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A study on the Orographic Effects on the Movement of Typhoon Haitang (2005) in East of Taiwan

T.-C. Yeh*, L.-F. Hsiao, D.-S. Chen, and K.-N. Huang
Central Weather Bureau, Taipei, Taiwan

1. Introduction

Tropical cyclones pass over a mesoscale mountain range, the motion, the intensity and the structure can be significantly modified by the topography. Such a phenomenon is often observed in the Central Mountain Range (CMR) in Taiwan and in the Luzon island in Philippines. Among the studies, Wang (1980) summarized several scenarios of the tropical cyclone track modification by the CMR after examining 120 tropical cyclones that threatened Taiwan between 1949 and 1977. With numerical model simulations, Chang (1982), Bender et al. (1987), Yeh and Elsberry (1993), Lin et al. (2005), and others have explained the mechanism cause the track and the structure changes.

Two very interesting cases were included in the Central Weather Bureau's database of the tropical cyclone tracks near Taiwan. The detailed analysis of the center location shows both Typhoon Mary (1965) and tropical cyclone Polly (1993) made loops before landfall at eastern Taiwan. In July 2005, the westward moving Typhoon Haitang also made a loop before landfall on Taiwan. Such kind of track change has not been studied and verified whether it is due to the Taiwan orographic effect. Since the previous studies explained the effect of the barrier to the impending tropical cyclone are based basically on blocking effect and on heating inducing cyclonic flow. The tropical cyclone motions due to those effects are shown either be deflected sideward or accelerated/decelerated in the moving direction. The looping, with backward movement, of the impending cyclone could not simply be explained by the already known mechanisms.

2. The track of typhoon Haitang

Typhoon Haitang moved with a smooth track before it moved to the east of Taiwan at 18 UTC July 17. With the high resolution of radar observations, the Central Weather Bureau was able to show that Haitang made a loop near the east coast of Taiwan prior to made landfall. The center turned southwestward by 21 UTC July 17 and followed by an eastward turn by 00 UTC July 18. The center then looped northward at 03 UTC before it moved westward at 06 UTC July 18.

3. Model simulation

The NFS, an operational limited area model at Central Weather Bureau, was able to prediction a similar track of Haitang with initial fields at 12 UTC July 17 (figure 1). To examine the effect of Taiwan orography to the motion of Haitang, simulations were conducted. The simulation 'tp0' is similar to the operational forecast except that the model terrain height of Taiwan Island is set to zeros at the initial time of 12 UTC July 17. The simulation 'tp024' is similar to 'tp0' except that the model terrain height of Taiwan Island is set to zeros starting from 4 update cycles (24 hours) prior to the forecast initial time of 12 UTC July 17. The simulated track of Haitang follows a smooth curve when the terrain of Taiwan Island is removed in 'tp024'. However, the simulated track of Haitang from simulation 'tp0' is similar to the NFS operational forecast. We found that, the initial fields in 'tp0' include the terrain-induced perturbations although no mountain was included during the time integration. When a small part, over southern Taiwan and the nearby ocean, of the initial field of 'tp024' is replaced by 'tp0', the simulated track is similar to simulation 'tp0'. Therefore, the cyclonic loop of Haitang in east of Taiwan is shown due to the orographic effect of the mountain range of Taiwan.

The piecewise potential vorticity inversion analysis shows (figure not included) that the contributions of the middle latitude trough and the subtropical height to the motion of Haitang are northward and northwestward, respectively, and are very steady during the period of 12 UTC July 17 to 12 UTC July 18. The piecewise potential vorticity inversion analysis also shows that the contribution to the backward movement, therefore looping, of Haitang is contributing from the lower levels and inside the cyclone. We found that the Taiwan terrain induced a small-scale cyclonic vortex in leeside of the terrain. The induced small-scale perturbation vortex is relatively weak compare to the typhoon vortex and can only be identify from the fields when the typhoon vortex is removed. The perturbation vortex then sheds off from the terrain along the cyclonic flow of Haitang.

* *Corresponding author address:*
T.-C. Yeh yeh@cwb.gov.tw
Central Weather Bureau
64 Gong Yuan Road, Taipei, Taiwan.

By tracking the center of Haitang and the center of the perturbation vortex, we found that the two systems interact with each other similar to the motion of the binary vortex interaction (figure 2). Details will be given in the Conference.

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References

Bender, M. A., R. E. Tuleya, and Kurihara, 1987: A numerical study of the effect of island terrain on tropical cyclones. Mon. Wea. Rev., 115, 130-155.

Chang, S. W., 1982: The orographic effects induced by an island mountain range on propagating tropical cyclones. Mon. Wea. Rev., 1255-1270.

Lin, Y.-L., S.-Y. Chen, and C. M. Hill: 2005: Control parameters for the influence of a mesoscale mountain range on cyclone track continuity and deflection. J. Atmos. Sci., 62, 1849-1866.

Wang, S.-T., 1980: Prediction of the behavior and strength of typhoons in Taiwan and its vicinity. Research Report 108, National Science Council, Taipei, Taiwan, 100pp. (in Chinese.)

Yeh, T.-C., and R. L. Elsberry,1993: Interaction of typhoons with the Taiwan Orography. Part II: Continuous and discountinuous tracks across the island. Mon. Wea. Rev., 121, 3213-3233.

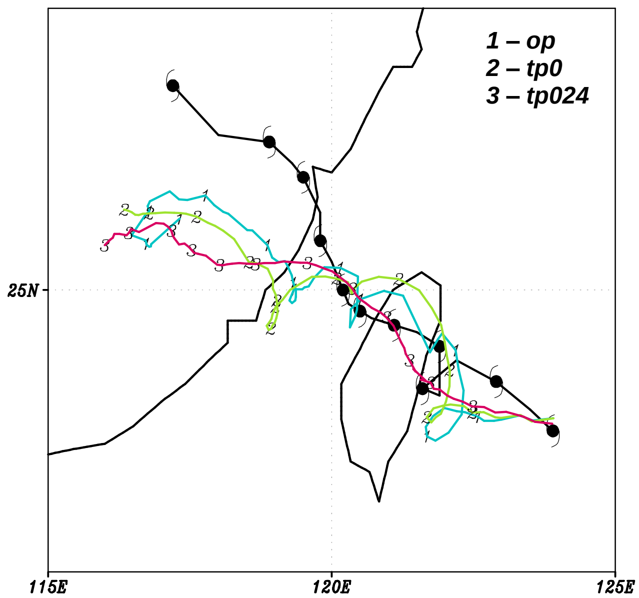

Figure 1. The best track and the model simulated tracks of Typhoon Haitang at 12 UTC July 17.

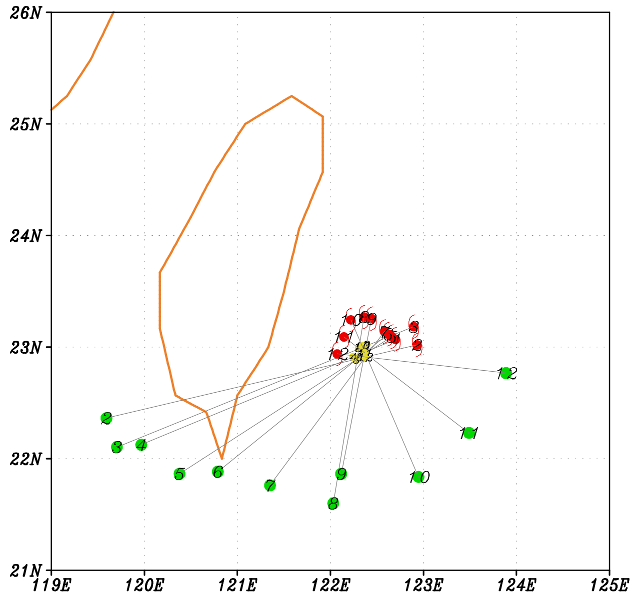

Figure 2. A diagram shows the binary interaction of Haitang (centers in reds and closer to each others) with the perturbation vortex (centers in greens). The centers are plotted with background at 19 UTC July 17 and the mean velocity of 3 m/sec easterly is removed.