

Diurnal Variation Characteristics of Precipitation (Rain and Snow) in the Kashgar Region (Postprint)

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Abstract

Using hourly precipitation data from 10 meteorological stations in Kashgar Prefecture, Xinjiang from January to December 2010-2017, the diurnal variation characteristics of rainfall and snowfall (hereinafter collectively referred to as precipitation) in Kashgar Prefecture over the past 8 years were analyzed and statistically examined. The results show that: (1) The diurnal variations of annual precipitation amount and frequency in Kashgar Prefecture exhibit obvious fluctuations, generally displaying a “sine wave” pattern with one peak and one valley. The precipitation amount peaks at 03:00 (Beijing Time, hereinafter the same) and reaches its minimum at 18:00; the precipitation frequency peaks at 04:00 and reaches its minimum at 18:00; the timing of the peaks and minima is similar for both. (2) From 2010 to 2017, the annual precipitation amount and frequency in Kashgar Prefecture showed a significant increasing trend; whereas the interannual variation of precipitation intensity remained relatively stable with no significant change. (3) The diurnal variation trend of precipitation intensity is not consistent with that of precipitation amount and frequency. (4) Precipitation in Kashgar Prefecture throughout the year is dominated by short-duration precipitation events, among which the number of 1-hour duration precipitation events is the maximum; however, the maximum values of precipitation amount and contribution rate both appear in 2-hour and 6-hour duration precipitation events. Precipitation throughout the year is mainly dominated by precipitation processes that begin in the late night and morning hours, and remains primarily short-duration precipitation.

Full Text

Preamble

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Abstract

Precipitation represents the most conspicuous indicator of climate change in any region, with its magnitude and distribution directly constraining national economic development, agricultural productivity, and individual livelihoods. Kashgar Prefecture in Xinjiang, China, located in the heartland of Central Asia, belongs to the warm temperate continental arid climate zone, characterized by distinct four seasons and abundant sunshine. The region exhibits large annual and diurnal temperature variations, scarce precipitation, and strong evaporation. Although Xinjiang's overall precipitation is relatively low, the contribution of extreme precipitation events to total precipitation amounts continues to increase. Previous research on precipitation in Kashgar has primarily focused on monthly precipitation patterns or diurnal variation characteristics. In the context of global warming, studying the annual variation of precipitation throughout the entire year is particularly important—not only for meteorological services in the region but also for guiding artificial flood control and precipitation enhancement operations, and for understanding climate characteristics and trends in Xinjiang.

This study utilizes hourly precipitation data from 10 meteorological stations in Kashgar Prefecture from January 2010 to December 2017 to analyze the diurnal variation characteristics of precipitation (including precipitation amount, frequency, intensity, and temporal distribution) for both rainfall and snowfall events. The results demonstrate: (1) Obvious fluctuations exist in the annual variation of both precipitation amount and frequency in Kashgar, forming a sinusoidal pattern with one peak and one valley. The precipitation peak occurs at 03:00 AM (Beijing time, same below) and the valley at 18:00 PM, while the frequency peak appears at 04:00 PM and the valley at 18:00 PM. (2) From 2010 to 2017, annual precipitation and precipitation frequency in the Kashgar region showed significant increasing trends, whereas annual precipitation intensity exhibited a gentle trend without obvious changes. (3) No consistency exists between the diurnal variation trend of precipitation intensity and the frequency or amount of precipitation. (4) Annual precipitation depends mainly

on short-duration events, with most precipitation lasting approximately 1 hour. Precipitation events with 2-hour duration contributed the most to total precipitation amount, while 6-hour duration events ranked first from the contribution ratio perspective. Precipitation in the Kashgar region is dominated by events occurring in the middle of the night and morning hours.

Keywords: precipitation (rain and snow); diurnal variation; precipitation frequency; precipitation intensity; Kashgar Prefecture

1 Introduction

1.1 Study Area

Kashgar Prefecture is located in the southwestern part of Xinjiang Uyghur Autonomous Region, between $74^{\circ}20' - 79^{\circ}57' E$ and $35^{\circ}20' - 40^{\circ}18' N$. The prefecture covers an area of $16.2 \times 10^4 \text{ km}^2$, with a maximum length of 750 km from east to west and a maximum width of 535 km from north to south. The region encompasses diverse topographical features including mountains, basins, plains, and deserts.

The study area experiences a warm temperate continental arid climate with four distinct seasons, ample sunshine, large diurnal temperature ranges, low precipitation, and high evaporation. The terrain slopes from southwest to northeast, with complex and variable landscapes. The climate conditions are harsh, with frequent meteorological disasters that significantly impact local agricultural production and socioeconomic development.

1.2 Data and Methods

This analysis employs hourly precipitation data from 10 meteorological stations across Kashgar Prefecture spanning 2010–2017. The dataset includes precipitation amount, frequency, intensity, and duration measurements. Precipitation events are classified into four temporal periods: morning (08:00–13:00), afternoon (14:00–19:00), evening (20:00–01:00), and night (02:00–07:00) [28].

The precipitation intensity threshold is defined as 0.1 mm/h. Extreme precipitation events are identified using the 95th percentile method [26, 31]. Statistical analysis focuses on diurnal variation patterns, temporal trends, and the contribution of different duration events to total precipitation.

2 Results

2.1 Diurnal Variation Characteristics

The diurnal variation of precipitation in Kashgar exhibits pronounced nocturnal dominance. Analysis reveals that precipitation amount peaks at 03:00 AM,

reaching a maximum of 124 mm for 1-hour duration events, accounting for 68.4% of total precipitation frequency [Figure 6: see original paper]. The minimum occurs at 18:00 PM. In contrast, precipitation frequency peaks at 04:00 PM, with the same minimum at 18:00 PM [Figure 5: see original paper].

The distribution shows that 70.2% of precipitation events occur between 00:00–12:00, with the highest frequency concentrated in the early morning hours. Events lasting 6 hours represent 54.6% of the total, while 15.7% of events exceed 6 hours in duration.

2.2 Precipitation Duration and Contribution

Short-duration precipitation events dominate the annual precipitation pattern in Kashgar. Events lasting approximately 1 hour constitute the majority of occurrences, while 2-hour duration events contribute the most to total precipitation amount. However, from a contribution ratio perspective, 6-hour duration events rank highest.

The contribution rate analysis demonstrates that precipitation events with 10-hour duration account for 67.5% of the total annual precipitation, with a total accumulation of 489.73 mm [Figure 7: see original paper]. The spatial distribution reveals that stations in the central and eastern parts of the prefecture show higher contribution rates from medium-duration events (6–9 hours), while western stations exhibit higher contributions from short-duration events (2–4 hours).

2.3 Temporal Trends

From 2010 to 2017, both annual precipitation amount and frequency demonstrate statistically significant increasing trends ($p < 0.05$). The annual precipitation intensity, however, shows no significant trend, indicating that the increase in total precipitation is primarily driven by more frequent events rather than more intense ones.

The seasonal analysis indicates that nighttime precipitation (02:00–07:00) contributes 33.4% to the total annual amount, followed by evening events (20:00–01:00) at 26.5%, morning events (08:00–13:00) at 27.3%, and afternoon events (14:00–19:00) at 12.8%.

3 Discussion

The nocturnal peak in precipitation amount (03:00 AM) aligns with previous studies on diurnal variation in arid regions [2, 7–10]. This pattern is associated with topographic forcing and atmospheric circulation characteristics unique to the Tarim Basin. The increasing trend in precipitation frequency without corresponding intensity changes suggests that climate warming may be altering

the hydrological cycle through more frequent but not necessarily more intense events.

The dominance of short-duration events has important implications for water resource management and flood forecasting in this arid region. While long-duration events are less frequent, their disproportionate contribution to total precipitation highlights the need for improved monitoring and prediction capabilities for persistent precipitation systems.

4 Conclusion

This study reveals distinct diurnal variation patterns of precipitation in Kashgar Prefecture characterized by: 1. A sinusoidal pattern with precipitation amount peaking at 03:00 AM and frequency peaking at 04:00 PM, both reaching minima at 18:00 PM. 2. Significant increasing trends in annual precipitation amount and frequency from 2010-2017, with no significant change in intensity. 3. Dominance of short-duration events, with 1-hour events being most frequent, 2-hour events contributing most to total amount, and 6-hour events showing the highest contribution ratio. 4. Nocturnal and morning precipitation dominance, accounting for over 60% of annual precipitation.

These findings provide crucial guidance for meteorological services, artificial precipitation enhancement operations, and climate adaptation strategies in Kashgar Prefecture and similar arid regions.

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

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