SIMULATION OF UT/LS AEROSOL WITH A CHEMISTRY-MICROPHYSICS-CLIMATE MODEL

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INTRODUCTION

While measurements enlarge our knowledge about the physical properties of the aerosol particles and their global distribution, aerosol model studies improve the basic understanding of the microphysical processes and their interactions with atmospheric chemistry and dynamics. In recent years the understanding of atmospheric aerosols and ice clouds and their interactive participation in the atmospheric system has improved significantly. But there is still a lack of basic knowledge on the factors controlling aerosol and ice cloud properties in the upper troposphere and stratosphere, their formation, their development and their role in the global climate. To comprehensively assess the impact of aerosol particles on ozone concentration, cloud formation and radiative forcing, information about the particle size and number density is necessary. We have therefore developed a chemistry-microphysics-climate model (CMCM) which explicitly calculates microphysical processes and their interaction with atmospheric chemistry and dynamics in a climate model.

THE CHEMISTRY MICROPHYSICS CLIMATE MODEL

The chemistry-microphysics-climate model consists of three different components: the middle atmosphere model MAECHAM4(Manzini *et al.*, 1998), the chemistry scheme CHEM (Steil *et a.l*,1998) and the global stratospheric aerosol model SAM (Timmreck, 2001):

- The global circulation model MAECHAM4 extends with 39 layers from the surface to 0.01 hPa. The prognostic variables are vorticity, divergence, surface pressure, temperature, water vapour, and cloud (liquid and ice) water content. The MAECHAM4 is run with a spectral triangular truncation at wave number 30 (T30). Physical processes and nonlinear terms of dynamical fields are calculated on a Gaussian longitude-latitude grid with a nominal resolution of $3.75° \times 3.75°$.

- The chemistry scheme CHEM describes stratospheric O_3 and tropospheric background NO_x-HO_x-CH4-CO-O_3 chemistry. 18 variables are transported, while family members and radicals are calculated analytically. 110 photochemical reactions and heterogeneous reactions on polar stratospheric clouds and sulphate aerosols are considered. In the CMCM CHEM is extended with sulphur chemistry and four new prognostic variables (DMS, SO_2, H_2SO_4 and COS) are introduced in the model.

- The global stratospheric aerosol model SAM treats the formation, the development, and the transport of stratospheric sulphuric acid aerosol. The aerosol size distribution and the sulphuric acid mass fraction are calculated as a function of the H_2SO_4/H_2O concentration, temperature, and air pressure in a size range between 0.001 μm and 2.58 μm. A new parameterisation of the binary homogeneous nucleation of H_2SO_4/H_2O (Vehkamäki *et al.*, 2002), condensation and evaporation of H_2SO_4 and H_2O, Brownian coagulation and gravitational sedimentation are included. Dry deposition and wet scavenging of aerosol and SO_2 is taken into account in the troposphere.

RESULTS

Mulit-annual background simulation have been performed with the CMCM model to calculate the sulphate aerosol mass, number and surface area density and the aerosol extinction. The seasonal and inter-annual variability of the results have been carefully analysed and compared to available observations. The explicit treatment of microphysical processes in the climate model allows to study the aerosol microphysical processes and the modifications of physical properties when the particles are transported from the boundary layer to the upper troposphere or between the troposphere and stratosphere. Budget calculations will be carried out to determine the fluxes across the tropopause. A special emphasis will be placed on the role of new particle formation in the UT/LS region. Although the amount of the H_2SO_4 concentration influences the strength of the nucleation, the occurrence of the homogeneous nucleation is mainly determined by the temperature. Hence, the formation of new particles through homogeneous nucleation takes place preferably in the tropics around 17 km, where the coldest temperatures in the model occur and at the winter poles (Figure 1).

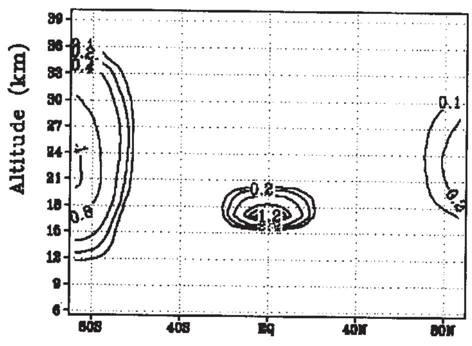

Figure 1. Annual averaged binary homogenous nucleation rate (cm^3 s^1) in the CMCM run .

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