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NESL's Atmospheric Chemistry Division Seminar

Meteoric Smoke in the Earth's Atmosphere

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Roughly 30 tons of interplanetary dust enters the Earth's atmosphere every day, although estimates of this number vary from 2 to 300 tons, depending on where the estimate is made between the Earth's surface and space. Most of the dust particles completely ablate at heights between 80 and 120 km. The resulting metal vapours (Fe, Mg, Si and Na etc.) then oxidize and re-condense to form nm-size particles, termed "meteoric smoke". These particles are too small to sediment downwards. Instead, they are transported by the general circulation of the atmosphere, taking roughly 5 years to reach the surface. There is great interest in the role they play as condensation nuclei - of noctilucent ice clouds in the mesosphere, and polar stratospheric clouds in the lower stratosphere - and in the ability of these particles to remove acidic gases.

In this talk I will describe laboratory kinetic experiments made with a novel mass spectrometer, complemented by electronic structure calculations and statistical rate theory, to understand how metal atoms are converted into smoke particles. The process is in some ways analogous to the formation of silicate dust in stellar outflows, the main difference being the much lower temperatures (~200 K). I will then describe the first global atmospheric model of meteoric metals and meteoric smoke, which we have developed by combining three components: the Whole Atmosphere Climate Community Model (WACCM) from the US National Center for Atmospheric Research, including the CARMA particle microphysics module; a description of the neutral and ion-molecule chemistry of five metals (Na, Fe, K, Mg and Si) based on the rate coefficients of more than 120 reactions measured by the Leeds group; and a meteor input function which combines the Leeds Chemical Ablation Model with an astronomical model of cosmic dust in the inner solar system.

The model has been evaluated against a number of available ground-based lidar measurements covering a wide range of latitudes in both hemispheres, as well as with global observations of the Na and K layers using the OSIRIS spectrograph on-board the Odin satellite. The predicted meteoric smoke distribution in the atmosphere is compared with optical extinction measurements made using the SOPHIE spectrometer on the AIM satellite, and number density measurements made during the HotPay 2 rocket experiment at Andøya, Norway. In general, the model performs well in simulating both the atomic metal layers and the meteoric smoke distribution above 60 km. The implications of smoke particles in the stratosphere and ocean bio-geochemistry will be discussed.

Monday, May 19th

3:15 p.m. Refreshments

3:30 p.m. – Seminar

FL2- 1022, Large Auditorium