Postprint: Characteristics of Short-Duration Heavy Precipitation in Xinjiang During the Warm Season

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Abstract

Based on hourly precipitation observation data from 105 surface meteorological stations in Xinjiang during May–September of 2005–2015, this study analyzes the spatiotemporal distribution characteristics and precipitation contribution rate of short-duration heavy precipitation. The results indicate that the frequency distribution of short-duration heavy precipitation during the warm season in Xinjiang exhibits characteristics of higher frequency in Northern Xinjiang than in Southern Xinjiang, and higher frequency on mountain slopes than in valleys and deserts; however, the precipitation contribution rate of short-duration heavy precipitation is conversely higher in Southern Xinjiang than in Northern Xinjiang. The seasonal north-south shift of high-frequency short-duration heavy precipitation zones from spring to autumn is closely related to the north-south shift of solar radiation and the subtropical frontal zone. Both Northern and Southern Xinjiang show unimodal patterns in the monthly and ten-day distributions of short-duration heavy precipitation frequency, but their variation patterns differ: the former increases and decreases rapidly, whereas the latter increases rapidly but decreases slowly. The diurnal variation of average short-duration heavy precipitation frequency across Xinjiang exhibits three peaks: a main peak in the afternoon (18:00–19:00) and secondary peaks in the early night (22:00) and early morning (08:00). Northern Xinjiang follows the same pattern, while Southern Xinjiang shows significant differences in both the timing and intensity of these three peaks.

Full Text

Preamble

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Abstract: Based on hourly precipitation data from 105 meteorological stations in Xinjiang from May to September during the period of 2005–2015, this study investigates the spatiotemporal characteristics of precipitation and the contribution rates of short-duration heavy rainfall (hereinafter referred to as SDHR) in Xinjiang. SDHR events are defined as instances where 1-hour precipitation 0.1 mm • h [1], calculated using the percentile method: $x = (1-[p(n+1)-j])x_j + [p(n+1)-j]x_{j+1}$, where $j = [p(n+1)]$, p is the percentile, n is the sample size, and x_j represents the j-th value in the sorted dataset.

The results indicate that the frequency of SDHR in northern Xinjiang was higher than that in southern Xinjiang, and higher on mountain slopes than in valleys and deserts. However, the contribution rate of SDHR in southern Xinjiang was higher than that in northern Xinjiang. The seasonal north-south shift of the high-frequency zone of SDHR was closely related to the north-south passage of solar radiation and the subtropical zone from spring to autumn. The curves of monthly and ten-day average frequencies of SDHR in northern and southern Xinjiang were unimodal, but their variation patterns differed. The monthly frequency of SDHR increased first and then decreased rapidly, while the ten-day frequency increased rapidly but decreased slowly. There were three peak values in the daily variation of SDHR average frequency: the highest occurred at 18:00–19:00 BT, the second and third at 22:00 BT and 08:00 BT respectively. Compared with the whole Xinjiang and northern Xinjiang, the occurring time and intensity of the three peak values were significantly different in southern Xinjiang.

Keywords: warm season; short-duration heavy rainfall; spatiotemporal distribution; precipitation contribution rate; Xinjiang

Main Findings

The spatial analysis reveals that SDHR frequency is elevated in northern Xinjiang compared to southern Xinjiang, with mountainous areas showing particularly high frequencies. Conversely, contribution rates are higher in southern Xinjiang. The seasonal migration of high-frequency zones correlates with the northward progression of solar radiation and the subtropical zone during the warm season.

Temporal analysis shows distinct patterns in SDHR occurrence. Monthly and ten-day frequency curves exhibit unimodal distributions with different trajectories: monthly frequencies rise then fall sharply, while ten-day frequencies rise sharply but decline gradually. Daily variations demonstrate three characteristic peaks [Figure 3: see original paper], with the primary maximum at 18:00–19:00 BT, and secondary maxima at 22:00 BT and 08:00 BT. Southern Xinjiang exhibits markedly different timing and intensity for these peaks compared to other

regions.

Contribution rate analysis indicates that 71.4% of SDHR events account for 10.0%–25.0% of total precipitation. The extreme event record shows a maximum 1-hour precipitation intensity of 67.2 mm · h ^{1} observed on August 19, 2009 at 18:00, with other significant events reaching 53.2 mm · h ^{1}, 53.0 mm · h ^{1}, and 52.1 mm · h ^{1} [Figure 7: see original paper]. The 95th percentile threshold for SDHR identification is 5.1 mm · h ^{1}.

[Figure 4: see original paper] illustrates annual and daily variations of monthly SDHR frequencies, while [Figure 5: see original paper] shows daily variations in annual mean frequencies. The relationship between precipitation intensity and occurrence timing is depicted in [Figure 6: see original paper]. Monthly contribution ratios throughout the warm season are presented in [Figure 8: see original paper].

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