Aircraft impact studies using a stratospheric CTM including liquid aerosol microphysics

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Introduction

The stratospheric impact of gaseous species injected by aircraft and the subsequent formation of volatile particles remain an open research field. The possible enhancement of the background aerosol surface area density (SAD) is likely to modify heterogeneous reactions rates, and thus to change the composition of the stratosphere (especially ozone). A Stratospheric Aerosol Microphysical Model (SAMM) using semi implicit schemes has been written in order to simulate aerosol processes occurring under stratospheric conditions (nucleation of H_2SO_4-H_2O droplets, coagulation, condensation, sedimentation). The integration of a model like SAMM (Figure 1) in a CTM (the Cambridge SLIMCAT model) is expected to describe properly the effect of both gas and particles injection from aircraft on the stratosphere. The presence of insoluble core particles makes the studies easily extendable to volcanic perturbations.

Microphysics

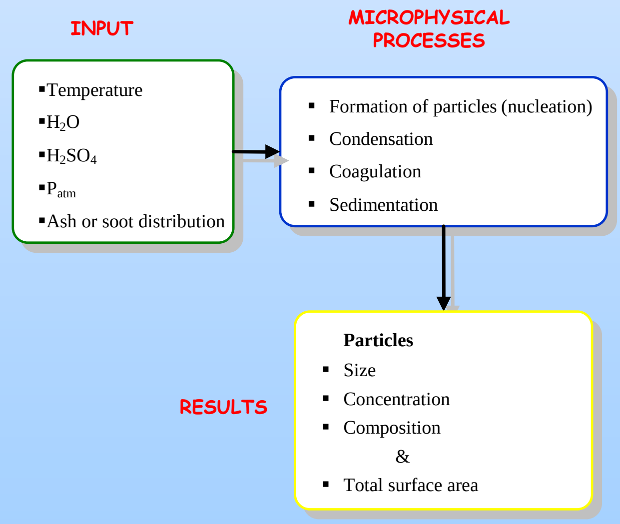

Figure 1. Schematic of the microphysical processes in SAMM

Figure 2 illustrates the difference in SAD determined using either an equilibrium parameterization or a full microphysical model. Discrepancies can be seen at high altitudes where SAMM predicts no aerosol presence, contrary to SLIMCAT results. In addition SAMM predicts larger SAD values at other altitudes. The impact of these discrepancies on chemistry is a function of various parameters such as temperature.

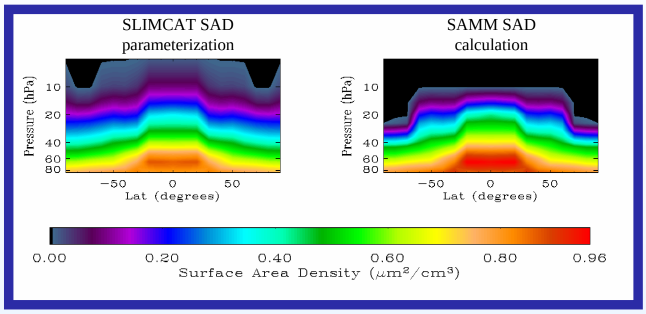

Figure 2. Surface Area Density (SAD) determined at 0º long. using either SLIMCAT parameterization or microphysical calculations (SAMM).

For example, the dOx/dNOx ratio at equilibrium can vary by a factor 5 when we enhance the initial NO_X concentration by 20% (see Figure 3).

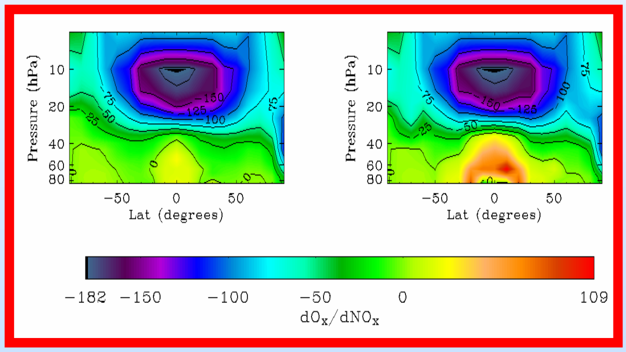

Figure 3. Comparison of the ratio dO_x/dNO_x using the SLIMCAT SAD parameterization (left) or SAMM (right)

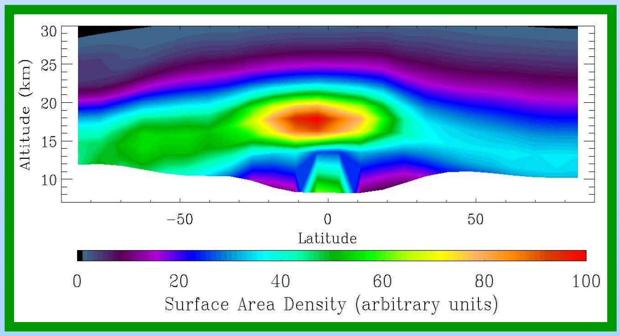

Figure 4. Zonal mean of the surface area density as a function of latitude and altitude, using arbitrary units, year 1995.

Finally, figure 4 represents a qualitative global distribution of the aerosol using a coupled transport-microphysics model.

Further development

We have started investigating the effect of NO_x, H_2O and H_2SO_4 on O_x species using a box model version of SLIMCAT. A microphysical model has been coupled to the 3D version of the SLIMCAT model and is a powerful tool for impact studies of aircraft and volcanoes on the global stratosphere. Studies on the sulphur budget are also in progress.