Global Forest/Non-Forest coverage and the change between 2007 and 2015 using the PALSAR and PALSAR-2

-Creation of the first PALSAR-2 global mosaic 2014/2015-

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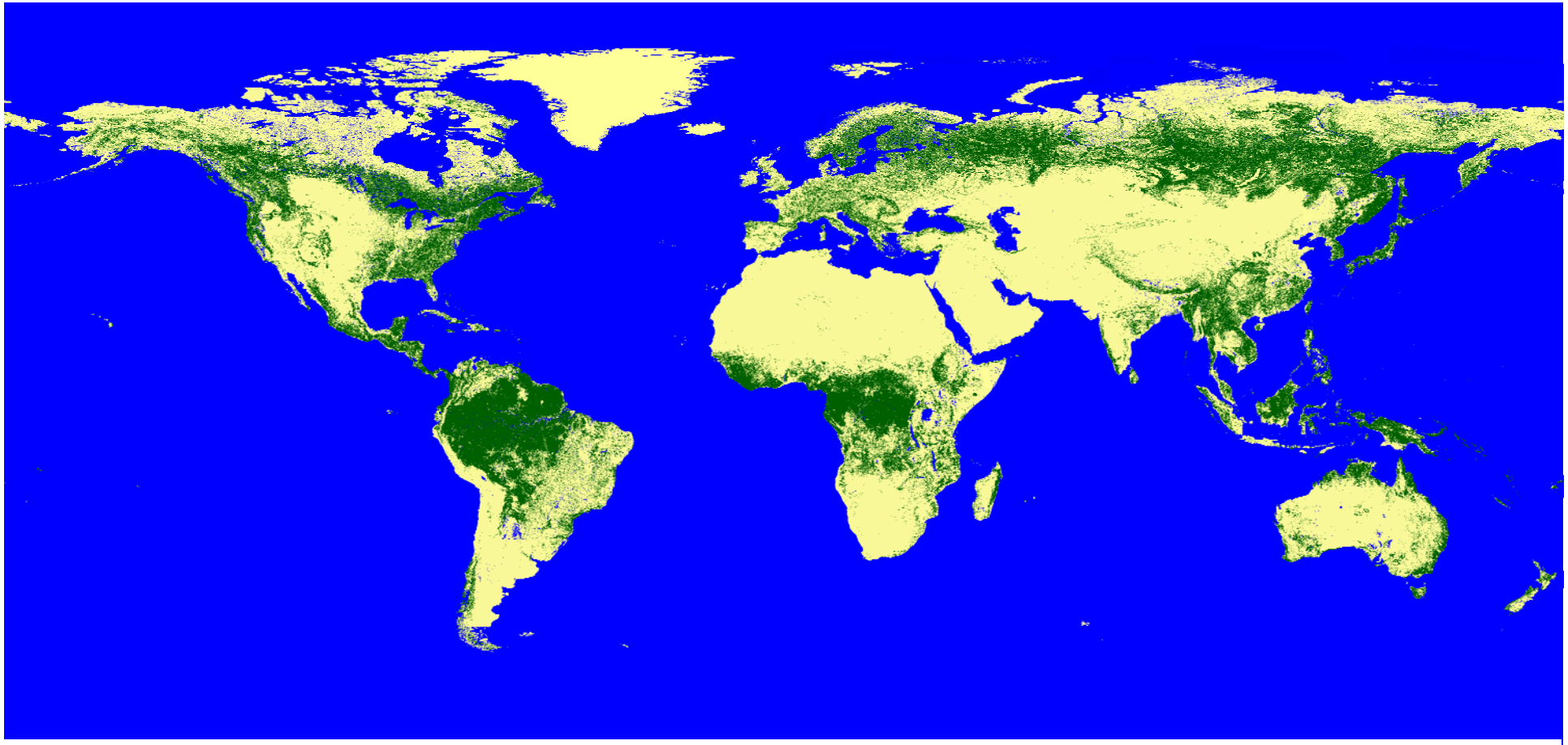
Background

- Carbon emission quantity from the land has a largest accuracy uncertainty due to human activity related.
- Deforestation accounts for 13% of the total terrestrial GHG emission.
- Under REDD+ or forest preservation activity, measurement of the forest carbon is required (although the quantification is difficult).
- Among three TIERs, forest/non-forest and temporal change are the lowest wall from the satellite and the ground truth data.
- Among two main streams of the high-resolution remote sensing, L-band radar (ALOS/PALSAR) has been prepared from 2007-2010 durations.
- ALOS-2/PALSAR-2 was launched in 2014 and the forest change after the death of ALOS in 2011 was the issue.
- This presentation shows the forest change in this five years.

PALSAR 25m Mosaic 2007, Forest/Non-Forest Map



- FNF map was generated by the region dependent threshold method shows the good agreement of 87.5~95% with the ground truth data and FRA.
- Forest is estimated as 38,000,000km2 and decreasing as timely.
- PALSAR : 2006-2011 terminated.

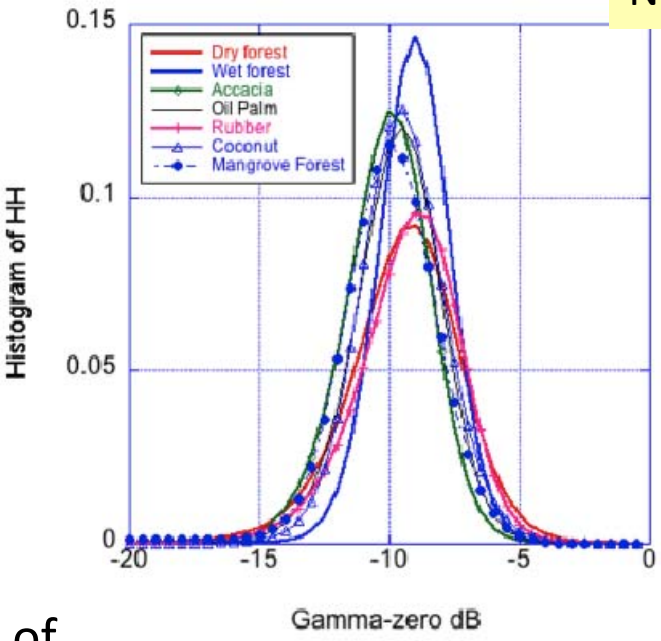
Histogram property

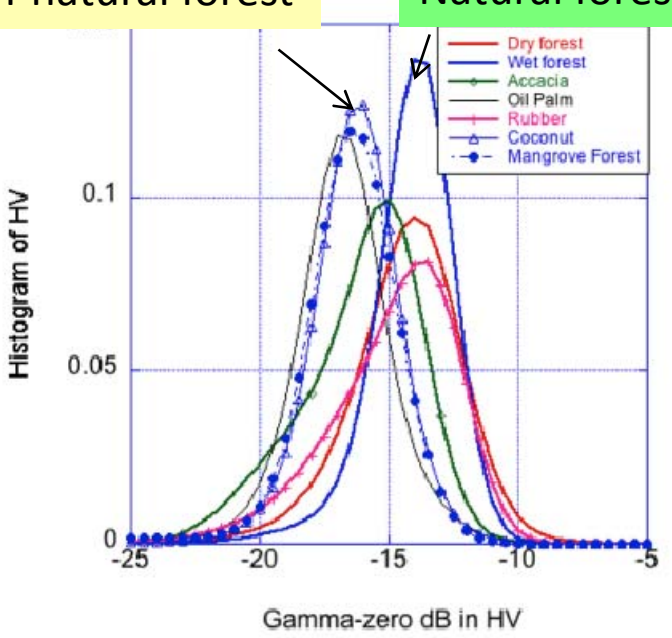
森林分類毎に反射係数に差がある

- Natural forest
- Natural mangrove fores
- Natural re-growth
- Acacia
- Oil Palm
- Rubber
- Coconut
- Open area
- Other
- Water

Non-natural forest

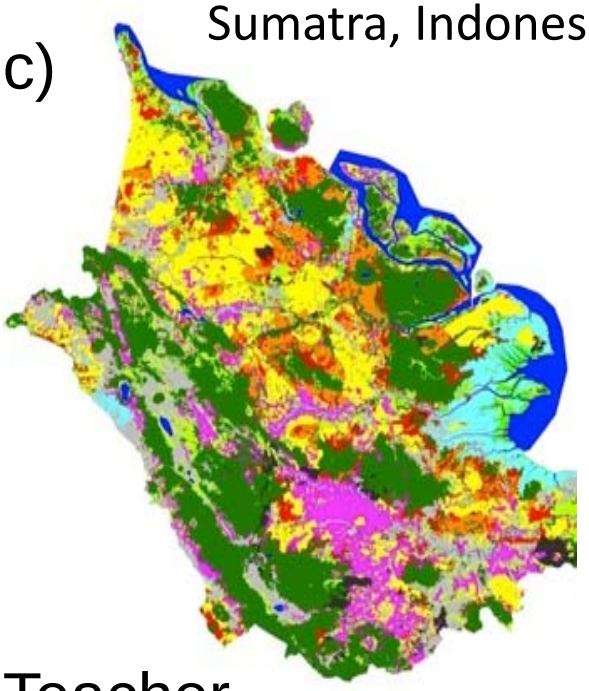
Natural forest



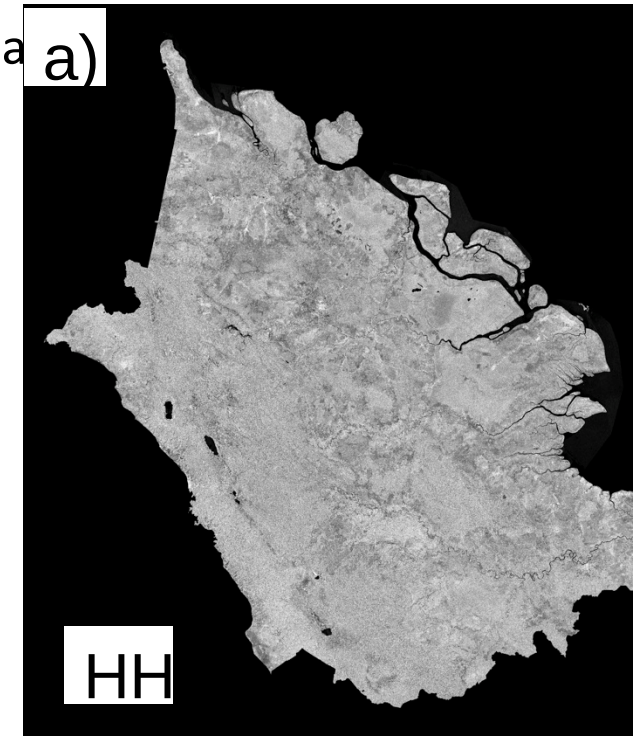


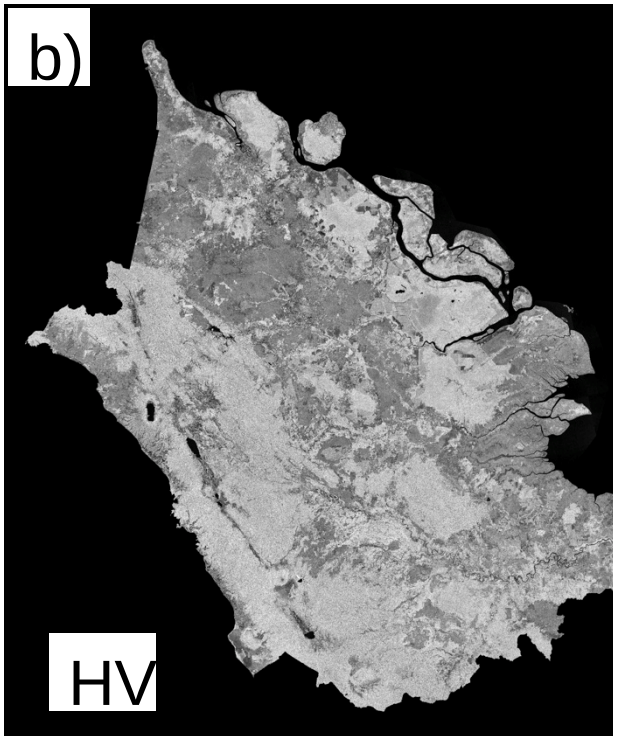
Riau province of Sumatra, Indonesia

c)



Teacher



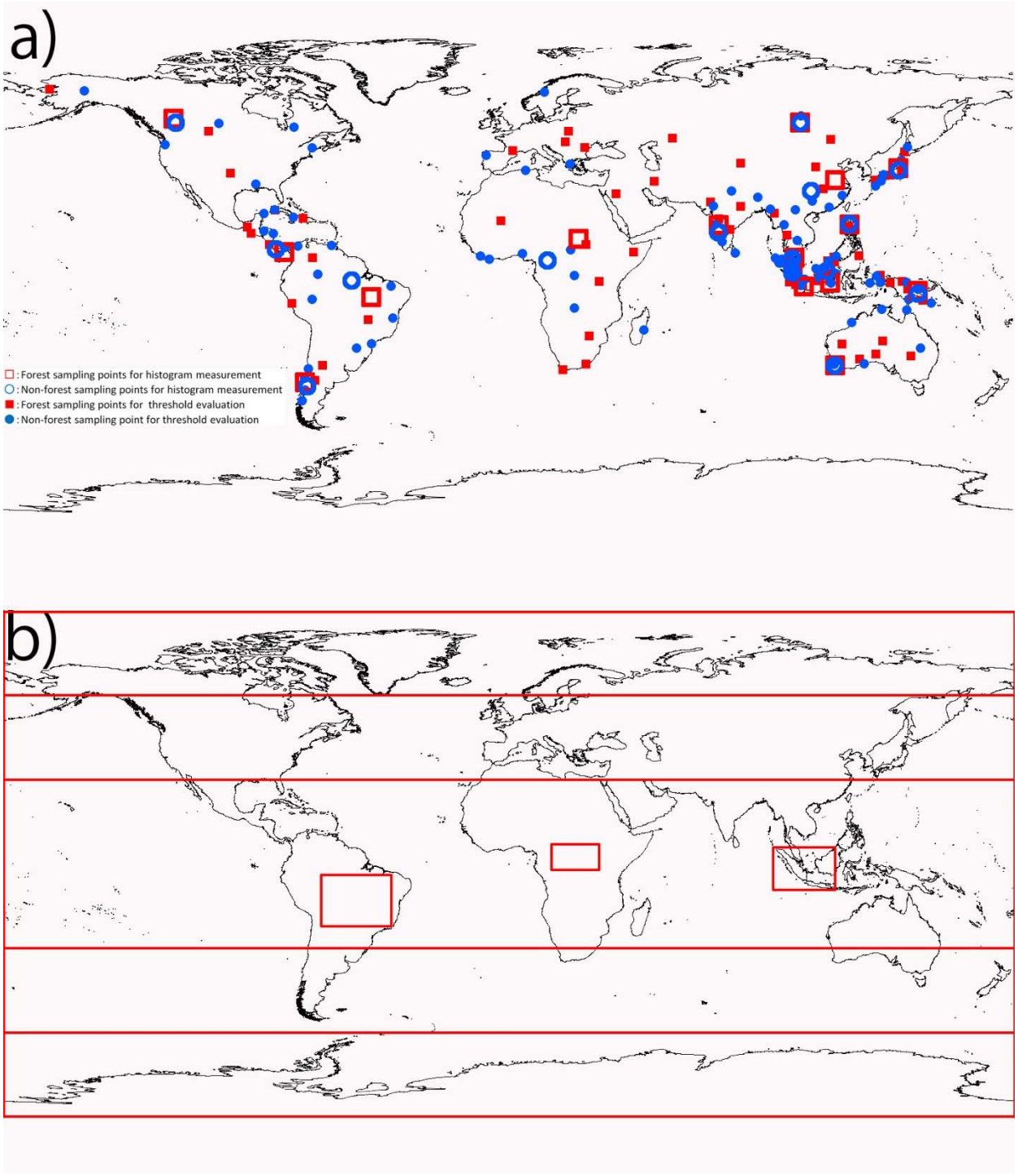


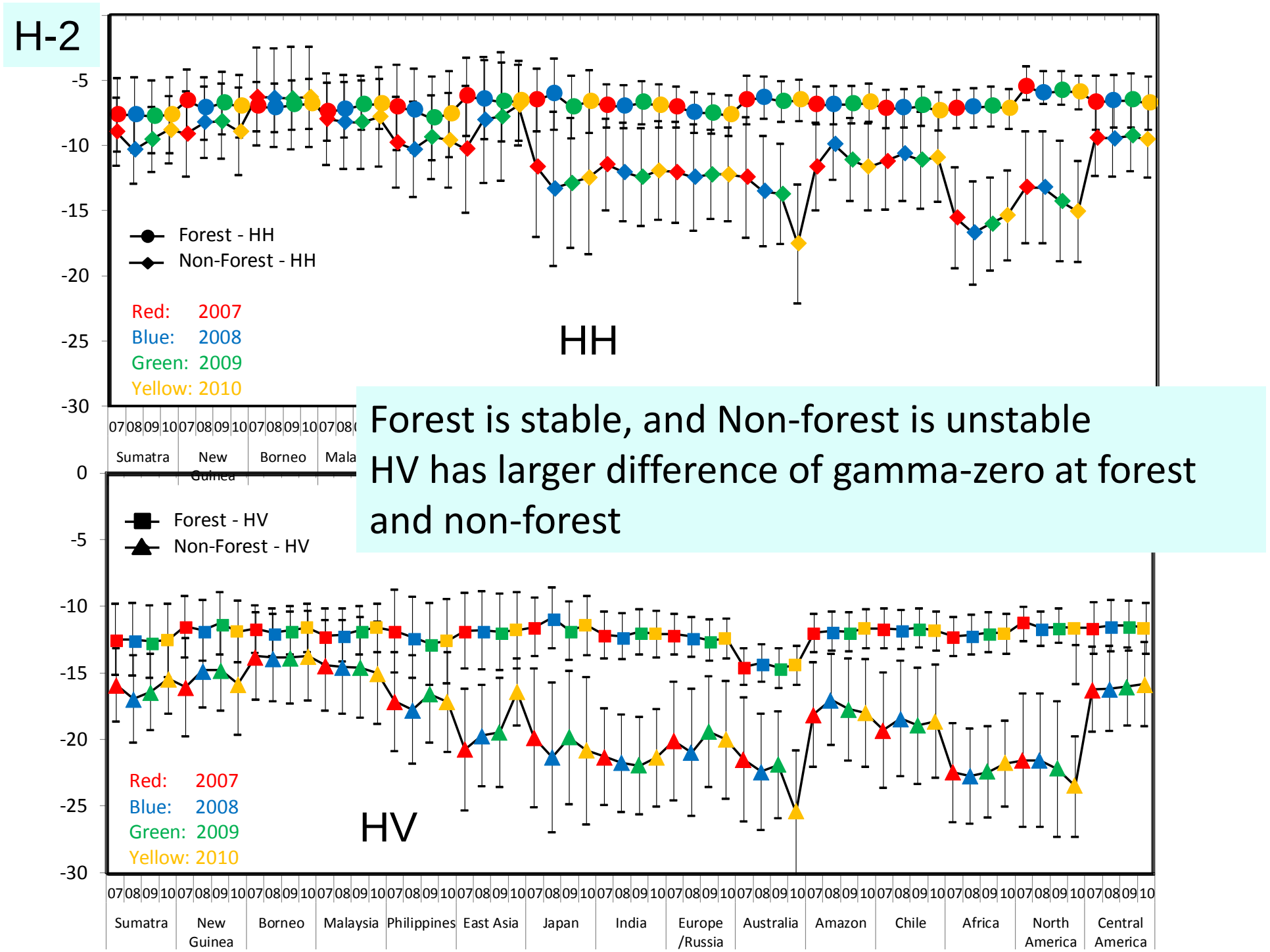
Investigation of the SAR data stability in three scales

H-１）global scale

H-２）１５ continental or sub continental scale

H-３）regional scale investigation with 10 smaller sub regions

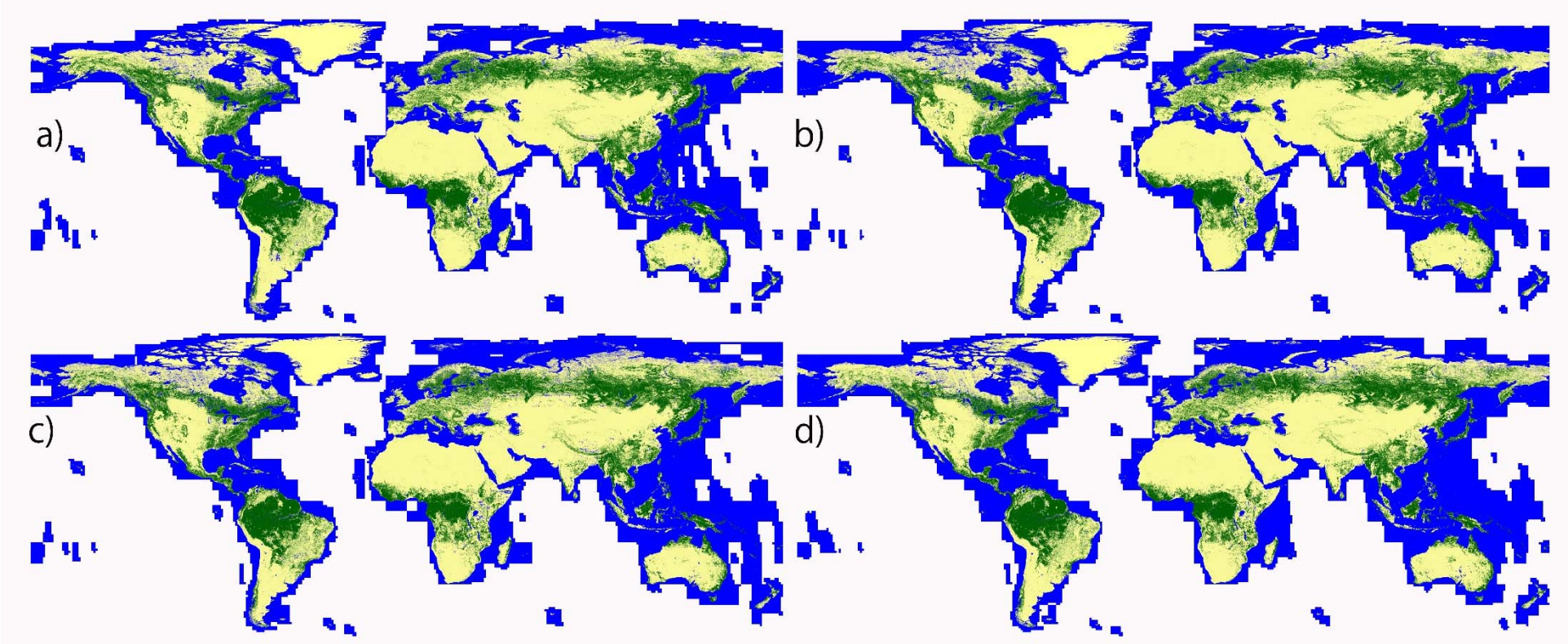



H-2
-5
-10
-15
-20
-25
-30
Forest - HH
Non-Forest - HH
Red: 2007
Blue: 2008
Green: 2009
Yellow: 2010
HH
07 08 09 10 07 08 09 10 07 08 09 10 07 08
Sumatra
New Guinea
Borneo
Mala
Forest is stable, and Non-forest is unstable
HV has larger difference of gamma-zero at forest and non-forest
0
-5
-10
-15
-20
-25
-30
Forest - HV
Non-Forest - HV
Red: 2007
Blue: 2008
Green: 2009
Yellow: 2010
HV
07 08 09 10 07 08 09 10 07 08 09 10 07 08 09 10 07 08 09 10 07 08 09 10 07 08 09 10 07 08 09 10 07 08 09 10 07 08 09 10 07 08 09 10 07 08 09 10 07 08 09 10 07 08 09 10 07 08 09 10
Sumatra
New Guinea
Borneo
Malaysia
Philippines
East Asia
Japan
India
Europe /Russia
Australia
Amazon
Chile
Africa
North America
Central America

Summary- ALOS/PALSAR(2007-2010)

- The PALSAR remained stable (within 0.065dB) over its lifetime (from 2006 to 2010) so changes in HV g^0 over time could be attributed to changes in the land cover.
- For forest areas, g^0 remained stable at both HH and HV, with annual averages of the standard deviation being 0.21 ±0.18dB and 0.21±0.19dB respectively.
- The thresholds for HH and HV g^0 for separating forest and non-forest were regionally variable, being −6.89±0.95dB in HH and −12.07±1.52dB in HV.
- In comparison to the DCP, GEI and FRA 2005/2010, accuracies of 84.86%, 91.25%, and 94.81% were obtained in the mapping of forest and non-forest at a global level with regional variations.
- Based on these estimates, the decrease in forest cover between 2007 and 2010 was 1.620 million ha (−0.042%), with the FRA estimating a decrease of 27.903 million ha (−0.687%; based on FRA2010 and FRA2005).
- g^0 decreased by 0.040dB yr^{-1} in HH and 0.028dB yr^{-1} in HV globally and regionally, with this potentially related to decreases in forest area and AGB and a smoothing of the non-forest area (e.g., as a consequence of agricultural management leading to improvement of cleared areas).

FNF classification results (2007-2010)



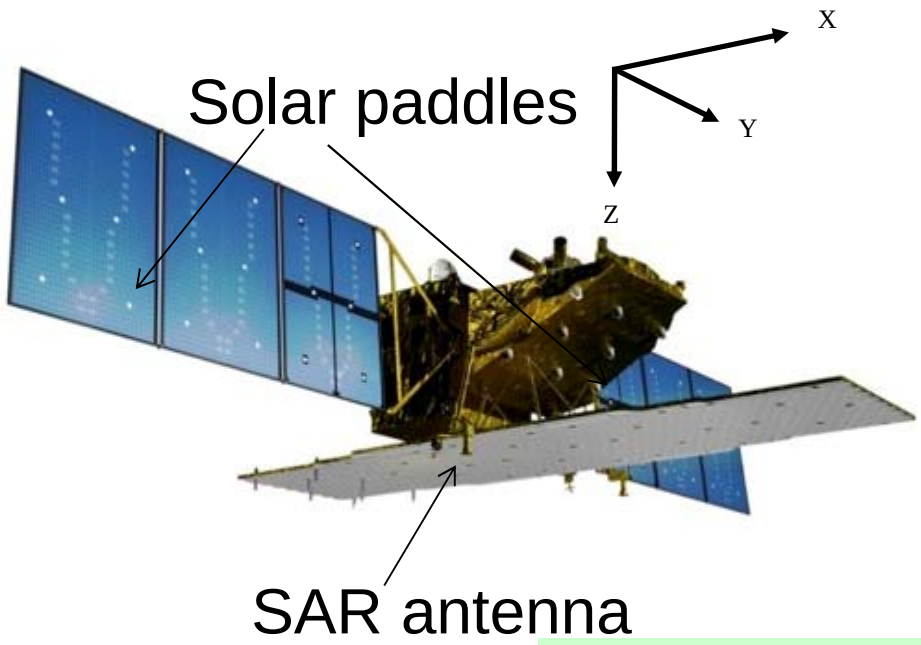
Masanobu Shimada, Takuya Itoh, Takeshi Motooka, Manabu Watanabe, Shiraishi Tomohiro, Rajesh Thapa, and Richard Lucas, "New Global Forest/Non-forest Maps from ALOS PALSAR Data (2007-2010)," Remote Sensing of Environment, DOI=10.1016/j.rse.2014.04.014.

ALOS-2 Specifications

ALOS-2 satellite

- **Launch** : **May 24, 2014**
- Orbit type : Sun-synchronous
- Altitude : 628 km +/- 500 m (for reference orbit)
- Revisit time : 14 days
- LSDN : 12:00 +/- 15 min

ALOS-2



PALSAR-2

- L-band Synthetic Aperture Radar
- Active Phased Array Antenna

type

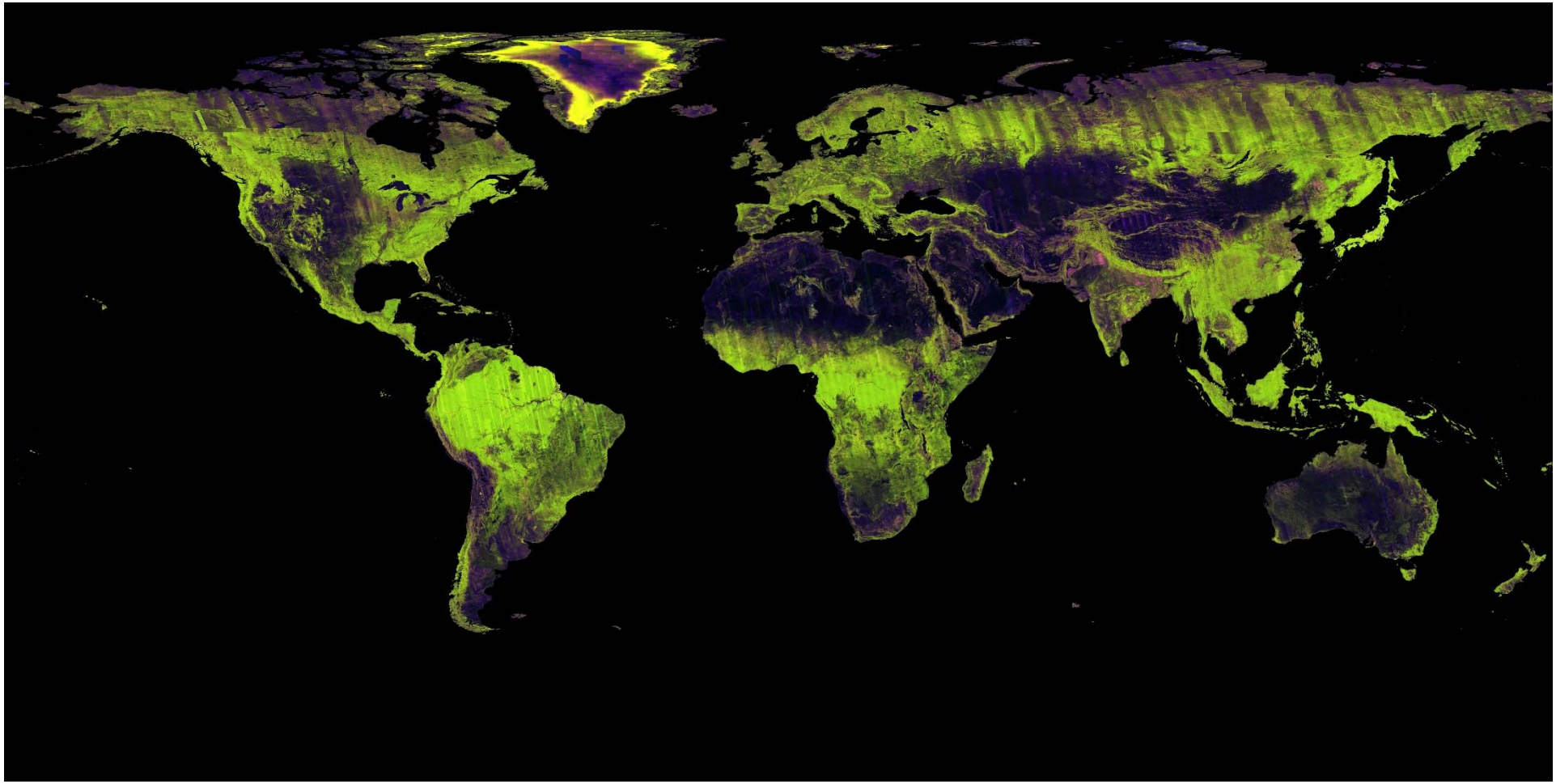
two dimensions scan (range and azimuth)

- Antenna size : 3m(El) x 10m(Az)
- Bandwidth : 14 – 84MHz
- Peak transmit Power : 5100W
- Observation swath : 25 – 490km
- Resolution : Range: 3 m to 100 m

Azimuth: 1 m to 100 m

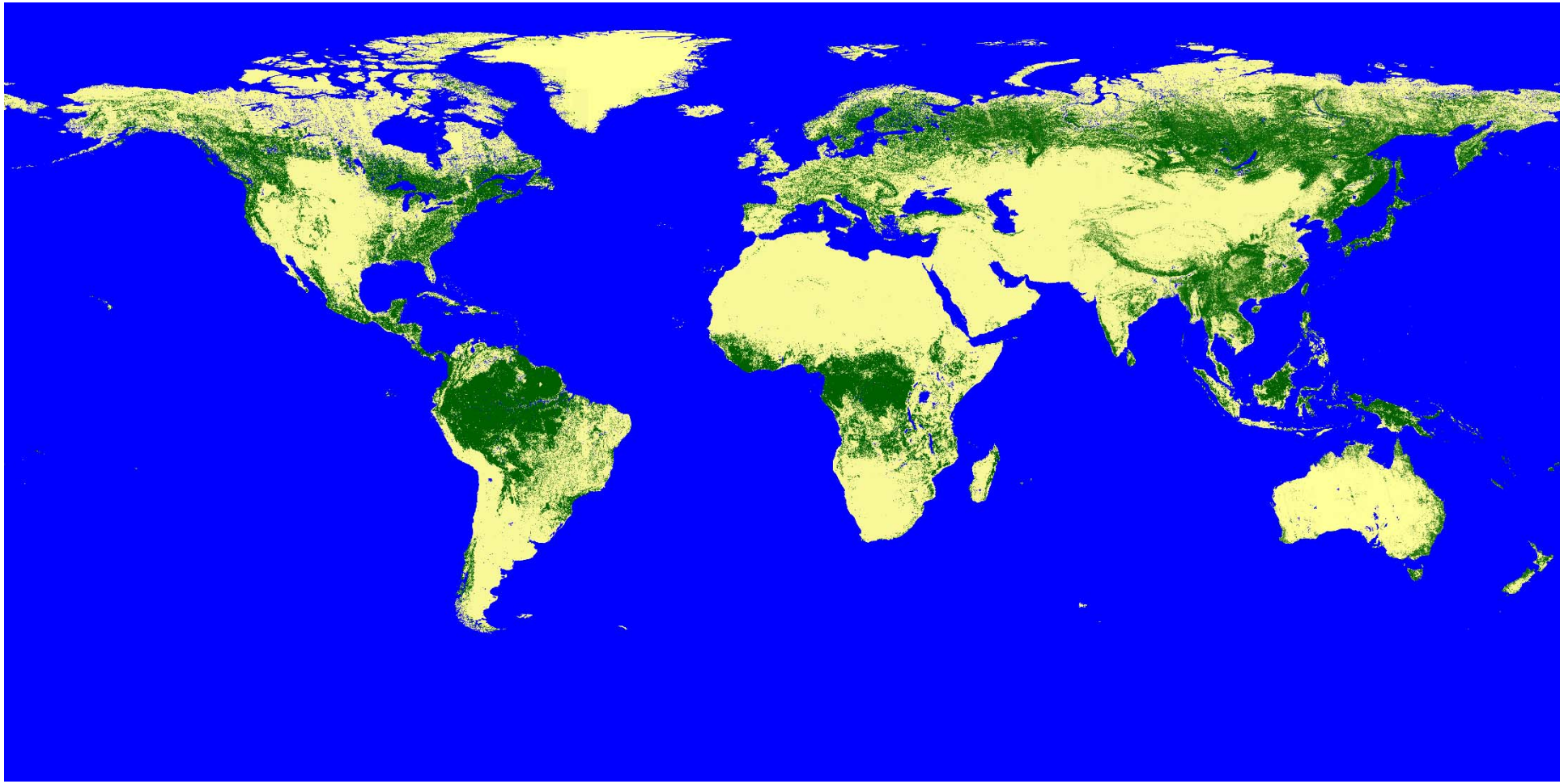
Status of the forest after 2014?

First 25m PALSAR/PALSAR-2 Global Mosaic as of Dec. 2015.



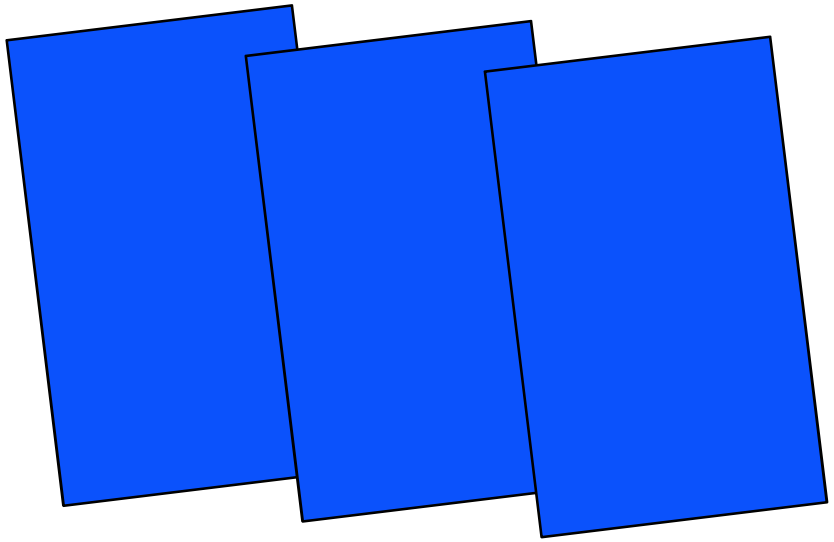
- Coverage ratio of PALSAR-2 at 2014 and 2015 is 97.65%, and 2.35% is ionosphere affected and replaced by PALSAR (2010).
- Slope-corrected and ortho-rectified 25 m spaced PALSAR-2 data.
- Although Eurasia is affected by the snow cover (dark stripes), other areas are normal.

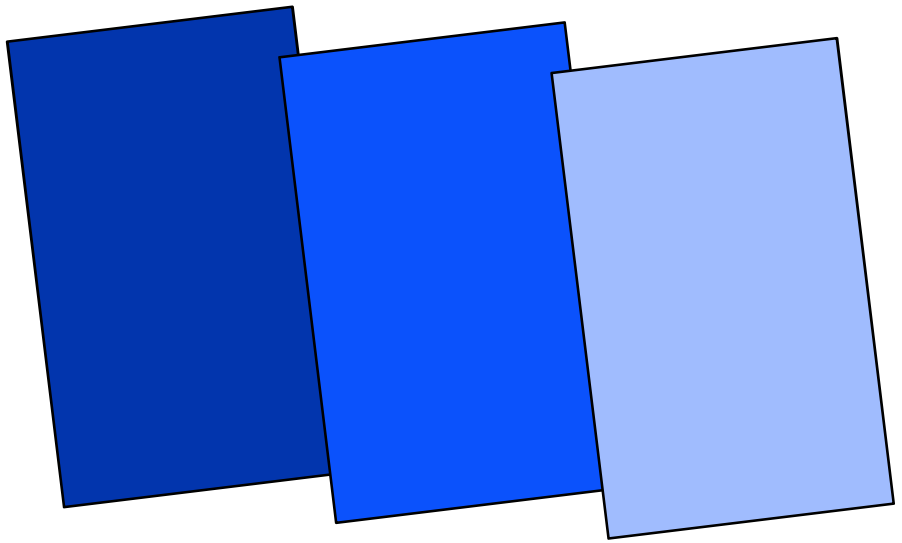
First 25m PALSAR/PALSAR-2 Global FNFas of Dec. 2015.



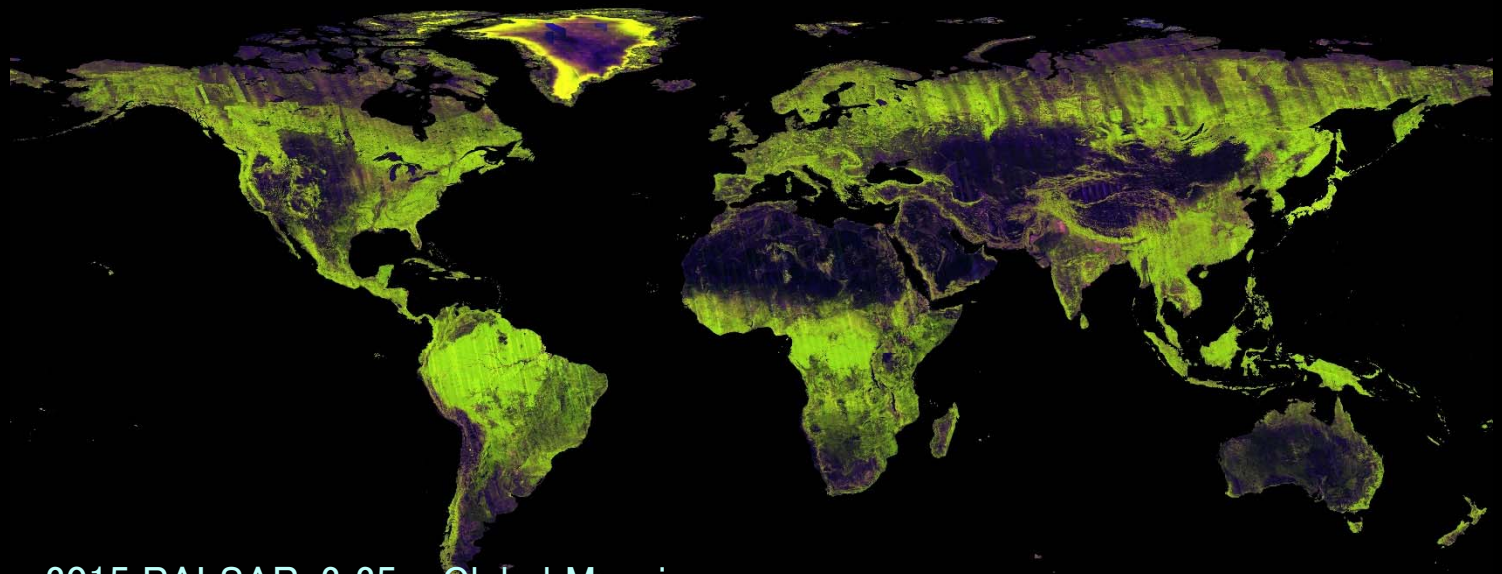
Differences between PALSAR/PALSAR-2

	PALSAR	PALSAR-2
Orbits and width/orbit over equator	671 59.6 km	207 64.4 km
Image width	70km	70km
Gain	MGC	AGC
Incidence angle range	~5 degrees (33~38 degrees)	~14degrees (28.5~33.9,33.7~ degrees)
Overlap	large	small

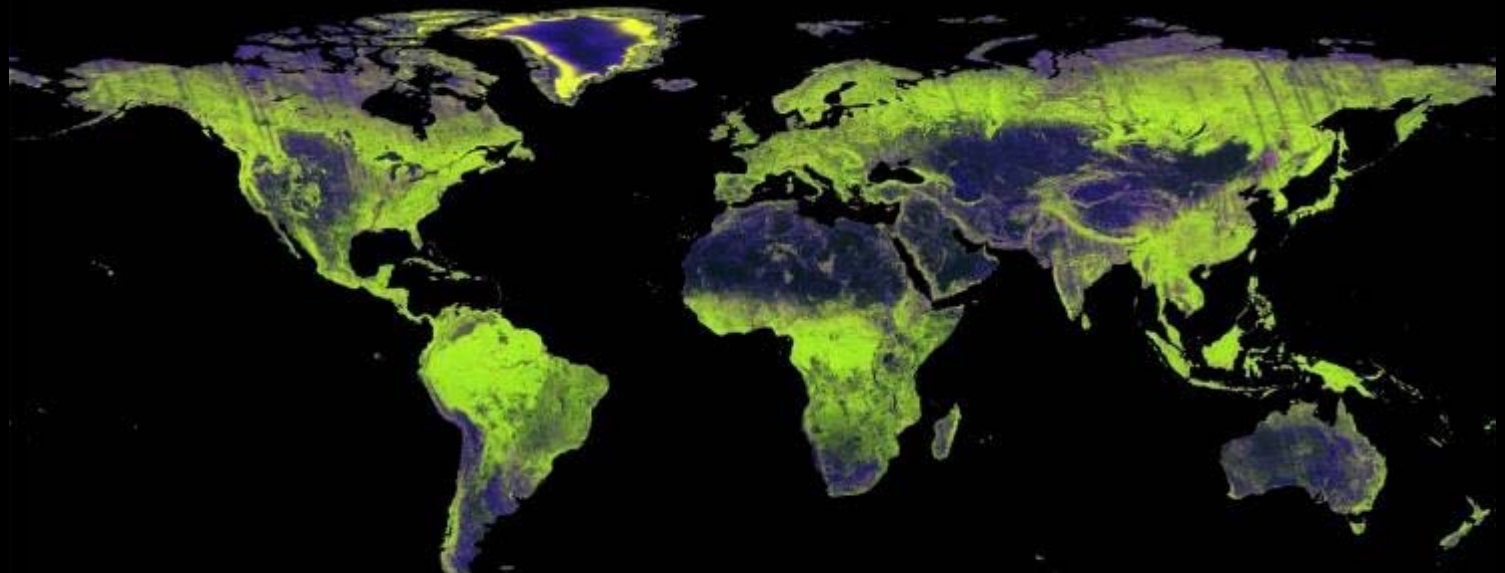




Comparison of 25m PALSAR/PALSAR-2

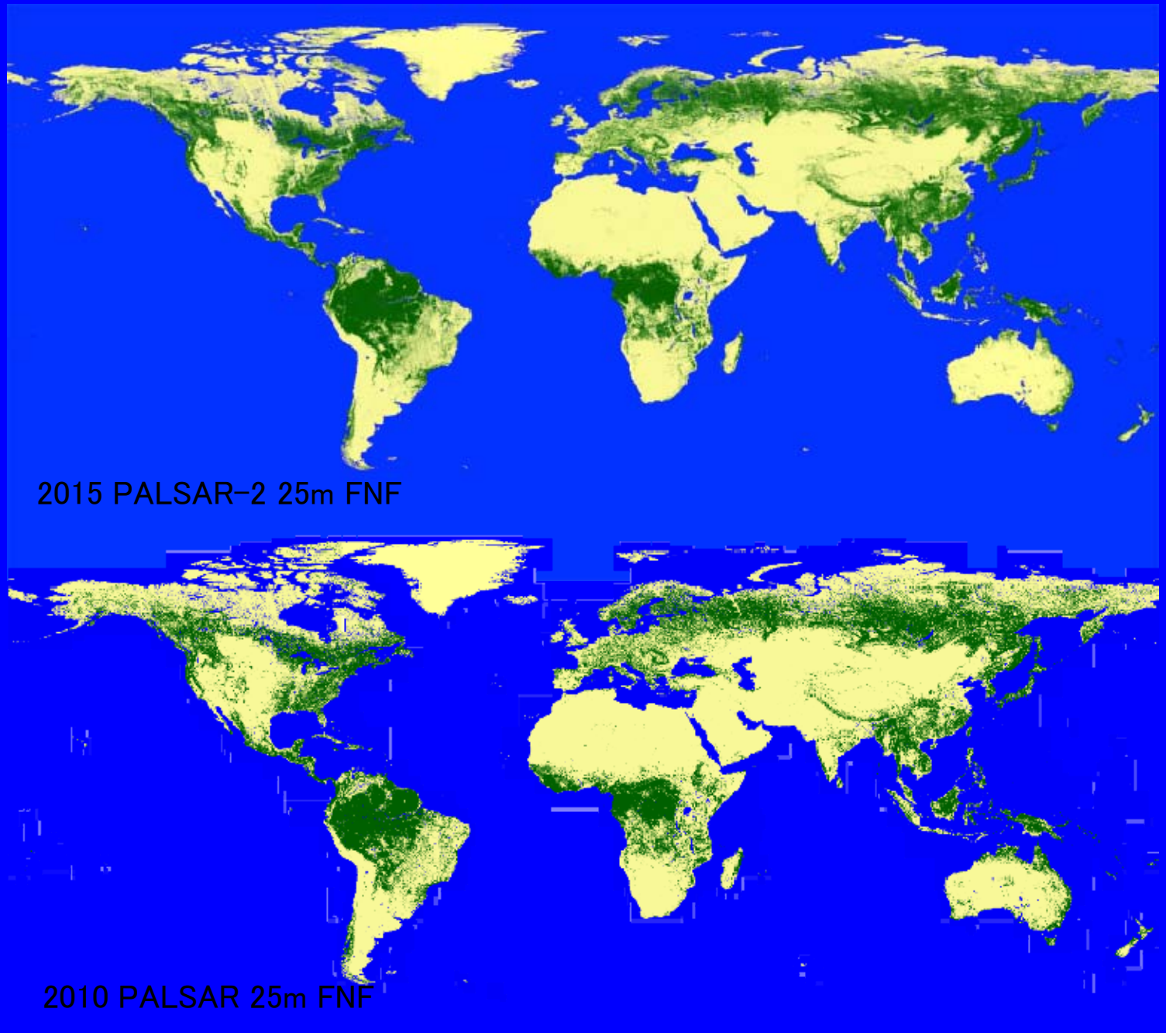


2015 PALSAR-2 25m Global Mosaic



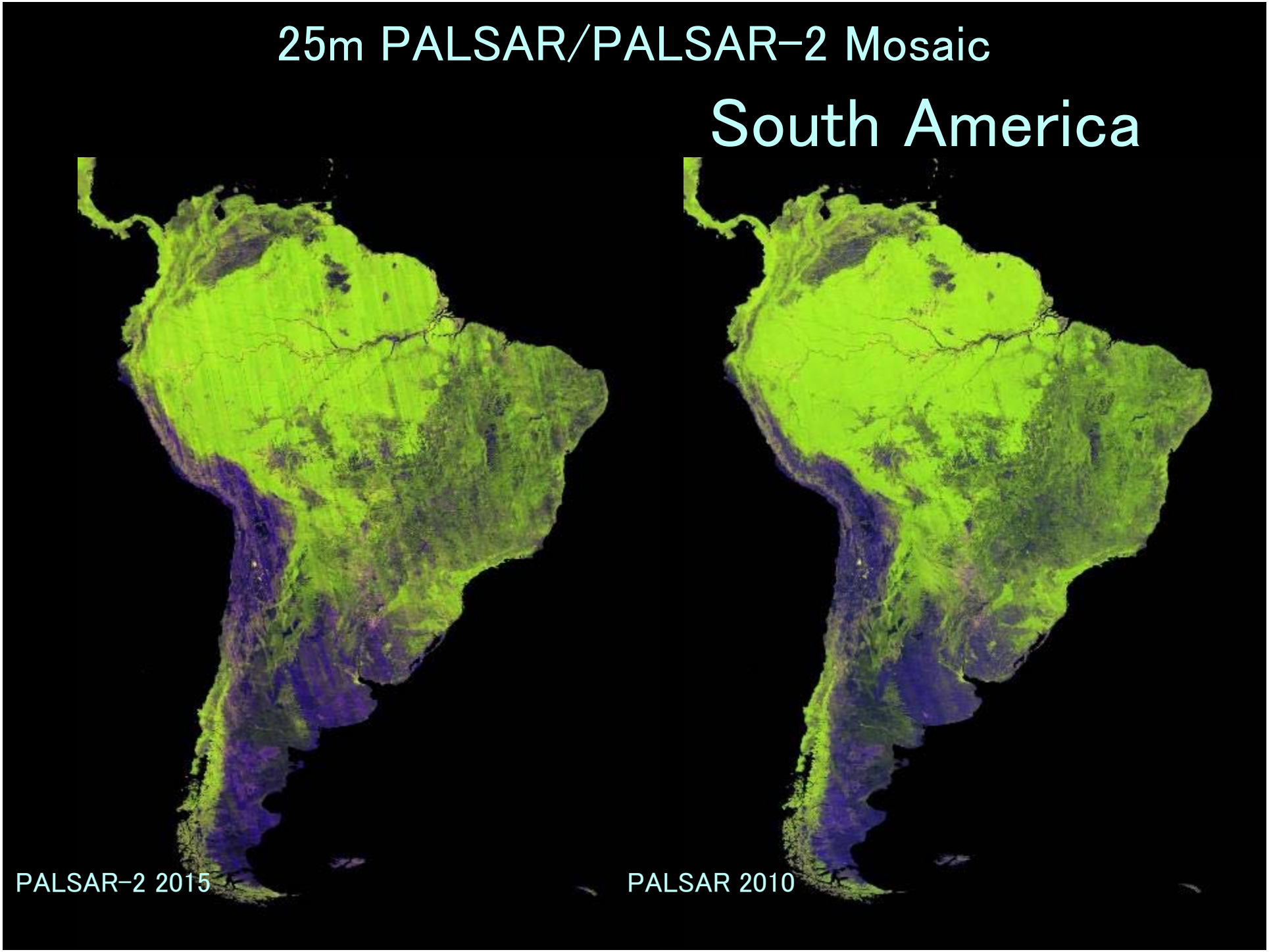
2010 PALSAR 25m Global Mosaic

25m PALSAR/PALSAR-2 Forest/Non-Forest

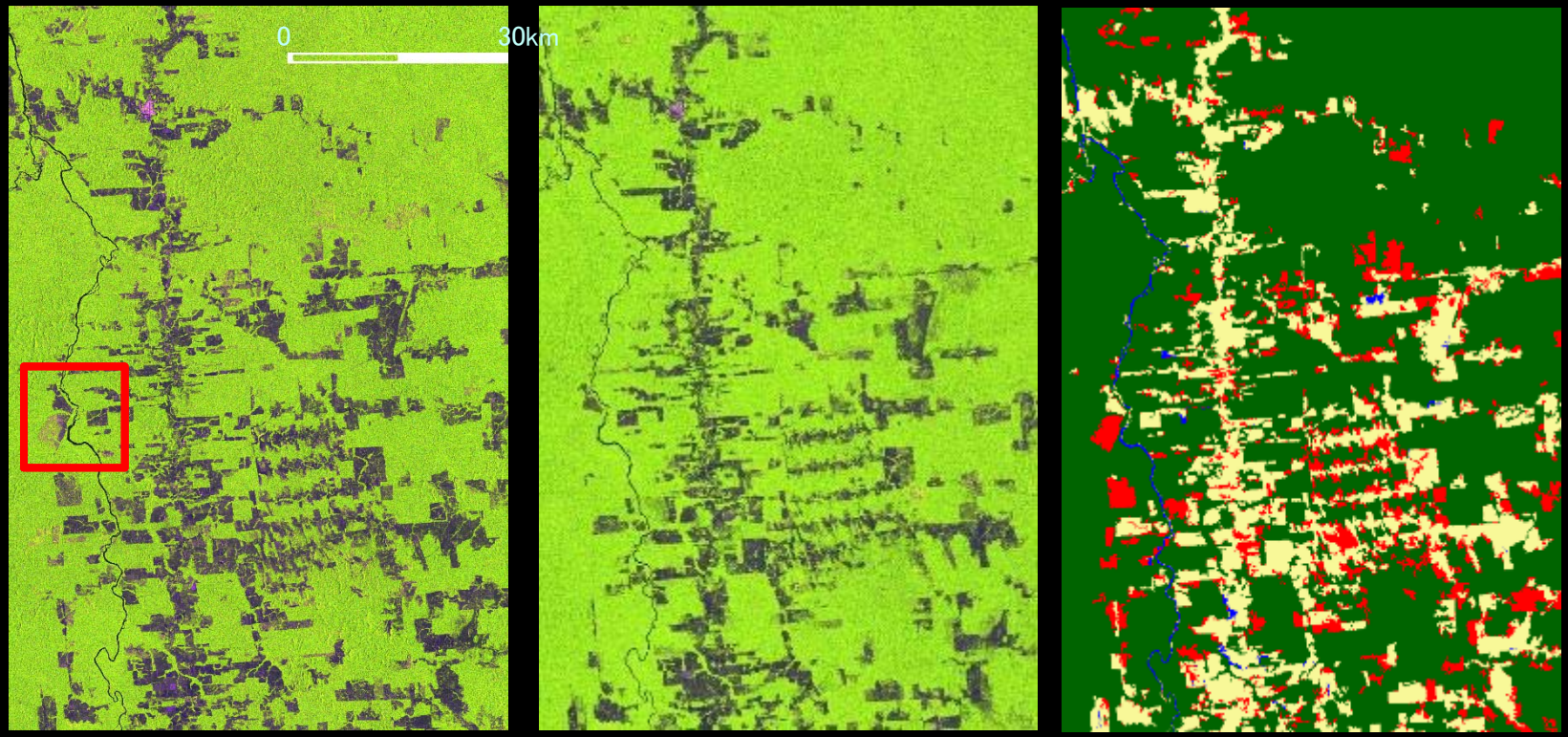


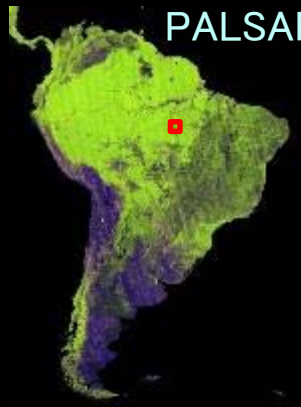
25m PALSAR/PALSAR-2 Mosaic

South America



25m PALSAR/PALSAR-2 Mosaic





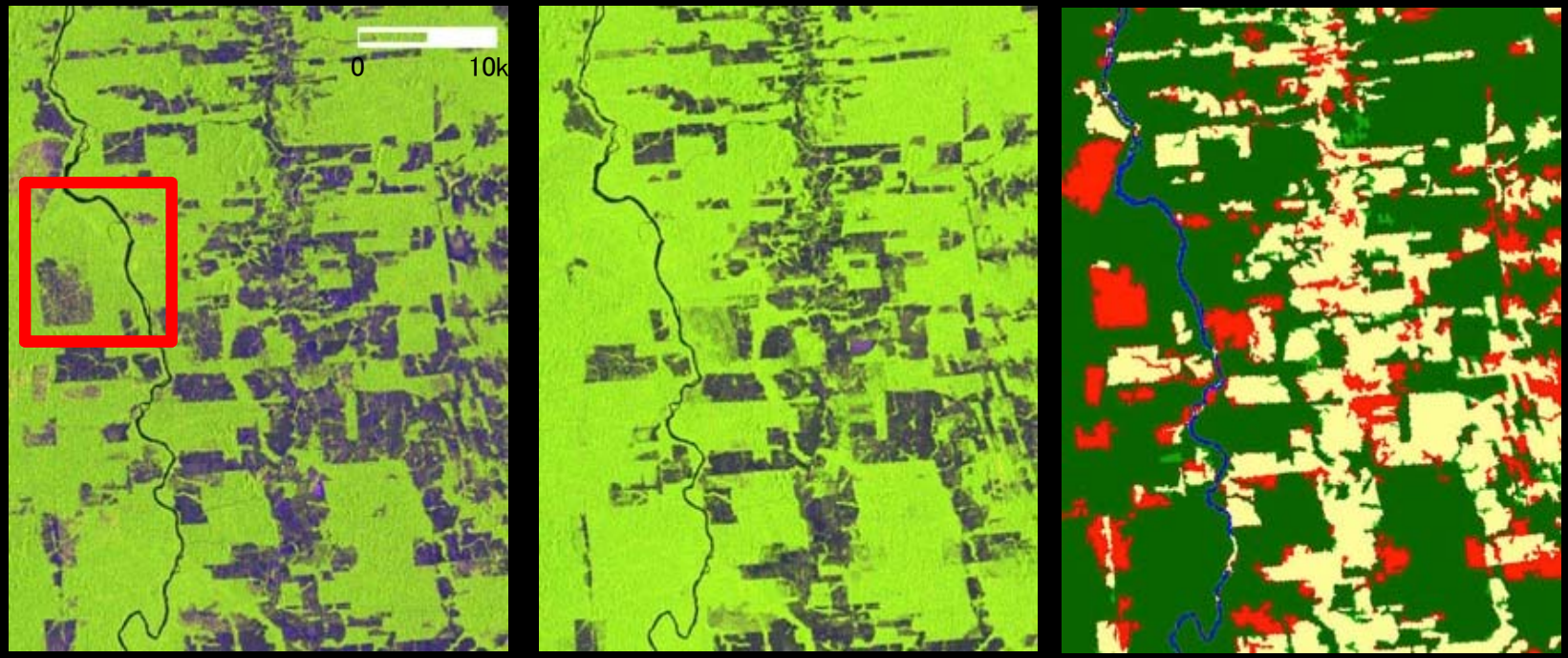
PALSAR-2 2015

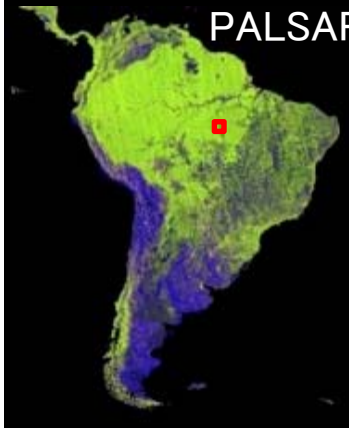
PALSAR 2010

South America (Brazil)

- : Forest
- : Non-Forest
- : Deforestation
- : Reforestation

25m PALSAR/PALSAR-2 Mosaic





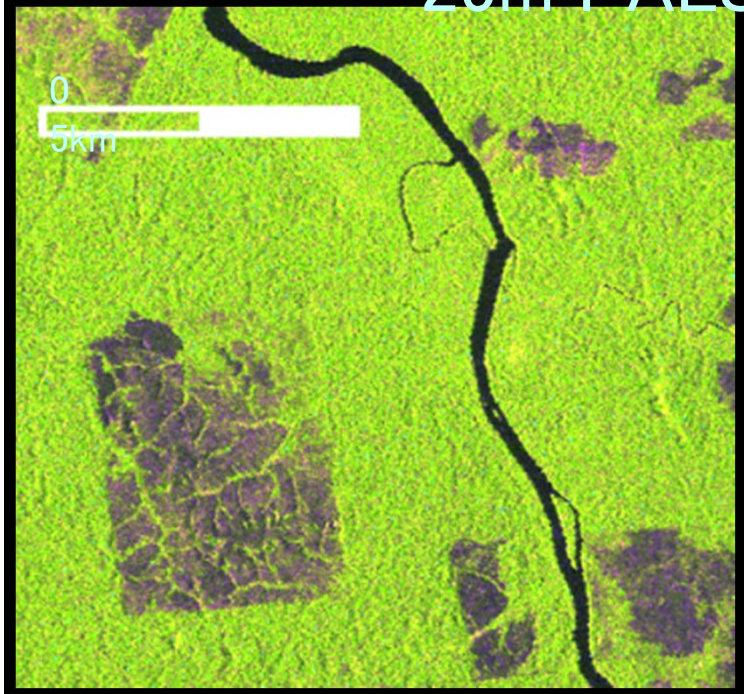
PALSAR-2 2015

PALSAR 2010

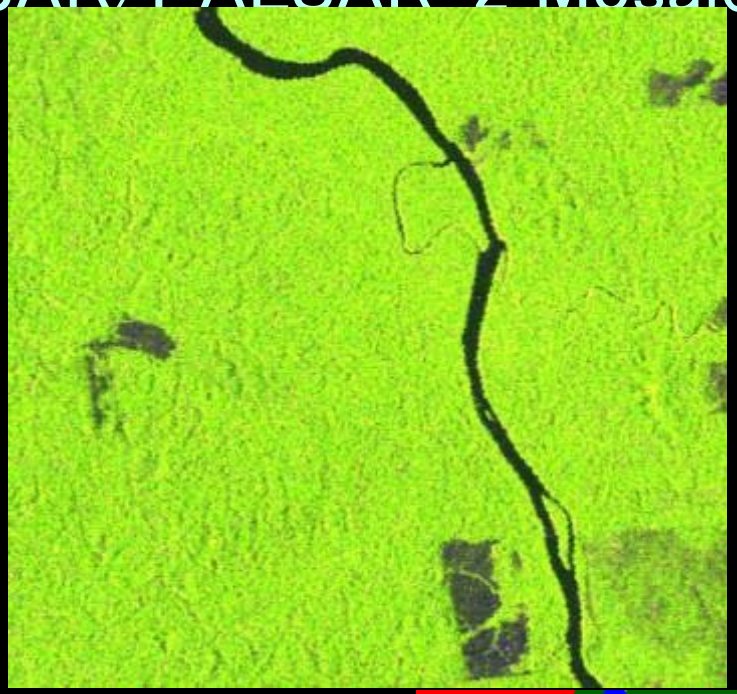
South America (Brazil)

- : Forest
- : Non-Forest
- : Deforestation
- : Reforestation

25m PALSAR/PALSAR-2 Mosaic

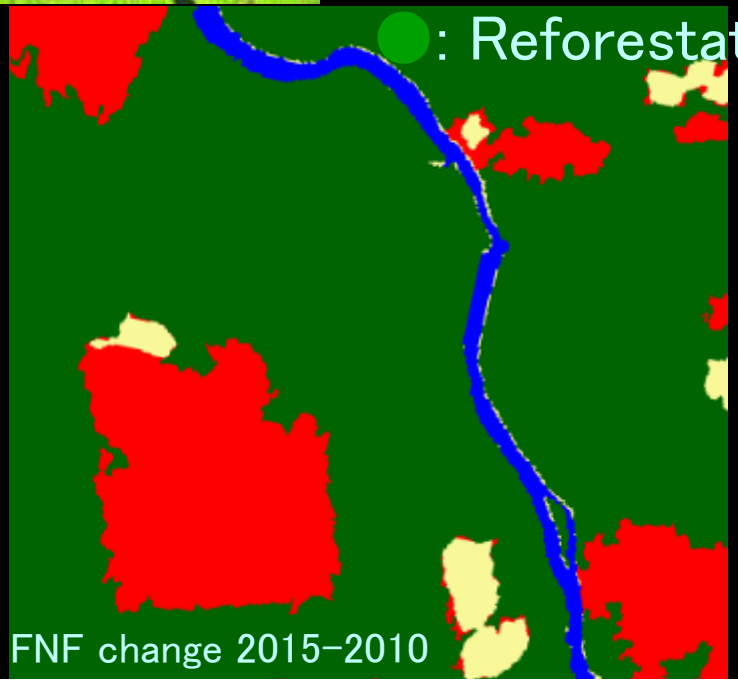


PALSAR-2 2015

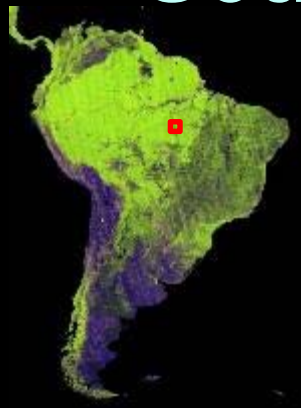


PALSAR 2010

: Forest
: Non-Forest
: Deforestati
: Reforestati



South America (Brazil)



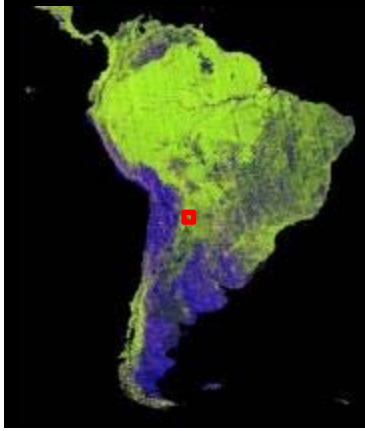
25m PALSAR/PALSAR-2 Mosaic

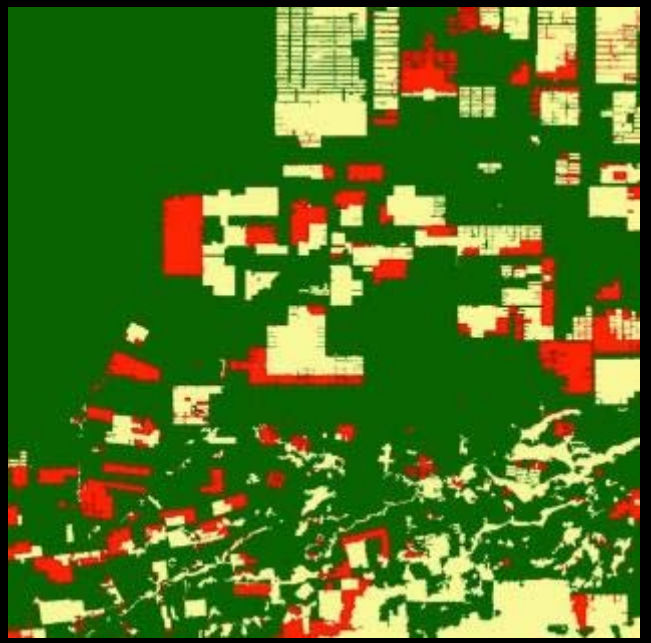
PALSAR-2 2015

PALSAR 2010

: Forest
: Non-Forest
: Deforestation
: Reforestation

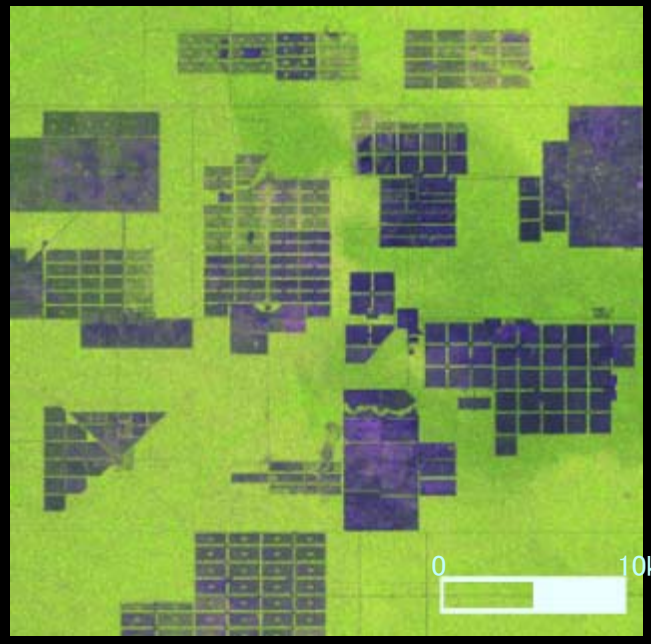
South America
(Paraguay)



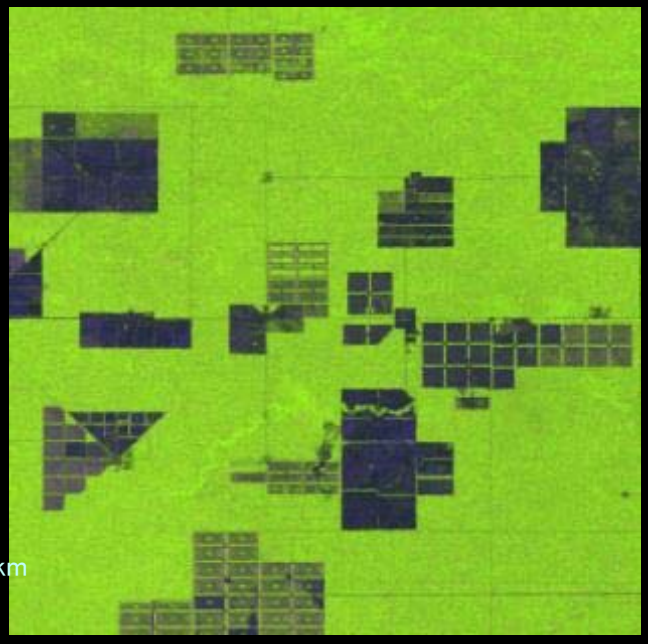


FNF change 2015-2010

25m PALSAR/PALSAR-2 Mosaic

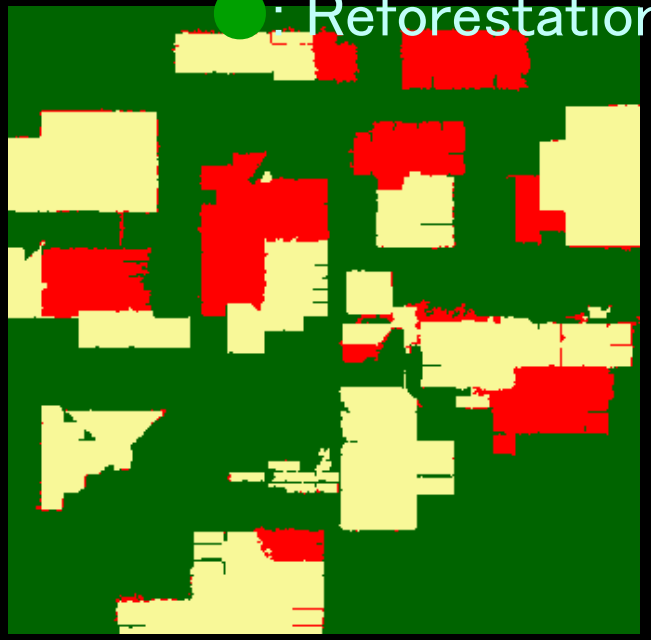


PALSAR-2 2015

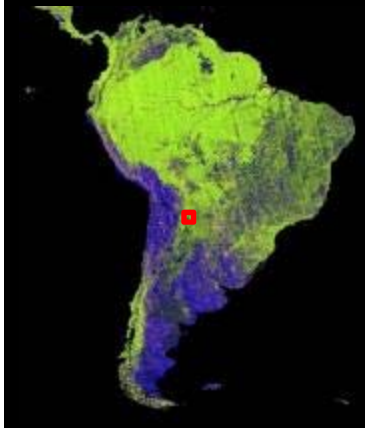


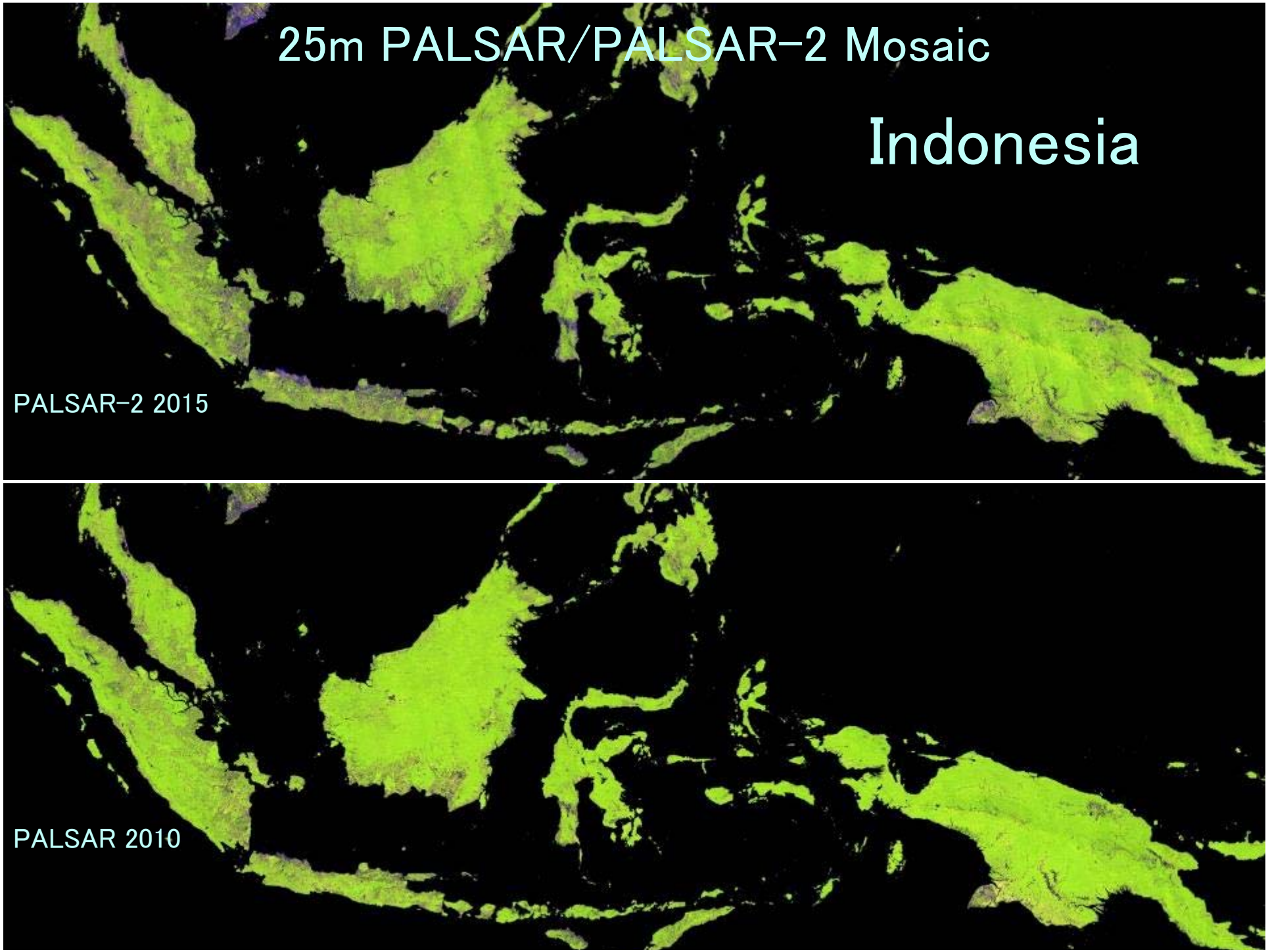
PALSAR 2010

: Forest
: Non-Forest
: Deforestation
: Reforestation



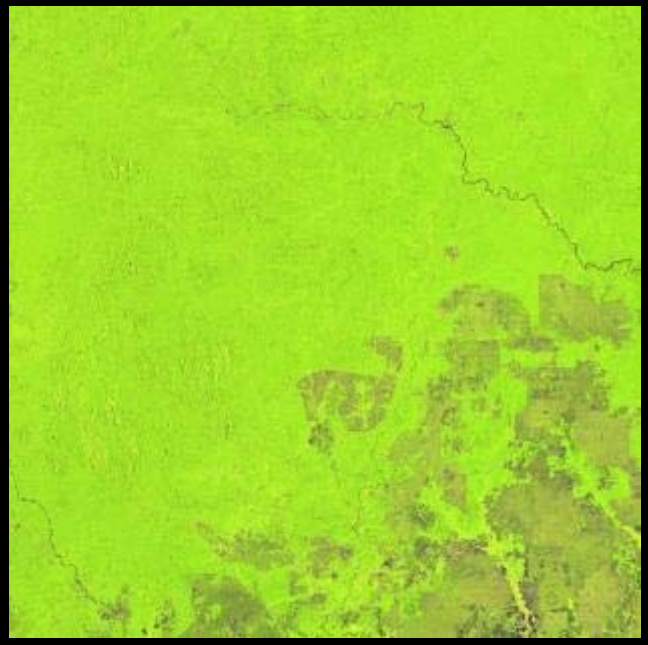
South America
(Paraguay)




25m PALSAR/PALSAR-2 Mosaic
Indonesia
PALSAR-2 2015
PALSAR 2010

25m PALSAR/PALSAR-2 Mosaic

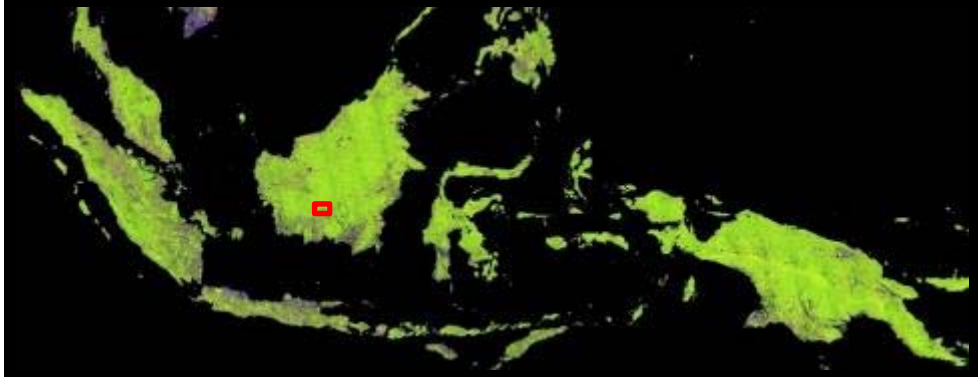
PALSAR-2 2015

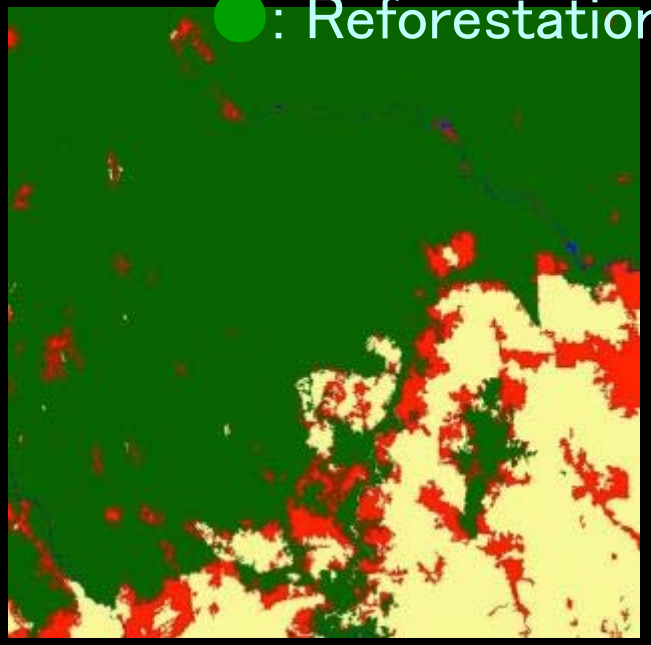


PALSAR 2010

: Forest
: Non-Forest
: Deforestation
: Reforestation

Indonesia (Kalimantan)

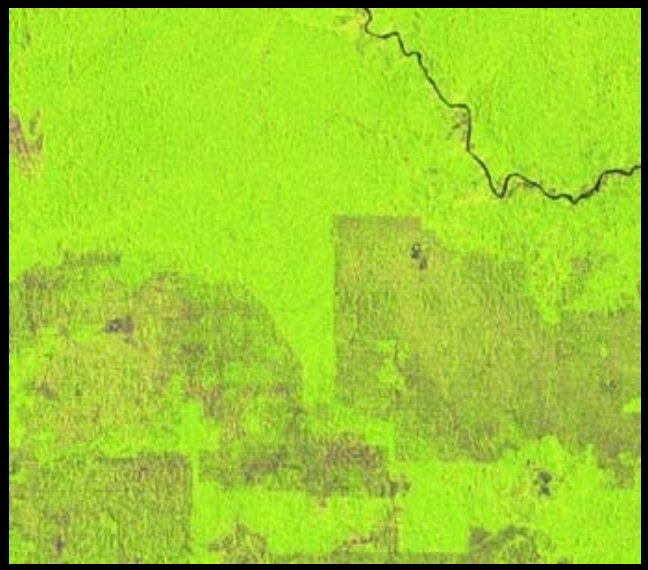




FNF change 2015-2010

25m PALSAR/PALSAR-2 Mosaic

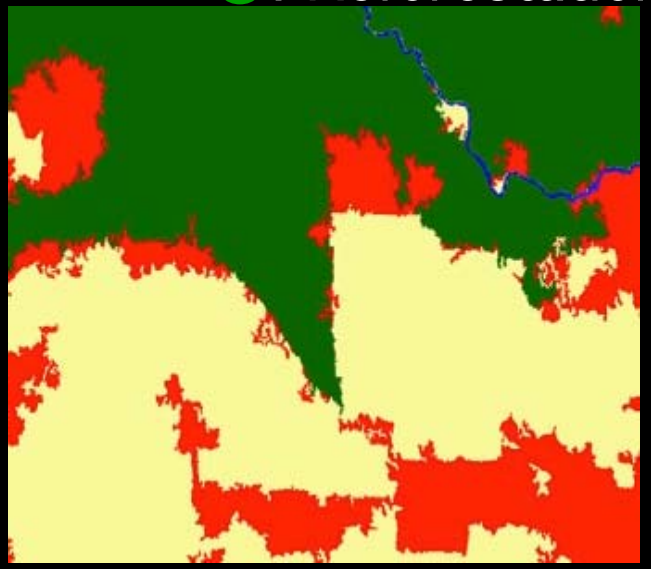
PALSAR-2 2015



PALSAR 2010

: Forest
: Non-Forest
: Deforestation
: Reforestation

Indonesia (Kalimantan)



FNF change 2015-2010

25m PALSAR/PALSAR-2 Mosaic

PALSAR-2 2015

PALSAR 2010

: Forest
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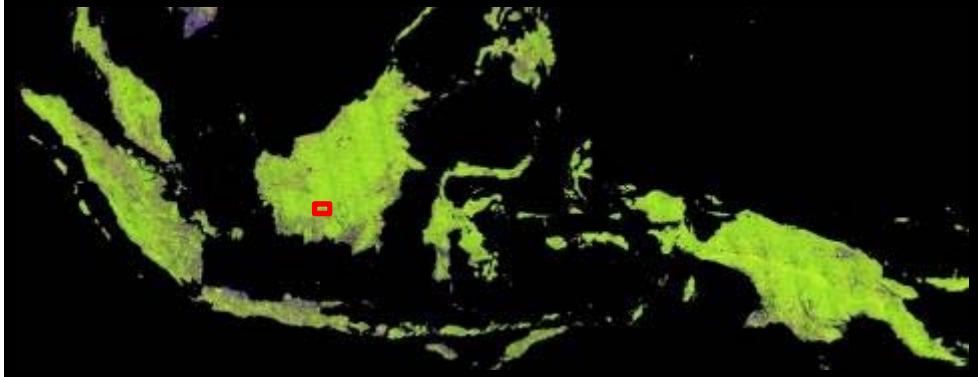
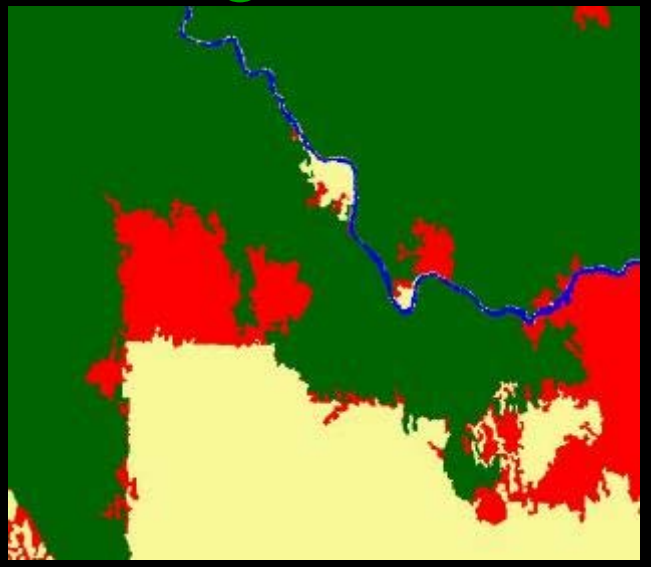
: Reforestation

Indonesia (Kalimantan)





FNF change 2015-2010

Comparison of the PALSAR-FRA

Area	2008			2009		
	PALSAR(2008) [1000ha]	FRA(2005) [1000ha]	Relarive Error (±) [%] (PALSAR vs FRA)	PALSAR(2009) [1000ha]	FRA(2010) [1000ha]	Relarive Error (±) [%] (PALSAR vs FRA)
Indonesia	100,544	97,857	2.75%	94,392	94,432	−0.04%
South America	825,212	860,443	−4.09%	813,203	843,995	−3.65%
Africa	630,185	654,586	−3.73%	641,822	638,187	0.57%
Brazil	452,545	506,734	−10.69%	446,721	498,458	−10.38%
Colombia	77,216	60,201	28.26%	75,712	58,635	29.12%
Peru	76,723	75,528	1.58%	76,266	74,811	1.95%
Venezuela	55,842	47,713	17.04%	55,015	47,505	15.81%
Ecuador	17,999	13,335	34.97%	17,045	12,942	31.71%
Indonesia	100,544	97,857	2.75%	94,392	94,432	−0.04%
Papua New Guinea	32,410	33,586	−3.50%	32,624	33,573	−2.83%
Malaysia	19,891	20,890	−4.78%	18,733	22,124	−15.33%
Congo (Kinshasa)	167,228	155,692	7.41%	166,466	154,135	8.00%
Mozambique	26,772	40,079	−33.20%	26,188	38,972	−32.80%
Tanzania	31,160	49,920	−37.58%	26,217	47,920	−45.29%
Central African Republic	48,414	22,326	116.85%	50,155	22,248	125.43%
Congo (Brazzaville)	24,738	22,471	10.09%	24,856	22,411	10.91%
Gabon	23,891	22,000	8.60%	23,942	22,000	8.83%
Cameroon	35,791	21,016	70.30%	36,807	19,916	84.81%
Nigeria	27,228	11,089	145.54%	27,056	9,041	199.26%

PALSAR, PALSAR-2 meets FRA generally. In average 95% agreement

Comparison of the PALSAR-PALSAR-2-FRA

	2010			2015		
Area	PALSAR(2010) [1000ha]	FRA(2010) [1000ha]	Relarive Error (±) [%] (PALSAR vs FRA)	PALSAR-2(2015) [1000ha]	FRA(2015) [1000ha]	Relarive Error (±) [%] (PALSAR vs FRA)
Indonesia	103,811	94,432	9.93%	95,703	91,010	5.16%
South America	811,082	843,995	-3.90%	789,918	833,881	-5.27%
Africa	653,447	638,187	2.39%	599,593	624,009	-3.91%
Brazil	436,358	498,458	-12.46%	435,823	493,538	-11.69%
Colombia	77,667	58,635	32.46%	73,117	58,502	24.98%
Peru	76,266	74,811	1.95%	74,656	73,973	0.92%
Venezuela	56,890	47,505	19.76%	52,856	46,683	13.22%
Ecuador	17,472	12,942	35.01%	16,794	12,548	33.84%
Indonesia	103,811	94,432	9.93%	95,703	91,010	5.16%
Papua New Guinea	31,124	33,573	-7.29%	31,916	33,559	-4.90%
Malaysia	17,964	22,124	-18.80%	18,578	22,195	-16.30%
Congo (Kinshasa)	167,631	154,135	8.76%	165,012	152,578	8.15%
Mozambique	26,961	38,972	-30.82%	24,359	37,940	-35.80%
Tanzania	27,029	47,920	-43.60%	25,584	46,060	-44.45%
Central African Republic	52,781	22,248	137.24%	51,521	22,170	132.39%
Congo (Brazzaville)	24,610	22,411	9.81%	24,499	22,334	9.69%
Gabon	23,861	22,000	8.46%	23,867	23,000	3.77%
Cameroon	36,565	19,916	83.59%	36,003	18,816	91.34%
Nigeria	28,317	9,041	213.21%	18,576	6,993	165.64%

PALSAR, PALSAR-2 meets FRA generally. In average 95% agreement

Forest area change 2007-2010-2015 at several countries

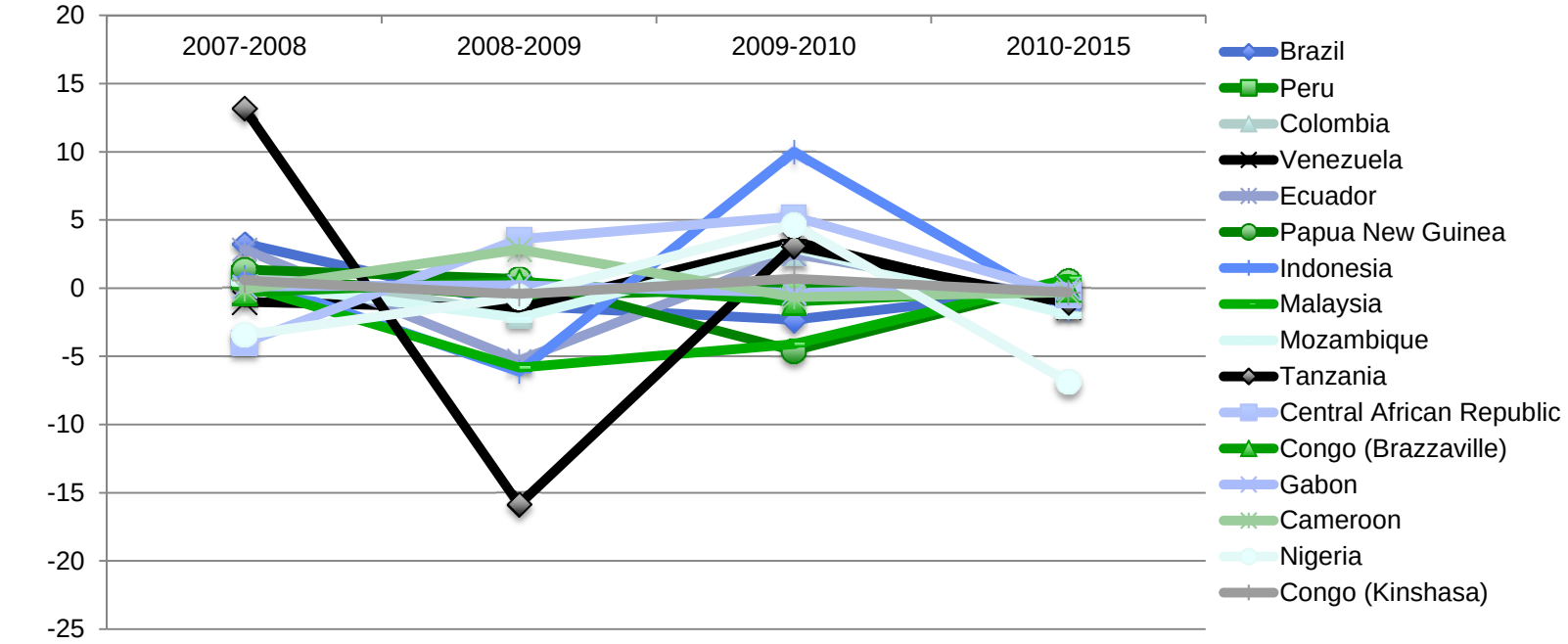
Area	Change(2010–2015)		Change(2007/2005–2015)	
	PALSAR/PALSAR-2 (2010–2015) [1000ha]	FRA (2010–2015) [1000ha]	PALSAR/PALSAR-2 (2007–2015) [1000ha]	FRA (2005–2015) [1000ha]
Indonesia	−8,108	−3,422	−4,029	−6,847
South America	−21,163	−10,115	−17,871	−40,277
Africa	−53,854	−14,179	−35,867	−67,360
Brazil	−535	−4,920	−2,445	−36,956
Colombia	−4,550	−134	−3,063	−2,502
Peru	−1,611	−838	−1,471	5,231
Venezuela	−4,035	−822	−3,556	−1,030
Ecuador	−678	−394	−708	1,695
Indonesia	−8,108	−3,422	−4,029	−6,847
Papua New Guinea	792	−14	−59	4,122
Malaysia	614	71	−1,275	1,305
Congo (Kinshasa)	−2,619	−1,557	−1,294	−3,114
Mozambique	−2,603	−1,032	−2,308	−2,139
Tanzania	−1,445	−1,860	−1,949	10,615
Central African Republic	−1,261	−78	1,082	−585
Congo (Brazzaville)	−111	−77	−316	−137
Gabon	5	1,000	2	1,000
Cameroon	−562	−1,100	173	−2,200
Nigeria	−9,741	−2,048	−9,622	−4,096
Europe	−221,822	1,901	−233,405	14,364
North and Central America	−64,519	374	−80,976	45,350
Asia	−113,357	3,956	−99,794	9,313
Oceania	−77,459	1,522	−85,881	−23,221
Total	−552,174	−16,539	−553,795	−61,832

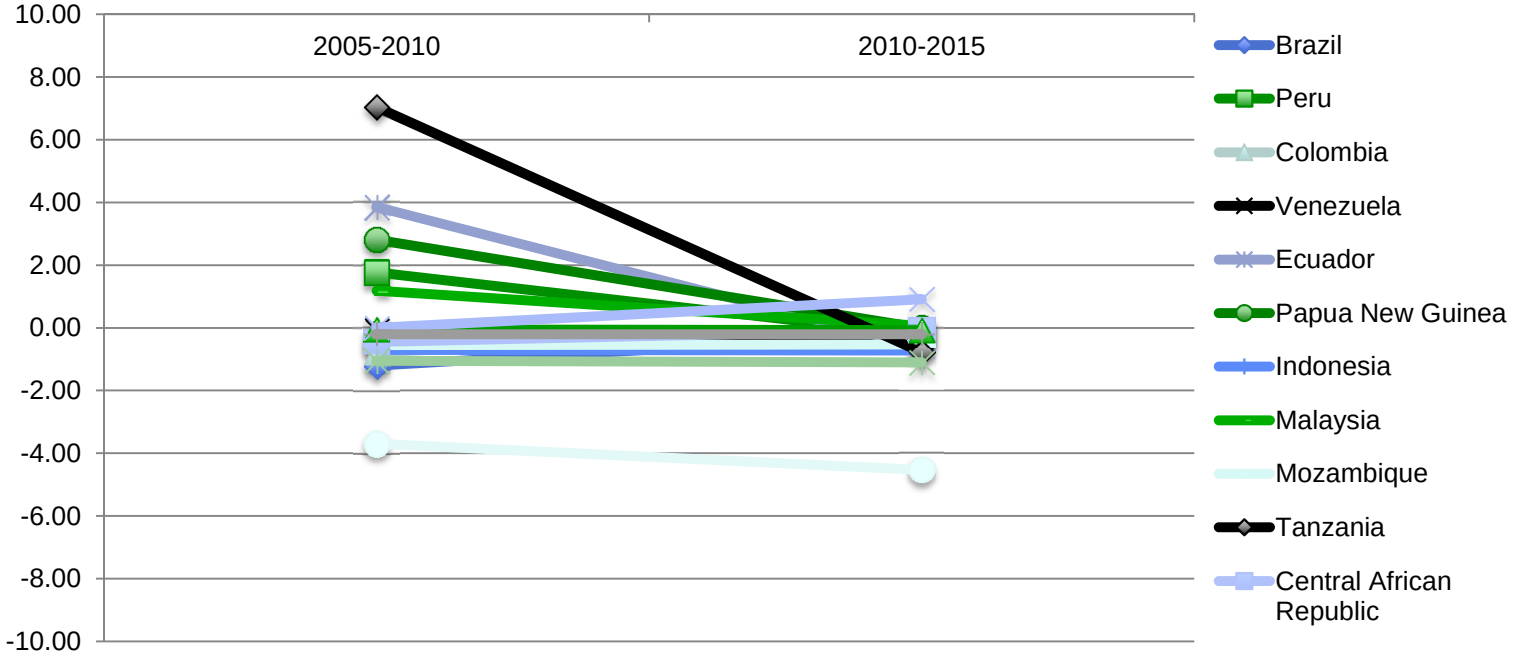
Most of the area shows forest decreases.

Forest area change 2007-2010-2015 at several countries (%).

	Annual Change Rate(%:2007-2010)		Annual Change Rate(%:2010-2015)	
Area	PALSAR/PALSAR-2 （2007-2015)	FRA(2005-2015)	PALSAR/PALSAR-2(2010-2015)	FRA(2010-2015)
Indonesia	-0.49	-0.91	-1.63	-0.70
South America	-0.28	-0.60	-0.52	-0.23
Africa	-0.69	-1.32	-1.69	-0.41
Brazil	-0.07	-0.93	-0.02	-0.19
Colombia	-0.49	-0.53	-1.19	-0.04
Peru	-0.24	0.87	-0.42	-0.24
Venezuela	-0.78	-0.27	-1.43	-0.34
Ecuador	-0.51	1.64	-0.78	-0.73
Indonesia	-0.49	-0.91	-1.63	-0.70
Papua New Guinea	-0.02	1.53	0.50	-0.01
Malaysia	-0.89	0.74	0.62	0.07
Congo (Kinshasa)	-0.10	-0.25	-0.31	-0.20
Mozambique	-1.07	-0.69	-1.95	-0.51
Tanzania	-0.90	2.77	-1.05	-1.05
Central African Republic	0.26	-0.33	-0.50	-0.07
Congo (Brazzaville)	-0.16	-0.08	-0.09	-0.07
Gabon	0.00	0.57	0.00	0.91
Cameroon	0.06	-1.38	-0.31	-1.05
Nigeria	-4.25	-5.66	-6.91	-3.69

Forest area change 2007-2010-2015 at several countries (%).



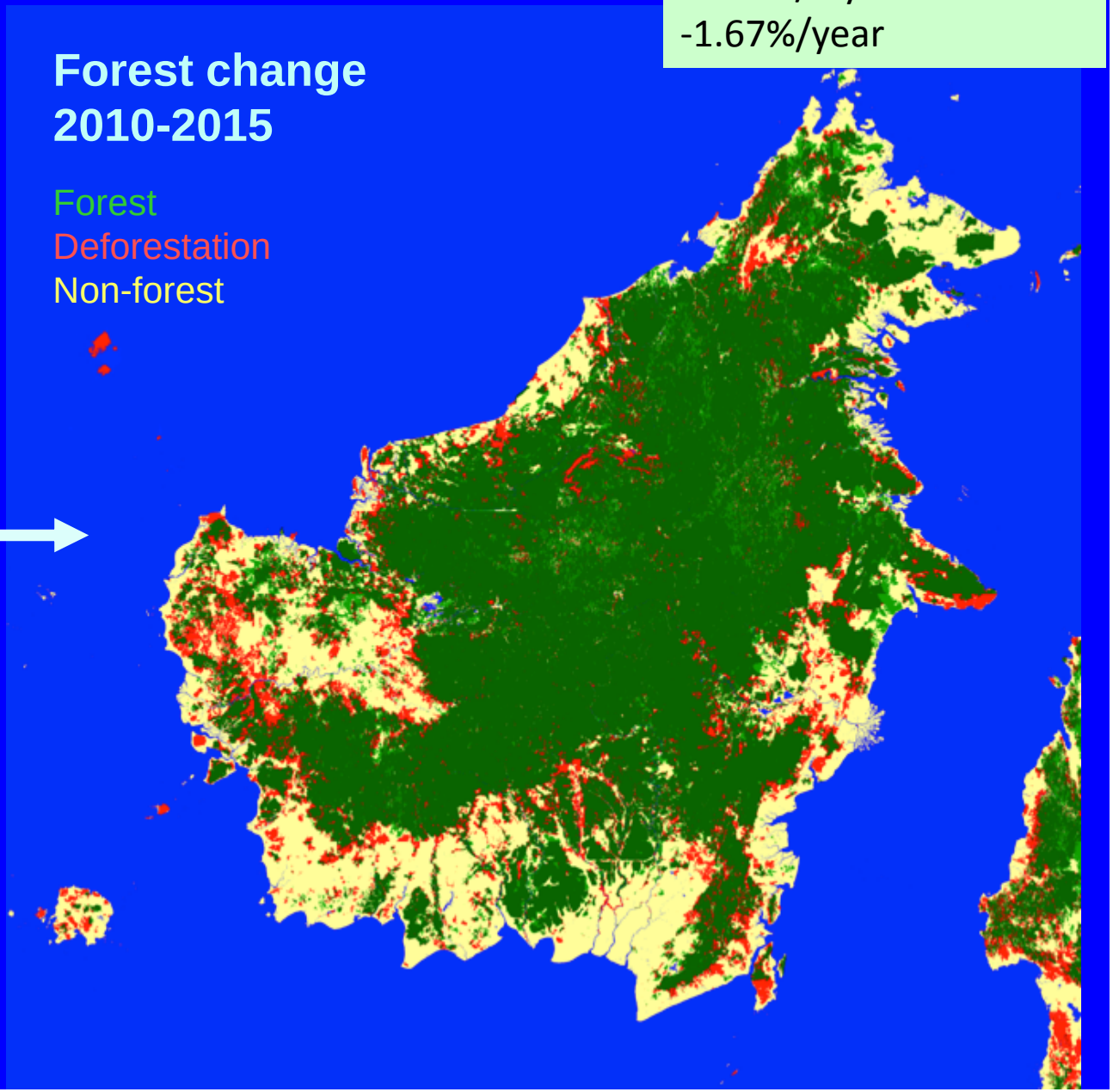


Forest Change in Borneo

2010: 34929.8[1000ha]
2015: 32010.4[1000ha]
-8.36%/5 years
-1.67%/year

Forest change 2010-2015

Forest
Deforestation
Non-forest



Conclusions(I)

- First PALSAR-2 global mosaic of 2014/2015 and the forest/non-forest were created after the ALOS-2 launch in 2014.
- PALSAR-2 FNF (2015) shows the good agreement with the FRA2015 as well as the PALSAR data because PALSAR-2 has better imaging and calibration performances even more than PALSAR.
- PALSAR/PALSAR-2 shows the annual decrease of the (natural) forest in the pan-tropical regions at in these years (2007-2015) and may cause the global warming.

Conclusions (II)

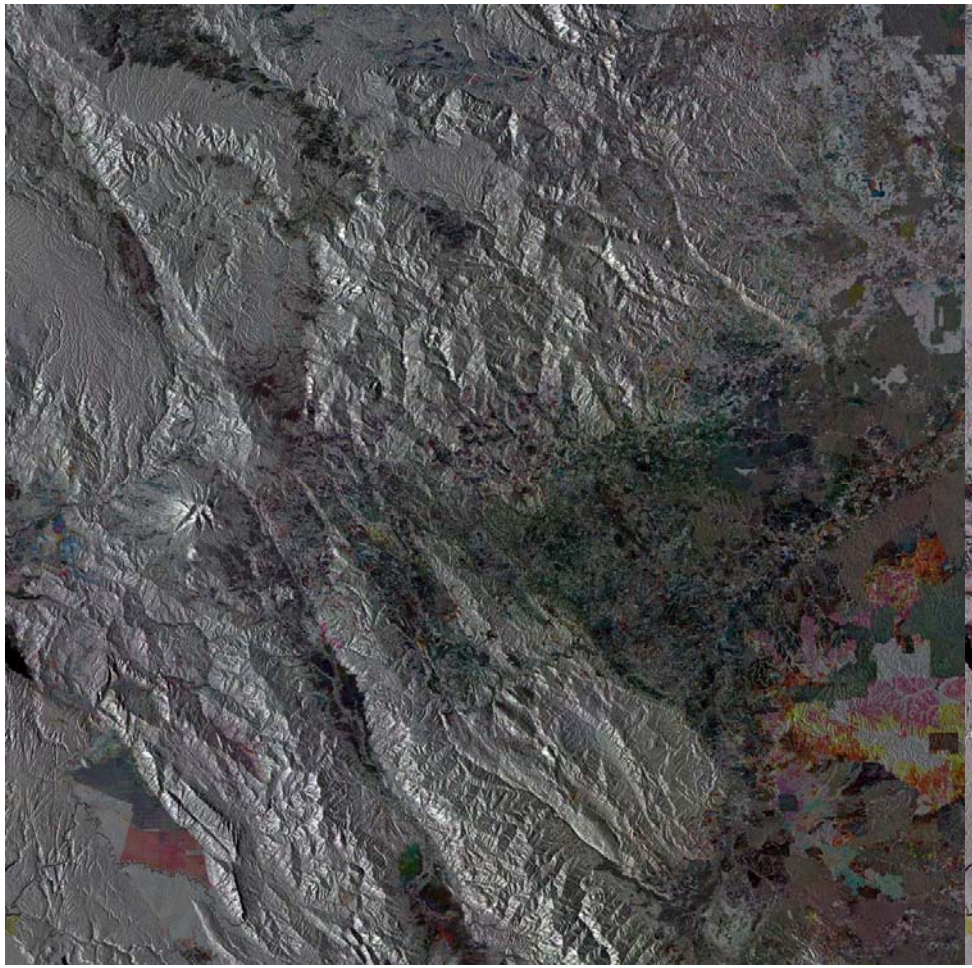
- Reprocessing of the PALSAR-2 data and more tempo-spatio analysis for determination of threshold.
- Eight year L-band SAR global data (2007-2015) is now available for the forest analysis.
- These data will be open to the public after January 2016.
- From now, global FNF will be generated routinely and annually and the change will be open to the public (Forest monitor).

Forest change 2007-2010-2015 at several countries

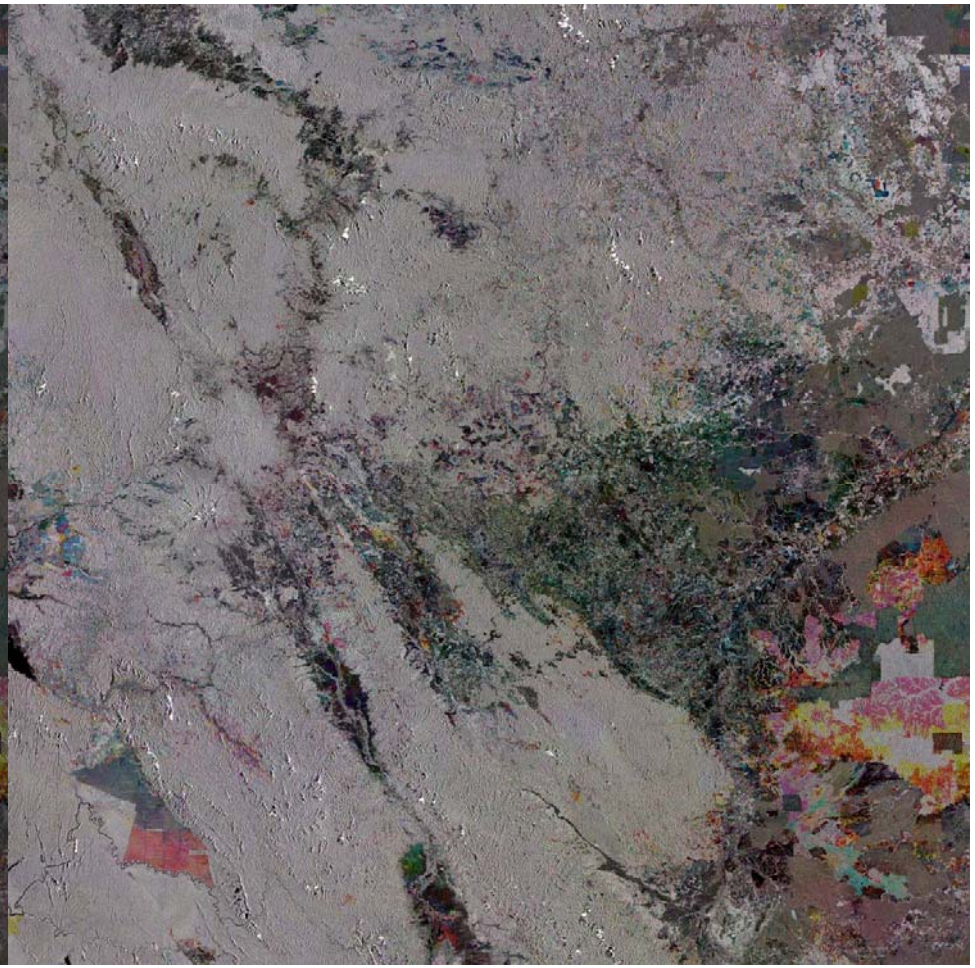
	PALSAR/PALSAR-2						FRA		
	2007	2008	2009	2010	2015		2005	2010	2015
Brazil	438,268	452,545	446,721	436,358	435,823	Brazil	530,494	498,458	493,538
Congo (Kinshasa)	166,306	167,228	166,466	167,631	165,012	Congo (Kinshasa)	155,692	154,135	152,578
Indonesia	99,731	100,544	94,392	103,811	95,703	Indonesia	97,857	94,432	91,010
Peru	76,127	76,723	76,266	76,266	74,656	Peru	68,742	74,811	73,973
Colombia	76,181	77,216	75,712	77,667	73,117	Colombia	61,004	58,635	58,502
Venezuela	56,412	55,842	55,015	56,890	52,856	Venezuela	47,713	47,505	46,683
Mozambique	26,667	26,772	26,188	26,961	24,359	Mozambique	40,079	38,972	37,940
Tanzania	27,533	31,160	26,217	27,029	25,584	Tanzania	35,445	47,920	46,060
Papua New Guinea	31,975	32,410	32,624	31,124	31,916	Papua New Guinea	29,437	33,573	33,559
Central African Republic	50,439	48,414	50,155	52,781	51,521	Central African Republic	22,755	22,248	22,170
Congo (Brazzaville)	24,814	24,738	24,856	24,610	24,499	Congo (Brazzaville)	22,471	22,411	22,334
Gabon	23,865	23,891	23,942	23,861	23,867	Gabon	22,000	22,000	23,000
Cameroon	35,830	35,791	36,807	36,565	36,003	Cameroon	21,016	19,916	18,816
Malaysia	19,853	19,891	18,733	17,964	18,578	Malaysia	20,890	22,124	22,195
Nigeria	28,198	27,228	27,056	28,317	18,576	Nigeria	11,089	9,041	6,993
Ecuador	17,502	17,999	17,045	17,472	16,794	Ecuador	10,853	12,942	12,548

	PALSAR/PALSAR-2						FRA		
	2007	2008	2009	2010	2015		2005	2010	2015
South America	807,790	825,212	813,203	811,082	789,918	South America	874,158	843,995	833,881
Africa	635,460	630,185	641,822	653,447	599,593	Africa	691,369	638,187	624,009
Indonesia	99,731	100,544	94,392	103,811	95,703	Indonesia	97,857	94,432	91,010

Effectiveness of time-series, slope-correction and ortho-rectification for change monitoring



R:2007, G:2009:B:2010



R:2007, G:2009:B:2010

Quick Deforestation Detection using ALOS-2

ALOS-2
ScanSAR

Deforestation Detection System

Basic Process
-Imaging(ScanSAR-HH/HV)
-Ortho rectification
-Slope correction
-Path Mosaic

Deforestation detection
-Segmentation
-Time series Analysis
-Forest Non Forest
-Automatic process

Detect
deforestation area(polygon)

Data distribution site

Field survey and validation

FNF-Time Data(downloadable)

End user (Government Agency)

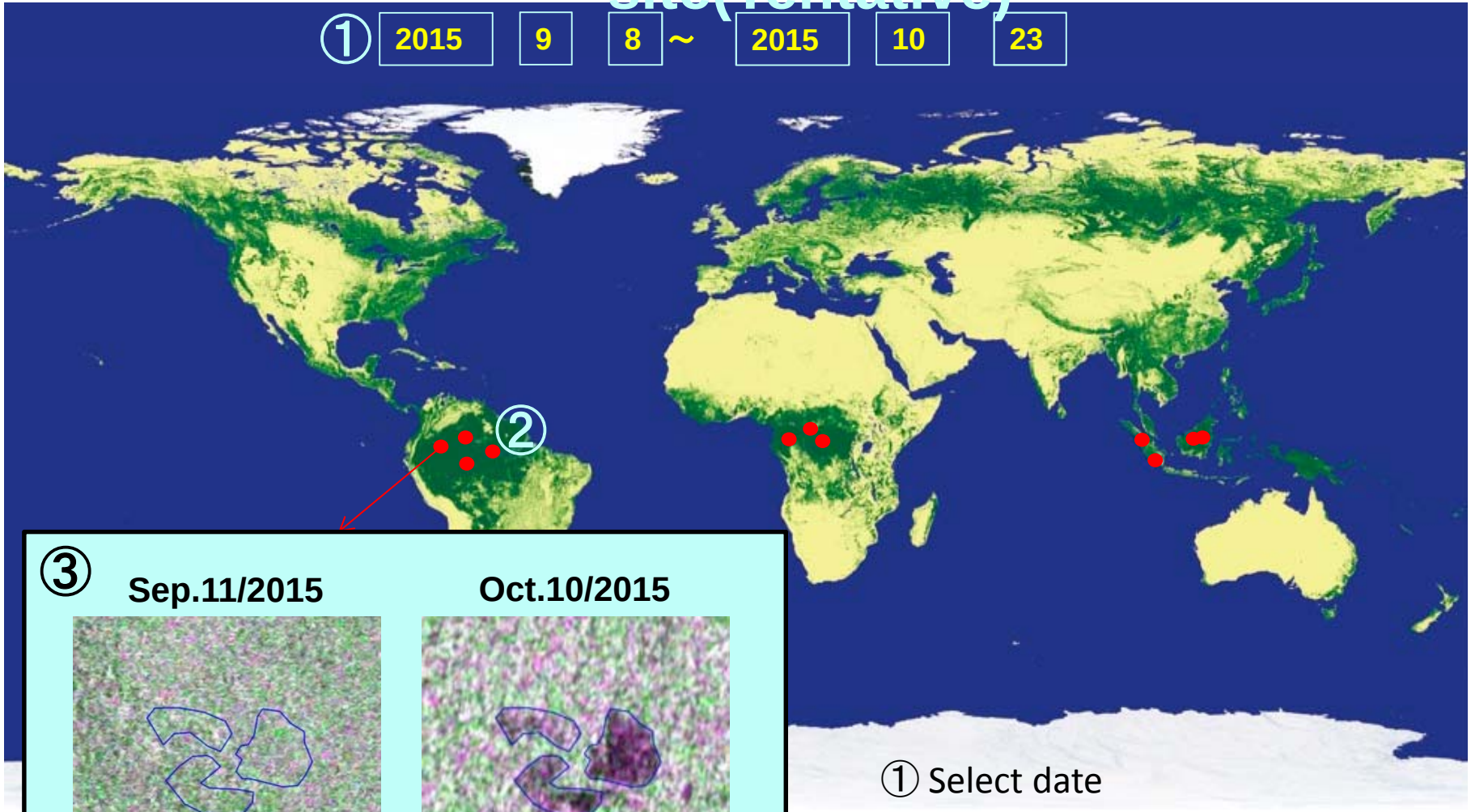
Feedback: in-situ data

Concept of the analysis system

- JICA plans to expand their project internationally to such as Peru, Columbia(South America), Myanmar(Asia), Gabon(Africa), etc., not only Brazil deforestation Monitoring Project.
- At that ti... it is not ... e installe... analysis system in eac... country, ... it will be constructed ... rest change detection ... analy... e ... sure... horizontal de... ne... efficiently.

ALOS era(2007~2011)   ALOS-2 era(2016~)

Data distribution site(Tentative)



① Select date
> Display forest change area as red dot
② Select area(dot)
> Display extended images
③Browse before and after of deforestation and download polygon

Introduction

1. Spatio-temporal dependency of the PALSAR gamma-zero on forest/non-forest (FNF) classification
2. Generation of the forest/non-forest map
3. Comparison with the Landsat Forest/non-forest map
4. Comparison of FNF between 2007-2015

- Masanobu Shimada, Takuya Itoh, Takeshi Motooka, Manabu Watanabe, Rajesh Thapa, and Richard Lucas, “New Global Forest/Non-forest Maps from ALOS PALSAR Data (2007-2010),” Remote Sensing Environment, DOI=10.1016/j.rse.2014.04.014 .

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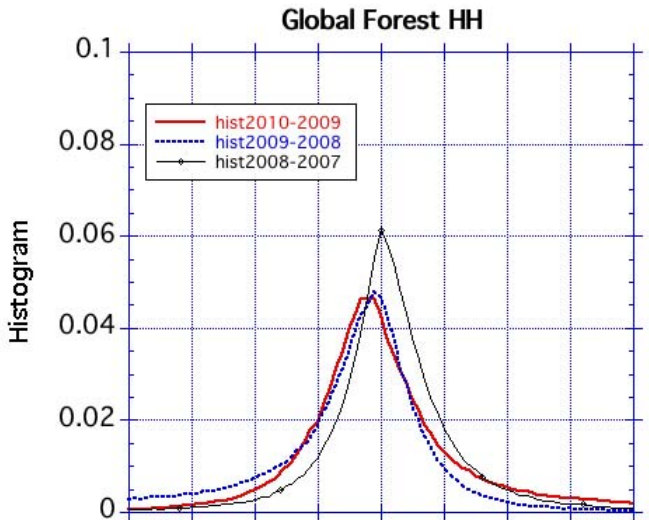
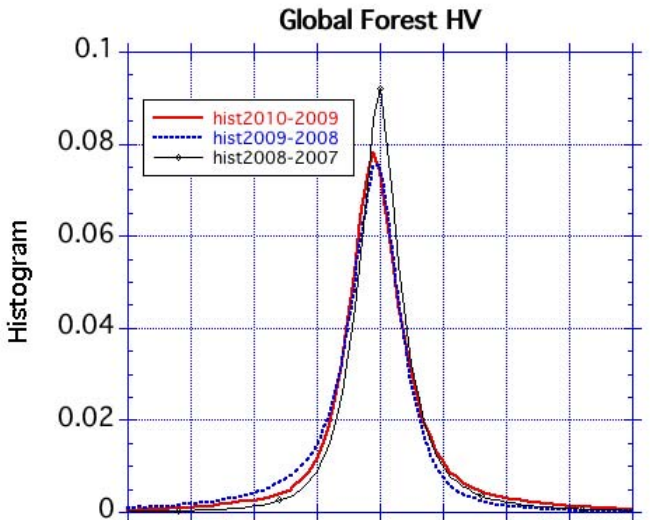
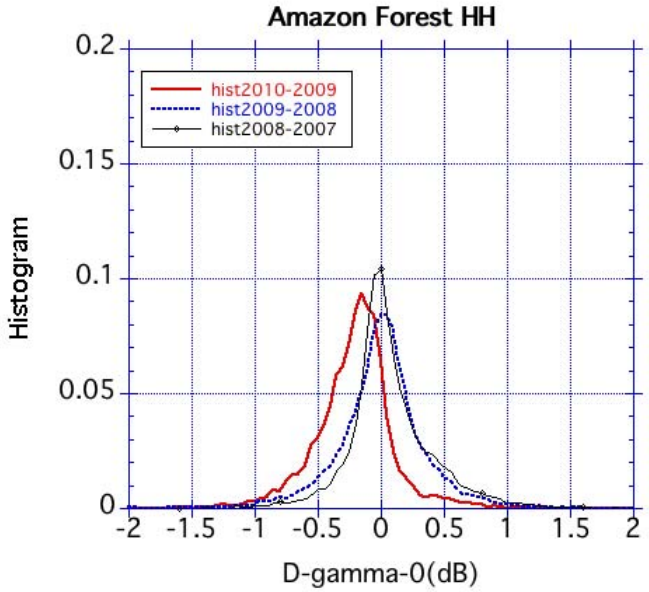
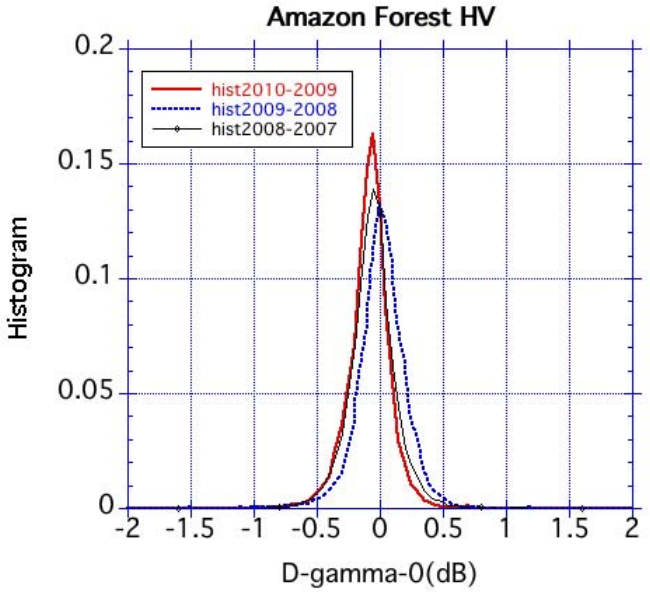
Annual Change of the gamma-naught (Global Forest and Amazon Forest)

H-1









H-1

Difference of two averages

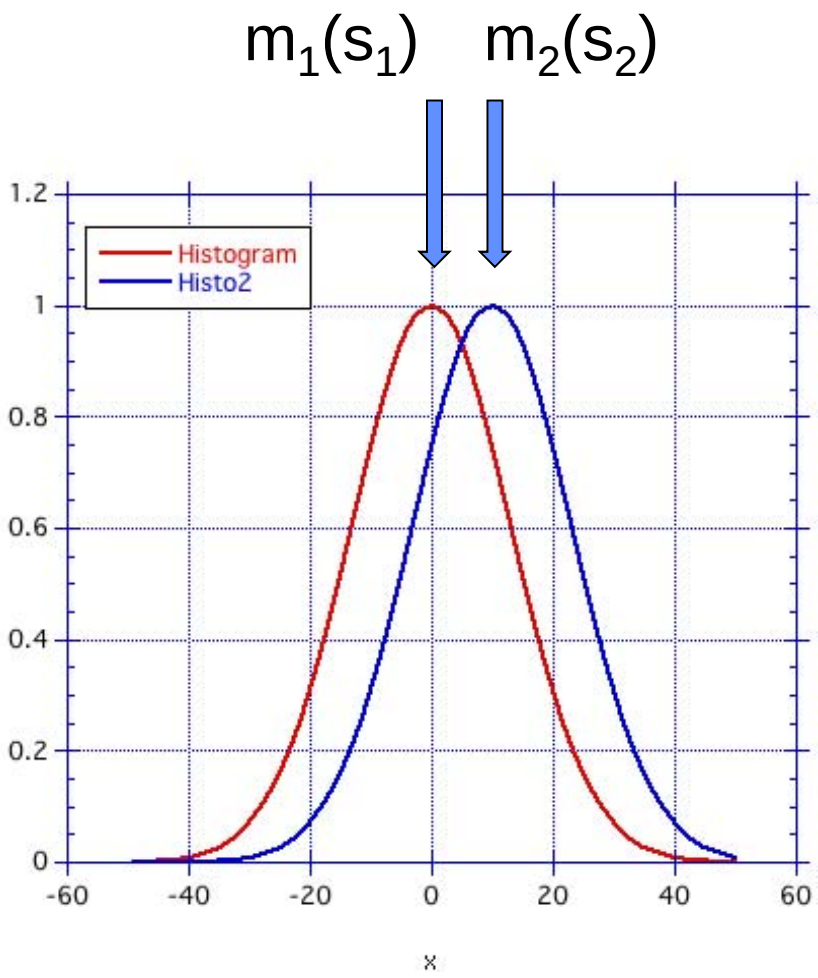
There are two distribution functions, each of which has averages of m_1 and m_2 and standard deviation of s_1 and s_2.

Averages m_1 and m_2 are different or same?

If |m1-m2|>δ95% or d99%, they can be “different” with 95% or 99% confidence.

$$\Delta_{95\%} = 1.960 \frac{\sigma}{\sqrt{n}}$$ ⇒ 0.003

$$\Delta_{99\%} = 2.576 \frac{\sigma}{\sqrt{n}}$$ ⇒ 0.004



Distribution of SAR data

H-1

Annual change of gamma-zero(dB/yr)

G0の年毎の変化率

Table 14. Differences in mean HH and HV γ^0 2007-2008, 2008- 2009 and 2009-2010.

Year		Global land	Global forest	Tropical forest	95% confidence	99% confidence
2007-2008	HH	-0.093	-0.106	0.008	0.0049	0.0064
	HV	-0.104	0.027	-0.044	0.0047	0.0061
2008-2009	HH	0.039	-0.441	-0.107	0.0049	0.0064
	HV	0.061	-0.130	-0.005	0.0047	0.0061
2009-2010	HH	-0.066	0.087	0.018	0.0049	0.0064
	HV	-0.040	0.010	0.006	0.0047	0.0061
Mean	HH	-0.040	-0.106	-0.027	0.0049	0.0064
	HV	-0.028	-0.031	-0.02	0.0047	0.0061

[1]The values for tropical forest are averaged from South East Asia, Amazonia and Central Africa. All the units are in decibels (dB).

g^0 decreased by 0.040dB yr^{-1} in HH and 0.028dB yr^{-1} in HV globally and regionally, with this potentially related to decreases in forest area and AGB and a smoothing of the non-forest area (e.g., as a consequence of agricultural management leading to improvement of cleared areas).

Spatio-temporal property of the forest back scatter（summary）

- Gamma-zero in forest （HH and HV ）is stable. That in non-forest is less stable.

- Gamma-zero(average) shows the region dependence. In Amazon, HH and HV g^0 was, on average, -6.84 and -11.85 dB, Indonesia, -7.68 and -12.54 dB.

- Difference of forest and non-forest is 3.97 dB in HH, 6.42 dB in HV.
-
- In general, g^0 はrelatively stable for all forest areas with HH and HV values averaging -6.89 ±0.95 dB and -12.07±1.52 dB respectively over the four years .

- A normal distribution was also followed, with the standard deviation being 2.13 and 2.04 dB respectively;) within all years but annual averages being as small as 0.21±0.18dB and 0.21±0.19dB when all four years were considered.
-
- Values of g^0 were lower and more variable for non-forest areas, averaging -10.86±4.78 dB and -18.49±3.84 dB at HH and HV polarization respectively.

HV has higher sensitivity than HH for forest/non-forest classification.
FNF classification is preferable using the threshold method.

1. FNF map generation

Determination of the threshold

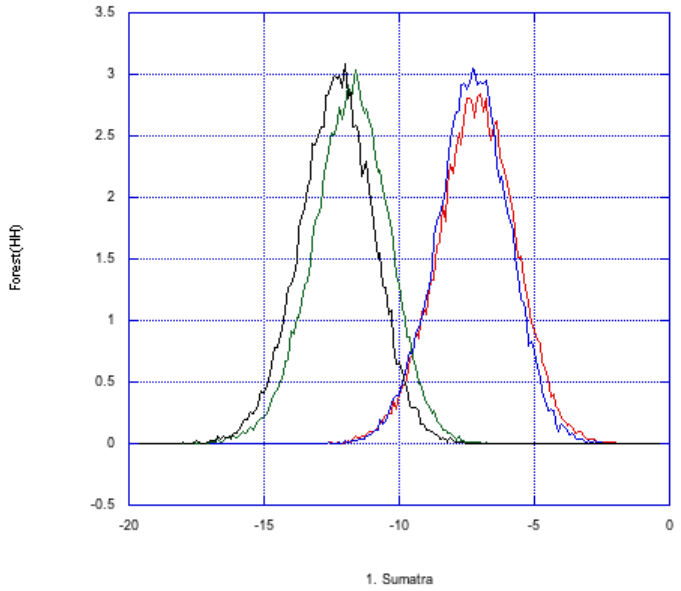
1) Measure the DF of “Forest” & “Non-F”
2) Calculate the Cumulative DFs and measure the “threshold” that maximizes the both.
3) Threshold is region dependent.

$$F_F(x) = 1 - F_{NF}(x)$$

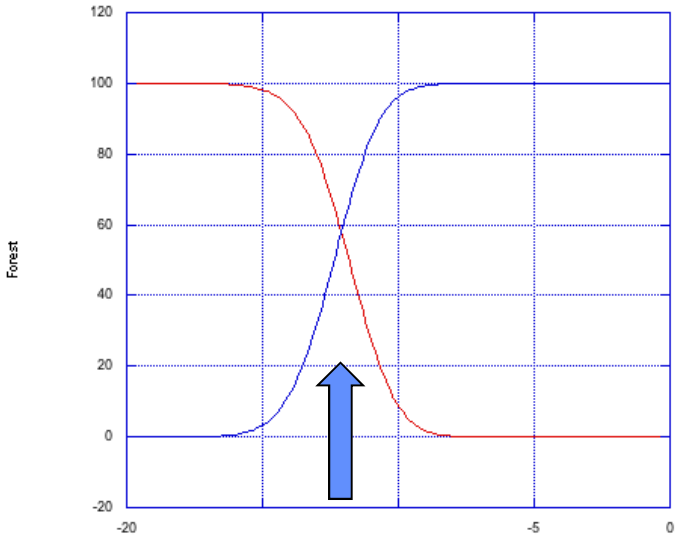
$$F_F(x) \equiv \int_x^{\infty} f_F(x')dx'$$

$$F_{NF}(x) \equiv \int_{-\infty}^{x} f_{NF}(x')dx'$$

Histograms for Forest & Non-forest (Acacia)



Cumulative Distribution Fn.



Sumatra Case

Threshold

1. FNF map generation

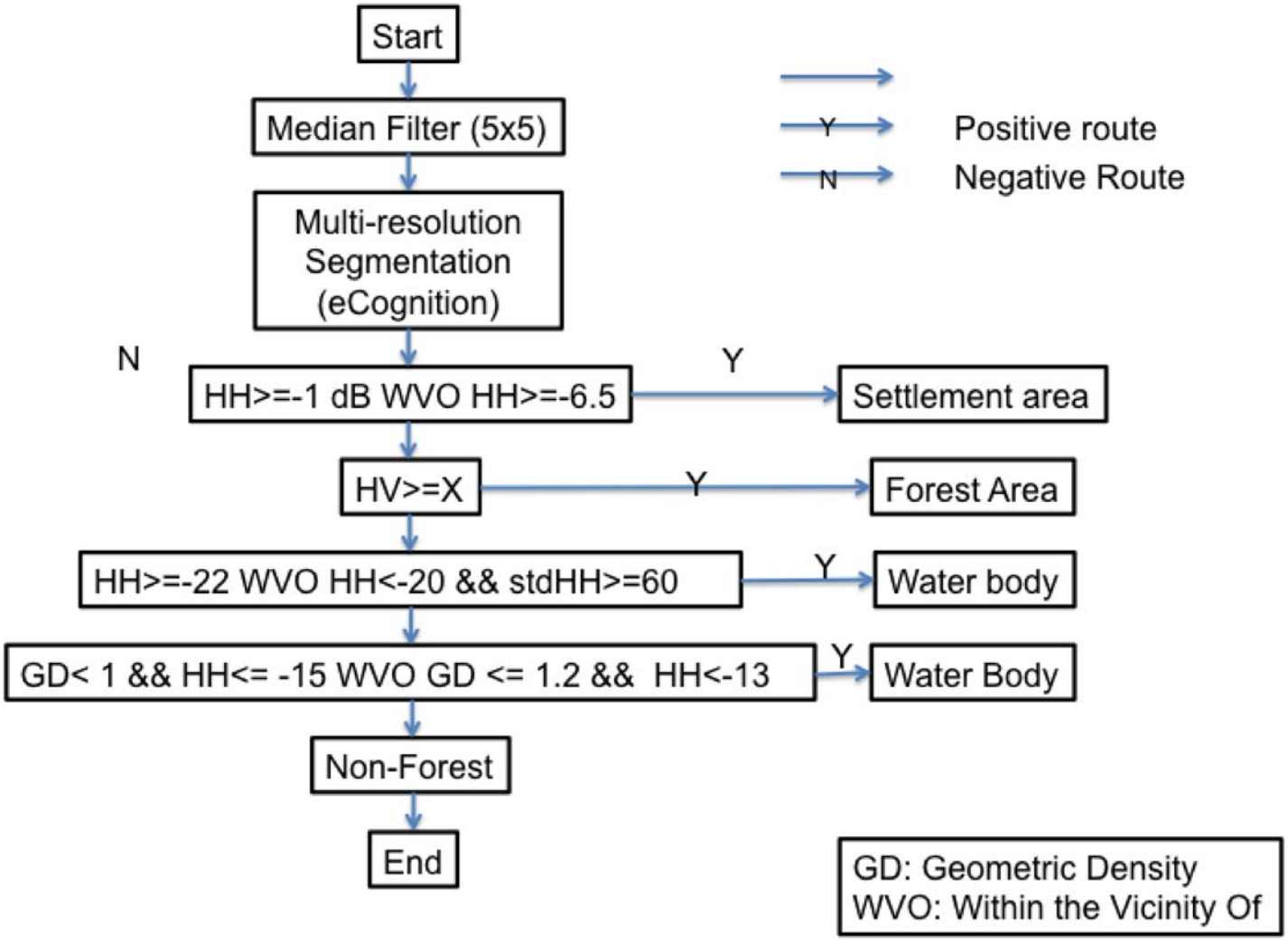


Figure. 11. Rules used for the classification of forest and non-forest areas from the ALOS PALSAR mosaic data.

3. Discussion

- Forest definition
- Comparison with Landsat data （Hansen, et al., FRA）
- Temporal variation of the gamma-zero

3.1 Forest definition

- PALSAR, FRA：Forest coverage larger than １０%, area larger than ０．５ha, natural forest, forest height(not from satellite)
- Landsat(Hansen et al.)：tree coverage：２６～１００%

3.2 comparison Landsat, FRA, PALSAR

Table 9. Comparison with FRA forest areas (x 1000 ha; 2005 and 2010)

Region	Landsat[1] (2000)	PALSAR (2007)	FRA (2005)	Diff (%)[2]	PALSAR (2008)	FRA (2005)	Diff (%)	PALSAR (2009)	FRA (2010)	Diff (%)	PALSAR (2010)	FRA (2010)	Diff (%)	PALSAR (2010 - 2007)	FRA (2010 - 2005)
Africa	664834	635460	691369	-8.09	630185	691369	-8.85	641822	674318	-4.82	653447	674318	-3.10	17987	-17051
Asia	545418	580807	584049	-0.56	581074	584049	-0.51	573354	592513	-3.23	594370	592513	0.31	13563	8464
Eurasia	992909	945540	1009462	-6.33	935662	1009462	-7.31	926121	1013297	-8.60	933957	1013297	-7.83	-11583	3835
N/C America	778456	697116	705183	-1.14	673179	705183	-4.54	686989	705281	-2.59	680659	705281	-3.49	-16457	98
Oceania	132427	187538	196745	-4.68	177026	196745	-10.02	177597	191385	-7.20	179115	191385	-6.41	-8423	-5360
S America	951614	807790	874158	-7.59	825212	874158	-5.60	813203	856269	-5.03	811082	856269	-5.28	3292	-17889
Total	**4065657**	**3854250**	**4060966**	**-5.09**	**3822337**	**4060966**	**-5.88**	**3819087**	**4033063**	**-5.31**	**3852630**	**4033063**	**-4.47**	**-1620**	**-27903**

[1]Derived from Hansen *et al.* (2013) for tree cover 26% to 100%,[2] Derived from 1-PALSAR dived by FRA

- Forest areas estimated from three method show almost the same values.
- Hansen et al (2013), Science showed the trend of the forest change(gain and loss) between 2000 and 2012.
- Both (Landsat and PALSAR) methods have similar evaluation method for their forest and non-forest areas.
- PALSAR's forest area is 5% less than Landsat value. : ＞1） L-band signal is slightly less sensitibe fro vegetation.

3.3 Accuracy Assessment (1/3) – PALSAR vs. FRA vs. Landsat

x1000ha

Region	Landsat(2000)	PALSAR(2007)	FRA(2005)	Diff
Africa	664834	635460	691369	-8.09
Asia	545418	580807	584049	-0.56
Eurasia	992909	945540	1009462	-6.33
N/C America	778456	697116	705183	-1.14
Oceania	132427	187538	196745	-4.68
S America	951614	807790	874158	-7.59
Total	**4065657**	**3854250**	**4060966**	**-5.09**

Hansen et al (2013), Science

This results

FAO

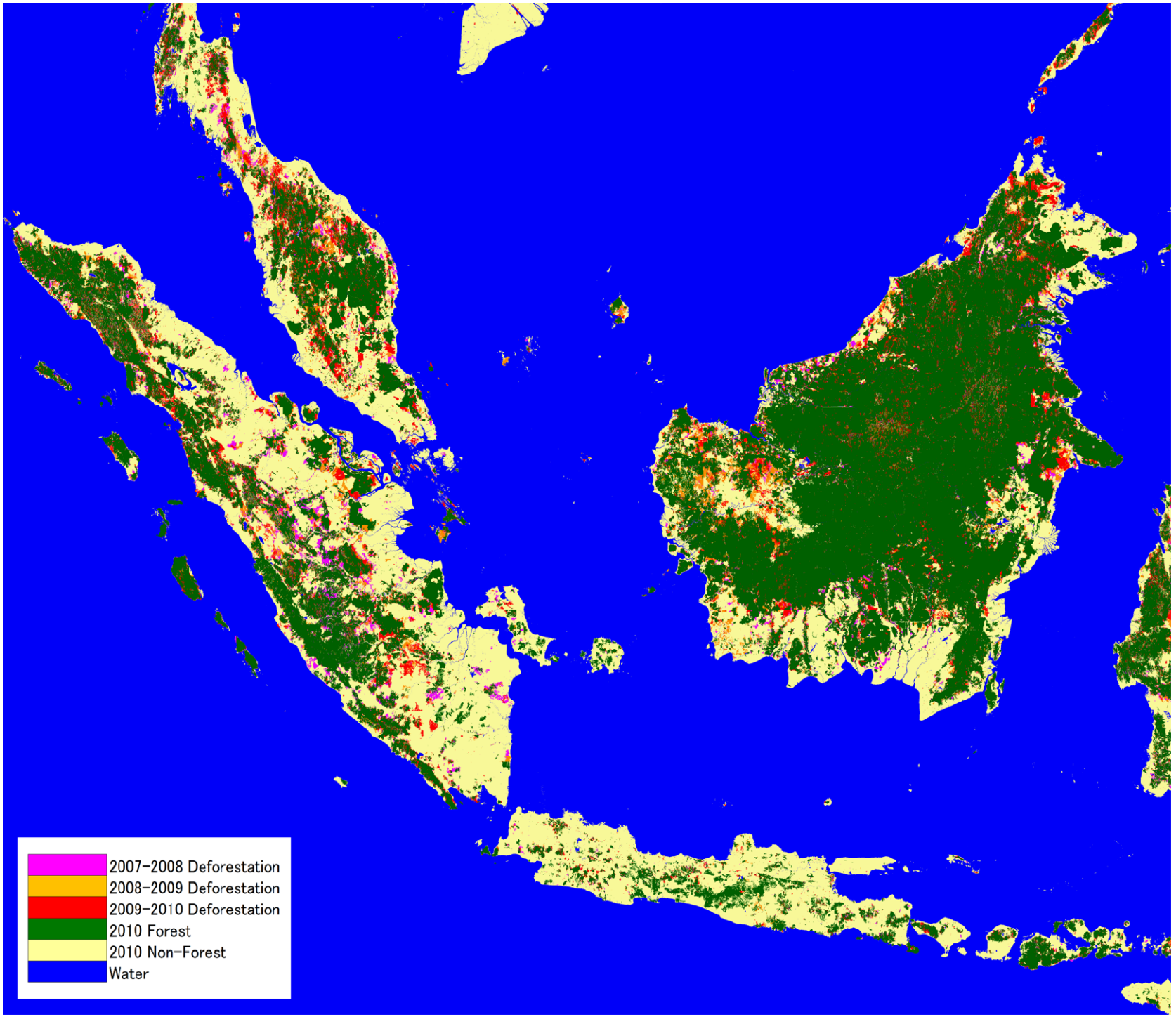
3.4 temporal variation

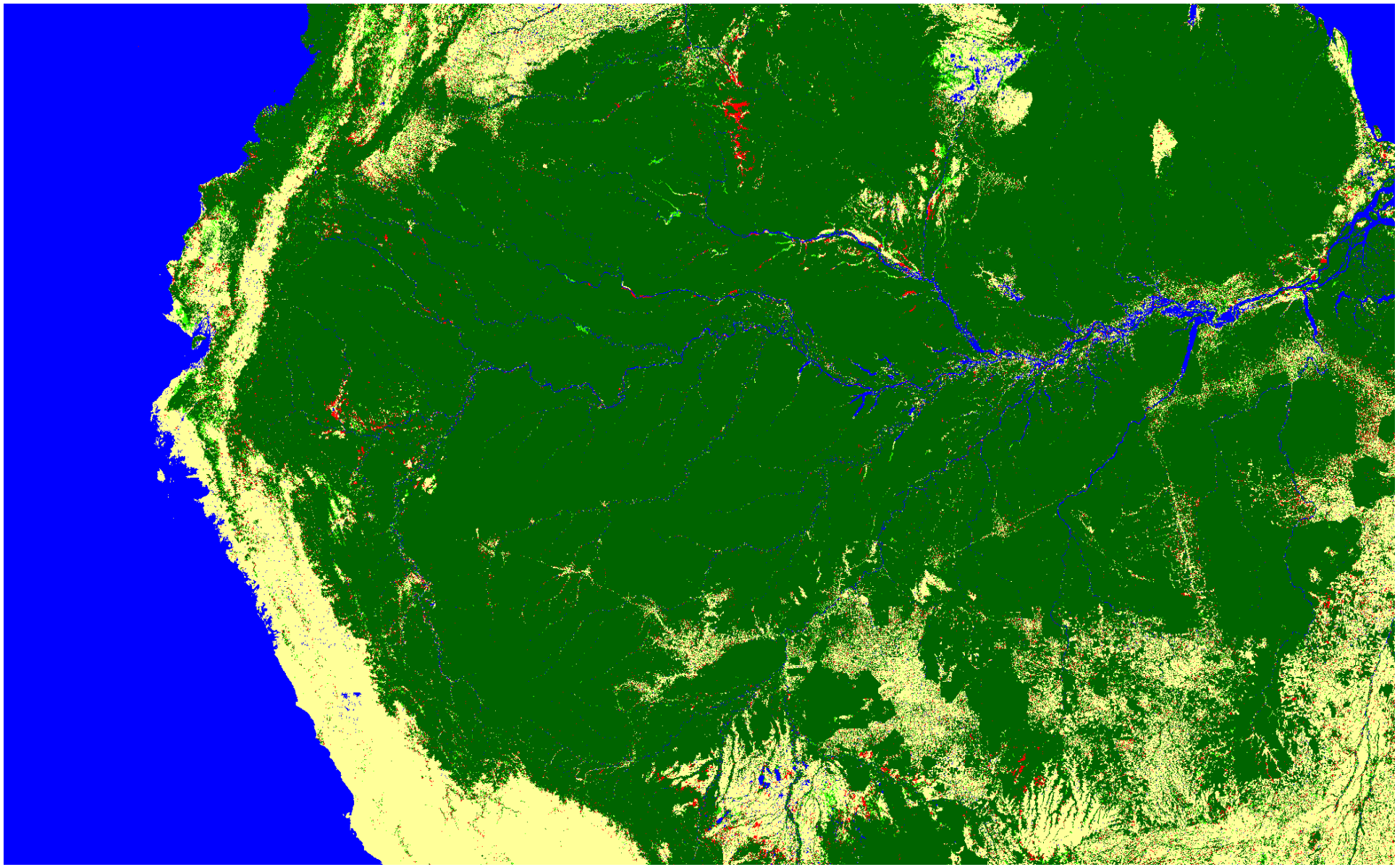
Table 11. Differences in the forest area (x1000ha) estimated from ALOS PALSAR data.

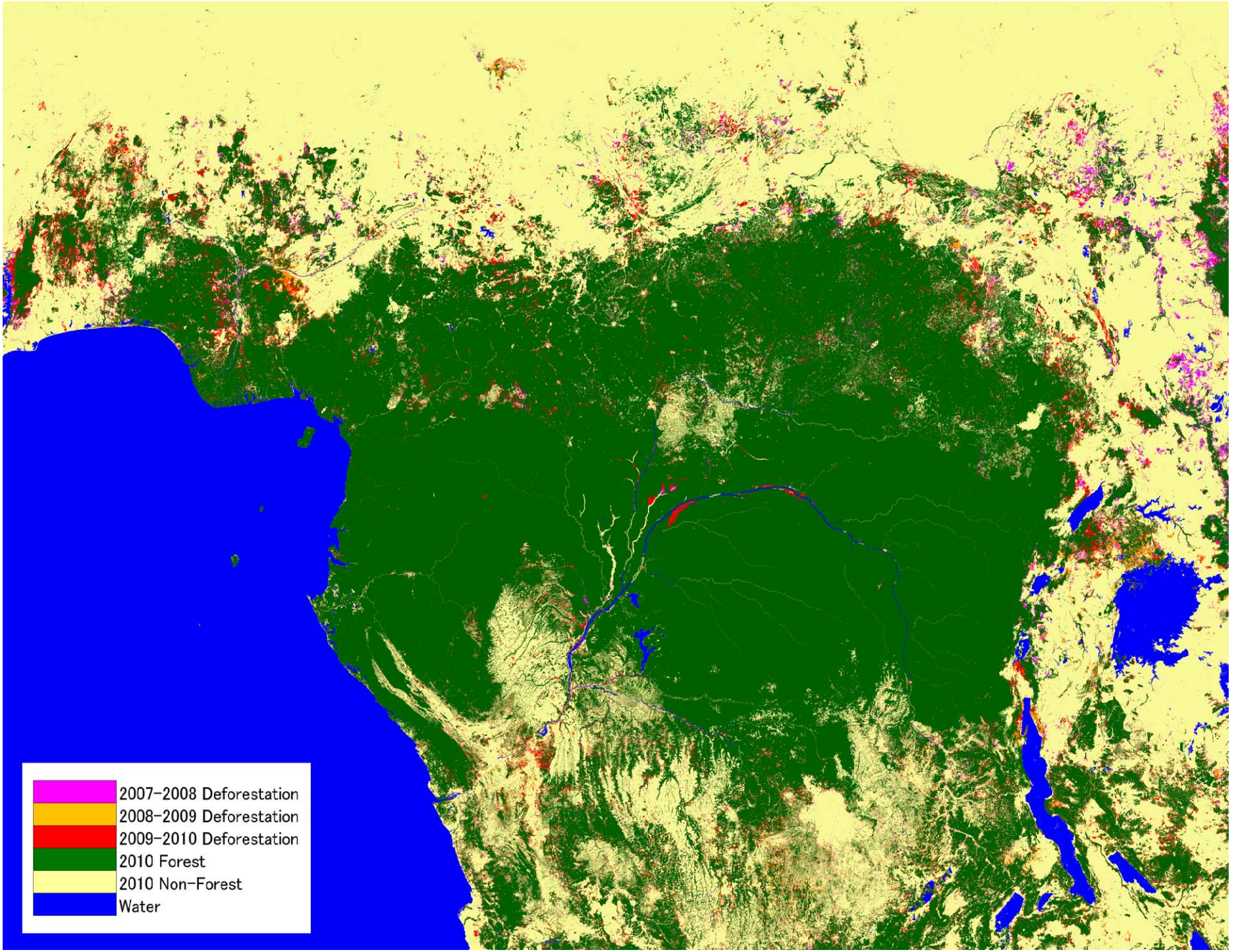
Region	2008 -2007	2009 -2008	2010 -2009	2010 -2007[1]
Africa	-5276 (-0.830)[2]	11637 (1.847)	11626 (1.811)	17987 (2.83)
Asia	267 (0.046)	-7719 (-1.328)	21016 (3.665)	13563 (2.34)
Eurasia	-9877 (-1.045)	-9541 (-1.020)	7835 (0.846)	-11583 (-1.23)
N/C America	-23937 (-3.434)	13810 (2.051)	-6331 (-0.926)	-16457 (-2.36)
Oceania	-10512 (-5.605)	571 (0.323)	1518 (0.855)	-8423 (-4.49)
S America	17422 (2.157)	-12009 (-1.455)	-2122 (-0.261)	3292 (0.407)
Total	-31913 (-0.828)	-3250 (-0.085)	33543 (0.878)	-1620 (-0.042)

[1]Average; [2]ratio of areas, year 2 to year 1; Number in bracket is percentile.

PALSAR's forest decrease(annual)shows 16Kkm^2(2007-2010),320Kkm^2(2007-2008), in average with several Kkm^2/yr.
FRA shows the decrease of 200Kkm^2(2005-2010), 40Kkm^2/yr.
In general, PALSAR and FRA meets.
Landsat(Hansen et al., 2013)is 2300Kkm^2/yr and quite large.


2007–2008 Deforestation
2008–2009 Deforestation
2009–2010 Deforestation
2010 Forest
2010 Non-Forest
Water




2007-2008 Deforestation
2008-2009 Deforestation
2009-2010 Deforestation
2010 Forest
2010 Non-Forest
Water

ALOS PALSAR 50 m global mosaic data
Open release

As of January 16, 2014, JAXA have made PALSAR 50 m global mosaic data openly available free of charge. (soon after, 25m will be avilable)
Annual mosaics from 2007, 2008, 2009 and 2010, covering all land areas except Greenland and Antarctica.
Generation will continue from 2014 with ALOS-2

The 50m mosaic data were generated by averaging from JAXAs 25m resolution mosaic products.

Available in 1°x1° tiles.

The data can be downloaded from
http://www.eorc.jaxa.jp/ALOS/en/palsar_fnf/fnf_index.htm

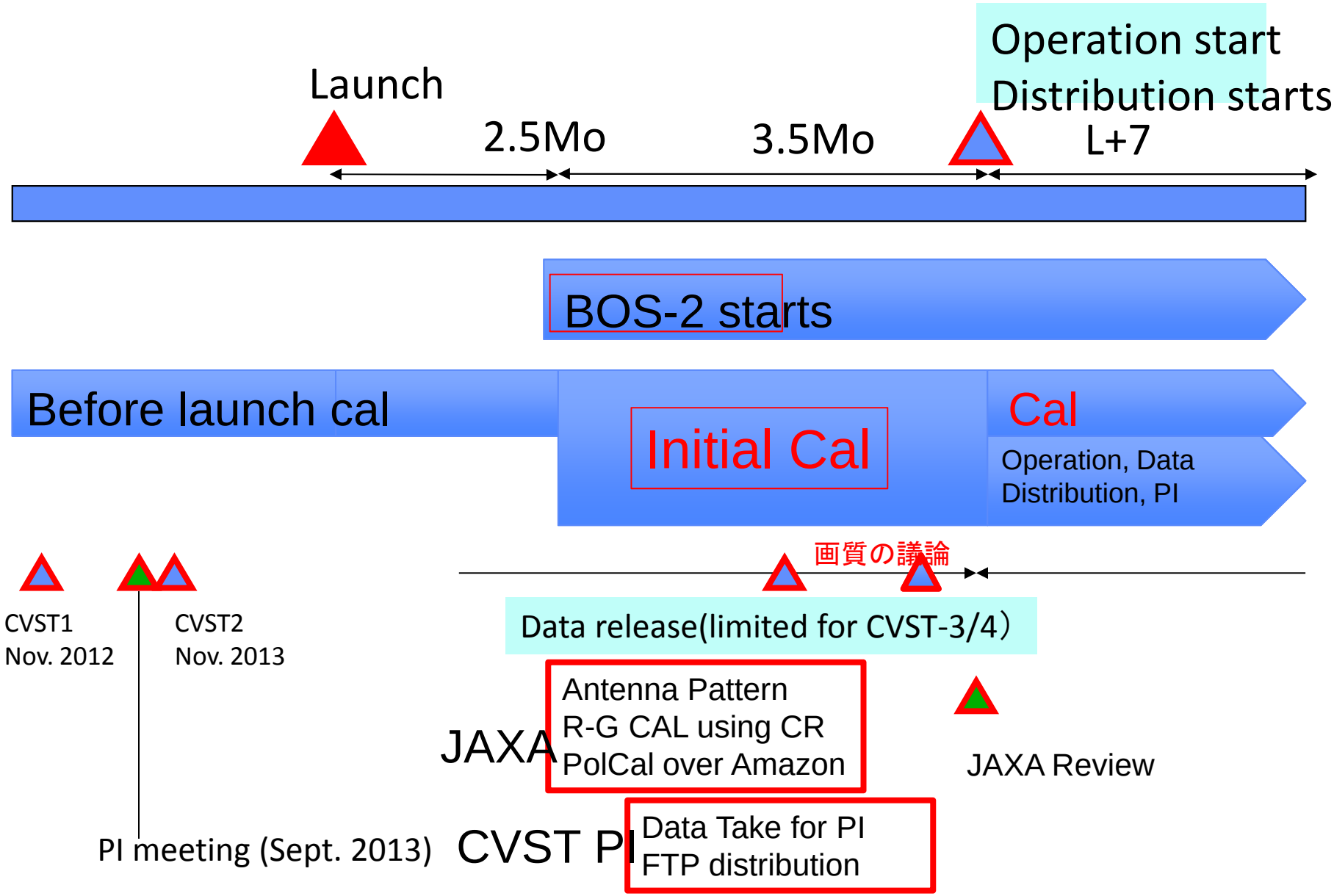
ALOS-2 Specifications

		Spotlight	Ultra Fine	High sensitive	Fine	ScanSAR nominal		ScanSAR wide
Bandwidth		84MHz	84MHz	42MHz	28MHz	14MHz	28MHz	14MHz
Resolution		Rg × Az : 3 × 1m	3m	6m	10m	100m		60m
Swath		Rg × Az : 25 × 25km	50km	50km	70km	350km (5-scan)		490km (7-scan)
Polarization		SP	SP/DP	SP/DP/FP/CP		SP/DP		
NESZ		-24dB	-24dB	-28dB	-26dB	-26dB	-23dB	-23dB
S/A	Rg	25dB	25dB	23dB	25dB	25dB		20dB
	Az	20dB	25dB	20dB	23dB	20dB		20dB

SP : HH or VV or HV , DP : HH+HV or VV+VH , FP : HH+HV+VH+VV , CP : Compact pol (Experimental mode)

Main applications:
Fine beam (DP): Forest and land cover monitoring
ScanSAR (DP): Rapid deforestation / wetlands / InSAR (ScanSAR-ScanSAR)
Spotlight (SP): Emergency observations
Ultra Fine (SP) : Global map, InSAR base mapping
High sensitive (QP): Global map
ScanSAR wide (SP) : Polar ice

ALOS-2スケジュール



The ALOS-2

Basic Observation Scenario (BOS)

(as of February 2014)

基本観測計画

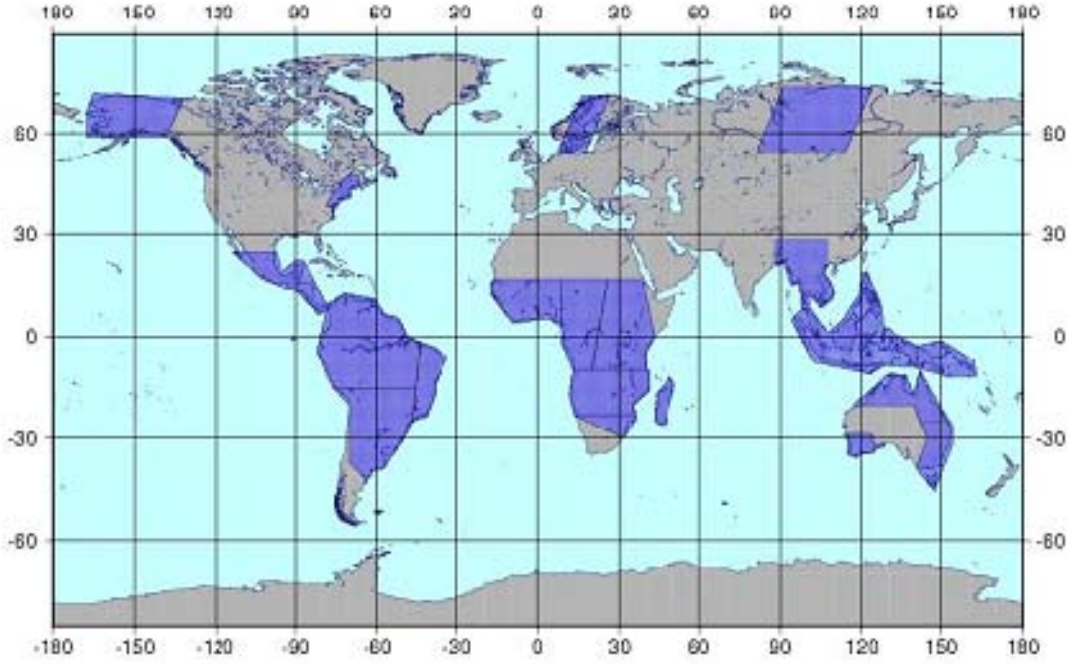
BOS-2

Forest monitoring

Temporal repeat: 6 cov/year

GSD: 10 m (off-nadir 28.2°-36.2°)

Mode: Stripmap Dual-pol (HH+HV/28MHz)



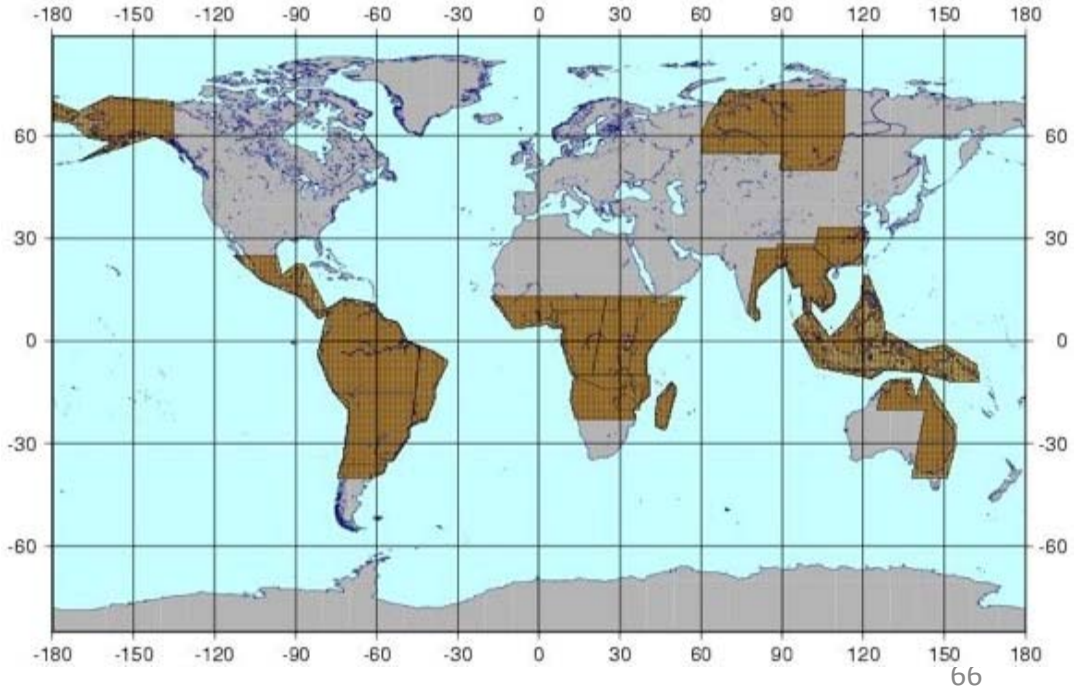
BOS-2

Wetlands & Rapid deforestation monitoring

Temporal repeat: 9 cov/year

GSD: 100 m (off-nadir 26.2°-41.8°)

Mode: ScanSAR 350km Dual-pol (HH+HV/14MHz)



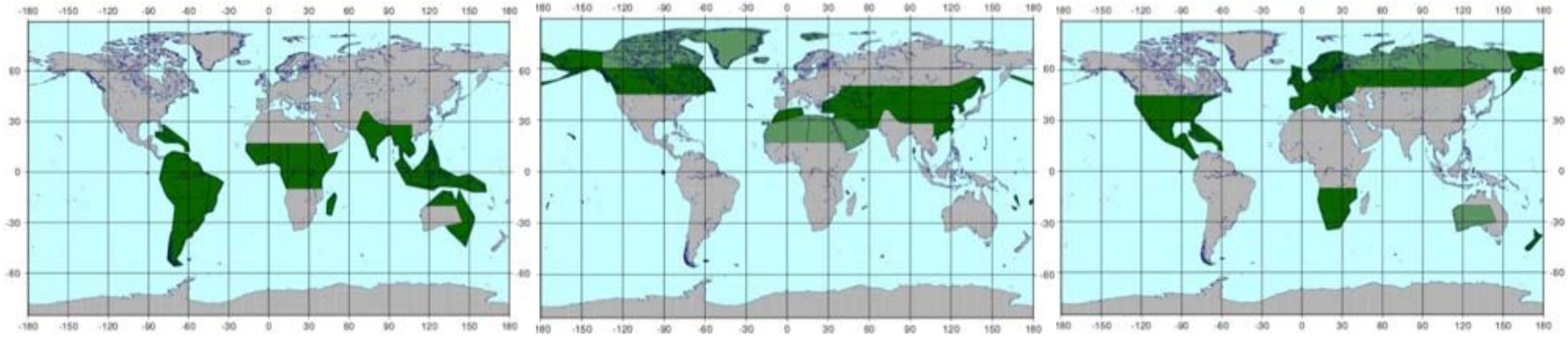
BOS-2

Global land areas – VHR baseline mapping

Temporal repeat: 1 cov/ 3 years

GSD: 3 m (off-nadir 29.1°-38.2°)

Mode: Stripmap Single-pol （HH/84MHz）



1st year 2nd year 3rd year

Prio 1
Prio 2

* 3 years required for global coverage in 3m mode

BOS-2

Global land areas – Quad-polarimetric baseline

Temporal repeat: 1 cov/ 5 years

GSD: 6 m (off-nadir 25.0°-34.9°)

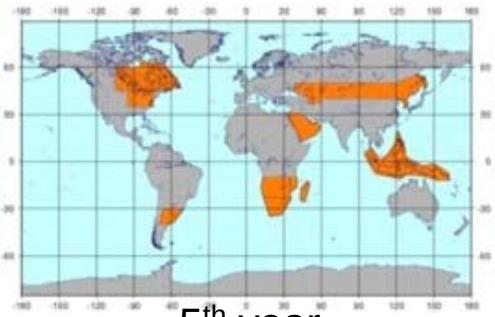
Mode: Stripmap Quad-pol (HH+HV+VV+VH)

1st year

2nd year

3rd year

4th year



5th year

Areas observed every year

* 5 years required for global coverage in 6m QP mode

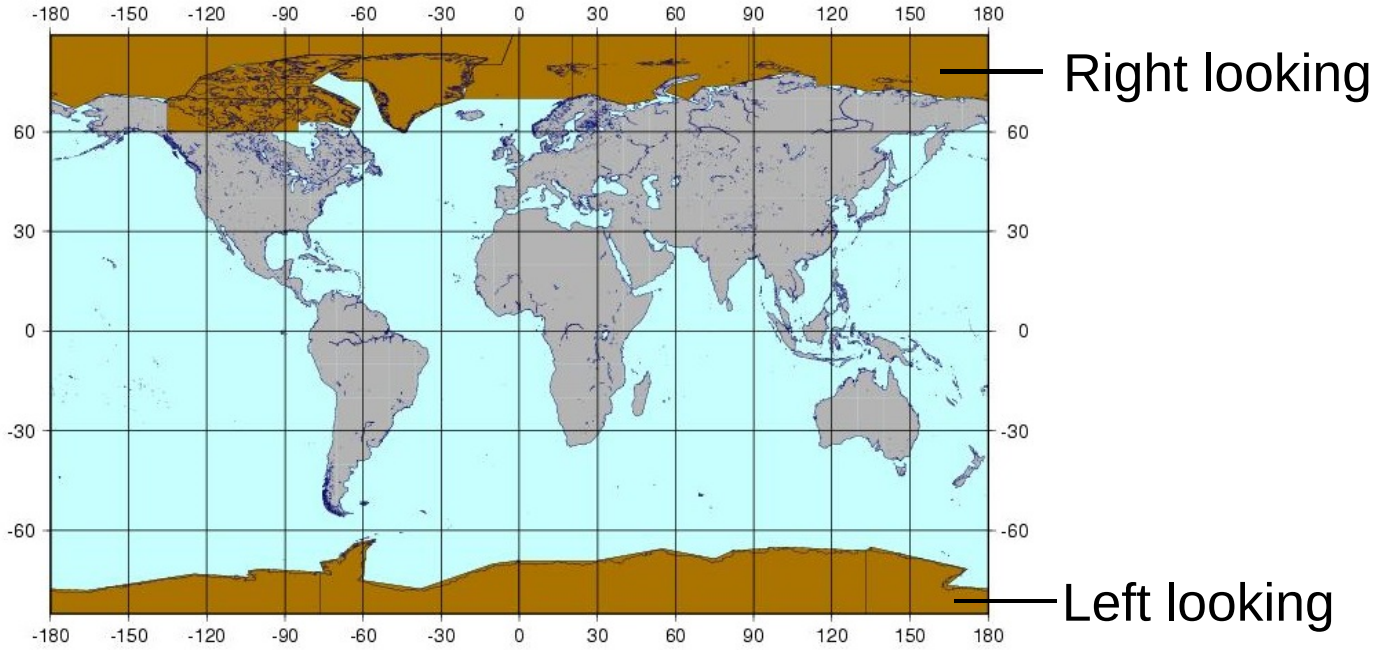
Basic Observation Scenario (Global)

Polar Ice

Temporal repeat: 3 cov/year

GSD: 100 m (off-nadir 26.2°– 41.8°)

Mode: ScanSAR 350km (HH+HV/14MHz)



BOS-2

Observation pattern for annual acquisitions*

Season	N:Winter/S:Summer				N:Spring/S:Autum						N:Summer/S:Winter							N:Autum/S:Spring									
Week of year	1-2	3-4	5-6	7-8	9-10	11-12	13-14	15-16	17-18	19-20	21-22	23-24	25-26	27-28	29-30	31-32	33-34	35-36	37-38	39-40	41-42	43-44	45-46	47-48	49-50	51-52
Desc	D+W+F		Arctic	D+W+F	14-day InSAR		D+W+F	14-day InSAR		D+W+F	14-day InSAR		D+W+F	Arctic	D+W+F	Glacier Antarctica		D+W+F	Glac. Antarc	Arctic	D+W+F	Global (1/3)		D+W+F	Global (1/3)	
	WB 350km		WB490	WB 350km	DP(5) 10m	DP(5) 10m	WB 350km	DP(6) 10m	DP(6) 10m	WB 350km	DP(7) 10m	DP(7) 10m	WB 350km	WB490	WB 350km	DP(6)L	DP(6)L	WB 350km	DP(6)L	WB490	WB 350km	SP(6) 3m	SP(7) 3m	WB 350km	SP(8) 3m	SP(9) 3m
Asc	North Pole	World 1			Glacier Greenland		Global (1/5)						World 2			South Pole	N + S Pole	World 1					World 2			N + S Pole
	WB350	DP(7) 10m	DP(6) 10m	DP(5) 10m	DP(6)	DP(6)	QP(6) 6m	QP(5) 6m	QP(4) 6m	QP(3) 6m	QP(7) 6m		DP(7) 10m	DP(5) 10m	DP(6) 10m		WB350	DP(7) 10m	DP(5) 10m	DP(6) 10m			DP(7) 10m	DP(5) 10m	DP(6) 10m	WB350
																WB350L	WB350L									WB350L

DP 10m — 10m(HH+HV)28MHz Right

SP 3m — 3m(HH)84MHz Right

QP 6m — 6m(HH+HV+VH+VV)42MHz Right

(*) *Beam No.

Super sites (TBD)

WB 350km — ScanSAR350km(HH+HV)14MHz Right

WB 350km — ScanSAR350km(HH+HV)14MHz Left

WB 490km — ScanSAR490km(HH+HV)14MHz Right

DP 10m — 10m(HH+HV)28MHz Left

* 3m SP and 6m QP modes require 3 and 5 years for global coverage

Conclusions

- Hoping the successful launch of ALOS-2 in May 24 2014.

- Polar/Okhotsk sea ice distribution was observed by the ALOS/PALSAR
- Radar backscatter can be used for sea ice discrimination from the ocean.
- ALOS-2 will be used for the polar monitoring in summer (winter) for ship.

ALOS PALSAR 50 m global mosaic data
Open release

As of January 16, 2014, JAXA have made PALSAR 50 m global mosaic data openly available free of charge.

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Generation will continue from 2014 with ALOS-2

The 50m mosaic data were generated by averaging from JAXAs 25m resolution mosaic products.

Available in 1°x1° tiles.

The data can be downloaded from
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ALOS PALSAR global mosaic data
Open release

- Open release of 25 m versions foreseen for mid 2014

Same production chain availabe for ALOS-2

ALOS-2 Data Policy (Part)

- JAXA data policy defines tentatively 15m as the critical sensor data resolution . Lower resolution data can be distributed for free and higher data will be distributed commercially by a private operator. While the ScanSAR data has lower resolution, the data will be handled on commercial basis, as the data is considered to have a commercial value.

- Data distribution to the governmental users, that includes the international collaboration activities, i.e., CEOS, GEO, etc., can be conducted with the reasonable price. (General user needs to bear the commercial price which will be determined by the private operator).

- The reasonable price is approx. 10000 yen/ scene considering the costs converting from the level 0 to the 1.5.

- For GFOI, since its observation requirements are already included in the ALOS-2 Baseline Observation Strategy (BOS), observation request charge does not occur.

Conclusion（結論）

- ALOS/PALSARを基本とした森林非森林情報が９５％の精度で抽出されている。ALOS-2に繋げたい
- L-band time series SAR data showed the decrease of backscatter and forest areas.
- This means that the earth surface becomes smoother than before.
- JERS-1 SAR will be included in near future for longer time variation and ALOS-2/PALSAR-2 will be used for forest variation after 2013.
- Masanobu Shimada, Takuya Itoh, Takeshi Motooka, Manabu Watanabe, Rajesh Thapa, and Richard Lucas, “New Global Forest/Non-forest Maps from ALOS PALSAR Data (2007-2010),” Remote Sensing Environment, accepted March 25, 2014, in press.

Discussion

Table 10. Estimates of forest cover obtained from ALOS PALSAR data (2007) and Landsat sensor data (2000) (x1000ha).

	ALOS PALSAR	Landsat	% Difference
Africa	635460	664834	95.6 %
Asia	580807	545418	106.5 %
Eurasia	945540	992909	95.2 %
North/Central America	697116	778456	89.6 %
South America	807790	951614	85 %
Oceania	187538	132427	142.0 %
TOTAL	3854250	4065657	94.8 %

概要

- 宇宙航空研究開発機構（Japan Aerospace Exploration Agency, JAXA）は，陸域観測衛星（Advanced Land Observing Satellite, ALOS）が2007年から2010年にかけて取得した全球PALSARデータを高精度処理して25m分解能の全球PALSARモザイク画像を作成した[1,2,3]。
- それらを用いて全球の森林・非森林マップを試験的に作成した[4]が，今回，PALSARモザイク画像を地域毎・年代毎に詳細に評価し，光学衛星（Google Earth画像）や現地データを参考とした分類を行い，新森林・非森林マップ（検証済み版）を作成した[5]。
- 図1が 2010の年の森林・非森林マップである。森林・非森林マップは，森林土地利用の時間的な変化を把握し，陸域起源の地球温暖化の要因の特定や，Reducing the Emission from Deforestation and forest Degradation plus（REDD+）活動を推進する上で，非常に重要な基礎情報である。このマップは，3種類の検証データと比較した結果，約90%の精度を持つことが確認されている。
- JAXAではL-band SARデータが森林解析に使用されることを期待し， 50m分解能のデータ（PALSARモザイクデータ及び森林・非森林データ）公開することとした。上記精度は，無作為抽出での評価であり，森林の定義が国によって異なることを考慮すると更に改善の余地があり、今後時間をかけて精度向上を目指す。
- Masanobu Shimada, Takuya Itoh, Takeshi Motooka, Manabu Watanabe, Rajesh Thapa, and