Sixteenth Indian Expendition to Antarctica, Scientific Report, 2000
Department of Ocean Development, Technical Publication No. 14 pp. 34 to 67

A Report on meteorological studies carried out during XVI Indian Antarctic expedition winter period

S. VENKATESWARLU AND U. P. SINGH
Indian Meteorological Department New Delhi - 110 003

Introduction

The India Meteorological Department has been continuously participating in all the Antarctic expeditions from the beginning, with long-term objectives, To meet different scientific requirements and to build up climatological data, suitable meteorological programme is designed. Members of successive expeditions continue to collect data and progressive analysis is done. The department also provides data for research purposes to other scientific community in addition to valuable service to participating members of the expeditions by way of local weather briefings. The synoptic weather data generated is also transmitted over Global Telecommunication Network (GTN) on real-time basis for use by forecasters around the world.

Scientific Objectives

Scientific objectives for the meteorological programme during XVI Indian Antarctic Expedition are studies on Antarctic Meteorology in general and the following in particular.

1. The daily, seasonal and annual variations of atmospheric pressure surface wind, surface air temperature and cloud cover.
2. The radiation budget studies. Diffuse raditation observations, in addition to direct radiation observations, as well as radiometer sonde ascents.
3. Balloon-borne measurements of ozone for its vertical profile over Maitri, Antarctica for the study of the occurrence of ozone-hole over Antarctica during spring months. In addition, surface ozone measurements on-board the ship during onward and return voyages of the expedition.
4. Monitoring and archival of information through weather satellites and HF radio sets regarding weather systems affecting the antarctic continent.
5. Turbidity in Antarctic atmosphere.

Observational program

To achieve the above objectives, the program is divided into three main groups.

1. Observations during onward cruise
2. Observations at Maitri, Antarctica
3. Observations during return cruise.

Execution of the program

A. During onward cruise by ship MV Polar Bird, ship observations were taken 8 times a day at three hourly intervals form 12-12-1996 to 05-01-97 continuously, except for a break at Mauritius when the ship halted for official purpose. Four (00,06,12,18Z) observations out of them were transmitted to India over Inmersat-C terminal for real-time utilization. This data was also used to establish latitudinal variation of weather parameters during the cruise as discussed.

B. At Maitri, Antarctica, the following scientific work was done.

a. Surface synoptic weather observations comprising of wind, visibility, temperature, atmospheric pressure, clouds and weather phenomenon. Eight observations were taken every day and four out of them were transmitted to India Inmersat-B Telex for real time use.

b. A total of 28 ozone sonde ascents were taken during 1997 and results are presented.

c. Sunphotometer observations were taken during all clear weather days when direct sun-light was available for sufficiently longer duration.

d. Weather charts, whenever received and supplied by DEAL members (Who are the custodians of the receiver and recorder equipment's) were analyzed and used for local weather forecasts.

e. APT satellite pictures were received as required and were of great help in local weather prediction.

f. The following weather parameters were continuously recorded.

1. Surface wind speed
2. Air temperature
3. Atmospheric pressure
4. Global solar radiation
5. Diffuse solar radiation
6. Surface ozone concentration

g. Most of the defective equipment's were repaired and new sensor cables were laid as required.

h. Weather data supplied as and when required for the helicopter flying operations.

i. Management of stores, updating inventory register, finalising and packing all back - loading materials etc. handled.

j. Return Cruise : Studies similar to onward cruise conducted.

Results and Discussion

A. Onward Cruise: The brief outcome of the ship observations during onward journey form Goa port till reaching near Antarctica coast (polynya) waters are presented graphically in figures 01, 02 and 03. Figure 01 shows the ship, MV Polar Bird's Course latitude versus longitude. The graph has got a kink just after crossing equator showing heavy wind, which caused slowing down of the ship's speed. The ship encountered the ITCZ area here. Just after crossing equator, the ship cut across the latitudes faster and maintained a steady course. This was possible because the ship did not encounter any major systems during this cruise.

Figure 02 represents the surface temperature profiles of both 00Z and 12Z observations which shows marginal range in Antarctic waters and almost no range during mid-southern latitudes, It also depicts a wide range just south of equator around 5 degree south where the insolation plays a major role in determing air temperature over the sea surface. The temperature profiles have taken a sharp fall around 40 deg S where the temperature fell drastically and by 50 deg S they were near zero. The interesting feature of this cruise is that the temperatures were not significantly low. This is because no severe polar low pressure system was encountered.

Figure 03 presents the surface wind profile along the cruise. The break in the graph shows that the ship was anchored at Mauritius, for the expedition cargo handling. Though the graph shows significant rise in wind velocity at 60 deg S it is only about 25 kts and lasted for single day.

B. Return Cruise : The ship's traverse in the return cruise in March 1998 is plotted as longitude versus latitude in figure 04. This shows that there is a reduction in the speed of ship between 57deg S and 50 deg S. This is due to high winds experienced in this region. The sailing had been smooth afterwards. A break at about 20 deg S is due to berthing of ship at Mauritius for cargo handling.The sailing had been smooth and fast in polar waters upto 57 deg S because fast ice was not encountered in this region and winds were also relatively light.

Figure 05 shows the variation of atmospheric pressure with latitude along the cruise. Atmospheric pressure has been low around 980 hpa till 57 deg S and m m

rapidly rose to around 1020 hpa at 47 deg S, then gradually fell to 1010 hpa later. A kink at 35 deg S is due to passing low pressure system in this area. The high pressure gradient values around 50 deg S can be attributed to the high winds experienced in this region.

Figure 06 shows the variation of temperature with latitude. The temperature gradually rose form 0 deg C to 5 deg C upto 48 deg S but rapidly rose to 22 deg C at 35 deg S. This rapid rise in temperature indicates the presence of polar convergence zone. Fog also was noticed in this area during which visibility of less than 100 meters was recorded. Temperature remained more or less steady at 28 deg C between 10 deg S and 10 deg N as this region receives uniform solar radiation.

Figure 07 shows the variation of wind with latitude. Winds were lighter in the polar regions, high from 65 deg S to 45 deg S and moderate upto 15 deg S. Winds were again light in tropical region. This pattern is in accordance with the standard pattern of atmospheric circulation.

Height of wind waves over sea area were generally upto 1 metre till 56 cleg S, 1.5 to 2 metres till 47 deg S, around $^{1}/_{2}$ metre upto 17 deg S and almost zero afterwards till reaching India. This is in accordance with the surface wind experienced en route. This also confirms the experience of human discomfort due to rolling and pitching when the wind waves were 1.5 metres or high. This occurred generally between roaring forties and howling fiftees. Due to absence of low pressure systems in Arabian sea no such wind waves or tidal waves were observed.

C. Surface Weather Observations:

Figures 08 to 16 give a detailed picture of variations in different weather parameters like surface atmospheric pressure, air temperature, wind, blizzards, cloud cover etc. at Maitri during 1997.

a) Atmospheric pressure: Figure 08 shows the maximum, average and minimum atmospheric pressure. Monthly maximum and minimum values are obtained by averaging daily maximum and minimum values of pressure. These graphs show that the pressure moved around an annual average of 985 hpa. The variations in January to May and September to December were almost similar indicating limited intrusion of strong high and low pressure areas during this period. Steep fall of minimum pressure in June is a very good indicator of movement of intense low pressure system during this month. Very large variation of pressure of (55 hpa) in June also tells us that intense high pressure system also passed the station during this month for a longer duration.

b) Air Temperature: Figure 09 shows the monthly variation of temperature during 1997-average maximum, average and average minimum. The temperature gradually fell from January to July. But rapidly rase up to December. Upward kinks in the graphs of April. June and August can be attributed to the steep rise in pressure during blizzards.Figure 10 indicates a comparative projection of monthly absolute maximum and minimum temperatures. It can be seen that the range is highest form May till November and least in January and December.

c) Surface Wind: Surface wind variations are shown in Fig.l. The curve of average wind shows that the average wind of the year is around 15 kts. April was windiest with 24 kts as average wind and January and December remained relatively calm at 13 kts. During winter months, July recorded lowest values. The curve of maximum wind during the months shows that May and June experience average peak winds (Not instantaneous gusts) of 66 kts during blizzard. Similarly during November there was a peak wind of 55 kls. Figure 12 shows number of days in each month when the wind has crossed 23 kts. On an average 20 days in each month, wind was above 23 kts. April and November had maximum number (greater than 25 days) of days with wind above 23 kts. Only January and December recorded higher winds for around 10 days. This figure is like a mirror image for the statement "Antarctica is the windiest continent in the world".

d) Blizzards: For practical pruposes a blizzard is defined as a weather phenomenon which satisfy the following criteria.

1. Blowing snow with or without snowfall.
2. Visibility less than 1 km
3. Wind speed greater than or equal to 23 kts.

Depending on the situation to call a meteorological condition 'a blizzard', some times any one of the above criteria is waived off. For example, copious sonwfall is recorded for two days at a stretch followed by winds, as low as 10 to 15 knots can cause a severe blizzard with visibility less than 10 metres as the area covered by snowfall sometimes exceed several hundred square kilometres in Antarctic regions. At times even in very high winds (around *60* to 70 kts) the visibility may not decrease to 1 km level due to little snowfall or very low temp. Such cases are also considered as blizzard.

Figure 13 shows a graph of number of blizzards in each month and number of days with blizzard in each month. Januray , March and December recorded no blizzards, whereas February and October recorded only one in each month which lasted for a day. August recorded 5 blizzards every one of which lasted for shorter duration only. In June, September and November the blizzards lasted for longer durations. Figure 14 shows the duration of longest blizzard in hours in each month. June recorded the longest blizzard which lasted for full 7 days at a stretch followed by the one in November that lasted a little over 5 days. It can be anyone's imagination how it would have been for inmates of Maitri who stayed indoors for 7 days at a stretch in cold polar winter with howling winds and darkness. (Members had. however ventured out regularly in groups for the necessary upkeep and maintenance of the station)

e) *Weather phenomena:* Days with snowfall, drifting snow and blowing snow apart form days with blizzards is analyzed and presented in Fig. 15 as shown.

About 8 days of snowfall is registered in April, May and December: about 5 days in June, July, September, October and November this year. Though snowfall days are less during polar winter days apparantly, a large number of snowfall days are associated with blizzards and could not be confirmed as exclusive snowfall days due to the poor visibility and high winds, Drifting snow was observed for 7 days in November due to availability of fresh snow and light winds during this month. Blowing snow without blizzard conditions was recorded for more than 10 days in April and May. During such blowing snow the visibility will be appreciably good and no snowfall/precipitation was generally observed. Rainfall was not observed during 1997.

f) *Cloud cover analysis:* It is a very wrong notion that people generally express that cloud cover is almost overcast over Antarctica for a good number of days. But the actual analysis of the cloud cover using 8 observations per day yielded the results that are presendted in Figure 16. For the purpose of classification, the following criteria is adopted.

Clear days - cloud cover less than ¼ of sky.

Overcast days - cloud cover more than ¾ of sky.

Obscured days - sky not disernable due to heavy snowfall/blowing snow or blizzard, making it impossible to view and estimate cloud cover.

Clear days generally resulted during the passage of a HIGH or when a 'COL' region was over the station area. Similarly overcast days generally occurred when low pressure systems moved across the station in addition to intense high pressure systems that produced a veil of cirrostratus. Obscured sky was observed in case of blizzards, intense snowfall, and heavy blowing snow. There were about 9 clear days and 7 overcast days on an average per month. January, February, July, August and October recorded 10 or more clear days. April. Recorded abnovrmal by high number of overcast days (21) though obscured days were highest in November, polar winter months of June to September recorded 8 days on an average.

g) *Global Solar Radiation:* Figures 17 and 18 show the distribution of global solar radiation at Maitri. Figure 17 shows the daily average of global solar radiation for the whole year. This curve suggests oscillatory pattern within the month. 4 peaks and 4 troughs can be easily approximated making the oscillation as weekly type. This gives us a clue to the type of overcast and clear - spell frequencies at Antarctica. However elaborate studies have to be made in this regard.

Figure 18 shows a graph depicting monthwise distribution of average daily globlal solar radiation during 1997. This curve shows that the global solar radiation received per day in each month fell rapidly till April and gradually till June. Similarly, it rose gradually till August and rapidly afterwards (till December). It also indirectly depicts the dip in the sufrace air temperature with a time lag of 1 month.

h) *Auroral Displays:* Auroral lights displayed in polar regions could be seen from Maitri during polar months. Though these displays are seen only during intense magnetic storms., all magnetic storms didn't produce the auroral displays. There were 30 days with aurora from March to September 97 as detailed below:

March-26,28,29
April-06,16,17,30
May-05,08,11,15,
June-6,8,25
July-3,17,18,31
Aug-1,3.21.28.29,30
Sept-2,3,10,11,13,23,

August and September recorded highest number of days with Aurorae as is apparent from the above data.

0 Abridged Climatological information for 1997: The Chart in figure 19 shows the weather at Maitri during 1997 in a nutshell. Unsusually large variation in the atmospheric pressure (55.5 hpa), temperature (39.7 C); high winds (66 kts peak and 24 kts monthly average in April); large number of blizzards and a few long blizzards are a numerical description of a typical Antarctic climate, which have been described elaborately earlier.

Weather Forecasting

Local weather forecasting at Antartica is always a challenging task. Non-availability of observatory network, weather analysis facilities, radar equipment, and presence of fast developing and moving nature of polar Weather Systems makes the task of local weather forecasting difficult, compared to traditional forecasting environment and techniques .

The IMD team basically used the satellite imageries received form NOAA 13 and NOAA 14 satellites for this purpose. Few analysed Fascimile weather charts received form Pretoria, South Africa with the help of communication experts from Defence Electronics Applications Laboratory (DEAL), Dehradun also helped in weather forecasting. Continuous monitoring of local weather parameters like atmospheric pressure, wind speed and direction, temperature change, cloud type direction of movement and direction of approach towards the station greatly help in correlating the developments/movements of low pressure systems as seen on the satellite imageries with that of ground reality.

The low pressure systems generally move form west to east at Maitri station. The pressure fall is a general indication of low pressure system approaching the station. Some times when a 'low' moves across the station longitude but form west to east without a significant southward component, there may not be significant dip in the atmospheric pressure but blizzards are caused due to heavy snowfall coupled with moderate winds. The passing of low pressure systems can be seen from wind speed and direction records under such circumstances.

The low pressure systems will generally have a single hook like cloud band extending form the centre. On most occasions the frontal cloud band leads the pressure centre. Thus when a blizzard approaches the station its intensity increases gradually and the peak lasts for longer duration's. When the system's center crosses the station, the wind rapidly falls and comes to an abrupt end in short time. It indicates that the wind field is not symmetrical around the center contrary to the case of tropical systems.

On rare occasions, and in case of intense and fast moving systems the main cloud band covers the station after the center has crossed. This is due to N-S orientation of the cloud band or due to E-W orientation where the cloud band lags behind the center, Due to movement of such systems the station experiences very high winds in short time thus causing intense blizzard from calm within hours.

At times large patches of featureless clouds spreading for hundreds of kilometers move across the station, causing moderate to heavy snowfall with light or calm winds. Even light to moderate winds upto 15 knots can cause moderate to intense blizzards if fresh snow is present on the ground. Such blizzards sometimes last for periods beyond 12 hours as the ground level snow is swept across the station from far off places, as far as 200 kms continuously. Visibility of less than 10 metres is quite common during such blizzards. Reasonably good vertical visibility is an indicator of such blizzards.

Polar low pressure systems generally move in families. Sometimes one low gives birth to another etc. or a family of lows move together. Formation of new lows can be expected if the frontal cloud band is very wide and the tapering is non-uniform. When new 'low' takes birth, generally the mother low becomes weak/dissipates or gives way to the stronger one to approach the land.

Close monitoring of the movement, formation, intensification and dissipation of the low pressure systems, and continuous correlation of satellite imageries to ground realities like cloud cover, snow fall, blizzard and wind speeds is helpful for local activities.

Temperature forecast is another area of great interest in Antarctica. Due to very slant angle of solar radiation, very high reflecting of snow/ice surface, low atmospheric turbidity, absence of vegetation and land etc., the air temperature of Antarctic climate is not mainly controlled by insolation. Temperature is influenced more or less by the heat transport mechanisms, radiation obstructing weather parameters and wind. Continuous clear sky with light wind only can cause gradual fall in air temperatures. At sub-zero temperature the water content in soil freezes with particles of soil, sand and rock embeded. This is called permafrost layer which is hard and poor in thermal conductivity. Hence when temperature changes are noticed even on land it is all most limited to top 1 metre layer with sluggishness.

When change in temperature is to be forecasted the following things are used as inputs.

1. Number of days with clear/mostly clear sky in the past one week.
2. Number of hours of sunshine per day.
3. Any low pressure system approaching the station or in the close vicinity (within 50 kms.)
4. Surface of earth bare land, fresh snow (high reflectivity), old snow etc.,
5. wind: whether above 10 knots or less than 10 knots, continuous or intermittent, whether katabatic type (cold winds) or low pressure system associated (warm winds) etc., Wind direction generally helps in this regard.
6. Temperature fall/rising trend in past 2 to 3 days.
7. Temperature of earth (rising/falling during the season)
8. Likely cloud cover on the next day (for which temperature is forecasted)

Though fall and rise in temperature can be predicated with greater confidence, the exact magnitude cannot be predicated if high winds and intense low pressure system are involved.

Vertical Distribution of Ozone

28 ozone sonde ascents were taken during 1997 to study the vertical distribution of ozone and temperature in the atmosphere. Ozone ascent data at Maitri shows the fall of maximum level of ozone from the first week of September to 3rd week of November continuously. Balloon ascents during October and November show double

peaks one around 200 hpa and the other around 20 hpa. The layer between these two levels where generally ozone maxima occurs has shown severe depletion during this period.

Figure 20 shows ozonograms (plot of ozone with height) before, during and after the ozone depletion. Ascent on 23-3-97 shows about 155 nb of partial pressure of ozone, 04-10-97 shows the peak around 60nb, wheras the same recovered to 170 nb on 04-12-97 after depletion period. Figure 21shows the vertical distribution of temperature in the atmosphere. During October the temperature has fallen to about -75 deg. C between 100 & 50 hpa levels indicating the presence of strong cold core at polar vortex. After depletion the temperature rose rapidly reaching to -40 deg. C and higher at this level.

Studies on Surface Ozone Concentration

Surface ozone concentration is also measured continuously at ground level in Antarctica. An efficient ozone pump with known air pumping rate is used to sample the air from the atmosphere. It is then pumped into a bubbler unit with KI solution and electrodes generates micro-currents proportional to the presence of ozone in the air. These currents are amplified and fed to recorder which gives a continuous record of surface ozone.

From hourly values of surface ozone in nanobars (of partial pressure) is tabulated and daily averages are found. For the convenience of analysis a deca-day analysis is made in such a way that salient features of the annual variation are not lost.

Fig 22 shows a graph of 10 day average of partial pressure of surface ozone to the concerned period in the month. Surface ozone shows about 8 nb till April which rose gradually to 27nb by July and remained so till November. It rapidly fell thereafter. This record shows that surface ozone concentration increases considerably during polar winters, form June to October. Though there are decca-day averages which are very high or very low from the general curve, these can be attributed to the movement of intense lows which causes bringing in of air masses from tropical latitudes and vertical mixing of air as well.

Acknowledgements

We express our sincere thanks to Dr. N. Sen Roy, DGM (Retd.) and Dr. R.R.Kelkar, DGM (LACD) for giving us this unique opportunity to work in Antarctica; to Dr. V.S. Tiwari, Director, NHAC Dr. V. Subramanyam, Director, CDR, Machilipatnam for their continuous encouragement and support; Dr. A.L. Koppar, Director and leader of XVI Expedition and all other summer and winter members who extended their unconditional co-operation and help, moral and physical, in achieving our scientific tasks.

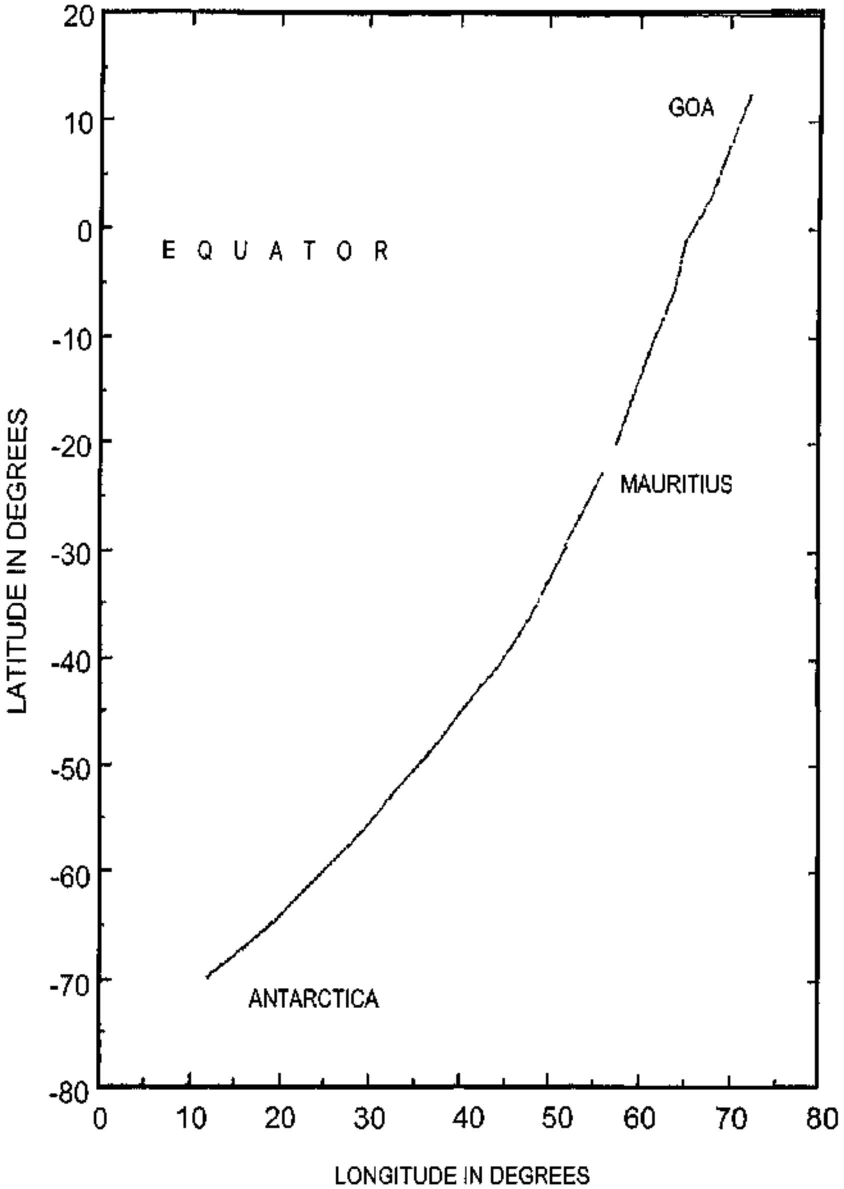
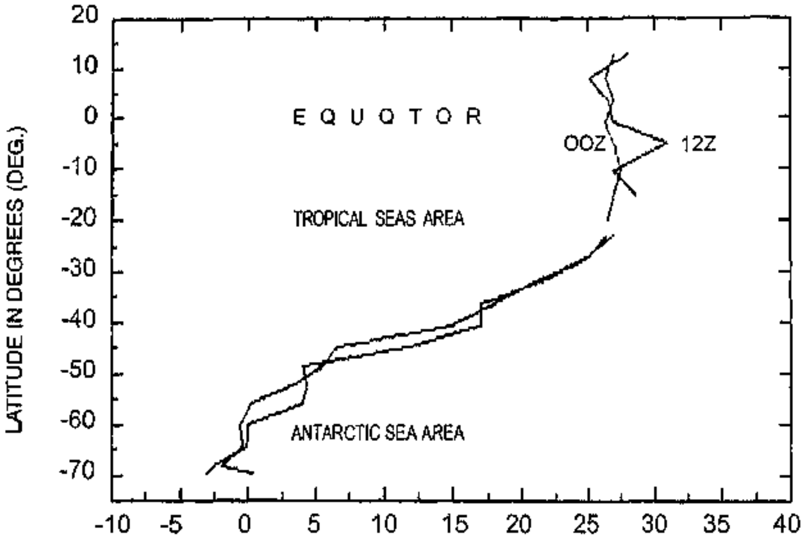


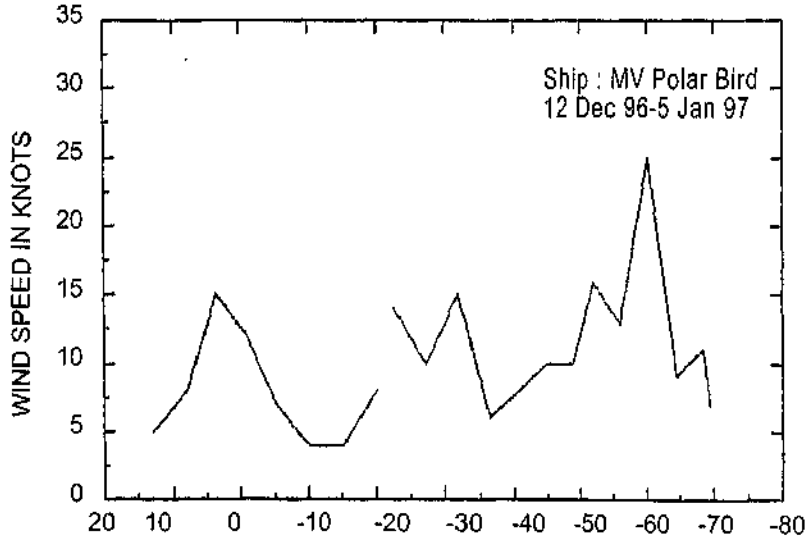
Fig. 1: Ship course (MV polar bird) 12 Dec 96 - 6 Jan 97

Fig. 2



TEMPERATURE IN DEG C

Fig. 3

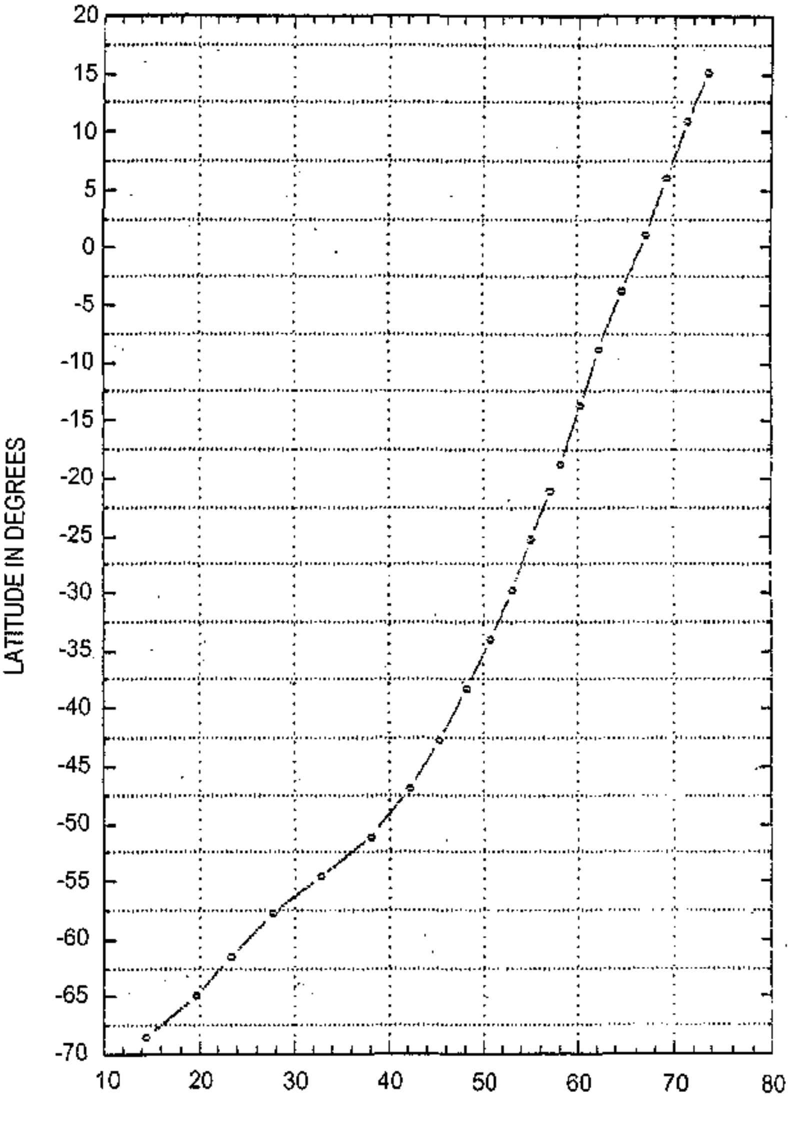


LATITUDE IN DEGREES

m m .

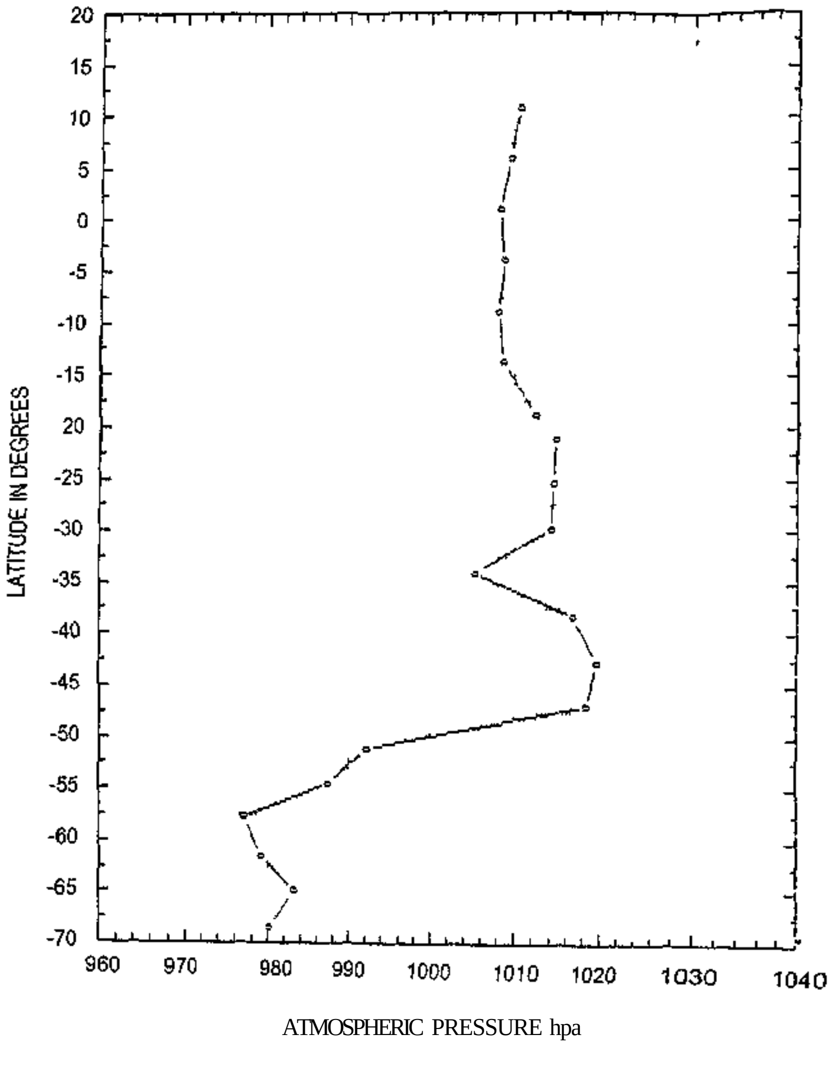
• i

Fig. 4



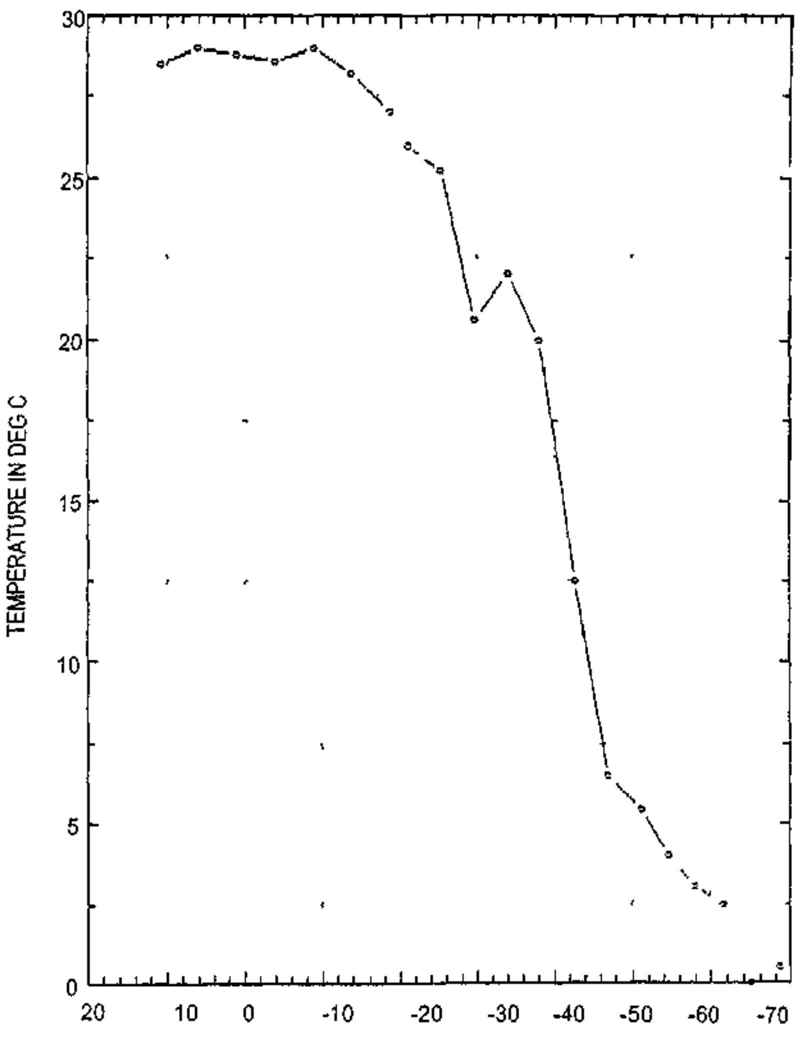
LONGITUDE IN DEGREES EAST

Fig. 5



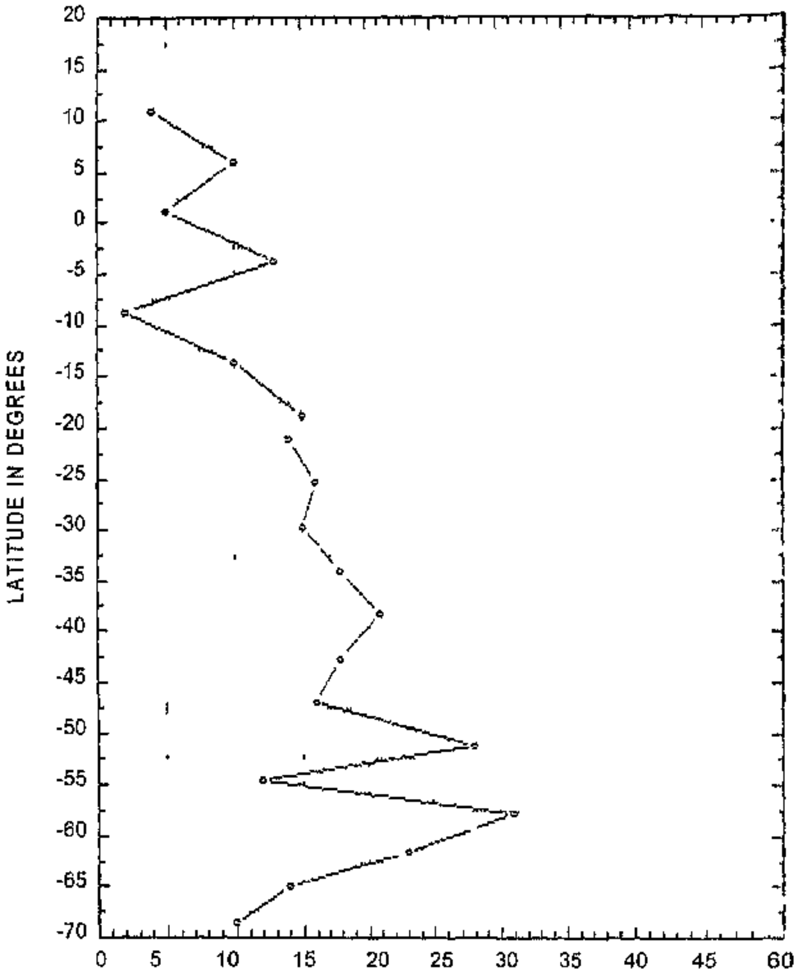
ATMOSPHERIC PRESSURE hpa

Fig. 6



30
25
20
15
10
5
0
TEMPERATURE IN DEG C
20
10
0
-10
-20
-30
-40
-50
-60
-70
LATITUDE IN DGREES

Fig. 7



WIND SPEED IN KNOTS

Fig. 8

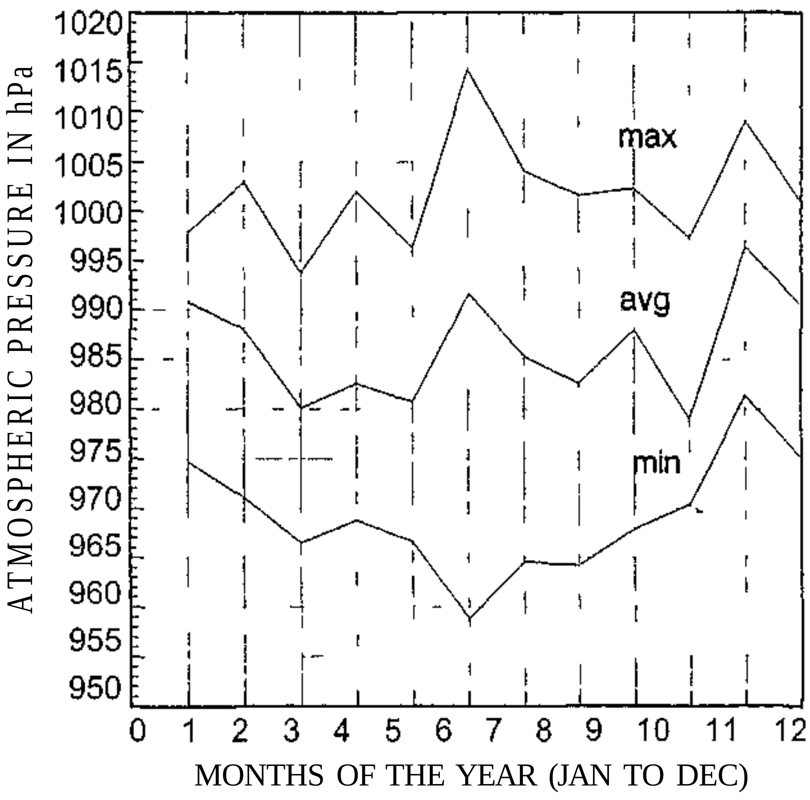

ATMOSPHERIC PRESSURE IN hPa
1020
1015
1010
1005
1000
995
990
985
980
975
970
965
960
955
950
max
avg
min
0 1 2 3 4 5 6 7 8 9 10 11 12
MONTHS OF THE YEAR (JAN TO DEC)

Fig. 9

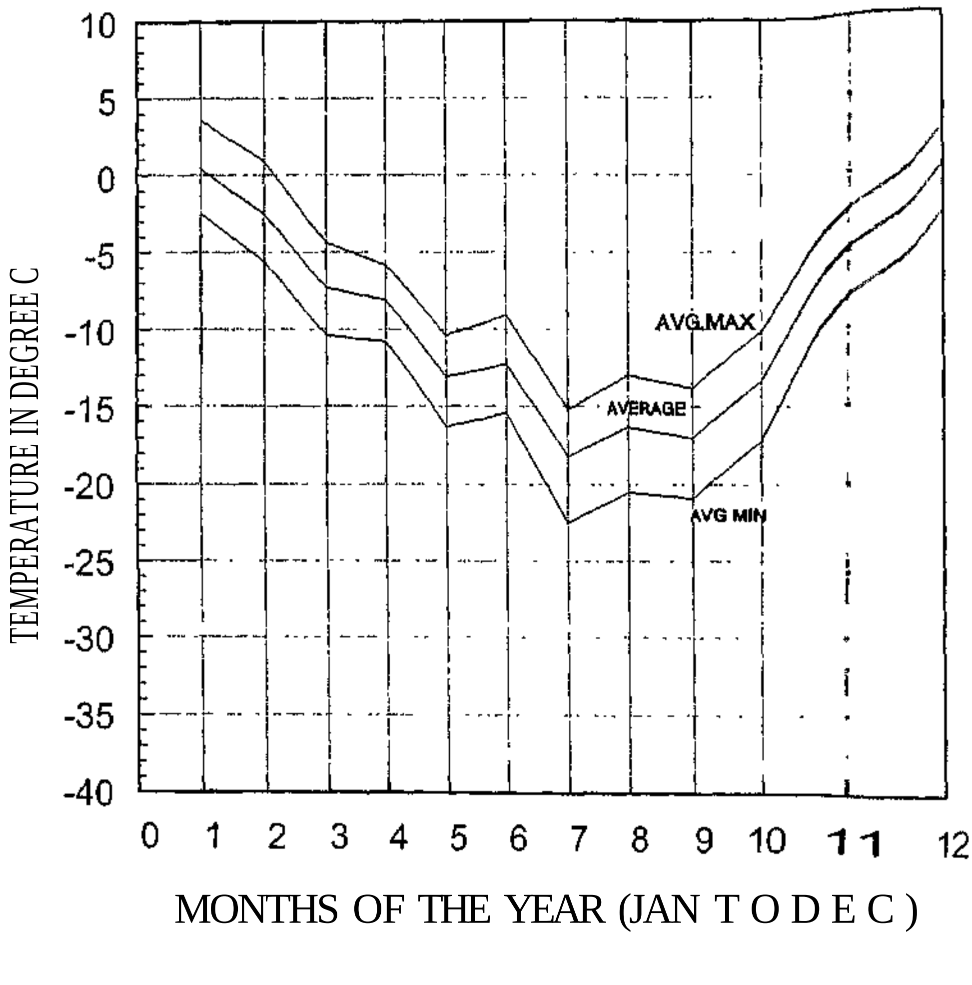

10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
TEMPERATURE IN DEGREE C
AVG.MAX
AVERAGE
AVG MIN
0 1 2 3 4 5 6 7 8 9 10 11 12
MONTHS OF THE YEAR (JAN T O D E C)

Fig. 10

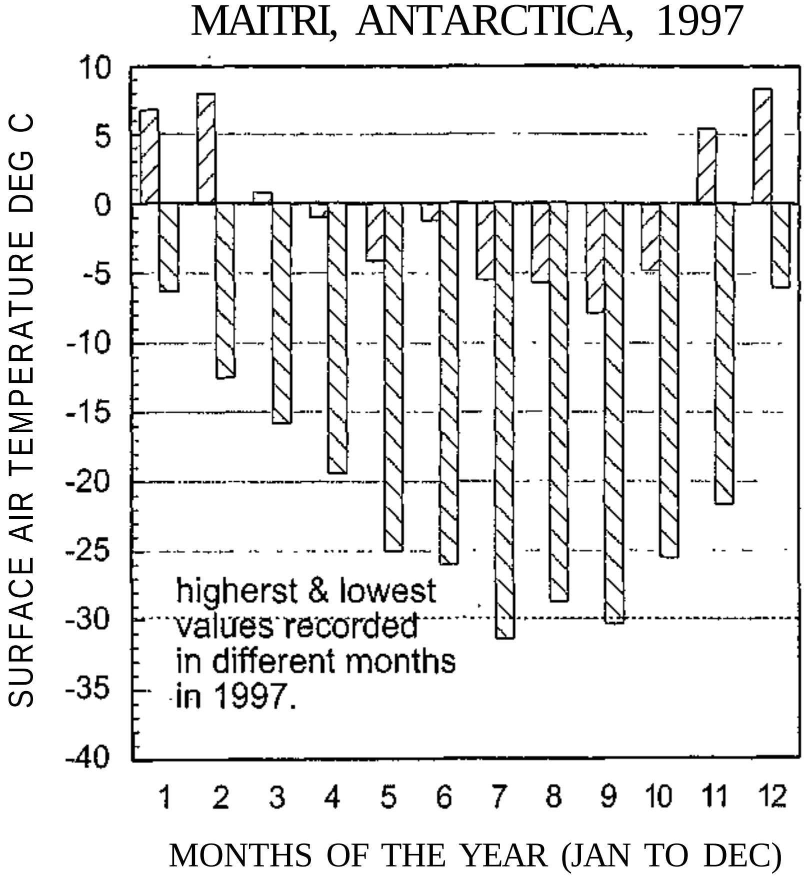

MAITRI, ANTARCTICA, 1997
SURFACE AIR TEMPERATURE DEG C
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
higherst & lowest
values recorded
in different months
in 1997.
1
2
3
4
5
6
7
8
9
10
11
12
MONTHS OF THE YEAR (JAN TO DEC)

Fig. 11

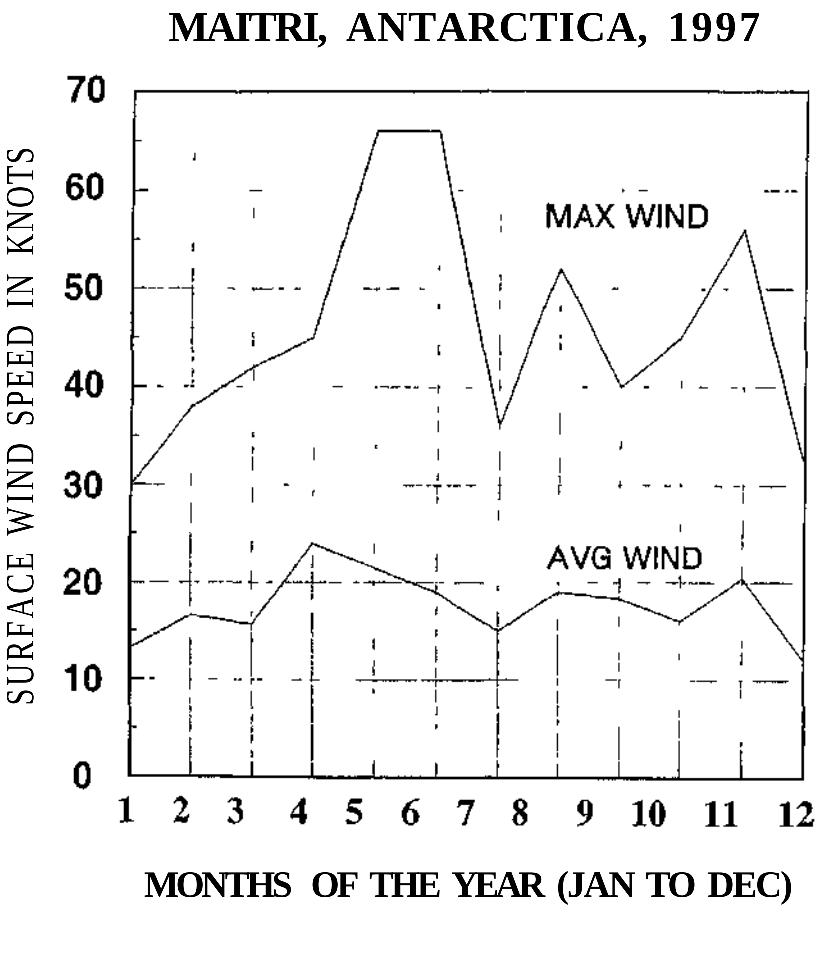

MAITRI, ANTARCTICA, 1997
SURFACE WIND SPEED IN KNOTS
70
60
50
40
30
20
10
0
MAX WIND
AVG WIND
1 2 3 4 5 6 7 8 9 10 11 12
MONTHS OF THE YEAR (JAN TO DEC)

Fig. 12

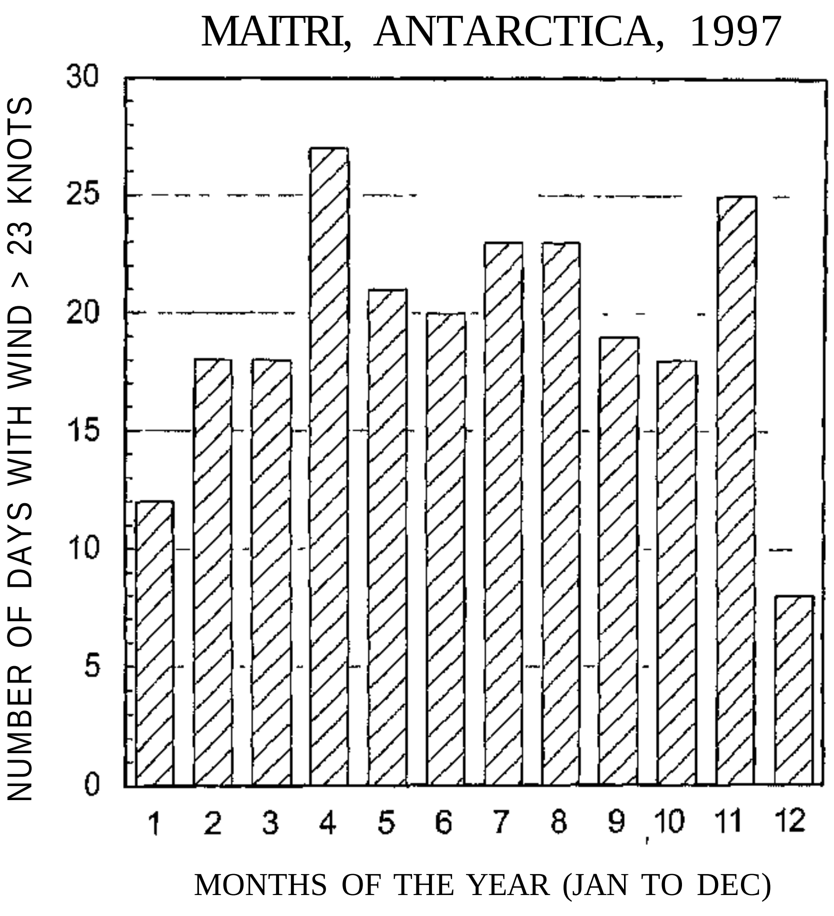

MAITRI, ANTARCTICA, 1997
NUMBER OF DAYS WITH WIND > 23 KNOTS
30
25
20
15
10
5
0
1
2
3
4
5
6
7
8
9
10
11
12
MONTHS OF THE YEAR (JAN TO DEC)

Fig. 13

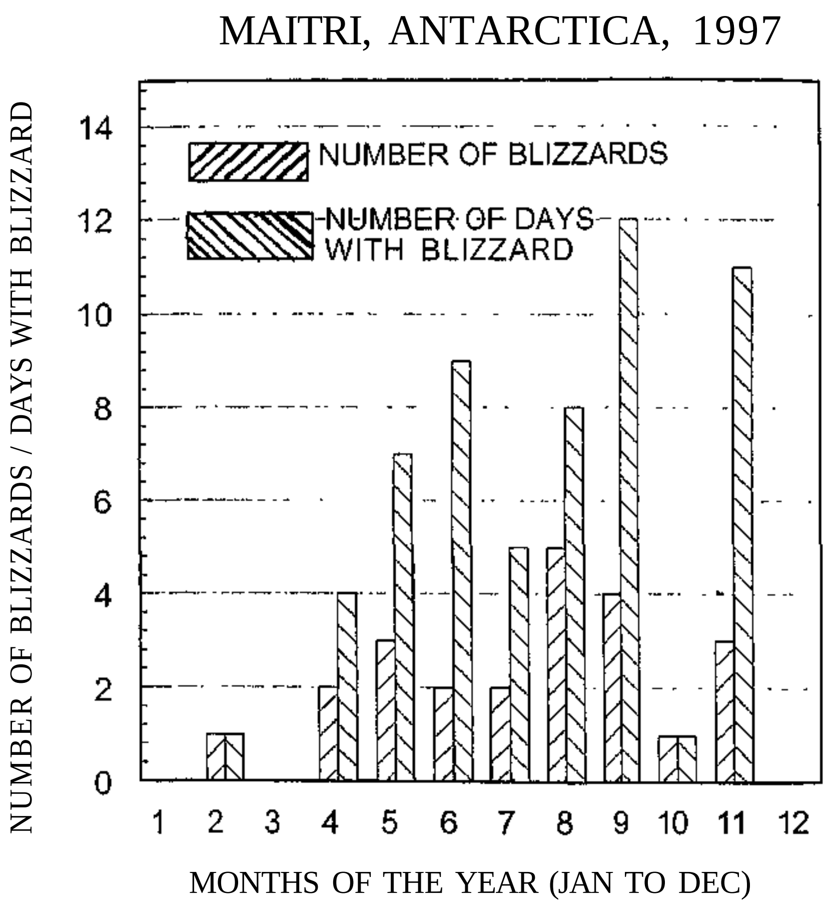

MAITRI, ANTARCTICA, 1997
NUMBER OF BLIZZARDS
NUMBER OF DAYS WITH BLIZZARD
NUMBER OF BLIZZARDS / DAYS WITH BLIZZARD
0
2
4
6
8
10
12
14
1 2 3 4 5 6 7 8 9 10 11 12
MONTHS OF THE YEAR (JAN TO DEC)

Fig. 14

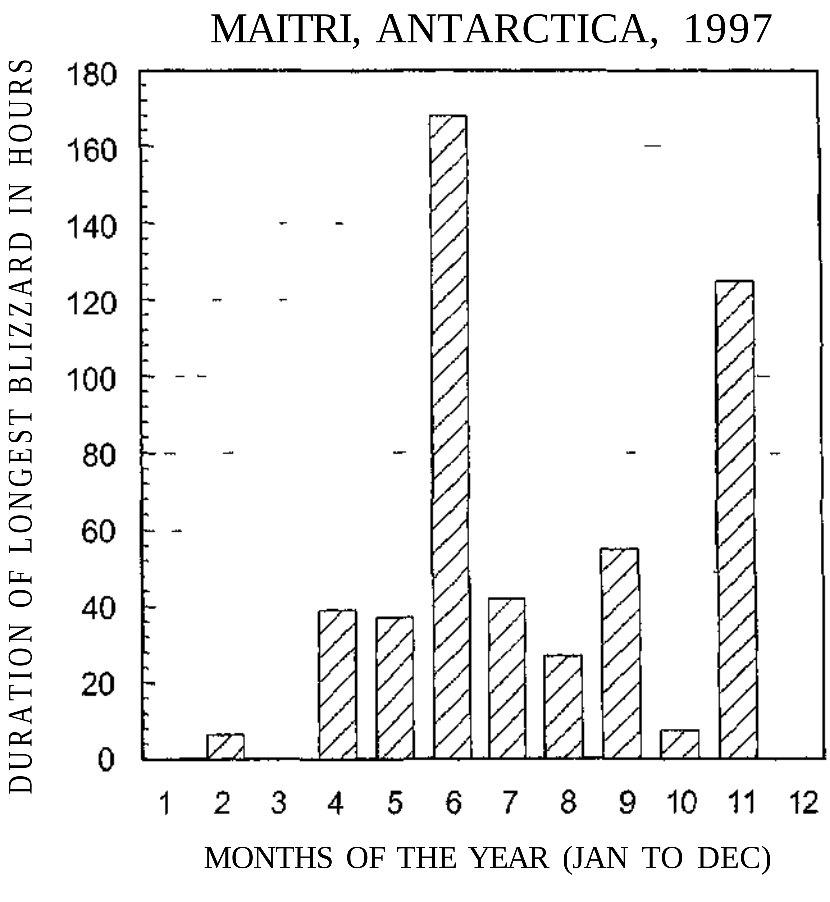

MAITRI, ANTARCTICA, 1997
DURATION OF LONGEST BLIZZARD IN HOURS
180
160
140
120
100
80
60
40
20
0
1 2 3 4 5 6 7 8 9 10 11 12
MONTHS OF THE YEAR (JAN TO DEC)

Fig. 15

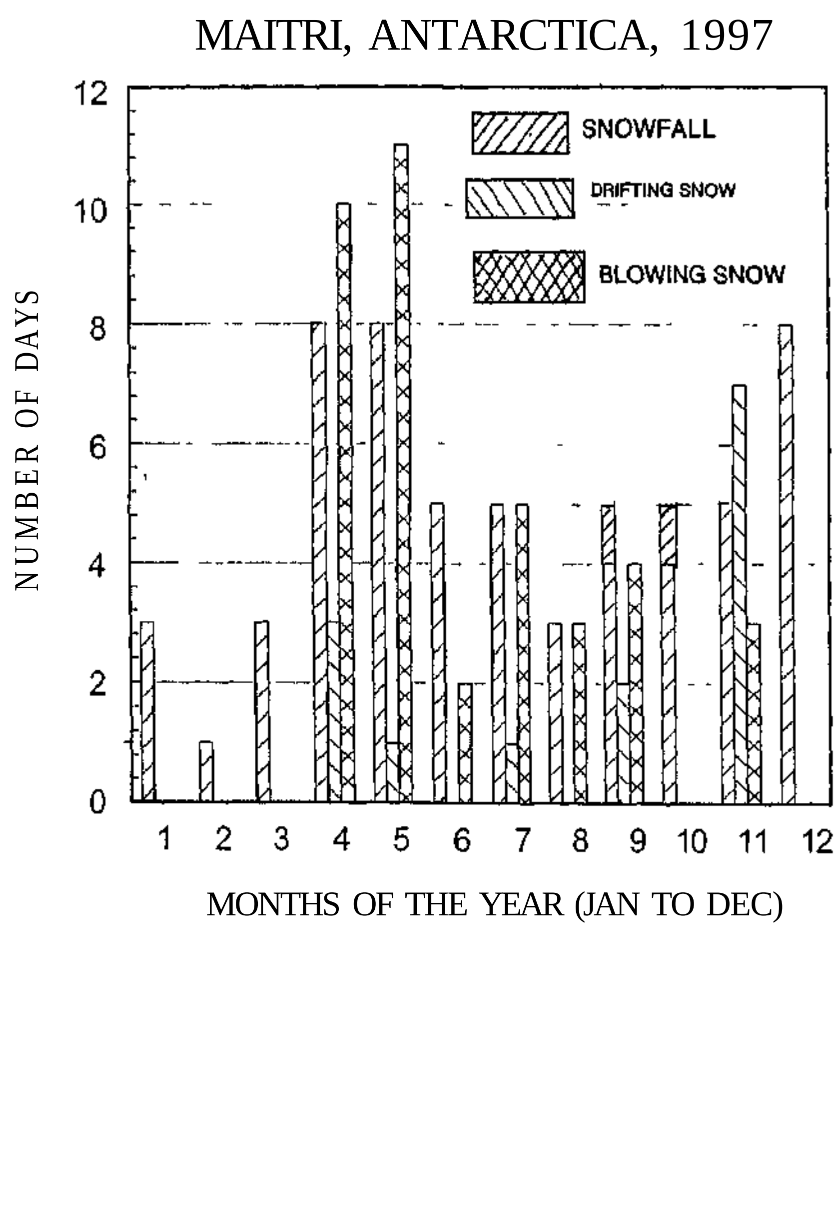

MAITRI, ANTARCTICA, 1997
SNOWFALL
DRIFTING SNOW
BLOWING SNOW
NUMBER OF DAYS
0
2
4
6
8
10
12
1 2 3 4 5 6 7 8 9 10 11 12
MONTHS OF THE YEAR (JAN TO DEC)

Fig. 16

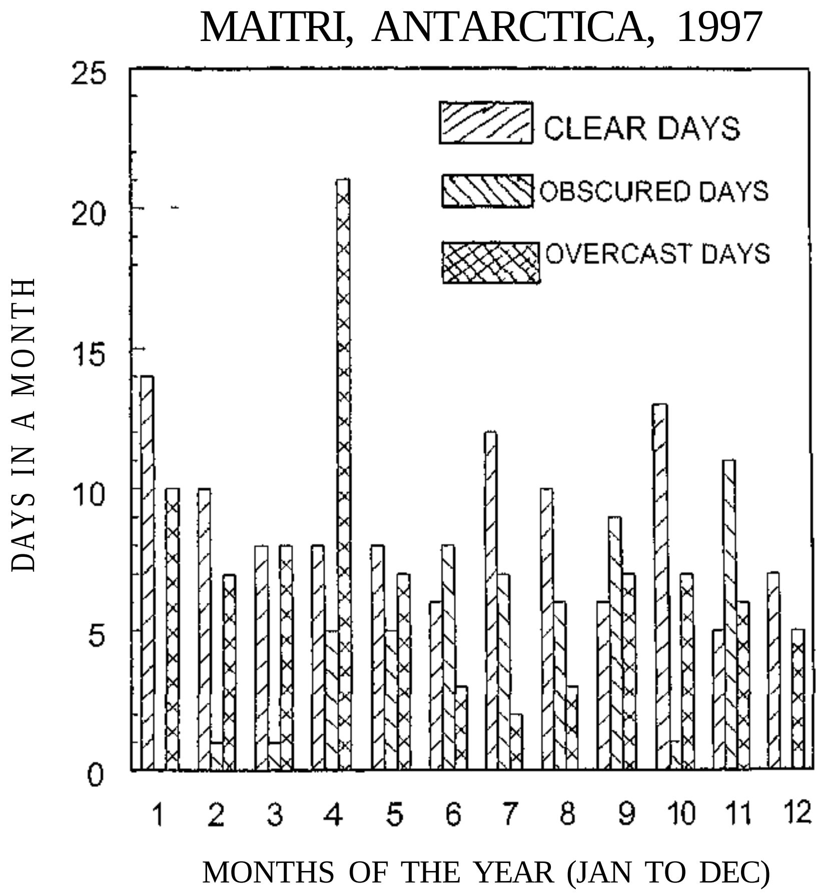

MAITRI, ANTARCTICA, 1997
CLEAR DAYS
OBSCURED DAYS
OVERCAST DAYS
DAYS IN A MONTH
25
20
15
10
5
0
1
2
3
4
5
6
7
8
9
10
11
12
MONTHS OF THE YEAR (JAN TO DEC)

Fig. 17

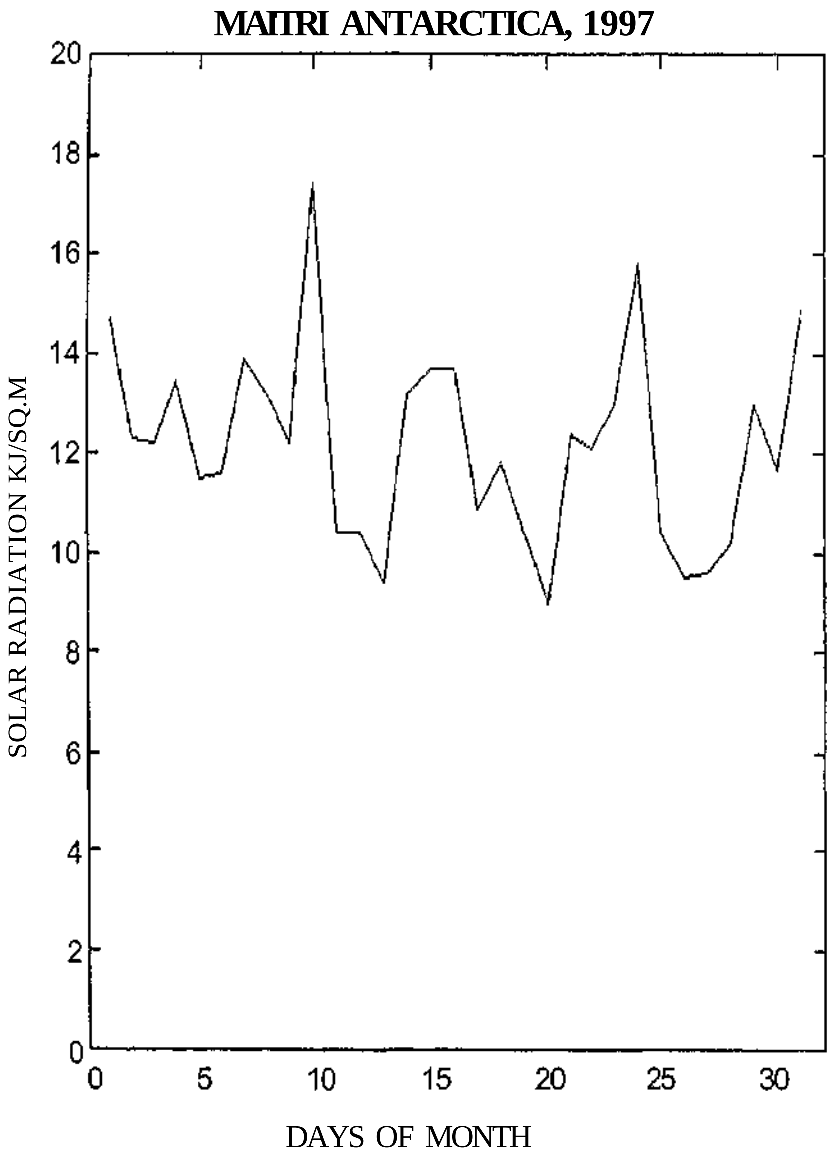
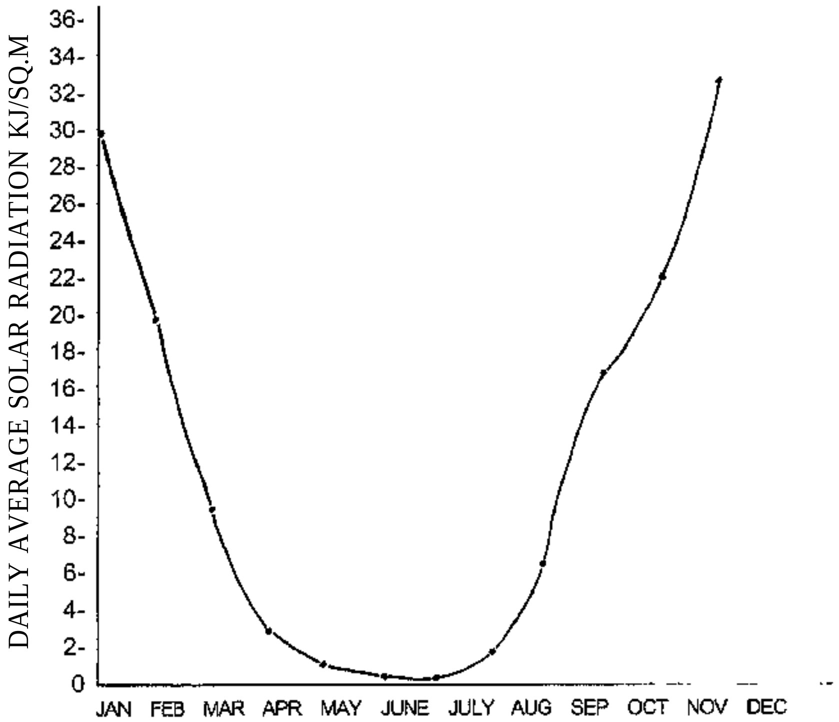

MAITRI ANTARCTICA, 1997
SOLAR RADIATION KJ/SQ.M
0
2
4
6
8
10
12
14
16
18
20
0
5
10
15
20
25
30
DAYS OF MONTH

Fig. 18

MAITRI, ANTARCTICA, 1997



MAITRI CLIMATOLOGICAL INFORMATION FOR 1997

1. ATMOSPHERIC PRESSURE

Highest value	-	1014.3 hPa in June
Lowest value	-	958.8 hPa in June

2. SURFACE TEMPERATURE

Maximum value	-	+8.3°C in December
Minimum value	-	-31.4°C in July
Average for 1997	-	-09.3°C

3. SURFACE WIND SPEED

Average wind (not gust)	-	66 knots
Average wind for 1997	-	17.56 knots
Windiest month	-	April with 24 knots of average wind

4. BLIZZARDS

Maximum number of blizzards	-	5 in August, 3 in November
Maximum number of blizzard days	-	12 day in August. 11 days in November
Longest period of a single blizzard	-	168 hrs in June. 125 hrs in November

5. SKY CONDITION

   Maximum clear sky days were seen in January, February, July, August & October

   Maximum overcast sky days were seen in April for 21 days

6. Maximum days experiencing snowfall is in April for 10 days, may for 09 dasy

7. AURORAE

   Maximum number of clays auroras seen in August & September 6 days in each month

8. Maximum drifting snow seen in November for 7 days

9. Maximum blowing snow seen in April for 10 days & in May for 11 days

Fig. 19

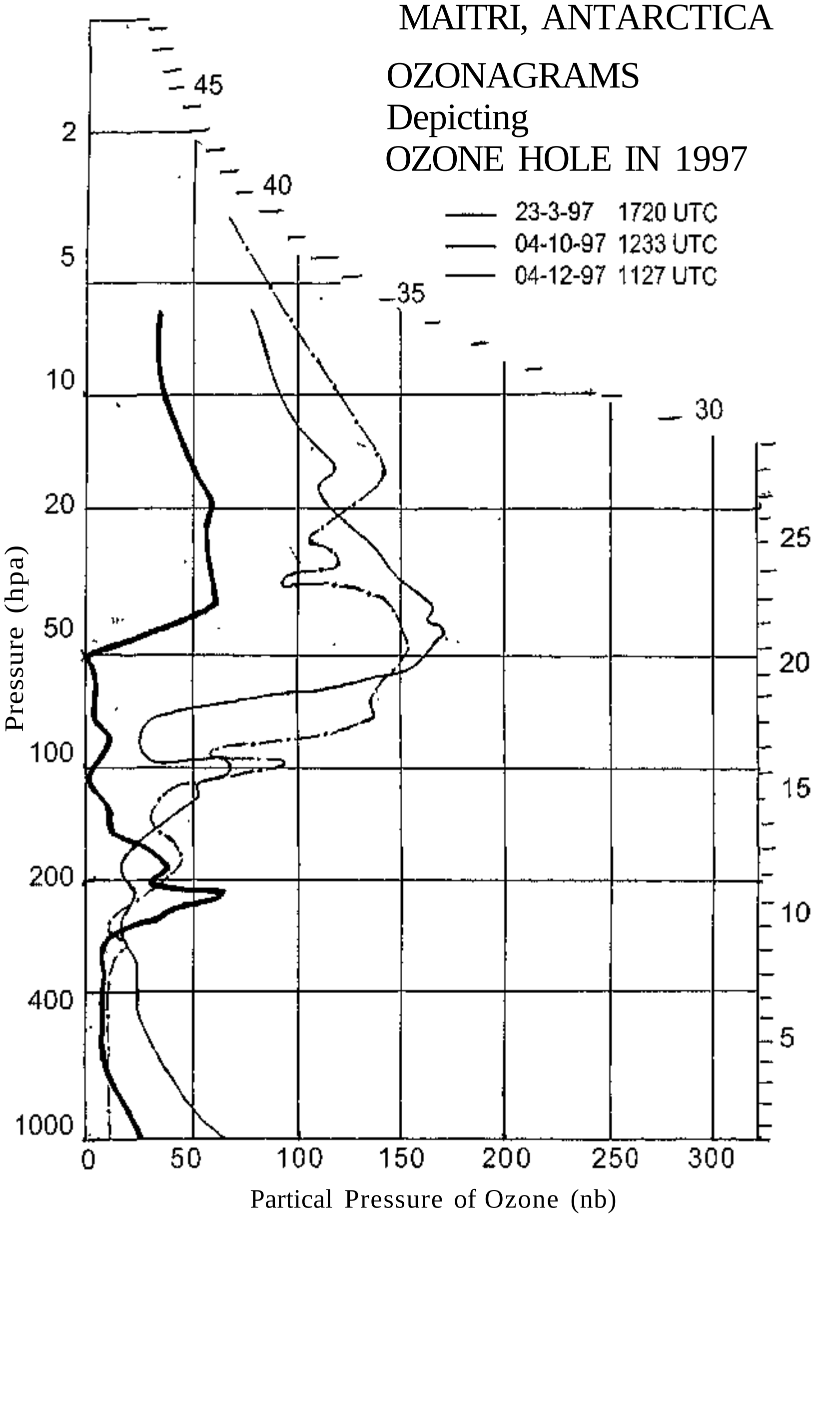
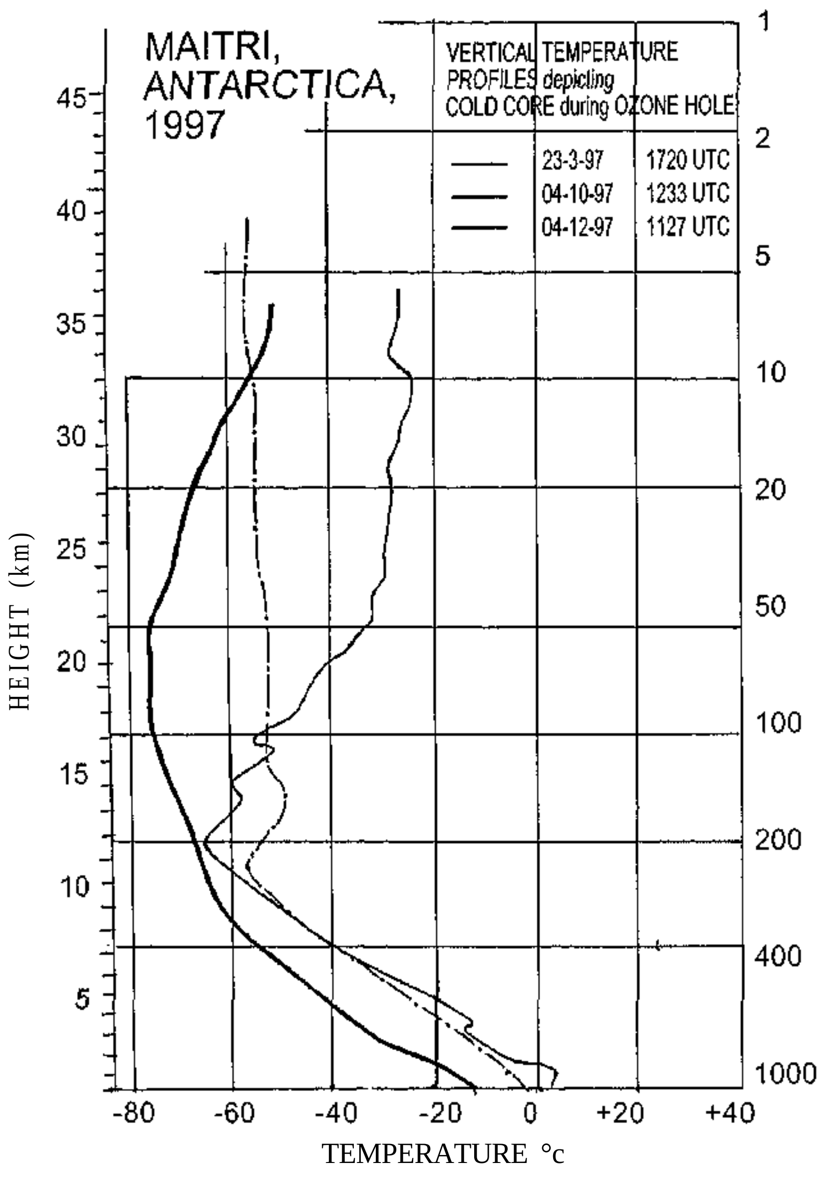

MAITRI, ANTARCTICA
OZONAGRAMS
Depicting
OZONE HOLE IN 1997
23-3-97 1720 UTC
04-10-97 1233 UTC
04-12-97 1127 UTC
45
40
35
30
2
5
10
20
50
100
200
400
1000
25
20
15
10
5
0
50
100
150
200
250
300
Pressure (hpa)
Partical Pressure of Ozone (nb)

Fig. 20


MAITRI,
ANTARCTICA,
1997
VERTICAL TEMPERATURE
PROFILES depicting
COLD CORE during OZONE HOLE
23-3-97 1720 UTC
04-10-97 1233 UTC
04-12-97 1127 UTC
HEIGHT (km)
45
40
35
30
25
20
15
10
5
1
2
5
10
20
50
100
200
400
1000
-80 -60 -40 -20 0 +20 +40
TEMPERATURE °c

OZONE CONCENTRATION
(MICRO MILLBAR)

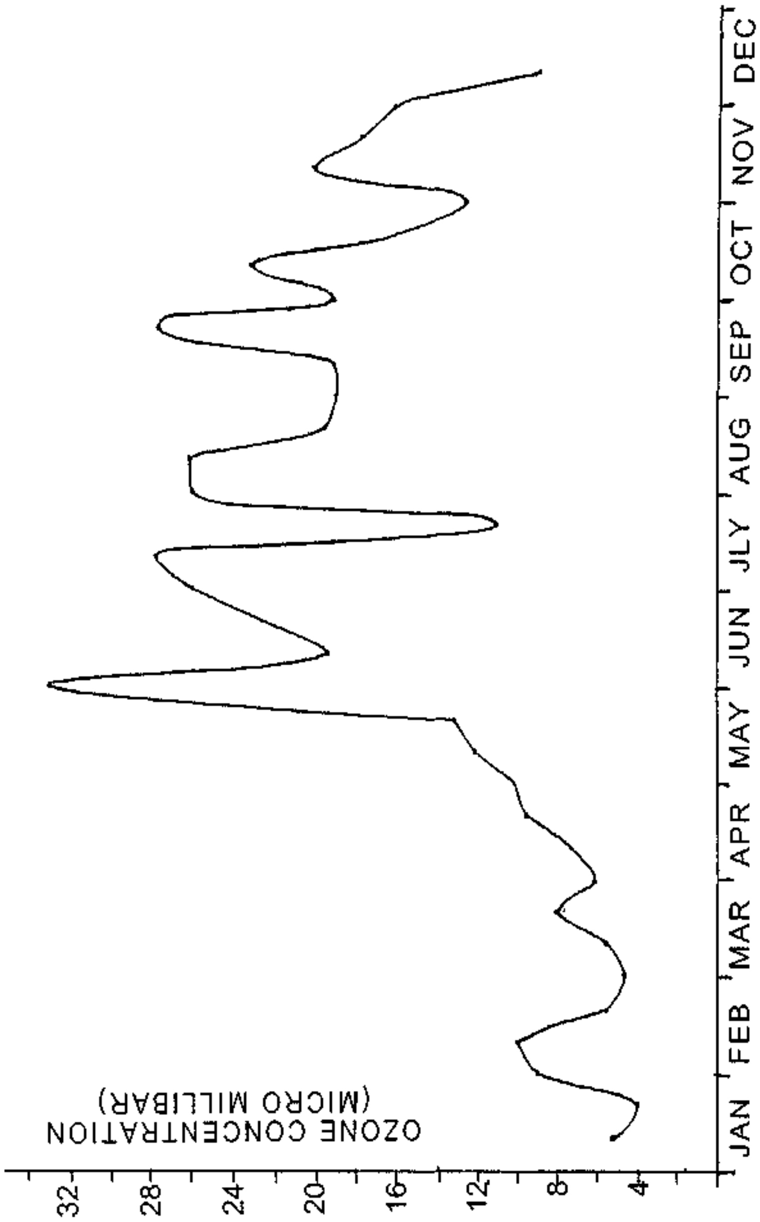


Fig. 21: *Variation of surface ozone concentration during 1997 Maitri, Antarctica*

DESCRIPTION OF SUCCESSFUL OZONE SONDE ASCENTS TAKEN AT MAITRI (ANTARCTICA) DURING 16TH EXPEDITION 1997

Sl. No.	Date of Ascent	Time of Ascent (UTC)	Mux. height hpa	Level of max. Ozone height hpa/microbar partial pressure
1.	18.01.97	1608	6.5	67.5/118.0
2.	14.02.97	1845	6.0	69.0/75.3
3.	25.02.97	1400	12.5	50.0/77.2
4.	09.03.97	1410	12.0	50.0/116.9
5.	23.03.97	1720	3.0	49.0/160.4
6.	31.03.97	1755	37.4	45.2/111.7
7.	28.04.97	1250	8.6	85.6/178.0
8.	21.05.97	1933	-	97.5/152.6
9.	28.05.97	0217	-	80.0/143.0
10.	20.06.97	1612	10.2	48.5/95.2
11.	23.06.97	2002	41.5	60.0/158.3
12.	02.07.97	0225	13.0	36.0/126.8
13.	08.07.97	2132	17.4	77.3/202.1
14.	31.07.97	1713	40.0	90.0/141.9
15.	07.08.97	2257	19.4	67.0/184.5
16.	14.08.97	1605	38.1	90.7/145.6
17.	23.08.97	1400	8.2	43.4/147.4
18.	07.09.97	1349	27.0	62.0/106.4
19.	04.10.97	1233	6.1	20.0/63.5
20.	07.10.97	1329	5.4	60.7/16.0
21.	13.10.97	1615	4.0	184.0/89.9
22.	19.10.97	1447	52.0	200.0/56.7
23.	29.10.97	1926	44.0	204.0/66.0
24.	09.11.97	0222	16.0	19.0/81.2
25.	04.12.97	1127	5.8	43.5/180.4
26.	08.12.97	1832	6.5	52.5/139.5
27.	15.12.97	1230	5.0	42.8/144.1
28.	29.12.97	1427	8.5	40.0/151.3

Plate-1
Totex 2000 balloon being Inflated for balloon borne Ozone Sonde ascent.

Plate-2
Ozone Sonde balloon about to be launched

Plate-3
Snowgauge installed during Summer of 1998