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A dynamical perspective on the energetic particles precipitation-middle atmosphere interaction

Khalil Karami (1), Miriam Sinnhuber (1), Stefan Versick (1), Peter Braesicke (1,2)

(1) Karlsruhe Institute of Technology, Institute for Meteorology and Climate Research, (2) Cambridge Centre for Climate Science, University of Cambridge, Cambridge, United Kingdom

Energetic particles including protons, electrons and heavier ions, enter the Earth's atmosphere over polar region of both hemispheres, where the geomagnetic lines are considered to be open and connected to the interplanetary medium. This condition allows direct access for energetic particles of solar or galactic origin to directly deposit their own energy into the middle and upper atmosphere. Such particle precipitations can greatly disturb the chemical composition of the upper and middle atmosphere. At polar latitudes, these particles have the potential to penetrate from thermosphere deep into the mesosphere and in rare occasions into the stratosphere. The most important are changes to the budget of atmospheric nitric oxides, NO_y, and to atmospheric reactive hydrogen oxides, HO_x, which both contribute to ozone loss in the stratosphere and mesosphere.

The chemistry-climate general circulation model ECHAM5/MESSy is used to investigate the impact of changed ozone concentration due to energetic particles precipitation on temperatures and wind fields. The simulated anomalies of both zonal mean temperature and zonal wind suggest that these changes are very unlikely to be caused in situ by ozone depletion and indirect dynamical condition is important. The results of our simulations suggests that ozone perturbation is a starting point for a chain of processes resulting in temperature and circulation changes in many areas of the atmosphere. Different dynamical analysis (e.g., frequency of sudden stratospheric warming, dates of stratospheric final warming, divergence of Eliassen-Palm flux and refractive index of planetary waves) are performed to investigate the impact of ozone anomaly originated from high energetic particle precipitation on middle atmospheric temperature and circulation.