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Analysis of the Causes of the Intensity Enhancement of the Typhoon "Tiange"

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Abstract

This paper analyzes the causes of the offshore strength enhancement of Typhoon Tiange (No. 1713) from four aspects: high and low layer divergence, vertical wind shear, southwest monsoon transport, offshore sea temperature and weak cold air. The conclusions are as follows: The high-level airflow divergence enhancement and positive vorticity advection in the offshore, strengthen the middle rise movement of the "Tiange", and the ascending movement enhances the strength of the "Tiange" by strengthening the lower layer convergence; The high offshore sea temperature and sea temperature are changing temperature, which also has a certain effect on the strengthening of "Tiange" in the offshore; The strengthening of the southwest warm and humid airflow provides sufficient water vapor and energy for the development of "Tiange", which is beneficial to the maintenance of the typhoon warm heart structure; The intrusion of weak cold air, enhanced the radiation cooperation of the lower typhoon disturbance, which is beneficial to the enhancement of "Tiange".

Keywords

Typhoon, Offshore Strengthening, Cause Analysis

1. Introduction

The intensity change of typhoon is one of the key points and difficulties of typhoon forecasting. It determines the intensity and distribution of wind and rain, which directly affects the government's decision to prevent Taiwan from resisting Taiwan. The sudden increase of typhoon offshore is often caused by serious disasters due to insufficient estimation. For a long time, meteorologists have done a lot of research on this and have achieved many results for business applications. Ye et al. (2011) analyzed the reasons for the strengthening of Typhoon Morandi in the offshore area of 1010, and concluded that the large amount of water vapor and energy of mesoscale convective clouds in southern Guangdong was involved and absorbed by "Morante". The convection development on the northwest side of the typhoon caused the "Morante" to rapidly strengthen into a typhoon in the offshore near the landing. Wang & He (2014) analyzed the typhoon "Morante" No. 1010 and concluded that weak vertical shear is the most important factor for typhoon offshore reinforcement; the cross-equatorial airflow provides water vapor source; the leakage of weak cold air, the high vortex value is transmitted, and the "Morante" obtains a positive vortex, which releases the latent heat of condensation through the enhanced convection activity to provide energy for its reinforcement. Gao et al. (2016) analyzed the super strong typhoon "Weimason" of No. 1409. It is concluded that the sea temperature in the sea area after the "Weimason" is abnormally high, the vertical wind shear is small, and the southwest monsoon jet is enhanced, which is conducive to its offshore strengthening; "Weimason" and the monsoon rapids meet in Hainan's Wenchang offshore, prompting the latent heat energy near the typhoon center continued to increase, and the warm-hearted structure became more complete, which was an important reason for its sudden strengthening.

On the 13th of 2017, Typhoon "Tiange" was formed at 14 o'clock on August 20th (Beijing time, the same below) in the northwest Pacific Ocean (20.4˚N, 128.0˚E); after that, the intensity continued to increase, at 8 o'clock on August 22 Strengthened into a strong tropical storm and entered the South China Sea. At 15 o'clock, it strengthened into a typhoon. At 7 o'clock on August 23, it was strengthened into a strong typhoon. The typhoon level jumped 2 levels in 24 hours, and the maximum wind force jumped 5 levels in the center, which increased from 9 ($m\cdot s^{-1}$) to 15 (48 $m\cdot s^{-1}$). After entering the South China Sea, the speed of the "Tiange" has accelerated, which has been above 25 $km\cdot h^{-1}$, and some time periods have exceeded 30 $km\cdot h^{-1}$. From entering the South China Sea to landing only 29 hours, the arming time is tight. At around 12:50 on August 23, the typhoon level (14, 45 $m\cdot s^{-1}$) landed in Zhuhai City, Guangdong Province, China. At the time of landing, the maximum wind force near the center was 14 (45 $m\cdot s^{-1}$). At the central minimum pressure of 950 hPa, 16 (51.9 $m\cdot s^{-1}$) instantaneous winds were observed between 12:10 and 15 minutes in Zhuhai, breaking the local wind speed record. At 14 o'clock on August 24, it weakened to a tropical low. At 17 o'clock, the Central Meteorological Observatory stopped its numbering. Storm surges and huge waves have seriously threatened the safety of personnel and facilities in coastal low-lying areas.

This paper analyzes the main factors that cause the intensification of the typhoon "Tiange" in the 1713 offshore, and aims to provide a reference for the intensity prediction of such typhoons.

2. Data and Methods

The data used in this paper are: 1) NCEP/NCAR reanalysis wind field 2.5˚ × 2.5˚

grid point data; 2) ERA-Interim reanalysis of divergence, vorticity, wind field 2.5˚ × 2.5˚ grid points Data; 3) surface meteorological observation temperature data; 4) Fengyun satellite infrared cloud image data. We use synoptic meteorological principles in this study (Su et al., 2007; Zhu et al., 2000).

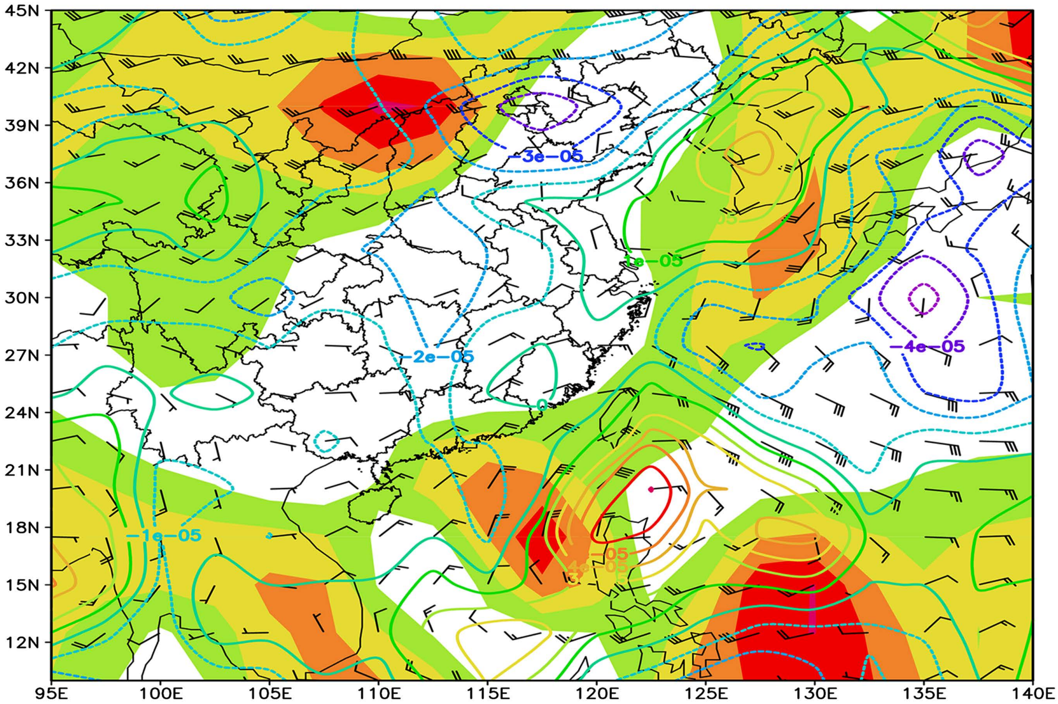
3. Results and Analysis

3.1. High-Level Divergence Field

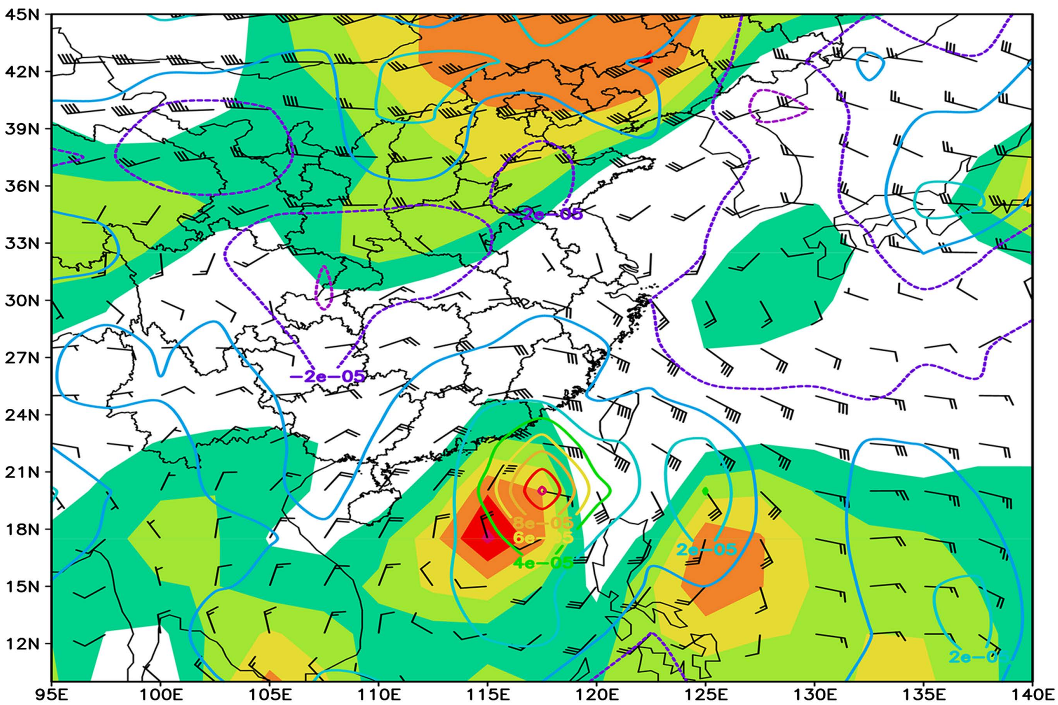
The typhoon moving path is mainly controlled by the typhoon guiding air flow. Since the guiding air flow over the typhoon and its changes depend on the configuration and changes of a large circulation system, Suoyi's method of weather analysis is mainly to judge the typhoon moving path based on the analysis of weather charts, starting from the circulation situation and combining forecasting experience and indicators. Satellite cloud image is an effective tool to locate and track typhoon movement, and the typhoon path can be judged mainly according to the change of cloud pattern or brightness distribution in the cloud image. Analysis of the 200 hPa divergence field, at 20 o'clock on the 21st (**Figure 1(a)**), the high-altitude divergence zone is mainly located in the western part of the Philippine Sea. At this time, the "Tiange" typhoon center is located in the south east of Taiwan, the strong divergence center and the typhoon center. The distance is far; at 20 o'clock on the 22nd (**Figure 1(b)**), the center of the high-altitude divergent center moves slightly westward. At this time, the center of the "Tiange" moves westward to the sea surface of the northern part of the South China Sea, and the strong convergence with the strong divergence center strengthens the high-altitude strong divergence. The celestial body rises in the middle layer, while the ascending movement strengthens the typhoon intensity by strengthening the lower layer convergence (**Figure 1(b)**). The vorticity field of 500 hPa is analyzed. At 20 o'clock on the 21st (**Figure 1(a)**), the center of the typhoon center is slightly positive west, and the center value is 7×10^{-5} s^{-1}. Under the guidance of 500 hPa airflow, the typhoon moves in front of the path. The side is positive vorticity advection; at 20 o'clock on the 21st (**Figure 1(a)**), the positive vorticity center value increases to 12×10^{-5} s^{-1}, and the 500 hPa guide airflow is enhanced, and the positive vorticity advection on the front side of the typhoon moving path The enhancement is conducive to the vertical ascending motion enhancement, which makes the typhoon strength increase rapidly in the offshore.

3.2. Vertical Wind Shear Reduction

At 20 o'clock on the 21st, the "Tiange" Typhoon's center is located in the southeast of Taiwan. It can be seen from **Figure 2(a)** that the vertical wind shear is 200 $m \cdot s^{-1}$ at 200 - 850 hPa above the sky. At 20 o'clock on the 22nd, the center has moved to the southwest of Taiwan. At this time, the vertical wind shear low center value has been reduced to 3 $m \cdot s^{-1}$. When the typhoon is in a small wind vertical shear environment, the heat generated by convection is not easily lost, and the heat of the typhoon is accumulated, so that the warm heart structure can be generated and maintained. It can be seen from the vertical wind shear changes of 200 - 850 hPa in the first two times, the weak vertical wind-shear field is very beneficial to the strength strengthening of “Tiange”.

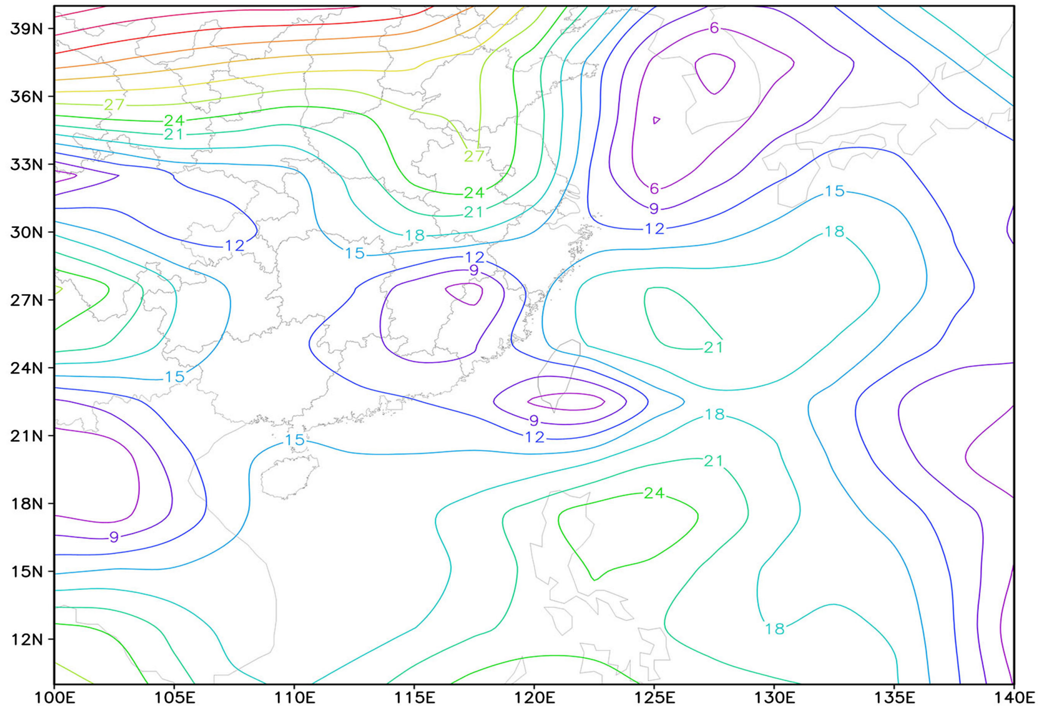


(a)



(b)

Figure 1. A comprehensive map at 20 o’clock on August 21 and 22 (the mapping part is the 200 hPa divergence area; the wind direction rod is the 500 hPa flow field; the line is the 500 hPa vorticity field).



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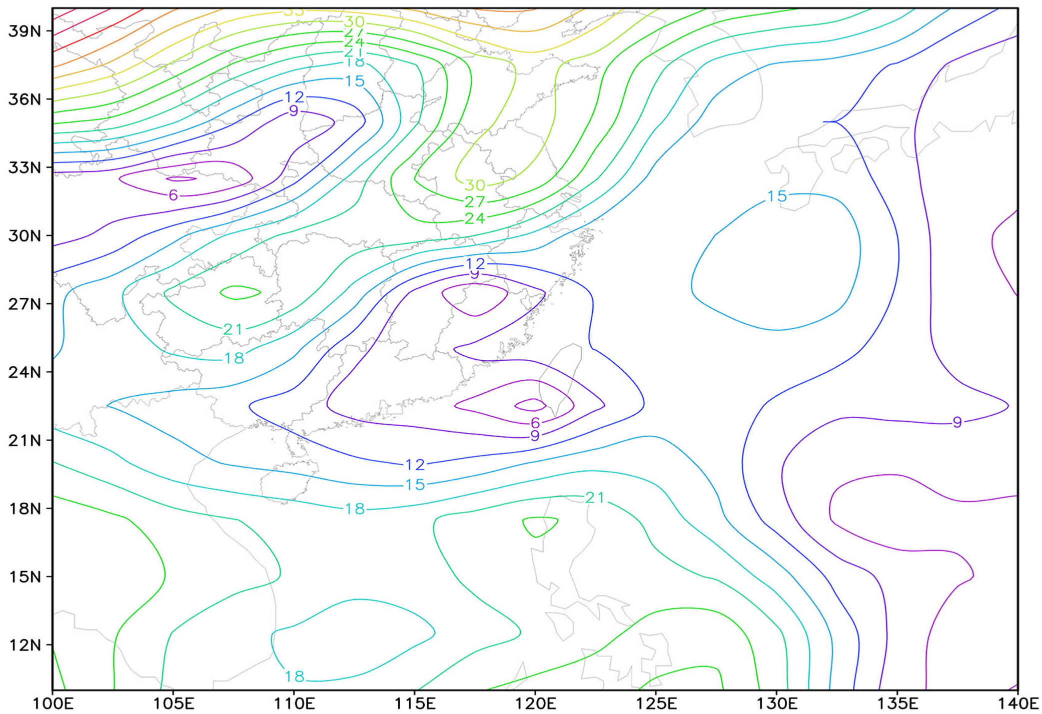


(b)

Figure 2. August 21 (a), 22 (b) 20 o'clock 200 hPa and 850 hPa vertical wind shear.

3.3. Southwest Warm and Humid Air Transport

It can be seen from Figure 3(a) that the water vapor source of the typhoon "Tiange" at 20 o'clock on the 21st is mainly the southeast jet stream on the

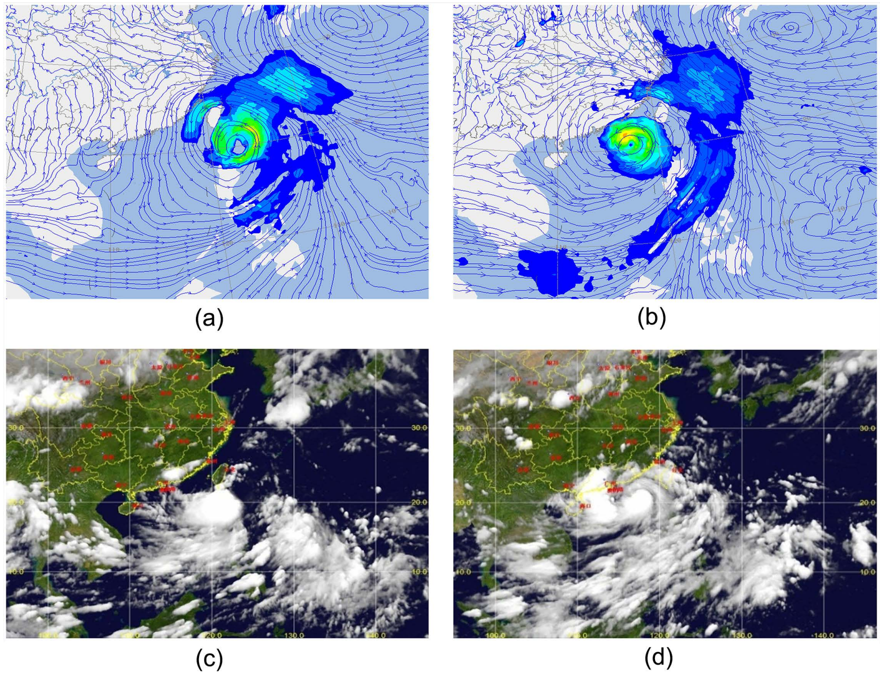
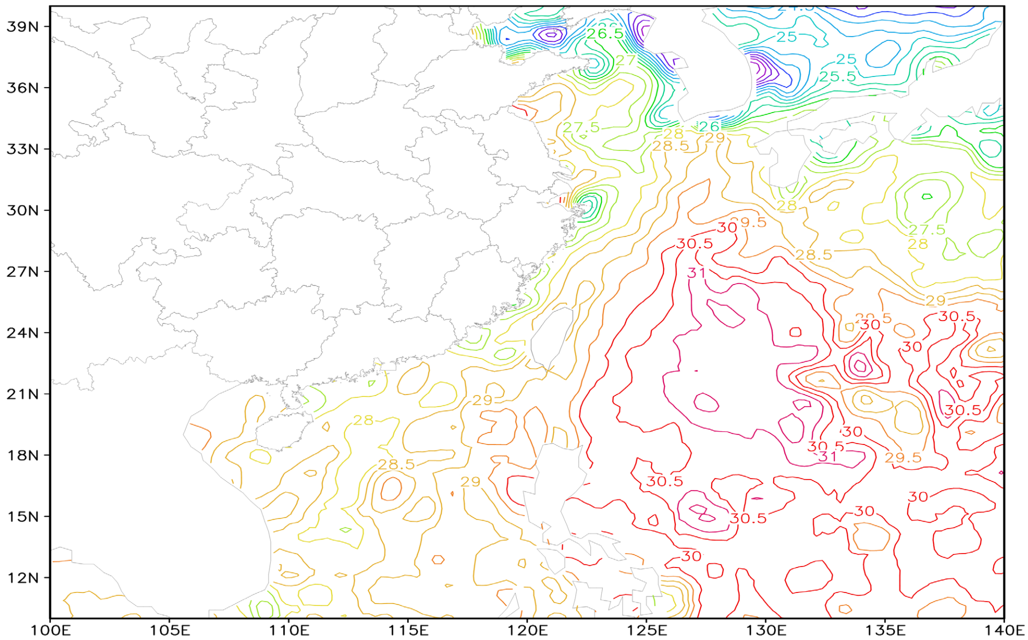


Figure 3. The horizontal flow field at 20 o'clock at 850 hPa on August 21 and 22 ((a) (b), coloring represents wind speed ≥ 12 $m \cdot s^{-1}$) and satellite infrared cloud map ((c) (d)).

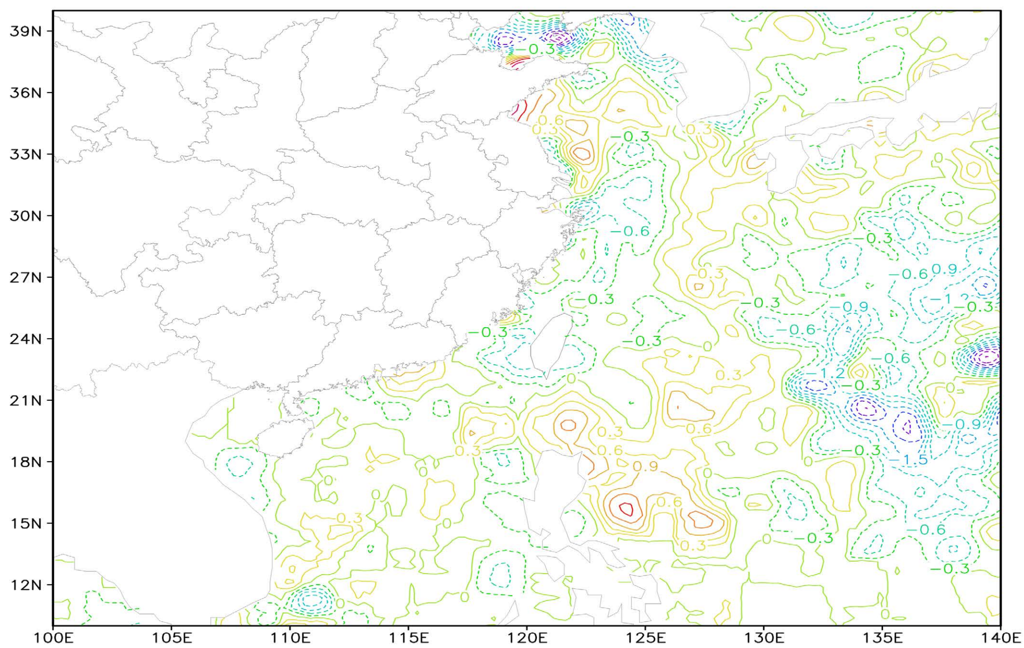
southwest side of the western Pacific subtropical high. At this time, the southwesterly flow on the south side of the typhoon is not strong; at 20 o'clock on the 22nd. The water vapor source of the "Tiange" has become two, one is the southeast rapid stream on the southwest side of the subtropical high, and the other is the southwest rapid stream on the south side. The two water vapor channels provide favorable conditions for the "Tiange" reinforcement. Comparing the satellite infrared image at 20 o'clock on the 21st and 22nd, it can be seen that at 20 o'clock on the 21st, the "Tiange" typhoon cloud system is a relatively isolated cloud with no obvious spiral cloud band, indicating that the typhoon is at this time. The environmental field is not good for the development of the typhoon. At 20 o'clock on the 22nd, it can be clearly seen that the southwest monsoon cloud system developed and connected with the typhoon main body. Studies have shown that the transport of monsoon water vapor is conducive to the strengthening of typhoon intensity (Deng, Zhou, & Yu, 2005); in addition, the cloud system on the northeast side of the typhoon has also increased. The two water vapor channels are opened, providing a source of enhanced water vapor for the "Tiange" offshore.

3.4. Offshore Sea Temperature Conditions

It can be seen from **Figure 4(a)** that the sea temperature in the southern part of Taiwan on the 22nd to the north-central coastal area of Guangdong is about 28˚C to 29˚C, and the sea temperature conditions are conducive to the development of typhoon. It can be seen from **Figure 4(b)** that the sea surface temperature along the "Tiange" moving path is expressed as positive temperature change on the 22nd, and there is a positive temperature change center in the south and south of Taiwan. The center value is 1.2˚C, "Tiange" It is also from the intensity near the center of the positive temperature change that is significantly enhanced. In addition, there is also a positive temperature-changing center on the north-central coast of Guangdong with a central value of 0.9˚C. Good sea temperature conditions are conducive to the release of latent heat, which promotes the enhancement of the strength of the "Tiange" in the offshore.



(a)



(b)

Figure 4. SST distribution on August 22 (a) and its difference between the 22nd and 20th (b).

3.5. Weak Cold Air Supplement

At 08 o'clock on the 22nd, the ground weak cold air spreads from the west road, and the northwest airflow flows through the area of Guangdong to the sea. The northerly wind engulfed with the southwest monsoon and the north side of the typhoon meets in the southern part of the Taiwan Strait. The convergence of air masses is conducive to the development of convection; from the 22 h ground temperature field on the 22nd, it can be seen that under the influence of cold air, most of South China has a negative temperature change, the most variable temperature is −6˚C, and the typhoon is strengthened due to the invasion of weak cold air. The radiance of low-level disturbances also promoted the typhoon to a certain extent (Lin et al., 2005).

4. Conclusion and Discussion

In summary, the reason for the increase in the offshore strength of the typhoon "Tiange" is as follows: the strong divergent center of the high altitude in the sky is superimposed on the top of the "Tiange", which makes it always in the favorable development environment of high altitude and strong divergence. In the middle, the high-altitude strong divergence strengthens the middle rise movement of the "Tiange", and the ascending movement enhances the strength of the "Tiange" by strengthening the low-level convergence.

The strong positive vorticity advection on the front side of the typhoon moving path is conducive to the vertical ascending motion enhancement, which makes the strength of the "Tiange" stronger. The vertical shear of the ambient wind weakened and the sea temperature in the sea increased, which also played a role in the strengthening of the "Tiange" in the offshore. The strengthening of the warm and humid airflow in the southwest provides water vapor and heat energy for the "Tiange", which is conducive to the maintenance of the typhoon warm heart structure and also provides sufficient energy for the development of "Tiange". The intrusion of weak cold air has strengthened the convergence of the low-level disturbance of the typhoon, which has also promoted the typhoon to a certain extent.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

Deng, G., Zhou, Y. S., & Yu, Z. J. (2005). Water Vapor Transport Characteristics of Typhoon Dan (9914). *Journal of Tropical Meteorology, 21,* 529-540.

Gao, A. N., Li, J., Chen, J. et al. (2016) Strengthening of Typhoon "Weimason" Offshore and Causing Abnormal Rainstorm in Guangxi. *Meteorological Science and Technology, 44,* 653-668.

Lin, Y., Liu, A. M., & Liu, M. (2005). "Lily" Typhoon Offshore Strengthening Cause Analysis. *Taiwan Strait, 24,* 22-26.

Su, L. X. et al. (2007). The Relationship between the Vertical Shear of Ambient Wind and the Intensity of the Whole Life History of a Case TC. *Guangdong Meteorology, 29,* 30-32.

Wang, R. G. & He, H. Q. (2014). Analysis of the Causes of Typhoon Moranti (1010) Strengthening Offshore. *West China Science and Technology, 13,* 59-61.

Ye, B. B., Lin, Z. P., & Tong, H. J. (2011). Analysis of the Causes of Typhoon Moranti's Strengthening in the Sea. *Journal of Guangdong Meteorology, 33,* 17-20.

Zhu, Q. G., Lin, J. R., Shou, S. W. et al. (2000). *Principles and Methods of Synoptic Meteorology* (pp. 537-538). China Meteorological Press.