

## Responses to comments of Reviewer #2:

We greatly appreciate the Referee #2's valuable comments, which we have used to substantially improve our manuscript. We have carefully considered the constructive comments and suggestions from the reviewers, and we provide answers to them here accordingly. Reviewer's comments are in black, our replies are in blue.

Wang et al. aim to retrieve N limitation information via data model fusion using a C-only model and coupled C-N model. They applied this approach to a field N enrichment experiment at an alpine meadow in the Qinghai-Tibet Plateau. The topic of nutrient limitation is of increasing importance in view of their role in constraining future land C sink in response to rising air CO<sub>2</sub>. I agree with most comments by Reviewer 1 and I have several additional comments that may further help to improve this work.

First, the term of nitrogen limitation needs to be clearly defined. Do you mean N limitation to plants, microbes or both? We don't usually say "ecosystem N limitation". Please also define "N limitation information" and clearly show how this is quantified in this study. Additionally, this manuscript seems to set up a background that N limitation occurs everywhere (L35-44). It would be helpful to provide an update of this view and mention that P instead of N is limiting in many tropical and subtropical ecosystems. The limitation by other nutrients needs to be mentioned or discussed in this manuscript. Second, there are many undefined terms and missing information in this manuscript (see specific comments). This hinders an in-depth evaluation of this work. Moreover, model structure and data assimilation are described in the method section but it is unclear how the two questions of this study were addressed (L91-93).

Response: Thank you for your comments. We will improve the description of the nitrogen limitation concept in the revised manuscript. In the context of this manuscript, the term of nitrogen limitation basically refers to limitation in plant primary production. We agree in that P and other nutrients limit process rates more strongly in other ecosystems. We will modify the manuscript accordingly.

For the detailed information about data assimilation methods, we will add them in the revised manuscript. We will also answer the questions more straightforward in the results and discussion parts.

Specific comments

L17-18 & 31: Exactly, how to provide guidance for policy making or ecosystem management?

Response: Sorry for the confusion, to avoid any potential misunderstandings, we will delete this description in the revised manuscript.

L24: Explain "carbon exit rates"

Response: “carbon exit rates” is the proportion of carbon outflow from a carbon pool at a time unit, these parameters represent the senescence rate of leaf and root, the decomposition rates of litter, and the decay rates of soil pools. We will add the explanation when we revise our manuscript.

L41-43: P limitation is also important but fully ignored.

Response: Agreed, we will add the P limitation effect when we revise the manuscript.

L45-48: The best way to address N limitation issues in earth system models is better understanding and representation of various N cycling processes (especially biological N fixation).

Response: Yes, we totally agree and will delete discussions on Earth System Models in the revised manuscript.

L45-55: Uncertainties are discussed for these methods. I would expect a description of the advantage of the data model fusion approach.

Response: Agreed, we will add the description of the data model fusion approach when we revise the manuscript.

L68: Explain “ecological information”

Response: “ecological information” refers to the information about ecological processes, such as the ecosystem functions, ecosystem services, nutrient limitation and so on. To avoid misunderstandings, we will change it to “information about ecological processes” and explain it when revising the manuscript.

L72-74: Any advantage (e.g., more accuracy) in comparison to other approaches(45-55)?

Response: Yes. We highlight two main advantages of our method to retrieve nutrient limitation. On the one hand, by comparing the parameters shift and pools size, we can more easily evaluate the N limitation effect on any specific C cycle process of an ecosystem. On the other hand, as long as some basic C and N variables are available, we can use them to evaluate the N limitation anywhere by a C-only model and the coupled C-N model with data assimilation technique.

L96-103: Provide additional information such as whether plant growth is N limited in the studied meadow and the level of N deposition.

Response: Agreed, we will add the information.

L139: The equation is not clear.

Response: Sorry for the typo, LPE is the same as  $SN_{vcmax}$  here. We will correct it.

L227: Make sure that the GECO model simulated C pools of microbes.

Response: In this study, the microbial pool is used to constraint the fast SOM by a mapping vector which was introduced at 207-213. We will remove “microbe” in the new version.

L231-233: Again, explain “C exit rate”

Response: “carbon exit rates” is the proportion of carbon outflow from a carbon pool at a time unit, these parameters represent the senescence rate of leaf and root, the decomposition rates of litter, and the decay rates of soil pools. We will add the explanation when we revise our manuscript.

Figure 3: Does it mean C-N model overestimate LPE or C-only model underestimate LPE?

Response: It is likely that C-N model overestimated LPE when the observation was N limited. Because it needs to be multiplied by a nitrogen limiting scalar to match the observations, and the nitrogen limiting scalar should be less than 1 when the observation was N limited.

Figure 4: Please add titles for each axis

Response: Agreed. We will add.

Figure 5&6: It would be good to include the field observed data in comparison to the modelled results.

Response: Agreed, we will add the observed data to compare with the model results.

Figures 3-6: Any significant differences between modeling results?

Response: We used one-way ANOVA to test the differences between on different parameters and C pools and fluxes, we will add the significance in the revised figures.

L282-293: Not clear how N limitation was quantified and compared here. Do you mean the strength of N limitation changes with different levels of N additions for the same meadow?

Response: Yes, our basic assumption is that as nitrogen addition increases, the nitrogen limitation effect on the productivity and ecosystem carbon storage decreases.

Kind regards on behalf of all co-authors,

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