Ozone depletion in the Northern Hemisphere middle atmosphere due to the October-November 2003 solar proton events

P. T. Verronen (1), A. Seppälä (1), L. Backman (1), E. Kyrölä (1), S. Hassinen (1), C. J. Rodger (2), M. A. Clilverd (3), A. Hauchecorne (4), J. L. Bertaux (4), D. Fussen (5), C. F. Enell (6), E. Turunen (6), and Th. Ulich (6)

(1) Finnish Meteorological Institute, Earth Observation, Helsinki, Finland.
(2) Physics Dept., University of Otago, Dunedin, New Zealand.
(3) British Antarctic Survey (NERC), Madingley Road, Cambridge, U.K.
(4) Service d'Aeronomie du CNRS, Verrieres-le-Buisson Cedex, France.
(5) Institut d'Aeronomie Spatiale de Belgique, Brussels, Belgium.
(6) Sodankylä Geophysical Observatory, Sodankylä, Finland.

Email: pekka.verronen@fmi.fi

The GOMOS instrument on board the European Space Agency's Envisat satellite has been observing the middle atmosphere since March 1, 2002. GOMOS is a stellar occultation instrument measuring altitude profiles of several minor gas constituents, *e.g.* ozone and NO_2, with a good global coverage that includes the polar regions. The altitude resolution of the measured constituent profiles depends on the measurement geometry but is always better than 1.7 km.

As a result of a coronal mass ejection from the Sun towards the Earth, ionization rate due to precipitating energetic protons may increase by several orders of magnitude in polar middle atmosphere. This phenomenon is called a solar proton event. The enhanced ionization affects not only the ionosphere but also some of the minor neutral constituents between upper stratosphere and the mesopause. Odd hydrogen (HO_x = H+OH+HO_2) and odd nitrogen (NO_x = N+NO+NO_2) species are produced via proton and secondary electron impact on N_2 as well as in ion chemical reactions. Subsequently, the amount of ozone is reduced in catalytic reactions with odd hydrogen and odd nitrogen species.

In late 2003, GOMOS monitored the effects of a great solar proton event on the Northern Hemisphere polar atmosphere. For the first time, the depletion of ozone due to a solar proton event was measured in polar night conditions, *i.e.* in the dark. The results show increase in NO_2 concentration by several hundred per cent and a simultaneous decrease in ozone by tens of per cent at altitudes above 36 km. The maximum effect, a 60% reduction in ozone at 42 km, is seen in the end of November, a month after the solar proton events. Afterwards, a partial recovery of ozone occurs towards the end of the year.