Meteorological Studies at Dakshin Gangotri during 1988

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Abstract

Meteorological studies conducted at Dakshin Gangotri during 1988 are discussed in brief. August was the coldest month with lowest monthly mean air temperature -26.0 Deg C and extreme lowest air temperature -42.2 Deg C of the year. Pressure alone was not a good indicator for predicting weather. Temperatures were warmer during blizzard period. There were in total 123 blizzard days during the year 1988. Strongest wind of 85 knots gusting to more than 100 kts was recorded during the longest blizzard of about 9 days duration in March. Annual mean tropopause was at 288 hPa level at the height of 8839 gpm and -59.5 Deg C air temperature. All isobaric levels were at highest height with warmest air temperatures in January and lowest in August during the year. Results of radiosondes are also discussed in brief.

Introduction

Ninty two members team of Seventh Indian Antarctic Scientific Expedition under the leadership of Dr R Sengupta, left Goa on 25.11.1987 and reached Antarctic ice shelf near Dakshin Gangotri on 20.12.1987. IMD component consisted of 2 members for winter and one member for summer. Winter team stayed in Antarctica upto 03.03.1989 until the Eigth Expedition's ship left Antarctica and reached back to Goa on 26.03.1989. Meteorological studies during the expedition is included here, since it was not published earlier and which will be useful for comparative estimation of weather at Dakshin Gangotri and Maitri locations, which is essential to know especially for convoy movements over shelf during the future expeditions. Ozone studies are included in a separate article.

Meteorological programme of Seventh Antarctic Expedition (both summer and winter) was mainly the continuation of the long term programme of IMD introduced in earlier expeditions to enable the collection of surface and upper air observations for preparing the climatology of the area and to study the inter annual and inter seasonal variations of the weather over Antarctica and also their relationships with the Indian weather; radiation observations with surface

based and balloon borne instruments for estimating the radiation budget; measurements of total ozone as well as its vertical profile as part of an international programme for the investigation of ozone-hole occurrence over Antarctica during the spring alongwith atmospheric turbidity measurements; the reception of cloud imageries from the polar orbiting weather satellites and radio facsimile weather charts broadcast by the forecasting offices in the region as part of the weather services for logistic and scientific programmes of the expedition.

IMD activities at Dakshin Gangotri during 1988 in brief

(i) Routine weather observations: Recording 3 hourly synoptic observations, passing 6 hourly main synops to IMD headquarters, New Delhi on real time basis.

(ii) Facsimile weather charts: Reception of weather charts from Molodyoznaya and Pretoria

(iii) Cloud pictures: Reception of cloud pictures from NOAA satellites.

(iv) Continuous recording:

  (a) Surface weather elements,viz., air pressure, air temperature, wind speed and direction.

  (b) Global solar radiation

(v) Data Collection Platform: Automatic sampling and transmission of hourly surface weather data on surface pressure, air temperature, wind speed and direction to M.D.U.C., New Delhi through INSAT.

(vi) Atmospheric turbidity observations by Eko and Voltz sunphotometers during clear sun.

(vii) Upper air observations:

  (a) Radiosondes: for pressure, temperature and humidity profiles (twice in a week- total 77 nos.)

  (b) Radiometersondes: For longwave radiation profiles during nights along with air pressure, temperature and humidity profiles (about twice in a month- total 17 nos.)

  (c) Ozonesondes: For ozone profile along with pressure, temperature and humidity profiles (normally once in a fortnight and once in a week during ozone depletion period- total 34 nos.)

  (d) Weather service: Weather advice was provided from time to time for planning the activities of the expedition and maintenance of the station.

Results and Discussion

Brief outlook of weather from 1.1.88 to 28.2.89

Table 1 summarises some interesting values at Dakshin Gangotri for the period:

(i) Surface air temperature: Monthly mean air temperature during 1988 decreased gradually from -1.3 Deg.C in January to -19.7 Deg.C in May. It increased to -15.2 Deg C in June and then decreased to -26.0 Deg.C in August which is the coldest month of the year; and then increased until January 1989. The unexpected warmer mean temperature in June was due to strong winds resulting in maximum number of blizzard days for a month during 1988. When low pressure systems pass closer to the station along sub-polar trough, the station experiences strong easterly winds, warmer air temperatures due to the incursion of low latitude air mass towards polar regions and obstruction to outgoing radiation due to overcast skies.

Highest temperature of the year 1988, +9.9 Deg.C was recorded on 10th January around 09 GMT when the wind was calm and sky was overcast. Unexpectedly the month of March had highest maximum temperature +1.0 Deg.C which was recorded on 20th during a strong blizzard. During 1988-89 summer highest temperatures +1.2 Deg.C was recorded on 21st and 27th December and +1.0 was on 12th and 22nd January.

As generally seen, August recorded extreme lowest temperature of the year -42.2 Deg.C around 00 GMT of 12th when the sky was cloud free, no sunshine and surface wind was light.

(ii) Mean Sea Level Pressure: Highest maximum pressure of the year 1988 was 1015.5 hPa and it was recorded on 10th June. Lowest minimum pressure of the year 951.7 hPa was recorded on 17th July. Extreme lowest pressure during the period under consideration 951.1 hPa was recorded on 3rd February 1989.

There was no systematic variation in monthly mean pressure around the year. Highest mean monthly pressure of the year 996.8 hPa was in the month of June. Station experienced highest number of blizzard days in the month of June. As per the experience, pressure is not a good indicator for predicting day to day weather at Dakshin Gangotri. There were many experiences when there was a steep fall and rise in surface pressure but no significant corresponding change in wind speed and there were occasions when wind speed was increasing but no significant corresponding change in pressure field.

(iii) Surface Wind: Highest wind speed recorded during 1988 was 85 knots gusting to more than 100 knots on 20th March. Highest mean monthly wind

Table 1: Monthly weather data of Dakshin Gangotri for the period 01.01.1988 to 20.02.1989
(Mean values are based on three hourly synoptic observations)

Month	Air Temperarature (°C)			M.S.L.Pressure (hPa)			Wind Speed (Knots)		Mean Cloud (Octa)	Number of blizzard days
	Highest	Lowest	Mean	Highest	LoweSt	Mean	Highest	Mean		
Jan'88	+09.9	-10.6	-01.3	1001.1	0976.0	0988.5	45	12.3	5.7	05
Feb'88	-01.0	-16.3	-06.6	0995.3	0962.9	0982.2	62	22.3	6.3	18
Mar'88	+01.0	-25.2	-10.4	1003.0	0965.2	0986.7	85	24.5	4.8	13
Apr'88	-09.5	-30.7	-17.3	1011.6	0969.4	0987.5	69	19.5	5.3	13
May'88	-06.0	-35.1	-19.7	1006.5	0967..5	0992.0	64	17.1	4.7	12
Jun'88	-07.0	-32.5	-15.2	1015.5	0982..5	0996.8	60	23.9	6.4	19
Jul'88	-11.5	-37.5	-22.7	0997.6	0951..7	0981.5	45	14.4	5.0	07
Aug'88	-08.0	-42.2	-26.0	1005.9	0973..8	0986.9	66	15.0	3.8	09
Sep'88	-08.1	-39.5	-23.2	1006.7	0963..8	0989.5	55	16.5	4.5	12
Oct'88	-09.4	-31.8	-19.1	1006.6	0984.1	0996.1	45	11.8	4.3	06
Nov'88	-03.8	-26.2	-13.8	0997.3	0978..0	0987.2	36	09.1	3.8	04
Dec'88	+01.2	-15.7	-05.8	1000.7	0971..4	0988.3	36	09.6	4.7	05
Jan'89	+01.0	-13.1	-03.9	0997.3	0976.1	0989.8	35	14.6	6.5	11
Feb'89	-00.5	-15.6	-06 3	0992.2	0951..1	0981.4	50	21.7	5.6	14

speed was 24.5 knots in March followed by 23.9 knots in June. Very strong winds were experienced from 12th to 20th March 1988 which was the longest blizzard of the year 1988 at Dakshin Gangotri.

Wind speed is a very important weather element for ice-shelf stations, which controls the day to day activities and the safety of men and materials. As wind speed increases not only effective cooling temperature decreases due to wind chill factor but also visibility decreases drastically due to drifting and blowing snow. Sudden deterioration in weather from very light or calm wind, clear sky and good visibility to strong winds resulting in drifting and blowing snow, poor visibility, overcast or obscured sky in a matter of few minutes to hours is a common phenomena in Antarctica especially at the stations on ice-shelf, like Dakshin Gangotri. Generally when persistent wind speed crosses about 20 knots, surface drifting snow; about 30 knots, slight to moderate blowing snow; about 40 knots, heavy blowing snow results. The intensity of drifting or blowing snow depends not only on wind speed but also on the surface hardness which in turn depends on temperature, history of the past weather. During winter when temperatures are pretty cold, the ice surface becomes hard. Hence in winter generally drifting or blowing snow is lighter for the corresponding wind speeds in summer when snow surface is soft due to warmer temperatures.

There were in total 123 blizzard days out of 366 days during the year 1988. This amounts to 33.6 percent stormy weather days at Dakshin Gangotri station during the year. The station experienced longest duration blizzard of the year from 12.03.1988/03 GMT to 20.03.1988/2300 GMT. November was the best weather month of the year 1988 at Dakshin Gangotri with only one day with daily mean wind speed with more than 20 knots and slight blowing snow on 22nd. Monthly mean speed was only 9.1 knots which was the lowest.

Table 2 indicates the percentage of wind directions on 8-point compass observed at Dakshin Gangotri during 1988. Easterly to east-south-easterly wind directions is the predominant one. During the year percentage of wind coming from east was 56.0 and that from east to south east was 79.4. Wind from other directions was a rare phenomena, generally either with light speeds and associated with the passage of high pressure belts.

(iv) Cloud: Cloud amounts at Dakshin Gangotri are highly variable from day to day. Generally increases in cloud amount and rise in wind speed are seen when the sub-polar lows approach closer to the station and decrease in cloud amount when the systems pass away. Generally only stratus, stratocumulus, altostratus, altocumulus, cirrus, cirrostratus, cirrocumulus clouds are seen at Dakshin Gangotri. Cumulus with little vertical development are sometimes seen at the northern horizon. Generally sky is obscured and it is not possible to

Table 2: Percentage of wind directions on 8-point compass observed at Dakshin Gangotri during 1988 (based on all 3 hourly synoptic weather observations during the year)

Direction	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	NolV	Dec	Annual
N	00.0	00.0	00.0	00.0	00.0	01.3	00.0	00.0	00.0	00.0	00.4	01.2	00.2
NE	02.8	00.0	01.6	00.4	00.0	02.1	00.4	00.0	00.8	00.4	00.4	06.5	01.3
E	59.7	81.9	68.5	57.1	48.8	77.1	46.0	41.5	60.4	46.4	38.8	46.0	56.0
SE	13.3	14.2	21.4	25.4	23.8	15.0	42.7	35.1	22.5	35.5	18.8	13.7	23.4
S	06.1	03.4	05.2	13.3	12.9	00.8	06.9	21.4	13.8	09.7	11.7	15.3	10.0
Sw	03.2	00.0	02.4	01.7	04.4	01.3	02.0	02.0	02.1	04.4	12.5	05.6	03.5
W	00.8	00.0	00.0	00.8	00.4	01.3	00.4	00.0	00.0	00.0	11.7	02.4	01.5
Nw	02.0	00.0	00.0	00.0	00.0	00.8	00.8	00.0	00.4	00.0	00.4	00.8	00.4
Calm	12.1	00.4	00.8	01.6	09.6	00.4	00.8	00.0	00.0	03.6	05.4	08.5	03.6

estimate the cloud amount during moderate to heavy blowing snow. During 1988, February and June were the most cloudy months with only 3 days each with daily mean cloud amounts less than or equal to 4 Octa. Annual mean cloud amount during 1988 was 4.9 octa.

Some interesting weather events experienced at Dakshin Gangotri

(i) Longest blizzard of the year from 12.03.88 to 20.03.88 [see Fig. 1.]

The station experienced longest blizzard of the year of duration 8 days and 20 hours during March from 03 GMT of 12th to 23 GMT of 20th. The following features are seen during the blizzard:

(a) Such a long life of the blizzard was maintained due to passage of a cyclone family consisting of a series of low pressure areas. This can be seen on the microbarograph.

(b) Winds were very strong almost throughout the period reaching highest wind speed of the year 85 knots gusting to more than 100 knots on 20th around 12 GMT. Mean wind speed of the blizzard from 03 GMT of 12th to 23 GMT of 20th was 53.4 knots(based on all 3 hourly synoptic observations).

(c) Sky was obscured and the station experienced heavy blowing snow and poor to very poor visibility continuously from about 06 GMT of 12th to about 15 GMT of 20th. One interesting point which is appropriate to mention here is that though mean wind with about 50-60 knots gusting to about 70 knots was persisting at the station between about 1630 and 1830 GMT of 20th, there was only slight to moderate surface drifting snow, visibility improved sharply from very poor(less than 10 meters) to about 1000 meters. The sky which was obscured until 15 GMT could be seen as overcast cloudy sky. Though strong winds were persisting, the occurrence of this phenomena is due to hard snow surface of the ice shelf when most of the loose snow on the ice shelf surface was blown away due to persistent strong winds during the preceding about 9 days.

(d) Air temperatures at the station were warmer during the blizzard period. Daily mean air temperature was -20.2 Deg.C on 11th which increased gradually to -0.1 Deg.C on 20th and then decreased to -17.7 Deg.C on 25th. Daily maximum temperature was -15.1 Deg.C on 11th increased to +1.0 Deg.C on 20th and then decreased to -17.7 Deg.C on 25th. Daily maximum temperature was -15.1 Deg.C on 11 th, increased to +1.0 on 19th and 20th and then decreased to -13.5 Deg.C on 25th. The corresponding daily minimum temperatures are -24.5 Deg.C on 11th, 0.8 Deg.C on 20th and -25.5 Deg.C on 25th.

Warmer air temperatures at Dakshin Gangotri were experienced during blizzard throughout the year 1988. This is due to incursion of low latitude

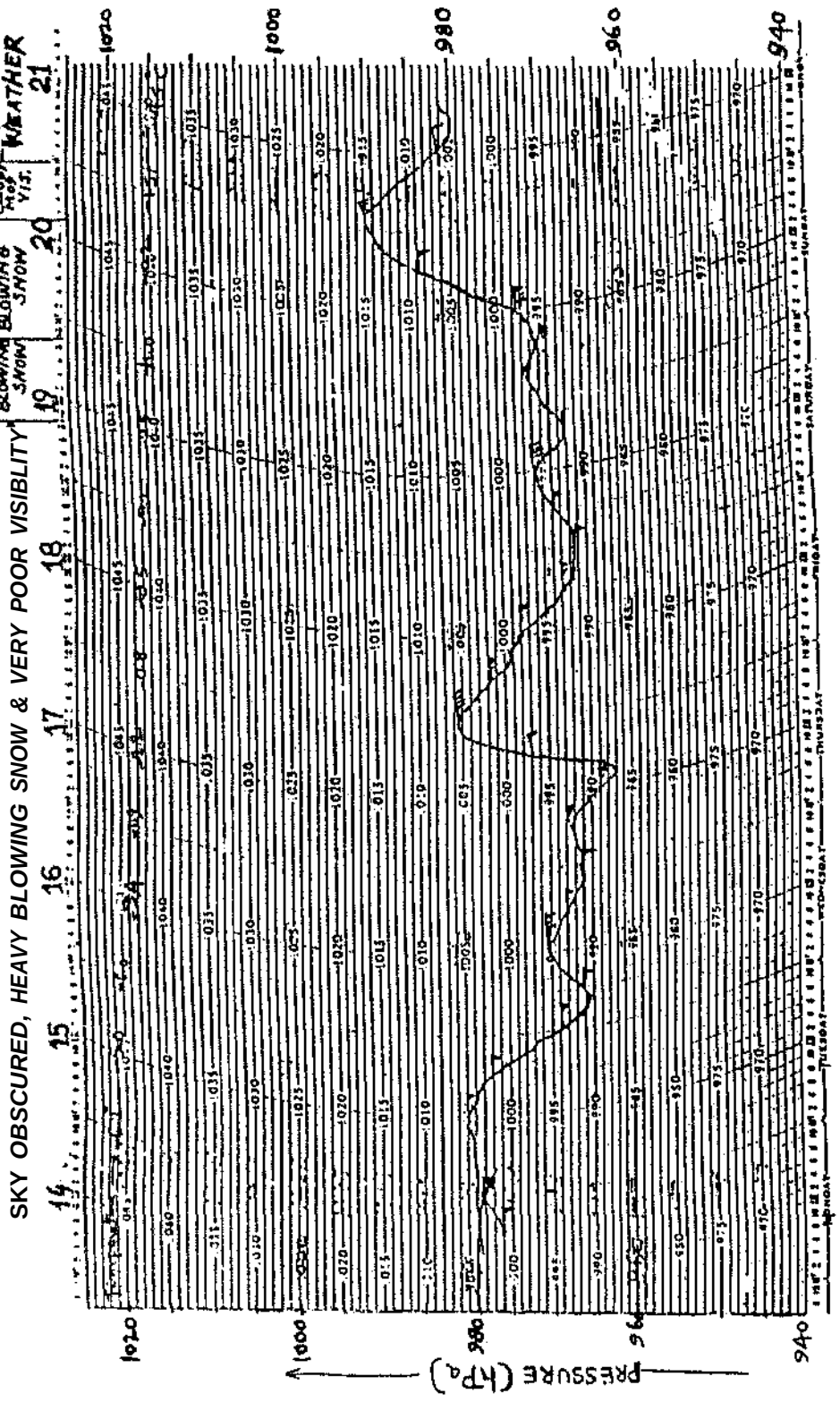

Fig. 1: Microbarograph recorded at Dakshin Gangotri from 14.03.88 to 21.03.88

warmer air mass towards polar regions and obstruction to outgoing radiation due to overcast sky. Due to highest number of blizzards, June had abnormally warmer temperatures [see Table 1.]

(ii) Suitability of surface pressure tendency parameter for predicting wind speeds:

Wind speed is the most important factor which decides the working environment and safety of men and materials in Antarctica. Wind speed controls not only the intensity of drifting and blowing snow and then visibility but also effective air temperatures due to wind chill factor. Hence estimating winds in advance atleast in suitable ranges is very important in Antarctica for planning day to day logistics and safety. Generally pressure and wind are well correlated in tropics. When pressure falls considerably at a station, wind speed increases and vice versa. But unfortunately this is not always so in Antarctica. In the following, two interesting occasions of sharp fall and sharp rise in surface pressure and associated wind speeds are discussed.

(a) 7th to 9th April 1988 [see Fig. 2]

Surface pressure decreased sharply by 27 hPa from 994 hPa at 12 GMT of 7th to 967 hPa at 12 GMT of 8th. Correspondingly wind speed at 12 hourly intervals from 00 GMT Of 7th to 12 GMT of 8th were 15, 39, 57 and 69 knots respectively.

From 12 GMT of 8th to 12 GMT of 9th the pressure increased sharply by 18 hPa from 967 hPa to 985 hPa. The corresponding winds at 12 hourly intervals were 69,21 and 13 knots. This is a good example where the tendency of surface pressure variation at Dakshin Gangotri was an indicator for estimating the tendency in surface wind speeds.

(b) 29th to 31st May 1988 [see Fig. 3]

There was a sharp fail of pressure of 22.5 hPa from 21 GMT of 29th to 18 GMT of 30th and steep rise of 33.5 hPa from 18 GMT of 30th to 24 GMT of 31st. The wind speeds at 12 hourly intervals from 12 GMT of 29th to 24 GMT of 31st in order are only 22, 25, 10, 17,07 and 14 knots respectively. Weather was very good on 30th May with good visibility and little cloud cover. On 31 st sky was overcast until about 07 GMT and the station experienced snowfall. This is a good example for non-existence of correlation between surface pressure and wind speed variations. Such instances are many in Antarctic weather.

Instead of pressure tendency at a single station, if we consider pressure gradient over a considerable area, it may give a good indication for predicting winds and weather. For studying the pressure gradient, we need a suitable density of observations and a network of data-exchange. Moreover we have to

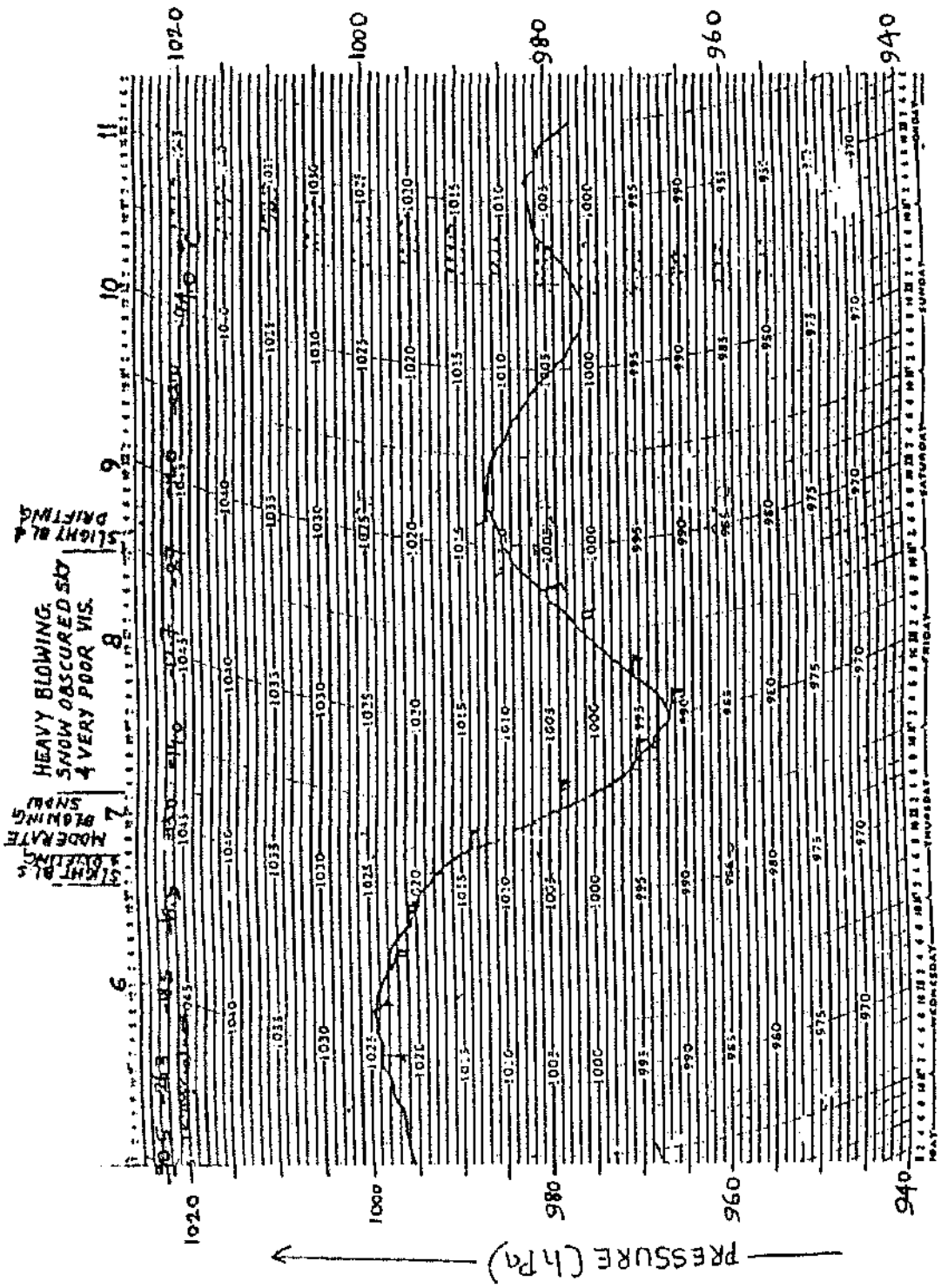

Fig. 2: Microbarograph recorded at Dakshin Gangotri from 6th to 11th April 1988

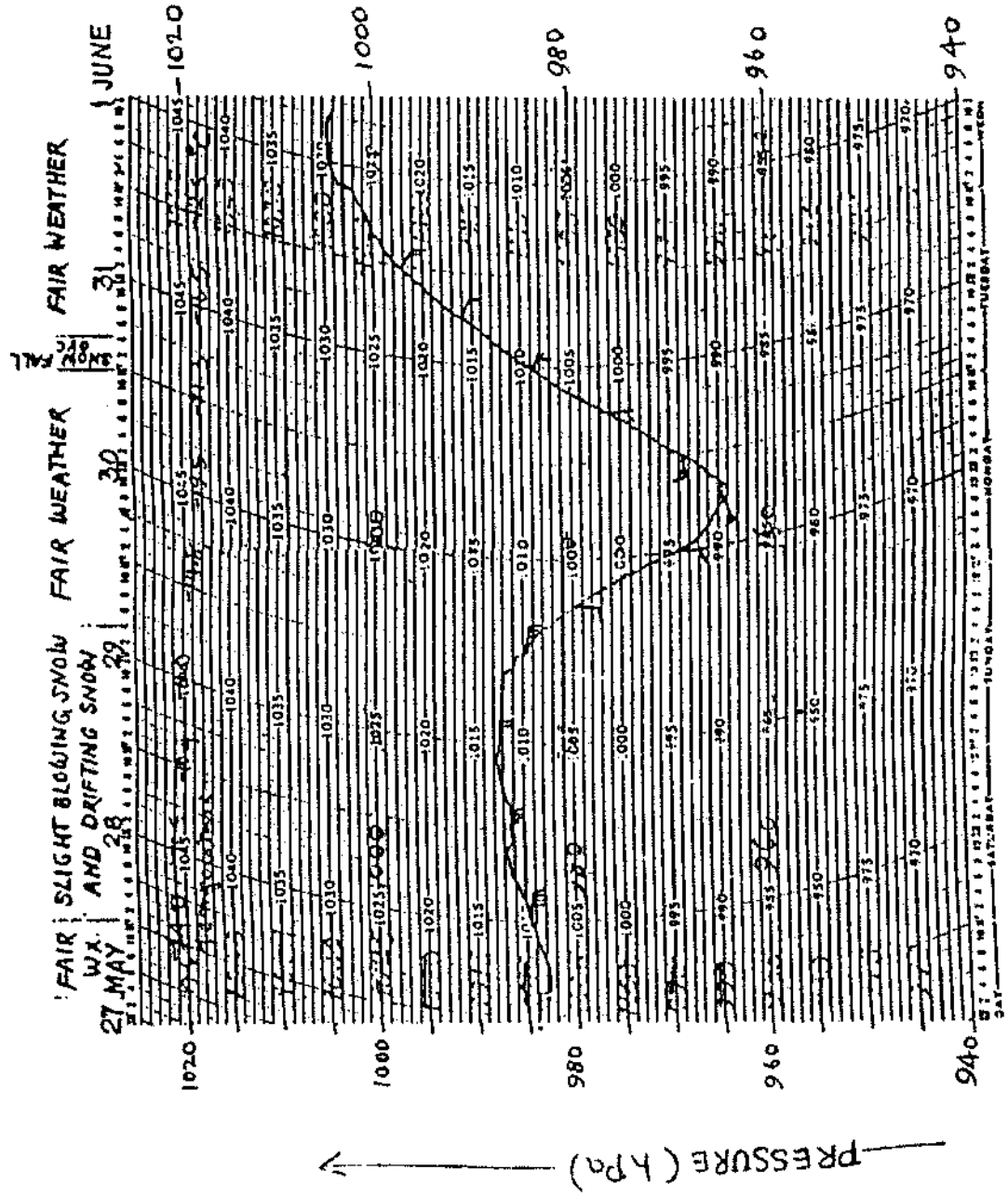

Fig. 3:Microbarograph at Dakshin Gangotri from 27th May to 1st June 1988

take into account the effect of katabatic winds of Antarctic continent on its ice-shelf regions.

Upper atmosphere at Dakshin Gangotri during 1988

Based on 71 successful radiosondes during the year (from January to December 5, 3, 4, 4, 5, 5, 6, 7, 5, 8, 10 and 9 ascents in order) monthly mean geopotential heights, temperatures and thicknesses of standard isobaric levels are tabulated in Tables 3 to 5. The following clear annual variations at almost all pressure levels are seen:

(a) Heights of all pressure levels are highest in January. They decreased gradually reaching lowest values in August and then started increasing until end of the year.

(b) Air temperatures at all levels are warmest in summer (December & January) and coldest in winter reaching lowest value in July & August.

(c) Thickness between standard pressure levels are highest in summer and lowest in winter.

The above results indicate that at Dakshin Gangotri warmer atmosphere is observed in January just at the verge of 24 hour sunshine whereas the colder atmosphere is observed in August about a month after the end of 24 hour total absence of sunshine.

Conclusions

(a) At Dakshin Gangotri, August was the coldest month during the year 1988. Both lowest monthly mean air temperature -26.0 Deg.C and extreme lowest air temperature of the year -42.2 Deg.C were recorded in August. During blizzards warmer air temperatures were experienced.

(b) Highest mean sea level pressure of the year recorded in 1988 was 1015.5 hPa in June and the lowest 951.7 hPa in July. Experience shows that pressure tendency alone is not a good indicator for predicting wind speeds.

(c) Longest duration blizzard of the year was of about 9 days experienced in March. Highest maximum wind speed of the year, 85 knots gusting to more than 100 knots was recorded during the same blizzard. Such a long duration of the blizzard was maintained due to the passage of a series of low pressure areas along sub-polar trough affecting the station.

June had the maximum number of blizzard days and November had the best weather during the year. The station experienced in total 123 days blizzard out of 366 days in 1988.

Table 3: Monthly mean heights of standard isobaric levels (in geopotential meters)

	Pressure levels (hPa)													
Month	**850**	**700**	**500**	**400**	**300**	**250**	**200**	**150**	**100**	**70**	**50**	**30**	**20**	**10**
Jan	1253	2770	5257	6823	8758	9990	11516	13504	16308	18748	21138	24717	27638	32689
Feb	1187	2693	4484	6699	8609	9821	11331	13253	16027	18490	20802	24372	27235	32003
Mar	1156	2632	5093	6649	8574	9764	11224	13145	15839	18167	20333	23697	26383	-
Apr	1173	2640	5049	6566	8430	9605	11065	12947	15574	17777	19954	23165	-	-
May	1172	2622	5011	6508	8348	9478	10886	12693	15169	17353	19298	-	-	-
Jun	1239	2689	5091	6595	8427	9504	10876	12637	14954	17070	-	-	-	-
Jul	1083	2509	4886	6364	8158	9253	10613	12307	14650	16985	19296	-	-	-
Aug	1084	2495	4848	6328	8144	9254	10604	12239	14769	16870	-	-	-	-
Sep	1169	2600	4990	6491	8331	9442	10775	12480	14870	16966	18982	22222	-	-
Oct	1209	2656	5076	6593	8445	9576	10914	12655	15122	17319	19481	22815	25473	-
Nov	1172	2644	5105	6629	8508	9676	11106	12964	15609	17994	20292	23821	26861	33122
Dec	1197	2689	5173	6743	8670	9872	11382	13339	16115	18604	20915	24537	27451	33336
Annual mean	1174	2637	5005	6582	8450	9603	11024	12847	15417	17695	20049	23668	26840	33287

Table 4: Monthly mean air temperatures at standard isobaric levels, (All temperatures are negative and upto first decimal in degree celcius)

	Pressure levels (hPa)													
Month	850	700	500	400	300	250	200	150	100	70	50	30	20	10
Jan	063	143	287	389	427	406	389	381	371	359	327	287	255	227
Feb	076	159	320	413	483	414	405	399	386	381	357	335	308	293
Mar	103	170	307	408	500	500	483	470	463	484	491	480	463	-
Apr	136	218	363	467	538	509	487	494	540	577	588	600	-	-
May	160	224	391	500	585	577	575	594	656	697	715	-	-	-
Jun	141	223	375	497	613	643	627	657	726	749	-	-	-	-
Jul	175	243	411	530	651	705	723	751	736	399	190	-	-	-
Aug	226	273	417	527	629	671	696	742	730	737	-	-	-	-
Sep	195	248	381	486	619	676	696	714	714	697	650	448	-	-
Oct	153	218	364	471	591	632	659	661	639	582	514	413	300	-
Nov	108	177	319	434	541	544	534	519	474	423	345	248	198	171
Dec	067	145	281	387	487	456	416	397	385	359	329	288	265	225
Annual mean	134	203	351	459	555	561	557	565	568	537	451	387	298	229

Table 5: Monthly mean thicknesses between standard pressure levels (in gpm)

Month	1000-850 hPa	850-700 hPa	700-500 hPa	500-300 hPa	300-200 hPa	200-100 hPa
Jan	1275	1517	2487	3502	2758	4792
Feb	1281	1506	2458	3458	2722	4696
Mar	1254	1476	2462	3481	2649	4592
Apr	1242	1467	2408	3382	2635	4509
May	1229	1450	2389	3337	2555	4294
Jun	1242	1451	2402	3336	2489	4137
Jul	1209	1426	2375	3301	2419	4027
Aug	1196	1411	2353	3297	2449	4089
Sep	1217	1432	2389	3341	2424	4093
Oct	1233	1448	2419	3370	2484	4208
Nov	1256	1472	2461	3409	2597	4502
Dec	1280	1492	2485	3496	2705	4733
Annual mean	1243	1462	2424	3393	2574	4389

[Values in Tables (3) to (5) are based on 71 successful radiosondes during the year (from January to December 5, 3,4,4, 5, 5,6, 7, 5, 8, 10 and 9 ascents in order)]

(d) Almost all isobaric levels were at highest height with warmest air temperatures in January and lowest in August during the year. Annual mean tropopause was at 288 hPa level at the height of 8839 gpm and -59.5 Deg.C air temperature.

Acknowledgements

I am indebted to my organisation, India Meteorological Department and Department of Ocean Development for sponsoring me to participate in Seventh Indian Scientific Expedition to Antarctica as a winter team member. I gratefully acknowledge the help and cooperation extended by Shri P.M. Gulhane, another winter member of IMD team who equally contributed with me for successful implementation of IMD programme during 5th wintering period. I also thank Sri G Srinivasan, IMD team member of summer team and many other members of the expedition which is not possible to name here who actively cooperated in making the IMD scientific program successful in the expedition. My special thanks are due to Col P Ganesan, Station Commander of Dakshin Gangotri and other winter team members during 5th wintering period who actively supported

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Reference

Scientific Report on Meteorological Programme Carried out at Dakshin Gangotri, Antarctica during 1987-89 submitted to IMD by G.Sudhakar Rao, IMD Team Leader, 7th Indian Scientific Expedition to Antarctica.