In this study, Kou-Giesbrecht reported the GFDL LM4.1-BNF model with a new representation of biological nitrogen fixation and evaluated the impact of competition between nitrogen-fixing and non-fixing plants on simulated carbon, nitrogen and demographic dynamics in a temperate forest site. They showed the LM4.1-BNF did a fair job in simulating the many lumped variables reported in the US forest inventory and analysis database for a temperate forest site at Coweeta Hydrologic Laboratory in North Carolina. Particularly, they showed that the competition between N-fixing and non-N fixing plants is an important factor in interpreting the dynamics of carbon accumulation. Overall, the paper is clearly written, but there are some issues need to be resolved before the model is able to be considered as doing sufficiently well.

More details are listed below

The abstract is generally OK; however, it lacks details on the model performance. The authors may consider to add more content from their model evaluation against the observational data.

***AUTHORS' RESPONSE: Thank you for this excellent suggestion. We have added a comparison between simulated and observed symbiotic BNF and asymbiotic BNF to the abstract to emphasise the ability of LM4.1-BNF to effectively reproduce them: "LM4.1-BNF effectively reproduces asymbiotic BNF rate (13 kg N $ha^{-1}$ $yr^{-1}$) in comparison to observations (11 kg N $ha^{-1}$ $yr^{-1}$). Importantly, LM4.1-BNF effectively reproduces the temporal dynamics of symbiotic BNF rate: LM4.1-BNF simulates a symbiotic BNF rate pulse in early succession that reaches 73 kg N $ha^{-1}$ $yr^{-1}$ at 15 years then declines to ~ 0 kg N $ha^{-1}$ $yr^{-1}$ at 300 years, similarly to observed symbiotic BNF which reaches 75 kg N $ha^{-1}$ $yr^{-1}$ at 17 years then declines to ~ 0 kg N $ha^{-1}$ $yr^{-1}$ in late successional forests."***

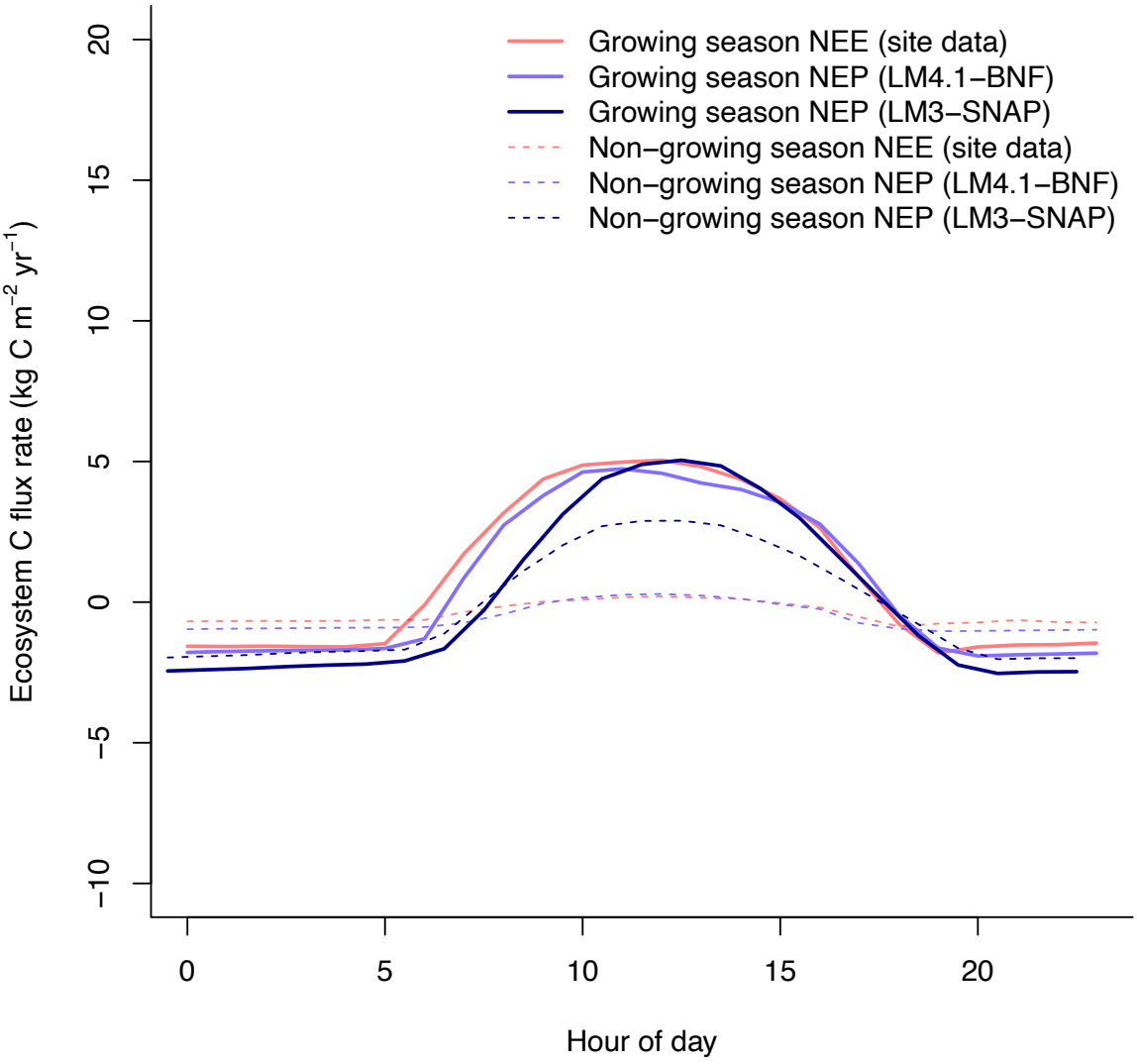
Technical description is long but written well.

***AUTHORS' RESPONSE: We have attempted to reduce Section 2 (Model description) by summarising the relevant aspects of LM4.1-BNF (asymbiotic BNF, symbiotic BNF, N limitation, etc.) and describing LM4.1-BNF in detail in Appendix A.***

For results, my major complain is the authors have yet to demonstrate the model LM4.1-BNF compares well with high frequency temporal data, such as eddy flux measurement of carbon and water fluxes. The comparison with lumped data is fair, but not great. This is especially important to evaluate the effect of new temperature response function. Perhaps the authors should consider applying the model for a site with eddy flux measurements as well?

***AUTHORS' RESPONSE: This is an excellent point. We have added an analysis of eddy covariance data from Coweeta Hydrologic Laboratory to the manuscript. We compared observed and simulated net ecosystem exchange / production at the hourly timescale for the growing season and for the non-growing season (Fig. 7, below). LM4.1-BNF effectively reproduces net ecosystem exchange / production at the hourly timescale, and is improved relative to LM3-SNAP.***

***Figure 7: Simulated net ecosystem production (NEP) by LM4.1-BNF and LM3-SNAP compared to net ecosystem exchange (NEE) CHL site data at the hourly timescale. Simulated data are averaged over the last 100 yr of the 300 yr simulation to reflect the data which is from mature forests.***




Further the discussion is a little bit detached from results. Authors may consider move some of the analysis into discussion to better explain the significance of updated processes.

***AUTHORS' RESPONSE: Thank you for this suggestion. We have split Section 4 (Evaluation) into two sections: 4.1 Evaluation results and 4.2 Evaluation discussion. We hope that this will clarify the results and their significance.***

Code availability: some of my colleagues say "upon request" is a bad exercise. Authors should at least provide whom to send such a request, or provide a web link to send such a request.

***AUTHORS' RESPONSE: Thank you for pointing this out. We have added a contact email to the Code availability section. Additionally, LM4.1 code will be made available shortly (Shevliakova et al., in prep).***

Other comments

Table 2. Missing group separation between 2nd and 3rd sets of analyses?

***AUTHORS' RESPONSE: We did not distinguish between the second and third analyses because we used the same six numerical experiments for both analyses. We have clarified this in the table caption.***

Figure 2. Why does the model under predict the low dbh growth rates?

***AUTHORS' RESPONSE: Even though the alignment between simulated and observed dbh growth rates is not perfect, LM4.1-BNF makes reasonable estimations. Additionally, the central improvement is that LM3-SNAP (and most other land models) cannot distinguish between plant cohorts with different dbhs or distinguish between Robinia and Acer (because they cannot represent community dynamics).***

Figure 4. Use stronger color contrast between two FIA data? Or maybe even different symbols? Currently, it is not easy to differentiate them.

***AUTHORS' RESPONSE: Thank you for pointing out that this was unclear. We have changed the colours and symbols (below).***

***Figure 4: Simulated relative basal area of Acer and Robinia over time compared to FIA data (in North Carolina). Simulated data are trees with dbh > 12.7 cm to reflect the dbh range of FIA data. FIA data of all non-fixing trees are aggregated to represent Acer. Each point represents an FIA plot. See Fig. D9 for absolute basal area.***

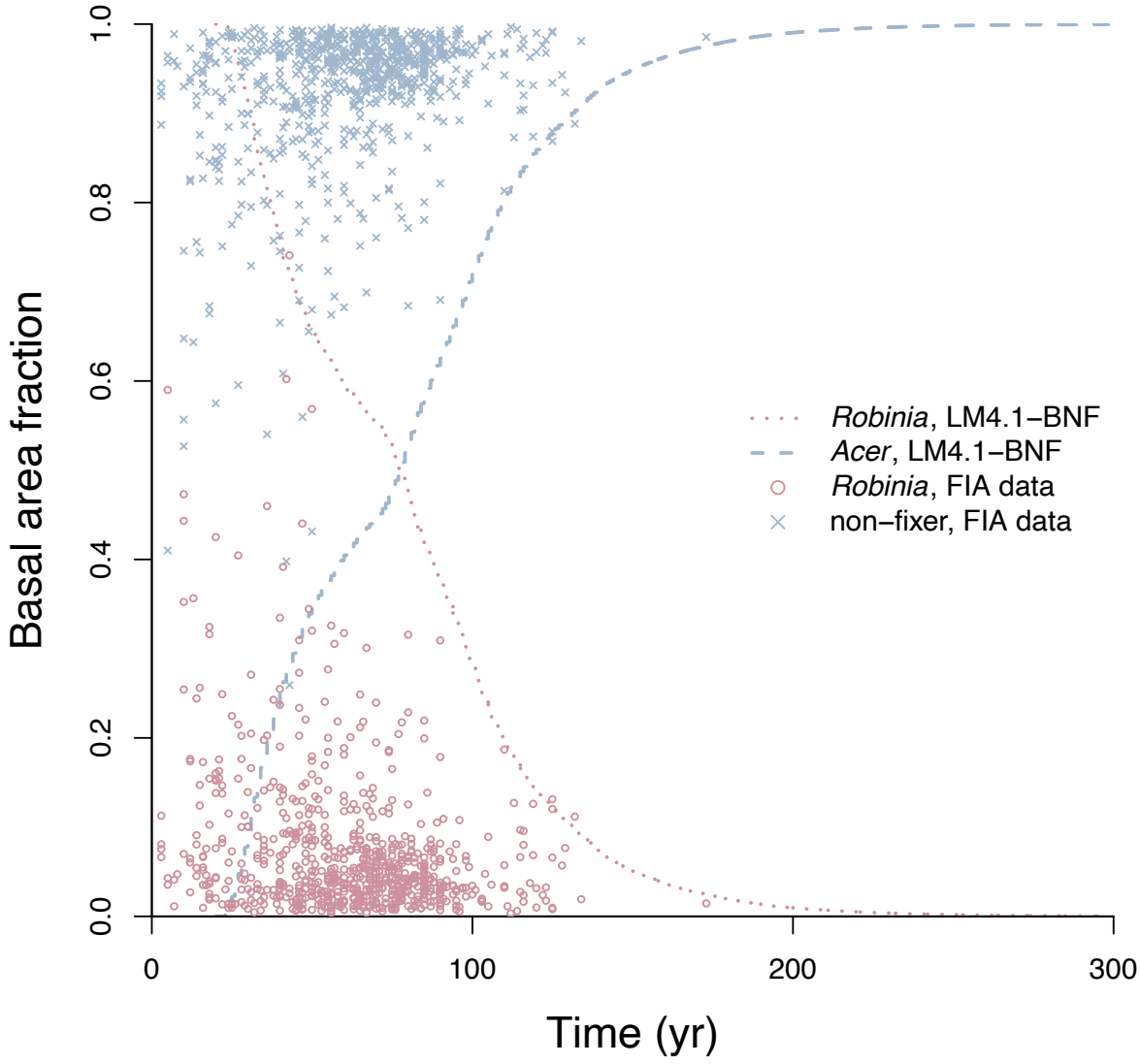



Figure 6. What is the uncertainty of the data points? Also, why does LM3-SNAP predict more evident oscillations?

***AUTHORS' RESPONSE: Unfortunately, Boring and Swank 1984 did not provide uncertainty for their symbiotic BNF rate measurements. LM3-SNAP exhibits more evident oscillations in late-successional symbiotic BNF because it is non-zero, whereas, in LM4.1-BNF, late-successional symbiotic BNF is zero. Both LM3-SNAP and LM4.1-BNF are forced with the same meteorological forcing*** (Sheffield, Goteti, & Wood, 2006) ***which spans 1948 to 1978 and is looped, causing cycles of approximately 30 years. If late-successional symbiotic BNF were non-zero in LM4.1-BNF, it would also exhibit evident oscillations.***

Figure 9a: what happened to LM4.1-$BNF_{NPP}$? Why its time series is much shorter?

***AUTHORS' RESPONSE: Thank you for pointing out that this was unclear. In LM4.1-BNF$_{NPP}$, BNF (and N deposition and mineralization) is insufficient to sustain total plant biomass C accumulation, i.e., the plant dies. We have extended the line representing LM4.1-BNF$_{ET}$ to 300 years to clarify that it maintains zero total plant biomass C.***

Equation (A1), why is there no adsorption effect considered? The behavior of NH4 and NO3 are quite different in soil.

***AUTHORS' RESPONSE: This is an excellent point. The different behaviour of $NH_4^+$ and $NO_3^-$ in soil is reflected by solubility parameters, which differ between $NH_4^+$ and $NO_3^-$. The solubility of $NO_3^-$ is greater than that of $NH_4^+$ which reflects a higher cation exchange capacity than anion exchange capacity. These solubility parameters determine $NO_3(k)$ and $NH_4(k)$ in Equation (A1). We have added a description of this to Appendix A.***

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***Literature Cited***

Sheffield, J., Goteti, G., & Wood, E. F. (2006). Development of a 50-Year High-Resolution Global Dataset of Meteorological Forcings for Land Surface Modeling. *Journal of Climate*, *19*(13), 3088–3111. https://doi.org/10.1175/JCLI3790.1