State Key Laboratory of Numerical Modelling for Atmospheric Sciences
and Geophysical Fluid Dynamics(LASG)
Institute of Atmospheric Physics Chinese Academy of Sciences

Simulation of the Last Millennial Climate Change with LASG/IAP Climate System Model

Tianjun ZHOU, Wenmin MAN, Jie ZHANG

zhoutj@lasg.iap.ac.cn

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Outline

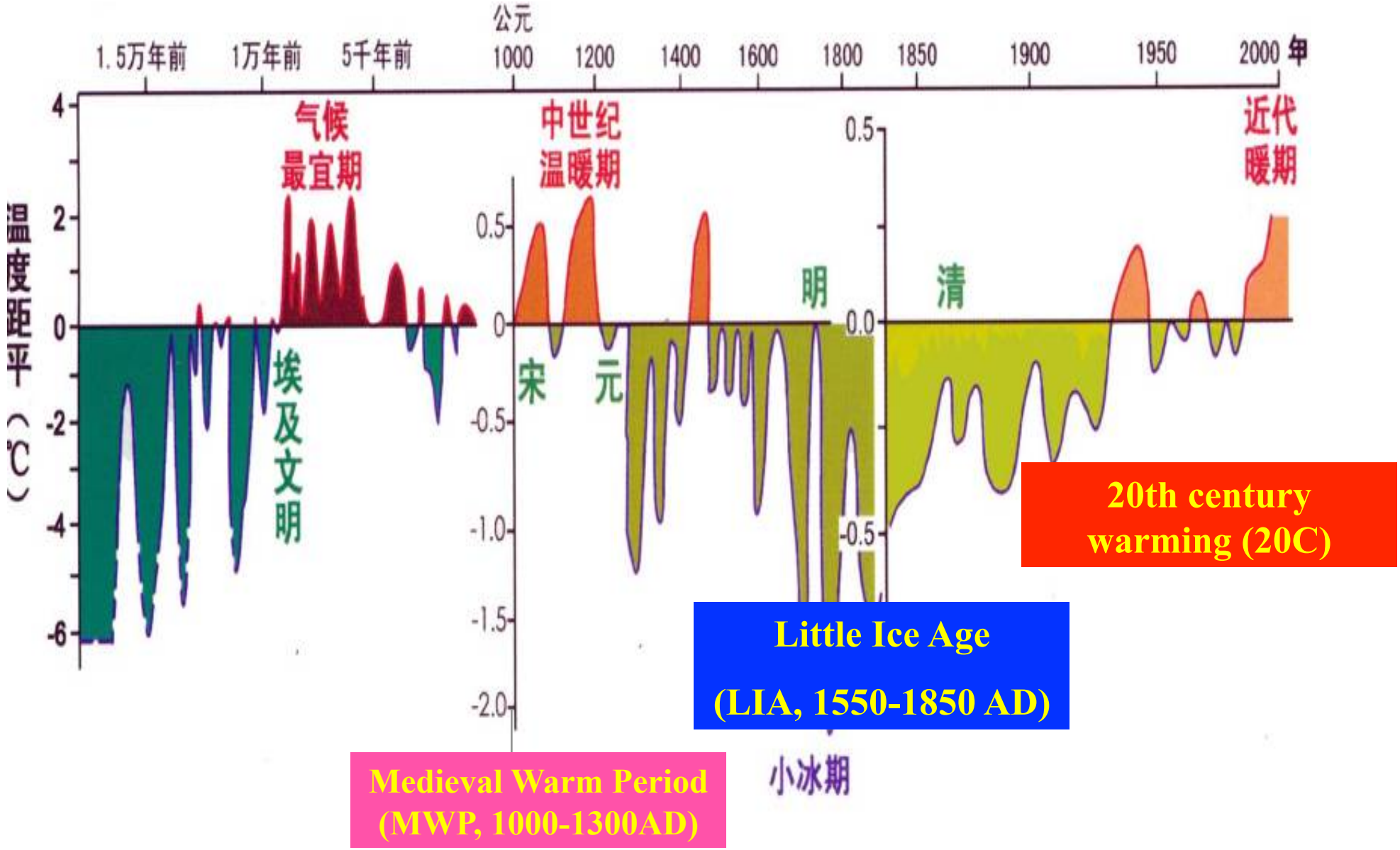
1. Background & motivation
2. Model introduction
3. Results (3-questions)
4. Summary

Background

- A project entitled "Numerical simulation of the last millennial climate change over China", as one part of a NSFC Major Program entitled "Tree Ring and Millennial Climate Change Research in Chinese Domain", granted by the National Natural Science Foundation of China (NSFC).
- **Motivation:**

To understand the mechanisms of the last millennial climate variation, with focus on East Asia.

Climate of the past millennium



Questions

- How about the performance of the model ?

  Long-term control run

- How well does the model simulate the 20th century warming ?

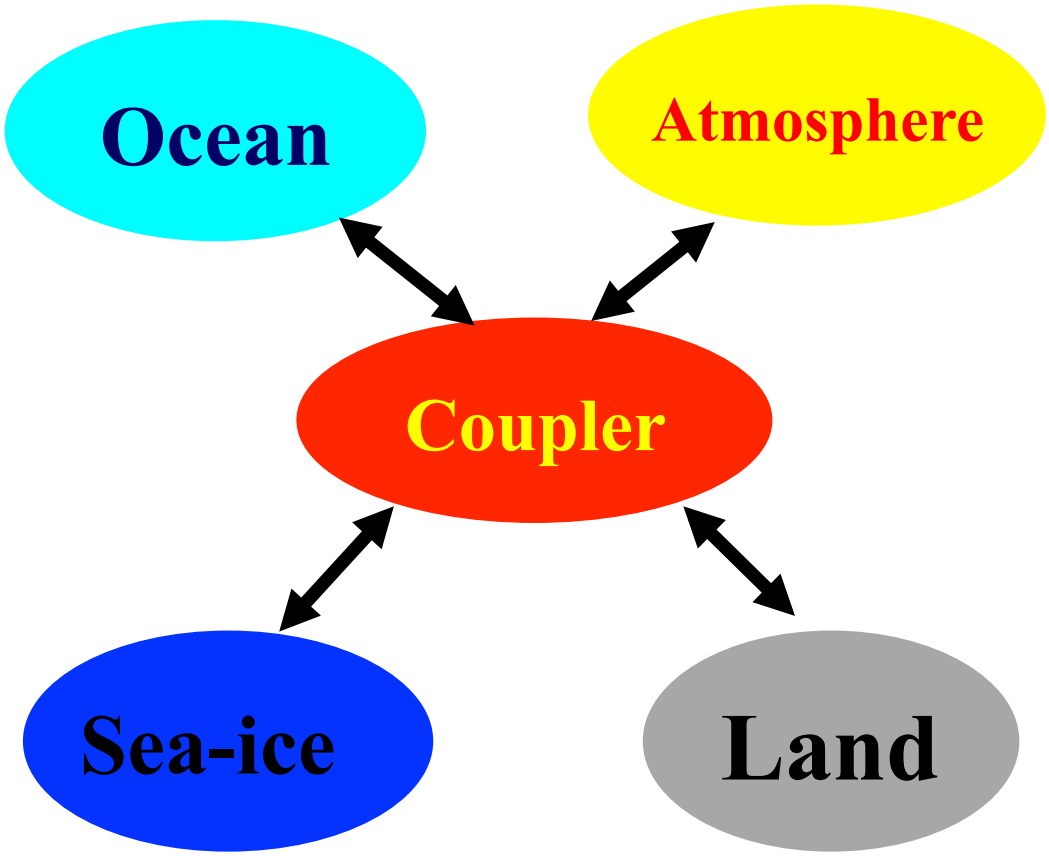
  Model & instrumental data comparison

- Are the simulated Medieval Warm Period and Little Ice Age climate true?

  Model-proxy data comparison

Framework of FGOALS_gl

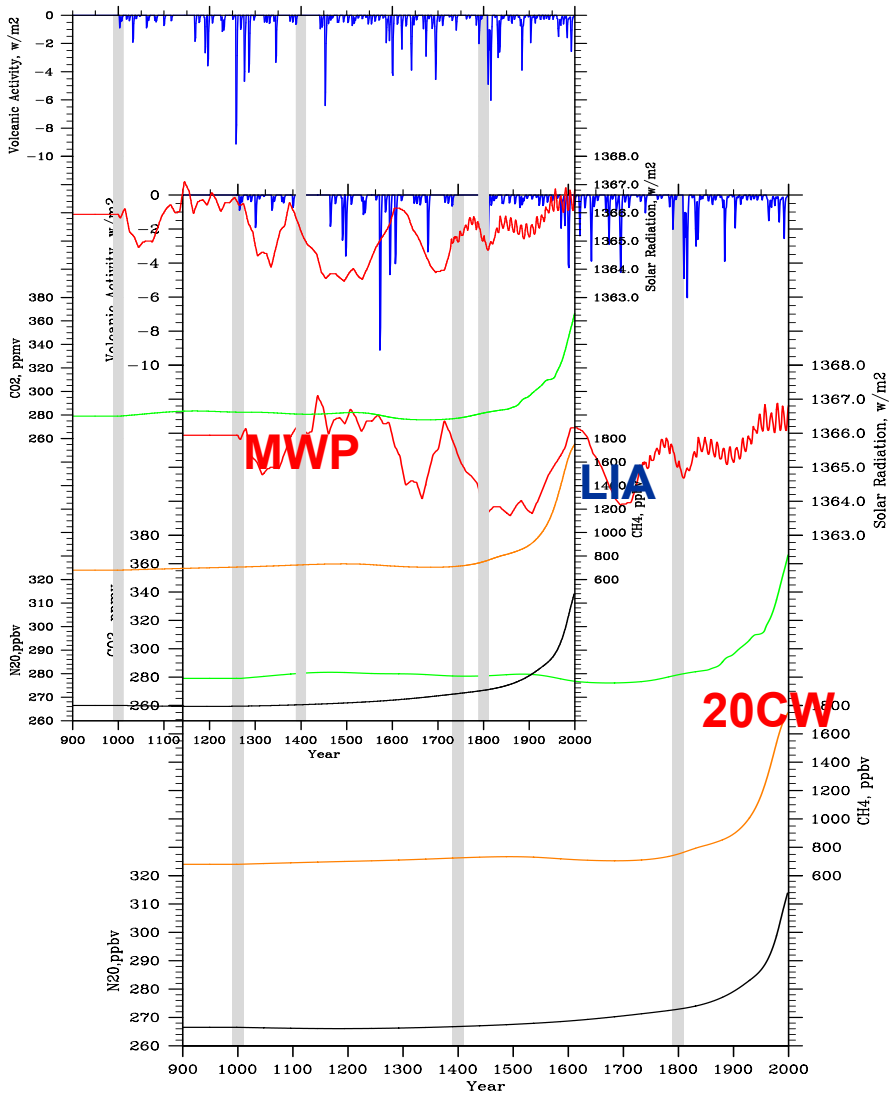
1.0*1.0 L30
LICOM



GAMIL LOW
5°*4° L26

Zhou et al. 2007, AAS

Forcing data used in driving the model



- MWP: strong solar activities and less volcanisms
- LIA: weak solar activities and more volcanisms
- 20CW: anthropogenic forcing

(Crowley 2000; Caspar et al. 2007)

List of Experiments

	Exps	SCON	CO2	Integration(yr)
1	Preindustrial control	1365W/m^2	280ppmv	100
2	MWP Equilibrium	1367W/m^2	-	100
3	LIA Equilibrium	1363W/m^2	-	100
4	MWP Transient	Crowley	Caspar	1100-1200
5	LIA Transient	Crowley	Caspar	1650-1750
6	20C Transient	CMIP3	CMIP3	1850-2000
7	Preindustrial control	1365	280	2*1000
8	All forcing	-	-	1000

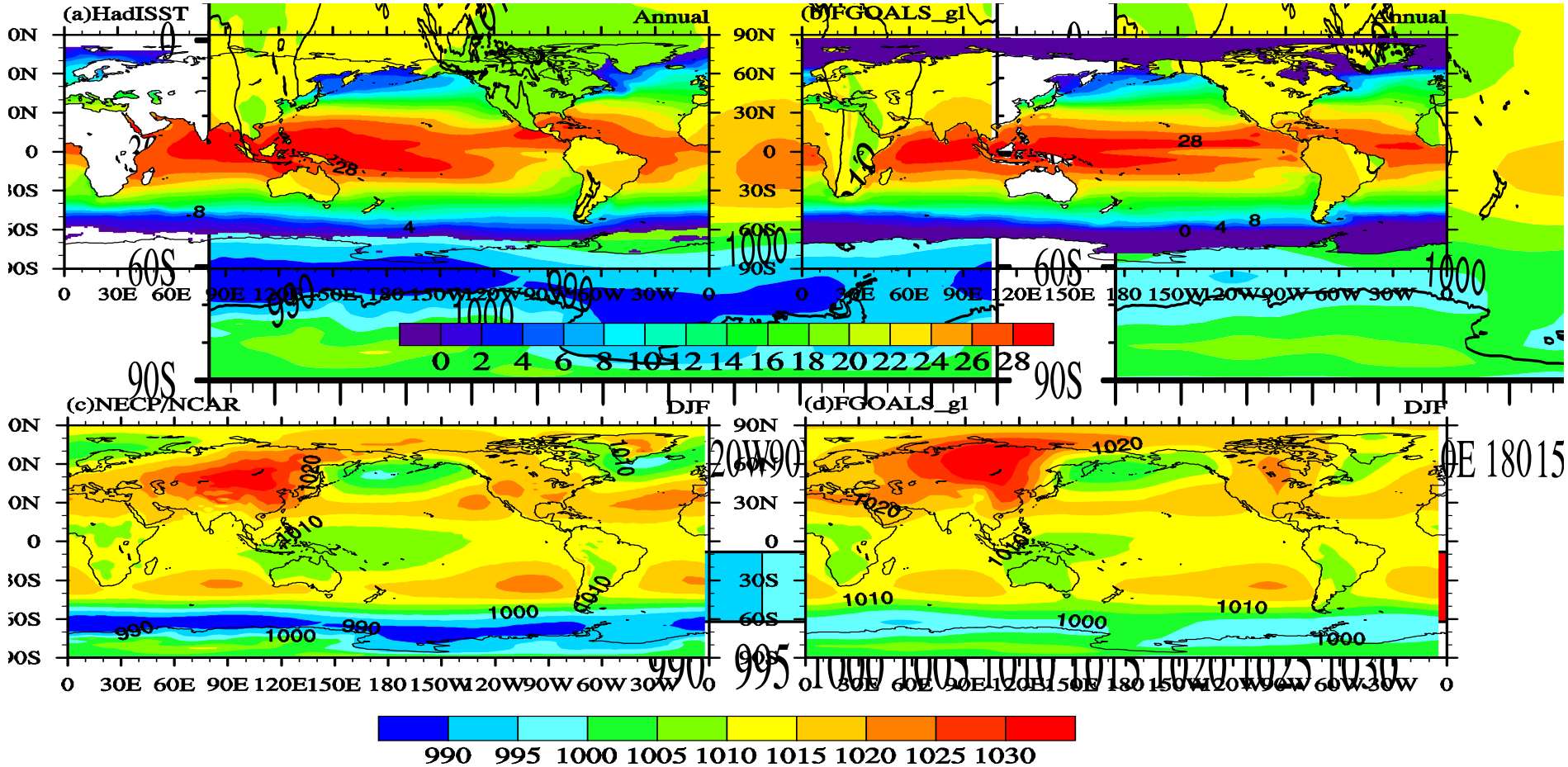
Yellow background: Done.

Blue background: Ongoing

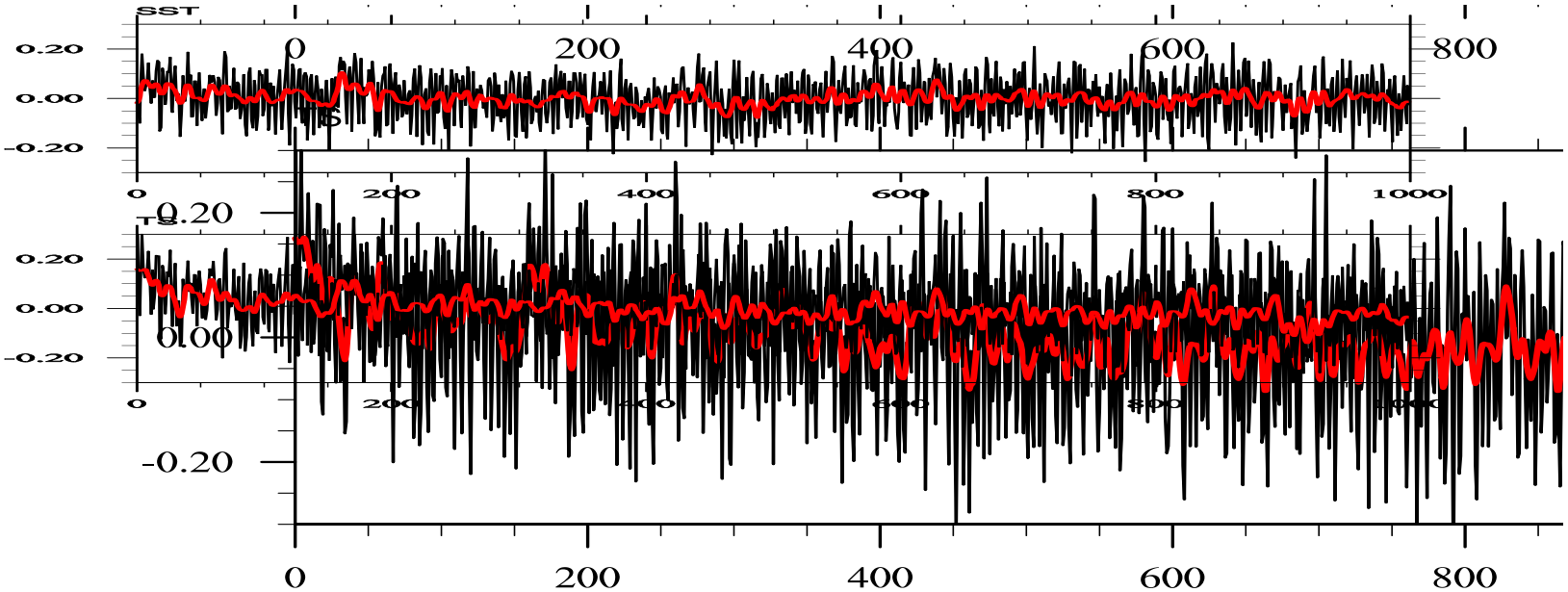
Question-1

How about the performance of the model?

Annual mean SST in control run

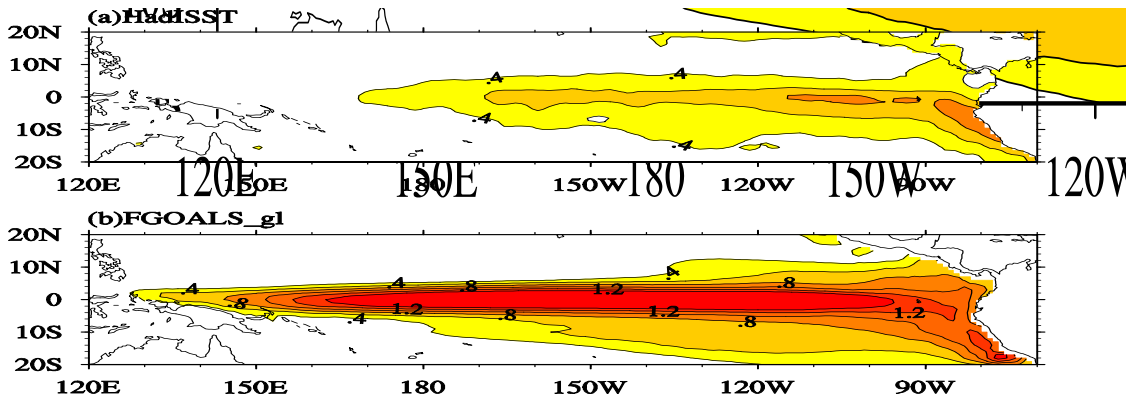


Global mean SST、SAT in control run



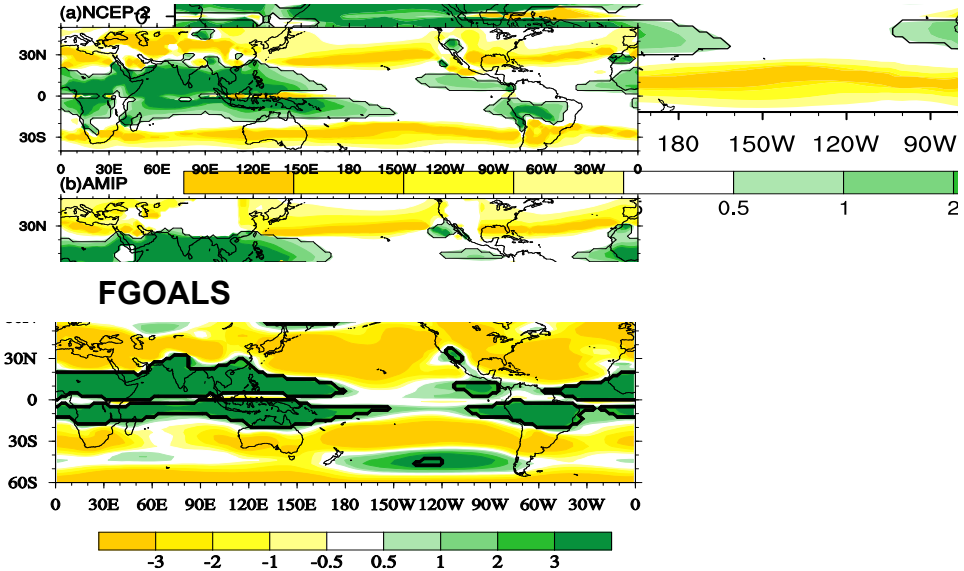
The climate drift is well controlled.

Standard Deviation of SST

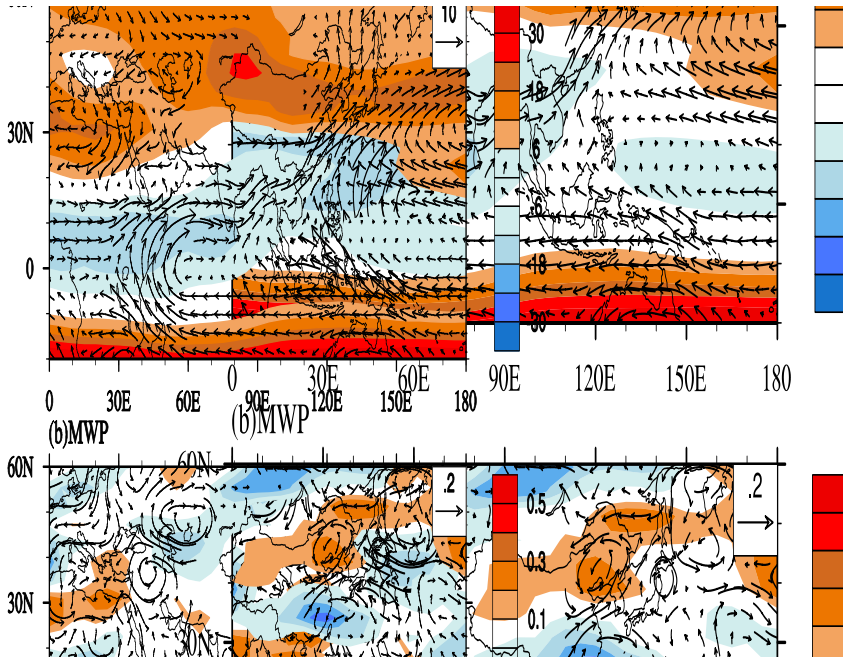


Interannual variability is stronger than the observation.

Monsoon Simulation

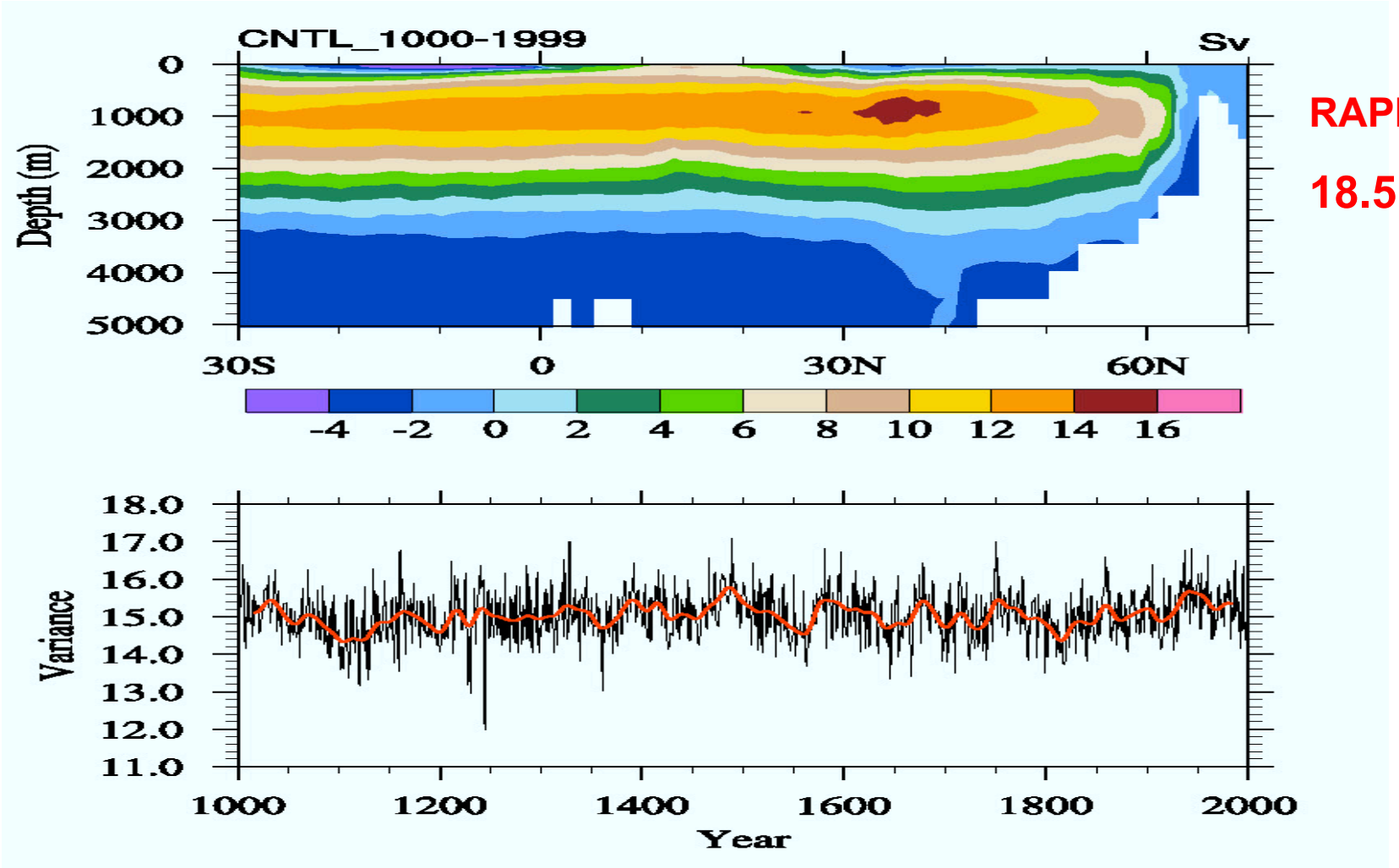


Global monsoon domain



EA monsoon circulation

N. Atlantic Thermohaline Circulation



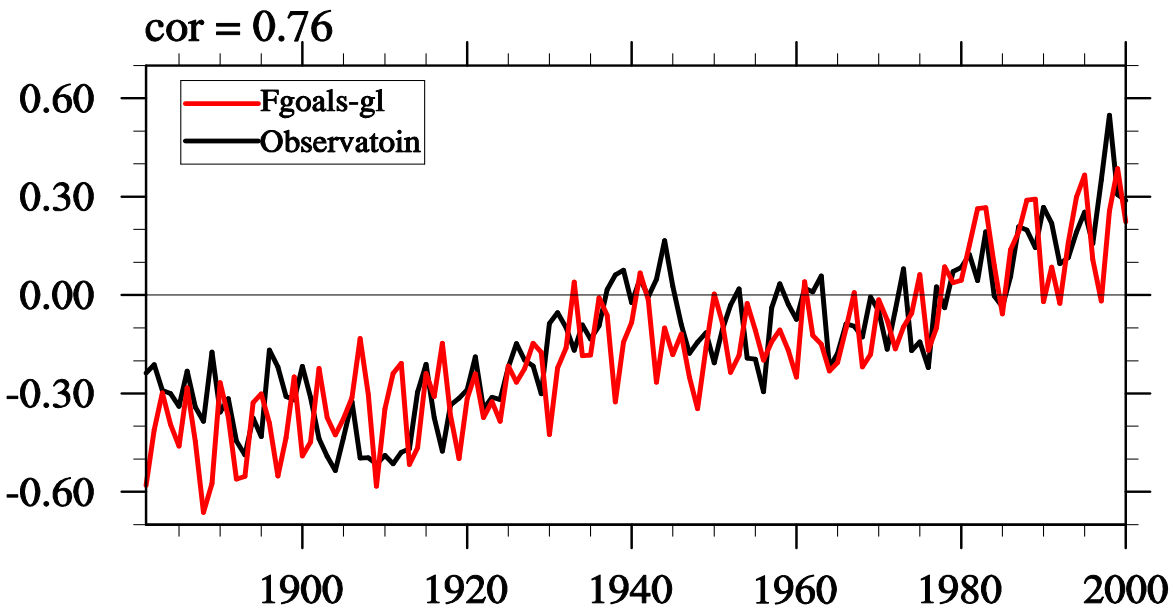
RAPID Observation:

18.5 Sv, 2004-2009

Question-2

How well does the model simulate the 20th century warming ?

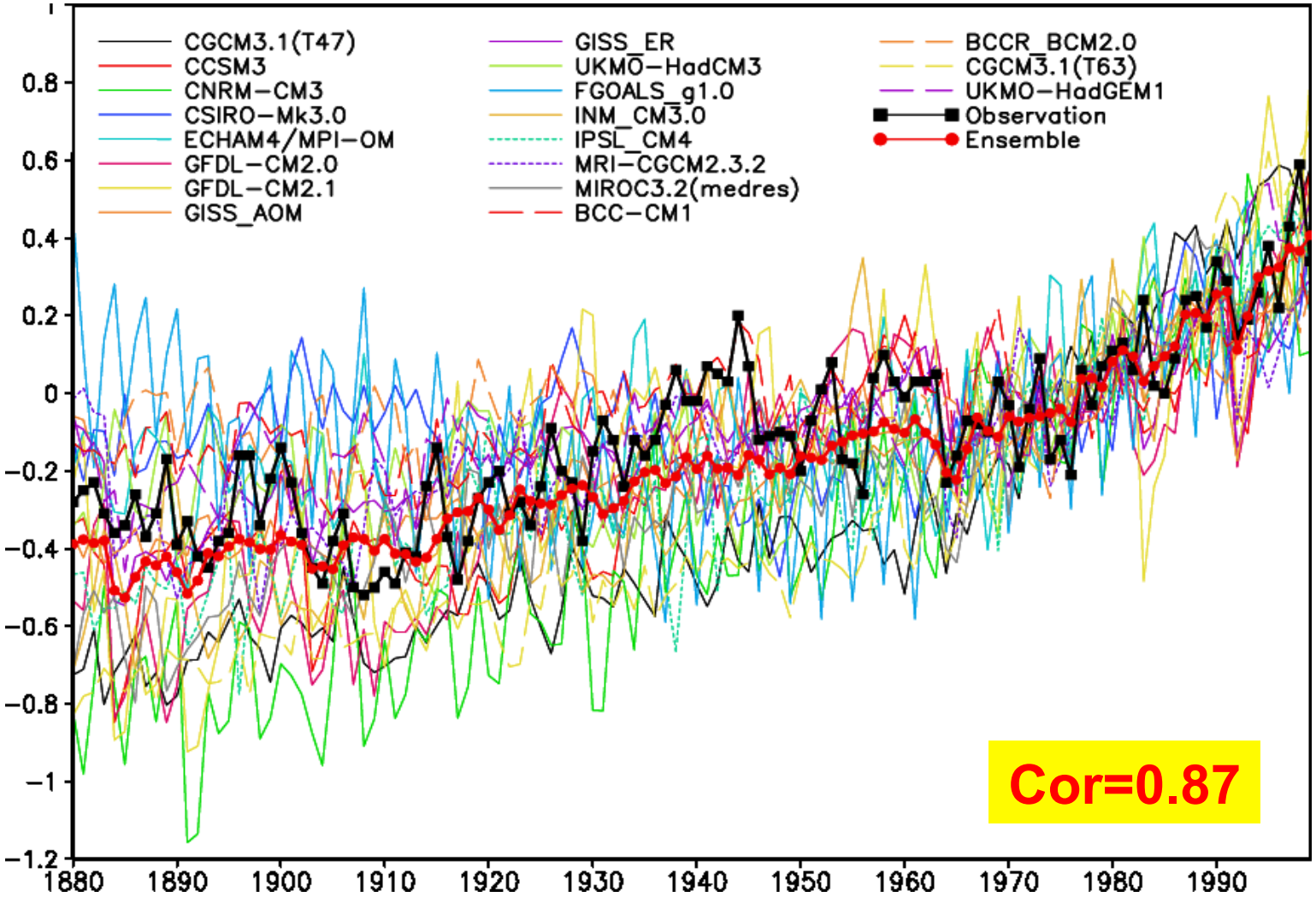
Global Annual mean SAT



Cor=0.76

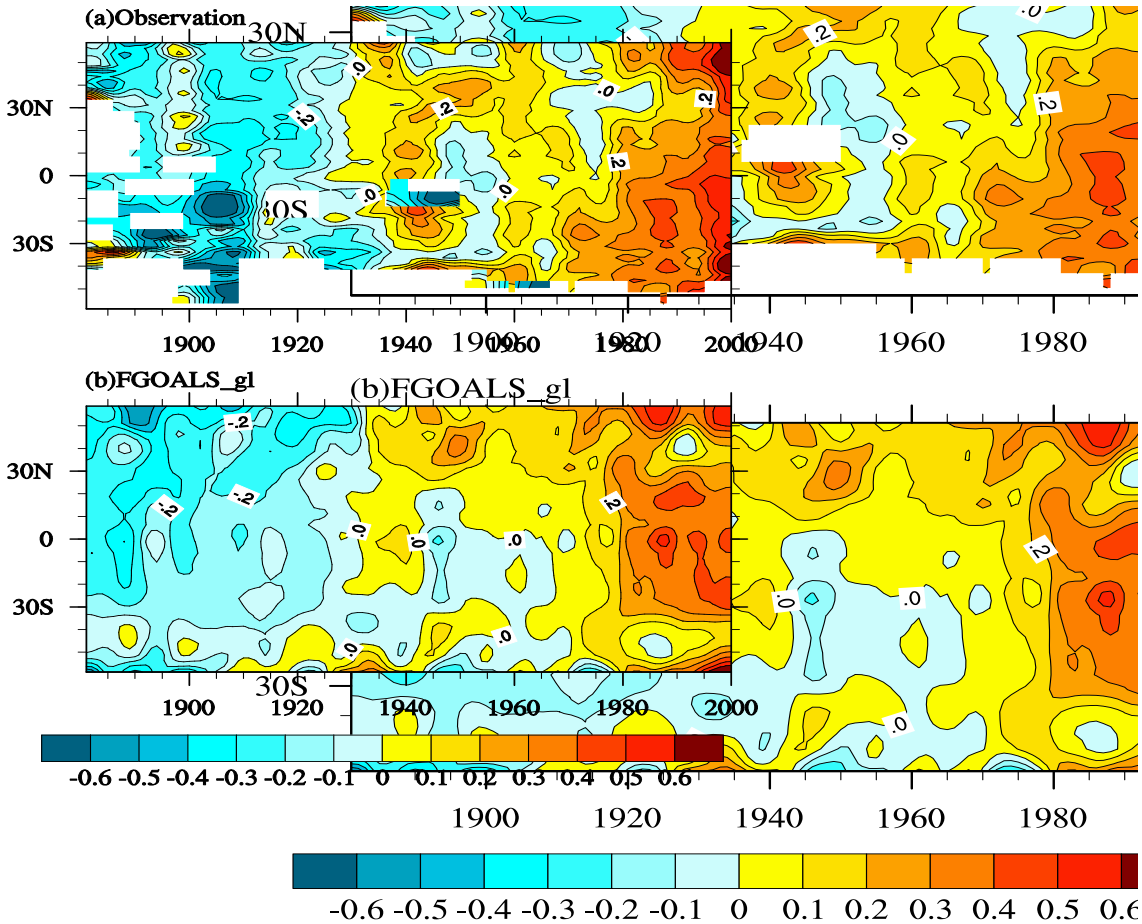
Natural warming around the 1940s, the cooling before the 1970s , recent warming after the 1970s

Global average SAT in CMIP3 Models



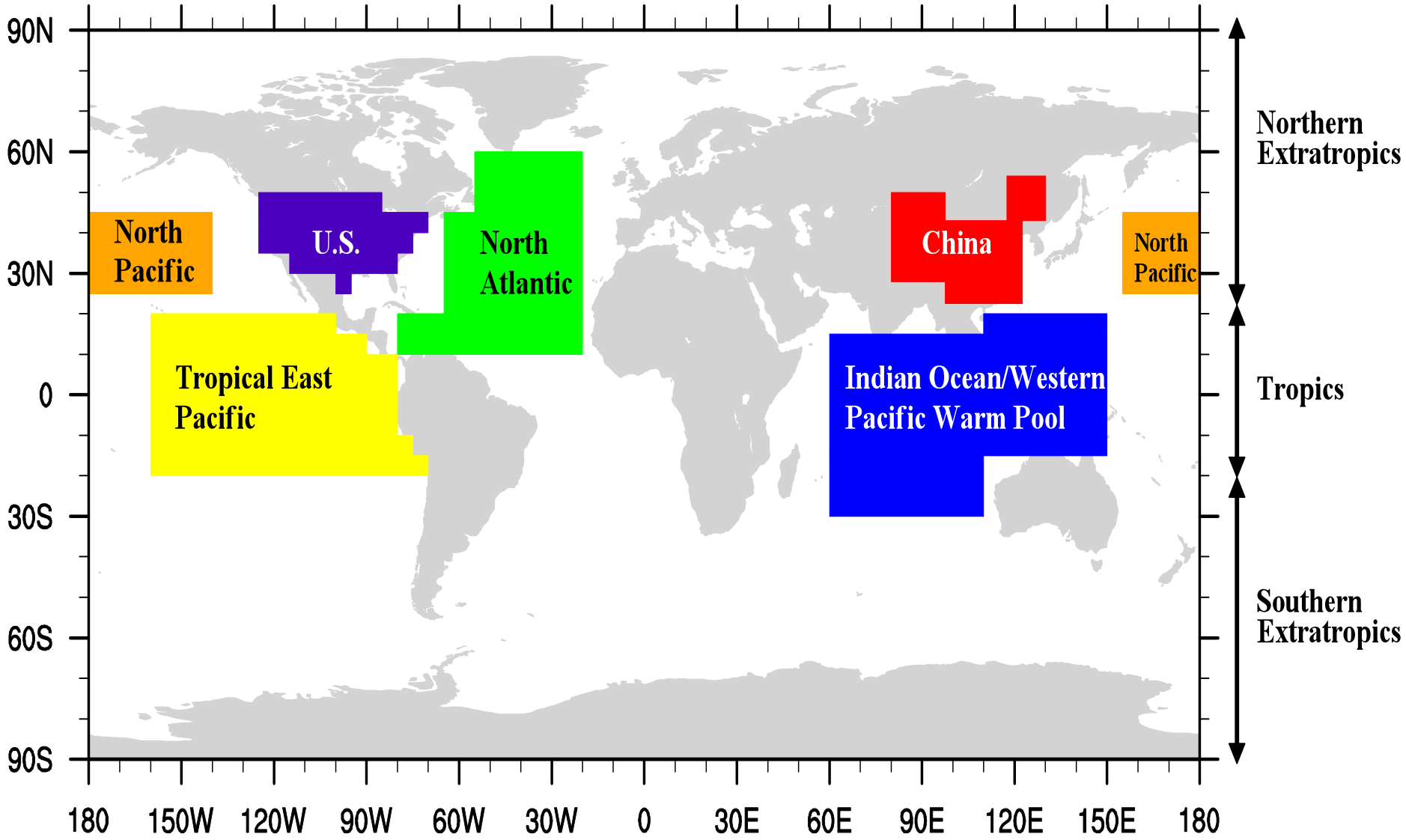
Zhou and Yu, 2006, J. Climate

Zonal Mean SAT : Observation vs Simulation

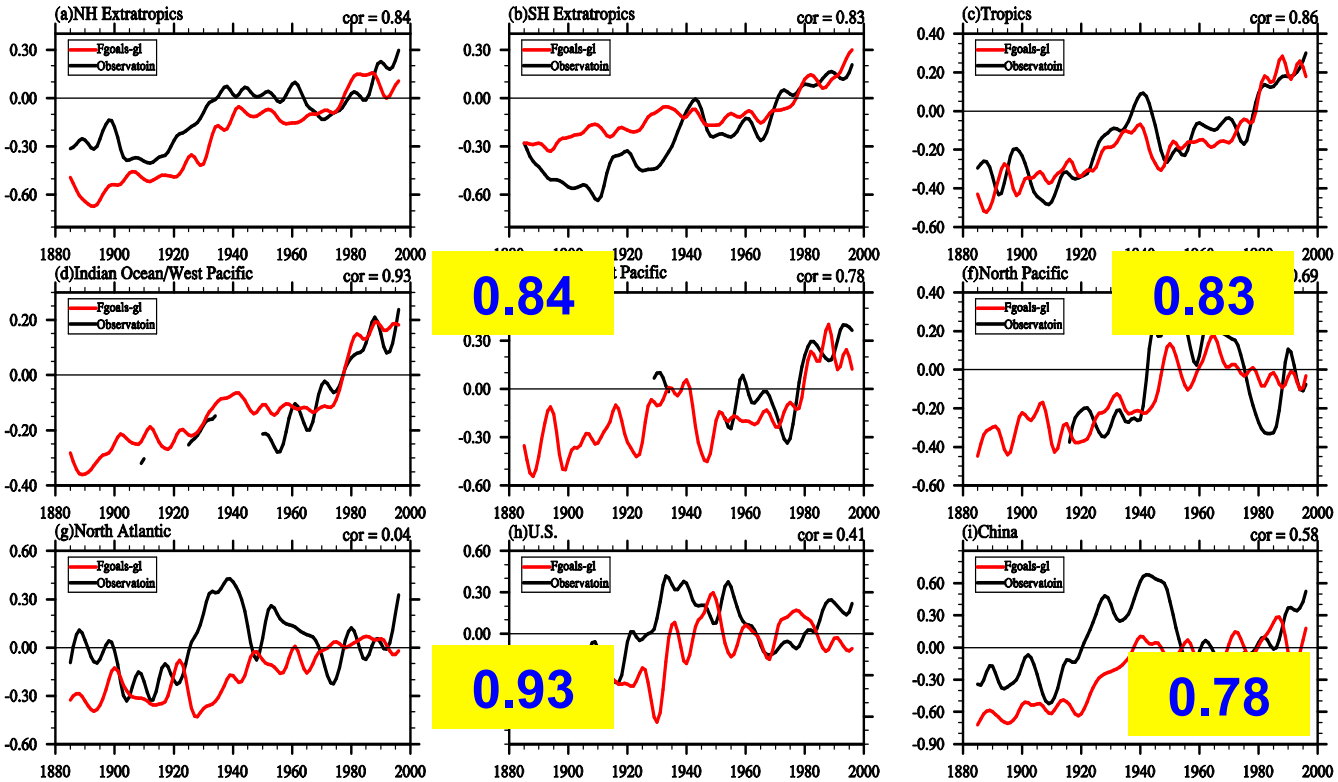


The latitude-dependence of the 1940s warming and recent warming

Definition of 10 sub-regions



Regional averaged SAT time series: Simulation vs Observation



0.84

0.83

0.86

0.93

0.78

0.69

0.04

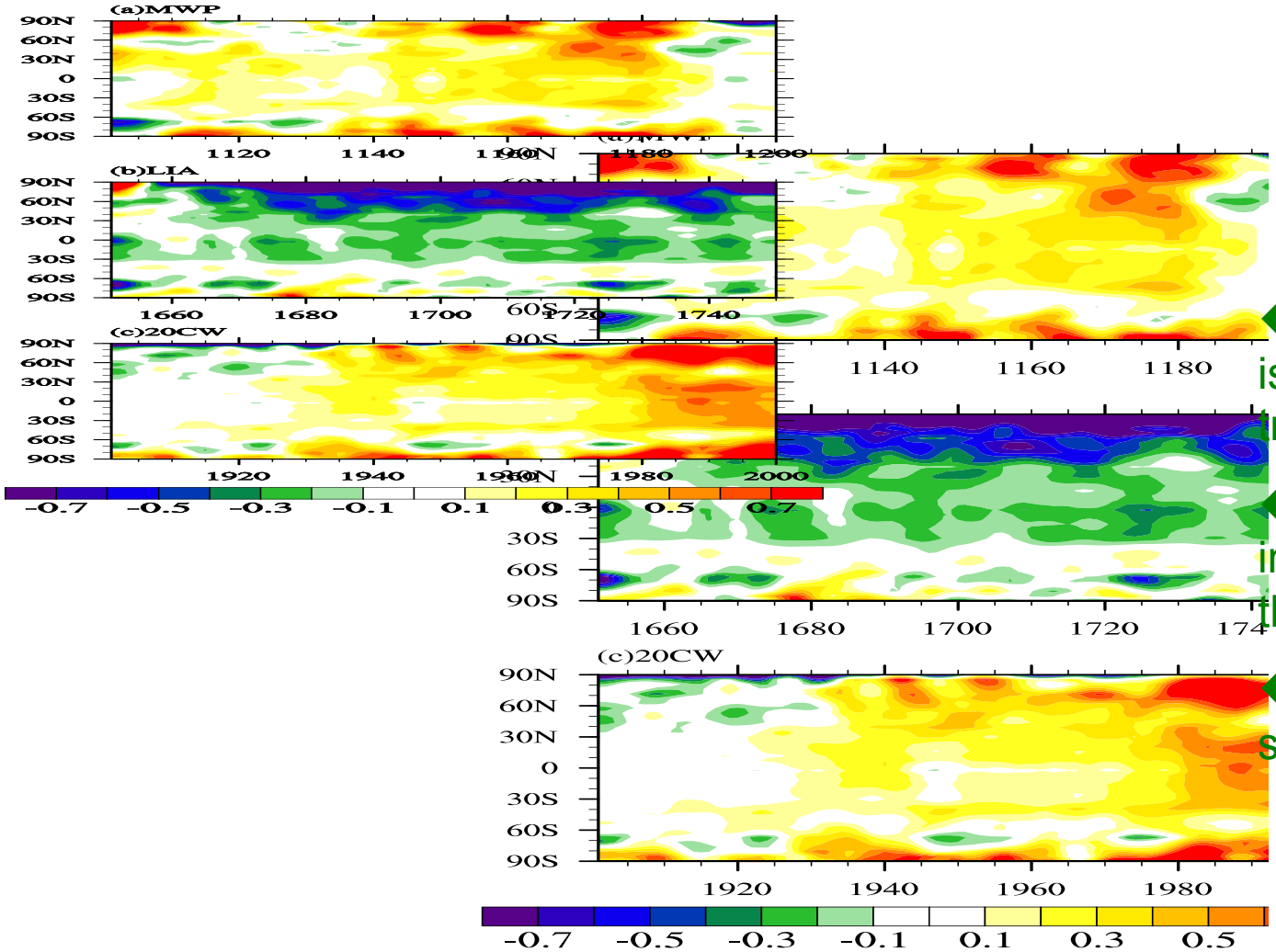
0.41

0.58

Question-3

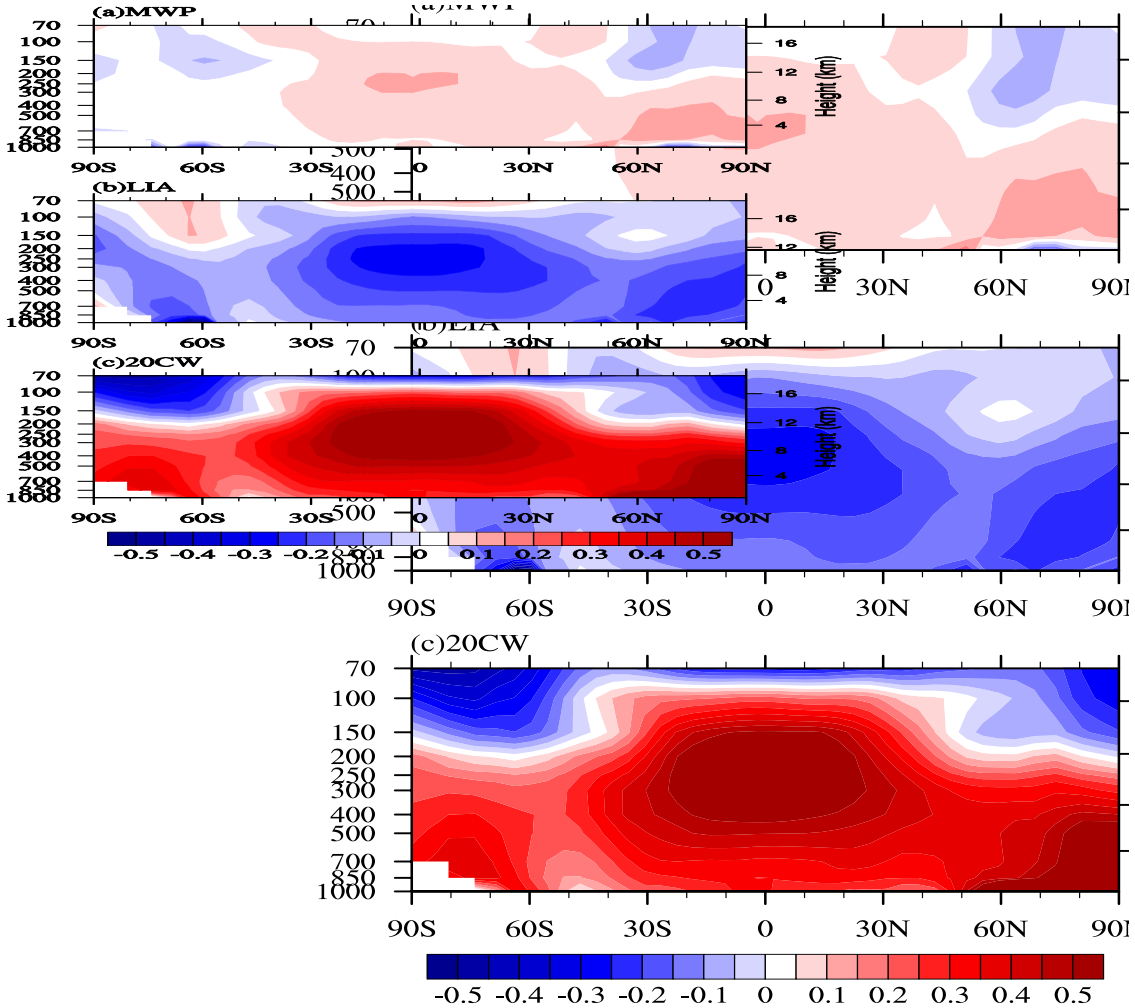
Are the simulated Medieval Warm Period and Little Ice Age climate true?

Zonal mean SAT anomalies (relative to 1860C)



- Response in high latitudes is stronger than that in the tropics.
- The high latitude cooling in LIA is more uniform than the MWP warming.
- The N. H. cooling is far stronger than that of SH.

Cross-section of Zonal Mean Temperature Anomalies



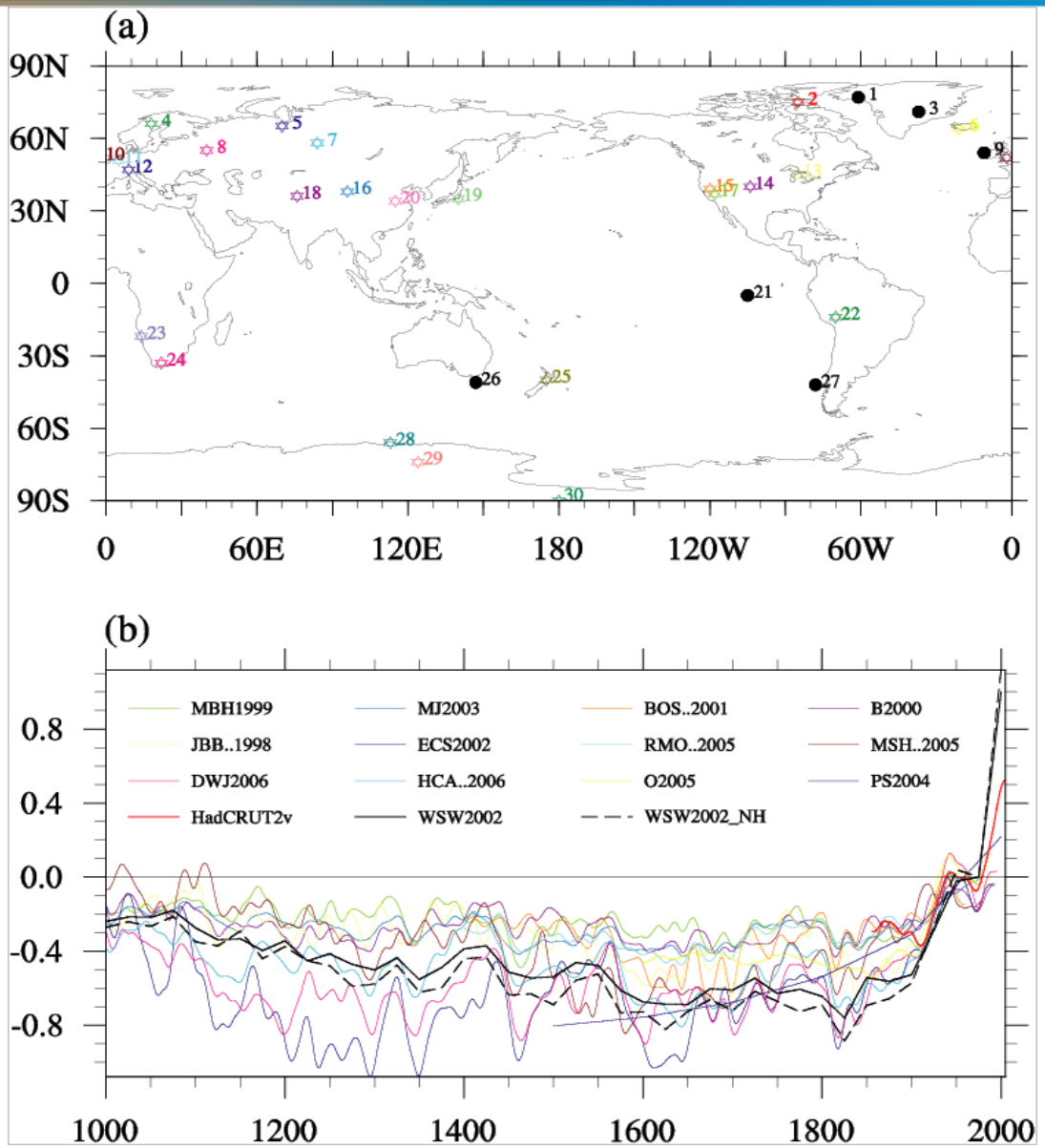
◆The magnitude increases with height to about 300 hPa.

◆The Medieval warming is weaker than that of 20C.

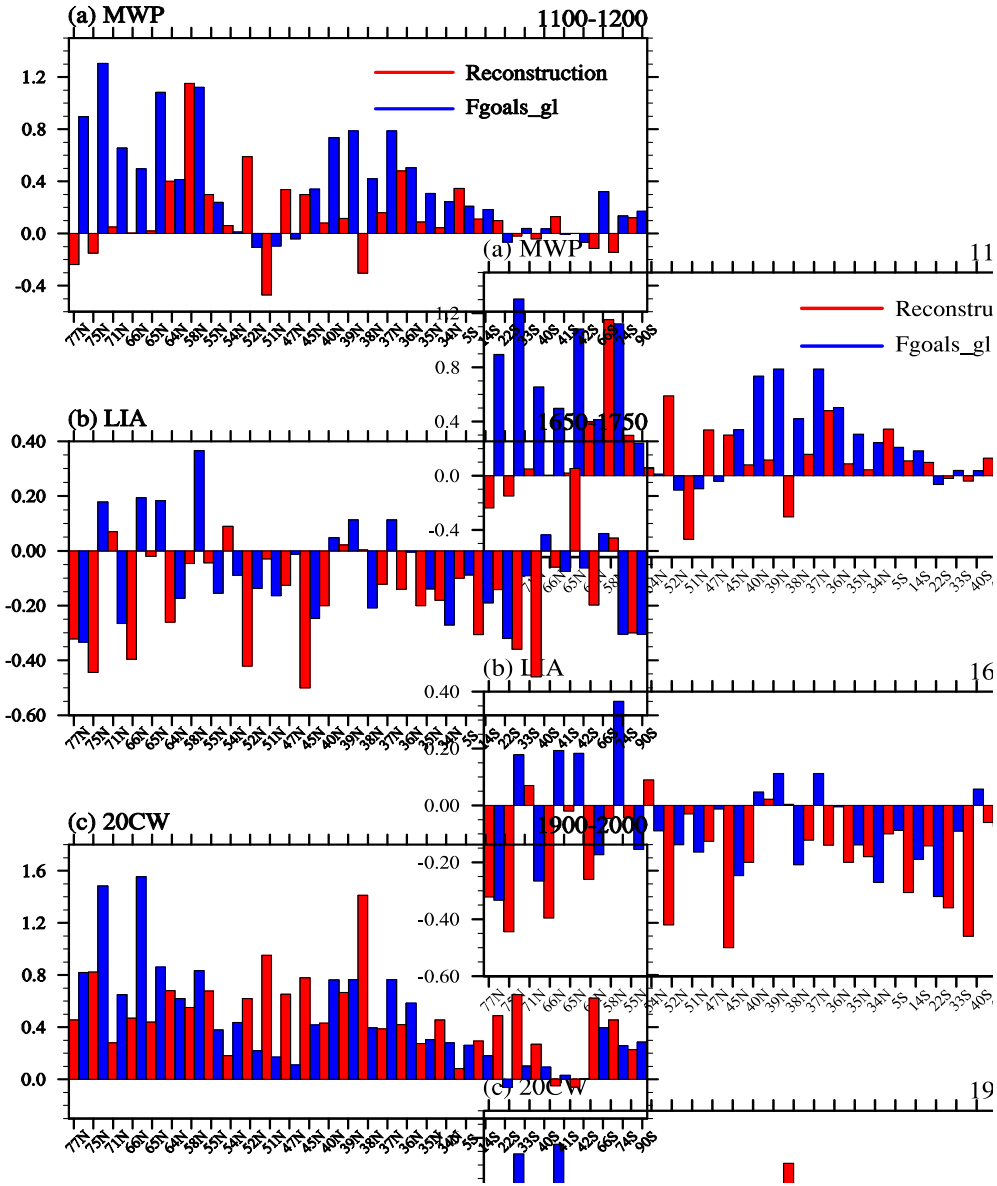
Proxy data of Wang SW

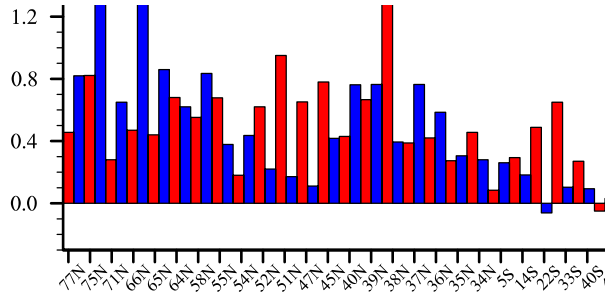
Location of 30 proxy data (Wang SW)

NH mean SAT



Same-Sign-Rate between the simulation and proxy data in 30 stations



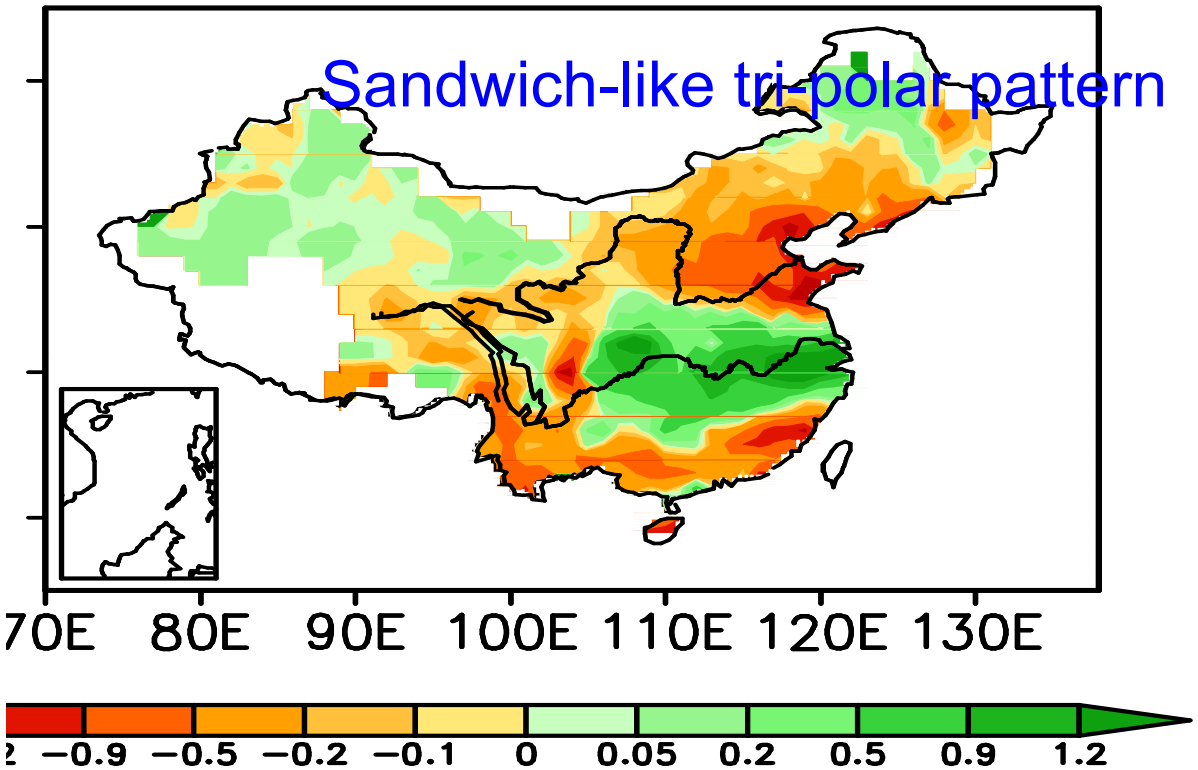


MWP: 19/30 points= 63%

LIA: 17/30 points= 56.%

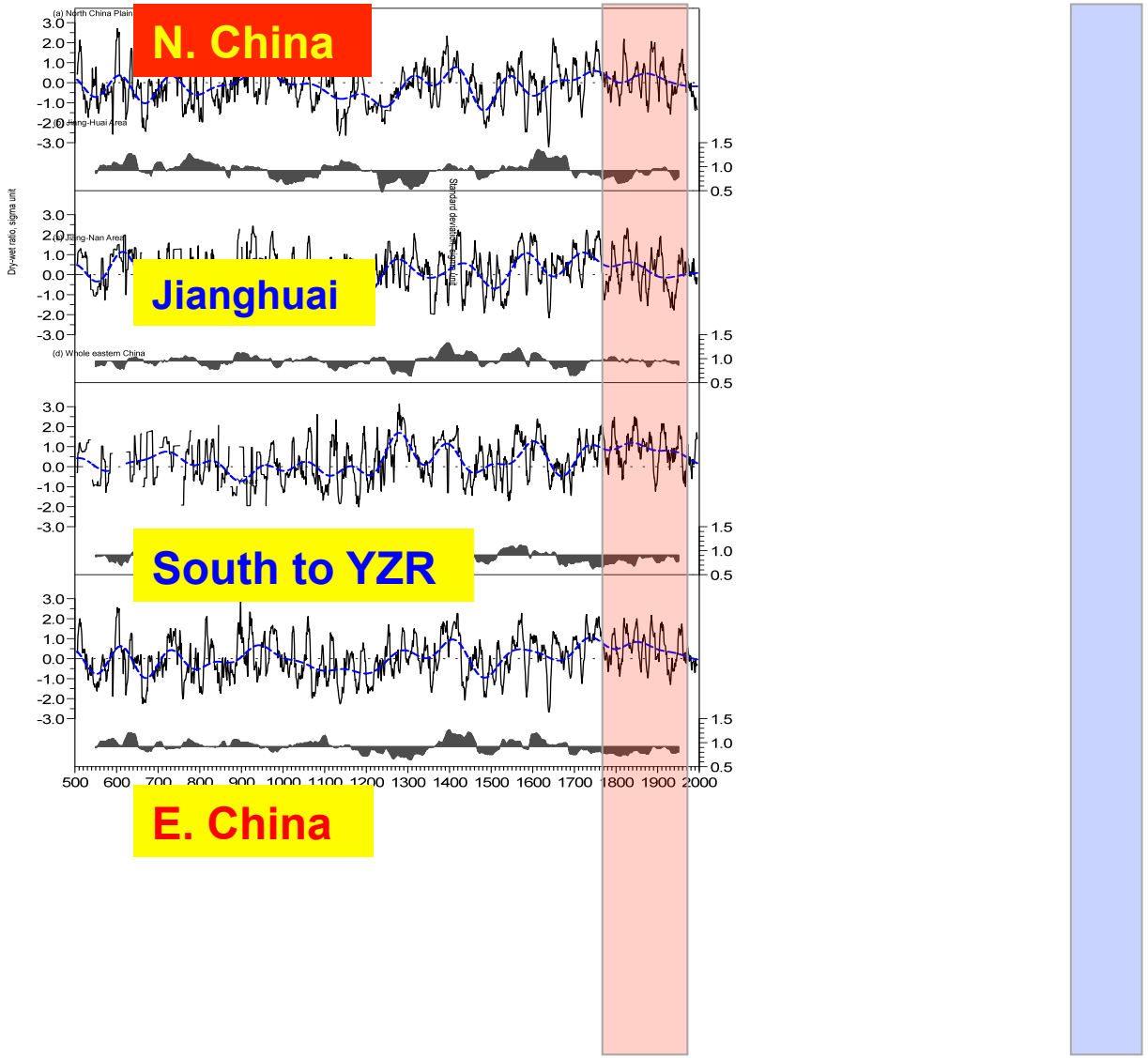
20CW: 27/30 points= 90%

Summer rainfall change in observation



Trend during 1951-2000

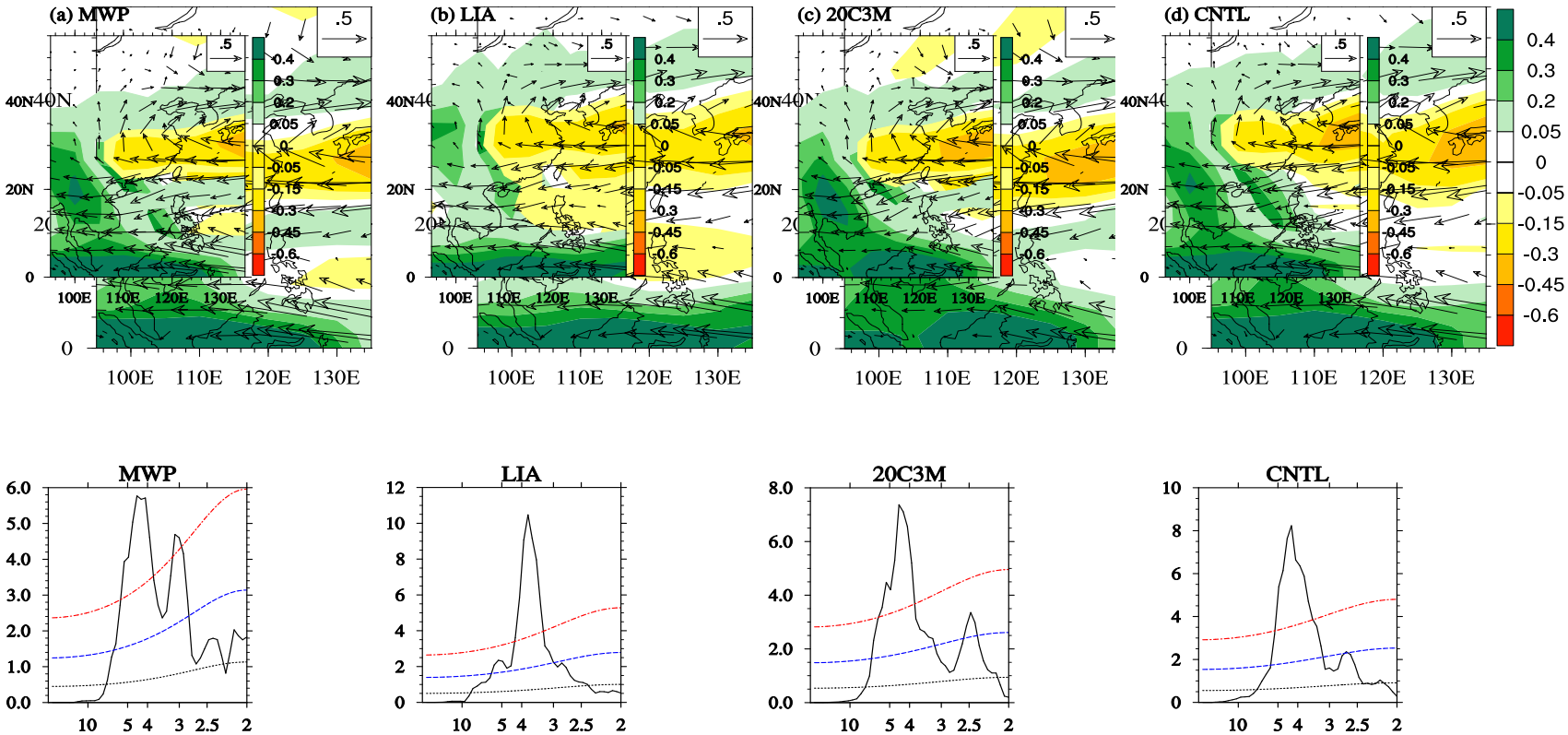
Wetness change from historic documentary



Tri-polar pattern more evident in MWP.

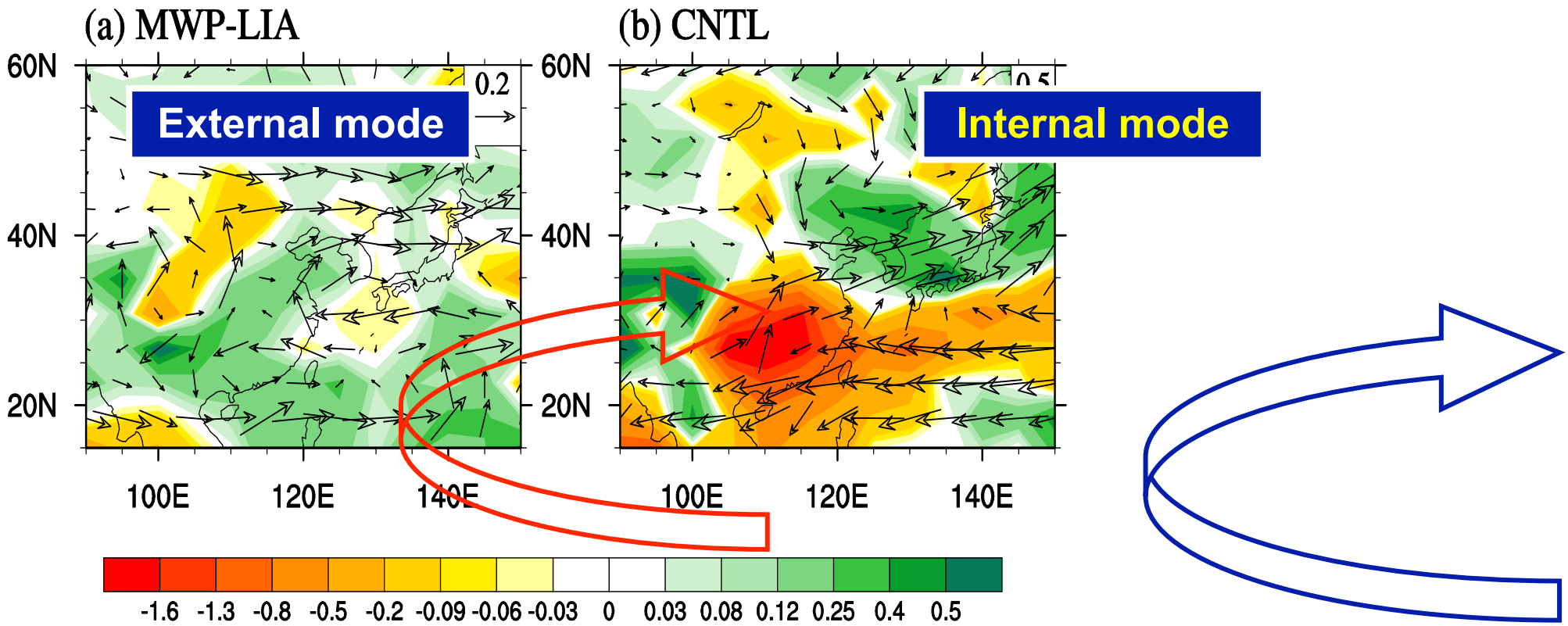
(After Ge 2008)

Leading mode of summer rainfall (shading) and 850 hPa wind anomalies

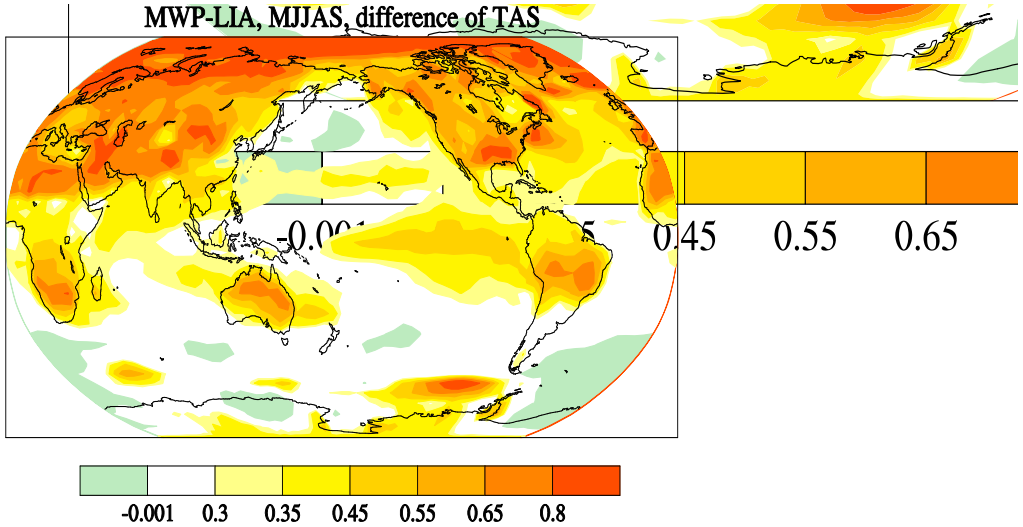


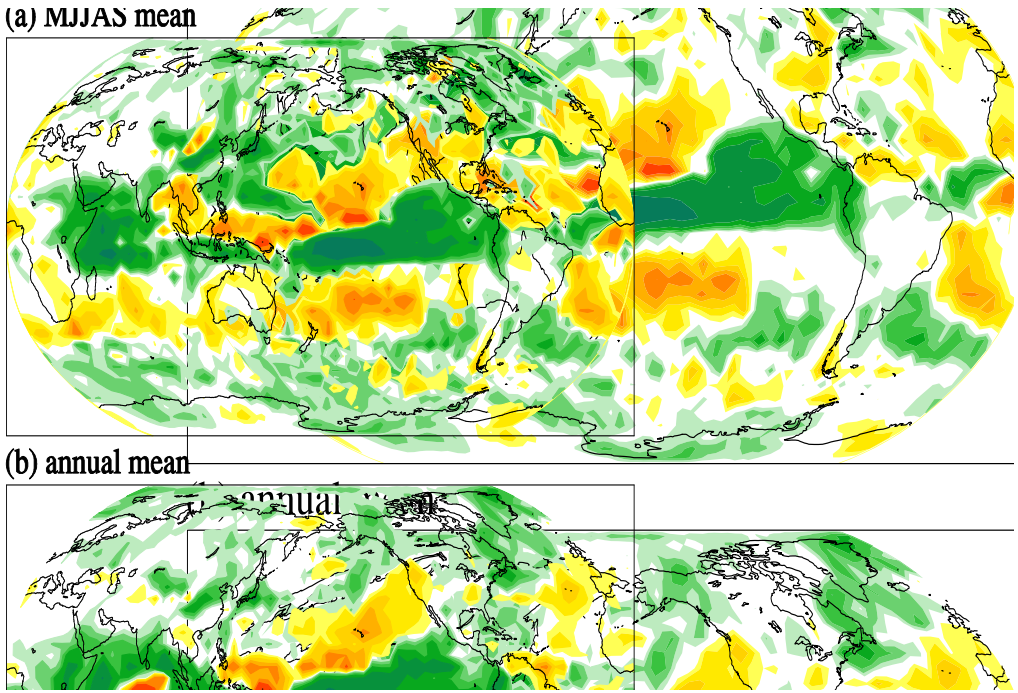
Tri-polar pattern & double peaks are more evident in a warmer climate.

Summer Rainfall (shading) and 850 hPa Wind Anomalies



Surface temperature (left) and rainfall (right) changes for MWP-LIA





Temperature

Precipitation

Summary

Q1: How about the performance of the model?

A: The long-term drift in the 1000-yrs preindustrial control run is not significant. The ENSO is stronger than the observation. Decadal oscillation is evident in THC.

Summary

Q2: How well does the model simulate the 20th century warming ?

A: The 20C century warming trend is well simulated except for the N. Atlantic, where internal variability associated with THC may dominate. The result is comparable to MME of CMIP3.

Summary

Q3: Are the simulated Medieval Warm Period and Little Ice Age climate true?

A: Major features of SAT change during MWP and LIA are reproduced, as evidenced by the “Same-sign-rate” between the simulation and the proxy data.

The MWP warming is weaker than that of 20C.

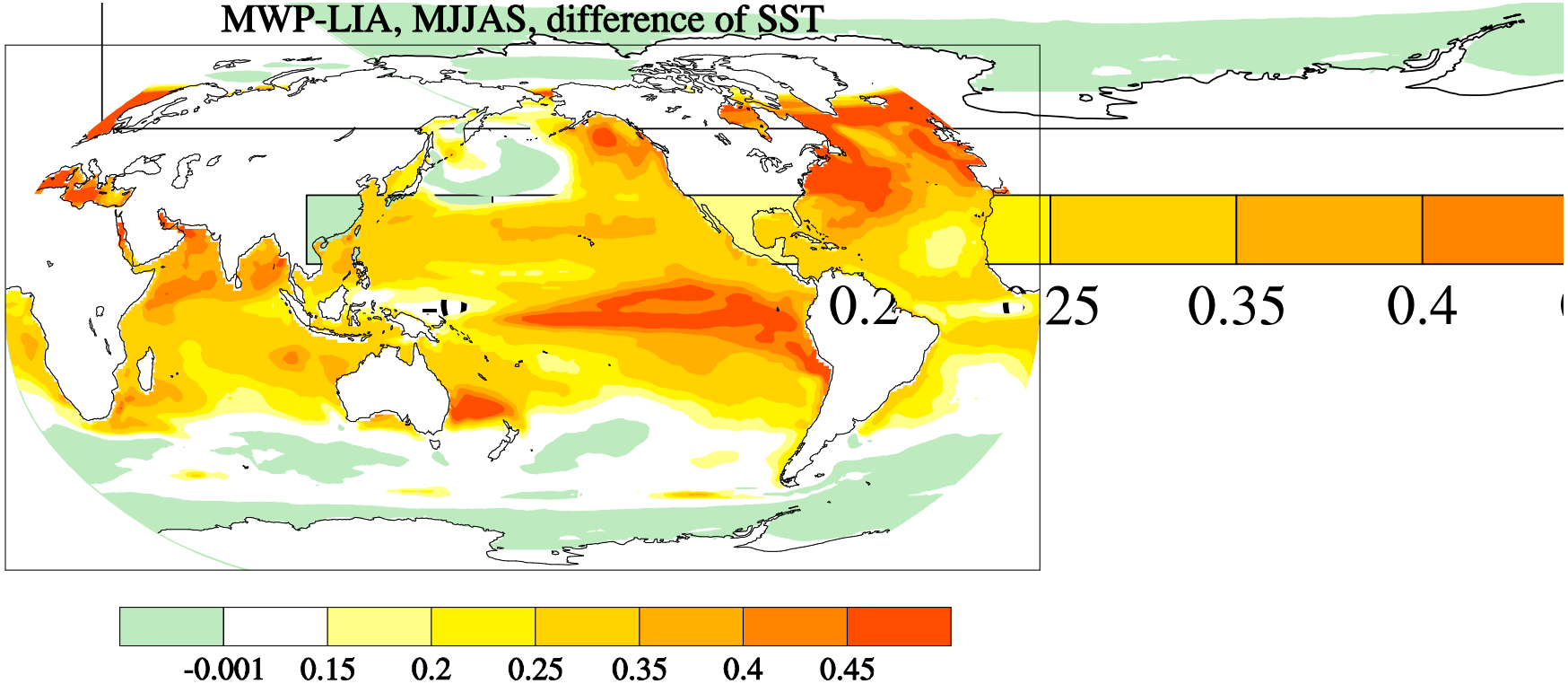
The tri-polar rainfall pattern is an internal mode, but more evident in warmer climate, also different to external mode.

LASG

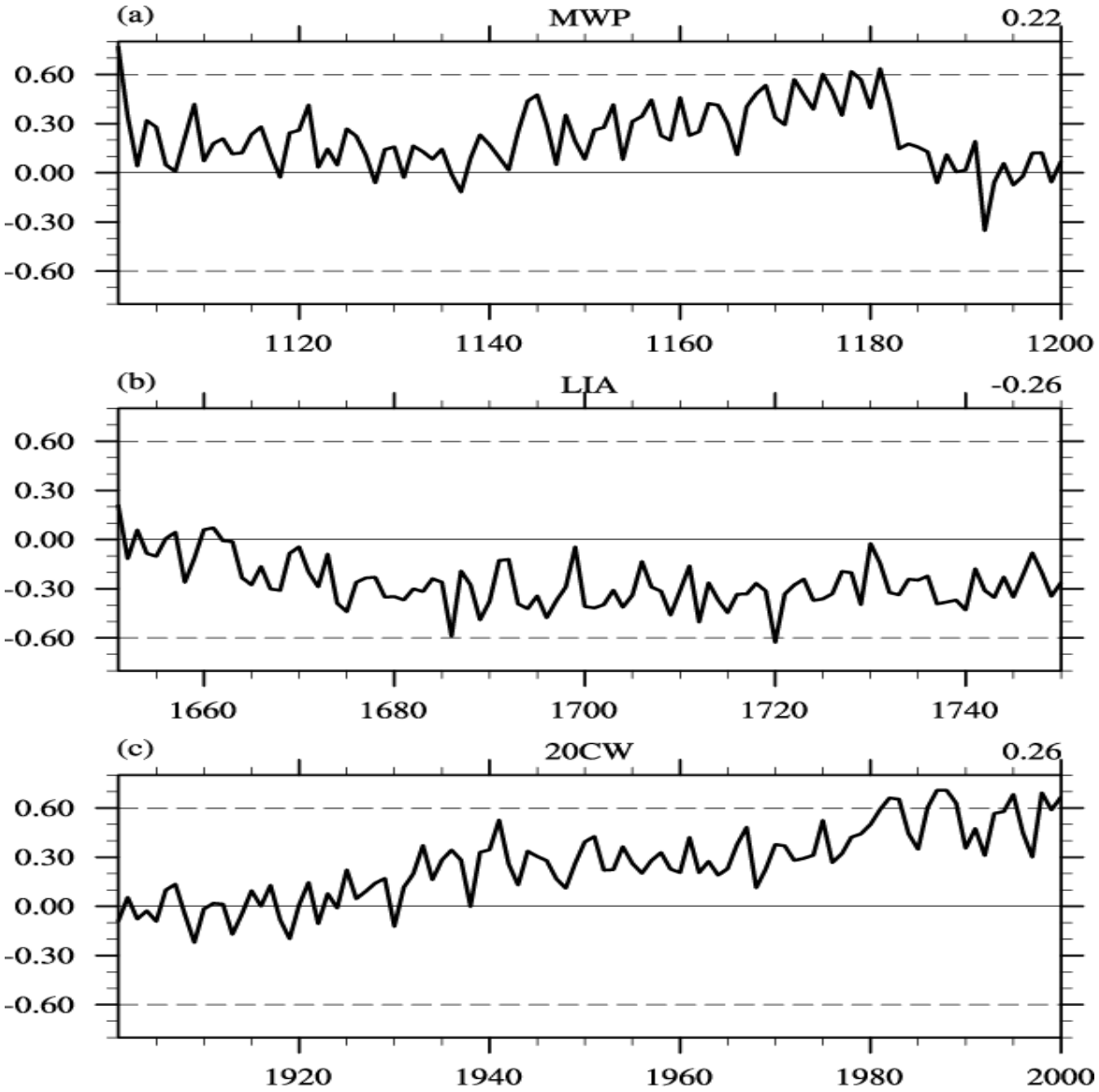
THANKS

http://www.lasg.ac.cn/staff/ztj/index_e.htm

SSTA between MWP and LIA



Global mean SAT anomaly in transient simulation (relative to 1860)

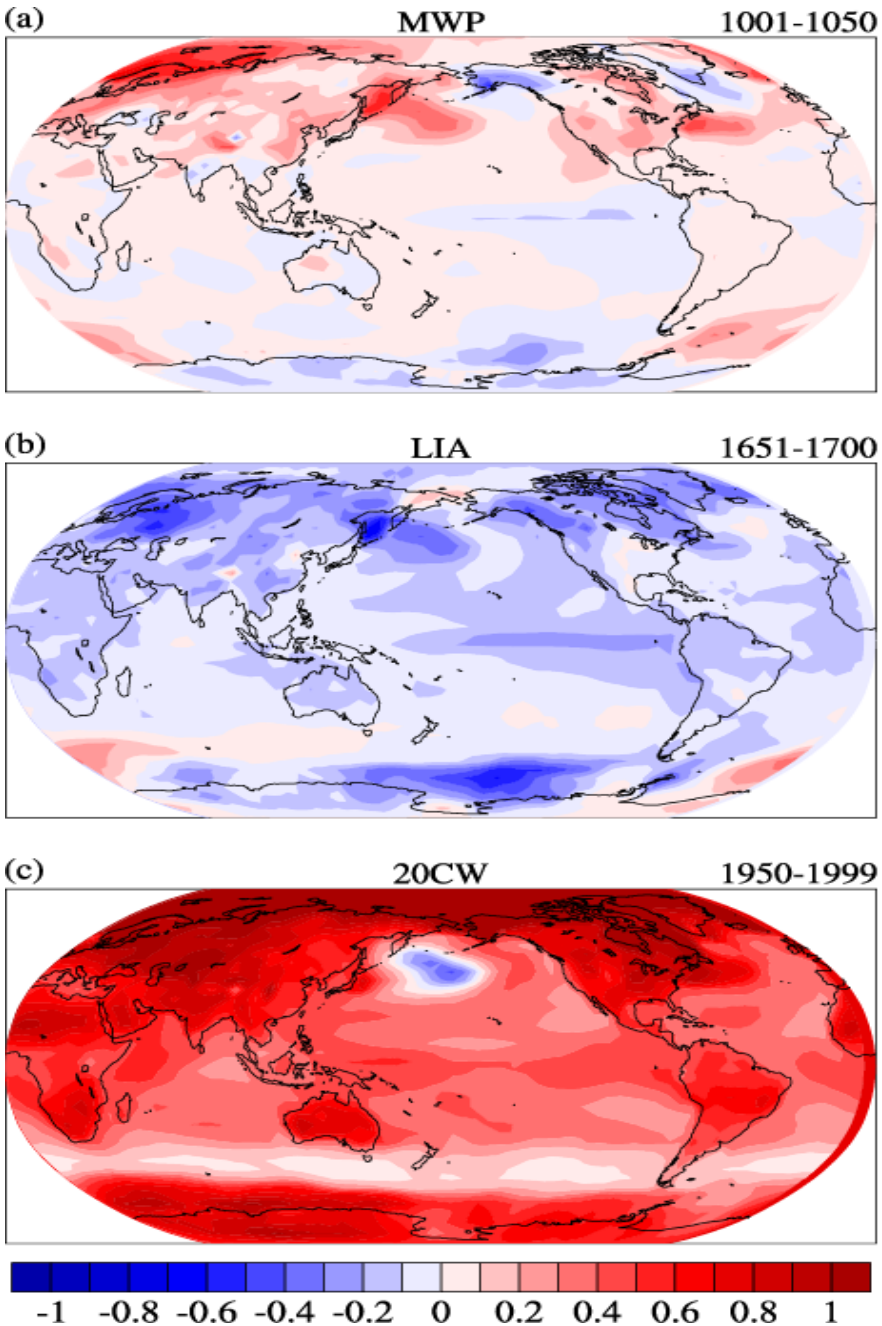


MWP

LIA

20C

Annual mean SAT

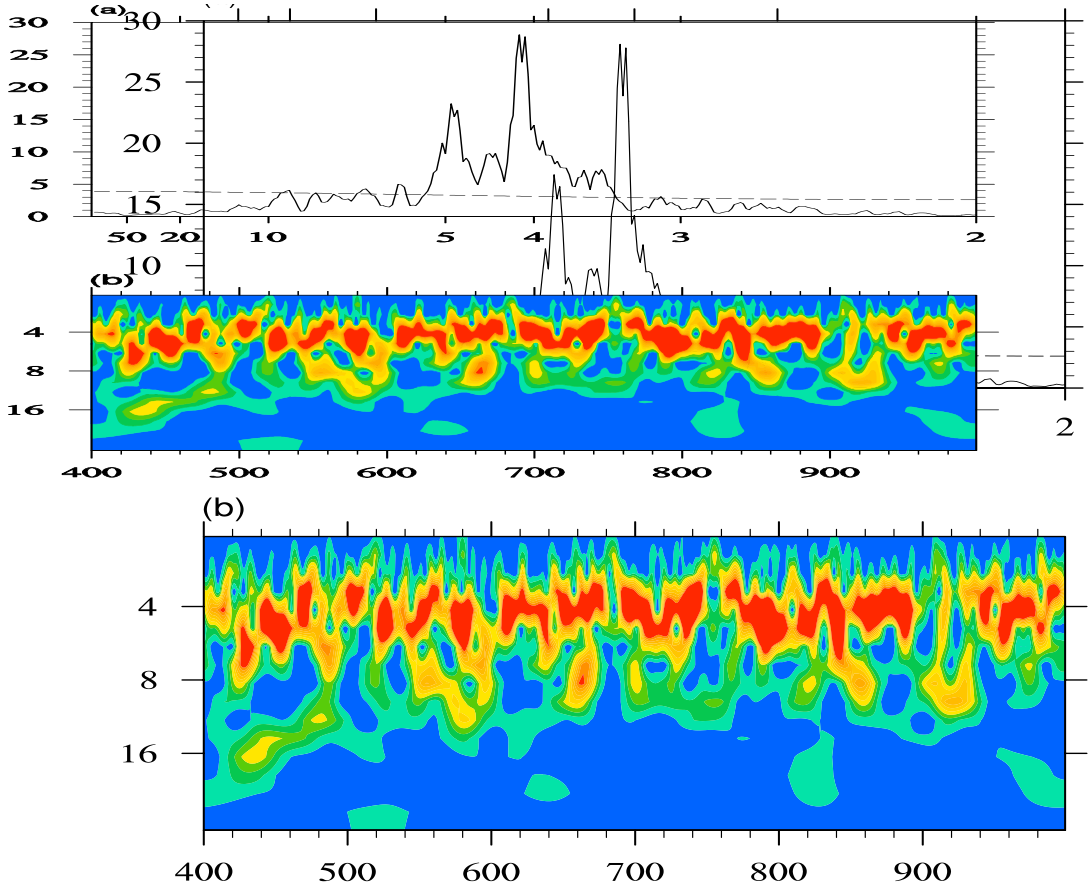


Stronger changes in high latitudes, in particular N. H.

The MWP warming s weaker then 20C.

A La Nino pattern is seen in E. Pac (Fig.a-b), in particular in LIA.

Spectral and Wavelet analysis of Nino-3.4 index time series



Double peaks are evident, as the observation.

Global Monsoon Domain

(Use precipitation or westerly)

$$GMPI = \frac{Annual\ range}{Total\ annual\ rainfall}$$

$$Annual\ range = MJJAS - NDJFM\ (NH)$$

$$or\ NDJFM - MJJAS\ (SH)$$

GM precipitation domain can be delineated by

Annual range exceeds 300 mm

AR exceeds 50% of the annual total

GM wind domain can be constructed by westerly by using similar formula and criteria.