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La Niña and climate degree of contact

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Abstract. Studies have shown that the 2022 anomalous climate change is different from previous La Niña phenomena. Using the data of the maximum temperature, minimum temperature and temperature difference from 2020 to March 2021 in Hong Kong, the grey model was used to compare the maximum and minimum temperature values in 2022 with the actual values and found that the values were close. The La Niña phenomenon occurred in March 2022, concluding that La Niña is not a major contributor to climate change in Hong Kong. Climate change in Hong Kong is also linked to typhoons, increased carbon dioxide levels in the air, ocean temperatures and other factors. The study concluded that the main cause of the extreme weather in Hong Kong in 2022 was not the occurrence of La Niña, but a combination of factors such as cumulative carbon dioxide emissions, human activities, the altitude of the Tibetan Plateau, and typhoons.

Keywords: Climate change, Gray prediction model, Maximum precipitation, Warming temperatures, La Niña

1. Introduction

In the year La Niña 2022, temperatures rose and precipitation increased abnormally. Some studies have shown that La Niña is not the main cause of the unusual cause of climate change. So, the purpose of this study is to detect whether La Niña is the dominant factor in the extreme weather of the year and what causes the extreme weather to occur. Using gray models to predict the temperature of La Niña in 2022 compared with the actual temperature. The precipitation in each season of Hong Kong is mainly low in the year affected by La Niña events [1]. The water vapour distribution in Hong Kong is related to successive typhoons, and typhoons occur frequently in summer due to Hong Kong's proximity to the ocean. The atmospheric water vapour content was higher than the pre-typhoon level during the interval between successive typhoons [2]. So, the purpose of this study is to dispel the stereotype that La Niña will have a large impact on the climate as long as it is produced, which is wrong. Experimental results have shown that La Niña does have a certain impact on extreme climate change, but there are other factors that combine to cause abnormal climate changes.

2. Changes in Hong Kong's Climate and Unusual Changes in La Niña Years

2.1. Change in Hong Kong's Climate

The data used in this experiment came from the Hong Kong Observatory. Hong Kong is located in the subtropics. Some of the data refer to Guangdong, which has a similar climate to Hong Kong. The information below is between 1991 and 2020 year. The Hong Kong climate was extremely mild for

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almost half a year. November and December have the best weather with moderate temperatures. In January and February, there are more clouds, and occasionally there are cold passings, bringing dry north winds; Temperatures in urban areas can sometimes drop below 10 degrees Celsius. March and April are warmer, but occasionally extremely humid. The weather is hot and humid from May to August. July usually has a period of sunny weather. From May to November, Hong Kong may be hit by tropical cyclones of varying intensity. July to September is the month's most likely to be affected by tropical cyclones. In the western North Pacific, East China Sea and South China Sea, an average of 30 tropical cyclones from each year, about half of which reach typhoon strength. When tropical cyclones gather about 700 to 1,000 kilometers southeast of Hong Kong, the weather in Hong Kong is usually sunny and hot, but there may be localised regional thunderstorms at dusk. If the center of the tropical cyclone moves closer to Hong Kong, winds will strengthen and heavy rains may occur in a wide area. Heavy rains from tropical cyclones can last for several days. About 80% of the rainfall was recorded between May and September. June and August are usually the wettest months, while January and December have the least rainfall.

2.2. Unusual Changes in La Niña Years

With record-breaking hot July and the warmest autumn months from September to November, the weather in 2022 was 0.4 degrees above the normal value of 1991-2020. The number of hot nights and hot days in 2022 is 52 days. In 2022, there were 15 days when the maximum temperature was 35.0 degrees or above. These figures are quite high since records began in 1884. The average precipitation in February 2022 was 2.7 times higher than the same period in history, the highest since 1986.

3. A Minor Contributor to Climate Change in 2022

3.1. Gray Prediction Model Establishment

Gray Forecast Model is a prediction method that establishes mathematical models and makes predictions through a small amount of incomplete information, and is an effective tool for dealing with small samples (4 can do) prediction problems.

It is generally divided into 4 steps:

(1) Data inspection. Modelling with GM (1,1) requires testing the data, first calculating the cascade ratio of the series

$$a(k) = \frac{x^0(k-1)}{x^0(k)} \tag{1}$$

where k=2, 3, ..., n.

If all the gradations fall in the tolerable coverage interval

$$x = \left(e^{\frac{-2}{n+1}}, e^{\frac{2}{n+1}}\right) \tag{2}$$

Then the series x (0) can establish a GM (1,1) model for gray prediction. Otherwise, you need to do appropriate transformation processing on the data, such as translation.

(2) Build a gray model. Through the process of defining gray derivatives, generating series, defining gray differential equation models, etc., it is listed according to the method of matrix:

$$b = \begin{bmatrix} a \\ b \end{bmatrix} \tag{3}$$

$$Y = \begin{bmatrix} x^0(2) \\ x^0(3) \\ \cdots \\ x^0(n) \end{bmatrix} \tag{4}$$

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$$B = \begin{bmatrix} -z^1(2) & 1 \\ -z^1(3) & 1 \\ \cdots & \cdots \\ -z^1(n) & 1 \end{bmatrix} \tag{5}$$

(3) Forecasting. The whitening model is obtained, and then solved to obtain the predicted value

$$x^1(k+1) = \left(x^0(1) - \frac{b}{a}\right)e^{-a} \tag{6}$$

where k=1, 2, 3, ..., n-1.

(4) Inspection. In order to predict the maximum and minimum temperatures in March, which will be affected by La Niña in 2022, a gray model is constructed here. First, get the 2020 and 2021 maximum and minimum temperatures, including the temperature difference, as shown in the chart. If all the step ratios are in the interval (e^(-2/(n+1)), e^(2/n+1)), the data are suitable for model construction. If the cascade test is not passed, the sequence is "translated transformed" so that the sequence after the translation transformation satisfies the cascade ratio test. From the chart analysis, it can be seen that all the step ratios of the translated series are located in the interval (0.8, 0.93), indicating that the series after the translation transformation is suitable for constructing a gray prediction model, as shown in Table 1:

Table 1. La Niña gray prediction.

Year	Highest temperature	radio	Lowest temperature	difference	radio
2020	28	0.93	16	12	0.8
2021	30		15	15	
2022 (Predicted value)	32.2		13.5	18.75	
2022 (Real value)	30		13	17	

Moreover, the posterior difference ratio is calculated to be 0.13, indicating that the model accuracy is high [3]. The predicted and actual values are close, indicating that La Niña is not a major factor in changing temperature.

3.2. By Comparison with Previous La Niña Phenomena

Since the 90s of the 20th century, the impact of ENSO cold and warm events on precipitation in February in Guangdong in the following year has basically been inverse. In the following year of El Niño, the sky over the Philippines was an anticyclonic circulation, and the southwesterly wind on its northwest side carried water vapour over Guangdong from the South China Sea and the Bay of Bengal, causing more precipitation in most of Guangdong. The following year, La Niña was the opposite, with cyclonic circulation anomalies over the Philippines, with northwesterly winds carrying dry cold air from the north over Guangdong, causing most of the province to receive less precipitation. The abnormally high precipitation in Guangdong in February 2022 is different from the impact of typical La Niña in the following year, indicating that La Niña background is not the cause of this precipitation anomaly. Guangdong drought is basically La Niña type, and the probability of positive abnormal drought in the equatorial Pacific Ocean has increased significantly after 1975, especially in Guangdong drought in recent years. Some studies have also pointed out that the drought disaster in Guangdong Province is not closely related to La Niña events, nor is it related to the intensity of La Niña events, and the impact on drought has a strong regional impact. According to the data analysis from 1951 to 2003, it is pointed out that the precipitation in each season of eastern Guangdong is mainly low in the year affected by La Niña events [1]. The cross-wavelet transform analysis of ENSO eigenvalues Nino3.4, SOI and temperature and precipitation data in Hong Kong, China showed that there was no significant correlation in the whole time period, the temperature data of Hong Kong, China had a certain local correlation with Nino3.4 and SOI, and the precipitation data of Hong Kong, China had a weak correlation with Nino3.4 and SOI. The results obtained from the crossed wavelet angle show that the two-eigenvalue series of ENSO are not

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significantly correlated globally in Hong Kong, China, and there is a certain local correlation. Since ENSO's climate impact is a complex system, it only shows that ENSO's direct impact on the climate in Hong Kong, China is not significant [4].

4. Other Factors Contributing to Climate Anomalies in 2022

4.1. Qinghai-Tibet Plateau Altitude Field

The February precipitation anomaly in Guangdong Province is closely related to the altitude field of the Qinghai-Tibet Plateau. Under the background of La Niña events, if the altitude field of the Qinghai-Tibet Plateau is abnormally low, Guangdong Province has more precipitation in February. If the altitude field of the Qinghai-Tibet Plateau is slightly low, there is a high possibility that Guangdong Province will have less precipitation in February. When the altitude field of the Qinghai-Tibet Plateau is abnormally low, it is conducive to the active Indo-Burma trough on the southern side, transporting abundant water vapor from the ocean to the sky over Guangdong, so that Guangdong Province has more precipitation in February. In February 2022, the altitude field index of the Qinghai-Tibet Plateau was abnormally low, the fourth lowest since the 90s, and the abnormally low altitude field of the plateau was the main reason for the abnormally high precipitation in Guangdong this month [5].

4.2. Typhoon

In addition to the influence of low-latitude tropical Pacific SST anomalies, drought is also related to atmospheric circulation at middle and high latitudes, snow cover in Eurasia, Arctic oceans, and precipitation brought about by typhoon landfall [6]. The influence of continuous typhoons on the distribution of water vapour in Hong Kong has an overall correlation in terms of magnitude, and the water vapour content rises with the arrival of the typhoon and decreases as it subsides, but during the interval of the continuous typhoon, the atmospheric water vapour content is still higher than the level before the typhoon [7]. The typhoon path will affect the change rate and distribution of local atmospheric water vapour content, and the scope, time and degree of influence on water vapor level distribution are related to the grade. Water vapor accumulation is a prerequisite for heavy rainfall. When the accumulated amount of water vapor is similar, the actual accumulated rainfall is positively correlated with the accumulated duration of water vapor [8].

4.3. Carbon Dioxide Concentration

Based on the spatial distribution of heterogeneous carbon dioxide concentration, the spatial simultaneous equation system model was used to estimate the relationship between carbon dioxide emission and warming, and the positive influence mechanism of carbon emissions on warming was discovered [9].

4.4. Coastline, Latitude and People

In cold and wet years and cold dry years, the altitude field in East Asia is "high in the north and low in the south", and the Siberian high pressure is strong, which is conducive to the active southward movement of cold air. In warm and dry years, there is a circulation distribution of north, low and high south in middle and high latitudes, the East Asian trough and Siberian high pressure are weak, which is not conducive to the formation of cold air and southward, and the sky over Guangdong is controlled by positive altitude and flat distance, and the temperature is high. At the same time, the SST in the eastern equatorial Pacific Ocean showed a neutral cold state in warm and dry years, and the sky over Guangdong was controlled by anticyclonic circulation, with radial sinking, high temperature and little rain [10]. The trend of extreme temperature extremum index is more correlated with latitude and population size, which is the most affected by socio-economic factors (population, GDP, three major industries, number of automobiles and crude oil production) [2]. It is found that the average temperature of Hong Kong has shown an increasing trend in inter-annual changes and different seasonal changes in the past 100 years, mainly due to the rapid economic development of Hong Kong under the background of global warming,

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a large number of high-rise buildings and impervious layers have led to a significant urban heat island effect, and the artificial greenhouse temperature emissions are large. With the deepening of urbanization, the size of the area where meteorological stations can reflect the climate characteristics in observation is significantly affected by human activities (including greenhouse gas emissions and underlying surface changes). It should also be noted that climate change is more affected by local natural and anthropogenic environments. Due to population density and natural environment, the average temperature changes in Hong Kong have significant local characteristics, and the time nodes and average temperature oscillation cycles of climate abrupt changes are also affected by the above factors, resulting in differences in the average temperature trend increase rate, abrupt time nodes and oscillation cycles [11].

5. Conclusion

By comparing the temperature prediction and actual values of the gray prediction model, La Niña is not the main cause of abnormal climate change. Gray predictive models can predict more accurate outcomes with limited data. In addition to La Niña, the factors affecting climate change in Hong Kong include typhoons, carbon dioxide concentrations, altitude fields on the Qinghai-Tibet Plateau and other factors.

It cannot be said that La Niña has no effect on precipitation anomalies in February 2022 because of the abnormally high precipitation in February 2022, which is different from the impact of typical La Niña in the following year, but the altitude field of the Qinghai-Tibet Plateau is abnormally low during the same period, and it is certain that La Niña has no effect on precipitation anomalies, and more data and examples are needed to support this view. Water vapor accumulation is a prerequisite for heavy rainfall.

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