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Severe Weather in Zhoushan Sea Area - Analysis and Prediction of Typhoon

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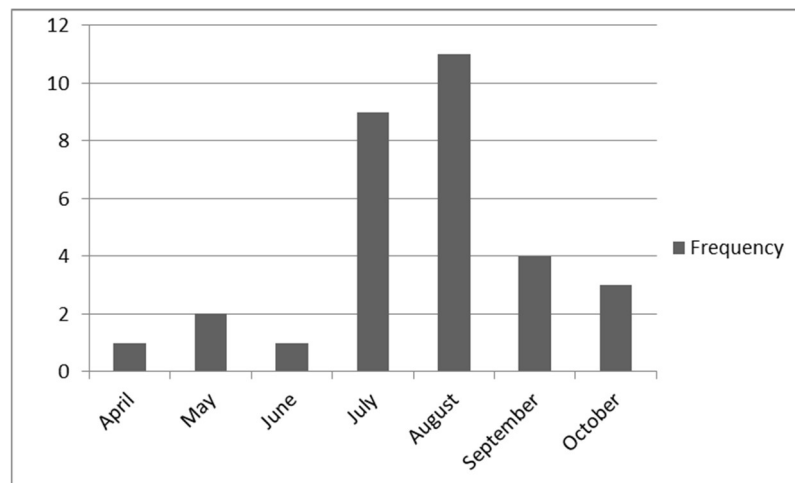
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Abstract. Severe weather analysis system can provide historical typhoon parameters such as longitude, latitude, wind circle, path, time and so on. It also can form clear and reliable horizontal and vertical contrasts with the meteorological information at that time, and can bring the data of these typhoons into the numerical simulation model of the system for dynamic display and path estimation. This system provides real and reliable data for the analysis and prediction of future typhoon paths, and provides technical support for quickly judging and predicting the arrival of typhoons. The system can provide historical typhoon parameters such as longitude, latitude, wind circle, path, time and so on. It also can form clear and reliable horizontal and vertical contrasts with the meteorological information at that time, and can bring the data of these typhoons into the numerical simulation model of the system for dynamic display and path estimation. This system provides real and reliable data for the analysis and prediction of future typhoon paths, and provides technical support for quickly judging and predicting the arrival of typhoons.

1. Introduction

According to the latest statistics of the World Meteorological Organization (WMO), there are about 83 tropical cyclones occurring in the world each year, most of which occur in the Northwest Pacific Ocean, with an average of 25.7 per year, accounting for 30.7% of the world. China is located in the southeastern part of the Asian continent and on the northwestern coast of the Pacific Ocean. Historically, typhoons have caused serious disasters to China's coastal areas. Zhoushan City is located in a special geographical position on the southeast coast of China and on the eastern ocean surface of the outer edge of Hangzhou Bay. The geographical position is between 121°30'-123°25' east longitude and 29°32'~31°04' north latitude. It is 182 kilometers long from east to west and 169 kilometers wide from north to south. The Zhoushan Islands are surrounded by the sea and have a subtropical monsoon climate. They are warm in winter and cool in summer, mild and humid, and full of sunshine. Due to the influence of monsoon instability, the summer and autumn are vulnerable to typhoon (tropical storm), generally occurring from May to November, and July to September is the high incidence of typhoon. The typhoon center has a low air pressure, and the maximum wind speed is generally 30-50 m/s, sometimes even exceeds 80 m/s. Its wide range of influence and strong destructive power often cause severe weather phenomena such as huge waves, squally winds and heavy rains, which seriously affect the safety of navigation and port security in Zhoushan sea area. Therefore, it is very important to analyze and predict the bad weather in Zhoushan sea area.

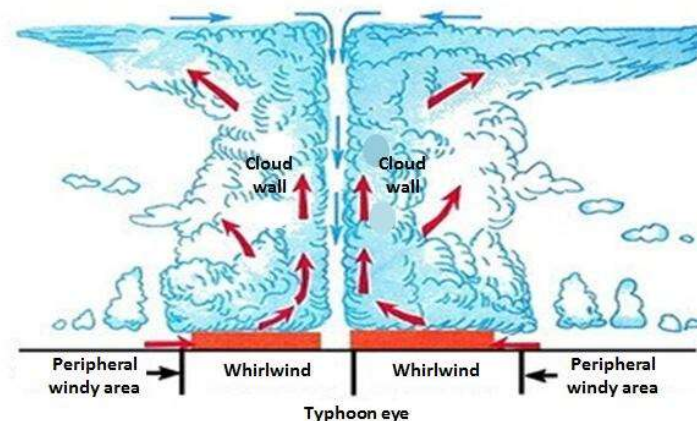


Table 1. Monthly distribution of typhoon intrusion in Zhoushan sea area in recent years

2. Analysis of typhoon affecting China

2.1. Formation and structure of typhoon

In tropical or subtropical oceans where the ocean surface temperature exceeds 26 °C, due to the high temperature near the ocean surface, a large amount of air expands, causing the air pressure near the ocean surface to decrease. The peripheral air is continuously replenished and inflows. Under the influence of the ground bias, the inflowing air rotates. When the rising air expands and cools, and the water vapor cools and forms a water droplet, the heat is released, and the low-level air is continuously raised. In this way, the air pressure on the near ocean surface drops lower, the lower the air pressure, the greater the wind, which makes the center air rotate more violently, eventually forming a typhoon. Under the influence of the ground bias, the inflowing air rotates. When the rising air expands and cools and the water vapor cools and forms a water droplet, the heat is released and the low-level air is continuously raised. In this way, the air pressure on the near ocean surface drops lower, the lower the air pressure, the greater the wind, which makes the center air rotate more violently, eventually forming a typhoon. The typhoon is a deep low-pressure system with a very low center pressure, typically between 990 and 870 hPa. The lower layer has a significant centrally converging airflow and the top airflow is mainly diverging outward. If the typhoon is cut from the horizontal direction, three distinct areas can be seen, from the center to the outside: typhoon eye area, vortex area, and peripheral area.

**Figure 1.** Typhoon structure vertical schematic straight section

2.2. The impact of typhoon on ship maneuvering

The wind speed in the peripheral area of the typhoon is getting bigger and bigger, and the center is out of the swell. In areas where the wind is greater than 8 levels, the waves are generally above 5 meters. The wind speed in the vortex zone is the largest, up to 60-70m/s, often accompanied by thunder and lightning, rainstorms, bad waves, and darkness. This will greatly increase the probability of accidents at sea, which will have a great impact on the maneuvering of ships navigating in the area or the anchoring or even out of control drift of the ship that is anchored against the platform. The eye area is more prone to triangular waves or pyramidal waves and the sea conditions are very bad. The ship entering the ship may have deformation or even fracture or overturn.

2.3. Typhoon path affecting China

2.3.1. Westbound path. The tropical cyclone of this path is generally generated near the northeastern sea area in the central South China Sea. Then from the east side of the Philippines, it has been moving westward, passing through the South China Sea, landing in the south China coast, Hainan Island or Vietnam. It accounts for 90% of the total number of tropical cyclones in the Pacific Ocean in the northwest. The prevailing period is from September to February.

2.3.2. Northwest path. The tropical cyclone of the route is generally formed in the northern ocean face of Palau, east of the Philippines and the western island of the Caroline Islands. From the east of the Philippines to the west-northwest direction, landing in Fujian, Taiwan, or from the east of the Philippines to the northwest, through the Ryukyu Islands, landing in Zhejiang. Such routes account for approximately 27% of the total number of tropical cyclones in the Pacific Northwest.

2.3.3. Parabolic path. The tropical cyclone of the route is generally formed near the central part of the Caroline Islands in the south of Guam. From the east of the Philippines to the east, or to the east of Taiwan or to the south of Japan, first move northwest, then north, then turn northeast. The longitude change of the turning point is gradually moving westward from May to September (referred to as the offshore steering class), and moving eastward from October to December (referred to as the Yuanhai steering class). The turn-around tropical cyclone accounts for about 49% of the total number of tropical cyclones in the western North Pacific.

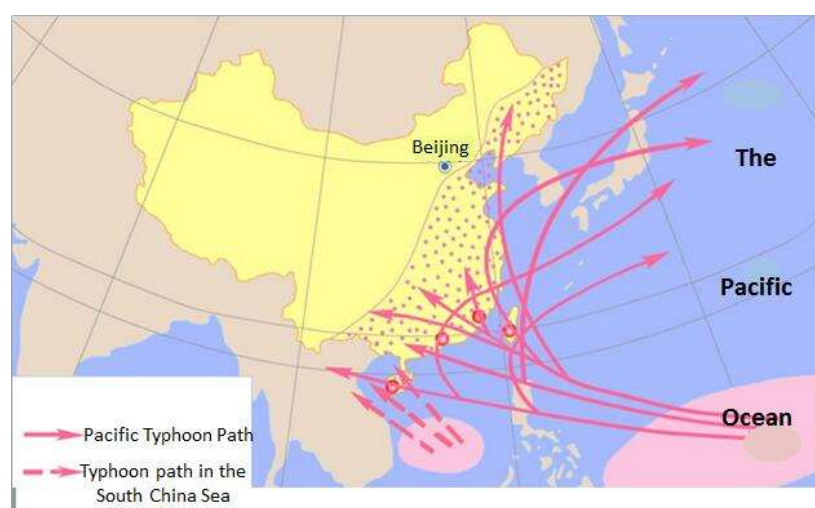


Figure 2. Typhoon path map invading China

In addition to the above-mentioned main conventional paths, sometimes complex and variable abnormal paths may occur, such as irregular movements such as meandering, swinging, spinning,

stagnation, sudden acceleration, and sudden steering. Such routes represent only 5% of the total number of tropical cyclones in the Pacific Northwest and are not discussed here.

3. Case Analysis of Typical Typhoon in Zhoushan Sea Area

According to the statistics of meteorological data in the past 52 years, the number of typhoons affecting Zhoushan has reached 215 times, with an average of 4.1 times per year, including 8 tropical storms, 34 strong tropical storms and 164 typhoons. There were 63 times of disasters of different degrees, with an average of 1.2 times per year. Because Zhoushan is in the northern hemisphere, the cyclone counter-clockwise convergence, so the typhoon usually winds north or southeast. According to the statistics of meteorological data, there are 57 windy processes in which the wind direction is all north (NN-NNW). The wind direction is all south (ESE-WSW) 21 times and the remaining 14 times are alternating north and south in the same gale process. The typhoon path that has the greatest impact on the sea area near Zhoushan is mainly northwest and parabolic. For example, the typhoon "Chan Hong" No. 9 in 2015 is a typical parabolic typhoon. "Changhong" landed at Zhujiajian, Zhoushan around 16:40 on July 11, 2015. The maximum wind force near the center was 14 (45m/s) when the landing, and the minimum pressure of the center was 955 hectopascals. "Chanhong" moved northward through the Zhoushan Islands at a speed of about 15 kilometers per hour. Moved into the southern part of the Yellow Sea and then approached the coast of the Korean peninsula. The reason for the turn is that when the bottom of the deep westerly trough reaches south of 35°, the subtropical high weakens eastward, causing the tropical cyclone to move to the north side of the subtropical high and to move east or northeast.

4. Typhoon pre-judgment in Zhoushan sea area

4.1. *Watching the typhoon*

When the typhoon approaches, sometimes the color of the sky changes from a normal color to a general color. Radiant cirrus clouds (also known as horsetail clouds) appear in the sky and gradually become thicker and denser. The direction of the center of the convergent cloud is the direction in which the tropical cyclone is located. With the approach of tropical cyclones, high-rise clouds and stratus clouds of the volcanic clouds gradually emerged, and the gray-black chopped clouds and shredded clouds associated with the low-altitude rushed with the wind. In the mid-latitudes, high clouds generally move from the west to the east. Therefore, if you see the sky color turns red and the high cloud moves to an abnormality, it can be used as a sign before the typhoon.

4.2. *Listening to the sea sound prediction typhoon*

Two days before the arrival of the typhoon, some places can sometimes hear the sound of the sea, like the sound of the horn in the distance. The sound of the sea is different from the sound caused by the usual wind and waves. It is often heard in silence, lasting longer, sometimes at the same time in two locations. The fishermen have a common saying that "the east is called, the west is supposed to be, and the typhoon is coming to the nose." Therefore, if you hear a clear sea noise, it can be used as a sign before the typhoon.

4.3. *Tide wave predicts typhoon*

The huge waves caused by tropical cyclones can spread to a great distance. It travels more than three times faster than the tropical cyclone itself, so the swell will arrive first 1-2 days before the tropical cyclone approaches. If there is no wind and swell, there may be a typhoon or other storm in the distance. Just like the weather slang, "There is no wind and long waves, and soon the wind and rain are mad." The long waves here are the swells. In addition, before the typhoon, there will be a phenomenon in which the tidal currents are chaotic, the flow rate becomes sharp, the tide level increases sharply or sharply and the time of high tide and low tide is abnormal. Therefore, the variability of swells and tides can be felt during navigation, which can be used as a sign before the typhoon.

4.4. Check data to predict typhoon

Before the arrival of the typhoon, the relevant maritime bureaus, meteorological bureaus and other relevant units will issue notices and warnings in advance according to their respective meteorological observation data. The ship needs to receive the navigation notice in time and analyze and calculate the status of the navigation and the sea area information at any time, so as to facilitate the comparison and prediction of the data. Or, the sea state information and meteorological information received are input into the sub-platform-severe weather analysis system of the dynamic intelligent monitoring and drifting analysis platform of the uncontrolled ship under bad weather and the typhoon is predicted based on the result.

5. Feasibility analysis of severe weather analysis system

The system can provide historical typhoon parameters such as longitude, latitude, wind circle, path, time and so on. It also can form clear and reliable horizontal and vertical contrasts with the meteorological information at that time, and can bring the data of these typhoons into the numerical simulation model of the system for dynamic display and path estimation. This system provides real and reliable data for the analysis and prediction of future typhoon paths, and provides technical support for quickly judging and predicting the arrival of typhoons. All of these have greatly improved the safety of ships sailing and port security in the Zhoushan sea area and have effectively promoted the safe, scientific, reliable and efficient development of Ningbo-Zhoushan Port.

6. Conclusion

Any advanced system and method are based on certain statistics and analysis. It will bring convenient and quick information and solutions to ship drivers and promote the development of high-speed informationization in the shipping industry. However, remember not to blindly rely on the convenience of the system and abandon the calculation and analysis of the actual weather conditions and sea conditions. To improve the navigation safety of ships in inclement weather, comprehensive analysis is also based on a variety of materials. The system also needs to continue to carry out more and updated experiments to improve and improve, and improve its application value.

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