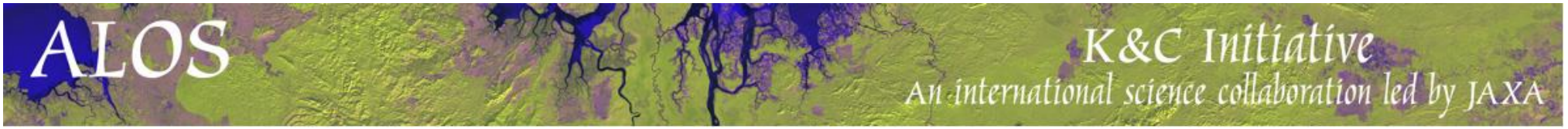


K&C Phase 4 – Status report

F7: Wide area forest monitoring of Insular SE Asia and Guiana Shield

Dirk Hoekman
Wageningen University

Martin Vissers and Boris Kooij, SarVision

Science Team meeting #24
Tokyo, Japan, January 29-31, 2018

Project outline and objectives

1. Continue development of techniques for time-consistency (PALSAR-1/2) and the use of ScanSAR in dynamic and irregularly inundated areas. Integration with C-band Sentinel-1 data, which may significantly increase possibilities for land cover and biomass stratification. Status: In progress; tested with PALSAR 2015 FB mosaic data; preparations for strip data
2. Wide-area application of the multi-model slope correction model (entire Borneo). Status: DONE for PALSAR-2009 FB strip data

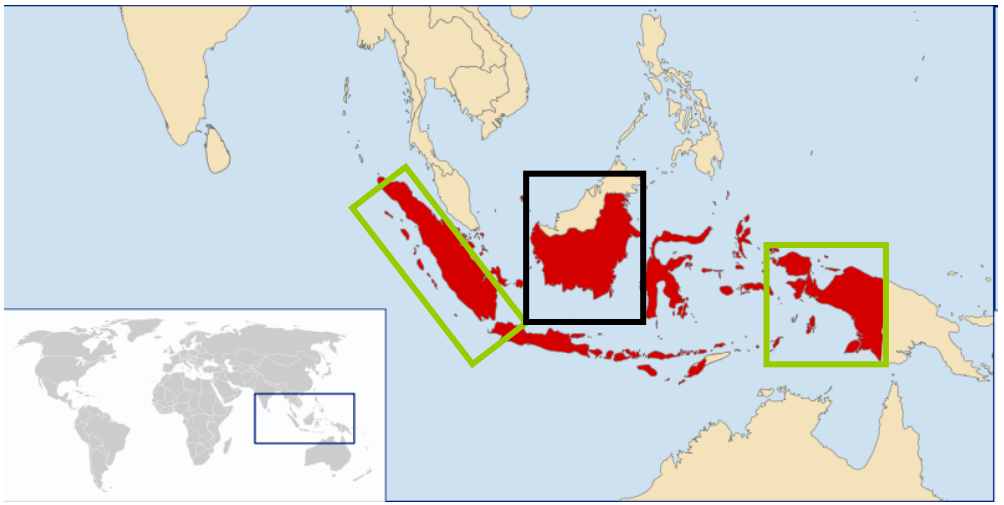
Project outline and objectives

3. Integration of PALSAR data, aerial LiDAR/photography and field data to support the development of carbon accounting methodology for the Indonesian REDD agency (in collaboration with Bill Salas; 60 LiDAR sites in Kalimantan). Status: DONE; empirical relationships PALSAR and LiDAR derived biomass established
4. Forest baseline mapping and decadal change mapping (using PALSAR-1/2 and JERS-1). Status: In progress
5. Study of forest degradation (in combination with TerraSAR-X data at sites in Brazil). Status: New site in Calha Norte; in progress; first results are good

Project outline and objectives: *project areas*

Focus on two major biomes with persistent cloud cover:

- **Guiana Shield**, with focus on Guyana, Suriname and Brazilian state of Para
- **Insular SE Asia**, with focus on Borneo



Project outline and objectives: *thematic drivers*

Carbon cycle: Contribution to operational national MRV systems, such as INCAS and Indonesian REDD agency

Climate change: Contributions to GFOI and UNFCCC

International **C**onventions: Monitoring Ramsar sites, such as Danau Sentarum National Park, Indonesia.

Environmental **C**onservation: Early alert and degradation monitoring (using PALSAR, Sentinel-1 and TSX); Indigenous reserves Para.

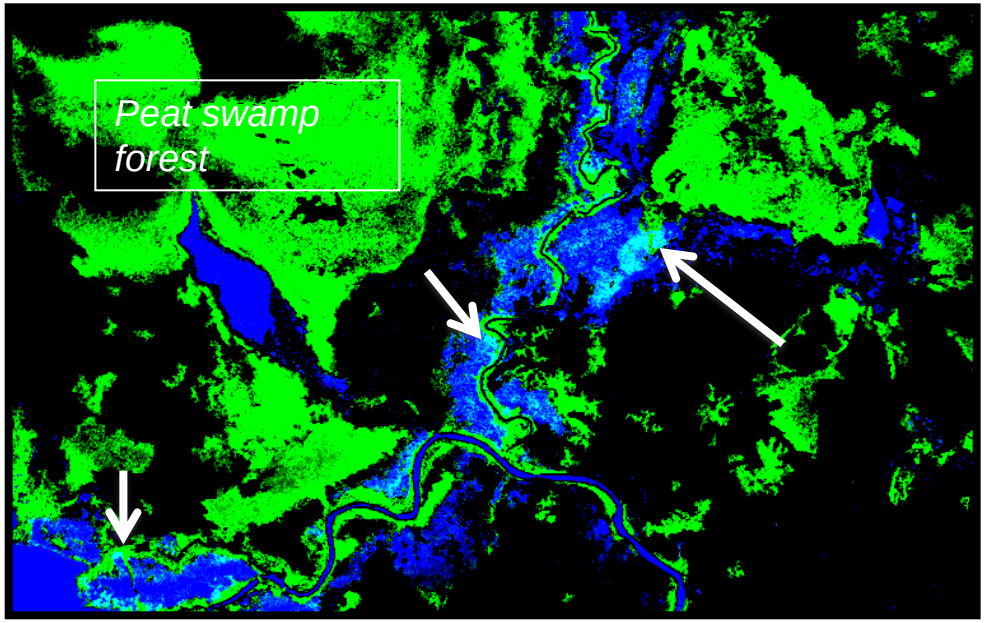
Phase 4 Extension: Support Indonesian Peat Restoration Agency(BRG)

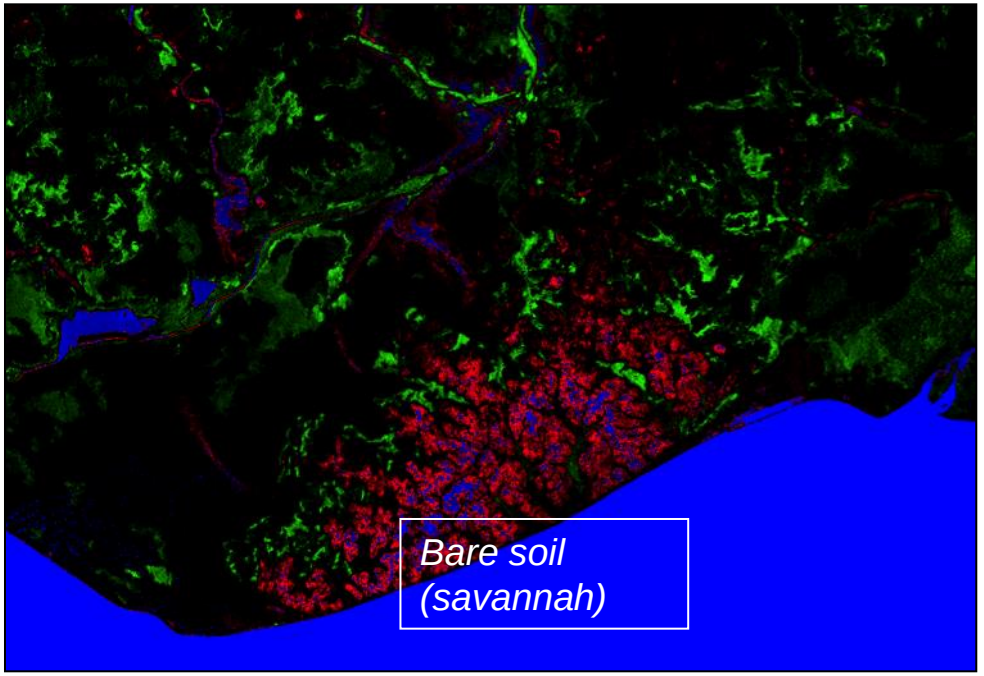
Results and significant findings thus far

Describe project outcomes and significant findings to date

(several slides OK!)

Flood frequency dual inc. angle map Borneo





Legend

Blue: Open water frequency (0-100%)

Green: Flooded vegetation frequency (0-100%)

Red 1: Bare soil frequency (0-100%)

Note that pixels have multiple values

Cyan area: fully submerged forest occurs

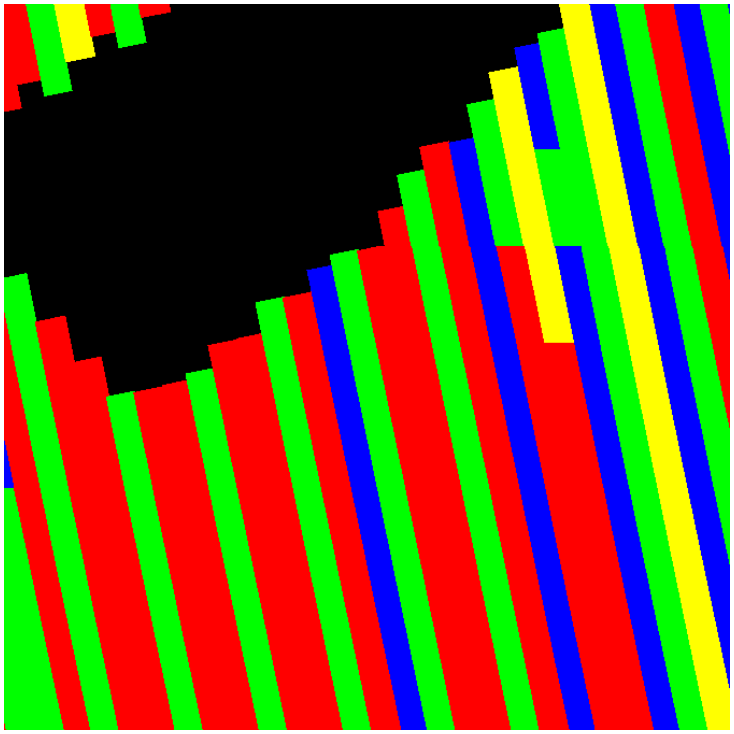
ScanSAR swath overlap is > 50%

Bare soil (smooth) is distinguished from open water (smooth) because of dual inc. angle mapping approach.

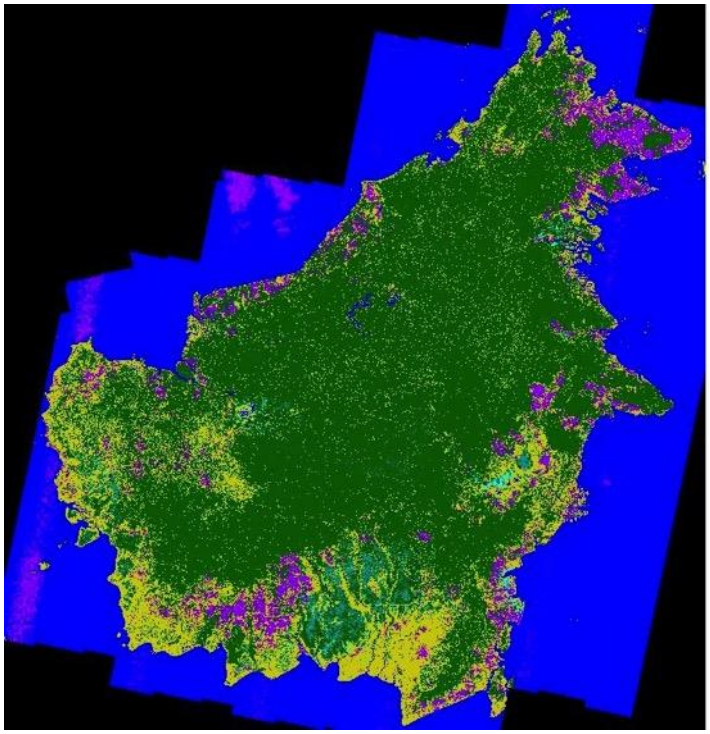
Important for good results in savannah and wet agriculture areas.

Methodology PALSAR – Sentinel-1 integration

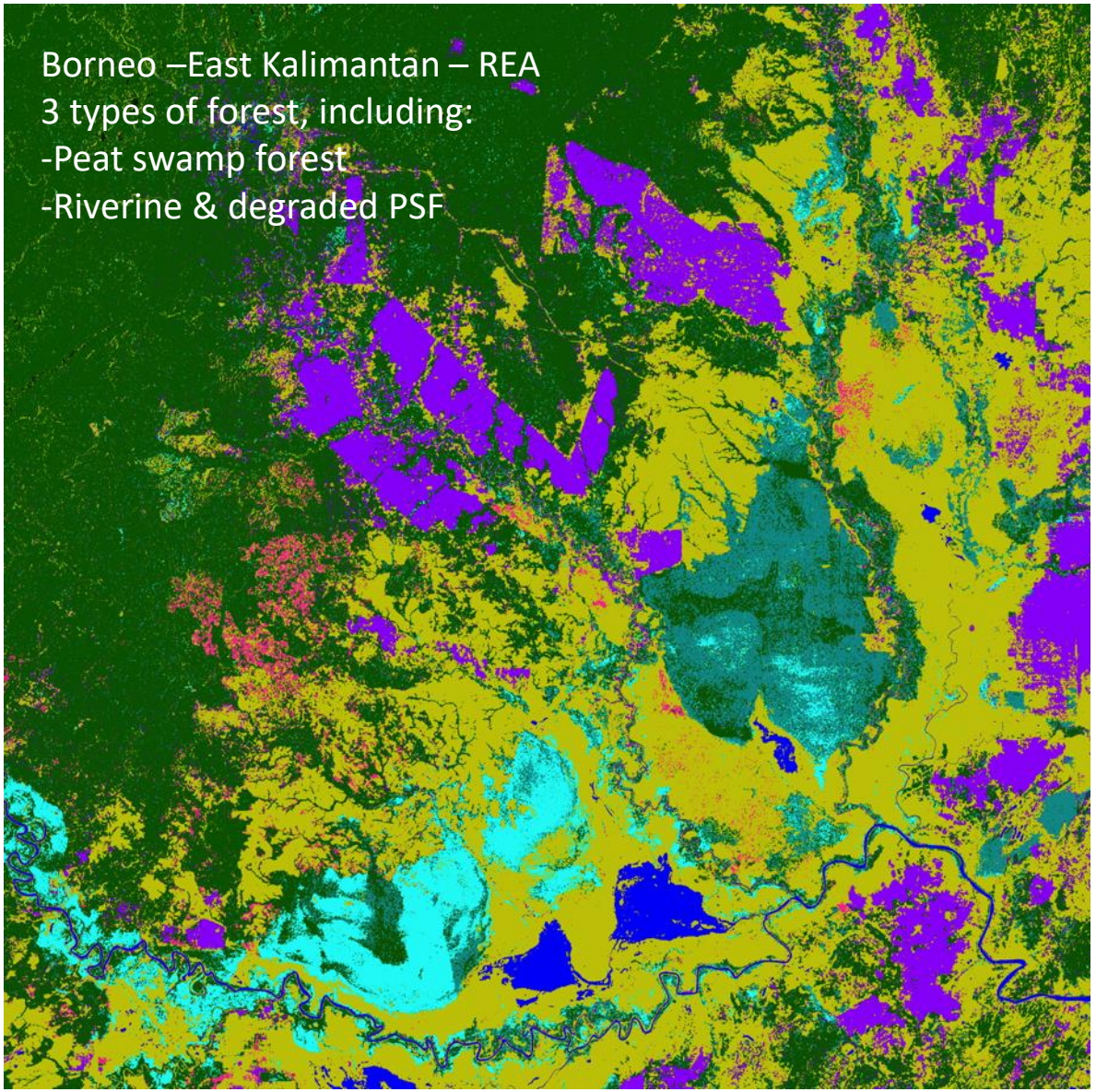
PALSAR-2 FB mosaic data / Sentinel-1 land cover



Date layer FB mosaic 2015
Wet season 2015 (blue)
Early-mid dry season 2015 (green)
Late dry season 2015 (red)
Late dry season 2014 (yellow)



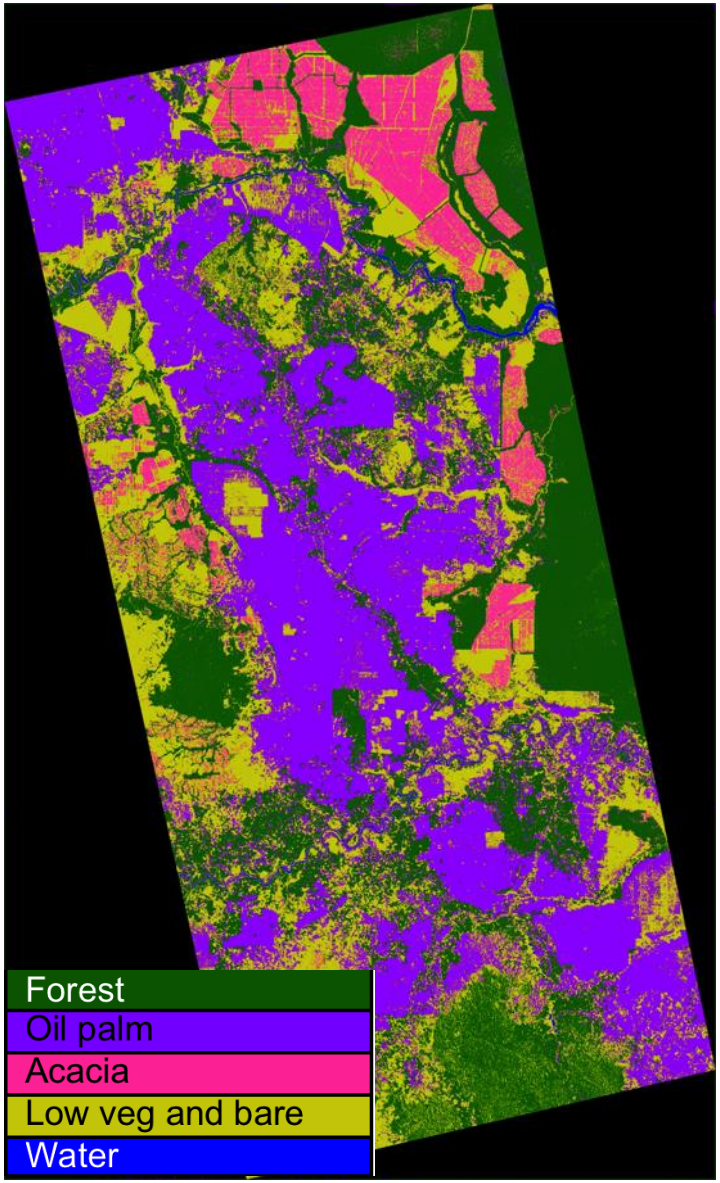
Land cover P2/S1 2015
7 classes
Issue: seasonality FB mosaic data complicates wide area LC mapping, notably for plantation forests



Combining PALSAR-2 and Sentinel-1

Locally, good results are obtained using local training data. For example, oil palm plantations can be mapped much better and age classes can be distinguished well.

Consistent (locally) with PALSAR-1 maps



Combining PALSAR-2 and Sentinel-1

This example shows mapping of acacia plantations in Sumatra, which is not well possible using PALSAR only.

Compared to P1 the mapping of P2-S1 data with P2 mosaic data is complicated by wider incidence angle ranges, P2 mosaic seasonal mixture and ASC (P2) and DESC (S1) combination.

Ongoing work includes creation of large signature database (3000+ signatures; notably for forest plantations of different age classes) covering all seasons, whole incidence angle range and use of path data.

Methodology mountains & steep slopes

Completed

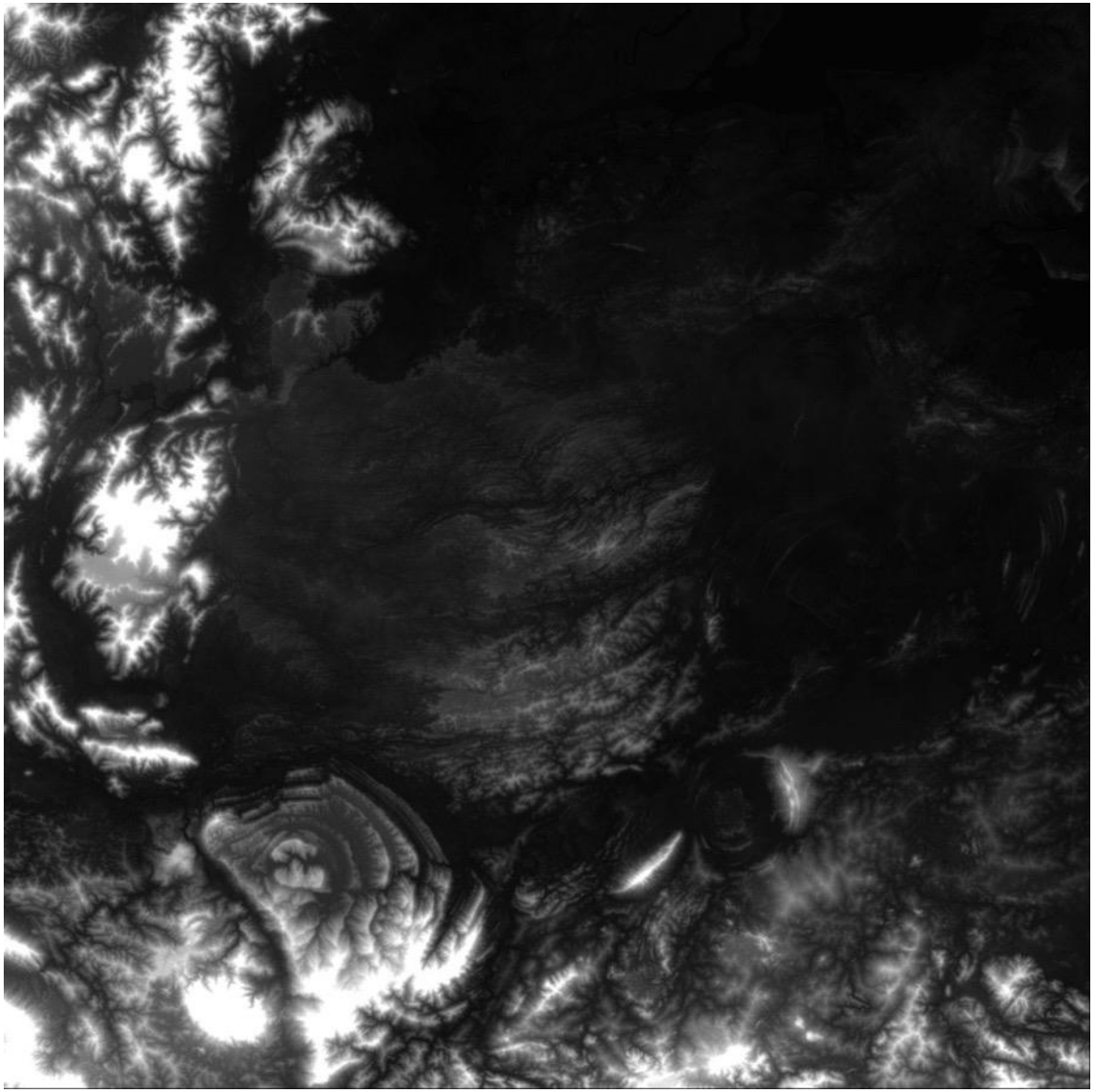
1.Semi-empirical model of slope induced effects on average backscatter intensity (multi-model approach*)

In progress

2.Empirical model of other slope induced (temporal) effects in forests (related to canopy roughness)

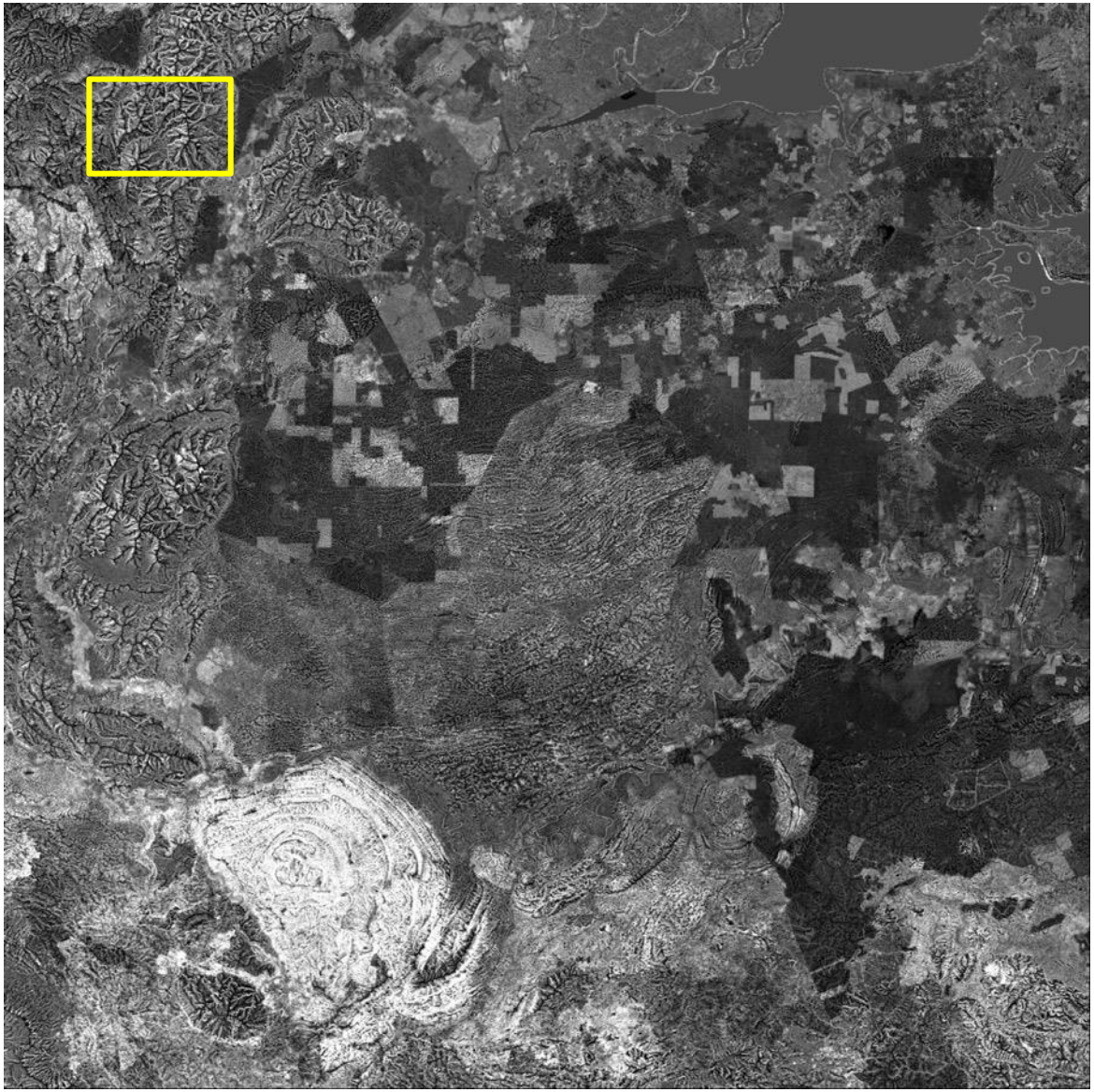
3.Approaches to adjust DEM (in particular in forest areas) from radar data

*) Hoekman, D. H., and J. Reiche, 2015. Multi-model radiometric slope correction of SAR images of complex terrain using a two-stage semi-empirical approach. *Remote Sensing of Environment*, 156, 1-10.



SRTM
- Acquired: February 2000
- Resolution: 60 m
- Pixel spacing: 1.0 arcsec (approx. 30 m)

WorldDEM4Ortho
- Acquired: 2011 – 2014
- Resolution: 24m
- Pixel spacing: 0.4 arcsec (approx. 12 m)

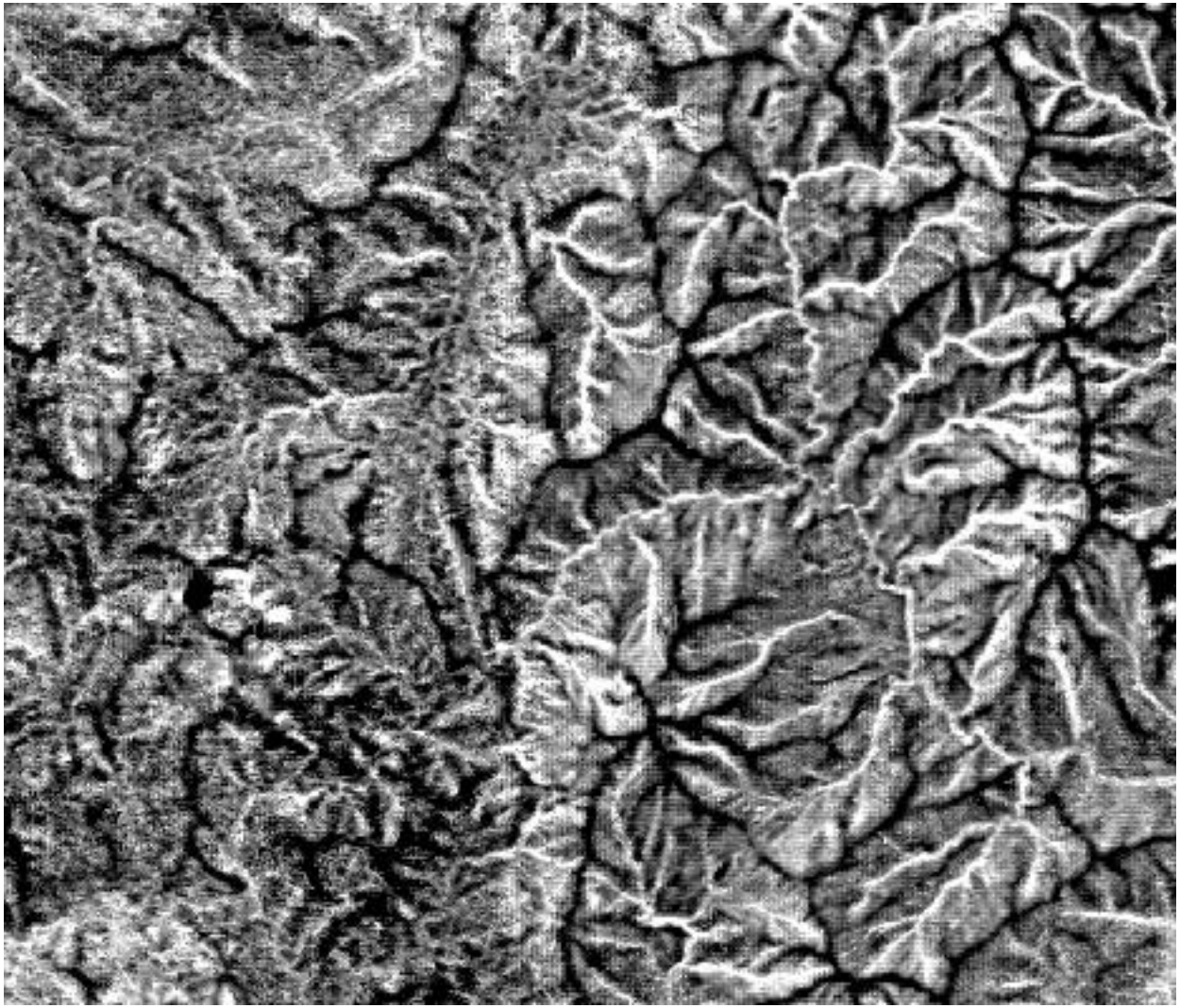


SRTM minus
WorldDEM4Ortho

Bright: decreased height, such as deforestation and degradation

Dark: increased height, such as growth in plantations

Medium: similar height, such as water bodies



SRTM minus WorldDEM4Ortho

DETAIL showing resolution effects in stable forest area

Bright: deepest parts of valleys

Dark: highest parts of mountain ridges

Forest clear-cut monitoring with Sentinel-1 radar

(including mountainous areas / steep slopes)

- In Indonesia and Malaysia;
- Around industrial plantations in relation to zero-deforestation commitments;
- In cooperation with TFT and Airbus (optical monitoring, incl. SPOT)

Operational service "Starling":
http://www.starling-verification.com/;
http://www.intelligence-airbusds.com/starling/

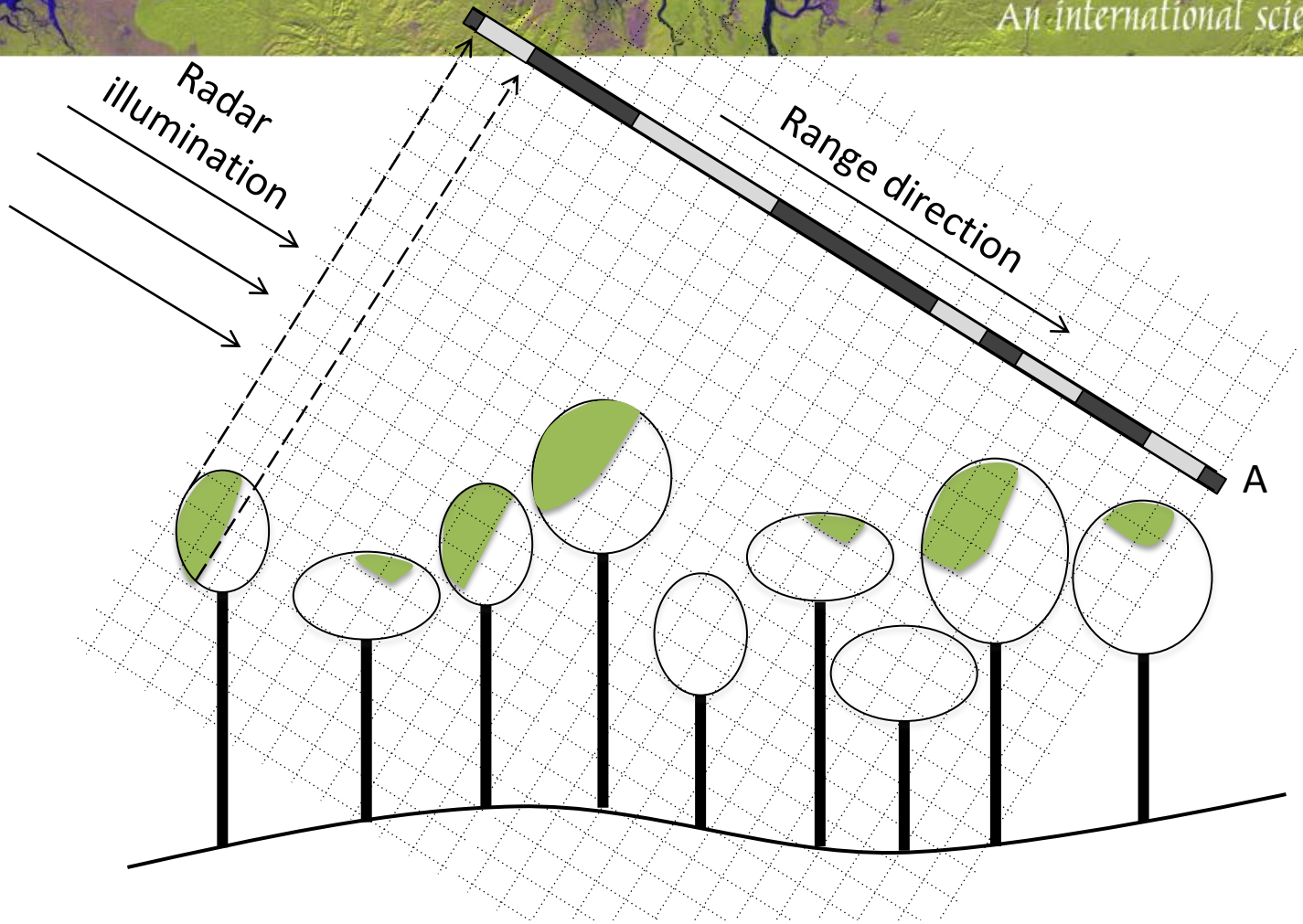
Methodology TSX - PALSAR integration

New textural and topological time series analysis approach to map (legal or illegal) selective logging of individual trees

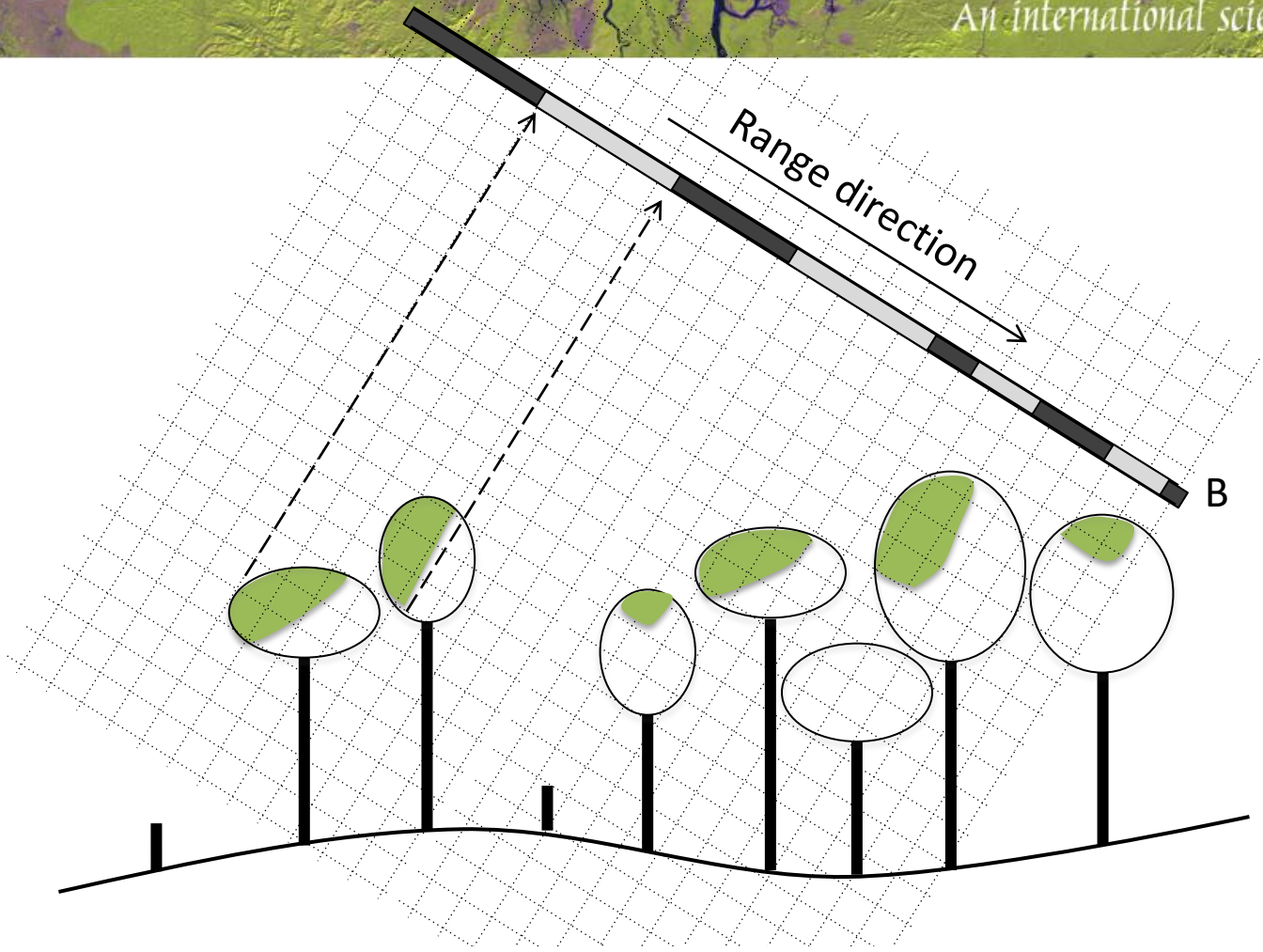
Renewed cooperation with IDEFLOR-Bio to test methodology in Calha Norte (between Amazon river and Surinam) in timber concessions

Establish relationships between logging intensity (TSX map) and detection capabilities of PALSAR and Sentinel-1 data

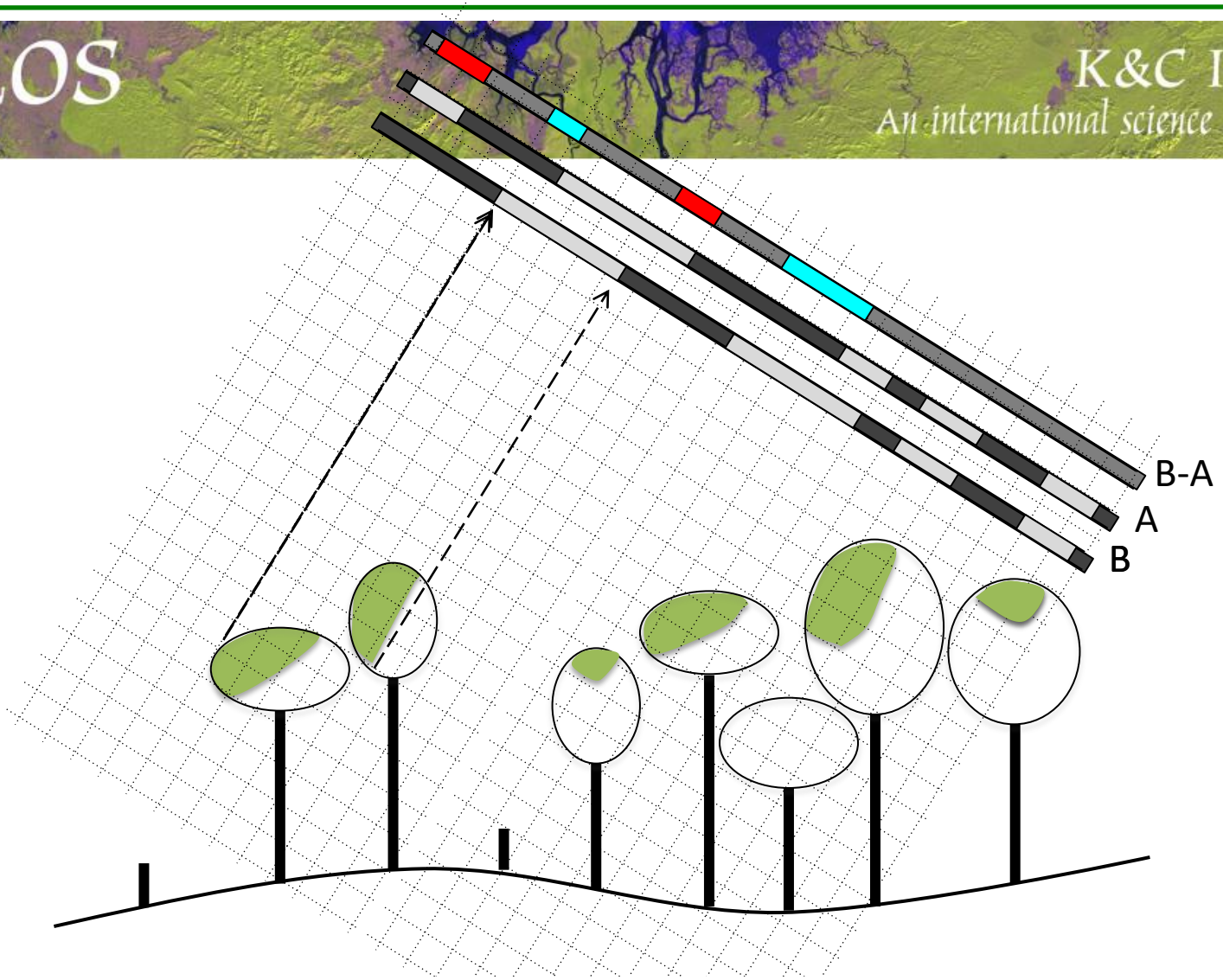
Note: in previous presentation PALSAR maps of shifting cultivation in Calha Norte were presented.



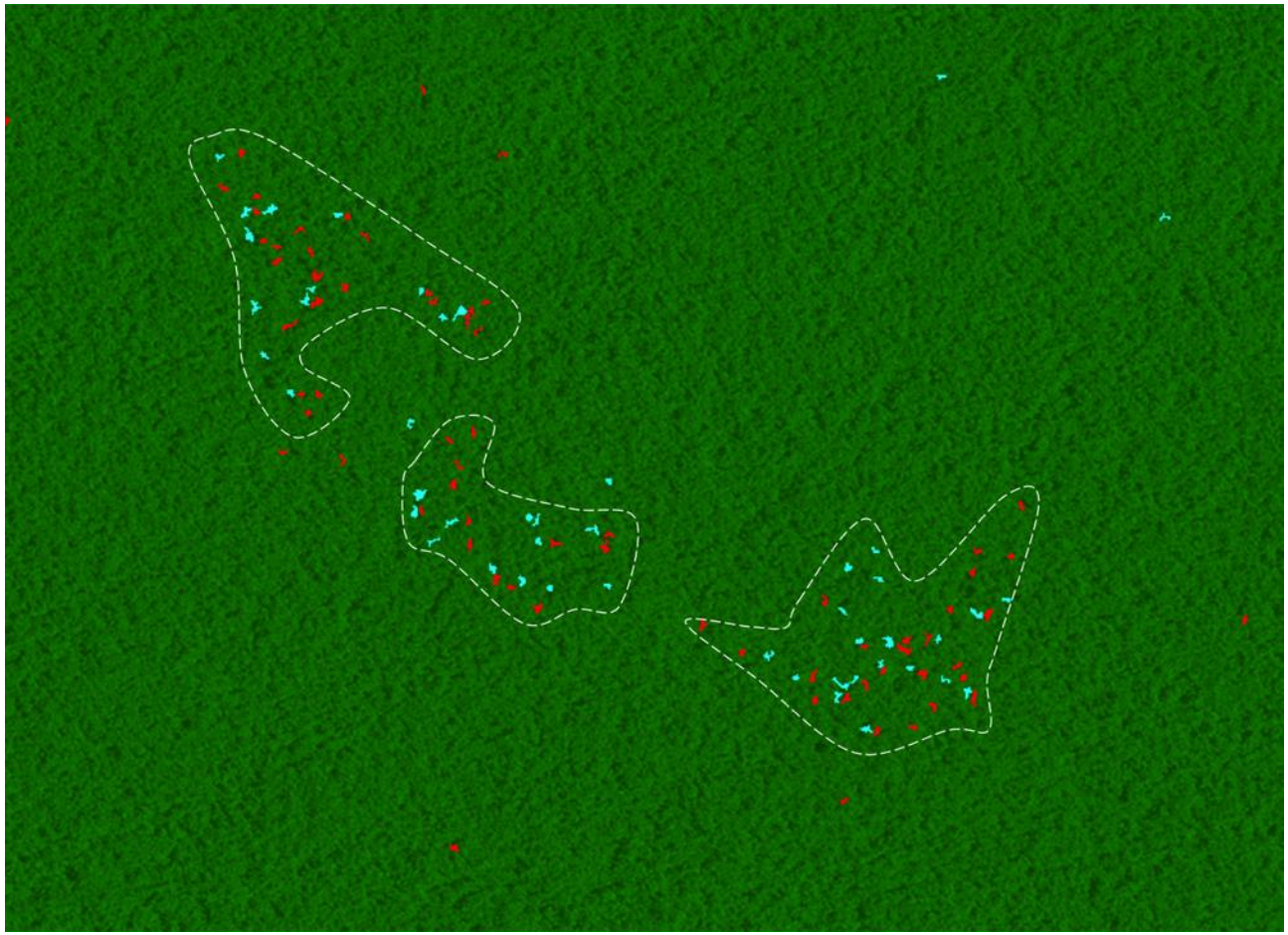
Green areas are illuminated by radar. Radar returns from illuminated areas are imaged by projection in range direction (light grey). Range cells without illuminated areas show radar shadow (dark).



Removal of trees changes the pattern of illuminated areas and shadows.



The removal of a tree crown usually causes an area of backscatter decrease (red), while the illumination of an area behind the tree crown that was previously not illuminated (radar shadow area) causes backscatter increase (cyan).



TSX tree logging maps
Maps are made at 33-day intervals using StripMap data

Methodology time series analysis

New generic approach for time series analysis based on Kalman filtering

Kalman filtering has some disadvantages for operational use

A “Many-model” Kalman type filter was developed which generates two output series:

(1) State map series

(2) Model map series

Temporal seamless NRT updates of state and model was demonstrated for Vietnam and Indonesia, using Sentinel-1 data only

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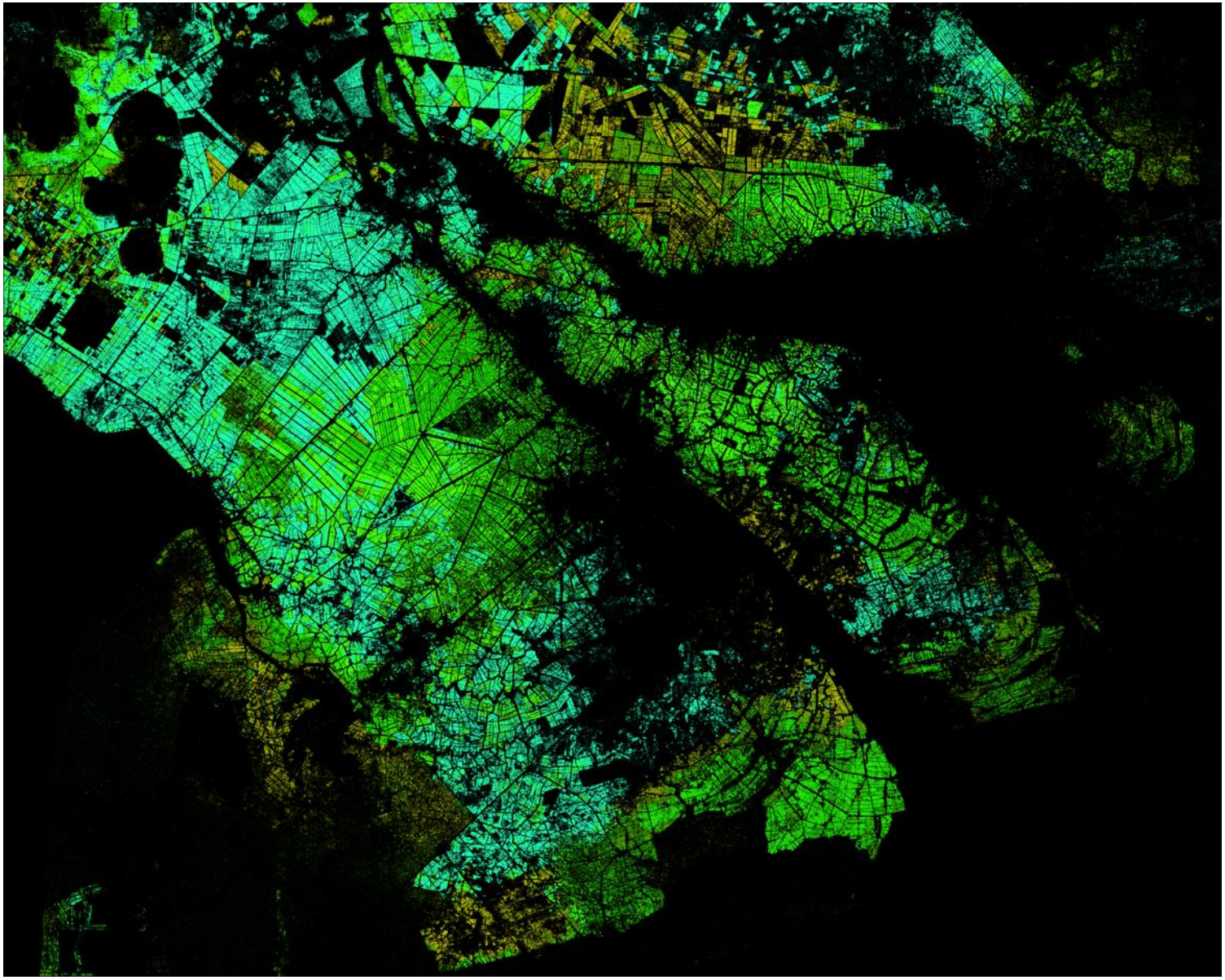
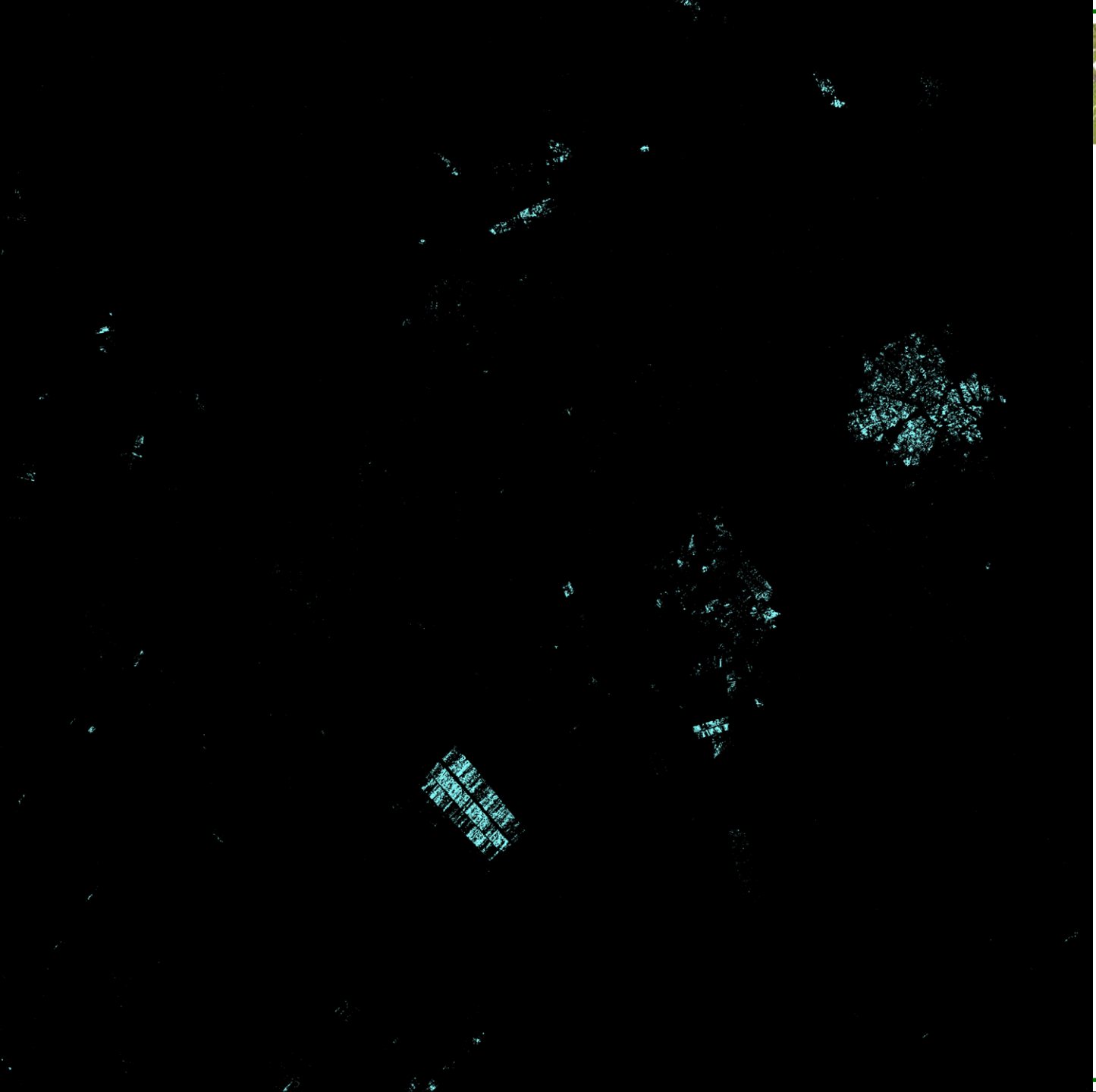


Mekong - Rice growing stages and fallow



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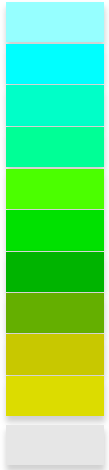
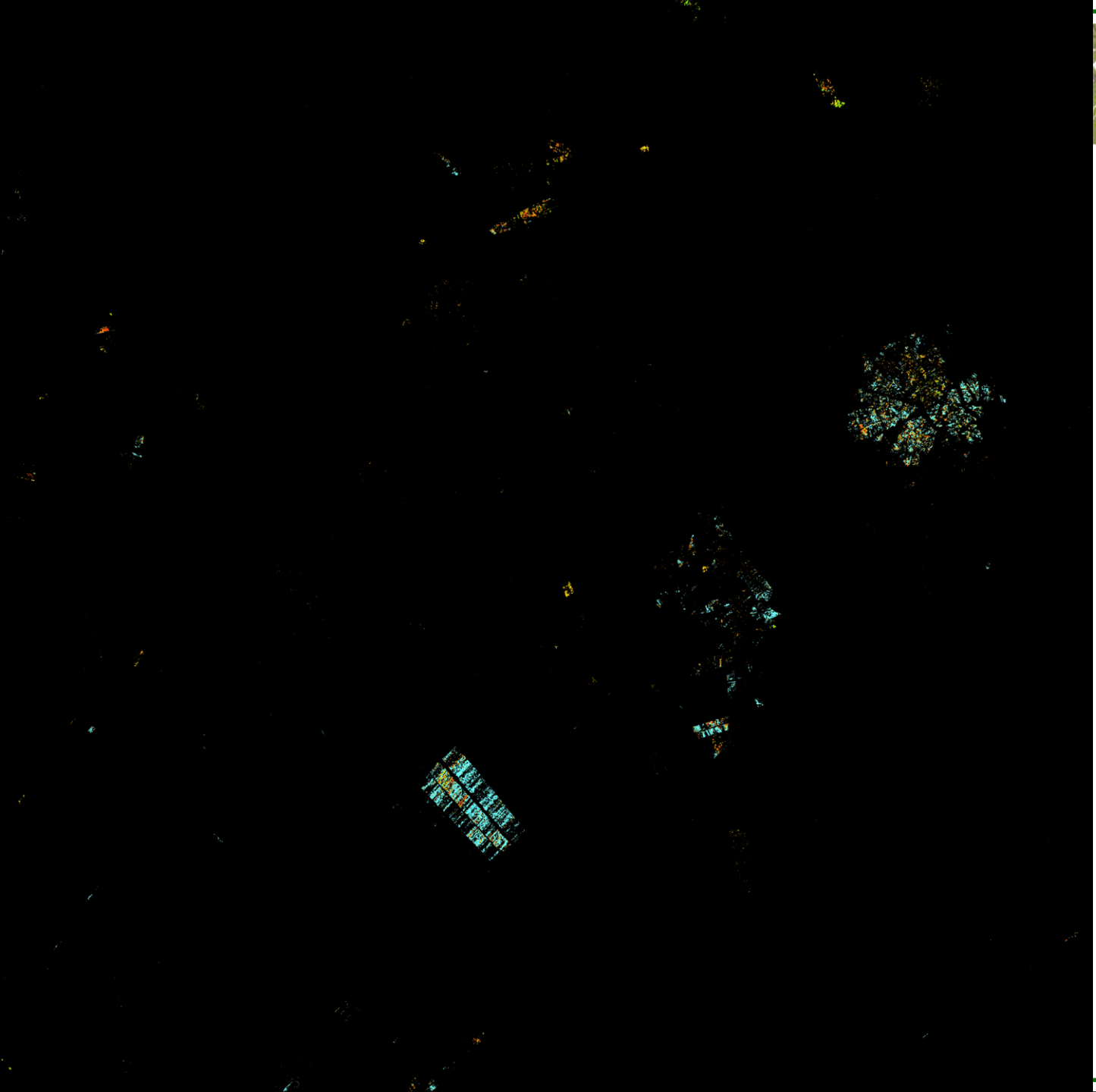
Animation Mekong

Only Sentinel-1 radar data used (one year), showing 3 full rice cycles.

State maps

Results can be shown as age, growing stage, plant height, SoS maps (every 6 days in NRT); and fallow period characteristics (methane emission)





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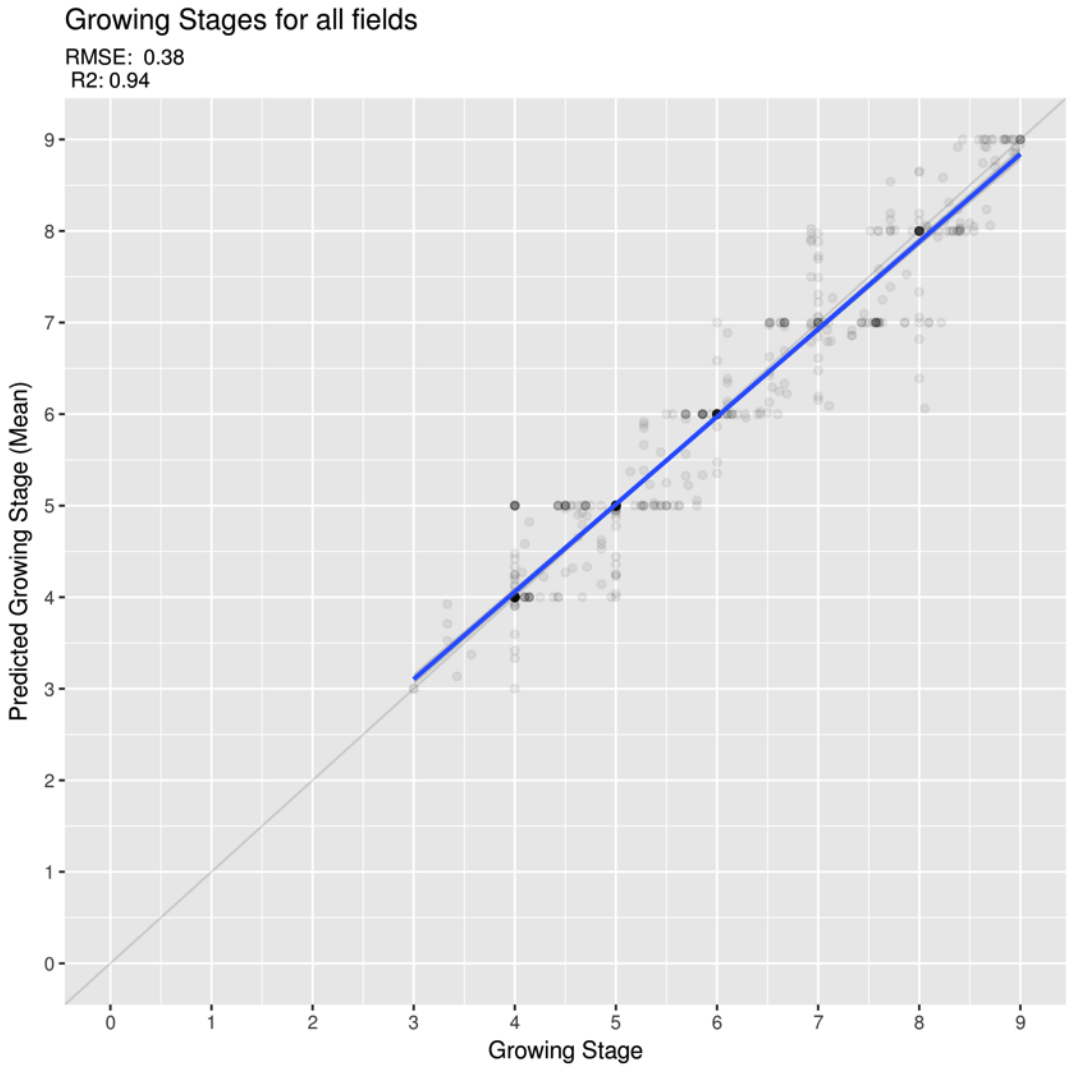
Animation Mekong
Only Sentinel-1 radar data used (one year), showing 3 full rice cycles.

Model maps
Results relate to differences in varieties and management and growth characteristics. Note the model can change after completing a rice cycle.

Methodology time series analysis



Validation

Good results for almost all 150 reference fields

System also works well in Indonesia, even on terraces

Viewer available

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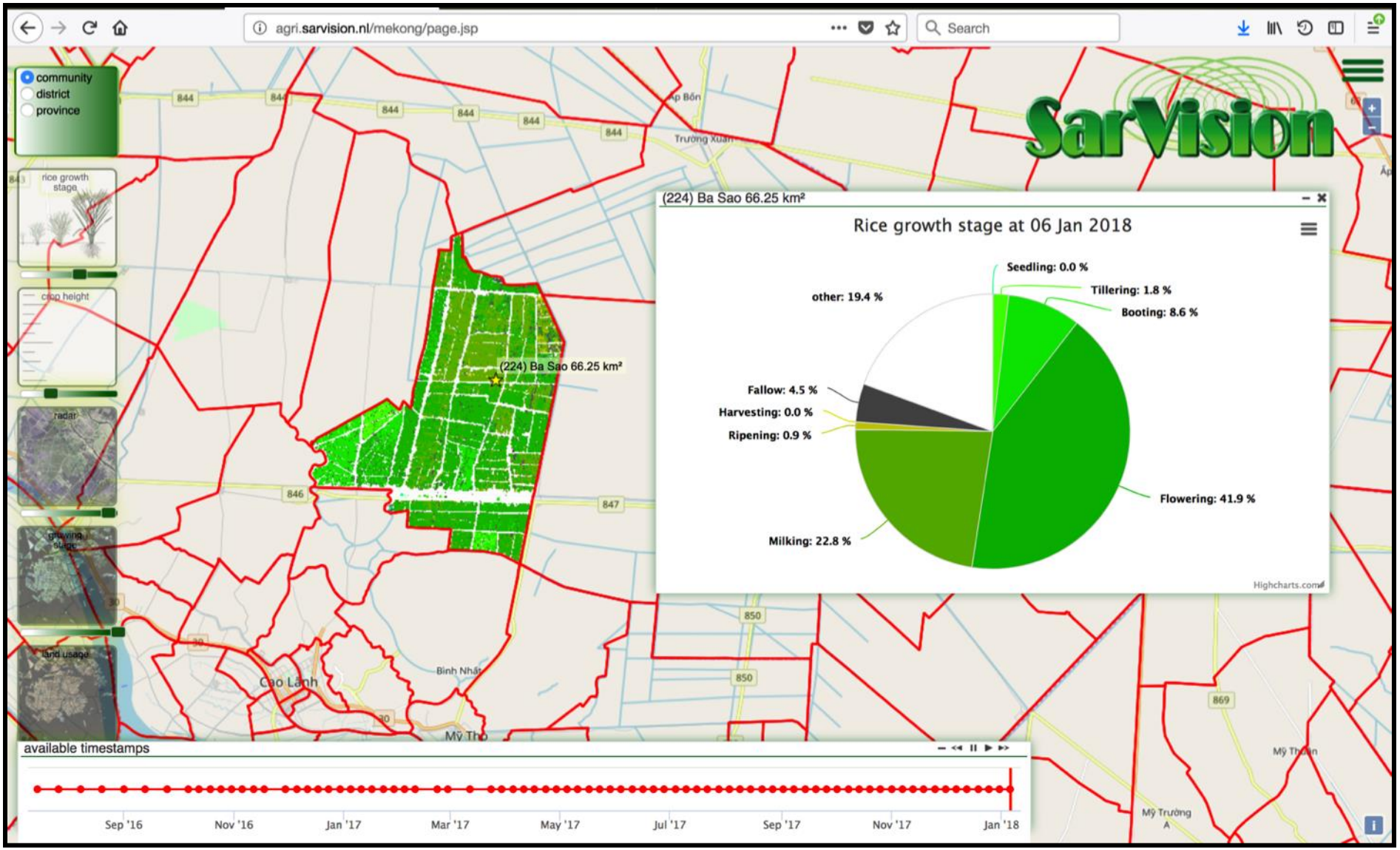

Tropical Peat Watch

L-band has unique observation capabilities to monitor peat (peat swamp forests): (a) below canopy flooding and (b) peat soil wetness

Indonesia has most of the tropical peatlands (±50%)

Until 20 years ago Indonesia's peatlands were used for selective logging. This was followed by large scale drainage and deforestation. Restoration relies on raising water levels.

The Indonesian Peat Restoration Agency (BRG) has the mandate to implement peat ecosystem restoration in 7 provinces.

The target is to rewet 2 million ha in the next 5 years; blocking more than 10,000 km of canals; for which more than 10,000 dams need to be constructed.

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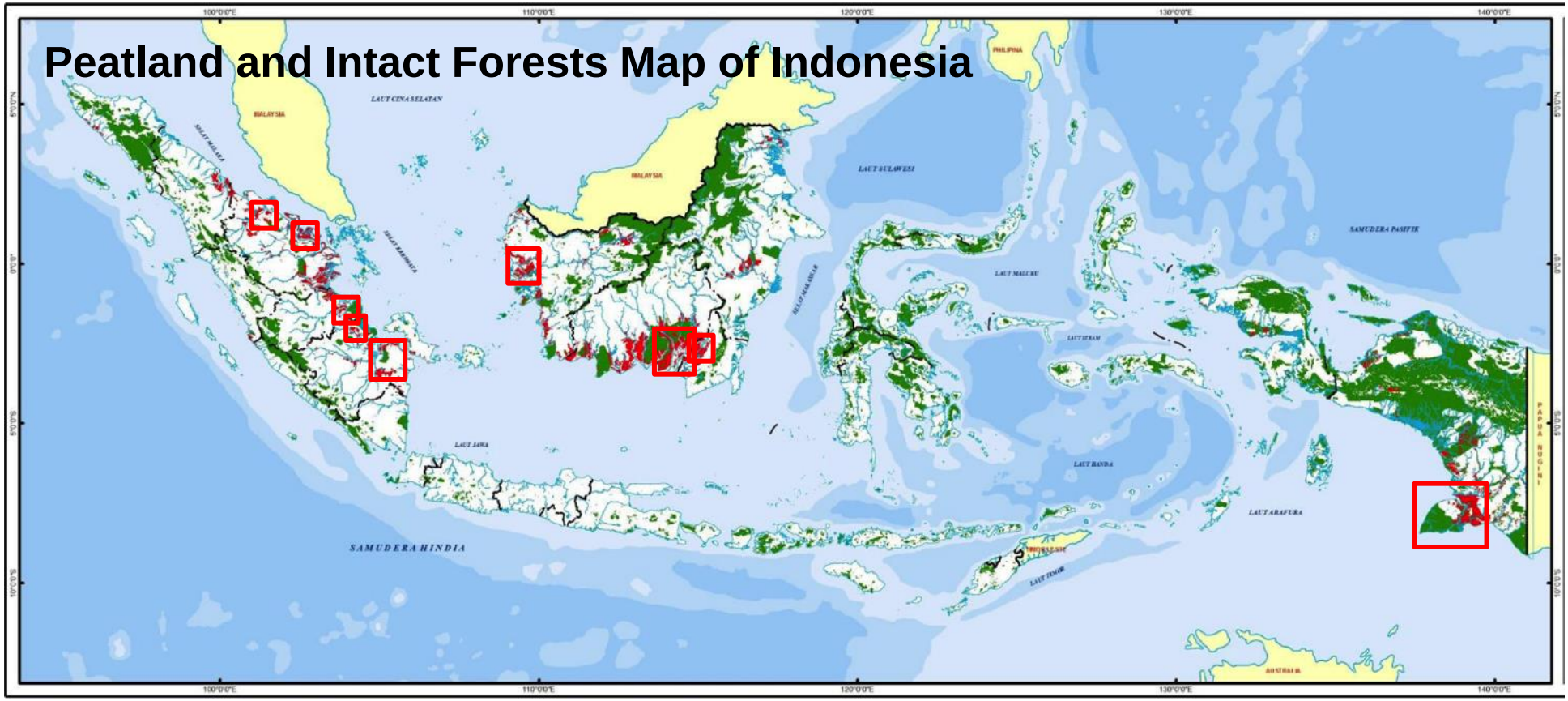
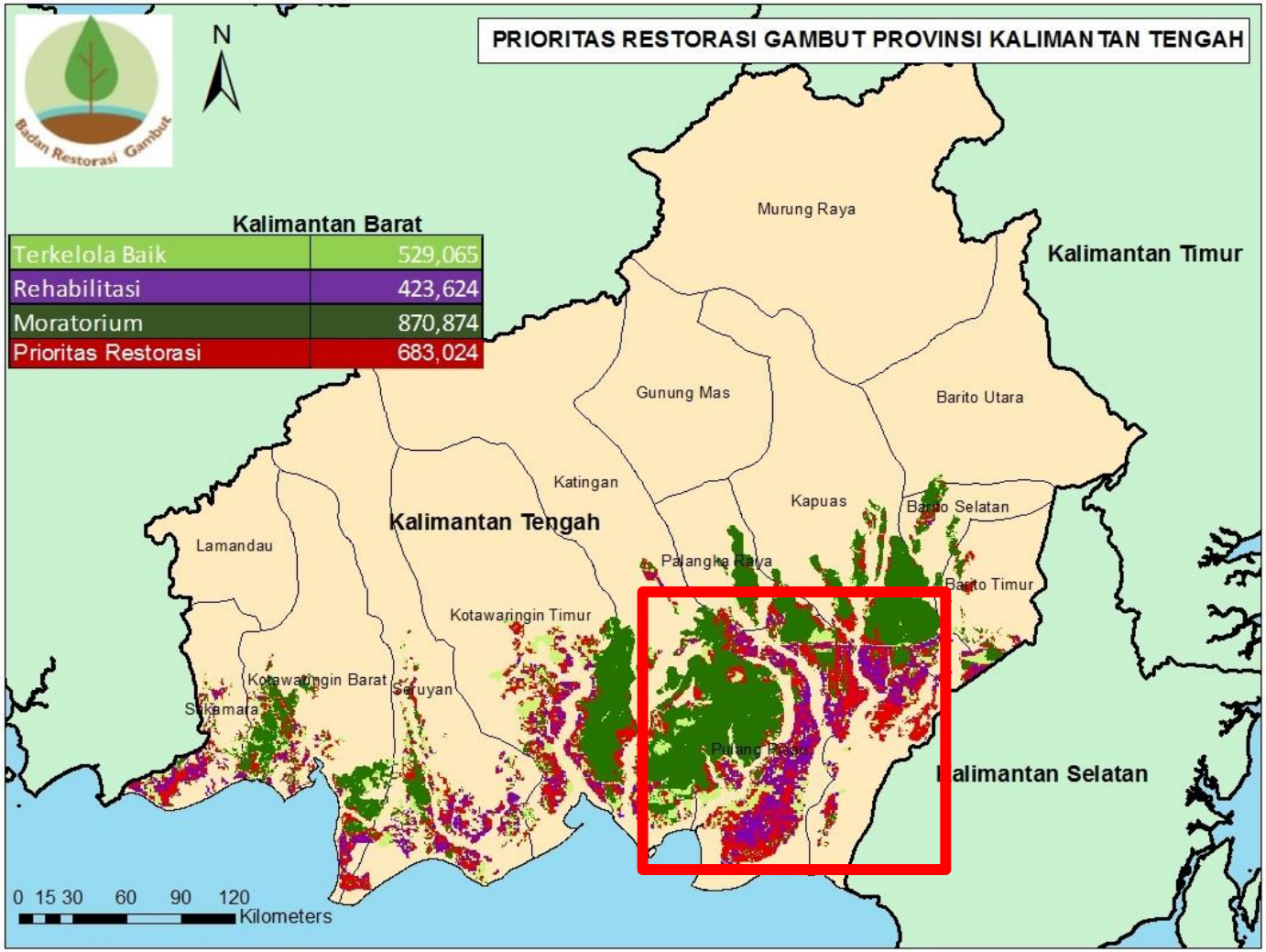
Tropical Peat Watch



Nine peat restoration areas located in Sumatra, Kalimantan and Papua (7 provinces).
In these 7 provinces there is 16.1 Mha peatland, of which 5.8 Mha ombrogenous peat (domes) and 2.7 Mha assigned as priority for peat restoration.



Example of peat restoration priority map: Central Kalimantan (*Source*: BRG, LAPAN)

Tropical Peat Watch

TPW can support BRG by (NRT) processing of radar satellite data for:

- Monitoring land cover change
- Detecting newly constructed (often illegal) canals
- Assessment and monitoring flooding dynamics (support canal blocking)
- Assessment effects of restoration (rewetting)
- Assessment land subsidence dynamics

Relevant expertise (for a TPW science team) is already available in K&C science team and IPP team:

- **K&C:** AGS, LAPAN, Wageningen, BPPT, JAXA, soloEO, WWF, …
- **IPP:** AGS, LAPAN, Wageningen, BPPT, …

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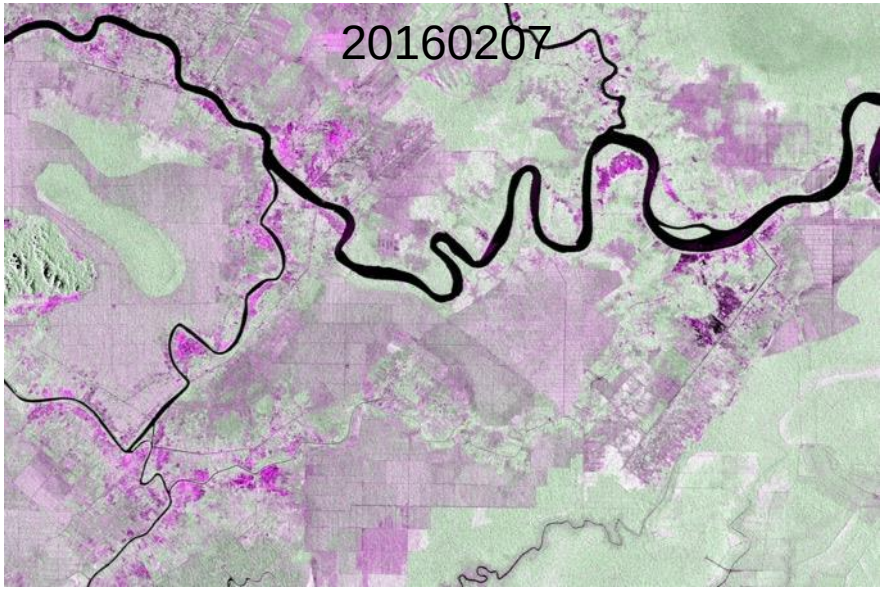
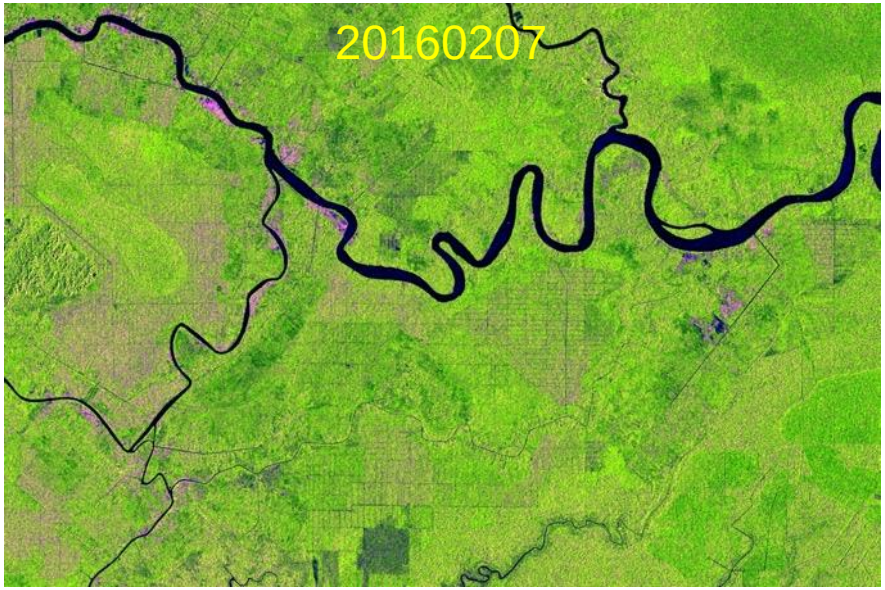
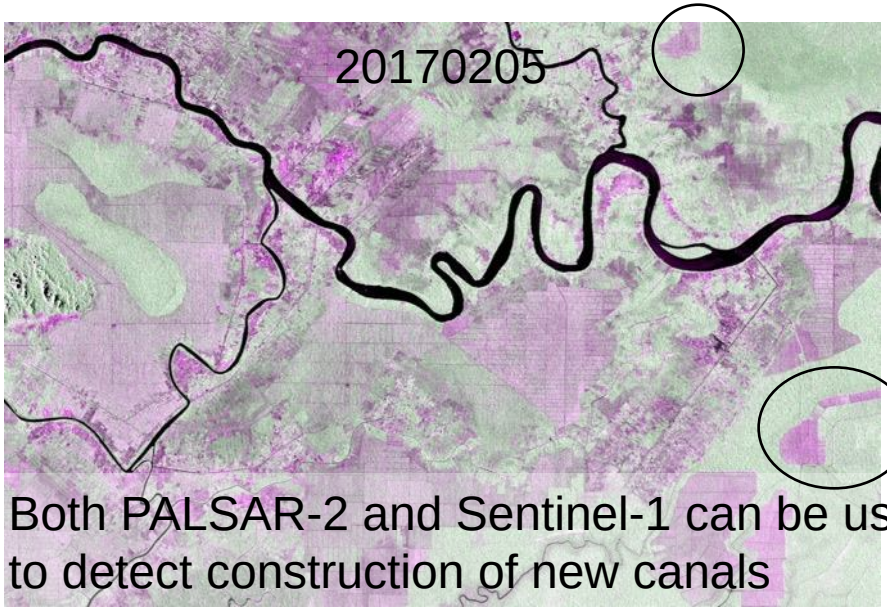
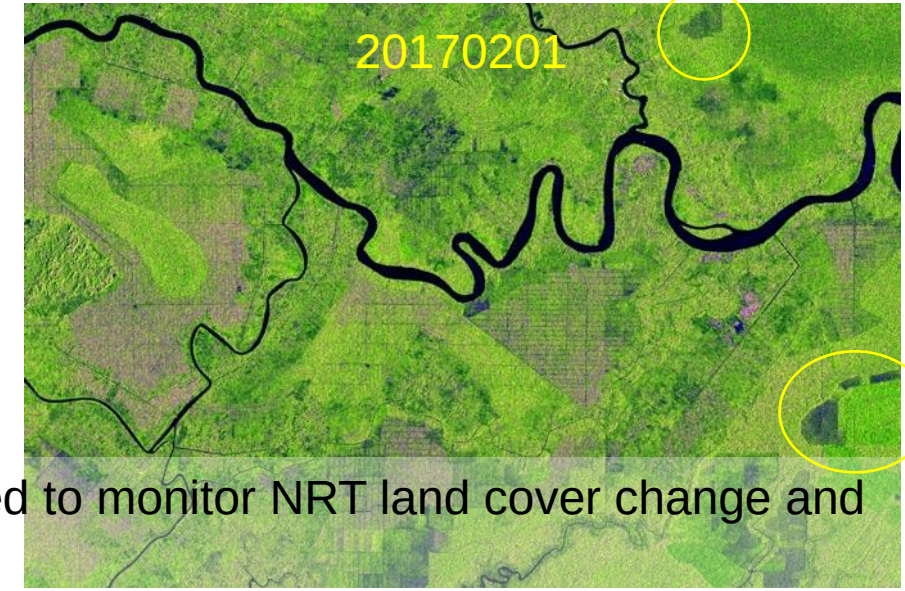
PALSAR-2

Sentinel-1









Both PALSAR-2 and Sentinel-1 can be used to monitor NRT land cover change and to detect construction of new canals

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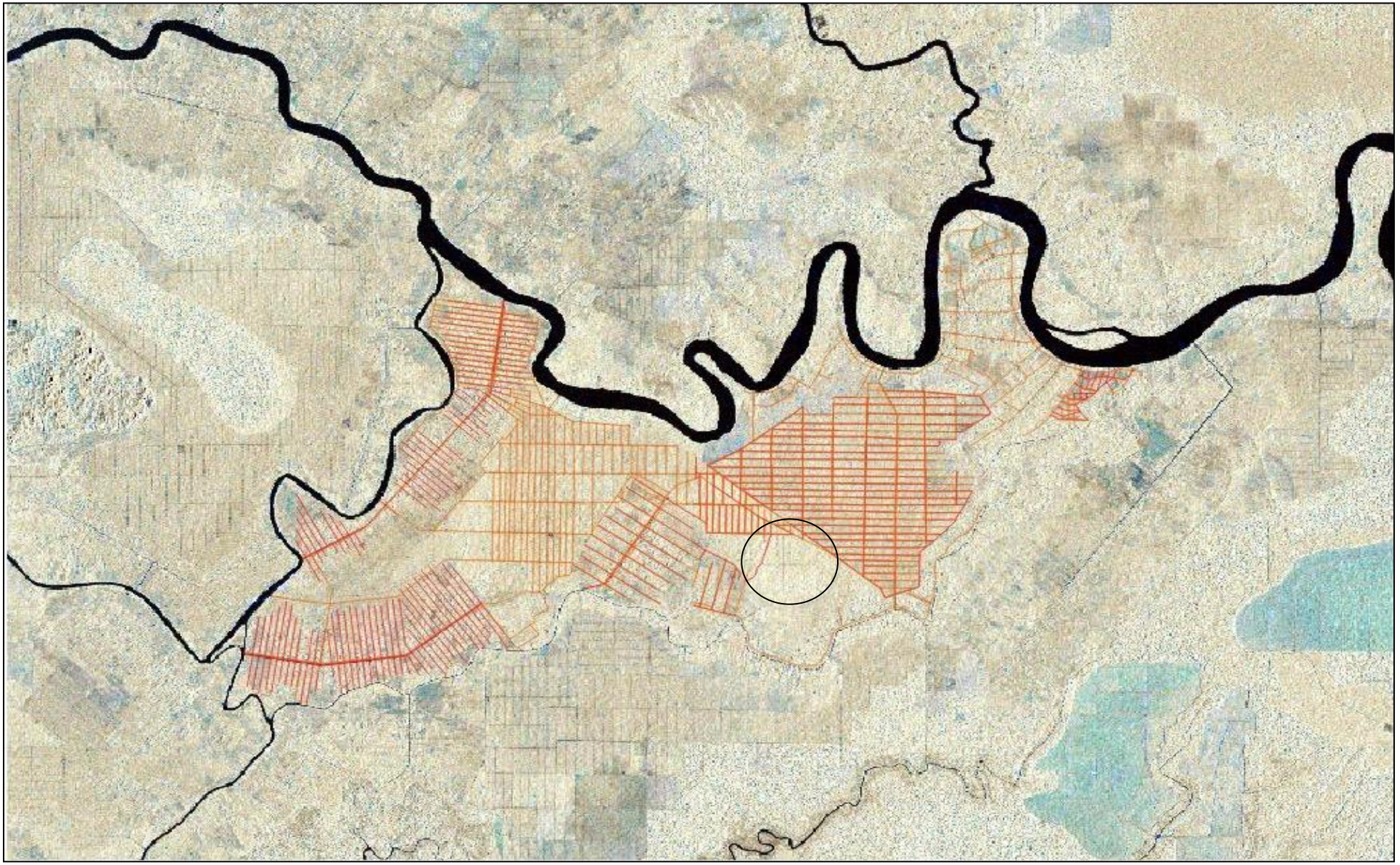
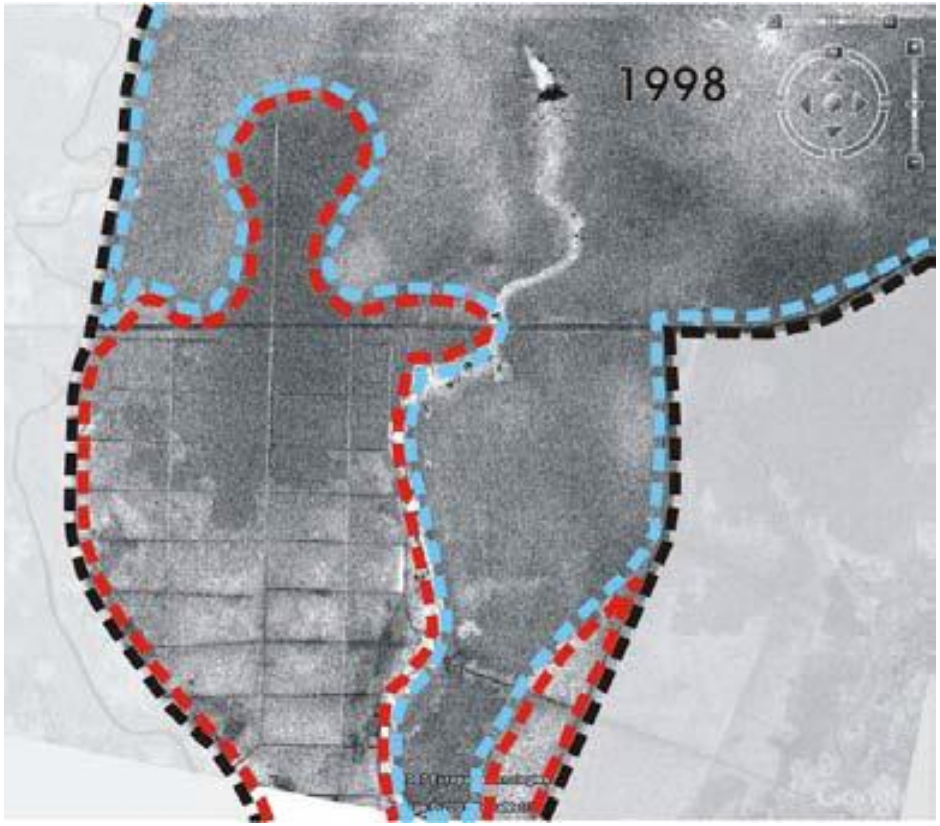
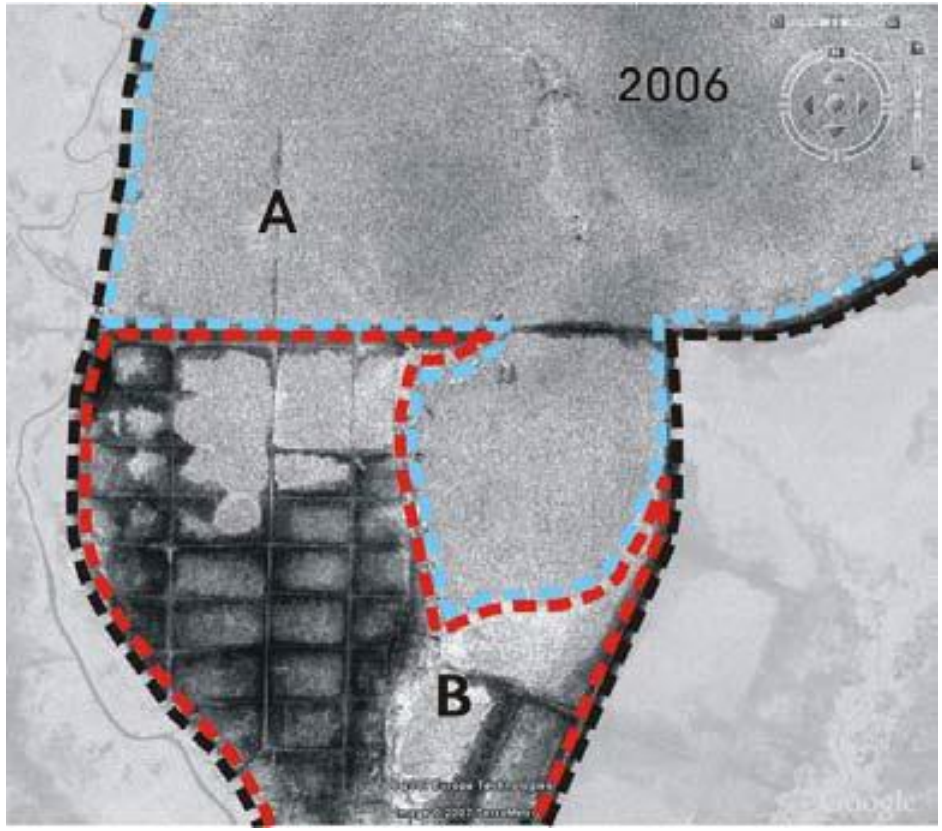






Effect of canal blocking: Peat swamp degradation (B) and restoration (A) in the Mawas area between 1998 (JERS-1) (a) and 2006 (PALSAR) (b). The red area is degraded; the blue area is intact or regenerating.

Project milestones

List the project milestones until March 2018.

Project milestones

A. Consistent time series of wide area land/forest cover maps for Borneo and Guiana Shield (2007-2010 & 2014-2017); Dec 2018 (path data now available)

B. Decadal change maps ± 1997 – 2007 – 2017 (using JERS-1 mosaics and PALSAR-1); Dec 2018

C. Wetland dynamics maps of Borneo (periods 2007-2010 and 2014-2017); **Aug 2015 (Palsar-1)**; Dec 2018 (Palsar-2)

D. Multi-band wide area demonstration maps of Borneo (PALSAR-2 & Sentinel-1); **LC June 2016**

E. Forest and biomass stratification maps and deforestation hot spots maps for Borneo and Guiana Shield; **Multi-model slope Oct 2015; TSX Nov 2015; Borneo Jun 2016;** Guiana Shield Dec 2018

Project milestones

Project milestones

F. Flood frequency mapping using the Mosaic data, not only covering the test sites, but also the peat restoration sites in Sumatra and Papua; Dec 2018

G. Methodology development/comparison: 1-2 incidence angles (mosaic data, path data), 1-2 polarizations (P2 HH only, HH&HV), 1-2 bands (P2 only, P2 & S1); Dec 2018

Deliverables

Project deliverables until March 2018

- Methodology development
- Wide area test products Borneo (Flood frequency; Refined slope correction; Dual-frequency; Land cover)
- Ground truth data sharing (Borneo; Suriname)

Additional deliverables by March 2019

- Final wide area products based on path data
- Final wide area products based on ScanSAR mosaics
- TPW demo products

PALSAR/PALSAR-2 data access

Path data PALSAR-2 Cycle 2-88

ScanSAR Borneo:	217 requested, 132 received (61%)
ScanSAR Guiana Shield:	248 requested, 206 received (83%)
Fine Beam (both sites):	460 requested, 413 received (90%)

PALSAR/PALSAR-2 ScanSAR mosaics (both sites)

PALSAR-1/2 ScanSAR:	batch 1-4 received; batch 5 in Feb2018
JERS-1:	204 mosaics received

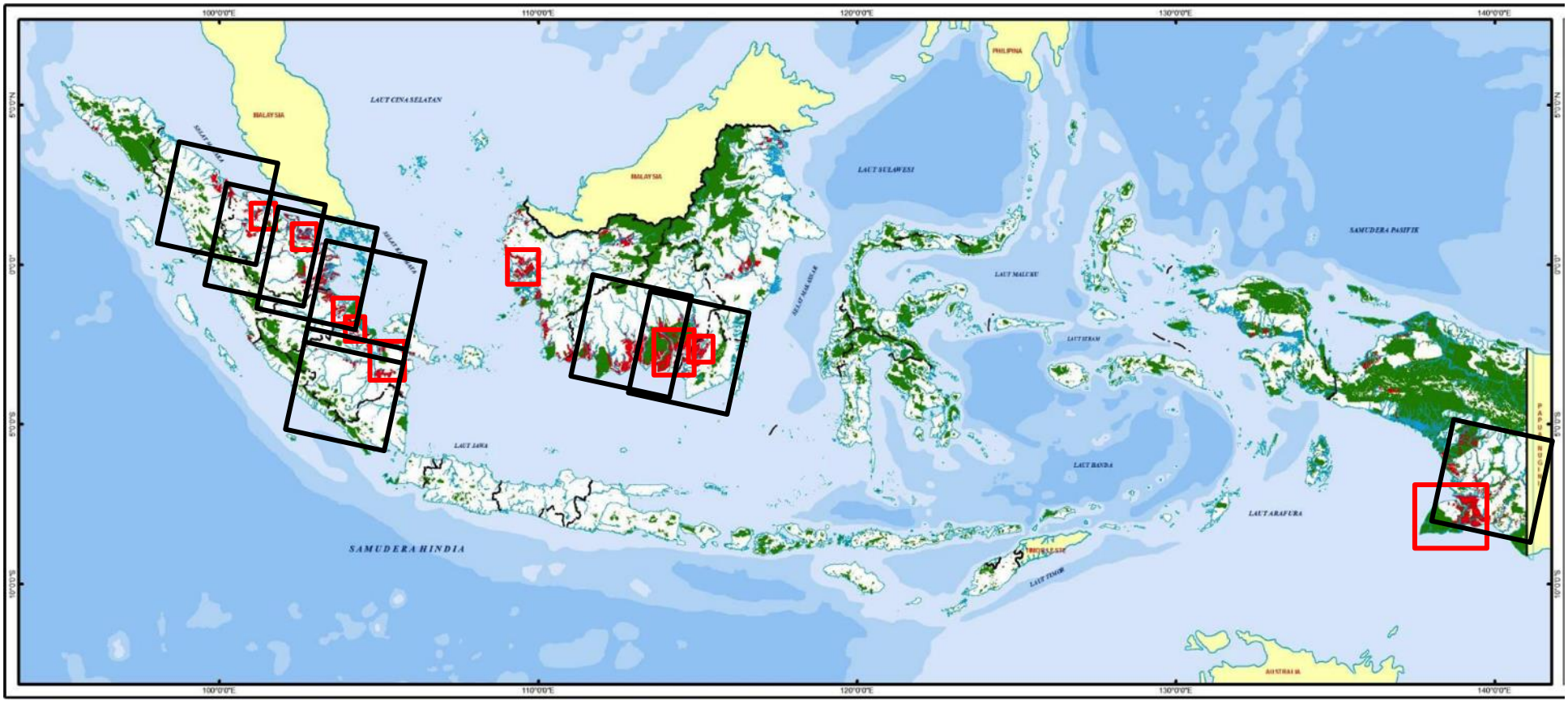
Standard ScanSAR data

PALSAR-1: Papua (27)

PALSAR-2: Papua (21); Sumatra (67); Borneo (33)

PALSAR/PALSAR-2 data access

Standard ScanSAR data covering peat restoration sites



PALSAR/PALSAR-2 data access

Describe your plans for use of the EORC ScanSAR mosaics

- Flood frequency mapping using the Mosaic data, not only covering the test sites, but also the peat restoration sites in Sumatra and Papua
- Demonstration products (for Indonesia) and methodology for a Tropical Peat Watch

Acknowledgement

This work has been undertaken within the framework of the JAXA Kyoto & Carbon Initiative. ALOS PALSAR data have been provided by JAXA EORC

Thank you