Modeling land surface processes in Tibetan Plateau and their interactions with climate at continental scales

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and many other collaborators

2018 GEWEX Science Conference, Canmore, Alberta, Canada
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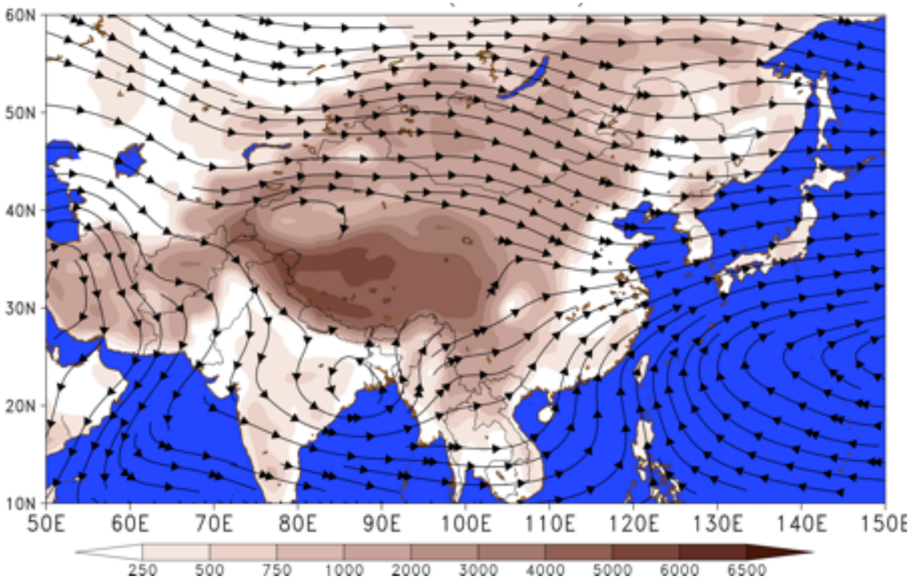
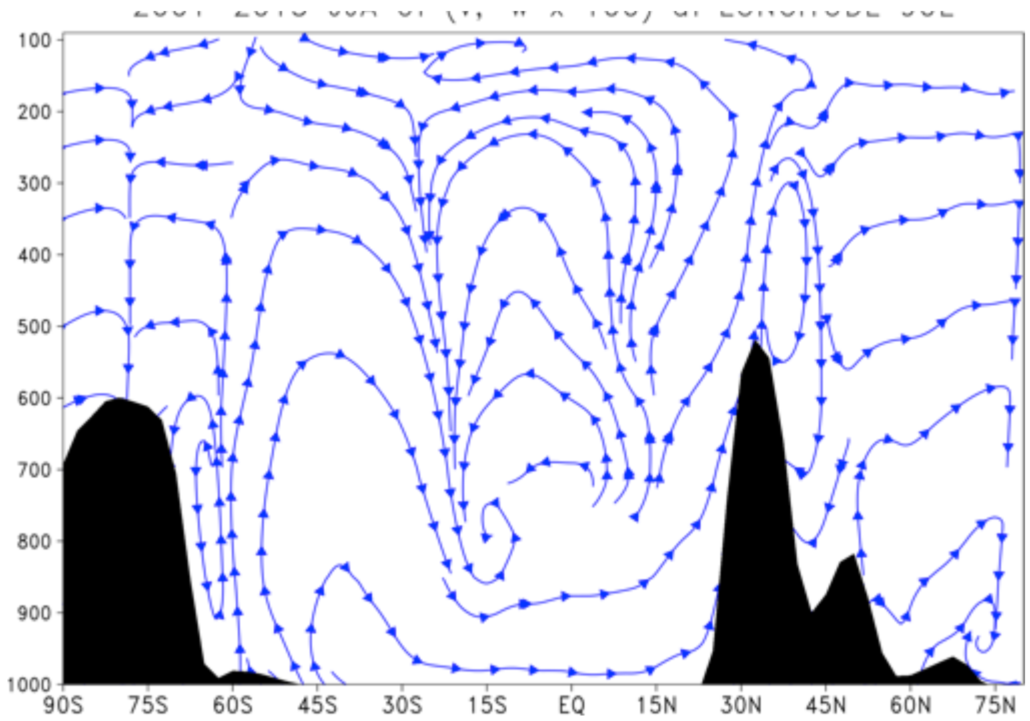
I). General Characteristics of Tibetan Climate and Future Projection



2001-2005 JJA Zonal Wind at 600 hPa

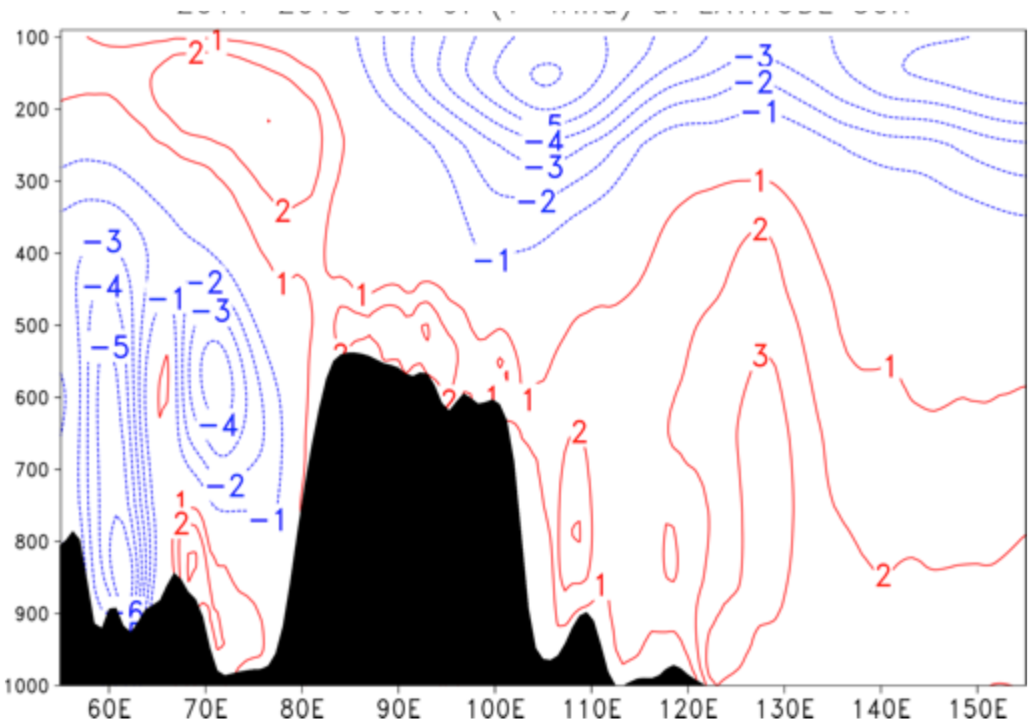
2001-2015 JJA (v – w x 100) at 90°E



South Pole

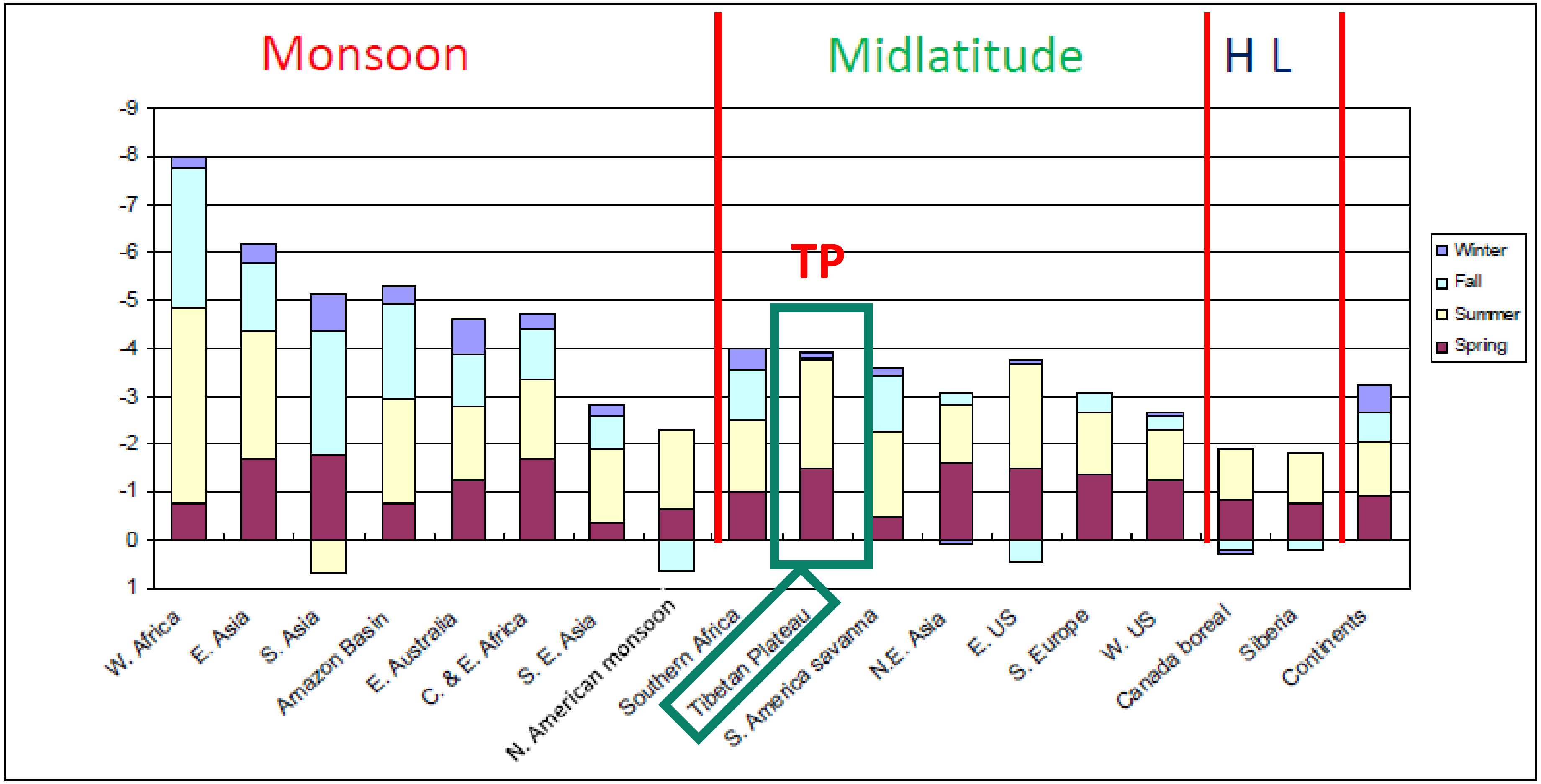
Tibetan Plateau

2001-2015 JJA of meridional wind at 30°N



Tibetan Plateau

Regions with strong land/atmosphere interaction



Red: spring; Yellow: Summer; Cyan: Fall; Light blue: Winter

Figure 8 The reduced absolute annual mean bias of precipitation (mm/day) simulations (or improved prediction accuracy) due to land processes in the GCM. Based on Xue et al. (2010, J. Climate)

2). Effects of Tibetan Plateau Land Surface/subsurface temperature and snow on the East, South, and Central Asian Climate

AGU100 ADVANCING EARTH AND SPACE SCIENCE

JGR

Journal of Geophysical Research: Atmospheres

RESEARCH ARTICLE

10.1029/2017JD028246

Spring Land Surface and Subsurface Temperature Anomalies and Subsequent Downstream Late Spring-Summer Droughts/Floods in North America and East Asia

Yongkang Xue[1,2], Ismaila Diallo[1], Wenkai Li[1,3,4], J. David Neelin[2], Peter C. Chu[5], Ratko Vasic[6,7], Weidong Guo[3,4], Qian Li[8], David A. Robinson[9], Yuejian Zhu[7], Congbin Fu[3,4], and Catalina M. Oaida[2]

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Key Points:
- Possible remote effects of large-scale land surface temperature in geographical areas upstream on droughts/floods have largely been ignored
- Observations show significant lagged correlation between spring surface temperature and downstream drought-flood in North America and East Asia
- North America and East Asian modeling studies show causal relationship between spring land temperature anomaly and downstream summer drought/flood

Supporting Information:
- Supporting Information S1

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Citation:
Xue, Y., Diallo, I., Li, W., David Neelin, J., Chu, P. C., Vasic, R., et al. (2018). Spring land surface and subsurface temperature anomalies and subsequent downstream late spring-summer droughts/floods in North America and East Asia. *Journal of Geophysical Research: Atmospheres, 123*. https://doi.org/10.1029/2017JD028246

Received 28 DEC 2017

Abstract Sea surface temperature (SST) variabilit
precipitation, although SSTs are unable to fully predi
The possible remote effects of large-scale land surface
anomalies in geographical areas upstream and closer
ignored. Here evidence from climate observations and
of observational data using Maximum Covariance An
springtime 2-m air temperature (T2 m) cold (warm) a
Plateau and downstream drought (flood) events in la
findings, climate models are used in sensitivity studie
produce observed T2 m anomaly, to demonstrate a c
spring warm T2 m/LST/SUBT anomalies in western U.
Plains and adjacent regions and between spring cold
the severe 2003 drought south of the Yangtze River r
America are associated with a large-scale atmospheri
LST/SUBT anomaly region. The effects of SST in these

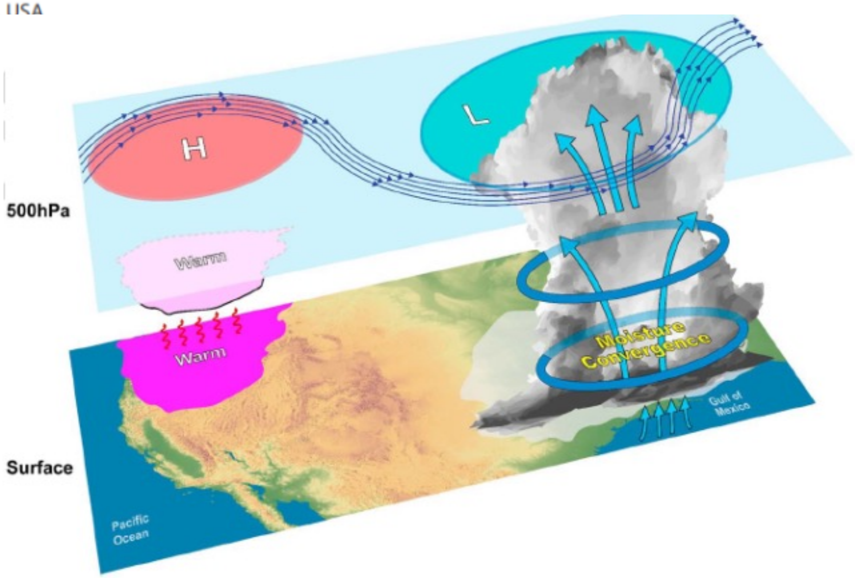
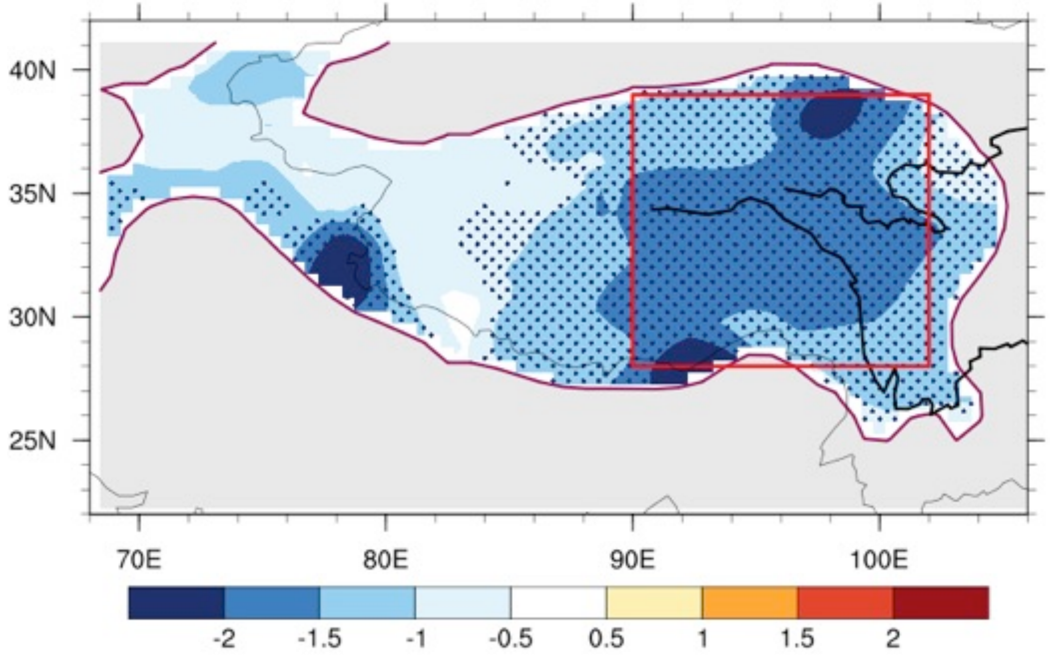


Figure 13. Schematic diagram describing the processes associated with the impact of LST and SUBT anomalies affecting downstream precipitation.

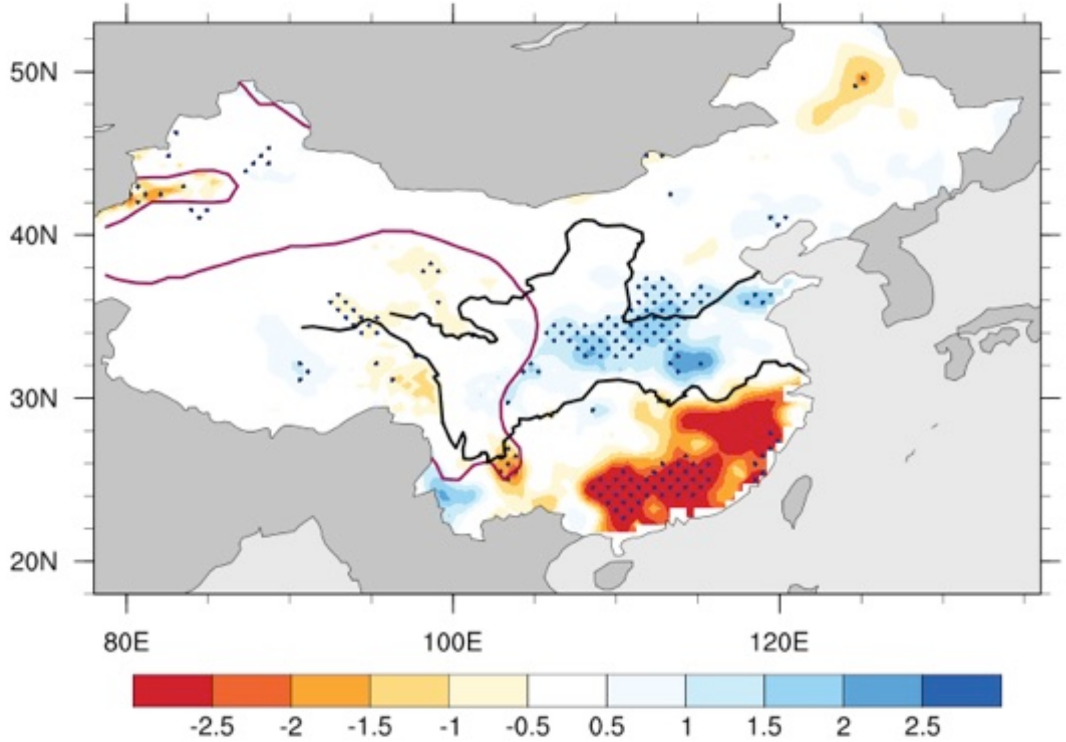
Journal of Geophysical Research: Atmospheres, 123. https://doi.org/10.1029/2017JD028246

Observed May land surface temperature (LST) difference (K) and June precipitation difference (mm day^{-1}) between coldest and warmest years (based on Tibetan Plateau LST)

Obs. **May Temp**. Difference



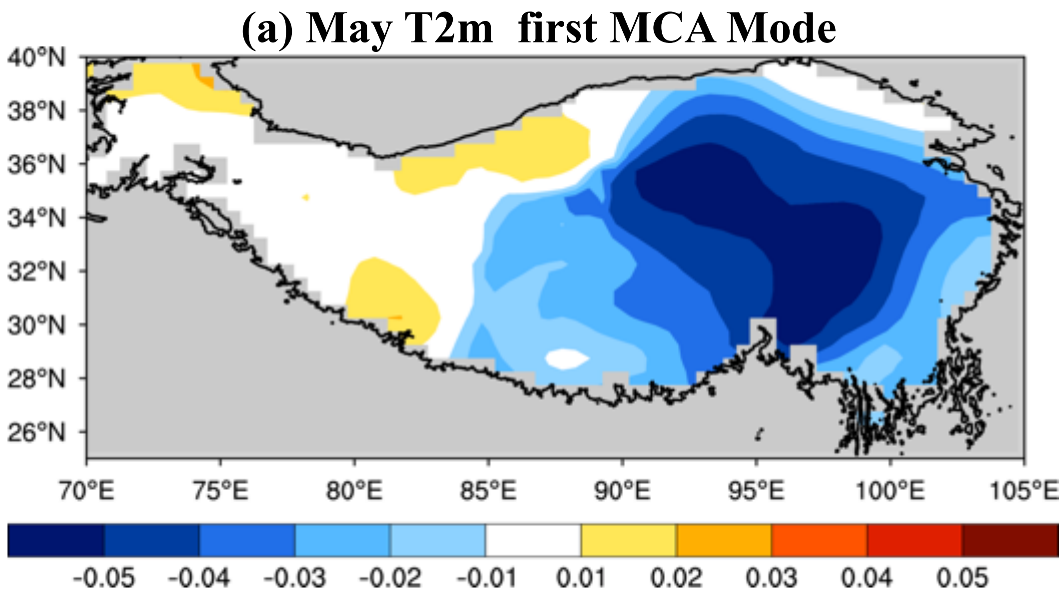
Obs. **June Precip**. Difference

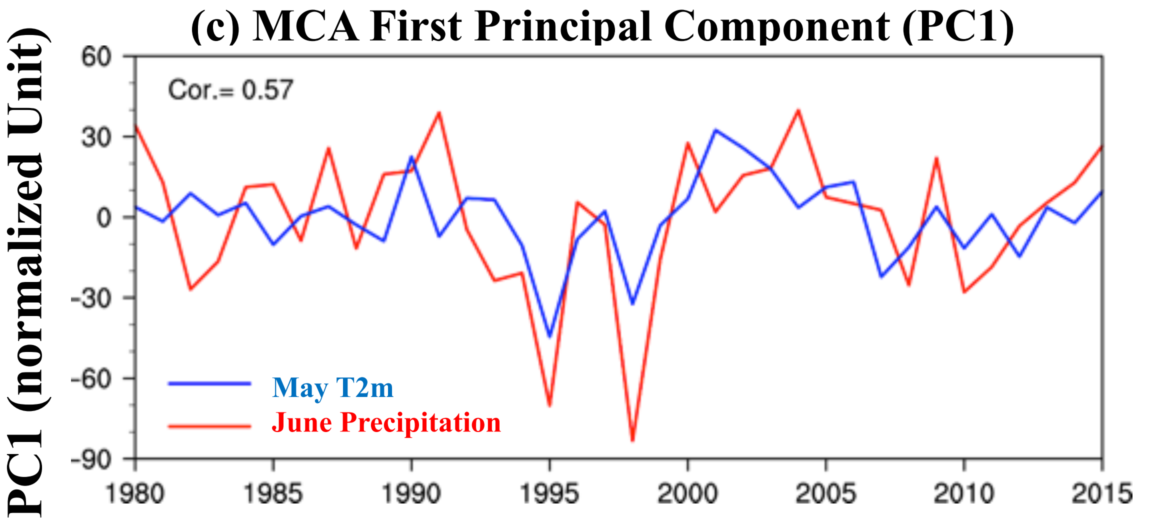


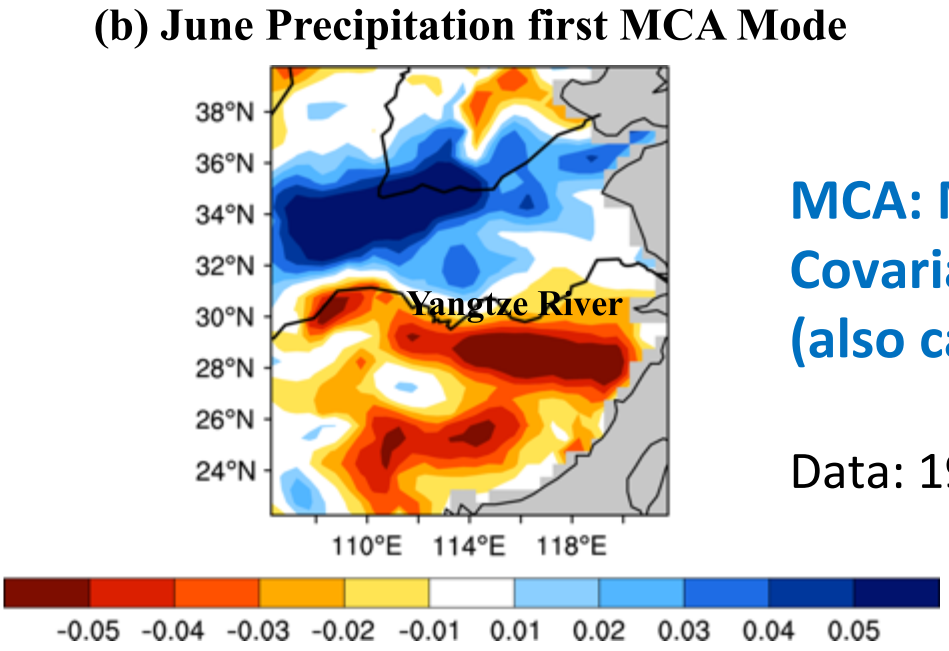
The years with temperature anomalies larger than 0.5 Standard Dev. over 90E-102E and 28N-39N

Warm: 1994, 1995, 1998, 2007, 2008, 2009, 2010, 2011,2012

Cold: 1980, 1982, 1984, 1987, 1990, 1992, 1993, 2001, 2002, 2003







MCA: Maximum Covariance Analysis, (also called SVD analysis)

Data: 1980-2015

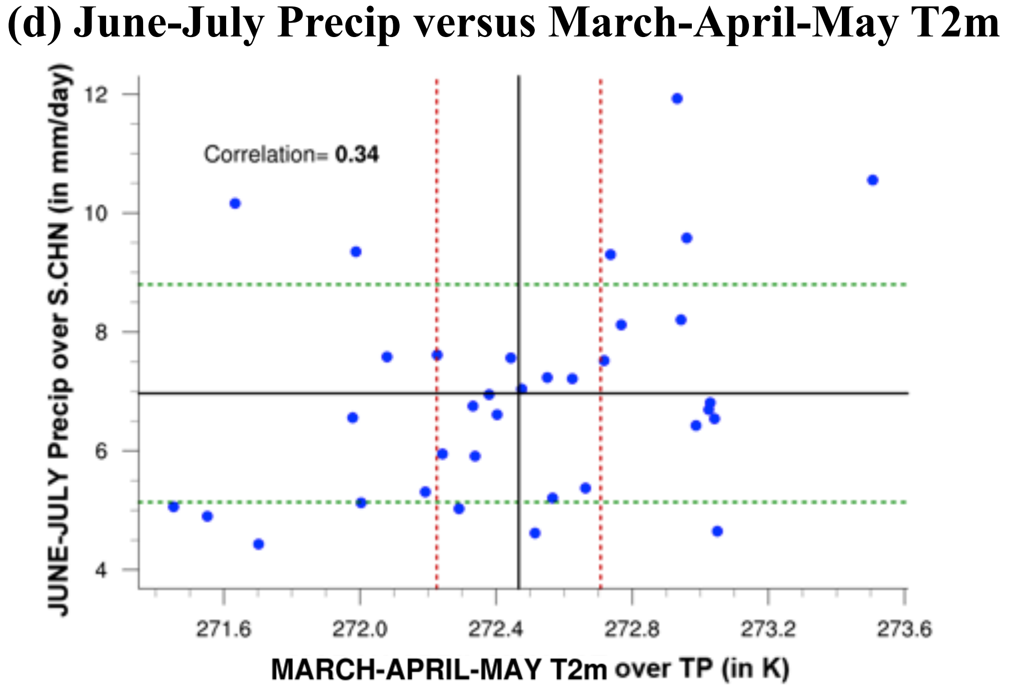


Figure 2. MCA over East Asia. (**a**) and (**b**) Spatial patterns of MCA1 for May T2m over Tibetan Plateau and June precipitation over East Asia, respectively. (**c**) PC1 of MCA during 1980-2015 for May T2m (blue line) and June precipitation (red line). (**d**) Scatter plots of March-April-May T2m (in K) over Tibetan Plateau (28–37ºN, 92–102ºE) and June-July precipitation (in mm/day) over Yangtze River region (29–32ºN, 112–121ºE). In (**d**), black lines indicate means; green (red) dashed lines denote +/−1 (+/−0.5) standard deviation boundaries for precipitation (T2m). (a), (b) & (c) are expressed in normalized unit.

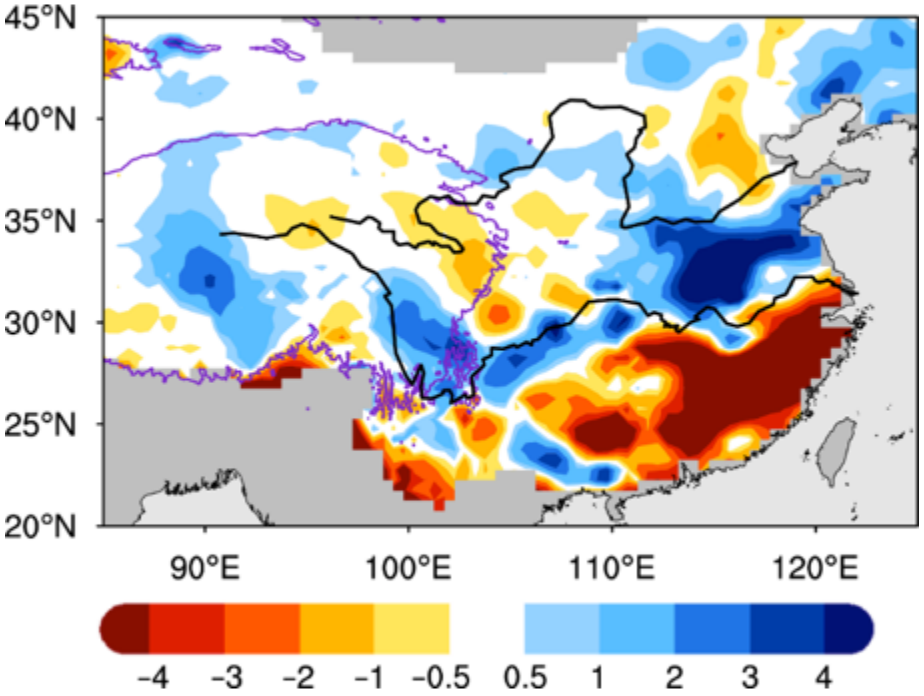
2003 Case Study

TABLE 2. Drought years over East Asia from 1900 to 2010. The events from 1900 to 2006 were obtained from the appendix table of Zhang et al. (2009).

Year(s)	Region	Impacts
2003	Drought over the south of the Yangtze River and south China in autumn	Resulted in 100×10^6 kg crop yield losses and CNY 5.8 billion economic losses.

The dry and cracked river bed in 2003 in Hangzhou, East China's Zhejiang Province. [newsphoto.com.cn]
The drought, which started in June and intensified in July, is the worst in the last three decades (China Daily 2003-08-14)

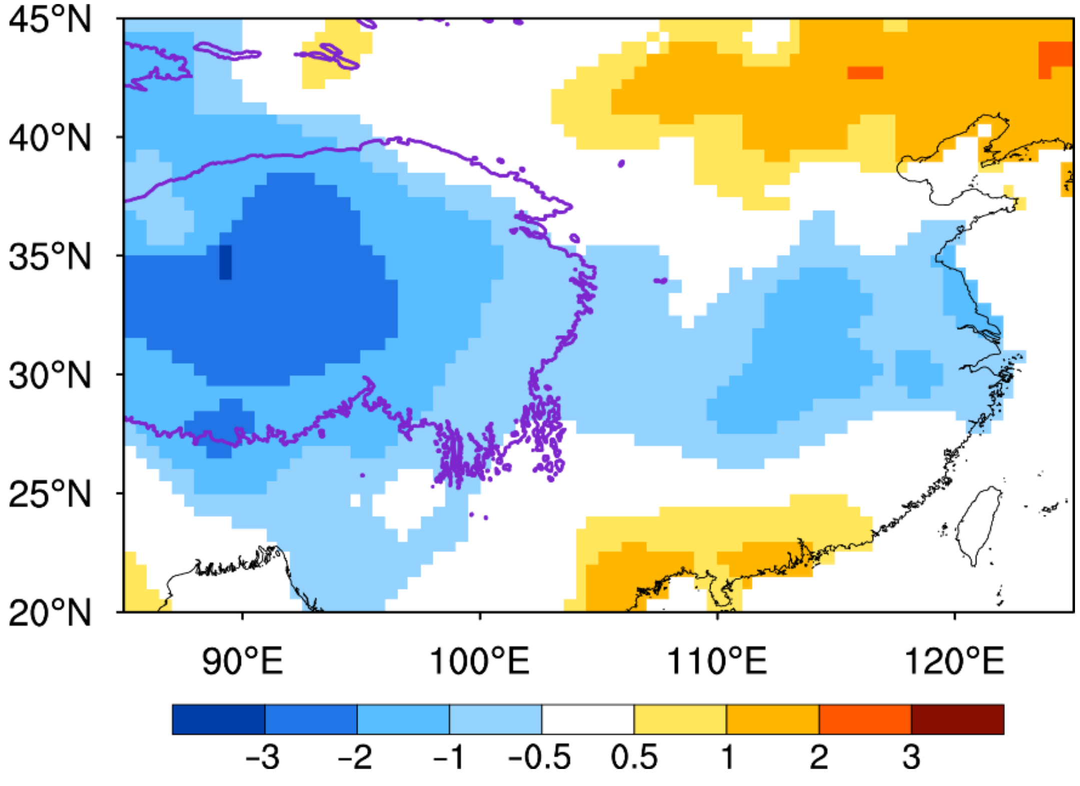
June 2003 Precipitation Anomaly



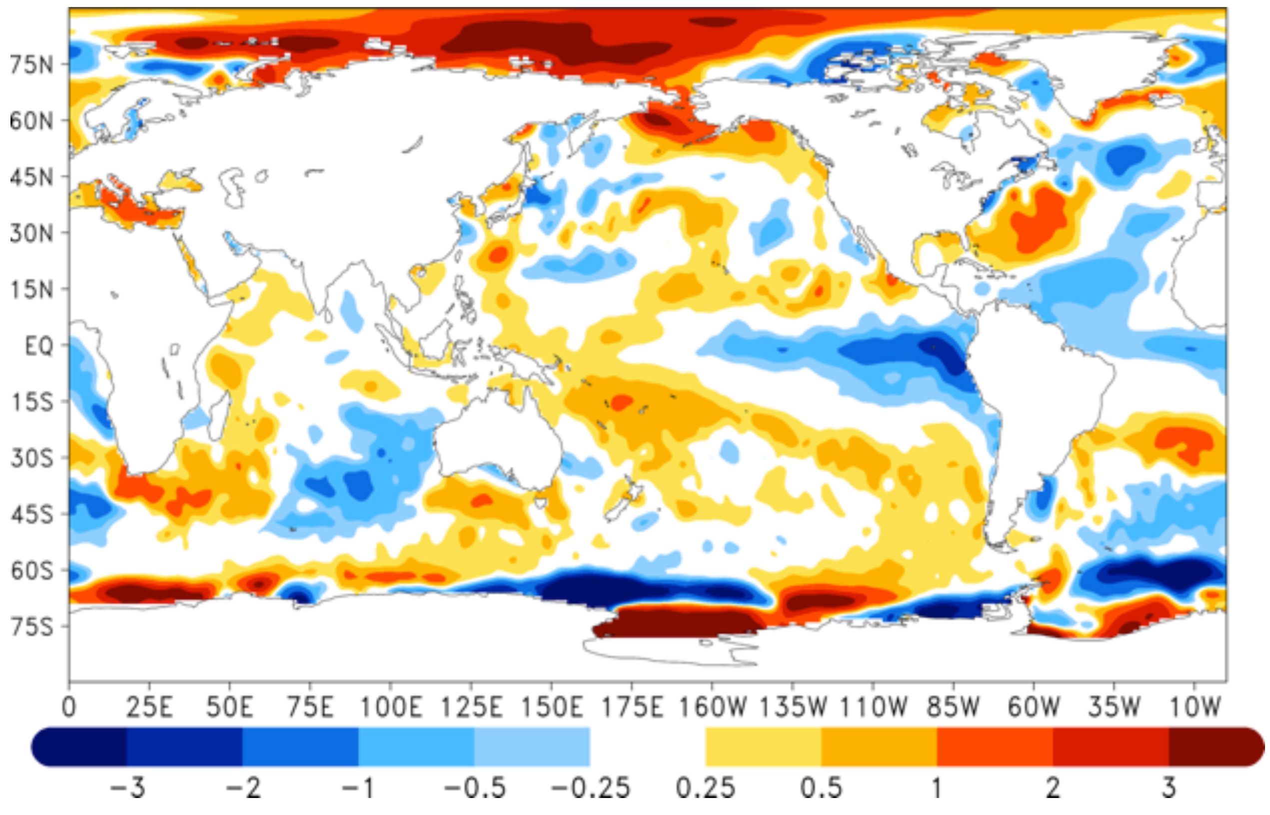
A view of the swollen Yangzi river in Nanjing, on July 18, 2003,

Observed land surface temperature (LST) and SST anomalies

May 2003 LST Anomaly

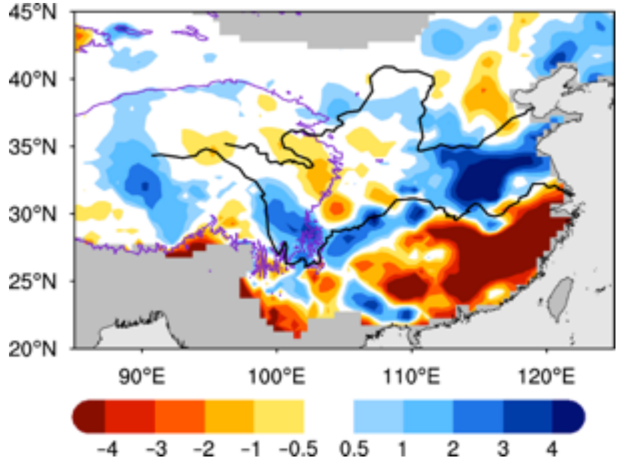


May 2003 SST Anomaly

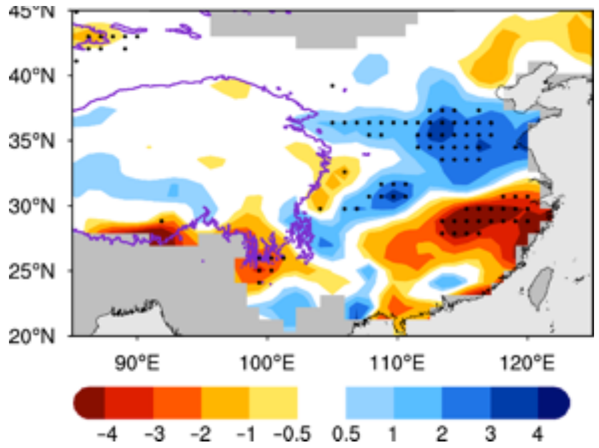


A

Obs. June 2003 Precip. anomaly

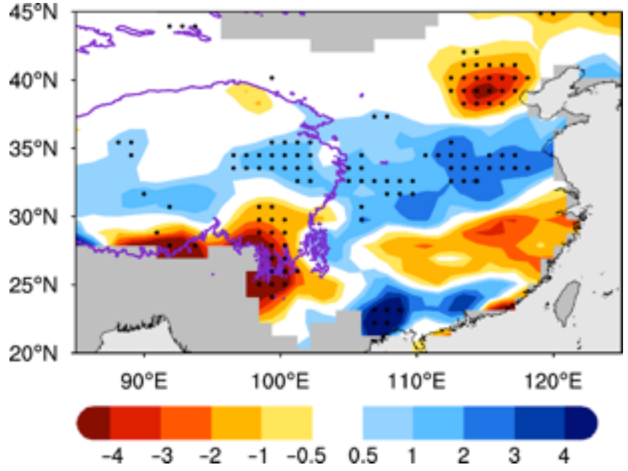


GCM(GFS)-Simulated June 2003 Precip. Diff due to LST & SUBT Effect



Impose initial LST &SUBT anomalies At FIRST time step

GCM(GFS)-Simulated June 2003 Precip. Diff due to SST Effect



Impose obs SST anomaly every time step

LST: Land surface temperature; SUBT: Subsurface temperature

The stippled areas denote statistical significance at the α <0.1 level of t-test values. The gray shaded areas indicate no observational data. Unit: mm/day

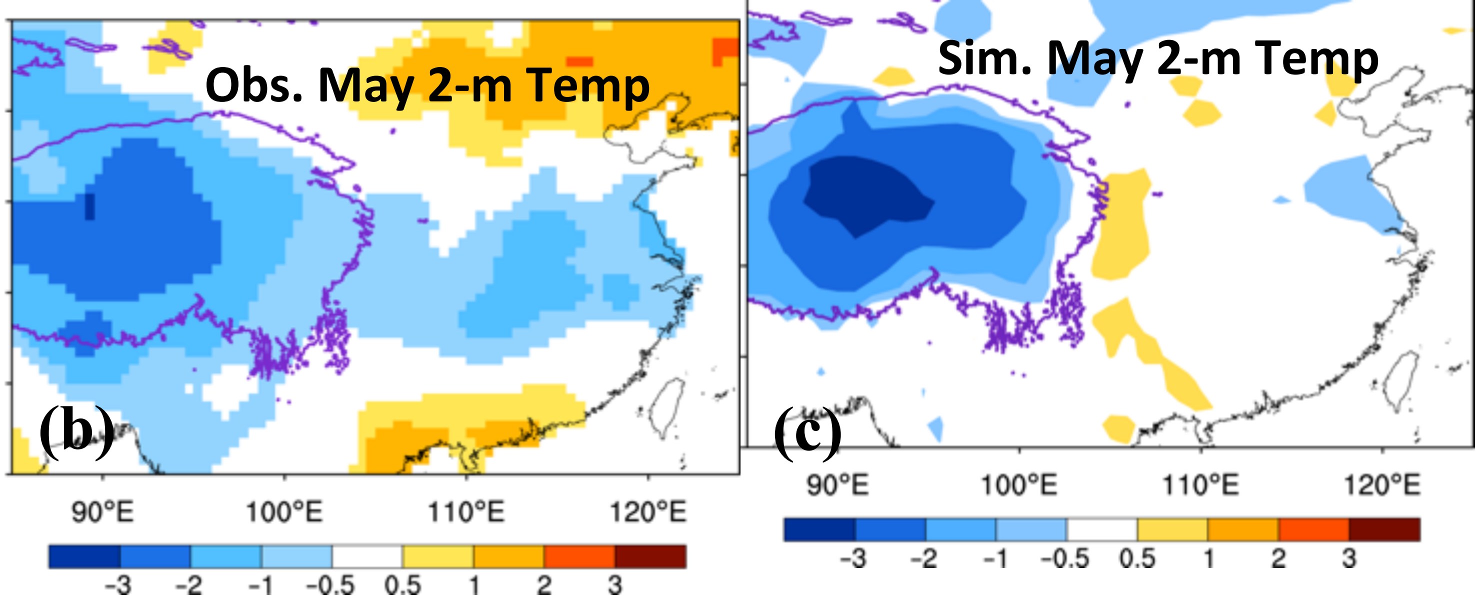
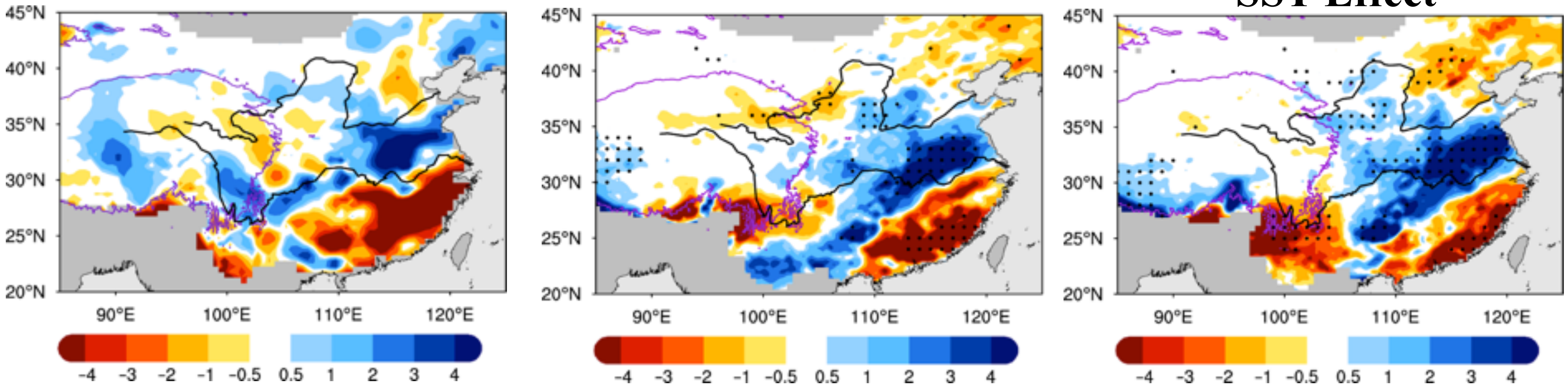


Figure 7. (**a**) Imposed sub-surface temperature (SUBT) difference over Tibetan Plateau at the first time step of the model simulation between Case 2003_EA and Case noSUBT_EA. (**b**) Observed May 2m-temperature (T2m) anomaly between 2003 and the reference. (**c**) GFS-simulated May T2m difference between Case 2003_EA and Case noSUBT_EA.

Obs. June 2003 Precip. anomaly

WRF-Simulated June 2003 Precip. Diff due to LST & SUBT Effect

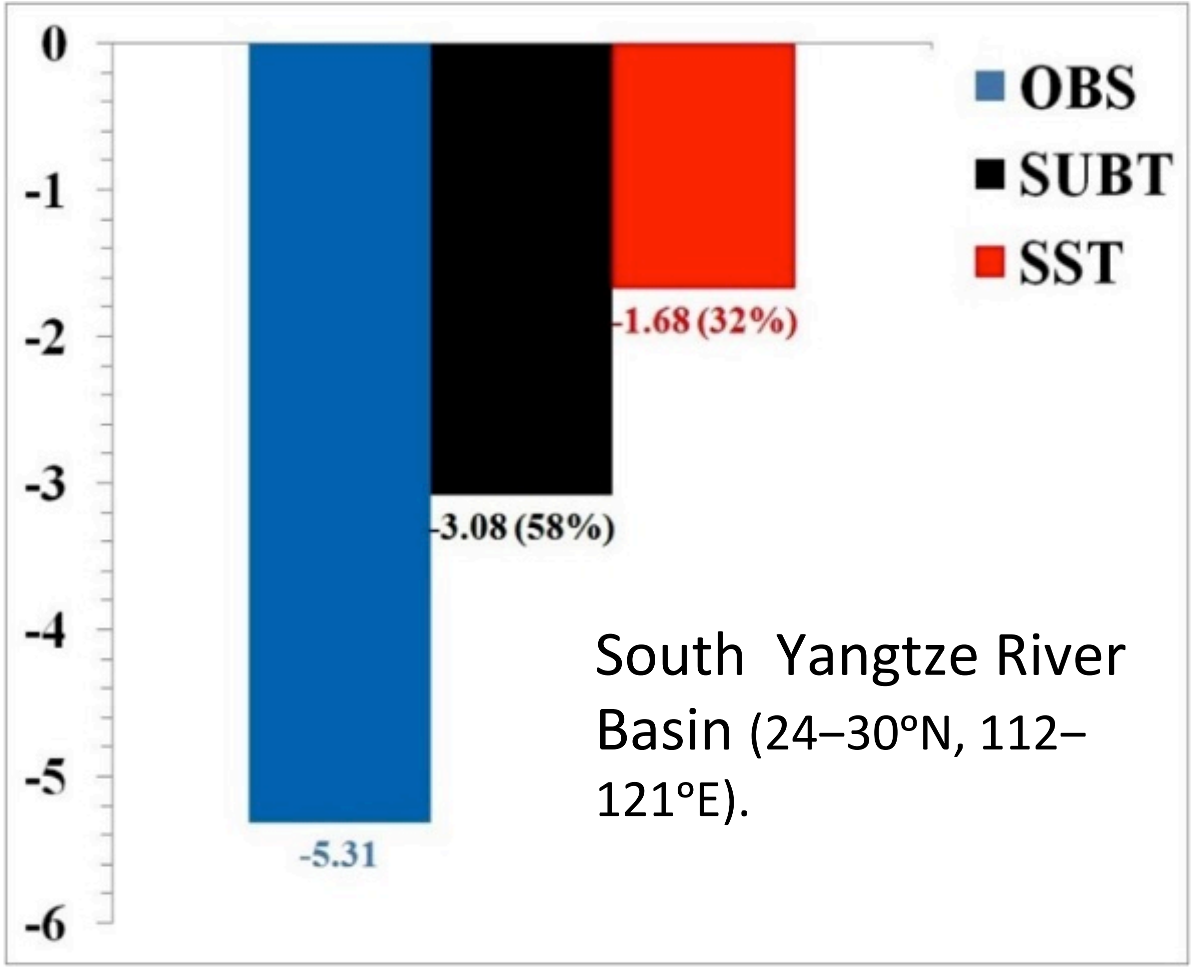
WRF-Simulated June 2003 Precip. Diff due to SST Effect

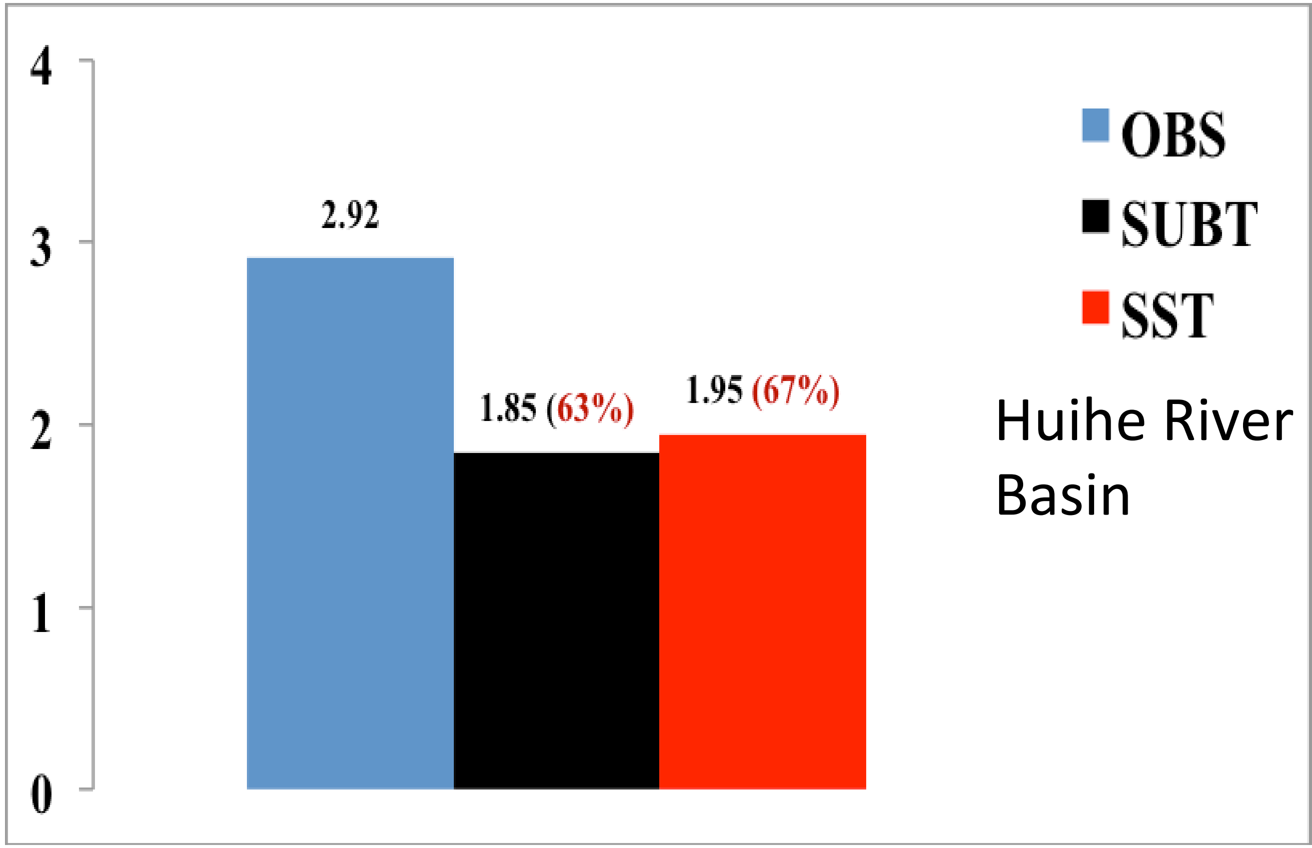


Using the Corresponding GCM outputs as lateral Boundary conditions

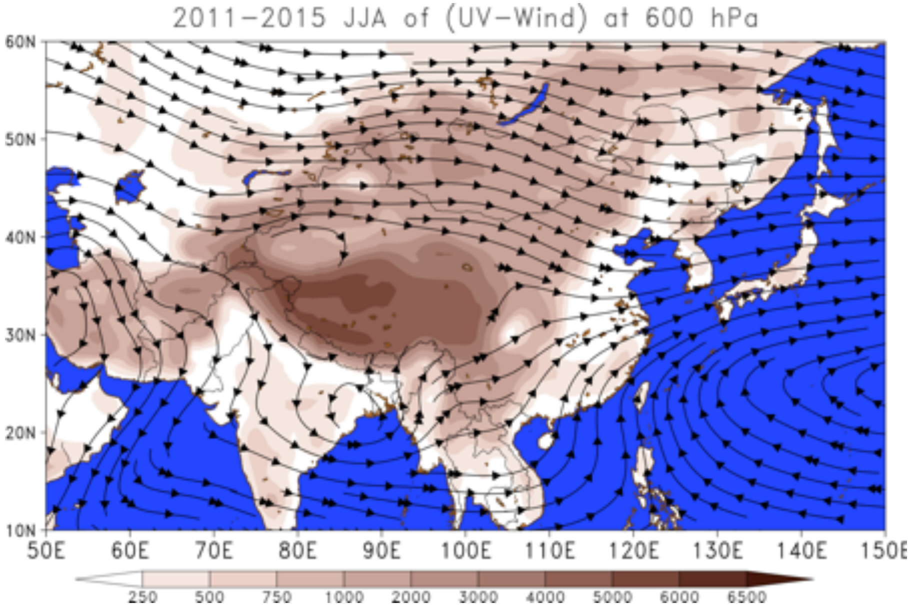
The stippled areas denote statistical significance at the α <0.1 level of t-test values. The gray shaded areas indicate no observational data. Unit: mm/day

Area-Averaged Obs. and Simulated Precipitation (mm/day) Difference





This relationship has been found beyond East Asia



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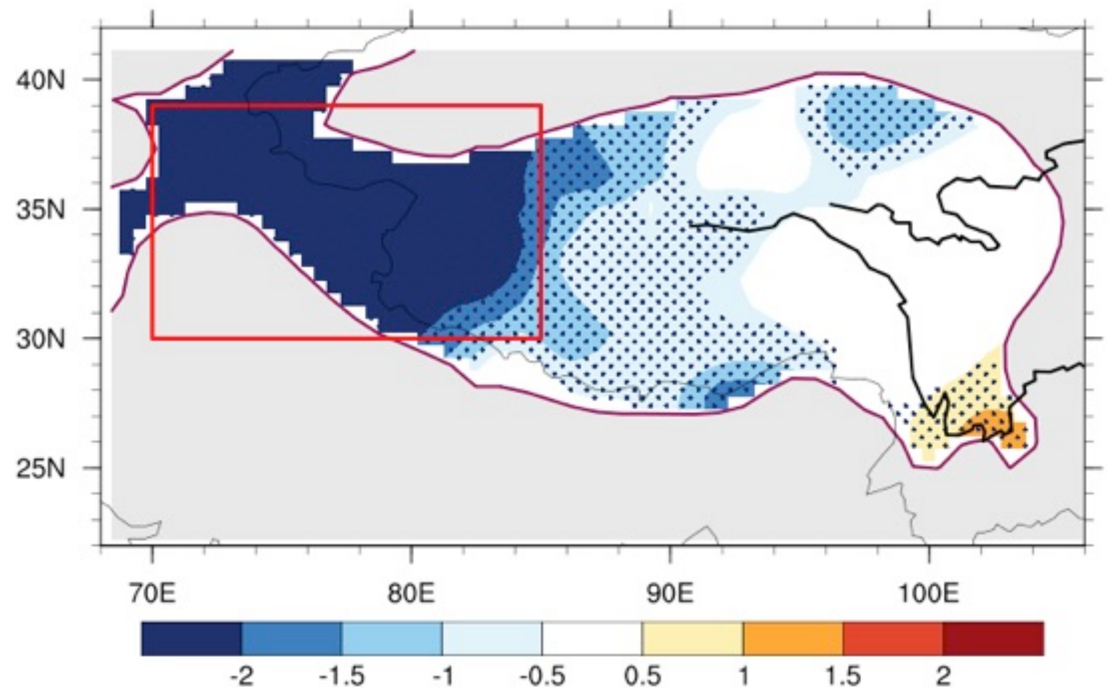
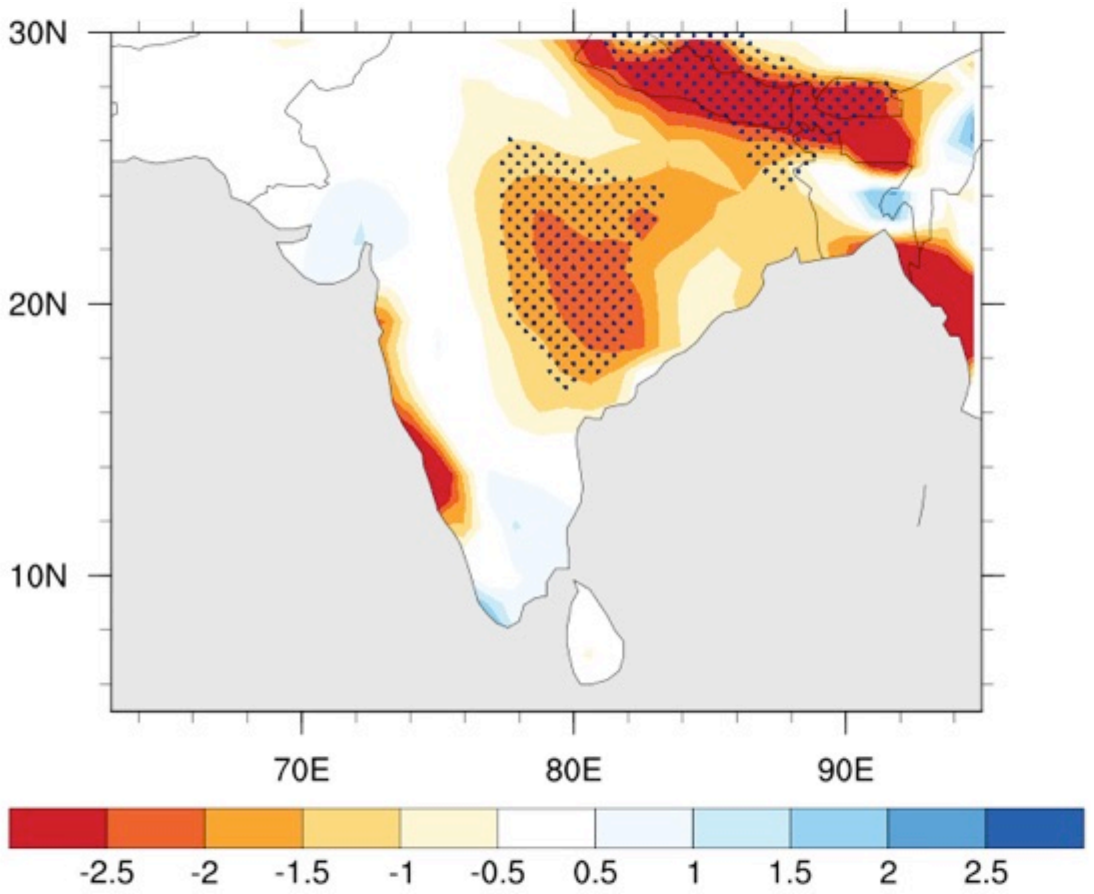


Obs. June Precip. Difference



The years with temperature anomalies larger than 0.5 Standard Dev. over 70E-85E and 30N-39N

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Cold: 1982, 1983, 1985, 1986, 1987, 1989, 1991, 1992, 1993, 1996, 1997, 2003, 2005

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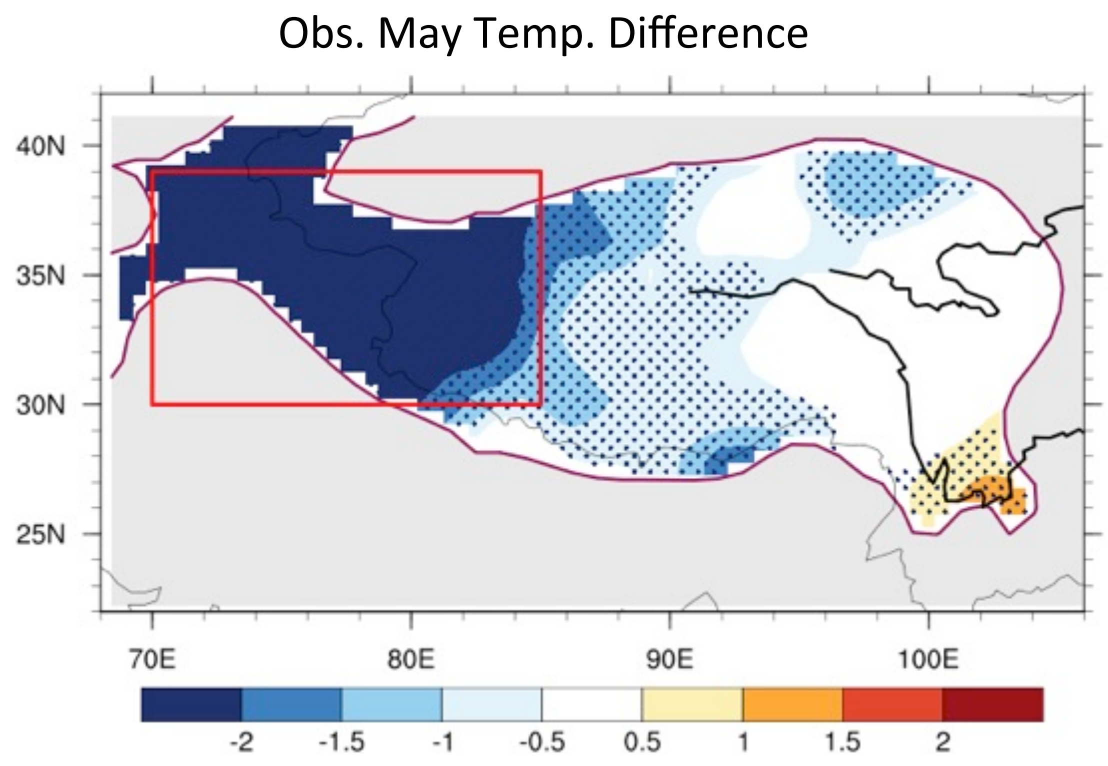

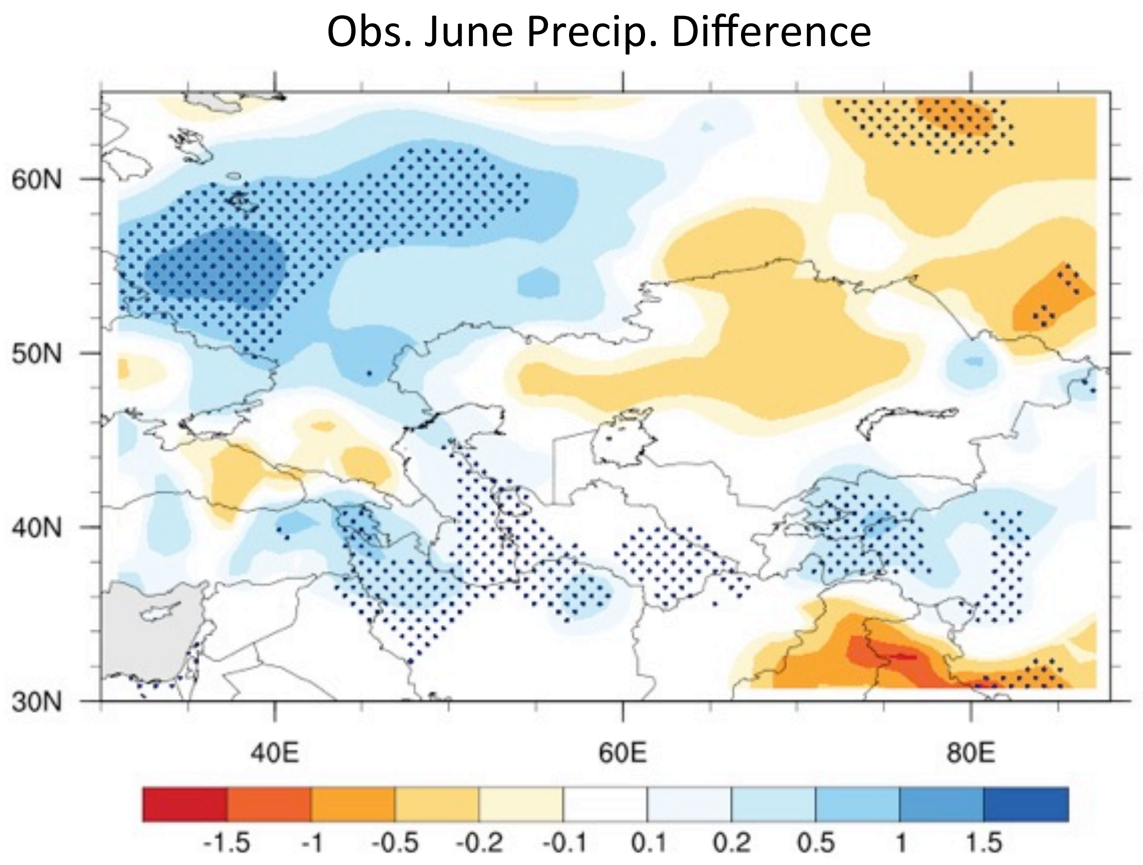

The years with temperature anomalies larger than 0.5 Standard Dev. over 70E-85E and 30N-39N

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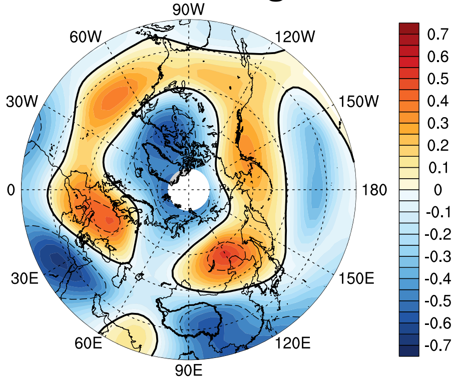
Cold: 1982, 1983, 1985, 1986, 1987, 1989, 1991, 1992, 1993, 1996, 1997, 2003, 2005

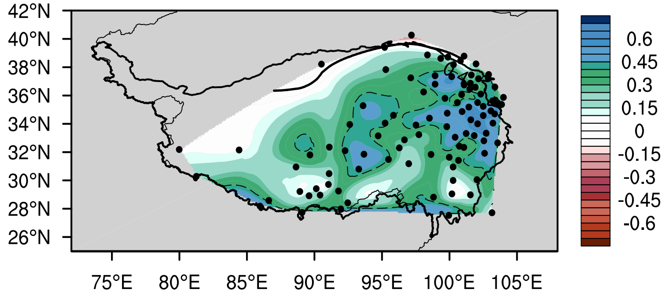
Winter circulation and Tibet snow days

Tibet snow days and spring soil temp.

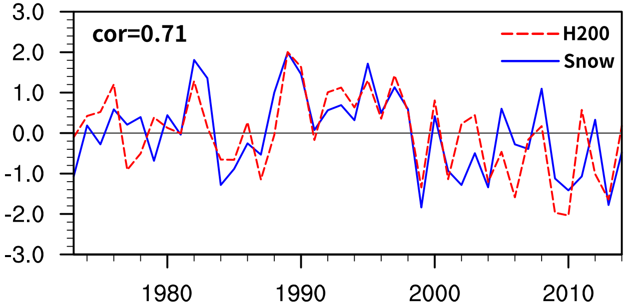
(a) Feb. 200 hPa Geo. Height First MCA Mode



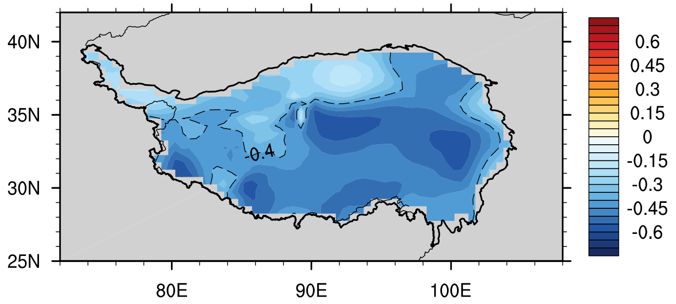
(b) FMA Snow Days First MCA Mode



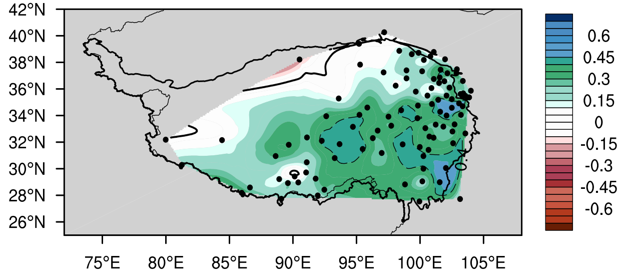
(c) MCA first Principal Component (PC1)



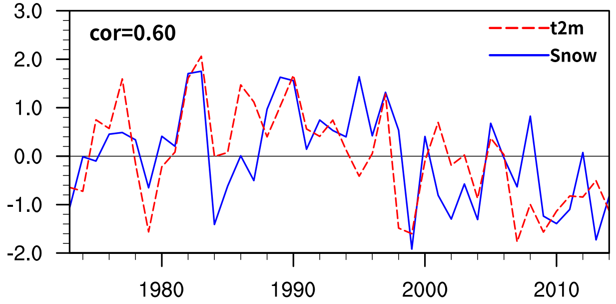
(d) AM 2-m Temp. First MCA Mode



(e) FMA Snow Days First MCA Mode

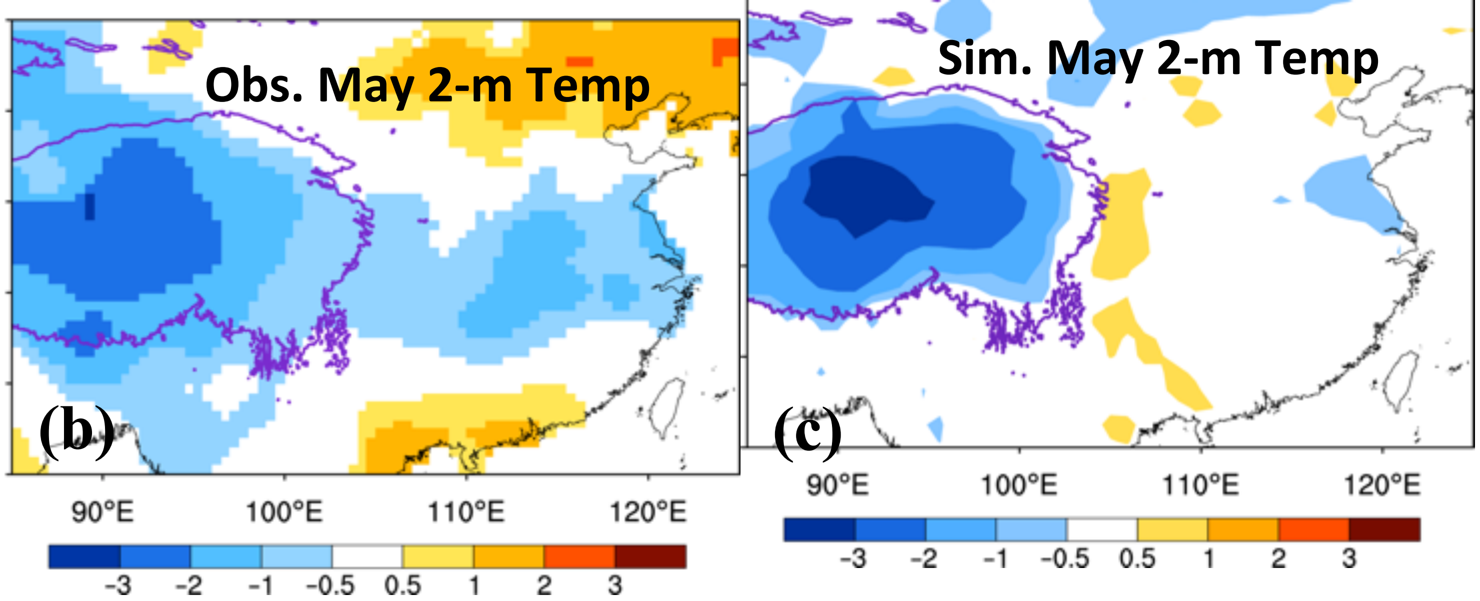


(f) MCA first Principal Component (PC1)



Yang Zhang and Zou Tao (2018)

2). Significant deficiencies of current land surface modeling and land data (Discovered based on Tibetan Plateau Measurement)



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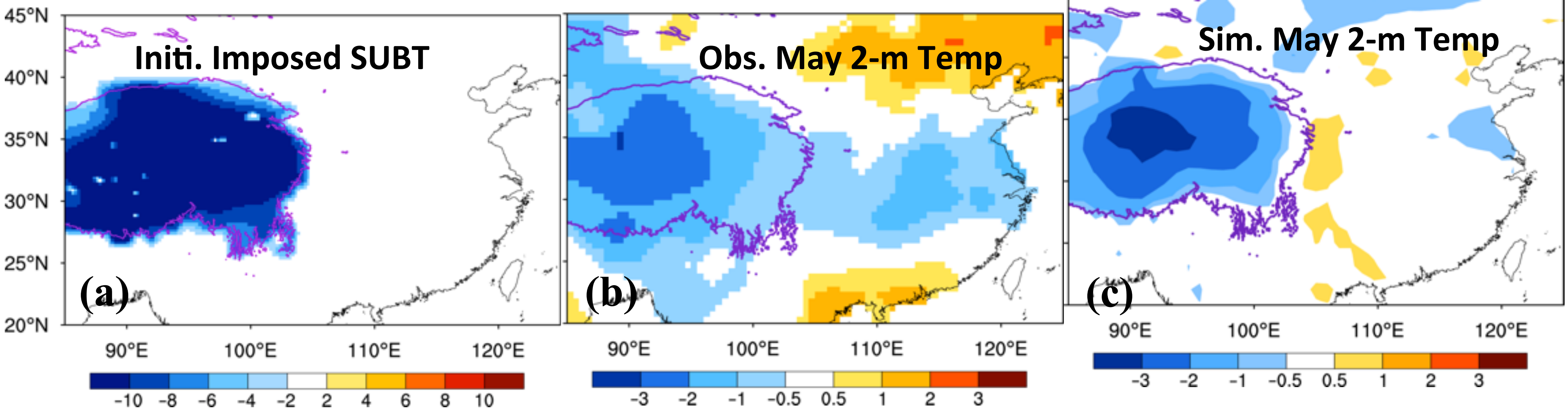

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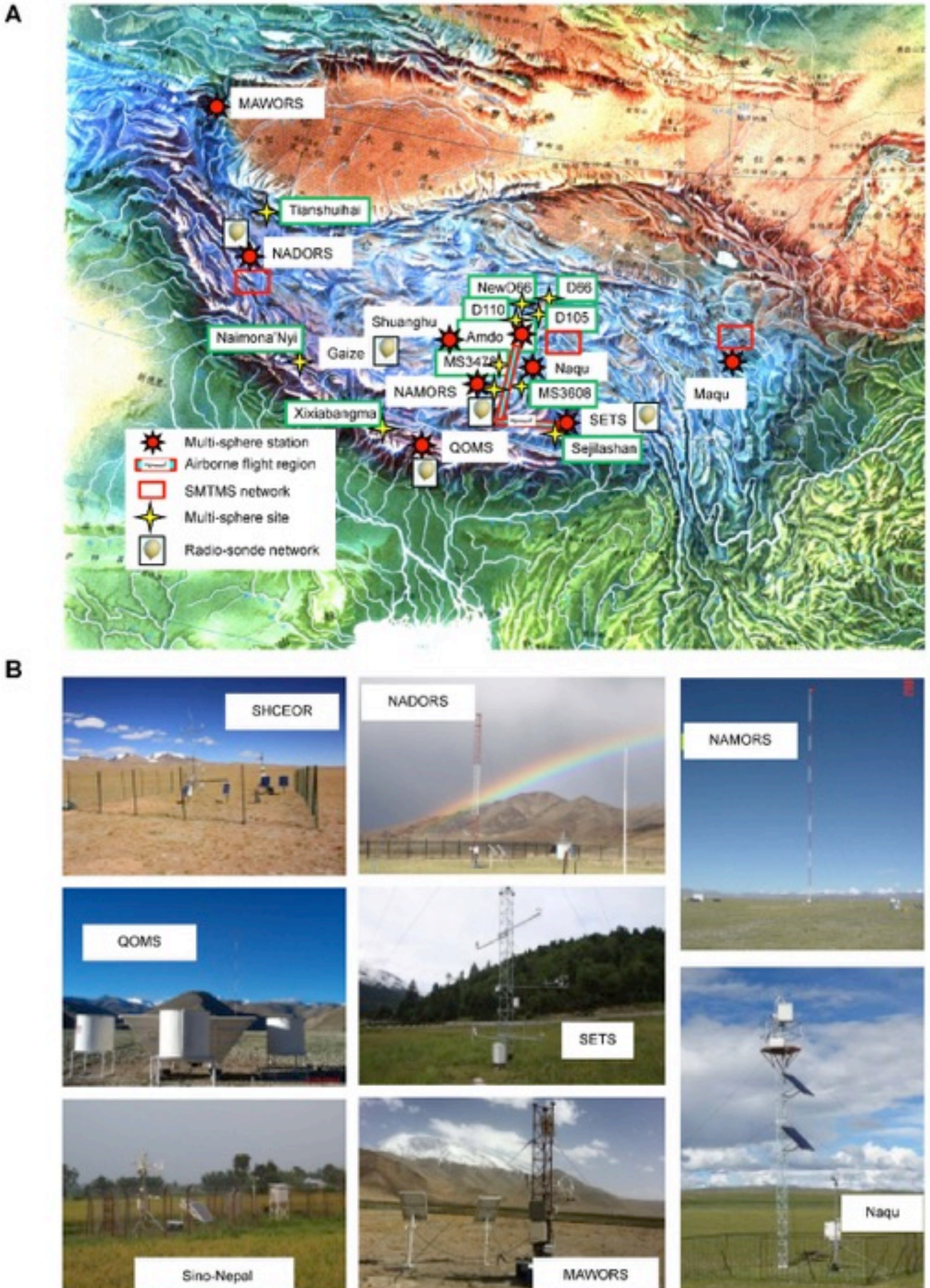
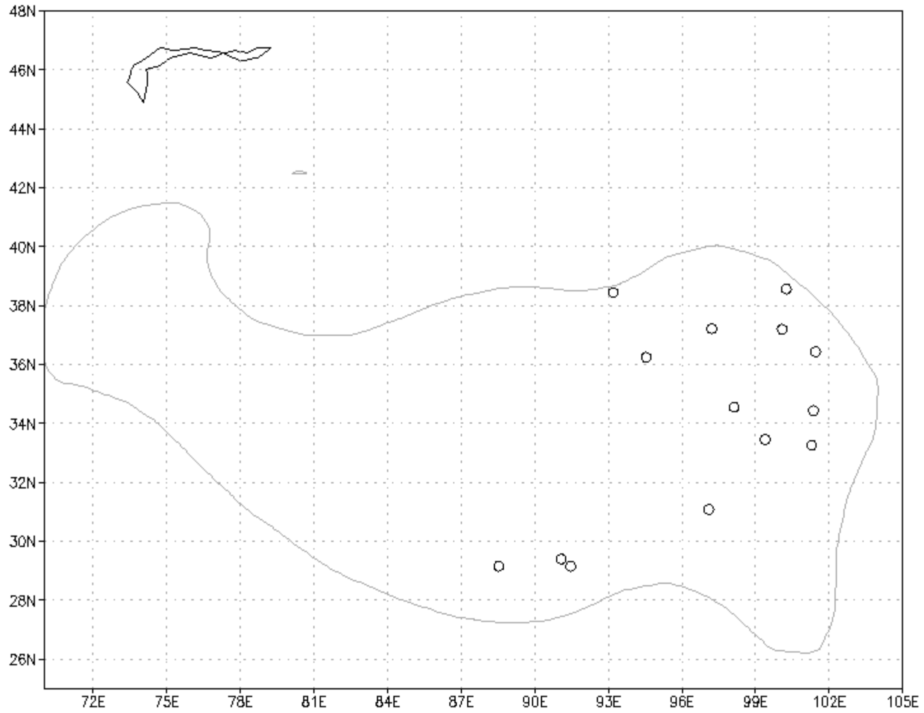
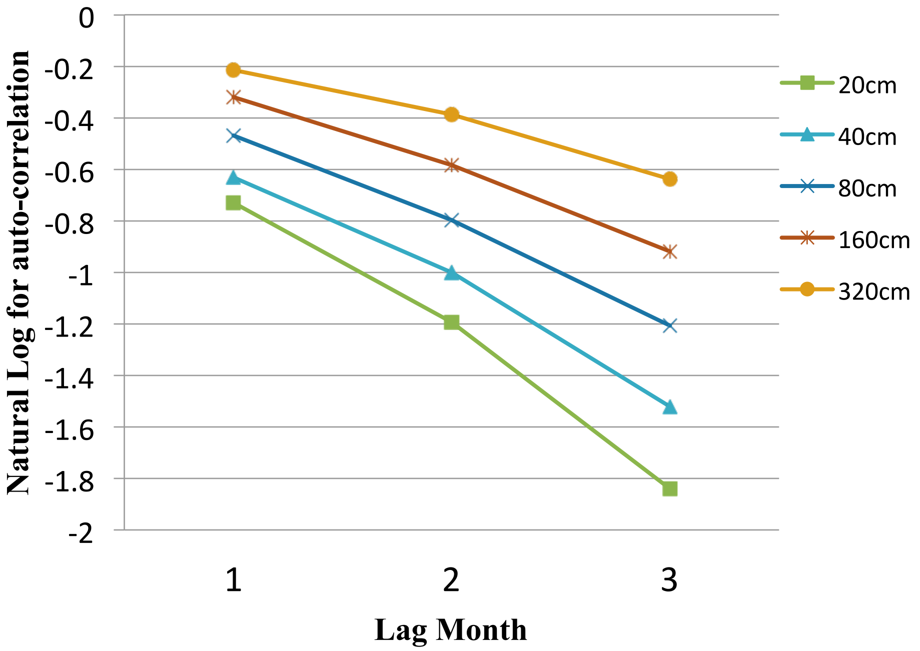


The spatial distribution of major stations of water-cryosphere-atmosphere-biology interactions over the TP; (b) the typical observation instruments for different land covers.

Observed sites (14) over TP and the soil memory

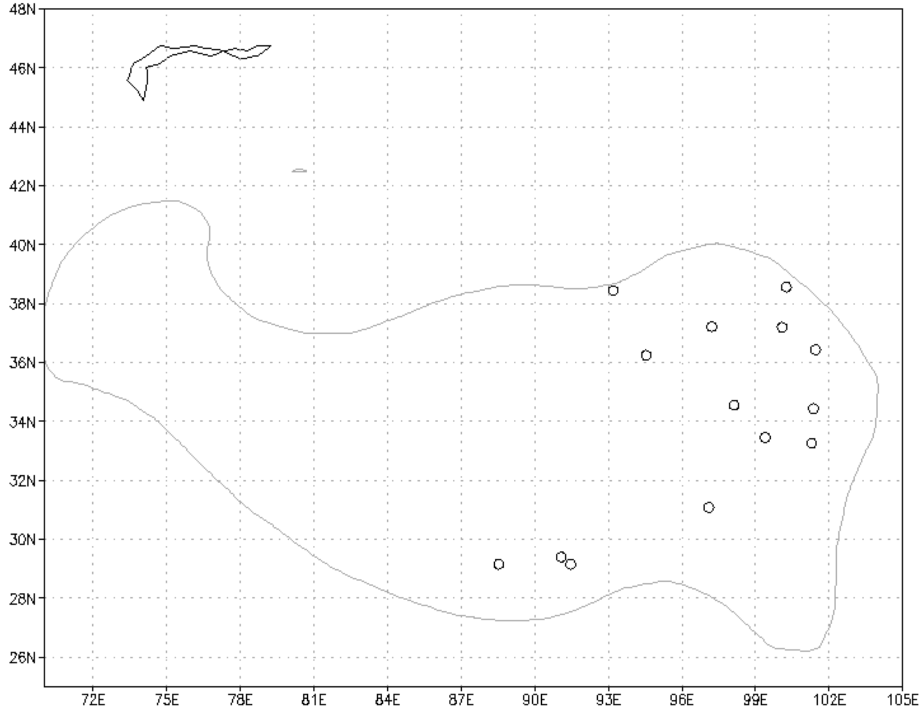




	Persistence
15cm	1.66
20cm	1.8
40cm	2.25
80cm	2.71
160cm	3.3
320cm	4.7

Calculated based on the method described in Entin et al. (2001) and Hu and Feng (2004).

Observed sites (14) over TP and the soil memory



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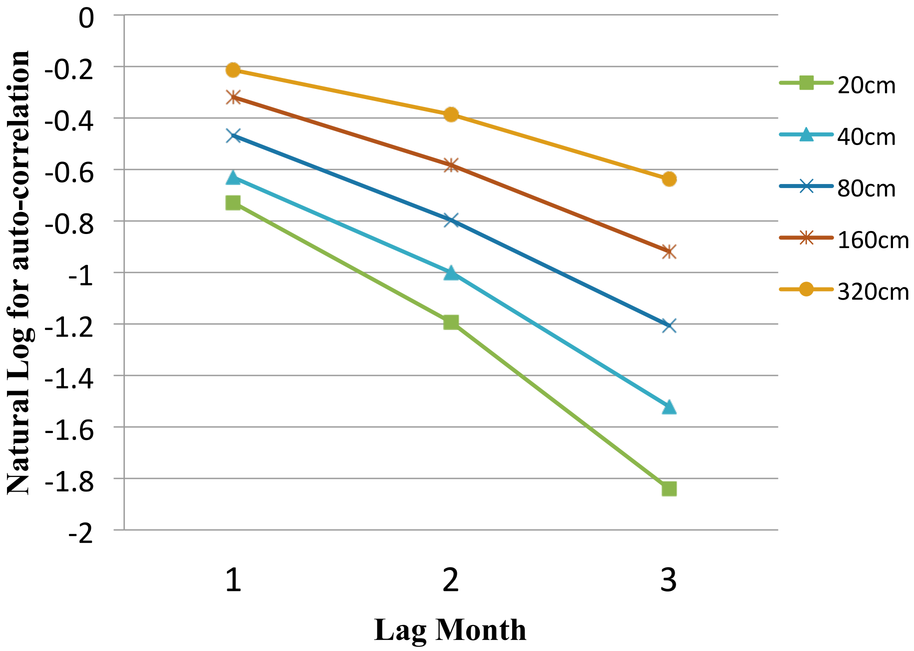
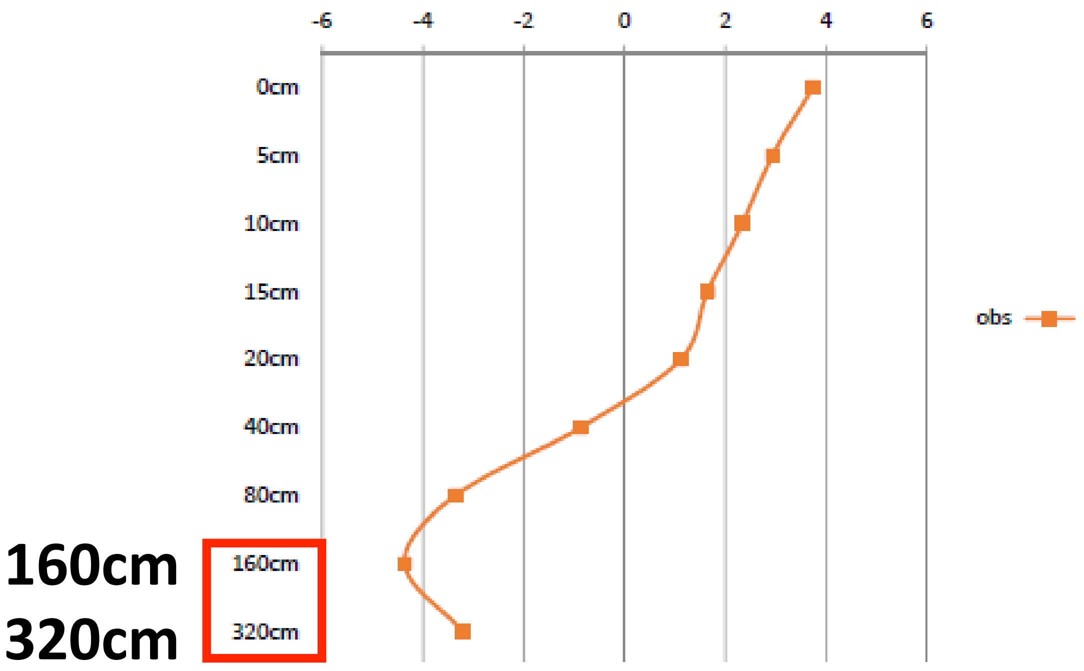


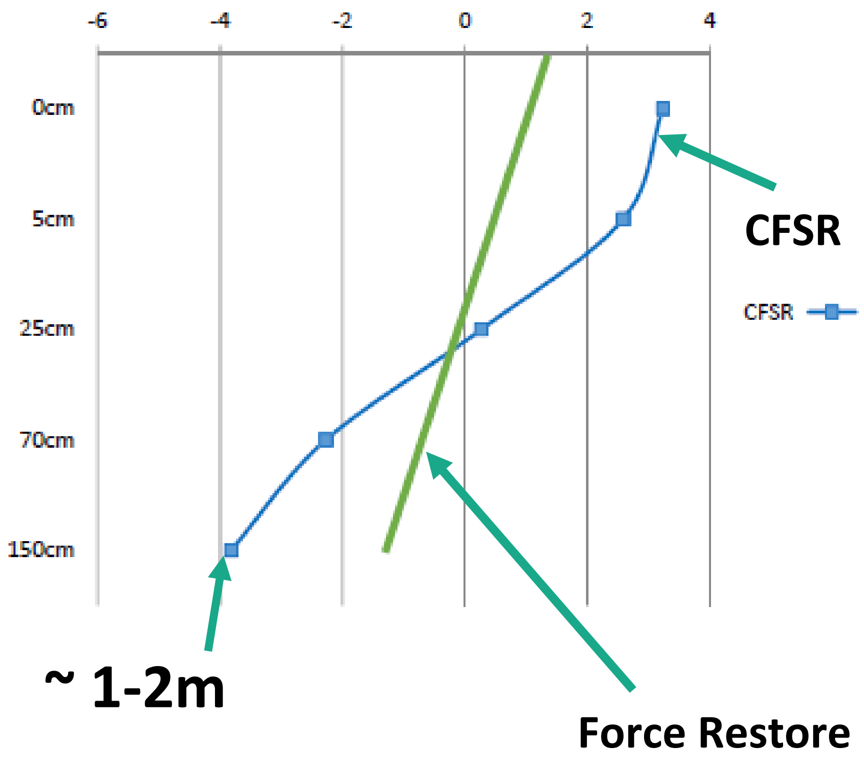
Force Restore Method

	Persistence
Tgs (2cm)	1. 2
Td (~1.5m)	1. 23

Observed Soil T Profile



Reanalysis and Force Restore T Profile



May soil temperature Profile over the Tibetan Plateau

Joint Efforts of

The Third Pole Experiment (TPE) Earth System Model (ESM) Intercomparison Project (TPEMIP)

Co-Chairs Yongkang Xue, Tandong Yao

GEWEX/GASS Initiative

Impact of initialized land temperature and snowpack on subseasonal to seasonal prediction (ILTSS2S) (First Phase)

Co-Chairs: Yongkang Xue (yxue@geog.ucla.edu), Tandong Yao (tdyao@itpcas.ac.cn); Aaron Boone (aaron.boone@cnrm.meteo.fr)

with potential GLASS and CLIVAR Monsoon Panel Participation

Project Goals

- What is the impact of the initialization of large scale LST/SUBT and snow pack, including the aerosol in snow, in climate models on the S2S prediction over different regions?
- What is the relative role and uncertainties in these land processes versus in SST in S2S prediction? How do they synergistically enhance the S2S predictability?

Plan to have a kick-off Workshop in 2018 AGU (Saturday and Sunday)

2nd workshop in Beijing in 2019 summer

More than 10 Global Earth System models and even more RCM (U.S., China and other East Asian countries, Europe, and other continents) will participate.

Summary

1). Tibetan Plateau (TP) land surface processes exerts great influence on the climate and environment at continental and even larger scales sue to its high elevation and geographic location and will experience substantial changes in next several decades.

2). The spring surface temperature (LST) and subsurface temperature (SUBT) over TP have significant impact on the summer droughts/floods (precipitation and temperature) in East Asia, South Asia, and Central Asia. The TP spring LST and SUBT anomalies are probably influenced by the winter snow and circulation.

3). Current land surface models/reanalysis data have severe deficiencies in reproducing the land memory that presented in the observational data, which would hamper the model S2S prediction ability.

4). TPE Earth System Model (ESM) Intercomparison Project (TPESMIP) and GEWEX/GASS Initiative of "Impact of initialized land temperature and snowpack on subseasonal to seasonal prediction" First Phase will jointly investigate the TP LST/SUBT effect on the droughts/floods