

## Response letter-1

### General comments:

1. ...For these reasons, it seems problematic to compare N-fixation with N<sub>2</sub>O production, and I would ask for an expanded justification for this aspect of the study.

*Response: After a careful consideration on the problem, we think it needs further work to build a solid convincing relation between natural BNF and N<sub>2</sub>O emissions. Thus, in the revision, we will focus on modeling BNF only.*

2. I also think the title is somewhat misleading.....

*Response: Because of the adjustment in content, we will give a new title. A tentative title is "Modeling biological nitrogen fixation in global natural terrestrial ecosystems"*

3. ...it seems that the model cannot accurately estimate fixation rates for Arctic regions with its current structure leaving me to wonder how to interpret the values reported for Arctic regions?

*Response: More observational data in Arctic area will be helpful for a more reliable simulation. Currently, it is not so convincing as that from other ecosystem types. We will try our best to search for more on-site data and related works, for further interpretation of the modeled fixation in Arctic regions.*

4. Grammatical mistakes

*Response: Thank you for your suggestion. We will correct these.*

### Minor revisions:

- Ln30: This sentence needs to be tightened up, but the second half could be changed from, 'and decrease from the equator', to 'which decreases from: : :'.  
*Corrected.*

- Ln 34: Remove 'the' prior to 'fixation'.  
*Corrected.*

- Ln 36: Change 'types', to 'type'.  
*Changed*

- Ln 36: Remove 'the' before 'biological nitrogen fixation'.  
*Changed.*

- Ln 51: Gruber and Galloway, 2008, Nature, 451(17), 293-296, would help constrain the quantitative aspect of this sentence.  
*Thank you for your suggestion. we have added information related to anthropogenic nitrogen into this sentence.*

- Ln 80: I think it would help to have a model schematic here - I understand a schematic of the broader model has been published previously, but repeating that schematic and focusing on the newly

integrated processes would help the reader.

*Please refer to Figure 1 from Yu and Zhuang (2019). The model schematic is very similar to this one, if not the same.*

- Ln 112: What data is required to derive these estimates?

*Please refer section 2.3 to the information of data.*

- Equation 4: What is the origin of the soil nitrogen inhibition values? Please reference the manuscript these values were taken from.

*$N_s$  is soil mineral nitrogen, which is a variable calculated in our model.  $f_{Nup}$  is a parameter related to legume nitrogen fixation. Its value and reference manuscript can be found in Table 1.*

- Ln 174: I think the authors mean 'a priori values', no?

*Yes, it is.*

- Ln 226: Should this value be -5 % rather than 5 %? I think the value of -5 % is reported elsewhere in the manuscript.

*Thank you for your careful reading. It should be -5% here. we have corrected this part.*

- Ln 229: What controls N<sub>2</sub>O fluxes within the model?

*You can find every detail about the controls of N<sub>2</sub>O fluxes from Yu and Zhuang (2019). But actually, we will remove the discussion on N<sub>2</sub>O emissions in revision.*

- Ln 297: What does 'affected' mean here? It would help to be more specific about direction, for example, does it mean enhanced or reduced?

*We have clarified this sentence. It is also explained in the rest of this paragraph.*

- Ln 368: Change subheading 'Major controls to: :', to, 'Major controls on: :':

*Changed*

- Seems like Fig. 1 is a repetition of data in the tables? Is Fig. 1 needed? Particularly because there is far more information in the tables.

*It is a straightforward visualization with the location information of Table 1. We will consider whether to keep it after the adjustment of text content.*

- Please improve the quality of the figure 2, which is quite poor. Why are the x-axis values just floating in the middle of the figure? And why abbreviate them?

*We will replot the table. Abbreviations are used here because the original ones are too long.*

Technical comments:

- Ln 84: It's not clear to me if the published ARA studies used to calibrate the model have all themselves been calibrated with <sup>15</sup>N measurements? The ARA approach is notoriously difficult to

interpret without reliable calibration, and the conversion of acetylene reduced to nitrogen fixation ranges significantly depending on various factors include the specific nitrogenase enzyme.

*We will add a brief introduction about the published methods.*

- Ln 124: I'm confused by this temperature relationship, is this a Gaussian distribution similar to that laid out by Houlton et al., (Nature, 2008, 454, 327-330)? It doesn't appear to be - this relationship sounds like there is a very broad plateau whereby temperature does not limit fixation across a wide range (12 - 35 C). Is this correct?

*This paragraph gives some examples on the temperature influence on different vegetation types. It is not a Gaussian distribution. We will add some explanation in this part to avoid confusions.*