Changes in the composition of the upper stratosphere – lower mesosphere at northern high latitudes after a sudden stratospheric warming

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The sudden stratospheric warming (SSW) of January 2009 induced important changes in the chemistry of the upper stratosphere at northern high latitudes. Data from Michelson Interferometer for Passive Atmospheric Sounding (MIPAS) aboard ENVISAT and the Microwave Limb Sounder (MLS) on Aura show record high values of O3 and ClO and low values of temperature and HCl for the winters of 2005-2012, and a simultaneous enhancement of ClONO2, in February 2009. The low temperatures favor a more effective ozone production and a greater O3/O ratio and cause ClOx to be repartitioned towards ClO. Increases of ClO lead to high ClONO2 concentrations at high latitudes, where its photodissociation rate is smaller. The altitude and the magnitude of this layer of high ClONO2 are comparable to those for the ClONO2 enhancement which occurred after the solar proton event of October-November 2003.

Temperature and O3 in the polar vortex result to be anti-correlated for long time scales (i.e. months) while the vortex dynamics tends to hide this relationship for shorter time scales. The ingression of air rich in CH4 and a small reduction of the sum of VMRs of ClONO2+ClO+HCl characterized the period between the SSW occurrence and early February 2009 when a horizontal air mixing between polar and mid-latitude air occurred. On the other hand, the sum of VMRs is roughly constant and similar to the usual year-to-year variability during the remaining days of February and in March.

The investigated altitudes are not influenced by the descent of mesospheric air rich in NOx which develops after the SSW. Some limited enhancements in NOx are detectable at very high latitudes after 20 February but they did not substantially influence O3 and ClONO2 in February. Overall, because of the dominant nighttime conditions, the influence from the catalytic cycles on the O3 variation was limited in February while they are important in explaining the O3 depletion in middle March.

References

Damiani A., Funke B., López-Puertas M., Gardini A., von Clarmann T., Froidevaux L., Santee M.L., R.R. Cordero, Impact of the sudden stratospheric warming in February 2009 on the composition of the northern polar upper stratosphere, Journal of Geophysical Research, DOI: 10.1002/2014JD021698, 2014.