Millimeter-wave measurements of stratospheric O_3 and N_2O from the high-altitude station of Testa Grigia (Italy; 45.9°N, 7.7°E, 3500 m a.s.l.)

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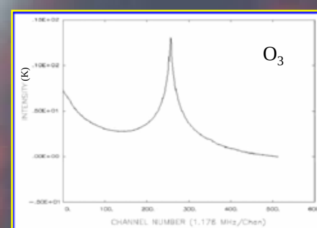
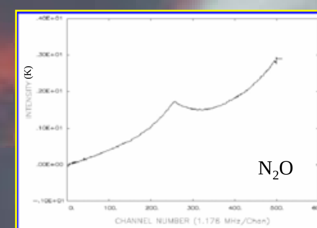
During the winter 2003-2004, we started a project aimed at studying the mid-latitude stratosphere at Plateau Rosa (or Testa Grigia, 45.9°N, 7.7°E, elev. 3490 m above mean sea level), a high mountain site near Cervinia, on the Italian Alps, at the border between Italy and Switzerland. The high elevation makes Testa Grigia an excellent site for carrying out measurements at mid-latitudes with instruments that require a low water vapor columnar content.

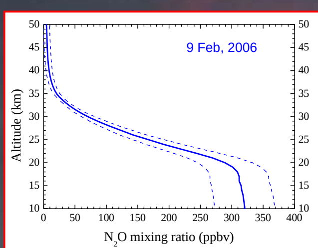
Measurements of rotational lines at frequencies between 230 and 280 GHz were carried out with a heterodyne spectrometer (Ground-Based Millimeter-wave Spectrometer, or GBMS) [*de Zafra*, 1995]. The GBMS measures rotational lines in emission of O_3 (276.923 GHz), HNO_3 (269.211 GHz), CO (230.538 GHz), HDO (255.050 GHz), N_2O (276.328 GHz), and HCN (265.886 GHz) with a spectral pass band of 600 MHz and a maximum resolution of 65 kHz, resulting in the retrieval of vertical profiles of species concentrations between ~15 and ~75 km altitude. Observations took place during 4 winter periods, from February 2004 to March 2007, for a total of 116 days of measurements [*Muscari et al.*, 2007; *Santee et al*., 2007; *Fiorucci et al*., 2008].

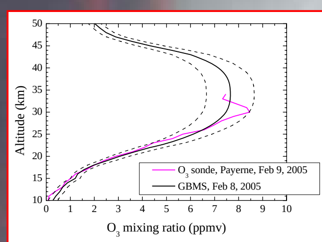
Typical spectra





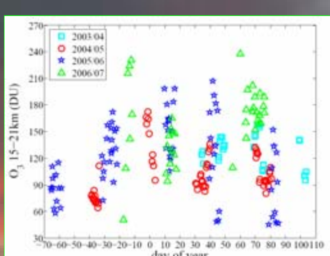
Typical vertical profiles with their uncertainties



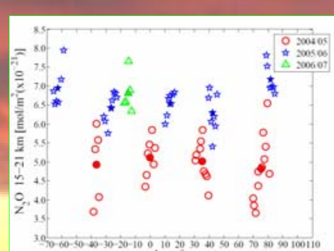


Generally, GBMS O_3 profiles from Testa Grigia are in good agreement with concurrent balloon-borne O_3 measurements carried out from the NDACC station of Payerne (46.8°N, 6.9°E) [Courtesy of the Federal Office for Meteorology and Climatology, MeteoSwiss].

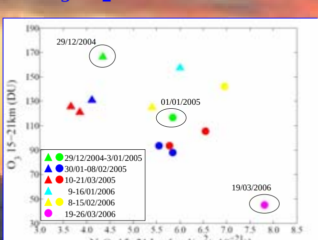
Column densities between 15 and 21 km



During most times of GBMS observation a large part of O_3 columnar content variability is concentrated in the column below 21 km, with tropospheric weather systems and advection of tropical tropospheric air into the lower stratosphere over Testa Grigia having a large impact on the observed variations. Nearly concurrent measurements of N_2O are used for determining the origin of the observed air masses.

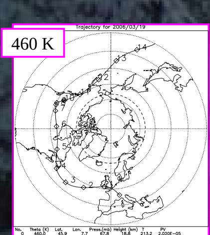


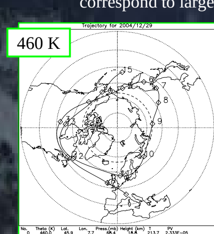
O_3-N_2O Correlation

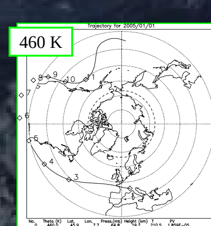


For each field campaign the correlation between O_3 and N_2O is shown only for N_2O column density values differing from the mean value more than one standard deviation (figure on the left). Different colors are used to indicate different field campaigns; solid circles and triangles refer to values greater and smaller than the mean values, respectively. The analysis is restricted to the period late December-March of the winters 2004-2005 and 2005-2006. Generally, during these observation periods, lower values of N_2O columnar content (suggesting advection of polar air masses) correspond to larger amounts of O_3.

15-day backtrajectories arriving at Testa Grigia for specific dates (circled and indicated in the figure) are shown [Courtesy of the Goddard Space Flight Center, NASA].

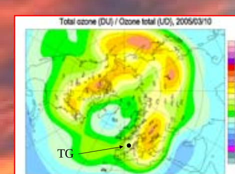


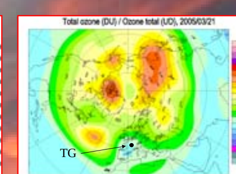




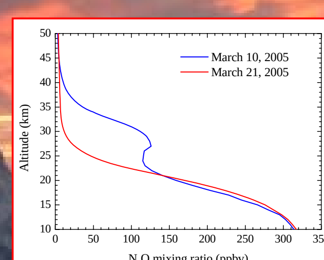
A case study: March, 2005

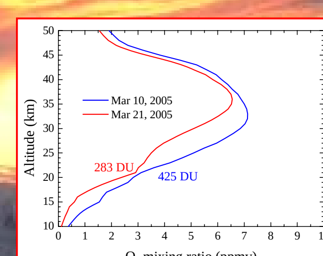
The Arctic Winter 2004-2005 was characterized by a particularly cold lower stratosphere and a remarkable Ozone depletion [e.g., *Manney et al.*, 2006].

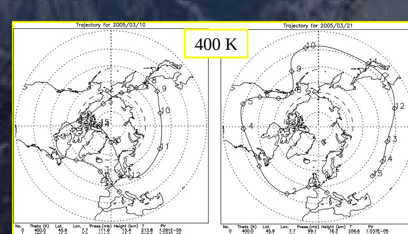


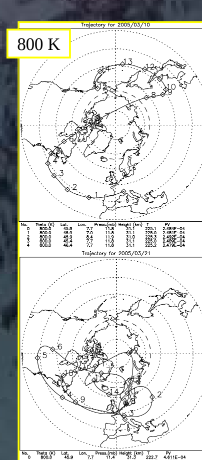


[Courtesy of the Environment Canada (http://es-ee.tor.ec.gc.ca/), employing ground-based measurements available from the World Ozone and Ultraviolet Radiation Data Centre].









References

Muscari G., C. Cesaroni, C. Bianchi, R. L. de Zafra, T. Di Iorio, I. Fiorucci, D. Fuà, V. Romaniello, and E. Zuccheretti, Millimeter wave spectroscopic measurements of stratospheric and mesospheric constituents over the Italian Alps: stratospheric ozone, *Ann. Geophys.*, 50, 469-482, 2007.

Santee, M. L., A. Lambert, W. G. Read, N. J. Livesey, R. E. Cofield, D. T. Cuddy, W. H. Daffer, B. J. Drouin, L. Froidevaux, R. A. Fuller, R. F. Jarnot, B. W. Knosp, G. L. Manney, V. S. Perun, W. V. Snyder, P. C. Stek, R. P. Thurstans, P. A. Wagner, J. W. Waters, G. Muscari, R. L. de Zafra, J. E. Dibb, D. W. Fahey, P. J. Popp, T. P. Marcy, K. W. Jucks, G. C. Toon, R. A. Stachnik, P. F. Bernath, C. D. Boone, K. A. Walker, J. Urban, and D. Murtagh, Validation of the Aura Microwave Limb Sounder HNO_3 Measurements, *J. Geophys. Res.*, 112, D24S40, doi:10.1029/2007JD008721, 2007.

de Zafra, R. L., The ground-based measurements of stratospheric trace gases using quantitative millimeter wave emission spectroscopy, in *Diagnostic tools in atmospheric physics*, Proceedings of the international school of physics "Enrico Fermi", pp. 23-54, Società italiana di fisica, Bologna, 1995.

Fiorucci, I., G. Muscari, C. Bianchi, P. Di Girolamo, F. Esposito, G. Grieco, D. Summa, G. Bianchini, L. Palchetti, M. Cacciani, T. Di Iorio, G. Pavese, D. Cimini, and R. L. de Zafra, Measurements of low amounts of precipitable water vapor by mm-wave spectroscopy: an intercomparison with radiosonde, Raman Lidar and FTIR data, *J. Geophys. Res.*, doi:10.1029/2008JD009831, in press (accepted 29 May 2008).

Manney, G. L., M. L. Santee, L. Froidevaux, K. Hoppel, N. J. Livesey, and J. W. Waters, EOS MLS observations of ozone loss in the 2004–2005 Arctic winter, *Geophys. Res. Lett.*, 33, L04802, doi:10.1029/2005GL024494, 2006.