Geosci. Model Dev. Discuss., 4, C1164–C1167, 2011
www.geosci-model-dev-discuss.net/4/C1164/2011/

Geoscientific Model Development Discussions

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

Anonymous Referee #1

Received and published: 12 December 2011

General:
The paper describes a new model to simulate and predict the effect of contrails on the radiative budget of the atmosphere. In particular, the optical depths of an ensemble of contrails caused by the air traffic can be quantified in a very realistic way. This realistic representation of contrails from their formation until their dissipation within the ambient atmosphere is the most important strength of this paper. Also the clear presentation of the physical and technical aspects of this model is exceptional. The model is numerically efficient and can be coupled with a GCM. Thus, I would like to recommend this paper for publishing in Geoscientific Model Development with only some minor points listed below. I also include some general ideas and recommendation how the model can be improved in the future.

General comments:

- "time integration and segment trajectories"
  The trajectory scheme presented in this paper uses the so-called "kinematic" approach with the pressure tendency $\omega = \dot{p}$ as the vertical velocity. However, the so-called "diabatic" approach seems for me to be more suitable for transport of aged contrails in the free atmosphere not far away from the tropopause. "Diabatic" denotes transport calculations in an isentropic coordinate system θ with cross-isentropic motion $\dot{\theta} = D\theta/Dt$ determined from diabatic heating rates J due to radiation, latent heat and other diabatic processes, e.g. due to shear-flow turbulent mixing, i.e. (see the textbook: Andrews at al., 1987):

  $$c_p \frac{D\theta}{Dt} = J \frac{\theta}{T} \,. \qquad (1)$$

  Here T and c_p denote the temperature field and the specific heat, respectively. Note that for the ERA-Interim reanalysis, the temperature tendencies J necessary for such calculations are now available (Fueglistaler et al, 2009, Q. J. Roy. Meteorol. Soc)

  The nearly adiabatic nature of the atmospheric large-scale motion, with the flow mainly being along surfaces of constant potential temperature, seems to favor the diabatic approach based on the isentropic coordinate system. On the other hand, the ω-wind is calculated as a small residual between the large horizontal wind terms in the continuity equation. Such vertical velocity is strongly disturbed by atmospheric waves like planetary or gravity waves which are mostly adiabatic processes. The kinematic approach is not only an "ill-conditioned" problem but is also disturbed by the deficiencies of the assimilation procedures (e.g. ECMWF) (Schoeberl et al., JGR, 2003, Ploeger et al., JGR, 2010, Ploeger et al., ACP, 2011).

  Because of a short length of the trajectories of the order of 1-2 days which are typical for the aged contrails, the difference between the diabatic and kinematic approach is probably very small. However, only in the diabatic approach you can directly include the radiative effect of contrail (i.e. local heating or cooling due to contrails) on their vertical, cross-isentropic motion.

- "Radiative forcing"
  I think that this section can be removed. You show only results with the optical depth and optical depth is the quantity that connects spatial and temporal properties of the contrails with their radiative effect. If you decide to include this section, maybe more explanations are necessary (RF are fluxes or heating rates ?, why RFs are calculated at the top of the atmosphere ? I would expect downward and upward fluxes (or flux changes) at the position of the contrails)

Minor points:

- L. 28
  "contrail outbreaks" sounds strange
- L. 132
  NWP - please explain this abbreviation
- L 203
  We use the well-known Schmidt-Appleman Criterion (SAC)....
- Fig. 4
  Maybe you should explain that every point is one aircraft
- L 320
  I do not understand the contribution of the last 2 term. Maybe 1 sentence more...
- L 334
  ...above expression (20) gives a negative...

- Fig 5
  every point is one aircraft ?
- Fig 10
  What is τ^* ?
- Fig 18
  I do not understand the red dotted curve on the right side (with many maxima). This is the difference between .... ?

Interactive comment on Geosci. Model Dev. Discuss., 4, 3185, 2011.