MONSOON LOW-LEVEL JET OBSERVATIONS OVER GADANKI

K. Madhu Chandra Reddy, D. Narayana Rao, A.R Jain and Yuichi Ohno[1],

National MST Radar Facility, Gadanki, India
E-mail: madhucomcom@rediffmail.com
[1]Communications Research Laboratory, Tokyo, Japan.

Abstract

Lower Atmospheric Wind Profiler observations of the Low Level Jet (LLJ) over Gadanki (13.5°N, 79.2°E), a tropical station in India, have been discussed. The present study utilizes vertical profiles of wind parameters, such as 3-D wind vectors (U, V and W), horizontal wind speed, wind direction and wind shear, during the years 1998-2000 in the height range of 0.6 – 4.0 km to explore the LLJ characteristics. The LLJ statistical characteristics and associated probable wave and turbulence effects have been investigated.

Introduction

The Low Level Atmospheric Jet is supposed to be a nocturnal phenomenon (Stull, 1990). It is well established that a strong cross-equatorial westerly Low Level Jet-stream (LLJ) with core around 850 hPa, roughly around 1.5 km above mean sea level (AMSL), exists over the Indian ocean and South Asia during the boreal summer monsoon season, i.e. June to September. Joseph and Raman (1966) established the existence of a westerly low-level jet stream over peninsular India with strong vertical and horizontal wind shears. This LLJ over tropical India could have strong link with Indian monsoon (Sam and Vittal Murty, 2002). This paper concentrates on LLJ observations confined over Gadanki.

System description and Data details

Lower Atmospheric Wind Profiler (LAWP) is a UHF coherent, pulsed doppler, phased array radar with an effective peak power aperture product of about 1.2×10^4 Wm^2. The radar is operated at a frequency of 1357 MHz and the receiver has a maximum gain of 120dB. This radar has been configured to operate in Doppler Beam Swinging (DBS) mode. The antenna beam can be positioned, through electrical phase switching, at three fixed orientations, viz., Zenith, 15°down to East and North. The backscatter echo from three non-coplanar beam beams are utilized to obtained the three-wind vectors, viz., Zonal (U), Meridonal (V) and vertical (W). The wind profiles obtained by this radar are single station observations, i.e. above Gadanki. But, on calm fair-weather day, these wind observations may be representative of a few kilometres over Gadanki. Care has been taken in choosing the calm and fair-weather times wind data for this study. Vertical profiles of 3-D wind components are averaged for every hour, unless otherwise stated, the same is used for this study.

Observations and discussion

In order to understand the overall three-year wind speed information, we have averaged height profiles of wind speeds for every 5 days. The monthly such wind speeds information for the years 1998-2000 is shown in figure 1. It can be seen from this figure that the westerlies prevail during May - September and easterlies during other months.

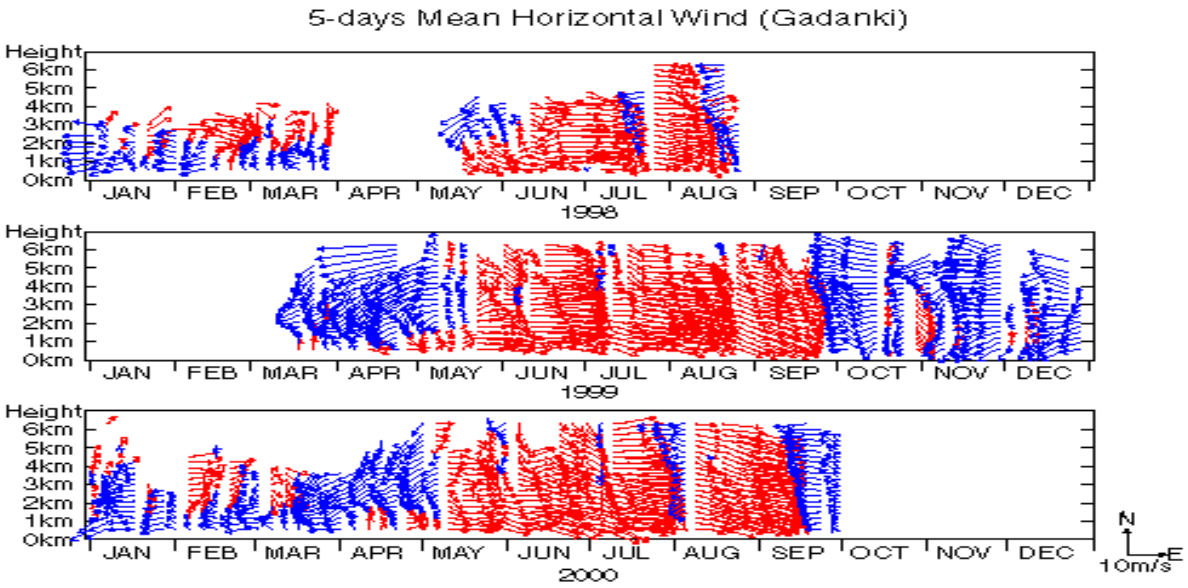

Figure 1. Wind vector diagram for the monthly horizontal wind speed trends for the years 1998-2000.

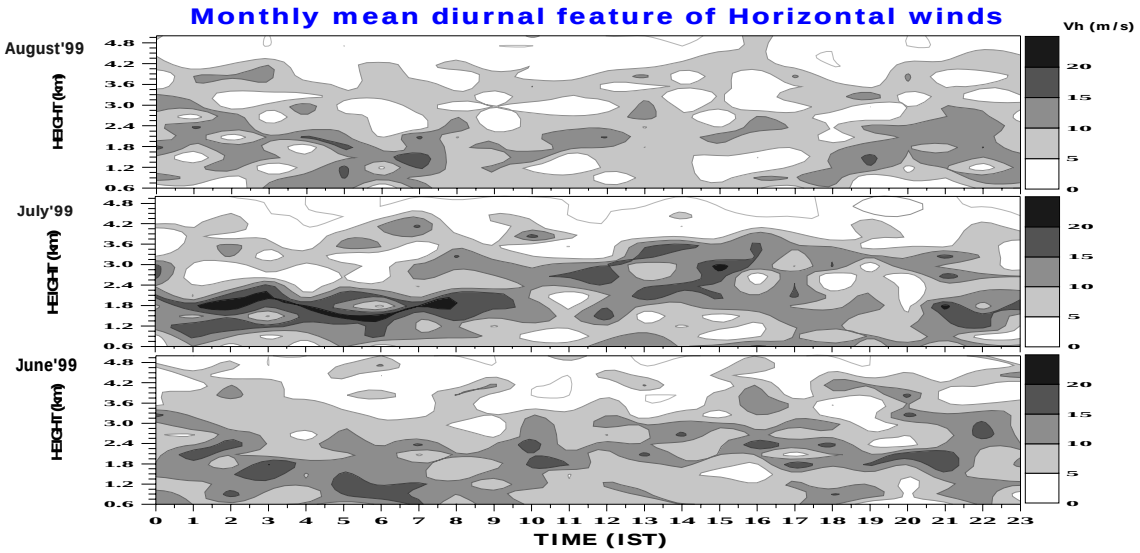

Figure 2. Mean monthly diurnal features of Horizontal wind contours.

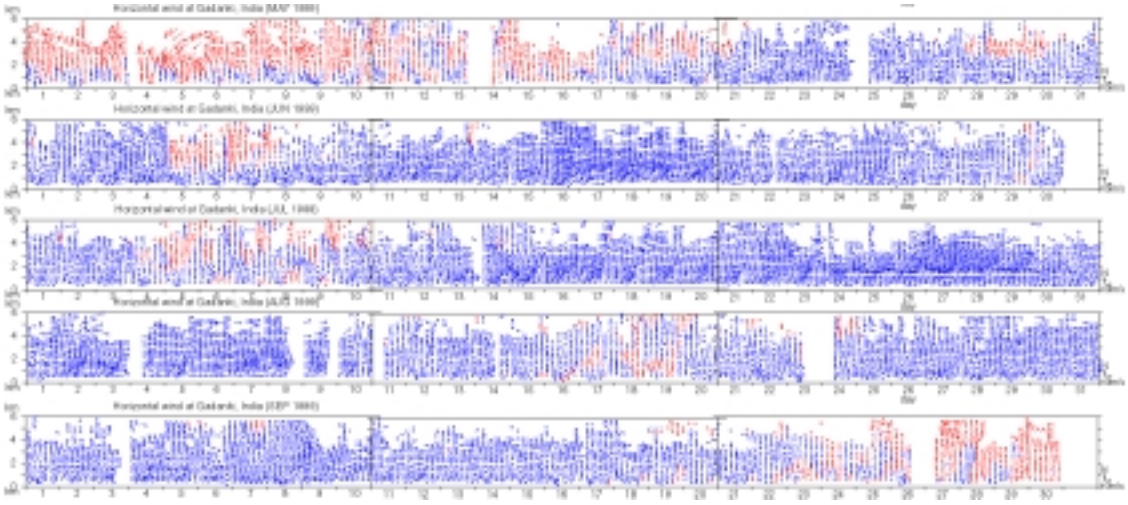

Figure 3. All days Monthly Horizontal wind vector diagram for the year 1999.

The monthly diurnal mean of horizontal wind speeds for the months of June-August is shown as a contour map in figure 2. It can be seen from figure 2 that, in July 1999, the mean wind speeds are high and are in the range of ~ 20 ms^{-1}. Moreover, the jet appears from 2100 – 1000 (LT) around 1.6 ± 0.5 km. During LLJ times, the wind direction is westerly (can be seen from figure 1). LLJ features seem to be diluted in between 1000 and 2200 (LT) and the wind speeds are below 15 ms^{-1} at these times. In the months of June and August LLJ wind speeds are in the range of ~ 10-15 ms^{-1}. The mean strong LLJ feature observed in the month of July is seen to be much more significant than June and August. More or less the same features are observed in 1998 and 2000 as well.

The three-year hourly averaged wind observations on fair-weather days show that horizontal winds are normally below 6-8 ms^{-1} in the height range of 0.6 – 4.0 km. At LLJ times, the maximum wind speed (jet streak) is observed to range from 12 to 30 ms^{-1}. These magnitudes are comparable with Great Plains LLJ observations (Yihua Wu and Sethu Raman, 1998). The LLJ features have observed to be significantly stronger in the monsoon times, especially during the months of June-July. Moreover, during the boreal summer (South-West) monsoon time LLJ intensities are stronger and persist for much longer time in comparison to winter (North-East) monsoon. This can be seen from the figure 3, which is an arrow diagrammatic picture of horizontal wind speeds for each day for the months from May to September 1999. From figure 3, it is clear that the LLJ core seems to appear around 1.5 km. The arrowhead indicated towards east, which confirms that the LLJ direction is mostly westerly during summer monsoon times. In every year, LLJ seems to be stronger and prominent in the Southwest monsoon time over Gadanki, especially in the months of June–August. This can be observed from figure 3.

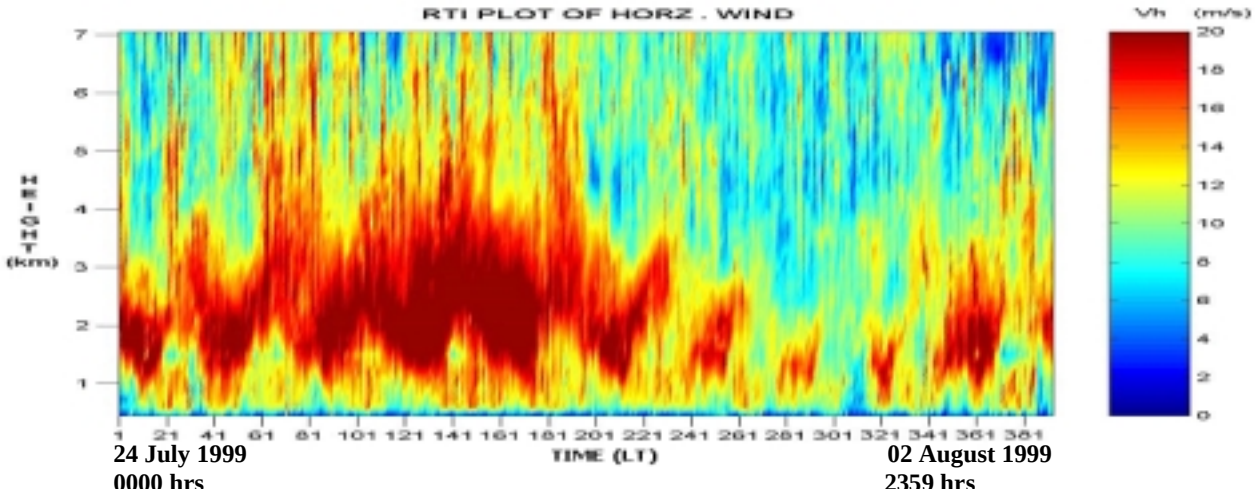

Figure4. Range Time section of Horizontal winds from 24 July – 02 August 1999. Every tick mark on abscissa corresponds to 12 hours.

From figures 2 & 3 it can be understood that the LLJ features are stronger in the month of July. Three years of wind data are also revel that frequent strong LLJ has been observed during day and night continuously for a few days mostly in July. On such occasions Gadanki LLJ seems to be as similar as East-African (Somalia) jet, which lasts day and night for many days (Stull, 1990). So a case study has taken up to understand the wave and turbulence features during the strong LLJ times. For this case study particularly July 1999 is chosen because of availability of simultaneous radiosonde observations at NMRF, Gadanki. Such a typical example can be seen on July 1999 from figure 4. Figure 4 shows the range

time intensity (RTI) of horizontal wind speeds for 10 days i.e. 24 July – 02 August 1999. Abscissa is time in days; every 41 interval represents a day. Here, the height profiles of horizontal winds are averaged for about half an hour to understand the wave and turbulence features at the LLJ times. The vertical extension of LLJ is seen from 0.6 km to even above 4.0 km. From these observations, it is understood that the wind directions are relatively constant in the jet region but not the wind speeds. The maximum wind speed (jet streak) is observed to be 30 ms^{-1} on 27 July 1999. This figure also shows significant information about diurnal variation of LLJ over Gadanki. The axis of the LLJ appears to be shifting up at afternoon times. This may be due the local ground based convective forces. The generation, maintenance and strength of the LLJ are very sensitive to the parameterisation of turbulent mixing in the Boundary layer. Thus, the Turbulent Kinetic Energy (TKE) and the magnitude of the turbulent fluxes associated with LLJ are important and are very interesting to study.

Summary

Single station three-year wind information over Gadanki reveals that the winds are strong and westerly in direction during June–September, boreal summer monsoon period. Low Level Jet features have been most prominently and consistently observed in the months of June to August. The strong LLJ features are most significantly seen in the month of July. The observed average LLJ characteristics are summarised as follows:

Level of jet	1.6 ± 0.5 km
Direction	Westerly, South westerly
Mean wind speeds	20 ms^{-1}
Max. wind speed	30 ms^{-1}
Diurnal features	Maximum during midnight and early morning times and LLJ features has been diluting during the day time.
Persistence	Very steady in direction and variable in speeds.

Most of the times, LLJ observed to be prominent in the early morning times. But it has been observed sometimes, especially in the months of July. The LLJ has been persisting continuously day and night and lasts for a few days similar to Somalia (East Africa) Jet, with varying core height and intensity. Moreover the depth of the Jet (vertical extent) is more than 3 km during on such time. In the afternoon times the axis of the LLJ has shifted to higher altitudes as compared to the early morning observations.

References

Joseph, P. V., and P. L. RamanExistence of low level westerly jet-stream over peninsular India during July. *Ind. J. Met. Geophys.*, **17**, 437-471, 1966.

Sam, N.V., and K.P.R. Vittal Murty Characteristics of monsoon low-level jet (MLLJ) as an index of monsoon activity. *Indian Acad. Sci. (Earth Planet. Sci.)*, **111**, No.4, 453-457., 2002.

Stull, R.B, An introduction to Boundary Layer Meteorology, Kluwer Academic publication, Boston, 500-522, 1990.

Yihua WU, and Sathu Raman, The summertime Great Plains low level jet and the effects of its origin on moisture transport. *Boundary Layer Meteorology*, **88**, 445-466, 1998.