LS4P Regional Climate Model Intercomparison : from Phase I to Phase II

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And
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Outline

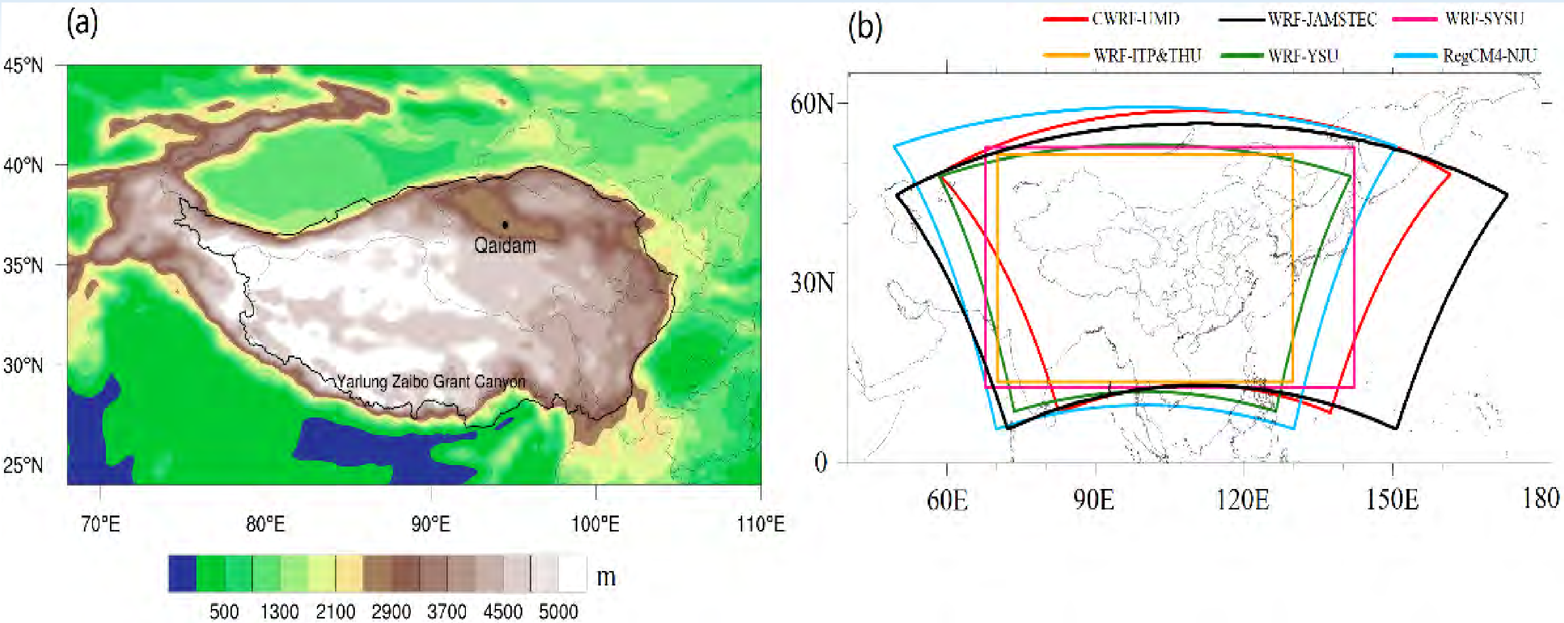
- **Summary of LS4P-I RCM Experiments**
- **LS4P-II RCM Intercomparison for Tibetan Plateau**
- **LS4P RCM Phase II Prototype Experiments**
- **Conclusions**

Summary of LS4P-I RCM Experiments

To assess the ability of RCMs to simulate the regional climate from later spring to summer over the TP with several LS4P regional models

LS4P-I RCM	Institutions	Land models	Cumulus schemes	Planetary Boundary Layer	Microphysics	Radiation	Forcing
CWRF-UMD (Liang et al., 2012, 2019)	University of Maryland	CSSP ((Liang et al., 2005a, 2005b, 2012; Choi et al. 2007, 2013)	ECP (Qiao and Liang, 2015, 2016, 2017)	CAM (Holtslag and Boville, 1993; Liang et al., 2006)	GSFCGCEE (Tao et al. 2003)	GSFCLXZ (Chou and Suarez, 1999; Chou et al., 2001; Liang and Zhang, 2013)	ERA-Interim (Dee et al., 2011)
WRF-JAMSTEC	Japan Agency for Marine-Earth Science and Technology	NOAH (Chen and Dudhia, 2001)	Grell-3D (Grell and Devenyi, 2002)	MYNN2.5 (Nakanishi and Niino, 2006)	Thompson (Thompson et al., 2008)	Dudhia (Dudhia, 1989) RRTM (Iacono et al., 2008; Baek, 2017)	ERA-Interim
WRF-SYSU	Sun Yat-Sen University	NOAH	Grell-Freitas (Grell and Freitas, 2014)	BouLac (Bougeault and Lacarrere, 1989)	Morrison (Morrison et al., 2009)	RRTM	MERRA2 (Gelaro et al., 2017)
WRF-ITP&THU	CAS, Institute of Tibetan Plateau Research, & Tsinghua University	NOAH	Grell-3D	MYJ (Janjic, 1994)	New-Thompson (Thompson and Eidhammer, 2014)	Dudhia RRTM	ERA-Interim
WRF-YSU	Yonsei University	NOAH+YSL (Lee et al., 2020)	Kain-Fritsch (Kain, 2004)	YSU (Hong et al., 2006)	WSM6 (Hong and Lim, 2006)	RRTMG	ERA-Interim
RegCM4-NJU-B	Nanjing University	BATS (Dickinson et al., 1993)	Tiedtke (Tiedtke, 1993)	Holtslag (Holtslag et al., 1990)	SUBEX (Pal et al., 2000)	RRTM	ERA-Interim
RegCM4-NJU-C	Nanjing University	CLM4.5 (Oleson et al., 2008)	Tiedtke	Holtslag	SUBEX	RRTM	ERA-Interim
RegCM4-NJU-E	Nanjing University	CLM4.5	Emanuel (Emanuel, 1991)	Holtslag	SUBEX	RRTM	ERA-Interim

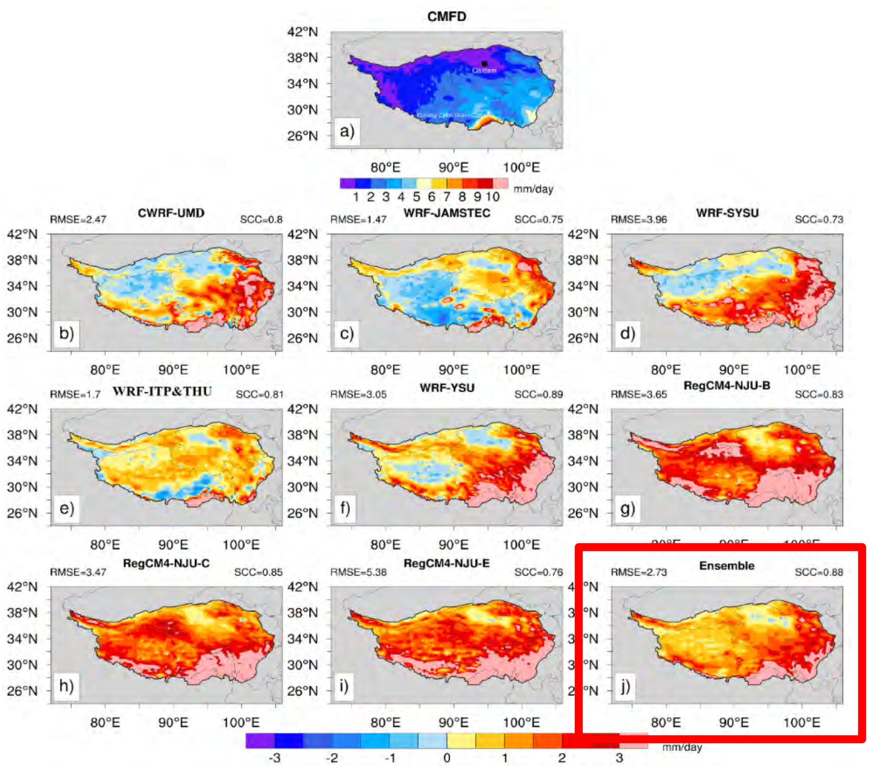
8 RCM results from 6 RCM groups



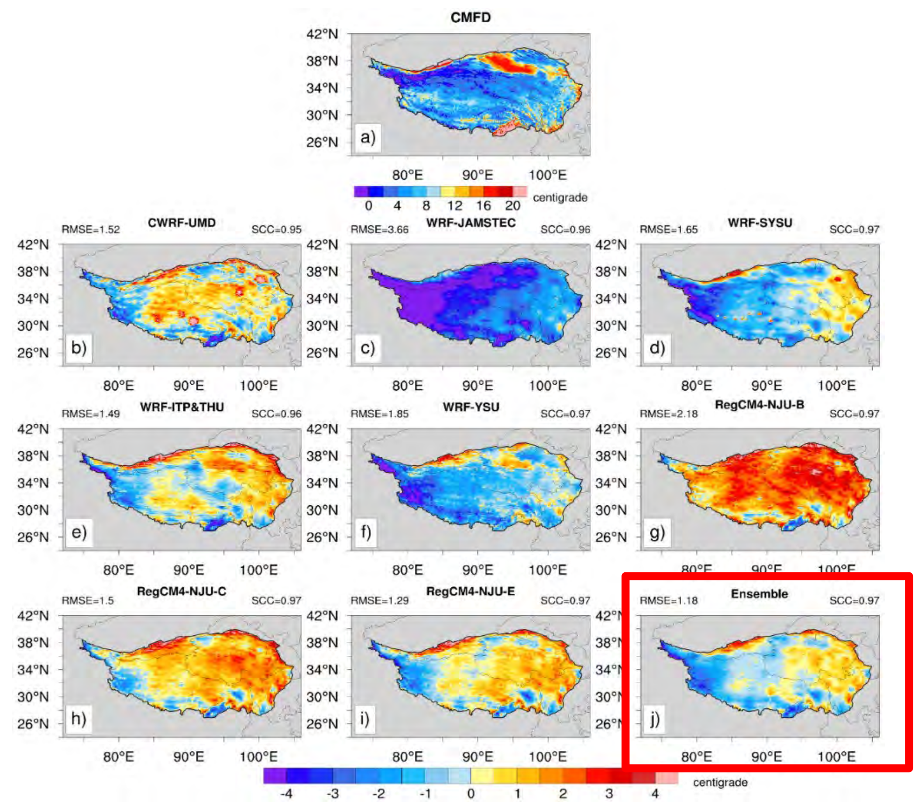
- Horizontal Resolution : 20-30 km (CWRF-UMD is 30km)
- Simulation Period : From April 1 to Sep 1., 1991-2015
  CWRF-UMD (1980-2015) and WRF-ITP&THU (1991-2015) take the continuous integration approach)

- Observation : the China Meteorological Forcing Dataset (CMFD), 0.25x0.25

Precipitation



Temperature

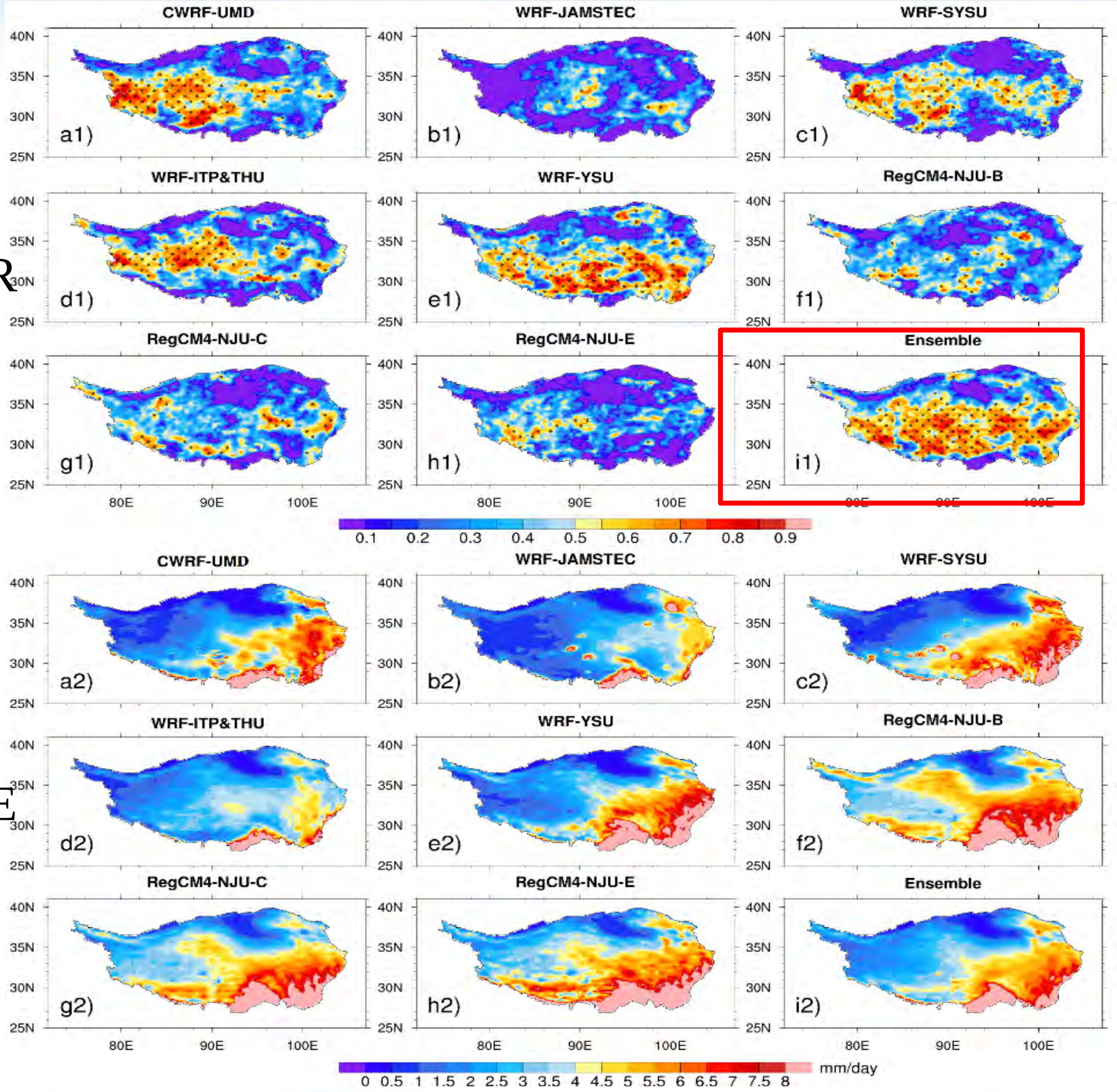


- The downscaling characteristics differ significantly between RCM experiments
- The multi-model ensemble mean can better reproduce the climate mean and inter-annual variation of precipitation and surface air temperature

Inter-annual Variation of Precipitation

CORR

RMSE

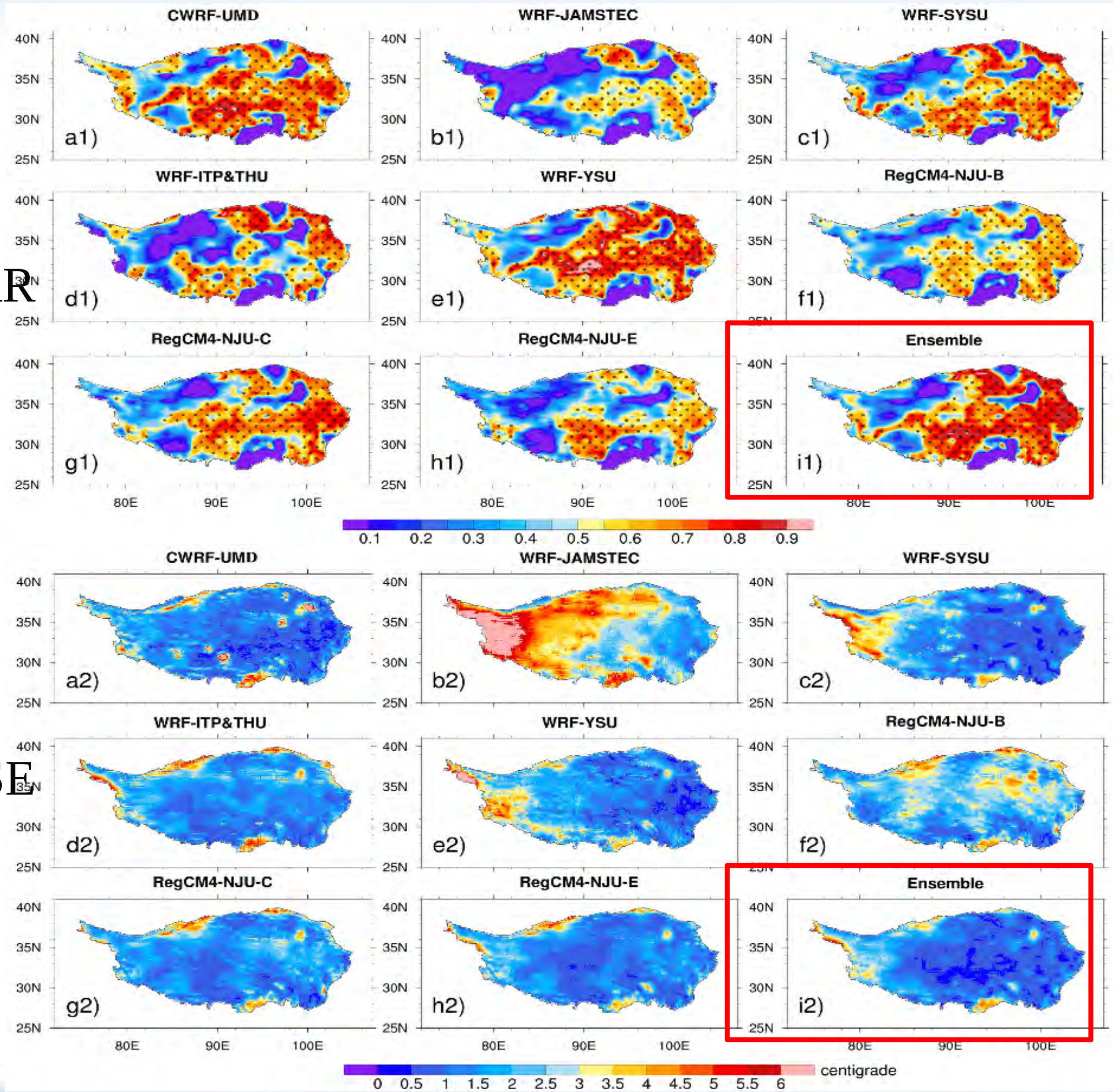


- the multi-model ensemble mean can better reproduce the observed inter-annual variation of observed MJJA precipitation

Inter-annual Variation of Temperature

CORR

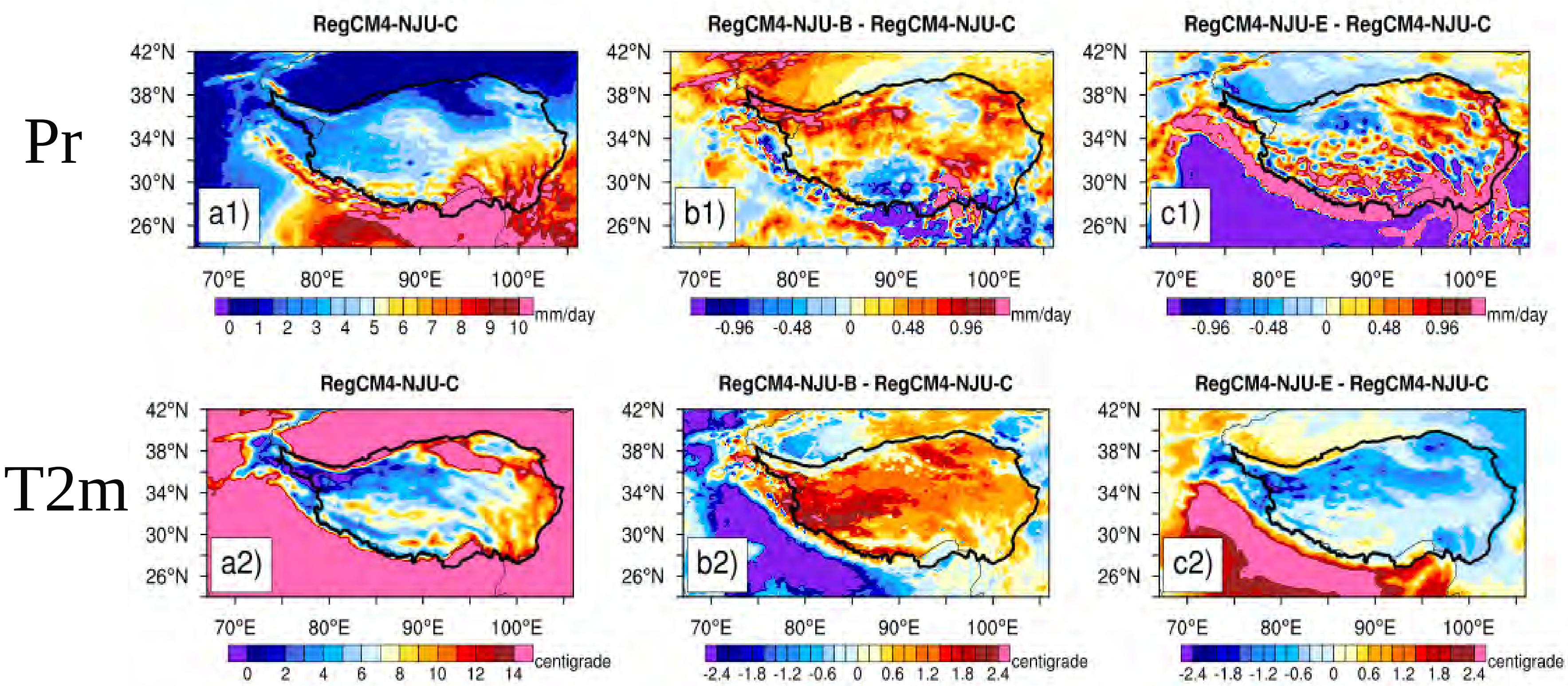
RMSE



- The multi-model ensemble mean can better reproduce the inter-annual variation of MJJA mean temperature over the TP with the highest correlations and the smallest RMSEs over most regions.

Comparison of RegCM4 Experiments

LSMs: CLM4.5 and BATS
CUs: Tiedtke and Emanuel



- BATS LSM and Emanuel cumulus scheme tend to simulate more precipitation over the TP

Difference of Moisture and Circulation

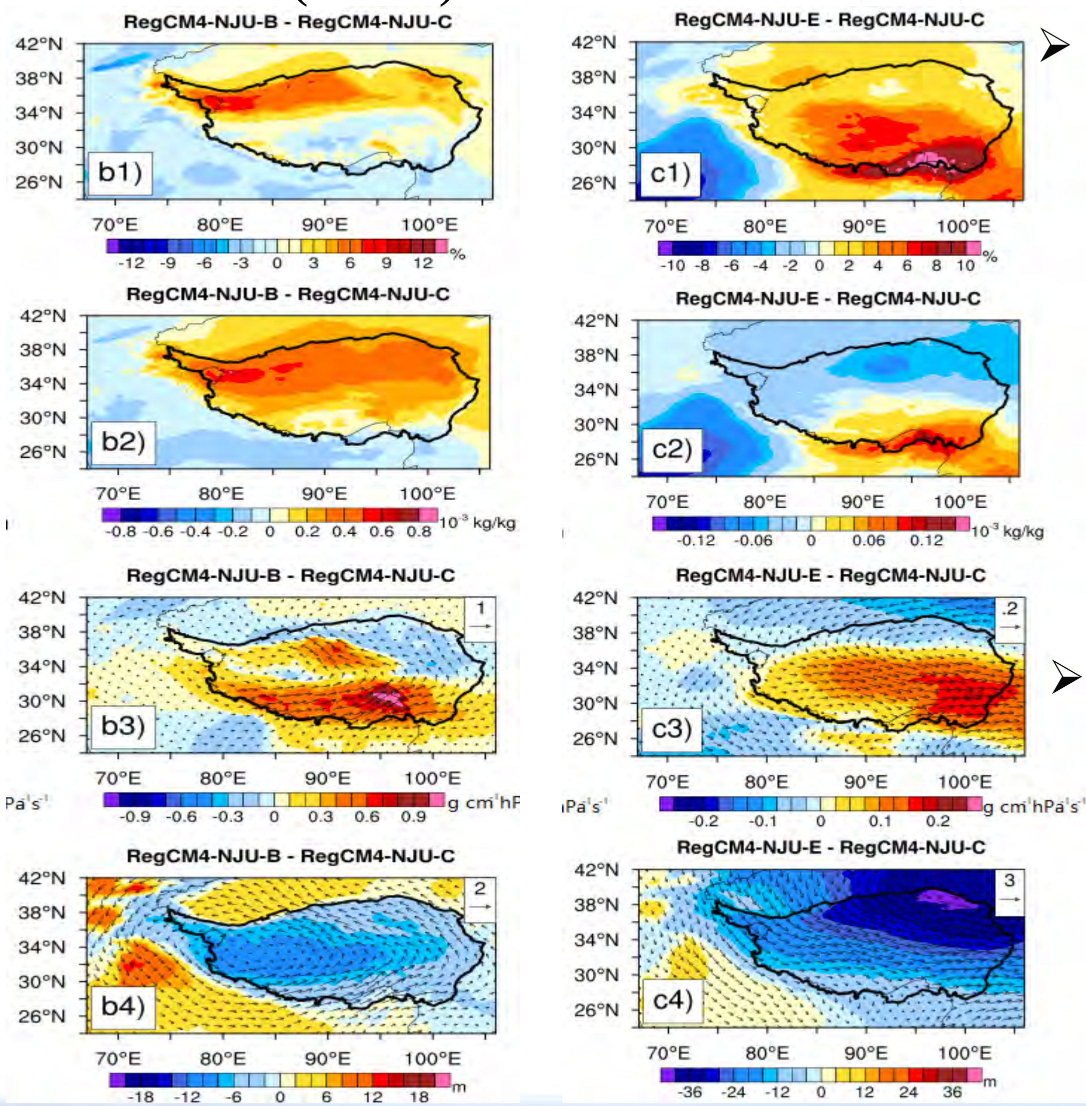
500hPa (LSMs) | 300hPa (CUs)

relative humidity

specific humidity

moisture transport

wind and height



- RegCM4 with BATS simulates higher relative humidity and specific humidity at 500 hPa over the northern TP, where large difference of precipitation exist

- The Emanuel scheme produces more mositure along the southern boundary of the TP.

Summary of LS4P-I RCM Experiments

- RCMs can generally reproduce the spatial patterns of MJJA mean precipitation and surface air temperature over the TP. The multi-model ensemble mean shows the better performance.

- The multi-model ensemble mean can better reproduce the observed inter-annual variation of MJJA precipitation and temperature.

- The dry (wet) biases in the RCMs are related to the predominant underestimation (overestimation) of precipitable water.

- The precipitation differences between different land and cumulus convection schemes in RegCM4 are induced by moisture and atmospheric circulation conditions in the middle and upper troposphere.

Tang, J., Xue, Y., Long, M. *et al.* Regional climate model intercomparison over the Tibetan Plateau in the GEWEX/LS4P Phase I. *Clim Dyn* (2023). https://doi.org/10.1007/s00382-023-06992-4

LS4P-II RCM Intercomparison for Tibetan Plateau

-Experimental Designs and Work Plan

Objectives

The LS4P-II RCM Intercomparison aims to study the impact of the land surface conditions over the TP on the regional climate.

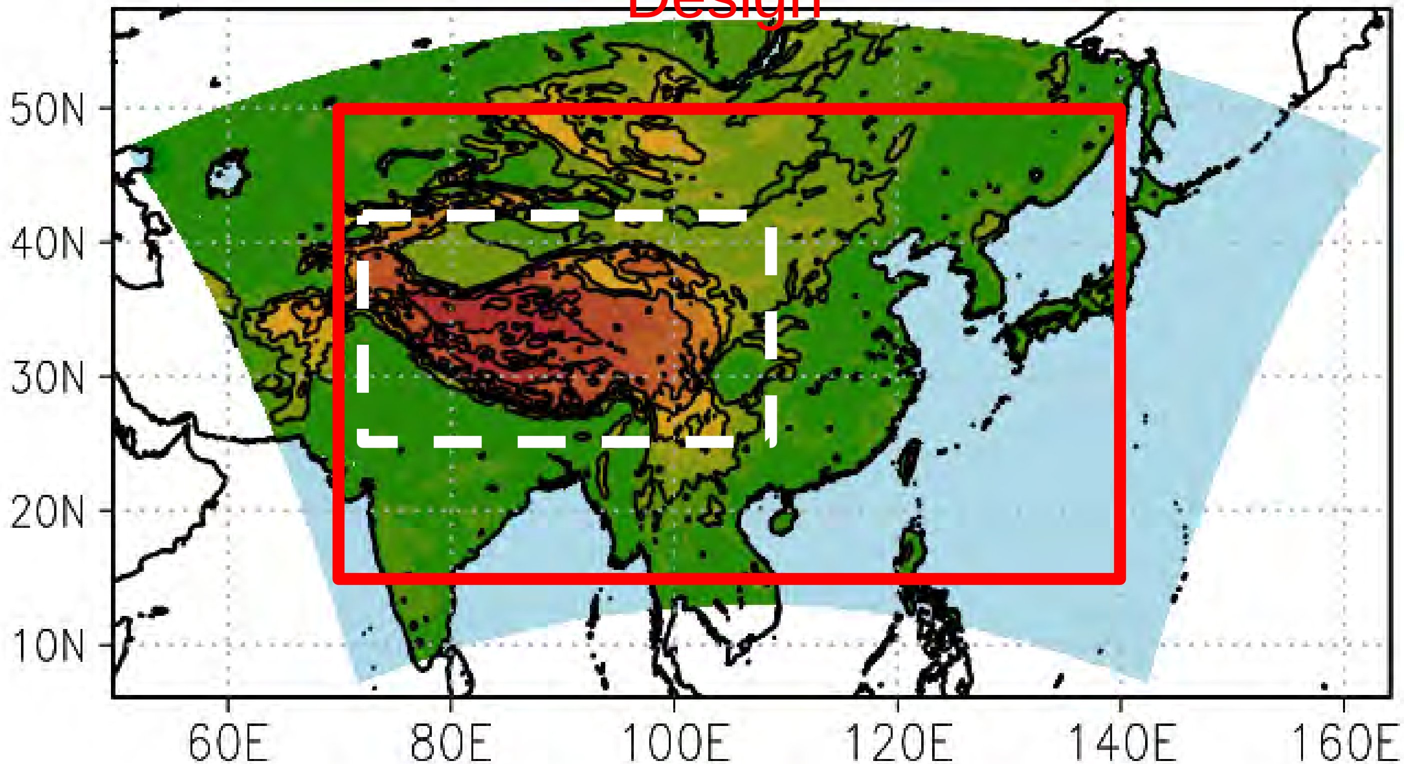
The objectives of this project

- to assess the sensitivity of the TP precipitation to the initialization/surface boundary condition of land surface temperature/subsurface temperature (LST/SUBT), snow cover, and soil moisture over the TP;
- to understand the impact of the TP land surface conditions on the precipitation anomaly over eastern Asia.

Experiment specification

Domain and Resolution

Suggested Minimum RCM Intercomparison Experimental Design



The Minimum RCM Domain (Red Solid Line) : 70-140E, 15-50N

Horizontal Resolution : 18km

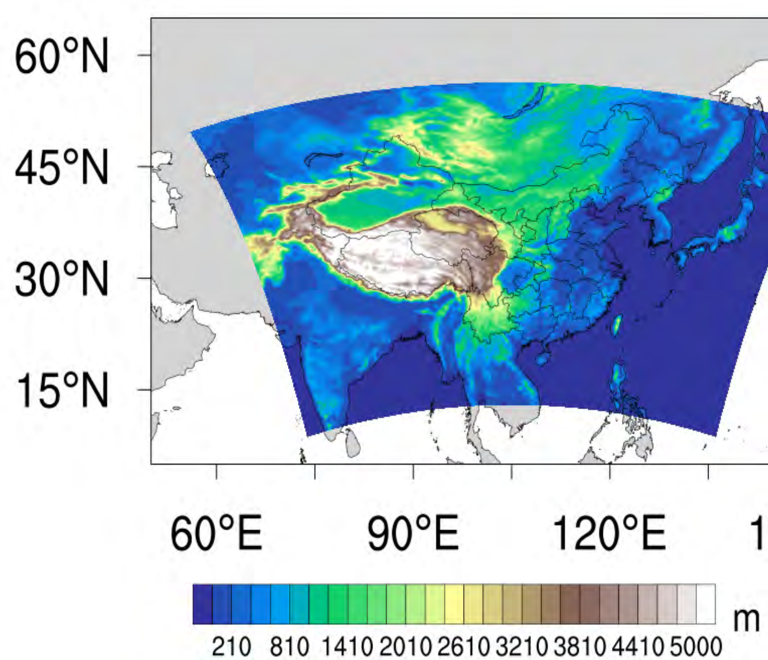
LS4P-II RCM Experimental Design

Experiment	Description
Task 1 CTL	RCM ERA5 reanalysis forcing control run: Atmospheric initial and lateral boundary conditions are from ERA5 reanalysis. The control experiments run from late April through August for 2010-2015, 1998 and 2022.
Task 2 LST	Same as Task 1, except for an initial LST/SUBT mask will be imposed over the TP. At least two sensitivity experiments with +5 ℃ (Task 3 LST+5) and -5 ℃ (Task 3 LST-5) LST/SUBT anomaly will be performed. Each group can process the LST/SUBT setting according to its own LSM's options, such as regarding how to change consistently water vapor phase.
Task 2.1 LST-CS	Same as Task 2, except for different cumulus parameterization schemes are used.
Task 3 SMI	Same as Task 1, except for the different initialization of soil moisture with extremely wet anomaly and extreme dry anomaly of soil conditions based on soil moisture data 3. Two sensitivity experiments (Tsk3 SMI-wet and SMI-dry) will be conducted.
Task 4 SWI	Same as Task 1, except for the different initialization of snow depth. Different initialization of snow depth based on the snow depth data will be conducted. Two sensitivity experiments with snow depth at -20% (Task 4 SWI-20) and +20% (Task 4 SWI-20) anomaly of observation will be conducted.

LS4P RCM Phase 2 Prototype Experiments

Experimental Design

Domain and Terrain Height



Resolution : 18km

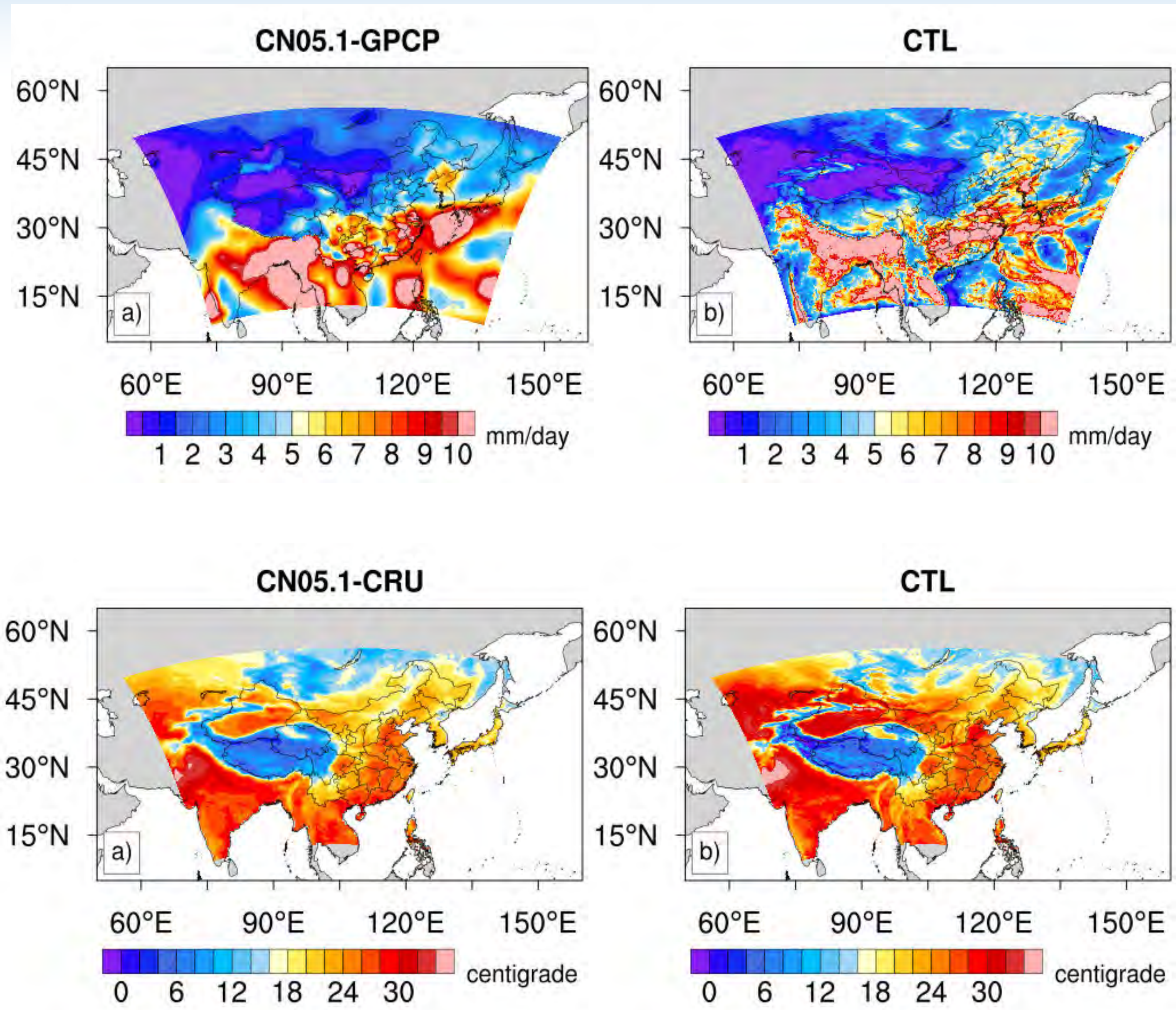
WRF Expeirments

CTL	**CTL simulation using ERA5 forcing**
2015jja-80sm	**With the initial soil moisture at 80% SMI-dry**
2015jja-120sm	**With the initial soil moisture at 120% SMI-wet**
2015jja-lst-5	**The initial land surface temperature -5℃**
2015jja-lst+5	**The initial land surface temperature +℃**

Simulation period : From April 21 to Sep 1., 2015

IC and LBC Forcing : ERA5

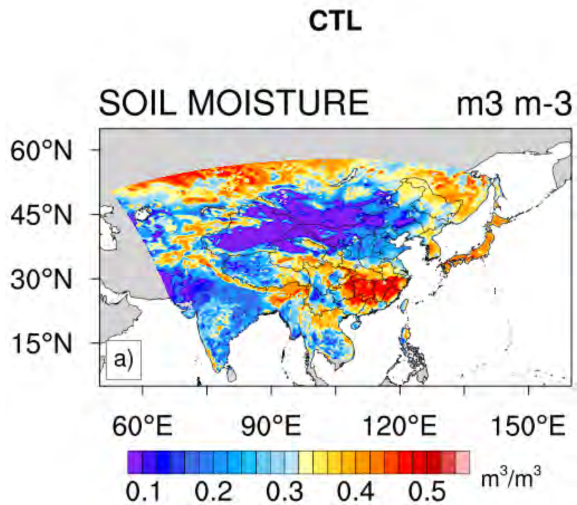
Evaluation of CTL Experiment



- The CTL experiment can generally capture the spatial pattern of JJA mean precipitation and surface air temperature in 2015 over East Asia.

SMI Experiments

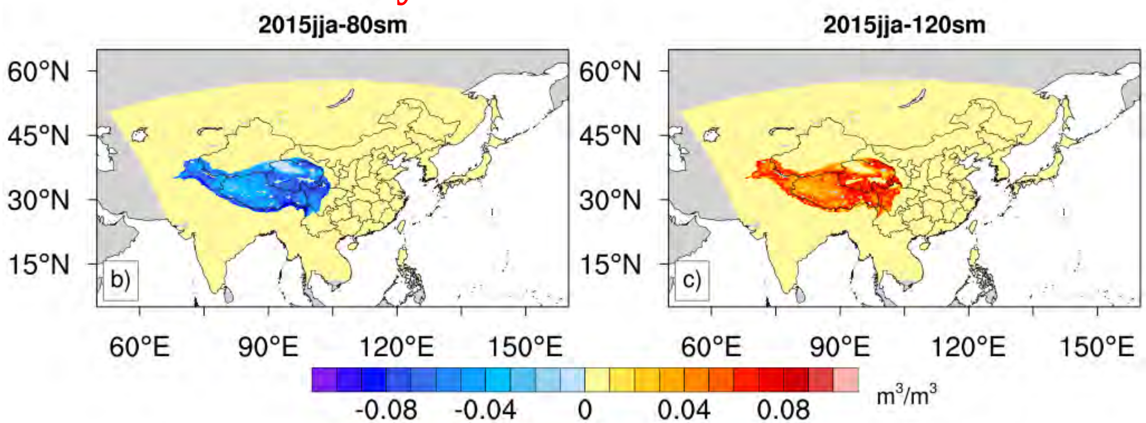
0.1m Soil Layer SM (initial)



With the initial soil moisture at 80% (SMI-dry) and 120%(SMI-wet) of CTL experiment (ERA5) over the TP

SMI-dry

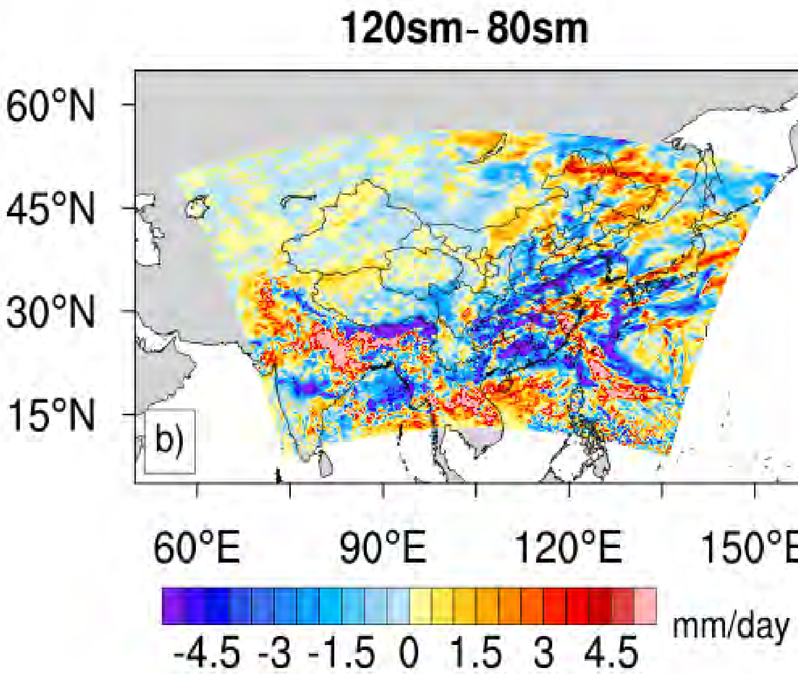
SMI-wet



SMI Anomaly

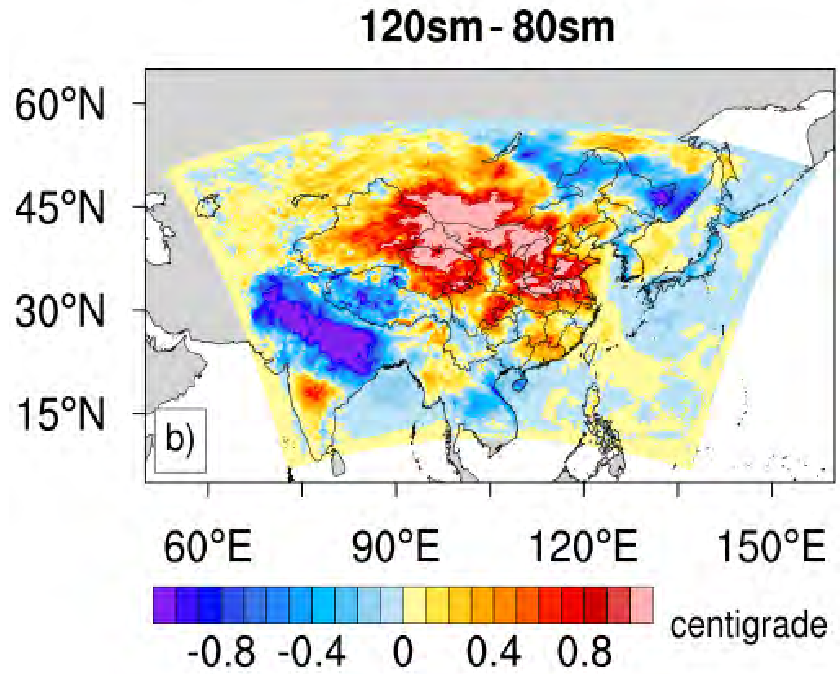
Effects of SMI on Preciptaiton and Temperature

Precipitation



- SMI-Wet tends to simulate less precipitation over most regions in eastern China, and more precipitation over the north Indian Peninsula, Indochina Peninsula and South China Sea.

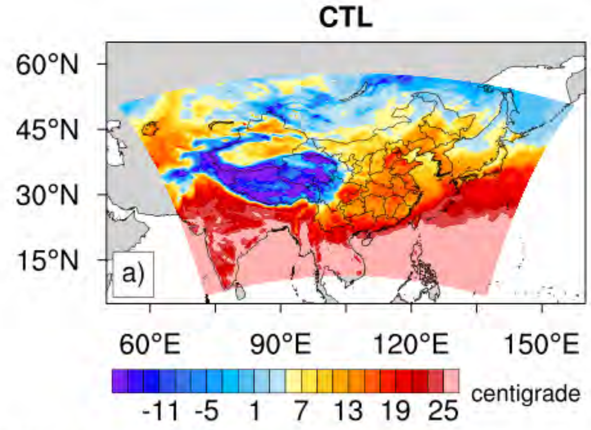
Temperature



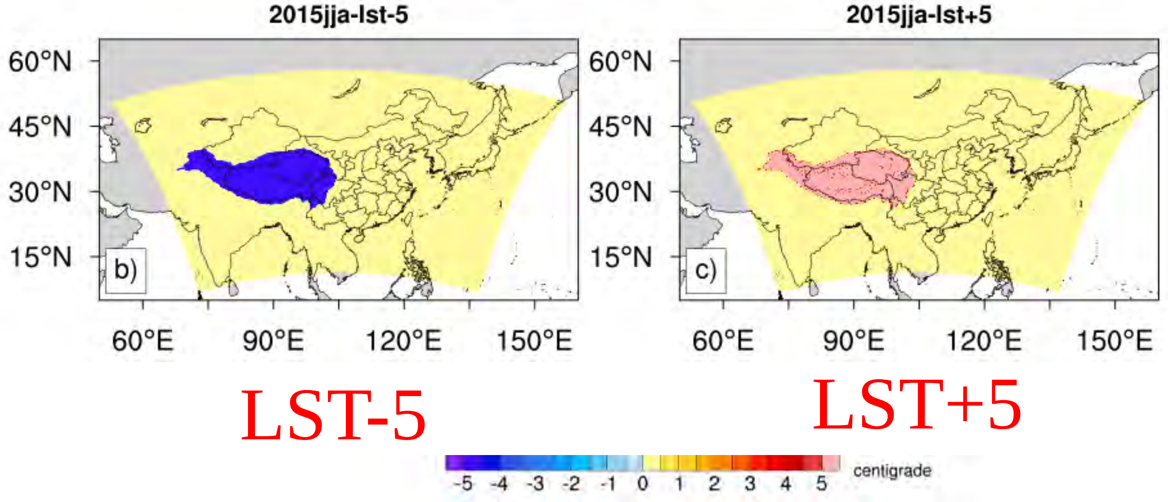
- SMI-Wet simulates warmer temperature over most regions in China and Mongolia, but colder temperature over the north Indian Peninsula and west TP.

LST Expeiments

Initial Condition of LST



The initial land surface temperature : -5 and +5°C

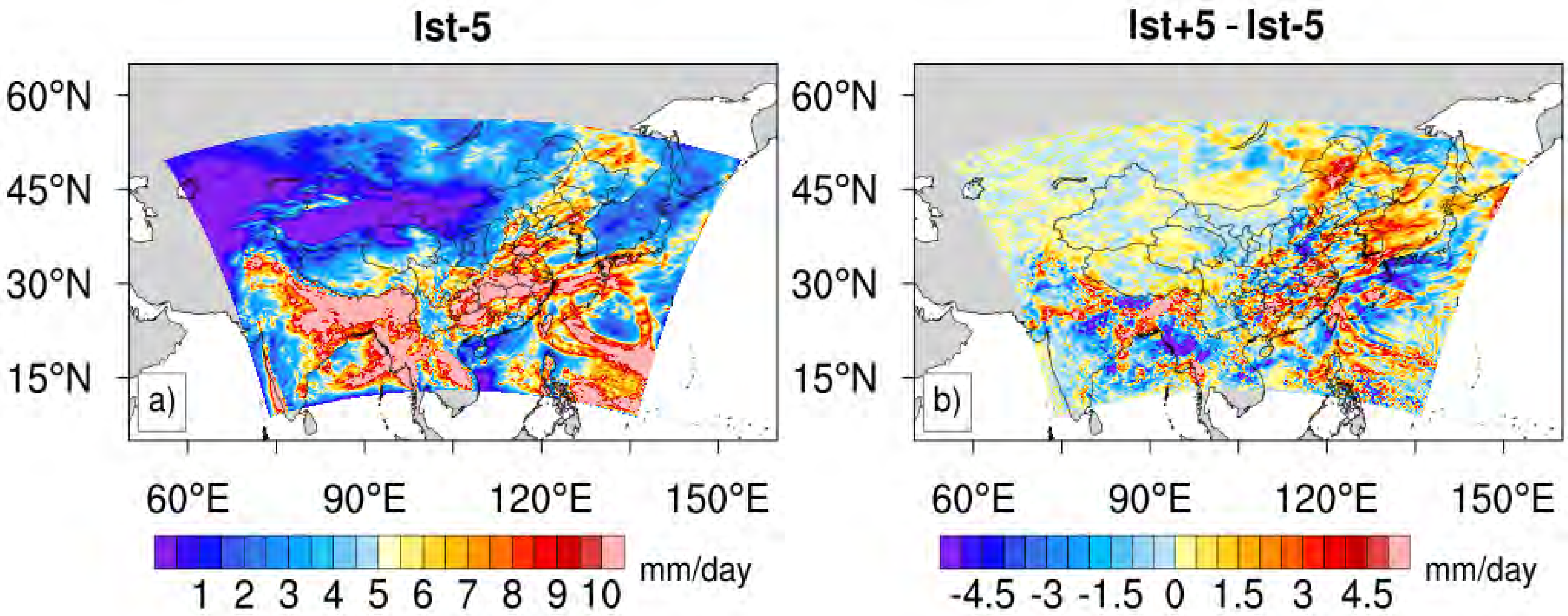


LST-5

LST+5

LST Anomaly

JJA precipitation in 2015



- Compared to LST-5, LST+5 tends to simulate more precipitation over eastern China, and most regions in north western Pacific.

Summary of LS4P-II Prototype Exp

- Compared to SMI-Dry, SMI-Wet tends to simulate less precipitation over most regions in eastern China, which may be related to the anticyclone anomalies and lower specific humidity.

- The warm bias over most regions in China may be related to the significant anticyclone anomalies.

- LST+5 tends to simulate more precipitation over eastern China, and most regions in north western Pacific, which may be related to the cyclone anomalies and higher specific humidity.

Thank you □

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