K&C Phase 3 – Progress

Aboveground Biomass and Carbon Stock Mapping and Changes Monitoring in the Forest of Peninsular Malaysia Using L-Band ALOS Palsar and JERS-1

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Forest Research Institute Malaysia (FRIM)

Science Team meeting #19 – Phase 3
JAXA TKSC/RESTEC HQ, April 9-11, 2013

Presentation Outline

- Recapitulation
- Forest cover classification:
  - Data, methods, and justification
- Redefining the study area
- Progress on biomass estimation

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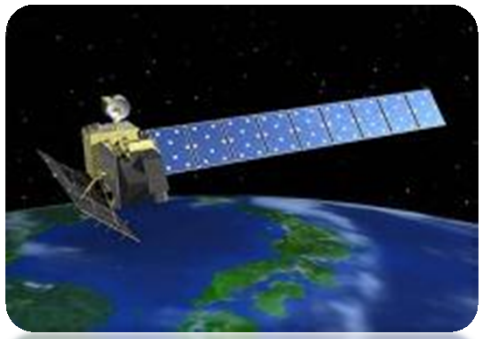

Project Summary

Kyoto & Carbon Initiative (Phase 3)

TITLE:	Aboveground Biomass and Carbon Stock Mapping and Changes Monitoring in the Forest of Peninsular Malaysia Using L-Band ALOS Palsar and JERS-1
DURATION:	Two years (April 2012 – March 2014)
EXEC. AGENCY:	Forest Research Institute Malaysia (FRIM)
LOCATION:	Peninsular Malaysia

Project objectives and schedule

Objectives:

(i) to establish empirical relationship between aboveground biomass and L-Band signals for tropical forest ecosystem,

(ii) to determine aboveground biomass by using L-band SAR data, and

(iii) to map the current status and identify changes of aboveground biomass and carbon stocks in the forest in Peninsular Malaysia.

Deliverables:

(i) Forest cover in the study area (1995 & 2010)

(ii) Pattern of spatial distribution of above ground biomass & carbon stocks in the forest (1995 & 2010)

(iii) Changes of biomass and carbon stocks from 1995 to 2010.

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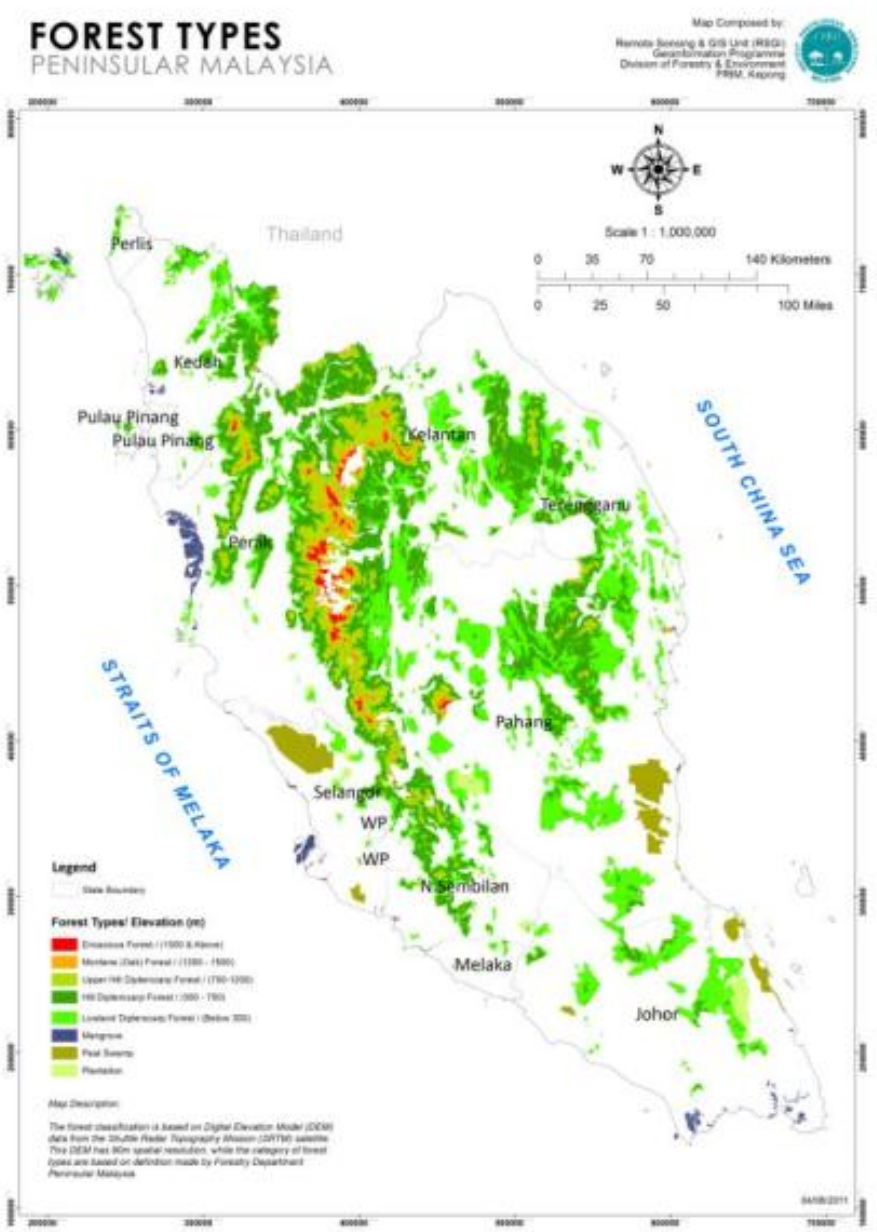
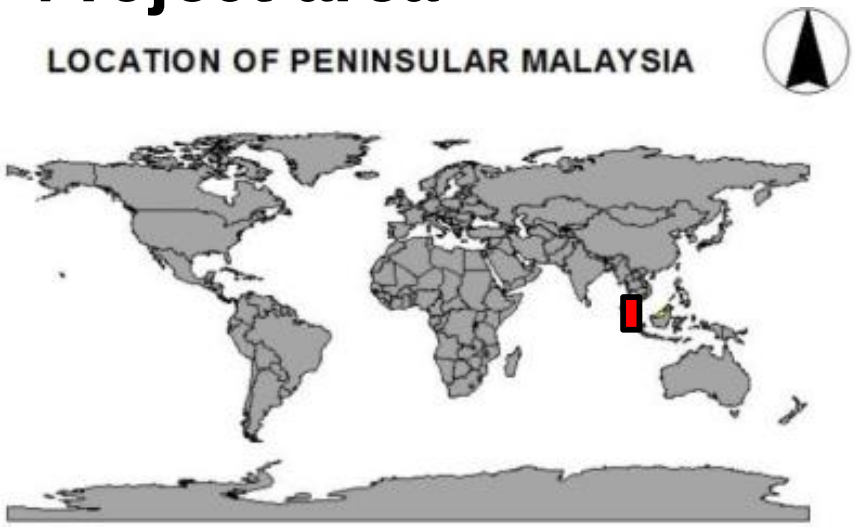


Project area



Forest Cover in Peninsular Malaysia

Location of Peninsular Malaysia:

Upper left Latitude/Longitude

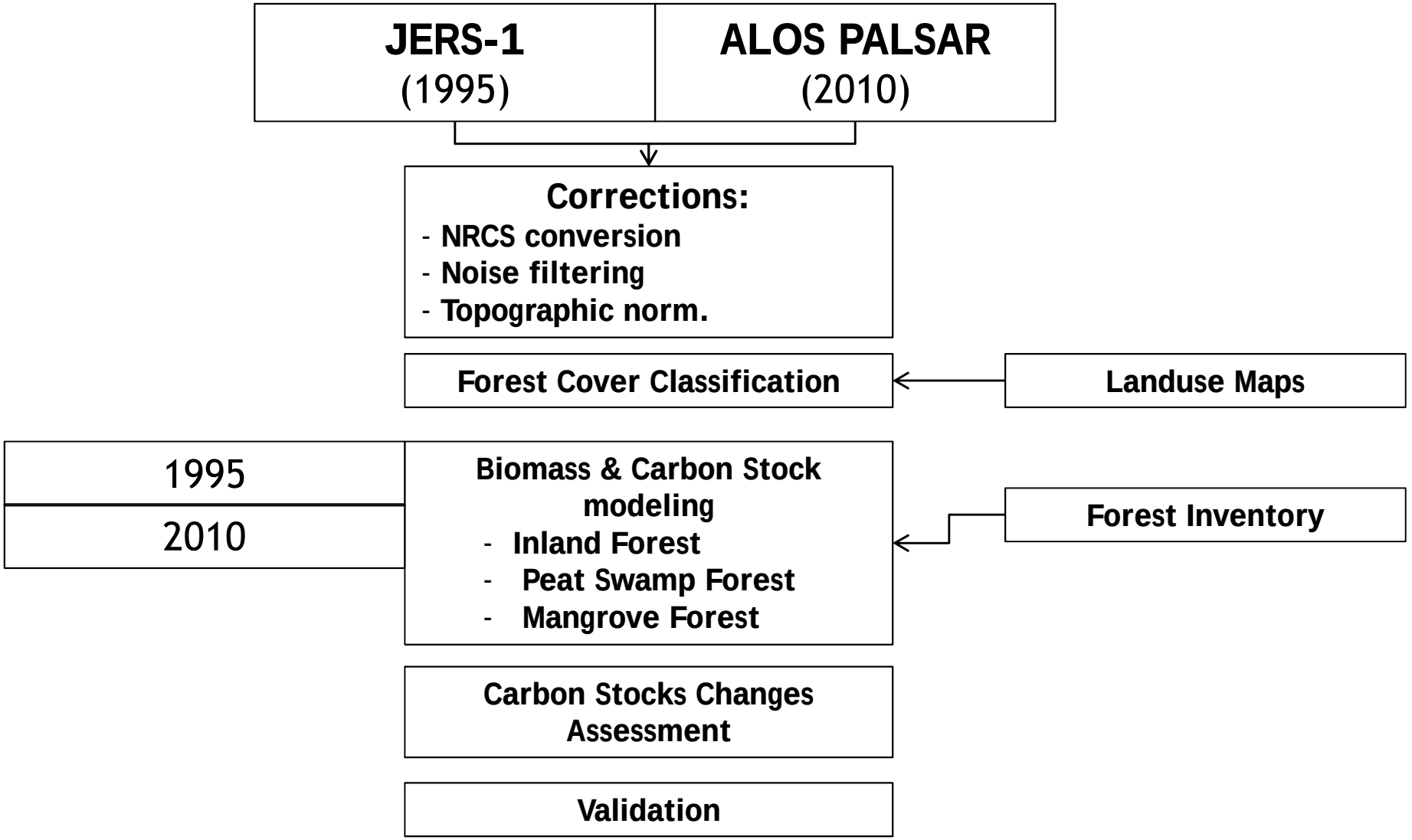
6° 30’ 00” / 100° 00’ 00”

Lower right Latitude/Longitude

1° 00’ 00”/ 105° 00’ 00”

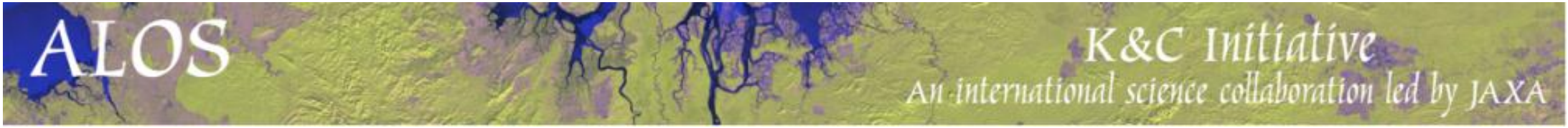
Region	Land Area	Natural Forests			Total Forested Land	% of Total Land Area
		Dry Inland Forest	Swamp Forest	Mangrove Forest		
Pen. M’sia	13.18	4.58	0.24	0.10	5.86	44.4

Methodology



Project milestones

No.	Key-milestone	Date of completion
i	Forest inventory data	Jun 2012 ●
ii	Maps of forest cover in the study area (1995 & 2010)	September 2012 ●
iii	Spatial distribution map of biomass and carbon stock (2010)	March 2013 ●
iv	Spatial distribution map of biomass and carbon stock (1995)	Jun 2013 ●
v	Spatial distribution map of biomass and carbon stock changes over 15 years (1995 - 2010)	Dec 2013 ●
vi	Project report	March 2014 ●



Project Schedule

Japanese Fiscal Year 2012 (April) – 2015 (March)

X : Activities

● : Planned milestone

Project Activities	2012/13												2013/14											
	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
•Agreement signing & ALOS Palsar + JERS-1 Data collection	X																							
•Secondary data collection	X	X																						
•Ground data collection/Plot Sampling	X	X	●																					
•Ground data analysis	X	X																						
•ALOS Palsar Image pre-processing: - Image Mosaic - Topographic normalization - DN to NRCS (dB) Conversion		X	X																					
•ALOS Palsar Image processing: - Forest classification - Biomass modeling				X	X	●																		
•Mapping of Current AGB & Carbon Stocks (2010)							X	X	X	X	X	●												
•JERS-1 Image pre-processing: - Image Mosaic - Topographic normalization - DN to NRCS (dB) Conversion		X	X																					
•JERS-1Image processing: - Forest classification				X	X	●																		
•Mapping of AGB & Carbon Stocks in 1995										X	X	X	X	X	●									
•Mapping of AGB & Carbon Stocks Changes (1995-2010)																X	X	X	X	X	●			
•Validation and verification																						X	X	
•Project completion report																						X	X	●

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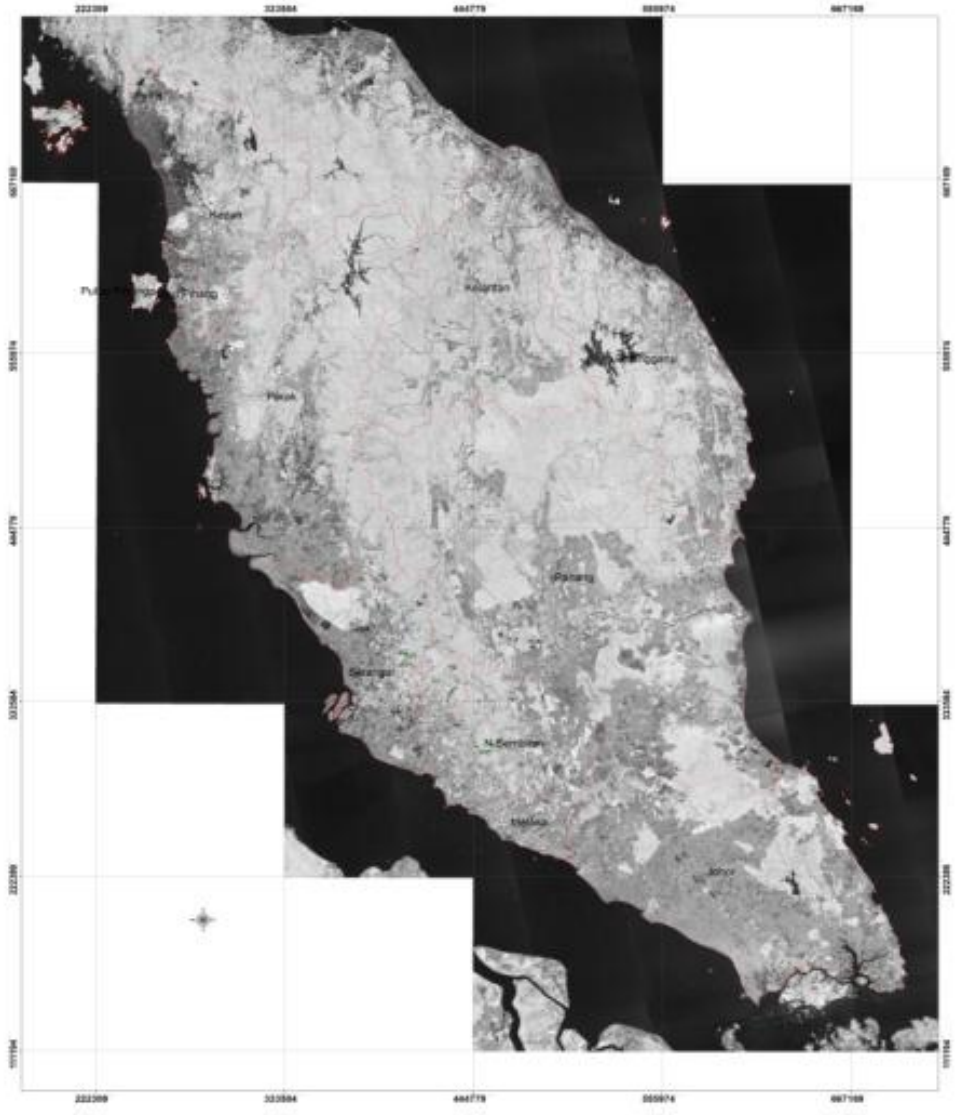


Forest Classification

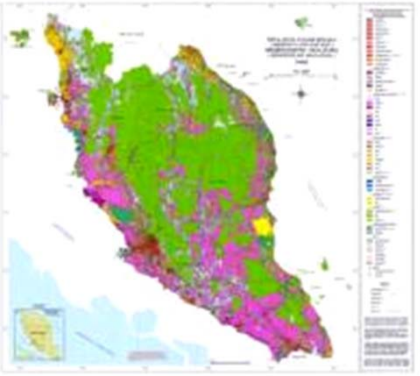
ALOS PALSAR

Pre-Processing
- NRCS conversion
- Noise filtering
- Topographic normalization

Derivation of Image Variables
- HH, HV
- H/HV; HV/HH
- (HH+HV)/2
- √(HHxHV)

GLCM
Segmentation
Forest Cover Classification
- Inland Forest
- Peat Swamp Forest
- Mangrove Forest

Accuracy Assessment

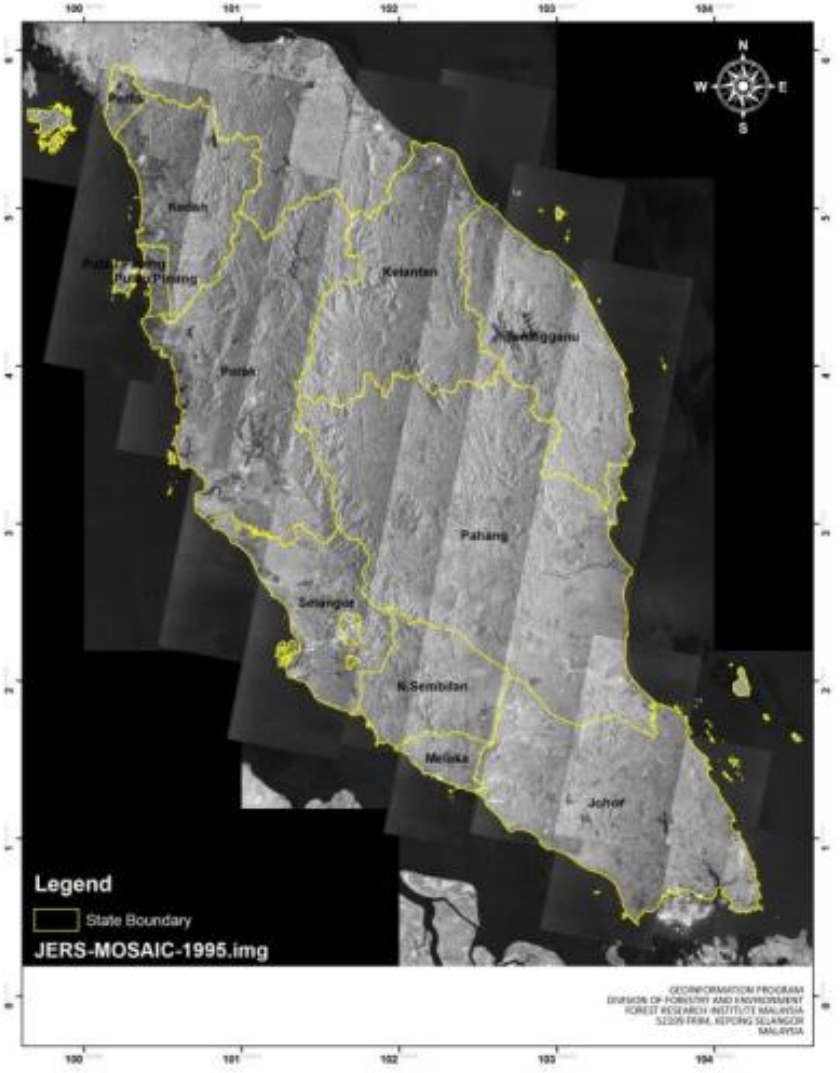


Landuse Maps

Ground thruthing

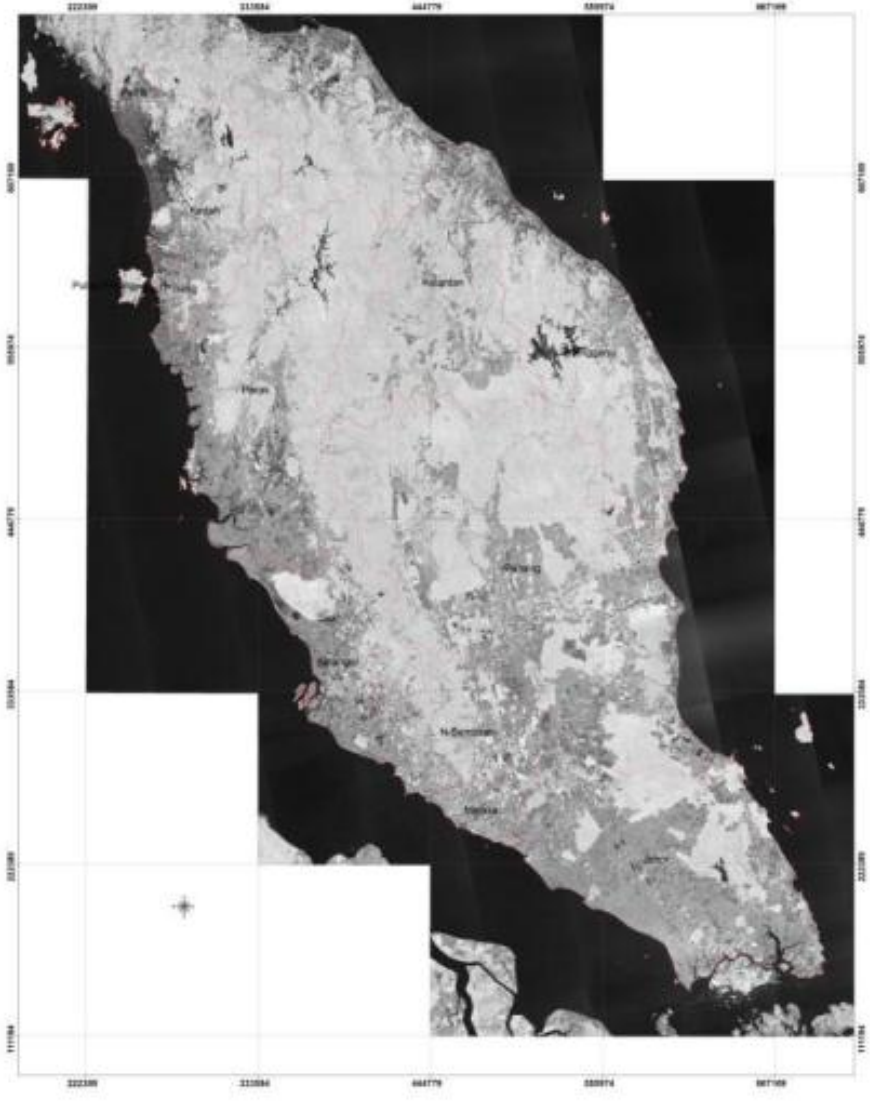
JERS-1 HV MOSAIC OF YEAR 1995

PENINSULAR MALAYSIA

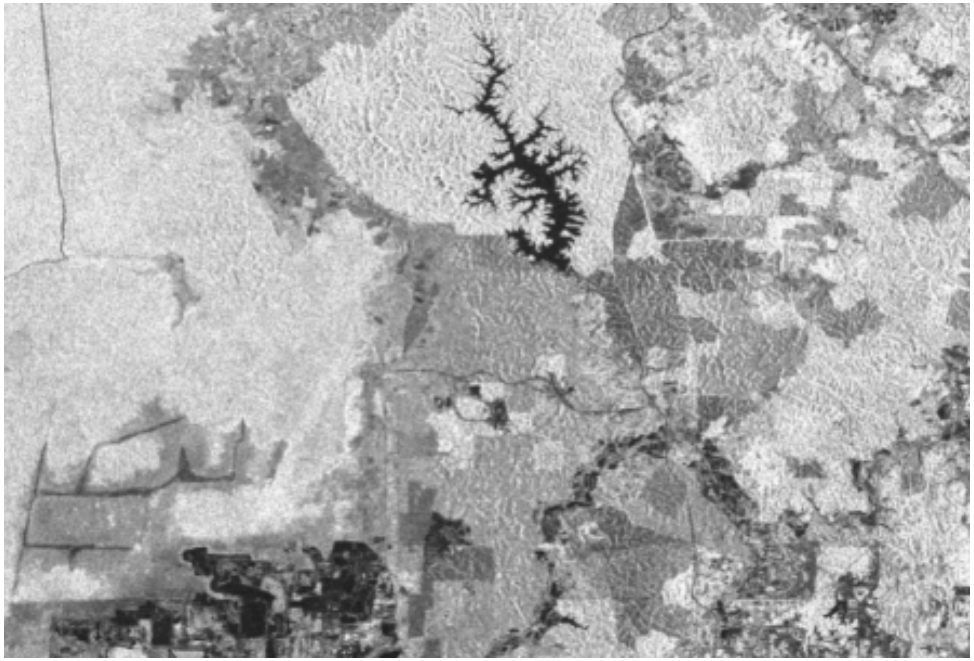


ALOS PALSAR FBD MOSAIC OF YEAR 2010

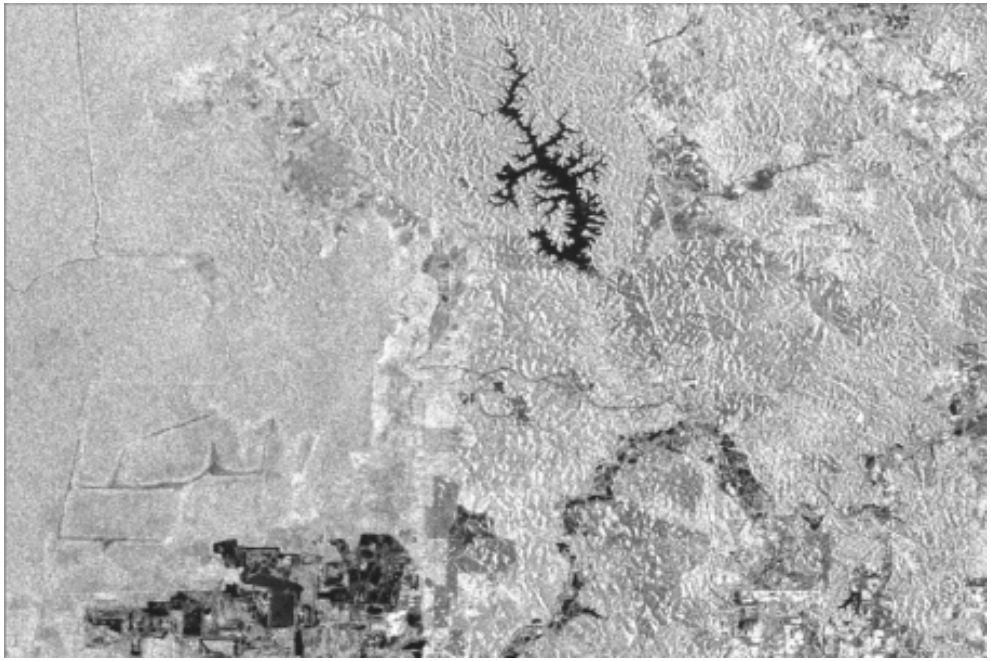
PENINSULAR MALAYSIA



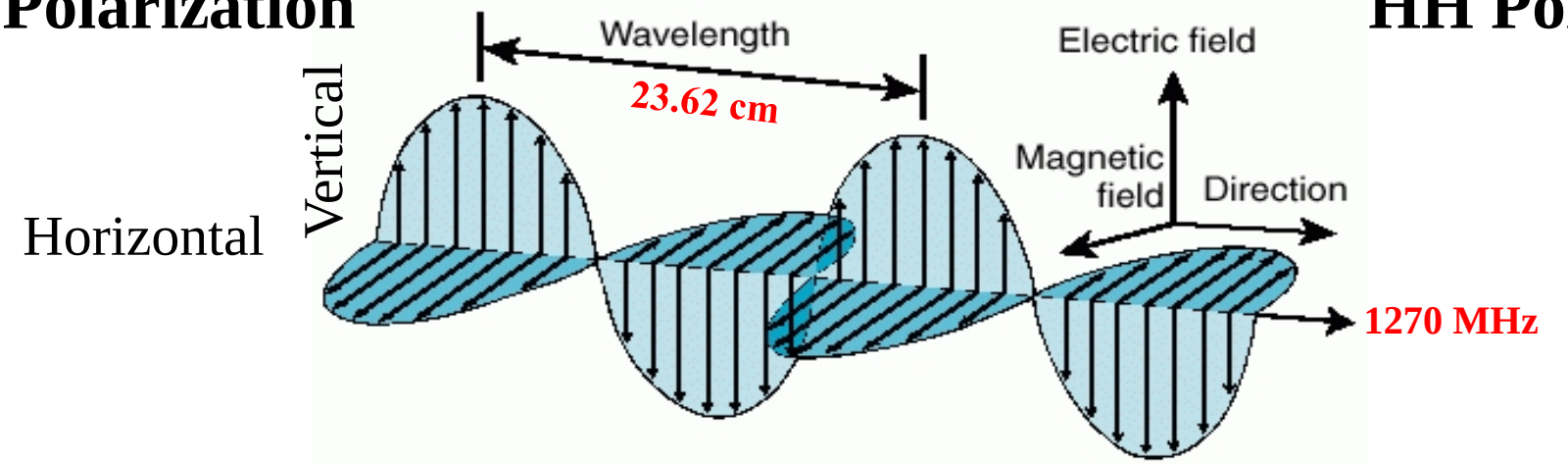
ALOS PALSAR Polarization

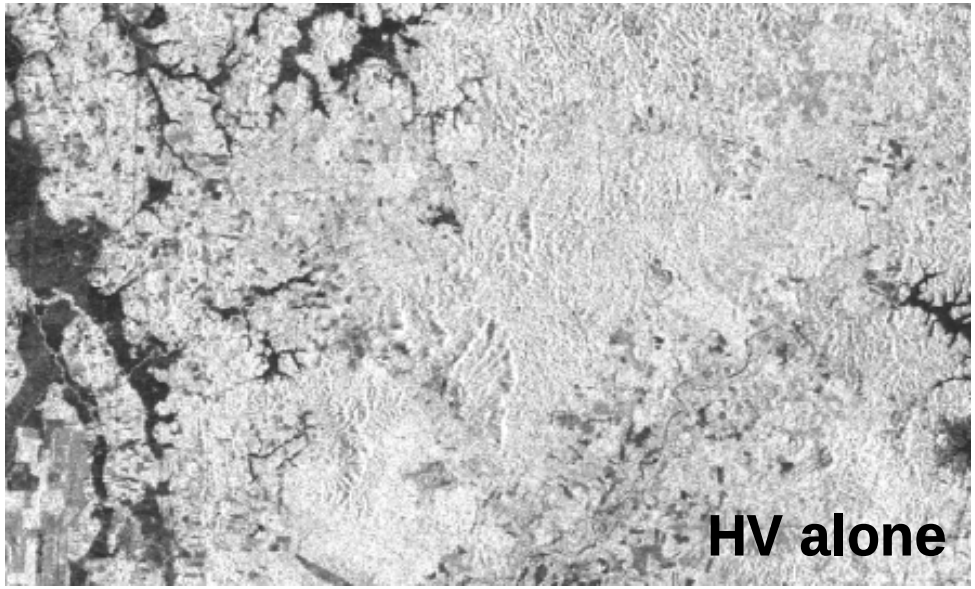


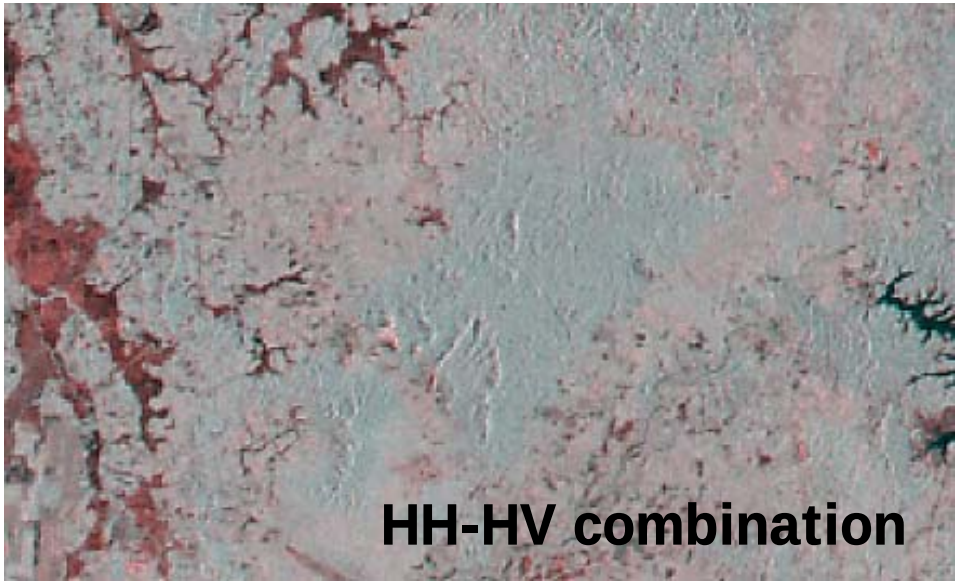
HV Polarization

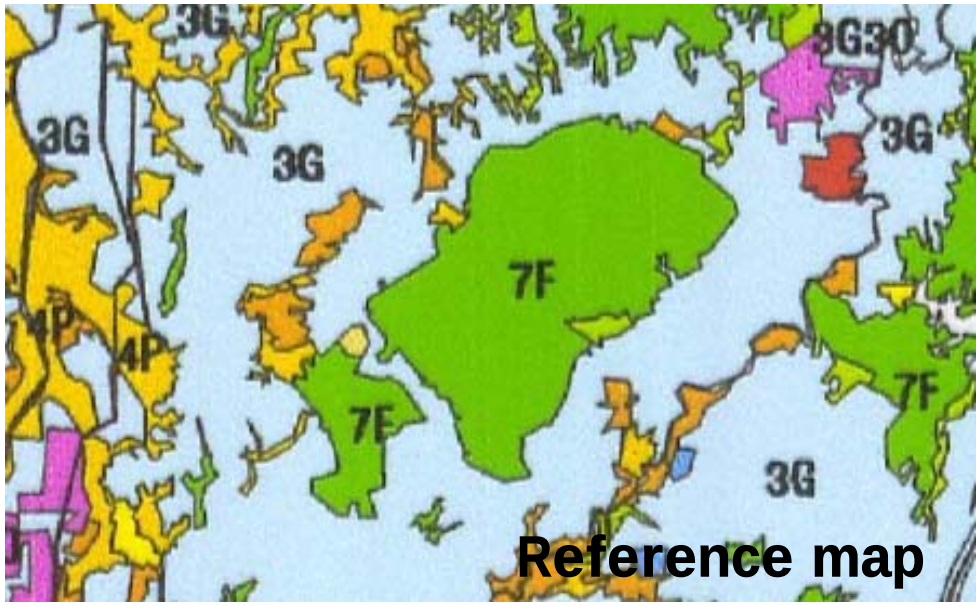


HH Polarization




HV alone


HH-HV combination


3G
3G
3G
3G
3G
7F
7F
7F
4P
4P
3G
Reference map

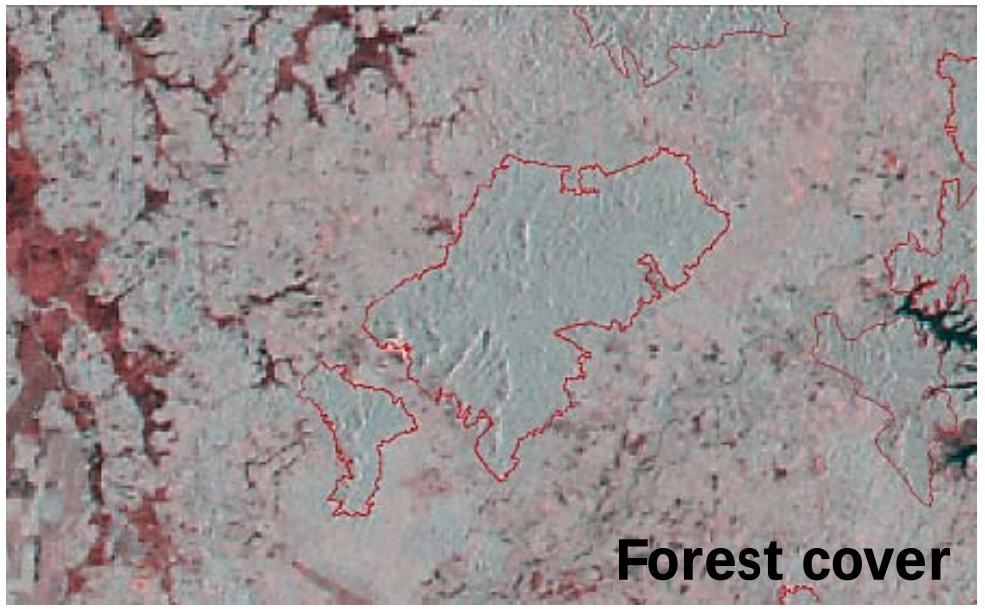
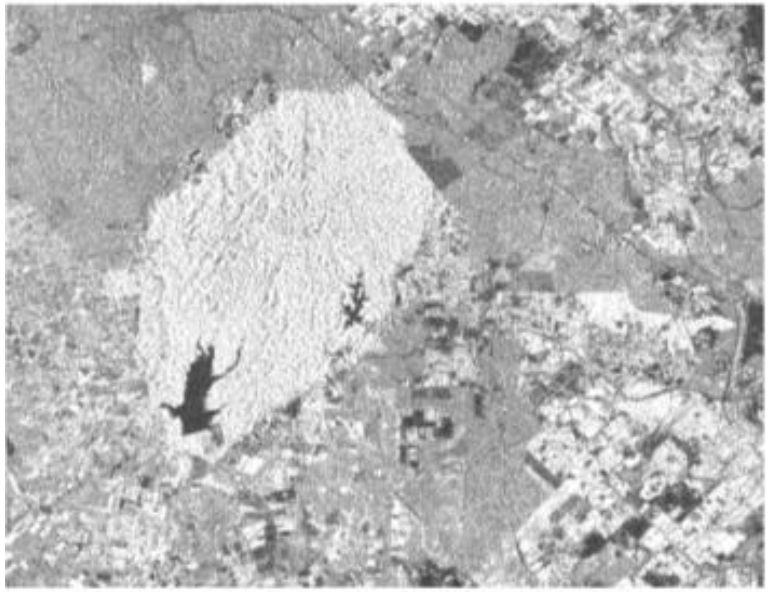

Forest cover

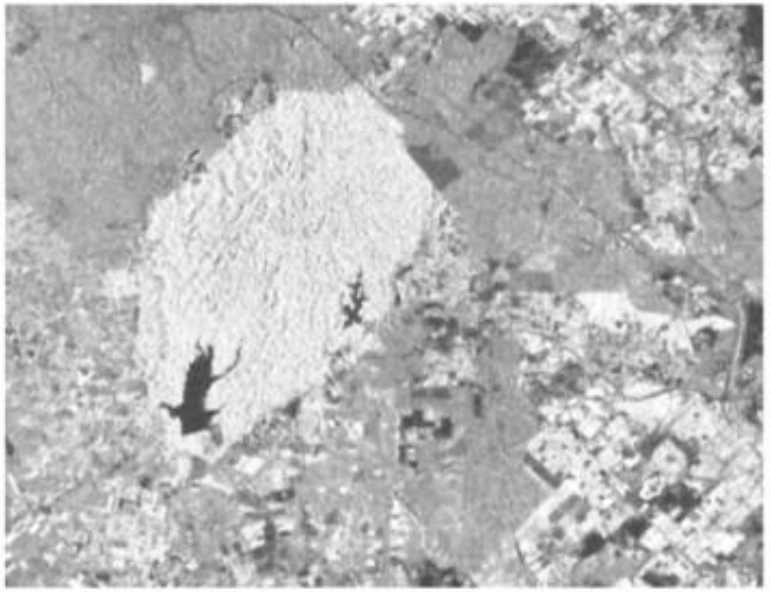
Image variables used for forest classification

Image variable	Description
HV	An image containing pixels values of original backscattering (σ, dB) from HV polarization.
HH	An image containing pixels values of original backscattering (σ, dB) from HH polarization.
HH/HV	Simple ratio dividing HH with HV polarizations (unitless)
HV/HH	Simple ratio dividing HV with HH polarizations (unitless)
(HH+HV)/2	Average of HH and HV (unitless).
√(HHxHV)	Squared root of HH and HV multiplicative product (unitless).

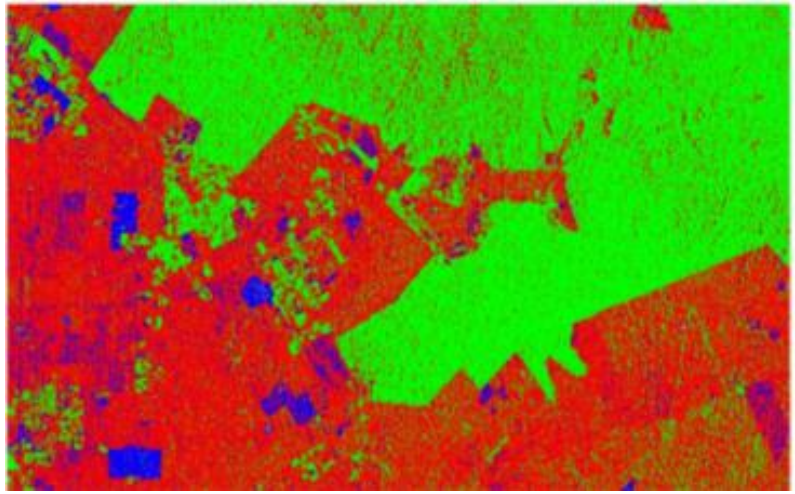
Grey Level Co-Occurrence Measure (GLCM)



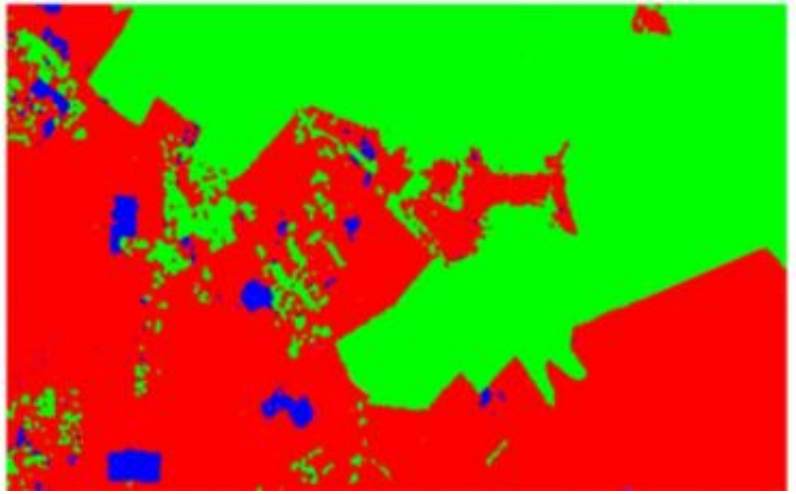
Original image



After GLCM

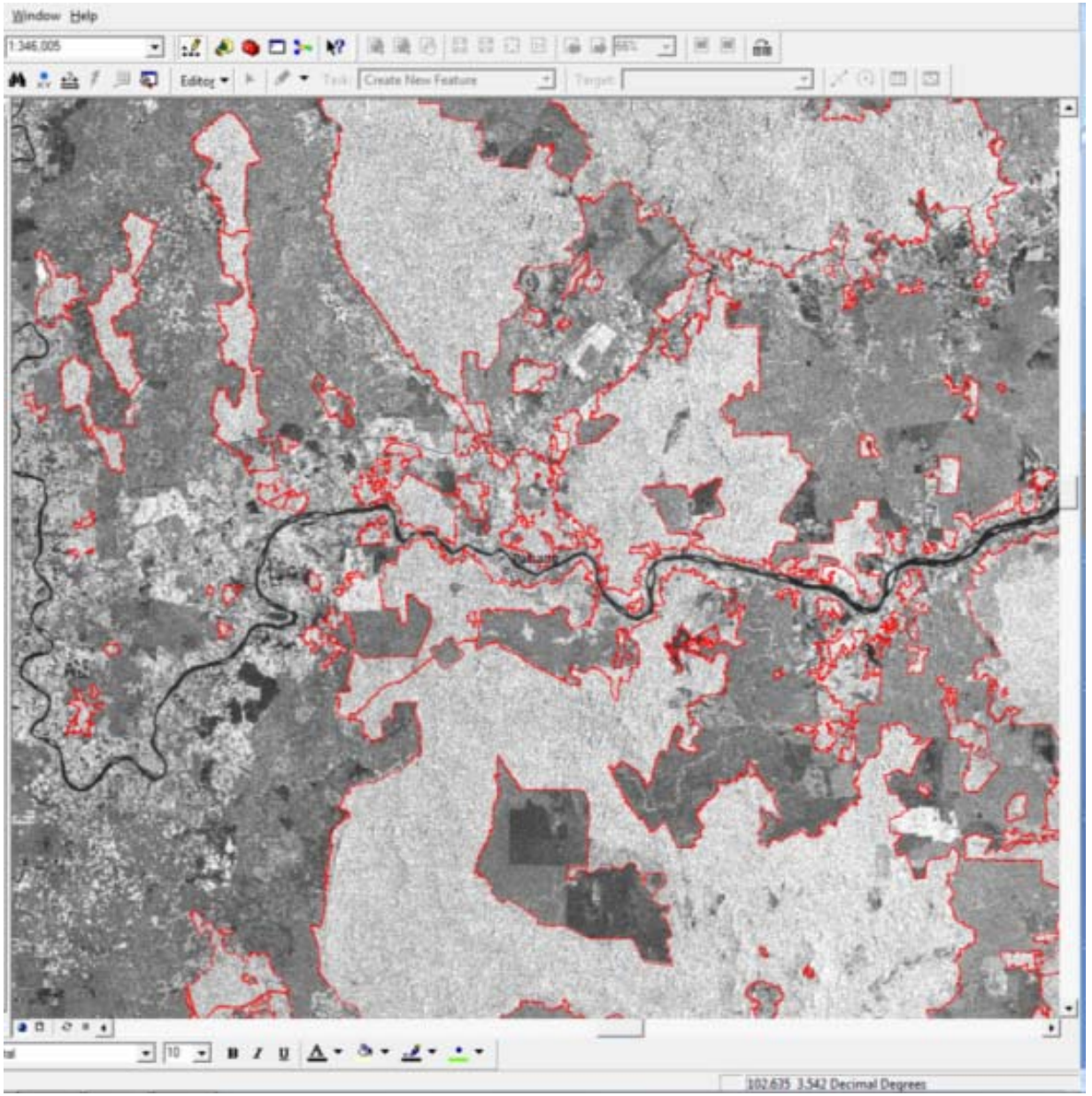


Traditional classification

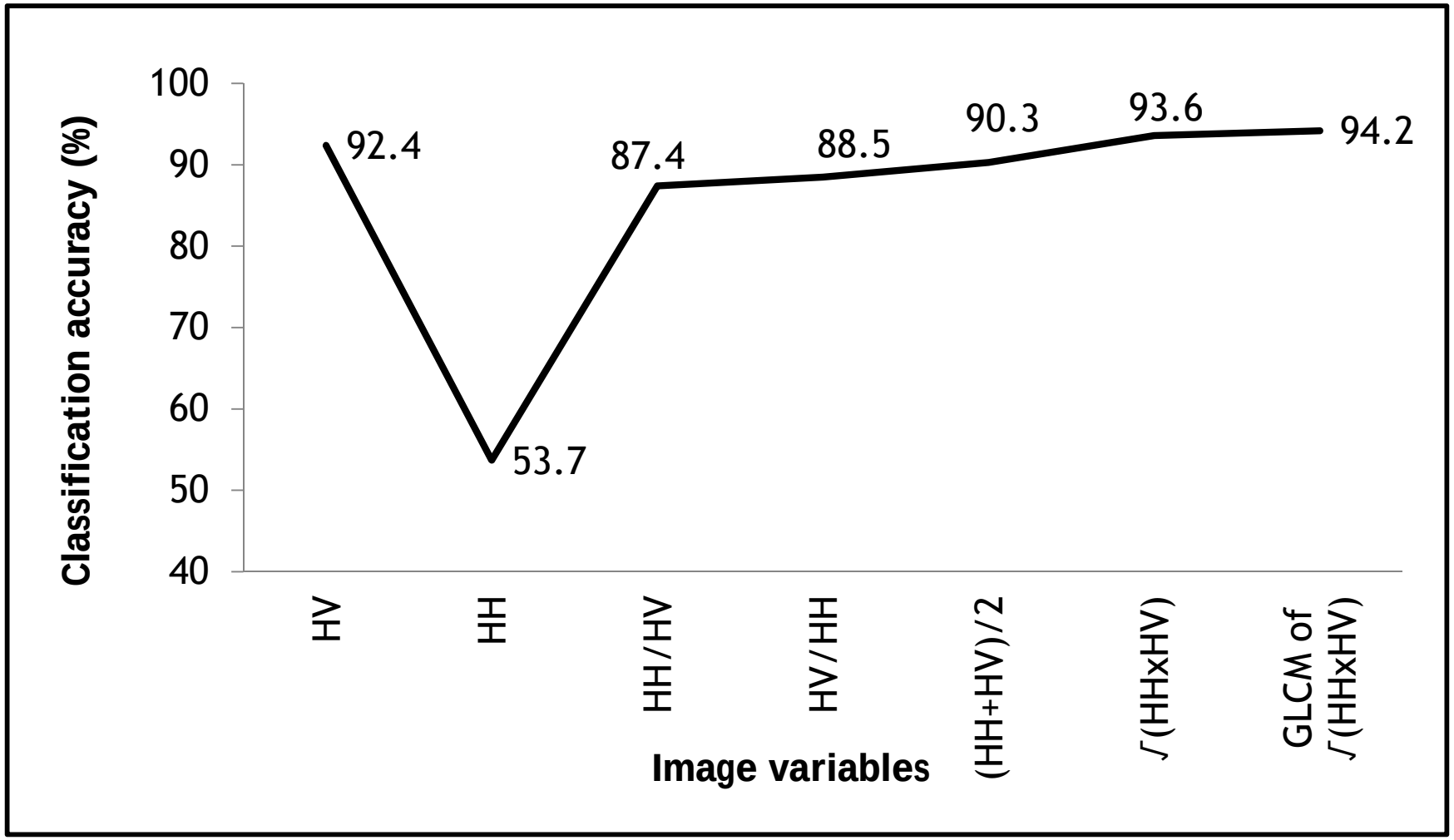


Segmentation

Closer look of classification results



Accuracies of classifications from different image variables (Test site)



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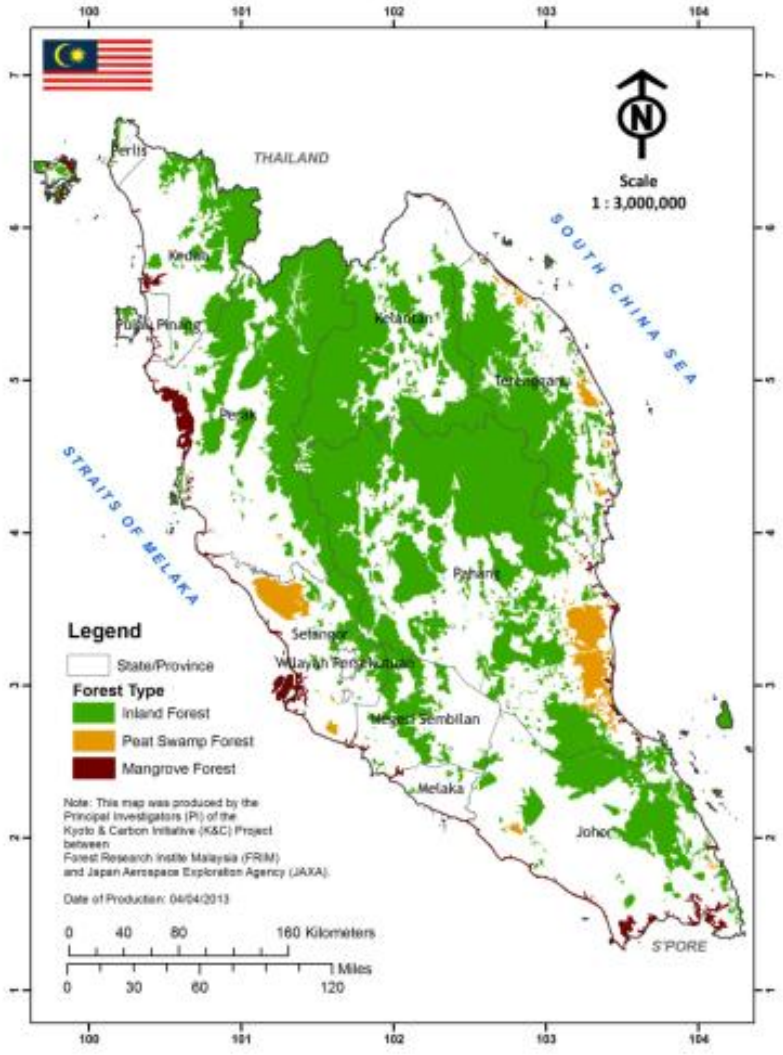
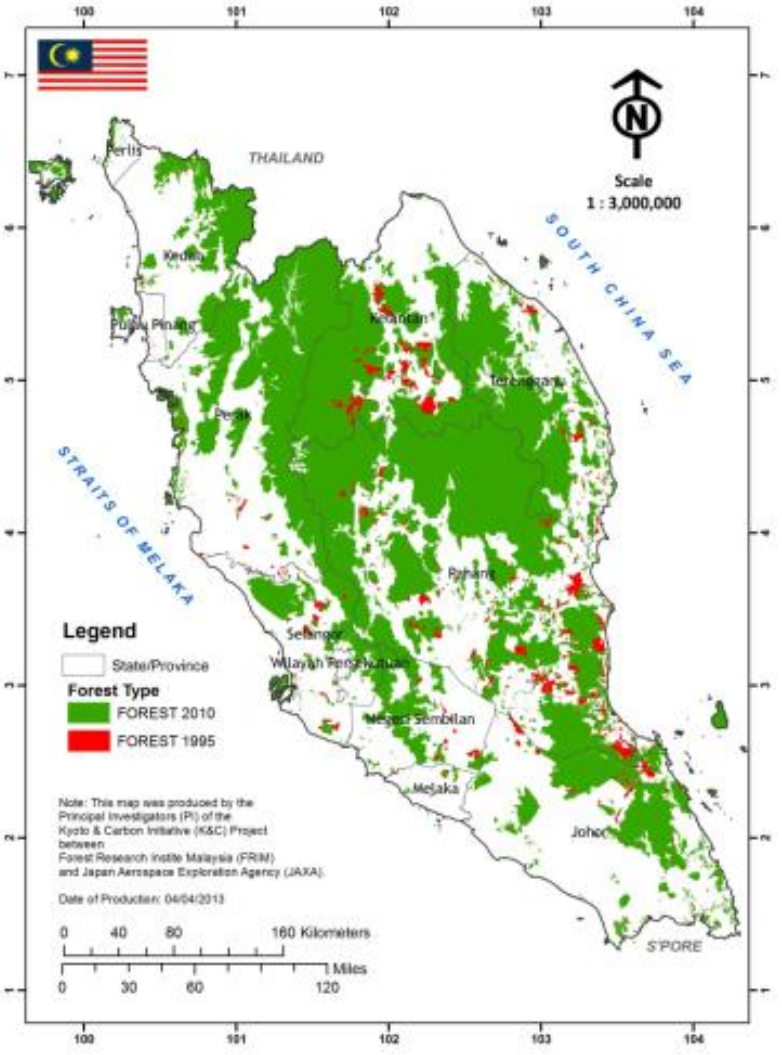
PENINSULAR MALAYSIA
FOREST COVER & TYPES (2010)



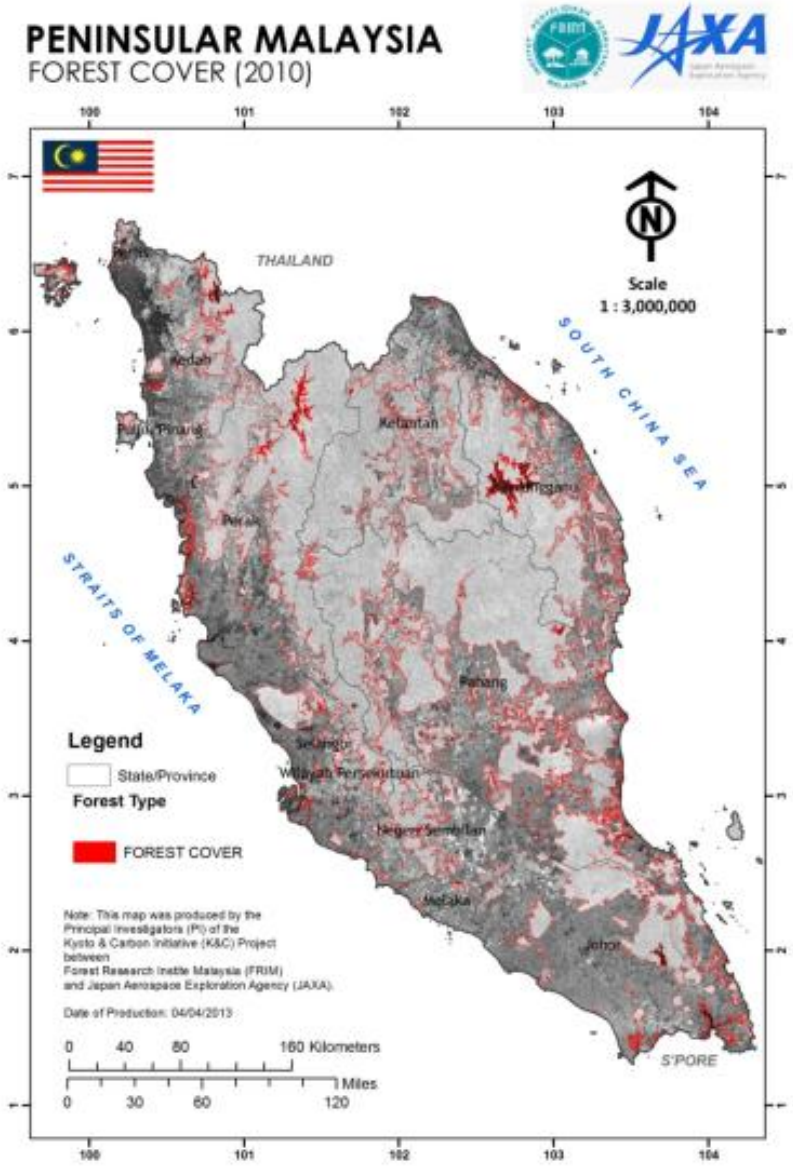
PENINSULAR MALAYSIA
FOREST CHANGES (1995 & 2010)

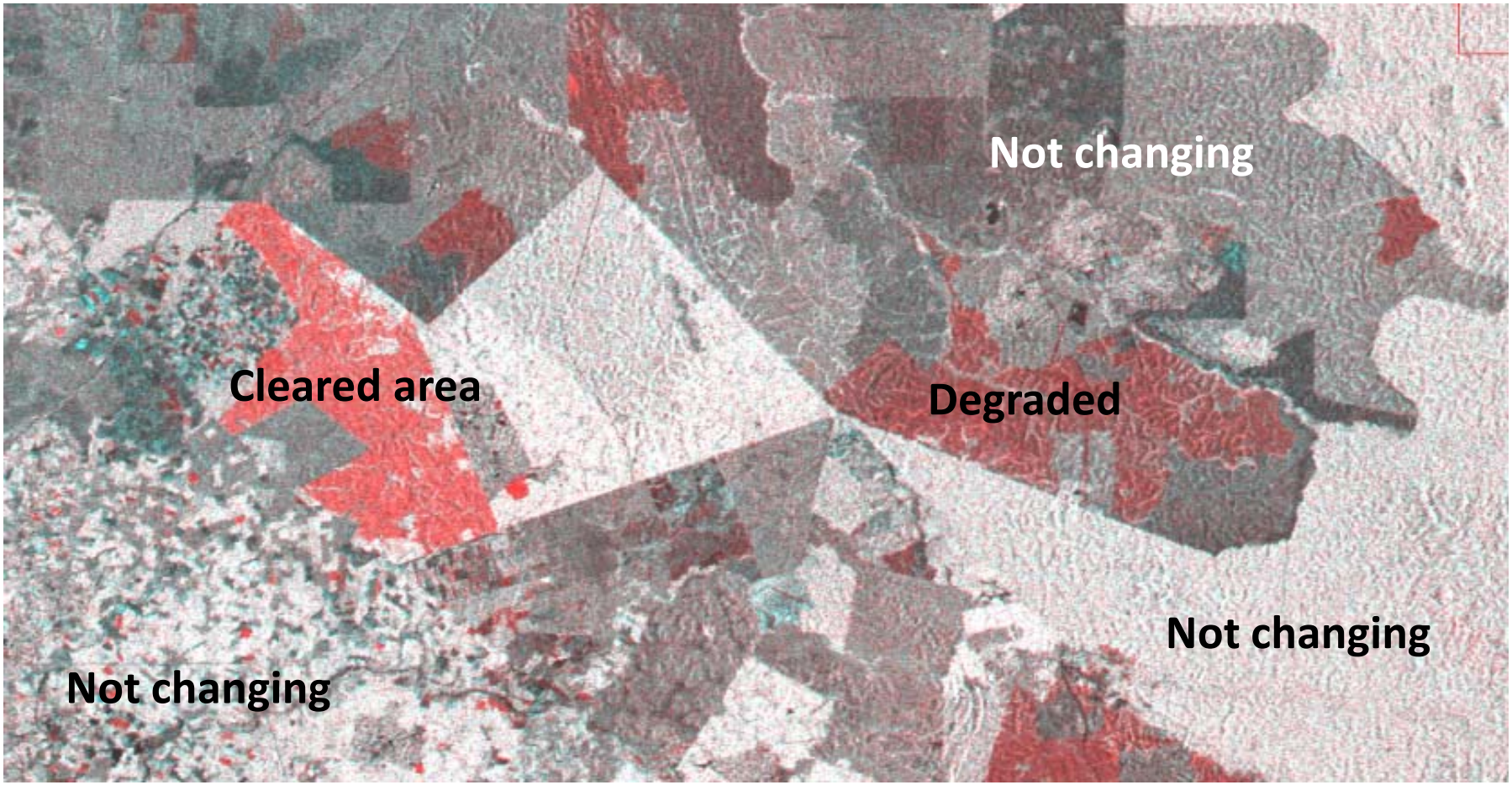


Results

Forest Type	Extents (ha)	Percentage (%)
Inland Forest*	5,690,815.57	93.3
Peat Swamp Forest**	290,038.47	4.8
Mangrove Forest***	115,180.60	1.9
Total	**6,096,034.64#**	**100.0**

**Including forest plantation.*
***Including fresh water swamp and Melaleuca cajuputi forests.*
****From Hamdan et al. (2012).*
#Figure is not final and not to be quoted.





Changes of forest cover (lowland dipterocarp) from 2009 to 2010

RGB = HV 2009; HV 2010; and HV 2010

Redefined study area

- Most land conversion occur only in stateland forest that reside on Lowland Dipterocarp regime.
- Production area (within forest reserve) also mostly reside on lowland and hill dipterocarp forests.
- No logging activity in the forest elevating >1000 m (m.s.l)
- Upper hill (750 – 1200m) and montane forest (>1200m) have different ecosystem and stands structure – cannot be included in estimation model (that focuses only on dipterocarp forest).
- Upper hill and montane occupied by rugged topography that affect the radar illumination – need to avoid.
- Biomass changes occur only within these regimes due to production.

Lowland and Hill Dipterocarp regimes:

Lowland dipterocarp forest	: <300 m
Hill dipterocarp forest	: 300 – 750 m

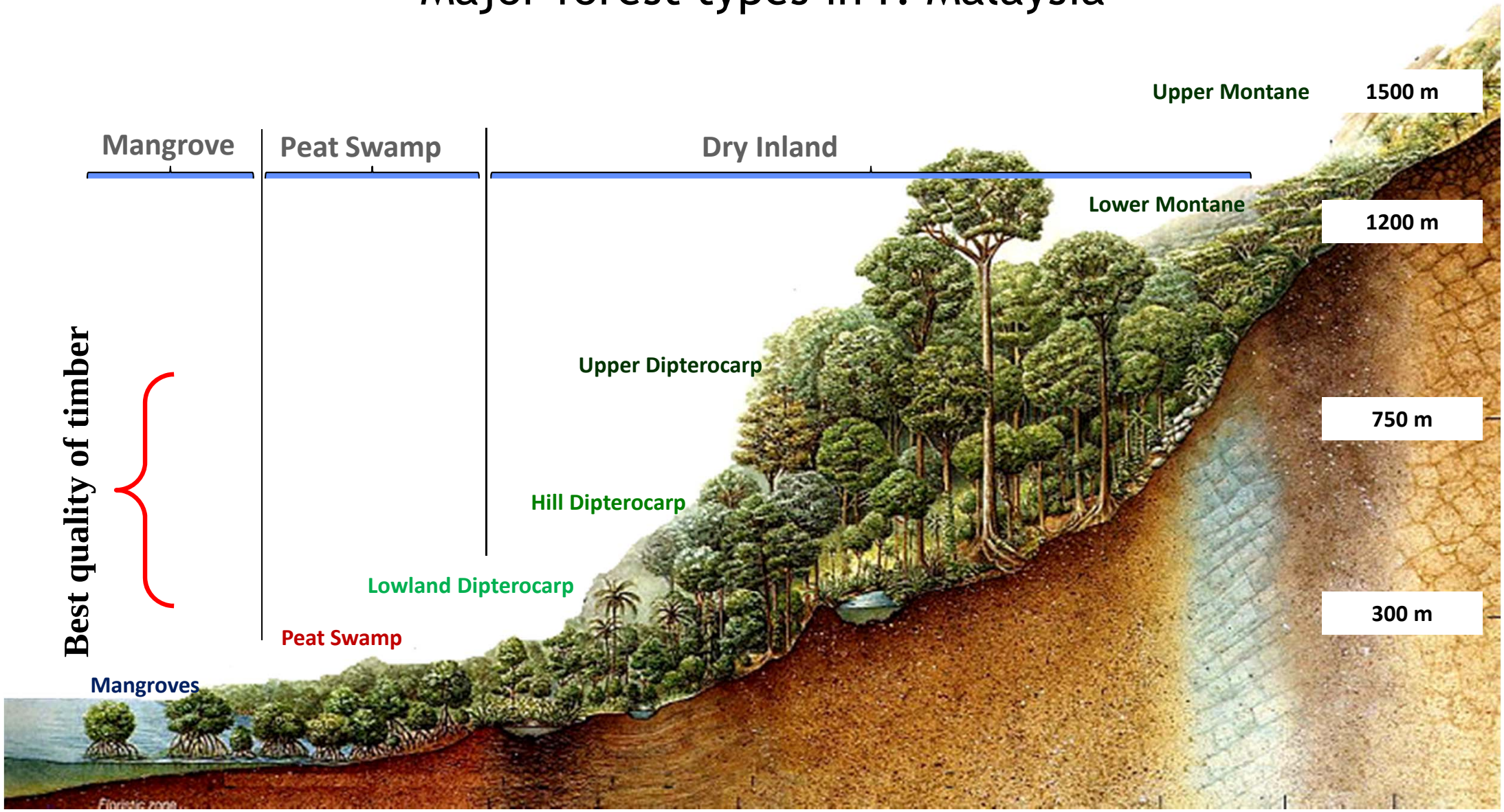
Permanent Reserved Forest in Malaysia, 2010 ('000,000 ha)

Study Area	Protection Forest	Production Forest	Total PRFs
Pen. M'sia	1.98	2.82	4.80
Percentage	41.25	58.75	100

Comprise mainly **Lowland** and **Hill Dipterocarp** Forests
(with minor portions of Peat swamp and Mangrove forests)

Sources: *Forestry Department Peninsular Malaysia (2011)*
Sabah Forestry Department (2011)
Forest Department Sarawak (2011)

Major forest types in P. Malaysia



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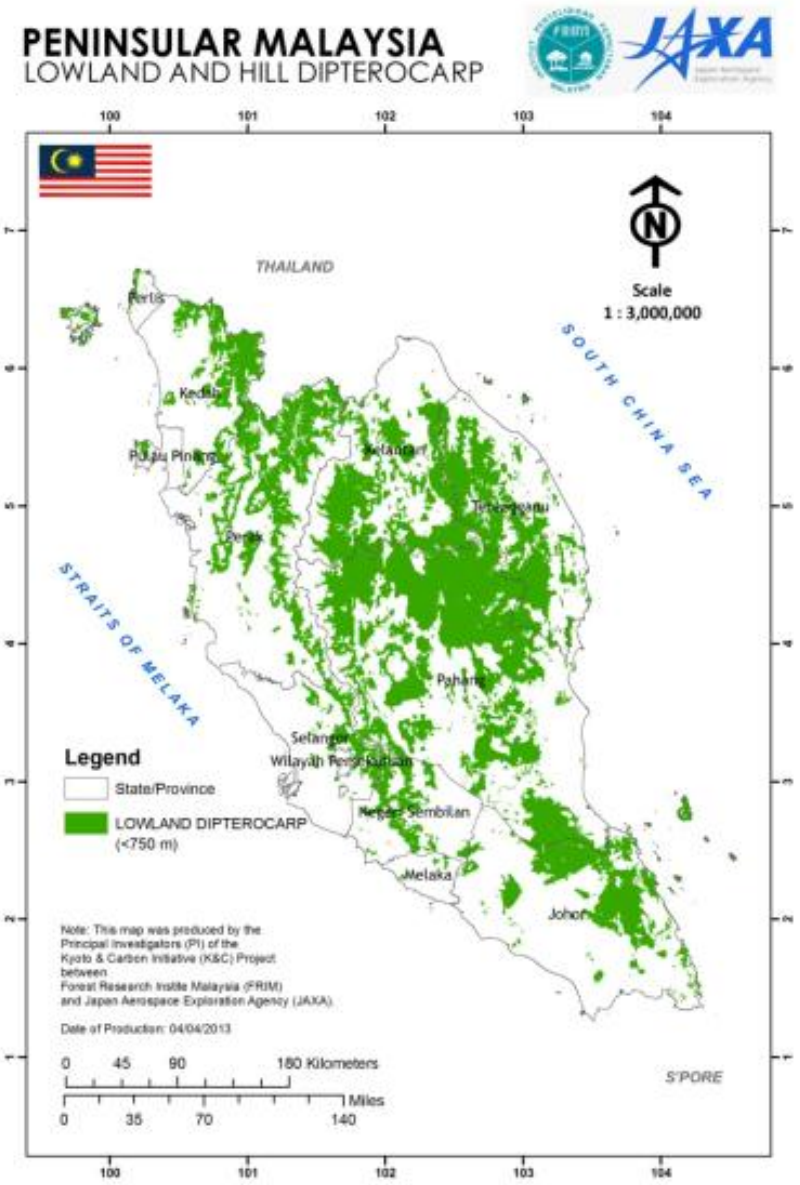
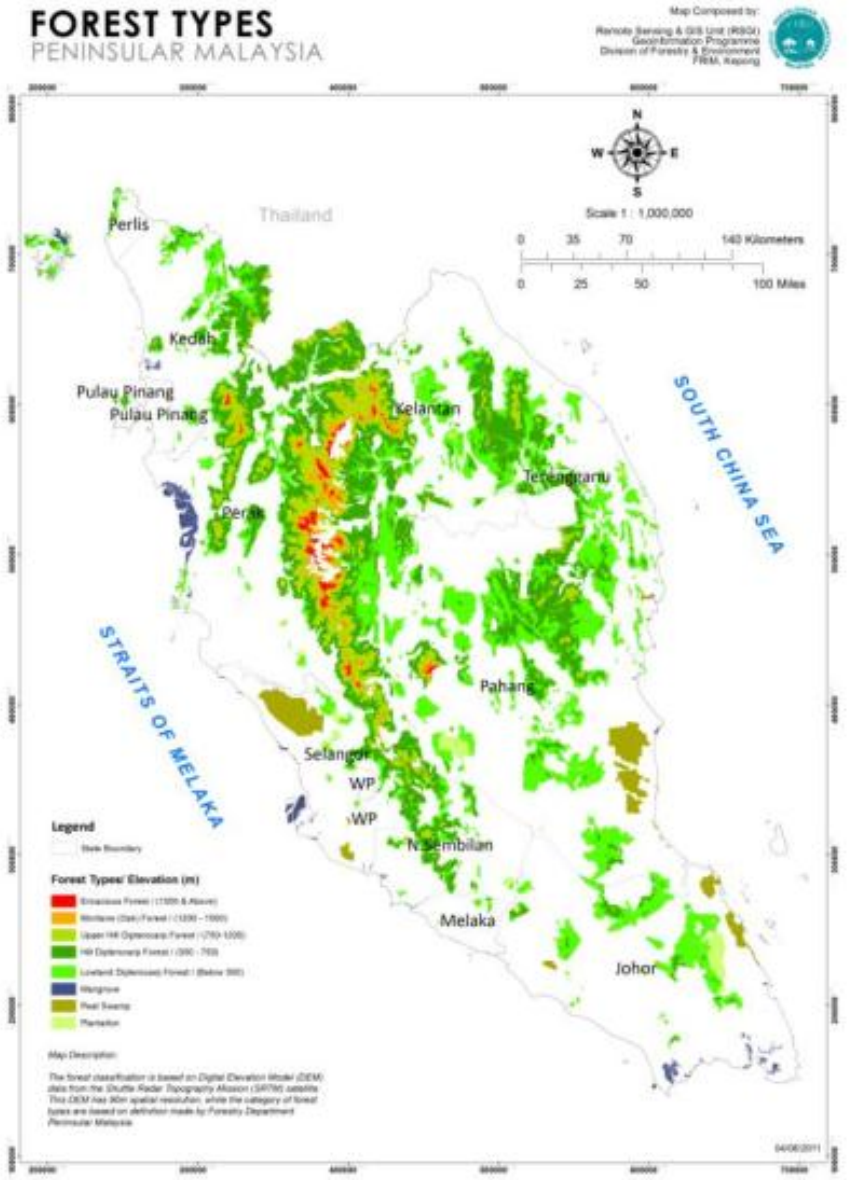
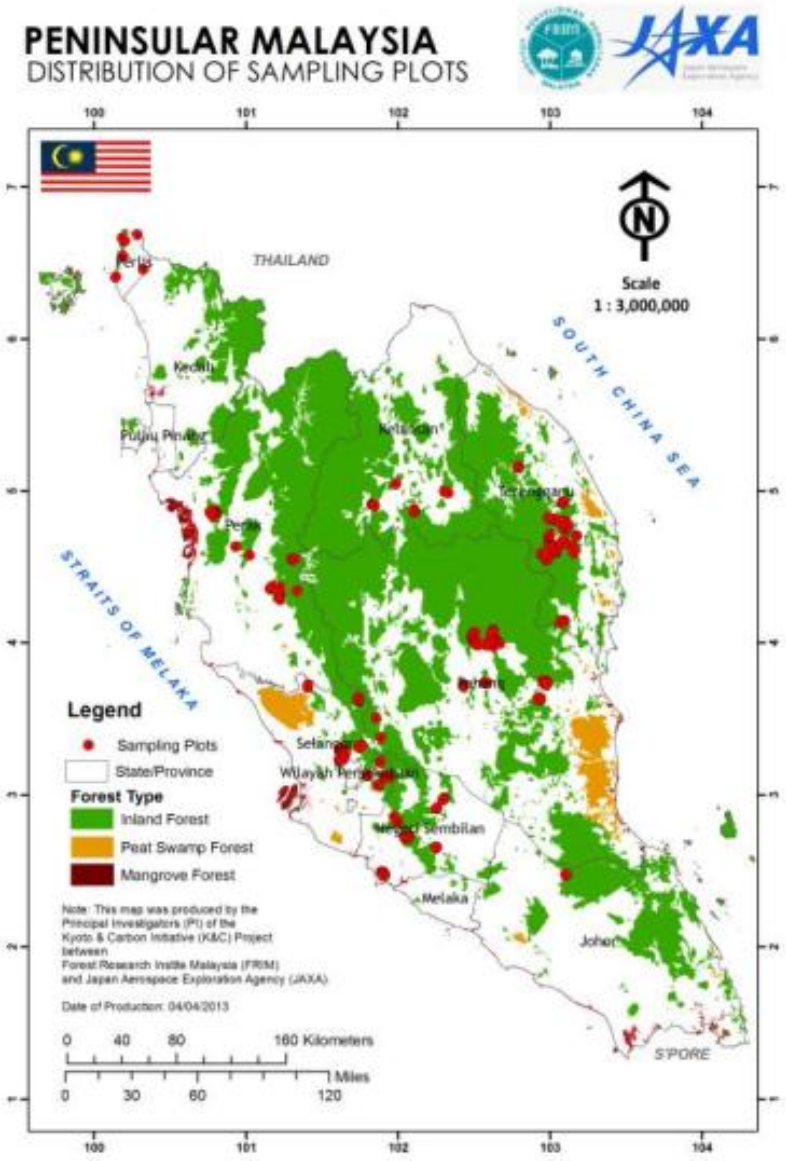




New study area

Forest Type	Lowland Dipterocarp Forest (ha)	Hill Dipterocarp Forest (ha)	Total Area (ha)
Extents (ha)	2,704,815.54	2,004,990.80	4,709,806.34
Percentage (%)	57.43	42.57	100



Sampling and modeling

A total of 318 plots sampling plots consisting biomass values were observed on ground covering lowland & hill dipterocarp forests.

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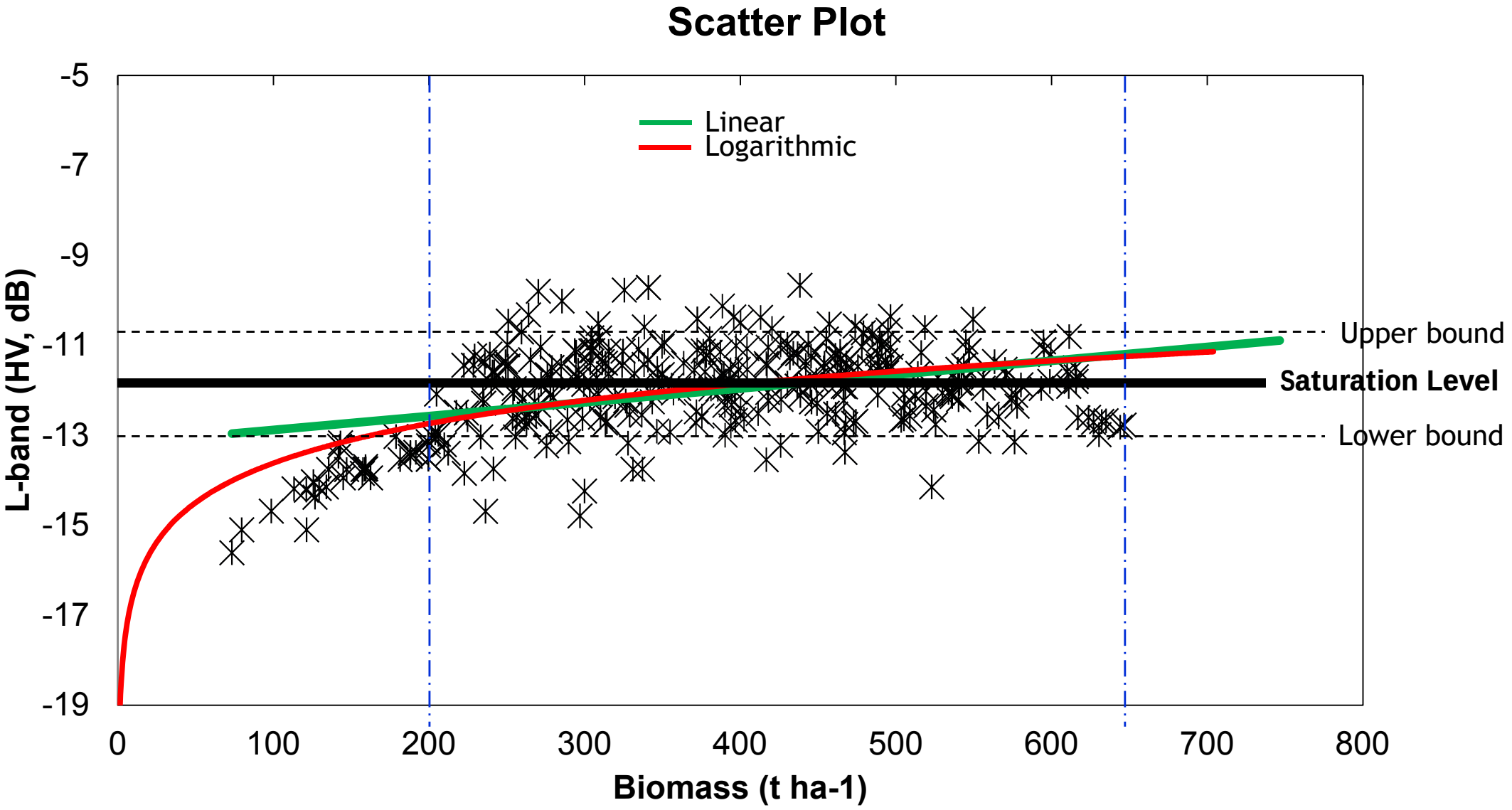
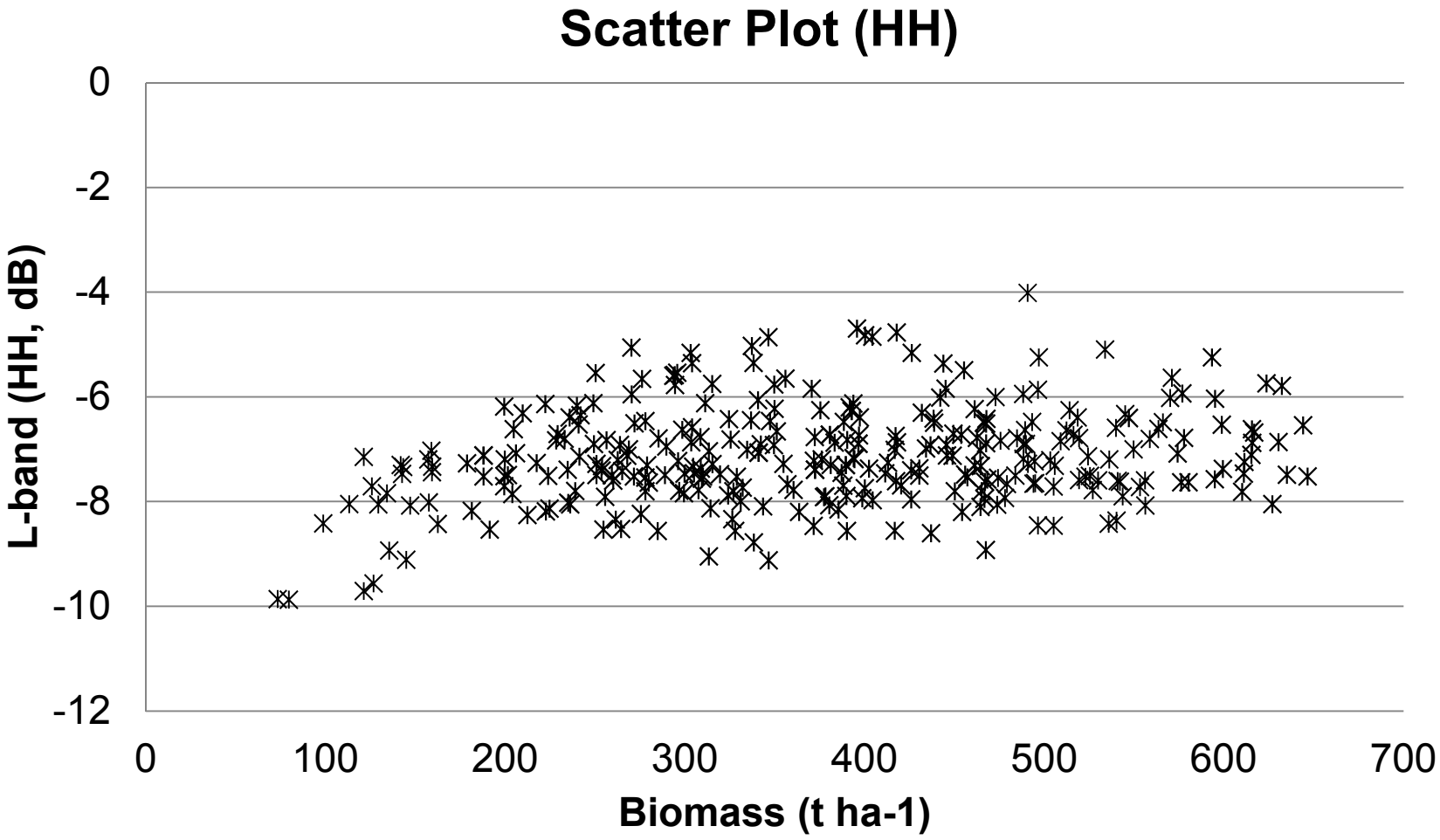
Hamdan


Scatter Plot
Linear
Logarithmic
Upper bound
Saturation Level
Lower bound
L-band (HV, dB)
-5
-7
-9
-11
-13
-15
-17
-19
0
100
200
300
400
500
600
700
800
Biomass (t ha-1)


Scatter Plot (HH)
L-band (HH, dB)
0
-2
-4
-6
-8
-10
-12
0
100
200
300
400
500
600
700
Biomass (t ha-1)

Linear

Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
.391	.153	.150	.955

The independent variable is BIOMASS.

Logarithmic

Model Summary

R	R Square	Adjusted R Square	Std. Error of the Estimate
.502	.252	.250	.898

The independent variable is BIOMASS.

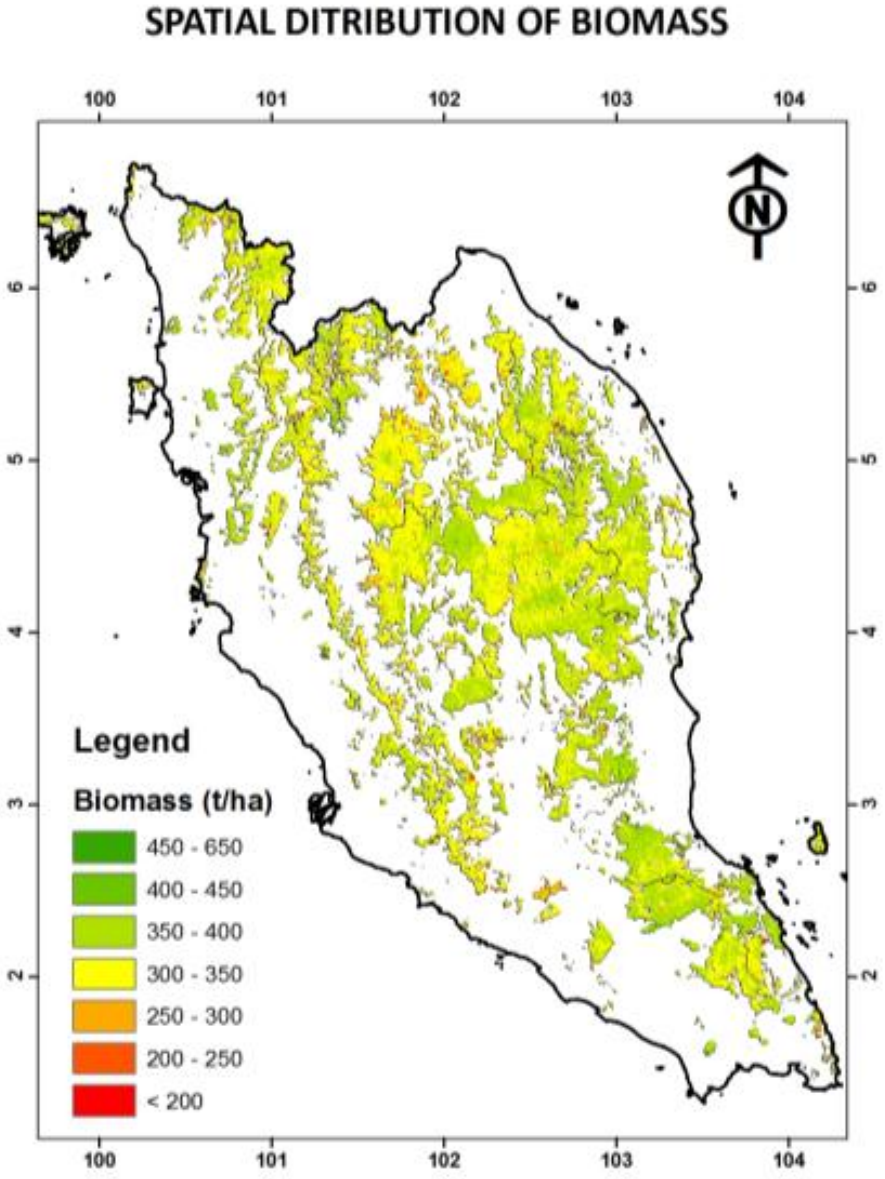
Coefficients

Linear

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
BIOMASS	.003	.000	.391	7.549	.000
(Constant)	-13.186	.162		-81.274	.000

Logarithmic

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
ln(BIOMASS)	1.269	.123	.502	10.314	.000
(Constant)	-19.464	.722		-26.940	.000



Basic Statistic

Image Stat.	Biomass ($t\ ha^{-1}$)
Min	51.34
Max	669.90
Mean	275.49
Std. Dev.	252.75

Conclusion

- Study has successfully classified and quantified the forest extents using L-band Palsar data.
- Biomass in this region are relatively high exceeding the saturation levels.
- Study found that both HV and HH polarizations still to deal with the saturation issues on tropical forest.
- Different variable (e.g. gamma naught) should be examined.
- Limitation on direct estimation method need also to be addressed.

Acknowledgement

- Thanks to JAXA for providing the L-band data sets.
- All FRIM's staffs that involved in ground data collection.
- Thanks to RESTEC for delivering the data and hosting the K&C Meetings.

Thank you

Terima kasih

ありがとうございます