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Analysis of an Extensive Heavy Rainfall Weather Process during 23-24 April, 2021 in China

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Abstract

An extensive rainfall occurred in central and eastern China during 23-24 April, 2021. This research mainly uses the reanalysis data of NCEP/NCAR every 6 hours to analyze this heavy rainfall weather process. The results show that the main reason for this precipitation process is the shear formed between the cold air and the warm and humid air flow in the southwest. The low temperature on the ground allows the warm and humid air flow to lift up to form precipitation. The shear system is strengthened to a low vortex, which greatly strengthens the vertical ascent movement. Good water vapor and dynamic conditions form a large range of heavy rainfall.

Keywords

Low Vortex, Heavy Rainfall, Cold Air, Synoptic Method, Literature Reading Methods

1. Introduction

In late April 2021, a large range rainfall occurred in central and eastern China, of which the strongest occurred from April 23 to 24. Rainfall began on the night of April 22. April 23 to 24 was the main rainfall period of this heavy rainfall process. On April 23, the center of precipitation was located in eastern Sichuan and northern Chongqing. On April 24, the rainfall affected Hubei, Hunan, Jiangxi, Guangxi and other regions, and the rain was still strong. On April 25, the rainfall intensity gradually weakened.

Many scientists have done a lot of research on heavy rainfall process. Wang & Zhang (2006) found that the mid-scale shear line ensured by the wind data of automatic weather stations has some relationship with the region, the intensity

and the happening time of rainfall, and the geographic effect plays an important role in the appearance of the mid-scale shear line. Zhang et al. (2012) pointed out that the trigger of severe convective storms is the cold front, and meanwhile the local topography of the Pearl River Delta, mid-level jet over Guangdong and large wind shear are considerably important in maintaining and developing of the storm. Wang et al. (2006) focused on chemical compositions in the precipitation and used backward trajectory method to identify different rainfalls. Wang et al. (2013) analyzed the evolution of the phase transformation of precipitation happened in spring from March 31 to April 2, 2011 and found that the incursion of cold air making the temperature of intermediate and low-level atmosphere decreased is the main reason of the change in precipitation phases. Chang'a et al. (2020) assessed the evolution, distribution and the socio-economic impacts of extreme rainfall over East Africa during the March, April and May (MAM) rainfall season, focusing on assessing the trends and contribution of MAM rainfall in mean annual rainfall across the region.

There are few studies of heavy rainfall which used the latest data. And this research analyzes an extensive heavy rainfall weather process during 23-24 April, 2021 in China and discusses its formation and development, so as to accumulate forecast experience for such weather.

2. Data and Methods

2.1. Data

The research mainly uses the reanalysis data of NCEP/NCAR, the data about the 500 hPa mean geopotential height field and precipitation in late-April, 2021. The use of the most recent heavy rainfall data in the study is novel in this work and distinguishes it from others' work.

1) The reanalysis data of NCEP/NCAR every 6 hours with a spatial resolution of 2.5˚ × 2.5˚ are from the National Oceanic and Atmospheric Administration (NOAA). The data includes geopotential height and sea level air pressure during 23-25 April, vector wind at 925hPa on 23 April and relative humidity at 850 hPa on 23 April. (https://psl.noaa.gov/)

2) The National Climate Center of China provided data about 500 hPa geopotential heights filed in Northeast Asia and precipitation across China in late-April, 2021. (http://cmdp.ncc-cma.net/)

2.2. Methods

This research uses synoptic method and literature reading methods to analysis. The relevant principles of these methods are as follows. The synoptic method uses the basic laws of the occurrence, development and changes of weather phenomena and weather system to analyze. After obtaining various meteorological elements at different heights through measurement, use the basic formulas and laws of atmospheric motion to analyze weather phenomena.

The literature reading method analyzes by comparing previous articles. The

literature related to the research is obtained through network resources such as CNKI and university library databases. And the ideas of other researches are used for reference to organize and summarize.

3. Results and Analysis

3.1. Weather Brief

From Figure 1, it can be seen that in late April 2021, the circulation situation in the middle and high latitudes of the Eurasian continent was basically maintained. But the East Asian trough deepened and developed and the longitude increased. As a result, the cold air activities were frequent. In the low latitude, south branch trough is significantly deepened, which is conducive to the northward transport of warm and humid airflow.

Precipitation across China in late-April, 2021 is shown in Figure 2. From the night of April 22, 2021, a large-scale precipitation process occurred from northwest to southeast in central and eastern China. On the 23rd, there were heavy rains in parts of southern Shaanxi, western Hubei, and northeastern Sichuan Basin. On the 24th, the precipitation center shifted to the southeast, and there were heavy rains in parts of eastern Guizhou, Hubei, Hunan, northern Jiangxi, and northern Guangxi. The precipitation gradually weakened on the 25th.

3.2. Atmospheric Circulation

From the perspective of the situation, the precipitation weather process from April 23 to 24 was caused by the shear formed by the cold air from the south and the warm and humid air from the southwest.

Figure 3 shows the 500 hPa geopotential heights at 08:00 on April 23. The central and eastern regions of China were controlled by a ridge of high pressure. The Northeastern China to the Korean Peninsula was a high-altitude trough. And a plateau short-wave trough moved eastward to the Sichuan Basin-southern

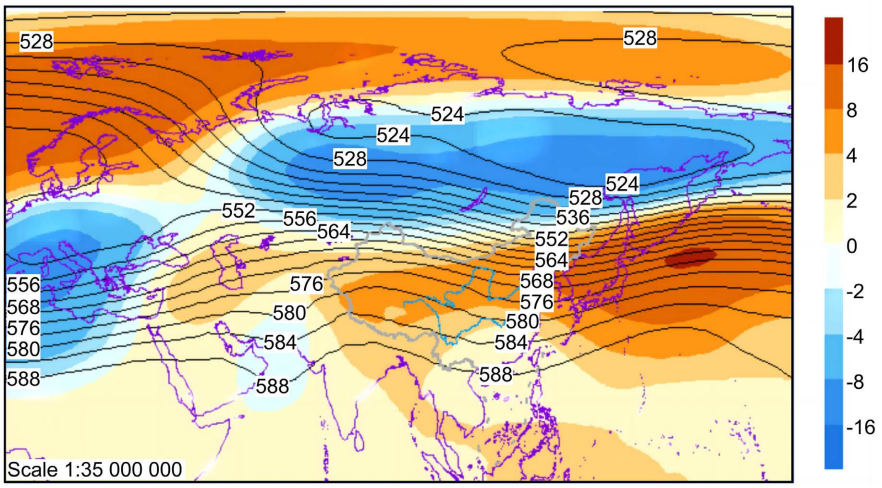

Figure 1. The 500 hPa geopotential heights mean (contour) and anomaly (shaded) filed in Northeast Asia in late-April, 2021 (unit: dagpm).

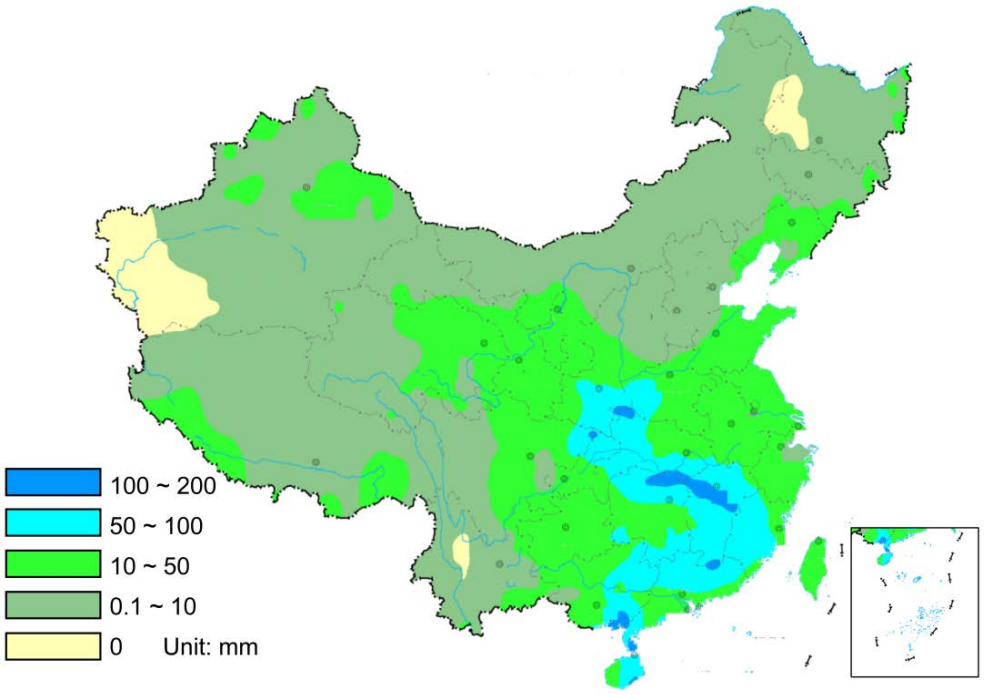

Figure 2. Distribution map of precipitation across China in late-April, 2021.

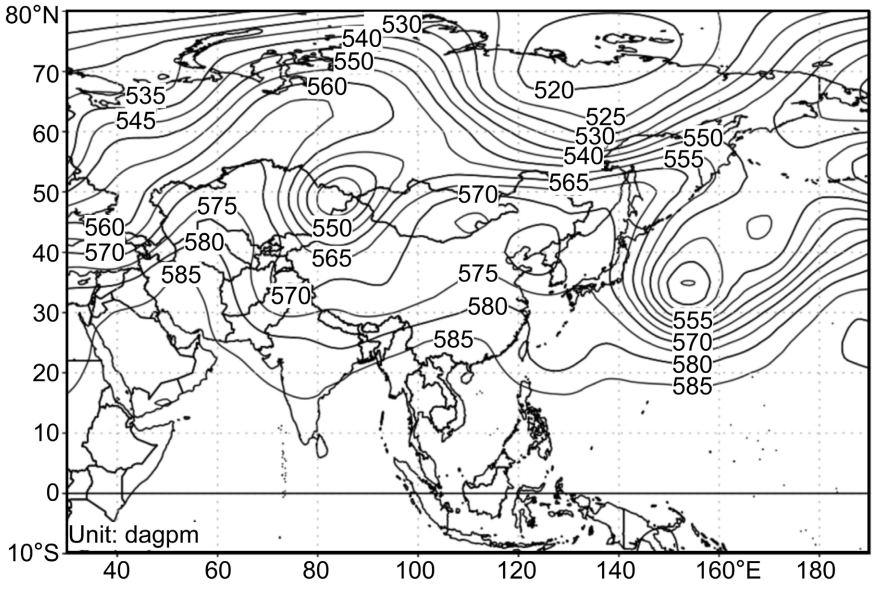

Figure 3. The 500 hPa geopotential height in Asia at 08:00 on 23 April. (Beijing time, the same below).

Northwest China and developed and deepened, forming a system, which provided a good dynamic forcing effect. Figure 4 shows that the main part of the cold air is located in the Mongolian Plateau, the eastern part of Inner Mongolia and Northeastern China. The cold air at the bottom of the trough penetrated from the eastern part of the North China, and presses southward to the eastern part of the Northwest China, the Sichuan Basin, and the Huanghuai area. The

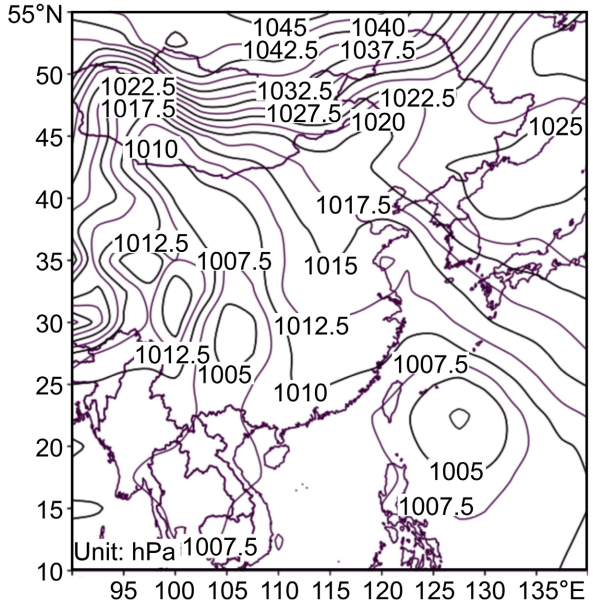

Figure 4. Sea level pressure in East Asia at 08:00 on 23 April.

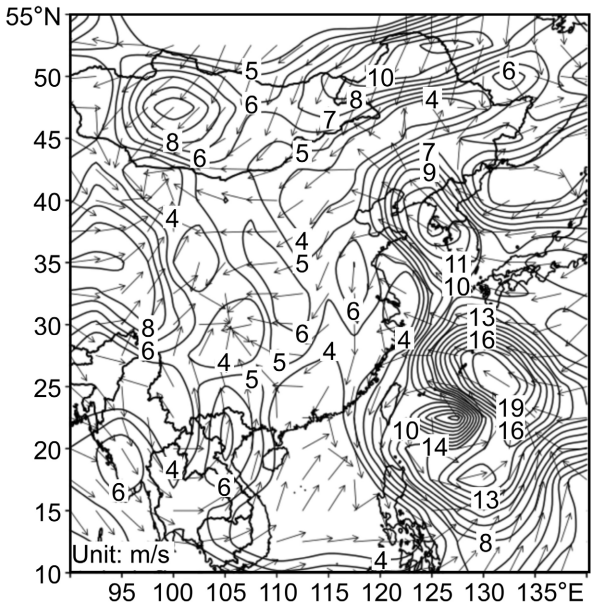

Figure 5. The 925 hPa wind field in East Asia at 08:00 on 23 April.

cold air merged with the southwest warm and humid air flow conveyed by the south branch trough and formed a shear system. The shear system gradually strengthened to form a low vortex. From Figure 5 we can learn that at 925 hPa, easterly winds blew over the above-mentioned areas. These areas were affected by cold air, and the temperature near the surface dropped significantly, forming a "cold pad". At 700 hPa and 850 hPa, the warm and humid airflow climbed along the "cold pad", bringing strong updrafts.

From the perspective of water vapor conditions, the deepening of the southern branch trough promotes the water vapor transport of the southwest warm and

humid airflow. Under the continuous and stable transportation of the warm and humid air flow in the southwest, the precipitable water in southern Gansu, southern Shaanxi, eastern Sichuan, Chongqing, and western Hubei generally reached more than 30 mm (Figure 6(a)), and the 850 hPa specific humidity reached 8 - 12 g/kg (Figure 6(b)). Flush water vapor conditions are an important course of this regional rainstorm in the above-mentioned areas.

It can be seen from Figure 7 that at 08:00 on April 24, the vortex continued to develop and moved eastward. And the shear line pressed southward to the south of the Yangtze River and South China. With good water vapor conditions, it caused widespread heavy rain and local heavy rain.

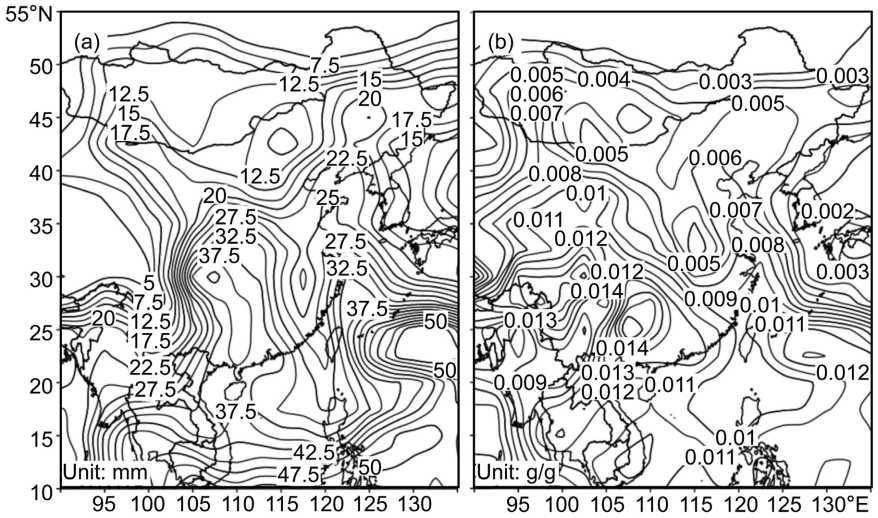

Figure 6. The precipitable water (a) and 850 hPa specific humidity (b) at 20:00 on 23 April.

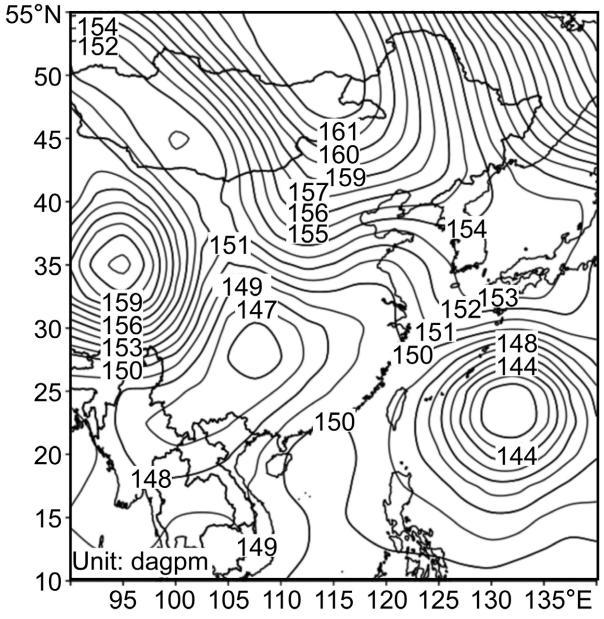

Figure 7. The 850 hPa geopotential heights in East Asia at 08:00 on 24 April.

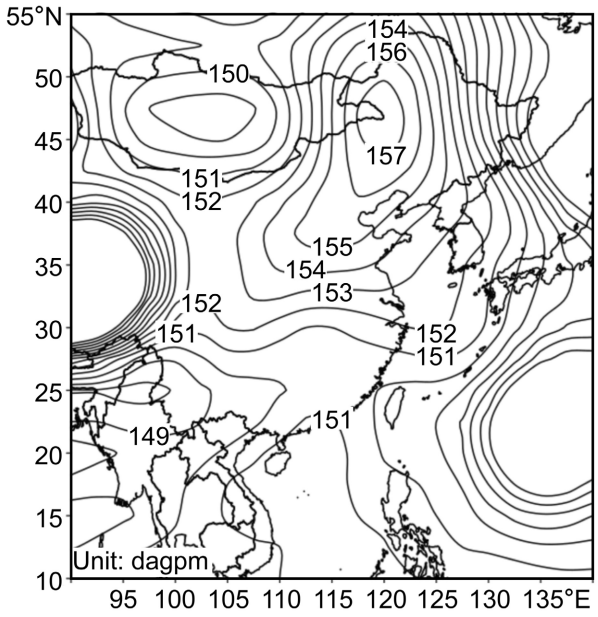

Figure 8. The 850 hPa geopotential heights in East Asia at 08:00 on 25 April.

Figure 8 shows that at 08:00 on April 25, as the shear line continued to move southward into the sea, the cold air weakened, and this round of precipitation ended.

4. Conclusion

Based on the above analysis, the following conclusions can be drawn: The precipitation process from April 23 to 24, 2021 was caused by the southward cold air and the low vortex. Central and eastern parts of China have been affected by cold air, bringing down temperatures near the ground. The southwest warm humid air provides abundant water vapor and merges with the cold air to form a low vortex. The low vortex brings strong upward movement, under the condition of sufficient water vapor, resulting in this heavy rainfall weather process. On the 25th, the shear line moved into the sea, and this round of precipitation end. Because this research is mainly based on the weather analysis method, which is a qualitative and empirical forecasting method, there are some limitations and errors. At the same time, it is hoped that in the future research process, more high-precision and real-time observation data can be combined to make the weather analysis process more accurate and valuable.

Conflicts of Interest

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

References

Chang'a, L. B., Kijazi, A. L., Mafuru, K. B., Nying'uro, P. A., Ssemujju, M., Deus, B., et al. (2020) Understanding the Evolution and Socio-Economic Impacts of the Extreme

Rainfall Events in March-May 2017 to 2020 in East Africa. *Atmospheric and Climate Sciences*, *10*, 553-572. https://doi.org/10.4236/acs.2020.104029

Wang, H. X., Miao, A. M., Dong, C. Q., Dong, W. X., & Zhang, H. W. (2013). Cause Analysis on the Phase Transformation of Precipitation in Shanxi in Spring. *Plateau Meteorology*, *32*, 1787-1794.

Wang, X. M., & Zhang, Z. Y. (2006). Analysis of a Rare Rainy Process in Spring. *Meteorological Monthly*, *32*, 94-98.

Wang, X. M., Yang, L. Y., Qing, B. Q., & Ling, W. S. (2006). Chemical Composition and Origin of Spring Rainwater in Taihu Lake. *Oceanologia et Limnologia Sinica*, *37*, 249-255.

Zhang, T., Fang, C., Zhu, W. J., Zhang, G. C., & Zhou, Q. L. (2012). Analysis of the 17 April 2011 Severe Convective Weather in Guangdong. *Meteorological Monthly*, *38*, 814-818.