Response to Comments of Reviewer #3

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Authors: Jiachen Cao, Xu Yue and Mingrui Ma
Title: Simulation of ozone-vegetation coupling and feedback in China using multiple ozone damage schemes

We are grateful to the referee for his/her time and energy in providing helpful comments and guidance that have improved the manuscript. In this document, we describe how we have addressed the reviewer's comments. Referee comments are shown in black and author responses are shown in blue text.

This paper use the established methods of chemistry-meteorology-ecosystem modeling to simulate ozone damage on plants over China, and the associated impacts on surface energy balance, carbon sink, meteorology and air quality. The manuscript is well-organized. Compared to earlier papers in this topic, the authors focus on comparing several established methods of calculating ozone damage (S2007 vs L2013), which is an important and new contribution. Minor revision is recommended to address several linguistic and conceptual problems:
Thank you for your positive evaluations. All the questions and concerns have been carefully answered.

L48: Rewrite as "…adverse effects on ecosystem functions, global warming and O3 pollution through…"
Response: Rewrite as suggested.

L60: rewrite as "…growth, suppressing ecosystem carbon uptake."
Response: Rewrite as suggested.

L104: "surface energy balance"
Response: Rewrite as suggested.

L107: "but" -> "and"
Response: Corrected as suggested.

L311: what is "instant O3 concentration"?
Response: In revised paper, we modified inappropriate description as follows: "at low O_3 concentrations." (Line 309)

L 310 – 313: Clearer explanation is required. L2013 (Table 2) has a lot of PFTs with 0 slopes. That means when stomatal O3 flux is above 0.8 nmol m-2 s-1, the response of photosynthesis and stomatal conductance remain constant. I believe this causes the same phenomenon described in L 366 – 367, especially during ozone season. A few CUO and PFT plots could help explain/verify this.

Response: In the revised paper, we clarified as follows: "In contrast, the L2013 scheme depends on the accumulated O_3 flux and assumes constant damages for some PFTs (Table 2), resulting in reductions of photosynthesis even at low O_3 concentrations." (Lines 307-309) We also added Figures S2 and S3 to show the CUO and PFT over China.

L316 – 318: There is no direct observation suggesting plants in southwest receive less ozone damage. This is not a valid conclusion and not necessary for the paper. Remove this statement or provide more direct evidence. On the other hand it is fair to point out L2013 lacks distinction between sunlit and shaded leaves since direct evidence were given by the authors.

Response: We agree with the referee's comments. In the revised paper, we removed the original statement on Lines 316-318 and clarified that S2007 reasonably captured the differences of O_3 damages to photosynthesis of sunlit and shaded leaves, which was supported by observations: "In contrast, the L2013 scheme depends on the accumulated O_3 flux and assumes constant damages for some PFTs (Table 2), resulting in reductions of photosynthesis even at low O_3 concentrations. Consequently, we found limited differences in the O_3 damages between sunlit (Figure 2c) and shaded (Figure 2f) leaves with L2013 scheme. Observations have reported that surface O_3 has limited impacts on the shaded leaves (Wan et al., 2014), consistent with the results simulated by the S2007 scheme. " (Lines 307-313)

L 343 – 346: Like I explained above: for a lot of PFTs L2013 has constant response after stomatal O3 flux is higher than a threshold, while S2007 depends on instantaneous stomatal O3 flux. It's more appropriate to highlight the difference in model structure/assumptions that leads to different result between S2007 and L2013 than judge which scheme is better without comparing with direct empirical evidence (e.g. plant trait and EC measurements).

Response: We agree with the referee's comments. In the revised paper, we removed the original judgement on Lines 344-346 and explained the differences between schemes as follows: "The most significant differences are located in Tibetan Plateau with limited damages in S2007 but strong inhibitions of both GPP and TR in L2013. The low temperature (Figure 1a) and O_3 concentrations (Figure 1d) jointly constrain O_3 stomatal uptake (Figure S2), leading to low O_3 damages over Tibetan Plateau with the S2007 scheme. However, the L2013 scheme applies b_p=0.8021 for grassland (Table 2),

suggesting strong baseline damages up to 20% even with CUO=0 over Tibetan Plateau where the grassland dominates (Figure S3)." (Lines 338-344)

L 393: This paper suggests that O3 damage increase isoprene emission because of increased leaf temperature, which is in line with previous studies (Sadiq et al., 2017). However, isoprene production is coupled to photosynthesis. There are empirical evidence, that high O3 exposure actually reduces isoprene emission when O3 exposure is prolonged enough to suppress photosynthesis (Bellucci et al., 2023). As an empirical parameterization, MEGAN does not include this effect. While this does not completely invalidate the O3 feedback result, this possible artifact in isoprene emission and its potential impact on the result have to be discussed thoroughly.

Response: In revised paper, we added following discussion as suggested: "First, we predicted increases of isoprene emissions in eastern China mainly due to the increased leaf temperature, which is in line with previous studies (Sadiq et al., 2017; Zhu et al., 2022). However, isoprene production is coupled to photosynthesis. There are empirical evidences showing that high dose of O_3 exposure reduces isoprene emissions when O_3 exposure is prolonged enough to suppress photosynthesis (Bellucci et al., 2023). Inclusion of such negative feedback might alleviate the O_3-induced enhancement in isoprene emissions. " (Lines 454-461)

Reference:

Bellucci, M., Locato, V., Sharkey, T. D., De Gara, L., and Loreto, F.: Isoprene emission by plants in polluted environments, Journal of Plant Interactions, 18, 2266463, https://doi.org/10.1080/17429145.2023.2266463, 2023.

Sadiq, M., Tai, A. P. K., Lombardozzi, D., and Val Martin, M.: Effects of ozone-vegetation coupling on surface ozone air quality via biogeochemical and meteorological feedbacks, Atmospheric Chemistry and Physics, 17, 3055–3066, https://doi.org/10.5194/acp-17-3055-2017, 2017.