A GEWEX/GASS Initiative: Impact of initialized land temperature and snowpack on sub-seasonal to seasonal prediction (LS4P) Phase I Summary

Yongkang Xue, Tandong Yao, Aaron Boone, Ismaila Diallo and LS4P-I Team

Project Goals: This project intends to address two questions:

- ***What is the impact of the initialization of large-scale land surface temperature/subsurface temperature (LST/SUBT)*** *and snowpack, 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?***

Tibetan Plateau LST/SUBT Effect is the focus in the first phase because of its high elevation and significant areal coverage, plus the comprehensive field measurements by the Third Pole Environment and other projects in past decades. The June 2003 is selected as the first case.

21 (18) ESM Groups; 9 RCM Groups; 7 Data Groups; 1 Data Base

Three GEWEX/GASS/LS4P-TPEMIP Workshops play crucial role in the development of LS4P project

1). Kick-off workshop in 2018 AGU: Washington, D.C., December 8-9, 2018

2). Second Workshop in Nanjing University, Nanjing, July 7-9, 2019

3). 3rd Workshop in 2019 AGU, San Francisco, 13 Dec. , 2019

Publications

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Geoscientific Model Development
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EGU

Impact of Initialized Land Surface Temperature and Snowpack on Subseasonal to Seasonal Prediction Project, Phase I (LS4P-I): organization and experimental design

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BAMS In Box

Spring Land Temperature in Tibetan Plateau and Global-Scale Summer Precipitation

Initialization and Improved Prediction

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Supplemental material: https://doi.org/10.1175/BAMS-D-21-0270.2
In final form 5 September 2022

Diallo, I., Y. Xue, Q. Chen, X. Ren, W. Guo, 2022: Effects of Spring Tibetan Plateau Land Temperature Anomalies on Early Summer Floods/Droughts over the monsoon regions of South East Asia. *Climate Dynamics*. DOI: 10.1007/s00382-021-06053-8

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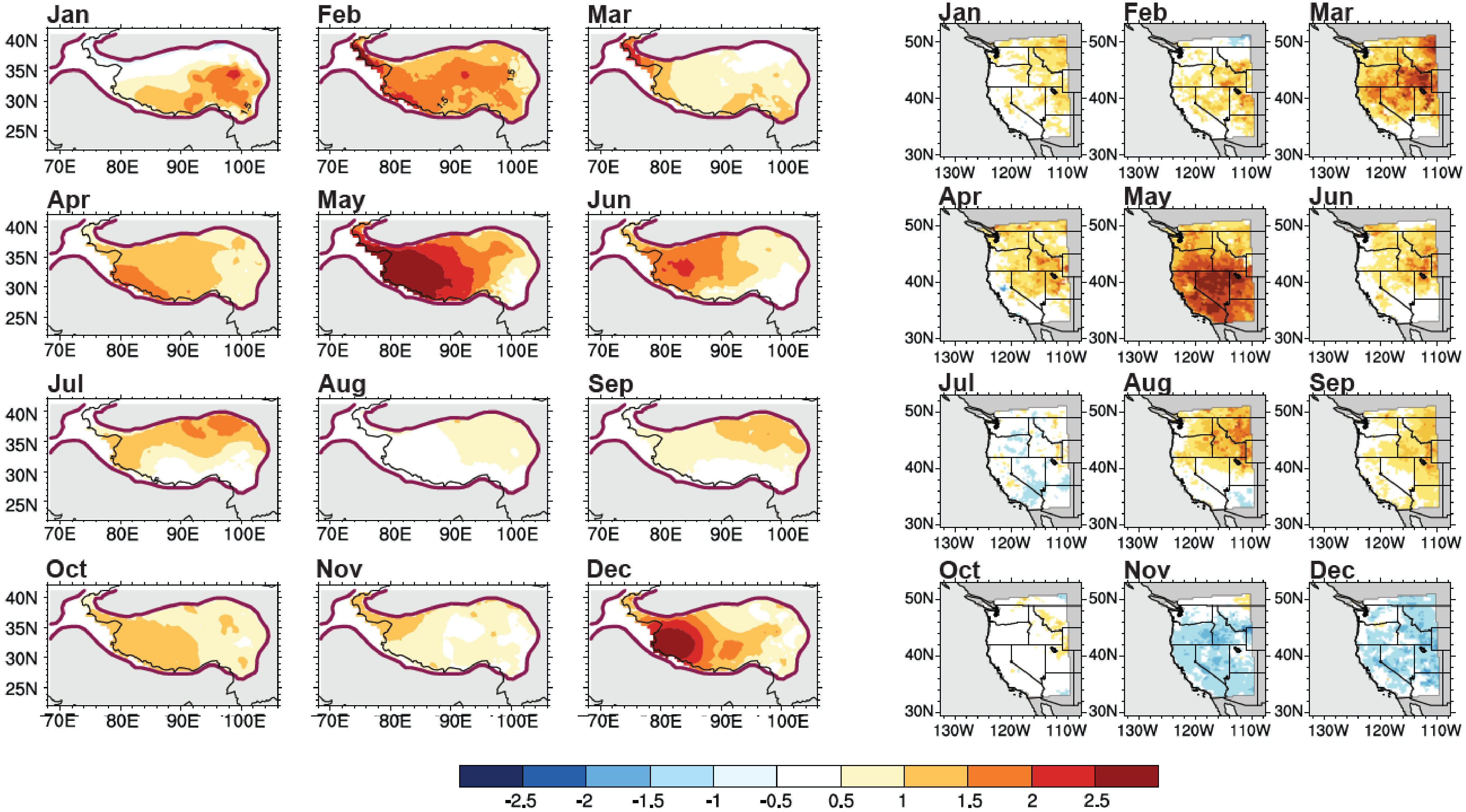
Climate Dynamics Special Issue: Sub-seasonal to Seasonal (S2S) predictability and Land-induced Forcing

I. Observational Evidence of TPI and RMI LST/SUBT Memory and their interaction

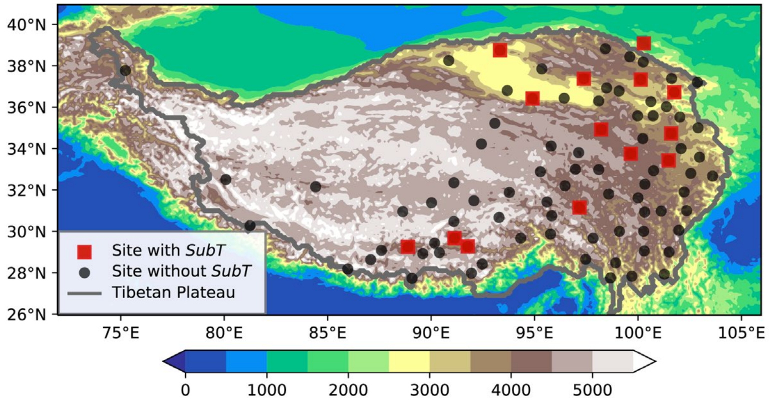
Monthly 2-m Temperature difference between Warm and Cold Years based on May anomaly

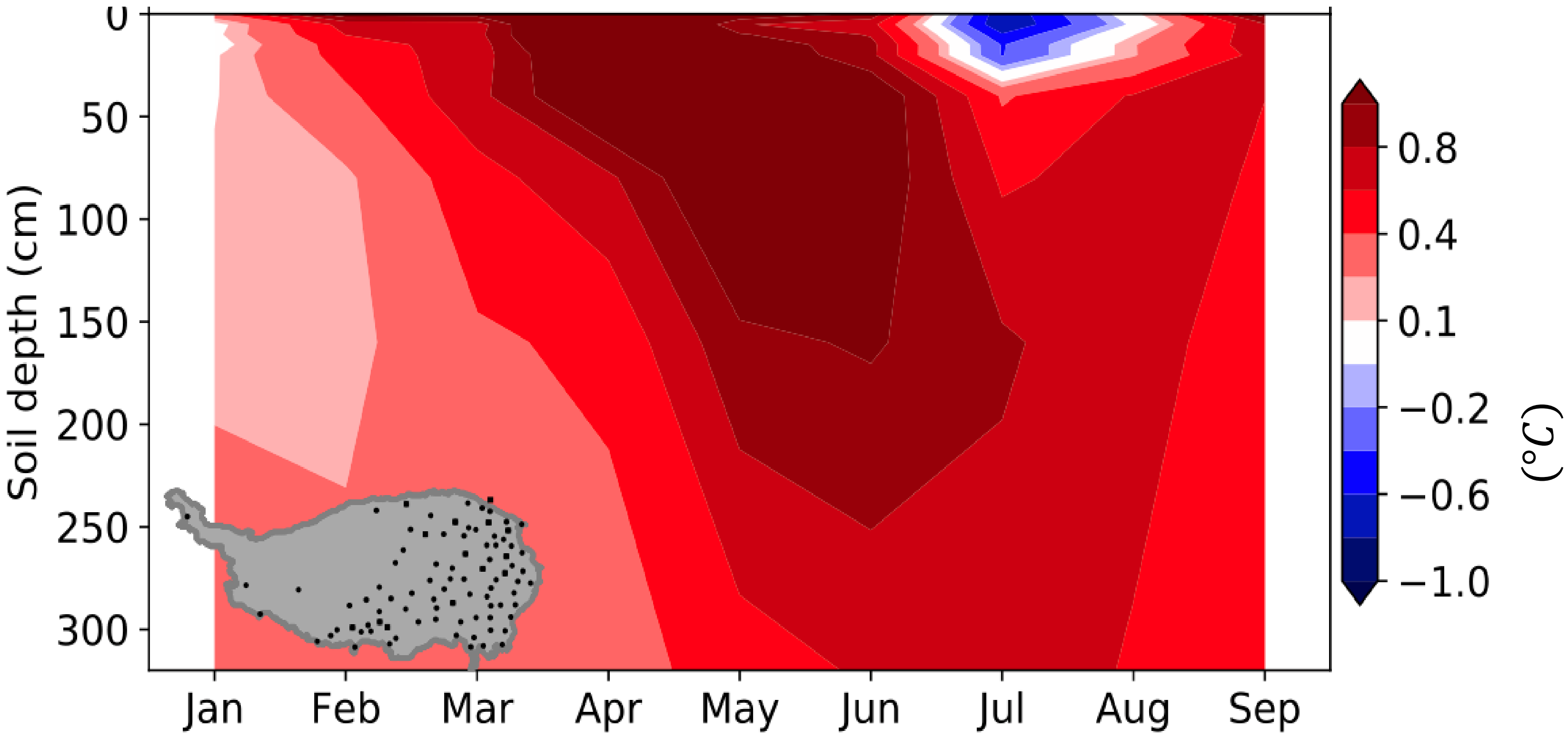


TPI: Tibetan Plateau Index; RM: Rocky Mountain Index

Years are selected based on the May anomalies using a threshold of one-half standard deviation during the period 1981-2010.

Observed difference of surface & subsurface temperature and snow *between year with warmest and coldest springs*

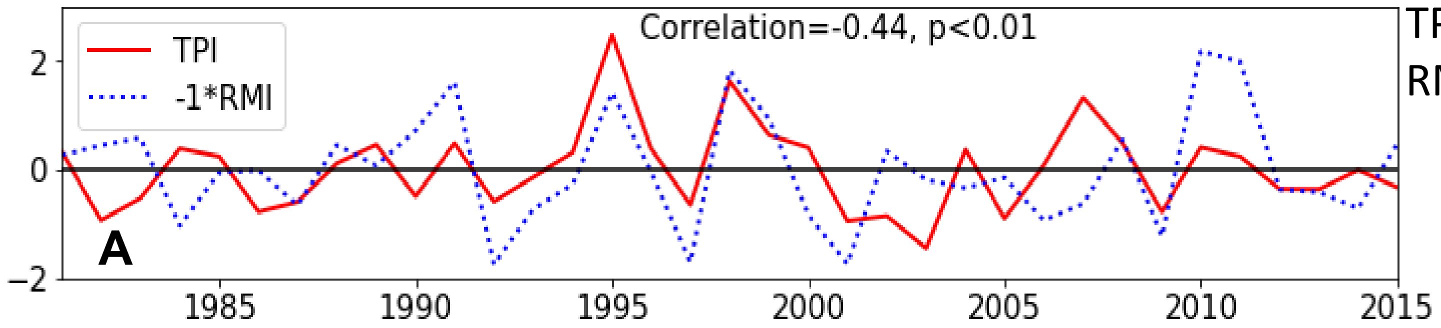




Liu et al., 2020, JGR

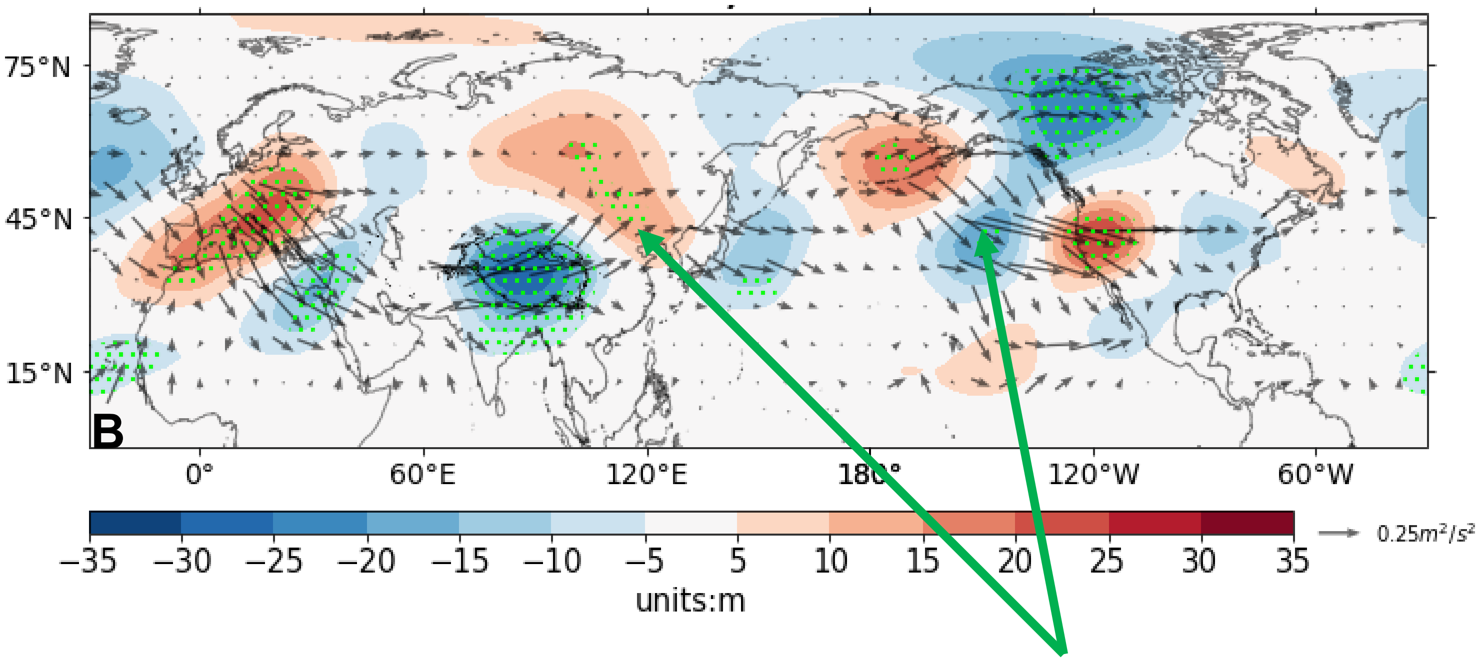
Cold: 1982, 1983, 1986, 1990, 2001
Warm: 1999, 2004, 2007, 2009, 2010, 2015

Observed May TPI and RMI time series from 1981-2015



TPI: Tibetan Plateau Index
RMI: Rocky Mountain Index

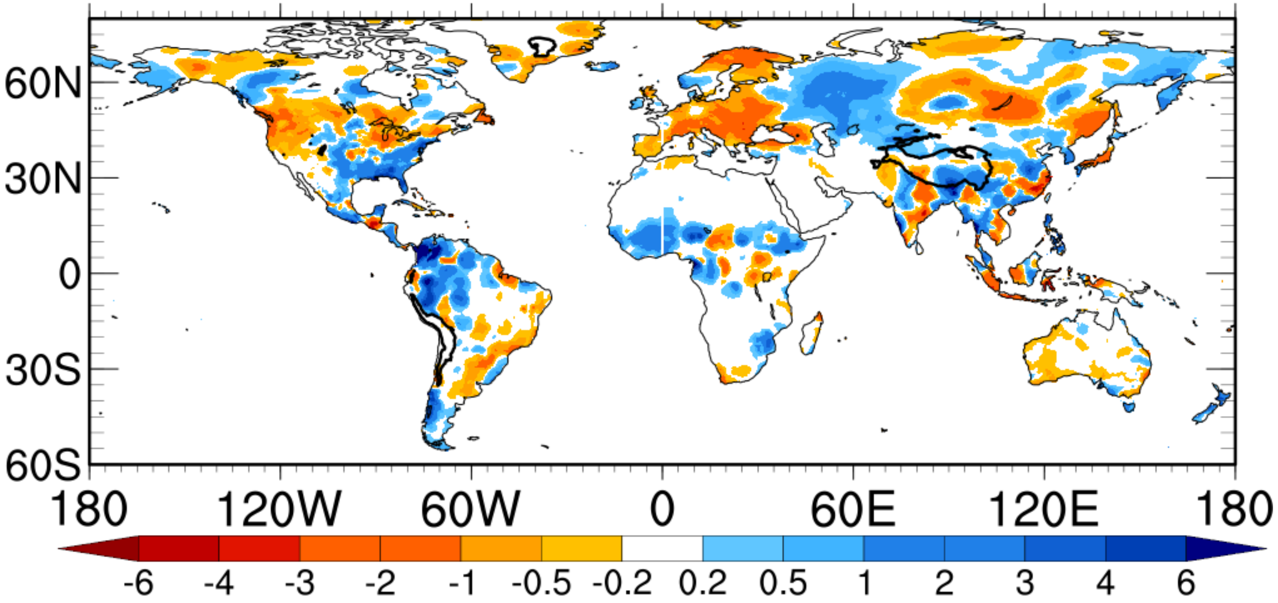
Observed Wave Train due to TP May T2m anomaly



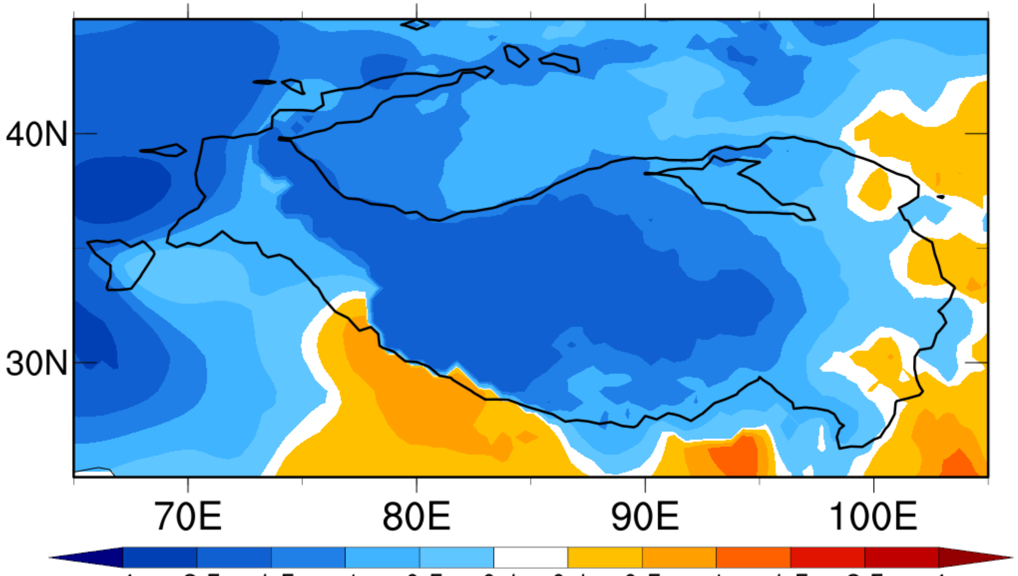
Wave train

II Observed relationship between TP LST/SUBT and Global Precipitation anomalies

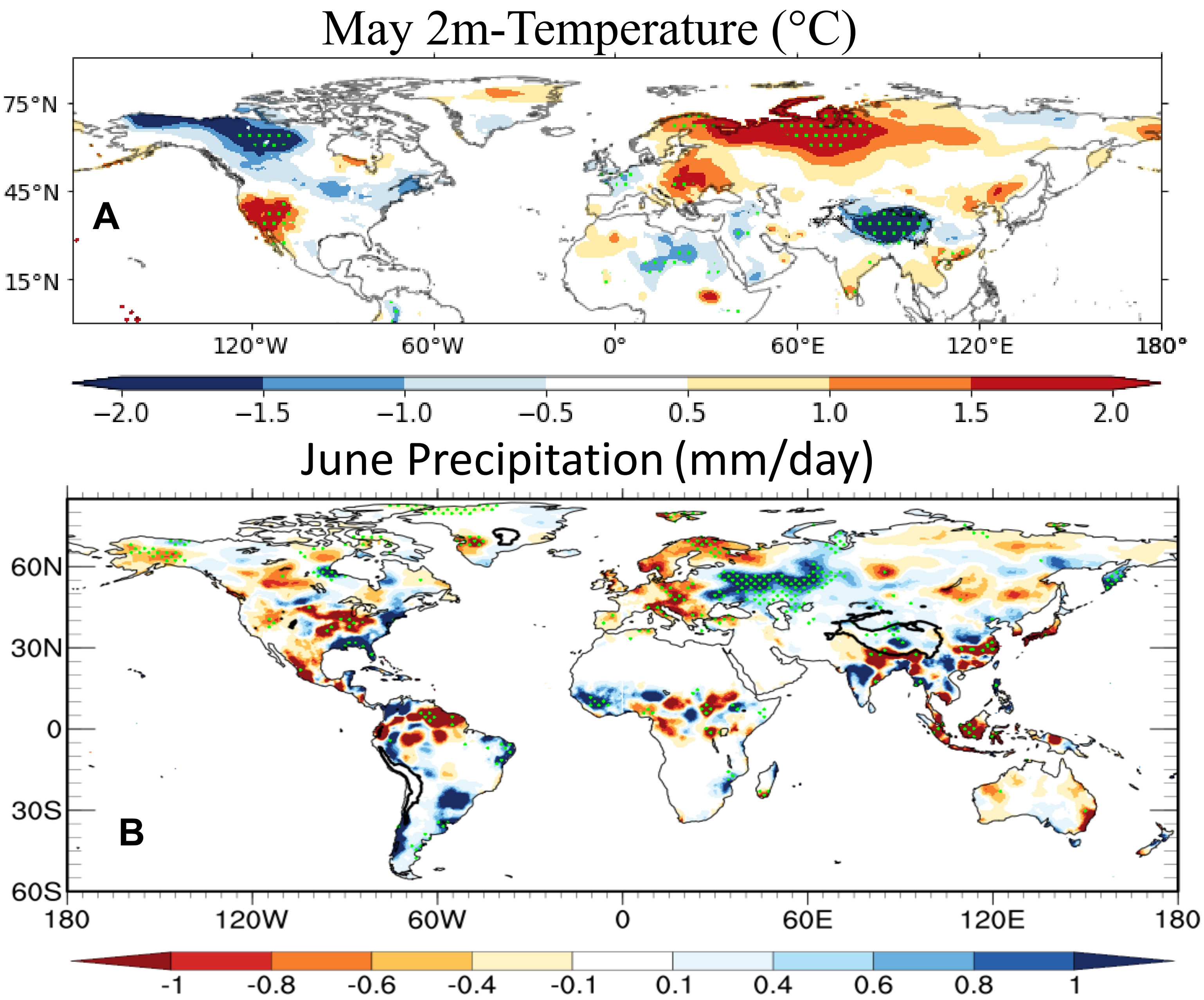
Observed June 2003 Precipitation anomaly (mm day^{-1})



Obs. May 2003 T2m Anomaly (°C)



Observed differences between five cold and five warm Mays in the Tibetan Plateau



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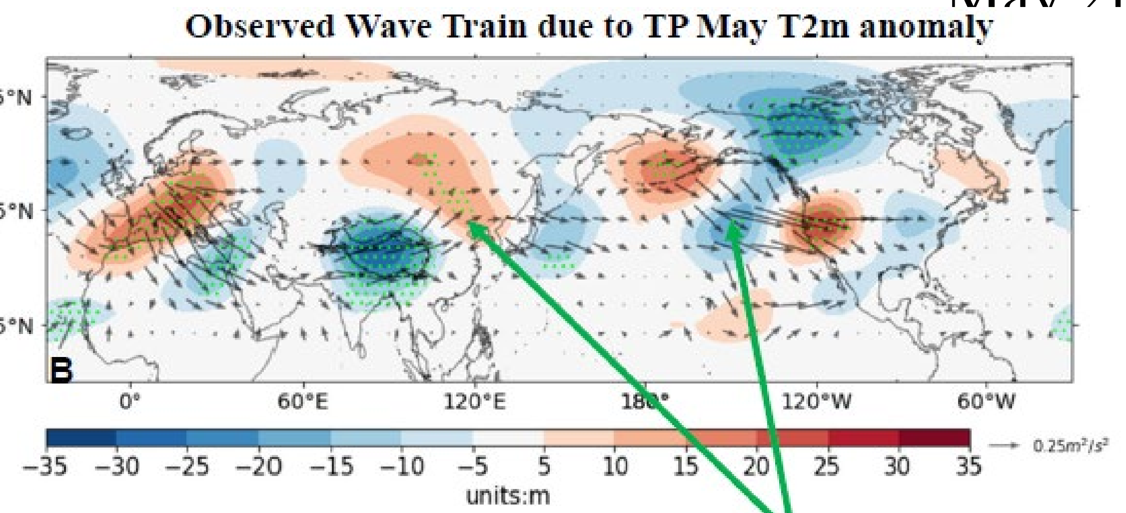
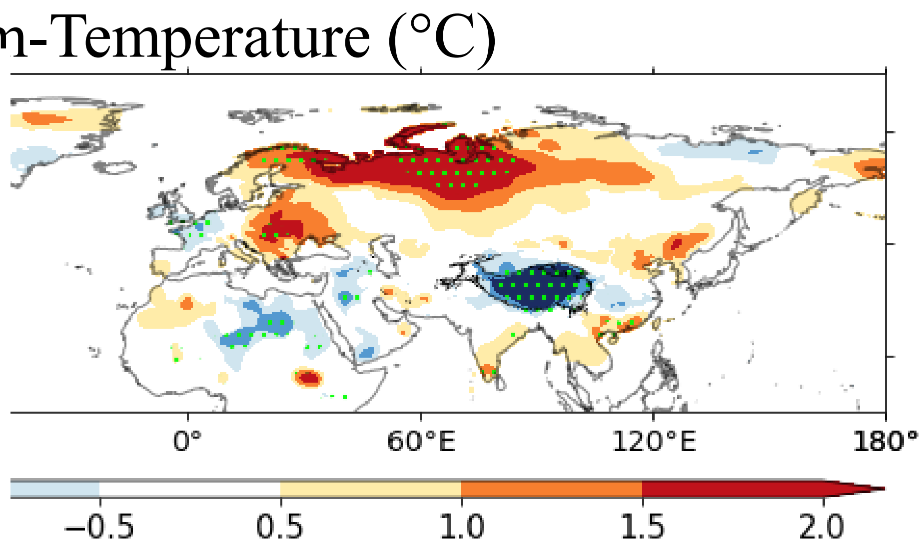
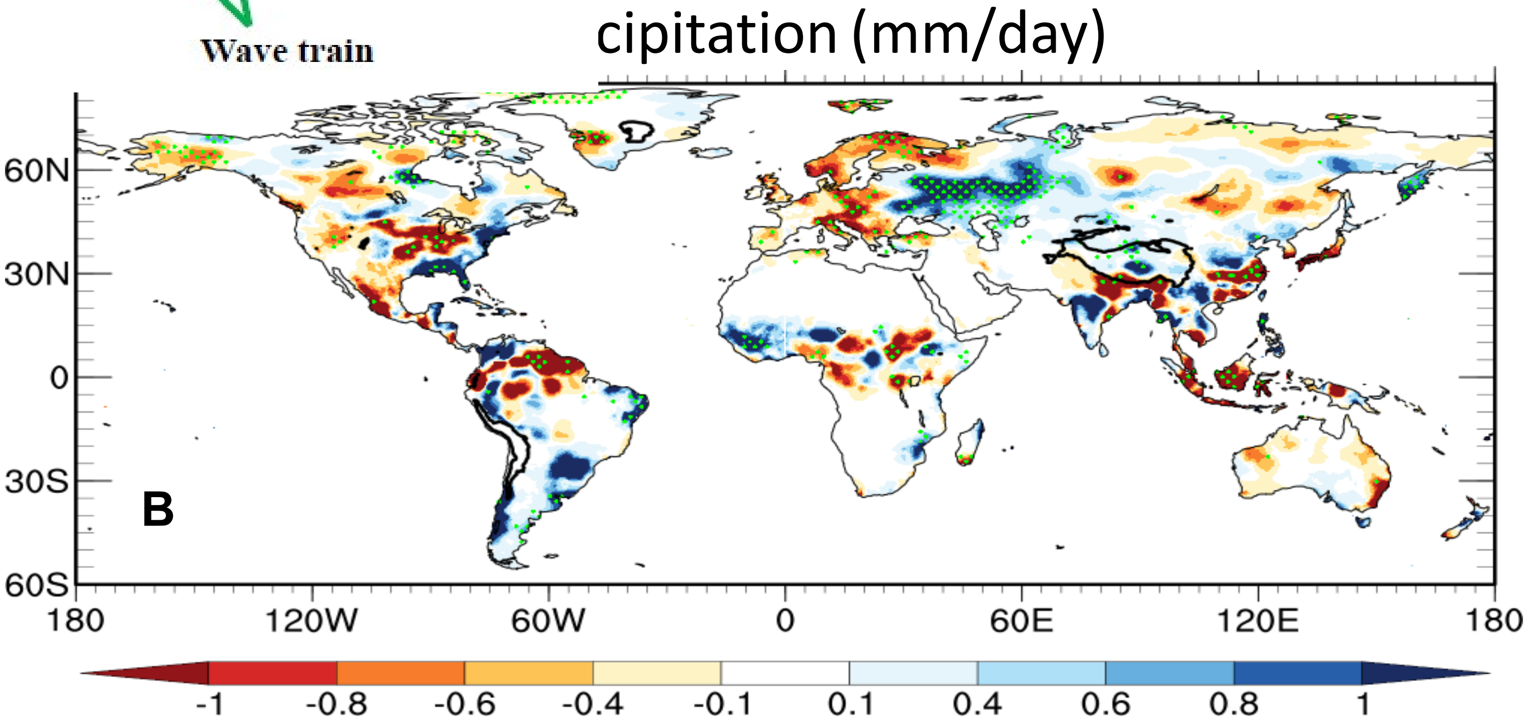




Wave train



Lag Relationship between May T2m (EOF1) and June Precipitation

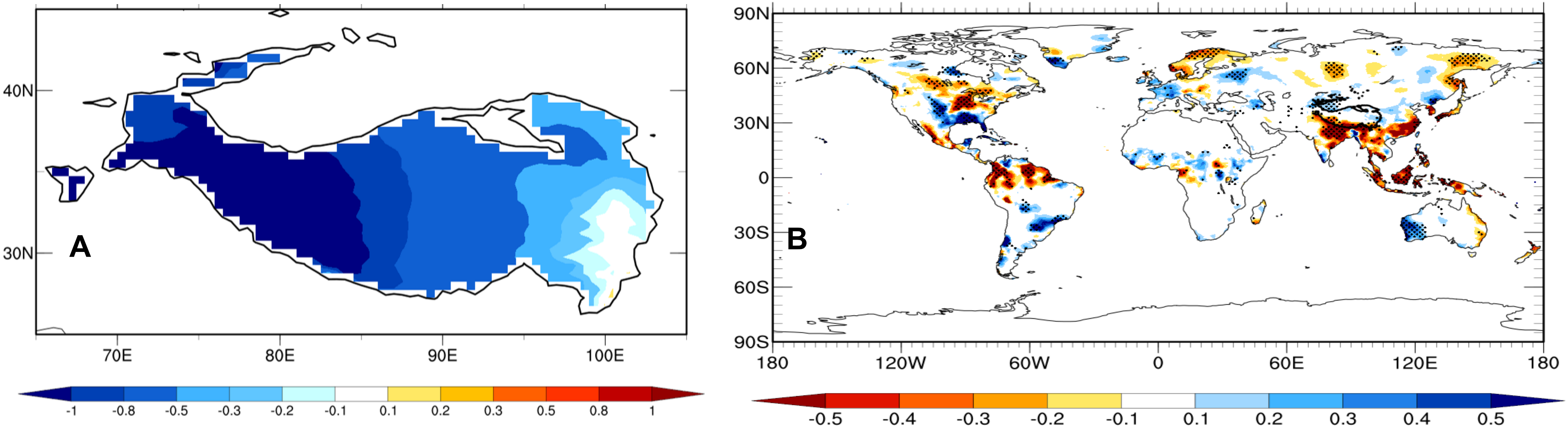


Fig. S2. Lag Relationship between May T2m and June Precipitation. (A) May T2m EOF1 (°C); (B) The regression of the observed June precipitation (mm/day) from 1980-2011 onto PC1 of TP T2m EOF.

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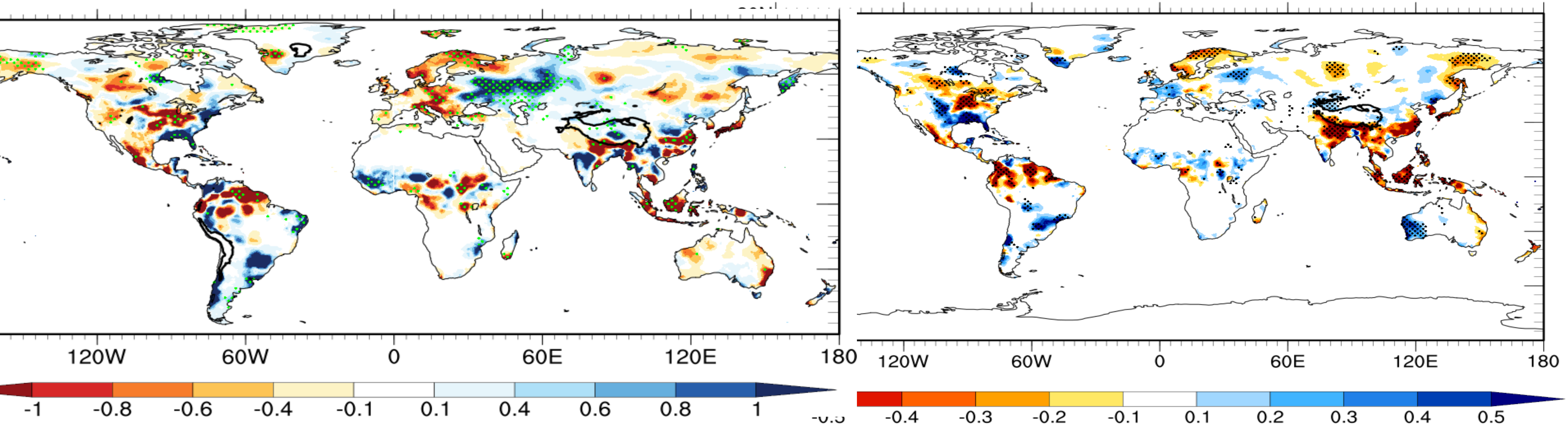

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LS4P-I Experiments

Table 1. Summary of different tasks under the LS4P-I framework.

Name	LST/SUBT initialization (imposed mask)	Period	Description
Task 1	No	Two months (late April–30 June 2003)	Task 1 is the default run from the Earth system model (ESM) with starting date around late April 2003.
Task 2	No	1981–2010 (climatology)	Task 2 is the ESM climatology. Only major climate research centers provide this data set.
Task 3	Yes	Two months (late April–30 June 2003)	Task 3 is the same as Task 1, but the mask is imposed over the Tibetan Plateau at the first time step of the ESM integration.
Task 4	No	Two months (late April–June 2003)	Task 4 is the same as Task 1, but here the 2003 SST is replaced by the climatology (1981–2010) SST.

LS4P-I Experiments

Table 1. Summary of different tasks under the LS4P-I framework.

Name	LST/SUBT initialization (imposed mask)	Period	Description
Task 1: Check whether the ESM has large bias on May TP T2m and June precipitation			
Task 2	No	1981–2010 (climatology)	Task 2 is the ESM climatology. Only major climate research centers provide this data set.
Task 3	Yes	Two months (late April–30 June 2003)	Task 3 is the same as Task 1, but the mask is imposed over the Tibetan Plateau at the first time step of the ESM integration.
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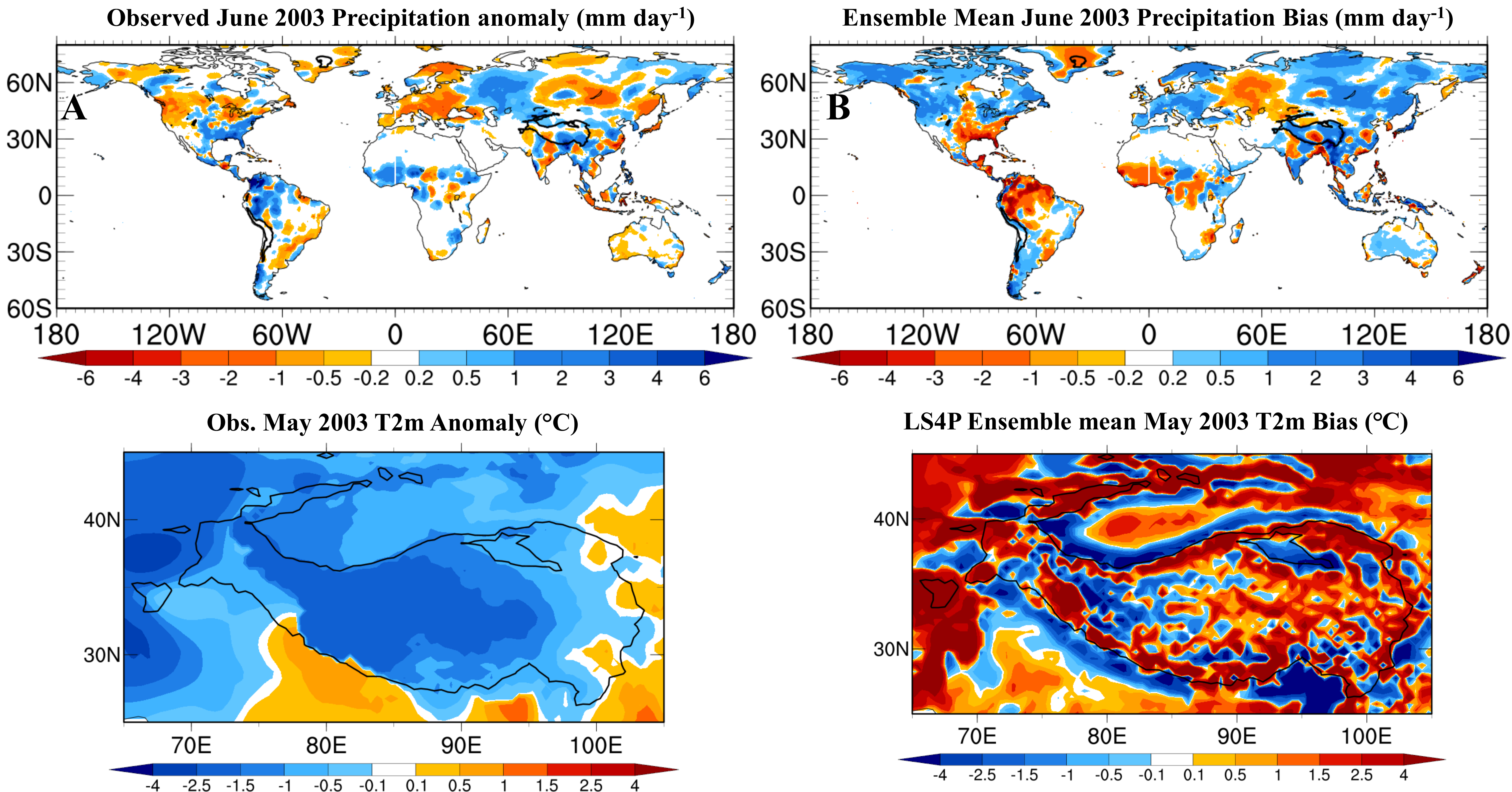
Observed June 2003 Precipitation anomaly (mm day-1)
Ensemble Mean June 2003 Precipitation Bias (mm day-1)
A
B
60N
30N
0
30S
60S
180
120W
60W
0
60E
120E
180
-6 -4 -3 -2 -1 -0.5 -0.2 0.2 0.5 1 2 3 4 6
Obs. May 2003 T2m Anomaly (°C)
LS4P Ensemble mean May 2003 T2m Bias (°C)
40N
30N
70E
80E
90E
100E
-4 -2.5 -1.5 -1 -0.5 -0.1 0.1 0.5 1 1.5 2.5 4

LS4P-I Experiments

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Task 2: Check whether the ESM biases in 2003 also exist in model climatology			
Task 3	Yes	Two months (late April–30 June 2003)	Task 3 is the same as Task 1, but the mask is imposed over the Tibetan Plateau at the first time step of the ESM integration.
Task 4	No	Two months (late April–June 2003)	Task 4 is the same as Task 1, but here the 2003 SST is replaced by the climatology (1981–2010) SST.

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Task 2	No	1981–2010 (climatology)	Task 2 is the ESM climatology. Only major climate research centers provide this data set.
Task 3: Test TP LST/SUBT effect			
Task 4	No	Two months (late April–June 2003)	Task 4 is the same as Task 1, but here the 2003 SST is replaced by the climatology (1981–2010) SST.

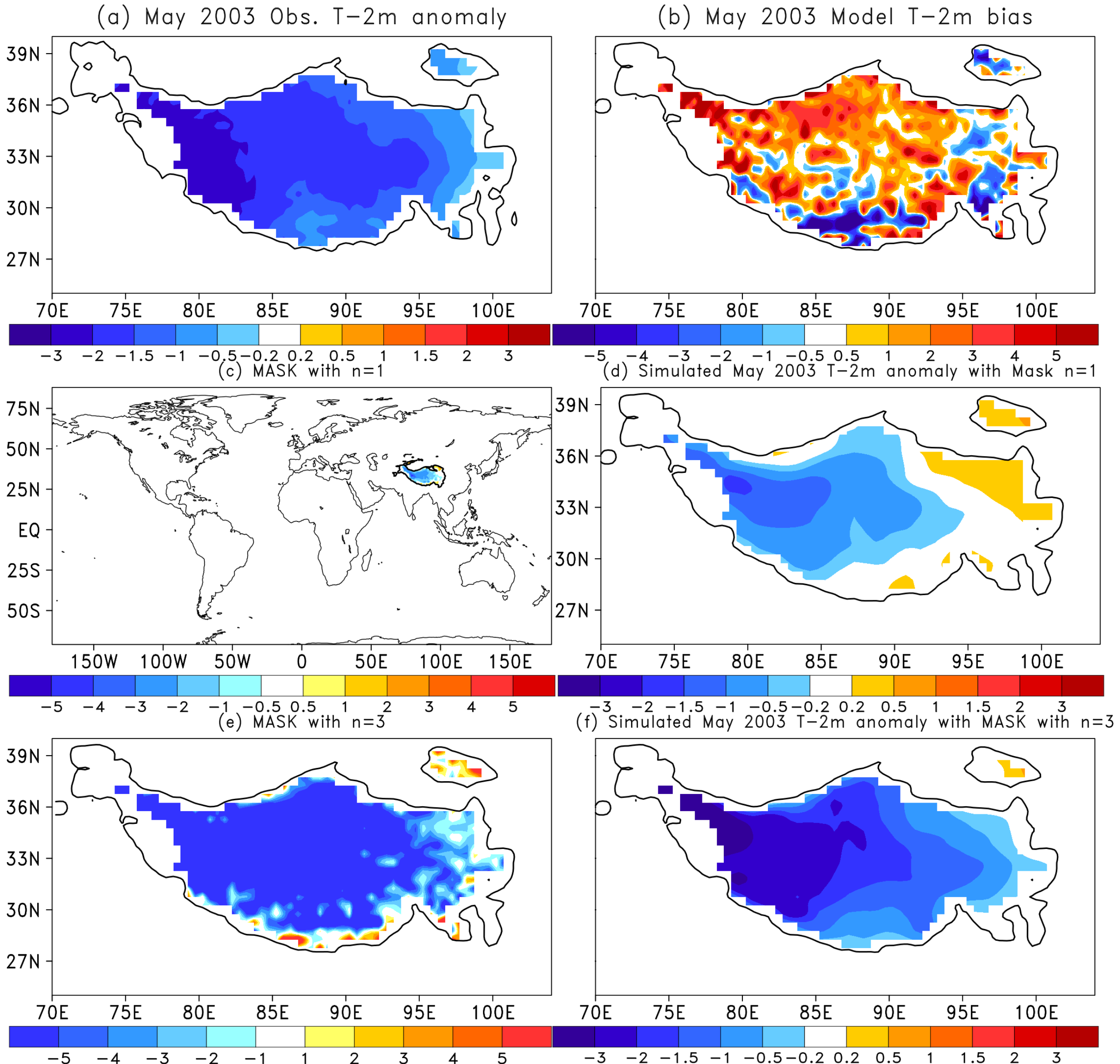
Development of Initialization Methodology

Principles Consideration: (1) Model bias; (2) Observed Anomalies; (3) Tuning parameter

Applying the mask, $\tilde{T}_0(i, j)$, will be defined as follows:

$$\tilde{T}_0(i, j) = T_0(i, j) + \Delta T_{\text{mask}}(i, j) = T_0(i, j) + \left[-n \times T_{\text{obs anomaly}}(i, j) - T_{\text{bias}}(i, j)\right],$$

when $\bar{T}_{\text{obs anomaly}} \times \bar{T}_{\text{bias}} \geq 0,$ (1a)



LS4P-I Experiments

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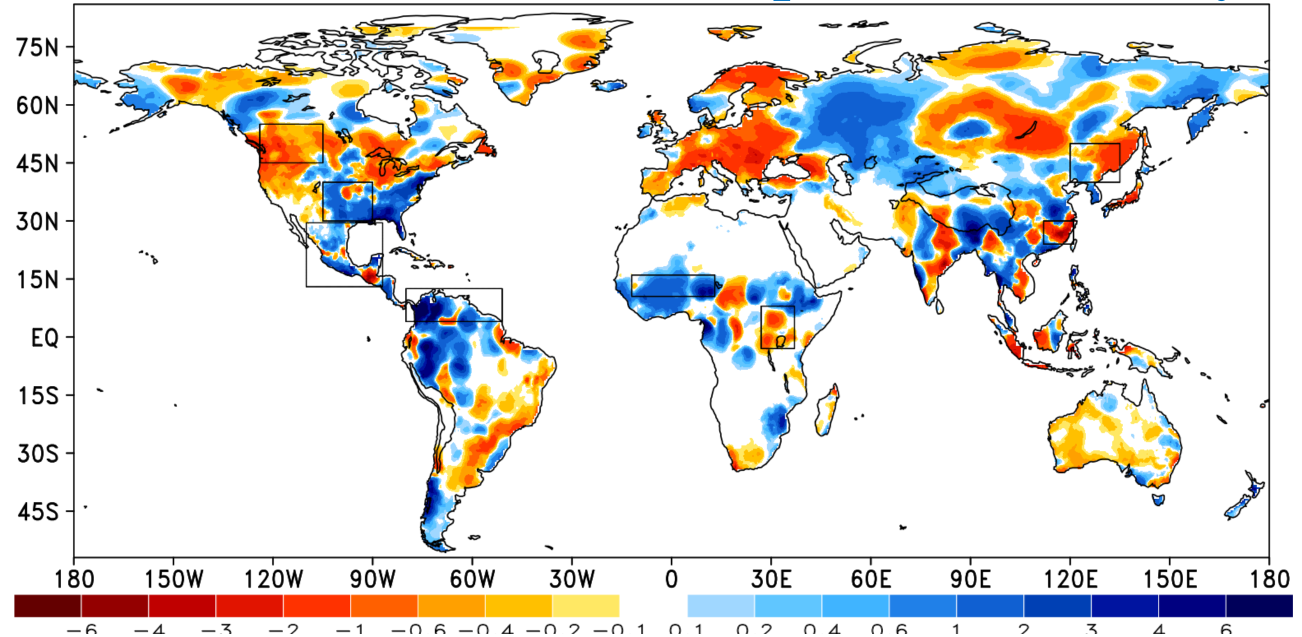
Task 4: Test SST effects			

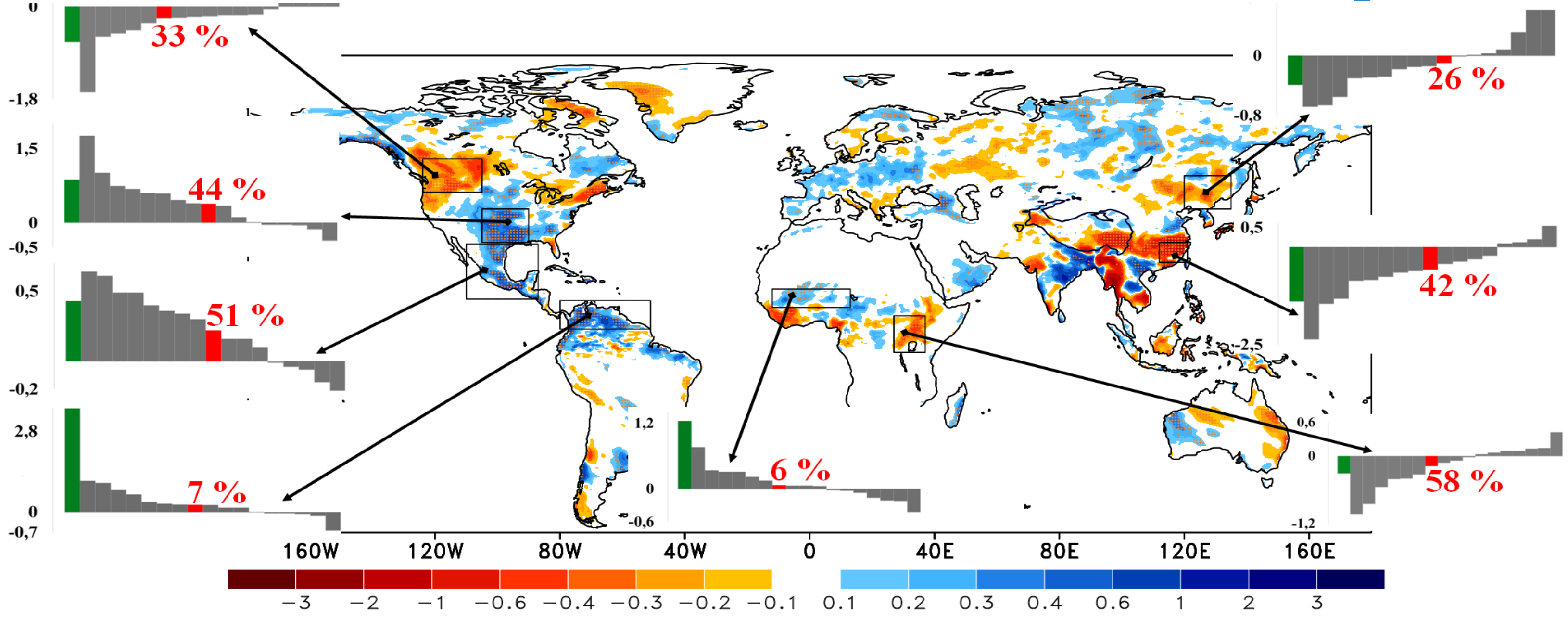
Observed June 2003 Precipitation Anomaly

A



Simulated TP LST/SUBT effect on June 2003 Precipitation

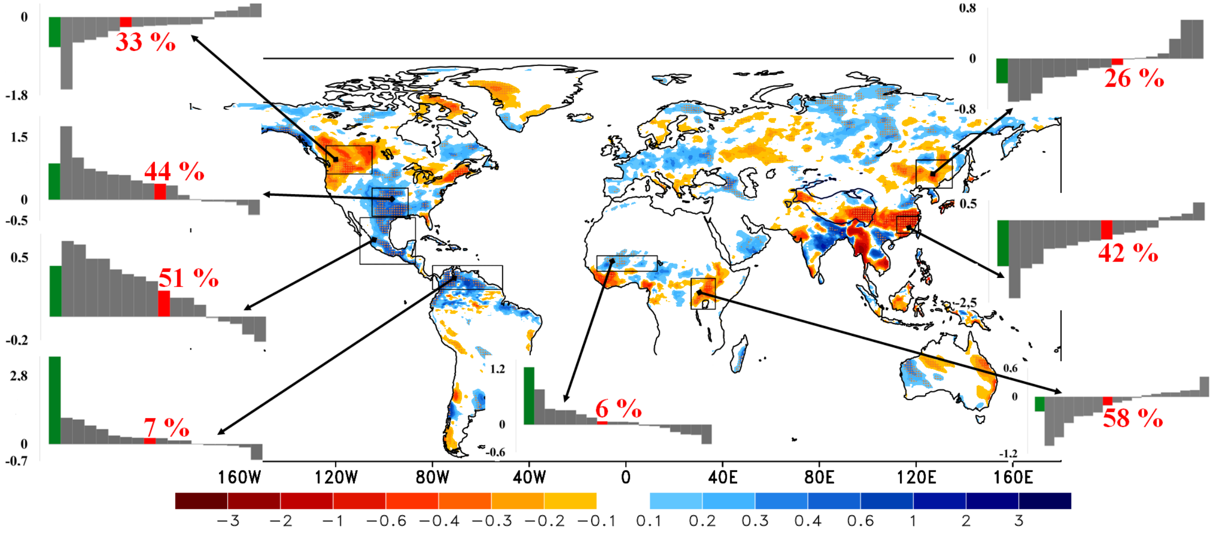
B



Comparison of June 2003 Precipitation Anomaly due to LST/SUBT and SST Effect(mm/day)

LST/SUBT Effect

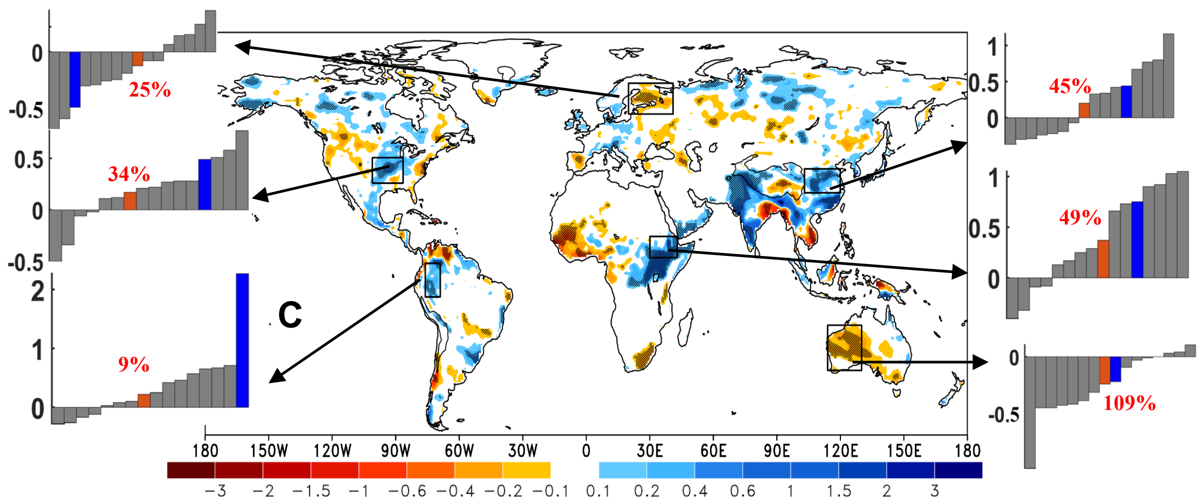
TP LST/SUBT hot spots



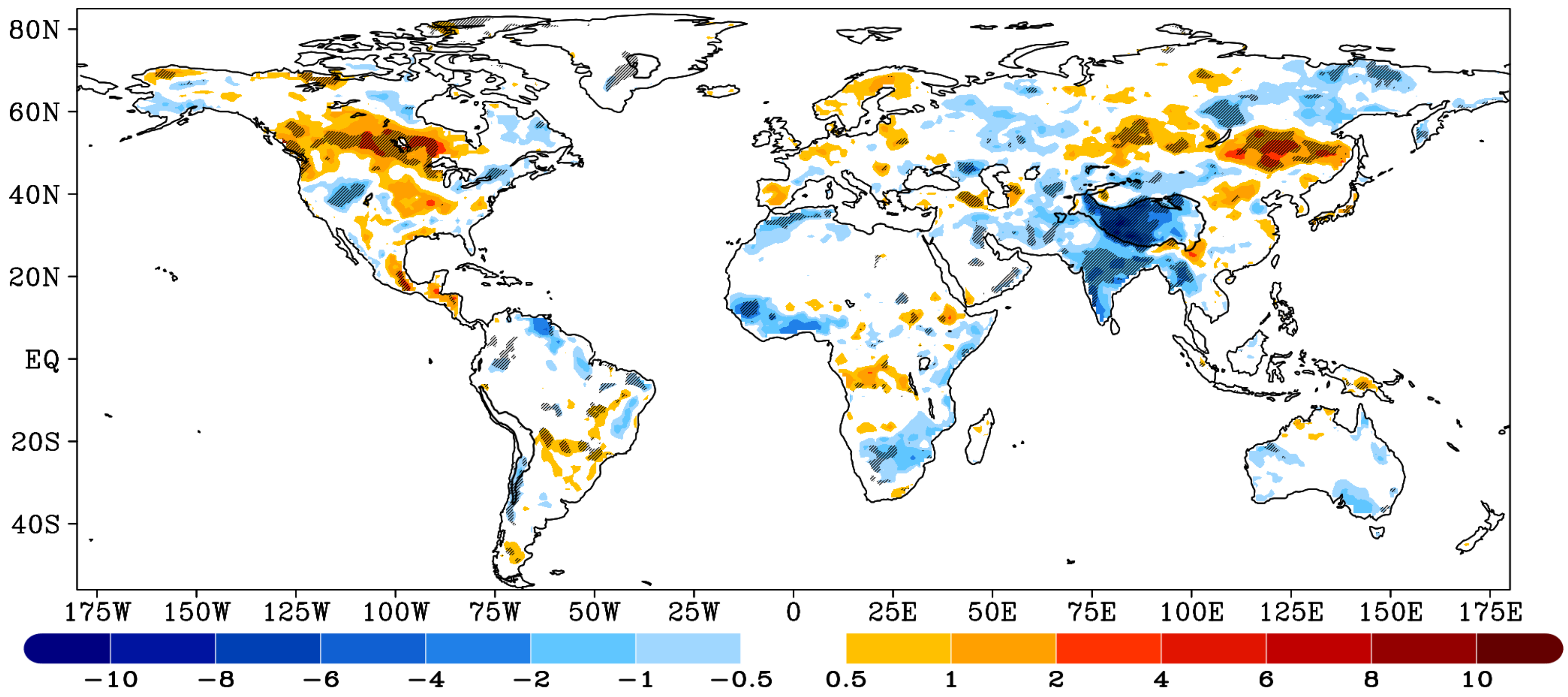
B

Simulated June 2003 Precipitation Anomaly (mm/day) due to SST anomaly

Global SST hot spots



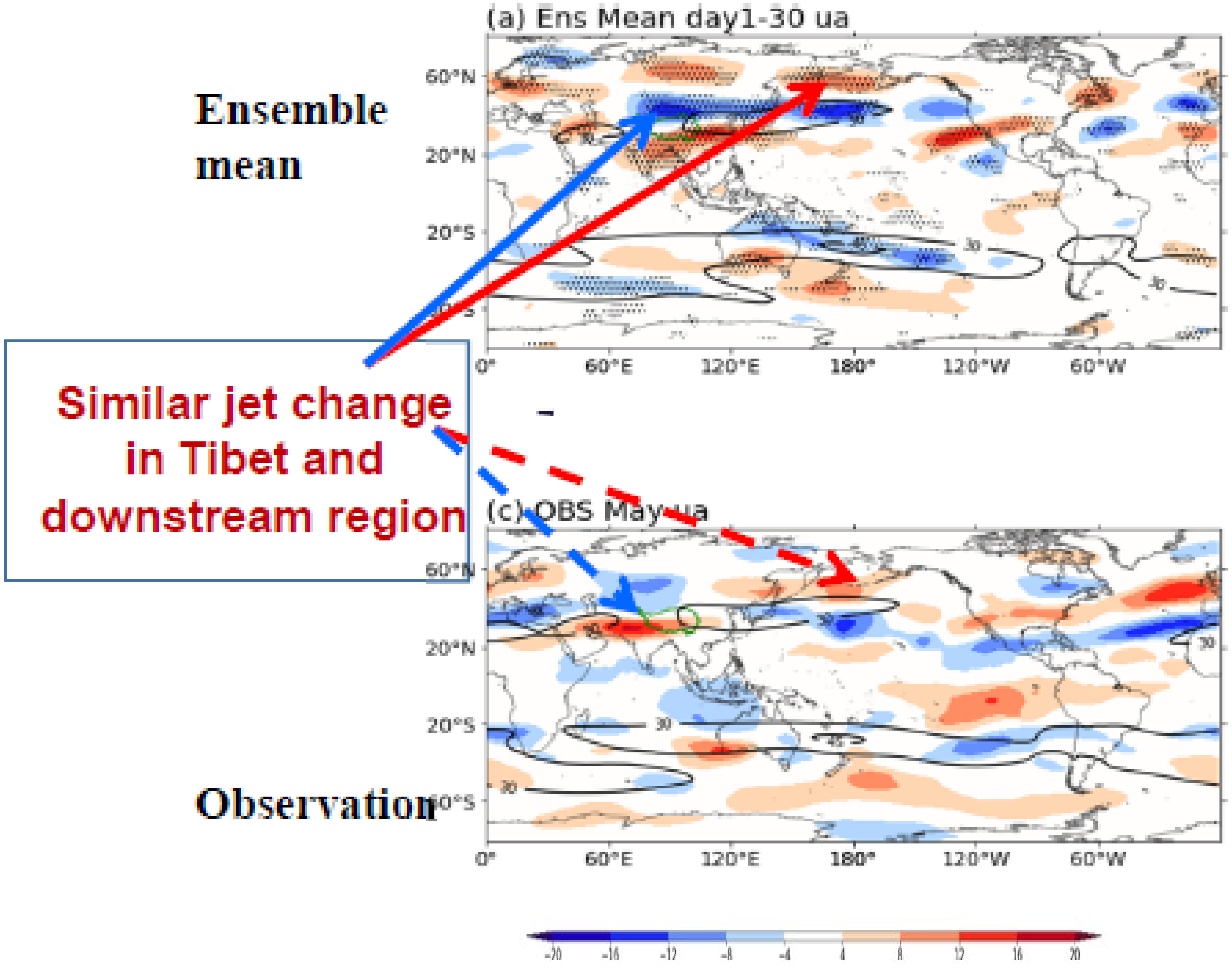
May 2003 sensible heat flux difference (W/m2) due TP LST/SUBT Effect



Response of 200 hPa zonal winds

Ensemble mean

Observation

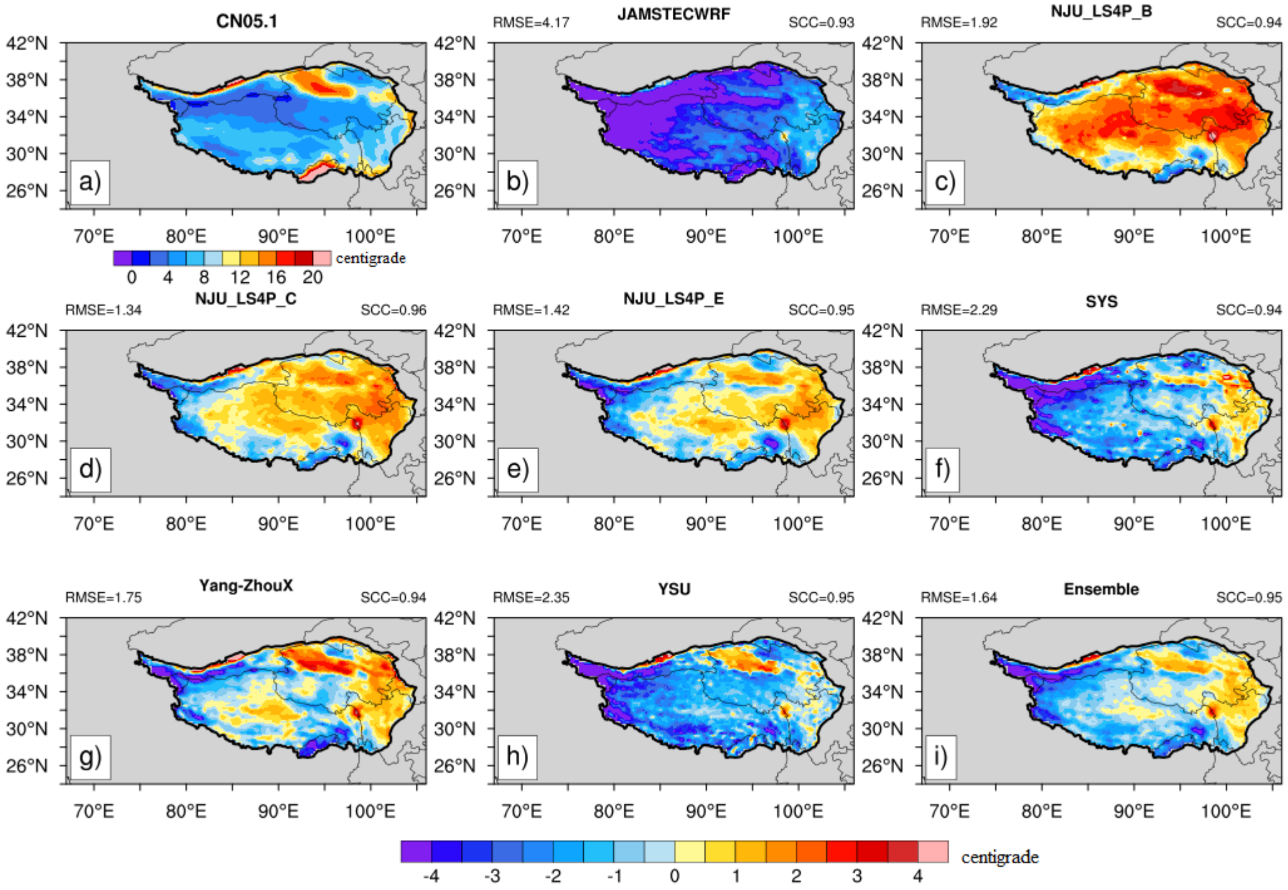


Zhang et al.

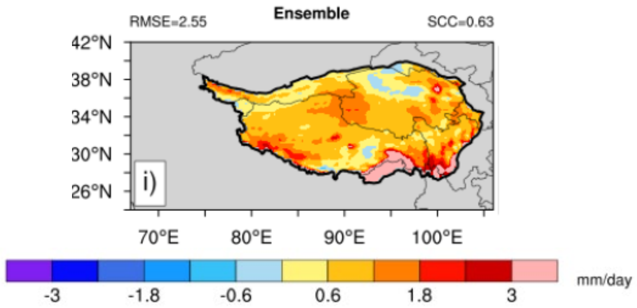
LS4P regional climate model (RCM) intercomparison over the Tibetan Plateau

J. Tang et al.

T2m Simulation biases (May-June-July-August 1991-2015)



Precipitation Bias



- All RCMs can reasonably produce the distribution of T2m with high correlation, but large RMSEs exist especially in WRF simulations.
- RegCM4 tends to simulate warm biases, while WRF has cold biases.

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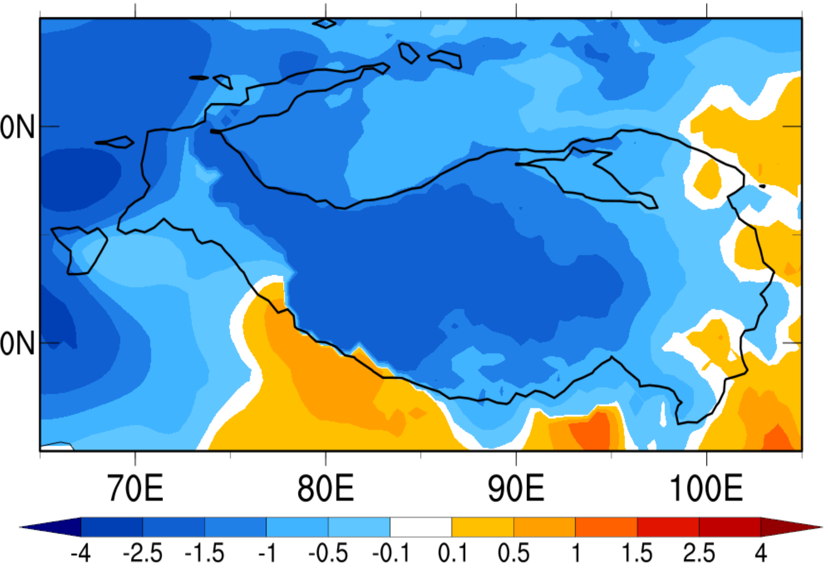
Climate Dynamics Special Issue: Sub-seasonal to Seasonal (S2S) predictability and Land-induced Forcing

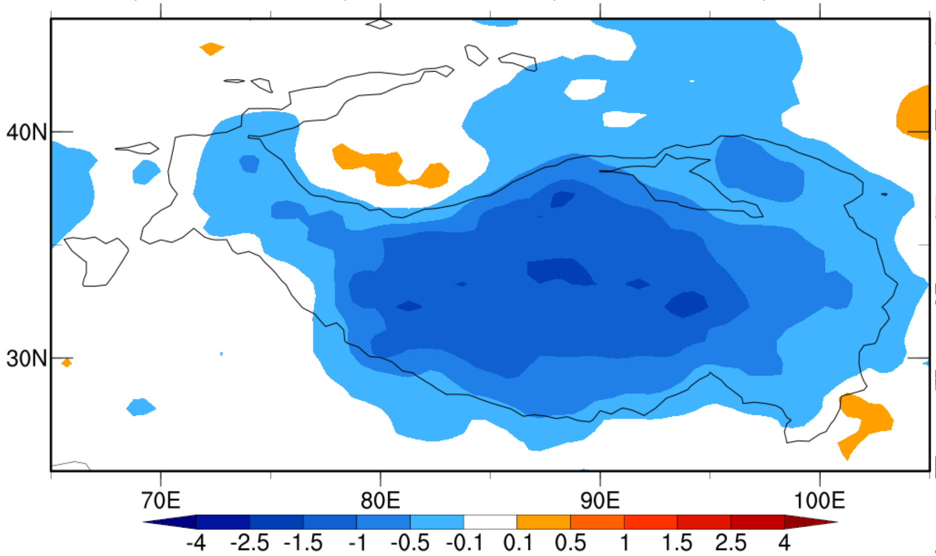
Challenging Issus

1). Initialization

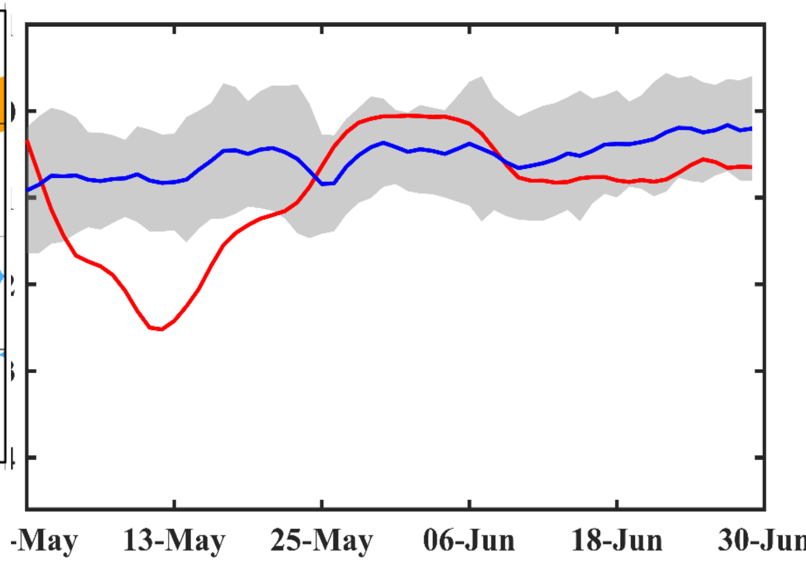
May T2m Anomaly



Ensemble mean May 1st T2m Difference



T2m Time series



Red line: observation

Blur line: ensemble mean

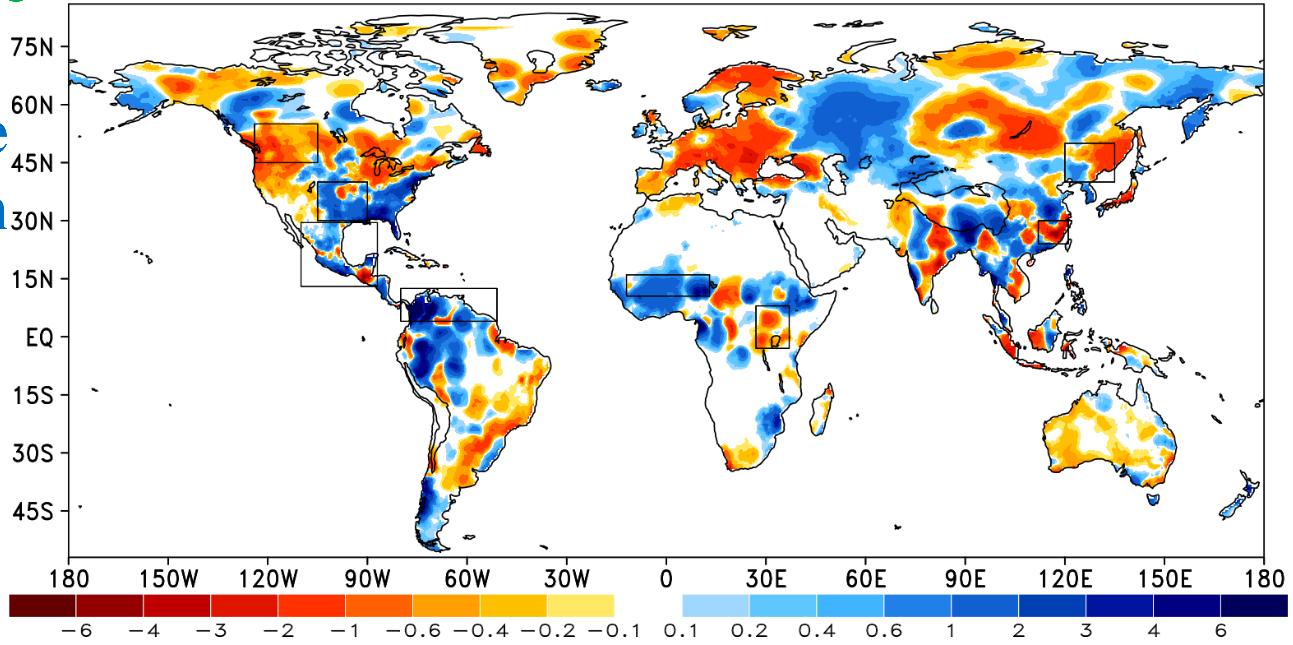
Possible causes for the short memory:

(1)Land model parameterizations

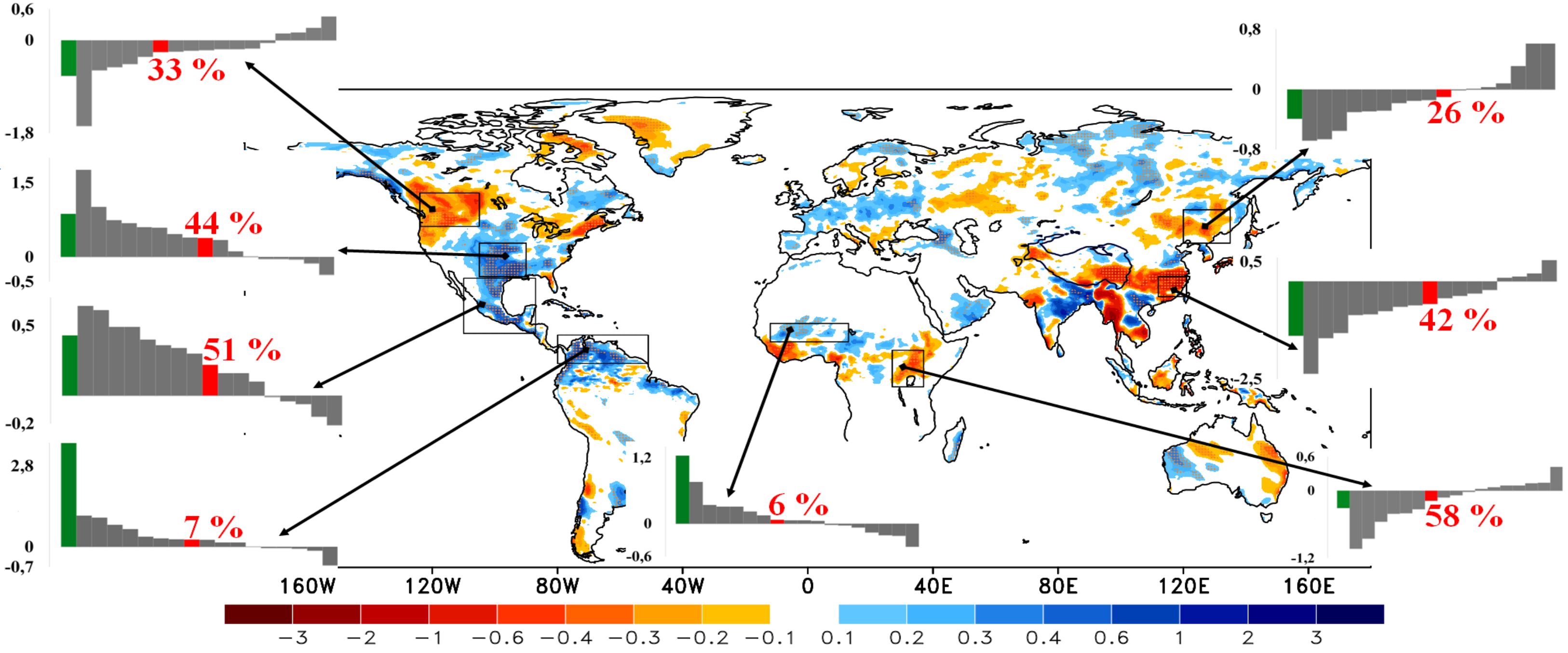
(2)Reanalyses data for initialization

2. Hot Spots Issues

Observed June 2003 Precipitation Anomaly

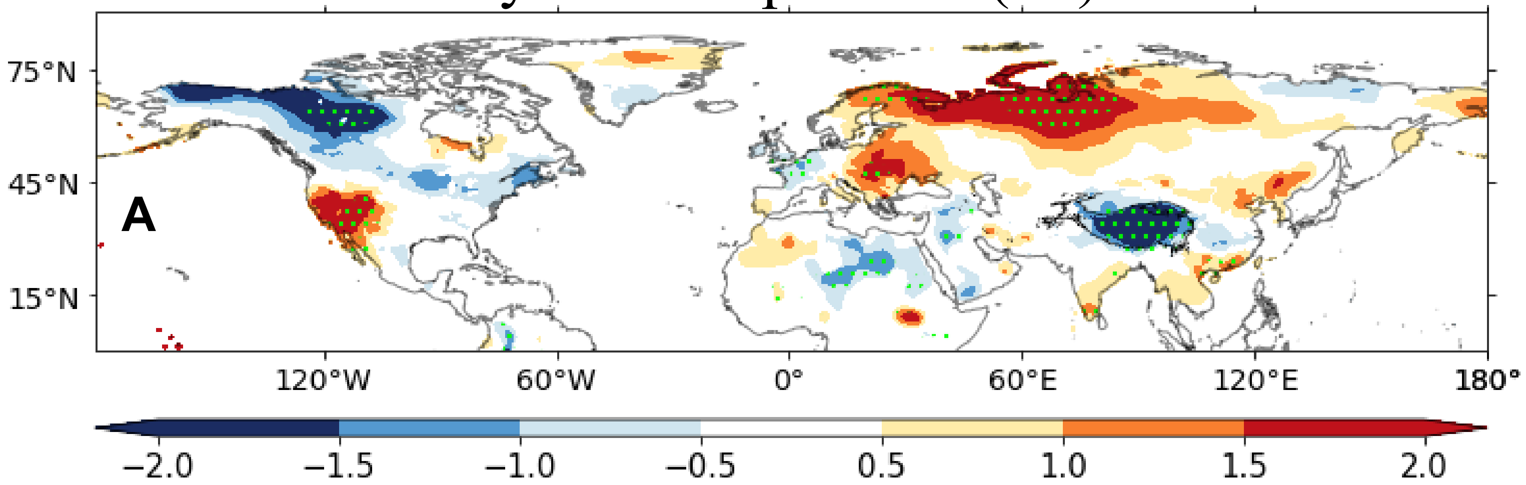


Simulated TP LST/SUBT effect on June 2003 Precipitation

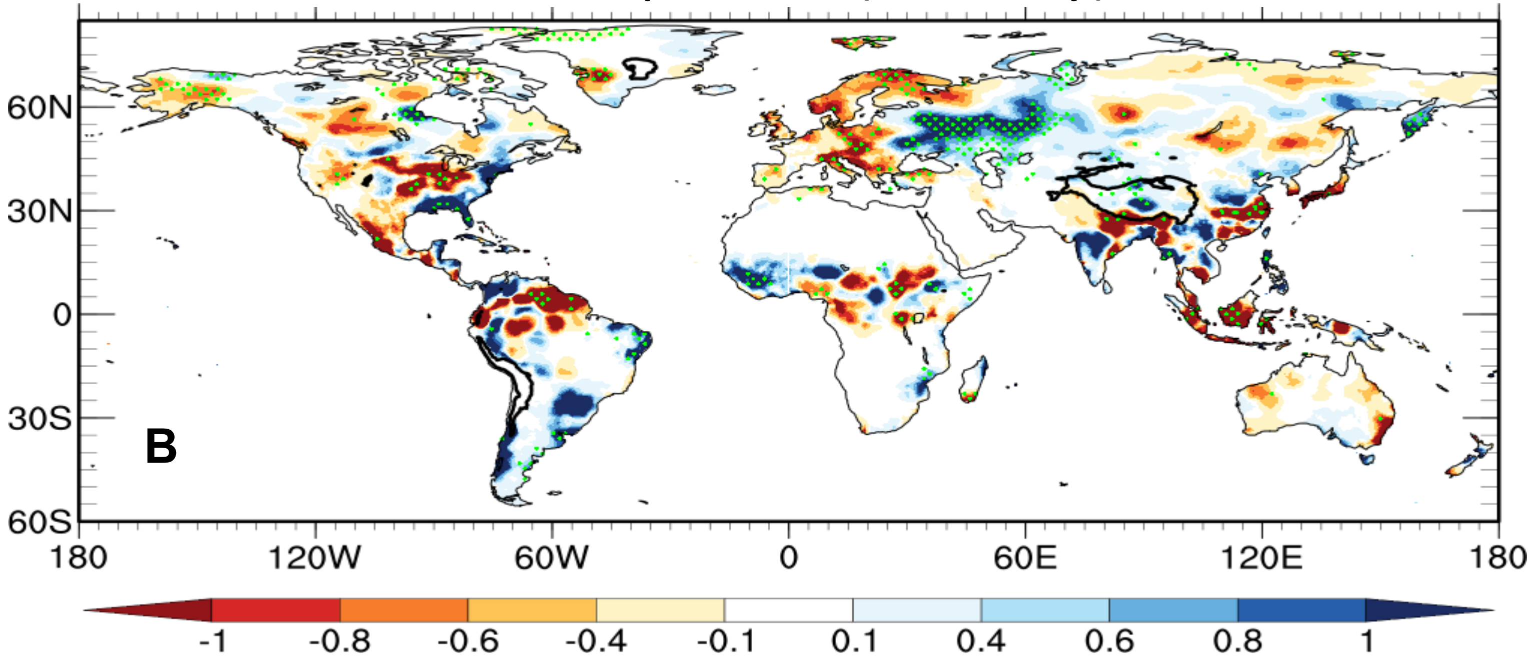


Observed differences between five cold and five warm Mays in the Tibetan Plateau

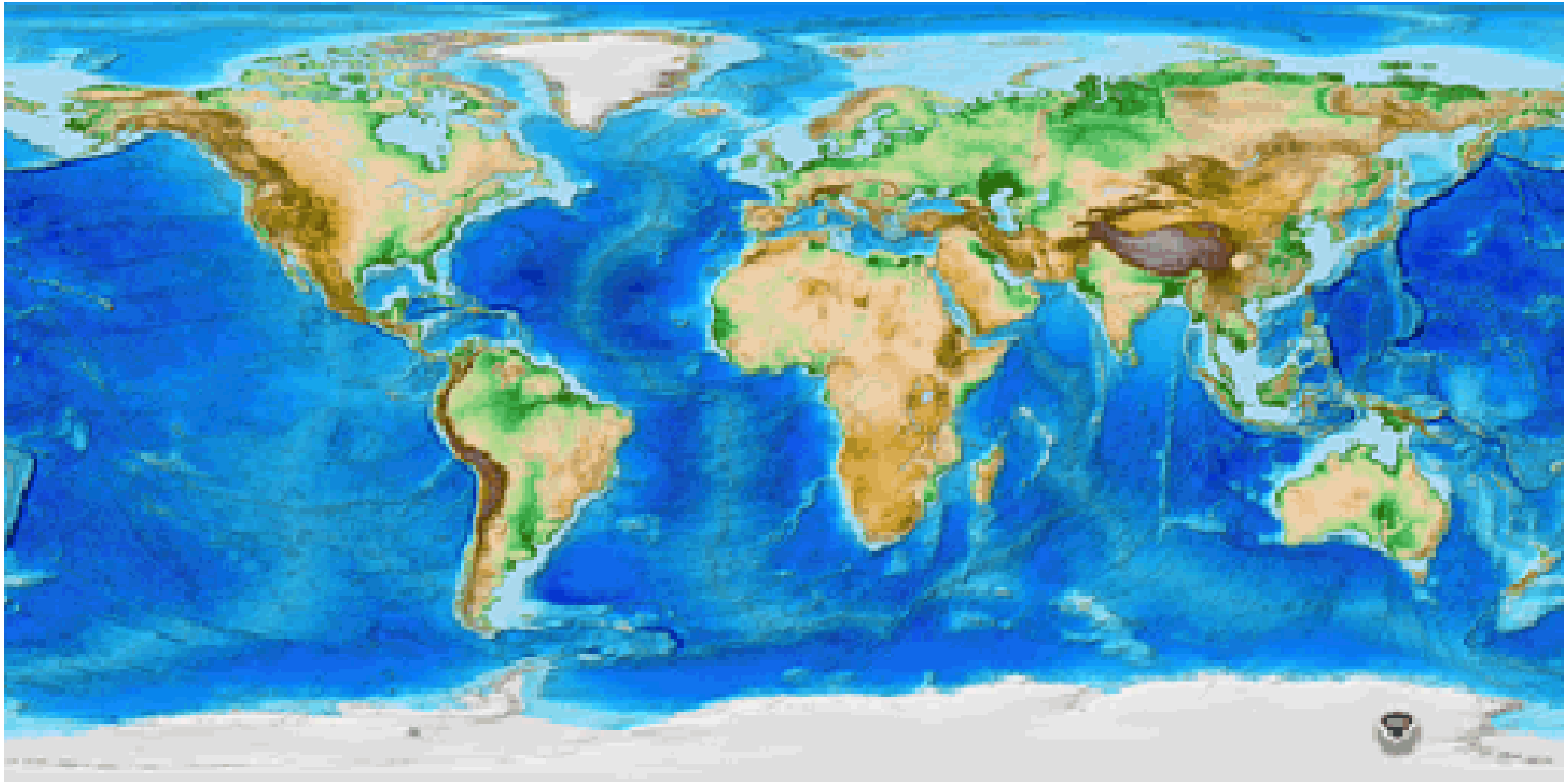
May 2m-Temperature (°C)



June Precipitation (mm/day)

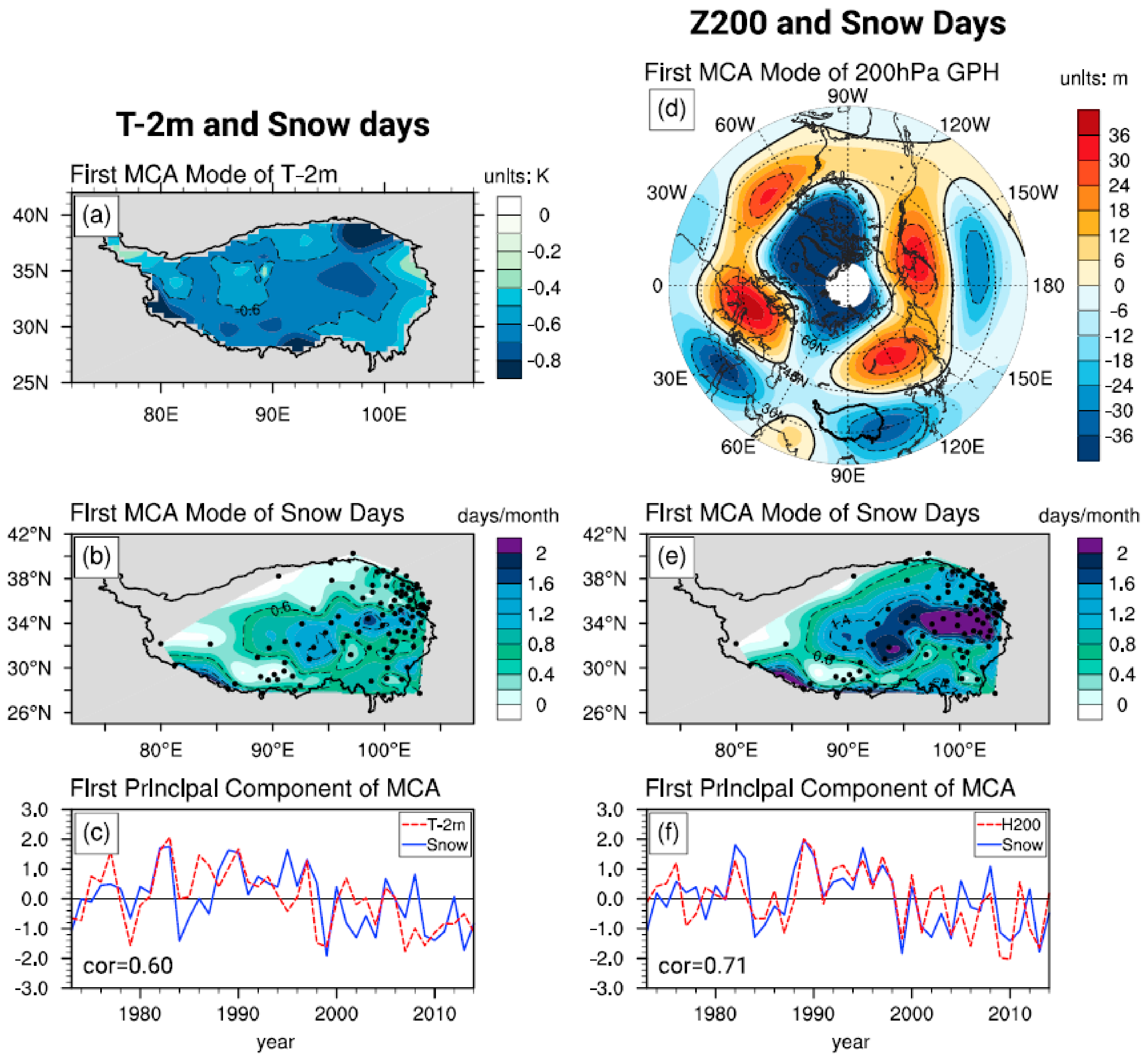


3. Other high mountain regions



4. LST/SUBT Anomaly Causes
The relationship with snow, including aerosol in snow, arctic circulation in winter, SUBT memory, etc.

5. Possible mechanisms



T-2m: April-May
Snow: Feb-April
GHP: Feb.

Zhang et al., 2019 GRL

Publications

Xue, Y., Yao, T., Boone, A. A., Diallo, I., Liu, Y., Zeng, X., Lau, W. K.-M., Sugimoto, S., Tang, Q., Pan, X., van Oevelen, P. J., Klocke, D., Koo, M.-S., Lin, Z., Takaya, Y., Sato, T., Ardilouze, C., Saha, S. K., Zhao, M., Liang, X.-Z., Vitart, F., Li, X., Zhao, P., Neelin, D., Guo, W., Yu, M., Qian, Y., Shen, S. S. P., Zhang, Y., Yang, K., Leung, R., Yang, J., Qiu, Y., Brunke, M. A., Chou, S. C., Ek, M., Fan, T., Guan, H., Lin, H., Liang, S., Materia, S., Nakamura, T., Qi, X., Senan, R., Shi, C., Wang, H., Wei, H., Xie, S., Xu, H., Zhang, H., Zhan, Y., Li, W., Shi, X., Nobre, P., Qin, Y., Dozier, J., Ferguson, C. R., Balsamo, G., Bao, Q., Feng, J., Hong, J., Hong, S., Huang, H., Ji, D., Ji, Z., Kang, S., Lin, Y., Liu, W., Muncaster, R., Pan, Y., Peano, D., de Rosnay, P., Takahashi, H. G., Tang, J., Wang, G., Wang, S., Wang, W., Zhou, X., and Zhu, Y., 2021: **Impact of Initialized Land Surface Temperature and Snowpack on Subseasonal to Seasonal Prediction Project, Phase I (LS4P-I): Organization and Experimental design**, ***Geosci. Model Dev.***, 14, 4465–4494, https://doi.org/10.5194/gmd-14-4465-2021.

Xue Y., I. Diallo, A. A. Boone, T. Yao , Y. Zhang, X. Zeng, J. D. Neelin, W. K.M. Lau , Y. Pan, Y. Liu1, X. Pan, Q. Tang, P. J. van Oevelen, T. Sato, M.-S. Koo, S. Materia, C. Shi, J. Yang, C. Ardilouze, Z. Lin, Xin Qi, T. Nakamura, S. K. Saha, R. Senan, Y. Takaya, H. Wang, H. Zhang, M. Zhao, H. P. Nayak, Q. Chen, J. Feng, M. A. Brunke, T. Fan, S. Hong, P. Nobre, D. Peano, Y. Qin, F. Vitart, S. Xie, Y. Zhan, D. Klocke, R. Leung, X. Li, M. Ek, W. Guo, G. Balsamo, Q. Bao, S. C. Chou, P. de Rosnay, Y. Lin, Y. Zhu, Y. Qian, P. Zhao, J. Tang, X.-Z. Liang, J. Hong, D. Ji, Z. Ji, Y. Qiu, S. Sugimoto, W. Wang, K. Yang, M. Yu, 2022: **Spring Land Temperature in Tibetan Plateau and Global-Scale Summer Precipitation – Initialization and Improved Prediction**. ***Bulletin of American Meteorological Society.*** DOI: https://doi.org/10.1175/BAMS-D-21-0270.1 . **December issue**