Biogeosciences Discussions

Biogeosciences Discuss., referee comment RC1
https://doi.org/10.5194/bg-2020-483-RC1, 2021

Comment on bg-2020-483

Anonymous Referee #1

Referee comment on "A novel representation of biological nitrogen fixation and competitive dynamics between nitrogen-fixing and non-fixing plants in a land model (GFDL LM4.1-BNF) " by Sian Kou-Giesbrecht et al., Biogeosciences Discuss., https://doi.org/10.5194/bg-2020-483-RC1, 2021

General comments:

Kou-Giesbrecht et al., presented a new version of GFDL land model that considers symbiotic fixation, competitive interactions between fixer and non-fixer plants. The model development is convincing and well explained, while the following up model evaluation needs to be improved, more discussions are needed to clarify the simulated C/N dynamics. Below are my major comments and some specific suggestions.

1. Since the major development is N2 fixation, it will be good to emphasize the model evaluation more on N2 fixation. Figure 6 showed that the LM4.1-BNF capture asymbiotic fixation rate for the mature forests, however, the LM4.1-BNF performed worse than LM3-SNAP (or maybe equal) for simulated symbiotic BNF rate along with the forest successional development.

One strategy could be using a part of the data to first tune the model parameters that are related to N2 fixation processes (e.g., rNfix) and then use the rest for evaluation purposes.

A deep dive into LM4.1-BNF simulated N2 fixation rate is further needed. For example, what are the temporal dynamics of Nodule biomass, NSC, Nstress, soil microbe biomass, how they drive the changes of symbiotic and asymbiotic BNF?

2. The LM4.1-BNF simulated C cycle is convincing (e.g., biomass, GPP, NPP), however, the N cycle showed largely bias, compared with observations (e.g., Figure 7). LM4.1-BNF has too much inorganic N (both NH4 and NO3), while very low soil organic N. Does it imply that the soil nitrogen immobilization rate and soil organic matter formation rate are largely

underestimated? Or the soil organic matter C:N stoichiometry was problematic?

LM4.1-BNF had reasonable NO3 leaching loss, but overestimated N2O emission, which means the system is too open/leaky. Is it part of the reason why less available inorganic nitrogen is incorporated into soil organic nitrogen pool?

3. Model structure change versus parameterization. LM4.1-BNF improve the existing model structure and showed some improvement in model performance at the site level. But 1) how much of the performance improvement could be achieved just by tuning existing parameters; 2) how much of additional model uncertainty is introduced by the model structure changes and by adding new model parameters? I would suggest running some sensitivity tests (e.g., perturb critical model parameters) for both LM4.1-BNF and LM3-SNAP to fully answer those questions.

Specific comments:

P1L13 is important for nitrogen enabled land model

P2L47 another group of land models simulates N2 fixation with nitrogenase enzymatic activity (e.g., Vmax, KM kinetic parameters), root nodulation, and temperature constraint (CABLE, Wang 2007; ELM-ECA Zhu 2019).

P2L63 downregulation of N fixation under weak N limitation must be discussed together with upregulation of N fixation under strong P limitation. Otherwise, the model will simulate an extremely low N fixation rate over tropical ecosystems that has abundant N.

P3 L70-77. It will be good to add some discussion about the importance of asymbiotic N2 fixation so that the existing land model should include this flux. For example, how much of global N2 fixation is from asymbiotic fixation, how efficient can plants get nitrogen from asymbiotic pathway.

P4L101. It will make the model evaluation more concrete if the model could run at least two sites (tropical site with abundant soil N versus the temperate site with relatively strong N limitation).

P4L108-117 belongs to section 2. model description

P4L122 Does LM4.1-BNF have to run at fixed spatial resolution (roughly 1degree by 1 degree)? Or it could run at any resolution? How about the temporal resolution?

P5L138-140. What are fine root, sapwood, heartwood, seed C:N ratios, how about soil organic pools C:N ratios?

L6 Eq1,2. How to parameterize rNfix? What is the functional shape of f(T)?

P7L180 One microbe pool for all soil microbial activities? Please justify.

P7L185 How to parameterize rNfixasymb? What is the functional shape of f(T)?

P11L312 Did LM4.1-BNF-NPP and LM4.1-BNF-ET restart from steady-state of LM4.1-BNF

spinup simulation? Will LM4.1-BNF spinup steady-state differ dramatically from LM4.1-BNF-NPP(/ET) steady-state?

P13L365 Here need more discussion about the model bias in dbh growth rate. For example, is that because N stress is too weak?

P16Figure3 The y-axis scale is misleading (suggest not using log-scale). The model vs data difference is actually big. Again, discuss why and how it occur in LM4.1 model. How is the LM4.1-SNAP simulated density, compared with FIA data?

P25L480 and Figure 10. What's the implication of zero BNF rate during the late succession when the model initialized with mixed Acer and Robinnia? The whole ecosystem will rely on soil mineralization generated inorganic N? Will all plants gradually die?

Reference

Wang, Y.P., Houlton, B.Z. and Field, C.B., 2007. A model of biogeochemical cycles of carbon, nitrogen, and phosphorus including symbiotic nitrogen fixation and phosphatase production. Global Biogeochemical Cycles, 21(1).

Zhu, Q., Riley, W.J., Tang, J., Collier, N., Hoffman, F.M., Yang, X. and Bisht, G., 2019. Representing nitrogen, phosphorus, and carbon interactions in the E3SM land model: Development and global benchmarking. Journal of Advances in Modeling Earth Systems, 11(7), pp.2238-2258.