Grand challenges of TPE water cycle research

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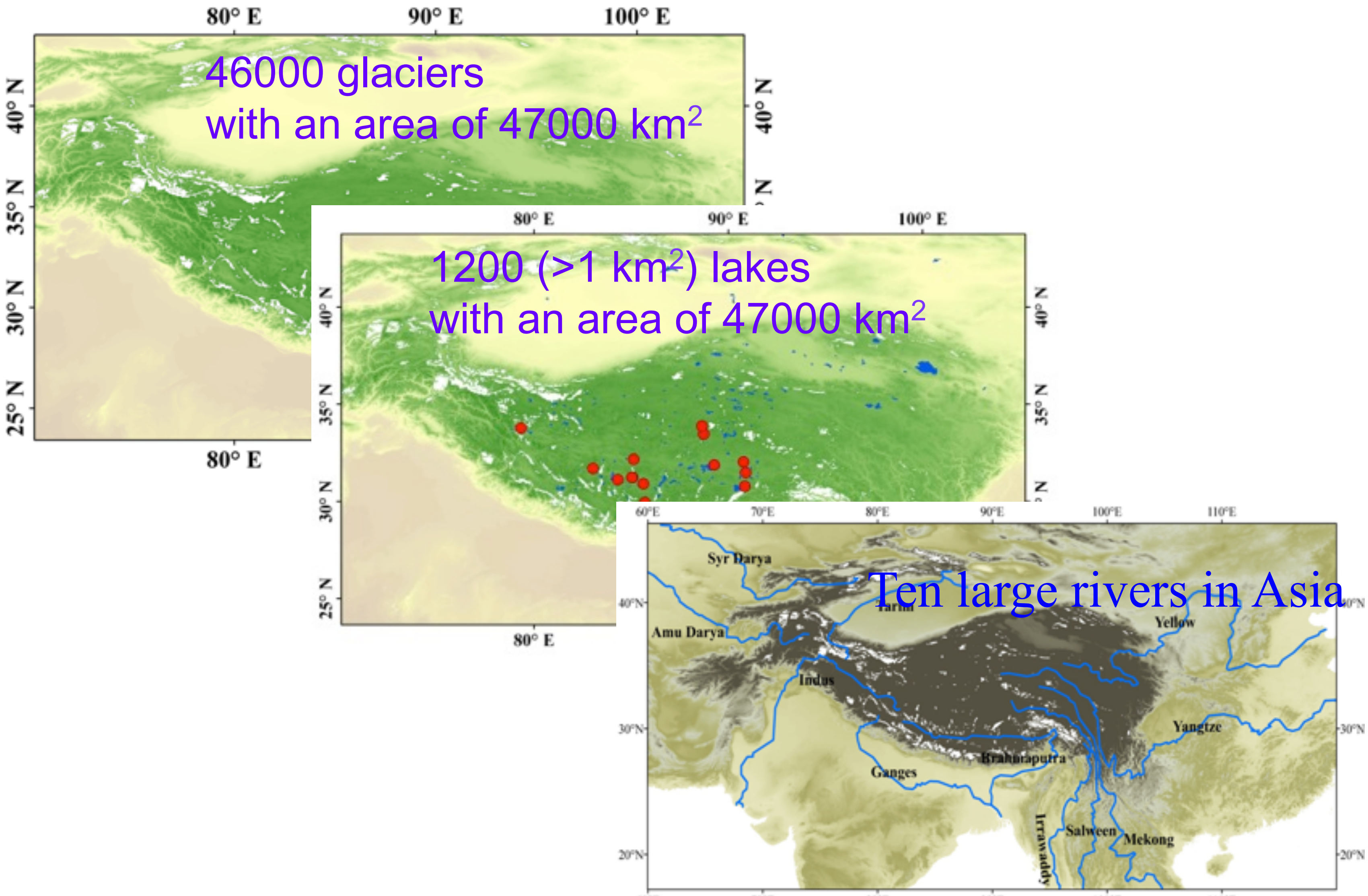
My activities in GEWEX

- 2002: Joined GEWEX/CEOP fieldwork
- 2006 : Joined International Soil Moisture Network Working Group workshop
- 2007-2011: Chaired CEOP/WEBS cross-cut project
- 2010 : Co-organized CEOP-CAHMDA with Dr. Xin Li in Lhasa

Crucial to understanding and modeling water cycle across multi-spheres in the Tibetan Plateau



GC1: Develop a high-resolution reanalysis dataset for TP
We have developed China Meteorological Forcing Dataset

Fusion

Parameters:
- Wind, Ta, qa
- Pa, Prec, Rad

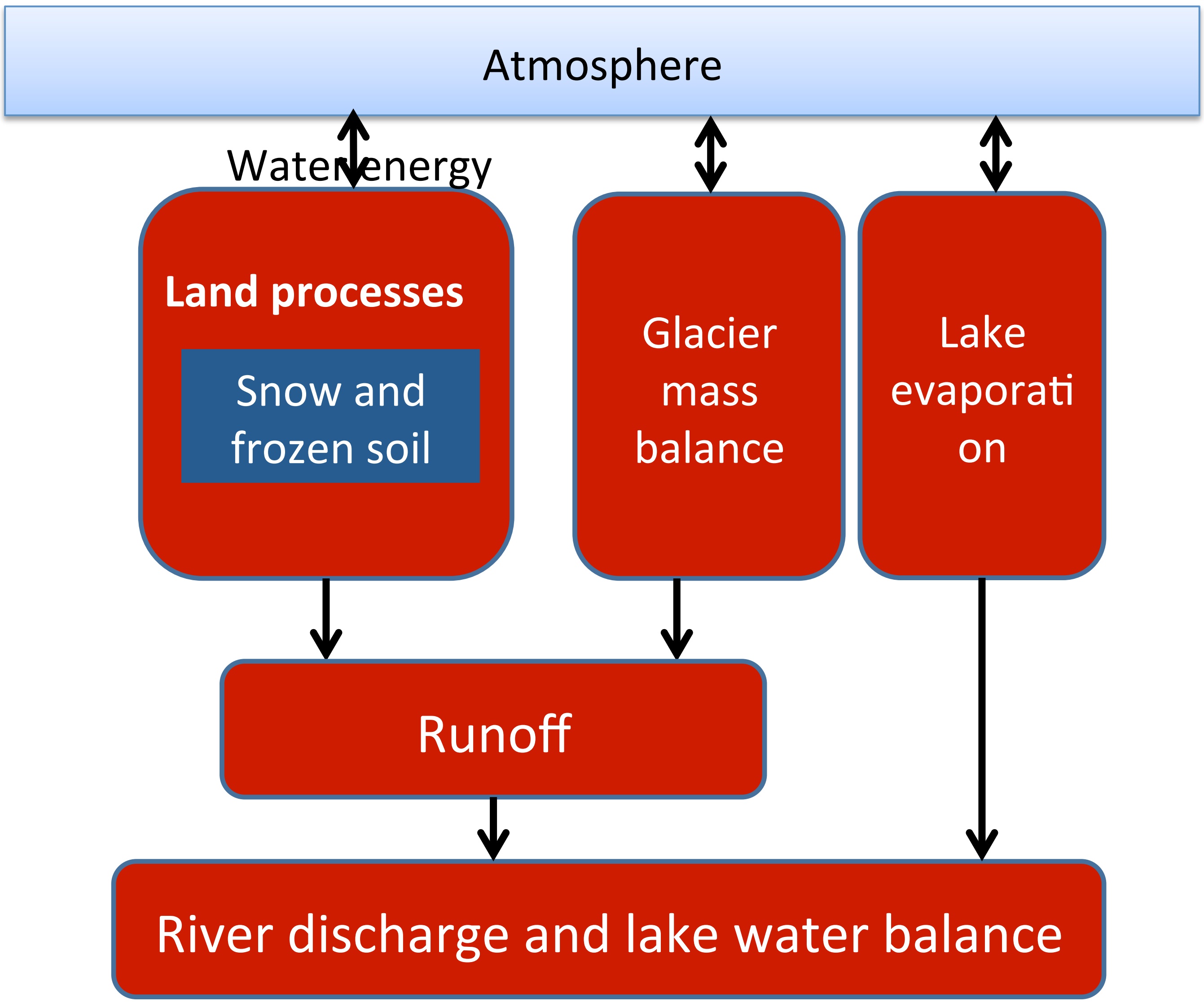
Spatial coverage:
- Mainland China

Temporal coverage: 1979-2015

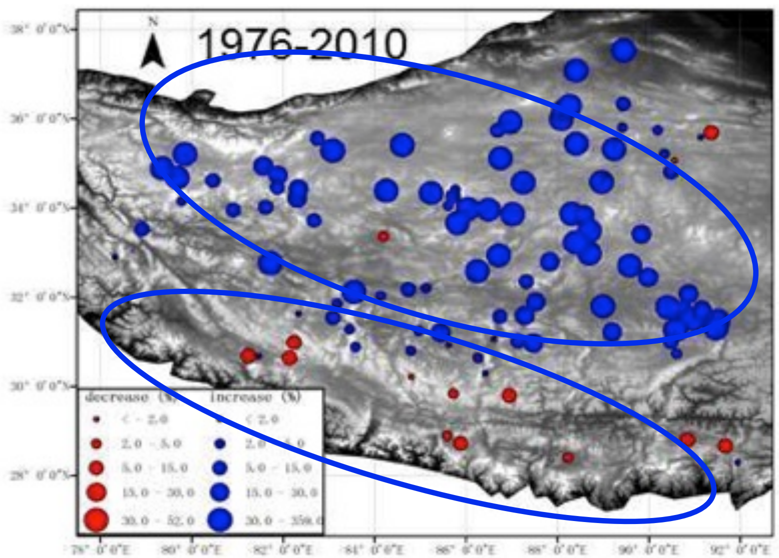
Resolution:
- 0.1 deg, 3 hrs

Precipitation: Guage data at ITP + Persiann at UCI

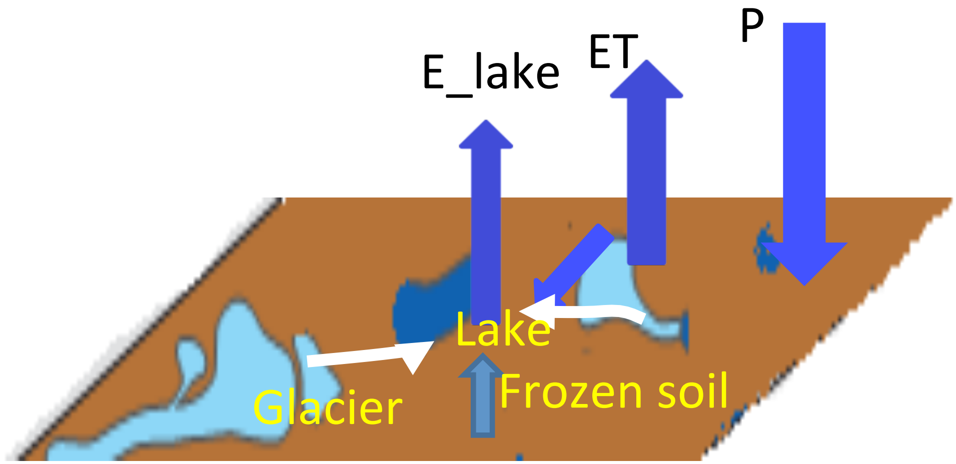
GC2: Developing an integrated model to quantify the interactions among multiple spheres



- To understand water cycle change (Precipitation, land/lake evaporation, glacier/snow melting, frozen soil degradation), such as lake expansion in central and north and shrinkage in south



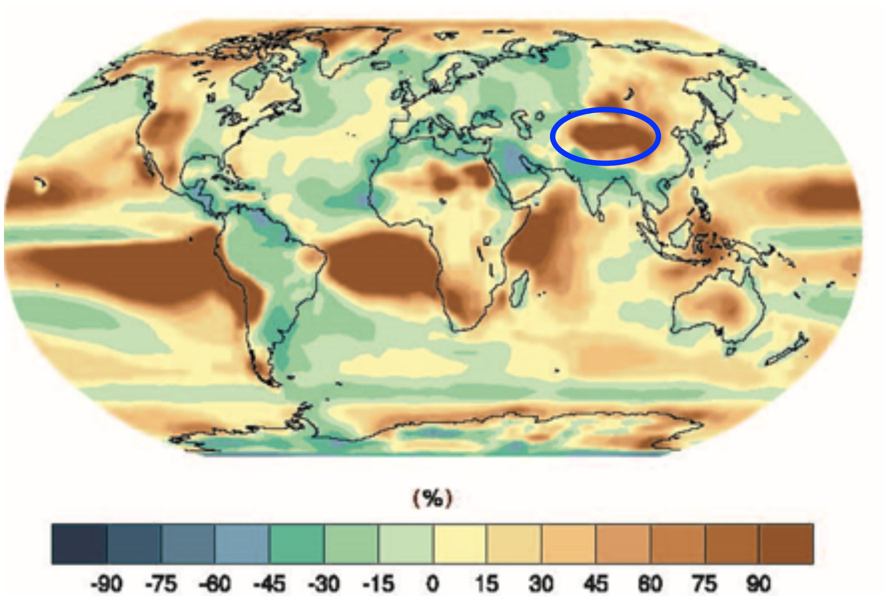
(Lei et al, 2014, Clim. Chang.)



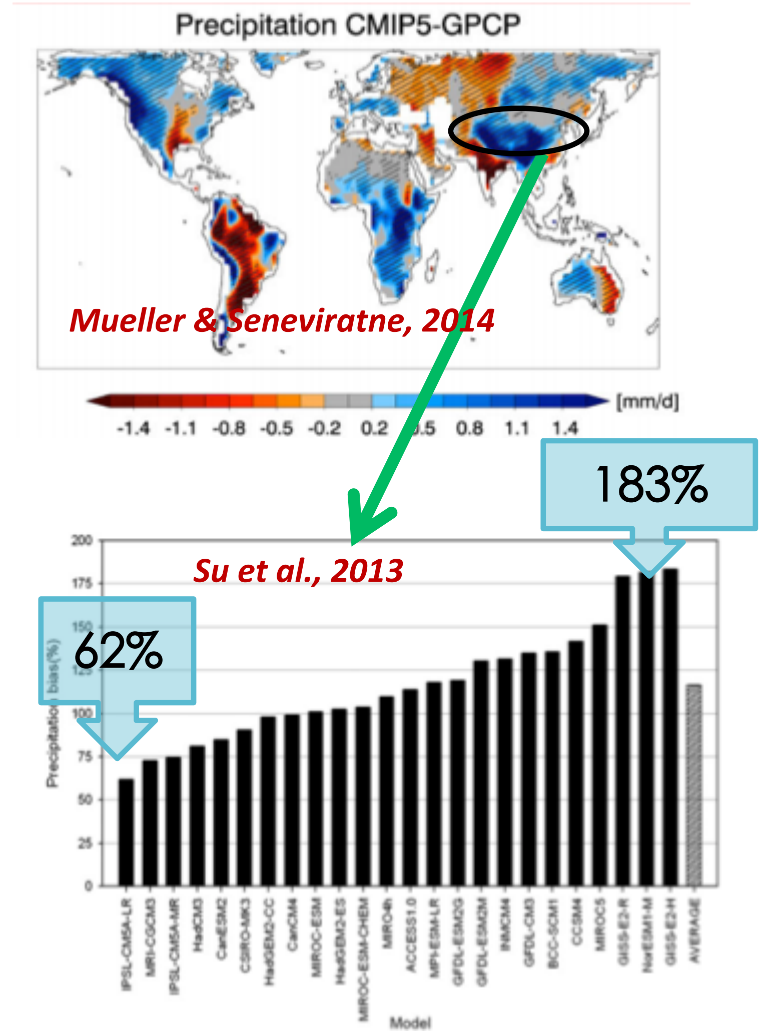
- Model inter-comparison between TP and Arctic (with Gianpaolo): Land, Lake, Frozen soil, Glacier

GC3： Reduce distinct precipitation biases in models: much more in the Plateau and less in adjacent regions!

The largest relative bias in GCMs over global land is on the Tibetan Plateau



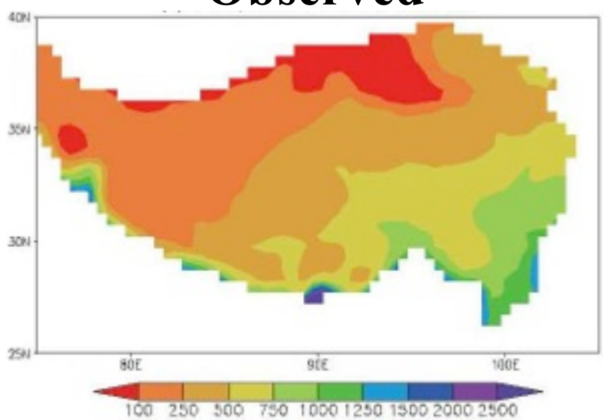
(Flato et al., 2013)



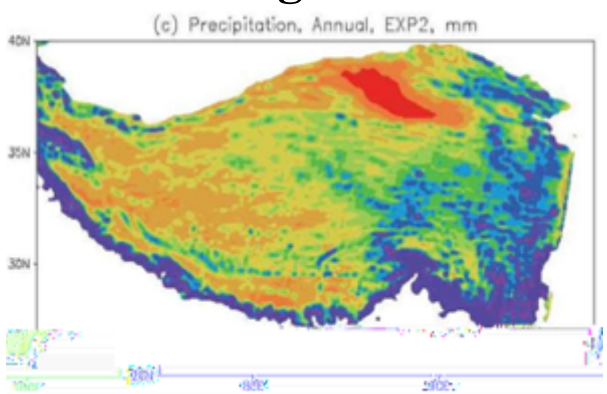
Biases across CMIP5 models

GC3：Reduce distinct precipitation biases in models: much more in the Plateau and less in adjacent regions!

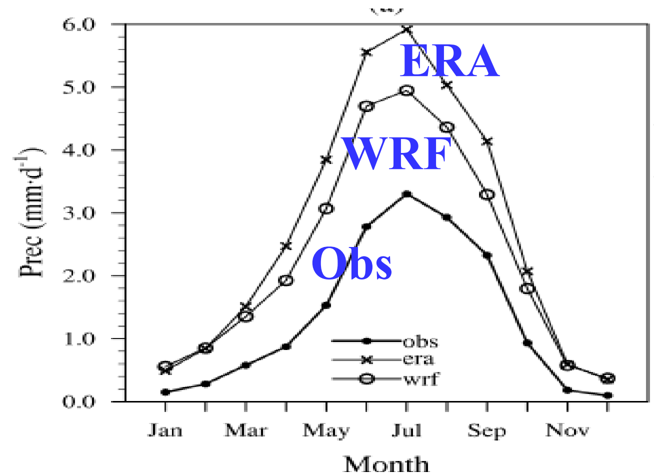
Observed



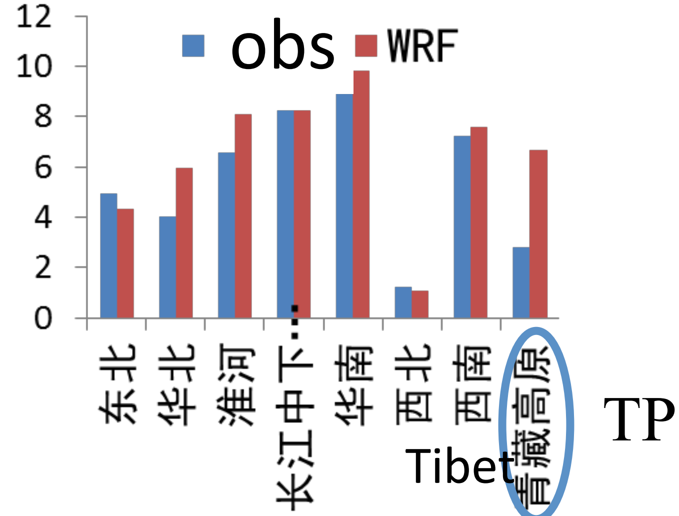
10km RegCM simulated



(Ji & Kang, 2014)

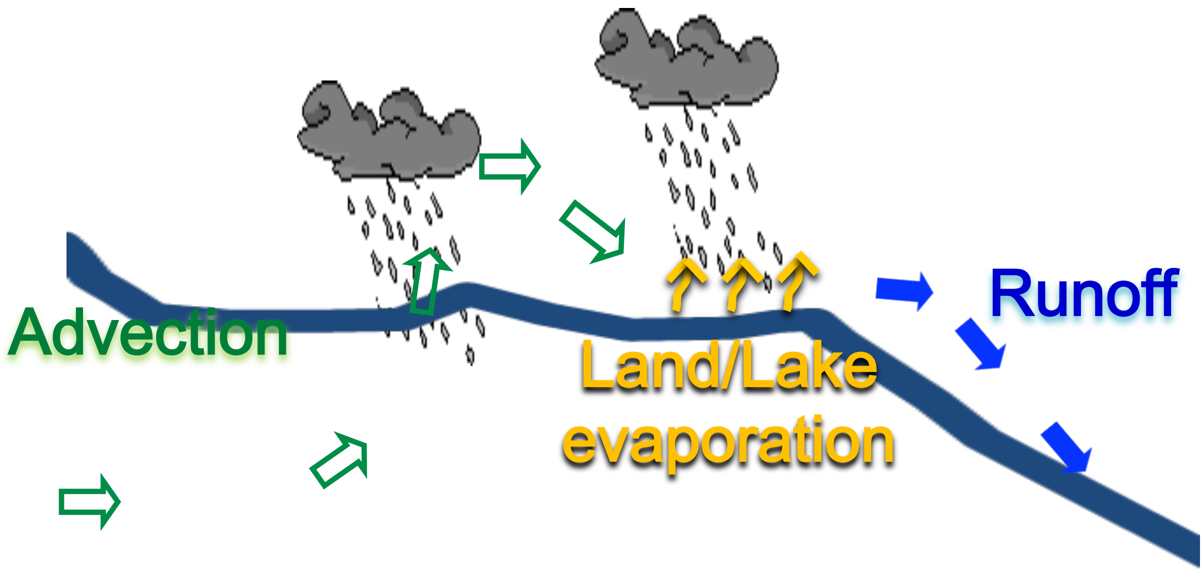


(Gao Yanhong et al., 2015)



(Ma Jiehua et al., 2015)

Understand biases through two water vapor sources

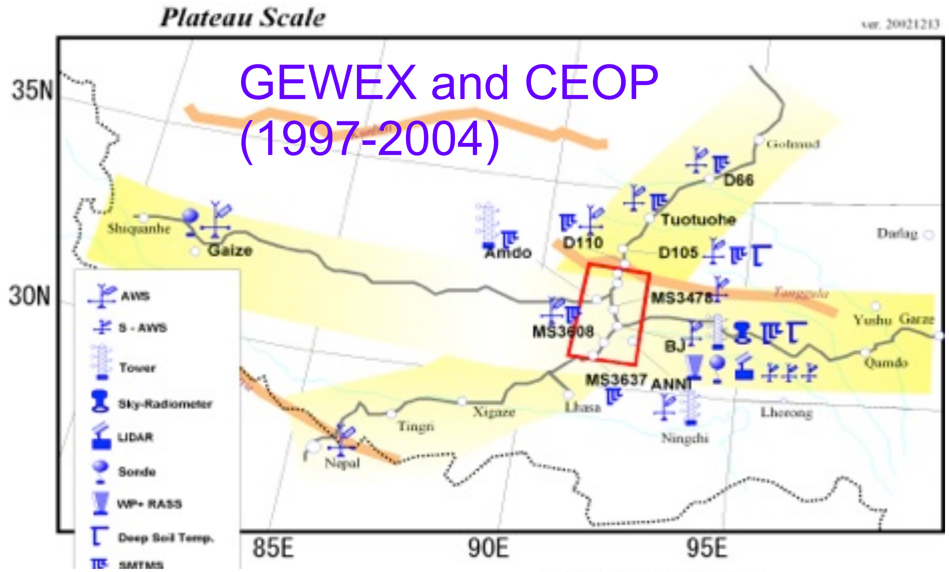


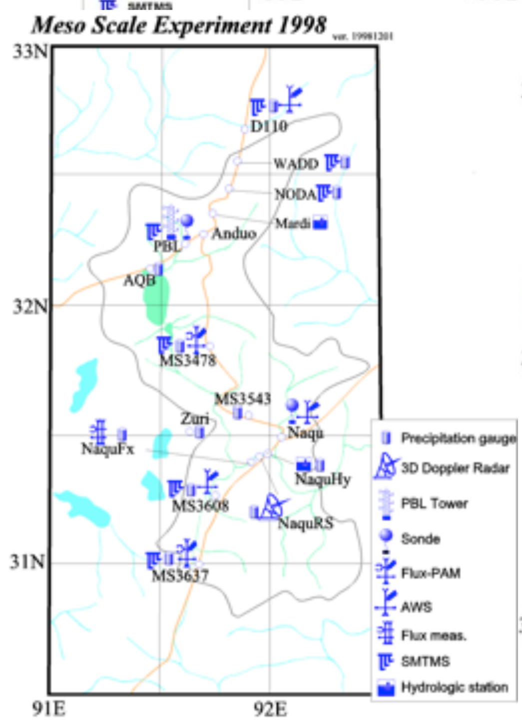
- Land evaporation depends on land surface and atmospheric conditions
- Vapor advection depends on vapor gradient, wind speed and topography

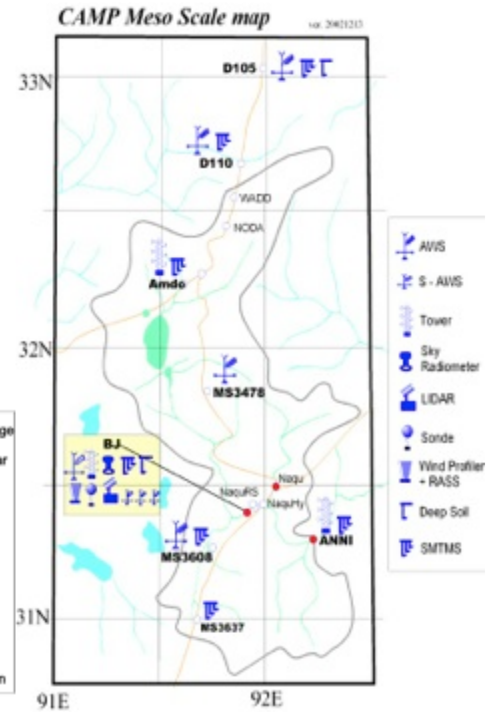
Key processes in terms of water cycle

- Soil moisture-evaporation-precipitation
- Topographic (mountain & valley) impact on water vapor transfer
- Complex terrain enhancing momentum loss (retard wind and vapor transport) and runoff
- Soil organic matters control on moisture
- Lake-air interaction

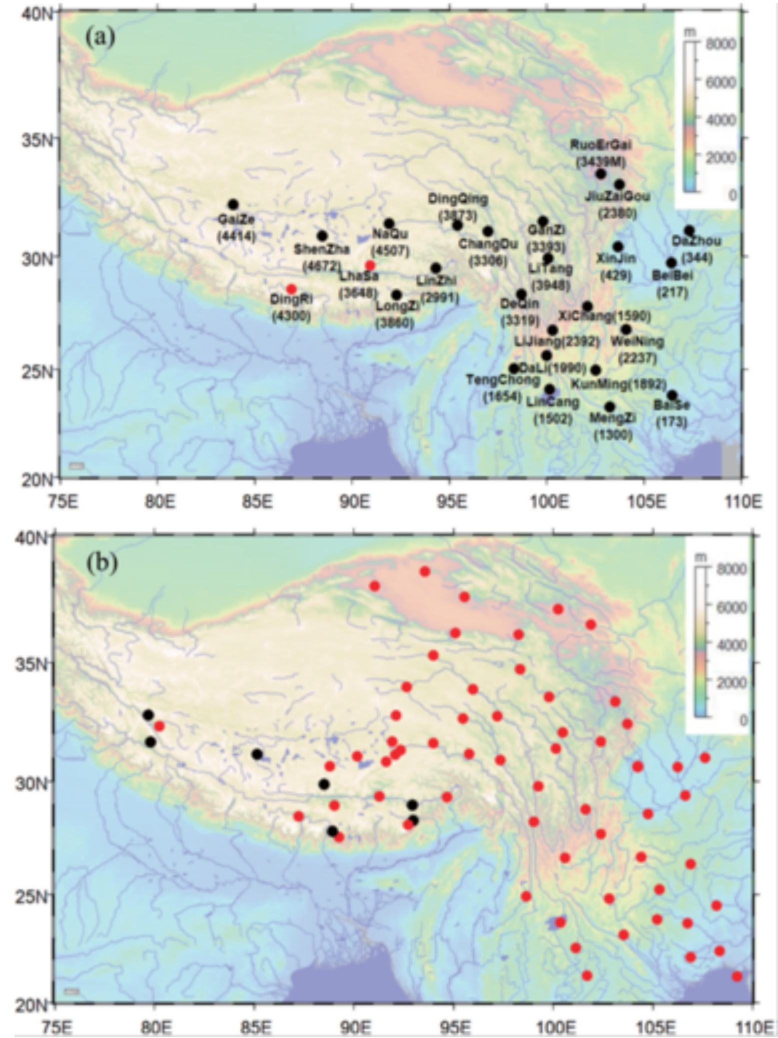
Networks for process understanding and model development





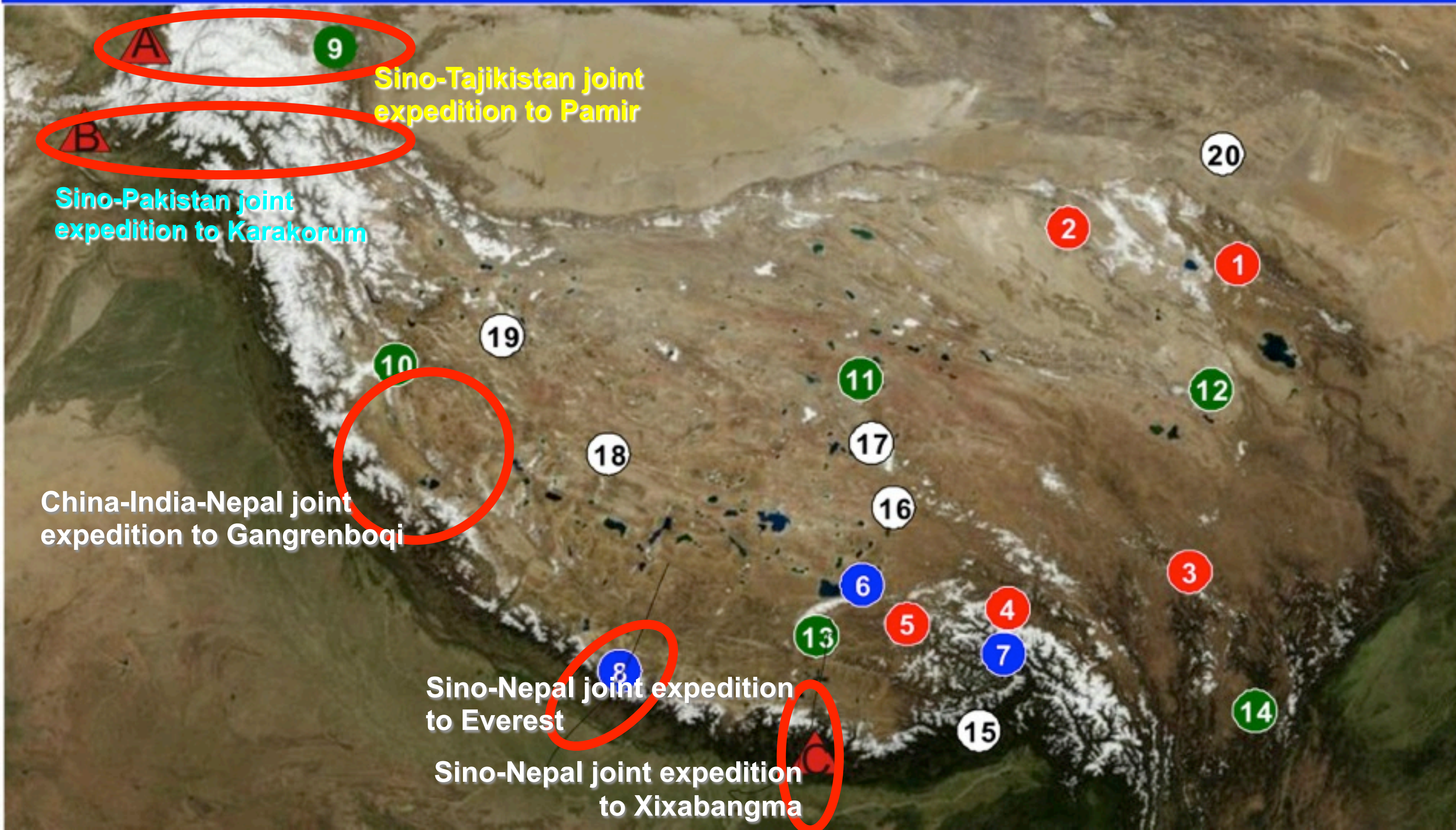


JICA (2005-2009)



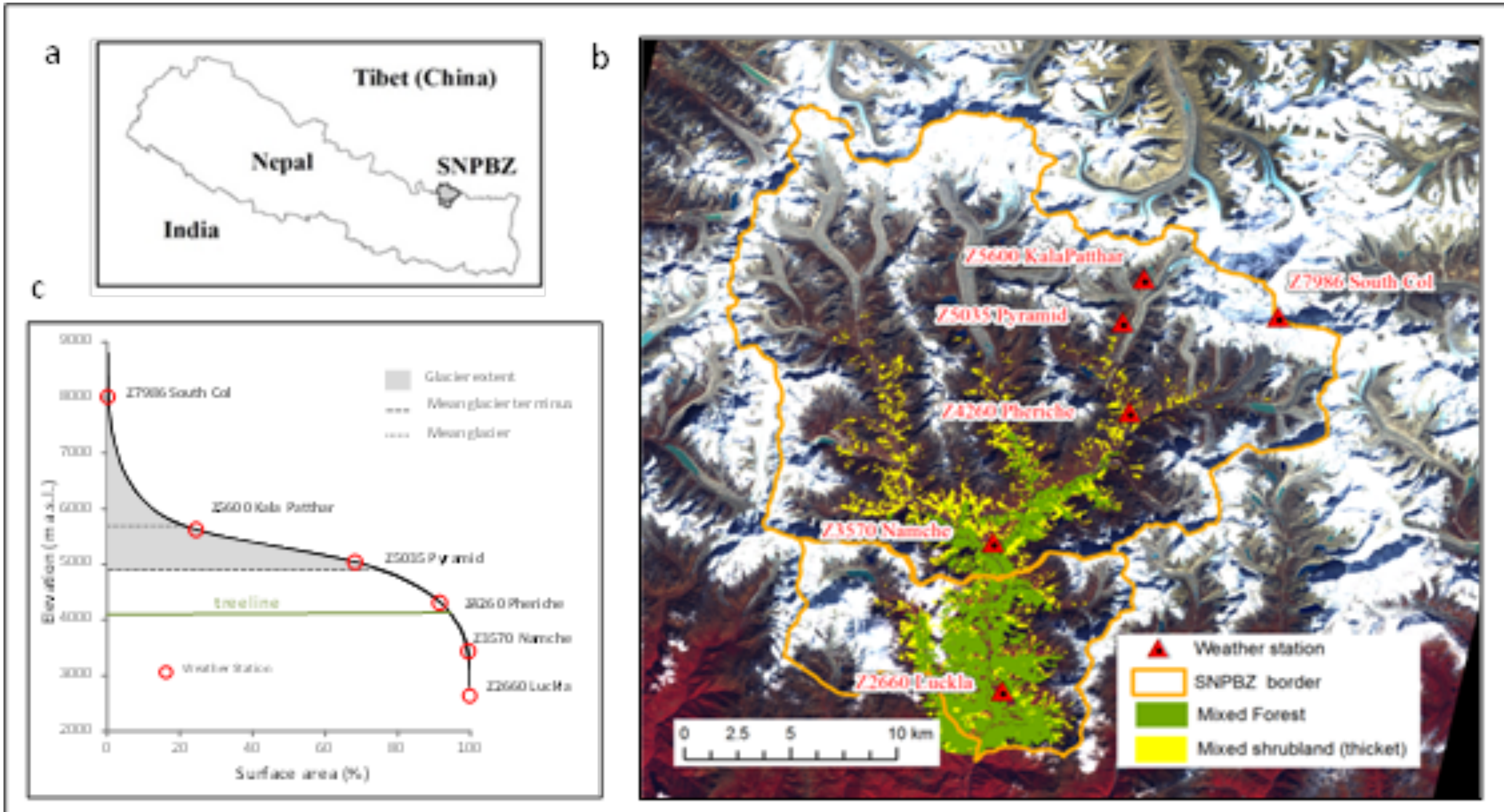
Process-oriented network

1 Haibei
2 Northern Plateau
3 Mt Gongga
4 Nyinchi
A Sino-Tajikistan station
5 Lhasa
6 NAMORS
7 SETORS
8 QOMORS
B Sino-Pakistan station
9 Mutztag Ata
10 NAWORS
11 Beiluhe
12 Maqin
13 Yazhog Yumco
-Nepal station
17 Mt Tangglha
iguan

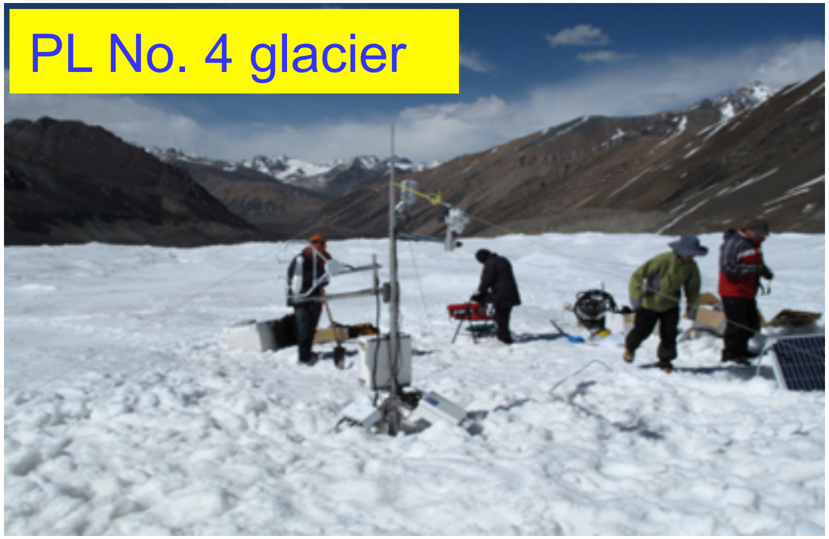


South slope of Everest: Pyramid network

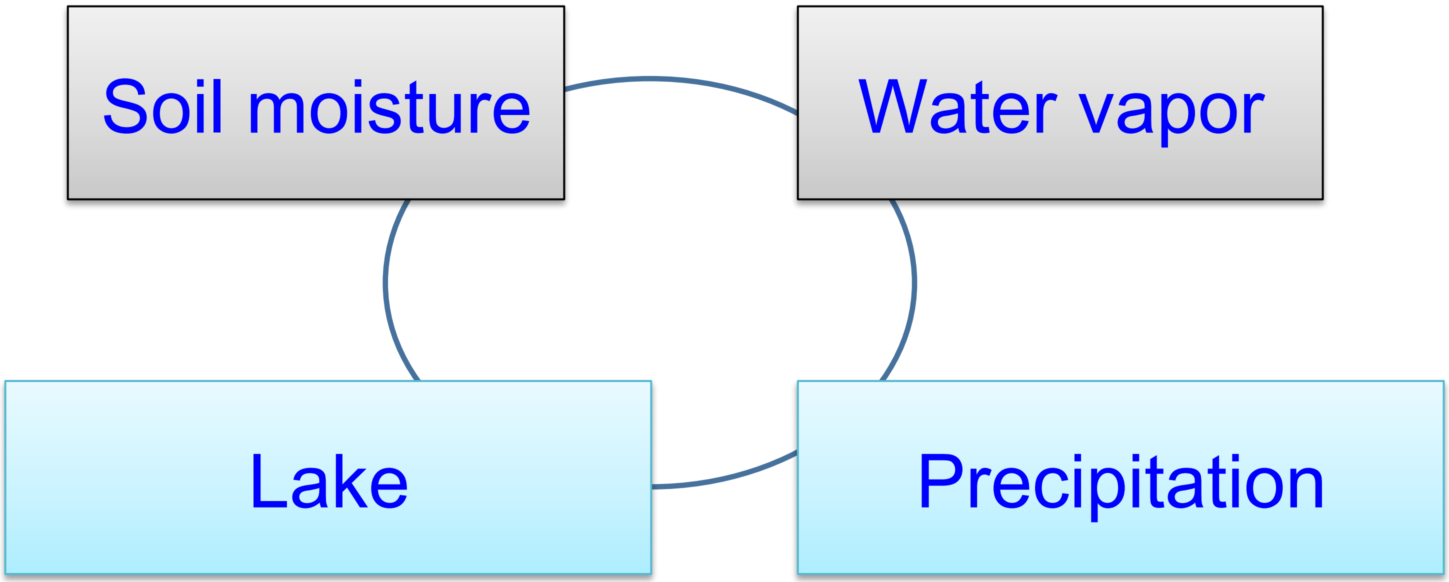
Precipitation, radiation, wind, Tair, and RH are observed at six stations from 2660- 8000 m



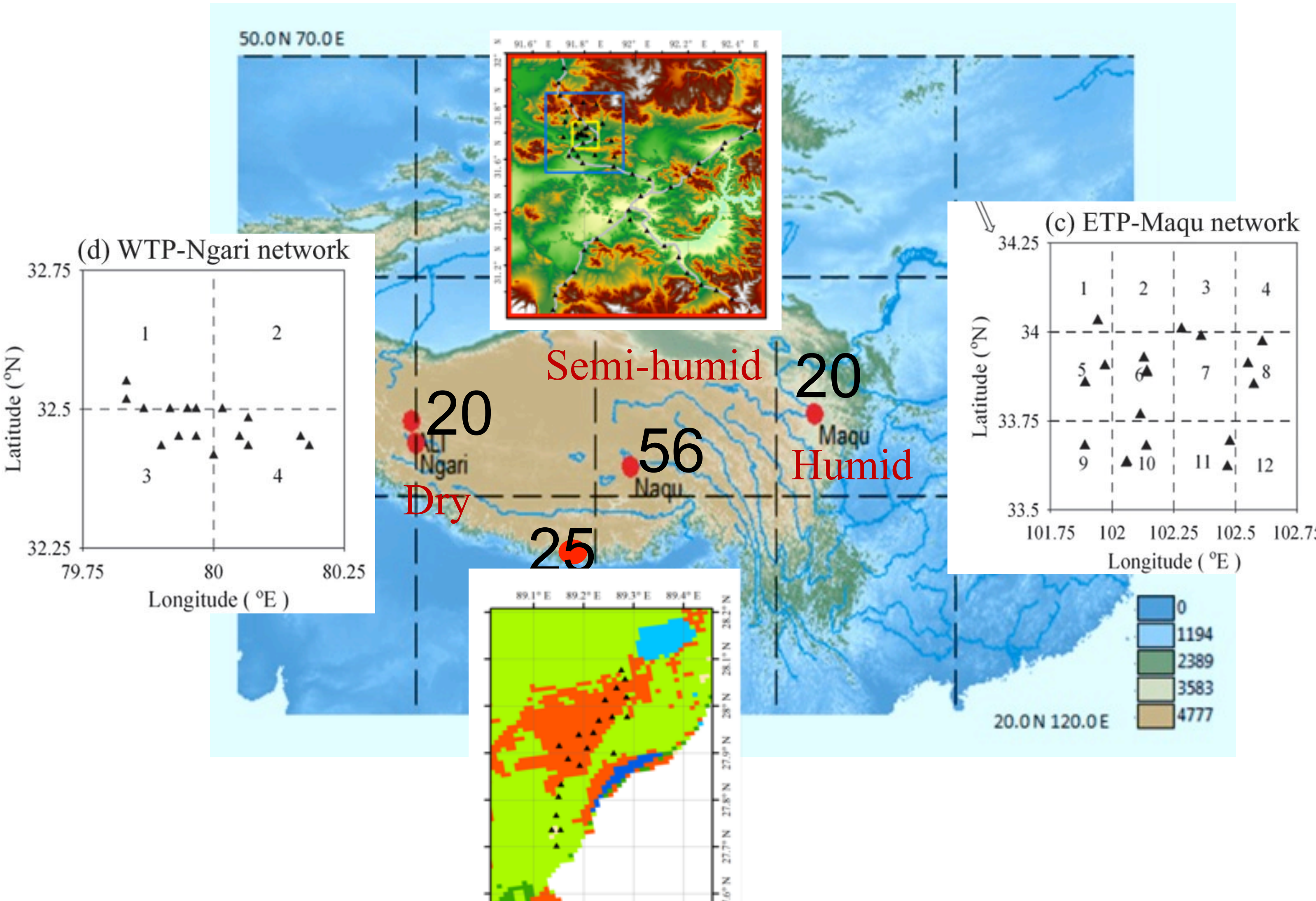
Glacier-air and lake-air interaction measurements for the model development



Networks for remote sensing algorithm development, calibration and validation



Soil moisture and soil temperature networks



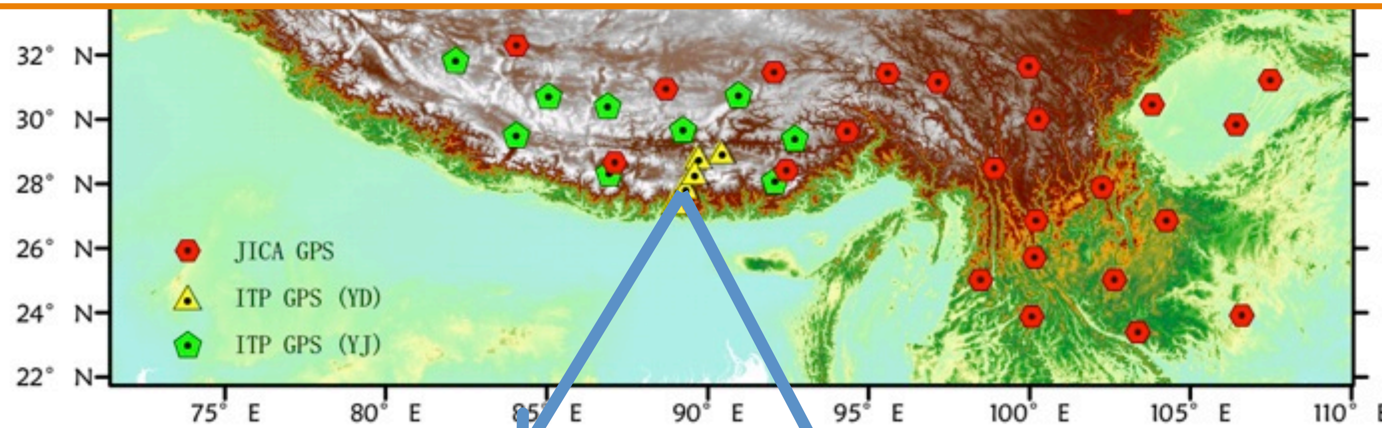
(Su et al., 2011 HESS; Yang et al., 2013)

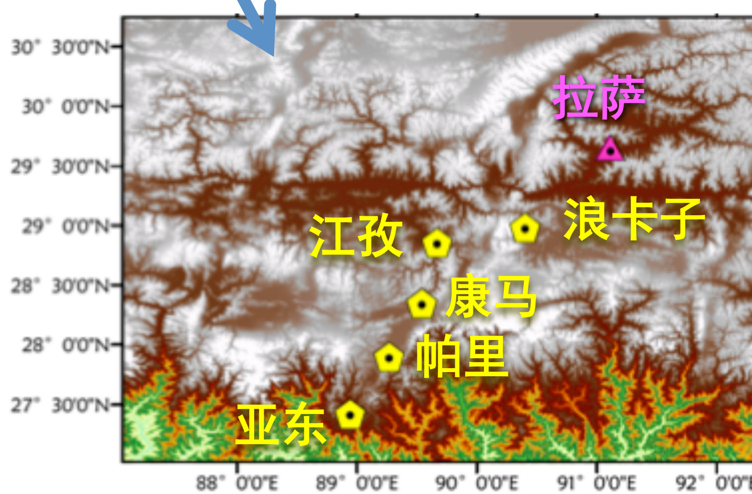
PWV measurement: GPS network in South TP

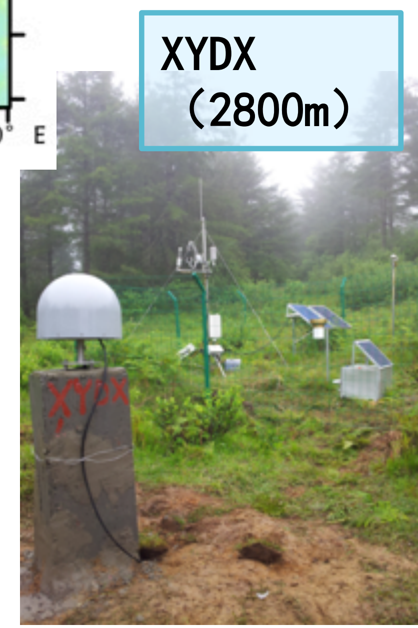
JICA GPS： 24 stations （2008.01.01-10.31）

ITP GPS： 9 stations (2007.05--) in Yarlung Zangbo valley

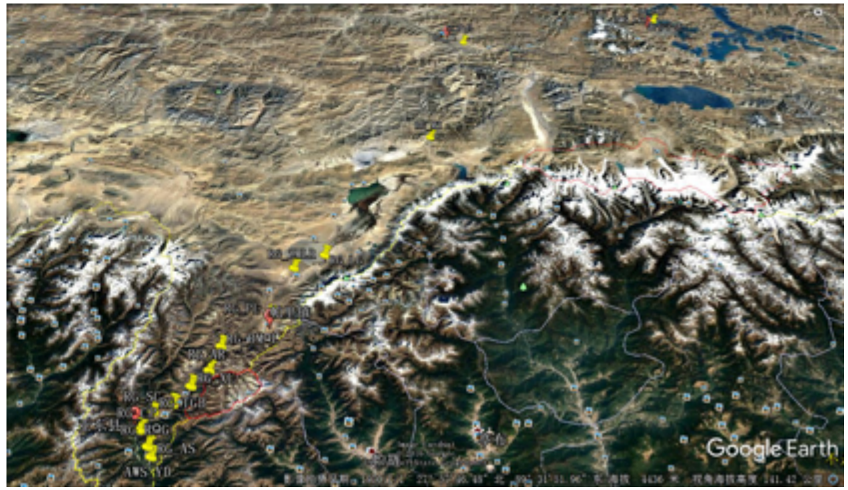
5 stations (2015.6.26--) along Yadong-Lhasa transect

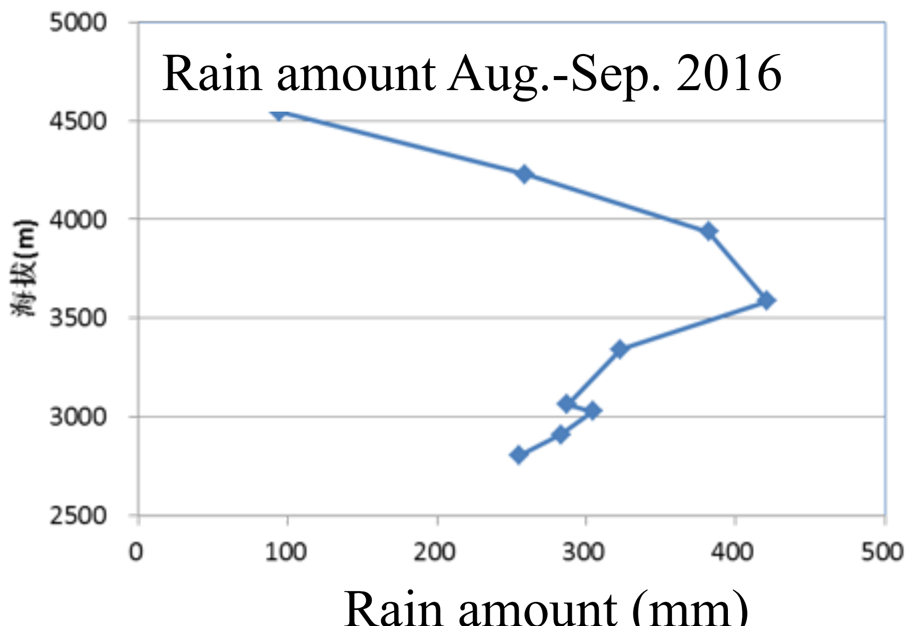




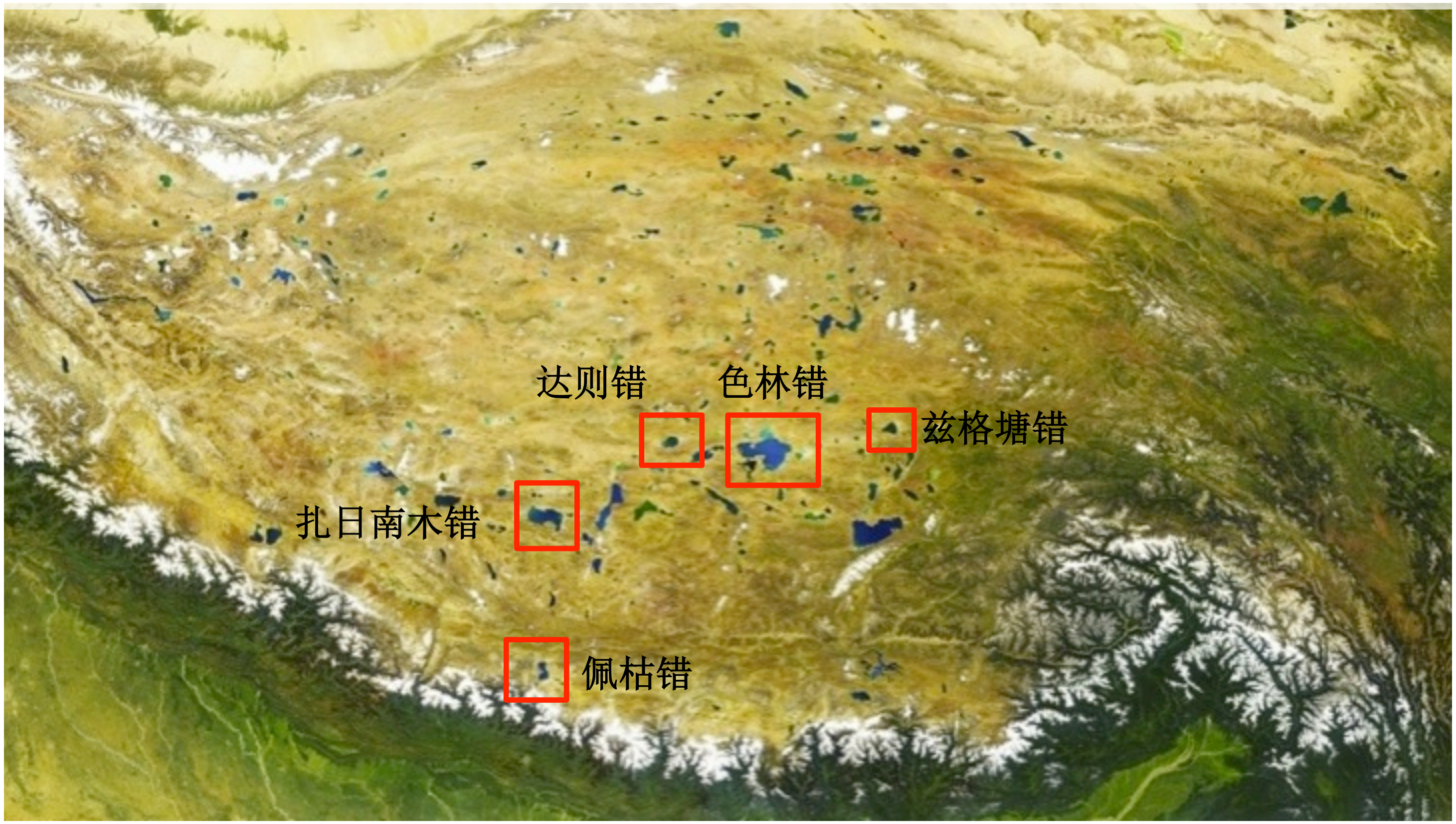


Precipitation:14 rain guages along Yadong valley (since 2016.7.26)





Lake temperature profile for eight large lakes

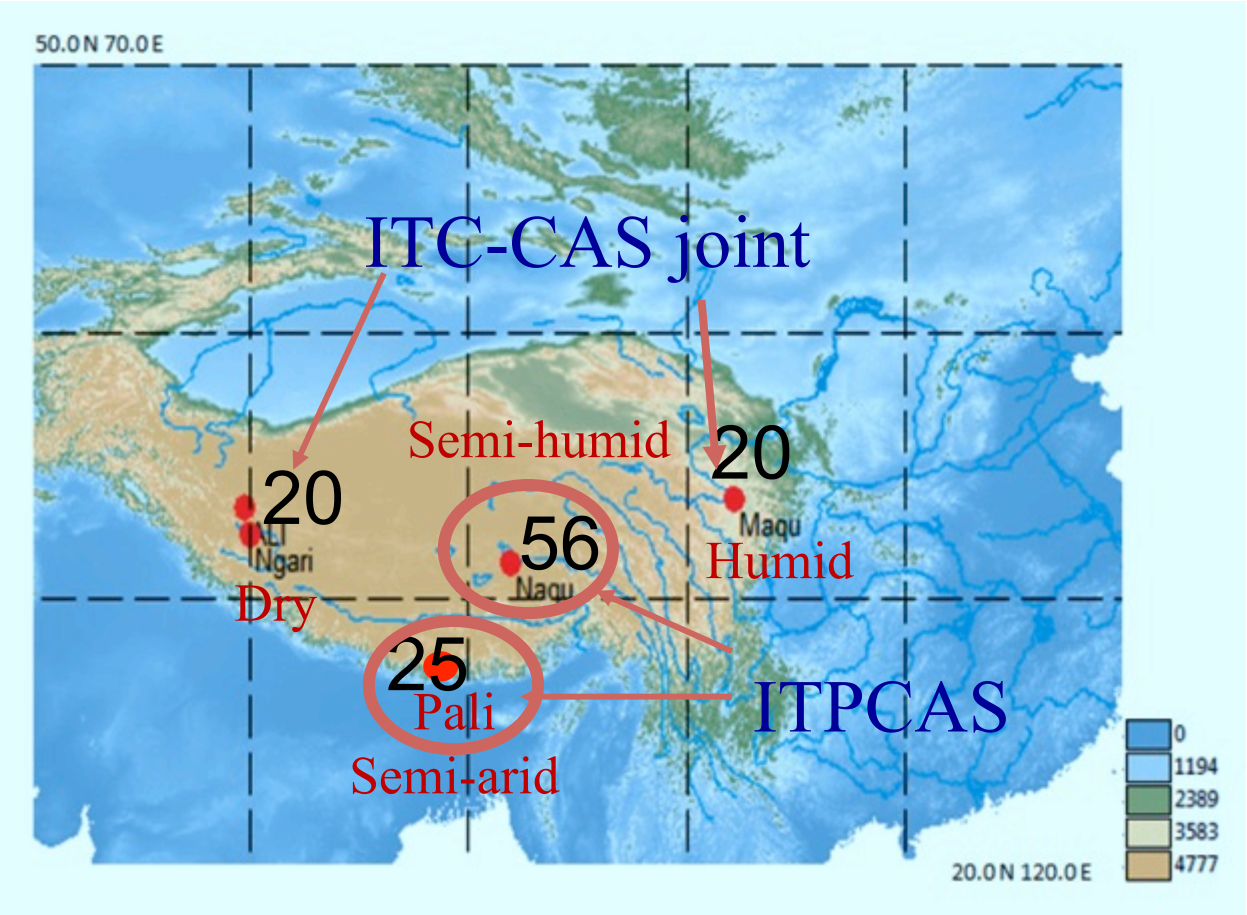


Lake	色林错	扎日南木错	达则错	佩枯错	兹格塘错
Area (km^2)	2335	1001	292	270	233
Max. Depth (m)	50	72	42	70	39

Progress of soil moisture studies

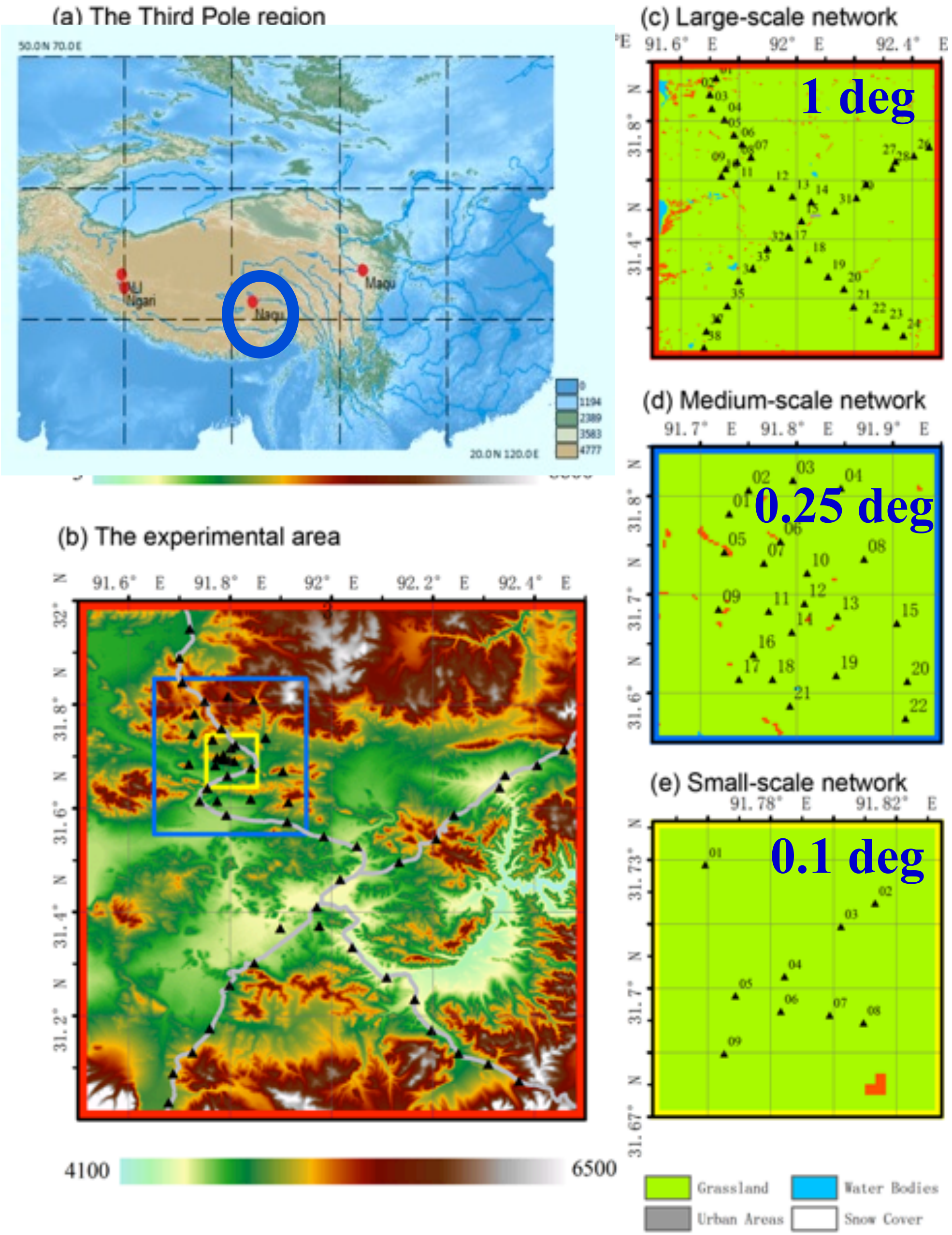
- Constructed two soil moisture measuring networks in the Tibetan Plateau, covering different soil moisture regimes.
- Evaluated major satellite soil moisture for the Tibetan Plateau.
- Developed a validated soil moisture dataset for China covering 2002-2011 through land data assimilation.
- Demonstrated the potential to calibrate land models at grid-scale instead of point-scale through satellite data assimilation.

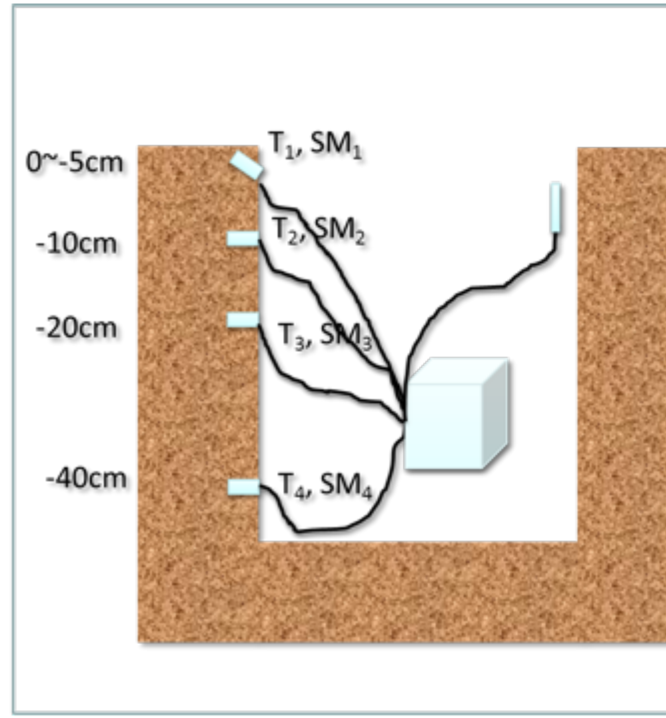
Four soil moisture and soil temperature networks are the validation basis of satellite soil moisture products



(Su et al., 2011 HESS; Yang et al., 2013)

Naqu multi-scale soil moisture and temperature network in CTP

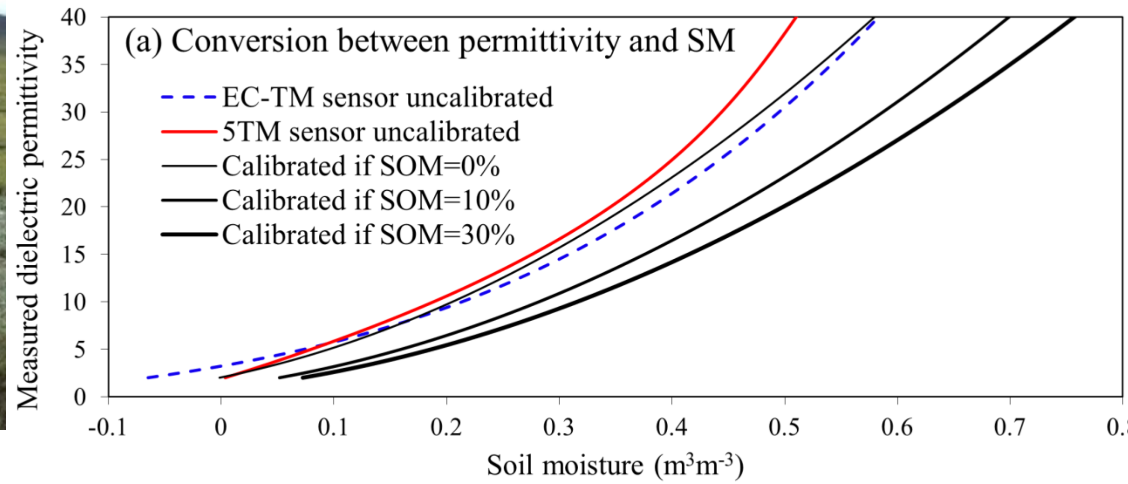


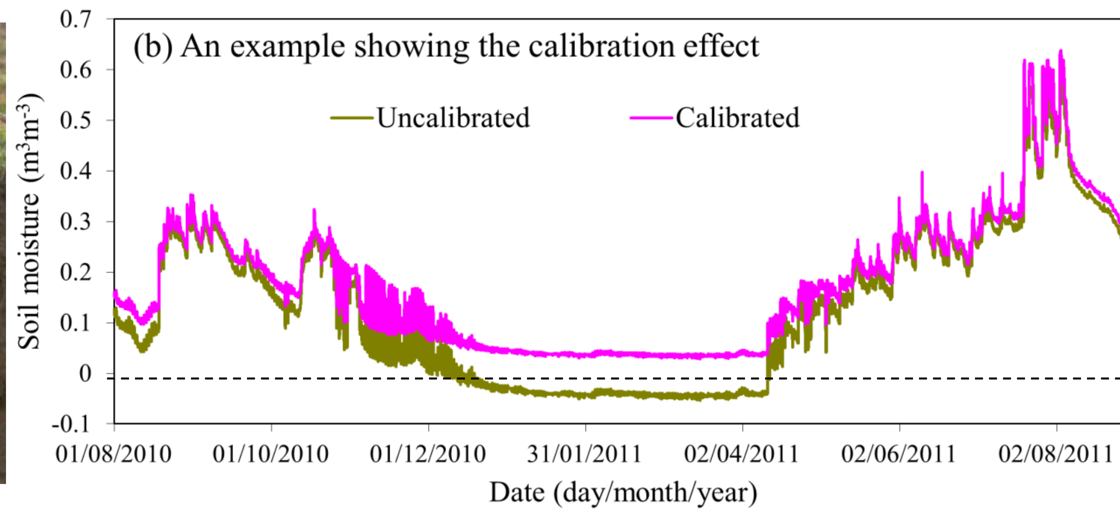


- Above 4500 m a.s.l.
- Sensor calibrated,
- Data accessible through ISMN

(Yang et al., 2013 BAMS)

Sensor calibration according to soil texture and SOC
Based on relationship established by laboratory experiments

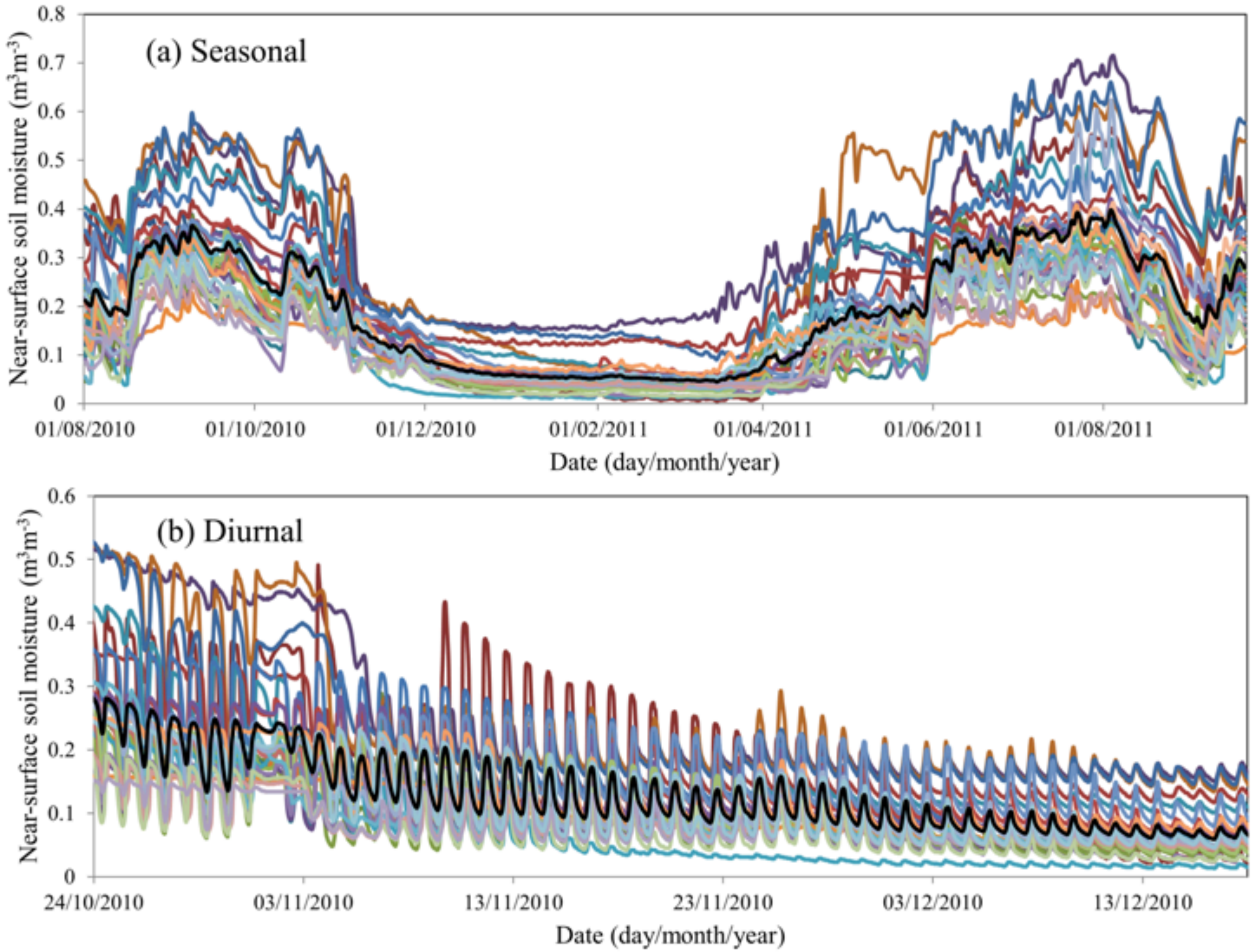




very high soil organic matters content

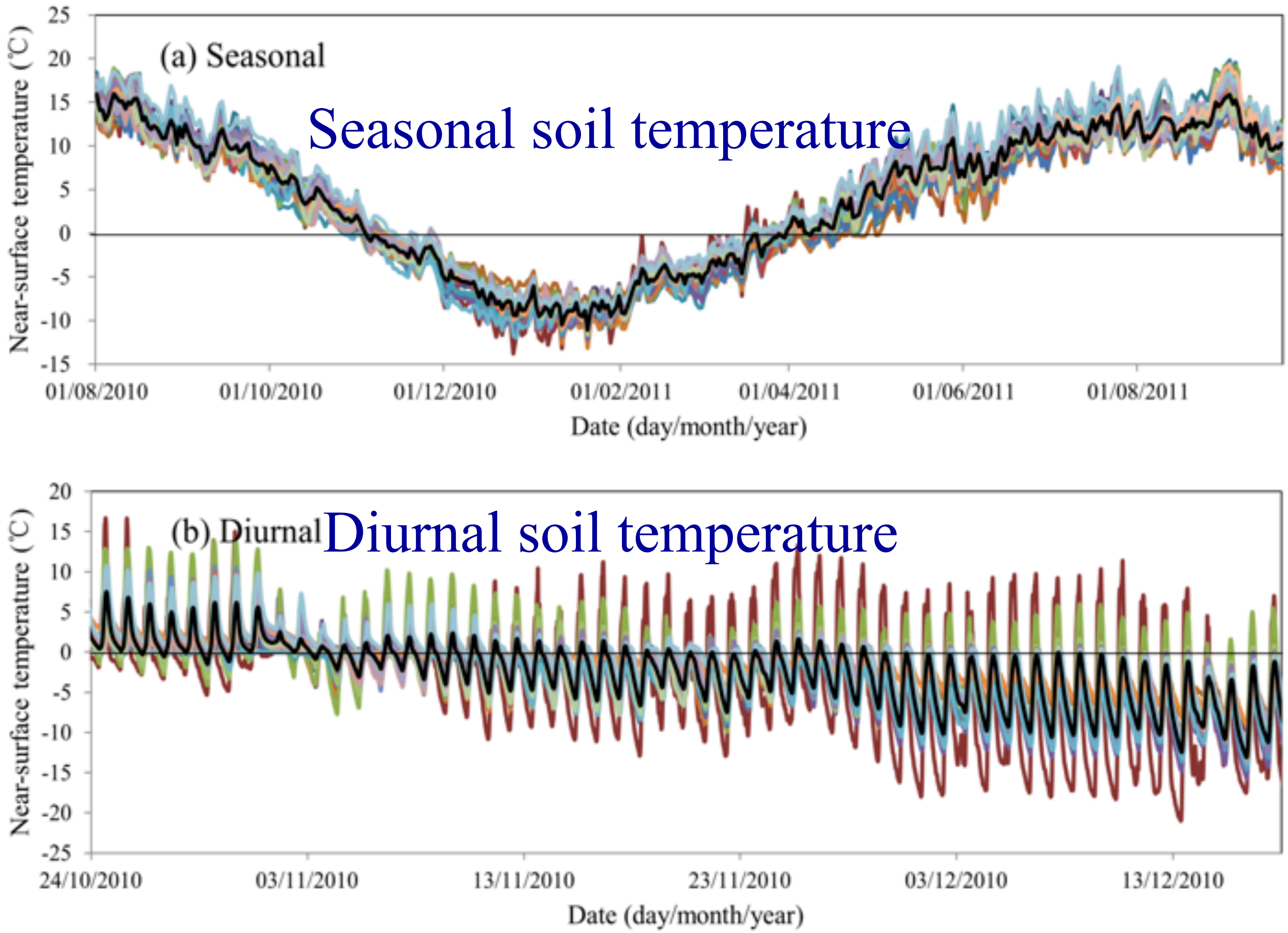
(Yang et al., 2013 BAMS)

Observed soil moisture



(Yang et al., 2013 BAMS)

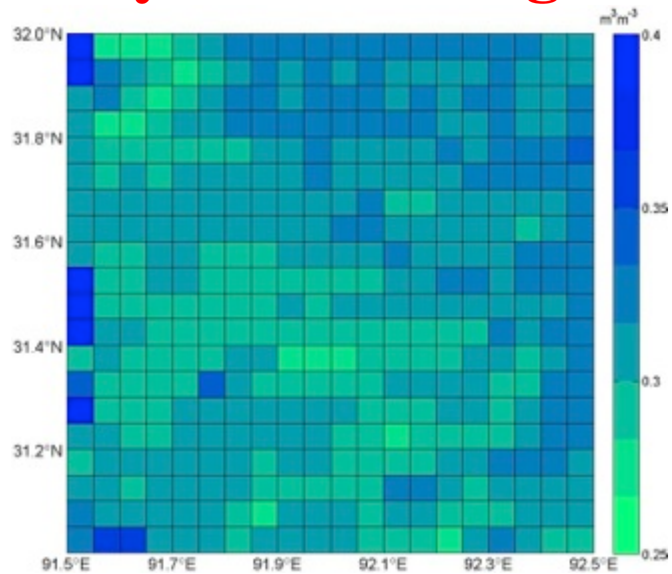
Observed seasonal soil freezing and thawing

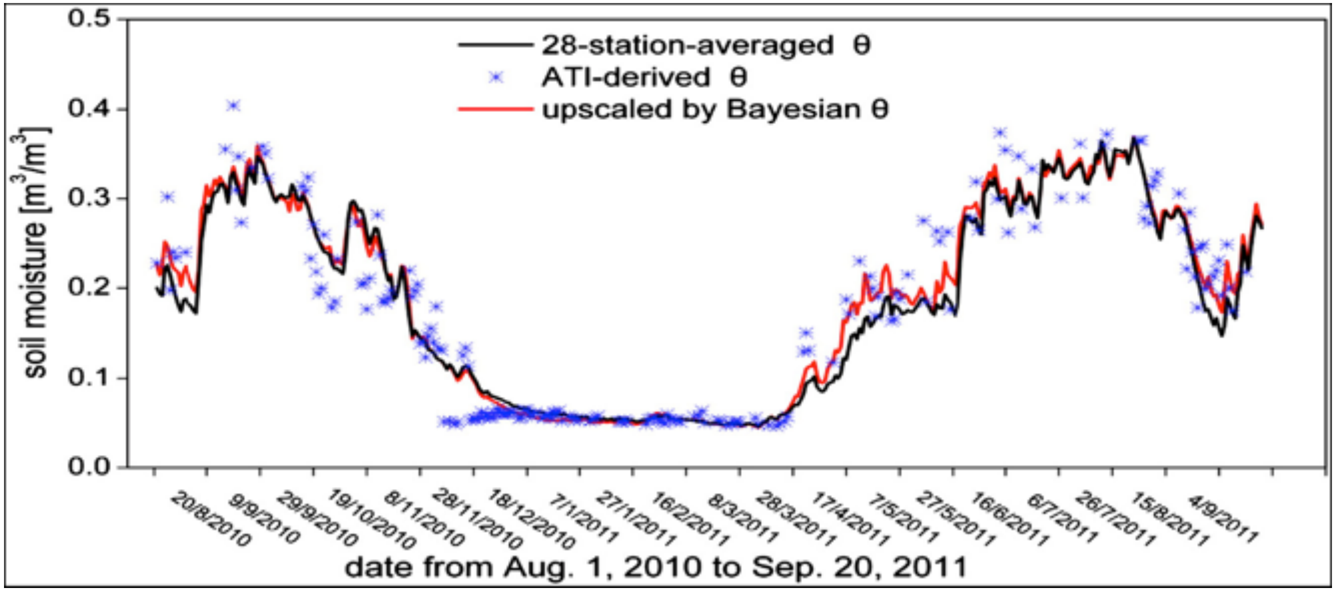


(Yang et al., 2013 BAMS)

Upscale from points to pixels by introducing MODIS LST

Soil moisture distribution obtained by upscaling





(Qin et al., 2013RSE)

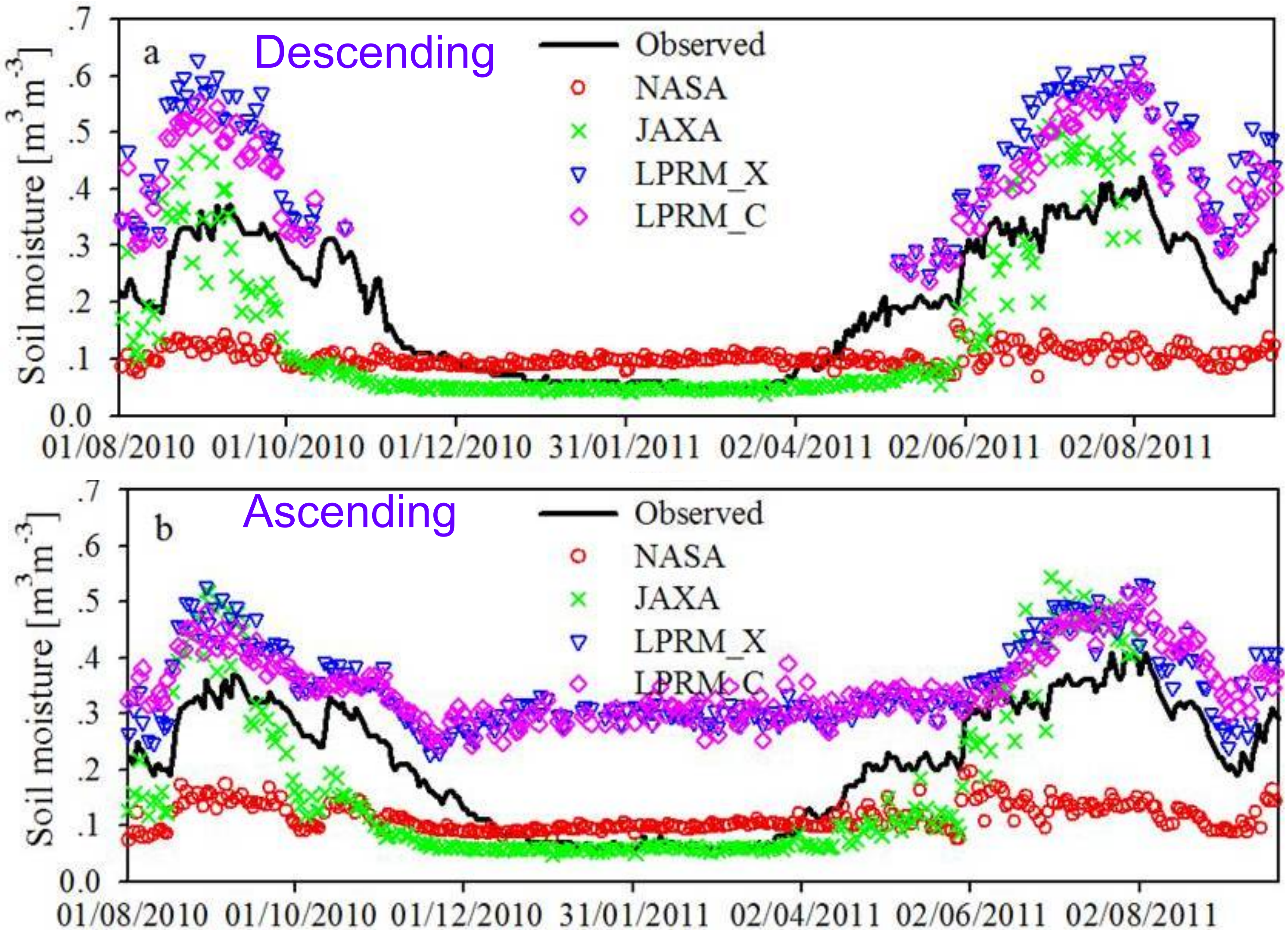
Data sharing through ISMN

- Cooperation with ISMN Network
  - Network
    - Required: general info/contact person(s)
  - Station
    - Required: name/Lon/Lat/Ele
    - Optional: Image/photo…
  - Data
    - Required: monitoring depth(s)/sensor info/ acquisition time (UTC)/
    - Optional: meteorological variables/soil properties/land cover…
  - Data sharing policy
    - Scientific use only
    - No onward distribution
    - Acknowledgement and citation (the original data provider and the ISMN)
    - Delivery may be suspended or terminated at any moment.
- Data access
  - Data portal through DAM

http://www.ipf.tuwien.ac.at/insitu/

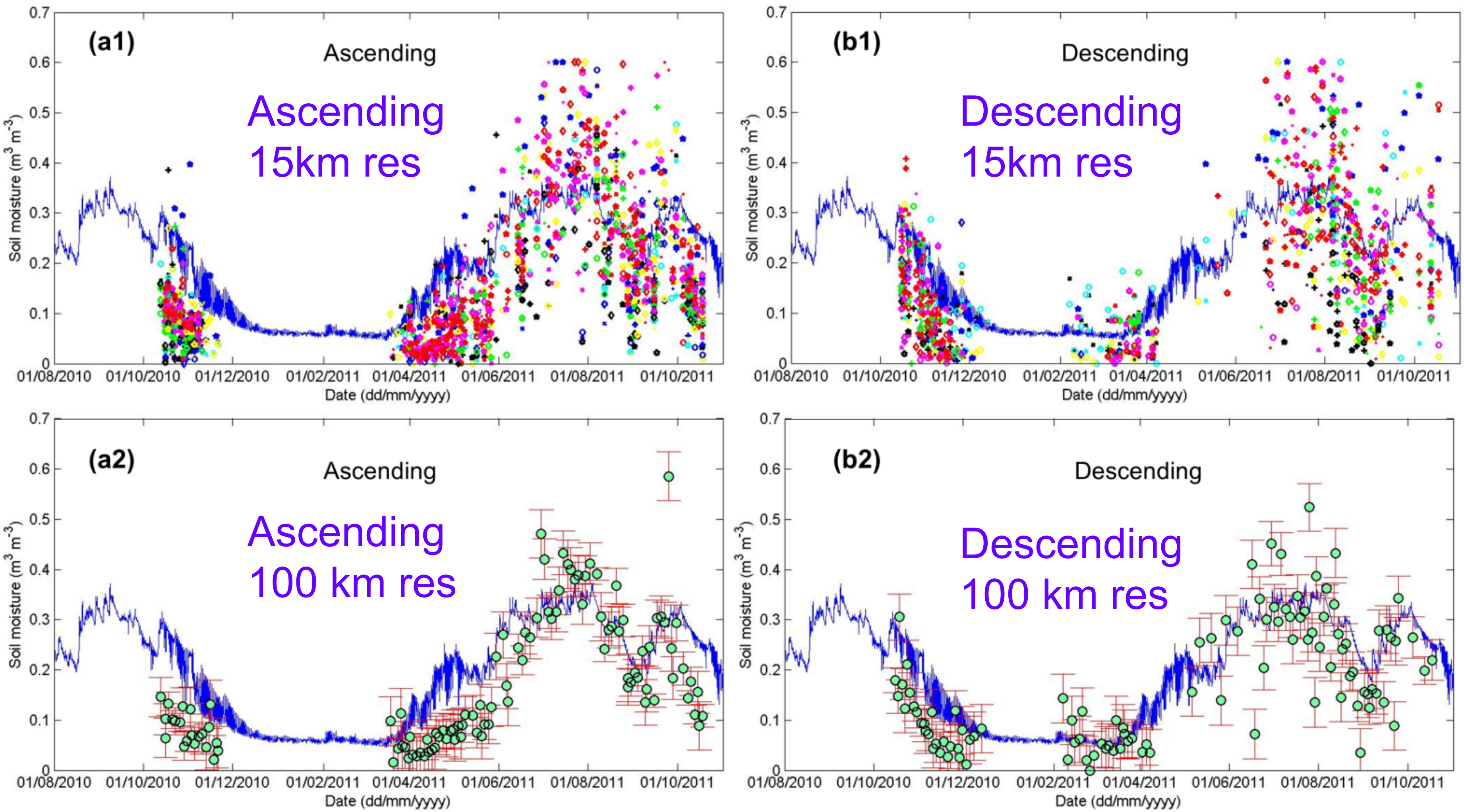
http://dam.itpcas.ac.cn/rs/?q=data

Evaluation: four AMSR-E satellite products have large biases, either underestimated or over-estimated



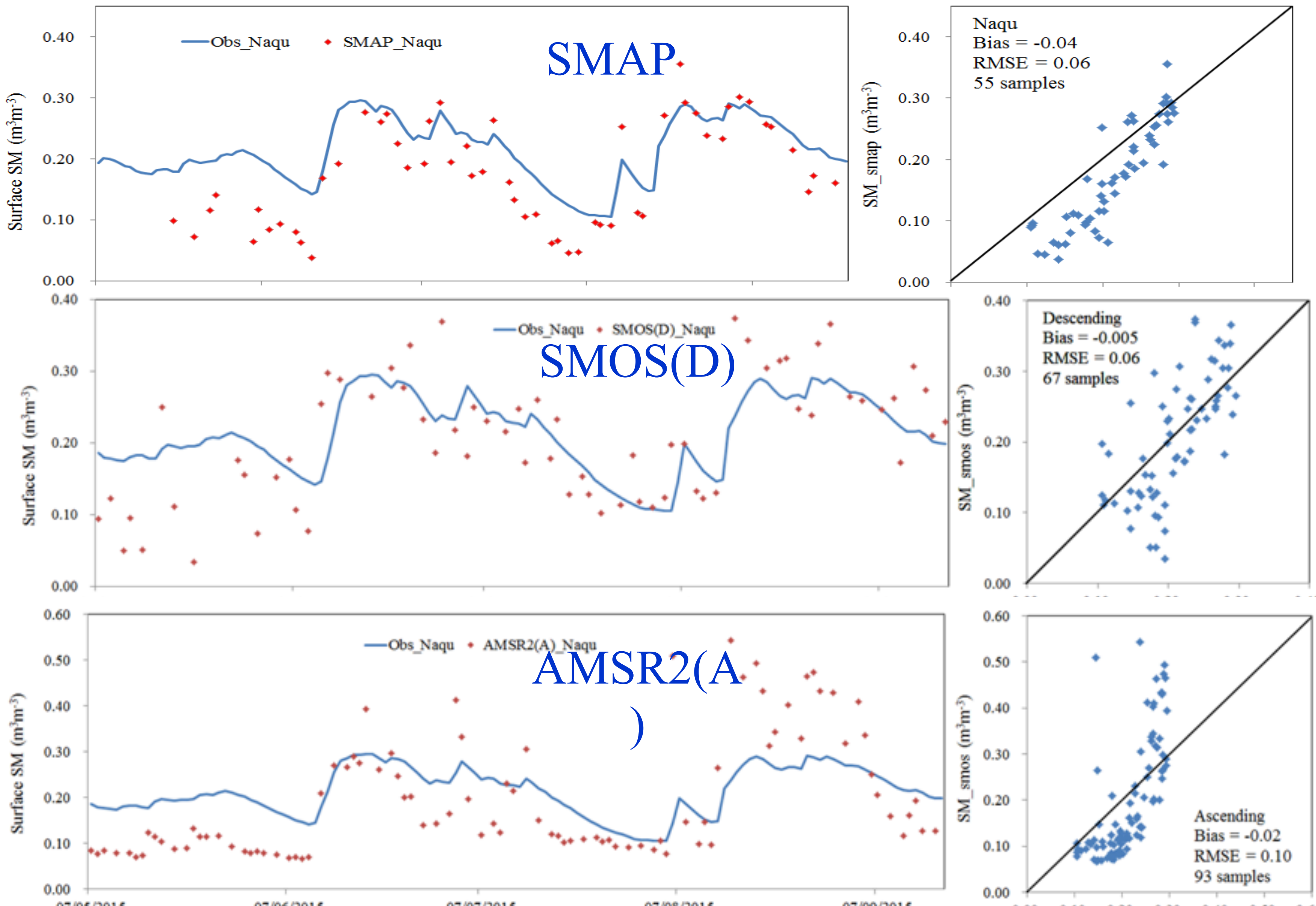
(Chen et al., 2013 JGR)

Evaluation: The accuracy of SMOS L2 SM data is scale-dependent; higher accuracy at coarser resolution



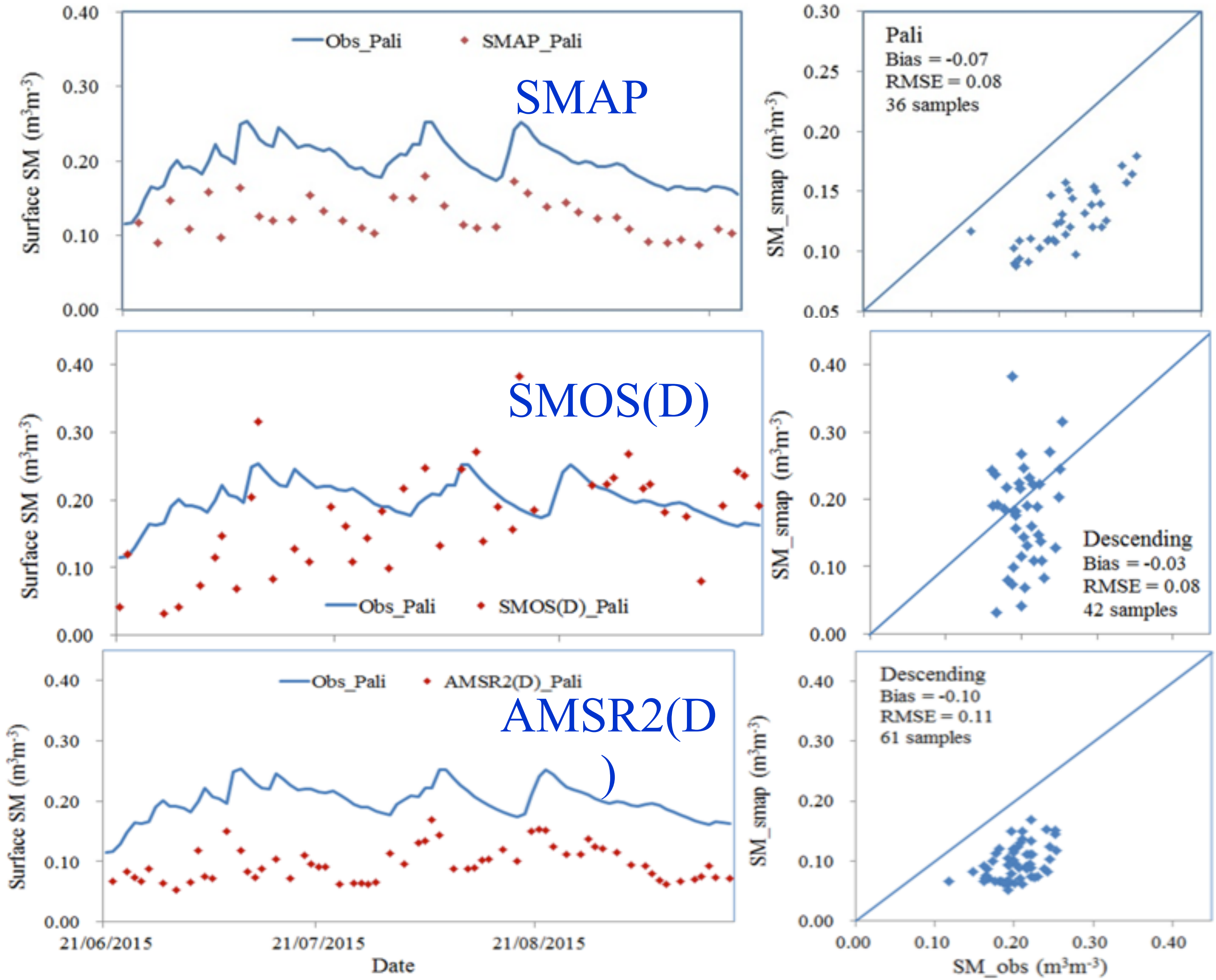
(Zhao et al., 2014 RSE)

Evaluation in CTP network



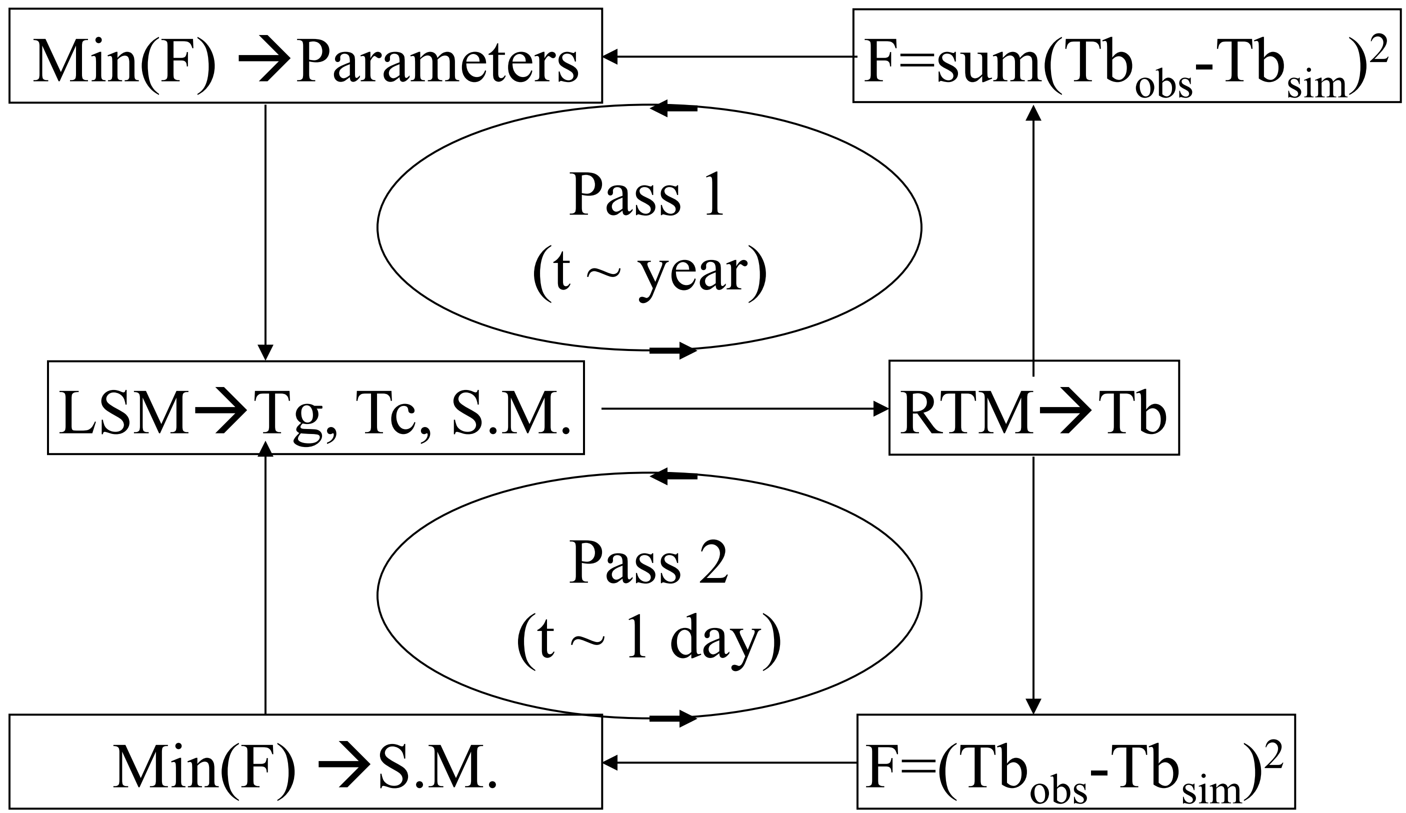
(Chen et al., in preparation)

Evaluation in STP network



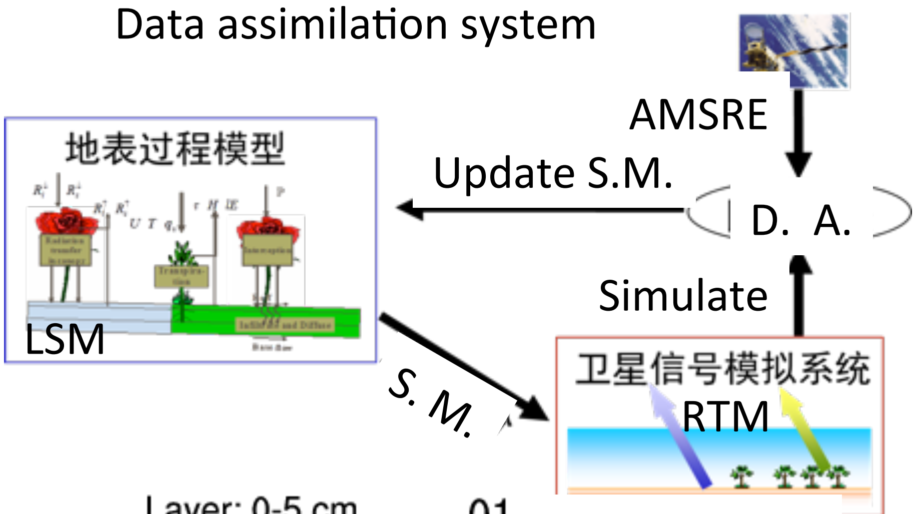
Developed a dual-pass (calibration + assimilation) data assimilation system

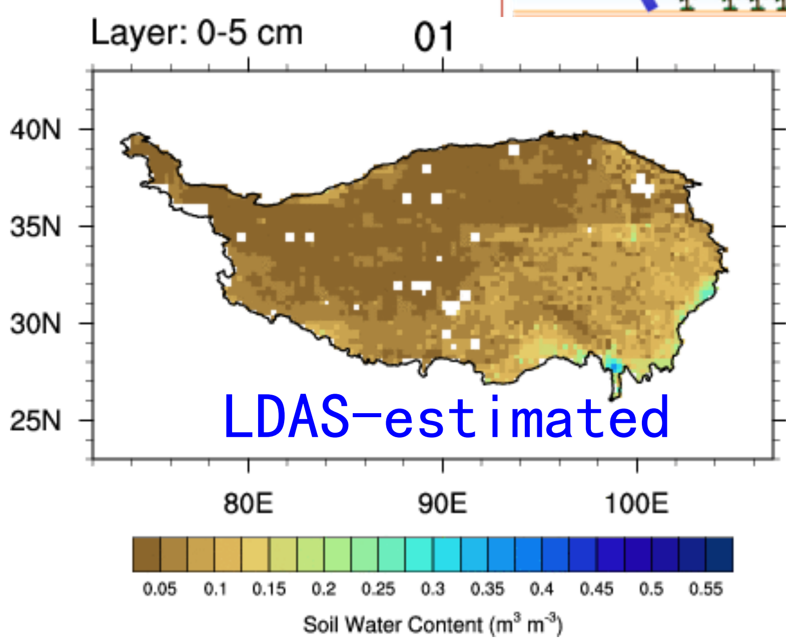
- Pass 1: Optimize parameter values in a long-term window (~year)
    - Tuning parameters with satellite data
    - time-consuming but only conduct once.
- Pass 2: Estimate land state in a short-term window (daily)

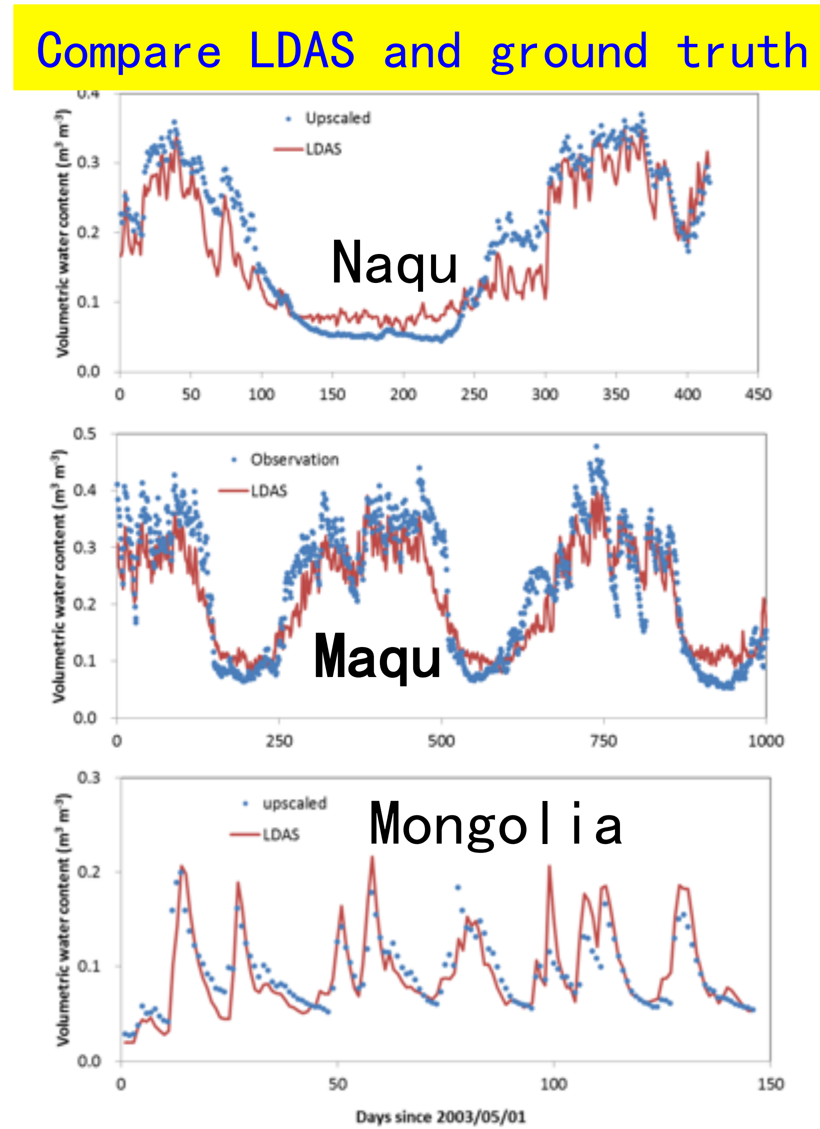


(Yang et al., 2007JMSJ; 2009 JHM)

Produced soil moisture in China during 2002-2011 by the system and validated in Tibetan and Mongolian Plateau

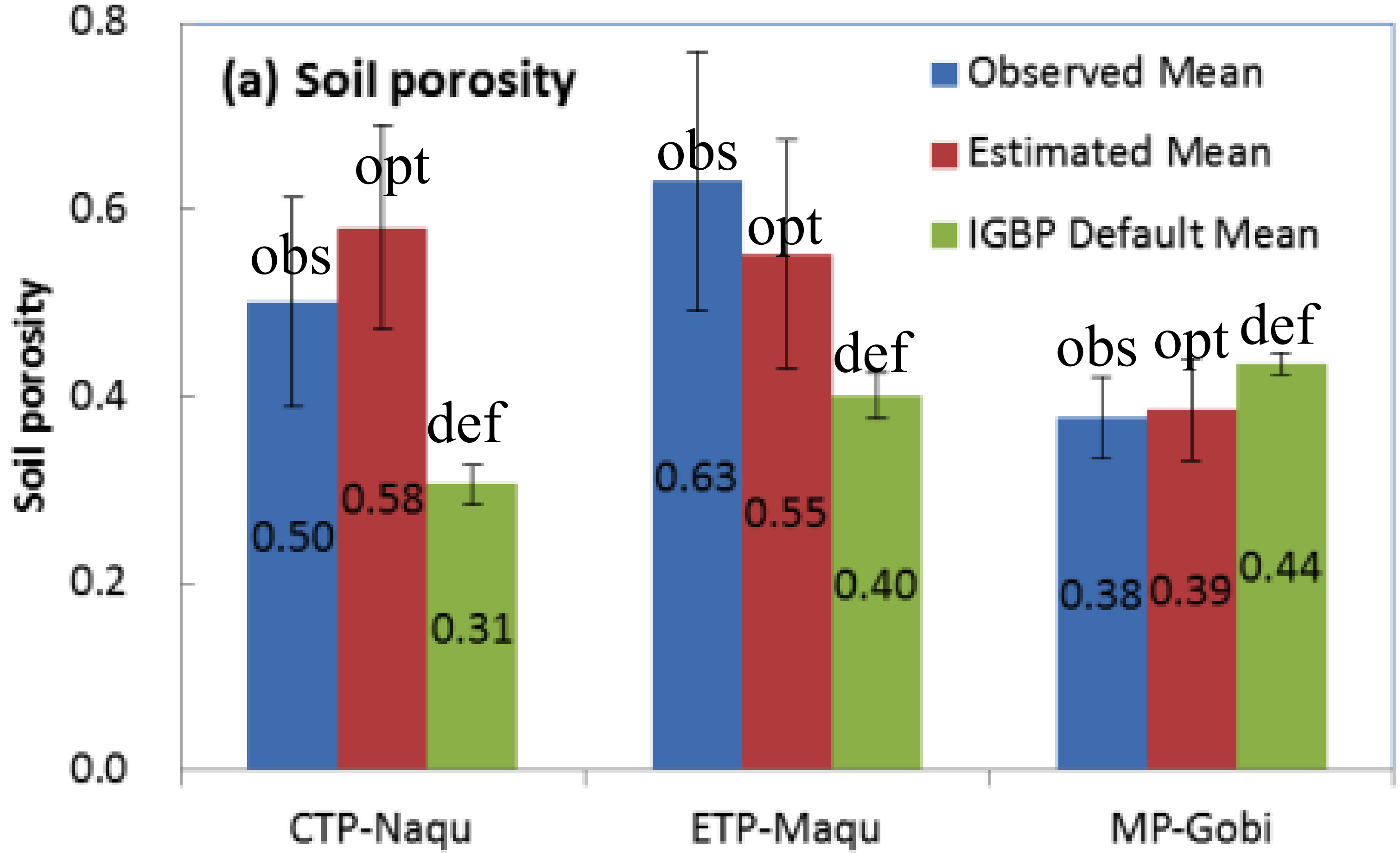






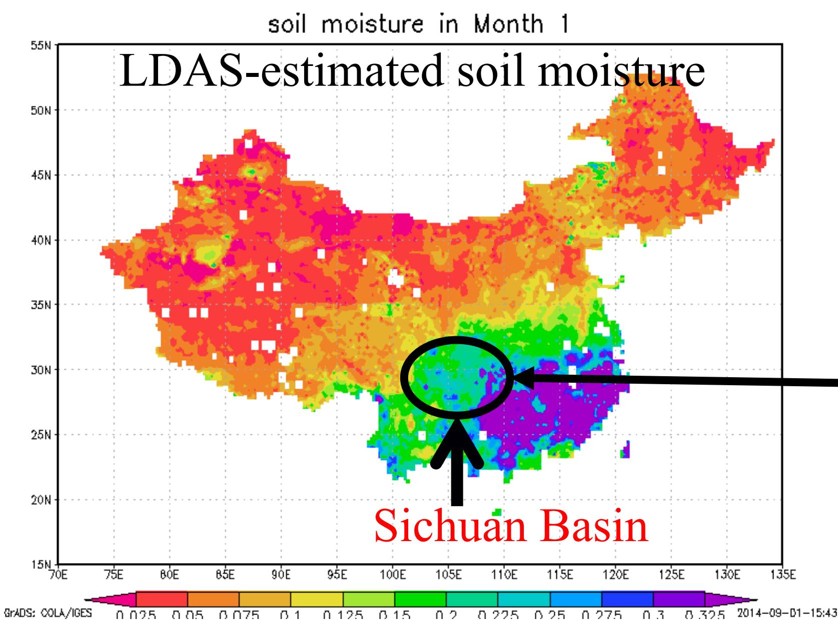
(Yang et al., 2007, 2009, 2016)

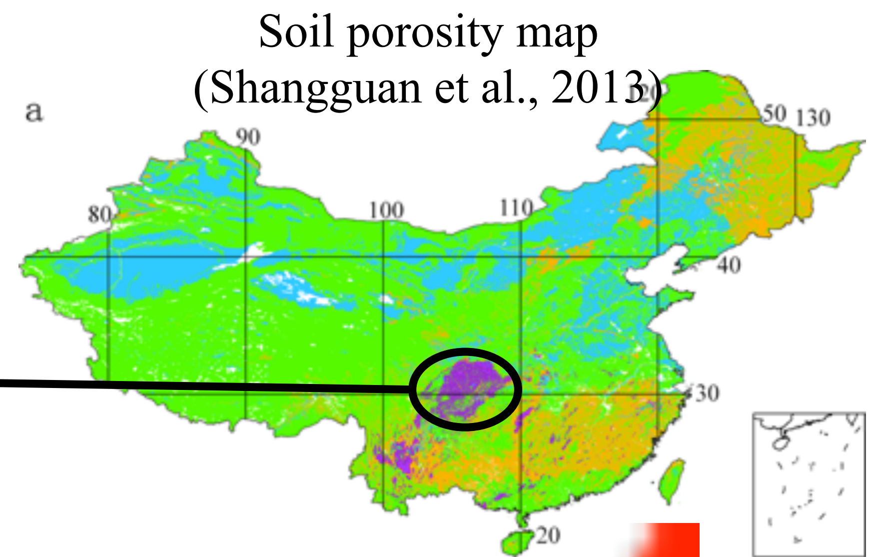
Improved soil porosity (the most important parameter for soil moisture) through the satellite data assimilation



(Yang et al., 2016 JoH)

Two independent datasets (our soil moisture product and the latest soil porosity dataset in China) are consistent at regional scale





Precipitation amount is high in Sichuan Basin but LDAS yields low soil moisture values

The soil in Sichuan Basin is a kind of purple soil and has low porosity.