551.553.1:551.552:551.553.21 (548.4)

DIURNAL VARIATION OF TROPOSPHERIC WINDS DURING SOUTHWEST MONSOON OVER SRIHARIKOTA

Tropospheric winds play an important role in energy exchange process in the tropics and thus has a dominant part to play in making weather changes over a place. In aerospace engineering these upper wind profiles are used in vehicle design studies primarily to establish structural and control system capabilities. Internationally these tropospheric wind measurements are made using rawin ascents twice a day as enunciated by World Meteorological Organisation, mostly around 00 UT and 12 UT. But the trend of wind speeds and direction, if any, between these two times is not clearly known. Harris (1957), Herring and Borden (1962) could record a diurnal trend in winds at some stations in central USA in summer. A stray attempt (Parthasarathy & Narayana 1953) in a India has noticed diurnal variation in winds up to 6 km.

A diurnal trend in planetary boundary layer has been observed over Sriharikota (Rama and Sivaramakrishnan 1990) recently. It is of interest to investigate the diurnal trend in the winds over full troposphere. For aerospace activities, the study will have a direct and very important relevance to know how far we can take the wind profile measured for a scheduled launch to a delayed launch due to any 'holds.' Again the information will also be helpful to plan the launch time window in a day, conducive to the design of the vehicle or rocket. In case any diurnal trend is established it can help to forecast the wind profile to any part of the day from the profile measured at a particular time of the day. Sriharikota being the main launching centre of Indian Space Research Organisation, a program to study the diurnal trend of tropospheric winds was conducted in 1989 and 1990. Since southwest monsoon period is the season of strong winds and shears the program was conducted first for this season. The analysis of the data collected is presented here.

Five compaigns were conducted during 29/30 June 1989, 18/19 July 1989, 31 August/1 September 1989, 21/22 August 1990 and 20/21 September 1990. 4-hourly rawin ascents were taken both during day and night on these dates and upper winds were computed at 300 m altitude intervals. The mean daily vertical wind profile was derived for June-September. The important features typical to the southwest monsoon were identified from these profiles. Then the vertical time section of rawin winds was constructed for each of the compaigns. The variation of the basic features identified, if any was examined in the time-section. The standard deviation of the wind speed for each level was computed and the variability of the wind speed is discussed. The steadiness of wind direction and the speed at different levels were evaluated and studied.

The mean wind profile for each of these four months are shown in Fig. 1. The main features can be identified as :

(a) There is decrease in wind speed from around 5 km altitude and wind speed starts picking up significantly from around to 10 km agl.

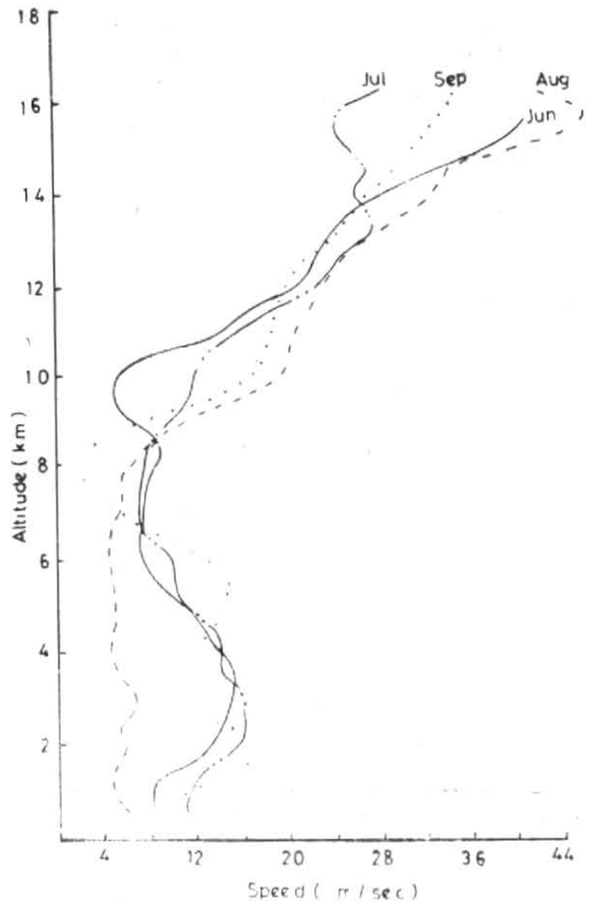

Fig. 1. Mean wind profiles (Jun-Sep)

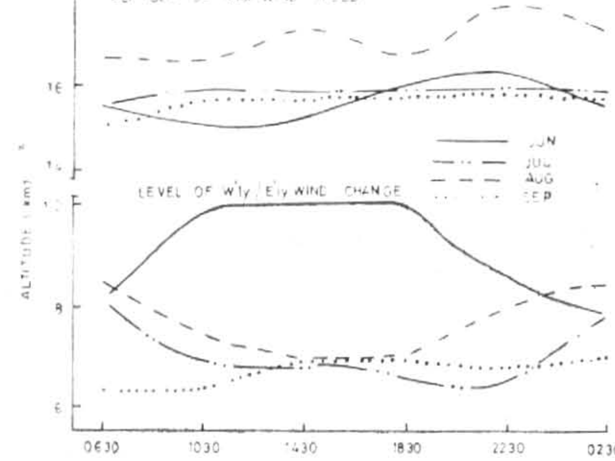

Fig. 2. Variation of altitudes of maximum wind speed and level of wind change (W-E)

(b) There is a peak wind speed around 15/16 km altitude. This phenomenon is the Tropical Easterly Jet (TEJ) stream. TEJ is prominently seen from Lat. 13°N to 15°N in this season. Since Sriharikota is at 13.7°N latitude, this phenomenon is expected to occur over this place.

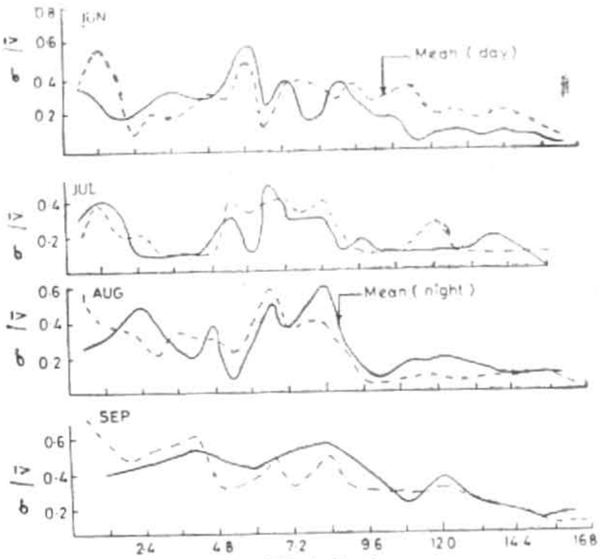

Fig. 3. Upper wind variability over SHAR

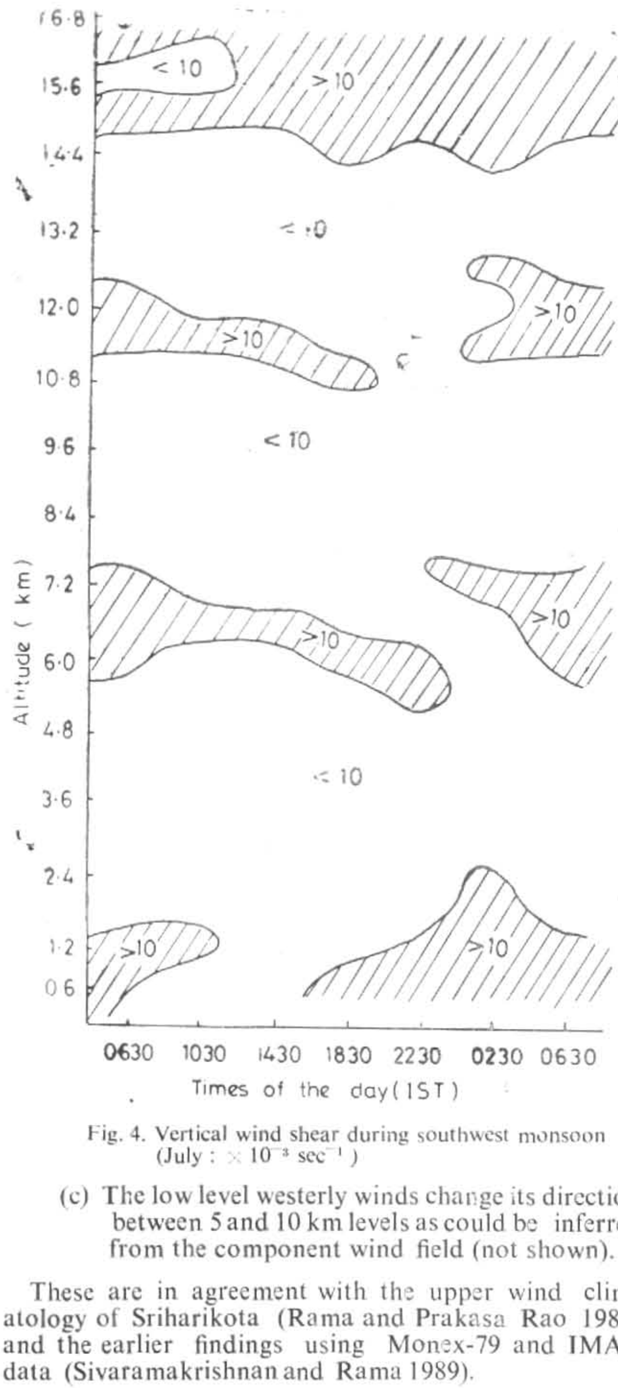

Fig. 4. Vertical wind shear during southwest monsoon (July : $\times 10^{-3}$ sec^{-1})

TABLE 1

Thickness of strong wind region (km)

Time (IST)	Jun	Jul	Aug	Sep
0630	4.5	4.5	1.8	1.5
1030	2.7	5.4	2.9	2.3
1430	3.8	5.5	2.4	2.4
1830	3.9	3.6	1.8	1.7
2230	4.4	3.9	3.1	1.0
0230	3.5	3.2	2.4	2.0
Mean	3.8	4.4	2.4	1.8

TABLE 2

Lowest altitude where wind speed exceeds 25 mps

Time (IST)	Jun	Jul	Aug	Sep
0630	13.2	12.3	14.1	13.8
1030	13.5	12.6	13.7	13.5
1430	13.2	12.1	14.4	13.8
1830	13.0	13.8	13.7	13.0
2230	12.6	12.8	13.2	13.2
0230	13.2	13.3	12.0	13.8

(c) The low level westerly winds change its direction between 5 and 10 km levels as could be inferred from the component wind field (not shown).

These are in agreement with the upper wind climatology of Sriharikota (Rama and Prakasa Rao 1989) and the earlier findings using Monex-79 and IMAP data (Sivaramakrishnan and Rama 1989).

The variation of the altitude of maximum wind speed as well as the level of westerly to easterly wind change are shown in Fig. 2. It is seen that the level of westerly to easterly transition level is around 10 km during day time in June and this is 8 to 9 km in night. However, this level is around 7 to 8 km in July at all times. During August and September, this is steady around 7 km. Thus, June or early part of monsoon facilitates extension of westerlies up to 10 km during day and confines the same within 8 km altitudes during night.

It is widely believed (King 1967, Lindzen 1967) that the diurnal wind variation in atmosphere wherever found is linked with the response of atmosphere to the space-time variations of diabatic heating and cooling produced by the diurnal cycle. Because of strong insolation and existence of mainland (Peninsula) to the west of the island, the westerly compensating flow for the sea breeze facilitates extension of westerlies to greater heights in day time than in night in June. Strictly speaking this tendency should continue in July and August also. However, because of the increase in the frequency of convective thunderstorms (Sivaramakrishnan 1990) in afternoon/evenings and moisture due to the monsoon airmass as well as the thunderstorm activities, this feature is not prominent in July and August.

We defined the wind speeds greater than 25 mps as very strong winds. This definition is relevant more due to aerospace engineering consideration than due to meteorological conventions. The thickness of strong wind regime was scrutinised. The thickness at different times of the day of this regime is shown in Table 1. The thickness is 3.8 km in the month of June and this increases to about 4.4 km in the peak of southwest monsoon, namely, July and subsequently falls to a value less than 3 km in August (2.4 km) and September (1.8 km). But no diurnal trend in the thickness could be established in any of these months except the apparently high day time values compared to night time in July. Another useful information for operational aerospace engineers is the lowest layer where the wind speed becomes strong (>25 mps). Table 2 presents this information. In June irrespective of day or night this level is 13 km. In July this level is 12 to 13 km. In August and Septembter this is between 13 and 14 km at any part of the day or night.

It was seen that the overall signatures of the individual profiles remained the same though random variation of speed are present in all the levels. This was found to be applicable for all months of this season. The observations were tacitly divided into day time and night time ones as the meteorological parameters that exhibit any diurnal variation are linked to the lunar tide. The mean and standard deviation of wind speed for all the levels valid for June-September have been computed separately for day and night. Standard deviation (σ) divided by mean wind (v) is the variability. The variability of wind speed throughout the troposphere can be understood from Fig. 3. Except between levels of 5 and 9 km the σ/v value is very less (<0.3). Thus 5 to 9 km is the layer where the wind speed variability is significant in southwest monsoon season if measured at different parts of day/night.

The percentage steadiness of wind direction was investigated. It was above 90% from surface up to 5 km and again at levels above 9 km during this season. The values varied between 40% and 78% in the sandwitched layer. This is because of the existence of the level of transition from westerly to easterly zonal components within this layer.

The mean vertical wind shears valid for different parts of the day during the active part of the season (July) is shown in Fig. 4. Shears exceeding to 10 sec^{-1} are seen at all times above 14 km. This is the shear zone associated with the TEJ. Similarly, high shear is seen in a narrow band between 6 and 7 km and between 11 and 12 km also. These two are the boundaries of the zonal component direction change region.

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T.R. SIVARAMAKRISHNAN

Regional Meteorological Centre, Madras

K. PRAKASAM

Meteorological Facility, ISRO-SHAR Centre, Sriharikota

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