Mausam, (1988). 39, 3, 313-316

551.510.534 : 551.508.952 (99)

Antarctic ozone-hole investigation programme — Preliminary results of ozonesonde ascents during January-February 1987

A. A. FARUQI, A. L. KOPPER* and S. C. NAGRATH*

India Meteorological Department, Goa

(*Received 21 May 1987*)

सार — जनवरी-फरवरी 1987 के दौरान, परस्पर तुलना के लिये, अन्टार्कटिका में जर्मन डेमोक्रेटिक रिपब्लिक (जी. डी. आर.), भारतीय और जापानी स्टेशनों से लिये गये ओजोनसोन्दे आरोहण के प्रारम्भिक परिणामों का इस शोध-पत्र में संक्षेप में उल्लेख किया गया है। ये आरोहण अन्तर्राष्ट्रीय अन्टार्कटिका ओजोन-विवर निरीक्षण प्रोग्राम के प्रारम्भ में लिये गये हैं। भारतीय स्टेशन दक्षिण गंगोत्री के ओजोन-सोन्दे आंकड़ों की तुलना, अंटार्कटिका के दूसरे भारतीय वैज्ञानिक अभियान (जनवरी-फरवरी 1983) के दौरान लिये गये प्रेक्षणों से भी की गई है।

ABSTRACT. The paper summarises the preliminary results of ozonesonde ascents taken at GDR, Indian and Japanese stations in Antarctica during January-February 1987 for intercomparison purpose. These ascents were taken as prelude to the international Antarctic ozone-hole investigation programme. The ozonesonde data of the Indian station, *Dakshin Gangotri*, is also compared with the observations taken at the station during the Second Indian Scientific Expedition to Antarctica (January-February 1983).

1. Introduction

In recent years there has been increasing interest among the scientists throughout the world over growing evidence on the depletion of ozone in the stratosphere, where more than 90% of the total atmospheric ozone resides. Changes in the content of atmospheric ozone would modify the amount of biologically harmful ultra-violet radiations penetrating to the earth's surface with potential adverse effects on human health, and on the aquatic and terrestrial ecosystems. Ozone in the upper atmosphere acts as a shield protecting our planet and its inhabitants from the sun's ultra-violet radiations, excessive amount of which can cause skin cancer in humans, damage crops and harm fish and other wild-life.

To understand the processes which control atmospheric ozone, the effect of various natural and man-made pollutants injected in the atmosphere, periodic and episodic phenomena such as solar activity and volcanic eruptions as well as chemical, radioactive and dynamical processes which contribute to the temporal and spatial distribution of various atmospheric constituents, have to be considered. The man-made pollutants which play significant role in ozone chemistry of the atmosphere, include the nitrogen oxides (NO_x) from subsonic and supersonic aircrafts, nitrous oxide (N_2O) from agricultural and combustion practices, chloro fluoro carbons (CFC's) used as aerosol propellants, foam blowing agents and refrigerants, brominated compounds used as fire retardants, carbon monoxide (CO) and carbon dioxide (CO_2) from combustion processes and methane (CH_4) from a variety of sources including natural and agricultural wetlands, tundra, biomass gas burning and enteric fermentation in ruminants. In recent years, much importance has, however, been given to the possible role of chloro fluoro carbons, *viz.*, CFC-11 ($CFCl_3$), CFC-12 ($CF_2 Cl_2$) on stratospheric ozone. The atmospheric life-time of these have been estimated to be from 75 to 110 years. They are not destroyed or removed in the lower atmosphere by rain-out, oxidation or sunlight. Instead, they drift into the upper atmosphere, where their chlorine components are released into the atmosphere under the effects of ultra-violet radiation and where they encounter and destroy ozone.

2. Antarctic ozone-hole

During past few years, ozone measurements over Antarctica have brought to light a most puzzling phenomenon of marked depletion of ozone in the stratosphere during spring months. The phenomenon is now popularly known as Antarctica ozone-hole and has caused world-wide concern.

The decreasing tendency of ozone was first reported by Chubachi *et al.* (1986) as an extraordinarily low-value of total ozone from September to October in 1982 at the Japanese station Syowa (69° 00′S, 39° 35′ E).

---

*Members of winter party of Sixth Indian Scientific Expedition to Antarctica from Met. Offices, New Delhi and Pune respectively.

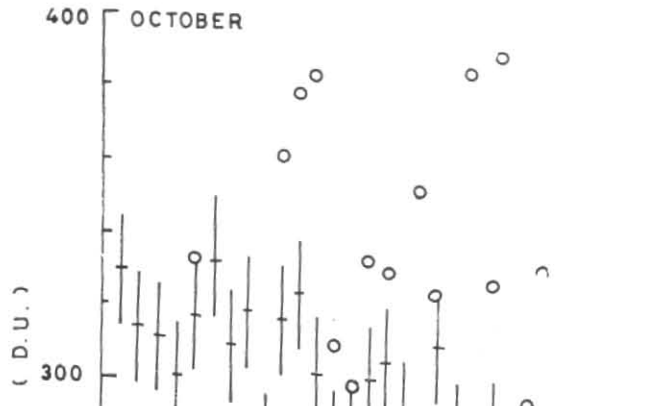

Fig. 1. Monthly mean total ozone values for October months, for Syowa and Halley Bay
(*After* Chubachi & Kajiwar 1986)

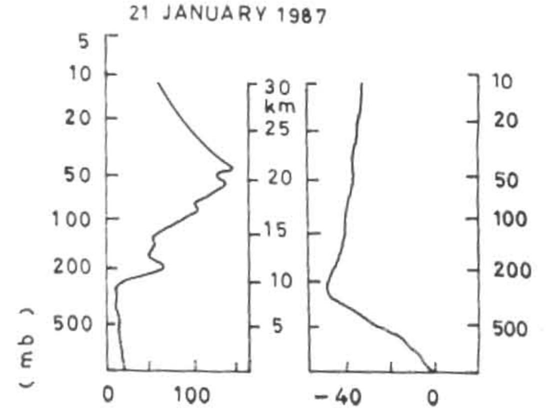

Fig. 2. Vertical ozone and temperature profiles over *Dakshin Gangotri*

The trend of the low values of total ozone during spring months became apparent from the observations of the following years at the station. Later, decreasing total ozone amounts during October months reported from observations at U. K. station Halley Bay (75° 30′ S, 26°35′ W) by Ferman *et al.* (1985) drew immediate attention of the scientific community. Comparative values of the data of two stations (Fig. 1) for the month of October indicate that the rapid fall off in ozone at Halley Bay began in 1971 whereas it commenced over Syowa from 1982. Also on average, the total ozone values at Halley Bay were lower than those at Syowa. The average difference was observed of about 48 D.U.

According to the observations of Halley Bay, the decrease of total ozone during the month of October was about 40% since 1951 to 1985. Other months, however, do not show any significant trend. Satellite data from NIMBUS—Total Ozone Mapping Spectrophotometer (TOMS) instrument and Solar Backscatter Ultra-Violet (SBUV) instrument confirm these findings and show a minimum which is highly confined to the high south polar latitudes (Bhartia *et al.* 1985).

3. International programme

The sensational discovery of the Antarctic vernal ozone trend from the ground observations at Syowa and Halley Bay and later confirmed by satellite observations, drew immediate attention of the international scientific community. There appeared urgent need to investigate further on the temporal and spatial extent of the phenomena to identify the underlying causes which may provide an assessment of the likely effect of human activity on the ozone layer. This became an urgent need, otherwise society may err in taking timely action for controlling or failing to control the factors that may contribute to ozone loss.

The nineteenth session of Scientific Committee on Antarctic Research (SCAR) meeting held at San Diego, USA, in June 1986 and World Meteorological Organisation Executive Committee Working Group on Antarctic Meteorology meeting held at Geneva in September 1986, made recommendations for joint international effort for ozone observation programme for the characterisation of ozone-depletion trend over the sub-continent and to understand physical, chemical and/or dynamical processes which cause the phenomena. Several countries of the world including India have since extended their active support in the programme.

4. Indian programme

India Meteorological Department (IMD) foreseeing the importance of ozone monitoring over Antarctica, took up the venture during its Second Scientific Expedition in the year 1982-83 during which five ozonesonde ascents were attempted to obtain the vertical profile of ozone at the temporary Indian station, *Dakshin Gangotri* (69° S, 12° E). The ascents were taken during the Antarctic summer and the

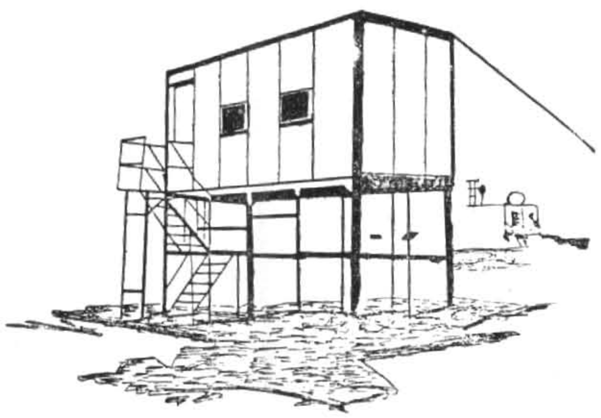

Fig. 3. Dobson spectrophotometer hut at Indian permanent station, *Dakshin Gangotri*

TABLE 1

Ozonesonde observations during January-February 1987 taken at *Dakshin Gangotri*, Novolazerskaya and Syowa

Date (1987)	Time of ascent (GMT)	Duration of ascent (min)	Max. ht (mb)	Maximum ozone				Intercomparison of maximum ozone			
								Novo		Syowa	
				Alt. (mb)	Cur. (μA)	P.P. (μmb)	Temp. (°C)	Alt. (mb)	P.P. (μA)	Alt. (mb)	P.P. (μA)
17 Jan	0133	96	13	67.6	3.5	129.07	—	—	—	—	—
21 Jan	1347	114	10	59.0/47.0	3.4/4.0	142.7/ 149.9	—39.8/ —39.1	—	—	62.9	—
28 Jan	1250	98	10	67.0	3.55	131.64	—36.7	64.2	115	—	—
04 Feb	1420	MISAD due to instrument damage during release						67.3	125	59.4	163.5
11 Feb	1600	104	07	67.0	—	148	—	41/48	136	—	—

Cur— Value of current measured, P.P.—Value of partial pressure

profiles were found to indicate similarities in the features of vertical ozone distribution with those from ozonesonde observations during the same period at Syowa (Sreedharan *et al.* 1986). In addition, surface ozone measurements were also made at *Dakshin Gangotri* during this expedition.

IMD made elaborate arrangements to join the international efforts for Antarctica Ozone-Hole Investigation Programme which commenced in 1986. India Meteorological Department team for the Sixth Expedition has installed instruments for the following observations at Indian permanent station *Dakshin Gangotri* to monitor the depletion of ozone during the spring of 1987 :

(a) Surface ozone.

(b) Vertical profile of ozone — Balloon ascents.

(c) Total ozone — Dobson spectrophotometer.

(d) Atmospheric turbidity — Sun photometer and UV photometer.

(e) Upper air observations — Radiosonde ascents.

Dobson spectrophotometer installation required elaborate arrangements. A suitable hut (Fig. 3) with arrangements for temperature control inside was designed for housing the delicate equipment at the icy continent. With its installation, *Dakshin Gangotri* has become one of the few stations on Antarctica for Dobson measurements of total ozone.

5. Intercomparison of ozonesonde data

To obtain the vertical profile of ozone during the spring months, ozonesonde ascents are planned from a number of stations in Antarctica. As a prelude, German Democratic Republic, India and Japan organised a programme of intercomparison ascents during the summer months, *viz.*, January-February 1987 at Novolazerskaya, *Dakshin Gangotri* and Syowa. For the purpose, five ascents were attempted at the *Dakshin Gangotri*. The preliminary result of the performance of these ascents is summarised in Table 1.

The first ascent at *Dakshin Gangotri* on 17 January 1987, was the test ascent. Subsequent ascents were taken at the weekly intervals for intercomparison. Available maximum ozone level observations which were received on near real-time basis at *Dakshin*

Gangotri from the other two stations are presented in the table alongwith the data of *Dakshin Gangotri*.

Vertical profiles of ozone at *Dakshin Gangotri* obtained from the ascents taken on 21 and 28 January are presented at Fig. 2, alongwith the temperature profiles. The two profiles present the features which are similar to those observed by Sreedharan *et al.* (1986) from the ascents taken at *Dakshin Gangotri* during the second expedition in February 1983. These are briefly as follows :

(*i*) Low concentration of tropospheric ozone between 15 & 23 μmb.

(*ii*) Sharp increase in the ozone concentration above the tropopause level with value of about 65 μmb which is close to 200 mb.

(*iii*) The second increase in the ozone concentration commences near 100 mb and reaching nearly double the value of the first maximum around 60-65 mb, *i.e.,* at the height of about 20 km. In the ascent of 21 January, another maximum, however, also appears very close to second maximum.

From the data of three ascents during February 1983, Sreedharan *et al.* (1986) reported maximum ozone concentration of second maximum of 117-120 μmb at *Dakshin Gangotri*. The level of maximum was between 55 and 35 mb. Vertical profiles from ozone ascent data during summer months of 1986, however, indicate increase of ozone concentration higher by about 10-20 per cent at the level of maxima. Ozone profile of Delhi presented by Chatterjee (1984) also indicates well marked double ozone maximum layers for spring months. As in the profile of *Dakshin Gangotri* for summer months, the first maximum of ozone concentration is near 200 mb. The second maximum in the stratosphere is, however, at about 30 mb over Delhi which is at an altitude of about 4 km higher than over *Dakshin Gangotri*.

It may be seen from Table 1 that for the four dates of intercomparison ascents taken at *Dakshin Gangotri*, the maximum ozone data were available from GDR and Japan stations for three and two dates respectively. Values of ozone concentration over the GDR station which is nearly 100 km south of *Dakshin Gangotri*, are in fairly good agreement. The altitude of maximum ozone was reported near 67 mb on three occasions over *Dakshin Gangotri* and it was near the same altitude at GDR station on two occasions. *Dakshin Gangotri* reported two levels of maximum ozone on one occasion which were quite close to each other (59 & 47 mb). The similar feature was reflected in one of the three ascents at GDR station with level of maximum ozone at 41 & 48 mb. At the total ozone concentration varied at *Dakshin Gangotri* between 129 & 150 μmb and at GDR station between 115 & 136 μmb. The higher values of ozone concentration were observed at both the stations on the day when double maxima occurred. At the Japanese station which is nearly 1000 km east of *Dakshin Gangotri*, the level of maximum ozone concentration was observed at an altitude of 59-63 mb. The value of ozone concentration was, however, available only for one ascent which was higher than the values of the other two stations. This difference may be due to difference in the location of the stations.

6. Conclusion

The results presented in the study are based on data collected on real-time exchange basis. These will apparently need to be validated and adjusted with total ozone observations. The preliminary results, however, do not suggest decrease in ozone at *Dakshin Gangotri* during the summer months. The available data from the ascents taken at the GDR, Indian and Japanese stations at Antarctica, indicate fairly good agreement both in the value of maximum ozone concentration and its altitude.

Acknowledgment

The study was conducted under the kind guidance of Shri M.G. Gupta, Director. The author is grateful to him for his support, encouragement and guidance in the preparation of this paper.

References

Bhartia, P.K., Heath, D.F. and Fleig, A.J., 1985, Observations of anomalously small ozone densities in South Polar stratosphere during October 1983 and 1984, Presented at 5th General Assembly IAGA Symp., Praque, Chechoslovakia.

Chatterjee, Kalipada, 1984, Atmospheric ozone measurement variations & trends, Proc. of Indo-US Workshop on Global Ozone Problem, January 11-20, 1983, New Delhi, 63-85.

Chubachi, S. and Kajiwara, R., 1986, Total ozone variations at SYOWA, Antarctica, *Geophys. Res. Lett.*, **13**, 1197-98.

Farman, J.C., Gardiner, B.G. and Shanklin, J.D., 1985, Large losses of total ozone in Antarctica reveal seasonal ClO*x*/NOx interactions, *Nature,* **315**, 207-210.

Sreedharan, C.R., Chopra, A.N. and Sharma, A.K., 1986, Vertical distribution of ozone over *Dakshin Gangotri*, Antarctica, *IJRSP*, **15**, 159-162.