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The long-term effects of the Oct/Nov 2003 SPEs on ozone in the polar winter atmosphere

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A large solar disturbance like a flare or a coronal mass ejection can result in emission of high-energy protons and other ions from the Sun. If these particles reach the Earth they set off a Solar Proton Event (SPE) during which the charged particles precipitate into the Earth's atmosphere causing ionization in the middle atmosphere. The effect of the SPEs is confined to the polar cap regions, where the particles are guided by the magnetic field. Ion chemistry leads to increased production of odd nitrogen (NO_x = N + NO + NO_2) and odd hydrogen (HO_x = H + OH + HO_2) which participate in catalytic reaction cycles that decrease the amount of ozone in middle atmosphere. HO_x gases have a short chemical lifetime but the NO_x gases are mainly destroyed by photodissociation. Hence during winter, when little or no sunlight is available in the polar atmosphere, the effect of the NO_x cycles can be long-lasting.

We have used the nighttime observations of mesospheric and stratospheric O_3 and NO_2 made by the stellar occultation instrument GOMOS on board the European Space Agency's Envisat satellite to monitor the increase of NO_2 and depletion of ozone due to the SPEs of October-November 2003. The results show NO_2 enhancement of several hundred per cent and tens of per cent ozone depletion in the stratopause region, an effect which lasts several months after the events. The GOMOS observations are used to trace the SPE triggered effects throughout the polar night until the following spring. The October-November 2003 series of solar storms was the first occasion when the SPE effects on atmosphere were monitored during polar night conditions by satellite instruments with good spatial and temporal coverage.