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Meteorological Programme During Summer Period of Twentieth Indian Antarctic Expedition — A Report

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Abstract

The Antarctic continent plays a vital role in shaping the global climate and **will** apparently influence the future global climatic change. Monitoring the Antarctic weather parameters continuously is very important. This paper attempts to highlight the weather parameters observed during Austral Summer of 2001. Based on the observations during both onward & return journeys and at Maitri, latitudinal variation of meteorological parameters, synoptic systems, summary of weather at Maitri is discussed. UV-B radiation, total ozone, N02 and SO, concentrations in the atmosphere and vertical profiles of ozone concentration and temperature studied during the expedition are also reflected.

Introduction

The India Meteorological Department (IMD) has been continuously participating in all summer and winter components of Indian Antarctic expeditions since the first expedition. The aim of the meteorological program is to study and understand Antarctic weather and climate and its relations to global weather systems. IMD is also showing keen interest on the ozone hole phenomenon over Antarctica and is continuing with its monitoring programme of ozone and ozone depletion. Moreover UV-B radiation, total ozone, $N0_9$ and SCX, concentrations are measured using the versatile Brewer spectrophotometer. In addition to the main program at Maitri, IMD is also having program during both onward and return voyages. Three hourly monitoring of weather parameters during voyages give latitudinal variation of meteorological parameters which is also an invaluable tool for weather forecasting all over the world on sea, where the observational network is poor. But due to practical problems and lack of facility in the ship, ozone sonde ascents could not be taken during voyages.

Meteorological Programme

Scientific objectives of the meteorological program during 20th Antarctic expedition included study of Antarctic meteorology in general and the following in particular:

(a) The daily, seasonal and annual variations of atmospheric pressure, surface wind, air temperature and cloud cover.

(b) Study of the radiation budget.

(c) Balloon borne measurements of ozone for its vertical profile over Maitri, Antarctica for the study of ozone hole phenomena **over** Antarctica during spring months.

(d) Measurement of total ozone concentration, D-UV or **UV-B** radiation, NO_2 and SO_2 Concentrations in the atmosphere using Brewer spectrophotometer.

(e) Atmospheric turbidity in Antarctica.

(f) Monitoring and archival of information through weather satellites and HF radio sets regarding weather systems affecting the Antarctic continent.

Outcome

For the first time while in flight from Mumbai to Cape Town **via** Johannesburg and during return flight to Mumbai, upper level observations of meteorological parameters were done which are shown in Table 1.

Table 1: Wind speed & temperature data collected during flight from Mumbai to Cape Town and from Cape Town-Johannesburg-Mumbai

Date	Time (UTC)	Lat. S	Long. (E)	Alt. (Ft)	Wind Dir. / speed (kts)	Temp. (°C)
Onward Journey						
29.12.2000	2245	2°51'	60°45'	35000	170/31	-45
29.12.2000	2330	Equator	58°44	39000	200 / 28	-45
30.12.2000	0200	13°38' S	44°05'	39000	120/08	-55
30.12.2000	0245	17°15'S	38°08'	39000	265 / 07	-53
30.12.2000	0840	30°42' S	22°33'	39000	105/ 19	-51
Return Journey:						
21.03.2001	1105	19°47' S	34°52'	33000	270/ 19	-39
21.03.2001	1236	12°48' S	45°16'	37000	150/15	-48
21.03.2001	1502	Equator	58°48'	37000	140 / 05	-48
21.03.2001	1550	05°00'N	62°20'	37000	090 / 25	-48
21.03.2001	1724	14°36' N	69°21'	41000	270 / 30	-58

Onward voyage

Surface observations: Three hourly surface observations of the following parameters were taken during the voyage from 31st Dec 2000 after leaving Cape Town, South Africa till reaching Antarctica on 12th Jan 2001:

1. Wind speed and direction
2. Visibility
3. Surface pressure
4. Air temperature
5. Humidity
6. Clouds
7. Sea surface temperature and weather

The observations were recorded in the MET -96 registers. But observations could not be passed in real time due to the problem in ship's telex machine.

Return voyage

Three hourly surface observations of the above-mentioned meteorological parameters were taken starting from 8th Mar '01 (from leaving Antarctica) to 17th Mar '01 (till reaching Cape Town, South Africa) and entered in logbook. Observations of meteorological parameters during onward and return voyages are given in Table 2.

Table 2: Observed Latitudinal variation of meteorological parameters during onward and return voyage

Date	**Lat.** S	Long. E	Air Temp. (°C)	Press, (mb)	Wind (kts)	Cloud (octa)
Onward voyage **to Antarctica**						
31.12.2000	35°5'	**17*7'**	17.5	1012.0	230/20	7
01.01.2001	40°3'	17°4'	15.8	1025.0	190/22	6
02.01.2001	44°5'	16°23'	10.8	1015.2	250/07	8
03.01.2001	48°5'	13°58'	7.2	1013.2	330/05	8
04.01.2001	52°4'	11°29'	6.8	997.4	300/16	5
05.01.2001	55°3"	08°20'	0.8	985.0	280/40	8
06.01.2001	59°0'	6°15'	3.8	984.2	250/15	7

(Contd.)

Table 2: Observed Latitudinal variation of meteorological parameters during onward and return voyage *(Contd...)*

Date	Lat. S	Long. E	Air Temp. (°C)	Press. (mb)	Wind (kts)	Cloud (octa)
07.01.2001	63°3'	4°54'	3.8	981.2	140/08	7
08.01.2001	67°5'	4°53'	1.7	983.5	140/05	8
09.01.2001	68° 1'	8°34'	4.0	982.1	020/05	8
10.01.2001	69°3'	10°27'	0.0	985.8	110/10	8
11.01.2001	69°3'	9°28'	2.1	985.5	140/05	7
12.01.2001	69°3'	12°00'	8.7	989.2	150/04	6
Return voyage						
08.03.2001	69°9'	12°47"	-2	990.2	140/05	7
09.03.2001	65°2'	12°4"	0.1	985.5	140/06	7
10.03.2001	62°4'	i3°r	2.8	983.5	140/06	7
11.03.2001	58°0'	14°3'	1.5	996.3	230/06	5
12.03.2001	54°4'	15°2'	-0.1	996.1	320/40	8
13.03.2001	50°4'	15°4'	5.2	1001.9	290/40	3
14.03.2001	47°0'	16°2'	5.2	1003.5	160/18	8
15.03.2001	43°5'	16°9'	10.6	1019.4	200/14	4
16.03.2001	39°8'	17°5'	16.5	1023.0	250/12	3
17.03.2001	36°3'	17°1'	16.5	1022.5	160/20	7

During the journey by flight from Cape Town-Johannesburg-Mumbai, the upper level observations of meteorological parameters taken are mentioned in Table 1. Slight turbulence was experienced and cumulus, altocumulus clouds were seen during both onward and return journeys.

At the Indian Antarctic Base — Maitri

Following parameters were taken while at Maitri during the January and February 2001.

1. Surface observations: Continuos recording of wind speed, wind direction, pressure, temperature and direct solar radiation on self-recording instruments.
2. Recording of 3 hourly synoptic observations.

3. Atmospheric turbidity observations: Turbidity observations were taken on clear sunny days, using sun photometer with filters of 500 nm and 560 nm.
4. Fax reception: Analyzed charts of surface weather were received from Pretoria (southAfrica) on H/F
5. Ozone observations: Surface ozone was being recorded continuously. Ozone sonde ascents were taken at the rate of about once in a week.
6. Total ozone, UV-B, NO_2 and SO_2 concentrations were measured using Brewer spectrophotometer.

Results and Discussions

Weather summary of period during journey

Table 1 gives the variations of wind speed, direction and temperature at upper levels at various latitudes observed between Mumbai and Cape Town during onward and return journeys of the expedition. The values are comparable with the normal.

Latitudinal variation of meteorological parameters during onward voyage from Cape Town to Antarctica and return voyage to Cape Town during Jan '01 and Mar '01 respectively. Table 2 gives the meteorological observations undertaken during both onward and return voyages of the expedition at 1200 UTC.

In general, the weather was fair during both voyages except for small period when the ship negotiated with rough sea weather. The surface pressures during both the voyages are higher in forties of southern latitudes, the sub-tropical high region as seen in fax weather chart dated 31st December 2000 (0600 UTC) Fig. 2. Beyond the sub-tropical high belt up to the periphery of Antarctica, the day-to-day variation of pressures are variable depending upon the presence of the pressure systems and fronts. The meteorological parameters in Table II during onward journey during 5th to 8th Jan 2001 authenticates the rough weather / sea due to pressure system, confronted at 55°S during onward voyage (Fig. 3). Strong surface winds crossing 40 knots were experienced. During the return voyage also, strong surface wind of 40 knots between 55°S and 50°S was experienced due to rough sea / weather associated with the pressure gradients. The Antarctic continent is surrounded with many pressure systems, generally centered / moving in the latitudinal belt 50°-60°S around Antarctic continent which subscribes to a typically unique climatology of the region.

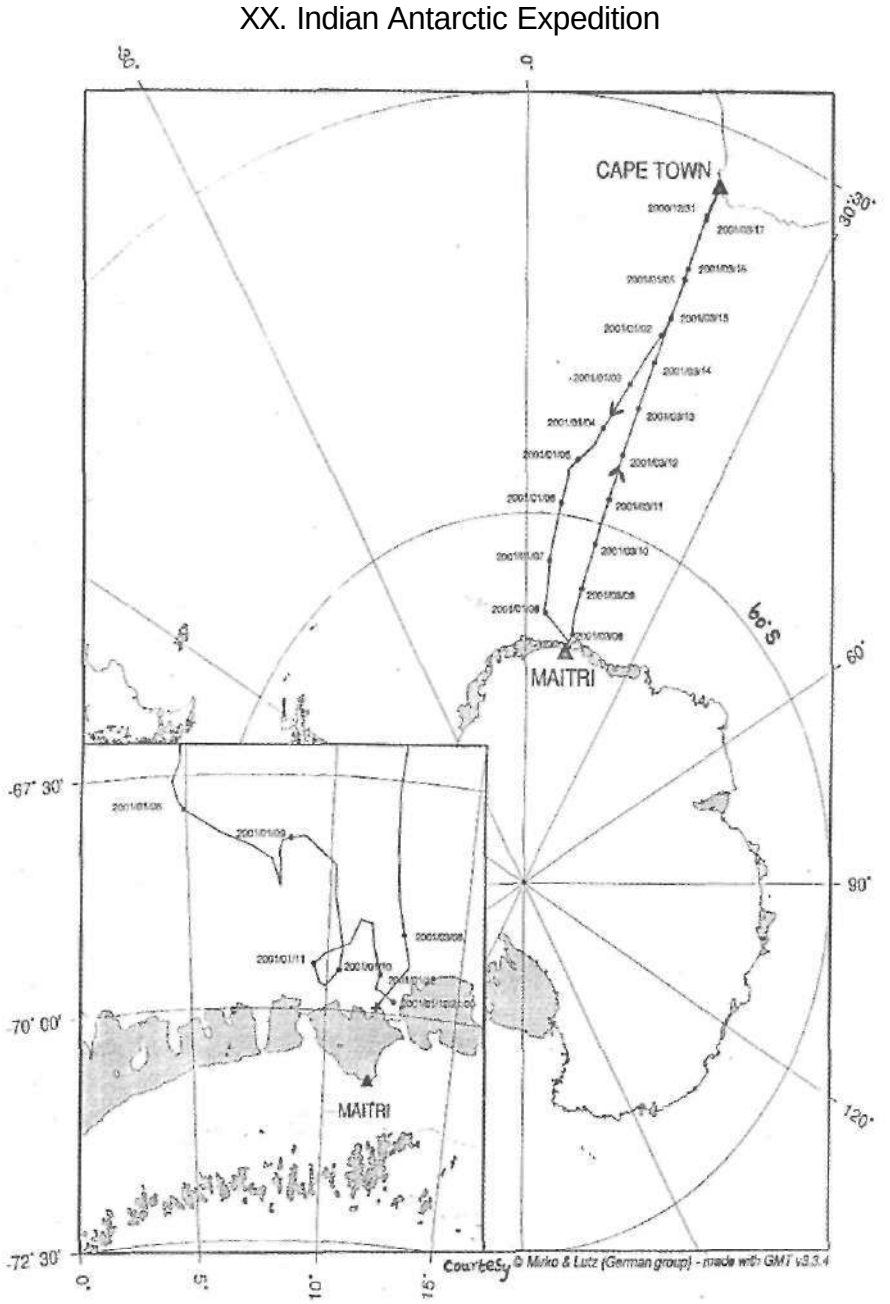


Fig. J: The approximate course of the ship "Magdelena Oldendorjf', chartered for twentieth Indian Antarctic Expedition.

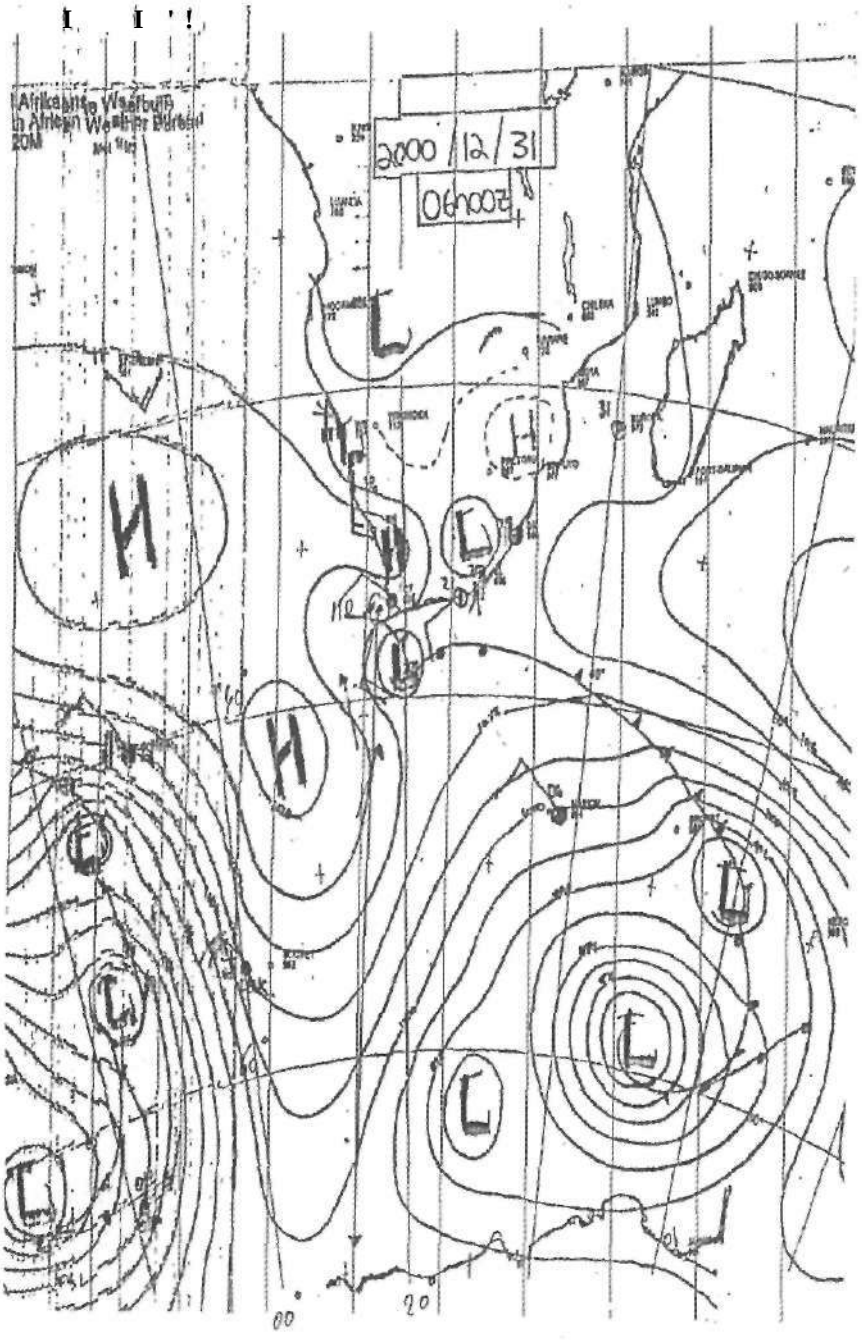
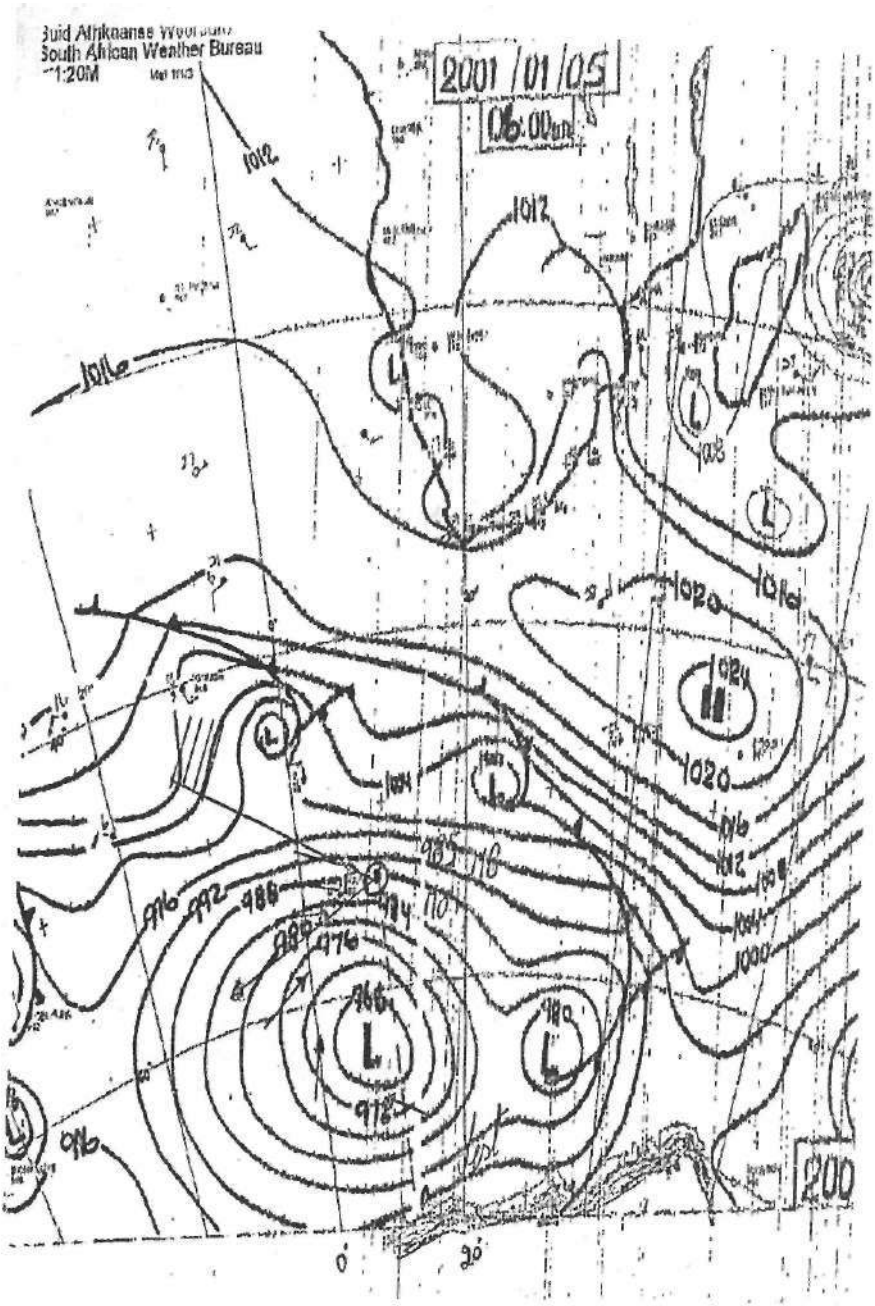


Fig. 2: Analysed isobaric surface chart of 31$^{s'}$ December 2000 (0600 UTC)



F/g.3: *Analysed isobaric chart of 5th January 2001 (0600 UTC) delineating rough weather enroute to Antarctica.*

Table 3: Weather Summary at Maitri (70° 46'S, 11° 45'E)
during **Jan '01 and Feb '01**

Meteorological Parameter	Jan '01	**Feb** '01
1 PRESSURE (hPa)		
Highest / date	1001.6/31^{s1}	1004.7/01^{s1}
Lowest / date	997.2 / 09^{lh}	973.4/ 15*
Average	979.0	989.9
2 TEMPERATURE (°C)		
Maximum / date	5.9 / 01st	3.5 / 05^{lh}
Minimum / date	-6.1/04^{1h}	- 14.0 / 27^{,h}
Average	0.3	-2.2
3 WIND SPEED (Knots)		
Highest / date	35 / 27*	36/ 16^{h}
No. of days with speed > 23kts	13	13
Average	14	16
Maximum gust / date	50 / 27^{,h}	50/ 16^{lh}
4 BLIZZARD	Nil	Nil
5 SKY CONDITION		
No. of days with		
- Clear sky	2	2
- Overcast sky	5	17
- Obscured sky	Nil	Nil
6 WEATHER		
No. of days with precipitation (Snow)	7	6
Fog	1	Nil

Weather Summary at Maitri (70° 46'S, 11° 45'E) during Jan '01 and Feb '01

At Maitri strong surface wind of speed gusting to maximum of 50 knots was recorded on 27th Jan 01 and 16th Feb 01, (OOOOUTC) due to the low pressure systems (Fig. 4). The wind direction was mainly southeasterly as per the general circulation pattern and the cloud types were mainly altostratus and altocumulus.

Information regarding ozonesonde ascents taken at Maitri during Jan-Feb '01

The vertical profiles of ozone and temperature from ozone sonde ascents on 16th Jan '01 and 11th Feb '01 are given in Figures 5 and 6.

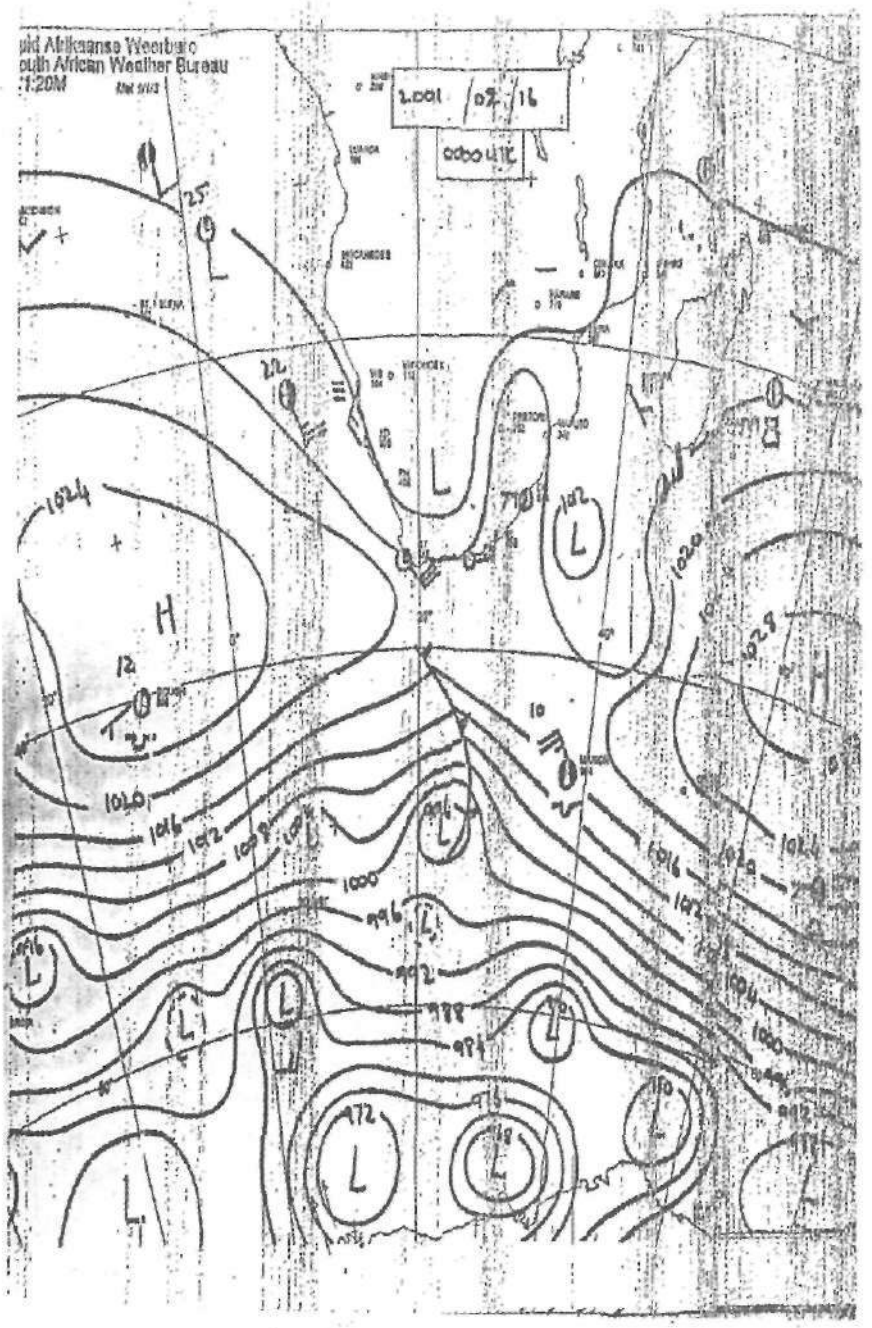


Fig. 4: Analysed isobaric chart of 16^{h} February 2001 (0000 UTC) delineating low pressure system near Maitri that caused strong surface winds

Table 4: Information regarding ozonesonde ascents taken at Maitri during Jan-Feb '01

Date	Pressure level at which ozone maxima (hPa)	Ozone (partial pressure) (nb)	Temp, (°C)
16.01.01	35.6	**113.4**	-30.3
24.01.01	41	**126.6**	-34.1
04.02.01	22.3	112.1	-38.7
11.02.01	56.4	111.4	-43.9

The observations made of total ozone concentration, UV-B, NCX„ $S0_9$ concentrations in the atmosphere Using Brewer spectrophotometer is given in Table 5.

Table 5: Summary of measurements taken using Brewer Spectrophotometer during Jan - Feb 2001 at Maitri

J Days	Date	Total 0_3 (DU)	Max. D-UV (Mw/m^2)	SO_2 (DU)	$N0_2$ (DU)
1	1.1.01	301	124	1.9	1.02
2	2.1.01	293	95	**2**	**0.84**
6	6.1.01	302	125	2.5	1.03
7	7.1.01	299	129	**2.5**	1.06
8	8.1.01	310	118	**1.7**	**1**
11	11.1.01	321	75	**1.3**	0.84
12	12.1.01	302	117	2.8	**1.11**
14	14.1.01	**308**	101	**2.6**	0.94
15	15.1.01	305	112	2.9	1.08
16	16.1.01	311	86	**2**	**0.94**
18	18.1.01	314	106	2.1	0.95
19	19.1.01	307	106	3.2	0.85
22	22.1.01	294	119	2.1	**0.99**
23	23.1.01	285	**111**	**2.7**	**1**
24	24.1.01	292	108	2.4	**0.99**
25	25.1.01	289	107	2.3	**0.96**
26	26.1.01	**300**	100	**2**	**0.89**

(Contd.)

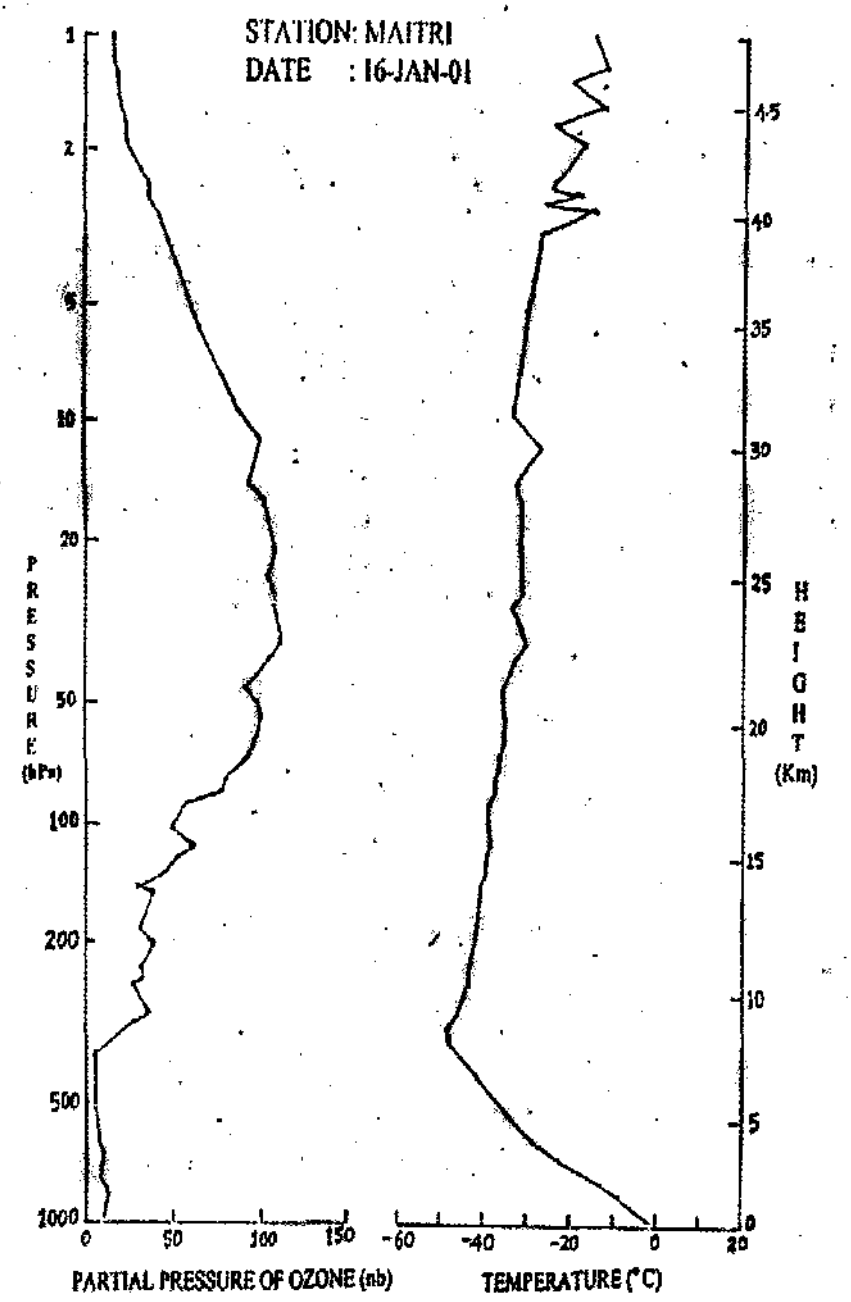
Table 5: Summary of measurements taken using Brewer Spectrophotometer during Jan - Feb 2001 at Maitri *(Contd.)*

J Days	Date	Total 0_3 (DU)	Max. D-UV (Mw/m^2)	$S0_2$ (DU)	NO, (DU)
29	29.1.01	280	104	2.3	0.92
30	30.1.01	279	102	2.6	1.02
32	1.2.01	288	92	1.5	0.86
33	2.2.01	279	97	2.1	0.9
34	3.2.01	274	98	2.1	0.89
36	5.2.01	262	91	3.2	1.01
39	8.2.01	253	88	2.2	0.89
40	9.2.01	251	101	2.6	0.94
41	10.2.01	264	86	2.3	0.83
43	12.2.01	275	60	2.6	1.42
45	14.2.01	298	69	1.4	0.8
52	21.2.01	297	57	1.5	0.71
54	23.2.01	293	55	1.4	0.74
55	24.2.01	291	53	2.5	0.74
57	26.2.01	275	56	1.9	0.93
58	27.2.01	280	52	1.5	0.8
59	28.2.01	288	52	1.5	0.73

Total Ozone

The largest ever ozone hole of size 28.3 million sq.kms over Antarctica was recorded on 3rd Sep. 2000 and reported by NASA. After the revival of ozone in Nov 2000, the total ozone amount became normal in Dec. '00, with the maximum total ozone amount of 335 DU on 1st Dec over Maitri. But the mean values remained 15% below normal. The values indicate that Maitri and Halley Bay recordings are comparable.

The day to day maximum value of ioiai ozone recorded in Jan 0i was 321 DU on 11th Jan, against the maximum value of 301 DU recorded



tig. D: uzone ana temperature projue oj uzonesonae Ascend oj 10 January 2001 over Maitri.

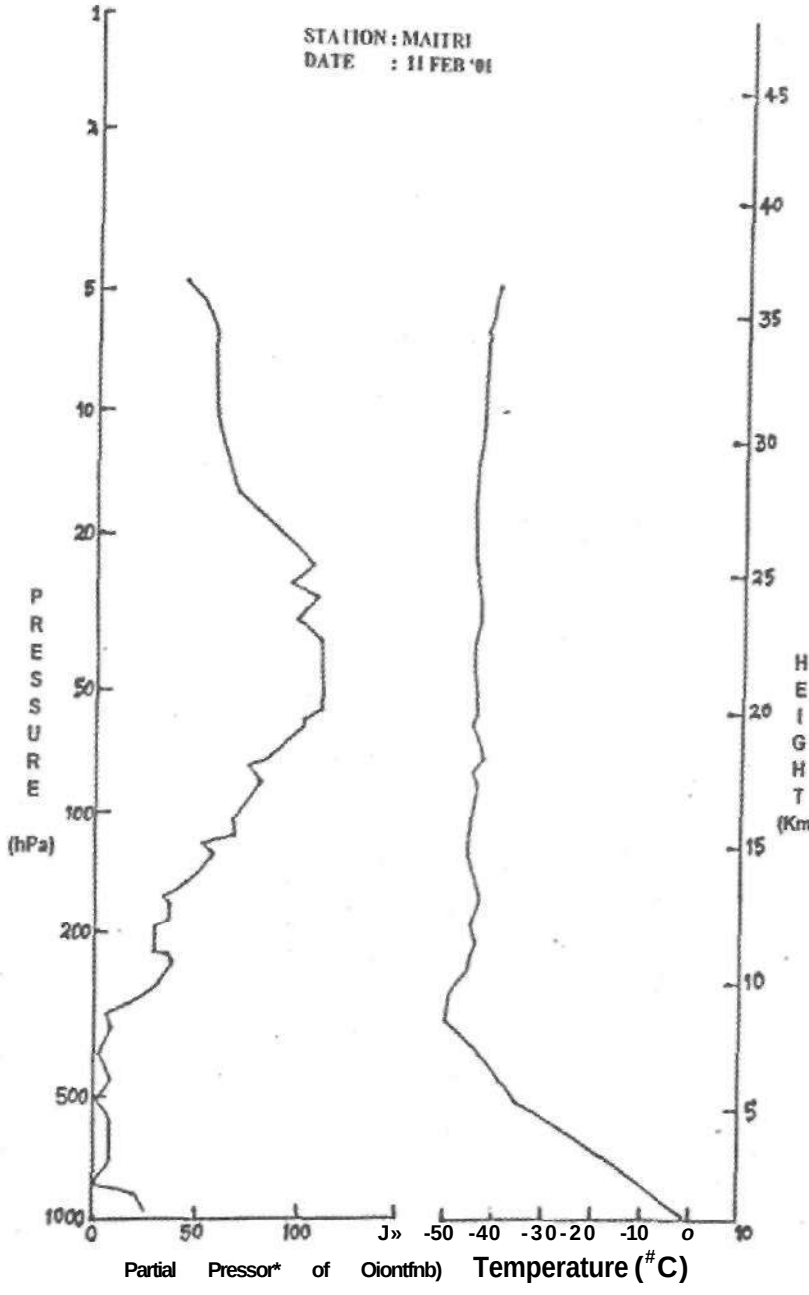


Fig. 6: Ozone *and temperature propie of Ozonesonae on 11 February 2001 over Maitri*

on 15th Jan '00. Fig. 7 shows the daily mean total ozone recorded at Maitri during Jan - Feb '01. During the first week of Feb '01, the mean total ozone of 270 DU was recorded. The maximum total ozone was 298 DU on 14th Feb'01.

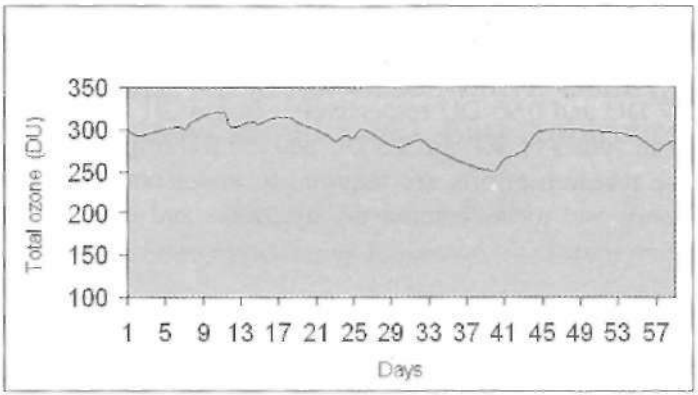


Fig. 7: Daily mean total ozone during J an-Feb '01 at Maitri

However the average values of total ozone during the period Dec '00 - Feb '01 never reached those of pre-ozone hole times.

UV-B

The damaging UV radiation (D-UV) or the UV-B radiation of wavelength 280 - 320 nm has been measured. As the sun's elevation decreases day by day, the intensity of UV-B radiation also decreases as shown in the Fig. 8. Maximum UV-B value recorded on 7th Jan '01 was 129 mW / m^2 which is lesser than 142.5 mW / m^2 recorded on 2nd Jan

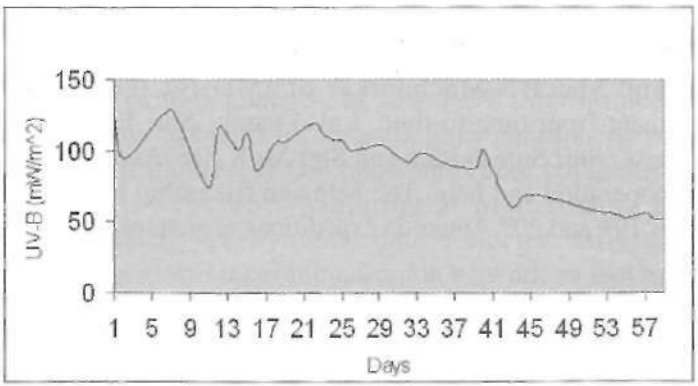


Fig. 8: Daily maximum UV-B during Jan-Feb '01 at Maitri

'00. The lowest recorded value of UV-B was 75.3 mW / m^2 on 11th Jan '01 during which the total ozone value was maximum. This shows that when the value of total ozone increases, the value of UV-B decreases.

NO_2 and SO_2 Concentrations

The monthly mean values of NO_2 Concentrations in Jan '01 and Feb '01 are 0.97 DU and 0.95 DU respectively. In Jan '01 and Feb '01, the monthly mean values of SO_9 are 2.3 DU and 2.0 DU respectively.

Intense research efforts are required to understand the long-term climatic trends and to understand the dynamics and chemistry of the atmosphere.

Weather Service

Weather service in the form of present condition of weather and expected weather in a day or two was being provided from day to day, for planning and execution of flying operations, convoy movements, scientific and other logistic activities. Some of the data collected by IMD scientists was utilized by many organizations, which were the part of the expedition like NEERI, PRL, IIG, DIPAS, and Indian Navy and by the scientists from the University of Dresden, Germany.

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