al. (2015) instead.

Jammet, M., Crill, P., Dengel, S. and Friborg, T.: Large methane emissions from a subarctic lake during spring thaw: Mechanisms and landscape significance. J. Geophys. Res.-Biogeo., 120, 2289-2305, http://doi.org/10.1002/2015JG003137, 2015.

L117: the hypothesis seems unargued and not very helpful, e.g. what is average CH4 flux ? please strengthen

Answer: We changed the text to 'We hypothesise that this moist tundra ecosystem is a net carbon sink during the growing season and that the summer emissions of methane will be at levels comparable with other methane emitting high Arctic ecosystems.'

L187: Some of these observations are quite far away, please reflect on the impact of that.

Answer: We will add the following text to that section: Using data from the more distant locations, Svalbard airport and Adventdalen, introduces some additional uncertainty. Concerning global radiation data we could compare in situ measured half-hourly radiation with the corresponding data from Adventdalen for a shorter period and it showed general good agreement although with relatively large scatter ($y = 0.84x + 15.9$; $r^2=0.57$; $n=580$). According to Dobler et al. (2020) the amount of precipitation in the area where Kapp Linne and Svalbard airport are located don't show any significant differences on an annual basis and Vickers et al. (2020) analysed timing of snow cover in Svalbard and they show that the mean (2000-2019) first snow-free day is very similar in areas where Kapp Linne and Svalbard airport are located. Thus, we are confident that using data from these relatively remote locations does not introduce serious bias in our analyses.

L291: I find the definitions of the seasons difficult to relate precisely to e.g. what is "*daily air temperature started to stay above zero more steadily*" or "*when most of the snow had disappeared*" – quantified how?

Answer: We have removed the temperature dependent definition as described above and we try to be more precise in definition of the growing season as described above.

L330: a further sub-division of the vaguely defined season does not help me. Please consider a simplification.

Answer: Good point, we have changed the text to specific dates.

Table 1: May all be significant but none of the three explain much of the variance – please explain

Answer: We don't see any other reason than that there is a large scatter in the data as shown in Fig. 4 and that there are several variables that affect the CO_2 fluxes.

L367: No permafrost here???

Answer: This whole paragraph (L362-L369) is removed since we focus on growing season.

Figure 8: as indicated earlier I find the time steps and general impression of the seasonal variability off and not a good representation of the actual measurements.

Answer: See above, Fig. 8 replaced by new plus a new Fig. 9.

Figure 9: I have difficulties with this one as well both because of the negative GPP values – negative photosynthesis? Which appears because GPP is normalized for light response. I don't think the you can do that with two parameters which as dependent as temperature and light.

Answer: It is a common procedure to estimate a 'light response curve' from measurements of the net exchange without considering effects of temperature. We believe that such curves truly show the overall light response and that the temperature response is shown by the scatter around the light response curve. In this paper we have used the sign convention that a positive flux is upwards from the ecosystem into the atmosphere and vice versa for a negative flux. Thus, negative GPP means uptake. But as always when working with EC measurements there is a scatter in the data because of the nature of turbulent exchange (see e.g. Fig. 7). Thus, getting both positive and negative values in a situation like this is not unusual. It is the overall response that is important and not the individual points. If we are convinced that the light response curve reflect the impact of light on the processes, then the method that we have used should be in order.