

551.578.45(9)“1996”

"BLIZZARD" - A DISASTROUS WEATHER PHENOMENA OVER ANTARCTICA REGION AND A CASE STUDY OF LONGEST BLIZZARD OVER MAITRI (ANTARCTICA) DURING 1996

1. Antarctica, the world's largest, coldest, driest and windiest ice desert ringed by the stormiest ocean with unpredictable extreme weather conditions, especially the weather phenomena like blizzard (snow storm) which is a

combination of strong winds and moderate to heavy snow blowing, reducing the horizontal visibility condition to nearly zero. Blizzard brings all the out door activities to a halt and can cause considerable damage to unprotected machinery, buildings and some times loss of human lives also. Blizzard is a result of interaction between powerful Katabatic or gravity wind, resulting from the rolling down of cold dense air over the continental surface and the warm moist air from the ocean surface creating the narrow storm belt ringing the continent producing extremely strong blizzard. Therefore the continent is also known as "The Home of Blizzards".

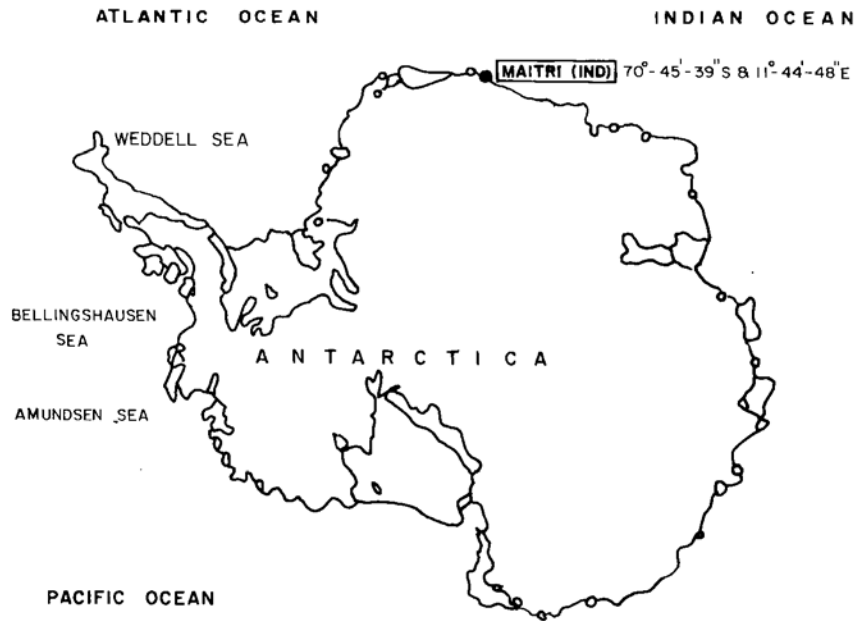


Fig. 1. Map of Antarctica showing location of Maitri station

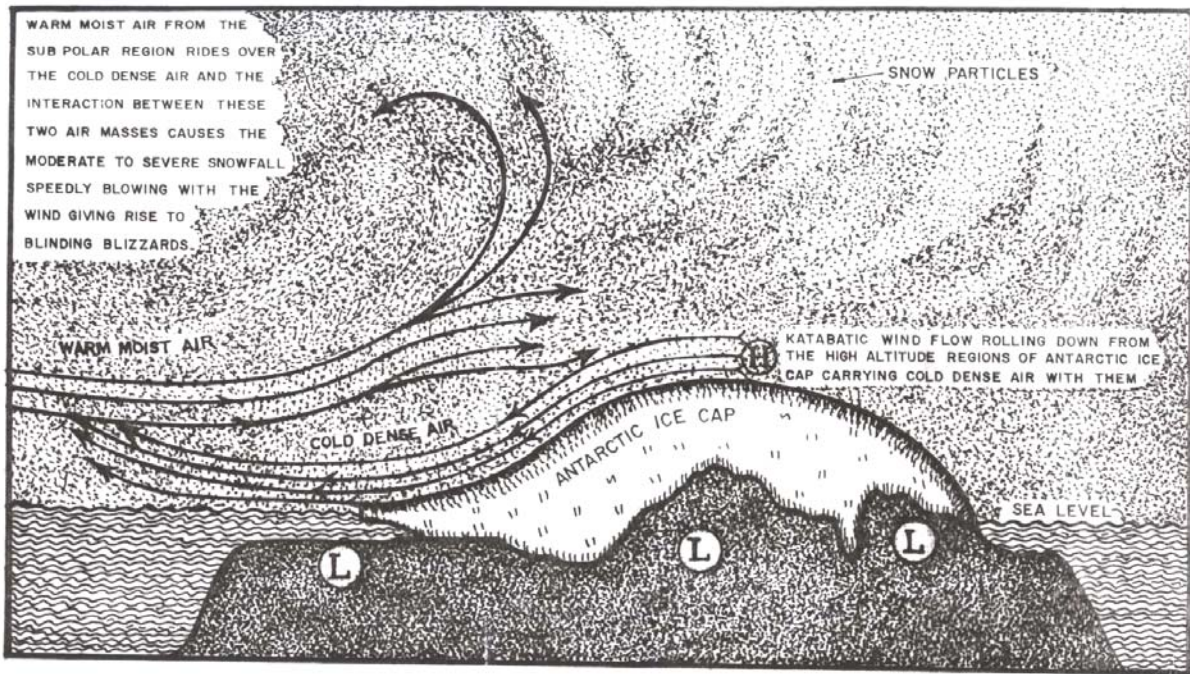


Fig. 2. Schematic diagram showing the initiating forces giving rise to blizzards (snow storms) over Antarctic regions

During 1996, a total of 48 blizzards were experienced at the 'Maitri' station (Antarctica) out of which the blizzard experienced during 19 to 24 July was

the longest and strongest one covering a total period of 113 hours recording the highest wind speed of 68 knots (126kmph) gusting to 112 knots (208kmph) which is a

TABLE 1

Behaviour of the meteorological parameters during the blizzard over Maitri (Antarctica) during 19 to 24 July 1996

Date	Starting hour	Wind speed (kts)	Temp. (°C)	Pressure (hPa)	Weather
(1)	(2)	(3)	(4)	(5)	(6)
19 July 1996	1300	23/30	-9.1	980.3	
	1400	28/38	-9.1	980.2	
	1500	27/34	-9.2	980.2	
	1600	28/40	-9.2	980.2	
	1700	29/35	-9.4	980.0	
	1800	32/40	-8.4	980.0	
	1900	28/36	-8.4	980.0	
	2000	31/37	-8.3	980.0	Moderate drifting and blowing of snow
	2100	33/45	-8.8	980.0	
	2200	33/43	-8.8	979.6	
	2300	30/41	-8.8	979.8	
	0000	30/37	-8.7	979.9	
	20 July 1996	0100	30/37	-8.7	980.0
0200		30/40	-8.5	979.9	
0300		37/49	-8.7	979.5	
0400		38/50	-8.7	980.0	← Very heavy blowing and drifting of snow Severe blizzard conditions
0500		37/50	-8.5	980.0	
0600		38/50	-8.8	980.0	
0700		38/48	-8.5	980.3	
0800		36/45	-8.2	980.4	
0900		42/50	-8.2	979.5	
1000		41/52	-8.0	979.5	
1100		37/48	-7.5	979.7	
1200		38/48	-7.3	979.4	
1300		38/56	-6.5	978.8	
1400		39/52	-6.0	978.8	
1500		37/48	-6.0	978.5	
1600		40/49	-5.9	977.8	
1700		36/46	-6.0	977.9	
1800		34/47	-5.8	978.0	← Highest temperature
1900		35/42	-7.0	978.3	
2000		40/60	-7.0	978.6	
2100	42/52	-7.5	978.7		
2200	30/41	-7.8	980.0	Intensity reduced. Mod. Blizzard	
2300	27/32	-6.7	980.5		
0000	32/38	-8.0	981.5		
21 July 1996	0100	32/38	-8.0	981.5	
	0200	30/38	-7.8	982.0	
	0300	30/42	-8.0	982.5	Moderate Blizzard condition
21 July 1996	0400	30/41	-8.3	983.0	
	0500	29/40	-8.0	983.5	
	0600	27/38	-8.0	984.0	
	0700	26/35	-8.0	984.9	
	0800	24/30	-8.0	985.5	
	0900	25/34	-8.0	986.2	Moderate Blizzard condition
	1000	25/34	-8.0	986.7	
	1100	25/34	-8.0	986.7	
	1200	26/38	-8.0	987.4	
	1300	29/39	-8.1	988.0	
	1400	30/41	-8.3	988.2	
	1500	26/34	-9.0	988.3	← Highest pressure
	1600	28/38	-9.2	988.0	
	1700	34/56	-9.3	987.5	Intensity increased
1800	32/42	-9.5	987.0		
1900	33/43	-9.5	986.0		
2000	35/46	-9.6	985.5		
2100	38/42	-9.7	984.0		
2200	34/50	-9.7	983.5		

TABLE 1 (Contd.)

(1)	(2)	(3)	(4)	(5)	(6)
21 July 1996	2300	32/40	-9.8	983.5	
	0000	30/40	-9.5	982.5	
22 July 1996	0100	34/45	-10.0	980.5	
	0200	38/54	-10.5	980.1	
	0300	36/47	-10.3	979.0	
	0400	41/54	-10.0	977.0	
	0500	40/55	-10.6	975.9	
	0600	36/43	-10.5	976.0	
	0700	40/50	-11.0	975.9	Very heavy drifting and blowing of snow
	0800	36/44	-11.0	975.8	
	0900	40/52	-11.0	975.7	
	1000	42/54	-11.0	976.0	
	1100	38/49	-11.2	976.0	
	1200	37/48	-11.5	976.4	
	1300	35/44	-11.0	976.3	
	1400	34/50	-10.6	976.0	
	1500	36/50	-11.0	975.5	← Visibility condition reduced to zero
	1600	40/52	-11.0	975.0	
	1700	45/58	-11.5	974.0	
	1800	43/58	-12.0	973.8	
	1900	43/57	-12.0	972.0	
	2000	42/64	-12.0	970.7	
2100	44/56	-12.2	970.0		
2200	42/64	-12.2	968.4		
2300	45/68	-13.0	967.6		
0000	46/70	-12.4	965.5		
23 July 1996	0100	50/75	-13.0	964.0	} Lowest temperature
	0200	51/68	-13.0	962.0	
23 July 1996	0300	58/73	-12.4	957.5	
	0400	58/78	-11.5	955.0	Very heavy drifting and blowing of snow
	0500	56/78	-11.5	953.0	
	0600	64/112	-11.2	952.0	← Maximum gusting
	0700	64/92	-12.0	950.6	
	0800	62/84	-12.0	950.0	
	0900	68/86	-12.0	948.0	
	1000	66/88	-12.0	947.0	} Lowest pressure
	1100	62/83	-11.5	947.0	
	1200	58/77	-11.5	947.2	
	1300	58/78	-12.0	948.0	
	1400	61/82	-12.0	949.0	
	1500	51/68	-11.5	950.0	
	1600	50/70	-11.3	951.3	
	1700	55/74	-11.1	952.0	
	1800	56/66	-11.6	953.0	
	1900	53/74	-11.5	954.2	
	2000	54/77	-11.5	955.0	
	2100	46/66	-10.3	956.3	
	2200	45/60	-10.5	957.4	
2300	45/64	-10.0	958.5		
0000	45/64	-10.6	959.2		
24 July 1996	0100	50/68	-10.0	960.2	
	0200	40/55	-10.0	962.7	
	0300	36/46	-10.7	964.8	
	0400	35/46	-10.2	965.2	Decreasing intensity
	0500	32/43	-10.5	966.0	
	0530	33/43	-10.5	966.8	

Hereafter Blizzard ended but the system remained over the station as deep depression

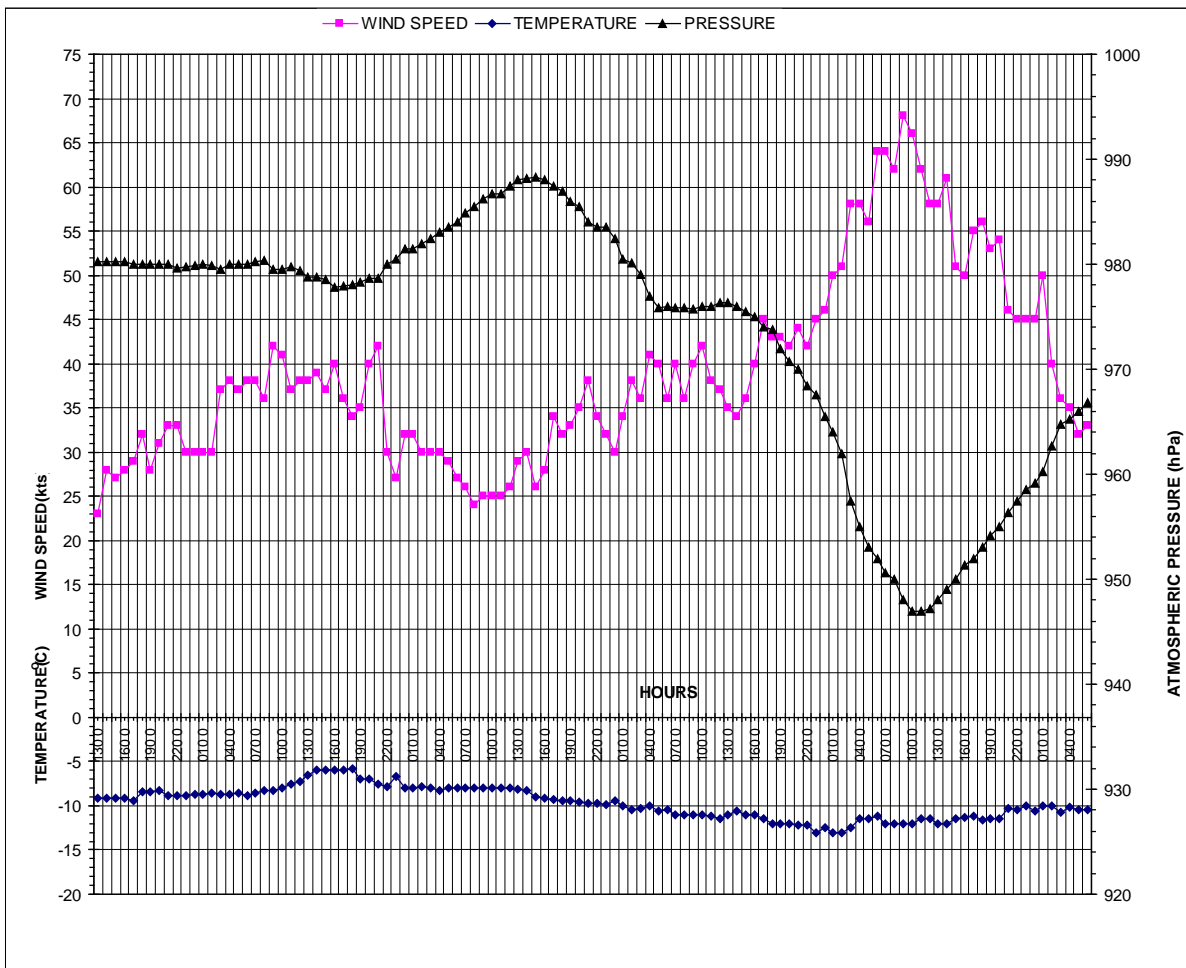


Fig. 3. Hourly changes in pressure/ wind/temperature during longest blizzard of 1996

record for Maitri station since 1990. A case study of this blizzard describing the causes and the behaviour of the meteorological parameters during the blizzard period are discussed here.

2. 'Maitri' the Indian Antarctic research station situated at 70°-45' South and 11°-44' East over the coastal region of east Antarctica and its height above m.s.l. is 117m. [A location map of Maitri station given in (Fig. 1)]. The main weather feature surrounding this continent is the circumpolar trough of low pressure which dominates the area between 60° S to 65° South throughout the year. Frequent depressions move east or southeast at about 20 to 30 knots in the vicinity of this trough, resulting in very changeable disturbed weather conditions and gales are common. On the Antarctic side of this circumpolar trough the winds are mainly from E to SE. As it is a windiest continent the land mass is scored by a

regime of persistent and powerful katabatic or gravity wind which are the result of cold and dense air rolling down the continental slope from the high plateau. These gravity winds interact with the warmer air from the ocean and produce a narrow storm belt ringing the continent. When the low pressure systems in the circumpolar region intensifies and the wind attains gale force it carries warm and moist air from the sub-polar region to the coastal regions of the continent and this warm and moist air rides over the cold dense air flow rolling down from the high continental plateau and the interaction between these two air masses causes moderate to severe snow fall which blows with the strong wind and give rise to extremely severe blizzard or snow storm. Monthly frequency of the blizzard during 1996 is given in Table 3. (A. S. Rasal & D. R. Mahor/Technical Publication No. 13 by D.O.D.) The most extreme conditions experienced at Maitri Antarctica are associated with blizzard.

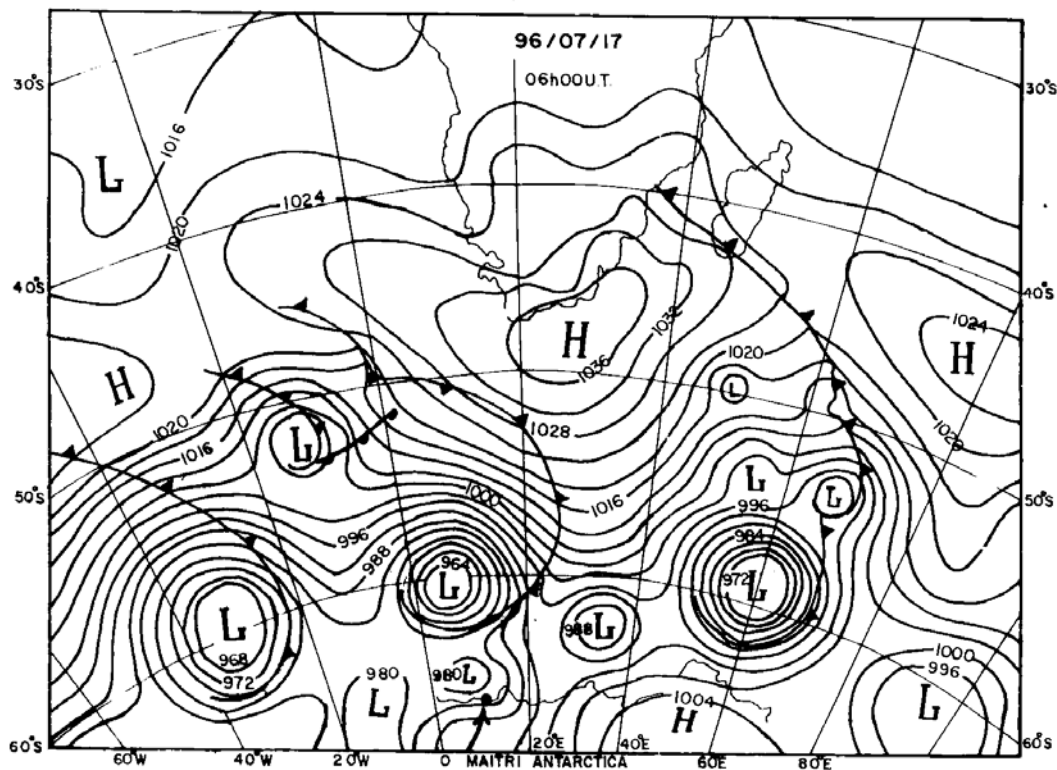


Fig. 4. Pretoria weather charts of Maitri (Antarctica) during blizzard period for 0600 hours of 17 July 1996

A blizzard is reported when the wind speed is more than 23 knots accompanied with moderate to heavy drifting and blowing of snow reducing the visibility to less than 1000m. Under favourable conditions when the surface wind reaches hurricane intensity, falling snow or loose snow is blown to several tens of km. Snow particles flying with tremendous speed penetrate through window and door gaps, clothes, buildings etc. The blizzard can last as long as a week or even more, the longest and strongest blizzard observed during July 1996 lasted for 6 days. There were several severe blizzards during 1996 but the blizzard that occurred during 19 July to 24 July 1996 was having typical characteristics as an ideal blizzard and so it is selected for the case study and it is based on the Antarctic Expedition data for 1996 collected by I.M.D. team.

3. The study pertains to 'Maitri' station (Antarctica) located in the coastal region of east Antarctica at an elevation of 117 meters. The data required for this study was collected during the 15 Indian Antarctic Expedition in 1996 by I.M.D. in Maitri station and the weather charts were received from Pretoria (South Africa).

4. Before the occurrence of the blizzard reported here a series of blizzards was started from 16 July 1996

and the blizzard of our study also was a part of the same series with a break period of 7 hrs between these two successive blizzards. From 1500 hr of 15 July regular fall in pressure was recorded which continued upto 0000 hr of 18 July and a total fall of 24 hPa was recorded during this period. This was the effect of continuous movement of a series of sub-polar low pressure systems from west to east with a well marked trough at 60° S on 17 July with a core pressure of 964 hPa (Fig. 4). The anticyclones around 48° S were pushing the warm and moist air towards the coastal regions of Maitri causing continuous rise in temperature and was supplying energy to initiate blizzard when the cold dense air rolling down from the high plateau of the ice cap region towards the coastal region met with this warm and moist air and the interaction between these two air masses caused snowfall due to freezing of the water particles of the air which were drifted and blown with the high winds giving rise to a series of blizzards in the coastal regions around the Maitri station. A schematic diagram showing the initiating forces giving rise to a blizzard is given in Fig. 2. On 18 July this trough further moved southward travelling a distance of 7 latitudes in a day. [(Fig. 5) indicates the location of the trough]. The low pressure system over nearby areas of Maitri station continued blizzard over Maitri station. The

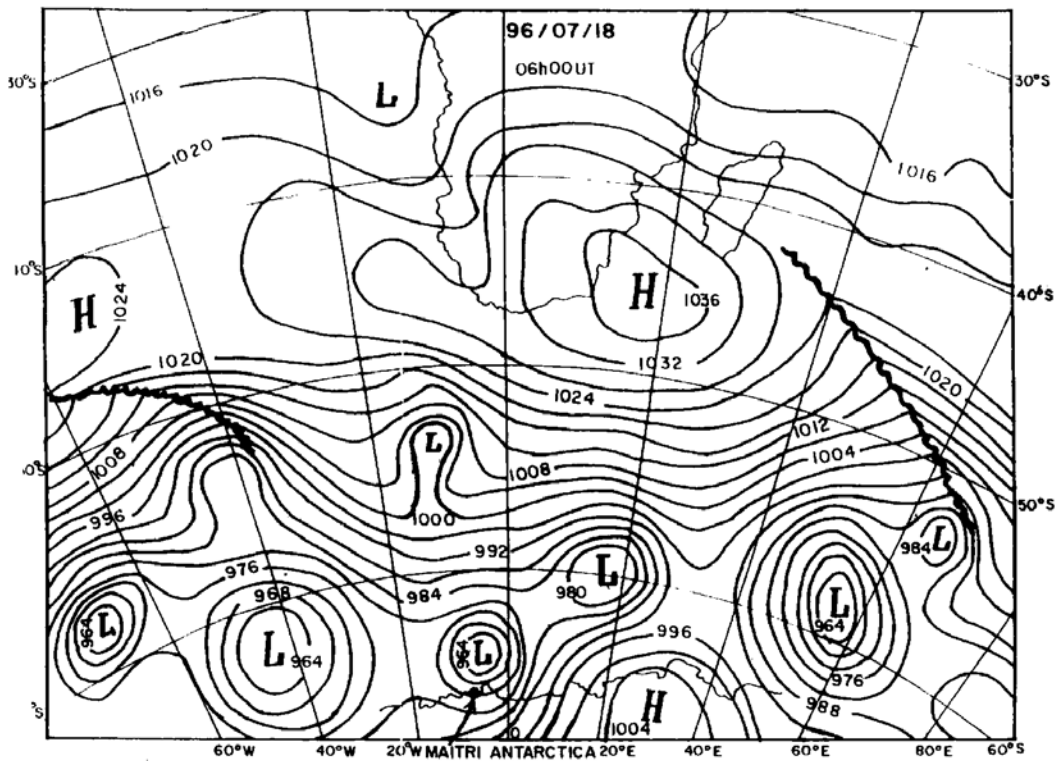


Fig. 5. Pretoria weather charts of Maitri (Antarctica) during blizzard period for 0600 hours of 18 July 1996

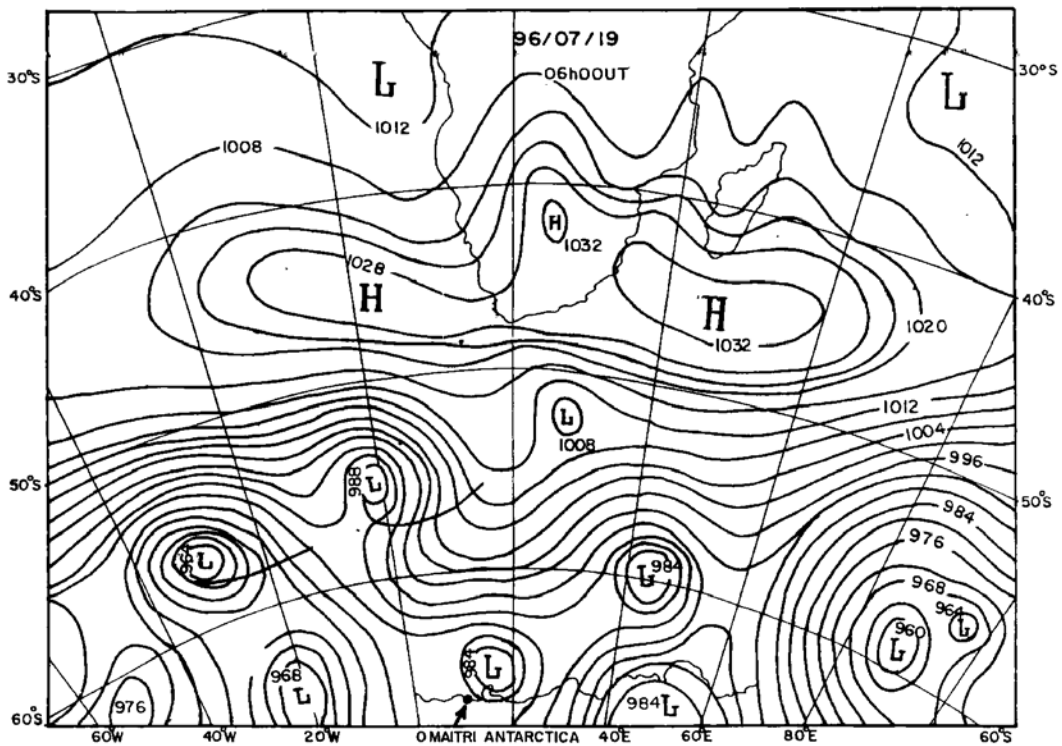


Fig. 6. Pretoria weather charts of Maitri (Antarctica) during blizzard period for 0600 hours of 19 July 1996

TABLE 2
Weather summary during the period 15 July to 24 July 1996
Station Maitri (Antarctica)

Date	Temperature (°C)			Pressure (hPa)			Wind speed (kts)			Wind direction Max/Min	Sky condition (oktas)
	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean		
15 July 1996	-14.3	-23.8	-20.9	985.8	983.0	984.6	17	00	05	140/00	0
16 July 1996	-14.4	-22.5	-17.4	983.0	974.3	979.0	37	14	25	140/90	Obscured
17 July 1996	-10.2	-15.2	-13.2	973.8	961.2	967.0	56	40	47	140/140	Obscured
18 July 1996	-8.0	-11.0	-9.9	972.3	962.0	967.9	52	40	44	140/130	Obscured
19 July 1996	-8.0	-11.0	-8.4	980.4	972.3	978.4	38	20	29	150/120	Obscured
20 July 1996	-5.0	-9.0	-7.6	981.5	977.8	979.4	42	30	37	140/130	Obscured
21 July 1996	-6.5	-10.2	-8.5	988.3	981.5	985.2	38	25	30	130/120	Obscured
22 July 1996	-7.0	-14.0	-11.0	982.5	965.5	974.9	45	30	38	130/120	Obscured
23 July 1996	-9.8	-12.5	-11.6	965.5	947.0	953.4	68	45	56	140/130	Obscured
24 July 1996	-9.5	-12.5	-11.0	974.4	959.2	969.7	48	27	34	130/100	Obscured

eastward movement of this system was restricted by the anticyclone existing towards its East side, so on 19 July very little eastward movement of this system can be seen from the Fig. 6. The ultimate effect of this resulted in weakening of this system which remained as a depression over the station and the series of blizzard started since 16 July ended at 0600 hr of 19 July. Hereafter there was a break of seven-hr *i.e.* from 0600 hr to 1300 hr of 19 July in between the commencement of (next) blizzard of this study. The reason for this break was absence of loose snow and reduction of wind speed due to weakening of the system present over the station (Fig. 6). On 18 July at 0700 hr-wind speed was 44kts, which reduced to 18kts at 0700 hr of 19 July and the core pressure of the low pressure system over the station at 0600 hr of 18 July (Fig. 5) was 964.0 hPa, which rose to 984.0 hPa at 0600 hr of 19 July (Fig. 6), a rise of 20 hPa in 24 hr, which ultimately caused the end of blizzard series. During this break period wind speed was around 20kts and the rise in temperature was also recorded during the period due to the stoppage of snowfall. Sky condition was also obscured during this break period. On most of the blizzard occasions it is observed that prior to its commencement cloudiness progressively increases over the station. As the frontal system approaches the station causing incursion of warm and moist air giving rise to stratiform clouds engulfing the station sky.

5. *Synoptic situation before starting of blizzard and daily progress of blizzard – 19 July 1996* - The movement of low pressure systems from west to east was continued further during this break period, which is clearly seen from the low pressure systems, located near

60° W and 20° W in Fig. 6. which caused step by step increase in wind speed, which reached blizzard intensity and a blizzard started again from the 1300 hr of the 19 July. Initially a rise in pressure and slight fall in temperature recorded for few beginning hrs of blizzard which was the effect of a cold and dense katabatic flow from the high plateau and then the incursion of warm and moist air caused rise in temperature and slight fall in pressure during the day. Moderate drifting / blowing of snow was present during the period. (Table 1 & Fig. 3 gives the hourly changes in pressure, wind speed and temperature respectively)

20 July 1996 - Moderate drifting and blowing of snow continued upto 0200hrs but thereafter sudden rise in wind speed occurred and very heavy drifting and blowing of snow started since 0300hrs which continued upto 2100 hrs and during this period severe blizzard conditions were experienced with visibility conditions reduced to nearly zero at the station. Continuous temperature rise and fall of pressure was also recorded during this period and a highest temperature (-5.8° C) of the entire blizzard period was recorded at 1800 hr and lowest pressure during that day was also recorded at this hour. Wind speed was between 35 to 42 kts during this period. Rise in pressure and fall in temperature started from 1900 hr and the intensity of blizzard step by step reduced to moderate blizzard condition.

21 July 1996 - Yesterdays moderate situation continued further upto 1600 hr and fall in temperature and pressure rise recorded during this period and a highest pressure of the entire blizzard period was recorded at

TABLE 3

No. of days/ monthly frequency of blizzard during 1996

Month	No. of days	Frequency
January	1	1
February	1	0
March	4	4
April	7	4
May	13	9
June	9	7
July	15	6
August	4	2
September	10	9
October	3	2
November	2	2
December	4	2
Annual	73	48

1500 hr of this day which was 988.3 hPa this was the effect of prominent cold katabatic flow from the high plateau of the ice cap region. After 1700 hr step by step the intensity of blizzard started increasing due to falling pressure trend and sudden increase in wind speed. Visibility condition also started deteriorating.

22 July 1996 - Continuous fall in pressure and increase in wind speed recorded during the day and continuous fall in temperature also recorded since 1500 hr which continued further upto 0200 hr of the next day. Due to continuous incursion of warm and moist air from the overseas region towards the coastal region interacting with the cold and dense air sliding down from the ice cap region gave rise to very heavy drifting and blowing of snow causing reduction in visibility condition to nearly zero. This situation remained throughout the day. Ending hours of the day indicated the starting of peak period of entire blizzard duration.

23 July 1996 - Falling pressure and heavy increase in wind speed continued further. Fall in temperature due to heavy snow fall and cold winds continued further and the lowest temperature of the entire blizzard period was recorded at 0100 hr which was -13.0° C. Heavy increase in wind speed recorded during the day and a maximum wind gusting of 112 kts (208 kmph) and speed of 68 kts (126 kmph) of the entire blizzard period was recorded at 0600 hr and 0900 hr respectively and this was the record wind gusting speed over the Maitri station since its installation. (A.S.Rasal&D.R.Mahor/Technical Publication No. 13 by D.O.D.). This was the peak period of the entire blizzard period in all respect. Record fall in pressure was also observed at 1000 hr UTC and the lowest pressure recorded was 947.0 hPa. A total fall in pressure

of 41.3 hPa during last 42 hr was recorded during this peak period. Wind speed was between 58 to 68 kts during these peak hrs and the visibility condition was also nearly zero. Steady rise in pressure and temperature started from the 1500 hr UTC but the intensity of the blizzard was blinding upto the 0000 hr UTC.

24 July 1996 - These were the last six hours of the blizzard during which the decreasing trend of the blizzard started. Step by step the rise in pressure and decrease in temperature and wind speed was recorded during this period. Thus the longest blizzard ended at 0530 hr UTC on 24 July 1996. Even though the wind was quite strong but due to absence of loose snow and moisture supply it ended but remained as a deep depression over the Maitri station. The wind direction during the blizzard period was mostly southeasterly. (Weather summary for 15 to 24 July is given in Table 2).

6. *After effects of blizzard* - During peak hours of the blizzard roof sheets of some sheds of the station were blown kilometers away and station building was shaking due to high wind speed. All outside activities of the station ceased due to heavy blowing snow and very bad visibility conditions. Hydrogen gas cylinders and LPG cylinders and many other things got buried down the heaps of snow and doors of the stations were completely blocked by the snow. Eastern part of the station building was fully covered behind the huge hill of snow. Station's telecommunication system failed during the blizzard period and therefore we could not get the facsimile weather charts of the actual blizzard period.

7. *Salient features experienced during the course of this blizzard*

(i) Interactions between the two air masses, one of warm and moist air from the overseas area and the cold and dense katabatic flow speedily rolling down the slopes of the ice cap gave rise to this blizzard reducing the visibility condition to nearly zero.

(ii) Maximum wind gusting of 112 knots (208 kmph) which was also a record for Maitri station since the inception of the station. Maximum wind speed of 68 knots (126 kmph) was recorded during this blizzard period.

(iii) Record fall in pressure of 41.3 hPa during this blizzard was recorded. Highest pressure recorded = 988.3 hPa, Lowest pressure = 947.0 hPa.

(iv) Highest temperature of -5.8° C & lowest temperature of -13.0° C was recorded during the blizzard period.

(v) Lot of damage to shelters and telecommunication system was caused due to this blizzard.

(vi) All outside activities of the station came to a halt during this period.

The author express his sincere thanks to Dr. H.P. Das IMD, Pune for providing all required facilities for preparation of this paper and for encouragement given by him. He also thankful to Dr. R. P. Samui, IMD, Pune for his co-operation. He express his special thanks to

Smt. Swati R. Agale S.O. for her devoted efforts in preparation of this manuscript excellently.

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(23 October 2001, Modified 4 February 2003)
