



EGUsphere, referee comment RC1
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Comment on egusphere-2022-786

Anonymous Referee #1

Referee comment on "Development of an ecophysiology module in the GEOS-Chem chemical transport model version 12.2.0 to represent biosphere–atmosphere fluxes relevant for ozone air quality" by Joey C. Y. Lam et al., EGU sphere, <https://doi.org/10.5194/egusphere-2022-786-RC1>, 2022

In this work, an ecophysiology module was implemented in the GEOS-Chem model. The dry deposition velocity of O₃, vegetation productivity, isoprene emission rate, as well as O₃ vegetation damage, were simulated under both present-day and elevated CO₂ concentration scenarios. The coupling of vegetation processes with CTM is an important update for studying the interactions between ecosystem and atmospheric chemistry. However, the effectiveness of the ecophysiology module was not sufficiently evaluated. Before the possible publication in GMD, I suggest the authors enrich this manuscript in the following aspects to further strengthen the validations and calibrations of key biophysical processes.

Here are some main concerns:

1. The case 1a experiment is the baseline of this study. It shows some improvements in simulating V_d in Figure 3 compared with case 0. However, the explanation for such changes is almost like no explanations: "*The more significant decreases in v_d for broadleaf trees and needleleaf trees than for other PFTs are only due to the differences in formulations, but not due to any other physical reasons.*" Why it becomes smaller? Differences in what formulations? I think the improvement is limited, as there are still obvious PFT-specific biases in baseline Case 1a. For example, the V_d of needleleaf is much lower than observations. Is it because of the scaling by βt , which turns down the V_d for deciduous trees and consequently decreases the V_d for needleleaf trees as well?
2. In Figure 3, the ecophysiology module seems significantly affected by βt . The larger the parameter, the higher the V_d. This factor is emphasized in the analysis of improvement from Case 0 to Case1a. However, such implementation introduces two

problems/uncertainties into the model. First, observations do not always show the dependence of V_d on soil moisture, especially for needleleaf trees and some C3 grassland. Second, the calculation of βt is dependent on data from MERRA2. It's unclear how accurate are the MERRA2 soil moisture data. For the first point, the updated model will show incorrect responses of V_d to moderate drought. For the second point, both the spatial and temporal biases in the soil moisture of reanalyses data will affect the simulated A_n , g_s , and V_d , but to what extent remains unclear.

3. Figure 4 shows the coupling of the ecophysiology module worsens the simulation of surface ozone. Although the authors tried to explain the causes, these results diminish the meaning of the model improvement with ecophysiology module. Considering that the new module has limited and even negative effects on the ozone simulations, more solid evaluations of carbon cycle modeling is needed rather than three lines of demonstration of *"our results demonstrate a seasonal cycle of GPP that peaks at around $130 \text{ g C m}^{-2} \text{ month}^{-1}$ in July and falls steadily to around $60 \text{ g C m}^{-2} \text{ month}^{-1}$ in February. This resembles with observation-derived datasets like FLUXNET-MTE, as shown in Fig. 3a of Slevin et al. (2017)"* (in Line 472-474). For example, site-based evaluations for GPP, stomatal conductance g_s , and O_3 stomata flux are all crucial. The SynFlux dataset includes these variables in addition O_3 concentrations and O_3 deposition velocity for further evaluation.

4. The response sensitivity of GPP to CO_2 and the damage sensitivity of O_3 to GPP highly rely on key parameters originally adapted in JULES rather than the ecophysiology module implemented in this study. Necessary validations or calibrations for these two sensitivities should be conducted within this whole different framework.

5. Line 607: "In particular, LAI does not change dynamically with climatic conditions or O_3 damage in the current model". To what extent the LAI dataset is fixed? Is this a reasonable configuration? LAI is a key parameter regulating carbon fixation, ozone dry deposition, and isoprene emissions. Such omission will likely weaken the interactions between atmosphere chemistry and biosphere especially when CO_2 fertilization is considered.

Specific comments:

Abstract: The abstract is too lengthy. It can be truncated by half.

Line 139-141: *"This approach is particularly useful for examining how ecosystem structure may respond to long-term atmospheric chemical changes over multidecadal timescales, but may be unnecessarily computationally expensive for problems involving shorter timescales...It also introduces extra uncertainties that arise from the computation of ecosystem structure, which involves complex representation of plant phenology and biogeochemistry"*. Biospheric calculation is normally not the resource-consuming part in the atmospheric-chemistry-involved simulations. Are there any comparisons in speed and

uncertainty with other CTM with a biosphere model?

Equation 11: How is this related to stomatal conductance and how to get the closed relationships among A_n , G_s , and C_c from this additional equation?

Line 358-359: "*Figure 2 shows the locations of 36 SynFlux sites used in our evaluation of the ecophysiology module*". What are the selection criteria for these sites?

Line 398: "*resistance*" should be conductance.

Line 461: "*We note also that such changes in GPP is entirely due to higher photosynthetic rate, and no changes in LAI are simulated*". Isn't LAI prescribed? "*.. changes in GPP is..*", should be "*..are..*".

Figures 3 and 4: The inclusion of ozone damage doesn't cause significant changes to V_d and ozone. I suggest remove the first two columns.

Figure 8d: Why the O₃-damage-induced isoprene emission reduction doesn't match O₃ damage in Figure 5c. For example, the high O₃ damages in eastern U.S. show limited impacts on the regional isoprene emissions.