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Trend Detection in Annual Temperature, Precipitation and Sunshine in Handan City over the Past 65 Years

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Abstract: Human responses to climate change are increasingly constrained, underscoring the urgent need for intensified global mitigation efforts. Here, we examine abrupt shifts and long-term trends in temperature, precipitation, and sunshine duration in Handan City, Hebei Province, from 1955 to 2020. Our results indicate a pronounced increase in mean temperature, with a striking rise of 13.5°C over 66 years, corresponding to 0.21°C per decade. The Mann-Kendall test identified an abrupt temperature shift in 1999. Precipitation showed a significant decline of 20.57 mm per decade, with a marked change detected in 2001. Sunshine duration also exhibited a pronounced decrease, with a loss of 88.82 hours per decade and an average annual sunshine duration of 2,377.1 hours. The most significant reduction in sunshine hours occurred in 1995. These findings underscore profound regional climate shifts over the past six decades.

Keywords: temperature; precipitation; sunshine; climate change; Handan

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Introduction

In 2022, the Intergovernmental Panel on Climate Change (IPCC) reported the 1.1°C global temperature increase since 1890 on ecosystems and human societies [1]. The report highlights the growing limitations of human adaptive capacity in the face of climate change, emphasizing the urgent need for intensified global action.

Extensive research on regional climate change has been conducted both domestically and internationally. Yu Haiying identified a significant rise in both annual mean and minimum temperatures in Guiyang over nearly seven decades, with abrupt shifts detected in 1996 and 1993, respectively [2]. Post-shift, the temperature increased by 0.044°C and 0.056°C annually. Ling Jian's analysis of annual and seasonal temperatures in the Chengdu Plain (1960-2019) revealed a general warming trend following an initial decline [3]. The onset of abrupt surface temperature changes was observed in the early 21st century, and shifts in seasonal temperatures (excluding spring) were evident during the 1990s, preceding those of ground temperatures [4]. Sheng Gao reported a strong warming trend in Hulunbuir from 1960 to 2014, with a linear trend of 0.42°C per decade, driven largely by rising spring temperatures (0.49°C per decade) [5]. Abrupt temperature changes were detected in 1985, followed by a significant upward trend from 1991 to 2014. In Turpan and Hami, abrupt temperature shifts occurred in 1986 and 1996, respectively [6].

However, climate in temperature, precipitation, and sunshine duration in Handan City has not been investigated for the past 65 years. Whether the climate in Handan City align with broader regional climate patterns remains unknown. This study analyzes meteorological data to investigate the climate trends and variability in Handan, contributing to enhanced climate prediction, disaster prevention, and climate adaptation strategies.

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Methodology

Handan City is located at the southern end of Hebei Province, on the eastern foothills of the Taihang Mountains [7]. It spans between longitude 114°03′-40′ E and latitude 36°20′-44′ N, bordered by the Taihang Mountains to the west and the North China Plain to the east, adjacent to the provinces of Shanxi, Shandong, and Henan. Handan City experiences a warm temperate continental monsoon climate with distinct seasons. Spring is often dry, summer is hot and rainy, autumn is mild and cool, and winter is cold and dry [8]. The annual average temperature is 13.5°C, with the coldest month (January) averaging -2.3°C and extreme lows reaching -19°C, while the hottest month (July) averages 26.9°C with extreme highs of 42.5°C.

The data used in this study consists of precipitation, average temperatures, and maximum and minimum temperatures observed at 16 national basic meteorological stations in the Handan region from 1955 to 2020. These data were obtained from the Hebei Provincial Meteorological Information Center. The seasons were categorized as follows: spring (March to May), summer (June to August), autumn (September to November), and winter (December to February of the following year). Climate change trends were analyzed using linear trend analysis and the Mann-Kendall test.

The Mann-Kendall test is a widely applied non-parametric method for detecting trends in climatological [9,10] and hydrological [11] time series. This test offers two key advantages: it does not require the data to follow a normal distribution, and it is less sensitive to abrupt shifts caused by inhomogeneities in the data [12]. Non-detect data points are handled by assigning them a value smaller than the smallest recorded value in the dataset. In the Mann-Kendall test, the null hypothesis (H_0) posits no trend, assuming that the data are independent and randomly ordered, while the alternative hypothesis (H_1) assumes the presence of a trend [13,14].

The M-K trend test statistic can be calculated as shown in Equation (1) [15].

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1} sign\ (x_j - x_k) \tag{1}$$

x_j denotes the ordered data values; n is the length of observations and S is the M-K statistics. The sign of the test statistic is [11].

$$sign\,(x_j - x_k) = \begin{cases} 1 & if\, x_j - x_k > 0 \\ 0 & if\, x_j - x_k = 0 \\ -1 & if\, x_j - x_k < 0 \end{cases} \tag{2}$$

For n ≥ 10 then the S statistic is approximately normally distributed with mean zero (E(S) = 0) and variance as in Equation (3).

$$V\,(S) = \frac{n\,(n-1)\,(2n+5) - \sum_{k=1}^{nk} t_k\,(k)\,(k-1)\,(2k+5)}{18} \tag{3}$$

In cases where ties or duplicate values occur in the time series, tkt_ktk represents the number of ties at extent kkk, and Equation 3 is applied to account for these ties. The total number of ties in the dataset is denoted by nkn_knk. When n≥10n \geq 10n≥10, the standardized test statistic for the Mann-Kendall (M–K) test can be calculated using Equation (4). The test statistic ZsZ_sZs is used to assess the significance of the trend.

$$Z_S = \begin{cases} \frac{S-1}{\sqrt{V(S)}}, & (if\, S > 0) \\ 0, & (if\, S > 0) \\ \frac{S+1}{\sqrt{V(S)}}, & (if\, S > 0) \end{cases} \tag{4}$$

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The statistical analysis for the Mann-Kendall test was conducted using Addinsoft's XLSTAT 2020. The null hypothesis was tested at a 95% confidence level for both temperature and precipitation data across nine states. To supplement the Mann-Kendall test results, linear trend lines were plotted using Microsoft Excel 2020.

2. Results and Analysis

2.1. Temperature

2.1.1. Characteristics of Annual Average Temperature Change

From 1955 to 2020, the average temperature in Handan City shows an increasing trend (significant at the 0.01 level of significance) (**Figure 1A**). The average temperature was lower in 1984 at 12.2°C and higher in 2014 at 14.8°C, with a difference of 2.6°C. The multi-year average temperature is 13.5°C, and the temperature trend rate is 0.21°C/10 years. From 1956 to 2007, the climate trend of average temperature in Hebei Province was 0.364°C/10 years, with Handan's warming slightly lower than the provincial average, showing a gradual increase in temperature. As shown in Figure 1, the 10-year moving average values were lower than the multi-year average before 1998. Since the 1990s, the moving average curve has consistently remained above the multi-year average line, with significant increases and an overall fluctuating upward trend.

Statistical analysis of the decadal average temperatures in Handan City from 1955 to 2020 and calculation of their coefficients of variation reveal certain differences in average temperatures across decades. The highest average temperature occurred in the 2010s at 14.3°C, while the lowest temperatures were observed in the 1960s, 1970s, and 1980s at 13.1°C. The overall average temperature is 13.3°C, with the temperatures in the 1990s, 2000s, and 2010s higher than the average, while those in other decades were lower than the average.

2.1.2. Characteristics of Seasonal Temperature Change

The average spring temperature in Handan City from 1955 to 2020 exhibits a linear increasing trend, with a rise rate of 0.3°C/10 years (significant at the 0.01 level of significance), which is 1.4 times the annual average increase rate (**Table 1**). The maximum average temperature occurred in 2014 at 17.1°C, while the minimum was recorded in 1991 at 12.3°C, resulting in a range of 4.8°C.

Table 1. Average seasonal temperatures by decade in Handan, Hebei from 1955 to 2020.

	1955-1960	1961-1970	1971-1980	1981-1990	1991-2000	2001-2010	2011-2020
Winter	-0.4	-1.1	-0.9	-0.9	0.4	0.3	0.3
Spring	13.9	14.0	14.1	14.0	14.2	15.1	15.9
Summer	26.1	26.2	25.6	25.6	26.1	26.1	26.6
Autumn	13.6	13.5	13.6	13.6	13.8	14.2	14.5
Average Tem	13.3	13.1	13.1	13.1	13.6	13.9	14.3

The average summer temperature is also increasing, with a rise rate of 0.087°C/10 years. The maximum values were observed in 1955 and 2018 at 27.7°C, while the minimum occurred in 1976 at 24.7°C, resulting in a range of 3°C.

The autumn average temperature shows an increasing trend (significant at the 0.01 level of significance), with a rise rate of 0.179°C/10 years. The maximum temperature was recorded in 1998 at 16°C, while the minimum occurred in 1967 and 1992 at 12.5°C, resulting in a range of 3.5°C.

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Similarly, the winter average temperature is increasing (significant at the 0.01 level of significance), with a rise rate of 0.3℃/10 years. The maximum temperature was observed in 2002 at 2.1℃, while the minimum occurred in 1969 at -3.1℃, resulting in a range of 5.2℃.

Therefore, over the past 66 years, the average temperatures across all four seasons in Handan City have shown consistent increasing trends, albeit with varying rates of increase. Comparatively, the spring and winter seasons exhibit the highest rates of increase, followed by autumn, with the lowest rate observed in summer.

Table 1 shows the decadal variation characteristics of the average seasonal and annual temperatures in Handan City. It can be observed that over the past 66 years, the average temperatures in all seasons in Handan City have generally exhibited an increasing trend, but the magnitude of change varies across seasons. The average temperature has increased by 0.0136℃ per year in spring, 0.0136℃ per year in summer, 0.0075℃ per year in autumn, and 0.009℃ per year in winter. The order of increasing enhancement from smallest to largest is spring, summer, winter, and autumn.

2.1.3. Analysis of Temperature Change Detection

Using the Mann-Kendall (M-K) test, an analysis of temperature changes in Handan City was conducted to identify abrupt changes in temperature patterns. The use of the U-F (UF) curve reveals that before 1993, the UF curve fluctuated around the zero line, with most UF values below zero. After 1994, the UF curve was consistently above zero, exceeding the critical significance level of ±0.01 in the 2000s, indicating a significant warming trend in temperatures in Handan. The UF and U-B (UB) curves crossed around 1999, indicating a sudden change in warming trends in Handan's annual average temperatures, with the abrupt change occurring in 1999.

The M-K test for seasonal temperature changes shows the following (**Table 2**):

- Spring temperatures before the 2000s fluctuated around the zero line, with most UF values above zero starting from 1997. By 2007, UF values exceeded the critical significance level of 0.01, and the UF and UB curves crossed around 2004, indicating an abrupt change in spring temperatures in 2004.
- Summer average temperature UF and UB curves have three intersection points, corresponding to UF values above zero, suggesting abrupt increases in summer temperatures. However, these intersections fall within the critical range, indicating that the changes are not significant (**Figure 1B**).
- Autumn average temperature UF and UB curves have four intersection points in 1998, 1999, 2003, and 2009, with corresponding UF values above zero, indicating abrupt increases in autumn temperatures. These intersection points also fall within the critical range, indicating non-significant changes. After 2013, UF values exceed the critical line, indicating a significant upward trend in autumn temperatures.
- Winter average temperature UF and UB curves intersected only once in 1991, with the corresponding UF value above zero, indicating an abrupt increase in winter temperatures. After 2013, UF values exceed the critical line, indicating a significant upward trend in winter temperatures.

Using the Mann-Kendall non-parametric test and trend analysis, the trend changes and verification of temperature in Handan, Hebei from 1955 to 2020 were obtained (see Table 2). It can be observed that the annual temperatures show an overall increasing trend, with significant upward trends observed in spring, autumn, and winter seasons. These trends are verified through a significance test at the 0.05 level (Z-statistic), with the following rate of changes: winter (0.0303), spring (0.0301), summer (0.0088), and autumn (0.0181). The winter season experienced an abrupt change in 1991, the spring season in 2004, and the autumn season in 1998.

Table 2. Trend analysis and M-K test statistics of temperature in Handan, Hebei from 1955 to 2020.

Temperature	R	$(d \cdot a^{-1})$	Z	Year
Winter	0.238	0.0303	0.30349**	1991

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Spring	0.3144	0.0301	0.39953**	2004
Summer	0.0581	0.0088	0.1487179	2009
Autumn	0.1828	0.0181	0.298834**	1998
All Year	0.4006	0.0208	0.436829**	1999

**Significant change.

2.1.4. Spatial Distribution of Annual Average Temperature

The average annual temperatures in Handan gradually increase from north to south (**Figure 1C**). The annual average temperature in Wu'an is 13.4°C, while in Fengfeng it is 14°C. The highest extreme temperatures in the city usually occur in June, while the lowest extreme temperatures are mainly in December (e.g., Daming at -23.6°C). Over the past 66 years, the temperatures across the entire region have shown a significant increasing trend (significant at the 0.01 level), and these variations exhibit a systematic pattern.

The areas with the highest warming trends in the region are observed around Yongnian, with a temperature increase of 0.44°C per decade (**Figure 1D**). This is followed by Wu'an, where the temperature has increased by 0.4°C per decade, and Handan City and Jize area, where the temperature has increased by 0.36°C per decade. Conversely, Daming in the southeast corner of Handan has experienced a much lower temperature increase of only 0.2°C per decade.

2.2. Precipitation

2.2.1. Characteristics of Annual Precipitation

From 1955 to 2020, the annual average precipitation in Handan City exhibited fluctuations but demonstrated an overall decreasing trend (**Figure 2A**), with a reduction of 20.57 mm per decade (statistically significant at the 0.05 level). The lowest average precipitation was recorded in 1992 at 286.2 mm, while the highest was in 1963 at 1148.3 mm, with a difference of 862 mm, which is more than three times the amount in 1992. The multi-year average precipitation is 535.1 mm.

The 10-year moving average values were consistently above the multi-year average before 1973, during 1976–1978, and in 1991. In contrast, from 1973–1975, 1979–1990, and 1992–2020, the 10-year moving averages remained below the multi-year average. Since the 1990s, the moving average curve has continuously stayed beneath the multi-year average, indicating a significant long-term declining trend.

Statistical analysis of decadal average precipitation in Handan City from 1955 to 2020 and calculation of its coefficient of variation reveal variations in precipitation levels across different decades. Precipitation was relatively high in the 1950s and early 1960s, with an average of 685 mm per decade, significantly exceeding the multi-year average of 535 mm. From the late 1960s onwards, the average precipitation began to decline overall. Since the 2000s, there has been an increasing trend in annual average precipitation. This seems somewhat inconsistent with previous precipitation trend analysis results, mainly because over the 65-year time series, most of the time the annual average precipitation has been decreasing, with the increasing trend primarily observed from the 20th century onwards. Further analysis incorporating cyclic patterns will be needed to understand future trends in annual precipitation changes in the Handan area.

2.2.2. Characteristics of Seasonal Precipitation Variation

Looking at seasonal patterns, precipitation distribution in Handan is highly uneven, with distinct wet and dry seasons. The majority of precipitation occurs in summer, with slightly higher precipitation in autumn compared to spring, and the least in winter.

Spring and winter precipitation levels show a fluctuating upward trend, while summer and autumn exhibit a downward trend. The average precipitation in spring is 77.3 mm, with an increasing rate of 2.43 mm per decade (not significant at the 0.05 level of significance); winter precipitation

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averages 15.3 mm, with an increasing rate of 0.395 mm per decade (not significant at the 0.05 level of significance). The decrease in summer precipitation is relatively significant (significant at the 0.05 level of significance), with an average of 344.8 mm and a decreasing rate of 19.96 mm per decade. Autumn precipitation averages 96.7 mm, with a decreasing rate of 3.43 mm per decade (not significant at the 0.05 level of significance).

2.2.3. Analysis of Precipitation Change Detection

Using the Mann-Kendall (M-K) method, a change detection analysis of precipitation in Handan City was conducted (**Figure 2B**). The UF curve indicates that before 1994, the UF curve fluctuated around the zero line, with most UF values below zero. After 1994, the UF curve consistently exceeded zero, and before 2004, it remained below the critical significance level of 0.01, indicating a significant downward trend in precipitation in the Handan area. The UF and UB curves intersected around the 2000s, but did not surpass the confidence level line, indicating no abrupt changes in precipitation.

The M-K test for seasonal precipitation changes shows the following:

- In the summer season, from 1956 to 1962, there was a significant downward trend, and around 1960, UF and UB intersected. In 1963, there was a slight rebound to a small peak due to the summer precipitation in Handan reaching 917.8 mm. However, from 1964 to 1970, there was another significant downward trend. Since 1958, the UF curve has remained mostly below zero, indicating a downward trend in precipitation since the 1960s, with multiple instances of surpassing the confidence level threshold. The decreasing trend in precipitation is evident, and based on trend analysis results, there is no significant change point detected in the average summer precipitation in Handan.

2.2.4. Spatial Distribution of Annual Average Precipitation

The annual average precipitation in Handan ranges from 490 to 540 mm (**Figure 2C**). The spatial distribution of annual precipitation is highly uneven, with a general trend of more precipitation in the southeast and less in the northwest. Ji'ze is the driest area in Handan, with annual precipitation less than 500 mm. Next is the area around Yongnian, Feixiang, and Quzhou, with annual precipitation around 500 mm. On the other hand, Wu'an, Fengfeng, and Wei County are the rainy centers of the city, with annual precipitation reaching up to 540 mm, followed by areas in Shexian and the western part of Wu'an, with annual precipitation around 530 mm. Over the past 52 years, there has been significant spatial variability in precipitation in Hebei Province. Precipitation across the region has shown a decreasing trend. In terms of trend, apart from Yongnian and Guantao, the rest show a declining trend, with only Da Ming's declining trend passing the 0.05 significance level (**Figure 2D**).

2.3. Sunshine

2.3.1. Characteristics of Annual Average Sunshine Hours

An analysis of annual sunshine hours in Handan from 1955 to 2020 revealed that the annual average sunshine hours in Handan were 2377.1 hours, showing a significant decreasing trend (through a significant test of 0.01), with a rate of decrease of 88.82 hours per decade (**Figure 3A**). Over the past 66 years, the highest annual average sunshine hours were in 1965 (2896.8 hours), and the lowest was in 2003 (1868.4 hours), with a difference of 1028.4 hours, showing considerable variability.

Comparing the changes in sunshine hours across different decades reveals the following trend: the average sunshine hours in the 1950s were 2562.9 hours, followed by the 1960s with 2553.9 hours, the 1970s with 2519 hours, the 1980s with 2500.2 hours, the 1990s with 2325.5 hours, the 2000s with 2128.4 hours, and the 2010s with 2123.9 hours. The significant decrease in sunshine hours from the 1980s to the 2000s is mainly due to the rapid economic development in China, leading to a rapid increase in energy consumption and a weaker capacity for pollution control, resulting in a significant increase in particulate matter in the air. Additionally, stable weather systems in autumn and winter during this period are unfavorable for the dispersion of pollutants, leading to a decrease in average

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total cloud cover and consequently, a decrease in average sunshine hours. The relative decrease in other decades is relatively smaller.

2.3.2. Analysis of Seasonal Sunshine Hours Variation Characteristics

Based on the trend distribution of seasonal sunshine hours, it can be observed that the sunshine hours in each season are decreasing. The decreasing trends per decade are as follows: spring -3.804 hours/10 years, summer -30.718 hours/10 years, autumn -26.8 hours/10 years, and winter -27.5 hours/10 years. Except for spring, the decreasing trends in the other seasons are statistically significant at the 0.01 level, with summer showing the most pronounced decline.

Specifically:

- Spring: Sunshine hours increased from 1955 to 1962, reaching a peak in 1962 at 847.9 hours and a minimum in 1964 at 476.6 hours, a difference of 371.3 hours. There was a slight increase from 1965 to 1981, followed by a continuous decrease from 1982 to 2003, with an increase observed from 2018 to 2020.
- Summer: Sunshine hours were relatively high from 1955 to 1965, then rapidly decreased from 1966 to 1981, slightly increased from 1983 to 1986, and then sharply declined from 1987 to 2020.
- Autumn: Sunshine hours have been continuously decreasing.
- Winter: Sunshine hours have shown a consistent decline, with a rapid decrease observed from 1980 to 2001 and a slower decline from 2004 to 2019.

Based on the intergenerational seasonal variation patterns:

- Spring: Sunshine hours increased from the 1950s to the 1980s, with relatively high sunshine hours in the 1980s.
- Summer and Winter: Relatively high sunshine hours were observed in the 1960s.
- Autumn: Relatively high sunshine hours were observed in the 1950s.
- From the 1990s to the 2000s, sunshine hours decreased across all seasons.
- In the 2010s, sunshine hours increased in spring and summer but continued to decrease in autumn and winter.

2.3.3. Analysis of Sunshine Hours Change Detection

An analysis using the Mann-Kendall (M-K) change detection method on the annual sunshine hours in Handan from 1955 to 2020 revealed the following:

- Before 1970 and during 1974-1979, UF values were less than 0, indicating a decreasing trend in sunshine hours.
- During 1970-1973 and 1980-1988, UF values were greater than 0, indicating an increasing trend in sunshine hours.
- After 1989, UF values were less than 0 again, showing a decreasing trend in sunshine hours, with a significant deviation beyond the 0.01 confidence level around 1999.

The UF and UB curves intersected only once within the confidence interval in 1995, indicating a clear change point.

An M-K change detection analysis on the seasonal sunshine hours in Handan from 1955 to 2020 showed the following (**Table 3**):

- Spring: UF values alternated around 0 from 1956 to 1965, with fluctuating sunshine hours. There were three intersections of UF and UB curves within the confidence interval, suggesting no significant change.
- Summer: Sunshine hours showed a decreasing trend from 1955 to 1958, 1960-1965, and 1967 (UF < 0), followed by an increasing trend in 1959, 1966, and 1968-1970 (UF > 0) (**Figure 3B**). After 1973, UF values decreased again (UF < 0), with a significant deviation beyond the 0.01 confidence level around 2002. The UF and UB curves intersected only once within the confidence interval in 1994, indicating a clear change point.
- Autumn: Sunshine hours increased from 1955 to 1959 (UF > 0), followed by a decreasing trend after 1960 (UF < 0), with a significant deviation beyond the 0.01 confidence level around 1999. The UF and UB curves intersected only once within the confidence interval in 1995, indicating a

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clear change point.

- Winter: The UF and UB curves intersected only once within the confidence interval in 1995, suggesting a clear change point.

Table 3. Trend Analysis and M-K Test Statistics for Sunshine in Handan, Hebei from 1955 to 2020.

Sunshine	R	d· a^{-1}	Z	Year
Winter	0.4	-2.7506	-0.45268**	1994
Spring	0.0121	-0.3804	-.076923	
Summer	0.4429	-3.0718	-0.46946**	1994
Autumn	0.4266	-2.68	-0.476923**	1995
All Year	0.5582	-8.8828	-0.533799**	1995

**Significant.

2.3.4. Spatial Distribution of Sunshine

The western part of Handan is characterized by the Taihang Mountains, while the eastern part comprises the North China Plain, resulting in relatively complex terrain that influences sunshine distribution (**Figure 3C**). Areas such as Feixiang, Guangping, and Wei County receive the highest sunshine hours, reaching up to 2240 hours annually, whereas the sunshine hours are relatively lower in the western mountainous areas, averaging between 2200 to 2240 hours per year (**Figure 3D**).

Conclusion

Daily precipitation data from 16 surface meteorological stations in the Handan region, spanning the period from 1955 to 2020, were analyzed using linear regression and M-K test to assess trends in temperature, precipitation, and sunshine duration. The key findings are as follows:

(1) Temperature: the average temperature in Handan displayed an increasing trend from 1955 to 2020, with a multi-year mean of 13.5°C and a temperature trend rate of 0.21°C per decade. Seasonal temperature trends also showed increases: spring temperatures rose at a rate of 0.3°C per decade, summer at 0.087°C per decade, autumn at 0.179°C per decade, and winter at 0.3°C per decade. M-K test detected a significant temperature shift in 1999. Seasonal M-K analysis revealed temperature mutations in spring (2004), autumn (1999), and winter (1991), while no significant mutation was observed for summer.

(2) Precipitation: the annual average precipitation in Handan exhibited fluctuations but overall displayed a decreasing trend, with a decline of 20.57 mm per decade (statistically significant at the 0.05 level). The lowest average precipitation occurred in 1992, measuring 286.2 mm, while the highest was recorded in 1963 at 1,148.3 mm, marking a substantial difference of 862 mm—1992's precipitation was nearly three times lower than that of 1963. The multi-year average precipitation was 535.1 mm. M-K test identified a significant shift in average precipitation in 2001.

(3) Sunshine duration: analysis of annual sunshine hours in Handan from 1955 to 2020 revealed an average of 2,377.1 hours per year, with a significant decreasing trend at a rate of 88.82 hours per decade (significant at the 0.01 level). The highest recorded sunshine hours occurred in 1965 (2,896.8 hours), while the lowest were in 2003 (1,868.4 hours), a difference of 1,028.4 hours, reflecting substantial interannual variability. M-K test detected a significant shift in sunshine duration in 1995, as indicated by the intersection of the UF and UB curves within the confidence interval.

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