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Reinterpretation of Ozone data from "Base Roi Baudouin"

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Abstract.

The ozone Dobson measurements obtained in Antarctica at the Belgian "Base Roi Baudouin" (70°26' S, 24°19' E) in 1965 and 1966 were retrieved from the KNMI (Royal Netherlands Meteorological Institute) archives in De Bilt. Despite excellent treatment at the time by the meteorologists in charge at the KNMI (Wisse and Meerburg, 1969), a study of the original observers notes was made in order to check possible seasonal ozone phenomena. No systematic anomaly in the first analysis was found; meteorological data from the site together with Brewer-Mast ozone soundings concur that the conditions did not correspond either in 1965 nor 1966 to the current ozone hole (Farman et al, 1985) situation, however, the data yields excellent correlation with stratospheric temperature and shows in 1966 a clear November maximum in opposition to an October value around 344 Dobson units.

Observations and treatment.

The station was opened during the international Geophysical year 1957-1958 and was fully equipped with meterorological equipment during the Belgo-Dutch expedition of 1964-1967. The station activities were interrupted in March 1967 when the last expedition left. "Base Roi Baudouin" is situated on an ice-shelf on the coast of Queen Maud land down katabatic winds and is now entirely covered by snow with some masts signalling its existence; it cannot be reopened now without major reconstruction. A map is shown on figure 1.

Dobson spectrophotometers were installed in Antarctica since 1956 at the insistence of the Secretary General of the International Geophysical Year and of Professor Dobson himself (Dobson, 1966, 1968). The longest continuous series being those of the British Antarctic Survey bases (Farman and Hamilton, 1974) and of the Japanese Syowa base (Chubachi and Kajiwara, 1986). One of the first surprises (Dobson, 1968) of these first observations were very low values at the return of the Sun in October and a November maximum exhibiting an asymmetric behavior compared to Northern hemisphere Spitzbergen values. Dobson (1968) explained these low October values (in October 1956 and 1957, about 150 Dobson units lower than expected) by dynamics: "It was clear that the winter vortex over the South Pole was maintained late into the spring and that this kept the ozone values low". One of the rationales of this present study was to see if a similar phenomenon, so close in appearance to the present ozone hole did exist in 1965 and 1966 at "Base Roi Baudouin". These anomalous 1956 and 1957 values led to special care and monitoring of the instruments stationed in Antarctica and in particular of Dobson instrument Number 51 at the British base of Argentine Islands. This particular instrument belongs to the International Ozone Commission and was in use from October 1957 to December 1961 (Farman and Hamilton, 1974). It showed a degradation of the optical wedges which finally necessitated their replacement in May 1961, after this date, the instrument was fully recalibrated and it was instrument Number 51 which was later used for the Belgo-Dutch expeditions. The ozone data of "Base Roi Baudouin" were reported in the Ozone Data of the World and in one publication (Wisse and Meerburg, 1969. The original observers' logs were archived in the KNMI and the instrument and its documentation were returned to Switzerland after the return of the equipment to the Netherlands. A letter showing traces of a nominal calibration of the instrument is present in the archives of the KNMI, but the calibration history of the instrument appears to have been lost as a modification of this instrument into an automatic prototype was attempted in the early seventies. As far as known to us and to the original observers (Wisse, 1992), no anomalous instrumental behavior was noticed during nor the 1965-1967 expedition nor the subsequent calibration.

Analysis of the original logbooks.

The analysis of the original logbooks show that the observation was performed as much as possible, leading in the best days to up to eight observations a day. It was found that the parameters recorded correspond exactly to the Dobson (1957) IGY procedure, it was found also that data were sometimes rejected by crossing an observation line with a pencil in the logs. These rejected values were studied and do not show to be significantly lower than the others. There were two causes of rejection. One was a change of conditions between instrument setting and observation, and the other was vibrations of the instrument related to the strong surface winds blowing from the Pole. The instrument was protected in a hut, but this shelter was apparently much less effective than the present installation in Syowa in protecting the Dobson instrument. Special care was also taken in order to avoid the base's own plume. The temperatures recorded inside the instrument show that the hut was well thermally protected from the fluctuations of the outside temperature. In conclusion, despite the difficulty of these very low sun observations, the observers did manage to obtain all the possible results and were following the standards of the British Antarctic Survey bases.

Other ozone and related observations.

The Belgo-Dutch expeditions performed normal ground meteorological observations supplemented by radiosondes. These radiosondes monitored generally up to the 50 mb level and on rarer occasions (less than 10%) up to 10 mb. Brewer-Mast ozone sondes were also flown while the surface ozone concentrations were permanently monitored using also a Brewer-Mast ozone recorder. The data from the sondes are partially published in Ozone Data of the World while the ground ozone data exists only in Wisse and Meerburg (1969). The total of 23 sondes flown contains October values for 1965 and 1966, and in both cases, the change in shape which is associated with the present ozone hole was not observed. (Fig. 2) The surface ozone is discussed at lengths by Wisse and Meerburg (1969), their main finding is that strong Winter and Spring polar wind lead to increases in tropósperic ozone, their values were however always lower then the Amundsen-Scott South Pole values.

Data discussion.

In the absence of the instrument calibration history, the values computed in the logs were checked in a few cases and accepted as correct. A search was conducted for low ozone values in both valid and rejected cases, the averages of all valid measurements for October was found to be 331 for 1965 and 344 for 1966, the lowest October daily means were 296 Dobson units in 1965 and 279 Dobson units in 1966; thus, it can be said that no evidence for a significant ozone October depletion exists in these data. The most significant result of the ozone series is a large 1966 November maximum correlating significantly with a 1966 stratospheric warming (Fig. 3).

Conclusions.

These data are important as they come from a time where CFC's were not yet measurable in the earth's stratosphere and where all chemical effects on stratospheric ozone were predominantly driven by natural sources, the main source of chlorine being then natural methyl chloride. They do not show the anomalous low values reported by Dobson (1968) for 1956 and 1957 nor the low Terre-Adélie 1958 values recently reanalysed by Rigaud and Leroy (1990) , they are also significanly higher than the 250 Dobson units reported by Aikin (1992) for October 1970; they do however show good agreement with the corresponding part of the Syowa series (Fig. 4). They reproduce also very well the November peak described for the years 1960 to 1964 by Dobson (1966). One can strongly regret not having firmer guidelines for reinterpretation of data with newer ozone cross-sections and also the absence of a relevant instrument documentation file in the original data repository. Finally, it is clear that the observation of ozone by itself does not permit to separate the effects of dynamics and chemistry; in the case of these observations, a knowledge of the nitrous oxide concentrations would have permitted to decide clearly on subsidence of stratospheric air (Reed, 1950) as the cause of the high surface ozone values.

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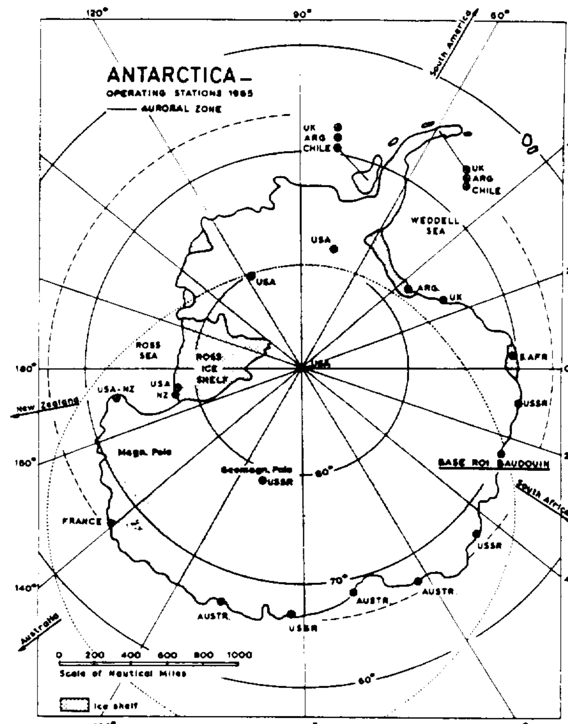

ANTARCTIC BASES IN 1965

Fig. 1: Antarctica map showing the relative positions of Base Roi Baudouin, Syowa, Halley Bay and Dumont d' Urville.

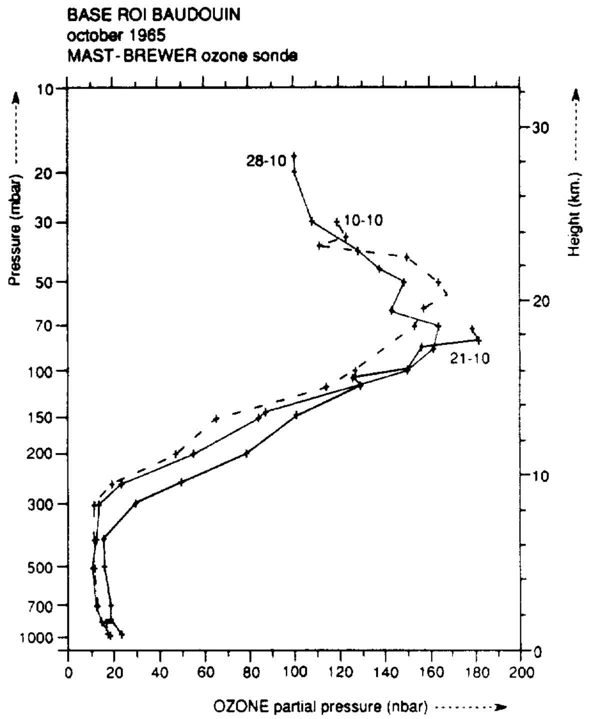

Fig. 2: October Brewer-Masts soundings of the atmosphere at "Base Roi Baudouin" showing no depletion in the present ozone hole altitude range.

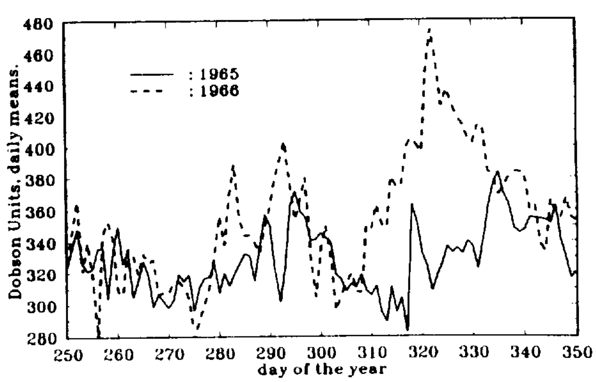

Fig. 3: Daily means for the last trimesters of 1965 and 1966 showing a November maximum in 1966 relating to a sudden stratospheric warming, no October ozone hole appears in these data.

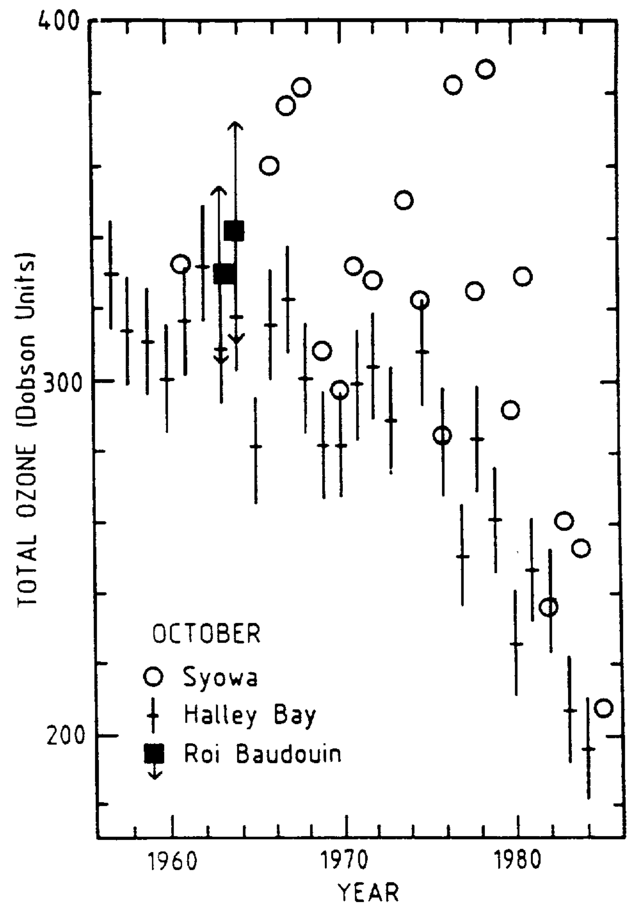

Fig. 4: Comparison of the "Base Roi Baudouin" ozone data with the Halley Bay (Farman et al, 1985) and Syowa series (Chubachi and Kajiwara, 1986). The error bar for "Base Roi Baudouin" corresponds to one σ.