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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Projected global tropospheric ozone impacts on vegetation under different emission and climate scenarios" *by* Pierre Sicard et al.

Anonymous Referee #1

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The work presented in this paper is based on the surface ozone concentration fields from 6 global models that have simulated atmospheric composition for recent history (around year 2000) and for the end of the 21st century under three of the IPCC future climate scenarios RCP2.6, RCP4.5 and RCP8.5. The model simulations were conducted already under the ACCMIP project. From the surface ozone concentrations the authors derive AOT40 values for ozone for each model and each simulation and also a potential vegetation injury risk factor due to ozone (IO3) for each model and each simulation. For each model, the % change in the AOT40 and IO3 values are presented for the three future scenarios relative to the historical scenario. The variations in the values of the metrics and in the simulated future changes in the metrics are discussed

in terms of differences between the 6 models, global geographic patterns, and differences between the future scenarios.

Scientific comments:

(1) The main conclusion of the work as stated in the last sentence of the abstract (and in lines 585-587) is the recommendation that improved evaluation of regional exposure of ecosystems to O3 requires improved chemistry-climate modelling systems, fully coupled with dynamic vegetation models. This is a conclusion that (a) provides no additional insight to the reader – it could have been written down before reading this study, and (b) is not based on data provided by this study – the authors do not demonstrate in this study that these modelling improvements improve the modelling of O3 ecosystem impacts.

(2) The core of this paper is the calculation and use of the AOT40 value but the description in the Methods section of how AOT40 values are calculated in this work is currently very unclear (line 143 and onwards). Was the calculation of an AOT40 for a model grid for all hours in the year, or for hours between 08.00 and 20.00 for all days of the year, or for the local 'daylight' period for all days of the year? At one point the text refers to calculation during 'daylight hours' (Line 144) but in another place 'daylight' is defined as 08.00-20.00 (Line 137), and the formula presented in Equation 1 implies calculation using all hours in the year. Derived values of AOT40 depend on this issue.

If using a 08.00-20.00 time-stamp to define daylight, the authors should confirm that this is reference to the local time for that grid cell.

If using local daylight hours then the authors should confirm how this was defined as function of latitude and day-of-year.

(3) As noted above, it appears that in this work the AOT40 value is evaluated for all days of the year, whilst, as the authors have noted, for application of AOT40 to evaluate potential vegetation damage the AOT40 value needs to be evaluated over a certain

period only during the year, a period which is different for different vegetation types. The authors state that calculating AOT40 for all days of the year in this work is not an issue when they are considering changes (in AOT40) between historic to future simulations. But surely this is not true. The seasonal distribution of ozone concentrations will change between different scenarios so relative changes in AOT40 computed for all-year will very likely be different from the relative changes in AOT40 computed for a sub-set of the year, as AOT40 values for vegetation damage assessment should be calculated. This issue needs much more discussion and justification.

(4) Having stated in the Methods section that even if they overestimate AOT40 their study is focused on the relative changes in AOT40, they then later make statements about extent of exceedance of absolute AOT40 critical values. For example line 547 in the Conclusions states: "[The] most important results from the study are the significant overrun of exposure metric (AOT40) in comparison with the AOT40-based critical level for the protection of forests (5 ppm.h) and crops (3 ppm.h). Furthermore, they appear to fail to acknowledge or take account that the AOT40 critical values for forests and crops require calculation of AOT40 over defined months, not the full year as their method in Equation 1 has done.

(5) The authors apply an alpha factor to their (all-year) AOT40 values to calculate a potential ozone vegetation risk factor IO3 (Equation 2 in Line 167). The units of alpha are quoted as per mm per ppb. When alpha is multiplied by an AOT40 value, which has units of ppb.h, this means that the IO3 metric has units of h/mm (i.e. dimensions of time per length). Can the authors explain the physical/biological basis for a photosynthetic assimilation risk factor having these dimensions?

When I check the associated citation (Anav et al. 2011, GCB) I note that the equivalent formula in this latter paper also includes a stomatal conductance variable g, which is not present in Equation 2 and not mentioned in the current manuscript.

(6) The conclusions section is almost 3 pages long and much of it is discus-

sion/statement of prior literature and not conclusions from this work. For example, lines 552-560, lines 573-582 and lines 592-598 are generally re-statements of previous published findings and conclusions, not conclusions from this work.

(7) The abstract contains contradictory text. The first sentence states that concentrations of surface O3 are expected to increase in the future. Later in the abstract it is stated that for two of the RCP scenarios investigated ozone concentrations and vegetation injury decreases in the future.

(8) Overall, whilst the extensive discussion of the variation in surface O3 mixing ratios (geographically, with model, and with scenario) is valid (but probably also described in other publications that have emanated from the ACCMIP project), I am not convinced that statements made about changes to ozone ecosystem injury are quantitatively valid.

Minor technical/typographical corrections:

Line 17: change "overrun" to "exceedance".

Line 39: no capital letter for "globe"

Line 44: the authors refer to "tropospheric O3 levels", but do they mean "surface O3 levels" here? Throughout the Introduction there appears to be use of "tropospheric" when "surface" is meant. Ensure that terminology is used accurately.

Line 61: the authors refer to "expected" mean concentrations of O3 of 97 ppb in 2100, without comment that this is just an estimate under a particular scenario, nor comment that this increase of 50 ppb O3 in the 21st century is substantially at odds with what they write in their abstract of possible increases of a few ppb O3 under the 'worst case' RCP scenario evaluated.

Line 71: only one of the phrases "state-of-the-art" or "up-do-date" is needed here.

Line 83: the Latin "in fine" is not generally used in English, replace with something like

“and finally”

Line 84: rephrase as “This rising CO2 reduces. . .”

Lines 190-192: Please clarify whether the O3 levels quoted for the extratropics are average over land surfaces only (as was the case for the data quoted in the previous sentence) or for all extratropic areas. Similarly for the data presented in the subsequent sentence relating to AOT40 hours. It may be helpful to have a general statement somewhere that all spatial averages are for land and non-land surfaces unless stated otherwise (or whatever is an appropriate equivalent statement for this paper).

Line 220: rephrase as “the different chemical schemes used.”

Lines 262-266: this paragraph contains general statements about ozone deposition that are not directly related to either the preceding or subsequent paragraphs that contain discussion of modelled O3 level in specific regions of the world.

Line 271: rephrase as “Several investigations of. . .” and delete the commas after “investigation” and after “Greenland”.

Line 275: lower case for “peroxyacetyl”

Line 279: space required before “concentrations”

Line 365: write as “all the RCP scenarios include”

Line 375: change “Inversely” to “In contrast”

Line 459: rephrase as “are not associated with an increase”

Line 488-490: rephrase to make it clear whether the stated GPP reduction exceeding 30% is referring to “our results” or to the cited Sitch et al. study.

Line 515: see above for line 83.

Line 548: change “overrun” to “exceedance”.

Caption of Figure 1: clarify exactly what is plotted “Surface ozone annual average concentrations. . .”?

Caption of Figure 2: clarify what is plotted. What is an AOT40 mean? Delete the word “mean”?

Figure 3: the middle panel on the top row has a “No contour data” error message on it.

Table 2b: Suggest moving the column with the CH4 data to be the last column in each of the groups of columns since the data in the other columns in each group refer to % change in emissions whilst the data in the CH4 column refer to % changes in atmospheric burden.

Caption of Table 3a: clarify what is presented. Is it better phrased as: “Global and hemispheric (averaged over the domain) mean annual-average surface ozone concentrations (in ppb) and mean AOT40 (in ppm.h) for. . .”?

Caption of Table 3b: clarify what is presented. Is it better phrased as: “Simulated percentage (%) changes in global and hemispheric mean annual-average surface ozone concentrations. . .”?

Caption of Table 3c: clarify what is presented. Is it better phrased as: “Simulated percentage (%) changes in global and hemispheric mean AOT40. . .”?

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