Comparative Analysis of Wind Speed Data from the Old and New Sites of Gansu Wuwei Station (Postprint)

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Abstract

To scientifically and rationally utilize meteorological data before and after station relocation, this study employs statistical methods including mean and variance significance tests, correlation coefficient analysis, and linear regression to comparatively analyze the variation characteristics, differences, and underlying causes of wind speed changes between the new and old sites of the Wuwei National Basic Meteorological Station in Gansu from 2006 to 2018. The results indicate that wind speeds at both sites exhibit a decreasing trend, with the decreasing rates of average and extreme wind speeds being greater at the new site than at the old site, while the decreasing rate of maximum wind speed is smaller at the new site. Most comparative observations show positive wind speed differences between the new and old sites, with the primary causes being variations in the surrounding environment, geographical location, and altitude of the observation field before and after relocation. The significance tests for wind speed differences are inconsistent between variance and mean tests: the former shows no significant differences, while the latter indicates mostly significant differences. Wind speeds between the new and old sites demonstrate significant positive correlations, with most correlation coefficients passing significance tests. The monthly linear regression equations are highly significant, passing the F-test at the $\alpha = 0.01$ significance level. After regression correction, wind speed differences are substantially reduced, indicating that wind speed data from the new and old sites can be statistically merged. This research provides a scientific reference basis for station migration, forecast prediction, meteorological services, scientific research, and large-scale engineering construction.

Full Text

Contrast Analysis of Wind Speed Data from the New and Old Stations in Wuwei City, Gansu Province

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Abstract

To ensure scientifically rational utilization of meteorological data before and after station relocation, this study employs statistical methods including mean and variance significance tests, correlation coefficients, and linear regression to analyze wind speed variation characteristics, differences, and their underlying causes between the new and old sites of the Wuwei National Basic Meteorological Station in Gansu Province, based on comparative observation data from 2006 to 2018. The results demonstrate that wind speeds at both stations exhibit decreasing trends, with the new station showing greater decline rates for average and extreme maximum wind speeds but a lower decline rate for maximum wind speed compared to the old station. Most comparative observations reveal positive wind speed differences between the new and old sites, primarily attributable to changes in the observation field's surrounding environment, geographic location, and altitude following relocation. Significance tests yield inconsistent results: variance tests show no significant differences, whereas mean tests indicate mostly significant differences. The wind speeds between the two sites display clear positive correlations, with most correlation coefficients passing significance tests. Monthly linear regression equations are highly significant, passing F-tests at the $\alpha = 0.01$ significance level. After regression correction, wind speed differences are substantially reduced, indicating that the wind speed data from both stations can be combined for statistical applications. This research provides a scientific reference for station migration, forecasting, meteorological services, scientific research, and large-scale engineering construction.

Keywords: basic station; wind speed; comparative analysis; Wuwei

Introduction

Meteorological stations often relocate due to urban expansion and other factors, making it essential to analyze differences in observational data before and after such moves to ensure proper data utilization and avoid erroneous results from discontinuities. Previous studies have examined these issues: Shi Dengke et al. conducted homogeneity research on long-term data series before and after station relocations to provide correction methods, while Li Youjun et al., Bian

Tao et al., Zhou Haonan et al., and Liu Weiping et al. performed comparative analyses of temperature, pressure, and precipitation data following station moves. Sun Lei et al., Wang Qiuxiang et al., and Gao Tingting et al. investigated the impacts of relocation and instrument changes on wind speed data, and Jia Xiaoqin et al. and Wang Qiuxiang et al. analyzed differences in ground temperature and meteorological elements in extreme arid regions.

The Wuwei National Basic Meteorological Station (hereafter "Wuwei Station") has relocated twice since its establishment, most recently due to urban expansion. By 2015, the old site had become surrounded by increasingly numerous and tall buildings that compromised data accuracy and representativeness, resulting in an assessment score that failed to meet the standards specified in the *Specifications for Surface Meteorological Observation*. To improve the observation environment and ensure data quality and comparability, the station relocated in 2015 to the Wuwei Agricultural Meteorological Experiment Station in Qingyuan Town, Liangzhou District, approximately 18.7 km from the old site. Parallel observations began on January 1, 2015, and the new site officially commenced operations on January 1, 2016, while the old site continued as a regional station observing temperature, precipitation, and wind speed. This study analyzes the 2015–2018 parallel wind speed observations to examine trends, differences, and their causes, providing scientific guidance for the appropriate use of meteorological data.

1. Environmental Overview of the New and Old Sites

The old site, located at Xinguan Village, Gaoba Town, east of Wuwei's Liangzhou urban area, had been in use since 1976. Recent urban expansion led to a proliferation of tall buildings around the observation field, severely degrading the detection environment and compromising data quality. The site received an assessment score of only 8.7 points, far below the *Specifications for Surface Meteorological Observation* standard. In contrast, the new site in Qingyuan Town (rural area) offers flat terrain, open vistas, and unobstructed airflow, with few permanent buildings taller than 8.7 m nearby. It achieved an assessment score of 94.5 points, with topography, landforms, soil, and vegetation similar to conditions at the old site's initial establishment. Situated on forestry land with a stable and reliable observation environment, the new site can represent the climatic conditions of the original detection area and meets all environmental requirements for meteorological observations.

3. Wind Speed Comparison Analysis

3.1 Annual Wind Speed Comparison Analysis of annual average, maximum, and extreme maximum wind speeds reveals decreasing trends at both sites. The old site's average and maximum wind speed trends passed significance tests at $\alpha = 0.01$, indicating highly significant decreasing trends, while its extreme maximum wind speed trend was not significant. At the new site, the average wind speed trend was significant at $\alpha = 0.05$, but maximum and extreme maximum wind speed trends were not significant. Annual differences between the two sites were positive for average and maximum wind speeds, with average wind speed differences ranging from -1.0 to 3.1 $\mathrm{m \cdot s^{-1}}$ (maximum in 2015, minimum in 2018), maximum wind speed differences from 0.2 to 2.4 $\mathrm{m \cdot s^{-1}}$ (maximum in 2015, minimum in 2018), and extreme maximum wind speed differences from -2.9 to 3.4 $\mathrm{m \cdot s^{-1}}$ (maximum in 2015, minimum in 2018). The synchronous variation of the two curves indicates similar trends, though differences are more pronounced for daily data.

Using linear trend regression analysis with the equation $x_i = a + bt_i$, where x_i is the climatic variable, t_i is time, and b represents the climate tendency rate, the results align with previous research showing generally decreasing wind speeds across the Hexi Corridor and northern/southern Xinjiang. Global warming, which weakens cold air intensity and reduces its frequency, may be a primary cause of this reduction.

[Figure 1: see original paper]

3.2 Monthly Wind Speed Comparison Monthly average, maximum, and extreme maximum wind speed differences were mostly positive (except for extreme maximum in January), indicating higher values at the new site. Monthly average wind speed differences ranged from 0.3 to 0.6 $\mathrm{m \cdot s^{-1}}$ (maximum in April, minimum in January), maximum wind speed differences from 0.5 to 2.4 $\mathrm{m \cdot s^{-1}}$ (maximum in April, minimum in January), and extreme maximum wind speed differences from -0.3 to 2.0 $\mathrm{m \cdot s^{-1}}$ (maximum in April, minimum in January). Wind speed differences peak during spring when cold and warm air masses alternate. From winter through spring (January to April), average, maximum, and extreme maximum wind speeds show a gradual increasing trend before decreasing.

4. Significance Testing, Correlation, and Regression Analysis

4.1 Variance Significance Testing F-tests were conducted on monthly variances of average, maximum, and extreme maximum wind speeds. At $\alpha = 0.05$, all calculated F-values were below the critical value F_α, indicating no significant variance differences between the new and old sites.

4.2 Mean Significance Testing T-tests on monthly means revealed significant differences for most months. At $\alpha = 0.05$, average wind speeds showed significant differences in all months except January; maximum wind speeds were significantly different in all months; and extreme maximum wind speeds were significantly different in all months except January, February, and December. These results indicate that wind speed data from before and after relocation cannot be used continuously without correction.

4.3 Correlation and Regression Analysis Correlation coefficients between monthly wind speeds at the two sites show strong positive relationships (Table

6). Most correlation coefficients for maximum and extreme maximum wind speeds passed significance tests at $\alpha = 0.01$. Average wind speed correlation coefficients were significant at $\alpha = 0.01$ for April, May, and October; at $\alpha = 0.05$ for March, June, and September; at $\alpha = 0.1$ for February, July, and August; and not significant for January, November, and December.

Linear regression equations were established with new site wind speed as the independent variable and old site wind speed as the dependent variable. F-tests at $\alpha = 0.01$ with degrees of freedom (1, n-2) showed all regression equations to be highly significant. After applying these equations for correction, the mean absolute differences for average, maximum, and extreme maximum wind speed sequences were reduced to 0.5, 0.9, and 1.3 $\mathrm{m \cdot s^{-1}}$, respectively—substantially lower than the pre-correction differences of 1.8, 2.1, and 2.5 $\mathrm{m \cdot s^{-1}}$. This demonstrates that corrected data from both stations exhibit homogeneity and continuity, allowing for combined statistical application.

5. Causes of Wind Speed Differences

5.1 Observation Environment The primary cause of wind speed differences is the changed observation environment. The old site, originally suburban, has become increasingly urbanized with numerous tall buildings that obstruct wind flow, while the new site in a rural area remains open and unobstructed. This aligns with findings from Guo Xiaoqin et al., Sun Chengfang et al., and Li Hongjun et al. Additionally, the old site exhibits a pronounced urban heat island effect, with temperatures rising faster than at the new site. Research by Wang Zongcheng et al. indicates that temperature increases can contribute to wind speed reductions, suggesting that the urban heat island effect is another factor causing lower wind speeds at the old site.

5.2 Altitude Altitude differences between the two sites also affect wind speeds. Using the power law $V_2 = V_1 \times (H_2/H_1)^{\alpha}$, where V_1 is wind speed at known height H_1 and V_2 is wind speed at estimated height H_2, with $\alpha = 0.15$ for rural/suburban areas, adjusting new site wind speeds to the old site's altitude reduces the absolute differences to 0.7, 1.4, and 2.0 $\mathrm{m \cdot s^{-1}}$ for average, maximum, and extreme maximum wind speeds—significantly smaller than the uncorrected differences. This confirms that altitude substantially contributes to wind speed variations.

6. Conclusions

Wind speeds at both Wuwei's new and old stations show decreasing trends annually, monthly, and daily, with most differences being positive. Wind speed differences increase from winter to spring before decreasing. Typical monthly diurnal variation curves for average, maximum, and extreme maximum wind speeds exhibit synchrony between the two sites. Differences arise primarily from variations in detection environment, altitude, topography, and urban heat island effects, with observation environment and altitude being the main contributors.

Variance tests show no significant differences in monthly average, maximum, and extreme maximum wind speeds, while mean tests indicate significant differences, confirming that the data cannot be used continuously without correction. However, strong positive correlations exist between the two sites, with most correlation coefficients passing significance tests. Monthly linear regression equations are highly significant, and after regression correction, the data demonstrate homogeneity and continuity, enabling combined statistical application.

This study not only analyzes wind speed trends and differences between Wuwei's new and old sites but also provides homogeneity corrections, avoiding errors from non-uniform and discontinuous data. The results offer scientific guidance for future station relocations, meteorological services, scientific research, and large-scale engineering projects.

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