

Review of “Intercontinental trans-boundary contributions to ozone-induced crop yield losses in the Northern Hemisphere” by Holloway et al. Submitted to Atmos. Chem. Phys.

This study presents a series of model simulations designed to investigate the contribution of anthropogenic NO_x emissions on crop yields, through the impact of NO_x on ozone concentrations. The authors compare simulations where anthropogenic NO_x emissions are reduced by 100% in Europe, North America and Southeast (SE) Asia, against a control simulation with full emissions. This “source-receptor” style experiment allows the authors to see the impact of a given region’s emissions on local ozone concentrations, as well as those downwind through intercontinental transports.

The impact of regional ozone concentrations on crop yields is assessed for 6 different crops, using different exposure metrics and previously published yield/metric relationships. Globally, the study finds that removing all SE Asian anthropogenic NO_x emissions results in the greatest reduction of yield loss for wheat, rice, potato and cotton; removing all North American NO_x emissions leads to the greatest reduction of yield loss for maize and soybean. North American NO_x emissions have the greatest impact on trans-boundary crop yields, due to the efficiency of trans-Atlantic transport compared to export of Asian emissions to the States and European emissions to Asia.

Overall, I think that the study provides an interesting and important spin on trans-boundary pollution modeling studies. However, I have a few scientific and general comments that I would like the authors to address, as well as several minor comments and corrections. I am an atmospheric chemist, rather than crop scientist, and my comments are therefore mainly concerned with that aspect of the study.

SCIENCE COMMENTS

(In no particular order)

1. Use of AOT40?

Much of the analysis and discussion seems to center on the AOT40 metric results, as this gives the largest impact. Yet at the end of Section 3.1 it is stated, “from a modeling perspective, AOT40 may be a less robust metric [compared to the M_x indices]”. Also, Figure 10 shows how sensitive the metric is to small changes. Based on this, perhaps the authors could provide more justification for the fact that this metric is the one used to give the “headline” results.

2. NO_x emission sources

Section 2.1 should explicitly point out that biomass burning and natural NO_x emission sources are not removed in the emission scenarios. (What happens to aircraft emissions?) Currently, this fact is not really highlighted until the Discussion section, but it is obviously important in the analysis of the results. For instance, Section 3.4 mentions that removing local emissions does not totally eliminate local yield losses in North America. Can you say whether this is because of the remaining emissions, or because of trans-

boundary pollution? Similarly, are the residual NO_x emissions responsible for keeping SE Asia's yield loss at 87.8% (P8658, L20)?

Related to this (and maybe assisting the analysis), Table 1 could be replaced with a 3-panel figure showing (a) the "full" NO_x emissions, (b) NO_x emissions after removing the anthropogenic component in each region, and possibly (c), the difference between (a) and (b).

3. Comment on more realistic NO_x reductions?

While I see that 100% NO_x reductions are a useful model sensitivity exercise, it would be interesting to consider the impact of smaller (more achievable?) reductions. Since ozone production/concentration is not a simple linear function of NO_x, presumably any relationship with yield reductions would also be non-linear. Could inferences be drawn from other experiments conducted as part of HTAP? (Perhaps if AOT40/M_x was found to roughly scale with the monthly mean model output that might be available.) At the very least, I think this should be included in the discussion.

4. Error

Is it possible to put the change in the metrics from the emission scenarios in the context of the model error? E.g. hypothetically, what does it mean if there is a 20% change in AOT40, but the model bias is 25%?

OTHER COMMENTS

I disagree with reviewers 1 and 2 about the clarity of the manuscript. In general, the writing could be much tighter, making the messages much easier to understand. Some specific suggestions follow below, but I would encourage the authors to thoroughly read through any revised submission (and perhaps ask colleagues to do the same).

1. Introduction.

This is very long and we do not learn of the object of the study until the end. I would recommend (1) briefly saying what the study is about near the beginning and (2) separating out the description of the metrics into its own section. I think this should make it more readable, especially for interested atmospheric chemists who might not be familiar with these terms.

2. General clarity, reducing repetitiveness, tightening the text.

E.g. the last paragraph on P8654 is very long, confusing, and states facts that were already mentioned previously (e.g. plant damage from ozone below 40 ppbv). Also, the last paragraph of P8656 is long and quite tedious. There really is no need to describe every nuance in the figure – try and limit to highlighting a few key results. Also, the paragraph finishing at the top of page 8649 – what is the take home message here? Shorter sentences would also improve clarity.

MINOR COMMENTS / CORRECTIONS

Throughout:

- Where there are multiple references, it's better to put them in chronological order to emphasize any progression in understanding.
- Refer to references as people rather than books. E.g. "It is shown by Liu et al." rather than "It is shown in Liu et al." (P8667, L7)
- Check parentheses for the references. E.g. same example as above "(Liu et al., 2010)" should be "Liu et al. (2010)". There are several instances of this.
- Check apostrophes (e.g. worlds -> world's on P8647, L13; also: AOT40's, region's, Northern Hemisphere's).
- Should "N America" be "North (N) America" the first time? Same for Southeast (SE) Asia.
- Abbreviation for Northern Hemisphere is used inconsistently.
- Check for consistency of US/British spelling (Presumably the latter is preferred for this journal: "modeling" -> "modelling"). Also "parameterized" or "parameterised"?
- Say "year 2000" (or similar) rather than just "2000", which could be ambiguous (e.g. P8651, L2, L13).
- Check tense consistency, especially in the method section.

P8646: Consider cutting the abstract to less than 300 words.

P8647:

L4. Spell out "US EPA" the first time

L10. While Prather et al. (2001) talk about changes in ozone from the PI, they also say how uncertain the trends are. Maybe say "likely led to increased..."

L13. "(NO_x in particular)" – You've already defined NO_x above.

L17. "Royal Society" (space), but weren't there authors/editors for this report? (Fowler et al.?)

L18 and L23. Pick either "AQS" or "AQSs" (I think the latter reads better)

L19. "...for human health, to which enhanced...detrimental. However, compared to those for vegetation, these tend..." (There are several other places where sentences should be split – please proof read carefully.)

L21. "impact processes" is a bit vague – what do you mean?

L24. Spell out "EEA"

L25. What is "ozone risk"?

L28. Are the units of AOT40 correct? (ppm -> ppmv, but also "h daylight hour"?)

P8648:

L12. Not equal weighting to **all** concentrations surely, since it is only calculated for a certain time periods (?)

L15-L17. This is not clear. What is the "Mx Weibull relationship"?

L23. "less biologically significant lower ozone concentrations" – but you just said that concentrations < 40 ppbv matter!

L26. "As such..." Isn't this sentence a bit obvious?

P8649:

L26. Is it also due to the lack of a land/ocean boundary between Europe and Asia?

L27. "...exceedences of AQSs..."

P8650:

L9. "Mills et al. (2007) review...." (?)

L24. "...emission scenarios. In particular they focus on the impact..." The rest of this sentence could be made clearer (what are "production losses"?)

L27. Define what is meant by yield losses. As I understand it (from later in the text), it means the reduction in yield compared to a theoretical case where there is no pollution (...?)

P8651: L13. "with" -> "against"

P8652:

L1. Use commas rather than dashes.

L6. Why is "2000" in quotation marks?

L8. Spell out "POET"

L12. Colon at the end of this sentence.

L26. Aren't the model levels defined as mid-points anyway? Also, is this a hybrid-sigma model? If so, I guess the position of the lowest level above the surface will depend on the surface pressure – i.e. it will vary globally. (Not too big a deal if you're mostly near sea-level.)

P8653:

L3. Spell out "LRTAP Convention" (authors/editors though?)

L9. Perhaps point to Figure 1 here.

L11. "...50 Wm⁻². Values are..."

L28. Are there references for the statements about "ozone sensitive" and "moderately ozone tolerant" crops?

P8654, L7-8. "...such that the relative yield is equal to 1."

P8655:

L2. "...using data from..." (you mention the nature of the data below)

L16. Consider an introductory paragraph to let the reader know what to expect in the results section.

P8656, L2. "...Data Centre..."

P8657:

L10. "...Fig 2, except that SE Asia has been replaced by Japan, since the latter is..."

L19. Reference for "model failing to decouple the shallow nighttime..."?

P8658:

L6. "While larger than the biases..."

L13-. Are you using 3-month mean AOTs? Please clarify.

P8661:

L11. “are” -> “were”

L14. “These differences could (?) be explained by the use...”

L20. Quite likely different ozone distributions. E.g. see Stevenson et al. (2006) JGR, ACCENT ozone intercomparison.

P8662:

L20 (and throughout). Percentages of percentages are a bit confusing. How about just saying the absolute changes in relative yield?

L22. I’d just quote values to 1 d.p.

P8664, L22-. This is all repetition from the previous section.

P8665, L8. “Potato” -> “potato”

P8666:

L18. “Assuming that under...”

L25-. Not clear what this is getting at.

P8667, L12-17. Section before “An additional factor” should be in the same paragraph as the statements about climate/crops in the previous paragraph.

P8668, L25. “However, it is important to consider...”

P8669, L3. So, do you think that the results from this study are conservative estimates?

Table 1: Delete “receptor” (as these are also source regions, right?)

Table 2/3: Delete redundant reference column and add to title (since all the same references). Are there any errors quoted for the functions’ coefficients?

Table 4: Remove URLs and add as table footnotes (save repeating the same information)

Table 5: Please add units.

Figures 2/3/4: Spell out what “NMMB” is in the caption.

Figures 5/6/7. I would consider having the panels stacked vertically, with the CONTROL results at the top (own color bar), followed by the sensitivity studies underneath. Also, could better values be chosen for the color bars (i.e. integers)?

Figure 10. Describe that the standard deviation refers to a normal distribution in the caption. As with the color bars, how about having better values for the contours? Integer

percent values? Maybe a color plot would help to read what the values are in the top left panel.

Supplementary material: Is this really needed? Could just leave it with the statement that AOT30 and AOT60 gives similar results in the main text (P8659). Figure 2 of the material might be better in the main text too. (If this material is kept, I would suggest adding proper figure captions.)