Ozone loss in the Arctic stratosphere over Kiruna, Sweden, during winter 2005/06

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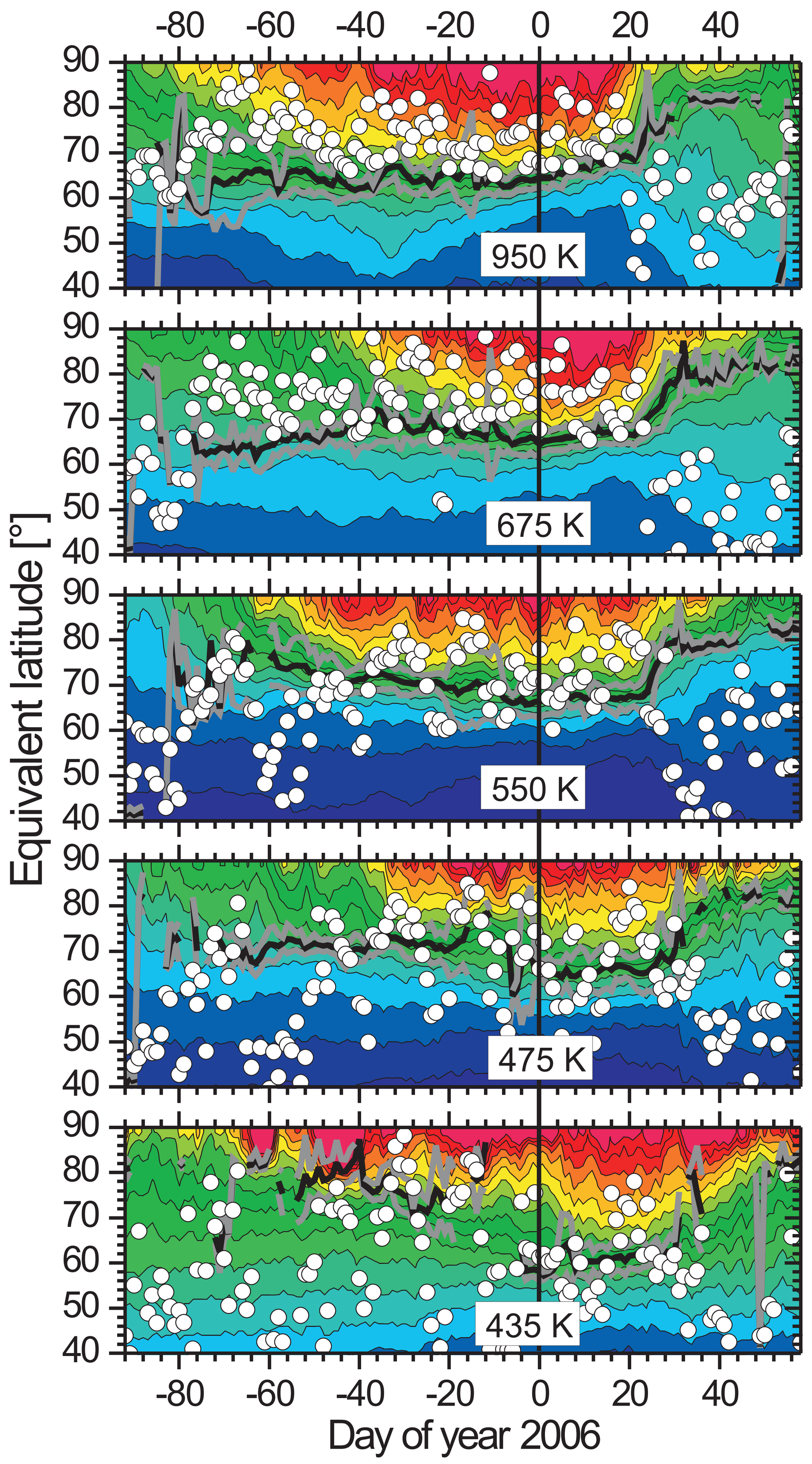

Figure 1: Evolution of the polar vortex in terms of equivalent latitudes. The white lines describe the inner and outer edge of the vortex, respectively, while the black line describes the mean vortex edge, i.e. the strongest gradient in PV for the particular day. The colour coding shows the strength of the vortex in PVU. The open circles depict the PV over Kiruna on the particular measurement days and refer to the underlying PV colour coding, showing how far away from or how deep inside the vortex a measurement has been taken at IRF.

Introduction

IRF Kiruna is located above the polar circle (67.8° N/20.4° E). With the millimetre wave radiometer KIMRA we investigate the ozone layer within the polar vortex during Arctic winter. The ground-based observations of stratospheric trace-gases cover the altitude range from 15 up to 55 km. Here we present continuous observations of stratospheric ozone covering the winter 2005/2006. From the measurements we calculated ozone profiles and partial column densities. For the estimated ozone loss we considered only measurements well within the polar vortex defined by the 'Equivalent Latitude' method described by Nash et al. [1996]*. In order to discriminate dynamic effects we deploy N_2O data from the Odin satellite.

* Nash, E. R., P. A. Newmann, J. E. Rosenfield, and M. R. Schoeberl, An objective determination of the polar vortex using Ertel's potential vorticity, J. Geophys. Res., 101, 9471 - 9478, 1996.

Measurements

Observations of stratospheric ozone at 195 GHz provide an almost uninterrupted time series of ozone data. The data in figure 2 present the period October 2005 to February 2006.
Deploying the FWHM of the averaging kernels we can obtain a vertical resolution of the ozone profiles of at best 6 km (at 25 km altitude). Contributions from the measurements to the retrieved profiles are typically larger than 75% in the altitude range between 15 and 55 km. However the partial column densities are calculated for 10 to 80 km.

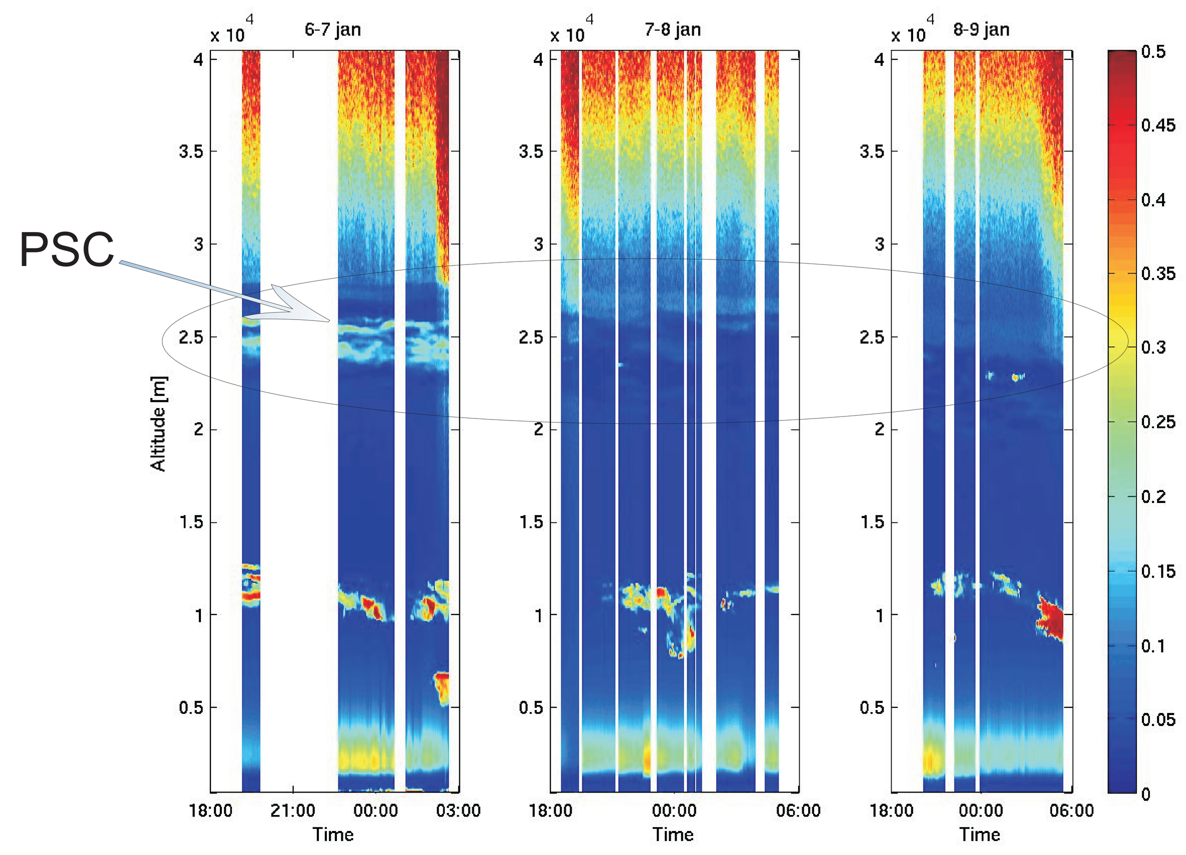

Figure 5: Observations of the new IRF lidar system from Jan 6-9. The layer at around 10 km depicts high cirrus clouds. The layer at 25 km indicates PSC (type II) with moderate depolarization on Jan 7. PSC with low depolarization (type I) were observed Jan 8-9.

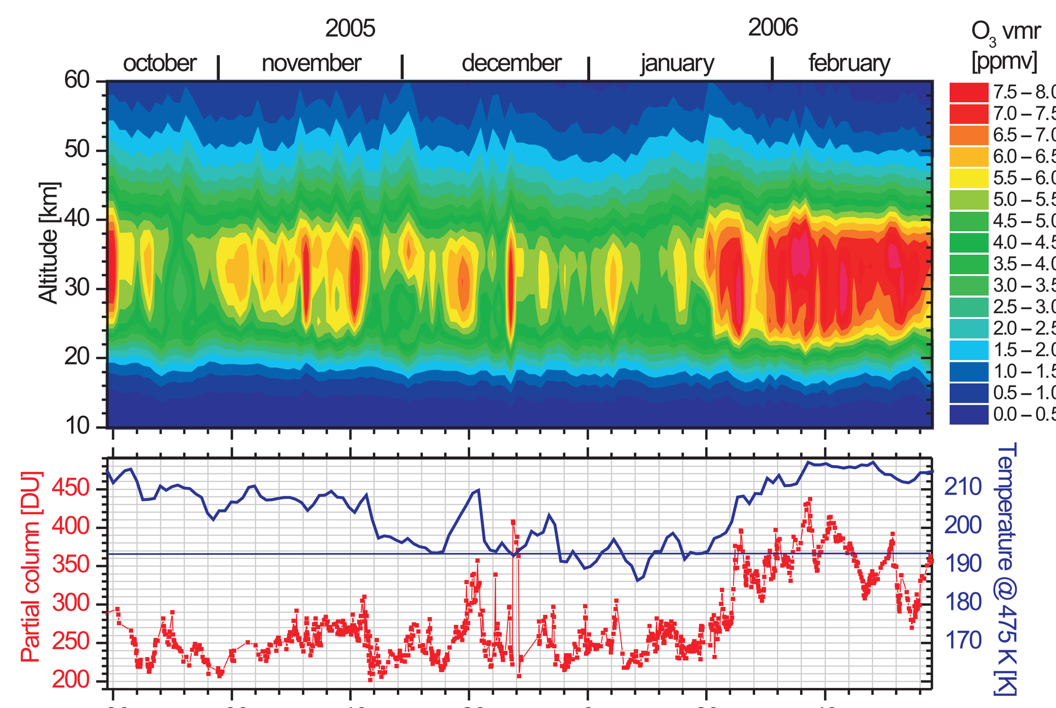

Figure 2: Time series of O_3 during winter 2005/06 (upper panel). The contour plot shows the volume mixing ratio in ppmv. The lower panel presents the partial O_3 column density from 10 to 80 km. The blue line indicates the temperature at 475 K isentropic level over Kiruna.

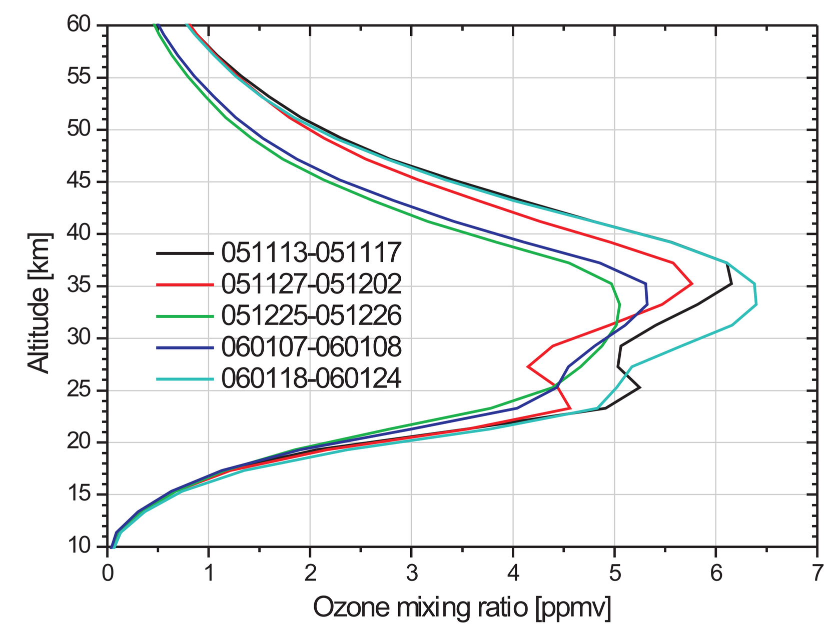

Figure 3: Ozone profiles for periods with inside-vortex measurements of KIMRA.

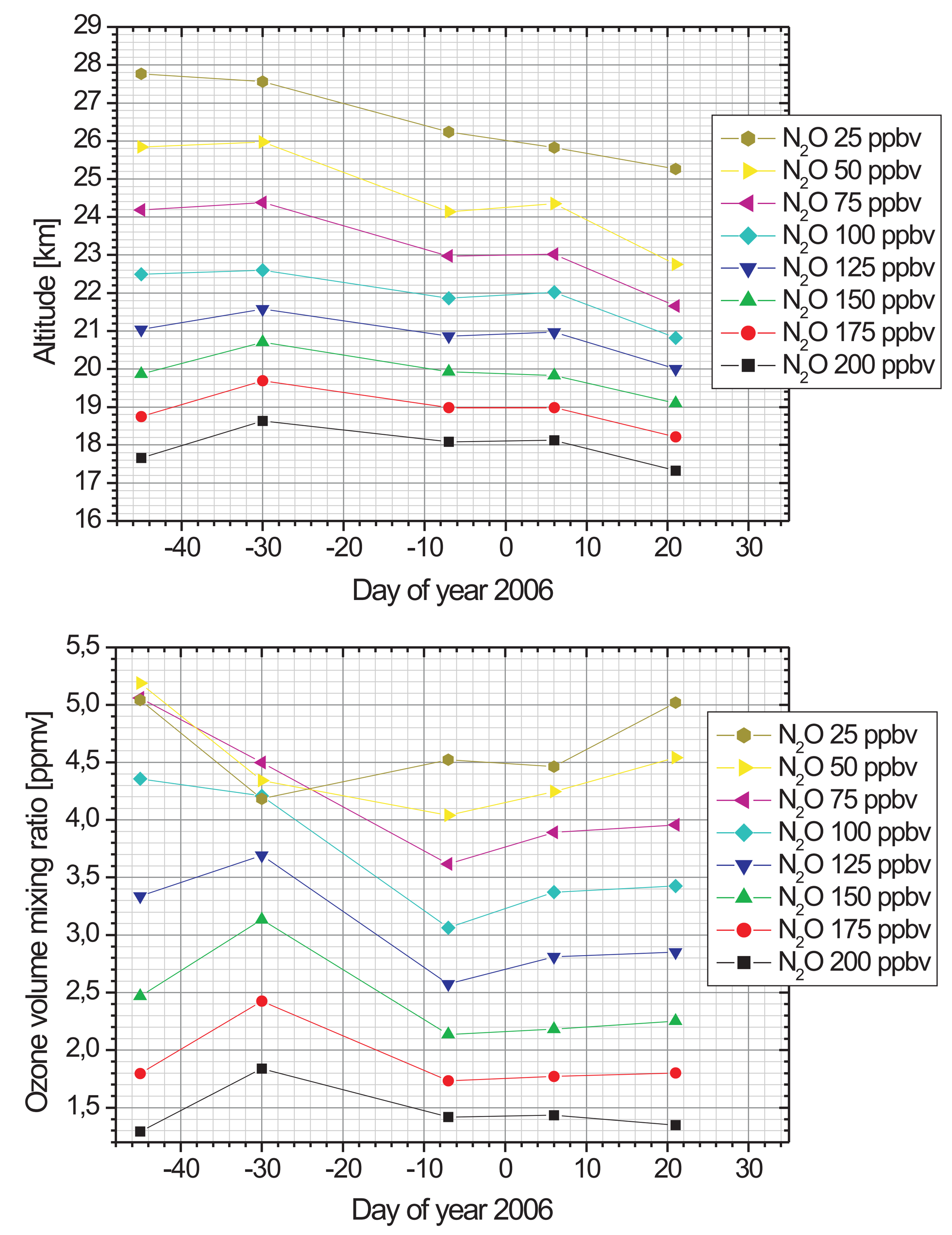

Figure 4: N_2O isopleths as measured by Odin (upper panel) indicating the subsidence of air masses. In the lower panel the vmr data as shown in figure 3 are calculated on N_2O isopleths provided by Odin data in order to eliminate effects of diabatic subsidence. The systematic error for the ozone vmr data between 17 and 27 km is of the order of 20% or 0.2 - 1.1 ppmv respectively.

Results

The Arctic winter 2005/06 has started with moderately low temperatures in November and December. In late December and early January a period of very low temperatures as far down as 186 K at 475 K isentropic level (as shown in fig. 2) with observation of persistent polar stratospheric clouds appeared (see fig 5). However, unlike other winters the polar vortex was neither very large nor stable and at the end of January it has virtually disappeared again in the middle stratosphere (550 K and upward). Certainly Kiruna was not located under the vortex after day 30 as can be seen from the equivalent latitude calculations in fig 1. In order to estimate the winter ozone loss we identified 6 periods with measurements well inside the vortex between November 13 (day -46) and January 24 (day 23) (see profiles in fig. 3). Part of the total ozone loss is covered by the diabatic subsidence inside the vortex. In order to correct for the diabatic subsidence Odin vortex mean values of N_2O are used (see fig. 4).
The calculated ozone loss between early December and late January was 20-30% with a maximum around 23 km. With respect to the weak and warm polar vortex during February and March we expect no further substantial ozone loss during this period.

Acknowledgements

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