

ESA–MOST Dragon Cooperation

中国科技部-欧洲空间局“龙计划”合作

2017 DRAGON 4 SYMPOSIUM

2017年“龙计划”四期学术研讨会

Project C3-ID32439 (MUSYCADHARB)

Sub-project:

Satellite data products on each component of the terrestrial water cycle at the land – atmosphere interface (SADTALE)

26–30 June 2017 | Copenhagen, Denmark

2017年6月26-30日, 丹麦 哥本哈根

Project C3-ID32439 (MUSYCADHARB)

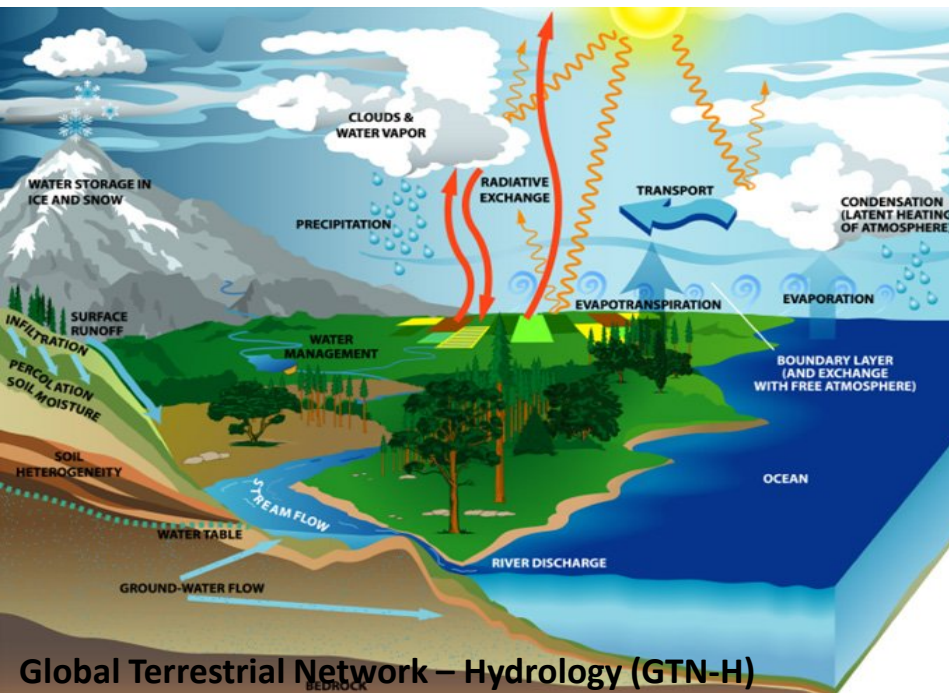
RECENT PROGRESSES IN HYDROLOGICAL VARIABLES FROM SATELLITE DATA

**Li Jia, Chaolei Zheng, Guangcheng Hu, Jing Lu, Jie Zhou, Kun Wang,
Tianjie Zhao, Jingxiao Zhang, Massimo Menenti**

**Institute of Remote Sensing and Digital Earth (RADI)
Chinese Academy of Sciences (CAS)**

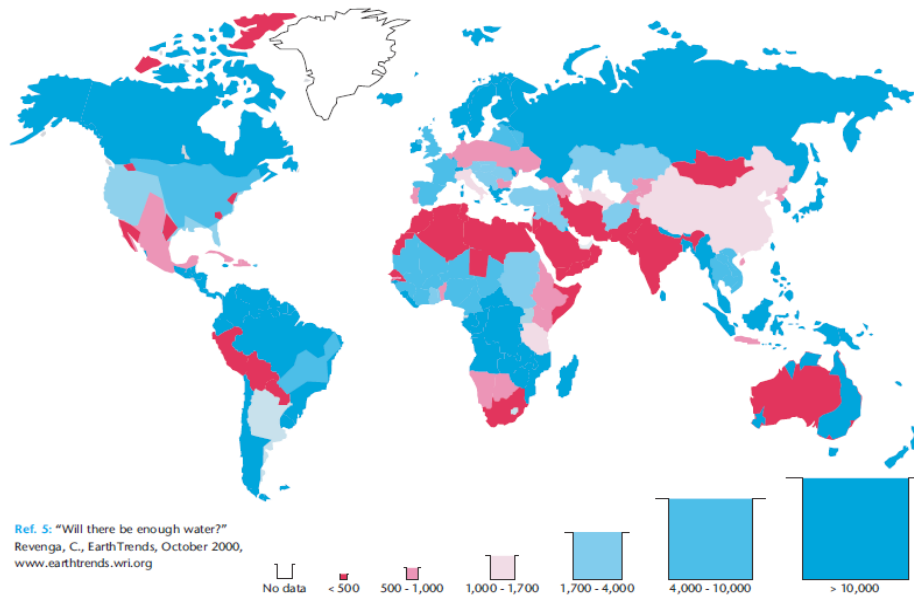
26-30 June 2017, Copenhagen, Denmark

Terrestrial Water Cycle



Water is not distributed evenly over the globe

Annual renewable water ($\text{m}^3/\text{person}/\text{year}$)⁵



Annual renewable water ($\text{m}^3/\text{person}/\text{yr}$)

Ref. 5: "Will there be enough water?"
 Revenga, C., EarthTrends, October 2000,
www.earthtrends.wri.org

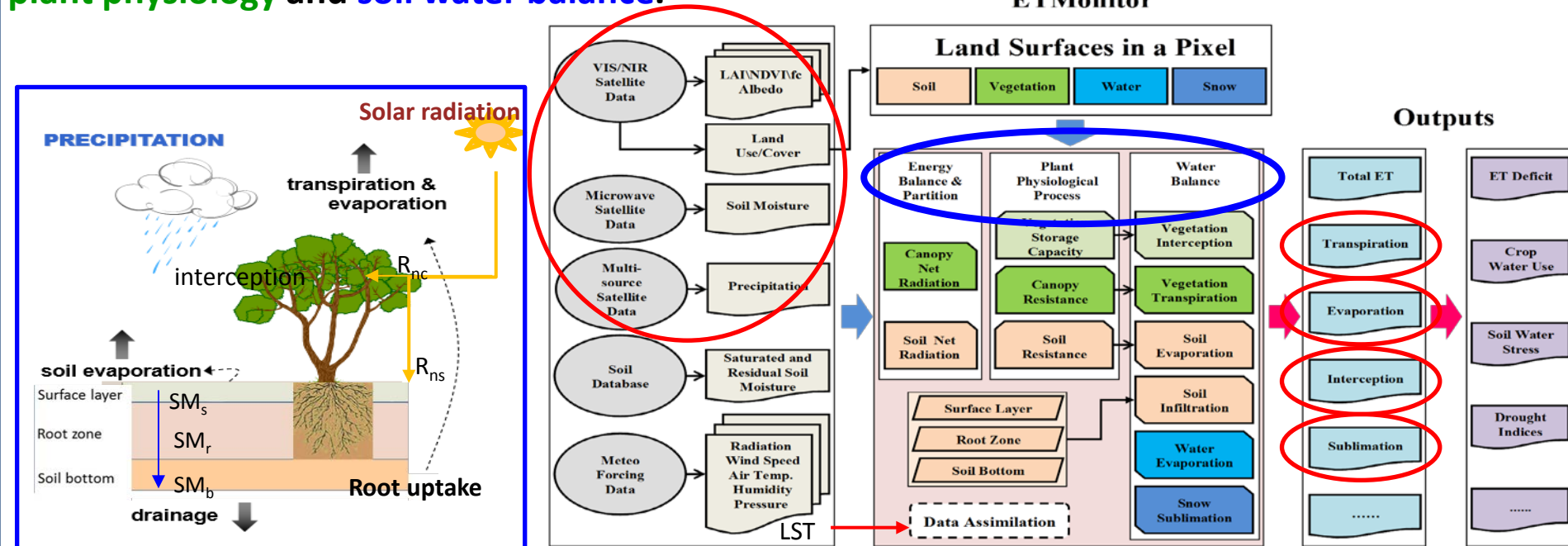
- **Evapotranspiration**
- **Glacier Area and Thickness**
- **Soil Freeze/Thaw Status**

Model: ETMonitor

ETMonitor: A process based model implementing processes of **energy balance**, **plant physiology** and **soil water balance**.

- Combining optical and microwave remote sensing observations

ETMonitor



Data used

EO data

Albedo and LAI (Global LAnd Surface Satellite - GLASS)

Soil Moisture (ASCAT)

Precipitation (CMORPH V1.0)

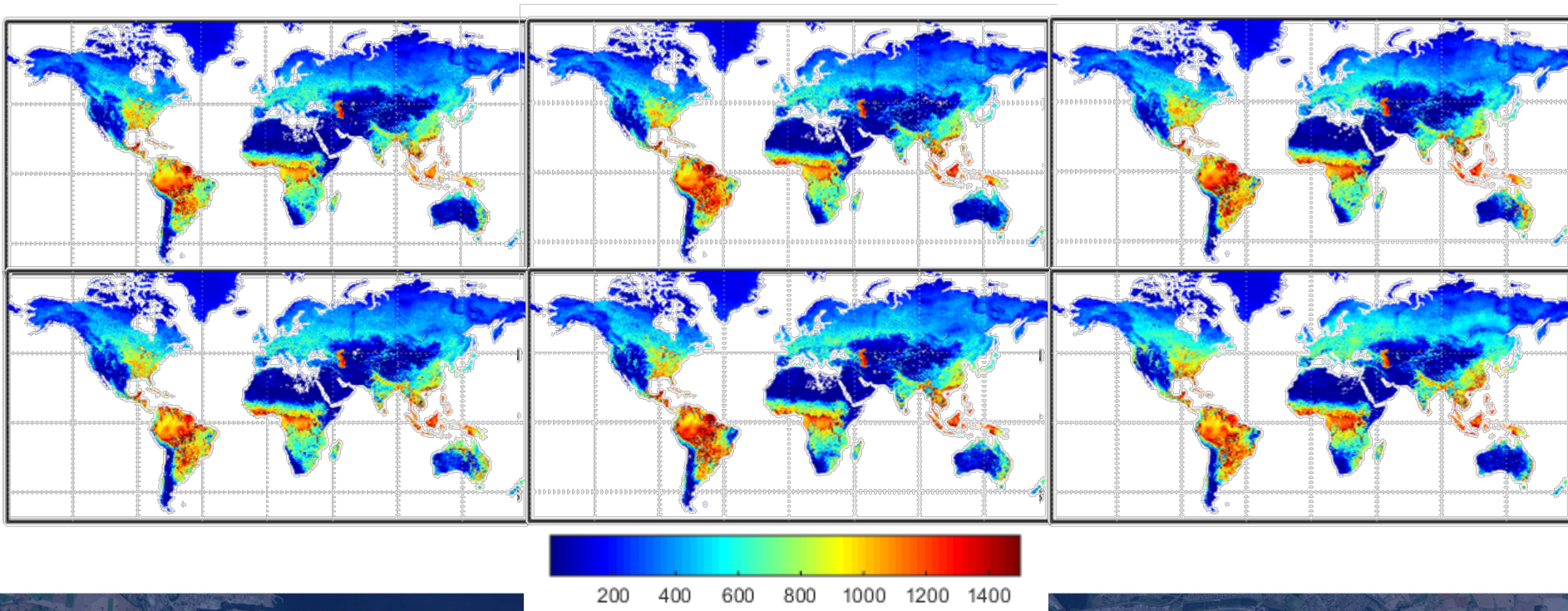
Land Cover (MODIS MCD12Q1)

Forest Height (JPL)

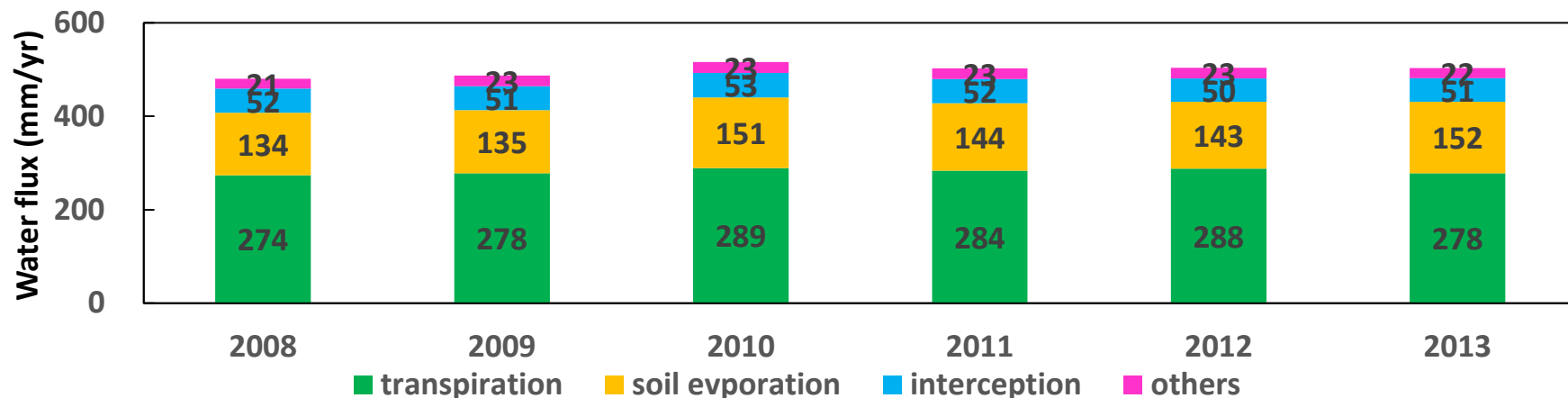
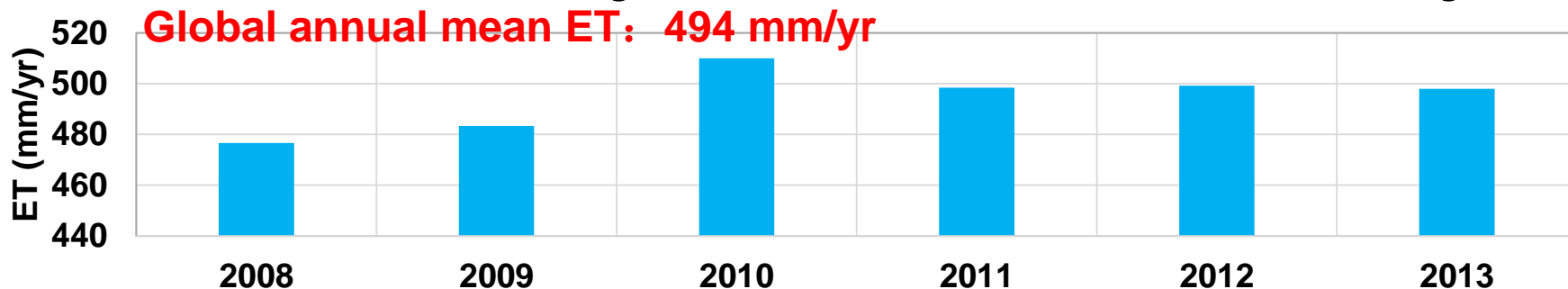
Meteorological data (ERA - Interim)

DEM (SRTM)

Global annual mean ET by ETMonitor, 2008-2013 (mm/yr)



Global annual mean ET by ETMonitor, 2008-2013 (mm/yr)

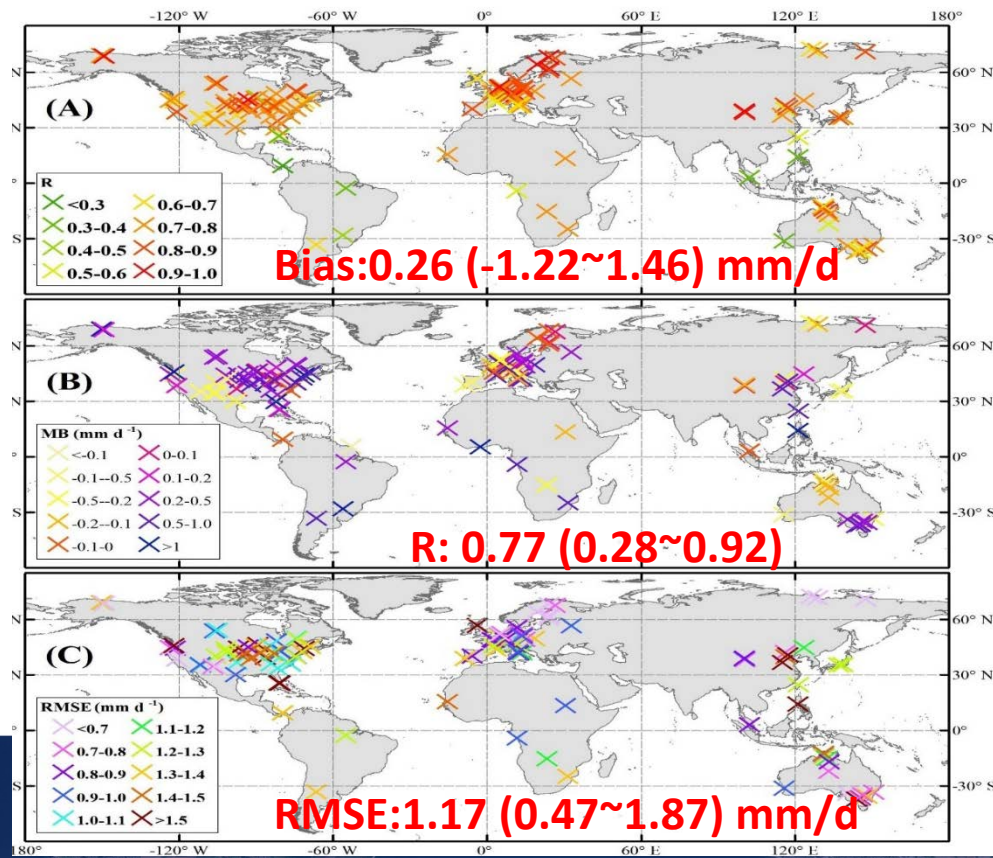


Global annual mean ET by ETMonitor, 2008-2013 (mm/yr)

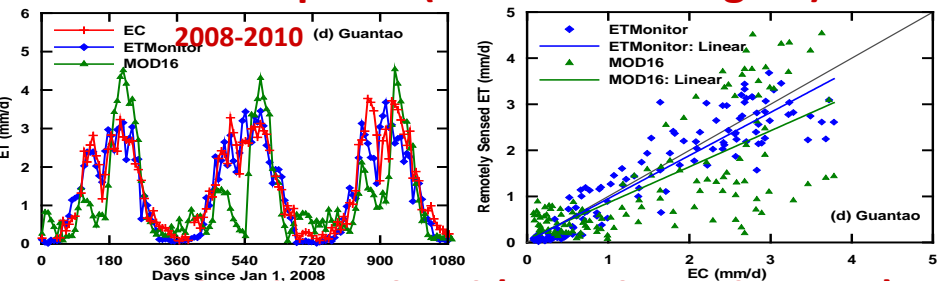
• validation

➤ 153 flux sites:

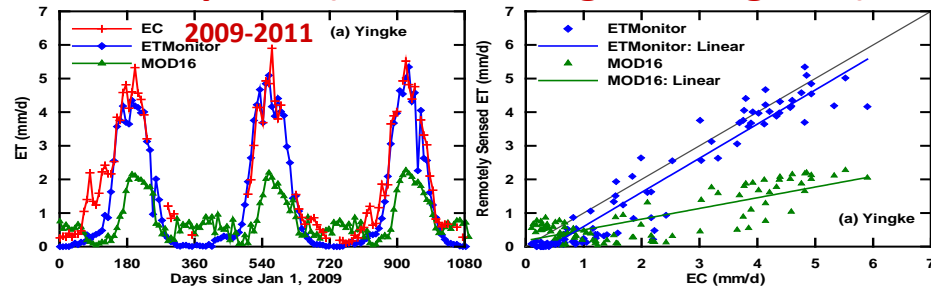
- 98 from Fluxnet2015
- 6 from HiWATER
- 37 from AmeriFlux
- 8 from EuroFlux
- 4 from AsiaFlux



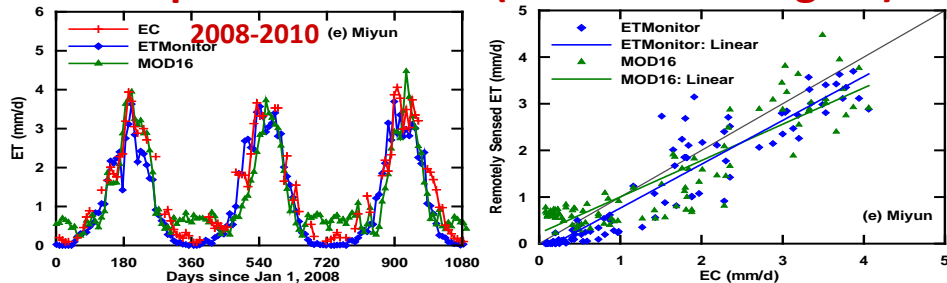
Haihe Cropland (semi-humid region)



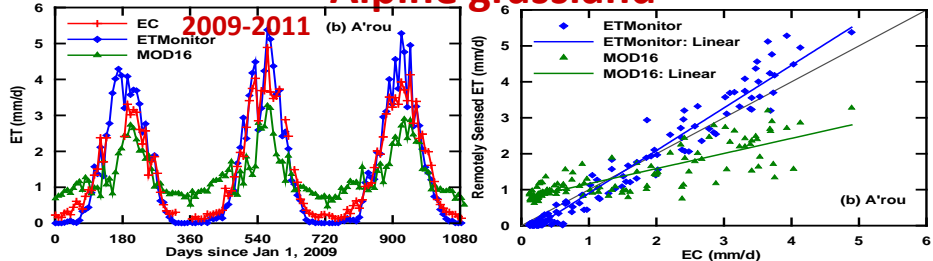
Cropland (semi-arid region, irrigated)



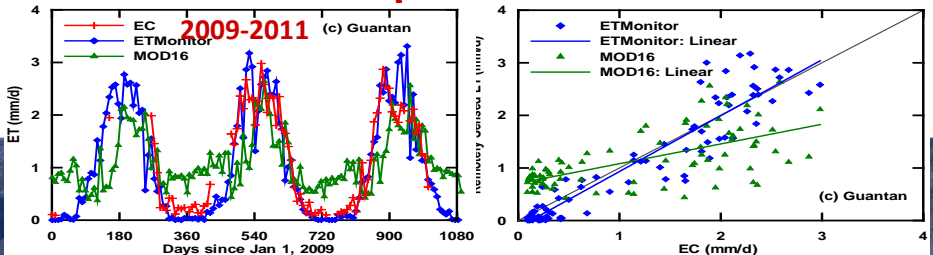
Cropland + orchard (semi-humid region)



Alpine grassland



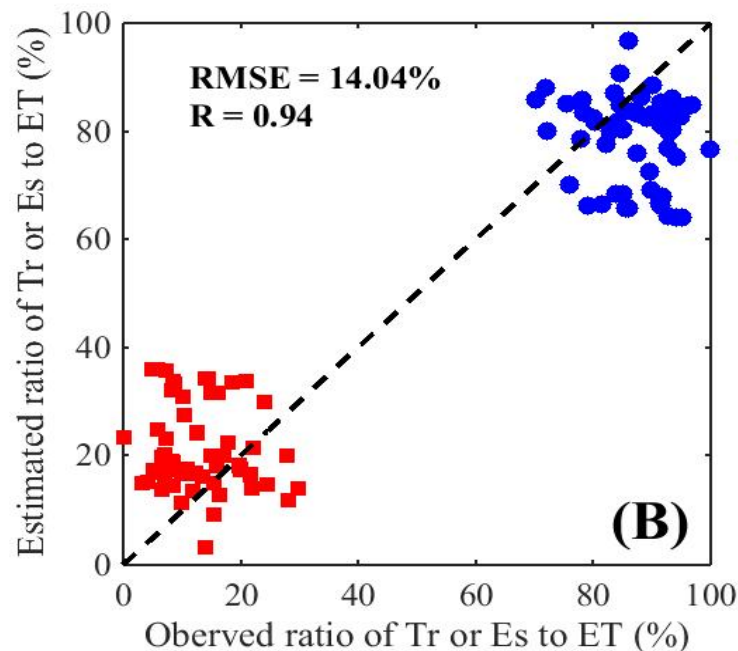
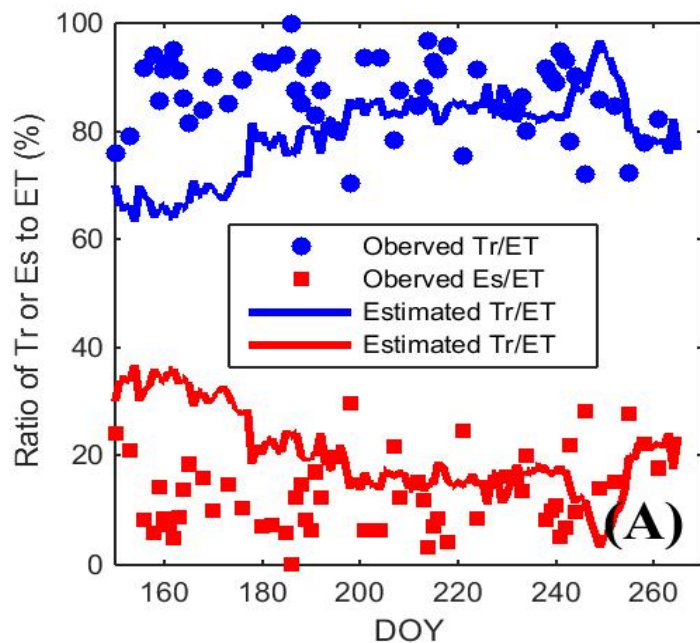
Alpine forest



→ ETMonitor performs better than MOD16

- ET partitioning validation

Comparison of Tr and Es with isotope observation in Heihe river basin, 2012



- Comparison with other ET products

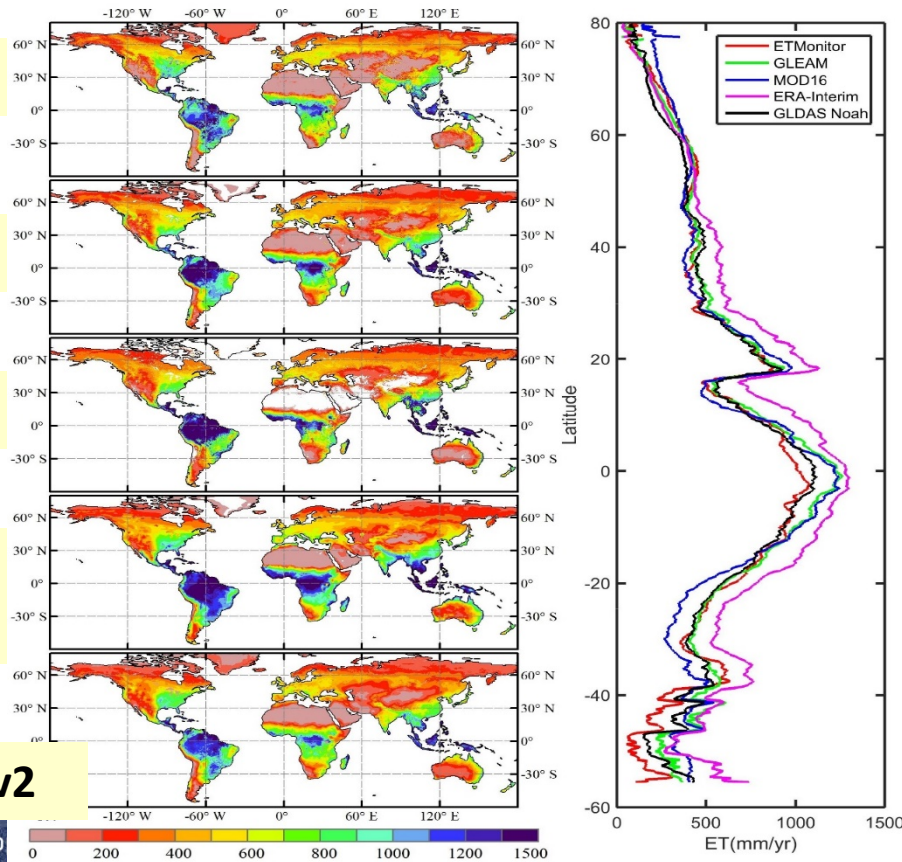
ETMonitor

GLEAM v3a

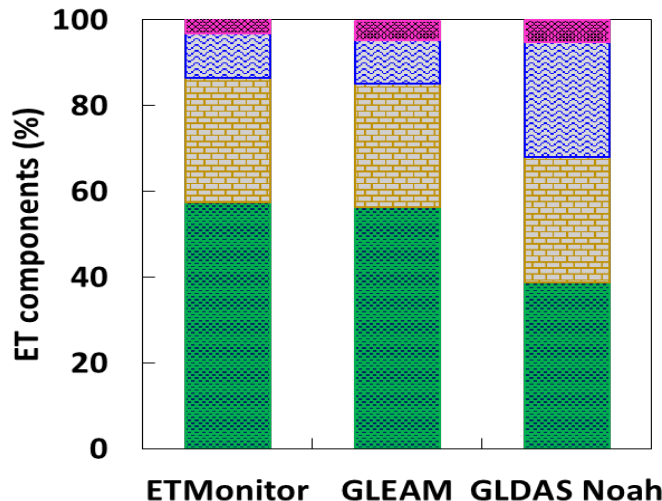
MOD16

ERA-Interim
reanalysis

GLDAS Noah v2



$$ET = Tr + Es + Ei + Ew$$



Tr: transpiration

Es: soil evaporation

Ei: rainfall interception loss

Ew: water evaporation + snow
sublimation

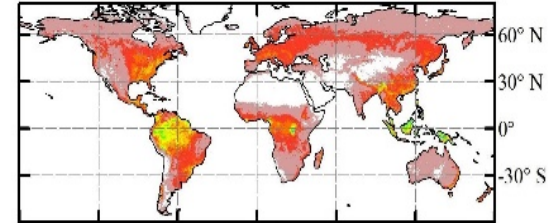
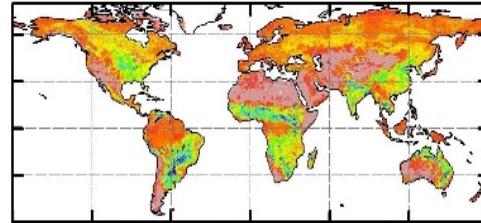
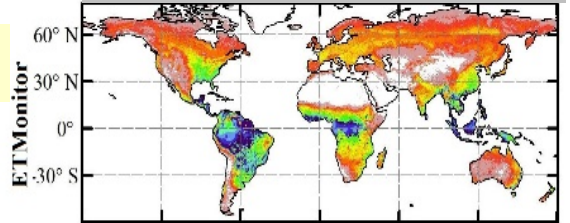
- Comparison with other ET products

plant transpiration

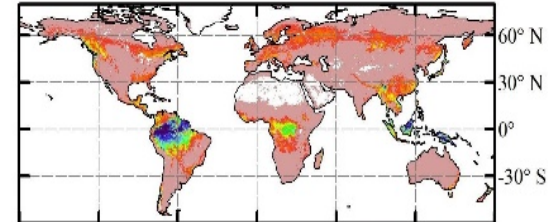
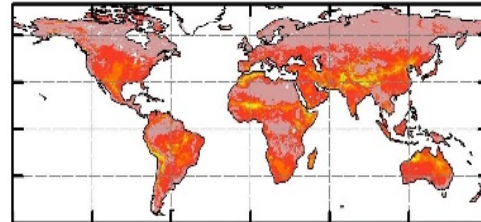
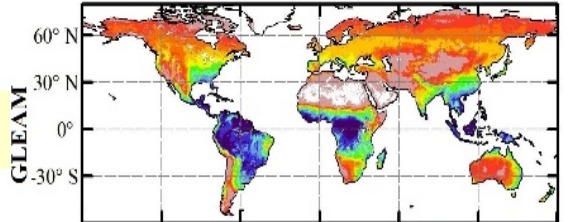
Soil evaporation

Interception loss

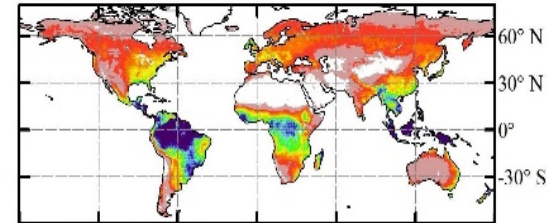
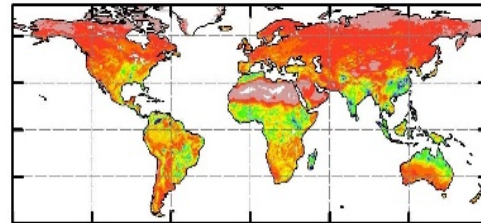
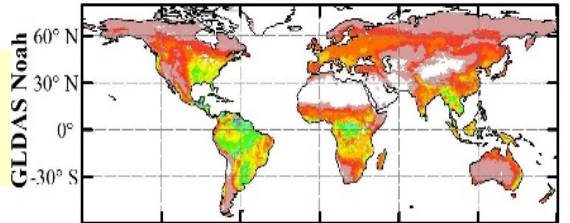
ETMonitor



GLEAM



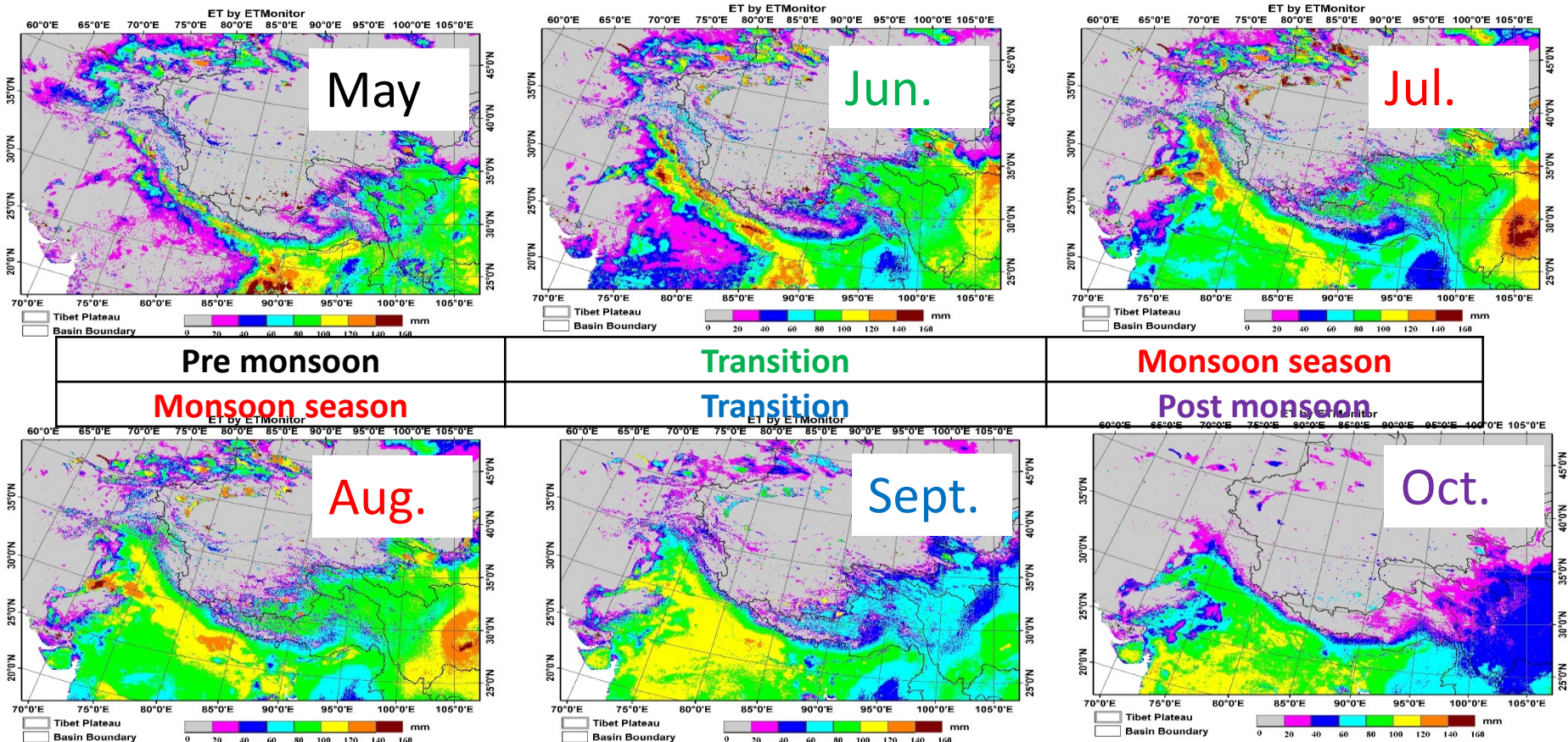
GLDAS
Noah v2



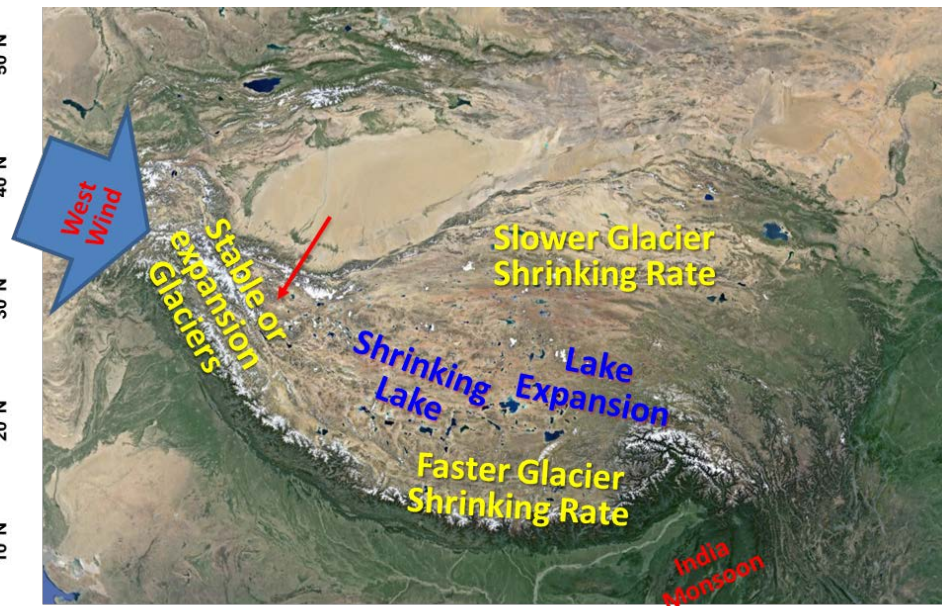
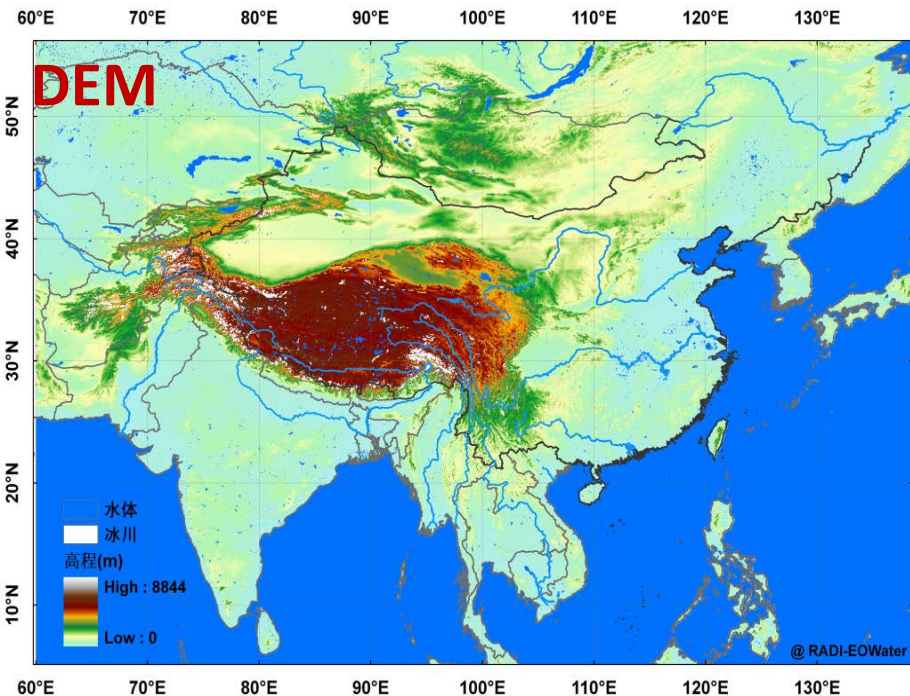
2017 DRAGO

26-30 June 2017 | C

- Seasonality of ET in high Asia



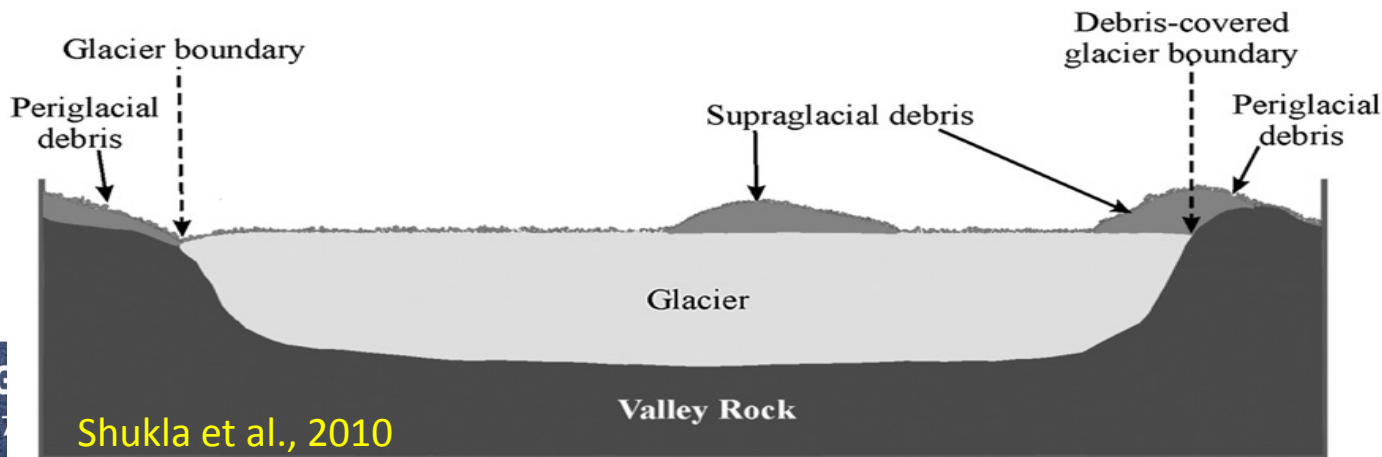
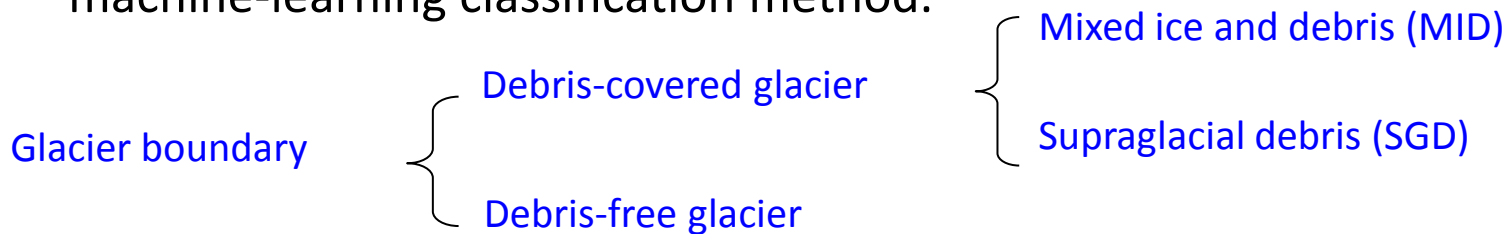
- Evapotranspiration
- **Glacier Area and Thickness**
- Soil Freeze/Thaw Status



Name	Coverage	Temp. range	Data source	Note	organization
First Chinese Glacier Inventory (FCGI)	Western China	1956-1984	Aerial topographic maps and aerial photographs.	long data span; with debris area but no boundary info	CAREERI, CAS,
The Second Chinese Glacier Inventory (SCGI)	Western China	2004-2011	Remote sensing images after 2004 including Landsat TM/ETM+ and ASTER images, and DEMs from SRTM.	Not complete in Lancang River, Nu River, and the eastern part of Yarlung Zangbo River due to clouds and snow coverage; with debris area but no boundary info.	CAREERI, CAS,
World Glacier Inventory (WGI)	Global	1900-2003	aerial photograph and topographic maps	location, total area, type of debris; no glacier boundary info.	NSIDC
Global Land Ice Measur. from Space (GLIMS)	Global	After 1950	ASTER + aerial photograph and SPOT data	Long time span; GLIMS in China is from FCGI	NSIDC
MODIS Persistent Ice (MODICE) data	Global	After 2000	MODIS data with 500m spatial resolution	total glacier area, not distinguish debris-covered area.	NASA, NSIDC
Hindu Kush Himalayan (HKH) glacier data	HK Himalayan	2005	Landsat satellite data and SRTM DEM data		ICIMOD)
Glacier Area Mapping for Discharge from the Asian Mountains (GAMDAM)	High-mountain Asia	1999-2003	Landsat images		Nagoya University

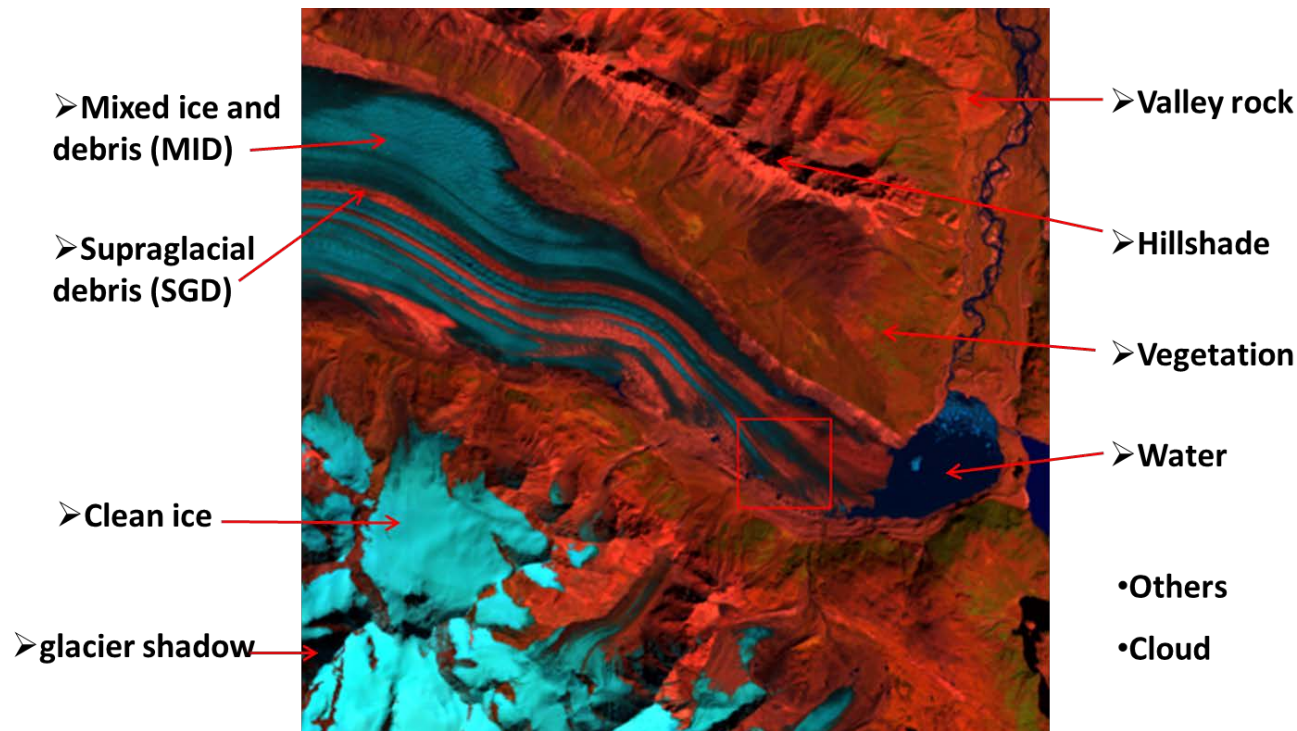
Objective:

- to produce multiple years datasets;
- to distinguish debris-free glacier area and debris-covered glacier area using machine-learning classification method.



Progress:

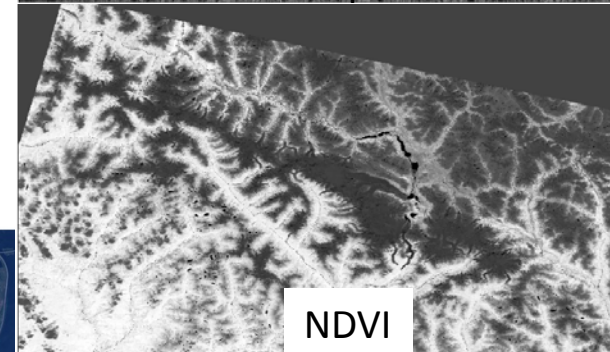
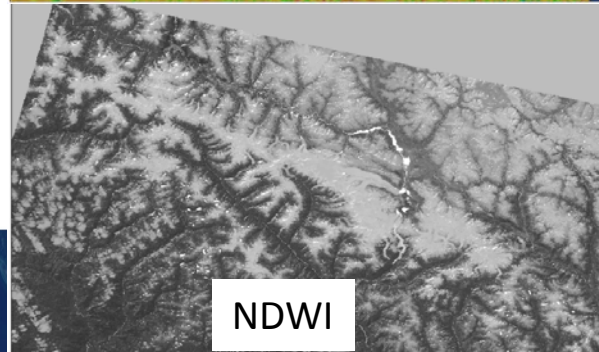
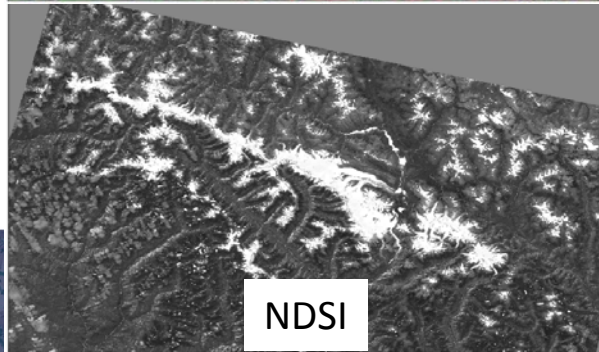
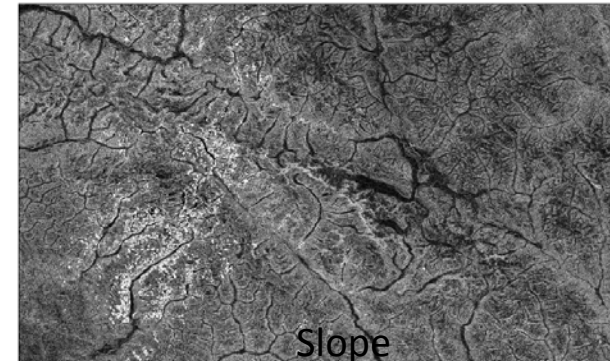
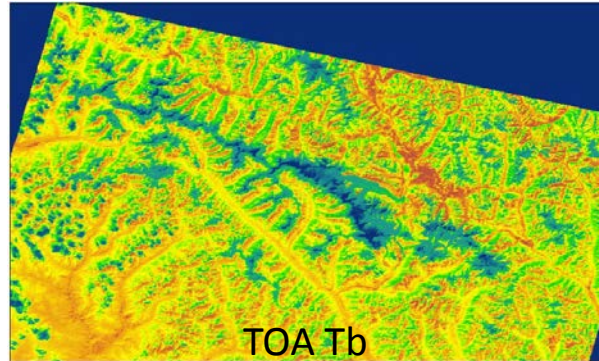
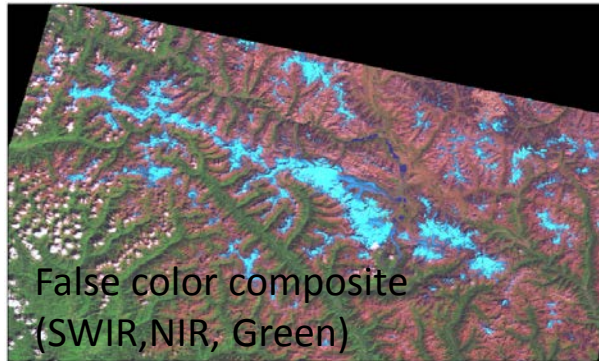
machine-learning
algorithm (random
forest) for
automatic glacier
mapping



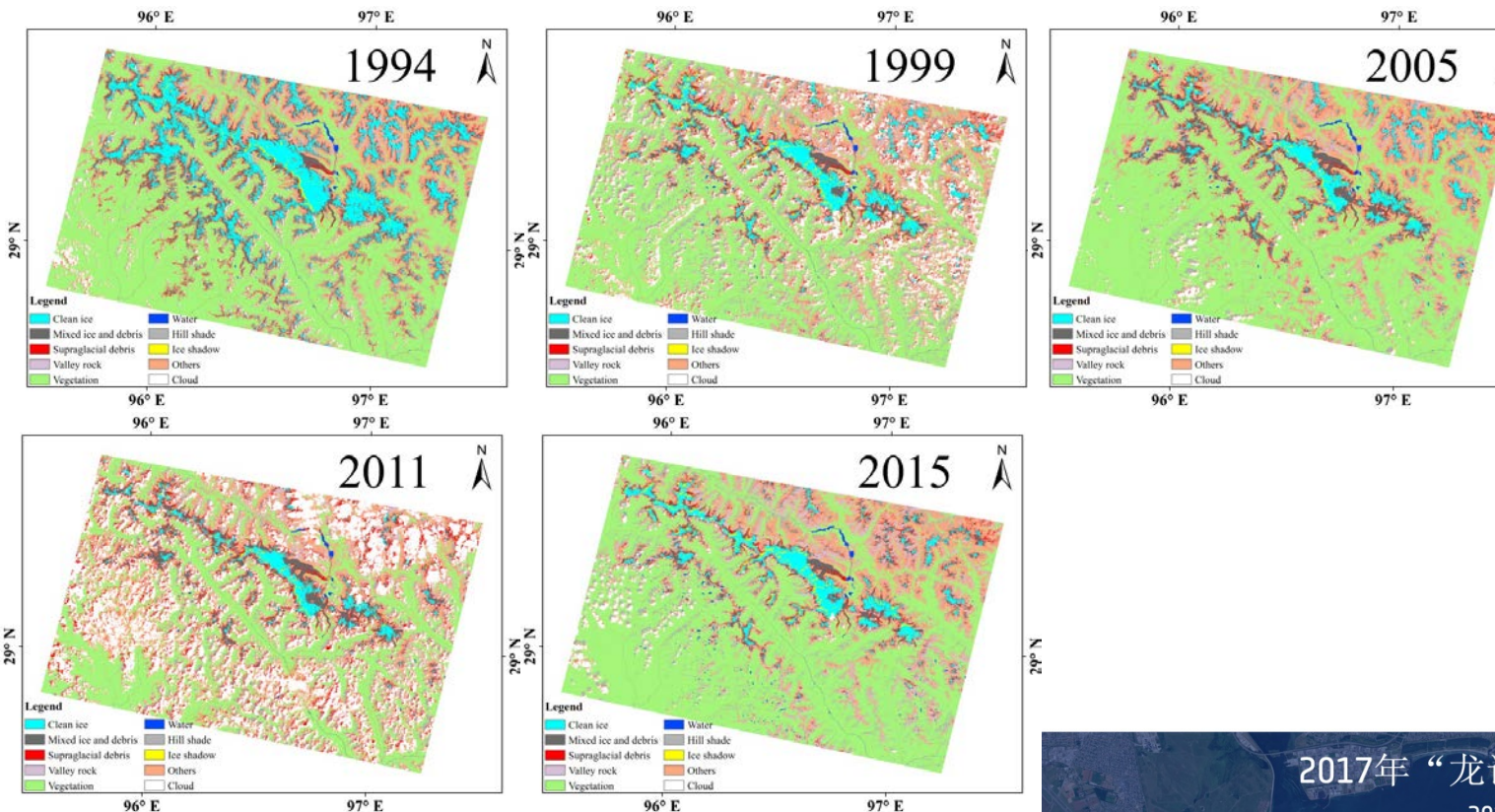
Glaciers and Lakes in HMA Region

Data: Landsat (TM, ETM+, OLI); GF-1 PMS, Sentinel 2; ASTER GDEM 30m (slope, aspect and elevation); Google Earth image

Choose images from ablation season (least snow cover and cloud free)



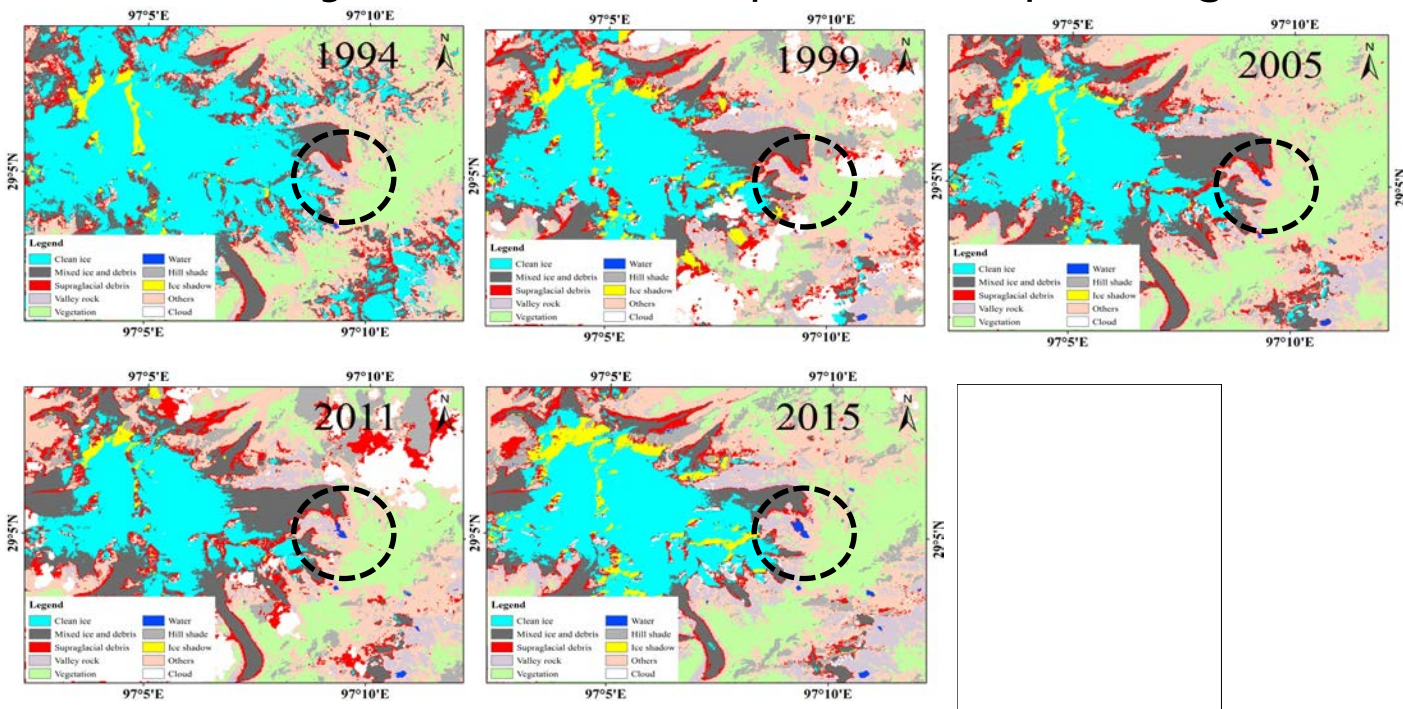
Preliminary results:



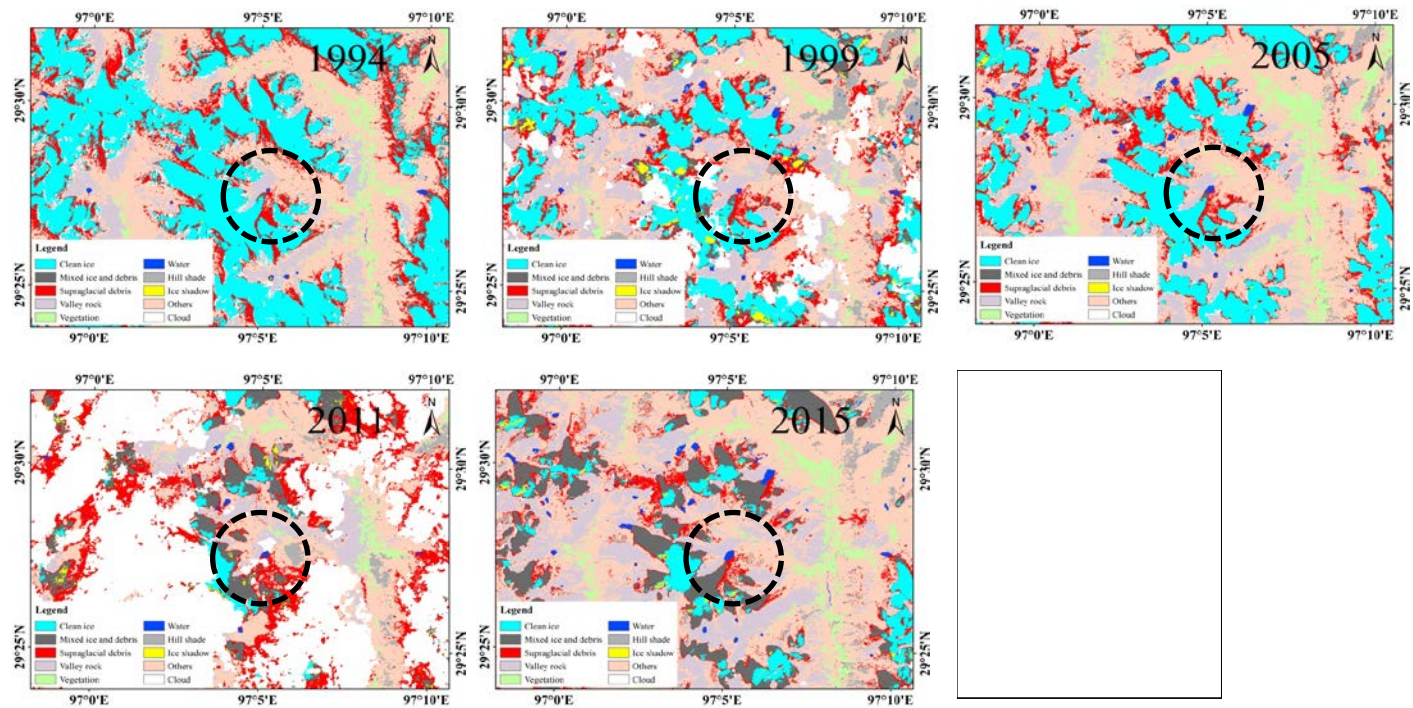
2017年“龙计划”四期学术研讨会

2017年6月26-30日, 丹麦 哥本哈根

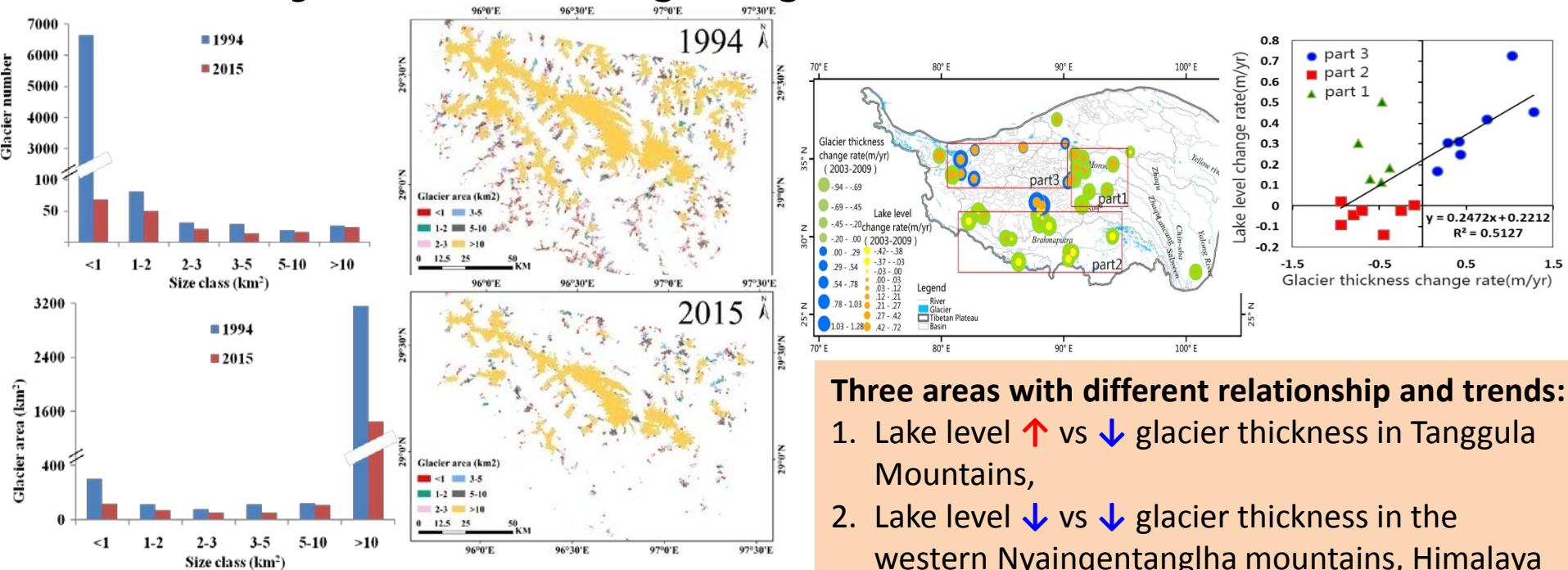
Preliminary results: Example 1- a expanding lake at glacier tongues



Preliminary results: Example 1- a expanding lake at glacier tongues



Preliminary results: Change of glacier number and area



Three areas with different relationship and trends:

1. Lake level ↑ vs ↓ glacier thickness in Tanggula Mountains,
2. Lake level ↓ vs ↓ glacier thickness in the western Nyainqentanglha mountains, Himalaya mountains, and Gangdise mountains,
3. Lake level ↑ vs ↑ glacier thickness around Kunlun Mountains.

- Both area and number of glaciers are decreased;
- More significant decrease in number of small sized glaciers

- Evapotranspiration
- Glacier Area and Thickness
- **Soil Freeze/Thaw Status**

Linear regression method for F/T by fusion of microwave and thermal infrared data

F/T boundary

$$D_F - D_T = -0.08 \cdot Tb_{36.5V} + 5.36 \cdot \frac{Q_e Tb_{18.7H}}{Tb_{36.5V}} + 15.64 = 0$$

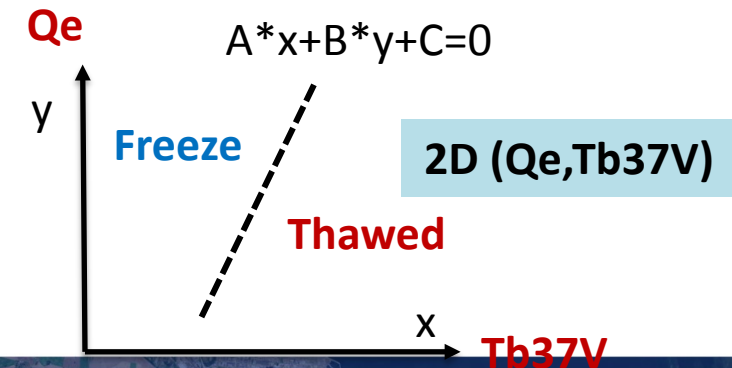
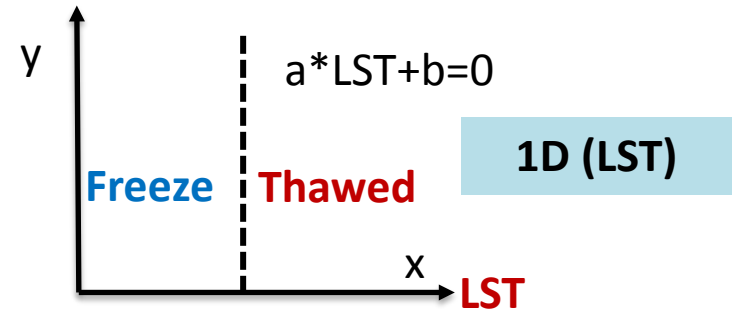
Binary results to quantitative values

$$FTI = D_F - D_T$$

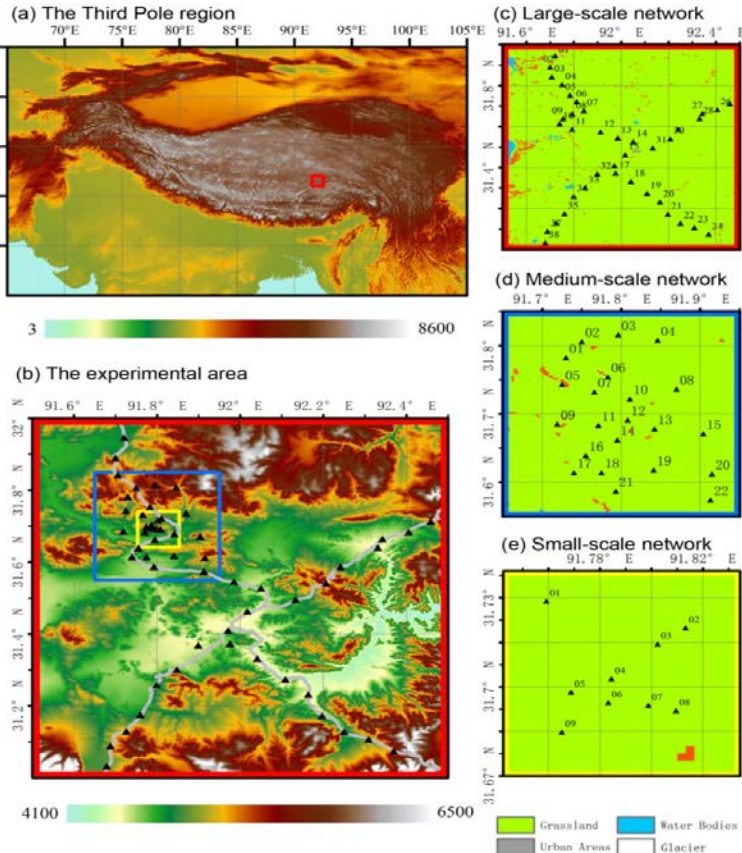
Linear relationship with LST

$$FTI = A \cdot LST + B$$

Data: MSRE, MODIS; FY3



In-situ measurements: Multi-scale monitoring network in Naqu of TP



Totally 56 stations at three different spatial scales, and 30 sites recorded data from August 1, 2010

Alpine grasslands: area of about 10,000 km² (31-32N, 91.5-92.5E)

Soil moisture and temperature (5TM) @ 5, 10, 20, 40 cm

- Soil surface starts its diurnal freeze-thaw cycle from October and becomes fully frozen during December to February.

- **MODIS LST data products**

Spatial resolution: 0.05deg

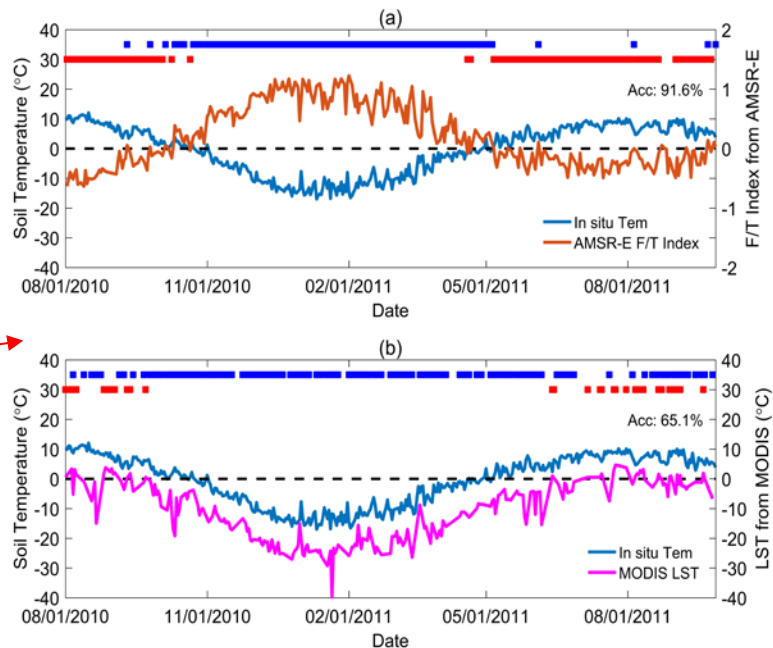
- **AMSR-E Tb data products**

Spatial resolution: 0.25deg

Preliminary results: Validation

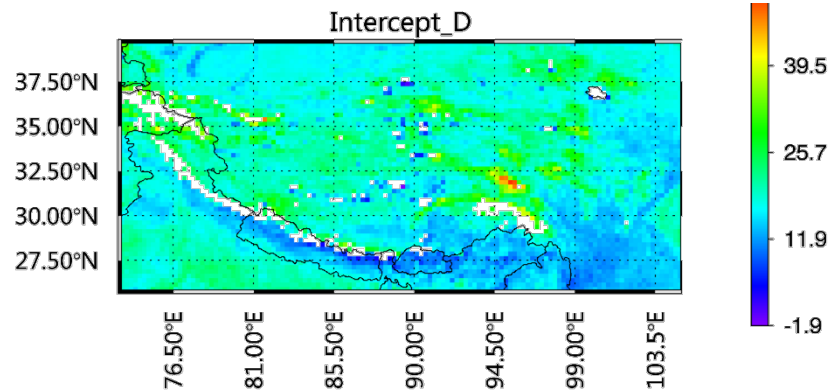
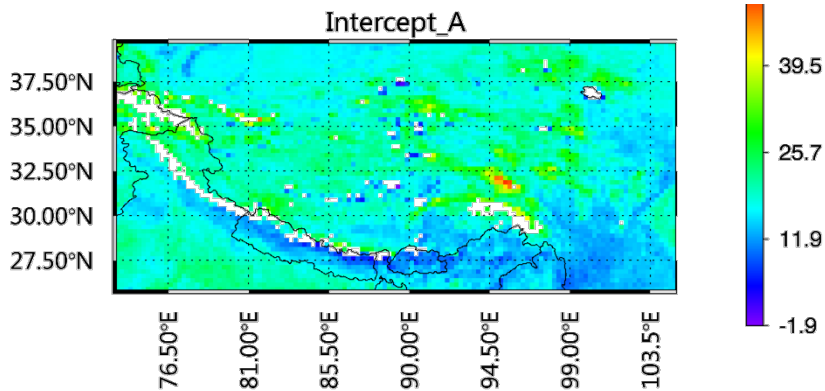
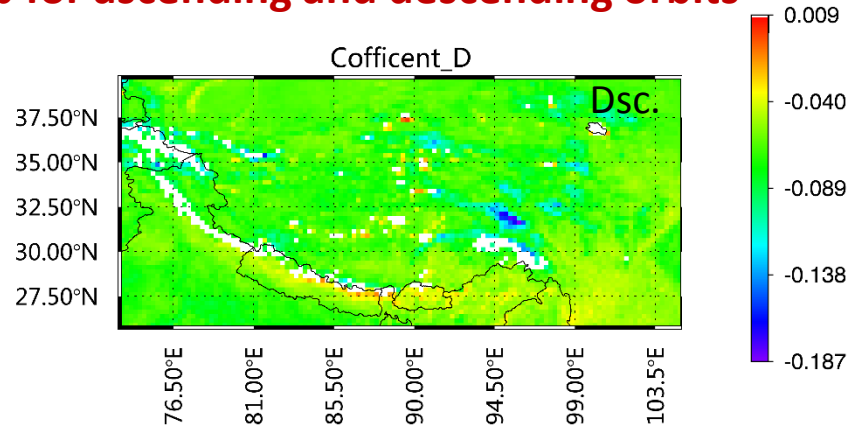
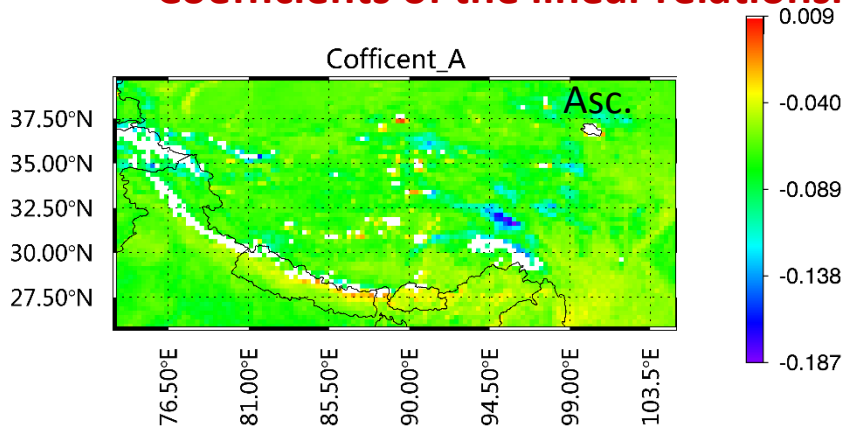
Column	Row	Number of Sites	microwave			thermal		
			Correct	Incorrect	Accuracy	Correct	Incorrect	Accuracy
1086	235	3	202	84	70.6%	133	107	55.4%
1087	235	1	222	56	79.9%	129	102	55.8%
1088	235	1	246	50	83.1%	131	109	54.6%
1089	235	2	206	59	77.7%	126	112	52.9%
1087	234	3	241	40	85.8%	140	89	61.1%
1088	234	3	258	35	88.1%	138	83	62.4%
1086	233	1	214	72	74.8%	151	85	64.0%
1087	233	7	241	22	91.6%	149	80	65.1%
1088	233	2	237	19	92.6%	140	81	63.3%
1089	233	3	239	33	87.9%	124	99	55.6%
1086	232	3	229	61	79.0%	165	71	69.9%
1087	232	1	241	32	88.3%	144	96	60.0%
Overall			2776	563	83.1%	1670	1114	60.0%

Comparison of results from microwave and thermal sensor



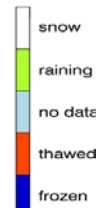
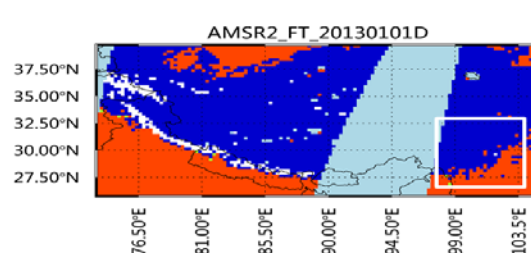
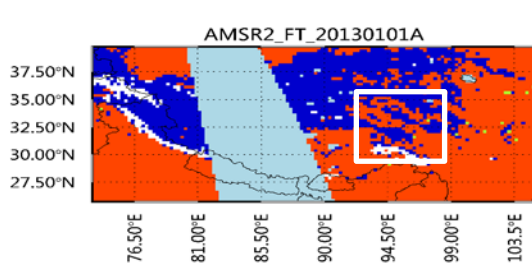
Preliminary results:

Coefficients of the linear relationship for ascending and descending orbits

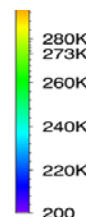
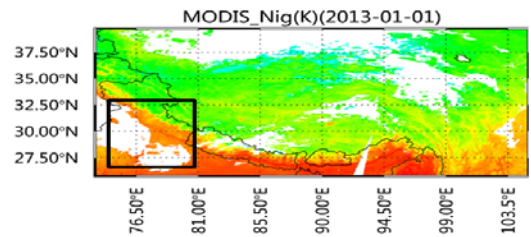
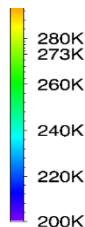
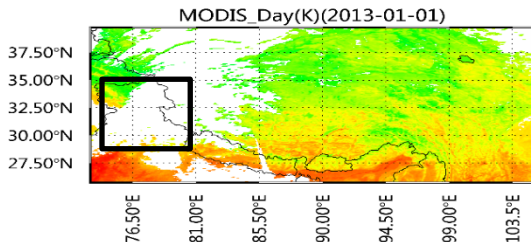


Preliminary results: F/T detection by fusing microwave and thermal data

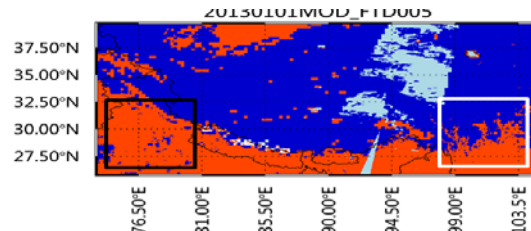
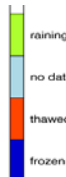
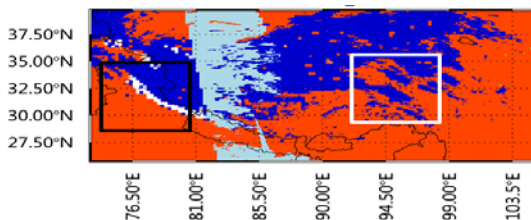
microwave



**Thermal
infrared**

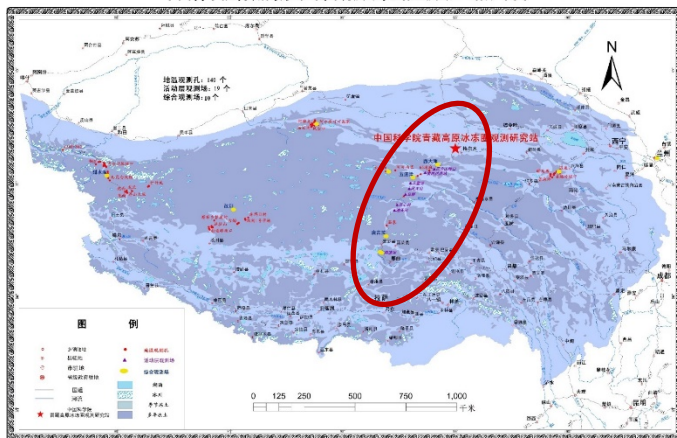


Integrated



Preliminary results: Validation

中国科学院青藏高原冰冻圈观测研究站监测场、站分布图



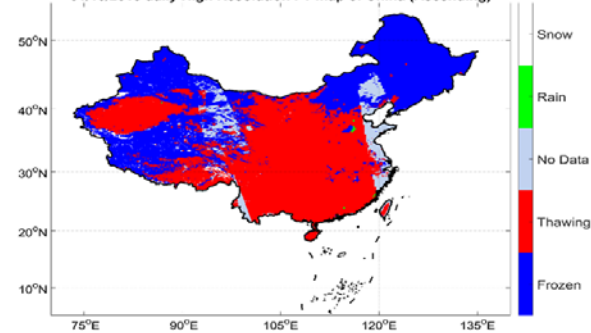
**Active layer
monitoring sites along
the Qinghai-Tibet
Highway/Railway
(since 1998)**

Microwave

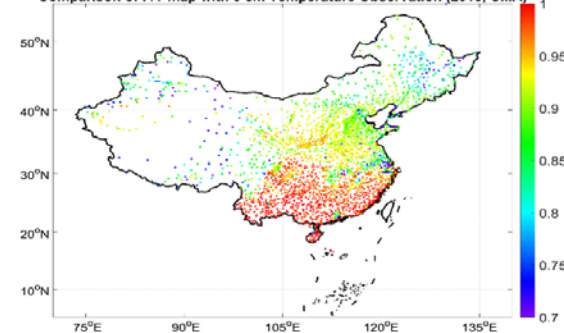
Microwave + thermal

Assessment of the estimate at CMA meteorological stations

01/10/2013 daily High Resolution FT map of China (Ascending)



Comparison of F/T map with 0 cm Temperature Observation (2013, CMA)



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Number	Number of Discrimination	Accuracy	Number of Discrimination	Accuracy
China03	2379	78.4%	3149	67.7%
China04&05	2249	82.6%	3039	71.4%
QT01	603	82.4%	782	74.7%
QT02&03	1358	82.8%	1755	75.1%
QT05	1967	75.2%	2687	61.4%
QT06	1720	73.0%	2364	61.5%

Deliverable	Description	Due date
De 1.1	Data base for algorithm development (FY-3, DPR raingauge and weather radar data)	KO + 6
De 1.2	Retrieval algorithm implemented and tested	KO +18
De 1.3	Merged FY-3 and GPM data product	KO +24
De 1.4	Validated precipitation data products	KO +30
De 2.1	Improved ETMonitor	KO+12
De 2.2	Preliminary set of ETMonitor data products	KO+24
De 2.3	Validated ETMonitor data products	KO+36
De 2.4	Time series of ETMonitor data products for selected river basins	KO+48
De 3.1	Expanded multi – source retrieval system	KO+12
De 3.2	Preliminary set of land surface variables	KO+24
De 3.3	Validated land surface variables	KO+36
De 3.4	Time series of land surface data products for selected river basins	KO+48
De 4.1	New / improved algorithms implemented	KO+12
De 4.2	Preliminary set of snow and ice data products	KO+24
De 4.3	Validated of snow and ice data products	KO+36
De 4.4	Time series of snow and ice data products for selected high elevation catchments and river basins	KO+48
De 5.1	Improved open water delineation algorithm implemented	KO+12
De 5.2	Time series of extent of selected inland water bodies	KO+36

Thank you for your attention !

Li Jia

Team Earth Observation for Water Cycle (EOWater)

State Key Laboratory of Remote Sensing Science

Institute of Remote Sensing and Digital Earth (RADI),

Chinese Academy of Sciences (CAS)

jjiali@radi.ac.cn

<http://eo-water.radi.ac.cn/en>