551·510·52 : 550·124(543)

Existence of low level westerly Jet Stream over peninsular India during July

P. V. JOSEPH and P. L. RAMAN

Meteorological Office, Bombay Airport

(*Received 6 December 1965*)

ABSTRACT. From an analysis of July rawin and pilot data over peninsular India it is shown that a low level jet stream (as defined by Reiter) exists over peninsular India on a large number of days, with level of wind speed maximum near 1·5 km asl and with core speeds ranging from 40 to 60 kts. High vertical wind shear is observed below the jet core.

1. Introduction

Low level jet stream according to a definition suggested by Reiter (1961), should have marked gradients of wind speed in the horizontal and the vertical. A few workers in the field have considered only significant vertical wind shears for the low level jet stream (Blackadar 1957, Barad 1961, etc). Upper wind mean charts show that during the summer monsoon months wind speeds are high over peninsular India near 2 km. A study was undertaken to see whether a low level jet stream exists over this region. July was taken as a typical monsoon month and the present study was confined to July only.

In this study the authors have investigated the occurrence of significant wind speed maximum in the vertical and of low level jet stream as defined by Reiter. The authors define a significant low level wind maximum in the vertical in accordance with the following criteria, on the lines of Fay (1958) —

(*i*) A maximum wind speed should exist below 6 km,

(*ii*) The wind speed should increase and then decrease with height, both through at least 10 kts without more than 40 degrees change in wind direction.

2. Data used

Wind data were taken from the Indian Daily Weather Reports (IDWR), for the five year period 1961—1965, for the heights 0·3, 0·6, 0·9, 1·5, 2·1, 3·0, 4·5, 5·4 and 6·0 km asl. There are five rawin stations over the peninsula, namely, Trivandrum, Madras, Visakhapatnam, Bombay and Nagpur and this study makes use of the data of these stations. There are a large number of pibal stations over the peninsula, but their data are not used in this study (except in Fig. 5 for the analysis of the wind field at 1·5 km asl) as during the monsoon season the pibal ascents are mostly limited to the lowest few hundred metres because of the high incidence of cloudiness and rain. Rawin ascents are made at these stations twice daily at 0000 and 1200 GMT. Out of the expected 310 ascents for each station available ascent data range from 276 to 304.

3. Analysis of the data

A few typical wind speed profiles in the vertical are given in Fig. 1, for cases of wind speed maximum greater than 40 kts. In general it is found that vertical wind shears are higher below the speed maximum than above it. Bunker (1965, with a large number of aircraft wind observations using Doppler radar, has constructed a vertical wind profile for a location (11°N, 58°E) in Arabian Sea for 1 September 1964. This profile also gives larger vertical shears below the wind maximum than above it.

Fig. 2 gives the distribution of the number of cases of significant wind speed maxima, with the wind speed at the level of maximum wind, for each of the five rawin stations. It is seen (as given in the figure) that at Trivandrum 128 ascents out of the available 304 ascents show significant wind speed maxima. Nagpur and Bombay show only very few cases. The highest frequency of occurrence, at all the stations is for a speed of 30 kts (28—32 kts). The highest maximum speeds obtained are of the order of 60 kts.

An analysis of the frequencies of heights of significant wind speed maxima shows that the height most favoured by the wind maximum is 1·5 km asl.

Fig. 3 gives the vertical profile of wind speed using all the available cases of significant wind speed maxima at Trivandrum and Madras for 0000 GMT, with the maximum wind speeds between 40 and 50 kts (In all 27 such cases could be found and the speed data of these cases are

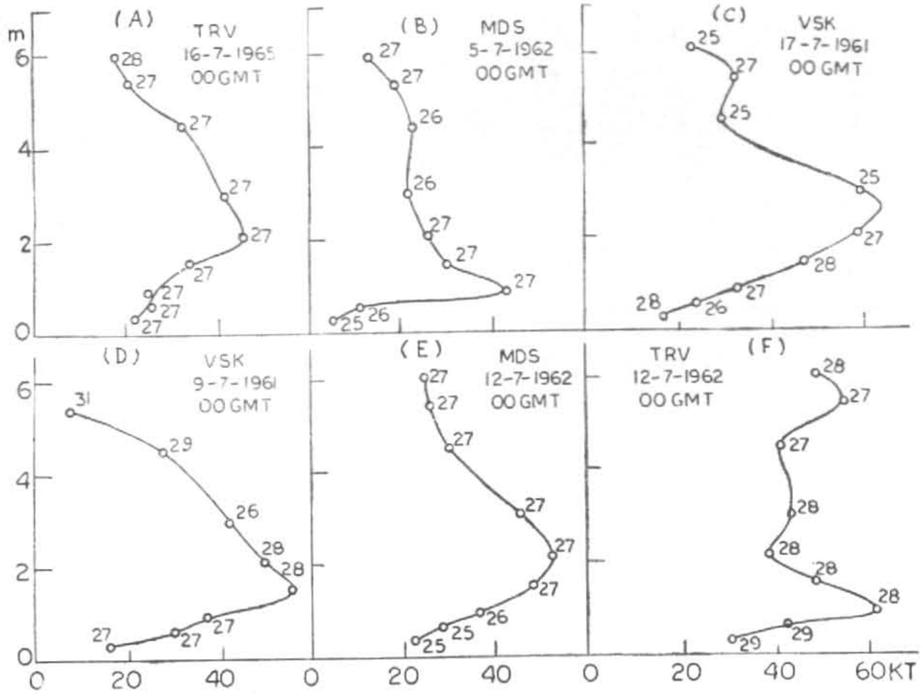

Fig. 1. Typical vertical wind speed profiles for cases of maximum wind speeds >40 kt

The higher values of vertical wind shears below the level of speed maximum than above it may be seen in most of the cases. The highest shear out of these six cases is in Fig.1(B), below the speed maximum and it is of the order of 100 kt per km. The directions in degrees of the winds are marked near the dots omitting the last figure. The great steadiness of the wind direction near the speed maximum may be noted. Only winds having westerly components are marked in these figures

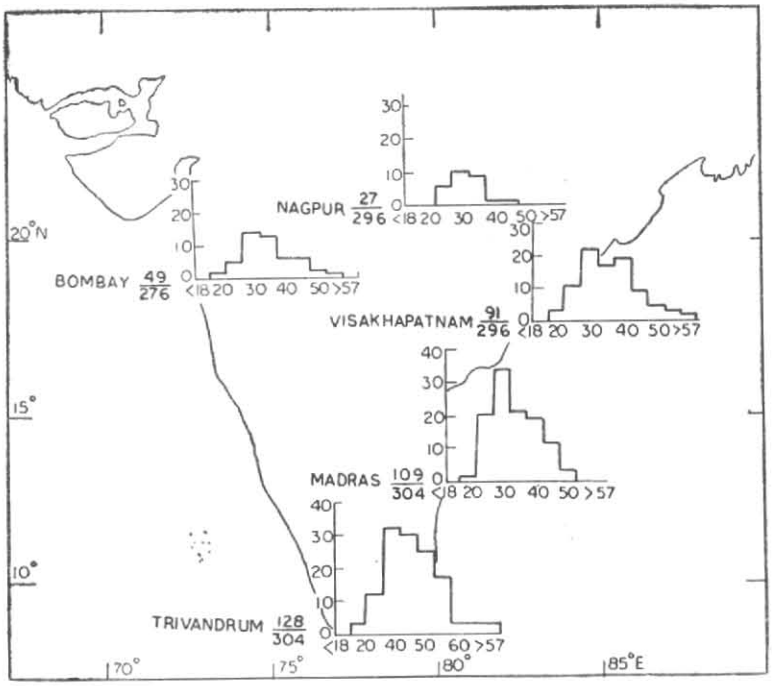

Fig. 2. The distribution of maximum wind speeds in the cases of significant wind speed maxima

At the top right corner of each inset diagram are given the number of cases of significant wind maxima (above) out of available 0000 GMT and 1200 GMT rawin ascents upto 6 km (below). Wind speed in kt is marked along the x-axis, and number of cases is marked along the y-axis

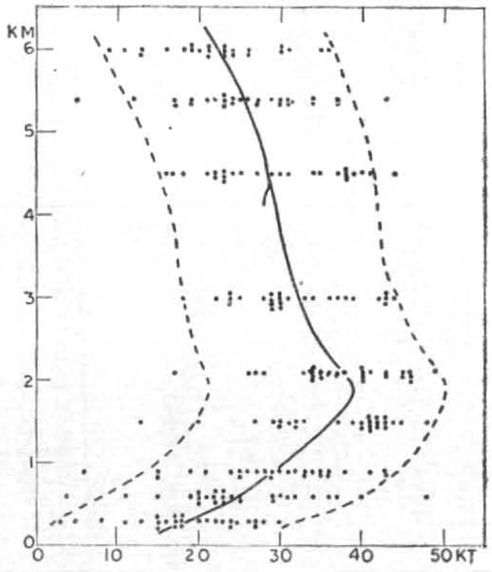

Fig. 3. The dots represent the wind speeds as reported at the 9 levels from 0·3 to 6·0 km in IDWR for the 27 cases of significant speed maxima between 40 and 50 kt for Trivandrum and Madras 0000 GMT ascents only. The continuous line joins the mean of the speeds for each level. Note the larger vertical wind shears below the speed maximum. The dashed line gives the limit of the scatter omitting one speed value at either side at some levels. Out of the 27 cases, for 3 maximum wind is at 0·9 km, for 9 maximum wind is at 1·5 km, and for 12 maximum wind is at 2·1 km. Only winds having westerly components are marked in the figure

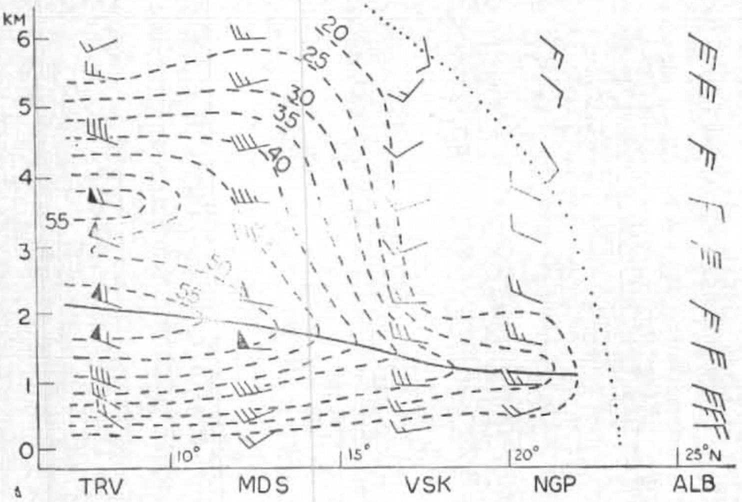

Fig. 4. Vertical wind cross-section using rawin data only, along 80°E, for 13 July 1962, 0000 GMT

The line of dots shows the approximate line of separation between easterlies and westerlies. The approximate position of the level of maximum wind, as obtained from the isotach analysis is marked by the thick line. The isotachs are marked at intervals of 5 kt. Trivandrum shows a second wind maximum at 3·6 km

used in the construction of the diagram). The continuous line gives the mean wind speed distribution in the vertical, using the same data. This mean picture also brings out the higher vertical wind shear below the speed maximum.

A careful examination of the significant wind maxima collected for the five years showed that when Trivandrum and Madras show significant wind maxima of large speeds, Visakhapatnam, Bombay and Nagpur either do not show such maxima, or if they show, the maximum speeds are smaller, and *vice versa*. This could be due to a low level jet stream which moves from one latitude to another. Examination of the 1·5-km level wind chart given in the IDWR together with the data of the wind speeds in the vertical confirmed the existence of a low level jet stream as defined by Reiter.

A vertical wind cross-section along 80° E is shown in Fig. 4. The level of maximum wind slopes down to the north. There is a packing of isotachs below the level of maximum winds, which shows the existence of higher vertical shears of wind speed below the level of wind maximum than above it. It may be mentioned here that in the upper tropospheric jet streams the vertical wind shear is generally more above the jet core than below it.

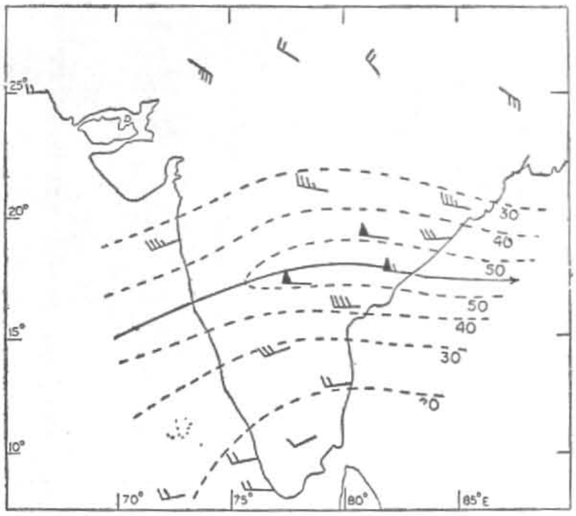

Fig. 5. Rawin and pibal winds at 1·5-km level for 9 July 1961, 0000 GMT

The horizontal axis of maximum wind is marked by the thick line. Iostachs are drawn at intervals of 10 kt. This figure along with figure 1(D) shows the existence of a synoptic scale low level jet stream, with marked horizontal and vertical wind shears

Fig. 5 gives the wind velocity distribution at the 1·5 km asl level on 9 July 1961, at 0000 GMT. Although the wind observations available are not many, the existence of an axis of maximum wind as marked by the thick line is clearly shown. The isotachs show the existence of marked horizontal shears. The vertical profile given in Fig. 1 (D), shows the existence of marked vertical wind shears above and below 1·5 km asl at Visakhapatnam. The reported maximum wind speed at Visakhapatnam is 56 kt. Such an axis of maximum wind could be easily located at about the latitude of Visakhapatnam on all the 0000 GMT and 1200 GMT wind charts for 1·5 km asl level from 5 to 12 July 1961.

4. Conclusions

From Fig. 5 and the wind speed profile in Fig. 1 (D), the existence of a low level jet stream passing through Visakhapatnam is quite clear. This jet stream persisted near about Visakhapatnam latitude from 5 to 12 July 1961 Similar studies for other days also establish the following points —

(*i*) Low level jet stream appears over peninsular India on many days in the month of July, with core at about 1·5 km asl and core speeds of the order of 40–60 kt.

(*ii*) Quite often this jet shows a persistence of a few days at any one latitude.

(*iii*) North-south movement of the jet axis can be discerned. Further study on this aspect is in progress.

(*iv*) The wind shear in the vertical below the jet core is found to be more than that above it and displays large values, which can be hazardous to aviation in landing operations.

This jet stream is expected to have effect on the distribution of rainfall with respect to its axis. A preliminary study has revealed the importance of this jet stream in the forecasting of southwest monsoon rainfall over peninsular India. A study on this aspect will be reported in a future communication.

5. Acknowledgements

The authors are grateful to Dr. T. M. K. Nedungadi, Director, Regional Meteorological Centre, Bombay, for kindly going through the manuscript and giving valuable suggestions and to Dr. A. K. Mukherjee, Meteorologist-in-charge, Meteorological Office, Santacruz Airport, Bombay, for help and advice in the preparation of the manuscript of the paper.

REFERENCES

Barad, M. L. 1931 *Sci. Amer.*, **205**, 2, pp. 120-131.

Blackadar, A. K. 1957 *Bull. Amer. met. Soc.*, **38**, pp. 283-290.

Bunker, A. F. 1965 Symp. Met. results of IIOE, 22-26 July 1965.

Fay, R. 1958 *Bull. Amer. met. Soc.*, **39**, pp. 360-362.

Reiter, E. R. 1961 *Jet-Stream Meteorology*, University of Chicago Press, pp. 265-271.