Annual temperature reconstruction in the Eastern part of the Northeast China since A.D. 1765 based on tree-ring width data

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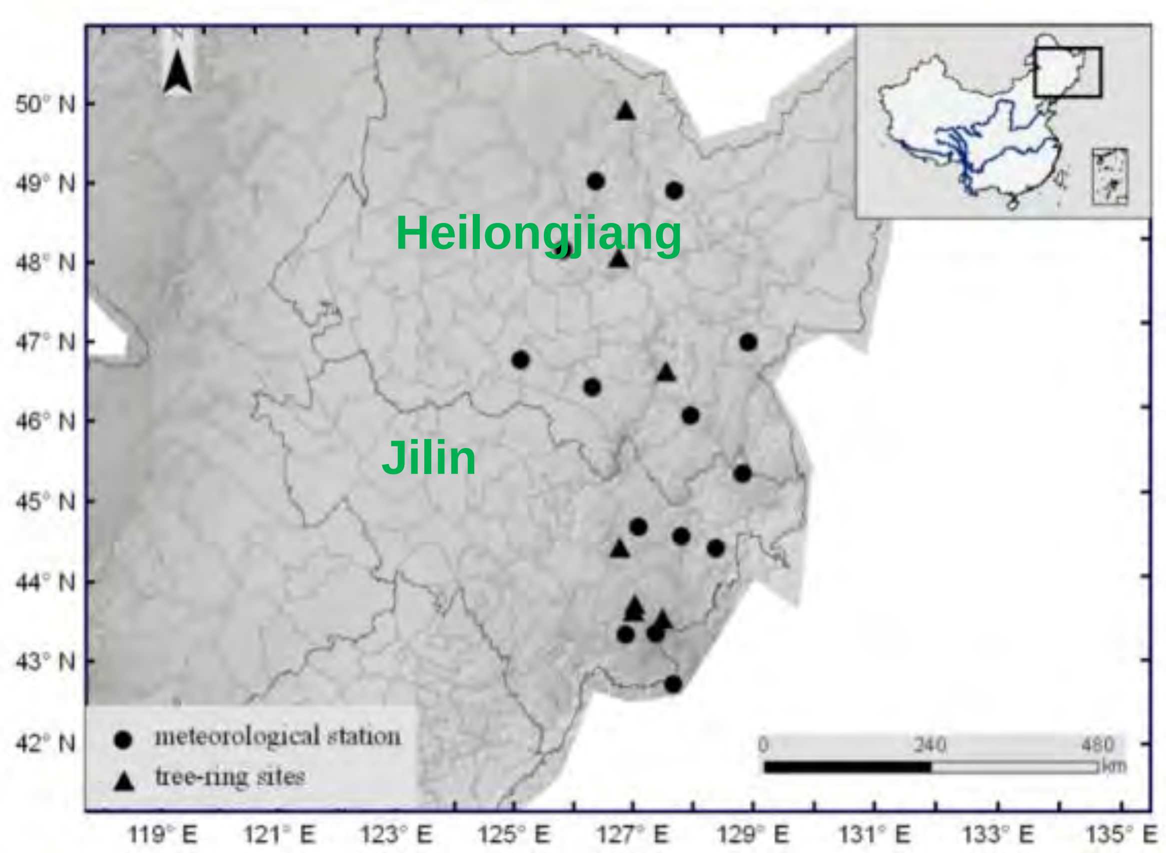
Introduction

In many regions meteorological records are too short to investigate long time scale climate change. These data are frequently limited to the most recent decades. For northeast China, most of climate data starts in the 1950s and contain little information in variability of climate over decades and longer. Indirect evidence of climatic variability such as long time series of tree-ring growth measurements may serve as proxy records of past conditions.

Objectives

The purpose of this study is to assemble a tree-ring chronology in Northeast China and investigate its potential to reconstruct regional annual temperature based on tree-ring width of Korean Pine (*Pinuskoraiensis*).

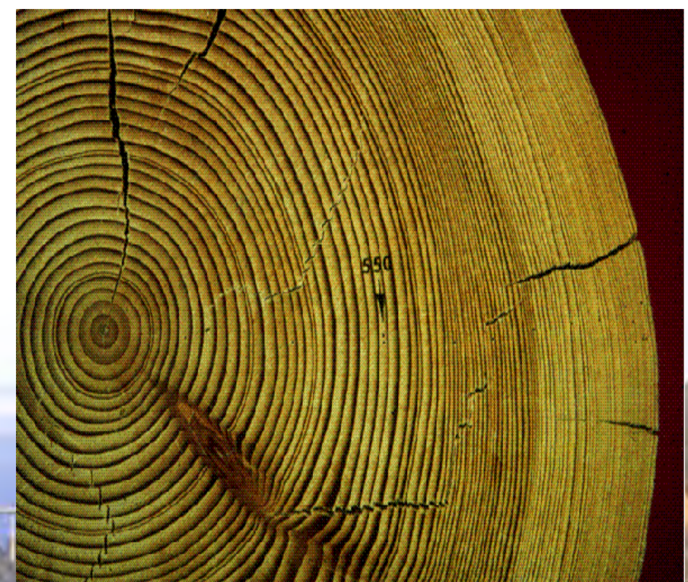
Northeast China



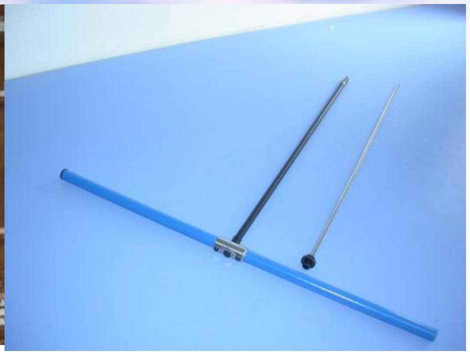
Tree Ring Chronologies

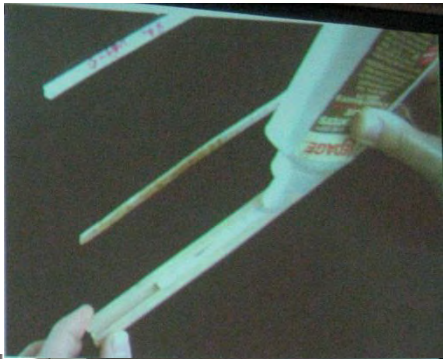
- **Korean Pine (Pinuskoraiensis)**

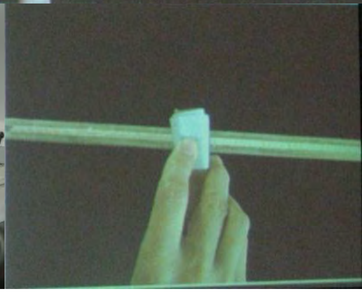
Site	Lat	Lon	Elev	TS	C/T	Y_{EPS}>0.85
CB4	42° 12′	128° 15′	1188	1651–2002	27/14	1810
LSH	42° 27′	127° 53′	870	1743–2002	40/21	1825
FA	42° 22′	127° 46′	940	1689–2002	40/27	1765
SMZ	43° 11′	127° 47′	765	1742–2002	57/29	1800
TWH	48° 32′	129° 47′	497	1770-2004	63/27	1830
DZL	46° 44′	128° 58′	865	1603-2004	51/23	1660
PAL	45° 12′	129° 21′	781	1636-2004	38/19	1765



Materials and methods

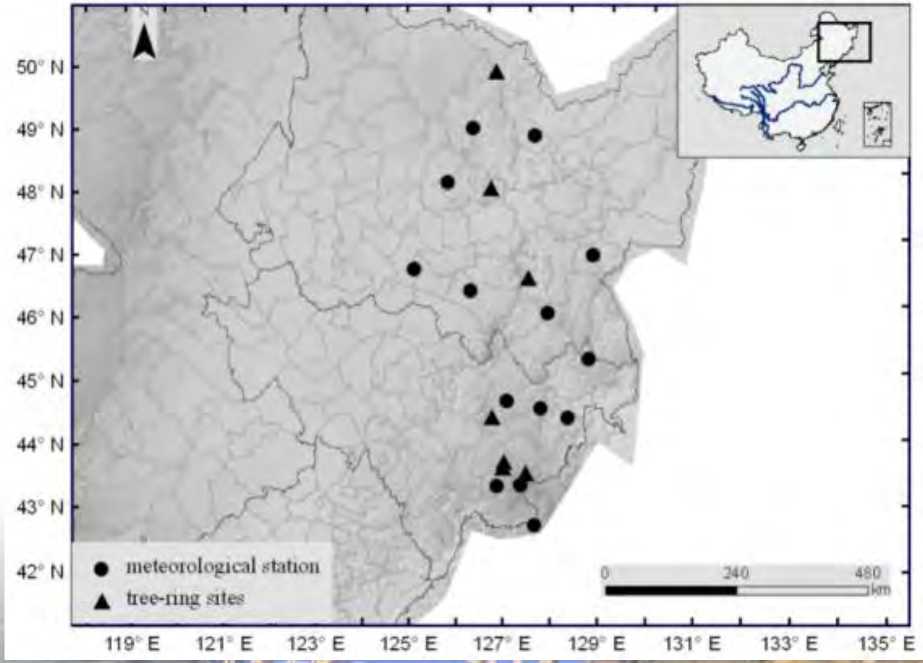




- Mounted, Crossdated and Measured through traditional process.
- A 180-year cubic smoothing spline to remove the long-term growth trends of raw ring-width series. Then average to build the site chronologies.
- To evaluate the reliability of the chronologies,50-year moving Expressed Population Signal (EPS) with a 25-year lag.
- A regional chronology(RC) from 1765 to 2002 was developed by averaging all seven standard chronologies from 1765 when the EPS>0.85.

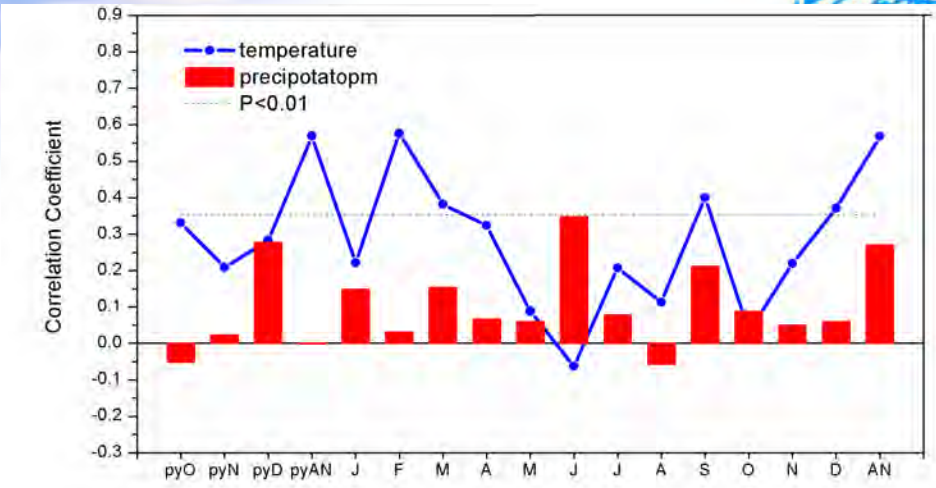

Climatic Data (1959-2002)

- CC of annual temperature is 0.89
- CC of Precipitation is 0.45
- Annual mean temperature is 2.9℃
- Annual precipitation is around 628mm



Materials and methods

- "py" means previous year
- "AN" means annual



Correlation function between regional ring-width chronology and temperature, and precipitation.

- The previous Jan to current Dec, and annual
- Tree-ring significant correlated with in Feb, Mar, Sep, with previous and current
- Warm winter lead to positive carbon gains for trees when their leaves are not frozen.
- A positive effect of winter temperature on tree growth was also reported for other temperate coniferous forests.

Correlation coefficient between annual and monthly temperature and variance of monthly temperature in 1959-2002.

	1	2	3	4	5	6	7	8	9	10	11	12
Ceo	**0.35**	**0.70**	**0.58**	**0.65**	0.32	0.33	0.27	0.37	0.41	0.40	0.38	0.60
Var	**4.53**	**5.81**	**4.47**	**2.13**	1.25	1.45	0.86	0.97	0.82	1.61	3.77	3.55

- Why the chronology is significant correlate with the annual temperature?
- Larger variance in Jan, Feb and Mar
- CC is the highest between annual and Feb.
- Because lag effect of climate on tree growth, CC significant between tree-ring and previous and current

Transform Equation

$$T = c_0 + c_1 P_1 + c_2 P_2$$

T Annual Temperature

P_1 The standard chronological at t year

P_2 The standard chronological at t +1 year

c Regression coefficients

- A transfer function was estimated by multiple linear regressions using this year t and the next year t+1 chronologies.
- Captured 45.8% of the total variance in the annual temperature in 1959-2002.

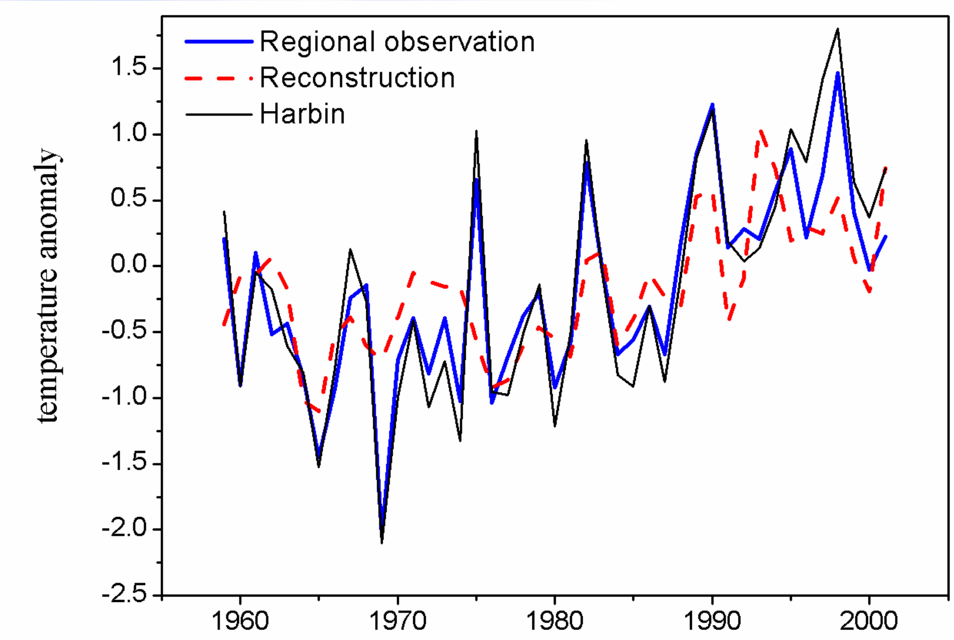
the calibration and verification statistics Parameters (1959~2002).

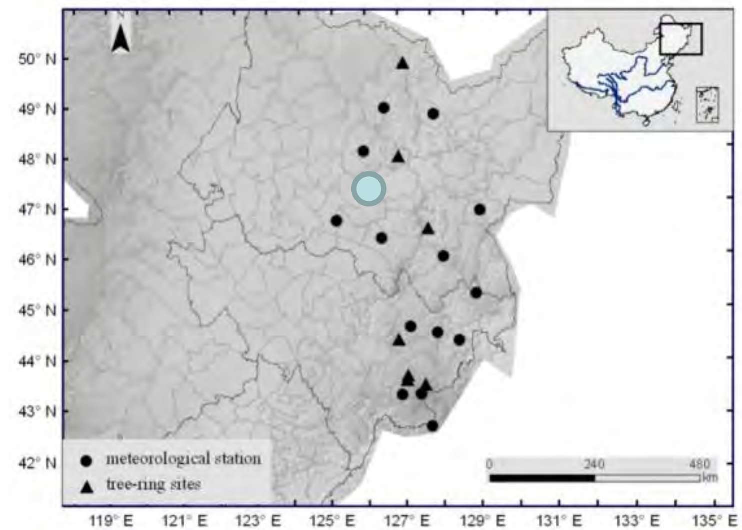
	Calibration				Verification	
	R^2	R_a^2	SN1	SN2	RE	r
C1C12	0.458	0.431	24	29*	0.368	0.612

R^2 : Explained variance
r: Pearson’s correlation coefficient
RE: reduction of error (positive RE is evidence for a valid regression model)
SN1: sign test of the first different(indicating the high-frequency)
SN2: sign test of raw data (indicating the lower-frequency)

Results

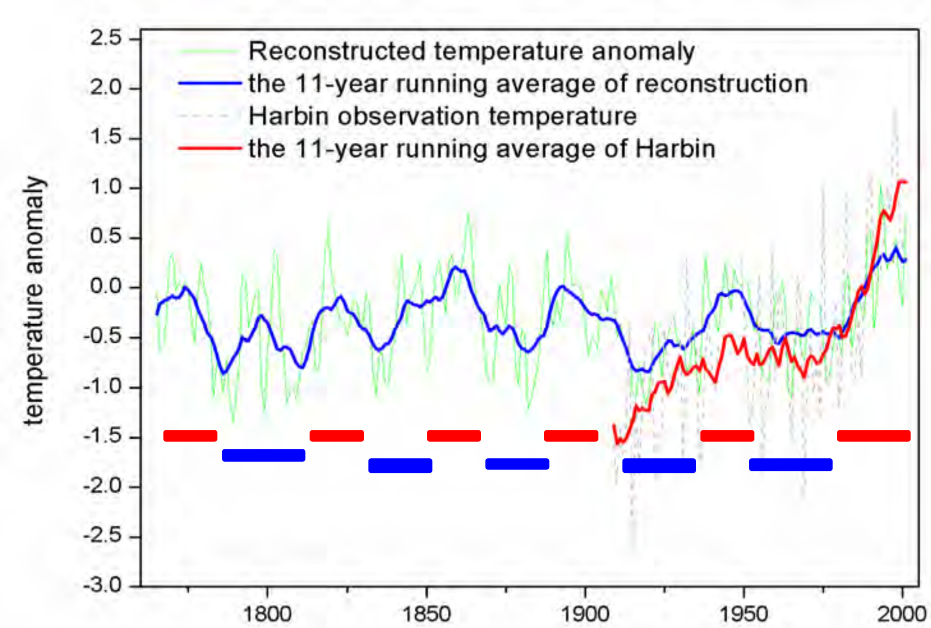
Comparison(1959-2001)





- Similar variation trend between reconstruciton and observed.
- Harbin have a long-time meteorological record(1909-2012,1943-1948missing)
- Influence of urbanization, the amplitude of Harbin temperature series(larger).

Reconstructed Series (1765~2002)



- The long-term increased trend was not detected
- One reason is **urbanization influence**. Another is the method of **de-trend the tree growth removed a part of climate signal**.
- The **total growth trend curve** preserve more low-frequency variations. Most cores reach the tree pith. Estimate the number of rings missing from the pith

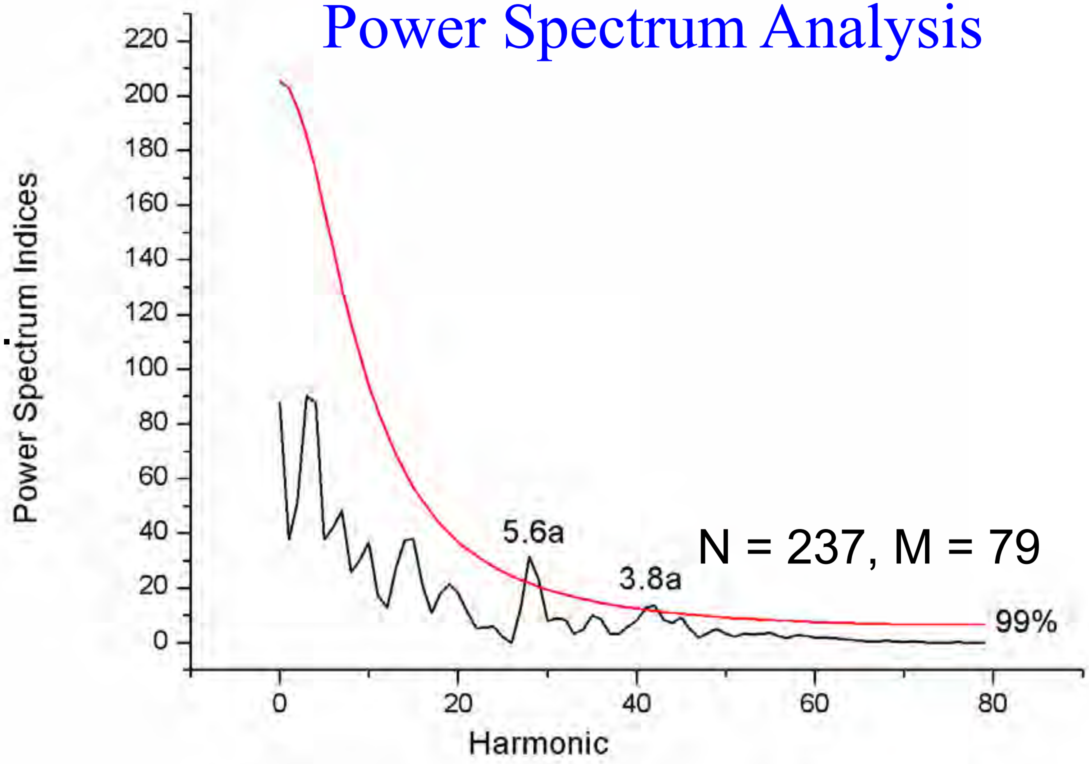
Periodic Analysis (1765~2002)

➢Periodicity was analyzed by the spectrum method.

➢Periodic characteristics of 5.6-year and 3.8-year (P<0.01).

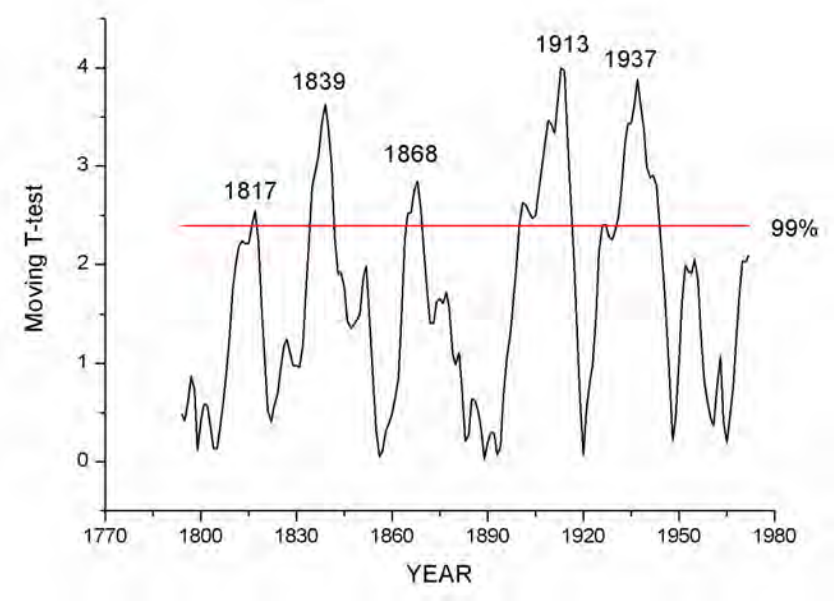
➢Around 5.6-year period is consistent with double oscillation periods of solar activity

Power Spectrum Analysis



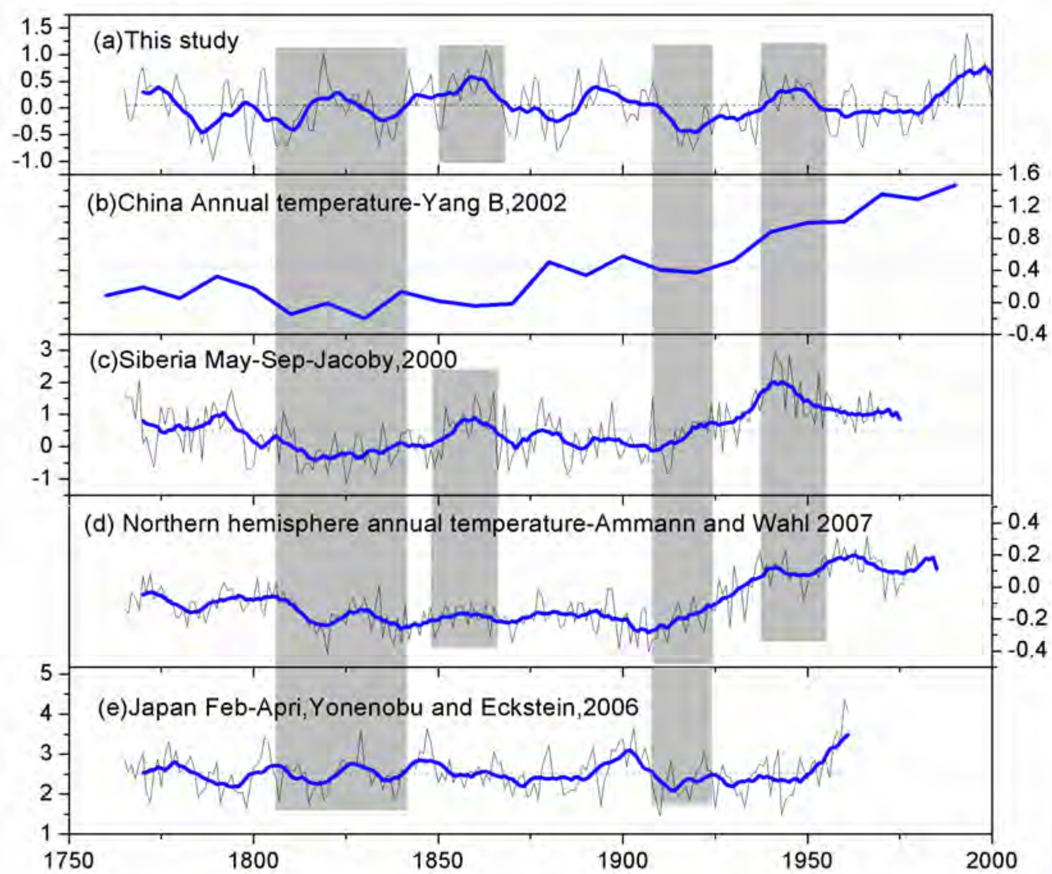
Abrupt Changes Analysis(1765~2002)

- The abrupt changes were detected by the methods of smoothing *t*-test.
- 30-year average is used as basic climatic state
- Significant abrupt changes in the mean value were detected .



smoothing *t*-test of the 30-year scale

Comparison of reconstruction results



- Some warm or cold periods appear simultaneously.
- The comparison reflected the reliability of reconstruction results.

Discussion

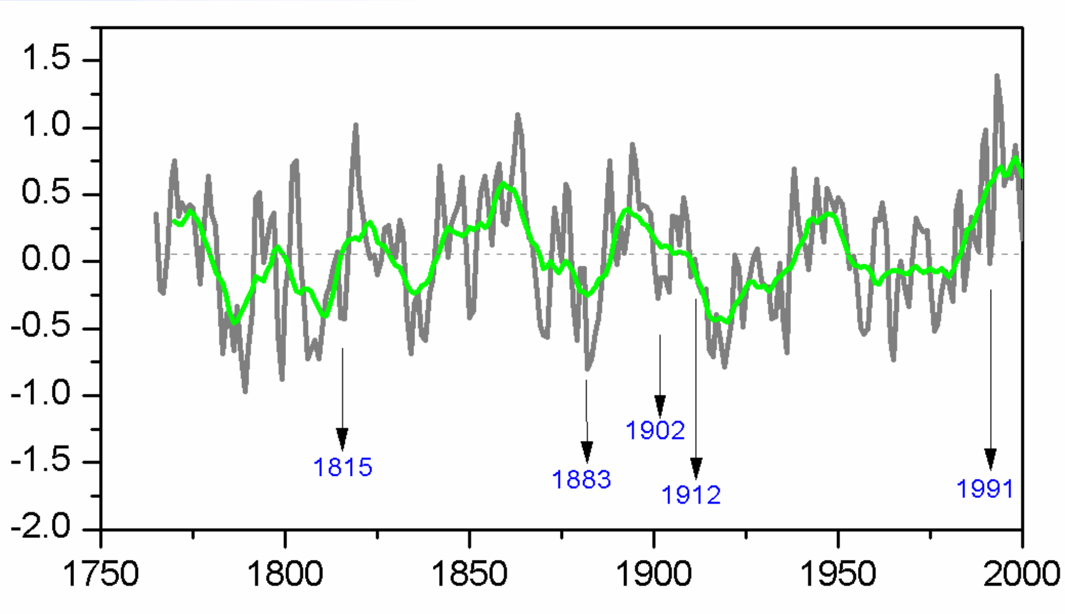
Largest explosive volcanic eruptions since A.D. 1800

Year	Month	Volcano and region	Lat.(deg)	Long.(deg)	VEI	Low tem.
1815	3－5	Tambora, Lesser Sunda Is	8.3S	118.0E	7	1815－1822
1883	6－8	Krakatau, west of Java	6.1S	105.4E	6	1883－1886
1902	4	Santa Maria, Guatemala	14.8N	91.6W	6	1902－1904
1912	6	Novarupta (Katmai),laska	58.3N	155.2W	6	1912－1921
1991	9－11	Pinatubo, Philippines	15.1N	120.4E	6	1991－1992

- Find the strong volcanic activity signal.
- Five strong volcanic with intensity index beyond 6 since 19th Century.
- Lower temperature periods appear after volcanic eruption.

Discussion

The relationship between cold period and strong volcanic activity



➢Average temperature in 1815 to1817 was lower than mean temperature (ME)

➢The eruption of Tambora also resulted in extreme cool summer in Europe and North America and cooler summer in 1816 in Eastern China.

➢Average temperature during 1883 to 1886 was lower than ME by 0.62℃

Summary

- The study reconstructed the annual mean temperature since A.D. 1765 based on tree-ring data in the Eastern part of the Northeast China. Six cold periods and five warm periods were identified based the 11-year moving average of reconstructed annual temperature series.
- The periods of 5.6-year and 3.8-year are found significant with a 99% confidence based on the power spectrum method.
- Significant abrupt changes were observed for around 1817,1839,1868,1913and 1937with a 30-year moving T-test.
- Comparisons with other paleoclimatic proxies show that some cold and warm periods coincide with Siberia, Japan, China and Northern Hemisphere temperature.
- After strong volcanic eruptions in 1815, 1883, 1902,1912 and 1991,the reconstruction temperatureareon a low side.


THANKS