Geoscientific Model Development Discussions

Geosci. Model Dev. Discuss., referee comment RC2
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Comment on gmd-2022-227

Anonymous Referee #2

Referee comment on "Implementation of trait-based ozone plant sensitivity in the Yale Interactive terrestrial Biosphere model v1.0 to assess global vegetation damage" by Yimian Ma et al., Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2022-227-RC2, 2022

This paper addresses the importance issue of properly representing interspecific variations of plant sensitivity to ozone damage in global ecosystem or Earth system models, by taking advantage of the observed relationships between leaf-based traits (such as leaf mass per area) and ozone sensitivity. The methodology and analysis are scientifically rigorous and valid, and potentially important implications for all future studies of plant-ozone interactions. I recommend the publication of this manuscript as long as the following suggestions have been addressed.

Section 1:

Overall, the introduction is too short, thus the motivation and justification for the importance of their work are relatively weak. It is also not as informative as what an introduction section should be like. The authors are thus recommended to lengthen the introduction, especially to:

- How exactly are the different kinds of plant sensitivities currently used in models measured/determined? What are the differences between the different approaches (e.g., Felzer vs. Lombardozzi vs. Sitch)? Based on experimental values or field observations? A discussion on the methodological and theoretical basis of the current approaches should be included. Moreover, a comparative analysis of the numerical results from the different approaches and studies should be included to highlight the uncertainties and justify the need to revise the current approach.
- In addition to semi-mechanistic representation of sensitivity of photosynthesis to ozone

exposure, there have also been other more empirical approaches to quantify plant sensitivity to ozone, including the concentration-based approach (e.g., AOT40) and flux-based approach (e.g., DO_3SE, POD). These approaches have been mostly applied to crops but also to some extent to natural vegetation. A paragraph should be devoted to discuss the merits and shortfalls of these various approaches, so as to justify the importance of mechanistically representing photosynthetic responses to ozone exposure. Some references that should be discussed include Tai et al. (2021) and Emberson et al. (2018).

- A proper representation of ozone-vegetation interactions is important in Earth system and atmospheric modeling as much as in ecosystem modeling, because ozone damage on plants can subsequently affects land surface fluxes and thus atmospheric chemistry and climate. Some discussion should be done on these aspects, with references to, e.g., Zhou et al. (2018), Gong et al. (2020), and Zhu et al. (2022).
- The possible theoretical basis behind the connection between LMA and ozone sensitivity should be discussed. Possible uses of equations are recommended.

Section 2.2:

The authors describe the POD approach here. As mentioned above, a due discussion comparing the various approaches including POD should be given in the introduction section.

Section 2.3:

Since the calibration exercise is so crucial to this study, the authors are recommended to include at least a table or two for the calibration (from Table S3–S7), ideally the most important one or a consolidated one, in the main paper. Details of the calibration method (e.g., Monte Carlo? Or simply varying the value manually until it fits the best?) should be given in the text or table caption.

Section 2.4:

Since the global distribution of ozone concentration is so crucial in evaluating the resulting GPP reductions, the global map of ozone concentration should be given in the main text instead of in the supplementary materials.

Section 3:

The use of tenses seems to be inconsistent across the paper. Section 2 mostly uses the present tense, but the past tense is sometimes used in Section 3. The authors are recommended to consistently use tenses throughout the paper (i.e., using the past tense for the research tasks and actions they did for their study and for the actions done by previous researchers, but the present tense whenever the results are presented and discussed).

Section 3.2:

- It is not surprising that "the simulation with the optimal a =3.5 nmol-1 s g predicted a global GPP reduction of 4.8% (Fig. 4a), which was similar to the value estimated with the area-based S2007 scheme", because ultimately the LMA approach is derived from the area-based approach. This then comes to an important question – why do we need to use the LMA approach after all, if the resulting GPP is similar? This should be addressed. I suspect that using the LMA approach may better capture the regional differences and intra-PFT variations, but these are not explicitly shown or analyzed by the authors, who are thus recommended to address these issues (e.g., by elaborately comparing the PFT-specific and/or regional differences of ozone damage from the area-based approach vs. the LMA approach). This is done in part in Fig. 4, but the attribution to PFT or regional variations are lacking. It may be important to show how each PFT behaves differently under the two approaches.
- A more elaborate discussion should be given to how "the differences in LMA and simulated O3 sensitivities of these PFTs were the main cause of discrepancies in GPP damage at the large scale".

Section 4:

The authors have described the possible mechanisms behind the LMA-ozone damage relationships here. As suggested above, some of these should be devoted to the introduction section (at least discussed briefly), and here the authors may discuss how their model development and simulations verify them and allow them to derive a fuller picture.

Section 4.3:

The authors well justify the merits of their LMA-based approach. Indeed, this can bring potentially significant unification and simplification of global modeling. I would further recommend an additional merit is that the LMA-based approach can even address the intra-PFT (not just inter-PFT) variations in ozone sensitivity because species in the same PFT can have largely varying LMA. Even though for now each PFT may have a fixed LMA in many models, this LMA-based approach provides a unifying way to model ozone damage as more spatially resolved LMA data become available in the future.

References to cite:

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- Tai, A. P. K., Sadiq, M., Pang, J. Y. S., Yung, D. H. Y., & Feng, Z. (2021). Impacts of surface ozone pollution on global crop yields: Comparing different ozone exposure metrics and incorporating co-effects of CO_2. *Frontiers in Sustainable Food Systems*, *5*, 534616.
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- Zhu, J., Tai, A. P. K., & Yim, S. H. L. (2022). Effects of ozone-vegetation interactions on meteorology and air quality in China using a two-way coupled land-atmosphere model. *Atmospheric Chemistry and Physics*, *22*(2), 765-782.