

3.6 Radiation belt electron precipitation due to geomagnetic storms: significance to middle atmosphere ozone chemistry

Craig J. Rodger (1), Mark A. Clilverd (2), Annika Seppälä (2 & 3), Neil R. Thomson (1), Rory J. Gamble (1), Michel Parrot (4), Jean-Andr  Sauvaud (5), and Thomas Ulich (6)

(1) Department of Physics, University of Otago, Dunedin, New Zealand

(2) British Antarctic Survey (NERC), Cambridge, United Kingdom

(3) Earth Observation, Finnish Meteorological Institute, Helsinki, Finland

(4) Laboratoire de l'Environnement et de l'Espace, Orleans, France

(5) Centre d'Etude Spatiale des Rayonnements, Toulouse, France

(6) Sodankyl  Geophysical Observatory, University of Oulu, Sodankyl , Finland

Geomagnetic storms triggered by coronal mass ejections and high-speed solar-wind streams can lead to enhanced losses of energetic electrons from the radiation belts into the atmosphere, both during the storm itself and also through the post-storm relaxation of enhanced radiation belt fluxes. In this study we have analyzed the impact of electron precipitation on atmospheric chemistry (30-90 km altitudes) as a result of a single geomagnetic storm. The study conditions were chosen such that there was no influence of solar proton precipitation, and thus we were able to determine the storm-induced outer radiation belt electron precipitation fluxes. We use ground-based sub-ionospheric radio wave observations to infer the electron precipitation fluxes at L=3.2 during a geomagnetic disturbance which occurred in September 2005. Through application of the Sodankyl  Ion and Neutral Chemistry model, we examine the significance of this particular period of electron precipitation to neutral atmospheric chemistry. Building on an earlier study, we refine the quantification of the electron precipitation flux into the atmosphere by using a time-varying energy spectrum determined from the DEMETER satellite. We show that the large increases in odd nitrogen (NO_x) and odd hydrogen (HO_x) caused by the electron precipitation do not lead to significant in-situ ozone depletion in September in the Northern Hemisphere. However, had the same precipitation been deposited into the polar winter atmosphere, it would have led to >20% in-situ decreases in O₃ at 65-80 km altitudes through catalytic HO_x cycles, with possible additional stratospheric O₃ depletion from descending NO_x beyond the model simulation period.

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