Specific comments on the ACPD manuscript "Effect of contrail overlap on radiative impact attributable to aviation contrails" by I. Sanz-Morere et al.

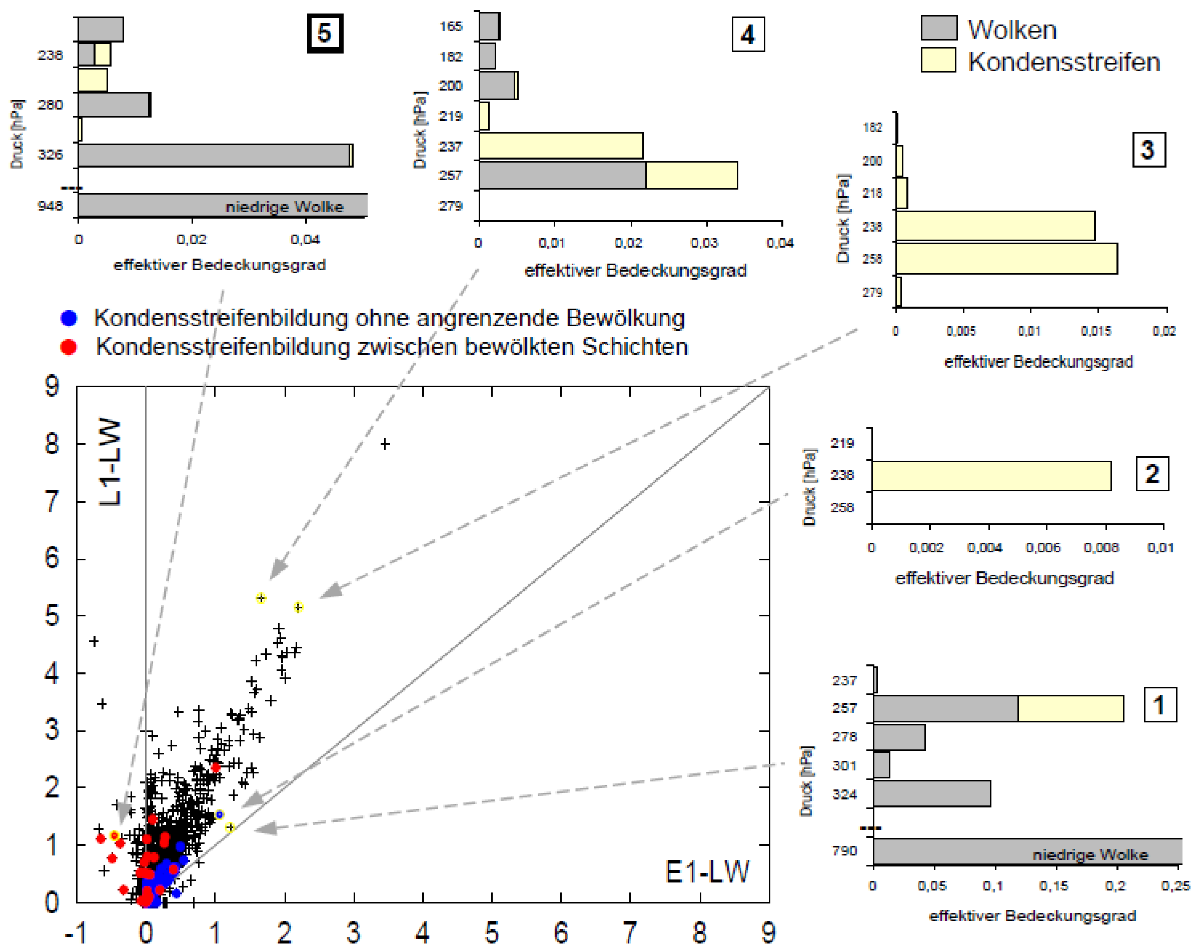
Introductory remarks

I find this work of Sanz-Morere et al. quite interesting as it emphasizes an important aspect in contrail radiative impact studies that usually has not been investigated as systematically as is done here. In this respect, I feel the two official referees have taken a somewhat stern attitude towards the paper. I think that using a parameter scanning approach in assessing cloud-contrail and contrail-contrail overlap situations goes beyond what currently available studies have done. Figure 3 of the present paper is certainly worthwhile providing. Yet, the referees are certainly right when reminding the authors not to overreach their conclusions, given the limitations of the model framework used in the paper. It is also true, I agree, that some aspects (and even whole papers) of previous research work has been overlooked by the authors.

However, this specific comment is mainly written to provide additional information (including insider knowledge of previous papers) that can help to rectify some statements where the authors – in my view - have interpreted previous work inaccurately.

General comments

- Contrail-cloud overlap has been generally accounted for in previous contrail radiative impact studies in the way the contrail radiative forcing is usually given under clear-sky as well as all-sky conditions (Myhre and Stordal, 2001; Stuber and Forster, 2007; Yi et al., 2012, and others cited by the authors). It has been a common finding that both the shortwave and the longwave radiative forcing decrease in magnitude under cloudy-sky conditions. Often, but not always, the daily mean net radiative forcing gets more positive with natural clouds included.
- As rightly pointed out by referee 2, contrail-contrail overlap has usually been accounted for in contrail studies with global climate models (Marquart et al., 2003; Rap et al., 2010, Burkhardt and Kärcher, 2011; Bock and Burkhardt, 2016), except for when used in idealized setups like the GCMs (ECHAM and CNRM) contributing to Myhre et al. (2009). For illustration what situations can occur in climate models, I reproduce a figure from the PhD thesis of Marquart (2003, unfortunately only available in German language). This picture makes it clear that layers with contrails not only may overlap with layers containing natural cloud, but that situations with contrails and natural clouds existing side by side in the same grid box are also possible. That renders the overlap situations in models like that rather complicated, even if the overlap principle is straightforward. Anyway, it is clear that the climate model parameterizations can include the effect.



Possible grid box column situations containing contrails (yellow) and natural clouds (grey) in the ECHAM4 model of Ponater et al. (2002), Marquart (2003), and Marquart et al. (2003). Adapted from Marquart, 2003, her Figure 2.7.

<u>Specific comments</u>

- It is important to realize that the GCM studies (at least those based on the ECHAM climate model) use the maximum-random overlap scheme for calculating radiative fluxes in allsky columns. This refers to contrail-cloud overlap as well as to contrail-contrail overlap situations. See, for example, Figure 4 in Marquart and Mayer (2002).
- It may be of interest for the present study that the use of the maximum-random overlap principle has been shown to create severe problems when used in an unfavorable parameterization combination, as discussed by Marquart and Mayer (2002). This has caused the radiative forcing values given by Ponater et al. (2002) to be basically incorrect (amended in Marquart et al., 2003).
- It is not correct (as given in your Table 1) that the overlap assumption in the studies of Marquart et al. (2003) and Frömming et al. (2011) is different. Both use the maximum-random overlap principle in the radiative transfer calculations, as do Burkhardt and Kärcher (2011).
- Note that the ECHAM4 studies of Ponater et al. (2002), Marquart et al. (2003), and Frömming et al. (2011) mainly give mean optical depth values of *visible* contrails (i.e., averaged over those contrails that exceed a “visibility threshold” of

0.02), to enable comparison with observations. However, the "invisible"contrails are not excluded from the radiative forcing calculations. This may confuse an unaware viewer of your Table 1.

I also note that the visibility threshold has been a subject of debate. According to Kärcher et al. (2009) a threshold value of 0.05 is more appropriate and has been preferred in later studies (e.g., Bock and Burkhardt, 2016).

- The global mean optical depth value of 0.05 given in Table 1 for the Frömming et al. (2011) results seems to be incorrect. Table 2 in that paper provides the consistent value of 0.08 . The confusion may originate from the first paragraph of Frömming et al.'s section 3.1, where the optical depth of all contrails (including "invisible" ones below 0.02) is additionally given, and this one is indeed 0.05 .
- Finally I recommend to split your Table 1 into two parts, one referring to line-shaped contrails (first two rows), and one to contrail cirrus (last four rows). Otherwise any reader observing totally different radiative forcings for nearly the same air traffic volume will be misleaded and will mistakenly be tempted to attribute the difference to the cloud overlap assumptions!
- Line 89: As stated above, I disagree with the claim that Frömming et al. (2011) assume random overlap in the radiative transfer calculations.
- Line 239: Do you mean sufficiently *thick* or sufficiently *extended*? Yet, either assumption appears to be somewhat bold for contrails, I think.
- Line 256: "Due to the *known* strong dependence …"I think at this point the fundamental work of Markowicz and Witek (2010) on the subject ought to be acknowledged.
- Line 408: Here, or somewhat earlier, the notion of "quantifying the effect of cloud overlap by the difference of all-sky minus clear-sky" should be scrutinized a little bit. The point is that Rap et al. (2010) extensively discuss the potential effect of a correlation between contrails and natural clouds, increasing the frequency of all-sky situations with respect to clear-sky situations in comparison with a setup assuming climatological background (natural) clouds. My impression is that you do not account for this correlation in your calculation setup. If this is true, it might be fair to mention this as a caveat.
- Line 431: I think that there are also many contrails below 0.05 (see Kärcher et al., 2009). This only supports your approach to extend your parameter space down to tau = 0!
- Line 439: In situ measurements like the one cited here may not fully represent the parameter range of contrails, hence you might consider to add some citation of a satellite study such as Bedka et al. (2012) or Minnis et al. (2013).

<u>References</u>

Bedka, S., et al., 2013: Properties of linear contrails in the Northern Hemisphere derived from 2006 MODIS observations, Geophys. Res. Lett., 40, 772-777.

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Marquart, S. and Mayer, B., 2002: Towards a reliable GCM estimate of contrail radiative forcing, Geophys. Res. Lett., 29, 1179.

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Stuber, N. and Forster, P., 2007: The impcts of diurnal variations of air traffic on contrail radiative forcing, Atmos. Chem. Phys., 7, 3153-3162.

Yi, B., et al., 2012: Simulation of the global contrail radiative forcing: a sensitivity analysis, Geophys. Res. Lett., 39, L00F03.