Observation-model integration for simulating water cycle in the Third Pole

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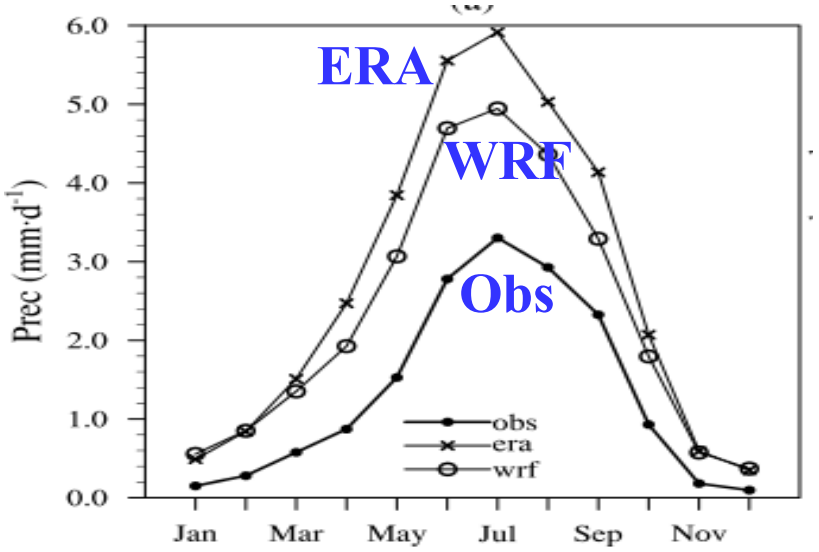
Outline

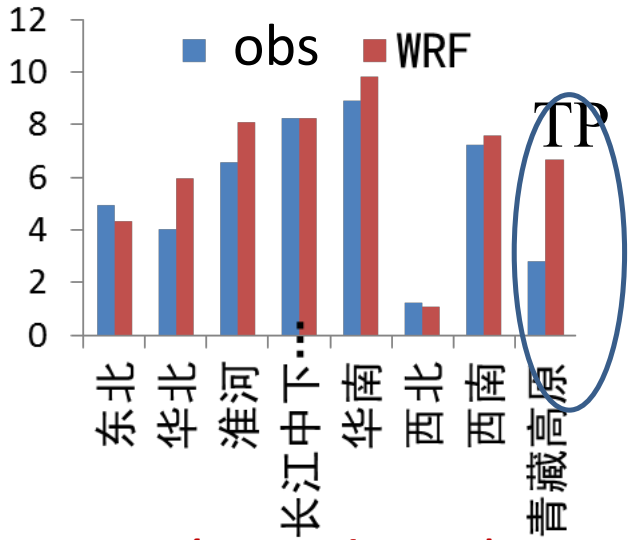
- Motivation
- Validation basis for Third Pole Modeling
- Model improvements for the Third Pole
- Plan for TPE FPS

Motivation: Too much precipitation for the Tibetan Plateau (TP) in models

Precipitation

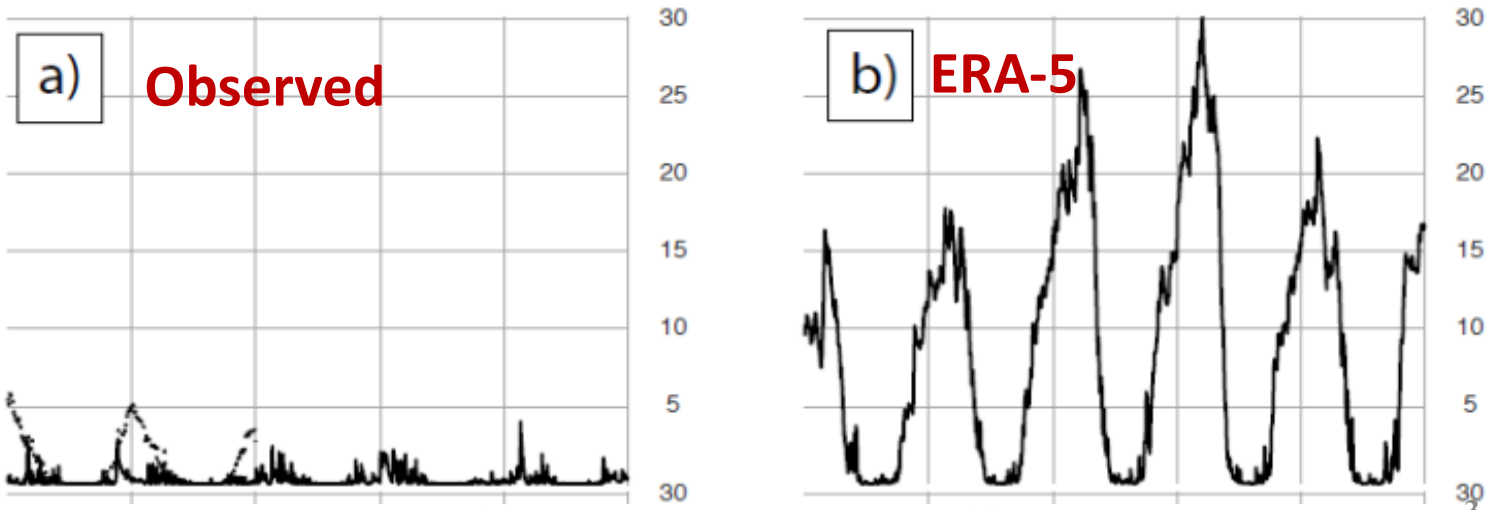


(Gao et al., 2015)



(Ma et al., 2015)

Snow depth



(Orsolini et al., 2019, TC)

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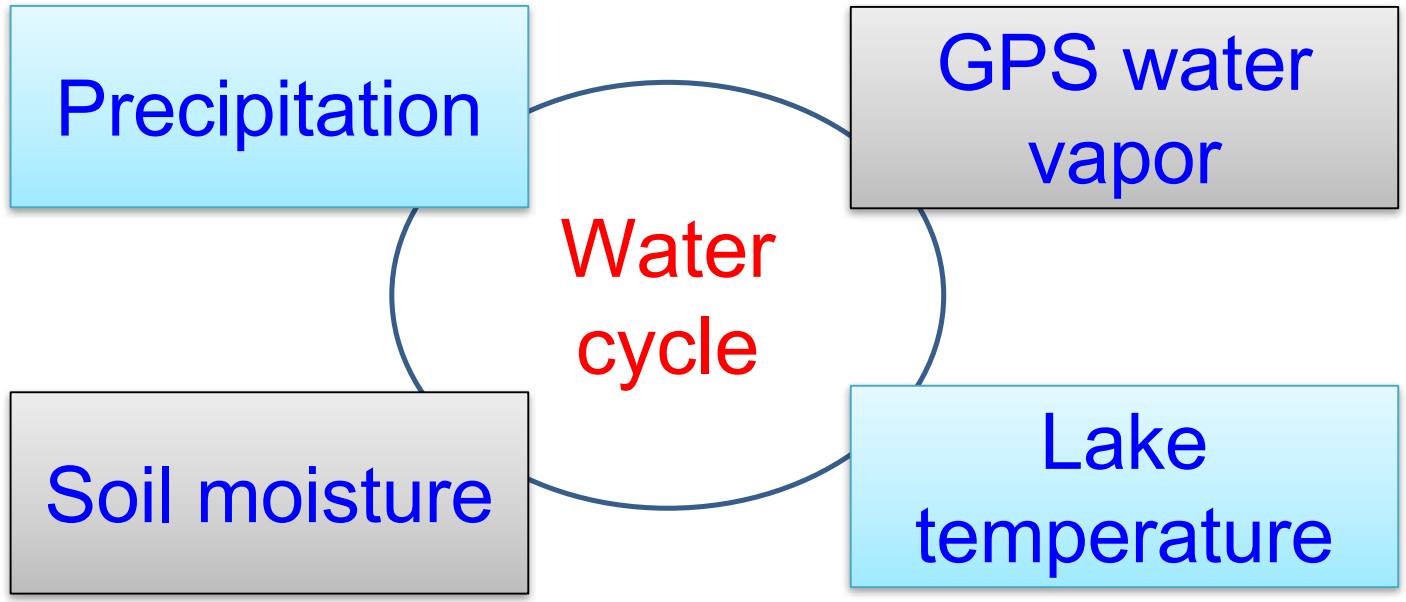
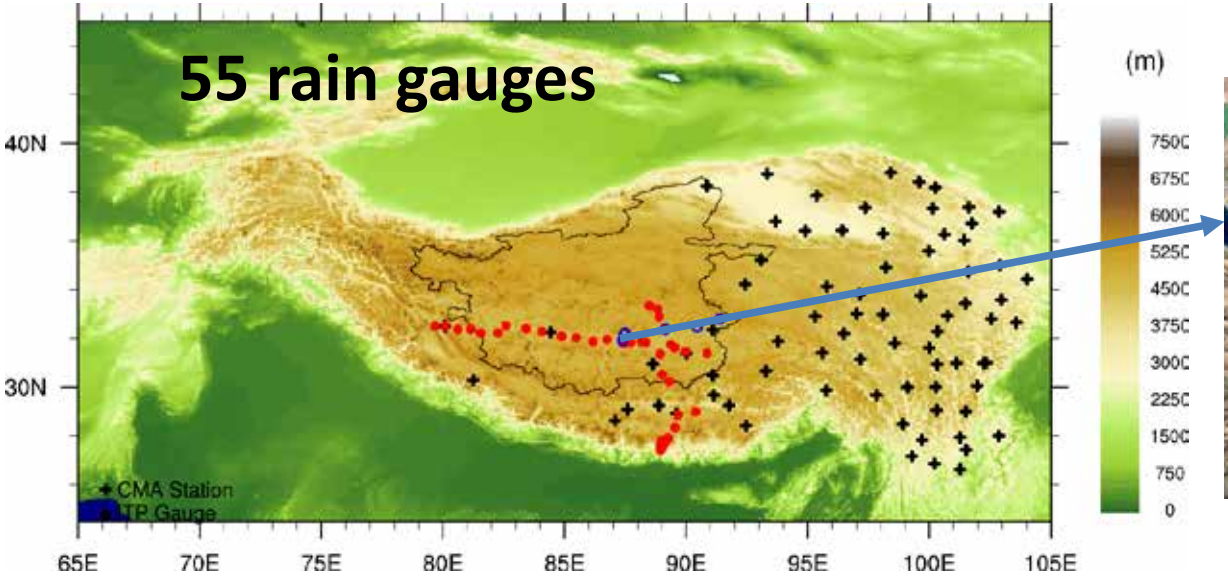
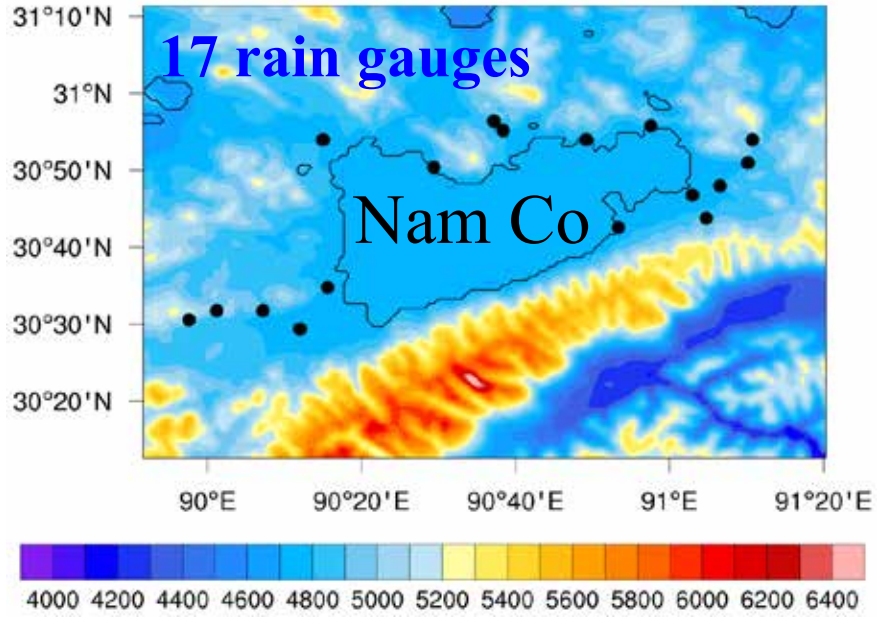
Established observing networks



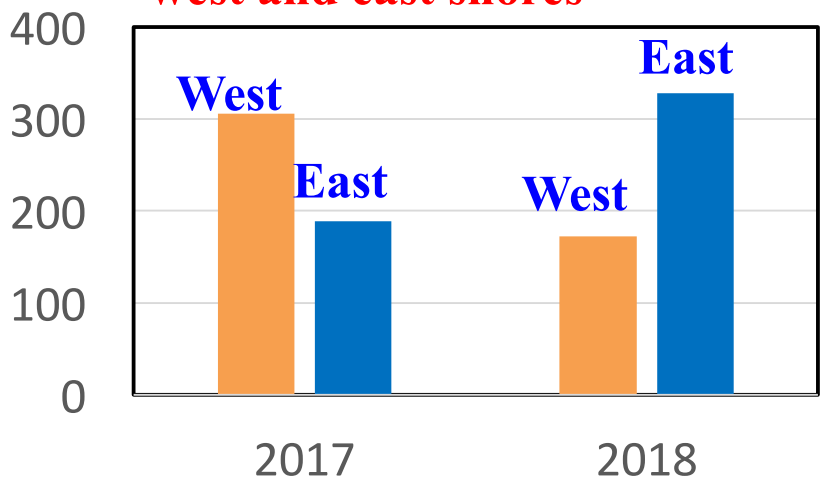
Newly constructed rainfall observing network



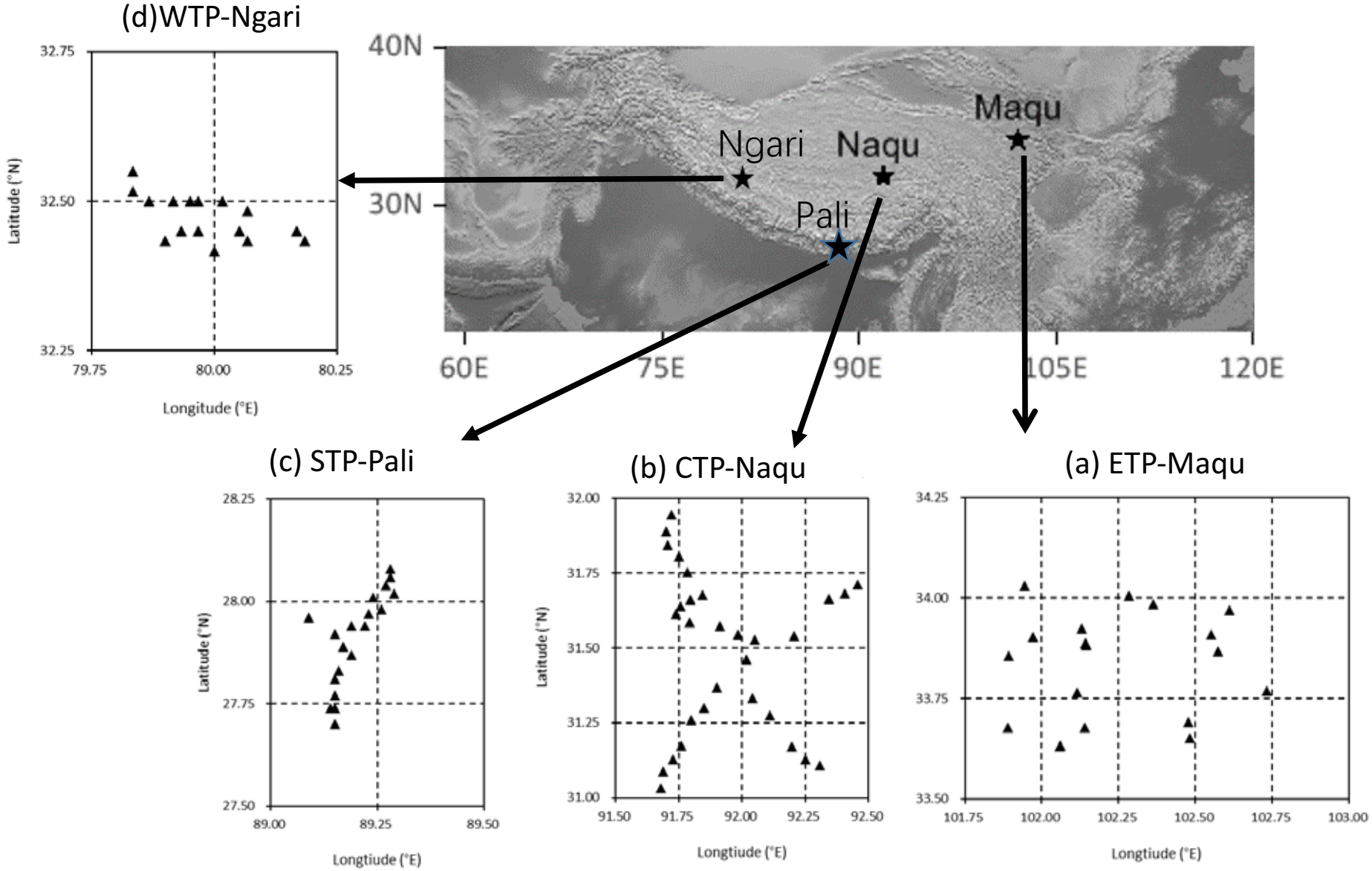
Lake Selin Co



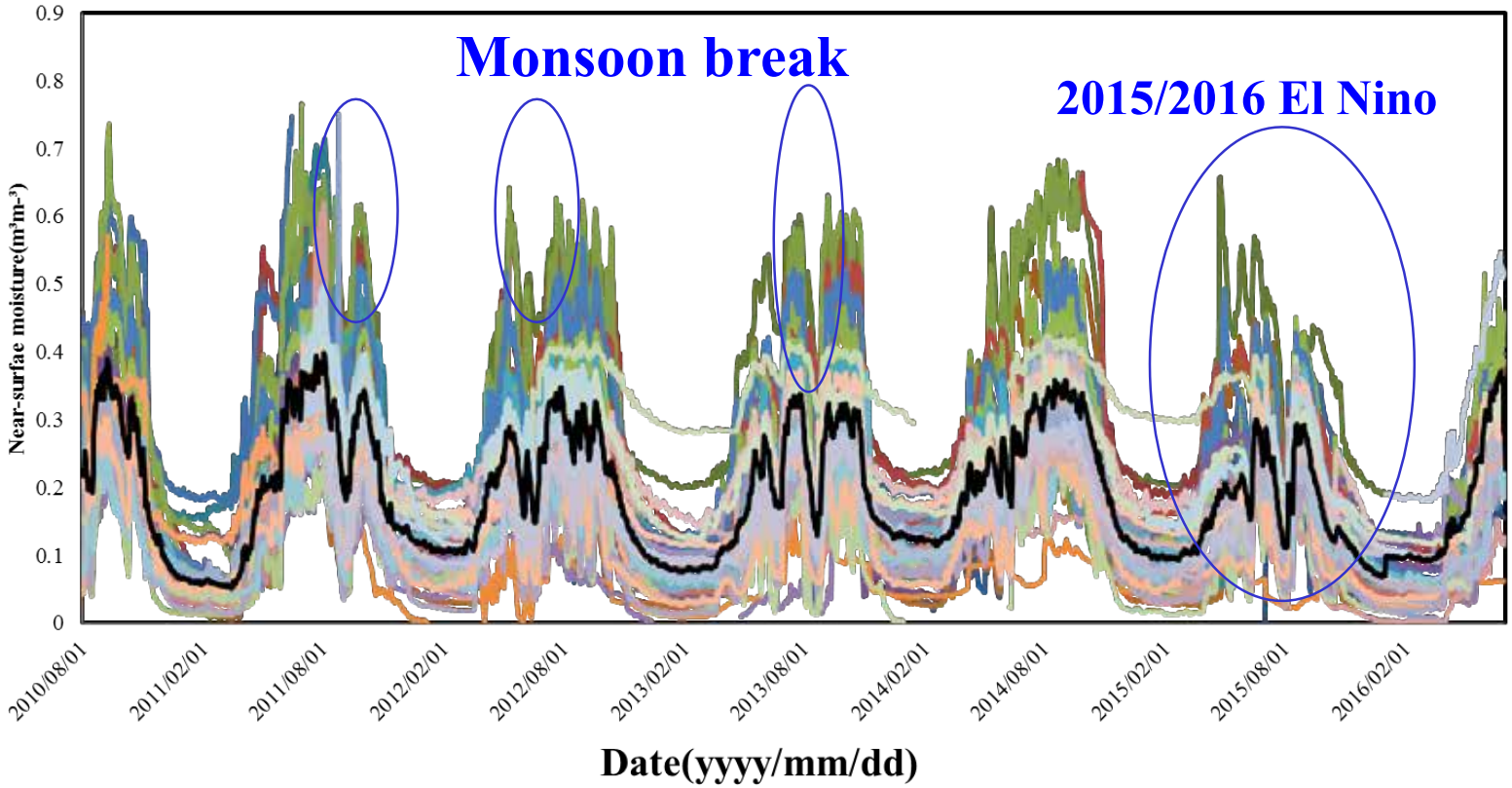
Precipitation oscillation on west and east shores



Four soil moisture and temperature networks on the TP (efforts convergence of ITP, CAREERI and ITC)

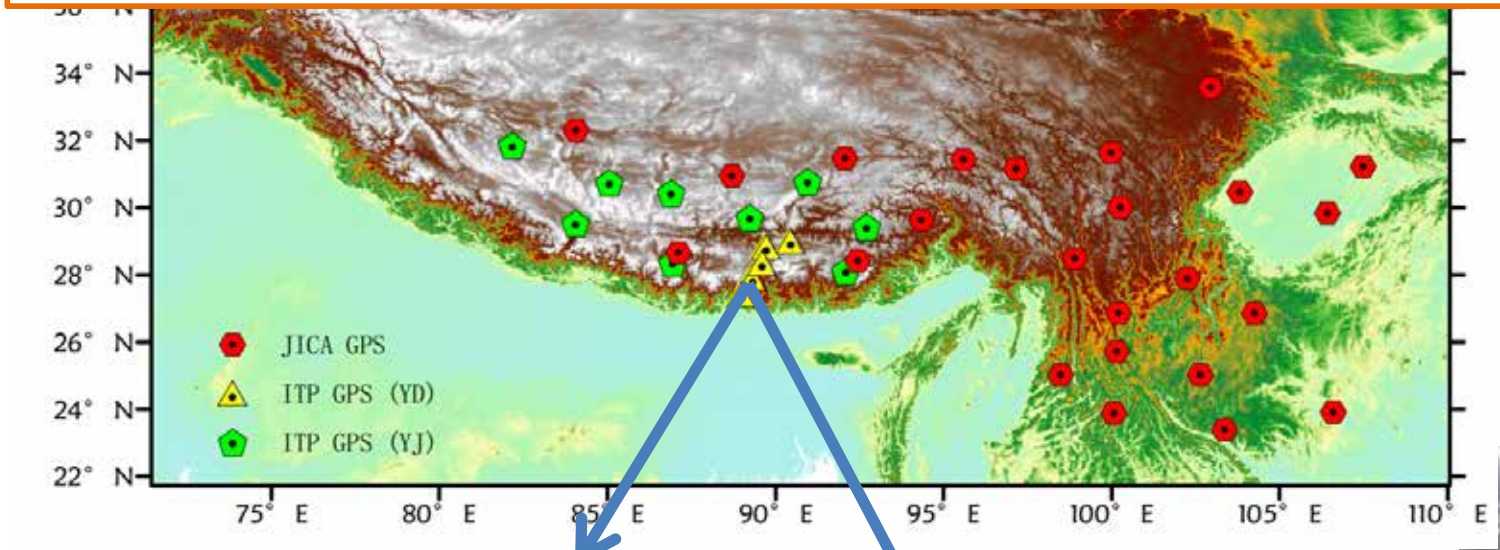


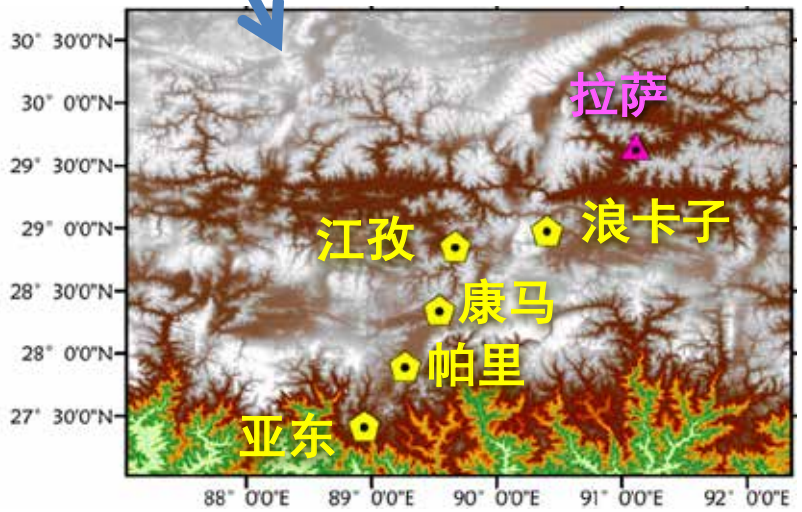
Impacts of monsoon break and 2015/2016 El Nino are seen in soil moisture data

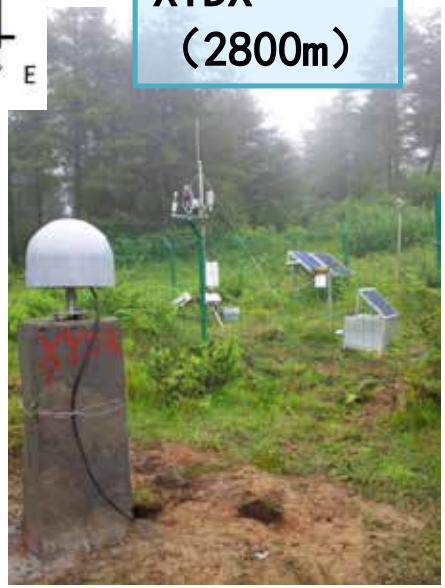


Water vapor measurement: GPS network in South TP

ITP GPS ： 9 stations (2007.05--) in Yarlung Zangbo valley
5 stations (2015.6.26--) along Yadong-Lhasa transect

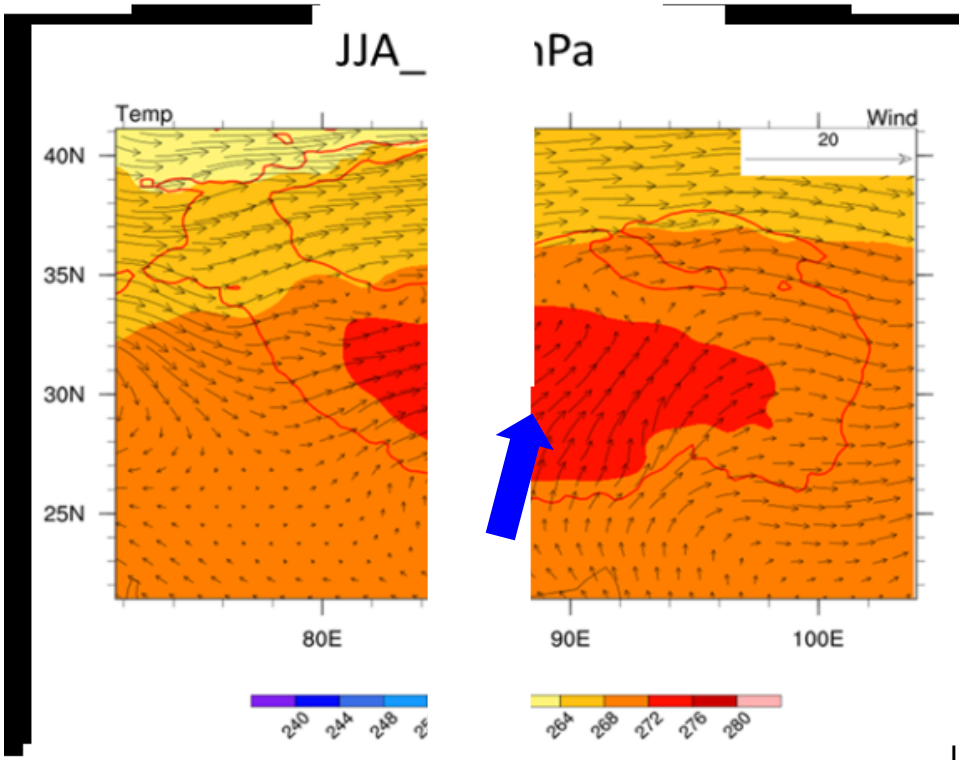


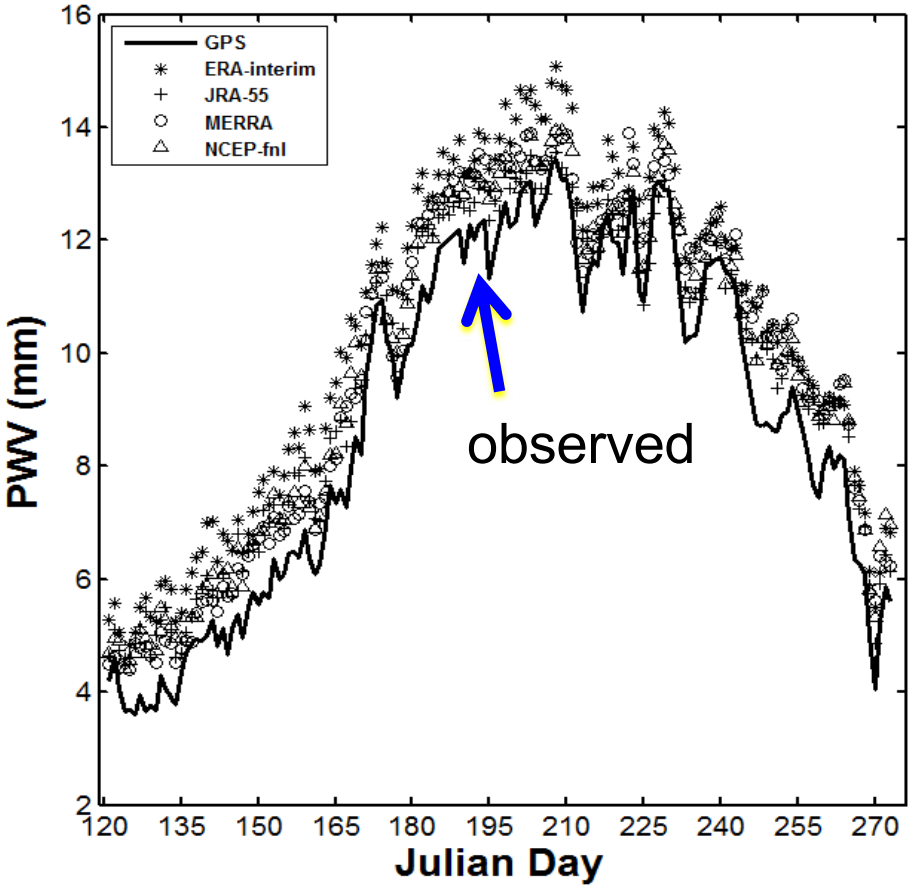




All reanalysis models over-estimated PWV

Northward water vapor transport

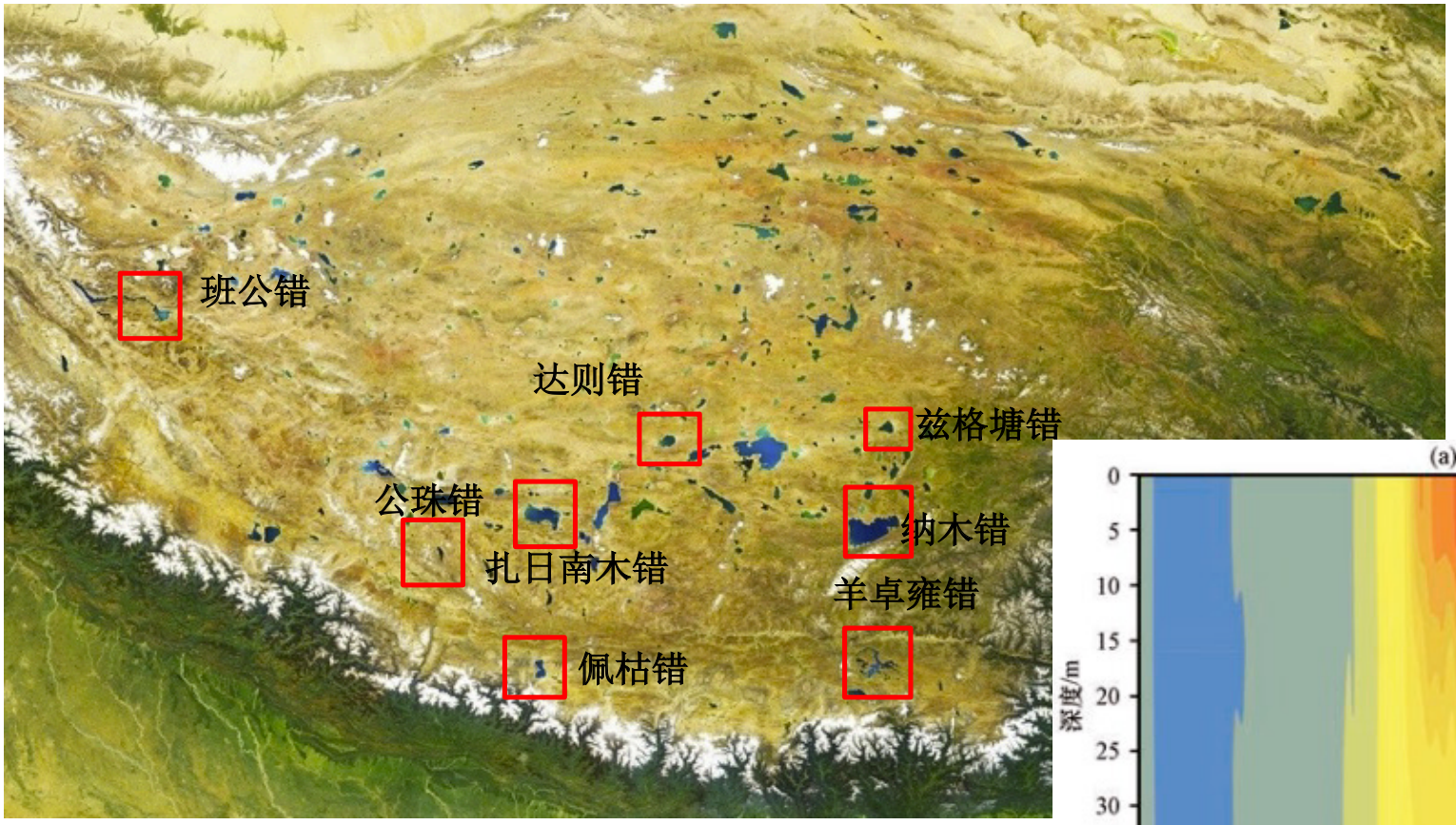


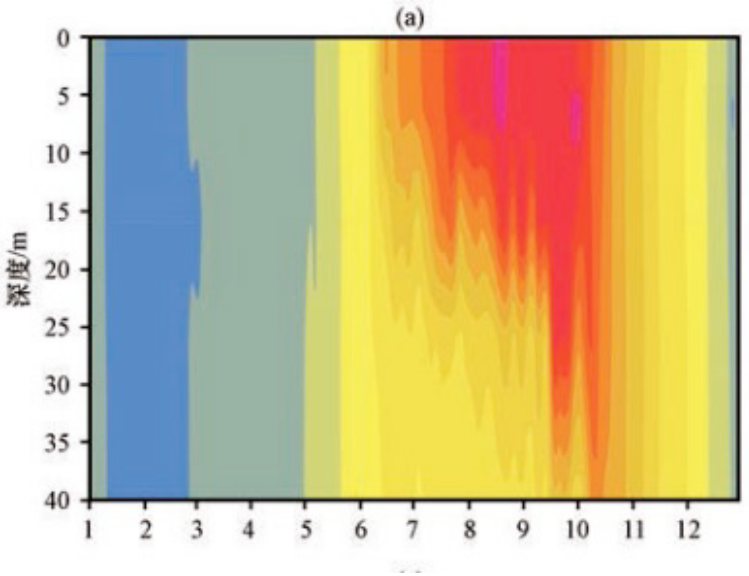


Seasonal march between observation and reanalyses, after elevation correction and average at 9 GPS stations during 2007~2013

(Wang, Yang et al., 2017, JC)

Lake temperature observations at eight lakes (2016-)





Heat into deep layer

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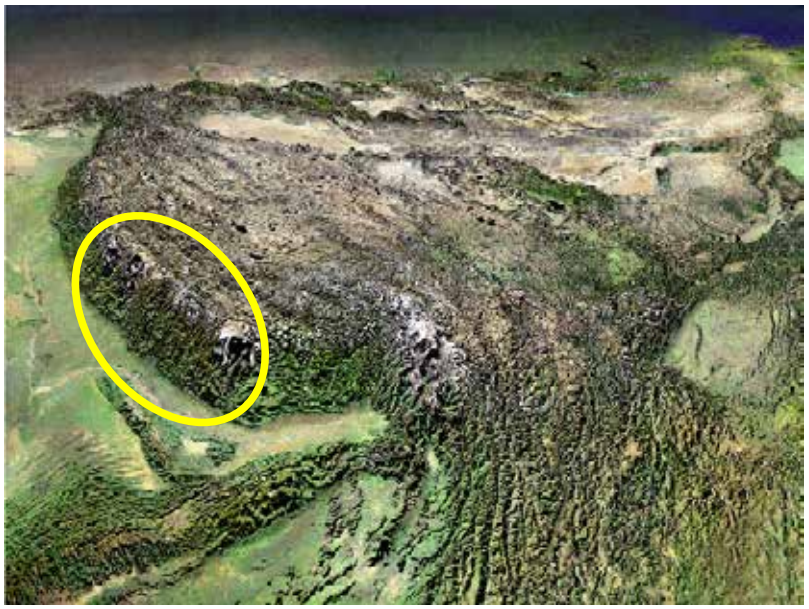
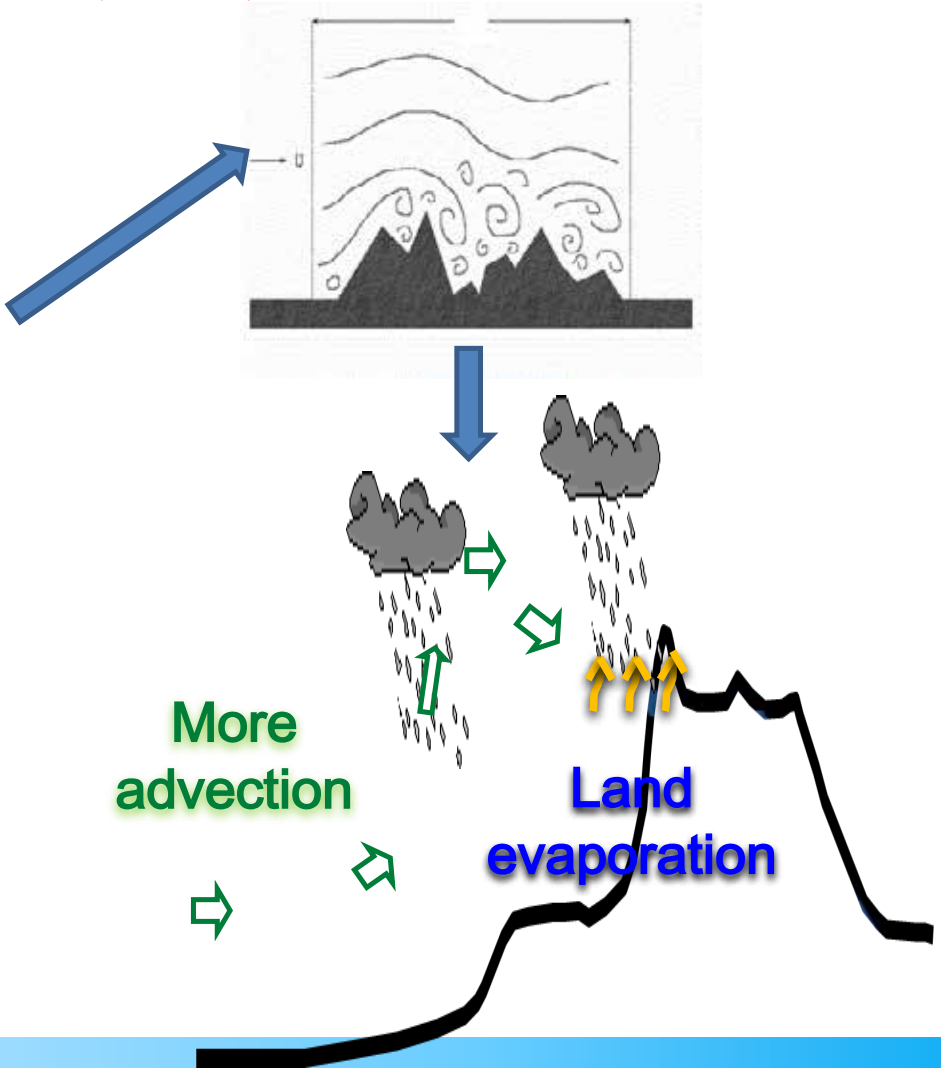
1. Turbulent scale orographic form drag (TOFD). Steep and complex terrain in the Himalayan range is not resolved in models, which may cause excessive water vapor and precipitation in models for the TP

Steep and complex terrain in Himalaya

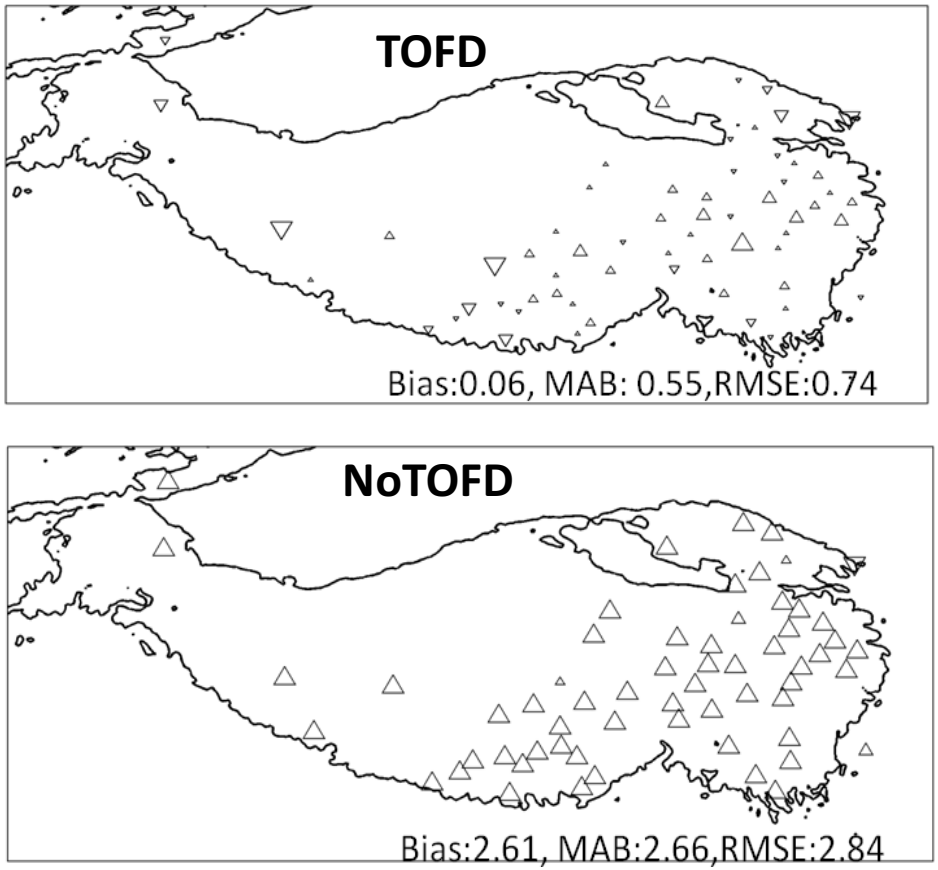


Turbulent scale orographic form drag (TOFD)



Implement TOFD scheme developed by Beljaars et al. (2004) in WRF to enhance momentum loss, weaken wind speed and water vapor transport

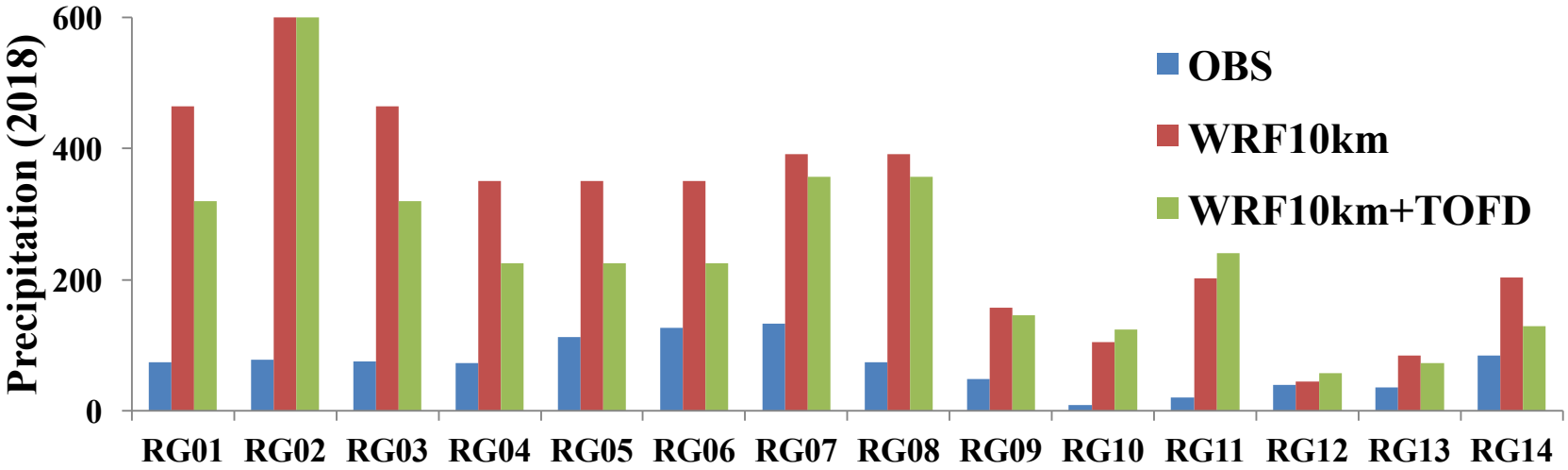
Monthly mean wind speed (m/s)

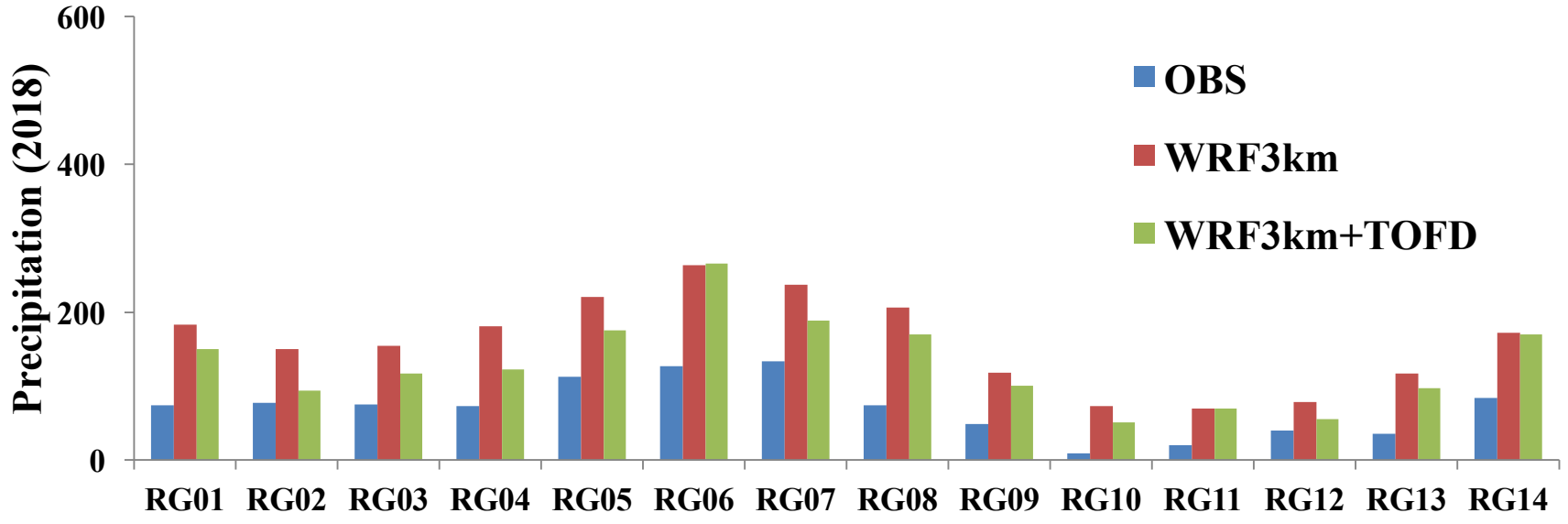


(Zhou et al., 2019, CD)

In the upper Himalaya, WRF biases can be effectively reduced by improving resolution and using TOFD

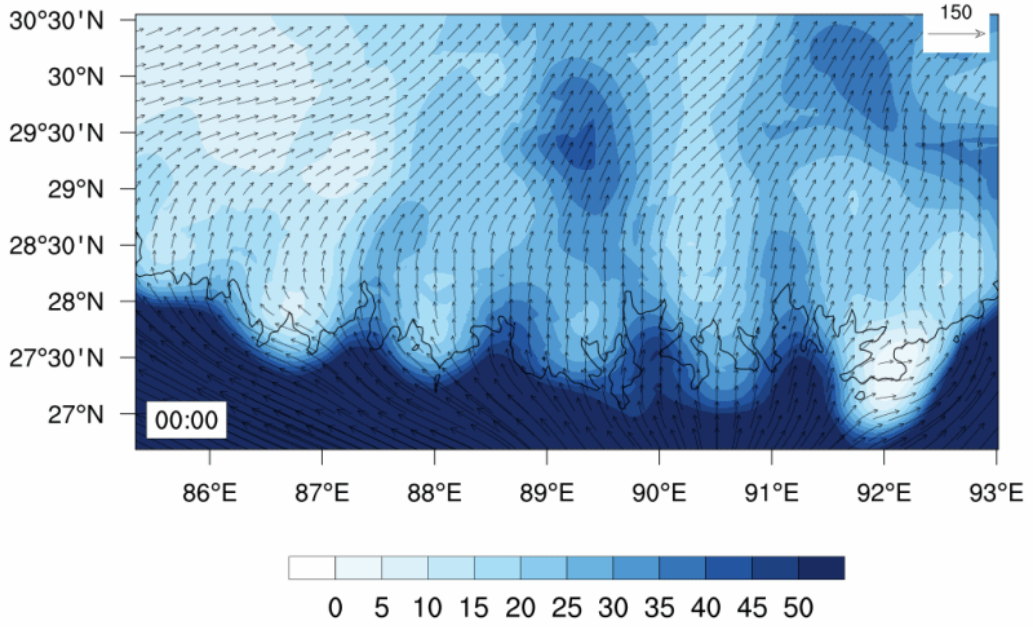
385% in WRF10km → 127% in WRF3km→86% in WRF3km+TOFD



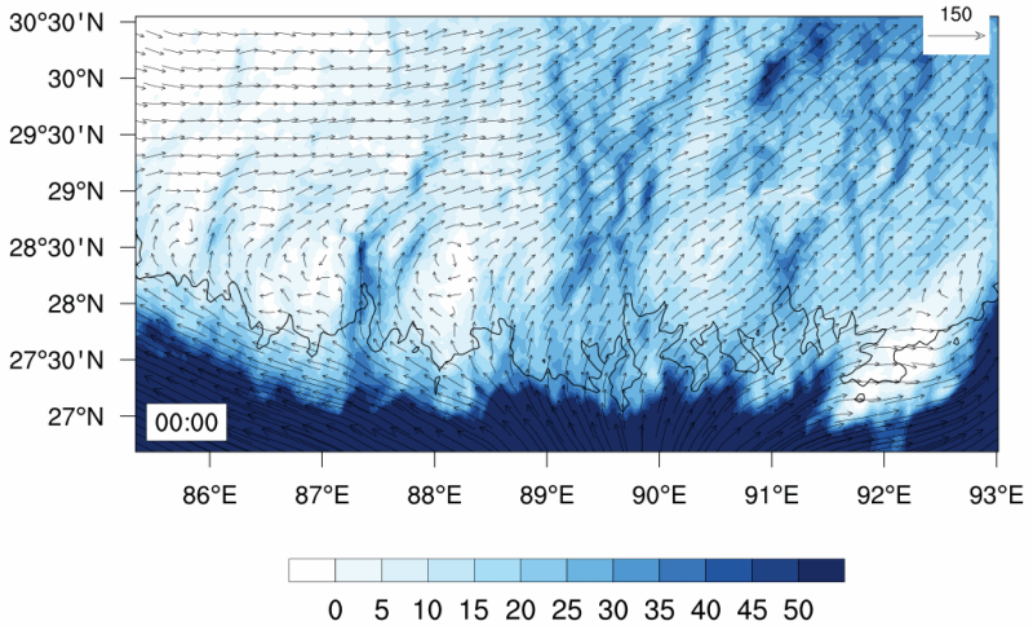


Summer-mean diurnal cycle of water vapor transfer (color indicates northward transfer). WRF-3km shows water vapor transfer through valleys

ERA5_31km



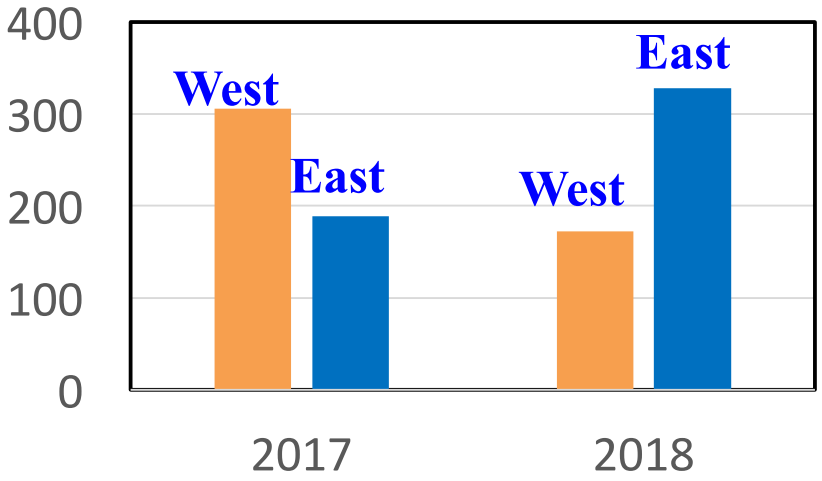
WRF_3km

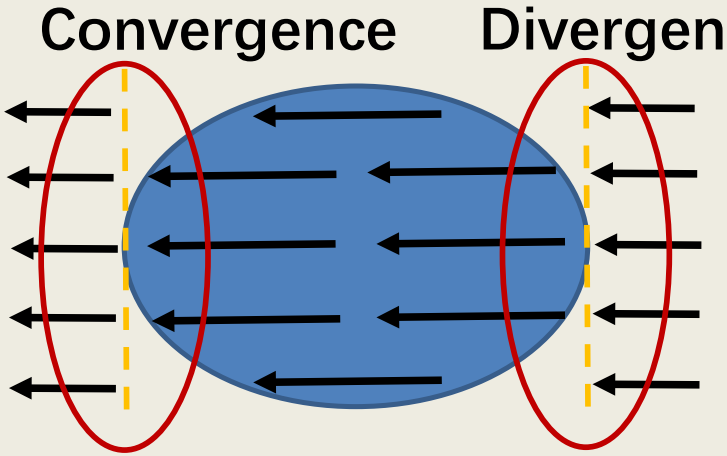


2. There are thousands of lakes on the Third Pole. Both lake-air vapor/heat and momentum exchanges must be expressed well

Lake Selin Co

Precipitation oscillation on west and east shores



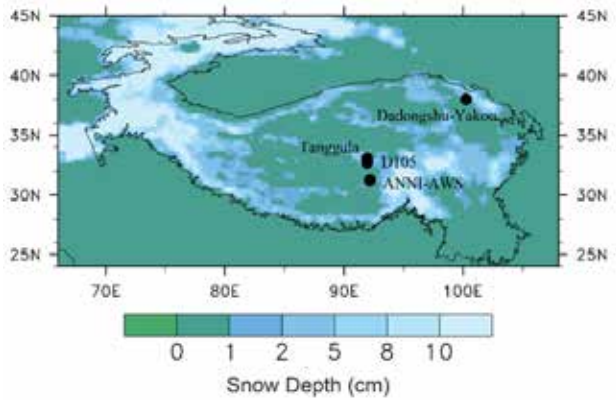


Blue: lake ; Grey: land

Lower roughness may cause downwind convergence

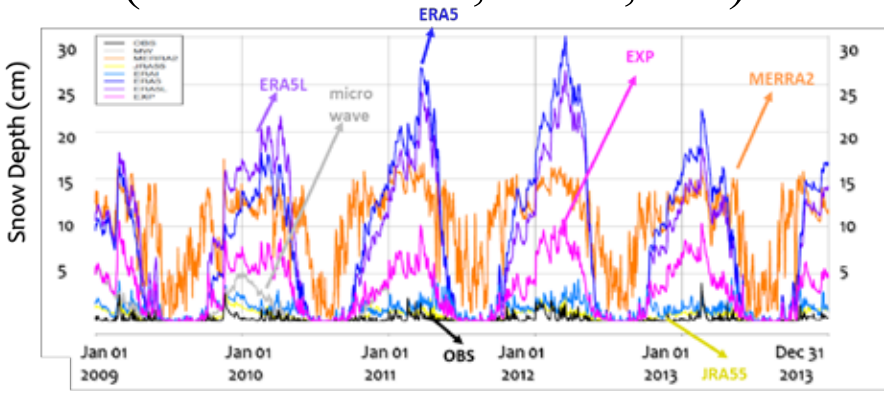
3. Parameterizing surface albedo of shallow fresh snow is crucial

Snow depth (SD) is shallow (~ cm) in the inner Tibetan Plateau

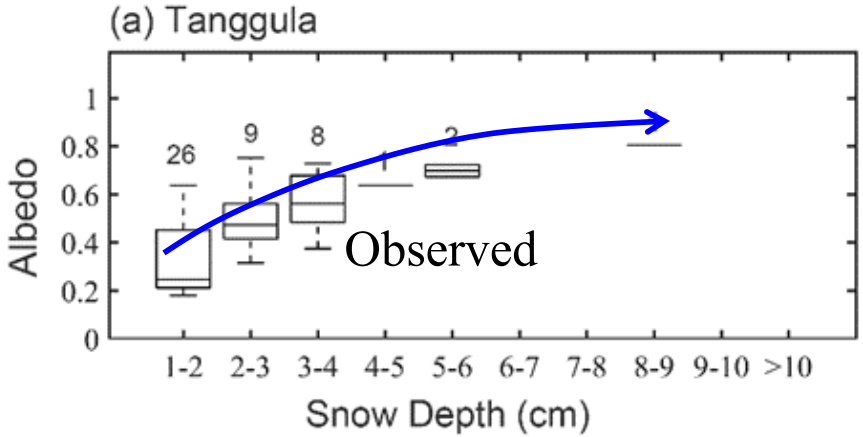


（Che et al.）

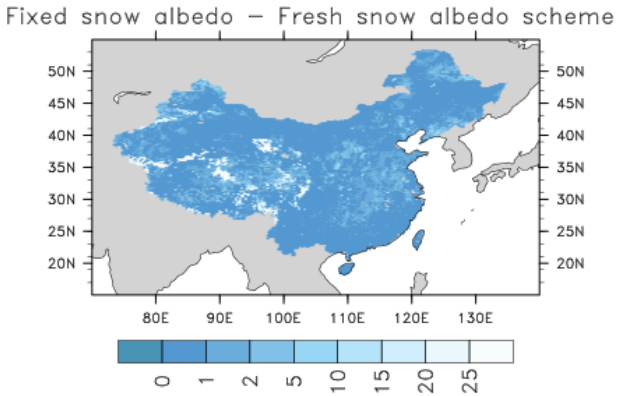
Current models much overestimate SD (Orsolini et al., 2019, TC)



Fresh snow albedo highly depends on SD, but does not in most of LSMs



Considering the dependence can much reduce the over-estimation in Noah-MP



SD diff.

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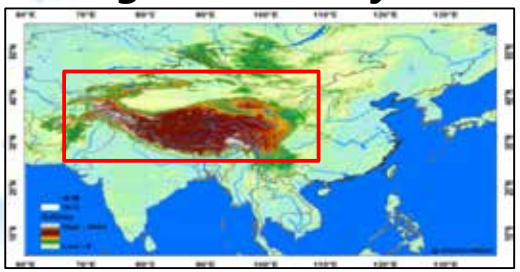
Plan for TPE high-resolution modeling

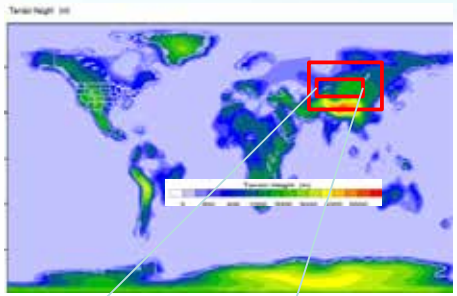
Regional reanalysis

9km



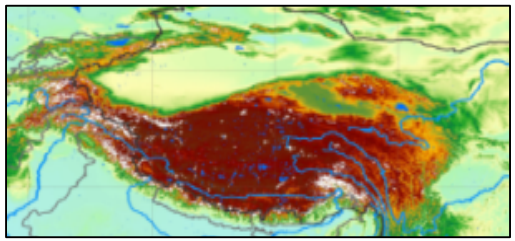
WRF-DA

ERA5, 31km



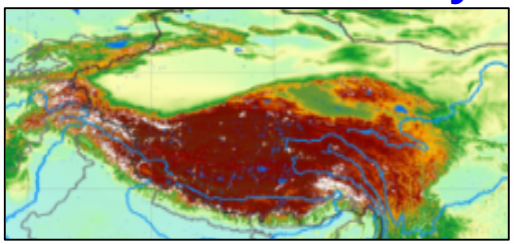
WRF-TP

3km

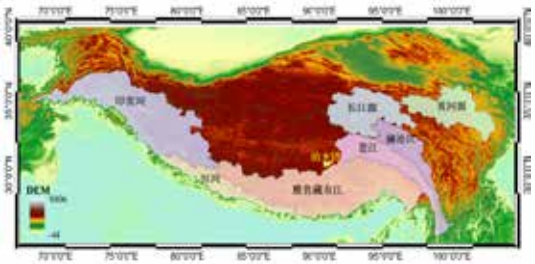


Near-surface reanalysis

3km



Applications

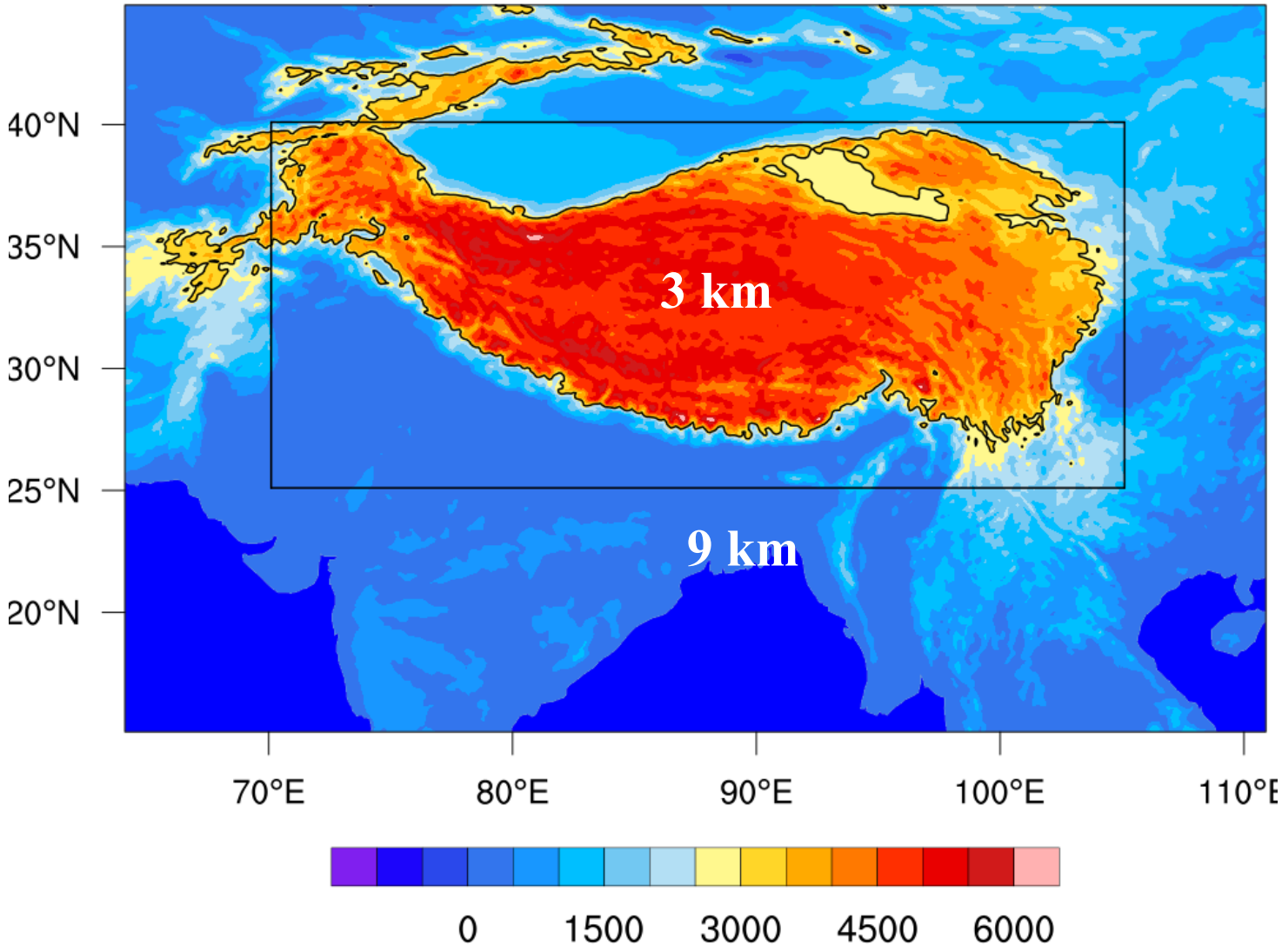


Model improvements

- TOFD
- Flake
- Shallow snow
- Land parameters
- Cloud physics

Ground and satellite observations

9km reanalysis domain and 3 km downscaling domain



Perspectives

- High-resolution regional modeling system development →Representing complex-terrain, lake, snow and land-air interactions is crucial and challenging for this region.
- Coordinated high-resolution regional climate modeling → Simulated precipitation is very sensitive to the resolution for complex-terrain.
- Cooperation with AsiaPEX for in situ data collection, model evaluation and process studies
- Welcome young talent scientists with RCM expertise: two postdoc positions (yangk@tsinghua.edu.cn)

ERA5 has a much larger mean bias in precipitation in the upper Himalaya (292%) than the Qiangtang Plateau (58%)