Major Remarks

The manuscript could benefit from a more detailed discussion of the potential uncertainties and limitations associated with the observational data and model implementation.

1. Figure 5 shows the simulated O_3 concentration. Is there any way to quantify the uncertainties and how this uncertainty would affect the impact of POD?

Reply: I apologize for any confusion caused. In this study, the O_3 concentration data were not simulated by CLM5. Instead, we used 3-hourly 0.75º O_3 concentration data from the ECMWF Atmospheric Composition Reanalysis 4 (EAC4) as input for CLM5, as detailed in Sec. 2.3.3.

To avoid confusion, we have added the following to the Fig. 5 caption: "The O_3 concentration data used as input for CLM5 are sourced from the ECMWF Atmospheric Composition Reanalysis 4 (EAC4)."

2. Figures 3 and 4 set the foundation of the new scheme, as mentioned by Reviewer #1, the spread of the data point suggesting POD may not be the dominant factor driving the photosynthetic response. For instance, the fitted line for crop indicates a large reduction in photosynthetic rate with POD increase from 0 to 10 mmol m-2. Considering the large spread of the data points within this POD range, the concern would be this fitting line could be associated with large uncertainties. This uncertainty can propagate in the model and affect the O3 impact GPP, An, and gs analysis, such as the large reduction of An and gs of the crop in response to O3 in Figure 8.

Reply: Extensive field experiment analyses have identified POD as the best ozone index to link O_3-induced photosynthetic and stomatal responses so far, thus making it the most widely used index within both the observation and modeling communities. POD accounts for the cumulative O_3 uptake of plants, considering the comprehensive impact of O_3 concentration, exposure duration, and stomatal conductance (Explained in Para. 5 in the Introduction). Even though Wu et al. (2021) proposed a detoxification-capacity-based O_3 index that is better correlated to crop yield response based on observations, its required calculation of the difference between O_3 fluxes reaching cell wall surface and plasmalemma is currently an unfeasible task in existing global process-based land surface models.

The spread of data points in Figs. 3 and 4 arise from our aggregation of observations from various plant species into broader vegetation types, following the building of earlier schemes. Compared to the pursuit of explaining more variation of small data, we think a function that can represent the statistically significant O_3 response relationship observed in big data is more important and more suitable for global models that generalize global vegetation into several PFTs or biomes (rather than plant species). It's worth noting that all our response functions captured the observed statistically significant relationship between POD and photosynthetic /stomatal response. Introducing more explanatory variables (e.g., leaf trait variables as suggested by earlier studies) and conducting PFT-specific fitting may explain the variation better. These are the future development directions as listed in Sec. 5.1.4.

The larger reduction in the photosynthetic rate when POD is smaller (e.g., "0 to

10 mmol m-2 for crops") depicted by our fitting lines reflects the change in plant adaptability or transition from sensitivity to tolerance among plant species within a vegetation category, as observed in the real world and discussed in Sec. 5.1.2. Furthermore, our results that crops are sensitive to O_3 ("large reduction of An and gs of the crop in response to O_3 in Fig. 8") are consistent with earlier observational analyses (Reich 1987; Wang et al., 2024) and modeling works (Ma et al., 2023). We have added the comparison in Sec. 5.2.

We agree that our fitting lines could be associated with uncertainties that can propagate in the model and lead to uncertainty in quantifying the influence of ozone plant damage. We have added discussions on potential uncertainties and limitations of the parameterization scheme in Sec. 5.1.4 as follows: "Even though the new scheme has advantages over earlier schemes, as listed in the previous section, there are still noticeable variations in observations that have not been explained (Figs. 3 and 4). This limitation may introduce uncertainty in modeling carbon and water cycles, yield, biomass, and ecosystem structure and composition in large-scale process-based models, as well as in quantifying the role of ozone plant damage in the Earth system using these models to conduct numerical experiments.". In addition, the limitations of observations and suggestions to the observational community were presented in Sec.5.3.

Specific Remarks

1. BT and NT are defined in Line 336, but used before this line.

Reply: Thanks for pointing this out. In P7, we have added the definitions "BT and NT represent broadleaf trees and needle trees, respectively" in the title of Table 1.

2. Line 449-450: The manuscript states that the global reduction in leaf photosynthetic rate and stomatal conductance is 8.5% and 7.4%, respectively. It would be useful to provide a comparison with previous estimates from earlier schemes, either at global or regional scales, if any.

Reply: Thanks for your suggestion. We have added these comparisons to Sec. 5.2, along with all other comparisons: "Our estimates of the O_3-induced reduction in global average photosynthetic rate and stomatal conductance are around half of those calculated using the L15 (20.4% and 13.9%, Fig. 7). They are also lower than those estimated by Lombardozzi et al. (2013) (21% and 11%), which were derived from the average differences between control and O_3-fumigation experiments. Lombardozzi et al. (2013) used a smaller dataset than ours, did not differentiate between vegetation types or control experiment types, and did not filter out low-confidence data.".