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Meteorological Studies at Dakshin Gangotri (Antarctica) March 1984 to February 1985

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ABSTRACT

The Third Indian Scientific Expedition to Antarctica established a permanent meteorological station at *Dakshin Gangotri* to monitor both surface and upper air parameters. This report contains results of these observations continuously taken at this station for one year. The variations in temperature wind velocity and atmospheric pressure and their influence on different weather systems are discussed. The low pressure systems moving over and around Antarctica carry warm and moist air whereas ridges draw in cold air. Significant fluctuations in temperature pressure and wind speed have been noticed in moving weather systems.

INTRODUCTION

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.

During the Third Indian Scientific Expedition which started from Goa on December 3, 1983, extensive meteorological measurements were made on board ship, at base camp and also at the permanent meteorological station which was established at *Dakshin Gangotri* on February 24, 1984 as one of the objectives of the expedition.

The meteorological observatory at *Dakshin Gangotri* was installed on an ice-shelf about 20 km. from the coast. The thickness of ice-shelf was estimated between 150 and 200 m. The height of the station above mean sea level was about 27 m.

The other objectives of the expedition were to take up studies on the following aspects :

1. Antarctic weather and its effect on lower latitudes of the southern hemisphere
2. The possible effect of Antarctic weather on weather systems affecting Indian sub-continent like the monsoon system
3. Radiation balance in Antarctica
4. Radiation flux in upper atmosphere and heat transfer in various layers over Antarctica
5. Temperature inversion in lower levels of Antarctica
6. Thermal structure of Antarctic atmosphere
7. Atmospheric ozone
8. Meteorological requirements for aircraft operations in Antarctica

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EQUIPMENT USED

The following instruments were used at the permanent meteorological station

1 401-MHz audiomodulated radiosonde ground equipment

2 Complete wind mast assembly with temperature and humidity sensors anemometer and wind vane attached with continuous recording and dial display facility

3 Barograph and aneroid barometers for measurement of atmospheric pressure

4 Potential gradient unit for measuring atmospheric electricity

5 Automatic Picture Transmission (APT) receiver unit to receive cloud pictures from *NOAA* and *METEOR* weather satellites at periodic intervals

6 Weather facsimile recorder to receive weather charts from various meteorological centres namely Molodyozhnaya (USSR station in Antarctica) and Pretoria (South Africa)

7 Different portable instruments for taking visual observations in the event of power failure

MEASUREMENTS

1 Continuous monitoring of all basic surface meteorological parameters (temperature pressure wind and humidity)

2 Three hourly surface observations at synoptic hours

3 Continuous recording of incoming global solar radiation

4 Continuous recording of surface ozone (for 2 months)

5 Upper air radiosonde and radiometersonde observations

6 Facsimile reception of surface and upper air analysis from Molodyozhnaya and Pretoria

7 Continuous recording of atmospheric potential gradient during the summer of 1985

8 Reception of clouds and ice-pictures on APT unit from *METEOR* and *NOAA* weather satellites during summer of 1985

RESULTS AND DISCUSSION

Seasons

Based on the annual temperature observations, only two seasons can be made out in Antarctica, namely summer and winter. However, due to transition periods between these two main seasons, one can interpose four seasons each corresponding to the following months

Summer	December, January, February
Autumn	March, April, May
Winter	June, July, August
Spring	September, October, November

January, April, July and October can be taken as representative months for the four corresponding seasons.

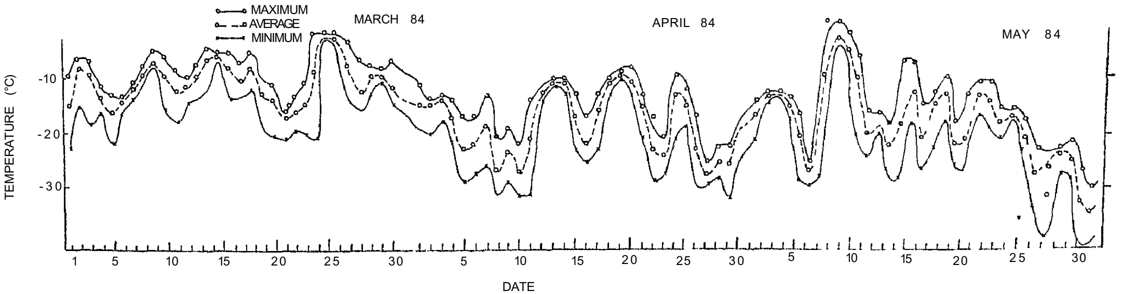


Fig.1

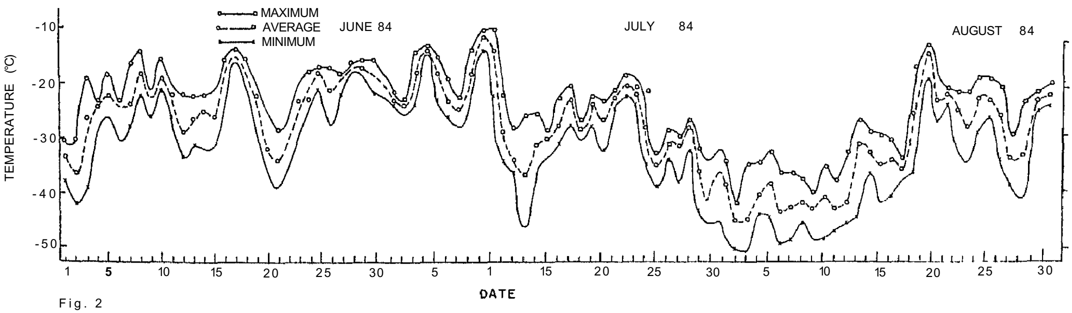


Fig. 2

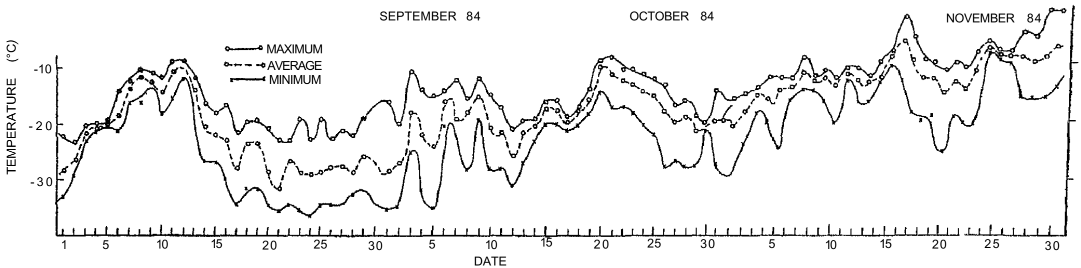


Fig. 3

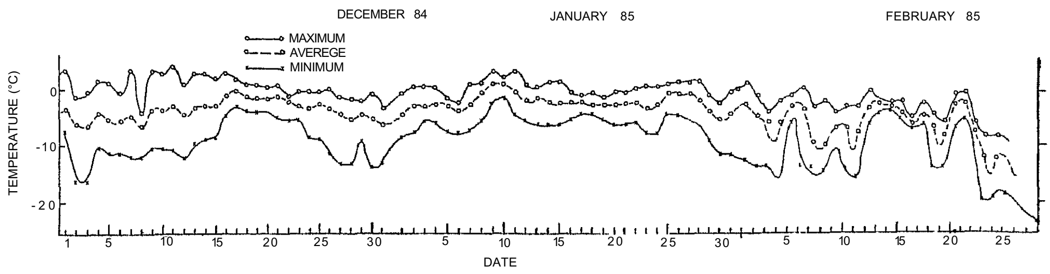


Fig. 4

Figures 1 to 4 Daily max and min. temperature from Mar. '84 to Feb '85.

TEMPERATURE

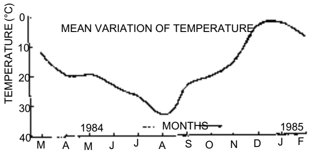


Fig 5 Monthly range of variation of temperature from Mar. '84 to Feb '85

Three types of thermometers were used at *Dakshin Gangotri,* conventional Assmann psychrometer, whirling psychrometer and electrical thermometer. Occasionally readings made by radiosonde equipment were also used with advantage.

The air temperature was taken at about one metre above the ice-shelf. Maximum and minimum air temperature for each day have been recorded for the entire period. The frequency distribution is given in tables 1 & 2 and daily variation is given in figures 1 to 4. The monthly range of variation of air temperature based on daily mean temperature values is given in Fig. 5.

Lowest minimum temperature - 50.5°C was recorded on August 3, 1984 and highest maximum temperature +5.0°C on December 11, 1984. The highest maximum and lowest minimum values for different seasons observed so far at *Dakshin Gangotri* are given in table 3.

TABLE 1

Frequency distribution of Daily Maximum Air Temperature

Air temperature (°C) (range)		1984 *Mar.*	*Apr.*	*May.*	*Jun.*	*Jul.*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	1985 *Jan.*	*Feb.*
+ 5	0	..	..	2		..	..	..	..	3	27	25	5
0	-5	5	..	1	..	..	..	..	..	4	4	6	15
-5	-10	16	2	6	..	2	..	3	2	13	..	..	..
-10	-15	9	15	9	2	4	1	5	13	9	..		..
-15	-20	1	7	7	14	4	8	13	15	1	..	..	..
-20	-25	..	5	4	10	10	4	9	1	..	..	..	..
-25	-30	..	1	2	3	7	5	..	..	..	..	..	..
-30	-35	..	..	..	1	4	7	..	..	..	..	..	..
-35	-40	..	..	..	..	..	6	..	..	..	..	..	..

TABLE 2

Frequency Distribution of Daily Minimum Air Temperature

Air Temperature (°C) (range)		1984 *Mar.*	*Apr.*	*May*	*Jun.*	*Jul.*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	1985 *Jan.*	*Feb.*
+ 5	0	..	..	..	..	..	..	..	..	..	..	..	..
0	- 5	2	..	1		..	..	.	..	..	8	13	4
- 5	-10	2	..	1	..	..	..	.	..	4	10	16	6
-10	-15	11	6	2	..	2	..	3	1	9	11	2	10
-15	-20	8	3	8	3	..	1	5	10	12	2	..	4
-20	-25	8	6	6	8	8	4	3	5	3	..	..	..
-25	-30	..	10	9	8	6	2	4	10	2		.	.
-30	-35	..	5	1	6	8	4	14	5	..	..	..	
-35	-40	..	..	3	4	3	6	1	..	..	.		..
-40	-45	..	..	.	1	3	6	.	..	.	..		..
-45	-50	..	..	..	..	1	7	..	..	.	..	..	..
-50	-55	..	..	..	.	..	1	..	..	..	..	..	.

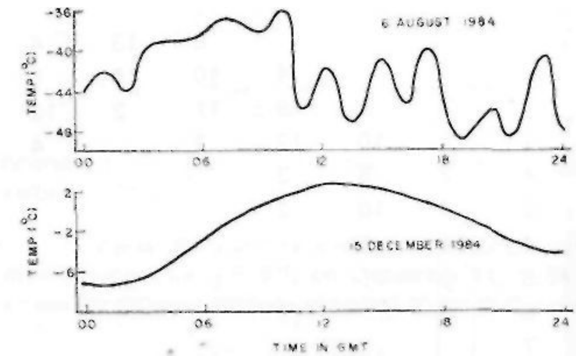
TABLE 3

Highest maximum and lowest minimum temperature corresponding to four seasons

Si. No.	*Seasons*	*Air temperature in degree C* *Highest maximum*	*Lowest minimum*
1.	Summer, 1982 (Jan. 11 to Jun. 18)	+ 2.5	— 7.2
2.	Summer, 1983 (Jan. 19 to Feb. 19)	+ 8.0	—15.0
3.	Summer, 1984 (Jan. 9 to Feb. 29)	+4.0	-22.0
4.	Autumn, 1984	0.0	—39.0
5.	Winter, 1984	—10.0	—50.5
6.	Spring, 1984	+ 2.0	-35.0
7.	Summer, 1985 (Dec. '84 to Feb. '85)	+ 5.0	-22.5

Diurnal variation of temperature

On average, diurnal variation of temperature was large in spring and autumn seasons as compared to summer and winter. This can be seen from the daily maximum and minimum variation curves **for** each month corresponding to these seasons. However, except in summer, no fixed pattern of this variation was observed. Sudden change of four to five degrees Celsius within a few minutes was not uncommon on many occasions during the peak winter period. Figs. 6 &7 give a typical surface air temperature pattern **for** a winter day (August 6, 1984) and a summer day (December 15, 1984) together with the temperature pattern for the warmest day (December 17,1984) and coldest day (August 2,1984).



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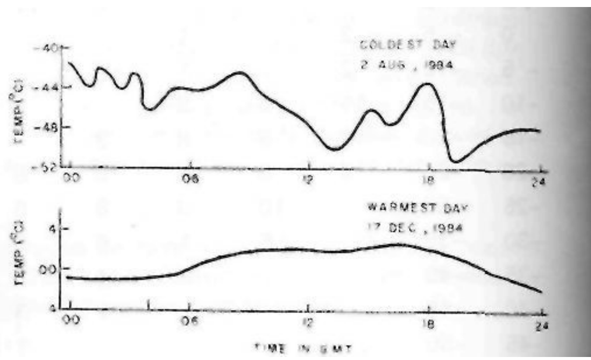

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On cloudy days, diurnal variation of temperature was found to be very low as compared to that on clear sky days as expected. Similarly night temperature used to drop considerably during cloud free nights.

A study of these temperature observations shows that Antarctica can be considered to be the best laboratory to explain the well-known cloud cover effects on air temperature.

Effect of cyclones and anticyclones on temperature

Generally it is found that 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 in 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. One such case on May 7, 1984 has been presented in Fig. 8.

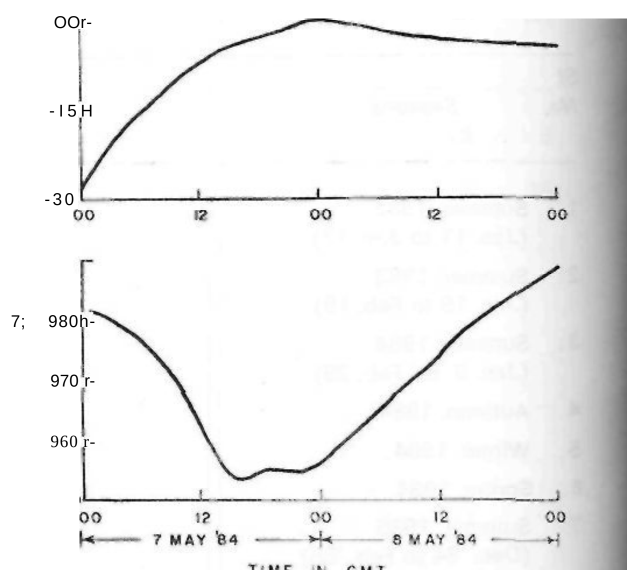


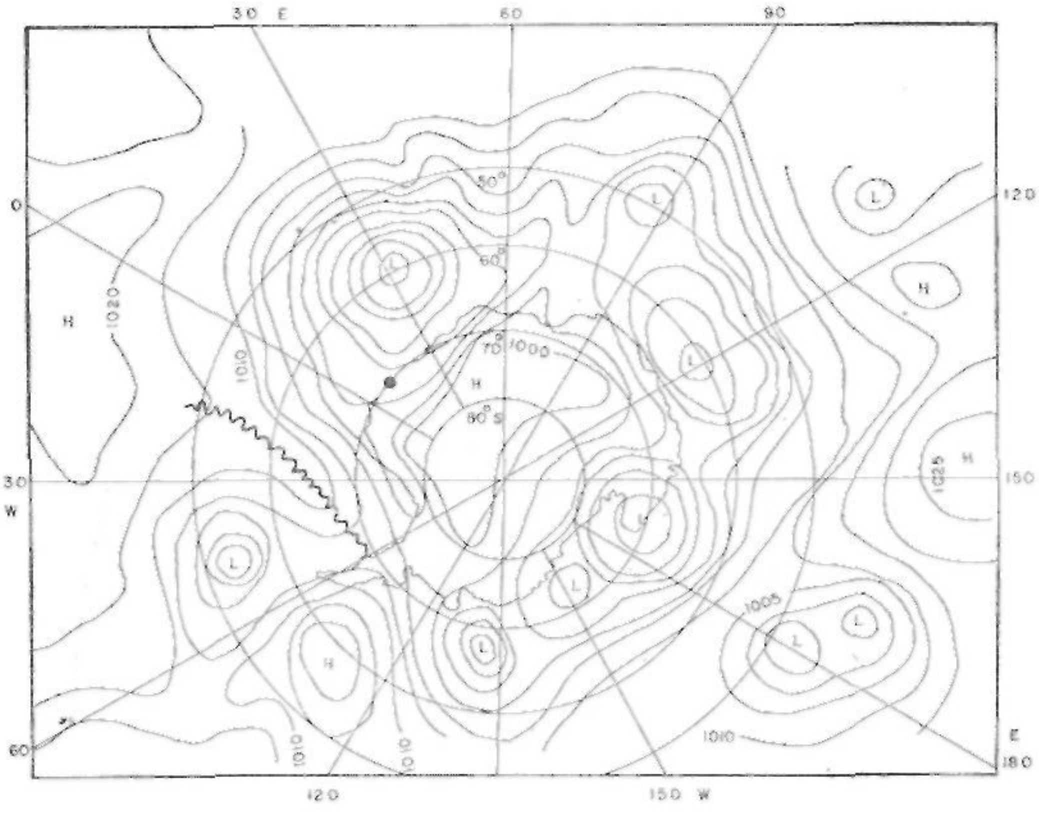
Fig. 8 Temperature and pressure variation on May 7 and 8, 1984

Continuous fall of atmospheric pressure with the approach of low pressure system carrying of heat is by the continuous rise of surface air temperature. The rise in surface air temperature m also have been due to the breaking up of low level surface inversions, which is one of the promine features of the Antarctic atmosphere.

These moving low pressure systems are found to be the main agencies of transporting h< from lower southern latitudes towards the higher Antarctic latitudes. On the other hand, the extensi of high pressure cells in the southern latitudes in the form of ridges, moving slowly to the east was fou to be an ideal situation for drawing in the cold and dry Antarctic continental air. On May 26, 19 when such a ridge passed over our station it resulted in severe cold in the late autumn season. Fie shows the surface analysis on May 25, 1984.

AMC MOLODYOZHNAYA- SURFACE ANALYSIS

TIME 12 GMT. 25 MAY 1984



● DAKSHIN GANGOTRI

Continuous rise of atmospheric pressure supported by backing of winds clearly indicates the gradual approach of high pressure system. Due to strengthening of southerly component of wind, cold Antarctic continental air is drawn, which is supported by a continuous fall of temperature. On this occasion the lowest temperature reached is -37.5°C. Table 4 shows six-hourly surface observations of wind, temperature and atmospheric pressure during the passage of this ridge.

TABLE 4

Six hourly surface observations on May 25 26 and 27 1984

Date	*Time (GMT)*	*Wind Direction (Degrees)*	*Wind Speed (knots)*	*Air temperature (°C)*	*Atmospheric pressure (mb)*
May 25	12	110	15	—18 8	983 4
	18	115	15	—21 0	983 0
May 26	00	165	05	—21 5	984 0
	06	180	03	—23 2	985 5
	12	170	03	—22 5	988 0
	18	VRB	03	—28 5	991 0
May 27	00	180	03	—32 5	995 0
	06	150	05	—35 5	996 6
	12	120	10	—32 5	999 5

WIND

Wind speed and direction are important parameters that affect life in Antarctica. Strong and gusty winds cause damage to the structures drift the snow and break up ice in the coast and carry it to the sea. The study of wind speed and direction in Antarctica is of great importance to meteorological studies.

At *Dakshin Gangotri* two types of anemometers hand anemometer 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. An electrical wind wane was also kept outside at a suitable height on a wind mast.

Wind direction

The most persistent wind direc tion was observed to be 110° During winter the southerly com ponent was dominating. Winds from NW sector was rarely found. Only on three occasions strong westerly winds reaching 40 knots were observed.

Annual variation of wind speed

On an average about 60% of the days average wind speed crossed 20 knots giving rise to very high wind chill. More than 40% of the daily maximum wind speed crossed 40 knots. Frequency distribution of daily maximum wind is given in table 5. The annual variation is given in Fig 10 and the daily van ations in Figs 11 to 14.

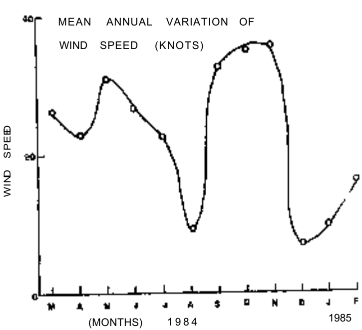
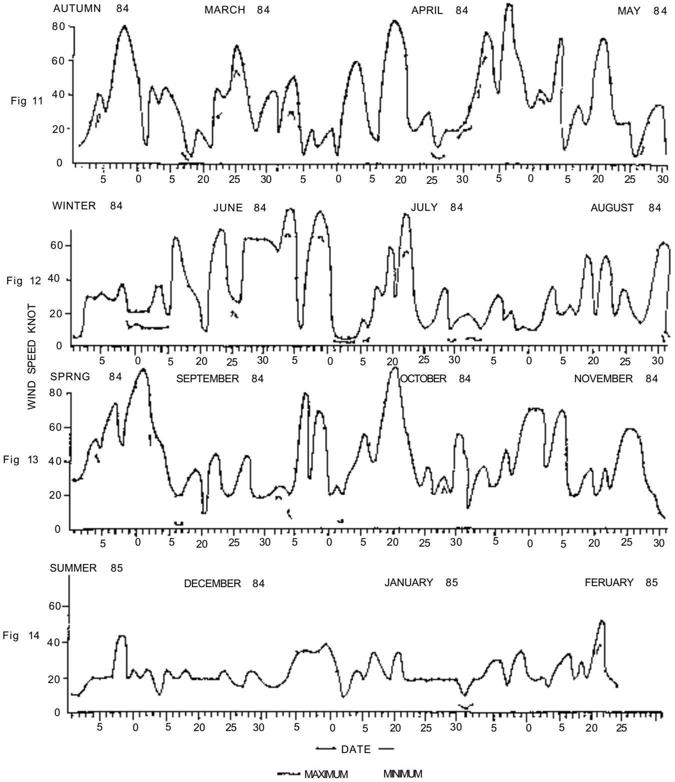


Fig 10 Annual variation of wind speed in knots (Mar 84 to Feb 85)



Figures 1 to 14 Day max and min wind speed in knots from March 84 to Feb 85

TABLE 5

Distribution of Daily Maximum Wind Speed

Wind Speed (Knots)	1984 *Mar.*	*Apr.*	*May.*	*Jun.*	*Jul.*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	1985 *Jan.*	*Feb.*
0 - 10	6	4	4	3	8	7	2	..	2	3	2	1
10 - 20	3	11	0	6	5	13	7	5	4	20	16	11
20 - 30	4	4	7	7	4	3	3	8	7	7	6	8
30 - 40	7	3	7	6	3	2	4	6	5	..	7	3
40 - 50	6	2	4	1	0	2	5	2	3	1	..	-
50 - 60	1	2	3	1	5	3	3	4	5	..	..	1
60 - 70	3	2	3	6	2	1	1	2	4	..	..	..
70 - 80	1	1	2	..	4	..	3	2	-	..	..	..
80 - 90	..	1	0	..	..	..	1	..	..	..	..	-
90 -100	..	..	1	..	..	..	1	2	..	.	..	.

Katabatic winds

The origin of these winds is connected with the cooling of air by radiation along the slopes of the ice plateau and with its movement under the force of gravity down the slope. Though the katabatic winds are the characteristic features of the climate of Antarctic coastal region the strong winds observed at *Dakshin Gangotri* did not have the katabatic nature. It is seen that at *Dakshin Gangotri* the strong winds are not mostly due to katabatic flow but mainly due to the passage of low pressure systems moving to the north of it.

Blizzards

The word blizzard is used to mean anything from light drifting snow with clear skies to a snow storm with high winds. Antarctica as it is also known as the home of blizzards is the windiest of all the continents. During blizzard it is just not possible to do any out door activity due to poor atmos pheric visibility and very high wind chill factor. When the wind speed crosses 70 knots it is not safe to go out in to the blizzard as there is every possibility of getting lost into the blizzard. Blizzards can last as long as 8 to 10 days continuously. The longest blizzard observed lasted for 12 days. Blizzards lasting for 5 to 6 days were very common. Table 6 gives the account of all blizzards observed during the period from March 1984 to February 1985.

Case study of a blizzard

Detailed study of different meteorological parameters has been carried out for the blizzards ob served between June 21 and June 24 1984. Fig 15 gives the measure of different meteorological parameters during this period.

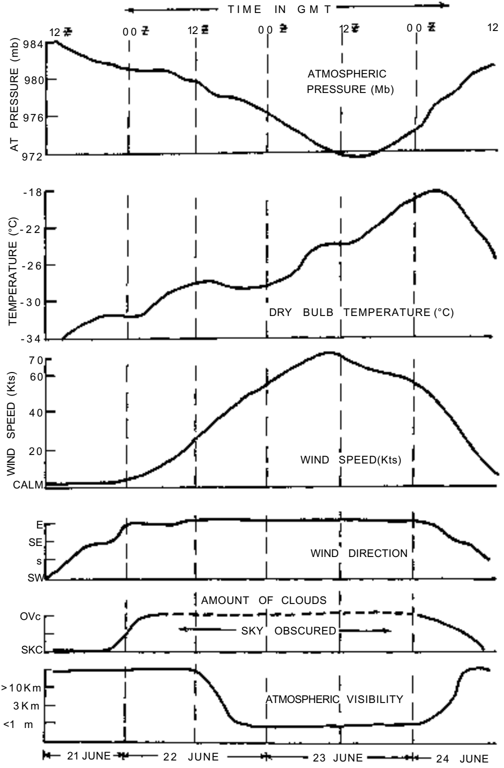


Fig 15 Variation of different meteorological parameters during a blizzard

TABLE 6

List of blizzards observed from March '84 to Feb '85

Sl No	START Date	START Time (GMT)	OVER Date	OVER Time (GMT)	Duration in hrs	Maximum wind speed (knots)
1	6-3- 84	1500	10-3- 84	1300	94	80
2	12-3- 84	0800	12-3- 84	2400	16	45
3	24-3-'84	0930	27-3-'84	0330	66	70
4	30-3- 84	0900	31-3-'84	1800	33	50
5	2-4-'84	1500	4-4-'84	1200	45	55
6	12-4-84	0000	14-4-'84	0900	57	60
7	17-4-'84	0900	20-4-'84	2300	86	85
8	1-5-'84	2100	5-5-'84	0400	79	60
9	7-5-'84	0600	8-5-'84	1500	33	95
10	9-5-'84	0600	10-5-'84	1200	30	70
11	11-5-'84	1800	13-5- 84	1100	41	50
12	14-5-'84	2300	15-5- 84	1200	13	75
13	20-5- 84	2000	22-5-84	0700	35	60
14	13-6- 84	0900	14-6- 84	0900	24	45
15	16-6-'84	0300	18-6-'84	0900	54	60
16	22-6-'84	1200	24-6-'84	0700	43	70
17	27-6- 84	0400	5-7-'84	0400	8 days	85
18	7-7-'84	0800	10-7-'84	1700	81	70
19	19-7-84	0000	20-7-'84	0100	25	65
20	20-7-'84	1730	22-7-'84	2230	53	70
21	18-8-'84	1800	18-8- 84	2200	04	50
22	21-8-'84	0230	22-8- 84	1130	33	50
23	29-8- 84	0500	30-8-'84	2000	39	60
24	3-9-'84	0300	14-9-'84	0300	11 days	95
25	18-9-84	1300	19-9-'84	1400	25	40
26	6-10-'84	0000	7-10-'84	0300	27	85
27	8-10-84	0500	9-10-'84	1500	34	80
28	15-10-'84	0000	16-10-'84	1500	39	55
29	17-10-'84	1900	23-10-'84	1430	6 days	95
30	30-10-'84	0000	31-10-84	0500	29	55

TABLE 6 *(Continued)*

Sl No	START Date	START Time (GMT)	OVER Date	OVER Time (GMT)	Duration in hrs	Maximum wind speed (knots)
31	2-11-84	0800	3-11-84	2100	37	35
32	6-11-84	0900	7-11-84	1000	25	45
33	8-11-84	0300	9-11-84	2000	41	70
34	10-11-84	0900	15-11-84	1700	6 days	70
35	23-11-84	1200	27-11-84	1400	4 days	65
36	8-12- 84	0800	8-12- 84	2000	12	45
37	5-1- 85	1300	6-1-85	0500	16	35
38	20-2- 85	1300	21-2-85	2000	31	55

ATMOSPHERIC PRESSURE

Importance of the study of atmospheric pressure

Knowledge of global distribution of atmospheric pressure and associated features is essential for clear interpretation of large and small atmospheric circulations of the world. In this respect the atmospheric pressure data collected round the year at Indian Antarctic station *Dakshin Gangotri* is of great use. It is also one of the basic meteorological parameters to understand the behaviour and intensity of the approaching weather systems at *Dakshin Gangotn.* Its rate of rise or fall is of great meteorological significance

Measurement of atmospheric pressure

Three types of barometers are used at *Dakshin Gangotri* for synoptic observation and continuous recording of atmospheric pressure. They are aneroid barometer (dial type) precision aneroid baro meter and weekly barograph The atmospheric pressure discussed here is the station level pressure not reduced to mean sea level and the daily average values are taken from daily atmospheric pressure curve by applying equal area method

Maximum and minimum atmospheric pressure

Maximum and minimum atmospheric pressure for each day were recorded for the entire period. The particulars of frequency distribution may be seen in tables 7 and 8 and Figs 16 to 19 give the daily variation of pressure for different seasons during the period. Lowest value of 915 5 mb was recorded on October 9 1984. The highest value of 1003 5 mb was recorded on three occasions ie on May 13 August 27 and December 19 1984 at *Dakshin Gangotri.* Mean annual pressure variation is given in Fig 20 It can be seen that October has the lowest atmospheric pressure and December the highest

Fig 16

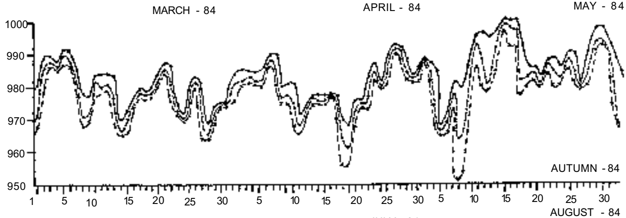


Fig 17

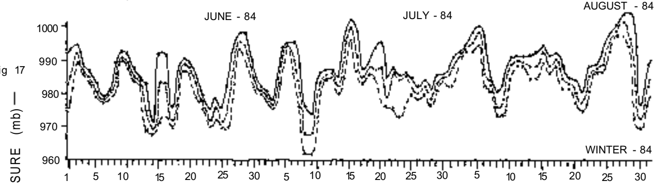


Fig 18

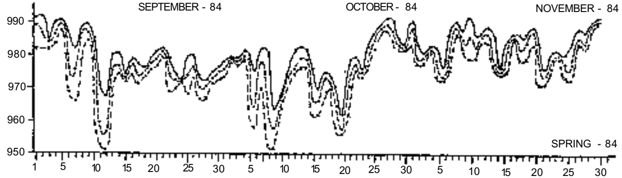
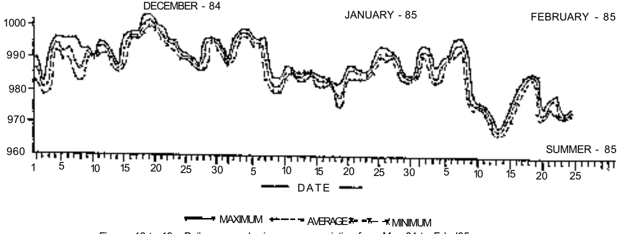


Fig 19



Figures 16 to 19 Daily max and min. pressure variation from Mar 84 to Feb '85

TABLE 7

Frequency Distribution of Daily Maximum Atmospheric Pressure

Atmospheric pressure (range-mb)	1984 Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	1985 Jan.	Feb.
955 - 960	--	--	--	--	--	--	--	--	--	--	--	--
960 - 965	--	--	--	--	--	--	--	2	--	--	--	--
965 - 970	2	1	1	--	--	--	1	2	--		--	1
970 - 975	4	2	1	1	1	--	6	5	2	--	--	6
975 - 980	8	8	--	4	2	1	7	6	4	--	--	6
980 - 985	9	6	3	6	8	6	7	11	7	1	7	2
985 - 990	6	7	8	7	11	4	6	3	14	3	13	2
990 - 995	2	5	8	8	4	14	3	2	3	11	5	5
995 - 1000	--	1	4	2	4	4	--	--	--	12	6	2
1000 - 1005	--	--	5	2	1	2	--	--	--	4	--	--

TABLE 8

Frequency Distribution of Daily Minimum Atmospheric Pressure

Atmospheric Pressure (range-mb)	1984 Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	1985 Jan.	Feb.
950- 955	--	--	1	--	--	--	2	2	--	--	--	--
955- 960	--	2	--	--	--	--	--	3	--	--	--	--
960- 965	3	--	--	--	2	--	--	4	--	--	--	--
965- 970	6	3	1	1	--	1	7	3	2	--	--	3
970- 975	6	3	4	8	1	4	11	5	9	--	-	5
975- 980	9	8	1	6	9	2	4	7	7	2	3	6
980- 985	4	11	12	7	12	9	5	5	9	3	15	3
985- 990	3	1	5	6	5	8	1	2	3	12	7	4
990- 995	--	2	4	1	1	5	--	--	--	7	4	3
995-1000	--	--	2	1	1	2	--	--	--	7	2	--
1000-1005	--	--	--	--	--	--	--	--	--	--	--	--

Seasonal variation

Based on the monthly mean values gradual rise of atmospheric pressure was observed during autumn and then it was more or less maintained during winter. Later it started falling in the beginning of spring followed by considerable rise in the late spring. In the second half it started falling again followed by its gradual rise in autumn. Thus on an average relatively low pres sure prevailed during spring and first half of autumn. Surface analysis charts from Antarctic Meteorological Centre (AMC) Molodyozhnaya prepared specially for Antarctic region which were received on facsimile weather chart recorder at *Dakshin Gangotri* on a regular basis clearly indicate that the circumpolar low pressure belt (trough) oscillated between 60° and 70°S twice in a year. This type of oscillation was very well reflected by the mean monthly annual atmos pheric pressure curve shown in Fig 20. Thus relatively high pressure prevailed during summer and winter.

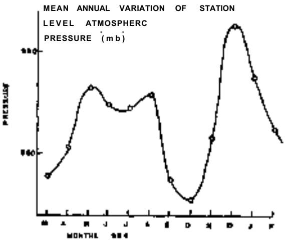


Fig. 20 Annual varation of pressure (Mar 84 to Feb 85)

Diurnal variation

On average the diurnal variation of atmospheric pres sure was found to be very less. However variations associated with the moving weather systems were observed to be as high as 32 mb in 24 hours. Cases of two to three mb variation in three hours were very common. On May 7 steepest fall of pressure of the order of six to eight millibar per three hours was observed followed by its rise at almost the same rate. Variation of atmospheric pressure for this period is shown in Fig 21.

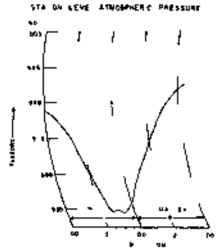


Fig 21 Variation of pressure on May 7 & 8 1984

Atmospheric pressure and blizzard

Generally it was found that in seventy per cent of cases significant fall of atmospheric pressure was an alarm signal for blizzard to set in. However in its rising trend also strong winds were observed. Such a case was observed between June 26 and June 29 1984. The atmospheric pressure was rising continuously on June 26 from 06 GMT onwards. Light to moderate snowfall was also seen from 18 GMT of June 26 onwards. The wind speed crossed 40 knots in the next three hours and very strong winds continued upto June 29. During this period continuous rise of pressure was observed. Six hourly surface observations during this period are given in table 9.

TABLE 9

Six hourly surface observations from June 26 to 29 1984

Date and Time		Wind direction (degrees)	Wind speed (knots)	Station level atmos pheric pressure (mb)	Air Temp (°C)	Amount of cloud
June 26	06	080	15	972 5	—18 5	Over cast sky
	12	125	03	977 5	—19 5	
	18	090	03	982 0	—26 0	
June 27	00	080	15	984 5	—22 0	Snow fall
	06	090	32	988 0	—21 5	
	12	080	50	990 0	—20 0	Sky obscured
	18	090	60	992 0	—19 0	due to heavy snow drift
June 28	00	080	55	995 5	—18 0	
	06	080	55	998 0	—18 0	
	12	080	55	999 5	—17 0	
	18	080	55	1000 0	—17 0	
June 29	00	080	55	1001 0	—16 5	
	06	080	40	1001 2	—16 0	

Fig 22 gives the variation of atmospheric pressure during this period

OZONE STUDY

Ozone being one of the trace gases present in the atmosphere continuous monitoring of surface ozone will give an opportunity to study the air chemistry of Antarctica. From meteoro logical point of view it is important for under standing the geophysical climatic changes. Besides it is important to know the ozone concentration as it absorbs the harmful ultra violet radiation.

To measure this fresh air was allowed to pass through the buffered potassium iodide solution kept in a specially designed glass bubbler at a fixed rate using a suction pump. While passing through the potassium iodide solution the ozone in the air reacted with this solution and the corresponding output was recorded suitably.

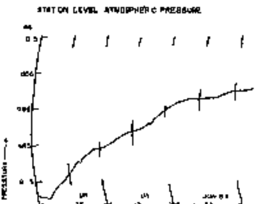


Fig 22 Variation of atmospheric pressure from June 26 to 28 1984

The surface ozone study at *Dakshin Gangotri* was carried out for about two months. But due to many technical reasons, it is feared that its recording may not be reliable. Attempts have been made to improve its recording in future.

DATA COLLECTION PLATFORM

During summer 1985 a data collection platform was successfully tried at Antarctica through Indian Geostationary Satellite INSAT I-B. In future this will be very helpful to act as an unmanned weather station in Antarctica.

UPPER AIR STUDY

About 100 upper air ascents, both Radiosonde and Radiometersonde, were taken for monitoring air temperature pressure and humidity of the upper atmosphere. In spite of lack of proper facilities for launching balloons all efforts were taken to maintain regular schedule of upper air observations. On average, six to eight observations could be taken per month 90% of the observations were taken at 12 GMT. More than 80% ascents penetrated beyond 200 mb and 5% crossed 150 mb out of which only 20% could go beyond 50 mb levels.

Upper air temperature

Based on these observations mean air temperature corresponding to each month for different isobaric levels has been prepared and given in table 10. It can be seen that as season changed from summer to winter not much change was observed in middle troposphere ie around 450 mb (nearly 6 km) as compared to lower and upper tropospheric levels.

Geopotential heights

Based on these observations table 11 has been prepared. It gives the mean heights in geo potential metres of different standard isobaric levels for each month. These heights have been com puted by using hypsometric equation directly. A computer programme was developed specially for its computation.

Upper air humidity

The humidity in Antarctic atmosphere was found very low 90% of the water content was found to be confined in the lower levels only. Beyond 500 mb, the atmosphere was observed to be almost dry. During summer, when sea was free of sea-ice the humidity used to extend upto 500 mb.

Tropopause

The tropopause in winter was found at lower height than in summer. The tropopause temper ature during summer was of the order of -50° to -55°C while in winter it was -65° to -70°C. Cases of double tropopause were also observed.

Stratospheric warming

The stratosphere was found to be cooling gradually as the winter advanced. During winter stratospheric temperature reached -70°C. But the warming was found very quick. Sudden warming by 10 to 15°C in stratosphere was noticed in October 1984 which confirms hither to unsolved mystery of the sudden stratospheric warming. However the lapse rate in stratosphere was found very less especially in winter.

TABLE 10

Mean Upper Air Temperature at Dakshin Gangotri in millibaric levels

	850	700	500	400	300	200	150	100	80	60	50	40	30	25	20
Mar '84	—11 7	—19.1	—30.1	—40.7	—51.3	—46.9	—46.0	—47.9	—48.5	—44.5	—44.0	—45.8	—45.0	—44.5	
Apr	—18 1	—22.3	—35.7	—46.3	—56.8	—53.6	—53.6	—56.9	—56.9	—56.9	—57.1	—58.2	—58.0	—54.0	—53.0
May	—16 2	—21.3	—33.8	—45.2	—56.8	—59.2	—60.1	—63.9	—65.2	—67.1	—69.2	—70.0			
Jun	—18 2	—23.9	—38.1	—47.9	—58.2	—61.8	—63.6	—68.1							
July	—17.5	—21.7	—35.7	—46.4	—57.4	—66.0	—68.7	—73.2	—74.1						
Aug	—20.7	—24.3	—39.0	—49.1	—60.3	—69.2	—71.1	—74.5	—76.4	—75.0	—76.0				
Sept	—18 8	—27.7	—38.5	—48.8	—58.1	—65.8	—69.2	—72.5	—73.2	—75.0	—75.5	—72.0	—69.5	—56.0	—35.5
Oct	—19.8	—25.4	—39.1	—49.0	—60.0	—66.8	—66.0	—66.0	—65.0	—63.5	—60.0	—55.0	—51.5	—38.0	
Nov	—12 2	—20.1	—33.6	—43.2	—53.9	—58.7	—57.6	—49.5							
Dec	— 7.7	—14.2	—26.8	—37.6	—48.6	—44.4	—44.8	—40.4	—39.7	—37.3	—35.0				
Jan '85	— 6 3	—16.0	—28.9	—39.8	—52.2	—44.8	—43.6								
Feb	— 8.4	—15.7	—29.3	—39.3	—50.5	—42.7	—41.5	—41.2	—40.8	—37.5	—37.5				

TABLE 11

Mean Height of the Standard Isobaric Levels in the Geopotential Metres

	850	700	500	400	300	200	150	100	80	60	50	40	30	25	20
Mar 84	1209	2577	5028	6578	8484	11144	13007	15717	17191	19157	20301	21789	23709		
Apr	1132	2570	4984	6241	8355	10928	12791	14821	16800	18629	19773	21144	22927		
May	1144	2590	4945	6541	8375	10916	12824	15226	16585	18324	19393	20720			
Jun	1117	2572	4959	6464	8314	10834	12608	15077	16550	18292					
Jul	1162	2593	5008	6225	8395	10866	12576	14951							
Aug	1128	2548	4937	6437	8275	10754	12464	14891	16186	17647	18704				
Sept	1085	2517	4906	6407	8260	10736	12435		16152	17802	18859	20150	21818	22886	24216
Oct	1118	2541	4918	6417	8253	10736	12391	14800							
Nov	1125	2580	4997	5462	8414	10965	12810	15403							
Dec	1245	2732	5213	6885	8718	11386	13293	15963	17758	19760	21118				
Jan 85	1271	2785	5306	6906	8878	11559									
Feb	1184	2683	5183	6761	8626	11297	13236	13798	17288	19210	20428				

Low level inversions

Ground inversion was found very strong during winter and was less marked during summer. About 10°C inversion in lower 50 mb layer was very common. The strongest inversion of the order of 25°C between surface (994 mb) and 930 mb level was observed on August 4 1984. Very strong surface inversion of the order of 15°C to 20°C prevailed throughout the months of July and August.

On many occasions very shallow inversions of the order of 1 5° to 3°C were also observed around 750 mb level.

SATELLITE IMAGERIES

In summer 1985 meteorological observatory at *Dakshin Gangotri* got equipped with an Auto matic Picture Transmission (APT) unit. With this arrangement satellite imageries were received periodically from *NOAA* and *METEOR* polar orbiting weather satellites. These pictures will help to study cloud cover ice extent and movement of weather system around Antarctica affecting the weather at *Dakshin Gangotri*.

ATMOSPHERIC ELECTRICITY

During the summer of 1985 a potential gradient unit was installed at *Dakshin Gangotri* to keep the continuous record of the atmospheric surface potential gradient ($\frac{1}{2}$ m potential gradient). It is a well established fact that this parameter is directly related with all meteorological activities in the atmosphere. In fact it is the resultant effect of all meteorological parameters.

SOLAR RADIATION

Solar radiation was measured by using a pyranometer. The mean hourly and daily global radiation for each month in megajoules per sq metre observed during the period from January 1984 to February 1985 are given in table 12.

VISUAL OBSERVATIONS

Clouds

At *Dakshin Gangotri* on about 40% of the days, the sky remained overcast. Cirrus, Cirrocumulus, Altocumulus, Altostratus and Stratus type of clouds were very common. Stratocumulus coluds were also observed on a number of occasions in summer. Cloud heights were determined by releasing balloons.

Visibility

It is difficult to estimate the atmospheric visibility at *Dakshin Gangotri* as there are no landmarks. One cause for the deterioration of visibility is the blowing or falling snow. Whenever wind speed crossed 30 knots, visibility came down to less than 5 km except in summer.

Precipitation

Precipitation was never observed in the form of rain. It was always in the form of snowfall. During light snowfall the snow was of granular form only, whereas large snow flakes were prominent at the time of heavy snow fall. In almost 80% of cases, the snow fall was associated with strong winds. This made its actual measurement difficult. Generally it was found that precipitation was more during autumn and spring compared to the other two seasons.

Fog

Formation of advection fog was more frequent in summer. Normally, it was seen clearly drifting from north especially during January and February months when the sea was open. However, cases of formation of radiation fog were also observed, specially towards the evening hours in late November and in December. Fog phenomena were less frequent during winter.

Corona, halo and fog-bow

Beautiful corona and halo used to appear very frequently. Almost circular fog-bow used to be seen in thick fog condition.

Pack ice

The distribution and seasonal variation of pack ice is of considerable meteorological interest since the physical properties of ice and water differ profoundly. Formation of pack ice in the sea starts from middle of April and by end of May very thick ice sheet covers the sorrounding sea completely. This pack ice starts breaking by late December and by middle of February sea will be almost free of pack ice. With the addition of the APT unit installed at *Dakshin Gangotri* study of the pack ice can be carried out on day to day basis.

Aurora and moon-light

Beautiful auroral lights with its colourful draperies were observed on many occasions. It is very difficult to put in words this phenomena which are sometimes referred as Heavenly light also. All of a sudden it used to appear in one part of the sky and while moving with very slow speed generally from north to south it used to constantly change its colour in a wave like pattern. Green colour used to be more prominent. Between late March and the beginning of April auroral light was very bright. It was more frequent in autumn and spring than in winter and it was practically absent in summer.

Moon-light in Antarctica used to be very bright. In moon-light one can walk outside very easily. Though there were no land marks, it was estimated that objects at about 2 km distance could very easily be seen, specially during summer.

CLIMATOLOGY OF DAKSHIN GANGOTRI

Based on meteorological data collected continuously for one year at *Dakshin Gangotri* station, a climatological table has been prepared and is given as table 13.

CONCLUSION

Preliminary analysis of surface and upper air observations taken at *Dakshin Gangotri* provides important information on temperature, wind speed and atmospheric pressure over Antarctica.

During the year the surface temperature varied between 5°C and -50 5°C. Occasions of sudden temperature fluctuations upto 5°C in a few minutes were observed during winter months. More than forty per cent of daily maximum wind speed exceeded 40 knots. On a few occasions atmospheric pressure changed rapidly variations of 6 to 8 mb in 3 hours and 32 mb in 24 hours, were observed. These fluctuations of meteorological parameters were noticed mostly at the time of moving weather systems passing around the region.

Tropopause height and temperature were considerably lower in winter than in summer. Sudden stratospheric warming to the extent of 10 to 15° C was seen.

Analysis of data of continuous observations for longer period will provide better information on meteorological processes in Antarctica.

TABLE 12

Mean global radiation in Megajoules per Sq metre (MJ/m^2) at Dakshin Gangotri
January 1984 to February 1985

Months	Hour ending at local apparent time														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Jan 84	0 11	0 14	0 21	0 38	0 64	0 93	1 22	1 49	1 82	2 22	2 63	2 78	2 81	2 67	2 49
Feb	0 07	0 11	0 15	0 24	0 49	0 69	0 94	1 20	1 41	1 62	1 77	1 80	2 23	2 08	1 93
Mar	0 00	0 00	0 00	0 00	0 01	0 05	0 19	0 42	0 74	1 02	1 23	1 39	1 54	1 51	1 35
Apr	0 00	0 00	0 00	0 00	0 00	0 01	0 01	0 03	0 09	0 21	0 34	0 45	0 50	0 43	0 29
May	0 00	0 00	0 00	0 00	0 00	0 00	0 00	0 00	0 01	0 03	0 04	0 11	0 12	0 07	0 02
Jun	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	0 00	0 00
Jul	0 00	0 00	0 00	0 00	0 00	0 00	0 00	0 00	0 00	0 00	0 00	0 06	0 06	0 01	0 00
Aug	0 00	0 00	0 00	0 00	0 00	0 00	0 01	0 02	0 09	0 22	0 34	0 41	0 40	0 33	0 21
Sept	0 00	0 00	0 00	0 00	0 01	0 02	0 14	0 39	0 74	1 05	1 31	1 38	1 40	1 21	0 94
Oct	0 00	0 00	0 00	0 03	0 12	0 33	0 64	0 99	1 38	1 72	1 98	2 12	2 10	1 94	1 66
Nov	0 01	0 04	0 10	0 32	0 59	0 90	1 26	1 67	2 04	2 37	2 66	2 75	2 75	2 54	2 27
Dec	0 04	0 08	0 19	0 45	0 77	1 11	1 50	1 92	2 37	2 63	2 84	2 94	2 94	2 96	2 72
Jan 85	0 02	0 05	0 18	0 47	0 76	1 00	1 35	1 60	1 99	2 32	2 42	2 56	2 45	2 30	2 07
Feb	0 02	0 03	0 06	0 18	0 34	0 58	0 94	1 30	1 63	1 88	2 11	2 25	2 20	2 12	1 88

TABLE 12 *(Contd)*

Months	Hour ending at local apparent time									
	16	17	18	19	20	21	22	23	24	Total
Jan 84	2 28	1 92	1 60	1 22	0 85	0 54	0 27	0 15	0 10	31 47
Feb	1 84	1 52	1 30	1 00	0 76	0 55	0 41	0 30	0 23	24 64
Mar	1 09	0 74	0 30	0 09	0 02	0 00	0 00	0 00	0 00	11 69
Apr	0 13	0 04	0 01	0 00	0 00	0 00	0 00	0 00	0 00	2 54
May	0 01	0 00	0 00	0 00	0 00	0 00	0 00	0 00	0 00	0 41
Jun	0 00	0 00	0 00	0 00	0 00	0 00	0 00	0 00	0 00	0 00
Jul	0 00	0 00	0 00	0 00	0 00	0 00	0 00	0 00	0 00	0 13
Aug	0 11	0 03	0 01	0 01	0 00	0 00	0 00	0 00	0 00	2 19
Sept	0 66	0 36	0 12	0 02	0 01	0 00	0 00	0 00	0 00	9 76
Oct	1 30	0 89	0 52	0 29	0 11	0 03	0 01	0 00	0 00	18 16
Nov	1 93	1 53	1 13	0 79	0 47	0 24	0 13	0 04	0 01	28 54
Dec	2 39	1 97	1 53	1 07	0 73	0 44	0 25	0 12	0 06	34 02
Jan 85	1 80	1 55	1 16	0 86	0 54	0 33	0 19	0 10	0 05	28 12
Feb	1 59	1 22	0 92	0 59	0 35	0 18	0 10	0 06	0 04	22 57

TABLE 13

Climatological Table for Dakshin Gangotri (Antarctica) March 1984 to February 1985

MONTH	AIR TEMPERATURE (°C)			STATION LEVEL PRESSURE (mb)			WIND SPEED (KNOTS)		No of blizzards	Duration of longest blizzards in No of days	No of windy days	No of over-cast days	Duration of sun-shine in hrs per 24 hrs
	Highest Max	Lowest Min.	Avg	Highest Max	Lowest Min	Avg	Highest Max	Avg					
Mar. '84	— 3.0	—22.5	—11.7	992.0	964.0	977.8	80	23.8	4	5	17	19	12
Apr.	— 9.0	—32.5	—19.6	994.8	957.5	980.4	85	21.8	3	4	9	18	3
May	0.0	—39.0	—18.2	1003.5	953.4	986.5	95	26.0	6	4	20	18	4
Jun	—14.0	—41.5	—23.8	1001.2	969.0	984.8	70	23.5	4	8	13	25	NIL
Jul	—10.0	—45.5	—26.2	1003.0	961.5	984.6	80	21.2	3	4	14	18	1
Aug	—12.0	—50.5	—32.6	1003.5	969.0	987.9	65	14.5	3	2	8	10	6
Sept.	— 8.0	—35.0	—22.4	992.0	952.0	977.5	95	26.4	2	12	15	16	12
Oct	— 8.0	—35.0	—20.1	992.0	951.5	975.9	95	27.2	5	7	17	20	16
Nov	2.0	—30.0	—11.4	991.0	970.0	981.7	70	28.0	5	6	17	19	20
Dec	5.0	—16.0	— 3.1	1003.5	979.0	992.9	45	13.0	1	1	1	16	24
Jan '85	4.0	—11.5	— 2.2	999.0	976.0	987.5	35	15.0	1	2	7	8	23
Feb.	2.0	—22.5	— 6.7	996.5	968.0	982.3	55	18.0	1	2	10	12	18