Producing global maps of aircraft-induced cirrus via microphysical modelling

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Introduction

We aim to quantify cirrus produced by aircraft via a microphysical model, using the best available input data. Persistent contrail occurrence and coverage can be predicted by the Schmidt-Appleman criterion [Schumann, 1996, Sausen, 1998]. More detailed information on the number and nature of ice particles formed from the exhaust is found by modelling ice crystal growth.

Input data

- Physical parameters (temperature, humidity and pressure) are available from ECMWF ERA40 data sets.
- Flight paths and fuel emission information can be found from aircraft inventories: TRADEOFF (see below) and AERO2k [Eyers et al., 2004].

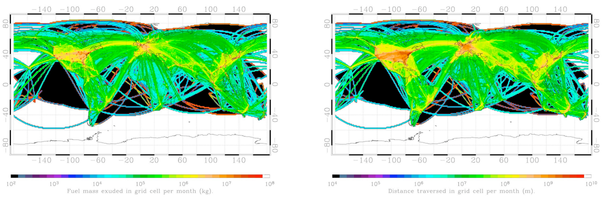

Figure 1: Distance and fuel information per grid cell from TRADEOFF.

Modelling

A Stratospheric Aerosol Microphysical Model (SAMM) has previously been developed at the University of Oxford [Tripathi et al., 2004] and duly tested [Kanawade & Tripathi, 2006]. It is capable of simulating the life cycle of liquid H_2SO_4-H_2O aerosol: nucleation, condensation, coagulation and, eventually, sedimentation.

SAMM is undergoing expansion such that additional species can be modelled: ice and ***graupel*** (mixture of ice and liquid aerosol). This will produce a new model, MMACC (Microphysical Model for Aerosol, Contrails and Cirrus), capable of simulating ice crystal formation and growth (see below).

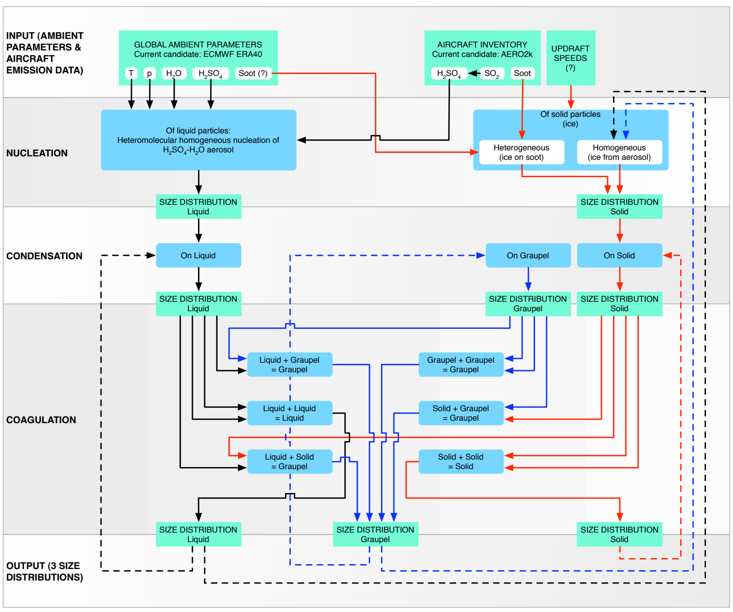

Figure 2: Proposed schematic of the new model, MMACC.

Several schemes for ice nucleation are being considered [Koop et al., 2000, Liu & Penner, 2005, Ren & Mackenzie, 2005]. Coagulation is based on Jacobson, 2002, but refinements are included for certain particle size ranges [Beard & Grover, 1974, Beard & Ochs, 1984, Wang et al., 1974].

Issues

- We are still investigating a suitable data set for updraft velocities, essential for ice nucleation.
- The coagulation module thus far can only produce graupel through the *liquid* + *solid* = *graupel* route. The other two creation terms (see schematic) are still required.
- The condensation module does not yet include evaporation from and condensation onto graupel.
- A criterion for discerning whether a certain size or number of ice crystals constitutes cirrus needs to be established.

Preliminary testing on a limited coagulation module has yielded expected results (see below). Testing and development are currently occurring for condensation onto multiple size distributions.

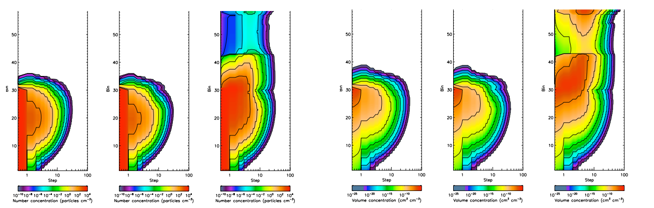

Figure 3: Particle size distributions for number and volume concentration (for liquid, ice and graupel) evolving due to coagulation module.

Conclusions

A method has been formulated to predict cirrus arising from aircraft. Whilst model development is ongoing, it is hoped that key results can eventually be compared with cirrus climatologies from remote sensing (ISCCP, HIRS, MIPAS, etc.) such that the cirrus signature from aircraft emissions can be quantified. Whilst initially developed for offline use, MMACC will be written with a view to future inclusion in a CTM.

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