# Analysis of Extreme Weather in Three Northeastern Provinces Based on Big Data

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**Abstract.** In recent years, with the aggravation of global climate change, extreme weather events occur frequently in the three northeastern provinces. Using the data of meteorological stations in Northeast China from 1960 to 2010 for more than 50 years, the occurrence regularity of common extreme weather phenomena is discussed. The results show that the occurrence frequency, harm degree and uncertainty of major meteorological disasters in the three provinces of northeast China are increasing. The paper also provides suggestions for accurate decision-making of relevant meteorological departments.

**Keywords:** Extreme weather · meteorological disasters · Northeast China · Big Data analysis · Distributed processing · Proactive and accurate decision-making

## 1 Introduction

Extreme weather is an event in which the weather (climate) state deviates so far from the average state that has a statistically small probability to occur. [1] As a large agricultural country, China has many types, wide distribution and serious losses of agrometeorological disasters. In particular, the three northeastern provinces have experienced frequent extreme weather events in recent years. [2] In this paper, the monthly mean precipitation and temperature of meteorological stations (distribution in Fig. 1) with effective data for more than 50 years from 1960 to 2010 and the major typhoon data from 2002 to 2018 are analyzed, and the occurrence regularity of common extreme weather phenomena is discussed. In combination with the impact of meteorological disasters on agriculture and the response methods of meteorological departments, suggestions on improving the accuracy of meteorological services and forecast products, coping with meteorological disasters and reducing losses were put forward.

## 2 Analysis on the Extreme Weather

### 2.1 Overview of Common Extreme Weather in the Three Northeastern Provinces

The three northeastern provinces are the main bases for grain production and animal husbandry in China. The region not only bears most of the national food security responsibility, but also accounts for 91.5% of commodity grain. According to the data released


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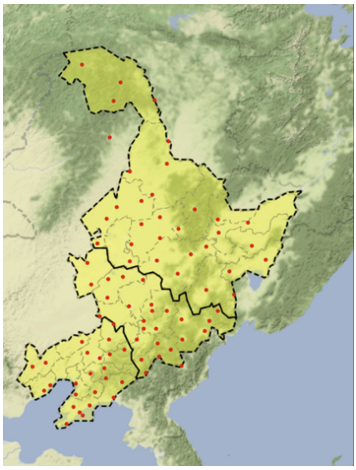

**Fig. 1.** Distribution of target weather stations

by the China Meteorological Administration, the development of agriculture and animal husbandry in Northeast China is greatly dependent on weather, and extreme weather accounts for a significant proportion of the causes of grain production reduction and animal husbandry disaster every year. The following are the frequently occurring extreme weather and conditions in the three provinces of Northeast China: The time series of drought, typhoon, rainstorm and cold injury of these four extreme weather events are analyzed, and their internal relations are considered, and the trend is simply summarized.

1) **Drought.** Agrometeorology defines agrometeorological disasters that reduce production due to lack of rainfall for a long period of time, resulting in insufficient soil moisture and destruction of crop water balance. [3] In recent years, the overall climate trend of the three provinces in Northeast China is warm and dry. By analyzing the data of the National Meteorological Data Network (Appendix 1) [4], the monthly average temperature from 1960 to 2010 are analyzed, and the trend chart of the seasonal average temperature and its anomaly and the average annual temperature and anomaly are obtained, as shown in Fig. 2, 3, 4 and 5. According to the analysis, the seasonal average temperature in the three northeastern provinces has been increasing since 1960 except winter.

The occurrence of drought events is very dynamic in time and space. Standardized Precipitation Evapotranspiration Index (SPEI) can be used to analyze the drought situation in the three provinces of Northeast China in the past 50 years. First, the temperature and precipitation data of 82 meteorological stations in the three northeast provinces were cleaned and revised to calculate the one-month scale SPEI index (Appendix 3). Based on the drought classification standard of Li Ming et al. [5], the drought conditions of stations in different spatial and temporal sequences were obtained, and the drought conditions in different regions in four seasons were aggregated (Appendix 3). It can be seen that the overall drought level is low in the Changbai Mountain region, Sanjiang Plain

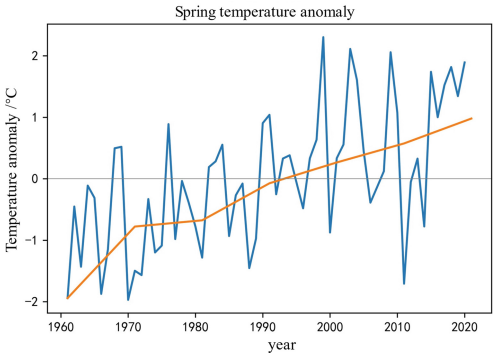


**Fig. 2.** Trend of mean temperature in spring

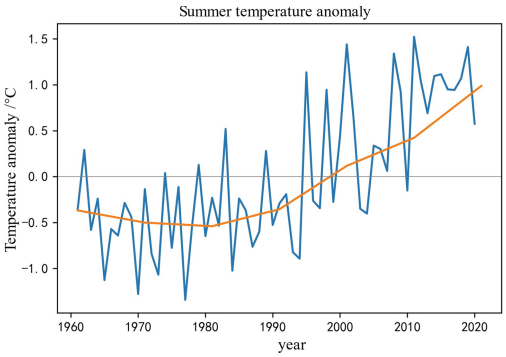


**Fig. 3.** Trend of mean temperature in summer

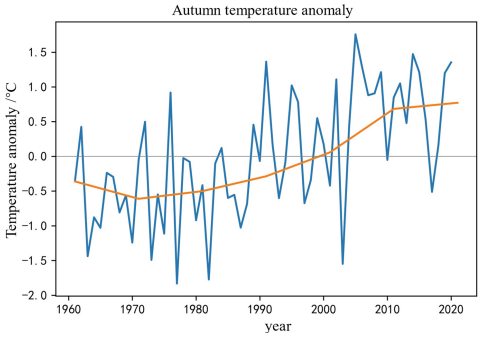


**Fig. 4.** Trend of mean temperature in autumn

and the southwest of Heilongjiang Province, but the frequency of severe drought events is increasing in the three northeastern provinces. According to Appendix 2, spring is the season with the most frequent occurrence of severe drought and extreme drought, while winter has the lowest frequency.

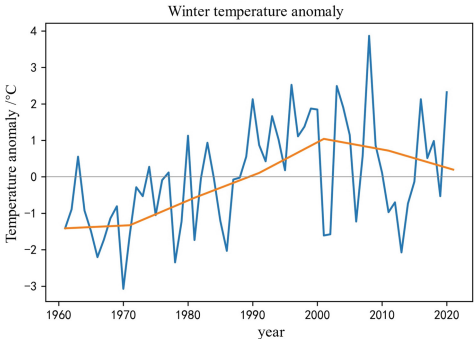


**Fig. 5.** Trend of mean temperature in winter

2) **Typhoon.** It refers to the low-pressure vortex occurring over the tropical or subtropical ocean, which is a strong and deep tropical weather system. Forming on the sea surface, it brings disasters to local areas in the form of high wind, heavy rain and so on after landing [6]. Typhoons often affect the three northeastern provinces under certain environmental factors. Typhoon paths are mainly divided into normal paths and abnormal paths, and abnormal paths are the main typhoon types affecting the three provinces in Northeast China [7]. Through the analysis of monthly mean precipitation and the comparison of typhoon-affected years, it can be concluded that 50% of the typhoon-affected years have higher precipitation than other years. [8].
3) **Rainstorm.** According to China's meteorological regulations, rainstorms are those that receive more than 50 mm of rain in 24 h. It is the main meteorological disaster in summer in the three provinces of northeast China. Cold vortex, shear, cyclone and typhoon are the common weather conditions that cause rainstorm in this region. There are two main water vapor conditions for rainstorm in the three provinces of Northeast China. One is water vapor transport over the sea, which plays a major role in precipitation. The other is water vapor transport by the northwest air stream. Compared with the sea passage, the water vapor contribution accounts for more than 50%. [9] As shown in Fig. 6, 7, 8 and 9, seasonal precipitation changes are shown. It can be found that in 1960, 1980 and 1990, there was abundant rainfall in the three northeastern provinces nearby, and in the middle of the 20th century, the rainfall was more and accompanied by a large number of rainstorm events. On the whole, the rainfall in the three northeastern provinces was the most in summer and the least in spring. In fact, there were more droughts in spring and more floods in summer, which was consistent with the analysis results.

The trend changes of average precipitation and precipitation variation range show that the precipitation in the three northeastern provinces is unbalanced and extreme, and the precipitation situation directly affects the occurrence intensity of drought and flood. The uneven distribution and variable frequency of precipitation in time and space lead to drought and flood in the history of the three northeastern provinces. Therefore, attention should be paid to the forecast and prevention of rainstorm.

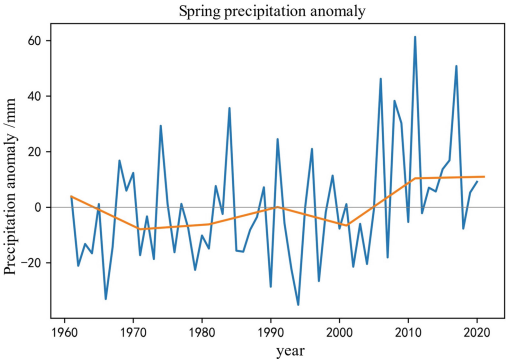


**Fig. 6.** Trend of mean precipitation in spring

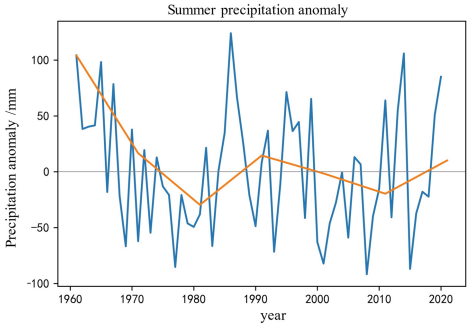


**Fig. 7.** Trend of mean precipitation in summer

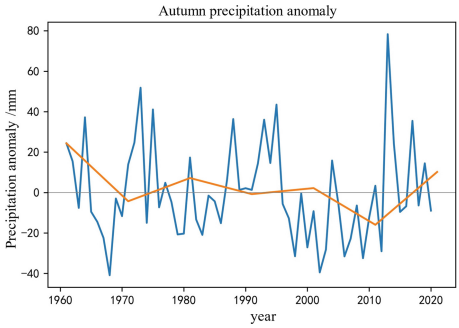


**Fig. 8.** Trend of mean precipitation in autumn

4) **Chilling injury.** The general view of academic circles is summarized. A chilling injury should occur above 0 °C, which has adverse effects on crop growth and development and leads to crop yield reduction. It has occurred all over China, with the three northeastern provinces the worst hit. Obstacle-type chilling injury occurs

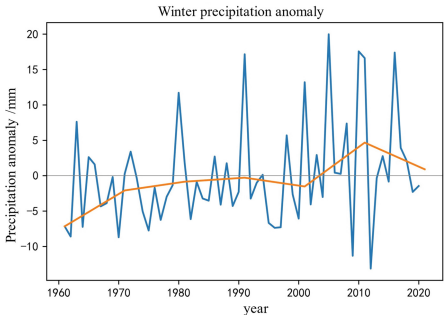


**Fig. 9.** Trend of mean precipitation in winter

in most areas after 2–3 years, resulting in an annual yield reduction of more than 20%. [10].

Chilling injury can be divided into delayed type and obstacle type. Delayed type of chilling injury occurred less after the 21st century, while obstacle type of chilling injury occurred more frequently after the 21st century, and its occurrence regularity decreased from north to south and from middle to east. [11].

Food production is 266.6 billion jins, in 2018, the three northeast provinces account for about 20.3% of the total grain production [12], thus yielding crops yield change seriously affect China's food supply, crop production factors in a year, chilling damages of huge, several kind of main food crops in different growth and development critical period will be affected by low temperature chilling damage, therefore should be given attention.

Based on the analysis found that the global temperature rise to instability energy increase, extreme weather has led to an increased agricultural meteorological disaster frequency, harm, most agricultural region and northeast area rely on hot water, so most of the groom crop growth and yield depends on the weather conditions, to do a good job of meteorological disaster prevention and mitigation is especially important for the three northeast provinces.

### 2.2 Meteorological Disaster Prevention and Mitigation

Meteorological disaster prevention in China includes early prediction of the time of disaster, provision of disaster information after the disaster, daily monitoring of agricultural production, advice for crop management, estimation of crop yields, and guidance for fallow planning. [13] In the early 21st century, some scholars proposed to design a defense decision support system by combining meteorological disaster prediction with computer network, so as to provide information and forecast for agricultural workers. [14].

However, due to the different technical level of equipment of meteorological stations in different places, the data acquisition accuracy is different, and the range is different. When large-scale disasters occur, it is difficult to ensure the high accuracy of decision-making. Therefore, there is still much room for improvement in meteorological disaster

prevention and mitigation. For example: improve meteorological service equipment; We will vigorously support the development of modern agriculture by using GPS, remote sensing and other technologies, and relying on the Internet to accurately transmit meteorological information. Establish a systematic disaster prevention and mitigation system, from data collection, disaster tracking, making predictions to convey defense and remedy suggestions, there should be a complete system to deal with sudden weather events; We will strengthen support and publicity for meteorological disasters, so that practitioners have a strong awareness of prevention.

## 3 Conclusion

In this paper, the average temperature and precipitation of the three northeastern provinces in recent 50 years are studied. According to the research of this paper, the following conclusions can be drawn.

1. The drought

   (1) The overall drought level in Changbai Mountain region, Sanjiang Plain and the southwest of Heilongjiang Province is relatively low.
   (2) The occurrence frequency of severe drought and extreme drought increased.
   (3) The drought was the most severe in spring and the lighter in winter.

2. The typhoon

   After the typhoon landed, it affected the precipitation in the three northeastern provinces and strengthened the intensity of the rainstorm. In some years, the precipitation in summer was significantly higher than that in other years.

3. The heavy rain

   (1) In 1960, 1980 and 1990, there was abundant rainfall in the three northeastern provinces. In the middle of the 20th century, the precipitation was more and accompanied by a large number of rainstorm events.
   (2) The precipitation was the highest in summer and the lowest in spring, which was consistent with the phenomenon of drought in spring and flood in summer.

4. Chilling injury

   There are two main types of chilling injury, the delayed type of chilling injury is less after the 21st century, while the obstacle type of chilling injury is more frequent, and the regularity of occurrence is decreasing from north to south and from middle to east.

Meteorological disasters cause huge agricultural losses every year. To limit the damage, China's meteorological services are constantly improving the effectiveness and accuracy of forecasts. In the future, by upgrading hardware equipment and improving the prevention and control system, the regional meteorological disaster losses in the three northeastern provinces are expected to be controlled within an acceptable range.

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## References

1. cusdn.org.cn
2. He X M. Impact assessment of agrometeorological disasters and temperature and precipitation on grain yield in three provinces of Northeast China [D]. Shenyang Agricultural University, 2018.
3. Gu Junxi. Dictionary of Atmospheric Sciences: Meteorological Press, 1994
4. National Earth System Science Data Center, National Science & Technology Infrastructure of China (http://www.geodata.cn).
5. Li Ming, Hu Weixia, Zhang Lianzhi, Wang Guiwen, Chai Xurong. Analysis of meteorological drought risk in Northeast China based on SPEI [J]. Journal of Arid Land Resources and Environment, 2018, 32(07):134-139. www.cma.gov.cn
6. Li Ying, Chen Lianshou, Zhang Shengjun. Statistical characteristics of tropical cyclones in China [J]. Journal of Tropical Meteorology, 2004, 20 (1):14-23. [8] Li Yongsheng, Zhu Yuxiang, Wang Ying. Preliminary Analysis on the Characteristics and Causes of Midsummer Precipitation Anomaly in Heilongjiang Province [A]. Chinese Meteorological Society. Innovation-driven development to improve the ability of meteorological disaster prevention: S6 short-term climate prediction theory, method and technology [C]. Chinese Meteorological Society: Chinese Meteorological Society, 2013:11.
7. Ma Liangchen, Sun Li, Wang Ning. Analysis on characteristics of water vapor transport of typical rainstorm cases in Northeast China [J]. Plateau Meteorology, 2017, 36(04):960-970.
8. Pei Yongyan, Yue Hongwei. Study on cold damage of crops in Northeast China [J]. Science and Technology Communication, 2009(09):16-17. (in Chinese)
9. Wang Duanjun. Agrometeorological Service [M]. China Meteorological Press, 2013.
10. China National Development and Reform Commission
11. Ye Mao, Deng Tao, Ning Honggui. The function and countermeasure of meteorological disaster prevention and mitigation service agriculture [J]. Modern Agricultural Science and Technology, 2020(16):163+166.
12. Li Yijun, Wang Chunyi. Conceptional model of decision support system for prevention of cold injury in Northeast China [J]. Journal of Natural Disasters, 2004(05):62-68.