17B.2 BINARY INTERACTION BETWEEN TYPHOONS FENGSHEN (2002) AND FUNGWONG (2002) BASED ON THE POTENTIAL VORTICITY DIAGNOSIS

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1. INTRODUCTION

Lander and Holland (1993) showed that rarely does the interaction of cyclones follow the classic Fujiwhara model. Instead, a series of interactions may occur, including capturing, stable cyclonic orbiting, and cyclone merging and escaping. Carr et al. (1997) and Carr and Elsberry (1998) has proposed detailed conceptual modes to categorize the binary interaction processes, namely, 1)the direct tropical cyclone (TC) interaction with one-way influence, mutual interaction, or merger of two TCs; 2)the semi-direct TC interaction involving another TC and an adjacent subtropical anticyclone; 3)the indirect TC interaction involving the anticyclone between the TCs. The interaction between two tropical cyclones with different core vorticities and different sizes is studied by Prieto et al. (2003) with the aid of a non-divergent barotropic model, on both the *f* plane and the sphere. They use the Dritschel–Waugh scheme (1992), which subdivides vortex interactions into five types: elastic interaction, partial straining out, complete straining out, partial merger, and complete merger.

In Wu et al. (2003), a newly proposed centroid-relative track, with the position weighting based on the steering flow induced by the potential vorticity (PV) anomaly associated with the other storm, is plotted to highlight the binary interaction process. Moreover, based on the piecewise PV inversion, the method provides means to quantitatively evaluate how the binary tropical cyclones interact with each other. As a follow-up work of Wu et al. (2003), here we study the binary interaction between Typhoons Fengshen (2002) and Fungwong (2002), and the impact of the large-scale flow fields on their motions. The impact of different data and resolutions on the evaluation of the binary interaction based on the PV method is also investigated.

The binary interaction between Fengshen and Fungwong is also examined from the meso-scale numerical model simulations. With different initial conditions from the bogusing of either or both storms, the sensitivity of the vortices characteristics on the binary interaction is demonstrated. These sensitivity experiments can be used to explore the factors controlling the interaction of binary vortices, and to further understand the impact of the uncertainty of the initial vortex conditions on the interaction of the nearby tropical cyclones.

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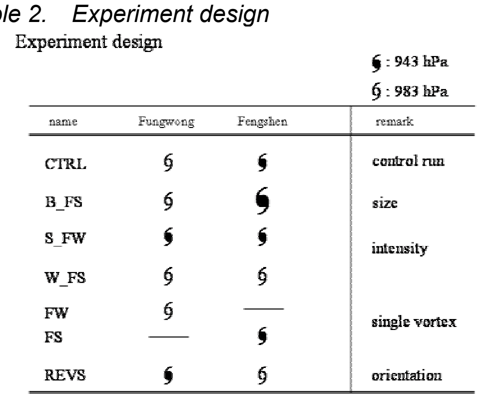
2. DATA AND METHODOLOGY

The data used in this study are based on the analysis fields of the TOGA-COARE from the European Center for Medium-Range Weather Forecasts (ECMWF), the Global Forecast System (GFS) from the Central Weather Bureau (CWB) in Taiwan, and the Aviation model (AVN) from the National Centers for Environmental Prediction (NCEP). Information on the data is shown in Table 1.

Table 1. The data character and range of domain and time.

data set	resolution	domain range	time range
EC_TOGA	2.5°×2.5°	5°N～50°N 100°E～180°E	0000 UTC 20 Jul ～ 0000 UTC 27 Jul, 2002; interval 12 hr
CWB_GFS	2.5°×2.5°	5°N～50°N 100°E～180°E	0000 UTC 20 Jul ～ 0000 UTC 27 Jul, 2002; interval 12 hr
NCEP_AVN	1.0°×1.0°	15°N～40°N 120°E～155°E	1200 UTC 22 Jul ～ 0000 UTC 26 Jul, 2002; interval 06 hr

Table 2. Experiment design



The PV diagnosis method is based on the newly proposed PV diagnosis scheme on Wu et al. (2003), with revised boundary condition as compared to Shapiro (1996).

The NCAR-PSU MM5 model version 2 is used to investigate the binary interaction between Typhoons Fengshen (2002) and Fungwong (2002). The model configuration includes 2 nested grids with horizontal resolutions of 60 km and 20 km, respectively, and with 23 sigma levels in the vertical. The simulation is integrated for 72 h, starting from 0000 UTC 23 July

2002. The initial and boundary conditions are taken from the ECMWF global analysis field with 2.5°×2.5° horizontal resolution. The experiment design is shown in Table 2, where the sensitivity of the TC size, intensity, relative orientation and environmental flow have all been studied.

3. RESULTS

The binary interaction between the two typhoons is well demonstrated by the potential vorticity (PV) diagnosis. Before 12Z of 24 July, the binary interaction follows the pattern of one-way influence, after that it becomes a mutual interaction (figure not shown). Consistent with Wu et al. (2003), the complicated binary interaction can be succinctly presented well quantitatively evaluate by the PV diagnosis.

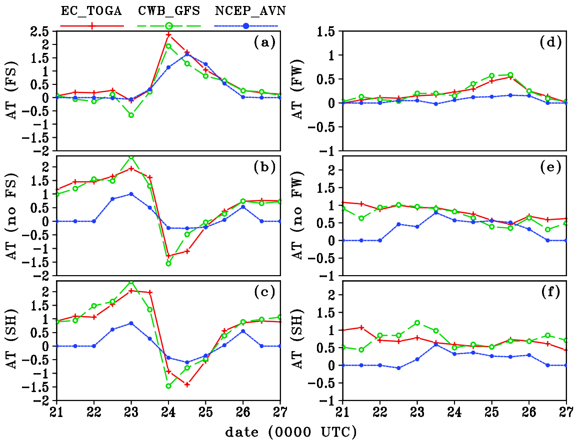


Fig. 1. the AT value (the normalized component of the steering flow associated with the PV perturbation in the direction parallels to the best-track motion vector) from 0000 UTC 21 to 27 July 2003 based on (a) EC_TOGA(+), (b) CWB_GFS(0)and (c) NCEP_AVN (solid circle)taking Fungwong as the mean flow. (d), (e), and (f), same as (a), (b) and (c), but taking Fengshen as the mean flow.

The evolution of binary interaction is well simulated by MM5, but it is sensitive to the initial conditions of the typhoon vortices. The motion of Fengshen is mainly affected by the steering flow associated with subtropical high (Fig. 1), while the monsoon trough and Fungwong plays the secondary role in steering Fengshen. The cyclonic looping of Fungwong is primarily induced by Fengshen.

Different patterns of binary interactions [i.e., 1. one-way and mutual interaction; 2. one- way influence; 3. a switched one-way influence] are produced in the sensitivity experiments (Fig. 2), thus indicating the potential impact of the uncertainty of the vortex structure on the simulation of the binary interaction of tropical cyclones. This result sheds lights on the importance of accurate representation of the initial vortices for a more profound understanding and confident prediction of nearby typhoons.

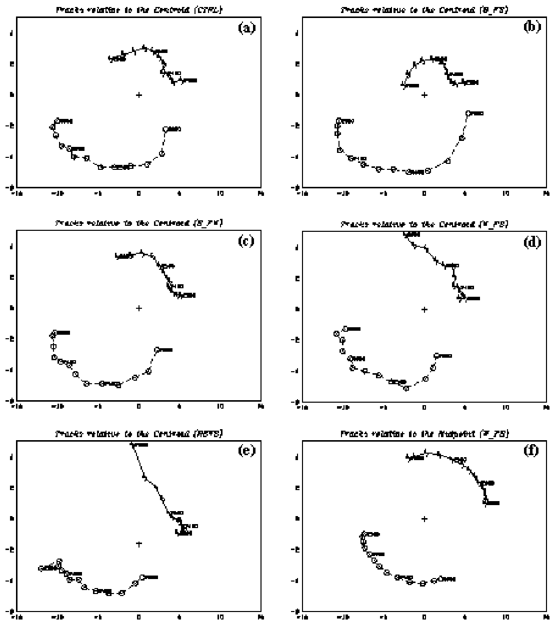


Fig. 2. The centroid-relative tracks between Fengshen(solid line) and Fungwong(dash line) for every 12 h from 0000 UTC 23 to 26 July 2002. (a)CTRL; (b)B_FS; (c)S_FW; (d)W_FS; (e)REVS. (f) 12-h track positions relative to the mid-points between Fengshen(solid line) and Fungwong(dash line) from W_FS. The centroid is indicated as "+".

4. REFERENCES

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