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# Analysis of Dust Weather Process in Most Areas of China from January 11 to 16, 2021

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## Abstract

The DERF2.0 model of China National Climate Center and NCEP (National Centers for Environmental Prediction) data were used in this paper. Using the knowledge of synoptic principles, the process of dust weather in most parts of China from January 11 to 16, 2021 was analyzed. The results show that: 1) Compared with previous years, this process has a large impact scope and appears earlier. 2) The continuous cold air caused the dust weather process. 3) The surface cold front is conducive to the development of dust. 4) Surface cyclone is conducive to the transport and diffusion of dust.

## Keywords

Dust Weather, Cold Front, Cyclone

## 1. Introduction

Since January 11, 2021, a large range and high intensity dust weather occurred in northern China. This was the first dust event in 2021 and the earliest since 2002. On January 10, influenced by cold air, southern Mongolia and Inner Mongolia west began to appear obvious dust weather in China. In the role of northwest wind, sand and dust along the southeast direction spread to central and eastern regions in China. Most of eastern northwest, north China, Huanghuai were affected by the large range of dust weather. Air quality slipped quickly. The primary pollutant was PM10. From January 15 to 16, the wind weakened in the sand source area in northwest China, and the main cold air affected central and eastern China from north to south. The atmospheric diffusion conditions became better, and the influence of the dust weather process gradually came to an end.

The situation of the former research is analyzed as follows. Through the analysis of atmospheric circulation and surface parameters, Wang & Fang (2004) believed that sandstorm prone areas are mostly arid and semi-arid areas, and vegetation growth capacity is weak. Compared with the surface parameters, the atmospheric dynamic factors are the main factors leading the interannual variation of sandstorm when the precipitation is not significantly increased and the vegetation growth is improved. Zhang et al. (2010) found that the combined effect of high temperature and low rainfall, cold air and Mongolian cyclone is the main reason for the strong dust intensity and late end of frequent occurrence period in spring 2006 in China. Lin et al. (2012) believed that sandstorms in North China lead to high concentrations of dust particles in the air, which are harmful to human health, social and economic losses and environmental degradation. Integrated sandstorm management systems can ensure sandstorm monitoring and early warning, determine the risk of sandstorm disasters, and track the progress of storms in real time. Suggestions for further improvement of numerical sandstorm simulation are also given. Duan et al. (2013) analyzed the weather and climate characteristics in the winter of 2010/2011 and the spring of 2011, and showed that soil moisture in the areas with frequent dust weather in northern China was higher than usual, soil condition was good and soil quality was not loose enough, which was an important factor for less dust weather in the spring of 2011. In the spring of 2011, the zonal wind in Mongolia and most areas of Inner Mongolia was a negative anomaly area with westerly wind, which was not conducive to the transport of sand and dust particles to the east. Han et al. (2006) analyzed the spatial and temporal distribution characteristics of the aerosol optical thickness (AOT) in China, and compared it with the dust weather in the same period. They found that the dust weather process and AOT value in southern Xinjiang Basin, Qinghai, Inner Mongolia and other regions changed synchronically. There is a good correlation between aerosol optical thickness and dust weather in the area of frequent dust weather. Therefore, it can be inferred that atmospheric aerosols in northern China, especially in arid desert areas, mainly come from dust release caused by dust weather process.

These results do give us a lot of insight (An et al., 2018; Li et al., 2016; Ma et al., 2019; Shang et al., 2012; Xing et al., 2012), but weather phenomena are constantly updated, and these findings are relatively old. Therefore, it is of innovative significance to study the dust weather process analysis in most areas of China from January 11 to 16, 2021 in this paper.

## 2. Data and Methods

### 2.1. Data

There are multiple sources of data in this paper, such as surface observation data and reanalysis data from NCEP. Other information such as geopotential height mean field picture is from China National Climate Center.

1) Based on surface observation data, the physical quantities of sandstorm weather in most areas of China from January 11 to 16, 2021 are analyzed.

2) The reanalysis data of NCEP 2.5˚ × 2.5˚ grid points were used to analyze the circulation patterns. The data types are daily average and 6-hour geopoten-

tial height, surface temperature and wind fields.

### 2.2. The Relative Theory of the Methods

Synoptic principles and literature review methods are used in this paper. This study used synoptic principles to analyze the source, development cause and end process of the dust process from January 11 to 16, 2021, including the analysis of upper and surface circulation.

Understand how other authors analyze the dust weather process by reading a large number of literatures (Demir et al., 2021; Irumva et al., 2021; Muita et al., 2021). Combined with the actual situation of the dust process, make my own analysis. The literature is from China National Knowledge Infrastructure, OALib (http://www.OALib.com).

## 3. Results and Analysis

### 3.1. Overview of Atmospheric Circulation and Precipitation

In mid-January 2021 (**Figure 1**), the Ural high pressure ridge showed a weakening trend, and the meridional dimension of China's mid-high latitude circulation decreased (compared with the first ten days of January 2021, the figure is omitted). The cold air activities affecting China in ten days are still frequent, but the influence has been decreased. From January 10 to 16, affected by cold air, central and western Inner Mongolia, central and northern Gansu, Qinghai, Ningxia, northern Shaanxi, Shanxi, southern Hebei, Henan, Hubei, Hunan, northern Jiangxi and other places have seen sand blowing or floating dust weather, Gansu, Inner Mongolia local sandstorm. This process is the first dust weather process in China this year, the impact scope is large, and the time is obviously earlier than the same period last year. The fluctuation of the southern branch is weaker than that of the same period of the year, and the precipitation in most parts of the country is low.

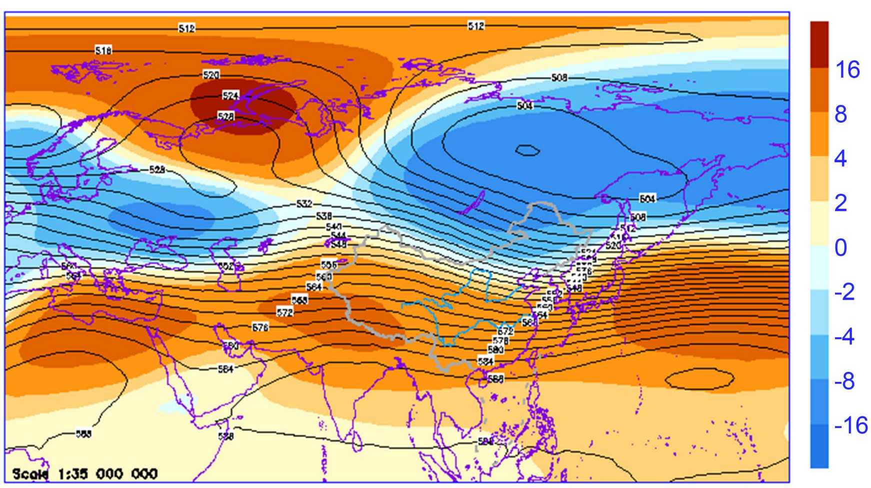



**Figure 1.** The 500 hPa geopotential height mean (contour) and anomaly (shaded) in mid-January, 2021.

### 3.2. Analysis of Dust Weather Process

Due to the frequent cold air activity in January, the precipitation in most parts of Northwest China is significantly less than that in the same period of the year, and the surface vegetation growth is normal and the soil water content is low, which is prone to dust weather process.

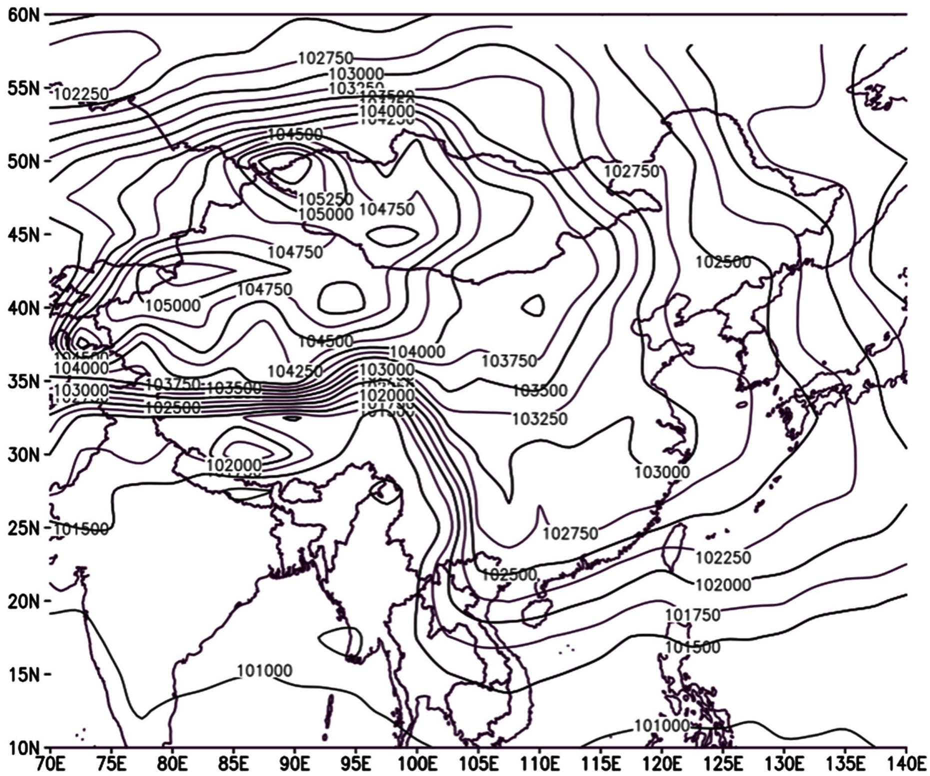
From January 10 to 16, central and western Inner Mongolia, central and northern Gansu, northern Qinghai, central and northern Ningxia, northern Shaanxi, Shanxi, southern Hebei, Beijing, Tianjin, Henan, Hubei, Hunan, northern Jiangxi and other places have seen sand blowing or floating dust weather, and Gansu, Inner Mongolia local sandstorm weather. This dust weather is the first dust weather process in 2021, and the earliest dust weather process since 2002, showing the characteristics of wide impact range and high intensity. The sandstorm process was mainly caused by persistent cold air.

At 08:00 on January 10 (**Figure 2(a)**), the surface cold high center was located in the west of Mongolia, and the central intensity reached 1055 hPa. The cold front ran from the eastern Inner Mongolia through Hetao region to the west of Inner Mongolia. Due to the dense isobaric line, large pressure gradient and strong northwest wind behind the cold front, obvious dust weather began to appear in the south of Mongolia and the west of Inner Mongolia. The favorable factors are strong wind and uplifting power, while the unfavorable conditions are recent low temperature, unthawed sand source and less floating soil. There was positive vorticity at 700 hPa near the border of China and Mongolia, which is good for lifting (**Figure 2(b)**).

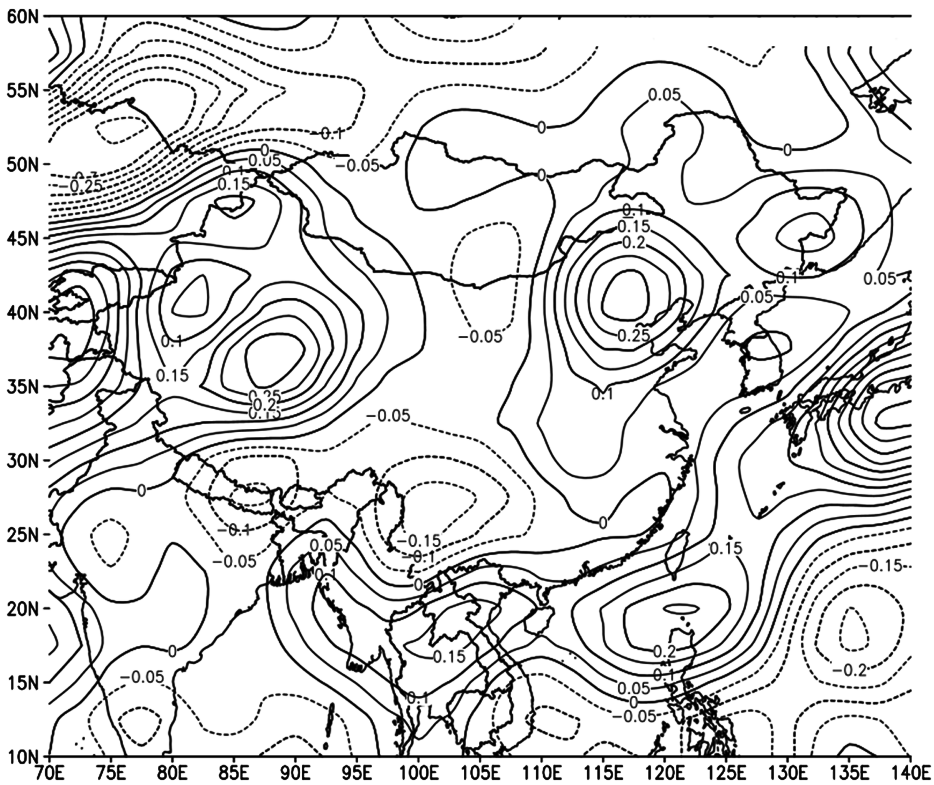
At 14:00 on January 11 (**Figure 3**), in the north and east region to generate a weaker cyclones speed faster, the cold high pressure at the back of the cyclone is fast east, this time with the increased flow into the upper air dust under the action of the northwest to the downstream areas and subsidence, cause most of eastern northwest, north China, Huanghuai air quality slip quickly. From 14:00 to 17:00 on November 11, dust in northern Shaanxi and southern Shanxi spread southeast along the low-level northwest air flow, causing dust pollution in many parts of Henan Province. At 17:00 in Luohe, the air quality was beyond the normal range of measurement, with PM10 significantly higher than PM2.5 (therefore, it was not haze, but dust).

At 20 o ‘clock on January 12 (**Figure 4**), the daily average of air quality index (AQI) in seven cities in the border area of Mongolia, Gansu, Shaanxi and Ningxia was beyond the normal range of measurement, and the primary pollutant was PM10. Dust affects a wide range of areas, from Gansu in the west to Shandong in the east, heavy or even serious pollution caused by floating dust or blowing sand occurred in many places in the Yellow River Basin. The dust spread eastward along the westerly wind at low altitude, affecting Beijing, Tianjin, Hebei, Shandong, Henan, Jiangsu and Anhui.

At 20 o'clock on January 13 (**Figure 5**), another cyclone formed in the middle high latitude area and rapidly moved eastward and southward to affect the




(a)




(b)

**Figure 2.** Sea level pressure (a) and omega fields (b) at 08:00 on January 10, 2021 (Beijing time, the same below).

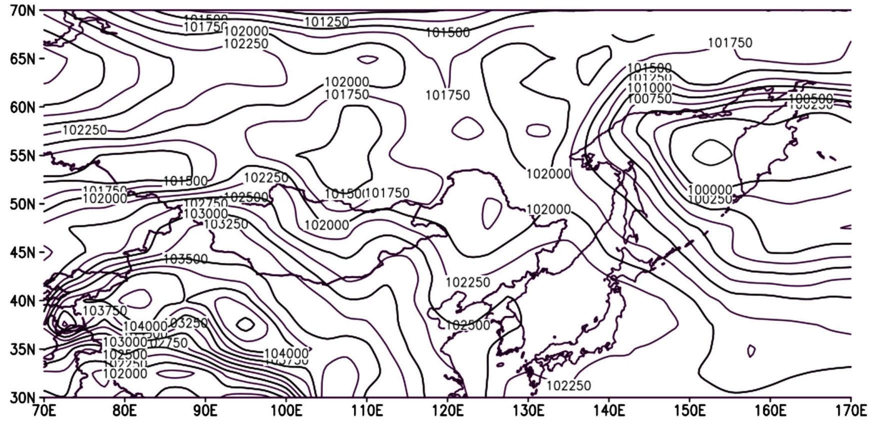



**Figure 3.** Sea level pressure map at 14:00 on January 11, 2021.

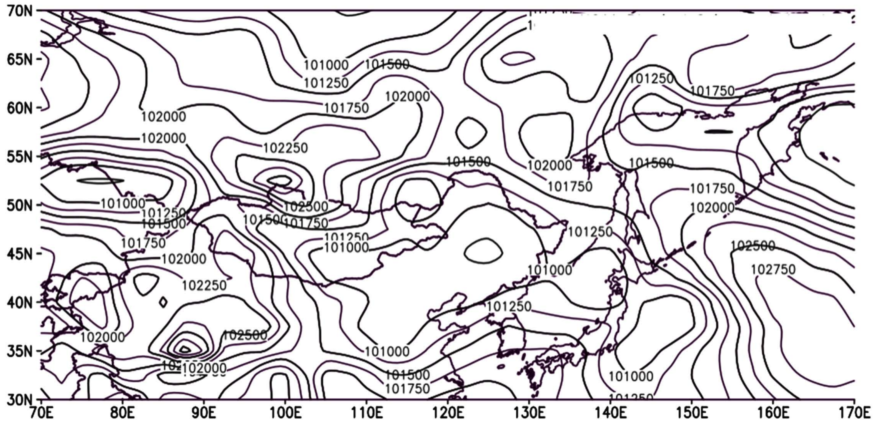



**Figure 4.** Sea level pressure map at 20:00 on January 12, 2021.

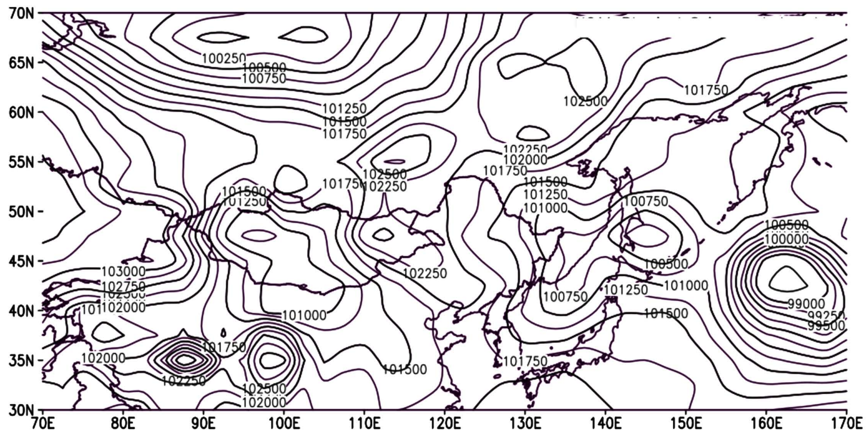



**Figure 5.** Sea level pressure map at 20:00 on January 13, 2021.

country. The intensity of the cold high pressure center behind the cyclone reached 1050 hPa. The central and western parts of Inner Mongolia, northern Shaanxi, Shanxi, central and northern Henan, Shandong and the Beijing-Tianjin-Hebei region continued to be affected by the dust, with the AQI index in most areas reaching 500. The primary pollutant is PM10, which is rarely found in places above 1000 and 2000, which is proved to be dust pollution. Among the provincial capital cities, Hohhot, Taiyuan and Shijiazhuang are all heavily polluted by dust and yellow sand, and visibility is low.

At 8 o'clock on January 14 (**Figure 6**), the surface cold front reached the central part of Xinjiang and moved southward rapidly. A new round of cold air has made most areas north of the Yangtze River cool successively from northwest to southeast. Strong northwest winds behind the cold front allow the dust weather to develop again. The PM10 concentration also increased in Huanghuai and northern Jianghuai regions. Dust pollution continued from Inner Mongolia to the Yellow River basin at 13:00 on the 14th. The PM10 index was above 600 in Ningxia Plain, Hetao Plain, Bayanzhuo, Baotou, Hohhot and Wuhai in Inner Mongolia, and Taiyuan and Datong in Shanxi, indicating very poor air quality. In Hebei, Shandong and Henan, many areas are also moderately or severely polluted, and the primary pollutants are PM10 and dust pollution. However, in Jianghuai and south areas, the dust was not affected due to the low altitude southwest wind.

At 08 o'clock on January 15 (**Figure 7**), the pressure gradient in the central and eastern parts of the country weakened significantly, the surface wind speed

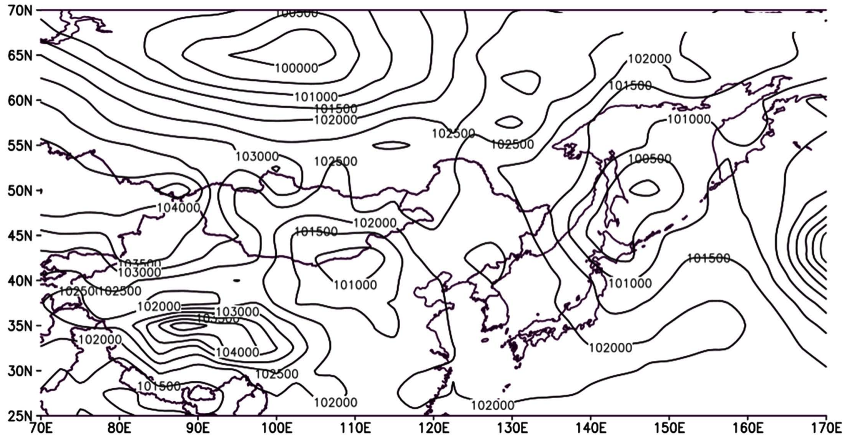



**Figure 6.** Sea level pressure map at 08:00 on January 14, 2021.

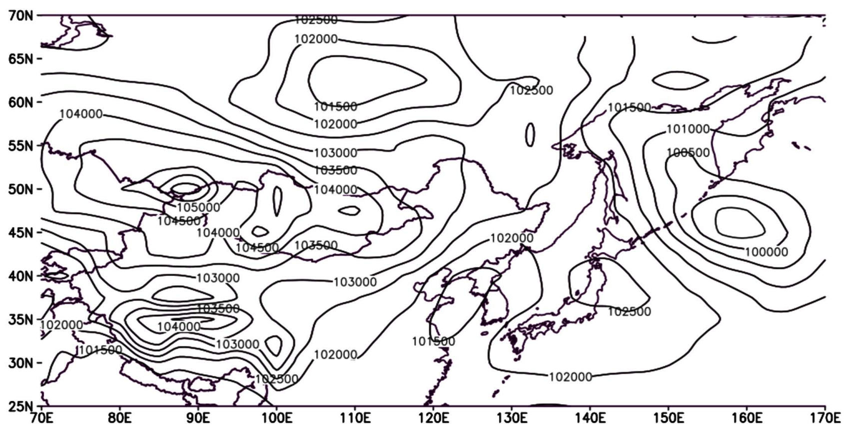



**Figure 7.** Sea level pressure map at 08:00 on January 15, 2021.

decreased, and the dust weather tended to end. Affected by dust transport, dust is still in some parts of the eastern part of Northwest China, central and western North China, Huang-Huai and other places. As the cold northerly wind moves southward, the sand-dust weather process in the above areas tends to end. However, due to the transmission impact, the Jianghuai and Yangtze River valleys may still be affected by dust, but for a short time.

At 8 o'clock on January 16 (**Figure 8**), affected by cold air, dust pollution in Inner Mongolia, Loess Plateau and North China was transmitted in the southeast direction, and the dust concentration in the above areas gradually decreased, and the air quality gradually improved. The cold air will continue to move southward, and the floating dust weather in the central and southern parts of North China and Huang-Huai regions will gradually weaken. However, due to the impact of transmission, some parts of Jianghan have floating dust, but the pollution lasted for a short time and will soon end. Under the guidance of the northerly air flow and the residual influence of the dust weather, the PM10 concentration in Jianghan and the northern part of Jiangnan still showed signs of short-term increase, and some cities were severely polluted.

At 8 o'clock on January 17 (**Figure 9**), the cold high pressure entered the Chinese mainland, with northerly wind and no large-scale haze.

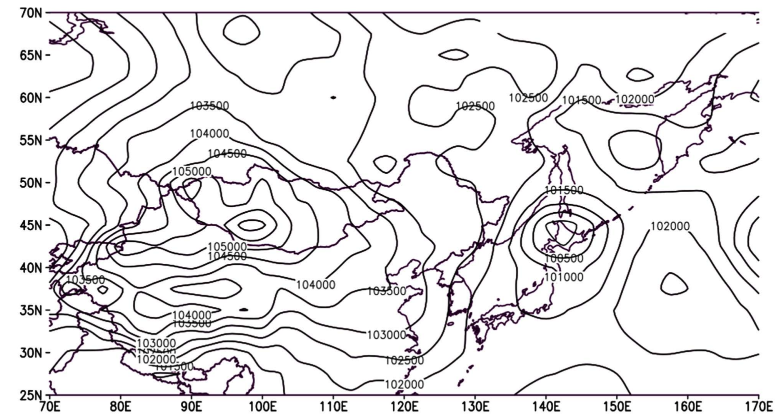



**Figure 8.** Sea level pressure map at 08:00 on January 16, 2021.

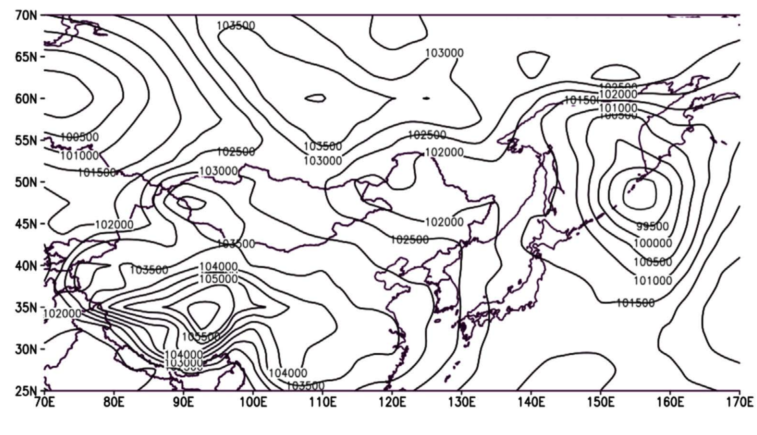



**Figure 9.** Sea level pressure map at 08:00 on January 17, 2021.

## 4. Conclusion

Using weather maps provided by China Climate Center and NCEP, this paper analyzed a dust weather process in China from January 11 to 16, 2021. The conclusions are as follows.

By analyzing the circulation pattern of mid and high latitude in Eurasia in mid-January 2021, the dust process was the first dust weather process in China this year, with a large impact area and a significantly earlier time than the same period in previous years.

The dust weather process was mainly caused by the continuous cold air. There is a strong northwest wind behind the cold front, and the wind is easy to produce sand and dust weather. The weak cyclone in the northern region moved eastward faster, which was conducive to the eastward migration of cold high pressure behind the cyclone and the transport of dust.

It is believed that with the continuous deepening of the research on dust weather, we can widely adopt various methods to analyze the occurrence and development process of dust weather in the future research, which will be helpful to the prediction of the development trend of dust weather. At the same time, we can continue to try to explore the sand and dust weather disaster and prevention.

## Conflicts of Interest

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

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