ON THE INTERACTION OF BINARY TYPHOON SYSTEMS WITH MM5

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1.INTRODUCTION

Track forecasting of tropical cyclones (TC) has been regarded as one of the most difficult challenges in the western North Pacific. Track anomalous are often occurred in this region, especially when two or more tropical cyclones coexisted. Multi- or binary tropical cyclones existing simultaneously over this region has a high frequency as 7.4 cases per year (Hsiao, 2000). Their interactions may cause sharp changes of tracks, intensities and moving speeds.

Laboratory experiments demonstrated that the relatively rotated binary vortices would merge or move away depending on the separation distance, the storm structures and intensities (Fujiwhara, 1921). The impacts of interaction on the change of tracks is found to be larger than that of the environment steering when the separation distance is less than six latitudes (Dong and Neumann, 1983). The position of typhoon pairs is an important factor to influence this kind of interaction (Liu, 1983; 1986). Rossby wave dispersion from the peripheral anticyclone would produce poleward and equatorward steering to the west and east typhoons' of the binary system, respectively (Carr and Elsberry, 1995). Carr and Elsberry (1997) proposed four conceptual modes to classify the interaction of binary tropical cyclones: (i) direct interaction, including one-way influence, mutual interaction and merger modes; (ii) semi-direct interaction; (iii) indirect interaction and (iv) reverse-oriented monsoon trough formation.

Many theoretical and numerical studies were performed to investigate of interaction of binary tropical cyclones (Chang, 1983; Liu, 1983, 1986; Pokhil, 1991; Chan and Law, 1995; Falkovich et al., 1995; Wang and Holland, 1995; Khain, 2000; Kuo et al., 2000). By the use of a 3-D baroclinic model with a prescribed heating function, Chang (1983) found that the attraction between binary storms occurred at greater separations than in a barotropic model and lower tropospheric inflows associated with the secondary circulation of the tropical cyclones induce the mutual attraction. Lander and Holland (1993) made a conceptual model to study the direct interaction of binary tropical cyclones and to account for the key prediction associated with the grasp of capture and release. Wang and Holland (1995) conclude that the divergent component of winds is responsible for the mutual attraction of storms. Falkovich et al. (1995) studied the interaction of two tropical cyclones using a coupled atmosphere-ocean model and found positive vorticity between binary storms is favorable but not sufficient condition for attraction. Khain et al. (2000) utilized an improved version of the coupled tropical cyclone-ocean model for several idealized cases and identified several regimes of binary storm interactions, depending on the initial separation distance and the difference in storm strengths. They also clearly indicated the importance of utilization of realistic convective parameterization and background flow in the model. So a better model with detailed physical processes should be used when to simulate realistic cases of binary tropical cyclones.

NCAR/Penn State Fifth-Generation Mesoscale Model (MM5) has been widely used for a broad spectrum of theoretical and real-time studies (Grell et al., 1995). It includes a non-hydrostatic dynamics, multiple nesting capability, and a four-dimensional data assimilation capability as well as detailed physics options, and portability to a wider range of computing platforms. It should be a good tool to study the problems we considered. In this paper MM5 is used to simulate a case of binary typhoons (Bopha and Saomai) occurred in September 2000 and to discuss the interaction of binary typhoons by taking off one typhoon circulation of the system.

2. SYNOPTIC ANALYSIS AND MODELLING

Typhoon Saomai and Bopha coexist in western North Pacific after Bopha forming at 0000 UTC, 6 September 2000. Typhoon Saomai results in severe disaster with heavy rainfall and winds in Japan and Korea. On 9 September, typhoon Bopha turned southward suddenly due to the interaction with Saomai. The objective diagnosis shows that mutual interaction of this binary system is mainly determined by the Fujiwhara effect, in which both TCs experience significant counterclockwise rotation. This direct interaction has pronounced effects on this typhoon pairs and makes their tracks abnormal. The role of the steering flow is weak during the period, It provides typhoon Saomai a favorable mechanism of development, which makes the separation distance decrease and the interaction between them intensified (Hsiao and Liu, 2001).

MM5 is used to simulate the motion of this binary system. The domain is divided into 141×94 grids in horizontal direction with 45km resolution, covering from 110°E to 160°E and 5°N to 40°N. Kain-Fritsch scheme, Blackadar PBL scheme and simple-ice scheme are adopted for cumulus parameterization, boundary and explicit moisture process, respectively. The initial data is NCAR/NCEP 1°×1° reanalysis data.

Four experiments are designed to exhibit the ability

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of MM5 in simulating a binary system. The simulation results show that MM5 has predicted the abnormal track of typhoon Bopha for 72 hours, successfully. For four experiments indicated that MM5 model has good ability to simulate the interaction of binary tropical cyclones, as the influence of environment flow is weaker, especially for equatorward deflection. In addition, the typhoon over the South China Sea also somewhat effect on Bopha, especially for the last stage of lifetime. However, the simulation of Pacific high couldn't be control well and induced the forecast error increased with the integration elongation.

Another simulation experiment is to distinguish the contribution of the steering and the mutual interaction. In it we remove the circulation of typhoon Saomai. The method of removing typhoon circulation is to replace each grid with the maximum geopotential height within typhoon circulation from surface to 200hpa, so do the wind field.

Comparing the results with control run we can see the interaction of binary typhoons is produced from the velocity field. In addition, interaction of binary typhoons indeed decreases typhoon acceleration. On the other hand, the moving direction also induces the lager rotation. In this case, the change of the velocity is lager than the direction. This interaction causes the intensity of typhoon Saomai decreases and the other typhoon develops, which is determined by the synoptic pattern. However, the situation would be much different when with the sharply variation of the environment flow.

4. SUMMARY

The study focuses on the interaction of binary typhoons and its impacts on the typhoon motion. The MM5 model is successful predicted the abnormal track of typhoon Bopha for 72 hours in this binary case. Based on the well prediction, the design of removing typhoon Saomai's circulation is adopted to further realize the interaction between binary typhoon by MM5 model. The results show the interactions would induce typhoon Bopha accelerative motion and larger rotation. On the other hand, interactions also cause the intensity of typhoon Bopha decrease except for the sharply variation of environment flow.

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