Response to Comments of Reviewer #1

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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.

The authors examined the meteorological and air quality feedback of O3 damage to vegetation by coupling WRF-Chem with two O3 damage schemes. This reviewer has a few questions.

First, S2007 seems to calculate instantaneous (for WRF-Chem's model integration time steps or hourly) values of the undamaged fraction F, whereas L2013 calculates the ozone damage ratio for the entire growing season. So, was one constant L2013-calculated, plant-specific, O3 damage ratio applied throughout the whole simulation period, whereas S2007-calculated O3 damage ratios were time-dependent, when the schemes were coupled with WRF-Chem?

Response: As mentioned by the referee, the ozone damage calculated by the S2007 scheme is related to instantaneous excessive ozone flux (dFO_3), while the ozone damage calculated by the L2013 scheme is related to the cumulative ozone uptake flux (CUO). As shown in Figure R1, both CUO and dFO_3 vary with time. The value of CUO increases month by month, reaching a maximum in August. In contrast, dFO_3 is affected by instantaneous O_3 concentration, which peaks in July, leading to highest dFO_3 in July.

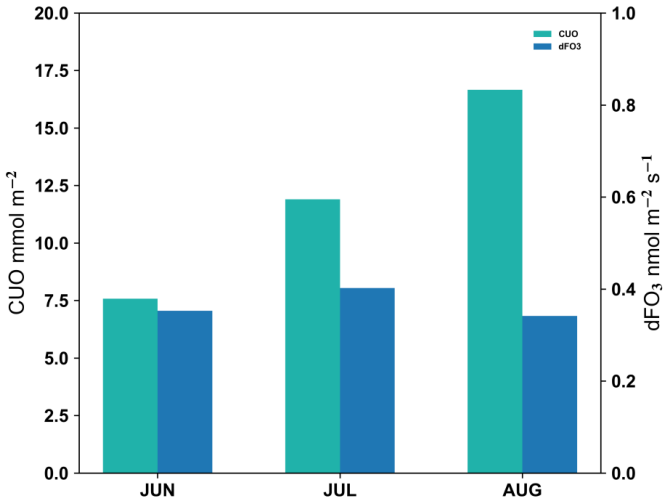

Figure R1 Monthly mean CUO and dFO_3 calculated for L2013 and S2007 schemes,

respectively. Here $dFO_3 = max\{f_{O_3} - y_{PFT}, 0\}$ in equation (3) of main text.

Second, the way the manuscript was written did not show the distinction between sunlit and sunshade in S2007- and L2013-calculated O3 damage ratios, which leads to the question how the ratios were applied to NOAH-MP. This leads to the next question. Why were L2013-calculated sunlit and sunshade O3 damage values for both photosynthesis and stomatal conductance were almost the same, whereas S2007-calculated ones showed such a contrast?

Response: In supplementary material, we added Text S1 to explain how we distinguish O_3 damages to sunlit and shaded leaves:

"In NOAH-MP, stomatal resistance is calculated separately for sunlit and shaded leaves. Therefore, the undamaged fraction $F_{(sunlit/shaded)}$ in S2007 is dependent on the sensitivity parameter a_{PFT} and excessive area-based stomatal O_3 flux, which is calculated as the difference between $f_{O3(sunlit/shaded)}$ and threshold y_{PFT}:

$$F = 1 - a_{PFT} \times max\{f_{O_{3(sunlit/shaded)}} - y_{PFT}, 0\} \quad (1)$$

The stomatal O_3 flux $f_{O_3(sunlit/shaded)}$ is calculated as:

$$f_{O_{3(sunlit/shaded)}} = \frac{[O_3]}{r_a + k_{O_3} \cdot r_{s(sunlit/shaded)}} \quad (2)$$

where $r_{s(sunlit/shaded)}$ represents stomatal resistance (s m^{-1}) for sunlit/shaded leaves.

For the L2013 scheme, the leaf-level CUO for sunlit and sunshade (mmol m^{-2}) over the growing season is calculated as follows:

$$CUO_{(sunlit/shaded)} = \sum(k_{O_3}/r_{s(sunlit/shaded)} + 1/r_a) \times [O_3] \quad (3)$$

$$F_{PO3(sunlit/shaded)} = a_p \times CUO_{(sunlit/shaded)} + b_p \quad (4)$$

$$F_{cO3(sunlit/shaded)} = a_c \times CUO_{(sunlit/shaded)} + b_c \quad (5)$$

where $F_{pO3(sunlit/shaded)}$ and $F_{cO3(sunlit/shaded)}$ are the damage ratios of photosynthesis and stomatal conductance for sunlit/shaded leaves, respectively."

The main reason why in the L2013 scheme, the sunlit and shaded leaves showed very similar damages for photosynthesis and stomatal conductance is that the L2013 scheme employed a_p=0 or a_c=0 for many PFTs (Table 2). In this case, the damages are independent of CUO which is different between sunlit and shaded leaves. Even for PFTs with non-zero sensitivities, such as grassland and cropland, the values of a_p and a_c are too low that the damaging ratio is mainly determined by b_p or b_c. 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. Consequently, we found limited differences in the O_3 damages between sunlit (Figure 2c) and shaded (Figure 2f) leaves with L2013 scheme." (Lines 307-311)

Third, isn't Eq. 5 supposed to be the integration of Eq. 4 according to its definition?
Response: By theory the accumulative flux (Eq. 5) should be the integration of instantaneous flux (Eq. 4). In practice, Eq 4 was used in the S2007 scheme while Eq. 5 was used in L2013 scheme with some differences. We maintained such differences because O_3 sensitivity parameters were derived based on the corresponding O_3 stomatal fluxes.