Prediction and Coping Strategies of Triple La Nina Event based on Time Series

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Abstract: According to the latest data from the World Meteorological Organization, the effects of the triple La Nina could last until the end of 2022 or beyond. Double La Nina events are common in the Northern Hemisphere, but triple La Nina events are rare. By studying the climate data and human data in recent years, this paper separated the climate data of Southeast Asia, Southwest America, China and South America, including PRCP (precipitation), TEMP (average temperature) and other indicators. Data of 34,847 cases in four regions were downloaded from National Centers for Environmental Information. ARIMA time series model was established to predict future indicator data, and abnormal values were found in indicator data. Therefore, triple La Nina events are more likely to occur in the future.

Keywords: Triple La Nina Event; ARIMA Time Series Model; Climate Data; Coping Strategy

1 Introduction

According to the latest data from the United Nations World Meteorological Organization (WMO), the La Nina event that began in 2020 is likely to continue until the end of 2022 and beyond. The intensity, duration and impact of the triple La Nina events expected to occur in future winters are highly uncertain.

Du Yongzheng et al. said that China is affected by the triple La Nina phenomenon, which led to large-scale precipitation in many places in the north and high temperature and hot summer weather in many places in the south, and predicted that the probability of La Nina phenomenon in 2022 was 70%.[1]Qiu Hui believed that extreme weather will occur in many places during La Nina events.[2]According to Wu Peng et al., from the perspective of statistical probability, there is a strong corresponding relationship between La Nina events and the yields of different crops in different regions of the world.[3] Yuan Yuan et al. found that the influence of La Nina event on winter temperature in southwest China had obvious interdecadal variation.[4]Chen Ying et al. believed that the reason for the atypical influence of "La Nina" on the temperature in Xinjiang in the winter of 2021/2022 was mainly from the atypical influence of eastern type weak La Nina events on the North Atlantic Oscillation and the area of the Asian polar vortex.[5]Gejun believed that due to the high temperature and little rain since the summer, most of the South had a serious drought, and there will be no obvious solution in a short time, and the National Climate Center was expected to be likely to have summer, autumn and winter drought. The drought continued to a certain extent, and the "triple" la Nina are

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connected.[6]Cui Guohui believed that from the perspective of global impact, when most La Nina events occur, the precipitation near the coast of South America decreased, while the precipitation in Indonesia and eastern Australia increased.[7]Kong Zhaoyang et al. applied correlations and possible physical processes to detect the occurring 2020-2021 moderate intensity La Nina event signal on the interannual component of the change in day length.[8]Wang Chunxiao believed that in winter, when most La Nina events reached their peak, the cold air activities affecting China were more frequent than usual, and the intensity was stronger.[9]Chen Mingcheng et al. believed that typical La Nina events usually decline slowly after reaching the strongest value in the winter of the developing year, and then intensify again to form the second La Nina event in the autumn of the following year.[10]

In summary, the possibility of triple La Nina events in the future is highly uncertain in the context of global warming. In this case, it is necessary to use the current data to study the possibility of its future occurrence and put forward corresponding measures.

2 Data Collection and Model Establishment

2.1 Data Collection

Climate data of four regions in China, Southeast Asia, Southwest America and South America, including MAX (maximum temperature), PRCP (precipitation) and TEMP (average temperature), were screened out, and these indicators were summarized to determine the possibility of triple La Nina events in the future through whether the predicted index data are abnormal. A total of 34,847 index data such as MAX (maximum temperature), PRCP (precipitation) and TEMP (average temperature) of each region were downloaded from National Centers for Environmental Information. Average values were computed one by one for the dates from June 1, 2022 to November 1, 2022, creating virtual sites and integrating the data.

2.2 Model Establishment

ARIMA model is widely used in the analysis and modeling of various time series data. The unit root test is carried out on the time series. If the time series is non-stationary, it needs to be transformed into a stationary series by difference,[11] and it needs to be transformed into a stationary series after several differences. d is the number of differences made when the time series is stationary.

First-order difference:

$$\nabla X_t = X_t - X_{t-1} = (1-B)X_t \quad (1)$$

2nd order difference:

$$\nabla^2 X_t = X_t - 2X_{t-1} + X_{t-2} = (1-B)^2 X_t \quad (2)$$

D-order difference:

$$\nabla^d X_t = (1-B)^d X_t \quad (3)$$

Where ∇^d is called the D-order difference operator, X_t, X_{t-1} is the index data actually measured.

$$\nabla^d \equiv (1-B)^d = 1-\binom{d}{1}B+\binom{d}{2}B^2+\cdots+(-1)^{d-1}\binom{d}{d-1}B^{d-1}+(-1)^d B^d \quad (4)$$

Using past observations of the sequence, future values of the sequence can be extrapolated. The future values of the sequence are expressed as linear functions of the current and lagging periods of the lag term and the random disturbance term, and the general form of the model is as follows:

$$Y_t = c+\alpha_1 Y_{t-1}+\cdots+\alpha_p Y_{t-p}+\epsilon_t+\beta_1 \epsilon_{t-1}+\cdots+\beta_q \epsilon_{t-q} \quad (5)$$

3 Empirical Analysis

3.1 Prediction process of China's maximum temperature index

Taking the maximum temperature index of China as an example, five sets of forecast values for the next 30 days were measured respectively, and the data of South America, Southeast Asia, and the southwestern region of the United States were predicted in the same way. The results are as follows.

Table 1 ADF test list

ADF test list							
variable	Difference order	t	P	AIC	Threshold		
					1%	5%	10%
MAX	0	1.284	0.637	480.231	3.474	2.881	2.577
	1	8.725	0.000 * * *	476.937	3.474	2.881	2.577
	2	6.802	0.000 * * *	498.166	3.478	2.882	2.578

Table 1 showed the results of ADF test, which was used to test whether the time series was stationary. The results showed that when the difference was of order 0, the significance P value was 0.637, the significance was not present at the level, the null hypothesis cannot be rejected, and the series was an unstable time series. When the difference was of order 1, the significance P value was 0.000***, showing significance at the level, rejecting the null hypothesis, and the series was a stationary time series. When the difference was of the 2nd order, the significance P value was 0.000***, showing significance at the horizontal level, rejecting the null hypothesis, and the series was a stationary time series.

Table 2 Model parameter table

Model parameter table						
	coefficient	Standard deviation	t	P>|t|	0.025	0.975
constant	0.069	0.091	0.763	0.445	0.246	0.108
ar.L1.D.MAX	1.15	0.164	7.028	0	0.829	1.471
ar.L2.D.MAX	0.517	0.071	7.262	0	0.657	0.378
ma.L1.D.MAX	0.696	0.196	3.555	0	1.08	0.313
Goodness of fit R^2			0.949			

Table 2 showed the parameter results of this model. The goodness of fit is 0.949, close to 1, so the model fits well. The optimal parameters were automatically found based on AIC information criteria. The formula of the model is as follows:

*Y (t) = 0.069 + 1.15 * y (t - 1) to 0.517 * y (t - 2) to 0.696 * epsilon (t - 1)*

In conclusion, the model had good fitting effect and good prediction effect for triple La Nina events.

3.2 Prediction results of time series of other indicators in China

The data prediction of the last 30 periods of the time series model of other indicators in China was shown in the following table 3 to 10.

Table 3 Solution results of the last 30 periods of precipitation index forecast in China

Predicted value		Predicted value		Predicted value	
Order (time)	**Forecast result**	**Order (time)**	**Forecast result**	**Order (time)**	**Forecast result**
1	0.8735	11	1.1192	21	1.0290
2	1.1326	12	1.1102	22	1.0200
3	1.1914	13	1.1012	23	1.0110
4	1.1824	14	1.0922	24	1.0020
5	1.1733	15	1.0831	25	0.9929
6	1.1643	16	1.0741	26	0.9839
7	1.1553	17	1.0651	27	0.9749
8	1.1463	18	1.0561	28	0.9659
9	1.1373	19	1.0471	29	0.9569
10	1.1282	20	1.0380	30	0.9478

Table 4 Solution results of the data prediction of the last 30 periods of China's mean temperature index

Predicted value		Predicted value		Predicted value	
Order (time)	**Forecast result**	**Order (time)**	**Forecast result**	**Order (time)**	**Forecast result**
1	80.4152	11	80.4152	21	80.4152
2	80.4152	12	80.4152	22	80.4152
3	80.4152	13	80.4152	23	80.4152
4	80.4152	14	80.4152	24	80.4152
5	80.4152	15	80.4152	25	80.4152
6	80.4152	16	80.4152	26	80.4152
7	80.4152	17	80.4152	27	80.4152
8	80.4152	18	80.4152	28	80.4152
9	80.4152	19	80.4152	29	80.4152
10	80.4152	20	80.4152	30	80.4152

4.3 Prediction results of time series of indicators in other regions

The data prediction of the last 30 periods of time series models of different indicators in other regions was shown in the following table.

Table 5 Solution results of the latest 30 periods of precipitation index forecast in Southeast Asia

Predicted value		Predicted value		Predicted value	
Order (time)	**Forecast result**	**Order (time)**	**Forecast result**	**Order (time)**	**Forecast result**
1	8.9454	11	9.3828	21	9.5613
2	9.1329	12	9.4007	22	9.5792
3	9.2093	13	9.4185	23	9.5970
4	9.2473	14	9.4364	24	9.6149
5	9.2721	15	9.4542	25	9.6327
6	9.2923	16	9.4721	26	9.6506
7	9.3110	17	9.4899	27	9.6684
8	9.3291	18	9.5078	28	9.6863
9	9.3471	19	9.5256	29	9.7041
10	9.3650	20	9.5435	30	9.7220

Table 6 Solution results of the last 30 data forecast of the mean temperature index in Southeast Asia

Predicted value		**Predicted value**		**Predicted value**	
Order (time)	**Forecast result**	**Order (time)**	**Forecast result**	**Order (time)**	**Forecast result**
1	81.0142	11	80.5652	21	80.4561
2	80.8292	12	80.5542	22	80.4453
3	80.7332	13	80.5432	23	80.4344
4	80.6808	14	80.5323	24	80.4235
5	80.6496	15	80.5214	25	80.4126
6	80.6288	16	80.5105	26	80.4018
7	80.6131	17	80.4997	27	80.3909
8	80.5998	18	80.4888	28	80.3800
9	80.5878	19	80.4779	29	80.3691
10	80.5763	20	80.4670	30	80.3582

Table 7 Solution results of the latest 30 periods of precipitation index forecast in Southwest United States

Predicted value		**Predicted value**		**Predicted value**	
Order (time)	**Forecast result**	**Order (time)**	**Forecast result**	**Order (time)**	**Forecast result**
1	6.0394	11	2.2574	21	2.2538
2	4.1416	12	2.2556	22	2.2538
3	3.1952	13	2.2547	23	2.2538
4	2.7232	14	2.2543	24	2.2538
5	2.4879	15	2.2540	25	2.2538
6	2.3705	16	2.2539	26	2.2538
7	2.3120	17	2.2539	27	2.2538
8	2.2829	18	2.2539	28	2.2538
9	2.2683	19	2.2538	29	2.2538
10	2.2610	20	2.2538	30	2.2538

Table 8 Solution results of the latest 30 data forecast of the average temperature index in the southwest of the United States

Predicted value		Predicted value		Predicted value	
Order (time)	**Forecast result**	**Order (time)**	**Forecast result**	**Order (time)**	**Forecast result**
1	57.7406	11	56.7586	21	55.9966
2	57.6560	12	56.6771	22	55.9207
3	57.2611	13	56.6015	23	55.8449
4	57.1603	14	56.5279	24	55.7691
5	57.2196	15	56.4525	25	55.6932
6	57.1840	16	56.3758	26	55.6174
7	57.0631	17	56.2996	27	55.5416
8	56.9631	18	56.2241	28	55.4657
9	56.9010	19	56.1484	29	55.3899
10	56.8375	20	56.0725	30	55.3141

Table 9 Results of the last 30 periods of precipitation index forecast in South America

Predicted value		Predicted value		Predicted value	
Order (time)	**Forecast result**	**Order (time)**	**Forecast result**	**Order (time)**	**Forecast result**
1	12.2336	11	12.7917	21	13.0429
2	12.5210	12	12.8168	22	13.0680
3	12.5842	13	12.8419	23	13.0931
4	12.6149	14	12.8670	24	13.1182
5	12.6408	15	12.8922	25	13.1434
6	12.6661	16	12.9173	26	13.1685
7	12.6912	17	12.9424	27	13.1936
8	12.7163	18	12.9675	28	13.2187
9	12.7414	19	12.9926	29	13.2438
10	12.7666	20	13.0178	30	13.2690

Table 10 Solution results of the last 30 data forecast of the average temperature index in South America

Predicted value		Predicted value		Predicted value	
Order (time)	**Forecast result**	**Order (time)**	**Forecast result**	**Order (time)**	**Forecast result**
1	72.1285	11	73.1439	21	73.3164
2	72.9458	12	73.1539	22	73.3320
3	73.2592	13	73.1755	23	73.3514
4	73.1821	14	73.1899	24	73.3673
5	73.0614	15	73.2117	25	73.3865
6	73.0068	16	73.2260	26	73.4026
7	73.0392	17	73.2466	27	73.4215
8	73.0760	18	73.2612	28	73.4379
9	73.1133	19	73.2814	29	73.4566
10	73.1255	20	73.2966	30	73.4732

4 Conclusions

According to the forecast data of each region and index obtained above, it can be seen that the future climate is in an abnormal state. However, due to the influence of global warming, the variation of outliers is small, and different regions show different degrees of influence. According to the data, triple La Nina events will still affect the global climate in the future. Judging from the double La Nina event last year, combined with the drought and less rain in the autumn of 2022, and the forecast results, the possibility of a triple La Nina event in the future is high.

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