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Measurement of total ozone, D-UV radiation, sulphur dioxide and nitrogen dioxide with Brewer spectrophotometer at Maitri, Antarctica during 2000

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सार – अंटार्कटिक स्थित स्थायी भारतीय वैज्ञानिक अनुसंधान स्टेशन मैत्री में पराबैंगनी विकिरण (डी.–यू.वी.) सल्फर डायक्साइड (SO_2) और नाइट्रोजन डायक्साइड (NO_2) के दुष्प्रभाव और कुल ओजोन का मानीटरन करने के लिए जुलाई 1999 में अत्याधुनिक स्पैक्ट्रोफोटोमीटर लगाया गया है। ओजोन को क्षीणता और उसके उतारचढ़ाव को वसंत ऋतु (अगस्त–अक्तूबर) में दिन प्रतिदिन मानीटरन किया गया है। वर्ष 2000 के दौरान एकत्र किए गए आँकड़ों का इस शोधपत्र में विश्लेषण किया गया है। कुल ओजोन और डी.–यू.वी. के मानों की तुलना प्रत्येक माह में की गई है। डी.–यू.वी. में अचानक वृद्धि अथवा कमी वसंत ऋतु के दौरान के उत्तरोत्तर दिनों में ओजोन की क्षीणता और पूर्ति की पुष्टि करती है। इन लिए गए मापों से वर्ष 2000 में अंटार्कटिक में ओजोन की विद्यमानता की पुष्टि होती है। मैत्री में SO_2 और NO_2 के माप बहुत कम मान दर्शाते हैं।

ABSTRACT. The latest state-of-art equipment called Brewer Ozone Spectrophotometer has been installed at Maitri, the permanent Indian Scientific Research Station, Antarctica in July 1999 to monitor total ozone, damaging part of ultra-violet radiation (D-UV), sulphur dioxide (SO_2) and nitrogen dioxide (NO_2). The depletion of ozone and its fluctuation were monitored day by day during Antarctic spring season (August-October). The data collected during the year 2000 are analysed in this paper. The values of total ozone and D-UV are compared in each month. The sudden increase or decrease of D-UV confirms further depletion or recovery of ozone in the successive days during the spring season. The measurements confirm the existence of 'Ozone Hole' over Antarctica 2000. The measurements of SO_2 and NO_2 at Maitri show very low values.

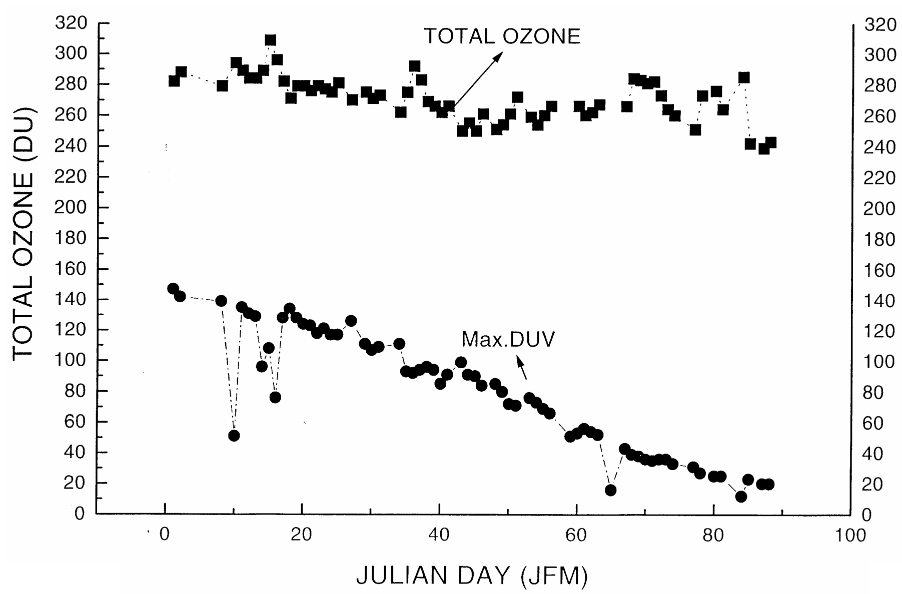
Key words – Brewer ozone spectrophotometer, Ozone hole, Sulphur dioxide, Nitrogen dioxide, D-UV radiation.

1. Introduction

It is now recognised that the significant fluctuations in atmospheric ozone and sulphur-dioxide concentrations are related to a variety of adverse environmental conditions. The ozone layer, which shields the earth from the harmful effects of solar ultra-violet (UV) radiation, is believed to be vulnerable to attack by chlorofluorocarbons (CFC) and other effluents. There is a general fear that the depletion of ozone concentration may alter climatic pattern of the earth. Atmospheric sulphur dioxide is closely associated with acid rain phenomenon, which like ozone depletion has implications for the global environment. From 1987 onwards, it has been confirmed that the depletion of ozone concentration during spring months (August-October) at Antarctica has increased year- by-years and its monitoring becomes an essential scientific program in Indian scientific expedition. India Meteorological Department (IMD) had used Dobson-spectrophotometer to measure total ozone at Dakshin Gangotri (70° 05' 37" S, 12° 00' 00" E) the first Indian Antarctic station during 1989. IMD installed Brewer at Maitri (Lat. 70° 45' 39" S and Long. 11° 44' 48" E) in July 1999 to monitor total ozone, UV Radiation, SO_2 and NO_2.

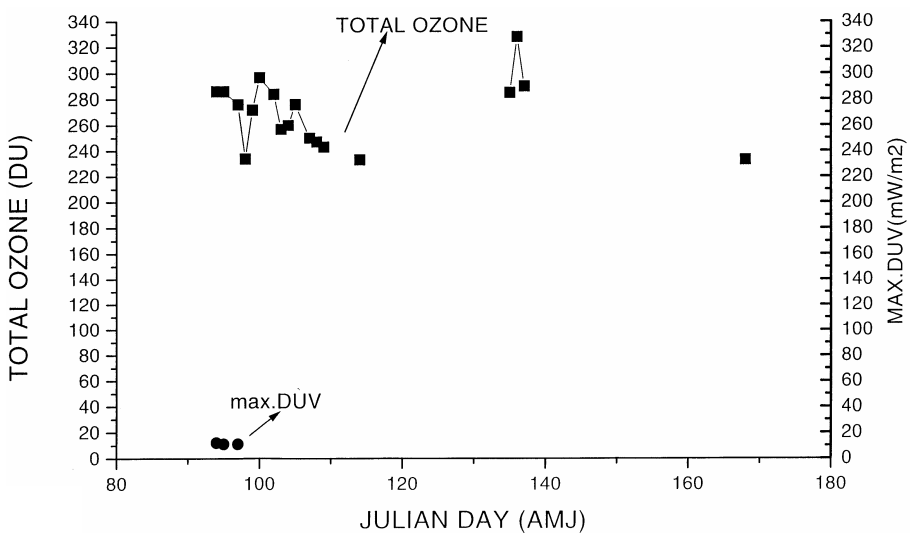
This instrument could be operated using moon light in the absence of sunlight during polar night period to measure total ozone, NO_2 and SO_2. Brewer is the latest state-of-art and highly sophisticated scientific instrument, which measures atmospheric ozone, D-UV radiation or UV-B, SO_2 and NO_2.

There were many papers devoted to the Antarctic processes in September-October after 1985, when a team led by British scientist J. Farman has discovered a new phenomenon-ozone depletion in this region which dived from year to year. Data seemed to indicate that column ozone level has been decreasing since 1977. The monthly



Year 2000

Fig. 1. Daily variation of column ozone & damaging part of ultraviolet radiation during January to March 2000



Year 2000

Fig. 2. Daily variation of column ozone & damaging part of ultraviolet radiation during April to June 2000

mean column ozone over Halley Bay, Antarctica (76° S),decreased from a high of 350 DU in the mid 1970s to values approaching 100 DU. Vertical Ozone profiles showed that the O_3 depletion was occurring at altitudes between 10 and 20 km (Peshin *et al.*, 1997). Heterogeneous reactions occurring on PSCs (Polar Stratospheric Clouds) play the pivotal role in polar ozone depletion in accordance to the modern conception (McElory *et al.*, 1986; Solomon *et al.*, 1986; Molina, 1991). This conception needs low temperature as (–85° C) at height of 15 to 20 km, determines a focus to temperature behaviour over south polar region.

2. Instrumentation and data

The ozone data used in this study were obtained with Brewer Ozone Spectrophotometer. The Brewer is fully automated allows for near simultaneous observations of

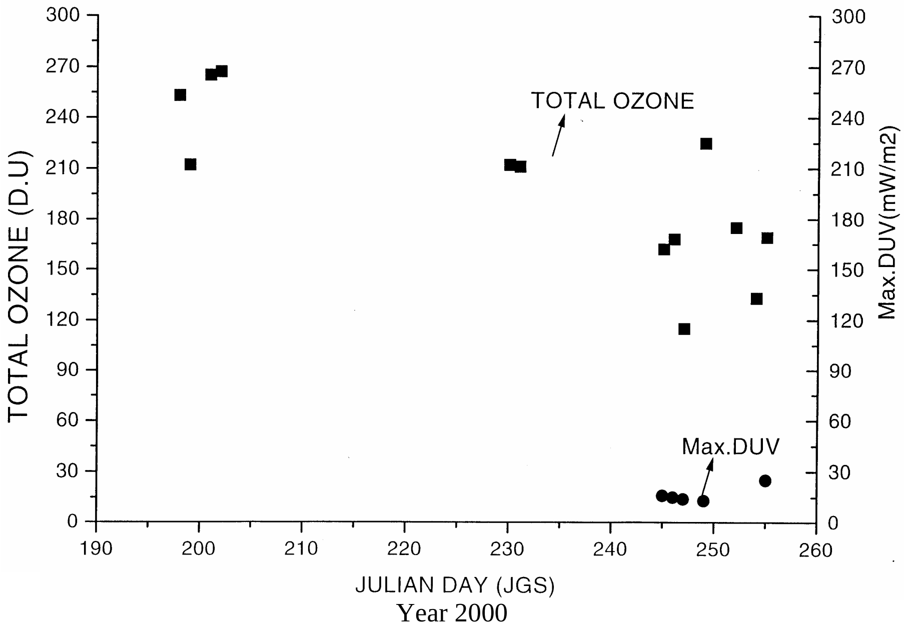


Fig. 3. Daily variation of column ozone & damaging part of ultraviolet radiation during July to September 2000

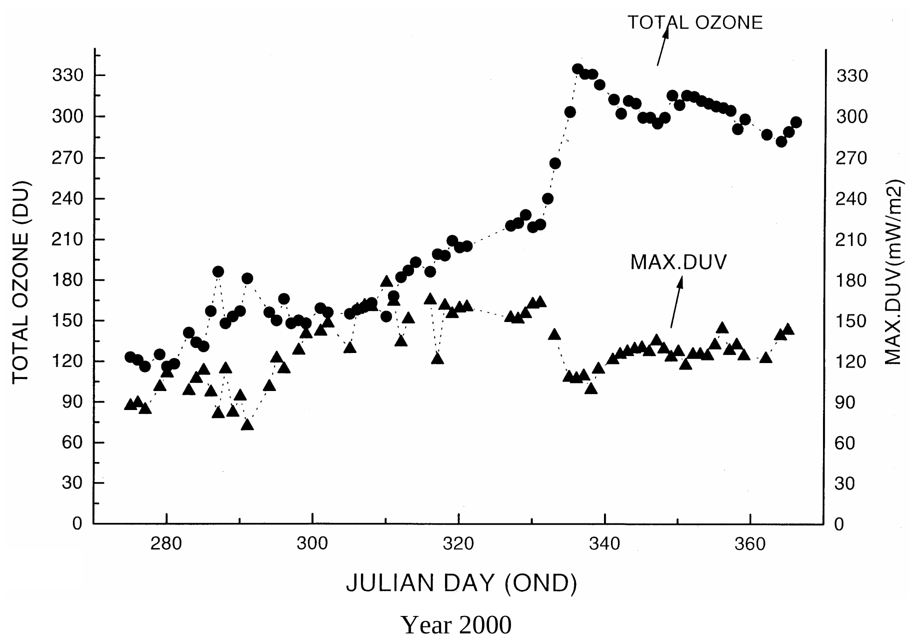


Fig. 4. Daily variation of column ozone & damaging part of ultraviolet radiation during October to December 2000

total column O_3 , SO_2 , NO_2 as well as UV-B . Two axis tracking ,appropriate filter sections, wavelength calibration and selection along with data logging are managed through internal electronics and an IBM compatible PC host computer. Control software for the host computer allows for twenty four hour scheduling and for remote unattended operation. The instrument is having accuracy: ±1% (on direct sun total ozone) and .6 nm @ 303.2, 306.3, 310.1, 313.5, 316.8, 320.1 nm for ozone and 0.85 nm @ 426.4 , 431.4, 437.3, 442.8, 448.1, 453.2 nm for NO_2.

For the measurement of UV-B irradiance a thin disc of teflon is used as a transmitting diffuser. The disc is mounted on the top of the instrument under a 5 cm diameter quartz dome and is thus exposed to the horizontal UV irradiance. UV-B spectral scans are managed by covering the 290-320 nm wave length range at 0.5 nm

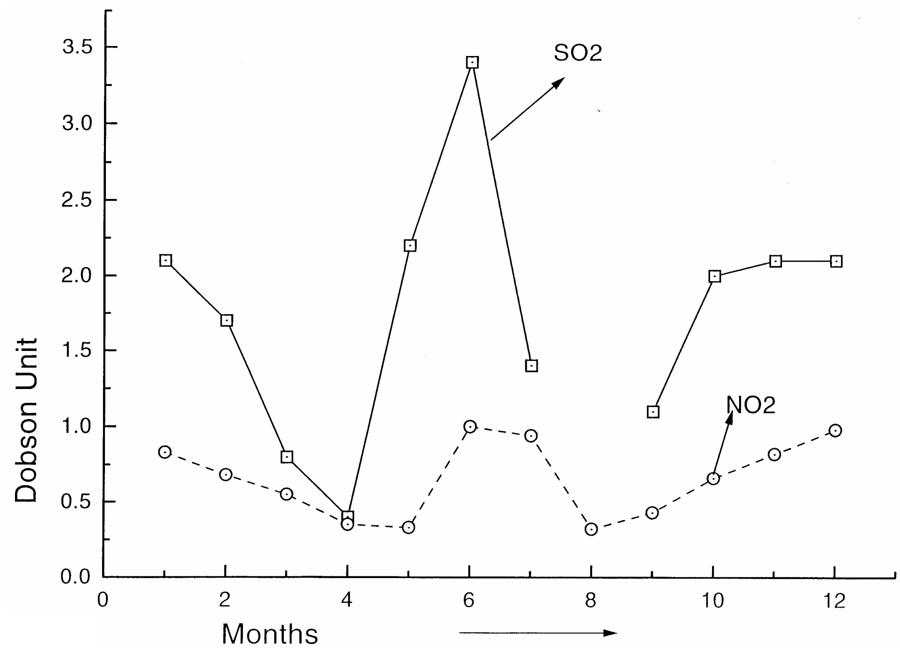


Fig. 5. Monthly variation of SO_2 and NO_2

increments, integrated over the 290-320 nm range (mW/sqm).

The details of the Brewer instrument are described by Kerr *et al*. (1980, 1985).

Brewer spectrophotometer has been operated in Maitri in all the months during 2000 subjected to the sky conditions. During polar nights (in absence of sun), the system was operated and it measured total ozone, SO_2 and NO_2 using focused moon light, Observations of total ozone, SO_2, NO_2 and D-UV radiation were taken in all the operated days. On an average, of about 20 days were operated through focused/direct sun light during summer and transition periods and about 6 days during polar winter months using focused moon light. Table 1 shows the number of Brewer operational days during the year 2000.

TABLE 1

No of Brewer operational days during the year 2000

Month	No. of days
January	23
February	21
March	19
April	20
May	07
June	06
July	07
August	13
September	17
October	24
November	22
December	27

3. Results and discussion

Mean daily values of total ozone, SO_2, NO_2 and maximum D-UV have been taken for analyzing the data.

(*i*) Total Ozone: Total ozone has been measured through direct sun (DS), zenith sky (ZS), focused sun (FS) and focused moon (FM). The daily values of total ozone have been plotted linearly and are shown in Figs.1-4. Total ozone has varied between 300 DU and 250 DU in the first seven months since January and reduced below 200 DU in August steadily. During September and up to first week of October the total ozone.

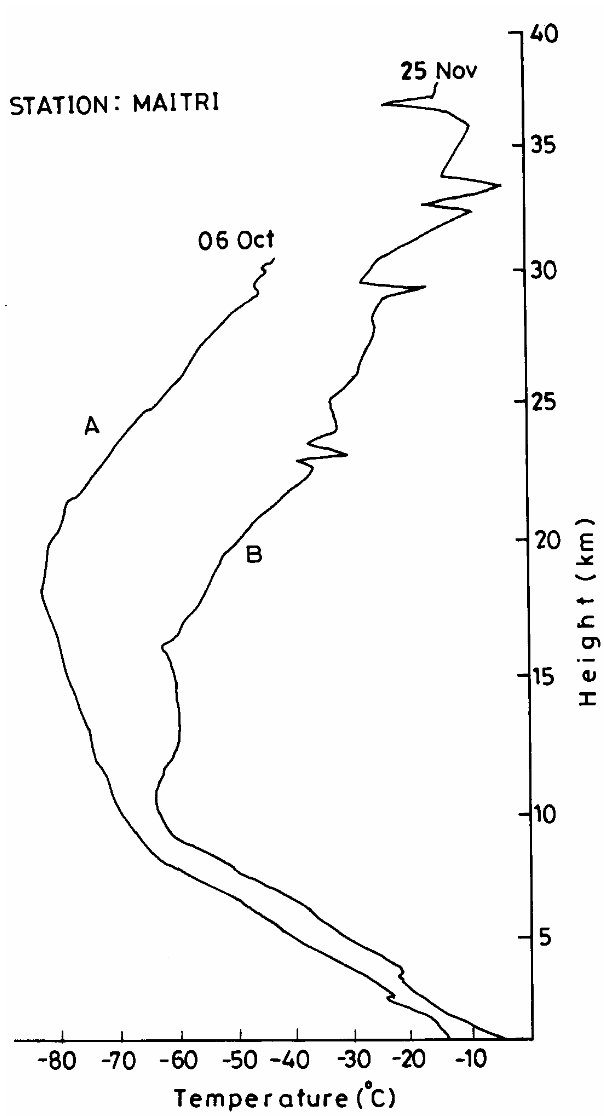


Fig. 6. Temperature profile of Maitri on (A) 06 October 2000 and (B) on 25 November 2000

(*ii*) Depleted steadily and declined to the lowest value of 113 DU on 27 September 2000 and 116 DU on 3 and 6 October. The last week of September and first week of October could be considered as severe ozone depletion period when the total ozone was below 125 DU. The ozone concentration recovered steadily from the value of 116 DU from the first week of October to 160 DU at the end of October. By the end of second week of November, total ozone value exceeded 200 DU. On 30 November, total ozone increased above 300 DU leading to sudden warming in the stratosphere noticed through temperature profile of ozone sonde ascent as shown in Fig. 6. This confirms the total recovery from the depletion of ozone over Antarctica.

(*iii*) The sun emits radiation over a wide range of energies, with about 2% in the form of high energy, ultraviolet (UV) radiation. Some of this UV radiation (UV-B) or damaging part of UV radiation (DUV) is especially effective in causing damage to living beings, for example, sunburn, skin cancer and eye damage to humans. The amount of solar UV radiation received at any particular location on the Earth's surface depend upon the position of the sun above the horizon , the amount of ozone in the atmosphere and local cloudiness and pollution. Damaging Ultra Violet radiation (D-UV) or UV-B (290-320 nm) radiation has been measured ozone mode on all the operational days except polar night period. In general, when the elevation of sun increases the value of UV-B radiation also increases and *vice-versa*. The maximum value reaches around the local noon of any day. At Maitri, it has been observed that the maximum values of D-UV were reported between 1030 and 1130 UTC. For discussion about D-UV values in different periods/seasons, maximum D-UV of each day was considered. Maximum D-UV values have been plotted for all months. The highest value of maximum D-UV radiation of 178 mW/m² has been reported at 1105 UTC on 5 November 2000 (Fig. 4).

In the Antarctic, the sun is well above the horizon only during October, November, December, January and February. Hence, the Brewer data are available only for these months. However, moonlight observations are taken in dark months March, April, May, June, July, August and September. Such data have large uncertainties, but are better than no data.

Figs. 1-3 show plot of three months data of (JFM: January, February, March; AMJ: April May, June; JAS: July, August, September; OND: October, November, December) total ozone values and ultraviolet radiation measured with Brewer ozone spectrophotometer.

(*i*) As can be seen in Fig. 1 (JFM) there is a large seasonal variation, the total ozone values ranged between 240-300 DU and UV-radiation values ranged between 150-20 mW/m^2.

(*ii*) In Figs. 2&3 (AMJ & JAS) direct sun measurements could not be taken due to dark months, only few moon observations were taken for total ozone measurements. September shows low total ozone values.

(*iii*) In Fig. 4 (OND) total ozone values show low till November. Thereafter, the values start increasing and then range between 280 and 330 DU and as expected the DUV-values start dropping from 140-100 mW/m^2.

The curves of total ozone and maximum D-UV for Antarctic autumn and spring months were compared. It is observed that the values of maximum D-UV in spring month (August-October) are more than one and a half times that of the values of autumn months (March-May) during 2000. The difference is mainly due to ozone depletion in the stratosphere, which causes more of ultra-violet rays to reach the ground over Antarctica.

4. Measurement of sulphur dioxide and nitrogen dioxide

The mean value of SO_2 and NO_2 in each month during 2000 is presented in the Fig. 5. The result shows that the pollutants SO_2 and NO_2 are present in the Antarctic atmosphere in a small quantity. The amount of both gases was more in summer than in winter months. This Fig. also shows the absence of SO_2 in August and less in April. In the same way, NO_2 was also more in summer than in the winter months. However, comparatively higher values of SO_2 as well as NO_2 were reported during polar nights (no sun available).

5. Conclusions

The measurements of total ozone, D-UV radiations, sulphur dioxide and nitrogen dioxide made by Brewer using direct sun light and focused moon light during 2000 were very much useful to monitor 'ozone hole' phenomenon over Antarctica. Daily variations of total ozone were observed in each month and especially during ozone depletion period. The sudden increase or decrease of total ozone and D-UV radiations confirmed further more ozone depletion or recovery of ozone during the Antarctic spring months. Brewer measurements also confirm the existence of ozone hole over Antarctica during spring months during 2000. The presence of very little amount of SO_2 and NO_2 in pollution free atmosphere over Antarctica is confirmed. Variations of these values are to be monitored for some more years to get a concrete conclusion. Further detailed analysis is required for better interpretation of results.

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References

Kerr, J. B, McElory, C. T. and Olafson, R. A., 1980, “Measurement of ozone spectrophotometer”, Paper presented at International Quadrennial Ozone Symposium, sponsored by International Ozone Commission and International Association for Meteorology and Atmospheric Physics, Boulder, Colo.

Kerr, J. B, McElory, C. T., Olafson, R. A. and Evans, W. F. J., 1985, “The automated Brewer spectrophotometer, in Atmospheric ozone”, edited by C. S. Zrerfos and A. Ghazi, 396-401, D. Reidel, Norwell Mass.

McElory, M. B., Salawitch, R. J., Wofsy, S. C. and Logan, J. A., 1986, “Reductions of Antarctic ozone due to synergistic interactions of chlorine and bromine”, *Nature*, **321**, 759-762.

Molina, M. J., 1991, “Heterogeneous chemistry on polar stratospheric clouds”, *Atmos. Environ*., **25A**, 2535-2537.

Peshin, S. K., Rao, P. Rajesh and Srivastav, S. K., 1997, “Antarctic ozone depletion measured by balloon sondes at Maitri–1992”, *Mausam*, **48**, 3, 443-446.

Solomon, S., Garcia, R. R. Rowland, F. S. and Wuebbles, S. J., 1986, “On the depletion of Antarctic ozone”, *Nature*, **321**, 755-758.