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Biogeosciences Discussions

# *Interactive comment on* "Large uncertainty in ecosystem carbon dynamics resulting from ambiguous numerical coupling of carbon and nitrogen biogeochemistry: A demonstration with the ACME land model" *by* Jinyun Tang and William J. Riley

**Anonymous Referee #2**

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Review of Tang and Riley

Given the current focus on explaining the large spread in carbon cycle predictions in CMIP5 simulations, studies such as this manuscript help clarify potential drivers of differences. Furthermore, it is important to highlight how subtle differences in process or implementation can potentially lead to large differences in terrestrial carbon stocks. This manuscript focuses on a seemingly subtle difference in how nutrient limitation is executed in a global biogeochemical model. While the authors highlight the issue



as mostly numerical, they are addressing a larger issue in ecosystem modeling that centers on whether plants, microbes, or hydrologic losses have first access to mineral nitrogen in soil solution. I think that the manuscript hides this question in the technical language about substrates, ambiguous coupling, and the equations. This technical detail is important but the paper will likely have a stronger impact if the issue was spelled out as a plant vs. microbe competition. The plant vs. microbe competition issue seems to be the key story of the manuscript, rather than the numerical issues, because the MNL and NUL simulations are very close (i.e., the lines from the simulations cover each other in the figure) with the big difference between the those and the PNL simulations. It seems that the MNL (or NUL) vs. PNL approaches represent two different ecological hypotheses about how the world works and the paper could explore the implications of these plant/microbe competition hypotheses on carbon cycling at the global scale. Such a focus would be easier to follow and provide a clearer and, in my opinion, more valuable contribution to the literature. Overall, the simulations are there but a recasting of the motivation (including reviewing the literature on plant –microbe priority for nitrogen) and an expansion of the discussion is needed.

I do have a concern about the level of detail used to examine the simulations. For example, the comparing Figure 2 suggest that there is missing carbon (total carbon != vegetation + soil) (North temperate MNL: 40 != 8 + 4). Is the missing terrestrial carbon important in the story? It is likely related to the dynamics of the CWD stocks because CWD is accounted for in the total carbon but not in the vegetation or soil carbon. Because of this issue and the (unrealistic?) PNLIC example, more discussion of the CWD dynamics is needed (i.e., how is nutrient limitation of CWD decomposition simulated?). Before the manuscript can be a useful contribution, this missing carbon and CWD issue needs to be explored in detail because it appears to be the primary driver of the differences. Otherwise the differences between the MNL vs PNL simulations at 2300 are small (∼4 Pg C change in north temperate– no change in vegetation + 4 Pg change in soil) and the differences are even smaller at 2100 (∼2.5 Pg C change). Overall, I am left wondering why the MNL/NUL and the PNL simulations are so different and

how it relates to CWD dynamics. In summary, more ecological insight as to why the simulations are different is needed for the manuscript to useful to a broader modeling community.

Additional Comments:

Currently the discussion is not well connected to the results section. The bulk of the discussion is focused on recommendations that do not directly reference or build off particular results of the paper. It causes the manuscript to read like a modeling study that is followed by an opinion paper. I recommend exploring the microbe vs. plant competition issue in more detail and tying the discussion points to specific results.

The introduction sets up two hypotheses without specifying how the hypotheses could be rejected. In a typical ecological study, there is an implied p-value that is used for hypothesis testing. In this simulation study without standard statistics, what is the criteria for accepting or rejecting the hypotheses? I recommend either being more specific with the criteria or shifting away from the hypothesis testing approach and more to addressing questions.

The motivation for using simulations that run to 2300 is not clear. It is hard to put the magnitude of sensitivity in context because the carbon storage out to 2100 is more commonly discussed. How does the spread between the simulations compared to CMIP5 model to model variation at 2100?

From a mass balance approach, the substrate equation 1 is incomplete. Why are losses that are not associated with uptake excluded from the equation?

The PNL simulation in Table 1 states that there is equal competition between plant and microbes. How is the equal competition implemented? (it is not clear from equation 7). Also, does this imply that MNL and NUL have competition that is not equal. I recommend clarifying the assumptions of competition in all the simulations.

Table 1 includes the default simulation but does not highlight how it is different from the



other simulations.

Page 4 Line 11: I recommend the phase ‘the to be released. . ..ACME-v1’ be removed because it will quickly date the manuscript and who knows if the models will change before the manuscript is published.

Page 7 Line 30: If the down-regulation of GPP was removed, how was vegetation carbon limited by nutrient availability? If the uptake of carbon is not limited by nitrogen but there is not enough N in the soil to grow plant tissue, there will be a build of labile carbon in vegetation and the C:N ratio of vegetation will increase.

Page 9 Line 17: Figure 1a is NEE but NEE is not discussed in the sentence.

Page 11 Line 2: The counter-intuitive result was not discussed in Section 4.1. Please be more explicit in the connections in the discussion

Section 3.4. This section does not add anything to the manuscript and I recommend removing (see discussion above about hypothesis testing)

Figure 3. I recommend using the same colors for each simulation throughout the figures. The colors switch between Figure 2 and 3. (the captions says that the colors changed but it is better for the reader to go ahead and match the colors).

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