Environment Construction Analysis and Prevention of Strong Wind-Storm / Blizzard-Freezing Disaster

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Abstract. The aim of this study is to explore the occurrence conditions of strong wind-storm / blizzard-freezing disasters, analyse the coupling law and interaction mechanism of disaster elements of various types of disasters, and explore the system of coupled disasters in accordance with similar criteria and construct a comprehensive test environment for this meteorological disaster. Based on this, we studied the effects of extreme disasters on various fields. We also wanted to discuss the defense measures in various fields for strong wind-storm / blizzard-freeze disasters to reduce the losses caused by disasters.

1. Introduction

In human life, there are often various events that threaten people's production, life, and even survival. We call these events that threaten human disasters. The disaster events caused by extreme and abnormal weather are meteorological disasters in natural disasters.

In recent decade, due to the El Niño and La Niña phenomena, extreme weather disasters facing our country have gradually increased. Among them, the disaster that is very close to us and has serious impacts is the 2008 Southern Snow Disaster. In the past, what we had done is to consider an extreme climate element for analysis, such as assessing the maximum daily precipitation commonly used for a heavy rain, assessing the extreme minimum (maximum) temperature in the process after an extreme temperature flag event. However, when assessing continuous extreme weather, a single factor cannot reflect the comprehensive impact and positioning of the process. Therefore, new models need to be constructed to evaluate long-term extreme meteorological disasters. [9]

This article proposes to couple multiple hazards such as low-temperature rain/snow freeze to construct a comprehensive disaster experiment environment. Based on the similarity theory, a comprehensive index calculation model of continuous strong wind-storm / blizzard-freezing process is constructed, and according to the characteristics of different types of disasters and the characteristics of disaster carrier damage, a strong wind-storm / blizzard-freezing coupling process is constructed in comprehensive disaster experiments. [2] The impact of strong wind-storm / blizzard-freezing disasters on different fields is also analysed, and good measures for disasters are summarized.

2. Computational model of comprehensive index of continuous strong wind-storm / blizzard-freezing process

The snow disaster in southern China in 2008 aroused widespread concern over large-scale strong wind-storm / blizzard-freezing disasters, and its various elements have been analysed. So it is necessary to detailed quantitative analysis and calculation of the disaster. According to the experience of the original,
we selected the longest continuous rain and snow days $d_5$, the total amount of rain and snow during the period $p_5$, and the continuous average daily temperature $\leq 0.5^\circ C$ $d_1$, the process average temperature $t_m$ and process extreme minimum temperature $t_{min}$ 5 factors as indicators to establish a strong wind-storm / blizzard-freezing comprehensive process index calculation model.

2.1. The similarity theory
When we study large-scale extreme weather, many of these disasters are too large to study with real objects. Therefore, it is necessary to conduct similar model research, that is, to make models based on similar theory. To make the model and the prototype similar in phenomenon, experiment the model to obtain the experimental data, correct the errors through various correction methods, and finally obtain the prototype data and analyse it. Similarity includes geometric similarity, time similarity, physical quantity similarity, and so on. And, if the similarity theory is used for analysis, the model needs to meet the following three conditions:

(1). The nature of the phenomenon is the same;
(2). The physical quantity with the same name is similar;
(3). There is a certain relationship between the similarity constants.

We usually call it the similarity three theorem. The similarity first theorem and the second theorem are similar facts that are often known in advance, which determine the nature of similar phenomena. The third theorem is the criterion on which the two phenomena are similar. [10]

2.2. Definition of continuous strong wind-storm / blizzard-freezing process
The continuous strong wind-storm / blizzard-freezing process refers to a weather process in which continuous low-temperature weather occurs for the same period or in the previous and subsequent periods of more than 5 consecutive days of rain and snow. Generally, we define the earliest date of the two start dates of continuous rain and snow and low-temperature and the latest date of the two end days as a continuous low-temperature rain and snow weather. [3]

For continuous rain and snow weather, the following definitions are given:

(1). Rainy and snowy weather for 5 consecutive days or more (1 day intermittent)
(2). Rain and snow for 7 consecutive days or more (with a 2-day interval during the allowable period)
(3). Continuous rain and snow for more than 10 days (3 days intervals allowed)

According to the above definition, the longest continuous low temperature rain and snow weather of each year is first calculated, and then the beginning day $t_1$ is pushed forward 10 days, and the end day $t_2$ is pushed forward 10 days, that is, the continuous low temperature period is selected from $(t_1-10)$ days to $(t_2+10)$ days. The earliest date of the continuous rain and snow or the continuous low-temperature and the latest date of the end date of the two are defined as a continuous rain and snow low-temperature freezing process.

2.3. Selection of comprehensive evaluation index factors for continuous strong wind-storm / blizzard-freezing process
Because the units of the five factors are different, it is difficult to compare and analyse at a unified scale, so we need to make them dimensionless. Let five index factors be:

$$y_i = \{d_{x_i}, p_{x_i}, d_{t_i}, t_{m_i}, t_{min_i}\}$$ (1)

where $i = 1, 2, 3 ... , n$ is the year.

First, we calculate the average of each indicator:

$$y_0 = \{d_{x_0}, p_{x_0}, d_{t_0}, t_{m_0}, t_{min_0}\}$$ (2)

where

$$d_{x_0} = \frac{1}{n} \sum_{i=1}^{n} d_{x_i}, p_{x_0} = \frac{1}{n} \sum_{i=1}^{n} p_{x_i}, d_{t_0} = \frac{1}{n} \sum_{i=1}^{n} d_{t_i}, t_{m_0} = \frac{1}{n} \sum_{i=1}^{n} t_{m_i}, t_{min_0} = \frac{1}{n} \sum_{i=1}^{n} t_{min_i}$$ (3)

then the value of the dimensionless index will be:
where $i = 1, 2, 3, ..., n$ is the year.

After dimensionless processing, the original data are converted into non-dimensionalized index evaluation values, that is, each index value is on the same quantitative level, so that the effect of all indicators on the evaluation scheme is the same, and arithmetic or weighted average can be directly performed for comprehensive evaluation analysis.

Then use the weighting scheme to sum up to calculate the composite index. Let the continuous low-temperature rain and snow weather comprehensive index be $Z_i$, it is easy to know:

$$Z_i = \frac{d_{x_i} + p_{x_i} d_{t_i} + \tau_{m_i} + \tau_{m_i}}{d_{x_0} + p_{x_0} d_{t_0} + \tau_{m_0} + \tau_{m_0}}$$

(5)

It shows that the longer the continuous rain and snow days $d_x$, the larger the total rain and snow $p_x$ during the period, the longer the continuous days with an average daily temperature $\geq 0.5 \, ^\circ{C}$, the lower the average temperature during the period, the lower the extreme minimum temperature in the process, that is, the larger the index values after dimensionlessization, the larger the comprehensive index $Z_i$, and the more severe the continuous low-temperature rain and snow process. [6]

2.4. Meteorological elements of strong wind-storm / blizzard-freezing weather

According to article 21197 of the glaze and rime in 1951-2009 weather records, calculated the range of the average daily temperature - 19 ~ 13 °C, we can be divided into 32 interval ($m = 32$), to 1°C ($\Delta = 1$) between each interval, according to the calculation formula of fuzzy information distribution (6) to compute all levels within the scope of the probability distribution of the average daily temperature, get the fuzzy distribution and cumulative probability as shown in Figure 1 (a). [4]

$$q_{ij} = \begin{cases} 1 - \frac{|x_i - u_i|}{\Delta}, & |x_i - u_i| \leq \Delta \\ 0, & |x_i - u_i| > \Delta \end{cases}$$

(6)

Figure 1. Distribution of fuzzy probability (column) and cumulative probability (solid line) of southern China meteorological elements.

It can be seen that when strong wind-storm / blizzard-freezing weather occurs, the probability of an average temperature above 2 °C in southern China is quite small, and the peak value of the bar graph is about -4 °C to -2°C. In the same way, we look at the probability distribution of the daily maximum temperature and the minimum daily temperature, and we found that the probability of daily maximum temperature peaked at -4°C when the disaster occurred, and the probability gradually decreased with increasing temperature, the probability distribution of daily minimum temperature between -5°C and 0°C was most concentrated, and the probability of greater than 0°C was very low, only 1.2%. Through comparative analysis, we can know that the probability distributions of daily average temperature and daily maximum temperature are very similar, while the probability distribution of minimum temperature has a certain difference. Because of the large uncertainty of the average temperature, we only need to
consider the distribution of the maximum daily temperature and the minimum daily temperature when analysing the disaster. The daily minimum temperature can reflect whether the freezing point is reached to a certain extent, and the daily maximum temperature is related to the melting point of rain and snow freezing.

Next, we consider the distribution of relative humidity and wind speed. We divide the relative humidity and wind speed into 51 levels and 24 levels, respectively, and use formula (6) to calculate the probability distribution in each level range, and obtain Figure 1 (d) (e). It can be seen that the relative humidity of rainy and foggy days is generally large, and the probability of ambiguity of ≥80% reaches 83.7%, and the weather is mostly cloudy, and the probability of sunshine duration ≤1h reaches 53.6%, more than half. Here we indicate the threshold conditions of several meteorological elements for low temperature rain and snow in the southern region: 1) Daily maximum temperature ≤6℃; 2) Daily minimum temperature ≤0℃; 3) Relative humidity ≥80%; 4) Wind speed ≤9 m · s⁻¹; 5) Sunshine hours ≤ 1h. Among them, when the highest daily temperature in southern China is around 6℃, the daily average temperature is close to 2℃.

2.5. Optimization of threshold conditions for strong wind-storm / blizzard-freezing weather

Next, analyse the number of days that meet the appeal conditions during the strong wind-storm / blizzard-freezing period (November to March) and find the average number of days and the linear trend, as shown in Figure 2.

Figure 2. Distribution of the average number of days when the meteorological elements in southern China meet the conditions of low-temperature rain and snow (November to March). Contours are multi-year averages; shades are 10a linear trend coefficients; polylines are time series of regional averages; straight lines are linear trend lines.

Because the wind speed ≤ 9 m · s⁻¹ is almost satisfied in all parts of the south, we round it off in the new threshold condition. In this way, new threshold conditions can be indicated: 1) Daily maximum temperature ≤ 6℃; 2) Daily minimum temperature ≤ 0℃; 3) Relative humidity ≥ 80%; 4) Sunshine hours ≤ 1h.

2.6. Establishment of comprehensive evaluation index of strong wind-storm / blizzard-freezing weather

Strong wind-storm / blizzard-freezing events lasting 1 to 3 days were classified as light, 4 to 7 days as intermediate, 8 to 11 days as heavy, and events over 12 days and above were classified as super heavy.
Based on the above meteorological conditions, the threshold of the comprehensive evaluation index of strong wind-storm / blizzard-freezing was further adjusted. The analysis was conducted at the Weining station in the southwestern region and the Poyang station in the southeast region (there are more strong wind-storm / blizzard-freezing events at both stations). The actual annual occurrence frequency of strong wind-storm / blizzard-freezing at all levels was compared with the evaluation frequency calculated by the formula, a comprehensive strong wind-storm / blizzard-freezing comprehensive evaluation index $I_{LFS}$ was established, and its calculation formula is as follows:

$$I_{LFS} = I_n(T_{max}(\leq 6), T_{min}(\leq 0), H_{ave}(\geq 80), S_{hr}(\leq 3))$$ (7)

In the formula: $T_{max}$ is the highest daily temperature; $T_{min}$ is the lowest daily temperature; $H_{ave}$ is the average relative humidity of the day; $S_{hr}$ is the number of hours of sunshine; $I_n$ is the number of consecutive days of strong wind-storm / blizzard-freezing events of this level. [5]

Then use this formula to predict the number of strong wind-storm / blizzard-freezing events at each level of Weining Station and Poyang Station every year, and then compared with the actual times, as shown in Figure 3(a) and 3(b).

![Figure 3](image)

Figure 3. Number of occurrences of low temperature rain and snow freezing (line1) and evaluation (line2) at each year in Weining Station (left) and Boyang station (right) from 1962 to 2010.

As shown in Figure 3(a), it can be concluded that in the past 51 years, strong wind-storm / blizzard-freezing light events occurred in weining station every year are usually 10 to 20 times. However, according to formula (7), evaluation events of weining station are mainly 5 to 15 times, with an average annual frequency 4.1 times less than the actual frequency and an absolute error of 30.2%. The estimated number of intermediate-level strong wind-storm / blizzard-freezing events (average of 1.84) was slightly less than the actual statistical times (average of 1.90), with an average absolute error of 2.9%. As can be seen from Figure 3 (b), the actual number of severe strong wind-storm / blizzard-freezing events in Weining Station totaled 11 years, of which 9 years were evaluated, and only 2 years (1972 and 1986) were omitted. The super heavy category is slightly more than the actual number of evaluations, and can better grasp the year in which the heavy incident occurred. For Boyang Station (Figure 3(c)), the young-level strong wind-storm / blizzard-freezing events (0-7 times) are generally higher than the actual value (0-3 times), although the error is higher than 200%, but the light time years were not missed, and the intermediate event predictions were higher than 0 three times; the severe strong wind-storm / blizzard-freezing event happened once in Boyang Station and was accurately predicted. The super heavy level did not occur, and it was also completely consistent with the evaluation results. In summary, we can say that the formula can predict the number of major low-temperature rain, snow and freezing events well, and it is more practical and reasonable for the actual judgment of meteorological disasters. [8]
3. Impact and prevention of strong wind-storm / blizzard-freezing disasters in various fields

The determination conditions of the strong wind-storm / blizzard-freezing disaster have been explained above. But because of the impact of the disaster chain, the damage caused to the society by the disaster is not caused solely by the incident itself. Therefore, it is necessary to prevent and mitigate a series of damages caused by extreme weather to the national society from various aspects. We select several main aspects for analysis.

3.1. Disaster chain

Disaster chain refers to the phenomenon of a series of subsequent disasters caused by the occurrence of a disaster. Our study use the 2008 Southern Snow Disaster as an example to explain a series of effects caused by extreme disasters. Based on field investigations of low-temperature rain, snow, and freezing disasters in the south, it is found that five types of secondary disasters may be caused by snow disasters in the south, namely: mountain forest fires, polluted landslides caused by drinking water sources, mudslides, collapses and other geological disasters, agricultural and forestry diseases and insect pests, and building structure safety problems. The snow disaster in southern China was characterized by low-temperature rain and snow as the main chain, which was composed of a series of cascading disaster chains and a concurrent disaster chain. The disaster chains were interrelated and very complicated.

![Figure 4. The 2008 strong wind-storm / blizzard-freezing disaster chain in southern China.](image)

The classification of disaster carrier based on the theory of disaster chains can effectively connect closely with secondary disasters. By sorting the disaster carriers at the nodes of the disaster chain and focusing on the monitoring and management of the top-ranked disaster carriers, the occurrence of secondary disasters can be controlled in terms of disaster prevention and reduction. According to the survey, the 2008 snow disaster in the south of China caused huge impacts on transportation, electricity, communications, people's lives, agriculture, and forestry.

3.2. Traffic

Strong wind-storm / blizzard-freezing disasters have an important impact on traffic, especially road traffic. Low temperatures will cause roads to freeze over a large area, leading to a series of problems such as road cracking, which will affect roads, railways, aviation, and other transportation modes, resulting in stranded people. Therefore, measures to control traffic sections need to be strengthened, including monitoring of frozen sections, and storage of various ice-breaking materials such as industrial salt, shovel, hard brooms, snow melting agents, gravel, straw, etc. to prevent roads from freezing and slipping. It also innovates snow removal methods, uses machinery reasonably to improve snow removal efficiency, and manpower is used as a supplement.
3.3. Electricity
The impact of low-temperature disasters on electricity can be divided into two parts. First, due to the effects of long-term rainfall and snowfall and freezing, some of the power transmission equipment was extremely damaged, which seriously affected the normal life and survival of people and the normal social turnover. The second is that for areas with normal power transmission, due to the effects of low temperatures, people's demand for electricity has greatly increased, and electricity has entered a shortage. Therefore, for power outages, on the one hand, we must do a good job in the rescue and comfort of personnel after power outages, and emergency power generation measures to ensure the most basic social turnover. On the other hand, it is necessary to make a good reserve of coal for electricity to ensure sufficient power supply in any event of an emergency.

3.4. Agriculture
Strong wind-storm / blizzard-freezing disasters have sustained large-scale low temperature and snowfall weather, which will cause severe freezing and cold disasters, such as meteorological and agricultural disasters, and cause significant losses to planted vegetables, facility agriculture and various fruit forests. According to the data, the direct agricultural economic losses caused by the snow disaster in southern China in 2008 exceeded 30 billion yuan, and due to the inconvenience of frozen road closures, the transportation of a large number of agricultural and sideline products was also blocked, which also caused certain losses. Therefore, it is necessary to provide certain economic subsidies to the affected farmers, and to innovate technologies to minimize the impact of disasters on farmers.

3.5. People's health
Strong wind-storm / blizzard-freezing weather caused a large number of people on roads, railway stations, and airports to stay, and the mental stress caused by the disaster to the stranded people, which easily induced collective respiratory and intestinal infectious diseases. At the same time, it is also prone to public health events such as food poisoning, frostbite, and carbon monoxide poisoning. Low temperature can also cause a surge in fractures and cardiovascular and cerebrovascular patients. The elderly, children, and other vulnerable groups have poor immunity in severe cold environments, and the probability of illness is greatly increased. At the same time, due to the dramatic increase in the number of patients and poor traffic, the hospital's drug reserves have also been severely tested. Therefore, emergency medical rescue and basic medical services in disaster-stricken areas, especially in remote mountainous areas, require emergency plans and work plans to be prepared before the disaster, material reserves, and precautions to ensure that they can act in accordance with the plan during the disaster and effectively deal with the surge of patients.

4. Summary and outlook
The large-scale strong wind-storm / blizzard-freezing weather climatic events that occurred in the southern China in 2008 appear to be the worst meteorological disaster since China's founding in terms of disasters and impacts. However, if only the extreme minimum temperature or the number of continuous rain and snow days are used as the location analysis, it will be concluded that the meteorological disaster is not serious. It can be seen that the composite similarity of strong wind-storm / blizzard-freeze coupling cannot be achieved by simply superimposing the single disaster similarity criterion. Based on the study of different disasters and their coupling action principles, this paper analyzes the manifestations of key physical quantities, extracts key characteristic parameters of physical quantities, proposes key characteristic parameter description methods, and constructs a composite similarity criterion system to provide valuable experience for the prevention of various composite disasters.

However, there are still many problems in the study of natural disasters in China. China has a vast area and a large number of disasters. There is no systematic set of natural disaster response technologies, and disaster laws, disaster education, regional disaster countermeasures, and disaster relief have not all
been achieved. There is still plenty of room for development to respond adequately to all disasters. All these are worthy of future research and development.

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