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Characteristics and Changes of the Temperature Field during Storms Operating in the East Sea under the Influence of Cold Air over Time

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Abstract: Michael *et al.* (2014) also suggested that, the increase of equivalent temperature and humidity during growth helps to maintain convective instability. Thus, the condensation potential energy is converted into potential energy and then some of the potential energy is converted into kinetic energy of the storm. In the center of the storm, the downdrafts warm the air adiabatic, so the temperature here increases the most. Falling currents also dry out the air considerably. Therefore, warming in the storm center does not increase convective instability (Lanh *et al.*, 2020). At the center of the storm, after the cold air entered, the temperature was even lower in the eastern and southern parts of the storm.

Keywords: Thermal core, Effect of cold air on tropical storm, distribution of temperature in tropical storm.

INTRODUCTION

Zhao & Jiang (2011) presented Storm surges in the Bohai Sea are not only associated with tropical cyclones and extra-tropical cyclones, but also cold-air outbreaks. Cold-air outbreaks attack China from four major tracks, with each track having its own prevailing wind over the Bohai Sea. As the pressure field of cold-air outbreaks can be converted into the surface wind, storm surges can be investigated by the pressure field of cold-air outbreaks entirely. This paper took the different major tracks, pressure field, and high wind period into consideration and constructed 20 scenarios to describe the actual situation of cold-air outbreaks. Based on the results modeled by FVCOM, the influence of various cold-air outbreaks on the maximum surge in the Bohai Sea and the probability of the surge elevation at three typical tide gauges were investigated. Finally, a powerful decision-making tool to estimate storm surges induced by cold-air outbreaks was provided. KeywordsStorm surge–Cold-air outbreak–The Bohai Sea.

Then, Son *et al.* (2022) showed The sea surface temperature (SST) drops rapidly when a typhoon passes over the western North Pacific, and the cold SST is known as cold wake. In general, more intense typhoons on the day of arrival cause stronger SST cooling via turbulent oceanic vertical mixing. Moreover, after intense typhoons have passed, there are cases in which the SST decreases further, and the cold conditions persist for approximately 2 weeks. In this study, we suggest possible mechanisms by which long-lasting cold SST responses to typhoon forcing are related to the generation of cold-core-like ocean circulation. The atmospheric surface cyclonic circulation causes divergent anticlockwise upper ocean currents owing to the Ekman transport, which in turn induces further upwelling and strengthens the cold SST. In the European Center for Medium-Range Weather Forecasts Ocean Reanalysis System 5, cold-core-like ocean current responses were strong in 5 typhoons among the 12 intense typhoons that passed through 30°N in the western North Pacific region from 2001 to 2019. The favorable conditions for a cold-core circulation to occur can be summarized as a slow typhoon migration speed with strong intensity, well stratification of vertical ocean layers, and the absence of large-scale strong background currents.

Then, Lai *et al.* (2021) mentioned Based on the typhoon best tracks of the China Meteorological Administration (CMA), ERA5 reanalysis data of ECMWF at 0.25 degrees horizontal resolution, and NOAA optimal interpolated sea surface temperature (OISST V2) data, the dynamical compositing analysis is used to study the north turning at nearly 90 degrees of 4 westward typhoons over the South China Sea (SCS). The composite analysis results show that: (1) As the

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typhoon goes westward into the SCS, the upper-level westerly trough moves eastward to the vicinity of 110°E in the mainland of China, and the western North Pacific subtropical high (SH) retreats eastward at the same time, which weakens the steering flow of typhoon and slowes down its movement. (2) The cold air guided by the westerly trough invades southwardly into the western part of SCS from the mainland leading to a descending and divergent airflow in the lower-to-middle atmospheric layers and enhancing the eastward pressure gradient force (PGF) in the west quadrant of the typhoon, which blocks and repels the typhoon from moving any further westward. (3) Due to the cold air intrusion, the vertical atmospheric stratification in the west quadrant of the typhoon becomes static and stable, which may suppress the convection, impeding a typhoon's westward motion. (4) With the cold air involving to the south of the typhoon, the direction of the PGF on the typhoon switches from eastward to northward, and the SH falling southward enhances the southwesterly airflow on the south of the typhoon at the same time. The remarkable increase of the northward steering airflows of the typhoon results in an abrupt northward turn. (5) In addition, the sea surface temperature (SST) and the ocean heat content (OHC) on the western part of the SCS is also reduced, attributed to the cold air cooling, and the typhoon is likely to avoid the cold ocean and approach a relatively warmer region. This study suggests that cold avoidance during the westward movement of typhoons is worthy of consideration in the operational forecast of typhoon tracks.

Therefore authors choose this topic "Characteristics and changes of the temperature field during storms operating in the East Sea under the influence of cold air over time"

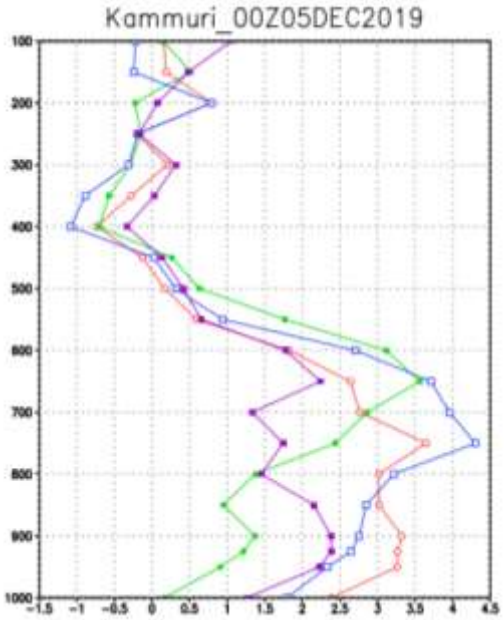
METHODOLOGY

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.

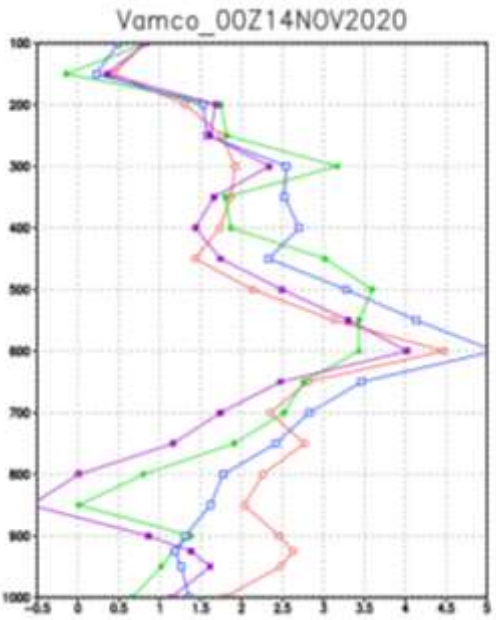
MAIN FINDINGS

There is also a similar distribution of storm Durian 2006, in the Vamco 2020 storm, there is also a hottest area at about 700 to 450hPa, but this hot area tends to be more inclined to the west and south of the center of the storm (Figure 2g). , H). For Typhoon Kammuri 2019, the hot area shifted to the east, southeast of the center of the storm with the highest temperature anomaly reaching from 3 to 40C, only ranging from 850hPa to 700hPa. Above the level of 700hPa, the temperature anomaly near the center of the storm gradually decreases, even above the level of 450hPa, the temperature in the center of the storm is even lower than the average temperature around the center of the storm. Similar to Typhoon Kammuri, the hottest area in Typhoon Damrey is also located to the east and south of the storm's center but is located above the 500hPa level (Figure 2c,d).

Vertical section through the center of the storm along the left column and along the right column during storms Durian 2006 (a, b), Damrey 2017 (c, d),



c)



d)

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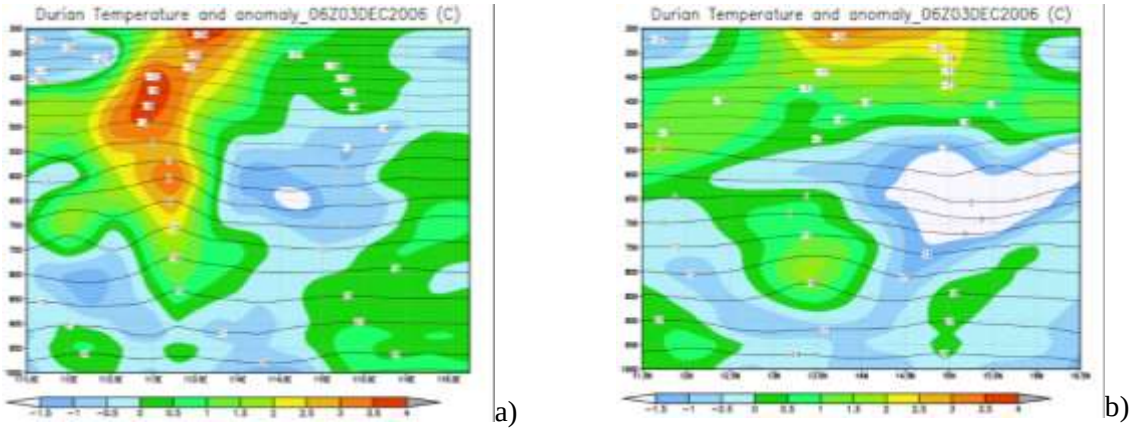

a) b)

Figure 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.

DISCUSSION AND CONCLUSION

Oceans and seas have great influence on the weather of continental masses. A large portion of the solar energy reaching the sea-surface is expended in the process of evaporation. These water evaporated from the sea/ocean is carried up into the atmosphere and condenses, forming clouds from which all forms of precipitation result. Sometimes, intense cyclonic circulations occur which is what we call the tropical cyclones.

Tropical cyclones are warm-core low pressure systems associated with a spiral inflow of mass at the bottom level and spiral outflow at the top level. They always form over oceans where sea surface temperature, also air temperatures are greater than 26°C. The air accumulates large amounts of sensible and latent heat as it spirals towards the center. It receives this heat from the sea and the exchange can occur rapidly, because of the large amount of spray thrown into the air by the wind. The energy of the tropical cyclone is thus derived from the massive liberation of the latent heat of condensation.

Tropical cyclone is defined as a non-frontal, synoptic-scale cyclone developing over tropical and sub-tropical waters at any level and having a definitely organized circulation. In other parts of the world, these are referred to as hurricanes, typhoons or simply tropical cyclones depending on the region. In the North Atlantic, Eastern North Pacific and South Pacific Ocean, they are called" hurricanes". In the bay of Bengal, Arabian Sea and Western South Indian Ocean, the name is"cyclonic". In the eastern part of the Southern Indian Ocean, it is "willy-willy", and in the Western North Pacific Ocean, they are called "typhoons".

Tropical cyclones can only form over oceans of the world except in the South Atlantic Ocean and the south eastern Pacific where a tropical cyclone could never be formed due to the cooler sea surface temperature and higher vertical wind shears. They develop at latitudes usually greater than 5° from the equator. They reach their greatest intensity while located over warm tropical water. As soon as they move inland, they begin to weaken, but often not before they have caused great destruction.

The Philippines is prone to tropical cyclones due to its geographical location which generally produce heavy rains and flooding of large areas and also strong winds which result in heavy casualties to human life and destructions to crops and properties. Thus, it is of utmost importance to have sufficient knowledge on such maritime phenomena for beneficial purposes (source: https://www.pagasa.dost.gov.ph/information/about-tropical-cyclone).

Author's Contribution

Developing ideas and choosing research methods: Huong C.T.T.; Data analysis and processing: Huong C.T.T.; Linh T.D..; Writing the manuscript: Huong C.T.T.; Linh T.D.; Revised: Dinh, T.N.H. Editing of the article: Huong C.T.T.

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Conflicts of Interest

The authors declare no conflict of interest.

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