Analysis of spatial and temporal variation of extreme climate events in Xinjiang ,China

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Outline

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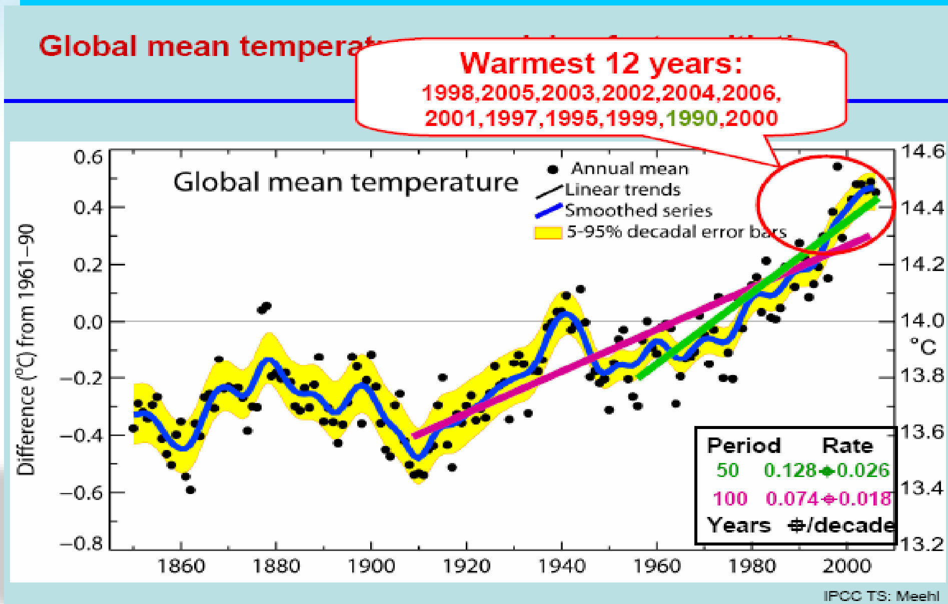
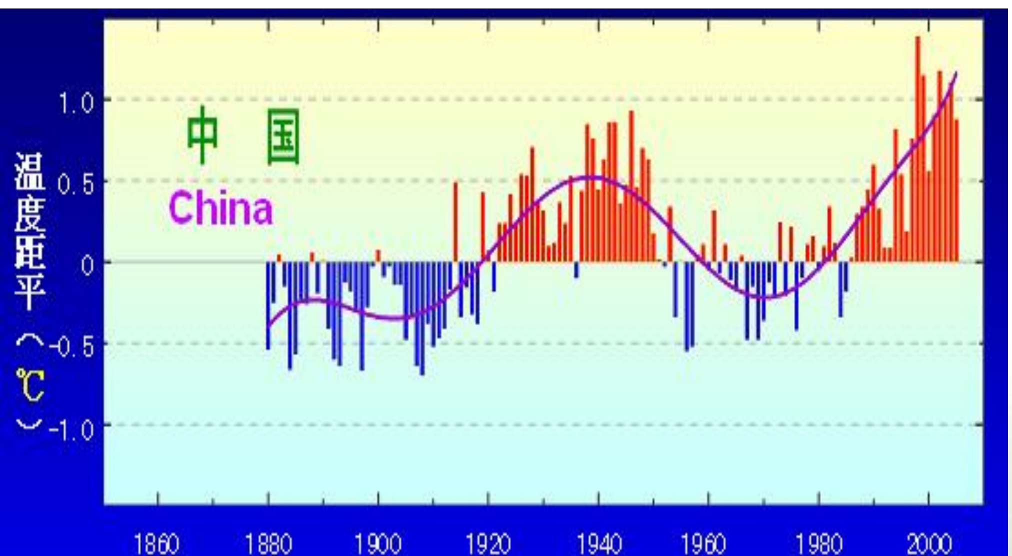
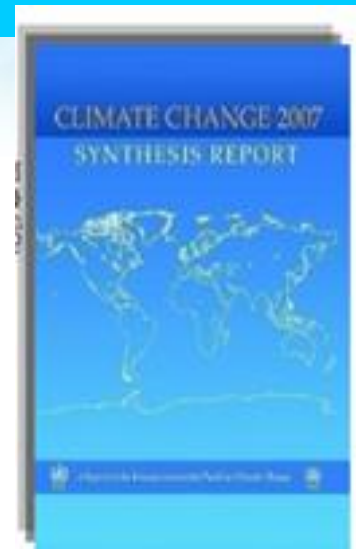
1 Background







联合国政府间气候变化专门委员会（Intergovernmental Panel on Climate Change，IPCC）《第四次评估报告》

- The Intergovernmental Panel on Climate Change (IPCC)(2007) report demonstrated that global warming has had an accelerating tendency since the 1910s. Global mean annual temperature increased by 0.74℃ during the last century, and it is predicted to increase by 1.1–6.4℃ by 2100 (IPCC, 2007). In China, the temperature increased by 0.4–0.5℃ from 1860 to 2005, and the temperature rise in winter has been higher, especially since 1951.

（IPCC AR4）

1 Background

◆Under the impact of global climate change, extreme events such as flood, drought, typhoon,etc., occurred more frequently which have caused increasing economic losses and exerted great influence on social stability, economic development and people's livelihood(Zhang et al., 2011).Therefore, extreme climatic event changes become a focused issue by all over the world.

1 Background

Typical desert ecological environment characteristics in Xinjiang are:

◆various types of ecosystems, but large variability;

◆drainage more inland lake basin as the end-result, lack of a wide range of water as the carrier of goods exchange capacity；

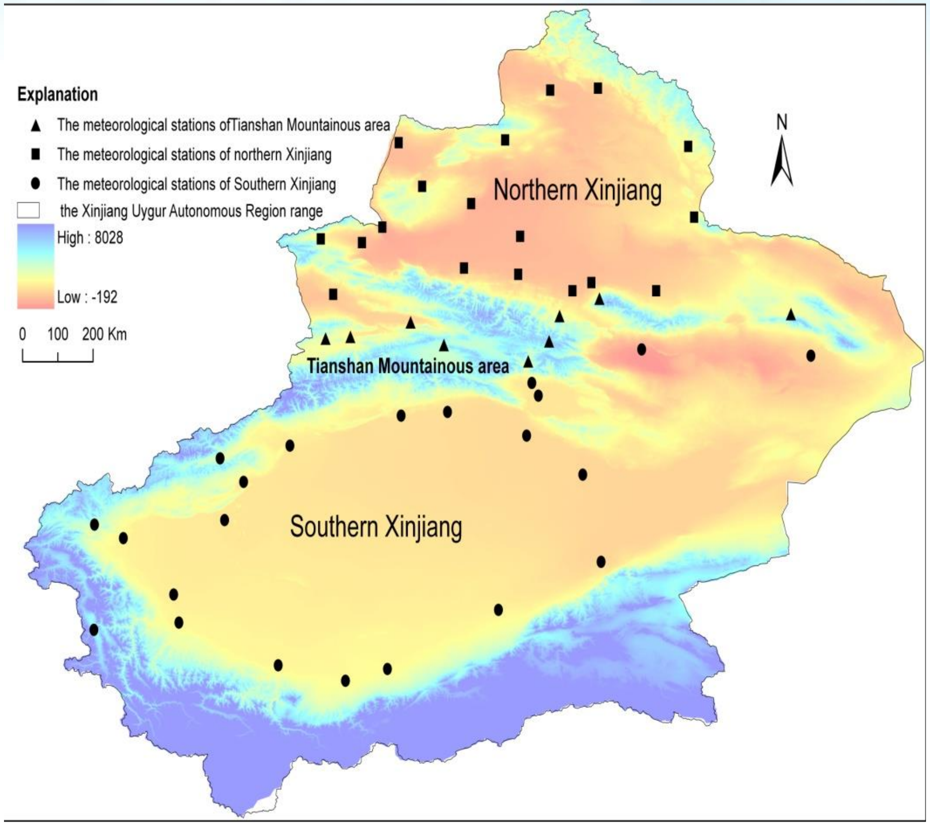
◆the territory is very large, but the scope of suitable for human living is very limited;

◆the fragile ecological environment, and strong irreversibility.

For the past few years, because extreme climatic events occurred in Xinjiang is high frequency, wide range and big hazard degree, caused serious influence and loss to local society, economic and human being livehood.

Therefore, this paper regard Xinjiang area as study target, use regional climate mode and GIS statistics method, study Xinjiang extreme climatic event evolvement feature and also adopt the latest regional climatic mode (RegCM4) for simulating the space variation on extreme precipitation in 1961-1990 and 2071-2100.

2.Research data and methods



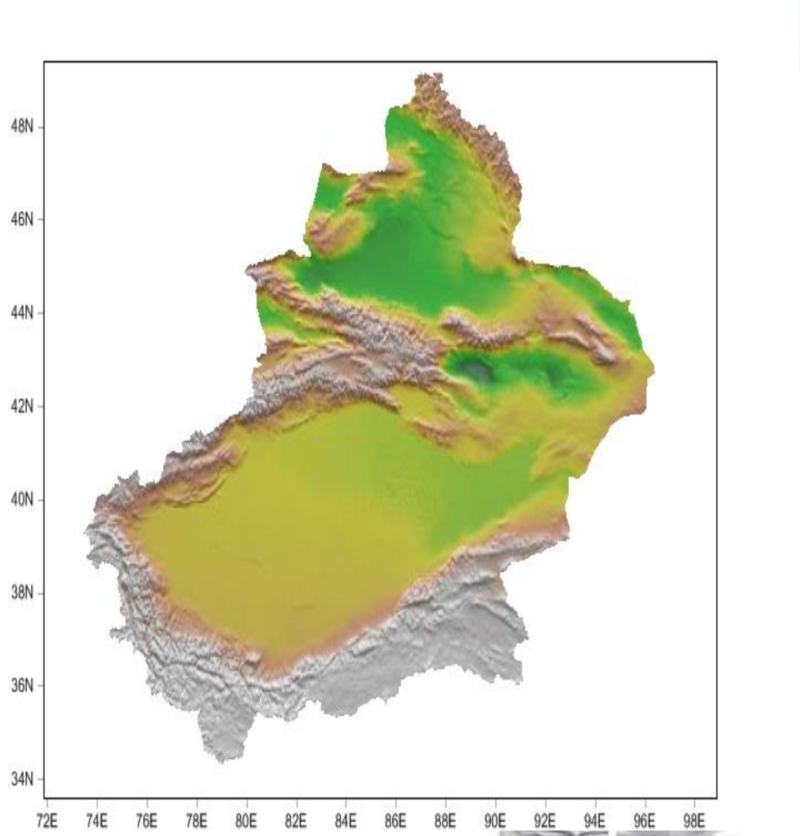


Fig. 1 (left) Distribution of meteorological stations in Xinjiang; (right)Simulation range and terrain distribution of Xinjiang.

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 49 meteorological stations (including 18 stations in the north, 22 stations in the south, and 9 stations in the Tianshan Mountains) were reviewed to identify problems with missing or misdetected observations. We selected high-quality data from 49 stations (Table 1, Fig. 1) as the study target. For missing and misdetected data from stations with less complete records, we used corrected data from Bai et al. (2012).

This methodology has been applied to many countries and regions (Aguilar et al., 2005), including Xinjiang (Zhang et al., 2012). 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).

Tab. 1 Definitions of 12 temperature indices used in this study

Index	Descriptive name	Definition	Unit
TXx	Warmest day	Annual highest TX	℃
TNx	Warmest night	Annual highest TN	℃
TXn	Coldest day	Annual lowest TX	℃
TNn	Coldest night	Annual lowest TN	℃
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 ℃ day number	d
DTR	Diurnal temperature range	Annual mean difference between TX and TN	℃

Notes: a, all the indices are calculated by RClimDEX; TX, daily maximum temperature; TN, daily minimum temperature; TG, daily mean temperature. Indices are included for completeness but are not analyzed further in this study

Table 2. Definitions of 7 precipitation indices used in this study

Index	Descriptive name	Definition	Unit
PRCPTOT	Wet day precipitation	Annual total precipitation from wet days	mm
SDII	Simple daily intensity index	Average precipitation on wet days	mm/d
CDD	Consecutive dry days	Maximum number of consecutive dry days	d
CWD	Consecutive wet days	Maximum number of consecutive wet days	d
R10mm	Number of heavy precipitation days	Annual count of days when RR ≥ 10 mm	d
RX1day	Maximum 1-day precipitation	Annual maximum 1-day precipitation	mm
RX5day	Maximum 5-day precipitation	Annual maximum consecutive 5-day precipitation	mm

Notes: a, all the indices are calculated by RClimDEX; RR, daily precipitation; a wet day is defined when RR ≥ 1 mm, and a dry day is defined when RR < 1 mm

3.Results and analysis

Changes in air temperature in Xinjiang in the last 50 years

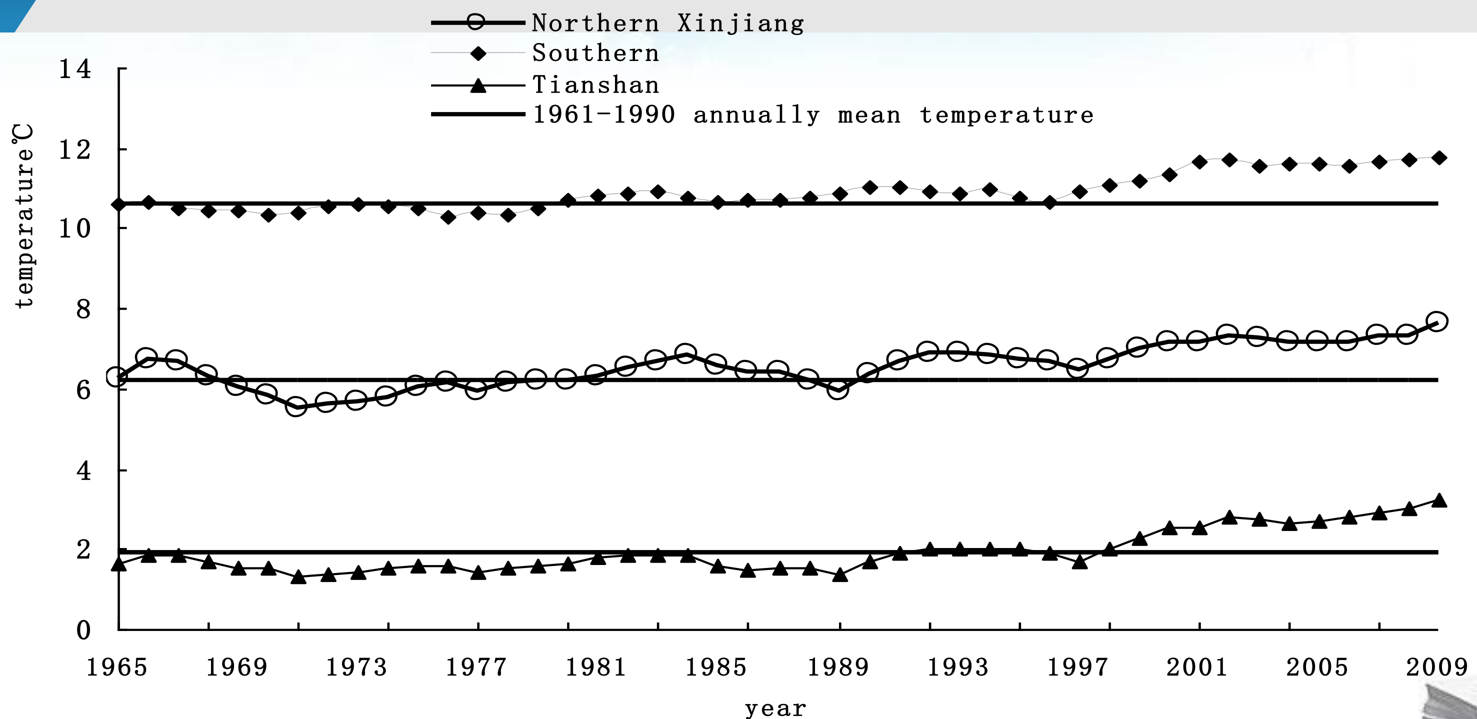


Fig.2 Temperature average variation trend within 5 years at the past 50 years in Xinjiang

The analysis of changes in air temperature in Xinjiang in the last 50 years revealed that the Tianshan Mountains and the southern and northern areas all experienced significantly increasing temperatures over time .The rate of increase in the three areas was 0.34ºC·10 year-1, 0.3ºC·10 year-1, and 0.32ºC·10 year-1, respectively, and all were significant with a confidence coefficient of α=0.05.This rate of temperature increase is higher than that for China as a whole over the same period, 0.22ºC·10 yaer-1 (Liu Bo 2009)

3.Results and analysis

Variation in precipitation in the past 50 years in Xinjiang

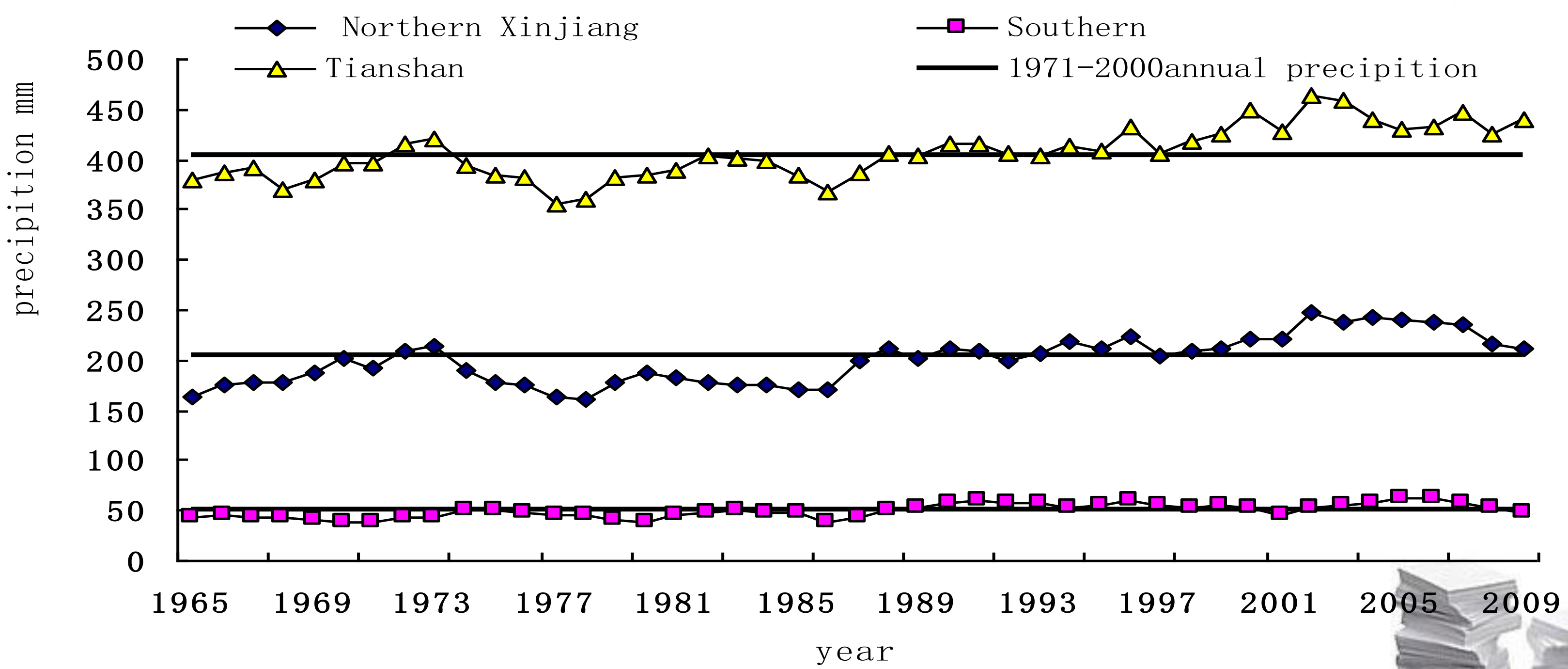
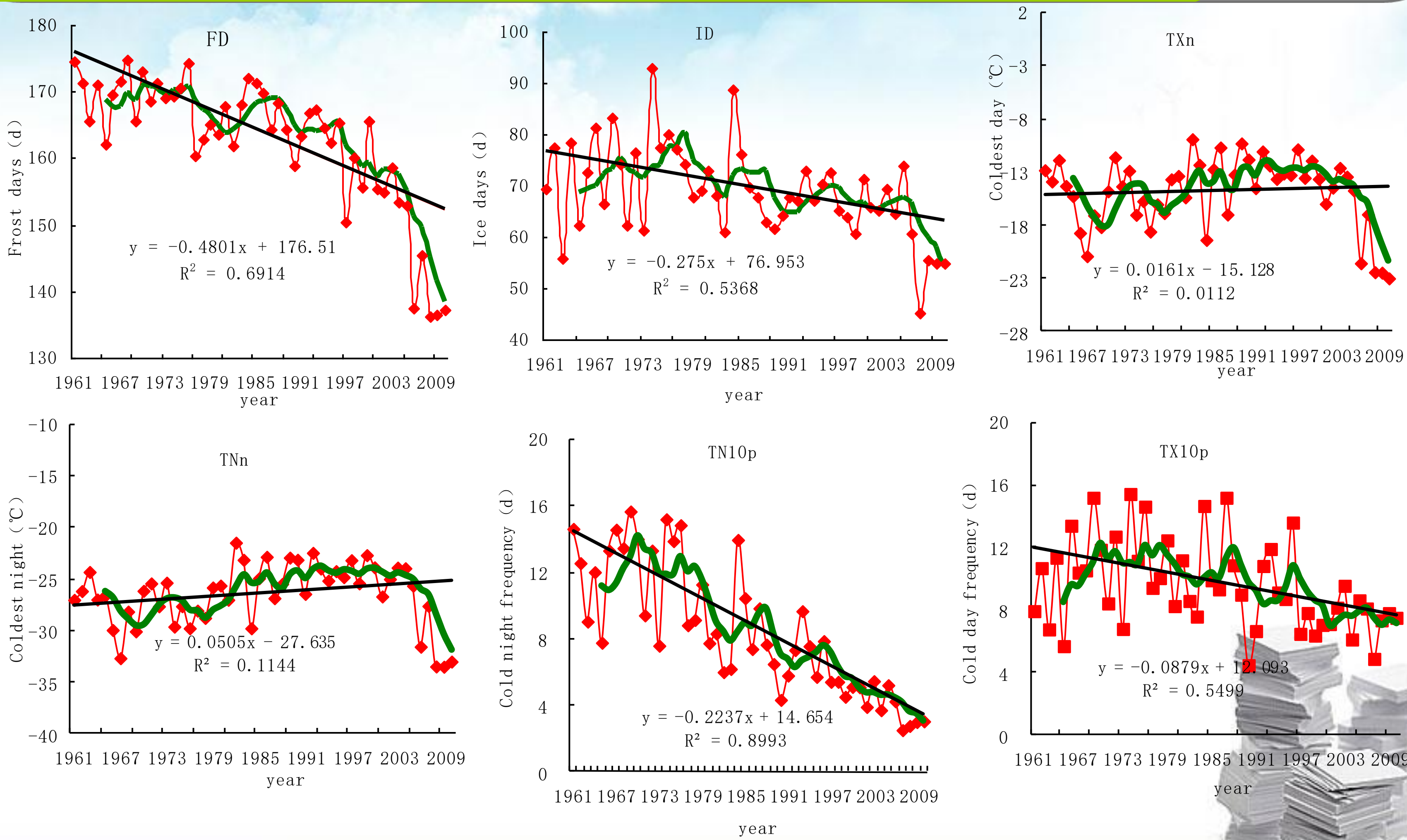


Figure3.Rainfall volume variation trend at the past 50 years in Xinjiang

It was clear from the data that levels of precipitation are rising in the region. Analyses of precipitation data for 1960–2010 in the three areas.

3.Results and analysis---- Temperature extremes(Cold extremes)



(Note: Line is the linear trend, and smoother line is the 5-year smoothing average))

Fig.4 Regional annual anomalies series during 1961-2010 for indices of cold extremes

The analysis of temperoral changes showed decreasing trends in cold extremes indices (except coldest days and coldest night)。

Spatial variation in extreme cold events

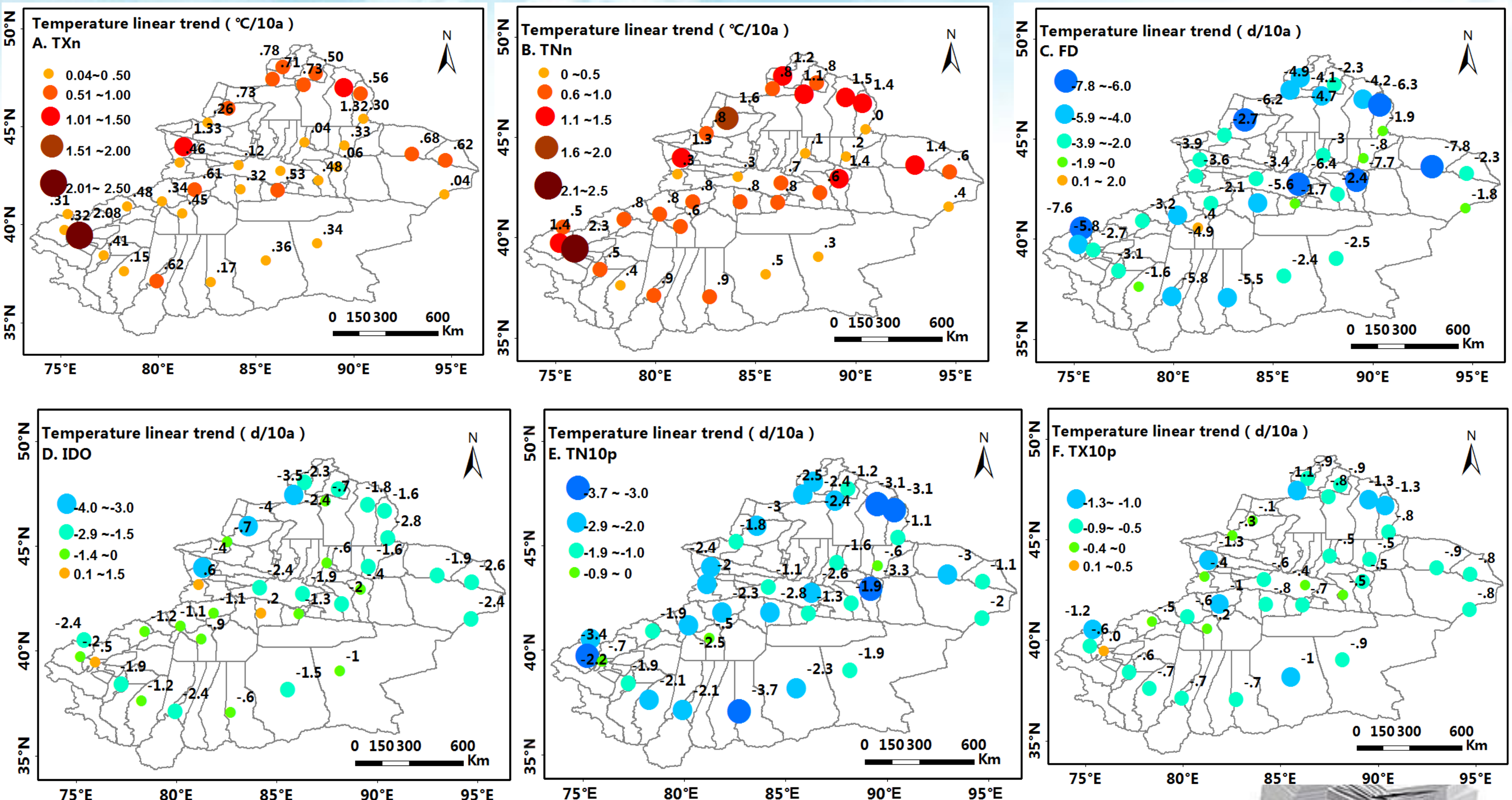
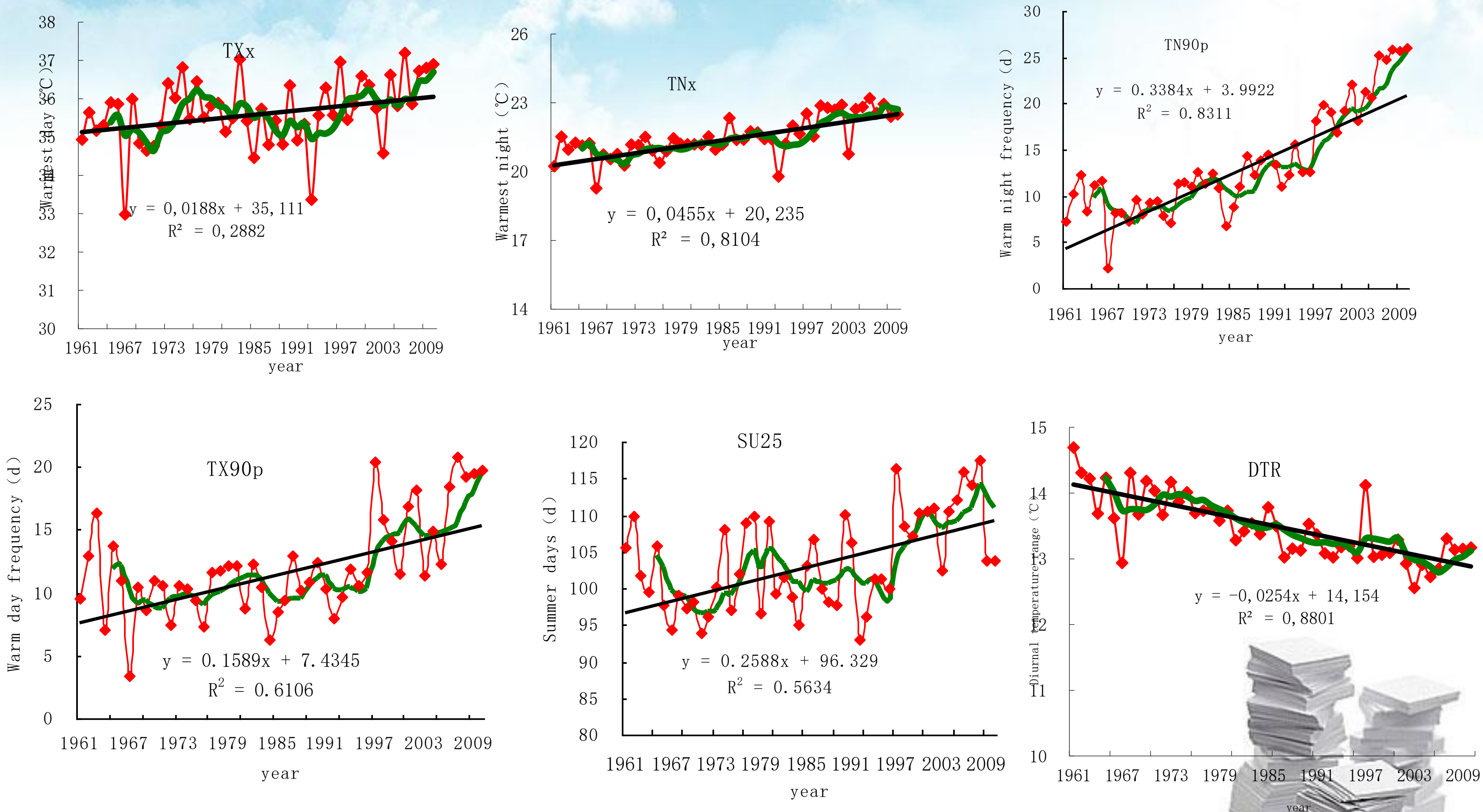


Fig.5 Spatial distribution of linear tendency rate for indices of cold extremes during 1961-2010

Interannual variation in extreme warm events



(Note: Line is the linear trend, and smoother line is the 5-year smoothing average)

Fig.6 Regional annual anomalies series during 1961-2010 for indices of warm extremes

Spatial variation in extreme warm events

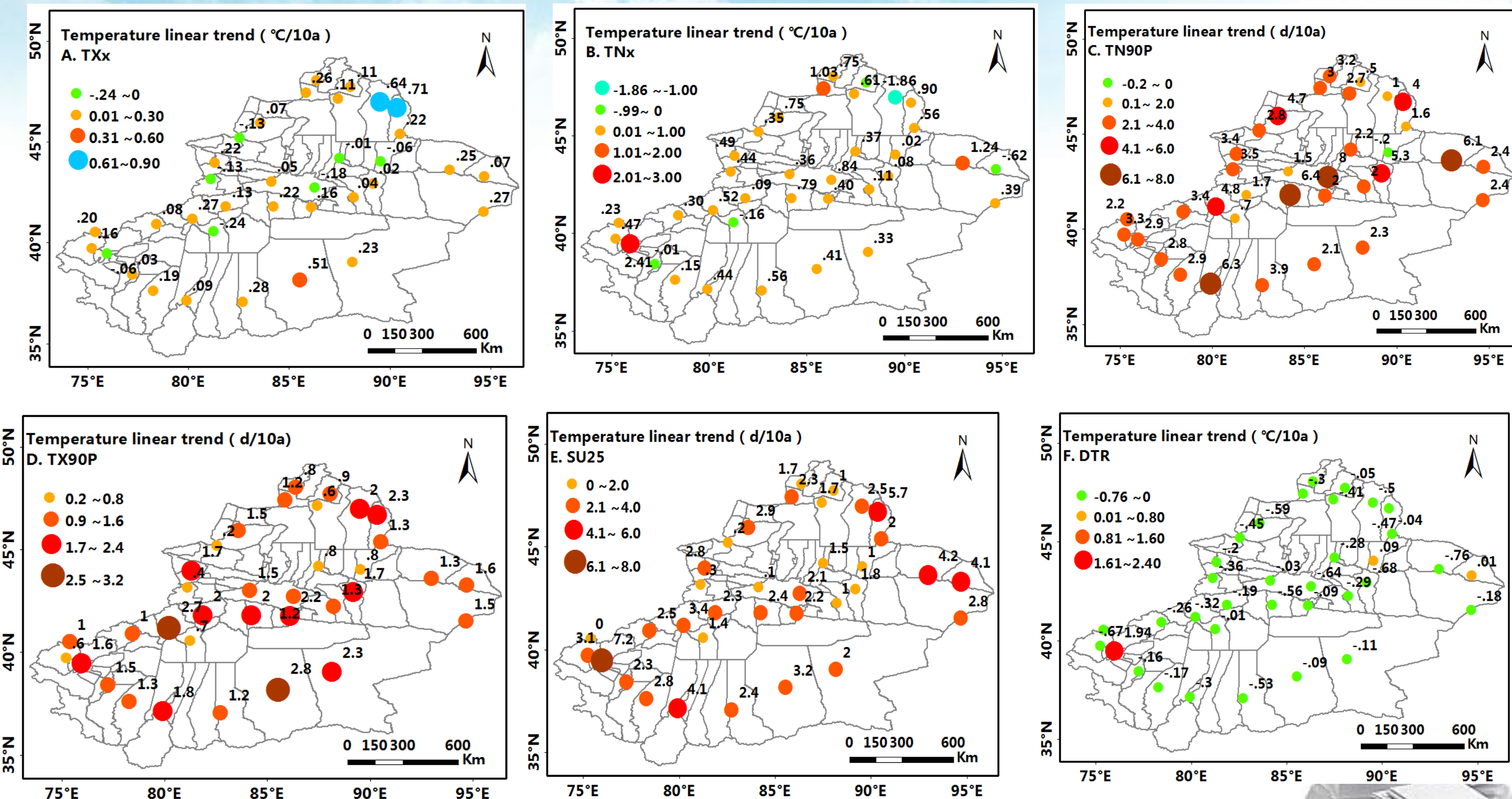
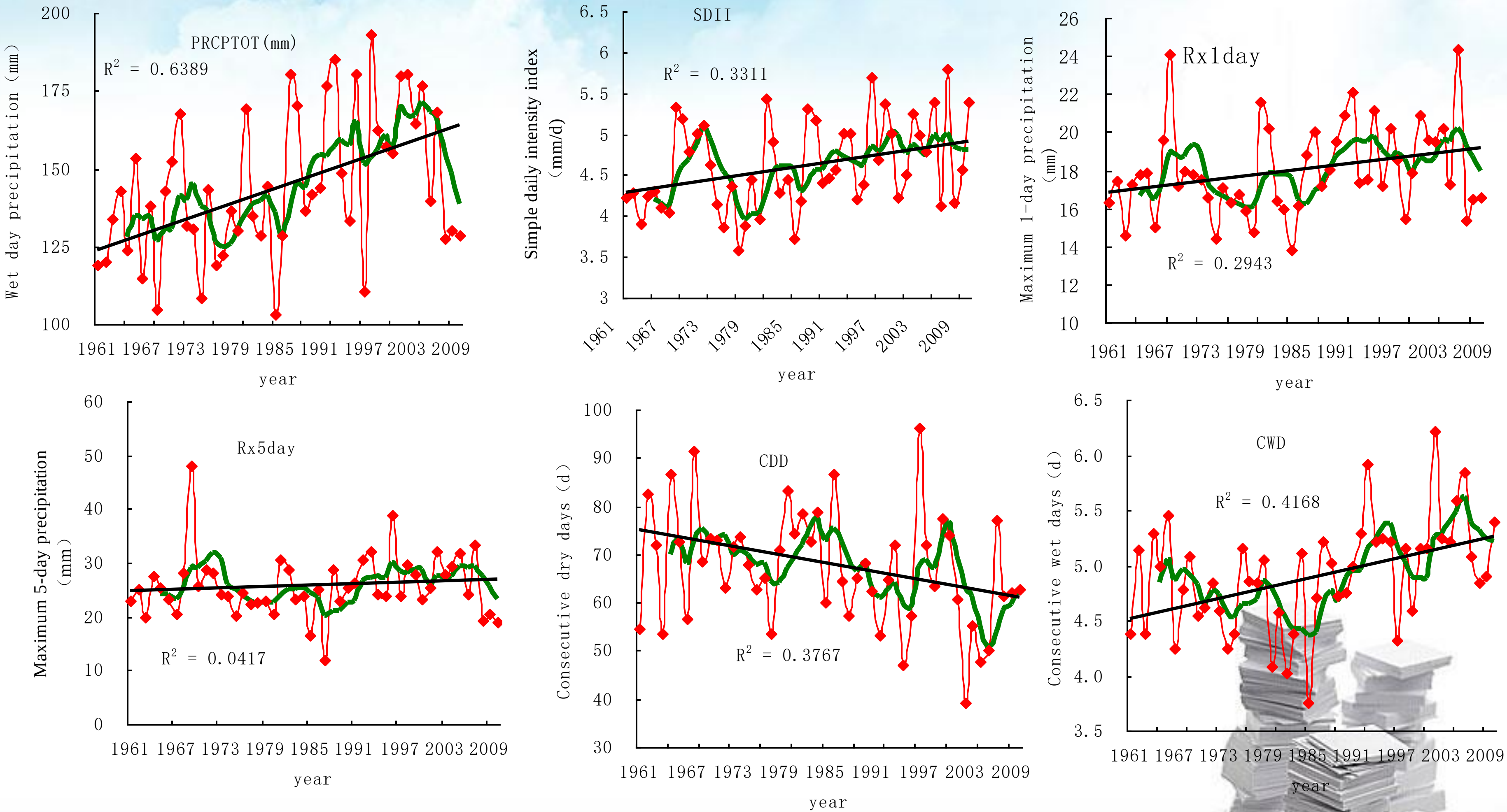


Fig.7 Spatial distribution of linear tendency rate for indices of warm extremes during 1961-2010

Precipitation events



(Note: Line is the linear trend, and smoother line is the 5-year smoothing average)

Fig.8 Inter-annual variation of precipitation extremes in Xinjiang during 1961-2010

Spatial distribution pattern of extreme precipitation indices

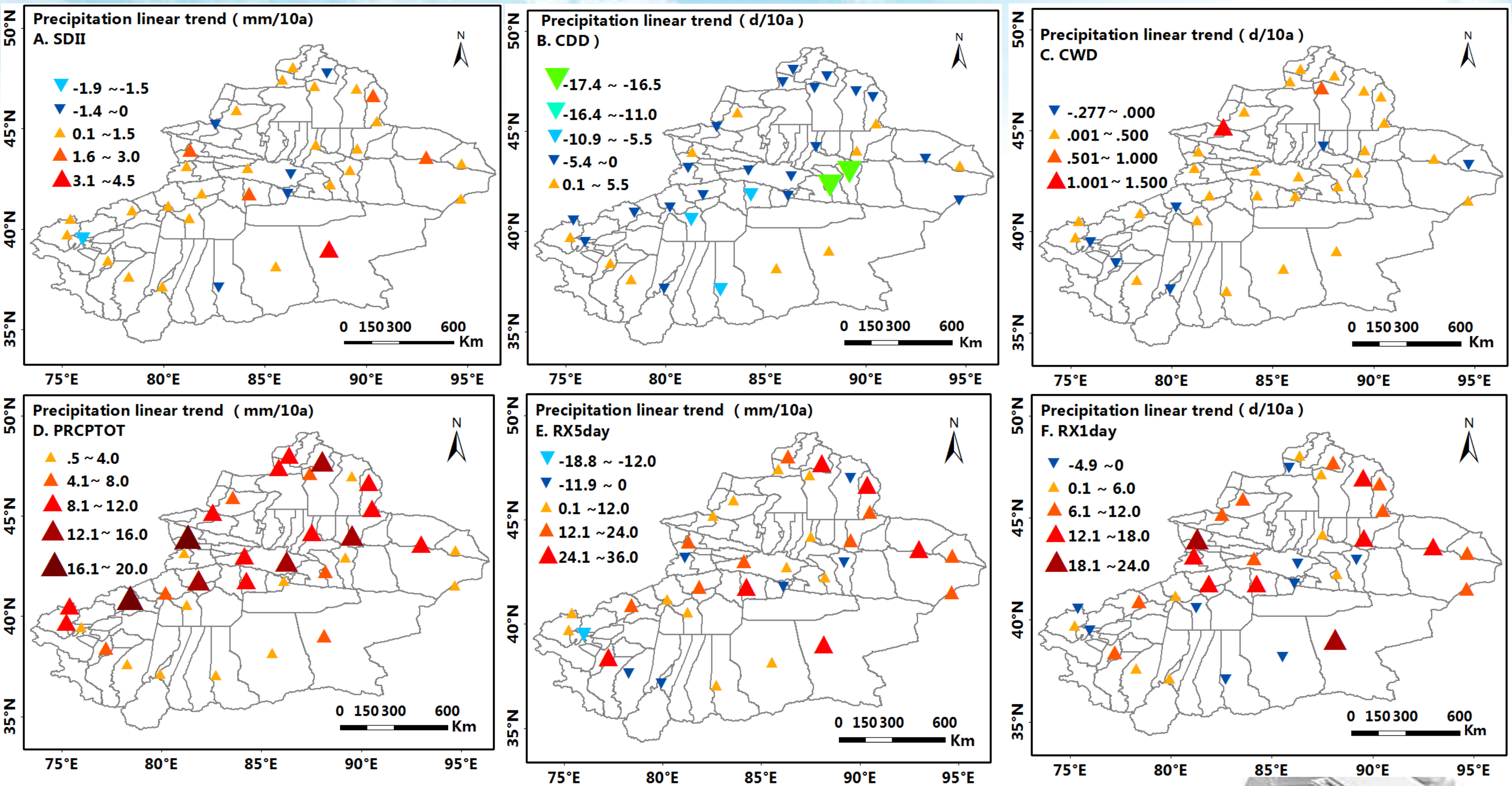


Fig. 9 Spatial distribution of inter-annual variation of precipitation extremes in Xinjiang during 1961-2010.

At last, the climate change situation in Xinjiang in furture was build based on statistical-based downscale method and regional climatic mode, and also adopt the regional climatic mode (RegCM4) for simulating the space variation on extreme precipitation in 1961-1990 and 2071-2100.

Comparison of observed and simulated values—RR1、SDⅡ

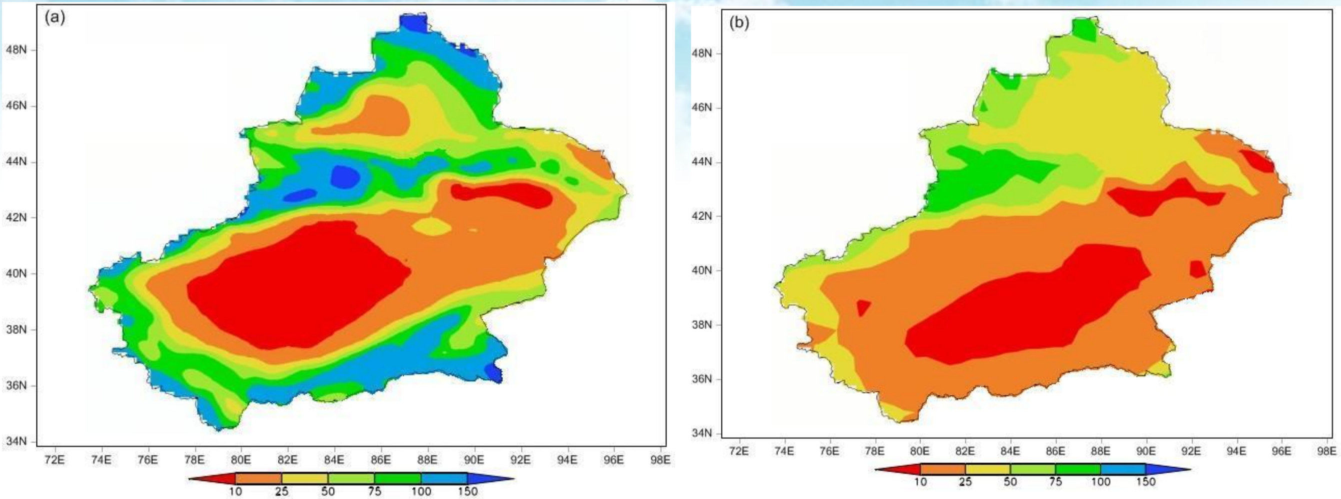


Fig. 10.RR1 Simulation of RegCM4 (a) ; （b） Observation value (unit: days)

Regional climate model capture rainy day distribution with the actual situation is consistent: a rainy day value (RRI) in desert region is smaller, more precipitation in Tianshan Mountains in the larger 。

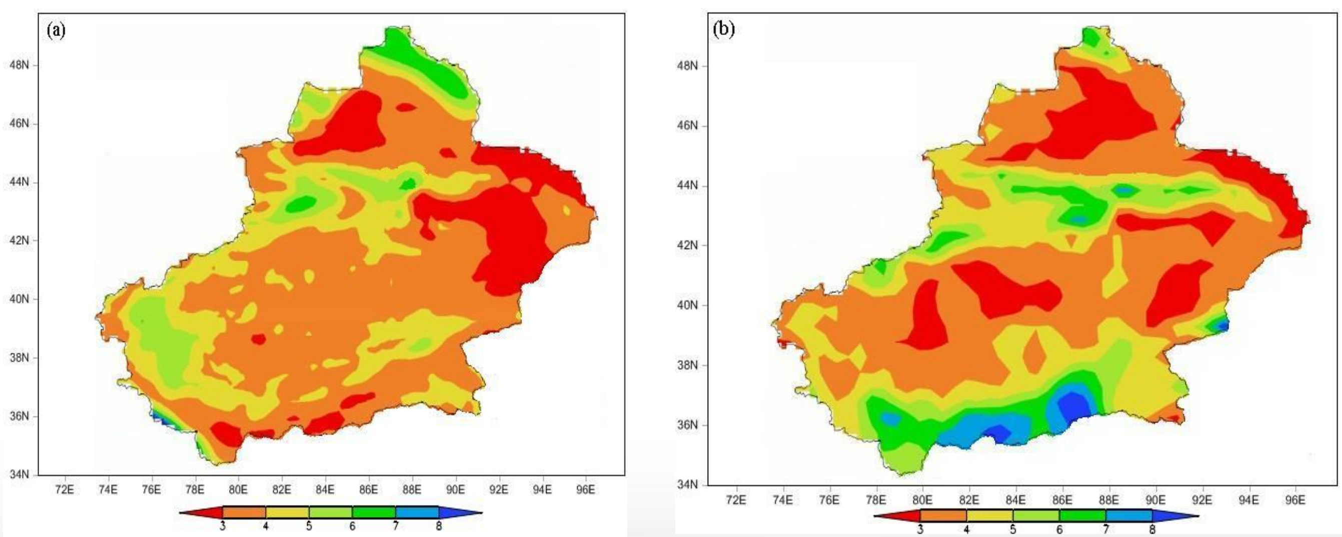


Fig. 11.SDII Simulation of RegCM4 (a) ; （b） Observation value (unit: days)

Comparison graph (a) and (b) found that the simulation results are poor, but the overall effect is good.

Comparison of observed and simulated values ---- R10mm、RX5day

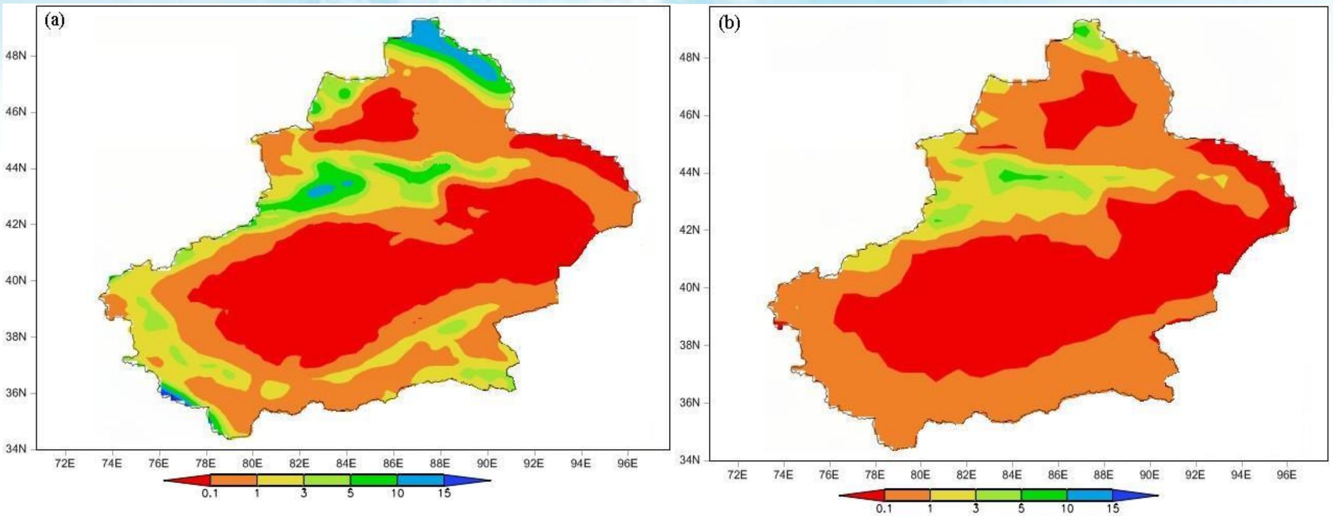


Fig. 12. Average R10mm: **Simulation of RegCM4 (a) ; （b） Observation value (unit: days)**

Zhungeer basin, Tarim Basin, Turpan - Hami area is smaller, in the mountains and the Yili River Valley area of strong rainfall days.

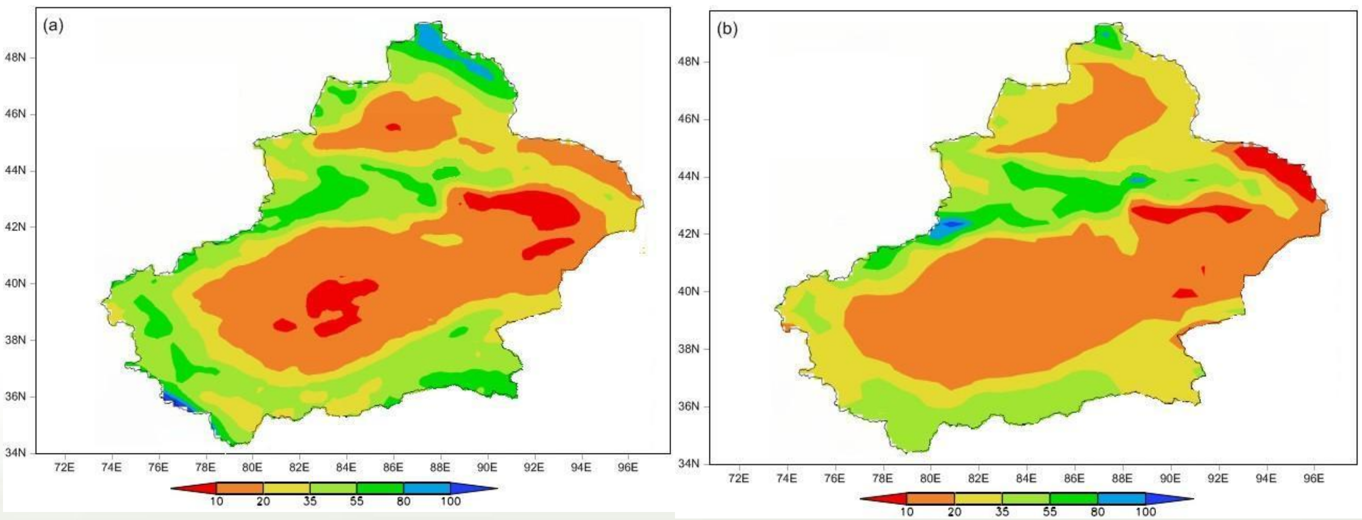


Fig. 13. Average RX5day: **Simulation of RegCM4 (a) ; （b） Observation value (unit: mm)**

High value region (55-100mm) is distributed in the mountainous area and the Yili River Valley area, while the Zhungeer basin, Tarim Basin, Turpan Hami area is the largest continuous 5 days of precipitation, the smaller the general in 20mm.

Prediction of extreme precipitation change -----SDII

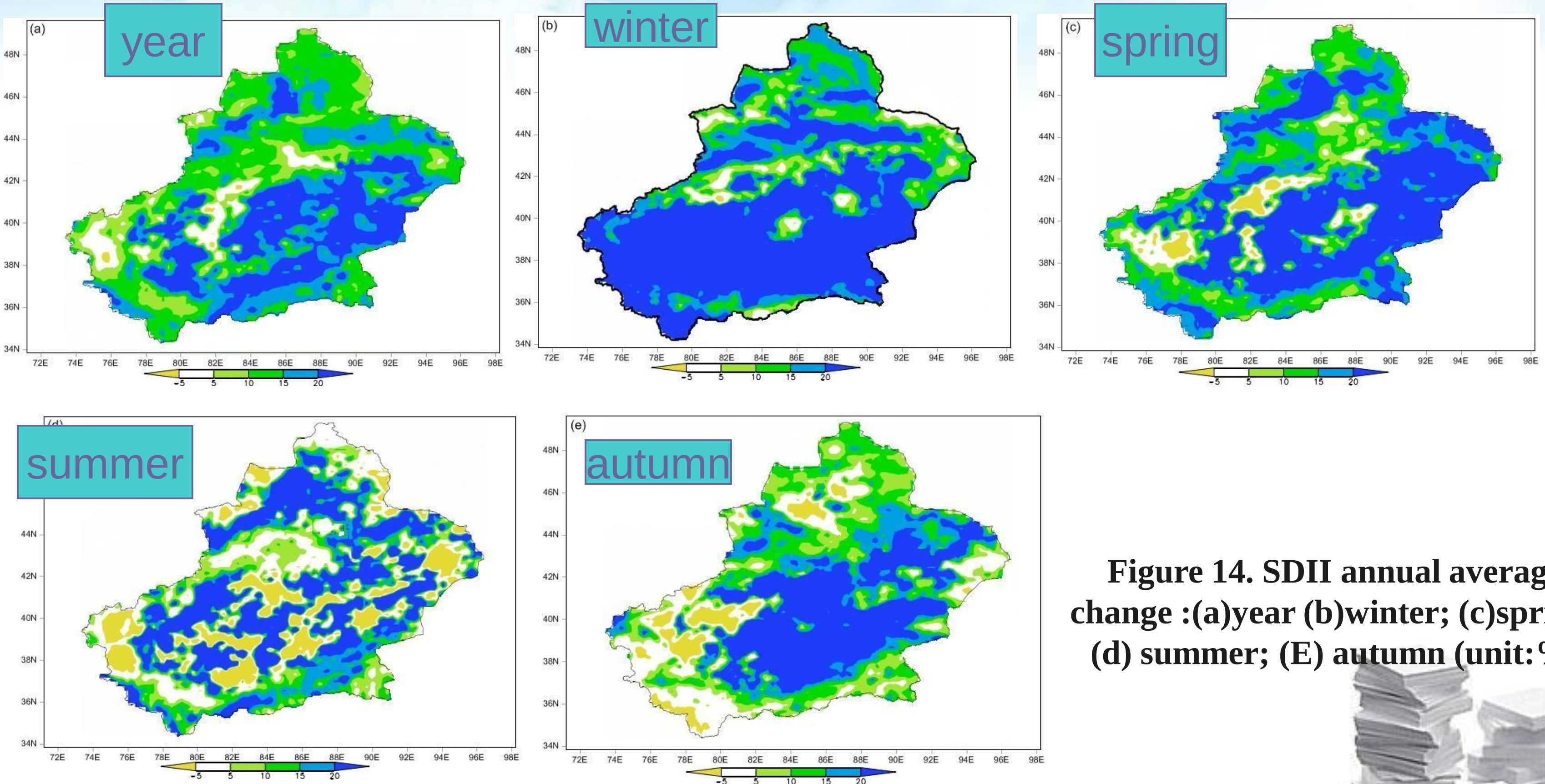
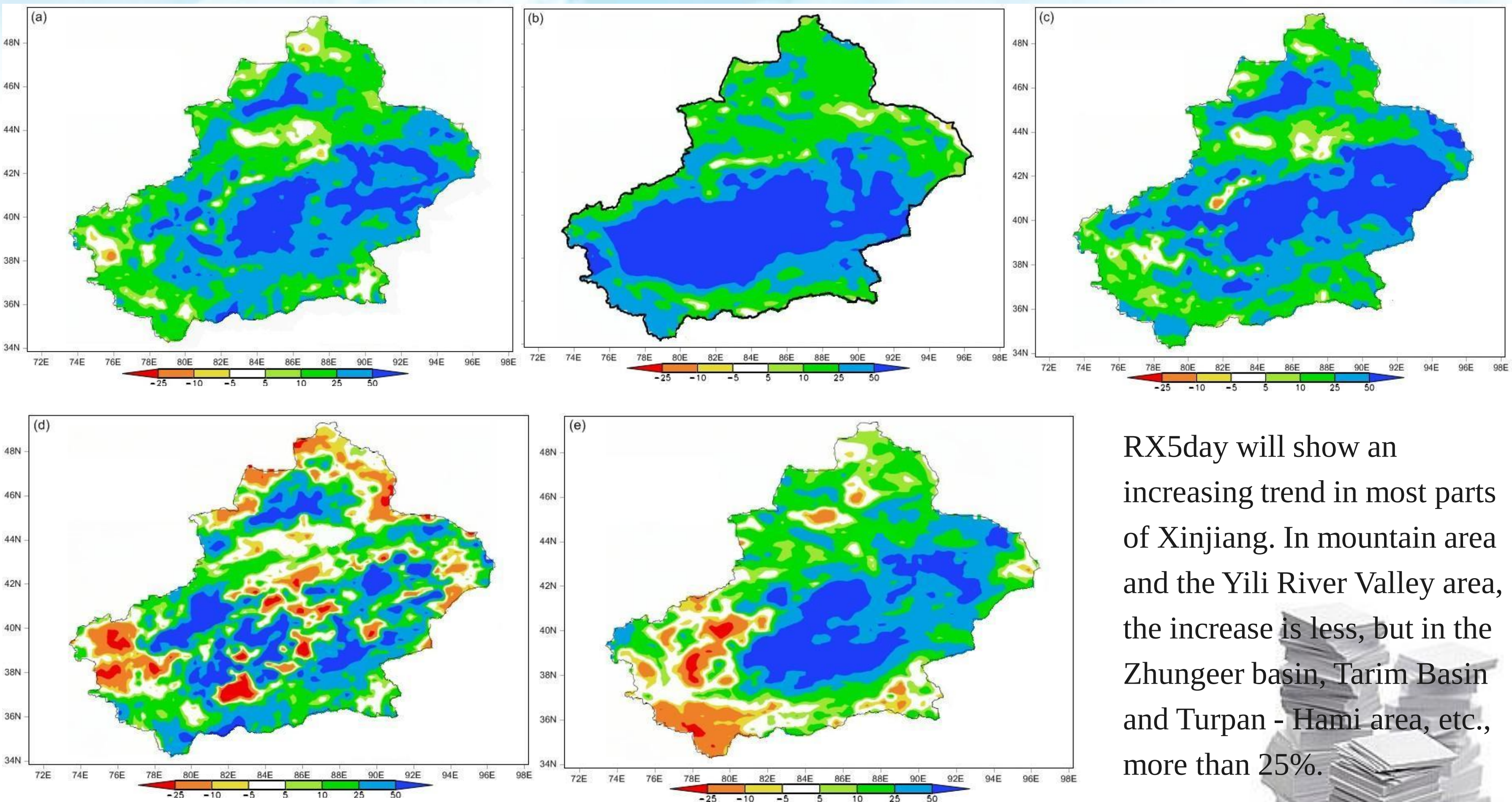


Figure 14. SDII annual average change :(a)year (b)winter; (c)spring; (d) summer; (E) autumn (unit:%)

SDII in the future under the A2 scenario, at the annual and seasonal mean that most of the variation is showing a trend of increase, especially in winter in southern Xinjiang and eastern Xinjiang region to increase the ratio reached more than 20%. A trend of decreasing in summer and autumn.

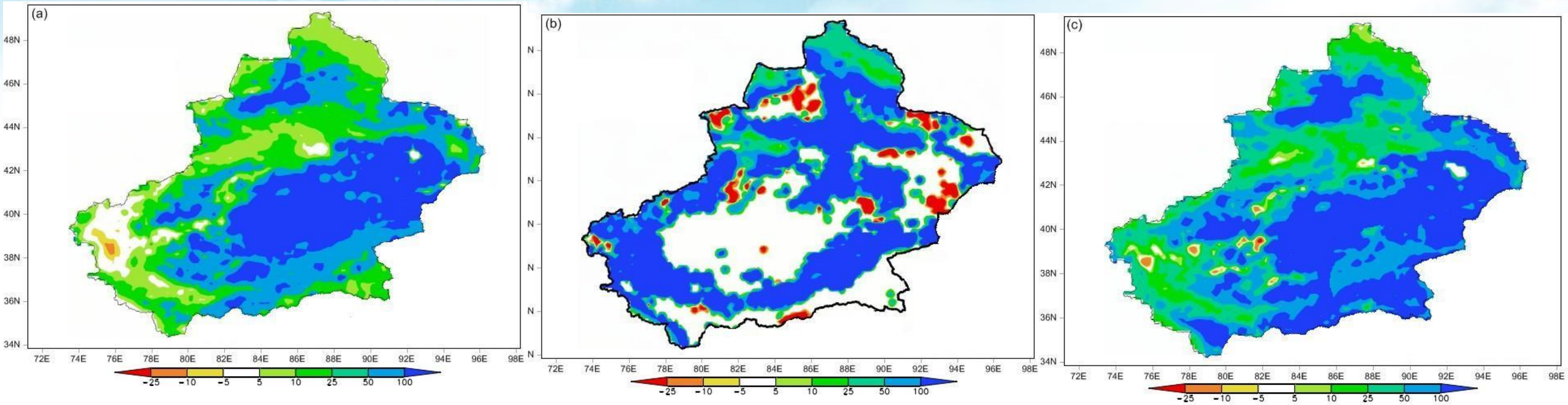
Prediction of extreme precipitation change ——————RX5day

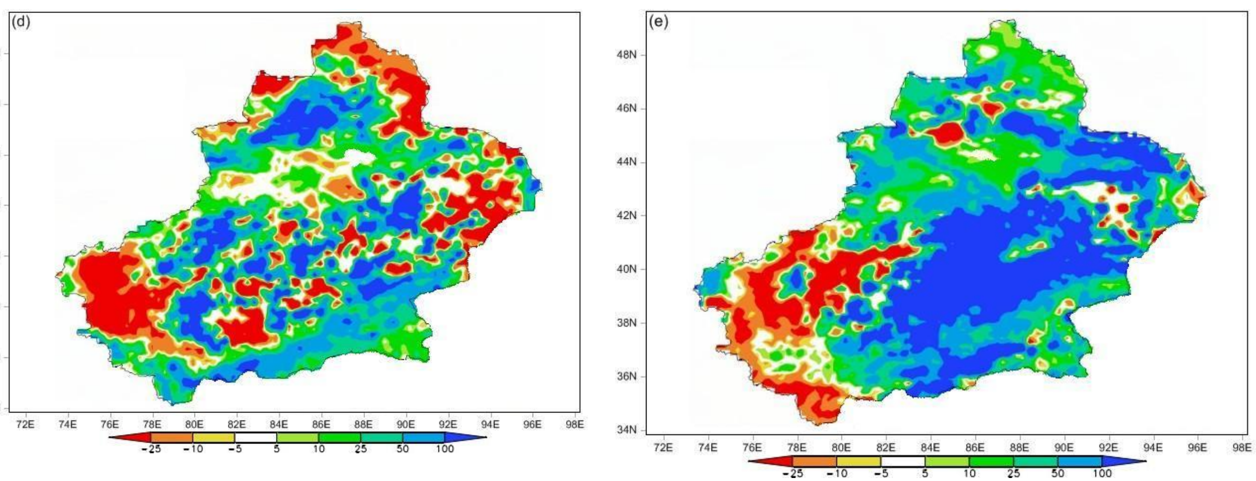


RX5day will show an increasing trend in most parts of Xinjiang. In mountain area and the Yili River Valley area, the increase is less, but in the Zhungeer basin, Tarim Basin and Turpan - Hami area, etc., more than 25%.

Figure 15. Annual and seasonal changes of RX5day: (a)year; (b) winter; (spring; (d) summer; (e)autumn (unit: %)

Prediction of extreme precipitation change ---R10mm





Most show an increasing trend. In mountain areas and the Yili River Valley area, the increase is less, but in the Zhungeer basin, Tarim Basin and Hami - Turpan area, etc.

Figure 16. Annual and seasonal changes of R10mm : (a)year; (b) winter; (spring; (d) summer; (e)autumn (unit: %)

4. Conclusions

◆In the past 50 years, temperatures have generally increased in the Tianshan Mountains and the southern and northern areas, most noticeably after 1990. The rate of increase was 0.34° C·10 year^{1}, 0.3° C·10 year^{-1}, and 0.32° C·10 year^{-1}, respectively (α=0.05 for all values) .

◆In the past 50 years, the rainfall in all three areas has shown an increasing trend. The rate of increase in rainfall in the Tianshan Mountains and the southern and northern area was 15.3 mm·10 year^{-1}, 3.0 mm·10year^{-1}, and 13.8 mm·10 year^{-1}, respectively.

◆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.

◆ 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, 0.154d/10a, and 8.232mm/10a, respectively).

◆ 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.

◆The extreme precipitation events in most Xinjiang area will show an increasing trend during 2071-2100.

Thank you for your attention !