Characteristics of vertical velocity observed during the passage of Tropical Mesoscale Convective systems (TMCS) using a VHF Radar

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Objective

To study the characteristics of Tropical Mesoscale Convective Systems(TMCS) and associated processes.

(i) Vertical velocity field

(ii) Tropopause weakening

(iii) Mass flux

(iv) Gravity waves

Introduction

The potential of VHF and UHF radars is to measure the three components of wind velocity (zonal, meridional and vertical) continuously with high temporal and height resolutions. So, they provide an opportunity to study highly dynamic convective systems and infer microphysical characteristics in a better way.

Extensive studies have been carried out on convective systems by many researchers using VHF and UHF radars at Gadanki [e.g. *Narayana Rao etal*.,1999;*Jain et al*., 2000; *Dhaka et al*., 2002; *Kumar et al*., 2004a,b; *Kumar*, 2006]. These authors show the characteristics of convective system over this tropical station.

In the present study, an effort has been made to characterize the vertical velocity Tropopause weakening and Gravity Waves during the passage of TMCS over Gadanki.

Data Analysis

For the present study observations are taken with the VHF radar located at Gadanki (13.5^{o}N, 79.2^{o}E). It is a pulsed coherent Doppler radar operating at 53 MHz with an average power aperture product of 7.7x10^{8} Wm^{2} (for detail see *Rao et al*., 1995].Two events are considered for the present study.

Case-I: July 19, 2005

Case-II: May 16, 2006

The height resolution for the present experiment is 150 m and the temporal resolution is ~48sec in case-I and ~1.3min in case-II.

Case-I:Results and Discussion

Figure 1 shows the height-time section of signal-to-noise ratio (SNR) (top panel) and spectral width (bottom panel) in zenith direction on July 19, 2005.

The intensity of turbulence is more from 22:30-22:45 IST as observed from height-time section of spectral width.

The SNR plot shows that the Signal is very weak during convection and after the passage of convective cell the strength of echo power increased to greater heights. It is also noticed that tropopause height is not well defined as generally observed by VHF radar, which is expected during convection. This may be weakening of the tropopause due to the occurrence of strong convection

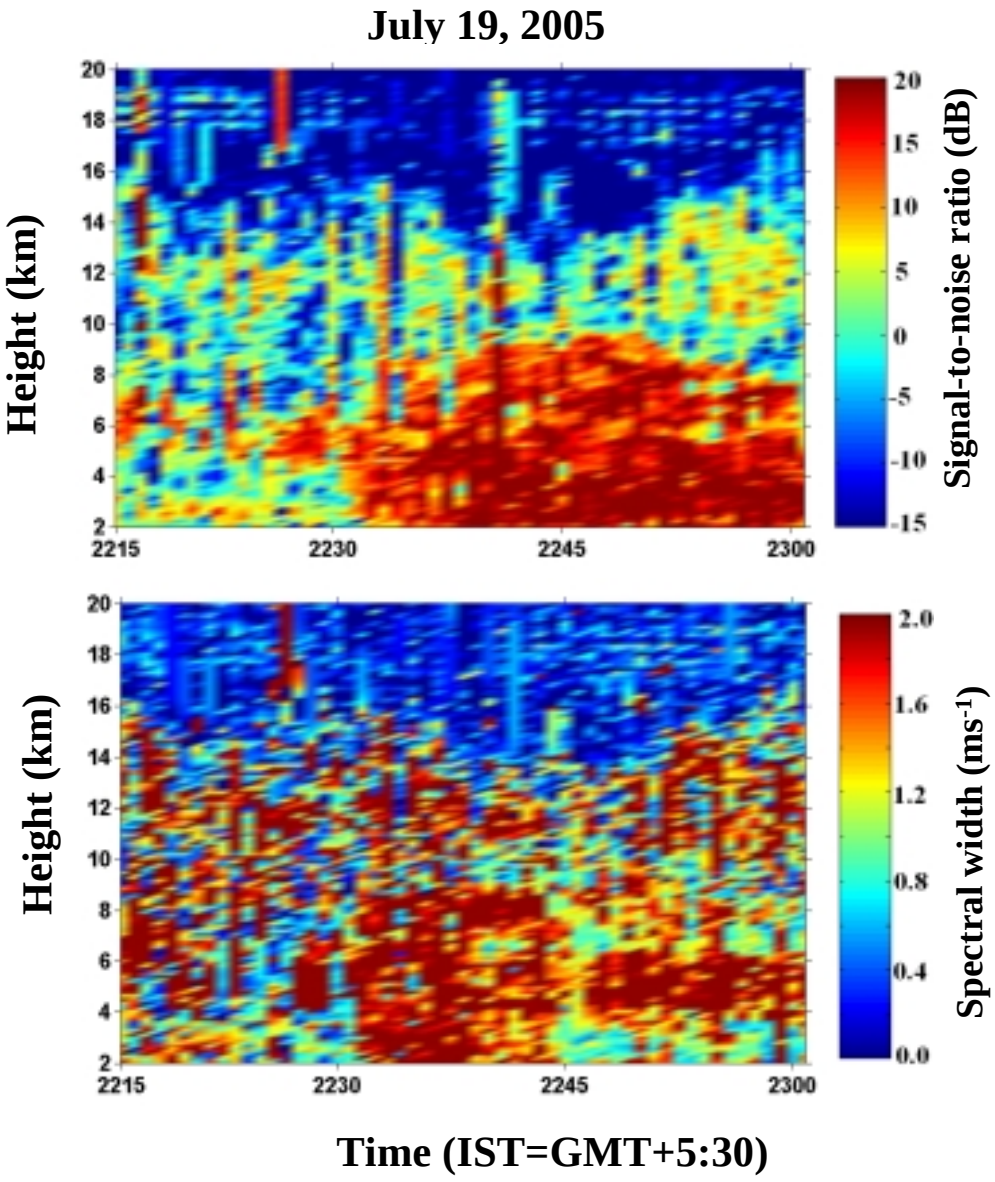

Figure-1

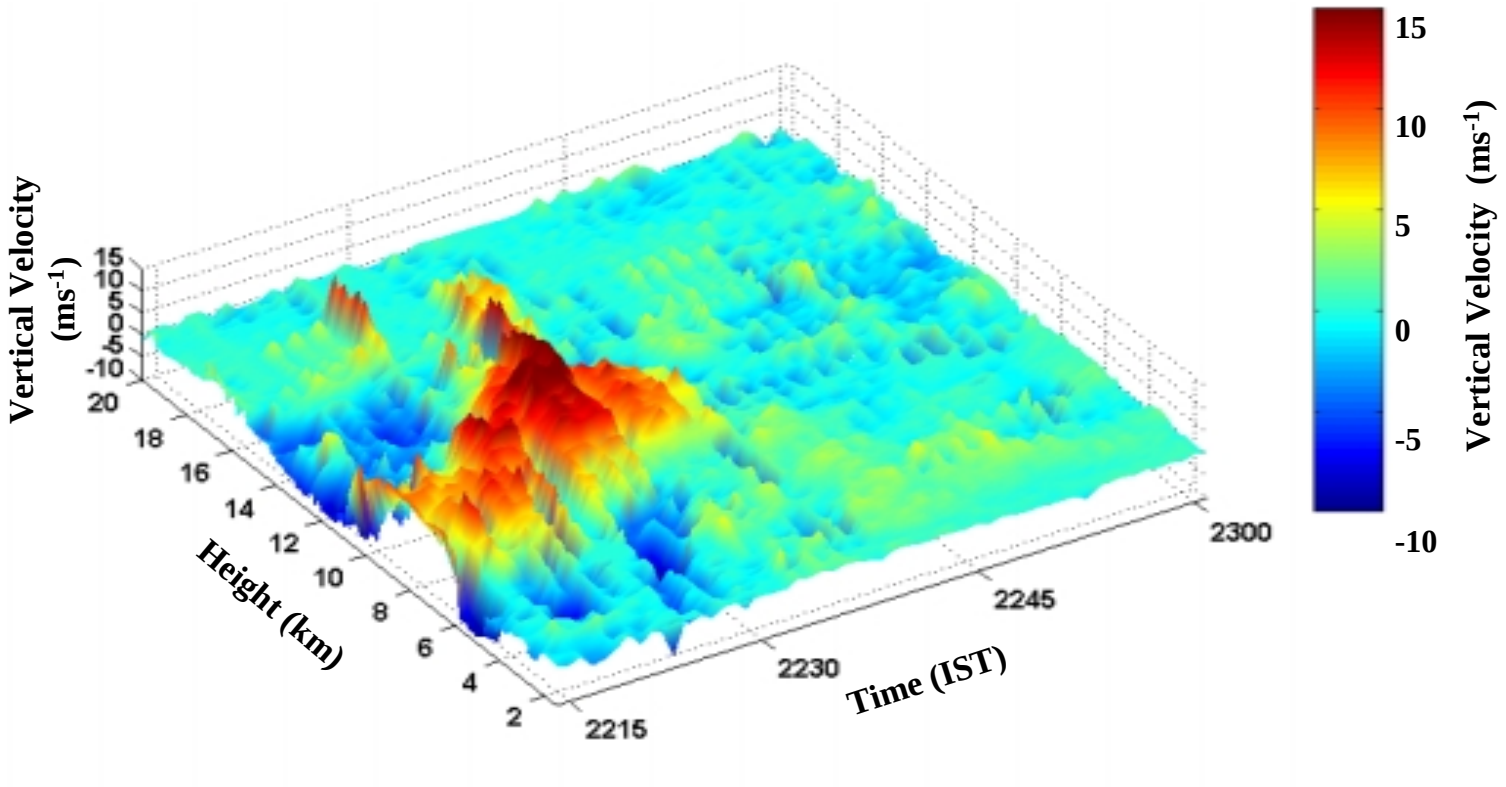

Figure-2

Figure 2 shows the height-time intensity plot of vertical velocity during convection. It clearly shows pairs of strong updrafts and downdrafts in the height range of 6-14 km. A single cell with vertical velocity of >15 ms^{-1} is observed in the height region of 10-14 km. However such magnitudes persists only for few minutes (~10 min), as revealed from the Figure. It is noteworthy that strong turbulence as observed from Figure 1 is seen in the vicinity of cores but not in the core.

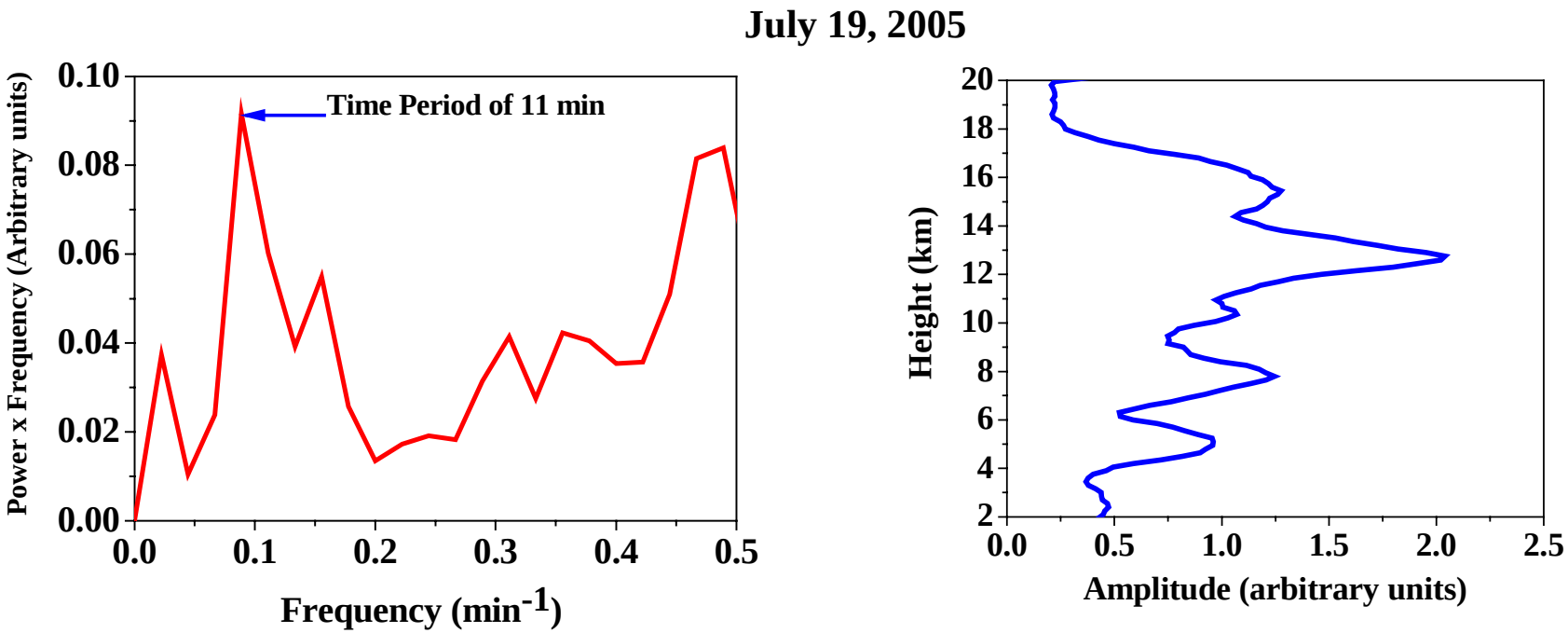

Figure-3

Figure 3 shows power spectrum (left panel) and amplitude (right panel) of vertical velocity perturbations averaged in the height range of 14.5-17 km. Dominant period as observed from the power spectrum plot is ~11 min, which lies in the periodicity of gravity wave spectrum. It can be seen from the figure that the wave amplitude increases with height upto 14km, then decreases perhaps due to dissipation of energy.

Case-II Results and Discussion

Figure 4 shows height-time section of signal-to-noise ratio (SNR) (top panel), spectral width (middle panel) and vertical velocity (bottom panel) on May 16, 2006. It is clearly seen from the figure that strong echo tops are going upto the height of 14 km during strong convection. During the passage of TMCS the radar tropopause is not clearly visible while after the passage of TMCS, the tropopause is seen clearly indicating that due to intense convection the tropopause weakens.

Spectral width shows the enhancement of turbulence activities during 17:15-18:50 IST on May 16, 2006. Enhanced turbulence activities are observed after the passage of TMCS.

The vertical velocity observed before and after convection are very less, whereas during the passage of convection it increases upto 15 ms^{-1}. After convection a strong downdraft is observed (3-4 ms^{-1}) which is well known aspect of convection.

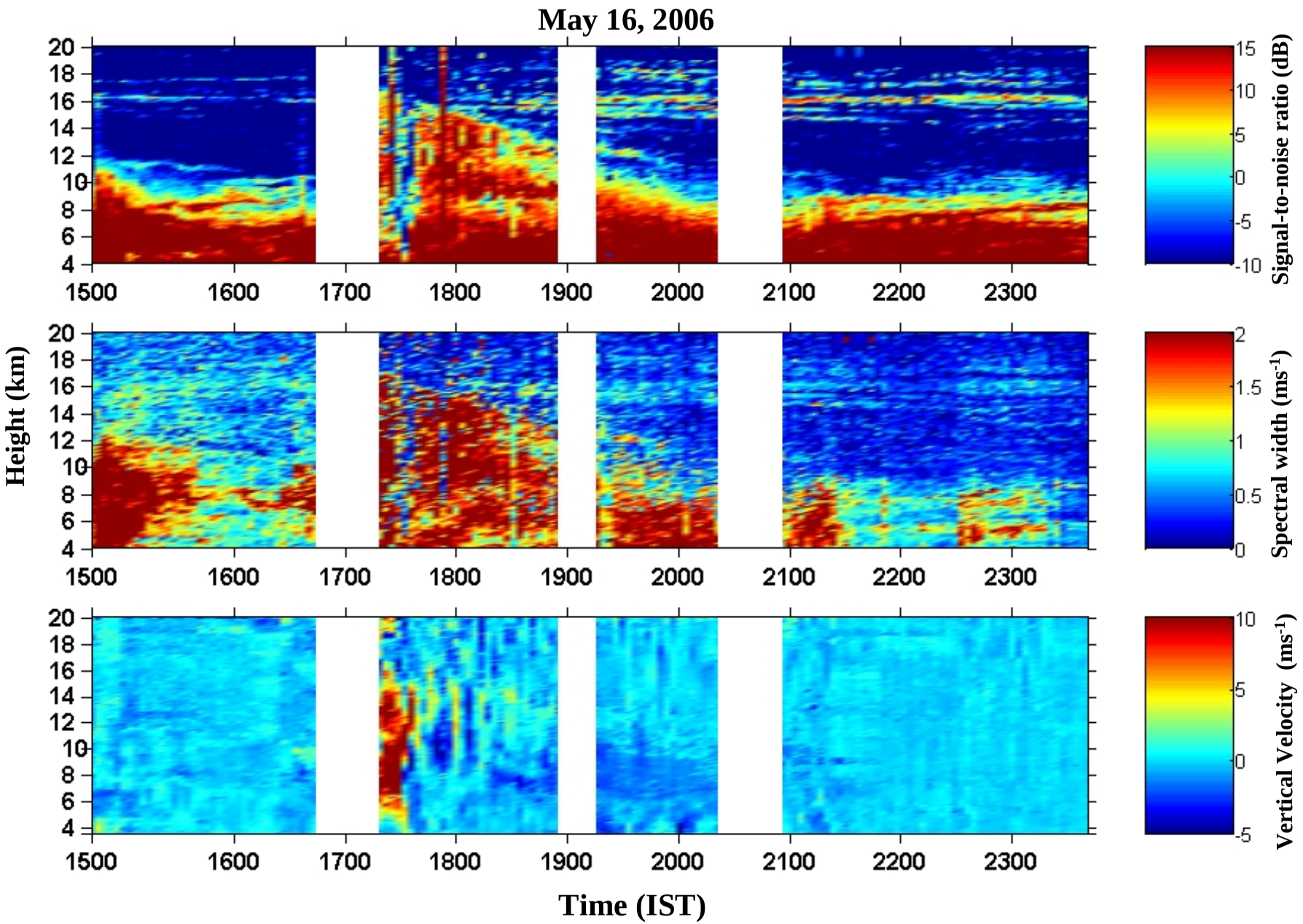
May 16, 2006
Height (km)
Time (IST)
Signal-to-noise ratio (dB)
Spectral width (ms-1)
Vertical Velocity (ms-1)

Figure-4

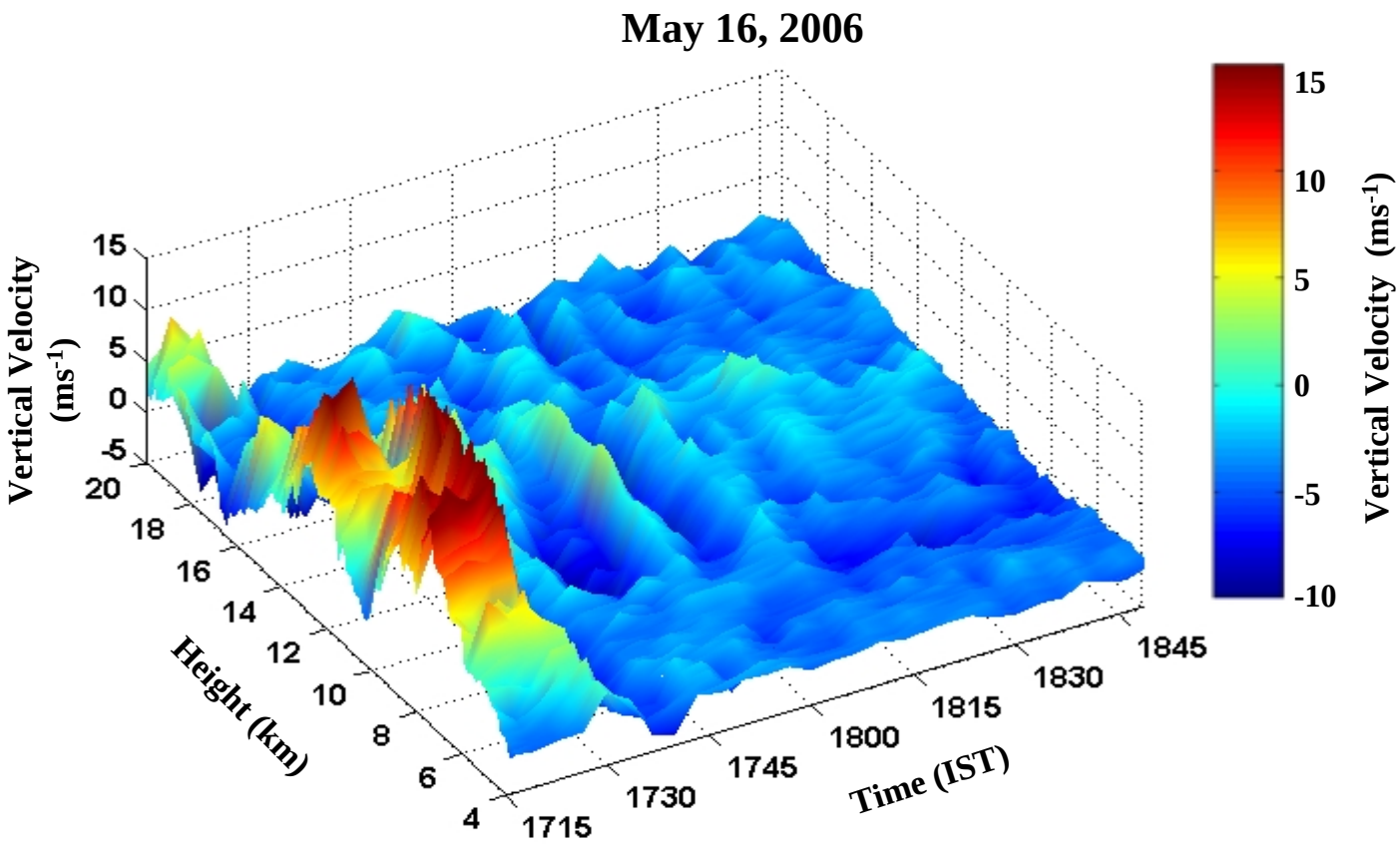

Figure-5

Figure 5 shows the height-time intensity plot of vertical velocity during convection. A single cell of vertical velocity ~15 ms^{-1} is observed in the height range of 10-16 km. In this case the strong updraft is observed till the height of 16 km thereby weakening the tropopause which is clearly seen from the intensity plot of Figure 4.

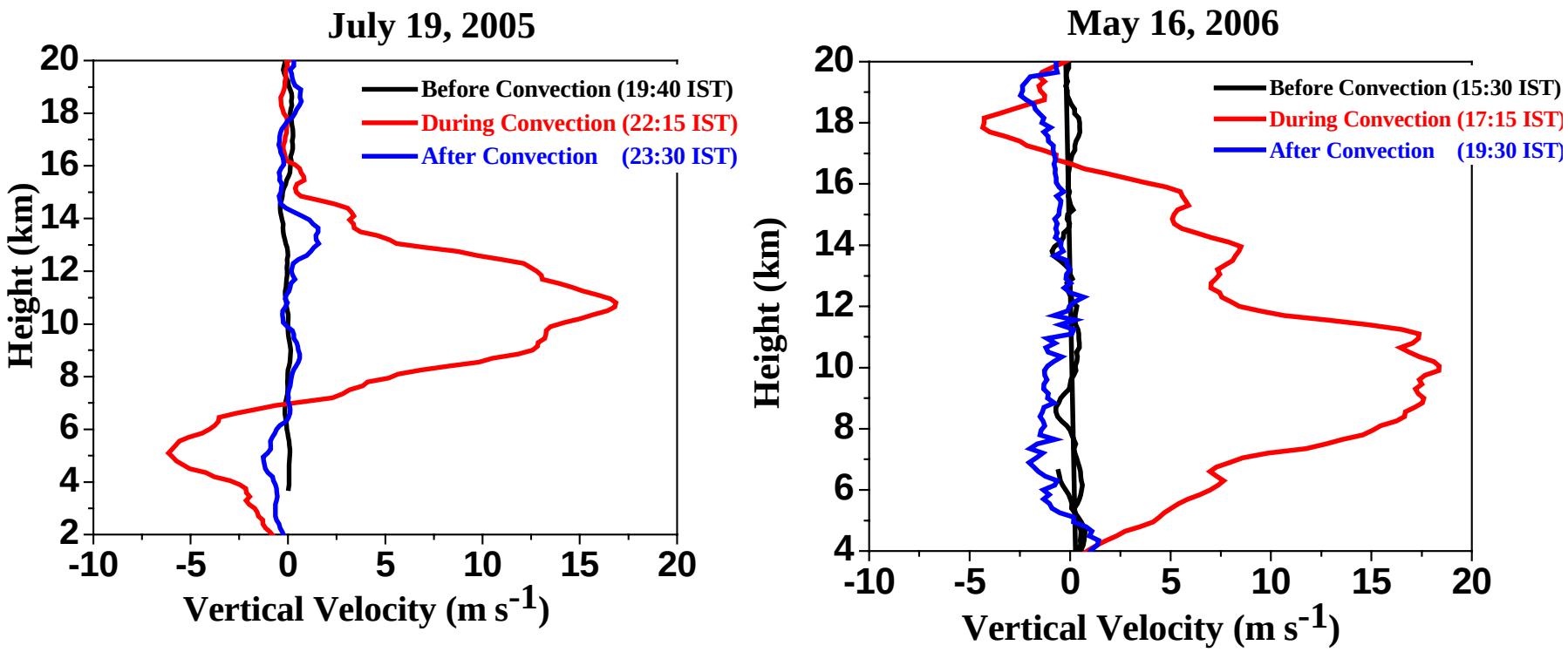

Figure-6

Figure 6 shows the height profile of vertical velocity before, during and after the passage of convective cell. This shows that the magnitude of vertical velocity before and after convection is less and during convection it goes upto 15-20 m/s. It should be noticed that after convection an oscillatory behavior is observed which may be due to convectively generated gravity waves.

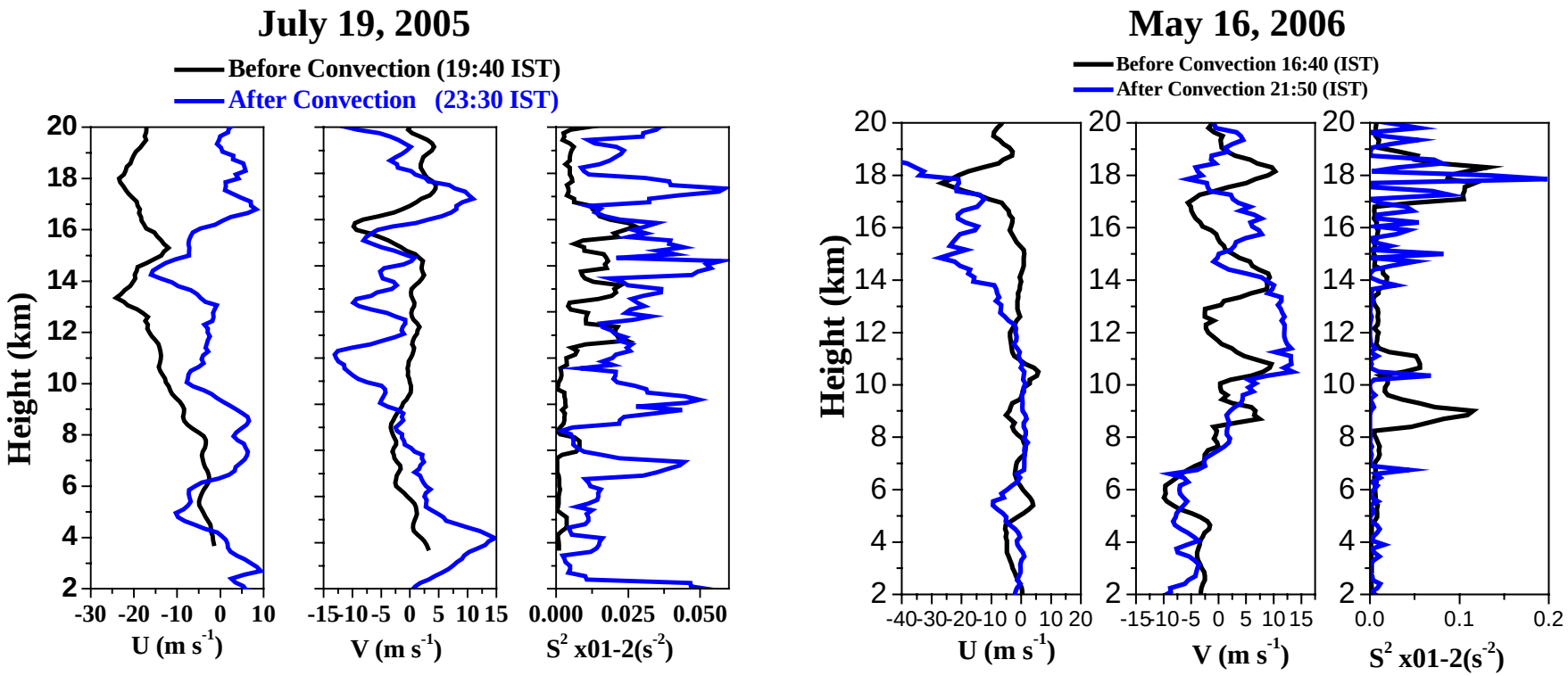

Figure-7

The characteristics of zonal, meridional and horizontal wind shear before and after convection are shown in Figure 7 for July 19, 2005 (left panel) and May 16, 2006 (right panel). The enhancement of the vertical shear of horizontal wind are observed in both the cases after the passage of convection, especially in the vicinity of tropopause.

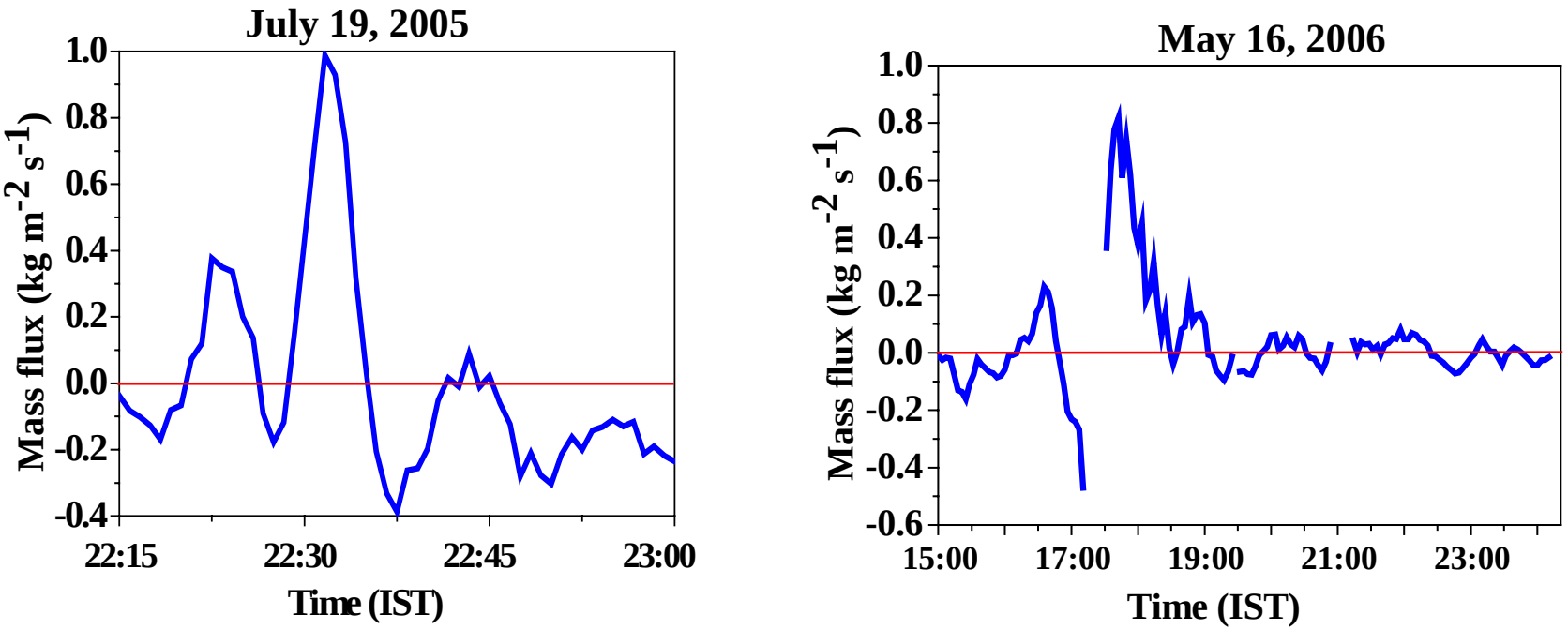

Figure-8

Figure 8 shows the time series plot of mass-flux at (16.05±300m) km on July 19, 2005 (left panel) and May 16, 2006 (right panel). Penetrative (Strong) convection is one of the major contribution for Stratospheric-Tropospheric Exchange (STE) and vice-versa. The Mass-flux is estimated for both the events. In both the events maximum mass flux of ~1.0 kg m^{-2} s^{-1} is observed during the passage of TMCS and after the passage, downward flux is observed. This transport contributes to the STE process. This may due to the weakening of tropopause associated with convection.

Summary & concluding remarks

The salient features of the observed convective system are as follows :

(1) Intense turbulence is observed with VHF radar located at Gadanki.

(2) It is also observed that during the strong vertical velocity, the radar signal strength is weak and once convection is in dissipation stage there is an enhancement in radar signal, which shows the turbulence activities.

(3) Wave like oscillation in the vertical velocity has been observed at upper troposphere and lower stratosphere (UTLS) region. Upward propagation is also observed in the wave oscillation.

(4) Power spectrum analysis shows the existence of ~11 min dominant periodicity in the vertical velocity perturbation at UTLS region.

(5) The amplitude of the dominant period goes on increasing from 2 km upto 14 km and then decreases.

(6) A single cell core of vertical velocity is observed at the height of 10-14 km of magnitude >15 ms^{-1}. Strong vertical velocity persists for ~10 min.

(7) **Strong pairs of updrafts and downdrafts are observed**

(8) **The tropopause is not well defined in the radar signal, which is the weakening of tropopause due to convection.**

(9) **Strong vertical wind shear of horizontal wind is observed after the passage of TMCS in the vicinity of tropopause.**

(10) **Enhancement in the mass-flux has been observed. The upward mass flux is observed during the intense convection, which shows the penetration of tropospheric air to stratosphere through the intermediate layer tropopause. This give rise to the STE processes.**

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