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Meteorological Observations and Ozone Hole Investigation during 2000 at Indian Antarctic Station, Maitri

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Abstract

India Meteorological Department (IMD) has been participating in Indian Antarctic Expeditions since the first expedition. During the year 2000, climatological data at Maitri, has been analyzed and the results are discussed along with the significant weather phenomenon. Ozone sonde ascents were taken once a week and the ozone concentration and atmospheric temperature were also measured. Ozone depletion in the stratosphere during Antarctic spring months, its recovery and stratospheric wanning are discussed. Radiometer sonde ascents were released in the winter period to study the net radiation balance. Global and diffused radiation has also been measured and discussed in the present paper.

Introduction

To understand the climatic variation of a station, we require at least 30 years of meteorological data. For this purpose, a manned permanent meteorological observatory was set up at Antarctica. The permanent Indian Scientific Station at Maitri has been functioning since January 1990. Various meteorological parameters are collected every year. Weather conditions at Maitri vary every year depending on the global variation of atmospheric systems and exchange of air masses between the poles and the tropics. During the year 2000, various meteorological parameters affecting the station and the associated low-pressure systems have been analyzed and discussed. In addition, radiometer sonde ascents were taken to understand the radiation budget. The whole world is now concerned about the "Ozone Hole" phenomenon which is seen during the spring months (August October) at Antarctica every year. To understand the depletion of ozone concentration in the stratosphere and its recovery to normal values in summer, ozone sonde ascents have been used and Brewer Spectrophotometer has been operated throughout the year.

Scientific Objectives

The scientific objectives of the meteorological programme during the 19th expedition included the study of Antarctic meteorology in general. The following programmes, in particular, have been conducted:

(a) The daily, seasonal and annual variations of atmospheric pressure, surface wind, surface air temperature and cloud.
(b) The radiation budget studies: Diffuse radiation observation in addition to direct solar radiation observations as well as radiometersonde (RMS) ascents.
(c) Balloon borne measurements of ozone for its vertical profile over Maitri, for the study of the occurrence of ozone hole over Antarctica during Antarctic spring months. In addition surface ozone measurements are to be made throughout the year at Maitri.
(d) Monitoring weather systems affecting the Antarctic continent using the Polar satellite pictures and the analyzed weather charts, transmitted from Cape Town, South Africa.
(e) Measurement of atmospheric turbidity in Antarctica.
(f) Study of total ozone, D-UV, $S0_2$ and $N0_2$ using Brewer Spectrophotometer.

Observational Programme

The following routine observations were taken at Maitri:

(a) Surface observations: Every three hourly synoptic observations were taken everyday and six hourly data (0000, 0600, 1200 and 1800 UTC) have been transmitted on real time basis to the IMD-HQ, New Delhi. Due to breakdown in communication system (Sat .Com. terminal at Maitri), surface observation data could not be to transmitted since the 2nd week of May 2000.
(b) Continuous recording of surface pressure, air temperature, wind (direction & speed) and surface ozone have been made. Due to some technical problem continuous recording of temperature could not be made since 2nd week of August.
(c) Continuous recording of total solar radiation and diffused radiation have been collected in the presence of sunlight. During polar night period, these instruments were switched off.
(d) Balloon ascents: 50 sonde ascents were taken at the rate of one ascent per week to monitor the ozone concentration and temperature profile in the upper atmosphere. And 15 radiometersonde (RMS) ascents were taken for radiation studies during the year 2000.

Results and Discussion

Climatological data of pressure, temperature and wind speed for each month during the year 2000 are shown in Table-IA.

Surface Observations

(a) Atmospheric pressure: The extra-tropical low-pressure systems are always moving round the icy continent in the clockwise direction between 50°S and 70°S. The centers of the systems depend on the boundary of the two air masses, (i) warm moist air from the mid-latitudes and (ii) the cold dry air from the polar icy continent. Hence the value of the surface pressure changes depending on distance of the low pressure system from the station. Fig. 1 shows the variation of highest maximum mean sea level (MSL) pressure, minimum MSL pressure and MSL pressure of the station. The mean MSL pressure curve shows increasing tendency from January to March and not much variation afterwards up to July. Thereafter, a peak appears in September, falls down drastically in October and again there is increasing tendency up to December. The highest maximum MSL pressure of 1011.9hPa was recorded on 01 September. The lowest pressure of 950.3 hPa was recorded in peak winter on 02 July with the center of the low-

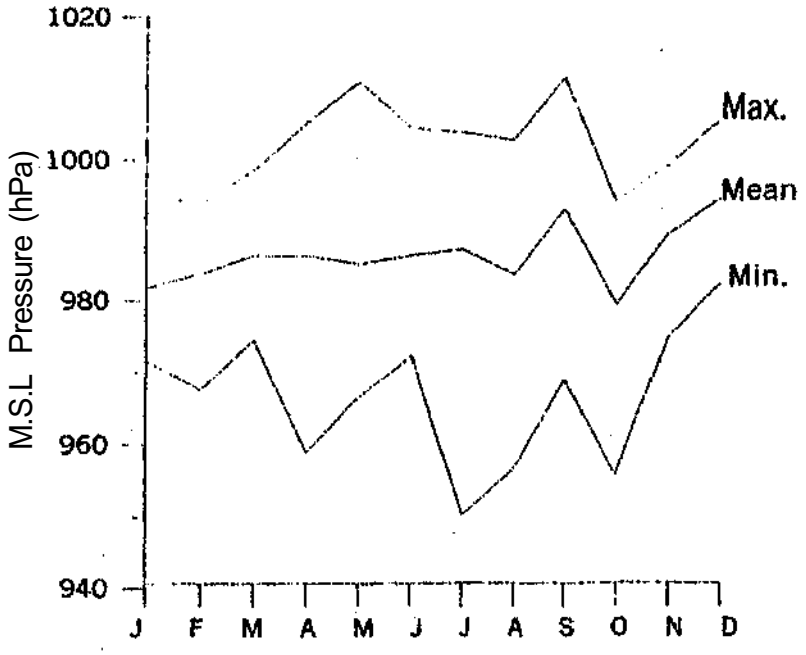


Fig. 1: Annual variation of mean sea level pressure during 2000

Table - 1A: Monthly mean values of met.parameters during the year 2000

Month	MSL Pressure (hPa)			Temperature (°C)					Wind Speed (kts)			Wind .Chill (°C)	
	Max.	Min.	Mean	Max.	Min.	Mean	Av.Max.	Av.Min.	Mean	Max.	Gust	Mean	Lowest
JAN	994.7	971.6	981.8	5.6	-8.1	-0.7	2.3	-4.6	14	34	47	-12	-24
FEB	993.8	967.8	983.9	4.6	-11.0	-3.8	-0.9	-7.5	16	45	61	-18	-34
MAR	998.6	974.6	986.5	-3.5	-18.8	-10.5	-8.0	-13.6	19	45	61	-28	-41
APR	1005.3	959.0	986.5	-3.8	-18.5	-11.6	-8.9	-14.7	21	40	63	-32	-45
MAY	1011.0	966.8	985.4	-2.0	-29.1	-16.3	-12.6	-19.9	17	46	76	-33	-53
JUN	1004.6	972.6	986.6	-4.2	-25.2	-12.7	-10.0	-16.0	22	50	69	-33	-46
JUL	1004.1	950.3	987.5	-3.0	-29.5	-16.9	-13.5	-20.2	16	50	74	-34	-52
AUG	1003.0	956.6	983.9	-3.9	-33.5	-18.5	-14.5	-22.0	18	55	89	-36	-53
SEP	1011.9	969.2	993.2	-4.6	-31.8	-15.0	-12.0	-18.6	17	48	72	-32	-49
OCT	994.3	955.9	979.8	-5.3	-22.8	-12.1	-9.7	-15.0	20	52	79	-31	-45
. NOV	999.7	975.3	989.7	3.7	-12.5	-4.3	-2.0	-7.7	20	45	70	-21	-37
DEC	1006.1	982.8	994.8	6.2	-9.7	-0.5	2.1	-4.1	11	34	43	-10	-23

pressure system present very close to Maitri, causing a blizzard. The copy of the actual record of barograph (as station level pressure) can be seen in Fig. 2 It is seen that after reaching the lowest value, the pressure shot up by about 30 hPa within 24 hours.

(b) Air temperature: The surface air temperature at Maitri was normally below the freezing point in most of the months except summer. During summer period (15 November to 15 February) the maximum temperature was above freezing level. The diurnal variation of maximum, minimum and mean temperatures during 2000 can be seen in Fig. 3. As the winter approached, the elevation of the sun deceased and the temperature lowered linearly from January to August, except in June, where the mean temperature was about 4 deg. Celsius higher than May and July. This is mainly due to the passage of more number of low-pressure systems crossing Maitri longitude, which brought warm moist air from low and middle latitude which mixed with cold polar continental air raising the air temperature. It is interesting to note that the mean wind speed of June was 5 Kts and 6 Kts higher than that of May and July, respectively. Hence, it may be concluded that in the absence of sunlight, the number of low-pressure systems and the strength of the prevailing wind controls the ambient air temperature. From August, the air temperature rose once again mainly due to the increasing elevation of the sun and so the incoming solar radiation gradually increases up to December. The highest maximum temperature of 6.2°C was recorded on 29th December and the lowest minimum temperature of -33.5°C on 7th August.

(c) Wind speed & direction: Continuous recording of wind speed and direction was made throughout the year. Hourly values of wind speed & direction and maximum gust of everyday were tabulated. Fig.4 shows the monthly variation of mean wind speed, maximum wind speed and maximum gust during the year 2000. The mean wind speed roughly increases linearly from January to April, decreases in May and again attains a peak in June. In July the wind speed decreased significantly and then increased from July to November. In May and July only one low-pressure system affected the station, whereas in June 6 blizzards occurred which caused the rise of wind speed. Maximum wind speed of 55 Kts was recorded in August and the highest maximum gust of 89 Kts was reported on 9th August.

The mean wind speed varied from 11 Kts in peak summer to 22 Kts in peak winter. The wind speed, in general increased from summer to winter and decreased once again when next summer commenced. The wind speed depends on the number of low-pressure systems crossing nearer to the

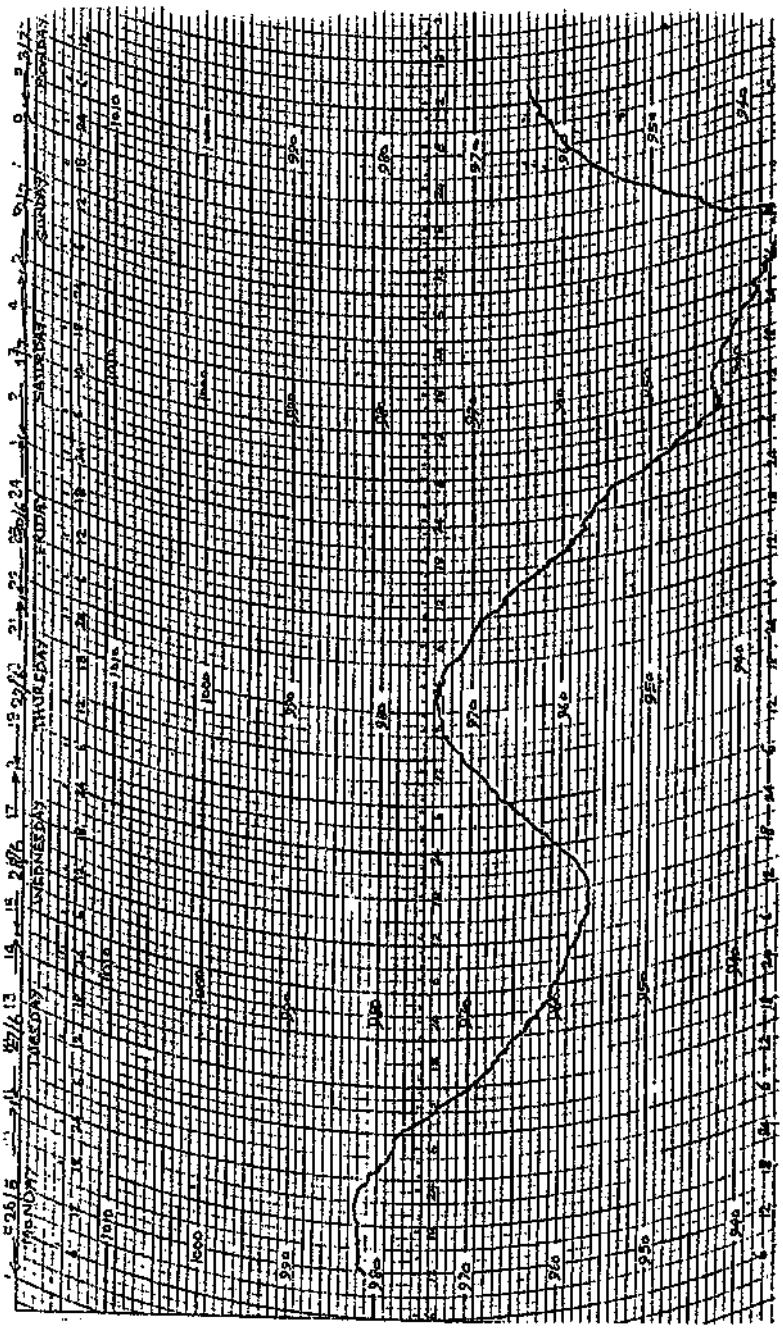


Fig. 2: Barograph chart of Maitri showing the lowest pressure on 02 July 2000

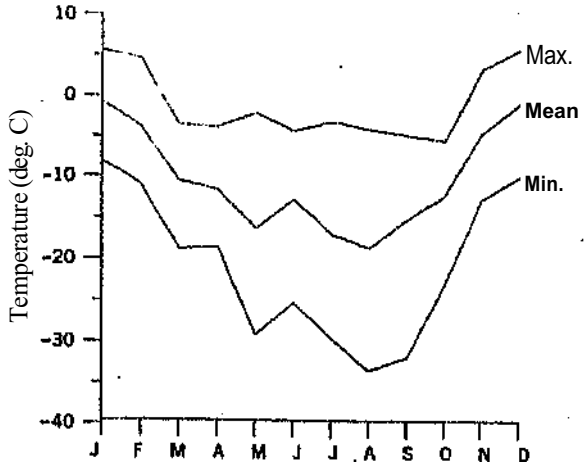


Fig.3. Annual variation of ambient temperature during 2000

station |Even though in August, maximum number of days of blizzard and snow-drift were **experienced over the station, the mean wind speed was 18** Kts only; where as june **reported the maximum mean wind speed of 22 Kts due to maximum number of low pressure systems in that month.**

The hourly direction and wind speed have been tabulated from the autographic chart of wind in each month. The frequency of wind direction is presented in Table-2, The prevailing wind direction at Maitri was southeasterly (SE) except in January whereas ESE direction was dominating and in April and May where southerly (S) direction was dominating. In general, the wind direction was varying between E and S. The wind from other directions are not significant. Another important feature is calm wind

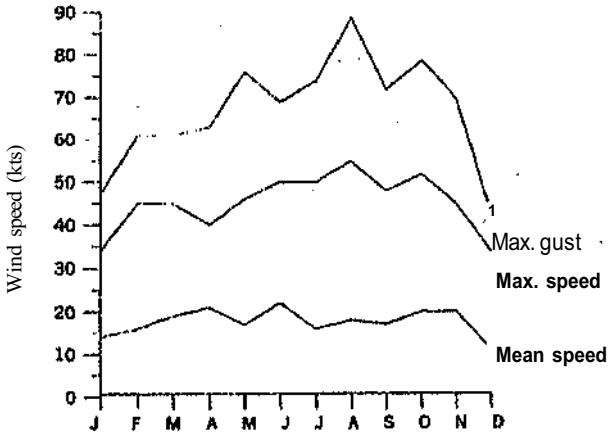


Fig 4: Annual variation of wind speed during 2000

in August, where it has been reported more than 20% and in May more than 15% prevailed at Maitri continuously for 4 days since 1st August, Westerly wind direction was very rare.

(d) Sky Condition: Details of sky condition during 2000 is shown in Table-1(B). During March, April, May and July 10 or more days of clear skies were been observed in each month. Maximum 14 days in March and minimum 2, days in November were reported as clear sky days during 2000. During 19th May to 23rd May, clear sky prevailed for more than 100 hrs continuously. Out of 12 months, 8 months reported more than 10 days of overcast skies each month. Maximum 15 days of overcast skies in August and minimum only one day in December was observed. Sky was obscured for 7 days during the year mainly due to very strong blizzard, out of which 3 days were in August.

Table IB: Sky Condition, Blizzard,Snowfall and Aurora during the year 2000

Month	Number of days						Blizzard			Cloud
	SKC	OVC	OBSD	snow drift	snow fall	aurora	total no.	no. of days	longest	Max. 8 octa
JAN	6	10	0	0	5	0	0	0	0	3.8
FEB	8	10	0	0	4	0	0	0	0	4.4
MAR	14	14	0	7	4	5	3	3	17 hrs	4.3
APR	12	12	1	7	6	11	2	3	6	3.9
MAY	14	5	0	2	3	17	1	3	43	2.9
JUN	7	12	1	0	4	12	2	2	25	4.5
JUL	10	8	1	2	5	9	1	2	7	3.8
AUG	5	15	3	13	14	10	6	9	30	5.0
SEP	4	12	0	4	8	10	1	2	26	5.1
OCT	3	11	0	9	10	4	2	3	17	5.2
NOV	2	8	1	5	9	0	3	4	19	4.8
DEC	4	1	0	0	5	0	0	0	0	4.1

SKC - sky clear; OVC - overcast; OBSD - sky obscurd

(e) Blizzard & snow drift; Antarctica is the home of the blizzard. Blizzards can occur either during snowfall with strong winds or without snowfall due to drifting of fresh loose snow by strong surface winds. To declare a blizzard, the following three conditions were applied:

(i) Wind speed = 23 Kts
(ii) Visibility <1000 m
(iii) Present weather should be blowing snow above eye level (weather code No. 38 or 39)

Table-2: Frequency of wind direction (%) at Maitri during the year 2000

Month	VRB	CAM	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	HRS
JAN	0.0	5.6	4.6	1.5	3.9	9.5	15.9	21.6	14.7	13.6	6.3	0.5	0.4	0.3	0.7	0.0	0.4	0.5	744
FEB	0.9	3.2	4.3	2.0	1.9	3.6	6.3	18.5	21.5	19.5	10.9	0.9	1.0	1.7	0.7	0.7	1.3	1.0	696
MAR	0.0	6.9	0.8	0.1	0.1	0.9	3.6	13.3	36.0	*22.2*	11.8	1.7	0.3	0.4	0.8	0.0	0.8	0.1	744
APR	0.0	4.9	0.3	0.3	0.5	0.0	8.8	3.6	25.3	21.3	36.8	3.3	0.8	0.4	1.0	0.0	0.3	0.4	720
MAY	0.0	16.8	0.7	0.1	0.!	0.1	2.4	4.S	22.0	16.0	2S.0	3.9	1.3	0.4	1.7	0.1	0.8	0.5	744
JUN	1.0	**7.1**	0.1	0.0	0.1	0.3	4.3	13.2	33.9	19.3	18.9	3.0	0.4	0.1	0.0	0.0	0.0	0.3	720
JUL	1.6	11.8	0.8	0.4	0.1	0.4	3.5	9.3	27.6	10.6	21.0	7.8	2.1	0.5	1.7	0.5	0.1	0.0	744
AUG	1.3	20.5	1.8	0.4	0.7	1.2	2.6	12.0	38.0	6.5	7.9	3.6	0.3	0.5	1.2	0.8	0.3	0.4	742
SEP	1.4	12.1	1.0	1.1	0.4	1.3	3.1	17.4	40.5	7.5	8.6	2.6	0.4	0.1	1.0	0.7	0.4	0.4	
OCT	0.4	1.9	1.6	0.7	0.8	1.2	2.7	17.3	46.8	13.0	9.1	2.0	0.3	0.3	0.4	0.4	0.3	0.8	744
NOV	0.1	4.6	1.3	0.3	0.7	2.6	9.5	21.2	38.6	9.6	8.8	1.0	0.1	0.1	.0.7	0.1	0.1	0.4	717
DEC	0.4	6.7	8.1	4.6	6.1	4.4	9.5	11.8	19.7	11.8	7.3	1.2	1.1	0.4	0.4	1.3	2.4	2.7	743

VRB - variable; CAM - calm

To declare snow drift, the following three conditions were applied.

(i) Wind speed =15 Kts

(ii) Visibility >1000 m

(iii) Present weather should be drifting snow below eye level (weather code No. 36 or 37)

Applying above conditions, the blizzard or drifting snow were classified. August showed largest number of 13 days snow drift and summer months (Jan, Feb & Dec 2000) were free from blizzard and Snow drift. Out of 21 blizzards during 2000, maximum of six in 9 days were reported in August. The longest duration of blizzard was 46 hours during 8-10th August. Whenever hurricane wind with fresh snow fall prevailed the visibility reduced to almost zero. Whenever visibility was more than 1000 m irrespective of wind speed, it was declared as drifting snow as per weather code. The history of all 21 blizzards is shown in the Table-3.

(f) A case study of blizzard on 24 & 25 August 2000: On the previous day of blizzard on 23rd August, partly cloudy skies with cirrus clouds in the early hours appeared in the sky. It became dense cirrostratus during mid-day and later the sky was overcast with medium clouds. Drifting snow was experienced due to very strong wind which continued on the 24th also. On 24th, at 0630 hrs UTC, southeasterly (SE) wind became stronger from 32 to 42 Kts with blowing snow and reduced the visibility to less than 1000 m. In the meanwhile, light continuous snowfall reduced the visibility to less than 50 m. At 1200 UTC , wind speed was maximum of 55 Kts. The sky was overcast throughout the day with altostratus (AS) clouds. The pressure chart is shown in Fig.5. On 23rd there was a low-pressure system centered at about 64 S/12 W and another feeble low centered at 62 S/40 E. The trough extended through 65 S/12 W, 68 S/15 E, 68 S/30 E and *66* S/40 E. This system intensified into an extra-tropical cyclone centered at 64 S/ 00 E with central pressure of 948hPa centered at 64 S/00 E. In addition, there was a subtropical ridge, extending southwards up to 67 S/38 E and an unusual high centered at 48 S/38 E. Due to this peculiar situation, Maitri experienced snowfall, strong drifting snow and blizzard from 23rd to 28th August. The weather charts of sea level analysis transmitted from Cape Town, South Africa on 24th and 25th are shown in Figs 6 & 7. The system has moved to 40 E on the 29th. The sky was very much clear and maximum wind speed of 58 Kts gusting to 78 Kts was reported on 24th. NOAA satellite picture of 24th and 25th August is shown in Figs 8 & 9. The spiral band of hurricane wind is clearly seen over east Antarctica coast.

Table - 3: History of Blizzard at Maitri during the year 2000

S.N	Commencement		Cessation		MSL Pressure(hPa)		Temperature(° C)		Max. Wind		Duration
	Date	Time	Date	Time	Max.	Min.	Max.	Min.	Speed	Gust	(Hours)
1	16-3-2K	1015	16-3-2K	1900	990.9	988.8	-7.6	-10.0	SE/42	50	9
2	31-3-2K	0430	31-3-2K	0800	985.2	984.8	-11.8	-12.0	SE/38	57	4
3	31-3-2K	1830	01-4-2K	1100	983.8	980.7	-9.0	-10.6	SE/45	60	17
4	22-4-2K	1410	22-4-2K	1700	990.3	989.4	-8.7	-8.8	SSE/40	50	3
5	29-4-2K	1900	30-4-2K	0100	961.4	959.6	-6.7	-6.9	SSE/38	46	6
6	02-5-2K	1610	04-5-2K	1100	984.8	973.4	-7.2	-9.5	SE/55	76	43
7	05-6-2K	1130	05-6-2K	1430	992.7	990.3	-8.0	-9.4	SE/42	60	3
8	30-6-2K	1100	01-7-2K	1200	981.7	966.7	-8.6	-14.5	SE/54	69	25
9	14-7-2K	1500	14-7-2K	2200	994.9	994.2	-11.0	-13.6	SE/42	55	7
10	08-8-2K	0915	10—8-2K	0700	980.9	962.8	-10.4	-20.0	SE/64	89	46
11	14-8-2K	0030	14-8-2K	0715	970.1	965.7	-10.5	-12.0	ESE/46	60	7
12	24-8-2K	0630	24-8-2K	2130	989.1	982.8	-10.4	-12.0	SE/58	78	15
13	25-8-2K	0030	26-8-2K	0630	985.2	966.7	-9.6	-13.0	SE/50	70	30
14	26-8-2K	0830	27-8-2K	0500	973.3	960.3	-5.3	-13.6	SE/50	65	21
15	27-8-2K	1700	28-8-2K	1100	971.7	956.2	-7.5	-10.0	SE/45	63	18
16	25-9-2K	1200	26-9-2K	1600	990.1	979.5	-8.1	-14.2	SE/50	72	26
17	19-10-2K	1100	19-10-2K	1900	983.9	981.8	-10.0	-13.2	SE/30	40	8
18	29-10-2K	1730	30-10-2K	1030	964.6	955.3	-8.7	-15.7	SE/56	79	17
19	04-11-2K	0930	04-11-2K	1700	982.8	980.8	-10.0	-10.6	SE/42	60	8
20	17-11-2K	1300	18-11-2K	0700	992.8	985.2	-5.0	-6.6	SE/54	70	18
21	18-11-2K	1930	19-11-2K	1430	986.5	979.5	-3.9	-7.5	SE/49	66	19

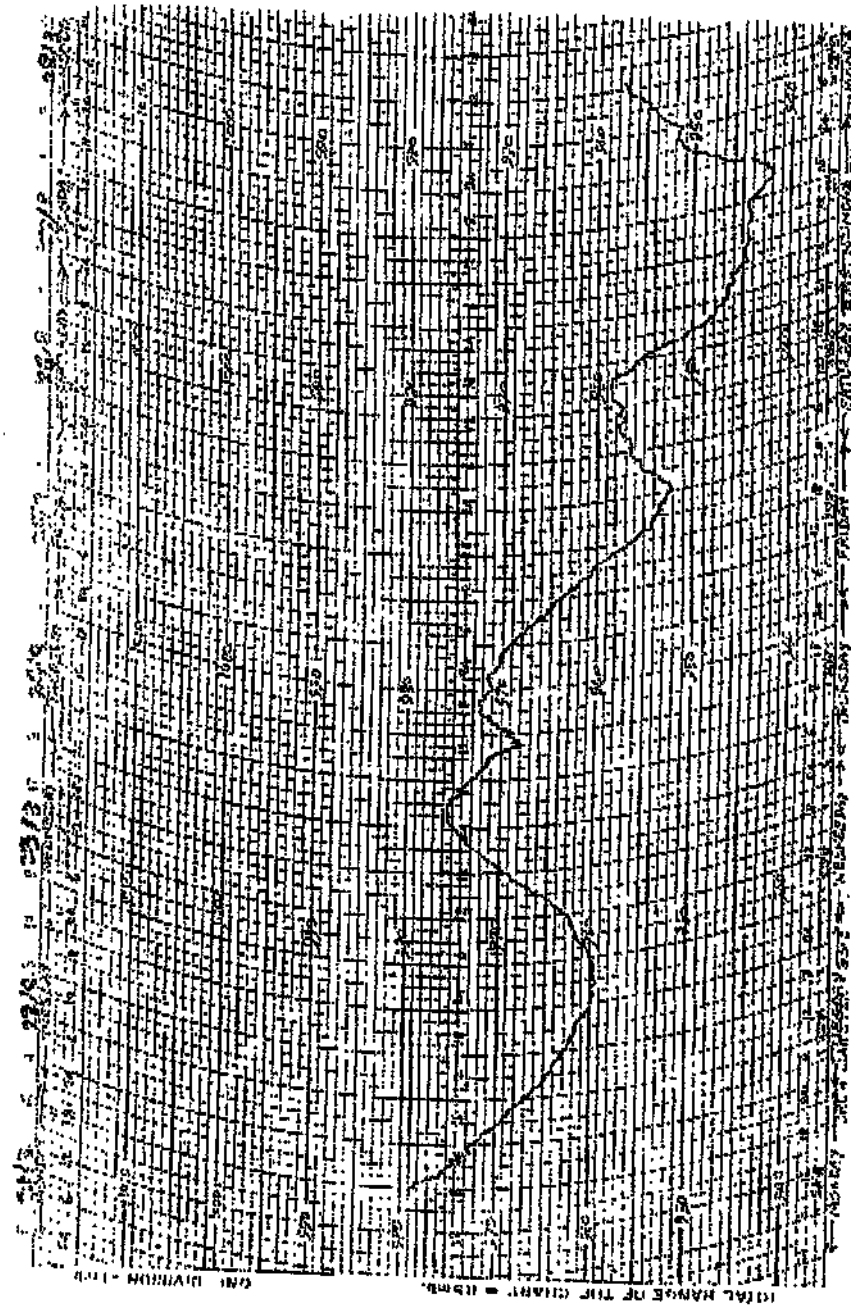


Fig. 5: Barograph chart of Maitri from 22-28 August 2000 during blizzard

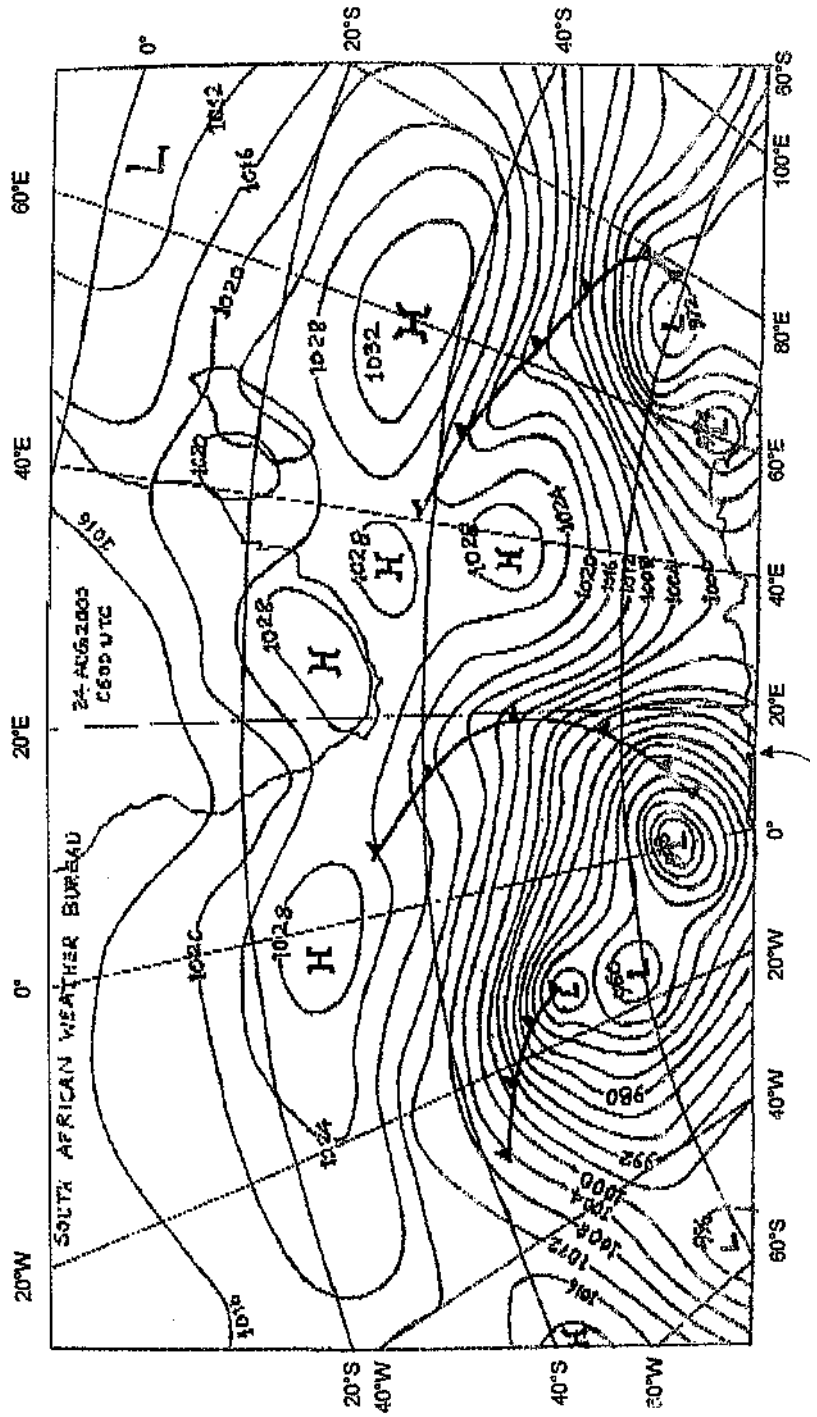


Fig. 6: Weather chart during blizzard at Maitri on 24 Aug 2000

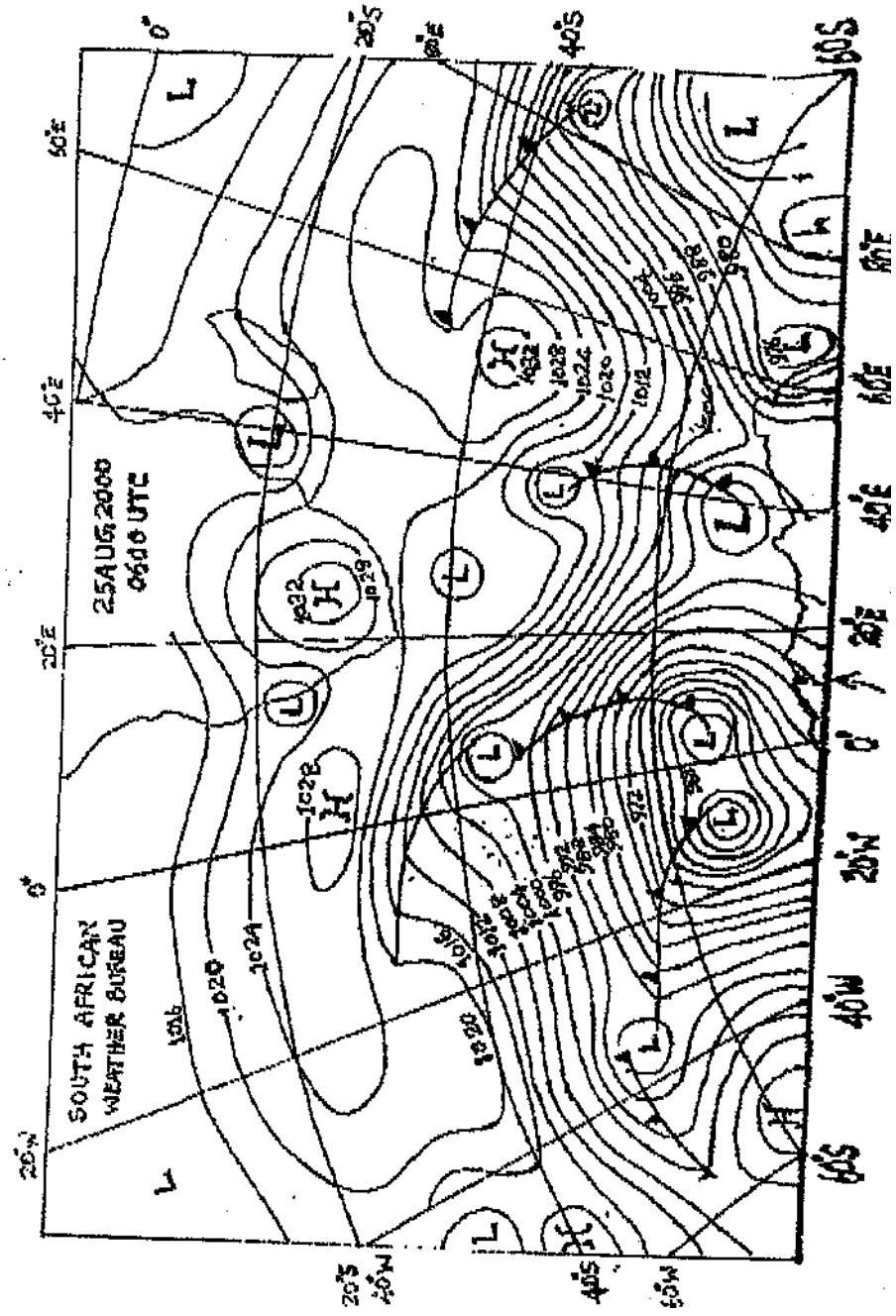
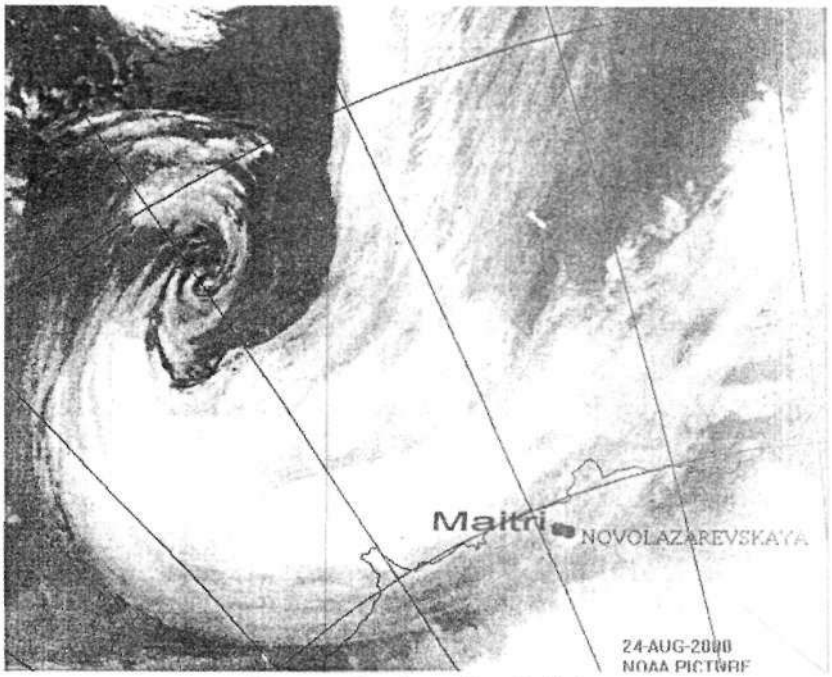


Fig. 7: Weather chart during blizzard at Maitri on 25 Aug 2000



(Courtesy: Novolazarevskaya Station)

Fig. 8: NOAA satellite picture during blizzard on 24 August 2000

(Courtesy: Novolazarevskaya Station)

Fig. 9: NOAA satellite picture during blizzard on 25 August 2000

(g) Cloud cover: Mean cloud cover of each month has been calculated from 8 synoptic observations in each day and shown in the Table -IB. Highest cloud cover of 5 octa was reported in October. In the month of May, the lowest value of 3 octa was reported due to less number of low-pressure systems crossing nearer to the station. In summer, low clouds of stratocumulus (SC), altocumulus (AC) and altostratus (AS) type were seen. From March to November AS and CS type of clouds were observed.

(h) Precipitation: Precipitation was mostly in the form of snow flakes and snow grain in Antarctica. Snowfall was measured after melting the snow. Snowfall was reported during all months. Out of 219.7rnm of total snowfall during 2000, August reported 88.4mm of snowfall on maximum number of 14 days. Whenever the wind was strong, the dry snow was drifted from one place to another causing very poor visibility due to blizzard.

(i) Fog: Formation of fog is very rare in the icy continent as the availability of moisture is very less. Maitri experienced for only 2 days of fog in December and 1 day in May. All the 3 days the fog was advection type. The ground inversion extended up to 500 m on 1st May and 12th December. The wind speed was calm/light with variable direction. The temperature profile of atmosphere on 12th December and the satellite picture are shown in Figs 10 & 11, respectively.

Vertical Distribution of Ozone: Ozonesonde ascent has been an important part of scientific programme of IMD in every Antarctic Expedition. To investigate ozone depletion in the stratosphere/ozone hole over Antarctica, one ozonesonde ascent was taken per week. Depending upon the wind speed, 50 balloon ascents were taken during 2000. Most of the ascents reached up to 30 km level. Vertical distribution of ozone concentration and temperature in each ascent were computed and analyzed. Few important profiles of ozone and temperature are shown in Fig.l2(a) to Fig. 12(h). During most of the season, in the lower level, ozone concentration was very less and increased gradually from 15 km and above attaining maximum concentration of ozone at about 20 km. Later, it gradually decreased in the higher level. 80% of ozone production occurs in the stratosphere (between 80hPa and 10hPa with peak at 50 hPa). The partial pressure of ozone was maximum (about 50 hPa) during summer months and the temperature at that level was higher than -40°C. In May, maximum ozone concentration was seen between 90 hPa and 10 hPa and the temperature gradually fell *to* less than -70°C in the stratosphere. In September , (beginning of spring season) the production of ozone in the stratosphere reduced significantly and maximum ozone level lowered between 100-200 hPa. The temperature in the stratosphere dipped below -75°C. During the 1st week of October,

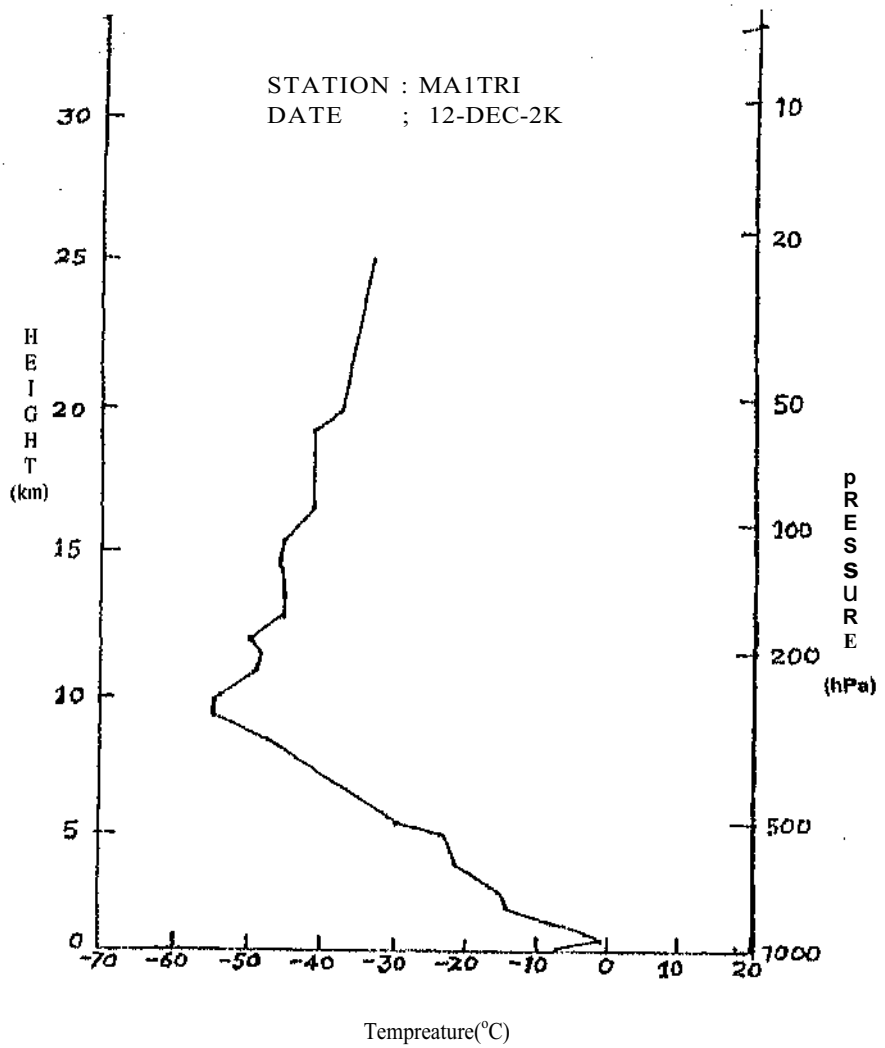
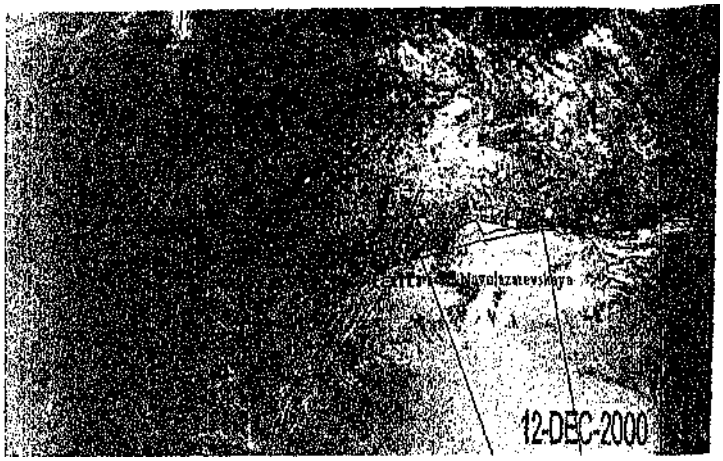


Fig.10: *Temperature profile of Maiiri during fog on 12 Dec 2000*

ozone concentration in the stratosphere depleted too much between 90 hPa and 40hPa and the maxima occurred in the higher level between 30hPa and 15hPa (23-28 Km).The temperature of stratosphere sank below -80°C, This condition can be seen from the ozonesonde ascent of 6th, October. There was no significant change till mid-October. From the third week of October, ozone production in the stratosphere improved gradually and the temperature exceeded -75"C. During November, there was replenishment of ozone. Maximum ozone concentration was seen about 35hPa. A sudden stratospheric warming was observed with temperature



(Courtesy: Novolazarevskaya Station)

Fig. 11: NOAA satellite picture during fog on 12 December 2000

shooting up from -55°C to -25°C in the last week of November. This can be seen from the ozone and temperature profiles of 25th November ascent. During stratospheric warming, there was an increase of partial pressure of ozone. During December, the ozone concentration became normal and a maxima appeared nearer to 50 hPa (about 20Km). The depletion of ozone totally disappeared.

Global Solar Radiation: Global solar radiation measurements were recorded using pyranometer. More than 60% of total solar radiation of the entire year was received during summer months (Dec-Feb). Due to more than 20 hrs of sun-shine, the exposed land warmed up, melting the snow and ice. Maximum solar radiation of 980.42 MJ/m^2 was received in December. A little lesser value of 960.19 MJ/m^2 solar radiation was received in January. During polar night period, there was no incoming solar radiation and the continent lost terrestrial radiation as long wave radiation. In May and July the radiation was very meager. Day-to-day radiation is presented in the Table-4. The monthly variation of radiation is shown as histogram in Fig. 13.

Katabatic Wind: The interior of the icy continent is having high altitude peaks and the ice plateau sloping downwards towards the coast on all sides. South of Maitri, there are Wohlthat mountain ranges. In summer, especially after 1800 hrs local time, the wind direction changes to southerly component (160° to 200°) and wind speed become stronger in the midnight (0000 UTC) and southerly wind prevailed till next day morning. Table-6 shows the number of Katabatic wind days during 2000. Maximum number of 19

TabIe-4: Mean Diurnal Variation of Wind Speed (kt) during the year 2000

Month.	1	2	3	4	5	6	7	S	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
JAN	13.6	13.6	14.5	15.1	16.5	17.1	17.3	15.6	15.S	15.7	15.5	14.3	12.S	12.1	11.2	10.3	10.1	10.5	9.2	9.4	9.3	12.3	13.6	14.0
FEB	19.3	19.4	20.4	20.2	19.7	20.2	1S.3	17.8	16.3	17.7	15.S	16.2	15.6	14.3	13.0	12.4	11.8	12.0	12.5	13.7	15.1	17.0	18.4	18.5
MAR	22.1	21.6	22.3	21.5	21.3	22.1	20.1	18.2	7.7	17.1	17.6	17.0	15.7	15.6	16.4	15.7	15.4	16.4	17.6	18.0	18.6	18.7	20.0	21.9
APR	24.1	23.0	23.4	23.6	23.2	23.S	23 2	22.3	21.9	21.5	21.5	20.4	19.5	20.2	21.0	20.1	19.9	22.9	23.1	24.0	23.1	22.8	23.2	23.2
MAY	17.0	18.2	18.2	17.2	17.3	16.3	16.7	16.6	16.2	17.7	17.3	17.0	15.0	17.2	15.9	16.7	1S.0	18.3	16.6	17.2	17.8	16.9	17.7	17.8
JUN	22.1	23.7	22.6	20.7	23.1	20.4	21.1	20.9	20.6	22.3	22.S	23.5	22.8	22.8	23.2	21.4	21.4	22.5	21.9	21.5	22.2	22.3	21.2	21.9
JUL	17.6	15.7	16.0	16.1	15.4	16.3	16.1	15.5	14.8	15.4	16.4	15.0	15.2	16.1	16.6	15.9	17.1	16.S	18.7	18.6	16.7	15.9	15.2	16.5
AUG	19.1	18.0	18.3	18.4	17.7	17.6	18.5	16.S	17.9	16.3	17.3	1982	16.8	16.8	16.5	17.1	17.7	18.6	17.9	18.8	19.9	21.0	20.4	20.3
SEP	18.4	16.8	17.3	17.4	18.2	17.8	18.1	18.1	16.9	17.0	16.0	17.3	16.8	16.1	16.5	15.2	15.7	16.4	17.8	17.2	17.7	17.8	17.7	17.2
OCT	22.9	22.9	22.5	22.5	22.5	21.1	20.7	19.7	20.2	19.1	18.9	18.7	18.1	17.9	16.9	17.2	16.9	16.7	17.0	19.0	19.7	20.2	21.0	21.7
NOV	22.0	21.7	23.1	23.2	23.1	23.2	22.6	22.2	21.9	21.5	20.7	19.3	19.3	18.9	18.3	17.7	16.4	16.8	18.3	17.9	18.4	19.8	20.0	22.5
DEC	11.1	11.7	12.2	12.1	13.5	12.8	12.9	14.3	14.2	13.4	12.1	13.1	12.1	11.5	9.3	9.3	9.3	8.8	8.2	7.6	7.7	8.8	10.0	10.5

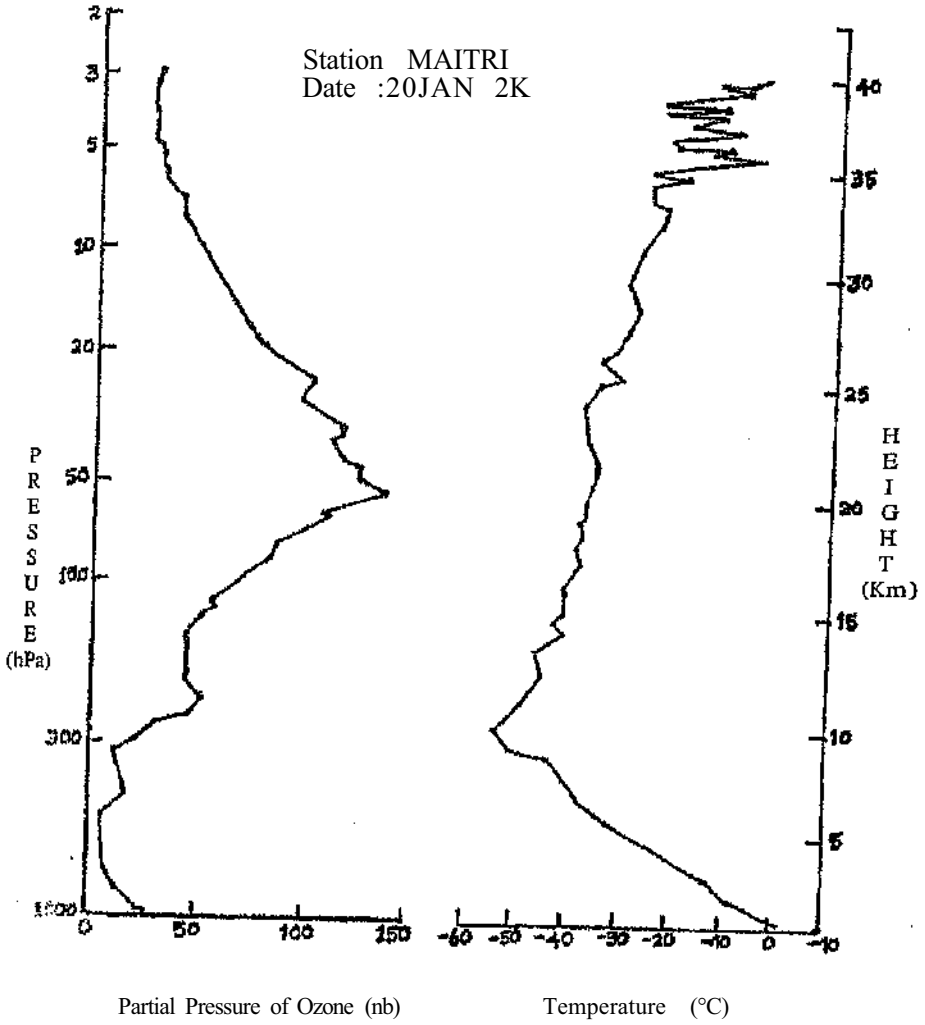
Table - 5: Total Global Solar Radiation (MJ/m^2) during the year 2000 at Maitri

DATE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	34.95	7.72	17.32	2.06	0.29	0.00	0.00	0.13	4.02	12.34	24.66	29.72
2	33.84	7.58	17.16	2.74	0.04	0.00	0.00	0.24	2.66	12.79	19.60	32.12
3	34.36	27.51	15.93	6.16	0.02	0.00	0.00	0.16	3.33	11.05	28.30	24.34
4	33.58	25.78	8.65	5.65	0.07	0.00	0.00	0.18	4.67	5.85	12.02	27.86
5	31.26	23.42	10.65	1.76	0.10	0.00	0.00	0.52	4.80	11.16	26.30	18.06
6	30.61	27.63	6.48	4.97	0.64	0.00	0.00	0.78	2.21	15.49	27.81	30.04
7	34.04	17.82	13.88	2.64	0.45	0.00	0.00	0.88	3.68	16.74	20.15	40.03
8	32.33	25.69	13.76	4.37	0.48	0.00	0.00	0.06	3.13	8.09	28.21	36.24
9	26.88	24.09	13.82	3.95	0.27	0.00	0.00	0.04	2.25	16.97	18.41	32.61
10	24.66	25.40	12.64	1.62	0.05	0.00	0.00	0.47	2.91	16.61	16.86	35.75
11	30.00	7.82	12.24	3.79	0.14	0.00	0.00	0.78	6.20	18.15	26.80	35.12
12	36.29	23.21	11.20	3.44	0.03	0.00	0.00	0.44	6.38	19.10	24.15	34.54
13	35.24	24.73	13.06	3.12	0.08	0.00	0.00	0.65	6.62	18.20	31.68	37.98
14	23.89	23.78	13.32	2.93	0.02	0.00	0.00	0.32	2.70	18.50	32.04	33.28
15	33.53	24.27	3.64	0.93	0.22	0.00	0.00	0.24	5.73	13.77	21.80	37.08
16	27.58	14.38	3.37	3.70	0.02	0.00	0.00	0.54	8.06	13.07	31.71	30.22
17	38.04	22.89	11.50	6.11	0.00	0.00	0.00	0.44	3.86	11.33	12.24	38.73
18	38.51	22.61	11.14	1.99	0.04	0.00	0.00	1.68	4.50	7.44	12.36	34.85

(Contd)

Table - 5: Total Global Solar Radiation (MJ/m^2) during the year 2000 at Maitri *(Contd)*

19	37.44	16.66	5.45	0.69	0.00	0.00	0.00	1.79	5.13	9.36	8.55	34.59
20	37.11	19.51	10.12	0.86	0.00	0.00	0.00	1.35	9.14	14.97	16.20	34.05
21	36.78	12.76	8.73	1.29	0.00	0.00	0.00	1.54	9.31	18.94	17.55	29.78
22	34.64	21.81	2.54	0.75	0.00	0.00	0.00	**1.29**	7.37	18.06	27.27	30.34
23	34.95	19.21	3.71	**1.19**	0.00	0.00	0.00	1.40	5.26	21.66	30.32	30.79
24	34.14	20.54	7.83	1.29	0.00	0.00	0.00	0.21	3.71	16.79	26.13	27.16
25	32.74	19.94	S.86	0.97	0.00	0.00	0.00	0.63	5.96	23.85	36.17	19.49
26	21.58	8.79	6.00	0.59	0.00	0.00	0.00	1.28	4.54	12.47	36.67	17.47
27	29.24	10.18	6.03	0.48	0.00	0.00	0.00	1.16	8.51	23.96	21.95	31.40
28	14.51	18.82	8.07	0.60	0.00	0.00	0.09	0.84	12.13	24.32	33.87	22.54
29	29.36	12.96	5.22	0.96	0.00	0.00	0.07	1.80	12.20	13.40	16.67	37.37
30	18.77		1.58	0.65	0.00	0.00	0.35	2.14	9.46	14.06	24.01	38.18
31	19.34		1.76		0.00	0.00	0.29	2.79		18.89		38.69
Total	**960.19**	**557.51**	**285.66**	**72.25**	**2.96**	**0.00**	**0.80**	**26.77**	**170.43**	**477.38**	**710.46**	**980.42**



Fig, 12 (a):Ozone and Temperature Profile of Maitri on 20 Jan 2K

days in April and a minimum of 5 days appeared each in August and September. During Autumn period (February to April), the katabatic wind was stronger than during the spring and summer months. In winter, the strength was moderate (about 10-15 Kts). Whenever katabatic winds set in, the sky was clear until the next day morning. After sunset, the air temperature dropped by 1-3 degree Celsius due to intrusion of cold air from south.

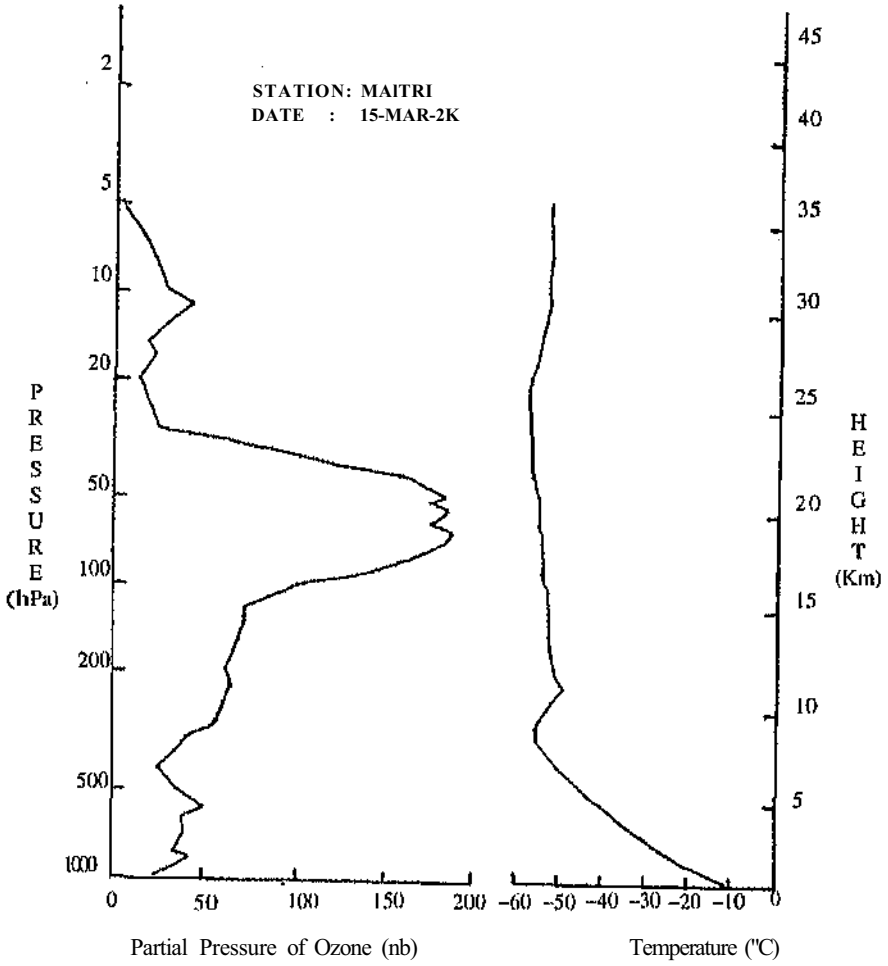


Fig. 12 (b):Ozone and temperature profile of Maitri on 15 Mar 2 K

Wind-Chill Temperature: In Antarctica, when the ambient temperature falls below sub-zero temperature, one ought to know the wind chill temperature in addition to actual air temperature . Human body loses heat when exposed to strong wind speed during field work. To avoid frostbite one should take precautions also. Daily mean wind chill, and lowest wind chill temperatures was calculated form the standard chart. Fig. 14 shows the minimum temperature, mean wind chill and the lowest wind chill temperatures of each month during 2000. The mean wind chill temperature falls from January to August and rises gradually up to December. When we compare with Table 1-A, the mean wind chill temperature is found

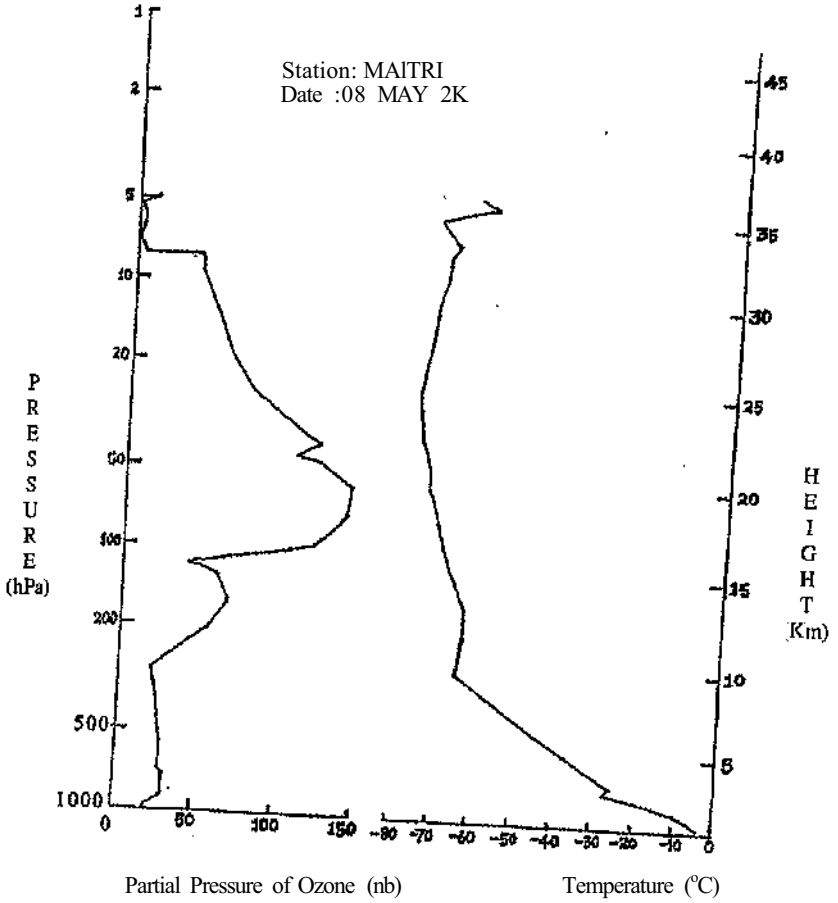


Fig. 12 (c):Ozone and temperature profile of Maitri on 08 May 2K

Table 6: Katabatic windy days at Maitri during 2000

Month	Number of days
January	10
February	17
March	13
April	19
May	14
June	12
July	11
August	5
September	5
October	13
November	9
December	11

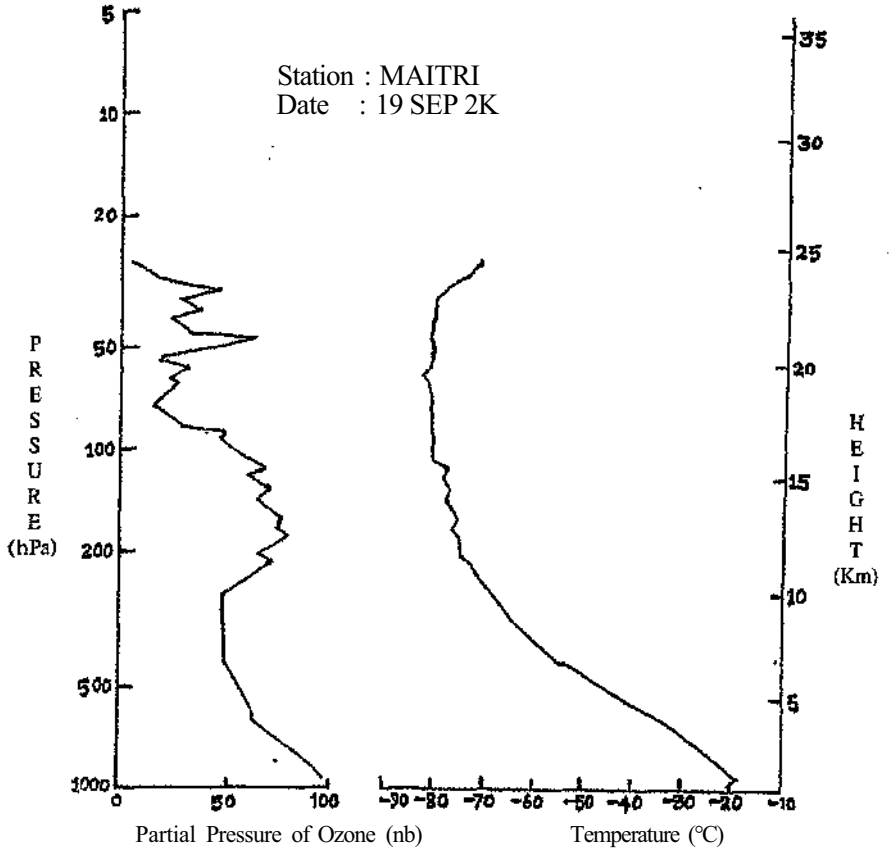


Fig. 12 (d):Ozone and temperature profile of Maitri on 19 Sep 2K

lower by about 10-20 degree than the monthly mean temperature. In the same way the monthly lowest wind chill temperature was very much lower (13-26 deg.C) than the lowest minimum temperature of that month. Lowest wind chill temperature of -53 deg. C was felt in May and August during the blizzard hours. Table-7 shows the salient features of Met parameters at Maitri during 2000.

Met Services to Other Organizations

1. Daily Met reports and forecast facility was provided to helicopter crew to operate the helicopters to various places.
2. With the usage of facsimile weather chart, received from South African Weather Bureau by DEAL communication officers, weather forecasting was given to Indian Army team members for carrying out the convoys between Maitri and Dakshin Gangotri.

Table - 7: Climatological features at a glance at Maitri during the year 2000

S.N.	Meteorological parameter	Value	Date/Month
1.	Highest maximum temperature	6.2 deg.C	29.12.2k
2.	Lowest minimum temperature	- 33.5 deg.C	07-08-2k
3.	Highest mean sea level pressure	1011.9 hPa	01-09-2k
4.	Lowest mean sea level pressure	950.3 hPa	02-07-2k
5.	Maximum gust of wind	89 kts	09-08-2k
6.	Warmest month of the year	- 0.5 deg.C	December
7.	Coldest month of the year	- 18.5 deg.C	August
8.	Windiest month of the year	22 kts	June
9.	Wannest day of the year	3.5 deg.C	29-12-2k
10.	Coldest day of the year	- 30.7 deg.C	07-08-2k
11.	Windiest day of the year	50 kts	09-08-2k
12.	Maximum solar radiation of the year	980.42MJ/m^2	December
13.	Maximum solar radiation day	40.03 MJ/m^2	07-12-2k
14.	Maximum snowfall month of the year	14 days	August
15.	Maximum snowfall day of the year	35.6 m.m	09-08-2k
16.	Maximum number of blizzard of the year	6	August
17.	Longest blizzard of the year	46 hrs	August
18.	Mean temperature of the year	- 10.2 deg.C	
19.	Mean sea level pressure of the year	986.6 hPa	
20.	Mean wind speed of the year	18 kts	
21.	Total precipitation of the year	219.7 m.m	

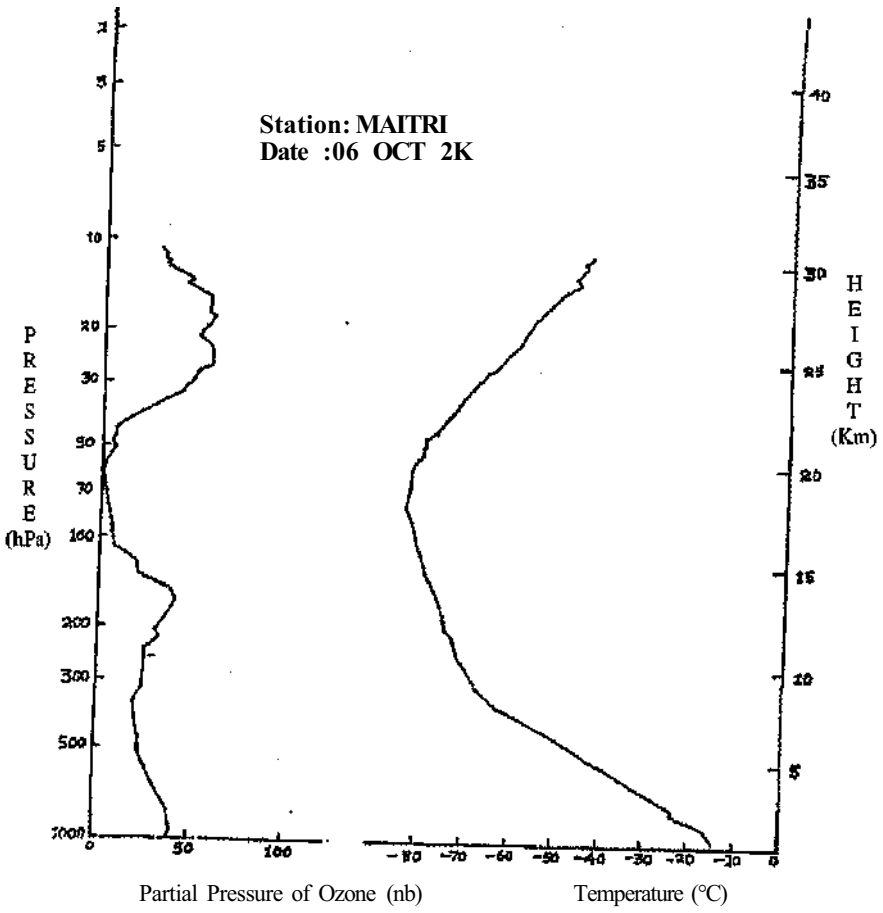


Fig. 12 (e):Ozone and temperature profile of Maitri on 06 Oct 2K

3. Met data were also provided to the Scientists from Snow & Avalanche Study Establishment, Indian Institute of Geomagnetism, Geological Survey of India for their respective studies and special request from ISRO through NCAOR, Goa.

Conclusions

All the proposed experiments were carried out successfully. The analysis indicates that the December was the Warmest month and August was the coldest month of the year 2000. There were 21 blizzards in the year and maximum number occurred in August. The maximum gust of 89 knots was also recorded in the same month. The months January, February

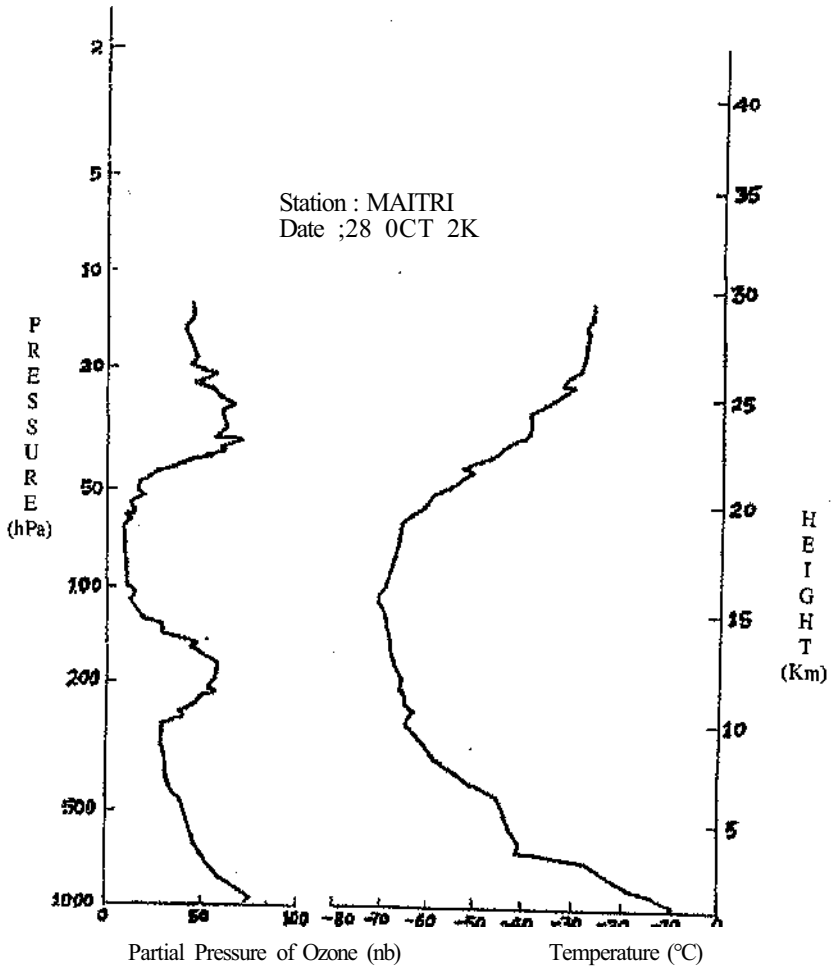


Fig. 12(f): Ozone and temperature profile of Maitri on 28 Oct 2K

and December were free from blizzards. Maximum total global solar radiation was received in the month of December.

As far as Ozone Sonde ascent experiment is concerned, 70 % ascents crossed 20 km height, and provided very good ozone and temperature profile of the atmosphere. The ozone depletion period began in mid-August and exhibited deep depletion between last week of September and first week of October 2000. The recovery of depletion started from mid October onwards and completely recovered to the normal value in the last week of November. The same phenomenon was also observed through Brewer Spectrophotometer. RMS ascents have to be tabulated and analyzed.

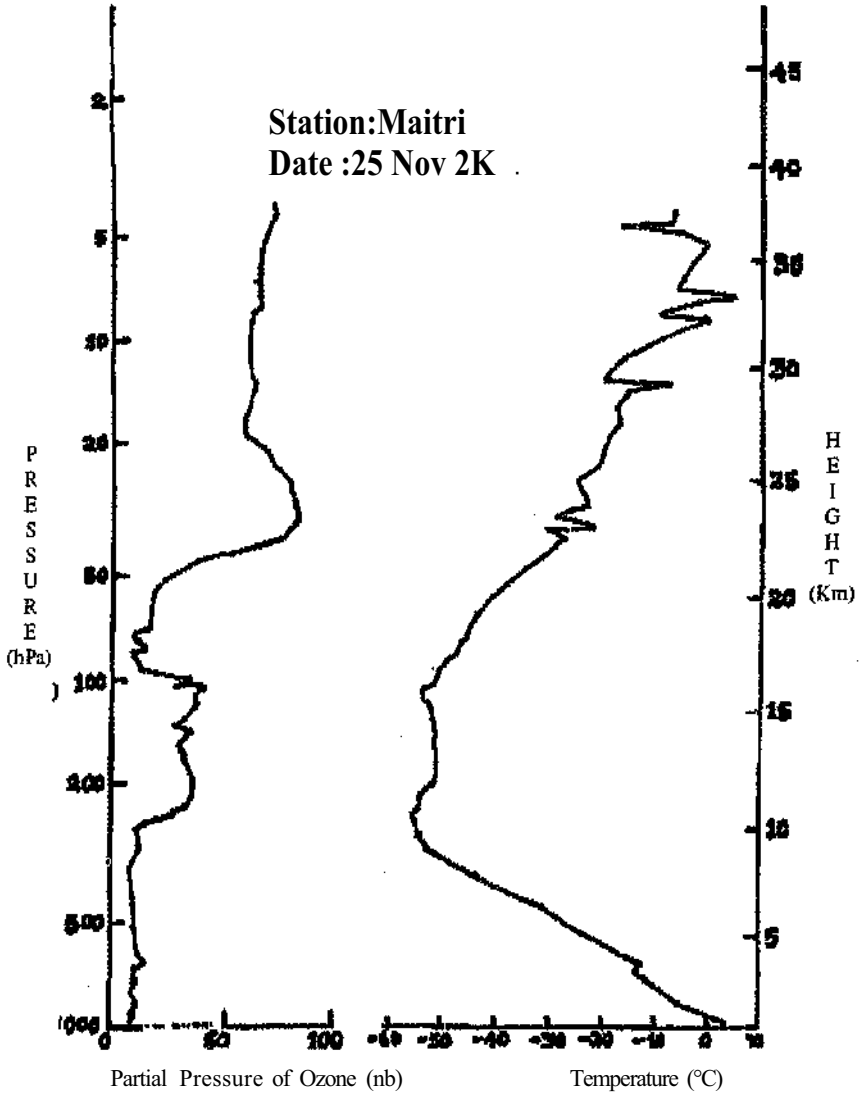


Fig. 12(g):Ozone and temperature profile of Maitri on 25 Nov 2K

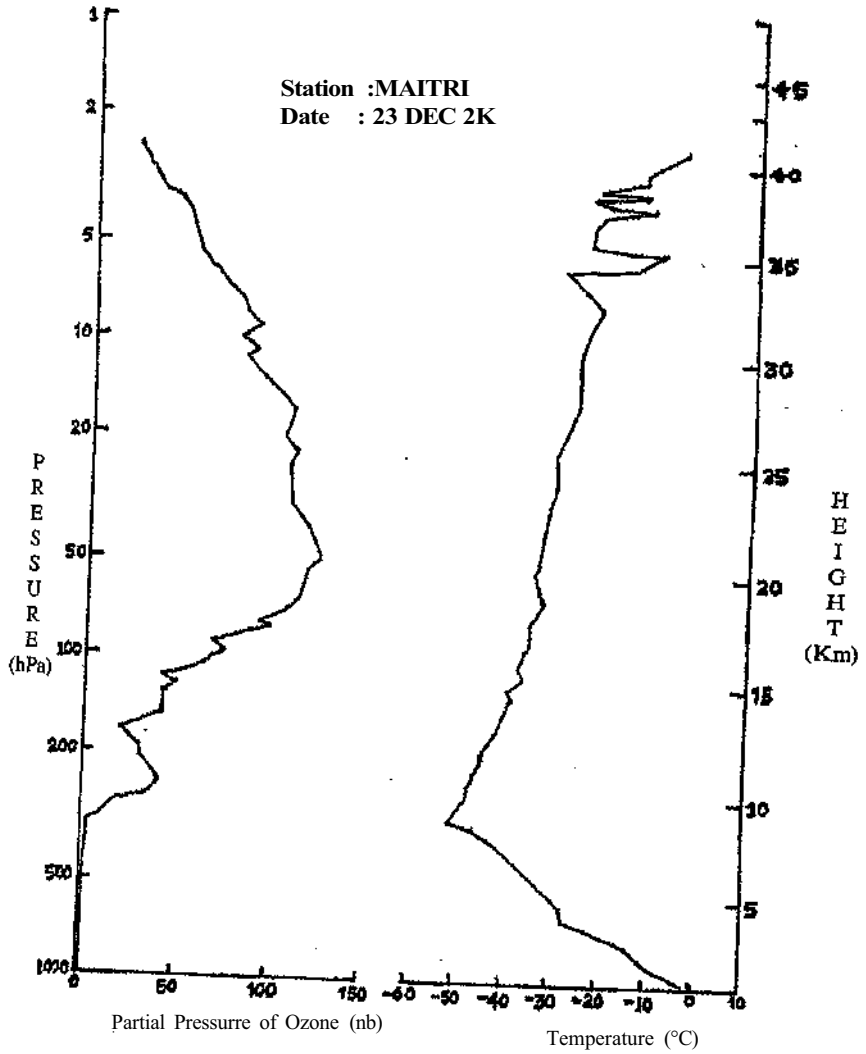
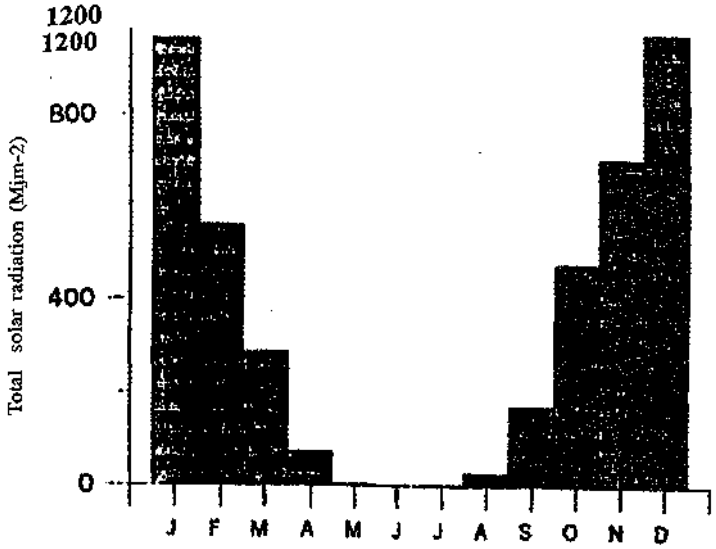


Fig. 12(h)-.Ozone and temperature profile of Maitri on 23 Dec 2K



Fig, 13: Annual variation of global solar radiation during 2000

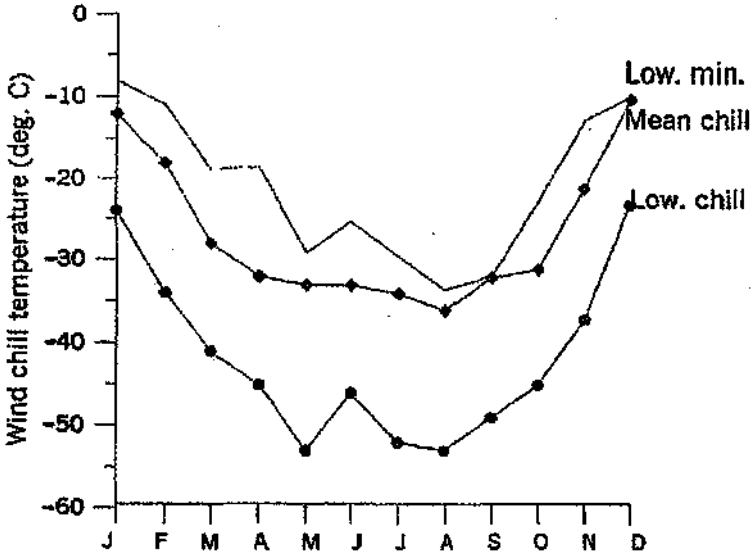


Fig. 14: Annual variation of wind chill temperature during 2000

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