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Space Weather Impacts on the Mesospheric Metal Layers

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Cosmic dust particles are produced from the sublimation of comets and by collisions between asteroids. The input rate to the atmosphere is estimated to be 27 +/- 14 tonnes per day globally. Because the particles enter the atmosphere at hypersonic velocities, collisional heating with air molecules causes about 30% of them to melt, leading to vaporization of their metallic constituents. The injection of these elements causes a wide variety of atmospheric phenomena, including: the formation of global layers of metal atoms between 80 and 105 km; airglow emissions; layers of metallic ions which affect radio communications; and the production of meteoric smoke particles which enable the nucleation of mesospheric ice clouds. Certain metal atoms can be observed very precisely by ground-based lidar and from satellites, providing an excellent tracer of dynamics and chemistry at the edge of geospace.

Atmospheric models of 10 meteoric elements (Na, Mg, Al, Si, P, S, K, Ca, Fe and Ni) have been constructed from laboratory measurements of the rate coefficients of over 180 individual reactions involving neutral and ionized species, together with theoretical estimates of rate coefficients which have not been measured. This chemistry, together with the relevant metal injection rates as a function of height, location and time, has been inserted into the Whole Atmosphere Community Climate Model (WACCM). Model simulations compare well against observations of metal atoms/ions from ground-based lidar, rocket-borne mass spectrometry and satellite remote sensing.

This presentation will describe a modelling study of the impacts of energetic particle precipitation (EPP) on the Fe, Na, K layers. Increased ionization above 90 km reduces the neutral metal densities through charge transfer with NO+ and O2+ ions. However, increased atomic O and H below 90 km increases the neutral metal densities, since O and H reduce molecular compounds (oxides, hydroxides and carbonates) back to metal atoms. During and immediately after the very strong solar proton event (SPE) in January 2005, the column abundances of Fe, Na and K below 90 km all show significant increases. A superposed epoch analysis of the metal densities during 19 SPEs of varying strengths between 2003 and 2005 is used to explore the relationship between these metal layers and SPEs in greater detail.

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