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# Analysis of Rain and Snow Weather Process in the Middle and East of China from December 28 to 30, 2020

**Ruiqi Li**

School of Atmospheric Sciences, Nanjing University of Information Science and Technology, Nanjing, China
Email: 1297248696@qq.com

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## Abstract

The China National Climate Center and National Centers for Environmental Prediction data were used in this work. Using the knowledge of synoptic principles and synoptic analysis, the rain and snow weather process in the middle and east of China from December 28 to 30, 2020 was analyzed. The results show that: 1) This weather process was a large-scale precipitation process. Affected by the cold wave, the temperature drops sharply, and the temperature in many places dropped below the extreme value, accompanied by strong winds. 2) This process is mainly caused by the eastward movement of the upper-level trough leading the cold air southward to intersect with the warm and wet air, and the shear thread in the lower layer cooperates. 3) The cold air is from the ocean east of Novaya Zemlya. 4) From the evolution trend of 500 hPa geopotential height field and ground pressure field, the cold surge process belongs to the type of transverse trough to vertical.

## Keywords

Precipitation, Cold Surge, Style, Cold Front, Atmospheric Circulation

## 1. Introduction

From December 28 to 30, 2020, the most intense cold surge struck China. This leads to the large range of rain and snow weather process in the middle and east of China. On the night of December 28, there was light rain to sleet in some areas north of the Huaihe River. On the 29th December, there was moderate snow along the Yangtze River and north of the Yangtze River, and there was heavy snow in some parts of Huaibei area, the eastern part between the Yangtze

River and Huaihe River, the Dabie Mountain area and some parts of the mountainous area in southern Anhui, including local snowstorms in the Dabie Mountain area. There will be light to moderate rain to moderate sleet or moderate snow in the south of the Yangtze River. Severe snow cover occurred in some areas, including 5 - 8 cm in the northeast of Jianghuai area, 10 - 12 cm in some areas of Dabie Mountain and high altitude southern mountainous areas in Anhui.

Many scientists have done a lot of research on rain and snow weather. Tao & Wei (2008) found that a large blocking circulation system stayed over the Asian continent with a blocking high pressure to the north of the Lake Baikal and a cut-off low near the Caspian Sea. This leads to the severe snow storm and freezing-rain in January 2008. The damage that the storm caused was very serious, particularly the damage of power delivery infrastructure in the Southern China. Wen et al. (2019) found that rain, fog and freezing rain are easy to cause wire icing, which is extremely harmful to facilities such as transmission lines and communication lines. The longer the icing of wires, the higher the ice disaster rate. Ye et al. (2009) analyzed in detail the regional characteristics of the ice distribution in Hunan Province, the influence of various meteorological factors and special terrain on the ice intensity, which was the most severely affected area. Hannigan & Godek (2020) aims to determine the reliability of the widely referenced guides for depicting the rain-snow line, and improve forecast aids for the vertical atmosphere during winter precipitation events, and indicate that the standard vertical boundaries are inaccurate indicators of a rain versus snow event in Albany, New York, US, also weather type indicates that the rain-snow boundary also varies depending on what air mass/weather type is present on a given day. Zeng et al. (2018) conclude that on the basis of a number of typical model cases of heavy rain of typhoon, we can reveal the mechanism which causes the heavy rain of typhoon by the mostly influencing systems in different circulation backgrounds and the causes of the heavy rain of typhoon.

This study will analyze rain and snow weather process in the middle and east of China. Although there are many previous studies on rain and snow weather, most of the data are old. This paper uses the updated data, combined with a variety of methods to analyze the specific weather process.

## 2. Data and Methods

### 2.1. Data

The climate monitoring and diagnosis data and figures generation tools in this research is from the National Climate Center of China, just like accumulation precipitation and average geopotential height field at 500 hPa. This work also uses some grid climate data and figures generation tools from NOAA Physical Sciences Laboratory of the US.

### 2.2. The Relative Theory of the Methods

This work mainly uses the research methods of classical synoptic analysis, statistical methods and diagnostic analysis (Zhu et al., 2007). The method of classical synoptic analysis is using upper-level weather charts, surface weather charts and various site data to analyze the difference stages of the weather process and infer the future trend. Statistical methods refer to the combination of multiple data samples, by calculating median value, mean value, extreme values and variance to reflect the characteristics of the weather process. Diagnostic analysis is a method to judge the movement and development of various weather systems using various physical quantities.

## 3. Results and Analysis

### 3.1. Atmospheric Circulation and Generalization of Precipitation

From **Figure 1**, it can be seen that in late December 2020, the continuous development of Arctic Ocean polar high experienced the early and middle stages, and the Siberian trough was generated. Most circulations in the middle and east of China have small meridionality, and the ground is controlled by even pressure field, which is a stable weather situation. From December 20 to 28, continuous fog and haze weather occurred in the middle and east of China.

From **Figure 2**, in the last days of late December, the transverse trough turned into the vertical trough leading strong cold air southward. At this time, most areas of China are experiencing a cold surge with a large range of rain and snow. Therefore, the minimum temperature in many areas breaks through historical extremes.

### 3.2. Analysis of Cold Surge and Precipitation Weather Process

From December 27 to 31, affected by the southward strong cold air in Siberia, most parts of China experienced a cold surge. The characteristics of this cold surge are wide range, significant drop in temperature, low temperature and long duration of strong wind.

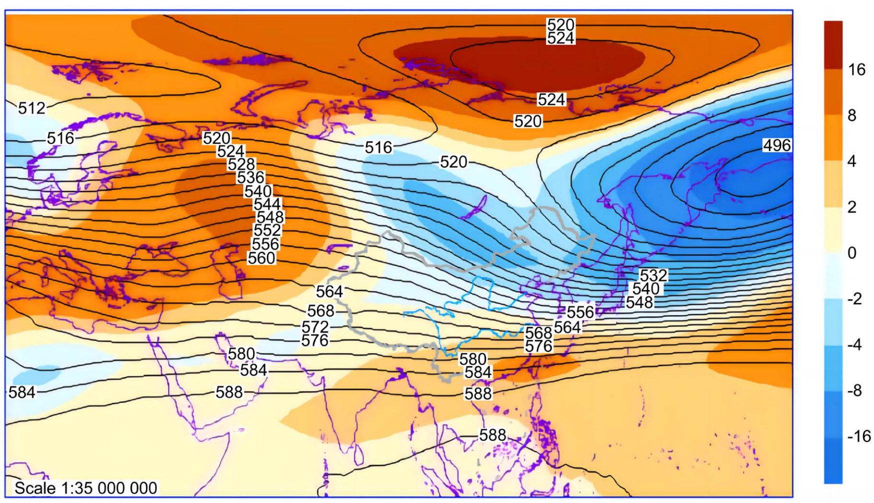


**Figure 1.** Average geopotential height field at 500 hPa in late December 2020 (from NCC, China, also as **Figure 2**).

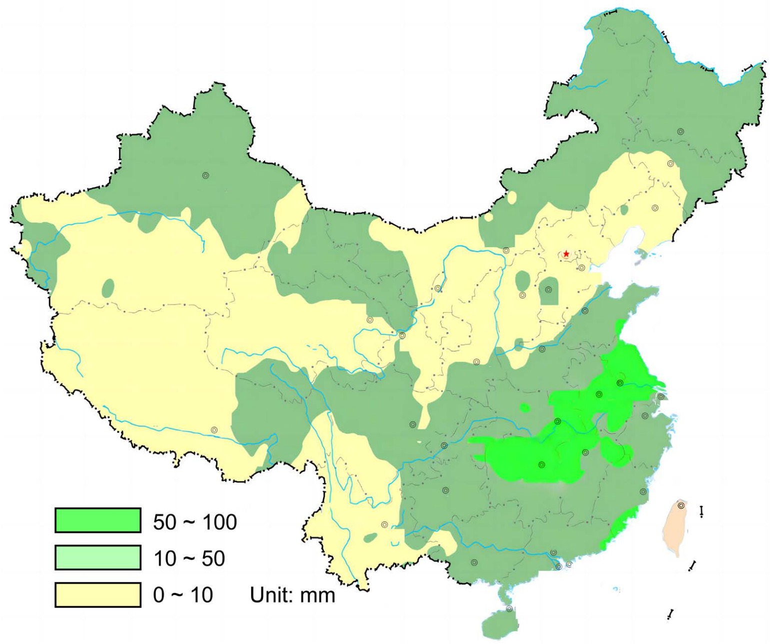


**Figure 2.** Precipitation accumulation map of China mainland in late December 2020 (Data for Taiwan Province of China are temporarily not available).

During December 28 to 30, a large-scale rain and snow weather occurred in the middle and east of China. Snowfall, rain or sleet occurred in Shandong, central and eastern Henan, Anhui, Jiangsu, Shanghai, middle and north of Zhejiang, northern Jiangxi, northeastern Hunan, northern and eastern Hubei. This process is mainly caused by the eastward movement of the upper-level trough leading the cold air southward to intersect with the warm and wet air, and the shear thread in the lower layer cooperates.

From the evolution trend of 500 hPa geopotential height field and ground pressure field, the cold surge process belongs to the type of transverse trough to vertical. From the moving path, the birthplace of cold air is the eastern ocean of the Novaya Zemlya, and it is merged with the cold high of Ural Mountains in the process of moving south.

### 3.3. Analysis of Weather Process on December 27, 2020

At 08:00 on December 27, the middle and east of China still located in the zonal circulation, and the transverse trough east of Lake Baikal continues to develop. At this time, the ground cold high occupies the Siberian region, and the central intensity reaches 1052 hPa (Figure 3).

### 3.4. Analysis of Weather Process on December 28, 2020

From Figure 4, it can be seen that at 08:00 on December 28, the ground cold high center has reached 1071 hPa, and the main part is located in the north and west of Mongolia. The front of the cold air front reaches the middle and east of Inner Mongolia and Northeast China.

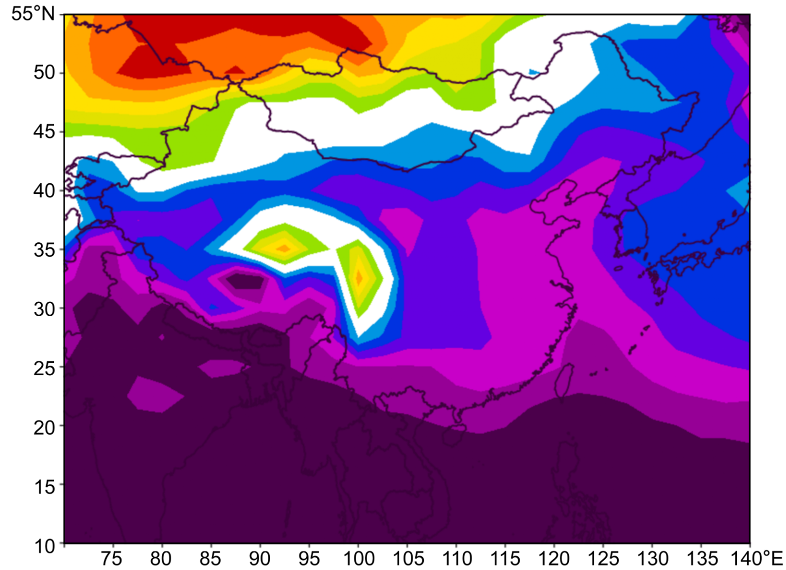


**Figure 3.** The sea level pressure field at 8:00 (Beijing time, the same below) on December 27, 2020 (from NOAA PSL, USA, the same below).

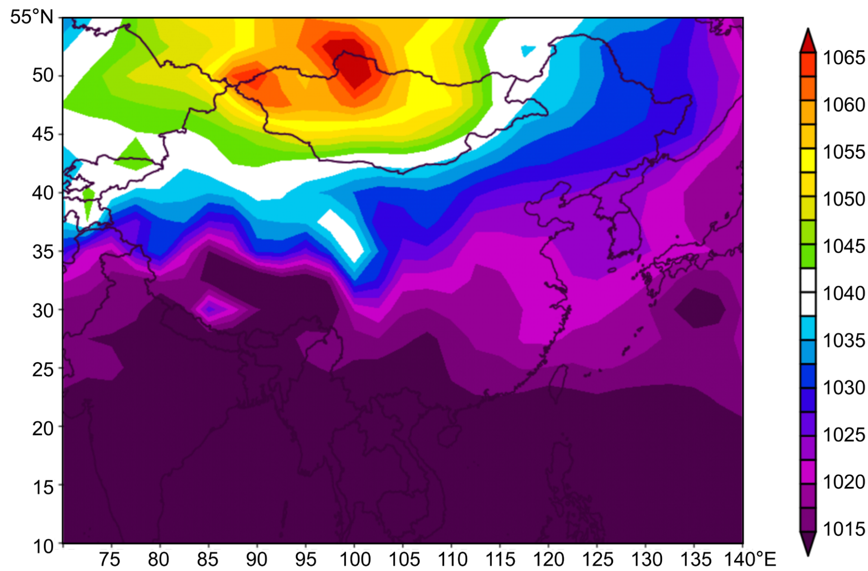


**Figure 4.** The sea level pressure field at 8:00 on December 28, 2020.

At 20:00 on December 28, the 500 hPa geopotential height field (**Figure 5**), upper-level trough southward to southeast Mongolia and northeast Inner Mongolia. The forcing effect in front of trough is beneficial to the development of low level jet. The southerly flow at 700 hPa further strengthened northward, and the water vapor transport conditions improved significantly (**Figure 6**). The shear line at 700 hPa (**Figure 7**) began to develop gradually in the Huanghuai area. The main precipitation period began and the water vapor transport conditions are obviously strengthened. Under the interaction of cold and warm airflow, some areas in Huanghuai, Jianghuai, Jiangnan and other areas have snowfall, rain or sleet.

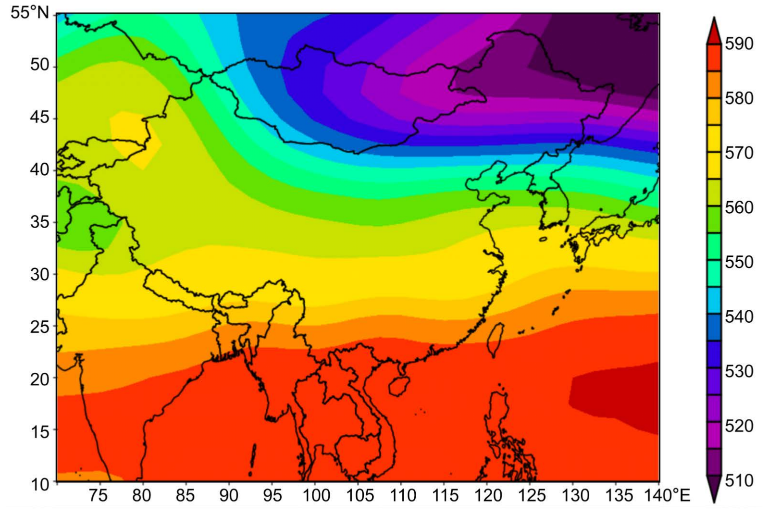


**Figure 5.** The 500 hPa geopotential height field at 20:00 on December 28, 2020.

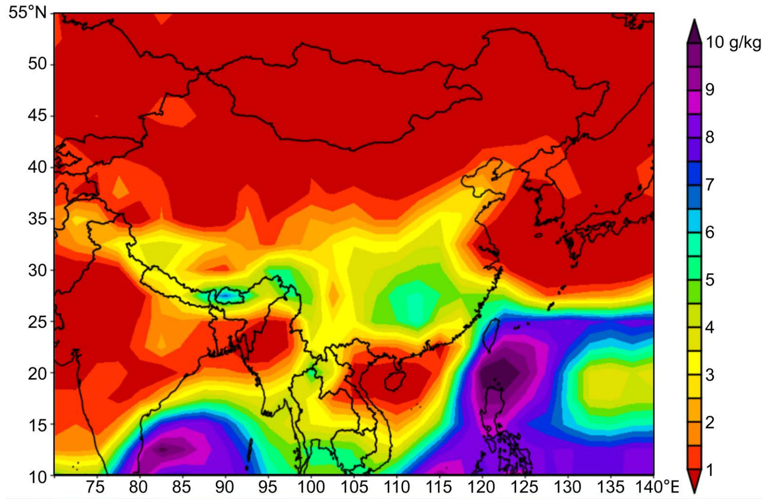


**Figure 6.** The 700 hPa specific humidity field at 20:00 on December 28, 2020.

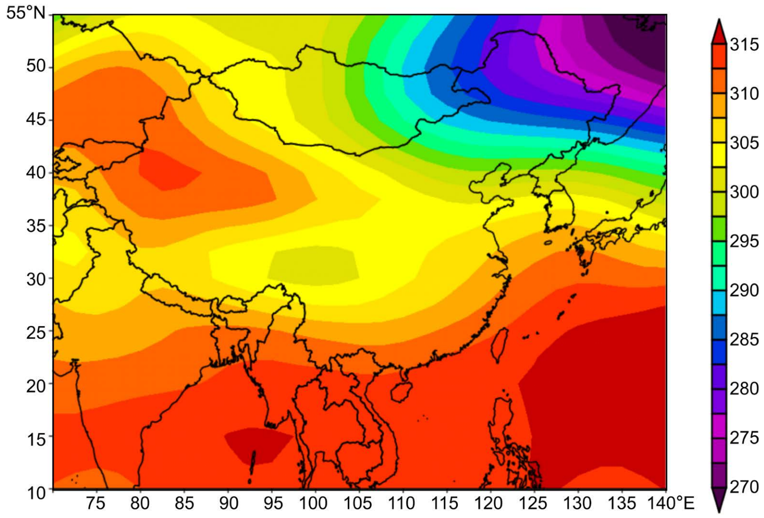


**Figure 7.** The 700 hPa geopotential height field at 20:00 on December 28, 2020.

### 3.5. Analysis of Weather Process on December 29, 2020

From Figure 8, it can be seen that at 8:00 on December 29, short wave trough moving eastward in front of the 500 hPa upper-level trough. The transverse trough moved south and turned into the vertical trough. Surface cold high moves eastward, guided strong cold air southward. The central pressure of the surface cold high has reached 1070 hPa (Figure 9). At the same time, the main body of ground cold air moves south slowly, but it is still in western Mongolia. In the early stage, the cold air flowing southward along the Hexi Corridor from northern Xinjiang merged with cold air from the Mongolian Plateau through northeast China, and then moved southward rapidly. Strong wind and strong cooling weather occurred in most areas north of the Yangtze River. See Figure 10 and Figure 11 for details.

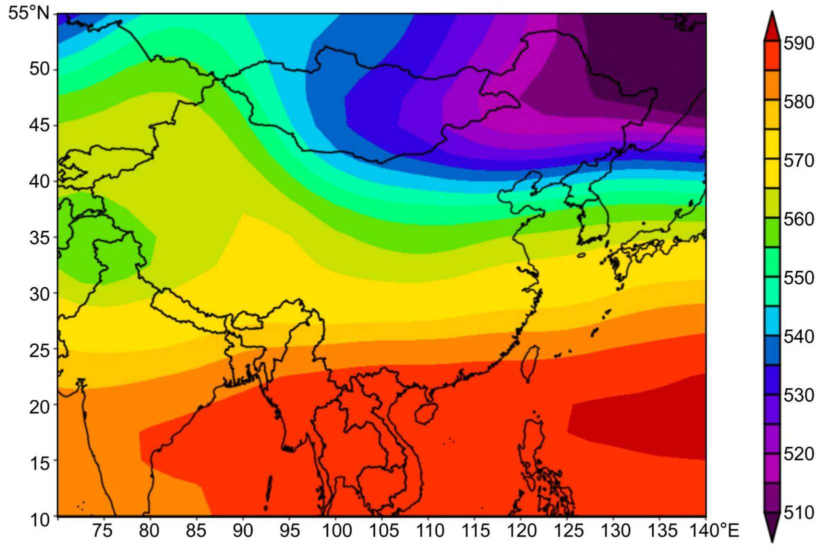


Figure 8. The 500 hPa geopotential height field at 8:00 on December 29, 2020.

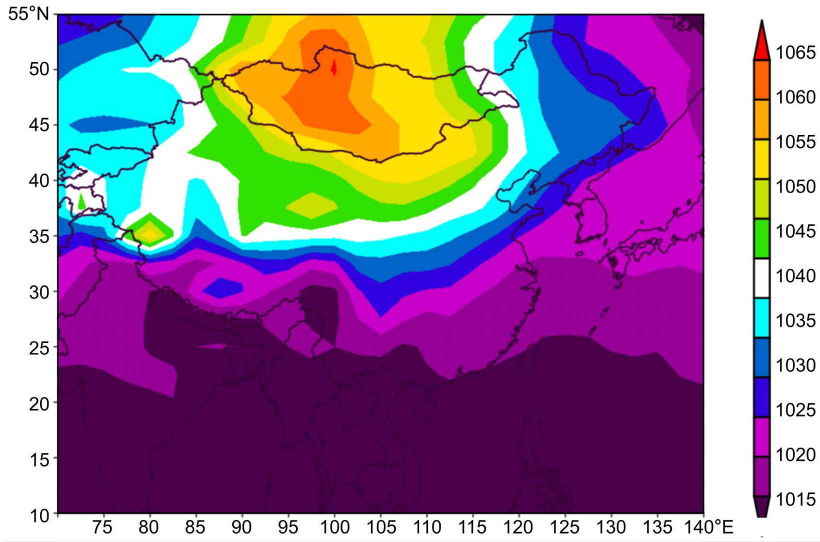


Figure 9. The sea level pressure field at 8:00 on December 29, 2020.

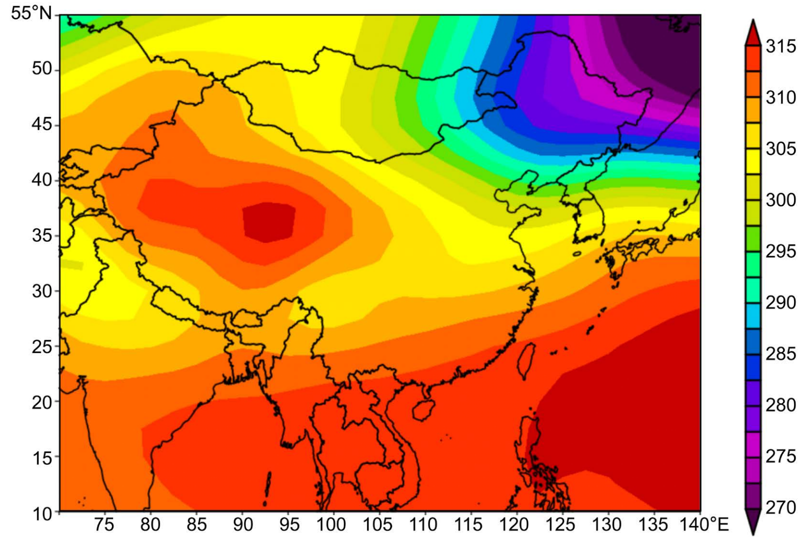


**Figure 10.** The 700 hPa geopotential height field at 8:00 on December 29, 2020.

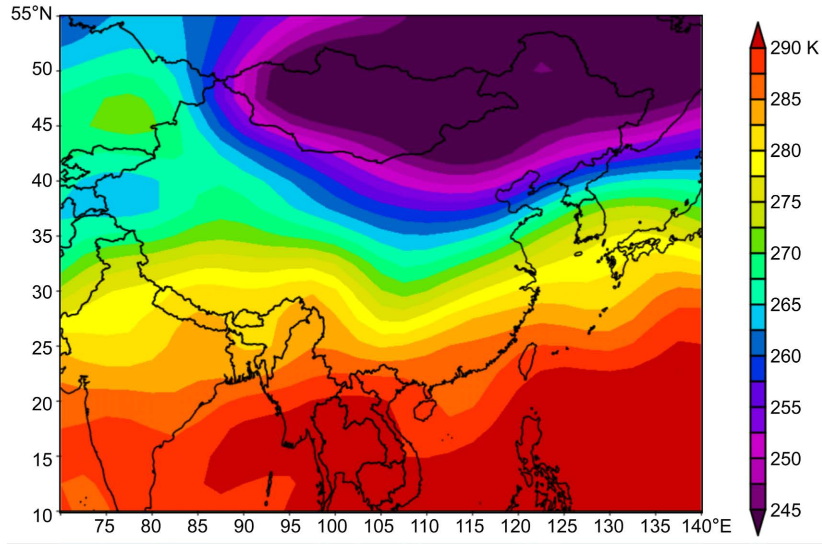


**Figure 11.** The 850 hPa temperature field at 8:00 on December 29, 2020.

From **Figure 12**, it can be seen that at 20:00 on December 29, the cold center minimum temperature at 850 hPa in Shandong Peninsula reached −18˚C, and the air-sea temperature difference is large. The cold air and the warm and wet air in front of the low trough converge, and the snowfall time is long. When the cold air intersects with the warm and humid air in front of the trough, it can form very unstable atmospheric conditions due to their large differences in temperature and humidity. This unstable atmosphere encourages water vapor to condense into clouds and trigger the process of snowfall. When cold air meets warm and humid air, the water vapor in the warm and humid air condenses into clouds and water droplets, forming precipitation. If the temperature is low enough, these droplets will freeze into ice crystals in the air, gradually growing as they fall and eventually forming snowflakes. The long snowfall time caused by the intersection of cold air and warm and humid air in front of the low trough may be because there is a large difference in heat and humidity between the two, making the snowfall process last for a long time. In addition, this atmospheric environment also contributes to the formation of a strong upward movement, further increasing the duration of snowfall.

### 3.6. Analysis of Weather Process on December 30 and 31, 2020

From **Figure 13**, it can be seen that at 8:00 on December 30, the whole 700 hPa layer is controlled by northerly airflow, and the precipitation process tends to end.

From **Figure 14**, it can be seen that at 8:00 on December 31, with the main body of cold high pressure moves eastward and weakening, the cooling process of cold surge tends to end.

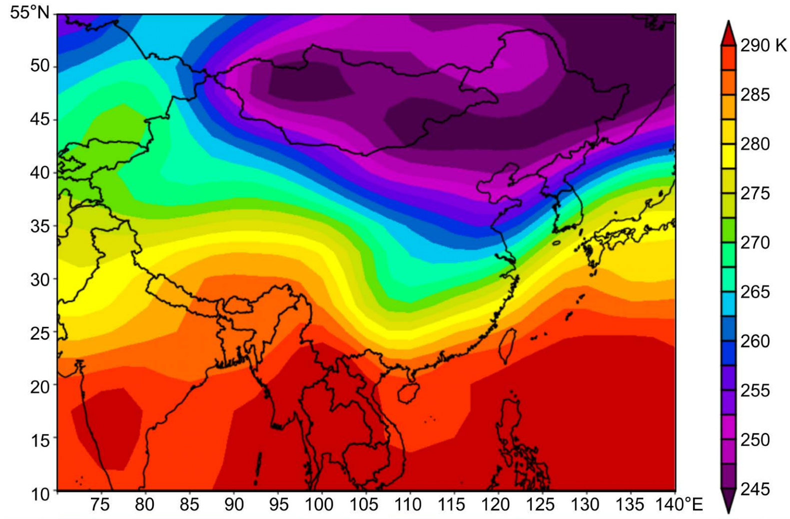


**Figure 12.** The 850 hPa temperature field at 20:00 on December 29, 2020.

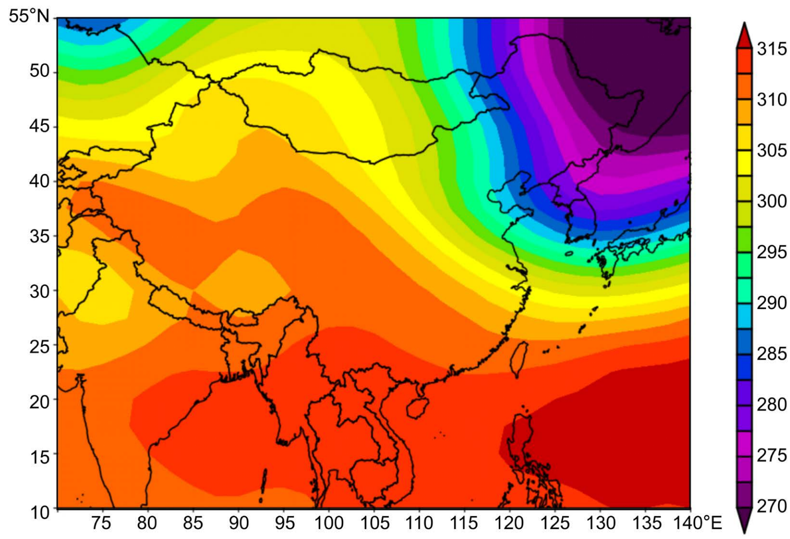


**Figure 13.** The 700 hPa geopotential height field at 8:00 on December 30, 2020.

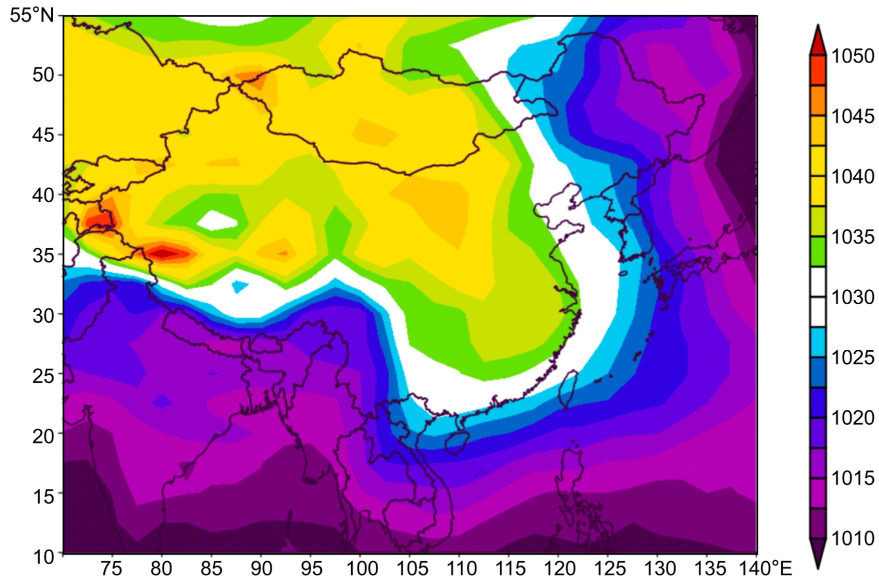


**Figure 14.** The sea level pressure field at 8:00 on December 31, 2020.

## 4. Conclusion

In this research, the rain and snow weather process in the middle and east of China from December 28 to 30, 2020 was analyzed by using different kinds of weather charts. Through research, the following main conclusions are drawn.

This weather process was a large-scale precipitation process. Affected by the cold wave, the temperature drops sharply, and the temperature in many places dropped below the extreme value, accompanied by strong winds. This process is mainly caused by the eastward movement of the upper-level trough leading the cold air southward to intersect with the warm and wet air, and the shear thread in the lower layer cooperates. The cold air is from the ocean east of Novaya Zemlya. From the evolution trend of 500 hPa geopotential height field and ground pressure field, the cold surge process belongs to the type of transverse trough to vertical.

It is important to note that the length of snowfall is also affected by other factors, such as circulation, topography and seasons. These factors can further adjust the temperature and humidity distribution in the intersection area, thus affecting the duration of snowfall.

## Conflicts of Interest

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

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