Postprint: A Refined Analysis of Temperature and Wind Speed Differences Before and After the Turpan Station Relocation

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Abstract

Based on hourly comparative observations of temperature and wind speed from the old and new Turpan stations in 2017, hourly differences were calculated and categorized; concurrently, monthly average temperature and wind speed data from 1988 to 2018 were selected for t-tests. The results indicate: (1) The temperature and wind speed differences between the old and new Turpan stations both display skewed distributions, with most values being positive and the differences widely scattered. Only 40.7% of temperature differences fall within -1 ℃< T<1 ℃, while 32.1% fall outside \$±\$2 ℃; 46% of wind speed differences fall within -1 m·s-1< S<1 m·s-1, while 21.4% fall outside \$$\pm 2 m \cdot s-$
$1.(2) Negativetemperaturedifferencesoccurprimarilyduringdaytimehoursfrom 11:$
$00 to 18:00, withmarginallylargernegativevaluesinthecoldseasonfromOctobertoMayofthefollowingyear, wit$
1.5℃$. Positivetemperaturedifferencesoccurprimarilybetween 18:00 and 11:$
$00 thefollowingday, withlargerdifferences(\triangle T$ 2℃$) occurringmainlyinthewarmseasonfromApriltoNovemb$
$seasonnights, whichcauseddiscontinuitiesinthemonthlyaveragetemperaturesfromMarchtoNovember(sprin$
$testwithP < 0.01).(3) ComparisonwithAksuStation, alsolocatedinanaridregion, revealsthattheunderlyingsur$
S \$1 m·s-1 occur mostly in the warm season from March to September; smaller wind speed differences (-1 m·s-1< S<1 m·s-1) are more prevalent in the cold season (October-December and January-March). The t-test shows (P<0.01) that discontinuities appeared in the monthly average wind speeds for all months when the station was relocated in 2016.

Full Text

Refined Analysis of Air Temperature and Wind Speed Differences Before and After the Relocation of Turpan Meteorological Station

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Abstract: Climate change research requires long-term, high-quality climate datasets, yet observational data are highly susceptible to environmental influences that can introduce non-homogeneities. This study examines the impact of station relocation on data quality in arid regions through a refined analysis of Turpan meteorological station, which experienced significant environmental changes during its move. Using hourly air temperature and wind speed data from 2017, we calculated and classified hourly differences between the old and new stations. Monthly average temperature and wind speed data from 1988–2018 were also subjected to t-tests to assess data continuity. The results reveal that: (1) Due to substantial environmental differences between the old and new stations, both temperature and wind speed differences exhibit positively skewed distributions. Only 40.7% of temperature differences fell within ± 1 °C, while 32.1% exceeded ± 2 °C; for wind speed, 78.6% of differences were within $\pm 1 m \cdot s^{-1}$, while 21.4% exceeded $\pm 2 m \cdot s^{-1}$. (2) Negative temperature differences occurred primarily during daytime (11:00–18:00), particularly in the cold season (October–May), with the lowest average difference reaching -1.5 °C. Positive temperature differences >2 °C occurred mainly at night (18:00–11:00) during the warm season (April–November), with maximum average differences up to 5 °C. These large nocturnal warm-season differences created breakpoints in monthly mean temperatures from March–November 2016 (significant at $P < 0.01$). (3) Compared with Aksu station in the same arid region, the underlying surface and observation environment fundamentally drive these differences. Positive wind speed differences $1 m \cdot s^{-1}$ occurred mainly in the warm season (March–September), while smaller differences ($-1\ m \cdot s^{-1} < \Delta < 1\ m \cdot s^{-1}$) dominated the cold season. T-tests revealed breakpoints in monthly mean wind speed for all months at the 99% significance level.

Keywords: air temperature; wind speed; difference value; comparative analysis; Turpan

Introduction

Climate change research relies on long-term, homogeneous climate data series, with century-long temperature records built upon consistent observational datasets. However, observational accuracy is easily compromised by environmental changes that introduce breakpoints, affecting data continuity. Urbanization has profoundly altered station environments in recent decades, creating non-homogeneities in climate records. Previous studies have identified urbanization bias as the largest systematic error in China' s surface temperature observations and have applied corrections to annual and monthly temperature series. While many stations have relocated to avoid urbanization effects, such moves raise questions about data continuity between old and new sites.

Differences between old and new station data arise from multiple factors: relocation distance, elevation differences, and contrasting observation environments. Research indicates that urban heat island effects impact old and new stations differently across time periods, with nocturnal differences typically exceeding daytime differences. Seasonal variations also exist, with larger differences in winter, spring, and autumn compared to summer, potentially creating breakpoints in post-relocation monthly averages. However, most previous analyses have focused on annual, seasonal, and monthly mean differences, which smooth out diurnal variations and obscure the precise timing of discrepancies. Hourly difference analysis provides the granularity needed to accurately characterize day-night contrasts and their impact on data continuity, forming a critical foundation for constructing homogeneous long-term climate datasets. Since temperature and wind speed are particularly sensitive to observation environments, this study employs 2017 hourly data from Turpan' s old and new stations to calculate, classify, and analyze diurnal difference patterns, laying groundwork for more precise data homogenization.

1.1 Station Observation Environment

Turpan' s old station was situated within the city, surrounded by buildings with a park immediately outside its walls. Building clusters, particularly to the southeast, south, and southwest, stood only 20–30 m from the observation field, blocking direct sunlight after 11:00 [Figure 1: see original paper]. The new station occupies an unobstructed Gobi location 4.364 km from the old site with a 1.5 m elevation difference. The underlying surface consists of coarse sand without trees or vegetation, creating stark environmental contrast [Figure 1: see original paper].

1.2 Data Selection and Methods

We selected 2017 hourly temperature and wind speed data from both stations, sourced from the Xinjiang Meteorological Information Center and subjected to rigorous quality control. Hourly differences (new station minus old station) were calculated and analyzed by distribution. Temperature differences were classified into five levels (with sparse categories merged appropriately), and wind speed differences into five levels (also with merges for sparse categories). Proportions were calculated for each difference class.

To further characterize difference magnitudes, we computed monthly hourly mean differences (hereinafter "hourly mean differences") to examine diurnal patterns. Using January 1, 2016 as the cutoff when the new station became operational, we performed t-tests on monthly mean temperature and wind speed from 1988-2015 (old station) versus 2016-2018 (new station) to assess data continuity.

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2 Results and Analysis

2.1 Temperature Differences

2.1.1 Magnitude Distribution Hourly temperature differences show a positively skewed distribution, with most values positive (new station warmer than old) and widely dispersed. Only 40.7% of differences fell within $±$1 °C, while 32.1% exceeded $±$2 °C. Positive differences accounted for 63.3% of observations, negative differences for 36.7% [Figure 2: see original paper]. Despite the short 4.364 km relocation distance and minimal 1.5 m elevation change, large environmental differences created substantial dispersion in temperature differences.

2.1.2 Monthly Distribution Positive temperature differences >2 °C concentrated in the warm season (April-November), particularly June-August when intense solar radiation on the Gobi surface elevated new station temperatures far above the tree-shaded, building-obstructed old station. Differences of 1-2 °C occurred relatively uniformly across seasons. Negative differences (-2 °C < $\Delta \leq$ -1 °C) appeared more frequently in cold seasons (October-May), with $\leq$-2 °C differences occurring mainly in spring and autumn, though comprising only 0.6% of total observations [TABLE:1, TABLE:2]. Overall, warm-season positive differences dominated, while cold-season negative differences were more common, requiring careful attention when merging datasets.

2.1.3 Daily Distribution Negative temperature differences occurred primarily during daytime (11:00-18:00), especially 12:00-17:00, when building shadows cooled the old station while the new station received full sun . Positive differences >2 °C appeared mainly at night (18:00-11:00), peaking before 09:00. This pattern reflects building geometry: before 11:00, the sunlit new station warmed rapidly while the shaded old station lagged; after 17:00, the old station fell into shadow and cooled quickly while the new station remained warm, maintaining higher temperatures.

2.1.4 Hourly Mean Difference Distribution Monthly hourly mean differences reveal seasonal patterns [Figure 3: see original paper]. Cold-season months (October–May) showed negative mean differences (old station warmer), with winter differences reaching -1.0 °C to -1.5 °C. Warm-season months (April–September) exhibited positive differences up to 5 °C, with June–August showing the largest values. Transitional months (May, September–October) displayed smaller differences, generally within \$±\$0.5 °C.

2.2 Wind Speed Differences

2.2.1 Magnitude Distribution Wind speed differences also show positive skewness, with 89.2% positive (new station windier) and only 10.8% negative. Differences were more concentrated than temperature: 78.6% fell within \$±1$m \cdot s$^{-1}\$, and 21.4% exceeded \$±2$m \cdot s$^{-1}\$ [FIGURE:2, TABLE:4]. The new station' s exposed Gobi location consistently experienced stronger winds than the city-obstructed old station.

2.2.2 Monthly Distribution Positive differences \$ 1$m \cdot s$^{-1}\$ occurred mainly in warm-season months (March–September) when new station winds swept across bare Gobi while vegetation at the old station created drag . Smaller differences ($-1\ m \cdot s^{-1} < \Delta < 1\ m \cdot s^{-1}$) dominated cold-season months (November–March) when defoliation reduced drag at the old station. Negative differences were minimal, comprising only 10.8% of observations.

2.2.3 Daily Distribution Wind speed differences $>1\ m \cdot s^{-1}$ were evenly distributed diurnally but slightly more frequent before 10:00 . Differences of 0–1 $m \cdot s^{-1}$ were uniformly distributed, while negative differences appeared more often before 12:00, though representing a small proportion overall.

2.2.4 Hourly Mean Difference Distribution Hourly mean wind speed differences varied seasonally and diurnally [Figure 4: see original paper]. Winter differences were smallest (mostly within 1 $m \cdot s^{-1}$), spring and autumn moderate (within 1.5 $m \cdot s^{-1}$), and summer largest (within 2.3 $m \cdot s^{-1}$). Diurnally, differences peaked around 04:00–06:00 and were smallest after 12:00, with a secondary peak in spring/summer around 14:00–16:00.

2.3 Long-term Data Continuity Test

Using January 1, 2016 as the breakpoint, t-tests revealed significant discontinuities in monthly mean temperatures for March–November ($P < 0.01$), with no breakpoints in December–February . For wind speed, all twelve months showed breakpoints ($P < 0.01$), indicating the relocated data cannot be used continuously without adjustment.

3 Discussion

The analysis shows that daytime negative temperature differences (old station warmer) align with urban heat island theory, as concentrated urban populations and heating systems elevate city temperatures. However, unlike typical findings where nocturnal urban temperatures also exceed suburban values, Turpan exhibits the opposite pattern: nighttime new station (suburban) temperatures exceed old station (urban) values from 18:00–11:00, especially in the warm season. This reversal stems not only from underlying surface differences but also from building shadows that prevent direct solar radiation from reaching the old station' s observation field after 11:00.

Comparing Turpan with Aksu station (also in an arid region) highlights this uniqueness . Aksu shows daytime old-station warmth across all seasons, consistent with typical urban heat island patterns. Nocturnally, Aksu' s old station remains warmer in summer, autumn, and winter, whereas Turpan' s new station is warmer at night in spring, summer, and autumn. Aksu' s 2011 relocation moved the station only 2.3 km to an industrial park with vegetation, where underlying surfaces were similar and differences primarily reflected urbanization effects. Turpan' s 4.364 km move to open Gobi created fundamentally different environmental conditions, producing its distinctive temperature difference pattern. Thus, Turpan' s anomalies arise not merely from its arid location but from the specific underlying surface and observation environment changes.

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4 Conclusions

This refined analysis of hourly temperature and wind speed differences before and after Turpan station' s relocation yields the following conclusions:

1. **Temperature differences** show positively skewed distributions with 63.3% positive values. Large environmental differences created dispersed differences: only 40.7% fell within ± 1 °C, while 32.1% exceeded ± 2 °C. Negative differences occurred mainly during daytime (11:00-18:00), particularly in the cold season (average minimum -1.5 °C). Positive differences >2 °C dominated nighttime (18:00-11:00) in the warm season, reaching 5 °C. These large nocturnal warm-season differences created statistically significant breakpoints ($P < 0.01$) in March–November monthly mean temperatures.

2. **Wind speed differences** also show positive skewness (89.2% positive), with 78.6% within $\pm 1 m \cdot s^{-1}$ and 21.4% exceeding $\pm 2 m \cdot s^{-1}$. Differences $1 m \cdot s^{-1}$ occurred mainly in the warm season (March–September), while smaller differences dominated the cold season. Hourly mean differences peaked at 2.3-2.5 $m \cdot s^{-1}$ in summer. T-tests revealed breakpoints in monthly mean wind speed for all twelve months ($P < 0.01$), precluding continuous use without correction.

3. **Environmental factors**: Unlike typical urbanization-affected stations, Turpan exhibits higher nighttime temperatures at the new suburban station. This pattern reflects not merely the arid climate but the fundamental influence of underlying surface and observation environment changes. Protecting observation environments is therefore critically important.

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