Total Ozone Observations at Syowa in 1966

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昭和基地における1966年のオゾン全量観測

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要　旨

南極昭和基地におけるオゾン全量の観測は，1961年に始められたが，1962年基地の閉鎖で中断され，1966年基地再開とともにまた開始された．本報告は，1966年2月から1967年1月までのオゾン分光光度計の保守状況，オゾン全量の計算法を述べた後，資料として同期間のオゾン全量の日代表値を提供する（ただし4～8月は太陽高度角が低すぎるため欠測）．月平均値の年変化曲線では9～11月のオゾン増加が著しい．9～12月（冬から夏）への 50 mb 温度とオゾン全量とを日日変化で比較すると，11月中旬の最高値（両者とも）までは良い対応が見られる．1966年の成層圏突然昇温のうち，10月20日頃のものは最も著しく，オゾン全量の増減もよくこれに対応しており，9～12月各月のオゾン全量，100 mb 高度，気温，風の南成分との相関が検討される．

1. Introduction

Total ozone observation with a Dobson spectrophotometer at Syowa Station (69°00′S, 39°35′E) was begun in 1961 by SEINO, SAEGUSA, SUZUKI and SAKAGUCHI (1963) of the 5th Japanese Antarctic Research Expedition, but the station was closed in early 1962. The spectrophotometer, which was brought back to Japan and recalibrated at Tateno, was installed again at Syowa in 1966 when the station was reopened, and since then the total ozone observation with the instrument has been continued, accompanying observations of vartical ozone distribution with chemical ozone sondes. This report describes briefly the total ozone observations from February 1966 to January 1967.

2. Conditions of the Instrument

The operation and maintenance of the Dobson spectrophotometer, and also technical terms and notations in this report were in accordance with the description by DOBSON (1957 a, b). The spectrophotometer was installed in a hut with a small

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hatch on the roof, through which the direct sunbeams were guided by a long sized sun director, or the scattered light from the zenith sky can enter the instrument window.

The wavelength setting of the Q dial for the instrument temperature was calibrated several times with the clear zenith sky near noon (Test 15 in the reference (DOBSON, 1957 b)) and with a mercury lamp (Test 16 (DOBSON, 1957 b)) especially for low temperatures below 0°C.

The optical density of the wedge was checked monthly with two standard lamps, but no severe change was found. The gradient of the optical density was calibrated by the 2-lamp method (Test 14.1 (DOBSON, 1957 b)) twice in the period. Although small differences from the calibration at Tateno were found near the thin end of the wedge, this end was not used in the observations and, therefore, the table relating dial reading R to N (logarithm of the intensity ratio of two wavelengths) prepared at Tateno was used without amendment.

In order to keep dry the inside of the spectrophotometer, silica gel was renewed monthly before it changed colour. In October 1966, several teeth of the bakelite wheel driving the sector were damaged, and temporary repair was made with a rubber adhesive tape to drive by friction instead of gearing, without interruption of the observations until the wheel was renewed in January 1967.

3. Observations and Calculations of Total Ozone Amounts

The observations of total ozone amounts were made with AD wavelength pairs from February 1966 to January 1967, except April through August 1966 when the sun was too low for ordinary setting observations. The Umkehr observations for getting information of vertical ozone distribution and the focused image observations on very low sun or moon were not tried.

The total amount of ozone Ω obtained by a direct sun observation was calculated with the equation below :

$$\Omega \text{ (in atm-cm)} = \frac{N_A - N_D - \Delta N}{1.388\,\mu} - 0.009,$$

where N_A (or N_D) is a variable concerned to the intensity ratio of A (or D) wavelength pair, μ is the slant path of the solar beam, and ΔN is a constant concerned to the instrument and the extraterrestrial intensities of the light used. N_A and N_D are obtained from dial readings of each observation and the tables prepared by the wedge calibration at Tateno. μ is calculated from the observation time and the solar declination. ΔN was determined as -0.003 from 22 pairs of observations at around noon and at the solar elevation of 20～30 degrees on the same day.

The total amount of ozone obtained by a zenith sky light observation was read out on the chart which was constructed with 146 pairs of comparison between zenith sky and direct sun observations made nearly at the same time.

The data of the total ozone amount thus calculated are presented in the Annex. The accuracy of the total ozone amount is estimated as about 3～5 matm-cm or 1～2% of total amount.

4. Some Results, Especially on the Ozone Increase from September to November 1966

Fig. 1 shows yearly marches of monthly mean total ozone amounts. The increase of ozone from September to November 1966 is remarkable both at Syowa and Roi Baudouin (70°26′S, 24°19′E) which is the nearest station west of Syowa, and the maximum in 1966 is much larger than in 1961. Another interesting feature is the increasing tendency in March at Syowa, although this is not noticed at Roi Baudouin.

Fig. 2 shows day-to-day changes of total ozone amount and 50 mb temperatures at Syowa for the period of September to December 1966. The temperature increased from −80°C in winter to −25°C in early summer with 2 or 3 sudden warmings and the total ozone increased parallel to the temperature, showing a remarkable correspondence.

According to Phillpot (1964), the accelerated warming over Antarctica appears

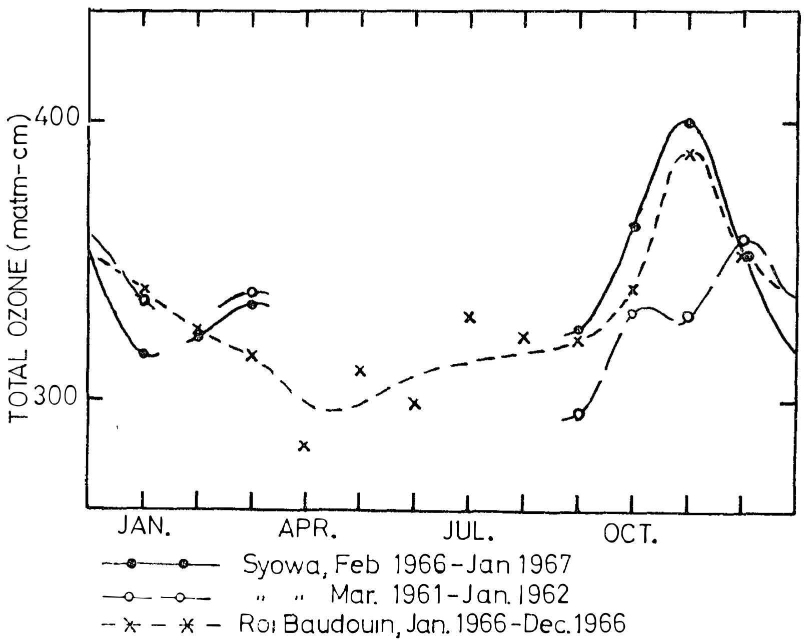

Fig. 1. Seasonal changes of the total amount of ozone at Syowa and Roi Baudouin.

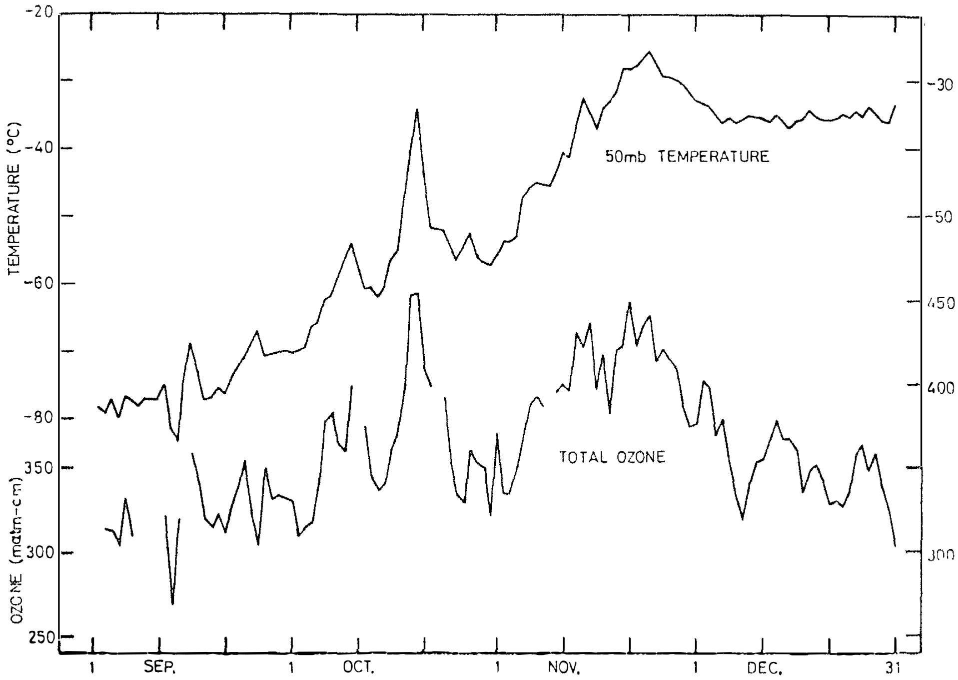

Fig. 2. Day-to-day changes of the total amount of ozone and the 50 mb temperature at Syowa from September to December 1966.

to be a result of warm air invasion, principally from the Australian sector, and possibly from the Indian Ocean sector. The warming in 1966 also appeared at first over the coastal stations in the Indian Ocean sector such as Roi Baudouin and Syowa. The sharp increase of the temperature accompanying the ozone peak around the 20th of October was the commencement of this warming. After the 21st, the warming region moved eastward to the Australian sector and poleward to Vostok, while cooling took place at Roi Baudouin and Syowa until the end of October. In November, the warming spread out to the South Pole, eastward to the South Pacific sector and again westward to the Indian Ocean sector, establishing the summer stratospheric regime in the middle of November.

Table 1 shows some statistical results of the total ozone amount, temperature, wind and height at 100 mb surface.

In September, the stratosphere over Syowa was still in the polar vortex and the 50 mb temperatures were below -70°C. The ozone changes were rather small, even for the large variations of S-N wind components. This might be a result of a small horizontal gradient of ozone in the vortex, although the poleward transport of ozone by northerly wind was only significant in winter as shown by the $\Omega : v$ correlation.

The ozone and temperature correlated positively from September through November. In December the small temperature change and the weak steadiness

Table. 1. Standard deviations of total ozone Ω, temperature T, southerly component of wind v, and geopotential height H, and correlation coefficients between them, and steadiness of wind (the ratio of vector mean to scaler mean speed). All data except Ω are the values at 100 mb surface.

1966	Sep.	Oct.	Nov.	Dec.
Stand. Dev.				
Ω (matm-cm)	18.2	37.2	29.2	22.1
T (°C)	3.1	4.9	9.6	1.1
v (m/s)	10.2	6.0	7.0	4.0
H (gpm)	204	161	272	94
Steadiness (%)	85	97	86	55
Corr. Coef.				
$\Omega : T$	+0.64	+0.69	+0.76	+0.38
$\Omega : v$	−0.52	−0.29	−0.28	−0.15
$\Omega : H$	−0.09	+0.33	+0.58	−0.64

of wind indicated the summer stratospheric regime, and the rather rapid decrease of ozone as shown in Fig. 2 resulted in the poor correlation between ozone and temperature. The relation between ozone and contour height system is not clear from the correlation of $\Omega : H$, but it may be said that the ozone amount is larger at troughs and smaller at ridges in winter and summer regimes, but, in the transitional season from winter to summer, the ozone amounts increase with the poleward contraction of higher altitude contours at a specified pressure level.

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ANNEX

Tables of Total Amount of Ozone

The following tables give the representative daily values of total amount of ozone observed at Syowa (69°00′S, 39°35′E), Antarctica, in February, March, September to December 1966 and January 1967.

YY Greenwich Day of the month on which the observation is made.

GG Greenwich Mean Time in "hour", closest to the observation time.

λ Wavelength used, reported according to a code system. In this report, only the code "0" is used which stands for "wavelength *AD*, ordinary setting".

S Kind of observation, reported according to the following code:

0–on direct sun

1–on direct moon

2–on blue zenith sky

3–on zenith cloud (uniform stratified layer of small opacity)

4– 〃 〃 (uniform or moderately variable layer of medium opacity)

5– 〃 〃 (uniform or moderately variable layer of large opacity)

6– 〃 〃 (highly variable opacity, with or without precipitation)

7– 〃 〃 (fog)

8–on hazy zenith

9–on sun through thin cloud, fog or haze.

(The definitions for "8" and "9" are used only in Japan.)

$\Omega\Omega\Omega$ Total amount of ozone in "matm-cm", thickness of all ozone in a unit vertical column reduced to 0°C and 1013mb.

Total Amount of Ozone

Station : Syowa 89532 (Antarctica)

Year Month	1966 Feb.			1966 Mar.			1966 Sep.			1966 Oct.		
YY	GG	λS	ΩΩΩ	GG	λS	ΩΩΩ	GG	λS	ΩΩΩ	GG	λS	ΩΩΩ
01				09	05	302				09	00	330
02				07	05	323				10	00	309
03				12	05	327				10	04	315
04				06	00	326				10	00	317
05				10	05	337				10	05	342
06				06	04	333				07	05	378
07				10	00	335				11	05	383
08	08	00	331	10	00	340				10	09	365
09			—			—				09	00	360
10			—	06	05	356				08	05	399
11	10	05	322			—			—			—
12	06	00	332	10	00	345	09	09	322	08	05	375
13	13	05	366	10	00	325	09	09	269	10	06	344
14	13	05	339	09	00	330	11	04	320	09	09	337
15	12	00	346	09	06	333			—	08	00	340
16	13	00	337	10	00	334	10	09	359	09	00	361
17	10	00	315	09	03	323	10	04	341	09	00	370
18	06	00	304	09	05	365	10	05	319	11	00	399
19	07	00	309	10	06	344	11	05	314	10	04	453
20	10	00	309	10	00	337	09	04	323	09	00	454
21	10	00	316	10	05	339	09	09	312	09	00	409
22	13	05	328	10	05	335	10	00	327	09	05	398
23	10	00	323	11	00	318	10	04	339			—
24	06	00	331			—	11	05	355	10	00	392
25	10	05	331			—	10	04	324	09	06	352
26	09	05	296	09	05	360	09	02	303	10	00	333
27	11	04	302	10	05	340	10	04	350	11	00	329
28	10	05	302	10	05	317	10	05	331	10	09	361
29				10	05	343	09	00	334	10	00	353
30				10	05	322	11	00	332	08	00	350
31				10	06	318				10	09	320
Mean			323			334			326			363

Total Amount of Ozone

Station : Syowa 89532 (Antarctica)

Year Month	1966 Nov.			1966 Dec.			1967 Jan.		
YY	GG	λS	ΩΩΩ	GG	λS	ΩΩΩ	GG	λS	ΩΩΩ
01	10	04	371	10	00	376	13	00	322
02	09	05	334	10	00	403	10	09	319
03	09	09	335	10	05	388	10	04	323
04	09	05	350	10	05	368	09	09	312
05	09	00	367	10	05	381	10	09	308
06	09	00	388	13	05	355	10	00	301
07	13	05	393	10	00	332	10	00	302
08	13	09	386	14	00	319	08	00	327
09			—	09	00	340	10	00	338
10	10	05	395	09	00	353	09	00	343
11	13	09	400	09	00	355	10	00	330
12	09	00	396	11	00	366	09	03	337
13	09	00	432	14	00	379	10	09	312
14	10	09	422	10	00	367	13	05	305
15	10	04	437	10	00	367	09	06	306
16	10	04	396	11	00	361	10	04	315
17	09	05	418	10	04	335	10	00	324
18	13	09	382	14	00	349	10	04	317
19	10	09	420	09	09	352	09	00	326
20	09	00	423	14	00	343	10	00	320
21	09	05	450	10	00	328	11	05	300
22	10	09	423	14	00	330	08	09	334
23	10	00	434	08	00	327	08	09	306
24	13	05	442	09	00	336	08	09	299
25	12	04	413	10	05	358	10	00	319
26	11	00	421	10	05	365	08	00	302
27	09	04	415	09	00	348			—
28	10	05	409	10	05	360			—
29	10	00	388	10	05	339			—
30	10	00	374	14	00	324			—
31				09	00	303			—
Mean			400			352			317