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

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

Goumang (Terrestrial ecosystem carbon monitoring satellite)

Lutan-1 (L-band SAR)
1.3 Sino-EU Cooperations

- Dragon Programme

734 scientists from 213 European and Chinese institutes (shown) are cooperating in Dragon 5
1.3 Sino-EU Cooperations

Symposiums

Training courses

China International Science and Technology Cooperation Award-2013

National Friendship Award-2014

About 1200 young scientists trained

Prof. Fabio Rocca

EU PI: Dr. Yves-Louis Desnos
1.3 Sino-EU Cooperations

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

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.

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

IFRIT+ University of Rennes 1, France

IFRIT+ Forest Research, Northern Research Station, UK

IFRIT+ Swedish University of Agricultural Sciences
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

<table>
<thead>
<tr>
<th>GFOI</th>
<th>S</th>
<th>P</th>
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<tbody>
<tr>
<td><strong>Data</strong></td>
<td></td>
<td></td>
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<tr>
<td>Full coverage /Yr</td>
<td>Landsat Sentinel</td>
<td>Large gap</td>
<td>Dense active and passive data</td>
</tr>
<tr>
<td><strong>Type &amp; Disturbance</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High resolution/ Automatically</td>
<td>Large samples Spatial &amp; spectral</td>
<td>Poor Transferability Low resolution</td>
<td>Small, multiscale, Transfer Learning</td>
</tr>
<tr>
<td><strong>Parameters</strong></td>
<td></td>
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<tr>
<td>Various scenario/ Wall to Wall</td>
<td>Sampling Single</td>
<td>Simple Unstable</td>
<td>Active &amp; Passive synergy</td>
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</tbody>
</table>
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 Collaborative 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

- Method and guidance documentation
  User-friendly methods and guidance materials that address UNFCCC requirements for REDD+ and comply with IPCC guidance.

- Research and development
  Addressing knowledge gaps to foster progress and continuous improvement in forest monitoring.

- Data
  Support for countries' capacities to access and use data and tools for countries for forest monitoring.

- Capacity building
  Joint capacity building for effective knowledge and technology transfer.

- 1 Monitoring System
- 5 Demonstrations
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 Canopy 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
- Selected area inside the Quercus mongolica plot
3.3 Tree Species Discrimination

Study area and data

Accuracy comparisons among 8 methods

<table>
<thead>
<tr>
<th>Model</th>
<th>BAcc</th>
<th>Pr</th>
<th>Re</th>
<th>F</th>
<th>kappab</th>
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<tr>
<td></td>
<td>Train</td>
<td>Test</td>
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<td>0.9618</td>
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<td>0.9411</td>
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</tr>
</tbody>
</table>

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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

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. $a_1, b_1, c_1, d_1, e_1$ 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 $(a_2, b_2, c_2, e_2)$ is the disturbance area caused by factors other than fire; $(e_3)$ 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.
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

- 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 Canopy height estimation using space-borne stereo images and LiDAR data

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 Canopy height estimation using space-borne stereo images and LiDAR data

Genhe study area and data

Model precision comparison

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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
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!