Academic Journal of Management and Social Sciences
ISSN: 2958-4396 | Vol. 4, No. 1, 2023

Damage Evaluation and Coping Strategies of Extreme Climate Disasters under the Triple La Niña Events

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Abstract: It is of great practical significance to conduct statistical analyses of the major countries and regions where the La Niña phenomenon occurs globally, to predict the duration and likelihood of the phenomenon occurring in the future, to assess the disasters caused by the La Niña phenomenon, and to take effective measures in the future. In this paper, the main countries and regions where La Niña phenomenon occurs globally are studied by constructing a mathematical analysis model, analyzing the Drought Disaster, Flood Disaster, Air Temperature, Precipitation, Niño 3.4 of the phenomenon in these countries, and summarizing their changing rules through calculation and analysis. Provides relevant policies for the prevention and control of La Niña phenomenon.

Keywords: Triple La Niña Event; Scientific Prevention and Treatment; La Niña Phenomenon.

1. Introduction

La Niña has been one of the "troublemakers" of global climate problems in the past three decades, affecting the climate in many regions of the world. For example, floods in northern China, Indonesia, and eastern Australia; abnormal droughts in southern China, western Europe, and the southern United States; and active typhoons in the South China Sea-Western Pacific. The extreme and abnormal weather and climate have brought economic losses and human casualties of certain scale to many countries or regions around the world that are affected by La Niña events. In terms of statistical probability, La Niña events have a strong correspondence with the yields of different regions and different crops in the world. During the impact of La Niña events, the risk index of yield reduction is high for Canadian wheat, U.S. corn and Argentine soybeans, and there is also a risk of yield reduction for corn, wheat and rice in China. Therefore, statistical analysis of the major countries and regions involved in global La Niña events, prediction of the duration and likelihood of future La Niña events, and assessment of the disasters caused by them are of great practical importance for taking effective measures in the future.

The three La Niña phenomena have different impacts on the climate, and the economic loss of climate disasters is the core of conducting statistics and assessment. Through reviewing domestic and foreign literature[1-3], it was found that flood disaster loss assessment was carried out earlier in foreign countries, and the basic information such as loss rate information and socio-economic information of various types of property required for loss assessment was more complete; domestic departments mastered the data, and it was more difficult to obtain comprehensive information[4], and it could not satisfy the requirements of coping with the diversification of disaster information[5]. In the process of disaster loss-related research gradually changing from qualitative description to quantitative analysis, the content and depth of the research are also developing[6], but the following issues are still in urgent need of research: at present, most of the domestic and foreign disaster loss assessment is the calculation of direct economic loss[7-8], and there are fewer studies on indirect economic loss and non-economic loss, and the indirect factor, which has more influencing factors, accounts for an increasing proportion of the loss assessment[9]. Quantitative research on indirect economic losses and non-economic losses is the direction of future development of this research problem [10].

2. The Basic Fundamental of Analysis Models

Our team statistically analyzed datasets from northern China, southern China and southern Europe. Maximum, minimum, mean, standard deviation, median, variance, kurtosis, bias and coefficient of variation were calculated for each regional dataset. Our team compared the monthly mean temperature and monthly mean precipitation of the three regions for the period 2020-2022 both vertically and horizontally, thus comparing and analyzing the changes in climate anomalies for the three La Niña events. To facilitate the calculations, an important meteorological station in one of the three regions was selected and the data observed at that station were analyzed. The regions where these weather stations are located are the ones most affected by the Three La Niña Events.

Maximum Value: Maximum value in the sample data.

Minimum Value: Minimum value in the sample data.

Mean Value: Meterage of sample data. The calculation formula is as follows:

$$\text{Mean Value} = \frac{1}{n}\sum_{i=1}^{n} x_i (i=1,2, \ ...n) \tag{1}$$

Standard Deviation: The arithmetic square root of the arithmetic mean. The calculation formula is as follows:

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(x_i-\mu)^2}{n}} \tag{2}$$

Median Value: Intermediate values of the sample data.

Variance's measure of dispersion in a random variable or a set of data. The calculation formula is as follows:

$$\sigma = \frac{\sum_{i=1}^{n}(x_i-\mu)^2}{n} \tag{3}$$

Kurtosis: Characterize the number of features at the peak of the probability density distribution curve at the mean. The calculation formula is as follows:

$$g_2 = \frac{m_4}{m_2^2} - 3 = \frac{\frac{1}{n}\sum_{i=1}^{n}(x_i-\bar{x})^4}{\left(\frac{1}{n}\sum_{i=1}^{n}(x_i-\bar{x})^2\right)^2} - 3 \tag{4}$$

Where m_4 is the fourth-order sample center moment, m_2 is the second order central moment, $\bar{x}$ is the sample average. Note that the divisor is N when the variance is calculated, not the sample variance separately (N-1).

Deviation: A measure of the direction and degree of the statistical distribution. The calculation formula is as follows:

Coefficient of Variation: Ratio of standard deviation of raw data to mean of raw data. The calculation formula is as follows:

$$S_k = \frac{\mu_3}{\mu_2^{\frac{3}{2}}} = \frac{\mu_3}{\sigma^3} \tag{5}$$

$$c_v = \frac{\sigma}{\mu} \tag{6}$$

3. Results

3.1. Data Sources

Our team collected several datasets from 1970 to 2022: daily air temperature and precipitation in northern China; daily air temperature and precipitation in southern China; daily air temperature and precipitation in southern Europe; and surface water temperature in the Pacific Ocean. However, there are missing values in the datasets, and all missing values were interpolated using the average of the previous two values to ensure data continuity.

The data sources used in this paper are shown in Table 1.

Table 1. Data source collection

Database Names	Database Websites	Data Type
Drought Disaster	https://www.mem.gov.cn/	Losses
Flood Disaster	http://www.mwr.gov.cn/	Losses
Air Temperature	https://www.ncei.noaa.gov/maps/daily/	Weather
Precipitation	https://www.ncei.noaa.gov/maps/daily/	Weather
Niño 3.4	https://www.ncei.noaa.gov/access/monitoring/enso/sst	Weather

3.2. Analysis of Experimental Results

As Triple La Niña Event began to affect our country after June 2022, so we selected the data from July 2022 to September 2022 of Hohhot weather station in Northern China for analysis. The results calculated by SPSS are shown in the table 2 and 3.

From the solution results, we can see that from July to September 2022, the highest temperature in Inner Mongolia, northern China, reached 27.5°C, and the lowest temperature reached 7.8, while the maximum daily precipitation reached 37.1 mm. It can be seen that Triple La Niña Event increased the precipitation in Inner Mongolia, leading to an increased blizzard. Since the coefficient of variation of precipitation is bigger than 0.15, we conclude that the daily precipitation of the three months was in abnormality, and abnormal precipitation occurred in Inner Mongolia at this time.

Table 2. Statistical Results 1

Variable	Sample Size	Maximum Value	Minimum Value	Mean Value	Standard Deviation	Median Value
Precipitation	91	37.1	0	1.826	5.422	0
Temperature	91	27.5	7.8	20.225	4.588	20.1

Table 3. Statistical Results 2

Variable	Vriance	Kurtosis	Deviation	Coefficient of Variation (CV)
Precipitation	29.394	23.104	4.46	2.9685163630755125
Temperature	21.054	-0.159	-0.514	0.22686732376899738

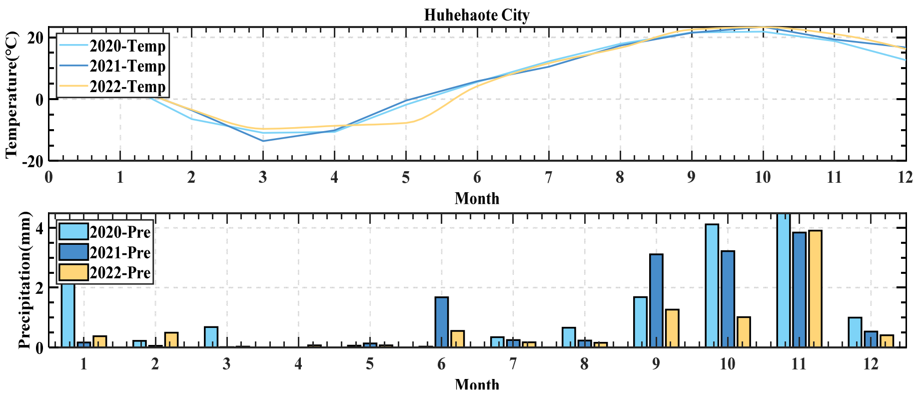

Figure 1. The monthly average precipitation and temperature change map

The figure 1 is a longitudinal comparison chart of the average monthly temperature and average monthly precipitation in Inner Mongolia from 2020 to 2022. We found that in 2022, under the influence of Triple La Niña Event, Inner Mongolia precipitation surged in November, significantly greater than in October precipitation. Moreover, the precipitation in September and October was significantly lower than that in 2020 and 2021, indicating that the abnormal precipitation phenomenon occurred in 2022 due to Triple La Niña Event.

Southern China

We selected the data from July 2022 to September 2022 of Hangzhou weather station in Southern China for analysis. The results calculated by SPSS are shown in the table 4 and 5.

From the solution results, we can see that the average daily temperature of Zhejiang Province from July to September is still maintained at about 30℃, and the variation coefficient of precipitation is greater than 0.15, indicating that the precipitation in these three months has an abnormal value. The average precipitation in the three months is only about 4㎜, so drought occurs in the region.

Table 4. Statistical Results 3

Variable	Sample Size	Maximum Value	Minimum Value	Mean Value	Standard Deviation	Median Value
Precipitation	91	57.4	0	4.126	10.498	0
Temperature	91	35.7	21.7	29.679	4.156	30.5

Table 5. Statistical Results 4

Variable	Vriance	Kurtosis	Deviation	Coefficient of Variation (CV)
Precipitation	110.204	13.249	3.458	2.544080994495613
Temperature	17.275	-1.226	-0.278	0.1400428159130846

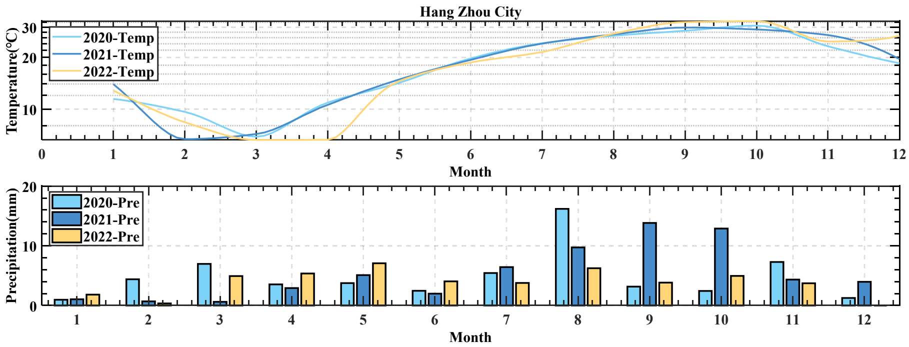

Figure 2. The monthly average precipitation and temperature change map

The figure 2 is a longitudinal comparison chart of the average monthly temperature and average monthly precipitation in Zhejiang Province from 2020 to 2022. We found that the air temperatures in August and September 2022 were significantly higher than those in 2020 and 2021, and that the high temperatures persisted above 35℃. Precipitation from August to September 2022 was also significantly lower than that in 2021, with only around 4㎜. Therefore, we inferred that drought occurred by Triple La Niña Event.

Table 6. Statistical Results 5

Variable	Sample Size	Maximum Value	Minimum Value	Mean Value	Standard Deviation	Median Value
Precipitation	91	20.8	0	1.203	3.046	0
Temperature	91	27.7	10.9	19.097	3.936	19.7

Table 7. Statistical Results 6

Variable	Vriance	Kurtosis	Deviation	Coefficient of Variation (CV)
Precipitation	9.281	21.706	4.259	2.531740581330964
Temperature	15.49	-0.28	-0.359	0.2060970744766864

We selected the data from July 2022 to September 2022 of France weather station in Europe for analysis. The results calculated by SPSS are shown in the table 6 and 7.

From the solution results, we can see that the average daily precipitation in southern Europe from July to September 2022 is only about 1 ㎜, and the average daily temperature remained at about 20℃, and the highest temperature even reached 27℃. Since the coefficient of variation of precipitation and air temperature is bigger than 0.15, we can infer the occurrence of abnormal air temperature and abnormal precipitation in these three months.

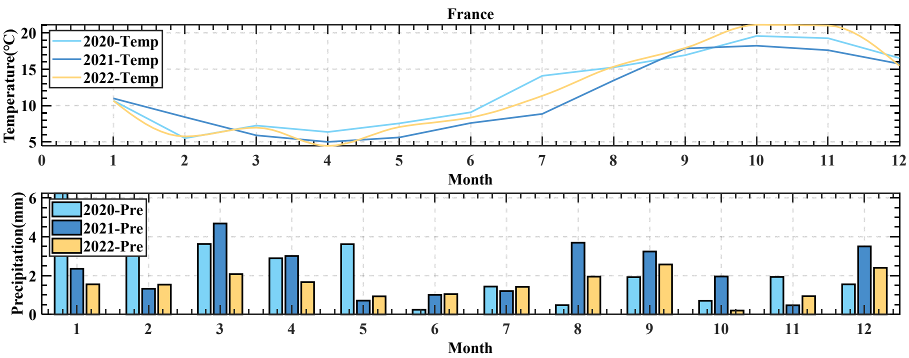

Figure 3. The monthly average precipitation and temperature change map

The figure 3 is a longitudinal comparison chart of the average monthly temperature and average monthly precipitation in Southern Europe from 2020 to 2022. We found that French temperature persisted above 20℃ from August to October 2022, and had significantly less precipitation in the same period than in 2021. Hence, we infer that the drought occurred affecting parts of France at this time.

4. Conclusion

This paper is of great practical significance in statistically analyzing the major countries and regions where the global La Niña phenomenon occurs, predicting the duration and likelihood of the La Niña phenomenon in the future, evaluating the disasters caused by the La Niña phenomenon, and taking effective measures in the future. In this paper, by constructing a mathematical analysis model, effective temperature data analysis is carried out in the main areas of the world where the disaster occurs, and then determine whether the disaster will occur in this part of the region. Such a method can provide an effective method for disaster prevention and control in the later practical application.

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