*Ninth Indian Expedition to Antarctica, Scientific Report 1994*
*Department of Ocean Development, Technical Publication No. 6, pp. 35-56*

# Establishment of A New Meteorological Observatory at Maitri and Study of Meteorological Parameters, Ozone Depletion in Antarctic Spring and Solar Radiation during Ninth Antarctic Expedition

SARABJIT SINGH & E. KULANDAIVELU

India Meteorological Department, New Delhi

## Introduction

The Southern polar continent — Antarctica, is endowed with unique features such as cold temperatures, strong winds, blizzards and the vast glaciers on the earth. Meteorology is considered paramount because it can foresay the weather conditions in any particular region, The synoptic systems around Antarctica are typically inhospitable and dreadful, unlike elsewhere. Prediction of weather in this region is complicated due to unpredicted movements of upper celestial phenomenal changes. In order to get a better prediction, it is necessary to correlate the data obtained by various meteorological observatories situated in the continent, besides satellite cloud imagery. Hitherto i.e. till 1989, the meteorological data were monitored from Dakshin Gangotri which is located on ice-shelf, and the same were quite variable as compared to data from a station located on land. India established its second permanent scientific research station Maitri (Lat 70° 45' 39"S, Long 11° 44' 48"E, Altitude 117M) in the Schirmacher ranges in 1988-89. India Meteorological Department established its full fledged meteorological observatory at Maitri in January 1990 and discontinued meteorological observations from Dakshin Gangotri. The various data collected at Maitri (WMO Station Index 89514) are forwarded to IMD HQ, New Delhi which in turn sends these to other world meteorological centres to help forecasting weather at any time in this region.

## Orography of Maitri

All meteorological parameters are variable and also depend upon orographical features of the place. Maitri is situated in the valley of Schirmacher ranges extending upto 7 Km in length and 0.5 to 2 Km in width. Towards its south, high glaciers occupy vast areas extending upto South Pole and towards the north, the ice shelf extends upto about 100 Km. There are also numerous lakes between rocky hills.

## Programme

(i) Establishing a new Meteorological Observatory at Maitri and monitoring weather conditions by keeping constant watch.

(ii) Recording of 3 hourly synoptic observations and disseminating the main 6 hourly synoptic data to IMD, New Delhi for its global exchange programme.

(iii) To investigate ozone depletion in the Antarctic spring season over this region.

(iv) To monitor the radiation flux in the upper atmosphere.

(v) To monitor surface ozone.

(vi) To do other activities as were done by the previous expeditions.

**Installation of Instruments**

A. (i) Stevenson Screen and two wind masts were installed during January 1990.

(ii) Due to space constraints in the main station, the installation of self recording instruments, Radiosonde Ground Equipment, APT Recorder, Ozone Generator etc. could be commissioned in mid February 1990 only.

(iii) Besides dry bulb thermometer, the maximum and the minimum thermometers were also positioned in the Stevenson Screen.

(iv) Electrical thermometer (YSI Thermister) was installed in a mini screen on DCP wind mast at the same height of Stevenson Screen for continuous recording of surface air temperature.

(v) Cup generator anemometer and wind vane were installed on the top of the building structure.

(vi) The omni-directional antenna and helical antenna were installed at the top structure of the building to receive cloud imagery and signals from upper air soundings, respectively.

(vii) Pyranometer was also positioned on top of the building.

B. The following instruments have been installed in the lab :

(i) Radio Sonde Ground Equipment for receiving signals from upper-air soundings (Ozone Sonde, Radio Sonde and Radio Meter Sonde).

(ii) Automatic Picture Transmission (APT) receiver-cum-recorder for receiving the visible and infra-red cloud pictures from Polar Orbitting (NOAA-10 and NOAA-11) Satellites.

(iii) Temperature recorder for continuous recording of surface air temperature.

(iv) Wind direction and speed recorders for'continuous recording of wind data.

(v) Recorder for continuous monitoring of surface ozone.

(vi) Protek recorder for continuous recording of Global Solar Radiation.

(vii) Microbarograph for self recording of atmospheric pressure.

(viii) Sunphotometer to measure atmospheric turbidity.

C. Data Collection Platform (DCP)

The DCP Unit was installed at Maitri in mid February 1990. The helical antenna was installed on top of the eastern end of the building. Since Maitri is surrounded by hills, the direct line of sight with the satellite was available from this corner only. The main unit consisting of Signal Conditioner and DCSTS (Data Conversion Storage and Transmission Sub-System) were installed in the loft. In addition to four sensors (Temperature, Wind Speed, Wind Direction and Pressure) that were already in use, an additional humidity sensor (Humicap) has been associated. The system was commissioned in mid February 1990 after calibration and comparison with ground truth values of various parameters. Since then the data was being transmitted and received at MDUC (Meteorological Data Utilisation Centre) New Delhi through INSAT 1B.

D. Weather Facsimile Recorder

Weather fax recorder was installed in March'90 to receive analysed weather charts from Molodezhnaya and Pretoria. However, charts from Pretoria could not be received due to very weak signals. On an average about two charts per day were received from Molodezhnaya. Charts could not be received during magnetic storms and poor signal days.

## Meteorological Data Collected

(i) Autographic records of atmospheric pressure, temperature, wind, surface ozone and solar radiation.

(ii) 3-hourly synoptic observations (00, 03, 06,09, 12, 15, 18 and 21 UTC).

(iii) Upper air radiation flux by Radio Meter Sonde,

(iv) Vertical ozone and temperature profiles.

(v) Cloud pictures from NOAA satellites.

(vi) Fax charts from Molodezhnaya.

(vii) Sunphotometer observations.

## Results and Discussions of Meteorological Data

A. *Pressure*

The station level pressure has been reduced to mean sea level (MSL) pressure for making a comparative study on synoptic scale. The mean monthly variation of MSL pressure during the period Jan'90 to Jan'91 is shown in Fig. 1A. There were two oscillations of pressure during the period, one peak in the month of May with mean value of 996.0 Mb and the other in November with value of 988.3 Mb. The MSL pressure fell to a low value of 981.6 Mb in February and then steadily rose till May. It fell again gradually till September with a very low value of 980.4 Mb and then again rose gradually. The highest MSL pressure of 1030.5 Mb was recorded in April whilst the lowest value of 948.9 Mb was observed in July.

B. *Air Temperature*

Monthly mean air temperatures have been depicted in Fig. 1B. The temperature gradually fell from January onwards due to onset of winter, upto August, except July. From August to September temperature rose slightly and thereafter shot up sharply by 10°C in October.

The surface air temperature rose from -16.3°C in June to -10.10° in July. This may perhaps be due to the frequent movement of extra-tropical low pressure systems which

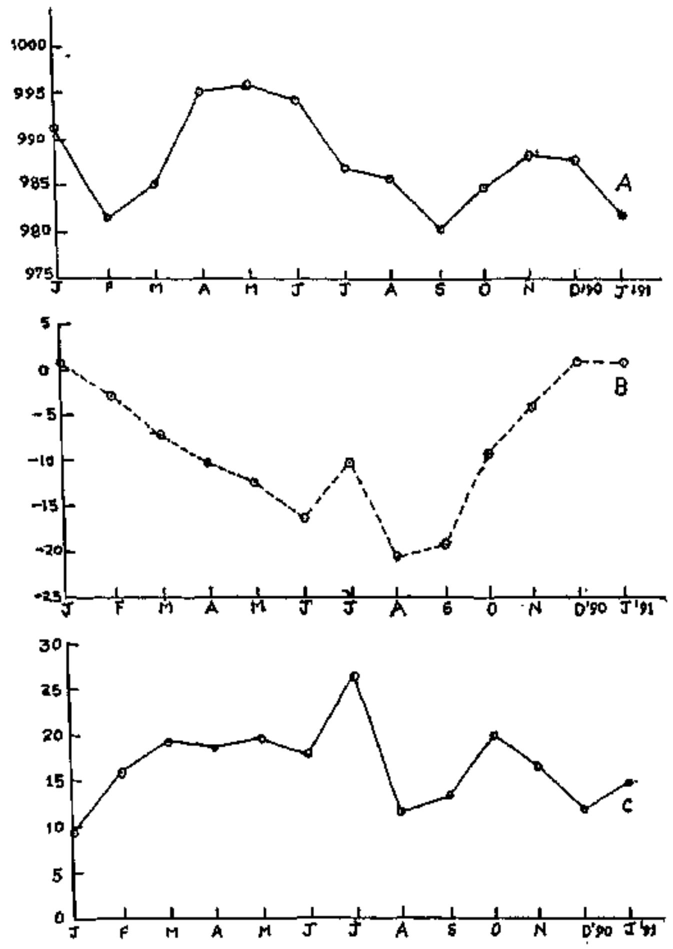


*Fig. 1. Mean monthly variations of (A) Mean Sea Level Pressure, (B) Surface Air Temperature and (C) Surface Wind Speed during January 1990 to January 1991,*

caused the warm and moist air drawn from lower latitudes and mixed with dry and cold continental air thus giving rise to the increase in temperature. The highest maximum temperature of 9.0°C was recorded in December and the lowest minimum was -32°C in August.

It was observed that the mean temperature of Maitri was more than that of Dakshin Gangotri by about 8-10 deg during all the months. This is due to the fact that Maitri is situated over rocky area whilst Dakshin Gangotri is on ice shelf. The solar radiations are mostly absorbed by the land during day time. During night, the land emits heat energy as

Table 1: Monthly Weather Summary of Maitri for the Period Jan. 1990 - Jan. 1991

| Month | M.S.L. Pressure (Mb) | | | Air Temperature (°C) | | | Wind Speed(Knots) | | No. of OVC | No. of SKC | No. of PPTN |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Highest | Lowest | Mean | Highest | Lowest | Mean | Max | Mean | Days | Days | Days |
| Jan.'90 | 1009.8 | 967.3 | 991.1 | 7.8 | -7.6 | 0.9 | 40 | 9.4 | 11 | 3 | 10 |
| Feb.'90 | 999.6 | 968.7 | 981.6 | 3.7 | -9.2 | -2.9 | 62 | 15.9 | 16 | 3 | 1 |
| Mar.'90 | 999.2 | 958.8 | 985.1 | -0.2 | -18.5 | -7.1 | 72 | 19.3 | 9 | 6 | 14 |
| Apr.'90 | 1030.5 | 971.1 | 995.2 | -1.0 | -21.6 | -10.1' | 60 | 18.6 | 6 | 3 | 5 |
| May'90 | 1018.6 | 977.1 | 996.0 | -2.3 | -30.8 | -12.3 | 61 | 19.7 | 15 | 4 | 9 |
| Jun.'90 | 1011.1 | 983.6 | 994.2 | -5.3 | -29.5 | -16.3 | 62 | 17.8 | 6 | 15 | 7 |
| July'90 | 1012.4 | 948.9 | 987.0 | -0.6 | -21.2 | -10.1 | 70 | 26.4 | 19 | 4 | 7 |
| Aug.'90 | 1002.9 | 966.4 | 985.9 | -8.8 | -32.0 | -20.5 | 61 | 11.5 | 3 | 13 | 5 |
| Sep.'90 | 1001.3 | 958.6 | 980.4 | -9.2 | -31.5 | -19.2 | 50 | 13.3 | 4 | 10 | 2 |
| Oct.'90 | 1011.9 | 964.9 | 984.9 | 1.0 | -22.8 | -9.2 | 85 | 19.9 | 10 | 7 | 6 |
| Nov.'90 | 1020.4 | 972.9 | 988.3 | 6.2 | -16.4 | -4.1 | 50 | 16.5 | 4 | 9 | 0 |
| Dec.'90 | 1001.9 | 963.2 | 987.8 | 9.0 | -5.1 | 1.0 | 41 | 11.8 | 2 | 2 | 5 |
| Jan.'91 | 994.6 | 960.0 | 981.8 | 8.2 | -5.6 | 0.9 | 62 | 14.8 | 2 | 6 | 7 |

OVC — Overcast, SKC — sky clear, PPTN — precipitation terrestrial radiations and warms the lower atmosphere at Maitri. Solar radiations are mostly reflected back to the space due to high albedo of snow at Dakshin Gangotri and virtually no terrestrial emission take place from ice during night.

C. *Wind*

Generally Maitri experiences wind speed between 15 and 20 Kts from East-South-East and South-easterly directions. Due to orographical reasons sometimes funnel type of wind also prevails. During the passage of extra-tropical systems, strong gusty winds from south-easterly direction prevail. For a few days in a month, katabatic flow from the south was experienced after 1800 hrs UTC and this phenomenon prevailed almost throughout the year. The variations of monthly mean wind speed is shown in Fig. 1C. There are two peaks, one in July and the other in October. In general, winds are stronger in winter than in summer. In July number of extra tropical systems around the continent were more, which caused strong gusty winds most of the days. July was the windiest month with mean value of 26.4 Kts, nevertheless the highest maximum speed of 85 Kts was recorded in October.

D. *Precipitation*

In Antarctica, precipitation occurs mainly in the form of snow flakes but rain might also occur during the summer season along the coastal areas around the continent and over the Antarctic peninsula. In the year 1990, Maitri experienced snowfall on 71 days, of which March recorded 14 days of snowfall while November had none. A light rainfall and drizzle was experienced on January 17, 1991. Table 1 gives the monthly weather summary during Jan'90 to Jan'91.

## Clouds

Medium type of clouds are common in Antarctica. Chances of low clouds are lesser in winter. Generally cloudless sky prevails in winter. However, due to the passage of low pressure systems a sudden incursion of moisture forms mainly altostratus and altocumulus type of clouds in winter. Chances of formation of convective type of clouds are very rare even in summer at Maitri.

### Weather **at A Glance during 1990 at Maitri**

| *S.No* | *Phenomena* | *Value* | *Date* |
|---|---|---|---|
| 1. | Highest Maximum Temperature | 9.0°C | 14 December |
| 2. | Lowest Minimum Temperature | -32.0°C | 18 August |
| 3. | Max MSL Pressure | 1030.5 Mb | 29 April |
| 4. | Min MSL Pressure | 948.9 Mb | 30 July |
| 5. | Max Wind Speed | 85 Kts | 12 October |
| 6. | Warmest month of the year | December with mean temperature of 1.0°C. | |

| | | |
|---|---|---|
| 7. | Coldest month of the year | August with mean temperature of -20.5°C. |
| 8. | Windiest month of the year | July with mean wind speed of 26.4 Kts. |
| 9. | Warmest day of the year | 14 December with mean temperature of 5.2°C. |
| 10. | Coldest day of the year | 5 September with mean temperature of-28.7°C |
| 11. | Windiest day of the year | 10 July with mean wind speed of 45 Kts. |
| 12. | Mean temperature of the year | -9.2°C |
| 13. | Mean MSL Pressure of the year | 988.1 Mb |
| 14. | Mean wind speed of the year | 16.7 Kts. |

## Balloon Ascents

A. *Ozone-hole studies*

To study the fluctuation of the ozone profile and investigate the ozone-hole during Antarctic Spring season, ozone sondes were released from mid Feb'90 onwards at Maitri. At the rate of one ascent per week, 50 ozonesonde ascents in 1990 and 3 in Jan'91 were taken. The maximum ozone concentration varied from 15 Km in winter to 35 Km in summer. The ozone depletion commenced in the last week of August and the ozone was reduced to less than half by the end of September. During the first week of November ozone concentration again built up. Fig. 2 shows the ozone profile during peak period (May), depletion period (September), and building up period (November).

B. *Upper-air temperature profile*

Temperatures at different standard millibaric levels were calculated from ozonesonde ascents during March'90 to Feb'91 and are given in Table 2. Heights of different isobaric surfaces were also tabulated and are given in Table 3. Monthly mean temperature curves for different levels upto 500 Mb were drawn and are shown in Fig.3. It may be seen from Fig. 3 that the trend of surface temperature was reflected upto 700 Mb and the same did not reflect in the upper troposphere. During July, the lower troposphere is warmer than it is during the preceding and the following months. This is due to frequent movement of extra tropical low pressure systems which brought warm and moist air from lower latitudes and mixed it with cold and dry continental air, upto 700 Mb height only.

C. *Low level inversions*

During August and September ground inversions generally occur upto 300 M but low level inversions can also be seen at around 2000 M height during other winter months. This is the reason the surface temperature curve intercepts the 900 millibar curve in August.

**Table 2 : Mean Monthly Upper Air Temperatures over Maitri at Different Millibaric Levels**

| Month | Millibaric levels | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 850 | 700 | 600 | 500 | 400 | 300 | 250 | 200 | 150 | 100 | 70 | 50 | 30 | 25 | 20 | 15 | 10 | 5 |
| Mar.'90 | -11.3 | -18.2 | -23.3 | -30.5 | - 40.1 | - 47.7 | - 45.1 | - 41.7 | - 41.2 | -38.6 | -39.9 | -39.4 | - 40.4 | -40.5 | - 40.4 | -35.4 | -33.8 | - 36.7 |
| Apr. | -15.9 | -22.0 | -26.9 | -33.8 | - 42.9 | -52.6 | -52.3 | - 48.7 | -50.0 | -51.4 | -53.2 | -54.7 | -54.9 | -55.4 | -55.2 | -53.1 | -52.8 | - 49.4 |
| May. | -16.7 | -23.7 | -28.7 | -35.6 | - 44.0 | -53.6 | -57.7 | -58.7 | -58.9 | -61.6 | - 66.4 | -69.2 | -66.6 | -65.6 | - 65.0 | -64.2 | — | — |
| Jun. | -19.6 | -24.7 | -28.5 | -36.6 | - 46.2 | -56.4 | -63.7 | - 68.1 | -70.4 | -74.3 | -73.3 | — | — | — | — | — | — | — |
| Jul. | -15.7 | -23.2 | -29.3 | -37.0 | - 46.9 | -59.7 | -63.5 | - 65.4 | -68.6 | - 71.5 | -80.0 | — | — | — | — | — | — | — |
| Aug. | -19.9 | -25.6 | -31.8 | -39.5 | - 49.1 | -59.2 | -64.1 | - 67.3 | -70.1 | -74.7 | -77.6 | -78.4 | -74.7 | -71.3 | -73.9 | — | — | — |
| Sep. | -19.8 | -26.1 | - 28.4 | -35.0 | -44.8 | -59.1 | - 66.5 | -71.9 | -74.2 | -76.5 | -75.9 | -75.5 | - 68.0 | - 65.3 | - 60.0 | — | — | — |
| Oct. | -13.4 | -17.3 | -24.1 | -33.4 | -40.7 | -52.9 | -58.3 | -63.9 | -67.0 | -67.0 | -62.2 | -56.7 | -50.4 | -43.9 | -46.0 | — | — | — |
| Nov. | -13.1 | -19.9 | -25.4 | -32.8 | -42.3 | -54.0 | -60.3 | -61.1 | -61.7 | -58.8 | -50.9 | -43.3 | -34.3 | -30.6 | -27.9 | -24.5 | -18.5 | -10.0 |
| Dec. | -3.4 | -13.5 | -17.7 | -25.8 | -35.4 | -48.8 | -52.0 | -51.4 | -50.3 | -46.5 | -40.4 | -34.7 | -28.3 | -27.0 | -26.4 | -20.9 | -19.9 | -15.3 |
| Jan.'91 | -4.3 | -13.9 | -18.8 | -24.9 | -34.4 | -45.7 | -49.9 | -45.8 | -43.8 | -41.3 | -38.9 | -36.4 | -33.3 | -33.0 | -31.5 | -30.5 | -29.0 | -26.3 |
| Feb. | -11.3 | -18.2 | -23.3 | -30.5 | -40.1 | -47.7 | -45.1 | -41.7 | -41.2 | -38.6 | -39.9 | -39.4 | -40.4 | -40.5 | -40.4 | -35.4 | -33.8 | -36.7 |

**Table 3 : Mean Height of Standard Isobaric Levels in Geopotential Metres over Maitri**

| Month | 850 | 700 | 600 | 500 | 400 | 300 | 250 | 200 | 150 | 100 | 70 | 50 | 30 | 25 | 20 | 15 | 10 | 5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mar.'90 | 1194 | 2665 | 3804 | 5118 | 6672 | 8593 | 9555 | 11311 | 13269 | 16033 | 18706 | 20765 | 24251 | 25491 | 27013 | 29244 | 32046 | 36420 |
| Apr. | 1189 | 2638 | 3758 | 5053 | 6590 | 8485 | 9652 | 11106 | 12978 | 15621 | 17926 | 20084 | 23345 | 24510 | 25929 | 27764 | 30205 | 34038 |
| May | 1214 | 2651 | 3765 | 5052 | 6579 | 8468 | 9628 | 11025 | 12810 | 15347 | 17424 | 19476 | 22556 | 23660 | 25016 | 26772 | — | — |
| Jun. | 1169 | -2591 | 3705 | 4987 | 6504 | 8372 | 9505 | 10859 | 12637 | 15067 | 17298 | | | | | | | |
| Jul. | 1188 | 2629 | 3743 | 5024 | 6538 | 8393 | 9517 | 10882 | 12621 | 15053 | 16929 | | | | | | | |
| Aug. | 1146 | 2551 | 3677 | 4942 | 6441 | 8299 | 9430 | 10782 | 12502 | 14877 | 16946 | 18860 | 21783 | 22859 | 23680 | — | — | — |
| Sep. | 1074 | 2498 | 3609 | 4901 | 6414 | 8279 | 9402 | 10726 | 12407 | 14752 | 16811 | 18754 | 21523 | 22643 | 24004 | — | — | — |
| Oct. | 1219 | 2690 | 3838 | 5197 | 6726 | 8643 | 9810 | 11198 | 12957 | 15366 | 17561 | 19608 | 22955 | 24138 | 25651 | — | — | — |
| Nov. | 1166 | 2610 | 3742 | 5045 | 6587 | 8484 | 9635 | 11019 | 12805 | 15327 | 17625 | 19820 | 23230 | 24812 | 26398 | 28472 | 31464 | 36858 |
| Dec. | 1202 | 2708 | 3872 | 5215 | 6802, | 8754 | 9943 | 11387 | 13260 | 15921 | 18325 | 20640 | 24264 | 25573 | 27181 | 29290 | 32310 | 36438 |
| Jan.'91 | 1160 | 2659 | 3819 | 5163 | 6757 | 8724 | 9922 | 11373 | 13293 | 16032 | 18464 | 20782 | 24342 | 25652 | 27197 | 29233 | 32123 | 37042 |
| Feb. | 1208 | 2697 | 3849 | 5177 | 6748 | 8682 | 9897 | 11368 | 13297 | 16002 | 18407 | 20688 | 24223 | 25469 | 27005 | 28850 | 31435 | 36408 |

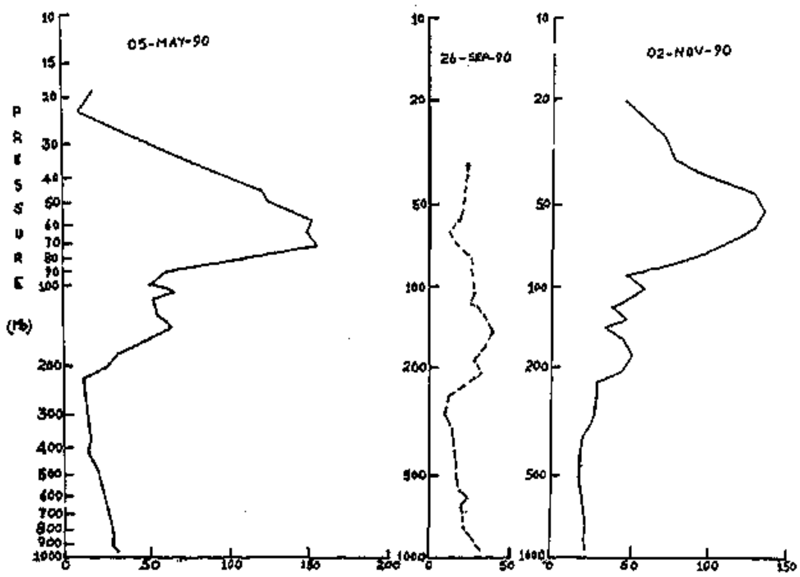


*Fig. 2. Sample of ozone profiles during May, September and November 1990.*

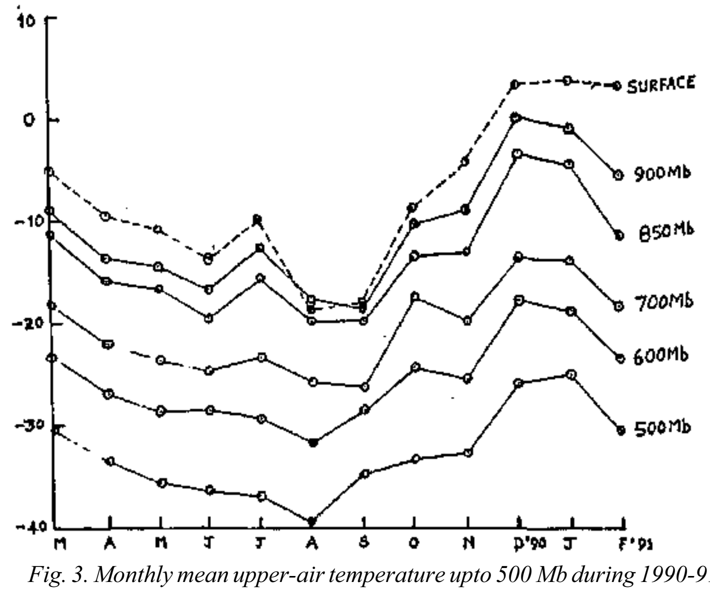


*Fig. 3. Monthly mean upper-air temperature upto 500 Mb during 1990-91.*

D. *Radiation flux in the upper atmospheric layers*

To investigate the radiation flux in the upper atmosphere and heat transfer in various layers over the region, 10 Radio Meter Sonde ascents were undertaken, after polar night period, mostly before and after blizzards.

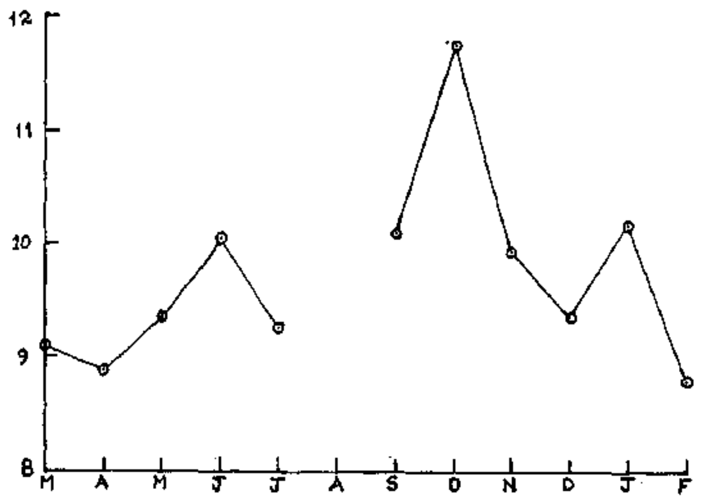


*Fig. 4. Mean height of Antarctic tropopause during March 1990 to February 1991.*

E. *Antarctic tropopause*

Using ozonesonde ascents monthly mean heights of tropopause were calculated from March'90 to Feb'91 and are shown in Fig. 4. Tropopause height generally varies from 8 to 10 Km. Highest tropopause (11.7 Km) occurred in October and coldest in September (-73°C). In August the tropopause was not well-marked.

## Global Solar Radiation

The polar region receives almost the equal hours of sunshine as do the equatorial regions. Due to the low elevation of sun and high albedo of the snow however most of the solar radiations are reflected back in the polar region to space. The surface absorbs only a little percentage of solar radiations falling over it.

Global solar radiation was monitored using the pyranometer and a protek recorder. Values were tabulated for every 10 minutes in local apparent time (LAT). The hourly mean values of radiations in each month are shown in Table 4. The total radiation for March'90 to Jan'91 is plotted in Fig. 5. During June and July the radiation was nil due to the absence of the sunshine and very low zenith angle of the sun. The second half of the year received more heat energy than the first half. December received the maximum radiation of 48.78 Mega Joules/Sq. Meter a day. This intensity of solar radiation is sufficient to defreeze the Antarctic ice but due to high albedo of snow/ice most of the solar radiations are reflected back to the space without affecting the frozen continent.

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Table 4: Mean Global Radiation in Megajoules per Sq. Metre (MJ/m$^2$) at Maitri from February 1990 to January 1991

| Months | Hour ending at local apparent time | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | .10 | 11 | 12 |
| Feb.90 | 0.00 | 0.00 | 0.00 | 0.01 | 0.15 | 0.43 | 0.92 | 1.34 | 1.62 | 1.97 | 2.09 | 2.19 |
| March | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.06 | 0.25 | 0.60 | 0.91 | 1.23 | 1.53 | 1.64 |
| April | 0.00 | 0.00 | 0,00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.20 | 0.41 | 0.58 | 0.70 |
| May | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 |
| June | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| July | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Aug. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.07 | 0.22 | 0.37 | 0.47 |
| Sept. | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.13 | 0.46 | 0.88 | 1.20 | 1.43 | 1.52 |
| Oct. | 0.00 | 0.00 | 0.00 | 0.00 | 0.12 | 0.36 | 0.77 | 1.20 | 1.55 | 1.86 | 2.18 | 2.36 |
| Nov. | 0.02 | 0.04 | 0.18 | 0.53 | 0.92 | 1.31 | 1.77 | 2.21 | 2.61 | 3.03 | 3.27 | 3.49 |
| Dec. | 0.14 | 0.33 | 0.65 | 0.92 | 1.25 | 1.67 | 2.22 | 2.67 | 3.17 | 3.62 | 3.93 | 4.07 |
| Jan.'91 | 0.02 | 0.04 | 0.12 | 0.42 | 0.69 | 1.04 | 1.55 | 2.04 | 2.51 | 2.88 | 3.14 | 3.29 |

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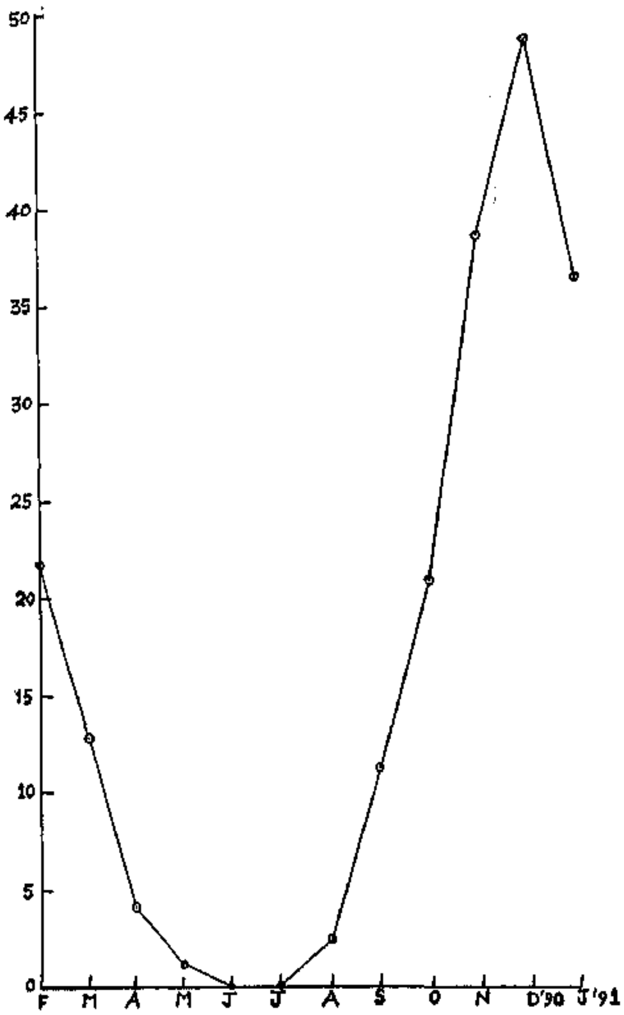
**Table 4**: ***Contd.***

| Months | Hour ending at local apparent time | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | Total |
| Feb.'90 | 2.15 | 2.24 | 2.11 | 1.61 | 1.29 | 0.85 | 0.49 | 0.19 | 0.05 | 0.01 | 0.00 | 0.00 | 21.71 |
| March | 1.58 | 1.55 | 1.33 | 1.02 | 0.68 | 0.32 | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 12.80 |
| April | 0.71 | 0.63 | 0.43 | 0.22 | 0.07 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 4.00 |
| May | 0.05 | 0.02 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.12 | 0.00 |
| June | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| My | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Aug. | 0.49 | 0.40 | 0.24 | 0.08 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.36 | 0.00 |
| Sept. | 1.55 | 1.41 | 1.17 | 0.82 | 0.44 | 0.14 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 11.16 |
| Oct | 2.28 | 2.07 | 1.85 | 1.59 | 1.25 | 0.85 | 0.43 | 0.09 | 0.01 | 0.00 | 0.00 | 0.00 | 20.82 |
| Nov. | 3.38 | 3.26 | 3.06 | 2.80 | 2.25 | 1.76 | 1.29 | 0.85 | 0.43 | 0.12 | 0.03 | 0.01 | 38.62 |
| Dec. | 3.90 | 3.82 | 3.60 | 3.14 | 2.54 | 2.16 | 1.71 | 1.31 | 0.97 | 0.59 | 0.25 | 0.15 | 48.78 |
| Jan.'91 | 3.27 | 3.13 | 2.88 | 2.70 | 2.15 | 1.69 | 1.25 | 0.82 | 0.52 | 0.23 | 0.05 | 0.02 | 36.45 |




*Fig, 5. Monthly total solar radiation for the period February 1990 to January 1991.*

**APT Pictures and Weather Fax Charts**

Cloud pictures from polar orbitting NOAA-10 and NOAA-11 satellites and weather fax charts from Molodezhnaya were received during the Expedition. The APT pictures, fax charts and barographic records of the corresponding period were correlated to understand the weather systems, and issue forecasts to different convoys and for determining the frequency of cyclonic storms encircling the continent. Fig. 6A shows a cyclonic system centred at 61° S, 20° E in the satellite picture. The subsequent surface analysis chart (Fig. 6B) received from Molodezhnaya shows a corresponding low pressure system over Schir-

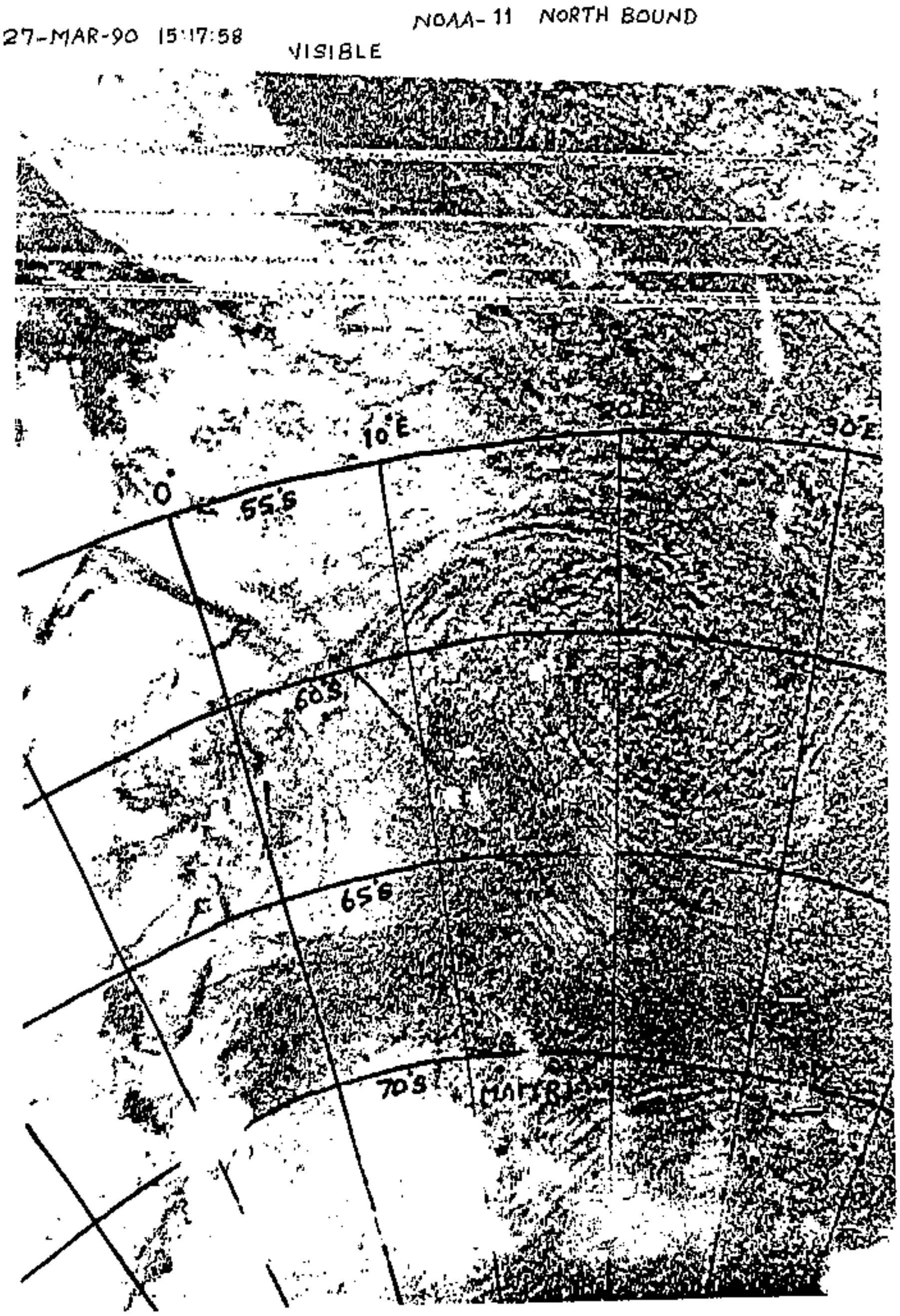



*Fig. 6. Sample of (A) Polar Orbitting NOAA Satellite Picture.*

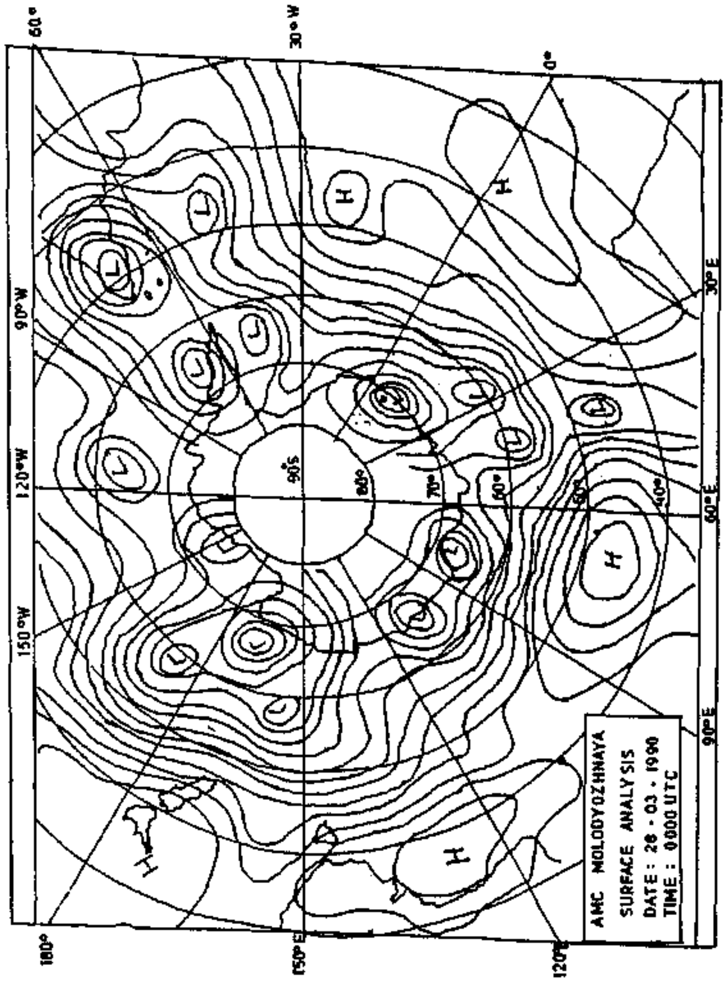



*Fig. 6. Sample of(B) Fax Chart transmitted from AMC Molodezhnaya.*

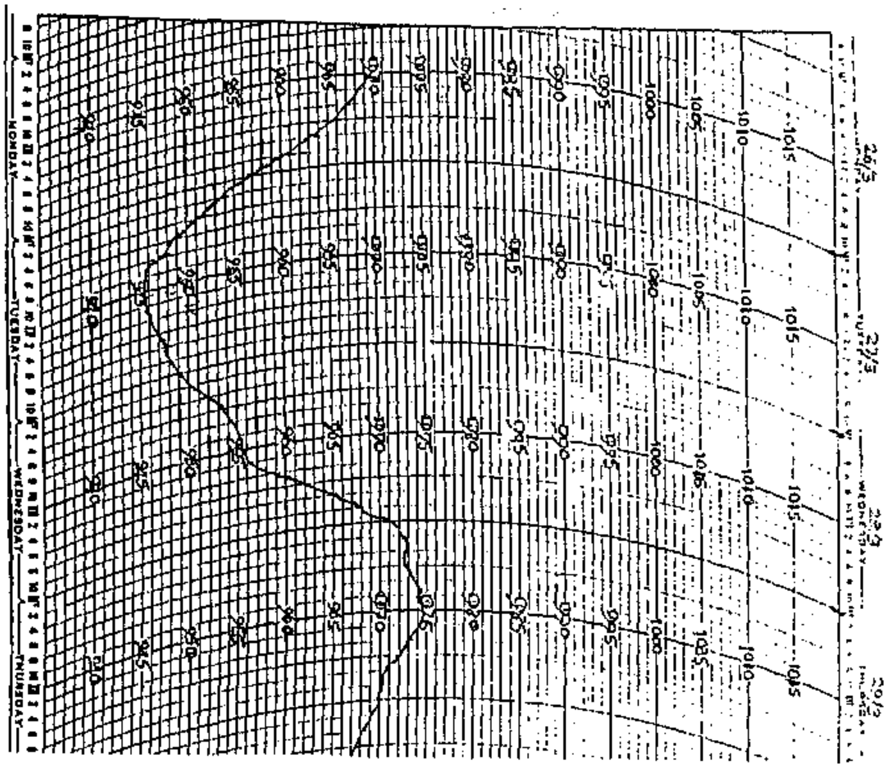


*Fig. 6. Sample of(C) Microbarigraph Chart of an extra-tropical system during March 26-28, 1990.*

macher ranges. The automatic barographic record for the same period (Fig. 6C) depicts the sharp fall in pressure, measuring about 11 Mb in just 12 hours. The correlation between the three charts clearly illustrates that a low pressure system was existing over the area on March 27, 1990 when Maitri station experienced snowfall and blizzard.

## Logistic Support

Using NOAA-10 and NOAA-11 satellite cloud pictures, fax charts and other meteorological parameters, forecasts were issued to all convoys and Humboldt and Petermann camps daily, through HF communication. APT pictures were very useful in locating the synoptic systems and in issuing the forecasts. During summer period METAR/Special reports were issued from Maitri for helicopter operations, as and when requested for.

## Comparison of Meteorological Parameters between Maitri and Humboldt Camp

During the geological surveys conducted by GSI team; temperature, pressure and wind observations were recorded at Humboldt which is 1400 M above mean sea level. The observations have been compared with the corresponding observations taken at Maitri at surface level and 800 Mb level and the same are depicted in Tables 5 & 6.

It may be seen from the Tables 5 & 6 that altitude of the area is very close to 800 Mb isobaric level. The winds in general are stronger over Maitri than Humboldt. The temperatures are much lower at Humboldt as compared to surface temperatures at Maitri but are quite comparable to the 800 Mb level temperatures at Maitri. The reasons for the winds to be stronger over Maitri is that it is.closer to the track of extra tropical low pressure systems. The temperature difference is due to the altitude difference of two places.

## Blizzards

Antarctica is the home of blizzards. Maitri experienced 25 days of blizzards during the year 1990. During May to December' 89 Maitri experienced blizzards on 9 days only whilst

**Table - 5**

| Date | Time 0900 UTC | | | |
|---|---|---|---|---|
| | Humboldt | | Maitri | |
| | Surface Pressure(Mb) | Wind Speed (Kts) | Surface Pressure (Mb) | Wind Speed (Kts) |
| 10 Oct.' 90 | — | 15 | — | 30 |
| 11 | — | 15 | — | 30 |
| 12 | — | 25 | — | 46 |
| 13 | — | 25 | — | 43 |
| 14 | — | Calm | — | 18 |
| 15 | — | Calm | — | 33 |
| 16 | — | Calm | — | 26 |
| 17 | 840 | 10 | 993.3 | 05 |
| 18 | 823 | 20 | 974.3 | 20 |
| 19 | 821 | 25 | 965.6 | 38 |
| 20 | 813 | 30 | 957.4 | 29 |
| 21 | 808 | 15 | 954.3 | 24 |
| 22 | 811 | Calm | 958.1 | 13 |
| 23 | 813 | 08 | 960.8 | 03 |
| 24 | 820 | 05 | 966.9 | Calm |
| 25 | 823 | 08 | 974.5 | Calm |

Table 6 : Temperature in °C Recorded at

| Date | 0900 UTC | | 1200 UTC | | 800 Mb Level |
|---|---|---|---|---|---|
| | Humboldt | Maitri | I-iumboldt | Maitri | |
| 5 Oct.' 90 | - | -9.3 | - | -10.5 | |
| 6 | -18.0 | -9.3 | -15.0 | -8.4 | |
| 7 | -19.0 | -8.8 | -16.0 | -8.8 | |
| 8 | -16.0 | -7.3 | -14.0 | -5.7 | |
| 9 | -16,0 | -6.2 | -14.0 | -4.6 | |
| 10 | -11.0 | -6.5 | -10.0 | -6.1 | |
| 11 | -8.0 | -6.0 | -8.0 | -4.7 | |
| 12 | -6.0 | -13,1 | -8.0 | -11.0 | |
| 13 | -12.0 | -8.7 | -9.0 | -6.4 | |
| 14 | -19.0 | -2.5 | -12.0 | +0.2 | |
| 15 | -17.0 | -2.1 | -13.0 | -0.6 | |
| 16 | -11.0 | -8.4 | -8.0 | -10.0 | |
| 17 | -18.0 | -8.8 | -16.0 | -8.1 | |
| 18 | -12.0 | -9.8 | -9.0 | -10.5 | |
| 19 | -12,0 | -10.0 | -10.5 | -8.8 | |
| 20 | -14.0 | -4.4 | -14.0 | -4.5 | |
| 21 | -19.0 | -10.7 | -19.5 | -6.4 | |
| 22 | -21.0 | -6.9 | -16.5 | -5.6 | |
| 23 | -19.0 | -9.7 | -17.0 | -7.8 | |
| 24 | -20.0 | -7.2 | -16.0 | -10.6 | |
| 25 | -17.0 | -9.4 | -13.0 | -10.0 | |
| 26 | -14.0 | -8.5 | -11.5 | -7 4 | |
| 27 | -19.0 | -7.8 | -14.0 | -6.0 | |
| 28 | -21.0 | -4.6 | -13.0 | -3.6 | |

Dakshin Gangotri experienced them on 59 days during the same period. Blizzards are very common over the ice shelf due to availability of loose snow. Maitri is surrounded by morainal land and continental ice-edge having very small amount of loose snow. As such, the frequency and intensity of blizzards is very low over Maitri, as compared to Dakshin Gangotri. Each blizzard has its own characteristics. History of each blizzard has been summarised in Table 7. Table 8 shows comparative figures of blizzards over Maitri and Dakshin Gangotri during 1989 and 1990.

Table 7 History of the Blizzards Recorded at Maitri during January'90 to January'91

| S.No. | Duration Dt/Time (UTC) | MSL Pressure (Mb) | | Temperature °C | | Max Wind (Knots) | Pressure Change | Temperature Change (°C) | Weather |
|---|---|---|---|---|---|---|---|---|---|
| | | Max | Min | Max | Min | | | | |
| 1. | March 08/0200 to 09/0230 | 990.3 | 981.3 | -1.4 | -7.4 | 72 | 9 Mb Fall | 6.0 Fall | Snowfall |
| 2. | March 11/1700 to 11/2000 | 988.3 | 987.6 | -2.0 | -4.2 | 49 | 0.7 Mb Fall | 2.2 Rise | Snowfall |
| 3. | March 27/0730-1230 | 962.2 | 959.7 | -4.0 | -6.3 | 47 | 2.5 Mb Fall | 2.3 Fall | Snowfall |
| 4. | April 04/2000 to 05/1130 | 992.8 | 985.5 | -7.0 | -13.5 | 180/47 | 7.3 Mb Rise | 6.5 Rise | — |
| 5. | April 24/0230-1130 | 1008.8 | 1005.6 | -13.4 | -15.3 | 110/42 | 3.2 Mb Rise | 1.9 Fall | Snowfall |
| 6. | April 25/1400-2120 | 1016.0 | 1015.3 | -6.7 | -10.0 | 110/42 | 0.7 Mb Fall | 3.3 Rise | Snowfall |
| 7. - | April 2671745-1815 | 1008.3 | 1006.8 | -6.7 | -10.2 | 160/45 | 1.5 Mb Rise | 3.5 Rise | — |
| 8. | April 26/1910-1930 | 1007.9 | 1006.5 | -6.9 | -11.0 | 160/41 | 2.4 Mb Rise | 4.1 Rise | — |
| 9. | April.26/2245-2310 | 1006.2 | 1005.0 | -7.4 | -14.5 | 160/43 | 1.2 Mb Rise | - 7.1 Rise | — |
| 10. | April 29/1030-2230 | 1027.6 | 1023.0 | -2.5 | -5.0 | 180/55 | 4.6 Mb Fall | 2.5 Rise | Snowfall Proceeding Day |
| 11. | May 02/0500-1600 | 1012.3 | 1011.0 | -4.1 | -6.9 | 140/53 | 1.3 Mb Fall | 2.8 Rise | Snowfall |

*Conld.*

Establishment

**Table 7: *Contd.***

| S.No. | Duration Dt/Time (UTC) | MSL Pressure (Mb) | | Temperature °C | | Max Wind (Knots) | Pressure Change | Temperature Change (°C) | Weather |
|---|---|---|---|---|---|---|---|---|---|
| | | Max | Min | Max | Min | | | | |
| 12. | May 03/0900 to 04/0800 | 1005.5 | 1003.3 | -3.0 | -5.5 | 140/56 | 2.2 Rise | 2.5 Fall | Snowfall Proceeding Day |
| 13. | May 16/0800-1140 | 986.1 | 985.3 | -8.4 | -13.5 | 160/41 | 0.8 Rise | 5.1 Rise | Snowfall |
| 14. | May 16/1730-1900 | 988.1 | 987.8 | -9.5 | -10.5 | 140/39 | 0.3 Rise | 1.0 Rise | Snowfall |
| 15. | May 20/1630 to 21/0130 | 999.8 | 994.6 | -9.9 | -1.4 | 140/49 | 5.2 Rise | 1.5 Fall | Snowfall |
| 16. | Jun. 02/2000 to 03/0700 | 990.6 | 986.9 | -6.9 | -9.8 | 140/23 | 3.7 Rise | 2.9 Rise | Snowfall |
| 17. | July 11/0230-1230 | 988.2 | 961.3 | -6.0 | -9.5 | 140/66 | 26.9 Rise | 3.5 Fall | Snowfall |
| 18. | July 15/0500-1130 | 1003.4 | 995.0 | -7.8 | -16.5 | 140/54 | 8.4 Rise | 8.7 Fall | — |
| 19. | Sept, 16/0100-0400 | 965.1 | 962.5 | -20.0 | -20.8 | 110/39 | 2.6 Rise | 0.8 Fall | Snowfall |
| 20. | Sept. 16/0630-0800 | 969.5 | 968.0 | -20.4 | -20.8 | 110/41 | 1.5 Rise | 0.4 Rise | Snowfall |
| 21. | Oct. 12/1230-1640 | 978.7 | 976.9 | -10.5 | -11.8 | 140/54 | 1.8 Fall | 1.3 Rise | Snowfall |
| 22. | Oct. 12/2030 to 13/1015 | 991.7 | 976.6 | -8.4 | -9.8 | 110/64 | 15.1 Rise | 1.4 Fall | Snowfall |
| 23. | Oct. 18/1045-2200 | 988.4 | 985.8 | -9.5 | -11.5 | 140/48 | 2.6 Fall | 2.0 Fall | Snowfall |
| 24. | Oct. 19/0630-1930 | 984.2 | 976.0 | -6.8 | -10.4 | 140/72 | 8.2 Fall | 3.6 Fall | Snowfall |

**Table - 8**

| Month | No. of Blizzards | | |
|---|---|---|---|
| | Maitri | | Dakshin Gangotri |
| | 1989 | 1990 | 1989 |
| May | 1 | 6 | 7 |
| June | 3 | 2 | 6 |
| July | 4 | 2 | 13 |
| August | 0 | 0 | 4 |
| September | 0 | 1 | 4 |
| October | 1 | 4 | 12 |
| November | 0 | 0 | 13 |
| December | 0 | 0 | 0 |

## Conclusions

**(i)** A new meteorological observatory was established at Maitri. All the instruments brought with the 9th Expedition were installed and were functioning excellently.

(ii) Valuable data of various meteorological parameters have been collected for analyses.

(iii) Ozone-hole investigation has been a specific task of the mission and careful efforts were made to investigate it.

(iv) It has been investigated that ozone-hole exists at Antarctica during spring season (September and October) and the total ozone reduces to less than half of its value during that time.

(v) A close liaison with George Forster (Germany) and Syowa (Japan) was maintained for exchange of ozone data for correlation and study.

**Acknowledgement**

We are very grateful to Dr. S.M. Kulshrestha, Director General of India Meteorology Department, for offering us a chance to work in Antarctica. We record our sincere gratitude to Shri M.G. Gupta, DDGM (Retd), Shri B.R. Avasthi, DDGM and Dr. C.R. Sreedharan, DDGM for guiding us during the Expedition. We also record our thanks to Shri R. Ravindra, Station Commander and all members of the Station especially Hav R. Raghunathan and Hav N. Selvaraj from Corps of Engineers for helping us in various ways.