Institute of Forest Information Resource and Techniques, CAF

GFOI Global Forest Observations Initiative | Plenary 9-11 May 2023

Cooperation project between China and Europe in Earth Observation on forest monitoring technology and demonstration applications

Xin TIAN

10th May. 2023

1. Background

1.1 GEO and GFOI

1.2 China EO satellites

1.3 Sino-EU Cooperations

1.1 GEO and GFOI

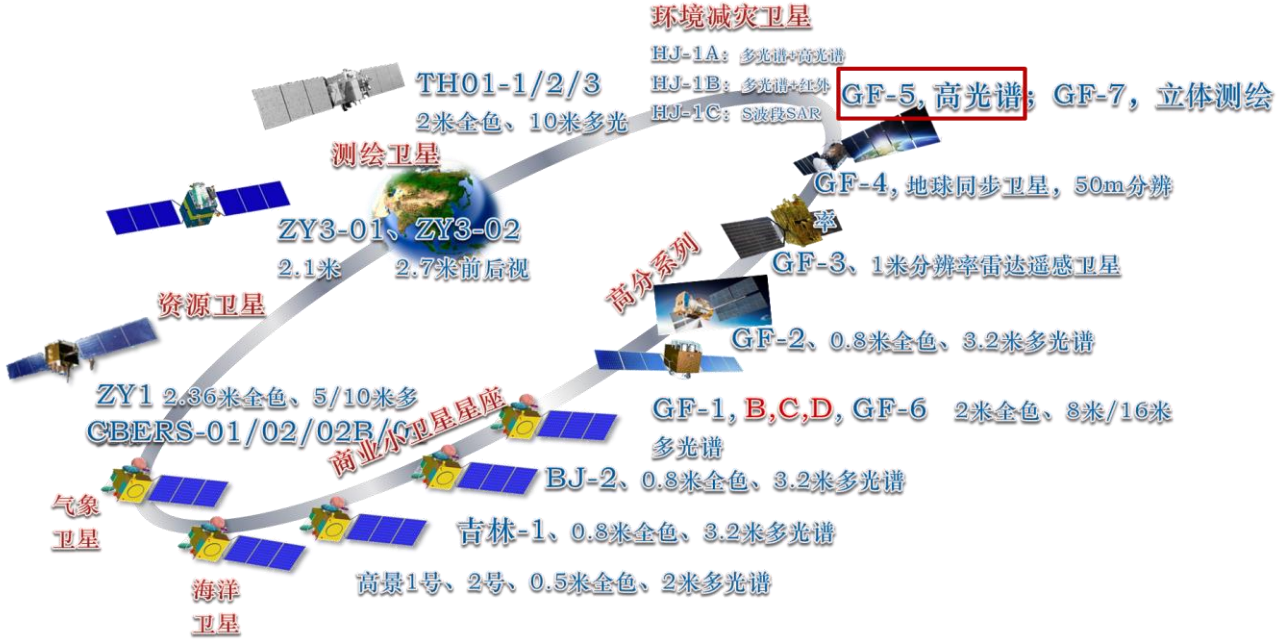
GROUP ON EARTH OBSERVATIONS → Global Forest Observations Initiative

GFOI is a partnership to help coordinate international support to developing countries on forest monitoring and greenhouse gas (GHG) accounting for REDD+ and related activities.

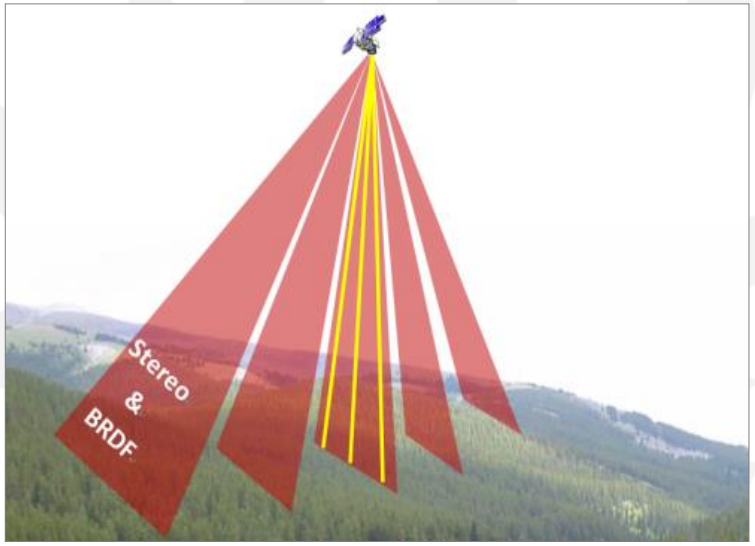
In the past, GFOI was mainly initialed and supported by Australia 、 Europe and US, and CEOS、ESA、FAO…

Recently, benefits from the continuous funding from the MOST, APFNet and etc., China has been making ever-greater contributions to the GFOI !

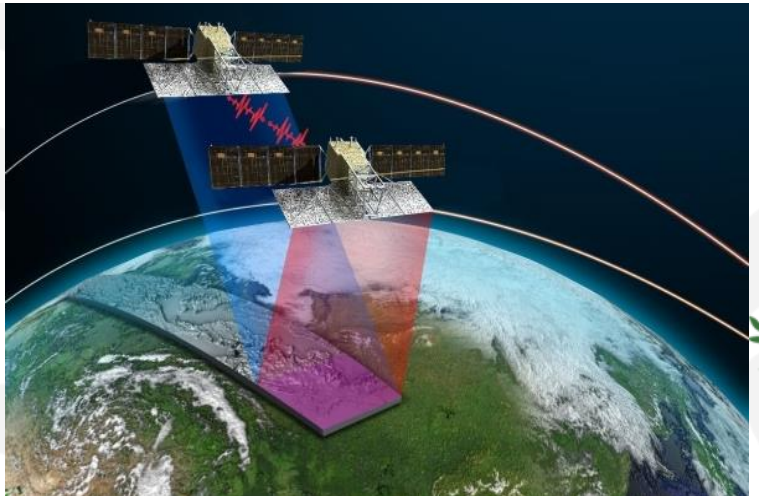
1.2 China EO satellites



Global Gaofen Images



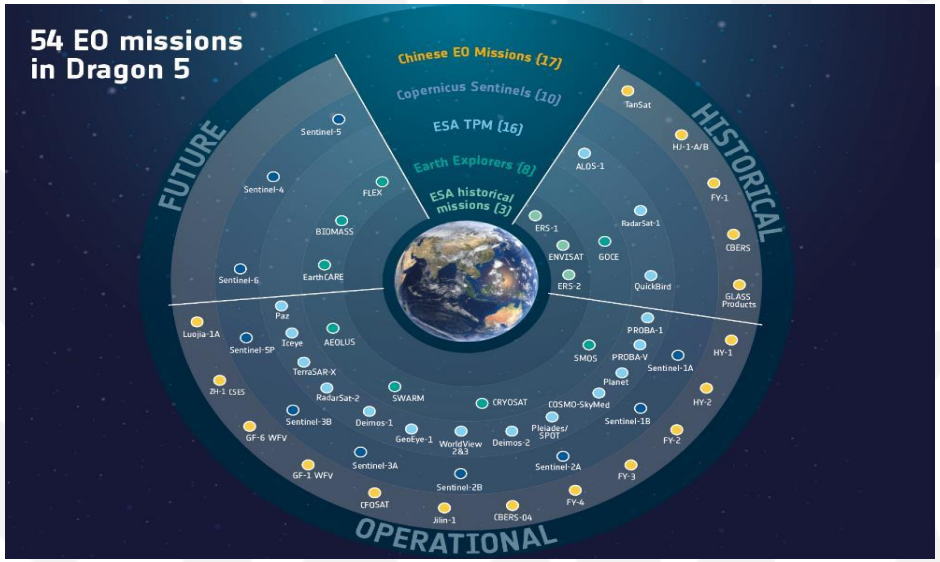
Goumang (Terrestrial ecosystem carbon monitoring satellite)

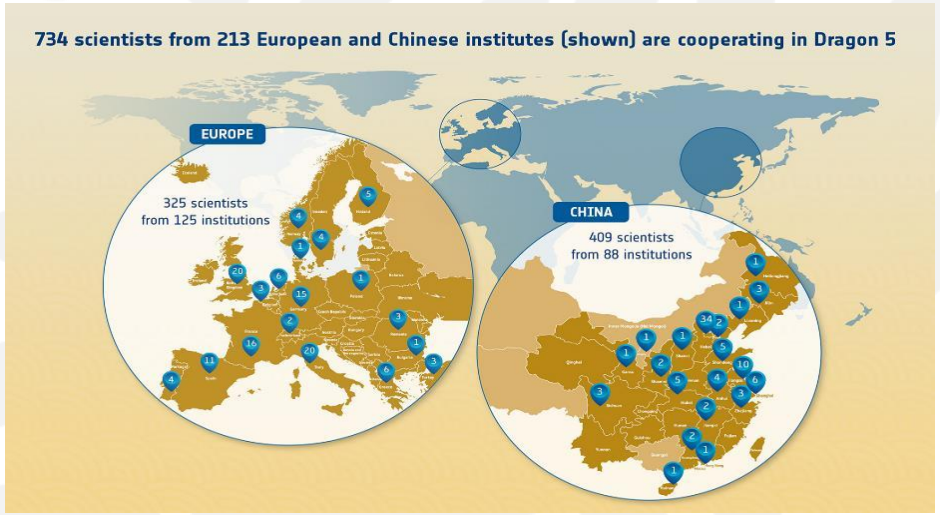


Lutan-1(L-band SAR)

1.3 Sino-EU Cooperations

Dragon Programme





1.3 Sino-EU Cooperations

Symposiums

Training courses

About 1200 young scientists trained

China International Science and Technology Cooperation Award-2013

Prof.Fabio Rocca

National Friendship Award-2014

EU PI: Dr.Yves-Louis Desnos

1.3 Sino-EU Cooperations


esa NRSCC

Dragon 5 Cooperation 2020–2024

Certificate of Acceptance

3–D Characterization and Temporal Analysis of Forests and Vegetated Areas Using Time–Series of Polarimetric SAR Data and Tomographic Processing (ID.59307)

PI Europe Dr. Laurent Ferro–Famil
University of Rennes 1
FRANCE

PI China Prof. Chen Erxue
Institute of forest resource information techniques, Chinese Academy of Forestry
CHINA

On behalf of ESA & NRSCC

Dr. Maurice Borgeaud
Head of Earth Observation Science, Applications & Climate Department European Space Agency (ESA)

Dr. Wang Qi'an
Director General National Remote Sensing Center of China (NRSCC)

IFRIT+University of Rennes 1 France


esa NRSCC

Dragon 5 Cooperation 2020–2024

Certificate of Acceptance

CEFO: China–ESA Forest Observation (ID.59358)

PI Europe Dr. Juan Suarez
Northern Research Station
UK

PI China Prof. Pang Yong
Institute of forest resource information techniques, Chinese Academy of Forestry
CHINA

On behalf of ESA & NRSCC

Dr. Maurice Borgeaud
Head of Earth Observation Science, Applications & Climate Department European Space Agency (ESA)

Dr. Wang Qi'an
Director General National Remote Sensing Center of China (NRSCC)

IFRIT+ Forest Research, Northern Research Station, UK


esa NRSCC

Dragon 5 Cooperation 2020–2024

Certificate of Acceptance

Mapping Forest Parameters and Forest Damage for Sustainable Forest Management from Data Fusion of Satellite Data (ID.59257)

PI Europe Dr. Johan Fransson
Swedish University of Agricultural Sciences, Department of Forest Resource management
SWEDEN

PI China Prof. Zhang Xiaoli
Beijing Forestry University
CHINA

On behalf of ESA & NRSCC

Dr. Maurice Borgeaud
Head of Earth Observation Science, Applications & Climate Department European Space Agency (ESA)

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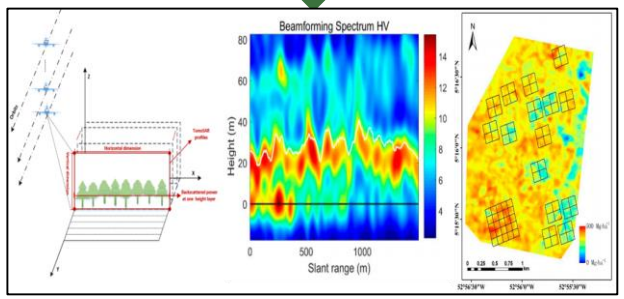
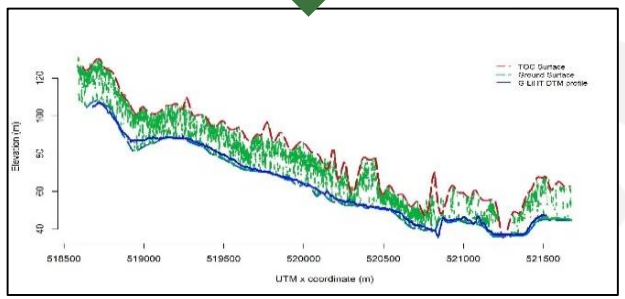
Director General National Remote Sensing Center of China (NRSCC)

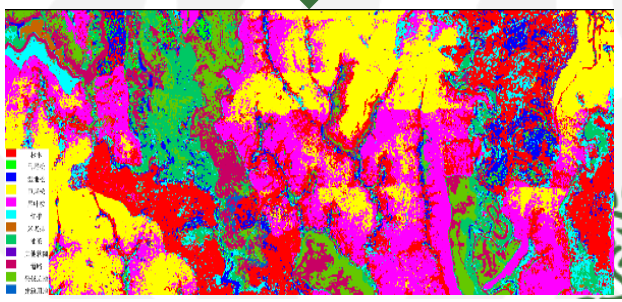
IFRIT+ Swedish University of Agricultural Sciences



Forest Aboveground Biomass Estimation Using Multi-Features Extracted by Fitting Vertical Backscattered Power Profile of Tomographic SAR



A forest structure parameter estimation method using the elliptical search based photon-counting LiDAR



A machine learning tree species classification technology for complex forest stands by fusing multi-dimensional features.

2. Introduction of the Project

2.1 Problem and Tendency

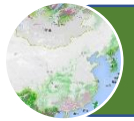
2.2 Project General Information

2.3 Research Contents

2.4 Expected Achievements

2.5 Research Team

2.1 Problem and Tendency



GFOI

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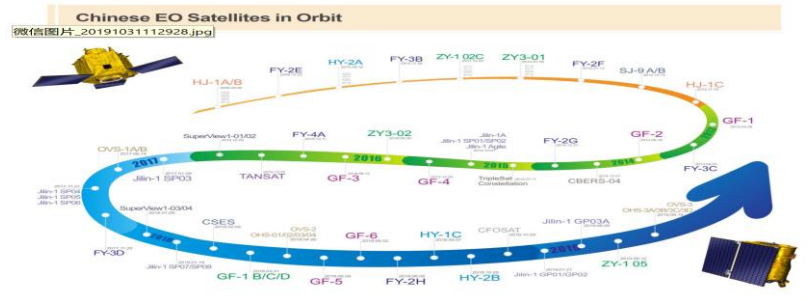
Data	Full coverage /Yr	Landsat Sentinel	Large gap	Dense active and passive data
Type & Disturbance	High resolution/ Automatically	Large samples Spatial & spectral	Poor Transferability Low resolution	Small, multisacle, Transfer Learning
Parameters	Various scenario/ Wall to Wall	Sampling Single	Simple Unstable	Active & Passive synergy

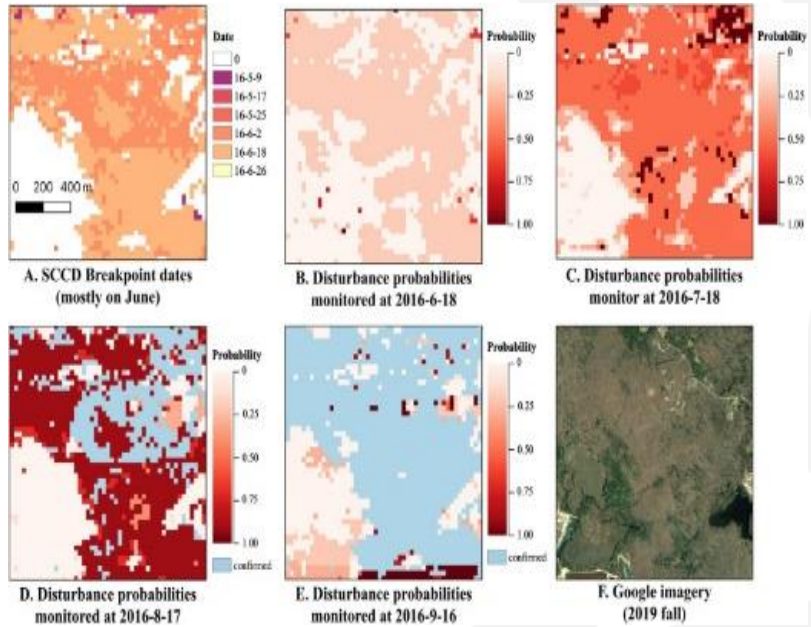
2.2 Project General Information

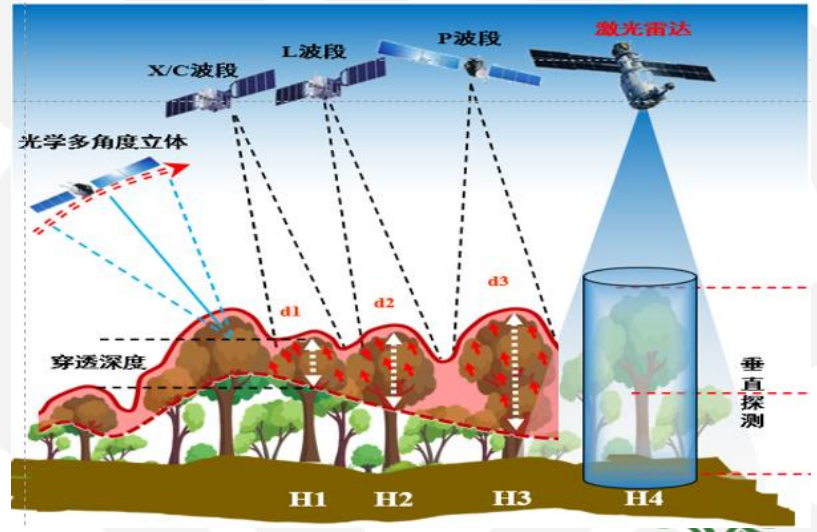
■ **Cooperation project between China and Europe in Earth Observation on forest monitoring technology and demonstration applications**

- **Key Issues: Poor robustness and low spatial and temporal resolution of regional forest remote sensing products**

- **Funding: 4 Million CYN**
- **Duration: 2022.01~2024.12**







To support GFOI's capacity building and product service for continuous observation of regional forest resources

2.3 Research Contents

Key Technology

1. Harmonizing the Chinese Gaofen and ESA Sentinel series satellite observations
2. Forest type identification and change and disturbance detection techniques fusing multi-modal characteristics
3. Extraction of Forest Vertical Structure information and Forest Biomass Collaborated Using Multifrequency SAR
4. Estimation of regional forest biomass based on Lidar and optical multi-angle stereo observation

Platform

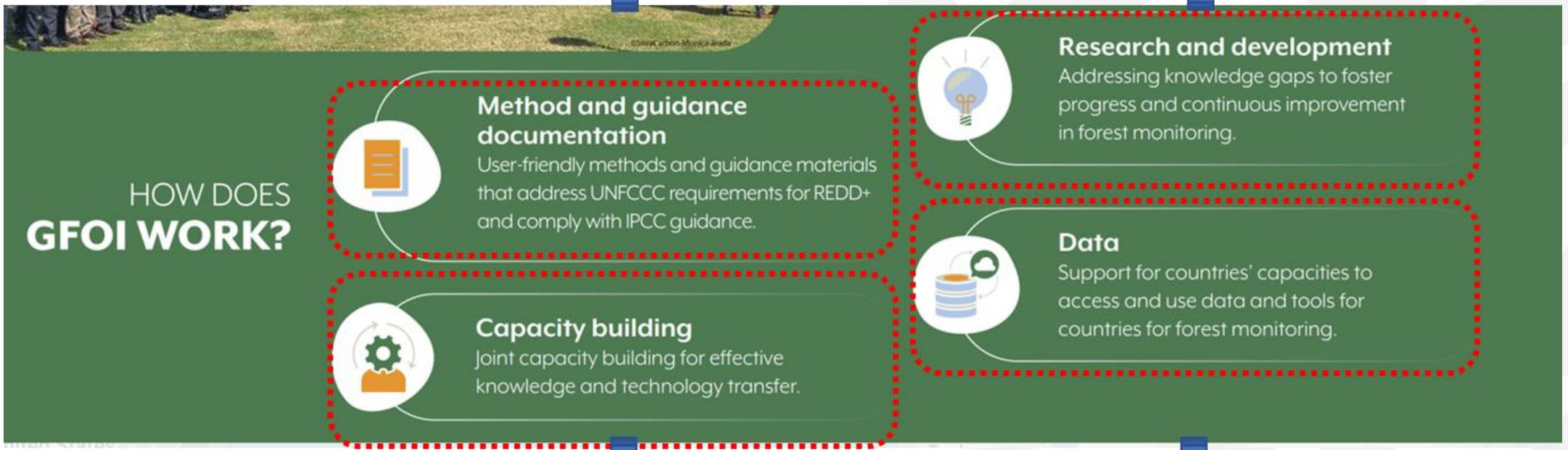
Forest resource monitoring system based on multi-source observation data

Demonstration

China	Genhe、Pu'er
Europe	French Guiana 、Kielder-UK、Vstra Gtaland -Sweden

2.4 Expected Achievements

- 1 Set of M&G
- 4 Key Techniques



- 1 Monitoring System
- 5 Demonstratoins

2.5 Research Team

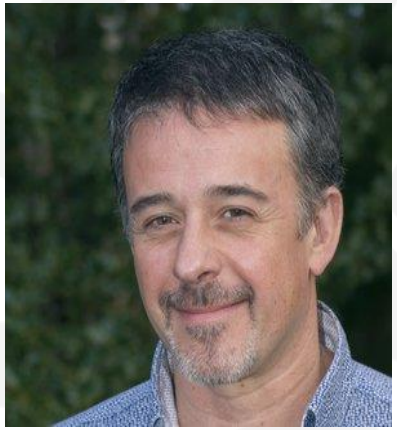
- IFRIT, Chinese Academy of Forestry
- Beijing Forestry University
- Northeast Forestry University
- Fujian Normal University
- University of Rennes 1, France
- Forest Research, Northern Research Station, UK
- Swedish University of Agricultural Sciences

Xiaoli ZHANG

Yanqiu XING

Guiying LI

Laurent Ferro-Famil



Juan Suarez

Langning Huo

3. Main Progress and Achievements

3.1 Harmonizing GF and Sentinel-2

3.2 Fusion of UAV and TLS point cloud data

3.3 Tree Species Discrimination

3.4 Forest Disturbance Detection

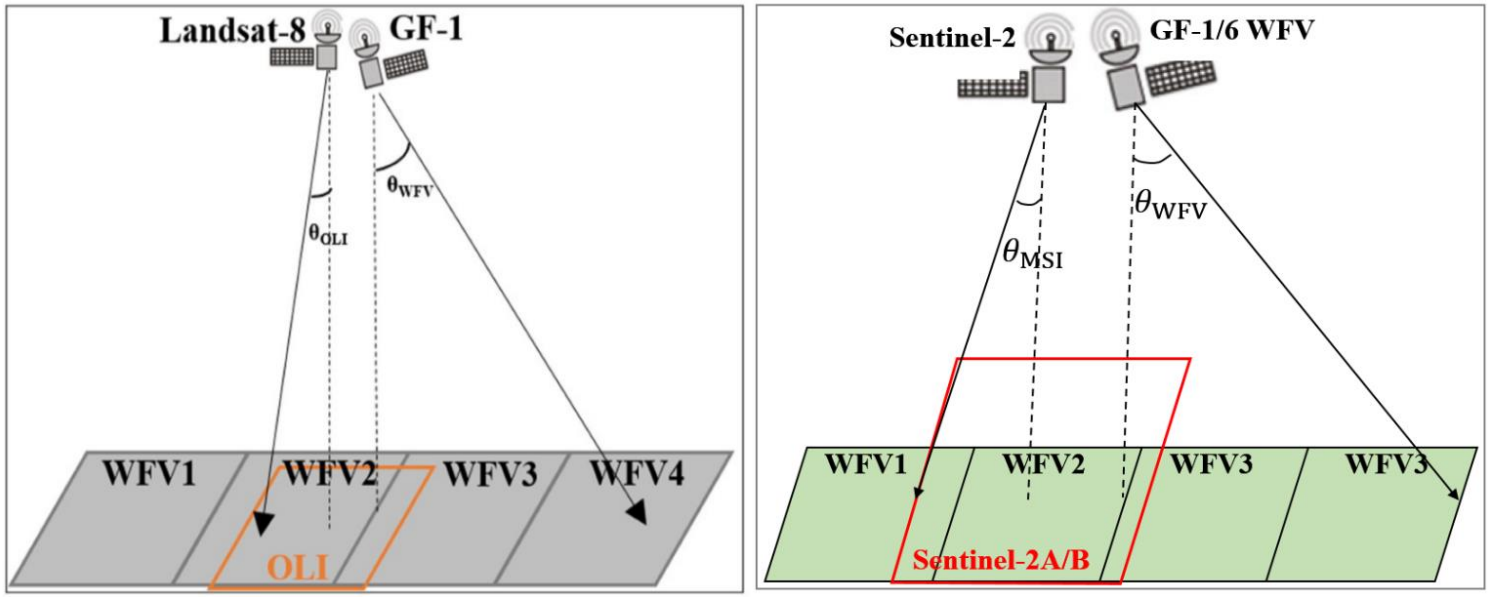
3.5 Forest Height Extraction Method Based On Multi-band InSAR

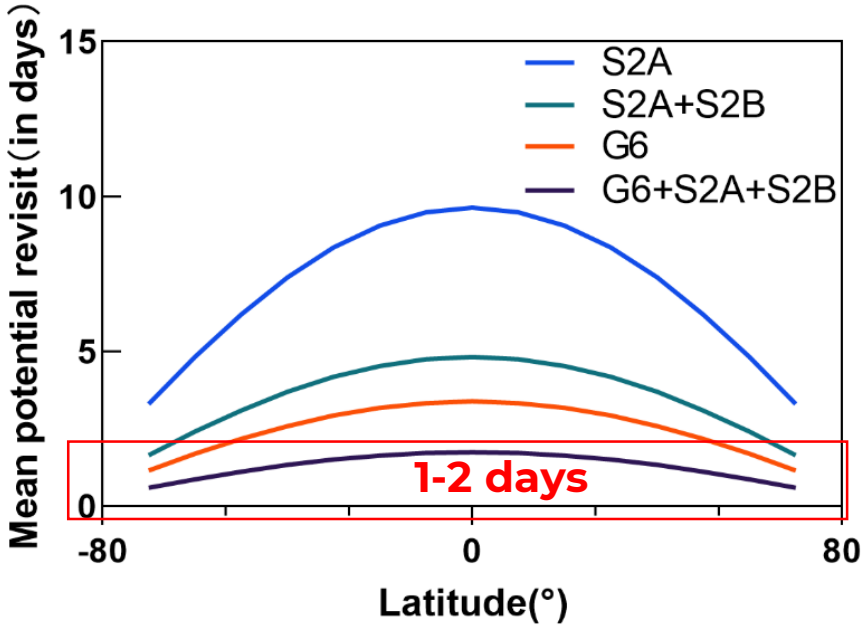
3.6 Canoy height estimation using space-borne stereo images and LiDAR data

3.1 Harmonizing GF and Sentinel-2

◆ Harmonizing GaoFen-1/6 WFV and Sentinel 2A/B MSI

The Gaofen-1/6 WFV have similar spatial resolution (16m) to Sentinel 2 MSI, but have larger image width (800Km) than Sentinel MSI and Landsat-8 OLI.

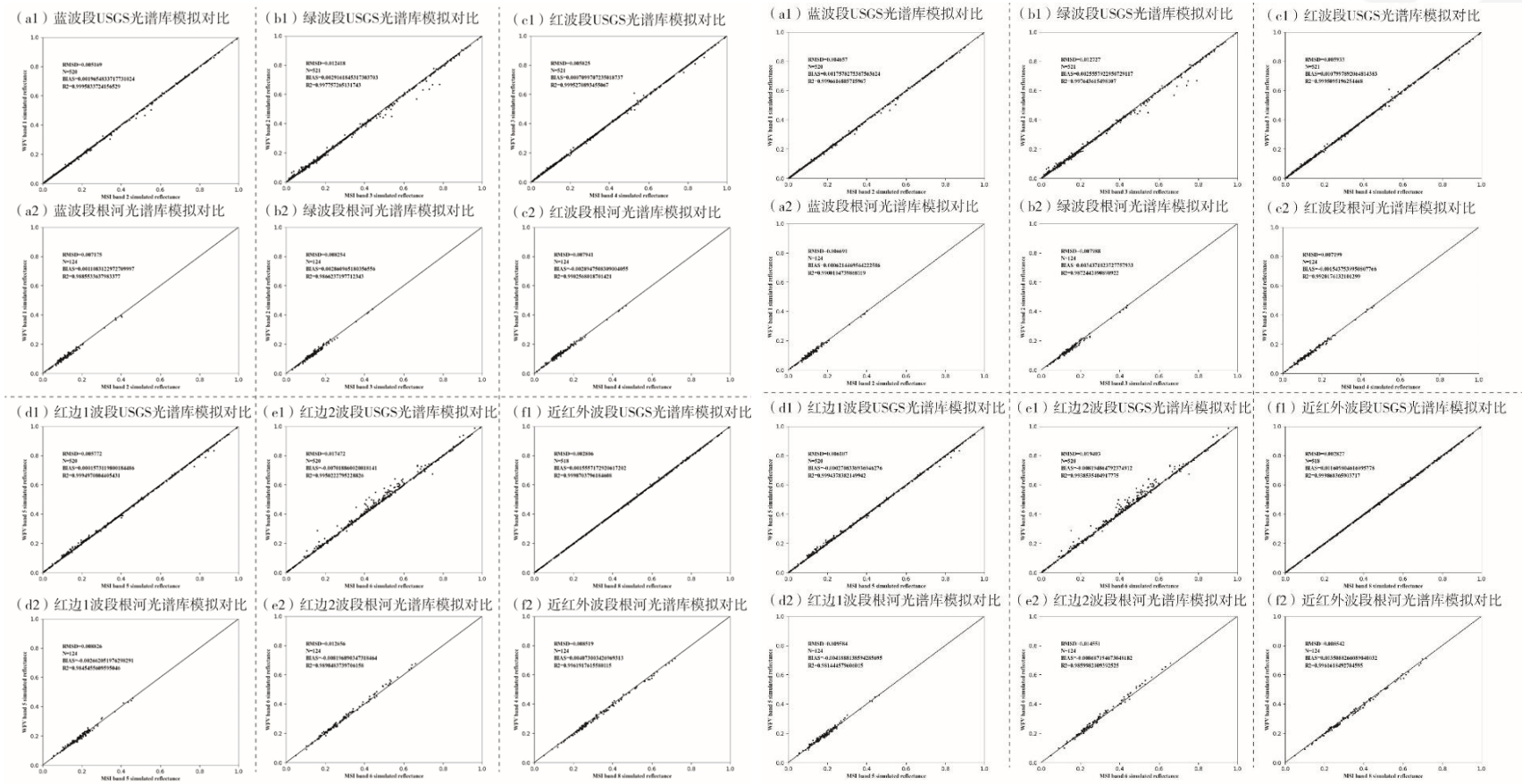




Harmonizing the Gaofen-1/6 and Sentinel-2 could help to increase the land surface observation frequency.

3.1 Harmonizing GF and Sentinel-2

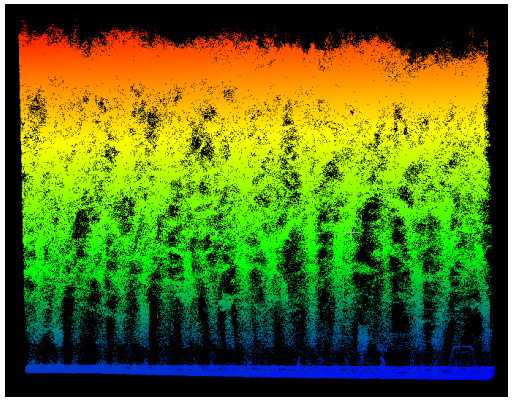
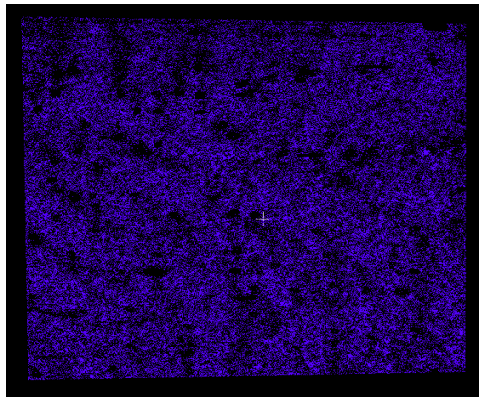
◆ Comparison of the simulated spectral reflectance and NDVI



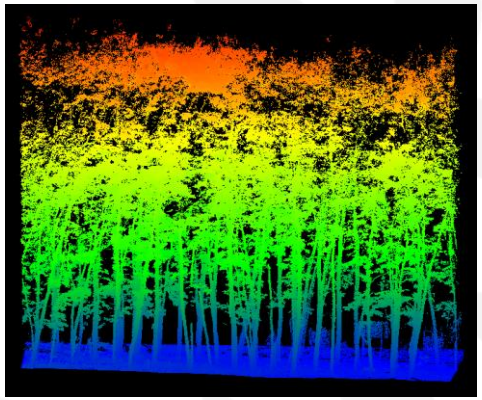
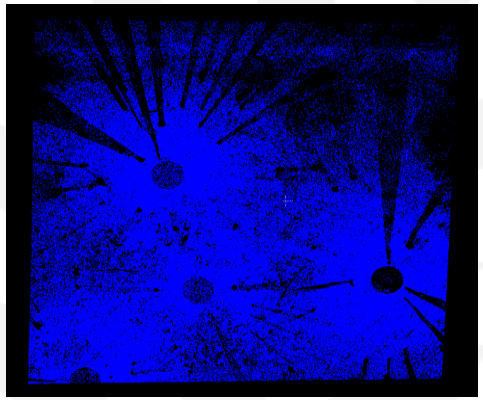
The RMSD values are quite small (< 0.019) for all of the reflective bands. The greatest reflective band difference is between the MSI NIR broad band 8 (785–900 nm) and the GF6 WFV NIR band 5 (770–890 nm) (RMSD=0.002).

The difference of simulated spectral reflectance is quite small.

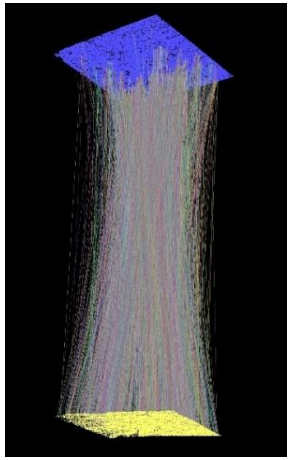
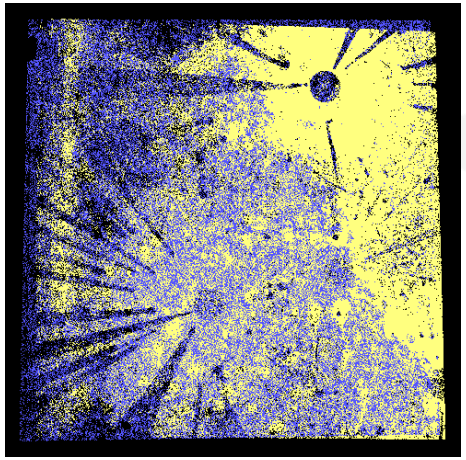
3.2 Fusion of UAV and TLS point cloud data

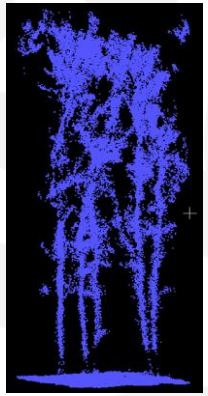
UAV point cloud and ground point extraction

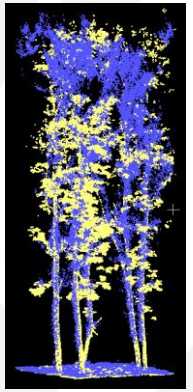



TLS point cloud and ground point extraction

FPFH feature matching and registration of ground point cloud



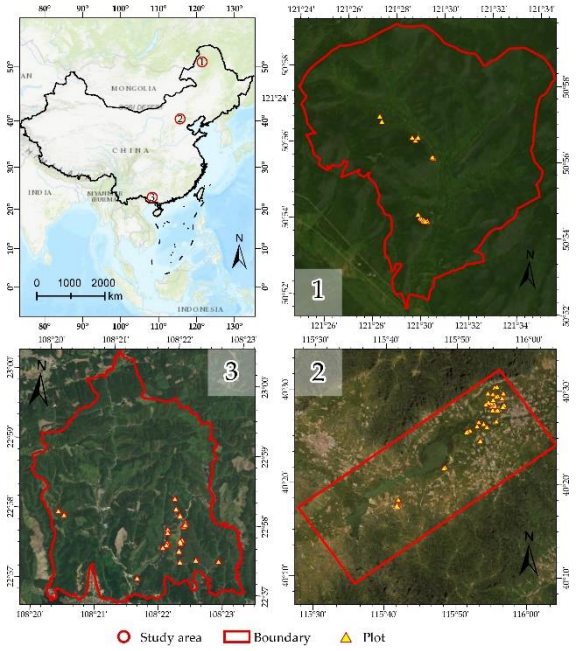


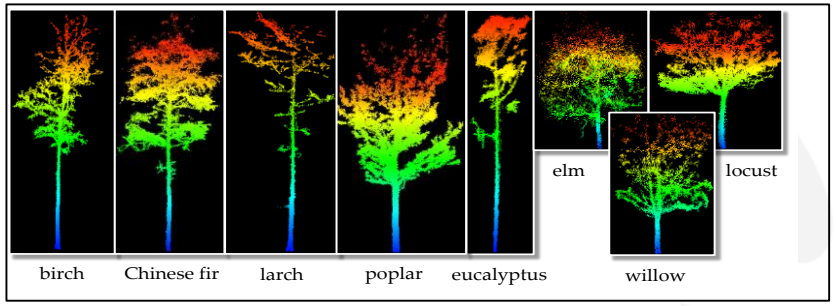
TLS-LiDAR UAV-LiDAR Fusion-LiDAR

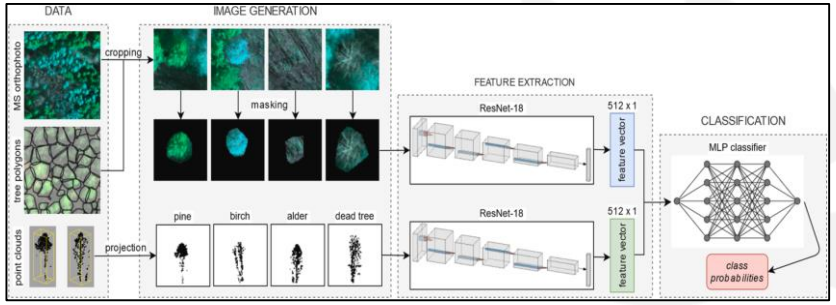
Selected area inside the Quercus mongolica plot

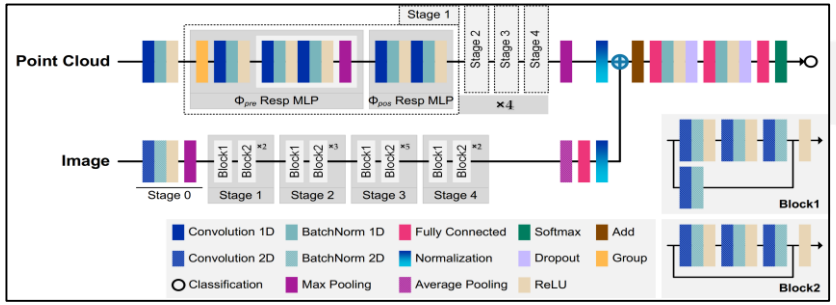
3.3 Tree Species Discrimination

Study area and data



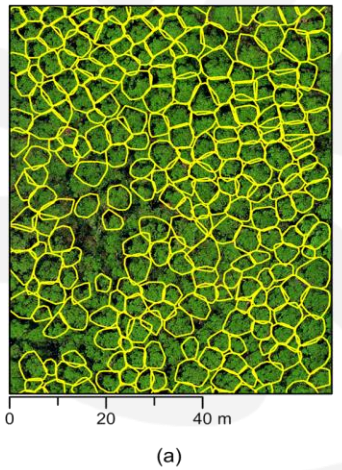


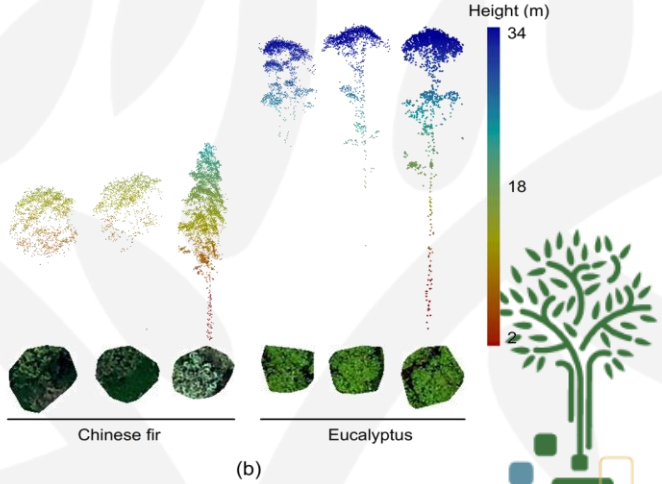




Accuracy comparisons among 8 methods

Model	*BAcc*		*Pr*		*Re*		*F*		*kappa*	
	Train	Test	Train	Test	Train	Test	Train	Test	Train	Test
PointNet	0.6251	0.7288	0.6277	0.7492	0.6351	0.7241	0.6288	0.7183	0.5726	0.679
PointNet++(MSG)	0.9642	0.9768	0.9648	0.974	0.9646	0.9732	0.9645	0.9731	0.9587	0.9687
PointNet++(SSG)	0.9579	0.9343	0.9579	0.9421	0.9579	0.9387	0.9578	0.9387	0.9508	0.9284
PointMLP	0.9097	0.9827	0.931	0.9818	0.9301	0.9808	0.9294	0.9808	0.9181	0.9776
PointMLP-elite	0.9467	0.9643	0.9562	0.9677	0.955	0.9655	0.955	0.9655	0.9473	0.9598
PointConv	0.9432	**0.9952**	0.9507	**0.9963**	0.9505	**0.9962**	0.9505	**0.9962**	0.9423	**0.9955**
DGCNN	**0.9759**	0.9614	**0.9847**	0.9648	**0.9847**	0.9647	**0.9845**	0.9647	**0.9821**	0.9588
PCT	0.9321	0.9232	0.9343	0.9441	0.9343	0.9425	0.9342	0.9426	0.9234	0.9329





3.4 Forest Disturbance Detection

Monitoring of European Spruce Bark Beetles

Early detection and large area mapping using Sentinel-2 images

- A new vegetation index (NDRS) was proposed to map the bark beetle damages.
- Spectral differences were observed before attacks

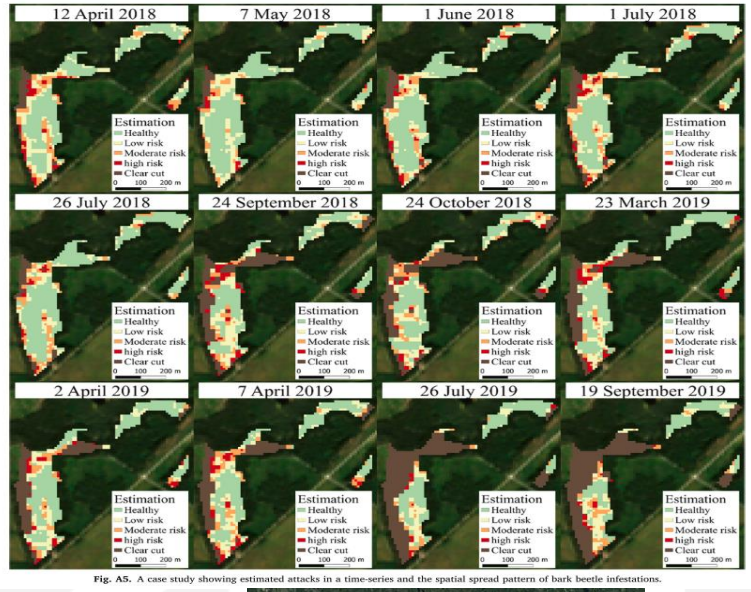
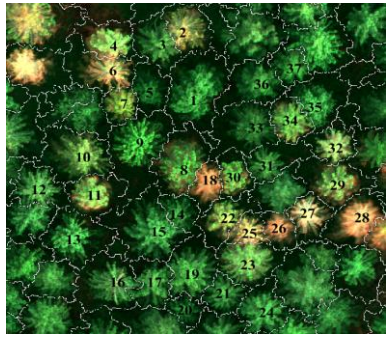


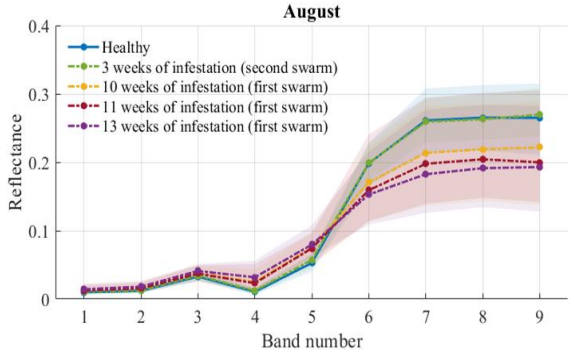
Fig. A5. A case study showing estimated attacks in a time-series and the spatial spread pattern of bark beetle infestations.

Early detection using drone images

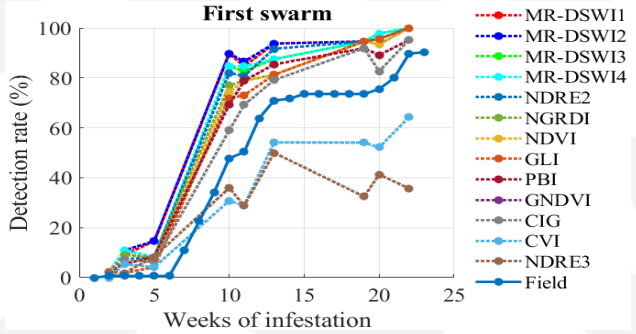
- How early did the infested trees show abnormal spectra was investigated.
- The continuous changes of the detectability during green-attacks was quantified.



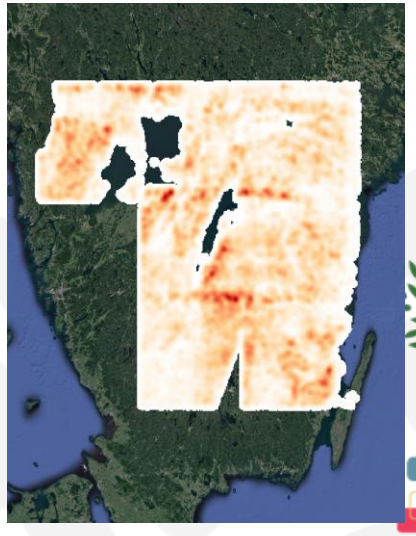
Segmentation of individual tree crowns in a drone image



Spectral signatures of tree groups infested for different duration



Detectability increased rapidly during 5 – 10 weeks of infestation



3.4 Forest Disturbance Detection

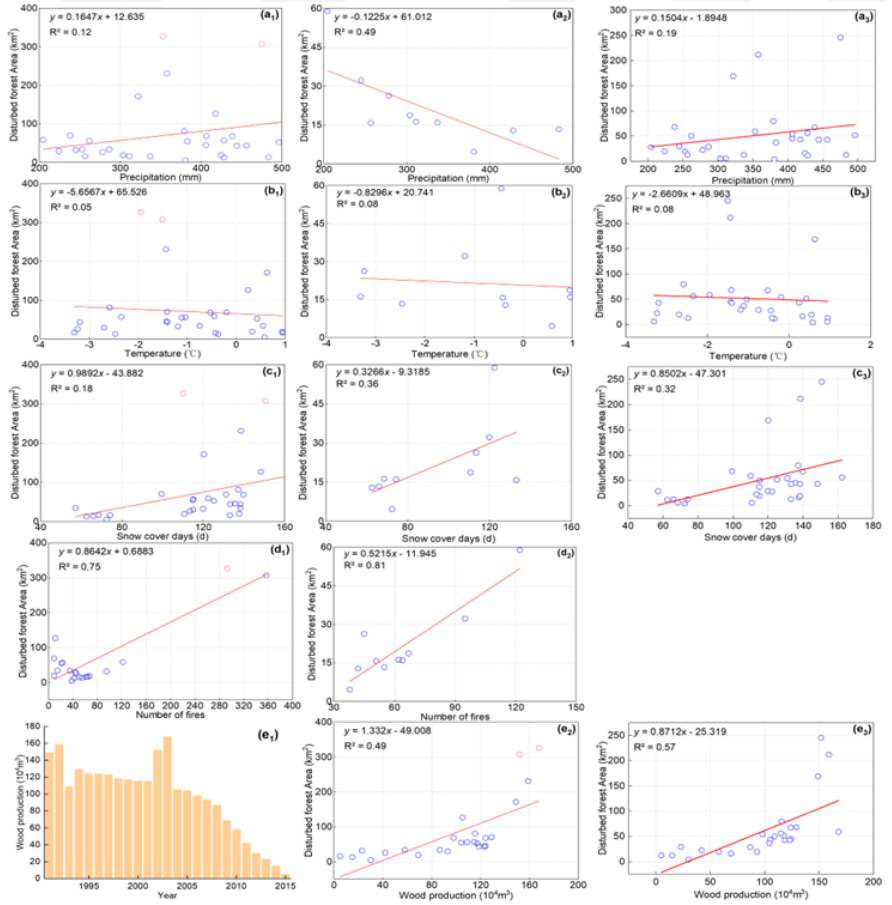
Tracking forest disturbance in Genhe

Occurrence pattern of forest disturbance

- Forests have been disturbed to the extent of 12.65% over the last 30 years, and the disturbed area generally showed a trend toward reduction, especially after commercial logging activities were banned in 2015. But there was an unusual increase in the disturbed area in 2002 and 2003 due to large fires.

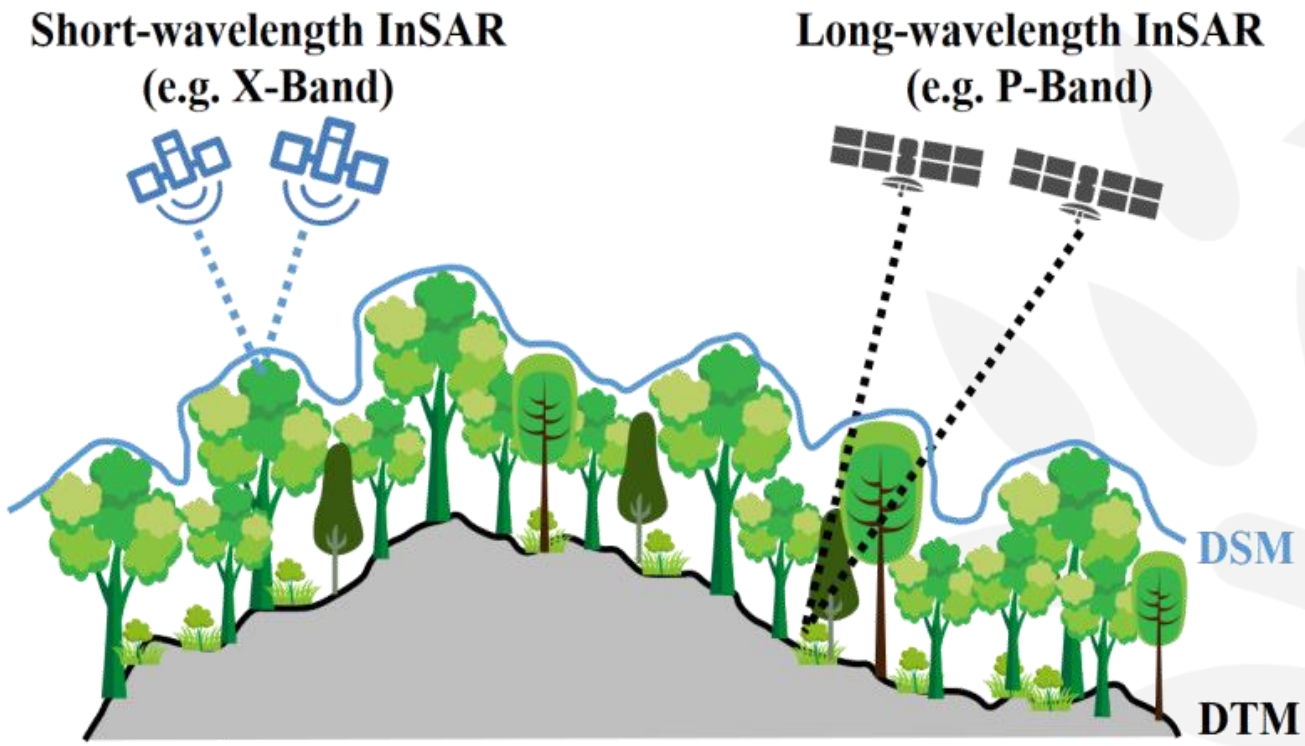
Influencing factor of forest disturbance

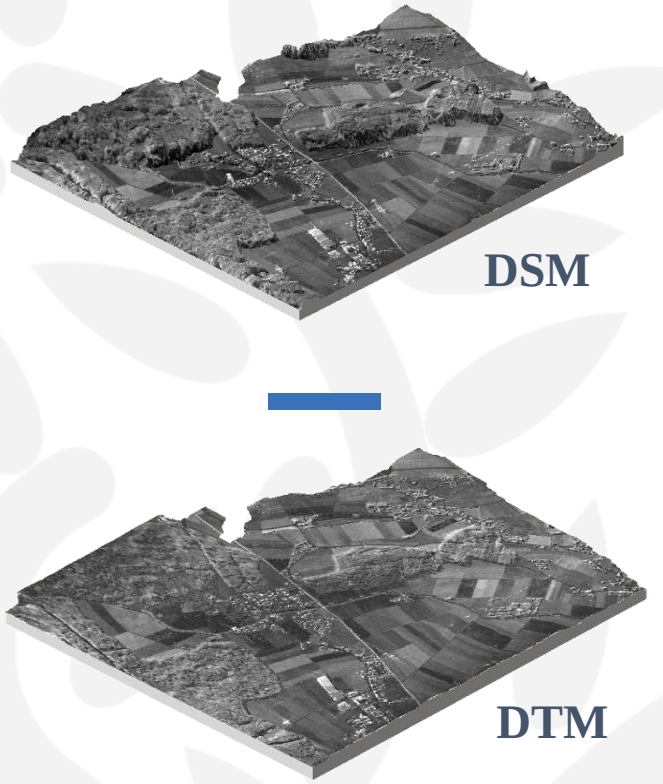
- Fire rather than climate is the main influence on forest disturbance.
- During the active period of commercial logging, disturbance was more strongly correlated with commercial logging and fire, both of which largely determined the distribution of forest disturbance across Genhe.



The Relationship between forest disturbance and its influencing factors. a_i, b_i, c_i, d_i, e_i are models between the area of disturbance for every year and its influencing factors (annual precipitation, annual average temperature, annual snow cover days, annual number of fires, annual commercial logging output) respectively; the disturbance area of (a_3, b_3, c_3, e_3) is the disturbance area caused by factors other than fire; (e_1) annual commercial logging output; the period of (e_2, e_3) is from 1991 to 2015.

3.5 Forest Height Extraction Method Based On Multi-band InSAR



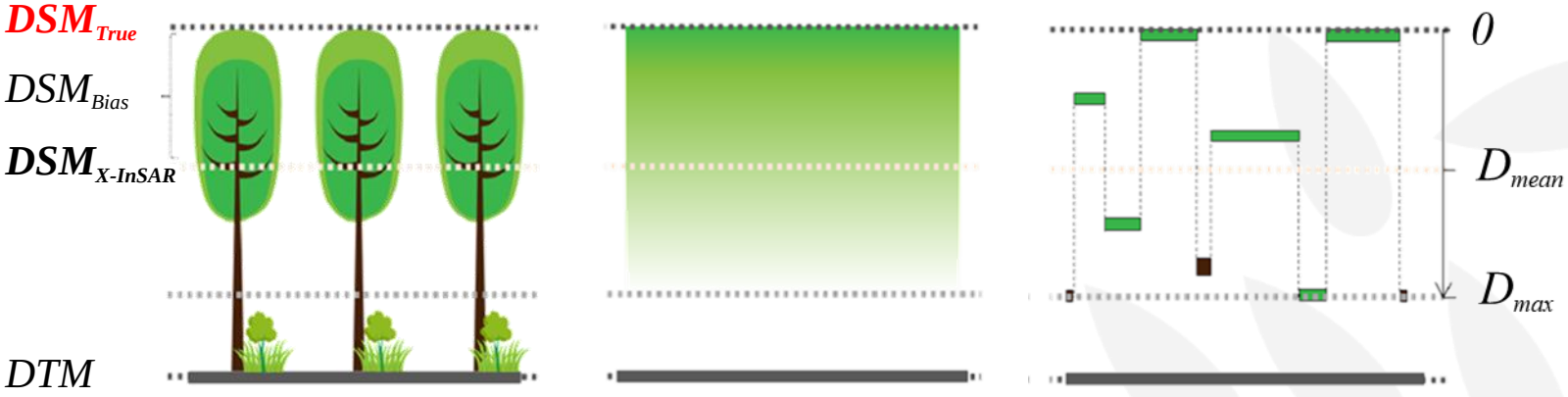


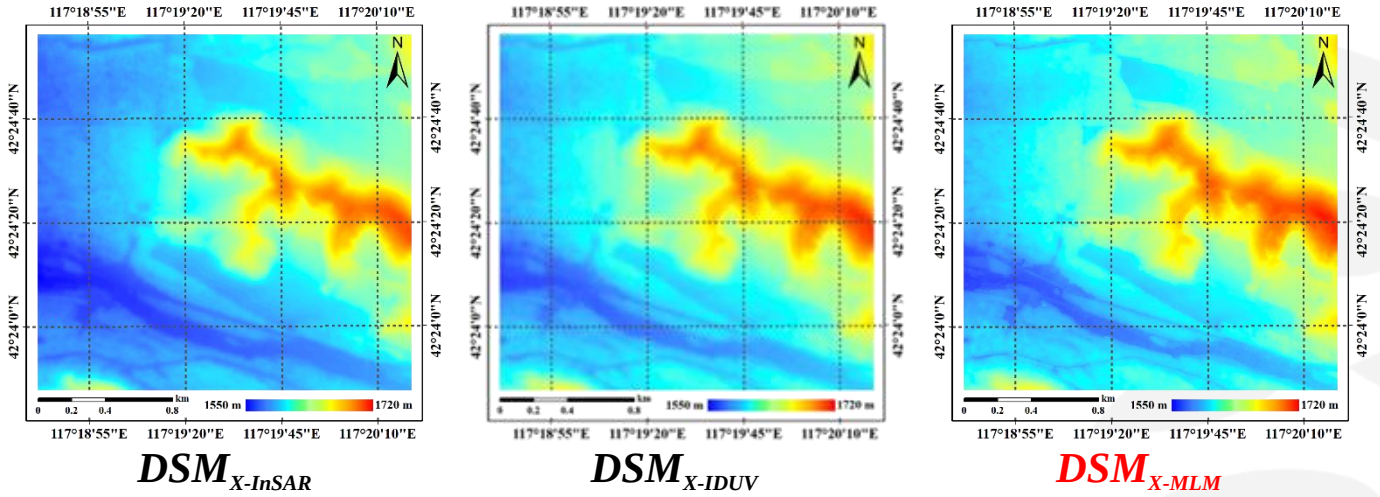
Utilizing the differences in forest penetration between long and short wavelength InSAR, the method obtains the forest height by extracting the high precision DSM and DTM.

Forest height

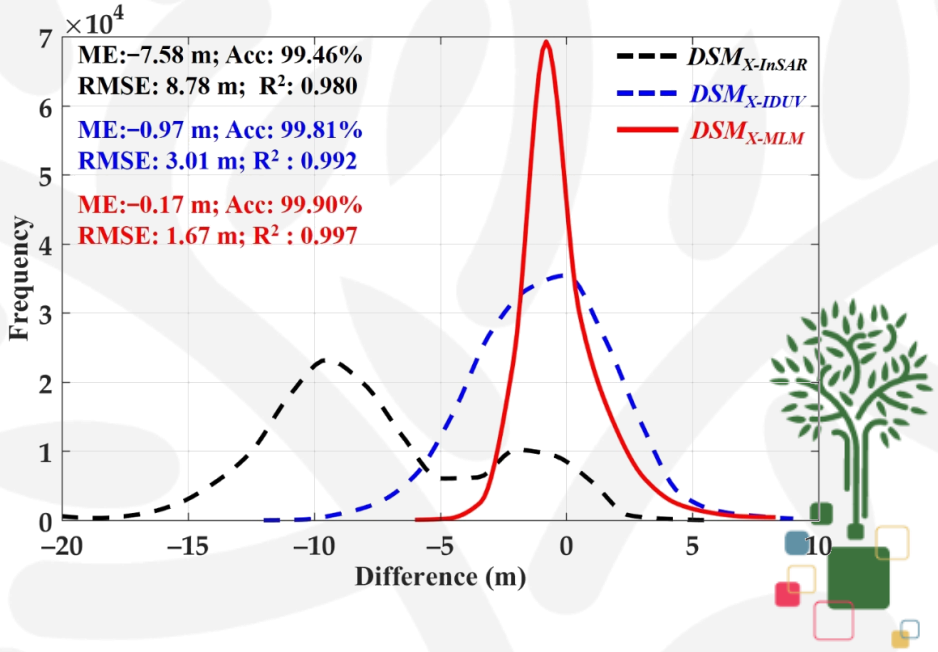
3.5 Forest Height Extraction Method Based On Multi-band InSAR

◆ X-band DSM compensation based on multi-level model (MLM)





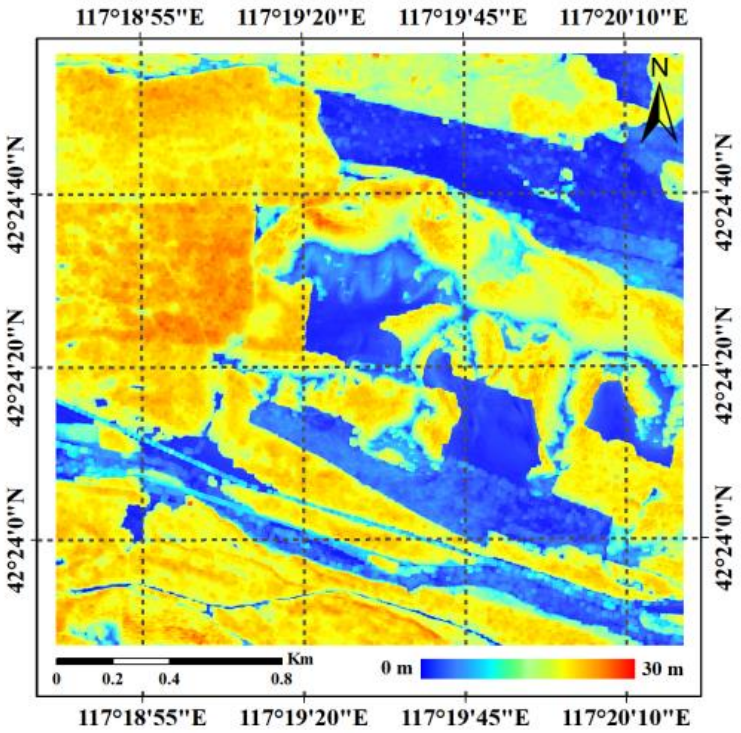
- In MLM, forest is seen as multi-layers scatters with gaps, which is more in line with the scattering mechanism of X-band InSAR under the forest scenario than existing model (IDUV model).



3.5 Forest Height Extraction Method Based On Multi-band InSAR

◆ Forest height estimation results based on Multi-band InSAR

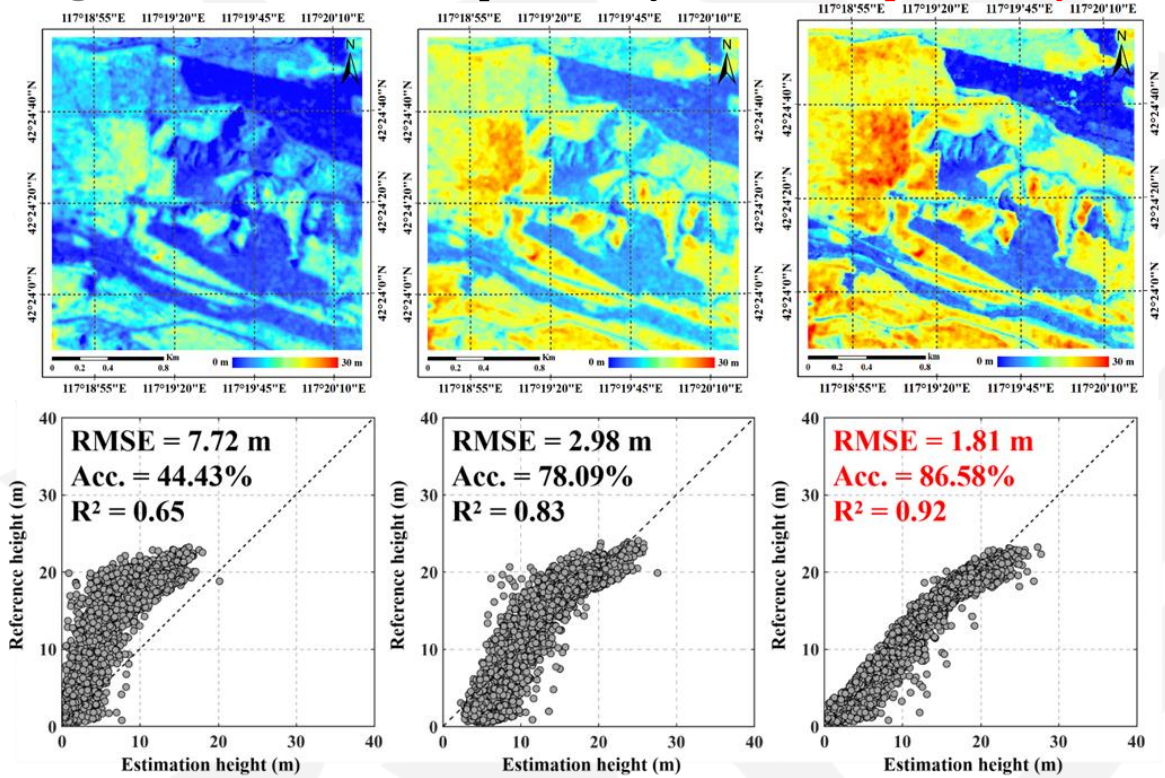
LiDAR CHM



P-band DTM + original X-band DSM

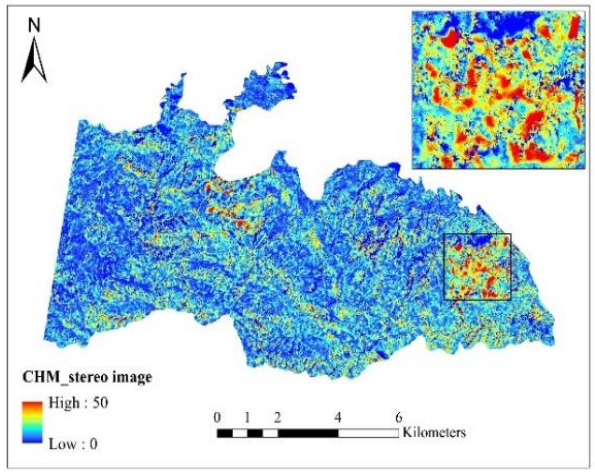
P-band DTM + DSM compensated by IDUV

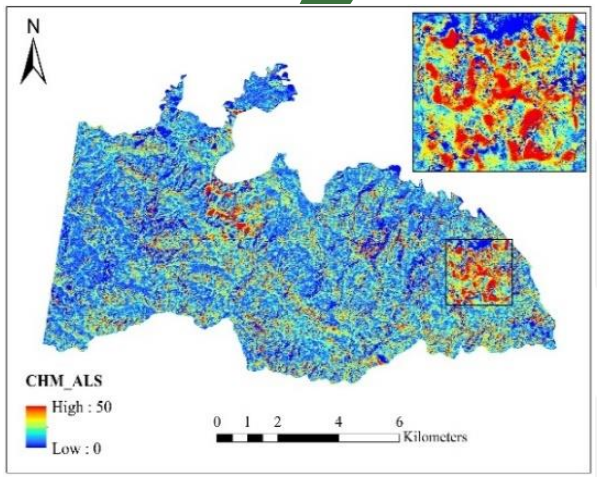
P-band DTM + DSM compensated by MLM



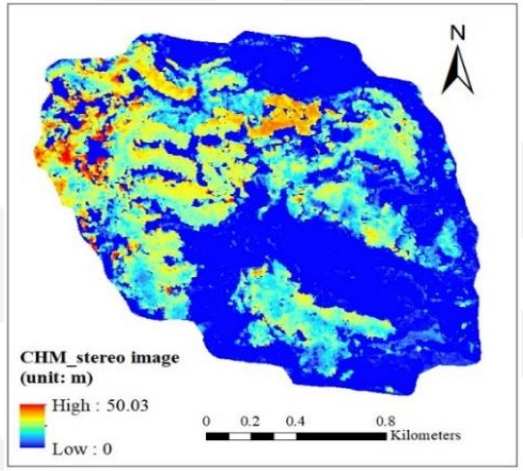
The forest height extraction based on original X-band DSM are significantly underestimated.

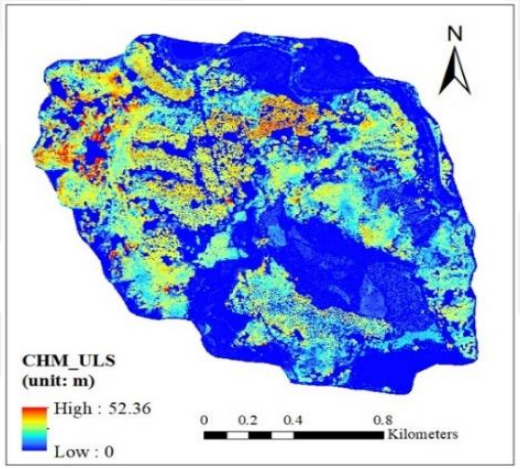
3.6 Canoy height estimation using space-borne stereo images and LiDAR data



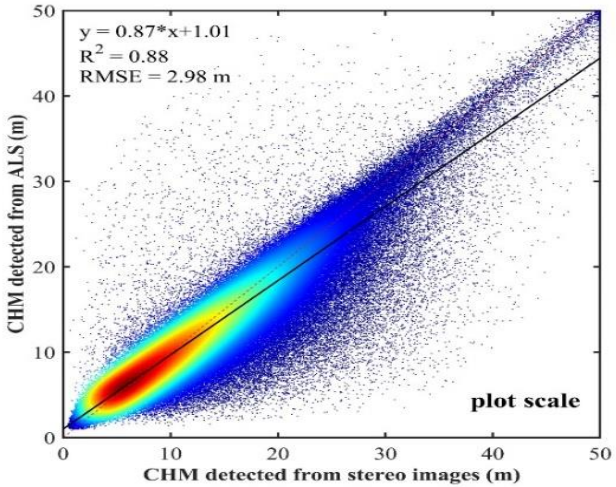


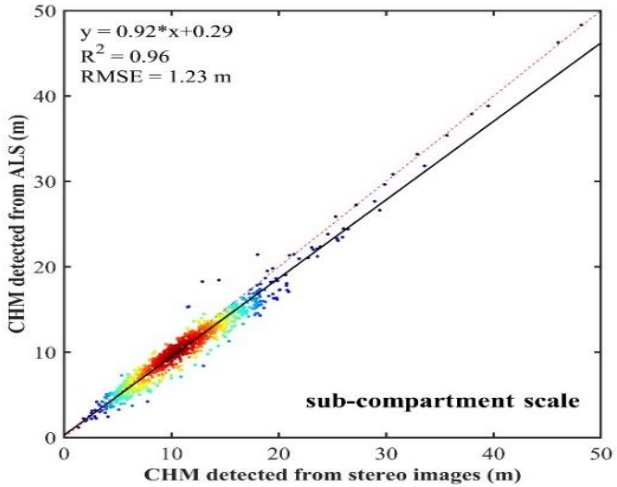
CHM obtained from GF7 stereo images (Left) and ALS (Right)



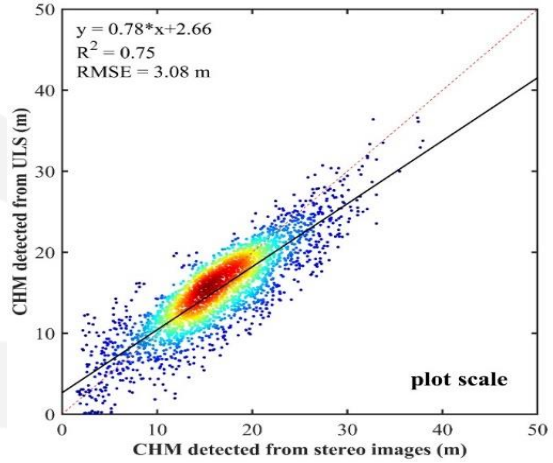


CHM obtained from GF7 stereo images and ULS





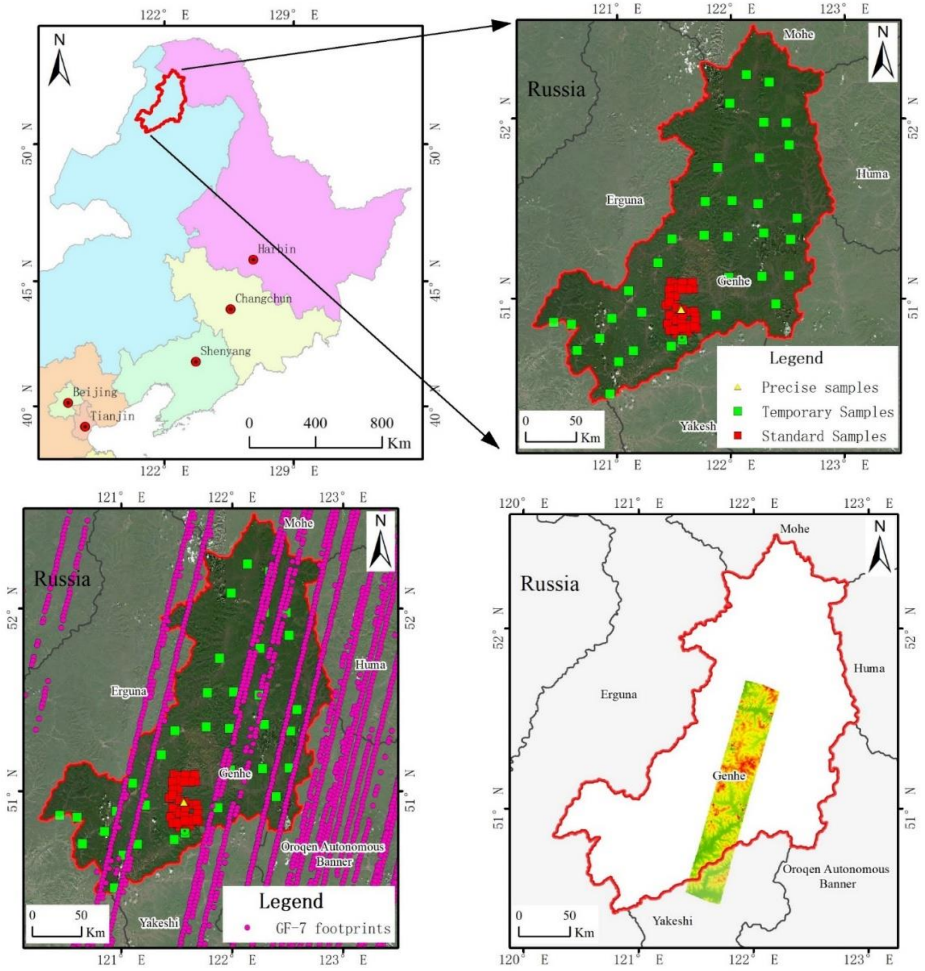
Validation of CHM detected from stereo images and ALS data

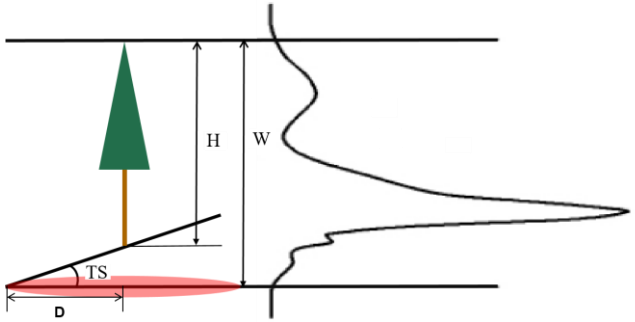


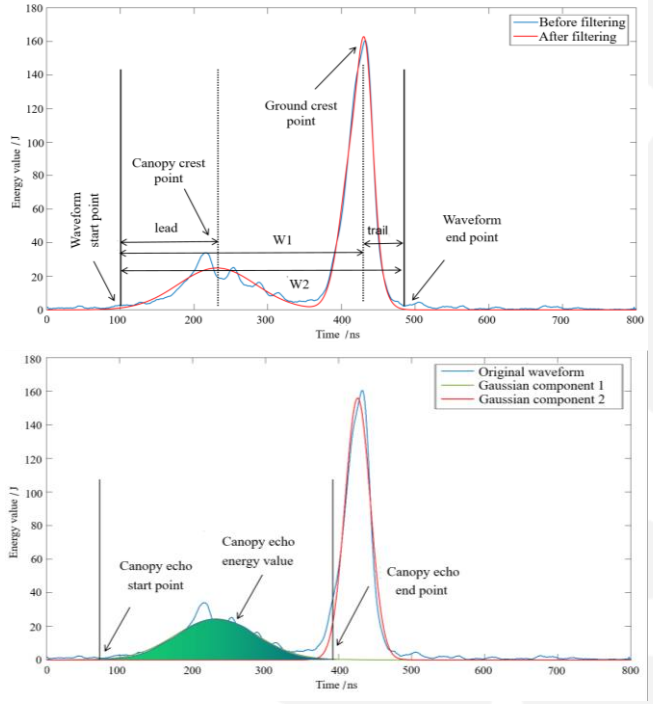
Regression result of CHM detected from GF-7 stereo images and ULS data

3.6 Canoy height estimation using space-borne stereo images and LiDAR data

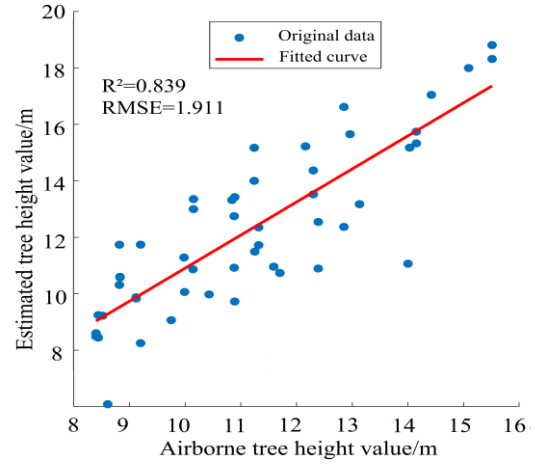
Genhe study area and data

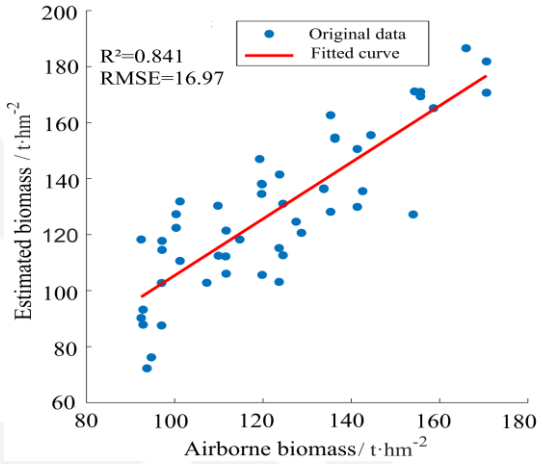






Model precision comparison





4. Other Activities

4.1 Remote Sensing Campaign

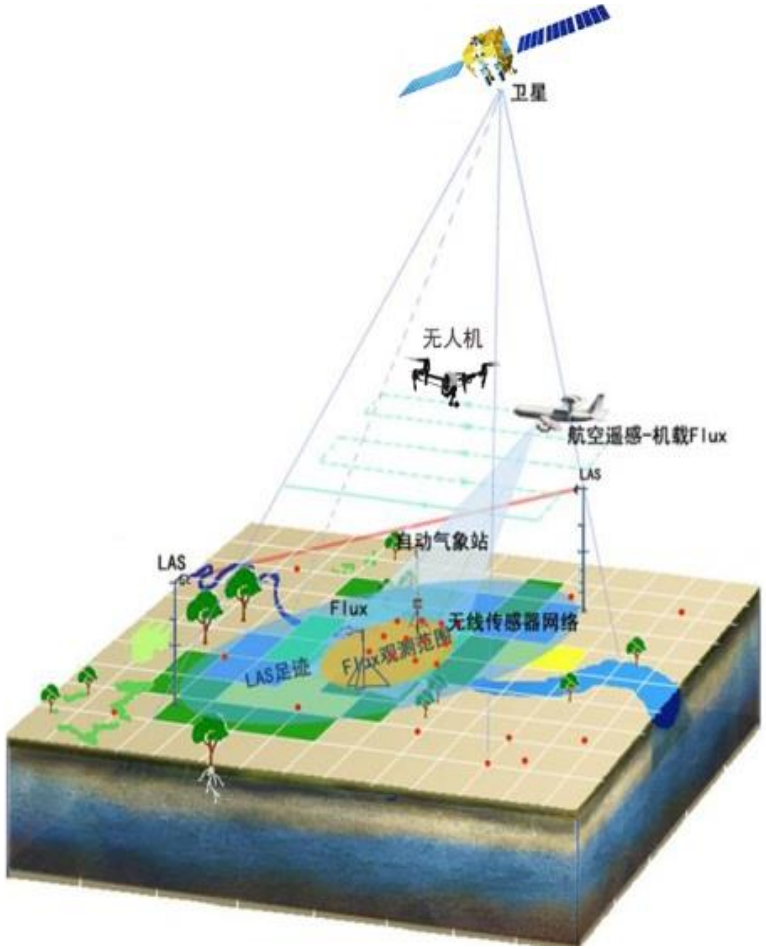
4.2 Airborne Sensors and Aircrafts

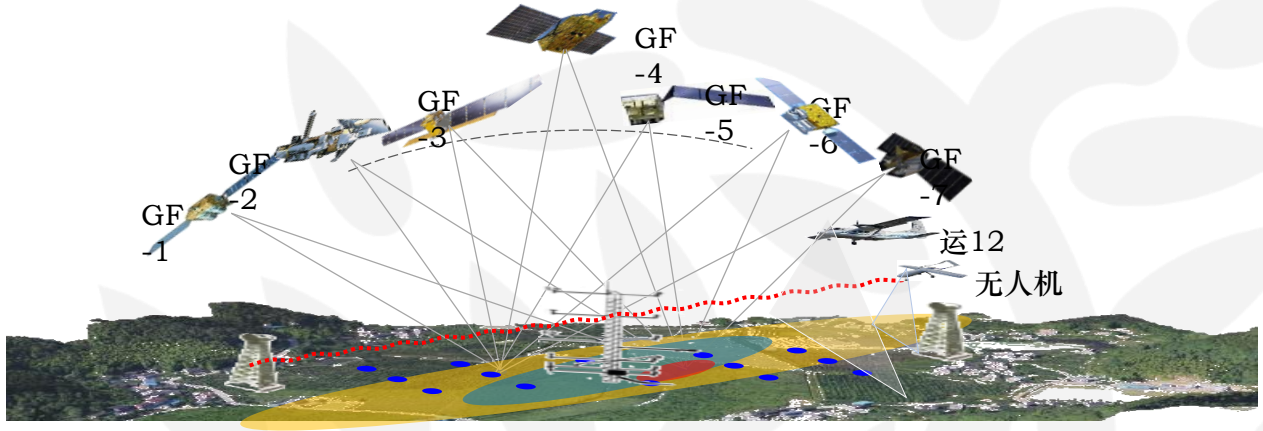
4.3 UAV Sensors and Aircrafts

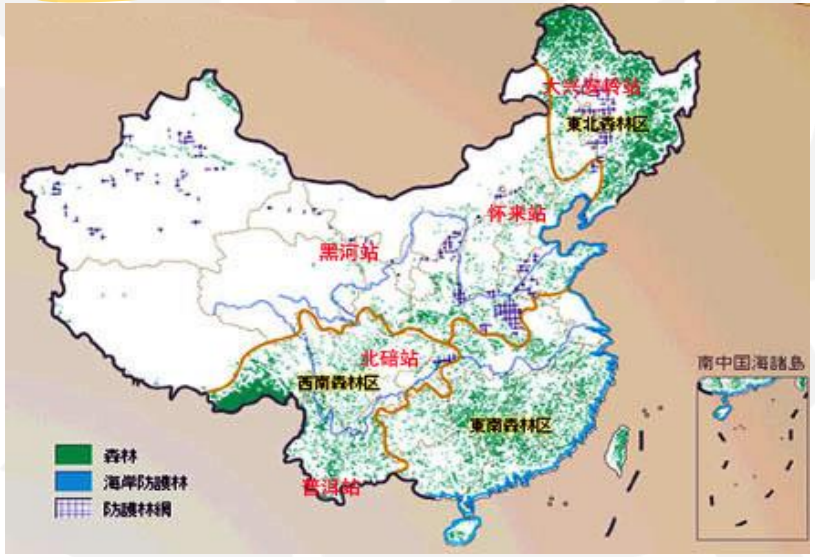
4.4 Field Measurements

4.1 Remote Sensing Campaign

◆ Spaceborn-Airborne-Ground-based Remote Sensing Campaigns







4.2 Airborne Sensors and Aircrafts

Multi-spectral

Lidar+Infrared +Hyper-spectral

C-SAR

Xinzhou-60

Quest Kodiak 100

Cessna 208

4.3 UAV Sensors and Aircrafts

Multi-spectral

Hyper-spectral

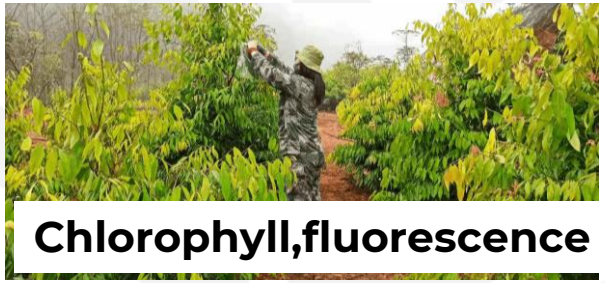
Lidar

4.4 Field Measurements

Pu’er, Yunnan-2020

A total of 1242 samples

- DOM/DSM:200
- Landcover/Landuse：716
- Forest plots:100
- Soil moisture:23
- Chlorophyll,fluorescence:63
- Water Color:35
- ASD、PAR、LAI、 Surface emissivity:105


Chlorophyll,fluorescence

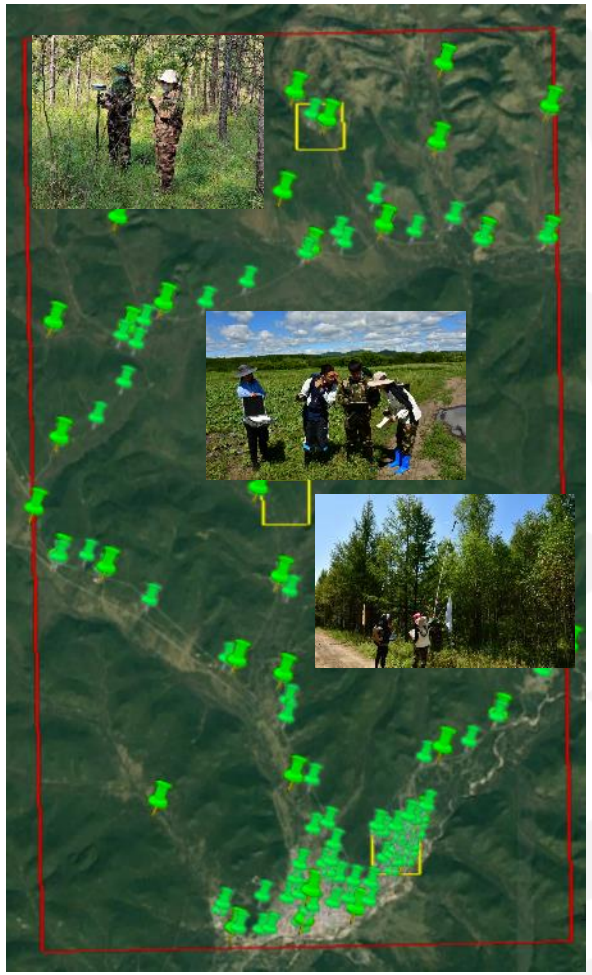

Forest plots

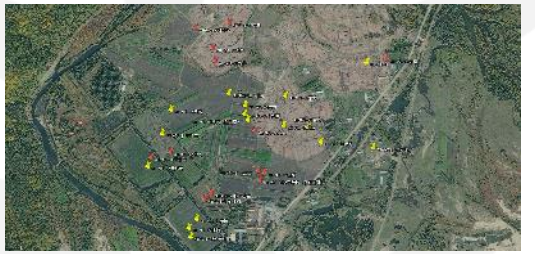

APAR


Water Color

4.4 Field Measurements

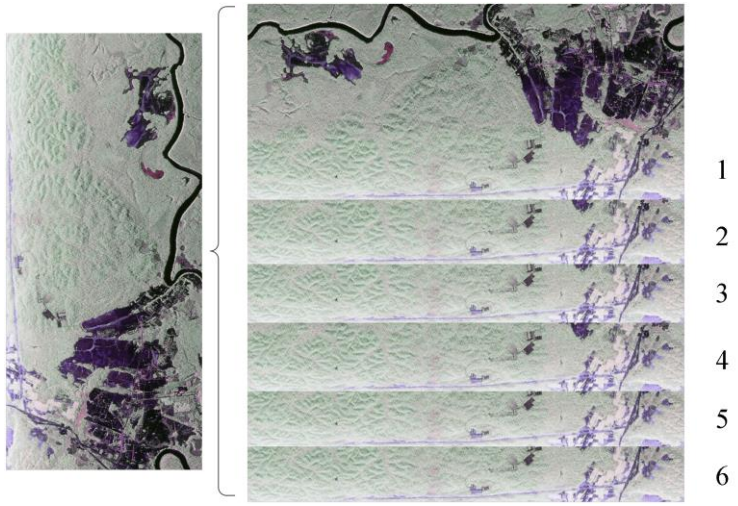
Genhe, Inner Mongolia-2022



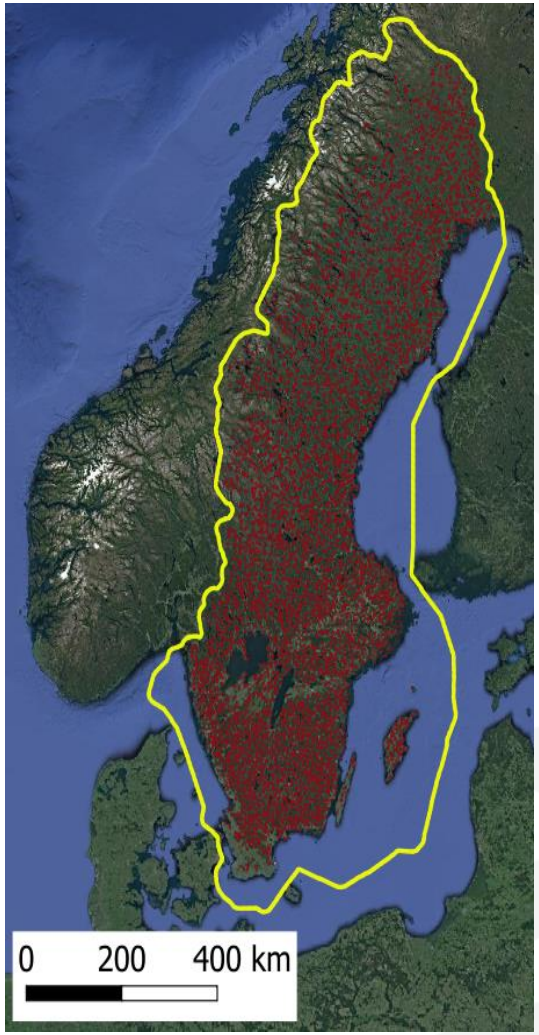


4.4 Field Measurements

French Guiana



Kielder, UK



Sweden

5. Summary

What we have:

- G: Good Guidance and performance of “carbon peaking and carbon neutrality goals”
- F: Full Functional and technical link connects forest observations
- O: Outstanding Organization on China GEO
- I: Insistent International cooperation mechanisms and platforms

We firmly believe China can contribute more to GFOI through our joint efforts

Thank you!