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Biogeosciences Discussions

Interactive comment on "Variability of projected terrestrial biosphere responses to elevated levels of atmospheric CO_2 due to uncertainty in biological nitrogen fixation" *by* J. Meyerholt et al.

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Response to Anonymous Referee #1

> We are grateful to AR #1 for the constructive comments and detail below our suggested revisions to the manuscript.

Perhaps what is missing, is the answer to the question what of these outcomes can really be attributed to the specific models or whether it is just caused by a particular selection of parameter. In other words, how robust are these differences, given that the parameter space can be changed? I think a total sensitivity analysis is beyond

the scope of this neat (!) paper. However, having worked with all the formulations the author will have a feel, what parameters in the different models are important. To demonstrate this in some way would further improve the paper. This could be done through a few key additional experiments in the best case, or through a conceptual walk through of the formulation in the discussion, and explain in a what-if scenario. Overall, I think what I am looking for is a subsection teasing out effects parameterization vs. model formulation on the model outcome.

> We agree that a sensitivity study would be very interesting, but a full analysis involving the internal feedbacks in the model would increase the manuscript length substantially. We further believe that for most schemes (FOR, AET, NPP, NDT), parameter changes would have straightforward consequences (both in unperturbed and eCO2 scenarios), because BNF scales more or less directly with the relevant parameter values. For the two other schemes (NDS, OPT) this is less obvious, but could be supplemented by some theoretical considerations (see Figs. 1-3). We believe that we can discuss the likely sensitivities based on such conceptual analysis, showing the relative importance of parameters. We will add a paragraph to the discussion of the revised manuscript which will summarize our thoughts on parameter sensitivity.

Further, in the discussion of the current map of BNF it might be interesting to discuss the need of BNF in NDT, NDS and OPT. For example, high losses, over which plants do not have control for, can increase BNF in these the formulations that include plant status or invoke the optimality approach. Hi uncontrollable losses (Thomas et al., 2015) would create N limitation and thus induce N fixation in these model formulations. Can hot spots of BNF for these formulations be explained by high "uncontrollable" losses in OCN?

> We have looked into this (see Fig. 4) to check for the relationship between BNF and N loss in the current maps. There is an approximate trend of higher BNF with higher N losses, however, this is not fundamentally different between the FOR, AET, PRO and NDT, NDS, OPT model groups. The highest BNF values in NDT, NDS do occur when

N losses are high, although high BNF can also happen in NDS when N losses are low. It is not clear that high BNF occurred because high N losses removed N from the system and thus increased plant N demand. It might be that N demand was high to begin with, leading to high BNF input, thereby also increasing N losses because the entirety of added N was not assimilated by plants. Based on the lack of clear evidence of model differences in this aspect, we would be hesitant to add this issue to the current manuscript.

P19431 L16: Zaehle unpublished. Perhaps the authors can explain a bit more instead of adding this reference?

> We apologize for the confusion caused by the "unpublished" reference. The NDT approach was developed in 2010, but never described or applied in a published study. We suggest to simply remove the (S. Zaehle, unpublished, 2010) reference from the text. The Supplementary Information describes this approach in detail, however, we will add more information to the main text to make the link between N limitation and BNF clearer.

P19432 L7: This sentence is long and awkard, and thus hard to understand. Can you rephrase?

> We propose changing "The plants' N requirement is determined by comparing the N potentially required to build new biomass from acquired C to the N available to the plant in its labile N reserve." to "From potential NPP, the amount of N required to support this growth is determined according to the tissue C:N ratios. This amount is then compared to the N available to the plant in its labile N reserve, giving the plants' additional N demand.".

P19434 L7: Gradually increasing CO2 concentration. This also occurs in A, doesn't it? Perhaps just state that the gradual increase in CO2 is higher in B compared to A.

> We propose changing "gradually increasing" to "a larger increase in", and change

P19434 L 8 (B) to (B; Fig. 2).

P19438 L 17: Although the author state "long-term" it would be helpful to say somewhere in this paragraph that the discussion here refers to simulations B and C.

> We propose to begin this paragraph with "When comparing simulations B and C, ...".

Table 2: It would add some information, if the N budget could be closed in Table 2. I feel the only budget terms would be N2 and NO loss (the remainder of the gaseous losses from nitrification-denitrification), fire and inputs via fertilizer deposition and accumulation. The question of N budget is hinted already via N leaching losses, see authors' note on P19437 L6:10. But a more thorough discussion about the "openness" of the N cycle would be a helpful and important insight. For example, for 2000-2013, one can then see how much of the N is accumulated (since this is transient), vs. lost via the different loss pathways.

> We agree and propose to add the missing N loss pathways and N accumulation in the biosphere to Table 2, and to add some discussion on the varying N-cycle openness to the corresponding results paragraph (P19435 L 3-12).

P19439 L 3-6: I am not sure that NDT and NDS formulation would allow "excessive" fixation, given their formulation where BNF only occurs if it is really beneficial. Perhaps one could say that BNF may remove strong constraints and restore (?, not sure if it's the right word) pre-eCO2 N levels of N limitation?

> We were led to call the magnitudes of BNF under eCO2 in NDT and NDS "excessive", because of the very open N cycle under eCO2, where large N inputs resulted in large N losses. Plants were apparently simulated to maintain "average" C:N ratios, rather than maximize growth responses. Therefore, the simulated plants did not incorporate the entirety of added N to support growth, even though this was the main motivation of the NDT and NDS formulations, and much of the added N was lost from the ecosystem. We propose to change "excessive" to "large", and to add some of this discussion to the

corresponding discussion section (currently P19442 L 1-10).

P19441 L6: typo “dynamics” > Thanks to AR #1 for spotting this, this will be corrected.

P19448: L 21: I have trouble with the units NPP_pot*fcost/CN_Leaf would be [gC y-1* gC gN-1 / (gCgN-1] = gCy-1?. However shouldn’t demand be in gNy-1 Table A1: I think this is a very valuable table. Would it also be possible to add the PFT specific parameter values?

> Our mistake here is that fcost was erroneously given a unit in Table A1, when it actually is a dimensionless scaling factor that accounts for the allocation of N to tissues with different C:N ratios. The correction equation is: D [gN] = NPP_pot [gC] * fcost [1] / CN_Leaf [gCgN-1] - N_avail [gN]. We will correct this in Table A1. We will also add the PFT-specific parameters as a new Table in the Supplementary Information, to avoid further complication of Table A1.

Interactive comment on Biogeosciences Discuss., 12, 19423, 2015.

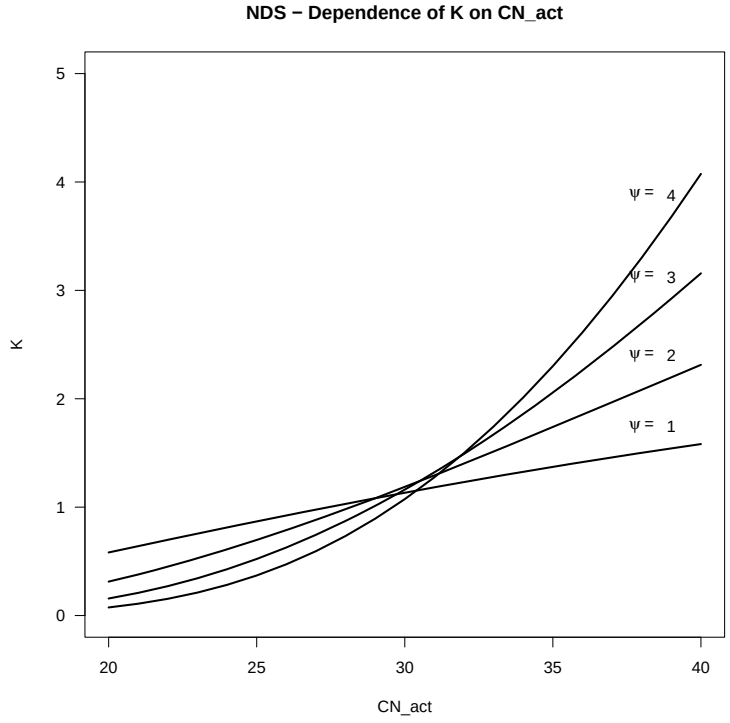

Fig. 1. NDS Model: Sensitivity of K to changes in cn_act and psi

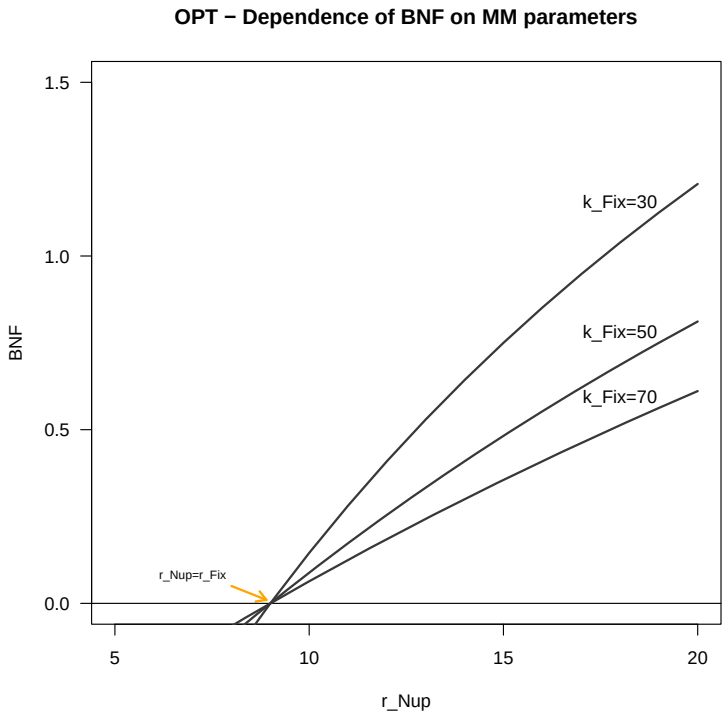

Fig. 2. OPT Model: Sensitivity of BNF to the Michaelis-Menten parametrization

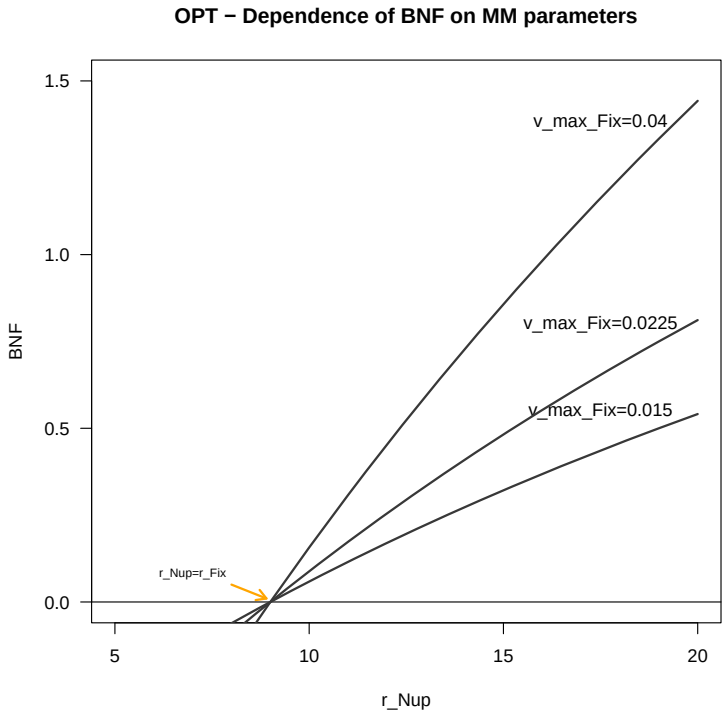

Fig. 3. OPT Model: Sensitivity of BNF to the Michaelis-Menten parametrization

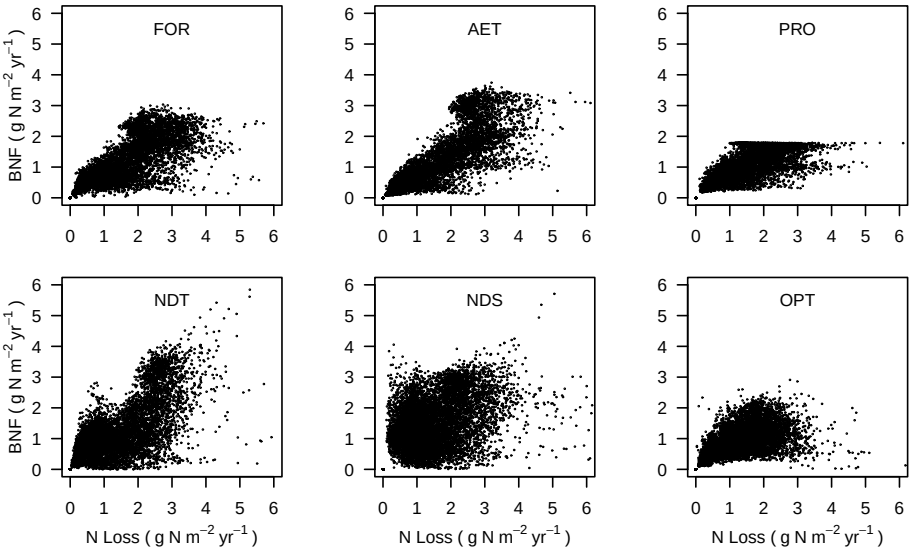

Fig. 4. BNF vs total N loss from 2000-2013 unperturbed maps