Hurricanes and Global Warming

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Abstract

In this paper, we studied the global warming and the number of hurricanes under the background of increasing global warming and increasing the intensity. We built a model to measure the degree of global warming and the intensity of hurricanes, and try to find out the relationship between global warming and the intensity of hurricanes.

In this paper, we use MATLAB, Excel and SPSS to analyze and solve the problem, which has a certain reference value.

Keywords

Wavelet analysis; Mexico caplet wavelet analysis; MATLAB ;spss.

1. Introduction

In order to indicate the origin of Hurricanes and Global Warming problems, the following background is worth mentioning.

Hurricanes (which also include storms known as ”typhoons” in the Northwest Pacific and ”severe tropical cyclones” in the Indian Ocean and Southwest Pacific) are extremely destructive and often responsible for the deaths of hundreds and occasionally thousands of people. Many meteorologists agree that global warming has occurred (around half degree C) in the last several decades at the earth’s surface, and the trend is likely to continue.

2. Measuring the degree of global warming and the global hurricane activity model

2.1 Model establishment

Using the basic theory of wavelet analysis based on MTLAB, the time series of global average temperature and the global time series of hurricane activity are analyzed and solved, Wavelet analysis originated in the late 1980s is a new mathematical analysis method. This method can simultaneously show the frequency of the data signal at different timescales. Therefore, wavelet analysis theory in a short span of ten years, rapid development and growth. In the continuous improvement of theory, combined with the theory of various disciplines, resulting in wavelet-based analysis software, Such as MATLAB, wavelab (wavelet laboratory) and other wavelet analysis software, make the extensive use of wavelet analysis possible.

Wavelet analysis is developed from the Fourier transform, However, the Fourier transform can only deal with the stationary signal, the Fourier transform can not meet the need when analyzing non-stationary signal. ompared with the Fourier transform, the wavelet transform not only makes up for the shortcoming of the Fourier transform in time analysis, but also can meet the requirements of signal analysis in the time window and the frequency window, and achieves high frequency resolution at low frequency and high frequency Higher time resolution. [1]

1) The concept of wavelet function

A wavelet is a waveform that has both decay and volatility. Meyer's wavelet function is defined as [2]

$$C_{\psi} = \int_{0}^{+\infty} \frac{|\psi(\omega)|^2}{\omega} d\omega < +\infty \qquad (2\text{-}1)$$

or

$$\int_{-\infty}^{+\infty} \psi(t)dt = 0 \quad (2\text{-}2)$$

According to the definition of Equation 3-1 and Equation 3-2, any characteristic with certain oscillation frequency can be defined as a wavelet function, that is, a fundamental wavelet.

2) Wavelet transform

Wavelet transform is the function, data, etc. divided into different frequency part, and then analyze the corresponding, The composition should be based on the standard. Wavelet transform includes continuous wavelet transform and discrete wavelet transform, and orthogonal wavelets and biorthogonal wavelets are two special cases of discrete wavelet The data analyzed in this paper is the time-series data of sea surface temperature and has the characteristics of continuous oscillation. Therefore, the one-dimensional continuous wavelet transform is chosen to analyze its variation characteristics. The following gives one-dimensional continuous wavelet transform and one-dimensional discrete wavelet transform formula. For a mother wavelet $\psi(t)$, Pass right $\psi(t)$ Scaling and panning to get the formula [3]

$$\psi_{ab}(t) = \frac{1}{\sqrt{|a|}}\psi\left(\frac{t-b}{a}\right) \quad a,b \in R; a \neq 0 \quad (2\text{-}3)$$

This is a wavelet sequence. Give an arbitrary function $f(t) \in L^2(R)$, The continuous wavelet transform has the formula:

$$W_f(a,b) = (f, \psi_{ab}) = |a|^{\frac{1}{2}} \int_R f(t)\psi\left(\frac{t-b}{a}\right)dt \quad (2\text{-}4)$$

In discrete transformation, The range of a is always limited to positive values, In this way, the original scale factor a and the time factor b in continuous wavelet transform are usually taken $a = a_0^j$, $b = ka_0^j b_0$, As a discretization formula. $j \in Z$ The discrete wavelet transform coefficients can be expressed as:

$$C_{j、k} = \int_{-\infty}^{+\infty} f(t)\psi_{j、k}^{*}(t)dt = (f, \psi_{j、k}) \quad (2\text{-}5)$$

3) Wavelet variance

The integral of the square of the wavelet transform coefficient in the b domain is the wavelet variance [4] ,The formula is:

$$W_f(s) = \int_{-\infty}^{+\infty} |W(a,b)|^2 ab \quad (2\text{-}6)$$

With the change of scale factor a, the variance of wavelet constitutes the variance curve, that is, the wavelet square Poor figure. It can clearly reflect the distribution of wavelet energy at different scales [5]. Then, the time scale corresponding to the peak of fluctuating energy is the period of data change.

4)The wavelet function in MATLAB

(1) Mexico caplet wavelet function

Mexican cap hawser, shaped like a hat named, also known as Marr wavelet, the function table. The style is:

$$\psi(x) = (1 - x^2)e^{\frac{-x^2}{2}} \quad (2\text{-}7)$$

Its wavelet form is:

$$\psi(s,t) = \sqrt{|s|}\psi(s(t-\tau)) \quad (2\text{-}8)$$

Marr wavelet shows good locality in both time and frequency domain, but it does not have orthogonality because of no scale function. The wavelet transform coefficients are in good agreement with the trend of climatic signals. Therefore, the changes of coefficients after Marr wavelet transform on different scales reflect the changing features of climate under this scale.

（2）Morlet wavelet function

Morlet wavelet is named after the French geophysicist Morlet, and it is a wavelet used when introducing the concept of wavelet when analyzing the local properties of seismic waves before and after 1984 Morlet wavelet is a complex valued wavelet,

It can extract the complex value and phase information of time course or signal under analysis and has good locality in both time and frequency domain. In MATLB software, Morlet wavelet function call format: [PSI，X]=morlet（LB，UB，N）[6-7]。

Question 1 deals with the global average temperature data series and global hurricane activity time series using the Mexican Cap and Morlet wavelets as wavelet bases for data transformation analysis.

2.2 Solution and result analysis

1）Global average temperature trend analysis

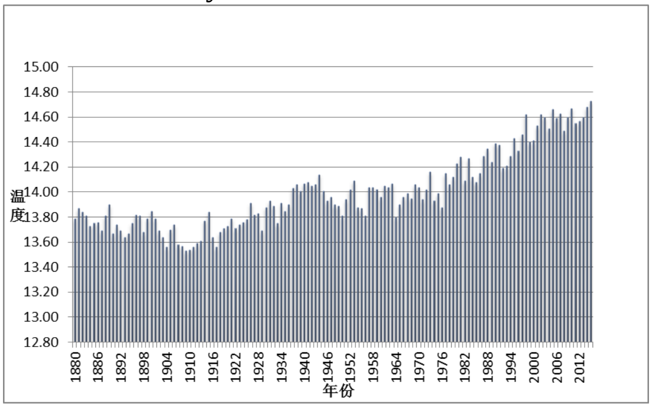

Figure 2-1 1880-2015 Global mean temperature histogram

As can be seen from Figure 2-1, the global average temperature has risen overall in the recent 135 years. The average temperature in 1880 was about 13.79 ° C and the maximum temperature was about 14.73 ° C in 2015, which rose about 0.94 ° C. The difference between the lowest temperature of 1903 13.53° C to the maximum temperature of 1.2 ° C.

2）Global hurricane activity frequency and trend of change

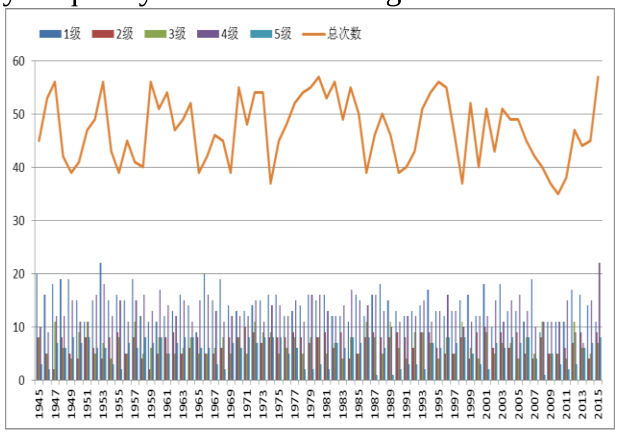

Figure 2-2Global Hurricane Frequency Line and Histogram 1945-2015

It can be seen from Figure 2-2 that the trend of the number of global hurricanes from 1945 to 2015 decreases first and then gradually increases. Reaching a minimum of 35 in 2010 and reaching a maximum of 57 in 2015. Hurricane activity levels worldwide have hurricanes 1-5 each year, of which hurricanes at levels one and four each year are the most, with the highest number of hurricanes at level 1 in 2007 and the highest number of hurricanes at level 4 in 2015.

3) Global Mean Temperature Evolution Characteristics Analysis

One-dimensional continuous wavelet transform of standard normalized global average temperature data was carried out by using MATLAB software, and then the change characteristics and periodic variation of global average temperature under different time scales were analyzed. Taking the Mexican caplet wavelet as the mother wavelet, the standard normalized data is subjected to one-dimensional continuous wavelet transform of 135-year scale, and the absolute grayscale of the one-dimensional continuous wavelet transform coefficient is obtained as shown in Figure 2-3. In the figure, the horizontal axis represents the change of time and the vertical axis represents the change of scale. In the figure, the higher the brightness is, the larger the absolute value of the wavelet transform coefficient is. The position corresponding to the zero value of the wavelet transform coefficient is the turning point of the global average temperature change at this scale. In the picture, we can see five obvious bright spots.

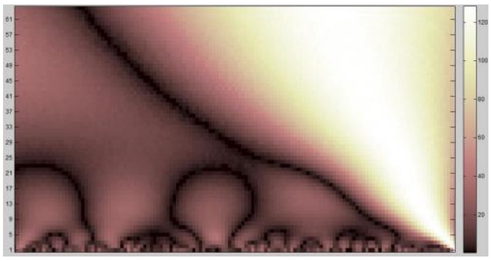

Figure 2-3 135-year-scale Mexico cap wavelet one-dimensional continuous change Change the absolute value of the coefficient grayscale

In order to more accurately analyze the evolution characteristics and abruptness of the 135-year atmospheric mean temperature, a contour map corresponding to the absolute grayscale image is shown in FIG. 2-4. There is a clear warmer period on the 70-100 scale. The center of warmth, located between 1953 and 1976, has a time span of about 23 years and its edge is fragmented and gap-shaped. This shows that the global sea surface temperature is rising at a century-long scale. There is a colder area on the 42-year scale, which is not closed due to data. At the 9-21 year scale, there are mainly four centers of cold and warm change in the global sea surface temperature. In 1989, the average global temperature was shown in Figure 3-3. The 135-year-old Mexican caplet wavelet one-dimensional continuous transform coefficient absolute grayscale warmer period entered the colder period, 1929 from the colder period into the warmer period, 1951 From the warm period into the colder period, the final re-enter the warm-end of the 20th century. Therefore, the global average temperature is the first from a warmer into a colder period, and then from the colder transition to warmer, into the colder, and then into the warmer period of change. The first warm center appeared in 1881-1894, the second warm center appeared in 1938-41; the first cold center was 1906-1919 and the second cold center was 1961-1976. In 1981 entered a very obvious period of warming. Temperature in the warm and cold period of continuous alternating gradually increased.

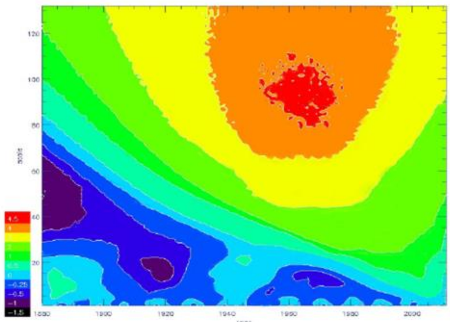

Figure 2-4 Mexico Cap-Wavelet Continuous Transform Analysis Graph with Global Average Temperature of 135 Years

In order to obtain the main periodicity of the global average temperature time series, we draw the wavelet variance map corresponding to the one-dimensional continuous wavelet transform coefficients. As shown in Figure 2-5, there is a relatively strong fluctuation energy on the 25-year scale. Around 200 years There is a strong wave of energy. On the time scale, the fluctuation energy is relatively small on the scales of 50 years and 150 years. This shows that over the past 135 years, the global sea surface temperature has evolved on a large scale. There is a main transformation period of about 200 years and a main transformation period of about 25 years. Wavelet variance energy diagram showed a significant bimodal type.

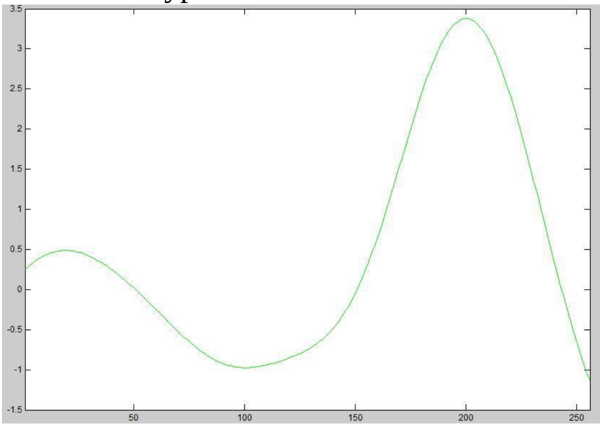

Figure 2-5 Mexican hat wavelet variance map

4) Evolutionary Analysis of Global Hurricane Activity

One-dimensional continuous wavelet transform of standard normalized global hurricane data was carried out by using Matlab software, and then the changing characteristics and periodic variation of global hurricane activities under different time scales were analyzed. Taking the Mexican cap-hat wavelet as the mother wavelet, a one-dimensional continuous wavelet transform is performed on the standard normalized data for 15 years to obtain the absolute gray value of the one-dimensional continuous wavelet transform coefficient as shown in Figure 2-6. In the figure, the horizontal axis represents the change of time and the vertical axis represents the change of scale. In the figure, the higher the brightness is, the larger the absolute value of the wavelet transform coefficient is. The location corresponding to the zero value of the wavelet transform coefficient is the turning point of the changes in the global hurricane activity at this scale. In the picture, we can see four obvious bright spots.

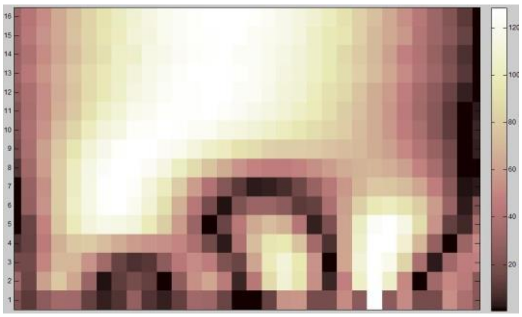

Figure2-6 One-dimensional continuous variation of 15-year-old Mexican cap-hat wavelet

In order to more accurately analyze the evolution characteristics and abrupt changes of the atmospheric mean temperature in the past 15 years, we made an equivalent line analysis map corresponding to the absolute gray scale map, as shown in Figure2-7. In the equivalent line analysis, we can see that there are six significant cold periods in the 70 year period of 1945-20115 years on the 10 to 20 year scale. Before 1950, it entered the first partial cooling period. The center was located in 1949-1953 years, second cold centers in 1958-1960 years, third cold centers in 1969-1972 years, and fourth cold periods in cold centers around 1980. There are 7 distinct warm regions on the 10-20 scale and six complete warm centers. In the scale of less than 10 years, there are some closed warm area.

Before and after 1980, there was a small cold center. Warm and cold alternating transformation time basically for 3-6 years.

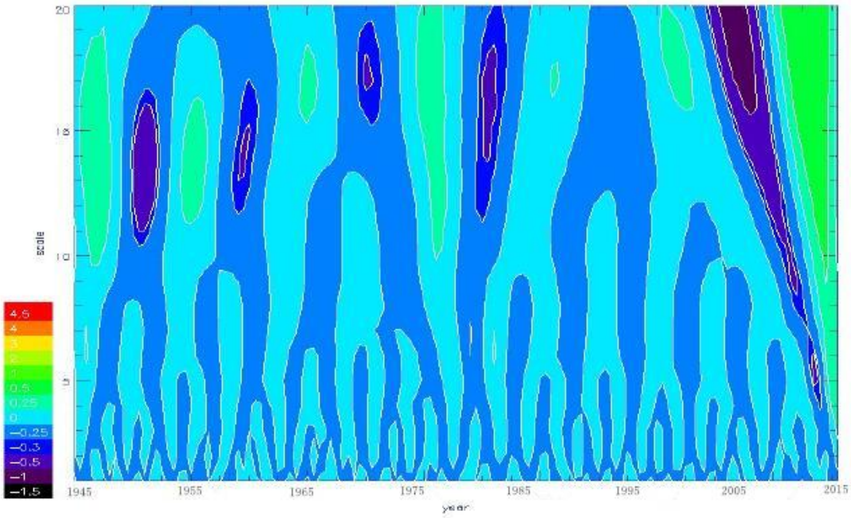

Figure 2-7 Mexico Hurricanes 70-year-scale Mexican Cap transformation analysis

In order to obtain the main periodicity of the global average temperature time series, we draw the wavelet variance map corresponding to one-dimensional continuous wavelet transform coefficients. As shown in Figure 2-8, there is a relatively strong fluctuation energy on the 25-year scale. At the 8-year scale There is a strong wave of energy. On the time scale of less than 5 years and more than 25 years, the fluctuation energy is relatively small. This shows that over the past 15 years, the global sea surface temperature has evolved on a large scale. There is an 8-year transformation main period and a 25-year transformation main period. Wavelet variance energy diagram showed a significant bimodal type.

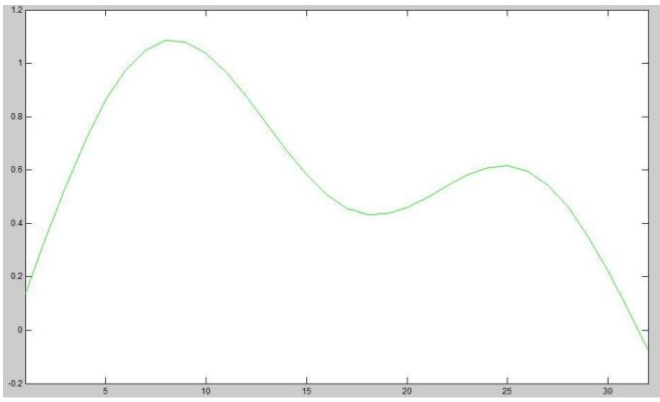

Figure 2-8 Mexico caplet wavelet variance plot

Based on the analysis of the change trend of global average temperature in 1880-2015 years, it is found that the warming and changing of global mean temperature in recent 135 years is experiencing a process of decreasing first, then rising, then decreasing and rising again, showing a long-term warming trend. There is a warm center in 1953 to 1976 between the warm period, the warm center is broken, change of temperature in the century scale that is rising in fluctuation in the. The wavelet variance energy is Shuangfeng type, which has a main cycle of about 200 years and a main cycle near 25 years.

Based on the analysis of the trend of global hurricane activity in 2000-2015 years, the trend of global hurricane activity in the recent 15 years has decreased and then increased. The wavelet variance energy is Shuangfeng type, which has a main cycle of about 15 years and a main cycle near 8 years.

3. The relationship between global warming and global hurricane activity

3.1 Model establishment

According to Unisys Weather released the relevant data, six of the world's ocean area (Atlantic, East Pacific, West Pacific, South Pacific, South Indian, North Indian) the hurricane data collection can be traced back to 1945, so the choice of the relevant data in the 70 years 1945-2015 the global average annual temperature and hurricane activity times, correlation analysis the data of the two groups, the first list of two sets of data, as shown in table 3-1:

table 3-1 1945-2015 global annual mean temperature and hurricane numbers

Particular year	Number of hurricanes	Average Global Temperature	Particular year	Number of hurricanes	Average Global Temperature
1945	45	14.01	1981	53	14.28
1946	53	13.93	1982	56	14.09
1947	56	13.96	1983	49	14.27
1948	42	13.90	1984	55	14.12
1949	39	13.89	1985	50	14.08
1950	41	13.81	1986	39	14.15
1951	47	13.94	1987	46	14.29
1952	49	14.02	1988	50	14.35
1953	56	14.09	1989	46	14.24
1954	43	13.88	1990	39	14.39
1955	39	13.87	1991	40	14.38
1956	45	13.81	1992	43	14.19
1957	41	14.04	1993	51	14.21
1958	40	14.04	1994	54	14.29
1959	56	14.02	1995	56	14.43
1960	51	13.96	1996	55	14.33
1961	54	14.05	1997	46	14.46
1962	47	14.04	1998	37	14.62
1963	49	14.07	1999	52	14.40
1964	52	13.80	2000	45	14.41
1965	39	13.90	2001	51	14.53
1966	42	13.96	2002	43	14.62
1967	46	13.99	2003	51	14.60
1968	45	13.95	2004	49	14.51
1969	39	14.06	2005	49	14.66
1970	55	14.04	2006	45	14.59
1971	48	13.94	2007	42	14.63
1972	54	14.02	2008	40	14.49
1973	54	14.16	2009	37	14.60
1974	37	13.93	2010	35	14.67
1975	45	13.99	2011	38	14.55
1976	48	13.88	2012	47	14.57
1977	52	14.15	2013	44	14.60
1978	54	14.06	2014	45	14.68
1979	55	14.12	2015	57	14.73
1980	57	14.23			

According to the data listed in the above table, we made a line chart of the two sets of data respectively to compare the trend of the two sets of data. As shown in Figure 3-1.

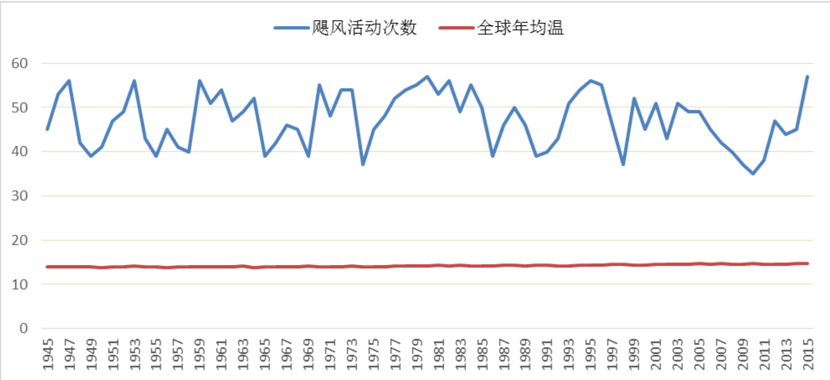

Figure 3-1 1945-2005 global annual average temperature and hurricane activities change line graph

As can be seen from the figure:

1. The two sets of data in the entire span of 70 years, showing an overall upward trend, and there is a certain correlation.

2. There is a certain period of change in annual global average temperature over X-X years, as mentioned above; there are also some cycles of change in the number of hurricanes.

3.2 Solution and result analysis

The above two groups of data are defined as variable X and variable Y respectively, and the statistical tools SPSS software are used to analyze the correlation of the two variables. After introducing the two sets of variables, run the Analysis-Dependencies-Bivariate command in SPSS and the results are shown in Table 3-2 below:

Table 3-2 Correlation

		Global average temperature	Hurricane activity frequency
Global average temperature	Pearson Correlation	1	-.081
	Significance (bilateral)		.502
	N	71	71
Hurricane activity frequency	Pearson Correlation	-.081	1
	Significance (bilateral)	.502	
	N	71	71

It can be seen from the above table that the correlation between annual average temperature and the intensity of hurricane activity is -0.081 and the significance is 0.502, so the correlation between them is small and negatively correlated. As we know, the change of global temperature is affected by many factors. The generation of hurricanes and the magnitude of their intensity are related to many uncertainties. With the existing scientific and technological means and data, it is not yet entirely certain whether the two are There is some correlation.

4. Conclusion

According to the above, we can draw a conclusion that the degree of global warming is occurring in the earth itself in a warmer period due to increased human activities have aggravated the global temperature, and the intensity of hurricane activity is also in a climate where their active period, and no obvious correlation between the two.

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