

# Analysis on the Climate Change Characteristics of Dianchi Lake Basin under the Background of Global Warming

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**Abstract.** Based on the data published by the State Statistical Bureau and the weather station data, the annual mean temperature, wind speed, humidity, light duration and precipitation of Dianchi Lake in 1990 ~ 2014 were analysed. Combined with the population The results show that the climatic changes in Dianchi Lake basin are related to the climatic change in the past 25 years, and the correlation between these factors and the main climatic factors are analysed by linear regression, Mann-Kendall test, cumulative anomaly, R/S and Morlet wavelet analysis. Population, housing construction area growth and other aspects of the correlation trends and changes in the process, revealing the population expansion and housing construction area growth on the climate of the main factors of the cycle tendency of significant impact.

## 1. Introduction

Global warming is a scientific issue which has always been the focus of attention of scholars at home and abroad. Climate change is the combined result of the internal processes of nature and the continual changes in human activities to atmospheric constituents and land use. Global climate change will bring disasters such as glacier melting, permafrost melting, coral reef dying, sea level rise, ecosystem change, aggravation of droughts and floods for mankind and ecosystem[1]. According to the IPCC, the global average surface temperature has risen by 0.5 °C over the past century [2]. World Meteorological Organization in 2007 announced that from 1998 to 2007 is the warmest decade recorded since then have been announced in 2009, 2011, 2012, respectively, the corresponding range of the warmest year, the global warming trend will continue [3]. "Second National Assessment Report on climate change" that China's climate warming rate may be 0.5~0.8°C/100a, higher than the global warming rate[4]. Plateau climate has obvious characteristics, for global warming under the study has a certain representation. Dianchi Lake is located in the Yunnan-Guizhou Plateau, north-south distribution, is the sixth largest freshwater lake, the lake about 1886 meters above sea level, an area of about 330 square kilometers, the average depth of about 5 meters, are semi-closed lakes, only the southwest of Haikou As the outlet, known as the plateau pearl, in the subtropical plateau southwest monsoon climate zone, climate change is mainly affected by the southwest monsoon and tropical continental air mass alternating control [5]. At the same time, Dianchi Lake is the main body of water for irrigating, transferring livestock and accepting in Kunming. It is also the basic condition of urban development, and plays an important role in climate regulation in Dianchi Lake Basin [5].



In recent years, the Dianchi Lake ecological environment has been seriously damaged, the climate of the basin had a certain impact, the issue of attention by the relevant departments. Therefore, it is necessary to study the climate change in the Dianchi Lake basin, which can provide data support for the relevant departments to protect and manage the environment and prevent the disaster caused by climate change. Wen H et al [6] studied the aquatic biota structure and water pollution factors and their spatial distribution characteristics in the Rivers of the Rivers by means of factor analysis and other methods based on the data of 29 aquatic organisms and water pollution in Dianchi Lake. Liang Z Y et al [7] based on the 1998-2010 Dianchi Lake monitoring stations, water quality indicators of the time series to STL and other methods of water quality trends in time and space characteristics of the identification and identification. Li Z Y et al [8] used the principle of conservation of mass to construct the simulation system of the pollution control effect of the old Yunliang River and calculated the pollution load into the Dian River. Chen C et al [9] used day-to-day sounding data from 1958 to 2013 in Wuhan, and used climatological tendency and wavelet analysis to reveal the relationship between periodic and aperiodic mean wind speed Sexual changes. Qi D L [10] used the basic meteorological data from 14 meteorological stations from 1964 to 2013 in the Sanjiangyuan area of Qinghai Province, and analyzed the temporal and spatial variation and trend of evaporation in the Sanjiangyuan area by using linear propensity estimation and Mann-Kendall method. Zhou D et al [11] used the linear trend, Morlet wavelet analysis, Mann-Kendall and other methods to analyze the influence of the temperature, precipitation and sunshine duration on 468 meteorological stations on the continent from 1961 to 2010, variation characteristics of each climate element. Ding W R [12] studied the effects of temperature, precipitation, precipitation and regional climate change in the Erhai Lake area from 1951 to 2014 on the basis of linear trend estimation, Mann-Kendall trend test, Morlet wavelet analysis and R/S analysis. Based on the previous research [13-16], and with reference to the above research team research methods and ideas, this paper studies and analyzes the climatic factors (temperature, wind speed, precipitation, duration of light) in the Dianchi Lake basin under the background of global warming on a long time scale , Humidity and so on), taking into account the human factors such as the total population at the end of Kunming and the housing construction area, to explore the causes of climate change and provide data support for further decision-making of related departments.

## 2. Data Selection and Methods

### 2.1. Data Selection

From 1990 to 2014, the population of Kunming and the floor space of the building were derived from the total population at the end of the corresponding year in Yunnan Statistical Yearbook, the area of housing construction and the floor space, average temperature, sunshine duration and precipitation from the China Statistical Yearbook, the average annual wind speed, relative humidity data from China Meteorological Data Network and the World Weather Web site published data (<https://www.wunderground.com>).

### 2.2. Method Introduction

The main research methods include linear regression [17-19], significance test [19], correlation coefficient [20], Mann-Kendall test [21], cumulative anomaly [22], Pettitt mutation test [23], R/S analysis [24] and Morlet wavelet analysis [4, 7].

**2.2.1. Correlation analysis.** The four factors, such as total population, light duration, annual minimum temperature and construction area, did not pass the normal distribution test. In order to facilitate the comparative analysis, this paper used Spearman correlation coefficient to describe the correlation between the factors and the linear relationship. The Spearman correlation coefficient, also known as the Spearman rank correlation coefficient, is used to estimate the correlation between two variables,  $x$  and  $y$ , where the correlation between variables can be described using monotonic functions. If the two

variables do not have the same two elements, then when one variable can be expressed as a good monotonic function of another variable, that is, the two variables have the same trend of change,  $r$  between two variables can reach 1 or -1. The formula is:

$$r = \frac{\sum_{i=1}^N (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^N (x_i - \bar{x})^2 \sum_{i=1}^N (y_i - \bar{y})^2}} \quad (1)$$

Where  $r$  is the Spearman correlation coefficient,  $x_i$  and  $y_i$  represent the  $i^{\text{th}}$  sample value of the  $x$  variable and the  $y$  variable, respectively, and  $N$  is the number of sample values. Spearman correlation coefficient ( $-1 \leq r \leq 1$ ) is generally divided into:

- $|r| < 0.4$  for low linear correlation.
- $0.4 \leq |r| < 0.7$  for significant correlation.
- $0.7 \leq |r| < 1$  for highly linear correlation.

**2.2.2. Cyclical analysis** Wavelet analysis is a powerful statistical tool, the earliest used in signal processing and analysis. In geosciences, various meteorological factors, hydrological processes and material exchange between ecosystems and the atmosphere can be seen as periodic signals with time, so the wavelet analysis method is also applicable to the field of geology. And the complex time structure of geo-science process.

A continuous wavelet transform of a discrete time series  $x_n (n=1, \dots, N)$  having an equal time step  $\delta t$  may be defined as the wavelet function  $\psi_0$  scale and the convolution of  $x_n$  at the conversion:

$$W_n^X(s) = \sqrt{\frac{\delta t}{s}} \sum_{n=0}^{N-1} x_n \cdot \varphi^* \left[ \frac{(n'-n)\delta t}{s} \right] \quad (2)$$

Where  $*$  is the conjugate complex number,  $N$  is the total number of data in the time series, and  $(\delta t/s)/2$  is a factor used to normalize the wavelet function, so that the wavelet function has unit energy at each wavelet scale  $s$ .

Morlet wavelet not only has no orthogonality, but also by the Gaussian adjustment of the index complex wavelet.

$$\varphi_0(t) = \pi^{-1/4} e^{i\omega_0 t} e^{-t^2/2} \quad (3)$$

Where  $t$  is the time and  $\omega_0$  is the dimensionless frequency. When  $\omega_0=6$ , the wavelet scale  $s$  is almost equal to the Fourier period ( $\lambda=1.03s$ ), so the scale term and the periodic term can be substituted for each other. It can be seen that Morlet wavelet has a good balance between time and frequency localization.

$|W_n^X(s)|^2$  is defined as the wavelet power spectrum, which expresses the magnitude of the time series fluctuation in a given wavelet scale and time domain. Since the Morlet mother wavelet is a complex wavelet,  $W_n^X(s)$  is also a complex number and its complex part can be interpreted as local phase. The wavelet power spectrum is averaged over a period to obtain the wavelet full spectrum:

$$W^2(s) = \frac{1}{N} \sum_{n=0}^{N-1} |W_n(s)|^2 \quad (4)$$

Wavelet full spectrum can show the unbiased and uniform estimation of real power spectrum of time series. Since the full spectrum of the wavelet can show the background spectrum measurement, the peak of the local wavelet can be verified, so the periodic fluctuation characteristics and intensity of the time series can be clearly discerned by the wavelet full spectrum.

### 3. Interannual variability of meteorological factors and human factors

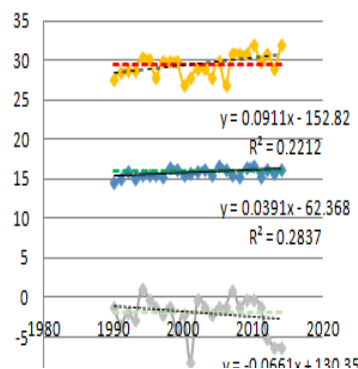
In the climate of global warming, the temperature of Kunming in the past 25 years is on the rise, the trend of temperature is  $0.391^\circ\text{C}/10\text{a}$ , the global temperature tendency is  $0.12^\circ\text{C}/10\text{a}$  (1951 ~ 2012) [4]. Which is higher than the global trend of temperature, with an average value of  $15.9^\circ\text{C}$ . As shown in Figure 1(a), the linear correlation coefficient is 0.28, and the trend of  $\alpha=0.01 (P=0.006)$  is significant.

The annual temperature changes have a certain fluctuations; the range did not exceed  $2^{\circ}\text{C}$ . Using the 3-year sliding average method, it can be seen that the fluctuation range of temperature has a tendency to increase. The annual maximum temperature has passed the significant test of  $\alpha=0.01$  ( $P=0.3099$ ), the upward trend is significant and the annual minimum temperature does not pass  $\alpha=0.1$  significance test, the decline trend is not significant.

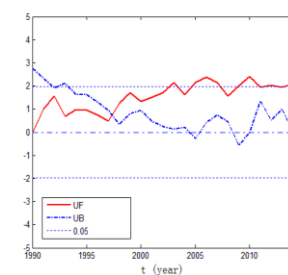
As shown in Figure 1(b), the UF values are all greater than 0, indicating an upward trend in temperature and a significant confidence level fluctuation at the level of  $\alpha=0.05$  after 2003, indicating a significant growth trend. UF and UB have only one intersection, and the cumulative anomaly, Pettitt method of seeking the same mutation time, all in 1997, the cumulative anomaly shown in Figure 1(c).

The Hurst exponent ( $H=0.73$ ,  $H>0.5$ ) of the annual mean temperature indicates that the memory of the time series is higher than that of the random walk, that is, persistent and the temperature will continue to rise in the future time series. In the Morlet wavelet analysis, there are two types of periodic changes in the temperature evolution process:  $0 \sim 9\text{a}$ ,  $10 \sim 17\text{a}$ . There are cold-warm-cold oscillations on the scale of  $10 \sim 17\text{a}$ , and the periodic variation is very stable throughout the analysis period, and it is global. The shocks appearing on the scale of  $0 \sim 9\text{a}$  are unstable, as shown in Figure 1(d).  $10 \sim 17\text{a}$  is weak in energy, but the period distribution is obvious, almost throughout the study time domain (1990 ~ 2014), and the period is local and obvious, as shown in Figure 1(e). There are three obvious peaks in the temperature evolution time series, corresponding to 5a, 14a and 22a in turn, and the maximum peak value is 14a, which shows that the periodic oscillation of this time scale is the strongest and is the first major cycle of annual mean temperature change. 5a and 22a As the second and the third main cycle, as shown in Figure 1(f), 1997 is the second main cycle and the first major cycle of the junction point, that is, the mutation, the three cycles of the fluctuations in the control of the entire time domain Variation characteristics of annual mean temperature.

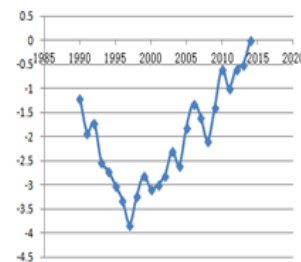
The Hurst index ( $H_{\max}=0.56$ ,  $H_{\min}=0.66$ ) of extreme temperature indicates that the extreme temperature time sequence has a certain random walkability, that is, the persistence is weak, and the significance test shows that the temperature extremum, and the trend is difficult to judge.



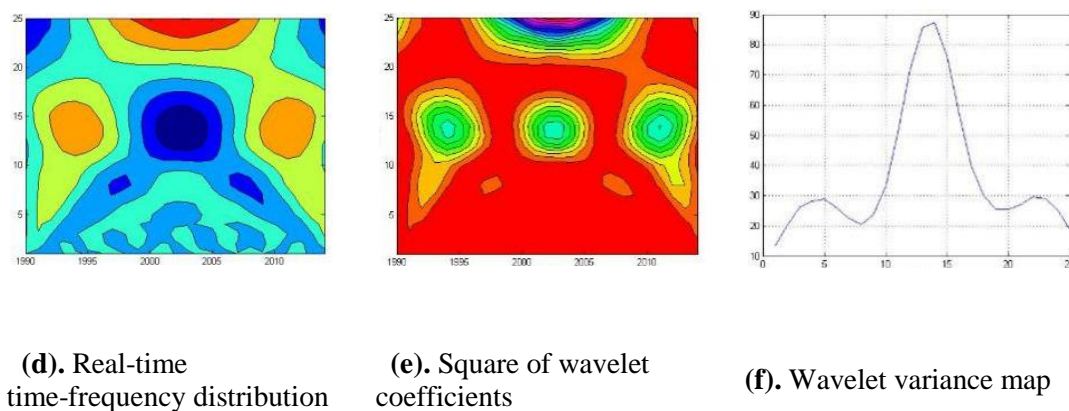
(a). Factor linear regression graph



(b). M-K test chart



(c). Cumulative anomaly

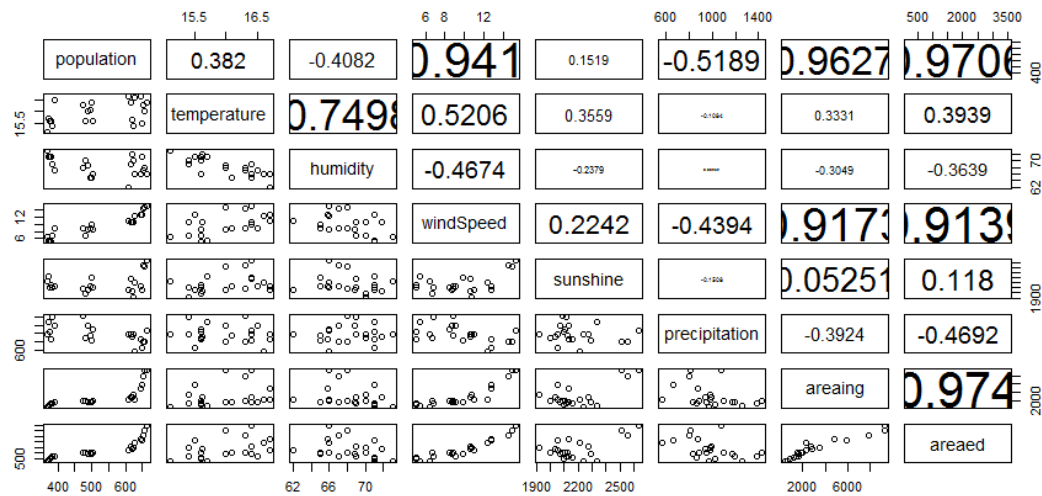
**Figure 1.** Temperature analysis

Several other factors were analyzed in the same way, as seen in the Conclusions and Discussion section.

#### 4. Multi-factor Composite Analysis

In multivariate linear regression analysis, multiple variables are contrasted and corresponding relationships are found. Usually, the method is time-consuming and difficult to compare with each variable, making the analysis more difficult. To this end, the study uses the scatter matrix to compare the relationship between the various variables, and use Spearman correlation coefficient that the correlation between the various factors. The scatter plot matrix and the Spearman correlation coefficient between the two factors are shown in Figure 2. The diagonal is the factor variable name, the lower left triangle is the scatter plot of the corresponding factor, and the upper right triangle is the correlation coefficient of the factor. The larger the absolute value of the correlation coefficient is, the larger the space occupied by the graph is, the stronger the covariant trend is between the variables, and the negative correlation coefficient indicates the negative correlation between them.

Among them, 7 groups of variables (air temperature-humidity, wind speed-population, construction area-population, construction completion area-population, construction area-wind speed, building completion area-wind speed, construction area-building completion area) passed the significance test of  $\alpha=0.001$ , indicating that the linear correlation of the variables is strong, and the sample  $r$  value is greater than 0.7. 9 groups of variables (temperature-precipitation, humidity-precipitation, duration of light-precipitation, duration of light-population, duration of light-wind speed, duration of light-construction area, duration of light-construction area, precipitation-construction area, precipitation-building The completion area) did not pass the significance test, indicating that the linear correlation is small, the significance of linear regression test shown in Table 1. With the population growth, the construction area and completion of the corresponding increase in area to meet the living, office and other needs; the contrary, the construction area of the growth, the construction area of the building area, but also for the population growth provides the necessary conditions.

**Figure 2.** A matrix of scatter plots**Table 1.** Significance test

Factor	Significance test	Spearman correlation coefficient	Correlation test	Mutation time
Temperature	0.0060	0.4856	0.0139	1997
population	8.80E-16	1	3.20E-07	2002
humidity	0.0017	-0.5968	0.0016	1994
Wind speed	1.90E-10	0.8921	2.12E-09	2007
Sunshine duration	0.0211	0.3177	0.1219	2013
precipitation	0.0825	-0.3615	0.0765	2006
Building construction area	2.25E-08	0.9738	2.68E-16	2010
Completed area of housing construction	3.22E-13	0.9792	<2.2e-16	2009

## 5. Conclusion and Discussion

Based on the above experimental analysis, we can see that there are some correlations among the eight factors, such as temperature, humidity, light duration, precipitation, wind speed, population, housing construction area and building completion area, as shown in Table 2.



Table 2. Factor correlation								
	Temperature	Humidity	Sunshine duration	Precipitation	Wind speed	Population	Building construction area	Completed area of housing construction
Time scale	10~17a	10~17a	10~17a	10~17a	11~25a	10~17a	4~22a	4~22a
Variety	Cold-warm-cold	Wet-dry-wet	Long-short-long	More-less-more	Small-large-small	Fast-slow-fast	More-less-more	More-less-more
The first main period	14a	14a	13a	13a	19a	15a	18a	18a
Future trends	rise	fall	rise	fall	rise	rise	rise	rise
Mutation Year	1997	1994	2013	2006	2007	2002	2010	2009

The change rate of humidity is 1.27%/10a after the year of mutation (1994), and it is about 8%/10a before 1994, about 6 times of the mutation. The temperature increase rate after 1998 is 0.134°C/10a, and the growth trend before 1997 is 1.1°C/10a, which is much higher than the warming rate of global warming, about 8 times of that before the abrupt change. The change trend of the two trends is obviously slowed down after the mutation year, and the change of the humidity is more than that of the air temperature. It can be concluded that the change of humidity affects the temperature change to a certain extent. Precipitation has a trend of increasing 31.32mm/10a before the year of 2006 and declining trend since 2006 (52.03mm/10a), while the population has a tendency of increasing. The rate of change produced 19.51 million people/10a changes, indicating that the population growth rate has been greatly improved, it is concluded that the decrease in humidity affect the temperature rise at the same time, the sharp increase in the population in the context of precipitation was significantly reduced trend, Followed by a significant increase in wind speed and duration of light before the abrupt year.

There were five periods of temperature, humidity, light duration, precipitation, and population and so on, and the first principal period of climatic factor was 13-14 years, and the first principal period of population factor was 15 years. From 2000 to 2002, the period from 2003 to 2004 was characterized by low temperature, high humidity, and long duration of light and high precipitation. The period from 2003 to 2004 was characterized by high temperature, low humidity, short illumination time and little rainfall. Low temperature, humidity, light for a long time, precipitation and more periods. Precipitation increased, and humidity increased, the first major cycle of precipitation than the reduction of the humidity of 1a, indicating that precipitation cycle ahead of the humidity, the wind continued to increase on the basis of the precipitation cycle will be further reduced, resulting in increased rainfall period, With the rise in temperature, which increased the drought, making the climate worse.

Population, housing construction and completion of the area to a large extent by the more serious human intervention, such as the promulgation and implementation of relevant policies and regulations, so discuss the relevance of which there are some limitations, but with the population growth, To meet the needs of people living space, the city will, housing construction area also increased, resulting in dramatic increase in impermeable surface, and have continued a clear upward trend, which the population in 2002 mutation in 2004 produced a sharp rise. Precipitation in 2006 produced a mutation, since then 8 years were less than 25 years of average precipitation; the mutation of wind speed is in 2007, after the growth rate was significantly higher than the previous growth rate; temperature and humidity since 2004 Fluctuation range is obviously increased. Housing construction and completion of the area were in 2010 and 2009, respectively, mutation in 2010 and 2011, a dramatic rise in light duration from 2011, the growth trend in 2013, a mutation. In summary, population and housing construction area of the sharp rise in the climatic factors of the cycle and tendencies have had a

significant impact.

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