Overview of China's Emergency Early Warning in 2021

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Abstract

This research uses the 59th-70th national emergency early warning information release monthly report data of China to study the total number of emergency early warnings in 2021, the general situation of early warning categories and regional distribution differences. The results show that: 1) there are 387,075 early warning information in China in 2021, and the early warning has obvious seasonality. 2) The issuance of early warnings is obviously related to the seasons, and the issuance of early warnings varies from month to month. The issuance of one kind of early warning can easily lead to the issuance of another kind of early warning, that is, the early warnings are closely related, and some specific disasters are easy to cause secondary disasters. 3) There are differences in the number of early warnings in each province. 4) The reason for the peak of early warnings in July and the large proportion of red early warnings in Henan Province is the sudden heavy rainstorm in Henan Province in July; the physical mechanism of this heavy rainstorm is sufficient water vapor, strong uplifting movement and stable situation and a long existence time.

Keywords

Emergency Early Warning in China, Secondary Disasters, Red Early Warning, Heavy Rainstorm in Henan

1. Introduction

China's natural disasters have four characteristics, including many types of disasters, wide distribution, high frequency, and heavy losses. The Chinese people have long fought tenaciously against emergencies such as natural disasters, accidents and disasters. The national emergency early warning information release system is an important part of the national emergency response system and the

only early warning information release system of the State Council's emergency platform. Early warning of emergencies refers to early warning information such as natural disasters, accident disasters and public health events that occur suddenly or may occur, have caused or may cause serious social harm, and need to take emergency measures to respond. The purpose of early warning analysis in emergency management is to inform people of possible events or the worsening state of events, so that people can take some effective measures in advance to kill possible emergencies or possible worsening events in the cradle state. The problem is how to judge possible events according to the changing trend of relevant information. An overview of China's emergency early warning in 2021 is of great significance for preventing and reducing natural disasters, accident disasters, public health and social security incidents and their resulting losses, and maintaining the safety of people's lives and properties.

The situation of the former research is analyzed as follow. Dong and Liu (2021) pointed out that early warning is the "information tree", "starting gun" and "baton" of emergency management work, which can not only prevent and reduce the occurrence of emergencies, control and reduce the consequences of disasters, but also help in emergency response. An important starting point, its purpose is to "maximize the prevention of emergencies from turning into disasters". The Party Central Committee and the State Council attach great importance to the release of emergency warning information. The importance of early warning information is enough to show. However, Tu et al. (2021) pointed out that in the face of the urgent needs of national economic and social development, my country's current meteorological disaster defense capabilities are still insufficient, the coverage and timeliness of meteorological disaster warning information released urgently need to be improved, and the dissemination of meteorological disaster warning information has not been fully covered. In the vast rural and remote areas, the "last mile" problem of early warning information remains to be solved. In fact, not only meteorological warnings, but also many aspects of early warning information still have room for improvement in communication and utilization. Such as Ni et al. (2021) keenly capture the problems in early warning and propose solutions: The study found that there are problems such as high entropy in early warning, serious loss of crisis information and weak early warning ability in the early warning of major public crises. To solve these problems, it is not only necessary to actively build a comprehensive inspection and monitoring system, improve the coding process, establish and improve the abstract analysis mechanism, but also strive to improve the ability of alarm diffusion and release, and continuously improve the absorption and response level of early warning information. Jiao (2013) once studied the public opinion guidance mechanism for emergencies. The National Emergency Early Warning Information Release Network, China has also released monthly and daily data, and provided detailed data from the perspectives of various types of early warning releases and provincial early warning releases. Kazancigil (2013) focused on the methodologies to use digital television as an efficient medium to convey timely and useful infor-

mation regarding seismic warning data to the public. These studies above are very rich, however, some problems existed in them should be addressed. For example, the National Emergency Warning Information Release Network, China does not have an annual warning report, nor does it have statistical analysis and explanation of specific data.

This work uses the year as a cycle to count the early warning data for the whole year of 2021, and conduct statistical analysis, comparison, citation demonstration and regression analysis to obtain a more objective and vivid data conclusion, and the physical mechanism behind the data is carried out. The research can provide reference for future early warning.

2. Data and Methods

2.1. The Data Samples

The data samples in this research contain the data on the release of various types of early warning information across China and the release of early warnings in various provinces across the China in 2021, organized from the 59th to 70th monthly reports on the release of national emergency warning information, that is, the monthly reports from January to December in 2021. This work also uses the early warning information issued by the Central Meteorological Observatory of China on March 26th, 2021.

2.2. The Relative Theory of the Methods

This work mainly uses descriptive statistics, comparative analysis and regression analysis. The relative theory of the methods is introduced as follow. Descriptive statistics refers to the use of tabulation and classification, graphs, and statistical summary data to describe central and discrete trends in data. Contrastive analysis, also known as comparative analysis, is the most commonly used method in statistical analysis. It is a method of reflecting the differences and changes in the quantity of things through the comparison of relevant indicators.

Regression analysis studies the relationship between dependent and independent variables, and this technique is often used to discover causal relationships between variables. Among them, linear regression is one of the most well-known modeling techniques, and it is often one of the techniques of choice when learning predictive models. In this technique, the dependent variable is continuous, the independent variable can be either continuous or discrete, and the regression line is linear in nature. Linear regression uses the best-fit straight line (also known as the regression line) to establish a relationship between the dependent variable (Y) and one or more independent variables (X). The least squares method is the most commonly used method for fitting regression lines. For observed data, it computes the line of best fit by minimizing the sum of squared vertical deviations from each data point to the line.

The correlation coefficient is a measure of the degree of linear correlation between the study variables, generally denoted by the letter R. Due to different re-

search objects, there are many ways to define the correlation coefficient, and the commonly used Pearson correlation coefficient is used in this study. The larger the absolute value of the correlation coefficient R is, the stronger the correlation is generally considered. At the same time, the p-value generally less than 0.05, indicating that the correlation between variables is significant, that is, there is a significant correlation between two variables.

3. Results and Analysis

3.1. Overview of the Number of Early Warnings in China in 2021

The monthly report released by the national emergency early warning information shows that in 2021, various departments across China, such as foreign affairs, natural resources, ecological environment, transportation, agriculture and rural areas, health and health commissions, emergency management, meteorology and other departments, will issue early warnings through the national early warning release system of China a total of 387,075 pieces of information. Figure 1 shows the distribution of various types of early warnings across the country. Statistical analysis and comparison can show that the number of warnings in July is the largest, 68,961, which is 4.25 times that of the least warning in February, 16,217. In summer, from June to August, the total number of warnings was the highest, which was 2.9 times that of winter. Lan et al. (2021) showed that my country is located in the East Asian monsoon region, which is easily affected by the monsoon in summer. At the same time, the temperature in summer is high, and the low-temperature air in the upper layer and the air temperature in the lower layer form atmospheric convection, which is also prone to hail, thunderstorms, tornadoes and other weather. That is, the weather characteristics of summer lead to frequent occurrence of summer warnings.

3.2. Overview of Alert Categories

There are four types of early warnings for each month, natural disasters, accidents and disasters, public health, and social security. Between the warnings of the same month, natural disaster warnings accounted for the vast majority, about 99%, and meteorological warnings such as thunderstorms and rainstorms were issued the most. It shows that natural disasters are easier to predict and publish than non-natural disasters.

Common early warning categories and monthly changes are shown in Figure 2. The number of warnings issued is obviously related to the season. From February to April in spring, the gale warning ranks first. In spring, sandstorm warnings are frequently issued. The Central Meteorological Observatory issued a yellow warning for sandstorms on March 26. From night to the next day, there will be sandstorms in many places in China, and the process of sandstorms is strong. Coupled with the strong wind in spring, the sandstorm greatly reduces the visibility, affects the travel of citizens, and pollutes the ambient air. In addition, in the spring of 2021, there will be a sudden drought, and the spring drought
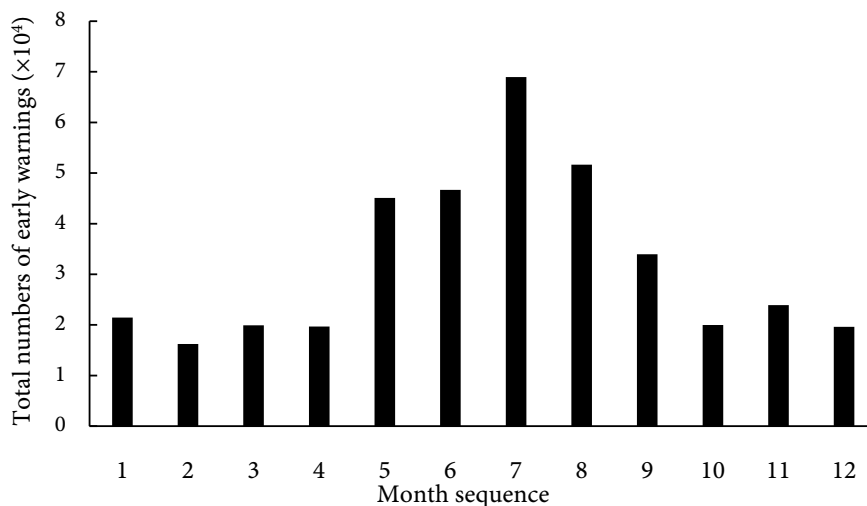
Figure 1. Numbers of early warnings by month in 2021 (on the horizontal axis, "1" represents January, "2" represents February... "12" represents December, the same below).
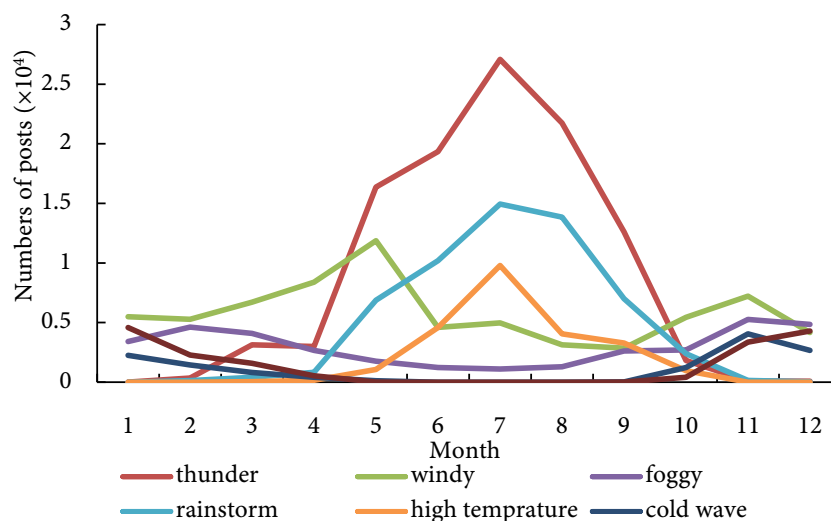

Figure 2. Distribution map of various types of early warnings.

warning accounts for 85% of the whole year, and the drought warning is obvious in stages. Lightning warning ranks first in summer warnings. In addition, strong winds, heavy rains, high temperatures, and typhoons also occur frequently. In autumn, warnings of strong winds and heavy fog continued to be issued frequently, and the number of cold wave warnings reached 4058 in November. "It's cold as ice during the Slight Cold and Great Cold solar terms", the most cold warnings in winter, small cold and winter solstice road icing. 2021 is the year of La Niña, and winter cold wave warnings are frequently issued, and the country has experienced 5 large-scale cold waves. Lightning warnings top the list from May to September, while gale warnings top the list from January to April and October to November. Among them, the number of thunder and lightning reached 105,431, the number of strong winds was 70,178, and the thunder and lightning

warning also ranked first in the year, which shows that China is a country with frequent thunder and lightning.

From April to July, the number of lightning warnings gradually increased, gradually becoming the main warning category, and the number reached its peak in July. Regression analysis was carried out on the number of lightning warnings and the monthly ordinal number, and the correlation coefficient of the regression equation reached 0.936, which was significantly correlated at the 0.05 level. (Regression analysis process and the values determined of the parameters are introduced in sub-section 2.2.) This is in line with the natural phenomenon that summer is a flood season in China with more rainfall. The number of high temperature warnings also gradually increased from June to July, and the number peaked in July at 9790, which is in line with the objective feeling of the extreme heat in summer in China.

In July, thunder and lightning warnings accounted for the largest proportion of 27,080, about 1/3; thunder and lightning, rainstorm, and high temperature warnings were also issued frequently, ranking the top three, and often caused secondary disasters.

For example, a bivariate correlation analysis was carried out on the number of lightning and rainstorm warnings issued in the same month, and the correlation coefficient was 0.982, which was significantly correlated on both sides at the 0.01 level, that is, the issuance of thunderstorm warnings was often accompanied by the issuance of rainstorm warnings.

There is a strong correlation between various types of early warnings and often go hand in hand. Yang et al. (2019) pointed out that floods, waterlogging disasters caused by short-term heavy rainfall and continuous rainfall, and secondary disasters such as landslides and debris flows caused by them are increasing. Lin and Chen (2020) demonstrated that typhoon disasters occur frequently and cause serious damage, mainly through storms, storm surges and the disaster chain caused by them. Strong winds will destroy buildings and trees, and heavy rains will cause huge secondary disasters such as flash floods, mudslides and flooding, resulting in huge losses of people's lives and property safety. Typhoons and their accompanying secondary disasters such as debris flows, floods, landslides, and other secondary disasters have led to severe disasters, and the chain effect in time and space has resulted in cumulative amplification of disasters.

Since the outbreak of the new crown epidemic, most of the public health warnings refer to the new crown pneumonia. According to the data, the public health warnings reached a peak of 213 in January. In November, the number was at least 95, but based on the data on the number of new crown diagnoses per month, there is no clear relationship between the two.

Figure 3 shows the monthly variation in the number of red alerts. Early warnings are generally divided into red, orange, yellow and blue. The red warning has the highest level and reflects a wider range of emergencies and a wider impact. Therefore, the statistics of red alerts are more important. There are many red
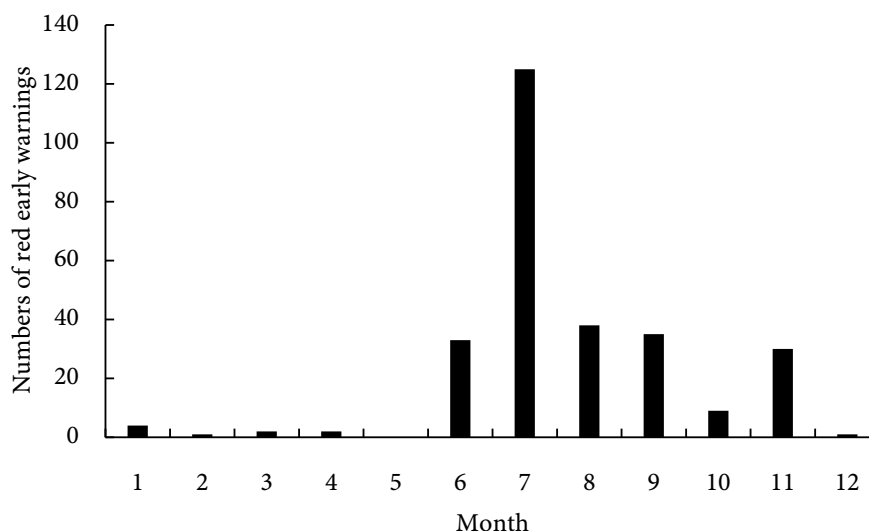
Figure 3. Numbers of red early warnings.

warnings and various warnings issued in Liaoning Province. As shown in **Figure 3**, from May to July, with the advent of summer, the number of red warnings gradually increased. The number of red warnings in July was significantly more than other months, accounting for 44.6% of the total number of warnings. From July to October, the number of red warnings, the number gradually decreases. Not only are there more total warnings in summer, but there are also more red warnings that could have serious impacts.

3.3. Overview of Early Warning in Each Province in China

Figure 4 lists the distribution of the number of early warnings in each province in 2021. As shown in the figure, in 2021, Hunan Province will issue the most warnings, reaching 28,210. At the same time, the three southwestern provinces of Hunan, Yunnan and Guizhou have more than 20,000 warnings throughout the year. Liu et al. (2011) believed that the southwest region is a typical climate vulnerable area, with frequent and repeated agrometeorological disasters, and weak disaster resistance. That is, under the influence of geographical location, climatic conditions and geological conditions, there are many early warnings of emergencies in southwest my country. The Tibet Autonomous Region issued the fewest warnings throughout the year, at 401. The four municipalities, Beijing, Tianjin, Shanghai and Chongqing, have fewer early warnings due to their small jurisdiction, with fewer than 4,000 warnings throughout the year. Liaoning Province has issued many red warnings and has a strong awareness of disaster prevention and mitigation. Tibet has the least number of warnings per unit area, and fewer warnings per unit area.

3.4. Abbreviations and Acronyms

In 2021, we have experienced extreme weather such as drought in the south, typhoon "In-Fa", and rainstorm "21.7". According to the Financial Associated
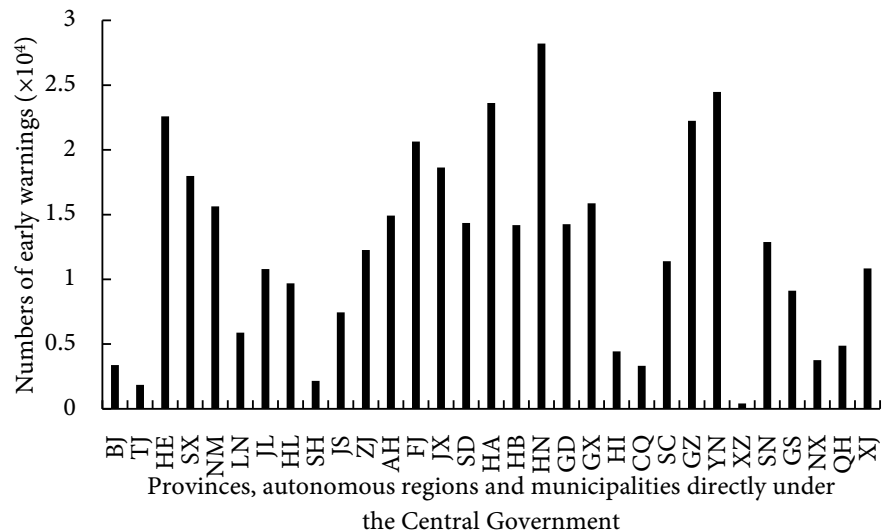
Figure 4. Annual warning histogram of 31 provinces, autonomous regions and municipalities directly under the central government in China (the abbreviation standard refers to the "Administrative Region Name" from the Ministry of Industry and Information Technology, P. R. China).

Press, Henan Province suffered from a historically rare torrential rain and suffered severe floods. The disaster caused a total of 14.786 million people in 150 counties (cities, districts) in Henan Province to be affected, and 398 people died or missing due to the disaster, including 380 people in Zhengzhou, accounting for 95.5% of the whole province; the direct economic loss was 120.06 billion yuan, of which 40.9 billion yuan in Zhengzhou. From the data available, the July warning and red warning in Henan Province reached the maximum at the same time, of which 18 were red warnings, accounting for 69.2% of the annual red warnings in Henan Province. It is particularly important to study the physical mechanism of rainstorm formation in Henan Province, because it can learn from its formation mechanism to forecast similar situations in the future and issue early warnings to prevent and mitigate disasters.

The three conditions for the formation of torrential rain are sufficient water vapor, strong uplift, stable situation and long existence time (Zhu et al., 2007). Specifically, 1) sufficient water vapor: in July, the subtropical high extended to the west obviously, and the intensity was relatively large. Henan was at the edge of the subtropical high, and the convection was unstable. In addition, under the influence of the remote control of typhoon "In-Fa", under the guidance of the combined airflow of the typhoon and the subtropical high pressure, a large amount of water vapor is continuously transported from the sea to the land through the easterly wind, bringing sufficient water vapor to Henan. 2) Strong uplifting movement: after the easterly airflow encounters the Taihang Mountains and the Funiu Mountains, the airflow climbs and rises, condensing and causing rain. 3) Longer duration: due to the stable atmospheric circulation situation. The western Pacific subtropical high and continental high were maintained over the Sea of Japan and the northwest region, respectively, resulting in the stagnation of the low-value

weather system between the two in the Huanghuai region and long-term precipitation in Henan.

4. Conclusion

There are a total of 387,075 early warning messages in China in 2021. Among them, early warnings have significant seasonality, and summer is the peak of the number of early warnings.

The issuance of early warnings is obviously related to the season: there are many warnings of strong winds in spring, more concentrated sandstorm warnings, and frequent drought warnings; more warnings of thunderstorms in summer; more warnings of strong winds in autumn; more warnings of road icing and frequent cold waves in winter. My country has issued the most lightning warnings. There is inter-month variation in early warning issuance: with the arrival of summer, thunder and lightning warnings are frequently issued, and the correlation coefficient between April and July and the monthly ordinal regression equation reaches 0.936, which is significantly correlated at the level of 0.05; the two peaks of strong wind warnings are in spring and autumn. There are also seasonal changes in red alerts, with frequent occurrences in summer. The correlation between various types of early warnings is strong, and the early warnings are closely related. The correlation coefficient between lightning early warning and rainstorm early warning reaches 0.982, which is significantly correlated at the level of 0.01. A specific disaster is prone to secondary disasters.

There are differences in the number of early warnings in different provinces: Hunan Province issued the earliest warnings; Southwest China issued more early warnings due to the fragile climate; four municipalities directly issued fewer early warnings; Tibet issued the least early warnings, with the lowest per-unit area ratio.

The three conditions for the formation of torrential rain are sufficient water vapor, strong uplifting movement, stable situation and long existence time. Under the specific circulation background in July 2021, coupled with the influence of geological mountains such as the Taihang Mountains and the Funiu Mountains, heavy rains formed, accumulated and fell in Henan Province, causing floods in Henan.

Acknowledgements

Conflicts of Interest

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

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