Summary of Session on Utilization of Multi-Source Observations

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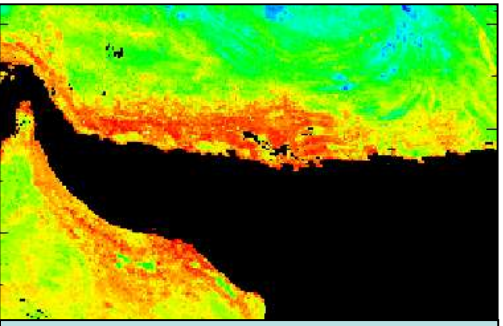
Presentations at this session

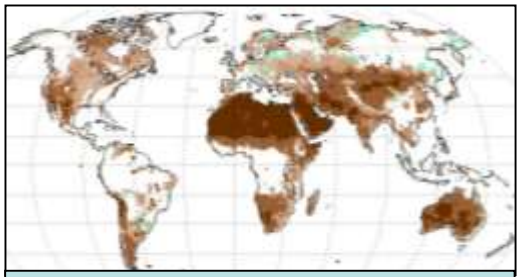
- Two keynotes
  - Rolf Reichle, Towards Multivariate Land Data Assimilation in the NASA GEOS-5 System
  - Paul Houser, Towards a Hyper-Resolution Integrated Water Observation and Prediction System
- Two contributed talks
  - Kinya Toride, Development of an Algorithm for Soil Moisture with High Spatial- and Temporal- Resolution
  - J. M. Bergeron, Using Multivariate Data Assimilation to Improve Streamflow Predictions for a Mountainous Watershed
- Posts

1. What is multi-source observations?

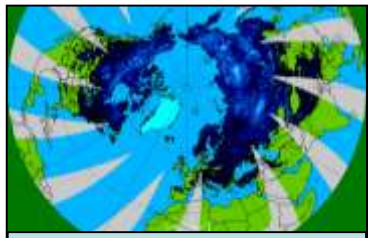
From Rolf Reichle



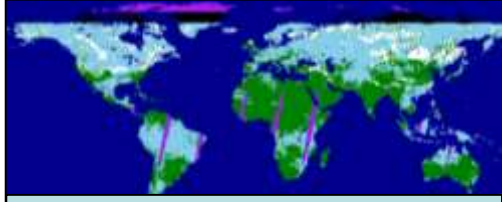
Land surface temperature
(MODIS, AVHRR,GOES,…)



Surface soil moisture
(SMMR, TRMM, AMSR-E,
ASCAT, SMOS, SMAP)

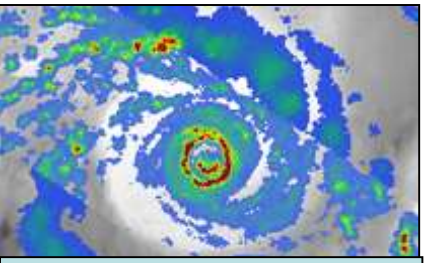


Snow water
equivalent
(AMSR-E, SSM/I,
SCLP)

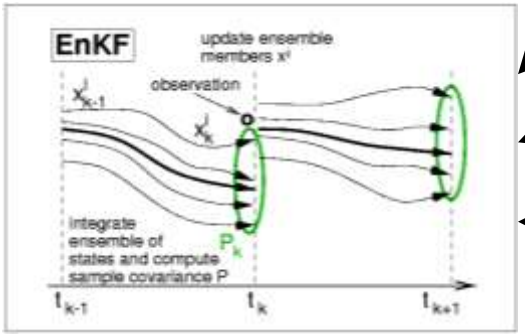


Snow cover fraction
(MODIS, VIIRS)

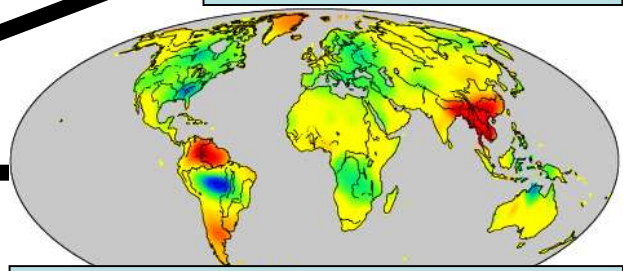
Water surface elevation
(SWOT)



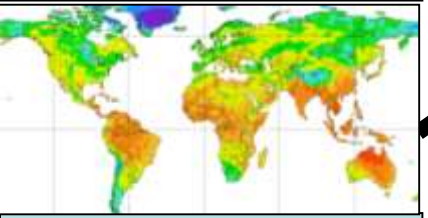
Precipitation
(TRMM, GPM)



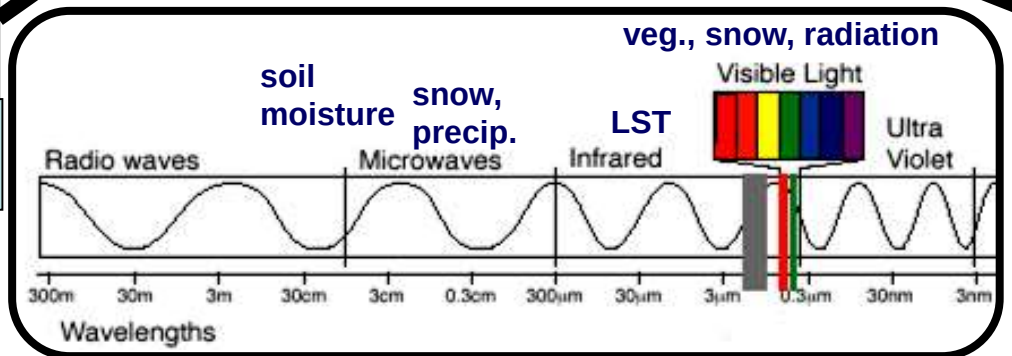
Land data assimilation system



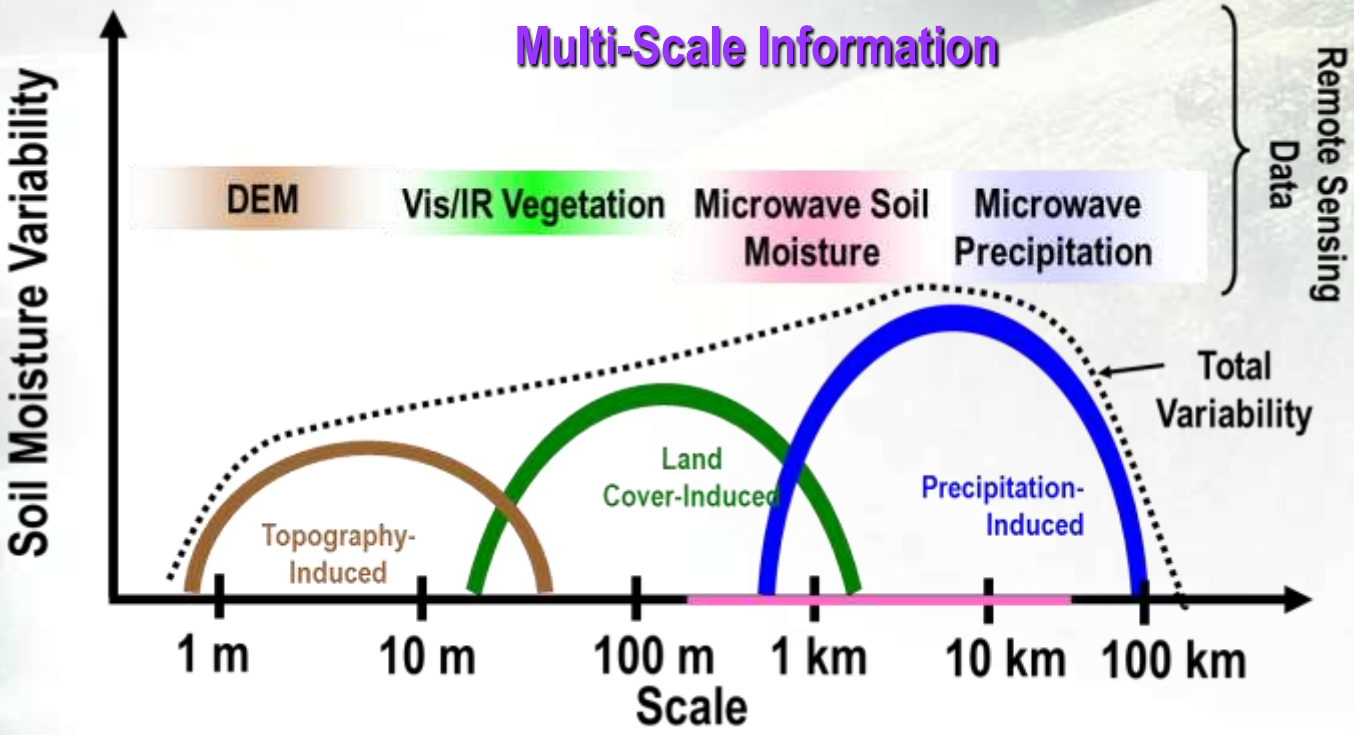
Terrestrial water storage (GRACE)



Radiation
(CERES, CLARREO)



Vegetation/Carbon
(AVHRR, MODIS, DESDynI,
ICESat-II, HyspIRI, LIST,
ASCENDS)



What does an 1/8 degree grid cell look like in real life?

Created by Paul Houser

Multi-source observations (1)

- Multi-sensor observations, e.g., hydrological cycle
  - SMOS, SMAP: soil moisture, freeze/thaw status
  - SWOT: surface water level, river flow
  - CoReH2O/SCLP: SWE
  - GRACE: water storage
  - GLAS: glacier mass balance, water level
- Multi-scale observations
  - VHR: TerraSAR-X, COSMO-SkyMed, and a lot of VNIR sensors
  - HR: PalSAR, EnviSAT, Sentine, LandSat/, HJ
  - Moderate resolution: MODIS, FY, MERIS
  - Coarse resolution: SMOS, SSMI, AMSRE, GRACE

Multi-source observations (2)

- Multivariate analysis: soil moisture, SWE, LST, fluxes
- Multi-purpose: water cycle, carbon cycle, energy balance
- Raw data (TB, reflectance) vs. data products
- *In situ* and remote sensing

Framework of Chinese Land Data Assimilation System (CLDAS)

Contributed by Huang Chunlin et al.

Input

RS Data

- MODIS LST
- GLASS & MODIS LAI
- MODIS SCA
- AMSR-E TB

Model Parameters

- BNU Soil Texture
- CAREERI Land cover Map

Forcing

- GLDAS Forcing
- ITPCAS Forcing

Models

PM-RTM

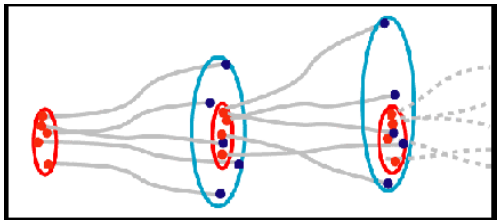
- Soil (thaw/freeze)
- Snow, e.g. MEMLS
- Water

LSM

- CoLM

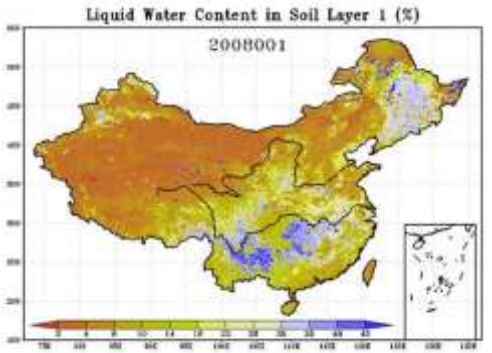
DA Algorithm

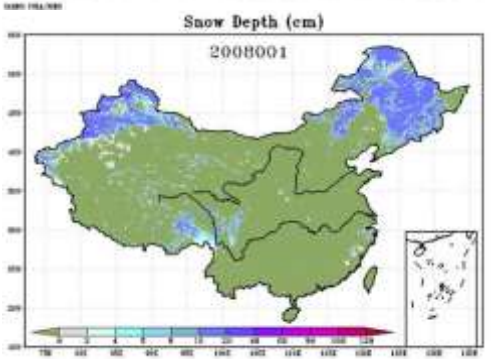
- EnKF



Output

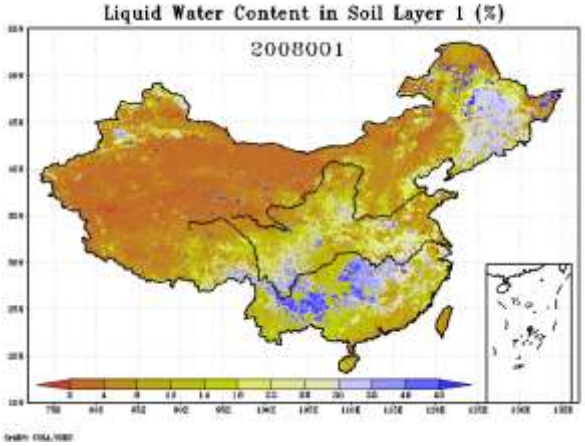
- Soil Moisture
- Soil Temperature
- Surface fluxes
- Snow



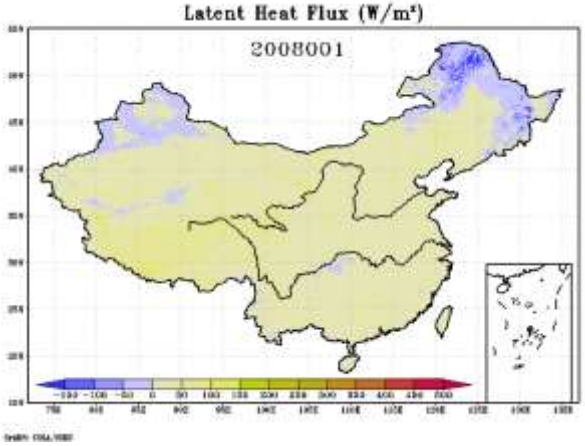


Assimilation Results (Daily) 2008

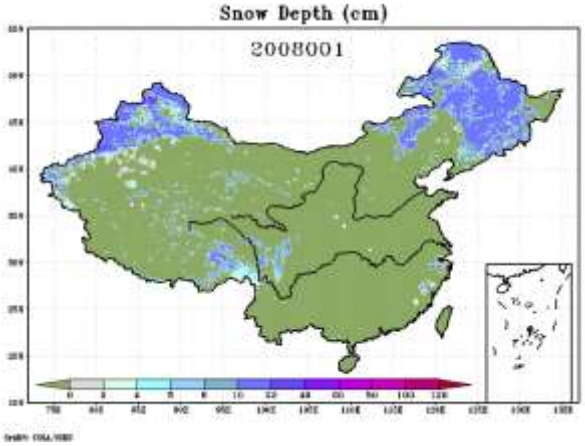
Soil Moisture (Layer-1)



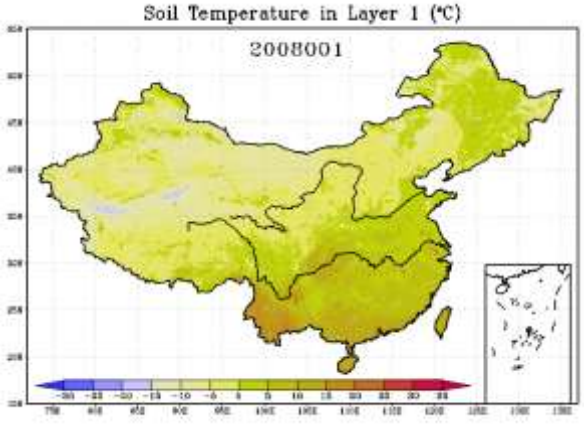
Latent Heat Flux



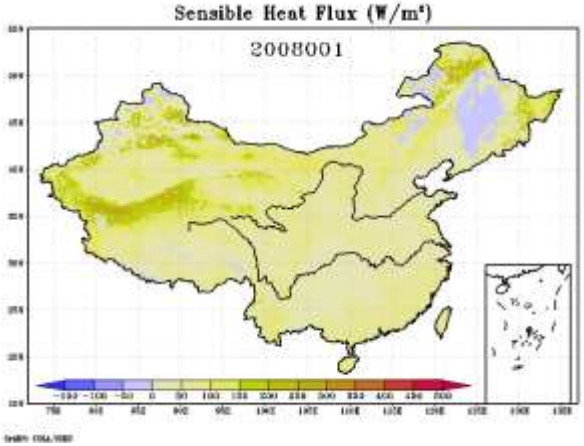
Snow Depth



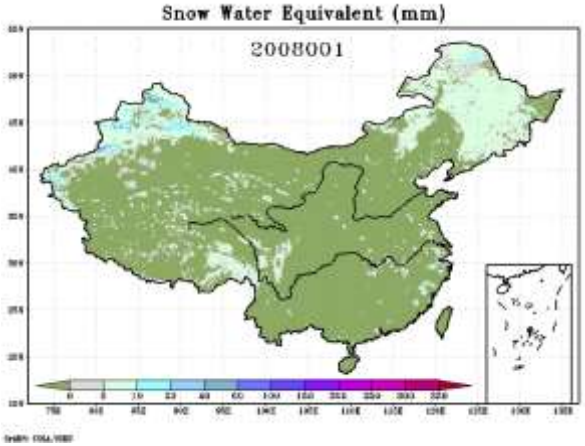
Soil Temperature(Layer-1)



Sensible Heat Flux



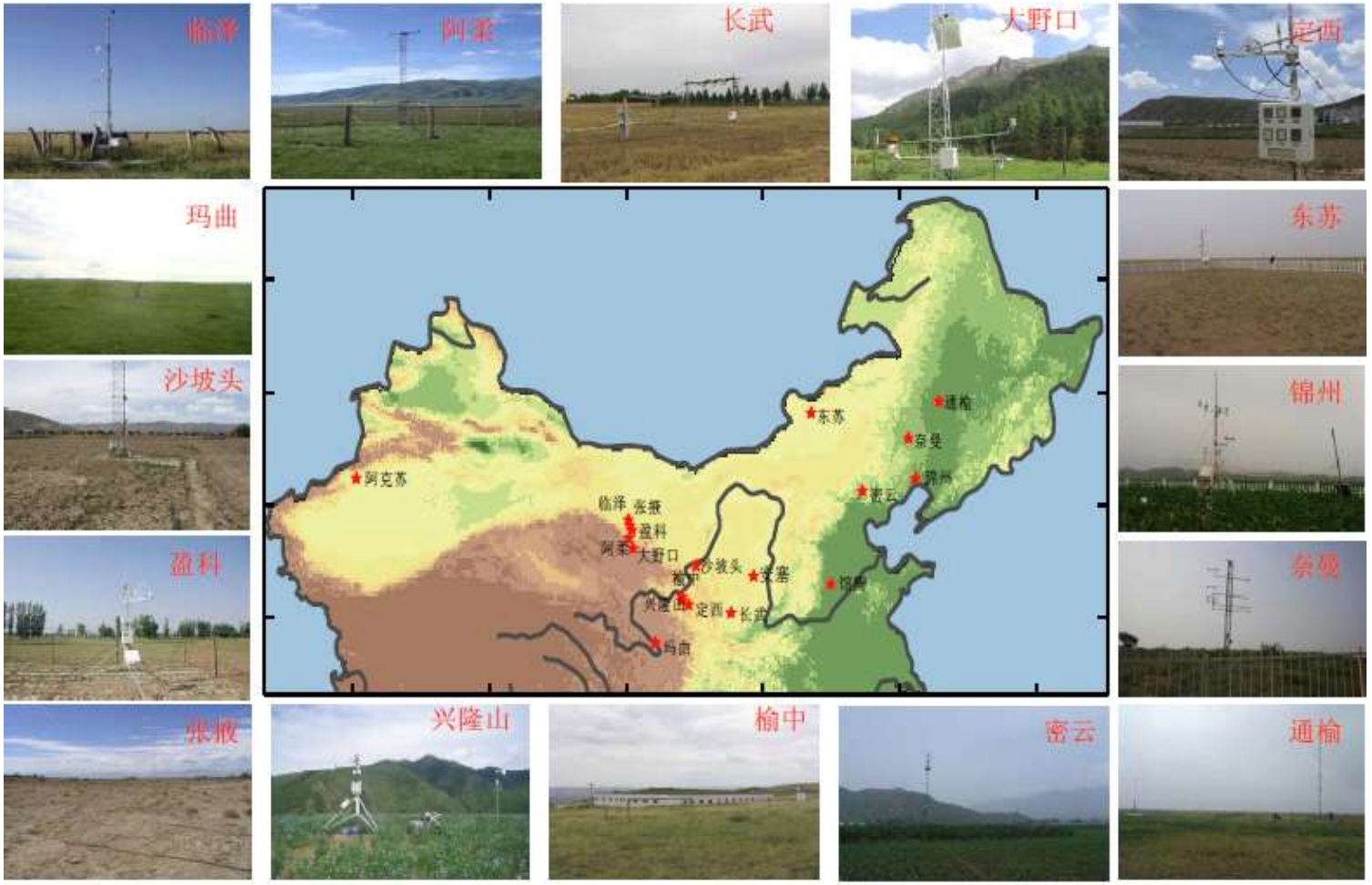
SWE



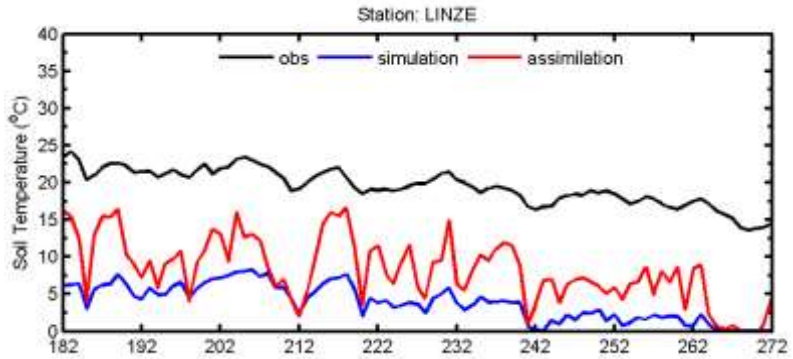
Validation

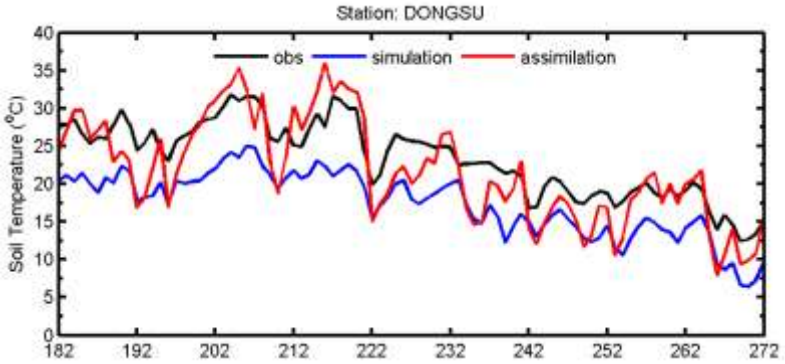
Soil moisture, soil temperature, surface fluxes

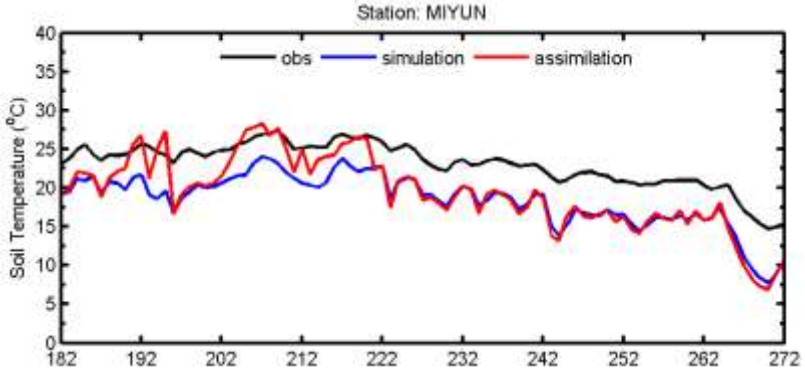
coordinated enhanced observation network in arid and semi-arid regions of northern China

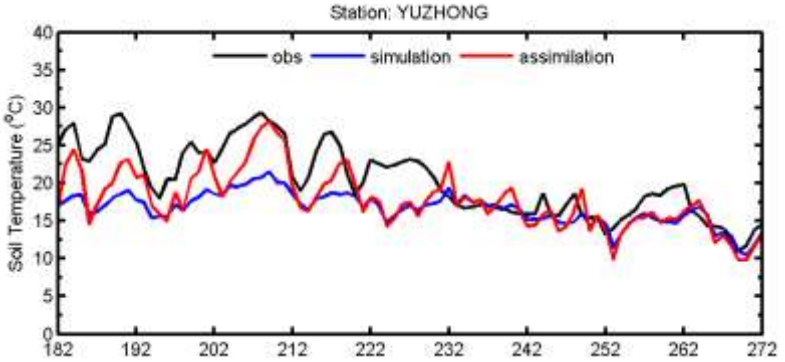


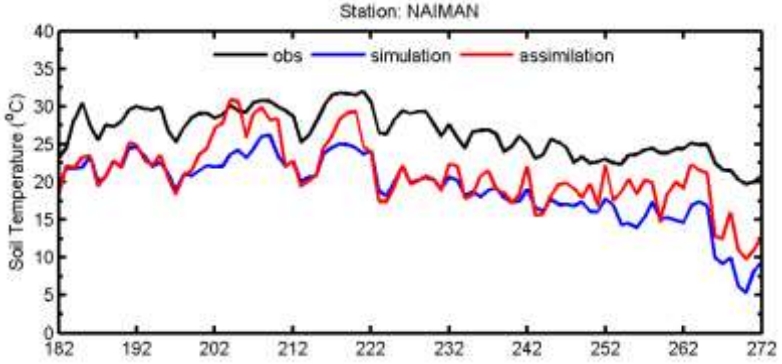
Soil Temperature

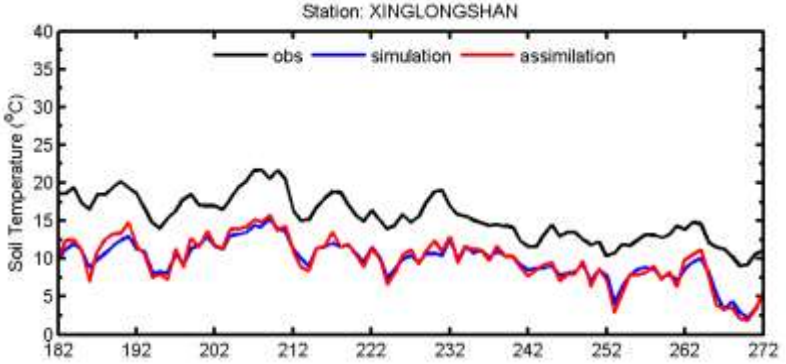




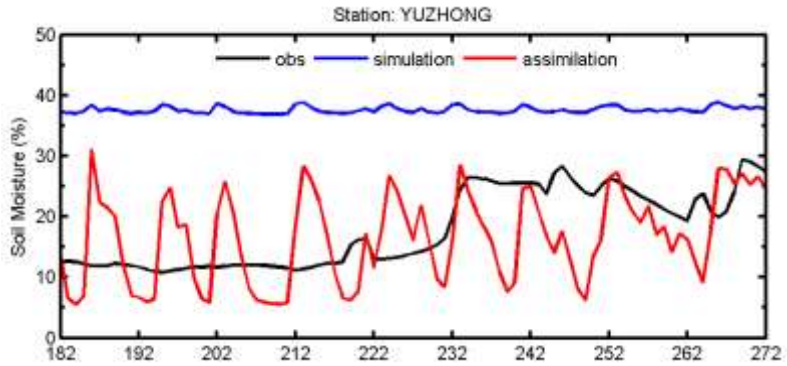


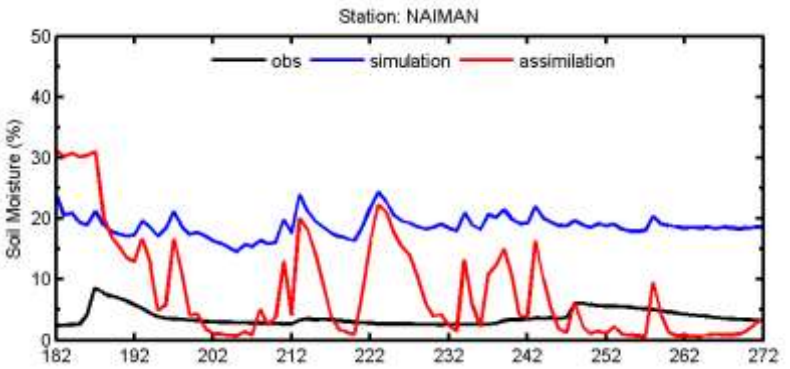


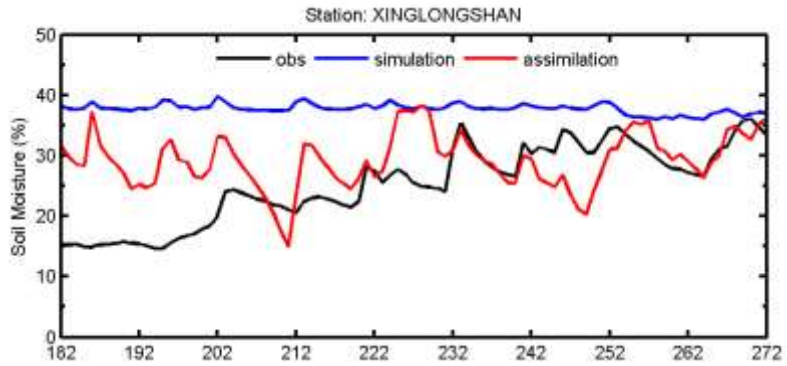


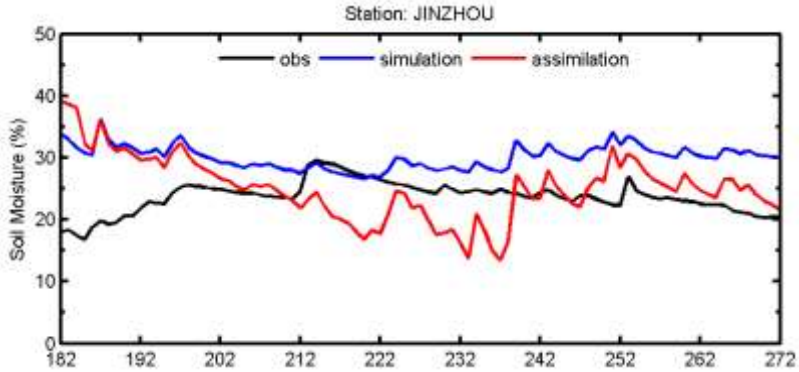


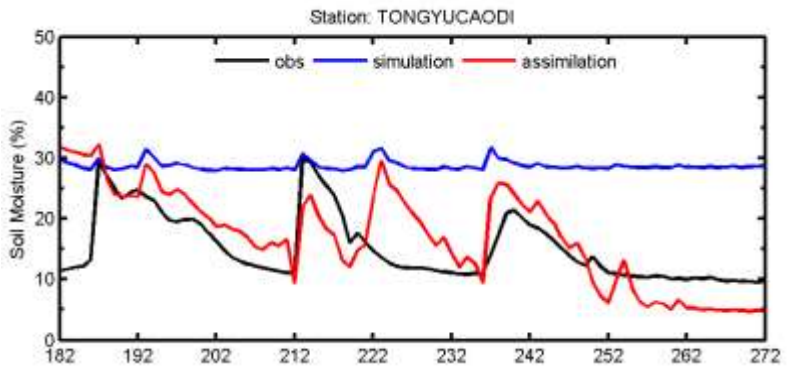
Soil Moisture

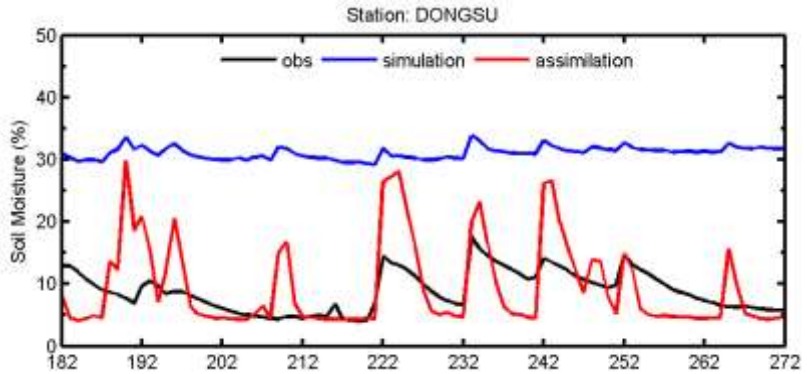




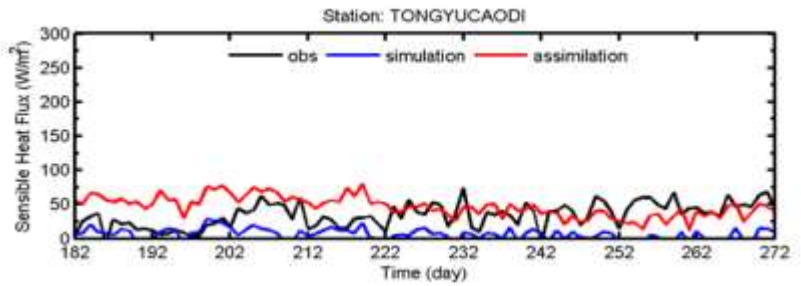


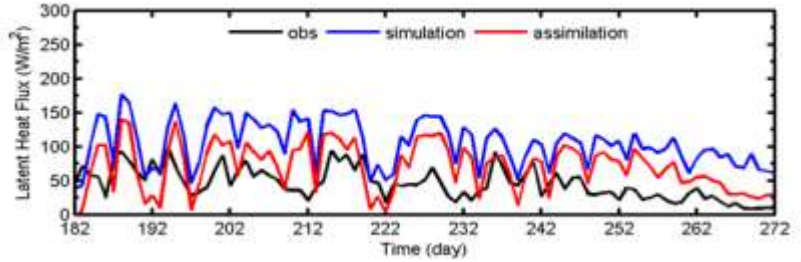


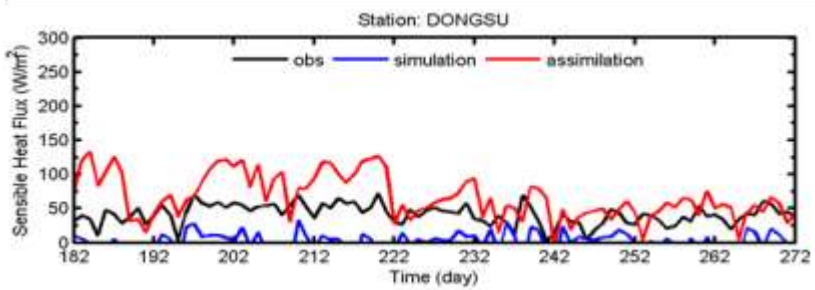


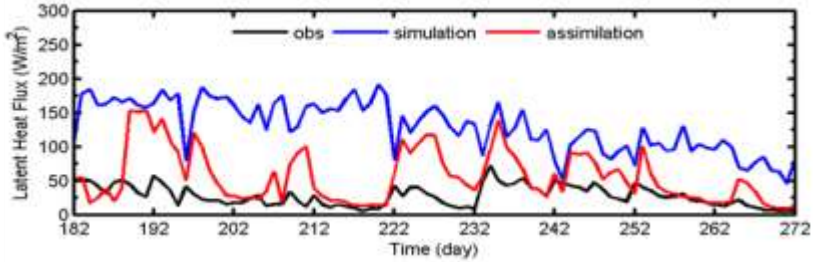


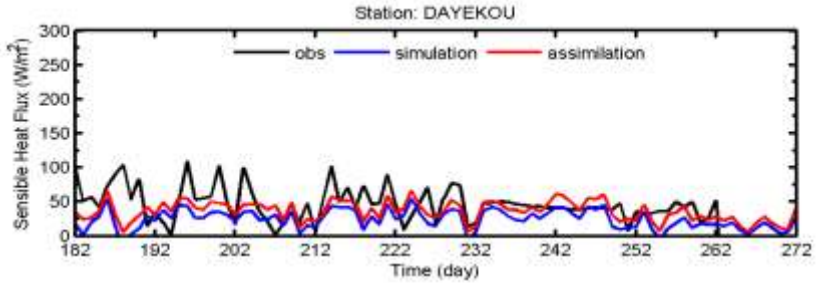
Fluxes

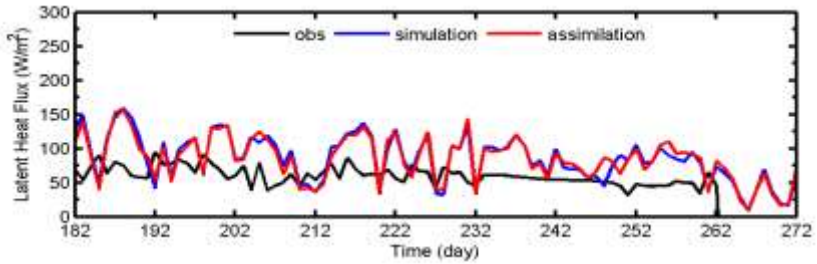

Station: TONGYUCAODI
obs
simulation
assimilation
Sensible Heat Flux (W/m²)
Time (day)


obs
simulation
assimilation
Latent Heat Flux (W/m²)
Time (day)


Station: DONGSU
obs
simulation
assimilation
Sensible Heat Flux (W/m²)
Time (day)


obs
simulation
assimilation
Latent Heat Flux (W/m²)
Time (day)


Station: DAYEKOU
obs
simulation
assimilation
Sensible Heat Flux (W/m²)
Time (day)


obs
simulation
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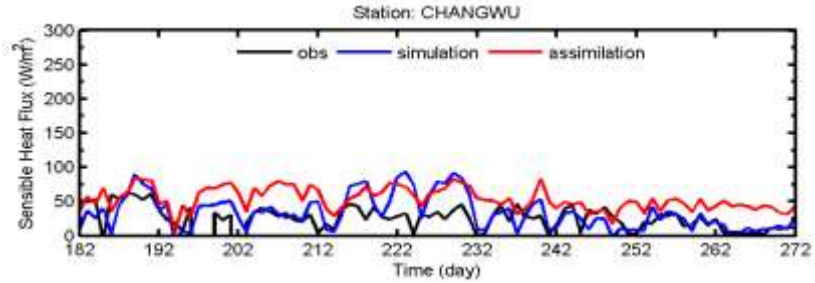
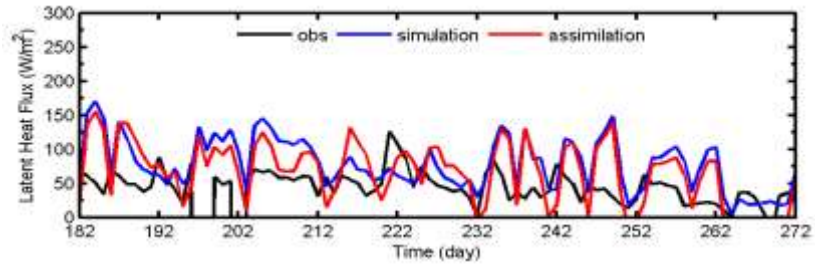
Latent Heat Flux (W/m²)
Time (day)


Station: CHANGWU
obs
simulation
assimilation
Sensible Heat Flux (W/m²)
Time (day)

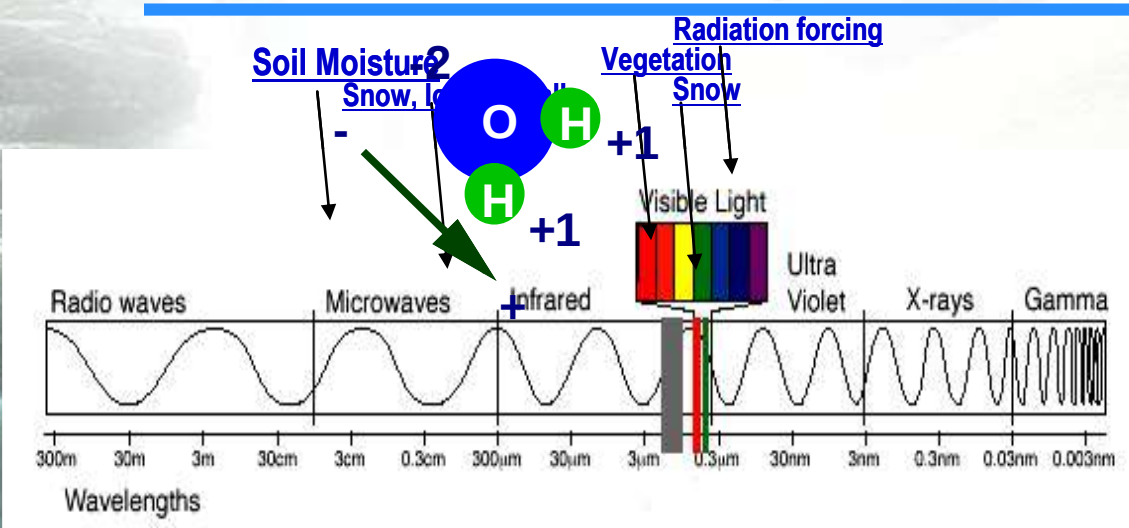

obs
simulation
assimilation
Latent Heat Flux (W/m²)
Time (day)

2. Opportunities

New sensors, new measurements

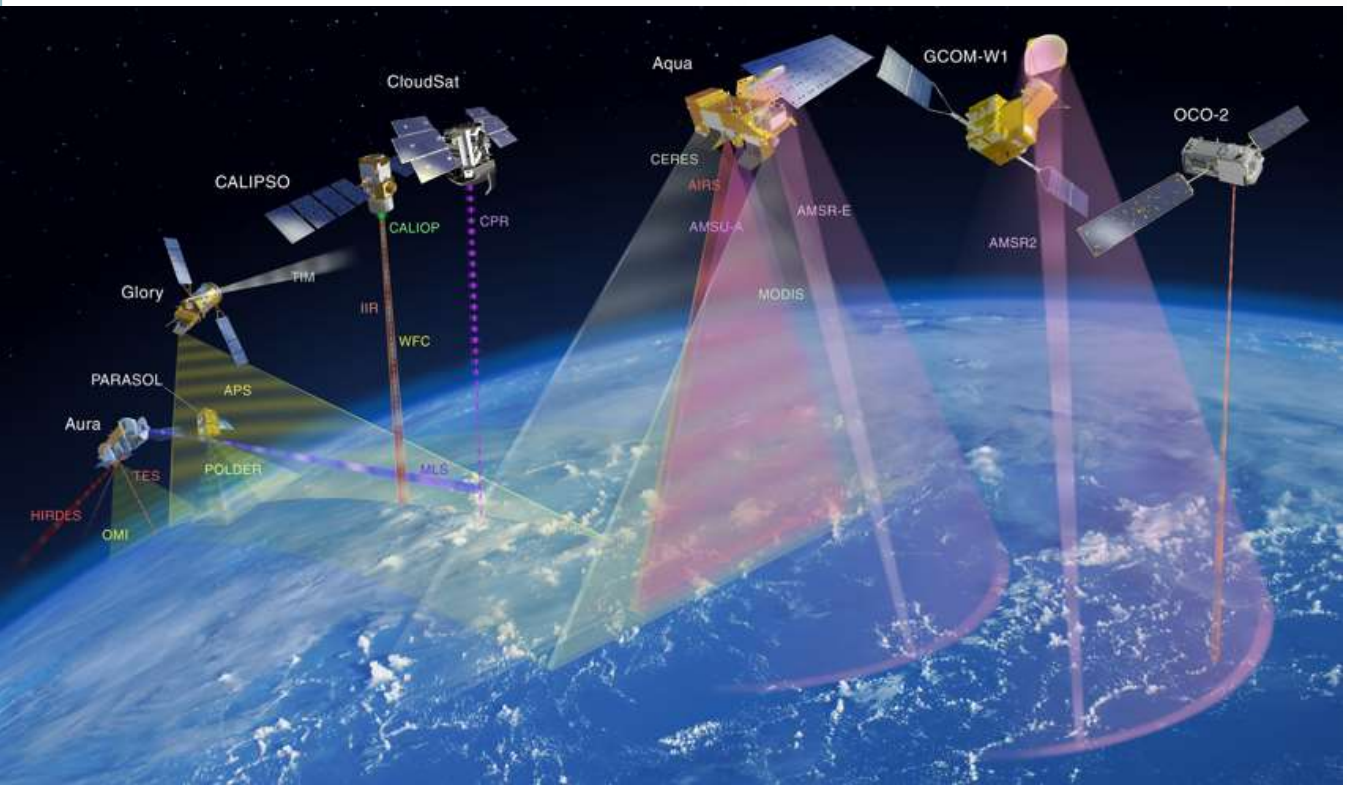
- Satellite missions (NASA, ESA, China)
- (Wireless) sensor network
- Footprint-scale in situ observations
  - COSMOS
  - LAS (infrared and microwave)
  - footprint scale SWE
- Flux network
- Other *in situ* observation network

Water Cycle Remote Sensing



Types of Microwave Sensors:

1. **Microwave radiometers:** Emission
2. **Non-imaging RADARs**
   - Altimeters – measure elevation
   - Scatterometers –microwave backscatter
3. **Imaging RADARs**
   - Synthetic Aperture Radars – map variations in microwave backscatter



The "A-Train"

AMSR-E radiometer (6-89 GHz)
AMSU-A (15 channels 15-90 GHz)
HSB profiler (150, 183 GHz)
CloudSat Radar (94-GHz)

The "W-Train"?

TRMM TMI radiometer (10.7-85.5 GHz)
GPM (future)
TRMM-PR (radar at 13.6 and 35 GHz)
Aquarius/SMAP (1.413GHz A/P).
SMOS (1.4GHz radiometer)

Created by Paul Houser

Snow observatory in Qilian Mountains, 4150 m asl

COSMOS Project Plans in the Next 4 Years

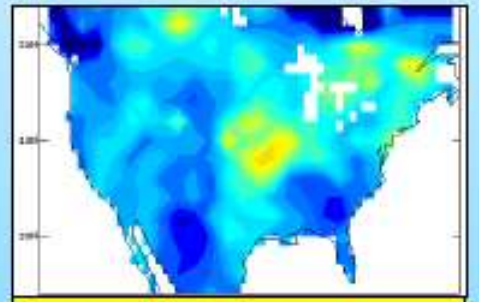
Potential COSMOS Collaborative Site (CCS) in National Networks

AMERIFLUX (various)

NEON (NSF)

CZO (NSF)

SCAN (USDA)



Diagnostically-determined indication of where soil moisture conditioning has the largest local and remote impact on precipitation on days 31-45

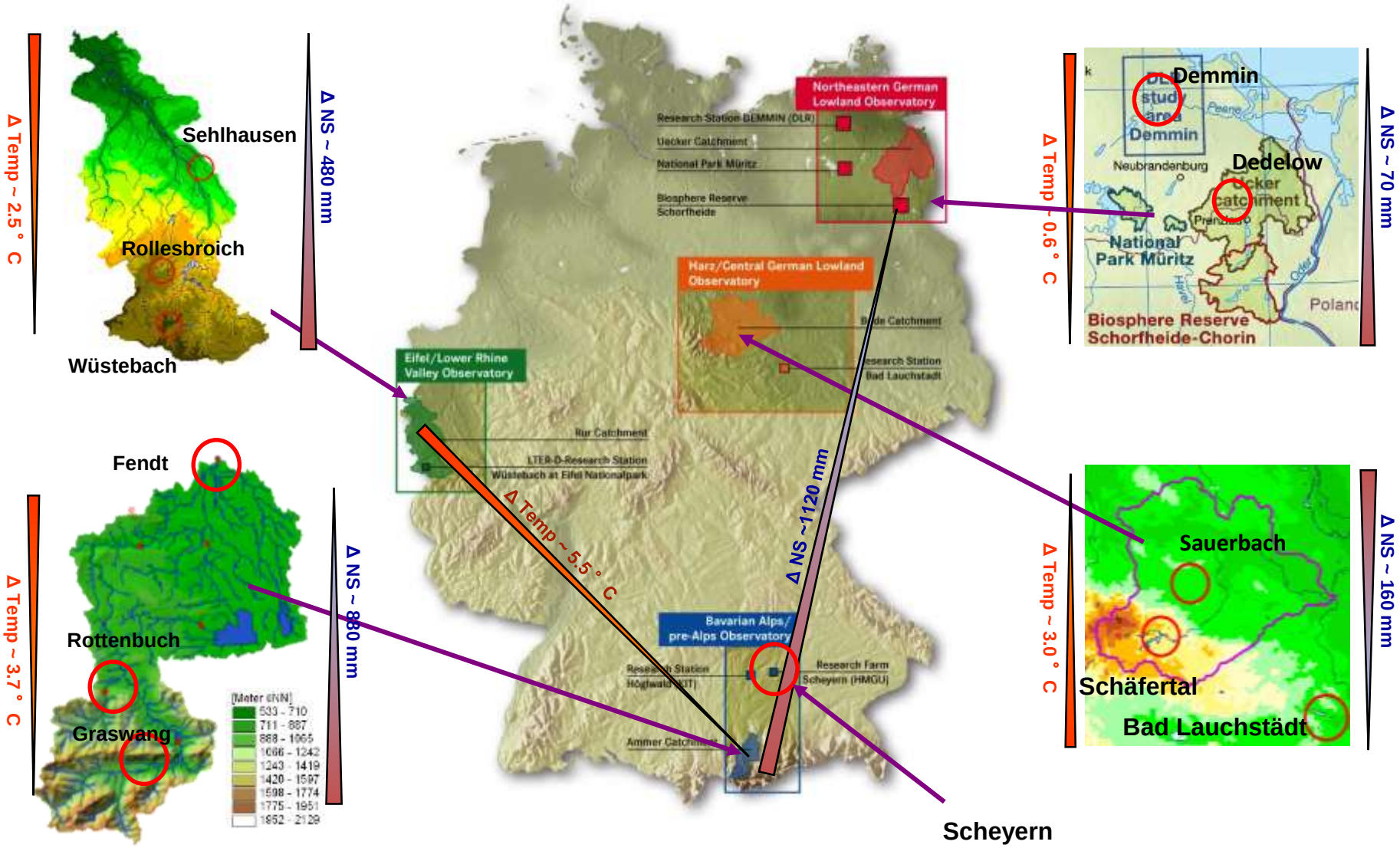
(The Koster Bulls Eye)

ARM-CART (DOE)

From Jim Suttleworth

TERENO
TERRESTRIAL ENVIRONMENTAL OBSERVATORIES

Lysimeter-Network TERENO SoilCan



From Harry Vereechen

3. Challenges

Challenges (1)

- Coordinate the observations
  - Satellite constellation (A-Train, W-Train, Paul Houser)
  - New satellite mission (WCOM, Jiancheng Shi)
  - Field campaigns to test hypotheses and validate data products
  - Networking the networks (soil moisture, flux)

Challenges (2)

- Harmonize the input
  - Remove of place-dependent, sensor-specific systematic errors (Rolf Reichle)
  - Estimation of observation errors of individual observation, a priori information of error matrix is still a challenge.
  - Error matrix structure of multivariate including their correlation could be very difficult to estimate
  - Estimate the representativeness error of radiative transfer models.

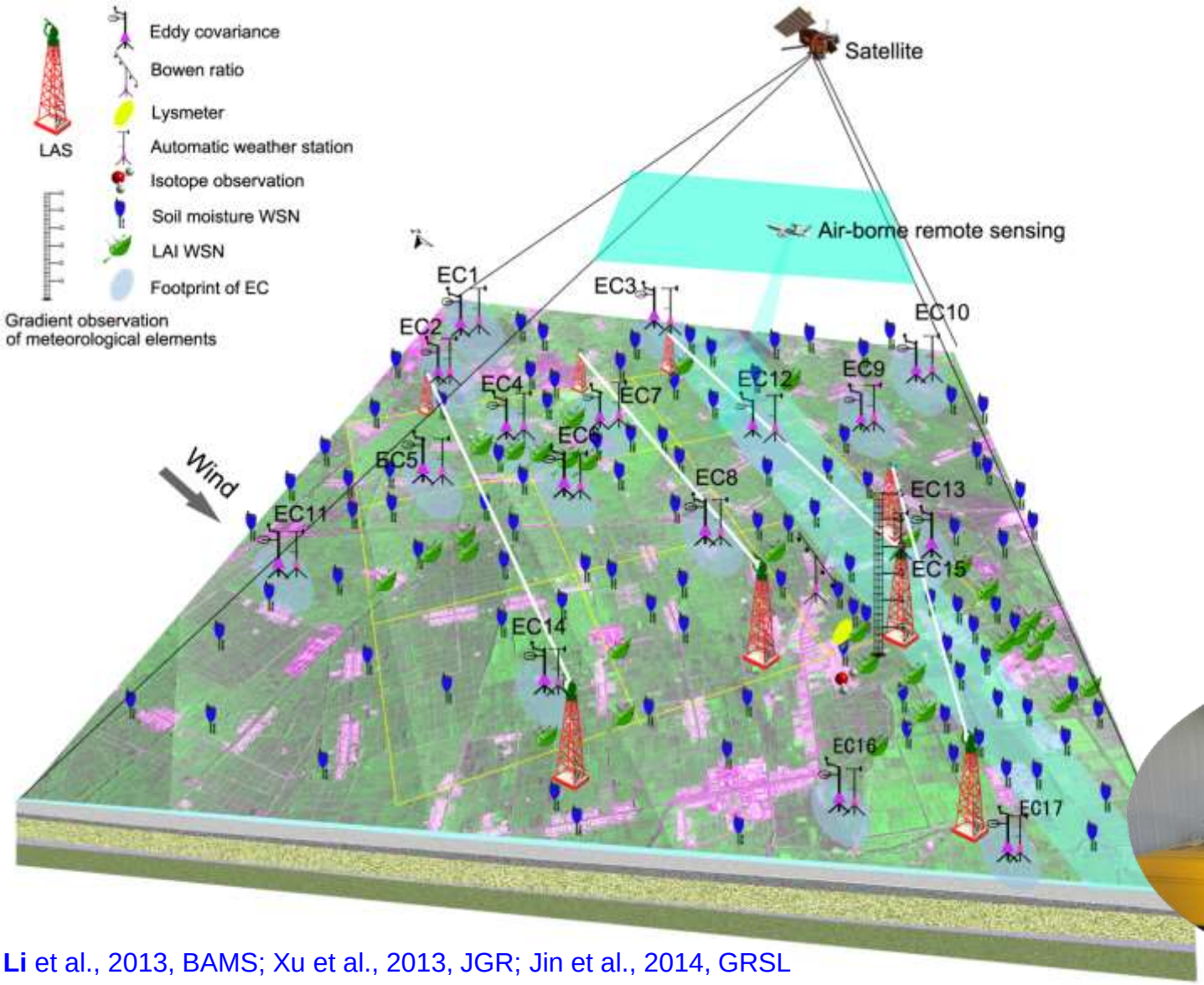
Challenges (3)

- Balance the output
  - Output priority
  - Physical constraint, e.g., water balance
  - Post-processing plays a role?

Challenges (4)

- Address the scale issue
  - Scale-explicit model, heterogeneity as an inherent part of the model
  - Different modeling approaches for different scales
  - Use of field campaigns to design true multi-scale observations to capture spatial heterogeneity and characterize the representativeness error of observations

HiWATER: An observation matrix to capture the land surface heterogeneity



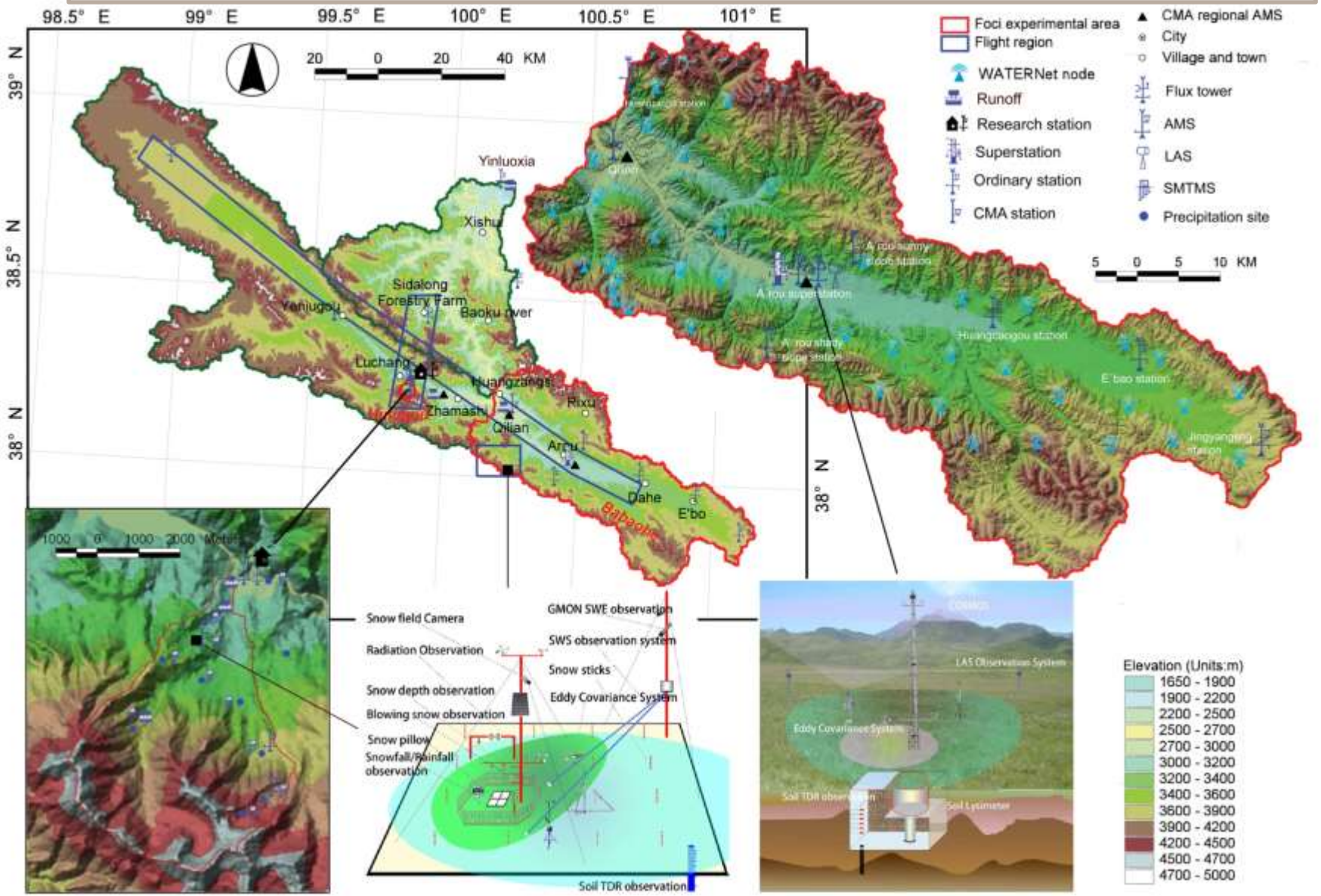
WATERNet

SoilNet

LAINet

Li et al., 2013, BAMS; Xu et al., 2013, JGR; Jin et al., 2014, GRSL

HiWATER nested multi-scale observation in an alpine watershed



Li et al., 2013, BAMS; Jin et al., 2014, GRSL

Airborne remote sensing

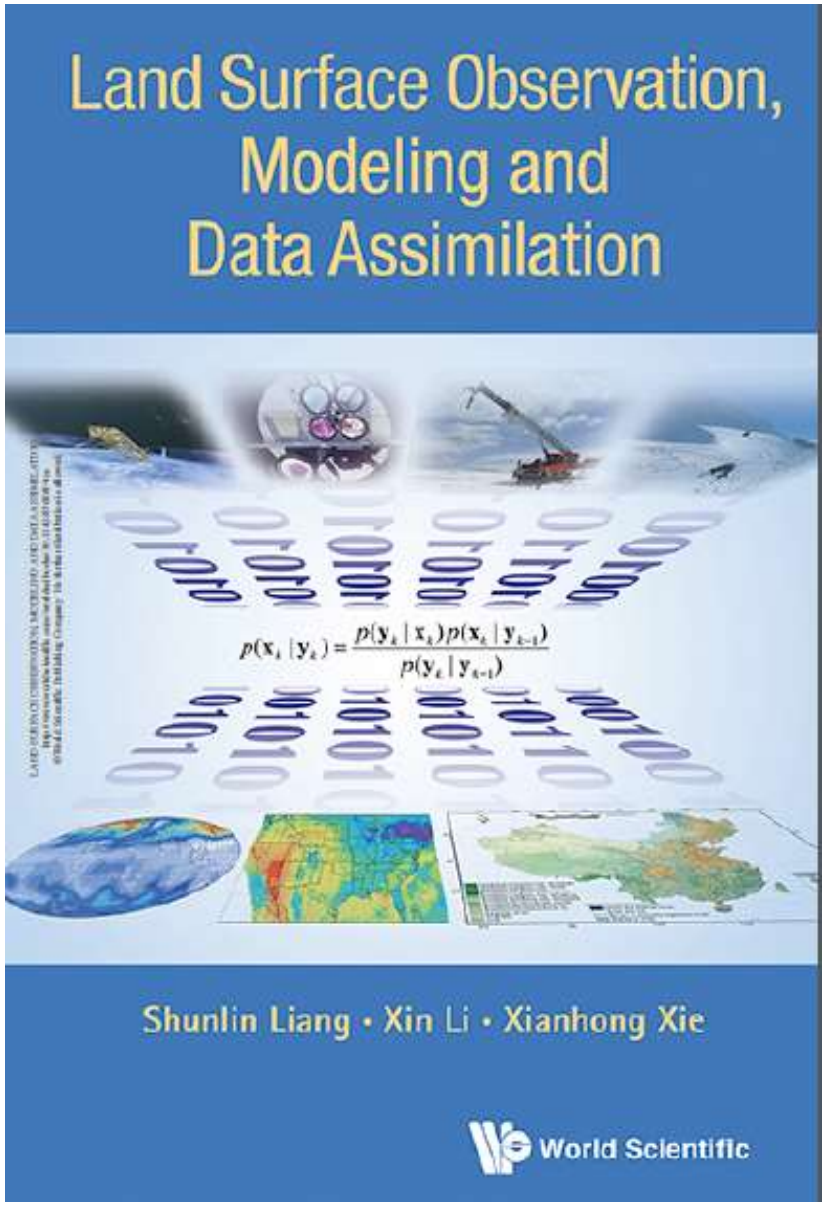
	Instrument	Observation items
	LiDAR+CCD	DEM (1m resolution), canopy structure, crop structure, aerodynamic roughness
	Imaging spectrometer	Vegetation classification, leaf area index, albedo, snow cover area, biogeophysical & biogeochemical parameters
	Multi-angle thermal imager	Land surface temperature, emissivity
	L-band microwave radiometer	Soil moisture

CAHMDA VII ?
Beijing, China?
Later summer or early autumn ?


陆面数据同化培训与研讨会
2007年8月7日-10日，兰州
中国科学院寒区旱区环境与工程研究所

The 2nd Summer School on Land Surface Observing, Modeling and Data Assimilation July 13-16, 2010

第 二 届 陆 面 观 测 、 模 拟 与 数 据 同 化 培 训 班 2010.7.13-16



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4th training workshop on land data assimilation in China
&
CAHMDA VII

Thank You !


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