Atmospheric
Chemistry
and Physics
Discussions

# Interactive comment on "Contrail cirrus radiative forcing for future air traffic" *by* Lisa Bock and Ulrike Burkhardt

**Anonymous Referee #2**

Received and published: 14 March 2019

This is a very interesting and generally clearly written paper, in an important area where there have been rather few earlier papers in the literature. I recommend it be accepted following modifications.

The more important comments are preceded by an "M".

1:12 It would be useful to say in the abstract what the 2050 forcing is, in W/sq.m, rather than just reporting the 2050:2006 ratio (especially as this paper disagrees significantly with the only other recent study).

1:16 The authors may have been up against a word limit here, but I feel it would be useful to qualify the statement on the global-mean insignificance of the climate change by a comment that there are regional forcing differences resulting from the effect of

climate change.

2:19 This crops up a few times in the manuscript. Is it correct that it is "a lower number OF LARGER ice crystals"? If so, I think this would add clarity.

2:33 Another frequent (albeit minor) issue. Optical depth is a wavelength-dependent quantity. I presume the authors mean "visible"? This should be clarified.

3:9 "different sensitivities" – different sensitivities to what? Changes in air traffic volume?

M4:10 I realise that the authors may push back on this suggestion, but given the likely policy interest in the results from this paper, it may be useful to provide a couple of sentences on how the AEDT scenarios are compliant, or not, with CORSIA ("stabilise CO2 emissions by 2020 and reduce 2005 emissions by 50% by 2050"), given that the CORSIA agreement came after these scenarios were developed. I realise that this is not simple, given the role that offsetting might play in meeting the CORSIA targets. Perhaps there is a catch-all paper on the implications of CORSIA on future emission scenarios in the aviation literature that can be referred to?

4:22 – 4:23 What is the vertical resolution of the AEDT dataset? Is the change from 200 to 240 hPa a shift in one level in the dataset (in which case, the interpretation requires some caution) or is it several levels, and hence more robust. Or perhaps this is the resolution of the climate model, rather than the parent dataset? From Fig 1a it looks as though it may be two levels, but still it is unclear whether that is the climate model or dataset resolution.

5:5 Presumably there is a slight inconsistency here in that the HadGEM SSTs would have been forced by more than just changes in CO2?

M4:28 – 5:3 I didn't find the simulation names very intuitive, especially 2006P when it is really 2050, and this inhibited understanding of the paper. I wonder if something like 2050T (T for traffic), 2050TC (C for climate), 2050TCS (S for soot or maybe M for

modified efficiency and fuels) would help the reader more?

M6:4 – 6:8 This should be explained more clearly. I eventually understood that "slant" meant in the vertical rather than horizontal dimension and that "track distance" and "ground projected" were the same thing. The paper does not clearly say that "slant" is better, but this is what I assume. That led me to wonder whether the global estimates in this paper should be multiplied by the factor of 1.14 to give a more reliable answer.

6:21-6:22 I found this unclear, even having worked in the area, and suggest the text is expanded to make it clearer. Is the "formation threshold" referring to a temperature or supersaturation threshold or both?

6:23 and 6:26: Sentences repeated? Also point out to the reader (6:23) that the ice supersaturation is not shown?

M7:5 The "shift of a large fraction" is interesting/ important but too vague. Could this be made quantitative? Presumably it differs between summer and winter, as the tropopause itself changes so much in mid-latitudes. Or perhaps this has been discussed in another paper and a reference could be given?

7:26 Would "contrail formation frequency" be better described as the "probability of contrail formation"? The frequency is dependent on an aircraft flying through the relevant grid box and so could be zero even if the probability is 1.

9:9 NORTHERN extratropics

9:14 Strictly I think this is the cold ice supersaturation frequency – as I understand it, it is the warming, rather than the humidity change, that is most influential in changing the tropics

9:25 Add "global-mean" to this sentence.

M10.3 If estimates of aviation CO2 radiative forcing from the 2 AEDT scenarios (or the CO2 amounts - as the forcing could be derived from the simple IPCC expresssions)

are easily available from other papers, their addition here (and the relative growth from 2006) would be useful to place the growth of the contrail forcing in perspective. It would be particularly useful to know if the contrail forcing grows more/less rapidly than the CO2 forcing. This may need a further caveat given the Ponater et al. (Atmos Env 2006) and Rap et al. (GRL 2010) papers indicating that the efficacy of contrail forcing may be significantly less than 1.

Figure 1: In (a) the (a) label obscures the lines. Also the y-axis is pressure not height

Figure 2 (a) caption says km per year but the y-axis label says km per second. I note that the labels (US/Mexico and East China/Japan) differ between here and Fig 4, and the text itself. I suggest making consistent.

M:Figure 3 needs some work to help the reader. On initial viewing it is indigestible. Y-axis labels are missing, when they need not be, and their addition would make it much clearer. It is also here that I most felt a more intuitive use of simulation names would help the reader. "2006 plus" feels particularly unhelpful.

Figure 5: The power of 10 labels are unreadable to me. Could they be removed from the figure and included in the caption instead?

Typos etc

1:26 "live time" -> "lifetime"

2:28 Irvine et al. missing from reference list, unless this meant to be Irvine and Shine

4:11 and 11:23 Barret -> Barrett

5:11 I advise using x not * for multiplying factors of 10 - see also Table 1 (maybe irrelevant if dealt with at the typesetting stage)

5:24 – 5:26 The O's are for Ost?

10:6 Section 4 not 5?

C5