

Mapping Industrial Forests in Tropical Monsoon Asia

Jinwei Dong

University of Oklahoma

Earth Observation and Modeling

University of Oklahoma

NASA LCLUC Science Team Meeting, April 18-19, 2016, Maryland

Acknowledgement :

A network of international collaborators for studying in tropical monsoon Asia

USA: Jinwei Dong, Xiangming Xiao, Yuanwei Qin, University of Oklahoma;
Williams Salas, Nathan Torbick, Applied Geosolutions, *Inc*.

Indonesia: Ketut Wikantika, Institute of Technology Bandung;
David Gaveau, Centre for International Forestry Research;

Laos: Thongmanivong Sithong, National University of Laos;

Malaysia: Khali Aziz, Forest Research Institute Malaysia;

Myanmar: Aung Lwin, Mandalay Technological Univ., Mandalay;

Philippine: Remedios Evangelista, Forest Management Bureau, Philippines;

Thailand: Manzul Hazarika, Asian Institute of Technology, Bangkok;

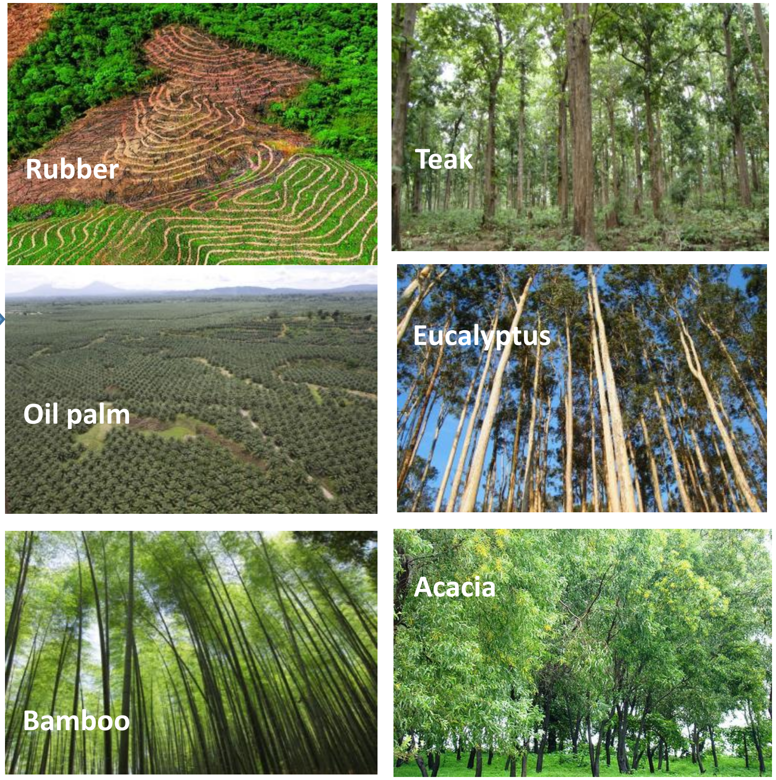
Vietnam: Nguyen Dinh Duong, Inst. of Geography, Hanoi;

China: Yong Pang, CAF;Bangqian Chen, Jun Ma, Fudan U; Weili Kou, SWFU

NASA Land-Cover and Land-Use Change Program LCLUC

Why care about industrial forests ?

Increasing tropical forests converted into industrial forests



Why care about industrial forests in monsoon Asia?

Most of the global forest conversion from natural to industrial forests happened in tropical monsoon Asia.

e.g.,
~90% global palm oil
~97% global natural rubber production
(Li and Fox, 2012)

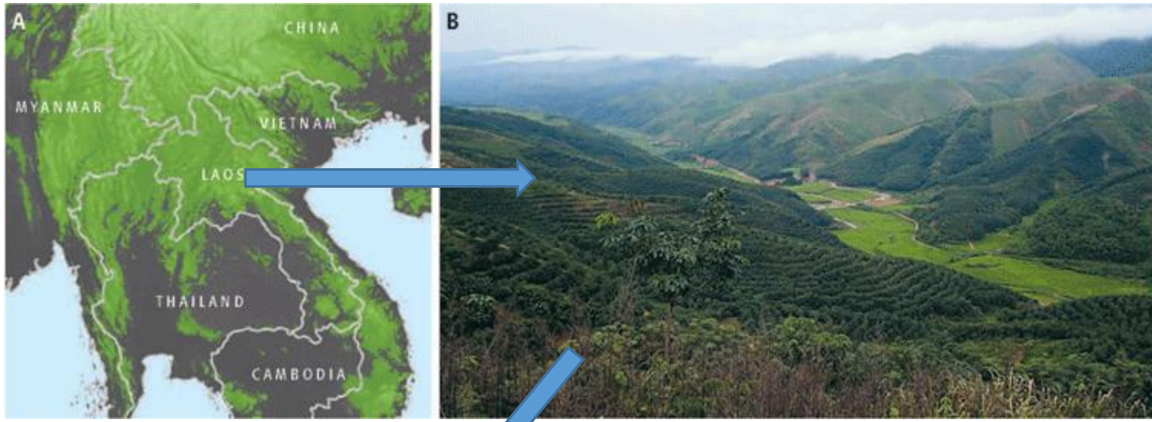
(Muller, 2012)

Rubber plantation expansion in tropical monsoon Asia

Some facts

- >95% of global rubber plantations from Southeast Asia
- Rubber production increased by more than 1,500 % from 1961-2011
- By 2020, almost 640,000 hectares of protected areas will be converted to rubber trees

(Ahrends *et al.*, GEC 2015)



(Ziegler *et al.*, Science 2009)

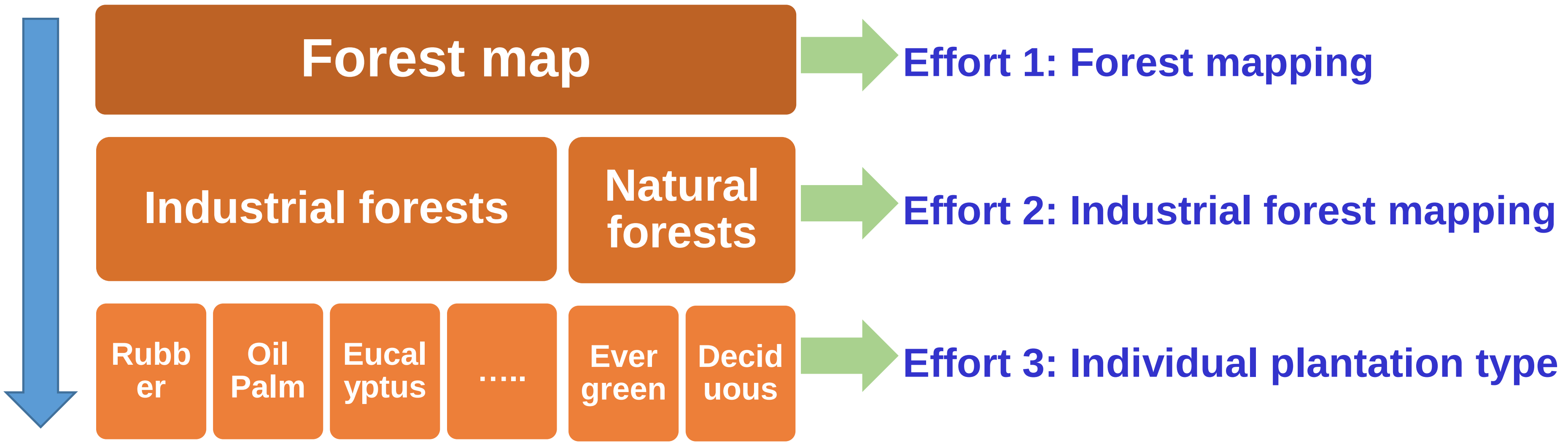
Soil erosion,
Biodiversity loss,
Carbon stock decrease,
Local climate change
……

However, industrial forest maps are very limited

Project objective

to map the major industrial forest plantations in tropical monsoon Asia and quantify their changes

From forest mapping to industrial forest mapping



How well existing forest maps support conservation policy?

Uncertainty in forest baseline

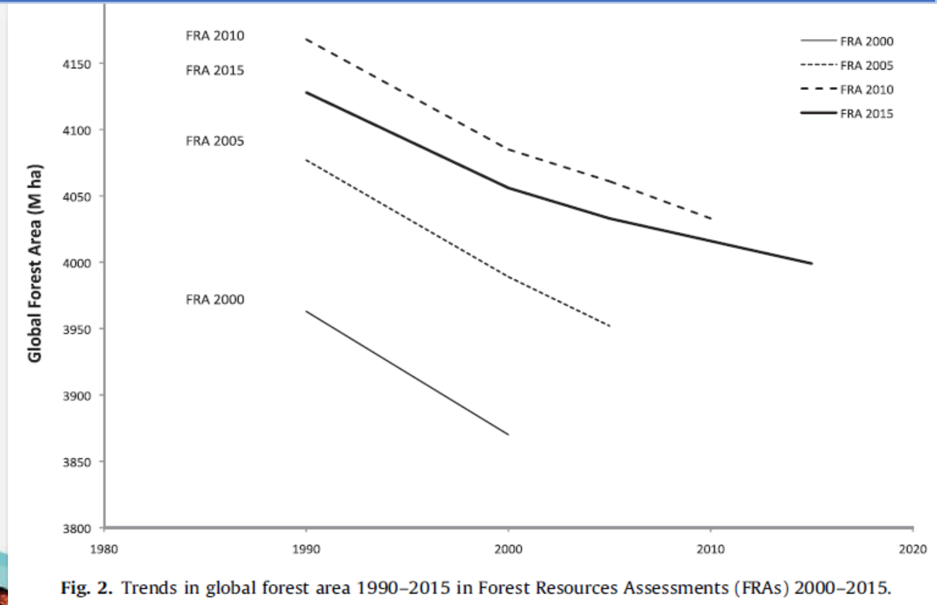
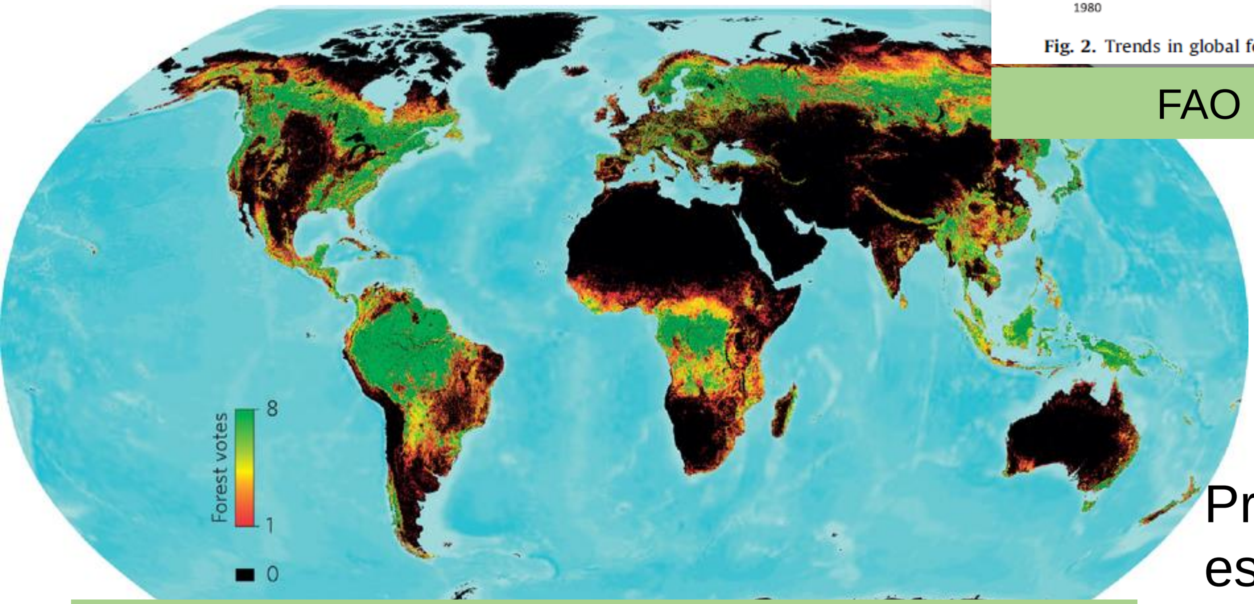


Fig. 2. Trends in global forest area 1990–2015 in Forest Resources Assessments (FRAs) 2000–2015.

FAO FRA 2000/2005/2010/2015

(Keenan *et al.*, FEM, 2015)



Great discrepancy in existing global forest maps

(Sexton *et al.*, Nature Clim Chang 2015)

Previous satellite-based estimates of global forest area range from 32.1×10^6 to 41.4×10^6 km^2

How well existing forest maps support conservation policy?

- A continued **sharp decrease of net forest area losses** with -3.3 Mha/yr from *ca.* 2010 to *ca.* 2015, mainly in the tropics.

  -----*FAO FRA 2015*

- Tree cover **loss is rapidly accelerating** in the tropics in 2014. -----*WRI/GFW 2015*

Uncertainty in forest dynamics

Baseline Map of Carbon Emissions from Deforestation in Tropical Regions

Nancy L. Harris,[1]* Sandra Brown,[1] Stephen C. Hagen,[2] Sassan S. Saatchi,[3,4] Silvia Petrova,[1] William Salas,[2] Matthew C. Hansen,[5] Peter V. Potapov,[5] Alexander Lotsch[6]

30% of previously published estimates for an overlapping time period. The largest source of uncertainty in our analysis is the estimates of gross forest-cover loss across large regions. This

(Harris *et al.*, Science 2012)

Objective 1: Improve forest maps through integration of optical and microwave images

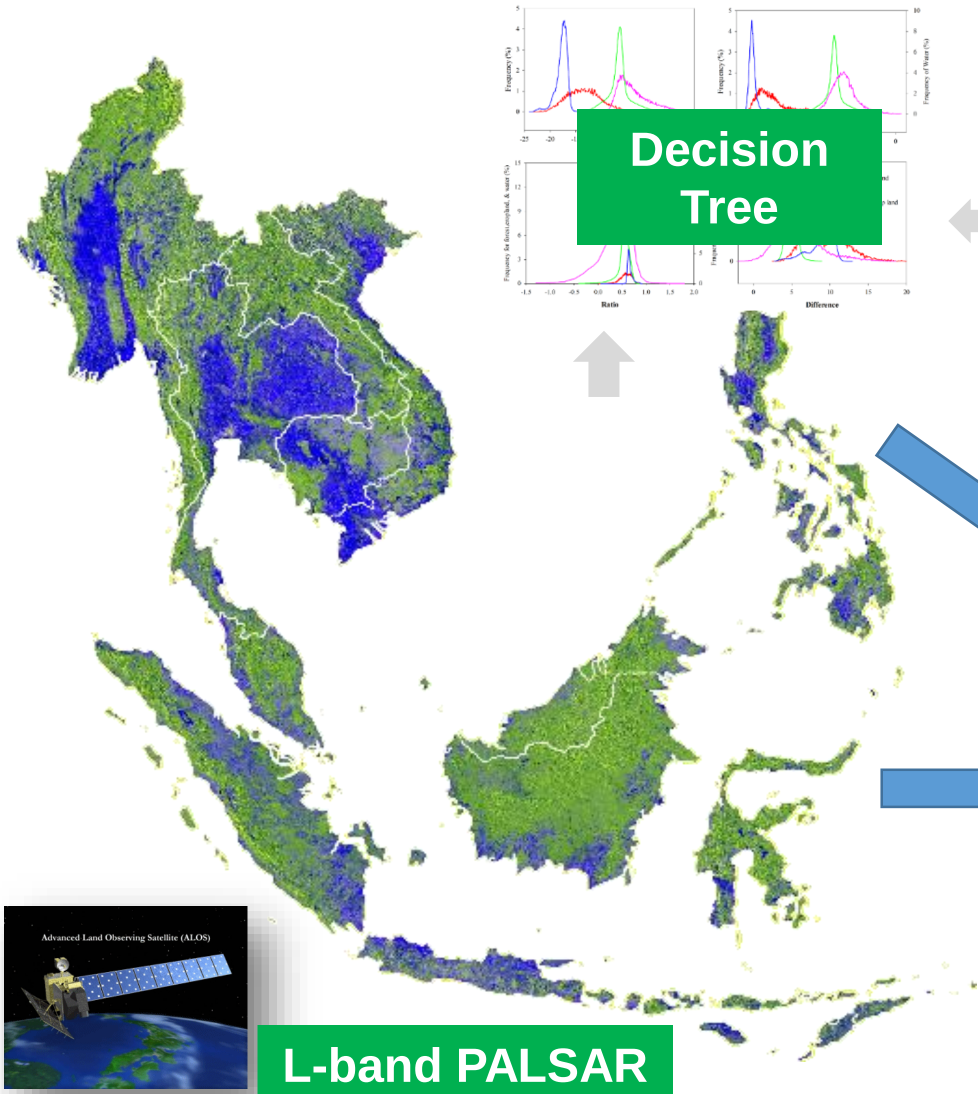
- Existing forest mapping efforts are generally based on optical RS.
- Advantages of L-band PALSAR has been recognized, but limitedly used due to data availability.

Hypothesis: Inclusion of both forest structure and canopy information will help to improve forest mapping

Optical RS: sensitive to vegetation/foliage cover

L-band PALSAR: sensitive to structure (e.g., tree height, biomass) and vegetation/surface moisture conditions

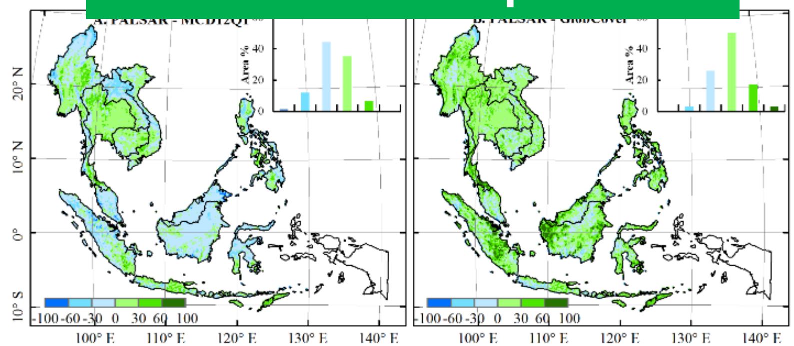
Cloud-free PALSAR based forest mapping *(Ver_0)*



Decision Tree

Global Field Photo Library

PALSAR-based forest cover map

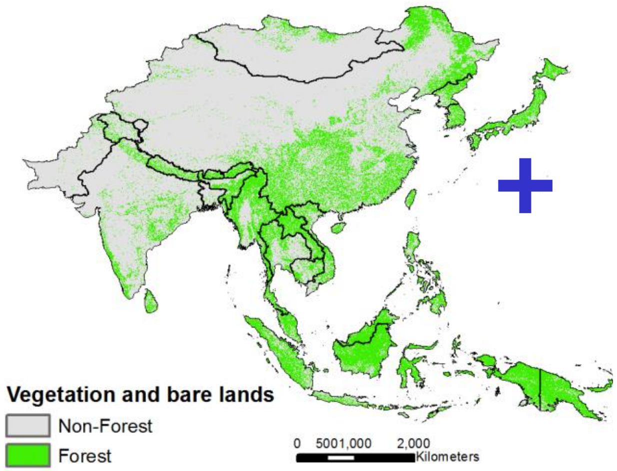


L-band PALSAR

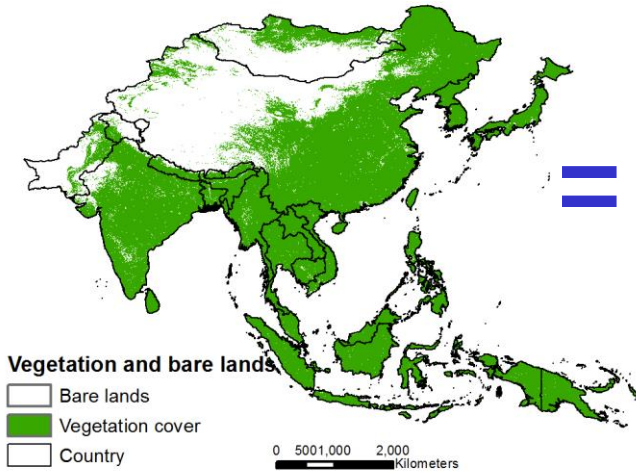
(Dong *et al*., RSE, 2012;)
(Dong *et al*., Plos One, 2014)

Improved PALSAR+Optical RS based forest mapping ***(Ver_1)***

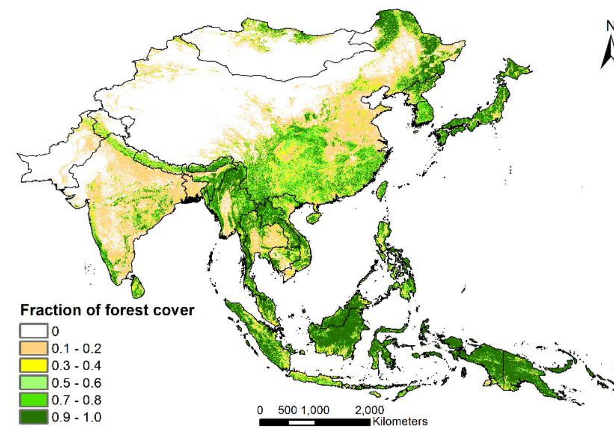
PALSAR-based Forest Layer + **Max NDVI-based Vegetated Layer** = **Forest Map**



A. PALSAR FNF



B. NDVI$_{max}$

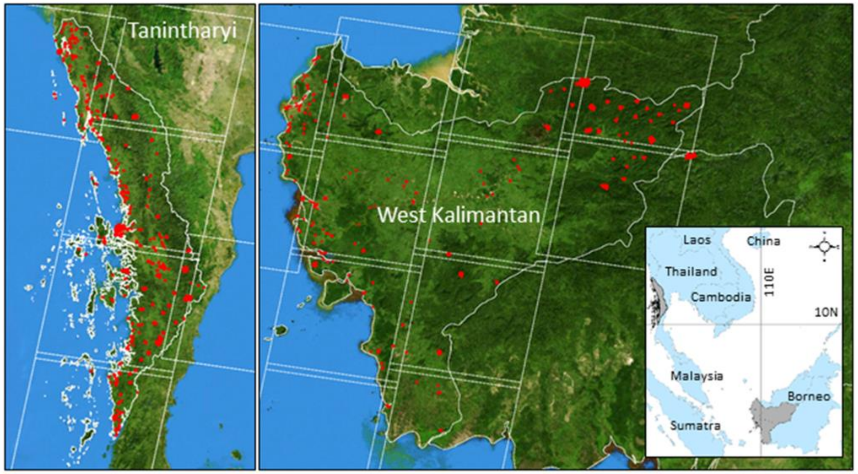


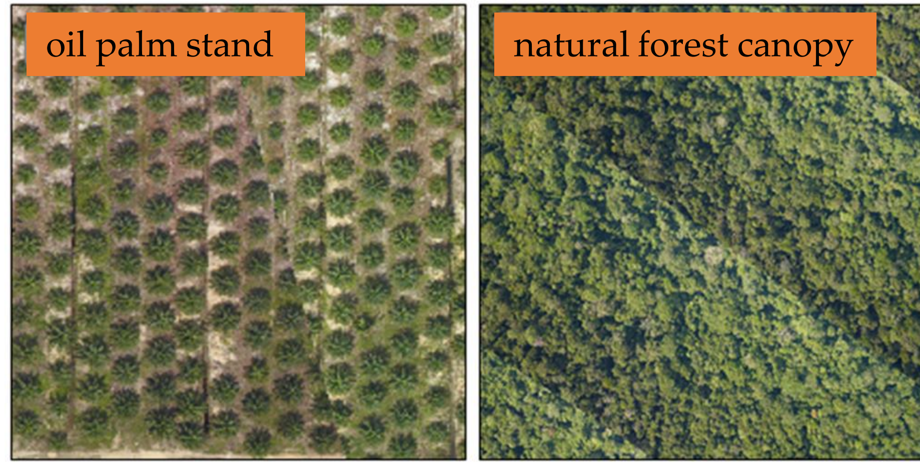
C. Forest map

(Qin *et al*., Scientific Report, 2016)

Objective 2: Identify and map industrial forests through integration of optical and microwave images

Hypothesis: Industrial forests/monoculture plantations are featured with structured planting and smooth/uniform canopy, in comparison to complex canopy and multi-layered structure from natural forests

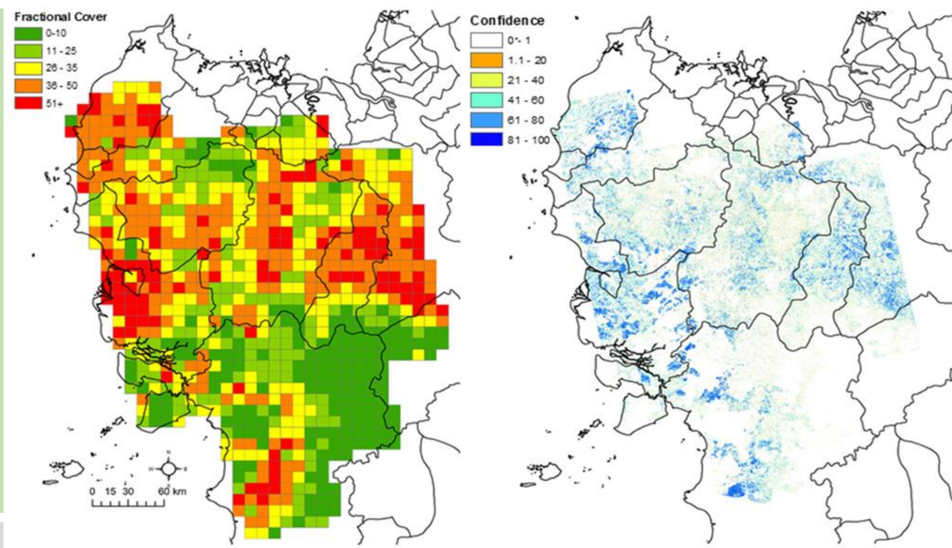




- **Landsat 8, PALSAR 2, Sentinel-1**

- **Common ratios** (HH/HV^2)
- **Vegetation indices** (NDVI, LSWI, SATVI, and NDTI)
- **Texture indices** (gray-level co-occurrence matrix, GLCM) , included mean, variance, homogeneity, contrast, dissimilarity, entropy, second moment, and correlation

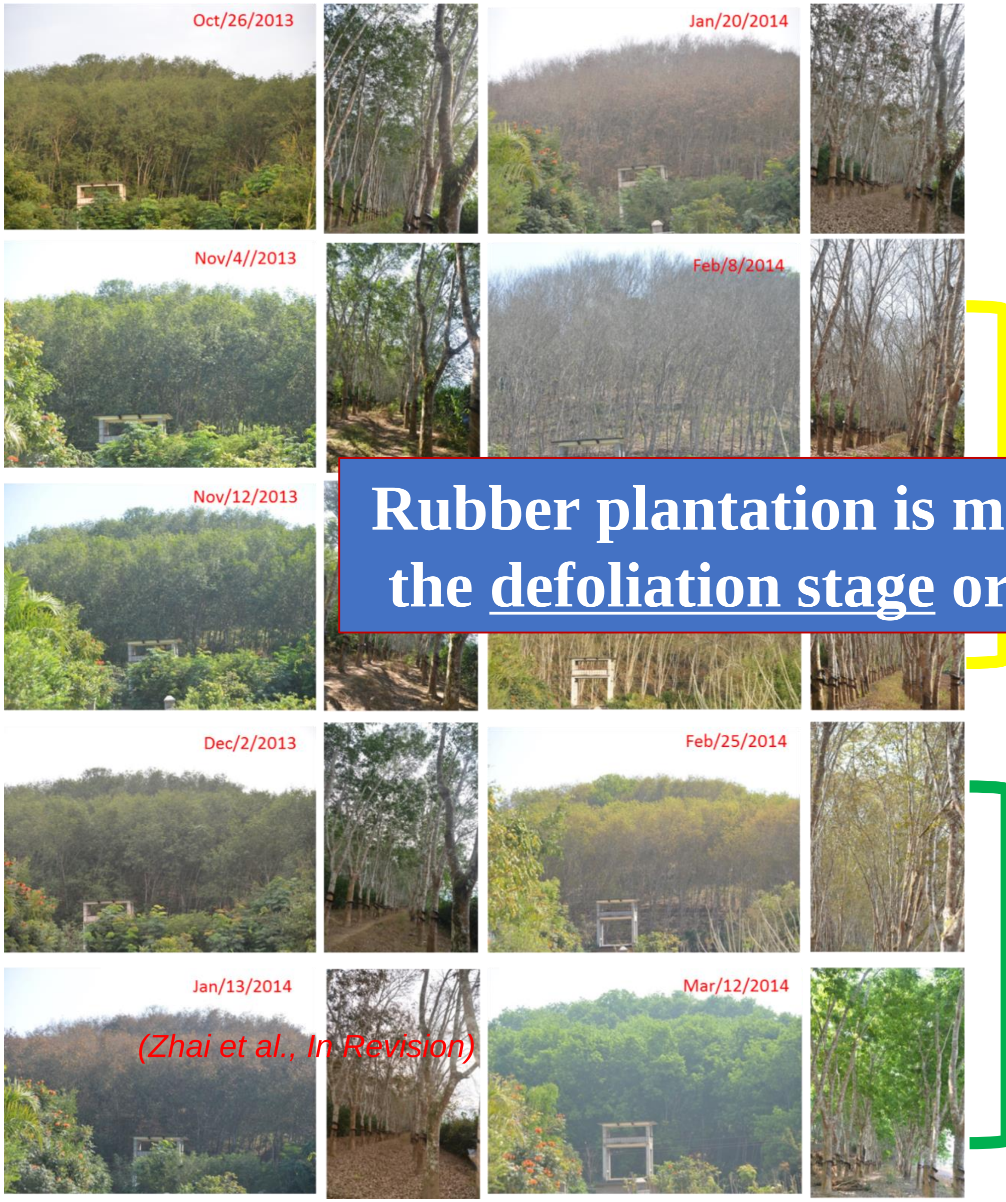
- **Classification and Regression Tree-Random Forest (CART-RF approach)**



(Torbick *et al.*, Remote Sensing, 2016)

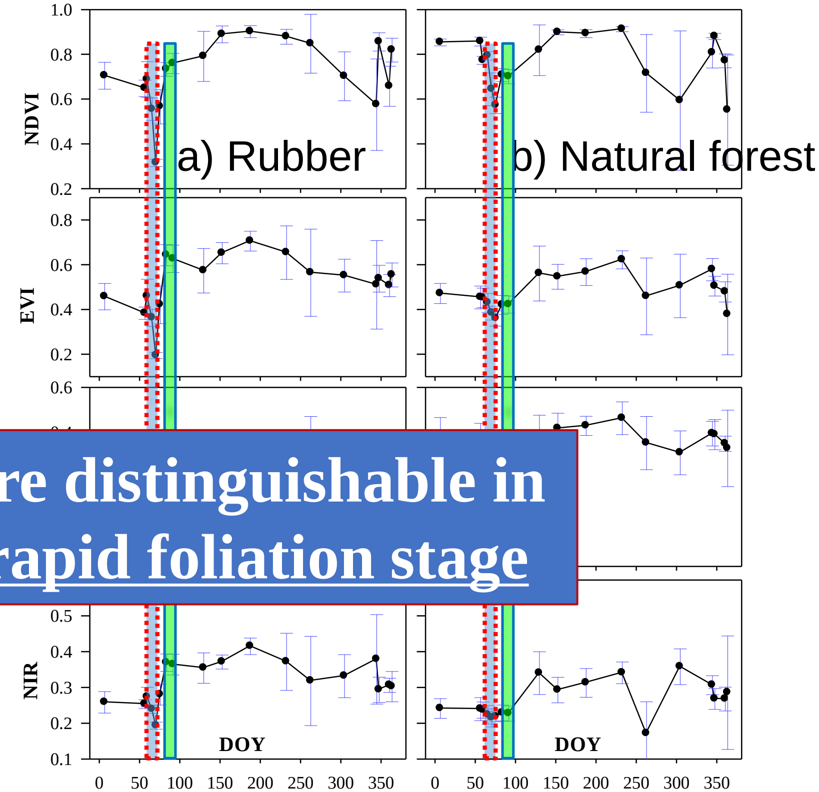
Objective 3: Identify and map individual industrial forest types through integration of optical and microwave images

Hypothesis: Deciduous rubber plantations have unique phenology feature in its canopy, which can be tracked by time series optical images.



(Zhai et al., In Revision)

Rubber plantation is more distinguishable in the defoliation stage or rapid foliation stage



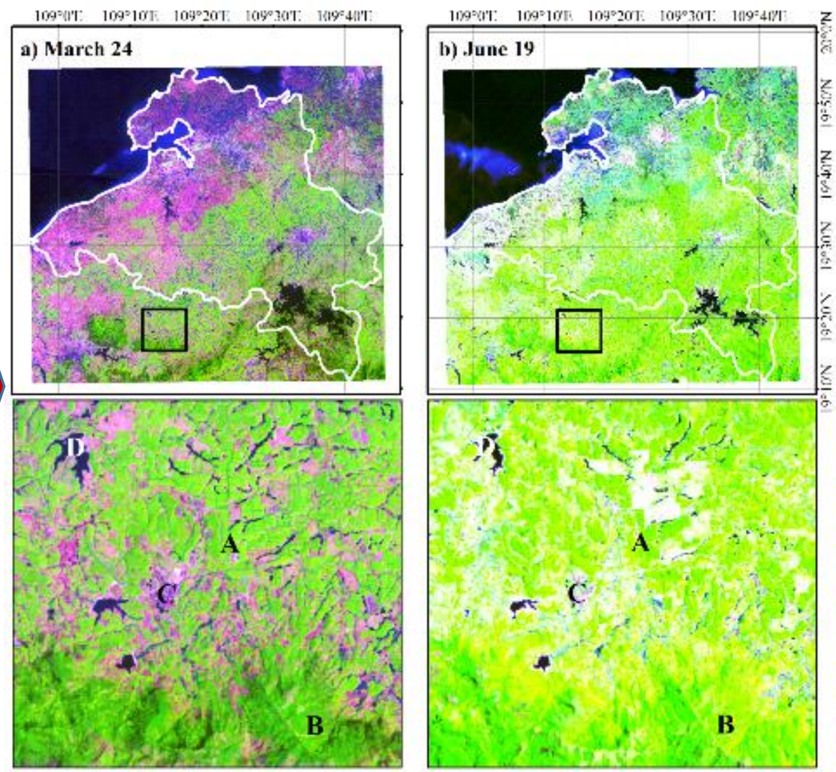
The temporal profiles of time series Landsat NDVI, EVI, LSWI and Near-Infrared (NIR) reflectance for (*a*) rubber plantations, and (*b*) natural forests.

(Dong *et al.*, RSE, 2013)

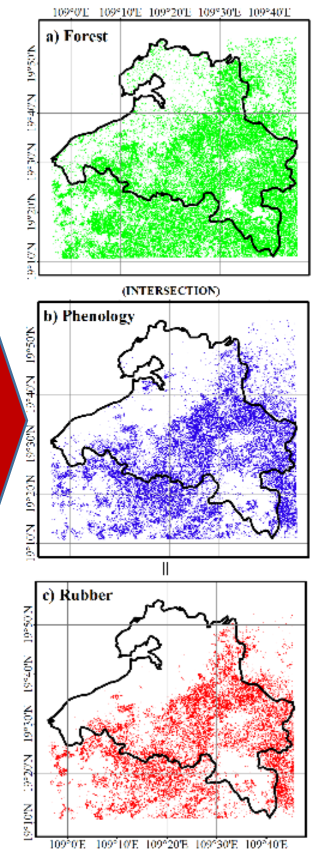
Rubber plantation mapping using phenology-based approach

Feature extraction

Time Window Selection: defoliation or rapid foliation stage



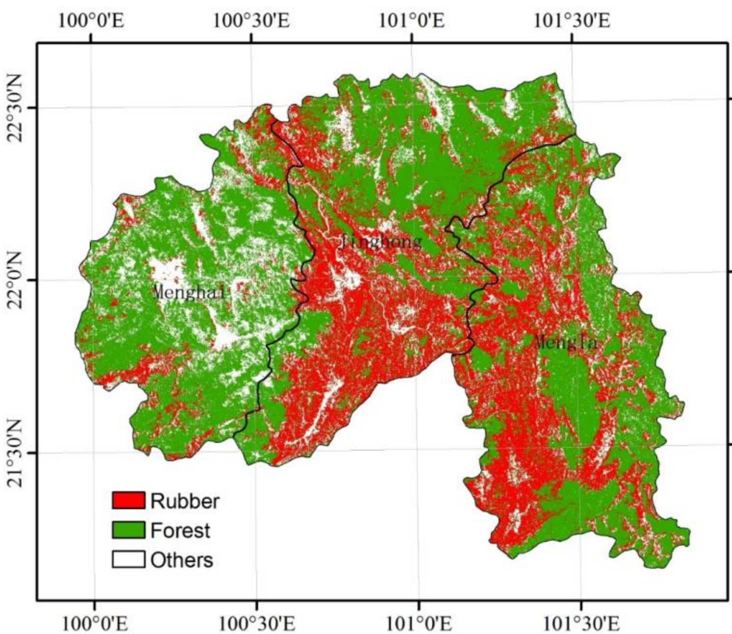
Rubber Mapping

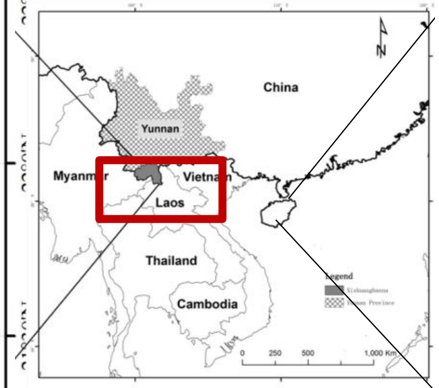


(Dong *et al.*, RSE, 2013)

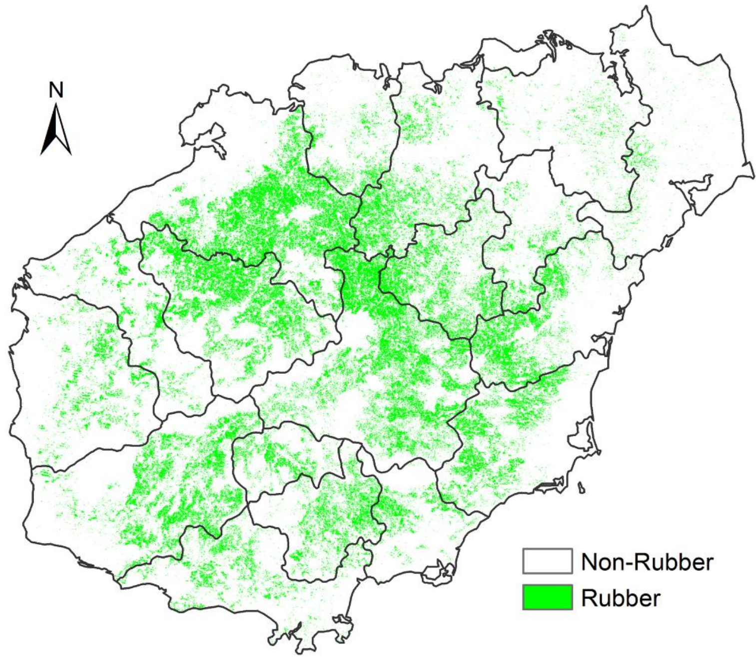
Rubber plantation maps in two rubber production hotspots

Xishuangbanna





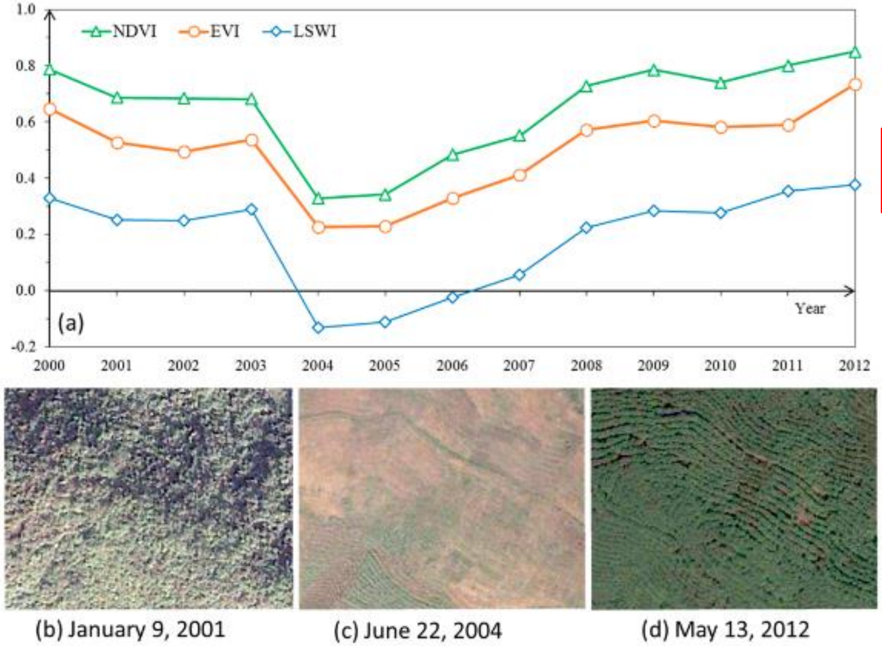
Hainan Island



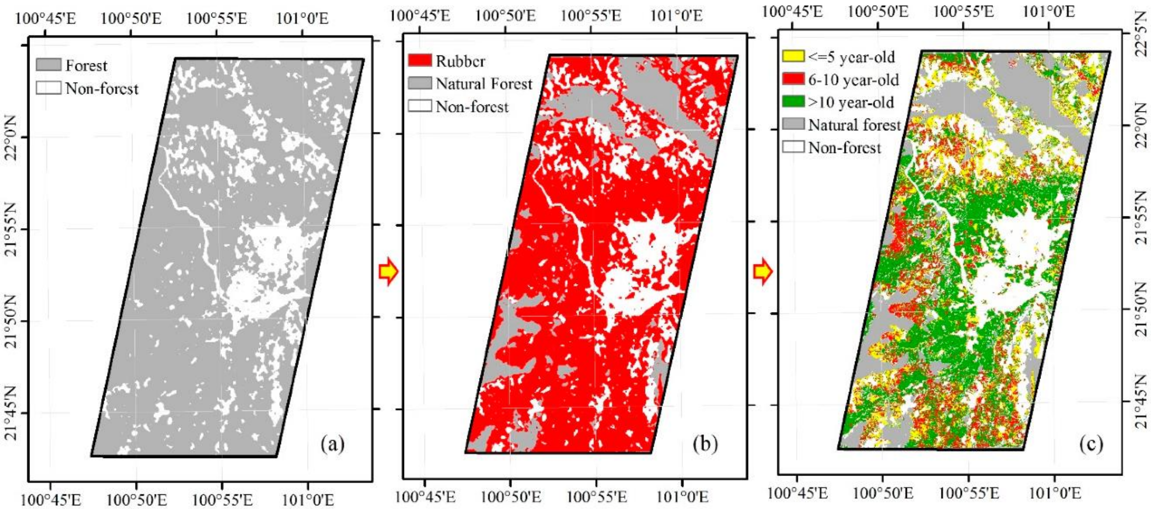
(Kou *et al.*, *In Review*)

(Chen *et al.*, Int J Appl Earth Obs, 2016)

Rubber plantation stand age mapping

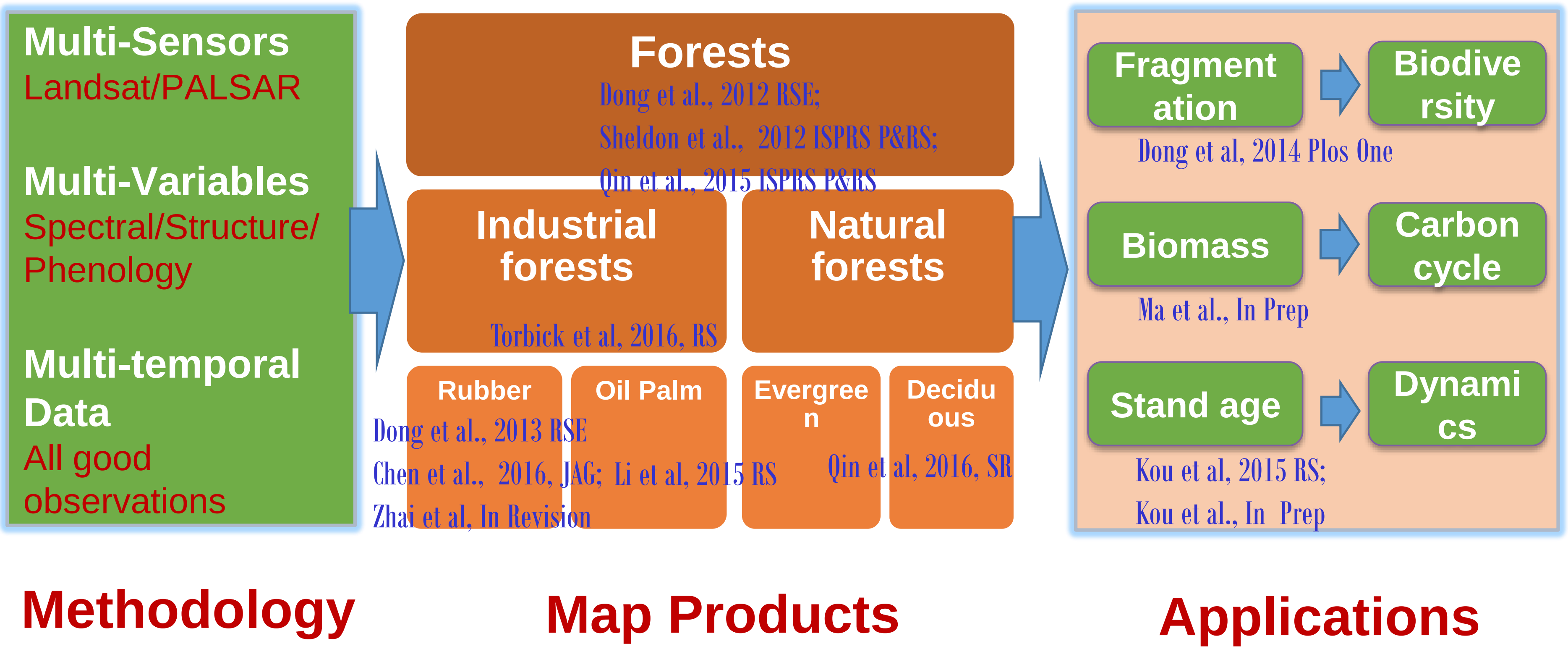


Stand age algorithm

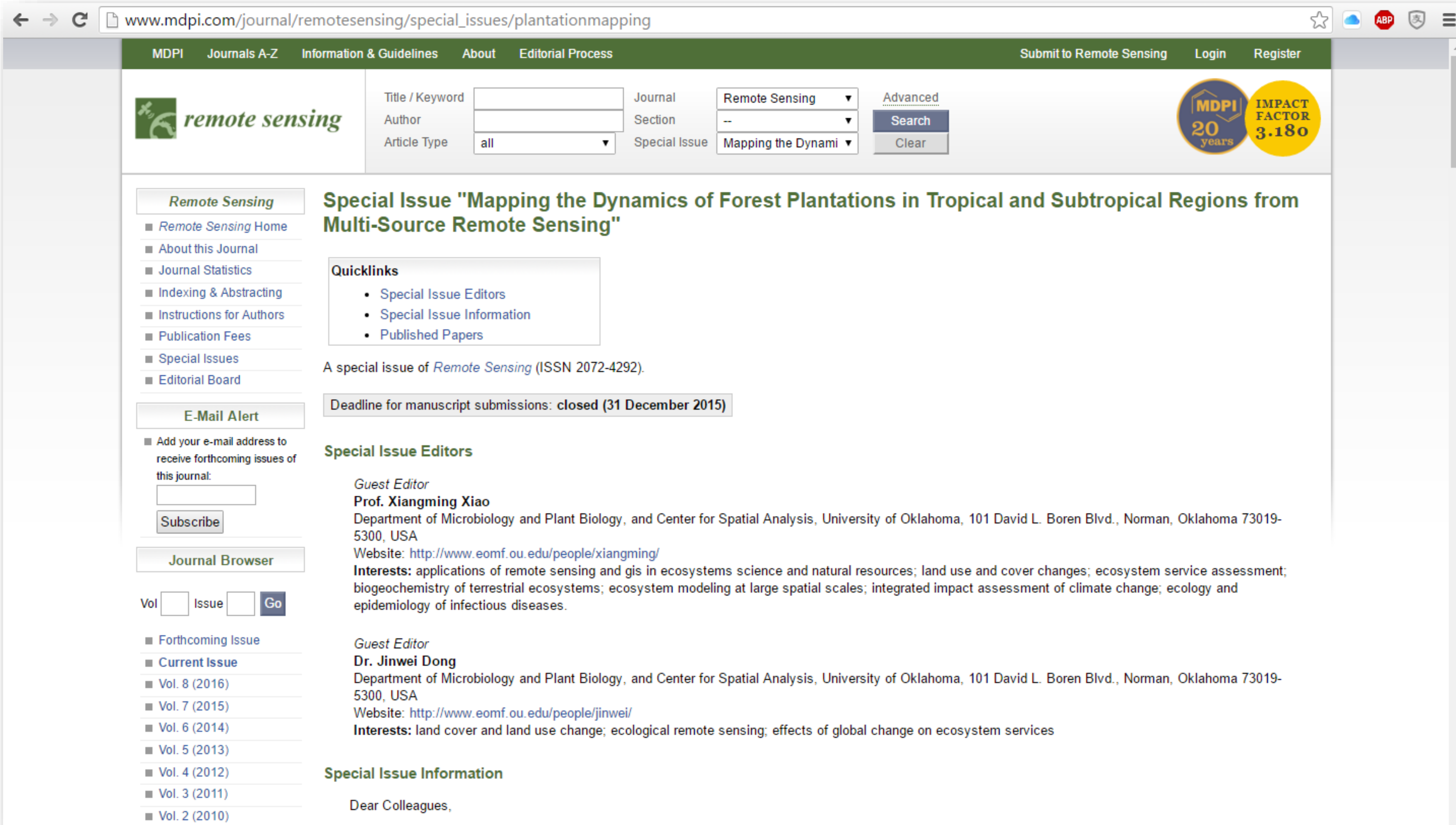


(Kou *et al*., RS 2015)

Summary of our efforts on forest/plantation mapping



Special Issue about forest plantations on *Remote Sensing*



www.mdpi.com/journal/remotesensing/special_issues/plantationmapping

MDPI | Journals A-Z | Information & Guidelines | About | Editorial Process | Submit to Remote Sensing | Login | Register

remote sensing

Title / Keyword | Author | Article Type: all | Journal: Remote Sensing | Section: -- | Special Issue: Mapping the Dynami | Advanced | Search | Clear

MDPI 20 years | IMPACT FACTOR 3.180

Remote Sensing

- *Remote Sensing* Home
- About this Journal
- Journal Statistics
- Indexing & Abstracting
- Instructions for Authors
- Publication Fees
- Special Issues
- Editorial Board

E-Mail Alert

- Add your e-mail address to receive forthcoming issues of this journal:

Subscribe

Journal Browser

Vol | Issue | Go

- Forthcoming Issue
- Current Issue
- Vol. 8 (2016)
- Vol. 7 (2015)
- Vol. 6 (2014)
- Vol. 5 (2013)
- Vol. 4 (2012)
- Vol. 3 (2011)
- Vol. 2 (2010)

Special Issue "Mapping the Dynamics of Forest Plantations in Tropical and Subtropical Regions from Multi-Source Remote Sensing"

Quicklinks

- Special Issue Editors
- Special Issue Information
- Published Papers

A special issue of *Remote Sensing* (ISSN 2072-4292).

Deadline for manuscript submissions: **closed (31 December 2015)**

Special Issue Editors

Guest Editor
Prof. Xiangming Xiao
Department of Microbiology and Plant Biology, and Center for Spatial Analysis, University of Oklahoma, 101 David L. Boren Blvd., Norman, Oklahoma 73019-5300, USA
Website: http://www.eomf.ou.edu/people/xiangming/
Interests: applications of remote sensing and gis in ecosystems science and natural resources; land use and cover changes; ecosystem service assessment; biogeochemistry of terrestrial ecosystems; ecosystem modeling at large spatial scales; integrated impact assessment of climate change; ecology and epidemiology of infectious diseases.

Guest Editor
Dr. Jinwei Dong
Department of Microbiology and Plant Biology, and Center for Spatial Analysis, University of Oklahoma, 101 David L. Boren Blvd., Norman, Oklahoma 73019-5300, USA
Website: http://www.eomf.ou.edu/people/jinwei/
Interests: land cover and land use change; ecological remote sensing; effects of global change on ecosystem services

Special Issue Information

Dear Colleagues,

Forest and Plantation RS Session in 2015 AGU Fall Meeting

AGU FALL MEETING

San Francisco | 14–18 December 2015

SEARCH

BROWSE PROGRAM

BROWSE BY PERSON

B51L
Remote Sensing of Forests and Plantations in the Tropical and Subtropical Zones I

Friday, 18 December 2015: 08:00-10:00
2006 (Moscone West)

Primary Conveners:
Xiangming Xiao, University of Oklahoma Norman Campus, Norman, OK, United States
Conveners:
Jinwei Dong, University of Oklahoma Norman Campus, Norman, OK, United States
Chairs:
Xiangming Xiao, **Jinwei Dong** and **Yuanwei Qin**, University of Oklahoma Norman Campus, Norman, OK, United States
OSPA Liaisons:
Xiangming Xiao, University of Oklahoma Norman Campus, Norman, OK, United States

08:00 **B51L-01** Dynamics of Industrial Forests in Southeast United States Assessed using Satellite and Field Inventory Data *(Invited)* (81600)
***Chengquan Huang**, University of Maryland, Department of Geographical Sciences, College Park, MD, United States and NAF-C team*

08:15 **B51L-02** Changes in rubber plantation in the cross-border area of mainland Southeast Asia through analysis of PALSAR and time series Landsat images (79275)
***Jinwei Dong**[1], Xiangming Xiao[1], Yuanwei Qin[1], Bangqian Chen[2], Weili Kou[3], Deli Zhai[4], Geli Zhang[5], Yao Zhang[1], Yuting Zhou[1] and Jie Wang[1], (1)University of Oklahoma Norman Campus, Norman, OK, United States, (2)Organization Not Listed, Washington, DC, United States, (3)University of Oklahoma, Norman, OK, United States, (4)Kunming Institute of Botany, Chinese Academy of Sciences, Kunming, China, (5)University of Oklahoma, Center for Spatial Analysis, Norman, OK, United States*

08:30 **B51L-03** Tropical-Forest Biomass Dynamics from X-Band, TanDEM-X DATA *(Invited)* (63944)
***Robert N Treuhaft**, NASA Jet Propulsion Laboratory, Pasadena, CA, United States*

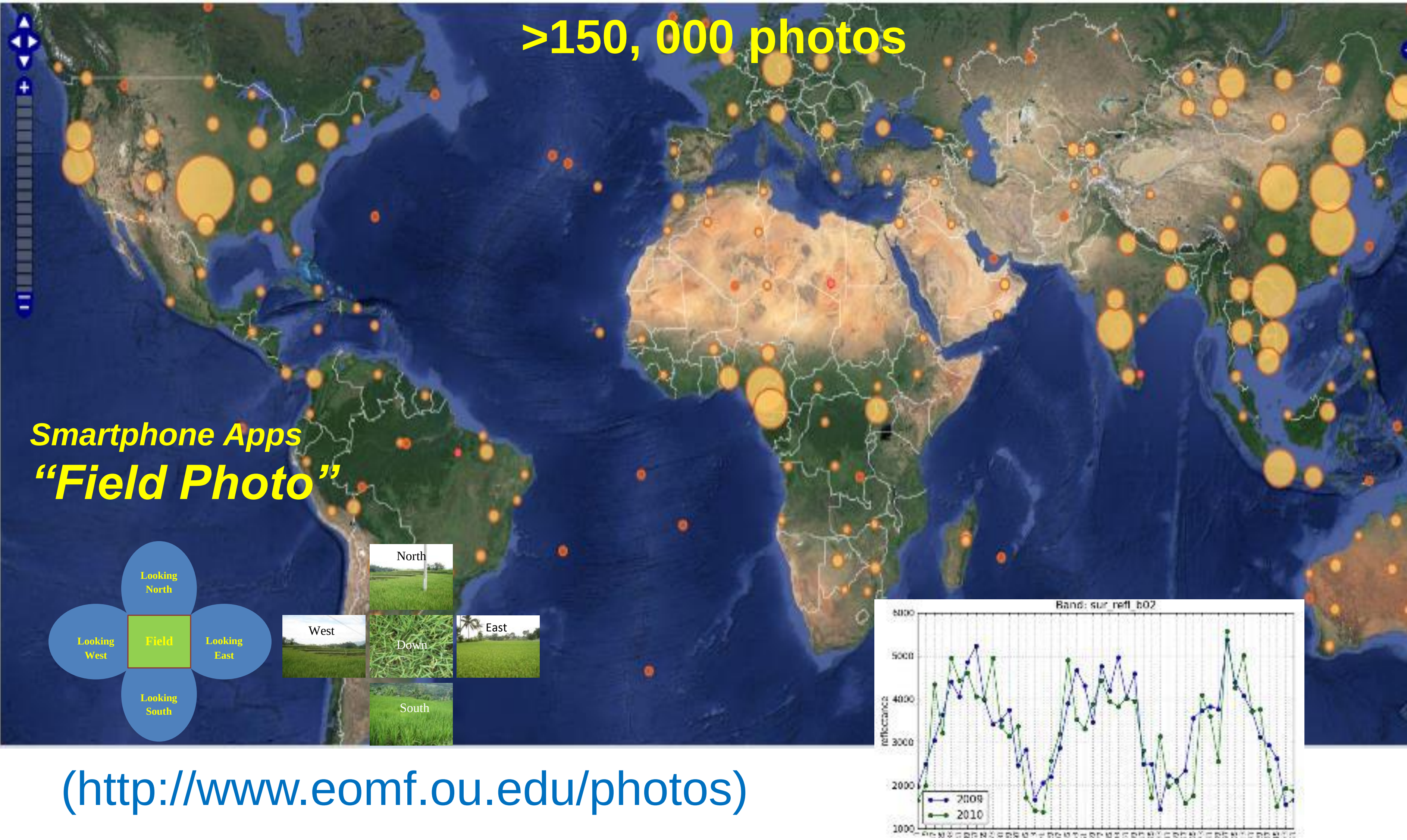
08:45 **B51L-04** Topographic Distributions of Emergent Trees in Tropical Forests of the Osa Peninsula, Costa Rica *(Invited)* (76240)
***Chris Balzotti**[1,2], Gregory Paul Asner[1,2], Philip Taylor[3], Rebecca J Cole[4], Brooke B Osborne[5], Cory C. Cleveland[6], Stephen Porder[7] and Alan R Townsend[3], (1)Carnegie Institution for Science Washington, Washington, DC, United States, (2)Carnegie Institution for Science, Department of Global Ecology, Stanford, CA, United States, (3)University of Colorado at Boulder, Boulder, CO, United States, (4)University of Hawaii at Manoa, Honolulu, HI, United States, (5)Brown University, Department of Ecology and Evolutionary Biology, Providence, RI, United States, (6)University of Montana, Missoula, MT, United States, (7)Brown University, Providence, RI, United States*

09:00 **B51L-05** Reconstructing Land Use History from Landsat Time-Series. Case study of Swidden Agriculture Intensification in Brazil (69205)
***Loïc Dutrieux**, Catarina C Jakovac, Latifah H Siti and Lammert Kooistra, Wageningen University, Wageningen, Netherlands*

09:15 **B51L-06** Tracing Forest Change through 40 Years on Two Continents with the BULC Algorithm and Google Earth Engine (85023)
***Jeffrey A Cardille**, McGill University, Natural Resource Sciences, Montreal, QC, Canada*

09:30 **B51L-07** Using CLASlite to Map Deforestation in Makira Natural Protected Area, Madagascar (79928)
***Alison Nicole Thieme**[1], Sean McCartney[1], John Rogan[1], Florencia Sangermano[1] and David Wilkie[2], (1)Clark University, Worcester, MA, United States, (2)Wildlife Conservation Society, Bronx, NY, United States*

Cal/Val LC database: Global Geo-Referenced Field Photo Library



(http://www.eomf.ou.edu/photos)

(Xiao *et al.*, EOS, 2011)

Individual photos are linked with time series MODIS data (2000-present)

Summary

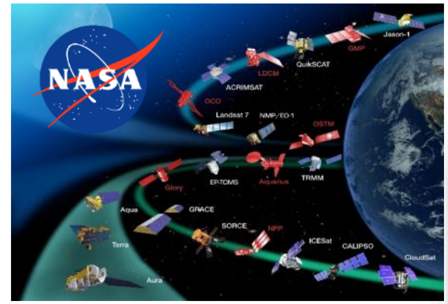
- 1. Cloud-free PALSAR data can effectively contribute to the existing forest mapping efforts. For example, the combined Landsat/PALSAR-based forest mapping approach is more robust.

- 2. Unique phenology signature makes rubber plantation identification possible in a simple way; however, its extensive application in other regions and other species should consider different factors.

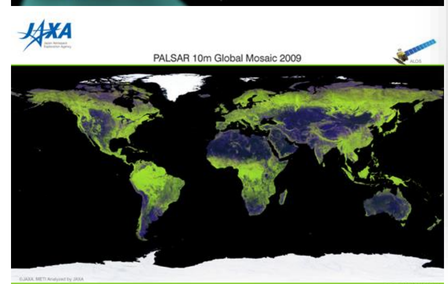
- 3. Emerging data sources (e.g., Landsat 8, Sentinel-1, Sentinel-2, and PALSAR-1/2) provide unprecedented opportunities for industrial forest mapping; however, new algorithms and computing technologies (e.g., cloud computing) are needed to make full use of these big data.

Work plan in 2016

- 1. Improved forest maps by integrating PALSAR and Landsat/Sentinel-2.
- 2. Extensive application of the rubber plantation approach on tropical monsoon Asia.
- 3. Development of new mapping algorithms for other industrial forest types.
- 4. Enhanced field photo and ground truth data portal (freely open to the public).



Multi-Sensors



SENTINEL 2

sentinel-1

esa

Questions?

Earth Observation and Modeling

http://eomf.ou.edu