Article ID: 1006-8775(2006) 01-0099-02

THE ANALYSIS OF TROPICAL CYCLONE PRECIPITATION AFFECTING THE LIAODONG PENINSULA

LIANG Jun (梁 军)[1,2], CHEN Lian-shou (陈联寿)[3], WANG Shi-gong (王式功)[1]

(1. College of Atmospheric Sciences of Lanzhou University, Lanzhou 730000 China; 2. Dalian Meteorological Observatory, Dalian 116001 China; 3 Chinese Academy of Meteorological Sciences, Beijing 100081 China)

Key words: Tropical cyclone; Liaodong peninsula; comparative analysis; severe precipitation

CLC number: P444 **Document code: A**

1 INTRODUCTION

Tropical cyclones (TCs) moving north and getting to the Liaodong Peninsula and waters of the Yellow and Bohai Seas are in their late phase of life cycle. While weakening rapidly, TCs carry a large amount of warm and humid air that forms heavy rainfall by itself on the one hand and interact with westerlies in the middle latitudes on the other. With their warm-core structure destroyed by intruded cooler air, TCs absorb baroclinic energy while it weakens and experiences extratropical transition (ET). With right conditions and complicated topographic features of the peninsula, the transformed extratropical cyclone evolves to intensify heavy rainfall in most cases and even results in secondary disasters like storm surges. Therefore, the extratropical transition of TCs is usually responsible for more serious damage in mid-latitude areas. For the forecast of heavy rain associated with north-going TCs experiencing extratropical transition, it not only involves their own intensity and structure but also the distribution of the surrounding field and its interactions with TCs. Most of the present studies discuss TCs-inflicted heavy rains or those taking place south of the Shandong Peninsula[1-9]. Focusing on intense precipitation resulted from TCs over the Liaodong Peninsula, this work analyzes the distribution of the ambient field and physical quantities hoping to help forecast TCs-related heavy rains accurately.

2 COMPARISONS OF RAINFALL, CIRCULATION AND TC STRUCTURE

Two TCs, Winnie (9711) and Tim (9406), with similar track of movement and tendency of turning in direction, are selected for comparison.

With regard to rainfall, heavy rainfall caused by Tim is mainly seen ahead of a westerly trough far from the typhoon center on the west side of the track, with cold air mainly in the north and west, the subtropical high advanced to the west of 120°E, and 10-mm precipitation is recorded in the peninsula. The heavy rainfall resulted from Typhoon Winnie is mainly on the east side of the track. With a favorable location of the subtropical high and interacting with southward-going cold air and, it intensifies through transition and causes heavy precipitation on the peninsula.

For the circulation, Tim's influence on the peninsula is accompanied by cold air from the east that transforms it slightly and advection of negative vorticity that is transported to Tim. As a result, Tim does not intensify through transition. The transportation of negative vorticity through advection in combination with superposition of convergence over low-level converging center is unfavorable for the intensification of the cyclone. With the center of subtropical high located more westward, Tim does not have much influence on precipitation of the peninsula.

Differences are compared of the TCs in vorticity, vertical velocity, energy, moisture and stability. Take vorticity for instance. When Winnie is over the peninsula, positive vorticity is over the area from 115°E to 123°E and its altitude extends beyond 100

Received date: 2005-07-28; **revised date:** 2006-05-15
Foundation item: Project 973 from the Ministry of Science and Technology of China (2004CB418301); a project of Natural Science Foundation of China (40175019)
Biography: LIANG Jun (1967-), female, native from Liaoning Province, senior engineer, undertaking the short-term weather forecasting.
E-mail: qinldj@163.com

hPa. As strong diverging flows and high potential vorticity in upper air keep flowing into the cyclone center, positive vorticity increases rapidly and is opposite in high and low levels within a limited area over the peninsula, the condition is right for intense precipitation to occur in the region[10]. When Tim is over the peninsula, positive vorticity, with two centers, is over the area from 115°E to 125°E and the difference of relative vorticity $\Delta\zeta$ between 300 hPa and 850 hPa is always above 0 to prevent positive vorticity from being transported, unfavorable for the typhoon to sustain or strengthen. Opposite areas of vorticity are superimposed northeast-southwest over the peninsula to restrain the development of convection. Consequently, no intense precipitation is recorded during the presence of Tim in the peninsula.

3 CONCLUSIONS

(1) When Winnie is active over the area, favorable and stable location of the subtropical high helps transport warm and humid air from the ocean to the southeast, Bay of Bengal and South China Sea to the Liaodong Peninsula and blocks a low system from moving out to sea so that precipitation keeps increasing. During the northward advancement of Tim, it has no major effect on the precipitation of the peninsula as the subtropical high center is more to the west and north than usual.

(2) When Winnie is active over the area, jet streams on upper and lower levels converge within the ascending branch of circulation at the inlet in upper air, positive vorticity is transported in advection and the center of strong divergence is superimposed over a low-level convergence center, being favorable for the development and intensification of the cyclone. When Tim is active over the area, however, jet streams on upper and lower levels interact within the descending branch at the outlet in upper air, negative vorticity is transported in advection and an area of convergence is superimposed over a low-level convergence center, unfavorable for the growth of the cyclone.

(3) In the case of Winnie, short-wave troughs east of Lake Baikal keep moving east and south, convection develops vigorously with the trigger of moderate cold air on both east and west sides of the warm convergence zone of the typhoon. As a result, huge amount of geopotential energy from baroclinic disturbance is released and the typhoon intensifies in transition to form an extratropical cyclone and causes heavy rain over the peninsula. In the case of Tim, however, there is a major meridional trough to the west of the typhoon and the upper-level trough east of Lake Baikal in the mid- and lower- troposphere has moved out of the peninsula and negative vorticity is transported into the typhoon through advection. It is only under the condition of weak cold air to its east that it experiences weak transition and does not lead to cyclogenesis. Furthermore, with baroclinic geopotential energy concentrated west of the western coast of Bohai Sea, only 10-mm precipitation appears over the peninsula.

REFERENCES:

[1] LIANG Jun, CHEN Lian-shou, WU Shi-jie, et al. Analysis of calamities by tropical cyclones affecting the waters of the Yellow and Bohai Seas [J]. Journal of Natural Disasters, 2006, to be published.

[2] LIANG Jun, CHEN Lian-shou. Motion and intensity and impact characteristics of tropical cyclone affecting the liaodong peninsula [J]. Journal of Tropical Meteorology, 2005, 21(4): 410-419.

[3] QIU Rong-yan. Weather patterns and interannual variations of typhoon torrential rain during midsummer in north China [J]. Meteorological Monthly, 1997, 23(7): 3-9.

[4] TAO Zu-yu TIAN Bai-jun, HUANG Wei. Asymmetry structure and torrential rain of landing Typhoon 9216 [J]. Journal of Tropical Meteorology, 1994, 10(1): 69-77.

[5] LI Ying, CHEN Lian-shou, WANG Ji-zhi. The diagnostic analysis on the characteristics of large scale circulation corresponding to the sustaining and decaying of tropical cyclone after its landfall [J]. Acta Meteorologica Sinica, 2004, 62(2): 167-179.

[6] LI Ying, CHEN Lian-shou, XU Xiang-de. The characteristics of sub-synoptic scale circulation of tropical cyclones sustaining over land [J]. Acta Meteorologica Sinica, 2004, 62(3): 257-268.

[7] MENG Zhi-yong, XU Xiang-de, CHEN Lian-shou. Mesoscale characteristics of the interaction between TC Tim (9406) and mid- latitude circulation [J]. Meteorological Monthly, 1998, 24(11): 16-21.

[8] ZHU Guan-zhong, ZHAO Cong-lan. Discussion on the heavy torrential rain area caused by the landing northward tropical cyclone [J]. Meteorological Monthly, 1998, 24(11): 16-21.

[9] ZHANG Shan-jun, ZHU Guan-zhong, CAO Gang-feng. Study on enhanced rainstorm fronm onland tropical cyclones moving northward in north China [J]. Journal of Nanjing Institute of Meteorology, 1995, 18(3): 455-459.

[10] YANG Ying-ming, TAO Zu-yu. Research on the Tropical Cloud Clusters for Tropical Cyclones Making Landfall and Moving Northward [C]// Proceedings of 12th National Scientific Conference on Tropical Cyclones. 2002: 281-286.