An Ensemble Analysis on Abrupt Northward Turning of Typhoon Meranti (2010) under the Influence of an Upper-Tropospheric Cold Low

Li Ying[1] (yli@cma.gov.cn), Wen Dian[1]

[1]*State Key Laboratory of Severe Weather, Chinese Academy of Meteorological Sciences, Beijing, China*

Introduction

The sudden change of typhoon track is a challenging issue in typhoon forecast. Typhoon Meranti originated over the western North Pacific off the south tip of the Taiwan Island in 2010. It moved westward entering the South China Sea, then abruptly turned north into the Taiwan Strait, and eventually made landfall on Fujian province. In its evolution, there was an upper-troposphere cold low (UTCL) moving northwestward to the north of Typhoon Meranti over the western North Pacific. Ensemble forecast products based on the European Medium Range Weather Forecast (TIGGE) presented a large spread for the northward turning. A study is implemented to investigate the main influence factors by comparing good group including eight ensemble members that predicted the abrupt northward turning well and the poor group that predicted unsuccessfully on track change of typhoon Meranti.

Typhoon Meranti Activity

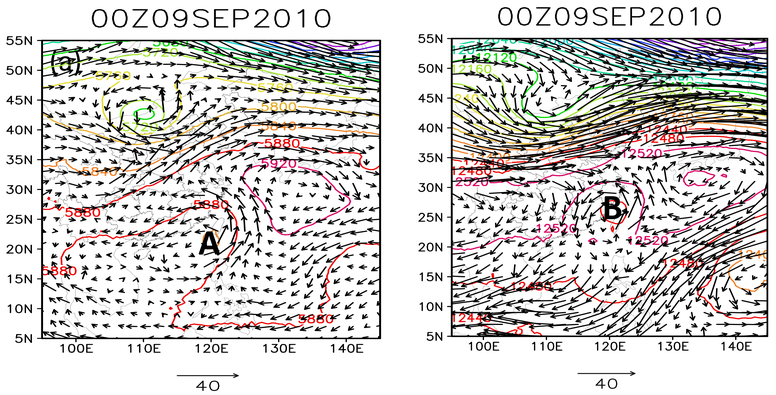
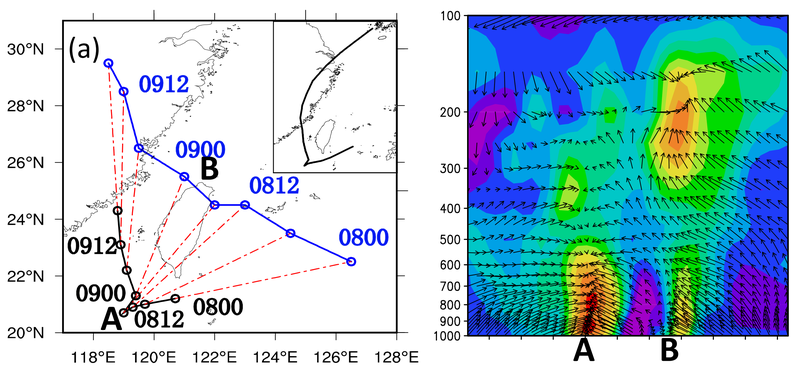


Fig. 1 Geopotential height field and horizontal wind vector field at 0000 UTC on 9 September 2010 at 500 hPa (a) and 200 hPa(b) at the turning time. A: typhoon center ,B: UTCL center



***F**ig. 2 (a) Tracks of typhoon Meranti (black circle line) and the upper tropospheric cold low (UTCL, blue circle line) at 6h intervals from 0000 UTC 8 Sept to 1800 UTC 9 Sept 2010. (b) Vertical vorticity (shaded, 10 -5 s -1) and horizontal wind vectors along a line connecting A and B at 0000 UTC 9 Sept. 2010*

Ensemble Forecast

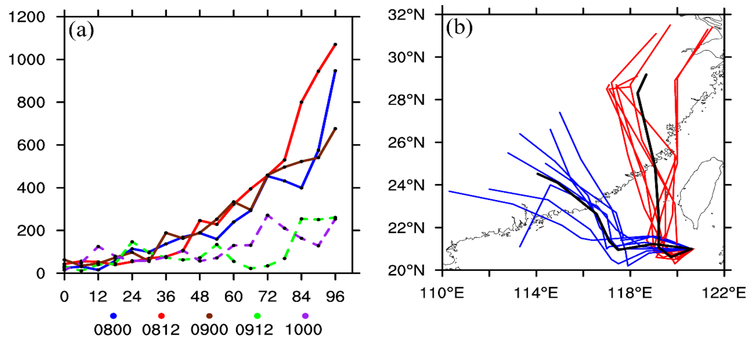


Fig.3 (a) Mean track forecast errors (left y-axis, units: km) for all 51 ensemble members at different initial times (bottom x-axis) from 8 to 10 Sept 2010, lines in different colors represent the results forecasted from different initial times (UTC); (b) the lines are tracks of good/poor (red/blue) group members initialized at 0000 UTC 8 Sept 2010, the black lines are the ensemble mean tracks for the good and poor groups, respectively.

Ensemble Synoptic Analysis

Relative position

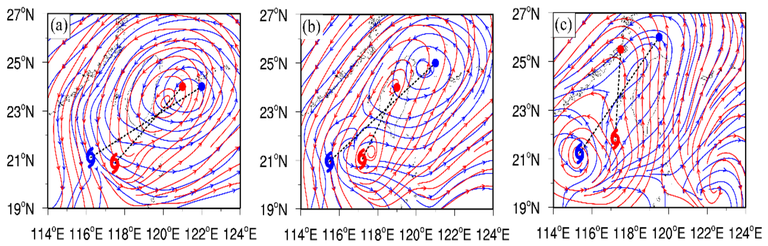


Fig. 4 Averaged 200 hPa stream fields of the 8 good and 8 poor members at (a) 1200 UTC 8, (b) 1800 UTC 8, and (c) 0000 UTC 9 Sept 2010. The TC symbol (dot) is the mean position of TC (UTCL) center, the black dashed line links the centers of typhoon and UTCL at the same time

Steering flow

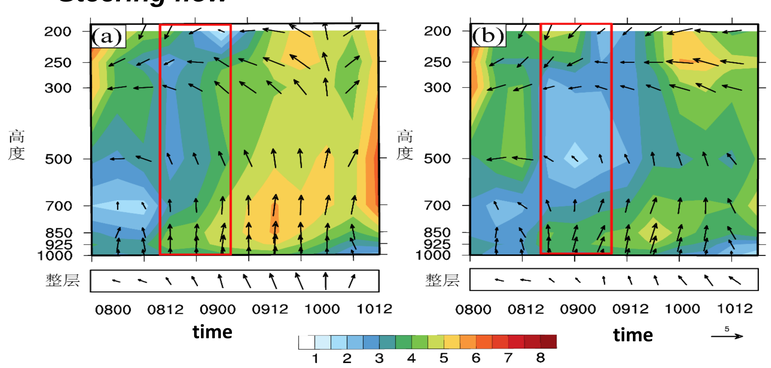


Fig. 5 Time series of mean steering flow (vectors) and its magnitude (shaded，units: m /s) of (a) good and (b) poor groups between 1000 hPa and 200 hPa from 8 to 10 Sept 2010. The red box indicates the abrupt northward turning period from 1200 UTC 8 to 0000 UTC 9 Sept 2010. The vectors in black box show the mean steering flow between 1000 hPa and 200 hPa

UTCL vertical structure

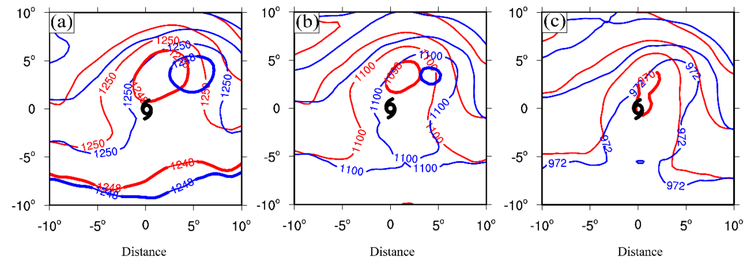


Fig. 6 (a) Geopotential heights (units: dagpm, contours at interval of 2 dagpm) of good (red) and poor (blue) groups on (a) 200 hPa, (b) 250 hPa,and (c) 300 hPa at 1800 UTC 8 Sept 2010. The black TC symbol is the TC center. Horizontal and vertical axes indicate the distance from the composite TC center in latitude/longtitude degree

Potential vorticity tendency

$$P = -g(\boldsymbol{k}f + \nabla_p \times \mathbf{V}) \cdot \nabla_p \theta \qquad -\boldsymbol{C} \cdot \nabla P_S = \partial P_1 / \partial t$$

P_s and P_1 are the symmetric component and wavenumber one component of P respectively. C is velocity of a typhoon.

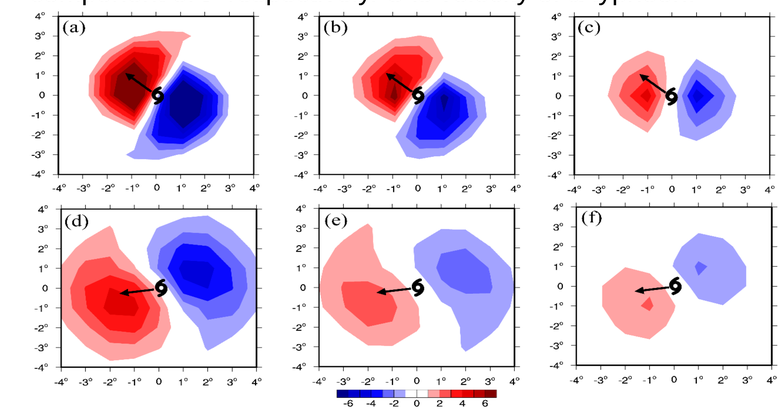


Fig. 7 The potential vorticity horizontal advection (shadings) of (a-c) good and (d-f) poor groups on 500 hPa at 1800 UTC 8 Sept 2010: (a, d) The wavenumber one; (b, e) the first term (-V 1 · ∇P s); (c, f) the second term (-V s · ∇P 1). The black TC symbol indicates the Typhoon center, and the black vector denotes the direction of typhoon movement tendency

Summary

- The abrupt northward turning of typhoon Meranti was related to the coupling between Meranti and the nearby the UTCL in the north-south direction.
- When the UTCL moved to the north of Meranti, the southerly component of the steering flow was enhanced, which was helpful for the northward movement of Meranti.
- The UTCL with wide and deep cyclonic circulation in vertical direction was more favorable for the typhoon track change.
- Under the coupling between Meranti and the UTCL in the north-south direction, horizontal advection of potential vorticity to the north of the typhoon was strengthened, which indicates the northward moving tendency of Meranti.