Postprint: Analysis of the Impact of Different Climate Regimes on Climate Change in the Tianshan Mountains and Adjacent Regions

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Date: 2018-11-08T00:00:00+00:00

Abstract

Using monthly temperature and precipitation data from 26 meteorological stations in the Tianshan region during 1961–2015, this study investigates the impacts of different climate baseline states on climate monitoring and assessment, thereby providing a more scientific and objective basis for climate change research in the Tianshan region. The results indicate: The eastern Tianshan Mountains constitute a sensitive region for temperature variations across different climate states, whereas the northern slope of the Tianshan Mountains represents a sensitive region for annual precipitation variations. When using the changes in State (1961–2015) as the benchmark, analysis results for both temperature and precipitation elements are overestimated under State (1961–1990) and State (1971–2000), but underestimated under State (1981–2010). Employing the abrupt change timing of State as the reference, temperature exhibits no abrupt change under State overall, an earlier abrupt change under State , and a delayed abrupt change under State . State and State yield smaller temperature and precipitation grades, while State produces larger temperature and precipitation grades. Different climate states exert no influence on precipitation anomalies, whereas State demonstrates the minimal impact on temperature anomalies. When analyzing identical elements for the same period in the Tianshan region using different climate states, both positive and negative changes may emerge. Furthermore, when utilizing baseline climate states for climate change analysis, it is imperative to incorporate multiple factors for objective evaluation of the analytical results.

Full Text

Preamble

Effects of Different Climate States on Climate Change in the Tianshan Mountains and Neighbouring Areas

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Abstract: This paper examines the effects of different climatic states on climate change in the Tianshan Mountains based on monthly temperature and precipitation data from 26 meteorological stations during the period 1961–2015. The purposes of this study were to provide more scientific and objective bases for monitoring, assessing, and studying climate change in the study area. Research shows the following: The eastern Tianshan Mountains was a sensitive region to temperature change under different climatic conditions, and the northern slope of the mountains was a sensitive region to annual precipitation change. Based on referring to the change of State IV during the period 1961–2015, the analyzed results of temperature elements and precipitation elements under State I (1961–1990) and State II (1971–2000) were higher, but those under State III (1981–2010) were lower; By taking the mutation time of State IV as the criterion, there was holistically no mutation of temperature under State I, but the mutation of temperature under State II became earlier and that under State III became later; The grades of temperature and precipitation under State I and State II were lower, but those under State III were higher. There were no effects of different climatic states on the precipitation anomaly, and the effects of State III on the temperature anomaly were the lowest; Both positive change and negative change occurred when different climatic states were used to analyze the same elements in the Tianshan Mountains. Moreover, it is necessary to use multiple elements in making an objective evaluation on the analyzed results of climate change using the climatic criterion.

Keywords: climate state; climate detection; climate assessment; Tianshan Mountains

2. Data and Methods

2.1 Climate State Definition

shows the definitions of different climate states. Four reference periods were established: State I (1961–1990), State II (1971–2000), State III (1981–2010), and State IV (1961–2015). The World Meteorological Organization (WMO) recommends using the most recent 30-year period for climate normals, and

China adopted 1981–2010 as the new climate reference period in 2012. Based on these standards, we analyzed temperature and precipitation changes under different climate states in the Tianshan Mountains region.

The temperature and precipitation data series from 26 meteorological stations were divided according to these four climate states. The analysis focused on how the choice of reference period affects the detection of climate trends and anomalies. The eastern Tianshan Mountains showed particular sensitivity to temperature variations, while the northern slope demonstrated heightened sensitivity to precipitation changes.

2.2 Temperature and Precipitation Level Standards

presents the classification standards for temperature and precipitation levels based on WMO guidelines. The classification uses standardized anomalies (ΔT/ for temperature and ΔR for precipitation) to define seven levels ranging from extremely high to extremely low. These levels provide a framework for assessing the magnitude of climate anomalies relative to the chosen reference period.

The standards show that when ΔT/ 2 or $\Delta R > 80\%$, conditions are classified as extremely high (Level 1). Conversely, when ΔT/ -2 or $\Delta R < -80\%$, conditions are classified as extremely low (Level 7). Intermediate levels are defined by progressively narrower thresholds, allowing for nuanced assessment of climate variability across different states.

3. Results and Analysis

3.1 Temperature Variations Under Different Climate States

[Figure 4: see original paper] illustrates the variation of annual temperature under different climate states in the Tianshan Mountains. The analysis reveals significant differences in temperature trends depending on the reference period used. Under State I and State II, temperature anomalies showed higher values, while State III exhibited lower anomalies. This discrepancy arises because State III (1981–2010) represents a warmer baseline period, making subsequent temperature increases appear less anomalous.

The M-K mutation test results ([Figure 5: see original paper], [Figure 6: see original paper], [Figure 7: see original paper]) demonstrate that the timing of detected temperature mutations varies substantially across climate states. For the northern slope, eastern Tianshan, and southern slope regions, State I showed no significant mutation, State II exhibited earlier mutation points (around 1983–1987), and State III showed later mutation points (around 1995–1998). This indicates that the choice of climate state fundamentally influences the detection of climate change signals.

3.2 Precipitation Variations Under Different Climate States

Unlike temperature, precipitation anomalies showed less sensitivity to the choice of climate state. The analysis found no significant effects of different climate states on precipitation anomaly detection. However, the grades of precipitation levels did vary, with State I and State II showing lower grades compared to State III.

[Figure 8: see original paper] displays the frequency differences of temperature and precipitation levels under different climate states. The results indicate that State III produces higher frequency counts for extreme temperature events compared to States I and II, while precipitation frequencies remain relatively stable across states.

3.3 Extreme Value Probability Differences

quantifies the differences in extreme value probability under different climate states. The table shows the percentage of years with temperature anomalies exceeding ±2 thresholds. For temperature, State I shows 9.09% of years above +2 and -1.82% below -2 , State II shows 12.73% above and -3.63% below, and State III shows 1.82% above and -1.82% below. These differences highlight how the reference period selection affects the statistical characterization of extreme events.

The analysis demonstrates that using State IV (the full 1961–2015 period) as a reference provides the most comprehensive baseline for detecting climate mutations. The mutation points identified using this approach (1995 for temperature, 1997 for precipitation) align with known climate regime shifts in the region.

4. Discussion and Conclusions

The study reveals four key findings: First, the eastern Tianshan Mountains are highly sensitive to temperature changes, while the northern slope shows particular sensitivity to precipitation variations. Second, temperature mutation detection is significantly affected by the choice of climate state, with State II producing earlier mutation detection and State III producing later detection compared to the full period analysis. Third, temperature and precipitation grades are lower under States I and II but higher under State III, while precipitation anomalies remain unaffected by state selection. Fourth, both positive and negative changes can occur when analyzing the same elements under different climate states, emphasizing the need for multi-element evaluation.

The results underscore the importance of carefully selecting climate reference periods for climate change detection and assessment. Using multiple climate states and evaluating their effects on various climate elements provides a more robust and objective basis for understanding climate change patterns in the Tianshan Mountains region.

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Note: Figure translations are in progress. See original paper for figures.