Geophysical Research Abstracts
Vol. 14, EGU2012-5445, 2012
EGU General Assembly 2012

Observations of nitric oxide in the Antarctic middle atmosphere during recurrent geomagnetic storms

D.A. Newnham (1), P.J. Espy (2), M.A. Clilverd (1), C.J. Rodger (3), A. Seppälä (1,4), D.J. Maxfield (1), P. Hartogh (5), K. Holmén (6), and R.B. Horne (1)

(1) British Antarctic Survey, Cambridge, United Kingdom (david.newnham@bas.ac.uk), (2) Department of Physics, Norwegian University of Science and Technology, Trondheim, Norway (patrick.espy@ntnu.no), (3) Department of Physics, University of Otago, Dunedin, New Zealand (crodger@physics.otago.ac.nz), (4) Earth Observation Unit, Finnish Meteorological Institute, Helsinki, Finland (Annika.Seppala@fmi.fi), (5) Max Planck Institute for Solar System Research, Katlenburg-Lindau, Germany (hartogh@mps.mpg.de), (6) Norwegian Polar Institute, Tromsø, Norway (kim.holmen@npolar.no)

The odd nitrogen (NO_x) species nitric oxide (NO) and nitrogen dioxide (NO_2) are produced in the middle atmosphere by precipitating energetic electrons and protons. In the thermosphere and upper mesosphere NO_x exists mainly as NO but below 70 km conversion to NO_2 occurs. In darkness NO_x has a sufficiently long lifetime to be transported downward by the polar vortex at high latitudes during winter and impact on ozone abundances. NO_x may be produced more frequently and persistently by energetic electron precipitation from the Earth's magnetosphere than by solar protons. However, it is unclear which electron energies are most important for stratospheric chemistry. Electrons in the range 10 keV to several MeV precipitate from the radiation belts in the subauroral zone at geomagnetic latitudes $\leq 75^{\circ}$, and particularly in the southern hemisphere and pole-ward of the South-Atlantic Magnetic Anomaly (SMA). Although in general the precipitating flux decreases rapidly with increasing electron energy this mechanism can produce NO_x directly in the stratosphere and mesosphere.

To establish high-latitude NO_x production throughout the polar night, follow its transport, and determine its effects on the composition and chemistry of the mesosphere and stratosphere we have developed and deployed a 230-250 GHz passive microwave radiometer in Antarctica to observe NO, ozone (O_3), and carbon monoxide (CO). Here we report ground-based measurements made from Troll station (72°01'S 02°32'E, geomagnetic latitude 65°), a location equator-ward of the auroral zone, pole-ward of the area of radiation belt precipitation and the SMA, and deep within the polar vortex during the Austral winter.

Our observations show enhanced mesospheric NO volume mixing ratio (VMR) reaching 1.2 ppmv at 65–80 km during a series of small recurrent geomagnetic storms in the 2008 polar autumn and winter. The Lomb normalized periodogram of the NO VMR time series averaged over 65-80 km for days 80 to 220 of 2008 (20 March to 7 August) shows a peak exceeding the 95% confidence limit at 27 days, matching the solar rotation period. For 2008 days 80 to 129 the radiometer NO VMR data is moderately correlated (r = 0.67, lag time of 0.9 days) with 90° telescope "trapped" electron count rate for the >300 keV channel of the SEM-2 MEPED instrument onboard the low altitude (<800 km) POES satellites at geomagnetic latitudes between 60° and 65° and Ap index (r = 0.48, lag time of 2.0 days). For the winter-time period (days 130 to 220) there is a weaker correlation (r = 0.38) between NO VMR and >300 keV electron count rate and a longer lag time of 4-5 days. The altitude profile of mesospheric NO, and ionisation data for the lower ionosphere from 30 MHz and 51.4 MHz widebeam riometers at SANAE IV station (71°40'S, 02°51'W) and the AARDVARK (Antarctic-Arctic Radiation-belt (Dynamic) Deposition - VLF Atmospheric Research Konsortium) network, suggests mesospheric NO is produced by ∼100-300 keV electron precipitation with significant downwards transport in the southern-hemisphere winter-time polar vortex.