Variation characteristics of surface temperature in Dianchi Lake Basin in recent 20 years

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Abstract. The ecological environment of the earth has changed with the development of economy. These changes also have an impact on human’s life. We can know that the average annual temperature in the Dianchi Lake Basin has shown an upward trend in the past 20 years through the analysis of temperature changes in the Dianchi Lake Basin. In the four seasons, there are various degrees of sudden changes, especially in autumn, the temperature rising trend is the most significant, and there is a downward trend in winter but the downward trend is not obvious. From the analysis of monthly average temperature data, it can be seen that the temperature is rising except for April and August, and the rising trend is also obvious in October, November and December.

1. Introduction
With the development of economy, human activities have also caused great impacts on environmental changes. Global warming has become the primary problem threatening human’s health. Based on the study of lake surface temperature, this research team has done a lot of research on the lake surface temperature of Dianchi Lake [1-6], and provided a lot of theoretical support for this article. Global warming will cause the glaciers to melt and sea levels to rise[7], affect the area precipitation[8], smoggy weather[9], the outbreak of some epidemic diseases and the deterioration of water quality and so on. This paper analyzes the variation trends of the average annual temperature, seasonal average temperature and monthly average temperature of Dianchi Lake to illustrate the variation trend of temperature in the Dianchi Lake Basin in the past 20 years. The results of this experiment can make people take environmental problems seriously and find solutions to them. Dianchi Lake is the center of Kunming, so the development of this city depends on it. Its changes are related to the economic development of Yunnan Province, and even more to the urban construction of Kunming[10], it can be seen that the significance of this study is significant.

2. Data
2.1. Temperature data
The temperature data comes from the 2-meter atmospheric temperature data with a resolution of 0.125*0.125 obtained by the European Centre for Medium-Term Weather Forecast (ECMWF). It contains the average annual temperature, the average temperature of the four seasons, and the average monthly temperature from 2001 to 2017.

2.2. Boundary extraction
The development of remote sensing technology and geographic information technology have also opened up new way for the extraction of watershed boundaries, but the accuracy of remote sensing images will also be affected due to different regions. So, in order to improve the accuracy of remote sensing images, this paper uses the method of mutual correction between DEM and remote sensing images [11] to obtain high-precision Dianchi watershed.

3. Methods
In this paper, we analyze the temperature of the Annual average, Seasonal average temperature and monthly average by the means of significance analysis [12], mutation analysis and trend analysis, through these methods we know the characteristics of temperature changes in different periods of time in the Dianchi Lake Basin from 2001 to 2017.

4. Results
4.1. Annual average temperature change
According to the statistical analysis of temperature data in Dianchi Lake Basin we know that the annual average temperature shows an upward trend from 2001 to 2017(Figure 1). The annual average temperature of the Dianchi Lake Basin has a sudden change in the past 20 years, and the temperature shows an upward trend but not obvious (Figure 2). As shown in Table 1, the annual average temperature of Dianchi Lake did not pass the significance test of $\alpha=0.01$(Where * represents statistics $|Z|\geq1.28$, ** represents statistics $|Z|\geq1.64$, *** represents statistics $|Z|\geq2.32$, and the table 2 and table 3 are the same means). Therefore, the temperature change is not significant.

Figure 1: The annual mean trend of air temperature in Dianchi Lake Basin.

Figure 2: Analysis of sudden change of annual temperature.
### Table 1: Significance of average annual temperature variation trend and Sen slope in Dianchi.

| Year 2001-2017 | Significance | Slope |
|---------------|--------------|-------|
| Day           | 0.027        |       |

#### 4.2. Seasonal average temperature change

According to the data from 2001 to 2017 we know that the temperature of Dianchi Lake showed a rising trend in spring, summer and autumn, but the temperature change in spring and summer was not obvious, and the change was the most significant in autumn. Only winter showed a downward trend, but the downward trend was not significant (figure 3). Figure 4 shows that the four seasons all showed abrupt phenomena, and the spring abrupt times were in 2013-2014, 2014-2015 and 2016-2017, the temperature showed a rising trend but the rising trend is not obvious. Summer also showed abrupt changes in 2005-2006 and 2008 respectively and also showed an insignificant upward trend. The fall also showed abrupt changes in 2008-2009 and has showed a significant upward trend. In winter the abrupt changes occurred in 2012-2013 and showed a not significant upward trend. It can be seen from the significance test that the average temperature in the spring of the Dianchi Lake Basin has not risen significantly in the past 20 years, and the significance test has been passed in summer, autumn and winter.

![Seasonal average temperature change trend](image.png)

Figure 3: Seasonal average temperature change in Dianchi Lake area.
Figure 4: Analysis of the change of temperature change in the monsoon season.

Table 2: Significant trend of seasonal mean temperature and Sen slope in Dianchi Lake Basin.

| Year    | Significance | Slope |
|---------|--------------|-------|
| Spring  | 0.050        |       |
| Summer  | *            | 0.129 |
| Autumn  | ***          | 0.193 |
| Winter  | ***          | 0.061 |

4.3. Monthly average temperature change

In the past 20 years, the monthly average temperature in the Dianchi Lake Basin has shown an upward trend except for April and August (figure 5). Significance analysis shows that the average temperature in March, November, and December has been rising in the past 20 years and passed the significance test of $\alpha=0.1$, besides, it also has passed the significance test of $\alpha=0.05$ in January, May, and September. In particular, the temperature’s rising trend was the most obvious and passed the significance test of $\alpha=0.01$ in October.
Figure 5: Trend Map of monthly mean temperature in Dianchi Lake Basin.

Table 3: Significance of monthly mean temperature change trend and Sen slope in Dianchi.

| Year     | Significance | Slope |
|----------|--------------|-------|
| January  | **           | 0.077 |
| February | -           | -0.041|
| March    | *            | 0.064 |
| April    |              | 0.004 |
| May      | **           | 0.102 |
| June     |              | 0.072 |
| July     |              | -0.041|
| August   |              | -0.010|
| September| **           | 0.105 |
| October  | ***          | 0.115 |
| November | *            | 0.107 |
| December | *            | 0.062 |
5. Discuss
This article compares and analyzes the data of annual, quarterly and monthly averages of the Dianchi Lake Basin it can be seen that has a rising trend from 2001 to 2017. However, the temperature has a downward trend that is different from the previous research results-global warming in winter [13]. It may be Kunming does not need to burn coal for heating in winter, thus avoiding increasing the concentration of pollutants. Studies have shown that the temperature in the Dianchi Lake Basin has a rising trend, but the change is not significant, this maybe because the development of Kunming's is dominated by light and chemical industries. So, human activities may be an important cause of global warming[14], But the article has not done research on these, there are still some shortcomings that need to be improved.

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