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Editorial Office
Atmospheric Chemistry and Physics

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Dear Editor,

Re: Submission of "Impacts of multi-layer overlap on contrail radiative forcing" to *Atmospheric Chemistry and Physics*

Thank you again for arranging the reviews of our work. We thank the reviewers also for their time and dedication. We have addressed each of the comments made by the two reviewers in the final submitted manuscript.

Please find below our responses to the comments from both anonymous reviewers. We have listed the reviewer's comments in *italics* and our responses in **bold**. All line numbers refer to the revised, clean manuscript.

Anonymous Referee #1

Nice paper!
Thank you!

Line 21: misses an „of" after "sign"
This has now been corrected.

Reference Myhre and Stordal (202) is missing
The appropriate reference (Myhre and Stordal, 2001) has now been added to the bibliography.

Anonymous Reviewer #2

As I commented already in my last review the paper is much improved. Therefore, I had only a quick look through the paper and want to comment on a couple of small mistakes and suggest slight changes. I want to congratulate the authors on this interesting paper.
We are grateful for the reviewer's comments, which we agree has resulted in a much improved paper.

Comments:
1. Table 1:
a) The Burkhardt and Kärcher estimates were calculated for air traffic of the year 2002 for both linear contrails and contrail cirrus. Please correct the year.
Done.

b) The Chen and Gettelman estimate was revisited and corrected in the Lee et al 2020 paper From Lee et al: 'The estimate of Chen and Gettelman (2013) was corrected by redoing the CAM simulation using a lower ice crystal radius of 7 µm and a larger contrail cross-sectional area of 0.09 km2 for the initialization of contrails at an age of about 15–20 min, in agreement with observations (Schumann et al., 2017). The resulting change in cirrus cloudiness including the adjustment in cloudiness due to the presence of contrail cirrus leads to a radiative forcing of 57 mW m− 2.' It would be good to note this in your table.
A comment has been added in the caption which clarifies this adjustment and directs the reader to Lee et al 2020.

2. Line 65: When you talk about the factors that are important for estimating the increase in contrail cirrus radiative forcing in the future you omitted 'climate change' as a factor. Chen and Gettelman (2016) as well as Bock and Burkhardt (2019) discuss (amongst other factors) the impact of climate change on the contrail cirrus radiative forcing for future air traffic.
We have added "changes in background conditions due to climate change" as a factor and cite both papers (lines 65-66).

3. Line 67: The impact of a reduction in initial ice crystal numbers (as resulting from a use of biofuels) on contrail properties is analyzed in detail in Burkhardt et al. (2018). They show a shortening of contrail life times and a decrease in contrail optical depth
We now cite Burkhardt et al (2018) when discussing the effect of use of biofuels (line 65).
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4. Lee et al (2020) includes a long discussion of uncertainties connected with contrail cirrus radiative forcing (see their Appendix E) discussing uncertainties in the upper tropospheric water budget, contrail cloud overlap, contrail life times and other factors
We have added Lee et al (2020) to the sources cited in the discussion (line 71).
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5. Line 173: 'These approaches'…. is a bit unclear. I suggest 'The approaches estimating the impact of cloud overlap on contrail radiative forcing' …
We have changed the wording as recommended (line 175).

6. Line 323: 'In several previous radiative forcing calculations in literature, clouds and contrails have been assumed to maximally overlap,'. You have deleted the entries in table 1 which specified the overlap schemes connected with the different models, but as far as I can see all entries would have been 'maximum random overlap' except for the Schumann and the Spangenberg estimate. Either you state that most models use maximum random overlap or you cite exactly which models use maximum overlap.
We have modified this discussion (lines 325-329) to more accurately describe the approaches used in the past. We now specify the two examples cited by the reviewer.

7. Line 326: According to your table 3, two models use random overlap while four models use maximum random overlap. Therefore, most climate models assume maximum random overlap. Please correct this.
The relevant discussion on lines 331-333 has been corrected appropriately.

8. Line 362: Please note that Bickel et al. (2020) estimate a much stronger reaction of natural clouds to the presence of contrail cirrus.
Bickel et al (2020)'s estimate is now included in our comparison on lines 364-365.

9. Line 739: It may be of interest to compare the contrail cloud overlap in this study with the results of Bock and Burkhardt (2016) who find a large variability in the fraction of contrail coverage that leads to an increase in overall cloud coverage. On average this fraction amounts to 43% while over the Northern Atlantic and Northern Pacific this fraction is about 20%.
We agree that this is an interesting and relevant comparison, as it may explain some of our observed variations. We have modified the discussion on lines 791-794 to call out the possible influence of this factor.

Thank you again for your time and effort in arranging the reviews of this paper. We hope you now find it satisfactory for publication in *Atmospheric Chemistry and Physics*.

Regards,

Sebastian D. Eastham