

## ***Interactive comment on “Variability of projected terrestrial biosphere responses to elevated levels of atmospheric CO<sub>2</sub> due to uncertainty in biological nitrogen fixation” by J. Meyerholt et al.***

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Response to Anonymous Referee #2

> We are grateful to AR #2 for the constructive comments and detail below our suggested revisions to the manuscript.

Consider exploring how interannual variability in NPP was sensitive to how N fixation was implemented. Did one approach show greater variability than another? This could help think about how the N fixation approach interacts with climate.

> Previous work with O-CN (Zaehle et al., 2010) has shown that the simulated inter-

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annual variability of the C cycle is in general not strongly affected by the simulated interannual variability of the N cycle. Because simulated BNF on global average only contributes roughly a tenth of annual N cycling, it is unlikely that internal variations in BNF will have strong influence on interannual C cycle variability, e.g. in NPP, see Table 2. Therefore, we believe that adding this analysis would not substantially advance the understanding of the interaction of BNF and climate. It would require a set of new simulations with focus on climate, which we consider outside the scope of this study.

(Zaehle, S., A. D. Friend, P. Friedlingstein, F. Dentener, P. Peylin, and M. Schulz (2010), Carbon and nitrogen cycle dynamics in the O-CN land surface model: 2. Role of the nitrogen cycle in the historical terrestrial carbon balance, *Global Biogeochemical Cycles*, 24(1).)

It might be valuable to explore how the N fixation approach influenced the baseline (1860) patterns and magnitude of N limitation. Did one approach lead to a more N limited state? If N limitation is low in the baseline (1860) state of the model for all N fixation approaches, that could partially explain why the NPP and GPP is so similar between approaches (i.e., nitrogen doesn't matter much in the model). Other work with the O-CN has suggested that N limitation is small in the O-CN (Thomas et al. 2013 *Global Change Biology*)

> We agree that the initial BNF and N limitation states would be helpful to highlight. We propose to add global 1860 BNF and leaf C:N values (reflecting N limitation of vegetation) for the models to the corresponding discussion paragraph (P19443 L 27 - P19444 L 1-9), and further discuss here the possible impact on simulated NPP and GPP. We would like to add that "N limitation", i.e. the difference between a N enabled and N disabled simulation, is not necessarily low in O-CN (see Zaehle, 2013), even if the effect of N dynamics is generally smaller than simulated by the CLM 4.5 model, as used in Thomas et al. 2013.

(Zaehle, S. (2013), Terrestrial nitrogen-carbon cycle interactions at the global scale,

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Philosophical Transactions of the Royal Society B: Biological Sciences, 368(1621), 20130125-20130125.)

(Thomas, R. Q., S. Zaehle, P. H. Templer, and C. L. Goodale (2013), Global patterns of nitrogen limitation: confronting two global biogeochemical models with observations, *Global Change Biology*, 19(10), 2986-2998.)

The color scale on figure 3 and 5 (especially the b panels) makes it hard to see key differences that are highlighted in the text. The greens and blues cover a large fraction of the scale but are difficult to differentiate.

> We have experimented with the colormap and suggest to invert the color scheme, so that 0 is red, and the crucial differences will be shown as variations between red and yellow/green, which will be easier to see than blue and green.

I may have missed it but the text doesn't seem to define the NDS and NDS acronyms

> All model acronyms are defined in section 2.2, see e.g. current P19429 L 26. We think that there is no change to the manuscript needed here.

Page 19433, Paragraph at Line 19: more clearly state that a unique spin-up was done for each N fixation implementation.

> We agree, this information will be added to the paragraph beginning at P 19433 L 19.

Page 19443, Line 1: In this paragraph (or somewhere else if more appreciate), it would be good to highlight that the O-CN was able to simulate the different N fixation approaches because it includes dynamic labile C and labile N pools. Without these pools the NDS and NDT approaches could not be simulated. Likewise, the dynamics of the labile C and labile N pools (and the foliar C:N) are likely an example of how the results for the NDS and NDT are partially model specific.

> We agree that this is another limitation to point out, and we propose to add this to the cited paragraph. Nevertheless, we do not think that the model specifics of O-CN

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affect the general functioning of the different BNF schemes, and that in particular the differences in model behaviour under elevated CO<sub>2</sub> are robust against these O-CN specifics.

Figure 4a: What do the horizontal dotted lines signify?

> These are grid lines. If needed, we could revise the plot to show the grid lines in front of the bars, instead of behind them.

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