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BOUNDARY LAYER WIND AND JET LIKE STRUCTURE AT JODHPUR

1. Diurnal variation of surface wind and the wind in the boundary layer has been studied by various authors. Blackadar (1957) reported jet-like profiles in the boundary layer wind studies. Brook (1985) reported on Koorin expedition to Daly waters that low level jet reached its maximum strength at 0500 CST on 19% of nights in winter months. Rama and Sivaramakrishnan (1990), in their study of variation of wind in the planetary boundary layer during southwest monsoon at Sriharikota and Sivaramakrishnan (1992) during northeast monsoon, studied the variation of wind in the planetary boundary layer at Sriharikota and concluded that stronger wind regime exists from 400 m onwards in the afternoon which shifts to above 800 m at night. Jodhpur (Lat. 26.25°N, Long. 73.05°E) is a semi-arid station in Rajasthan state. There are minor hill features to the westnorthwest of the station. The Aravali hill ranges oriented from SW to NE direction are located about 100 km to the SE of Jodhpur. The area is flat. It is observed that surface wind, which usually becomes light by sunset, picks up strength after three to four hours of sunset and continues to blow, past midnight, dropping in speed a little but continuing till sunrise on next day. Further, during pre-monsoon season, quite frequently, dust haze is observed in the morning hours, when no convective activity has been reported from previous day evening to next day morning. The dust haze could come only if surface wind became stronger during night to morning. In support of our observation, the average surface wind data (1964-1969) is reproduced (Table 1) from IMD publication (1982). The table clearly brings out that the surface wind at 0000 UTC is usually stronger than at 1200 UTC. This prompted the author to look into the daily wind profiles, based on the Rawin/Radiosonde ascents at 0000 and 1200 UTC and pilot-balloon (PB) ascents at 0600 and 1800 UTC. It was observed that wind profile at 1800 UTC usually showed a jet-like profile and the wind maxima in the layer from surface to 1.5 km (5000 ft) was stronger than at other times. The phenomenon was observed quite frequently during most of the months. This suggested that a closer examination of the data was in order.

2. Daily wind data from Rawinsonde and Radiosonde at 0000 and 1200 UTC and PB data at 0600 and 1800 UTC from 1 October 1991 to 30 September 1992 at Jodhpur at standard heights of 300 m, 600 m, 900 m and 1.5 km and temperature data at 0000 and 1200 UTC were studied. The diurnal variation of wind speed exceeding 15 kt and 20 kt, irrespective of the direction, from surface to 1.5 km on daily basis is given in Fig. 1. The lapse rate between surface to 850 hPa for October 1991, January, May and August 1992 are given in Table 3. The synoptic charts were also examined to study the effect of synoptic systems, if any. For comparison purposes, the wind data of Bhuj was also studied.

3. From Fig. 1 and study of wind profiles upto 1.5 km, it is noticed that wind speed in the layer from surface to 1.5 km acquired jet-like profile at 1800 UTC or 0000 UTC on many days in each month. Further, the wind speed is generally higher at 1800 UTC or 0000 UTC than at any other time of the day. Following the definition of Blackdar (1957), which does not lay down any value for the speed maxima, the number of days in each month when jet-like profile is encountered at Jodhpur, is given in Table 2. With an arbitrary minimum speed limit of 20 kt, the frequency of jet-like profile/jet stream, also included in Table 2, indicates higher frequency in summer months than in winter months. The direction of flow in winter months may be from NE to E, but more oftenly, it is from SW to W. The wind shear between surface to 0.3 km exceeded 20 kt on many days. In addition, there are a number of days in each month, when the wind speed exceeded 20 kt in the boundary layer, but without jet-like profile. On some days, the jet-like profile has also been observed at other times.

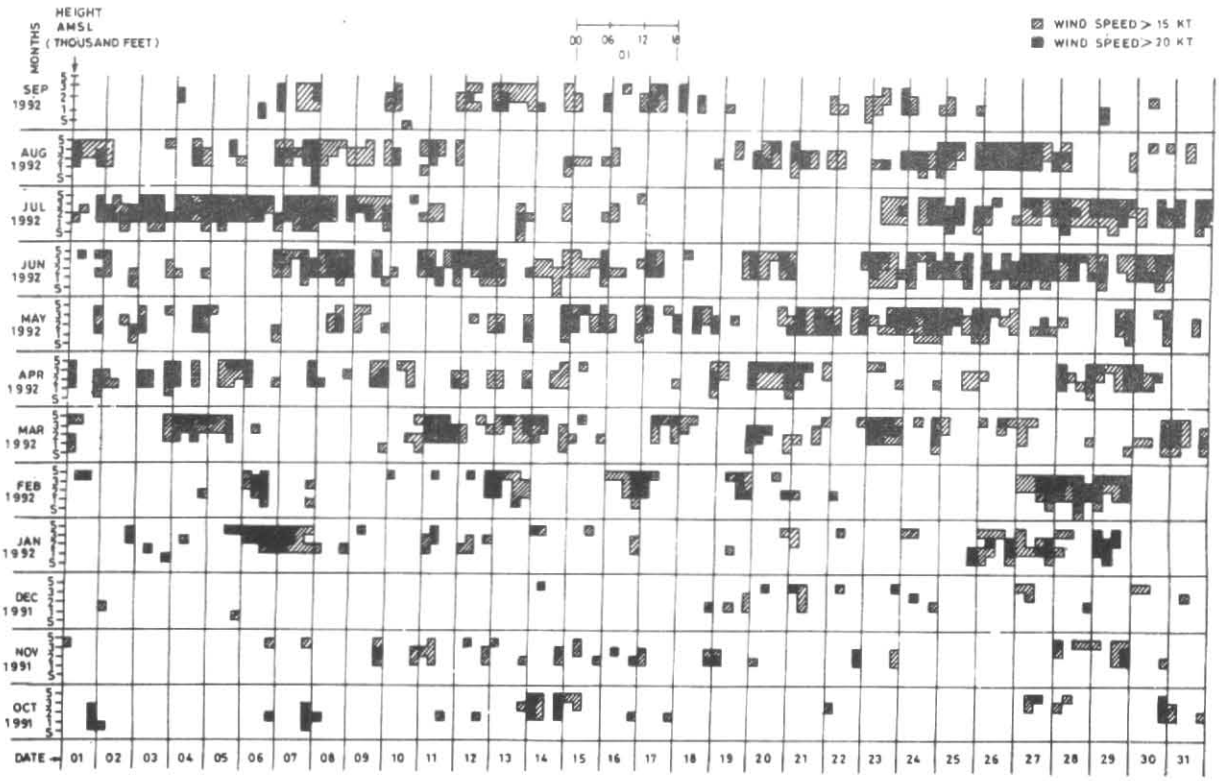

Fig. 1. Diurnal variation of wind in boundary layer at Jodhpur

TABLE 1

Mean surface wind at Jodhpur

(0000 & 1200 UTC for the period 1964-69)

Time	dd/ff	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0000	dd	052	050	017	074	235	228	229	227	231	008	055	053
	ff	3.1	2.8	1.0	1.2	4.7	7.1	6.7	4.5	2.6	0.4	1.8	3.5
1200	dd	012	285	264	252	238	222	221	225	229	285	355	022
	ff	1.2	1.3	1.9	1.9	5.8	5.4	5.1	4.1	2.4	0.6	0.7	1.5

dd—Direction of resultant wind in whole degrees

ff—Speed of resultant wind in meters per second (mps)

3.1. The study of lapse rate in the boundary layer [Table 3, coupled with Tables 1 & 2], indicates that development of stability or inversion in the boundary layer bears considerable relationship to the strengthening of the wind during night to morning time. But every occurrence of jet-like profile during night to early morning, can not be explained on this basis and appears to be linked with the passage of a western disturbance. In summer months, the increased frequency of jet-like profile with increased speed as compared to winter months, though is noticed to be associated with the passage of western disturbance and relative stability during night, but on many nights, the lapse rate conditions

TABLE 2

Frequency of occurrence of jet-like profile at Jodhpur

Cases	1991			1992								
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
No. of cases of jet profile/jet stream following Blackadar (1957) with a significant** maxima between 1800 & 0000 UTC	17	17	16	14	12	14	17	13	16	15	21	23
No. of cases of jet profile/jet stream following Blackadar (1957) with a significant maxima between 1800 & 0000 UTC but with a speed maxima of 20 kt or more	02	03	01	02	03	05	09	10	08	07	09	16

** A significant maximum is used to denote those occurrences in which the wind speed at the level of wind maximum exceeds the wind speed at the level of next higher minimum by 5 kt or more

have been found to be adiabatic and yet jet-like profiles have been observed. Since during summer months, the general direction of flow is SW to W'ly, it is possible that local topographical features, provide suitable thermal field particularly during night to early morning hours, which may build up thermal wind in the boundary layer. If this be the case, then strengthening of surface wind after reduction in the evening, can be expected during night/early morning.

3.2. For comparison purposes, the wind profiles between surface to 1.5 km at Bhuj were also studied. It is observed that phenomenon of strengthening of wind in the boundary layer during night to early morning is more marked at Bhuj as compared to Jodhpur. The wind shear from westerly direction between surface to 0.3 km has exceeded 20 kt quite often. Bhuj being not a TEMP station, the stability characteristics could not be ascertained, but it is believed to be similar to Jodhpur.

3.3. Further, some high ground features, running from west to east also exist to the south of the station. Data from other desert/semi desert stations such as Barmer or Jaisalmer is not completely available, but the available data does indicate the strengthening of wind in the boundary layer during night, particularly during summer months. The implication of jet-like profile for aviation, particularly for small aircraft which may encounter strong wind shear, and agriculture operations, such as, crop spraying during night/early morning, may be kept in view.

4. Following conclusions can be drawn from the present study :

(*i*) The wind in the boundary layer, *i.e.*, between surface to 1.5 km (5000 ft) at Jodhpur, shows a diurnal change. The winds during night to early morning hours are relatively stronger and show a jet-like profile.

(*ii*) The frequency of occurrence of strong winds during night or early morning in the boundary layer is higher in summer months as compared to winter months.

(*iii*) The wind shear between surface to 0.3 km above msl during night/early morning hours exceed 20 kt on many days.

(*iv*) The relative thermal stability during night, close to surface, as compared to day time stability coupled with local topographical features and passage of western disturbances are highly related features to the occurrence of jet-like profiles with strong winds in the boundary layer.

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TABLE 3

Lapse rate (°C/km) between surface to 850 hPa at Jodhpur

Date	Oct 1991		Jan 1992		May 1992		Aug 1992	
	0000 UTC	1200 UTC	0000 UTC	1200 UTC	0000 UTC	1200 UTC	0000 UTC	1200 UTC
01	1.5	12.8	5.3	11.4	3.4	7.5	6.0	7.0
02	1.2	07.5	4.5	11.0	1.1	6.2	—	11.8
03	2.0	11.7	5.7	08.2	7.3	3.7	+0.2	7.9
04	+3.1	09.1	2.3	10.2	6.5	7.4	+0.2	7.3
05	+6.3	08.3	+0.5	16.3	6.3	5.5	—	7.1
06	−4.5	11.6	6.3	11.4	5.3	9.2	+5.7	4.8
07	+1.5	09.8	4.5	11.0	6.1	7.0	+2.1	7.0
08	5.7	07.5	+0.6	07.7	6.1	11.0	3.0	11.0
09	2.7	11.6	6.5	13.8	2.7	07.9	3.0	08.1
10	1.9	12.2	1.4	07.9	4.9	06.8	0.2	12.1
11	−1.3	10.5	1.4	10.2	2.8	03.8	+0.4	08.5
12	1.2	—	5.0	14.0	—	07.6	+3.6	05.3
13	−1.8	+00.5	7.3	12.7	—	09.0	+4.1	12.0
14	—	11.1	5.1	09.9	3.4	08.5	+0.7	09.6
15	0.8	08.4	4.3	11.5	3.6	10.0	0.5	09.9
16	−0.5	08.9	9.4	12.1	4.9	06.4	3.0	09.9
17	−2.4	08.5	4.7	13.1	6.0	06.4	+1.3	09.8
18	1.1	09.0	+0.3	13.0	11.0	—	+1.8	11.2
19	+1.1	12.6	0.7	—	6.7	12.0	+1.5	08.0
20	2.3	07.5	±0.0	11.7	4.5	09.2	+4.1	09.7
21	1.0	08.4	3.4	07.1	3.8	06.0	+4.6	08.7
22	−2.6	10.0	2.4	11.0	5.9	07.1	+3.7	09.0
23	−0.3	08.9	2.9	08.7	2.9	5.6	+3.2	15.0
24	+6.1	09.8	3.1	09.5	3.4	8.9	+3.1	09.3
25	−0.3	11.1	4.7	10.0	9.0	7.5	+0.5	11.0
26	—	9.72	4.3	10.0	3.8	6.5	+4.2	12.2
27	−2.6	5.0	4.5	+1.4	6.3	8.1	−5.1	09.3
28	±0.0	4.6	+0.8	—	4.7	8.2	+1.8	06.8
29	5.7	—	2.8	10.5	8.2	10.7	+4.0	09.3
30	—	3.5	6.4	05.1	7.4	03.9	+3.1	07.2
31	3.7	7.7	3.1	09.5	5.1	08.6	+2.1	09.7

(*v*) The phenomenon of stronger winds in the boundary layer, during night as compared to day time, is more marked at Bhuj than at Jodhpur.

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