香 港 大 學
THE UNIVERSITY OF HONG KONG

Relationship between Climate Change in South China and Urbanization in the Pearl River Delta

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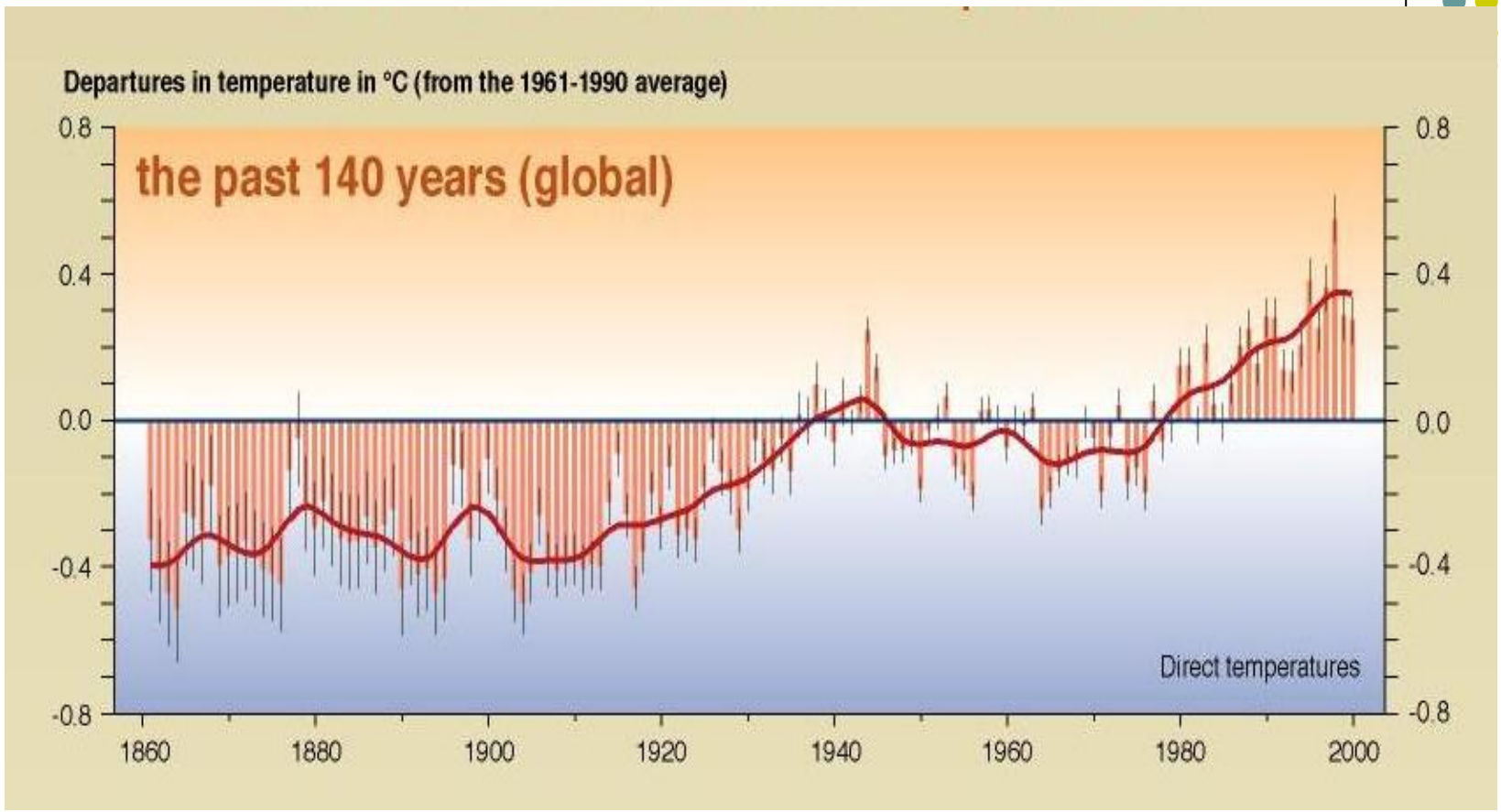
Workshop on Climate Change and Climate Prediction in the Pearl River Delta Region

December 15-16, 2008

Outline:

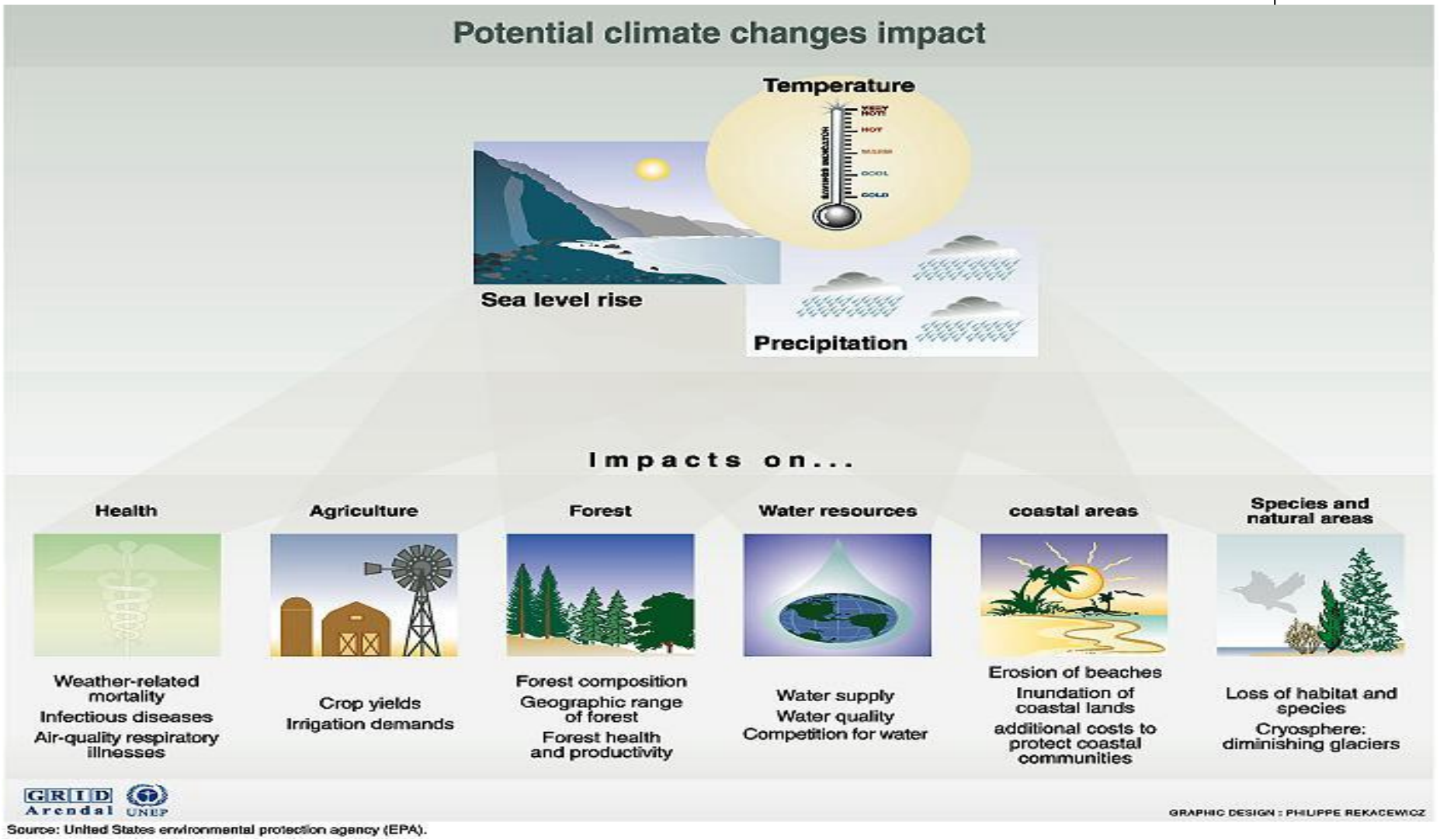
- Introduction
- Research objectives
- Data and the area of interest
- Methodology
- Results and discussion
- Conclusions

Introduction 1



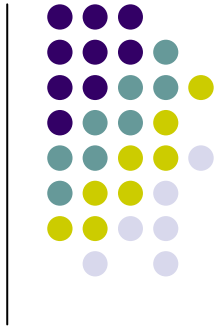
Variations of the Earth's surface temperature over the last 140 years (source: Intergovernmental Panel on Climate Change (IPCC), 2001)

Introduction 2:



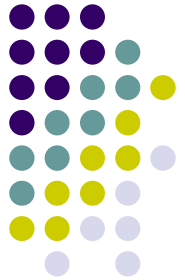
Source: United States Environmental Protection Agency

Introduction 3:



- The global surface temperature has increased around 0.6 ºC since the late 19th century (IPCC, 2001);
- Urbanization effect has a great impact on climate change (Collier, 2006; Kalnay & Cai, 2003);
- South China, especially Guangdong Province, is a fast socio-economic developing and urbanized area in China.

Research Objectives



- Analysis of climate change characteristic in South China, including temperature, precipitation and relative humidity
- Investigation of the impact of urbanization on climate variation in South China

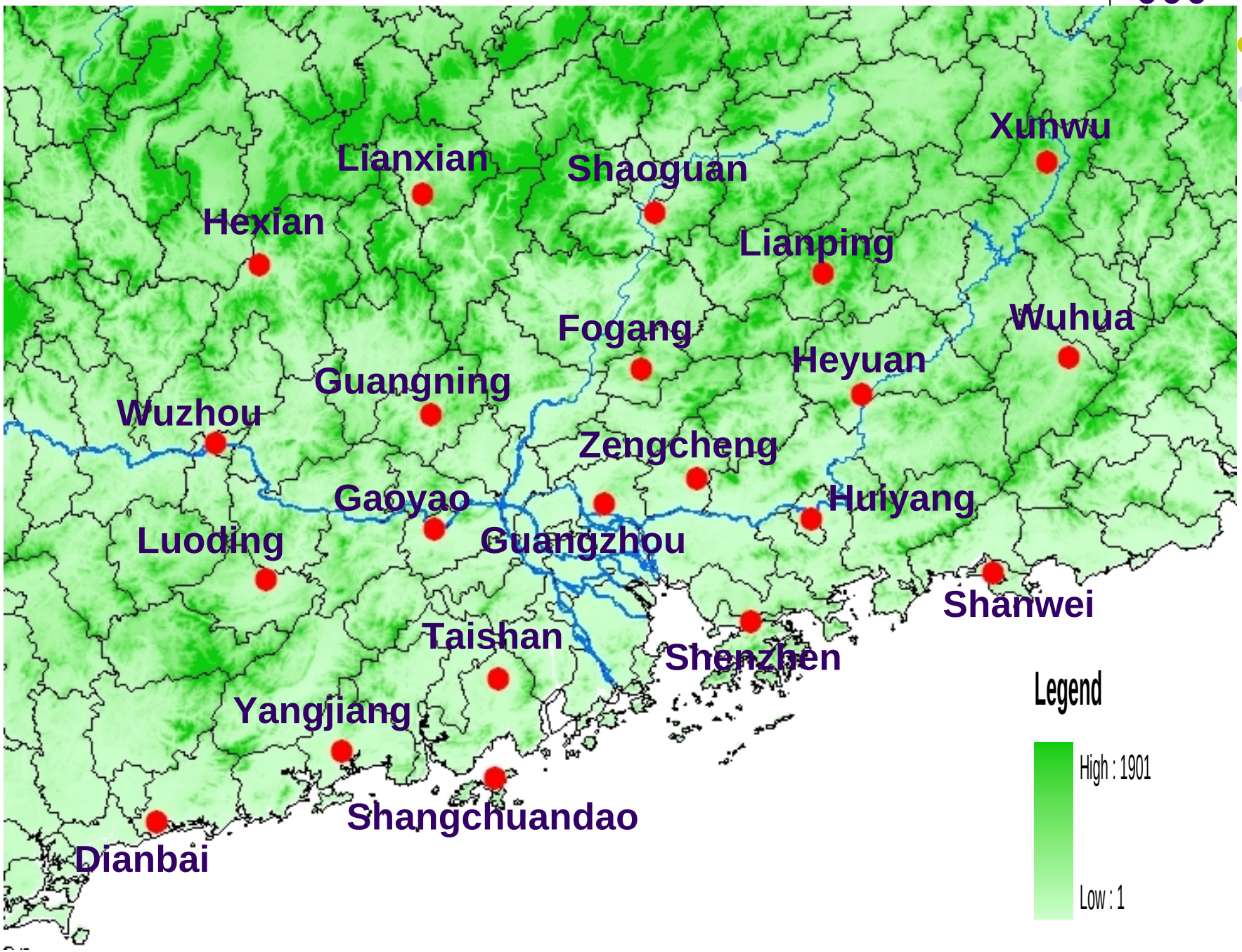
Area interested and Data

- Area:

  Latitude: 21N~25N

  Longitude: 111E~116E

  21 stations involved


Xunwu
Lianxian
Shaoguan
Hexian
Lianping
Wuhua
Fogang
Heyuan
Guangning
Wuzhou
Zengcheng
Gaoyao
Huiyang
Luoding
Guangzhou
Shanwei
Taishan
Shenzhen
Yangjiang
Shangchuandao
Dianbai
Legend
High : 1901
Low : 1

Area interested and Data

- **Data:** from 1960 to 2005
- **Monthly average of daily Tmax, Tmin, precipitation, relative humidity**

  (by: Chinese National Meteorological Center)

Methodologies

- Two non-parametric statistical methods

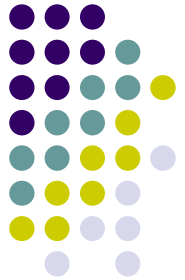
  Sen slope

$$b_{ij} = \frac{y_i - y_j}{x_i - x_j}$$

Sen's method is used for the estimation of trend. The slopes b_{ij} are first computed between each` possible pair of datapoints (x_i, y_i) and (x_j, y_j)

The trend estimate is then the median of all the pairwise slopes. (Sen, 1968)

Methodologies (cont.)

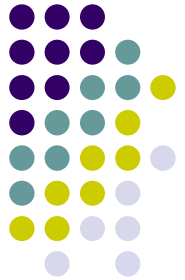


Mann-Kendall test

$$\tau = \frac{concordant - discordant}{\sqrt{concordant + discordant + sameX}\sqrt{concordant + discordant + sameY}}$$

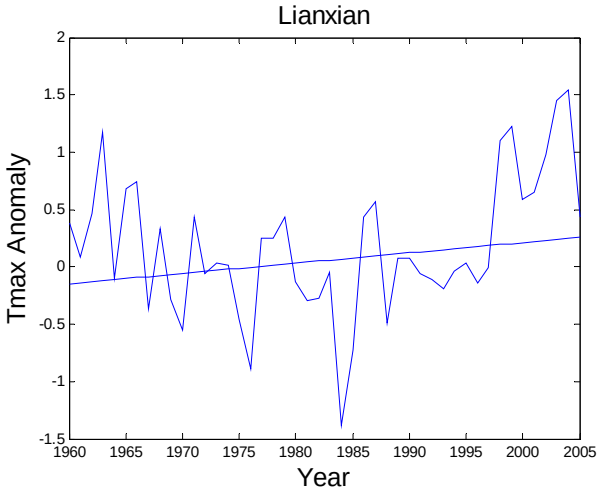
Concordant is the number of pairs where the relative ordering of x and y are the same; discordant where they are the opposite;
(Sen, 1968)

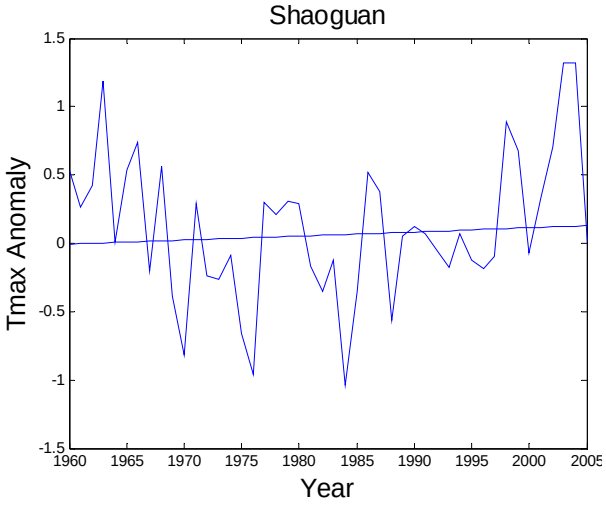
Comparison of parametric and non-parametric methods

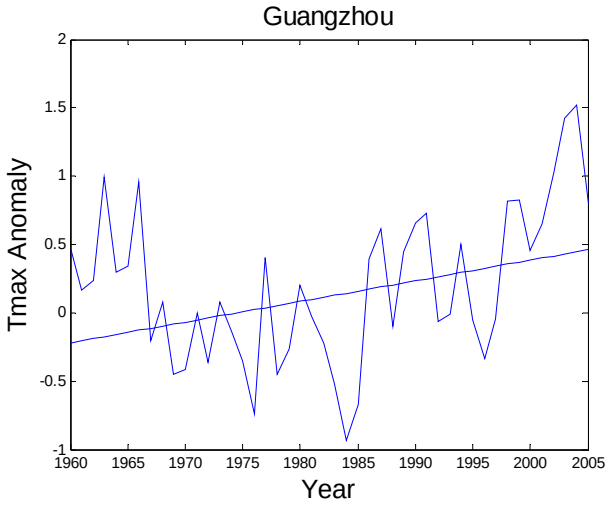


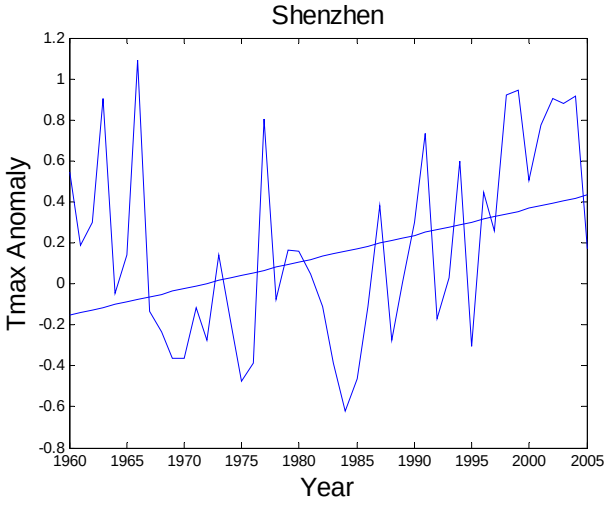
- Nonparametric methods are based on relative ranks of data points; therefore, there are no data distribution requirement (Haan, 2002).
- Least squares estimation for linear models is notoriously non-robust to ourliers. In the presence of any outliers, the estimates can be biased and inefficient .

Time series of annual average of Tmax anomalies from 1960 to 2005



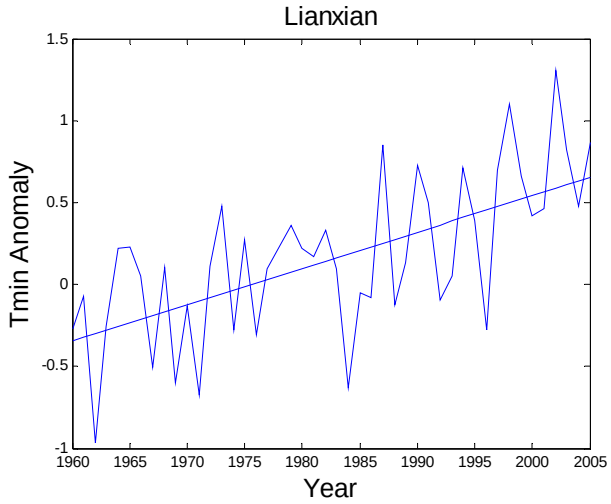


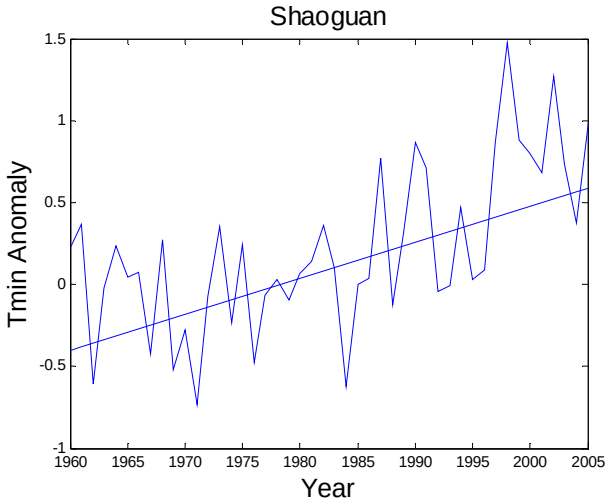


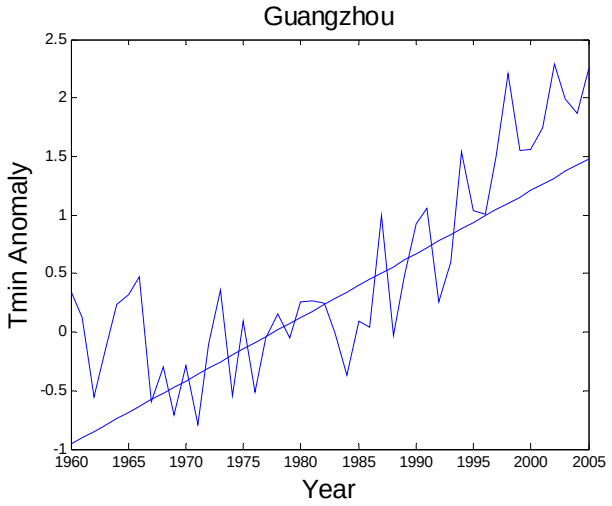


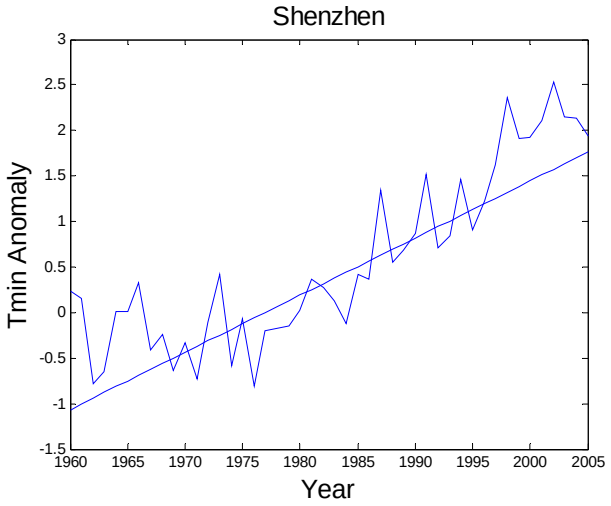
All four stations show increasing trends. The trends in Guangzhou and Shenzhen are statistical significant. The minimum temperature occurs in 1984 for all four stations.

Time series of annual average of Tmin anomalies from 1960 to 2005







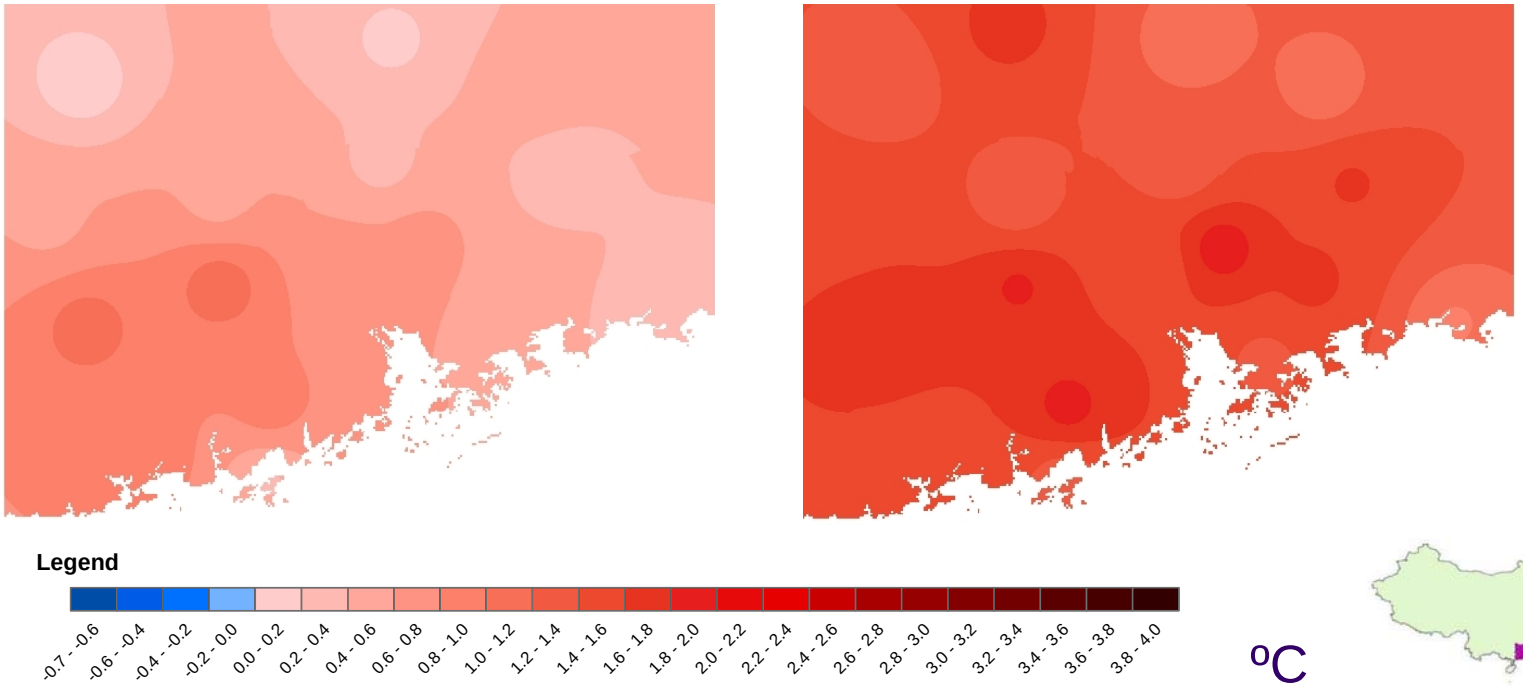


All of the increases are statistically significant at α =5%

Tmax Change from 1960 to 2005 and from 1984 to 2005

From 1960 to 2005

From 1984 to 2005



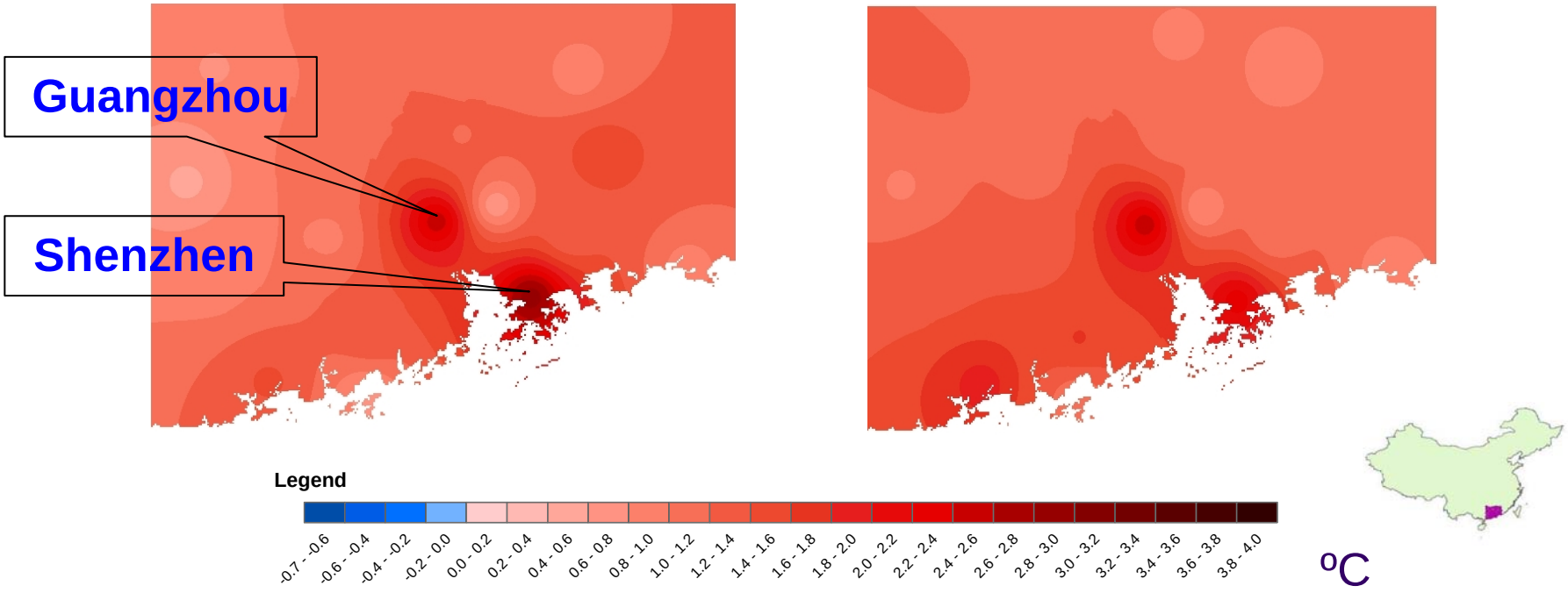
Tmax ↑ 0.54 ºC (0.117 ºC/dec.)
≈global rate (0.141 ºC/dec.)

Tmax ↑ 1.44 ºC (0.655 ºC/dec.)
> global rate (0.287 ºC/dec.)

Tmin Change from 1960 to 2005 and from 1984 to 2005

From 1960 to 2005

From 1984 to 2005



Tmin ↑ 1.12 ºC (0.243 ºC/dec.)

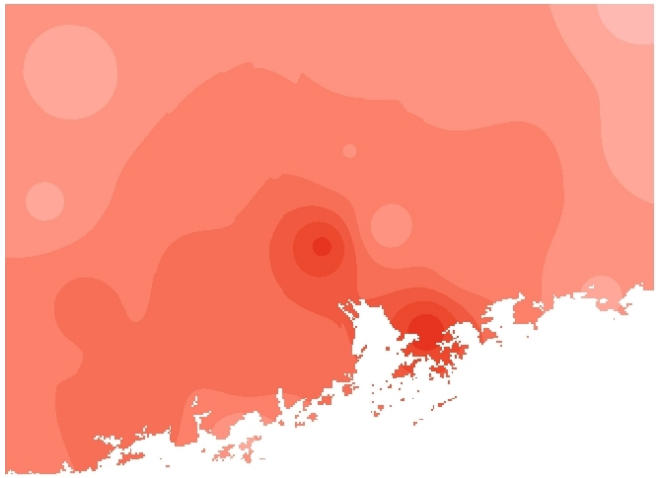
≈global rate (0.204 ºC/dec.)

Tmin ↑ 1.20 ºC (0.545 ºC/dec.)

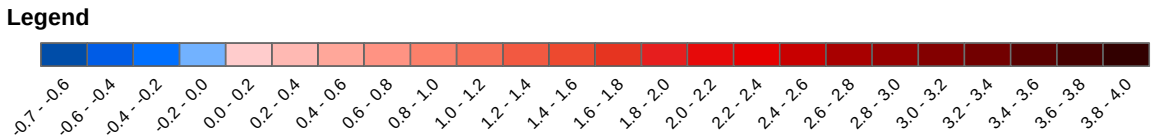
> global rate (0.295 ºC/dec.)

Tmean Change from 1960 to 2005 and from 1984 to 2005

From 1960 to 2005



From 1984 to 2005



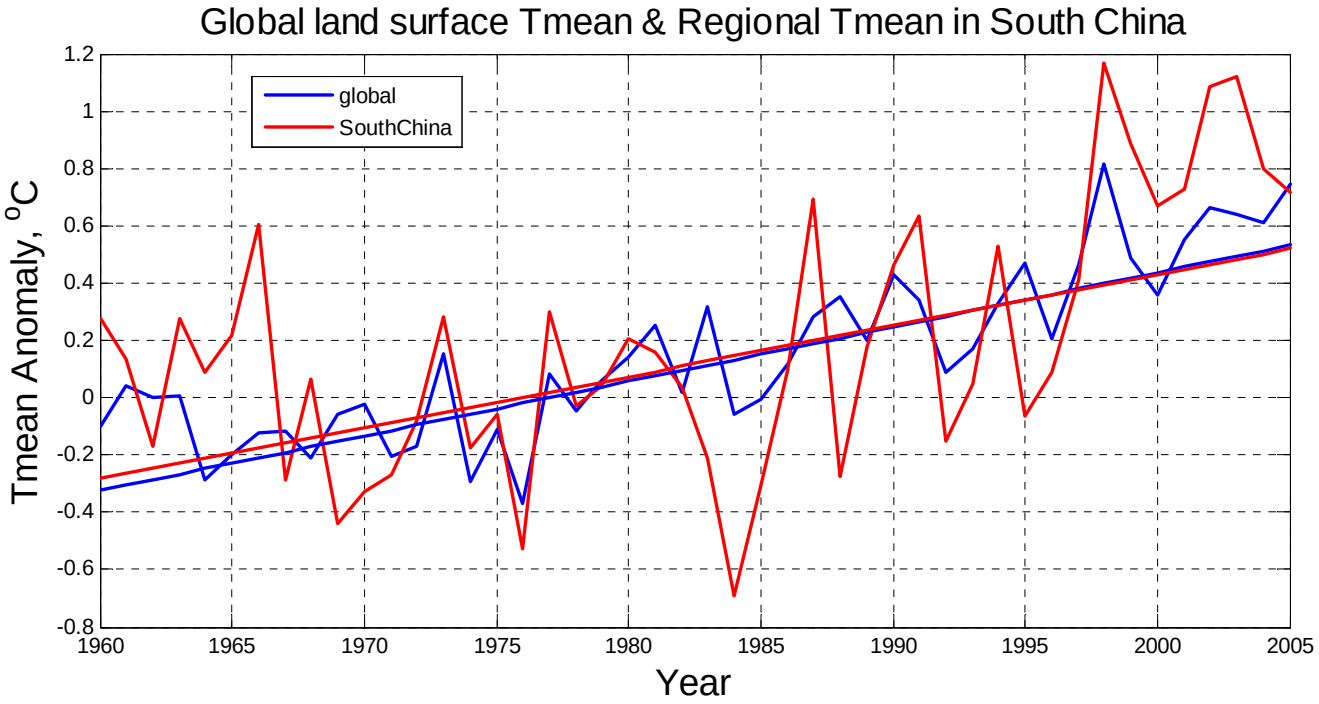
ºC

Tmean ↑ 0.82 ºC ≈global rate

Tmean ↑ 1.32 ºC > global rate

Tmean=(Tmax+Tmin)/2

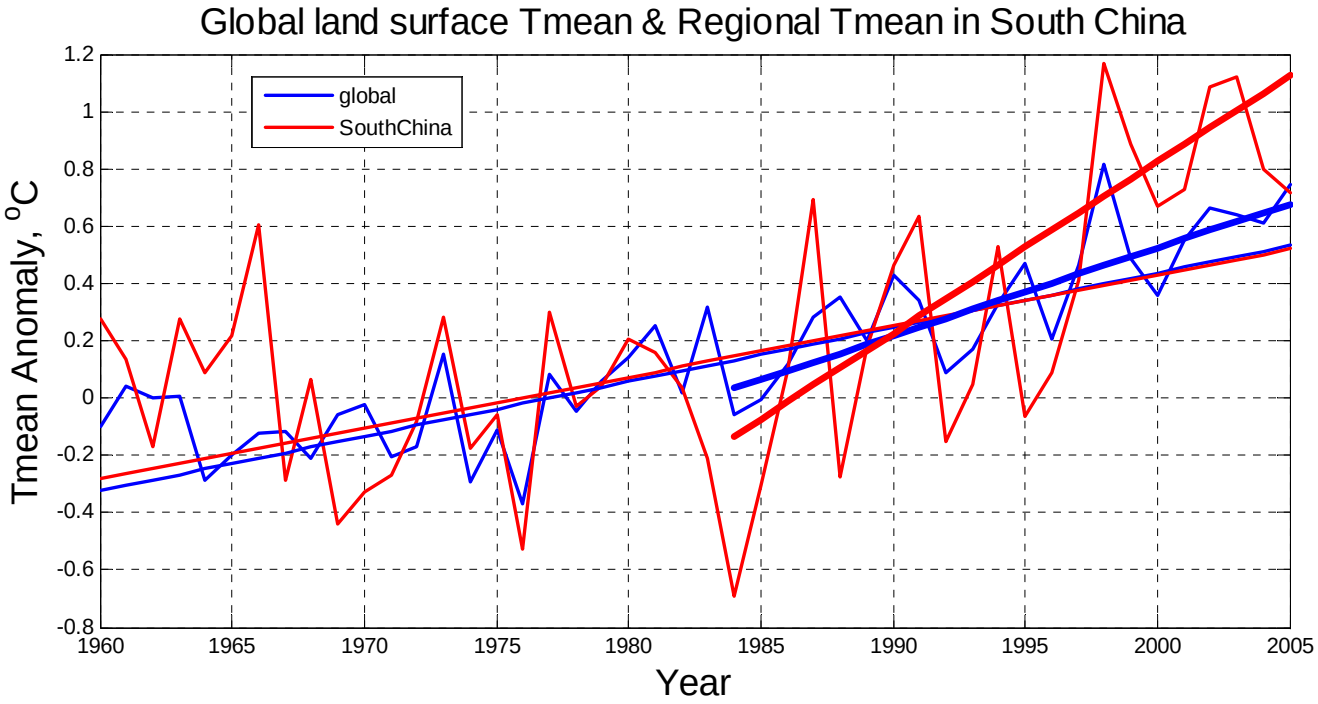
Comparison of regional and global Tmean change



	Tmean_Change (ºC)	
	1960-2005	1984-2005
Global land surface	0.87	0.67
South China	0.82	1.32

(Global data source: Hadley centre, UK)

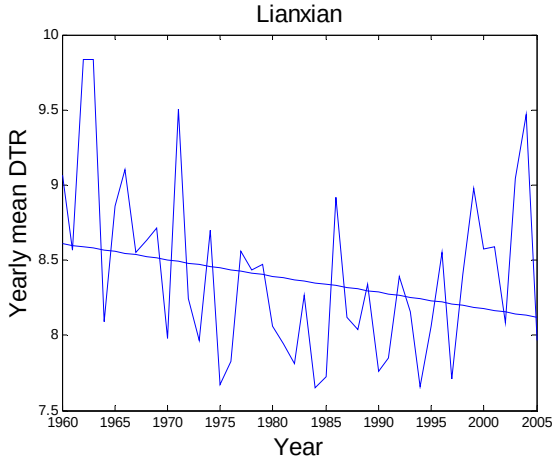
Comparison of regional and global Tmean change

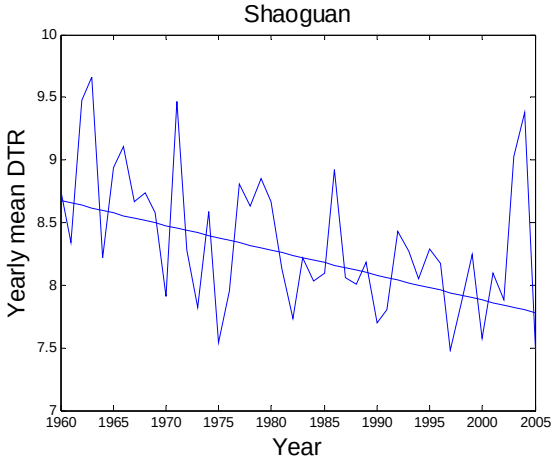


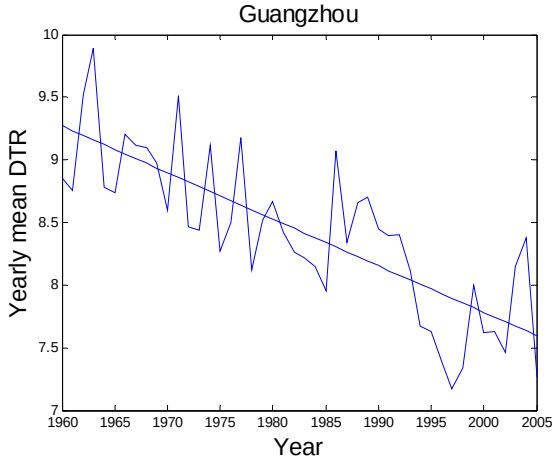
	Tmean_Change (ºC)	
	1960-2005	1984-2005
Global land surface	0.87	0.67
South China	0.82	1.32

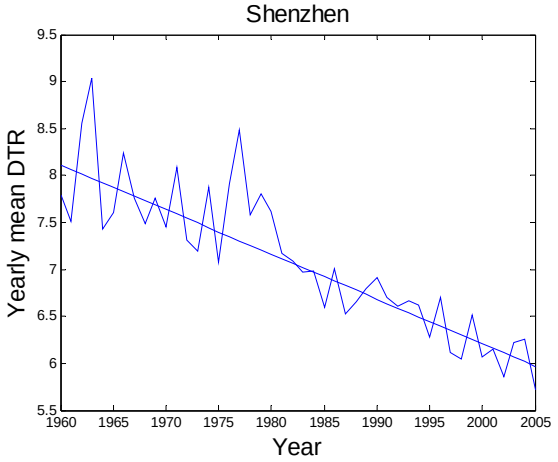
(Global data source: Hadley centre, UK)

Time series of annual mean of DTR from 1960 to 2005





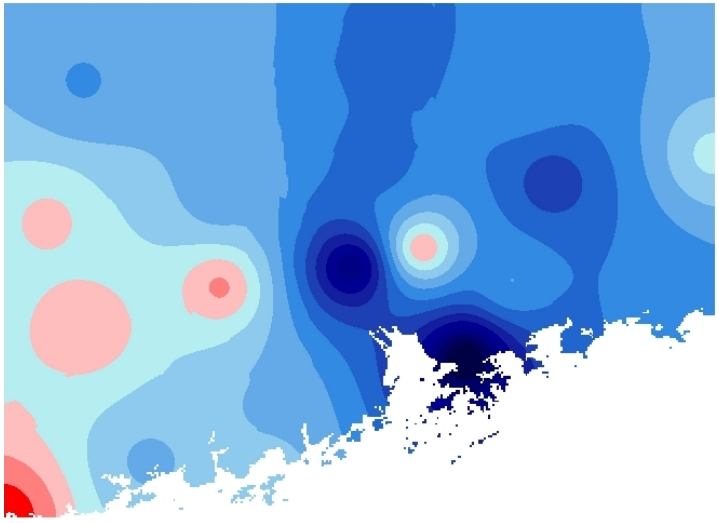




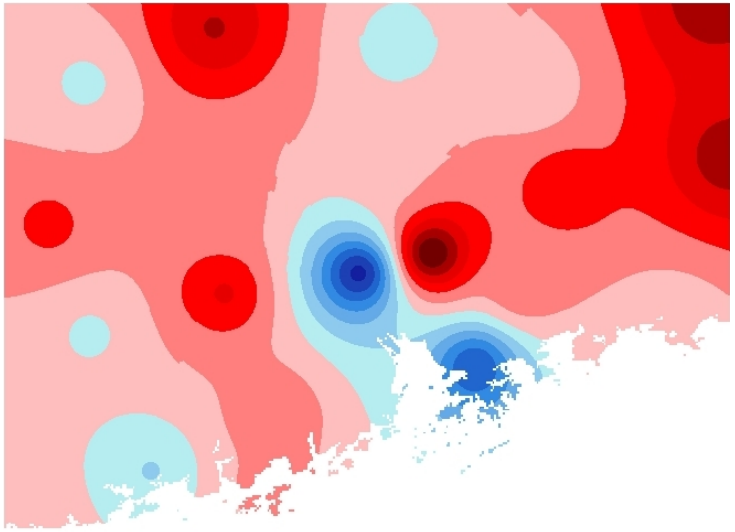
DTR (Diurnal Temperature Range) =Tmax-Tmin

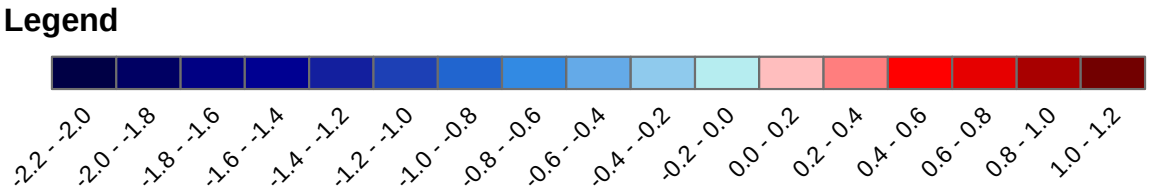
DTR Change from 1960 to 2005 and from 1984 to 2005

From 1960 to 2005



From 1984 to 2005





References

Urban and other land-use changes accounted for at least half of the observed decrease in diurnal temperature range

(Braganza et. al. (2004). Diurnal temperature range as an index of global climate change during the twentieth century)

(Kalnay & Cai (2003). Impact of urbanization and land-use change on climate)

In US, urbanization decreases Tmax and increases Tmin, leading a decreased DTR

(Karl et. al. (1988). Urbanization: Its Detection and Effect in the United States Climate Record)

Population and GDP development for part of the cities

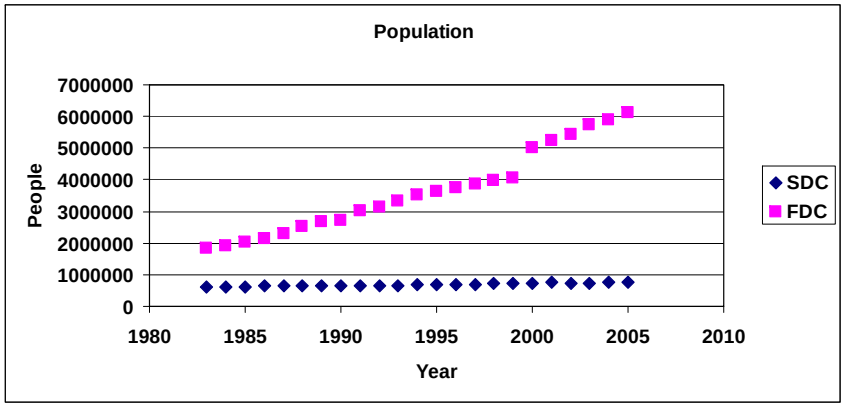
	Population		GDP (*100,000,000 Yuan)	
	1983	2005	1983	2005
Lianxian	432903	508129	0.74	37.89
Shaoguan	335581	907139	10.37	186.99
Fogang	239359	311357	0.28	31.19
Lianping	297917	378438	0.17	27.78
Guangning	454444	543646	0.60	33.99
Gaoyao	712952	728732	1.28	95.00
Heyuan	563950	290515	1.36	51.32
Zengcheng	587165	794295	1.00	269.68
Wuhua	878461	1252793	0.43	37.74
Luoding	789028	1106101	1.48	58.89
Taishan	945382	987514	2.93	109.49
Guangzhou	3170029	6172839	108.87	4792.44
Shenzhen	481400	6068900	7.20	4950.91

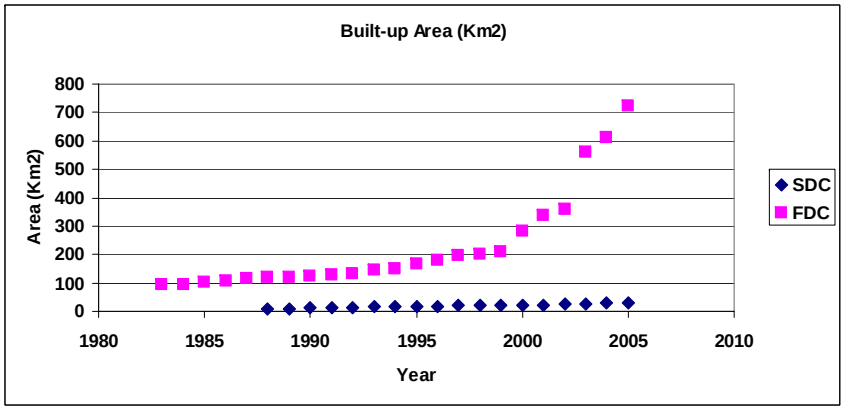
(Source: Guangdong Statistical Yearbook)

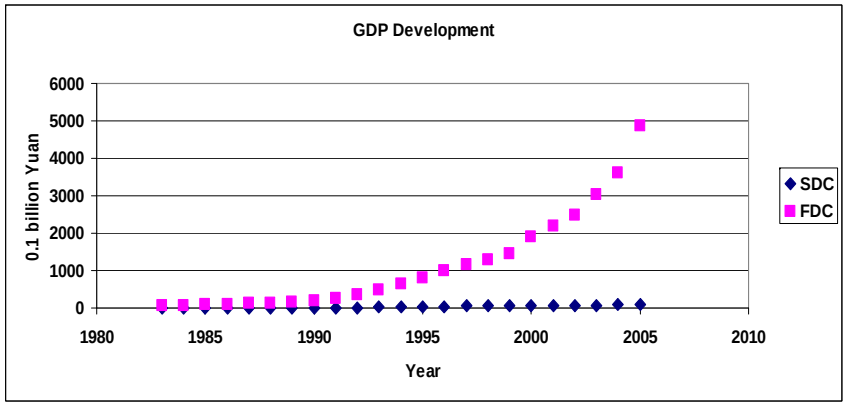
Development of Population, GDP & Built-up Area for slow-developing-city (SDC) and fast-developing-city (FDC)

Devel. rate=$(V_{2005}-V_{1983})/V_{1983}$

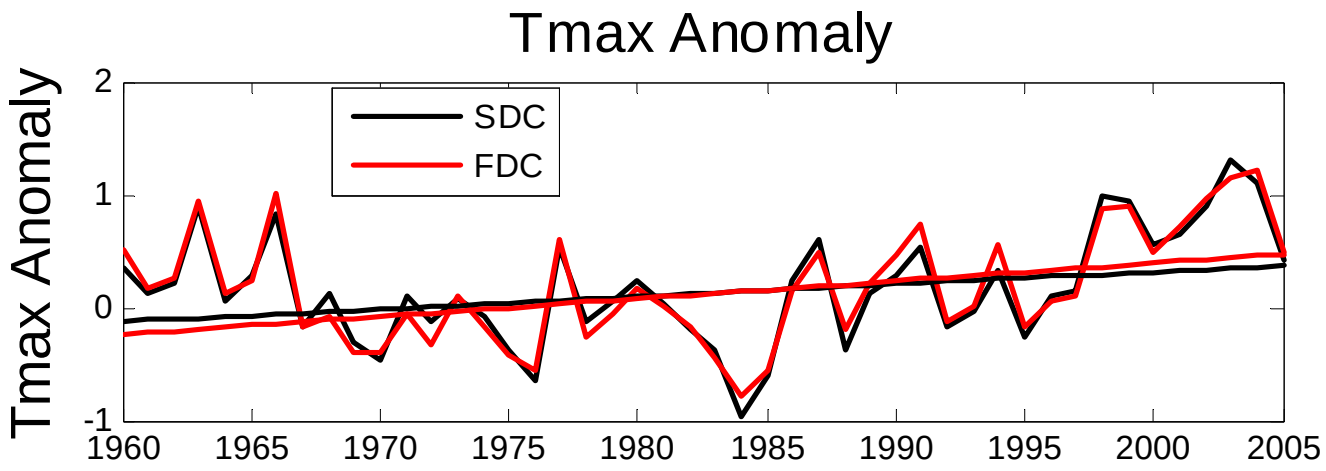
Devel. Rate	Popu.	Built-up Area	GDP
SDC	23.30%	247%	4950%
FDC	235.30%	662%	8294%

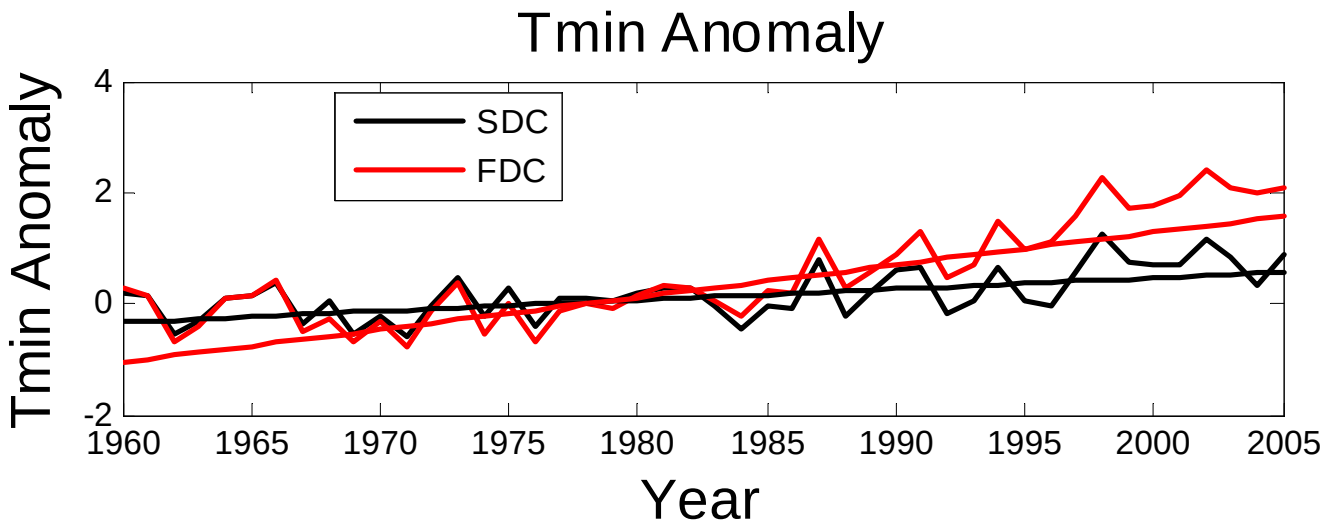






Urbanization Attribution for temperature change from 1961 to 2005



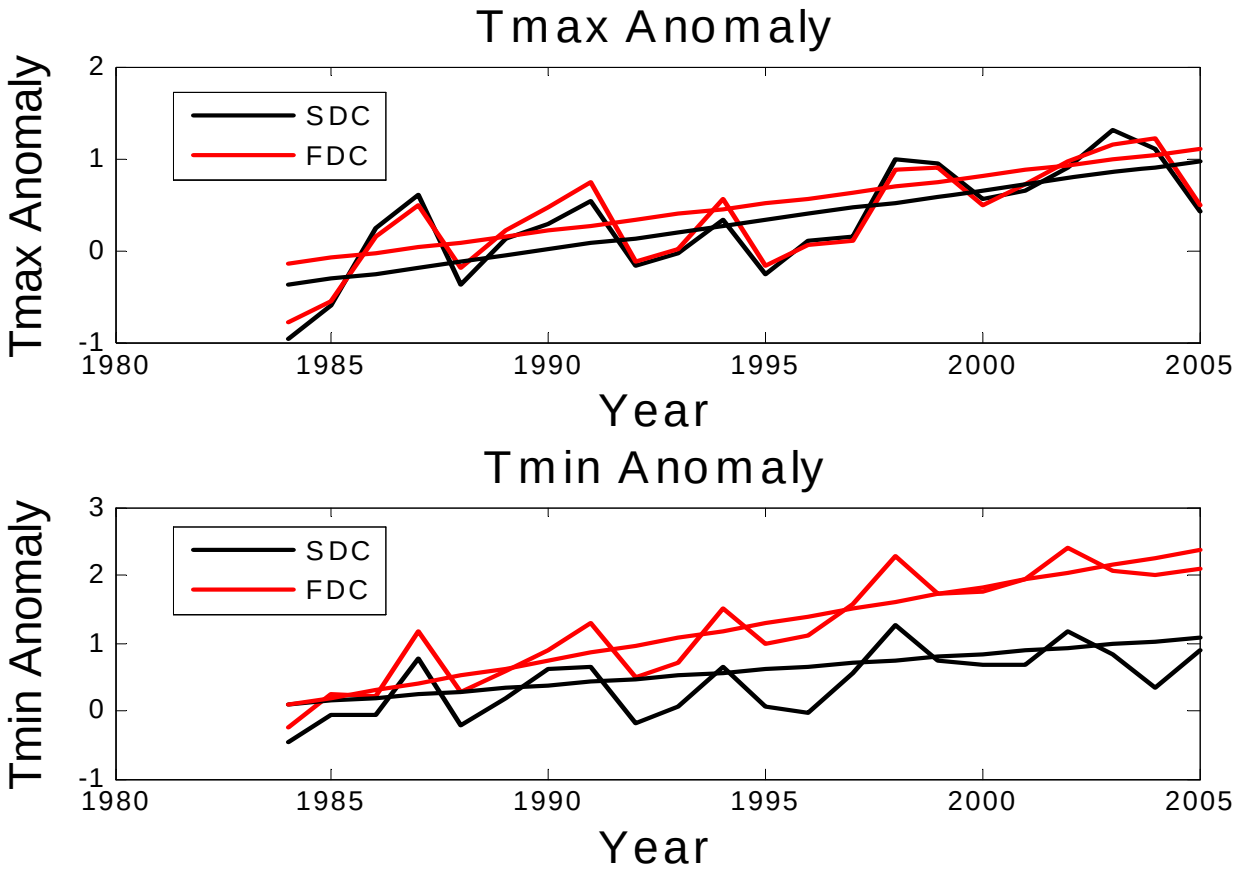


Tmin ↑

SDC, 0.20 ºC/dec.

FDC, 0.58 ºC/dec.

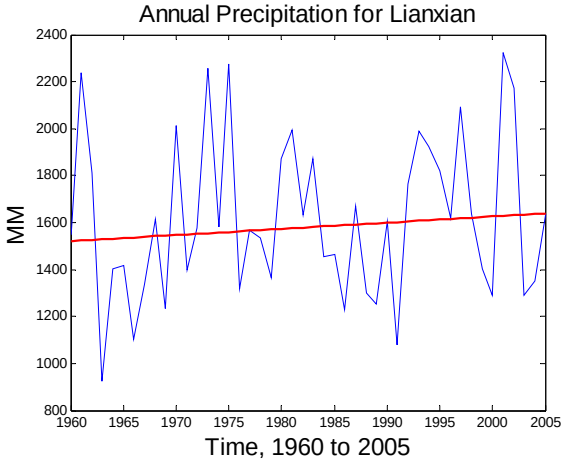
Urbanization Attribution for temperature change from 1984 to 2005

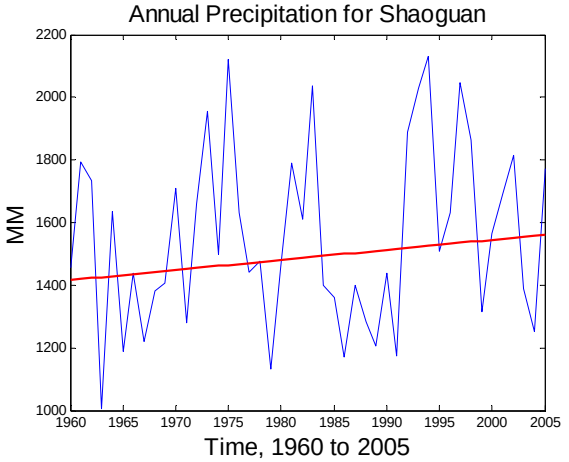


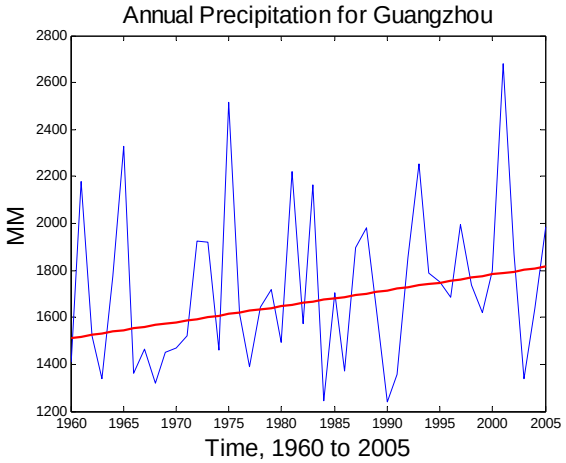
Tmin ↑
SDC, 0.46 ºC/dec.
FDC, 1.09 ºC/dec.

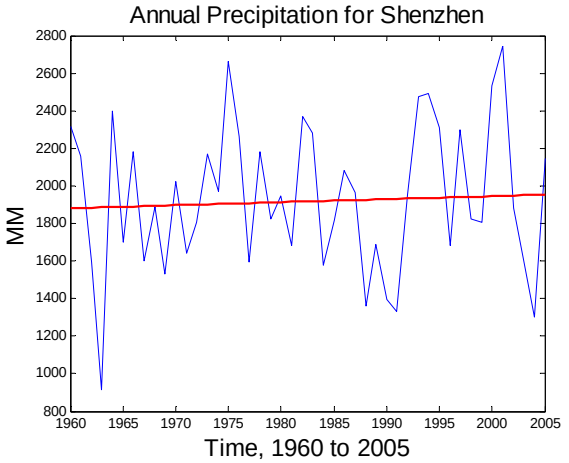
Urban warming accounts for 58% of Tmin increase in FDC

Time series of annual mean of precipitation from 1960 to 2005



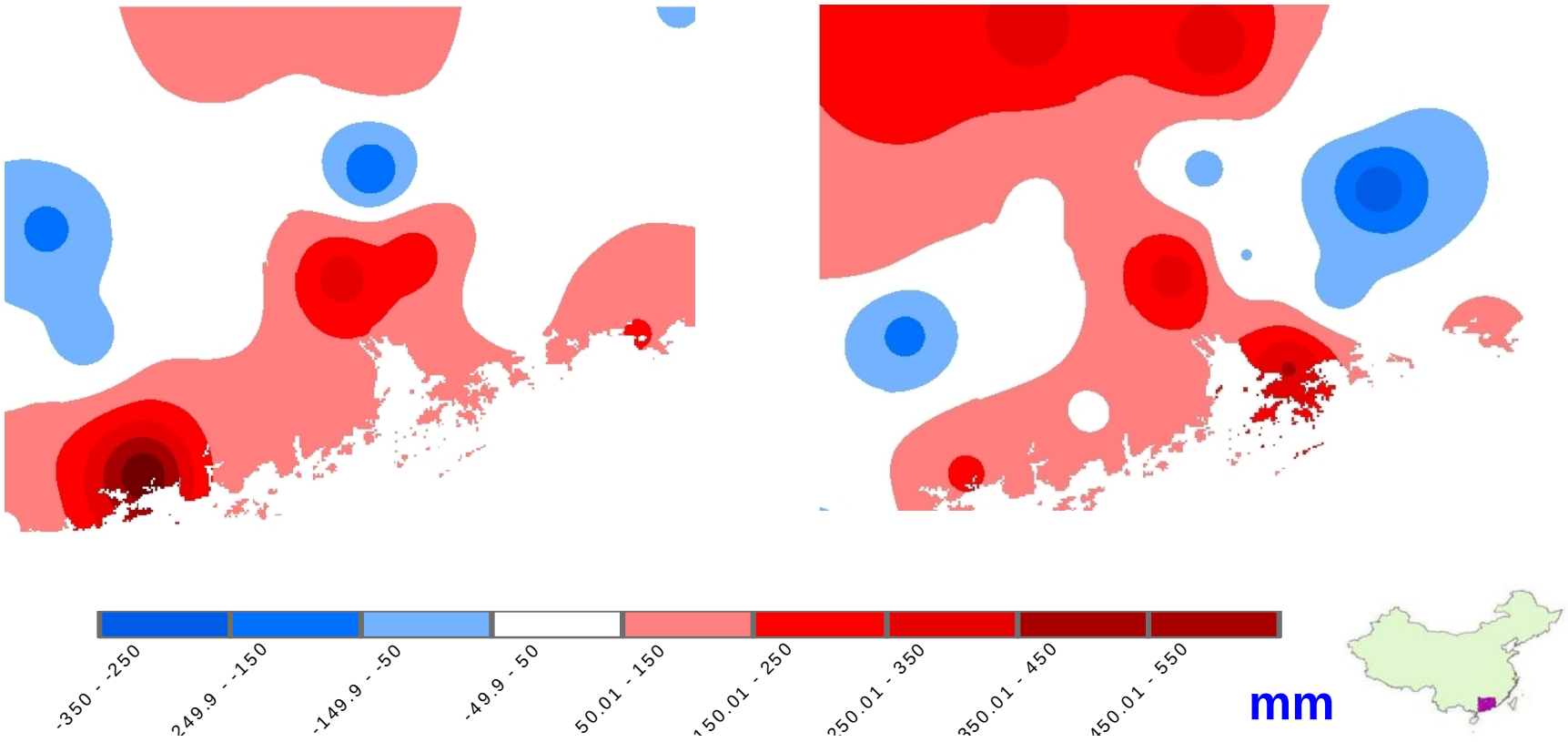






All changes are not significant at statistical 5% level.

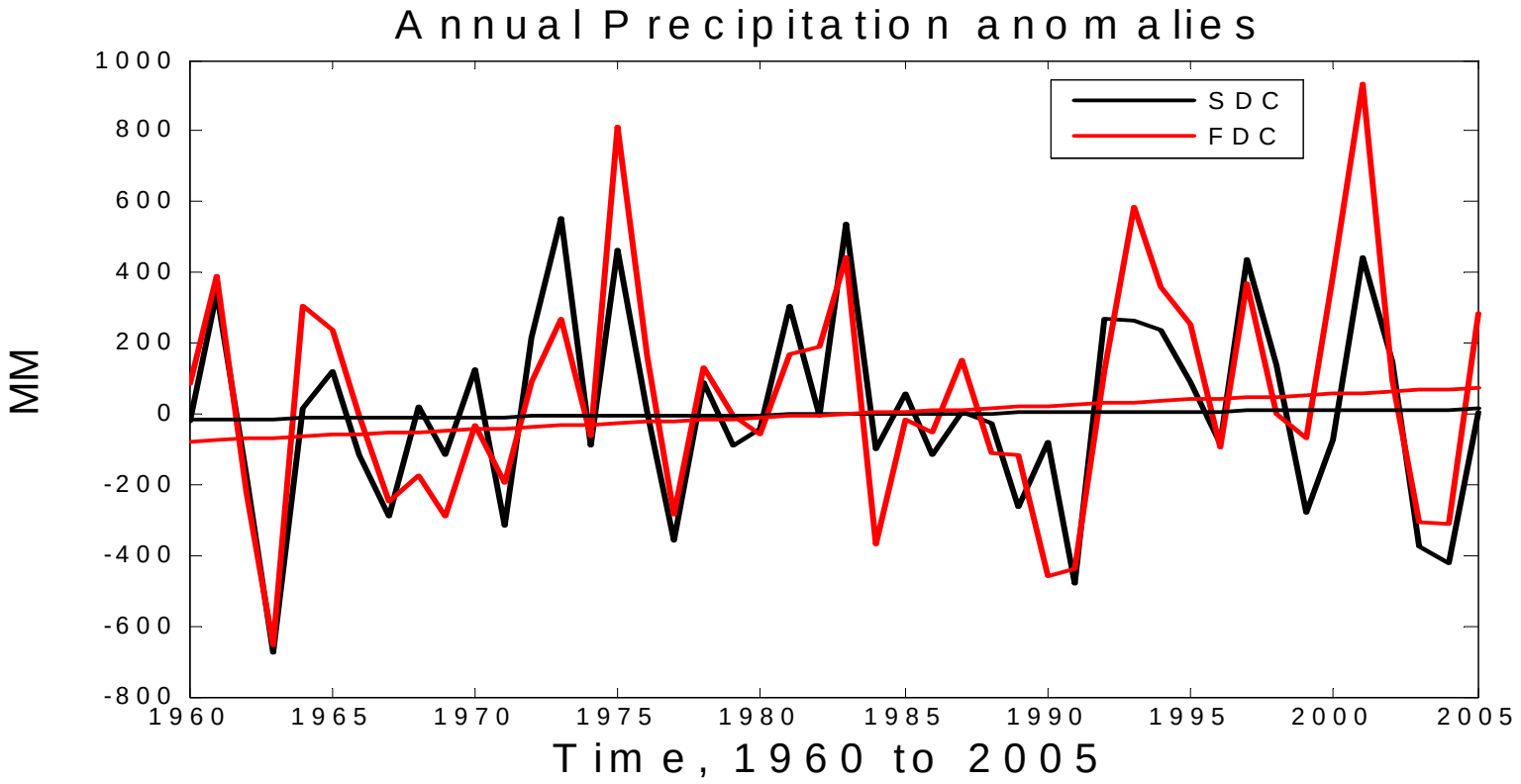
Precipitation Change from 1960 to 2005 and from 1984 to 2005



From 1960 to 2005

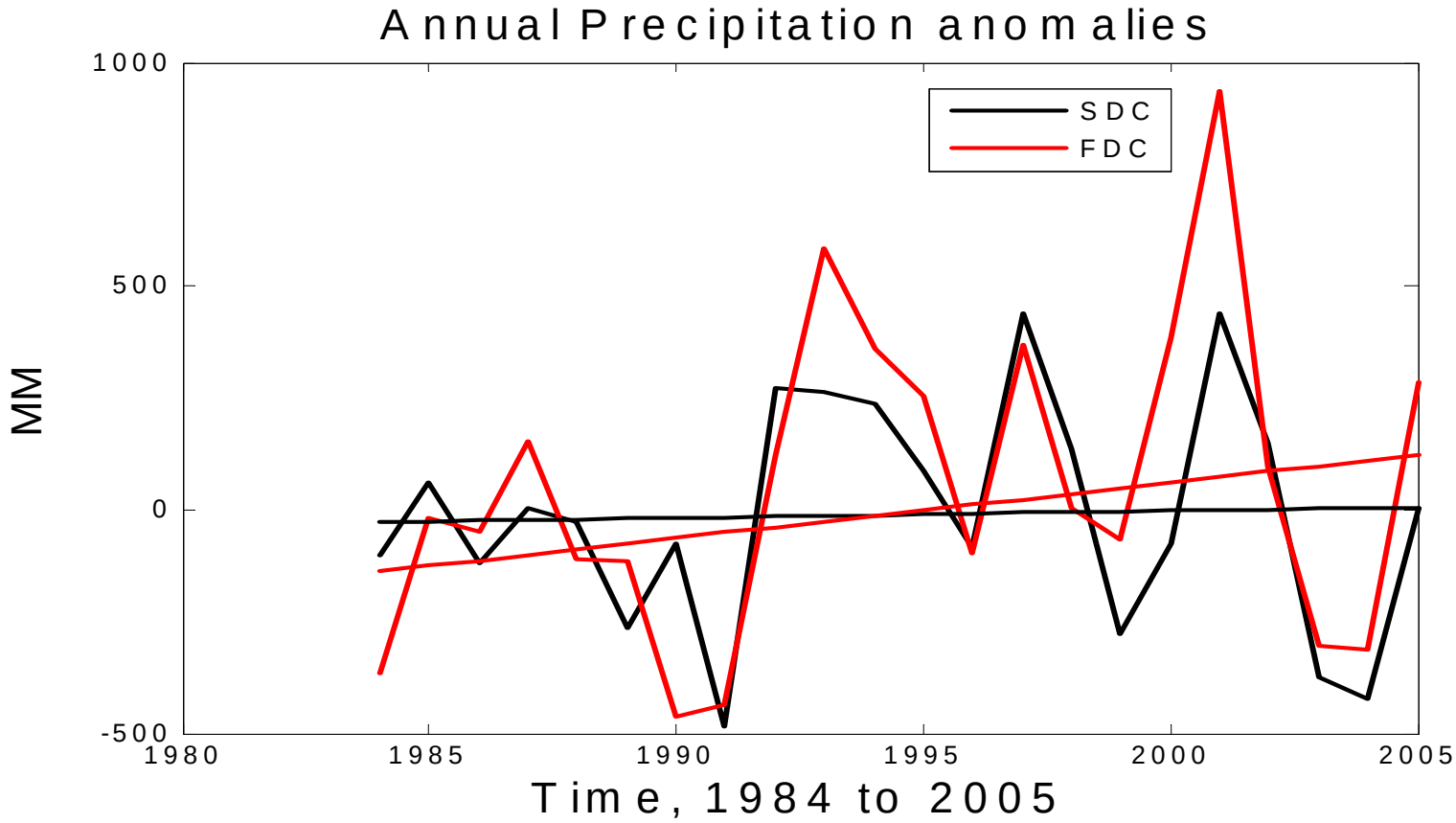
From 1984 to 2005

Urbanization Attribution for precipitation change from 1960 to 2005



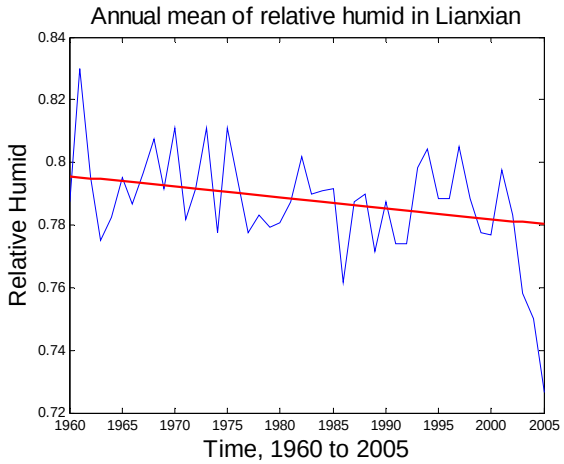
From 1960 to 2005, precipitation increasing rate is 6.44mm/dec. in SDC; precipitation increasing rate is 33.35mm/dec. in FDC

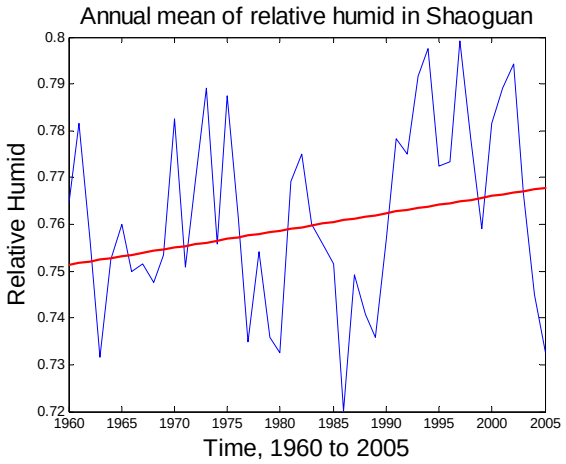
Urbanization Attribution for precipitation change from 1984 to 2005

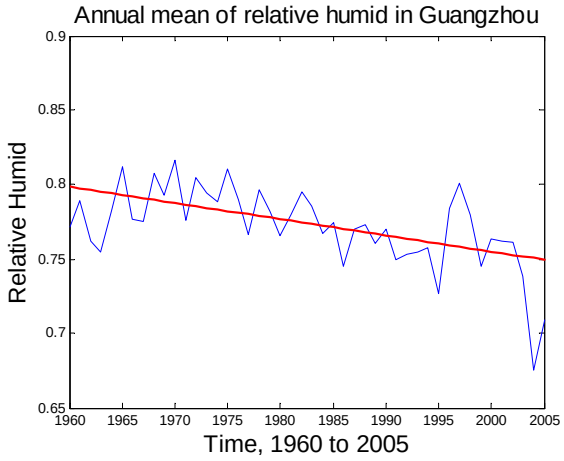


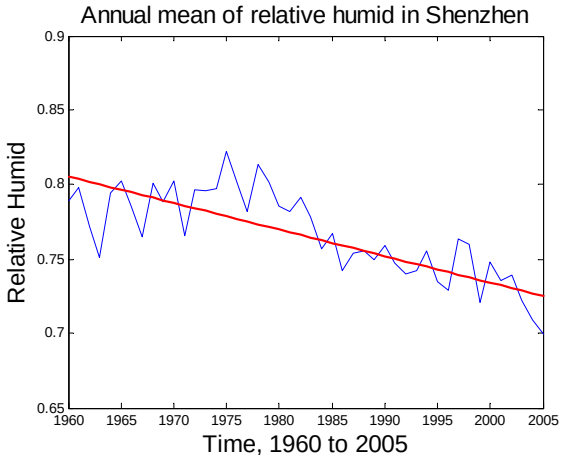
From 1984 to 2005, precipitation increasing rate is 15.88mm/dec. in SDC; precipitation increasing rate is 124.44mm/dec. in FDC

Time series of annual mean of relative humidity from 1960 to 2005



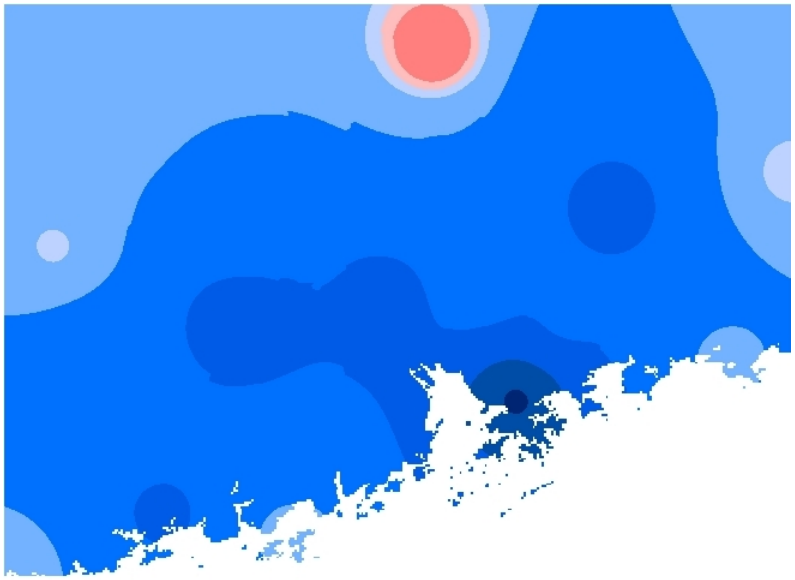


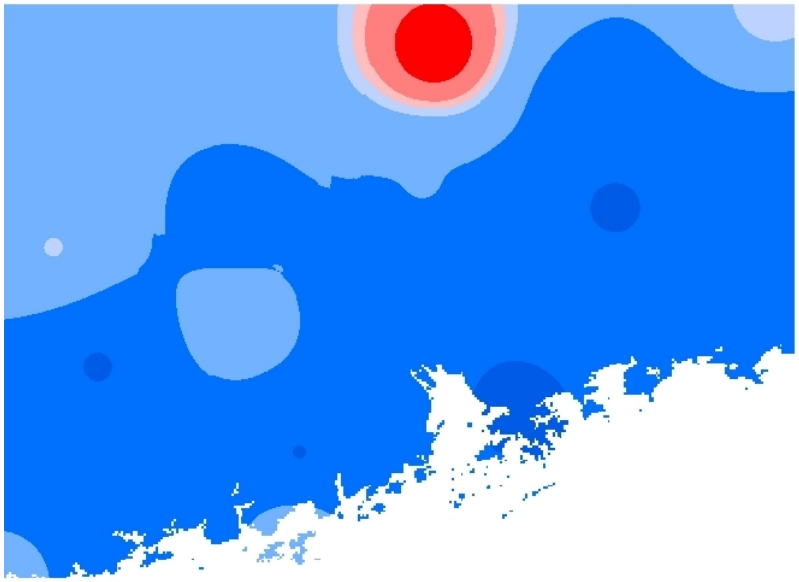


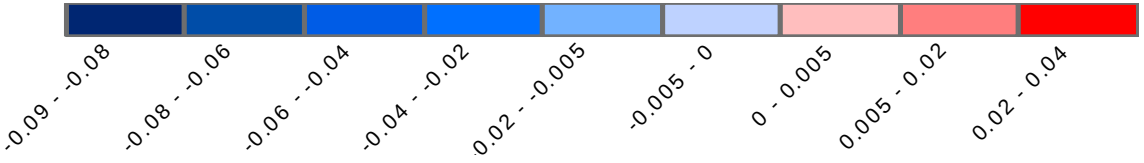


All trends are decreasing, except Shaoguan.

Relative Humidity Change from 1960 to 2005 and from 1984 to 2005



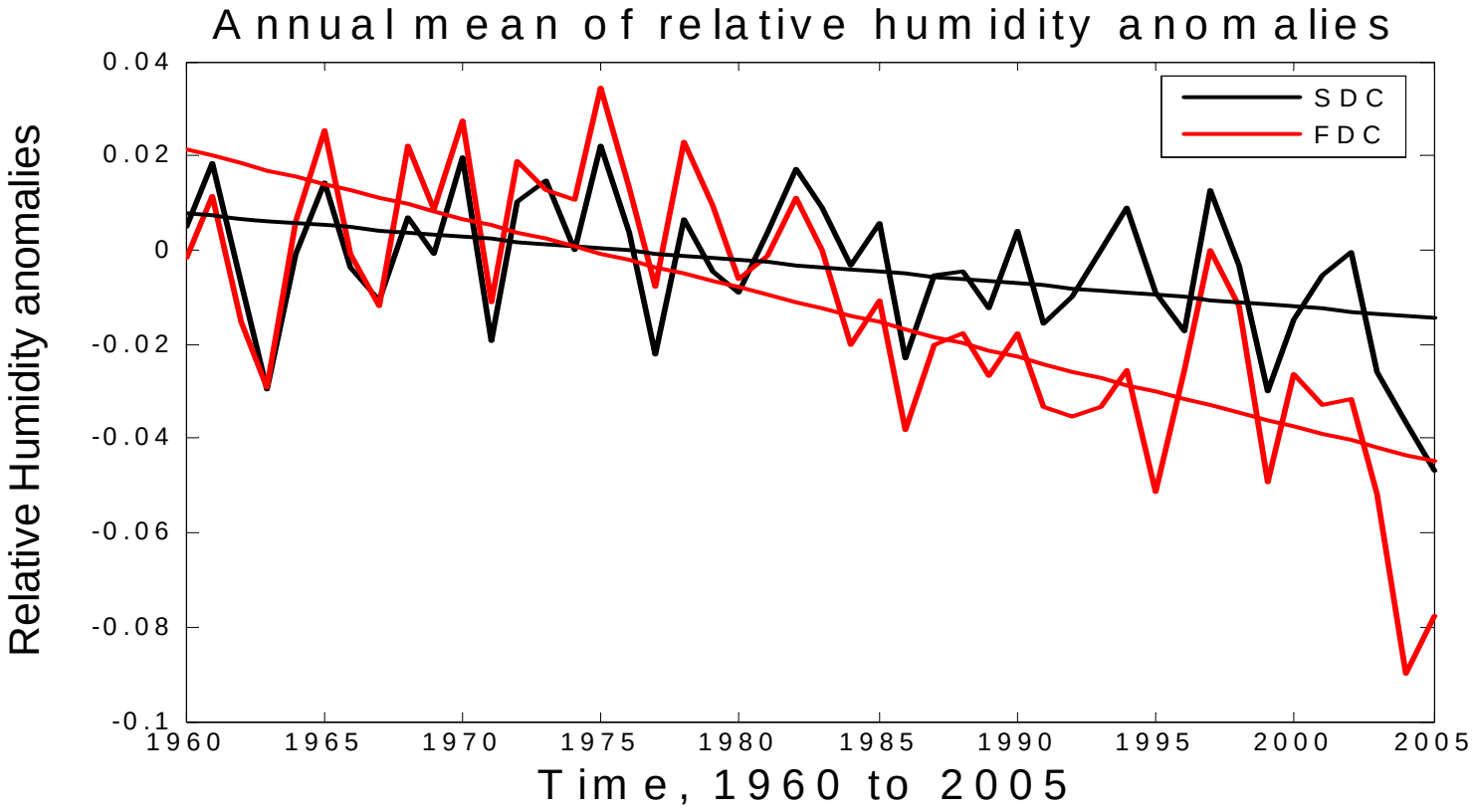




From 1960 to 2005

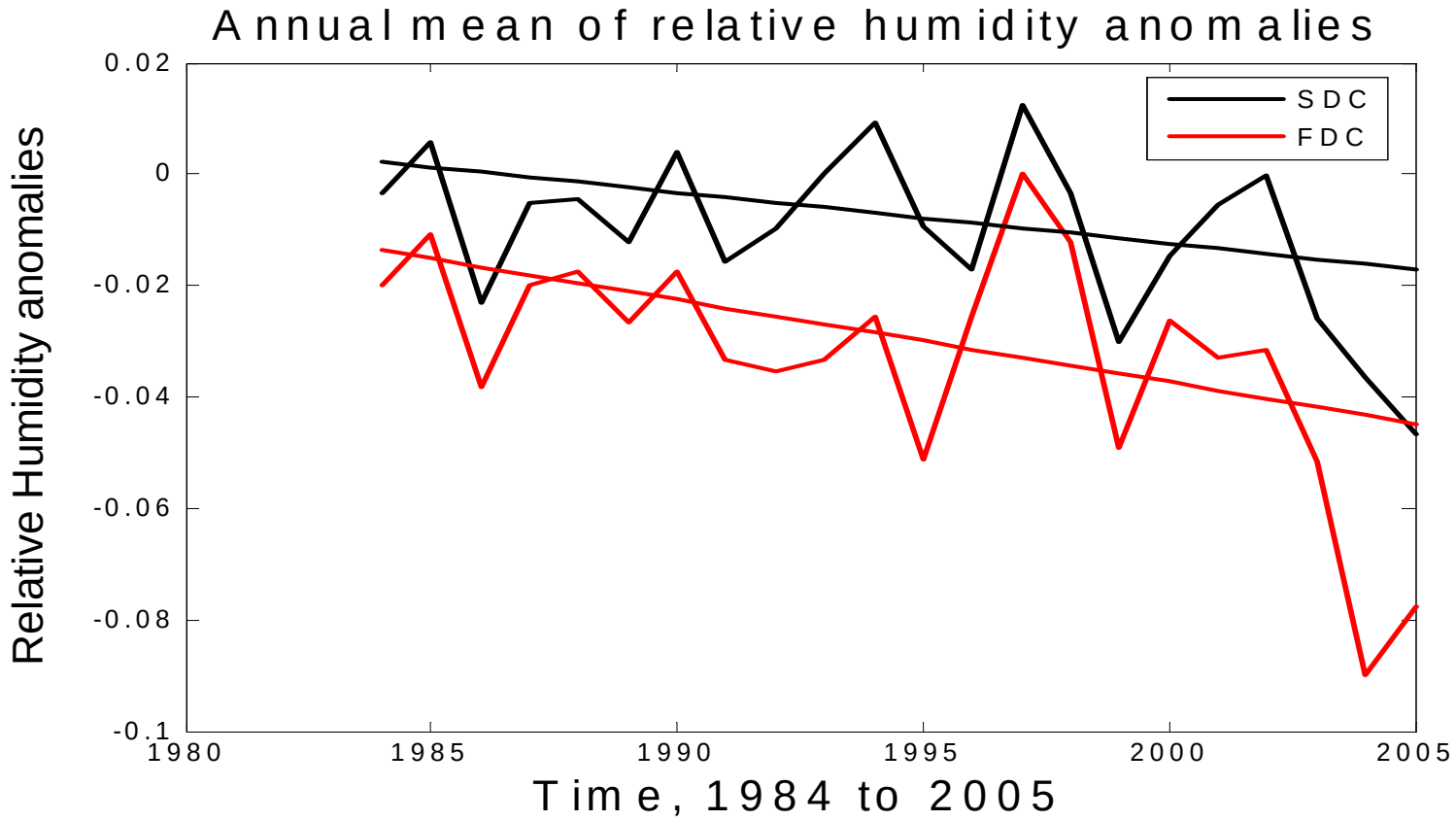
From 1984 to 2005

Urbanization attribution for relative humidity change from 1960 to 2005



From 1960 to 2005, relative humidity decreasing rate in SDC is 0.0049/decade; decreasing rate in FDC is 0.0147/decade.

Urbanization attribution for relative humidity change from 1984 to 2005



From 1984 to 2005, relative humidity decreasing rate in SDC is 0.0092/decade; decreasing rate in FDC is 0.0148/decade.

Conclusions

1. Climate change:

Temperature: Increase significantly in study region

1960 to 2005 Tmean ↑ 0.178 ºC/dec. ≈global rate

1984 to 2005 Tmean ↑ 0.287 ºC/dec. >global rate;

Precipitation: Overall, increased but not significant

Relative humidity: decreased significantly

2. Urbanization effect on climate change

Temperature:

1960~2005 Tmin ↑ 0.38 ºC/dec. more in FDC than in SDC

1984~2005 Tmin ↑ 0.63 ºC/dec. more in FDC than in SDC

Precipitation:

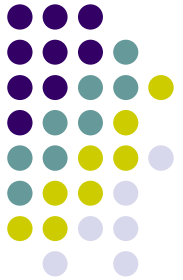
1960~2005 Precipitation ↑ 26.91mm/dec. more in FDC than in SDC

1984~2005 Precipitation ↑ 108.56mm/dec. more in FDC than in SDC

Relative Humidity:

1960~2005 Relative humidity ↓ 0.0098/dec. more decrease in FDC

1984~2005 Relative humidity ↓ 0.0056/dec. more decrease in FDC



Thank you!