Temperature trends and characteristics during 1957-2016 over Hangzhou, China

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Abstract. This research analysed the temperature trend and characteristics of Hangzhou, China, during 1957-2016. For residents to choose the best travel time and improve the quality of their life. The results show that the average value of temperature during 1957-2016 is 16.90 °C with the trend of 0.33 °C per decade. For seasonal change, highest temperature occurs in the summer, the lowest value appears in the winter, further observation shows that temperature in July and August shows the maximum value, and in December, January and February shows the lowest value. The value of temperature about worst 20%, 50% and best 20% is in an upward trend.

1. Introduction
With the development of our society, global warming has become an unquestionable fact. The Summary of Policymakers (SPM) for Climate Change 2013 has pointed out that: 1880-2012 Global Earth Surface Average temperature rises about 0.85 °C, and still showing a continuous upward trend in recent years. In the past 30 years (1987-2016), the global surface warming rate has been the highest level since 1850[1]. In addition, a large amount of data and research results show that the changes in China's average temperature over the past 100 years are very similar to the changes in the global average temperature [2-4], especially since the warming that began in 1970, the increase is higher than the global average warming level [5]. At the same time, this climate change is uneven [6], with obvious regional differences, the influence of the climate system, the weather and climate are extremely complex, and the temperature variability is high [7-10].

Rapid urbanization and economic development have led to a dramatic increase in resource consumption. Many regions are facing serious temperature rise challenge. This problem is particularly prominent in coastal cities. Hangzhou is located in the eastern part of Zhejiang Province, which is a country with a high population density and economy. One of the cities with strong vitality. In the past 30 years, Hangzhou City has experienced rapid economic development and urbanization. Climate change has a tremendous impact on human production and life. In recent years, many scholars have made changes in temperature. Li YH et al.’s research shows that the temperature in the whole time area decreased from 1959 to 2001[11]; Chen KC research the warming trend and seasonal variation in Hangzhou from 1961to 2012 shows that The air temperature of Hangzhou had increased clearly with the climatic rate 0.35ºC /10 a in recent 52 years [12-15].However, there is little report on the
characteristics of long-term temperature changes and influencing factors in this area. As a typical city in Zhejiang, the results of the study not only provide data support for the analysis of temperature changes in the region and the response to climate change, and can provide lessons for other regions in the south.

2. Materials and methods

2.1. Data
Atmospheric visibility and weather data are accessed from the National Oceanic and Atmospheric Administration (NOAA, https://www.climate.gov/) and the data monitoring interval is 1 hour [16].

2.2. Analytical methods
The study used 2 kinds of statistics and analysis methods: 1) statistical analysis of the annual variation of atmospheric visibility and diurnal variation; 2) calculating the atmospheric visibility Cumulative percentiles.

2.3. Data processing
Data analysis and image analysis are performed using SPSS 19.00 and EXCEL 2010.

3. Result and analysis

3.1. Yearly Variation
Table 1 shows the mean, average temperature, and year-to-year trends of temperature in Hangzhou City every 10 years from 1957 to 2016. Overall, the average temperature in 1957-2016 was 16.90°C, with a trend of 0.33°C per decade, indicating that as time progresses, the temperature is gradually rising. Figure 1 shows the average annual temperature of Hangzhou City from 1957 to 2016, showing an obvious upward trend from 1987 to 1996. After 2013, there was a clear downward trend, while other time variations were not obvious. Due to the government's climate in 2012-2016, as the intensity of change management increases, the annual average temperature begins to decline.

Table 1. Summary statistics of yearly temperature in Hangzhou (1957–2016)

|       | 1957-64 | 1964-73 | 1973-76 | 1976-86 | 1986-96 | 1996-2006 | 2006-2016 | 2007-2016 | 1957-2016 | 60-year trend (per decade) |
|-------|---------|---------|---------|---------|---------|-----------|-----------|-----------|-----------|---------------------------|
| Hangzhou(HZ) | 16.44   | 16.39   | 16.53   | 16.76   | 17.41   | 17.87     | 16.90     | 0.33      |           |                           |

Figure 1. Variations of yearly value of temperature during 1957-2016 in Hangzhou city
3.2. Seasonal and monthly characteristics
The highest temperature occurs in summer, and the lowest value occurs in winter. Further observation shows that the temperature generally assumes a maximum in July-August, while the lowest value occurs in December; the highest monthly temperature appears in summer, followed by spring, fall and winter. From the lowest temperature in the winter (5°C) and the highest temperature in the summer (25°C), it is shown that there is a strong difference in temperature in different seasons in Hangzhou. The spring and fall seasons are basically kept at 15°C, which can show better somatosensory comfort. Therefore, spring and fall are more suitable for outdoor play in Hangzhou.

From the characteristics of the changes in different months, the lowest temperature (below 5°C) in December, January and February, and the highest temperature in July and August (average temperature is 25-30°C), from January to July The temperature during the temperature rise is relatively flat, while the temperature drops from August to December.

![Figure 2. Variations of the monthly and seasonal value of visibility in Hangzhou city](image)

3.3. Cumulative percentiles
From Figure 5, it can be seen that the temperature of 20%, 50% and 80% of the figures are on the rise as a whole. From the perspective of the increase, the highest 50% is followed by 20% and 80%, respectively 0.040, 0.028 and 0.026 °C. Per year. Further analysis of 80% has a gentle upward trend in 1987-2006, which may be related to reform and opening up in the 1980s. In this period, 50% and 20% were in the period of fluctuation, and the change was relatively flat.

![Figure 3. The variation of the best 20% (80%), 50% and worst 20% temperature in Hangzhou city during 1957-2016.](image)
4. Conclusions and discussions
In Hangzhou, from 1957 to 2016, the average temperature was 16.90°C. The highest value appeared in summer, and the lowest value appeared in winter. The figure was inverted "V". This study clearly shows the characteristics of temperature changes in Hangzhou during different seasons and months. The analysis methods and related research results enrich the previous research gaps and have guiding significance for practice [17-19]. It has a higher reference value for residents and tourists' life and tour behaviour guidelines.

However, due to the limited data acquisition conditions [20-22], it is not possible to carry out multi-year trend analysis, and there is only one monitoring station data, and there is no setting and analysis of monitoring sites for different site conditions (e.g., downtown, suburbs, and suburbs) in Hangzhou. Related research needs to be further carried out.

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