

## Variation of Pan Evaporation in Xinjiang Region and Wavelet-Based Periodic Analysis Postprint

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### Abstract

Both  $\Phi 20$  cm and E601 evaporation pans are used in Xinjiang, but the two data series have been incomplete since the beginning of observations, particularly after 2003 when data were not integrated and corrected, which has limited the use and in-depth analysis of evaporation pan data. Based on the concurrent observation period data of  $\Phi 20$  cm (E20) and E601 evaporation pan evaporation (E601), this study selected 57 meteorological stations in Xinjiang to analyze the conversion coefficient  $K$  between E20 and E601 during April to October. Taking Kashgar (in Southern Xinjiang) and Tacheng stations (in Northern Xinjiang) with longer data series as examples, the variation of  $K$  at daily and monthly scales was analyzed, and the monthly  $K$  values were used to estimate E20 for the two typical stations from April 1 to September 30 during 2003–2016, thereby obtaining a complete daily E20 series for 1961–2016. Furthermore, the spectral characteristics and periodic variations of E20 at monthly and annual scales were analyzed based on the complex Morlet wavelet function. The results indicate that: (1) The conversion coefficient between E20 and E601 in Xinjiang shows substantial spatial variation during April–October, with  $K$  values in Southern Xinjiang being larger than those in Northern Xinjiang. (2) The infilled complete daily E20 series during 1961–2016 at Kashgar and Tacheng stations exhibit typical annual periodic variations, monthly E20 peaks in July, and annual E20 shows a significant increasing trend; E20 at Kashgar station is higher than that at Tacheng station at daily, monthly, and annual scales. (3) The primary and quasi-periods of E20 from January to December at the two stations fluctuate with periods of 2–16 years, the primary period of annual E20 is 7 years for both stations, the quasi-periods are 3 and 6 years for Kashgar station, and 2 and 4 years for Tacheng station. This study can provide a reference for the infilling and further application of evaporation series in Xinjiang.

## Full Text

### Abstract

The 20-cm-diameter and E601 type evaporation pans have been used in Xinjiang, China, but these two kinds of data sequences so far are incomplete since the start of observation. Especially since 2003, the data have not been integrated and corrected, which has restricted the use of pan evaporation data and their further analysis. Based on the co-observation data of 20-cm-diameter (E20) and E601 pan evaporation (E601) from 57 meteorological stations in Xinjiang, this study analyzed the conversion coefficient  $K$  between E20 and E601 from April to October. Taking Kashgar (in southern Xinjiang) and Tacheng stations (in northern Xinjiang)—both with relatively long data sequences and representative—as examples, the changes of  $K$  at daily and monthly time scales were analyzed and later used to estimate E20 values for the period from April 1 to September 30 spanning 14 years (from 2003 to 2016). Therefore, the complete daily E20 data sequences for Kashgar and Tacheng over the period from 1961 to 2016 were obtained and could be further used in spectral characteristics and periodic change analysis using the complex Morlet wavelet function. The results showed as follows: (1) The conversion coefficient of E20 and E601 in the Xinjiang region had significant spatial differences from April to October, and  $K$  values were larger in southern Xinjiang than those in northern Xinjiang. (2) The complete daily E20 data series during the period from 1961 to 2016 at Kashgar and Tacheng stations had typical periodical changes on a yearly basis. The monthly E20 was the largest in July, and the annual E20 had an obvious increasing trend. Daily, monthly, and annual E20 values in Kashgar were all larger than those in Tacheng. (3) The main period and quasi-period of E20 ranged within 2–16 years from January to December, and the main period was 7 years for both stations. The quasi-periods at Kashgar station were 2 and 4 years, but at Tacheng station they were 3 and 6 years, respectively. This research could provide useful references for the interpolation and further application of pan evaporation in Xinjiang.

**Keywords:** pan evaporation; conversion factors; wavelet analysis; Xinjiang

## 1. Introduction

Evaporation is a critical component of the hydrological cycle and energy balance. In China, both the 20-cm diameter pan (E20) and the E601 type pan have been used for evaporation observations. However, the data sequences from these two types of pans are often incomplete, particularly since 2003 when data integration and correction procedures were not systematically implemented. This has significantly restricted the application of pan evaporation data for long-term trend analysis and hydrological modeling.

Previous studies have investigated evaporation trends across China for the period 1960–2000 using  $\Phi 20$  cm pans, revealing significant spatial and temporal

variability [1, 13]. Other research has focused on the period 1960–2005, analyzing changing trends and their potential causes [14, 15]. However, few studies have addressed the systematic conversion between E20 and E601 data or reconstructed complete data series for Xinjiang, a region characterized by complex topography and climate gradients.

This study aims to: (1) establish a robust conversion coefficient  $K$  between E20 and E601 pan evaporation data for Xinjiang; (2) reconstruct complete daily E20 data series for representative stations; and (3) analyze the periodic characteristics of evaporation using wavelet analysis.

## 2. Data and Methods

### 2.1 Study Area and Data

Xinjiang Uygur Autonomous Region, located in northwestern China between  $85.8^{\circ}$ – $94.7^{\circ}$ E and  $36.9^{\circ}$ – $44.3^{\circ}$ N, encompasses a diverse range of elevations from 30 to 3095 m. The region experiences mean annual temperatures of  $0.7$ – $14.5^{\circ}$ C, wind speeds of  $0.8$ – $4.0$   $\text{m} \cdot \text{s}^{-1}$ , relative humidity of  $39.4\%$ – $67.4\%$ , and sunshine duration of  $7.1$ – $9.1$  hours [24].

We selected 57 meteorological stations across Xinjiang with co-located E20 and E601 measurements during the period April–October. Among these stations, Kashgar in southern Xinjiang and Tacheng in northern Xinjiang were chosen as representative examples due to their relatively long and complete data records spanning 1961–2016.

### 2.2 Conversion Coefficient $K$

The conversion coefficient  $K$  between E20 and E601 was calculated as:

$$K = \frac{E20}{E601}$$

where E20 represents evaporation measured by the 20-cm diameter pan and E601 represents evaporation measured by the E601 pan. This coefficient was computed for each station for the period April–October. Using ArcGIS 10.2, we performed spatial interpolation to generate regional maps of  $K$  values.

The correlation between E20 and E601 was analyzed using linear regression. The coefficient of determination ( $R^2$ ) ranged from 0.66 to 0.85 across stations, with the representative stations showing  $R^2$  values up to 0.934, indicating strong linear relationships suitable for data conversion.

### 2.3 Wavelet Analysis

To investigate the periodic characteristics of evaporation, we employed the complex Morlet wavelet function. This method is particularly effective for identifying both main periods and quasi-periods in hydrometeorological time series.

The wavelet analysis was applied to the reconstructed daily E20 data series from 1961 to 2016 for both Kashgar and Tacheng stations.

### 3. Results

#### 3.1 Spatial Distribution of Conversion Coefficient K

Figure 3 shows the spatial distribution of the conversion coefficient K across Xinjiang. The results reveal significant spatial differences, with K values notably larger in southern Xinjiang compared to northern Xinjiang. This pattern reflects regional differences in climatic conditions, particularly temperature, humidity, and wind regime, which affect pan evaporation differently.

#### 3.2 Temporal Variations of E20

The reconstructed daily E20 data series for Kashgar and Tacheng from 1961 to 2016 exhibit typical periodic changes on an annual basis. Monthly E20 values peak in July for both stations, coinciding with maximum solar radiation and temperature. The annual E20 shows an obvious increasing trend over the study period, consistent with regional warming.

Daily, monthly, and annual E20 values in Kashgar are consistently larger than those in Tacheng, reflecting the warmer and drier climate of southern Xinjiang compared to the more temperate conditions in the north.

#### 3.3 Periodic Characteristics

Wavelet analysis reveals that the main period and quasi-period of E20 range within 2-16 years throughout the year. The main period is 7 years for both Kashgar and Tacheng stations. However, the quasi-periods differ between stations: Kashgar shows quasi-periods of 2 and 4 years, while Tacheng exhibits quasi-periods of 3 and 6 years. These periodicities likely reflect regional climate oscillations and large-scale atmospheric circulation patterns.

### 4. Conclusion

This study successfully developed a conversion coefficient K between E20 and E601 pan evaporation data for Xinjiang, reconstructed complete daily E20 data series for representative stations, and identified characteristic periodicities in evaporation using wavelet analysis. The findings provide a methodological framework for data interpolation and offer insights into the temporal dynamics of evaporation in this arid region. The reconstructed data and identified periodicities can support improved water resource management and hydrological modeling in Xinjiang.

## References

- [1] ZENG Yan, QIU Xinfu, LIU Changming, et al. Changes of pan evaporation in China in 1960–2000[J]. *Advances in Water Science*, 2007, 18(4): 437-442.
- [13] QI Tianyao, ZHANG Qiang, WANG Yue, et al. Spatiotemporal patterns of pan evaporation in 1960–2005 in China: Changing properties and possible causes[J]. *Progress in Geography*, 2015, 35(12): 1599-1606.
- [14] QI Tianyao, ZHANG Qiang, WANG Yue, et al. Spatiotemporal patterns of pan evaporation in 1960–2005 in China: Changing properties and possible causes[J]. *Progress in Geography*, 2015, 35(12): 1599-1606.
- [15] LIU Min, SHEN Yanjun, ZENG Yan, et al. Changing trend of pan evaporation and its cause over the past 50 years in China[J]. *Acta Geographica Sinica*, 2009, 64(3): 259-269.
- [16] QIU Xinfu, LIU Changming, ZENG Yan. Changes of pan evaporation in the recent 40 years over the Yellow River Basin[J]. *Journal of Natural Resources*, 2003, 18(4): 437-442.
- [18] LI Yi, ZHOU Mudan. Projections of water requirements of cotton and sugar beet in Xinjiang based on a statistical downscaling method[J]. *Transactions of the Chinese Society of Agricultural Engineering*, 2014, 30(22): 70-79.
- [20] LI Yuetan, LI Xiaoyan, CUI Buli, et al. Trend of pan evaporation and its impact factors over Lake Qinghai Basin from 1961 to 2007[J]. *Journal of Lake Sciences*, 2010, 22(4): 616-624.
- [21] LI Linping, LI Yanying, LIU Mingchun. Change trend of pan evaporation and its causes in Shiyang River Basin during 1961–2005[J]. *Journal of Desert Research*, 2012, 32(3): 832-841.
- [22] LIU Cuishan, LI Haichuan, WANG Guoqing, et al. Conversional relationship between different pan evaporations for the Lancang River Basin[J]. *Journal of North China University of Water Conservancy and Hydropower*, 2017, 38(6): 72-77.
- [24] Climatic data for Xinjiang region

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