6th Asia-Oceania Group on Earth Observations (AOGEO) Workshop

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Development of A Global 30 m Land Surface Parameter Product Suite (Hi-GLASS) for Resource and Environment Monitoring

Tao He, Shunlin Liang, and Hi-GLASS Science Team

Wuhan University, China

Science Team Members from the following universities and institutes

AO GEO Earth Observations for Asia-Oceania

Content

Content

NASA EOS Missions

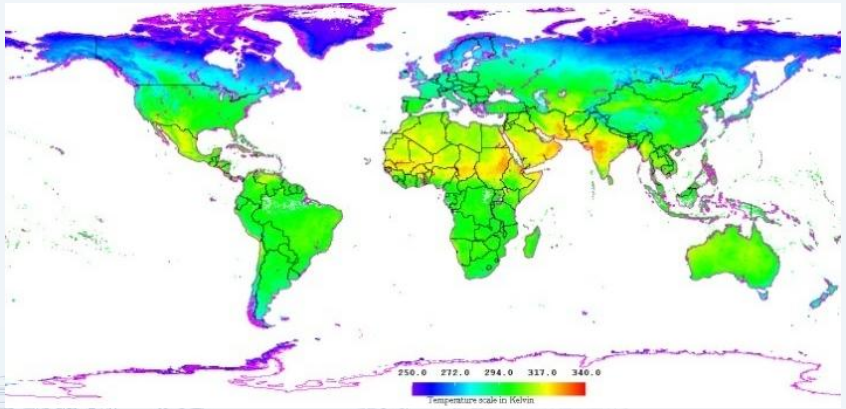
ESA Copernicus Missions

Satellites provided key information for monitoring global climate, resources, and environment during the past decades.

Accurate high-level remote sensing products are urgently needed to address issues in achieving SDGs.

From satellite observations to quantitative information

Retrieval methods: Visual inspection -> Statistical analysis -> Physical model-based retrieval



Radiometric calibration

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Preprocessing — Geometric correction; Cloud screening; Atmospheric correction

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Retrieval algorithms

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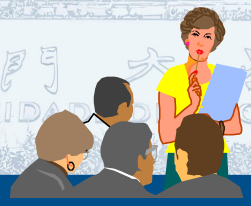
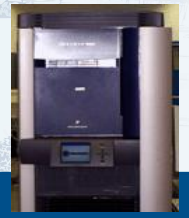
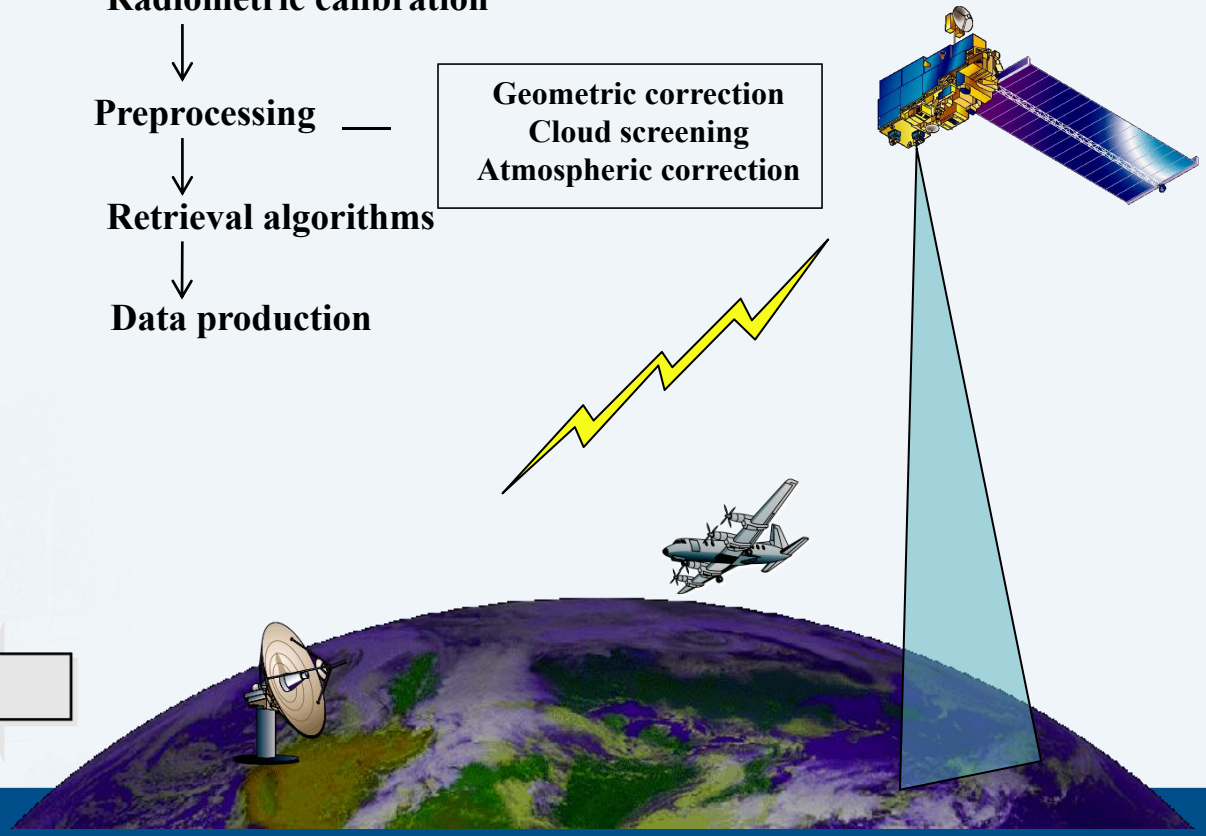
Data production

Property Retrieval







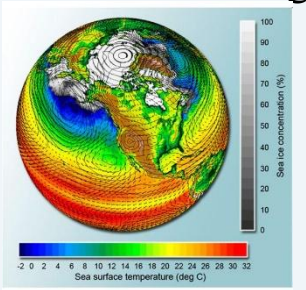
Global 1km long-term satellite products: GLASS products

No.	Product name	Temporal coverage	Spatial coverage	Temporal resolution	Spatial resolution	Accuracy
1	LAI	1981-2017	Global	8-day	Before 2000: 5km After 2000: 1km	MAB <0.5
2	FAPAR	1981-2017	Global	8-day	Before 2000: 5km After 2000: 1km	MAB <0.1
3	Albedo	1981-2016	Global	8-day	Before 2000: 5km After 2000: 1km	MAB ≤0.03
4	Emissivity	1981-2017	Global	8-day	Before 2000: 5km After 2000: 1km	0.02
5	LST	4 epochs	Global	Instantaneous	Before 2000: 5km After 2000: 1km	1 K
6	Longwave Net Radiation	4 epochs	Global	8-day	Before 2000: 5km After 2000: 1km	20W/m^2
7	Downward Shortwave Radiation	2000-2010	Global	Daily	5km	30W/m^2
8	PAR	2000-2010	Global	Daily	5km	20W/m^2
9	Net Radiation	2000-2010	Global	Daily	5km	30W/m^2
10	Fractional Vegetation Cover	1981-2017	Global	8-day	Before 2000: 5km After 2000: 1km	Relative error≤25%
11	GPP	1981-2016	Global	8-day	Before 2000: 5km After 2000: 1km	Relative error≤25%
12	ET	1981-2016	Global	8-day	Before 2000: 5km After 2000: 1km	20w/m^2

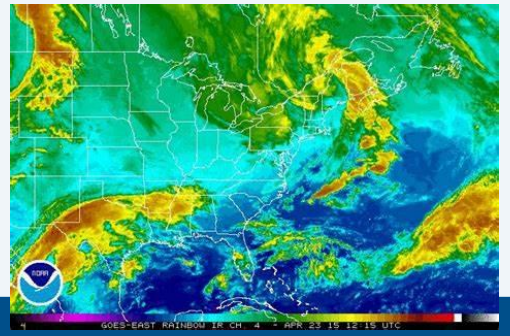
Product applications:

- Environmental change

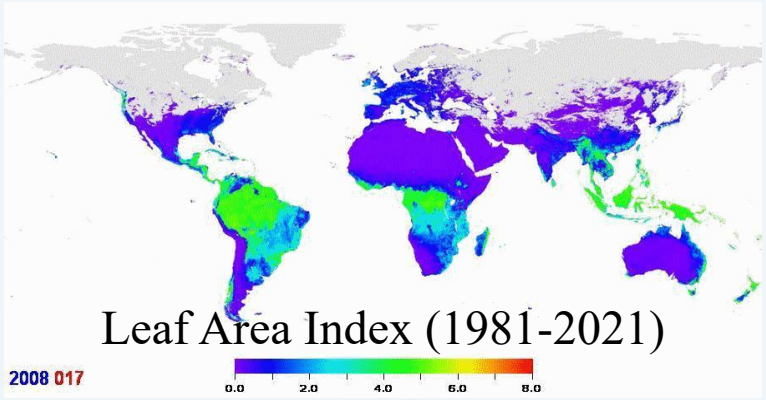
- Climate modeling

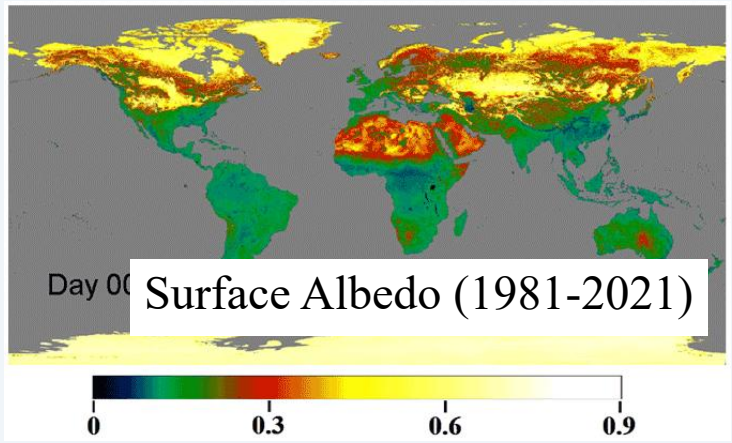


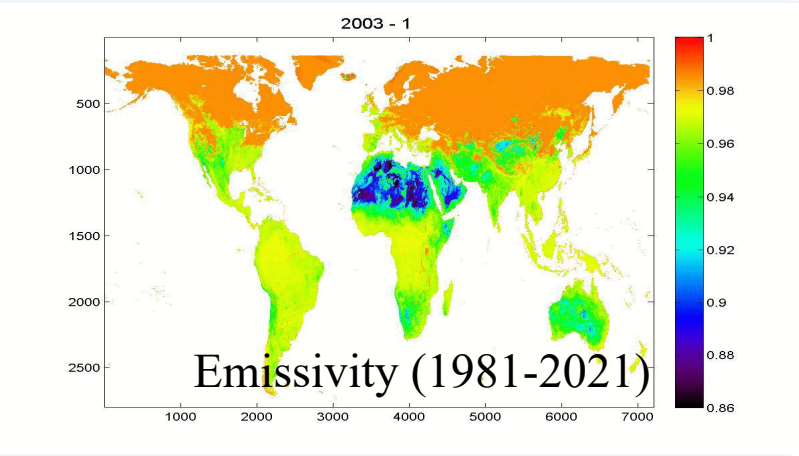
- Weather forecast

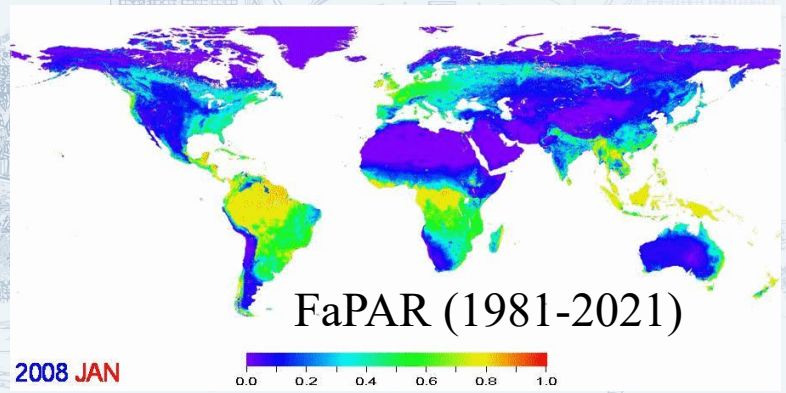


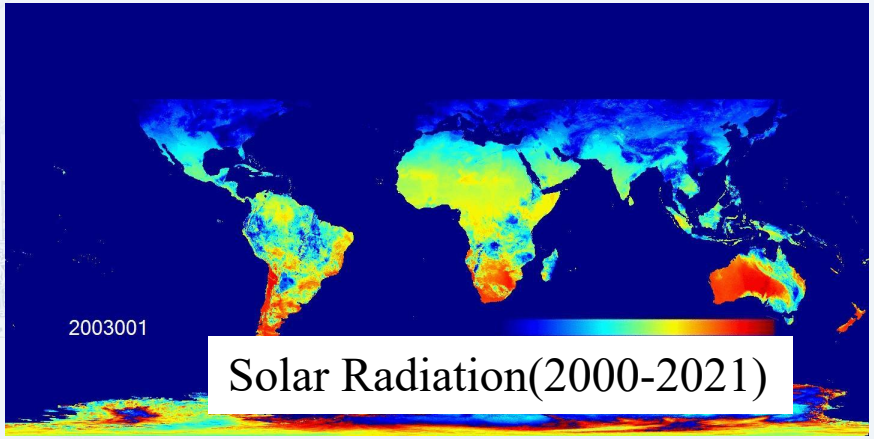
GLASS Product Samples

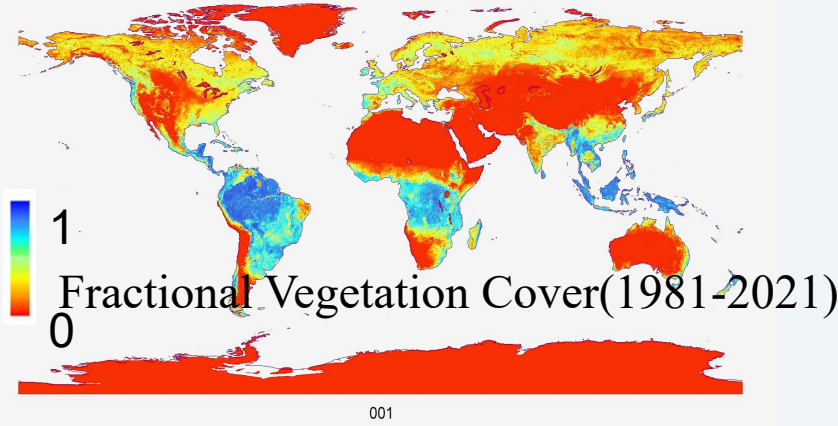






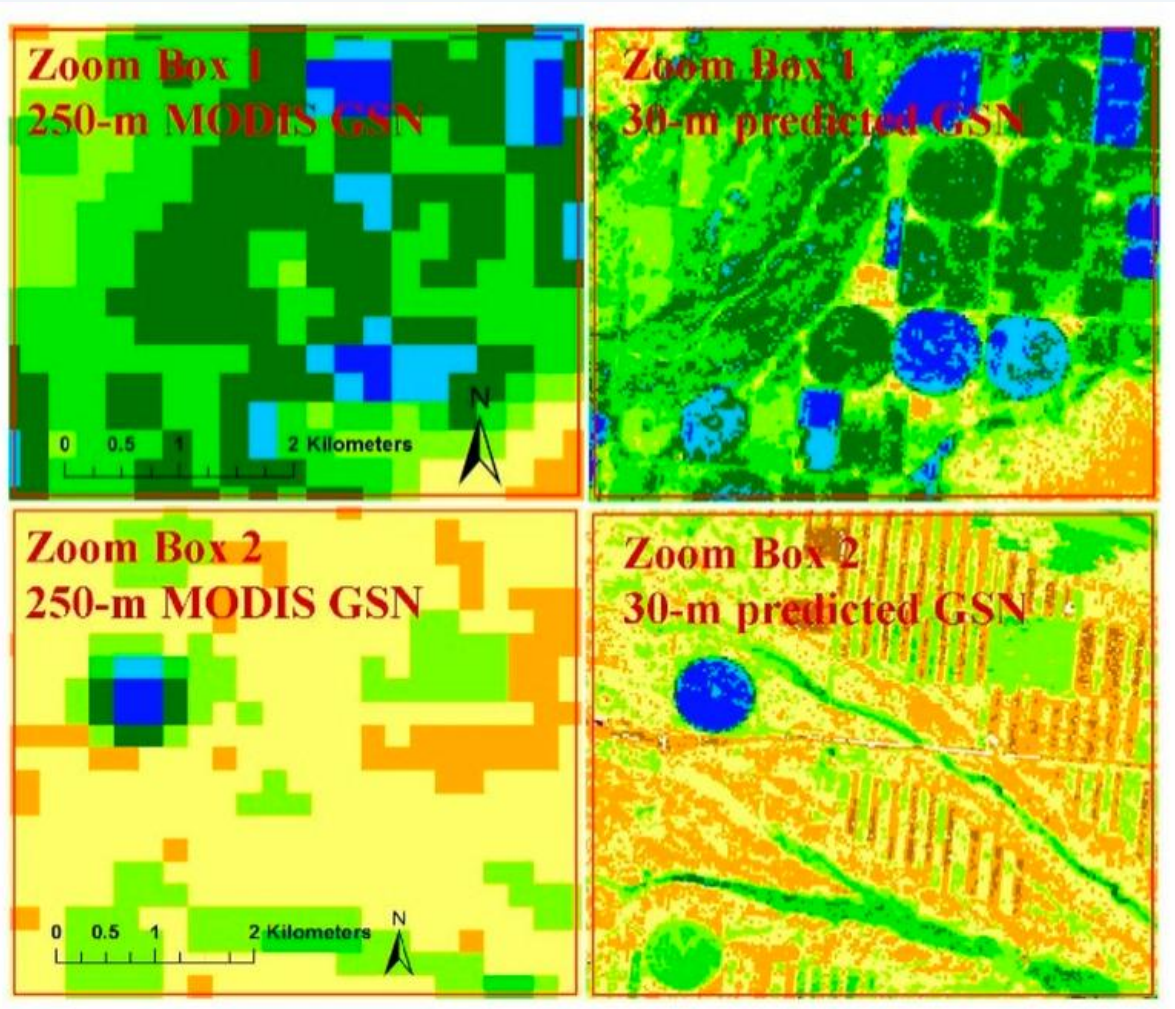






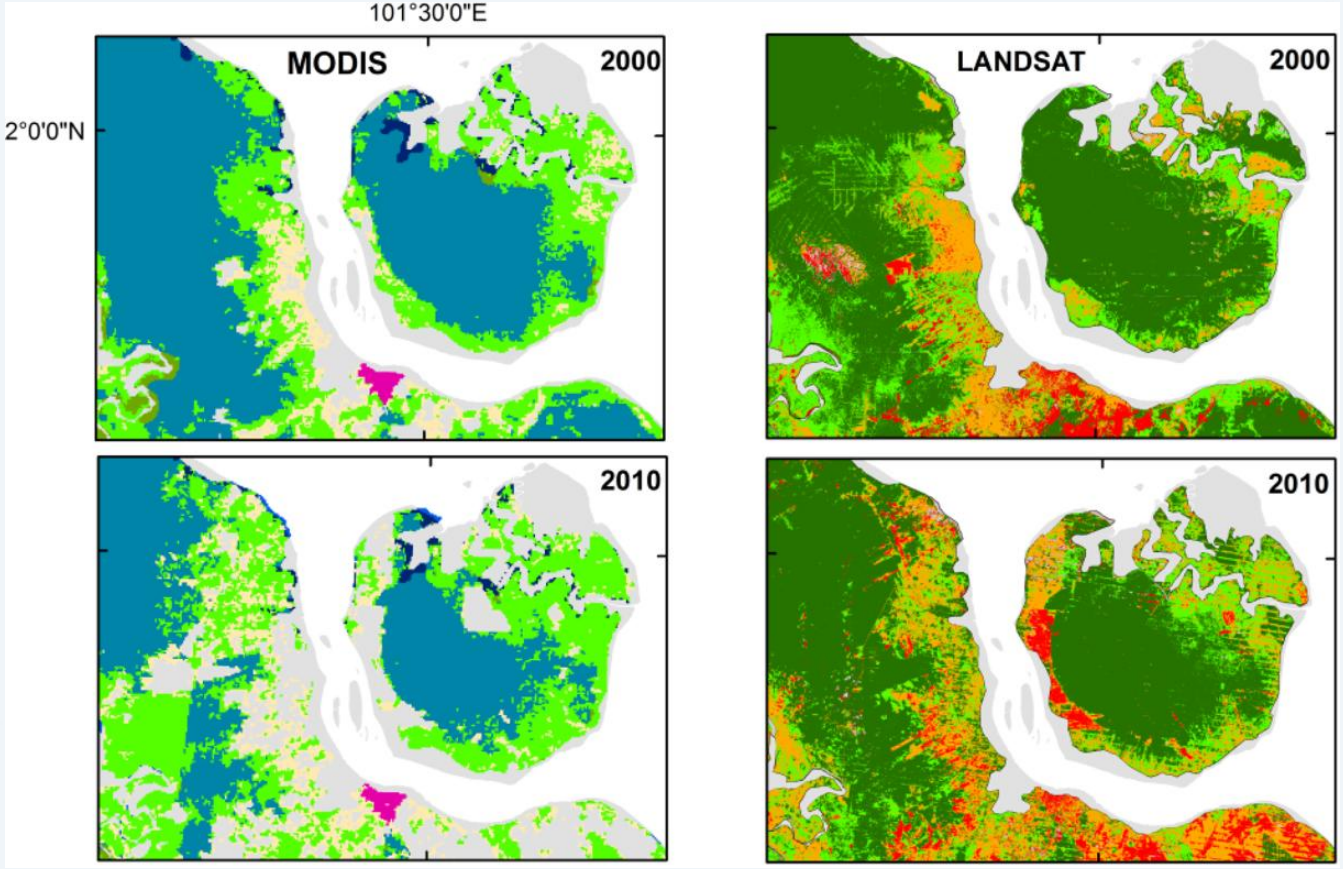
Coarse resolution products cannot satisfy the need for agriculture, resource, and environment applications; however, medium to fine resolution products are scarcely available.

Agriculture



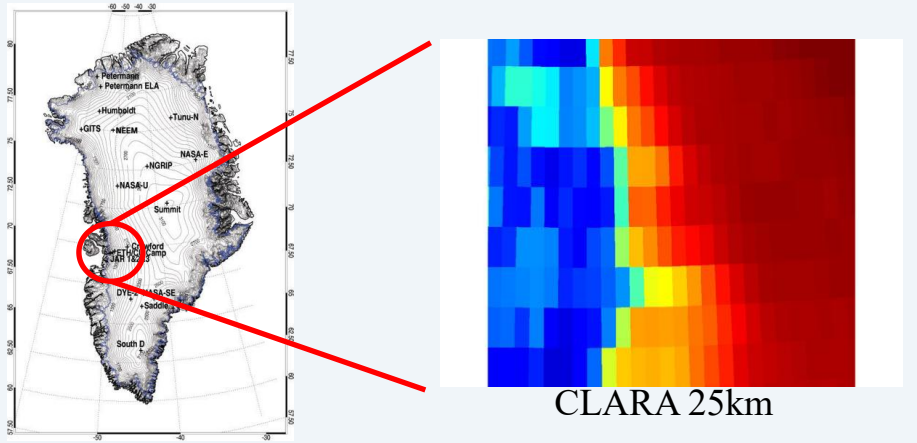
Urban Environment

Coarse resolution products cannot satisfy the need for agriculture, resource, and environment applications; however, medium to fine resolution products are scarcely available.



Coarse resolution products cannot satisfy the need for agriculture, resource, and environment applications; however, medium to fine resolution products are scarcely available.

Arctic Environment



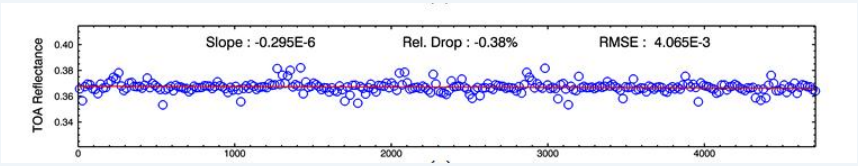
CLARA 25km

MODIS 1km

Landsat 30m

Fine-resolution observations from Landsat missions provide a reliable dataset

- Stable radiometric accuracy

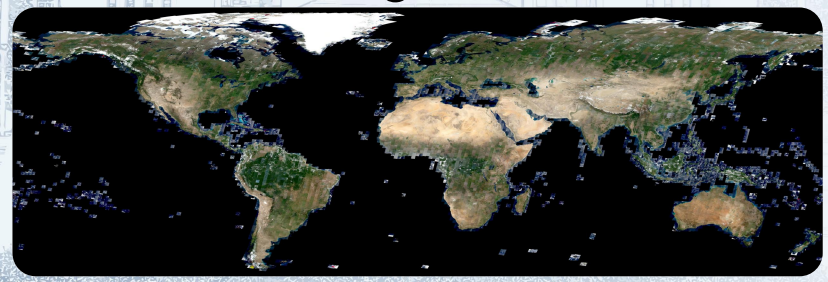


- High geolocation accuracy

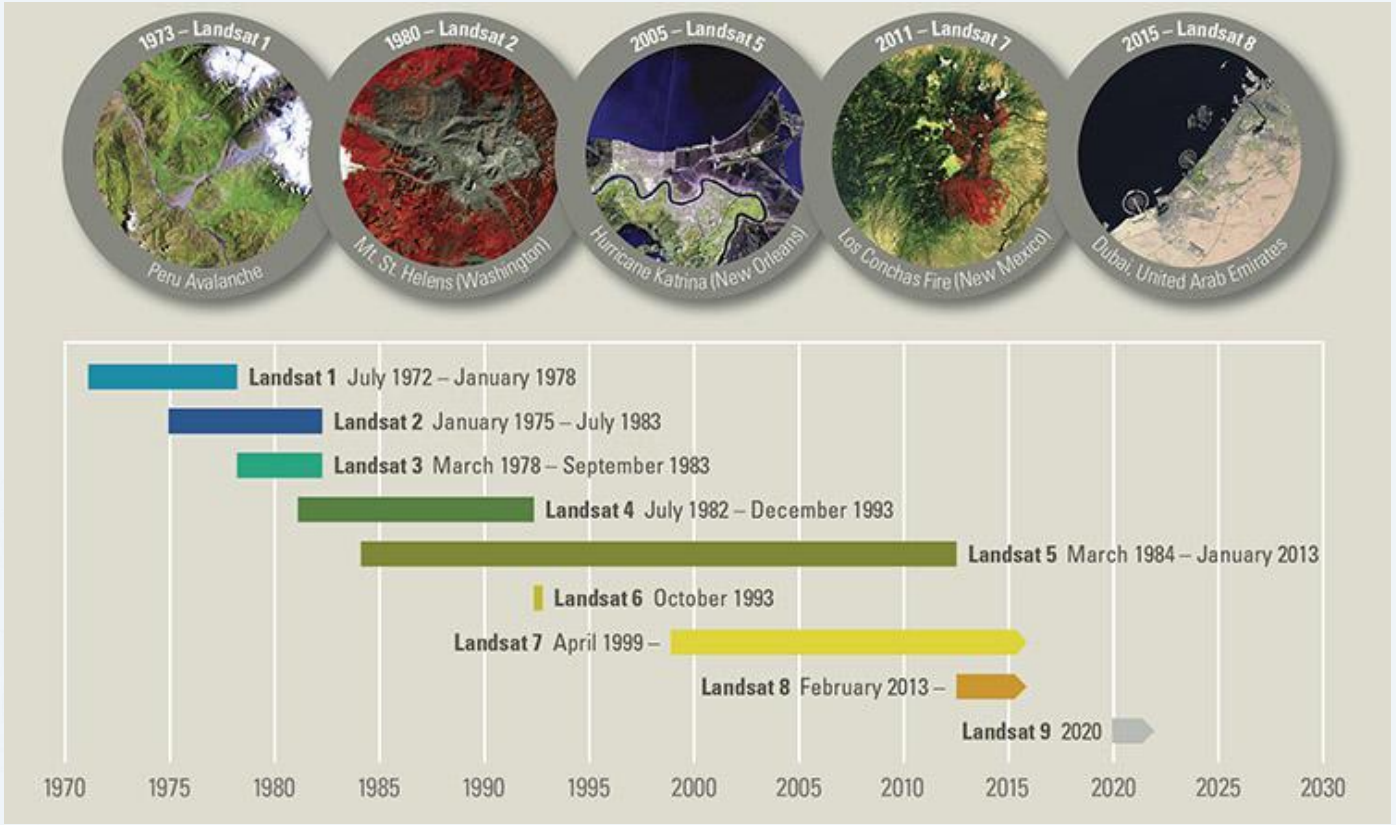
Table 1. Landsat 7 ETM+ and Landsat 8 OLI geometric performance requirements.

Requirement	ETM+ Specification	ETM+ Performance	OLI Specification
Absolute Geodetic Accuracy (CE90)	536.5 meters	45–190 meters (varied with gyro health)	65 meters
Geometric (Terrain Corrected) Accuracy (CE90)	N/A	15 meters	12 meters
Band Registration Accuracy (LE90)	8.4 meters	3.0 meters (reflective bands)	4.5 meters
Image Registration Accuracy (LE90)	12.0 meters	10.5 meters	12 meters

- Global coverage



- Long-term observations



Social-economic value of global medium resolution satellite products

Annual revenue of free Landsat data is estimated as 1.7B USD for the USA and ~0.4B for the rest world (2011 statistics); the numbers go up to 2.8B USD and 1.4B USD (2017 statistics)

Landsat Application	Estimated Annual Efficiency Savings
1. USDA Risk Management Agency	over $100 million
2. U.S. Government Mapping	over $100 million
3. Monitoring Consumptive Agricultural Water Use	$20 – $80 million
4. Monitoring Global Security	$70 million
5. Landsat Support for Fire Management	$28 – $30 million
6. Forest Fragmentation Detection	over $5 million
7. Forest Change Detection	over $5 million
8. World Agriculture Supply and Demand Estimates	over $3 – $5 million
9. Vineyard Management and Water Conservation	$3-5 million/year
10. Flood Mitigation Mapping	over $4.5 million
11. National Agricultural Commodities Mapping	$1.9 million/year
12. Waterfowl Habitat Mapping and Monitoring	$1.9 million/year
13. Coastal Change Analysis Program	$1.5 million
14. Forest Health Monitoring	$1.9 million/year
15. NGA Global Shoreline	over $90 million (one time)
16. Wildfire Risk Assessment	$25-50 million (one time)

Primary stakeholders

1.Food security

2.Land management

3.Environment monitoring

Content

Objectives: Global long-term fine-resolution multi-variable datasets (Hi-GLASS)

First stage: Global long-term datasets from Landsat observations

- Landsat data
- Temporal resolution: monthly
- ~ 10 variables

Second stage: High temporal frequency datasets

- Landsat & Sentinel-2 & MODIS data
- Temporal resolution: 5-10 days
- ~ 20 variables

Third stage: Spatio-temporally continuous datasets

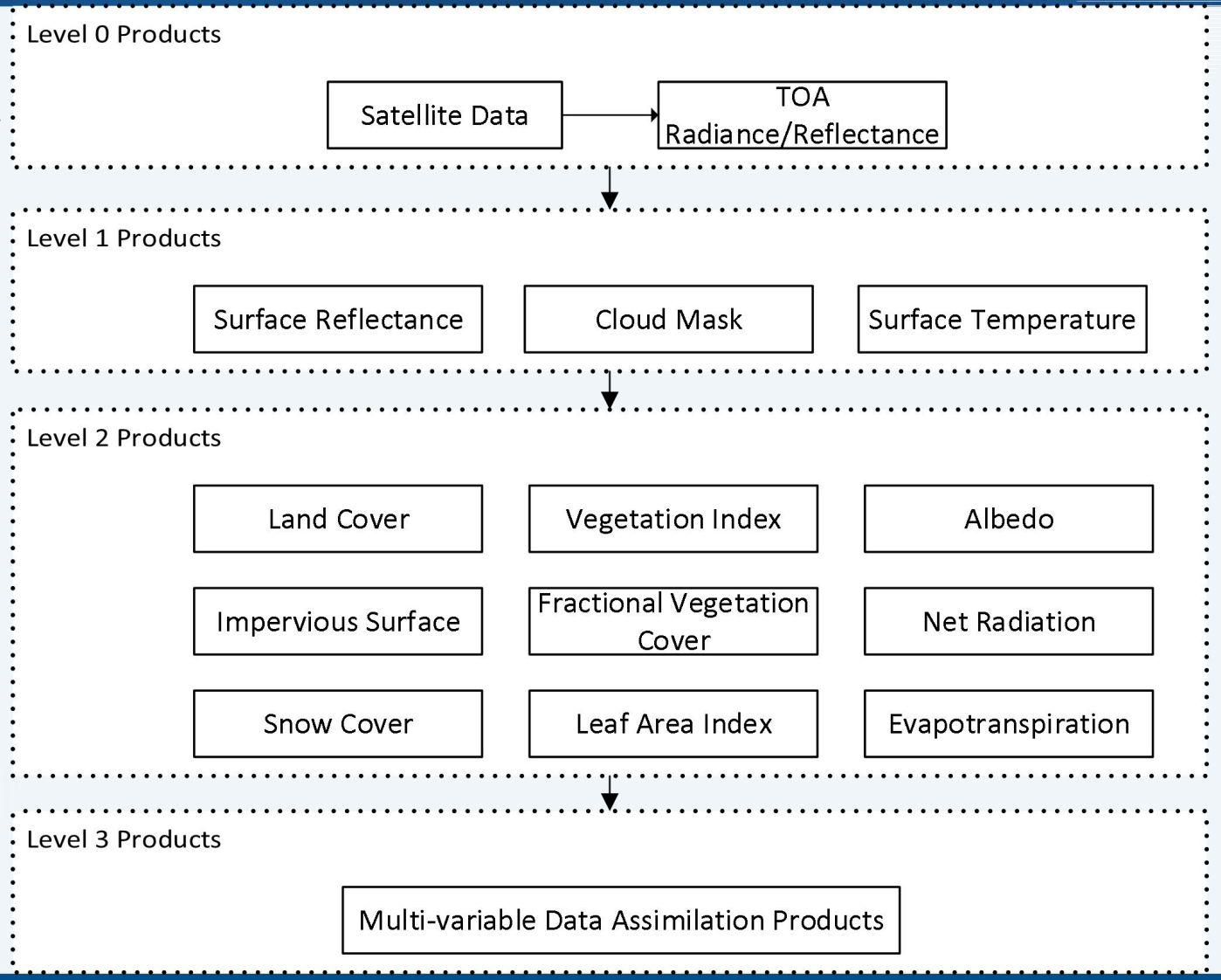
- Multi-sensor data and data assimilation methods
- Temporally continuous
- Consistency among different variables

Hi-GLASS Product Plan

Baseline products

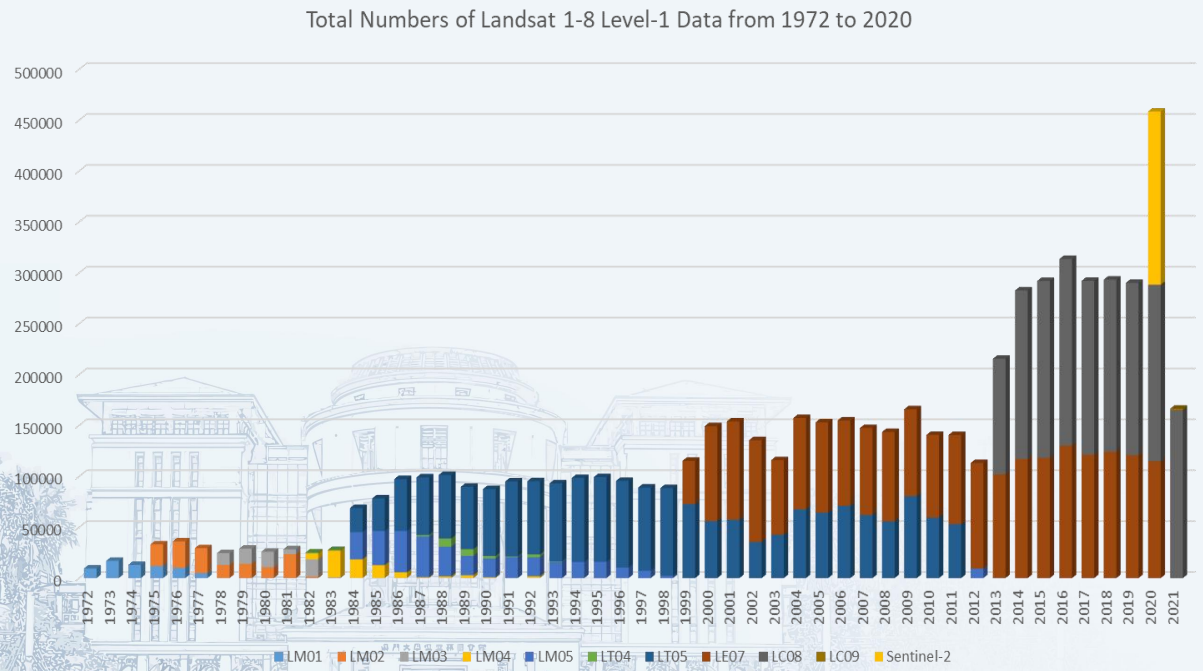
Instantaneous products:
1. Land cover
2. Vegetation properties
3. Energy budget components
4. Water cycle components

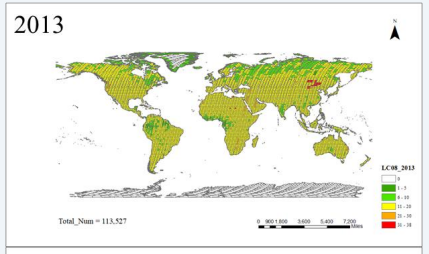
Spatio-temporally continuous products

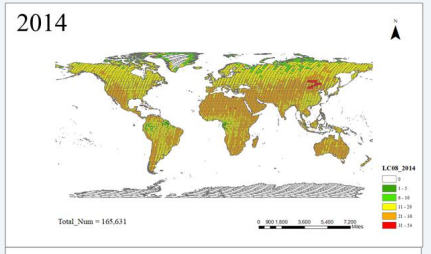


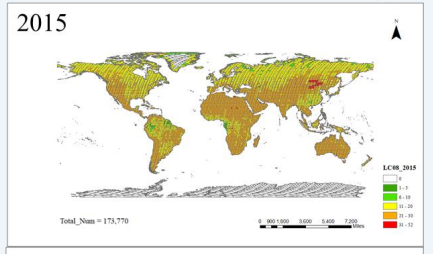
Content

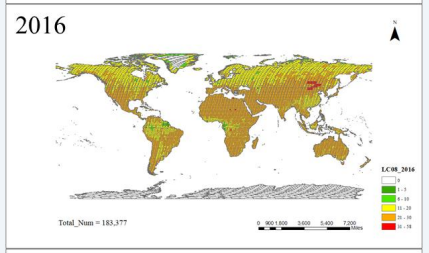
Data Collection

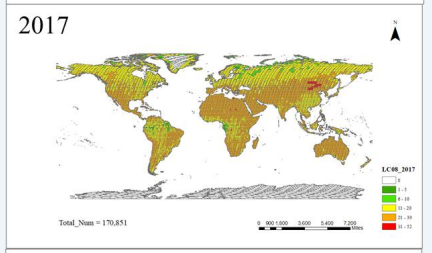


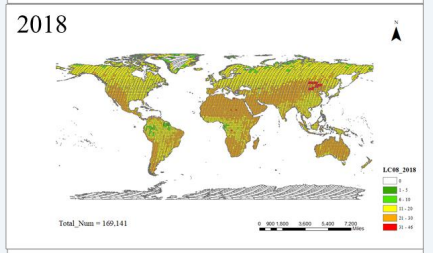


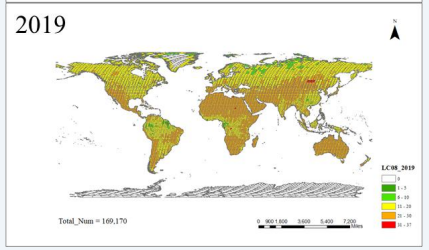


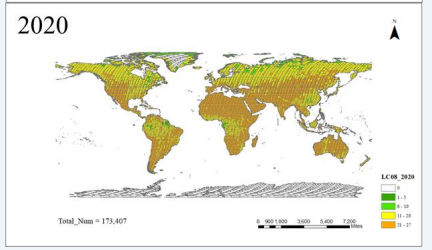


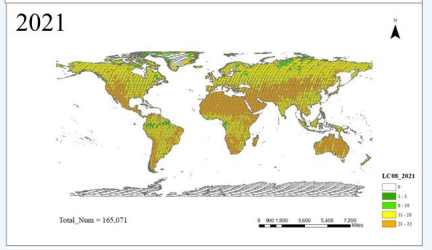










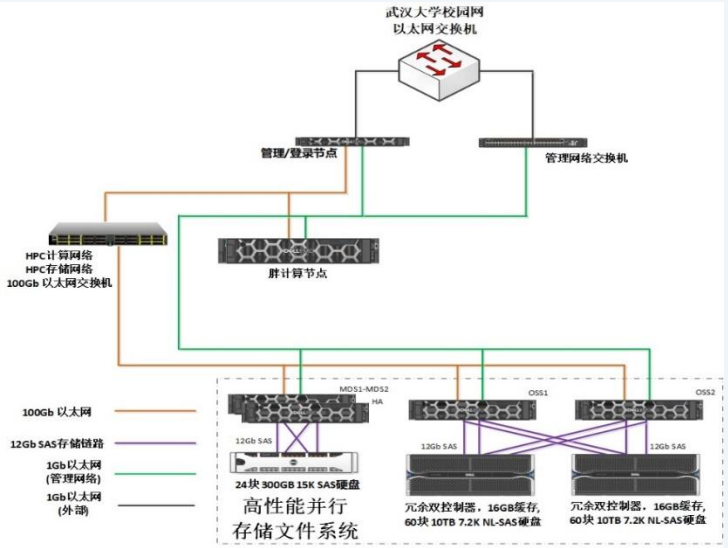


More than 6M scenes of Landsat and Sentinel-2 data with a global coverage

Landsat 5: 1.77M scenes; Landsat 7: 2.14M scenes; Landsat 8: 1.48M scenes

Hi-GLASS system: Capable for regional/global data production

- Data processing: HPC at Wuhan University（268 CPU nodes,100 GPU nodes）
- Data storage: Hi-GLASS data>7PB
- Algorithm integration: integrated data preprocessing and validated retrieval algorithms

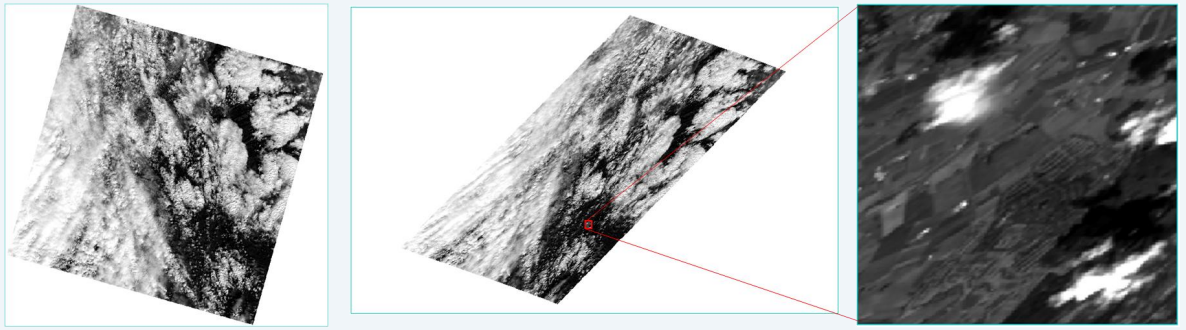


Upgrading Data Organization and Management

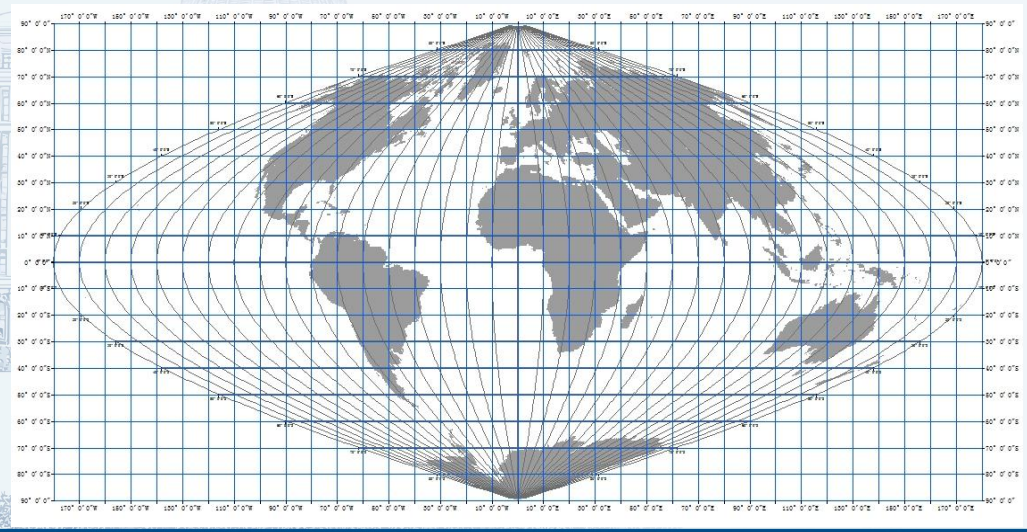
Traditional data management: scene-based

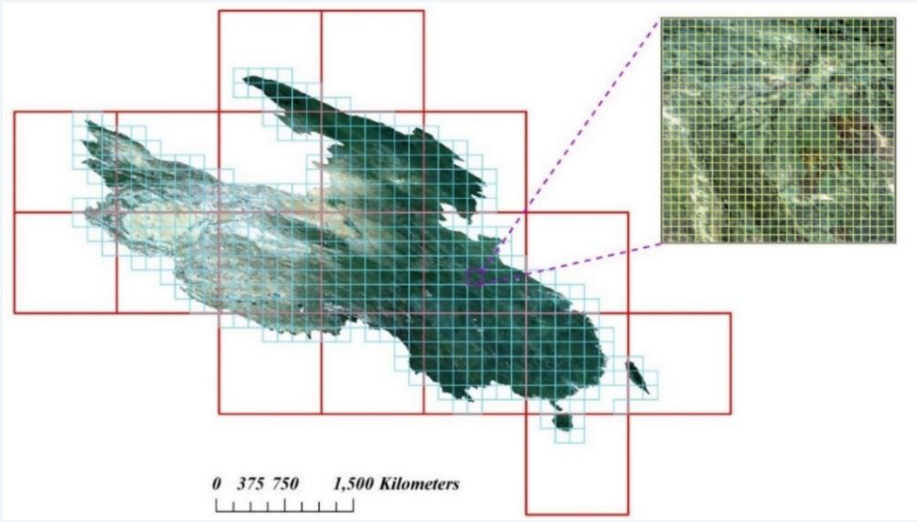
Creating data cubes

New data management: pixel-based



Band3原始影像　Band3正弦投影影像　Tile影像

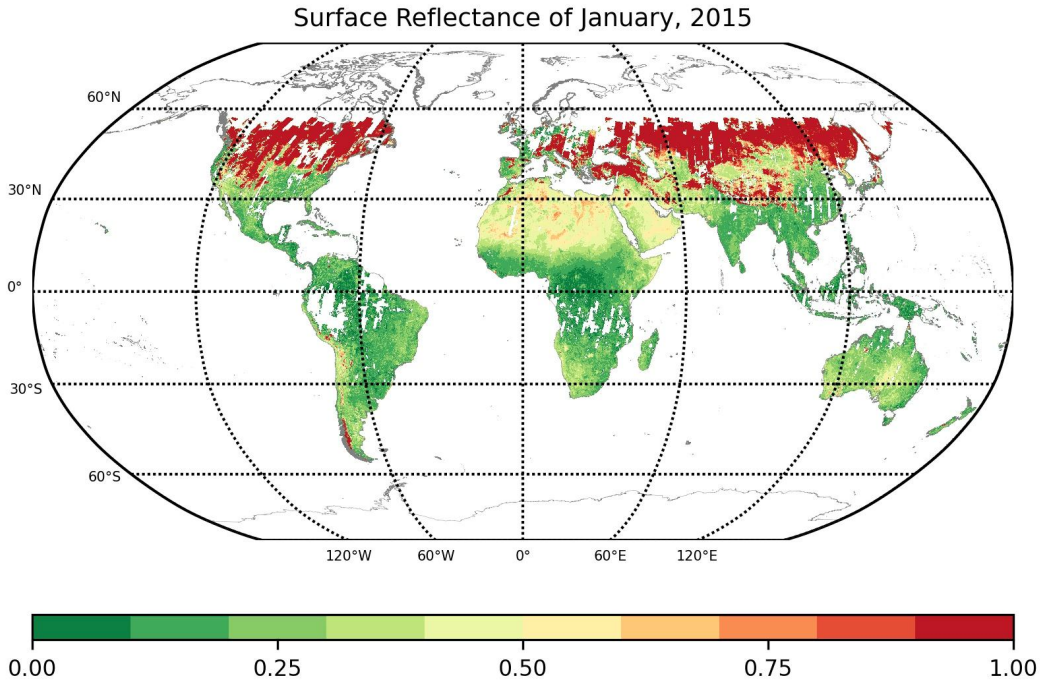




Hi-GLASS Product Example

Surface Reflectance

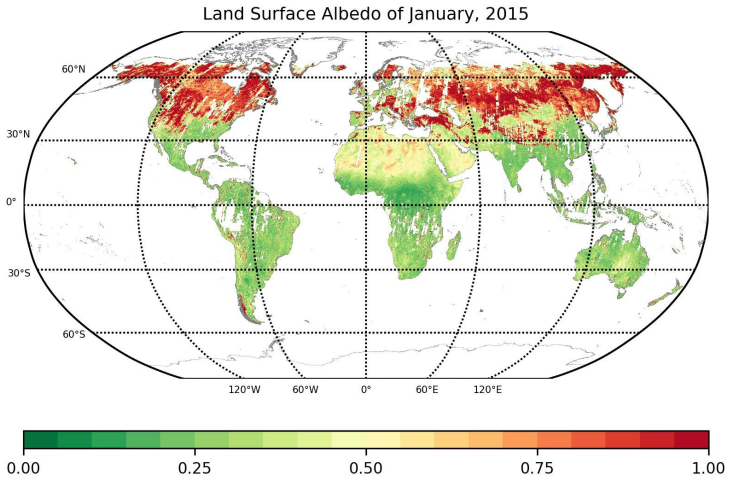
- Atmospheric Correction
- Topographic Correction
- Cloud masking



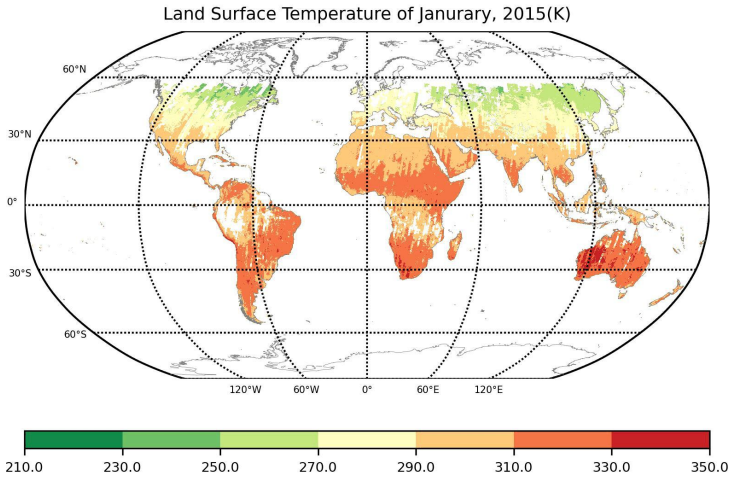
Long-term fine-resolution (30m) multi-variable product suite

Hi-GLASS Product Example: Radiation Budget Variables

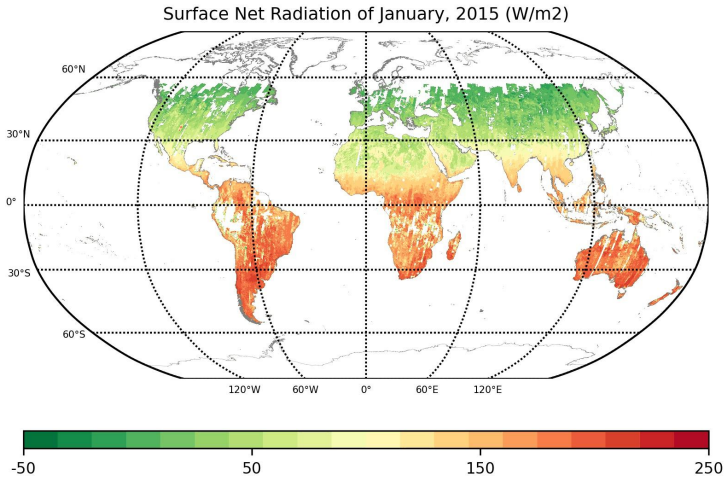
Surface Albedo



Land Surface Temperature

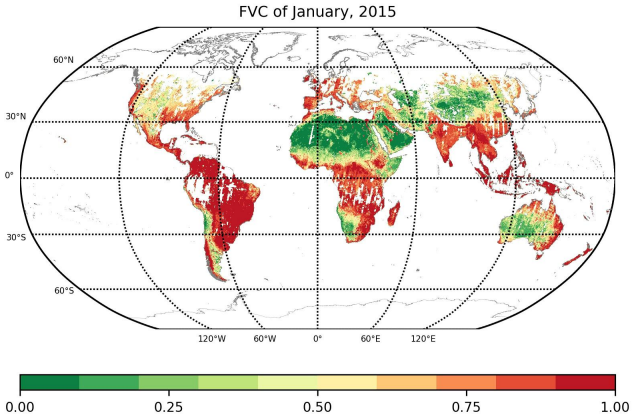


Net Radiation

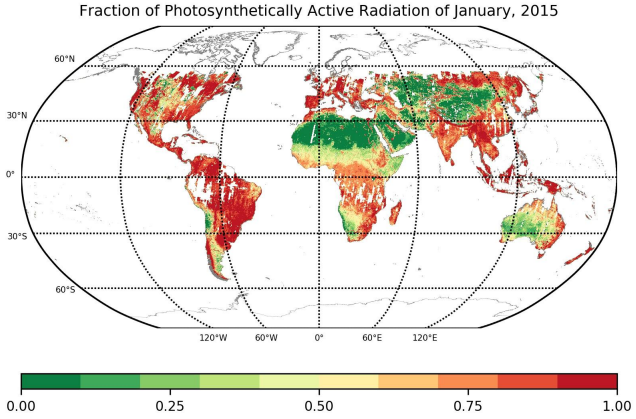


Hi-GLASS Product Example: Vegetation/Carbon Cycle Variables

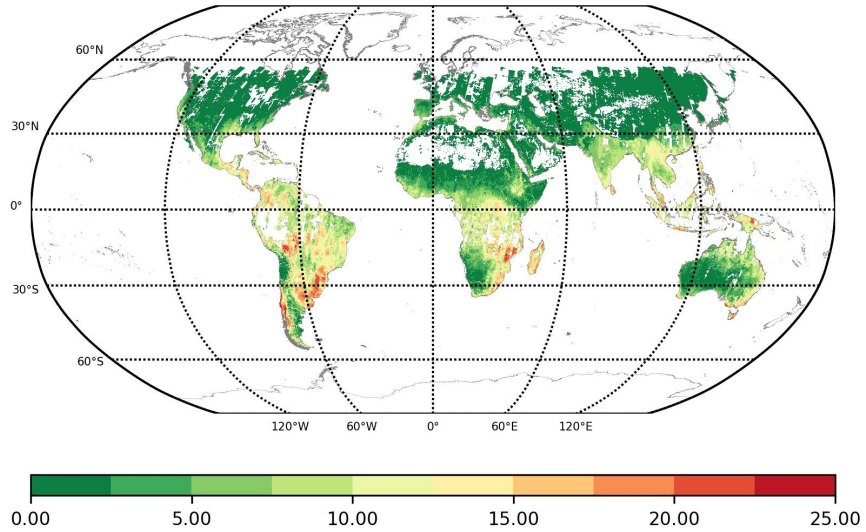
Fractional Vegetation Cover



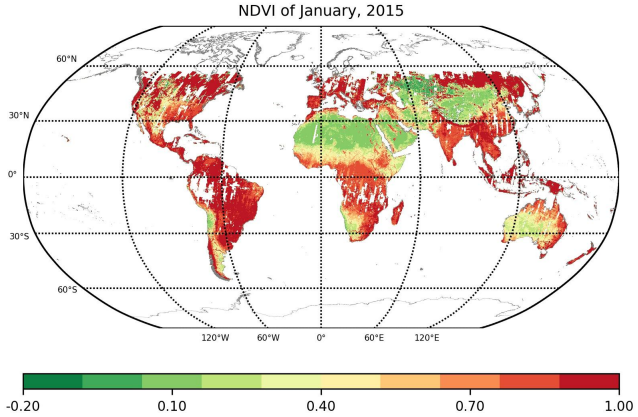
Fraction of Absorbed PAR



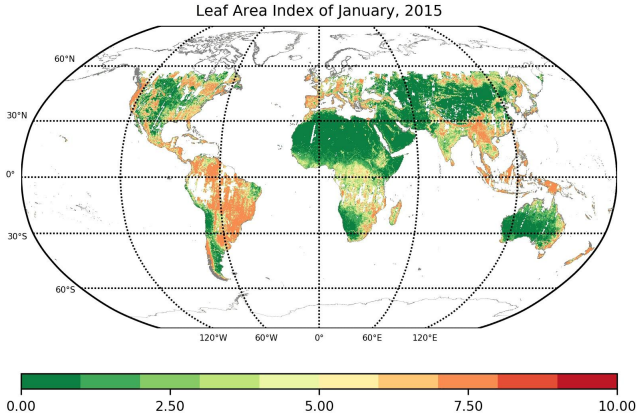
Gross Primary Productivity



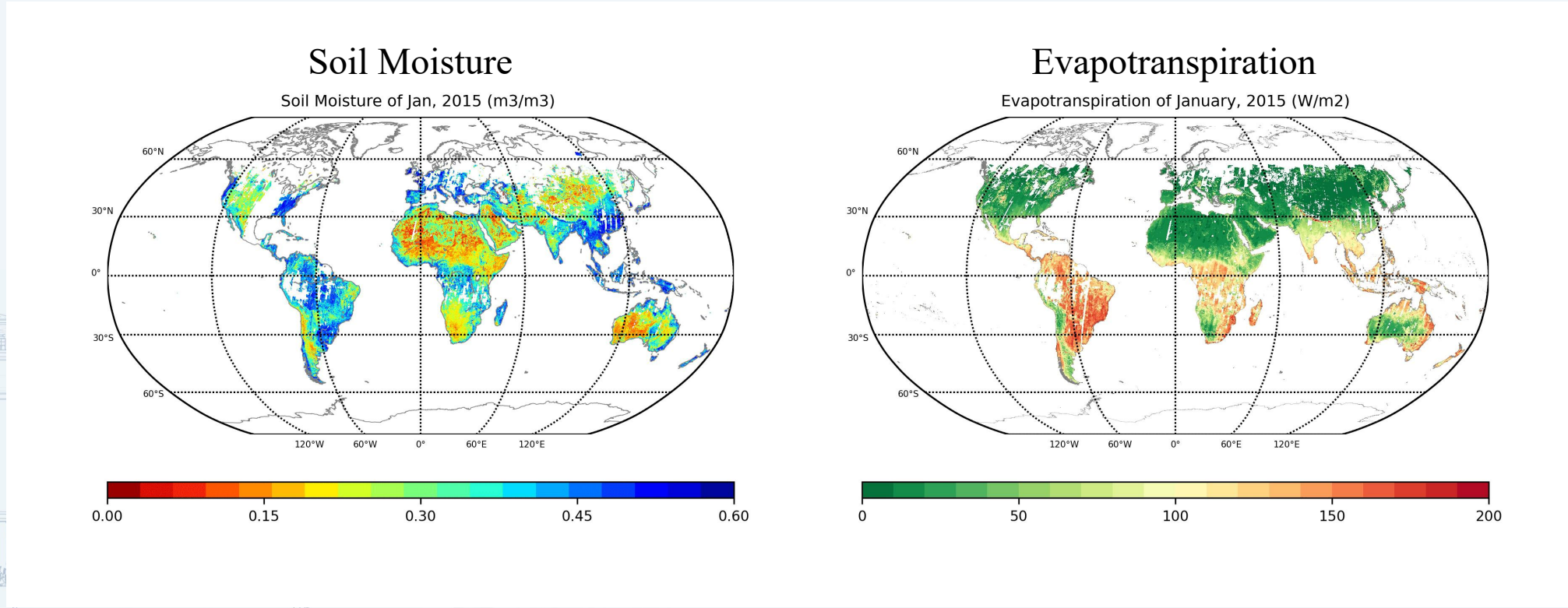
Vegetation Index



Leaf Area Index

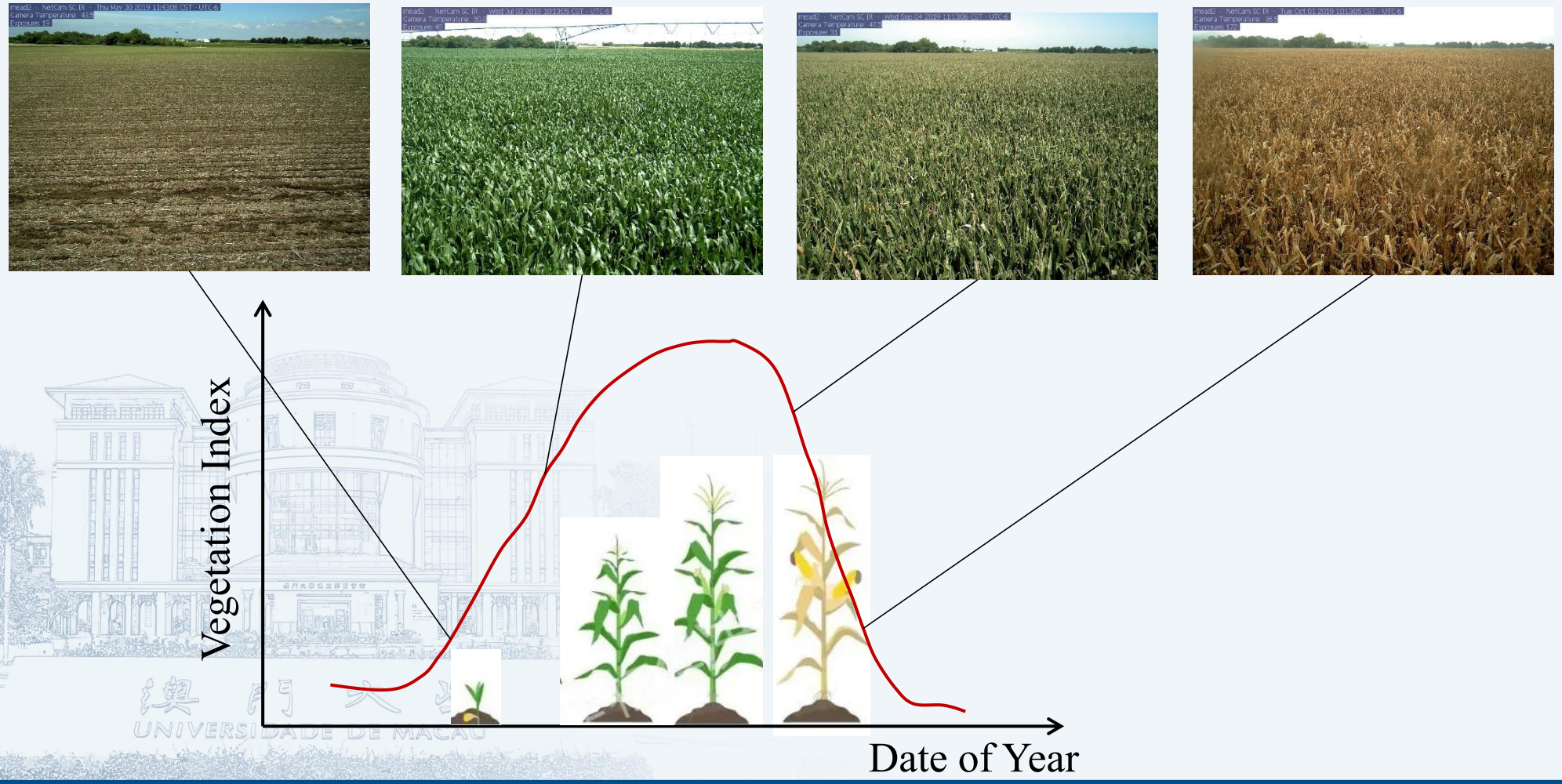


Hi-GLASS Product Example: Water Cycle Variables



Content

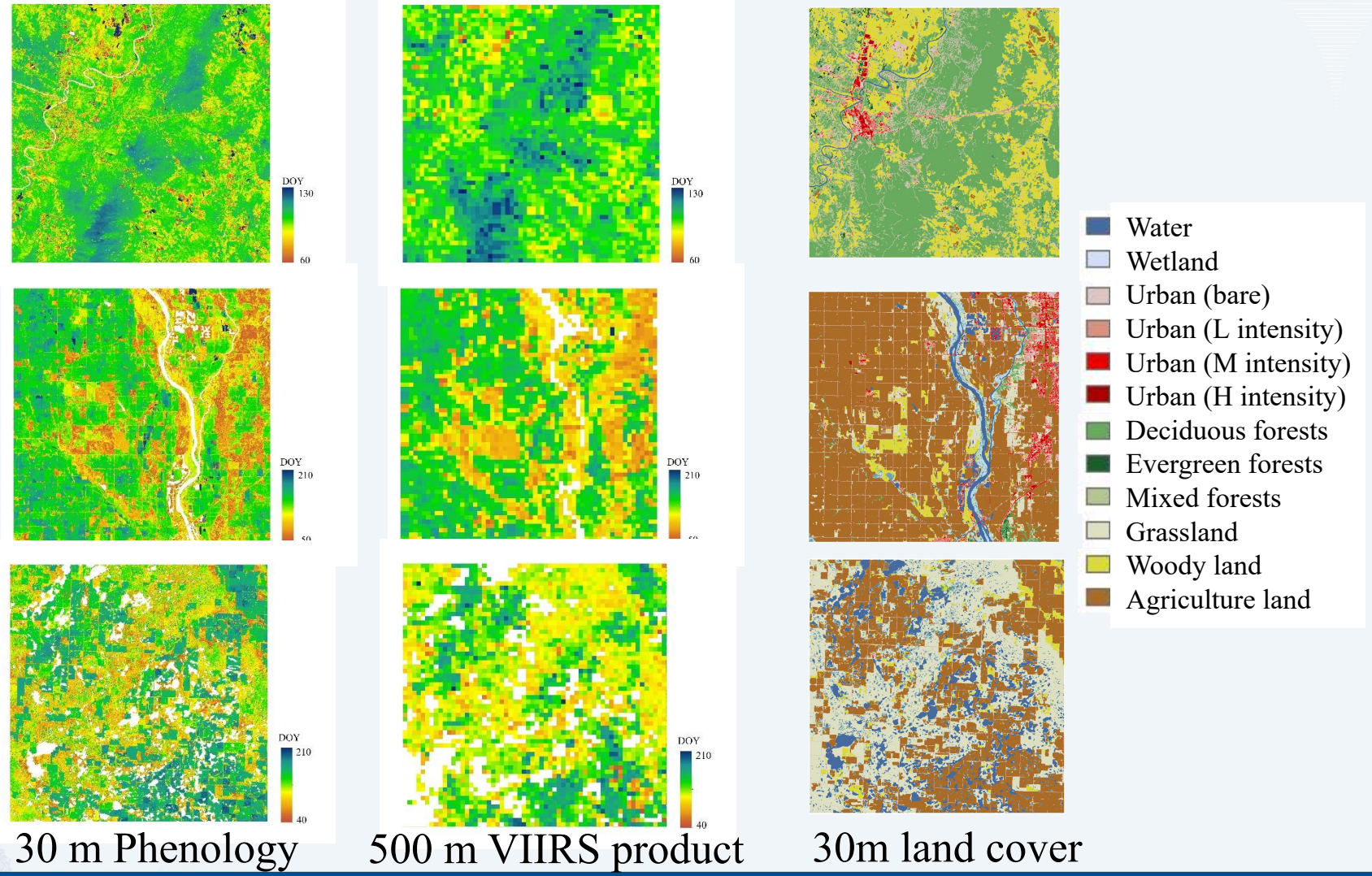
Application Example 1: Monitoring agriculture activity



SDG 2

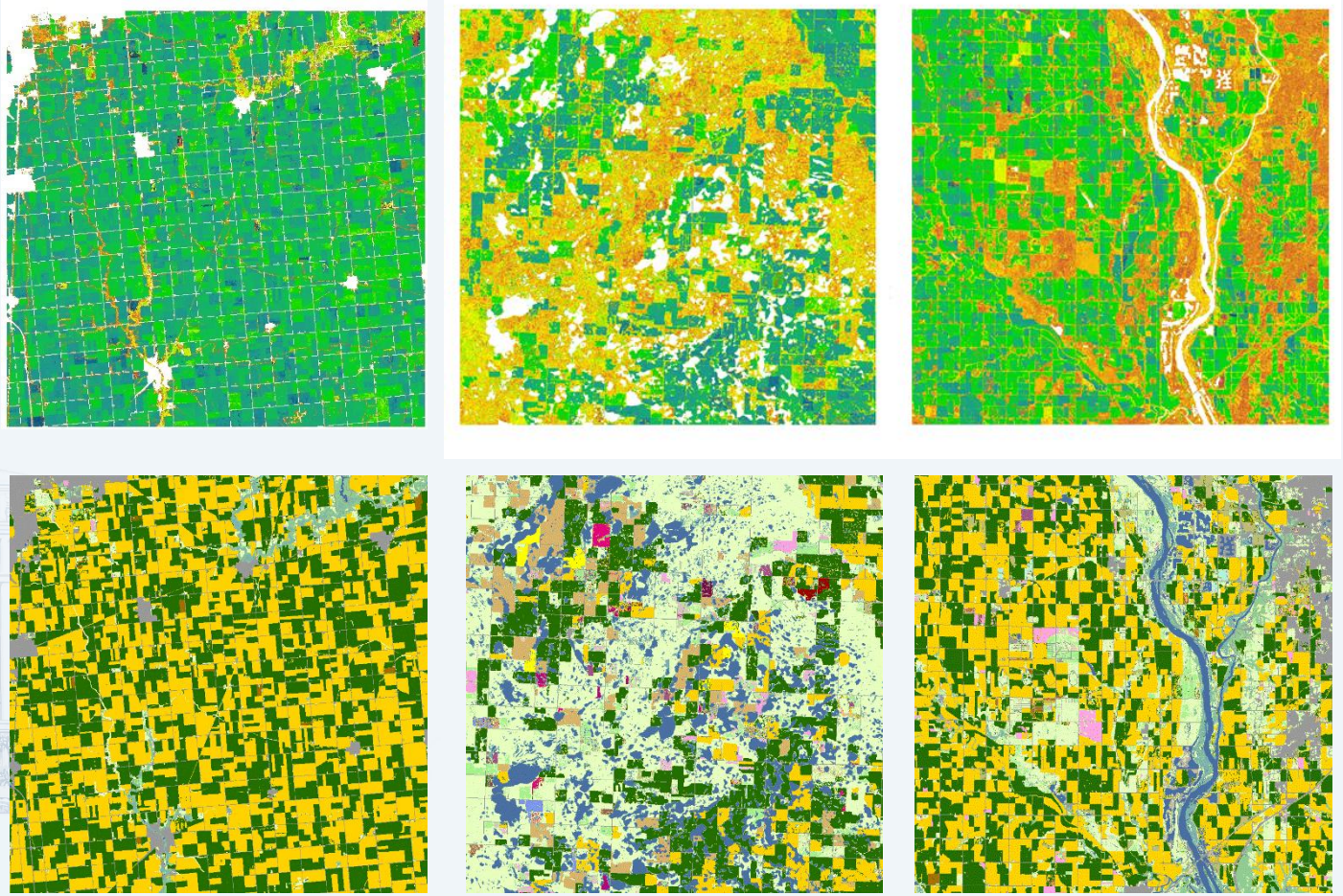
Inter-comparisons of phenology extraction results over different landscapes

- 30 m vs. 500 m



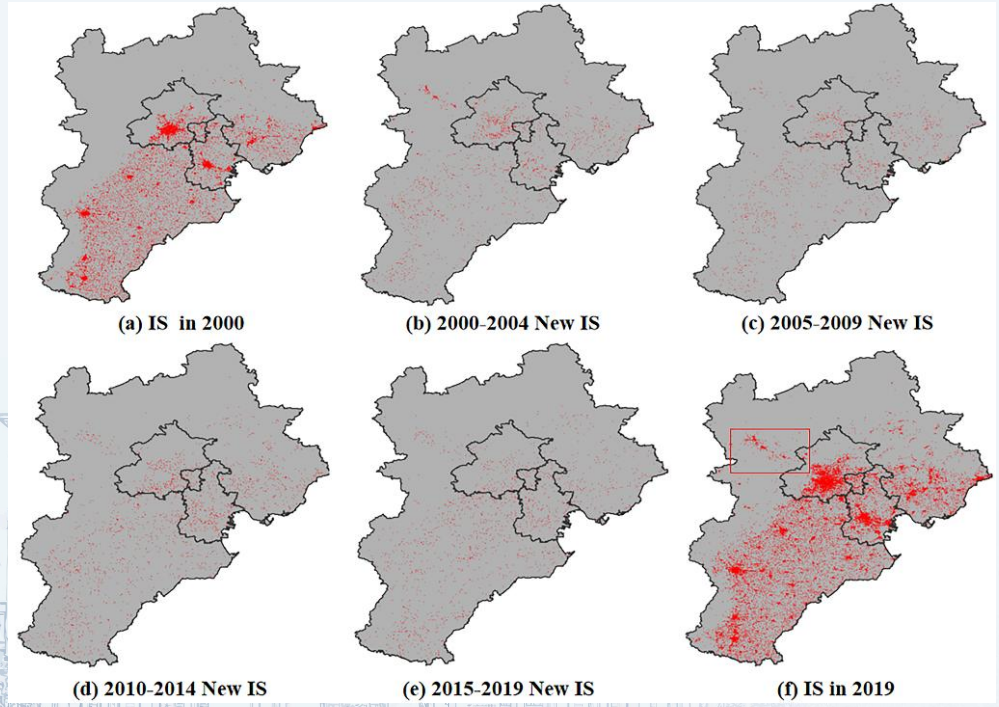
Phenology extraction results

Crop type maps



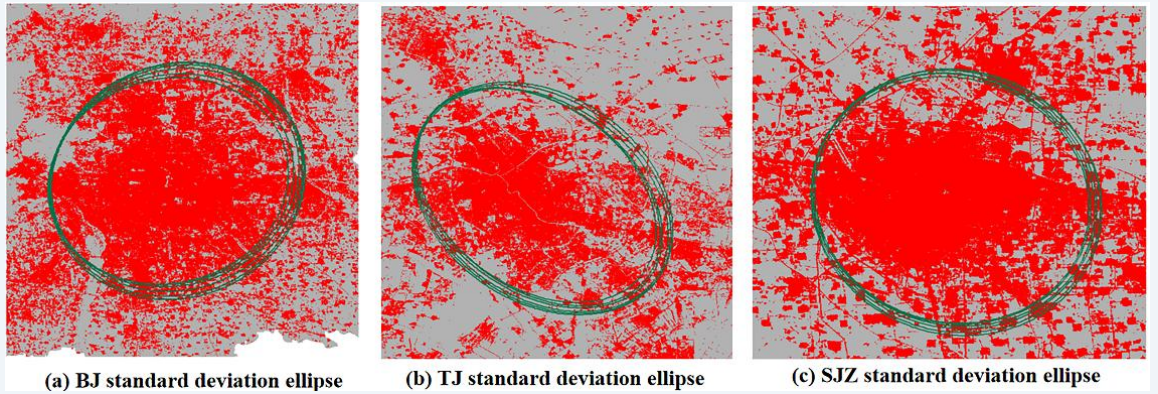
Application Example 2: Monitoring urbanization and its climate impacts

Urban expansion extent



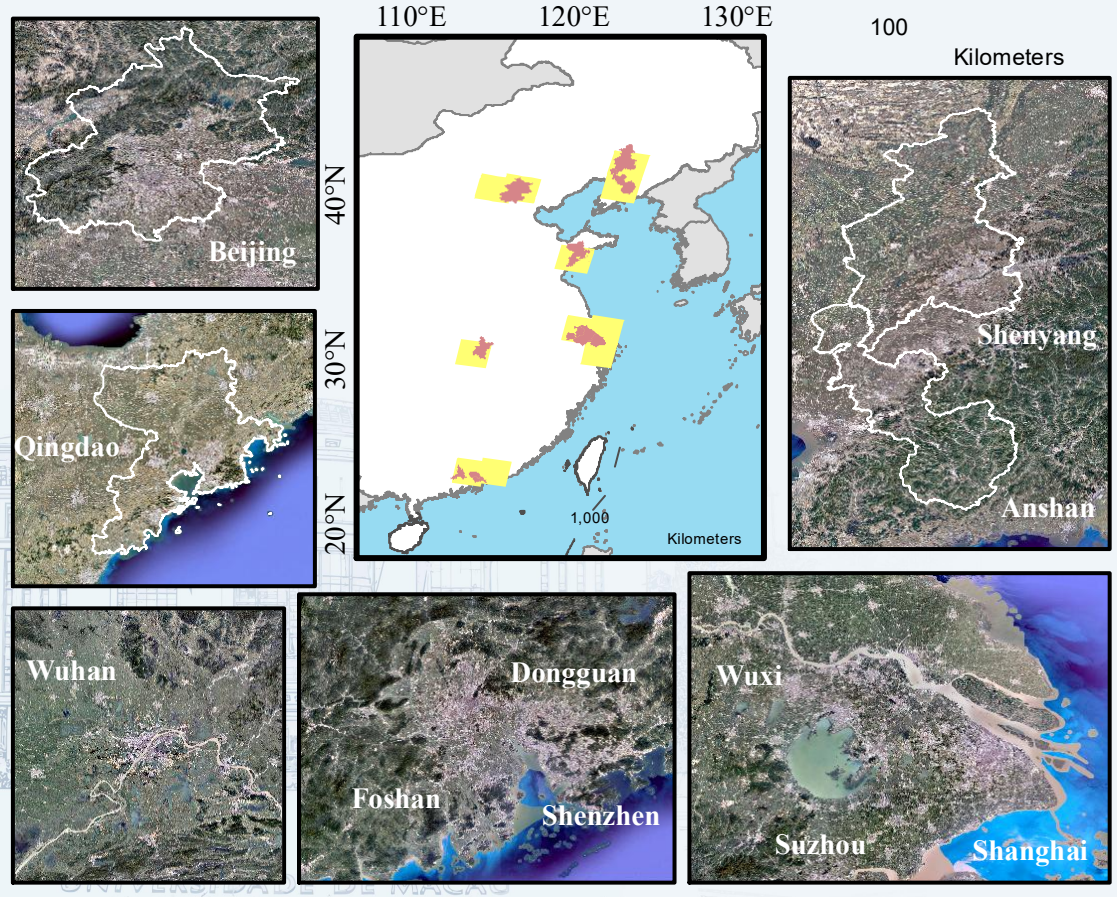
Impervious surface from 2000 to 2019

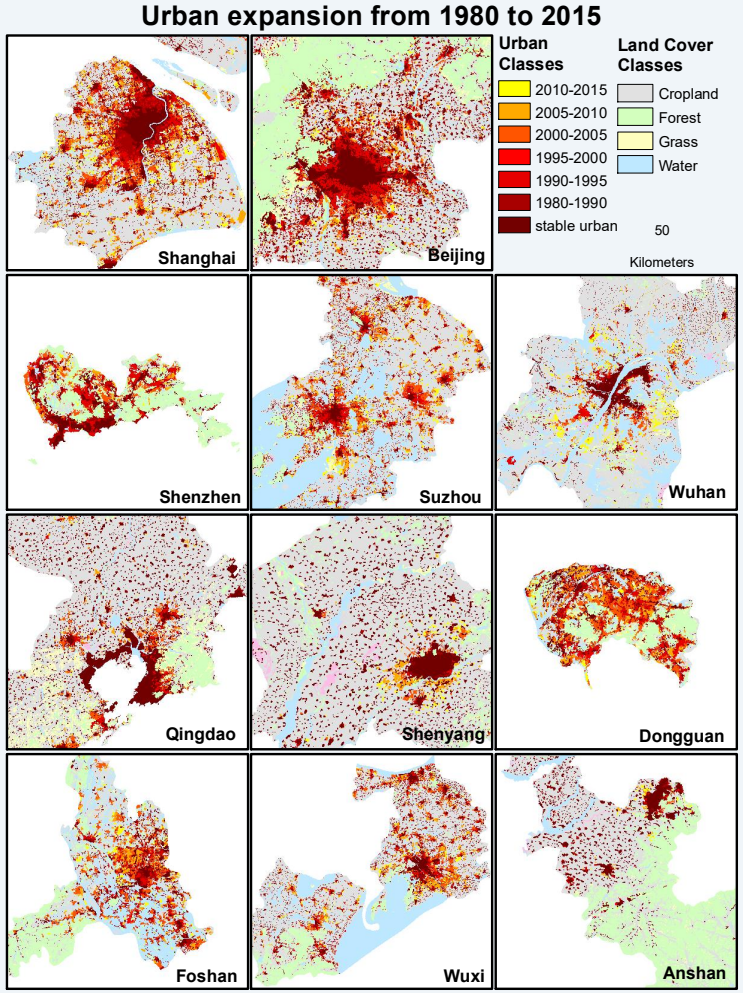
Urbanization trends

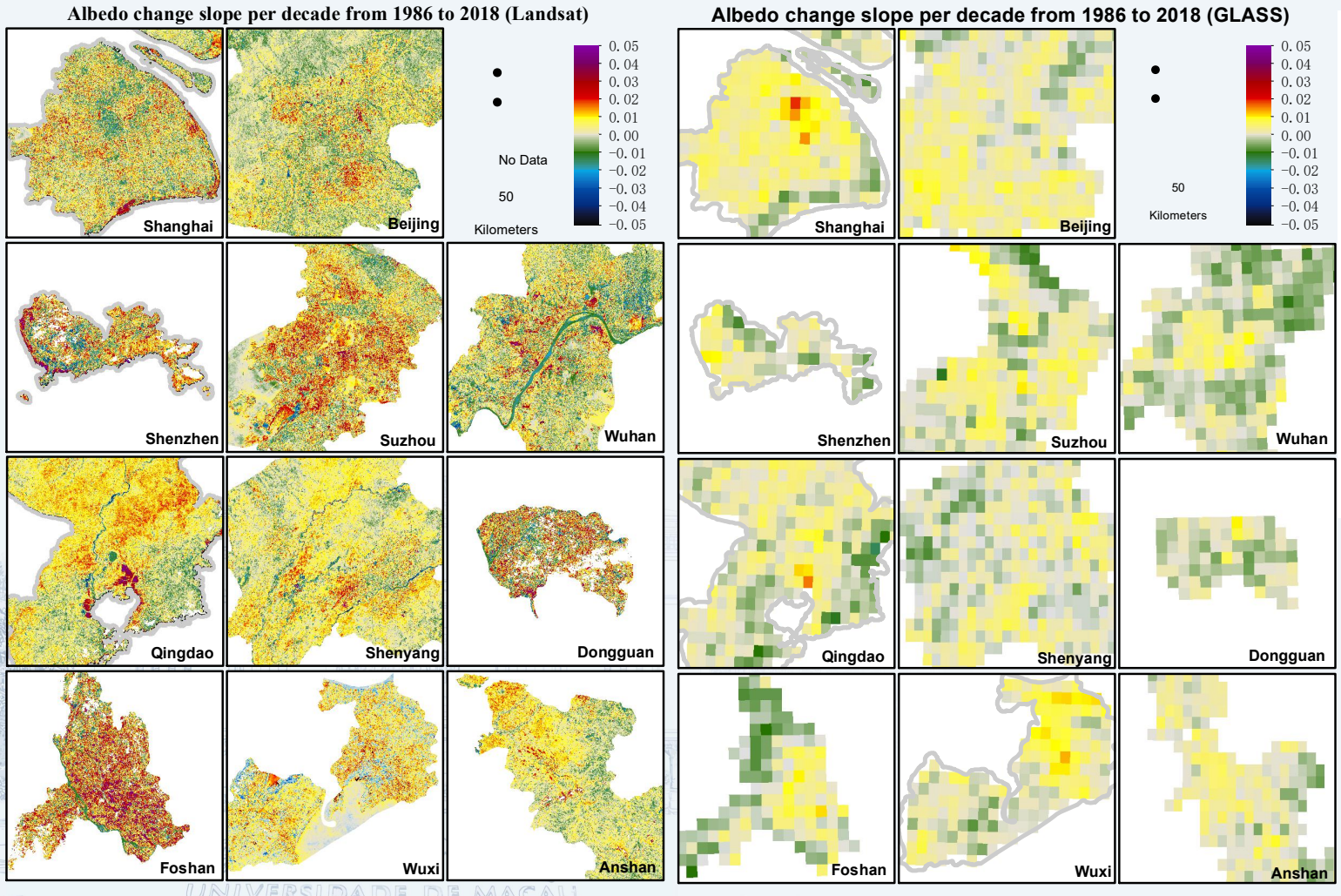


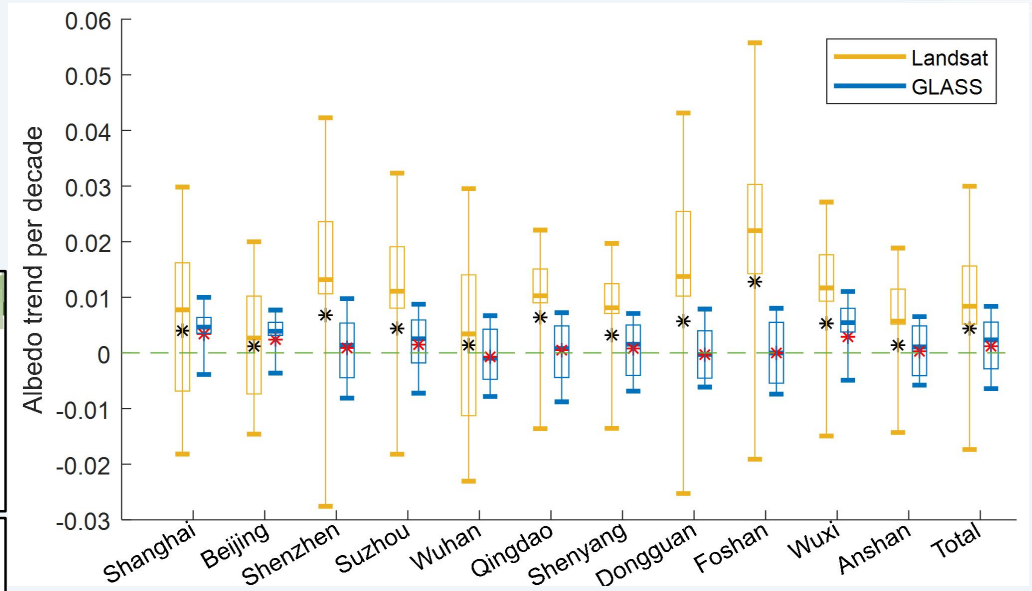
SDGs 11 & 13

Different stages of urban expansion in different Chinese cities







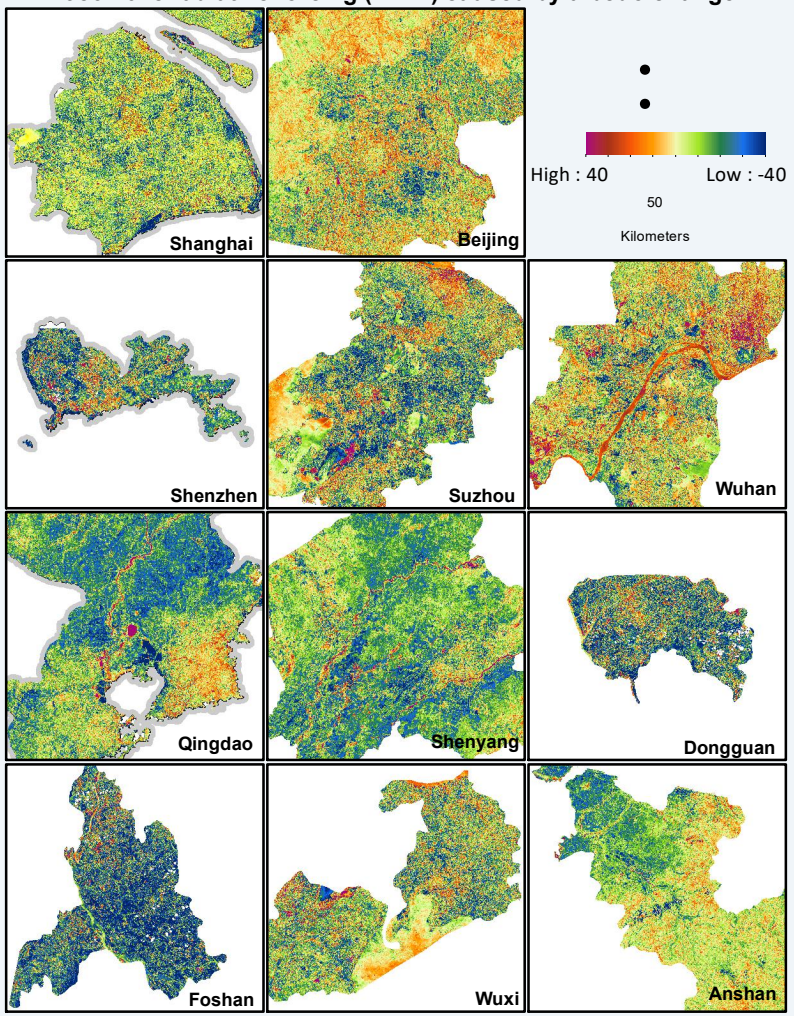


- GLASS and Hi-GLASS products show the different albedo trends in magnitudes;
- Coarse resolution dataset underestimated 2/3 of the urbanization effects.

Average Radiative Forcing (W/m^2) from 1986 to 2018, before and after the possible TP.

City Names	Whole Area RF	TP	RF before TP	RF after TP
Shanghai	−7.259	1996	−4.794	−2.465
Beijing	−0.475	1993	5.401	−5.877
Shenzhen	−15.029	2009	−15.224	0.195
Suzhou	−6.164	2006	−10.505	4.341
Wuhan	−0.542	1990	3.271	−3.813
Qingdao	−14.523	2008	−4.691	−9.837
Shenyang	−12.336	1990	−3.379	−8.957
Dongguan	−18.043	2012	−9.529	−8.514
Foshan	−29.359	2007	−16.251	−13.108
Wuxi	−7.054	1991	−12.563	5.509
Anshan	−4.760	2008	4.429	−9.189
Total Average	−7.757			

1986-2018 radiative forcing (W/m^2) caused by albedo change



Overall shortwave radiative effects from urbanization induced-albedo changes are negative;

Urbanization led to a net cooling effects.

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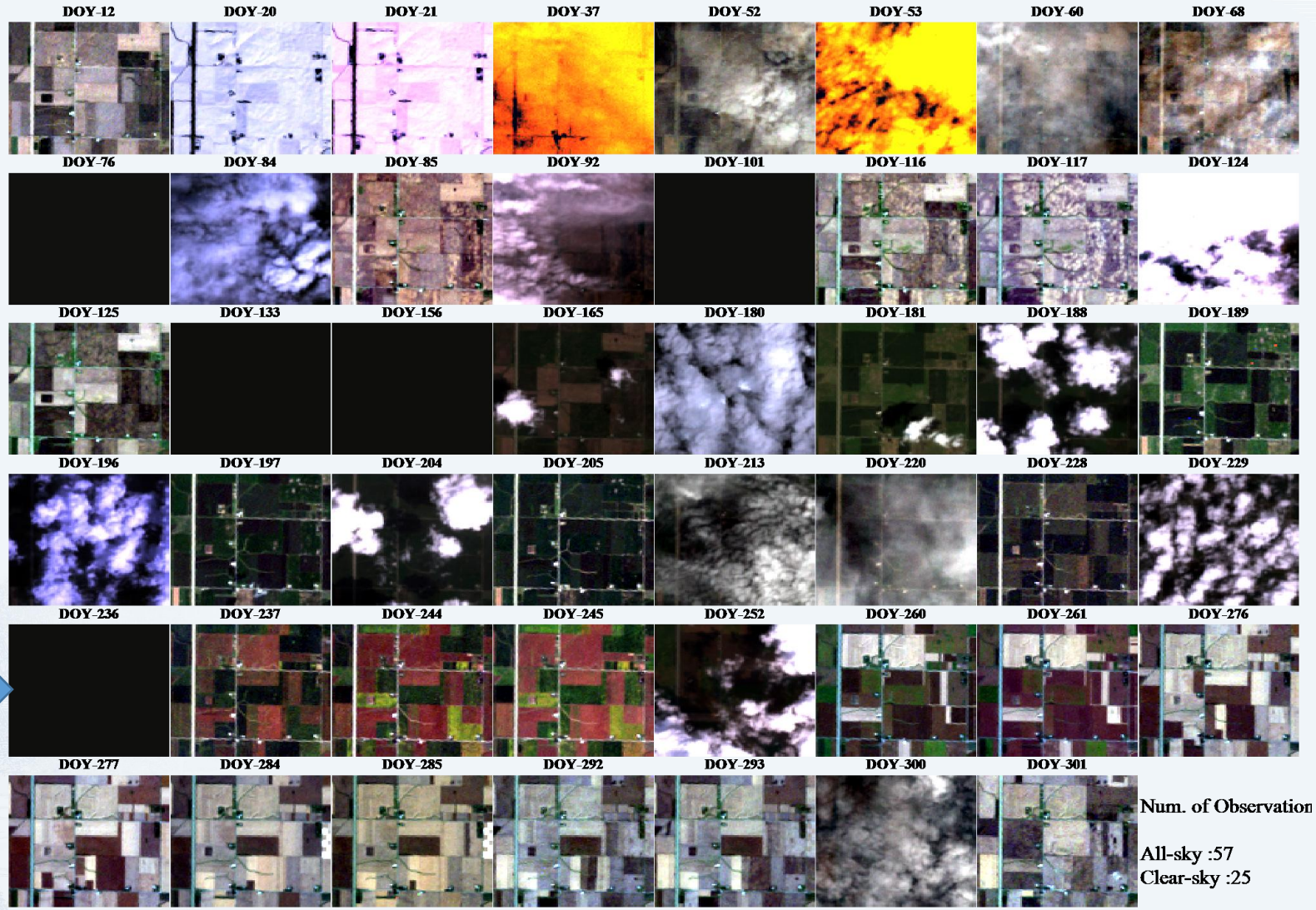
Content

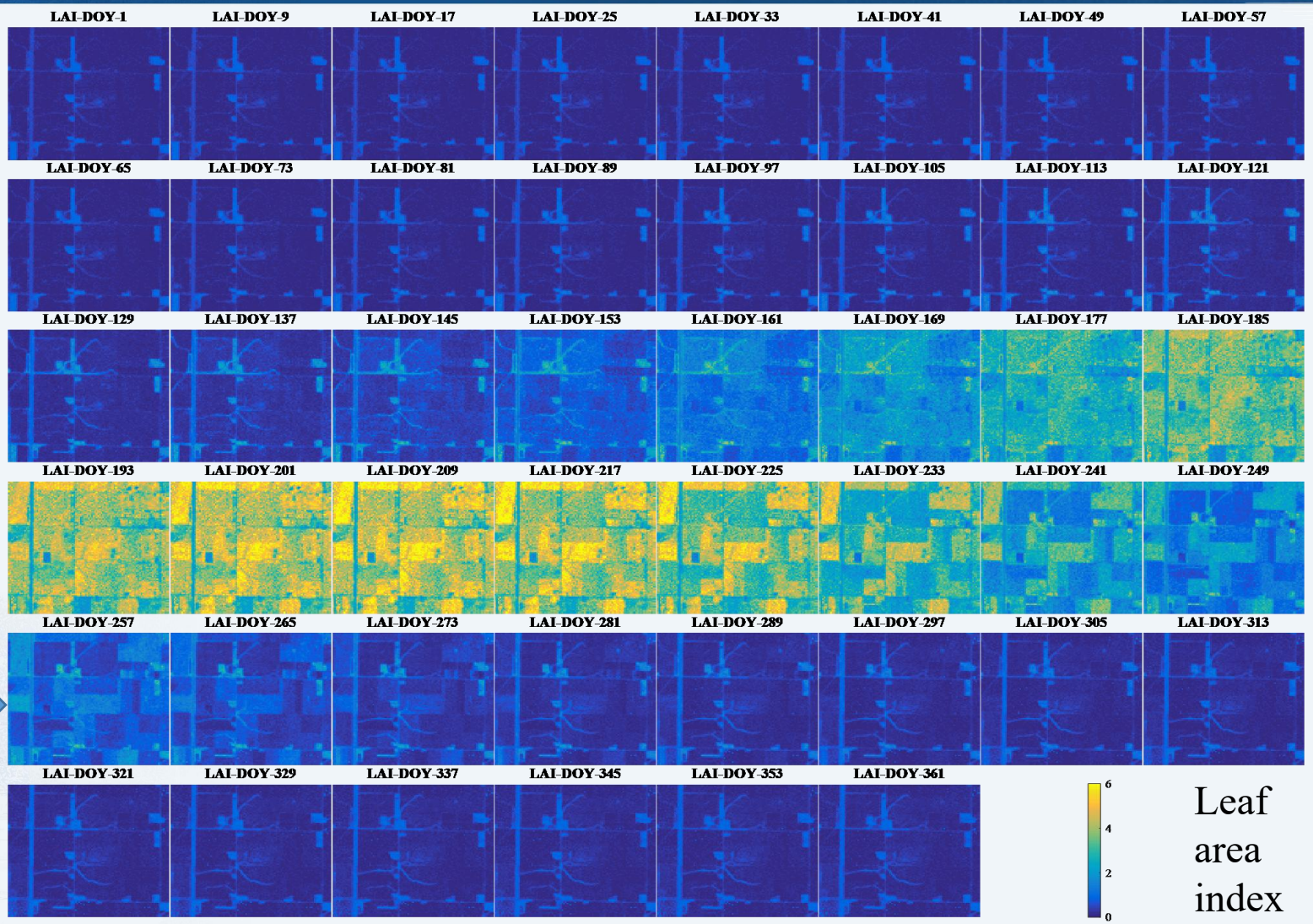
To implement a data fusion or reanalysis algorithm to generate spatio-temporally continuous products

Original satellite observations:
Low revisit frequency;
Cloud contamination.



To implement a data fusion or reanalysis algorithm to generate spatio-temporally continuous products

Derived high-level product



Collaborations Needed

1. Satellite data sharing
2. Product algorithm development
3. Extensive validation
4. Product application

Welcome to use and help improve our Hi-GLASS products!

For information about Hi-GLASS product, please contact:

Tao He
taohers@whu.edu.cn

Hi-GLASS website:
higlass.whu.edu.cn

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