

A Report on Meteorological Observations Made during Eighteenth Wintering (2001-2002) at the Indian Antarctic Base Maitri, Central Dronning Maud Land, East Antarctica

Suresh Ram and M. K. De

India Meteorological Department, New Delhi

Abstract

Meteorology remains at the core of all scientific expeditions to Antarctica. India Meteorological Department is involved with this all important task. During the year 2001 vital data on Meteorology was collected at the Indian Base Maitri. An average annual temperature of -9.50°C was recorded at the base. Besides the weather data important data on behaviour of ozone over Maitri was collected using ozonesonde ascents and Brewer Spectrophotometer. It was observed that Ozone reached its minimum during September-October 2001 period and showed remarkable recovery in the proceeding month of November 2001 and reaching almost the normal value in December 2001.

Introduction

The India Meteorological department (IMD) has been monitoring the crucial meteorological data at the Indian Base Maitri. The data being generated is an important input in the global weather database. The data generated at Maitri has wider implications and is used in analyzing the global climate/ weather changes. In year 1999 IMD installed a Brewer Spectrophotometer at Maitri for measuring the atmospheric ozone, sulfur dioxide, nitrogen dioxide, D-UV radiation. These parameters were also monitored during the 18th Wintering at Maitri using the Brewer Spectrophotometer. The Synoptic data collected daily were further transmitted using global telecommunication network on real time basis for use in weather forecasting world over.

The process of collecting meteorological data had been one major occupation at the Indian Base. This all important data was collected through following studies carried out at Maitri.

- a. Daily, seasonal and annual variation of atmospheric pressure, surface temperature surface wind, surface ozone, snow fall and cloud cover.
- b. The atmospheric changes with reference to specific synoptic weather systems.
- c. Radiation budget including total global solar radiation and diffused solar radiation.
- d. Monitoring and archival of information through weather satellite and HF radio sets regarding weather system affecting Maitri and Antarctic continent.
- e. Atmospheric turbidity in Antarctica
- f. Balloon born measurement of Ozone for its vertical profile over Maitri to study the ozone depletion phenomenon.
- g. Daily, seasonal and diurnal variation of total ozone, D-UV, SO₂ and NO₂ using Brewer Spectrophotometer.

Execution of Programme

- A. During onward cruise on board ship Magdalena Oldendorf, surface observation were taken eight times a day at three hour interval at synoptic hours from the next day of departure from Cape town and in similar way during return journey.
- B. The Surface observation programme was divided into the following categories.
 - (a) Surface observation of all weather parameters recorded at all synoptic hours on all the days and four observations out of eight were transmitted to IMD office New Delhi for onward transmission over GTN.
 - (b) Atmospheric pressure, temperature, wind speed, wind direction, surface ozone and global radiation were recorded continuously except for periods of diffused radiation.
 - (c) Sun photometer observations were taken on all clear weather days for analysis of atmospheric turbidity.
- C. For the study of Antarctic ozone hole phenomenon 39 Ozone-sonde ascents were taken using Indian electrochemical ozonesonde. For study of radiation balance 15 Radiometersonde ascents were taken.
- D. Making short term weather forecasts for helicopter operations and for groups engaged in carrying out field studies is a challenging task in Antarctica. This task becomes difficult with limited

resources i.e. weather charts and network observatories. However limited cloud picture images were down loaded from internet for this purpose. The IMD team in spite of the limitations managed a good weather forecast which helped in planning field tasks and helicopter operations during the expeditions.

Brewer spectrophotometer

The Brewer spectrophotometer which was installed in 18th Expedition (1999) functioned nonnally during the 18th Wintering. A minor technical snag had developed in April which was quickly rectified without affecting the observation schedule.

The mean maximum total ozone was measured in May 2001 at 303 DU (for Moon observation) where as the mean minimum ozone was 133 DU in October 2001 for sun observation. For sun observations the mean maximum ozone was 300 DU in January 2001 and it reduced by 15% in February .The values for March 2001 were similar to that of February 2001. The Sun observation was not made during the polar night period (April to July 2001). In August 2001 the values had declined by 27% over the value recorded in January 2001. The ozone depletion peaked in September and October 2001 when the values were less by 50% and 55% respectively from the values recorded in January 2001. In November'01 Ozone values rose by 50% and in December by 100% from the low recorded in October 2001. The maximum total ozone at 321 DU was recorded on 11 January 2001 and the minimum total ozone at 113 DU was recorded on 29th September 2001 (Fig. 1)

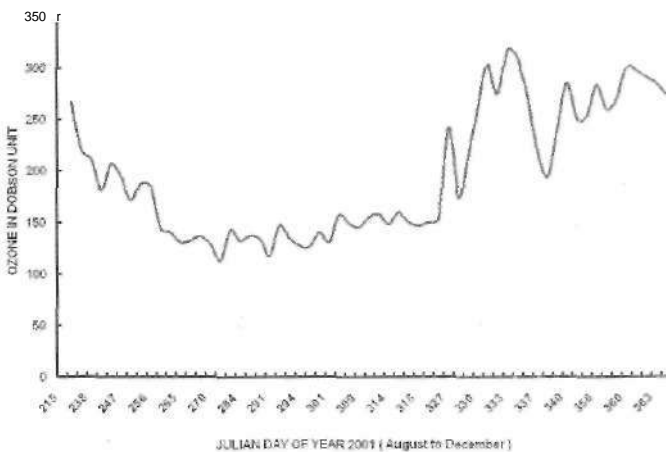


Fig. 1: Graph showing mean total ozone recorded using Brewer spectrophotometer no. 153 at Maitri, Antarctica

D-UV(UV-B) observations were also made along with the total ozone measurements (Fig. 2). It was observed that the values started to increase in September 2001 and reached a maximum level in November 2001. The highest value was recorded on November 17th at 225 m W/M². The SO₂ (Fig. 3) and NO₂ (Fig. 4) were also measured and variation is as shown in Figures and in Table 1, which also shows total ozone and UV-B for the period between August to December.

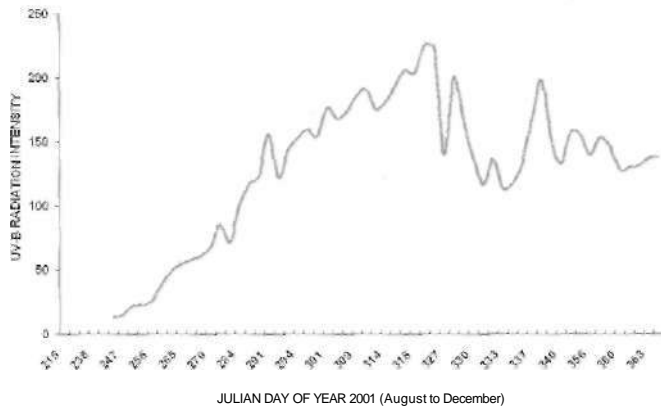


Fig. 2: Daily maximum damaging UV-B radiation measured at local noon time at Maitri, Antarctica

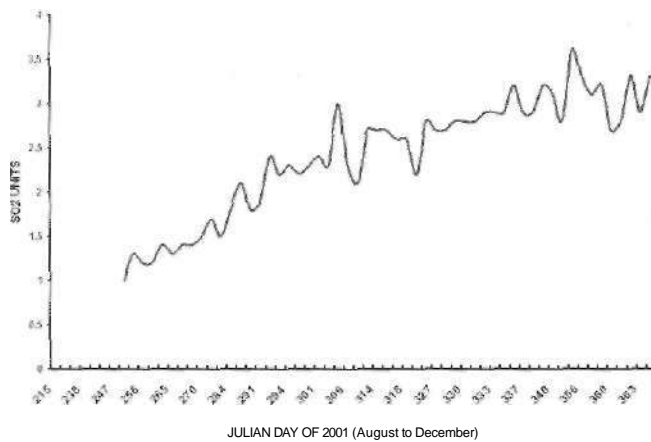


Fig. 3: Graph showing mean total SO₂ measurement recorded using Brewer spectrophotometer no.153 at Maitri, Antarctica

Table 1: Total ozone, SO₂, NO₂, and D-UV over Maitri, Antarctica for year 2001

Month	Mean Ozone	Max. Ozone	Min. Ozone	Mean SO ₂	Max. SO ₂	Min. SO ₂	Mean NO ₂	Max. NO ₂	Min. NO ₂	Avg D-UV	Max. D-UV	Min. D-UV
January	300	3231	279	2.3	3.2	1.2	0.97	1.11	0.84	188.5	129.4	85.1
February	258	298	250	2.2	3.2	1.4	0.74	1.01	0.74	75.8	101.9	51.5
March	255	257	253	0.9	1.2	0.4	0.59	0.65	0.55	37.4	47.6	22.0
April	No Obs.	---	---	---	---	---	---	---	---	---	---	---
May	303	---	---	---	---	---	---	---	---	---	---	---
June	No Obs.	---	---	---	---	---	---	---	---	---	---	---
July	No Obs.	---	---	---	---	---	---	---	---	---	---	---
August	220	267	182	---	---	---	---	---	---	---	---	---
September	155	207	113	1.3	1.7	1.0	0.48	0.58	0.37	44.0	84.7	13.1
October	133	147	118	2.1	2.4	1.8	0.70	0.82	0.65	140.4	176.7	99.7
November	198	309	145	2.7	3.0	2.1	0.99	1.18	0.77	162.3	225.4	117.0
December	266	301	194	3.1	3.6	2.7	1.11	1.23	1.09	146.6	198.3	128.4

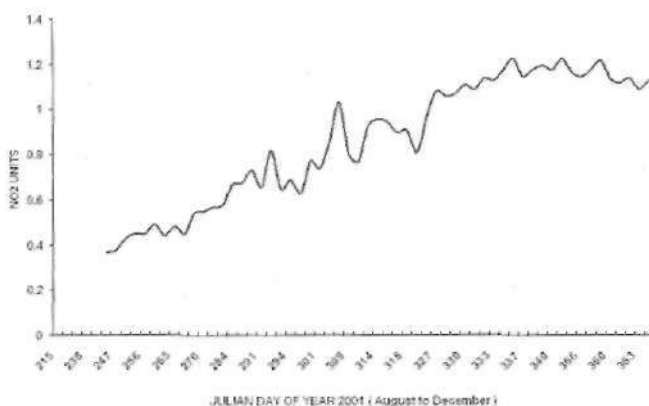


Fig. 4: Graph showing mean total NO₂ measurement recorded using Brewer spectrophotometer no. 153 at Maitri, Antarctica

Results and Discussion

Meteorological Studies

The synoptic data based on eight daily observations are used for computation of daily and monthly mean of temperature, wind, pressure and cloudiness. Annual summary of meteorological parameter for the year 2001 is given in the Table 2. For computation of short period normal the monthly mean values from the 1990 to 2001 are used which are shown in the Table 3.

Surface Temperature

As shown in the Table 2 the mean monthly temperature, mean maximum and minimum temperature falls rapidly from January to August and then gradually rise till December. The lowest temperature Minus 31.8°C was recorded on 28 July'01 and highest maximum temperature Plus 7.4°C was recorded on 24 December '01.

The annual average temperature was minus 9.5°C as shown in the Table 3 and Figure 4. The maximum temperature was in accordance to the values recorded in earlier years.

Surface Pressure

The annual average pressure was 982.9 mb. The mean monthly lowest pressure was 953.3 mb in November 2001 and mean monthly highest pressure was 990.5 mb in June 2001. The lowest mean sea level

Table 2: Annual summary of meteorological parameter recorded at Maitn, Antarctica during year 2001

Month	Temperature °C					Pressure mb			Wind Speed Kt		S/F mm	Clouds Octa	No. of Days' with		
	Month Mean	Mean Max.	Mean Min.	T Max.	T Min.	Mean Pr.	Pr Max.	Pr Min.	Mean	Max/ Gust			S/F	Bld	Aur.
Jan.	+0.3	+2.8	-3.1	+5.9	-6.1	986.3	1001.6	977.2	14	35/50	1.4	5.2	6	—	—
Feb.	-2.3	+0.5	-5.5	+3.5	-14.0	988.5	1004.7	972.7	16	36/50	1.9	5.4	4	—	2
Mar.	-7.2	-4.4	-10.2	-0.4	-15.5	986.5	999.9	976.6	19	38/60	Tr	5.0	1	1	6
Apr.	-11.4	-8.2	-14.3	-1.6	-23.5	979.5	993.1	962.8	21	44/ 65	0.4	5.0	2	3	7
May	-10.7	-8.3	-13.5	-3.2	-21.2	988.7	1011.4	969.0	22	50/74	—	5.5	—	1	2
June	-13.7	-9.5	-17.1	-4.1	-29.7	990.5	1008.7	962.4	21	65/84	3.4	5.4	5	7	—
July	-15.4	-12.0	-18.9	-5.8	-31.8	988.2	1011.0	967.8	20	58/79	1.0	4.0	1	5	2
Aug.	-19.2	-16.1	-22.5	-8.9	-31.5	984.0	1004.7	948.9	17	50/74	—	4.3	—	3	3
Sept.	-17.3	-13.9	-21.2	-5.2	-29.1	984.4	1004.2	944.2	14	50/60	7.0	3.7	3	1	9
Oct.	-12.5	-10.0	-15.7	-2.4	-22.5	983.6	1002.9	959.8	14	40/44	4.1	4.4	6	9	3
Nov.	-5.0	-2.1	-8.9	-3.4	-15.5	953.3	996.6	957.4	15	36/48	0.1	3.4	1	2	—
Dec.	00	+2.6	-3.6	+7.4	-6.6	981.4	1000.2	964.5	14	40/52	Tr	2.8	4	2	—

Table 3: Some significant data for Maitri from 1990 to 2001

Years parameters	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Annual Avg. Temp. °C	-09.1	-08.6	-09.4	-09.9	-09.7	-09.9	-08.1	-08.7	-08.5	-09.9	-10.2	-09.5
Lowest Min. Temp. °C	-32.0	-30.6	-31.7	4.5	-29.1	-32.6	-30.1	-31.4	-35.0	-32.5	-33.7	-31.8
	18	2	29	28	9	18	28	9	30	8	7	28
	AUG	AUG	AUG	AUG	AUG	SEPT	AUG	JULY	AUG	JULY	AUG	JULY
Highest Max. Temp. °C	09.0	10.3	07.8	08.2	06.8	07.3	12.2	08.3	09.2	08.5	06.2	07.4
	14	28	2	12	11	17	3	3	3	16	29	24
	DEC.	DEC.	JAN.	JAN.	DEC.	DEC.	FEB.	DEC.	JAN.	JAN.	DEC.	DEC.
Total Blizzard/ Longest Blizzard	24	15	25	27	25	19	43	23	21	34	21	17
	25	70	103	127	77	49	112	168	96	69	43	60
	HRS	HRS	HRS	HRS	HRS	HRS	HRS	HRS	HRS	HRS	HRS	HRS
Highest Wind Gust In Knot/ Date	85	82	80	92	65	90	68	66	78	110	89	84
	12	30	11	01	25	15	23	18	25	10	09	26
	OCT.	SEP.	AUG.	AUG.	AUG.	JUL.	JUL.	JUN.	OCT.	SEP.	AUG.	JUN.
Number of Auroral Days	42	47	80	51	33	44	7	26	21	23	78	34

Table 4: Frequency of wind over Maitri for the year 2001

Month	VRB	Calm	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N
January	1	5	9	6	16	40	34	69	20	31	8	1	1	2	0	1	2	2
February	0	9	3	4	7	14	62	83	18	19	0	0	0	1	0	1	0	3
March	0	8	1	1	3	26	57	83	48	18	0	0	0	0	0	0	1	2
April	0	29	0	0	1	23	60	56	47	22	1	0	0	0	0	0	0	1
May	0	13	0	0	1	2	29	116	68	15	2	0	0	2	0	0	0	0
June	2	24	1	0	4	2	33	102	44	15	11	1	0	0	1	0	0	0
July	0	19	0	0	0	0	22	120	49	20	15	3	0	0	0	0	0	0
August	0	35	0	0	1	1	4	115	15	47	21	1	0	4	4	0	0	0
September	0	27	0	0	0	0	6	107	18	39	22	5	3	8	2	1	0	2
October	0	36	0	3	1	3	9	152	13	12	6	2	2	2	0	3	0	4
November	0	15	0	3	2	4	3	126	18	38	15	4	1	1	1	3	0	6
December	0	18	1	9	4	9	9	126	11	32	5	4	0	4	2	9	0	5
SUM	3	238	15	26	40	124	328	1255	369	308	106	21	7	24	10	18	3	25

Table 5: Summary of blizzards recorded during year 2001

Sl.No.	Date/Time		Extreme values with (Date/Time)				
			Pressure		Temperature		Wind
	Start	Cessation	Max.	Min.	Max.	Min.	Max.
1	31/03/01 1250Z	01/04/01 1700Z	01/04/01, 12Z, 0982.4	01/04/01 03Z, 0981.4	01/04/01 00Z, 04.8	01/04/01, 00Z, -06.6	01/04/01, 12 Z, 62Kt
2	05/04/01, 0700Z	05/04/01 2200Z	05/04/01, 0969.609Z,	05/04/01, 21Z, 0965.2	05/04/01, 21Z, -04.0	05/04/01, 12Z, -04.9	05/04/01, 20Z, 62Kt
3	17/05/01, 1230Z	17/05/01, 2030Z	17/05/01, 12Z, 0973.7	17/05/01, 15Z, 0973.3	17/05/01, 15Z, -06.9	17/05/01, 15Z, -08.1	17/05/01, 15Z, 58 Kt
4	09/06/01, 1810Z	12/06/01 0610Z	12/06/01, 06Z, 1003.1	09/06/01 21Z, 982.4	12/06/01, 00Z, -5.8	10/06/01 00Z, -10.6	10/06/01 21Z, 54Kt
5	23/06/01 0700Z	23/06/01 1500Z	23/06/01 09Z, 0981.8	23/06/01 15Z, 0975.2	23/06/01 15Z, -13.5	23/06/01 09Z, -16.2	23/06/01 15Z, 50Kt
6	25/06/01 0700Z	26/06/01 1830Z	25/06/01 09Z, 0985.0	26/06/01, 15Z, 0962.4	26/06/01, 15Z, -09.2	25/06/01, 12Z, -15.5	20/06/01, 12Z, 65Kt
7	10/07/01 1400	12/07/01 2330	10/07/01 15 Z, 0988.8	12/07/01 09 Z, 0970.4	11/07/01 12 Z, -08.8	11/07/01 00 Z, -16.1	11/07/01 12 Z, 58 Kt
8	20/07/01 0800Z	21/07/01 2200Z	20/07/01 09 Z, 0994.7	21/07/01, 15 Z, 0979.4	21/07/01 12 Z, -08.0	20/07/0, 12 Z, -10.5	21/07/01, 03 Z, 48 Kt

(Contd.)

Table 5: Summary of blizzards recorded during year 2001 (Contd.)

9	09/08/01 1030Z	11/08/01 1510Z	09/08/01 12Z, 0982.4	11/08/01, 03Z, 0948.9	11/08/01, 12Z, -11.0	09/08/01, 12Z, -25.2	10/08/01 09Z, 50 Kt
10	19/09/01 1030Z	19/09/01 1500Z	19/09/01 15Z, 0949.8	19/09/01 12 Z, 0946.2	19/09/01 15 Z, -5.8	19/09/01 12 Z, -7.0	19/09/01 12 Z, 50 Kt
11	01/10/01 1810Z	02/10/01 1000Z	02/10/01 09Z, 0963.6	02/10/01 00Z, 0959.8	02/10/01, 09Z, -15.5	02/10/01 00Z, -20.2	02/10/01 02Z, 30Kt
12	04/10/01 1900Z	05/10/01 2200Z	05/10/01, 15Z, 0981.1	04/10/01 21Z, 0978.5	05/10/01, 21Z, -10.5	04/10/01 21Z, -14.1	04/10/01 18Z, 40Kt
13	26/10/01 1830Z	27/10/01 1400Z	26/10/01, 21Z, 0978.7	27/10/01, 06Z, 0972.9	27/10/01, 00Z, -0.8.7	27/10/01, 09Z, -12.0	27/10/01, 11Z, 32Kt
14	29/10/01 1100Z	31/10/01 0100Z	31/10/01, 00Z, 0999.5	30/10/01, 12Z, 0991.8	31/10/01, 00Z, -05.7	30/10/01, 12Z, -10.5	30/10/01, 17Z, 38Kt
15	31/10/01 2000Z	02/11/01 0200Z	31/10/01, 21Z, 996.7	02/11/01, 00Z, 986.7	02/11/01, 00Z, -2.9	01/11/01, 12Z, -5.4	01/11/01, 22Z, 36Kt
16	13/12/01 1830Z	14/12/01 1100Z	13/12/01, 12Z, 0975.3	14/12/01, 06Z, 0972.9	14/12/01, 00Z, -1.8	14/12/01, 00Z, -4.7	14/12/01, 03Z, 30Kt

Note:— January and February has no blizzard

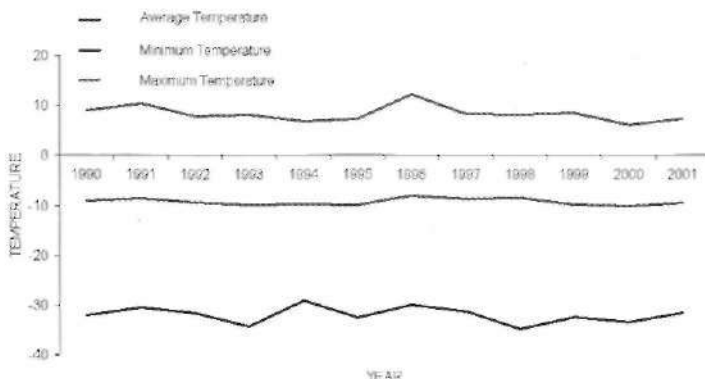


Fig. 5: Graph showing annual variation of temperature during 1990-2001 period

pressure of 944.2 mb was recorded on 19th September 2001 and the highest value of 1011.4 mb was recorded on 25th May 2001 (Table 2).

Surface Wind

The mean monthly wind speed varied from 14 to 22 Knots (1 Knot = 1.83 Km/h). The wind remained above 14 Knot for 8 months and it was 14 Knot in January, September, October and December'01. The annual average wind was 17 Knot. The maximum wind speed of 65 Knot was recorded on 26th June 2001 with gusts reaching 84 knots.

Surface wind direction

The analysis of surface wind direction is shown in Table 4. At Maitri the wind direction has a distinct E-S quadrant bias. The wind is dominantly flowing with shifts to SSE and ESE direction. The frequency of other wind flowing from other direction is rare.

Blizzards

During year 2001 seventeen well defined blizzards were experienced at Maitri though some of them were of very short duration and weak in intensity. The blizzards have been characterized on following criteria.

1. Wind speed is greater than or equal to 30 Knot.
2. Moderate or severe blowing snow
3. The horizontal visibility at surface is less than 1000m.

A summary of blizzard is shown in Table 5. No blizzards were recorded in the month of January & February 2001. Maximum, 4 numbers

of blizzards were recorded in October 2001. A blizzard in June 2001 lasting 60 Hrs was the longest blizzard recorded during the year. However the strongest blizzard was witnessed from 1030 UTC on 09.08.01 to 1510 UTC on 11.08.01 lasting for 53 hours. The weather parameters recorded during this period is reflected in Table 6.

Cloud cover

At latitudes above 60° the tropopause is at 9-10 km above mean sealevel which is considerably lower than other parts of the world. In Antarctic region the cloud activity is restricted to the Troposphere which is considerably lower as indicated. A summary of cloud cover observed above Maitri is reflected in Table 7.

The annual cloud cover analysis shows that the average cloud in a month was 5 Octa from January to June'01 and 4 Octa from July to October and 3 Octa each in November and December'01. The sky was obscured for 18 days due to blizzard, 65 days due to overcast and for 76 it was clear or covered with less than 2 octa cloud cover. On the remaining days of the year the sky remained partially covered with 3 to 7 octa of cloud cover.

Global solar radiation and atmospheric turbidity

Pyranometer observations were recorded on all sunny period for use in study of energy flux around Maitri. The atmospheric turbidity data along with radiation budget data, surface ozone, ozonesonde, data are being processed by IMD Research wing.

Snow fall

In Antarctica it gets slightly difficult to differentiate between the drifting snow and the snow fall. A summary of snow fall is reflected in Table 2. Snow fall occurred on 6 days in January and October 2001 followed by 5 days in June, 4 days in February and December, 3 days in September, 2 days in April and on 1 day in the remaining months. A total of 19.3 mm snow fall was recorded during year 2001. The visibility was less than 10 mm during the snow fall.

Aurora

In year 2001 the maximum number of aurora were seen in September 2001. They were generally observed around midnight. The auroras during the year were mostly of white long band type. A summary of Aurora observed at the Indian Antarctic Base are shown in Table 2.

Table 6: Weather parameters recorded during August blizzard

Date	Maxi.Press.	Min.Press.	Avg.Press.	Max.Temp.	Min.Temp.	Avg.Temp.	Max.Wind	Avg.Wind	GustyWind
08.08.01	989.1	983.9	985.7	-17.1	-22.0	-19.5	SE-24	15	41
09.08.01	985.0	977.0	982.3	-16.6	-20.0	-18.0	SE-36	27	47
10.08.01	974.1	950.7	960.7	-11.4	-25.2	-14.9	SE-50	44	74
11.08.01	964.9	948.9	955.0	-10.8	-13.6	-12.0	SE-35	29	46
12.08.01	976.7	966.1	971.7	-11.3	-13.6	-12.3	SE-35	30	42

Table 7: Sky condition recorded during year 2001 (in days)

Month	Clear sky	Mainly clear sky	Partly cloudy sky	Cloudy sky	Overcast	Sky obscured	Avg. cloud of the month (octa)
January	-	1	8	8	4	-	5
February	1	1	6	17	3	-	5
March	-	6	5	14	6	-	5
April	1	6	4	9	10	-	5
May	1	3	10	8	9	-	5
June	8	-	-	4	14	4	5
July	-	5	7	9	6	4	4
August	2	7	8	11	1	2	4
September	4	7	6	10	2	1	4
October	1	3	6	8	8	5	4
November	2	10	6	8	3	1	3
December	1	6	4	13	6	1	3

Clear sky=No cloud , Mainly Clear sky= 1-2 octa , Partly cloudy sky=3-4 octa , Cloudy sky=5-7 octa, Overcast =8 octa, Sky obscured= Sky not visible.

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