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Increased Amount Of Meteoric Material In The Winter Stratosphere-Implications For Heterogeneous Nucleation

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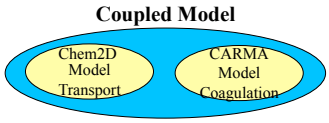
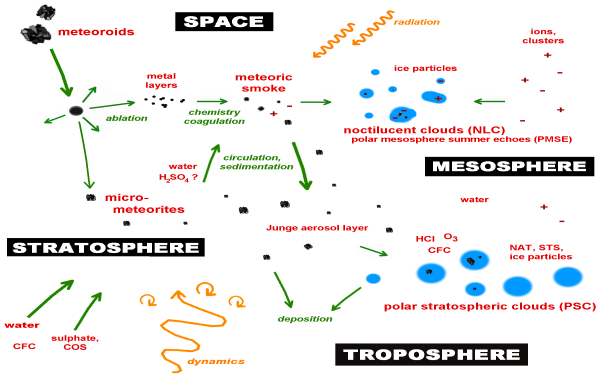
Modelling of meteoric smoke

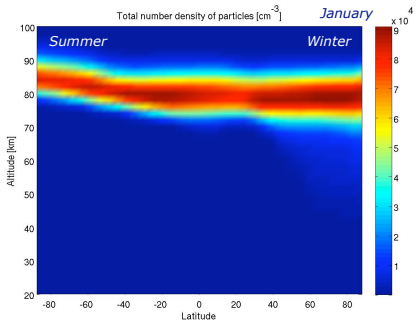


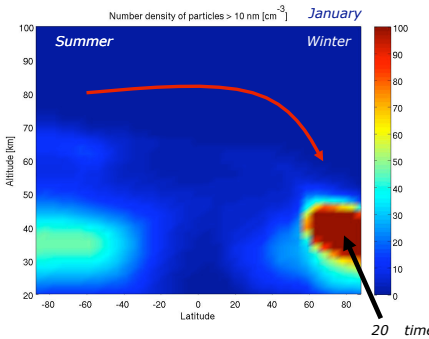
In order to study the distribution of meteoric material, **global model studies** are needed. To this end, we have coupled the microphysical model (CARMA) with a two-dimensional **chemical transport model** (NRL CHEM2D). For nanometer-size particles the effect of atmospheric circulation is prominent. It efficiently transports the meteoric material from the summer hemisphere to the winter hemisphere.

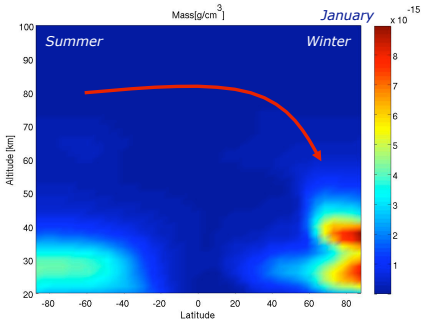
Meteoric material in the atmosphere

Every day of the order of 100 tonnes of meteoric material enters the atmosphere and ablates at 80-100 km. This material is expected to re-condense into nanometer-sized meteoric smoke particles, and sediment to the lower atmosphere. This material is **likely to be the dominant aerosol in the upper stratosphere** where the temperatures are high enough for the droplets of sulfuric acid solution to evaporate. Meteoric material has been suggested to be of importance for stratospheric nucleation, heterogeneous chemistry and positive ion chemistry. Studies concerning these processes have so-far been based on 1-dimensional models of meteoric material, which cannot properly handle atmospheric transport. The first 2-dimensional model, which includes both the coagulation and transport of meteoric material, shows that **this material is effectively transported to the winter stratosphere**. The majority of the global influx of material is thus funneled into the winter vortex. The number and size distribution of meteoric smoke are therefore, unlike what is implicitly assumed with the use of 1-dimensional models, highly dependent on latitude and season. We here present new estimates of number densities and particle area in the stratosphere, and discuss possible consequences for stratospheric processes.









20 times more than earlier 1D predictions [Hunten et al , 1980]

Consequences for the stratosphere

The highest number densities of meteoric material are found at the altitude at which the ablation takes place, i.e. the upper mesosphere (left figure). This material however, is mainly in the form of molecular sized clusters. As these small particles coagulate they are subject to an efficient transport towards the winter pole, so that the larger (nanometer sized) particles mainly appear at the poles and accumulate in the winter stratosphere.

The maximum mass is found in the winter stratosphere, whereto the residual circulation is directed. High concentrations are also reached in the summer stratosphere. These particles consist of material that was deposited here during the previous winter. As opposed to polar latitudes, the mid-latitudes are virtually free from meteoric particles (middle figure).

The maximum surface area of meteoric smoke material is also reached in the stratosphere. As the particles grow larger than ~5 nm radius they are believed to form loosely packed aggregates (Saunders et al., 2006), thereby further increasing the surface area. The surface area of meteoric particles in the winter polar vortex may be important for nucleation of NAT (Nitric Acid Trihydrate) particles. Voigt et al. (2005) find that their observations of PSC can be explained neither by homogeneous NAT nucleation nor by NAT nucleation on ice. Thus, they consider meteoric smoke particles to be **'favorable candidates for triggering NAT nucleation'.**

The number densities of particles larger than 10 nm in the polar stratosphere are about one order of magnitude larger than the ~10 cm^{-3} earlier 1-dimensional studies suggested (Hunten et al., 1980). Based on the 1-dimensional studies Zhao et al. (1995) have concluded that 'micro-meteoric particles themselves are unlikely to change the CN-concentration, or to form a distinct CN layer' . This conclusion should therefore be revalidated using the higher number densities. **The new estimates are potentially enough to make them important for the formation of the stratospheric condensation nuclei (CN) layer.**

References

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