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Particle precipitation impacts on the atmosphere

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Understanding the Earth's climate system and how it responds to changes is one of the largest challenges faced by society. Being able to understand past climate and to better predict how the Earth's climate will change in the future requires good understanding of both natural and anthropogenic sources of climate forcing. In addition to solar irradiance, energetic particle forcing from the Sun can have a significant impact on the atmosphere, with the effect being focused on the polar regions. This presentation will focus on this type of solar forcing and discuss the influence of energetic particle precipitation (EPP) on the polar atmosphere.

During solar storms the level of particle precipitation into the atmosphere can increase by several orders of magnitude, and some level of EPP is nearly continuously present. In the atmosphere EPP causes ionisation in the middle atmosphere (20-100 km). This effect is confined to polar regions, where particles are guided by the geomagnetic field. In the atmosphere enhanced ionisation leads to increased production of NO_x and HO_x. These are gases, which participate in catalytic ozone destruction. HO_x has a short-lived effect on the atmosphere; NO_x on the other hand is mainly destroyed by photodissociation. Hence during polar winter, when little or no sunlight is present, NO_x impact on the atmosphere can be long lasting. For example, following a series of solar storms in 2003, a 60% ozone depletion in the Arctic upper stratosphere was observed a month after the storms. Consequently, the EPP effect on the atmosphere has the potential to be long lasting (months to years). Dynamical coupling mechanisms between atmospheric layers can further provide coupling between this form of space weather and lower atmosphere and thus have indirect implications to polar climate.

Recently, the analysis of meteorological data and chemistry-climate model results have indicated that during the winter season polar surface temperatures show variability depending on the level of NO_x produced by EPP. Understanding this link between particle forcing from the Sun and climate requires a close examination of the dynamical and chemical coupling mechanisms connecting particle forcing driven changes in the atmosphere to changes in climate variables. In addition, the characteristics of EPP, particularly the energy spectrum and precipitation fluxes of electrons, crucial in determining the initial impact on atmosphere, are not well known.