Wide area forest monitoring of Insular SE Asia and Guiana Shield

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Science Team meeting #18
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Collaborators

- LAPAN: GEO-FCT National Demonstrators Borneo and Sumatra
- Guyana Forestry Commission: GEO-FCT National Demonstrator Guyana
- Wageningen University (CGI): EU Recover project in Guyana
- Equipe de Conservação da Amazônia (Amazon Conservation Team): ‘Karib Corridor’, Brazil
- SarVision
- Wageningen University (ESS)

Presentation outline

1. Introduction – Objectives Phase 3
2. Summary wide-area mapping Borneo 2007-2010
3. Progress Indonesia
4. Progress Guiana Shield
5. Plans for next half year

Project area(s)

Focus on two major biomes with persistent cloud cover:

- **Guiana Shield**, with focus on Guyana, Suriname, “Karib Corridor” and Colombia (including Choco)
- **Insular SE Asia**, with focus on Borneo, Sumatra and Papua (Indonesian part of New Guinea)

Project objectives

Primary objectives

The project primarily aims to develop techniques to improve time-consistency (and avoid error propagation) over wide areas.

This includes the automated adaptation of radar signatures to changing environmental conditions and the use of ScanSAR data to support classification in dynamic and irregularly inundated areas.

Note: Integration with Landsat is studied for development of high accuracy “GFOI Forest Information Products”

Project objectives

Secondary objectives

To improve **classification** and **biomass stratification** accuracy (and spatial resolution) it is intended to address technical issues such as:

- Further development of slope correction by adaptation to terrain characteristics and handling micro-relief (below resolution SRTM) (in progress)
- Study of the utility of texture (and preferably using 10 m mosaic data)
- Processing of denser time series
- and application of multi-temporal speckle filtering (done)

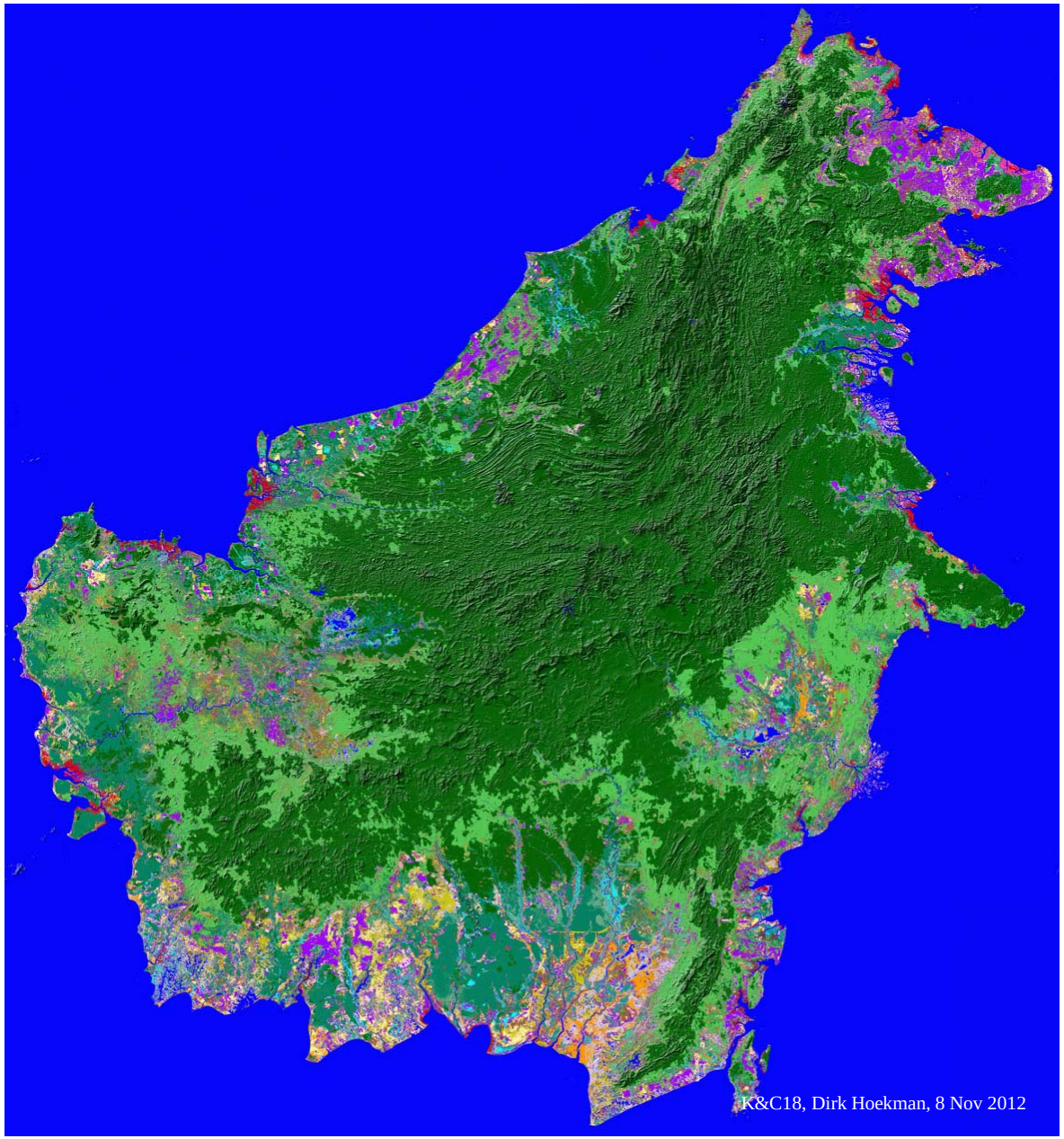
Wide area SAR mapping methodology: *Phase 2 Map res*

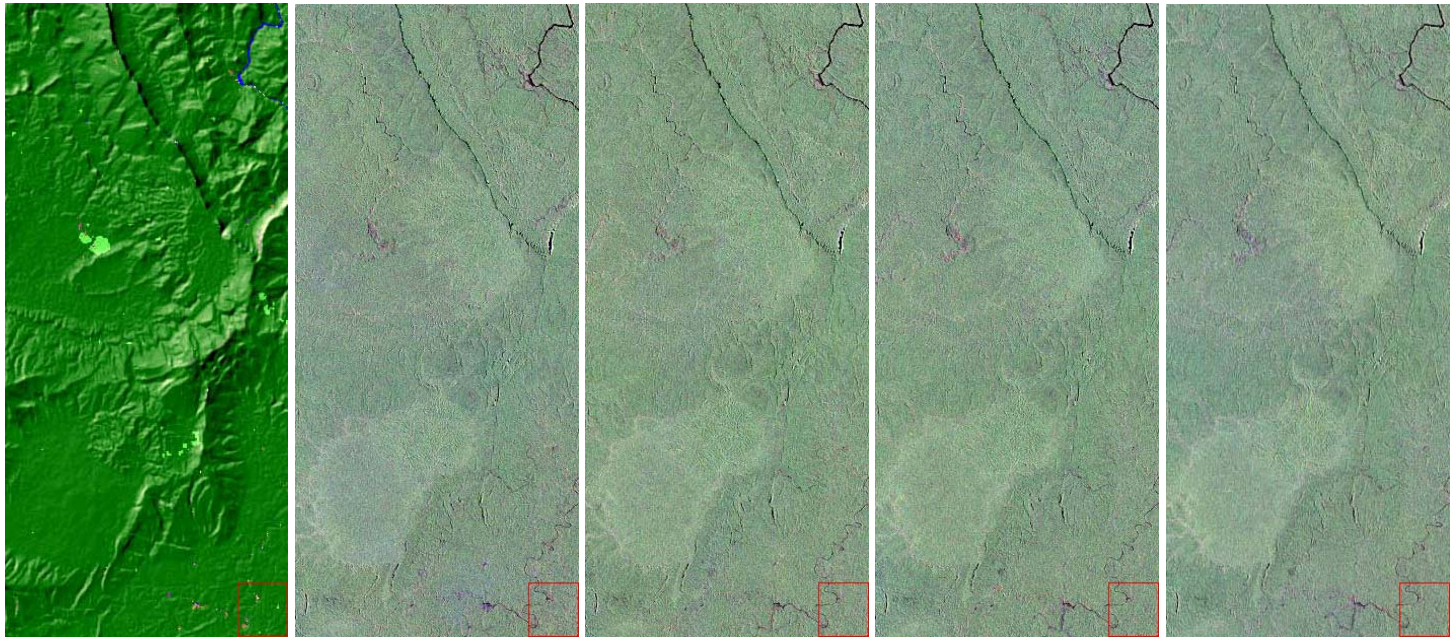
ALOS PALSAR 2007

LULC classification Borneo

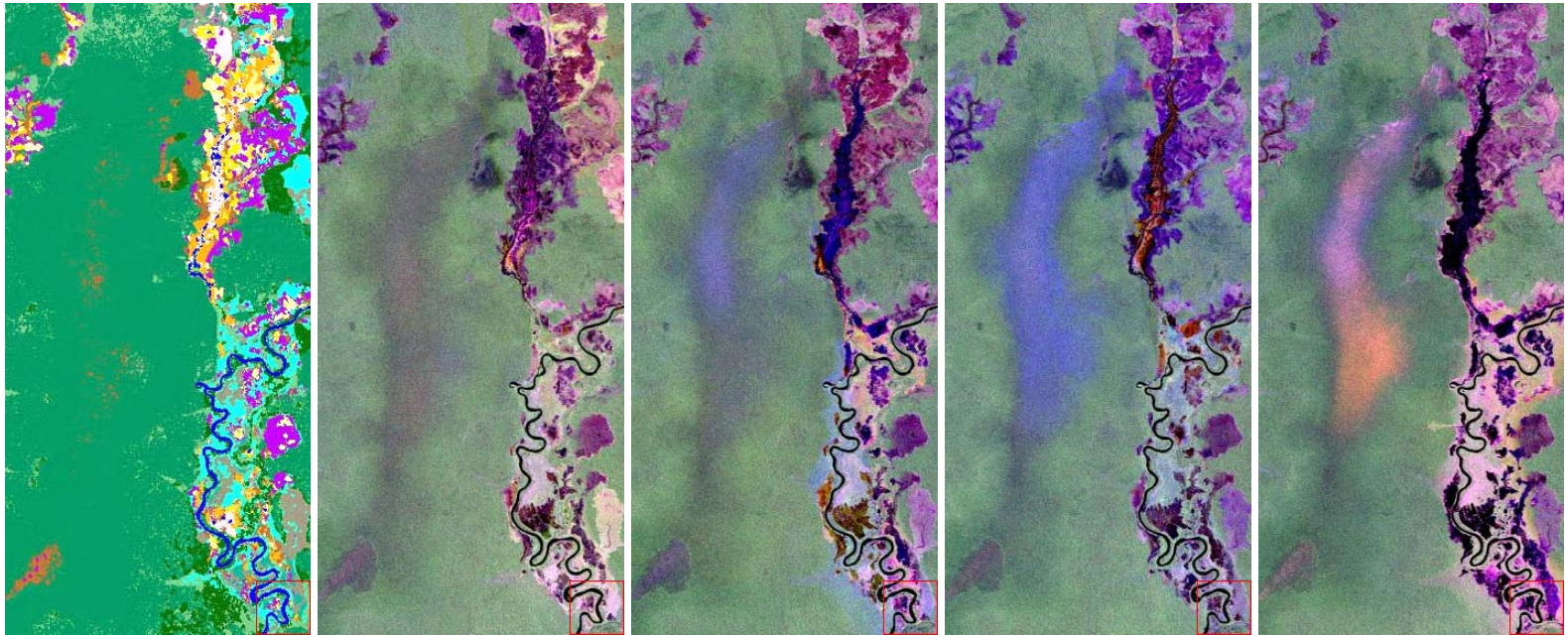
(shaded relief version)

- Lowland forest
- Riverine forest
- Swamp forest
- Mangrove forest
- *Nipah* mangrove forest
- Peat swamp forest (pole)
- Peat swamp/riverine shrub
- Forest mosaics/degraded
- High shrub
- Medium shrub
- Ferns / grass
- Grassland
- Cropland (upland)
- Cropland (irrigated)
- Plantations (oil palm)
- Tree cover, burnt
- Water bodies
- Layover /Shadow
- No strip coverage
- Mountain forest

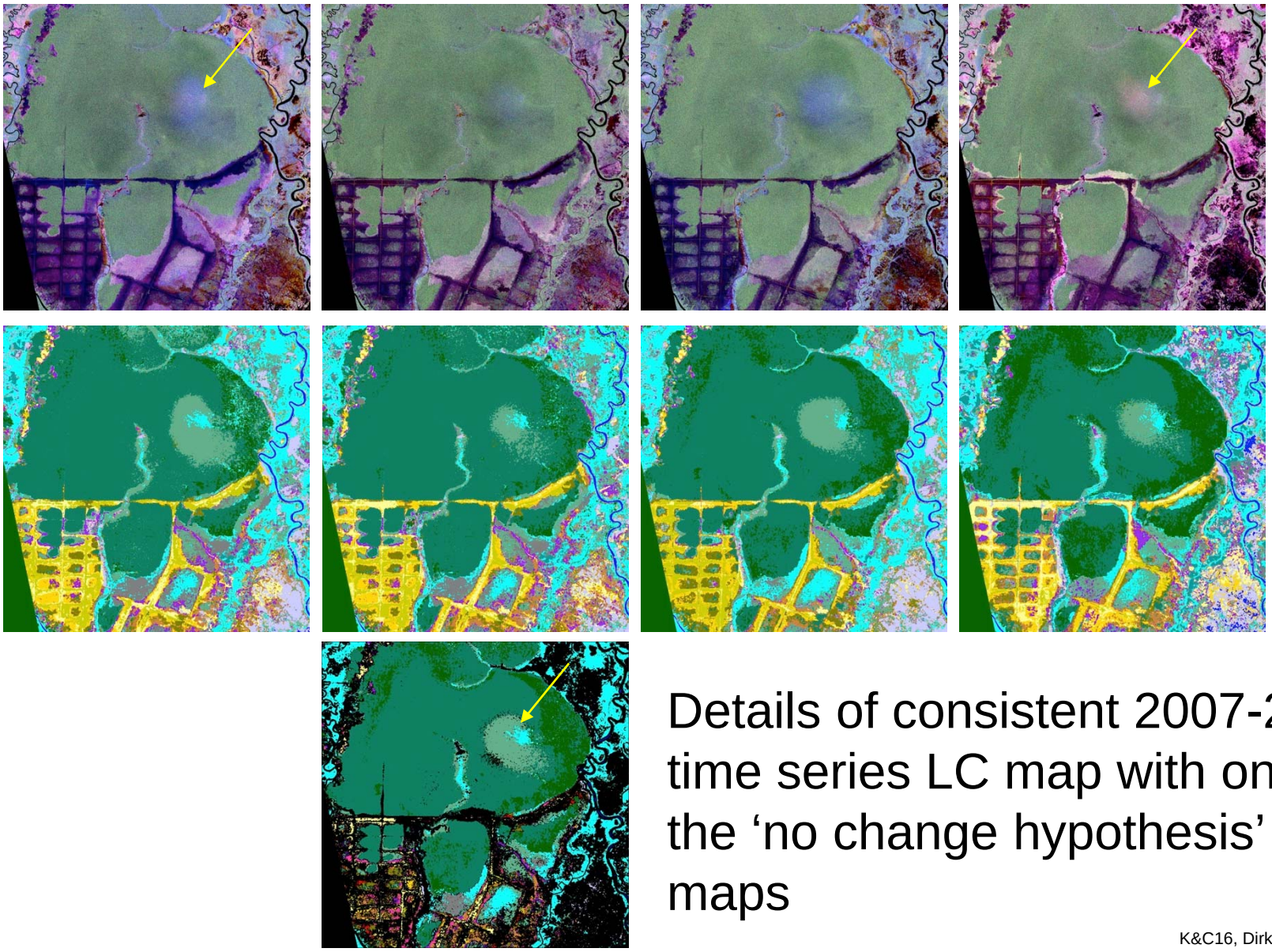




Forest. From left to right: map 2007, radar (FBS-FBD) mosaics 2007, 2008, 2009 and 2010. The forest areas feature very stable backscatter levels from year to year.



Peat swamp forest and floodplain. From left to right: map 2007, radar mosaics 2007, 2008, 2009 and 2010. The backscatter dynamics in the *padang* (or central) regions of the peat swamp forest is high and shows major inter-annual variation related to flooding events.



Details of consistent 2007-2010 time series LC map with one of the ‘no change hypothesis’ maps

Implementation in Indonesia (GFOI / INCAS /MRV)

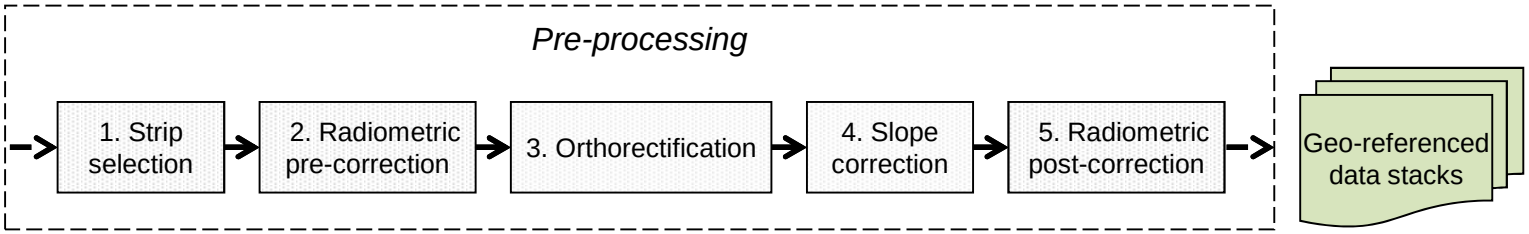
Indonesia will establish its MRV institute in 2013

Some issues are:

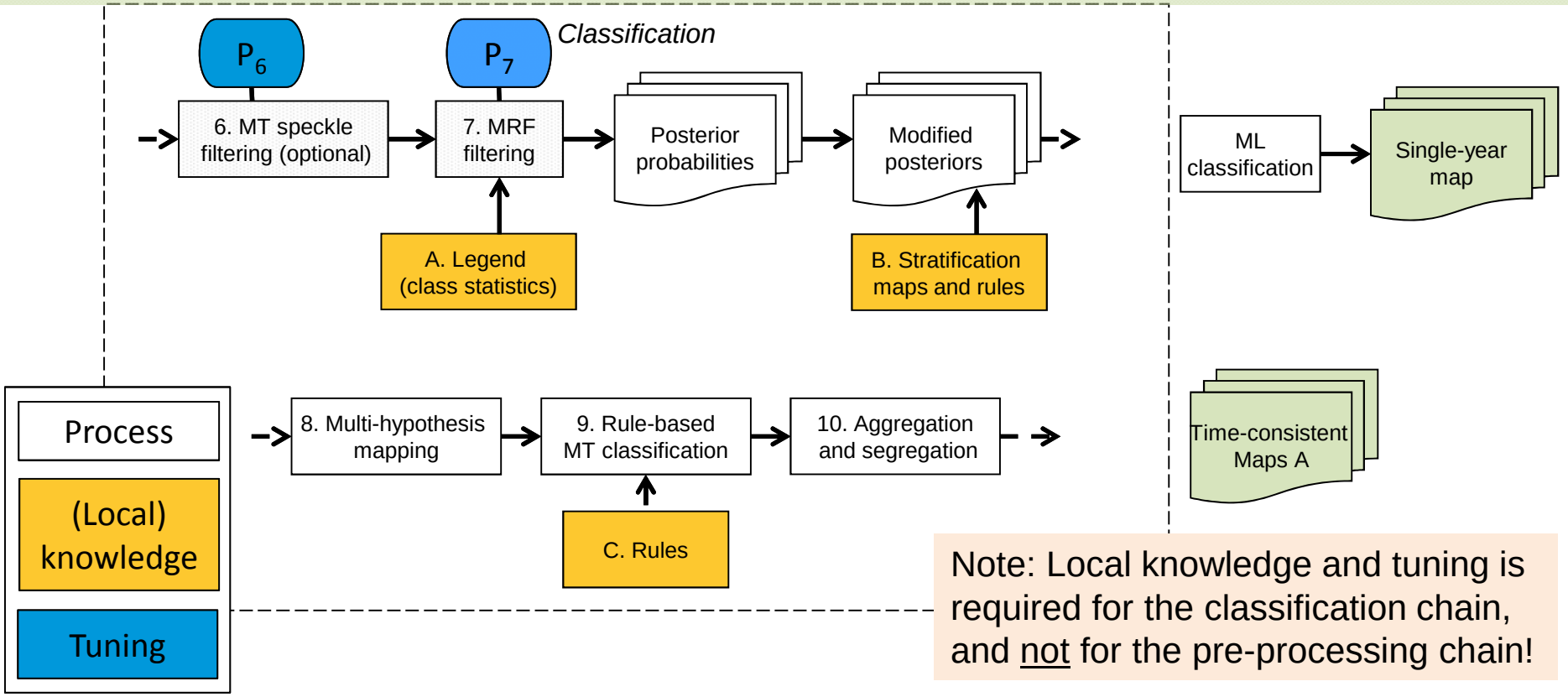
- How to make Palsar annual w2w land cover products
- How to realise sensor integration (such as C-band, Landsat) to achieve interoperability and higher accuracy
- How to coordinate this institutionally & inter-disciplinary

Flowchart consistent land cover mapping (system A)

Note 3: System B is for near real time deforestation/degradation monitoring (using other sensors)



Note 1: Framework for sensor integration at observable, stratification and thematic level (such as C-band, Landsat)
Note 2: Framework for institutional and inter-disciplinary cooperation



Note: Local knowledge and tuning is required for the classification chain, and <u>not</u> for the pre-processing chain!

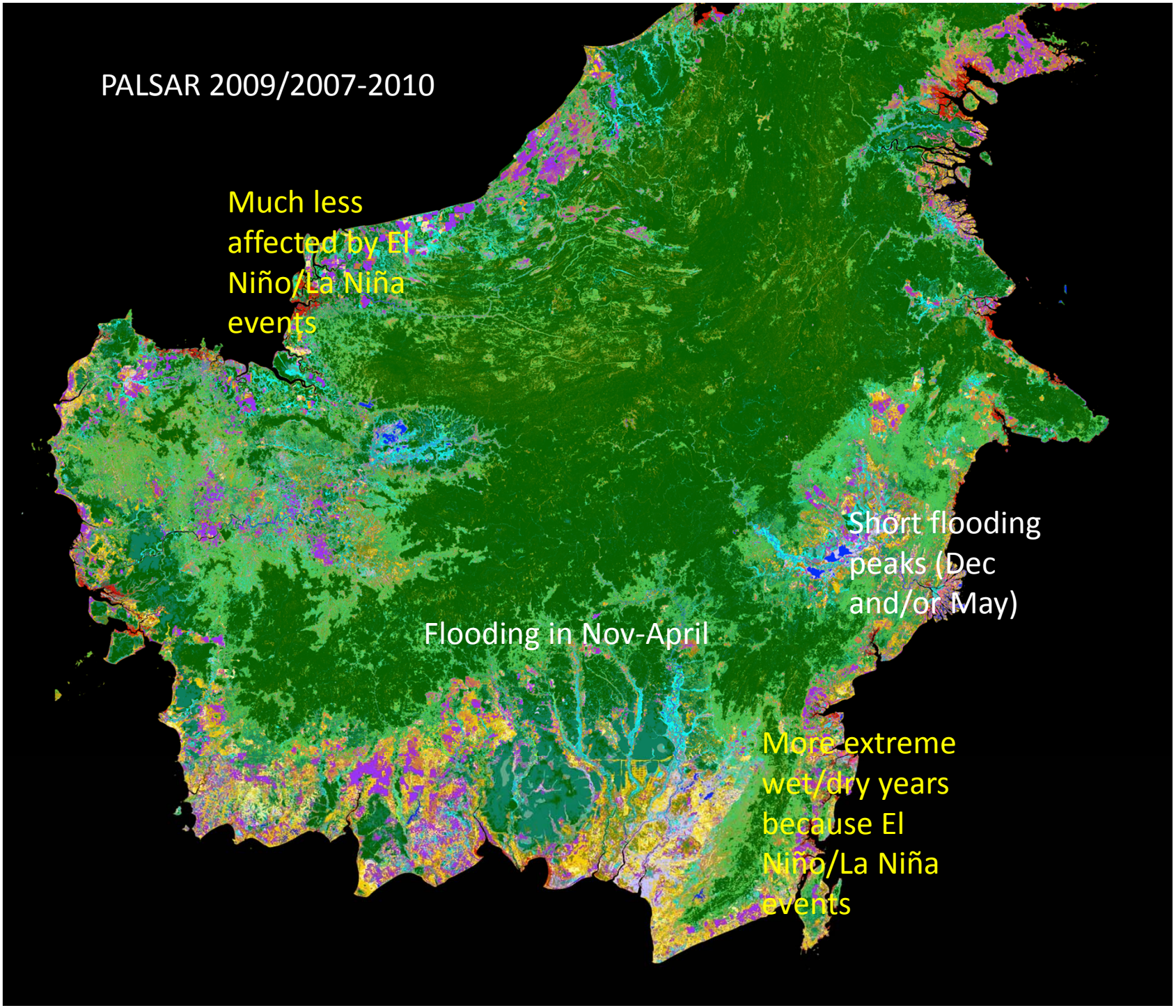
System will be used for automated interpretation at 25 m resolution of (individual) Fine Beam standard images (also from PALSAR-2), based on the dynamical behaviour observed over Borneo during the lifetime of the PALSAR-1.

2007-2008	~normal years
2009	El Niño year
2010	very wet year

It is intended to increase system versatility by developing an interface for user defined legends (which may improve performance after more validation has been done)

System is generic and can be expanded with, or used for, other sensors.

Main users may be LAPAN and Ministry of Forestry



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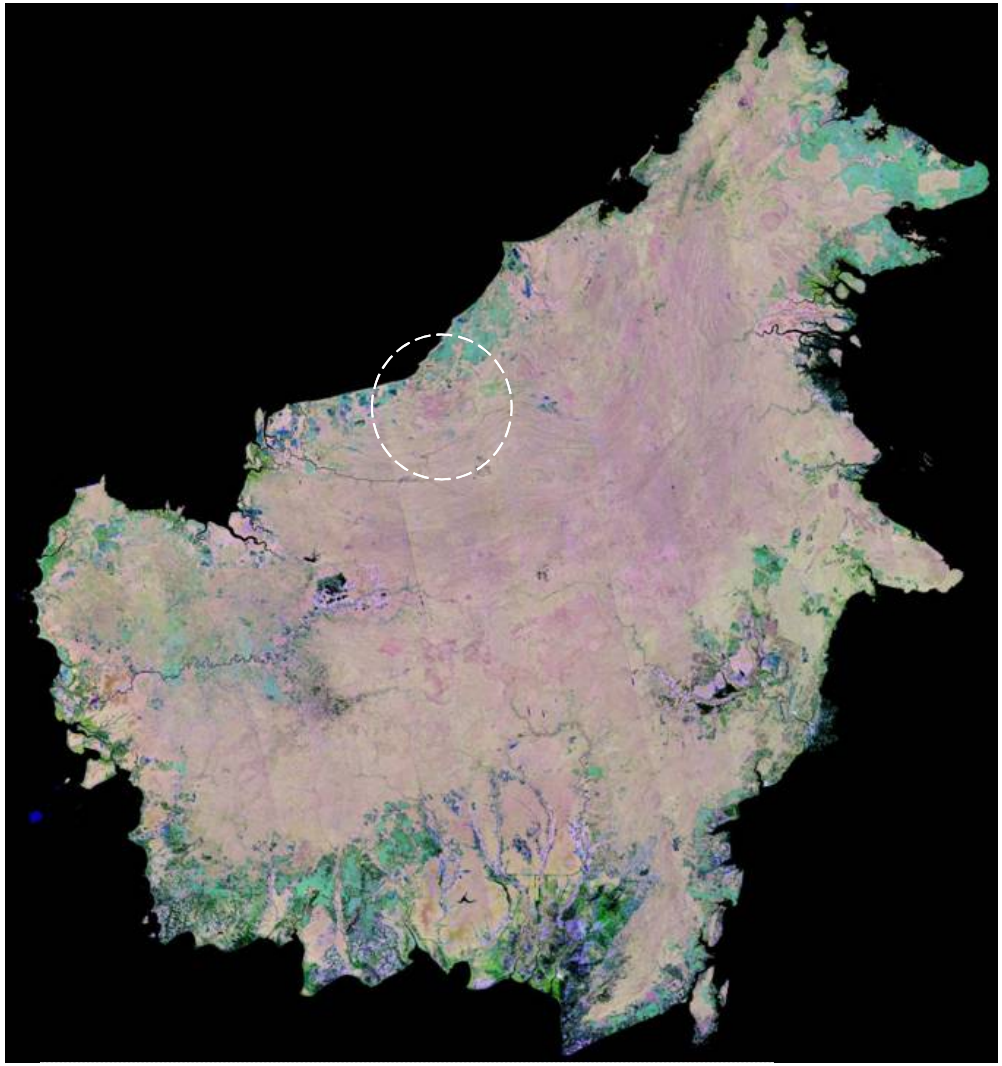


Composite mosaic C&L-band
2009-2010 HH-HV-VV
PALSAR HH-HV
Radarsat-2 VV-HV

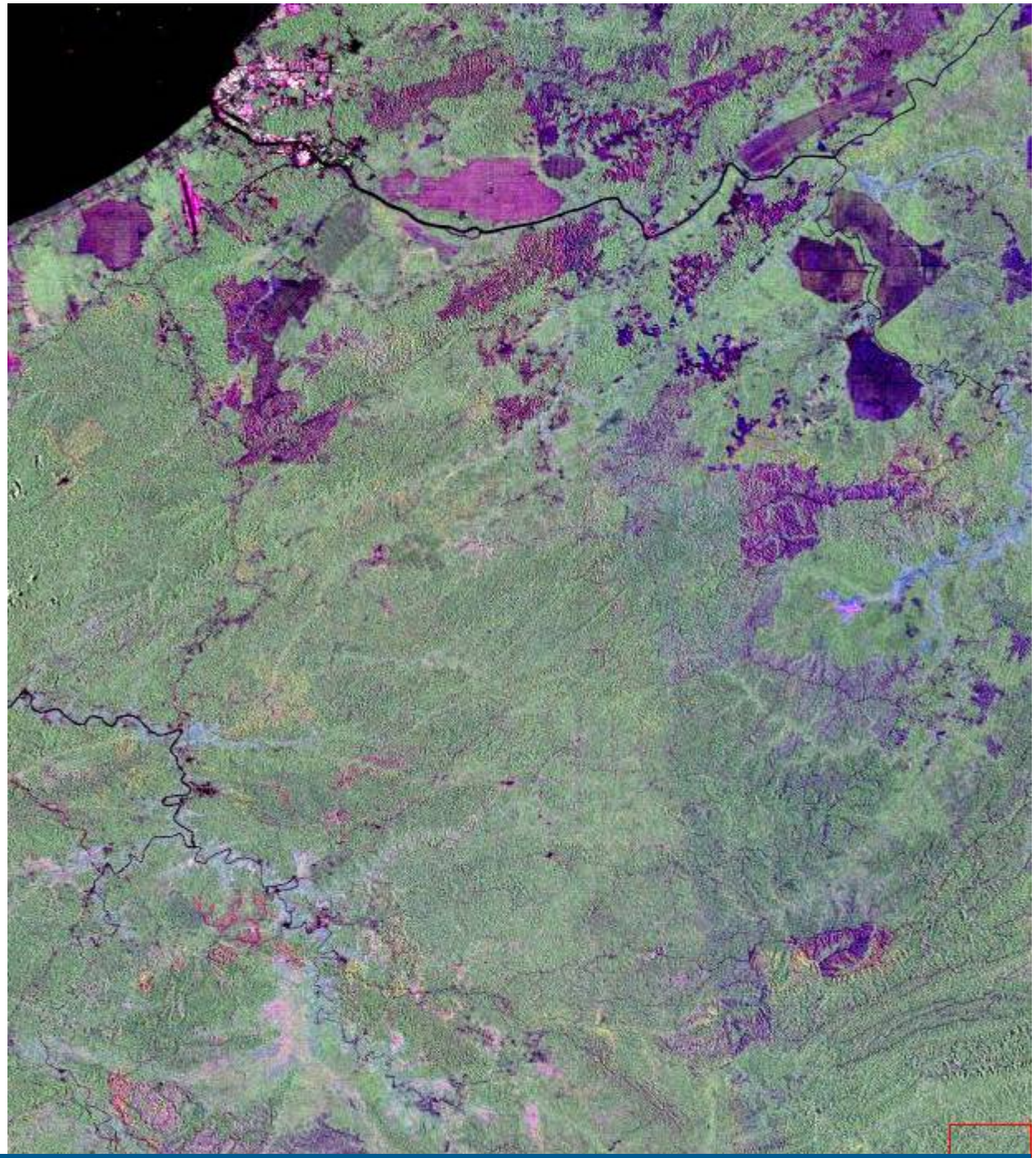
This demonstration product has been made during the 19-29 July 2011 ***"INDF Radar pre-processing Workshop"*** at LAPAN, Pekayon, by participants from LAPAN and Bakosurtanal. Pre-processed radar image products of PALSAR, Radarsat-2, ASAR, TerraSAR-X and Cosmo-SkyMed were created in a highly automated fashion by applying batch processing in Ubuntu LINUX in detached sessions using specialised software from the companies GAMMA and SarVision. This particular product features a wall-to-wall ortho-rectified multi-sensor radar mosaic of Borneo and is corrected for radiometric slope effects.

PALSAR 2009

FBD-HH

FBD-HV

FBS-HH

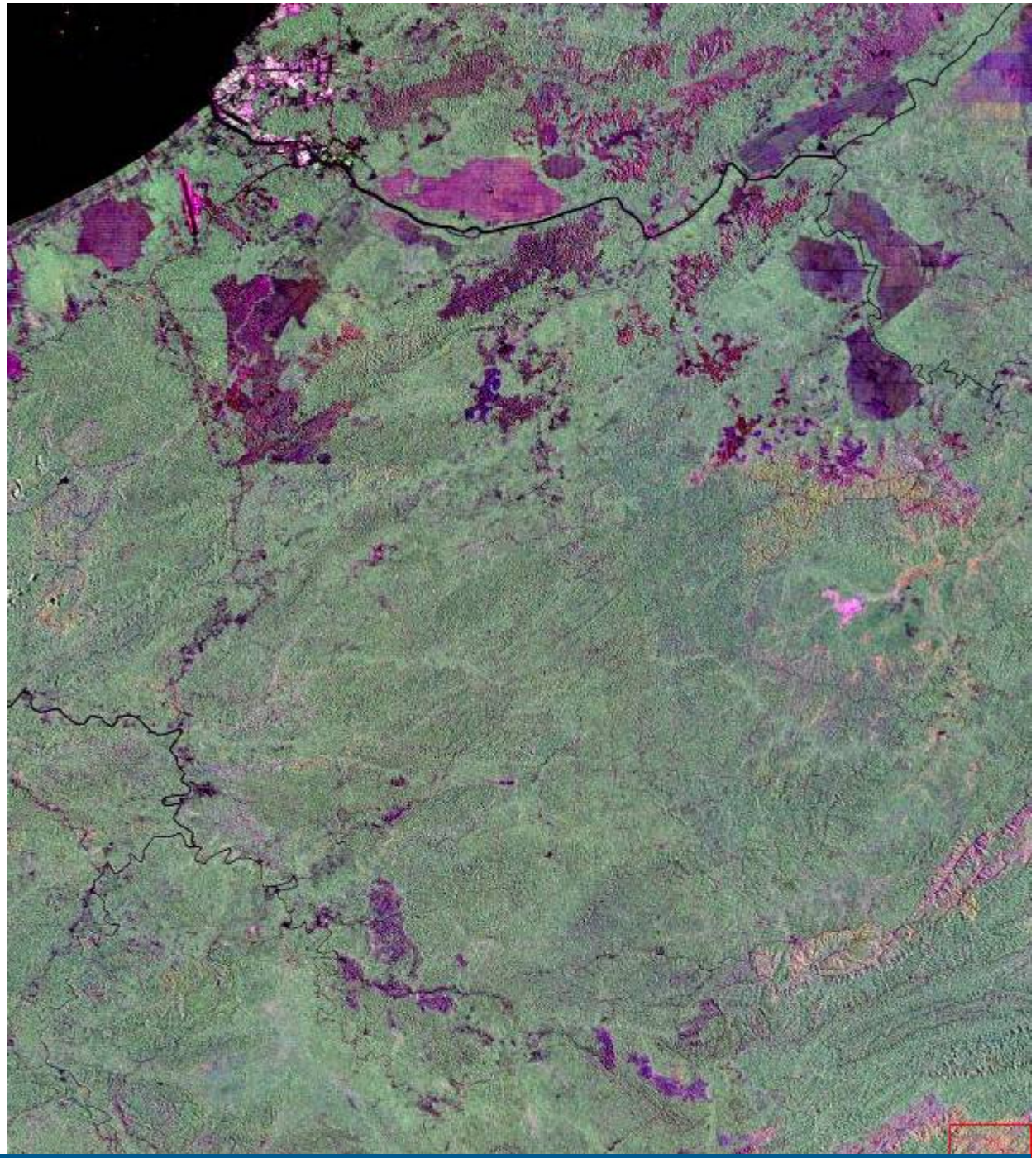


PALSAR 2010

FBD-HH

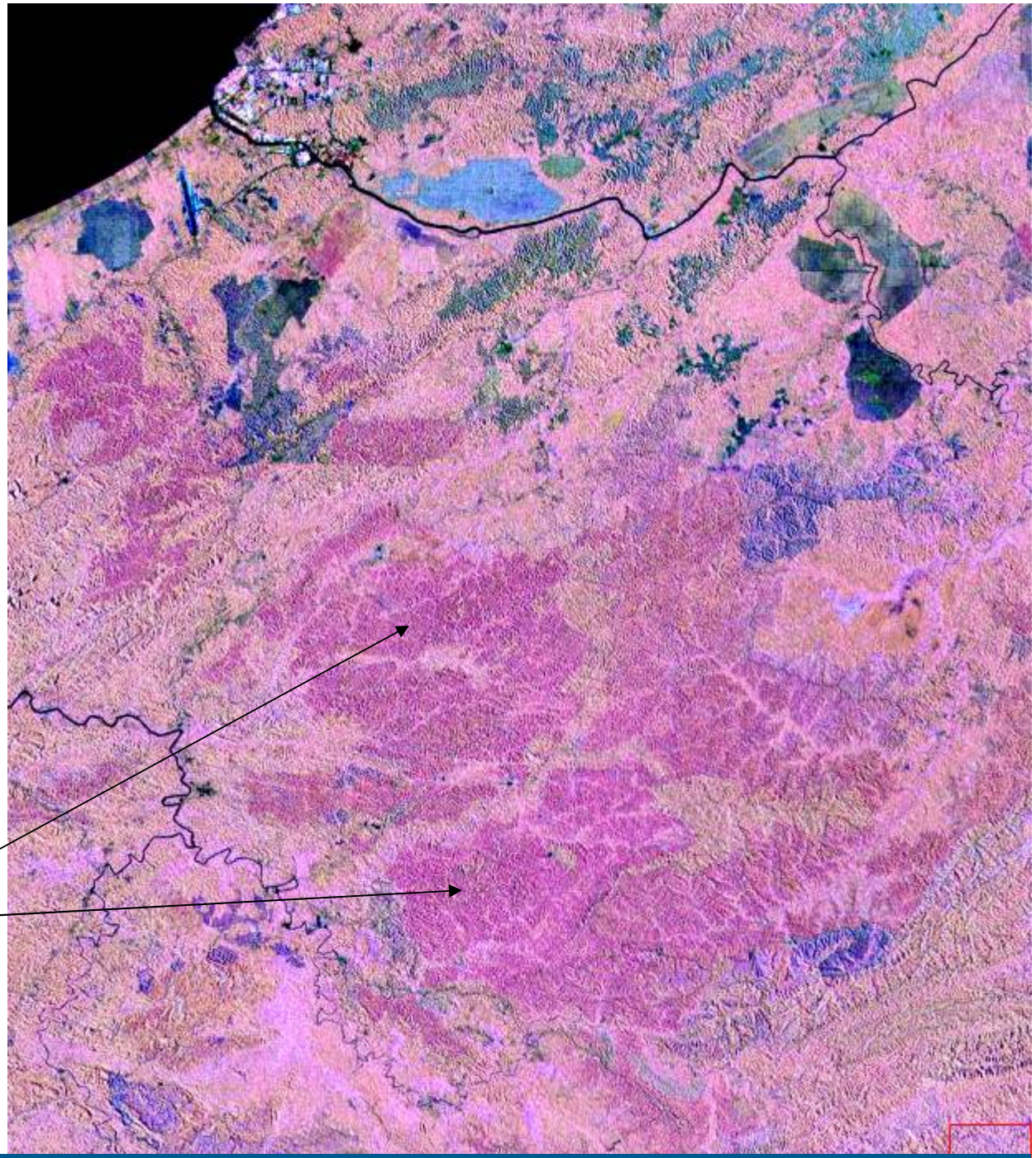
FBD-HV

FBS-HH



INDF mosaic
Radarsat-2 WB
Palsar FB
2009-2010
HH-HV-VV

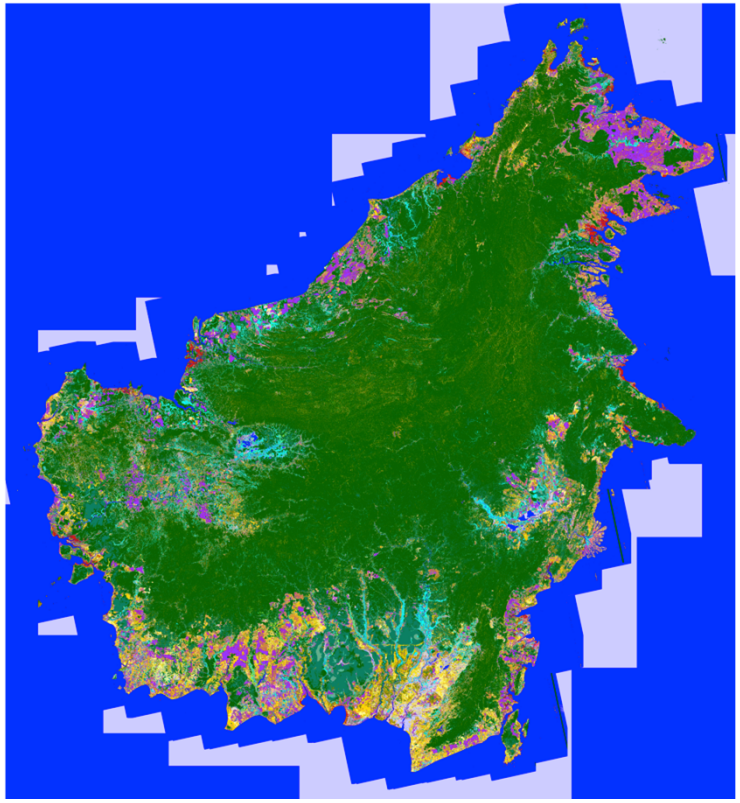
Better visibility of
Acacia plantations

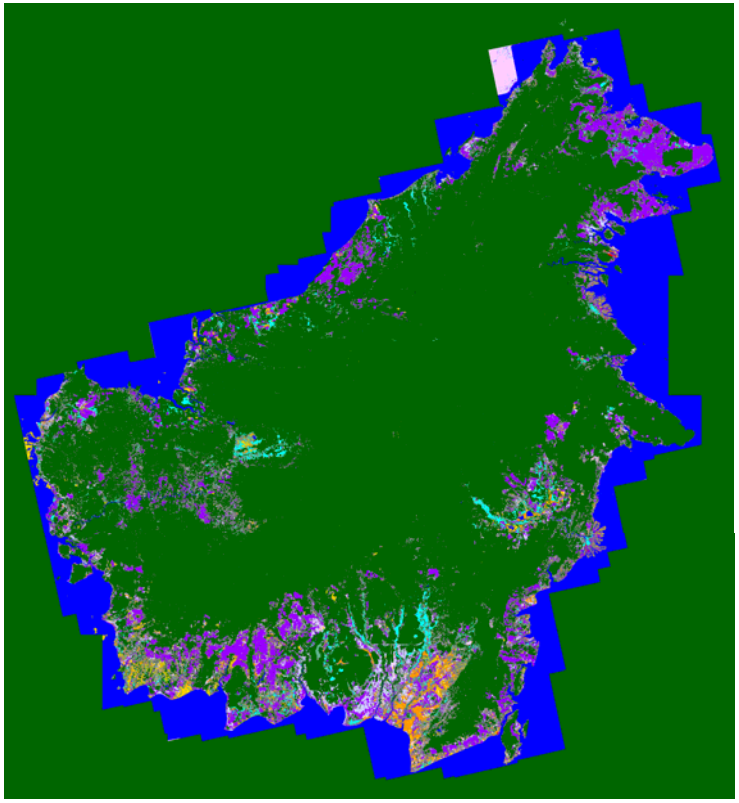


Contrasts between land cover classes increase when C-band (such as Radarsat-2, VV-HV) is used in addition to PALSAR (HH-HV) for the following forest and forest plantation types:

- “Pristine dryland Dipterocarp forest”
- Acacia
- Rubber
- Oil palm (mature)
- Heath forest (Kerangas)
- Peat forest
- “Primary forest patterns”

Result of INDF classification and validation training





Borneo 2009 land cover map according prototype legend proposed by Wageningen (left) and prototype legend developed by LAPAN (right)

Result INDF pre-processing workshop

- This multi-sensor (or multi-band) radar mosaic demonstrates the added value of C-band

- Note: Though this system is based on L-band, in principle, a very similar system could be build on the basis of C-band (such as from SENTINEL-1); Of course the legend may become somewhat different
- *To reduce speckle at least 4 SENTINEL-1 coverages would be needed*)

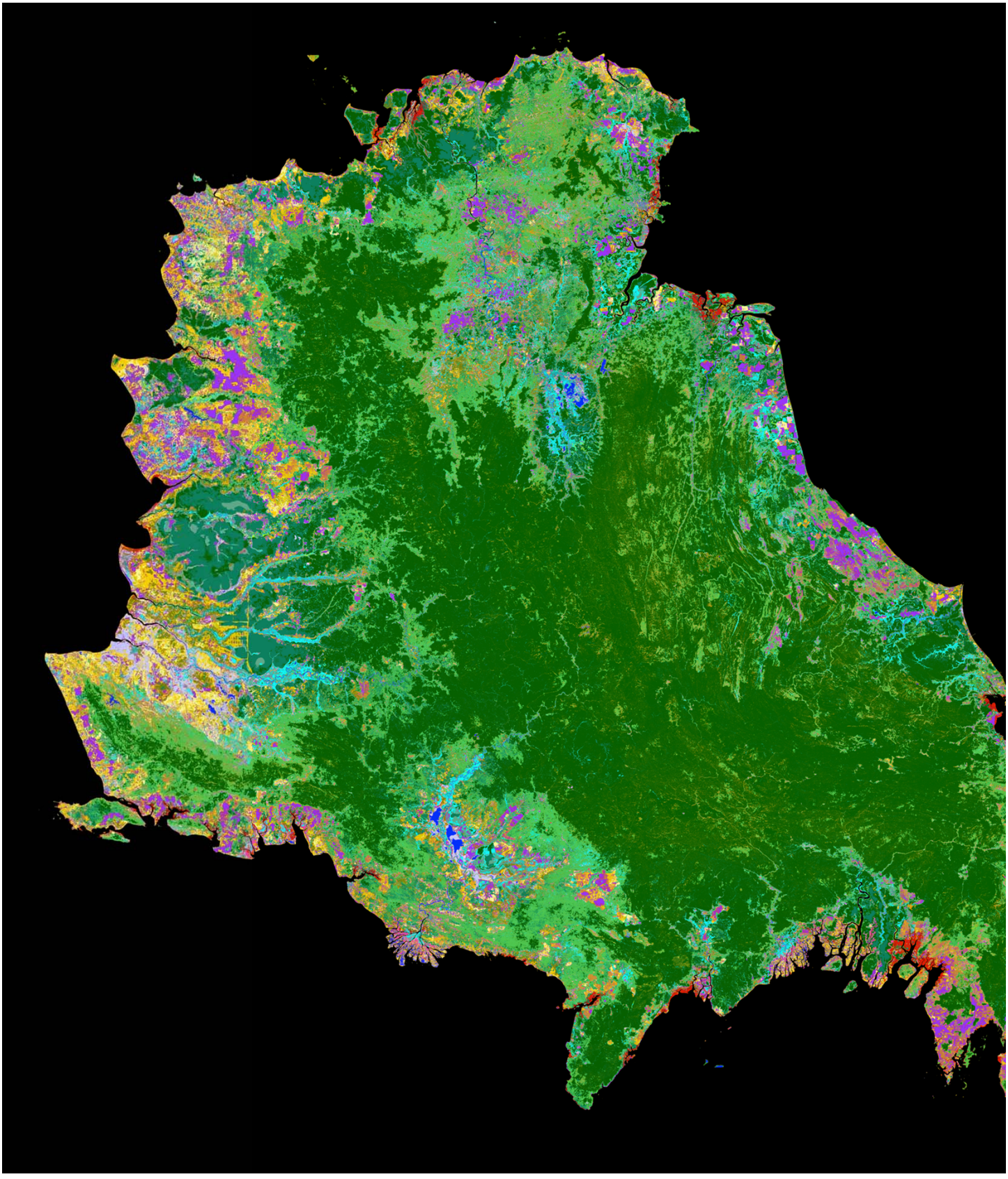
- The best option may be to extend the current L-band system (PALSAR-1) in the future with C-band (PALSAR-2 & SENTINEL-1)

At LAPAN 3 ‘teams’ are working on the Indonesian Carbon Accounting System (INCAS):

CSIRO :	Landsat
University of Maryland:	Landsat, MODIS
Wageningen:	Radar

Approaches to ‘Harmonization’ of these products will be studied in November at LAPAN

Results to be reported by LAPAN at SDS4



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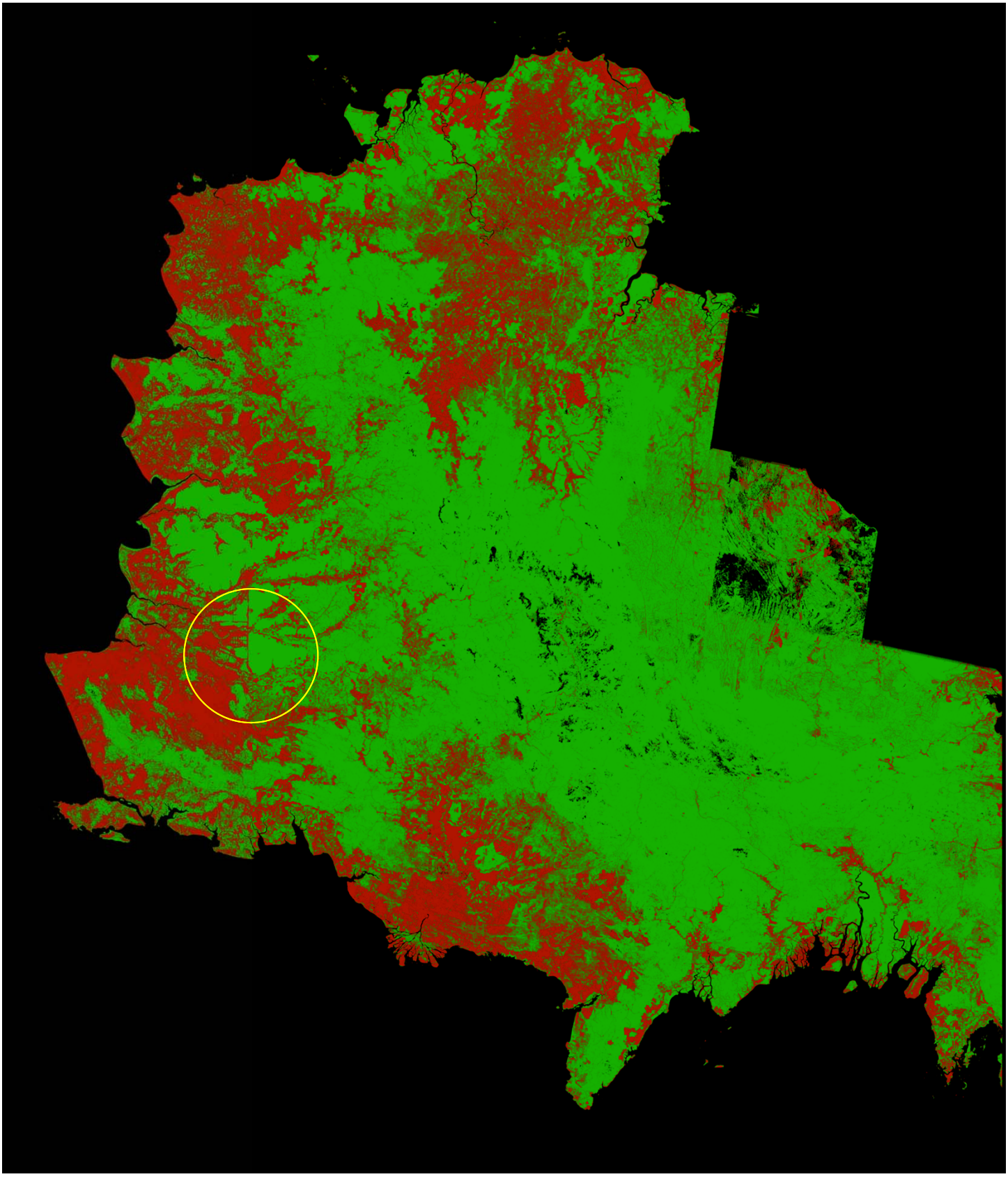

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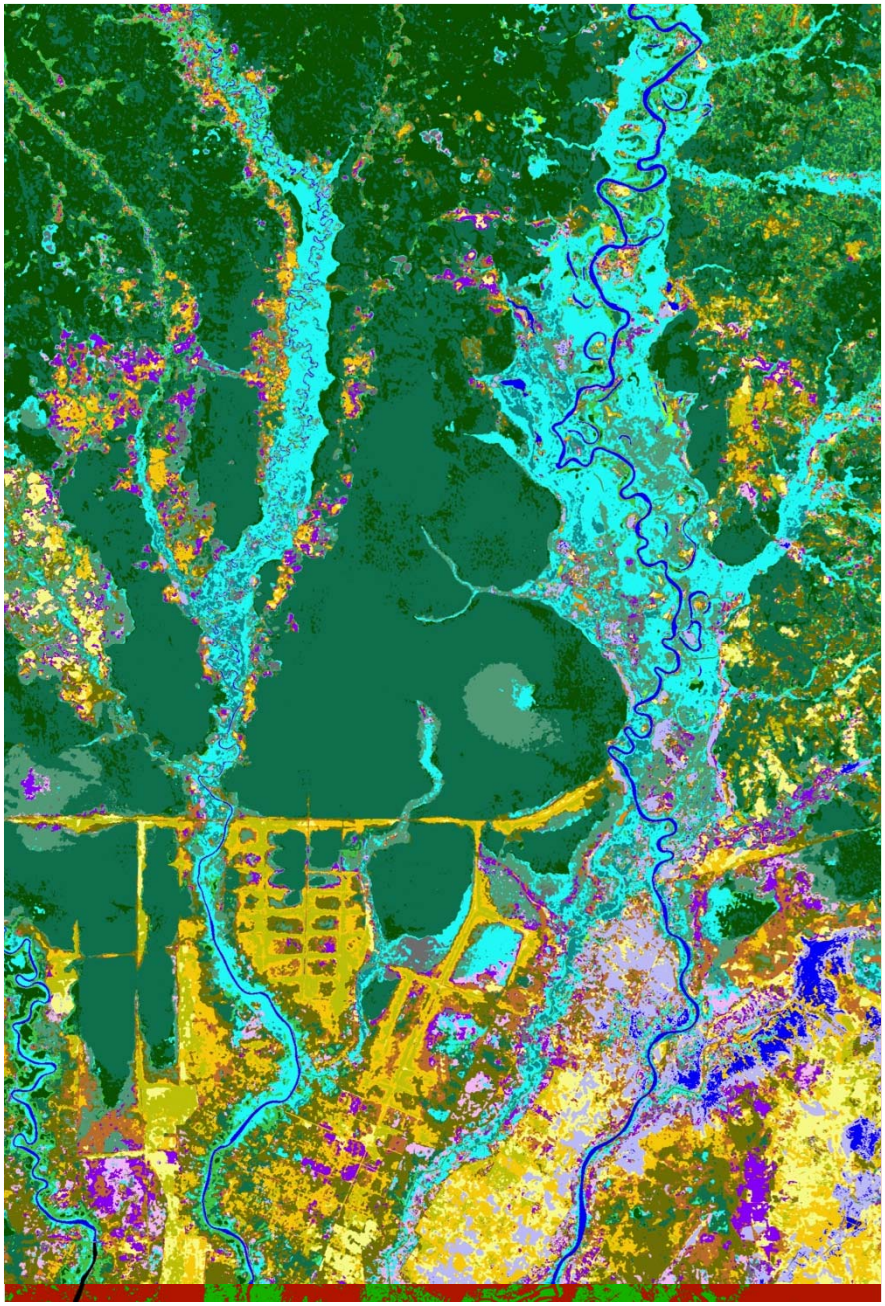

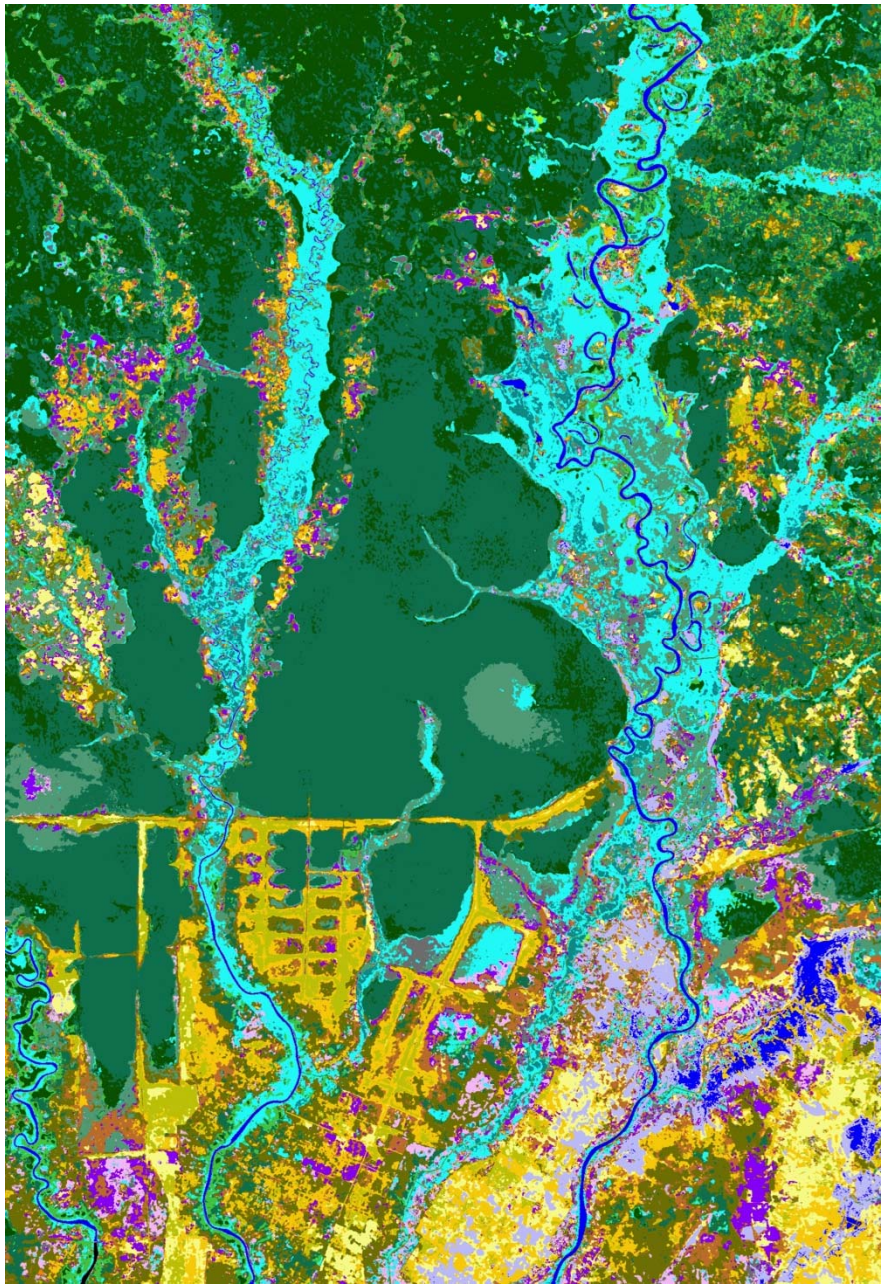

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Harmonisation issues

Preliminary results show very large agreement in dryland forest and dryland low biomass areas. Less agreement in wetland classes and classes such as "cropland/gardens" or "regenerating forest/agroforestry"

- Definition of classes: tbd
- Timing: Seasonal & spatio-temporal coherent (radar) versus inconsistent & incomplete (Landsat)
- Scale: 50 m (radar) versus 30 m
- Complementarity: e.g. oil palm, wetlands, use of C-band

"Harmonise legends" + synergy → Interoperability + higher accuracy

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Over 6000 geo-tagged photographs were collected along a 1300 km route in East and Central Kalimantan at 4 December 2012. Using a Cessna-Caravan from Balikpapan airport, the route carries along the main land cover types: the rubber and oil palm plantations in Penajam, crossing the Meratus mountain range, into forest conversion areas, wide river floodplains and peat swamp complexes in Central Kalimantan, extensive areas of wasteland, oil palm plantation and rice cultivation, into the kerangas (or heath forests), mining areas (for white sand, gold and coal), and, on the way back, major logging areas, coal mines, the Meratus range, tree plantations and gold mining. Since the route was too long a stop was made in Palangkaraya. During the flight oblique aerial photography was made in sideward direction with 6 cameras. The locations are indicated on the left. On the right two examples are shown.

P1050970

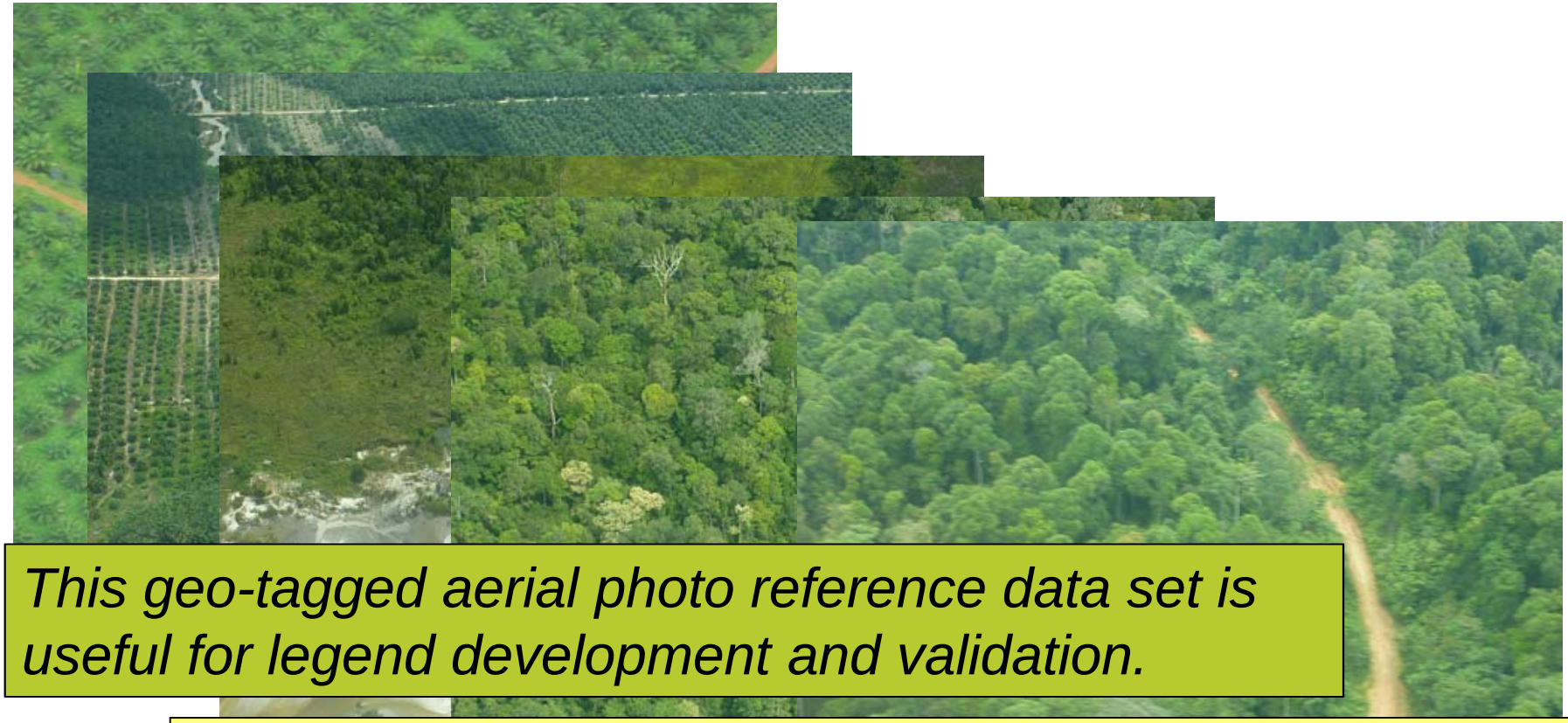
P1060046

5	Peat swamp forest
6	Peat swamp forest with low density

Radar data analysis reveals that several (sub-)classes of peat swamp forest can be mapped, and this notion is clearly supported by the results of our photo flight !

Aerial photo flight: ***5 ½ hrs, 6500 photos***

Result of INDF classification and validation training



This geo-tagged aerial photo reference data set is useful for legend development and validation.

Data is shared with LAPAN, MoF, Bakosurtanal; It is also meant to be used for harmonization with Landsat derived INCAS products (and JAXA-KC products).

INCAS ‘Radar unit’ at LAPAN

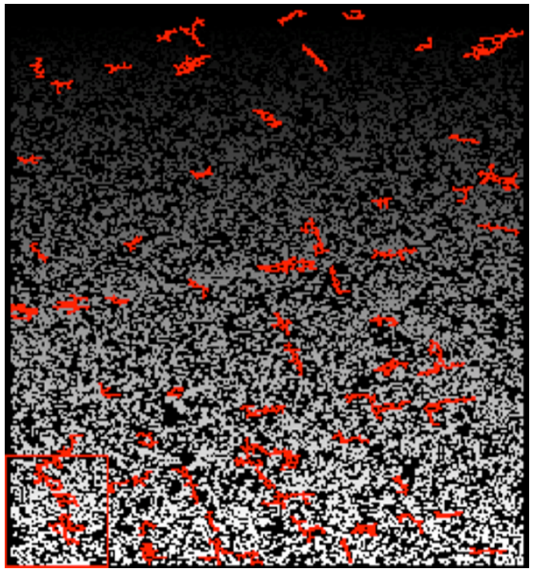
Multi-temporal speckle filtering of (dense) time-series

'Avoid solving one problem and creating another'

Criteria:

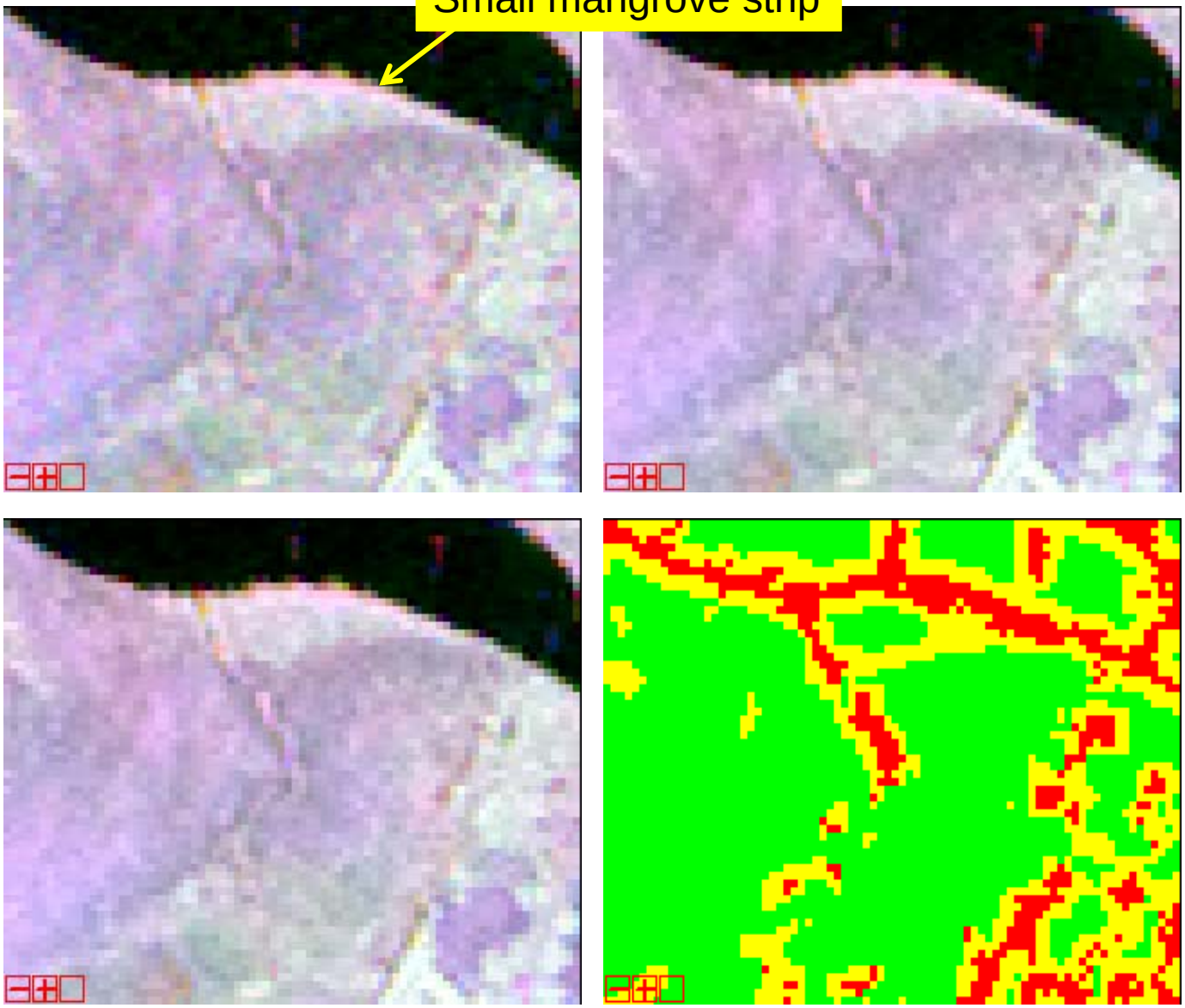
- Reduces speckle close to the theoretical maximum
- Creates no offset
- Preserves texture
- Creates no spatio-temporal deformation

*Software developed for fast computer-aided evalu*ation



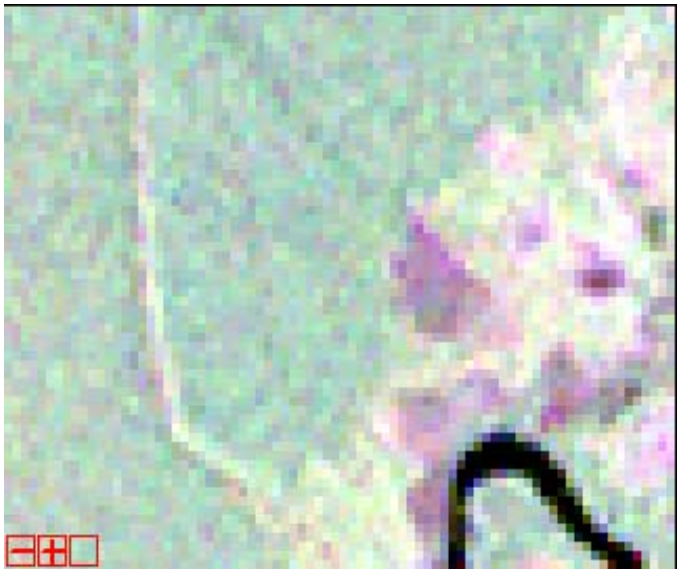
Compare original and filtered images:

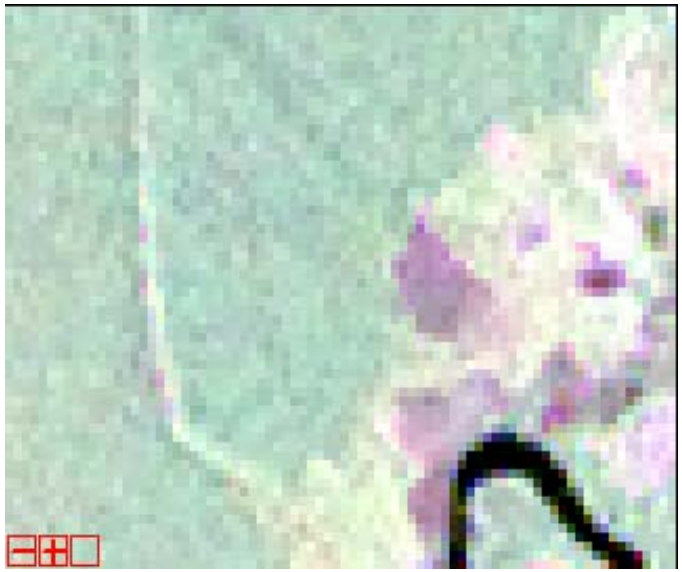
'Deformed' areas indicated in red

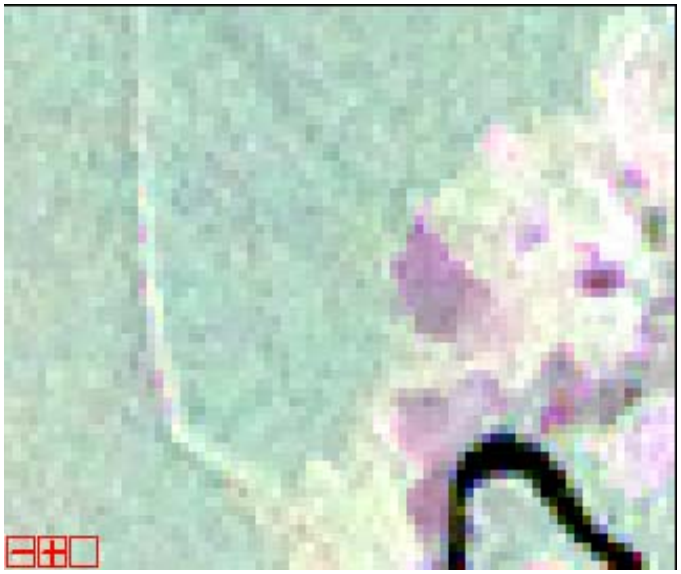


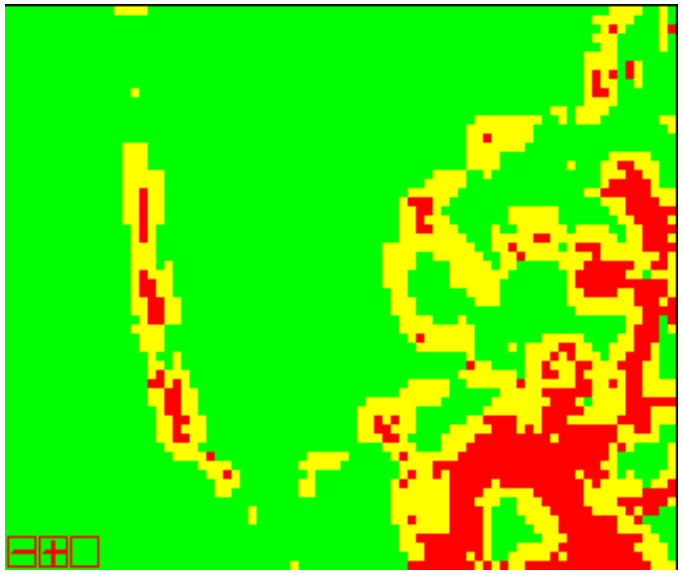
Some results for 50m FB strip data

In green areas the maximum speckle reduction is obtained.
In red areas this is not the case but fine spatio-temporal features are preserved.
This is very important for consistent change detection.

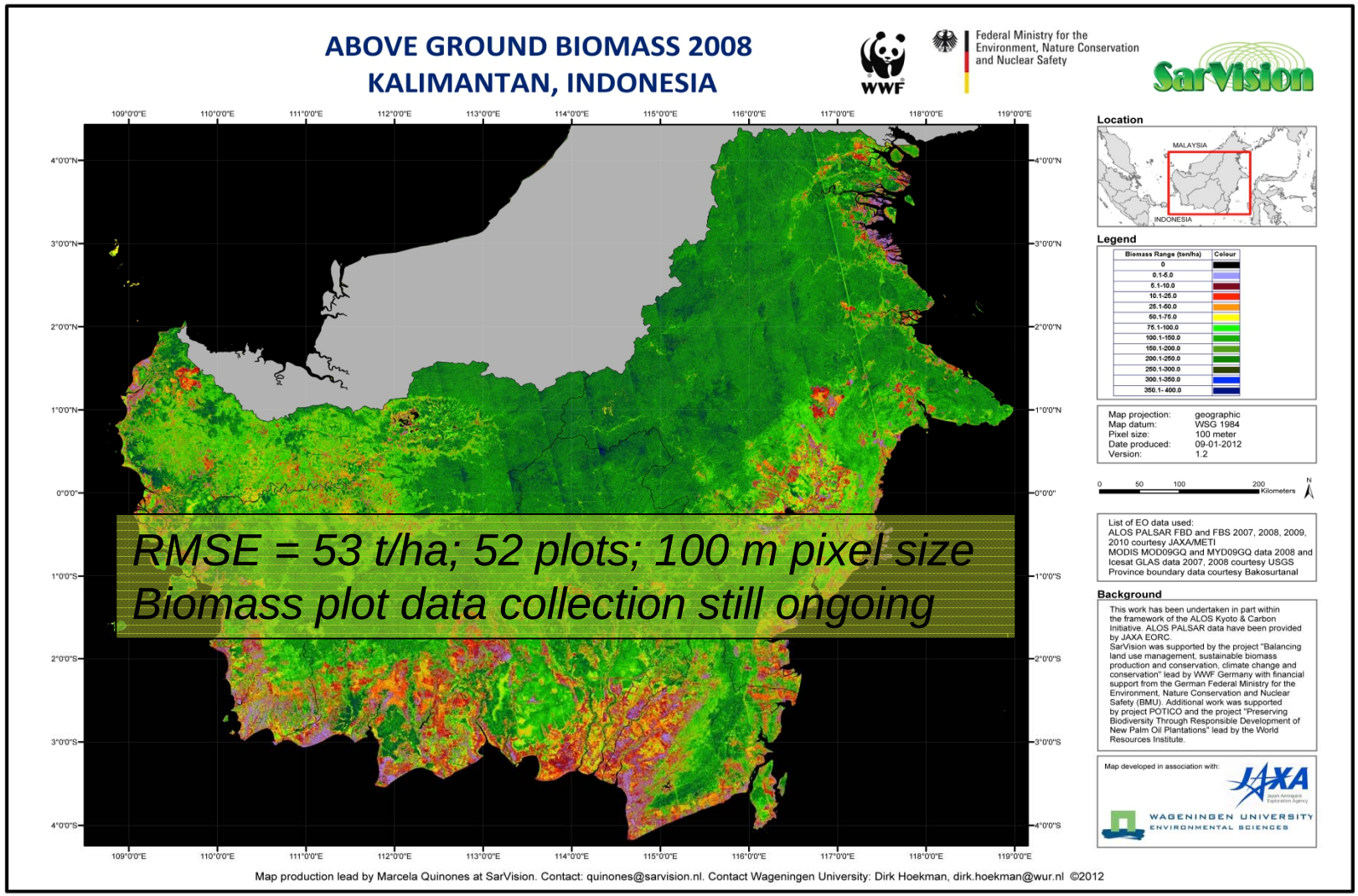








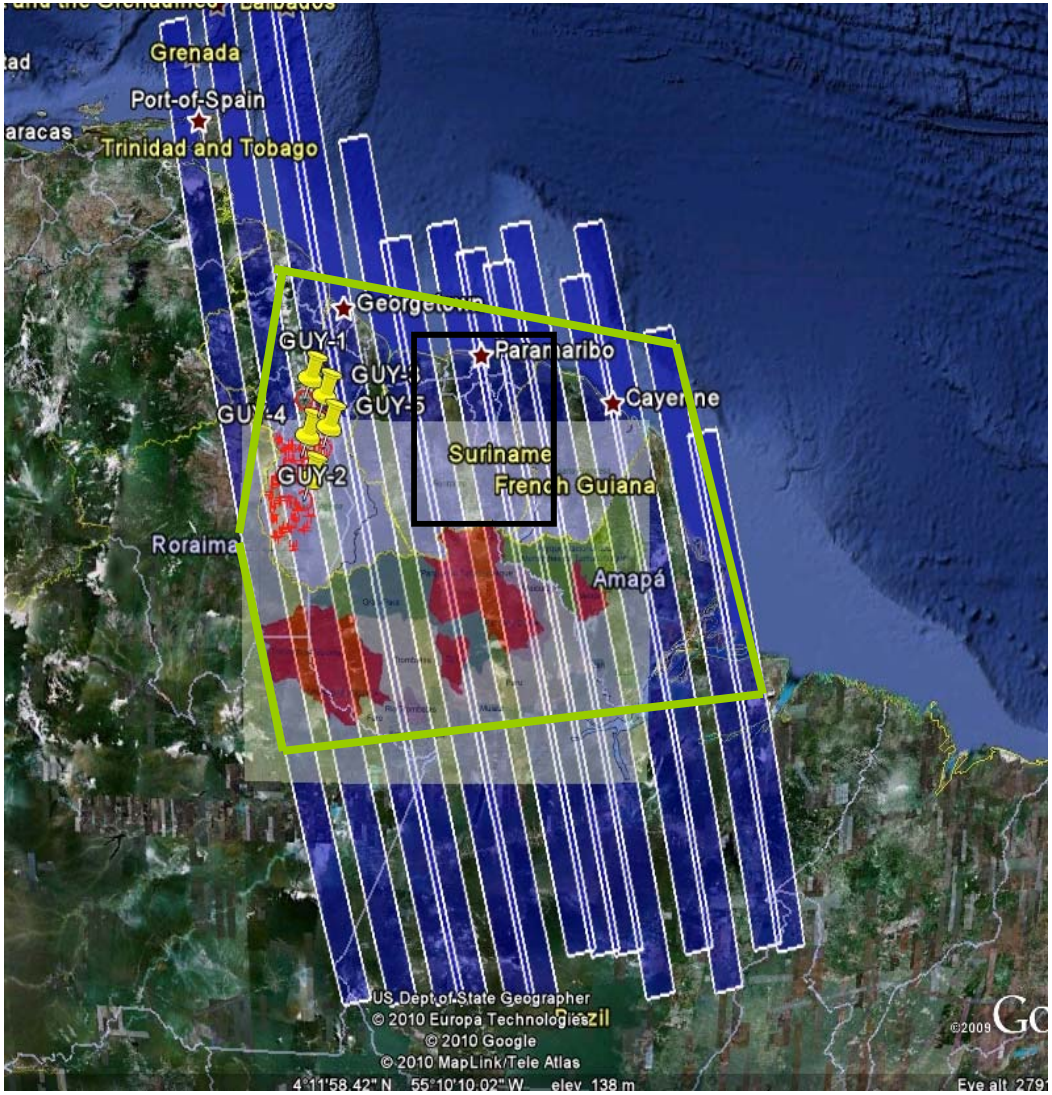
'Even for 50m strip data speckle reduction makes sense'



Borneo biomass stratification map. [Source: Quiñones, Hoekman and Vissers, 2011, A two step biomass mapping approach integrating L Band ALOS PALSAR and Lidar GLAS height data for high resolution wall to wall above ground biomass mapping. PEP-BIOMASS report.]


Guiana Shield
0 100 200 400 Kilometers
Extent of Guiana Shield
Pilot areas
Elevation
high
low
VENEZUELA
COLOMBIA
GUYANA
SURINAME
FRENCH GUIANA
BRAZIL
North Saramacca - Coppename mouth
Iwokrama
Matavén
Iratapuru
Orinoco
Meta
Caura
Essequibo
Branco
Rio Negro
Japurá
Trombetas
Jari
Paru
Oyapock
Amazon
© SarVision 2010

Landscape Guiana Shield, Brazil



Phase 2

Phase 3

+ parts Colombia

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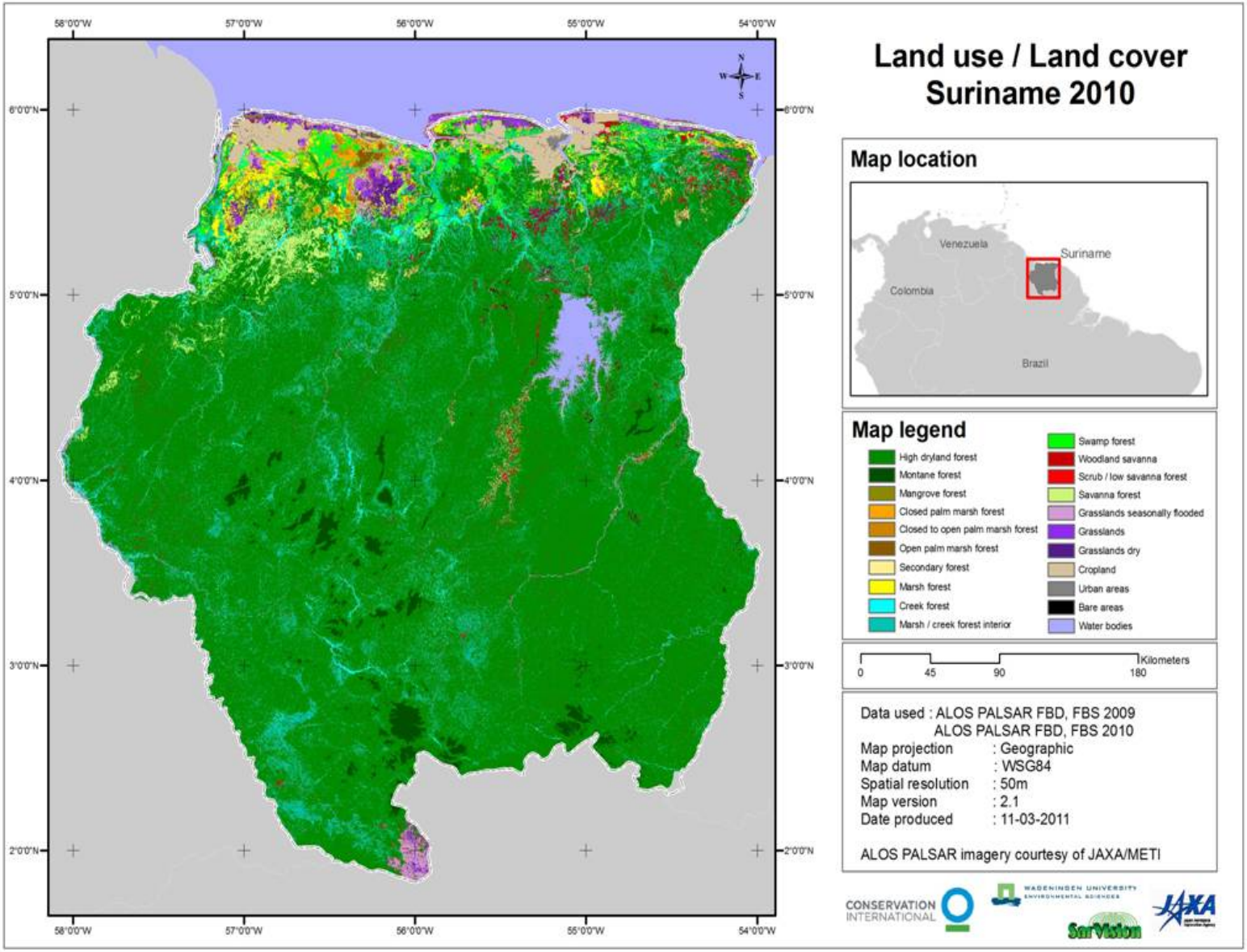

Land use / Land cover Suriname 2010

Map location

Map legend

- High dryland forest
- Montane forest
- Mangrove forest
- Closed palm marsh forest
- Closed to open palm marsh forest
- Open palm marsh forest
- Secondary forest
- Marsh forest
- Creek forest
- Marsh / creek forest interior
- Swamp forest
- Woodland savanna
- Scrub / low savanna forest
- Savanna forest
- Grasslands seasonally flooded
- Grasslands
- Grasslands dry
- Cropland
- Urban areas
- Bare areas
- Water bodies

0 45 90 180 Kilometers

Data used : ALOS PALSAR FBD, FBS 2009
ALOS PALSAR FBD, FBS 2010

Map projection	: Geographic
Map datum	: WSG84
Spatial resolution	: 50m
Map version	: 2.1
Date produced	: 11-03-2011

ALOS PALSAR imagery courtesy of JAXA/METI

CONSERVATION INTERNATIONAL

WAGENINGEN UNIVERSITY ENVIRONMENTAL SCIENCES

SarVision

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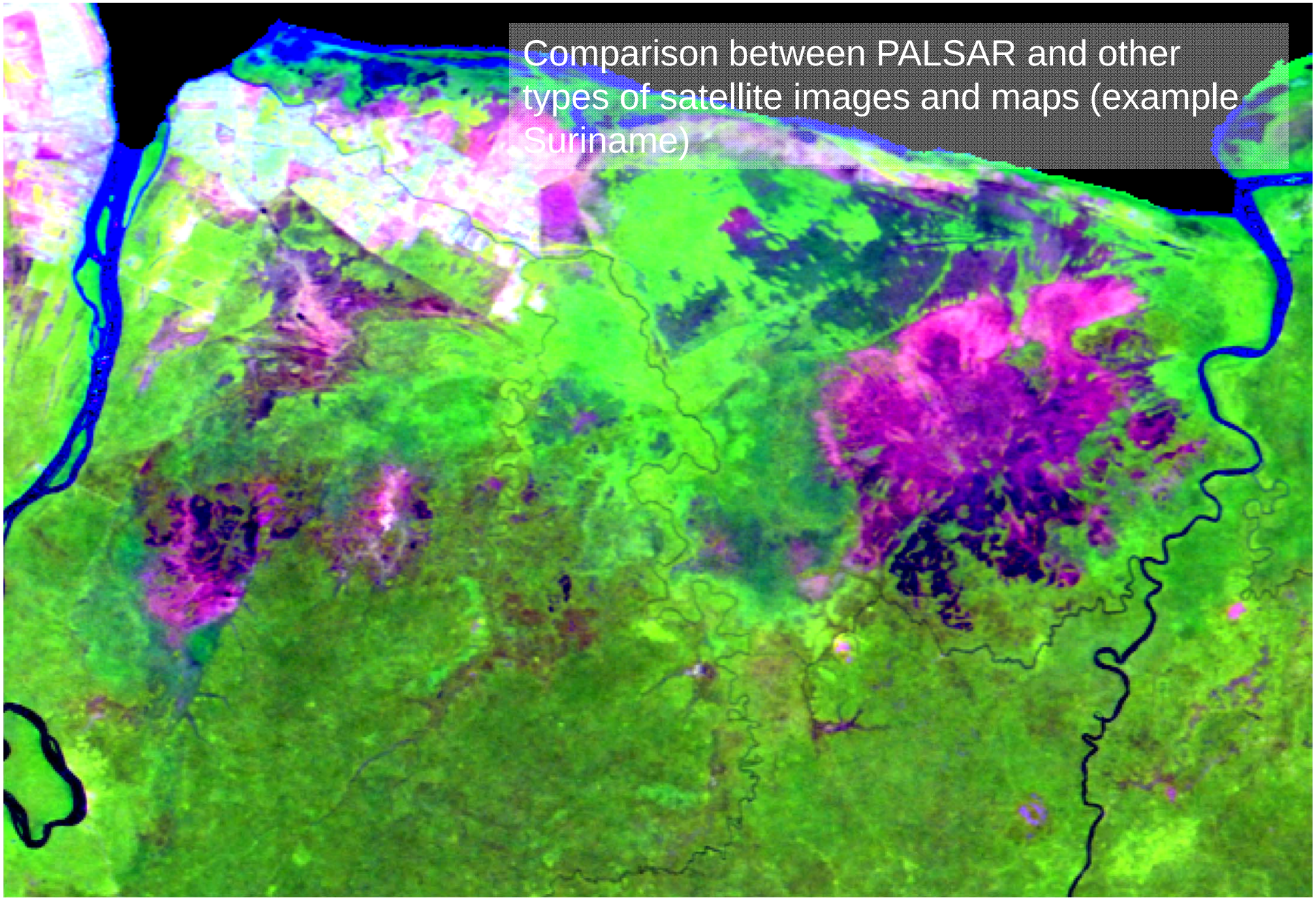
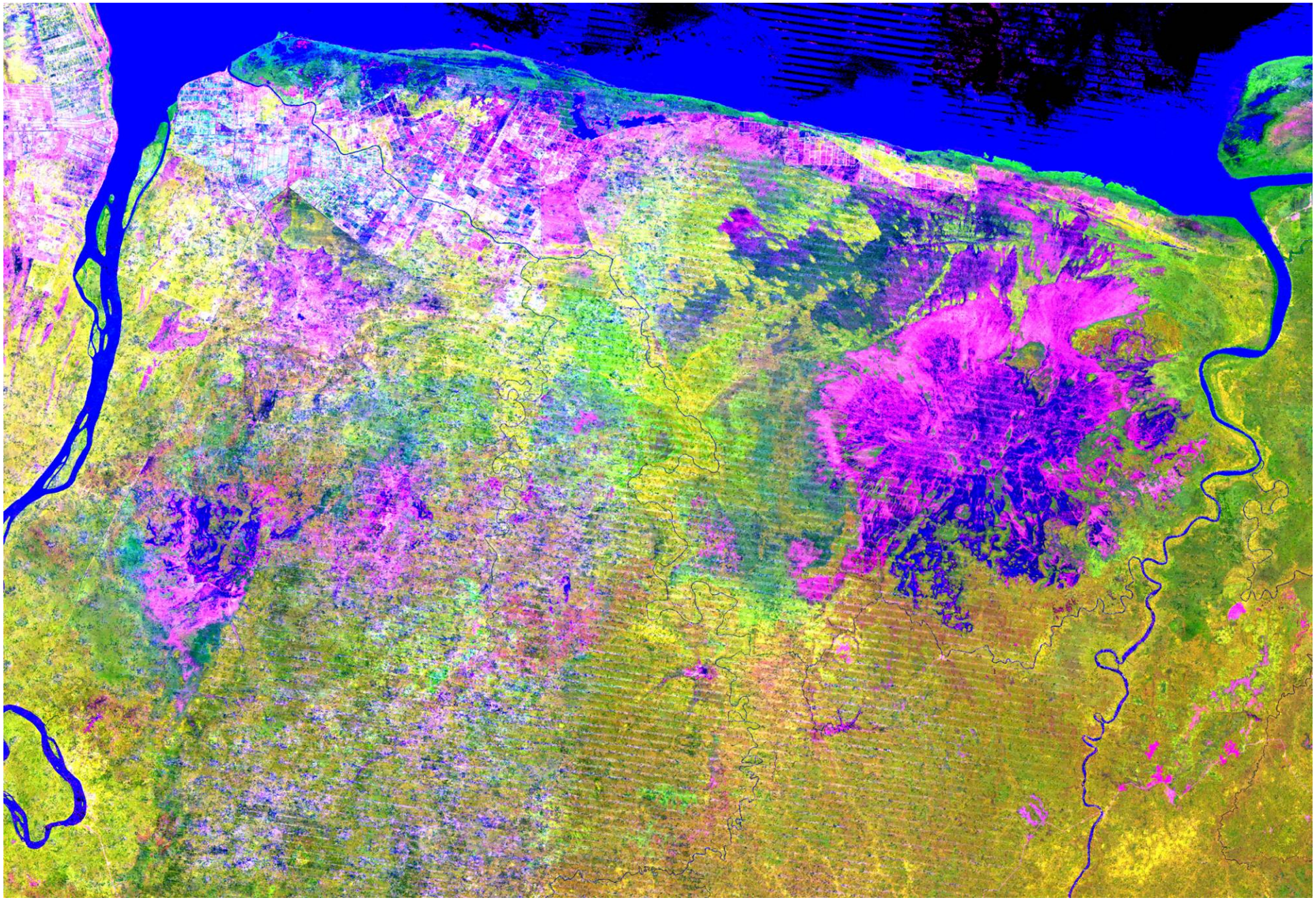
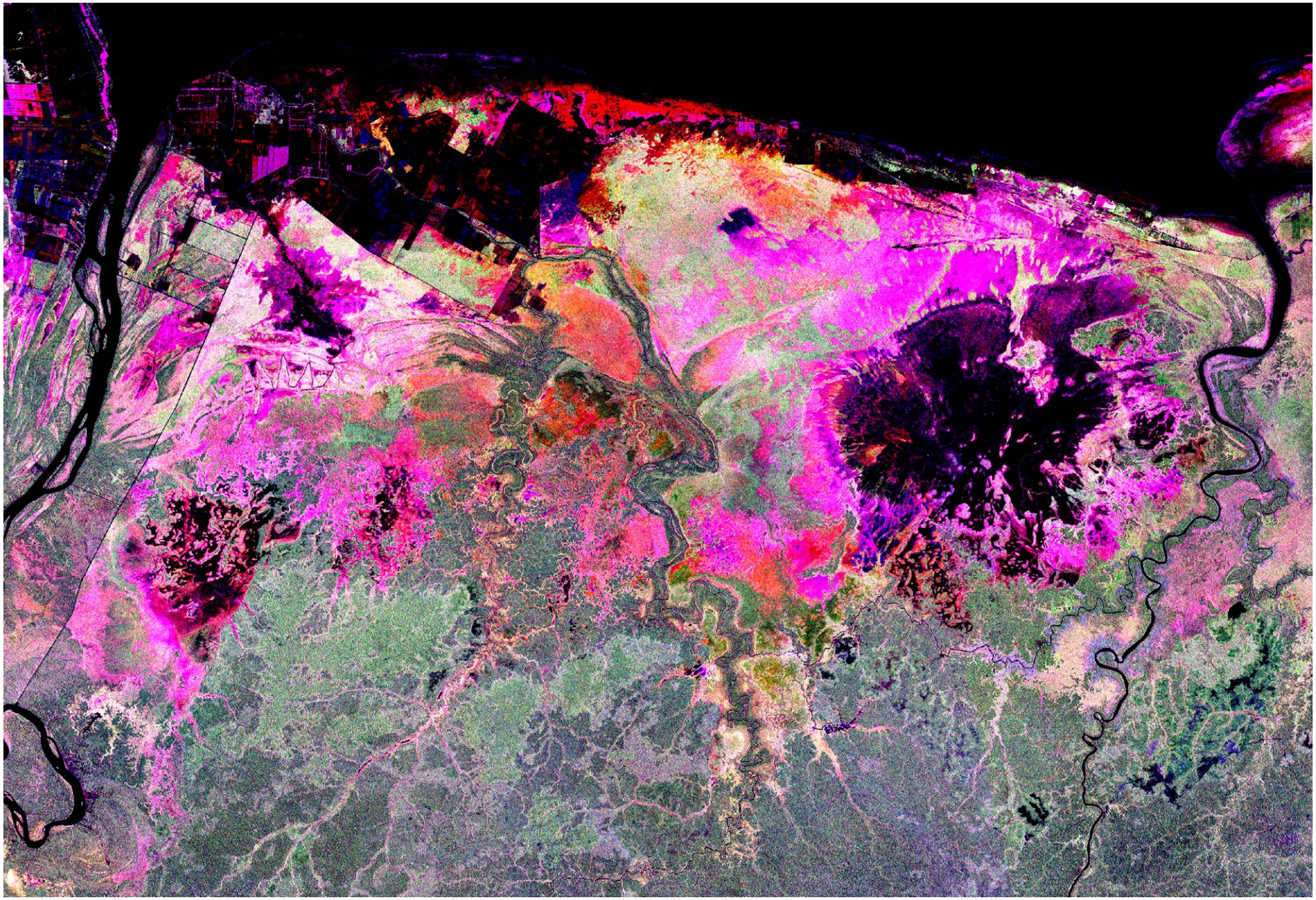


MODIS (250 m res)



Landsat



PALSAR

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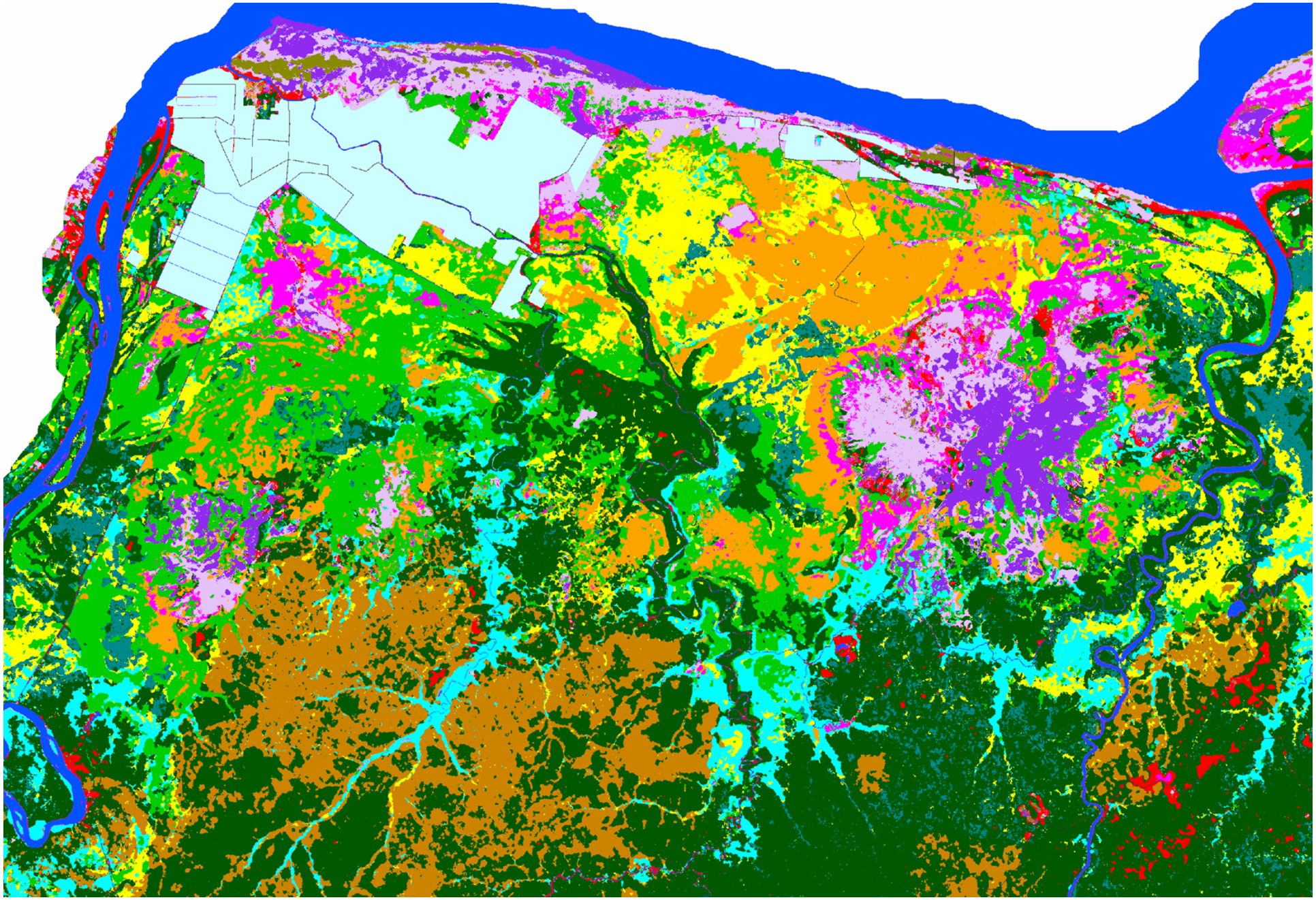

Detail (new) radar map

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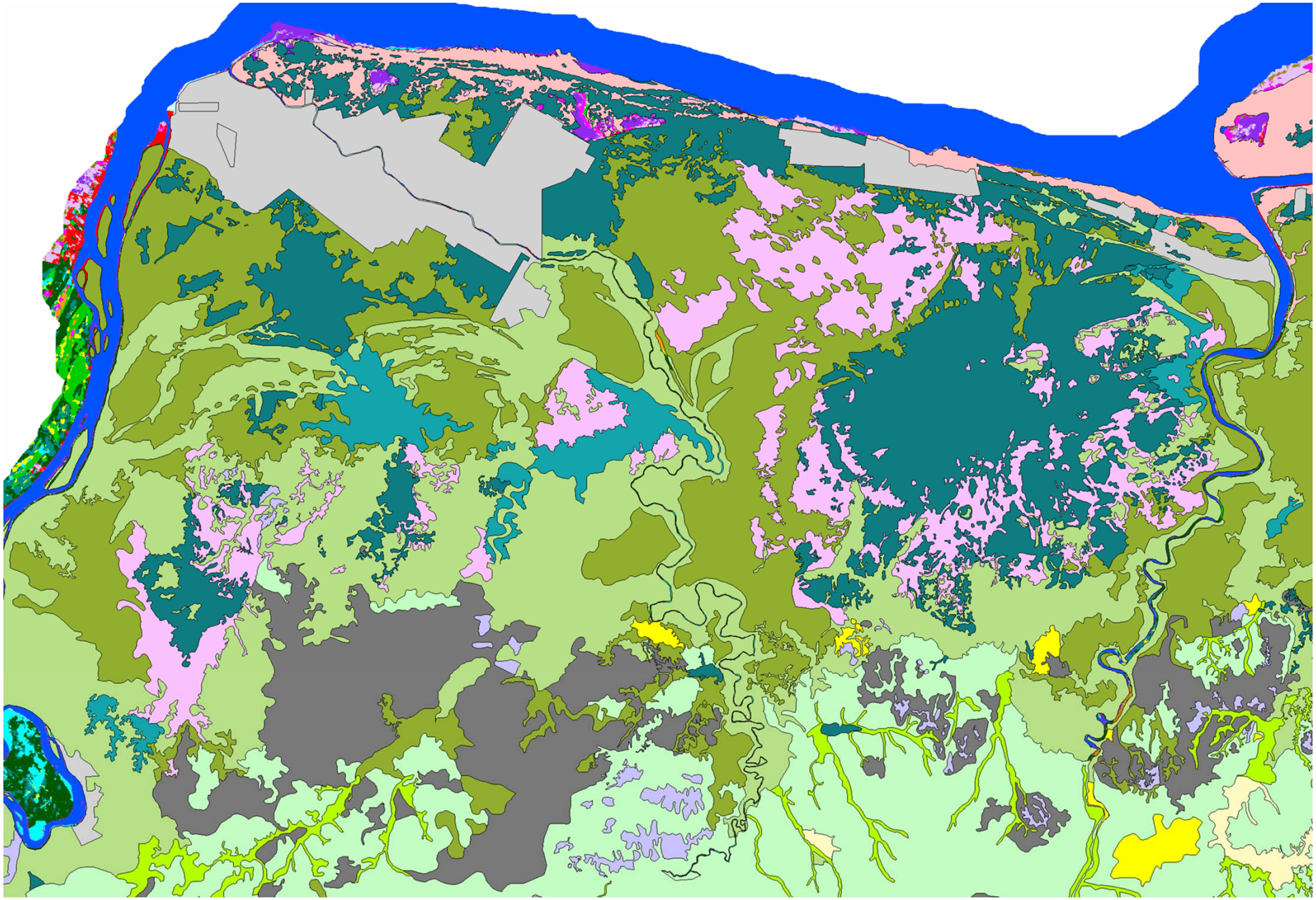

Detail (old) vegetation map based on aerial photography

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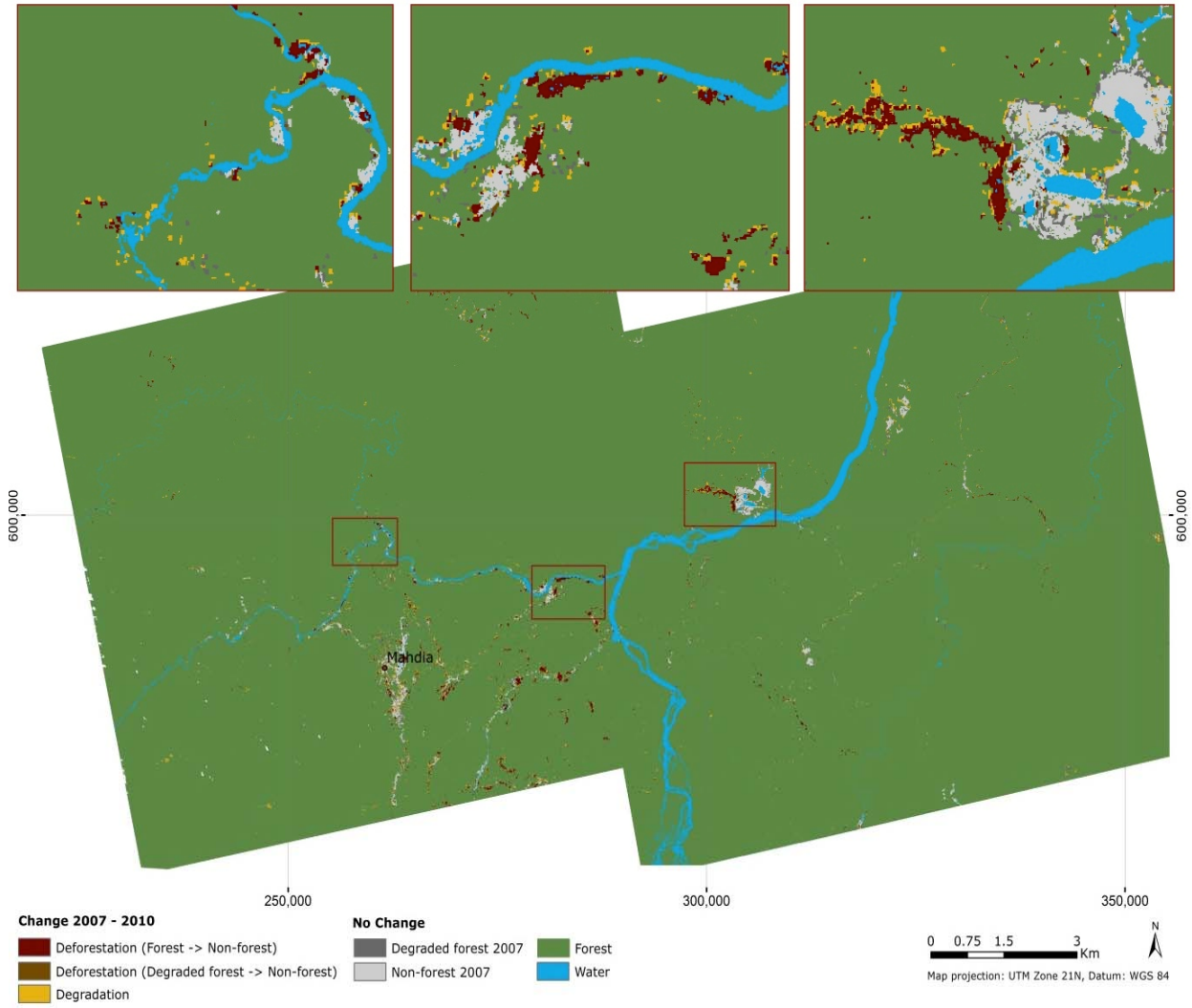


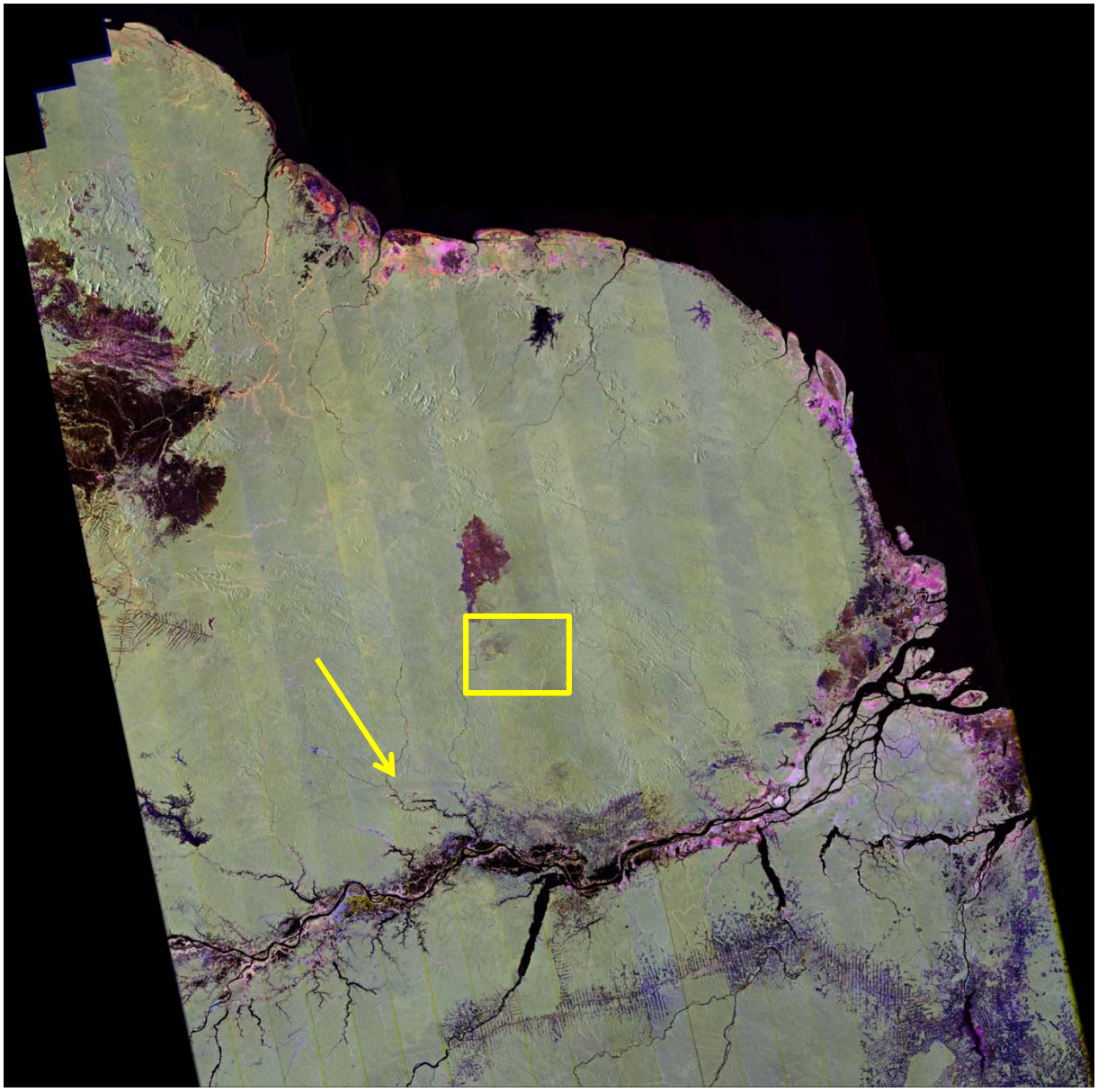
PALSAR-Landsat Forest - Land Cover (FLC) change map 2007-2010 of the Mahdia mining district (central Guyana), including three map details (red boxes).

Proof-of-concept demonstration. Overall accuracies of 88% and 89.3% for mapping forest land cover and detecting deforestation and forest degradation, respectively.

To be used for reporting

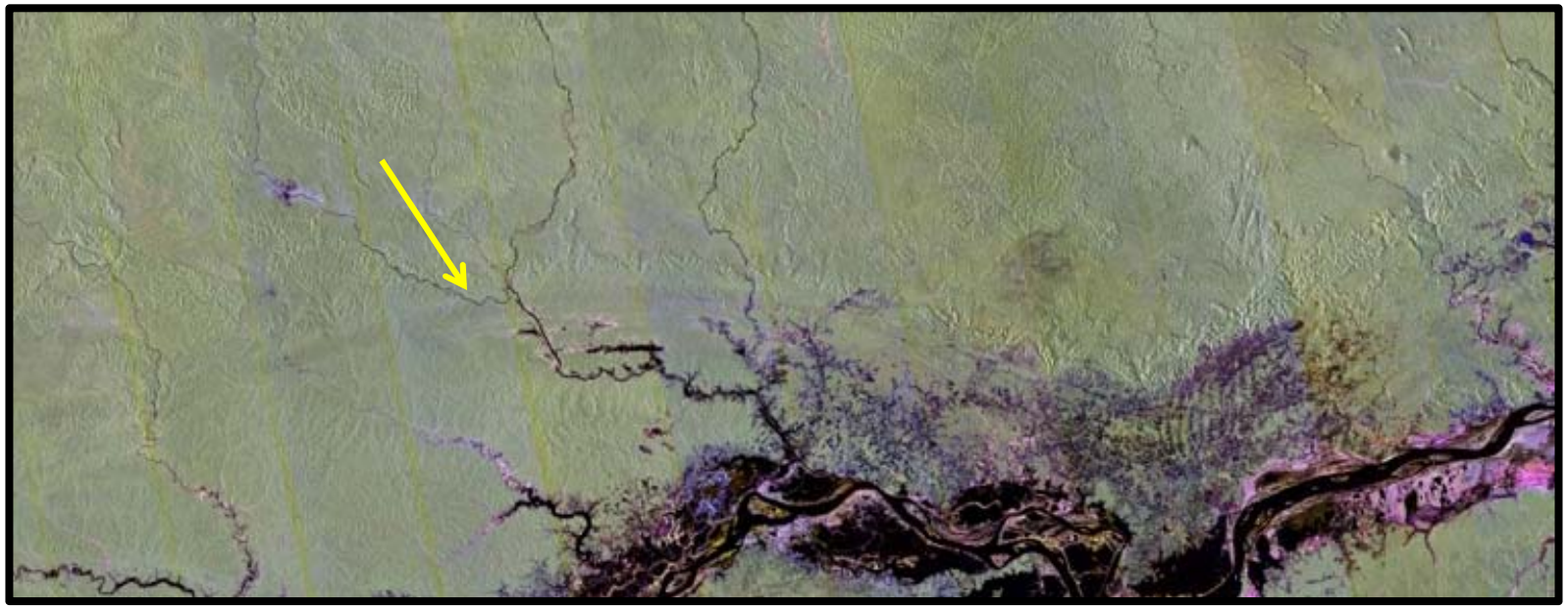
Source: Reiche, Souza, Hoekman, Verbesselt, Persaud, and Herold, 2012; Feature level fusion of multi-temporal ALOS PALSAR and Landsat data for mapping and monitoring of tropical deforestation and forest degradation (accepted, IEEE-JSTARS)

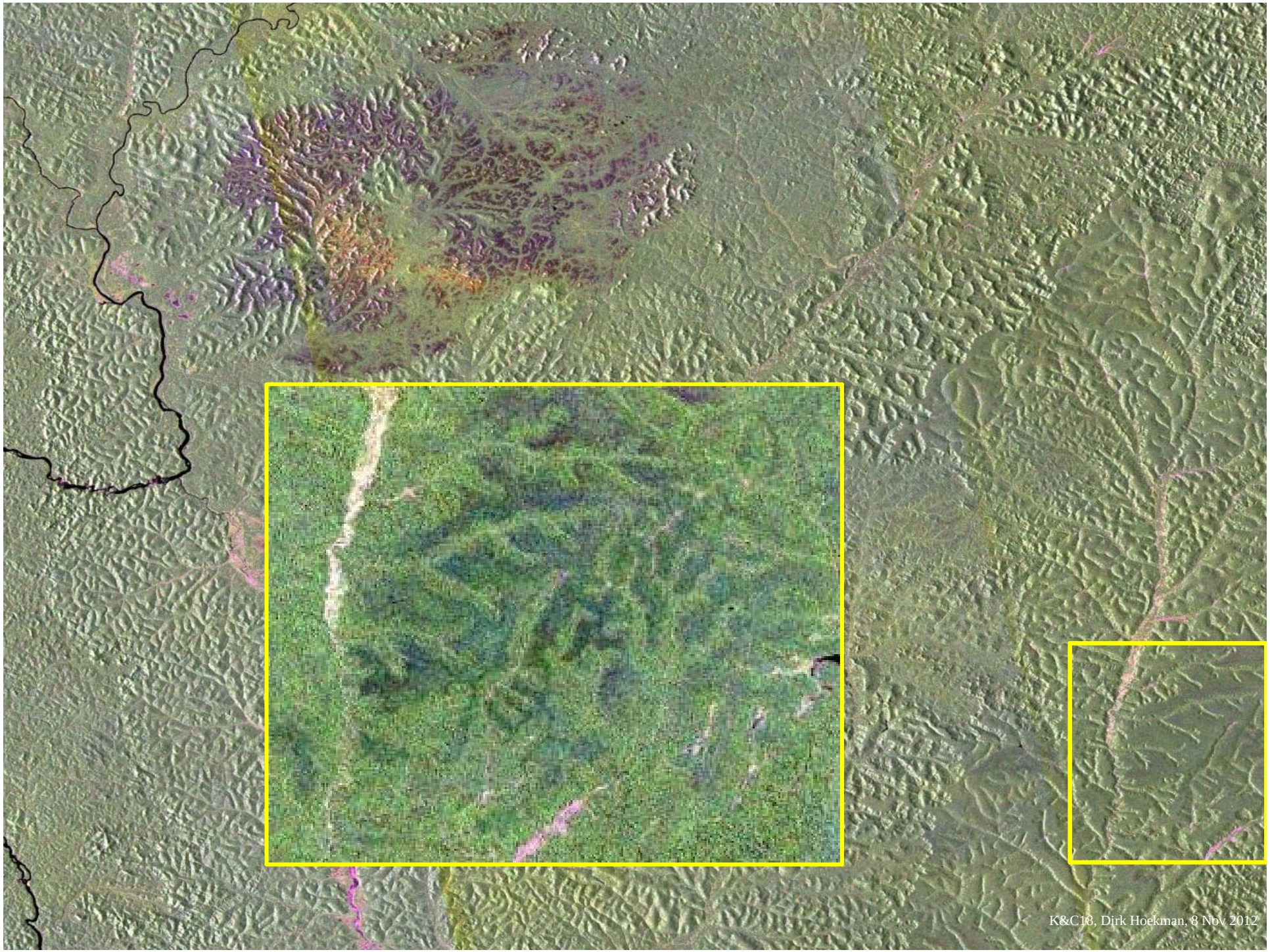
Guyana ND – Field campaign Mahdia



Quick-look PALSAR radar mosaic at 50 m resolution

Arc demarcates (geological) edge between Guiana Shield and Amazon basin

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Schedule next half year

So far we received no mosaic PALSAR & JERS-1 data and a very limited number of 25 m strip data.

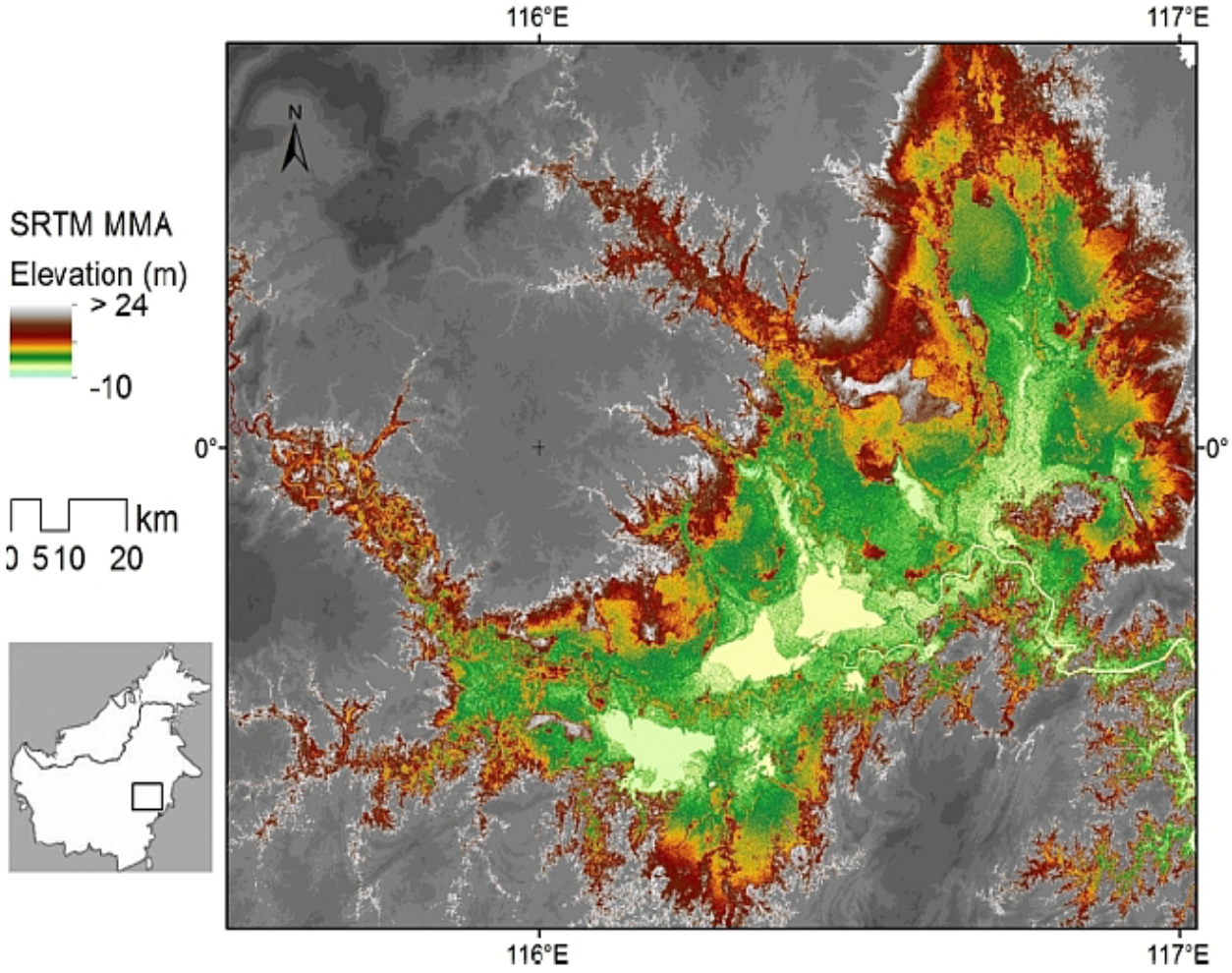
(Pending Phase 3 data availability)

A. Pre-process 25m strip data over Borneo (starting February 2013) and large section Guiana Shield (starting January 2013)?
B. Further development pre-processing chain, including advanced slope corrections, other radiometric corrections, texture, denser time-series.
C. Start development of products with Brazilian and Colombian partners
D. Harmonization workshop with Indonesian teams

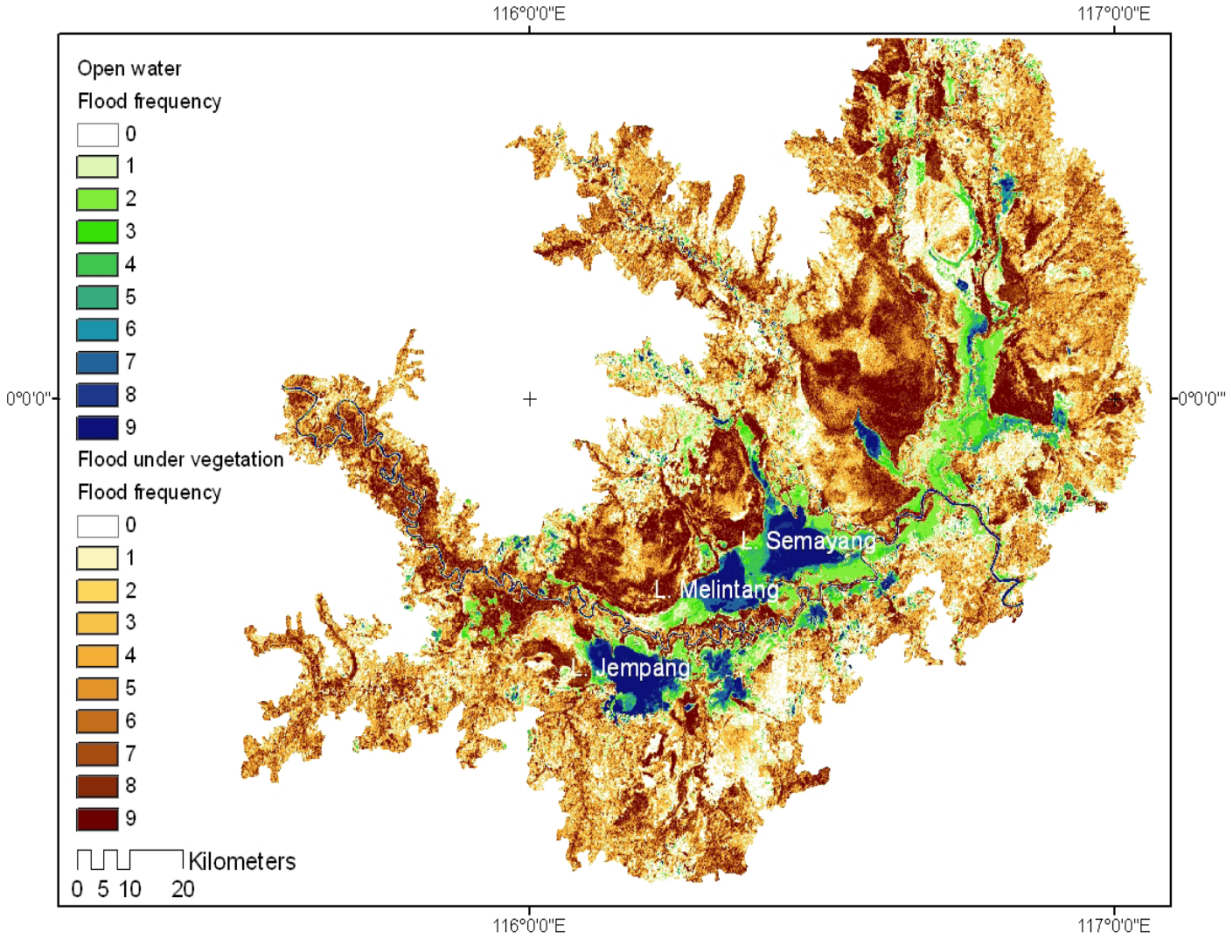
Acknowledgement

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


116°E
117°E
N
SRTM MMA
Elevation (m)
> 24
-10
0°
0°
km
0 5 10 20
116°E
117°E

Flood frequency map derived from PALSAR ScanSAR images 2008/2009.



Hidayat, H., Hoekman, D. H., Vissers, M. A. M., and Hoitink, A. J. F.: Flood occurrence mapping of the middle Mahakam lowland area using satellite radar, Hydrol. Earth Syst. Sci., 16, 1805-1816, 2012.

Correlation between lake depth and flood occurrence mapped by PALSAR W

Period of images	# images	r_{A-B}	r_{C-D}	r_{E-F}	r_{G-H}
2008–2009	9	0.85	0.84	0.83	0.83

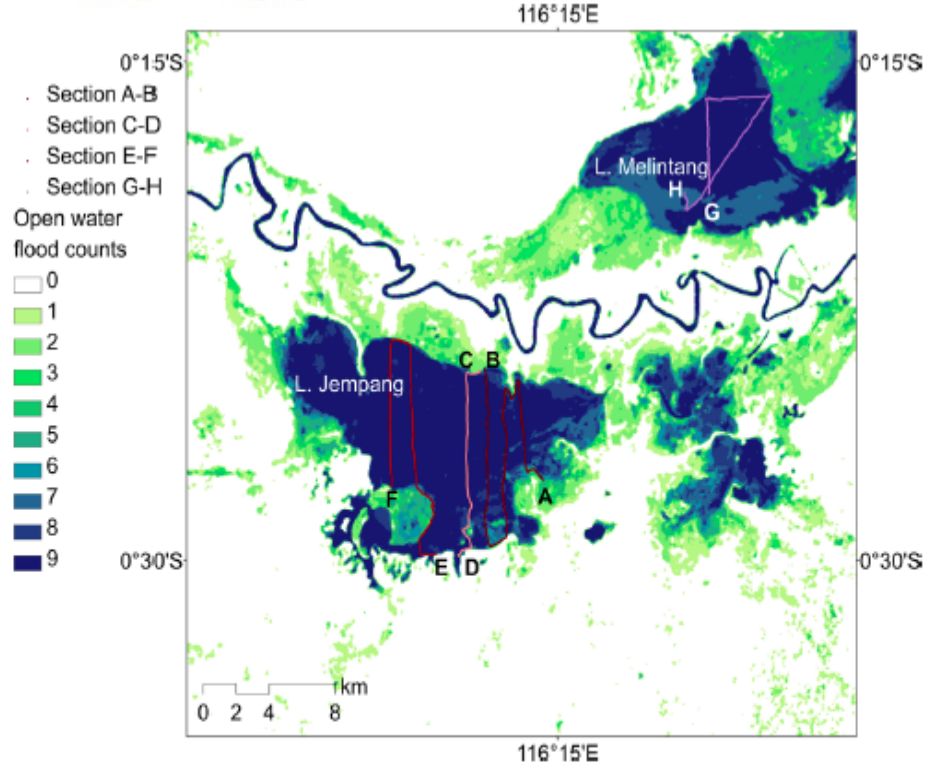
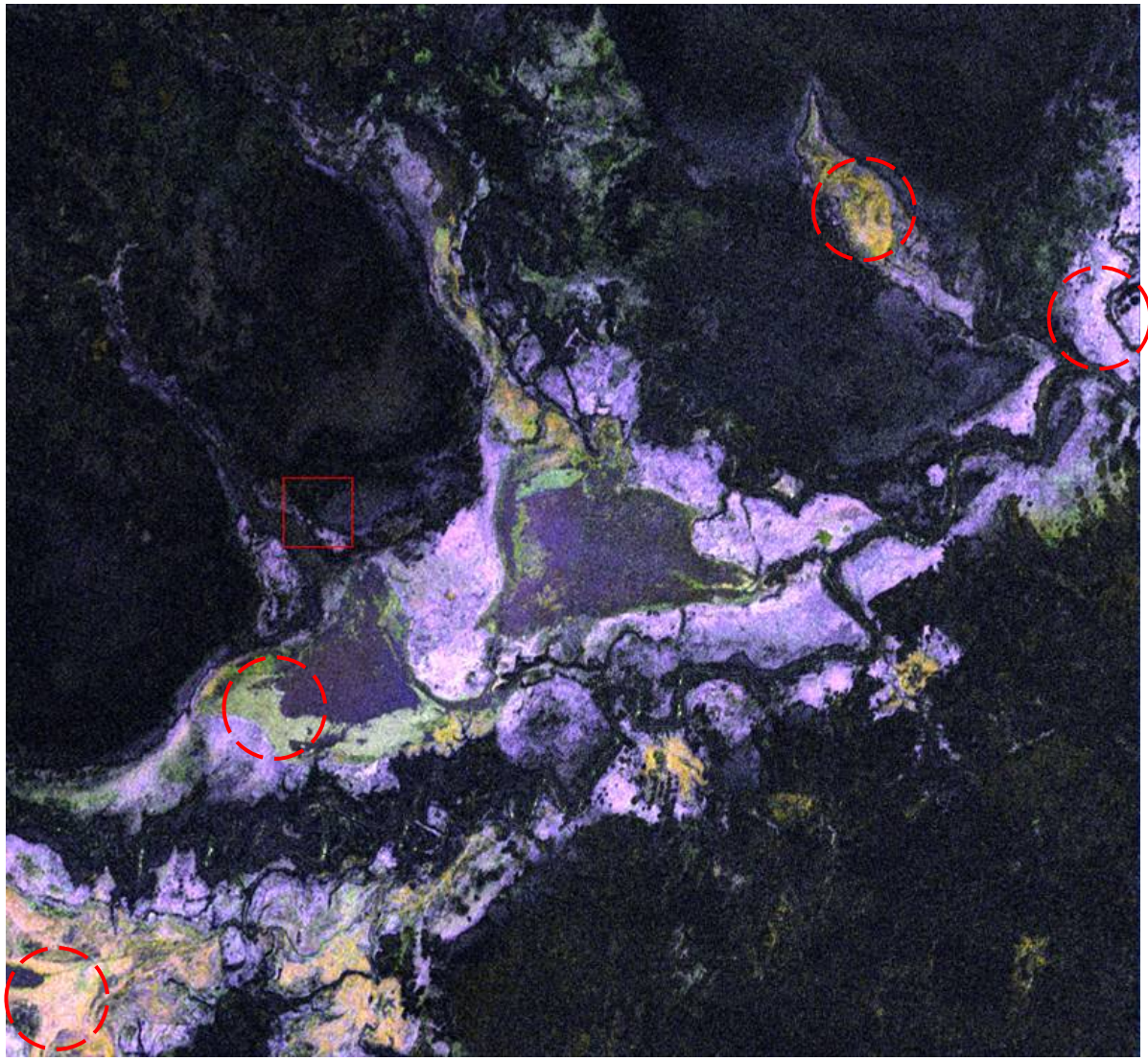


Fig. 10. Bathymetry measurement track in Lake Jempang and Lake Melintang plotted on the flood occurrence map from nine PALSAR images in 2008 and 2009.

Aquatic vegetation

Mahakam watershed, temporal analysis



Aquatic vegetation and irregularly inundated land can be mapped with WB, but not with FB

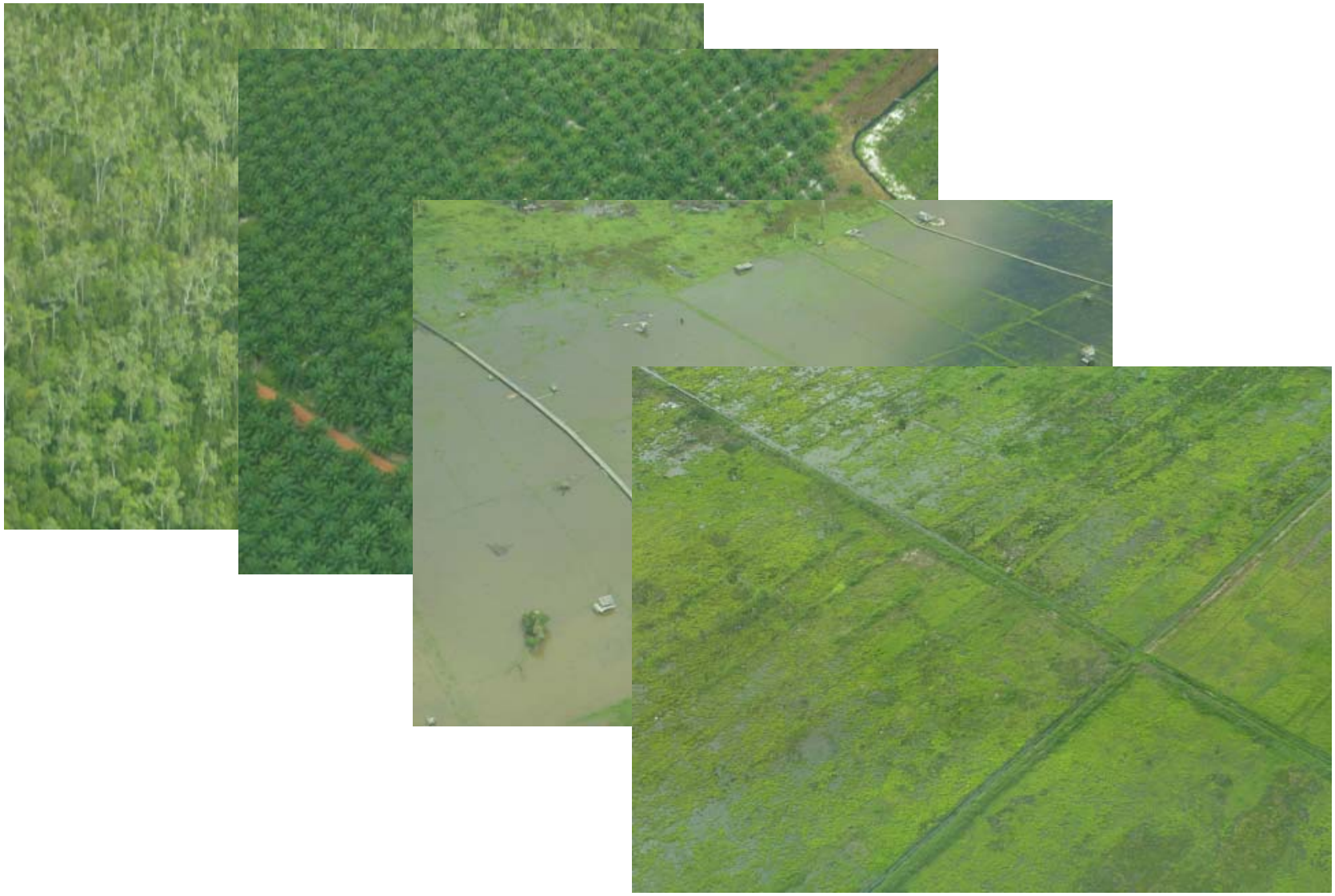
← Orange: water hyacinth

← Purple: irregularly inundated shrubland

← Green: reeds

← Yellow: rice growing areas in years when flooding is not too high

Aerial photo flight: *5 ½ hrs, 6500 photos*



Aerial photo flight: *5 ½ hrs, 6500 photos*