Meteorological Observation at Syowa Base during the 4th Wintering

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第4次南極地域観測隊越冬隊気象部門報告

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要　旨

1961年1月に，第3次越冬隊の気象部門の作業は，第4次越冬隊に引き継がれた．初めてレーウィンゾンデの器械が基地に運ばれ，その設置，調整に約1か月半を要し，3月1日より高層観測が始まり，12月末までに153回観測が行なわれた．

過去3回の越冬における地上の月平均気温の最低は，いずれも9月に現われており，春から夏にかけて気温の急上昇を示している．これは成層圏の上層になるに従っても著しい．月平均値による年の振幅は，成層圏の50 mbで45°C，地上で25°Cに達した．一方対流圏では，各層とも振幅は小であって，10°C位であった．この成層圏の昇温は，上層から次第に下層に及んでいるのがみうけられた．月平均値から計算された昇温率は一般に上層程大きく，100 mbで10～11月間に0.5°C/Day，50 mbで9～10月間に0.6°C/Dayに達した．

気球の破裂高度は冬期に著しく低くなる．この原因として，a) オゾン，酸素の酸化によるゴムの劣化，b) −30°C以下でゴムの張力の喪失，が考えられている．昭和基地においては，気球が−75°Cの高度より昇ることは少なかった．これらのことから，ゴムが直接大気に触れないような考慮が払われたら，破裂高度はもっと高くなると思われる．第3次隊の経験では，ゴムを軽油につけて油の膜を作り，飛ばしたが，結果は良かったことが判明した．

1. Preface

Meteorological observation was carried out at Syowa Base during the 4th wintering between Jan.–Dec., chiefly by two meteorologists, N. MURAKOSHI and A. YATA. The items of observation were as follows; Surface, Upper air, Solar radiation, Nocturnal radiation and Inland observation.

This paper briefly reports on the results of surface and upper air observations.

2. Surface observation

1. Outline of the surface observation

The surface synoptic observation was made 3-hourly (8 times a day) at the early stage of the 4th wintering successively from the 3rd wintering. After 7th Mar., the observation was reduced to 4 times a day due to the shortage of hand, in order to perform the rawinsonde observations, which has been newly assigned to the members

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of the 4th wintering party. The 3-hourly synoptic observations were restored on 1st Jan. 1961, having been taken over to the 5th wintering members.

To our regret, 10 observations were missed during the period from 18 G.M.T. 10th to 00 G.M.T. 13th Oct., because all the wintering members had to attend to the emergency rescue of S. FUKUSHIMA, who was lost in blizzard. Main meteorological elements for the above missing period, however, can be read through the selfrecording instruments.

The synoptic data were transmitted to I.A.A.C. via mother station, the Mawson Base, throughout the year. Furthermore we had contacted with the SANAE and Bergian bases once a day to exchange synoptic data.

Table 1. Ten days weather results at Syowa Base in 1960.

	P	T	MXT	MIT	H	WV	MXV	MXD	CA	SD
Jan. 1~10	983.9	− 0.9	2.9	− 6.4	79	5.7	21.5	NE	6.9	95.4
11~20	984.4	− 1.3	6.0	− 7.9	70	4.3	16.8	NE	6.8	115.1
21~31	987.1	− 0.4	3.2	− 4.0	80	9.1	32.3	NE	9.7	27.3
Feb. 1~10	993.6	− 2.7	1.7	− 8.9	70	4.1	22.5	NE	4.6	95.9
11~20	985.9	− 5.0	0.2	−12.0	67	2.6	15.0	ENE	6.5	73.9
21~29	981.3	− 6.6	− 0.6	−16.9	72	5.1	16.0	ENE	6.8	61.5
Mar. 1~10	972.9	− 6.0	0.1	−13.4	78	5.6	21.3	E	8.5	49.8
11~20	977.9	− 8.7	− 2.4	−19.5	85	6.5	18.5	NE	8.4	27.4
21~31	981.9	− 7.9	− 0.5	−22.1	86	7.5	31.7	NE	8.1	14.9
Apr. 1~10	980.8	− 9.1	− 4.2	−16.8	83	9.6	26.7	ENE	8.5	11.7
11~20	980.5	− 8.9	− 3.5	−17.1	72	7.2	24.0	ENE	8.6	8.3
21~30	985.8	−11.5	− 7.8	−17.6	78	7.8	26.3	ENE	9.1	5.4
May 1~10	991.0	−14.7	− 7.9	−30.2	64	3.9	18.0	E	5.5	13.4
11~20	991.4	−11.9	− 3.2	−27.0	76	7.7	32.0	ENE	6.4	9.3
21~31	990.3	−20.1	− 5.8	−28.0	71	4.8	22.5	E	2.4	9.4
June 1~10	981.3	−20.3	−10.8	−34.6	75	3.7	15.8	NE	7.8	—
11~20	987.4	−15.9	− 7.1	−25.4	77	10.2	25.0	NE	7.2	—
21~30	994.2	−22.4	−12.7	−33.8	75	4.6	13.3	NNE	5.6	—
July 1~10	981.8	−15.2	− 4.7	−32.6	80	9.4	33.3	ENE	8.6	—
11~20	987.2	−19.9	− 8.0	−37.3	76	6.5	28.7	NE	7.1	—
21~31	981.3	−22.5	−10.8	−40.0	76	5.0	26.2	NE	6.4	—
Aug. 1~10	980.5	−19.9	− 8.6	−37.3	79	6.7	32.0	ENE	6.3	13.3
11~20	989.2	−16.6	− 6.5	−30.5	77	7.8	33.3	ENE	7.1	18.9
21~31	983.1	−20.7	− 8.4	−33.3	75	3.7	20.2	ENE	5.6	40.2
Sept. 1~10	974.0	−19.2	−10.0	−34.0	69	6.0	19.5	NE	6.5	47.1
11~20	980.1	−26.3	−11.9	−38.4	71	2.2	12.8	NE	4.2	60.9
21~30	985.4	−21.6	−12.4	−29.6	72	4.1	31.7	NE	5.2	51.3
Oct. 1~10	987.4	−12.6	− 6.8	−23.4	81	10.3	33.3	NE	9.3	24.3
11~20	979.7	−12.8	− 7.1	−22.0	*80	6.5	31.0	NE	*8.6	23.2
21~31	986.6	−16.5	− 6.7	−26.5	72	2.9	15.3	NE	4.9	119.0
Nov. 1~10	977.6	− 8.3	0.1	−20.5	73	7.2	22.0	ENE	5.3	95.5
11~20	982.8	− 7.9	− 0.1	−16.5	67	3.8	13.0	NE	5.4	124.2
21~30	990.1	− 5.8	2.5	−15.6	64	3.9	13.5	E	6.0	116.8
Dec. 1~10	985.9	− 3.9	1.9	−10.5	69	5.7	16.8	NE	6.8	136.3
11~20	980.2	− 2.0	6.5	− 9.1	66	5.0	15.8	ENE	1.1	212.7
21~31	984.9	0.0	5.7	− 5.4	67	6.4	16.3	NE	6.2	128.9

P: Mean pressure (sea level) mb. T: Mean temperature °C. MXT: Maximum temperature °C. MIT: Minimum temperature °C. H: Mean humidity %. WV: Mean wind velocity. m/s. MXV: Maximum wind velocity m/s. MXD: Direction of maximum wind velocity. CA: Mean cloud amount. SD: Sunshine duration hours.

*: Mean from seven days results.

In summer season, when the relief operation was opened, temporary surface observations were carried out in aid of the air transportation, moreover, special weather reports, amounting to 70 times, were sent to the Soviet and Bergian aircrafts.

Table 2. Monthly weather results at Syowa Base in 1960.

	P	T	MXT	MIT	H	WV	MXV	MXD	CA	SD
Jan.	985.2	− 0.8	6.0	− 7.9	76	6.5	32.3	NE	7.9	237.8
Feb.	987.1	− 4.7	1.7	−16.9	69	3.9	22.5	NE	5.9	231.3
Mar.	977.7	− 7.6	0.1	−22.1	83	6.6	31.7	NE	8.3	92.1
Apr.	982.4	− 9.8	− 3.5	−17.6	78	8.2	26.7	ENE	8.7	25.4
May	990.9	−15.7	− 3.2	−30.2	70	5.3	32.0	ENE	4.7	32.1
June	987.6	−19.6	− 7.1	−34.6	76	6.2	25.0	NE	6.9	—
July	983.4	−19.3	− 4.7	−40.0	77	6.9	33.3	ENE	7.3	—
Aug.	984.2	−19.1	− 6.5	−37.3	77	6.0	33.3	ENE	6.3	72.4
Sept.	979.8	−22.4	−10.0	−38.4	71	4.1	31.7	NE	5.3	159.3
Oct.	984.7	−14.1	− 6.7	−26.5	*77	6.4	33.3	NE	*7.4	166.5
Nov.	983.5	− 7.3	2.5	−20.5	68	4.9	22.0	ENE	5.6	336.5
Dec.	983.7	− 1.9	6.5	−10.5	67	5.7	16.8	NE	4.7	477.9
YEAR	984.2	−11.9	6.5	−40.0	74	5.9	33.3	ENE NE	6.6	1831.3

*: Mean from 28 days results.

Table 3. Weather condition at Syowa Base 1960.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	YEAR
Gale 10.0 ∼14.9 m/s	5	4	5	11	6	7	5	4	4	5	12	13	81
Gale 15.0 ∼28.9 m/s	12	6	14	14	9	9	10	4	5	8	5	10	106
Gale 29.0≦	1	0	1	0	1	0	1	0	1	2	0	0	7
Total	18	10	20	25	16	16	16	8	10	15	17	23	194
Clear	3	7	1	0	9	5	2	5	9	3	8	13	65
Cloudy	22	12	24	23	10	18	16	15	10	21	11	11	193

Clear: Daily mean cloud amount <2.5 Cloudy: Daily mean cloud amount ≧7.5

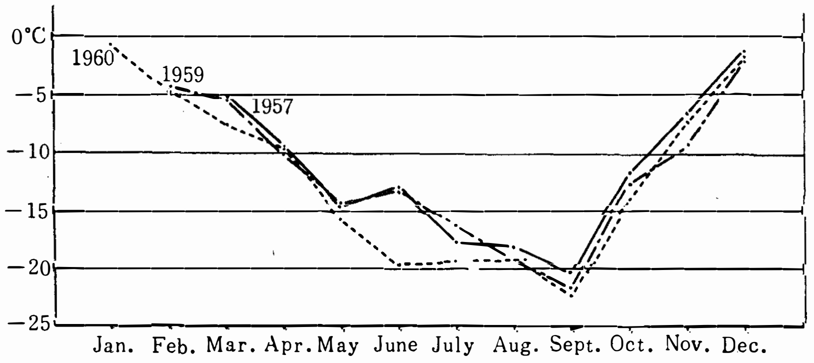

Fig. 1. Annual variation of monthly mean temperature at Syowa Base.

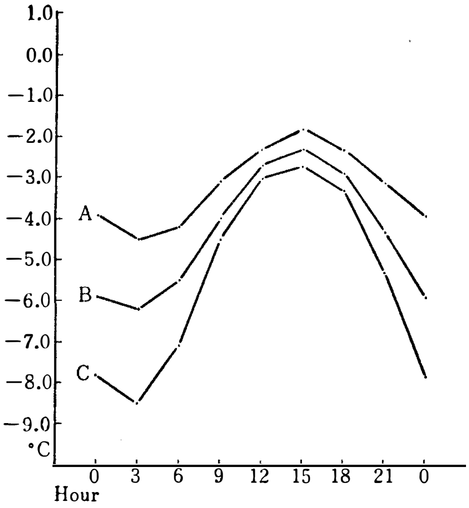

Fig. 2. Mean diurnal temperature variation for different cloud amounts at Syowa Base in 1959–1960 summer period.
A: Overcasts cloud amount =10
B: 4 months mean temp.
C: Clears cloud amont <3

2. Summary of the meteorological data

Tables 1, 2 and 3 summarize the results of the observations during the period from 1st Jan. to 31st Dec. 1960. Fig. 1 gives the annual variation of the mean monthly temperature as compared with those of 1957 and 1959.

3. The relation between the daily temperature range and the weather

As is easily understood, a close relation is found between the cloudiness and the amplitude of diurnal temperature variation. Fig. 2 illustrates this relation. It is pointed out that the amplitude is especially great on a clear day, when the radiative cooling takes place at night.

3. Upper air observation

1. Introduction

Upper air observation at Syowa Base has been carried out since Feb. 1959, and about 100 radiosonde observations were made during the 3rd wintering till Jan. 1960, when the 4th wintering party replaced the 3rd party. The 4th wintering party newly carried out rawinsonde observation as well as radiosonde observation. 109 rawinsonde observations and 44 radiosonde observations were made during Mar.–Dec. 1960. The installation of our rawin set was finished at the end of Feb., and the routine work has commenced since the beginning of Mar. Whenever weather permitted, the schedule of observation was as follows: Radiosonde on every Monday, Rawinsonde on every Tuesday, Thursday and Saturday, and each ascension at 12.00 G.M.T. Monthly frequencies of the observations, put in practice, are shown in Table 4.

Table 4. Monthly frequencies of the upper air observations.

Month	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	YEAR
RS	12	8	11	9	14	10	9	10	13	13	109
S	3	4	6	5	2	5	9	4	3	3	44
Total	15	12	17	14	16	15	18	14	16	16	153

2. Equipment

As the details of the equipments for the radiosonde observation have been already reported in the Japanese Antarctic Record No. 11 by Z. SEINO, we describe here mainly the equipments for the rawinsonde observation.

i) Rawinsonde receiver

Automatic tracking rawin set, J.M.A.* D55A type, which is similar to GMD1-A, was used. The antenna unit of D55A is separated from the receiving, antenna controlling and recording unit, and is connected between them by a feeder and control cables. At our Base, the former unit was installated outdoors, while the latter units in the meteorological hut as shown in Fig. 3. Being interfered by several obstacles such as the antennas for the communication and the ionospheric observation, the dwelling hut and the pole of the wind vane, the position of the antenna seemed inadequate for the rawin observation. However, the position was restricted by the length of the feeder as well as by the condition of the bedrock and snow deposit. The shelter for D55A was not used for the reason of difficulty in the air transport, nevertheless no trouble was caused by blizzard, low temperature, or snow deposit throughout the year.

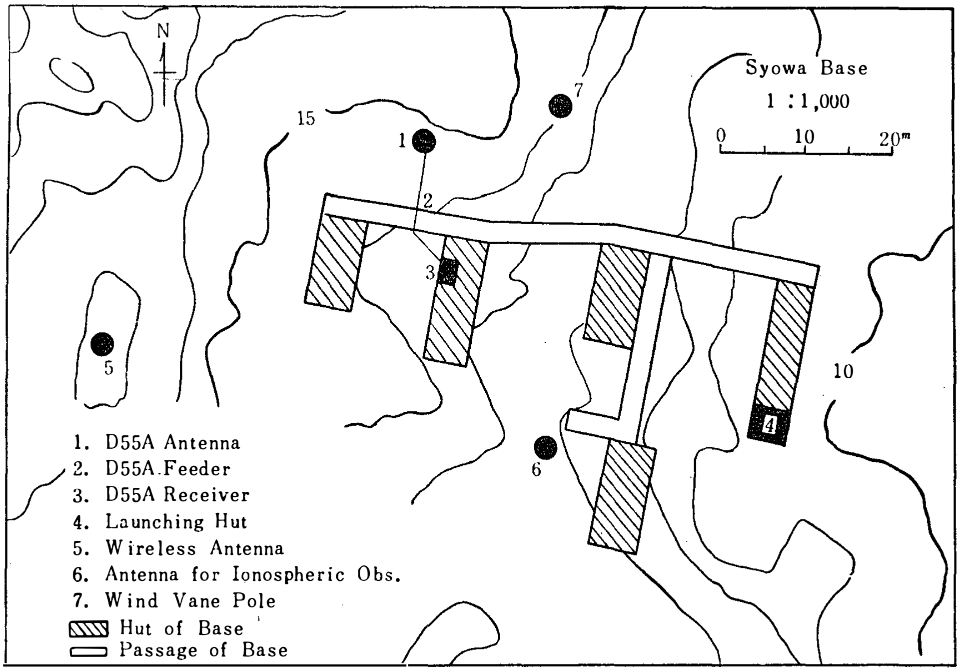

Fig. 3. Disposition of equipments for rawinsonde observation and obstacles for it.

Details of D55A are as follows:

Receiver	
receiving method	super heterodyne
receiving frequency	1660–1700 Mc
I.F.	30 Mc.
Antenna unit	
Antenna	$\lambda/2$ dipole

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* Japan Meteorological Agency.

Reflector	parabola (diameter is about 2 m)
Antenna pattern	
Width of beam at half value	3°
Scanning method	conoid
Scanning angle	3°
Scanning frequency	30 c/s
Tracking method	automatic equi-sensitivity method
Recorder	automatic and digital record for wind elements only
Weight (including the spare parts)	about 1,400 kg
Height of antenna unit	about 2.8 m

ii) Rawinsonde

J.M.A. RSII56 type was used.

Details of it are as follows:

Meteorological unit	similar to SIII56 radiosonde (c.f. Antarctic Record, No. 11, p. 81)
Transmitting unit	
Carrier frequency	1680 Mc.
Modulation	AM. (Audio frequency of blocking OSC. is shifted due to morse cord.)
Output	0.4 W
Weight (except battery)	750 gr

iii) Hydrogen gas

Hydrogen gas was mainly obtained from calcium hydride. Moreover, 22 gas cylinders were also in use to compensate the lack of calcium hydride.

iv) The hut for inflating and launching balloon

The hut, 3.6×3.6 m in floor and 2.7 m in height, made of wooden boards and ceiled by canvas sheets, was newly installed adjacent to the disel generator hut. In case of launching, the canvas sheet could be easily removed, when it was calm. But, in blizzard, it was very difficult to handle it as well as to launch balloon.

3. Brief results

Monthly mean values, of temperature, height and dewpoint-temperature are shown in Tables 6, 7 and 8. The numbers of observations, corresponding to Tables 6 and 7, can be found in Table 5. Unbalanced distribution of the observations may cause these mean values to deviate from the real mean values. There may be a systematic deviation, because the missing of data often occured on the days of blizzard. No attempt has been made to correct these errors, however, these mean values are considered sufficiently to know the general tendencies of the annual variation.

Fig. 4 gives the annual temperature variations for several standard levels. In this figure, an interesting difference of character is seen between the annual variations in troposphere and that in stratosphere.

Table 5. Number of temperature readings at stated pressure levels and tropopause.

	Surface	mb 850	mb 700	mb 500	mb 400	mb 300	mb 200	mb 150	mb 100	mb 80	mb 50	mb 30	mb 20	mb 15	Trop.
Mar.	15	15	15	15	15	15	14	14	14	12	9	5	2	2	14
Apr.	12	12	12	12	12	12	11	11	11	11	7	4			12
May	17	17	17	16	16	15	15	15	15	10	8	4	2		15
June	14	14	14	11	11	11	11	11	3	1					11
July	16	16	16	15	15	15	14	9	1						14
Aug.	15	15	15	15	15	15	11	6	3	1					12
Sept.	18	18	18	18	18	17	14	13	8	6	2	1			14
Oct.	14	14	14	14	14	14	13	13	13	11	7	6	3		13
Nov.	16	16	16	16	16	16	16	16	15	13	11	6			16
Dec.	16	16	16	16	16	16	16	15	14	13	11	4	1		16

Table 6. Monthly mean heights (gpm).

	Surface	mb 850	mb 700	mb 500	mb 400	mb 300	mb 200	mb 150	mb 100	mb 80	mb 50	mb 30	mb 20	mb 15	Trop.
	mb	m	m	m	m	m	m	m	m	m	m	m	m	m	
Mar.	976.0	1087	2556	4993	6535	8423	11066	12981	15682	17165	20275	23620	26281	28205	8669
Apr.	983.1	1130	2578	4982	6502	8392	10967	12830	15447	16882	19828	23096			7827
May	988.0	1152	2606	5028	6555	8425	10935	12720	15208	16544	19449	22577			9402
June	988.2	1128	2544	4906	6433	8150	10601	12321	14664	15894					9208
July	982.5	1089	2509	4867	6349	8161	10602	12296	14590						9698
Aug.	985.1	1110	2527	4887	6365	8179	10597	12344	14725						10159
Sept.	997.7	1042	2458	4820	6302	8109	10516	12182	14567	15885	18573	21567			9432
Oct.	985.2	1124	2557	4940	6438	8277	10751	12474	14915	16283	19224	22448	25273		10160
Nov.	982.4	1129	2579	4987	6507	8376	10901	12701	15300	16757	19867	23363			9317
Dec.	985.7	1151	2628	5086	6647	8563	11192	13098	13856	17390	20661	24156			9316

Table 7. Monthly mean temperatures (C°).

	Surface	mb 850	mb 700	mb 500	mb 400	mb 300	mb 200	mb 150	mb 100	mb 80	mb 50	mb 30	mb 20	mb 15	Trop.
Mar.	- 6.3	-11.3	-18.9	-32.6	-42.1	-53.5	-46.4	-45.7	-45.8	-45.2	-46.7	-48.1	-45.1	-44.4	-55.4
Apr.	- 8.9	-14.8	-22.5	-35.9	-45.1	-54.7	-52.6	-52.1	-53.4	-54.0	-55.9	-55.8			-57.1
May	-16.4	-16.6	-20.9	-34.4	-45.1	-57.7	-62.0	-61.6	-64.3	-65.7	-66.9	-67.3	-66.2		-64.1
June	-21.4	-21.5	-27.4	-44.1	-54.0	-63.9	-68.6	-69.9	-73.4	-77.3					-68.7
July	-20.0	-21.3	-26.1	-41.2	-52.0	-63.7	-70.9	-71.7	-76.3						-70.7
Aug.	-18.6	-21.5	-26.6	-41.6	-52.0	-63.3	-72.4	-73.6	-75.8						-72.7
Sept.	-23.6	-22.2	-26.5	-41.3	-51.3	-63.7	-73.4	-74.8	-76.2	-76.2	-78.4	-74.7			-73.3
Oct.	-13.7	-19.1	-24.3	-38.6	-48.9	-60.0	-68.0	-68.7	-66.1	-64.0	-59.4	-51.3	-38.9		-68.2
Nov.	- 4.1	-13.9	-22.3	-35.8	-45.2	-57.1	-68.8	-58.2	-50.9	-48.1	-43.8	-35.9			-61.9
Dec.	+ 0.8	- 8.9	-17.5	-29.8	-39.4	-51.4	-48.7	-43.8	-39.9	-37.8	-34.8	-32.0	-27.2		-55.8

Table 8. Monthly mean dewpoint-temperatures (T_d) and numbers (n) of humidity readings at stated pressure levels.

	Surface		850 mb		700 mb		500 mb		400 mb		300 mb	
	T_d(°C)	n	T_d(°C)	n	T_d(°C)	n	T_d(°C)	n	T_d(°C)	n	T_d(°C)	n
Mar.	−10.2	15	−15.1	15	−23.0	15	−42.9	3	−50.6	2	−60.5	1
Apr.	−13.3	12	−18.6	12	−25.2	12	−33.6	10	−48.2	1		
May	−20.7	17	−22.2	17	−27.1	17	−39.3	12				
June	−24.8	14	−25.0	14	−32.3	14	−42.7	1				
July	−23.3	16	−25.5	16	−30.8	16	−42.5	5				
Aug.	−22.2	15	−24.5	15	−27.0	15	−45.6	3				
Sept.	−27.2	18	−27.5	18	−32.8	18	−49.2	4				
Oct.	−17.6	14	−23.1	14	−30.2	14	−43.2	9				
Nov.	−11.8	16	−19.9	16	−28.8	16	−43.2	13	−38.9	1		
Dec.	− 5.8	16	−15.3	16	−25.1	16	−37.1	16	−42.3	7		

Throughout the layers higher than 300 mb level, the annual variation shows a so-called "Kernlose" type with a flat appearence from June to Sept., and the warming in spring is very remarkable. Such a remarkable warming is not found in any layer lower than 300 mb level.

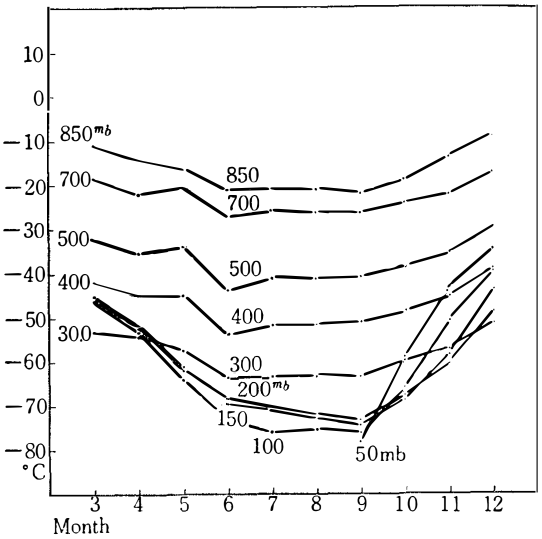

Fig. 4. Annual variations of mean monthly temperature at Syowa Base.

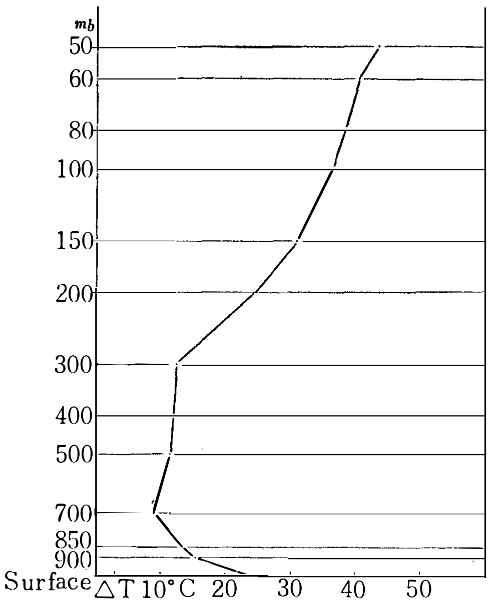

Fig. 5. Vertical profile of temperature difference between warmest and coldest month at Syowa Base in 1960.

As was already pointed out by Dr. WEXLER, the amplitude of the annual temperature variation in Antarctica is the largest in the stratosphere and the smallest in the troposphere. At Syowa Base, the above mentioned matters are quite identical; i.e., the amplitude is about 25°C at the surface, about 10°C in the troposphere, and 20°C at the lower layer in the stratosphere. Then, the amplitude increases with the hight in the stratosphere, and reaches 45°C at 50 mb level.

In Fig. 5, it is seen that the curves for the layer of the stratosphere simultaneously go across that for 300 mb layer in late autumn, while the warming in spring appeares at first in the upper layers and then proceeds to the lower layers.

The calculated warming rate for each layer of the stratosphere is shown in Fig. 6. As is seen in the figure, the warming rate at 400 mb level is small and has a constant increasing tendency. At 100 mb layer, it is as much as 0.5°C/day from Oct. to Nov. The maximum rate is found in 50 mb layer from Sept. to Oct., reaching 0.6°C/day.

In general, the higher is the level the larger becomes the warming rate, although the data for 50 mb layer may be unreliable for the scarceness of the observations.

4. The heights at which the balloons burst

The heights at which the balloons burst were remarkably low in winter. As this has extremely obstructed the study of the stratospheric frame, it is desired to find how to settle the matter.

The factors which lower the bursting height of balloon may be as follows:

a) Ozone and oxygen gas oxygenate latex, of which our balloon is made, and solar radiation intensifies this effect. The oxygenation degenerates latex.

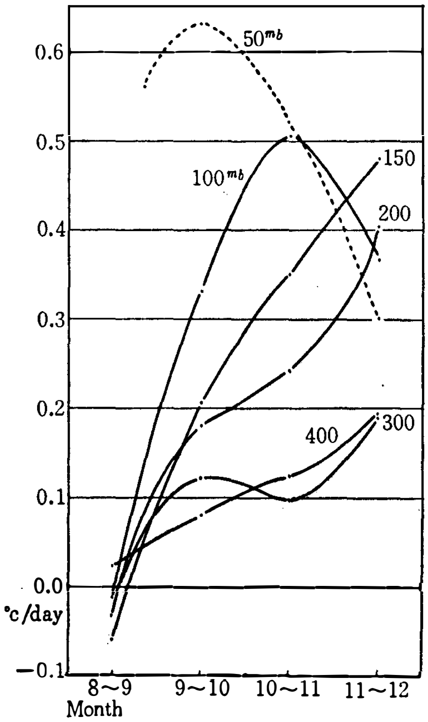

Fig. 6. Warming rate of stratosphere at Syowa Base.

b) Latex of the ascending balloon conserves the heat obtained at the ground, and generates Joule Heat with the extension of the balloon and electric reaction heat due to hydrogen gas leaking through the rubber membrane. But then the greater part of the above-mentioned heats must be carried off by air cooling. It is said that the expansibility of latex is lost at temperatures lower than about −30°C.

Figs. 7 and 8, plotting every bursting point on the isopleth diagrams in 1959 and 1960, reveal that the balloons could hardly rise above −75°C line (except Mark ● in Fig. 7), and that the bursting heights in other seasons are distributed more scatteringly than in winter. From these facts, presumable causes which would lower the bursting heights in winter are as follows:

(i) The cooling of balloon due to the cold upper air.

(ii) The degeneration of balloon due to ozone gas, with the increase of ozone density in the atmosphere.

The cause (i) is reasonable according to the generally considered factor b). Whether the cause (ii) is reasonable or not is a very interesting question, although we have no basis to refer to, nothing due to lack of information on the ozone distribution at Syowa Base.

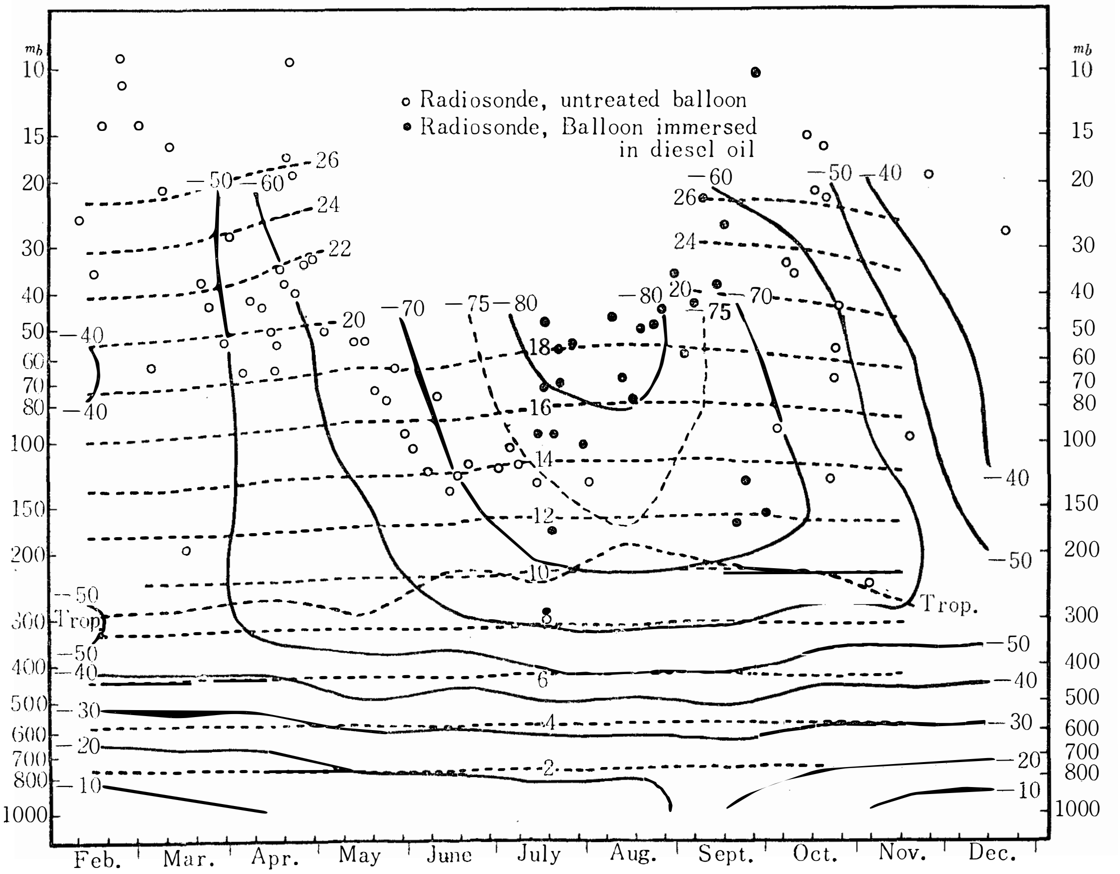

Fig. 7. Isopleth diagram, on which each bursting height is plotted, in 1959.
—— Isothermal line ···· Contour line

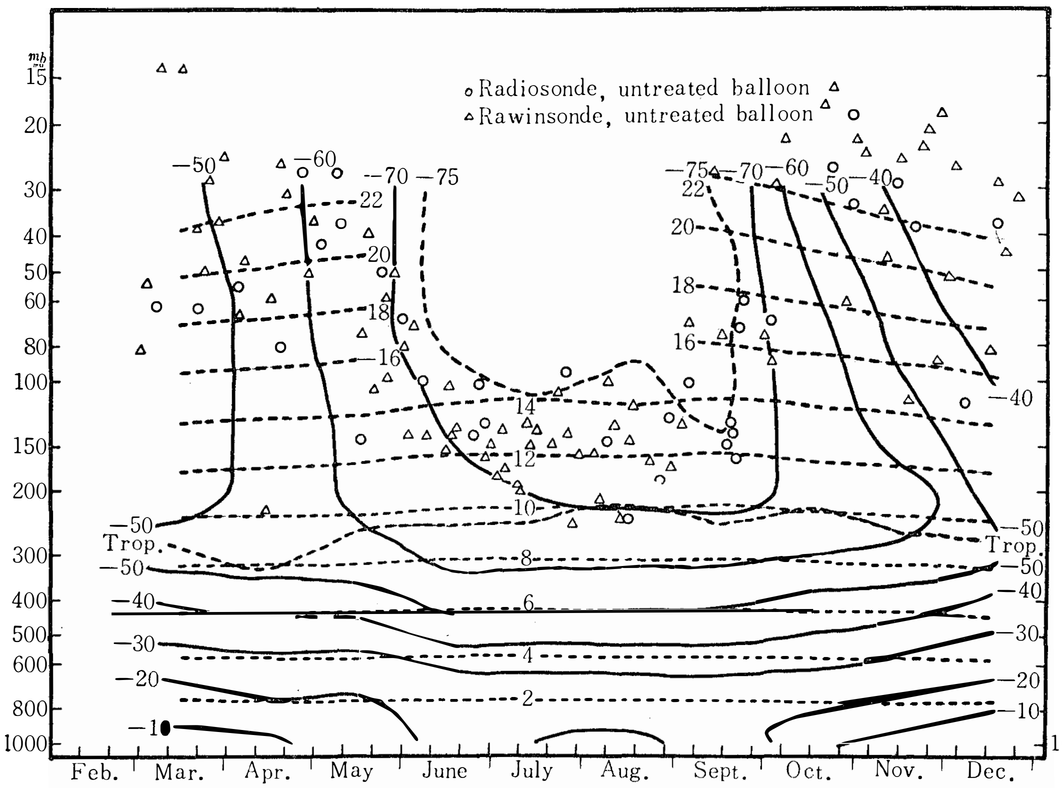

Fig. 8. Isopleth diagram, on which each bursting height is plotted, in 1960.
—— Isothermal line ···· Contour line

The ozone observation is being carried out now by the fifth wintering party.

Looking back the above-mentioned general consideration, it is known that both factors, a) and b), are derived from the contacting the air with the balloon. That is to say, ozone gas and oxygen gas cannot oxygenate latex without the direct touching, and the heat-loss of balloon must decrease according to the shielding from the air. If such a condition can be realized somehow or other, the limit of the bursting height may become higher than the present level.

The balloons used by the 3rd wintering party in July, Aug. and Sept. 1959, were immersed in diesel oil before the inflation. Those balloons could have easily risen above the −75°C line as shown by Mark ● in Fig. 7, for oil has an ill-effect on latex as a general rule. In view of this fact, the oil-film on the surface of balloon is supposed to conserve the heat of balloon as oil is a thermal insulator, and the film perhaps protects the balloon from the oxygenation due to oxygen and ozone. Using oil is certainly a good idea. But, more effective methods must be conceived for the future study.

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