

K&C Phase 3 - Summary Report

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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Science Team meeting #21 - Phase 3 & Phase 4 KYOTO RESEARCH PARK, December 3-5, 2014

Presentation Outline

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Recapitulation

LOS

- 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



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16th Science Team meeting
Date: October 17 - 21, 2011
Venue: JAXA, Tsukuba

19th Science Team meeting Date: April 9 - 12, 2013 Venue: RESTEC, Tokyo



18th Science Team meeting Date: November 7 - 9, 2012 Venue: RESTEC, Tokyo

Project objectives and schedule

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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.

Project milestones

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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	March 2013
	(2010)	
iv	Spatial distribution map of biomass and carbon stock	Jun 2013
	(1995)	
V	Spatial distribution map of biomass and carbon stock	Dec 2013 •
	changes over 15 years (1995 - 2010)	
vi	Summary report	March 2014

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Results

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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).



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Sampling and modeling

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

Focus area of Phase 3

- 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.

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- 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 forests:

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

STRAITS

Legend

hetween

0

OF MELAKA

State/Province

Note: This map was produced by the Principal Investigators (PI) of the Kyoto & Carbon Initiative (K&C) Project

Forest Research Instite Malaysia (FRIM) and Japan Aerospace Exploration Agency (JAXA).

70

101

Date of Production: 04/04/2013

45 90

100

35

(<750 m)

LOWLAND DIPTEROCARP

180 Kilometers

Miles

102

103

140

Low	and	Di	pt.
-----	-----	----	-----

Johor	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
104	Percentage (%)	57.43	42.57	100

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Fieldwork



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Scatter Plot (HH)

Linear

Model Summary

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

Logarithmic

Model Summary

or of mate	R	R Square	Adjusted R Square	Std. Error of the Estimate
.955	.502	.252	.250	.898

The independent variable is BIOMASS.

The independent variable is BIOMASS.

Coefficients

Linear		Unstandardized Coefficients		Standardized Coefficients		
		В	Std. Error	Beta	t	Sig.
	BIOMASS	.003	.000	.391	7.549	.000
	(Constant)	-13.186	.162		-81.274	.000
Logarithmic		Unstandardize	ed Coefficients	Standardized Coefficients		
		В	Std. Error	Beta	t	Sig.
	In(BIOMASS)	1.269	.123	.502	10.314	.000
	(Constant)	10/6/	722		26.040	000

Scatterplots of correlations between backscatter and AGB on (a) HV and (b) HH polarizations. The AGB from all sample plots were broken into intervals (1) < 200 Mg ha⁻¹, (2) > 200 Mg ha⁻¹, and (3) overall sample plots.

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Correlation functions and R² of HV and HV backscatter against the AGB in intervals

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Polarization	AGB interval (Mg ha ⁻¹)	No. of sample plots (n)	Model	R²	Residual (±Mg ha ⁻¹)
	< 200	32	$y = 2.0847 \ln(x) - 24.261$	0.7558	18.89
HV	> 200	252	$y = 0.475 \ln(x) - 14.558$	0.0264	97.66
	Overall	284	y = 1.5326 ln(x) - 20.89	0.3553	109.82
	< 200	32	y = 2.3828 ln(x) - 19.84	0.4335	26.71
нн	> 200	252	y = 0.1096ln(x) - 7.7058	0.0011	98.42
	Overall	284	$y = 0.6757 \ln(x) - 11.083$	0.0834	118.10

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t of: FRIM-JAXA Research Agree Carbon (K&C) Phase 3 Initiative 2

was produced from ALOS PALSAR

102°0'0"E

103°0'0"E

104°0'0"E

LOS

BIOMASS (AGB)

igh: 650.00

101°0'0"E

Low . 5 00

(Mg ha-1)

100°0'0"E

Basic StatisticImage Stat.Biomass
(t ha-1)Min51.3Max579.6Mean275.5Std. Dev.252.8

Total AGB: 1,297,504,548.67 tons **1.3 Billion tons**

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Changes of carbon stock

Year	Extents of lowland and hill dipterocarp (ha)	Carbon stock (Mg C ha ⁻¹)
2010	4,709,806.3	648,775,823.3
1995	5,073,375.2	698,857,439.3
Changes	-363,568.9	-50,079,798.1
Changes/yr	24,237.9 ha	3,338,653.2 Mg

Biomass Allometric Functions

No	Source	Allometric functions	Application to type of forest
5	Komiyam a et al. (2007)	Wt= $0.251\rho D^{2.46}$ Wr= $0.199\rho^{0.899}$ D ^{2.22}	Common equation applied to all trees in mangrove forest
6	Ong et al. (2004)	Log10(Wt)= 2.420 *log10(GBH) -1.832 Log10(Wr)= 2.611 *log10(GBH) - 3.454)	Specific equation <i>Rhizophora apiculata</i>

Polarizations manipulation

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AGB		No. of				Residual
interval		sample			Adjusted	error
(Mg ha⁻¹)	Model	(n)	R	R ²	R ²	$(\pm Mg ha^{-1})$
< 100	y = 1.3668 In(x) - 21.495	154	0.790	0.624	0.621	14.17
100 - 150	<i>y</i> = 0.0082 <i>x</i> - 16.208	78	0.175	0.030	0.018	16.21
> 150	y = -0.0014x - 15.07	88	0.105	0.011	0.000	40.27

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LOS

	Basic statisti	c (Mg ha ⁻¹)	
Minimum	Maximum	Mean	Mode
2.98	378.32	99.40	72.98

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Conclusion

LOS

- Study has successfully classified and quantified the forest extents using L-band Palsar data.

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- 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.

Deliverables – Papers and reports

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<u>1. Published</u> (PDF files are provided in K&C #21)

Journal

- Hamdan, O., Mohd Hasmadi, I., Khali Aziz, H., Helmi Zulhaidi MS. & Norizah, K. (2014). Forest Biomass Assessment with special Reference to L-Band Alos Palsar Data. *The Malaysian Forester* 77(1): 1-18. ISSN: 0302-2935.
- Hamdan, O., Mohd Hasmadi, I., Khali Aziz, H., Norizah, K. & Helmi Zulhaidi, M.S. (2014). Factors affecting L-band Alos Palsar backscatter on tropical forest biomass. *Global Journal of Science Frontier Research* 14(3): 51-63. ISSN: 0975-5896.
- Hamdan, O., Khali Aziz, H. & Mohd Hasmadi, I. (2014). L-Band Alos Palsar for biomass estimation of Matang Mangroves, Malaysia. *Remote Sensing of Environment*. 155: 69–78. ISSN: 0034-4257.

Proceedings

- Hamdan, O., Mohd Hasmadi, I. & Khali Aziz, H. (2014). Combination of SPOT-5 and Alos Palsar images in estimating aboveground biomass of lowland Dipterocarp forest. *IOP Conference Series: Earth and Environmental Science* 18: 012016. 6 pp.
- Hamdan, O., Mohd Hasmadi, I., Khali Aziz, H. & Mohd Hakimi, A.H. (2013). Methods for estimating biomass in the tropical forest using remotely sensed data. In Lai, F.S et al. (ed.) *Proceeding International Forestry Graduate Students' Conference* (FORGRAD) 2013. 2-4 July 2013, UPM Serdang. 122-128.

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- Hamdan, O., Nur Laila, C.M., Khali Aziz, H. & Mohd Hasmadi, I. (2013). L-band synthetic aperture radar (SAR) response to the tropical forest stands for carbon stock assessment. *AIP Conference Proceeding* 1528: 76-81.
- Hamdan, O., Maszarifah, I. & Khali Aziz, H. (2013). Alos Palsar for biomass assessment on rubber and teak plantations in Peninsular Malaysia. Poster presented at Asian Conference on Remote Sensing (ACRS), 20-24 Oct 2013, Bali Indonesia.
- Hamdan O, Khali Aziz H & Mohd Hasmadi I. (2012). The Use Of Polarized L-band Alos Palsar For Identifying Forest Cover In Peninsular Malaysia. Proc. Asian Conference on Remote Sensing. 26 – 30 November 2012, Pattaya Thailand.

Official Bulletin

Hamdan Omar & Abd Rahman Kassim. The first forest biomass map of Peninsular Malaysia. FRIM in Focus, December 2013.

Hamdan Omar. Forest carbon mapping at FRIM. FRIM in Focus, September 2013.

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2. Submitted/in preparation

No.	Title	Journal	Status	Expected date of publication
1	Determining L-band saturation level for aboveground biomass assessment of dipterocarp forests in Peninsular Malaysia	Journal of Tropical Forest Science	Under second review, submitted in July 2014	March 2015
2	Development of empirical models for estimating aboveground biomass in logged forest using L- band SAR	Jurnal Teknologi	Accepted in December 2014	January 2015
3	Estimating Biomass in Logged Tropical Forest Using L-Band SAR (PALSAR) Data and GIS	Sains Malaysiana	Under review, submitted in July 2014	NA
4	Evaluation of L-Band SAR Capability in Estimating Tropical Forest Biomass	PhD Thesis Dissertation	Finalization	March 2015

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Deliverables – Data sets and Thematic products (mosaics, classification maps etc.)

1. Completed and Delivered to JAXA

- Ground truth data of the observed aboveground biomass in lowland and hill dipterocarp forests
- K&C Phase 3 Summary Report

2. Completed, but not yet delivered (delivered in K&C #21)

- Shapefile of Forest Cover in Peninsular Malaysia 2010
- Image of Aboveground Biomass Distribution 2010

Acknowledgments

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Thank you Terima kasih ありがとうございます