3C.6 EYEWALL CONTRACTION, BREAKDOWN AND REFORMATION IN A LANDFALLING TYPHOON

Kun-Hsuan Chou[1] Chun-Chieh Wu[1] Yuqing Wang[2]

[1]Department of Atmospheric Sciences, National Taiwan University

[2]International Pacific Research Center, School of Ocean and Earth Science and Technology, University of Hawaii at Manoa, Honolulu, USA

Satellite images show that during the period when Typhoon Zeb (1998) devastated Luzon, its eyewall shrank before landfall (compare Fig. 1a, b), and then its inland portion disappeared likely due to the terrain effect and the masking of the high cloud (Fig. 1c). A few hours later, a wider eyewall reformed (Fig. 1d, e) as Zeb left Luzon and the eyewall contracted as it moved along the east coast of Taiwan (Fig. 1f). It is worth studying the dynamical mechanisms that control such eyewall evolution through a high-resolution numerical model.[1]

A triply nested MM5 model with 45/15/5-km resolution was used to perform a 72h simulation, starting from 1200 UTC, 13 October, 1998. The main features of eyewall contraction, breakdown and reformation processes during the period when Zeb was near Luzon are well simulated. As shown in Fig. 2a, b, the model estimated radar reflectivity at 700mb indicates that the eye size shrinks during the first 12h as Zeb approaches Luzon. Different from the satellite images in Fig. 1c, during the first few hours after Zeb making landfall at Luzon, the eyewall structure remains clear (Fig. 2c). The eyewall structure gradually breaks down while the inner rainband becomes less organized in the next few hours (Fig. 2d). Finally, interesting enough, the outer rainband gets organized and a large eyewall forms (Fig. 2e) when Zeb re-enter the warm ocean, and then contracts again (Fig. 2f) as it re-intensifies.

Fig. 3a indicates that the radius of maximum wind (RMW) reduces from 58 km at initial time to 48 km at 12h, the time before the eyewall makes landfall. The maximum mean azimuthal flow also weakens from 65 to 55 ms^{-1}. Another notable feature is the weakening of the outer circulation (e.g., the radius of 40-ms^{-1} wind decreases from 110 to 100 km) during this period. Such a tendency continues until 24h when Zeb leaves Luzon. The RMW increases with time between 24 and 36h while the intensity remains unchanged. However, from 36 to 48h, Zeb reintesifies with a maximum azimuthal wind of 60 ms^{-1} while the RMW decreases. All the above processes are generally consistent with the evolution of the mean radial inflow (Fig. 3b) and radar reflectivity (Fig. 3c).

We have also calculated the momentum budget similar to the analysis of Persing et al. (2002) and Wang (2002). As shown in Fig. 4a, both in the first 24h and during 36-51h when the strong circulation is present at the eyewall region, very large transport of azimuthal momentum by the mean inflow is apparent, with the maximum value just inside the RMW. Meanwhile, only a small portion of the above momentum transport is offset by the eddy flux (Fig. 4b), indicating that eddies (asymmetric motion) played a second role in causing the evolution of the simulated typhoon eyewall. As a result, the summation of the mean and eddy fluxes (Fig. 4c) shows a pattern similar to that in Fig. 4a.

Note that during the initial 5h the increase in RMW and decrease in maximum azimuthal wind of the simulated storm (Fig. 3a) are due to the lack of the model planetary boundary layer at the initial time. Over land, while the size of the eye keeps shrinking (Figs. 2b, c) and a positive tendency of azimuthal momentum (Fig. 4c) is present, the maximum wind actually decreases with time mainly due to the increased surface friction.

In summary, this study contains an interesting numerical simulation on the eyewall evolution of Zeb as it encountered the terrain of Luzon. Detailed analyses and budget calculation also reveal how the eyewall contracts, breaks downs, reforms, and contracts again, and how such eyewall evolution affects the intensity of the storm.

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Corresponding author address: Chun-Chieh, Wu, Dept. of Atmospheric Sciences, National Taiwan University, 61, Ln. 144, Sec. 4, Keelung Rd., Taipei 10772, Taiwan. e-mail: cwu@typhoon.as.ntu.edu.tw

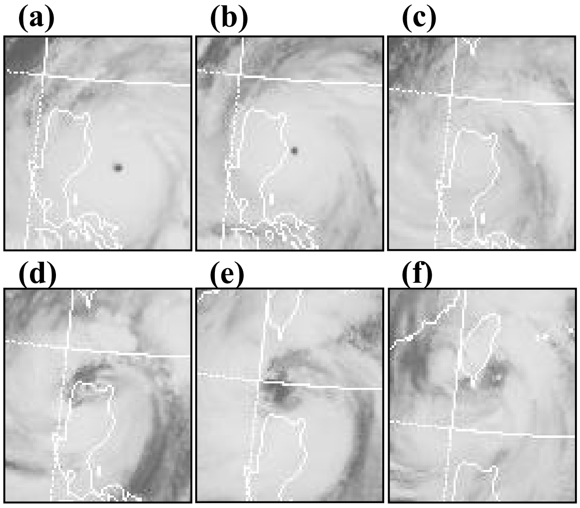


Fig. 1. GMS satellite IR images: (a) 1800 UTC 13 Oct. ;(b) 0000 UTC 14 Oct. ;(c) 0600 UTC 14 Oct. ;(d) 1500 UTC 14 Oct. ; (e) 0300 UTC 15 Oct. ; (f) 1500 UTC 15 Oct.

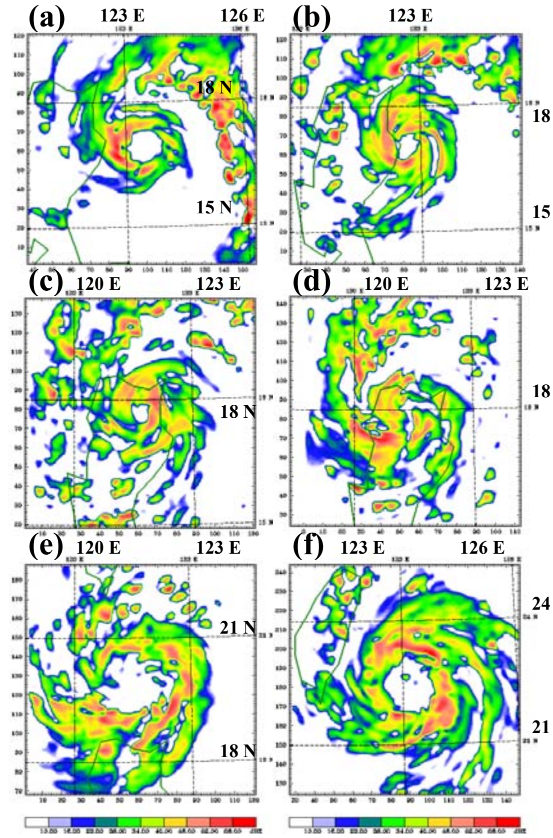
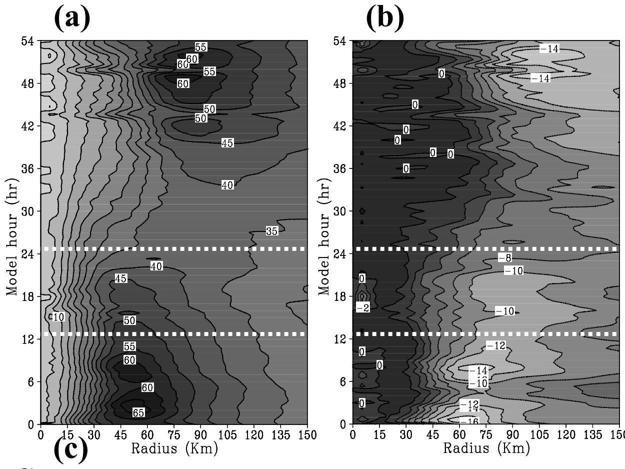


Fig. 2. Same time as Fig. 1, but for model simulated radar reflectivity (dBZ) at 700 mb: (a) 6h; (b) 12h;(c) 18h;(d) 27h; (e) 39h ; (f) 51h.



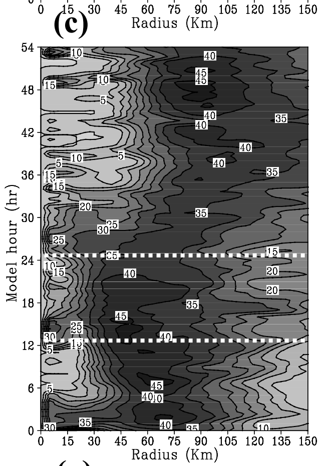
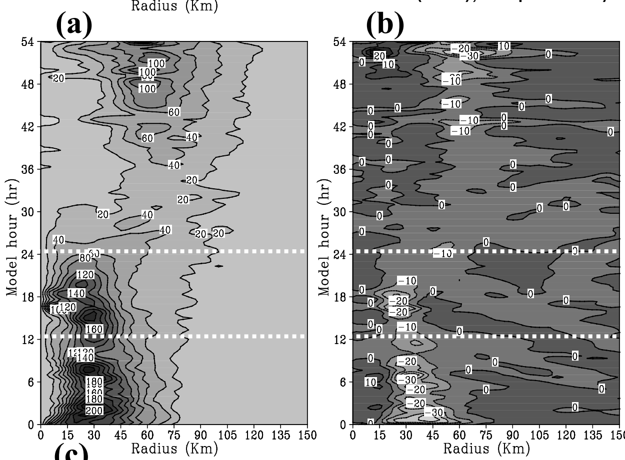


Fig. 3. Radius-time Hovmöller diagram of azimuthal average at 925 hPa from 1200 UTC 13 to 1800 UTC 15 Oct 1998 (model hour from 0 to 54 h): (a) tangential wind (m s^{-1}); (b) radial wind (m s^{-1}) ; (c)Radar reflectivity (dBZ). The white-dot lines show the time when Zeb makes landfall (12h) and leaves Luzon (24h), respectively.



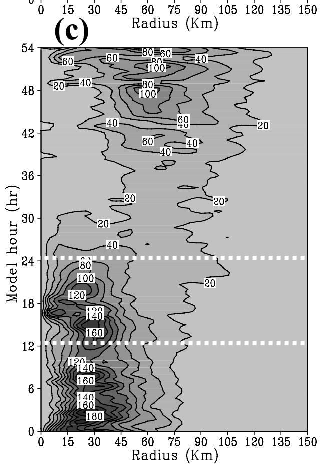


Fig. 4. As Fig. 3., but for angular momentum budget ($m^2 s^{-1} day^{-1}$): (a) Advection of relative angular momentum by the mean radial-vertical circulation; (b) eddy flux divergence of relative angular momentum; (c) summation of (a) and (b).