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Analysis of Rainstorm Process in South China from September 7 to 8, 2022

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Abstract

Based on the NCEP data of the United States, a rainstorm process in South China during September 7 to 8, 2022 was studied. Synoptic method is a qualitative and empirical forecasting method. The results show that: In early September 2022, the cold air behind the trough line from northeast China to North China can directly drive southward and invade South China from the east road. Typhoon Hinnamnor is located in the saddle field between the mainland subtropical high and the offshore subtropical high. It moves northward on the west side of the coastal subtropical high, affecting the Taiwan Island and the coastal areas of East China. During September 7-8, the wave trough of the 925 hPa Easterly wave was located near 110˚E. Easterly jet existed in the southeast of South China. The center of the easterly jet was located to the east of Hainan Island, which could transport abundant water vapor from the sea surface to the sky over South China. The precipitable water in the whole layer of the atmosphere decreased from the southern coastal areas to the north, reaching more than 50 mm in southern China, of which most of the South China Sea, Hainan Island and parts of the western part of Guangdong Province exceeded 60 mm, providing sufficient water vapor supply. The circulation field with convergence at low level and divergence at high level is conducive to vertical uplift to form precipitation.

Keywords

South China, Heavy Rain, Easterly Wave, Subtropical High

1. Introduction

From 8:00 (Beijing time, the same below) on September 7, 2022, there was moderate to heavy rain in central and northern parts of western Sichuan Plateau, southwestern Shaanxi, southeastern Gansu, eastern Xizang, most of Guangdong, southern Fujian, southern Jiangxi, southern coastal areas of Guangxi, Hainan

Island, Taiwan Island and other places. On September 7, the high temperature of 35˚C - 37˚C in some areas of Jiangnan, Jianghan, western South China, and eastern Southwest can reach 38˚C or above in local areas. South China from east to west rain weather, local heavy rain or torrential rain, accompanied by short-term strong precipitation (20 - 40 mm/h, local 50 mm/h above). Heavy rain is one of the main meteorological disasters in China. Torrential rain or heavy rain in a certain area often leads to flash floods, dam collapse of reservoirs, rivers overflow, houses collapse, farmland is flooded, traffic and telecommunications are interrupted, which will bring serious harm to the national economy and people's lives and property. Heavy rains, especially large-scale continuous heavy rain and concentrated heavy rain, not only affect industrial and agricultural production, but also may endanger people's lives and cause serious economic losses. Therefore, it is of great significance to study the causes of rainstorm for the protection of national economy and people's life and property safety.

Many experts and scholars have studied the rainstorm. Gong et al. (2023) observed and analyzed the process of an extreme rainstorm in Shandong Peninsula on July 22, 2020, and conducted a high-resolution numerical simulation of the local precipitation process using the mesoscale model WRF, finding that the precipitation occurred in the southwest air flow between the Northern Subtropical High and the bottom of the North China Low Vortex. Strong vortex and low-level jet stream are important weather systems affecting this rainfall, and deep vortex is the main influencing factor of this rainstorm. Wu et al. (2023) studied a heavy rainstorm in Nantong, Jiangsu Province in July 2019, and analyzed the causes of heavy rainstorm and its impact on agriculture. It was found that the westerly trough, the mid-low level shear line and the remote tropical storm were the weather backgrounds that caused the very heavy rain. A β mesoscale convective system developed from γ mesoscale convective cloud cluster caused the generation of heavy precipitation; the strong frontogenesis at the lower level resulted in the release of unstable energy, which was the trigger mechanism for the occurrence of extraordinary rainstorm. Zhong et al. (2023) analyzed the regional rainstorm weather process in Nanchong City from June 25 to 26, 2021, and found that the rainstorm was mainly a stable precipitation process due to the slow westward movement of subtropical high, the maintenance of the 500 hPa low value system in the basin, and the cooperation of the convergence system at the lower level. The maintenance of the southwest vortex from the central to the northeast of the 850 hPa basin, the 700 hPa low-level jet stream, and the shear line provided better power and water vapor conditions for the rainstorm. Zhu et al. (2022) analyzed the rainstorm process in central and southern Jiangxi during June 12-13, 2022. It was found that the rainstorm process was caused by the interaction of the 500 hPa upper trough, the low-level shear line, the low-level southwest jet stream and the surface stationary front under the circulation background of the subtropical high and South Asian High with stable and little movement and the westerly trough carrying cold air southward. The convergence at low level and divergence at high level produced deep vertical

upward movement, which provided the dynamic conditions for the continuous heavy precipitation. The sufficient water vapor transported by the warm and humid southwest jet at low level was conducive to the accumulation of unstable energy in the central and southern Jiangxi Province. Liang et al. (2022) analyzed the characteristics and forecast bias of a relatively heavy rainstorm process occurring in northern and central Guangxi from May 16 to 20, 2021. It was found that the rainstorm process was caused by multiple fluctuations of 500 hPa, low-level shear lines and cold air on the ground. The speed of surface cold air movement is an important factor affecting the intensity of rainstorm and the location of rain belt. The east-west midair jet (that is, the vertical wind shear is large) is conducive to the strengthening and development of convective cloud mass and the eastward movement forms the train effect, resulting in the strong east-west rain band. The distribution of the rainstorm area is consistent with the trend of the low-level shear line and the surface convergence line.

Previous studies did not use the latest research data to study, this paper uses the data of the past two years to analyze the rainstorm process. The method of previous studies and the latest weather data are used to analyze the weather situation more accurately, which is more beneficial to the research of this paper.

2. Date and Methods

2.1. Research Materials

In this study, data provided by the National Center for Environmental Prediction (NCEP) of the USA were used to map the distribution of altitude field, wind field and atmospheric precipitable water by an automatic mapping program (https://psl.noaa.gov/ provided by the U.S. government without intellectual property dispute).

2.2. Research Methods

Synoptic method: Synoptic method is a qualitative and empirical forecasting method, which mainly includes extrapolation method, kinematic method and formal forecasting. Although formal forecasting has become increasingly dependent on numerical forecasting methods, in many cases synoptic methods are still very commonly used.

The weather method is a qualitative and empirical forecasting method. The development of weather processes is often continuous at a certain interval of time, so the past evolution trend of weather systems can be extended to a later period of time to predict the future change of weather patterns. This method is called extrapolation forecasting method, abbreviated as extrapolation method. The extrapolation method can be used to forecast the movement and intensity changes of various weather systems.

3. Results and Analysis

In the result part, the precipitation process is analyzed in detail, and the signi-

ficance of the current work is clearly discussed, which provides ideas and materials for similar research in the future.

3.1. Atmospheric Circulation

In early September 2022, the middle and high latitudes of Eurasia are dominated by zonal circulation, showing a weak pattern of "two troughs and one ridge". The two troughs are located in Western Europe and the line between northeast and North China respectively. Cold air behind the troughs can drive directly southward and invade South China from the east, and the area north of Xinjiang is controlled by a high pressure ridge. This will increase the longitude of the circulation and form a narrow low pressure belt between this high pressure belt and the offshore subtropical high. Strong zonal distribution of the subtropical high in the eastern sea of China fracture, the subtropical high ridge line is stable near 25˚N, ten days of active typhoon Hinnamnor in the mainland subtropical high and the sea subtropical high between the saddle field, in the east of Taiwan after turning the sea surface, coastal subtropical high west of the north, affecting China's Taiwan Island and East China coastal areas. At the same time, under the influence of the main body of the subtropical high, the continuous high temperature weather occurred in the south of China, and the comprehensive intensity of the regional high temperature process reached extremely strong. The high temperature process intensified the meteorological drought in the Yangtze River basin.

3.2. Analysis of Precipitation and Its Influence System

From September 7 to 8, under the influence of the disturbance of the eastern wave and the convergence of low-level shear, heavy rain occurred in South China, and the precipitation in the central and western parts of Guangdong, Guangxi and the central and eastern parts of Hainan Island reached the level of heavy rain. Although the heavy rainfall lasted for a short time, it effectively alleviated the high temperature weather and meteorological drought in South China. From the perspective of circulation situation, in the early stage of the precipitation process, as shown in **Figure 1**, 500 hPa subtropical high and strong were distributed in a band. A tropical wave was active near Indochina Peninsula (**Figure 2**), and the trough line of the tropical wave extended to the east of Guangdong in the northeast direction. There were obvious wind direction changes before and after the trough, with northeasterly winds in front of the trough and southeasterly winds behind the trough, and air currents converged.

3.3. Analysis of Low Level Influence System and Water Vapor Conditions

In this precipitation process, the shear convergence of 925 hPa in the lower layer from Guangxi to the north of Guangdong maintained and developed, which provided favorable environmental uplift conditions for the occurrence of heavy rain. In the 925 hPa geopotential-altitude diagram (**Figure 2**), the existence of

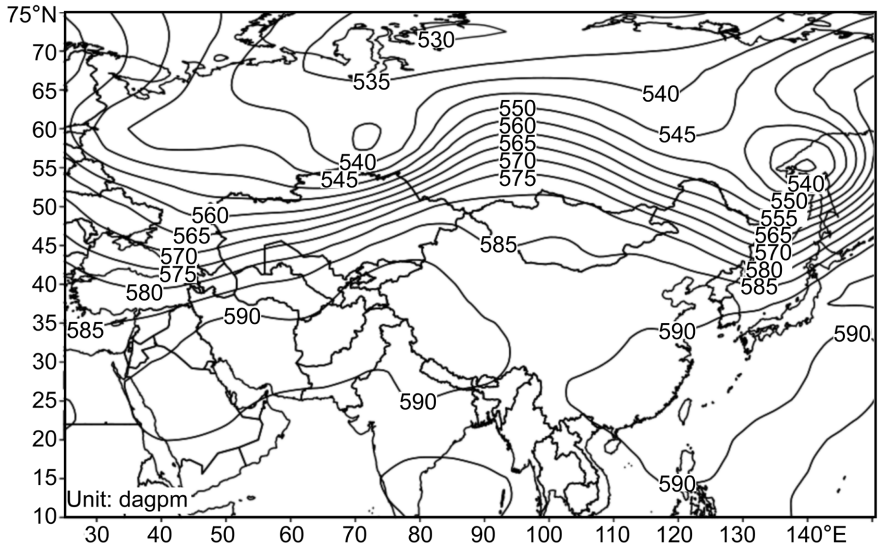

Figure 1. Geopotential height field of 500 hPa at 20:00 hrs on September 7, 2022.

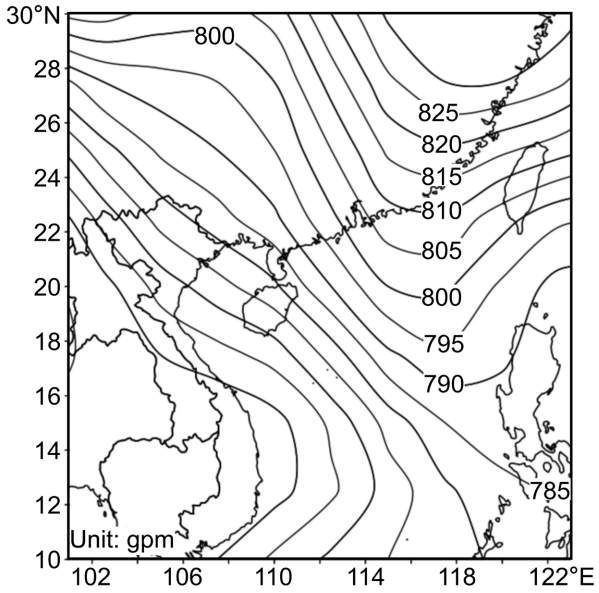

Figure 2. The 925 hPa geopotential height field at 20:00 on September 7, 2022.

the easterly wave can be seen, and the wave trough is located near 110˚E in a north-south direction. Meanwhile, in the 925 hPa wind field diagram (Figure 3), there is an easterly jet stream in the southeast of South China. The center of the jet stream is located to the east of Hainan Island, which can transport abundant water vapor from the sea surface to the sky over South China. Affected by topographic factors, the easterly jet is forced to rise after encountering the obstruction of Wuyi Mountain and Nanling Mountain, which is easy to produce precipitation.

The total atmospheric precipitable water decreased from the southern coastal areas to the north (Figure 4), reaching more than 50 mm in South China, among which most of the South China Sea, Hainan Island and parts of western

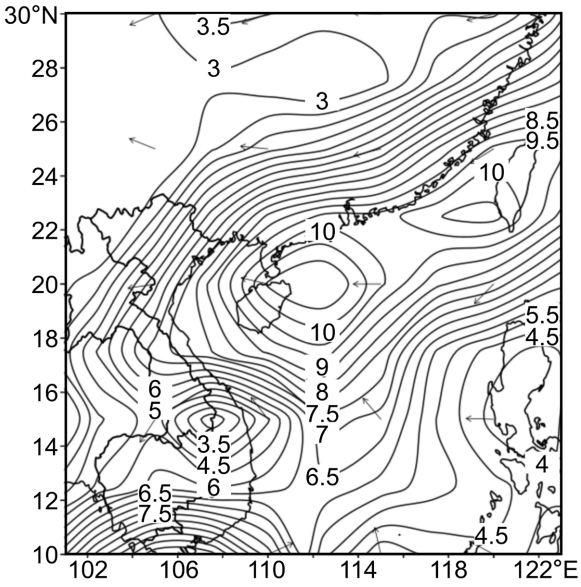

Figure 3. The 925 hPa wind field at 20:00 on September 7, 2022.

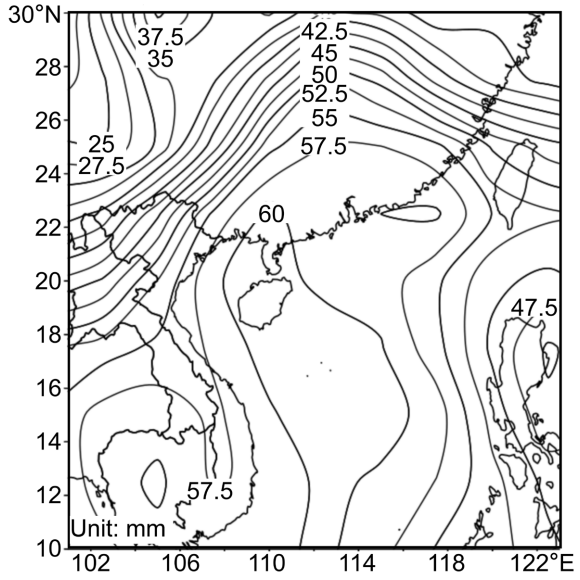

Figure 4. Atmospheric precipitable water at 20:00 on September 7, 2022.

Guangdong exceeded 60 mm, providing sufficient water vapor supply. The circulation field, with convergence at lower levels and divergence at upper levels, is conducive to vertical uplift to form precipitation. In addition, the easterly wave trough located in the north of Indochina Peninsula moved slowly and nearly stalled, and the atmospheric precipitable water of the whole layer in South China was maintained at about 52.5 mm for a long time, which was more likely to form time-concentrated heavy rain.

4. Conclusion

After the analysis of the above process, the following conclusions can be drawn:

In early September 2022, the cold air behind the trough line from Northeast China to North China may drive directly southward and invade South China from the east road. Typhoon Hinnamnor is located in the saddle field between the mainland subtropical high and the offshore subtropical high. It will move northward on the west side of the coastal subtropical high, affecting the Taiwan Island and the coastal areas of East China.

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The precipitable water in the whole layer of the atmosphere decreased from the southern coastal areas to the north, reaching more than 50 mm in southern China, of which most of the South China Sea, Hainan Island and parts of the western part of Guangdong Province exceeded 60 mm, providing sufficient water vapor supply. The circulation field with convergence at low level and divergence at high level is conducive to vertical uplift to form precipitation. The circulation field with convergence at low level and divergence at high level is conducive to vertical uplift to form precipitation.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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