Atmos. Chem. Phys. Discuss.,
https://doi.org/10.5194/acp-2020-46-RC1, 2020

Atmospheric Chemistry and Physics Discussions

Interactive comment on "The impact of weather pattern and related transport processes on aviation's contribution to ozone and methane concentrations from NO_x emissions" *by* Simon Rosanka et al.

William Collins (Referee)

w.collins@reading.ac.uk

Received and published: 26 February 2020

Review of Rosanka et al.

This study addresses how the impact of aircraft NOx emissions on ozone and methane vary according to the meteorological conditions. The concept is useful, but a lot more work is needed to present a coherent analysis.

The key variable used seems to be the time of the ozone maximum, but the explanation of why this is chosen is hard to discover. The most obvious variables to use would be

Printer-friendly version

Discussion paper

the integrated ozone perturbation (i.e. the area under the curve in figure 1). Or the integrated radiative forcing (i.e. integral of O3 scaled by a radiative efficiency as a function of altitude and latitude). For instance figure 2 shows a correlation between the maximum O3 concentration and time of the O3 maximum, but it is not at all clear that one is actually driving the other. Presumably both these are simply identifying regions of high O3 production efficiency.

It is not at all clear even what the time of the O3 maximum means at longer timescales. Presumably in these cases the O3 timeseries doesn't look like a stretched version of figure 1, but rather a varying timeline that happens to bump up at 40 or 50 days for some meteorological reason. Any NOx signal will have long dissipated after 20 days (figure 1) so it is not obvious that there is any physical meaning to the later ozone maxima. Example timeseries for "early" and "late" maxima need to be shown.

Nearly all the analysis is done for the winter (figs 2, 3, 4, 6, 7) when the effects will be far smaller than in the summer. The magnitude of the winter and summer impacts need to be compared. There is no need to consider the winter at all if it turns out to be unimportant, and certainly the analysis should focus on the summer.

Page 1

Line 12: It is not at all obvious that the time of maximum should be the controlling factor, rather than the magnitude of the maximum.

Line 13: It is more likely that the subsidence leads to greater ozone production efficiency, and that the earlier ozone maximum is a consequence of this, rather than a cause of it.

Line 15: This seems to be stating the obvious – the size of the CH4 decrease depends only on the size of the CH4 decrease.

Line 29: Presumably the aim of this study is to identify those meteorological conditions that are conducive to ozone formation so that the computationally expensive chemical

trajectories are not needed?

Line 30: It is not explicitly stated that the aim is to avoid producing ozone, but to enhance the destruction of methane.

Page 2

Line 12: It needs to be made clear in these sentences whether the climate impact is warming or cooling. It would help to contrast the effects on ozone and methane.

Page 4

Line 4: The method for calculating the trajectories needs to be described. How do they account for sub-grid scale vertical motion?

Page 6

Figure 1: Is this figure a change in the global burden? It would be useful to show changes along a trajectory since that is what is used in all subsequent figures.

Page 7

Figure 2: How well is the "Time of the O3 maximum" defined? It might be that after 20 days there is no well-defined peak, but rather fluctuations of greater or lesser magnitude.

Line 5: Why is it assumed that the early maximum is the cause? It could just as easily be written that an early O3 maximum is only possible if the concentration change is high.

Line 7: The processes involved here need to be understood. It could be that higher altitude emissions don't produce much ozone, so that any fluctuations in ozone appear as spurious "late" maxima. The timeseries for these late maxima need to be shown.

Line 9-13: The RF or CCF is not mentioned again in this study. It appears they come from other work with the REACT4C project. Unless these can be related to the case

studies analysed here it is not helpful to discuss them. For example the comments on Lacis et al. (1990) refer to a higher radiative efficiency at altitude in contrast to the lower ozone production efficiency found in this study. Why do the time and magnitude of the O3 maximum influence the climate impact? Instead it seems it should be the integral of the ozone perturbation with a radiative efficiency factor for latitude and altitude. What is CCF and how is it determined?

Page 8

Figure 3: The caption says the analysis is based on the first seven days after emission, but the figures show values out to 90 days.

Page 9

Line 2-3: It is not obvious why the altitude difference is the crucial variable, rather than the absolute altitude. The discussion makes plausible arguments about increased ozone production at lower altitudes, therefore it would seems more logical to plot the altitudes where the trajectory ends up (maybe the mean altitude in the first 20 days), whereas there doesn't seem to be any argument that it is the amount of descent that is important. Except obviously that if the emissions all occur at similar flight levels then greater descent will give lower trajectories.

Line 5-6: The use of the time of maximum as the controlling variable is not obvious. For instance the claim that the earlier maxima in summer give less time for downward transport is much more likely to be due to the enhanced photochemistry in the summer giving more ozone production at higher altitudes, hence for a descending trajectory the maximum will occur earlier.

Line 8: Rather than focussing on the early ozone maximum, it would be more scientifically rigorous to state that significant ozone production only occurs if an air parcel is transported to lower altitudes and latitudes.

Page 10

Line 2: To what extent is sub-grid scale convection included in the trajectory calculations?

Lines 14-24: In section 3 the argument was that earlier O3 maxima lead to greater ozone production. But here the opposite argument is being made – that increased ozone destruction leads to earlier maxima. In which case the early O3 maxima should be associated with less ozone not more. This is another example of why the time of the O3 maxima should not be used as a controlling variable. Note also that while reactions R2 to R4 might have negative temperature dependencies the origin of the HO2 and RO2 has strong positive temperature dependence, so higher temperatures do lead to more ozone production.

Page 12

Line 2: This sentence doesn't seem correct. Do you mean to correlate NOx with ozone maxima?

Page 15

Lines 10-14: This study uses prescribed emissions of NOx (5x10^5 kg) so there doesn't seem any value in comparing this to NOx concentrations in an aircraft study. I suggest removing this paragraph.

Line 32: Stevenson and Derwent only analysed summer as ozone production and methane depletion are not important in winter.

Page 16:

Line 14: There has been no calculation of "resulting climate impact" in this study, therefore it is not clear how this can be a conclusion from this work.

Interactive comment on Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2020-46, 2020.