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Analysis on the Heavy Rain Weather Process in Most Areas of China from July 26 to 30, 2022

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Abstract

To analyze a new heavy rain case over China during the year 2022, by using the data from NCC-CMA and NCEP, a heavy rain weather process in most areas of China from July 26 to 30, 2022 was analyzed. Synoptic methods were used in this research and results show that under the influence of low vortex and wind shear, the abundant water vapor supply brought by the southeast airflow in the lower level and the lifting of the Taihang Mountain, heavy rain weather occurred in the northern part of Henan, China. In the west of Liaoning and Jilin, the rainfall process had the characteristics of frontal rainfall and the stable precipitation resulted in heavy rain weather. To sum up, the rainfall process was mainly affected by the upper-level trough, low-level wind shear and low-level jet.

Keywords

Synoptic Methods, Low Vortex, Wind Shear, Water Vapor, Stable Precipitation

1. Introduction

From July 26 to 30, 2022, there was moderate to heavy rain in northeastern Inner Mongolia, northeastern Northwest China, northern and western North China, eastern Huanghuai, eastern Jianghuai, western Hubei, and northeastern Southwest China, among which some parts of Hebei, Beijing, Liaoning, Jilin, Shandong and Jiangsu saw heavy rain.

Zeng et al. (2018) analyzed the cases of landing and impact of the heavy rain of typhoon in Fujian, China and found that on the basis of Fujian special geographical location and terrain, there are four types (easterly jet, warm-type sheer, inverted V-shaped trough of typhoon, westerly trough) are conductive to the circulation patterns of causing the heavy rain of typhoon. Guo et al. (2018)

found that the linear mesoscale convective system in the continuous heavy rain in Fujian, China is mainly constructed later, and the trailing and parallel mesoscale convective system is conducive to the occurrence of continuous heavy rain in Fujian. The moving direction of the linear mesoscale convective system and convective monomer is mainly in the east direction, and the system duration is mostly 4 to 10 hours. Zhang et al. (2017) combined live and forecast data, aiming at the results of the mid-rainstorm forecast in North China during the period of July 19, 2016, and compared with the actual situation of the rainstorm, then carried out the mid-term forecast of the rainstorm. Auzani et al. (2022) used Radial Basis Function Neural Network (RBFNN) algorithm to predict rainfall and found that the model works better the more hidden nodes and the optimum learning rate is 0.01 with the RMSE 49% and the percentage accuracy is 57%. Sierra-Lorenzo et al. (2020) tested a set of 15 combinations of microphysics and cumulus parameterizations for the WRF numerical model in the forecast of a rain event on January 16 2018 over Panama and found that the scheme of Betts-Miller-Janjic showed the highest correlation factor and performed quite well representing the vertical profiles of relative humidity, temperature and wind.

The above research found the main weather systems which caused heavy rain and the distribution characteristics of atmospheric circulation situation field, however, their cases were quite old. I analyzed a new heavy rain case over China during the year 2022 by using synoptic methods, and brought new knowledge to this field.

2. Data and Methods

2.1. Data

The ten-day average tropospheric weather data was used in this study comes from the second-generation product of the extended set of monthly dynamic forecasts (DERF2.0, Dynamic Extended Range Forecast operational system version 2.0) of the China National Climate Center, which is established based on the atmospheric circulation spectrum model, providing the ten-day and monthly average circulation situation and meteorological elements in the next 40 days (Qi, 2021; Zhang et al., 2019; Wu et al., 2013).

This study also used the global atmospheric reanalysis data from the National Center for Environmental Prediction (NCEP), which was jointly developed with the National Center for Atmospheric Research (NCAR). This set of data is grid data formed by reanalysis of global meteorological data from 1948 to the present using observational data, prediction models and assimilation systems. Data variables include multiple meteorological variables of the surface, near surface and different pressure layers, such as precipitation, temperature, relative humidity, sea level pressure, geopotential height and wind field.

2.2. Methods

This study used synoptic methods in this research that based upon analysis of a

set and/or series of synoptic charts as the most common means of arriving at a weather forecast/analysis. These techniques usually contain elements of a physical, kinematic, and climatological nature (Zhu et al., 2007). The method of synoptic analysis can exert the initiative of weather forecasters and explain the results of objective weather charts effectively. Weather charts are available on the official websites of the meteorological departments of the Chinese and US governments, such as http://cmdp.ncc-cma.net/ in China and http://psl.noaa.gov/ in the USA.

3. Results and Analysis

3.1. Overview of Atmospheric Circulation

In late July 2022, the circulation in the middle and high latitudes of Eurasia toke the shape of one trough and two ridges (**Figure 1**). The two high pressure ridges over Eurasia were located in the northern Caspian Sea and the Far East respectively. Among them, the high pressure in the north of the Caspian Sea was weak, and the blocking high from East Siberia to the Far East was strong. The low trough of Baikal Lake deepened, but was blocked by blocking high pressure and moved slowly eastward. This led to the increase of meridional degree of the mid high latitude circulation in China, showing a trend of high in the west and low in the east, which was conducive to precipitation in the north central China. In low latitude areas, the subtropical high developed vigorously, continued to extend westward and northward, and was connected with the subtropical high from Iran Plateau to Africa in the west. The downdraft brought about by the subtropical high made southern China continued to experience high temperature and little rain.

3.2. Weather Situation Analysis

From July 26 to 30, 2022, a large-scale heavy rainfall weather process occurred in the eastern part of Southwest China, the Yellow River, Huaihe River and Yangtze River Basin, North China and Northeast China due to the joint influence of the eastward moving high trough, low level shear line and low level jet.

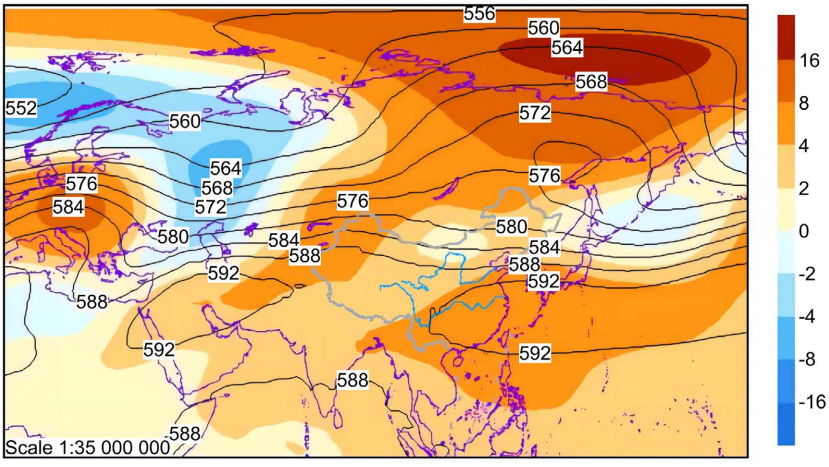

Figure 1. The 500 hPa geopotential height field and anomaly in July 2022.

The precipitation weather process could be divided into two stages. The first stage is represented by the weather situation at 20:00 on July 27. On the 500 hPa weather map (Figure 2), the subtropical high was located north by west, and its northern boundary moved to the Jianghuai and northern Jiangnan regions. In middle and high latitudes, there was a high trough of 500 hPa moving eastward to Shanxi and Hubei. A persistent shear line appeared on the 850 hPa weather map (Figure 3). This shear line was located in front of the 500 hPa high trough, which was conducive to the formation and development of the vortex.

The second stage is represented by the weather situation at 20:00 on July 28. On the 500 hPa weather map, the subtropical high had risen to the north. Blocked by the subtropical high, on the 850 hPa weather map, the vortex system moved relatively slowly, moving to Liaoning and Shandong. At the same time, there was a strong low-level jet over Liaoning, and there was a strong convergence area on the east side of the jet.

3.3. Water Vapor Condition Analysis

On July 27, 2022, the whole layer precipitable water of Hebei, Henan and other places was more than 40 mm, and there was continuous water vapor transport in the lower layer affected by the southeast airflow. Abundant water vapor supply and the uplift of Taihang Mountain topography led to heavy rain in the central and southern Hebei and northern Henan. The precipitation in this stage was local and sudden, and had a certain characteristic of convection weather.

On July 28, the precipitable water of the whole layer in the west and north of Liaoning exceeded 50 mm (Figure 4). Affected by the vortex shear line, the Bohai Bay provided abundant water vapor for the precipitation process, causing heavy rain in the central and western Liaoning and western Jilin. The precipitation process in this stage had the characteristics of frontal precipitation, mainly stable precipitation, and the precipitation duration was relatively long.

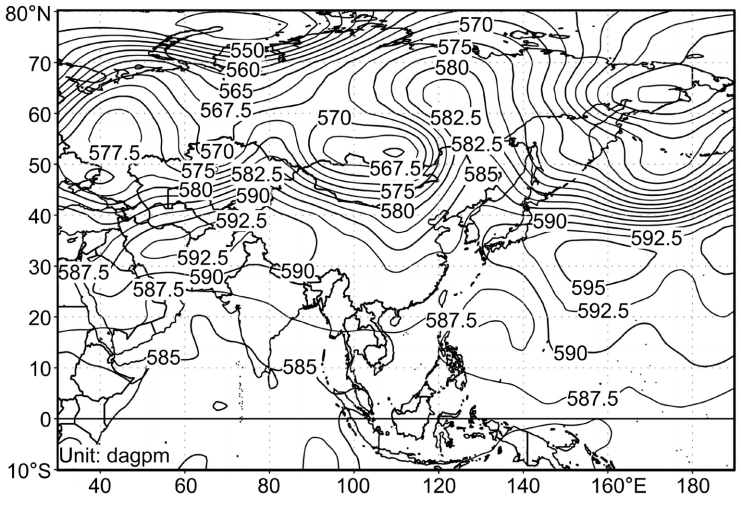

Figure 2. The 500 hPa geopotential height field at 20:00 (Beijing time, the same below) on July 27, 2022.

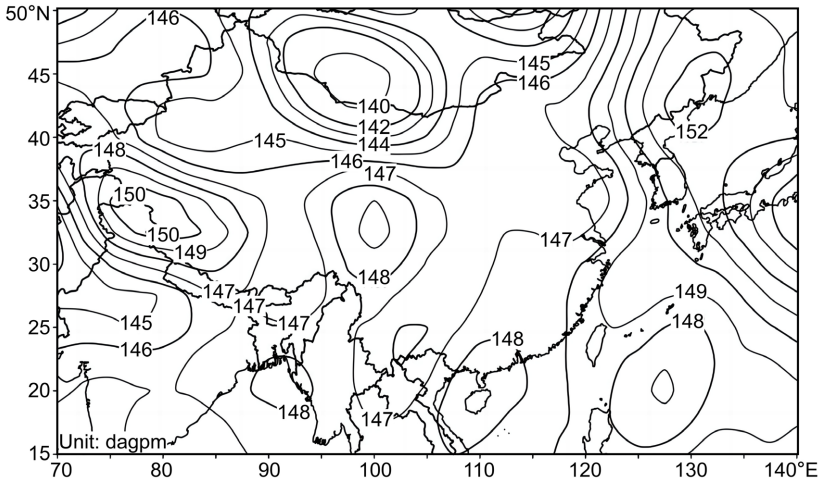

Figure 3. The 850 hPa geopotential height field at 20:00 on July 27, 2022.

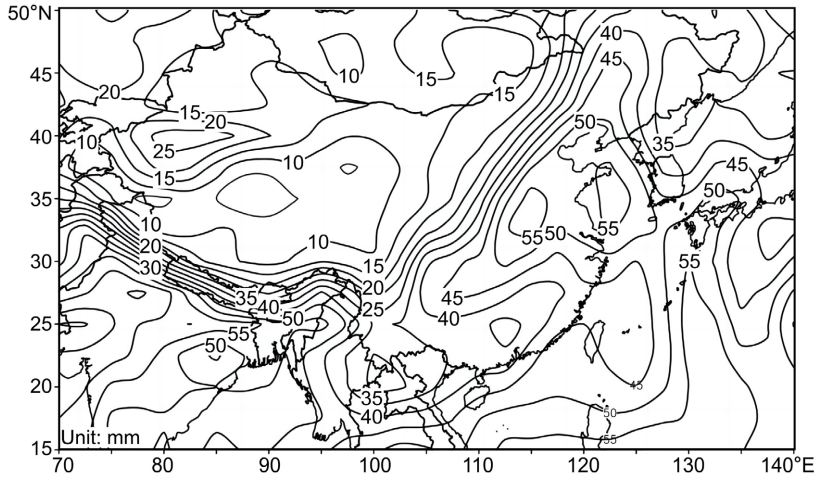

Figure 4. The colunmar precipitable water at 02:00 on July 28, 2022.

4. Conclusion and Discussion

The rainfall process was mainly affected by the upper-level trough, low-level wind shear and low-level jet. Low-level wind shear refers to the horizontal or vertical shear of the wind about 600 meters above the ground. It is mainly caused by low-level jet stream and frontal activities. Some shear lines are parallel to the low-level jet stream (Zhu et al., 2007). Under the influence of the dynamic system such as low vortex and wind shear, the abundant water vapor supply brought by the southeast airflow in the lower level and the unstable conditions such as the lifting of the Taihang Mountain, heavy rain weather occurred in the northern part of Henan, China. In the west of Liaoning and Jilin, the rainfall process had the characteristics of frontal rainfall, which was mainly stable precipitation. Rainfall duration was relatively long, resulting in heavy rain weather.

Conflicts of Interest

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

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