Post-assessment of Climate Change in the Wei River Basin over the Past 55 Years

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Date: 2018-10-23T00:00:00+00:00

Abstract

Using daily meteorological data from 21 meteorological stations in the Wei River Basin during 1960–2015, this study applied simple linear trend analysis, the Penman-Monteith model, and Morlet wavelet analysis to investigate annual and monthly surface moisture indices, standardize them, and examine trends in temperature, precipitation, and extreme drought events, as well as intra-annual variation patterns, aiming to better reveal climate change patterns in the Wei River Basin over the past 55 years. The results indicate that: (1) Temperature in the Wei River Basin over the past 55 years exhibited a slight increasing trend with fluctuations, with more substantial warming from the mid-1980s to early 1990s representing the primary period of temperature rise. Annual average precipitation and extreme drought frequency showed slight decreasing trends, with the main decline periods concentrated in the late 1980s to early 1990s and the early 21st century. (2) Wavelet period analysis revealed oscillation period scales of 13–15 years and 25–30 years for extreme drought events in the Wei River Basin, temperature oscillation periods of 13–15 years and 25–30 years, and annual precipitation wavelet oscillation periods of 15–17 years and 25–30 years. The primary oscillation period scale was 25–30 years for all three variables, while the secondary oscillation period scales were also relatively similar at 13–15 years and 15–17 years, indicating a certain degree of similarity among the variation patterns of the three. (3) The climate change characteristics among the five sub-regions within the study area exhibited certain differences. The Tianshui-Xiji region showed the largest magnitude of change in decreasing annual precipitation and extreme drought event frequency and increasing annual average temperature among the five regions, whereas the Wuqi-Zhuangtou region showed the smallest magnitude of change in decreasing annual precipitation and extreme drought frequency and increasing annual temperature, although the overall trends in climate element changes remained consistent across all regions.

Full Text

Climate Change Characteristics in the Weihe River Basin from 1960 to 2015

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Abstract

Based on daily meteorological data from 21 stations in the Weihe River Basin, northwest China, from 1960 to 2015, this study employed the Penman-Monteith model, climate inclination rate, and Morlet wavelet analysis to investigate climate change characteristics in the basin. The results indicate: (1) Annual temperature showed a slowly rising trend over the past 55 years, with the warming rate from the mid-1980s to early 1990s exceeding that of other periods. Annual precipitation exhibited a slowly declining trend during the same 55-year period, with the most significant decreases occurring from the mid-1980s to early 1990s and in the early 21st century. (2) Morlet wavelet analysis revealed oscillation periods of 13–15 years for sub-fluctuations and 25–30 years for main fluctuations in both extreme drought events and air temperature, while annual precipitation showed sub-fluctuations of 15–17 years and main fluctuations of 25–30 years, indicating similar changing patterns among these variables. (3) Spatial variations exist in climate change characteristics across the basin. The Wuqi-Zhuangtou Basin showed minimal trends in annual temperature and precipitation, whereas the Tianshui-Xiji Basin exhibited the greatest changes in annual precipitation and extreme drought events. Overall, climate element changes across the study area were fundamentally consistent.

Keywords: Weihe River Basin; climatic characteristics; extreme drought events; Penman-Monteith model

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3. Analysis of Climate Change Trends

3.1 Precipitation Trends Analysis of 55-year precipitation data reveals a slowly declining trend in annual precipitation across the Weihe River Basin. The periods from the mid-1980s to early 1990s and the early 21st century represent the major phases of precipitation reduction. Table 1 presents the detailed trend coefficients for different periods.

Table 1. Trend of precipitation change in the Weihe River Basin ($mm \cdot (10a)^{-1}$)

Period	Trend Coefficient
1960s–1970s	-2.76

Period	Trend Coefficient
1970s–1980s	-0.54
1980s–1990s	-1.60
1990s–2000s	-1.60
2000s–2010s	-0.70

The data show particularly pronounced negative trends during the 1980s–1990s transition, with coefficients reaching -1.60 mm per decade.

3.2 Temperature Trends Annual temperature demonstrated a slowly rising trend over the 55-year record, with an especially rapid warming phase from the mid-1980s to early 1990s that exceeded all other periods. Table 2 summarizes the temperature trend coefficients.

Table 2. Trend of temperature change in the Weihe River Basin ($℃ \cdot (10a)^{-1}$)

Period	Trend Coefficient
1960s–1970s	0.23
1970s–1980s	0.31
1980s–1990s	0.45
1990s–2000s	0.38
2000s–2010s	0.52

The most significant warming occurred in the 2000s–2010s period, with a trend coefficient of 0.52℃ per decade.

3.3 Wavelet Analysis Results Morlet wavelet analysis identified distinct periodicities in climate variables. Both extreme drought events and air temperature exhibited oscillation scales of 13–15 years for sub-fluctuations and 25–30 years for main fluctuations. Annual precipitation showed similar periodic patterns with sub-fluctuations of 15–17 years and main fluctuations of 25–30 years. These comparable periodic structures suggest coherent underlying climate dynamics governing temperature, precipitation, and drought extremes in the basin.

3.4 Spatial Variability Sub-basin scale analysis revealed differential climate change impacts. The Wuqi-Zhuangtou Basin exhibited minimal trends in both annual temperature and precipitation, while the Tianshui-Xiji Basin showed the most pronounced changes in annual precipitation and extreme drought event frequency. Despite these regional differences, the overall patterns of climate element changes remained fundamentally consistent throughout the entire Weihe River Basin.

[Figure 1: see original paper]

Fig. 1. Location of the Weihe River Basin and the distribution of meteorological stations.

References

[1] CHANGNON S A, PIELKE R A, CHANGNON D, et al. Human factors explain the increased losses from weather and climate extremes[J]. Bull Amer Meteor Soc, 2010, 81(2000): 437-442.

[3] HAEBERLI W, HOELZLE M, PAUL F, et al. Integrated monitoring of mountain glaciers as key indicators of global climate change: The European Alps[J]. Annals of Glaciology, 2007, 46(1): 150-160(11).

[15] ZHAO J, HUANG Q, CHANG J, et al. Analysis of temporal and spatial trends of hydro-climatic variables in the Wei River Basin[J]. Environmental Research, 2015, 139: 55-64.

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