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NOy from MIPAS/ENVISAT during the South Hemisphere Polar Vortex Split in September/October 2002

1. Introduction

The change in ozone abundances is controlled by abundances and partitioning of reactive nitrogen reservoir (NO_y). NO_y species are derived from limb radiances measured by MIPAS during the anomalous Antarctic vortex split and analysed to understand the budget, partitioning and photochemical and transport processes.

2. Spatial and Temporal evolution of Vortex

- The vortex edge PV (determined according to Nash criteria from UKMO analysis) for different periods differs from each other at levels above 775 K as well as from the scaled PV (Π_g=-44.3 PVU at $\theta_0 = 475$ K, $1PVU = 10^{-6}Km^2/kgs$) (Figure 1).
- ex-vortex airmass at SZA=80-100 degrees during the split
- Vortex was recentred on the pole and very low N_2O_5 and high NO_x in October (Figure 2).

PV at the edge of Vortex

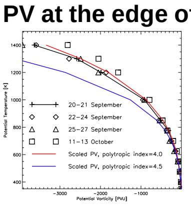

Fig. 1: The value of potential vorticity at the edge of the polar vortex determined according to Nash procedure from UKMO analysis data (symbols and line) and scaled PV according to $\Pi_g = P(\frac{\theta}{\theta_0})^{\epsilon}$ for $\epsilon = 4.0$ (red line) and $\epsilon = 4.5$ (blue line, Lait's version). Π_g is generalized form of Lait's modified PV given by Müller and Günther, J. Atmos. Sci., 60, 2003.

NO_y at 550 K

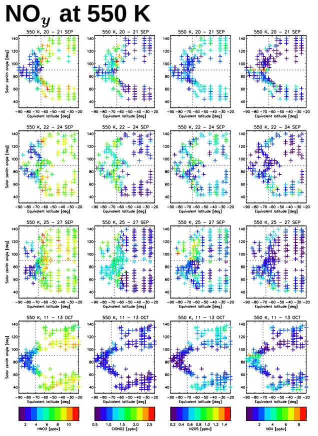

Fig. 2: The solar zenith angle dependence of NO_y at different equivalent latitudes.

3. NO_y partitioning

- NO_y inside the vortex is higher than outside for $\theta \leq 400K$ and lower above 400 K (see Figure 3).
- Vortex HNO_3 is the dominant part of NO_y for $\theta \leq 700K$ from 20-24, September and $\theta \leq 600K$ during the vortex split and $\theta \leq 550K$ in October while NO_x accounts for most part above these θ-levels (see Figure 3).
- vortex was inhomogeneous as noticed from NO_y spatial variability.
- enhanced photolysis of HNO_3 and subsequent build up of NO_x (Figures 4-6).

Daytime Averages

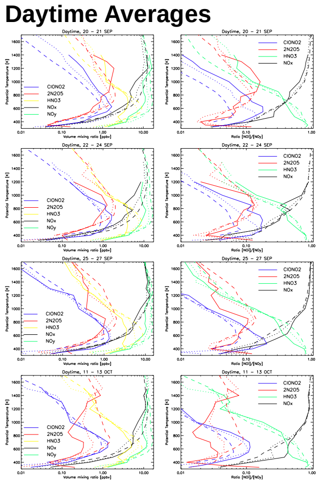

Fig. 3: The solid, dotted and dashed lines represent inside-vortex, vortex edge and ex-vortex regions respectively.

Vortex (geolocation wise)

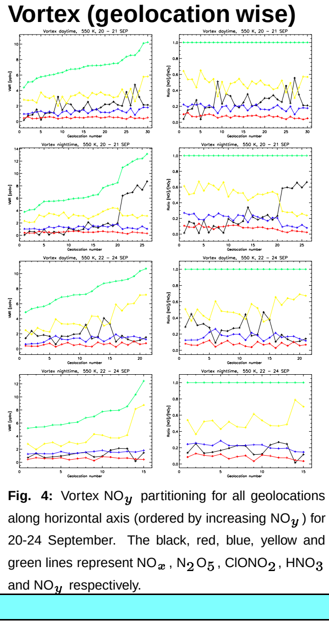

Fig. 4: Vortex NO_y partitioning for all geolocations along horizontal axis (ordered by increasing NO_y) for 20-24 September. The black, red, blue, yellow and green lines represent NO_x, N_2O_5, $ClONO_2$, HNO_3 and NO_y respectively.

Vortex (geolocation wise)

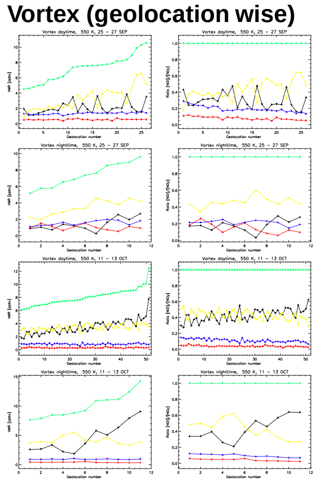

Fig. 5: the same as Figure 4 for 25-27 September and 11-13 October).

HNO3:NOx correlation

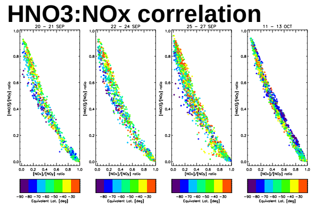

Fig. 6: Daytime HNO_3:NO_x correlation normalized by NO_y for potential temperature 400-1700 K.

4. Mixing and denitrification

- The ex-vortex CH_4:N_2O and NO_y:N_2O relations show small variability for the 4-periods (Figures 7-8).
- The vortex NO_y:N_2O relations show significant deviation from compact canonical relations for all periods.
- Quasi-horizontal mixing ≈ 3.45 ppbv and denitrification ≈ 5.33 ppbv of the observed deficit in NO_y at potential temperature of 475 K through out the study period.

CH_4:N_2O correlation

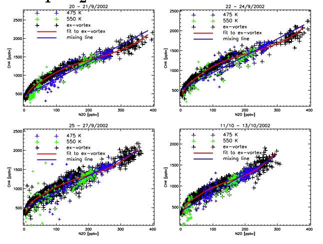

Fig. 7: Approximate quasi-isentropic mixing lines along 475 - 550 K levels (blue lines) plotted for the four periods (early presplit, presplit, split and postsplit periods). The red curves represent fits to ex-vortex CH_4:N_2O relation.

NO_y:N_2O correlation

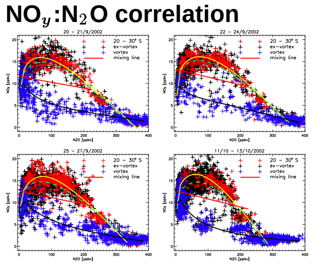

Fig. 8: The mixing lines determined from CH_4:N_2O are transformed in to NO_y:N_2O space (red lines). The Green, yellow and black curves represent fits to ex-vortex (south of 30^0 S equivalent latitude), $20 - 30^0$ S equivalent latitude, and vortex data respectively.

NO_y deficit

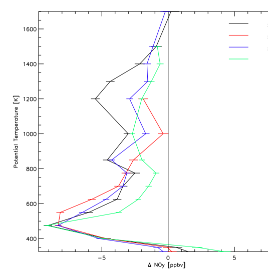

Fig. 9: Total NO_y deficit (bottom panel)

5. Summary and conclusion

- Spatial variability in vortex NO_y abundances (which was pronounced in September as compared to October) is an evidence for inhomogeneity of the vortex.
- There was formation of $ClONO_2$ (between 400-475 K) and N_2O_5 (above 700 K) during 22-27 September period. However, the major photochemical processes inside the vortex during the major warming was photolysis of HNO_3 and subsequent build up of NO_x.
- Quasi-horizontal mixing accounts for ≈ 3.45 ppbv while denitrification accounts for ≈ 5.33 ppbv of the observed deficit in NO_y at potential temperature of 475 K through out the study period implying that the vortex was isolated despite the major warming.

Acknowledgements

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