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Analysis of Cold Air and Precipitation in Central and Eastern China, 2-5 October, 2022

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Abstract

This paper used potential height field data published by the China National Climate Center and the US NCEP reanalysis data. A study was conducted on a strong cold wave weather process in central and eastern China from October 2 to 5, 2022. The results show that this weather process is a cold air weather process of "horizontal trough to vertical" type from the east of Novaya Zemlya Island. Cold air passes through Russia and Mongolia south, controlling northern China. The precipitation process is caused by the combination of high-altitude trough, ground front, warm and humid air flow, and precipitation weather formed by the influence of warm and humid air due to the 700 hPa shear line. The northern Sichuan Basin and the middle and lower reaches of the Yellow River in China can precipitate almost 50 mm. Water vapor is transported from the South China Sea to central and eastern China by the southwest warm and humid air flow along the west side of the West Pacific Subtropical High. Water vapor is concentrated over the precipitation area through horizontal convergence and is the most important source of water vapor causing precipitation.

Keywords

Meteorological, Method, Precipitation, Cold Wave, Cold Air

1. Introduction

From October 2 to 5, 2022, a strong cold wave weather process occurred in central and eastern China. Affected by this cold wave, the temperature has dropped "off a cliff". At the same time, China also experienced a strong precipitation process. Shanxi, Shaanxi, Hebei, Chongqing, Sichuan and other places were affected. The regional rainstorm process mainly occurred in the border areas of

Shaanxi, Sichuan and Chongqing, Henan and the neighboring borders of Shanxi, Hebei, Shandong, Jiangsu and Anhui provinces.

Chen and Ding (2006) studied the effects of precipitation and cold air activity in the southwest region in 2004. The paper points out that the occurrence of heavy precipitation is the result of the combination of high-latitude circulation changes and low-latitude systems. In addition, the warm and humid southwest summer wind is very active, and the two interact strongly in southern China, forming convective precipitation. Han et al. (2020) used Chinese precipitation data to analyze the correspondence between low-frequency oscillations of potential vortex and latitudinal wind and precipitation. The results show that there is a large positive correlation between potential eddies and zonal winds and precipitation. Jiang and Lu (2016) analyzed the circulation anomalies of continuous heavy rainfall in the Jianghuai River Basin from May to July 1991, and compared the importance of water vapor transport and cold air activity caused by the flood. The results show that the heavy precipitation in the Jianghuai River Basin is caused by the abnormal increase of water vapor in the lower troposphere and the abnormally low temperature, and the effects of the two are basically the same. Rahimi et al. (2018) examined trends in extreme temperature and precipitation indices in Iran during the period 1960-2014. There is a decreasing trend in the magnitude and frequency of cold extremes and an increasing trend in magnitude and frequency of warm extremes over the observational record, which is consistent with previous research reporting the warming trends of the climate. Varikoden et al. (2010) found that the precipitation zones have strong links with the intensity of the cold tongue. During stronger cold tongue periods the precipitation on either side of the cold tongue is considerably greater than during weaker cold tongue periods. The features of convection on the eastern and western sides of the cold tongue behave differently. On the eastern side convection is preceded by one day with SST gradient, while on the western side it is four days. Zhang et al. (2021) studied the effects of different levels of dry cold air, relative humidity, etc. on heavy rainfall. The results show that the strengthening of dry and cold air in the upper layer needs to be combined with a certain humidity to be conducive to precipitation, and the enhancement of dry cold air in the middle layer is conducive to the enhancement of heavy rainfall. However, the humidity is too low and is not conducive to the continuation of heavy rainfall, and the stronger the dry and cold air in the lower layers, the more conducive to the enhancement of precipitation.

Some previous studies mentioned have a certain relevance to this study, and the issues discussed in this paper have a certain connection with existing studies. This study draws on the research results of predecessors, and analyzes the latest precipitation process by using the latest national and climate center potential height data and NCEP reanalysis data. In addition, this study combines the average data of the month and month with the daily weather data to analyze the weather process, which is a relatively new research idea.

2. Material and Methodology

2.1. Information

The average potential height data used in this study are from the monthly dynamic extension ensemble prediction product of the National Climate Center of China (DERF2.0, monthly dynamic extension ensemble prediction system version 2.0). The system uses a combination of dynamic-statistical and physical statistical climate prediction methods to publish daily and monthly mean circulation and factor forecasting products in real time (Wang et al., 2020).

The study also used the National Center for Environmental Prediction reanalysis dataset. The dataset was produced jointly by the National Forecast Center (NCEP) and the National Center for Atmospheric Research (NCAR). It uses observational data, predictive models, and assimilation systems to reanalyze global meteorological data from 1948 to the present to form grid data. The data includes multiple meteorological variables such as precipitation, temperature, relative humidity, sea level pressure, relief altitude and wind field at surface, near surface, and different pressure layers. Weather charts can be found from the website http://psl.noaa.gov/.

2.2. Maintaining the Integrity of the Specifications

The method used in this study was meteorological. The meteorological method is a qualitative, empirical forecasting method. Although situation forecasting is increasingly relying on numerical forecasting methods, meteorological methods are still very important and common methods in many cases (Zhu et al., 2007). The extrapolation method is mainly used, and the 3 h variable pressure and system moving velocity formula are used to analyze the trough ridge and moving velocity. Finally, the dynamic principle of pressure change is used to estimate the future of the system.

3. Results & Analysis

3.1. Analysis of the Circulation Situation

From **Figure 1**, it can be seen that in early October 2022, the Eurasian high-latitude circulation situation was of the "two troughs and one ridge" type. The eastern trough is located from the Sea of Okhotsk to Japan, while the western trough is located in the Barents Sea. Both slots are stronger than the same period of the year. The ridge is located east of Novaya Zemlya Island, east of the Ural Mountains to the Caspian Sea, and is also stronger than the same period of the year. China is located in front of the posterior ridge of the trough. Cold air gathered behind the trough and moved south, causing a nationwide cold wave in early October. The source of the cold air this time is east of Novaya Zemlya Island. Cold air enters China through Russia and Mongolia. In the middle latitudes, near Lake Baikal there is a strong trough. In low latitudes, sub-heights occupy most of the south and are stronger than the same period of the year, resulting

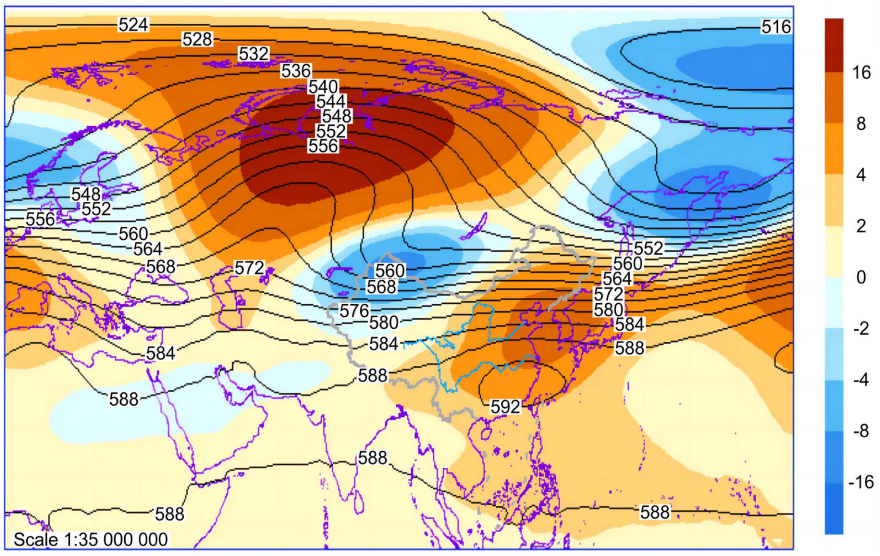

Figure 1. The average potential height of 500 hPa in early October 2022.

in high temperatures in the south of the Yangtze River. The convergence of cold and warm air on the north side of the sub-high caused a systematic precipitation process in early October, and significant precipitation occurred in the northern part of the Sichuan Basin and on both sides of the middle and lower reaches of the Yellow River.

3.2. 500 hPa Weather Map Analysis

It can be seen from Figure 2 that at 08 o'clock on October 2 (Beijing time, the same below), a large trough in the northeast-southwest direction appeared in the border area between Mongolia and Russia. China is located in front of the trough. Obviously, this cold wave weather process belongs to the "horizontal trough to vertical" type. The main body of cold high pressure is located north of Xinjiang. The sub-high is entrenched in the area south of the Yangtze River. As the trough moved east and gradually turned vertical, cold air entered northern China. At 08:00 on October 4, the trough continued to move east to the 3.3. Equations northeast-north China region and was completely vertical. China is located in the northwesterly air flow in front of the ridge behind the trough, directing cold air southward in a big way. The sub-high extends and strengthens to the west, and the area of the controlled mainland area increases significantly. The cold air meets the warm and humid air flow on the north side of the sub-height, causing significant rainfall. Subsequently, the East Asian trough continued to move eastward and away from China, and this cold air process tended to end.

3.3. 700 hPa Weather Map Analysis

Figure 3 shows that there was an inconspicuous low pressure center in the central Sichuan Basin at 08:00 on October 4. From the center of the low pressure

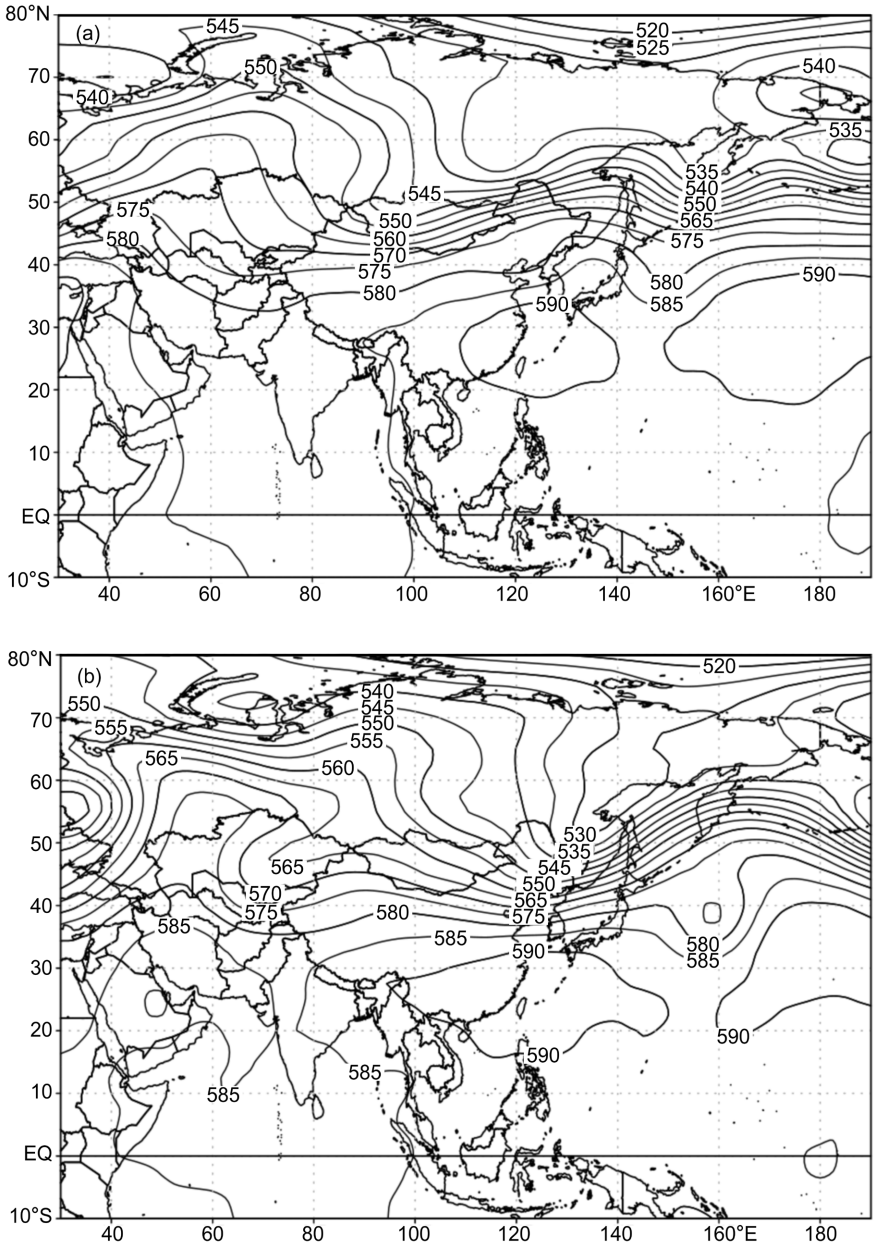

Figure 2. The 500 hPa potential height field at 08:00 on October 2 (a) and 4 (b), 2022.

extends transversely to the east a southwest-northeast shear line. This shear line spans southern Sichuan, southern Chongqing, and southern Hubei. The air flow on the shear line is a cyclonic circulation, and the horizontal convergence is obvious, which is conducive to upward movement and is a favorable condition for cloud and rainy weather. At this time, the Western Pacific Vice High still controlled most of Jiangnan and South China. Warm and humid air from the South China Sea moves along the northerly updraft on the west side of the West Pacific High to the north side of the Sichuan Basin, making the area abundant with water vapor. The above dynamic conditions and water vapor conditions work together to form precipitation in the northern area of the shear line.

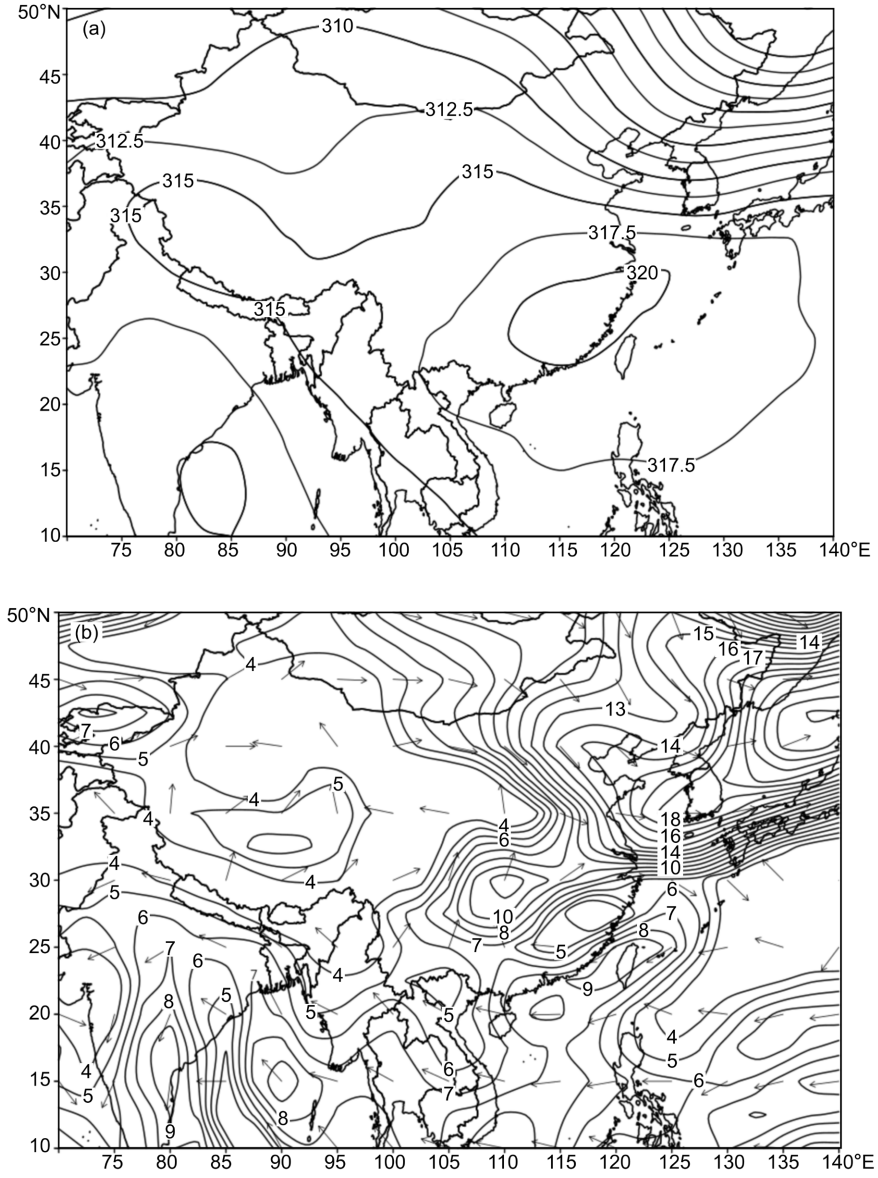

Figure 3. Potential height field (a) and vector wind field (b) at 08:00 on October 4, 2022.

3.4. Precipitable Water Analysis

Low-level humidity contributes the most to precipitation. Precipitable water refers to the amount of precipitation in which the water vapor of the entire atmosphere over the entire layer of the area per unit area is condensed and dropped to the ground, indicating the water vapor content of the entire atmosphere. Figure 4 shows that at 08 o'clock on October 4, the precipitable water in the northern Sichuan Basin and the middle and lower reaches of the Yellow River was greater than 40 mm, and the precipitable water in the coastal area even exceeded 50 mm, which provided abundant water vapor for this precipitation. Second, the southwest warm and humid air flow transports water vapor from the South China Sea to central and eastern China. When precipitation occurs, water vapor outside the precipitation zone is concentrated over the precipitation area through

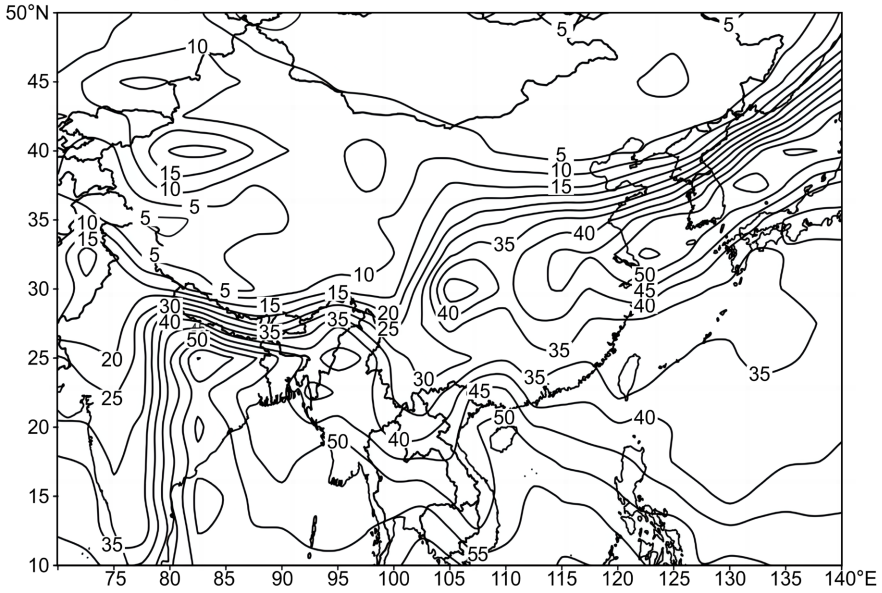

Figure 4. Precipitable wtaer at 08:00 on October 4, 2022.

horizontal convergence, which is the most important source of water vapor causing precipitation.

4. Conclusion

This weather process is a cold air weather process of "horizontal trough to vertical" type from the east of Novaya Zemlya Island, which caused a violent cooling in China. Cold air passes through Russia and Mongolia south, controlling northern China.

The system affects the formation of precipitation. The precipitation process is caused by the combination of high-altitude trough, ground front, warm and humid air flow, and precipitation weather caused by the influence of warm and humid air due to the 700 hPa shear line.

Sufficient moisture conditions and warm, humid air flowing from the southwest resulted in precipitation of nearly 50 mm in the northern Sichuan Basin and the middle and lower reaches of the Yellow River in China. Water vapor is transported from the South China Sea to central and eastern China by the southwest warm and humid air flow along the west side of the Western Pacific Subtropical High. Water vapor is concentrated over the precipitation area through horizontal convergence and is the most important source of water vapor causing precipitation. These two make the water vapor conditions in the precipitation area very favorable for precipitation.

The weather method is the traditional forecasting method, but it is still widely used today. This method assumes an ideal model to describe the relationship between atmospheric disturbance and local circulation phenomena, and predicts the changes of meteorological phenomena in the real atmosphere according to the structure and operation mechanism of this ideal model.

Conflicts of Interest

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

References

Chen, Y., & Ding, Y. H. (2006). Cold Air Activity in July 2004 and Its Impact on Heavy Precipitation in Southwest China. *Acta Meteorological Sinica, 6,* 743-759.

Han, L., Guo, W. Q., & Zhang, S. Q. (2020). Analysis of the Influence of Cold Air Low-Frequency Oscillation on Summer Precipitation in Huaihe River Basin. *Bulletin of Oceano-Limnology, 1,* 36-42.

Jiang, Y., & Lu, E. (2016). Flood from May to July 1991: Comparison of the Effects of Water Vapor and Cold Air. *Journal of Meteorological Science, 36,* 382-388.

Rahimi, M., Mohammadian, N., Vanashi, A., & Whan, K. (2018). Trends in Indices of Extreme Temperature and Precipitation in Iran over the Period 1960-2014. *Open Journal of Ecology, 8,* 396-415. https://doi.org/10.4236/oje.2018.87024

Varikoden, H., Samah, A. A., & Babu, C. A. (2010). The Cold Tongue in the South China Sea during Boreal Winter and Its Interaction with the Atmosphere. *Advances in Atmospheric Sciences, 27,* 265-273. https://doi.org/10.1007/s00376-009-8141-4

Wang, H. J., Ren, H. L., Chen, H. P., Ma, J. H., Tian, B. Q., Sun, B., Huang, Y. Y., Duan, M. K., Wang, J., Wang, L., & Zhou, F. (2020). Review of Climate Prediction Research and Business Development in China. *Acta Meteorological Sinica, 78,* 317-331.

Zhang, X. R., Wang, L. F., Wang, B., Liao, Y. F., & Pu, M. J. (2021). Numerical Test on the Influence of Dry Cold Air on Heavy Rainstorm in Jiangsu Tropical Low Pressure Trough. *Meteorological Journal, 47,* 791-804.

Zhu, Q. G., Lin, J. R., Shou, S. W. et al. (2007). *Principles and Methods of Synoptic Meteorology* (4th ed.). China Meteorological Press.