

**CMA-DOE Science Team Meeting**  
**27-28 Oct. 2003, Beijing**



# **Climate Change of the Past 100 Years in Mainland China**

**Guoyu Ren**

**National Climate Center, Beijing**





## **Scientists attending the study:**

Ren Guoyu, Xu Mingzhi, Tang Guoli,  
Liu Hongbin, Zhai Panmao, Lin Xuechun,  
Guo Jun, Chu Ziyang, Chen Zhengong,  
Liu Xiaoning, Li Qingxiang, Wang Ying,  
Zhang Li, Yang Hongqing, Ren Fumin,  
Zou Xukai, Gao Ge

National Climate Center, Beijing, China

## **Correspondence to:**

Guoyu Ren

Email: [gyren@homeway.com.cn](mailto:gyren@homeway.com.cn)



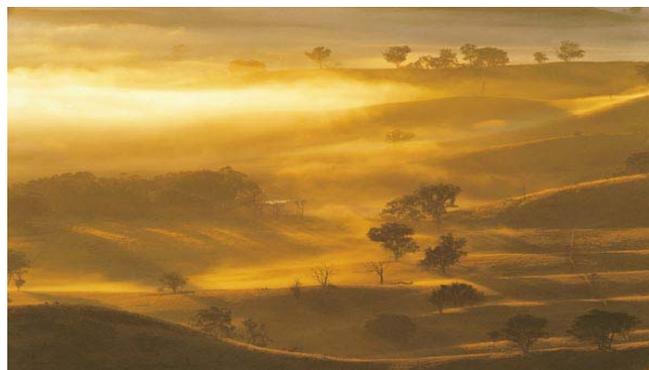
# Contents :

1. Data and Methods
2. Results and Findings
3. Conclusions





# 1. Data and Methods





# Data Used

1. A data set for about 700 stations
2. Monthly mean temperature  
Monthly precipitation  
Daily average temperature  
Daily precipitation (YZ River)  
Days with dust storm
3. Periods from 1905 to 2001 or  
from 1951 to 2001



# **Adjustment of data**

**The major in-homogeneities existing in the data of monthly mean temperature for the last 50 years checked and corrected, based on the P-E procedure**



## Types of main in-homogeneities

### Relocation of stations:

Stations relocated for two times and more: 276 (41%)

Stations relocated for one time: 206 (31%)

Stations without relocation: 189 (28%)

### Other changes in:

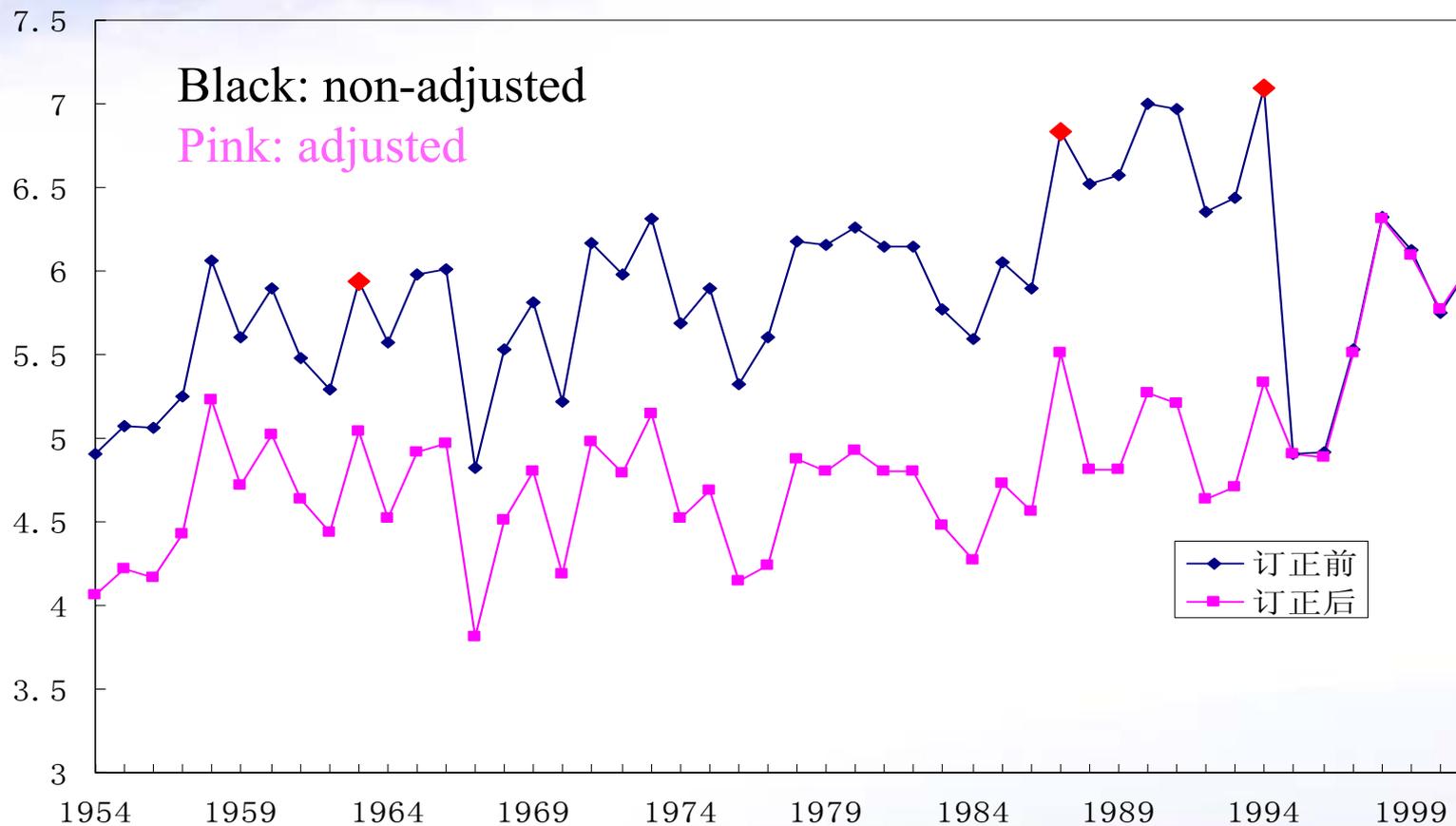
instrumental types

observation times

statistical methods



# Comparison between adjusted and non-adjusted annual mean temperature (Xining)



1995: station moved from the city to suburb



## Methods (1)

**National average temperature anomalies:**

**Jones' method;**

**But a grid box of  $2.5^{\circ}$  by  $2.5^{\circ}$  for the 50  
year series;**

**A new reference period of 1971-2000.**



## Methods (2)

**Annual precipitation tendency:**

**Correlation coefficient between total annual precipitation and the time series numbers for each station**



## Methods (3)

**Length of growth season:**

**Growth season: period with daily average temperature steadily above 0 °C in a year**



## Methods (4)

**Days with heavy rainfall and the tendency:**

**Heavy rainfall:**

**daily rainfall above 50 mm;**

**Tendency of days with heavy rainfall:**

**correlation coefficient between the days and the  
time series numbers for each station**



## Methods (5)

### **Days with dust storm and the tendency:**

**Dust storm: a weather phenomena with strong wind and large amount of dust in the air leading to a visibility less than 1000 m;**

**Tendency: correlation coefficient between total days with dust storm and the time series numbers for each station**



## 2. Main Results and Findings





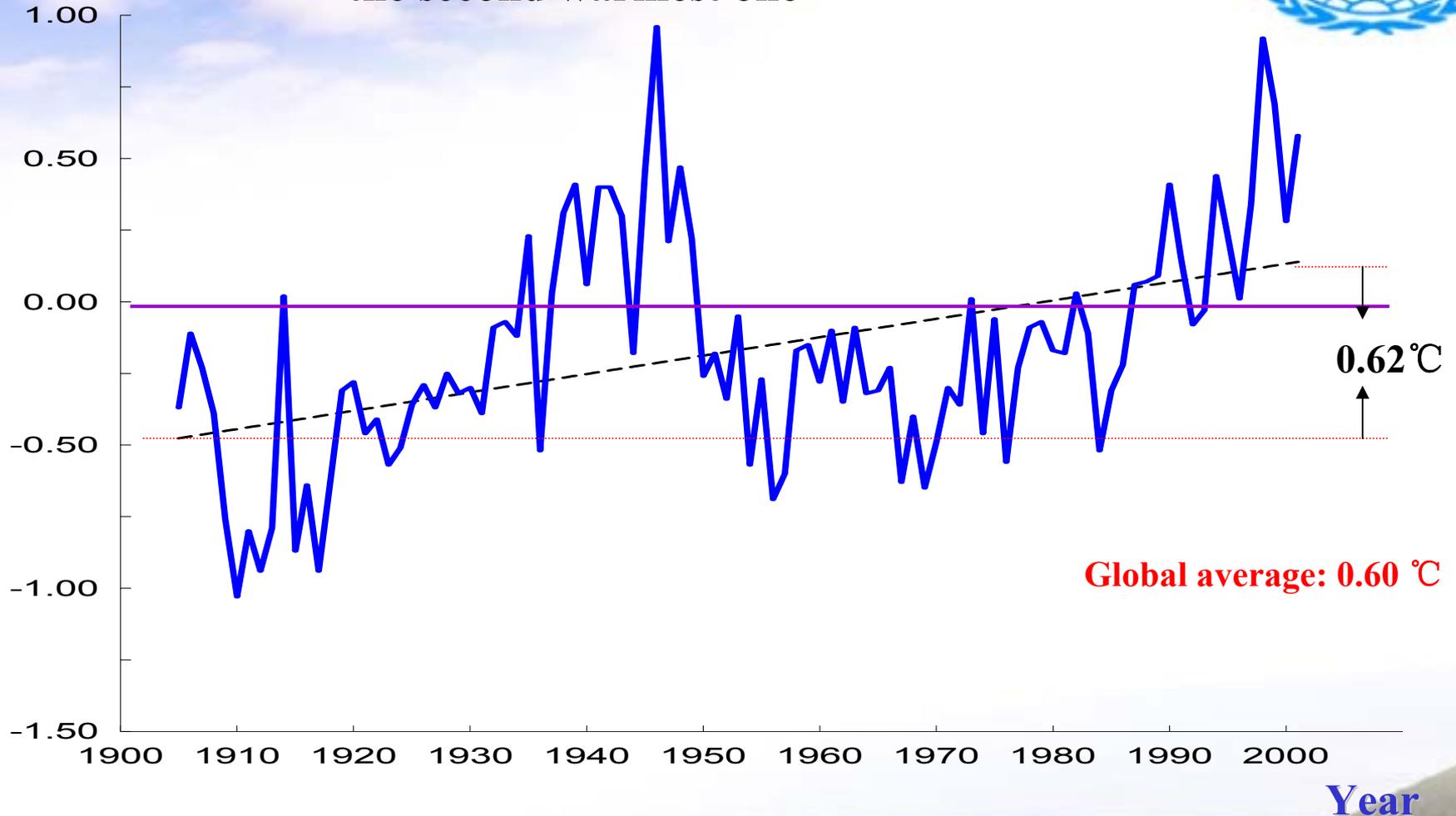
# Changes in surface air temperature



Two warm periods are obvious in 1930-40's and 1980-90's, with 1946 the warmest year and 1998 the second warmest one



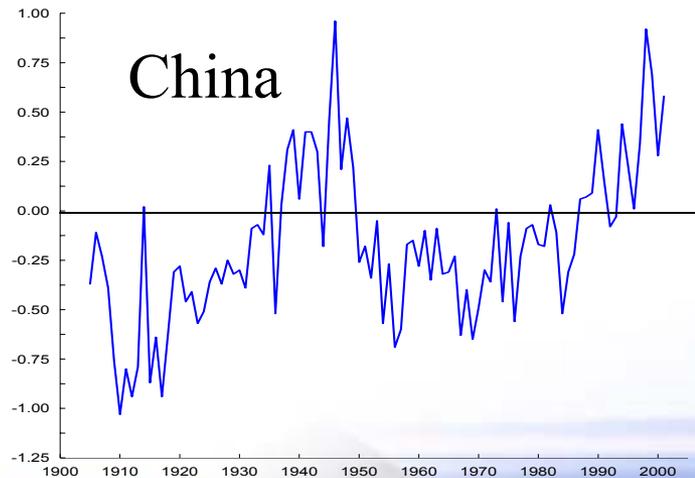
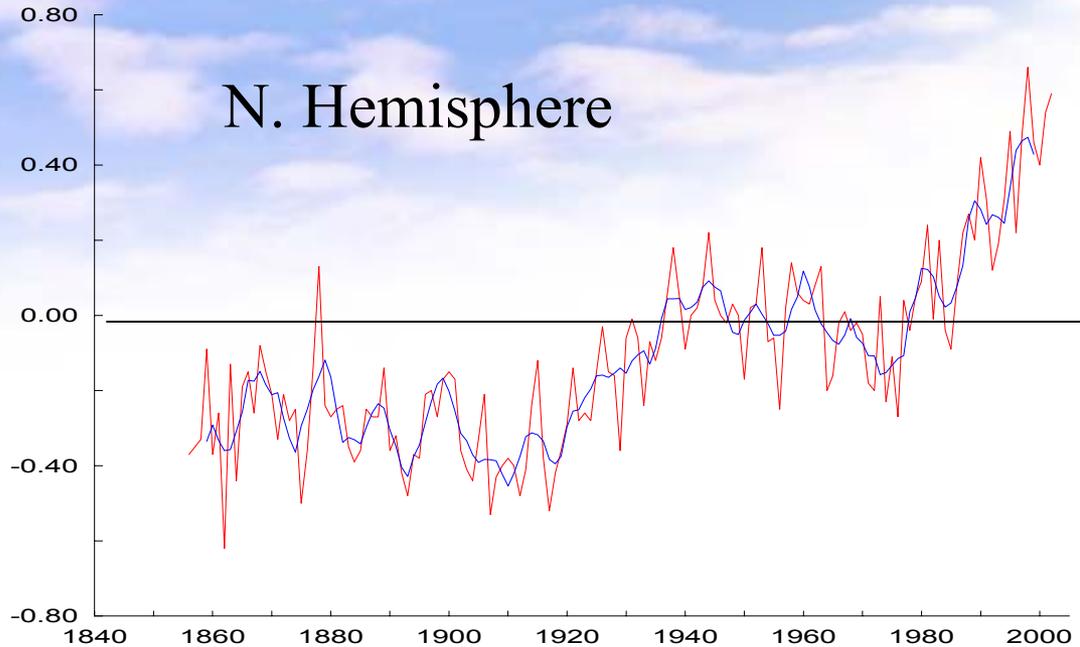
Anomaly ( °C)



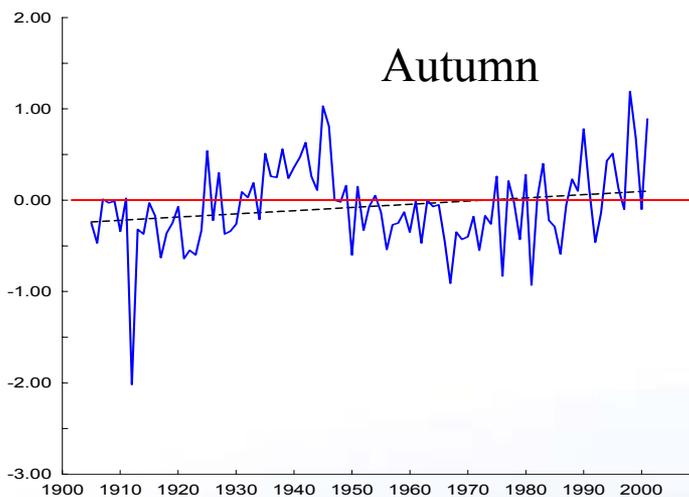
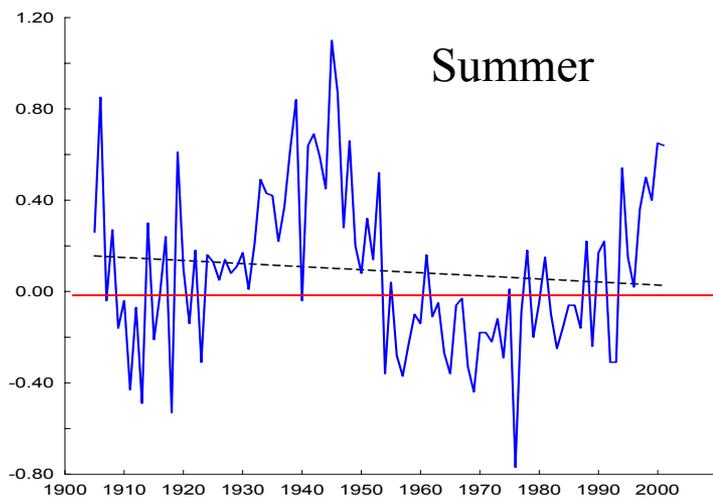
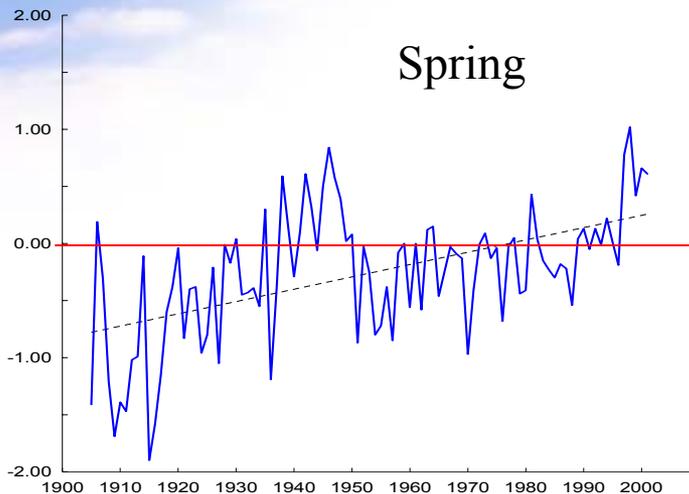
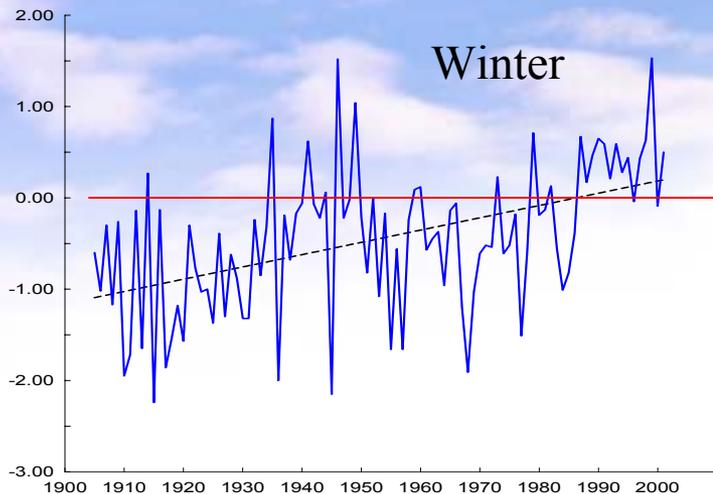
## Change in annual mean temperature in China (1905-2001)



# A comparison between northern Hemisphere and China



1. The same trend in the last 100 years;
2. 80's、90's close to 40's in China, but 80's、90's much warmer in N.H;
3. 50-70's relatively cool in China.



**A 1.3°C warming in winter, 1.1°C in spring, a cooling of 0.1°C in summer, and a warming of 0.4°C in autumn;**

**Warming mainly in winter and spring;**

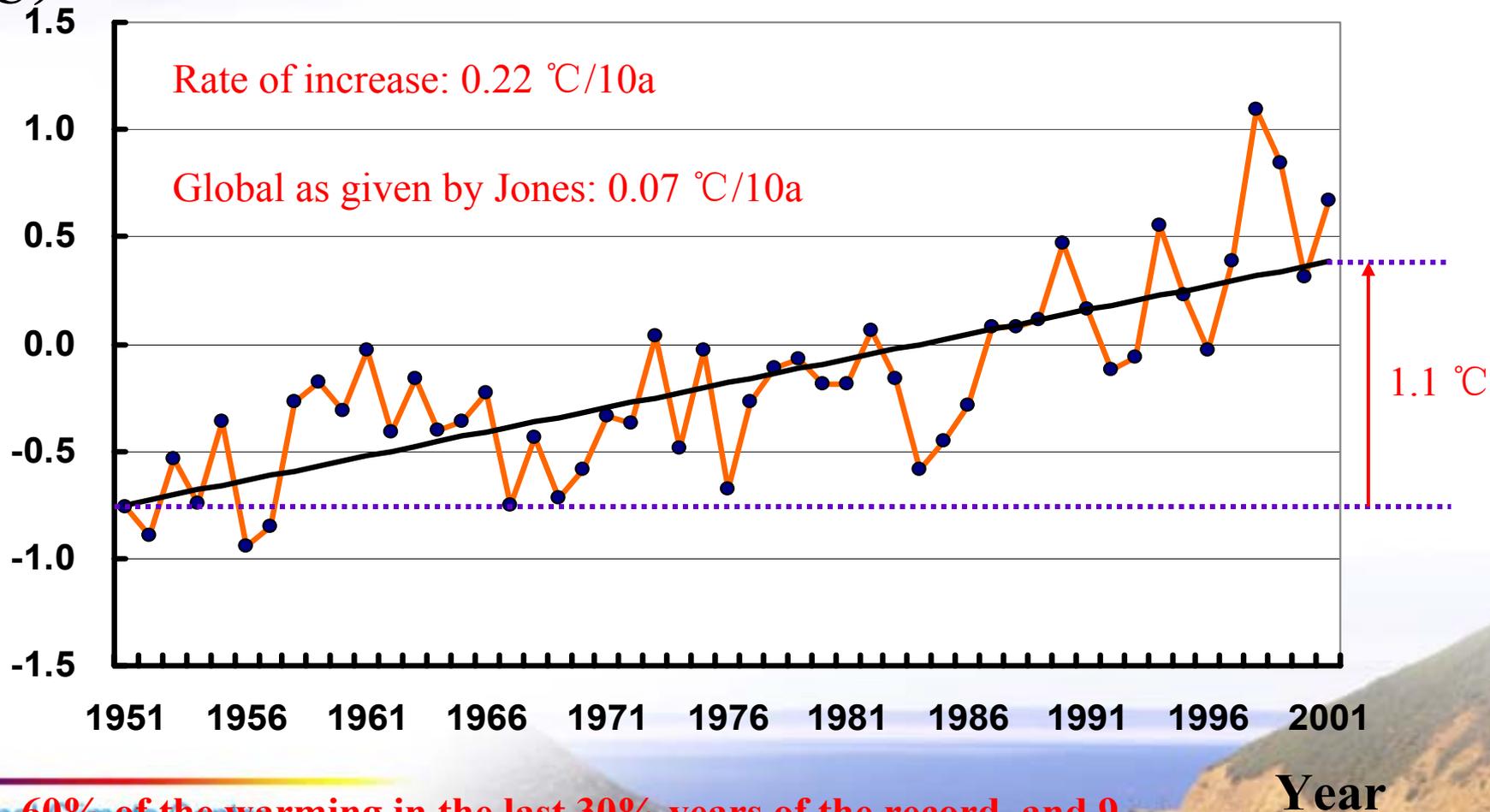
**The warmest years in 90's for spring and autumn, in 40's for summer, and 40's and 90's for winter.**

# Changes in seasonal mean temperature in China (1905-2001)

# Change in annual mean temperature in China 1951-2001



Anomaly  
(° C)



National Climate Center  
国家气候中心

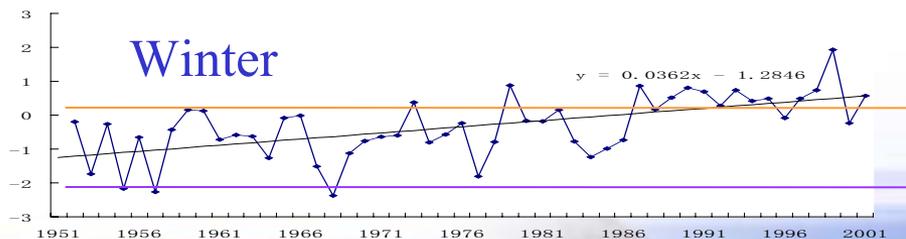
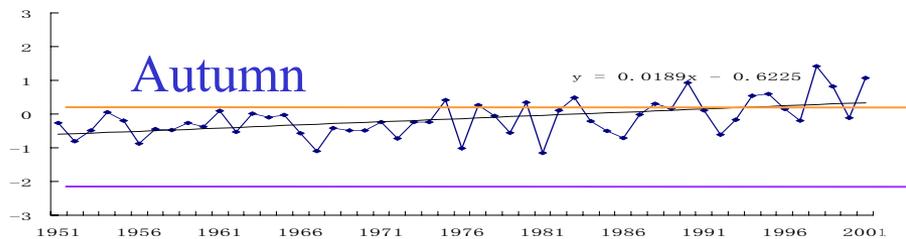
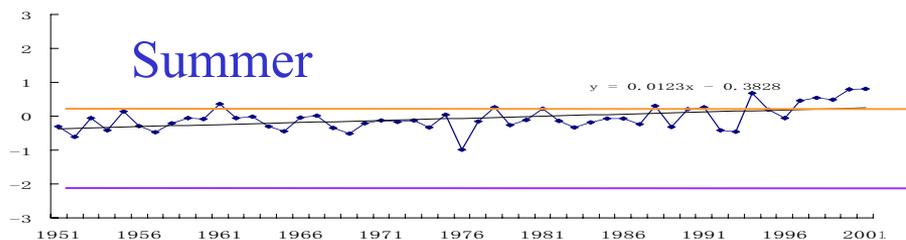
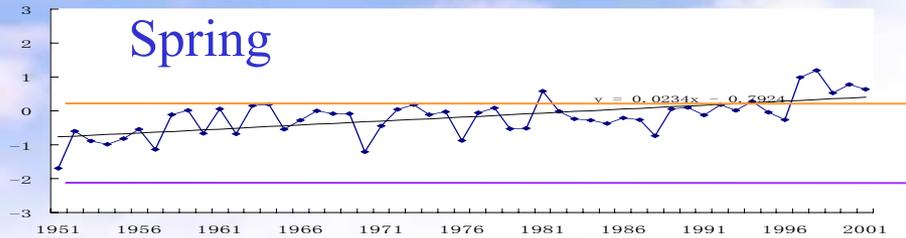
60% of the warming in the last 30% years of the record, and 9 warmest years in the last 12 years, with 1998 the warmest year.

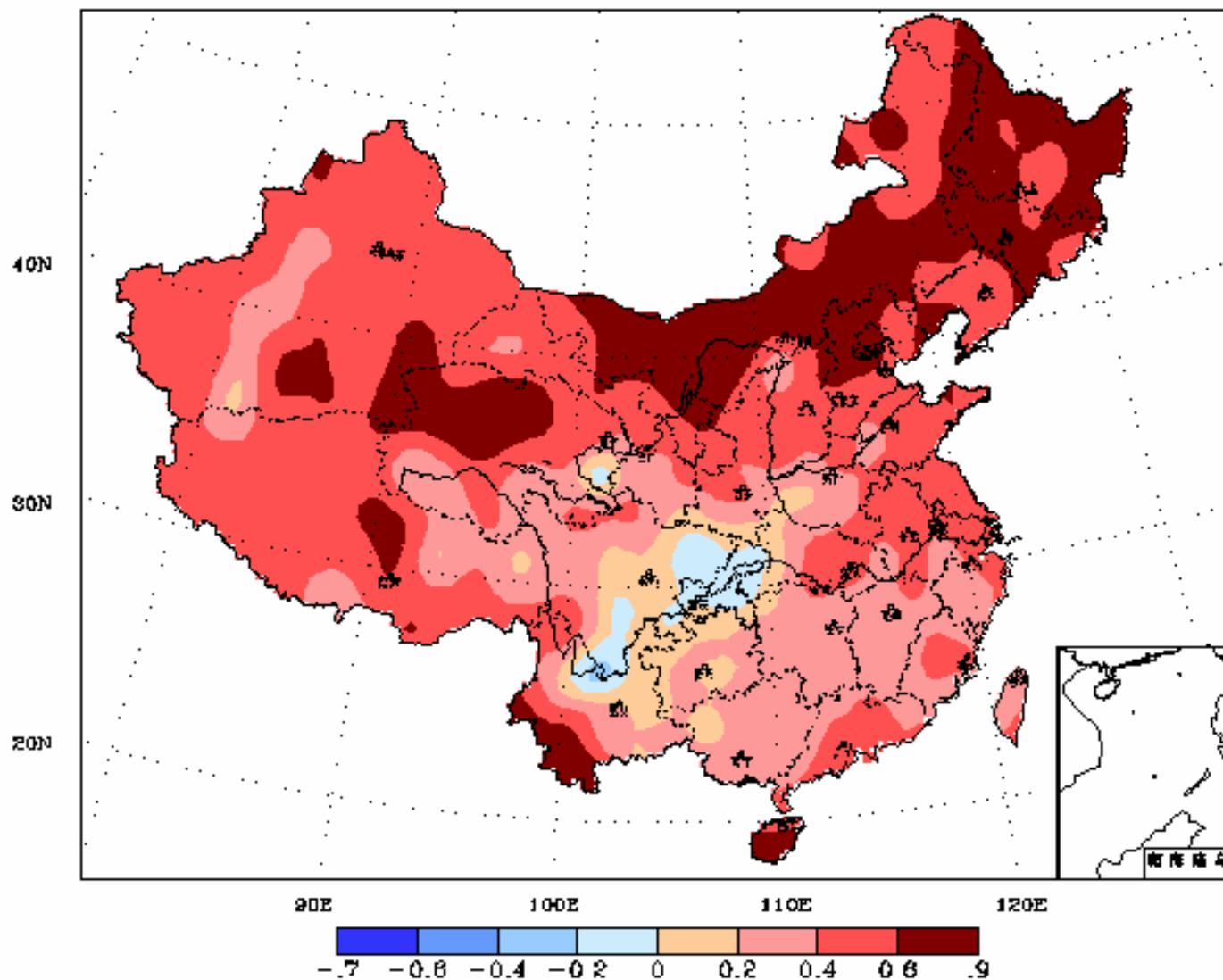


## Change in seasonal mean temperature over Mainland China (1951-2001)

- More rapid warming in winter and spring; Continuous 17 warmer-than-average winters so far.
- Change in summertime not marked until 1993

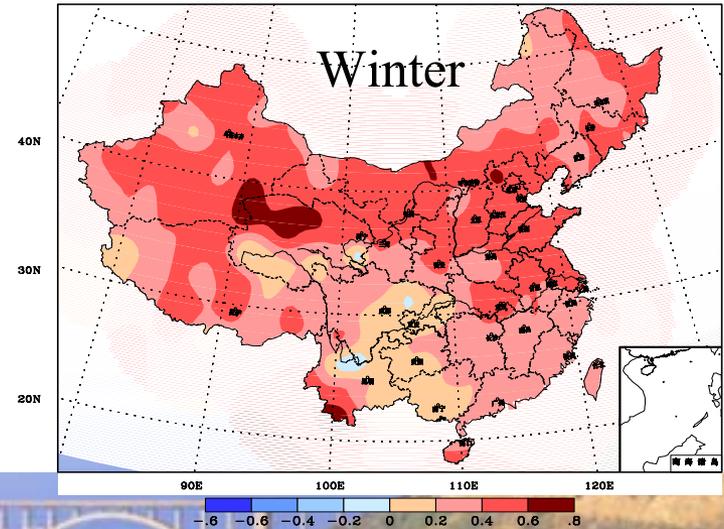
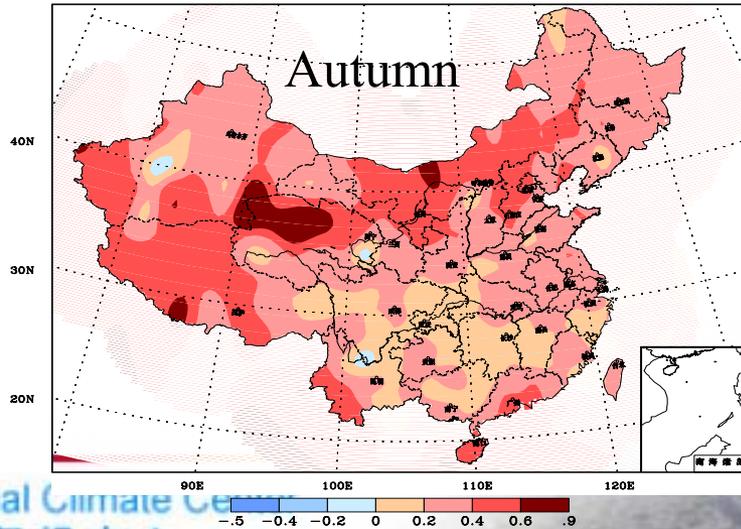
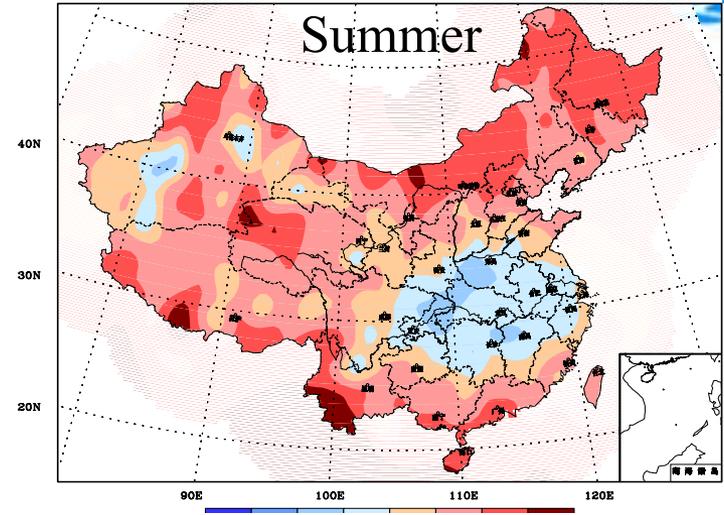
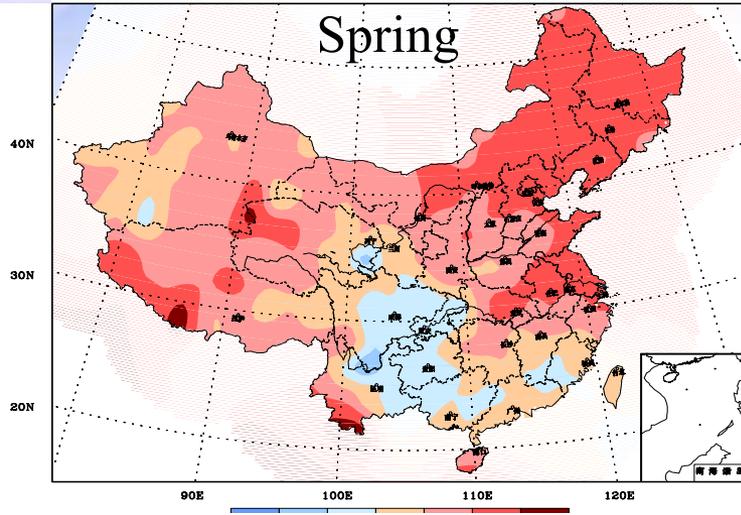
Temperature anomalies





**Tendency of annual mean temperature in China  
from 1951 to 2001**

# Tendency of seasonal mean temperature in China from 1951 to 2001





## Characteristics of temperature change over the last 50 years

- Annual mean temperature rose by 1.1 °C, much rapid than the global average over the same period;
- Spring mean temperature rose by 1.2 °C, summer 0.6 °C, autumn 1.0 °C, and winter 1.8 °C;
- The most significant increase occurred in the last 15 years, with 1990's the warmest decade, and 1998 the warmest year.



## Characteristics of temperature change over the last 50 years:

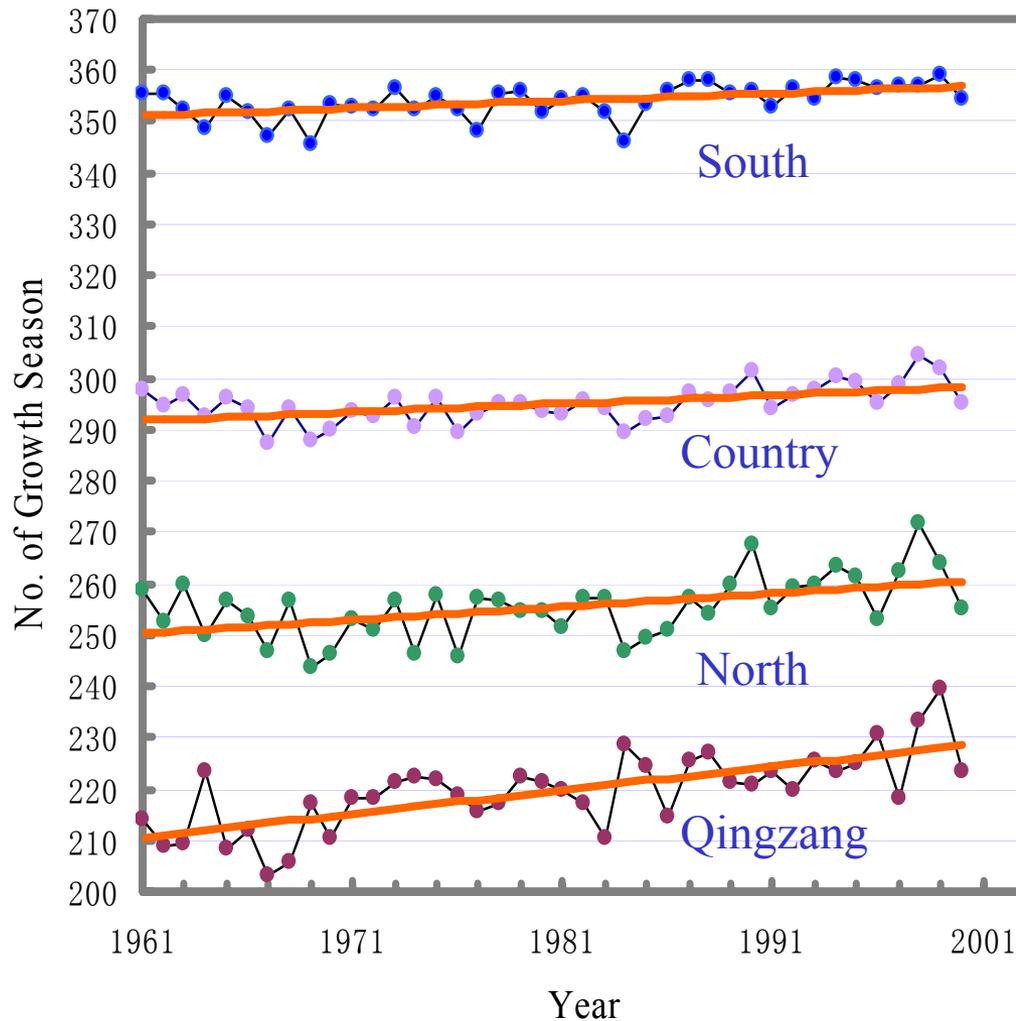
- **Seasonally cooling phenomenon is interesting, with the decreases of spring evident in the southwest and of summer obvious in the mid-to lower Yangtze River**



# Change in growth season



# Change in Growth Season over Mainland China (1961-2000)



**Growth season increased by:**

**6.6** days in Mainland China as a whole;  
**10.2** days in northern China;  
**4.2** days in southern China;  
**18.2** days in the Tibet Plateau.

The most rapid increase in 1990s, and 1998 with the longest growth season.



# Changes in precipitation



Joan Lebold Cohen/Photo Reseachers, Inc.



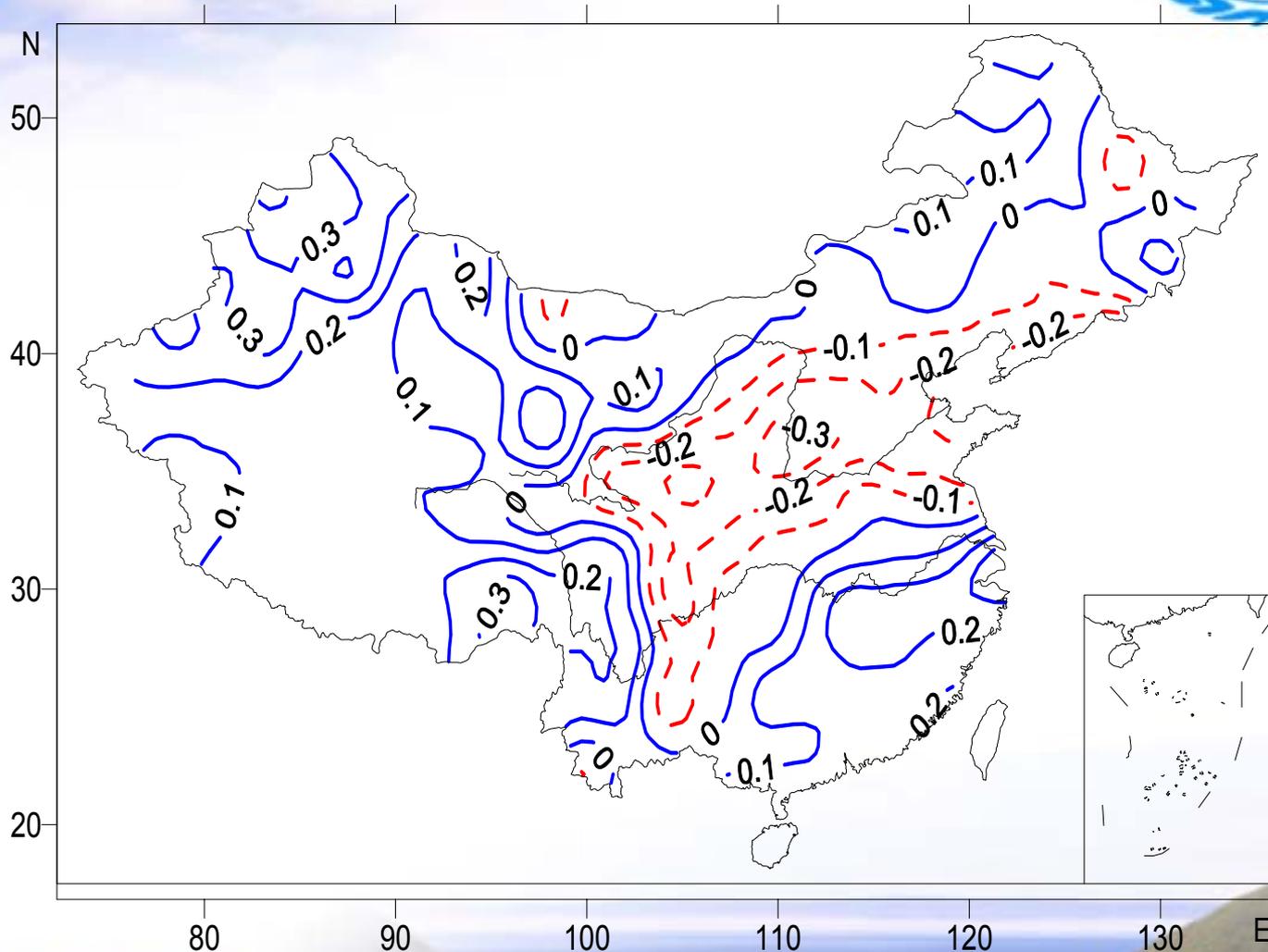
# Tendency in Precipitation over China

(1961-2002)



Increase in the Yangtze River Basin, most parts of Northwest, Tibet Plateau and Inner Mongolia (Mongolia also wetter);

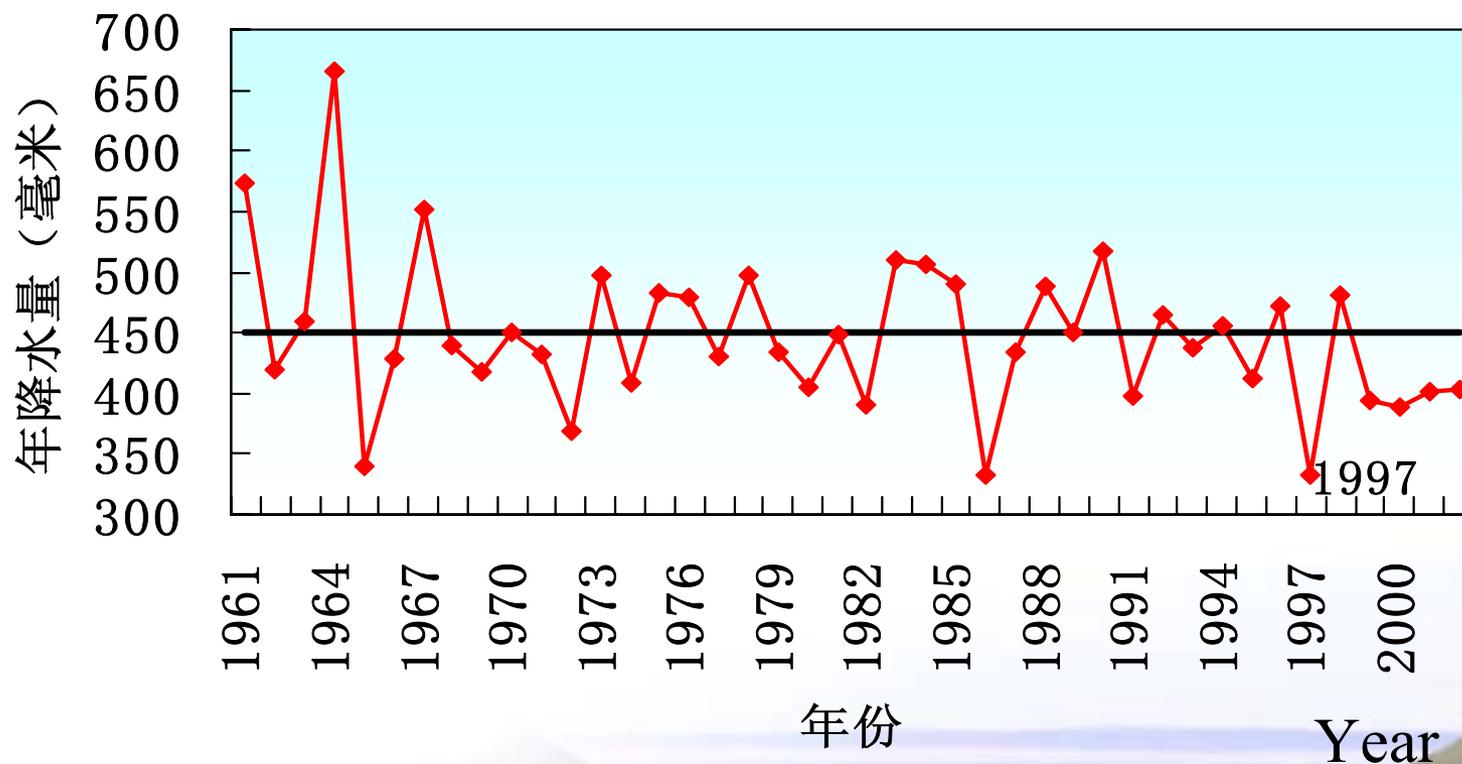
Decrease in the Yellow River Basin (Shandong, Liaodong and North Korea)





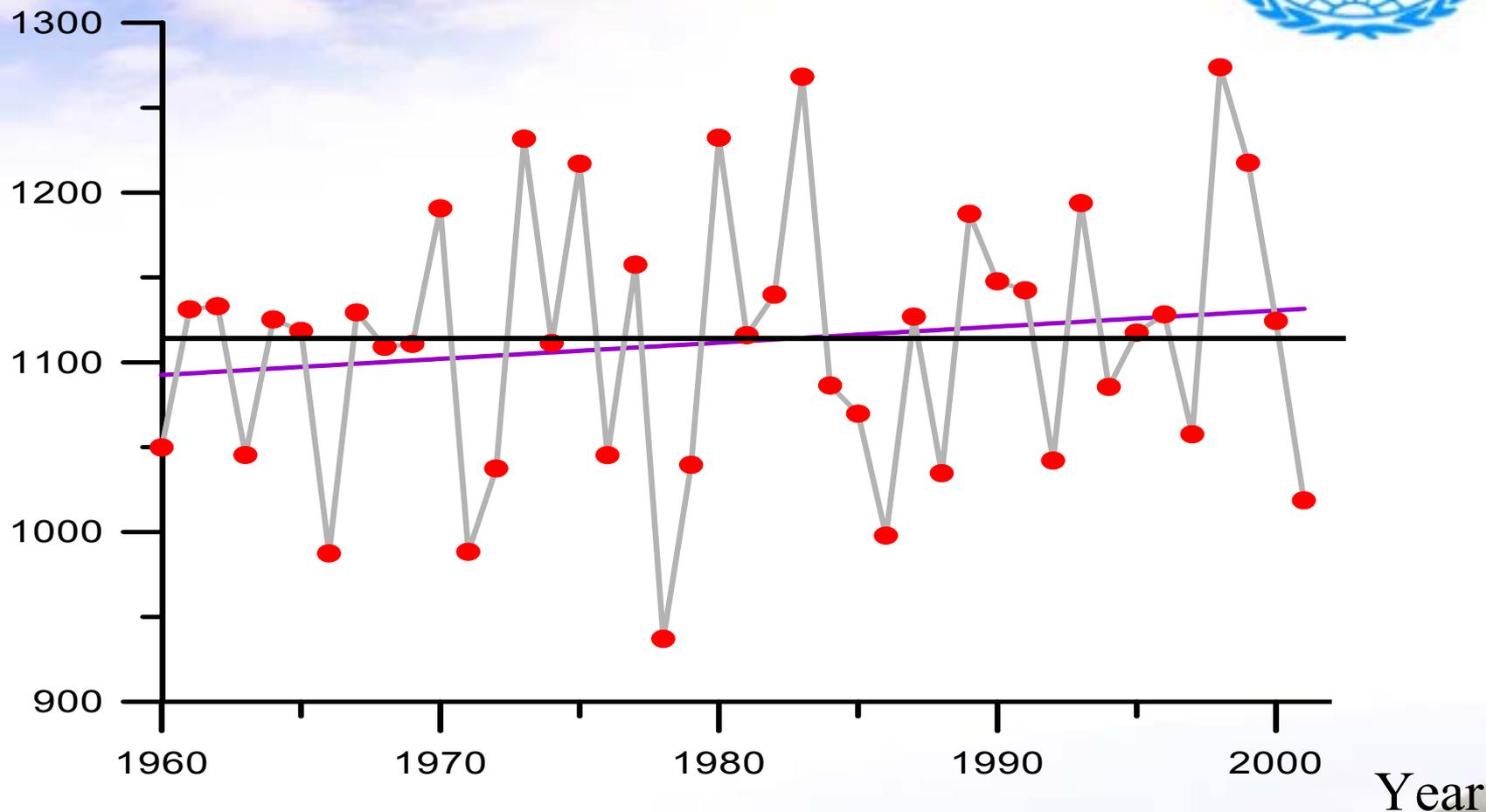
# Area-averaged annual rainfall in the Yellow River Basin: 1961-2002

Rainfall(mm)





Rainfall (mm)



**Area-averaged annual rainfall in the Yangtze River Basin: 1960-2001**



# Tendency of area-averaged rainfall in the Yangtze Basin (1960-2001)

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	<b>Spr.</b>	<b>Sum.</b>	<b>Aut.</b>	<b>Win.</b>	<b>Ann.</b>
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<b>Tendency</b>	-0.14	0.37***	-0.36***	0.28	0.15
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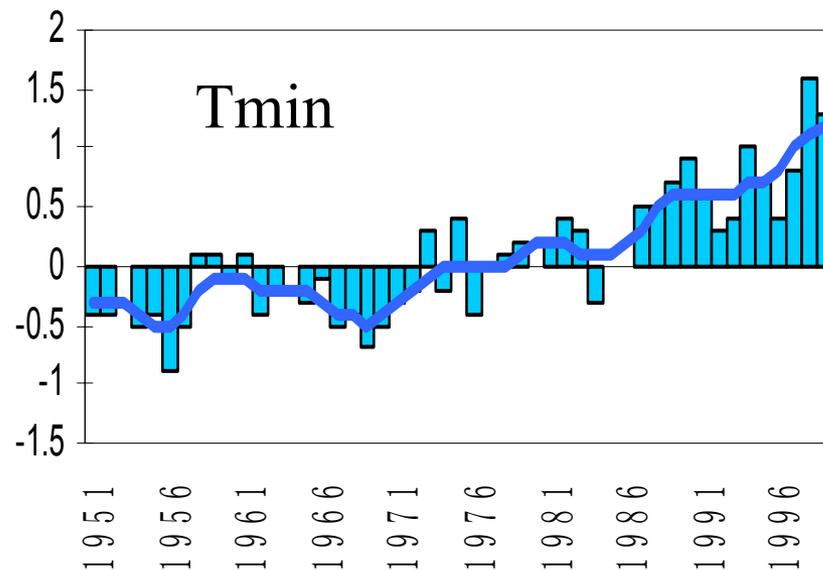
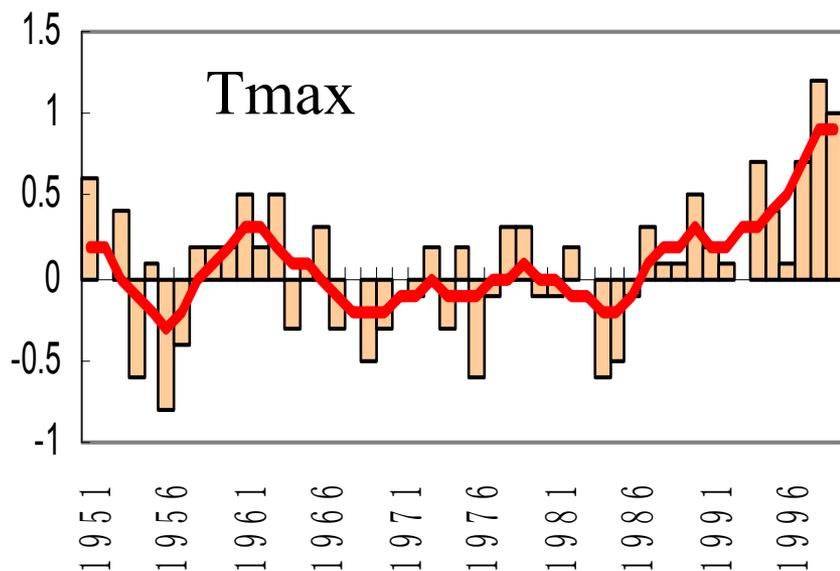
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**Note: \* \* \* indicating significance at level of 0.01**

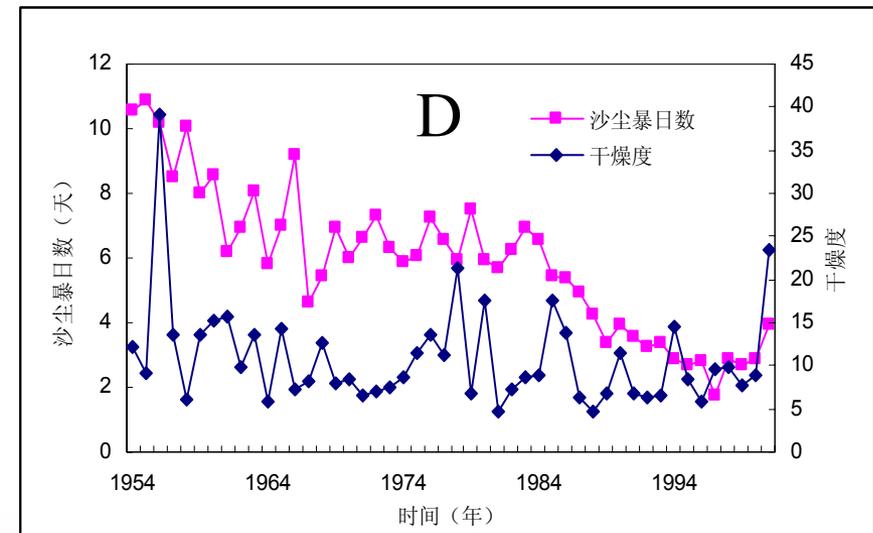
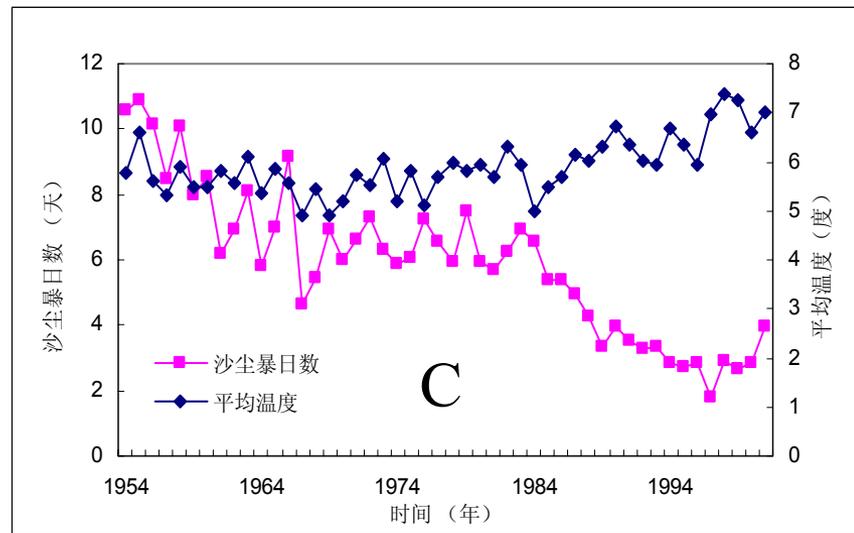
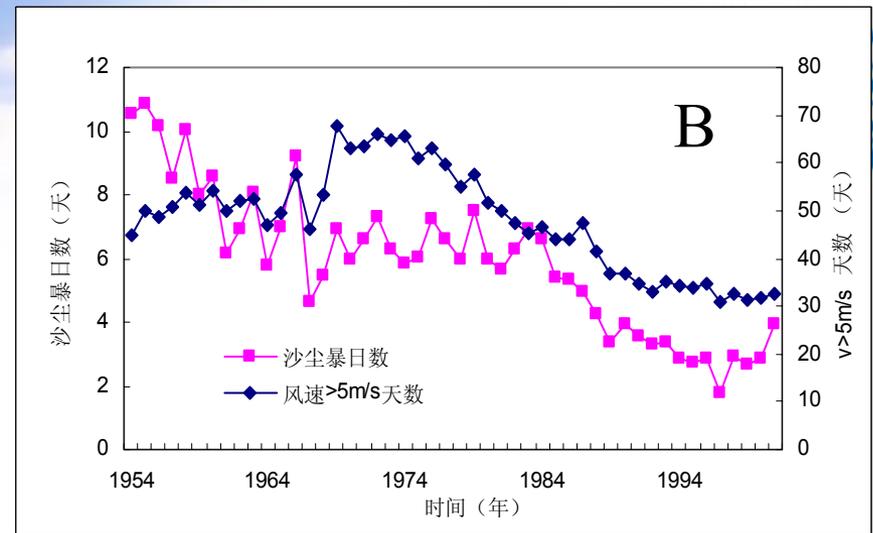
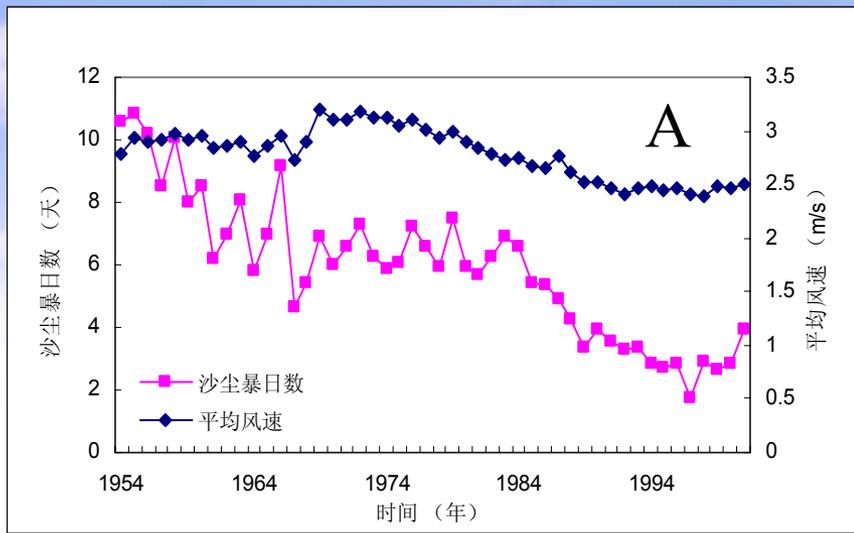


## Changes in extreme events





Anomalies of annual mean  
Tmax, Tmin in China:  
1951-1999

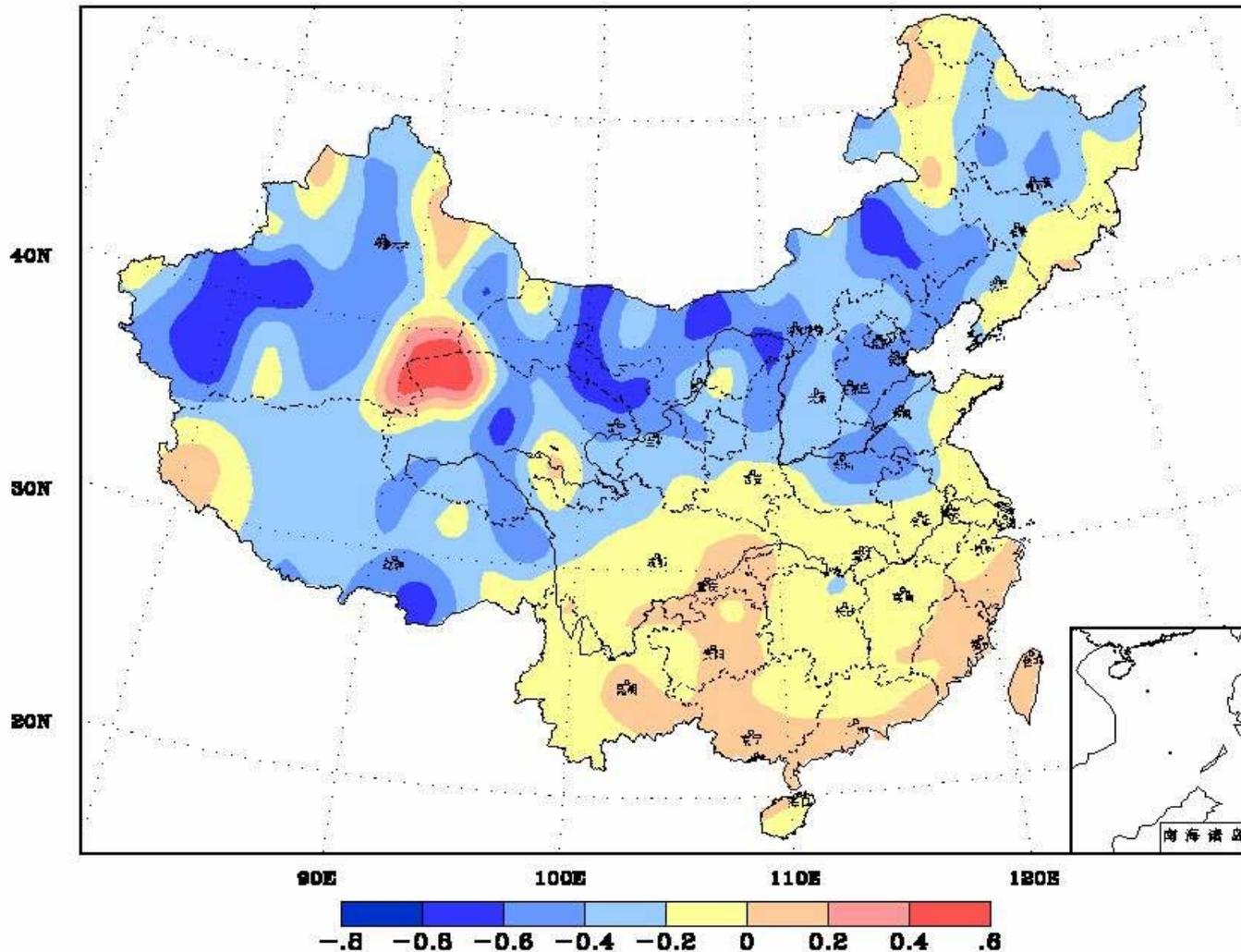


**Days with dust-storm in northern China (pink lines) as compared with mean wind speed (A), days with strong wind (B), mean temperature (C) and dryness index (D) (1954-2001年)**

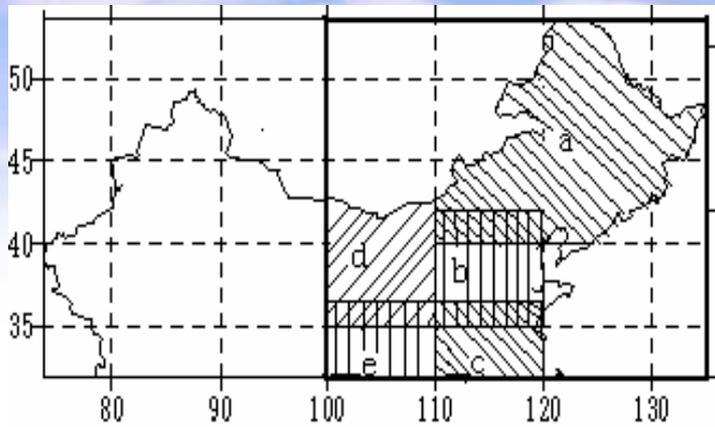
# Tendency in days of dust-storms over China (1960-2000)

1. Decrease in most parts of the dust storms-stricken area;

2. Wetter condition of the source areas and weaker wind speed might be the main factors.



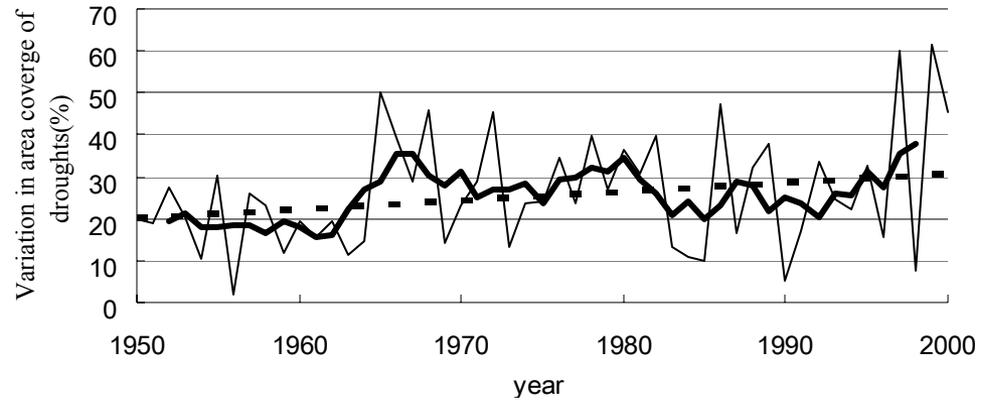
Blue color: positive trend; Yellow color: negative trend



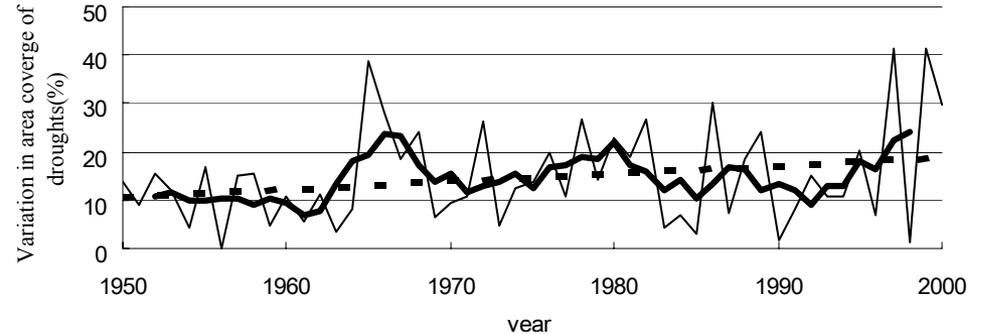
Main agriculture area in northern China (above)

## Changes in drought-stricken area in northern agriculture belt (1951-2001):

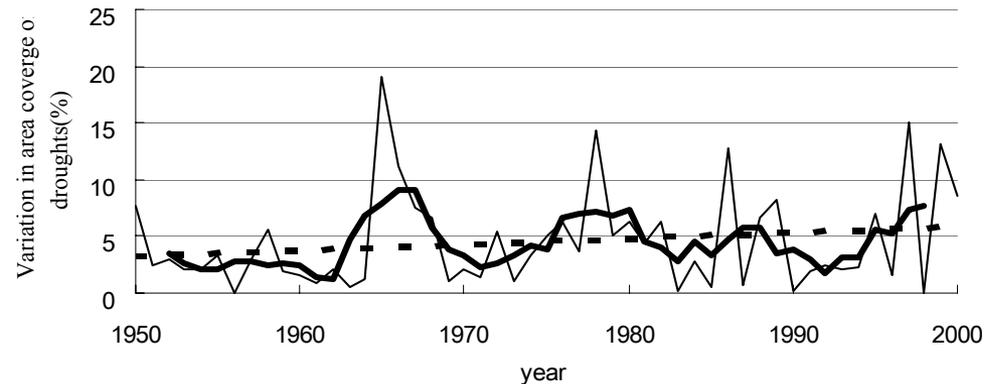
- (a) Slight drought
- (b) Medium drought
- (c) Severe drought



a

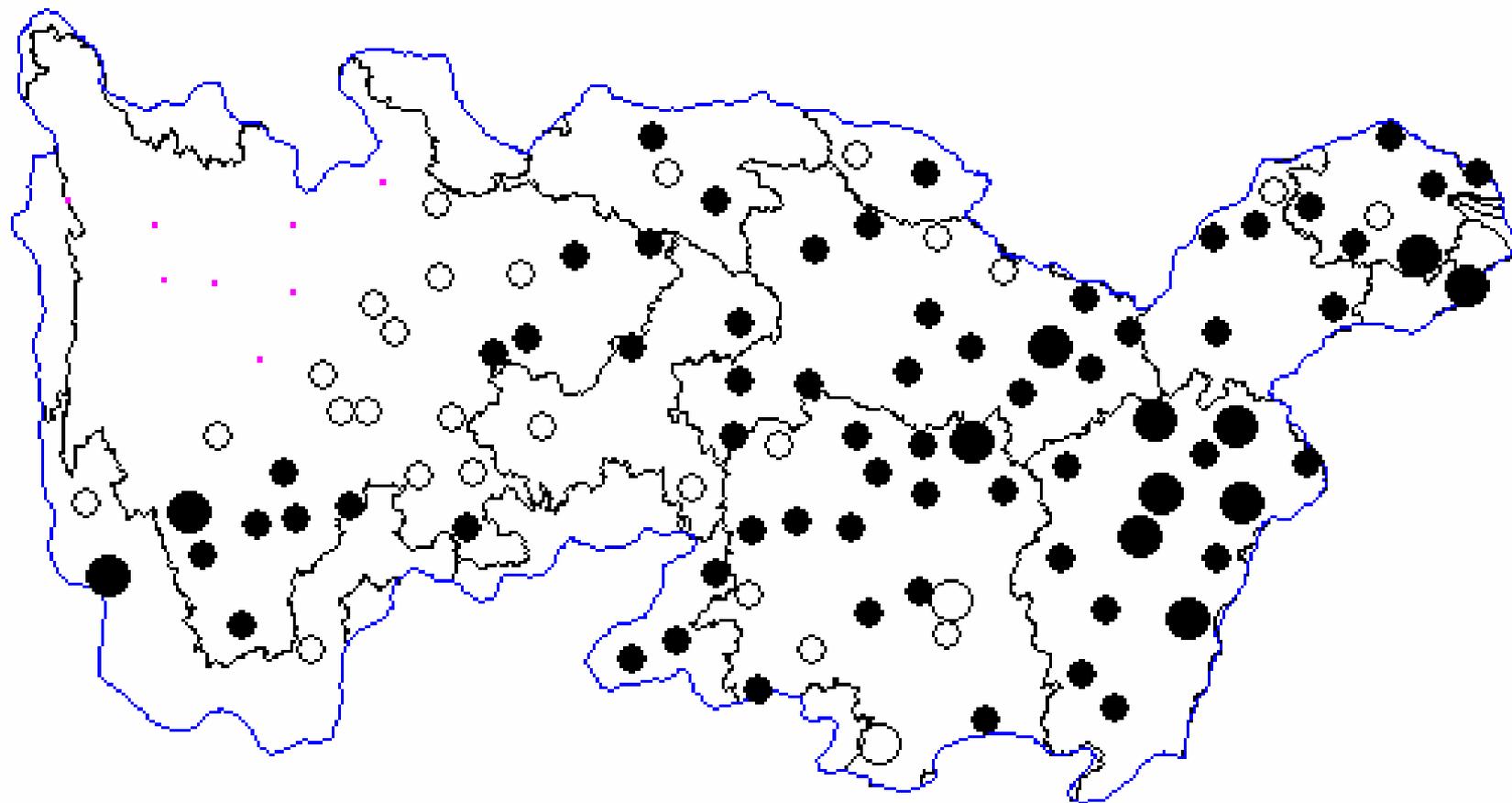


b



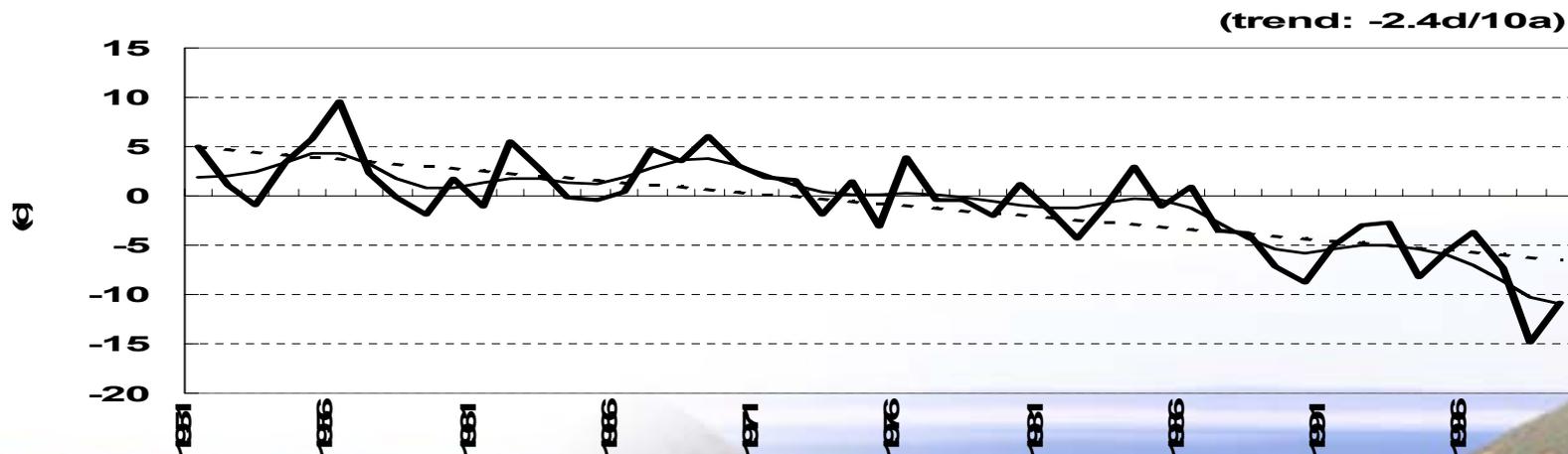
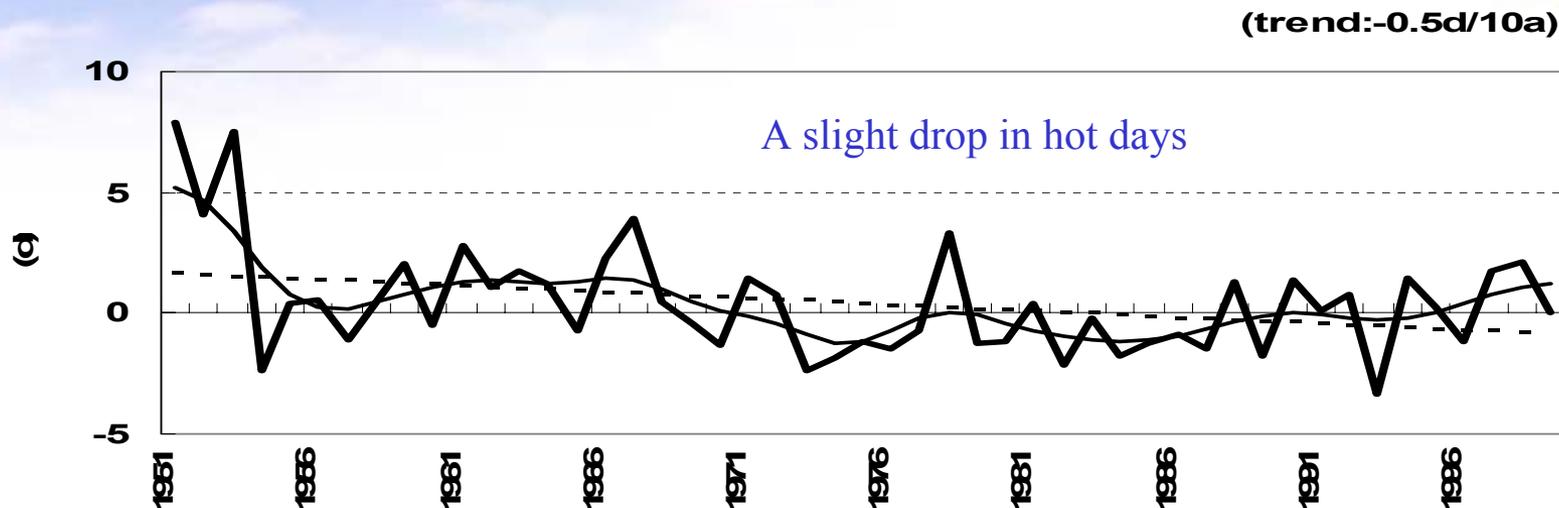
c

# Tendency of days with heavy rainfall in the Yangtze River Basin (1960-2001)



**Solid circle: positive; Open circle: negative; Larger circle: significant at 0.05 level; Pink point: place without heavy rainfall**

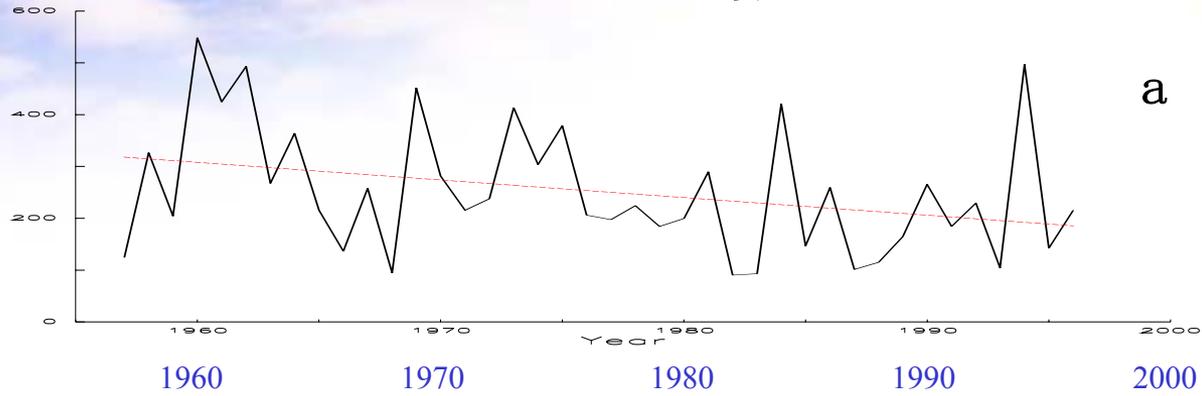
# Changes in hot days (above) and frost days (below) during 1951-1999



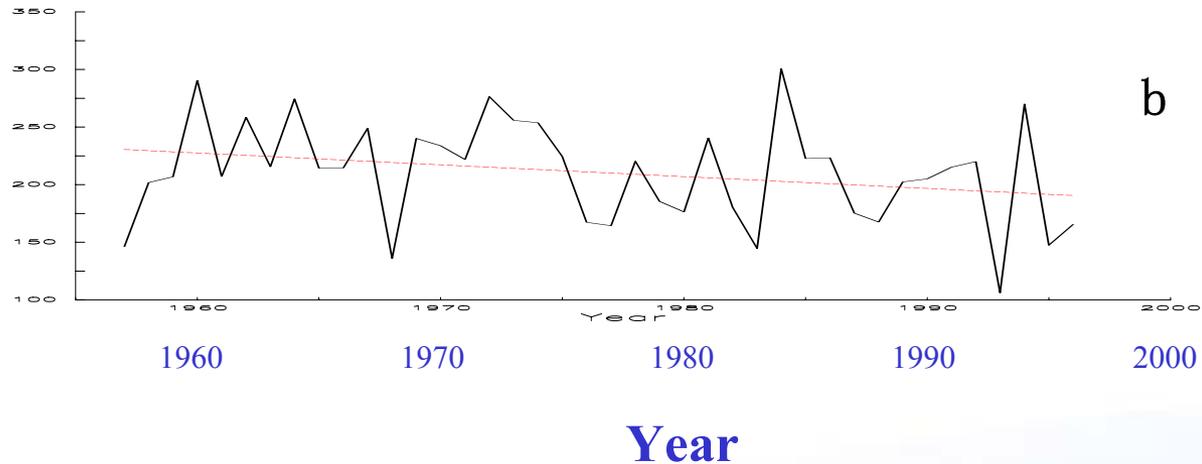
# Significant decrease in amount of the precipitation from 1957 to 1996



Amount



Area



**Changes in Typhoon-induced precipitation (a) and the affected area (b) in China: 1957~1996**



## 3. A few of conclusions





**1. Significant warming occurred during the 20<sup>th</sup> century, with the increase after 1985 much more evident;**

**The warming during the last 50 years mainly occurred in northern China and the Tibet Plateau, and in the cold seasons (winter and spring);**

**Lengthening of growth season in the warming regions in 1951-2001.**



## **2. Obvious regional difference in change of precipitation for 1951-present period:**

**Increase in annual precipitation and days with heavy rainfall in the mid-to lower Yangtze River and most parts of western China;**

**Decrease of precipitation in the Yellow River Basin.**



**3. Days with dust storm and dusty condition decreased in the record period;**

**Also evident are the decreases in days with cold wave, hot wave and frost phenomenon, and in Typhoon rainfall;**

**Dryness in the Yellow River basin and days with heavy rain in the Yangtze River basin seem to have increased in the past 40-50 years.**



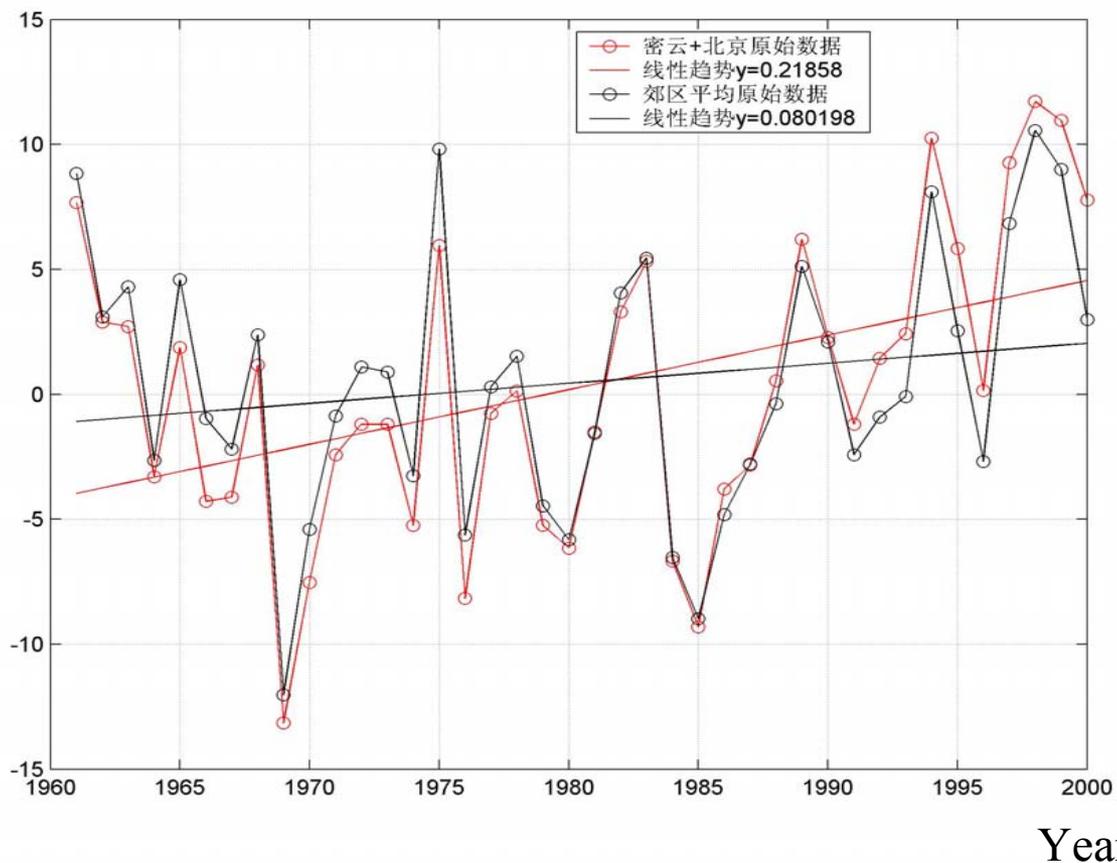
## **Two problems with temperature data remain:**

**For temperature analysis, in-homogeneity of data for earlier period needs to be further treated;**

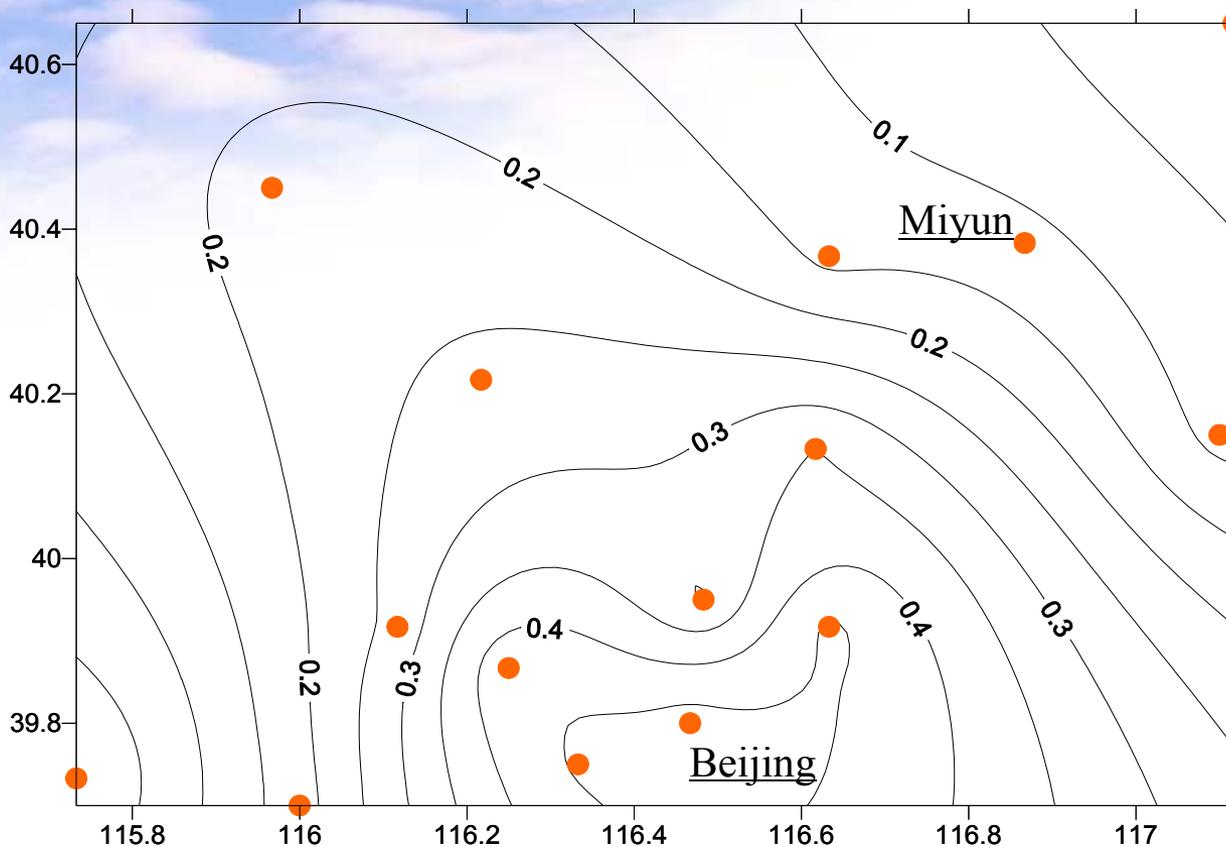
**For usefulness in detection and attribution studies of climate change, urbanization effect on temperature records has to be more carefully checked and corrected.**



Anomaly  
( $10^{-1} \text{ } ^\circ\text{C}$ )



**Averaged anomalies of annual mean temperature for BR stations  
(Pink) and rural stations (Black) in Beijing region  
1961-2000**



## Rate of change of annual mean temperature in Beijing region ( °C/10yr): 1961-2000



# Rate of change of annual mean temperature, rate of heat-island warming of BR stations and the percentages in the total warming in Beijing region ( $^{\circ}\text{C}/10\text{yr}$ ): 1961-2000

	Winter	Spring	Summer	Autumn	Annual
Averaged for BR stations	0.528	0.268	0.124	0.151	0.218
Averaged for rural stations	0.378	0.109	0.011	-0.001	0.080
Rate of heat-island warming for BR stations	0.15	0.16	0.11	0.15	0.14
Percentage in total warming for BR stations	28%	60%	88%	100%	64%



In the past 40 years, about **82** percent of the recorded warming at Beijing Station was caused by the enhanced heat island effect, and about **64** percent of the recorded warming for BR stations was caused by urbanization effect.



*Thanks!*



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