MAUSAM, **55**, 1 (January 2004), 95-102

551.555 (99)

Surface wind characterization at an Antarctic coastal station, Maitri

ARUN SRIVASTAVA†, V. K. JAIN* and H. N. DUTTA**

Development Alternatives, B-32, TARA-Crescent,

Qutab Institutional Area, New Delhi – 110 016, India

**School of Environmental Sciences, Jawaharlal Nehru University, New Delhi - 110 067, India*

***National Physical Laboratory, New Delhi - 110 012, India*

(*Received 24 January 2003*)

सार – इस शोध पत्र में, अंटार्कटिक स्थित तटीय भारतीय स्टेशन मैत्री (70.7° द., 11.7° पू.) के वायुमंडल में, वर्ष 1992 के दौरान की सतही पवनों का विश्लेषण किया गया है। इस विश्लेषण से यह पता चला है कि 165° ± 25° के क्षेत्र से सतही पवनें निरतंर बहती हैं। वर्ष 1992 में पवन के ठंडेपन के गुणांक से यह पता चलता हे कि ठंडापन अगस्त के महीने में सबसे अधिक और जनवरी के महीने में सबसे कम था। बर्फानी तूफान की दो घटनाओं, एक ग्रीष्म ऋतु की और दूसरी शीत ऋतु की, का भी यहाँ अध्ययन किया गया है। यह पता चला है कि बर्फानी तूफान के समय सतही पवनें दक्षिण पूर्व, दक्षिण दक्षिण पूर्व और दक्षिण पश्चिम के क्षेत्र से सक्रिय रूप से बहती हैं।

ABSTRACT. Surface winds in the atmosphere of Maitri (70.7º S, 11.7º E) a coastal Indian station have been analysed for the year 1992. Surface winds blow most frequently from the sector 165° ± 25°. Wind chill factor for the year 1992 shows that chilling is highest during the month of August and lowest during the month of January. Two cases of blizzards one during summer and another during winter have also been studied. Surface winds remained practically from the SE, SSE and SW sector during the blizzards.

Key words – Wind chill factor, Katabatic winds, Blizzards, Maitri

1. Introduction

Surface winds over the Antarctica continent have long been noted for their high directional constancy and high mean speeds. Such observations suggest that the surface wind field is a result of stably stratified air in the lower atmosphere overlying a sloping ice surface. The radiative flux divergence over the sloping ice surface is responsible for the forcing of the celebrated Antarctic surface wind regime, the katabatic winds. The intense cooling along the continent slope implies a density contrast between the very cold air adjacent to the ice and the relatively warm air some horizontal distance away. This results in a terrain induced horizontal pressure gradient force often termed as the 'sloped-inversion' force, which is directly proportional to the magnitude of the inversion strength (horizontal density contrast) and to the steepness of the terrain slope (Ball, 1960; Mahrt and Schwerdtfeger, 1970; Schwerdtfeger, 1970, 1984; Parish and Waight, 1987; King 1989).

An alarming feature for the Antarctica expeditioners is the wind-chill factor same as the wind-chill index. It can be defined as the net cooling effect expressed by a value of kilograms per hour per square meter of heat loss from skin surface by a body through the effects of air temperature and wind speed with variation per body size, composition and metabolic rate. The wind-chill index is based on the cooling rate of a nude body in the shade (Morris, 1992). In other words any combination of temperature and wind can be equated in terms of the rate at which the environment removes heat from the body to nearly still air and a lower temperature.

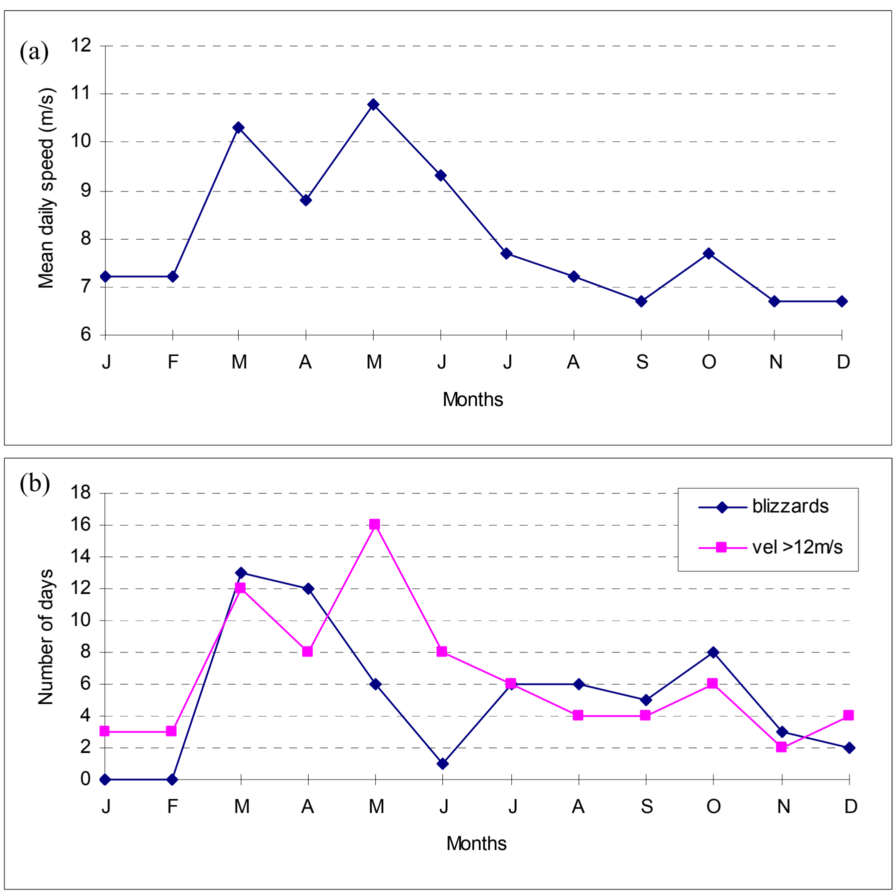
Blizzard is a special weather phenomenon in Antarctica. Under a blizzard, the surface snow starts blowing in association with strong winds, significantly reducing visibility (horizontal as well as vertical). Blizzards are frequent in Antarctica because of the continuous snowdrift-enshrouded katabatic storms throughout the non-summer months. For this reason Antarctica was dubbed as the "Home of the Blizzards".

Indian Antarctic station, Maitri (70° 45' 39" S; 11° 44' 48" E), is situated on the Schirmacher Oasis (Wastard and Singh, 1988) adjacent to one of the biggest fresh

†*Present affiliation* : School of Enviromental Sciences, Jawaharlal Nehru University, New Delhi – 110 067

Fig. 1. Location of the India Antarctic station, Maitri

Maitri 70.7° S, 11.7° E (1992)



Figs. 2 (a&b). (a) Average monthly variation of wind speed and (b) Number of days when winds were greater than 12.0 m/s and the number of days in each month when blizzards have been recorded

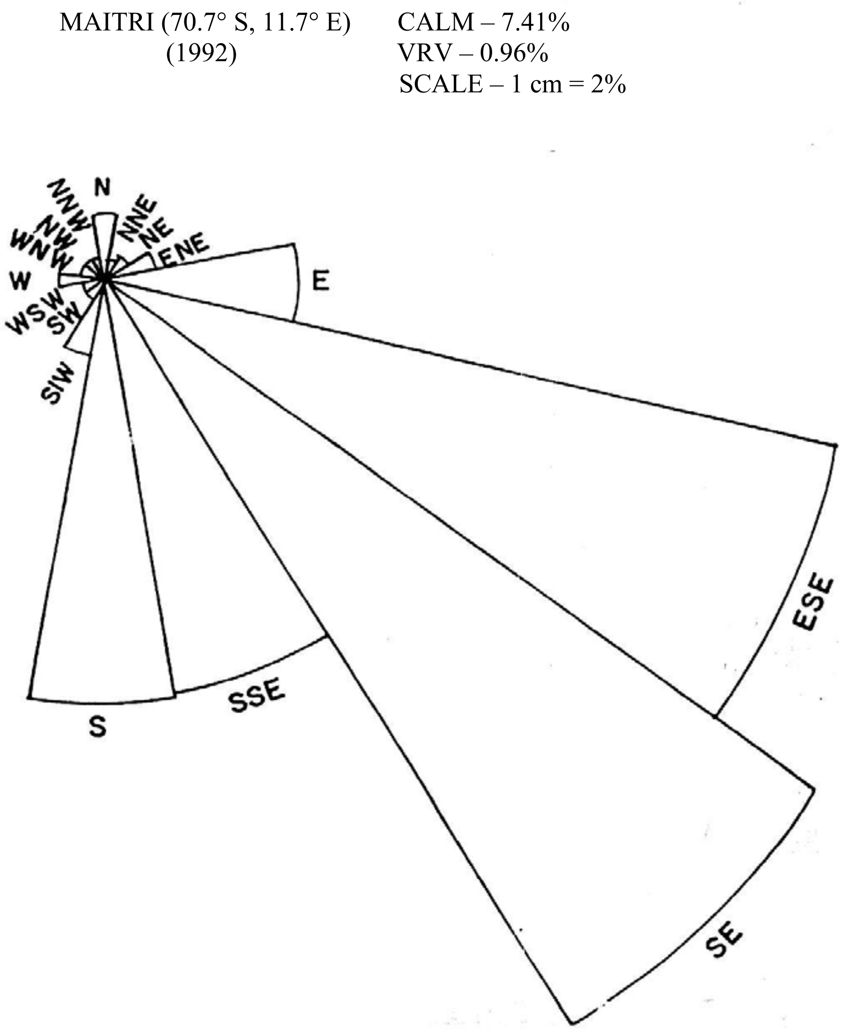


Fig. 3. Wind-rose data of the Indian Antarctic station, Maitri

water lakes called Zub lake. The general location of the station is shown in Fig. 1. Schirmacher Oasis is one of the smallest east-Antarctic Oasis. This region forms a part of Dronning Maud land and is about 70 km south of the Princes Astride coast of east Antarctica. It is a small range of low lying hills. The elevation of the Oasis ranges between 0 and 228 meter with an average of about 100 meter (Simonov, 1971). The coordinates of the oasis are 70° 46' 04" -70° 44' 24" S; 11° 49' 54" (+/- 48) - 11° 26' 03" (+/- 02) E.

2. Results and discussion

Fig. 2 (a) presents average monthly wind speed. Mean daily wind speed are found to be in the range of 6.7 to 10.8 m/s. Fig. 2 (b) gives number of days when winds were greater than 12.0 m/s and number of days, in each month when blizzards have been recorded. This figure shows that normally, winds are higher in transition seasons *i.e.* during March-May and September-October months.

The wind rose data of Maitri for the year, 1992 is given in Fig. 3. The figure depicts that winds are flowing out of the continent. A confluence zone between ESE and S where the surface winds from the continent converges. Such zones provide enhanced supply of radiatively cooled near surface air to the coastal slopes and allow the resulting katabatic winds to be stronger and more persistent. Thus, the katabatic winds provide a flushing arrangement over this station leading to several novel features.

We have made an attempt to study the chill factor at Maitri which the human body experiences. It is important to note that as the wind velocity increases the load of the

Maitri 70.7° S, 11.7° E (1992)

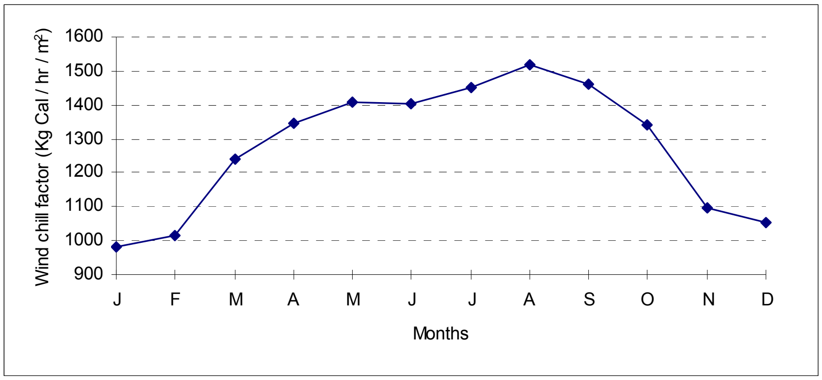


Fig. 4. Average monthly variation of wind-chill factor

Maitri 70.7° S, 11.7° E (1992)

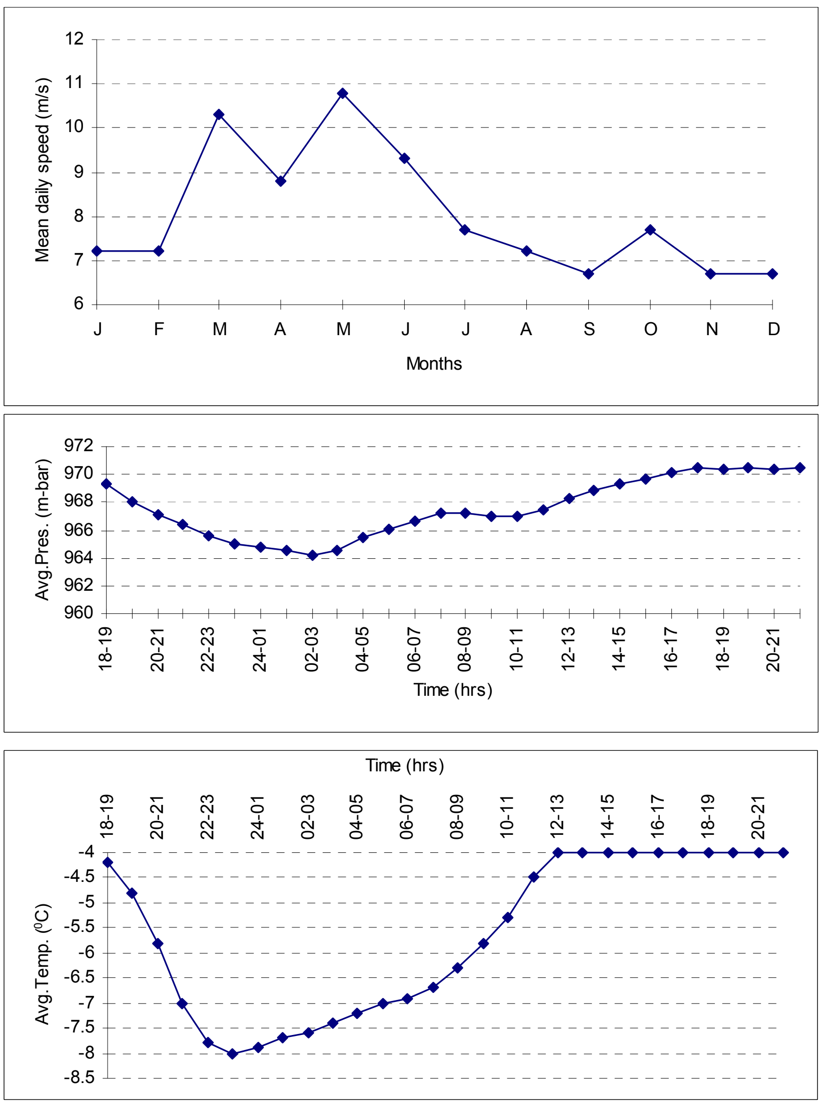


Fig. 5. Mean hourly variation of meteorological parameters during a summer blizzard

Maitri 70.7° S, 11.7° E (1992)

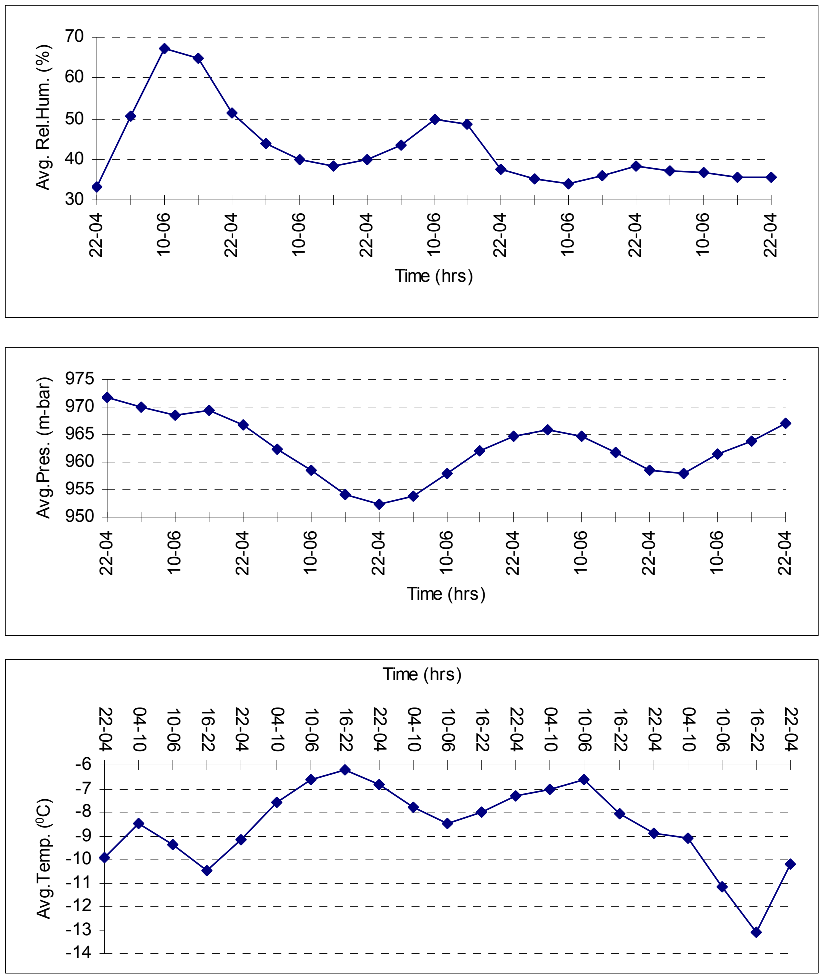


Fig. 6. Mean hourly variation of meteorological parameters during a winter blizzard

warm clothing on the body increases which results in reduced work efficiency in the outdoor activities. Moreover, high winds at Antarctica are often katabatic in nature with high gustiness full of drift snow forcing all activities to come to a halt.

It can be given as

$$Q_H = (9.0 + 10.9\sqrt{V} - V)(33 - T)$$

(Sipel and Passel, 1945)

Where,

Q_H = Chill wind factor (Wind chill index)

V = Mean wind speed

T = Ambient temperature in degree Celsius

Fig. 4 presents the monthly variation of wind-chill factor, it can be observed that wind-chill index is maximum in the month of August and minimum in the month of January this validates the problems faced by the winter expeditioners and relatively comfortable life of summer expeditioners.

During 1992 a total 25 blizzards of varying intensity were experienced at Maitri (Kopper, 1995). On the periphery of the continent, blizzards occur when low pressure systems move along or close to the coastline. Blizzards can be defined as anything between drifting snow with clear skies and moderate winds (5 - 10 m/s) to blowing snow storm with very strong winds. Strong winds

Maitri 70.7° S, 11.7° E (1992)

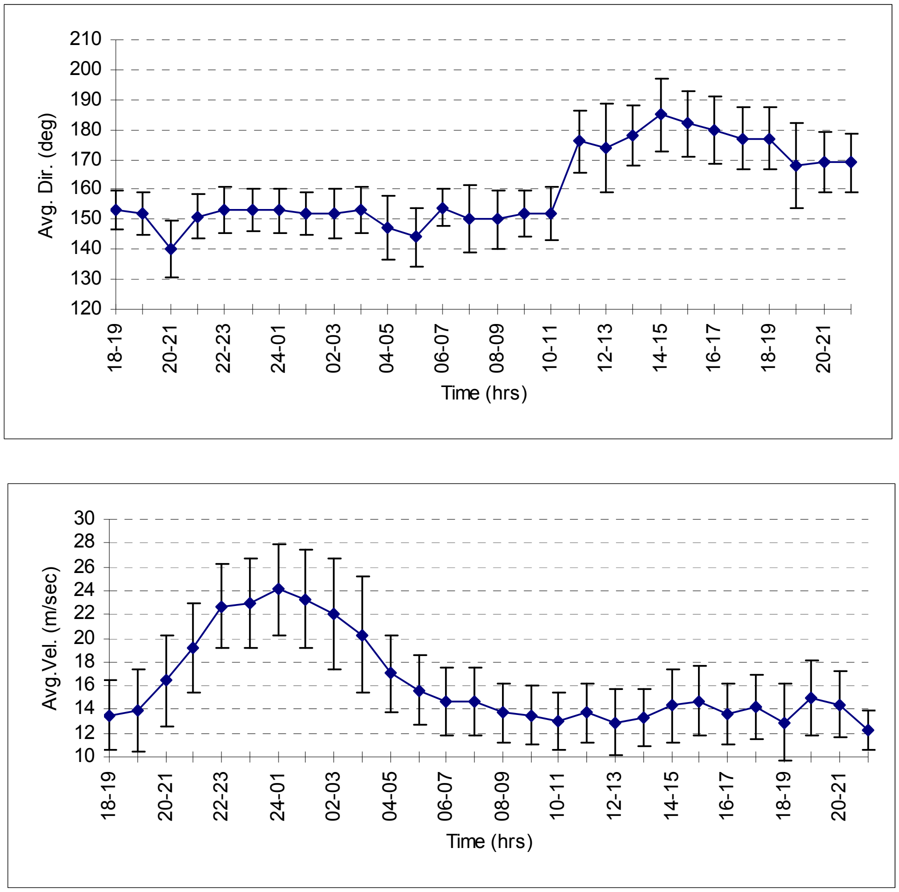


Fig. 7. Average trend in wind speed and wind direction during a summer blizzard

are usually accompanied by drifting or blowing snow, as loose snow on the surface becomes entrained in the air flow. The mass of snow picked up by winds increases very rapidly as the wind freshens (mass is proportional to the fourth power of wind velocity, Streten, 1990).

We have made an attempt to study the blizzards in detail for two cases, one during summer (December) and another during winter (June). In the summer month, a blizzard started at 2000 UTC on 13 December 1992 and ended at 2000 UTC on 14 December 1992. During the 24 hour duration of the blizzard, all the meteorological parameters have been plotted in Fig. 5. Similarly, the variation in various meteorological parameters of the winter blizzard which lasted for 103 hours (starting on 9 June 1992 at 0900 UTC and ending on 13 June 1992 at 1600 UTC) is given in Fig. 6.

Fig. 5 shows that the blizzard is responsible for the increase of temperature which is due to the turbulent mixing of the upper air with the ground level air which consequently resulted into the increase of RH (relative humidity). But instead there is decrease of temperature and RH during the winter blizzard this is because of the abundance of unconsolidated snow which disperses into the atmosphere, with increase in velocity lowering down the temperature to an appreciable extent.

The average trend in wind speed and wind direction is given in Figs. 7 and 8 for both the occasions. This can be inferred from these figures that when the wind speed and the variation in wind speed is high the variation in wind direction is low, it is almost uni-directional when the wind speed and the variation in wind speed is low, the wind direction is highly fluctuating. Thus, we can

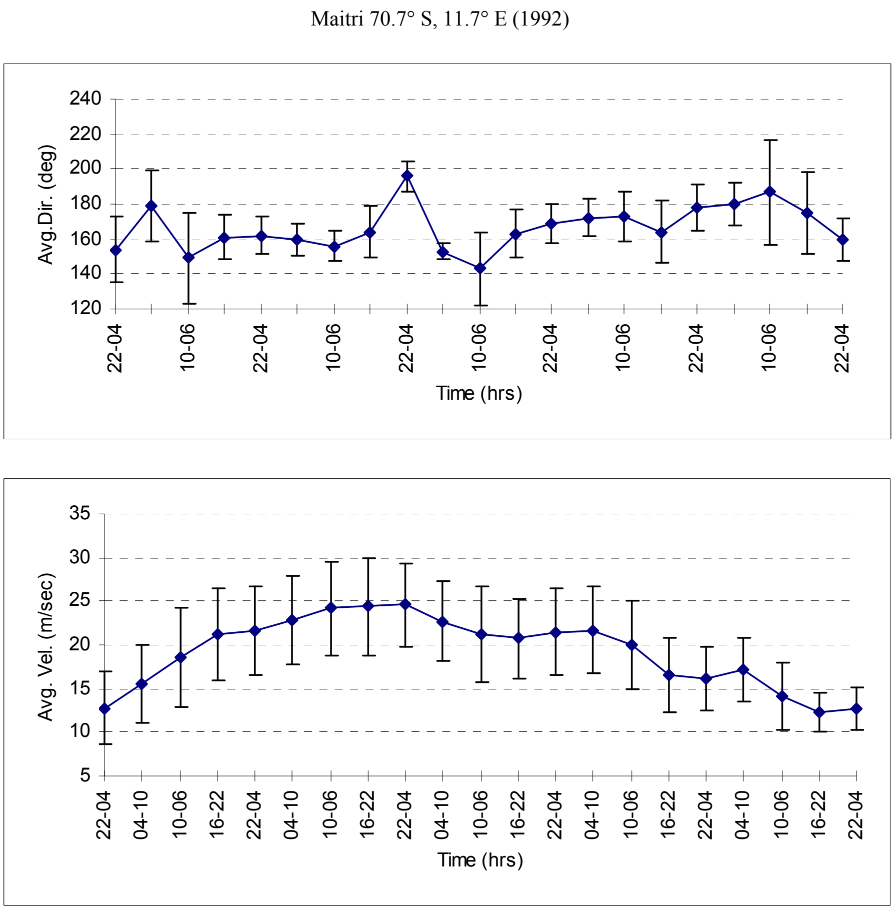


Fig. 8. Average trend in wind speed and wind direction during a winter blizzard

conclude that during the blizzards the katabatic winds forms a channel. Another important parameter which is of great interest is that the direction of the wind remained practically from the SE, SSE, SW sectors *i.e.* 140°-180° during the summer blizzard this can be due to the fact that, there are steep slope towards these directions. But during the winter the blizzard the wind direction is not exactly same as the summer blizzard, there is appreciable difference, the reason is that during the winter season almost whole of the continent is submerged by ice making the steepness to a gentle slope.

References

Ball, F. K., 1960, "Winds on the ice slopes of Antarctica", *Antarctic Meteorology*, Proceedings of the Symposium, Melbourne, 1959, New York, Pergamon, 9-16.

Houghton, D.D., 1985, *Hand Book of Applied Meteorology*, A Wiley-Interscience Publication, New York, 787-789.

King, J. C., 1989, "Low wind profiles at an Antarctic coastal station", *British Antarctic Survey*, **1**, 9, 169-178.

Kopper, A. L., 1995, Report on the meteorological programme carried out during eleventh Indian expedition to Antarctica, *Scientific Report*, Department of Ocean Development, Technical Publication No. 9, 53-78.

Mahrt, L. G. and Schwerdtfeger, W., 1970, "Ekman spirals for exponential thermal winds", *Boundary Layer Meteorol.*, **1**, 137-145.

Morris, C., 1992, Academic press dictionary of science and technology, Academic Press, San Diego, California.

Parish, T. R. and Waight, III T. R., 1987, "The forcing of Antarctic katabatic winds", *Mon. Wea. Rew.*, **115**, 2214-2226.

Schwerdtfeger, W., 1970, "World survey of climatology", The climate of Antarctica, edited by S. Orvig, New York, **14**, 253-355.

Schwerdtfeger, W., 1984, "Weather and climate of the Antarctic", Elsevier, New York, 261.

Simonove, T. M., 1971, "Oazisyna Vostosnom Antarktide" (Oasis of east Antarctica) Izdatelstvo, L. Gidrometeoizdat (in Russian).

Siple, P. A. and Passel, C. F., 1945, "Measurement of dry atmospheric cooling in sub-freezing temperatures", Reports on Scientific Results of United States Antarctic Service Expedition, 1939-1941, *Proc. Amer. Philos. Soc*., **89**, 200-234.

Streten, N. A., 1990, "A review of the climate of Mawson - a representative strong wind site in east Antarctica", *Antarctic Science*, **2**, 79-89.

Wastard, R. S. and Singh, K., 1988, "New permanent station at Maitri", Proceedings of Workshop on Antarctic Studies, edited by Diwedi, S. N., Mathur, B. S. and Hanjura, A. K., National Physical Lab., New Delhi, 376-387.