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Energetic electron precipitation impacts on the middle atmosphere: From satellite observations to chemistry-climate modeling

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Precipitation of energetic particles – mainly protons from solar coronal mass ejections or electrons accelerated in auroral or geomagnetic storms – directly affects the mesosphere and lower thermosphere. Nitric oxides (N, NO, NO_2) and hydrogen radicals (H, OH) are formed by particle impact dissociation and ionization and subsequent ion chemistry reactions. However, the stratosphere and possibly even tropospheric weather systems can be affected indirectly by downward transport of particle-induced nitric oxides from their source regions into the stratosphere during polar winter, subsequent ozone depletion, and dynamical feedbacks with radiative (ozone) heating and cooling. This so-called “EPP indirect effect” forms one aspect of solar-climate interactions which will be recommended to include in chemistry-climate models, e.g., in the upcoming CMIP-6 experiment.

We will present recent observations of mesospheric nitric oxide formation due to particle precipitation, as well as downwelling of particle induced NO_y. Observations are compared to results from three 3-dimensional global chemistry-climate and chemistry-transport models of the middle atmosphere, and the subsequent ozone depletion is assessed using CCM / CTM model results.