

## ***Interactive comment on “Particulate matter air pollution offsets ozone damage to global crop production” by Luke D. Schiferl and Colette L. Heald***

**Anonymous Referee #2**

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Over the last ten years or so it has become more and more evident that air pollution has a strong impact on the Earth's ecosystems with consequences for global ecosystem productivity and wellbeing. It also affects the efficiency with which the terrestrial vegetation acts as a carbon sink with obvious consequences for the climate. The impacts can be detrimental, as is the case with ozone, or they can be beneficial when for instance aerosols increase the diffuse fraction of PAR thereby increasing plant productivity. The interactions are complex and strongly depend on the prevailing environmental conditions such as for instance cloudiness, temperature or drought conditions. With an increasing global population the vulnerability of food crops is of special importance. This manuscript examines the impacts of pollution in the form of surface ozone and

C1

PM<sub>2.5</sub> on the productivity of major food crops (maize, wheat, rice) under PD (2010) and FU (2050) conditions at the global domain. The study applies global models that are coupled in an offline manner (GEOS-Chem to simulate atmospheric chemistry and RRTMG to compute the atmospheric radiation flux). Conventional pollution exposure metrics such as AOT40, M12 and M7 for ozone and radiation use efficiency (RUE) for PM<sub>2.5</sub> are used to quantify the impacts, in the latter case empirical DF-to- $\Delta$ RUE relationships are used to calculate the change in potential carbon production (P<sub>carb</sub>).

I think that this study's research question is very timely and important. In principal, the applied methods and models are appropriate but I also believe that the conclusions drawn from the modelling stretch the capabilities of the tools to their limits or maybe even beyond, but I will come back to this specific point later in my review. Overall, I think the study is executed well, the manuscript is well written and logically consistent, the data and figures are adequate and support the principal findings. Thus I am satisfied that the paper can be published in AP albeit after the conclusions have been revised.

My main concern with this manuscript is with its conclusions. The authors state for instance that they “demonstrate that including the DFE of PM on crop production can offset the negative impacts due to ozone”. I would prefer that it is made clear that this conclusion is drawn from a modelling study, that the bulk of the assessment is done with maximum DFE strength assumed and that feedbacks of PM with the climate system has been neglected (e.g., aerosol indirect effects, surface cooling, water vapour exchange, etc.). True, these facts have been mentioned individually in the preceding text but they have been omitted in the conclusions. I wish the conclusions were presented with more caution regarding the uncertainties.

In my reading of the paper I think the author have made a very valuable contribution by showing how large the uncertainties still are and that there is a potential for the DFE to counter the ozone impact but with current understanding the DFE can be almost anywhere between 0% and 100% of the ozone impact. For instance, Yue et al. in their study of the DFE over China (2017, doi:10.5194/acp-17-6073-2017) that the

C2

ozone impact on productivity seems to dominate in their modelling study. The direct DFE accounted only for roughly 50% of the ozone impact and was further reduced to approximately 25% of this effect when taking into account the feedbacks of aerosols with clouds etc. I guess I am arguing that our understanding of the processes involved is still too poor to make strong statements that are not caveated.

My recommendations are to revise the conclusions and include caveats that I have pointed out above. I think even with those stronger caveats the paper is a very important and valuable contribution to the field. It is very well written and presented and needs no further revisions than the ones I pointed out.

I therefore recommend publication with minor revisions and leave it to the editor to “enforce” them, i.e., to decide if and to what extent the conclusions need to be revised.

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