Radar Observation of Boundary Layer Wind Structure Associated with landfalling typhoons in China

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Abstract

The intensity of the TCs, often defined in terms of maximum wind speed or minimum sea level pressure, has yet not been well understood .The lack of comprehensive observations of wind intensity and structure in the lower troposphere, during landfall is one of the key problems.

The boundary layer (BL) is even more important on land. It will influence the track and intensity of the hurricane (Nolan et al. 2009). The complete knowledge of the structure of the boundary layer in rainband is therefore needed (Elsberry et al. 1992).This study examines, for the first time, the characteristics of BL wind structure associated with typhoons making landfall in South China from coastal radar-network observations using hurricane volume process (HVVP) technique (Harasti,2003).

Data being used are:

- Radar volume scan data is collected by radars at Yangjiang(YJRD) and Zhanjiang(ZJRD) with 6-minute intervals, and the rawinsonde is from China Meteorological Bureau(CMA).
- Careful manual QCs are done by NCAR SOLO software.
- The typhoon center is determined by GBVTD- Simplex algorithm [*Lee and Marks*, 2000].
- The HVVP is used to derive the vertical wind profile.

The four chosen typhoons move from South China Sea to Guangdong Province

near Yangjiang(YJRD) and Zhanjiang(ZJRD) radar(Fig.1 (a)). During the typhoon moving, the radar has been through the different parts of each typhoon. Fig.1 gives the typical Composite dBZ for Prapiroon(Fig.1 (b)), Vicente(Fig.1 (c)), Chanthu(Fig.1 (d)) and Koppu(Fig.1 (e)), arranged by the relative distance from typhoon center to the radar. So Basically the distant rainband in Prapiroon , inner core in Vicente and eyewall in Koppu and Chanthu have all been observed by radars. Therefore, the different structure of boundary layer in typhoons could be studied.

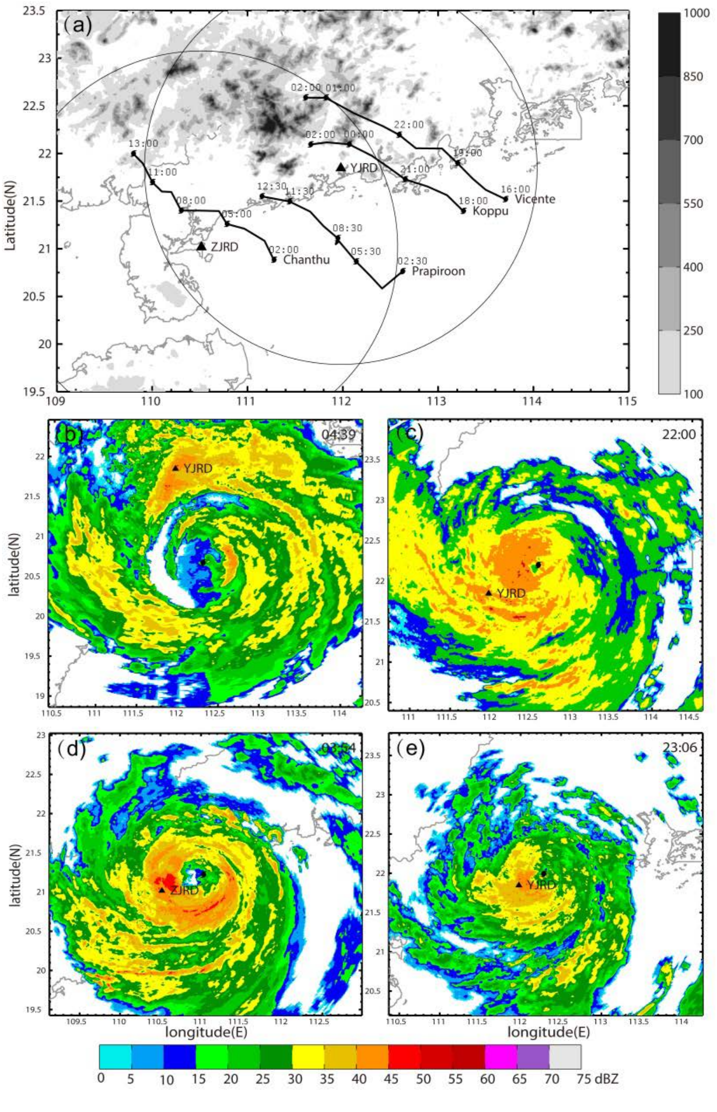

Fig.1 The four typhoons' path(a) and the typical horizontal structure time of each one's Composite dBZ (b for Prapiroon at 04:39 on 03 August in 2008, c for Vicente at 22:00 on 23 July in 2012, d for Chanthu at 03:54 on 22 July in 2010 , e for Koppu at 23:06 on 14 September in 2009).

The HVVP connects the estimated coefficients of a second-order Taylor series expansion of the wind field to the kinematic properties of the analytic datasets in a three-dimension volume. And the HVVP uses the data in a thin horizontal layer(that is the full azimuth occupied) instead of a conical volume data so the information of horizontal wind could be captured better. The comparison between HVVP deduced wind and GTS rawinsonde in Fig.3 shows that the retrieval wind is consistent with the observation.

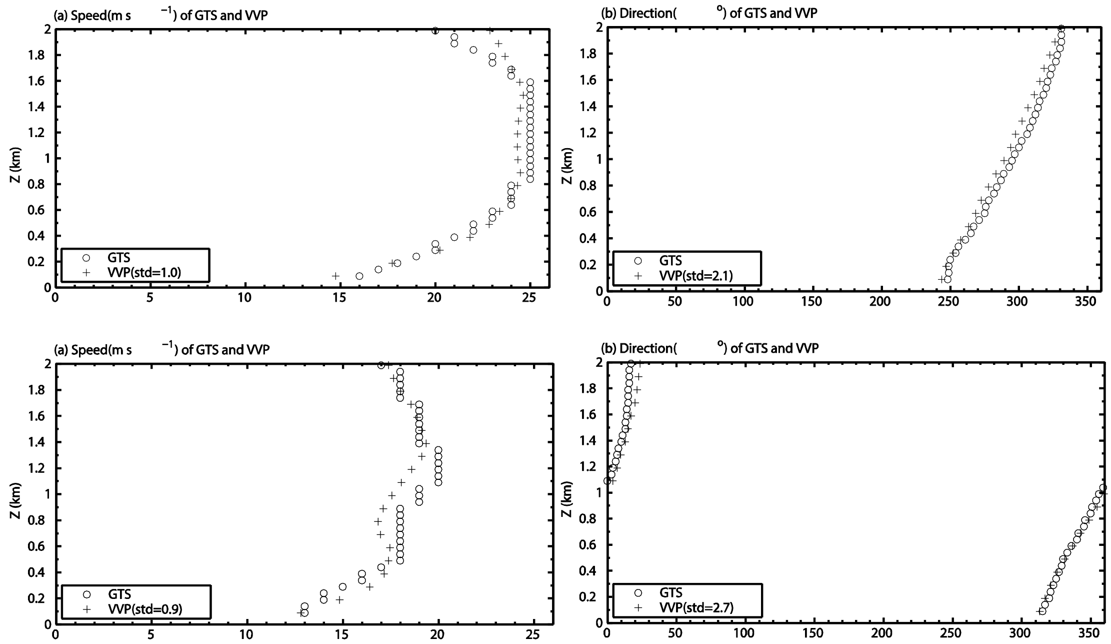

Fig. 3 The comparison of the radar retrieved wind and the rawinsonde observation on 07:16 22 July 2012（upper two) and 07:15 05 August 2009(lower two); (a) wind speed (b) wind direction) . STD is the standard deviation .

Due to the different path of each typhoon and the radar location, the distant rainband in Prapiroon(Fig. 4), primary rainband in Vicente(Fig. 5), eyewall in Chanthu(Fig. 6) and Koppu(Fig. 7) are observed by radar. The distant rainband in Prapiroon has a high inflow layer which means a deep boundary layer. Correspond with it, the height of maximum tangential wind is high. The inflow and tangential wind in primary rainband of Vicente are quite strong and stable. Eyewall in Chanthu and Koppu has a low inflow layer and decreasing height of maximum tangential wind. Notice that the height of maximum tangential wind show an obvious dropping trend with the decreasing distance to typhoon center.

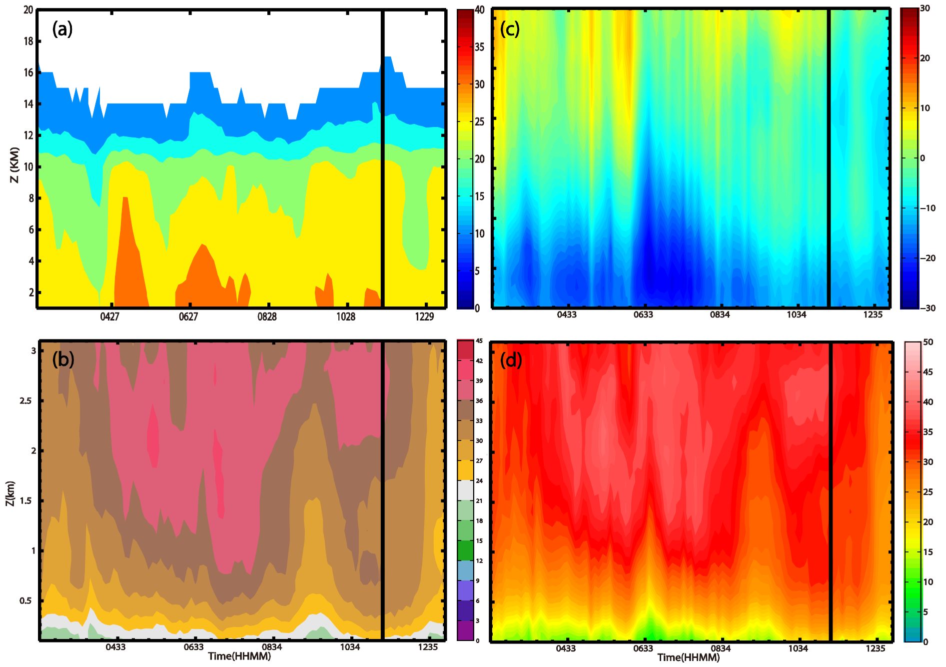

Fig.4 The temporal variation of vertical wind profiles for Prapiroon (a) dBZ; (b) WS, wind speed; (c) VR, radial inflow; (d) VT, tangential wind. The black solid line in each picture represents the time when typhoon landed.

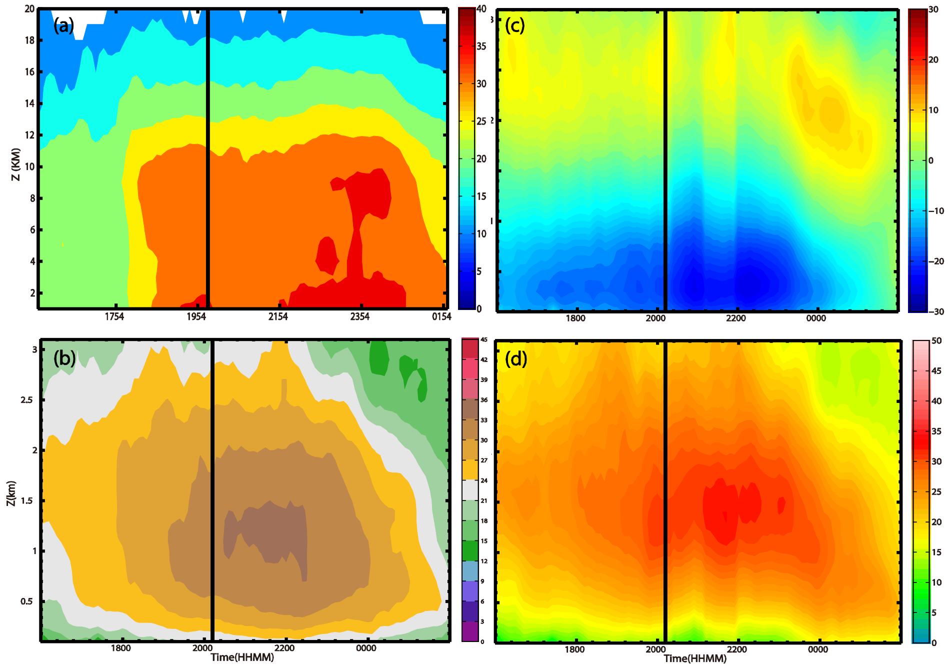

Fig.5 The temporal variation of vertical wind profiles for Vicente (a) dBZ; (b) WS, wind speed; (c) VR, radial inflow; (d) VT, tangential wind. The black solid line in each picture represents the time when typhoon landed.

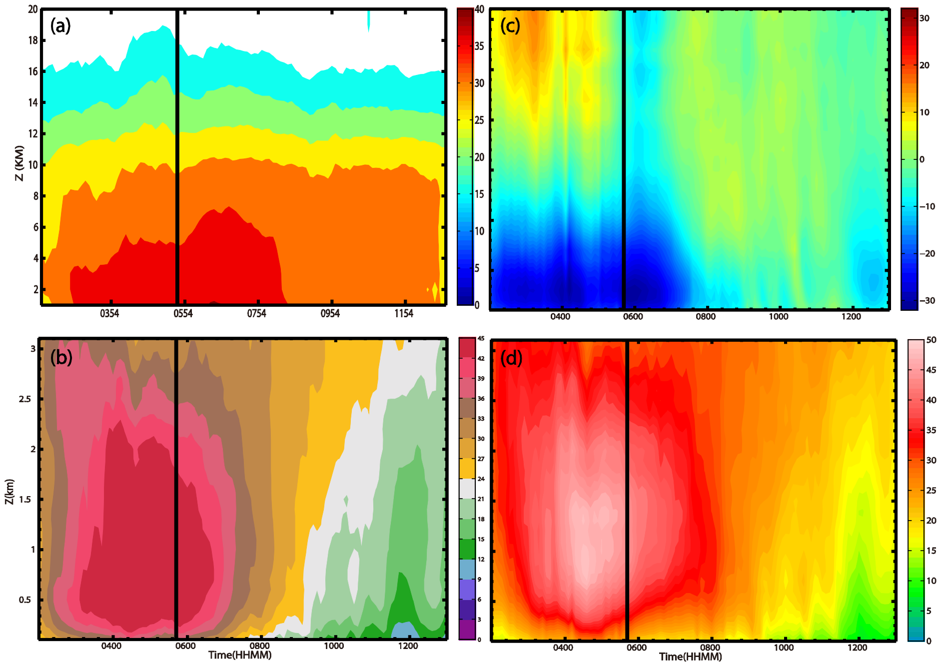

Fig.6 The temporal variation of vertical wind profiles for Chanthu (a) dBZ; (b) WS, wind speed; (c) VR, radial inflow; (d) VT, tangential wind. The black solid line in each picture represents the time when typhoon landed.

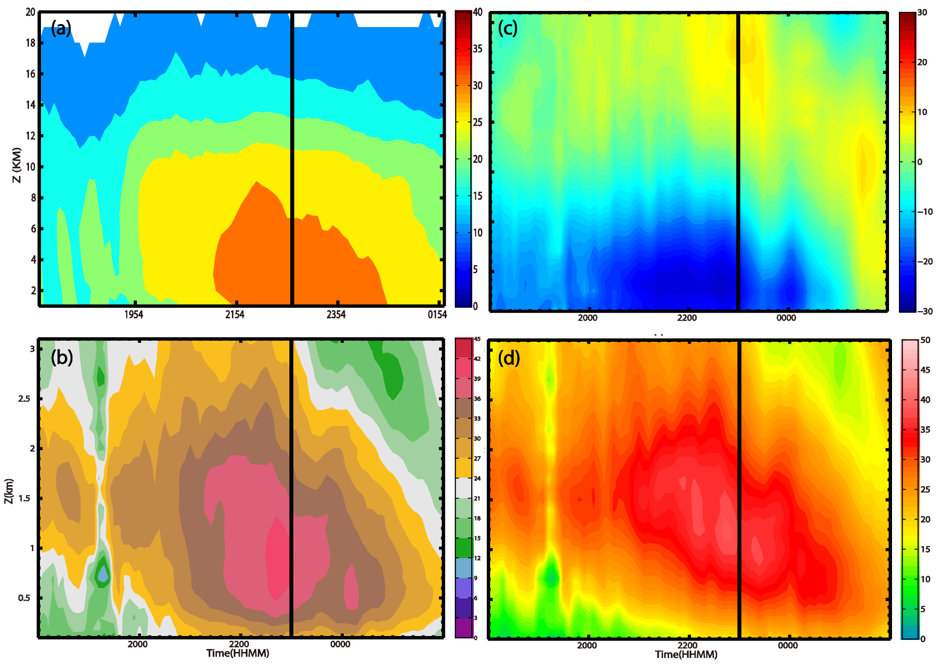

Fig.7 The temporal variation of vertical wind profiles for Koppu (a) dBZ; (b) WS, wind speed; (c) VR, radial inflow; (d) VT, tangential wind. The black solid line in each picture represents the time when typhoon landed.

To understand the profiles in different part of typhoon more clearly and directly, normalize the VR(left) and VT(right) with the wind in 3 km and plot them into one picture(Fig. 8).Obviously the height of maximum tangential wind and zero inflow decrease with the reducing distance as mentioned above. And jet in eyewall is 100% greater than the wind in 3 km while the jet in primary rainband is 20~40% greater than the wind in 3 km.

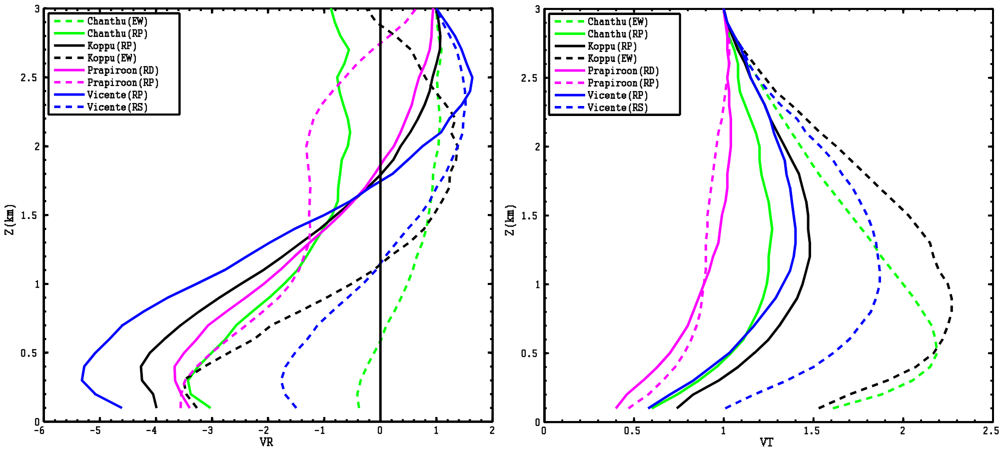

Fig. 8 The mean vertical wind profiles (left VR, right VT) for Chanthu(green), Koppu(black), Prap iroon(megenta), and Vicente(blue). The RD, RP, RS, EW represent distant rainband, primary rainband, secondary rainband and eyewall.