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CONTROL PARAMETERS FOR TRACK CONTINUITY AND DEFLECTION ASSOCIATED WITH TROPICAL CYCLONES OVER A MESOSCALE MOUNTAIN

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1. Introduction

The orographic influence on TC tracks has been studied extensively over Taiwan's Central Mountain Range (CMR) due to its almost ideal environment for research: steep mountain, almost north-south oriented mountain range, surrounded by oceans, and located directly in the path of many typhoons. Wang (1980) showed that the storm center can either cross Taiwan's CMR continuously or discontinuously. For the discontinuous track typhoons, two or more secondary lows tend to form over the lee (west) side of CMR, one of which eventually develops further and replaces the original low-level low pressure center blocked to the east of CMR. Based on the analysis of previous studies of idealized simulations and observational analysis, Lin et al. (2002) *hypothesized* that the track continuity of a typhoon when it passes over a mesoscale mountain is controlled by two parameters, namely $V_{\max}/Nh$ and $V_{\max}/Rf$. When both of them are large, typhoon's track tends to the continuous. Otherwise, it is discontinuous. In this study, we plan to prove this hypothesis by performing a series of idealized numerical experiments.

2. Results

In this study, we employ a simple mesoscale model (GFDM, see Lin et al. 1999 for details) to investigate the dominant control parameters for track continuity associated with the passage of a tropical cyclone over an idealized, mesoscale mountain. The influences of four potential control parameters, which include $V_{\max}/Nh$, U/Nh, $V_{\max}/U$, and $V_{\max}/Rf$, where $V_{\max}$ is the maximum tangential wind of the cyclone, N the Brunt-Vaisala frequency, h the mountain height, U the basic or steering wind speed, R the radius of the maximum tangential wind, and f the Coriolis parameter, on the track continuity and deflection associated with a tropical cyclone passing through a mesoscale mountain are examined by performing a series of idealized numerical experiments (Table 1).

In this study, our idealized simulations indicate that when $V_{\max}/Nh > 0.6$ the track is continuous. Otherwise, it is discontinuous. The track continuity appears to be independent of the other two parameters U/Nh and $V_{\max}/U$. These relationships are clearly shown for tracks of circulation centers (Fig. 1). The dependence of track continuity on $V_{\max}/Rf$ is yet to be examined by more numerical simulations. Physically, $V_{\max}/Nh$ may be regarded as a Froude number associated with the outer circulation of the TC vortex, thus measures the ability of the TC circulation to pass over the mountain. The parameter $V_{\max}/Rf$ may be regarded as the vorticity of the TC vortex nondimensionalized by the planetary vorticity, thus measures the inertial stability of the TC vortex.

The tropical cyclone is deflected to the north when both the basic-flow Froude number (U/Nh) and the vortex Froude number ($V_{\max}/Nh$) are very small. Otherwise, it is deflected to the south. This relationship is also shown in Fig. 1. Physically, this implies that the deflection is controlled by the orographic deflection of the steering (basic) flow and the outer circulation of the TC vortex. We also found that TC track can be deflected by the secondary vortex generated on the other side of the mountain through the induction mechanism.

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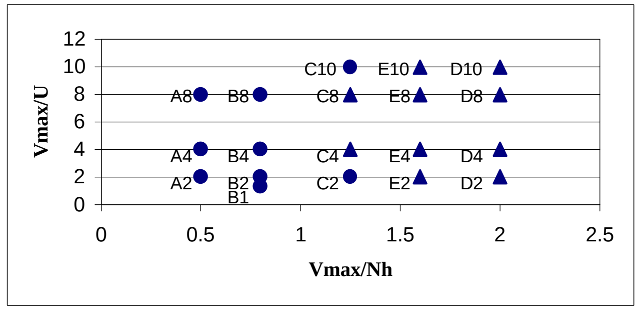
Table 1: Flow and orographic parameters used in the idealized simulations.

Case	Vmax	U	N	h	Vmax/Nh	Vmax/U	U/Nh
unit	m/s	m/s	1/s	m			
A2	20	10	0.01	4000	0.5	2	0.250
A4	20	5	0.01	4000	0.5	4	0.125
A8	20	2.5	0.01	4000	0.5	8	0.063
B1	20	15	0.01	2500	0.8	1.33	0.600
B2	20	10	0.01	2500	0.8	2	0.400
B4	20	5	0.01	2500	0.8	4	0.200
B8	20	2.5	0.01	2500	0.8	8	0.100
C2	20	10	0.01	1600	1.25	2	0.625
C4	20	5	0.01	1600	1.25	4	0.313
C8	20	2.5	0.01	1600	1.25	8	0.156
C10	20	2	0.01	1600	1.25	10	0.125
D2	20	10	0.01	1000	2	2	1.000
D4	20	5	0.01	1000	2	4	0.500
D8	20	2.5	0.01	1000	2	8	0.250
D10	20	2	0.01	1000	2	10	0.200
E2	20	10	0.01	1250	1.6	2	0.800
E4	20	5	0.01	1250	1.6	4	0.400
E8	20	2.5	0.01	1250	1.6	8	0.200
E10	20	2	0.01	1250	1.6	10	0.160



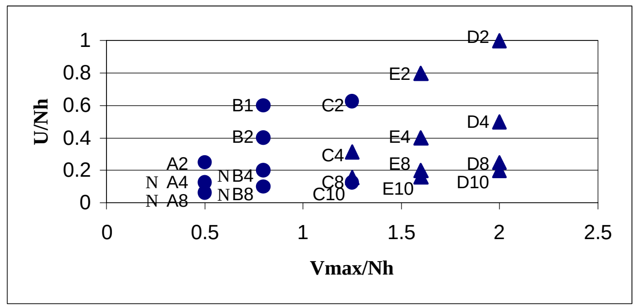


Fig. 1: Continuous (in triangles) or discontinuous (in circles) track of circulation centers for cases (see Table 1) performed. Tracks with northward deflection are denoted by N, otherwise they are deflected toward south.