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Spatial and Temporal Variations of Extreme Climate Events in Xinjiang, China during 1961-2010

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Abstract

Daily maximum/minimum temperature and precipitation data from 35 weather stations in Xinjiang during 1961-2010 were examined using kriging spatial analysis, linear tendency estimation, and correlation analysis. Temporal trends and spatial distribution patterns of extreme temperature and precipitation in this area were then analyzed using 12 extreme temperature and 7 extreme precipitation indices. The following results were obtained. 1) Over the past 50 years, extreme cold indices, excepting the monthly maximum temperature minimum value and monthly extreme minimum temperature, showed slight decreasing trends. These indices include the maximum number of consecutive frost days, icy days, cold-nighttime days, and cold-daytime days. 2) Extreme warm events generally showed significant increasing trends ($P < 0.01$), including the indices of summertime days, warm-nighttime days, warm-daytime days, monthly extreme maximum temperature, and monthly minimum temperature maximum value. 3) The spatial distributions of threshold values of extreme warm and cold events showed notable regional differences. A reducing trend of extreme cold events and an increase in extreme warm events has occurred mainly in northern Xinjiang. 4) For the past 50 years, six extreme precipitation indices, aside from consecutive dry days, showed significant increasing trends in Xinjiang ($P < 0.05$) and notable differences in spatial distribution. The increase in extreme precipitation events was more rapid at northern than at southern sites. Extreme precipitation intensity was greater in mountainous areas, and precipitation frequency increased in the plain region. 5) Factor analysis revealed good correlations among extreme temperature indices, excepting extreme temperature days.

Keywords

Xinjiang Area, Extreme Climatic Event, Spatial Change

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1. Introduction

At present, no doubt exists about global warming. The fourth assessment report of the Intergovernmental Panel on Climate Change [1] identified a warming trend of 0.13°C/10a over the past 50 years. The warming trend in China has been 0.22°C/10a [2], with significant increases in annual mean temperature and heating rate [3]. The increasing mean temperature not only affects the change in extreme temperature values, but can also leads to extreme climatic events, such as heat waves and rainstorms, which show trends of increasing frequency, strength, and intensity [4].

Many studies have indicated that frequent extreme climatic events cause huge losses for society and the economy, as well as loss of human lives [5]. The most recent statistics reveal an increase of up to 10-fold in the economic loss arising from global climatic change and related extreme climatic events over the past 40 years. In China, weather disasters caused by extreme climatic events account for 70% of all natural hazards [6]. Hence, extreme climatic events are sources of widespread concern for governments and researchers [7] [8]. Studies of changes in these events are necessary not only to guarantee state security and economic development, but also to prevent disasters, reduce damage-related needs, and, most importantly, safeguard people's safety and livelihoods.

Xinjiang, located far from the ocean in the center of Eurasia, in the border region of northwestern China, is impacted by the uplifted Tibetan Plateau, westerly wind circulation effects, and high mountain landforms. This region is thus an important route by which cold air invades China, and has a diverse climate. Northern Xinjiang has a variable continental arid and semi-arid climate, whereas southern Xinjiang has a warm continental arid climate; the ecology of these regions is fragile and has suffered greatly under the influence of climatic change [9]-[12]. In recent years, large studies have investigated the spatial and temporal distribution of and variation in extreme precipitation in Xinjiang [13]. These studies are of great importance for attaining a correct understanding of climatic variation in this region. However, most previous studies have considered single meteorological elements, such as temperature or precipitation in southern or northern Xinjiang, and discrepancies exist in the length of time represented by meteorological data and stations from which they were collected. Hence, this study was conducted using internationally recognized extreme climatic indices to examine long-term trends of change in extreme climatic events and their spatial distribution patterns, as well as problems existing in the whole of Xinjiang that have actual reference value for economic development and response to climatic disasters in the future.

2. Research Data and Methods

2.1. Research Data Source and Treatment

Daily precipitation and maximum, minimum, and mean temperature data from China's Meteorological Administration for the period 1961-2010 in Xinjiang were used for this study. Data from 43 meteorological stations were reviewed to identify problems with missing or misdetected observations. We selected high-quality data from 35 stations (**Table 1**, **Figure 1**) as the study target. For missing and misdetected data from stations with less complete records, we used corrected data from Bai Lei *et al.* [14].

2.2. Study Method

The standards used to define and calculate the extreme climatic indices used in this study were based on the World Meteorological Organization's Commission for Climatology World Climate Research and Climatic Variation and Predictability programs' expert team on climate change detection, monitoring, and indices [15]. This methodology has been applied to many countries and regions [16], including Xinjiang. Using RClimDex software (http://cccma.seos.uvic.ca/ETCCDMI/), 19 extreme climatic indices (7 related to precipitation and 12 related to temperature) were developed and applied (**Table 2**).

All of the extreme climate indices reflect three aspects of temperature or precipitation events: strength, frequency, and temporal duration of climatic change. In extreme climate research, a certain percentile value is usually adopted as a threshold (with values exceeding it defined as extreme), and calculations are performed according to the nonparametric method of Bonsal *et al.* [17], as follows: for a meteorological factor with N values, these values are sorted in ascending order ($X_1, X_2, \ldots, X_m, \ldots, X_N$); the probability that a certain value is less than or equal to the rank of X_m is then $P = (m - 0.31)/(N + 0.38)$, where P denotes percentile, m is the serial number

of X_m, and N is the number of meteorological values.

In this study, percentile values were used to calculate relative and other indices. Specifically, temperature data were sorted in ascending order, and the 90th and 10th percentile values were regarded as thresholds for extreme temperature. When the highest temperature on a given day exceeded the 90th percentile value, an extreme high-temperature event was considered to have occurred on that day; when the highest temperature on a given day was less than the 10th percentile value, an extreme low-temperature event was considered to have occurred. Secondly, we analyzed extreme climatic events using linear tendency estimation, the Mann-Kendall method, and the kriging method of spatial analysis.

Table 1. Site meteorological information in the study area.

| No.	Station	Longitude (°E)	Latitude (°N)	Elevation (m)	Period of series
1	Habahe	86.40	48.05	532.6	1961.01.01-2010.12.31
2	Jimunai	85.87	47.43	984.1	1961.01.01-2010.12.31
3	Fuai	87.47	47.12	500.9	1961.01.01-2010.12.31
4	Aletai	88.08	47.73	735.3	1961.01.01-2010.12.31
5	Fuyun	89.52	46.98	807.5	1961.01.01-2010.12.31
6	Qinghe	90.38	46.67	1218.2	1961.01.01-2010.12.31
7	Alashankou	82.57	45.18	336.1	1961.01.01-2010.12.31
8	Tuoli	83.60	45.93	1077.8	1961.01.01-2010.12.31
9	Beitashan	90.53	45.37	1653.7	1961.01.01-2010.12.31
10	Caijiahu	87.53	44.20	440.5	1961.01.01-2010.12.31
11	Qitai	89.57	44.02	793.5	1961.01.01-2010.12.31
12	Yinning	81.33	43.95	662.5	1961.01.01-2010.12.31
13	Zhaosu	81.13	43.15	1851.0	1961.01.01-2010.12.31
14	Baluntai	86.30	42.73	1739.0	1961.01.01-2010.12.31
15	Kumishi	88.22	42.23	922.4	1961.01.01-2010.12.31
16	Bayinbuluke	84.15	43.03	2458.0	1961.01.01-2010.12.31
17	Tulufan	89.20	42.93	34.5	1961.01.01-2010.12.31
18	Akesu	80.23	41.17	1103.8	1961.01.01-2010.12.31
19	Baicheng	81.90	41.78	1229.2	1961.01.01-2010.12.31
20	Luntai	84.25	41.78	976.1	1961.01.01-2010.12.31
21	Kuerle	86.13	41.75	931.5	1961.01.01-2010.12.31
22	Tuergate	75.40	40.52	3504.4	1961.01.01-2010.12.31
23	Wuqia	75.25	39.72	2175.7	1961.01.01-2010.12.31
24	Kashi	75.98	39.47	1289.4	1961.01.01-2010.12.31
25	Aheqi	78.45	40.93	1984.9	1961.01.01-2010.12.31
26	Alaer	81.27	40.55	1012.2	1961.01.01-2010.12.31
27	Ruoqiang	88.17	39.03	887.7	1961.01.01-2010.12.31
28	Shache	77.27	38.43	1231.2	1961.01.01-2010.12.31
29	Pishan	78.28	37.62	1375.4	1961.01.01-2010.12.31
30	Hetian	79.93	37.13	1375.0	1961.01.01-2010.12.31
31	Minfeng	82.72	37.07	1409.5	1961.01.01-2010.12.31
32	Qiemo	85.55	38.15	1247.2	1961.01.01-2010.12.31
33	Balikun	93.00	43.60	1677.2	1961.01.01-2010.12.31
34	Yiwu	94.70	43.27	1728.6	1961.01.01-2010.12.31
35	Hongliuhe	94.67	41.53	1573.8	1961.01.01-2010.12.31
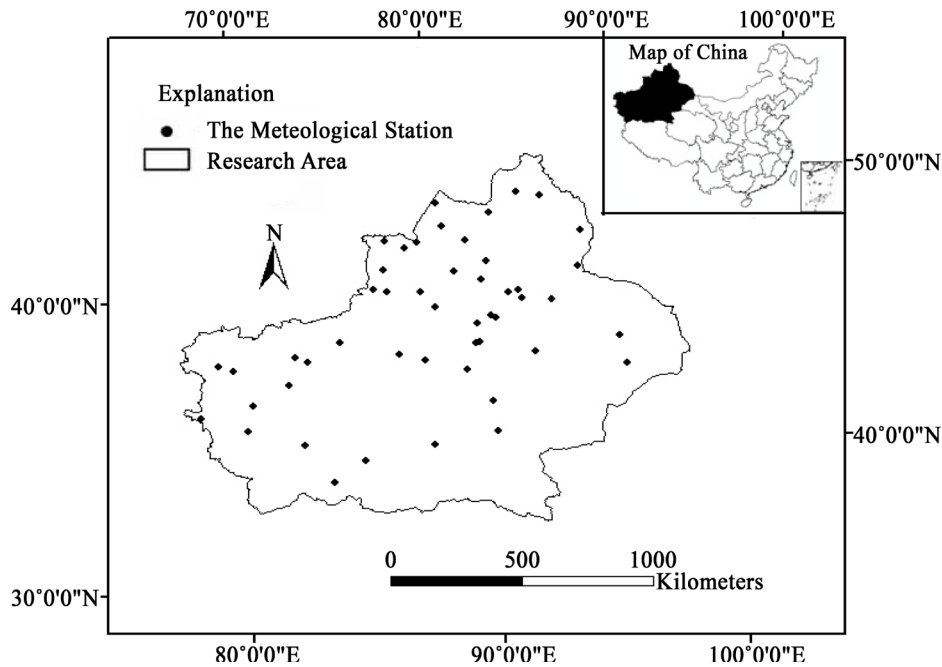
Figure 1. Distribution of meteorological stations in Xinjiang.

**Table 2.** Definition of extreme temperature and precipitation indices.

	Index	Descriptive name	Definition	Unit
Temperature	TXx	Warmest day	Annual highest TX	˚C
	TNx	Warmest night	Annual highest TN	˚C
	TXn	Coldest day	Annual lowest TX	˚C
	TNn	Coldest night	Annual lowest TN	˚C
	TN10p	Cold night frequency	Percentage of days when TN < 10th percentile of 1961-1990	d
	TX10p	Cold day frequency	Percentage of days when TX < 10th percentile of 1961-1990	d
	TN90p	Warm night frequency	Percentage of days when TN > 90th percentile of 1961-1990	d
	TX90p	Warm day frequency	Percentage of days when TX > 90th percentile of 1961-1990	d
	FD	Frost days	Annual count when TN < 0˚C	d
	ID	Ice days	Annual count when TX < 0˚C	d
	SU25	Summer days	the highest temperature is over 25˚C day number	d
	DTR	Diurnal temperature range	Annual mean difference between TX and TN	˚C
Precipitation	SDII	Simple daily intensity index	Average precipitation on wet days	Mm/d
	PRCPTOT	Wet day precipitation	Annual total precipitation from wet days	mm
	RX1day	Maximum 1-day precipitation	Annual maximum 1-day precipitation	mm
	RX5day	Maximum 5-day precipitation	Annual maximum consecutive 5-day precipitation	mm
	CDD	Consecutive dry days	Maximum number of consecutive dry days	d
	CWD	Consecutive wet days	Maximum number of consecutive wet days	d
	R95p	Very wet day precipitation	Annual total precipitation when RR > 95th percentile of 1961-1990 daily precipitation	mm

Notes: [a]All the indices are calculated by RCLimDEX. Abbreviations are as follows: TX, daily maximum temperature; TN, daily minimum temperature; TG, daily mean temperature; RR, daily precipitation. A wet day is defined when RR ≥ 0.1 mm, and a dry day is defined when RR < 0.1 mm. Indices are included for completeness but are not analyzed further in this article.

3. Changes in Extreme Temperature Events in Xinjiang over the Past 50 Years

3.1. Interannual Variation in Extreme Cold Events

Consistent with global changes, the frequency of extreme low-temperature events in the Xinjiang area was found to have decreased while that of extreme high-temperature events increased [18]. Linear variation in extreme cold indices in Xinjiang over the past 50 years generally showed a decreasing curvilinear trend (**Figure 2**). The interannual variation tendency rates for the maximum numbers of continuous frost days (FDs), icy days (IDs), cold-nighttime days (TN10p), and cold-daytime days (TX10p) were −4.8 d/10a, −2.75 d/10a, −2.24 d/10a, and −0.88 d/10a, respectively (all $\alpha \leq 0.01$), and their correlation coefficients by year were −0.774, −0.475, −0.827, and −0.39, respectively (**Table 3**).
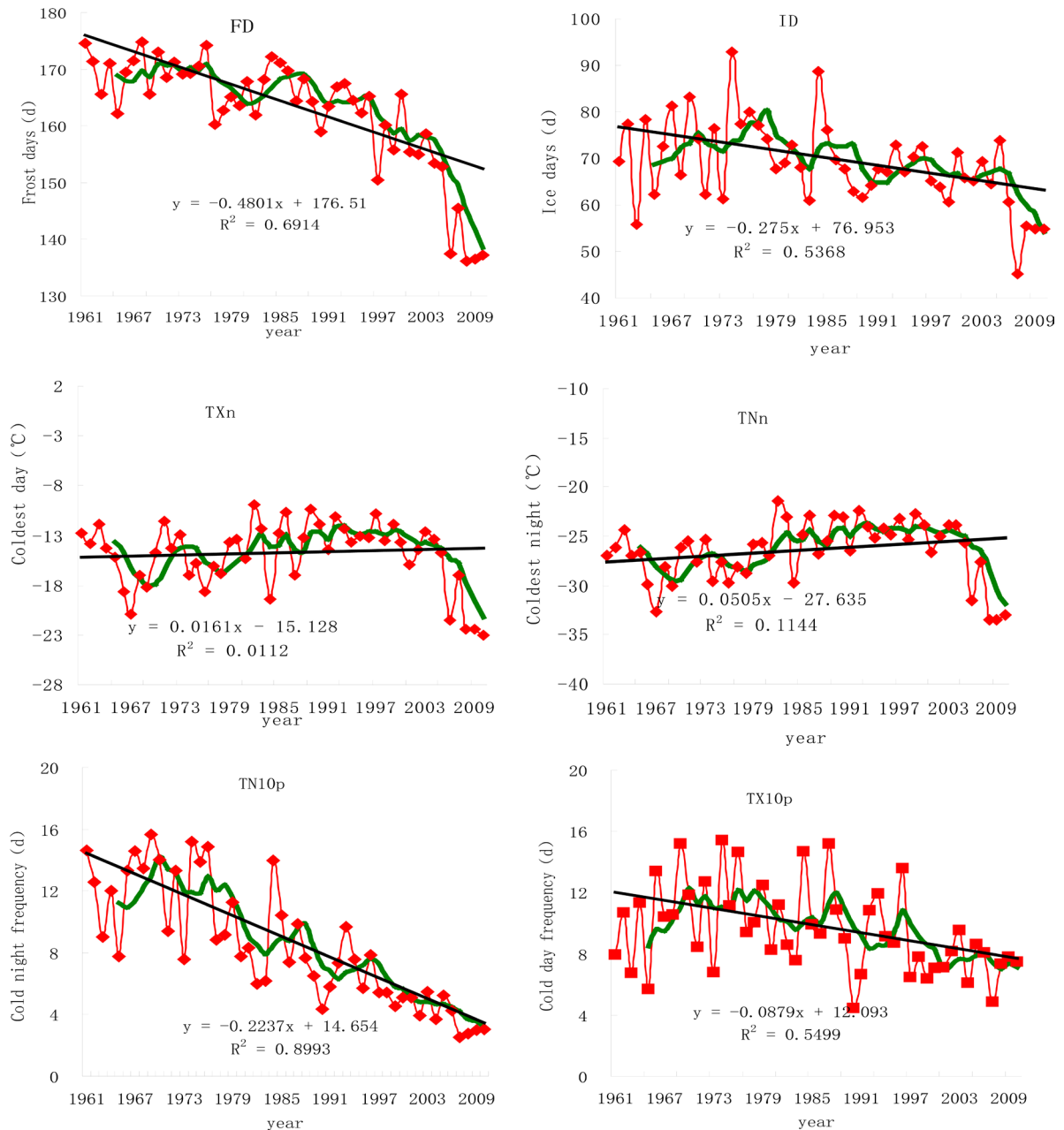
(Note: the straight line means linear fitting trend line, the smooth curve is moving average value in 5 years, attached mark is actual test value)

Figure 2. Regional annual anomalies series during 1961-2010 for indices of cold extremes.

Table 3. The extreme temperature mean value (˚C or d) and change range [˚C/10a)/or d/(10a)].

Index	Standard difference	Change tendency rate	Average value					
			Over the years	The 1960s	The 1970s	The 1980s	The 1990s	From the year of 2000s
FD	10.05	4.8	162.64	169.88	167.47	166.69	162.18	146.78
ID	8.85	2.75	68.799	72.07	73.8	69.3	67.8	60.9
TXn	3.29	0.16	−14.917	−15.8	−15	−13.3	−12.8	−17.8
TNn	3.01	0.505	−26.504	−27.8	−27.4	−24.7	−24.2	−28.4
TN10	3.88	2.237	8.44	12.7	11.1	8.1	6.4	3.9
TX10	2.81	0.879	9.54	10.4	10.9	10	8.9	7.5

The monthly maximum temperature minimum value (TXn) and monthly extreme minimum temperature (TNn) showed increasing trends, with interannual variation tendency rates of 0.16˚C/10a and 0.505˚C/10a, respectively, although these trends were not significant ($\alpha > 0.05$). The correlation coefficients of TXn and TNn by year were −0.133 and 0.042, indicating significant warming, especially on low-temperature days, the frequency of which has decreased over time.

3.2. Spatial Variation in Extreme Cold Events

Against the background of global warming, the extreme cold indices generally showed decreasing trends over the past 50 years, but changes in these indices were characterized by spatial variation (**Figure 3**). Change tendency rates of continuous FD ranged from −7.8 to −2.0 d/10a and displayed significant decreasing trends at about 91.4% of all stations (only 2.8% of stations showed increasing trends or no obvious trend). Variation tendency rates for IDs ranged from −4.0 to −1.5 d/10a, and were <0 at 80% of stations. Thus, the ID data showed significant decreasing trends in most regions, all of which were in northern Xinjiang.

Variation tendency rates for TN10p ranged from −3.7 to −0 d/10a and were <0 at 88.5% of stations; however, the decreasing trends were not significant. The rates for TX10p ranged from −1.3 to −0.5 d/10a and were < 0 at 48.5% of stations; these declining trends were significant. The variation tendency rates for TXn ranged from 0.04 to 2.5˚C/10a and exceeded 0 at 48.5% of stations; increasing trends were significant at 37.5% of stations. Variation tendency rates for TNn ranged from 0 to 2.5˚C/10a and showed obvious increasing trends at 94.2% of stations.

3.3. Interannual Variation in Extreme Warm Events

For the past 50 years, all extreme warm event indices, such as the numbers of summertime days (SU25), warm-nighttime days (TN90p), and warm-daytime days (TX90p), as well as monthly extreme maximum temperature (TXx) and the monthly minimum temperature maximal value (TNx), showed significant increasing trends in the Xinjiang area (**Figure 4**). The increasing rates for SU25, TN90p, and TX90p were 2.59, 3.38, and 1.59 d/10a, respectively (all $\alpha \leq 0.05$), with correlation coefficients by year of 0.48, 0.86, and 0.6, respectively (all with ≥99% confidence). The variation tendency rates for TXx and TNx were 0.23˚C/10a and 0.52˚C/10a, respectively, and the correlation coefficients by year were 0.36 and 0.64, respectively (all $\alpha \leq 0.01$).

The graph of changes in day-by-day temperature range (DTR; **Figure 3** & **Figure 4**) shows a decreasing trend in Xinjiang over the past 50 years (rate, 0.21˚C/10a), with a correlation coefficient by year of −0.54 ($\alpha = 0.01$). The trend of change in extreme annual temperature range in the entire Xinjiang area complies with that throughout China [19].

3.4. Spatial Variation in Extreme Warm Events

Against the background of global warming, the extreme warm indices in the Xinjiang area generally showed increasing trends over the past 50 years, but these changes were characterized by spatial variation (**Figure 5**). Variation tendency rates for SU25 ranged from0 to 8.0 d/10a, and about 100% of stations showed significant increasing trends. The variation tendency rates for TN90p ranged from −0.2 to 8.0 d/10a, and 62.8% of stations showed significant increasing trends. The variation tendency rates for TX90p ranged from 0.2 to 3.2 d/10a and exceeded 0 at 91% of stations, with 80% of stations showing significant trends. The variation tendency rates for

TXx ranged from −0.24 to 0.9˚C/10a and exceeded 0 at 77.1% of stations, with very significant increasing trends at 59.2% of stations. The variation tendency rates for TNx ranged from −1.86 to 3.0˚C/10a and exceeded 0 at 82.8% of stations. Trends of increasing TNx were very significant at 58.6% of stations.

Although the ranges of increase in variation tendency rates for TXn and TNn exceeded those for TXx and TNx, all stations showed decreasing trends for DTR.
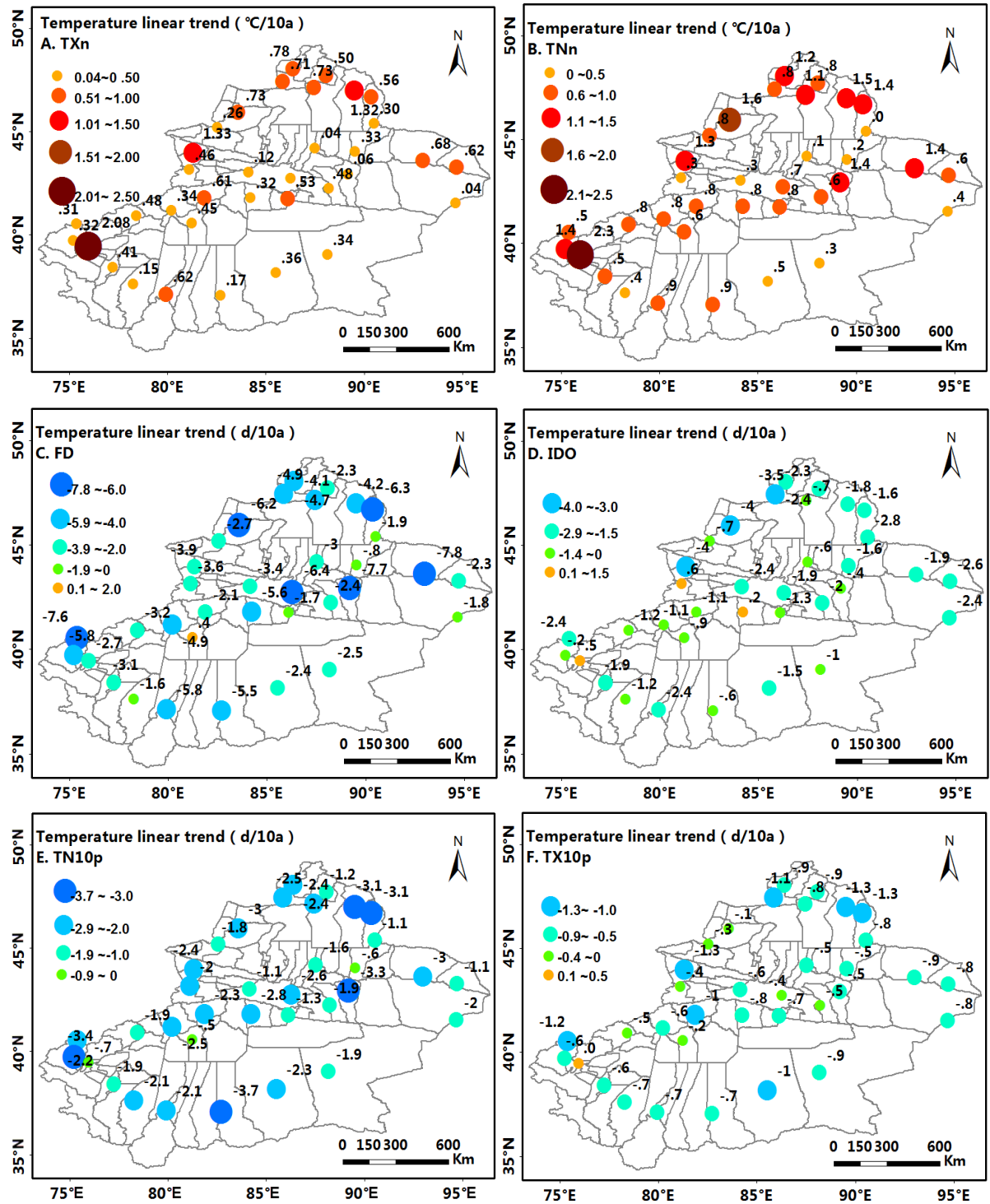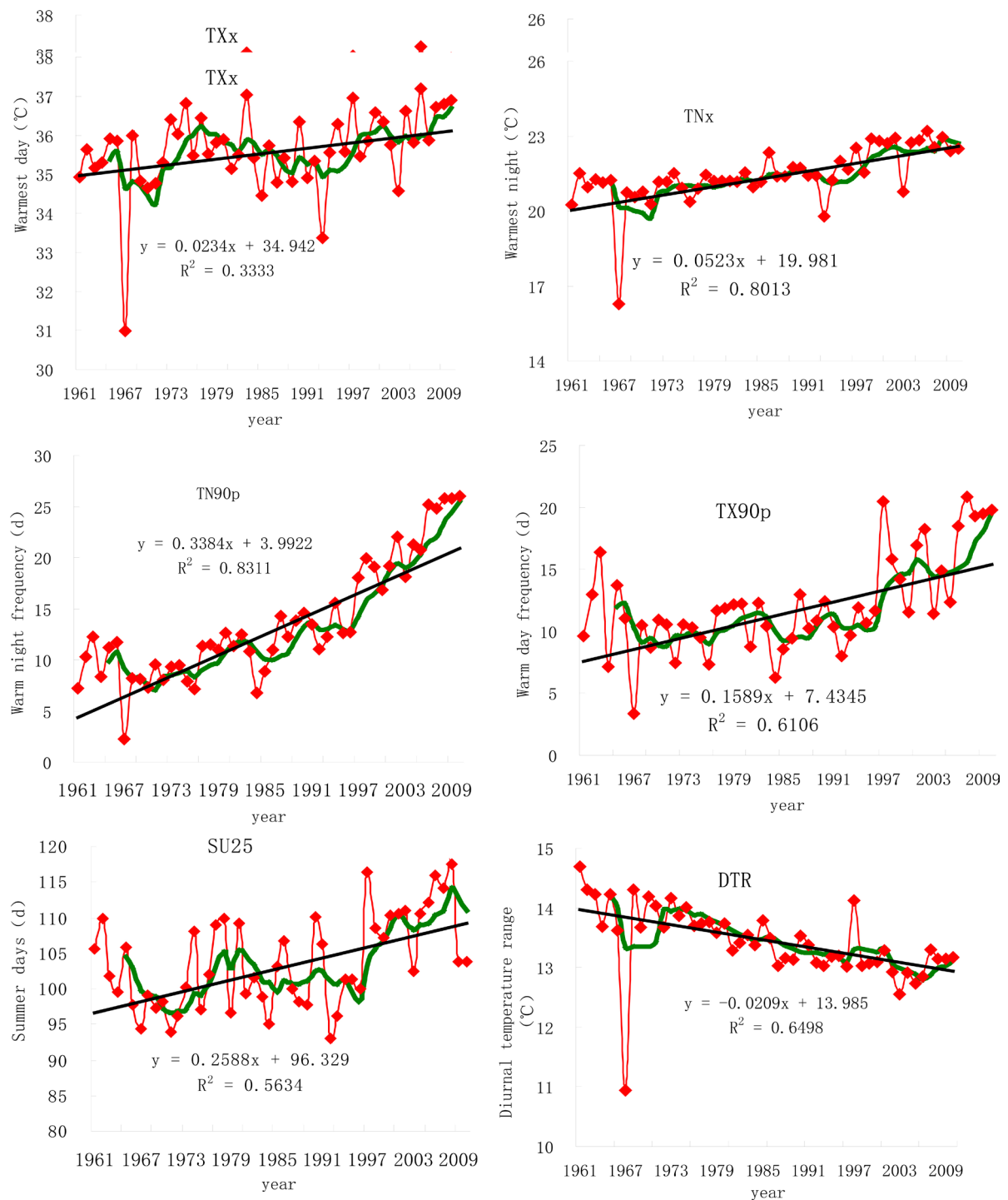

Figure 3. Spatial distribution of linear tendency rate for indices of cold extremes during 1961-2010.

(Note: the straight line means linear fitting trend line, the smooth curve is moving average value in 5 years, attached mark is actual test value)

Figure 4. Regional annual anomalies series during 1961-2010 for indices of warm extremes.

4. Changes in Extreme Precipitation Events in Xinjiang over the Past 50 Years

4.1. Interannual Variation Trends for Extreme Precipitation Indices

Precipitation intensity is one factor used to measure extreme precipitation, with greater intensity associated with greater possibility of disaster. Average precipitation intensity in the Xinjiang area showed a predominant trend

of annual increases over the past 50 years, consistent with global data and those for China [20]. However, the range of change indicated by the extreme precipitation intensity indices was small relative to those for extreme temperature events. Total precipitation during the wet season (PRCPTOT) in each year from 1961 to 2010 appeared to show a significant increasing trend (rate, 8.23 mm/10a; $\alpha = 0.05$; **Figure 6**). The correlation coefficient of PRCPTOT by year was 0.43 ($\alpha = 0.01$; **Table 4**). Average PRCPTOT over the years was 144.33 mm (standard difference, 23.297). The difference between the two periods of 1961-1980 and after 1980 was very significant.
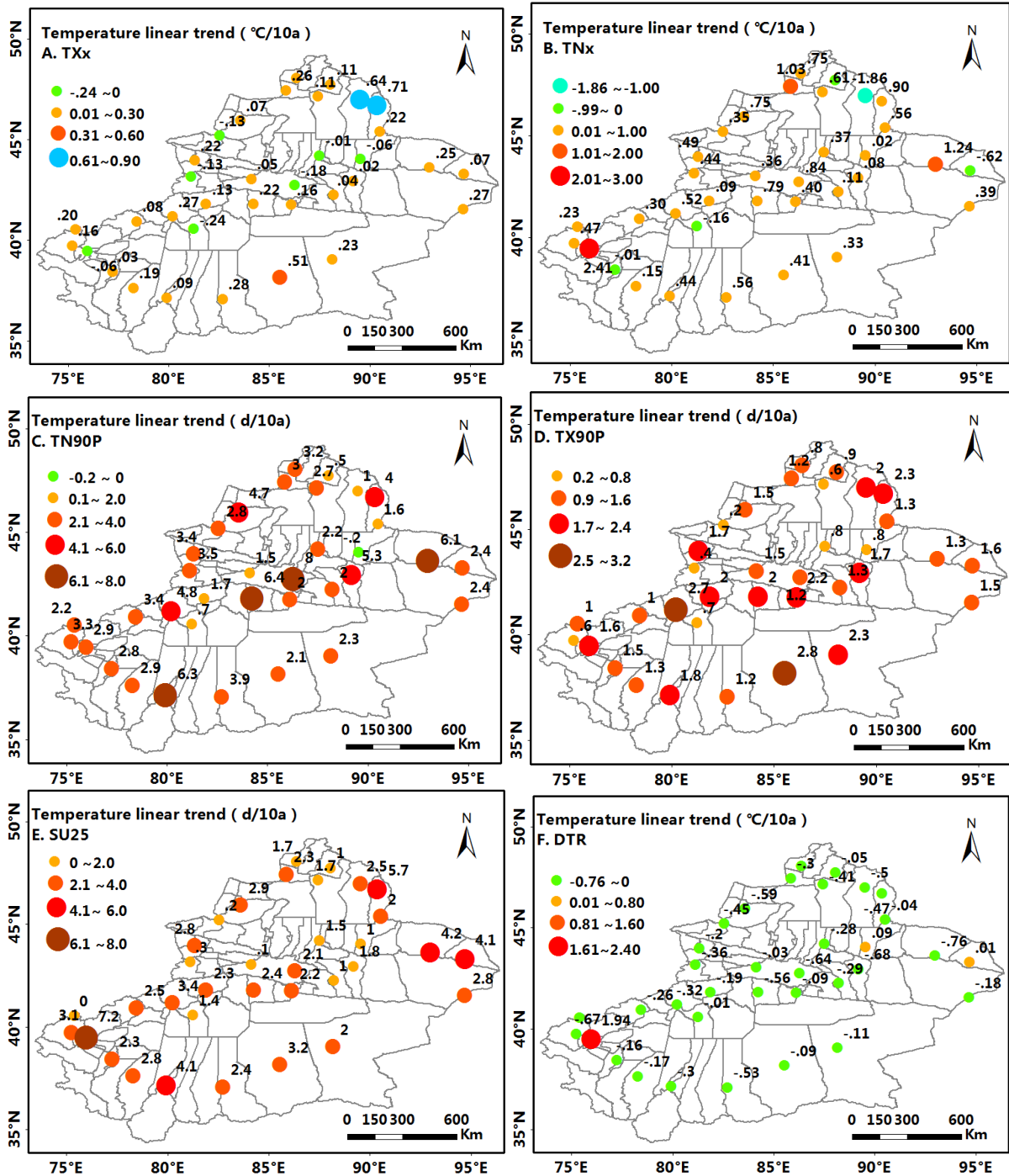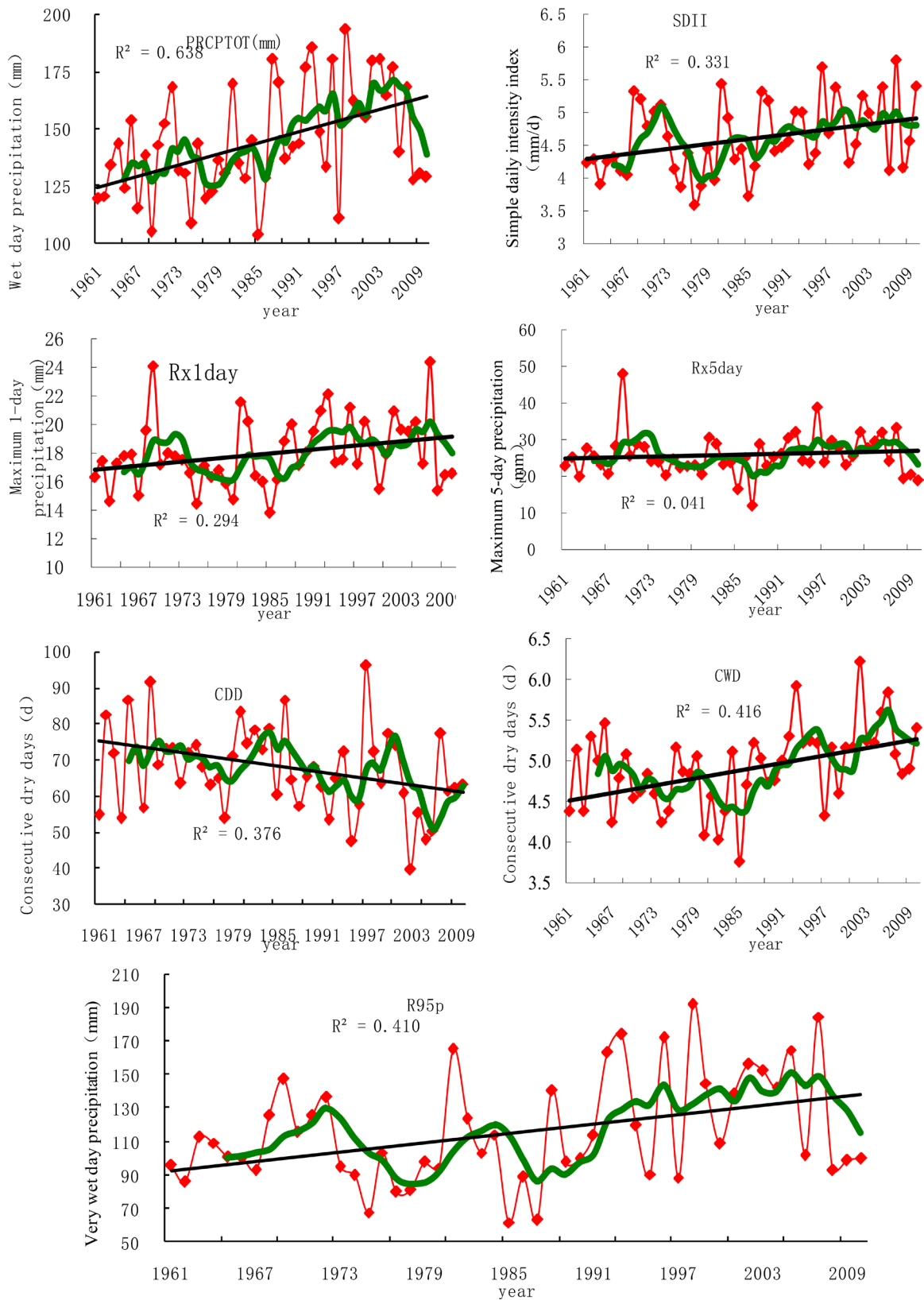

Figure 5. Spatial distribution of linear tendency rate for indices of warm extremes during 1961-2010.

Note: the red dot means actual measure value, green line means moving average in 5 years, the straight line means simple regression trend line.

Figure 6. Inter-annual variation of precipitation extremes in Xinjiang during 1961-2010.

Table 4. The standard difference of extreme precipitation index and change tendency rate (mm/10a) and mean value (d or mm) in Xinjiang.

Index	Standard difference	Change tendency rate	Mean value					
			Over the year	The 1960s	The 1970s	The 1980s	The 1990s	From the year of 2000s
PRCPTOT	23.297	8.232	144.33	129.38	134.16	143.79	159.22	155.11
SDII	0.549	0.13	4.62	4.45	4.3	4.64	4.82	4.9
RX1day	2.355	0.474	17.97	17.71	16.51	17.81	19	18.81
RX5day	5.639	0.434	25.704	26.68	23.86	23.69	28.01	26.29
R95	32.197	9.322	116.24	108.56	97.1	105.65	136.7	133.2
CDD	11.795	−2.867	67.2	71.23	68.53	70.59	66.59	59.04
CWD	0.49	0.154	4.92	4.83	4.67	4.63	5.11	5.35

The simple precipitation intensity index (SDII) showed small increasing trend at a rate of 0.13 mm/10a, but this trend was not significant ($\alpha > 0.05$; **Figure 6**). The standard difference in the SDII was 0.549, the mean value was 4.62 mm/d, and the correlation coefficient by year was 0.356, indicating that changes in the SDII were stable over the past 50 years (**Table 4**). All extreme precipitation indices, such as monthly maximum precipitation on 1 day (RX1day), monthly maximum precipitation in 5 days (RX5day), strong rainfall amount (R95), and number of consecutive wet days (CWDs), showed increasing trends; the rates of increase for the indices mentioned above were 0.47 mm/10a, 0.43 mm/10a, 9.32 d/10a, and 0.15 d/10a, respectively. Among these values, the increasing trends for R95 and CWDs were significant. The correlation coefficients by year for these indices were 0.25, 0.06, 0.35, and 0.41, respectively, with those of R95 and CWD reaching 95% confidence. The number of consecutive dry days (CDDs) showed a decreasing trend (rate, 2.87 d/10a), with a correlation coefficient by year of −0.29 ($\alpha = 0.05$).

4.2. Spatial Distribution Pattern of Extreme Precipitation Indices

Interannual variation tendencies for most extreme precipitation indices, with the exception of the CDD index, showed significant increasing trends at most stations in the Xinjiang area over the past 50 years (**Figure 7**). PRCPTOT showed decreasing trends at only 2.8% of the 35 stations from which data were analyzed; most stations showed increasing trends (range, −30.68 to 19.78 mm/10a). The rate of increase was greater in the Tianshan and northern Xinjiang areas. Only 17.1% of stations showed decreasing trends for SDII; 82.8% of stations showed increasing trends, and the rate of increase was greater at southern stations.

Increasing trends in the extreme precipitation indices of RX1day, RX5day, R95, and CWDs were found at 25 (71.4%), 28 (80%), 30 (85.7%), and 29 (82.8%) stations, respectively. More than 70% of stations showed increasing trends for PRCPTOT, SDII, RX1day, RX5day, R95, and CWDs, indicating that the frequency of extreme precipitation trends is generally increasing in the Xinjiang area. Analysis of CDD data from 11 (31.4%) stations in southern and northern Xinjiang revealed an increasing trend and demonstrated regional tendencies for increased numbers of disasters involving drought.

5. Conclusions

In this study, 12 extreme temperature indices and 5 extreme precipitation indices were used to examine temporal and spatial variation in climatic extremes in Xinjiang over the past 50 years. The main conclusions are described below.

1) Analysis of temporal changes revealed decreasing trends in extreme cold indices (*i.e.*, obvious reductions in the number of severely cold days and extreme low-temperature events), consistent with global warming. Linear variation in extreme warm indices showed notable increasing trends. The trends for TX10p, TN10p, IDs, and FDs (−0.88, −2.24, −2.75, −4.8 d/10a, respectively) decreased, whereas those for TX90p, TN90p, and SU25 (1.59, 3.38, and 2.59 d/10a, respectively) increased.

2) Analysis of temporal changes in extreme precipitation indices (except CDDs), such as RX1day, RX5day, R95, and CWD, as well as PRCPTOT, showed consistently increasing trends (rates of 0.474 mm/10a, 0.434 mm/10a, 9.322 d/10a, 0.154 d/10a, and 8.232 mm/10a, respectively).

3) Differences in the spatial distributions of the indices were notable. The frequencies of extreme cold and extreme warm events decreased in southern Xinjiang. The spatial distribution of extreme precipitation also showed obvious regional differences, with the directionality of trends differing between mountainous and desert basin areas. The response to global warming has been more notable in northern than in southern Xinjiang. Global climatic change has altered the ecology of northern Xinjiang and increased the frequency of extreme climatic disasters.

4) Changes in extreme cold and warm indices, as well as those in nighttime and daytime indices, showed notable asymmetry: the warming ranges of the cold and nighttime indices exceeded those of the warm and daytime indices, respectively.
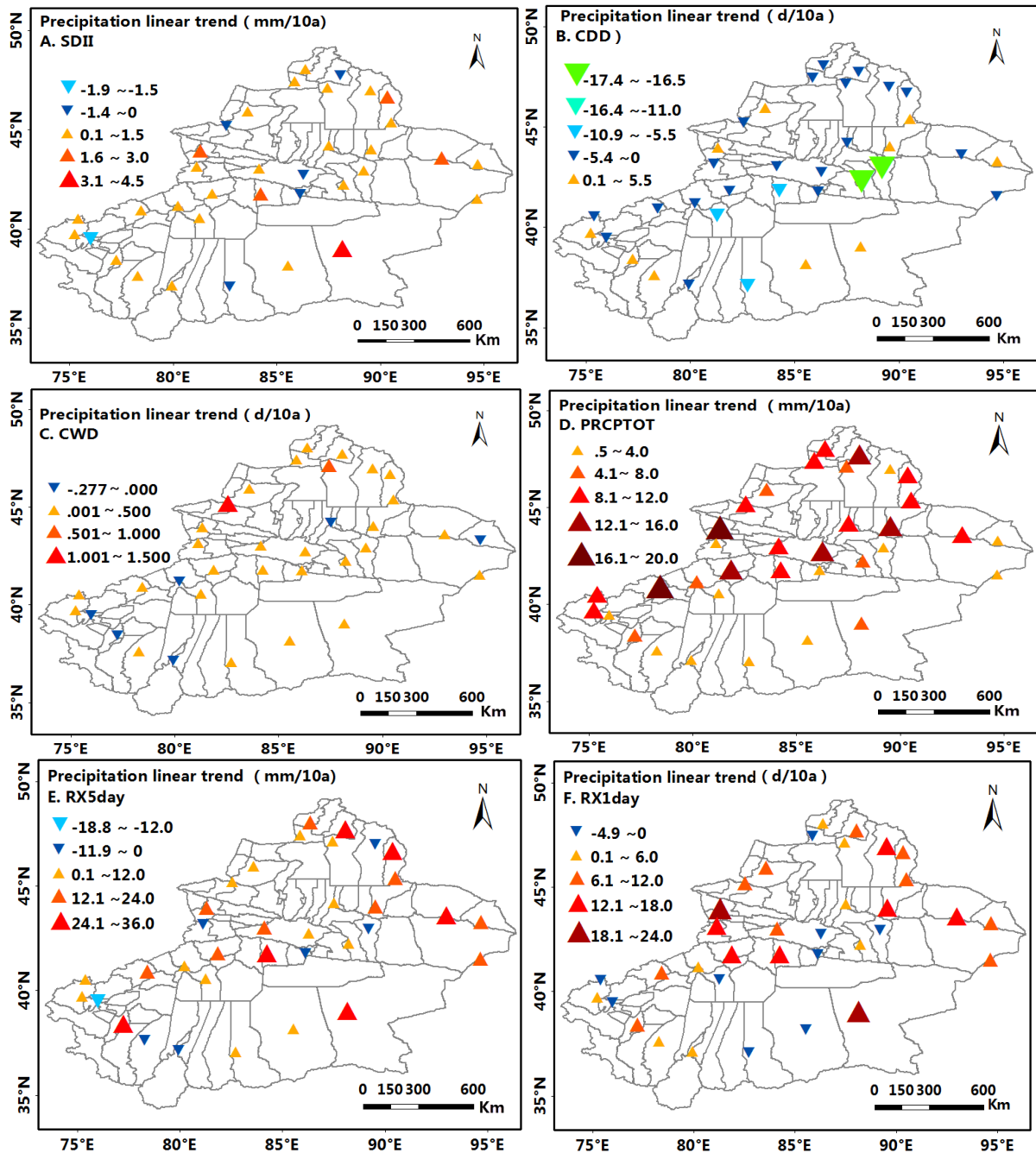

Figure 7. Spatial distribution of inter-annual variation of precipitation extremes in Xinjiang during 1961-2010.

Acknowledgements

References

[1] IPCC (2007) Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. In: Solomon, S., Qin, D., Manninget, M., *et al*., Eds., Cambridge University Press, Cambridge, New York.

[2] Ren, G.Y., Guo, J., Xu, M.Z., *et al*. (2005) Nearly 50 Years Chinese Ground the Basic Characteristics of Climate Change. *Journal of Meteorological*, 942-956.

[3] Zhang, Y.W., Wei, W.S. and Jiang, F.Q. (2012) Trends of Extreme Precipitation Events over Xinjiang during 1961-2008. *Journal of Mountain Science*, **30**, 417-424.

[4] Li, Z.X., He, Y.Q., Wang, C.F., *et al*. (2011) Spatial and Temporal Trends of Temperature and Precipitation during 1960-2008 at the Hengduan Mountains, China. *Quaternary International*, **236**, 127-142. http://dx.doi.org/10.1016/j.quaint.2010.05.017

[5] Easterling, D.R., Gerald, A.M., Camille, P., *et al*. (2000) Climate Extremes: Observations, Modeling, and Impacts. *Science*, **289**, 2068-2074. http://dx.doi.org/10.1126/science.289.5487.2068

[6] Ding, Y.H., Ren, Y.G., Shi, G.Y., *et al*. (2006) National Assessment Report of Climate Change (I): Climate Change in China and Its Future Trend. *Advances in Climate Change Research*, **2**, 3-8.

[7] Yan, Z.W. and Yang, C. (2000) In Recent Decades Chinese Pattern of Extreme Climate Change. *Journal of Climate and Environmental Research*, **3**, 267-272.

[8] Gao, X.J. (2007) Extreme Events Forecast Research in China. *Research Progress on Climate Change*, **3**, 162-166.

[9] Zhang, S.J., Wang, T.M., Wang, T., *et al*. (2010) Xinjiang in Recent 50 Years Precipitation Temporal Variation and Mutation Analysis. *Chinese Desert*, **3**, 668-674.

[10] Pu, Z.C. and Zhang, S.Q. (2011) 1961-2008, Heat-Humidity Climate Spatial Temporal Variation in Xinjiang Summer Half Year. *Resource and Environment in Arid Area*, **25**, 138-144.

[11] Wang, S.J., Yang, L.M. and Shi, Y.G. (2012) 1991-2010 in Urumqi, Rainfall Characteristics Analysis. *Chinese Desert*, **11**, 509-516.

[12] Yang, L.M. (2003) Climate Change of Extreme Precipitation in Xinjiang. *Acta Geographica Sinica*, **58**, 577-583.

[13] Jiang, F.Q., Hu, R.J., Zhang, Y.W. and Li, X.M. (2011) Variations and Trends of Onset, Cessation and Length of Climatic Growing Season over Xinjiang, NW China. *Theoretical and Applied Climatology*, **106**, 449-458. http://dx.doi.org/10.1007/s00704-011-0445-5

[14] Bai, L., Li, L.H., Li, Q., *et al*. (2012) Ralationship between Soil's Seasonal Freezing Process and Daily. *Journal of Glaciology and Geocryology*, **34**, 328-335.

[15] Peterson, T.C. Climate Change Indices. *WMO Bulletin*.

[16] Aguilar, E., Peterson, T.C., Ramirez Obando, P., *et al*. (2005) Changes in Precipitation and Temperature Extremes in Central America and Northern South America, 1961-2003. *Journal of Geo-Physical Research*, **110**, D23107. http://dx.doi.org/10.1029/2005JD006119

[17] Zhang, Y.W., Wei, W.S., Jiang, F.Q., *et al*. (2012) Assessment of Change in Temperature and Precipitation over Xinjiang, China. *Natural Hazards and Earth System Sciences*, **12**, 1327-1331. http://dx.doi.org/10.5194/nhess-12-1327-2012

[18] Alexander, L.V., Zhang, X., Peterson, T.C., *et al*. (2006) Global Observed Changes in Daily Climate Extremes of Temperature and Precipitation. *Journal of Geophysical Research*, **111**, DO5109. http://dx.doi.org/10.1029/2005JD006290

[19] Wang, Q., Zhang, M.J., Wang, S.J., *et al*. (2013) Analysis of Extreme Temperature Events in Yangtze River Basin from 1962 to 2011. *Journal of Geography*, **12**, 611-625.

[20] Zhang, Z.Y., Liu, L. and Tang, X.L. (2013) Tianshan Mountains in China Nearly 50 Years Precipitation Change Regional Differences and Mutation Characteristics. *Journal of Resources and Environment in Arid Areas*, **7**, 85-90.

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