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Meteorological Observations during 26th Indian Antarctic Expedition at Maitri

N. T. Niyas and R. N. Tripathy*

Meteorological Centre, India Meteorological Department,
Thiruvananthapuram-695033

*Meteorological Centre, India Meteorological Department,
Bhubaneshwar-751001

(*E-mail:niyasiata@gmail.com*)

ABSTRACT

Antarctica is the coldest, windiest, driest and the most remote continent on earth. India Meteorological Department (IMD) has been participating in Indian Antarctic Expeditions (IAE) since (1981). During the year 2007, meteorological data collected over the seas between India and Antarctica and at Maitri, have been analyzed and the results are discussed along with the significant weather phenomenon. Sutron make Automatic Weather Station (AWS) and their transmission antennas were installed at Maitri. The variations in atmospheric pressure, temperature and wind velocity with their influence on different weather systems are discussed. Significant fluctuations in temperature, pressure and wind speed have been noticed in moving weather systems. In addition, some important weather phenomena like blizzard have also been discussed.

INTRODUCTION

Meteorological observation programme has been an integral part of the Indian Scientific Expeditions to Antarctica ever since the first expedition to the icy continent during Antarctic summer of 1981-82. The first permanent Station at Dakshin Gangotri (latitude 70°45’13"S, longitude 11°38’14"E, altitude 150 m, World Meteorological Organisation (WMO) station index number 89510) was established by India in January, 1984 during the third expedition and a manned meteorological observatory was functioning at the Dakshin Gangotri Station round the year till 1989. India established its second permanent scientific research station at Maitri (latitude 70° 45' 39" S, longitude 11° 44' 48" E, altitude 117 m, WMO station index number 89514) in the Schirmacher ranges in

1988-89. Now India has established its third station Bharati at the Larsemann Hills (latitude 69°20' – 69°30' S and longitude 75°55' – 76°30'E). To prepare the climatology of the station, as per WMO norms, we require at least 30 years of meteorological data. We have updated short period climatology up to 2007.

The weather of Antarctica influences the global weather to a great extent. The study of meteorological parameters over Antarctica and their correlation with Indian weather will help in understanding important weather systems. The unique nature of the Antarctic atmosphere, the uniformity of physical structure of snow surface and frequent weather changes are important for the study of meteorological theories. The 26th IAE started from Goa on January 10, 2007. Meteorological measurements were made on board ship and also at Maitri as one of the objectives of the expedition.

In this paper various meteorological programmes undertaken during 26th IAE are presented. In addition, daily/annual variation of different meteorological parameters and some important weather phenomena observed at Maitri, Antarctica like blizzard has also been discussed. The observatory at Maitri is equipped with autographic instruments for continuous recording of meteorological parameters (e.g. surface temperature, pressure, wind speed and direction). It also has the equipment for the reception of weather charts broadcasts from forecasting offices in the region and the Automatic Picture Transmission (APT) equipment for reception of cloud imageries from the polar orbiting weather satellites (NOAA). The meteorological station at Maitri is thus a well equipped weather observatory which is capable of recording various meteorological observations as well as watching and monitoring the weather systems which may approach and affect the station during the course of next few days.

OBJECTIVES

AWS Installation

The Indian Meteorological Programme is an ongoing observational programme and also to make further efforts for the modernization of the station. For the latter purpose a Sutron make Automatic Weather Station (AWS) was established on experimental basis during the 26th expedition. It was aimed to conduct experiments on the reception of hourly surface

meteorological observations of Maitri through Indian geostationary satellite KALPANA. In this connection an AWS was installed at the station. The sensors and the helical antenna of the AWS were installed on top of the 10 m assembly structure and then shifed to the top of the station. The electronic component and the power supply unit of the AWS were kept in thermally insulated boxes in the assembly. During the wintering period, a close watch on the performance of this AWS system was kept and detailed report has been separately published in the TECO-2008 proceedings report (http://www.wmo.int/pages/prog/www/IMOP/publications/IOM-96_TECO-2008/P2(39)_Ranalkar_India.pdf).

Real-Time Transmissions

Another significant programme of the Wintering Team was the transmission of the coded meteorological observations on real-time basis. The meteorological observatory at Maitri was allocated station index number (89514) by WMO to facilitate international exchange of the observations recorded at the Indian station. Surface observations of four main synoptic hours viz. 00, 06, 12 and 18 GMT collected at ship (Emerald Sea) and Maitri, were transmitted to IMD, New Delhi through email system (rthnewdelhi@imdmail.gov.in) at the time of observation for the international exchange over Global Telecommunication System (GTS). Maitri thus became part of the WMO network of Meteorological Stations in Antarctica. From September 2007 onwards daily local weather data and forecast of Maitri, Antarctica are being updated in the IMD website link http://www.imd.gov.in/section/nhac/dynamic/maitri.htm.

Ongoing Programme

The ongoing meteorological programmes which continued during the expedition period, included the following:

1. From the ship, three hourly measurements of temperature, pressure, humidity, wind speed and direction, sea surface temperature, cloud cover, wave, ice and humidity were made. In addition, the ship carried facsimile equipment for reception of weather pictures from various countries.
2. Monitor weather conditions by keeping constant watch.
3. Record 3 hourly synoptic observations and disseminating the main 6 hourly synoptic data to IMD, New Delhi for its global exchange programme.

4. Study of daily, seasonal and annual variations of surface atmospheric pressure, winds, air temperature and cloud cover.
5. Monitor the weather systems affecting weather at the station by arranging reception of (a) Cloud imageries from polar orbiting satellites. Satellite pictures were regularly received from the polar orbiting NOAA weather satellites. (b) Regular reception of two analyzed charts broadcasted from Pretoria, South Africa. (c) Meteorological observations from stations in the neighbouring area.
6. Study the synoptic weather systems that affect the weather over Antarctica with special reference to their formation, intensification, movement and decay.
7. Provide weather forecasts for the purpose of planning and execution of the activities of the expedition in Antarctica.
8. Issue meteorological report and weather forecast for helicopter operations in Antarctica.
9. Maintenance of installed meteorological equipment.
10. Install AWS in Maitri station, Antarctica.

Instruments Used

1. Stevenson Screen, dry bulb thermometer, maximum thermometer, minimum thermometer and wind masts.
2. Complete wind mast assembly with temperature and humidity sensors anemometer and wind vane attached with continuous recording and dual display facility.
3. Electrical thermometer (YSI Thermister) and temperature recorder for continuous recording of surface air temperature.
4. Cup generator anemometer, wind vane, wind direction and speed recorders for continuous recording of wind data.
5. Omni-directional antenna was installed at the top structure of the building to receive cloud imagery.
6. Automatic Picture Transmission (APT) receiver-cum-recorder for receiving the visible and infra-red cloud pictures from Polar Orbitting weather Satellites of (NOAA) at periodic intervals.

7. Microbarograph for self recording of atmospheric pressure. Barograph and aneroid barometers for measurement of atmospheric pressure.
8. Sutron make AWS and its transmission antenna.
9. Weather fax recorder to receive analysed weather charts from meteorological centre Pretoria (South Africa).
10. Different portable instruments for taking observations in the event of power failure.

Meteorological Data Collected

1. Autographic records of atmospheric pressure, temperature, surface wind direction and speed.
2. 3-hourly synoptic observations (00, 03, 06, 09, 12, 15, 18 and 21 GMT).
3. Imageries of clouds and ice-pictures from NOAA satellites through WINSAT installed workstation.
4. Radio-Facsimile charts from Pretoria.
5. AWS records of location, atmospheric pressure, temperature, humidity, wind direction and wind speed.

RESULTS AND DISCUSSION

Weather Observations made during the Voyage

Routine weather observations were made at three hourly intervals (Total 147 records) from the ship platform from 06 GMT of January 11, 2007 to 12 GMT of February 15, 2007, except during the period of port call of the ship at Port Louis (Mauritius) and Durban (South Africa) from 09 GMT of January 11, 2007 to 09 GMT of January 22, 2007 and from 15 GMT of January 26, 2007 to 15 GMT of February 08, 2007, respectively.

Atmospheric Pressure

An aneroid barometer and a barograph were used to record the station level pressure. The station level pressure has been reduced to Mean Sea Level (MSL) pressure for making a comparative study on

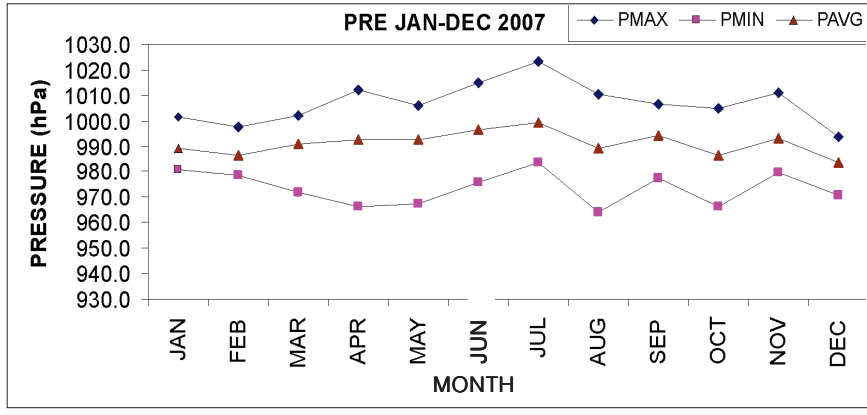

Fig. 1: Mean monthly variations of Mean Sea Level Pressure

synoptic scale. The highest MSL pressure of 1023.1 hPa and the lowest of 964.3 hPa were recorded on 28.07.07 and 13.08.07, respectively during the stay, while the average pressure was 991.2 hPa. The mean monthly variation of MSL pressure during 2007 is shown in Figure 1. There were three peaks in oscillations of pressure during the period, the highest being in the month of July with mean value of 999.5 hPa and the others in September and November with mean values 994.1 hPa and 993.2 hPa, respectively. The MSL pressure fell to a low value of 983.8 hPa in December 2007. Surface analysis charts from South African Meteorological Centre, Pretoria were received on facsimile recorder at ship and at Maitri on a regular basis.

On an average, the diurnal variation of atmospheric pressure was found to be very less. However, variations associated with the moving weather systems were observed to be high. Cases of two to three hPa variations in three hours were very common. It is the most important parameter to know the behavior and intensity of the approaching meteorological disturbance. Normally significant fall of pressure in a short period of time is an indication of bad weather. The forecasters in Antarctica are advised to use this parameter as a forecasting tool with extreme caution.

Short Period Climatology

Average annual air pressure reduced to MSL is 985.9 hPa. The highest MSL pressure of 1030.5 hPa was recorded on 29th April 1990

and lowest MSL pressure of 930.0 hPa was recorded on 9th August 2005. Generally, the low pressure systems move from west to east round the Antarctic coast along the polar low pressure belt which fluctuates north-south on both diurnal and seasonal basis. These low pressure systems which are associated with cyclonic (clockwise direction in the southern hemisphere) circulation carry warm and moist air to the south of it. As a result, continuous rise in temperature is observed with the approach of these systems.

Air Temperature

The electrical (YSI thermister) thermometers are found to be best suited for Antarctic conditions for remote reading and tracing a continuous record. The drawback with these thermometers is, however, that these are susceptible to all types of electrical interferences such as High Frequency (HF) Transmission interference and static electric charge interferences. The only alternative to this problem is to switch off the unit during such interferences which will apparently cause the break in the continuous record. The mean temperature was -8.6°C. The lowest minimum temperature of -28.0°C was recorded on 26th September 2007. Highest value of +10.0°C was recorded on 09th November 2007. The next high value of +8.5°C was in 11th December 2007.

Monthly mean air temperatures have been depicted in Fig. 2. It is seen that September is the coldest and January is the warmest month. In January the mean temperature is +0.9°C while in September it is estimated as -17.3°C. November 8, 2007 was the warmest day with

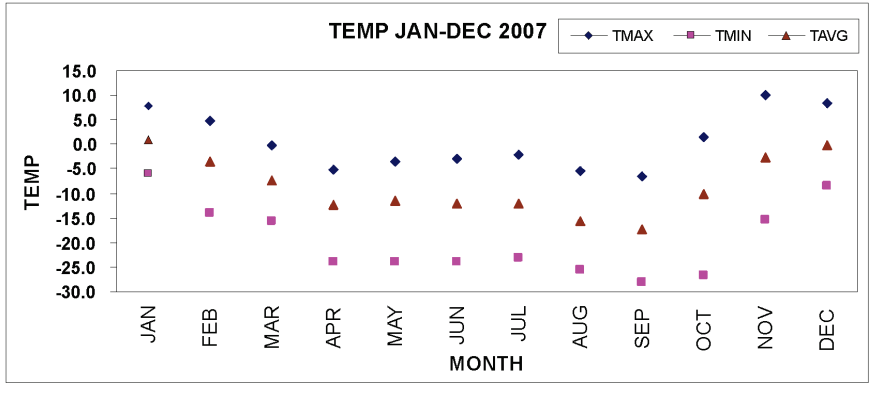

Fig. 2: Mean monthly variations of Air Temperatures

mean temperature 4.7°C. September 22, 2007 was the coldest day with mean temperature -24.8°C. The temperature gradually fell from January onwards due to onset of winter, up to September. From September onwards temperature rose slightly and thereafter shot-up sharply to +10.0°C in November. 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. This is also due to the fact that Maitri is situated over rocky area. The solar radiations are mostly absorbed by the land during day time. During night, the land emits heat energy as terrestrial radiations and warms the lower atmosphere at Maitri. Air temperature is very low because of high latitude, greater reflectivity of ice surface and lack of thick cloud cover to block outgoing radiation. Variation in the wind speed significantly affects the diurnal temperature cycle. Strong winds associated with moving low pressure systems in the ocean surrounding Antarctica invariably raise the atmospheric temperature because they move humid maritime air southward in lower troposphere. Low temperatures are always associated with calm wind conditions. Night temperature used to drop considerably during cloud free nights. Therefore, the study of the air temperature in Antarctica is very important not only from the point of view of human comfort but also for the behavior of different materials, instruments, machines and in particular the different types of vehicles and the lubricants used for them in the continent.

Short Period Climatology

The average annual temperature of Maitri is -9.5 degree Celsius. The lowest mean temperature and extreme daily minimum temperature have been recorded in August/September and the highest mean and extreme maximum temperatures in January/December. The Maximum temperature of 12.5 degree Celsius was recorded on 3rd February 1996. The lowest temperature of -38 degree Celsius was recorded on 23rd July 2006. Temperature shows a cooling trend of 0.26 degree Celsius per decade. The lowest temperature so far recorded on this continent is -88.3°C on 24thAugust, 1960 at the Russian station, Vostok (Lat. 78.45°S Long. 106.8°E, Alt. 3488 m).

Wind

The mean wind speed was 14 Kts. The windiest day was 12 October 2007 with an average wind speed of 45 knots. The month of

July was the windiest month during the wintering period with average wind speed of 22 Kts. The station experienced wind 92 Kts in gust on 02 September 2007. Generally, Maitri experiences wind speed between 15 and 20 Kts from south-easterly directions. 310 days gust wind crossed 23 Kts (Table 1). Due to orographical reasons sometimes funnel type of

Table 1–Weather at a glance during 2007 at Maitri

Sl.No	Phenomena	Value	Date
1.	Mean MSL pressure	991.2 hPa	
2.	Max MSL pressure	1023.1 hPa	
3.	Min MSL pressure	964.3 hPa	13 August
4.	Mean temperature	-8.6° C	
5.	Highest maximum temperature	10.0° C	08 November
6.	Lowest minimum temperature	-28.0° C	26 September
7.	Mean max temperature	-6.3° C	
8.	Mean min temperature	-10.9° C	
9.	Warmest month	0.9 °C	January
10.	Coldest month	-17.3° C	September
11.	Windiest month	22 Knots	July
12.	Warmest day	4.7° C	08 November
13.	Coldest day	-24.8 °C	22 September
14.	Windiest day	45 Knots	12 October
15.	Average wind direction	South Easterly	
16.	Mean wind speed	14 Knots	
17.	Max wind speed	92 Knots	02 September
18.	No. of days with Speed $\geq$ 23 Kts	310	
19.	No. of days with clear sky	103	
20.	No. of days with obscured sky	3	
21.	No. of days with overcast sky	168	
22.	No. of days with fog	4	
23.	No. of days with precipitation	58	
24.	Total Snowfall	57.6 mm	

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 and this phenomenon prevailed almost throughout the year. The variations of monthly mean wind speed is shown in Figure 3. There are three peaks, the highest in September followed by May and March. In general, winds

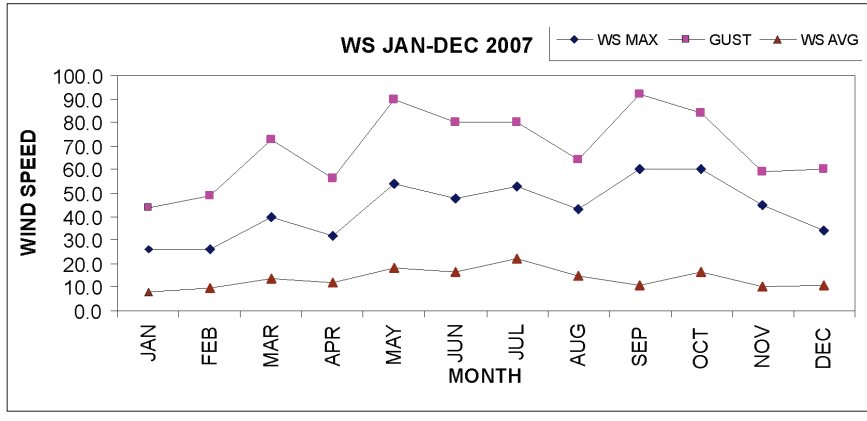

Fig. 3: Mean monthly variations of Wind Speed

are stronger in winter than in summer. In July the number of extra tropical systems around the continent was more, which caused strong gusty winds most of the days. When a low pressure system passed over the station, winds were generally stronger and wind direction changed with northerly component replaced by a southerly component. Winsonic sensor and electrical anemometer were used to keep continuous record of wind speed. Electrical anemometer was found to be the best for remote reading and tracing the continuous record.

Clouds

Medium clouds are common in Antarctica. Chances of low clouds are less during 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. The difficulties in making observation on clouds are particularly high in Antarctica. The cloud base for all sorts of

clouds was found to be quite low in comparison to tropical or sub-tropical regions. 168 days of overcast sky, 103 days of clear sky and 3 days of obscured sky have been reported.

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. During 2007 snowfall (water equivalent) of 57.6 mm was received in 58 snowfall days. Fog was reported only 4 days. Table 1 gives the weather at a glance during 2007 at Maitri. In almost all the cases, the snow fall was associated with strong winds. This made its actual measurement difficult.

Blizzards

Blizzards are generally very frequent over Antarctica and it is not possible to do any outside job during such periods. The blowing snow drops the horizontal visibility drastically to few metres in which it is hazardous to move out. Precipitation does occur in the form of snow flakes but it is not possible to record the actual amount of precipitation due to the drifting/blowing snow. Blizzards are very common over the ice shelf due to availability of loose snow. Maitri is surrounded by rocky land and continental ice-edge having very small amount of loose snow. As such, the frequency and intensity of blizzards are very low over Maitri. Each blizzard has its own characteristics. History of each blizzard is summarised in Table 2. A total of 10 blizzards were experienced during 26th IAE. The longest one lasting for 38 hrs was in the month of October 2007.

Severe blizzards occur under the influence of cyclonic storms/ depressions originating in the southern ocean between 40° S and the Antarctic circle. These affect mainly the coastal areas. In the interior, strong katabatic winds generally prevail which originate from the central highland and blow down the inclined slopes towards the coast. These winds onset suddenly with speed jumping to 30-40 knots. It also falls suddenly. Winds are more pronounced in the months with daylight. However, occasionally under the influence of cyclonic storms, the prevailing circulation is disturbed and violent blizzards (severe storms

Table 2–History of each blizzard (Wind Speed ≥ 23 Kts.)

				Extreme Values (with Date/Time)				
Sl. No	**Snow Fall**	**Date/Time**		**MSL Pressure(hPa)**		**Temperature (^{0}C)**		**Wind (Knots)**
	(mm)	**Commencement**	**Cessation**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**
1	1.6	25.03.07 0415	26.03.07 0512	996.3 25.03.07 0415	989.2 26.03.07 0512	-6.0 25.03.07 1145	-8.7 26.03.07 0430	60 25.03.07 2005
2	5.1	07.06.07 0620	07.06.07 1535	1009.8 07.06.07 1500	1007.2 07.06.07 1200	-3.0 07.06.07 1200	-12.6 07.06.07 0900	61 07.06.07 1255
3	5.1	18.06.07 1145	18.06.07 1845	1001.1 18.06.07 1840	998.9 18.06.07 1145	-7.8 18.06.07 1830	-9.5 18.06.07 1150	62 18.06.07 1410
4	2.8	19.06.07 1530	19.06.07 2200	983.0 19.06.07 1530	980.0 19.06.07 2200	-5.4 19.06.07 1600	-6.8 19.06.07 2035	52 19.06.07 1635
5	11.5	24.06.07 0030	25.06.07 0210	993.3 24.06.07 0030	986.9 25.06.07 0145	-5.0 25.06.07 0210	-7.6 24.06.07 0445	75 24.06.07 1240
6	TR	24.07.07 1135	24.07.07 1320	994.1 24.07.07 1320	990.7 24.07.07 1135	-8.0 24.07.07 1215	-8.9 24.07.07 1320	60 24.07.07 1200
7	1.8	12.08.07 1445	13.08.07 0530	981.7 12.08.07 1445	964.1 13.08.07 0400	-14.0 13.08.07 0445	-16.7 12.08.07 1530	61 12.08.07 2342
8	2.5	15.08.07 0605	16.08.07 0110	973.3 15.08.07 0605	970.0 15.08.07 1400	-17.7 16.08.07 0110	-18.4 15.08.07 0605	54 15.08.07 0930
9	0.1	17.08.07 1520	17.08.07 1700	980.0 17.08.07 1520	979.6 17.08.07 1700	-14.0 17.08.07 1640	-14.4 17.08.07 1520	39 17.08.07 1630
10	16.0	21.10.07 0500	22.10.07 1900	973.3 21.10.07 0500	957.9 21.10.07 1900	-05.7 22.10.07 1800	-12.0 21.10.07 1200	70 21.10.07 2130

laden with snow, wind speed exceeding 100 knots) may occur. Blizzards, which are associated with snow storms, are the most troublesome meteorological events of Antarctic weather.

Data Access

Maitri, Antarctica, meteorological data will be available at the office of Additional Director General of Meteorology (Research), India Meteorological Department, Shivajinagar, Pune – 411 005.

RECOMMENDATIONS

The electronic components are generally nearing their working limits in winter and hence military specifications components are a must. The sensors and the instruments will have to be periodically checked and regularly serviced to avoid uninterrupted data acquisition. The team at the permanent station should consist of an experienced weather forecaster and a specialist in meteorological instruments. One summer member (from instruments background) should visit the station and ensure the working condition of the entire instruments.

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