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Formation of stratospheric nitric acid by a hydrated ion cluster reaction: chemical and dynamical effects of energetic particle precipitation on the middle atmosphere

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In order to Improve our understanding of the effects of energetic particle precipitation upon the nitrogen family (NO_y) and ozone (O_3), we have modelled the chemical and dynamical middle atmosphere response to the introduction of a chemical pathway that produces nitric acid (HNO_3) by conversion of dinitrogen pentoxide (N2O5) upon hydrated water clusters H+•(H_2O)n. We have used an ensemble of simulations with the National Center for Atmospheric Research (NCAR) Whole-Atmosphere Community Climate Model (WACCM) chemistry-climate model. The introduced chemical pathway alters the internal partitioning of NO_y during winter months in both hemispheres, and ultimately triggers statistically significant changes in the climatological distributions of constituents including: i) a cold season production of HNO_3 with a corresponding loss of N2O5, and ii) a cold season decrease in NO_x/NO_y-ratio and an increase of O_3, in polar regions. We see an improved seasonal evolution of modelled HNO_3 compared to satellite observations from Microwave Limb Sounder (MLS), albeit not enough HNO_3 is produced at high altitudes. Through O_3 changes, both temperature and dynamics are affected, allowing for complex chemical-dynamical feedbacks beyond the cold season when the introduced pathway is active. Hence, we also find a NO_x polar increase in spring-to-summer in the SH, and in spring in the NH. The springtime NO_x increase arises from anomalously strong poleward transport associated with a weaker polar vortex. In the southern hemisphere, a statistical significant weakening of the stratospheric jet is altered down to the lower stratosphere, and we argue that it is caused by strengthened planetary waves induced by mid-latitude zonal asymmetries in O_3 and short-wave heating.