Prospective for the LS4P project and brief overview of the LS4P preliminary plan for discussion

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International Workshop of First Phase of GEWEX/GASS LS4P Initiative and TPEMIP
Washington D.C., December 8-9, 2018

This LS4P project aims to pursue a new approach, i.e., the effect of land surface temperature (LST) and subsurface temperature (SUBT), as well as associated effect of snow and aerosol in snow, contributing to the S2S prediction, especially the droughts/floods events, and understand related mechanisms, which will complement the effect of SST, soil moisture, and vegetation in this subject.

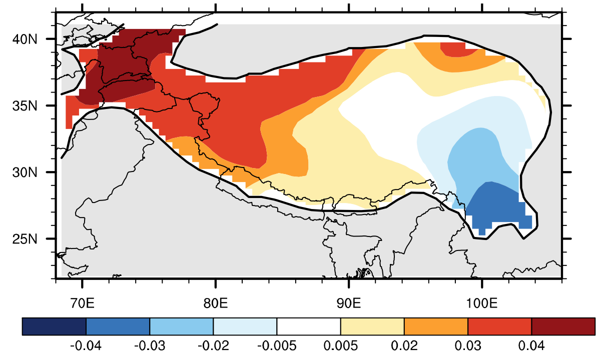
- What is the impact of the initialization of large scale LST/SUBT and snow pack, including the aerosol in snow, in climate models on the S2S prediction over different regions?
- What is the relative role and uncertainties in these land processes versus in SST in S2S prediction? How do they synergistically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

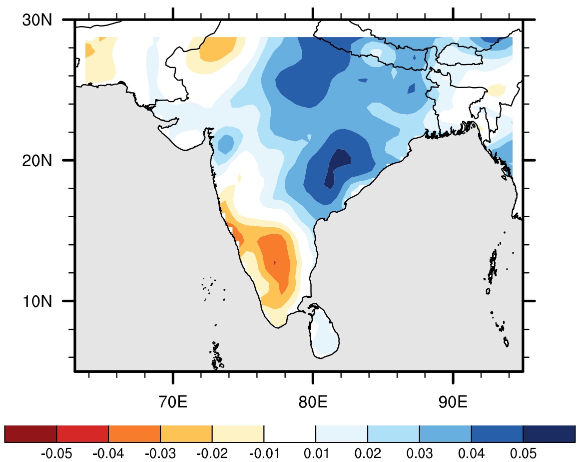
I). Demonstrating the potential in using LST/SUBT for S2S prediction

1) ESM approach with selected regions and seasons; some exploratory tests with statistical forecast. The first phase focuses on Tibetan Plateau LST/SUBT and will tests its effect on East, South, Northeast, Southeast, and Central Asia.

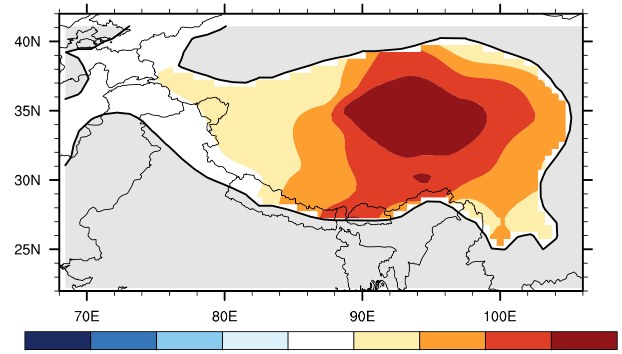
MCA analysis for TP May T-2m VS. June Precipitation

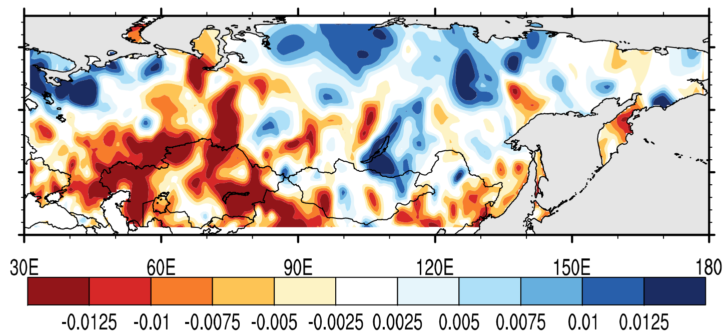
South Asia MCA I



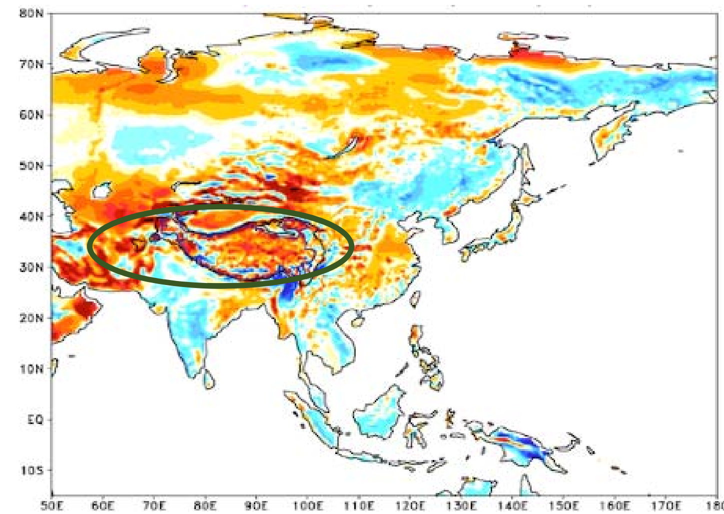


Eurasia MCAI

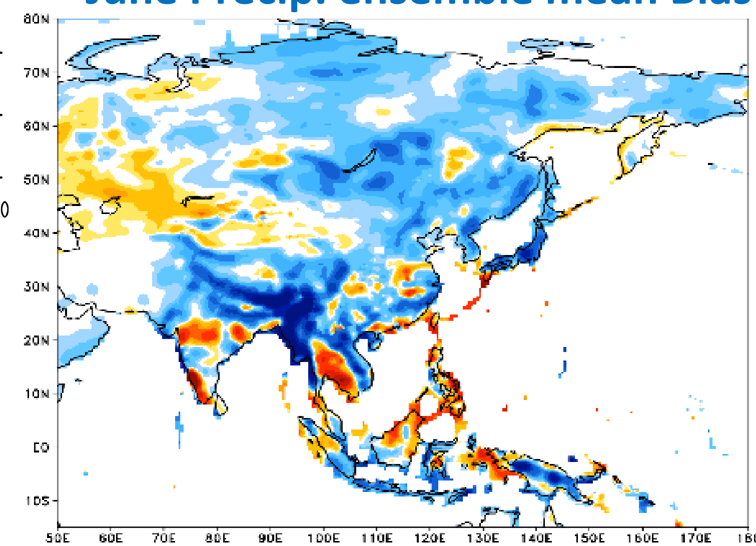




May T-2m ensemble mean Bias



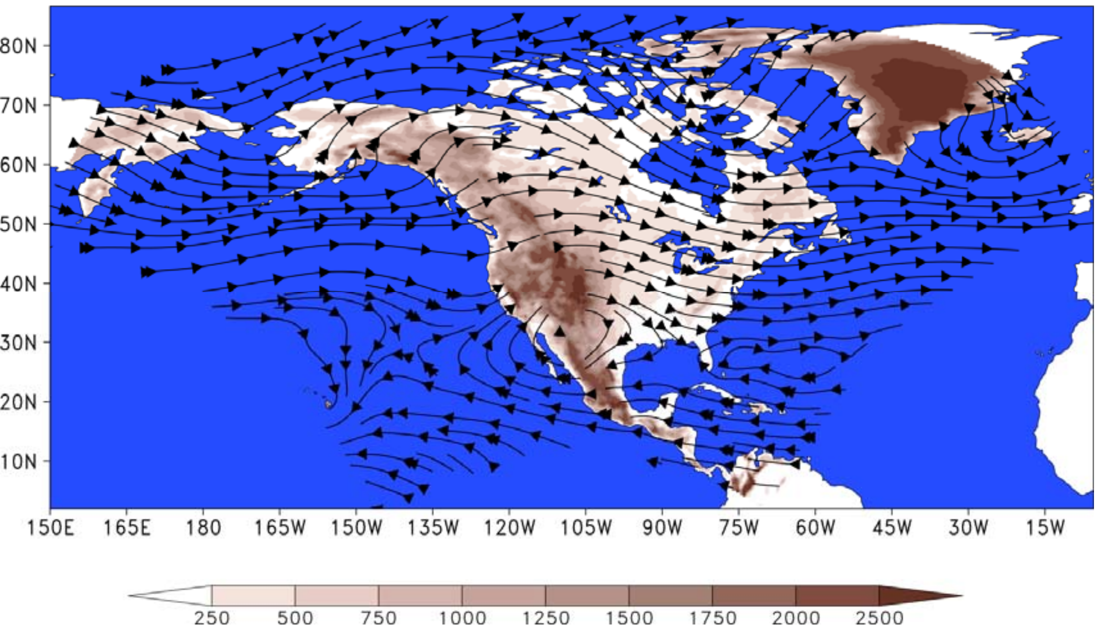
June Precip. ensemble mean Bias



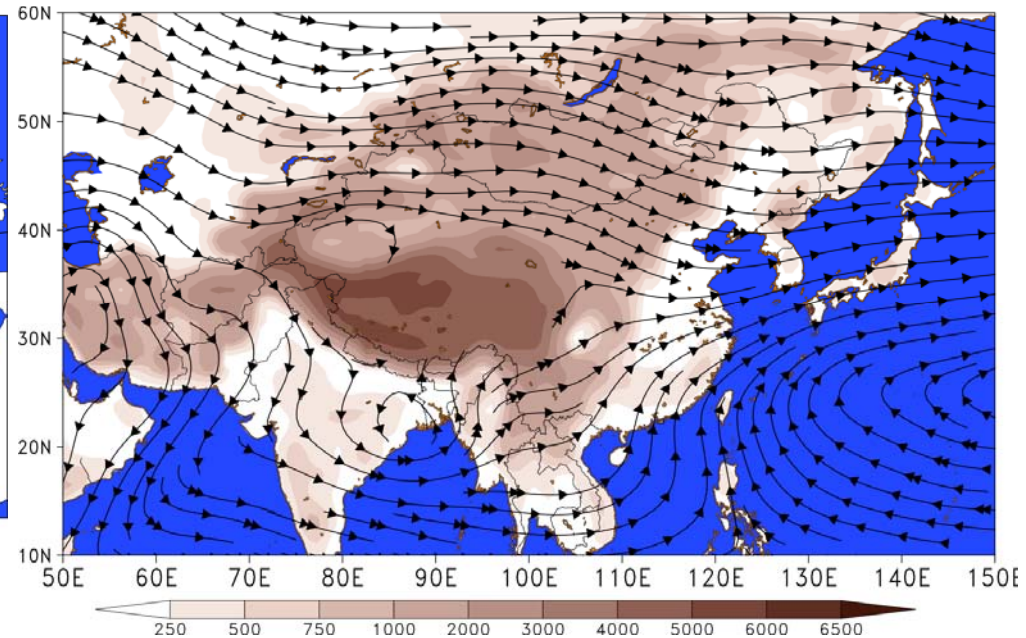
1). Demonstrating the potential in using LST/SUBT for S2S prediction

1a) In the second phase and 3rd phase, ESMs will identify Rocky Mountain LST/SUBT effects.

North American

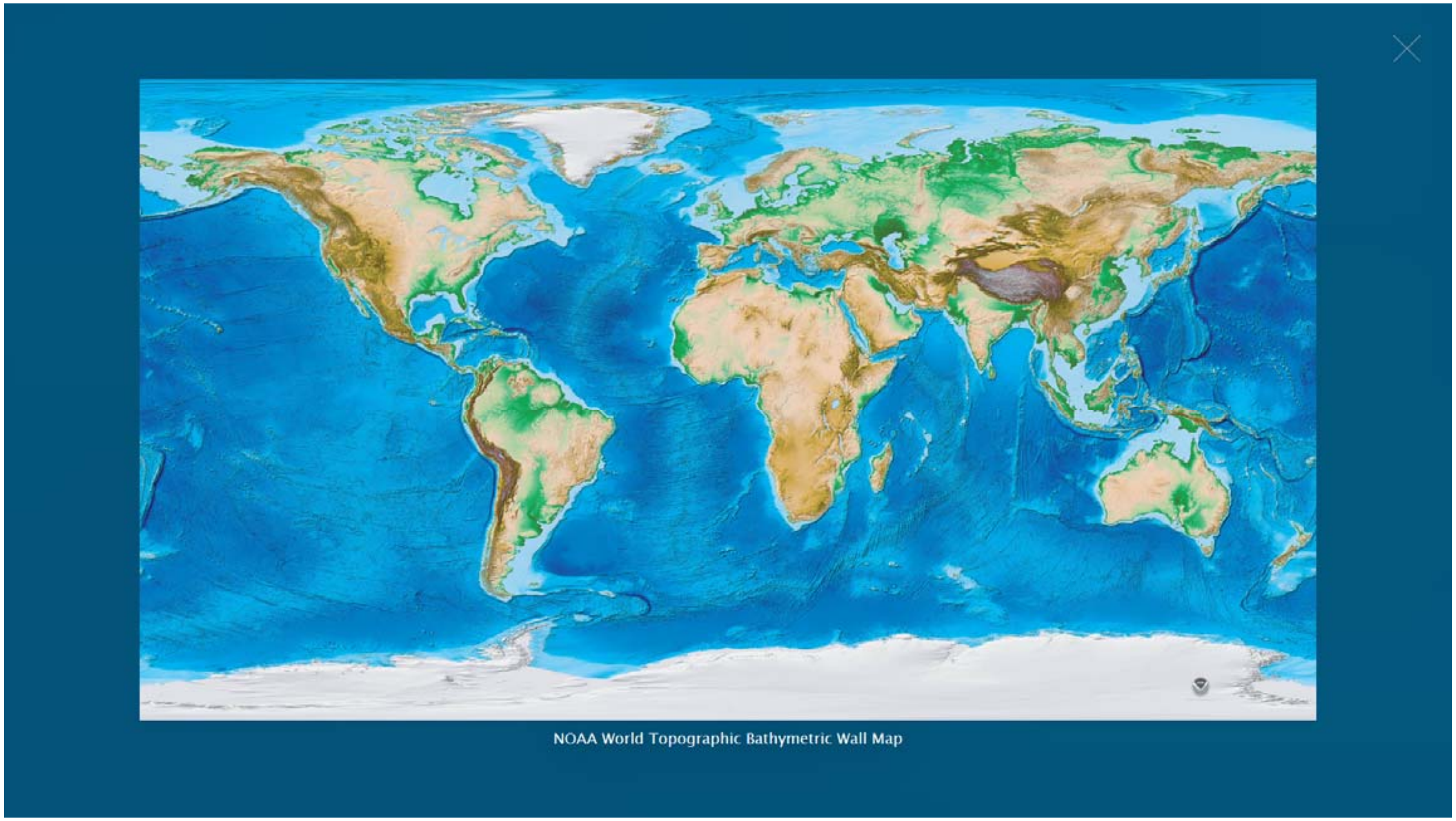


East Asia



1). Demonstrating the potential in using LST/SUBT for S2S prediction

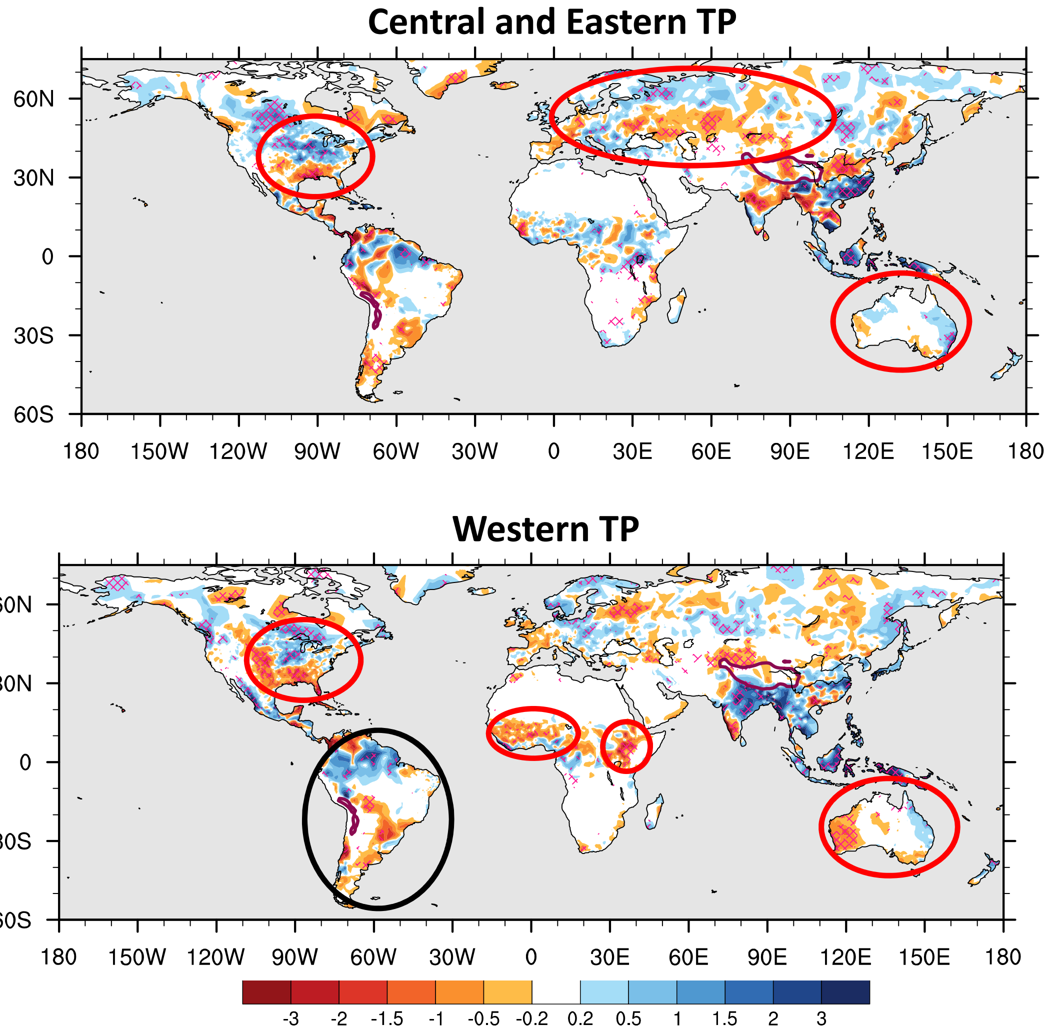
1a) In the second 3rd phase, ESMs will identify Andes Mountain LST/SUBT effects.



I). Demonstrating the potential in using LST/SUBT for S2S prediction

2) Data Analyses to show the relationship between T-2m/LST and Precipitation for different major mountains and to identifying hot sports over global where LST has great impacts, preliminary applications for statistic forecast.

Observed June Precip. Differences between Warmest and Coldest Years



Impacts of climate variability over Tibet on North American drought development during boreal spring and summer

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Drought is one of the most expensive recurring nature disasters to affect North America. Mitigating the societal impacts of droughts requires an advanced scientific understanding of the processes that drive them, as well as a proper incorporation of these processes in forecast models in order to provide reliable drought prediction and early warning systems. The prediction skill of warm season drought over North America in current operational forecasting systems, drought development in particular, however, is virtually nonexistent. This study investigates the causes of warm season drought development over North America by connecting them to climate variability over Tibet and nearby regions, and identifies processes that a forecast model needs to capture in order to properly represent the effects of the climate variations over Tibet. The results are based on an integrated analysis of observations, reanalyses, a suite of NASA GEOS-5 regional replay experiments and an assessment of prediction capability in the operational Subseasonal Forecasts project (SubX). It has been found that the development of a number of warm season droughts over North America were initiated by processes over central and east Asia via cross-North Pacific Rossby wave energy propagation. In particular, the variations of surface temperature over Tibet as well as subseasonal convective anomalies associated with the east Asian summer monsoon can potentially impact the North American drought development via exerting a downstream zonal wave train that propagate eastward under the Northern Hemisphere (NH) jet stream. Such impact mainly occurs during the months of May and June, during which the atmospheric basic flow, particularly the north Pacific jet, is relatively strong and facilities such wave train propagation. In order to properly represent these processes, a forecast model needs to be skillful in predicting the sources of the wavetrain and have a correct simulation of the jet stream over the north Pacific and North America. An evaluation of the SubX forecasts, however, shows an overall limited skill in representing the above processes. An additional investigation of the NASA GEOS-5 model biases and their global impacts, via a suite of comprehensive regional replay experiments, shows that the main sources of model bias in the NH middle latitudes appear to be over Tibet and nearby regions. These results point to the importance of correctly modeling processes over Tibet and nearby regions in order to improve the simulation and prediction of their local and remote impacts, including the warm season drought development over North America.

Spring soil temperature in central Asia has been used as a predictor of summer heatwaves over northwestern China.

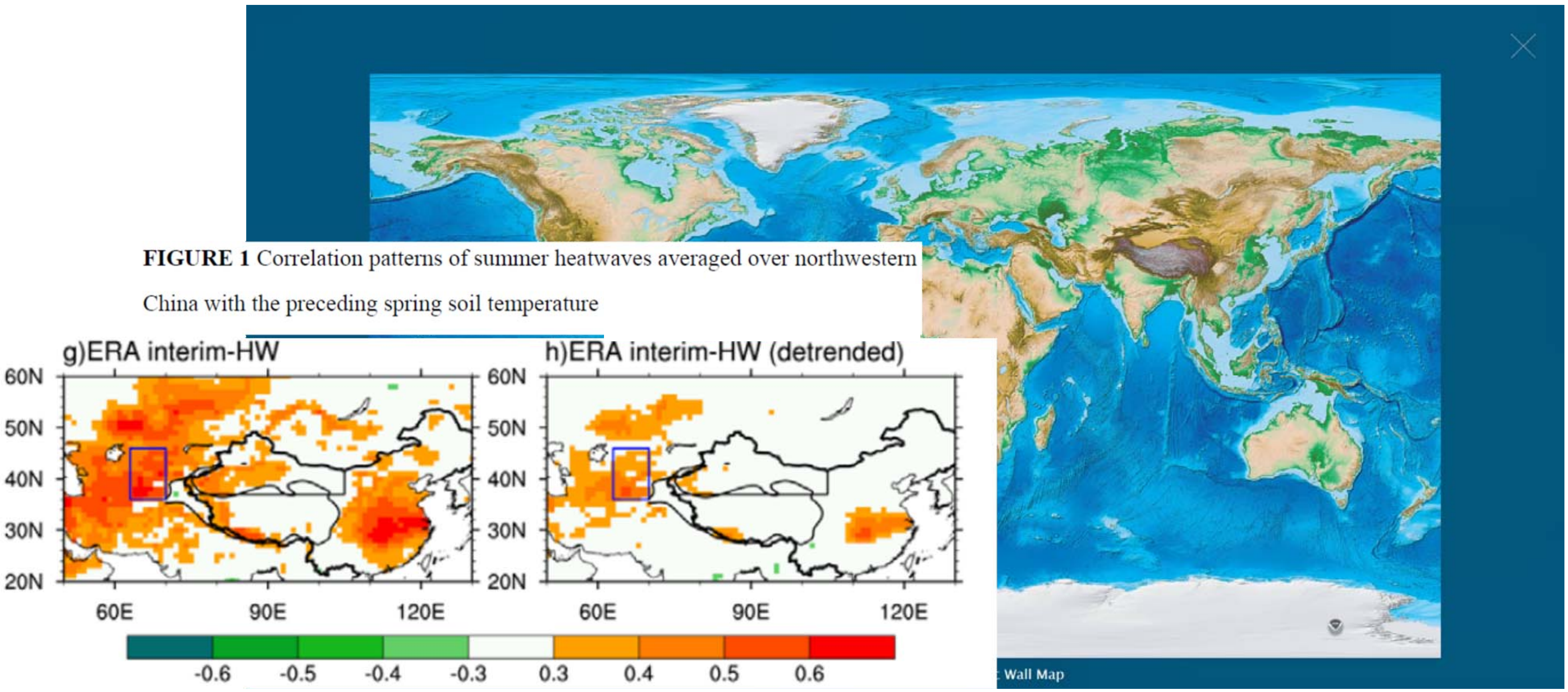
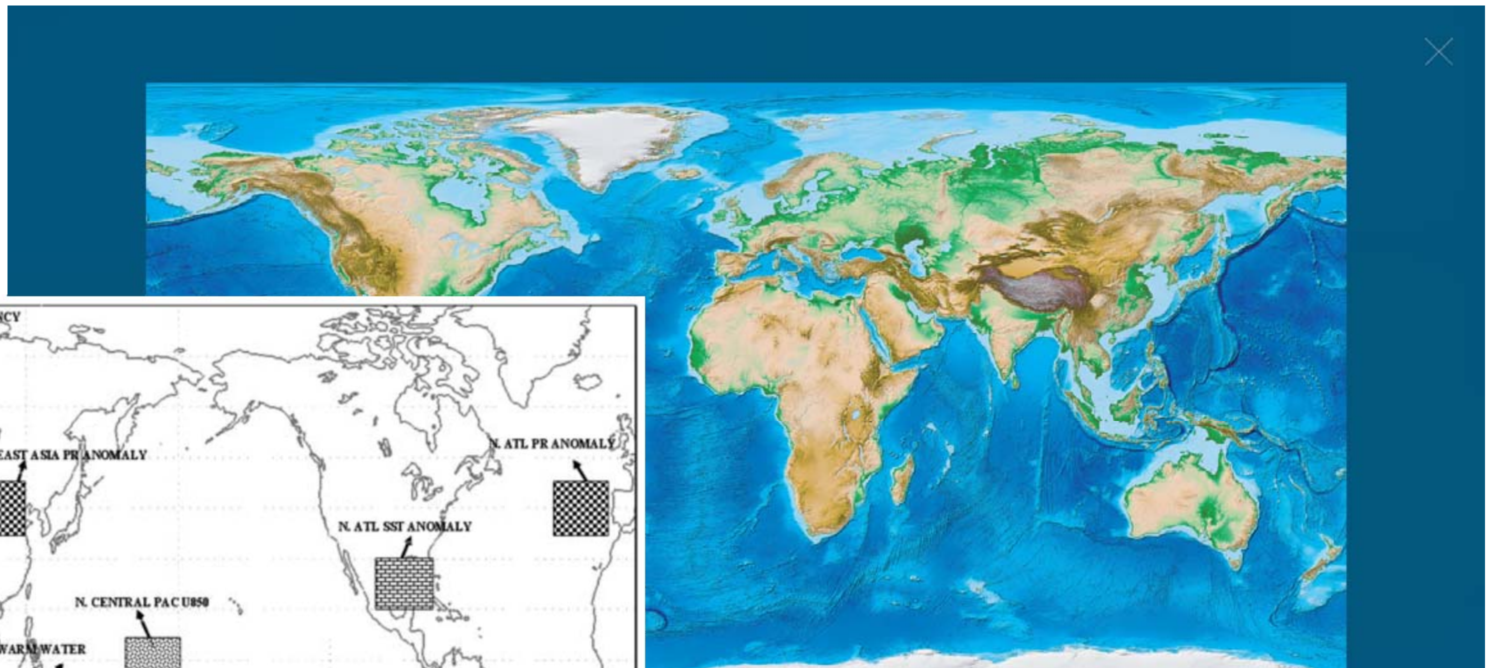
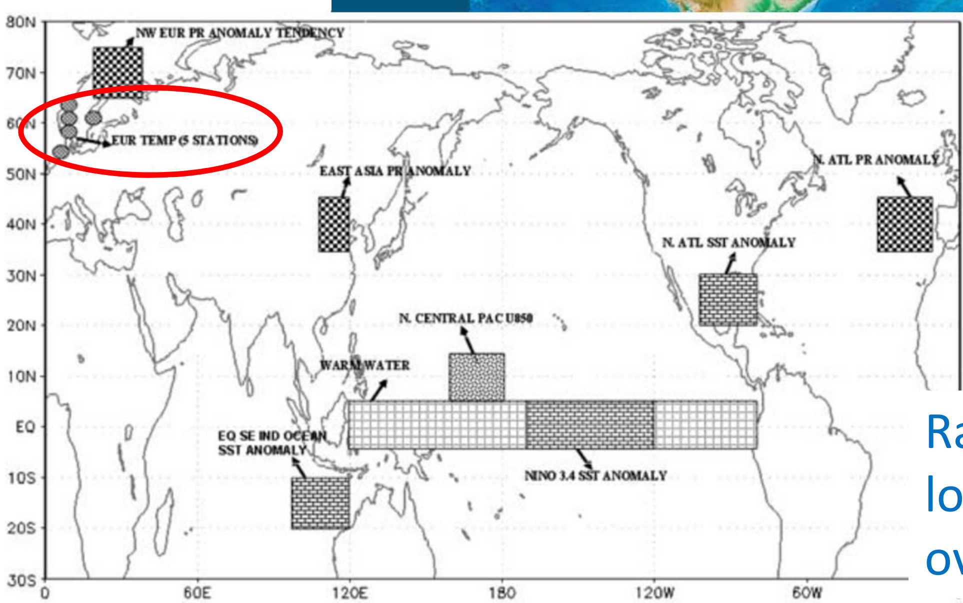


FIGURE 1 Correlation patterns of summer heatwaves averaged over northwestern China with the preceding spring soil temperature

Yang, Zhanmei et al., 2019.

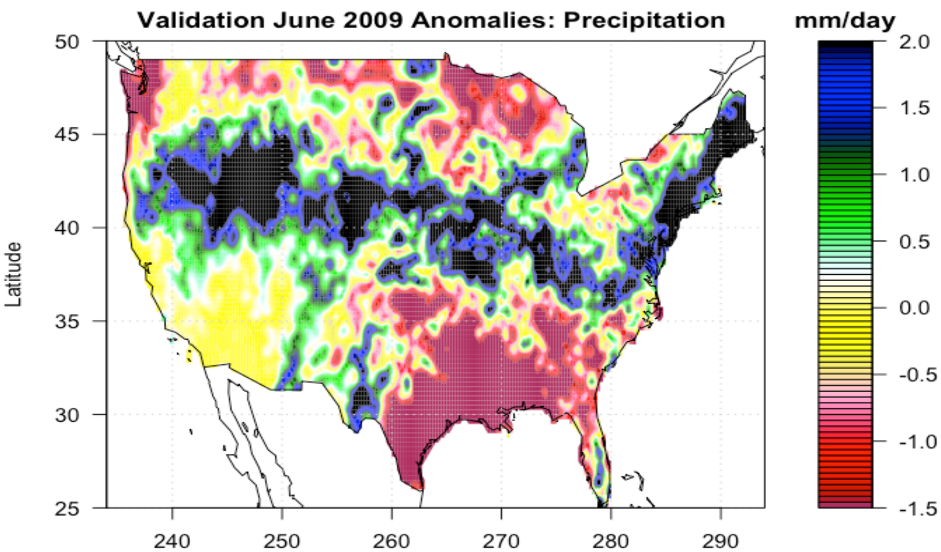
Five N. Europe station Temperatures have been used as an Indian monsoon predictor

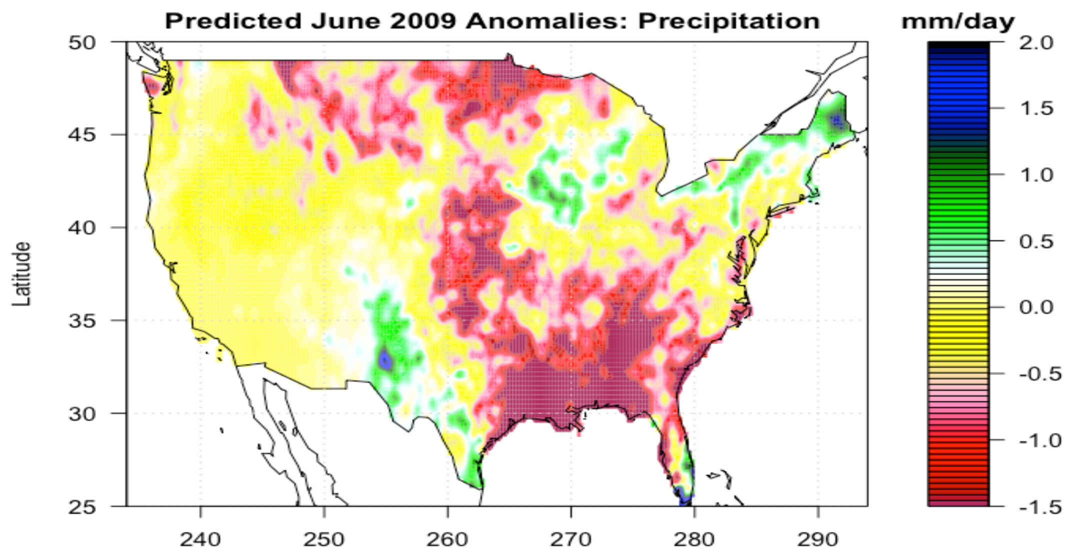




Rajeevan, M., et al., 2007, New statistical models for long-range forecasting of southwest monsoon rainfall over India. Climate Dynamics

Evidence in Statistic prediction



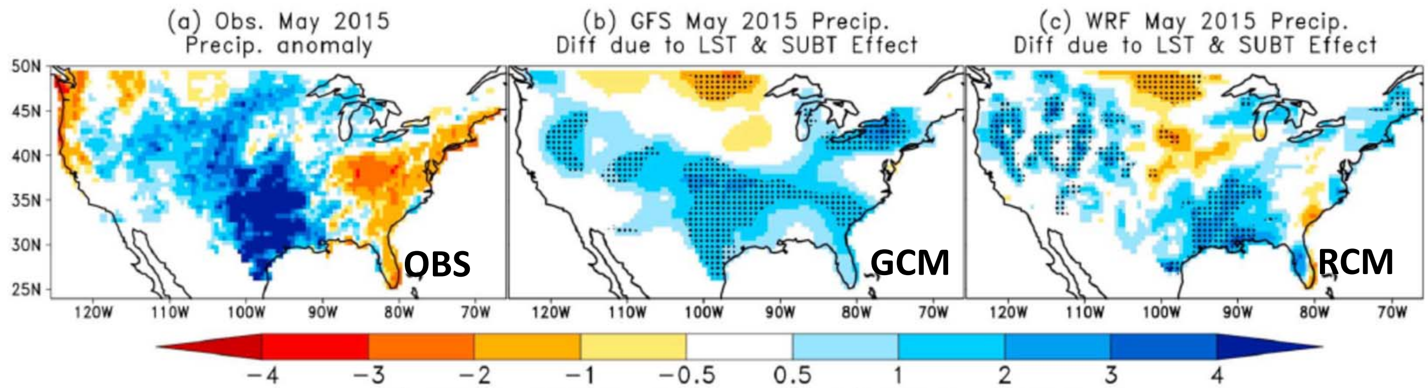


Sam Shen, SDSU

I). Demonstrating the potential in using LST/SUBT for S2S prediction

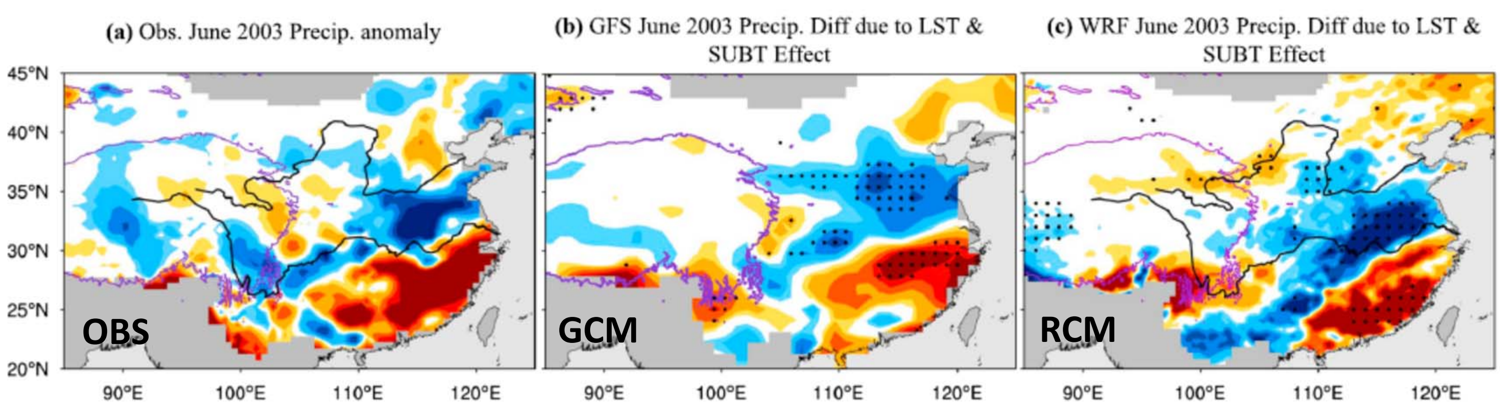
3) Demonstrating RCM downscaling effects in S2S prediction.

May 2015 N. American study

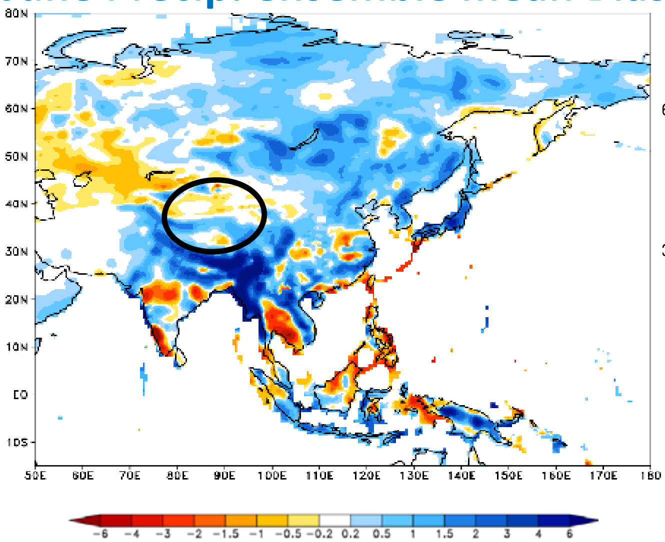


Xue et al., 2018, JGR

June 2003 E. Asian study

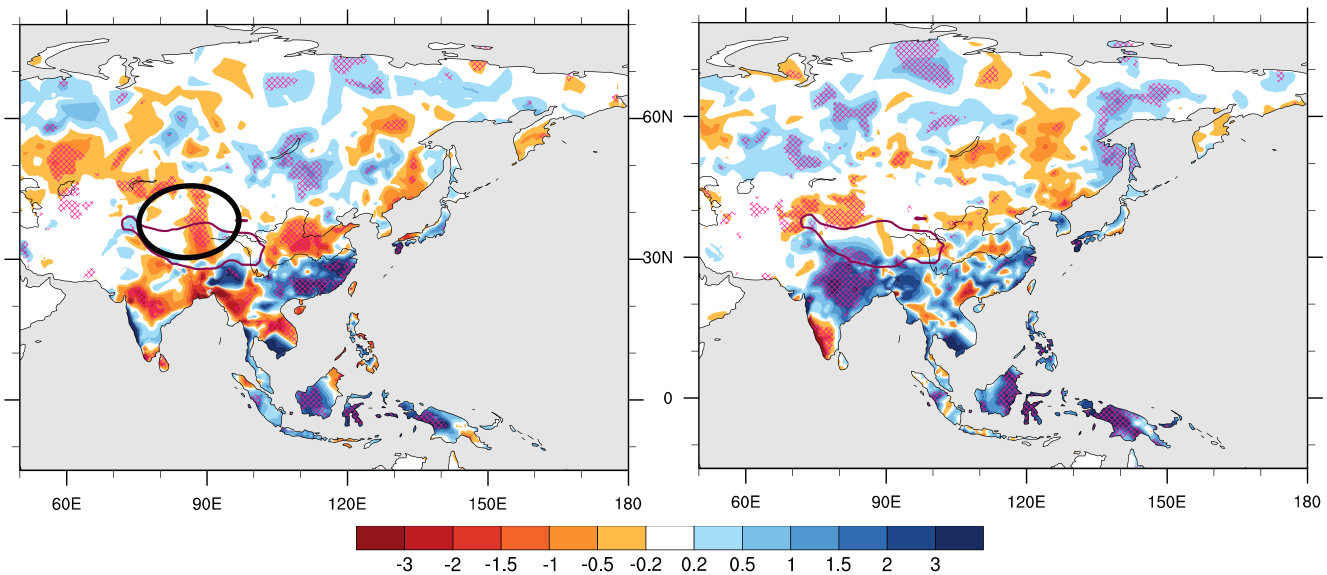


June Precip. ensemble mean Bias



Observed June Prec. Diff. between Warmest and Coldest Years

Central and Eastern TP / Western TP



June ensemble mean precipitation biases in TP areas NOT are in general agreement with the June precipitation anomalies between eastern-central TP/western TP warm years minus cold years

Applications of Observed TPE Data in RCM study

Multi-model Intercomparison in Asia: *From RMIP to TPEMIP*

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Nanjing University

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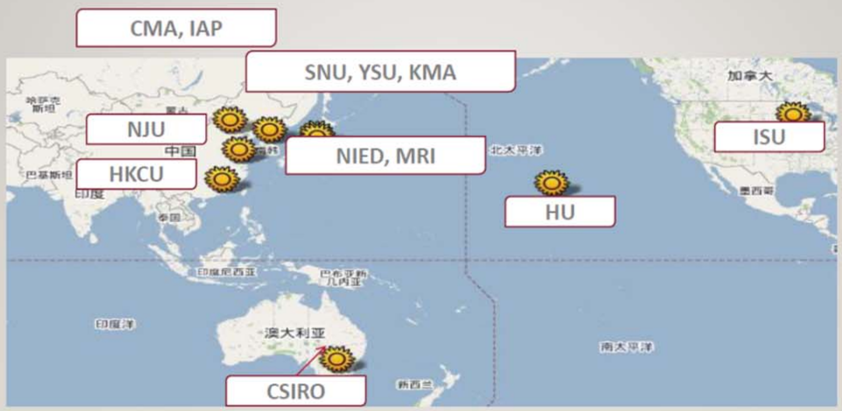
Long History of Collaboration on Regional Climate Studies

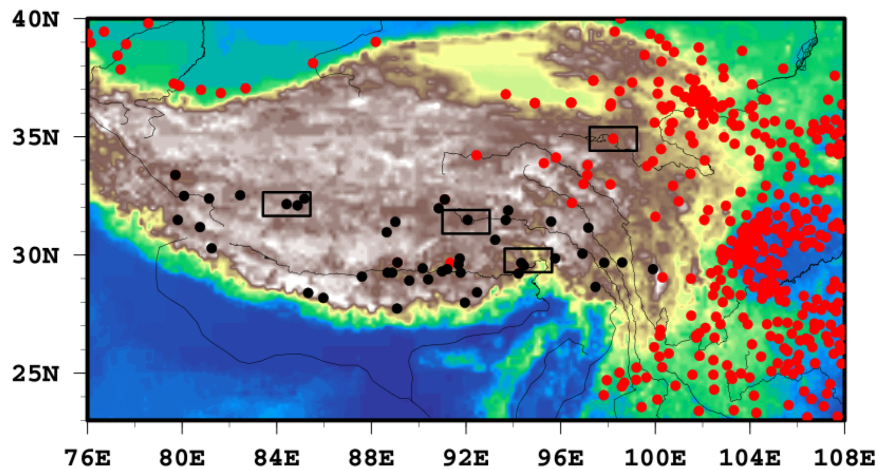


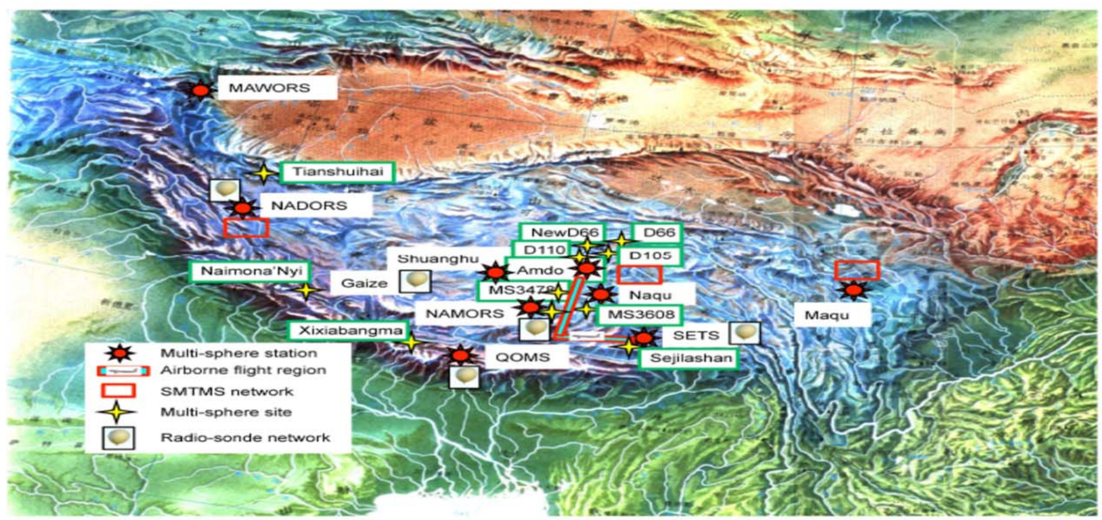
- universities, research institutes, government sponsored research agencies;
- collaboration involving scientists working on modelling, observation, *and end users;*
- *From RMIP to CORDEX, to TPEMIP*

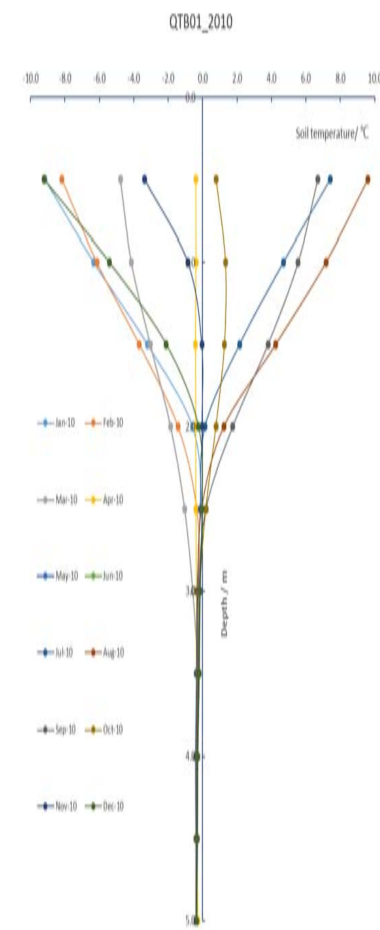
TPE and TOPEX III's Comprehensive Measurements Data Sets

Soil Temperature & Moisture Observations

- Red：operational observations
- lack：newly-established sites
- Box: regional intensive network



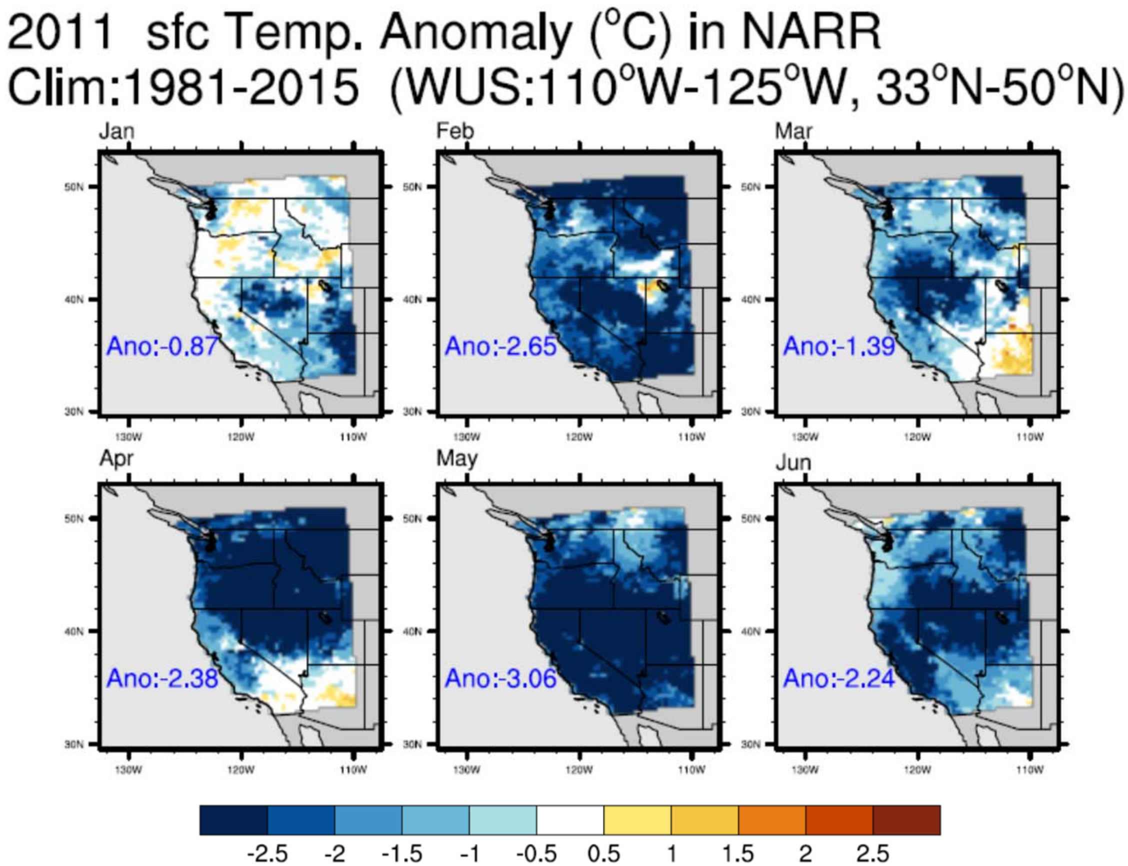


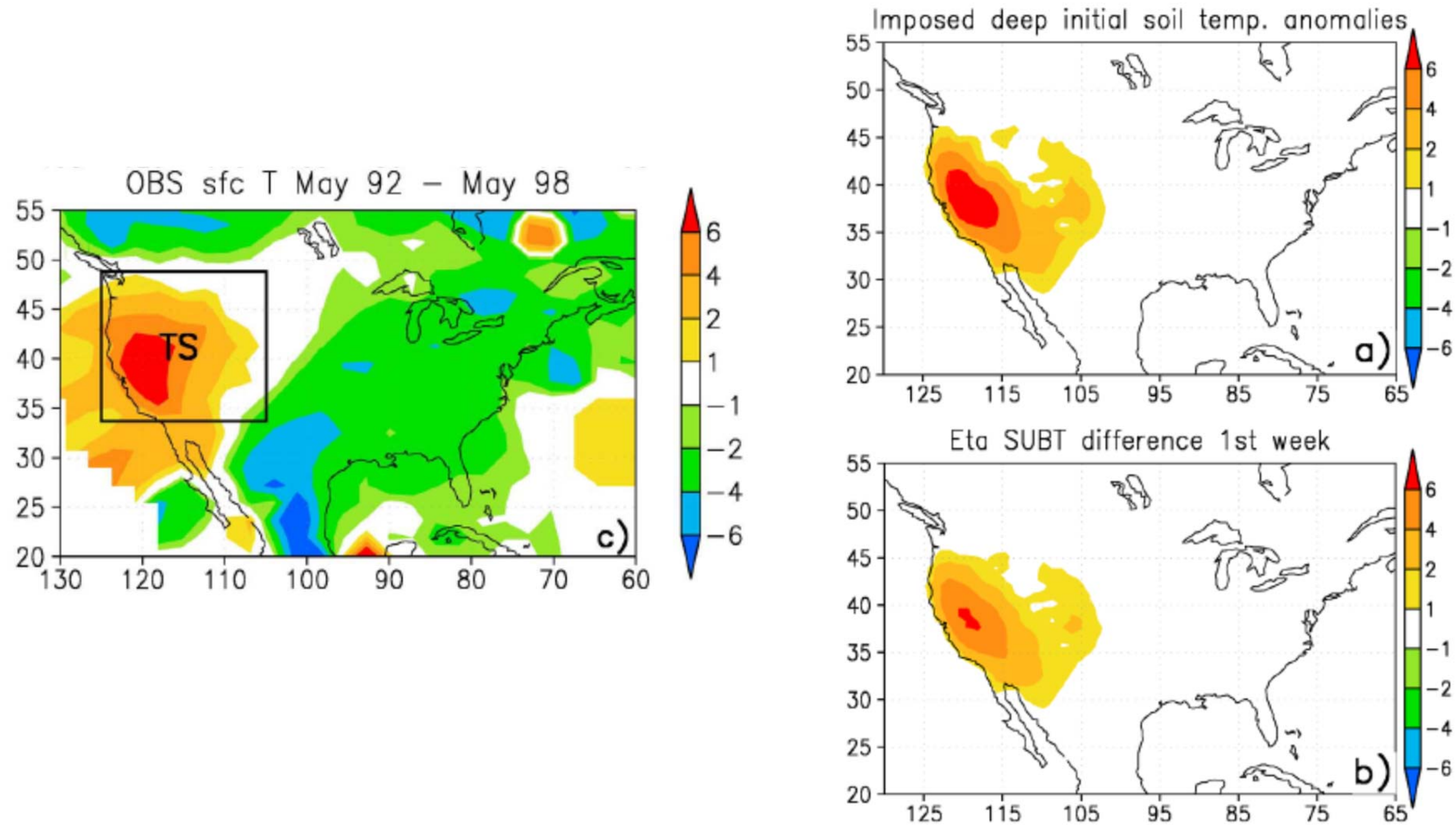


Other challenge Issues:

Large Domain RCM and high Resolution ECM

I). Demonstrating the potential in using LST/SUBT for S2S prediction
4) Improving land model and developing the land model initialization strategy (especially for multiple layer soil models).

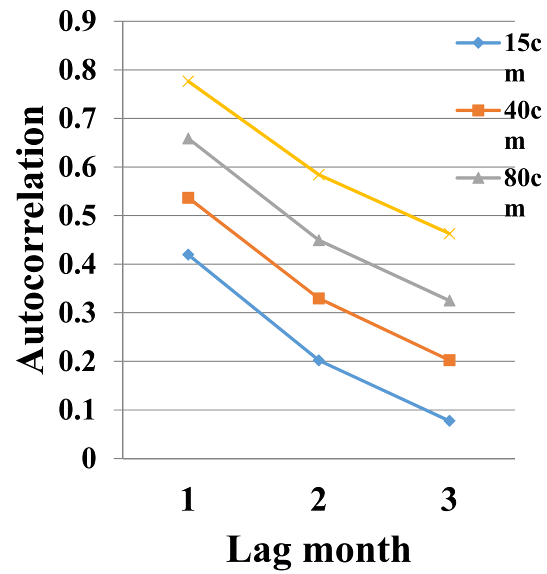




OBS sfc T May 92 – May 98
TS
c)
55 50 45 40 35 30 25 20
130 120 110 100 90 80 70 60
6 4 2 1 −1 −2 −4 −6
Imposed deep initial soil temp. anomalies
a)
55 50 45 40 35 30 25 20
125 115 105 95 85 75 65
6 4 2 1 −1 −2 −4 −6
Eta SUBT difference 1st week
b)
55 50 45 40 35 30 25 20
125 115 105 95 85 75 65
6 4 2 1 −1 −2 −4 −6

Soil Memory based on Tibetan observations

	Persistence
15cm	1.18
40cm	2.05
80cm	2.83
160cm	3.86



<u>FIG. S1</u>. Relationship of autocorrelation vs the time lag, for various thicknesses of soil layers. For convenience, the persistence, which is based on the slope of the lines on the left panel, is listed in the table. They are calculated based on the method described in Entin et al. (2001) and Hu and Feng (2004).

Soil Memory based on observations

	Persistence
15cm	1.18
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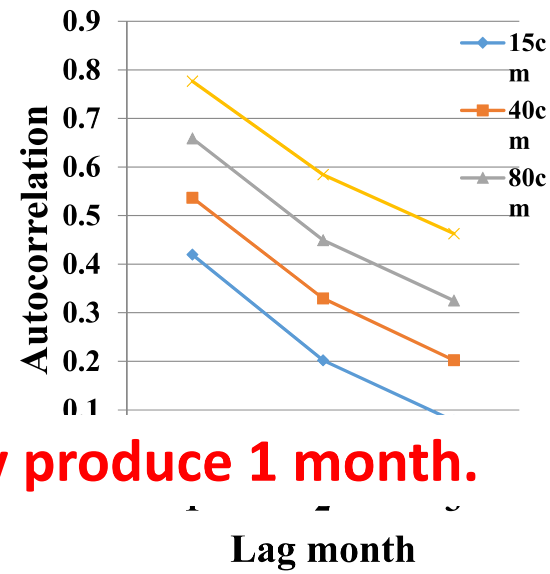
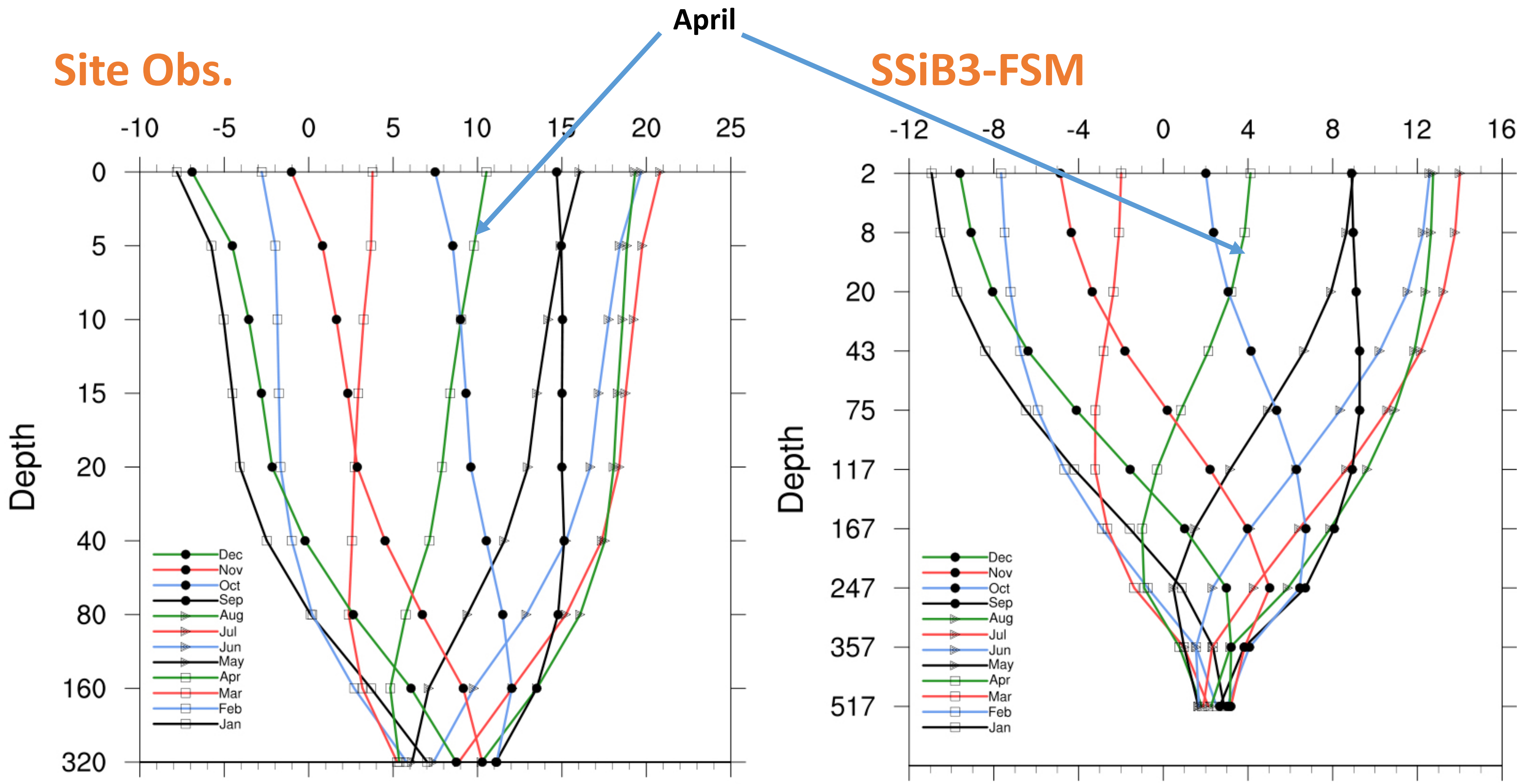


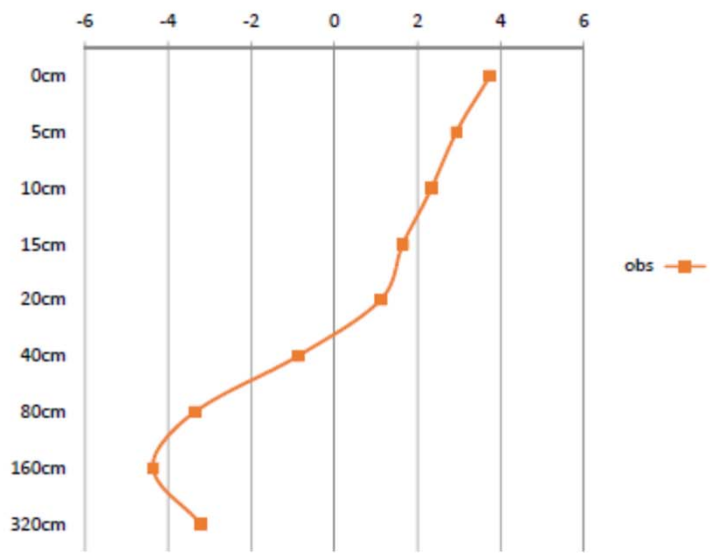
The force restore can only produce 1 month.

FIG. S1. Relationship of autocorrelation vs the time lag, for various thicknesses of soil layers. For convenience, the persistence, which is based on the slope of the lines on the left panel, is listed in the table. They are calculated based on the method described in Entin et al. (2001) and Hu and Feng (2004).

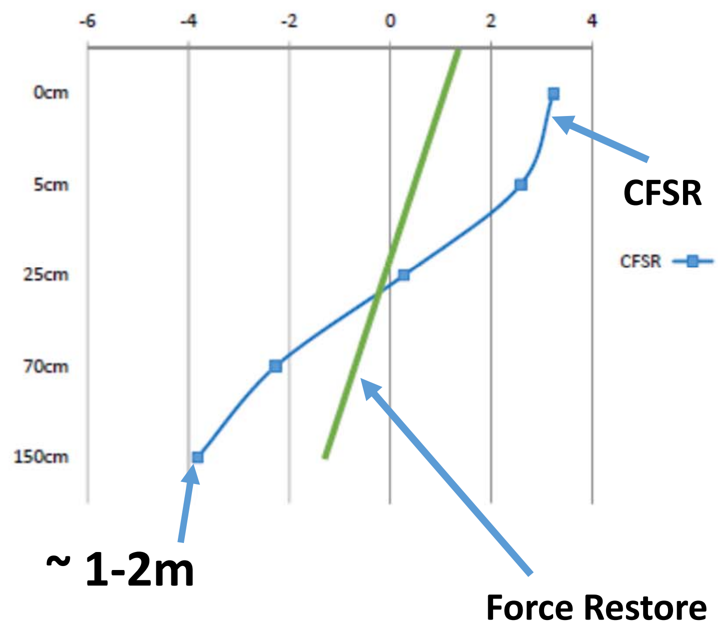
Soil temp. profile between ssib3fsm with obs over TP



Observed Soil T Profile



Reanalysis and Force Restore T Profile

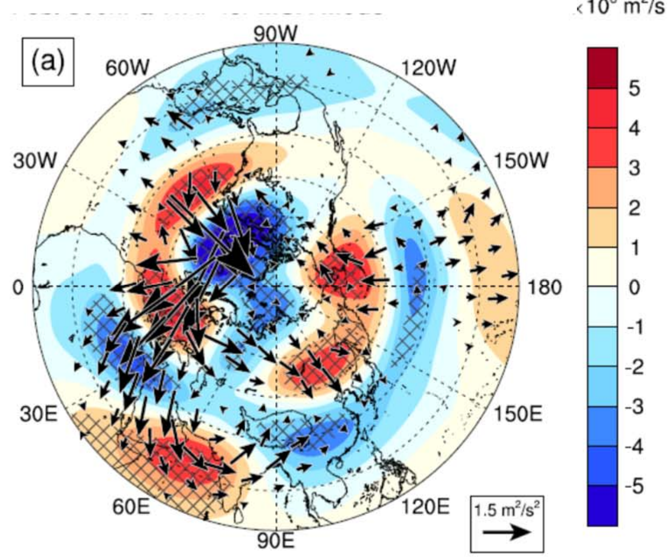


April soil temperature Profile over the Tibetan Plateau

1). Demonstrating the potential in using LST/SUBT for S2S prediction
5). Identifying the source of LST/SUBT anomalies and other mechanism study

Feb. 300hP WAF 1st MCA Mode

WAF: Wave Activity Flux.



Feb. 300hPa WAF for **+AO**

Feb. 300hPa WAF for **-WP**

Zhang, Yang et al., 2019.

Data Issue

1). Large-scale LST and SUBT data are still lacking.

2). Reanalyses: a number of studies have pointed out problems in reanalysis surface products For instance, May TP soil temperature profiles from TP observational stations (Yang & Zhang, 2016) shows that the te mperature warms at the surface then cools down until about 1.5 m then it warms again, a sign of the memory from previous months. The CFSR shows a straight cooling from the surface to 2 m in the soil.

Moreover, the CAMS and NMIC (2012) show that the mean May surface temperature over TP in 2003 was 1.2 °C, a cold year as mentioned before. The CFSR data show that the May 2003 TP surface temperature was 4.59 °C, a quite warm year.

Prospective

I). Demonstrating the potential in using LST/SUBT for S2S prediction

1) ESM approach with selected regions and seasons; some exploratory tests with statistical forecast. The first phase focuses on Tibetan Plateau LST/SUBT and will tests its effect on East, South, Northeast, southeast, and Central Asia. In the second phase and 3^{rd} phase, ESM will identify Rocky Mountain and Andes Mountain LST/SUBT effects, respectively.

2) Data Analyses to show the relationship between T-2m/LST and Precipitation for different major mountains and to identifying hot sports over global where LST has great impacts, preliminary applications for statistic forecast.

3) Demonstrating RCM downscaling effects in S2S prediction.

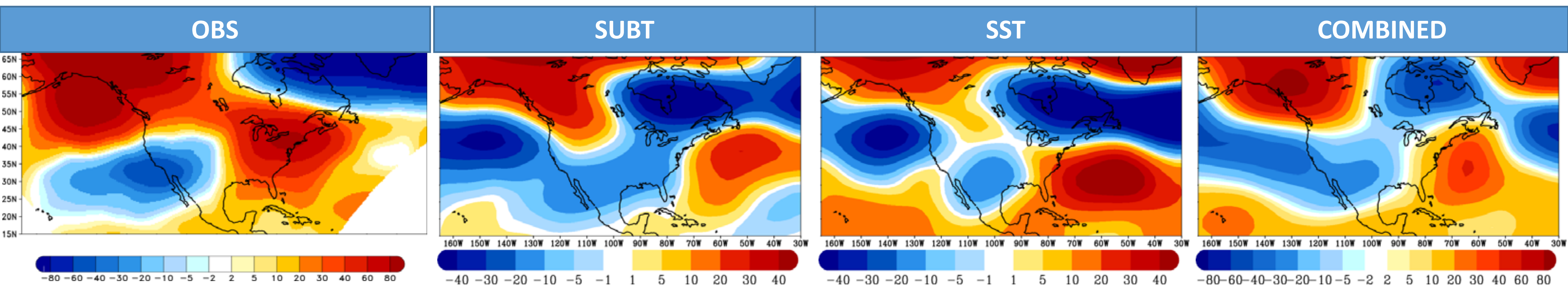
4) Improving land model and developing the land model initialization strategy (especially for multiple layer soil models).

5). Identifying the source of LST/SUBT anomalies and other mechanism study

II). Demonstrating how snow and aerosol in snow interacting with LST in enhancing S2S prediction

III). Identifying relative roles of SST and LST/SUBT in S2S. Develop strategy to using both LST/SUBT and SST to synergistically enhance the S2S predictability.

Hoping this project will stimulate measurements for soil temperature profiles and other relevant land variables (snow, GHF, etc.).


OBS
SUBT
SST
COMBINED
−40 −30 −20 −10 −5 −1 1 5 10 20 30 40
−40 −30 −20 −10 −5 −1 1 5 10 20 30 40
−80 −60 −40 −30 −20 −10 −5 −2 2 5 10 20 30 40 60 80

LS4P Plan for 2019

1). Evaluating ECM' ability in reproducing the May 2003 Tibetan Plateau Temperature anomaly and June precipitation anomaly, with the focus on the relationship between May T bias and June P bias. Simulation from around May 1 through June 30 with multi ensemble members.

2). 1st sensitivity experiment: Aiming to reproduce the observed May 2003 T-2m anomaly over Tibetan Plateau; and assessing with model-produced T-2m anomaly whether the model is able to reproduce the June observed precipitation anomaly over East, South, central Asia, etc. In the process, initialization scheme for reproducing the May T-2m anomaly will be developed.

3). Evaluation of RCM and GCM's performance over Tibetan Plateau with the observational data.

4). Further investigation with observational data and individual model to investigate T-2m anomalies over global mountains and their possible remote impacts.

6). Big impact paper based on (1), (2), and (3). Workshop (?) and a session in 2019 AGU (AMS?). A special Issue?

LS4P Plan for 2020-

1). Sensitivity for N. American region
2). Synthesize with SST
3). Testing effect of associated snow and aerosol in snow