

Interactive comment on “Simulated 2050 aviation radiative forcing” by C.-C. Chen and A. Gettelman

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Dear Reviewer,

We appreciate the suggestions and comments you made on our manuscript. We have modified our manuscript accordingly. We have added more description about our simulations and the parameterization. We have also performed significant tests to better represent regional perturbations induced by aviation emissions. We have also explained in detail why cloud cover in mid latitudes of the Northern Hemisphere may be reduced in 2050 when simulating only the impact of contrail cirrus. The text has been revised to acknowledge high uncertainties due to the treatment of aviation aerosols in the ice nucleation processes. We have also added the uncertainties of radiative forcing resulting from the background meteorology.

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Here are the response to your comments.

1. When we simulate the aviation H₂O effect, we do not consider the role aviation aerosols may play in the ice nucleation processes upon the formation of contrails. We have acknowledged this in the manuscript by citing work with such consideration, and remind readers that this can create great uncertainties in the results.

We do address soot effects: based on the assumptions we make, they are small (Gettelman and Chen, 2013). We recognize there is large uncertainty in this and we have noted the uncertainties in previous work. The sensitivity to assumptions about the particle size and the ice nucleation efficiency is also addressed in the previous work.

We do take into account that aerosols which form ice crystals may not participate in indirect effects: aviation aerosols may be scavenged by the clouds that form as contrail cirrus.

2. We have added discussion to address the uncertainties caused by the assumptions made for the role aviation aerosols play in the ice nucleation processes. The assumptions about nucleation thresholds and fraction of efficient ice nuclei are treated in our earlier papers (Chen and Gettelman, 2013, Gettelman and Chen, 2013). The sulfate has less uncertainty regarding efficiency, and the BC uncertainty may be high.

We have revised the caption of Fig. 3 to explain the uncertainty plotted is due to the background meteorology.

3. We kept the propulsion efficiency constant in this study and we have revised the manuscript to reflect this.
4. We have added discussion to remind readers that different results may be obtained by changing the propulsion efficiency.

5. The reduction of fuel burn from BL to SC1 is almost 50% (please see Fig. 1).
6. We have added discussion on the reduction of cloud cover. For this, there are two competing factors to consider. The first is the additional cloud fraction due to the formation of contrails. The second is due to the uptake of ambient water vapor when contrails form which reduces the relative humidity. A reduction in relative humidity will lead the cloud scheme to lower the overall cloud fraction in the grid cell. The results reveal that as the flight distance in 2050 increases significantly from 2006, the second factor has become more important and thus leads to a reduction in cloud cover.
7. We have revised figures to reflect the uncertainty. Figs.6, 8, 9, 10 only consider perturbations above two standard deviations of the corresponding control simulation in the ensemble mean calculation.
8. We have added comments to address the uncertainties resulting from the assumption of the initial ice particle size for contrails. However, we are looking at contrails which are 15-30 minutes old. Our treatment is consistent with Schröder et al, 2000.
9. We have added the total amount of fuel consumption and sulfate emissions in 2050 under BL in the manuscript.
10. The base year for comparison in the manuscript is 2006. We have used inventories for 2006 as the base, and 2016, 2026, 2036, 2050 for future projections.

Regards,

Chih-Chieh Chen and Andrew Gettelman

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