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ENVIRONMENTAL SCIENCES

SarVision

Mapping and monitoring tropical rain forest areas

Results Insular SE Asia

Final Science team meeting – Phase 1

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Tsukuba, 14 January 2009

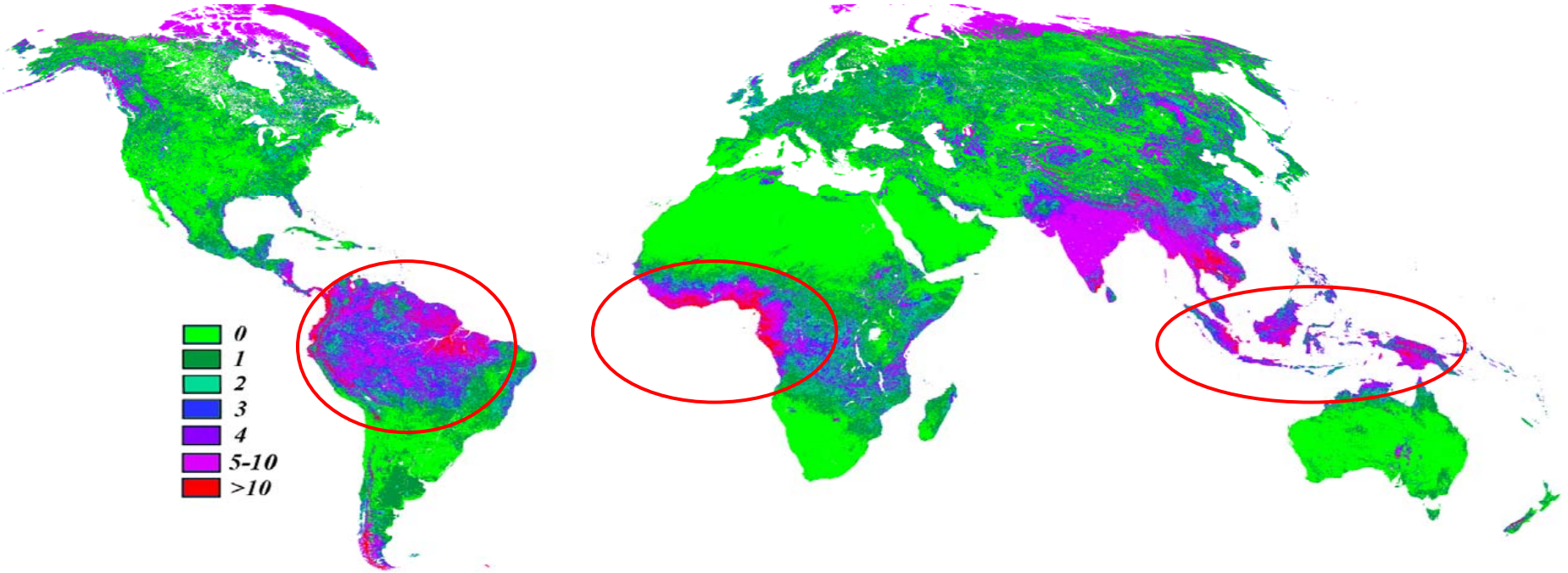
ALOS Kyoto & Carbon Initiative

11th Science Team Meeting, JAXA TKSC

Outline

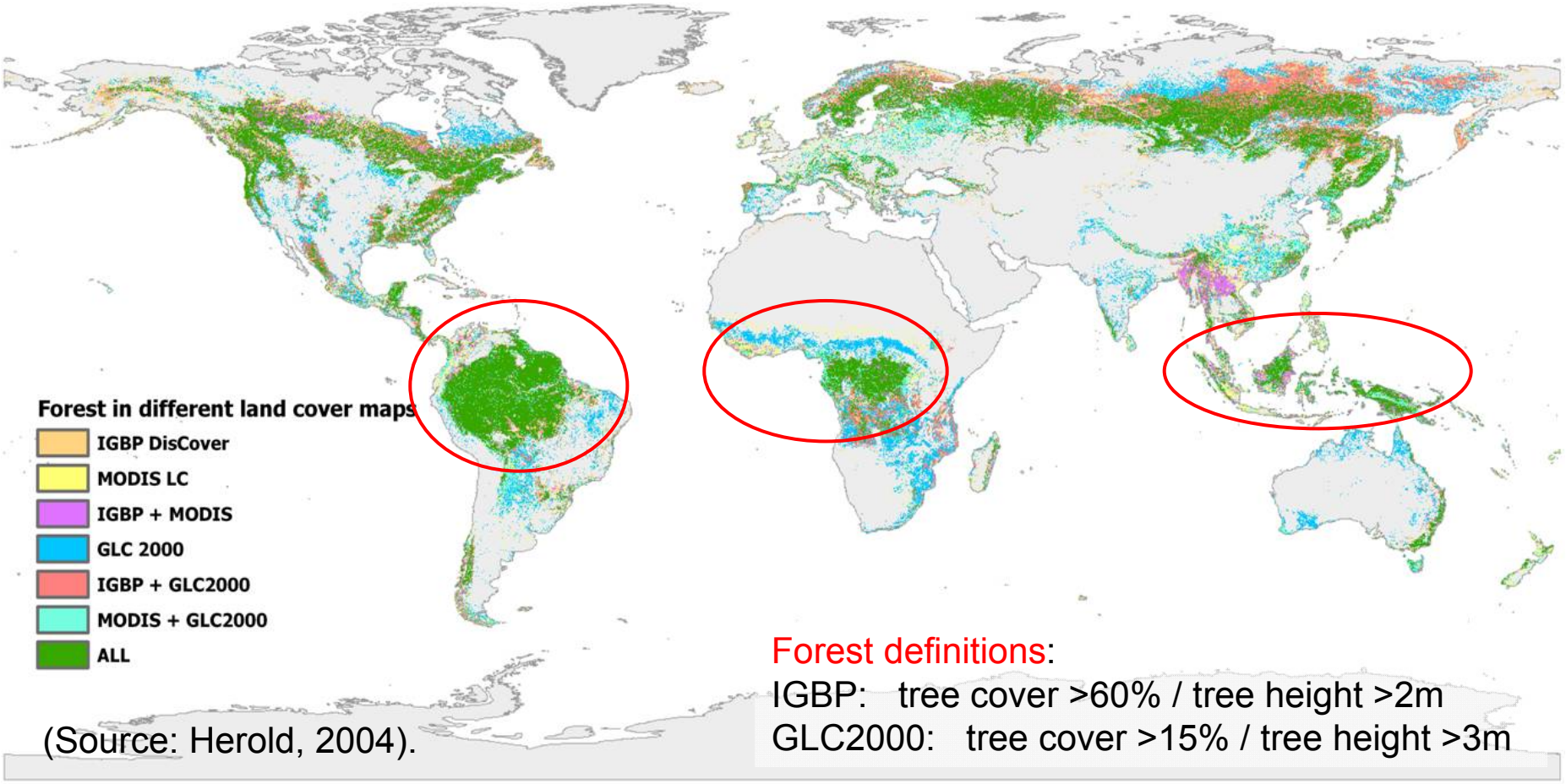
1. Introduction, Int. standards & Local partnership networks
2. Main prototype area Central Kalimantan, early results
3. Continental wide, high resolution mapping (Example Borneo)
    - First test results using standard FBD mosaics
    - Mosaicing (FBS & FBD & slope correction)
    - Classification approach
    - Extended classification approach (synergy with optical data)
    - Results
4. Validation
5. Some conclusions

Persistent cloud cover requires radar monitoring



Persistent cloud cover prevents optical remote sensing monitoring of the world's tropical rain forest areas. The colour code shows the estimated number of months per year LANDSAT fails to deliver useful images (Source: Friedl, 2006).

Forest land in different global land cover data sets



(Source: Herold, 2004).

Forest definitions:

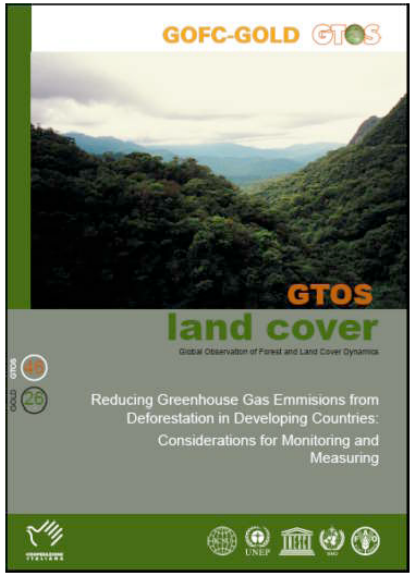
IGBP: tree cover >60% / tree height >2m

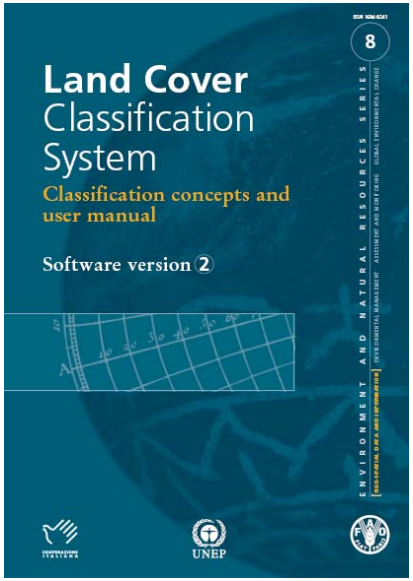
GLC2000: tree cover >15% / tree height >3m

International standards

- **GOFC GOLD (Global Observation of Forest and Land Cover Dynamics)**
  Expert group working towards standardisation and harmonisation of forest monitoring

- **FAO Land Cover Classification System (LCCS)**
  Internationally recognized accepted translation mechanism to compare and harmonize land cover classifications





Work through local partnership network

Example partnership network local end users - Indonesia:

National: Ministry of Forestry, World Resources Institute, SDSU

Papua: Provincial government, Conservation International, Sekala

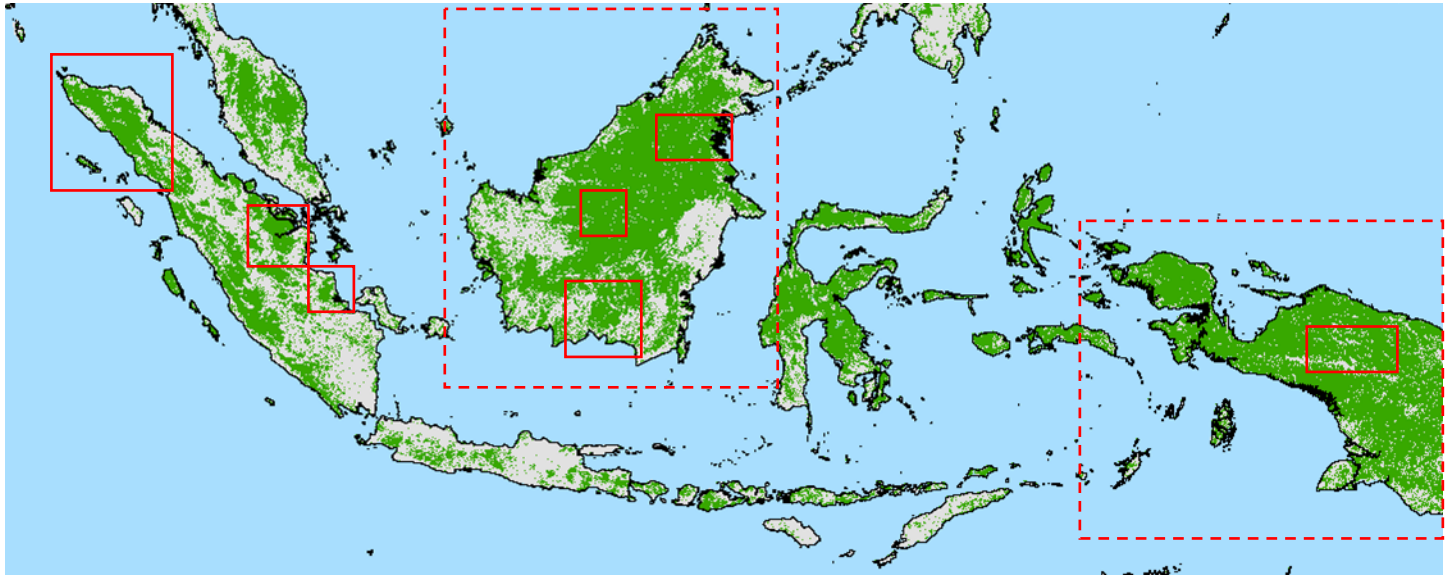
Borneo: Governments, Nunukan + Malinau districts, WWF Heart of Borneo

Central Kalimantan: Provincial government, EMRP MP, Wetlands International, BOSF

Sumatra: Provincial government NAD Aceh, Leuser International Foundation

Riau: APRIL, Leicester University-WL Delft Hydraulics, WWF

Jambi: Wetlands International, National Park Service Berbak-Sembilan

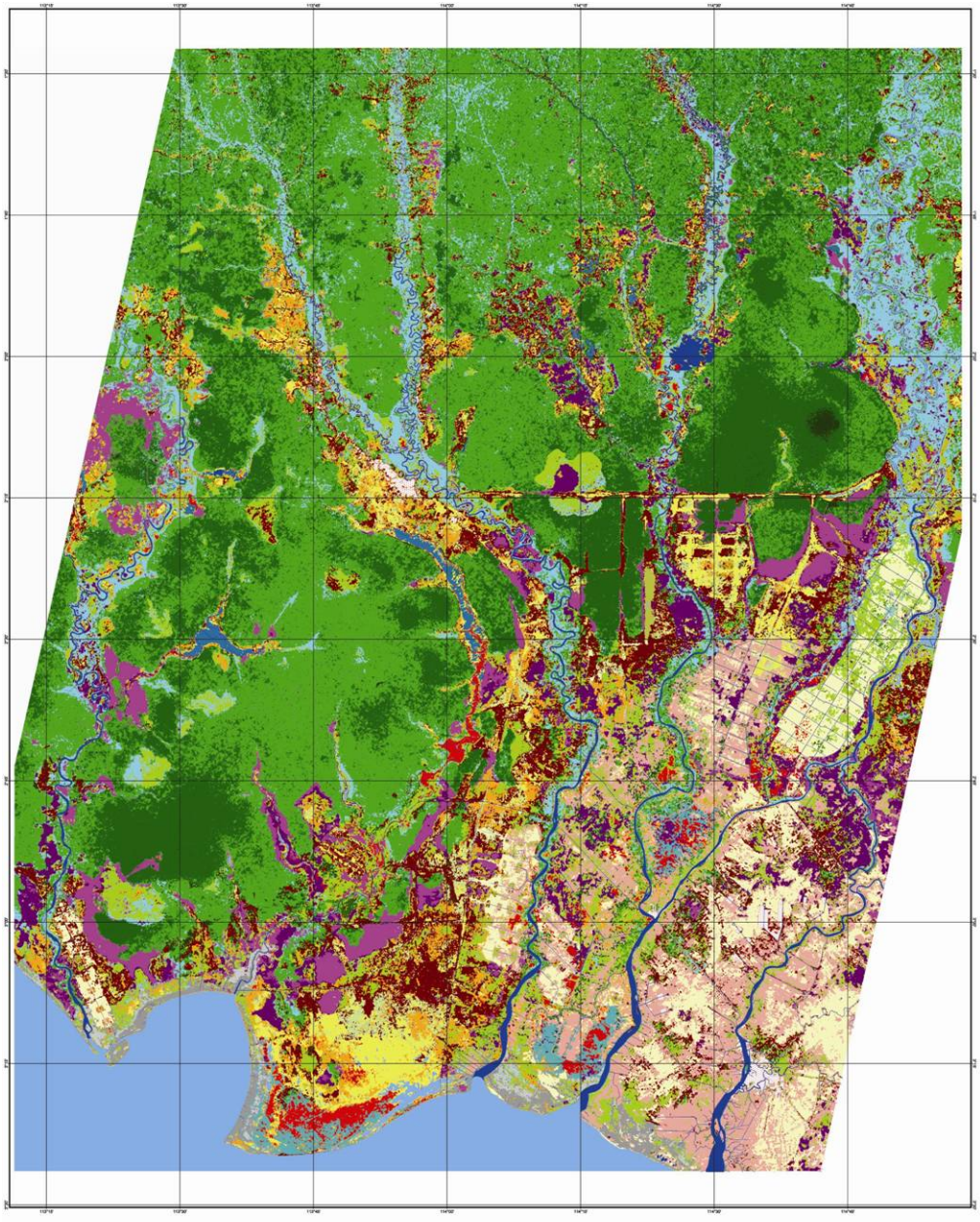


2. Main prototype area Central Kalimantan, early results

LULC map Central Kalimantan, main prototype area

Data used:
2 PALSAR images: FB HH-HV & WB1 HH

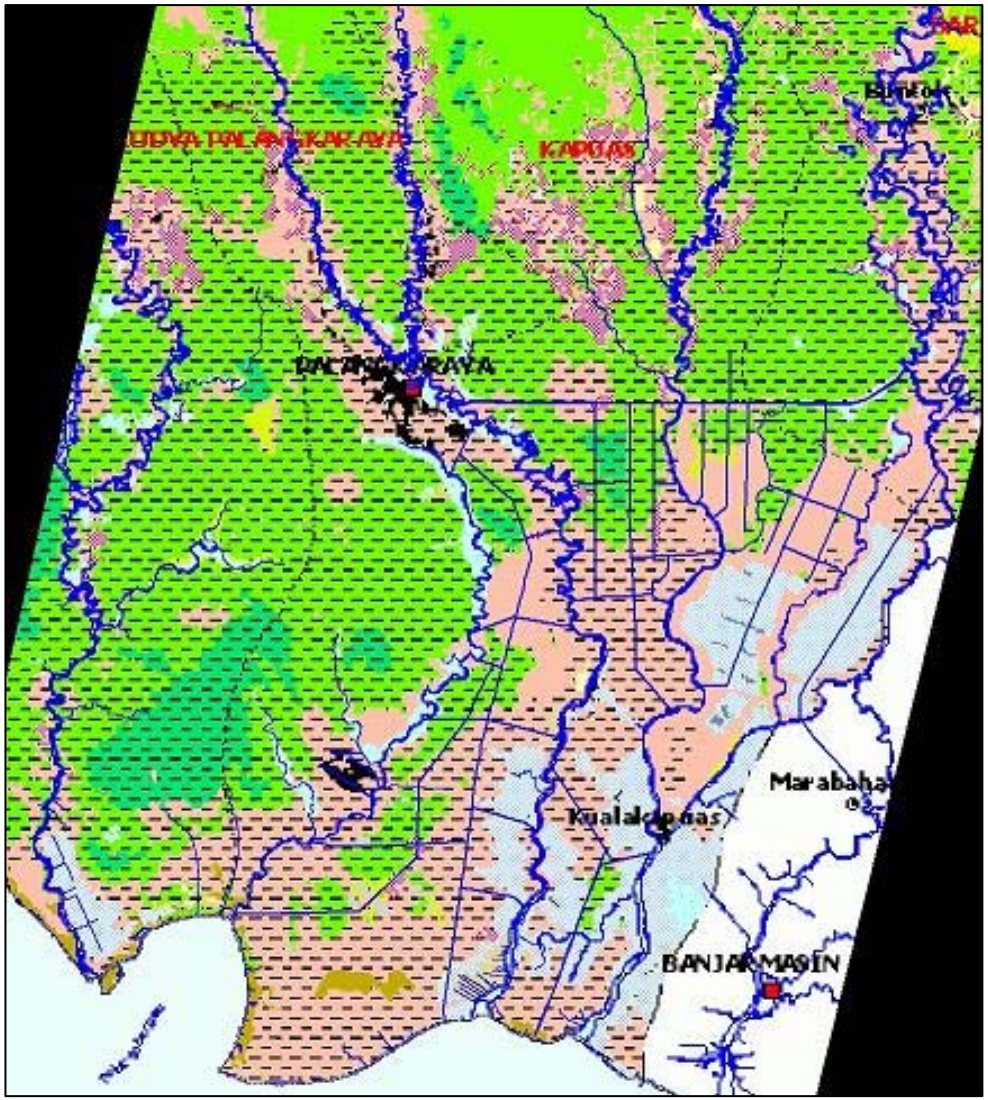
Land use/cover map of the EMRP project area and Sebangau in Central Kalimantan, Indonesia. This information is applied, among others, for peat swamp forest protection, hydrological restoration (such as canal blocking), reforestation, and development of REDD projects. On the basis of extensive groundtruth the accuracy is estimated to be over 84%.



Comparison with current practice

Local end users (government, national park and NGO's) prefer this PALSAR map over existing maps, which were based on Landsat visual interpretation.

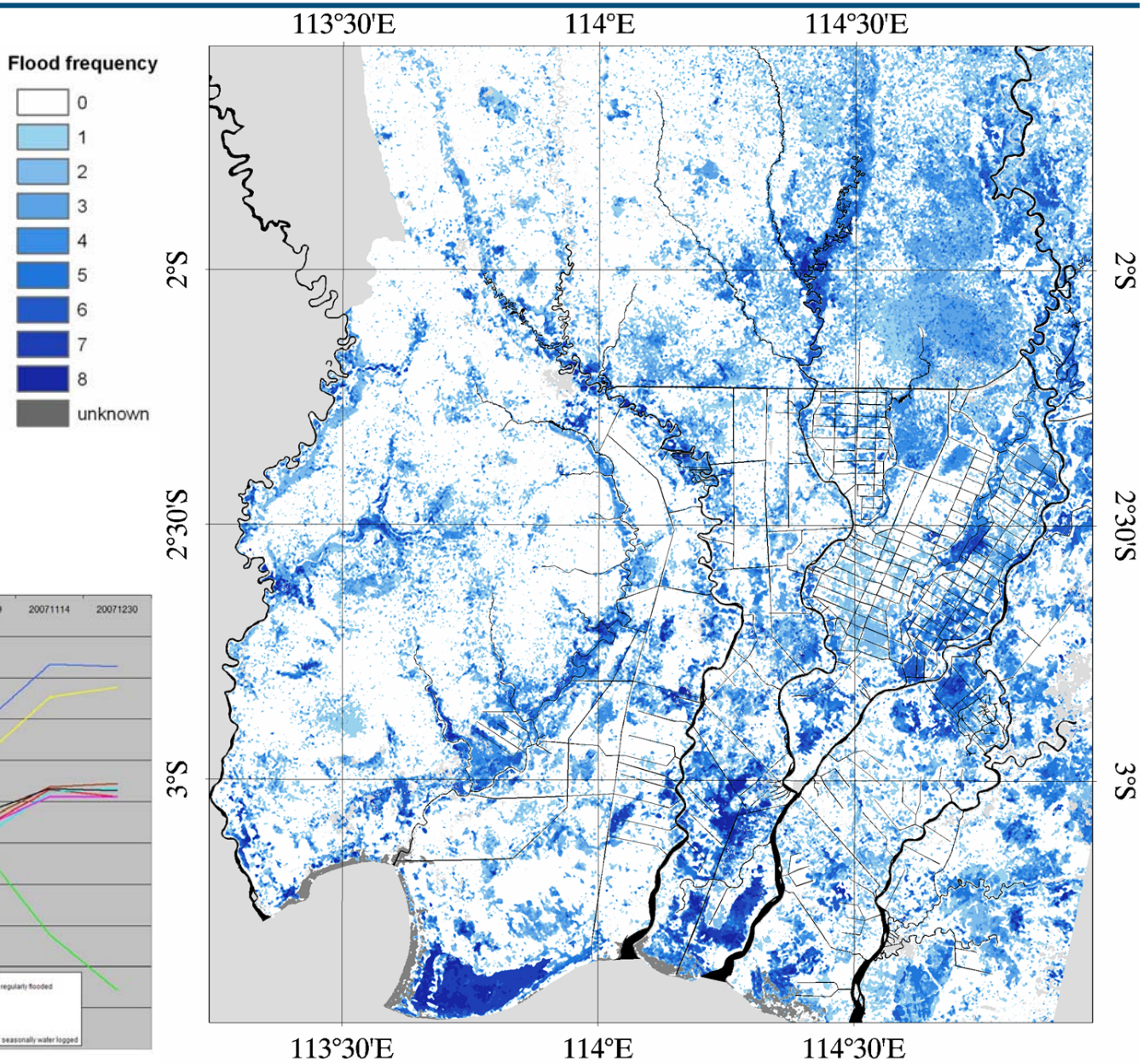
Indonesian Ministry of Forestry official map 2003

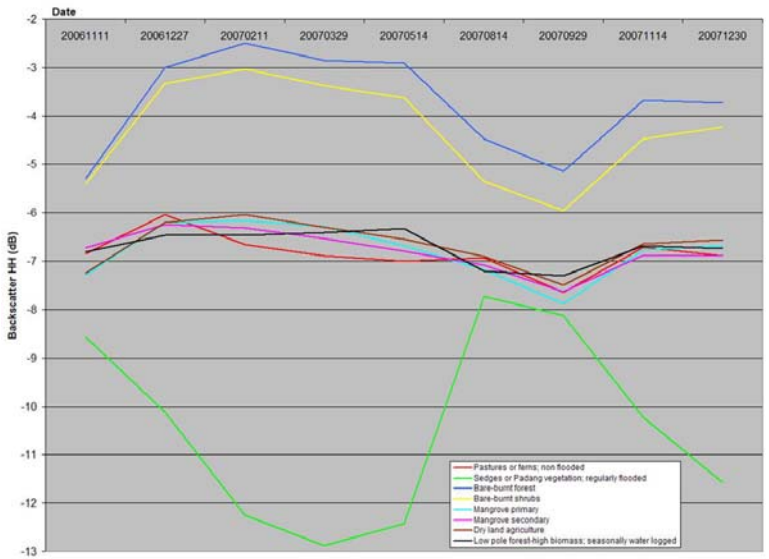


Flood frequency map Central Kalimantan

Data used:
9 PALSAR images: WB1 HH & LULC map (poster 1)

Proper flood frequency mapping requires knowledge on land cover.
Therefore this map may be considered as a second map layer.





3. Continental wide, high resolution mapping (Example Borneo)

First test results using standard FBD mosaics: Borneo

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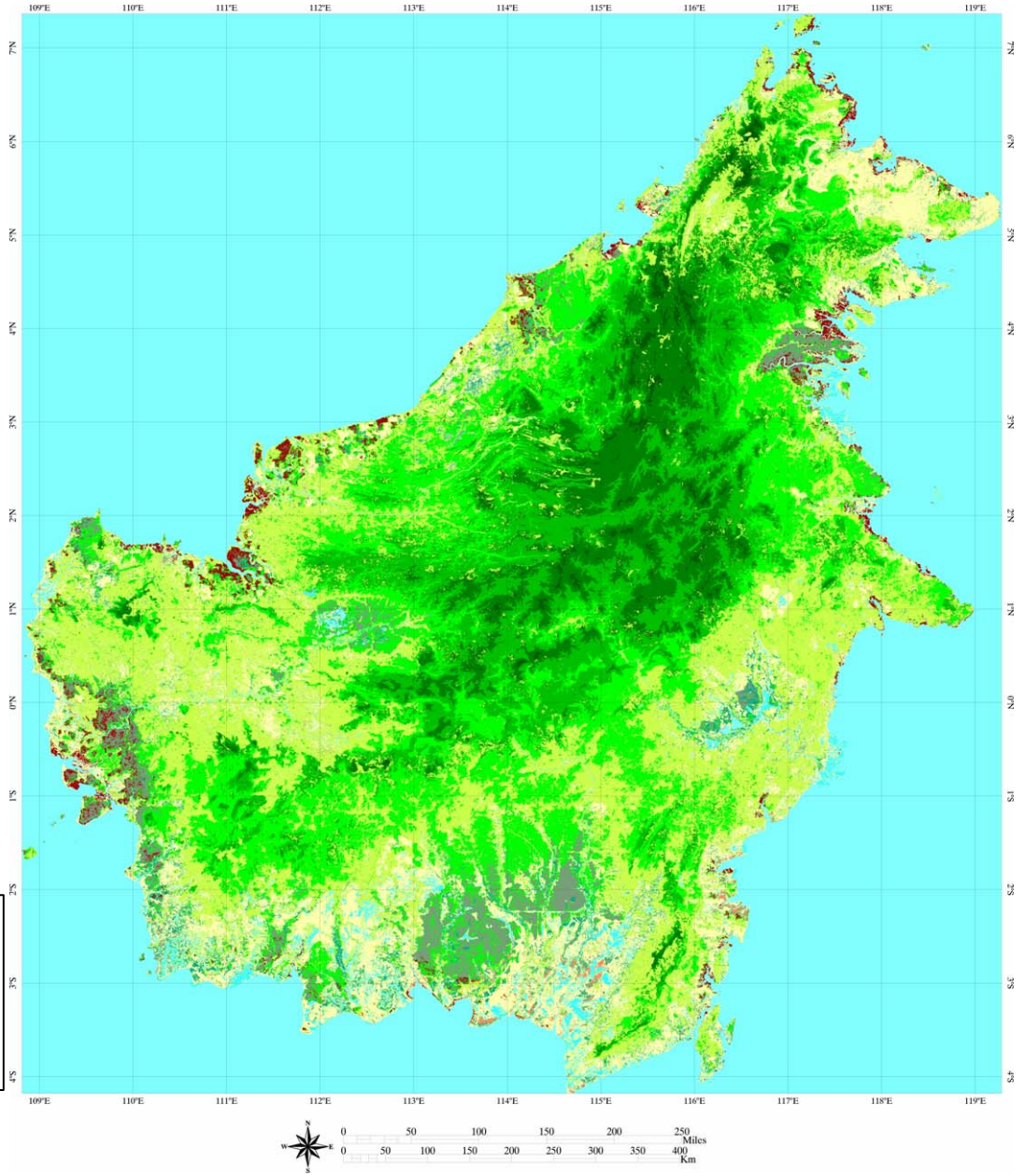
Data used:

PALSAR Borneo FBD mosaic (HH-HV)
SRTM
MODIS

Weaknesses:

- *Mountains*
- *Wet season missing*
- *Far less forest classes and other land cover classes can be differentiated (as compared to Central Kalimantan LULC map).*



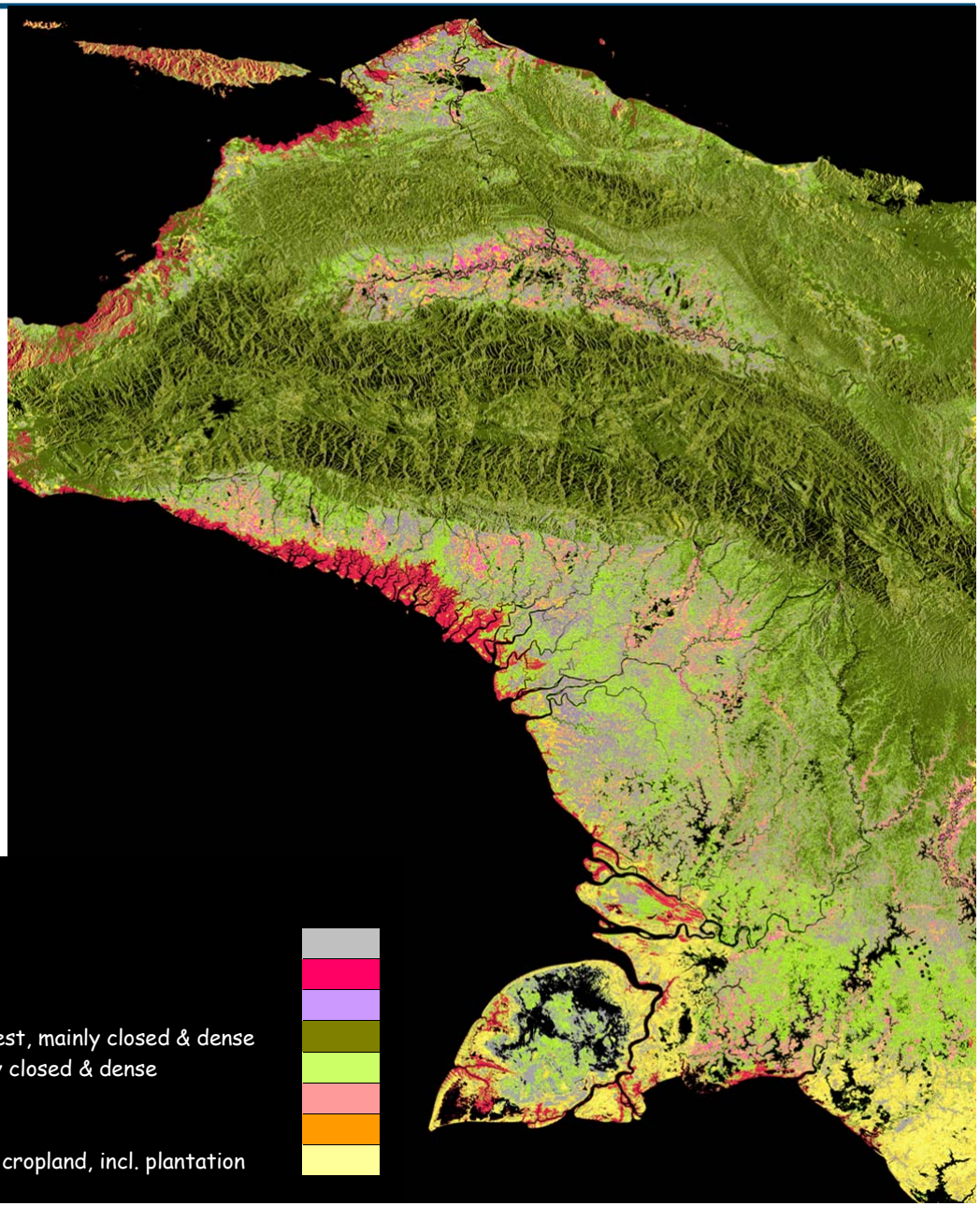
First test results using standard FBD mosaics: Papua

Data used:
PALSAR New Guinea mosaic (HH-HV)
GRFM JERS-1 mosaic

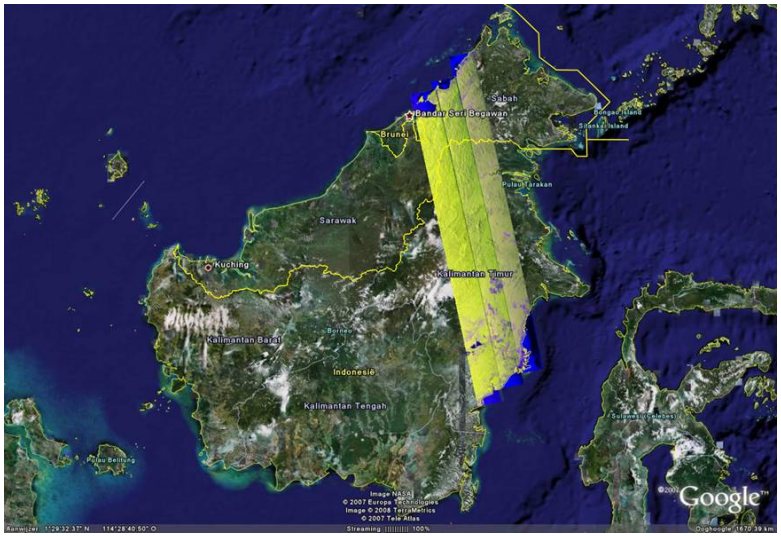
Weaknesses:
Mountains
GRFM mosaic not orthorectified

Conclusions: The first test results for Borneo and Papua show high consistency with existing maps (like TREES/JRC, based on optical data, 250-1000m), show additional details and show recent land cover change.

- *It is important to add a wet season observation (FBS)*
- *Slope corrections are needed*



Mosaicing: Finding replacement data (Example Borneo)

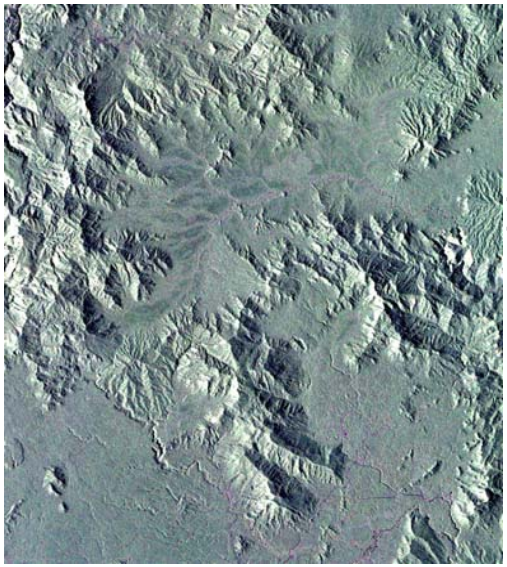


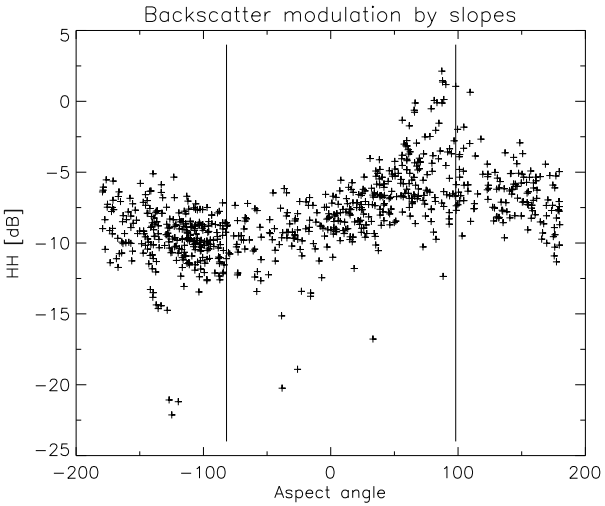
Data desired:
22 FBD strips, cycle 13
22 FBS strips, cycle 9

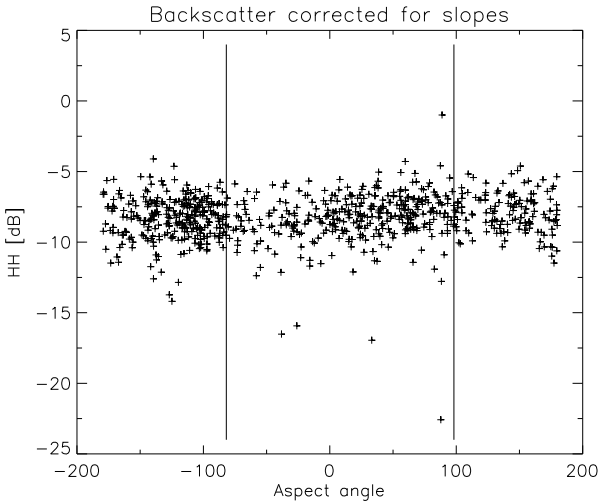
Data used:
4 FBD strips replaced, cycles 12 & 14
3 FBS strips replaced, from 2008(!)

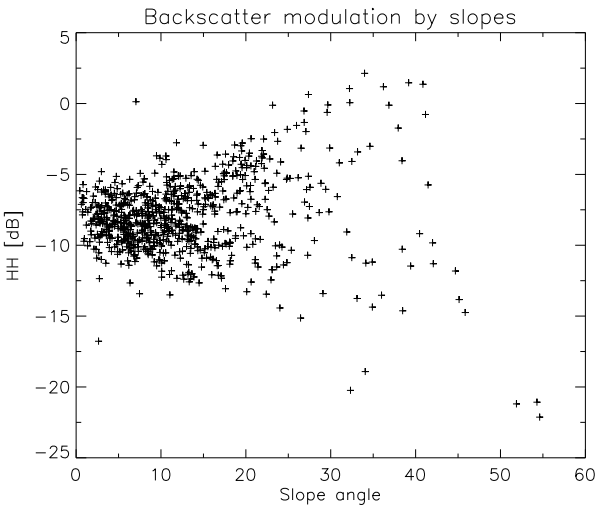
	FBD			FBS		
RSP	Date	Cycle	Shift	Date	Cycle	Shift
RSP410	20070804	13	+12	20070201	09	+12
RSP411	20070821	13	+29	20070218	09	+29
RSP412	20070723	13	0	20070120	09	0
RSP413	20070809	13	+17	20070206	09	+17
RSP414	20070826	13	+34	20070223	09	+34
RSP415	20070728	13	+5	20070125	09	+5
RSP416	20070814	13	+22	20070211	09	+22
RSP417	20070831	13	+39	20070228	09	+39
RSP418	20070802	13	+10	20070130	09	+10
RSP419	20070704	12	-19	20070216	09	+27
RSP420	20070905	13	+44	20070305	09	+44
RSP421	20070807	13	+15	20070204	09	+15
RSP422	20070824	13	+32	20070221	09	+32
RSP423	20070726	13	+3	20080126	17	+369
RSP424	20070812	13	+20	20070209	09	+20
RSP425	20070829	13	+37	20070226	09	+37
RSP426	20070915	14	+54	20070128	09	+8
RSP427	20070817	13	+25	20070214	09	+25
RSP428	20070903	13	+42	20070303	09	+42
RSP429	20070805	13	+13	20080205	17	+379
RSP430	20070707	12	-16	20080408	18	+442
RSP431	20070608	12	-45	20070121	09	+1

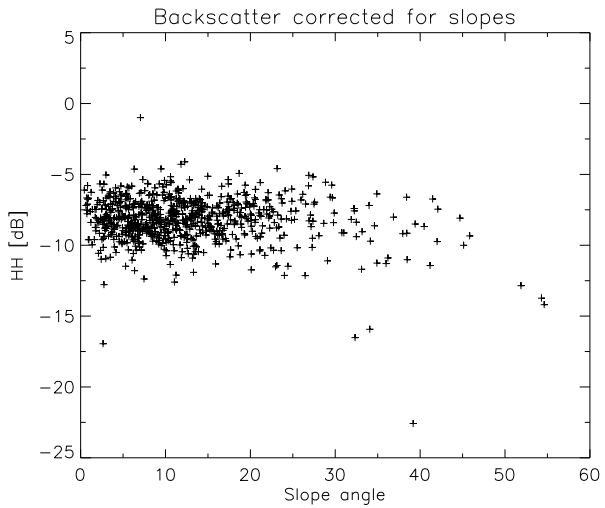
Slope correction/mitigation (1)









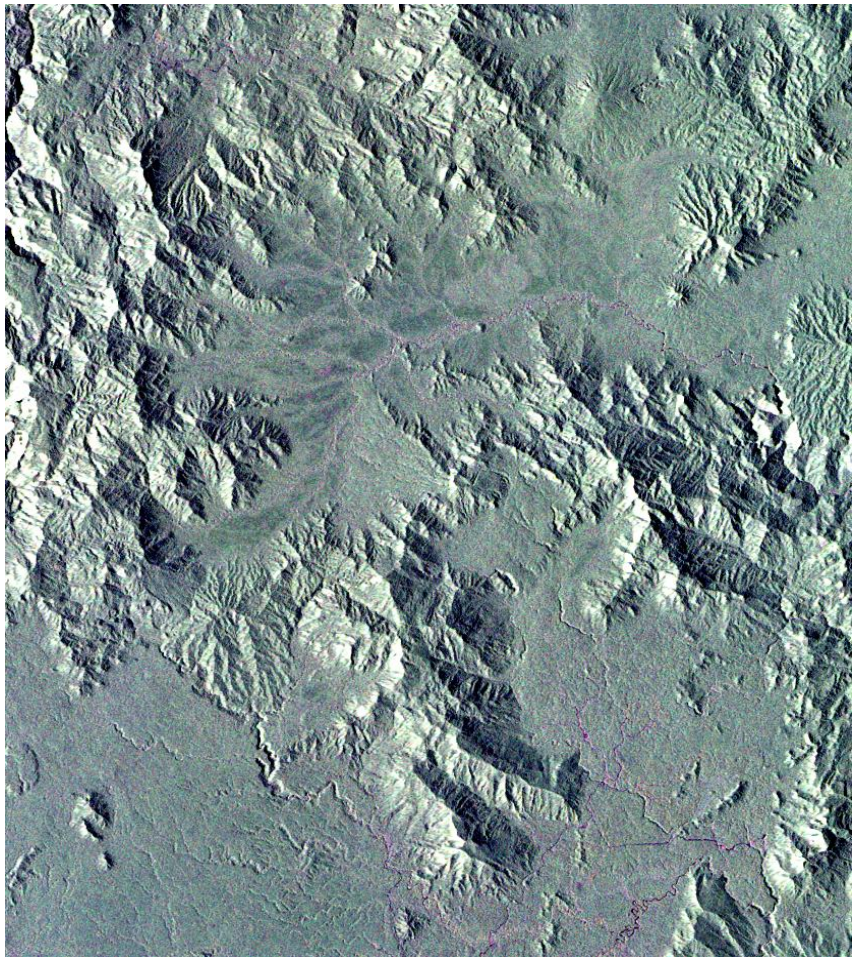


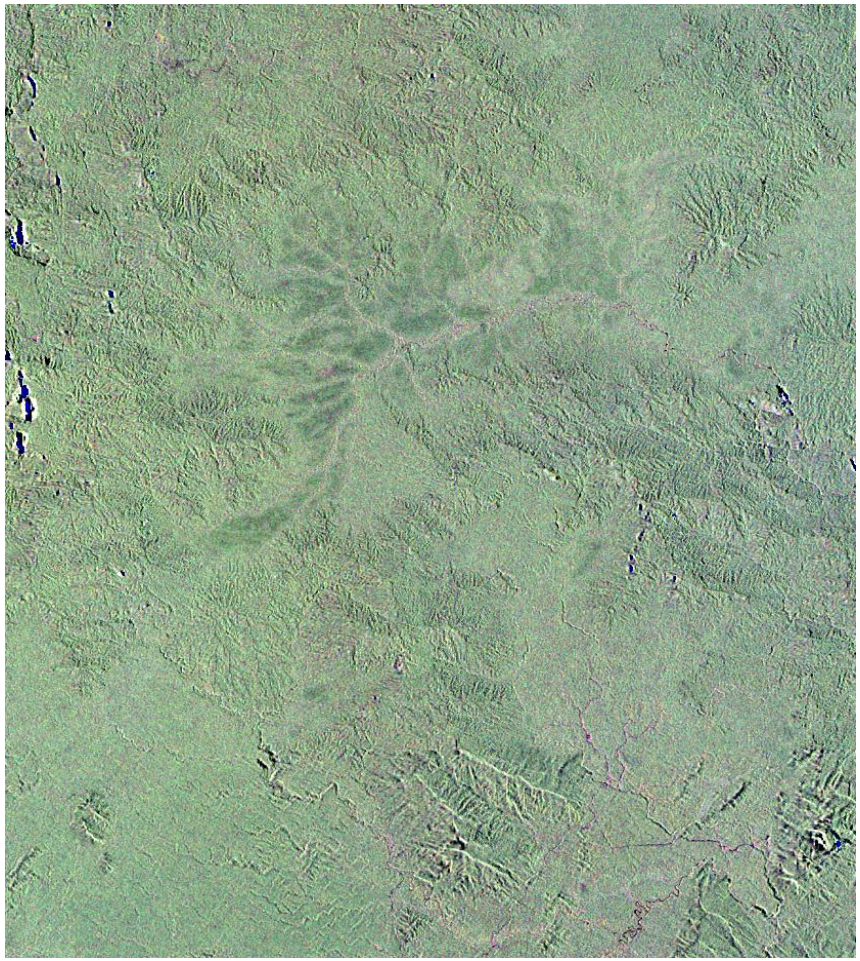
Data correction:

Using slope & aspect angle derived from SRTM

Assuming isotropic opaque volume scattering

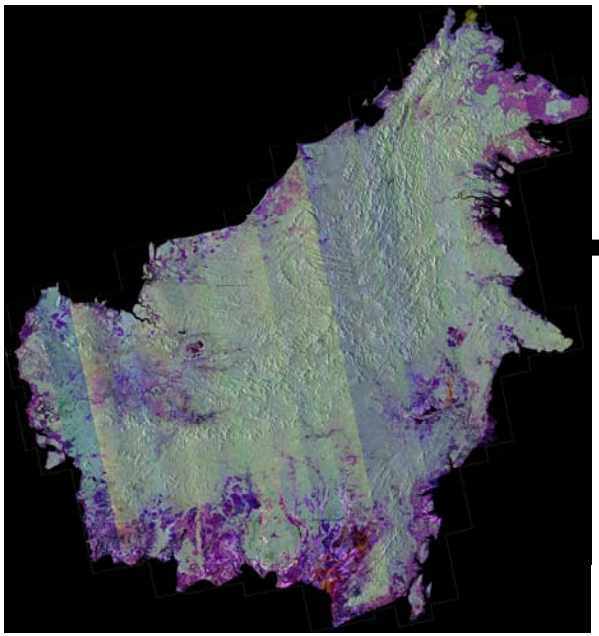
Slope correction (2)

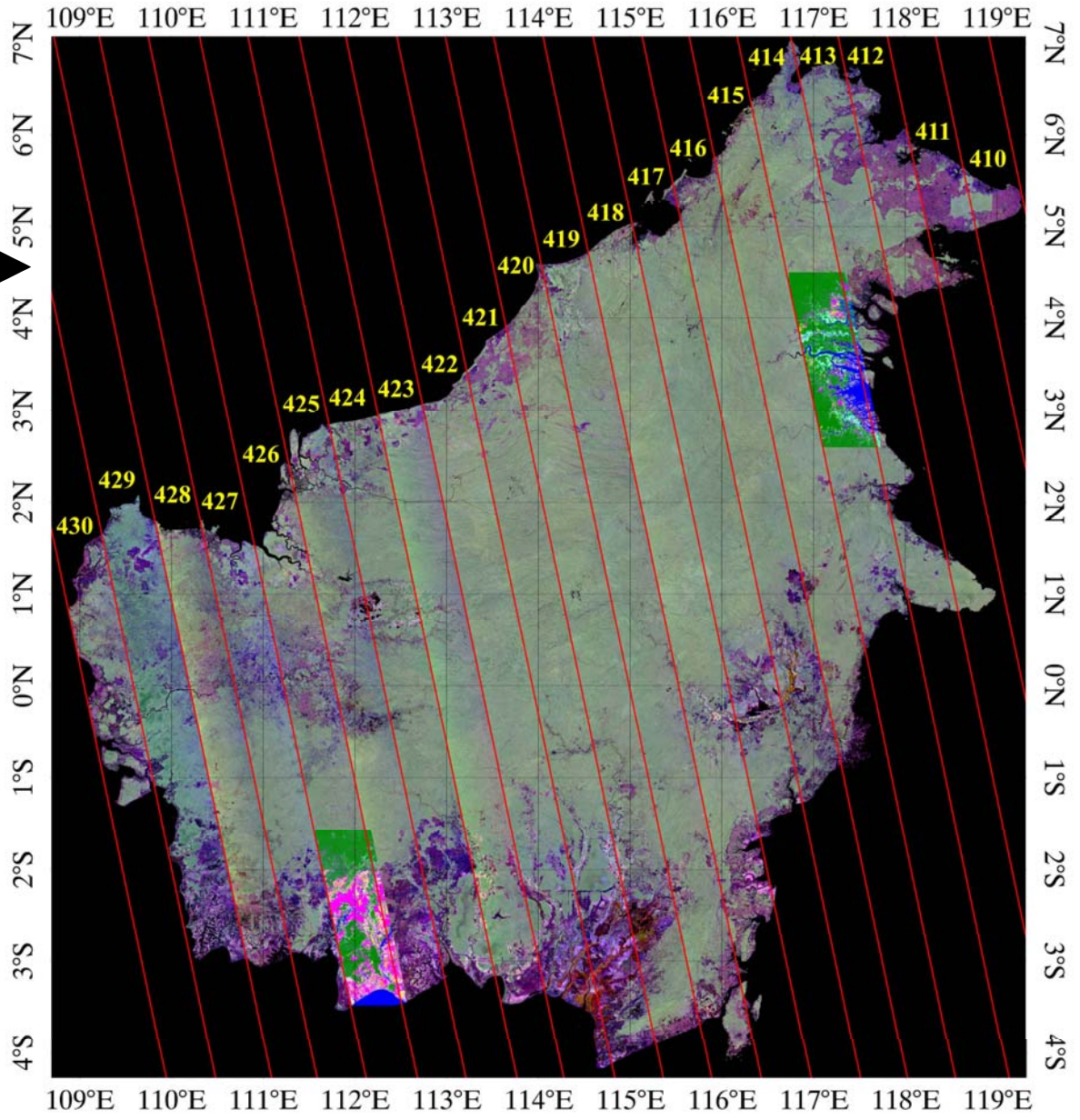




FBS/FBD composite before and after slope correction
(same backscatter scale)

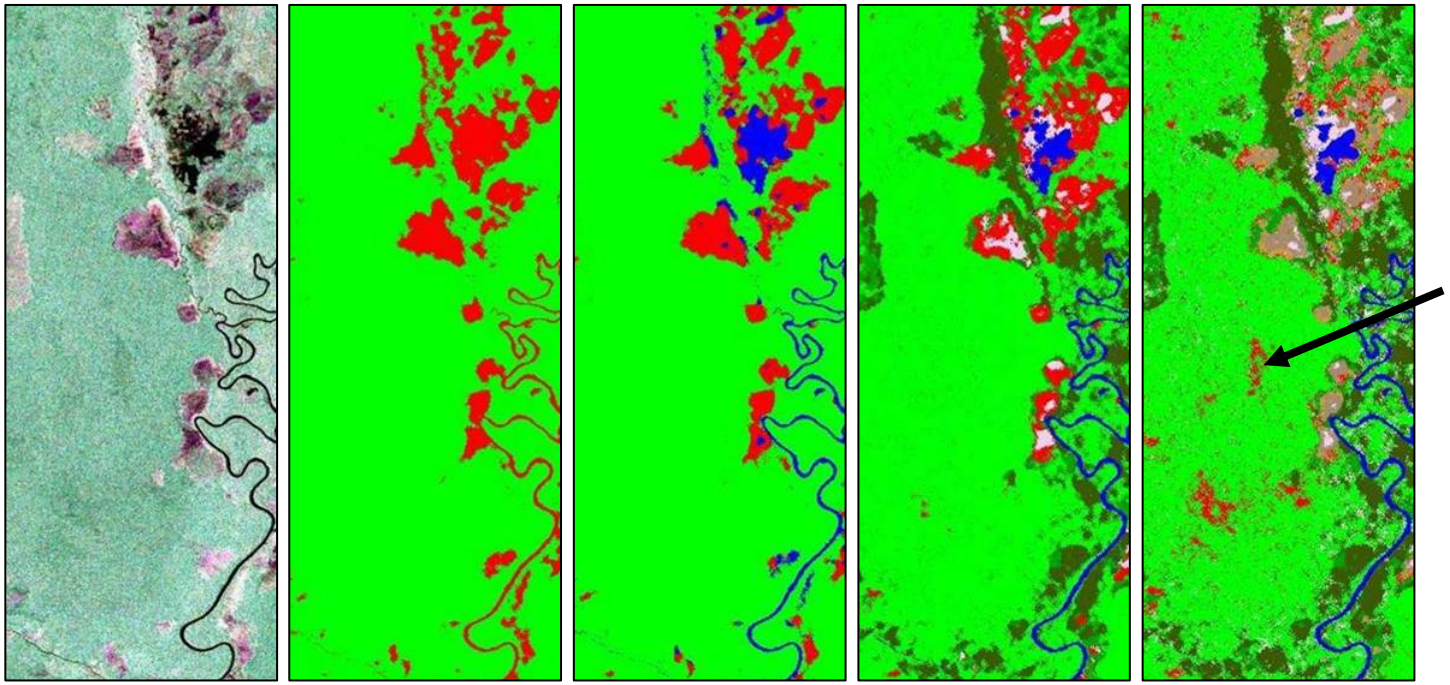
Mosaicing result: slope corrected FBS+FBD





After radiometric balancing, orthorectification and slope correction, strips are ready for classification (two classified areas are already shown).

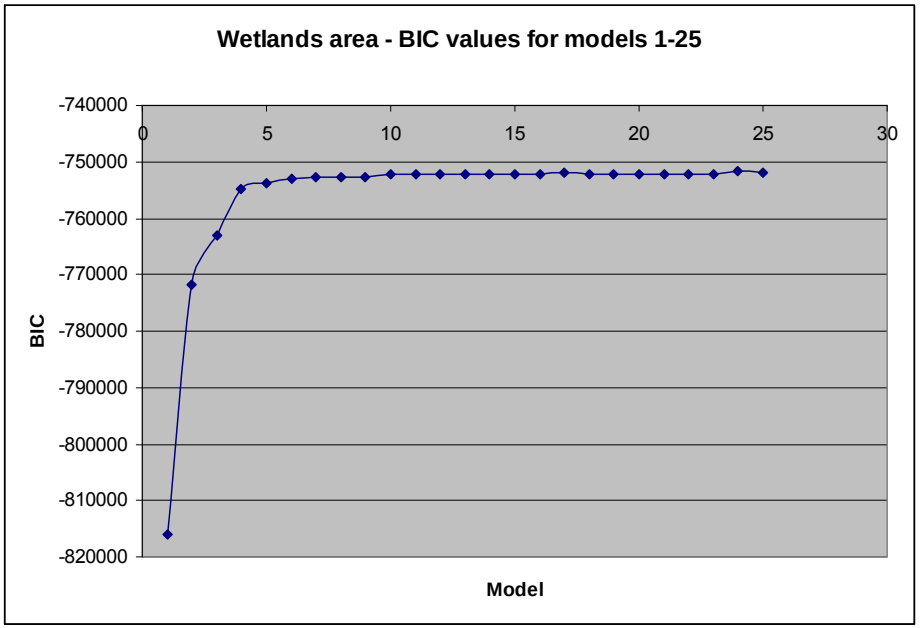
Classification approach (1): Example

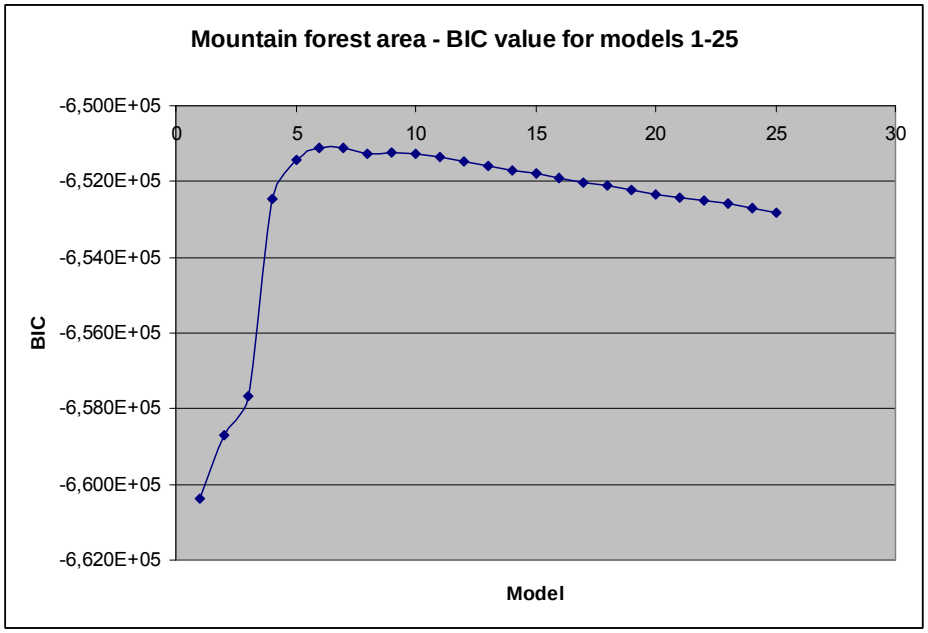


Mixture modelling followed by Markov Random Field classification of a small part of a polarimetric image over Central Kalimantan. Models of increasing complexity reveal a hierarchy of classes. Re-generating forests can be distinguished in model 10 (black arrow). The model number equals the number of clusters (*g*).

Algorithm described in: Hoekman *et al*., 2007; Tran *et al*., 2005

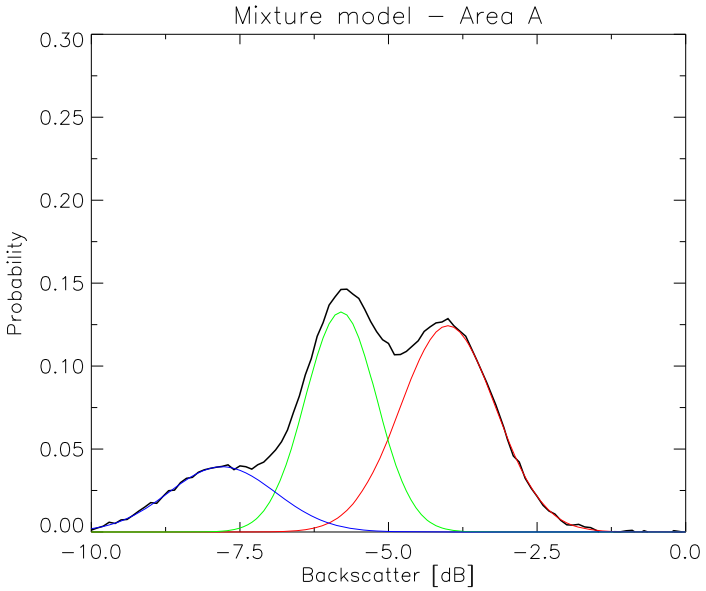
Classification approach (2): Number of clusters?

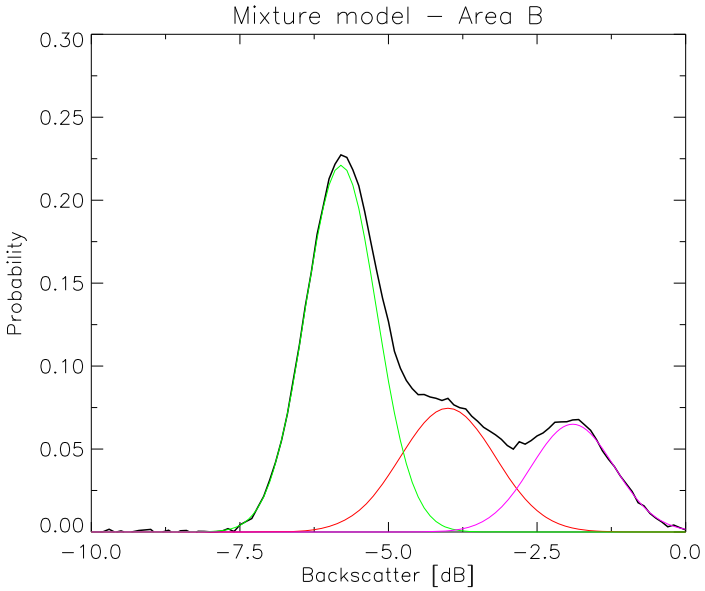




How many clusters? The Bayesian Information Criterion (BIC) is used to determine how many clusters (or classes/sub-classes) are present in a certain area (such as a peat swamp area, a mangrove area, or a dryland forest area. This technique is used to support the development of a legend for (the entire) Borneo.

Classification approach (3): Number of clusters?

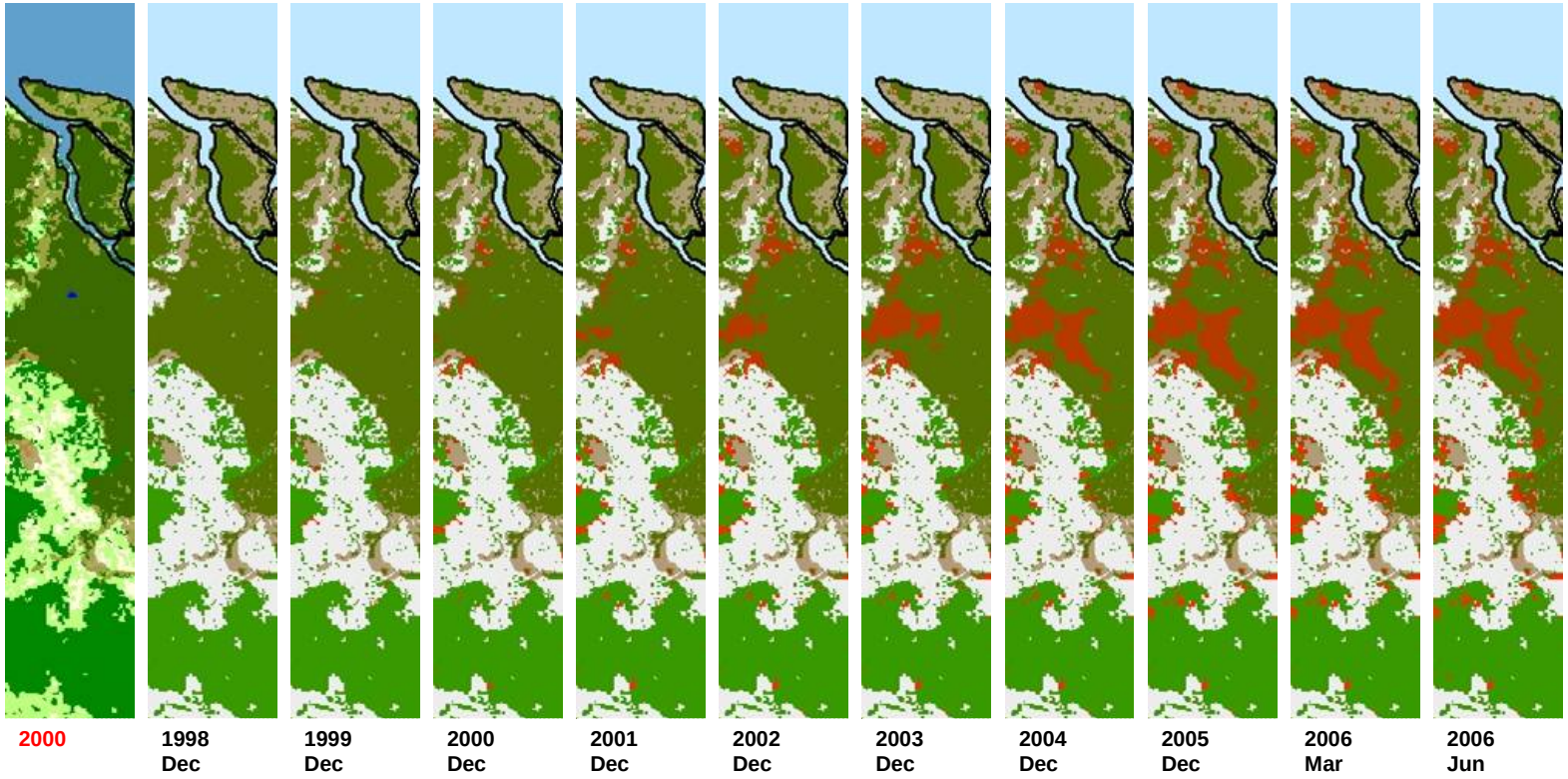




Selection and aggregation of clusters: In this theoretical one-dimensional example there are 3 clusters in area A and 3 in area B. Together they have 4 clusters. In practice we may select between 50-100 relevant clusters for the entire Borneo. Subsequently, clusters can be aggregated to form a (compound) thematic class.

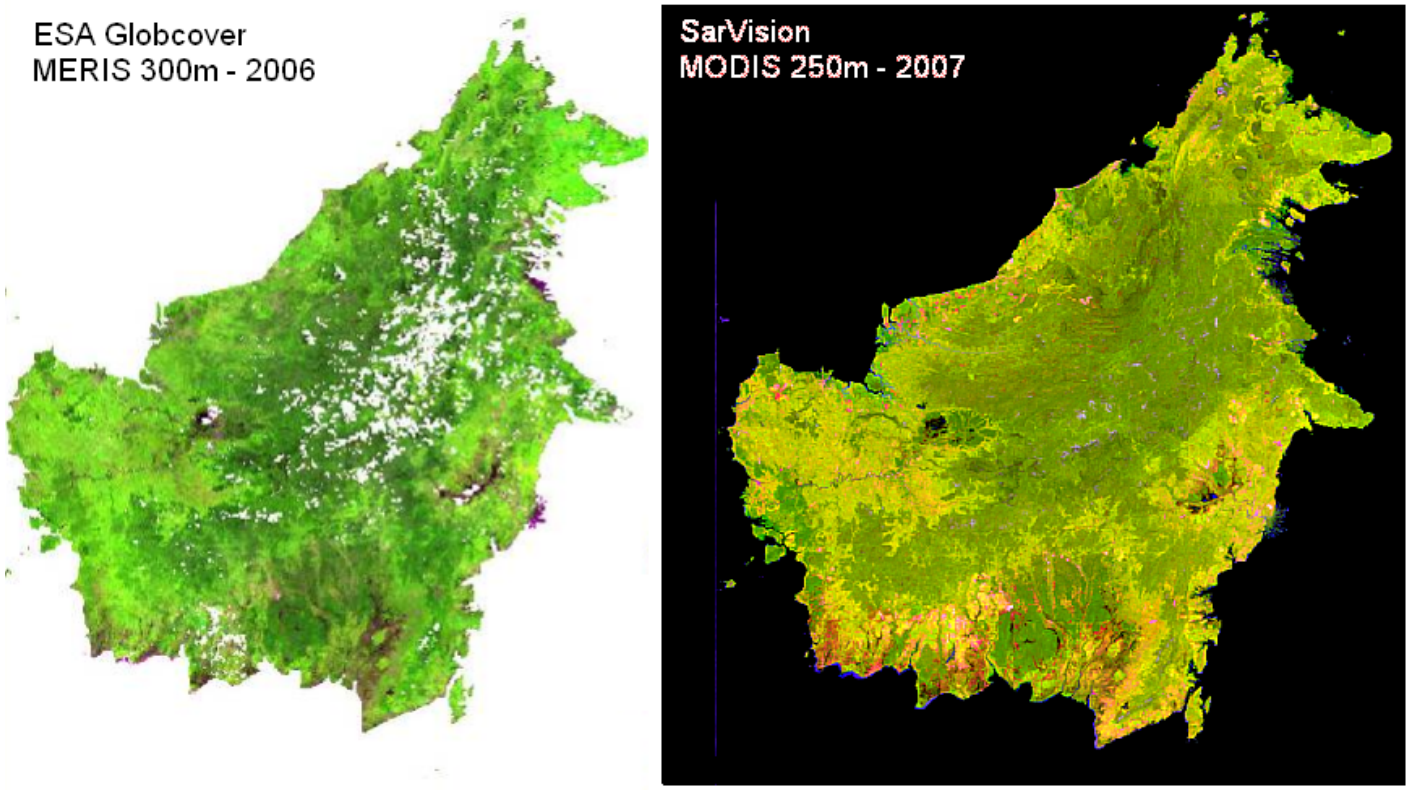
Extended classification approach: synergy optical data (1)

Legend: **forest** /peat area **/peat swamp forest** **/deforestation since 1999.**



Deforestation time-series based on SPOT-VEGETATION are updated (by SarVision) every 3 months. This information is useful since it provides knowledge on the age of secondary re-growth or tree plantations.

Extended classification approach: synergy optical data (2)



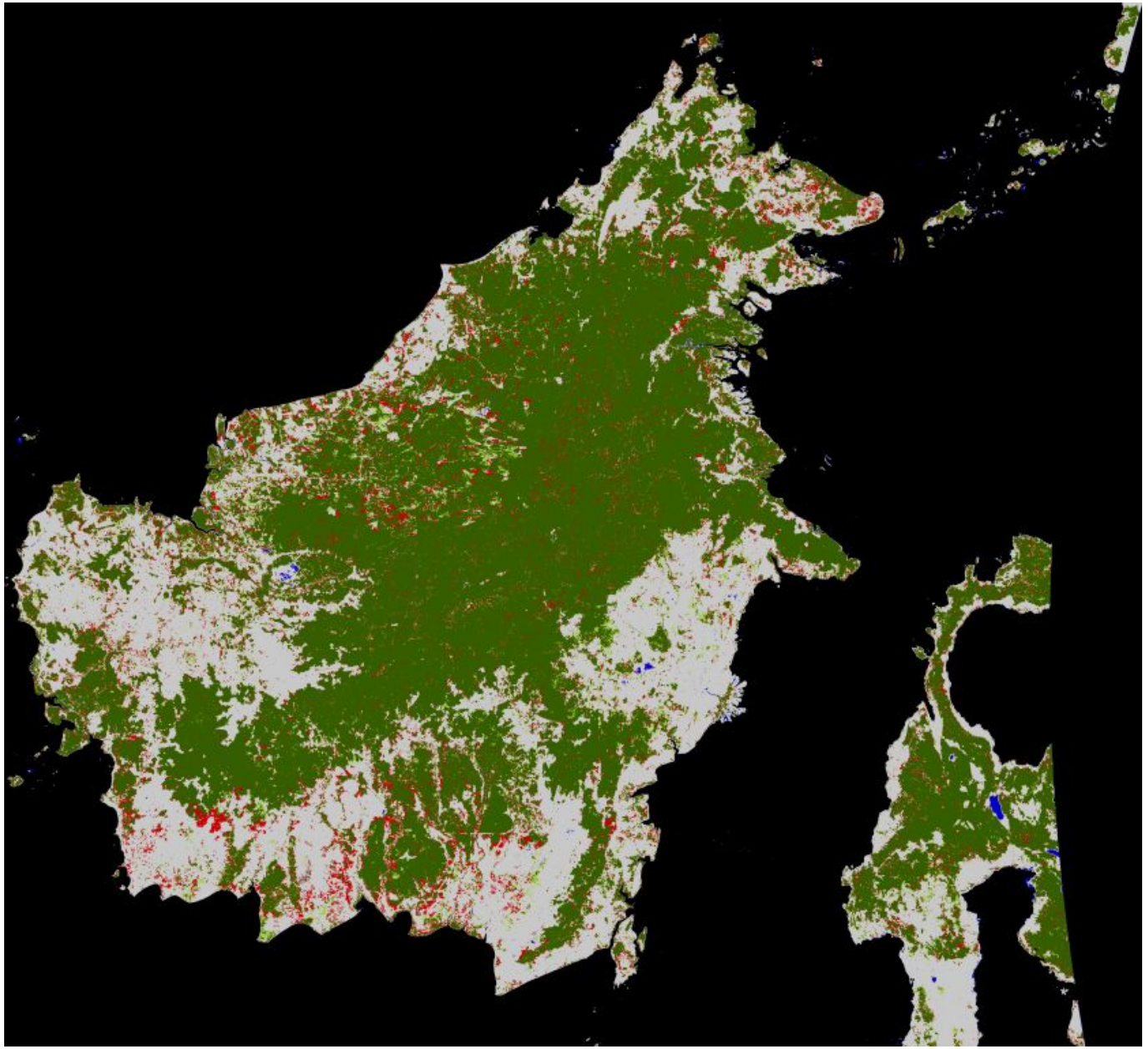
MODIS is better than MERIS in areas with persistent cloud cover.

Extended classification approach: synergy optical data (3)

Legend: **forest land** / **non-forest land** / **water** / **deforestation or severe forest degradation in 2007** / **forest re-growth**

Forest land 2007
Deforestation 2007

Deforestation maps based on MODIS are made annually by SarVision. For Borneo this is done in cooperation with WWF.



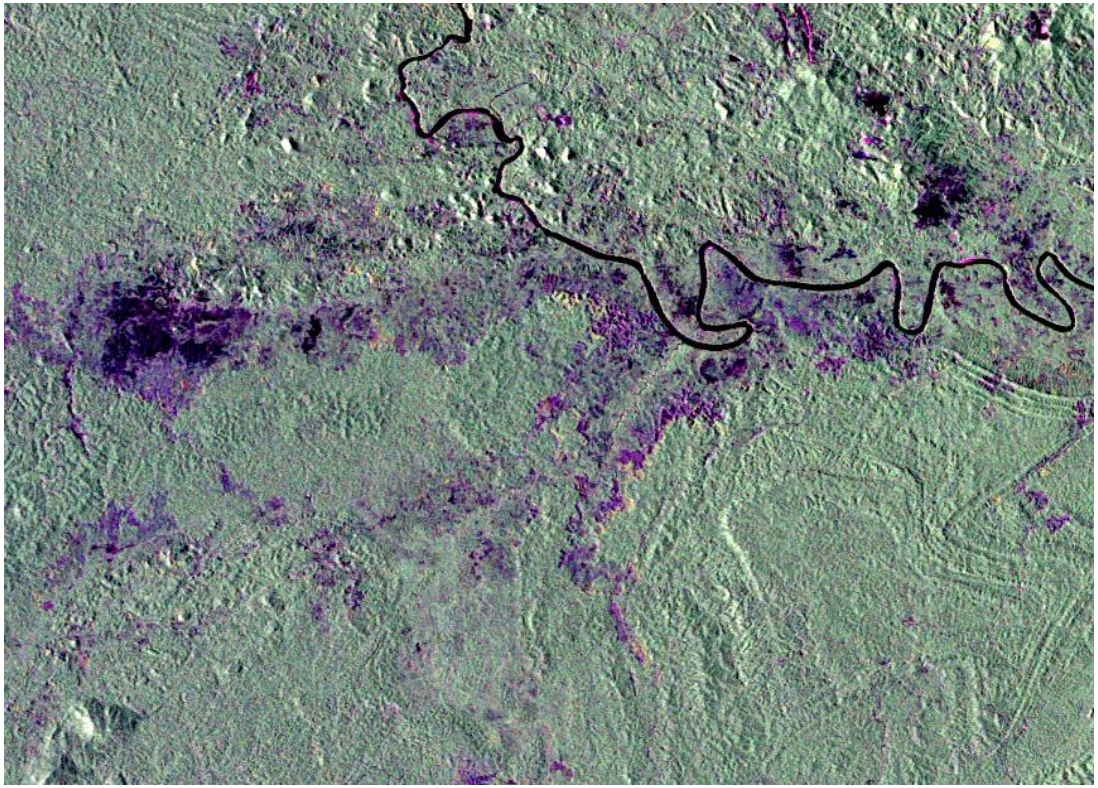
Extended classification approach: synergy optical data (4)

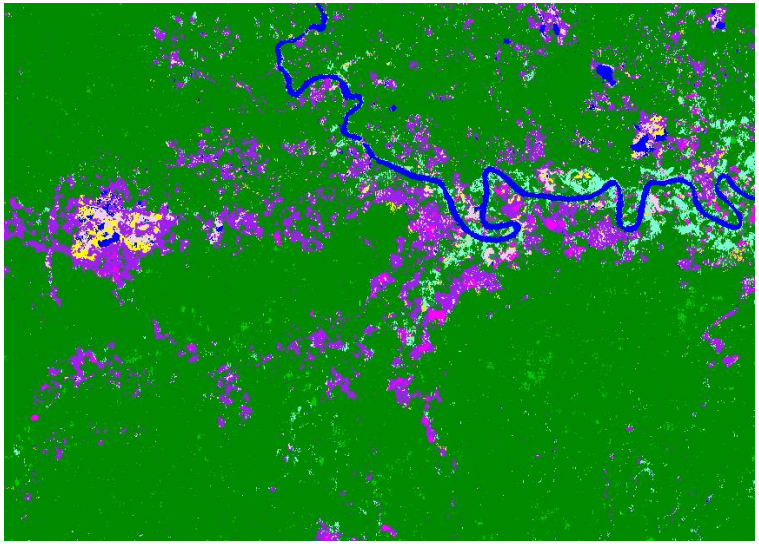
Note: The classification of PALSAR data can be done in several ways, such as:

1. Using PALSAR data only.
2. Using PALSAR data, in combination with MODIS data.
3. Using PALSAR data, with MODIS data or thematic data derived from MODIS and/or SPOT-VEGETATION as prior information.

We use PALSAR data only. In case the validation study reveals certain weaknesses (for example, with secondary forests), then approaches 2 and 3 will be further investigated.

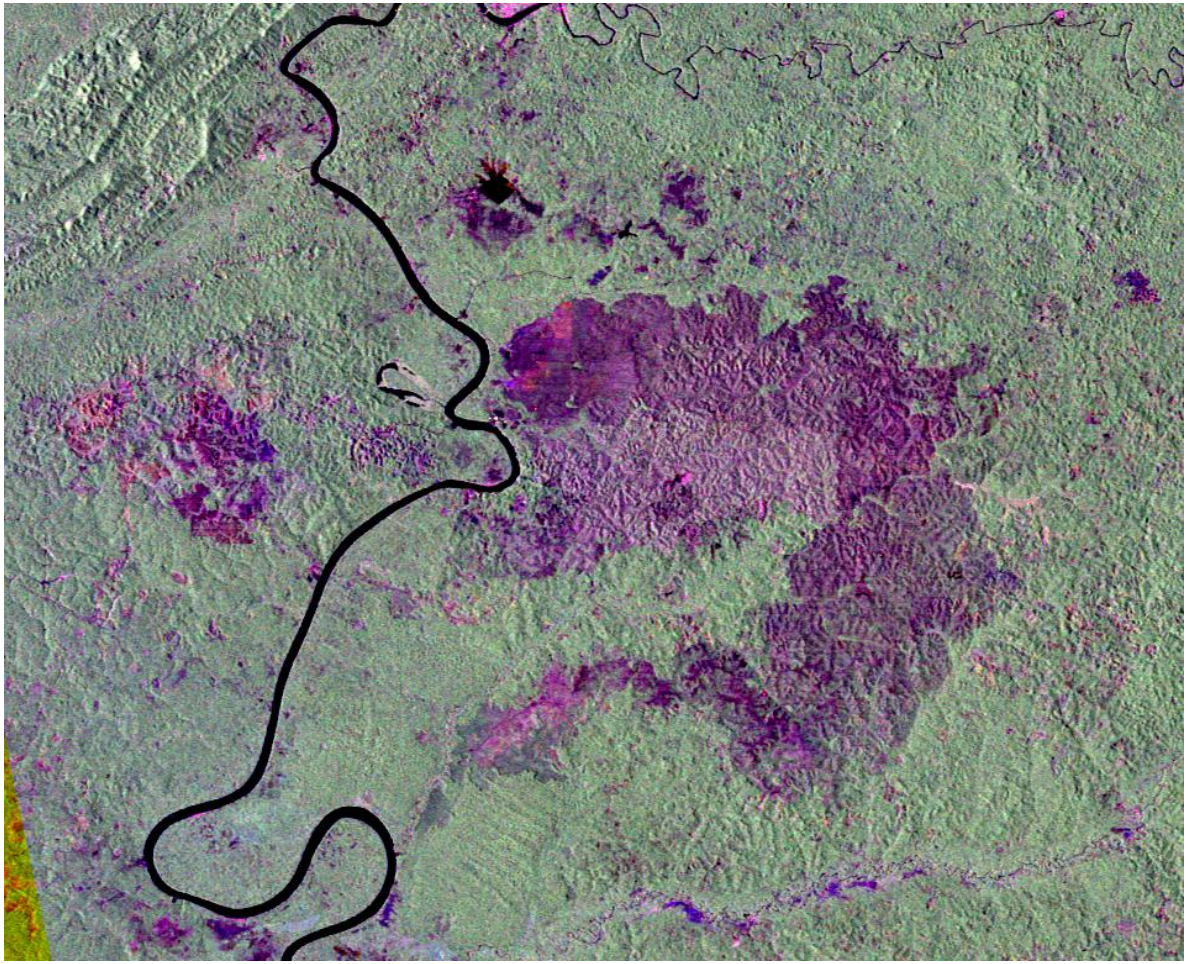
Results: Central Borneo (1)

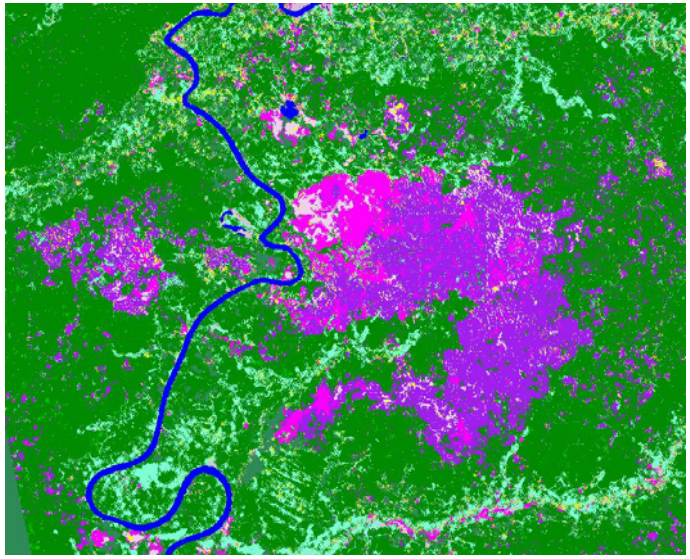




- Forest - Lower biomass and/or degraded
- Deforestation types
- Riverine-riperian and swamp forest
- Shrub land

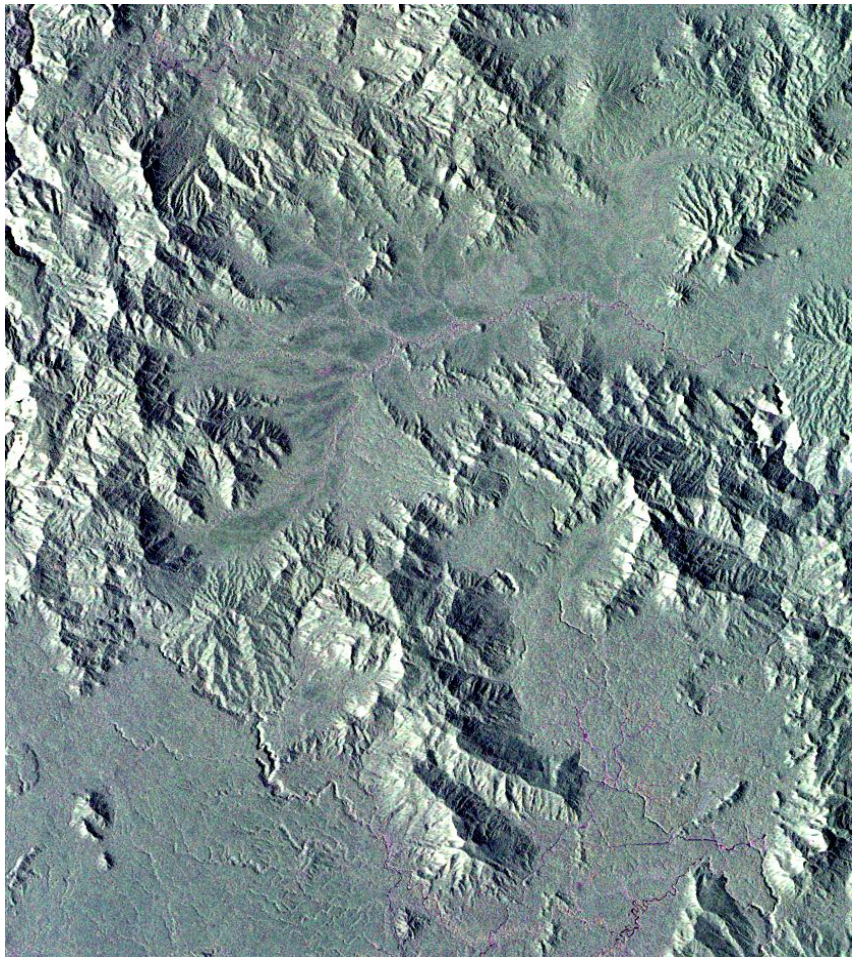
Results: Central Borneo (2)

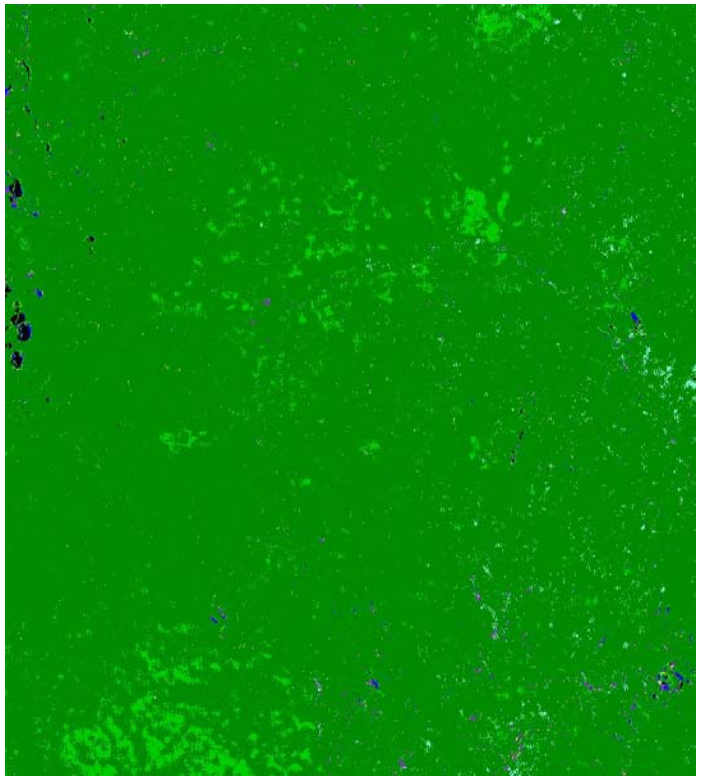




Deforestation types
Tree plantations and Palm oil

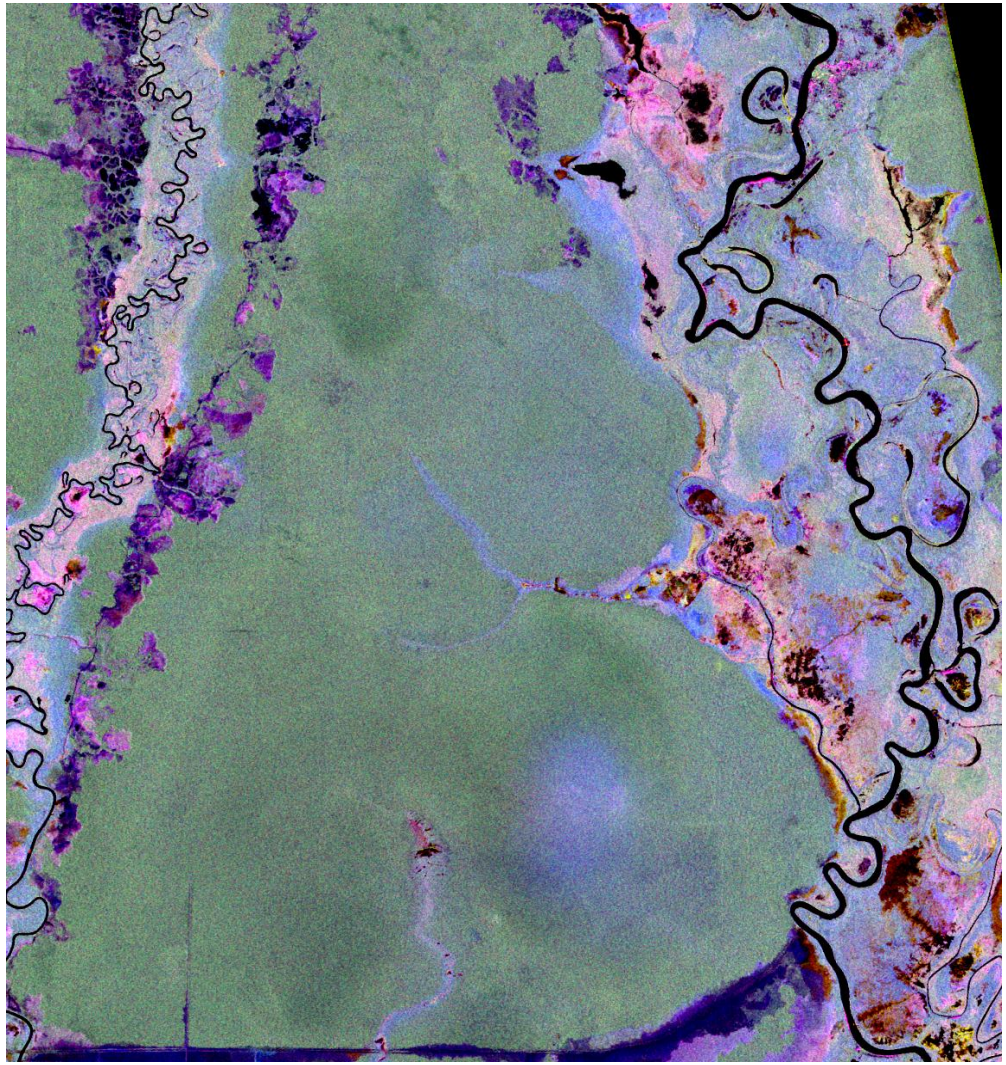
Results: Central Borneo (3)

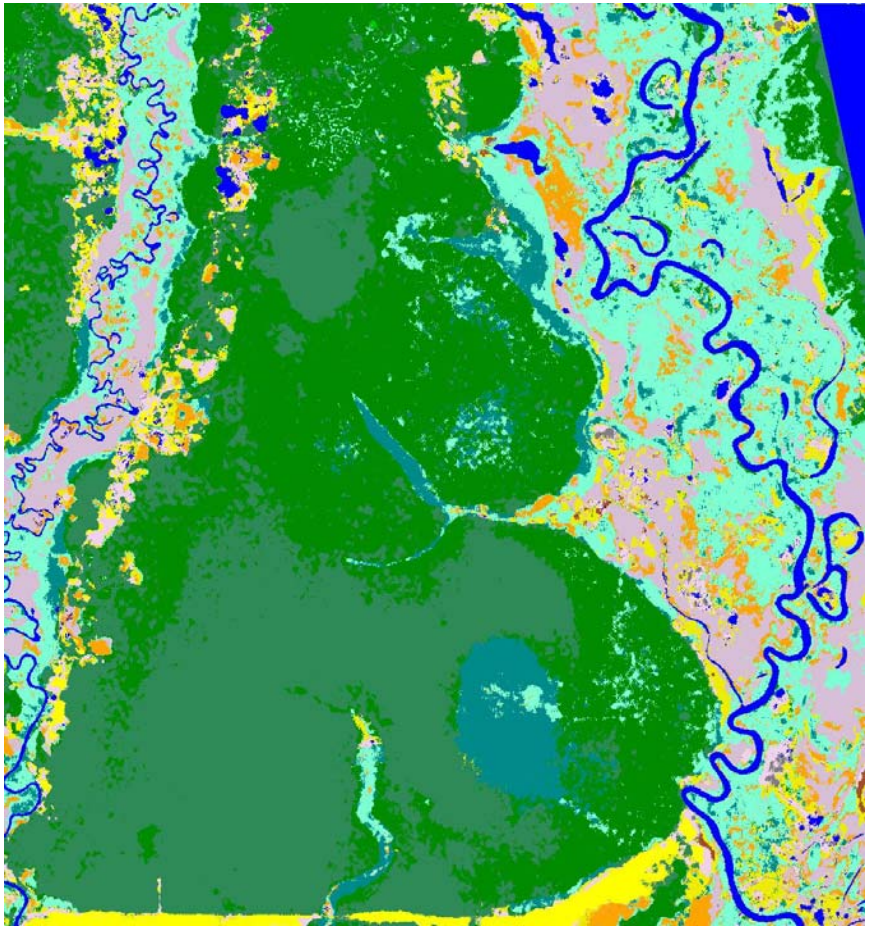




	Forest - Lower biomass and/or degraded
	Forest - Higher Biomass
	Deforestation types
	No data (radar shadow and layover)

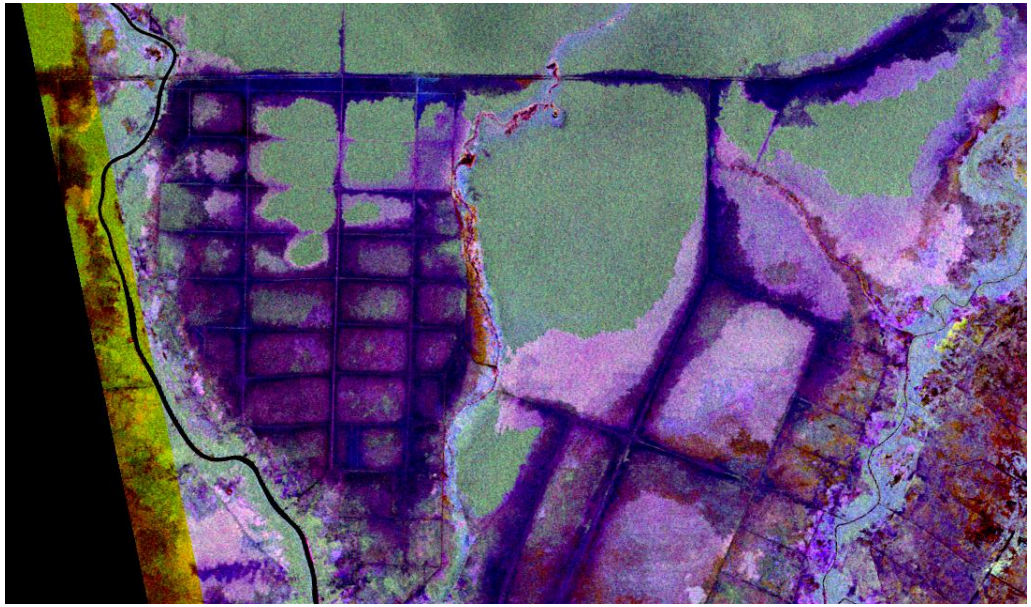
Results: Peat swamps

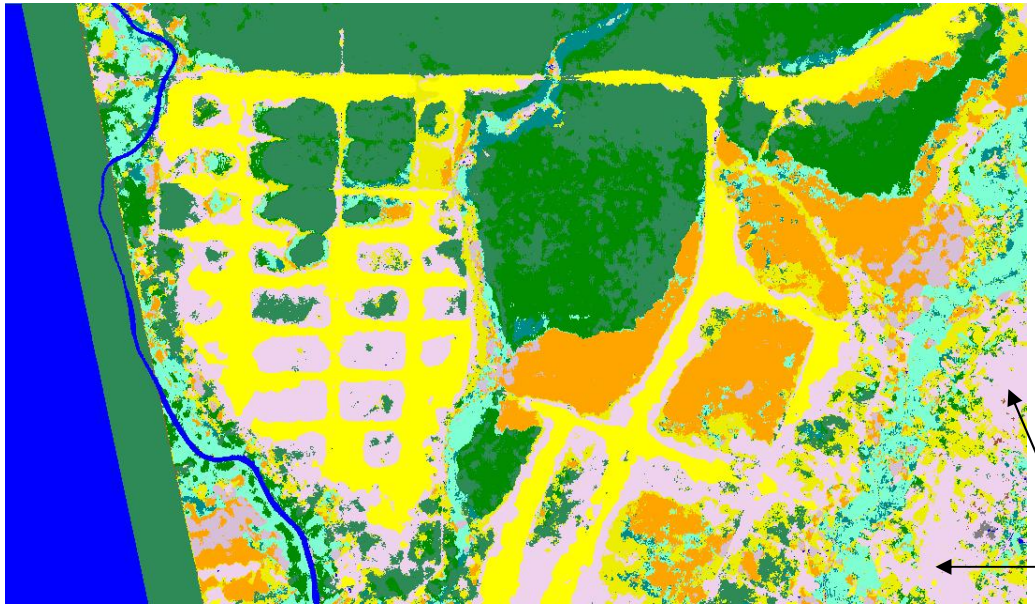




- Forest and forest on peat/heath
- Peat swamp less dense
- Peat swamp low pole
- Riverine-riperian and swamp forest
- Burnt shrubs and bare
- Shrub land

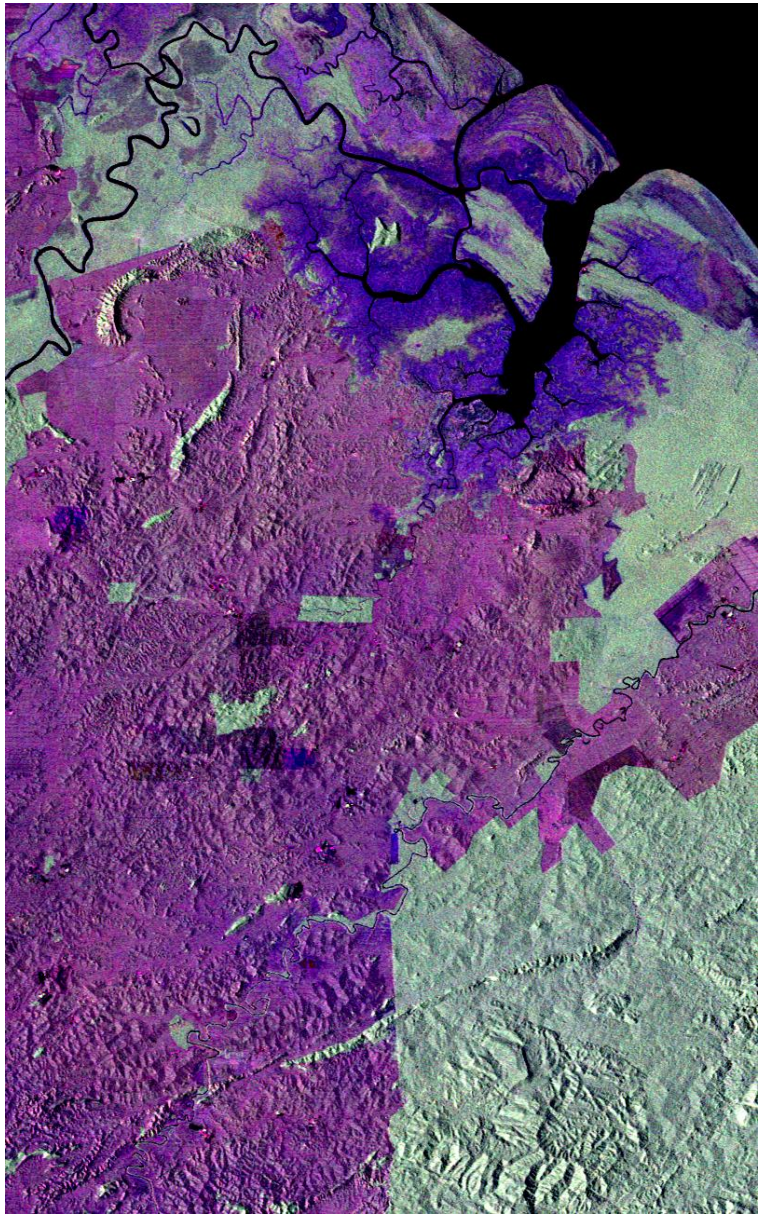
Results: Disturbed peat swamps

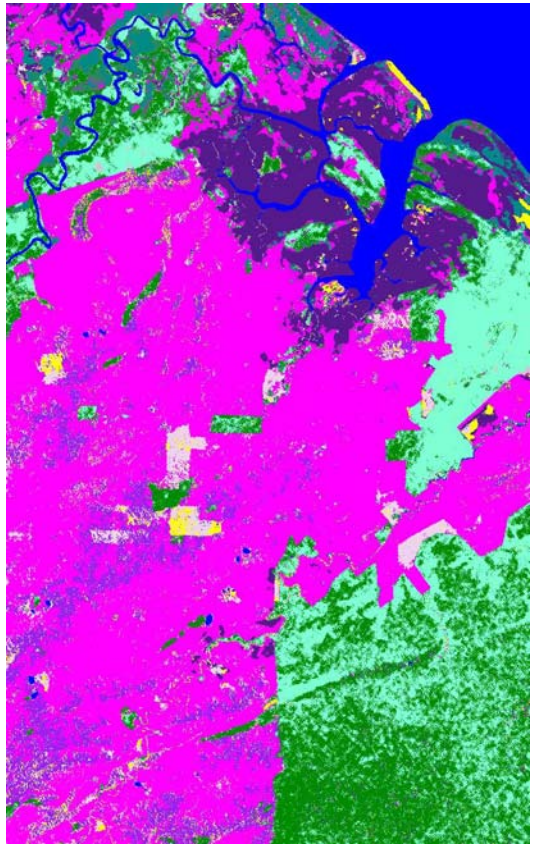




- Forest and forest on peat/heath
- Peat swamp less dense
- Riverine-riperian and swamp forest
- Burnt (peat) forest and bare
- Burnt shrubs and bare
- Shrub land
- Sawah

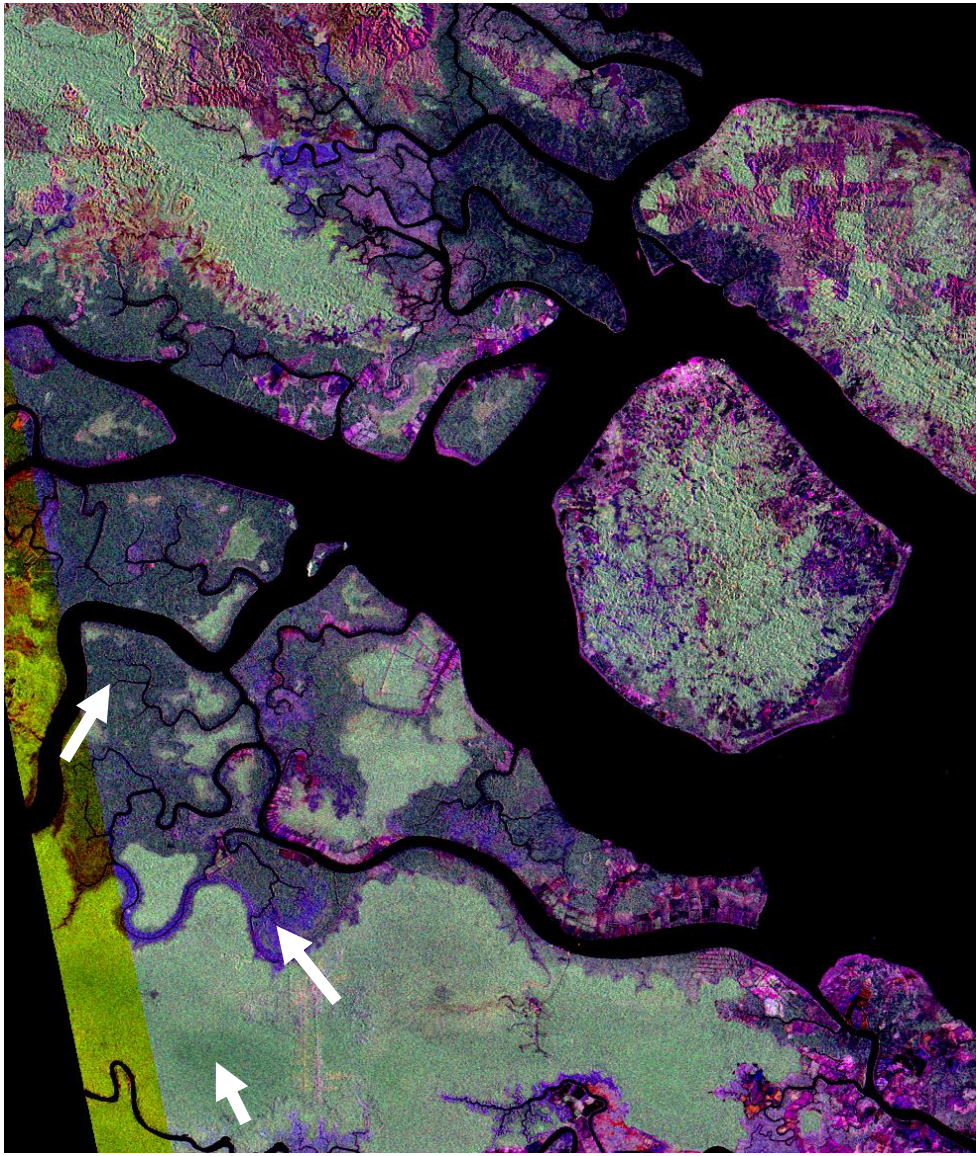
Results: Sabah

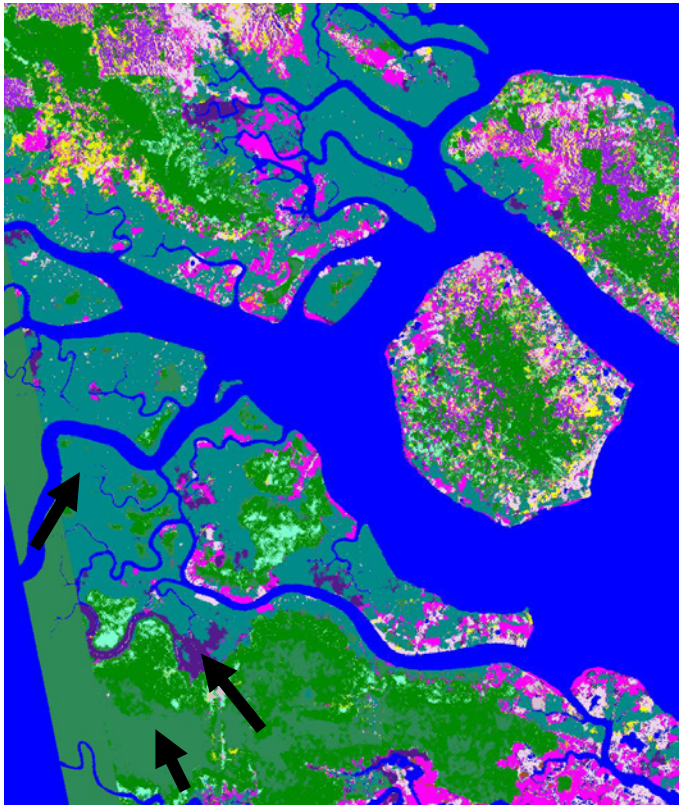




Mangrove 1
Tree plantations and Palm oil

Results: Mangroves Tarakan





Mangrove 1
Mangrove 2
Peat swamp less dense

Results: Overview

Wetland areas
Mangrove 1
Mangrove 2
Peat swamp less dense
Peat swamp low pole
Burnt (peat) forest and bare
Burnt shrubs and bare
Forest and forest on peat/heath

Dry land forest areas
Forest - Lower biomass and/or degraded
Forest - Higher Biomass
Deforestation types

Global types
Riverine-riperian and swamp forest
Shrub land
Shrub land – other types
Bare
Tree plantations and Palm oil
Dry land agriculture
Sawah
Water
Other land cover types / mixed
No data (radar shadow and layover)

With a single protocol and a single set of statistics all strips can be classified directly.

Several types of forest, shrubs, deforestation can be differentiated, i.e. more than in the tentative legend given here.

A validation study is ongoing, revealing a proper legend (i.e. what the radar can differentiate well) and associated accuracies.

4. Validation

Study Netherlands Ministry of Environment
Netherlands contribution to GEO task on Forest Carbon Tracking

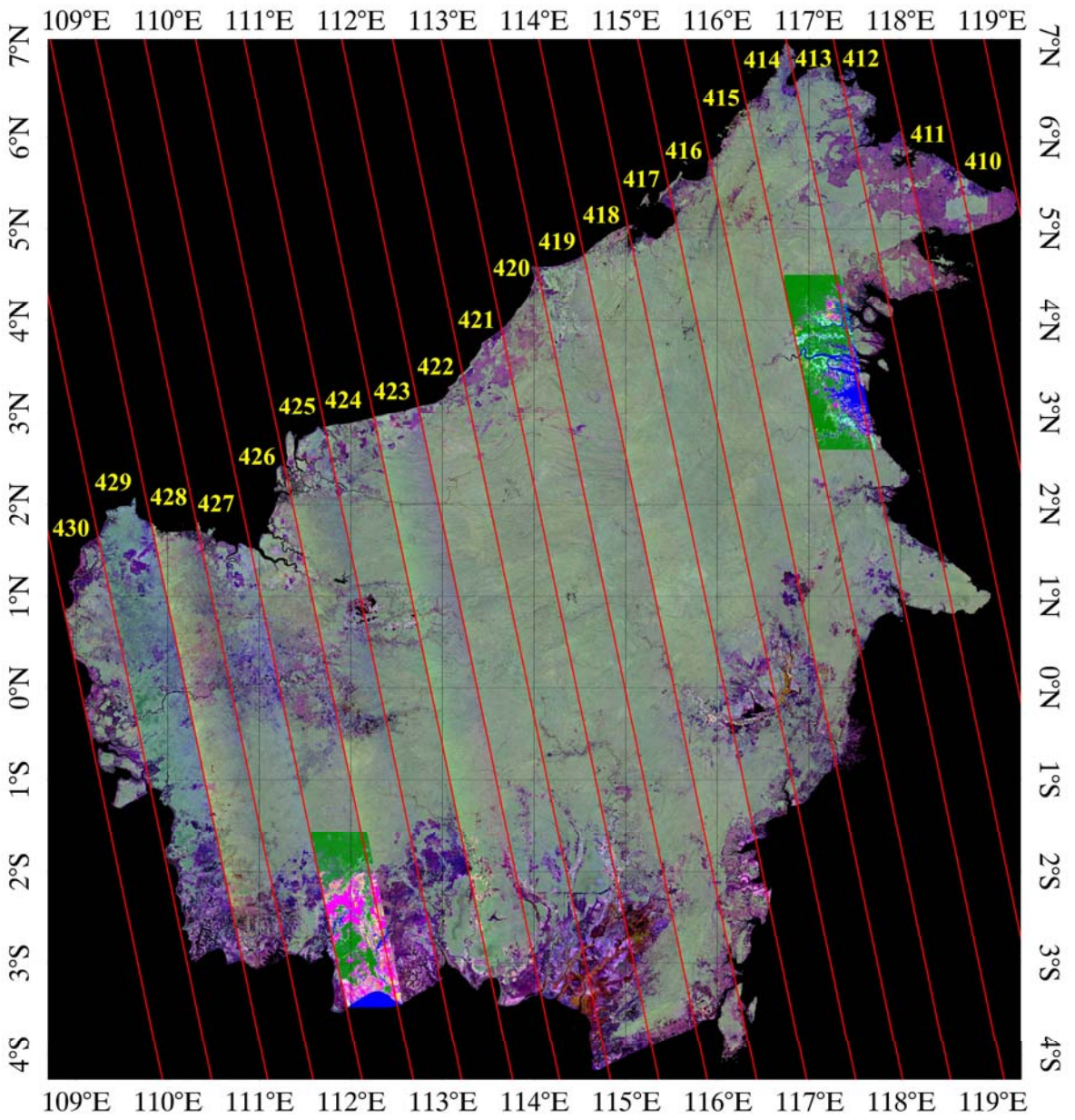
Validation: Example areas

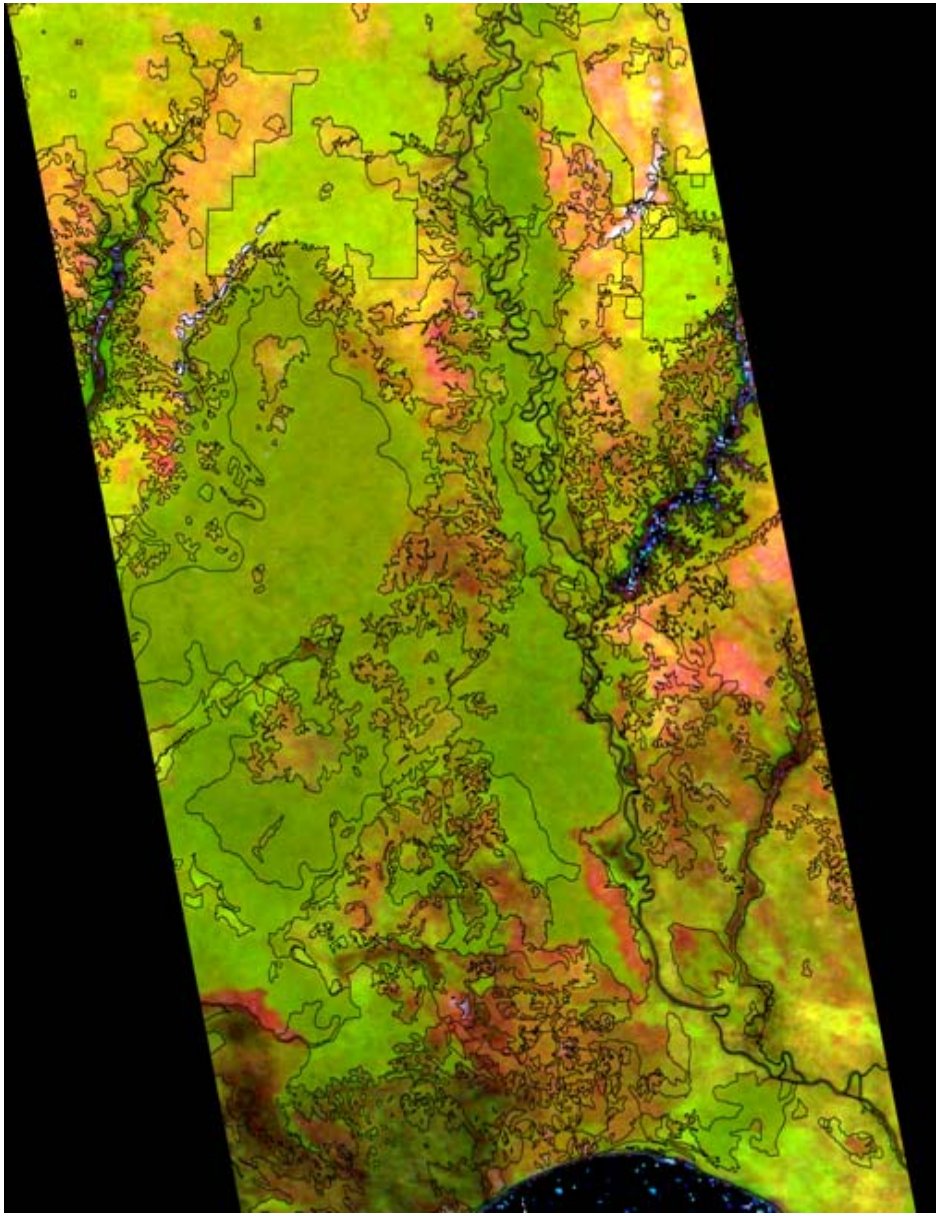
426. Oil palm development area

414. Mangrove area

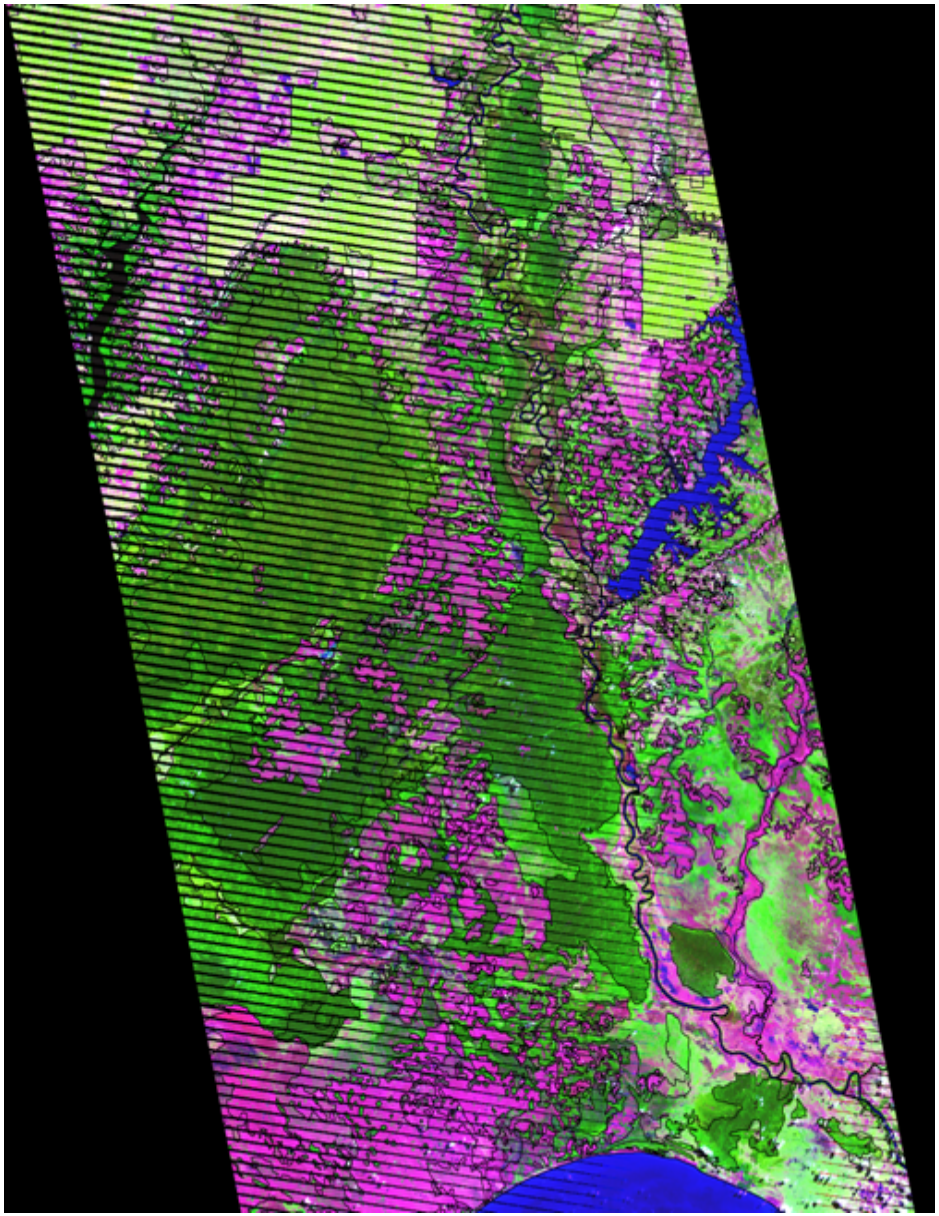
Comparison PALSAR results with:
- Landsat
- MODIS 2007
- Ministry of Forestry classification, 2005
- NRM classification, 1997
- GlobCover, 2006

- Selected validation data set

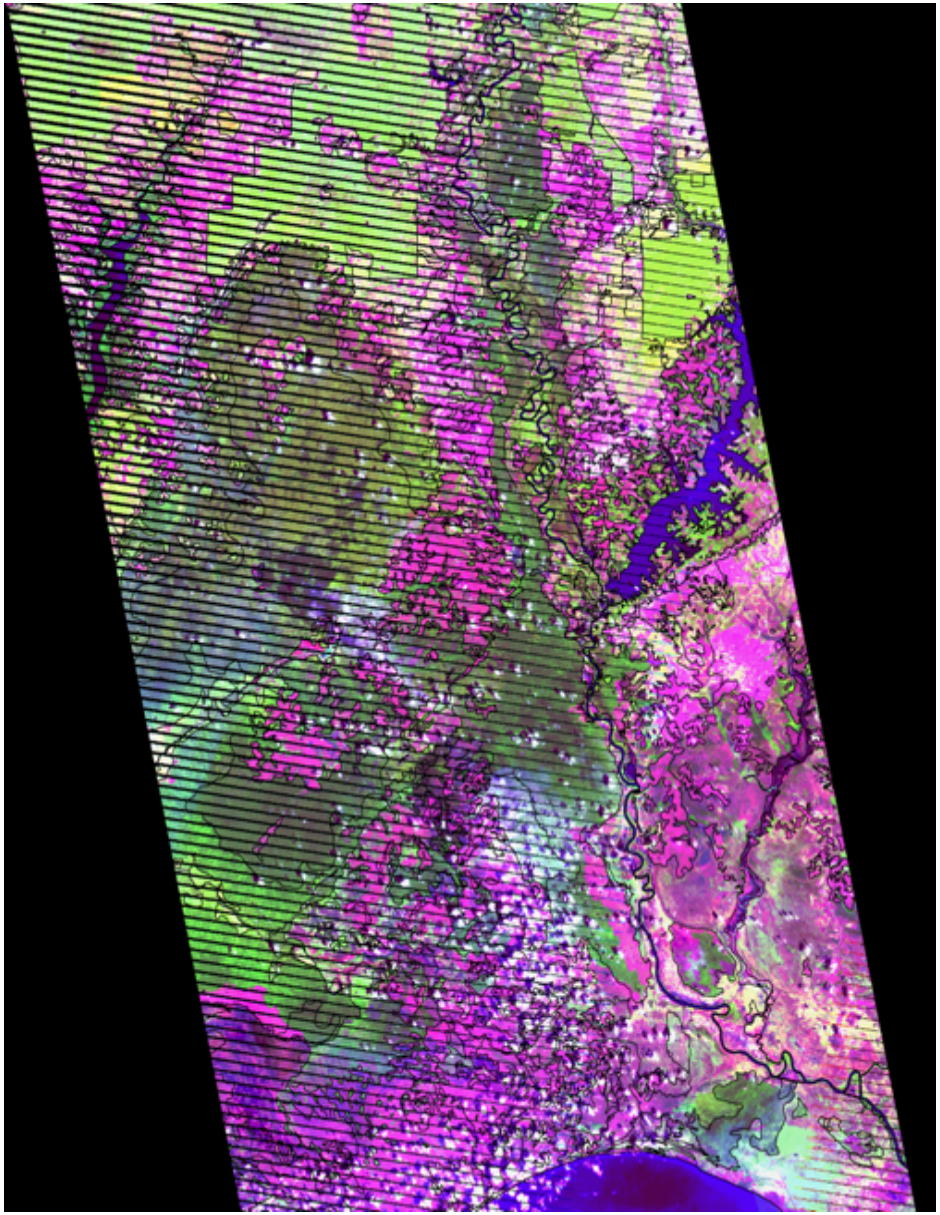




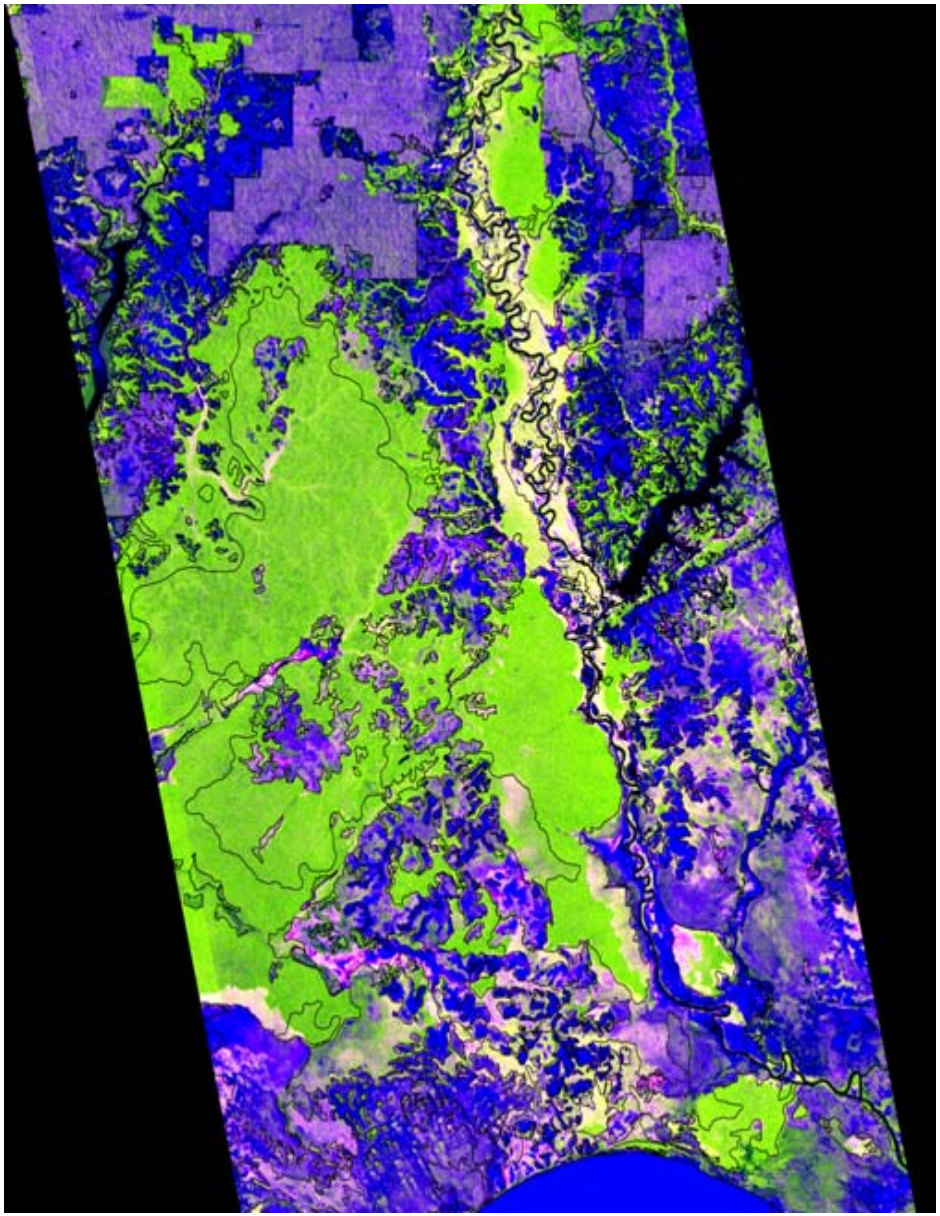
MODIS 2007



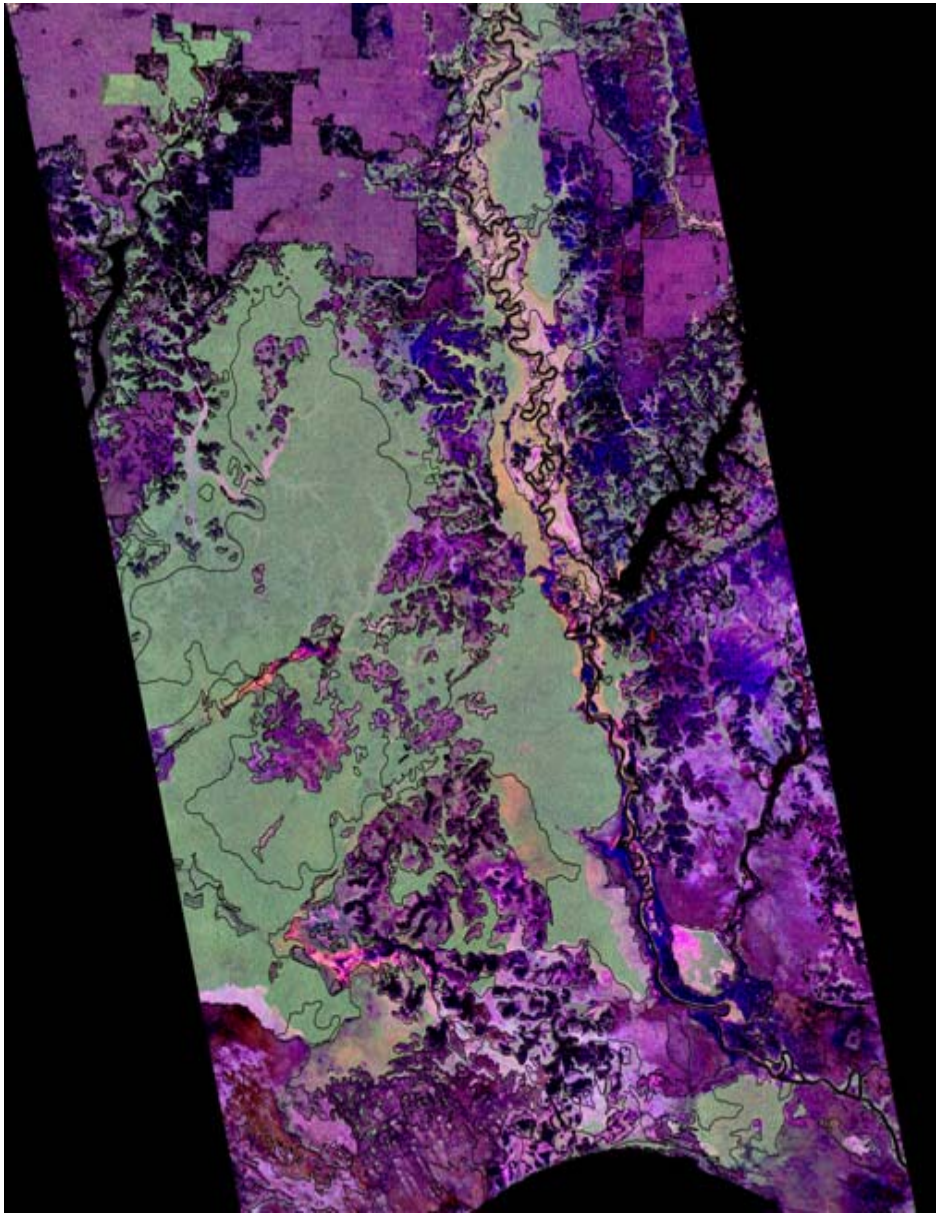
Landsat 2004



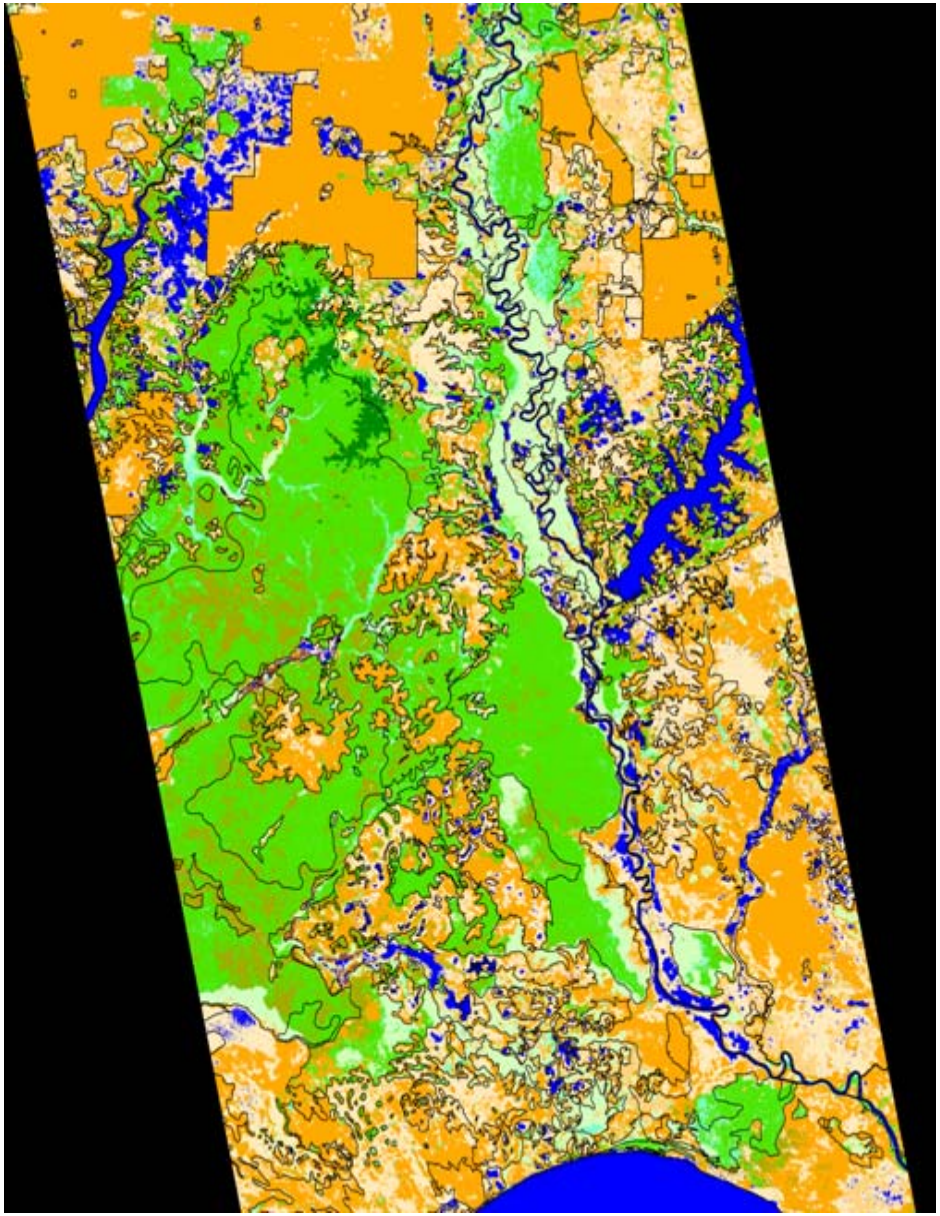
Landsat 2008 January



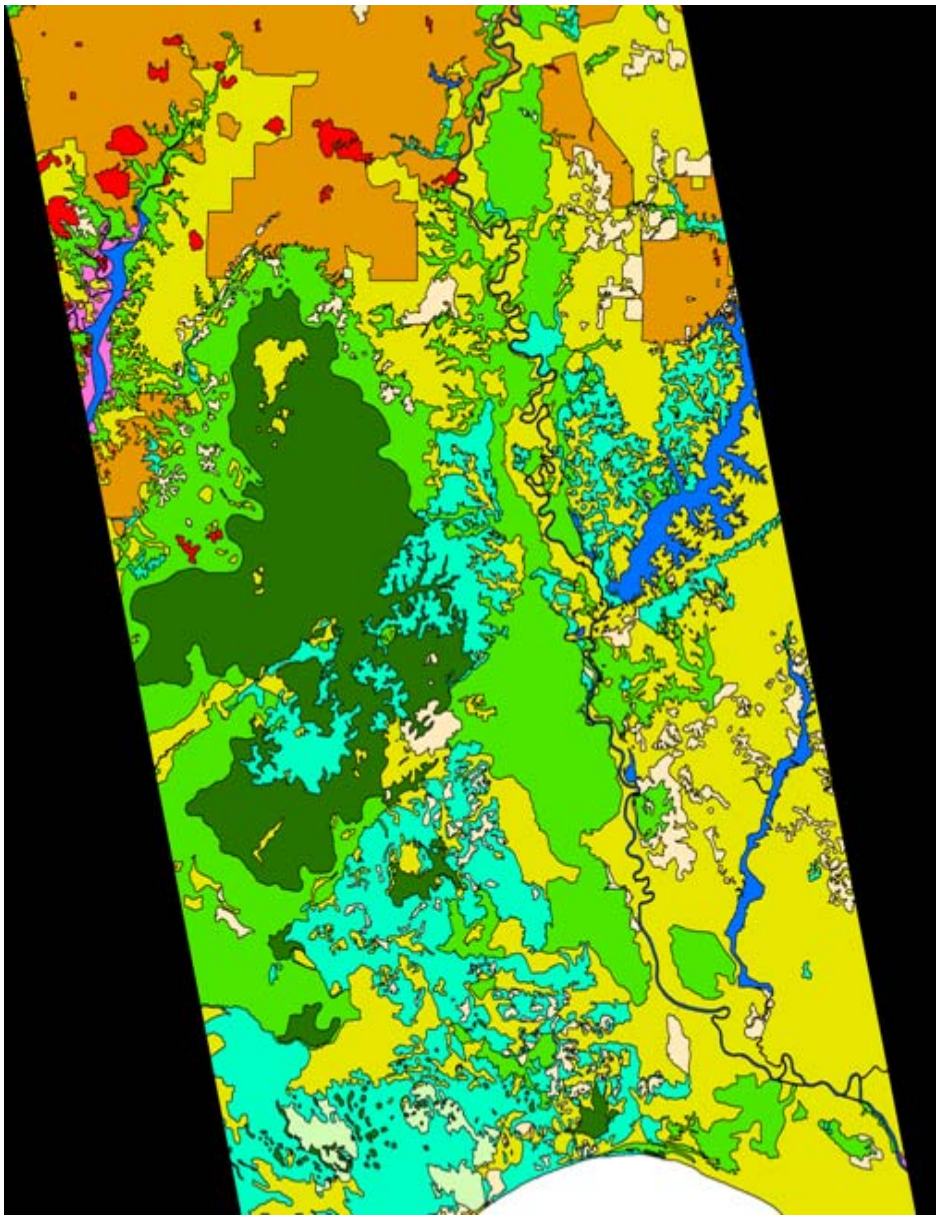
PALSAR 2007 JAXA (HH – HV – HH-HV)



PALSAR 2007 FBS-FBD

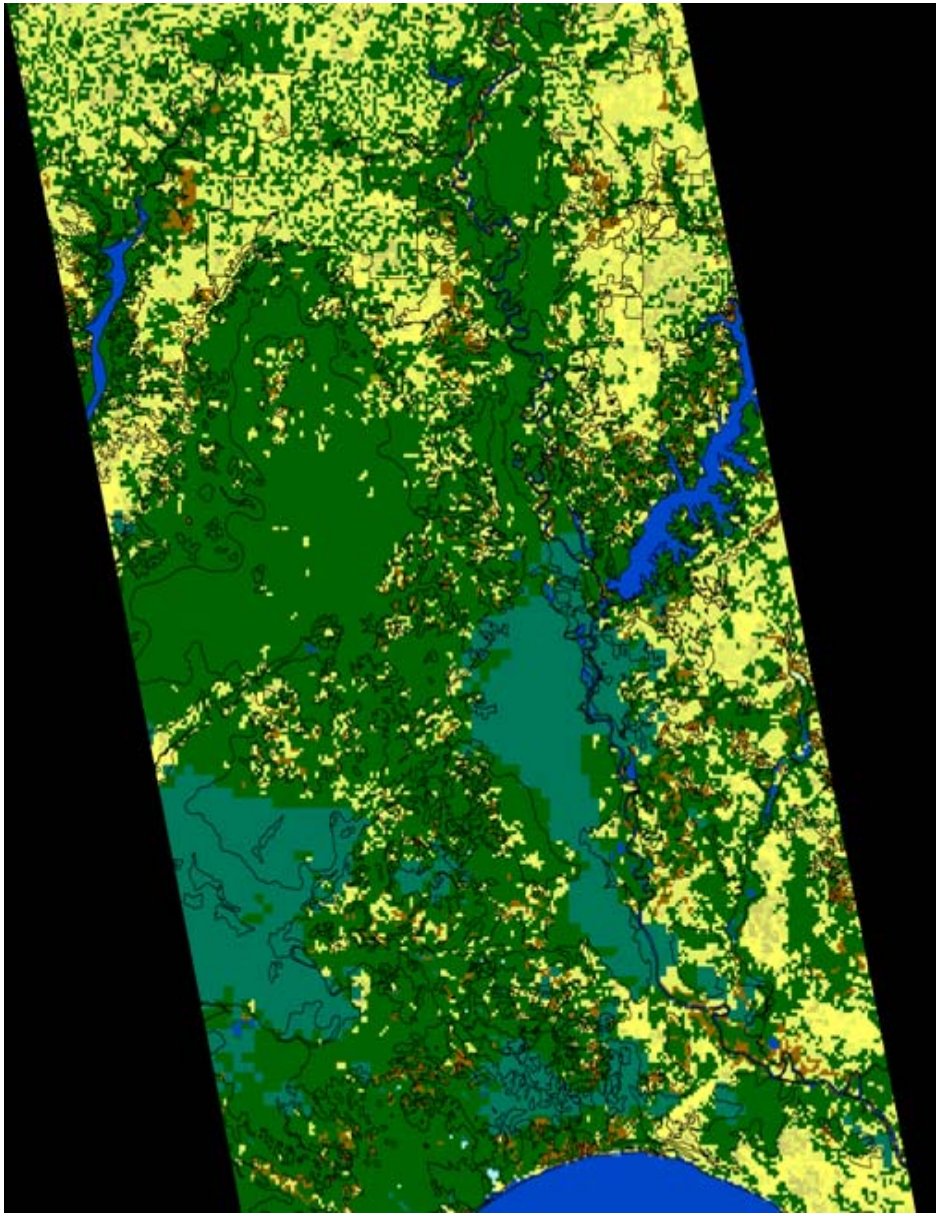


Classification PALSAR 2007



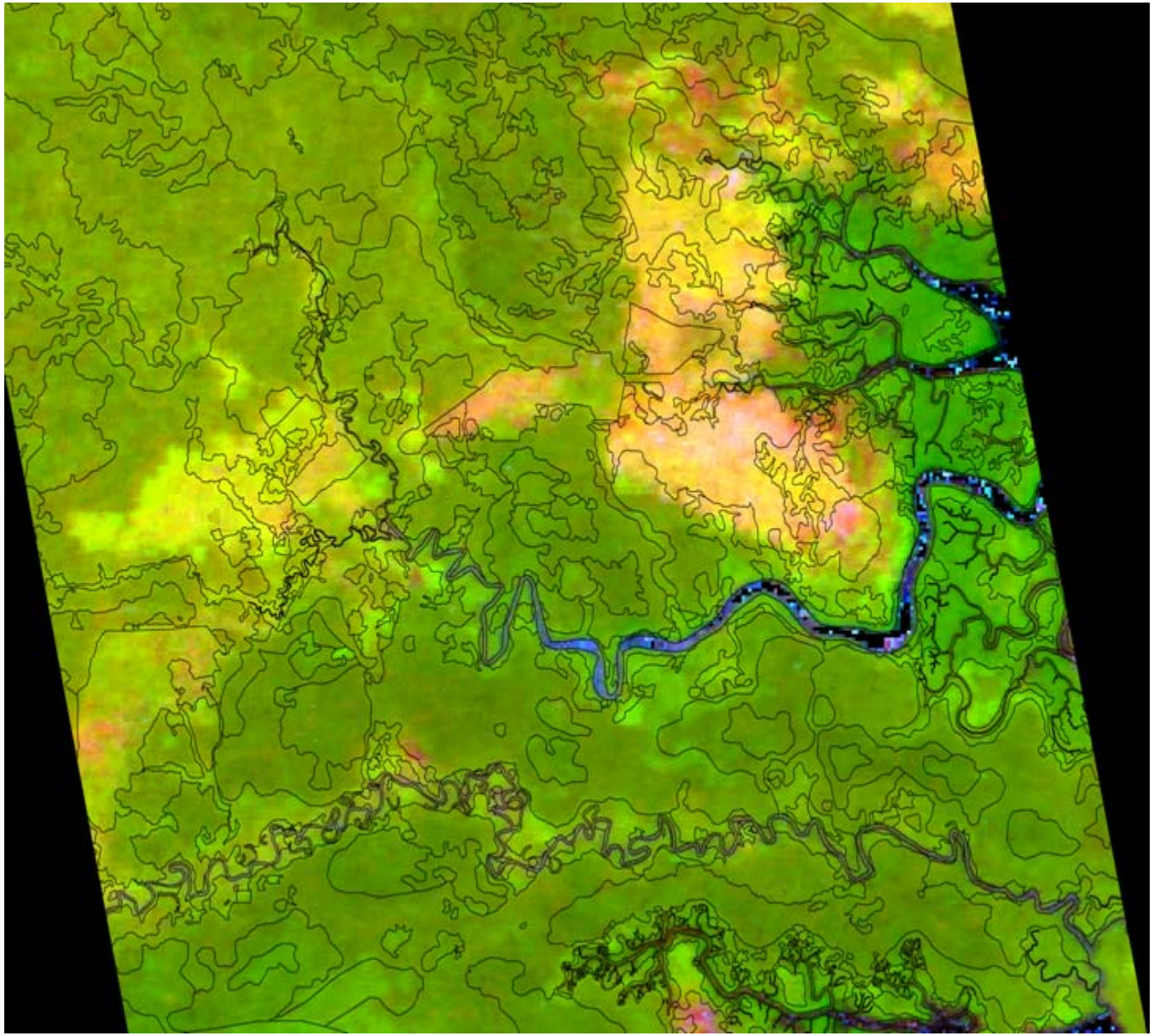
Classification 2005 Ministry of Forestry (Landsat)

- Bare
- Agriculture
- Shrimp / fish ponds
- Grassland
- Plantation
- Forest
- Mangrove
- Peat swamp forest
- Degraded forest
- Degraded mangrove
- Degraded peat swamp forest
- Settlement
- Shrub
- Swamp
- Water

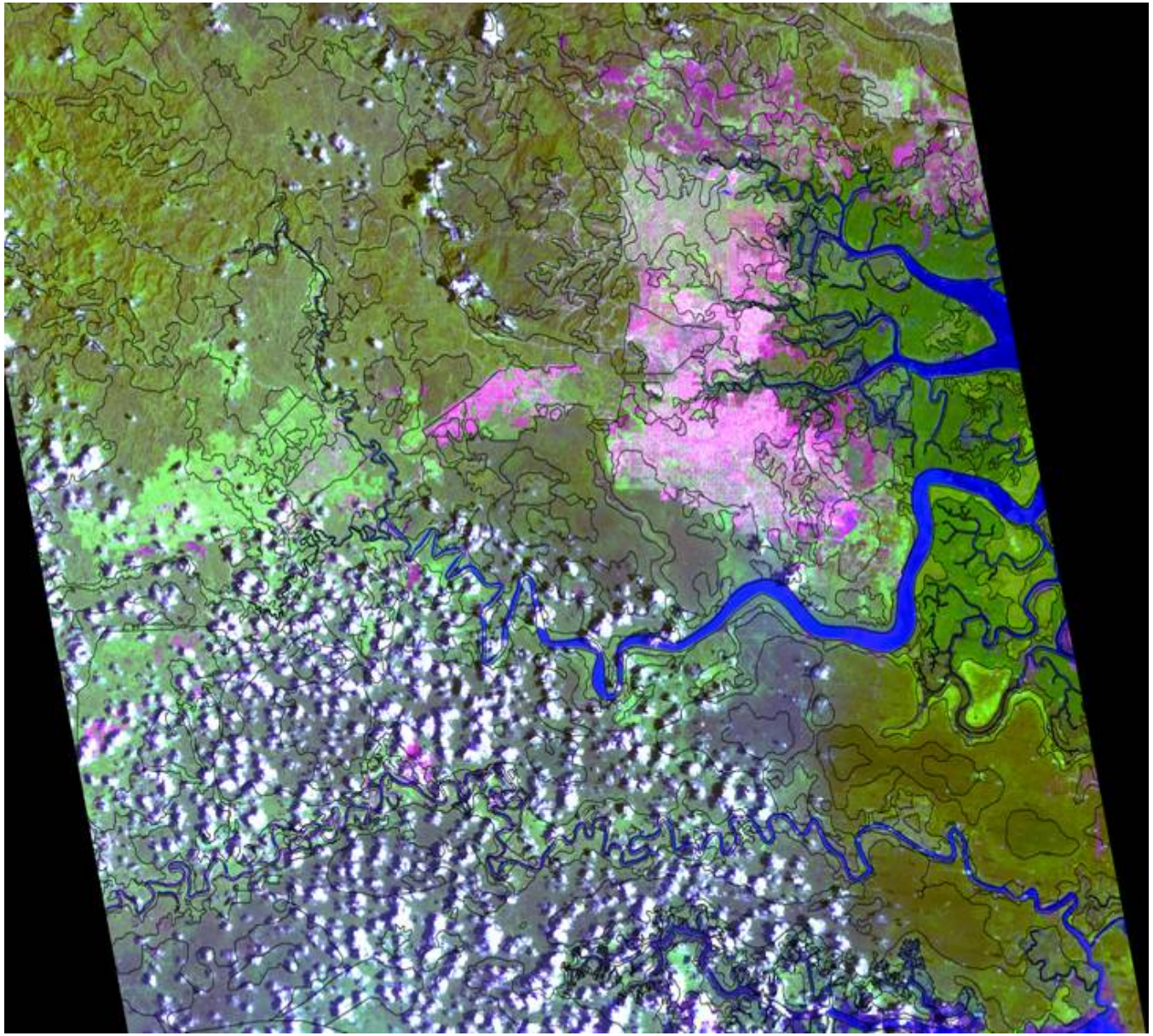


Classification 2005-06 GlobCover

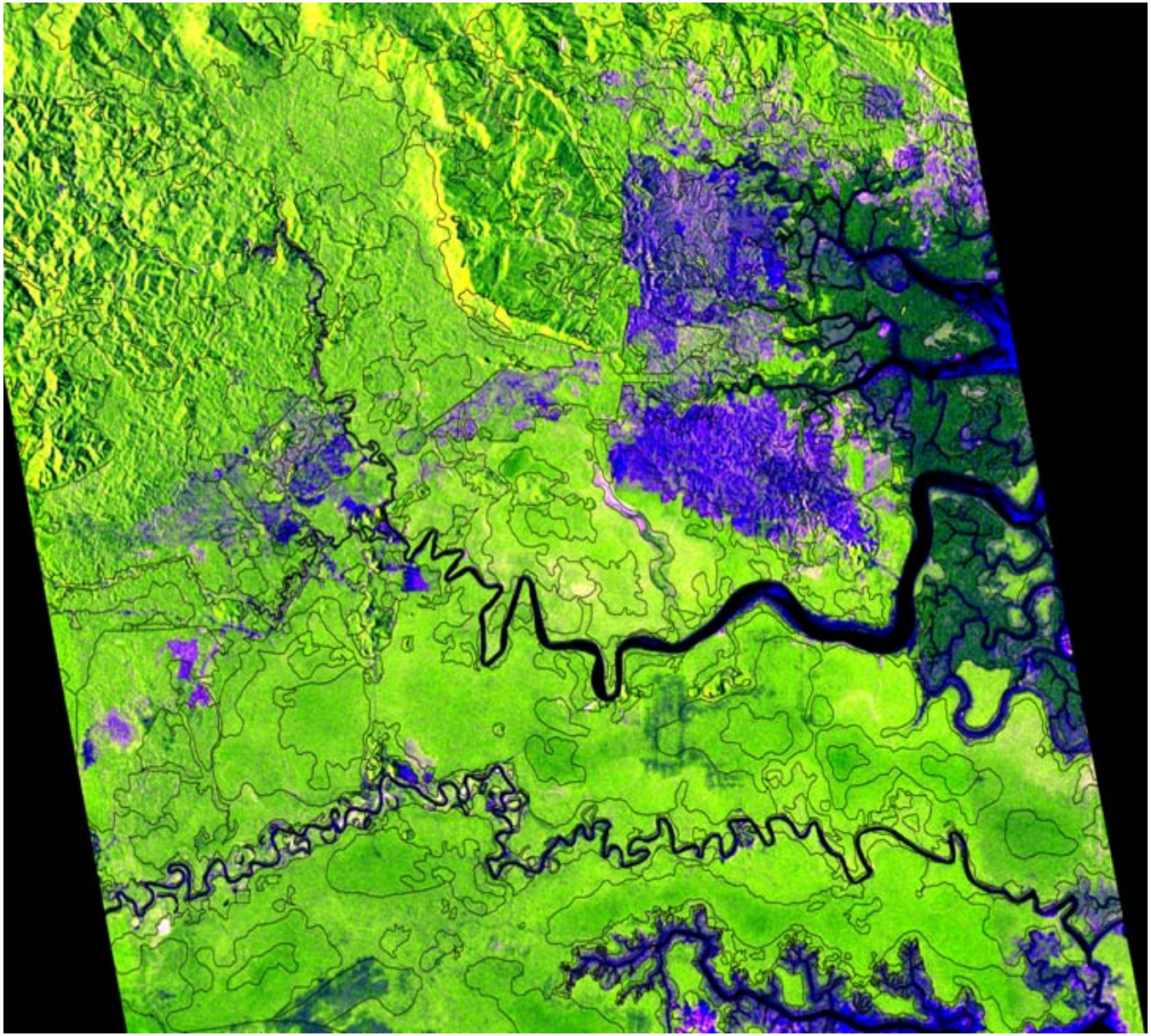
Value	Global Globcover legend (level 1)	
11	Post-flooding or irrigated croplands	
14	Rainfed croplands	
20	Mosaic Cropland (50-70%) / Vegetation (grassland, shrubland, forest) (20-50%)	
30	Mosaic Vegetation (grassland, shrubland, forest) (50-70%) / Cropland (20-50%)	
40	Closed to open (>15%) broadleaved evergreen and/or semi-deciduous forest (>5m)	
50	Closed (>40%) broadleaved deciduous forest (>5m)	
60	Open (15-40%) broadleaved deciduous forest (>5m)	
70	Closed (>40%) needleleaved evergreen forest (>5m)	
90	Open (15-40%) needleleaved deciduous or evergreen forest (>5m)	
100	Closed to open (>15%) mixed broadleaved and needleleaved forest (>5m)	
110	Mosaic Forest/Shrubland (50-70%) / Grassland (20-50%)	
120	Mosaic Grassland (50-70%) / Forest/Shrubland (20-50%)	
130	Closed to open (>15%) shrubland (<5m)	
140	Closed to open (>15%) grassland	
150	Sparse (>15%) vegetation (woody vegetation, shrubs, grassland)	
160	Closed (>40%) broadleaved forest regularly flooded - Fresh water	
170	Closed (>40%) broadleaved semi-deciduous and/or evergreen forest regularly flooded - Saline water	
180	Closed to open (>15%) vegetation (grassland, shrubland, woody vegetation) on regularly flooded or waterlogged soil - Fresh, brackish or saline water	
190	Artificial surfaces and associated areas (urban areas >50%)	
200	Bare areas	
210	Water bodies	
220	Permanent snow and ice	



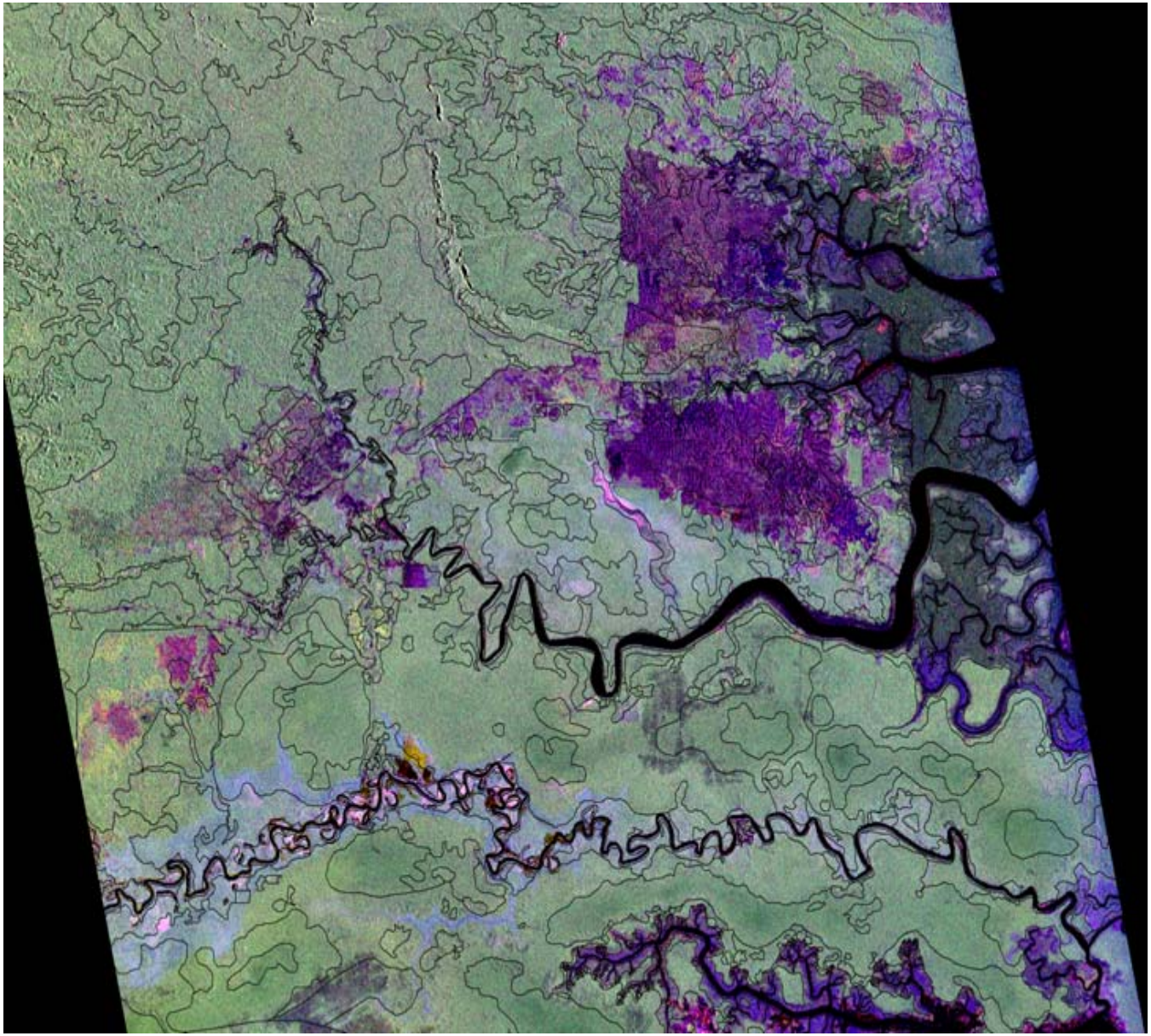
MODIS 2007



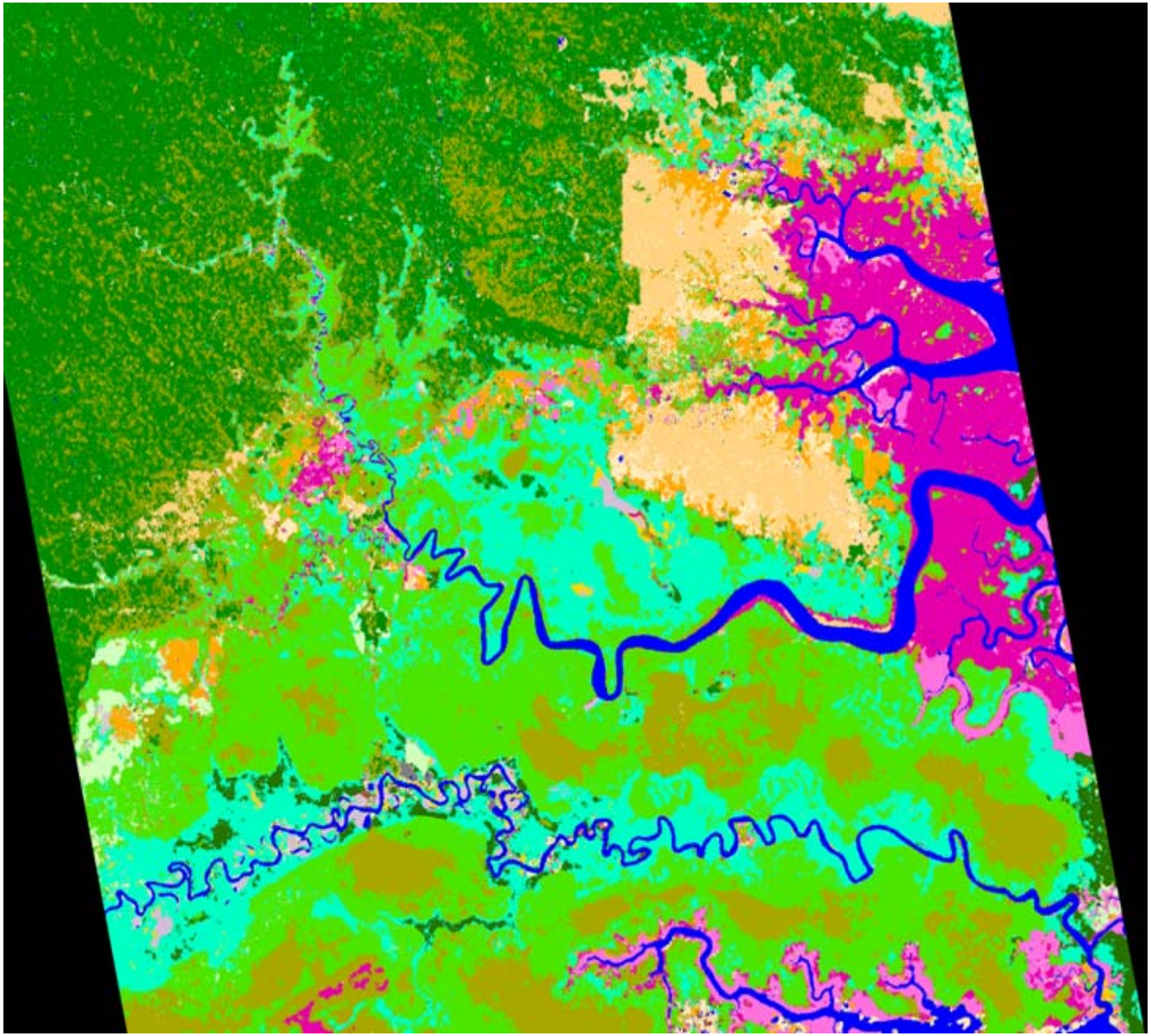
Landsat 2007 March



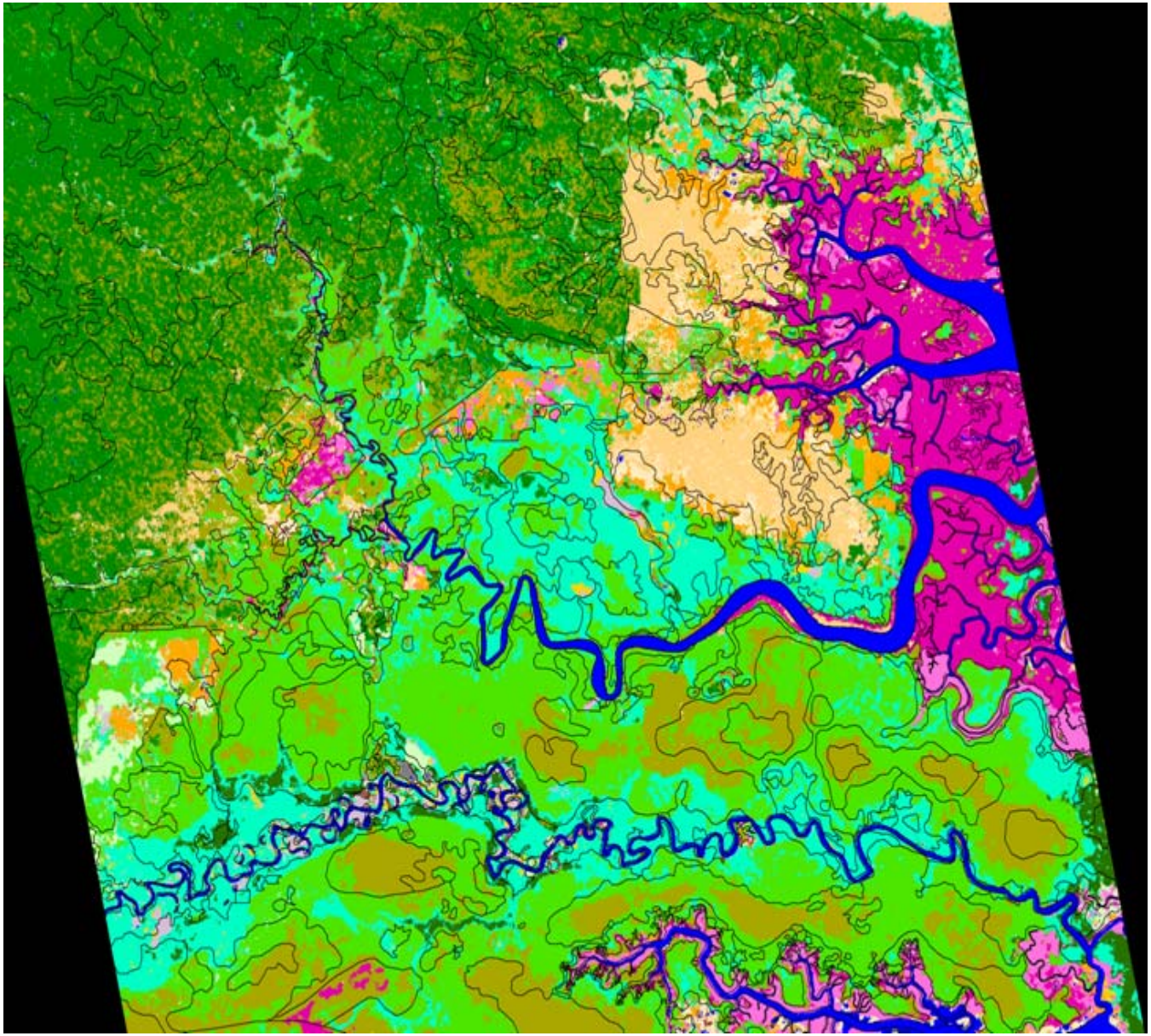
PALSAR 2007 JAXA
(HH – HV – HH-HV)



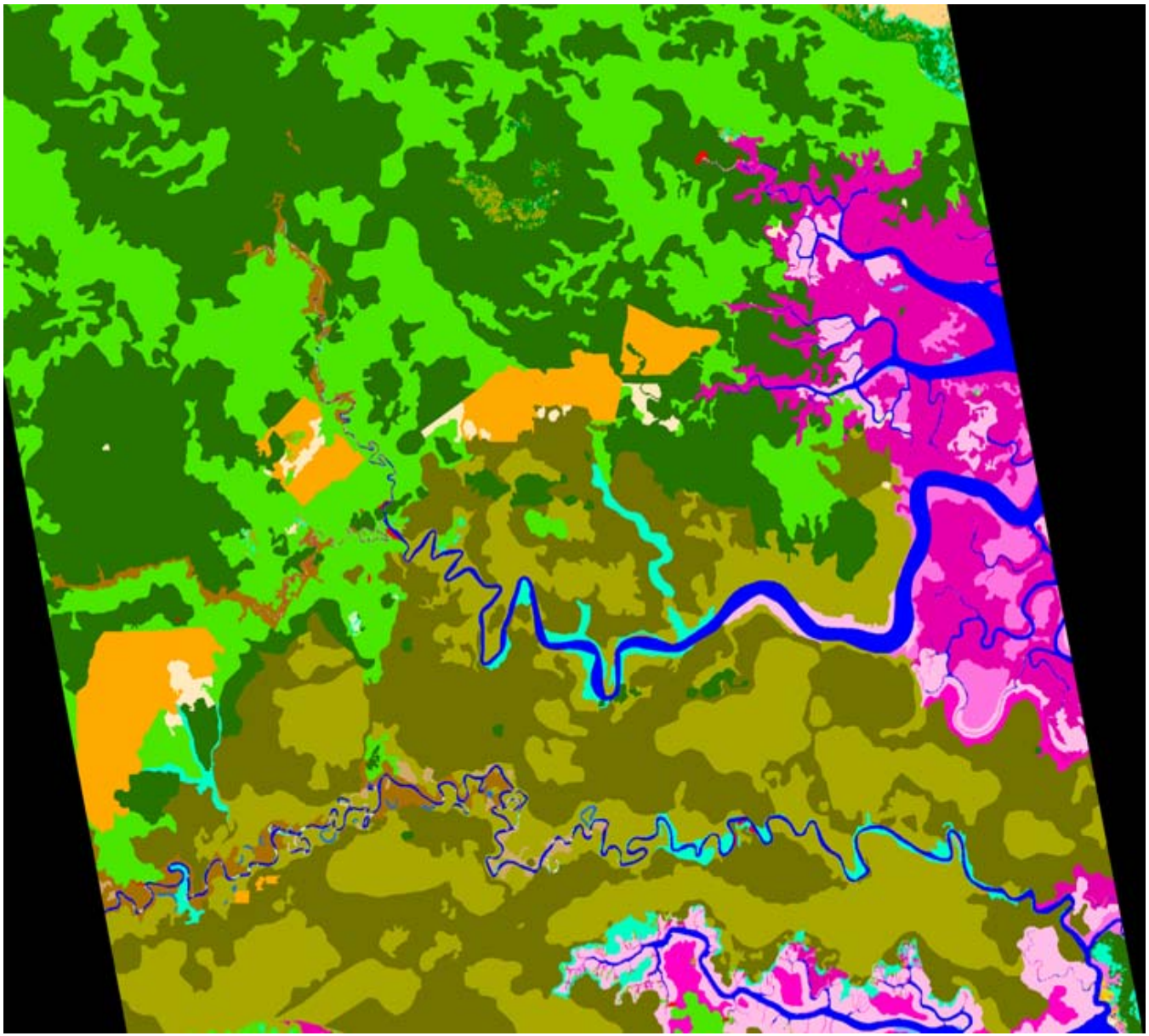
PALSAR 2007
FBS-FBD



Classification 2007
PALSAR

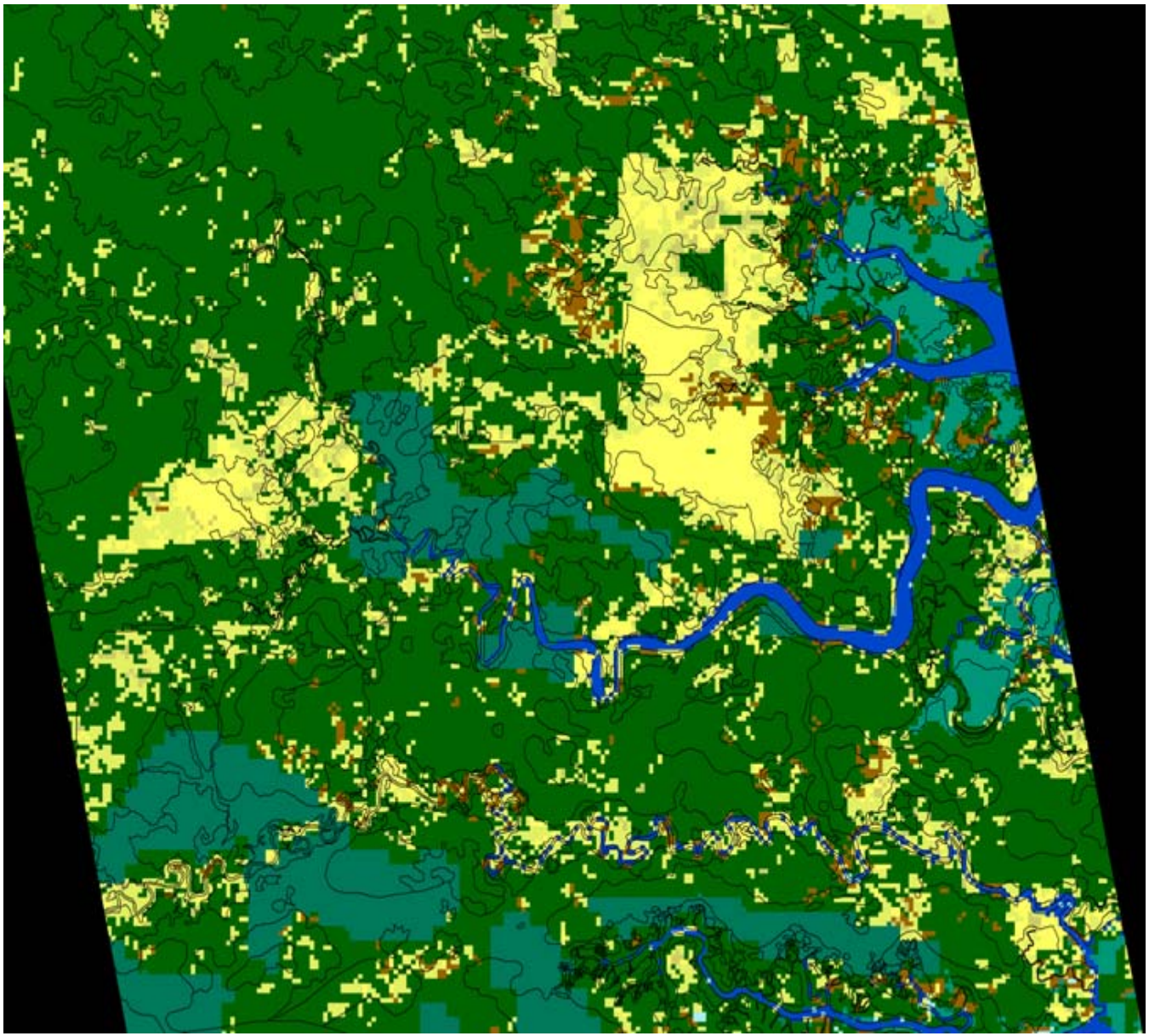


Classification 2007
PALSAR



Classification 1997 NRM (Landsat)

- Bare
- Degraded forest
- Degraded peat swamp forest
- Degraded mangrove
- Agriculture
- Forest
- Nipah
- Mangrove
- Water
- Peat swamp forest
- Plantation
- Mangrove
- Riverine - swamp forest
- Shrimp / fish ponds
- Settlement



Classification 2005-06
GlobCover

Value	Global Globcover legend (level 1)	
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190	Artificial surfaces and associated areas (urban areas >50%)	
200	Bare areas	
210	Water bodies	
220	Permanent snow and ice	

5. Conclusions

Conclusions

1. The quality of the LULC map of the main K&C prototype area in Central Kalimantan based on PALSAR exceeds the quality of maps previously made based on Landsat
2. A standard methodology for automated mapping of continental wide forest and land cover map at high resolution is available.
3. To improve classification of secondary forest, the optional use of auxiliary data sets derived from MODIS is considered. These data are made routinely available by SarVision.
4. The tentative legend already contains six forest types which have typical biomass ranges, and which can be mapped fairly accurate.
5. Likely, more types of deforestation, tree plantations and shrubs be differentiated.
6. Since more classes can be differentiated (on the continental scale) than initially foreseen, more validation effort is required.
7. It is expected that more characteristics of agricultural and peat forest areas can be obtained when the ScanSAR cycles are included in the classification (or parameter retrieval) procedures. These features are mainly related to cropping cycles, hydrological/seasonal cycles and flooding events.
8. The data set is large. It is proposed to deliver final products in sheets of 2x3 degrees.
9. Methodology is generally applicable. After the Borneo validation, other areas, namely Papua and Sumatra, should follow soon

Thank you