Scientific Research Publishing

Journal of Geoscience and Environment Protection, 2022, 10, 153-162
https://www.scirp.org/journal/gep
ISSN Online: 2327-4344
ISSN Print: 2327-4336

Analysis of Cold Weather Process in the North China during October 20 to 23, 2020

Shichen Wang

School of Hydrology and Water Resources, Nanjing University of Information Science & Technology, Nanjing, China
Email: wsc0710@sina.cn

How to cite this paper: Wang, S. C. (2022). Analysis of Cold Weather Process in the North China during October 20 to 23, 2020. *Journal of Geoscience and Environment Protection, 10,* 153-162.
https://doi.org/10.4236/gep.2022.1010012

Received: September 5, 2022
Accepted: October 28, 2022
Published: October 31, 2022

Abstract

To help the forecast of cold weather activity, the cold weather process in the North China from October 20 to 23, 2020 was analyzed by the methods of utilizing statistical analysis, such as composite, differential analysis and correlation analysis, and by using the data from the National Meteorological Information Center of China, the National Climate Center of China and the NECP data from NOAA Physical Sciences Laboratory. The results show that: 1) the cold air started from Siberia, took the east path to move southward, and finally affected most part of North China. 2) Almost no obvious weather occurred during the process. 3) The cold air mainly moved along with the form and development of the trough and ended when the trough got weaken.

Keywords

Cold Air, North China, Trough, Atmospheric Circulation

1. Introduction

From October 20 to 23, 2020, under the influence of severe cold air, the average temperature in parts of eastern Inner Mongolia and the North China dropped by 4˚C to 6˚C, among them, the temperature in the eastern Inner Mongolia and most parts of the North China dropped by 8˚C to 12˚C, and the temperature dropped by 14˚C to 16˚C locally. Since October 20, gusts of force 7 to 9 occurred in central and western Gansu, Ningxia, Inner Mongolia, central and northern Shanxi, central and northern Hebei, central and western Beijing, western Tianjin, central and western Heilongjiang, central and western Jilin and central and western Liaoning, with gusts of force 10 to 11 in parts of central Inner Mongolia and other places. Sand blowing weather occurred in central and Western Inner Mongolia, western Gansu and northern Shanxi, among which sand storms occurred in Jartai, Inner Mongolia, with visibility of 0.8 km. Rainfall, snow or sleet occurred in some areas in northeastern Tibet, southeastern Qinghai, northern Sichuan Plateau and northeastern Inner Mongolia, with a precipitation of 2 to 20 mm. From 08:00 on October 20 to 08:00 on October 23, affected by the strong cold air, the average temperature in some areas of eastern Inner Mongolia, North China, Northeast China, Huang Huai Area, northern Yangtze and Huaihe River area and other places dropped by 4˚C to 6˚C, among which, the temperature drop range in most parts of eastern Inner Mongolia and Northeast China reached 8˚C to 12˚C, and 14˚C to 16˚C locally. Some of the above areas were accompanied by winds of force 4 to 6 and gusts of force 7 to 9.

The conclusions of some previous studies are as followed. Kang et al. (2010) found that a multi-year intergenerational change cycle has occurred in the strong cold air activity in China, and the intensity of the cold high of cold wave has obvious seasonal variation characteristics, which most of its origins can be traced back to the polar region at the northern end of the Eurasian continent. Wang and Ding (2006) found the weakening of Siberian high pressure and winter wind intensity, the significant increase of low-level cold pile temperature over Siberia and China's surface temperature are the possible reasons for the reduction of cold wave frequency and its associated gales in China. Wu et al. (2007) pointed out the temperature advection and the surface wind field are interrelated and promoted by the allobaric field. The cold advection accompanied by the strong cold air enhances the ground allobaric field and the allobaric gradient, which is an important reason for the occurrence of gales near the coast of Jiangsu Province. Huang and Ren (2015) indicated the relationship between the winter air temperatures in our country and the cold air activities. In addition, some atmospheric circulation indexes are found out, which are good indicators for winter cold air activities, and can be used as tools for forecasting winter cold air activities. Qian and Zhang (2007) pointed out that during the past 45 years, cold wave and extreme cold wave events have generally decreased, which has led to the rise of the average value of the lowest temperature in winter to a certain extent, forming a continuous warm winter.

Consider that the data used in the previous studies are old, this study analyzes the recent data and draws reasonable and objective conclusions by using statistical methods such as comparative, comprehensive, difference analysis and correlation analysis.

2. Data and Methods

2.1. The Samples of Data

This study uses station meteorological observation data from National Meteorological Information Center of China (http://www.nmic.cn/), the monthly climate data from the National Climate Center of China (http://cmdp.ncc-cma.net/) and the NCEP data from NOAA Physical Sciences Laboratory (https://psl.noaa.gov/).

2.2. Research Methods

This study mainly uses comparative analysis, differential analysis and the basic equations of atmospheric motion to analyze the data (Yun, 2021; Ibragimov et al., 2021; Haro et al., 2015). These methods will be introduced as follow.

Comparative analysis method is to compare two or more data and analyze the differences, so as to reveal the development, changes and regularity of these things. It can directly see the change or gap in a certain aspect of things, and can accurately and quantitatively show how much the change gap is.

Differential analysis means the analysis of deviation of the causes and consequences of the required goal and the stage of the system when the error completes the system function, so as to reduce the error to the minimum. Common differential analysis methods include general error analysis, special error analysis, qualitative error analysis, quantitative error analysis, forward error analysis, backward error analysis, random error analysis and interval error analysis.

The basic equations of atmospheric motion include the equation of motion, the continuity equation, state equation, thermodynamic equation and water vapor equation. Through the use of these equations, we can calculate the state change of the atmosphere when we have the initial conditions and boundary conditions.

3. Analysis of the Cold Weather Process

3.1. Atmospheric Circulation and Weather

Figure 1 shows the mid latitude of Eurasia in late October 2020, which presented a situation of "three troughs and two ridges". The troughs and ridges deepened and the wavelength became shorter. The North China was controlled by the northwest air flow behind the troughs and the cold air activities were more frequent.

From October 20 to 23, sand blowing or sand dust weather occurred in central

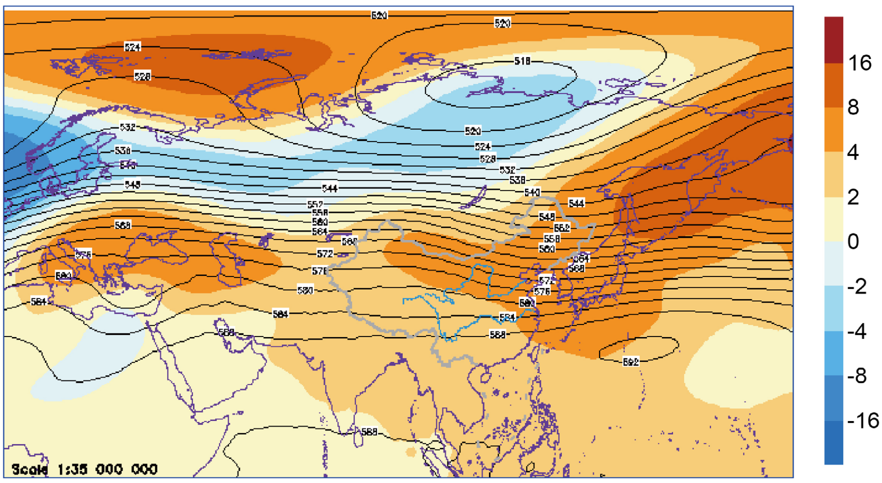

Figure 1. The 500 hPa average geopotential height field in late October, 2020.

and western Inner Mongolia, western Gansu and northern Shanxi. There are also small to moderate snow or sleet in the northeast of Tibet, Qinghai, the western Sichuan Plateau, the northeast of Inner Mongolia and the northwest of Heilongjiang, and heavy snow in the northeast of Inner Mongolia and the northwest of Heilongjiang; There is light to moderate rain in the middle east of the northeast China (Nie & Gao, 2021).

3.2. Analysis of Cold Air Weather Process on October 20, 2020

From the perspective of the situation, the cold air weather from October 20-23 was caused by the northwest air flow behind the troughs above the North China.

Figure 2 and Figure 3 show the 925 hPa geopotential height and temperature

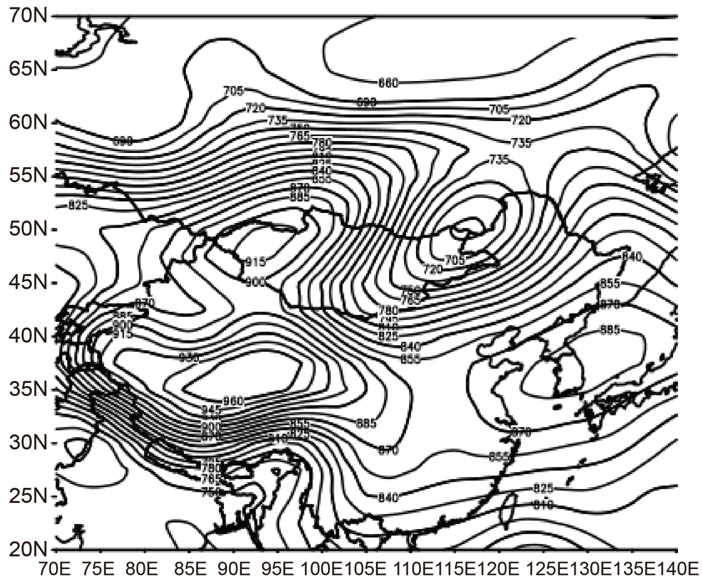

Figure 2. The 925 hPa geopotential height field at 8:00, October 20, 2020 (Beijing time, the same below).

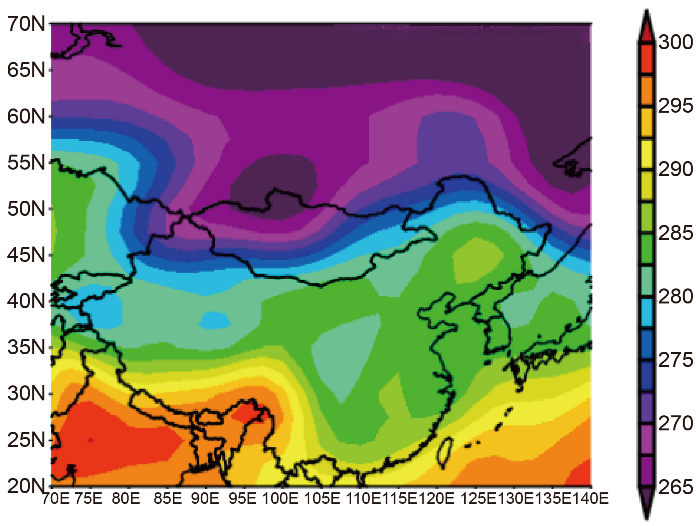

Figure 3. The 925 hPa temperature field at 8:00, October 20, 2020 (Unit: K).

fields at 8:00 on October 20. The cold center was located in the west of Lake Baikal, and there was a high-pressure center in the north of Altai Mountain, the intensity of the high pressure center value can be greater than 925 hPa. Meanwhile, there was also a low-pressure center in the west of the Greater Khingan Mountains, with the central air pressure, lower than 690 gpm and the transversal trough was located in the south of Lake Baikal, with strong cold advection behind the trough.

At 500 hPa geopotential height field (**Figure 4**), there is an evacuation trough in the area from the south of Lake Baikal to the south of Shanxi, which forms a forward inclined configuration with the 925 hPa transverse trough, which indicates that the system will further develop and deepen. And the cold air started to grow.

3.3. Analysis of Cold Air Weather Process on October 21, 2020

From **Figure 5** and **Figure 6**, it can be seen that at 08:00 on October 21, the 925 hPa high pressure center moved to the lower pressure center moved to the northern China, and the transverse trough turned vertical, driving the cold air to move eastward and southward, bringing the cold air to the northern China. There was a cold center below minus 10˚C in the east of Baikal Lake.

The 500 hPa (**Figure 7**) trough moved eastward to Lake Hulun and the Huai River basin, and it was significantly deepened. In eastern China, westerly troughs have sunk deep into the Huai River basin, allowing cold air to seep southward. This weather situation is more conducive to guide the cold air accumulated at high latitudes southward to affect most parts of China.

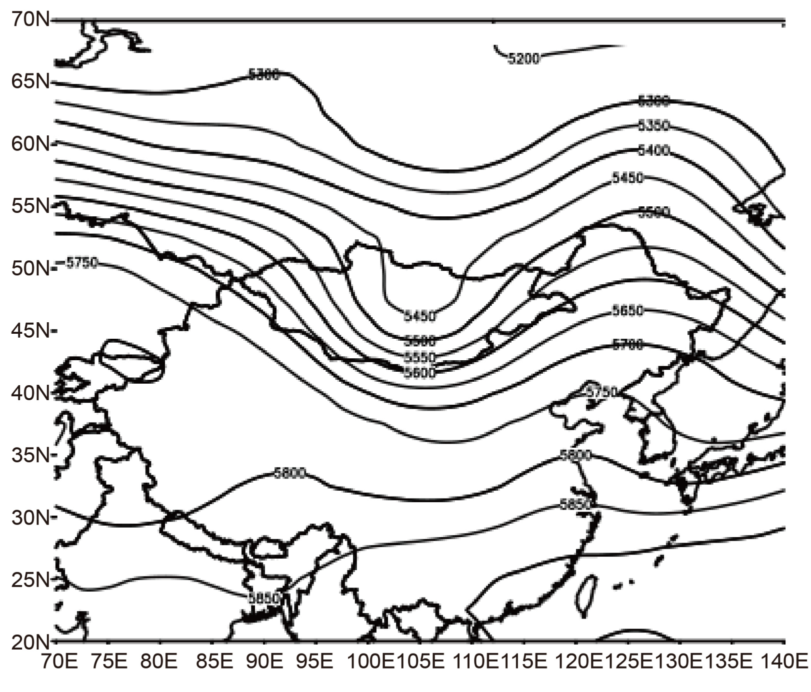

Figure 4. The 500 hPa geopotential height field at 8:00, October 20, 2020.

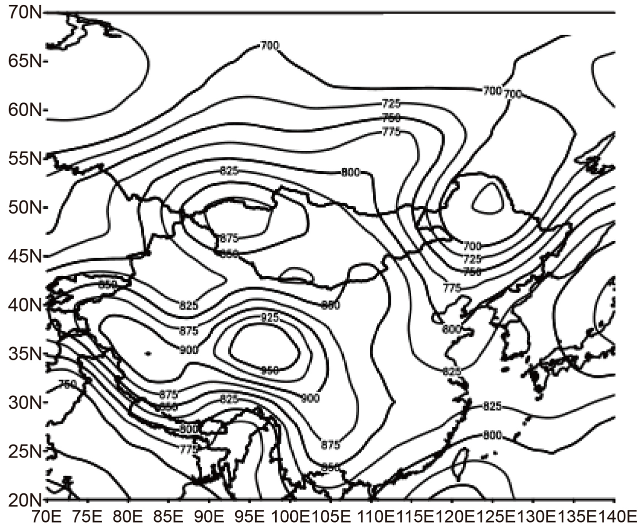

Figure 5. The 925 hPa geopotential height field at 8:00, October 21, 2020.

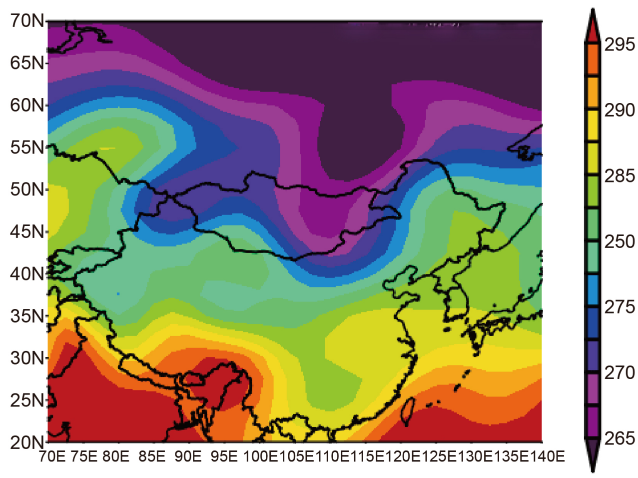

Figure 6. The 925 hPa temperature field at 8:00, October 21, 2020 (Unit: K).

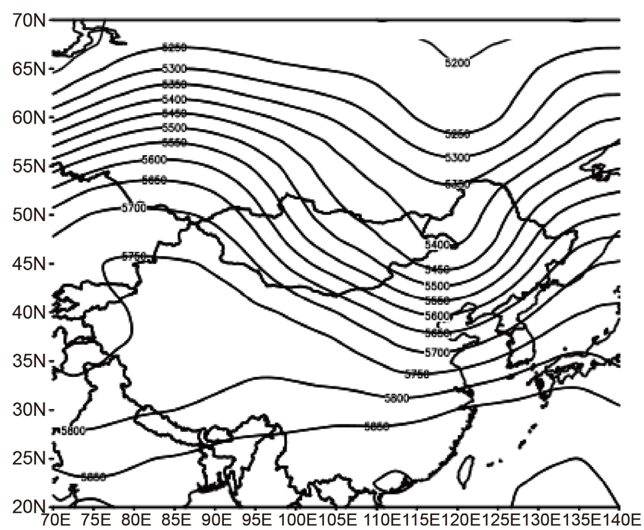

Figure 7. The 500 hPa geopotential height field at 8:00, October 21, 2020.

3.4. Analysis of Cold Air Weather Process on October 22, 2020

From **Figure 8**, it can be seen that the 925 hPa trough kept moving eastward and southward, which driving the cold air to the further south part of China. On the low-level 925 hPa weather map, cold air split southward, accompanied by the prevailing cold air from the northwest, which was conducive to the accumulation of cold air and provided a cold cushion.

And **Figure 9** shows that the 500 hPa trough moved to the Huang Huai Area, and became even deepened. The cold air became even strong than before. The 925 hPa temperature field at 8:00 on October 22, 2020 was shown in **Figure 10**, the temperature of some areas in the middle and eastern part of Inner Mongolia, North China, northeast and other places dropped seriously.

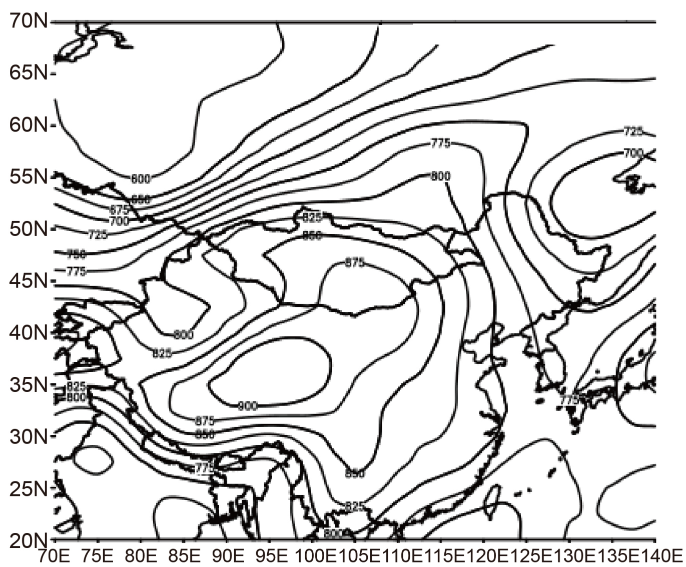

Figure 8. The 925 hPa geopotential height field at 8:00, October 22, 2020.

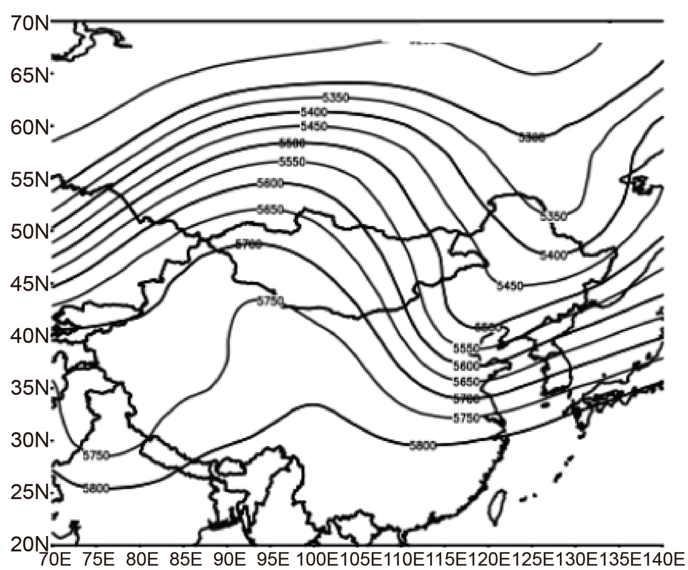

Figure 9. The 500 hPa geopotential height field at 8:00, October 22, 2020.

3.5. Analysis of Cold Air Weather Process on October 23, 2020

On October 23, as Figure 11 and Figure 12 shows, the mainland of China was controlled by the cold high pressure and located behind the 500 hPa trough. The temperature gradually increased and the cold air process ended.

4. Conclusion

Based on the above analysis, the conclusions of the cold air process are as followed:

The cold air started from Siberia, took the east path, passed through Mongolia, went across the Greater Khingan Mountains then entered North China, and started to affect northern China and central China. During the process, the

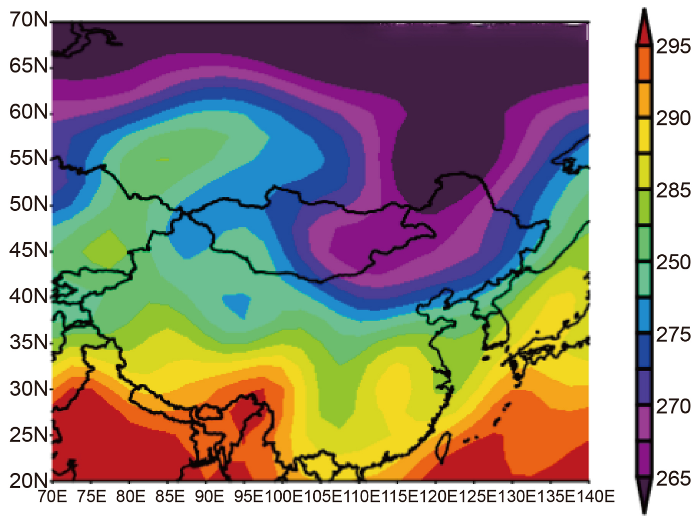

Figure 10. The 925 hPa temperature field at 8:00, October 22, 2020 (Unit: K).

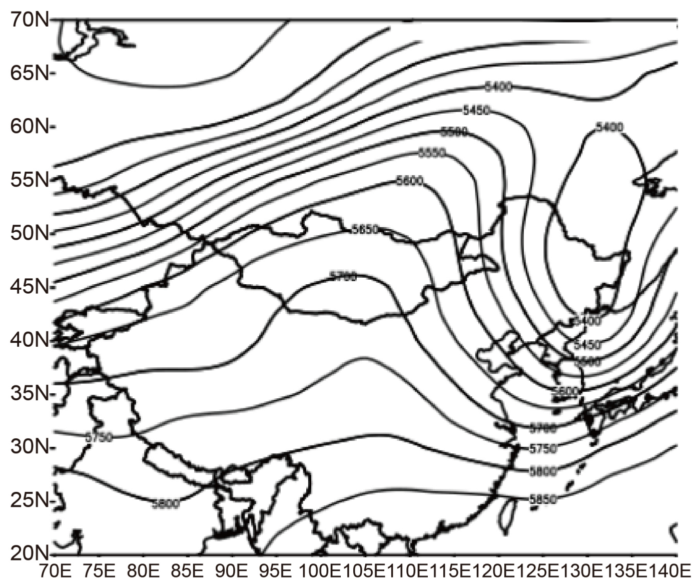

Figure 11. The 500 hPa geopotential height field at 8:00, October 23, 2020.

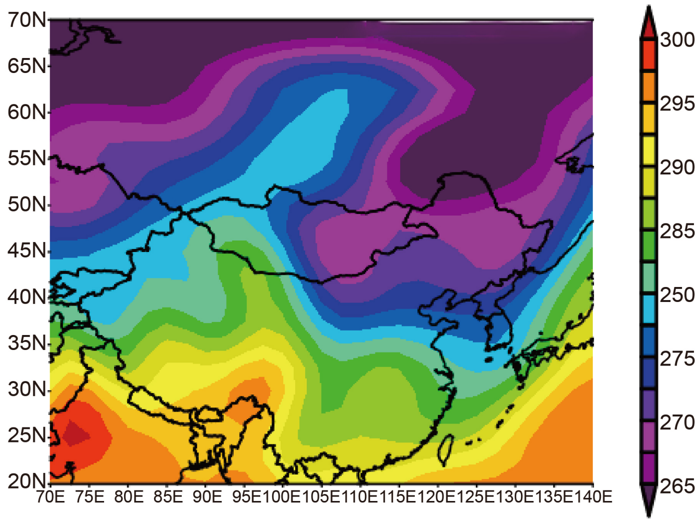

Figure 12. The 925 hPa temperature field at 8:00, October 23, 2020 (Unit: K).

cold air mass got stronger and larger ,and brought large scale cooling to most part of North China. And nearly no significant weather phenomenon occurred in the cold weather process.

In this process, the cold air mainly moved along with the form and development of the trough and finally finished when the trough got weaken and moved to the sea.

In this study, synoptic methods and statistical methods are mainly used to analyze the weather process, and the data are mainly weather maps, which have certain limitations. Numerical weather simulation methods, radar maps and satellite cloud images can be introduced into future research.

Conflicts of Interest

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

References

Haro, A., Limaico, C., & Llosas, Y. (2015) Characterization of the Atmospheric Dynamics in Riobamba City Using the Chaos Theory. *Atmospheric and Climate Sciences, 5,* 441-449. https://doi.org/10.4236/acs.2015.54036

Huang, Z. P., & Ren, G. C. (2015). Study on the Characteristics and Its Previous Affecting Factors of Winter Cold Air Activities in China. *Climate Change Research Letters, 4,* 237-242. https://doi.org/10.12677/CCRL.2015.44027

Ibragimov, R., Mongrain, L., Stimmel, B., Trozkaya, O., Lin, G., Zhang, S., Vatchev, V., & Stankiewicz, D. (2021) Visualization of Exact Invariant Solutions Associated with Atmospheric Waves in a Thin Circular Layer. *Journal of Applied Mathematics and Physics, 9,* 901-919. https://doi.org/10.4236/jamp.2021.95061

Kang, Z. M., Jin, R. H., & Bao, Y. Y. (2010). Characteristic Analysis of Cold Wave in China during the Period of 1951-2006. *Plateau Meteorology, 29,* 420-428.

Nie, G. Z., & Gao, S. Z. (2021). Analysis of the October 2020 Atmospheric Circulation and Weather. *Meteorological Monthly, 47,* 127-132.

Qian, W. H., & Zhang, W. W. (2007). Changes in Cold Wave Events and Warm Winter in China during the Last 46 Years. *Chinese Journal of Atmospheric Sciences, 31,* 1266-1278.

Wang, Z. Y., & Ding, Y. H. (2006). Climate Change of the Cold Wave Frequency of China in the Last 53 Years and the Possible Reasons. *Chinese Journal of Atmospheric Sciences, 30,* 1068-1076. 10.3878/j.issn.1006-9895.2006.06.02

Wu, H. Y., Sun, Y., Zeng, M. J., Yin, D. P., & Shen, S. Q. (2007). Discussion of Physical Mechanisms for a Gale Process Caused by Severe Cold Air Offshore Jiangsu. *Journal of Tropical Meteorology, 23,* 388-394.

Yun, T. (2021) Motion Equation and Solution of Mushroom Cloud. *Atmospheric and Climate Sciences, 11,* 86-97. https://doi.org/10.4236/acs.2021.111006