Microwave data assimilation practice in the Tibetan Plateau and its implication for land hydrological modeling

Kun Yang[1] (yangk@itpcas.ac.cn)

Jun Qin[1], Long Zhao[1,2], Yingying Chen[1], Lazhu[1]

1. Institute of Tibetan Plateau Research, Chinese Academy of Sciences
2. JSG, University of Texas at Austin

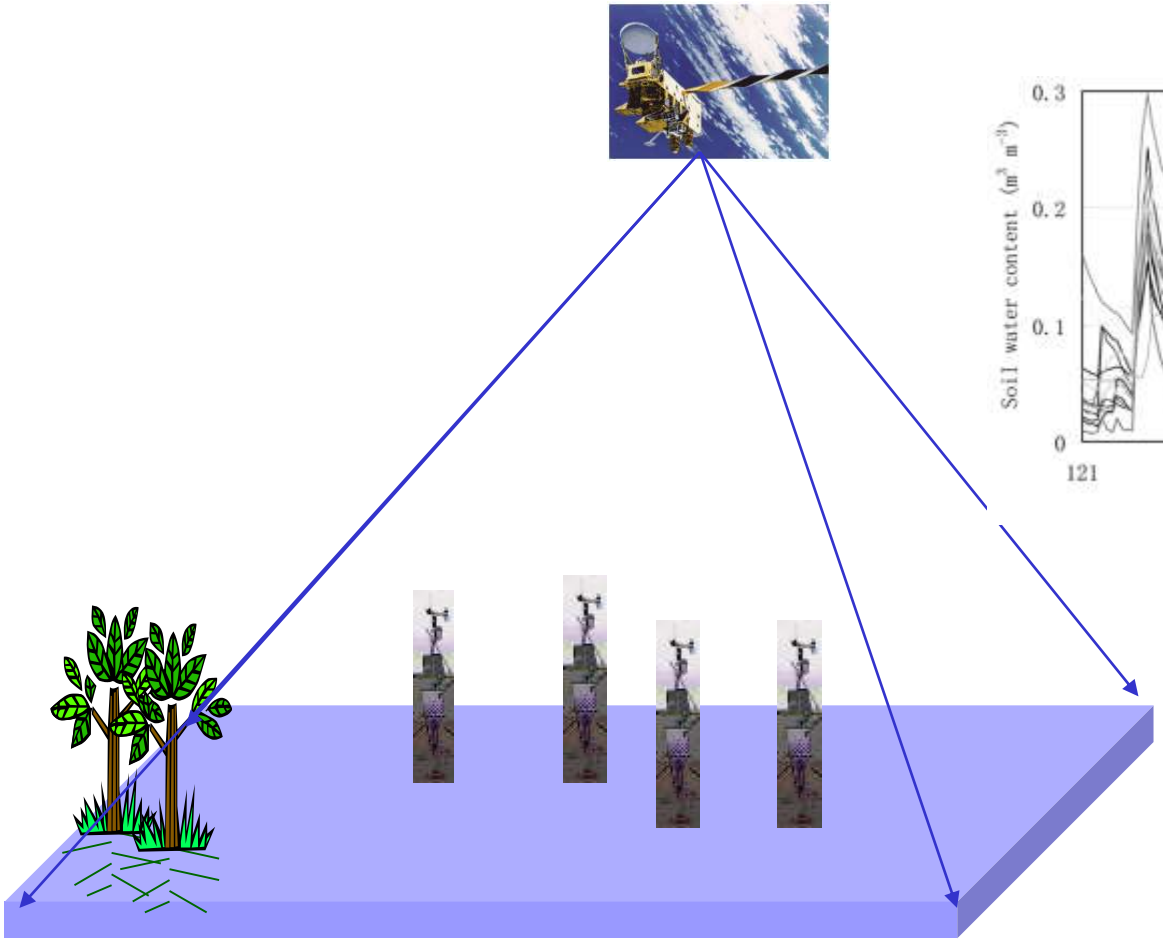
CAHMDA-VI and HEPEX-DAFOH III Workshop

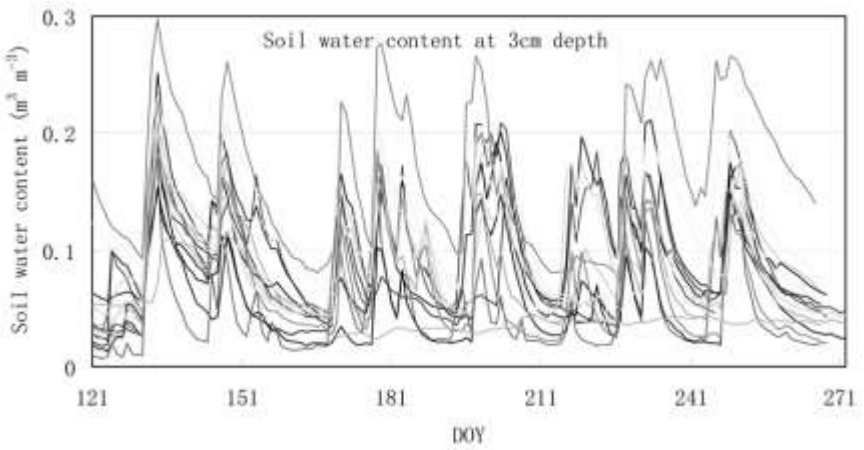
September 8-12, 2014

Outline

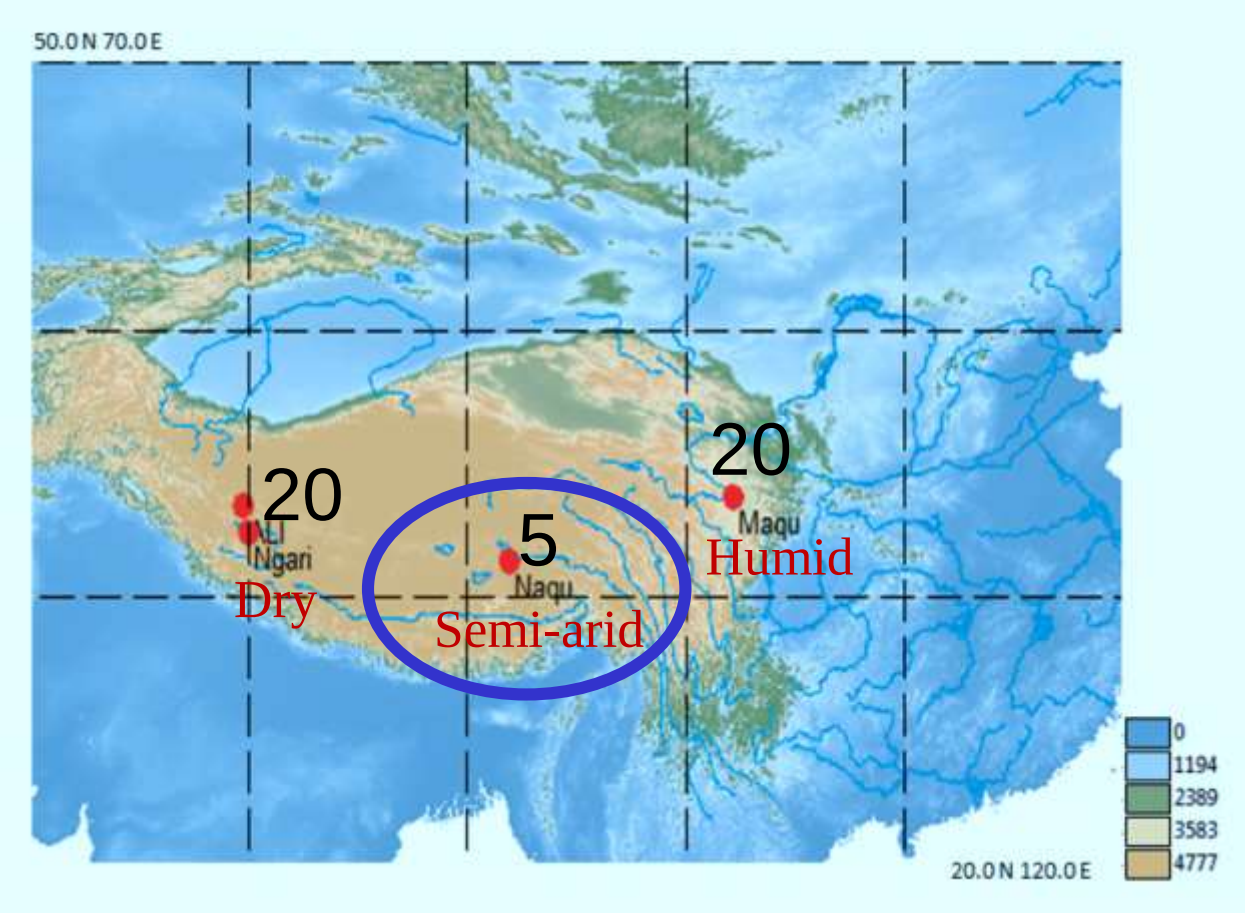
- Status of soil moisture observations and microwave retrievals in the Tibetan Plateau
- Validations and applications of an auto-calibrated land data assimilation system (LDAS)
- LDAS potential for improving land hydrological modeling

Validations of satellite soil moisture products needs dense in situ measurements, because soil moisture has high spatial variability.



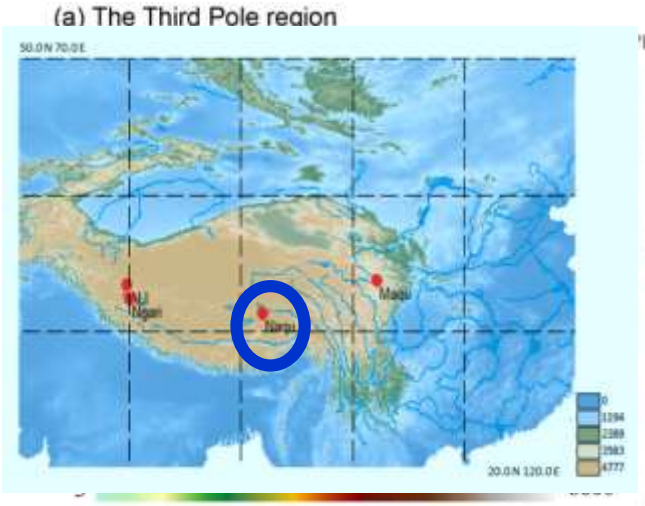


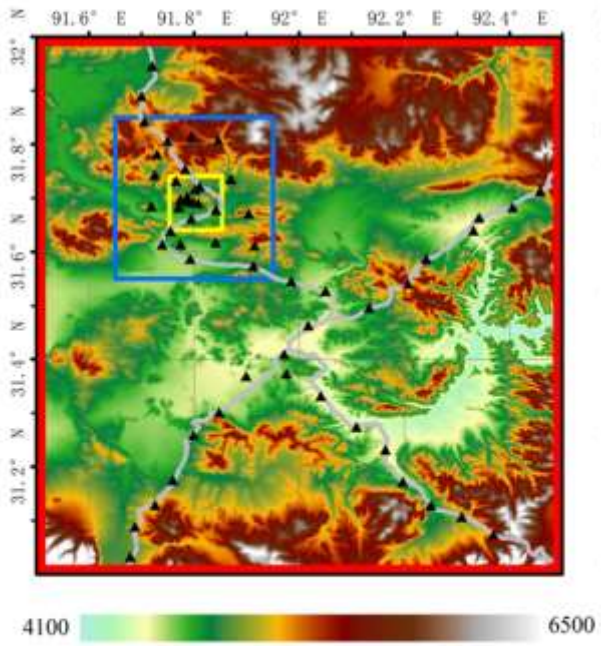
The Tibetan Plateau observatory of plateau scale soil moisture and soil temperature (Tibet-Obs)

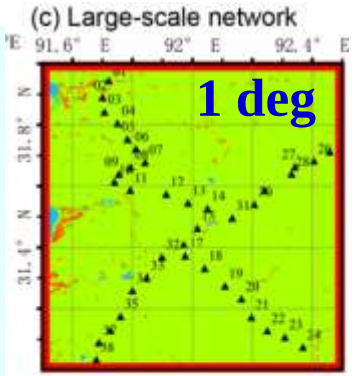


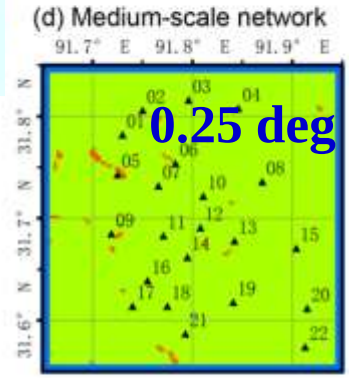
(Su et al., 2011 HESS)

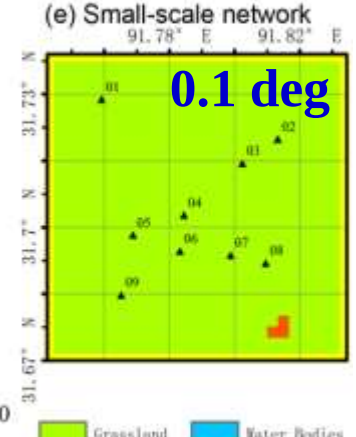
A multi-scale soil moisture and freeze-thaw network in CTP

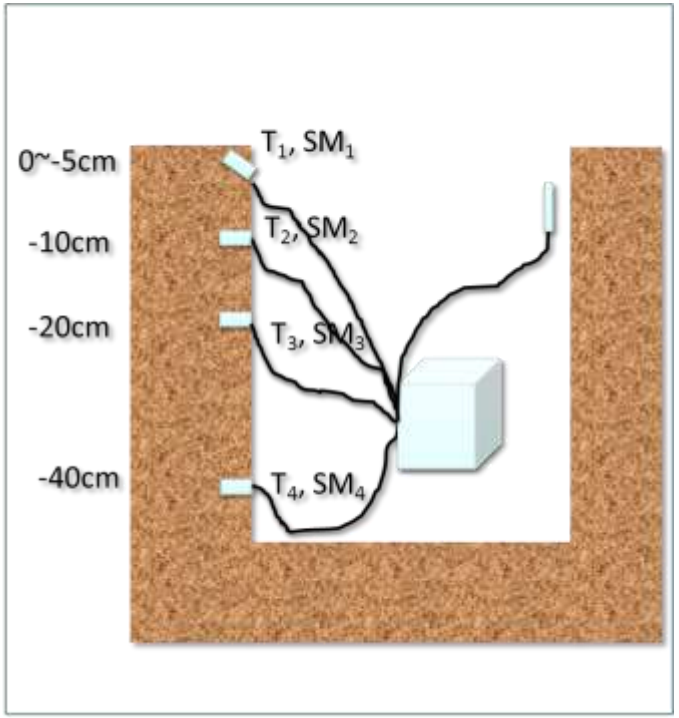






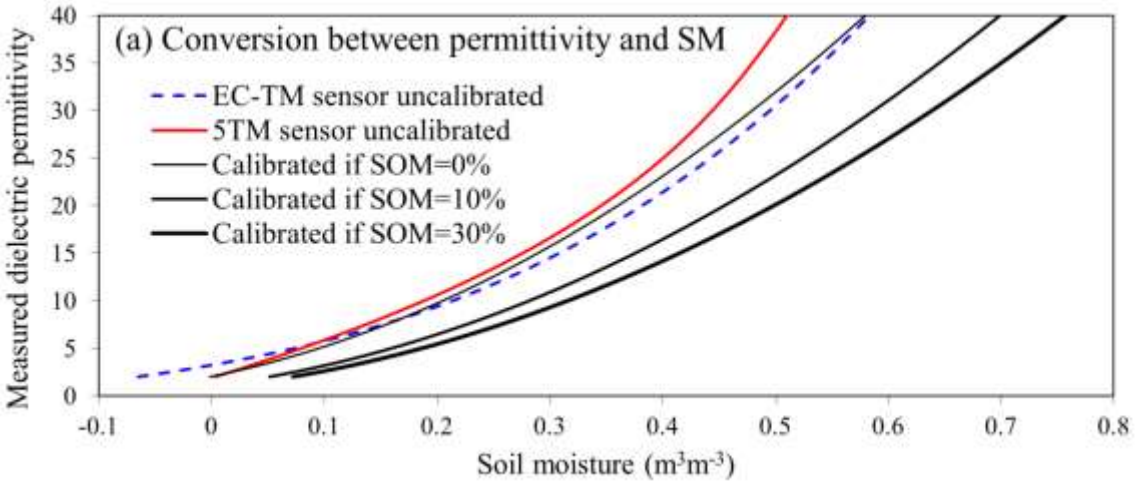


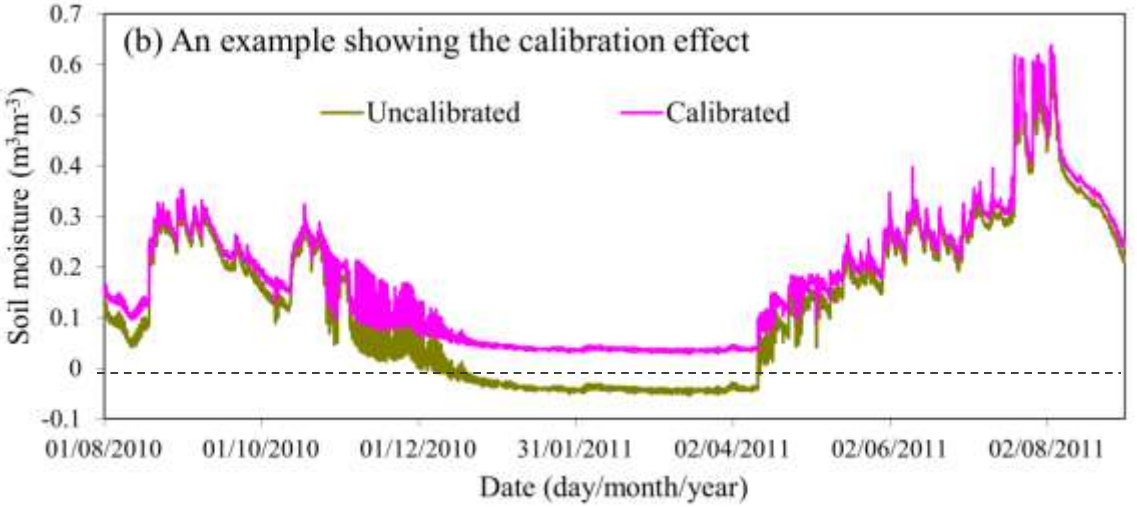




(Yang et al., 2013 BAMS)

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

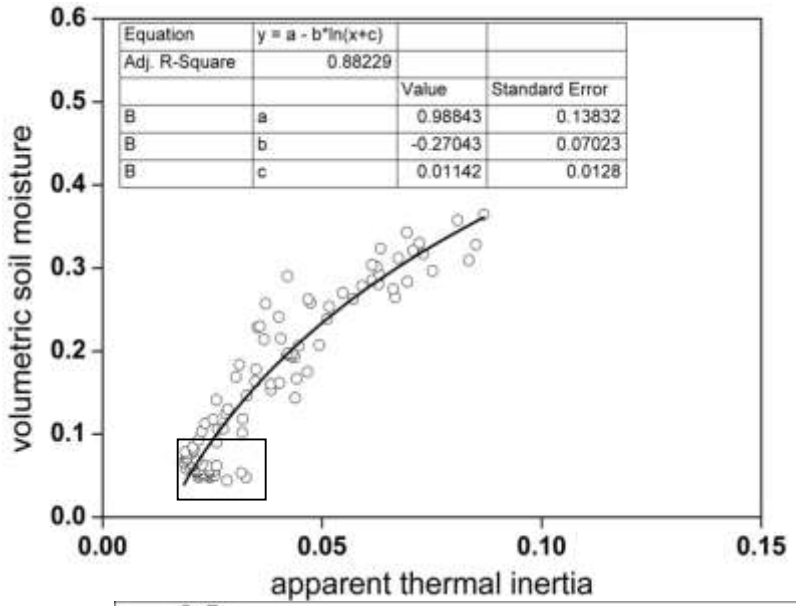


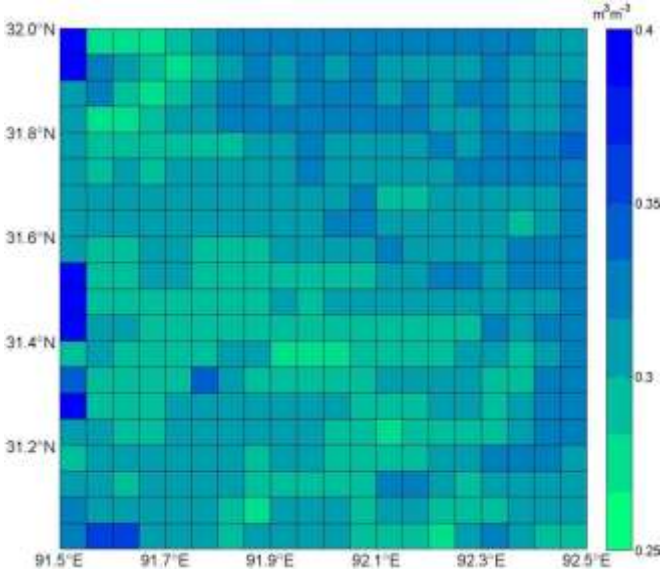


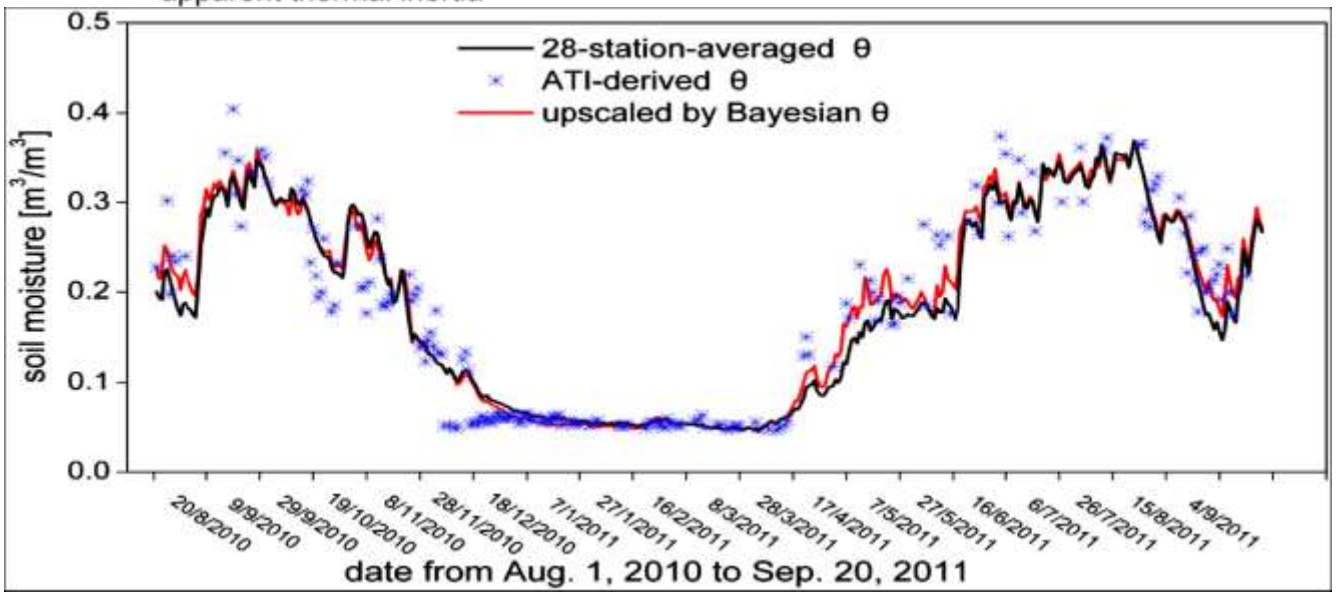
very high soil organic matters content

(Yang et al., 2013 BAMS)

Upscale from points to pixels by introducing MODIS LST



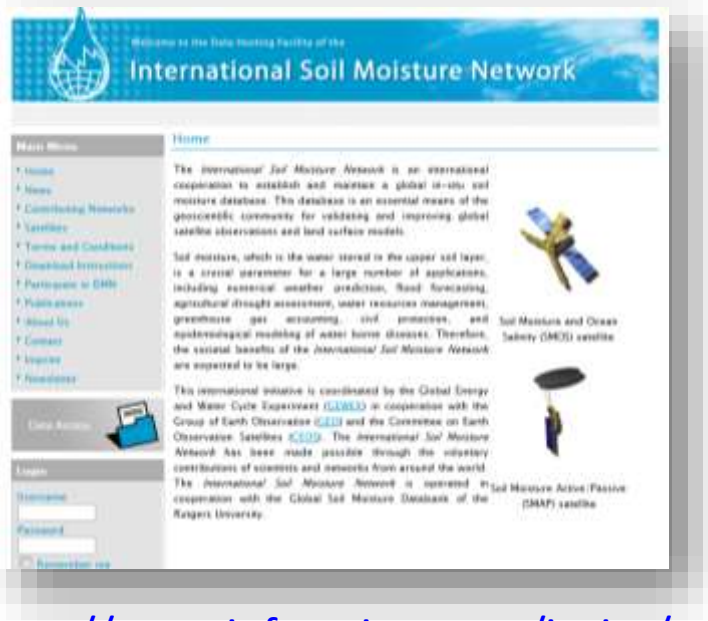




(Qin et al., 2013RSE)

Data sharing through ISMN

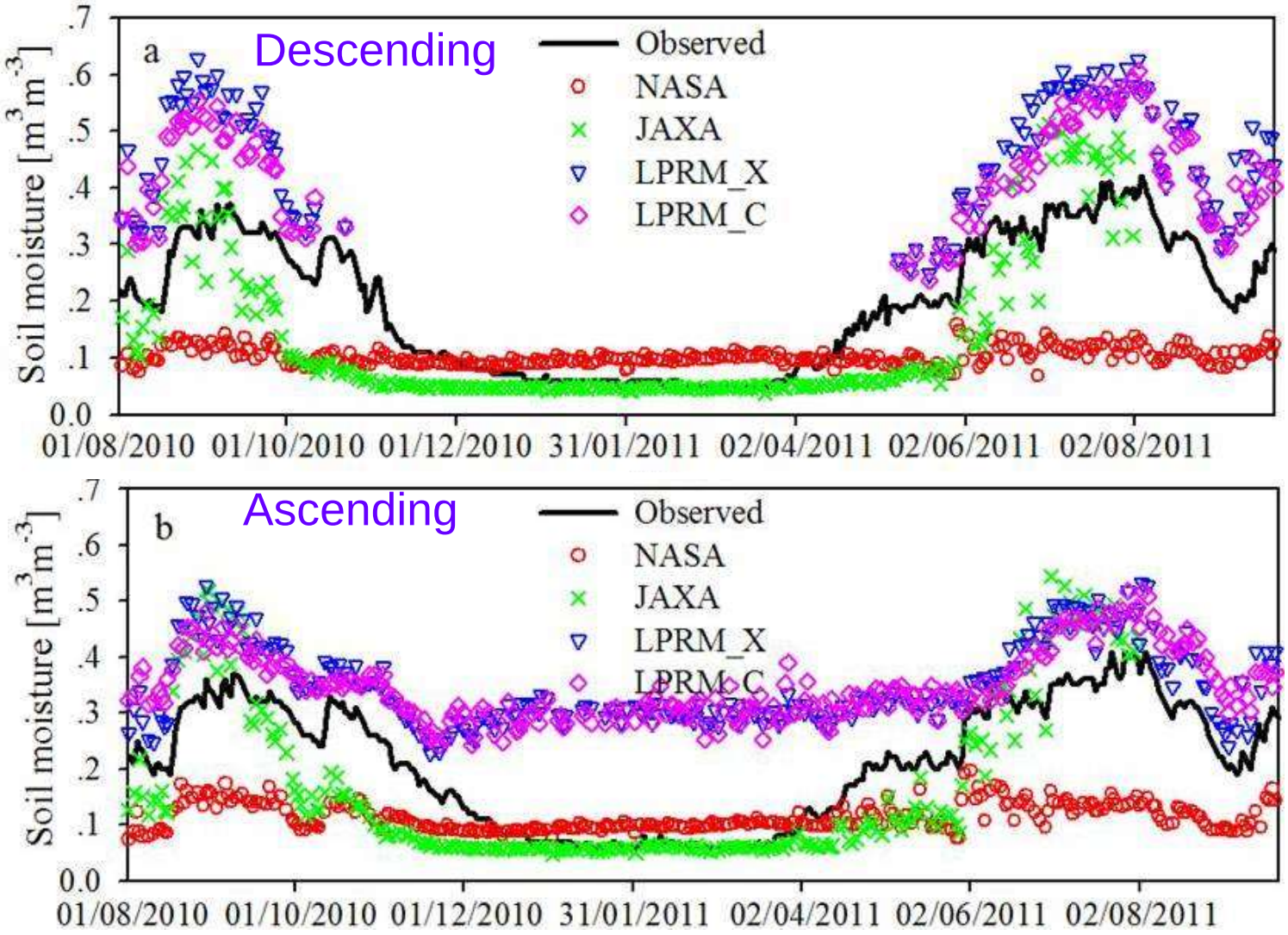
- Cooperation with ISMN Network
  - Network
    - Required: general info/contact person(s)
  - Station
    - Required: name/Lon/Lat/Ele
    - Optional: Image/photo…
  - Data
    - Required: monitoring depth(s)/sensor info/acquisition time (UTC!)/
    - Optional: meteorological variables/soil properties/land 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/

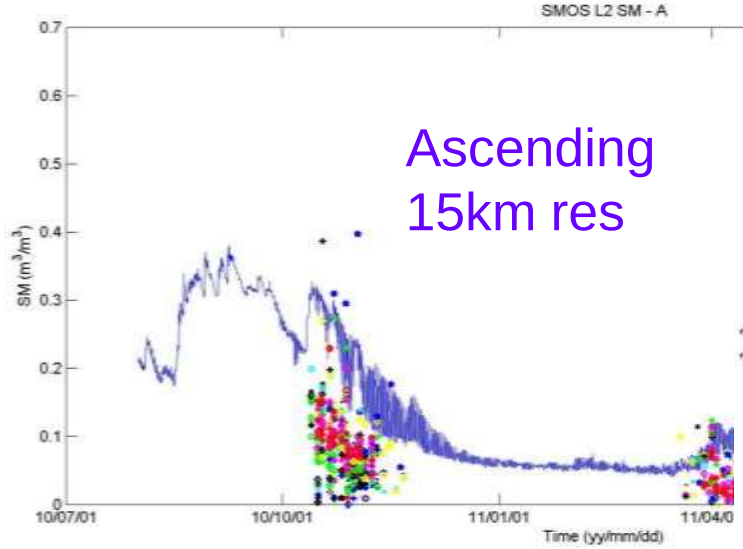
http://dam.itpcas.ac.cn/rs/?q=data

Evaluation: four AMSR-E products have large biases

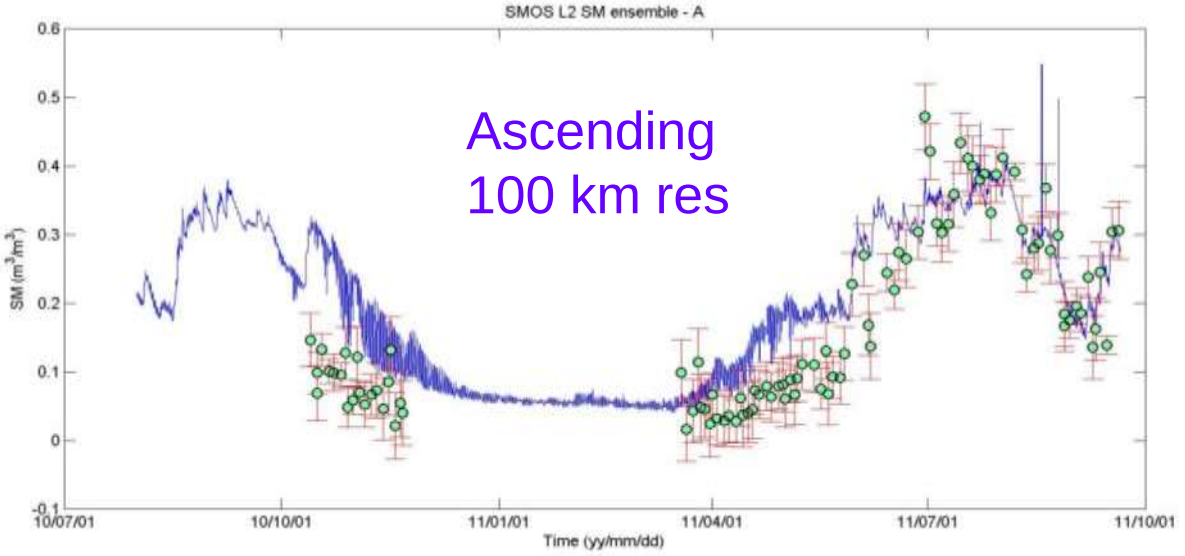


(Chen et al., 2013 JGR)

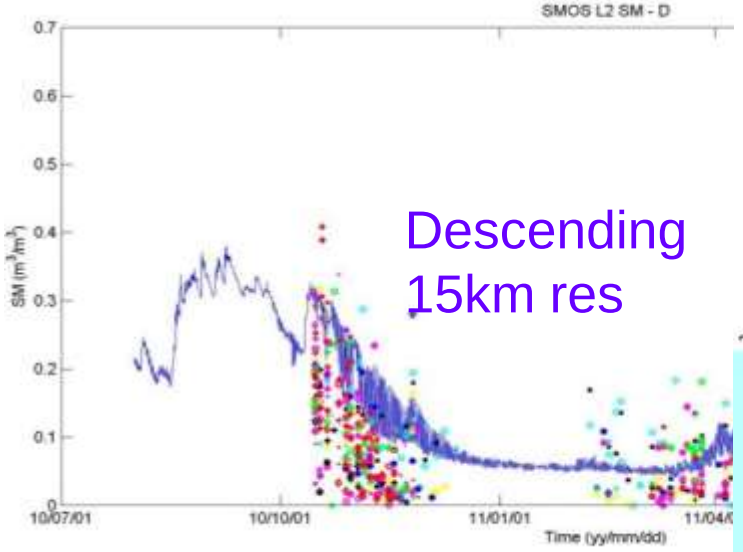
Evaluation: The accuracy of SMOS L2 SM data is scale-dependent; higher accuracy at coarser resolution



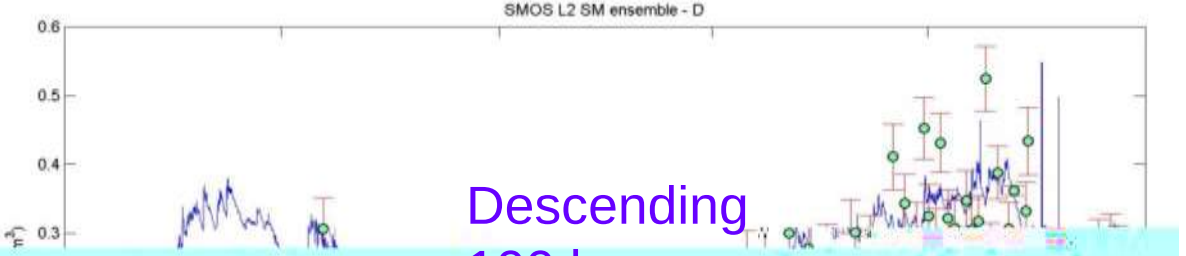
Ascending
15km res



Ascending
100 km res



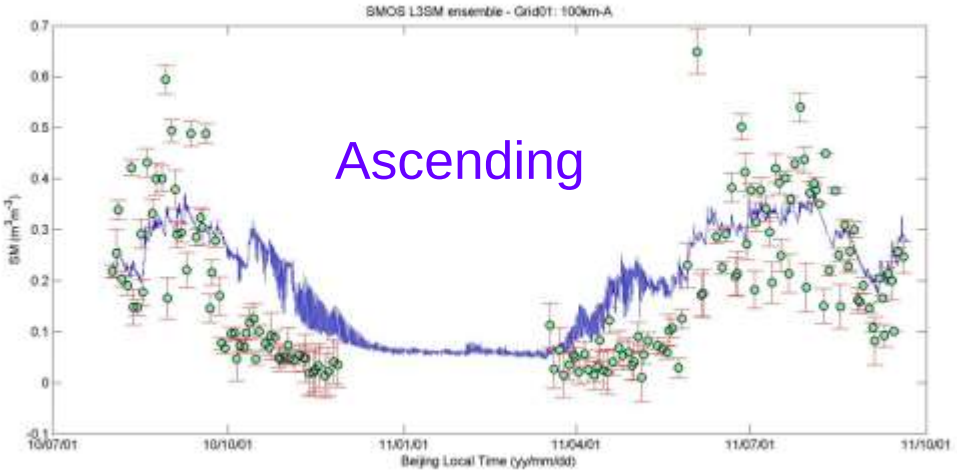
Descending
15km res

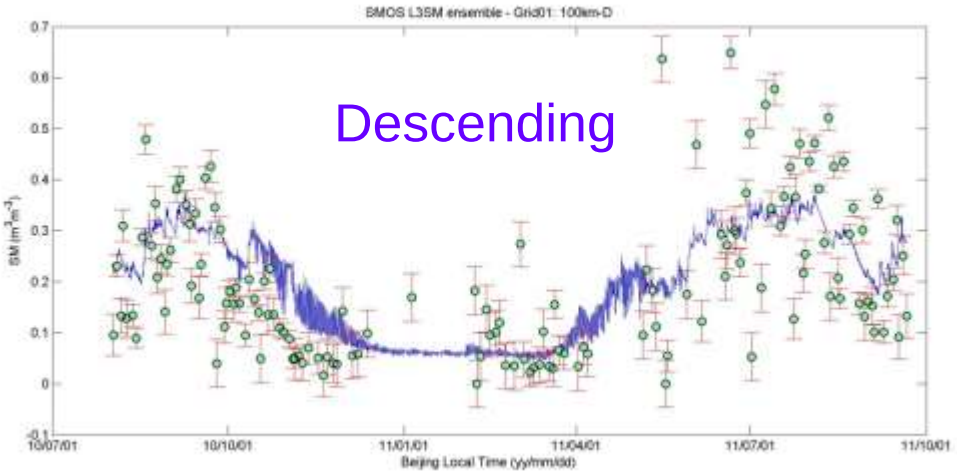


Descending
100 km res

(Zhao et al., 2014 RSE)

Evaluation: SMOS L3 SM data performs not well





(Zhao et al., 2014 RSE)

- SMOS L2 SM data at coarse resolution show acceptable accuracy in this region and good accuracy can be achieved when assimilated into land surface model (Zhao et al., RSE, 2014)

- Other products have low accuracy and the RMSE in the semi-arid area is > 0.12 m^3 m^{-3} (Su et al., 2011; Chen et al., 2013)

Outline

- Status of soil moisture observations and microwave retrievals in the Tibetan Plateau
- Validations and applications of an auto-calibrated land data assimilation system (LDAS)
- LDAS potential for improving land hydrological modeling

Regional soil moisture estimation through microwave TB assimilation

Land surface modeling

- Physically consistent
- Temporally continuous
- Model-dependent
- Parameter-dependent

Couple

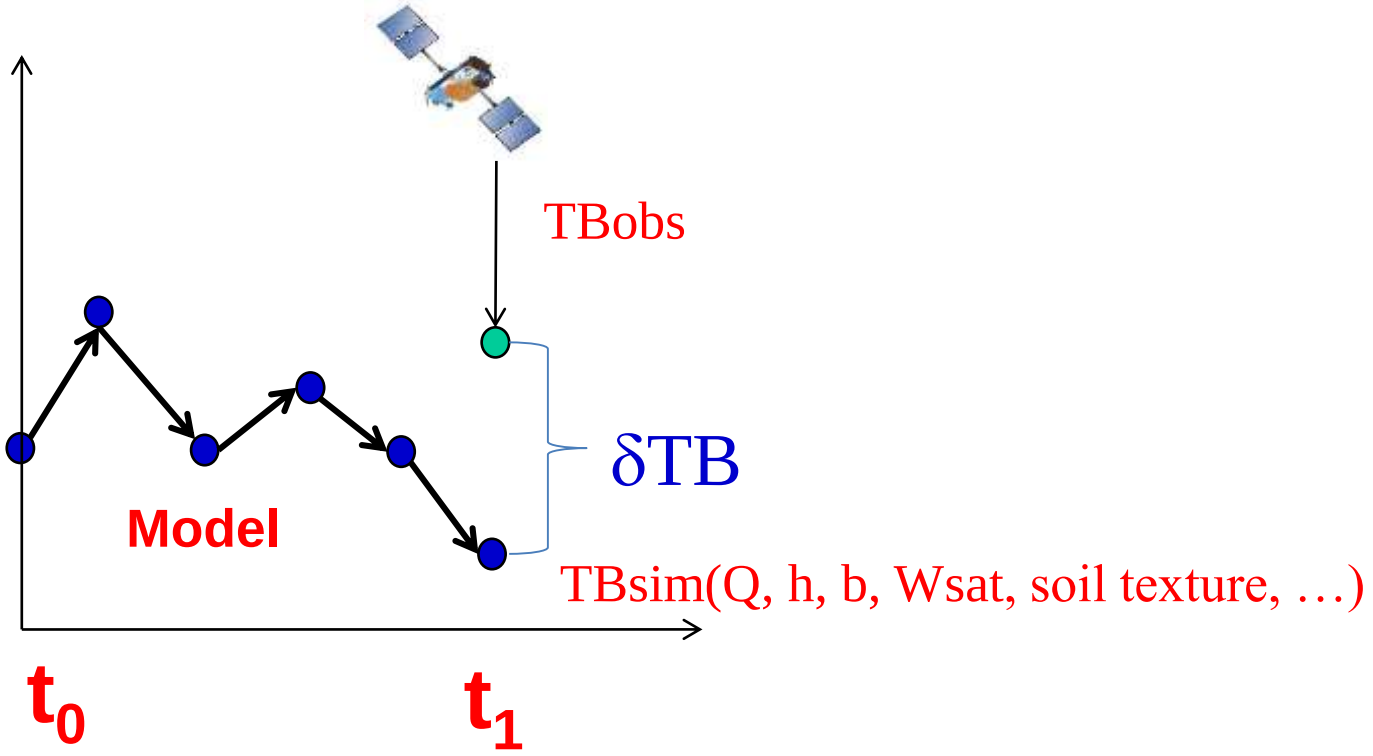
MV remote sensing

- "Observed" or Objective
- Spatially continuous
- Discontinuity in time
- Parameter-dependent

LDAS
（Land Data Assimilation System）

Overall goal
Reliable regional soil moisture product

Parameter calibration issue in LDAS



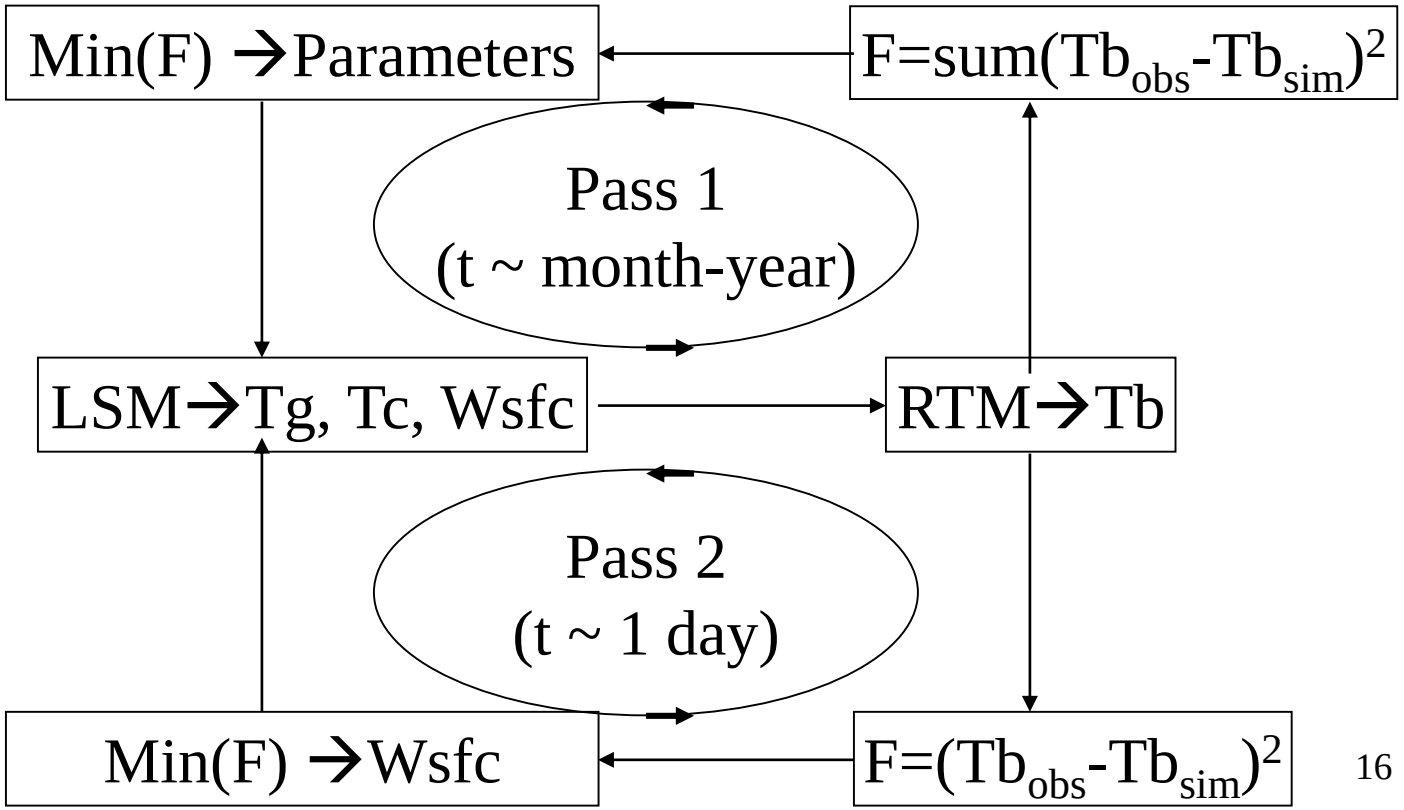
How to understand the gap (δTB) between model and observation?

1. Search for observation and model error covariances
2. Attribute the gap to inappropriate specification of model parameter values → optimize parameters based on the gap

Dual-pass (calibration + assimilation) Algorithm

(Yang et al., 2007JMSJ)

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



Develop a China Meteorological Forcing Dataset (CMFD) to drive LDAS in China

Fusion

Parameters:

Wind, Ta, qa

Pa, Prec, Rad

Spatial coverage:

Mainland China

Temporal coverage:

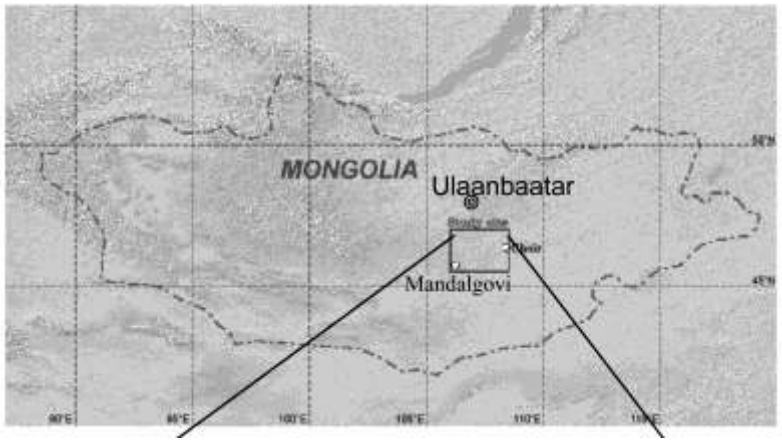
1979-2012

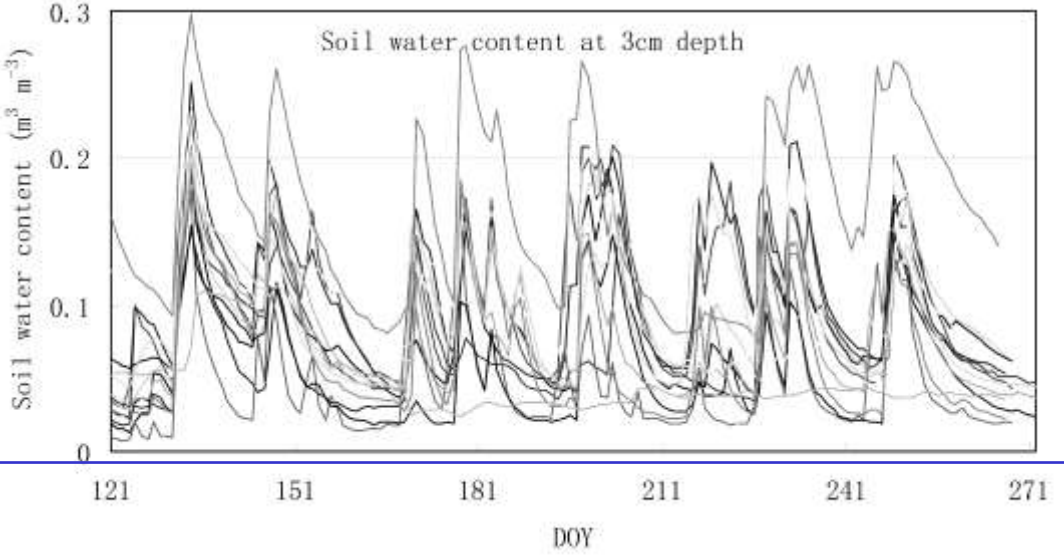
Resolution:

0.1 deg, 3 hrs

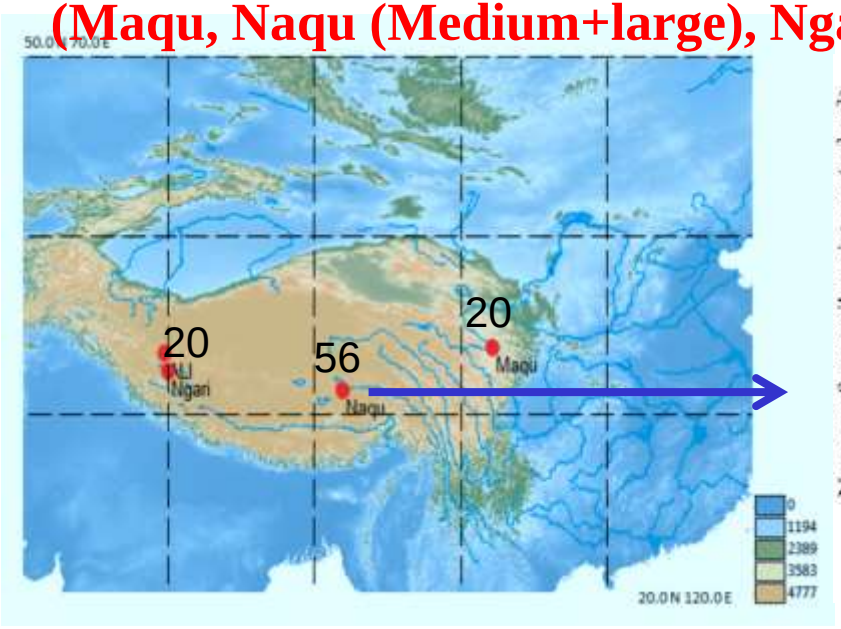
Validations at five sites

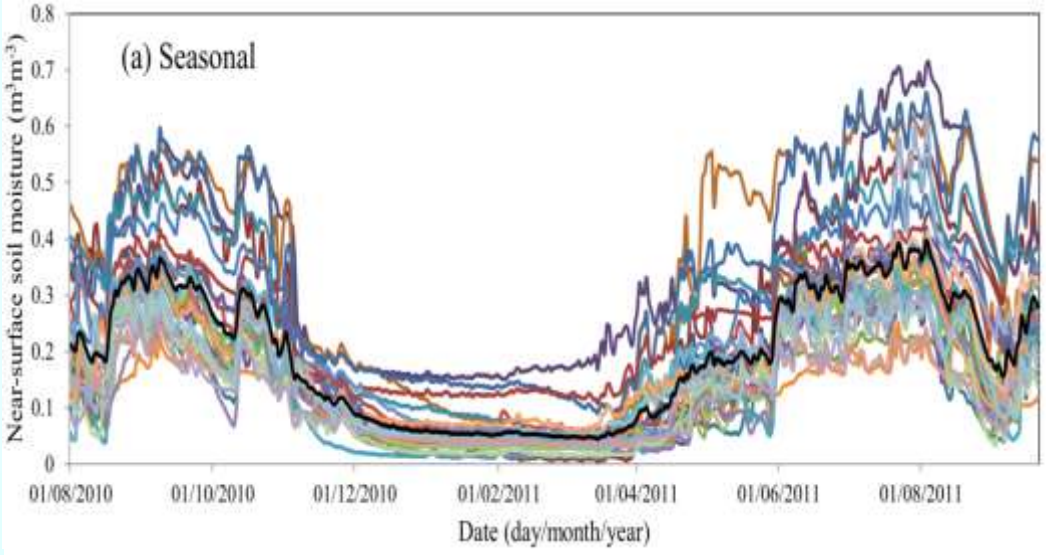
1 CEOP Mongolian site





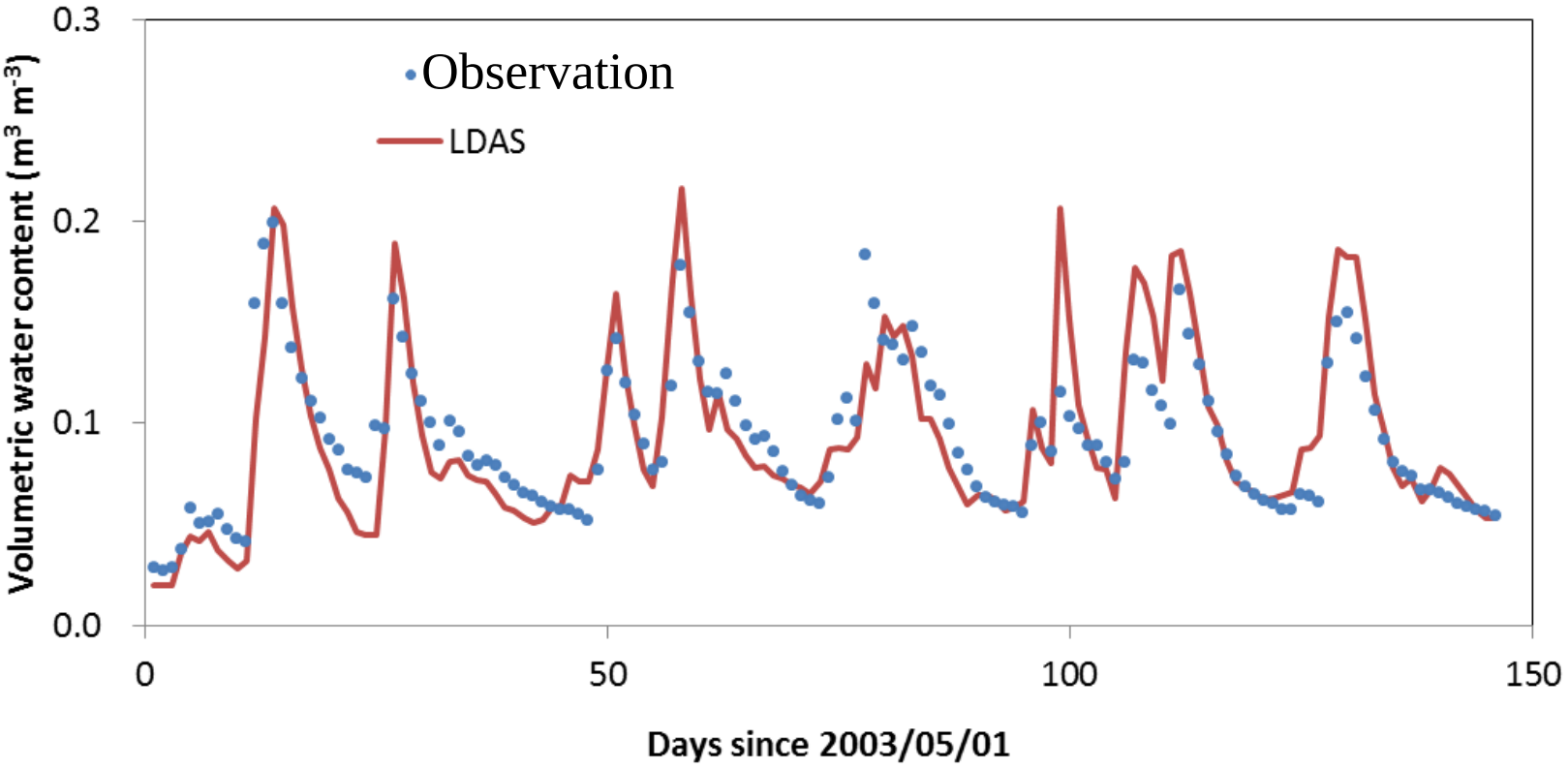
4 Tibet_obs sites
(Maqu, Naqu (Medium+large), Ngari)





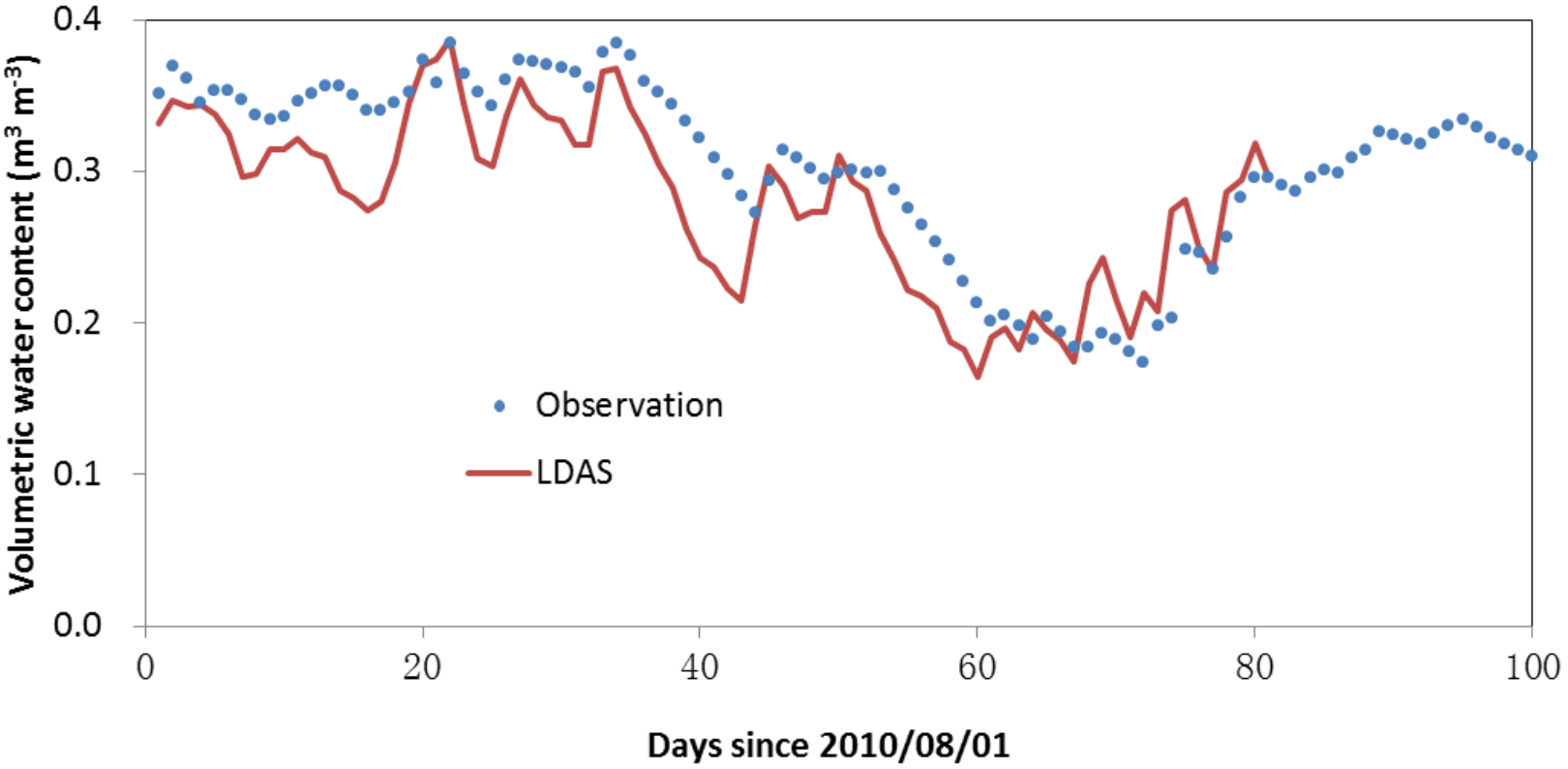
Evaluate: LDAS output against the Mongolian network

Assimilate AMSR-E TBv data (6.9, 10.7, 18.7 HGz) with TBv-based auto-calibration, driven by GLDAS forcing



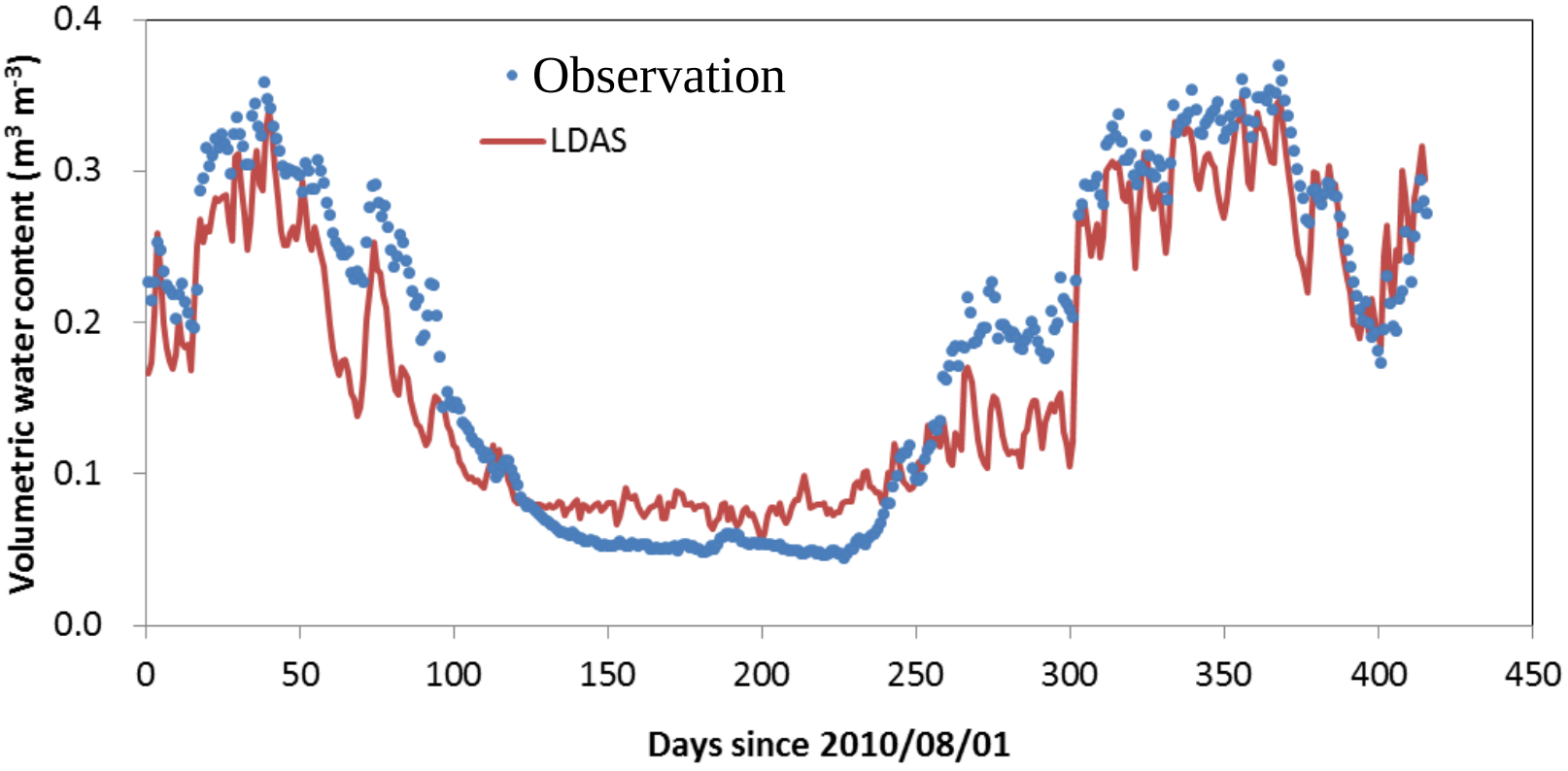
Evaluate: LDAS output against the Naqu Medium-network

Assimilate AMSR-E TBv data (6.9, 10.7, 18.7 HGz) with TBv-based auto-calibration, driven by CMFD forcing



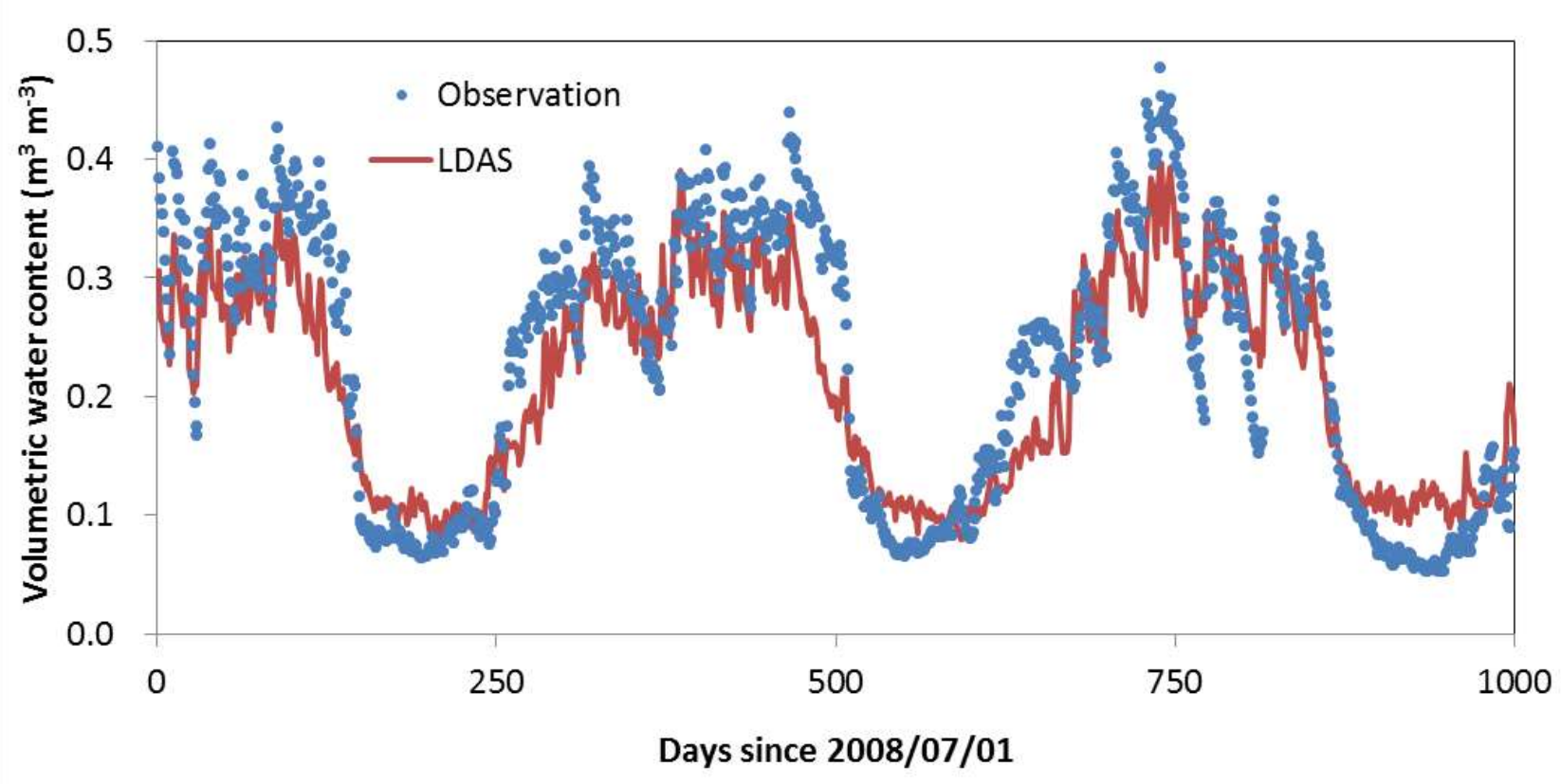
Evaluate: LDAS output against the Naqu Large-network

Assimilate AMSR-E TBv data (6.9, 10.7, 18.7 HGz) with TBv-based auto-calibration, driven by CMFD forcing



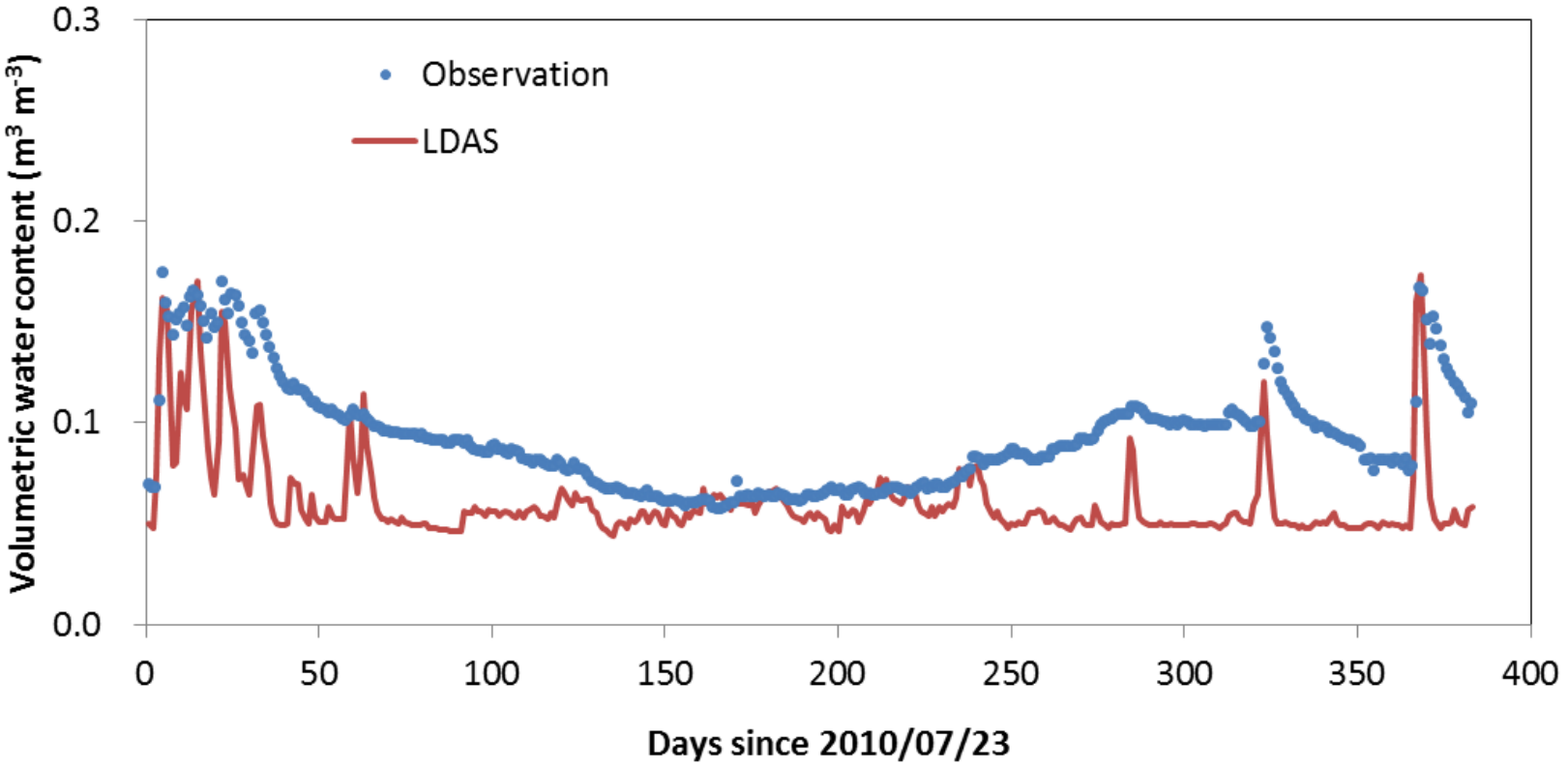
Evaluate: LDAS output against the Maqu network

Assimilate AMSR-E TBv data (6.9, 10.7, 18.7 HGz) with TBv-based auto-calibration, driven by CMFD forcing



Evaluate: LDAS output against the Ngari network

Assimilate AMSR-E TBv data (6.9, 10.7, 18.7 HGz) with TBv-based auto-calibration, driven by CMFD forcing



Outline

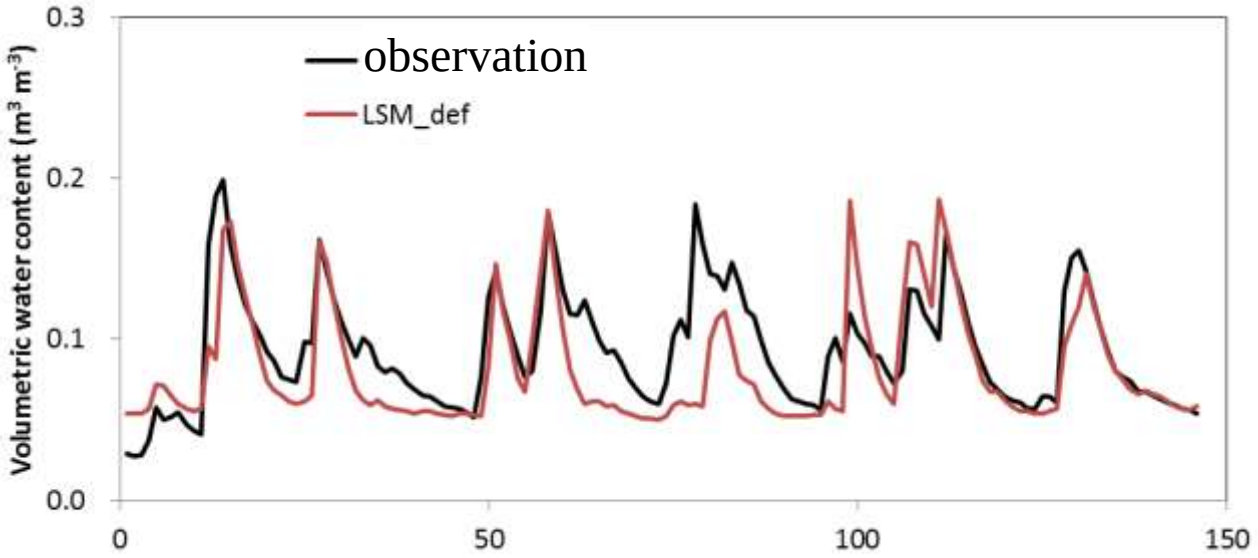
- Status of soil moisture observations and microwave retrievals in the Tibetan Plateau
- Validations and applications of an automatically calibrated land data assimilation system (LDAS)
- LDAS potential for improving land hydrological modeling

LDAS potential for improving land hydrological modeling

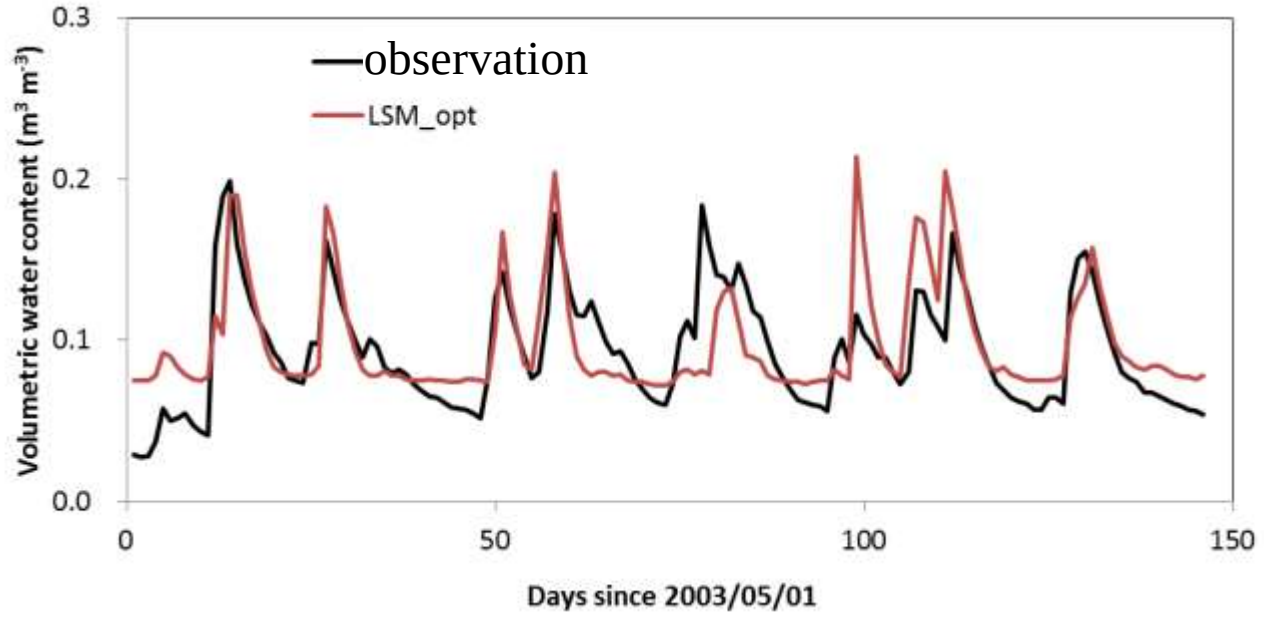
- Improving soil moisture initial conditions
- Improve land model parameters
  - The LDAS uses AMSR-E TB data to calibrate land model parameters so as the modeled TB is close to the observed one
  - Question: do the estimated parameter values really improve open-loop land hydrological modeling?
- Improve process understanding

Open-loop land surface modeling comparison for Mongolian network (2003 summer)

With IGBP
soil parameters

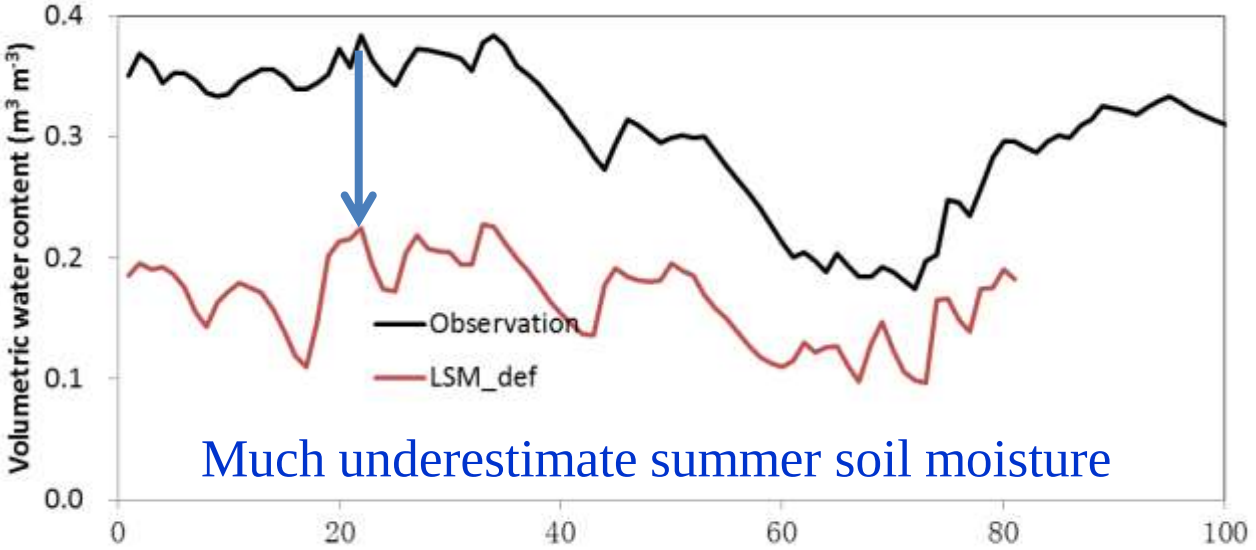


With LDAS
calibrated parameters

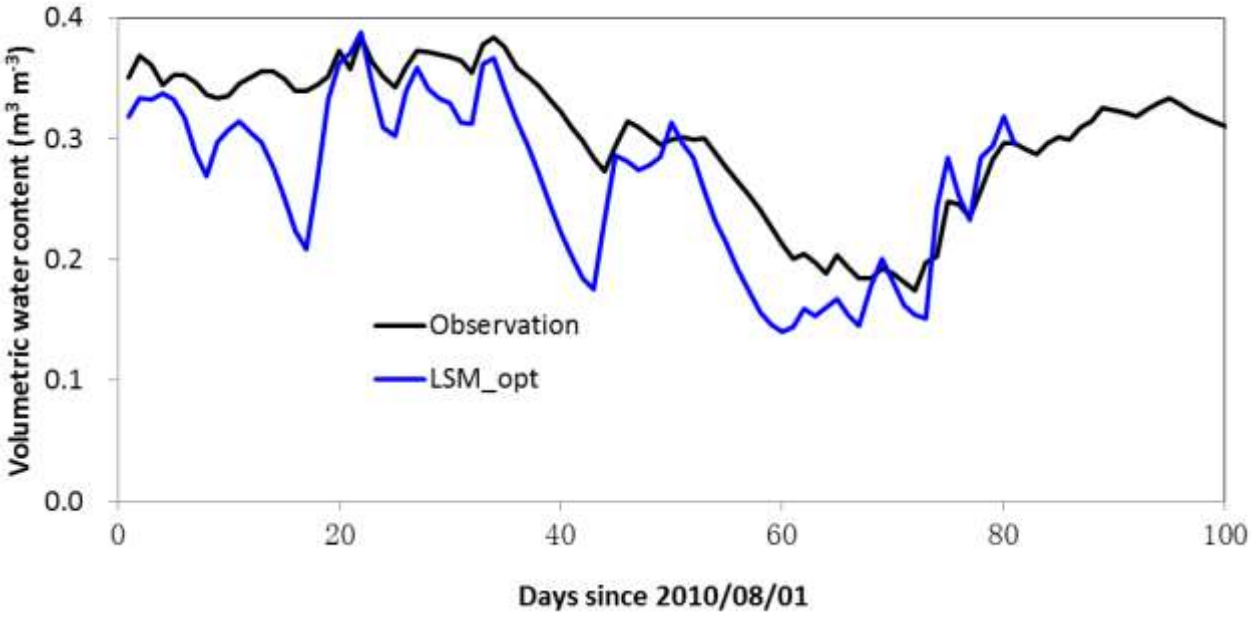


Open-loop land surface modeling comparison for Naqu Medium-network (2011 summer)

With IGBP soil parameters



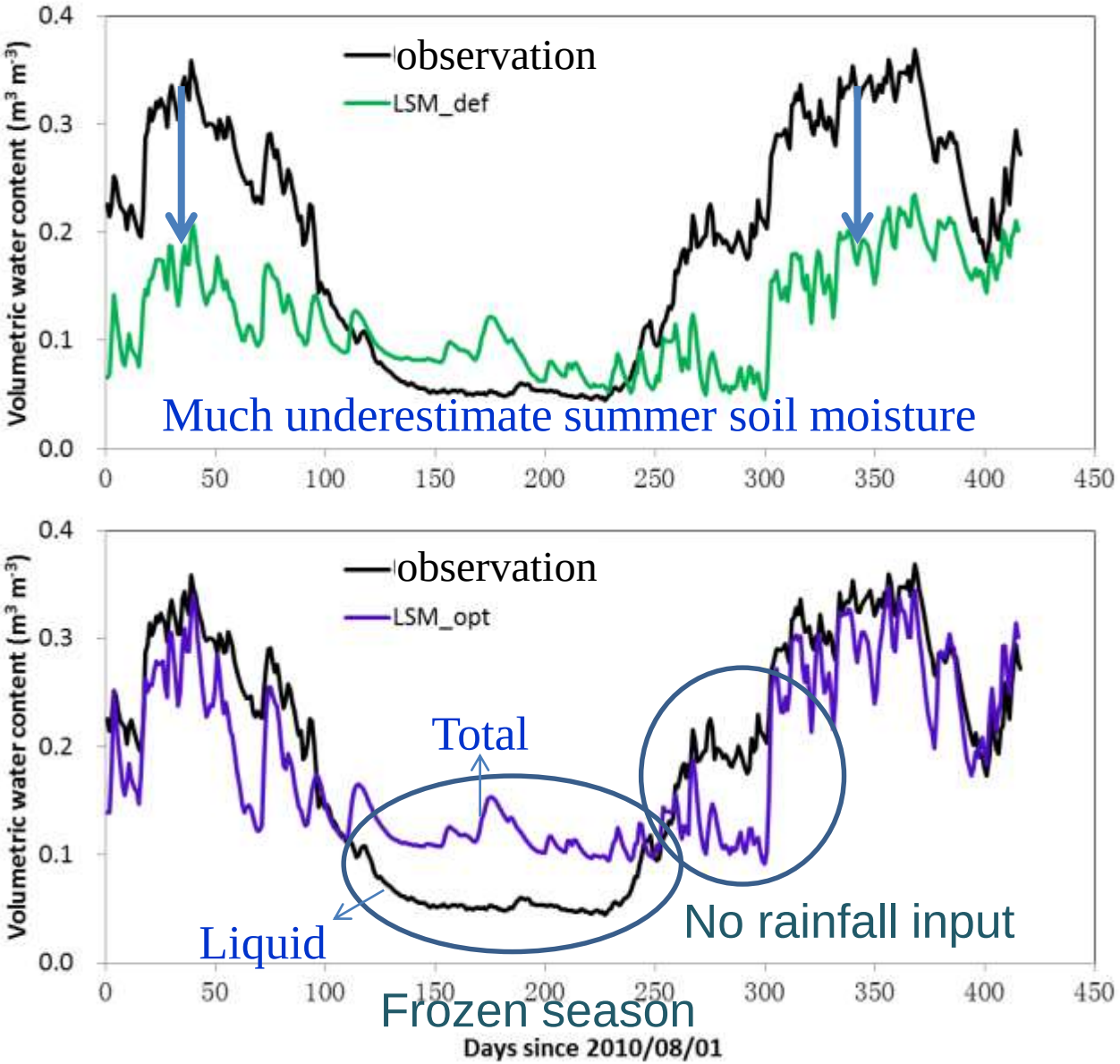
With LDAS calibrated parameters



Open-loop land surface modeling comparison for Naqu Large-network (2010-2011)

With IGBP soil parameters

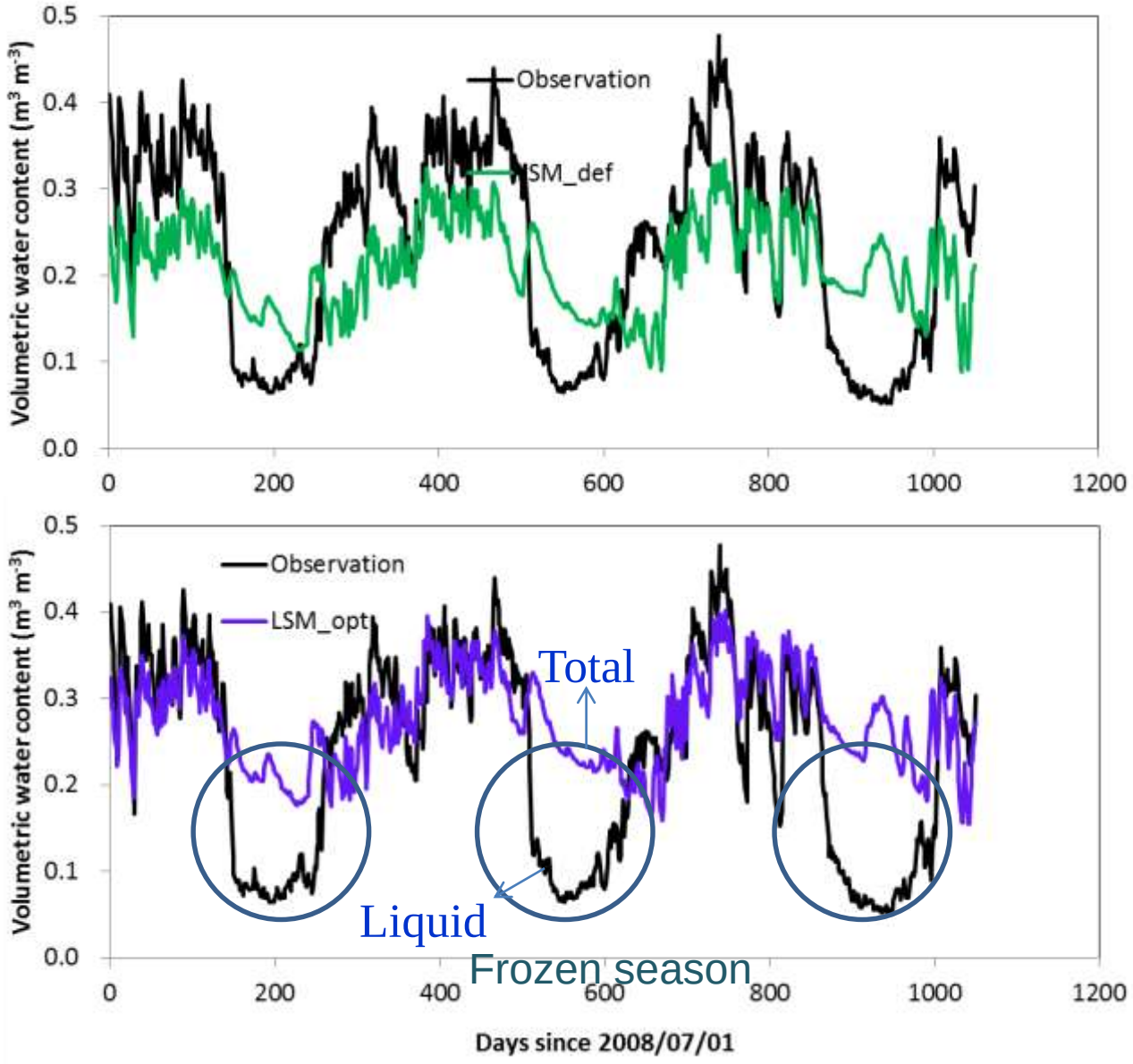
With LDAS calibrated parameters



Open-loop land surface modeling comparison for Maqu network (2008-2011)

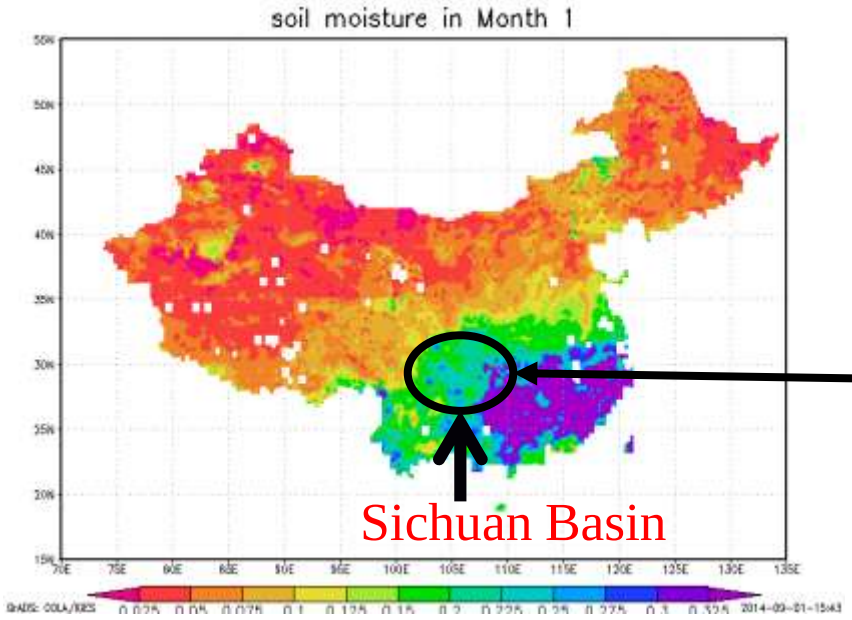
With IGBP soil parameters

With LDAS calibrated parameters

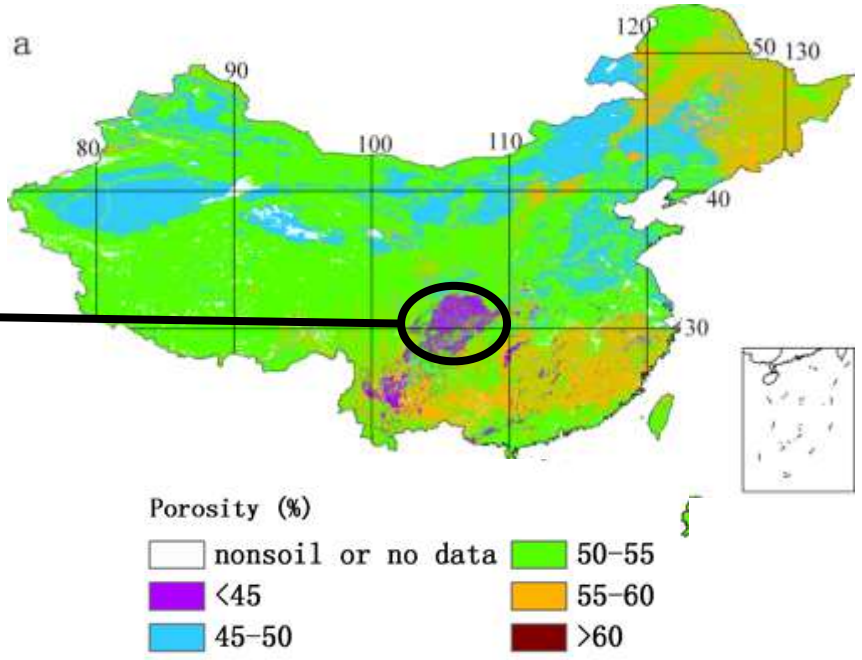


LDAS can reproduce some unique regional feature

LDAS-estimated soil moisture



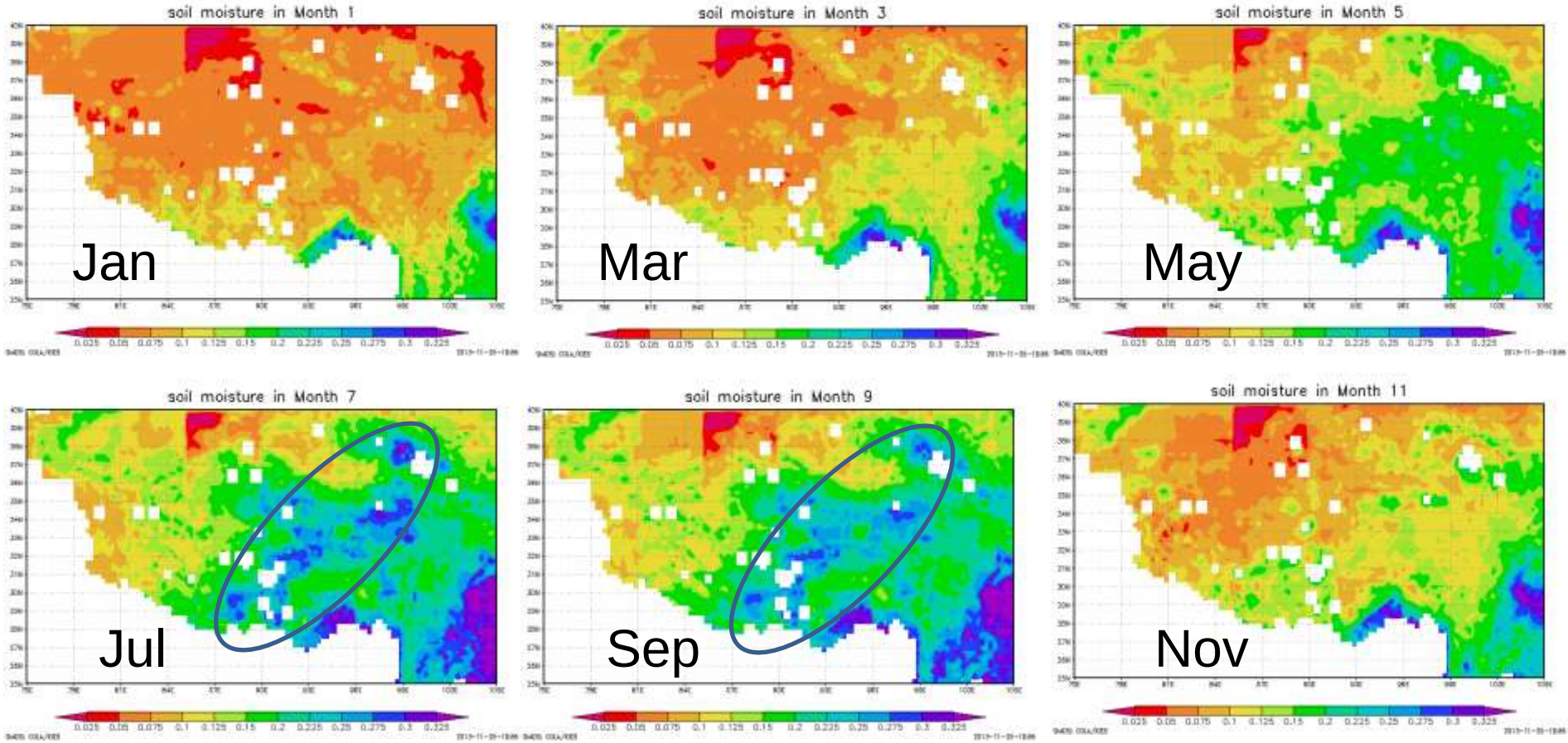
Soil porosity map
(Shangguan et al., 2013)



LDAS gives low soil moisture values in Sichuan Basin

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

LDAS-estimated soil moisture for Tibetan Plateau



Summer rainfall decreases from SE to NW Plateau, but soil moisture content does not strictly vary along the direction, perhaps due to terrain complexity. The circled flat area in the central Plateau has higher soil water content.

Summary and outlook

- Soil moisture data collecting platform has been well established on the Tibetan Plateau.
- The auto-calibrated LDAS can produce reliable regional soil moisture estimates for the Plateau (short grass)
- The LDAS has potential to be a feasible tool to calibrate land surface modeling at grid scale
- Future work:
  - Introduce prior information to avoid over-fitting
  - The nature of estimated parameter s: model-dependent?

Thanks for your attention !