Indian J. Phys. **75B** (3), 251–253 (2001)

I J P B
— an international journal

On the structure of horizontal wind flow in the surface layer of Maitri, Antarctica

N C Deb* and Amitabha Chanda
Electronics & Communication Sciences Unit, Indian Statistical Institute, 203, B T Road, Kolkata (Calcutta)-700 035, India
E-mail narayan@isical.ac in
and
H P Mazumdar
Physics and Applied Mathematics Unit, Indian Statistical Institute, 203, B T Road, Kolkata (Calcutta)-700 035, India
and
H N Dutta
Radio and Atmospheric Sciences Division, National Physical Laboratory, K S Krisnan Marg, New Delhi-110 011, India

Abstract : Wind field in Antarctica has been studied with the help of data, collected during XV-th Indian Scientific Expedition to Antarctica 1995-97 Based on the data of wind velocity measured at the surface layer of Indian Antarctic station Maitri (70 76°S, 11 73°E), a simple model on wind direction pattern is presented Analysis of the daily/monthly/seasonal (3 month/season) and yearly variation of such wind velocity is made from the statistical point of view Various aspects of the model, presented here are discussed

Keywords Wind velocity, log-normal distribution, Antarctica.

PACS Nos. 92 70 Cp, 93 30 Ca, 92.60.Gn

1. Introduction

The climatological study of wind is important as it provides information about various parameters, regarding changes in weather [1]. The statistical analysis of data on wind speed and its direction, measured at the meteorological station is considered important in this respect. The synoptic system around Antarctica are typically inhospitable and dreadful, unlike elsewhere. Many unique features like the presence of ice-sheet, long winter night, average slope of the continent, presence of continental scale inversion, occurrence of blizzard and associated other phenomena expectedly influence the meteorological variables significantly. Moreover, it is believed that the Antarctic climate directly influences the global climate in various ways [2]. The present study is concerned with the data, mainly on wind velocity, measured in the surface layer of the Indian Antarctic station Maitri. Various statistical features, such as monthly, seasonal and yearly variation of wind speed and its directional components are analysed [3,4] through calculations of mean, standard deviation, frequency distribution corresponding to time series data collected at the Maitri station. In this paper, it is examined if it is possible to build models of wind fields for the Antarctic climate.

2. Measurement and data collection

Extensive measurement was carried out to collect data on wind speed and direction. Instruments used in this experiment are a cup-anemometer and sensitive rotating arm wind vane to measure wind speed and direction. The accuracy in measuring wind speed and direction are 0 1 m/s and +2°, respectively. Each sensor was calibrated as per the standards maintained by the Indian Meteorological Department (IMD), Government of India. Sensors were mounted at 4 levels (1.8 m, 4.5 m, 11.3 m and 28 m) of a tower 28 meter high. The data were recorded by a microprocessor based data logging system connected with the sensors. The data were collected round the clock with 10 minute average basis. For the present analysis, we are considering only 4.5 meter level data which is available as a continuous time series. The raw data have been preprocessed for the present study in the following manner. Data set is first divided season wise then

* Corresponding Author

data at a particular time of the day have been averaged over the full season.

3. Observation and analysis

Daily wind variation is clear, it can be seen from the Figure 1 that wind speed in Winter and Spring remains higher than in Autumn and Summer. Wind speed started decreasing after 7:00 h local time (LT). It decreases to reach

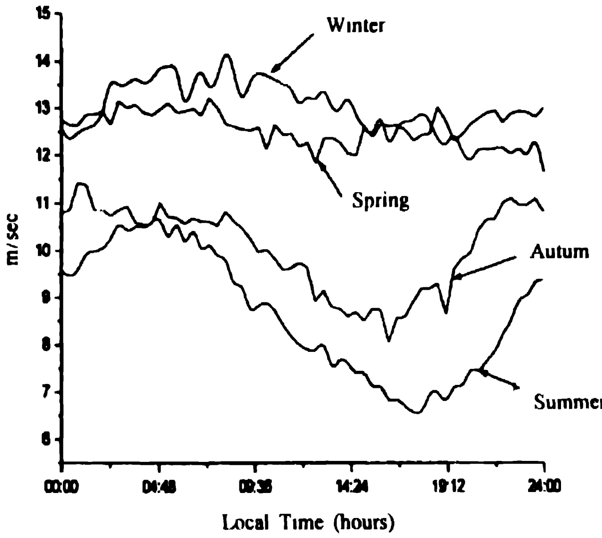

Figure 1. Season averaged diurnal wind speed for four seasons

the minimum at 18:00 h (LT) and then increases to reach the maximum at 7:00 h (LT) especialy in Autumn and Summer seasons. In Figure 2, we present the plot of wind direction for the four seasons. It can be seen from Figure 2 that the main wind directions are in the second quadrant (110° to 160°) throughout the year at the site of experiment. So, main

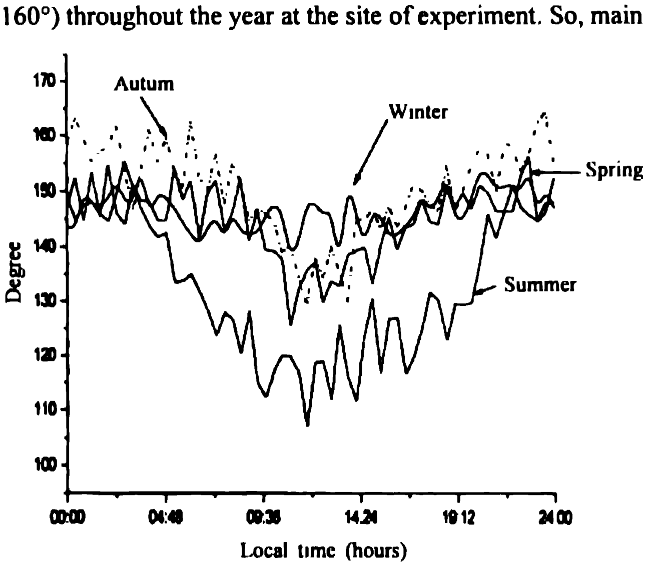

Figure 2. Season averaged diurnal wind direction for four seasons

winds blow from the fourth quadrants thoughout the year. This means that the prevailing wind directions are SE, ESE due to the channeling induced by the polar cap ice and the dome like shape of the continent. During Autumn, Winter and Spring season wind direction remains within (130° to 160°), whereas during Summer period wind direction may reduce to ESE (110°) in the second quadrant at 11:00 h (LT). After scrutinizing recorded observations thoroughly it is found that large fluctuations in wind direction occurred in Summer (110° to 147°). These two directions comprise 92% of the observations. Wind speed values < 1 ms^{-1} are below the anemometer threshold, and are considered to be calm. They represent 33% of the whole available data. From the observation it was revealed that frequency of wind direction have two dominant parts, one in the East direction and other in the South direction for all the four seasons. We have resolved wind velocity in two components as follows :

East component of wind velocity $V_e = u \sin \theta$ and South component of wind velocity $V_s = u \cos \theta$ (where 'u' is wind speed in meter per second and θ is the angle subtended by wind with the North).

Out of the eight distributions (shown in Figure 3a to 3h), five are unimodal and the other three are multimodal

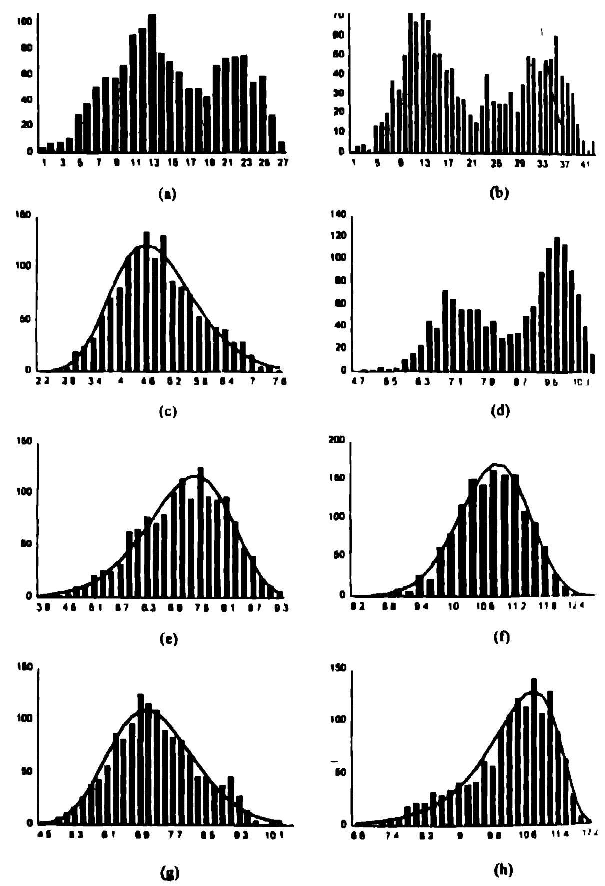

Figure 3. (a) V_e for Summer, (b) V_s for Summer, (c) V_e for Autumn, (d) V_s for Autumn, (e) V_e for Winter, (f) V_s for Winter, (g) V_e for Spring and (h) V_s for Spring.

We concentrate to fit three parametric log-normal distribution on frequency curve obtained from the wind velocity for unimodal cases only. In view of the observed skewness we have tried to fit three-parametric log-normal distribution in these cases instead of the normal distribution

There are two types of three-parametric log-normal distribution. In type I, the threshold value $\xi > \max[x]$ and in type II, $\xi < \min[x]$, where x is the instantaneous values of wind speed component. Type I and II may be given as below :

$$\textit{Type I}: \quad p = \frac{1}{(\xi - x)\sigma_1\sqrt{2\pi}} e^{-\frac{[\log(\xi - x) - \mu]^2}{2\sigma_1^2}} \qquad (1)$$

where $\mu_1 = E[\log(\xi - x)]$ and σ_1 is standard deviation of $\log(\xi - x)$.

$$\textit{Type II} \quad p = \frac{1}{(x - \xi)\sigma_2\sqrt{2\pi}} e^{\left\{-\frac{[\log(x - \xi) - \mu]^2}{2\sigma_2^2}\right\}}, \qquad (2)$$

where $\mu_2 = E[\log(x - \xi)]$ and σ_2 is standard deviation of $\log(x - \xi)$. Results which we have obtained using above equations are given in Table 1.

Table 1. Results obtained using eqs. (1) and (2)

Wind vector	ξ	μ	σ	χ^2	df*
V_e for Autumn	0 01	1 544	0 2037	42 44	28
V_e for Winter	12 5	1 664	0 186	35 09	30
V_s for Winter	18.0	1 9733	0 0931	24 22	24
V_e for Spring	0 01	1.9733	0 1455	56.5	30
V_s for Spring	12 9	0.8997	0 3909	56 48	29

4. Conclusions

It may be observed from the results in Table 1 and χ^2 chart [5] that winter velocity components pass χ^2 test with 5%. V_e for Autumn and V_e and V_s for Spring are marginally unsuccessful in passing the χ^2 test with 2%. So, it may be concluded that wind in winter and spring possesses some sort of statistical pattern. Same is true for the eastern component of wind in Autumn. As against this the other three cases, studied here have shown greater variability and no simple distribution pattern cannot be fit to them.

References

[1] M Martin, L V Cremades and J M Santabarbara *Int J Climatol* **19** 197 (1999)

[2] A C Brett and S F Taller *J Appl Met* **30** 823 (1991)

[3] H Ishida *Boundary-Layer Met* **52** 335 (1990)

[4] J Gavalda, J Massons J Camps and F Diaz *Theor Appl Clim* **46(2-3)** 143 (1992)

[5] John E Freund *Modern Elementary Statistics* (New York Prentice Hall) (1952)