PRELIMINARY RESULT OF OZONE OBSERVATIONS AT SYOWA STATION FROM FEBRUARY 1982 TO JANUARY 1983

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Abstract: In order to obtain better understanding of dynamical behavior of atmospheric ozone in Antarctica, extensive ozone observations were carried out at Syowa Station from February 1982 to January 1983. The total amount of ozone was observed throughout the year by the standard method of extinction of sunlight in summer and of moonlight in winter, together with 49 ozonesonde soundings.

The annual variation of total ozone shows two maxima, in July and November. A sudden increase of total ozone occurred on October 28, 1982. The total ozone increased from 240 to 380 in units of 10^{-3} atm-cm within 34 hours. The ozonesonde soundings show that this event was associated with a stratospheric warming.

1. Introduction

Stratospheric ozone plays a significant role in the stratospheric heat balance. Its behavior at high latitudes is of special interest, since the stratospheric ozone at high latitudes is thought to be transported from low latitudes through dynamical processes. However, only limited information has so far been obtained, because ozone observations at high latitudes are sparse. There are only two ozone observation stations operating in Antarctica: Syowa Station (69°00′S, 39°35′E) and Amundsen-Scott (90°S), where the total ozone has been observed in sunlit months only. To make up this deficiency, extensive observations were carried out at Syowa Station from February 1982 to January 1983 as part of the international Middle Atmosphere Program (MAP). This paper gives some preliminary results obtained from these observations.

2. Instrumentation and Observation

2.1. Total ozone

Total ozone was observed with Dobson spectrophotometer No. 122 which was replaced by No. 119 in February 1982. No. 122 was equipped with a new type of synchronous rectifier (Kôsô KISHÔDAI, 1983). The observations in summer were made with sunlight by the meteorological team of the 23rd Japanese Antarctic Research Expedition. Observations were made on 179 days from February 1 to April 4, 1982 and from September 4, 1982 to January 31, 1983 (ATMOSPHERIC ENVIRONMENT SERVICE OF CANADA, 1983b). The total number of observations was 730. We also carried out observations with moonlight in winter as made by ISHIDA *et al.* (1971),

when the moonlight was brighter than that of a half moon. The A and D pairs of wavelengths were used in the moonlight observations as in the sunlight observations. 220 observations were made on 41 nights from April 13 to October 4, 1982. 25 data obtained on 9 nights from September 4 to October 4, 1982 were compared with those obtained with sunlight in the same months. No systematic difference in total ozone was found between the sunlight and moonlight observations. Combining data from the two types of observations, we can depict the annual variation of total ozone at Syowa Station.

2.2. *Ozonesonde*

The vertical distribution of ozone was observed with two types of ozonesondes KC-79 and KC-79D, which are modified versions of KC-65 (KOBAYASHI and TOYAMA, 1966). The ozonesonde soundings were carried out two or three times per month before September. After September, the sounding frequency was increased to observe the variation of vertical ozone profile associated with the sudden increase of total ozone. The number of flights was 35 with the KC-79 sonde and 14 with the KC-79D sonde. Flights of the KC-79D sonde were operated by the meteorological team. 22 ozone profiles obtained with the KC-79 sonde are used in our present analysis; 13 other profiles could not be corrected with the total ozone becasue there was no similtaneous Dobson observation, or needed a larger correction factor than 1.5. The date and highest observation level of ozonesonde soundings with the KC-79 are listed in Table 1.

Table 1. Date and heighest levels of ozonesonde sounding with the KC-79. The flight schedule of ozonesonde number 15 was changed after ozonesonde number 17 because of transmitter trouble (ozonesondes were numbered in order to be identified).

No.	Date	Highest level		No.	Date	Highest level	
		Pressure (mb)	Height (km)			Pressure (mb)	Height (km)
1	Feb. 9, 1982	4.8	37	19	Aug. 6, 1982	7.6	29
2	16	4.5	37	20	15	—	—
3	27	5.1	36	21	29	63.3	17
4	Mar. 11	3.2	39	22	31	8.6	29
5	21	4.3	37	23	Sep. 17	17.3	25
6	29	5.9	34	24	23	20.9	24
7	Aug. 13	—	—	25	Oct. 5	7.9	30
8	14	10.5	30	26	14	7.6	31
9	25	22.7	24	27	27	12.9	29
10	May 8	44.0	20	28	28	15.6	28
11	24	5.9	31	29	Nov. 5	8.9	32
12	June 7	7.8	30	30	21	5.5	36
13	13	7.2	30	31	26	6.2	35
14	22	6.9	30	32	Dec. 5	6.2	35
16	29	14.1	25	33	17	6.1	36
17	July 6	13.8	26	34	Jan. 5, 1983	6.0	36
15	20	9.4	28	35	12	116.8	15
18	31	6.6	30				

3. Results

Figure 1 shows the seasonal variation of total ozone observed at Syowa Station from February 1982 to January 1983. The values shown in Fig. 1 are representative

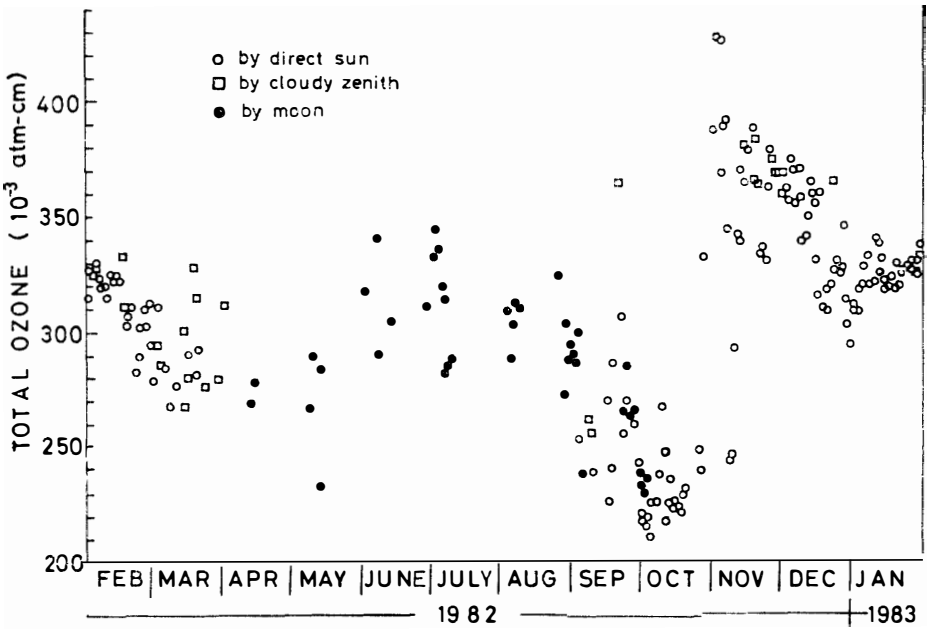

Fig. 1. Total ozone measured at Syowa Station. Open circles: direct sun measurement, squares: cloudy zenith measurement, and filled circles: moon measurement.

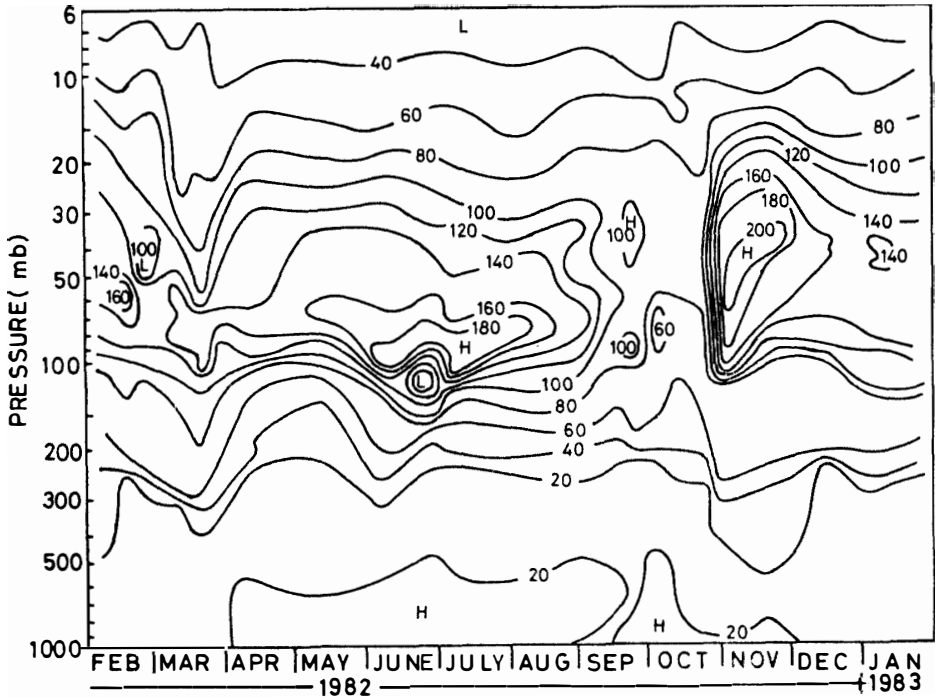

Fig. 2. Time-height cross section of partial pressure of ozone at Syowa Station constructed from 22 ozonesonde observations (unit: μmb).

values for each day, derived from several measurements on that day. Values from the moonlight observations are preliminary and the probable error is about $\pm 15 \times 10^{-3}$ atm-cm because the provisional constant was used in calculation of total ozone. The total ozone showed a decrease in February through April, a gradual increase in May and June, and again a decrease in August through October. A sudden increase of total ozone occurred on October 28. The total ozone increased from 240 to 380 in units of 10^{-3} atm-cm. After this sudden increase, it decreased slowly. The characteristic features of Fig. 1 are the June/July maximum, the November maximum, and the extremely small amount of total ozone from September to October.

Figure 2 shows that the increases in total ozone as shown in Fig. 1 are mainly due to the increase in the peak portion of the ozone profile. The increase occurred at about 90 mb level in June and July, and in the 60–40 mb region in October and November.

4. Discussions

It is interesting to see the change of total ozone in winter in Fig. 1. There is an increase of total ozone in winter 1982. However, such an increase was not found in winter 1969 (ISHIDA *et al.*, 1971; SAKAI, 1979). It is not clear whether such an increase in winter is peculiar to 1982 or common. Further observations in winter at Syowa Station are necessary to clarify the changes of total ozone in winter.

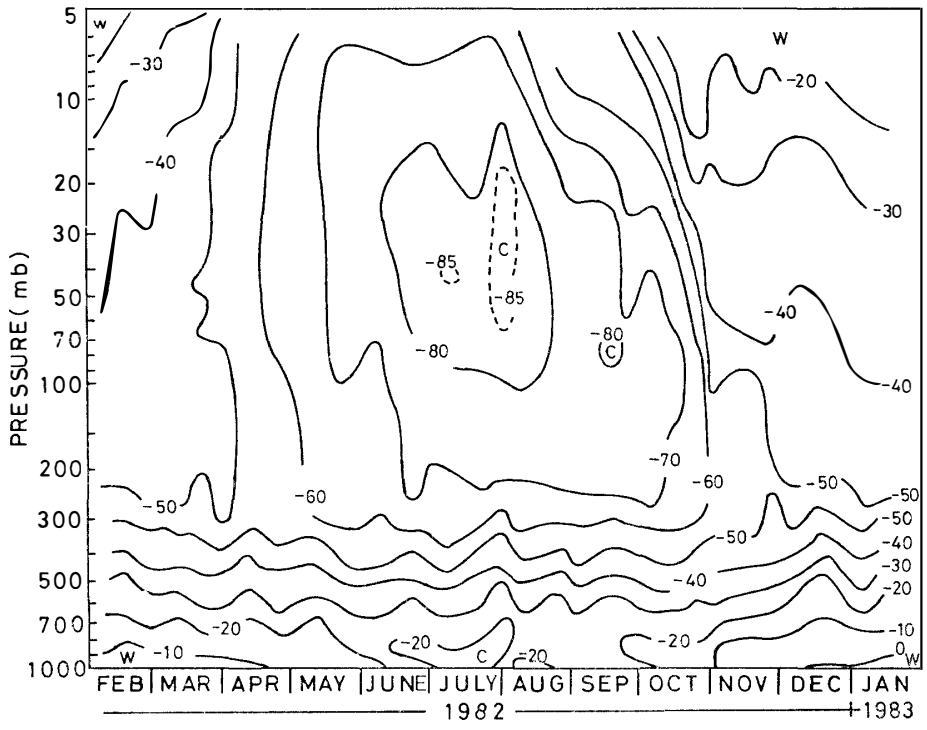

Fig. 3. Time-height cross section of air temperature at Syowa Station constructed from 33 ozonesonde soundings (unit: °C).

Figure 2 shows that the sudden increase of total ozone on October 28 was a result of the rapid increase of ozone partial pressure in the 100–20 mb region. A significant variation in partial pressure of ozone was found at 10 mb in early October preceding the sudden increase of total ozone on October 28. As revealed by the observations in 1966 by SHIMIZU (1969), Fig. 2 shows that the peak level of the ozone partial pressure is higher in summer than in winter.

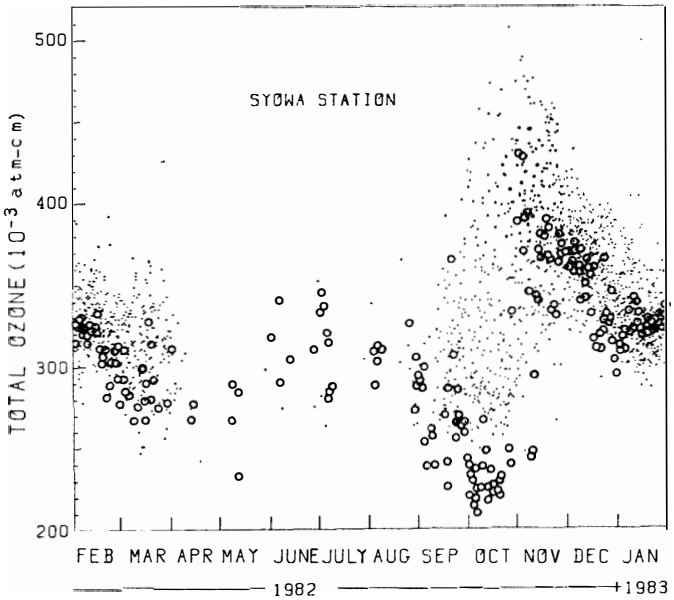

Fig. 4. Total ozone observed at Syowa Station from 1966 to 1980 (●) and from February 1982 to January 1983 (○).

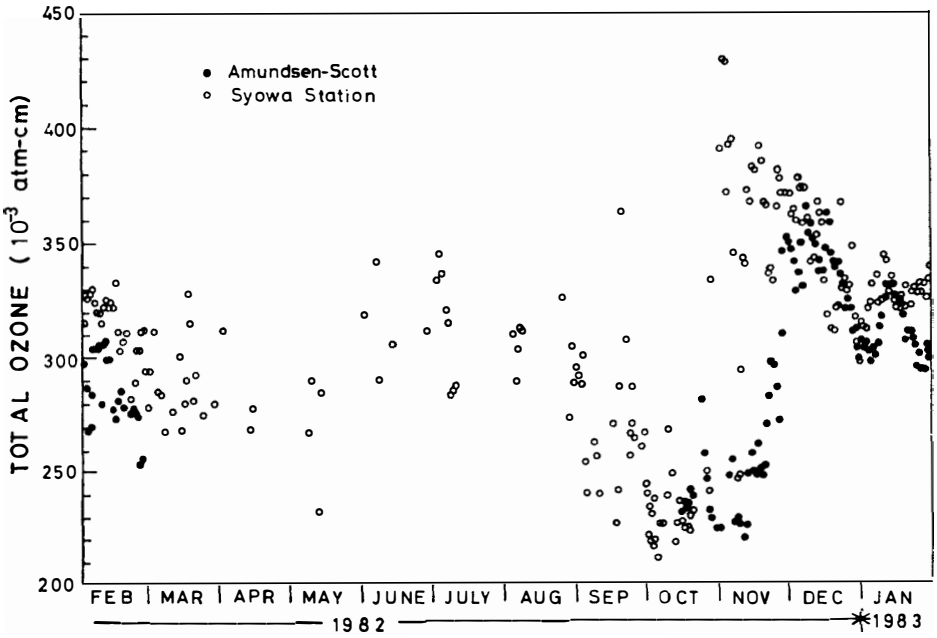

Fig. 5. Comparison of total ozone at Amundsen-Scott with that at Syowa Station observed from February 1982 to January 1983.

Figure 3 suggests that the sudden increase of total ozone is related to the increase of air temperature at 100–30 mb. At 10 mb, a rapid increase of air temperature was observed in early October preceding the sudden increase of total ozone on October 28.

Figure 4 shows that the annual cycle of total ozone observed from February 1982 to January 1983 is essentially similar to those in 1966–1980 at Syowa Station (KISHÔCHÔ, 1984). However, in September and October 1982, the total ozone was as small as 220×10^{-3} atm-cm. Similar values were observed at Amundsen-Scott in October and November (ATMOSPHERIC ENVIRONMENT SERVICE OF CANADA, 1982, 1983a).

Figure 5 shows that the increase of total ozone occurred at Amundsen-Scott about one month later than at Syowa Station (ATMOSPHERIC ENVIRONMENT SERVICE OF CANADA, 1982, 1983a, b)

Figure 6 compares the profiles of ozone and air temperature observed before and after the sudden increase of ozone. The ozone profiles are very similar to each other, if one is vertically shifted by about 2 km downward.

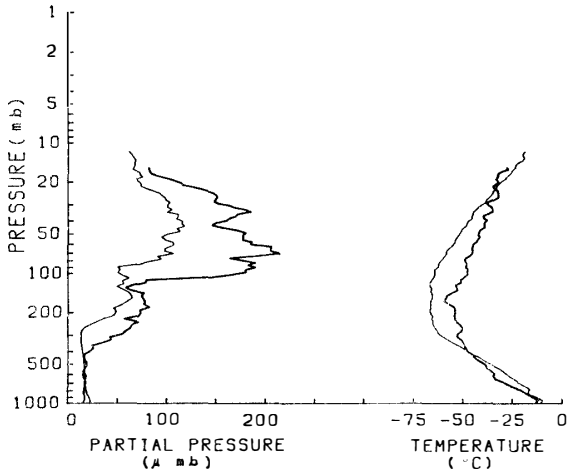

Fig. 6. Vertical profiles of partial pressure of ozone and air temperature obtained with ozonesonde soundings on the day of (October 28; heavy curve) and one day before (October 27; thin curve) the sudden increase of total ozone.

5. Summary

The preliminary result of the ozone observation from February 1982 to January 1983 performed at Syowa Station is presented here. The major features of the results are as follows;

1) The annual cycle of total ozone has two maxima. One is in July, and the other in early November.

2) The smallest value of total ozone since 1966 was observed in the present observation from September to October. Similarly small values were also observed at Amundsen-Scott at the same time.

3) On October 28, the sudden increase of total ozone was observed at Syowa

Station. About one month later, it appeared at Amundsen-Scott.

4) Just after the sudden increase of total ozone on October 28, the ozone maximum appeared at 60 mb, and then ascended to the 40 mb level.

Refining of the data analysis is now under way. The final results will be available after it is finished. In order to verify these results at Syowa Station, further extensive observations at Syowa Station are necessary. Simultaneous observations at Amundsen-Scott and Syowa Station will bring a great progress in the study of the dynamic behavior of ozone in Antarctica.

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References

ATMOSPHERIC ENVIRONMENT SERVICE OF CANADA (1982): Ozone Data for the World, **23**, 308–309.

ATMOSPHERIC ENVIRONMENT SERVICE OF CANADA (1983a): Ozone Data for the World, **24**, 10.

ATMOSPHERIC ENVIRONMENT SERVICE OF CANADA (1983b): Ozone Data for the World, **24**, 327–328.

ISHIDA, K., SUZUKI, T. and SAKAI, S. (1971): Syowa Kiti ni okeru 1969-nen no ozon zenryô kansoku (Total ozone observation at Syowa Station, Antarctica in 1969). Nankyoku Shiryô (Antarct. Rec.), **39**, 32–38.

KISHÔCHÔ (JAPAN METEOROLOGICAL AGENCY) (1984): Ozon kansoku shiryô no jiki têpu ni tsuite (Ozone data on magnetic tapes). Sokko Jiho (Weather Serv. Bull.), **51**, 21–39.

KOBAYASHI, J. and TOYAMA, Y. (1966): On various methods of measuring the vertical distribution of atmospheric ozone (3); Carbon iodine type chemical ozonesonde. Pap. Meteorol. Geophys., **17**, 113–120.

KÔSÔ KISHÔDAI KANSOKU DAI-3-KA (THIRD DIVISION OF THE AEROLOGICAL OBSERVATORY AND METEOROLOGICAL INSTRUMENT PLANT) (1983): Ozon bunkô kôdokei no dôki seiryûki no kaizô ni tsuite (An improvement of synchronous rectifier for the ozone spectrophotometer). Kôsô Kishôdai Ihô (J. Aerolog. Obs. Tateno), **43**, 47–51.

SAKAI, S. (1979): Total ozone observations at Syowa Station. Nankyoku Shiryô (Antarct. Rec.), **67**, 115–123.

SHIMIZU, M. (1969): Vertical ozone distribution at Syowa Station, Antarctica in 1966. JARE Sci. Rep., Ser. B (Meteorol.), **1**, 38 p.

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