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Meteorological Programme at Maitri, Antarctica During 25th Expedition

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ABSTRACT

The study of Antarctic meteorology is one of the most important objectives of the Indian Antarctic Scientific Expedition (IASE). India Meteorological Department has been actively participating from the beginning in all expeditions to Antarctica. The aims of IMD in participating in the expedition to:

- prepare the climatology of Indian station, Maitri;
- find out teleconnection if any between the behavior of Indian Monsoon and Antarctic weather systems and
- study of Ozone hole phenomenon over Antarctica.

To Study the influence of Antarctic weather on Global Warming is also important, in the present scenario.

INTRODUCTION

IMD's Antarctic expedition program began from the time when the ship started sailing to Antarctica from Cape Town (South Africa). During onward and return journeys 3-hourly Synoptic observations are being taken and the main synops viz 00, 06, 12,18Z are being transmitted to HQ by e-mail. These observations are also made available in GTS and thus utilized for forecasting by the Area Forecasting Centers.

As a part of the ongoing weather monitoring and analysis, synoptic observations are regularly being taken from Maitri and transmitted in real time basis to Global Telecommunication System so that it can be used by all area forecasting offices. In order to find out the current status of stratospheric Ozone depletion over Antarctica in spring season and stratospheric warming, ozone ascents are being taken every week. This data also helps the international ozone monitoring community to determine the degree and extent of ozone hole i.e. by intensity-wise and area-wise.

The continuous measurements of diffused and direct solar radiation and fortnightly release of radiometer sonde helps in the study of radiation balance over Indian station. The Brewer Spectrometer installed in 1999 at Maitri is a versatile instrument which provides details of UV radiation, total ozone, NO_2 and SO_2 concentrations with good accuracy in a cloud free atmosphere.

Surface ozone and atmospheric turbidity are other important measurements.

Scientific Objectives

In a nut shell, the objective of this ISEA is to study Antarctic meteorology and ozone profile i.e. its vertical distribution and seasonal variation. To achieve this, following procedures have been adopted.

1. Preparation of daily, seasonal and annual variations of weather parameters such as Atmospheric pressure, wind speed & direction, temperature, cloud base, horizontal visibility and significant weather phenomena.
2. Recording of direct and diffused solar radiation by thermo-electric pyranometer and RMS (Radio Meter Sonde) data from fortnightly ascents (except in polar nights), for radiation balance studies.
3. Weekly release of balloon borne ozone sonde instruments to study the ozone hole phenomenon over Antarctica. In addition, continuous recording of surface ozone also done.
4. Atmospheric turbidity measurements over Maitri station.
5. Measurement of intensities of damaging UV or UV-B spectrum (280-320 nm), concentration of NO_2 & SO_2 and total ozone with Brewer spectrometer.
6. Monitoring of weather system with the help of facsimile weather chart from Cape Town, and NOAA-APT cloud imageries to give local weather forecasts on a day to day basis for logistic and helicopter operations.

It is worth noting here that the PC based APT cloud imagery reception system supplied earlier by NCAOR was installed and was helpful, though it could not receive any high resolution picture from satellite due to its limitations.

Seasons of Antarctica

A rough classification of seasons in Maitri is as follows:

- February to April - autumn;
- May to August - winter;
- September to November - spring;
- December - January - summer.

General Weather

Several factors contribute in making Antarctica one of the coldest and least hospitable places on the earth. It is an island continent surrounded by an ocean so interior areas do not benefit from the warming influence ocean. The interior of Antarctica receives the most indirect sun rays for a smaller part of the year and no sunlight at all for the remaining part, which makes it colder. Almost all of the land area (around 98%) is covered by snow and ice hence most of sunlight is reflected back rather than absorbing it. The lowest minimum recorded temperature in Antarctica is around(-89)°C at Vostok on July 21, 1983. The average elevation of interior (especially eastern parts of Antarctica) is around 2 km (peak 4.7 km, Wilkes Land). Due to this frigid temperature, little or no moisture is held in the troposphere over interior area. So practically there is no cloud formation and therefore clear skies are observed at the South Pole. The extreme dryness of the air causes any heat that is radiated back into the atmosphere to be lost instead of being absorbed by the water vapor in the atmosphere. The average snow precipitation over interior side is around 50 mm per year. The annual average temperature is -50°C. Extremely low temperature, several months of complete darkness, fierce winds and blowing snow are some of the characteristic of interior Antarctica.

However, along the coast, weather disturbances are more frequent and cloudy skies are more common due to the maritime influences and polar circulation patterns. As the temperature starts to fall after summer, the continent cools rapidly. This results in large pressure such as differences at the edge of the landmass, and leads to an increase in storm activity. The cyclones carry the warmer moist air from the northern latitudes into the continent but may not penetrate very far inland. The polar cyclonic storm strengthens faster and moves double the speed of tropical storms (above 50 kmph). In Southern Hemisphere, cyclonic

storm usually start in middle latitudes and generally travel from west to east under the influence of polar westerlies and move to the south under the effect of Coriolis effect, bringing moisture and heat to the frigid Antarctic continent. The moisture freezes and gets deposited as snow as it moves inland. Most precipitation in coastal areas falls as snow and is highly variable depending on the location.

A zone of low pressure, called Antarctic circumpolar trough lies between 60° and 65°S and contains variable winds flowing from west to east. In this region fierce storms sweep warm moist air from the middle latitudes towards the pole, causing cloud and precipitation (mostly as snowfall). Between the Antarctic circumpolar trough and the continent, a narrow ring of easterly winds exists which is called the Coastal Polar Easterlies. Cold winds flowing off the continent are diverted to the west as a result of the Coriolis effect. This region is calmer and clearer than that of the Antarctic circumpolar trough. So coastal areas are characterized by milder temperatures and very higher precipitation rates, mainly as snowfall. Annual precipitation varies from 500 to 1000 mm. Summer temperature can go upto 10°C.

Analysis

Pressure, wind and temperature were analyzed and compared with *Short period (1990-2005) climatology of Maitri* (SPC) Lal (2006)**.

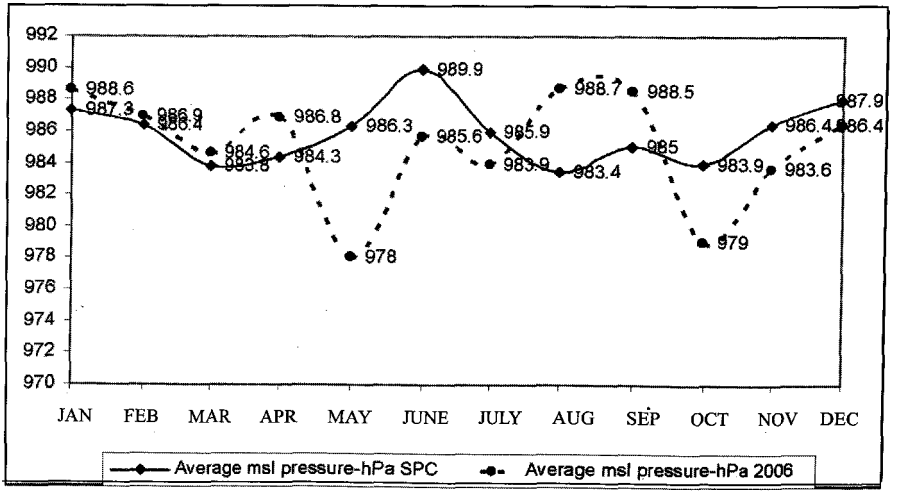

Fig. 1: Monthly variation of average msl pressure of 2006 in comparison with that of SPC

Table below shows the salient features.

SALIENT METEOROLOGICAL FEATURES DURING THE YEAR 2006

Warmest Month	January. (Average Temperature, +0.3°C)
Highest Temperature	+06.0 deg C (07th January) Coldest Month July (Average Temperature, –23.7°C)
Lowest Temperature	38.0 °C (23rd July)
Highest Pressure (msl)	1009.4 hPa (10th June)
Lowest Pressure (msl)	942.8 hPa (8th October)
Total numbers of Blizzards during the year	18
Total numbers of days with Blizzard	24
Total number of foggy days	5
Longest duration of Blizzard	53 Hours (From 14th August 2345UTC to 17th August 0510ZUTC)
Maximum Wind Speed	120 Kmph (on 16th August)
Maximum Gust	165 Kmph (on 7th October)
Total number of auroras observed	25
Total number of snowfall/drifting & blowing snow days	58
Total snowfall during the year 2006	732 mm

Atmospheric Pressure

In general, a significant fall in pressure indicates an approach of meteorological disturbances or bad weather. In Antarctica, although there are occasions in which a significant drop of pressure need not cause any bad weather but on many occasions, a little drop in pressure was found to be associated with onset of severe blizzards. This is an important point for weather forecasters in Antarctica.

It can be seen that except during the beginning and end of the year the average pressure of 2006 fluctuated widely from the short period normal.

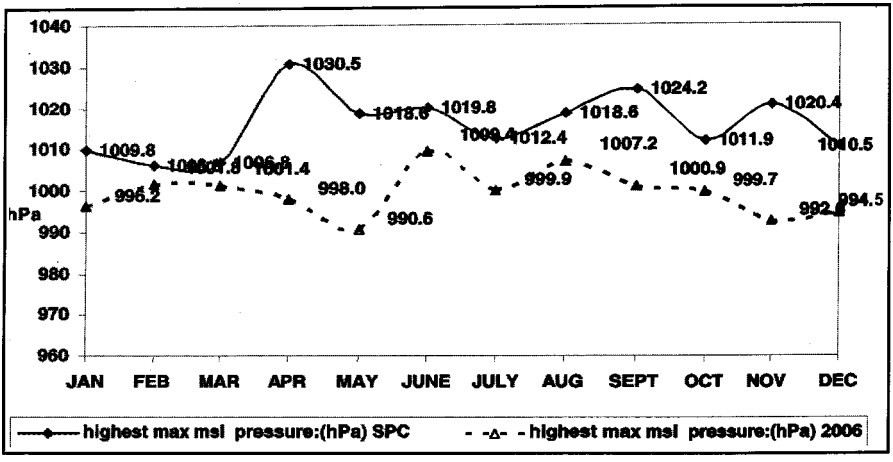

Fig. 2: Monthly variation of highest max msl pressure of 2006 in comparison with that of SPC

Highest maximum pressure of each month of 2006 was generally between 10 to 30 hPa which was lower than that of the short period value.

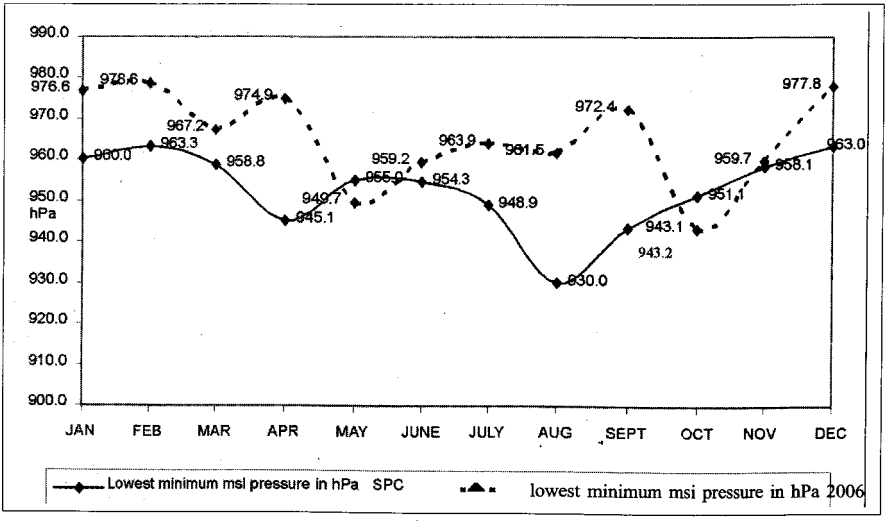

Fig. 3: Monthly variation of lowest minimum msl pressure of 2006 in comparison with that of SPC

Katabatic Winds and Surface Wind

Katabatic winds are a characteristic feature of the climate of coastal Antarctic region. Local orography and shape of the surface of the slope have a considerable influence on katabatic wind. This is particularly true for Maitri station. The origin of the wind is connected with the radiational cooling of the air along the slope of the plateau and its movement down the slope under the force of gravity. The vertical extent of katabatic winds is determined by the thickness of the layer in which air is cooled due to radiation. Therefore katabatic winds are always accompanied by an inversion over the ice surface. Wind data from other Antarctic stations shows that katabatic wind speed is at least twice greater than the normal winds. The onset of katabatic winds is characterized by the instantaneous increase in wind speed to 30-40 knots from calm condition and again the lulls appear. The intensity of the katabatic air movement depends up on the cyclonic activity over the ocean and near the coast as well. The increase in meridional exchange during the development of cyclonic activity leads to an increase in the katabatic movement of cold air from the interior of the continent. So the highest intensity of katabatic wind is observed at the rear end of the cyclones moving along the coast.

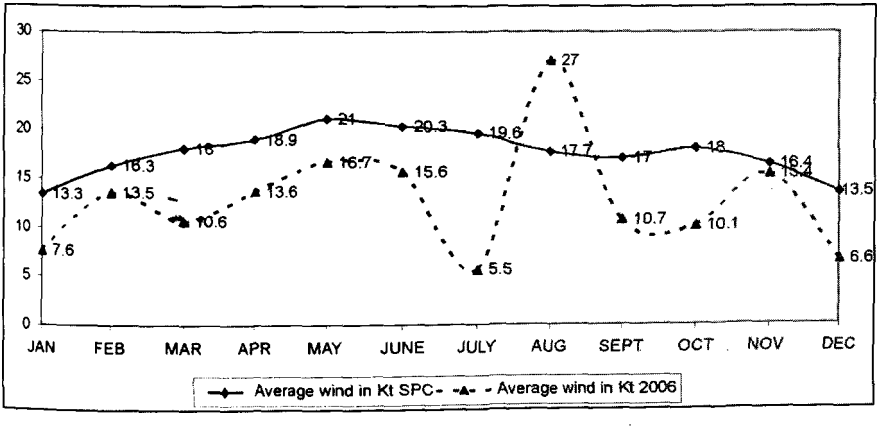

Fig. 4: Monthly variation of average wind in 2006 in comparison with that of SPC

July 2006 was a calm wind month which is quite unusual and August was a month of very bad weather. The wind speed and snow fall was very high. In fact July and August represents both extremes of wind speed.

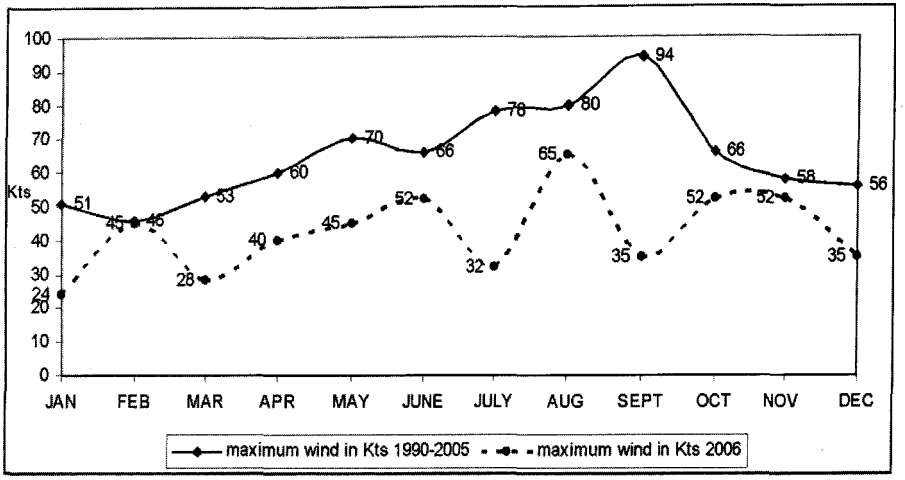

Fig. 5: Monthly variation of maximum wind in 2006 in comparison with that of SPC

Except for the months of February, October and November the strength of Max wind in 2006 was significantly lower than short period max value.

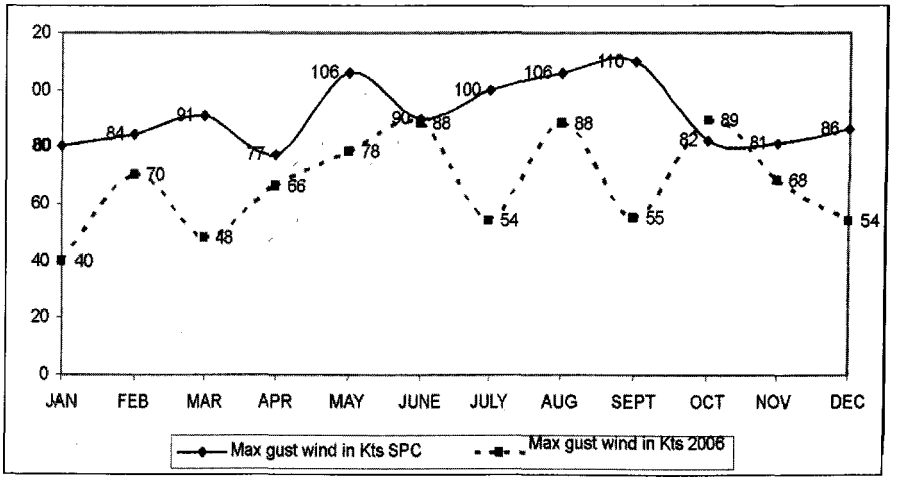

Fig. 6: Monthly variation of maximum gust wind in 2006 in comparison with that of SPC

The max gust wind in 2006 for each month also was lower than that of short period max gust value except for the months of June and October.

Temperature

Temperature is one of the important elements which directly affect human comfort. Here average temperature, maximum temperature, minimum temperature, highest maximum and lowest minimum temperatures have been compared with that of short period normal.

Till end of July there was no synoptic system along the station area from sea and wind was light. This is quite unusual, so the mean temperature dropped considerably. But August was a month of longest blizzard, hence temperature rose from normal values in this short period. This reason is also valid for the mean minimum temperature shown in below.

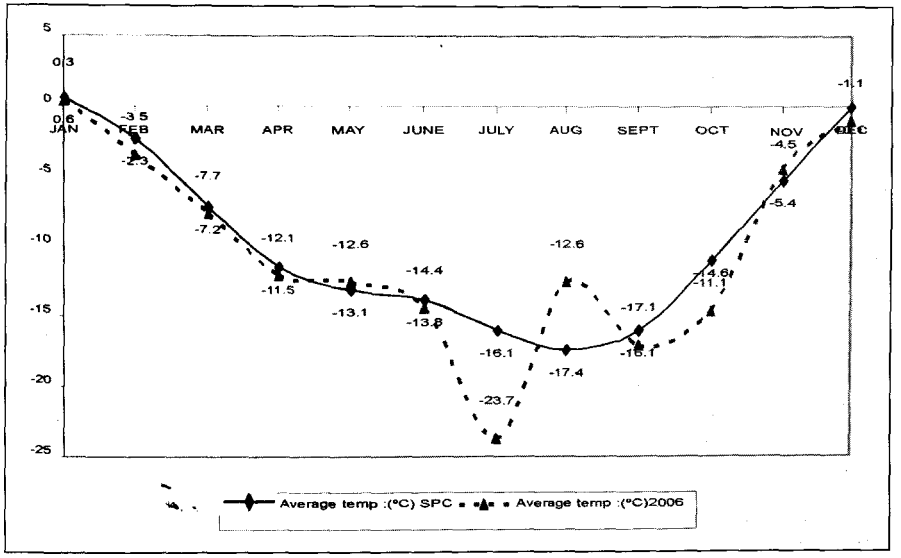

Fig. 7: Monthly variation of average temperature for the year 2006 in comparison with that of SPC

Mean maximum temperature for 2006 almost followed the short period normal value except for the months July and August.

The lowest minimum value recorded in 23rd July i.e. (-38°C) is the lowest in the available records.

It can be seen that the highest max temperature of each month of year 2006 was lower than that recorded during 1990-2005 period except for the month of October.

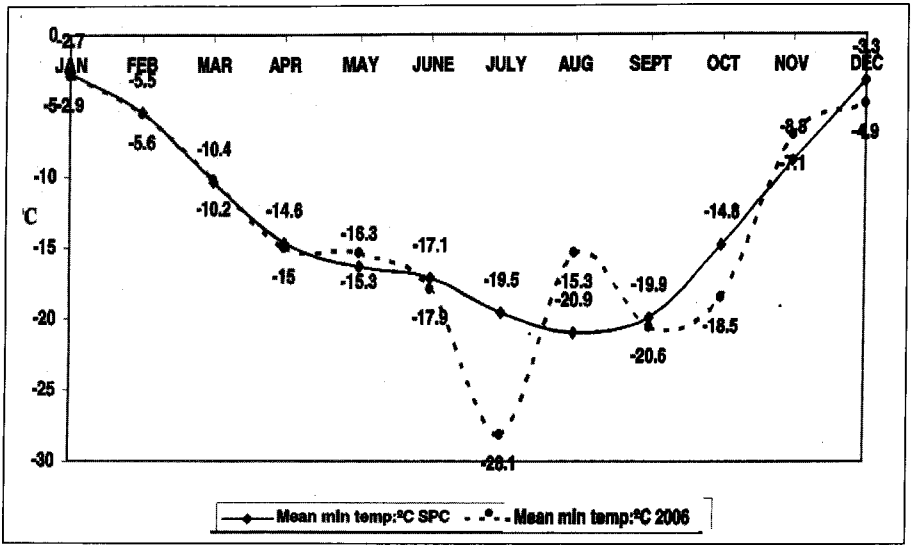

Fig. 8: Monthly variation of mean maximum temperature for the year 2006 in comparison with that of SPC

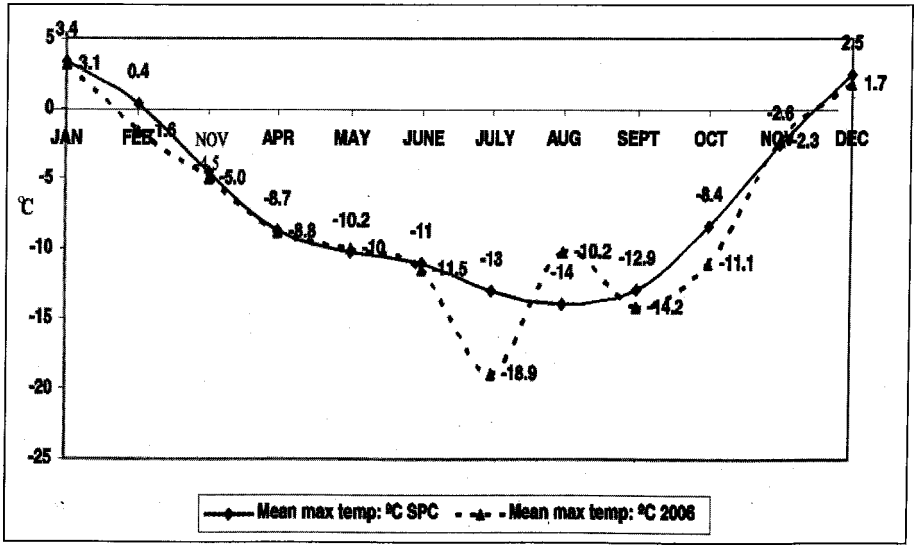

Fig. 9: Monthly variation of mean minimum temperature for the year 2006 in comparison with that of SPC

Blizzard

The word *blizzard* is quite loosely used in Antarctica, to mean anything from light blowing snow to severe snow storm with accompanying high winds. The criteria *for the blizzard condition* are taken like this, the wind speed should be 23 knots or more and visibility

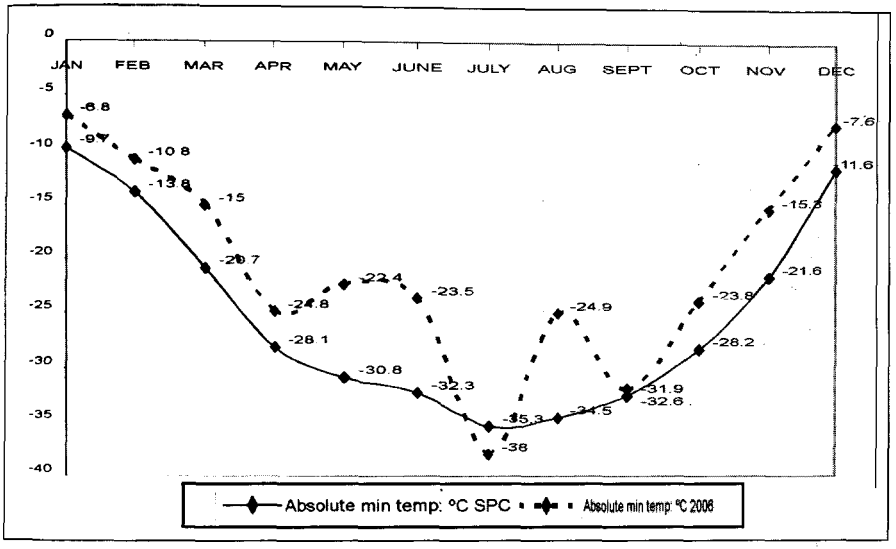

Fig 10: Monthly variation of lowest minimum temperature for the year 2006 in comparison with that of SPC

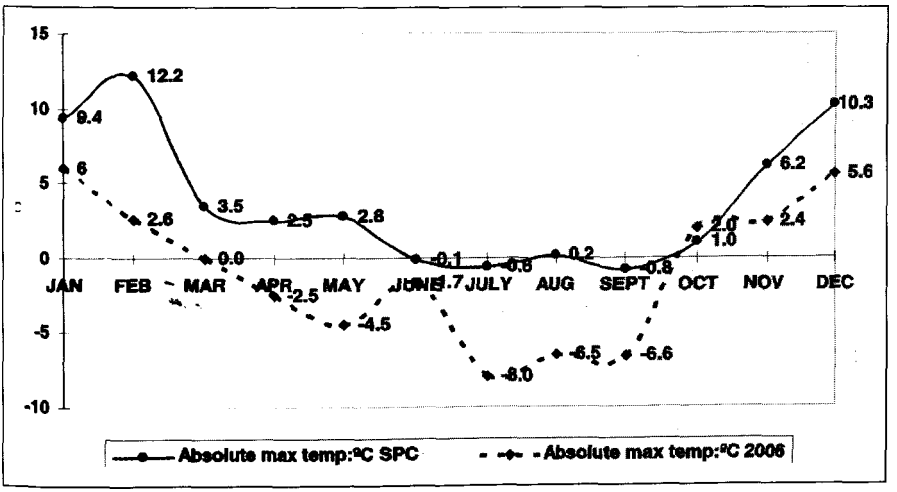

Fig.11: Monthly variation of highest maximum temperature for the year 2006 in comparison with that of SPC

should be 1 km or less. Once the wind speed reaches 60 knots, it is not at all safe to go out into blizzard. Snow particles fly with tremendous speed and penetrate tents, buildings etc. Strong gustiness is observed during its peak period of blizzard which is not at the initial or final

Weather summary for the year 2006

	Months → / Weather Elements ↓	JAN	FEB	MAR	APR	MAY	JUN	JLY	AUG	SEP	OCT	NOV	DEC
PRESSURE in HPA	Average	988.6	986.9	984.6	986.8	978.0	985.6	983.9	988.7	988.5	979.0	983.6	986.4
	Highest and date	976.6 29th	978.6 9th	967.2 4th	974.9 9th	949.7 8th	959.2 27th	963.9 21st	961.5 27th	972.4 3rd	942.8 8th	959.7 15th	977.8 16th
	Lowest and date	996.1 12th	1001.8 28th	1001.6 1st	998.0 7th	990.6 6th	1009.4 10th	999.9 8th	1007.2 3rd	1000.9 30th	999.7 1st	992.6 6th	994.5 29th
TEMPERATURE in °C	Average	0.3	-3.5	-7.7	-12.1	-12.6	-14.4	-23.7	-12.6	-17.1	-14.6	-4.5	-1.1
	Highest and date	6.0 7th	2.6 3rd	0.0 10th	-2.5 11th	-4.5 10th	-1.7 11th	-8.0 11th	-6.5 8th	-6.6 23rd	-2.0 29th	-2.4 25th	-5.6 30th
	Lowest and date	-6.8 25th	-10.8 28th	-14.5 26th	-24.8 30th	-22.4 14th	-23.5 10th	-38.0 23rd *	-24.9 25th	-31.9 5th	-23.8 14th	-15.3 1st	-7.6 20th
	Average maximum	3.1	-1.6	-2.5	-8.8	-10.0	-11.5	-11.0	-10.2	-8.5	-11.1	-2.2	-1.6
	Average minimum	-2.9	-5.6	-11.7	-15.0	-15.3	-17.9	-33.1	-15.3	-28.0	-18.5	-7.1	-3.5
WIND in KTS	Average speed	08	13	11	14	17	16	06	27	11	10	15	07
	Highest speed and gust	24G 40	45G 70	28G 48	40G 66	45G 78	52G 88	32G 54	65G 88	33G 55	52G 89	52G 68	35G 54
	Number of days of Obscured sky	0	0	0	0	0	3	0	11	0	0	0	2
	Number of foggy days	0	0	0	0	0	0	0	0	0	0	0	5
WEATHER	Number of days of precipitation (snow)	2	4	1	3	5	9	1	22	3	6	3	1
	Snowfall In mm	6	1.0	trace	0.5	5.8	247.7	trace	350.8	1	111.0	10.0	5.1

* Lowest in available records

stages. Steady increase of wind is associated with increase of cloudiness, rise in temperature and fall in pressure. In Maitri backing of the wind from South easterly to easterly generally gives a sign of approaching meteorological disturbance.

Out of eighteen blizzards during the expedition, two were very strong, six were normally strong and the remaining were of moderate type. A record snow fall of 732 mm occurred during the year and a snow fall of 451 mm occurred in August. Table 1 shows the condensed weather summary for the year 2006.

ACKNOWLEDGEMENTS

I express sincere thanks to Shri. Bhukan Lal, former Director General of Meteorology, for giving me a chance to participate in XXV ISEA. Grateful thanks are also due to some members of 25 ISEA team especially to Shri John Paul (DIPR) who was very helpful at all time irrespective of day or night for the balloon filling and releasing operations, Shri K.U Nair (IIG) for his technical support, and Shri Abraham Thomas (Indian Army) for his cooperation for the oil treatment of balloon in winter etc, as without their help the task could not have been accomplished.

REFERENCE**

Lal PR (2006); Short period (1990-2005) climatology of Maitri, Schirmacher Oasis. East Antarctica.