Observations coupled to the overpasses of the polar vortex over mid-latitude Europe in winter 1995-1996.

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INTRODUCTION

The spring 1996 polar vortex was very deep and cold, with temperatures down to the ice formation threshold, and persisted until March [1]. The northern hemisphere ozone decrease in winter 1995-1996 was larger than ever before in the nineties [1]. Particularly at the European mid-latitudes, transport of air masses from the polar vortex towards mid-latitudes had a noticeable impact on the stratospheric temperatures and composition. Such was not observed that clearly in the latest winter 1996-1997.

In this work, signatures of polar vortex overpasses in spring 1996 at several European mid-latitude stations are indicated. Most significant events have been observed at these stations within a delay of one to four days, on the following days: 18-22/1, 14-20/2, 1-6/3, 29-3, 15-17/4. The focus here will be on the two events in March.

EXPERIMENTAL DATA SETS

Ozone, pressure and temperature profiles are measured by ozone sonde at Uccle (Belgium, 51°N, 5°E) and at Payerne (Switzerland, 46.5°N, 6.6°E). SAOZ (Système d'Analyse par Observations Zénithales) and FTIR (Fourier Transform Infrared) instruments located at the International Scientific Station of the Jungfraujoch (ISSJ, Switzerland, 46.5°N, 8°E) provide ozone total columns. Lidar ozone profiles recorded at the Observatoire de Haute Provence (OHP, France, 43.9°N, 5.7°E) are used also

Meteorological analyses of potential vorticity at the 475 K and 550 K isentropic levels and of temperatures at 50 and 30 hPa are provided by the ECMWF (European Centre for Medium-Range Weather Forecasts) via NADIR-NILU. The same database gives access to TOVS O_3 maps.

RESULTS AND DISCUSSION

The time series of potential vorticity (PV) on the 550 K and 475 K isentropic levels clearly show that the polar vortex passed over Uccle, ISSJ and OHP several times during spring 1996 (Fig.1). This polar vortex is associated with cold temperatures, as can be seen on time series at 50 hPa (30 hPa). The stratospheric temperatures during the event centred around March 6 were cold enough for enabling NAT condensation (Fig.1). On March 5 the aerosol lidar located at Garmisch Partenkirchen detected a polar stratospheric cloud (PSC) for the first time since the beginning of its observations 20 years ago [H.Jaeger, private communication].

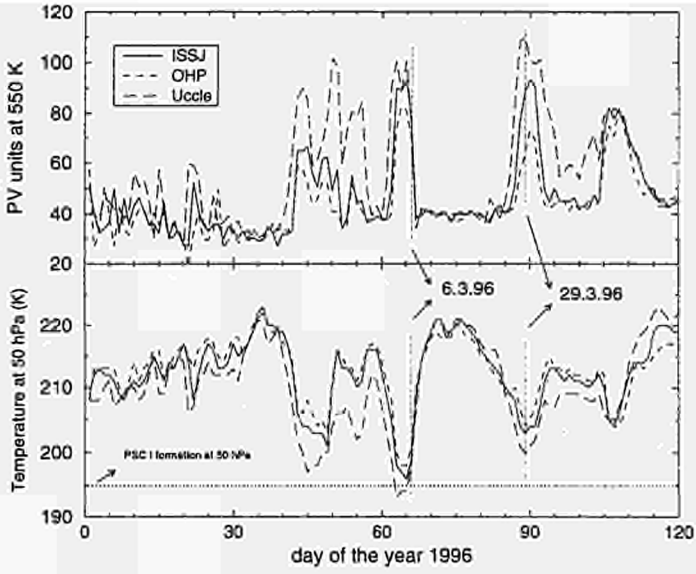

Fig. 1 PV at 550 K and temperatures at 50 hPa for European mid-latitude stations ISSJ, OHP and Uccle

For the two considered events, figures 2 and 3 show the O_3 perturbed profiles at Payerne and Uccle, respectively, and the corresponding temperature profiles. These O_3 profiles are compared to the O_3 profile for a day out of vortex (8/3 at Payerne, 11/3 at Uccle) and to the AFGL (Air Force Geophysical Laboratory) winter profile for mid-latitude. These perturbed ozone profiles picture a strong subsidence characteristic of the polar origin of the measured air mass, with low O_3 concentration in the low stratosphere.

For these two stations, the temperature profiles indicate the possibility of the formation of type I PSCs at altitudes between about 21 and 25 km.

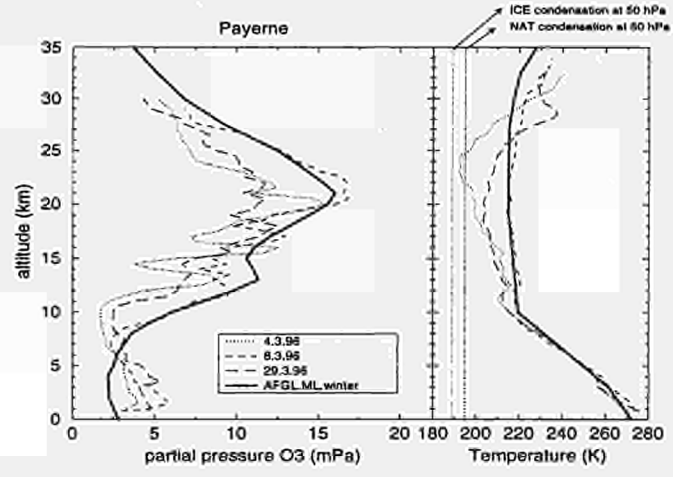

Fig. 2 Ozone and temperature profiles at Payerne, in the presence of the polar vortex (4 and 29/3/96) and in out-of-vortex conditions (8/3/96).

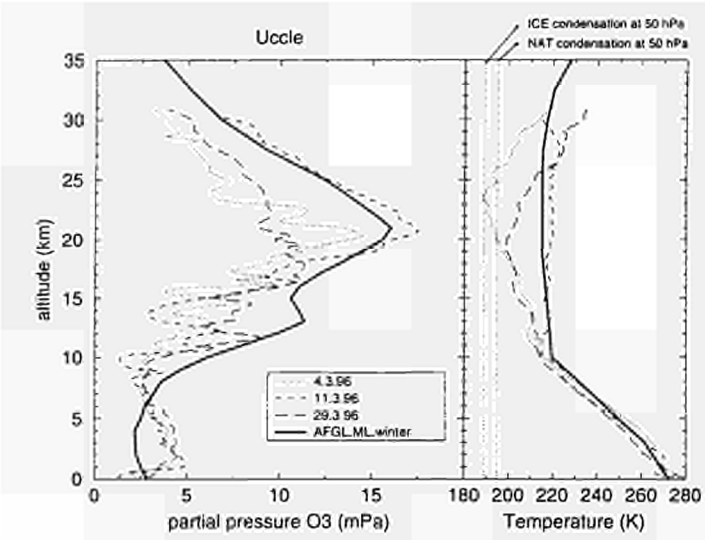

Fig. 3: Ozone and temperature profiles in the presence of the polar vortex (4 and 29/3/96) at Uccle and in out-of-vortex conditions condition (8/3/96)

From figure 4 it appears that for the studied events the O_3 profiles (and to a lesser extent the T profiles) look similar over Uccle and the Alps whereas the displacements of the air masses are different. Indeed for the first event, backward trajectory analyses demonstrate that the air mass coming from the north passed above Uccle before arriving above Payerne explaining the delay between the observations of similar profiles above the two stations. For the second event the air flows in from the West and hence arrives at about the same time above both stations: the compared profiles are measured on the same day.

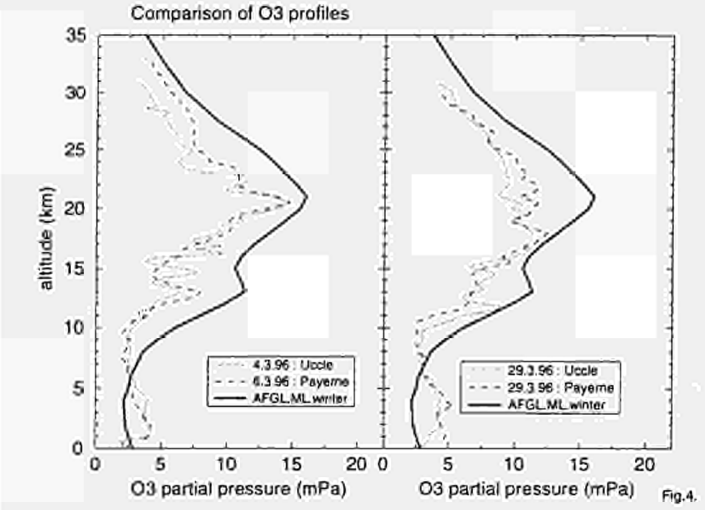

Fig. 4 : Comparison of ozone profiles at Uccle and Payerne for related air masses.

For the first event in early March, PV maps clearly show that the polar vortex was centred on Scandinavia and covered part of Europe. TOVS maps show low ozone columns over this area, with a minimum around 225 DU.

FTIR observations at ISSJ show that the O_3 decrease on March 29 is correlated with anomalously high HF columns, and low HCl/HF and O_3/HF ratios [2].

This study demonstrates again the interest of network-type observations for the investigation of phenomena on a hemispheric scale. It indicates signatures of the incursion of the polar vortex above mid-latitude Europe and it shows that these may be accompanied by local PSC formation, which is highly important regarding the issue of the mid-latitude ozone evolution..

Acknowledgements are due to P.Viatte, Section d'Aérologie, Météo Suisse, Payerne, for the Payerne O_3 sonde data, and to S. Godin, SA/CNRS, for the OHP Lidar profiles.
This study has been supported by the ESMOS/Alps II project.(EC contract ENV4-CT95-0084) and FWO - Krediet aan Navorsers 1995 (MDM).

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