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Geoscientific Model Development Discussions

Interactive comment on "A contrail cirrus prediction model" *by* U. Schumann

Anonymous Referee #2

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This is a very interesting paper addressing a very complicated issue of contrail (condensation trails) impact on climate. The complexity of this issue is caused by the fact that contrail radiative forcing (RF) depends on numerous parameters such as relative humidity (RH), temperature (T), wind shear, presence of ambient clouds, aircraft parameters, solar zenith angle, albedo, etc. The author made a brave attempt to account for all these issues and tried to provide a model which could provide estimates of contrail RF on the global scale. Since linear contrails in general and contrail cirrus in particular are the most uncertain aspects of the aviation impact on climate, publication of this study should be welcome.

My comments below should improve this paper.

1. Since the issue considered in this study is very complicated, the author was forced to make numerous simplifications and assumptions. My major comment is to ask the

author to extend validation of the CoCiP by using all available observations for this purpose where it is possible. For example, the author is well-aware about latest contrail results obtained in Pat Minnis' group (NASA Langley), which are not reflected in this paper. Also, latest cirrus observations by CALIPSO could be relevant for the CoCiP validation.

2. I have serious reservations about ability of bulk microphysics (BM) to describe a full life cycle of contrail. Limitations of the bulk microphysics are particularly obvious in predicting loss of the ice crystal number. Previous studies (Huebsch and Lewellen, TAC Proceedings, p.167-172, 2007; Unterstrasser and Soelch, ACP, 2010) clearly showed this drawback of the BM. Kelvin effect (which is also missed in CoCiP) is also important, especially when full contrail life cycles are studied. I understand that CPU limitations do not allow to use a size-resolving microphysics in CoCiP. Nevertheless, I got an impression that the author got overly optimistic about CoCiP ability to predict contrail ice crystal concentration. More critical analysis of this CoCiP part is needed.

3. Before discussing the complicated issues of contrail evolution and their RF, it is important to make sure that the CoCiP uses correct ambient atmosphere. In this context, it is important to compare primarily relative humidity at cruise altitudes and ambient cirrus clouds against available measurements. Detailed critical discussion on this subject is needed.

4. More discussion on contrail lifetime and CoCiP ability to capture this important parameter is needed. Besides missing sub-grid scale processes, buoyant sloshing, Kelvin effect, the CoCiP model also uses sedimentation velocity for spherical particles and does not account for contrail radiative feedbacks (which could be important, e.g., Gounou and Hogan, JAS, 1706, 2007). I am not sure that once contrail particles start to fall down, coagulation among them is important. Many contrail evolution models (including the DLR model by Unterstrasser and Gierens) ignore ice particle coagulation, which may be a useful assumption for the CoCiP bearing in mind CPU savings for its potentail use in a global model. Recent JGR paper by Jensen et al.

(10.1029/JD2010JD015417, 2011) could help here as well.

5. Comments on Figures: Some of them too busy. Figure 7 could have 4 panels instead of 2 panels. Fig.13 could either add new panels or drop some lines. I could not understand where are the thick and thin lines on its bottom panel. Fig.14-15 badly need more detailed figure caption explaining each and every curve.

6. Comment on paper structure. I would like to encourage the author either to move more equations from the main text to Appendices or even to separate all Appendices into a big Supporting Material. Only key equations should be left in the main text. This will make reading of this complicated paper a bit easier.

7. At the end of the paper it will be interesting to learn about possible future use of CoCiP. Projected use in a global model? Further comparison with observations? Participation in forthcoming aircraft campaigns? etc.

8. While my questions may be premature, I would like to know the answers to the following questions based on already performed CoCiP calculations: How sensitive are CoCiP results to the H2O accomodation coefficient onto ice (which varies from a few hundredths to 1 in published literature)? What regions of the atmosphere produce contrails with strongest RF? Any estimates of the global contrail RF based on CoCiP calculations? What technological options are promising for contrail mitigation?

9. Fig.11: As far as I understood the color bar for the bottom panel, cirrus+contrail optical thickness exceeds 10 for many regions over the globe. This value seems too large. Comments?

10. p.3194, line 7: Typo in: eta = F_a*V_a/(m_F*Q_fuel), i.e. the air speed V_a is missing.

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