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Interactive comment on "Contribution of the nongrowing season to annual N_2O emissions from the continuous permafrost region in Northeast China" *by* Weifeng Gao et al.

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Dear Referee:

Thank you for your letter and the constructive comments on our manuscript entitled "Contribution of the nongrowing season to annual N2O emissions from the continuous permafrost region in Northeast China" (No.: bg-2020-305). The comments are very helpful for improving our paper, as well as the important guiding significance to our research. We have revised the manuscript carefully according to the comments, which we hope meet with approval. Major modifications in the revised manuscript were noted

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Discussion paper

as yellow. All the responses to your comments are as following:

General comments

1. This MS evaluates the contribution of nongrowing season to annual N2O emissions, but during the winter period, N2O emission was not measured for almost the entire period from December to February. Although the authors state that winter period is longer than soil thawing period and therefore has more cumulative N2O emission (L482-490), there are no measurements that adequately cover this period. By linear interpolation, it is estimated that N2O emission continues to occur during this unmeasured period (Figure 1). However, could significant N2O emission occur during soil freezing? The authors should clearly explain the question of the legitimacy of the integrated release estimate caused by the lack of frequency of measurements.

The authors' answer:

Thank you for your meaningful suggestion. Previous studies reported that freezing-thawing cycles (include spring thaw period and autumn freezing period) had a significantly influence on the N2O emissions. We are also concerned about this issue. During this study period, we reported the response of N2O emissions to spring thaw period in the permafrost region. We found that there were no significantly burst or pulse of N2O emissions (range from -35.75 to 74.16 μg m-2 h-1) as observed in other ecosystems (Gao et al., 2018). From 27 September to 11 November 2019, we measured the N2O emission every week during the autumn freezing period. The results showed that the N2O emissions were ranged from -4.21 to 12.86 μg m-2 h-1 during the autumn freezing season (Unpublished). The N2O emissions were not significantly released during the soil freezing. Indeed, the sampling of N2O emissions during the winter were lack. According your meaningful suggestion, we clearly explained the question of the legitimacy of the integrated release estimate caused by the lack of frequency of measurements. In brief, the temporal variation of N2O emission during the nongrowing season were relatively stable in the permafrost-affect soils (Pei et al., 2004; Du et al.,

2016; Cao et al., 2018; Du et al., 2008; Kato et al., 2013). Significantly N2O emissions were only observed in October (autumn freezing period) in the subarctic (Marushchak et al., 2011). Thus, we estimated that the N2O emissions during the nongrowing season in the Daxing'an Mountains were relatively stable like previous studies (Pei et al., 2004;Du et al., 2016;Cao et al., 2018;Du et al., 2008;Kato et al., 2013). Please see L455-471.

Reference:

Cao, Y. F., Ke, X., Guo, X. W., Cao, G. M., and Du, Y. O.: Nitrous oxide emission rates over 10 years in an alpine meadow on the Tibetan Plateau, Pol J Environ Stud, 27, 1353-1358, https://doi.org/10.15244/pjoes/76795, 2018. Du, Y., Cui, Y., Xu, X., Liang, D., Long, R., and Cao, G.: Nitrous oxide emissions from two alpine meadows in the Qinghai-Tibetan Plateau, Plant Soil, 311, 245-254, https://doi.org/10.1007/s11104-008-9727-9, 2008. Du, Y. G., Guo, X. W., Cao, G. M., Wang, B., Pan, G. Y., and Liu, D. L.: Simulation and prediction of nitrous oxide emission by the water and nitrogen management model on the Tibetan plateau, Biochem Syst Ecol, 65, 49-56, https://doi.org/10.1016/j.bse.2016.02.002, 2016. Gao, W. F., Yao, Y. L., Gao, D. W., Wang, H., Song, L. Q., Sheng, H. C., Cai, T. J., and Liang, H.: Responses of N2O emissions to spring thaw period in a typical continuous permafrost region of the Daxing'an Mountains, northeast China, Atmos Environ, 214, 116822, https://doi.org/10.1016/j.atmosenv.2019.116822, 2019. Kato, T., Toyoda, S., Yoshida, N., Tang, Y. H., and Wada, E.: Isotopomer and isotopologue signatures of N2O produced in alpine ecosystems on the Qinghai-Tibetan Plateau, Rapid Commun Mass Sp, 27, 1517-1526, https://doi.org/10.1002/rcm.6595, 2013. Marushchak, M. E., Pitkamaki, A., Koponen, H., Biasi, C., Seppala, M., and Martikainen, P. J.: Hot spots for nitrous oxide emissions found in different types of permafrost peatlands, Global Change Biol, 17, 2601-2614, https://doi.org/10.1111/j.1365-2486.2011.02442.x, 2011. Pei, Z. Y., Ouyang, H., Zhou, C. P., and Xu, X. L.: N2O exchange within a soil and atmosphere profile in alpine grasslands on the Qinghai-Xizang Plateau, Acta Bot Sin, 46, 20-28,

https://doi.org/10.1046/j.1365-3180.2003.00373.x, 2004.

2. Although the MS focuses on N2O emissions during the nongrowing season, there are many descriptions that focus on the growing season (e.g., L295-298, 511-532); the discussion should be substantially reconstructed to focus on the description of nongrowing season.

The authors' answer:

Thank you for your meaningful suggestion. In the manuscript, we reconstructed the discussion. The description of discussion during the growing season were reduced. We fucus on the description of nongrowing season N2O emissions and highlighting the importance of N2O emissions during the nongrowing season.

3. "N2O emission is low in winter because the temperature is low". To state this, there is no need for redundant discussion as in this MS. Figures 3 and 4 are a rehash of the data presented in the previous section, but there is no significance in averaging the N2O emissions for each period and verifying the correlation with temperature again. Throughout the discussion, there are many overlapping statements. Environmental factors other than temperature are almost completely absent from the discussion. Although measurements were taken at three sites, there is no comparison between the sites. In light of the above, the discussion should be thoroughly restructured.

The authors' answer:

Thank you for your meaningful suggestion. We deleted the discussion of the difference of N2O emissions among different periods. We revised and deleted the overlapping statements. According you suggestion, we discussed the difference of nongrowing season N2O emissions among the three swamp forest types. Except for soil temperature, we discussed the effect of other environment factors on the N2O emissions. Please see Discussion 4.1 and 4.3.

Specific comments

1. L120-129: It is described as a “permafrost region”, but there is almost no information about permafrost (e.g., thickness of permafrost layer, active layer depth, soil thawing period, etc.)

The authors’ answer: Thank you for your meaningful suggestion. We have added the information about the permafrost. Please see L123-126.

2. L170-171: Did you place the collar in a different location for each measurement?

The authors’ answer: No, the collars were permanently inserted into the soil during the whole study period. On each measurement, the chamber was placed on the collar and filled with water to collect N2O emitted from the soil.

3. L201-205: Were soil samples taken for each gas measurement?

The authors’ answer: Yes. During each gas measurement, the soil sample were taken close to each collar except for the spring thaw period in 2017. The N2O emissions were measured every three to ten days during the spring thaw period, but the soil samples were taken every ten days. Gas samples were collected 45 times and soil samples were collected 38 times. The temporal variation of environment factors was shown in Fig. 2.

4. Figure 1: What do the error bars indicate?

The authors’ answer: The error bars were standard deviation (SD). We have added it in the Figure and tables.

5. L310-334: Soil C/N, TOC, and TN have been shown to be controlling factors for the temporal variations of N2O emissions, but do these values change over time like N2O emissions?

The authors’ answer: During the entire measurement, there had temporal variation on the soil C/N, TOC, and TN. We added the description and the figure of seasonal changes in environmental factors. Please see L227-259.

6. In this analysis, is there any spatial variation between iterations mixed in with the temporal variation? To verify the temporal variations, we should average the replications and then correlate them with environmental factors.

The authors' answer: Thank you for your meaningful suggestion. We used Pearson's correlation analysis, linear correlation analysis, and multivariate regression analysis to analyze the relationship between N2O emissions and corresponding environmental factors from each collar. According to your suggestion, we averaged the replications and then correlate them with environmental factors. After the average, the amount of data were small, and partial results became no significantly correlations. The analysis used in the manuscript would be more significantly.

7. In addition, the seasonal changes in environmental factors are not shown, so it is difficult to judge the correlation. L403-412: I think it should be shown in the results.

The authors' answer: Thank you for your meaningful suggestion. In the result section, we added the description and the Figure of seasonal changes in environmental factors. Meanwhile, we added the difference of soil environment factors among the three type of swamp forests (Table 1). Please see L227-275. According to your suggestion, we put the L403-412 to the results section.

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