Measured tracer profiles from the polar stratosphere covering all seasons 2000

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Abstract

DESCARTES is a lightweight balloon-borne grab-sampler instrument for the long-lived chemical tracer CFC-11 developed at the University of Cambridge. From Dec 3, 1999 and throughout 2000 it made 15 flights from Esrange and Andøya. Simultaneous balloon-borne ozone measurements were made during most flights. The evolution of the polar airmass over the whole year is studied from these flights and compared to model profiles at Kiruna and other subsidence studies.

1 Introduction

The polar vortex is heavily investigated during the spring period when the subsidence and catalytical ozone destruction takes place. This is especially true for the spring 2000 with the joint SOLVE/THESEO 2000 campaign, e.g. by Greenblatt et al. [2002]; Müller et al. [2002] and Harris et al. [2002]. The DESCARTES instrument [Danis et al., 2000] participated not only in that campaign but also in the SAMMOA [Orsolini et al., 2002] and SKERRIES campaigns during the summer and autumn. By the measurements from this long time-period the evolution and start of the polar vortex can be studied.

Potential temperature is a height scale that is preserved under adiabatic displacements. The idea in this study is to use the tracer mixing ratio as a height scale for the airmass that is preserved even under diabatic heating and cooling. This approach has recently been used by Greenblatt et al. [2002] for the spring period vortex. The tracer abundance and thus the associated height scale will change during mixing of air masses such as the vortex breakup.

2 Measurements

Figure 1 shows the ozone and potential temperature for all successful flights during the year, interpolated to isopleths of CFC-11. Interpolation has been done by first integrate the measurements over the sampling-time of the closest DESCARTES samplings and then linear interpolation between these points to get corresponding measurements. All potential temperature values are calculated from ptu units. For the flights 000128, 000209, 000307 and 000403 ozone are derived from SAOZ [Pommereau and Piquard, 1994] measurements, and for the rest from ozone sondes.

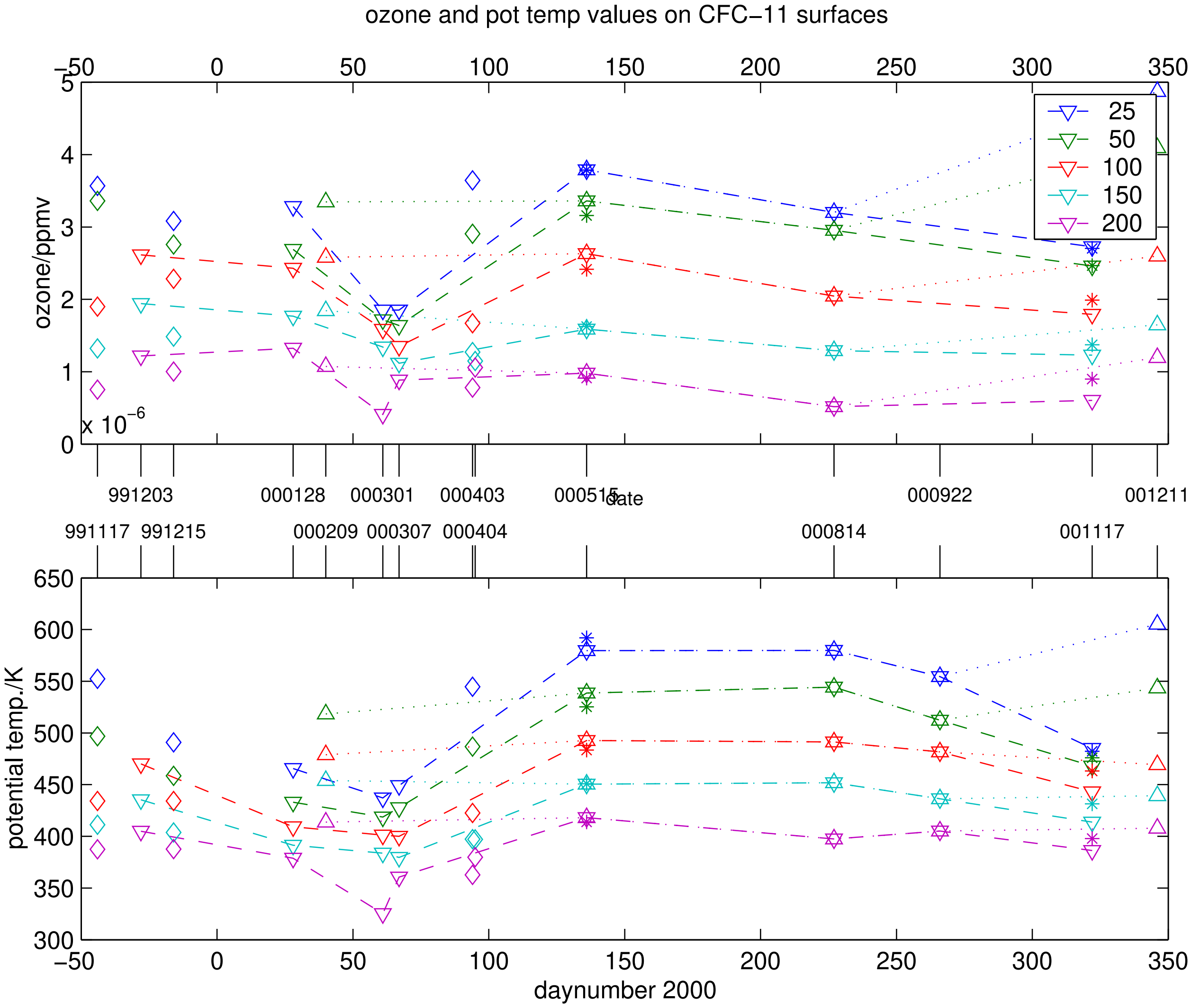

Figure 1: Ozone and potential temperature measurements interpolated to CFC levels from DESCARTES measurements. Downward facing triangles are in-vortex flights, upward facing are out of vortex flights, diamonds are vortex edge and stars are for double flights interpolations to the second DESCARTES profile and otherwise vortex edge. Flights in summer (May to October) are plotted with both the in and out of vortex series.

Vortex classifications are made by an upper and a lower PV threshold where over the upper means in-vortex, in between means on the edge and under the lower means out-of-vortex. These thresholds increases from 30 to 42 pvu at 475 K from first of November to new year for the upper and from 20 to 25 pvu for the lower. PV data are taken from the ECMWF analysis.

A special slimcat run has been performed during the winter/spring of 1999/2000 including several additional tracers, among which are CFC-11 and N_2O. This run is driven by UKMO analysis. Figure 2 shows a comparison between samplings of the model run over Kiruna (67.89N/22.08E) every second day during the run and the DESCARTES measurements. The model samplings are classified to be in or out of vortex according to the same criterion as the flights.

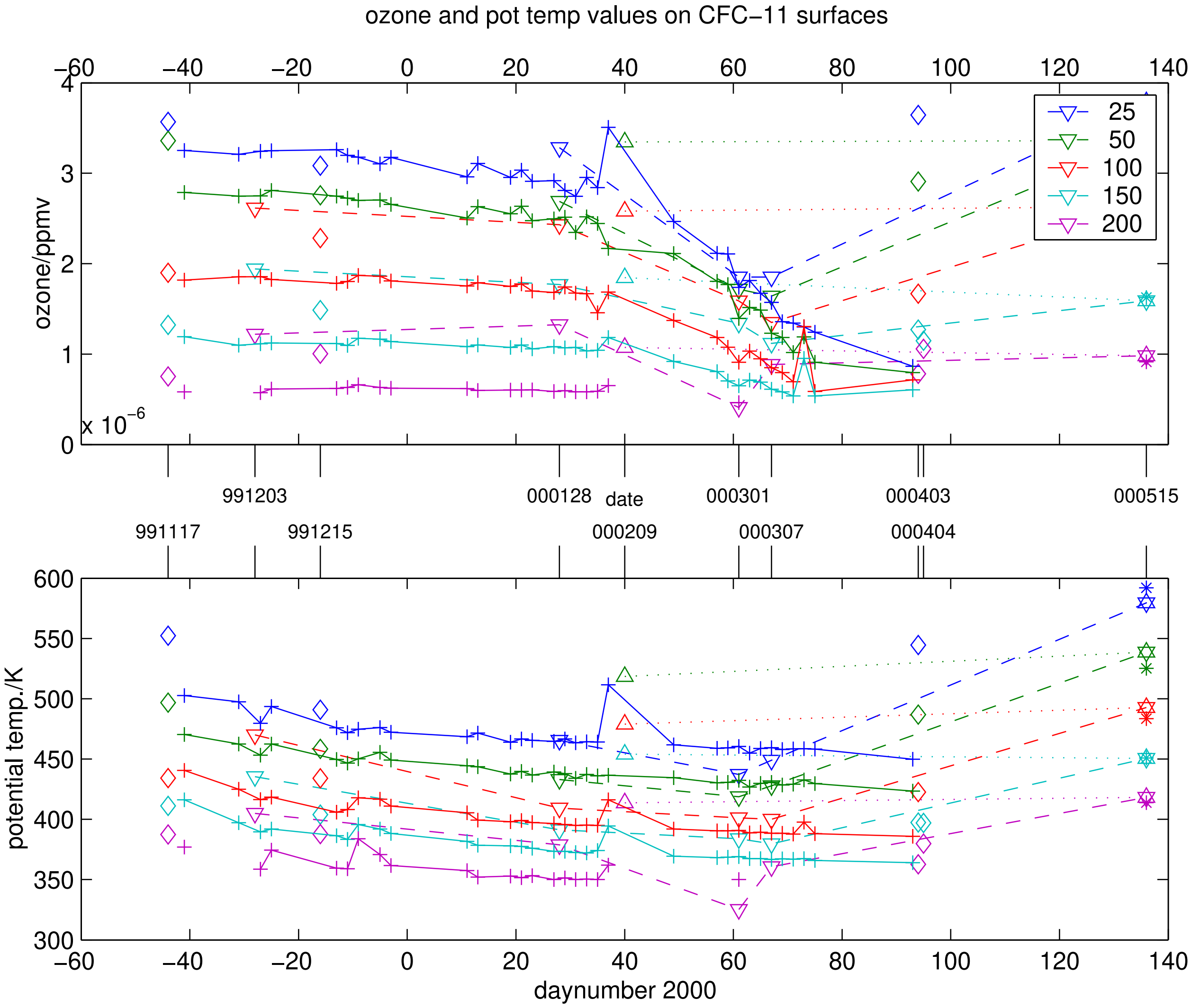

Figure 2: Detail of figure 1 for the springtime plotted together with a SLIMCAT simulation interpolated to KIRUNA. Plus-marks is the model in-vortex days.

3 Conclusions

According to figure 1 the polar air is undergoing a diabatic cooling in September even before a clear vortex has formed at the order of tenth of Kelvin at 25 pptv CFC-11.

Compared to Greenblatt et al. [2002] which is a similar investigation with the same model but averaged over the whole polar vortex (70–80° equivalent PV-latitude) the trend in this local series over Kiruna show slightly less diabatic cooling of the vortex. This is qualitatively in agreement with our measurements but as Greenblatt uses N_2O which is not measured by DESCARTES a direct comparison is not possible. Our few flights is also a very small statistical set for quantitative analyses.

Remarkable in the Greenblatt study is the simulated warming in higher altitudes that appears after day 70 but is not seen in their observational data and not in our local sampling of the model. Unfortunately there are not many model samplings over Kiruna in this time period which are in the vortex. The remaining difference compared to Greenblatt might be due to differences in the UKMO and ECMWF analysis. The flight 000403 is unfortunately in the vortex edge region. The flight data shows high potential temperature on CFC-11 isopleths compared to previous vortex measurements. The PV for this flight is very close to the upper threshold limit and could thus possibly support the model result discussed in Greenblatt et al. [2002]. However a proper back trajectory calculation of the sampled volumes must be performed in order to reach any substantial conclusion on this matter.

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