The MS entitled “Nitrous oxide emissions from pan-Arctic terrestrial ecosystems: A process-based biogeochemistry model analysis from 1969 to 2019” revised the Terrestrial Ecosystem Model (TEM) to quantify the temporal and spatial variability of $N_2O$ emission from Arctic ecosystems in the context of warming climate. The research topic is interesting and within the scope of the journal. The results are interesting and valuable for publication. But the MS is not particularly well organized. It may be accepted for publication after major revisions to clarify the following questions.

i) It is not clear what capabilities the original and enhanced models have. The authors may consider adding a schematic of key modules included in the existing and enhanced model to provide readers with an overview.

ii) As you shown, the $N_2O$ diffusion coefficient used in this study is a constant value of $1.26 \times 10^{-6}$ $m^2$ $s^{-1}$, which might vary with the air-filled porosity or moisture of soils.

iii) The equations should be cited in the text of the MS, which will be more readable. And make sure that all the variables and parameters were illustrated and correctly explained in the text. For example, $N_N$ was refered to the nitrification in Line 101, but NN might be the nitrification rate. And what $f_{nit}$ and $f_{deni}$ were refered to? And there were so many variables and parameters should be illustrated.

iv) The hypothesis that C and N density are uniformly distributed in vertical was not consistent with the actual status, which should be decreased with soil depth. The literature Wang et al., 2020, you cited, calculated the SOC stock at different depths with 1-m increment from the collected observed SOC content.

v) Why the simulated $N_2O$ emission from parameterization remained as the constant for several data in wet tundra. But the simulated $N_2O$ emissions with average parameters were varied for the same data in wet tundra.

In addition, the language and grammar should be improved throughout the text and some sentences are hard to understand.

***Specific comments:*** The author needs to align the whole text at both ends and change the paragraph spacing to be consistent.

Suggested modification for the title:

Nitrous oxide emissions from pan-Arctic terrestrial ecosystems from 1969 to 2019 based on a process-based biogeochemistry model

The difference between the MS and other studies and the shortages and future studies should be summarized at the end of the Abstract.

The production processes of and the influence factors on soil $N_2O$ uptake from the atmosphere should be stated in the Introduction section.

Line 6-9: Please provide thecomplete and right organizations.

Line 10: add “*” to the corresponding author.

Line 57: Change “Arctic” to “pan-Arctic” and changed them throughout the MS.

Line 17: add “,” between “...the Terrestrial Ecosystem Model (TEM)” and “to incorporate...”.

Line 21-22: Change “...1.2 - 1.3 Tg N $yr^{-1}$” to “...1.2 − 1.3 Tg N $yr^{-1}$”; “...1.1 - 1.2 Tg N $yr^{-1}$” to “...1.1 − 1.2 Tg N $yr^{-1}$”; “...0.1 Tg N $yr^{-1}$” to “...0.1 Tg N $yr^{-1}$”. Check the full text and change it.

Line 25: Modified the unit “...mg N m $r^{-1}$”.

Line 36: It is necessary to show how much permafrost soils are in the pan-Arctic before the authors stated that permafrost soils are also large nitrogen (N) reservoirs.

Line 45: Large? This expression is not specific. Can the author express specific expressions, such as covering 30% of the Arctic?

Line 54: delete “in” between “...involves” and “both...”.

Line 57: Change “reducing environment” to “a reducing environment”.

Line 58: Change “...$OH^-$” to “...$OH^-$”.

Line 60, 61, 62, 66, 67, 71, 72, 73, 74, 111, 112, 117: Please check and revise the formatting of in-text documentation, for example changing “...(Martikainen et al. 1993)” to “(Martikainen et al., 1993)”.

Line 70-80: The aim of the paper should be shown clearly. The author showed the purpose of developing the TEM, but this is only part of the paper.

Line 87: The specific process should be depicted rather than the effect factors. The effect factors can be described after the sentence.

Line 96: Change “...Atmospheric deposition...” to “...atmospheric deposition...”.

Line 110-113: Which variable and what period of the observations were used to calibrate the nitrification rate $k_n$?

Line 113-115: This sentence was confused and with a wrong grammer, rewrote it.

Line 116: The effects are from Del Grosso et al. (2000), and this sentence is misleading. Is the meaning the size of the parameter value?

Line 116: Change “...the substrate (fnc) and water function to $N_2$ ratio (fm)...” to “...the substrate (*f*nc) and water function to N2 ratio (*fm*)...” and change the corresponding formula as well. And check the whole MS and formulae about if the parameters are italic or not.

Line 122-126: What are the “$k_1$”, “diff”, and “$r_{n2}$”?

Line136 and 137: Add “a” between “...with” and “nitrogen density...” and between “...and” and “C density...”.

Line 177-180: why choose ± 3 of the temperature and ± 30% of rainfall for model sensitivity test?

Line 197: Checking and modifying tenses in the results section. For example, “...estimates...” should be modified as “...estimated...”, due to the work that was done in the past.

Line 202-204: This sentence for temporal variability was not suitable here. Delete this “,” between “...period” and “from...” in Line 203 and 210. Or change the title of 3.2 to “Temporary and spatial variability of $N_2O$ emissions”.

Line 237: add “by” between “...increases” and “about...”.

Line 241: change “dramatic change” to “dramatic changes”.

Line 243-244: The author showed that the pan-Arctic region had various responses to the change in precipitation in nitrification and denitrification. Where did the result be shown? What are the differences?

Line 251: delete the sentence “Wetland and peatlands are considered as the major N2O sinks (Schlesinger 2013)”. Because the sentence is not relevant to the content of the paragraph.

Page 17-23: The discussions of this article are disconnected from the results. And there are too many words used to describe the results.

Line 272: The noun phrase “previous study” seems to be missing a determiner before it. Add “A”.

Line 273: what do you mean of the global consumption?

Line 292: change “...dry alpine meadow...” to “...dry alpine meadows...”.

Line 293-294: The evidence of the impact of N deposition on $N_2O$ emissions depending on initial conditions needs to be shown. And what initial conditions?

Figure 6: Is the trend of N deposition decreasing then increasing? Is it the same or different from other studies? Please recheck it. And give the support references?

Line 303 and 306: change "p<0.001" and "<60°" to "$p < 0.001$" and "< 60°".

Line 318: change "rate..." to "rates..." .

Figure 2, 4. 7: The label "A", "B", "C", and "D" need to be amplified.

Figure 8: The A, B, C, D, E, and F are so small that we can ignore them. Please enlarge the font size. And the ordinate label of F is the same as E and should be modified. The note does not include the interpretation of F.

Line 332: add "a or the" to "... higher nitrification rate...".

Line 339-341: increase by what?.

Line 376: change "; recent…" to ", recent…".

Line 380: change "... stochiometric..." to "... stoichiometric...".

Line 453: change "... N2O..." to "... $N_2O$...".