Characteristics of oscillation in surface layer and above over Cochin

C.A. Babu[1], Hamza V[1], Kunhikrishnan P. K[2]. and Sabin T. P[1].

[1]Department of Atmospheric Sciences
Cochin University of Science and Technology, Cochin – 682 016
[2]Space Physics Lab, VSSC, Trivandrum-695 022
e-mail: babumet@gmail.com

Abstract

The oscillations in the Atmospheric Boundary Layer (ABL) are important because the transport mechanism from the surface to the upper atmosphere is governed by the ABL characteristics. The study was carried out using wind and temperature data observed at surface, 925 hPa and 850 hPa levels over Cochin and the different frequencies embedded in the boundary layer parameters are identified by employing wavelet technique. Surface boundary layer characteristics over the monsoon region are closely linked to the upper layer monsoon features. In this perception it is important to study the various oscillations in the surface boundary layer and the layer above. It is found that the wind and temperature at different levels show oscillations in Quasi Biweekly Mode (QBM) and Intra Seasonal Oscillation (ISO) bands as observed in a typical monsoon system. Amplitude of the oscillation varies with height. The amplitude of the QBM periodicity is more in the surface levels but in the upper levels the amplitude of the ISO periodicity is more than that of the QBM. From this, it is obvious that the controlling mechanism of QBM band is surface parameters such as surface friction and that for ISO band is associated with the active-break cycles of monsoon system.

Key Words : *Intra seasonal oscillation, surface layer, Quasi Biweekly Mode*

Introduction

Atmospheric boundary layer (ABL) is lower part of the troposphere in which surface forcings influence within a time period of an hour or less (Stull, 1993). The triggering mechanism for most of the atmospheric phenomena is initiated in this layer and hence the characteristics in this layer attained importance. Indian subcontinent is characterised by the seasonal reversal of wind from northeasterly during winter to southwesterly during summer. In addition to this intra annual variability, there are low and high frequency variability embedded in the meteorological parameters during the southwest monsoon. Atmospheric surface layer characteristics over this season are closely linked with the upper monsoon features and under this perception it is imperative to study the variability in the lower troposphere at different altitudes. In this study, we focus the variability associated with meteorological parameters in different time scales in different altitudes within the ABL and above during the southwest monsoon season. One of the major variability noticed in Asian summer monsoon is intraseasonal oscillation (ISO) with a periodicity of 30 to 60 days (Sikka and Gadgil, 1980) and is a manifestation of northward propagating maximum cloud zone over the region (Yasunari, 1979; 1981 and Krishanmurti and Subramaniam, 1982). This kind of variability is responsible for the occurrence of active and break spells of southwest monsoon (Krishnamuri and Ardunuy, 1980; Yasunari, 1981 and Goswami *et al* 2003). High frequency oscillation in a range of 10 to 20 days is called Quasi Biweekly Mode (QBM), which is another important variability found during the southwest monsoon season. These oscillations can be seen in spectral analysis of precipitation, convection and in many circulation parameters (Chen and Chen, 1993; Numaguti, 1995 and Kiladis and Wheelaer, 1995). The amplitude of the QBM is comparable to the amplitude of the northward propagating 30-60 day mode of variability (Goswami *et al* 1998; 2001). It is noticed that the QBM is also observed in the oceanic parameters and this variability of the upper ocean zonal transport in the equatorial Indian Ocean is driven by the fluctuations of the surface stress (Senguptha *et al* 2001). Praveena *et al,* (2005) studied such variability using UHF radar over an equatorial station. The features of the variability at different time scales over southern part of India are studied at different heights (surface, 925 hPa and 850 hPa) by subjecting temperature and wind to wavelet analysis for the decomposition of all the harmonics in the original data. From the different harmonics obtained, it is found that the major harmonics in the surface layer are 10 to 20 day mode and that in the layer just above ABL are 30 to 60 day mode.

Data and Methods

The data set used for the present study is wind and temperature at 20 m (representing surface) level from a micrometeorological tower observatory system installed for the boundary layer studies which was set up at Cochin, the southern tip of Peninsular India and the city is oriented to the coastline by 160-340 azimuth with a radial distance of 8 km from the micrometeo-rological tower observatory. Figure 1 shows the map of Cochin city and adjoining areas with the location of the tower system marked as T. The data set was collected in a regular interval of 30 minutes and averaged it over a day. Calibration and quality check of the observations from the tower system was carried out thoroughly. After completing the quality check, the data set was transferred to the data archive.

Continuous data set was considered during the monsoon period of 2002 with 128 data points from the micrometeorological tower observatory to carry out the wavelet analysis. To know the variability in the lower troposphere, other than surface, we considered daily averaged data set of zonal wind and temperature from the NCEP/ NCAR reanalysis, which is a good quality data set to carry out the research activities (Kalnay *et al,* 1996) with a spatial resolution of 2.5 x 2.5 latitude-longitude grid.

Wavelet decomposition is a method of time-frequency localization that is scale independent. This method of decomposition can be employed where a predetermined scaling may not be appropriate because of a wide range of dominant frequencies. Wavelet analysis attempts to solve by decomposing the time series signals into time/frequency space domains simulta-neously. This method of signal decomposition provides information on both the amplitude of any periodic signals within the series and how this amplitude varies with time. In this study,

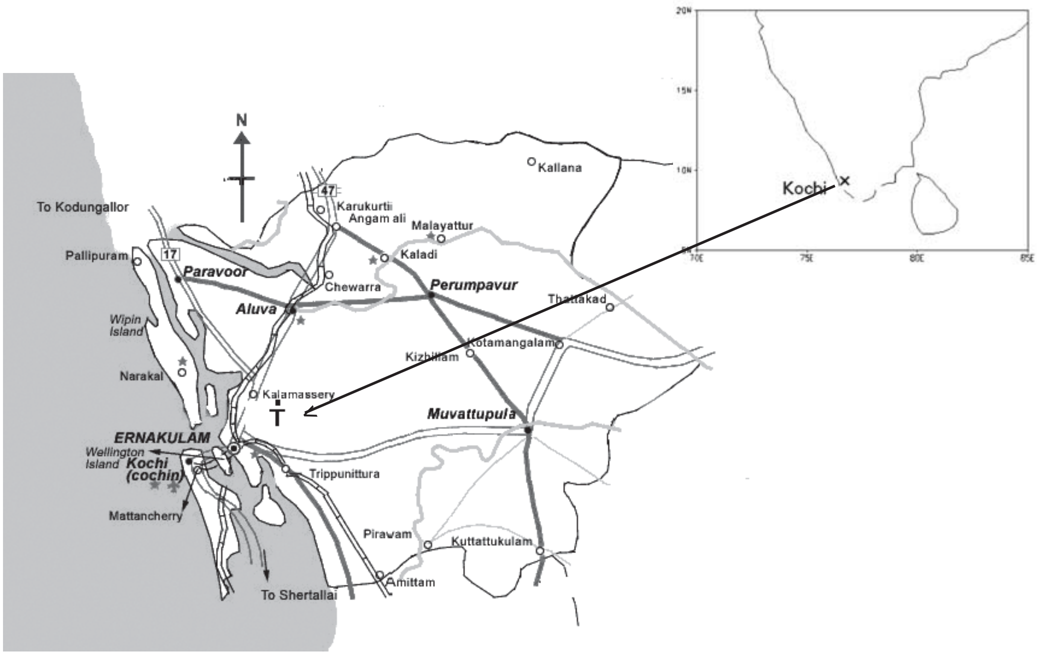

Figure.1 Map of Cochin city with the micrometeorological tower observatory, which is located near Kalamassery (marked as T.) The insight figure represents the location of Cochin city in the Indian peninsula.

dmey wavelet technique is utilized to obtain the predominant harmonics embedded in the time series of wind and temperature.

Results and Discussions

Figure 2 shows the wind during the southwest monsoon of 2002 at different heights (surface, 925 hPa and 850 hPa) and its major harmonics. In the figure the first, second and third columns show the original signal and its harmonics at 850 hPa, 925 hPa and surface respectively. The zonal wind at 850 hPa shows the clear indication of active (wind speed is more than 15 ms^{-1}) and weak (wind speed is less than 9 ms^{-1}) spells. The major oscillations are found to be 10 to 20 day mode (QBM) and 30 to 60 day mode (ISO). The QBM has a periodicity of about 11 days and the ISO is around 47 days. The amplitude of the harmonics is higher in the ISO band, so at 850 hPa the major oscillation is ISO band. In the case of zonal wind at 925 hPa, the oscillation is similar to the wind at 850 hPa but the magnitude is less. The QBM periodicity is around 13 days and ISO periodicity is around 43 days. Here, the important oscillation is ISO band because the amplitude of the harmonics is higher for the ISO band than that of the QBM band. In the surface layer, the wind pattern shows almost same behavior to the layer above. It is obvious that surface friction plays vital role on the surface wind. The important oscillation in this layer is QBM with a periodicity of about 12 days because the amplitude of this harmonics is higher than that of the ISO band. The ISO band has less influence in the surface layer and hence amplitude of ISO mode is far less than that of the QBM. The ISO band periodicity (39 days) is also less compared to the upper levels.

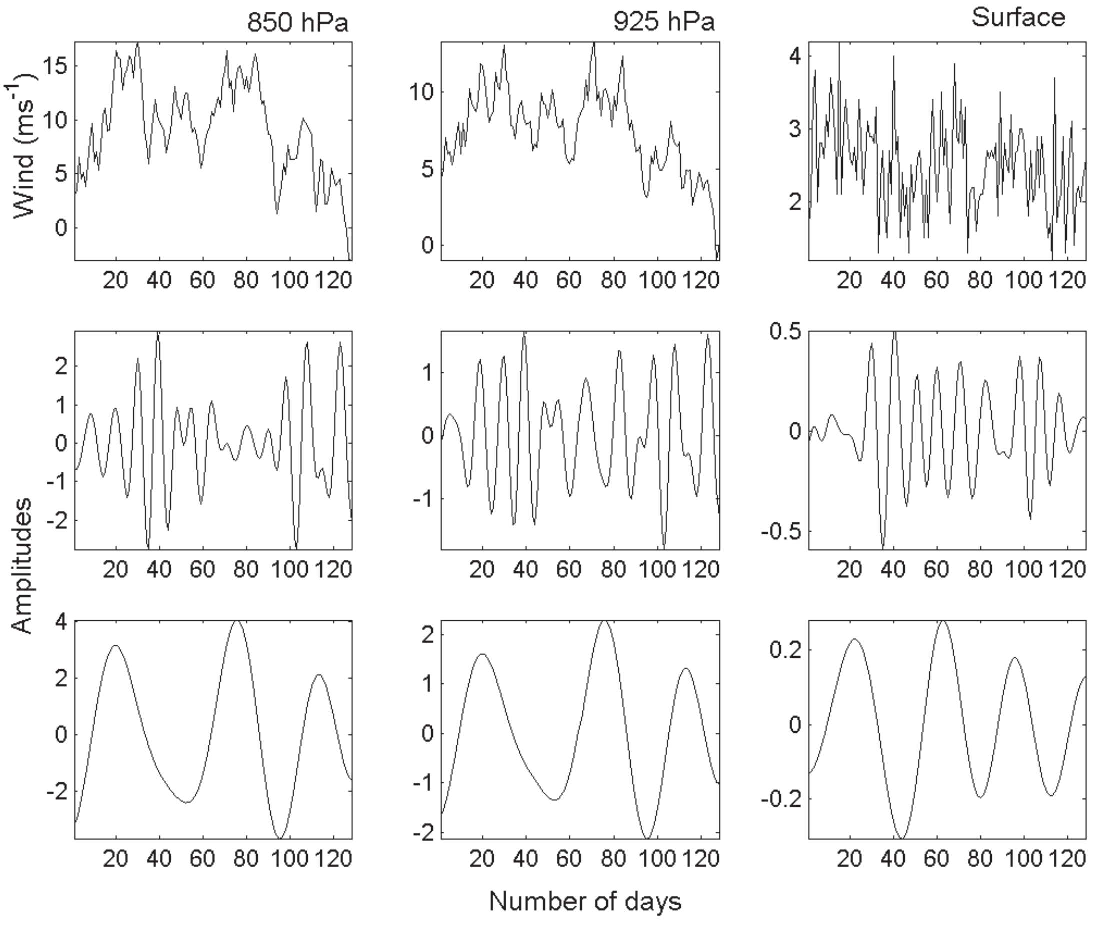

Figure.2 Wavelet analysis of the wind at 850 hPa, 925 hPa and surface during southwest monsoon of 2002. The first row represents the original signal, the second row gives the harmonics of wind in the QBM band and the next is same for ISO band.

The temperature at the above levels was also studied in the same way as that of the wind and the results are presented in Figure.3. The temperature oscillation is different from wind. The 850 hPa and 925 h Pa temperature exhibit the ISO and QBM periodicities around 37 and 10 days respectively with almost same amplitude. Hence the influence of ISO and QBM oscillations on temperature at the upper levels is almostsame. In the surface layer, QBM band is dominant compared to the ISO mode. The QBM periodicity is around 11 days and ISO has around 34 days. The periodicity and amplitude of temperature harmonics at 850 hPa and 925 hPa levels are less than that of the wind. But in the surface layer, the oscillation with maximum amplitude is found for the temperature in both QBM and ISO band.

Influence of surface friction and associated turbulent eddies can be attributed as the mechanism responsible for the intense QBM in the surface layer. It is found that the amplitude of ISO band increases towards 850 hPa. This is because the intra seasonal oscillation of the monsoon regime governs oscillations at this level. In other words one can infer that the surface layer controls the QBM periodicity and the upper levels control the ISO periodicity.

From the analysis of ABL characteristics associated with the different epochs of monsoon, it is found that the turbulent parameters are high due to the presence of organized convective clouds in the active monsoon situation and less during weak monsoon situation. The momentum transfer from the LLJ core to surface due to the

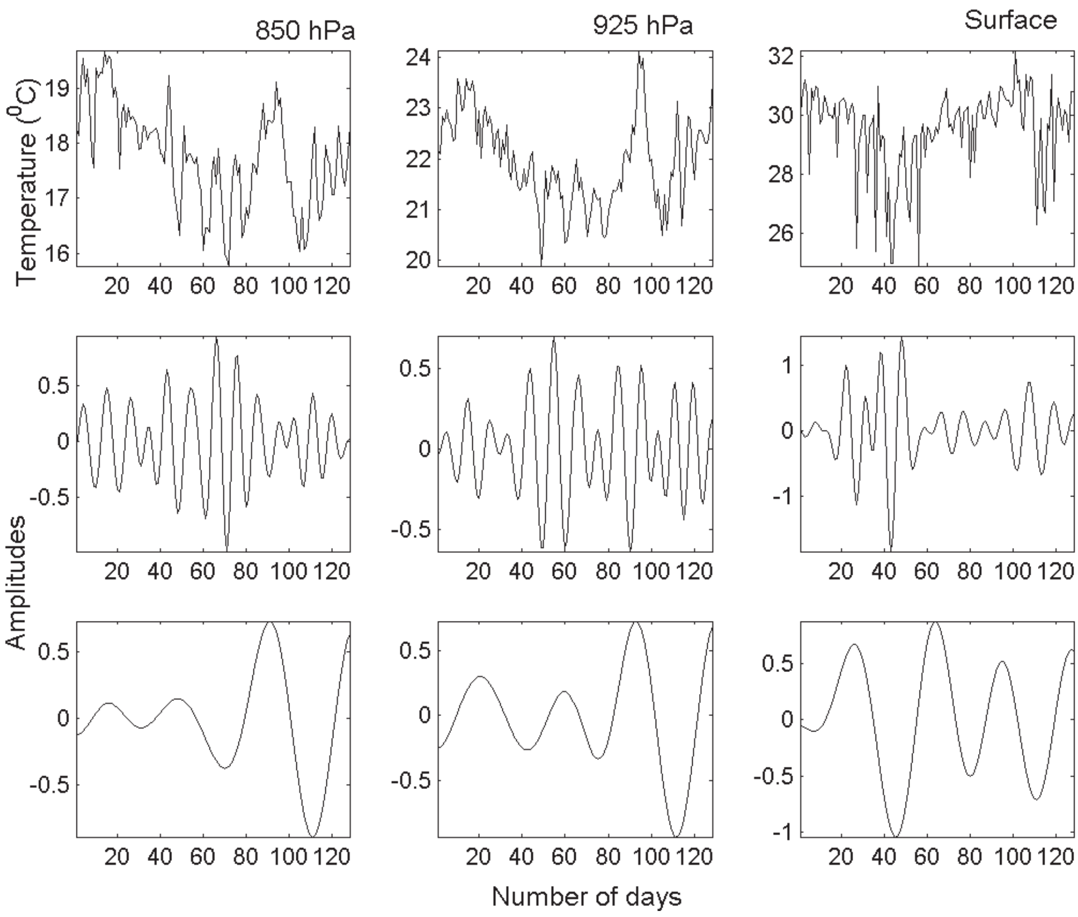

Figure.3 Wavelet analysis of the temperature at 850 hPa, 925 hPa and surface during southwest monsoon of 2002. The first row represents the original signal, the second row gives the harmonics of wind in the QBM band and the next is same for ISO band.

cumulus clouds and subsequent downdraft transfers the momentum over windward side while on the lee side, the momentum transfer takes place by the generation of large eddies by the heated land especially after noon. It is found that the thermodynamic parameters show variability during active and weak phases of monsoon. The prominent oscillations in the meteorological parameters in the surface layer are in the QBM and ISO bands. The amplitude of QBM dominates in the surface layer while ISO mode dominates in the 925 hPa and above.

Conclusion

It is found that the wind and temperature in the lower atmosphere show two dominant modes of oscillations: Quasi Biweekly Mode (QBM) and Intra Seasonal Oscillation (ISO). The amplitude of the QBM periodicity is more in the surface layer whereas in the upper level, the amplitude of the ISO mode dominates over the QBM. The predominant QBM mode in the surface layer parameters might be caused by the surface friction and that for ISO band in the upper level is associated with the intra seasonal oscillation embedded in the monsoon system.

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