Abstract

We used the GISS/Harvard/UCI 3-D CTM on the AER computer platform to perform a number of simulations to obtain the surface area from accumulation of Al_2O_3 particulates from solid rocket motors (SRM), orbital debris, and meteorites. In the calculation, the initial size distribution of the particulates emitted by SRM is represented by a tri-modal distribution with bulk density of 1.7 gm/cm^3. It is assumed that particles do not interact with each other so that particles in each size bin will evolve independently. Particles from orbital debris and meteorites are assumed to be 1 μm size particles with bulk density of 4.7 gm/cm^3 and 2.0 gm/cm^3, respectively. Apart from the large-scale transport, particle distributions are also affected by sedimentation. In addition, we consider the effect of removal of the particles by collision with the background sulfate layer.

The calculated surface area of Al_2O_3 particulates from SRM, with an input of 1120 tons/yr, is between 1-4x10^{-4} μm^2/cm^3 in the lower stratosphere with the largest values occurring at northern high latitudes. The assumed input from orbital debris and meteorites are much smaller at 10 tons/yr and 30 ton/yrs respectively. The calculated surface areas are also much smaller at 10^{-6} μm^2/cm^3 and 10^{-5} μm^2/cm^3 respectively. These values are to be compared with the sulfate surface area of 0.5-1.0 μm^2/cm^3 in the lower stratosphere during non-volcanic conditions, and value of 20 μm^2/cm^3 one year after the Pinatubo eruption.

The accumulation of Al_2O_3 particulates in the atmosphere may affect ozone via the heterogeneous reaction $ClONO_2 + HCl \rightarrow HNO_3 + Cl_2$ that converts $ClONO_2$ and HCl, chlorine reservoir species, into the more active form that will deplete ozone in the presence of sunlight. However, due to the very small Al_2O_3 surface areas calculated, ozone depletion on the global scale is very small. The impact on the stratospheric sulfate aerosol layer is likely to be small over most of the stratosphere, but the impact cannot be evaluated with accuracy at this time.