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Changes of the temperature field during storms and Effects of Cold Air on Structure of Thermal Fields in Typhoons – Case in China and Vietnam Sea

Chu Thi Thu Huong[1,*], Tran Dinh Linh[2], Dinh Tran Ngoc Huy[3], Nguyen Binh Phong[4]

[1,2,4]Hanoi University of Natural Resources and Environment (HUNRE), Hanoi, Vietnam
[3]Banking University HCMC Ho Chi Minh city, Vietnam – International University of Japan, Japan
*Corresponding Author

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Abstract— *This study goal is to explore Changes of the temperature field during storms and Effects of Cold Air on Structure of Thermal Fields in Typhoons. Typhoons are a kind of tropical cyclone that often occur on tropical or subtropical sea surfaces where the sea surface temperature is higher than 26.5 ◦C (HU et al, 2000). The results show that When affected by cold air, the hot core structure in the storm is broken. Temperature tends to increase gradually from west to east and from north to south. Temperatures in the northern and western regions were still lower than in the center of the storm, but in the eastern and southern areas of the center of the storm, the temperature was higher than in the center of the storm. Near the surface, below 800hPa, the temperature of the center of the storm is also lower than the average temperature of the areas around the center of the storm (except for typhoon Kammuri). The decrease in temperature in the lower central region and areas north and west of the center of the storm is due to the intrusion of the CA. This result demonstrates the role of cold air to the structure of the temperature field in the storm. However, further explanations are needed for the distribution of the maximum hot cores in the center of the storm.*

Keywords*— *Thermal core, Effect of cold air on tropical storm, distribution of temperature in tropical storm

I. INTRODUCTION

Ahn et al (2022) pointed : Typhoons are serious natural disasters in coastal areas. During the summer of 2011, successive typhoons Nesat and Nalgae appeared in the South China Sea, providing a unique opportunity for us to study the response of the upper ocean to successive typhoons. We comprehensively use satellite data and COAWST model data to explore the effects of successive typhoons on the temperature structure of the South China Sea. Nesat caused the sea surface temperature to decrease by up to 4.4 ◦C on the right side of the typhoon path, and the ensuing Nalgae caused the temperature to decrease by up to 2.2 ◦C. Because Nesat had already cooled the ocean, the response to Nalgae was more to the left of the track than one would normally expect. The upwelling dominates the change in subsurface temperature. Based on the increase caused by Nesat, the isotherm was further raised by Nalgae. The isotherm rising amplitude is larger in the upper and deeper layer and is smaller in the middle layer in the depth range of 0–200 m. Heat budget analysis indicates that in the area close to the typhoon path, vertical diffusion is the main reason for the decrease in ocean surface temperature, while total advection suppresses the decrease in temperature. In the area with a larger distance from the typhoon path, vertical diffusion and total advection lead to the decrease in ocean surface temperature, and total advection will gradually contribute more to temperature change and become the dominant factor. On the right side of the typhoon track, the reduction of the contribution rate of vertical diffusion with distance from typhoon track is slower than that on the left side of the typhoon track. Whether Nesat or Nalgae, the intensity and depth of effects of vertical diffusion on the right side of typhoon path are greater than those on the left side of typhoon path, and the near-inertial periodic oscillation of local temperature change rate is more obvious. When the vertical diffusion is weak, the influence of vertical advection and horizontal advection is deeper. Moreover, the near-inertial periodic oscillation of the local temperature change occurs in lower depth after Nalgae passed through than that after Nesat. The typhoon intensity of the two typhoons shows the opposite change: the first typhoon increases, and the second typhoon weakens. Therefore, the special case of successive typhoons should be fully considered in typhoon prediction to improve accuracy. Next, The hurricane season usually starts from May to December (Binh T.D, 1993) or from June to November (Huong C.T.T., et al, 2022; Weatherford, C. L, et al, 1988a) and gradually shifts from North to South with frequency that is higher in August, September.

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II. DATA AND METHOD

Research Methods

To determine the activities of the cold surge, the study analyzes the evolution of the 24-hour sea level barometric value in the region of 20-250N; 105-1150E. This is the area that is often affected first when KKL operates in East Asia in general and Vietnam in particular. Then, cold surge is considered to affect the area when the 24-hour transformer has a value greater than 1hPa.

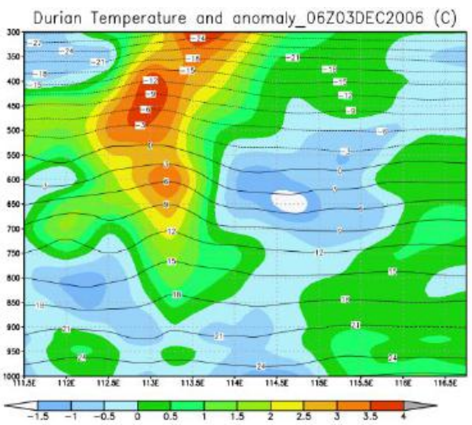
III. FINDINGS AND DISCUSSION

3.1 The key problem

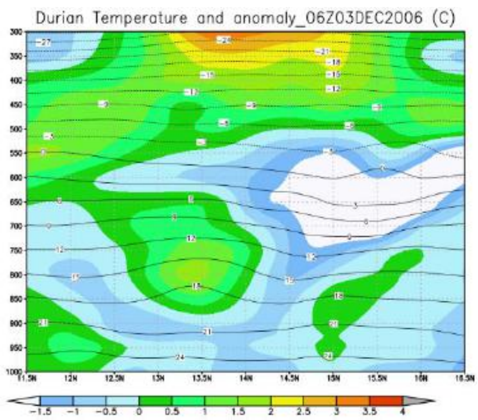
Han et al (2013) showed that the major change is the environmental circulation of tropical cyclone when the surges immerge into the outmost of the tropical cyclone. The warm air from the Northern Hemisphere will reduce the north wind of the tropical cyclone. The pulling force away from the center of the tropical cyclone is formed, which weakens the mass convergence. On the contrary, the cold air from the Northern Hemisphere will intensify the north wind of the tropical cyclone. The pushing force to the center of the tropical cyclone is formed, which intensifies the mass convergence. Because of the pushing force, on the one hand, the energy is transported to tropical cyclone, which is generated for the intrusion of the cold air; on the other hand, the temperature gradient is intensified.

At 13:00 on December 1, 2006, Typhoon Durian moved into the East Sea with the strongest wind speed of about 38m/s. The storm weakened to a tropical depression then disintegrated on December 6 (Figure 1a). Also during the period from November 27, 2006, a cold surge accompanied by a front affected the northern climate regions of Vietnam, causing the temperature in the area to drop from 5 to 70C. After that, the cold air intensified, affecting Vietnam until 7:00 am on December 4, 2006, when it weakened.

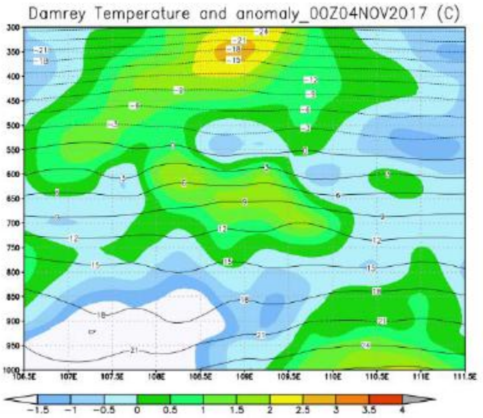
Next we see structure of themal core in the storm: In the lower atmosphere layer (below 800hPa), in all four storms, the results show that the temperature in the center of the storm is higher than the average temperature in the storm. The area is 4 degrees longitude far from the center of the storm in the directions from 0.5 to 2 o C. This difference is smaller in storm Durian and storm Damrey, while large in the other two storms, especially in Typhoon Kammuri with the difference can be up to nearly 3.5 o C.



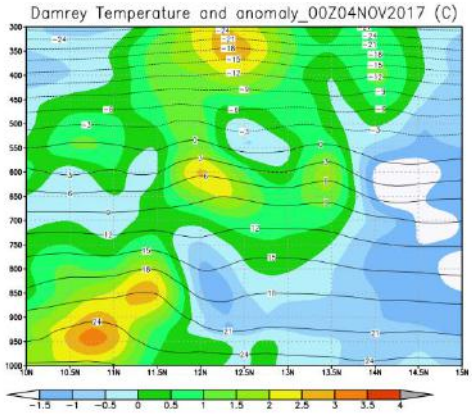
a)



b)



c)



d)

Fig.1. Temperature difference at the center of the storm with the average temperature along the longitude/latitude 4 degrees longitude far from the center of the storm towards the West (green line), East (Red line), North (blue line) and South directions (Purple line) before the respective KKL influence in the storms.

(source: authors)

During the time before the impact of the cold air, the temperature in the storm was still evident with a hot core in the center of the storm.

IV. CONCLUSION

From the reanalyzed data set (ERA5) of the temperature at isostatic levels from the surface to the level of 50hPa, the thermal field characteristics in some intense storms over the East Sea when influenced by air cold has been given in this paper. The results show that, under the influence of cold air, the temperature in the storms has an asymmetrical distribution. Before the cold air affects, the temperature in the storm clearly shows the structure of the hot core at or near the center of the storm. The elevation of the hot core grows from the surface up to 150hPa (except for typhoon Kammuri). The hottest zone exists between 500 and 300hPa (typhoon Damrey), between 850 and 600hPa (typhoon Kammuri) and 700 to 450hPa (typhoon Vamco). When affected by cold air, the hot core structure in the storm is broken. Temperature tends to increase gradually from west to east and from north to south. Temperatures in the northern and western regions were still lower than in the center of the storm, but in the eastern and southern areas of the center of the storm, the temperature was higher than in the center of the storm. Near the surface, below 800hPa, the temperature of the center of the storm is also lower than the average temperature of the areas around the center of the storm (except for typhoon Kammuri). The decrease in temperature in the lower central region and areas north and west of the center of the storm is due to the intrusion of the CA. This result demonstrates the role of cold air to the structure of the temperature field in the storm. However, further explanations are needed for the distribution of the maximum hot cores in the center of the storm.

AUTHOR'S CONTRIBUTION

Developing ideas and choosing research methods: Huong C.T.T.; Data analysis and processing: Huong C.T.T.; Linh T.D.; Phong N.B.; Writing the manuscript: Huong C.T.T.; Linh T.D.; Editing of the article: Huong C.T.T.; Linh T.D; revised: Huy, D.T.N

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