GENERATION OF 10m RESOLUTION PALSAR AND JERS-SAR MOSAIC AND FOREST/NON-FOREST MAPS FOR FOREST CARBON TRACKING

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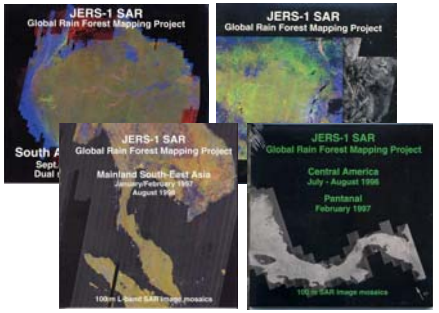
Earth Observation Research Center
APSAR2011
Sept. 28 2011, Seoul, Korea

CD-ROMs & DVD-ROM issued by EORC-JERS-1

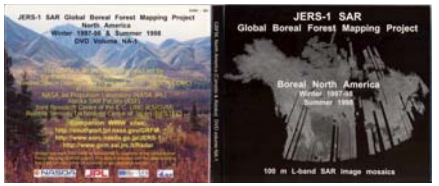
Global Rain Forest Mapping Project, CD



Science Program, CD

Brows Image Data Sets, CD

Global Boreal Forest Mapping Project, DVD



JERS-1 Earth View, CD

Contents

- Introductions
- Ortho rectification
- Slope Correction
- Mosaicking
- Accuracy
- 10 m mosaics
- Classification
- Conclusions

Global forest monitoring system using 18 year SAR dataset (JERS-1 SAR ~ ALOS/PALSAR)

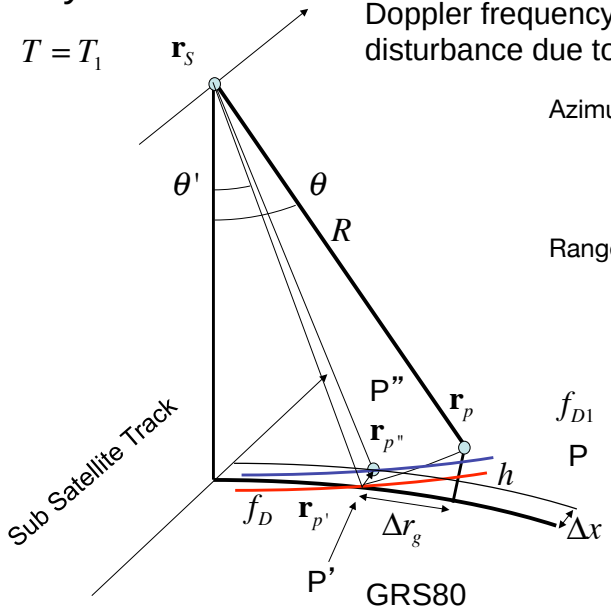
Product: Ortho-rectified and slope corrected high resolution global forestry data (**gamma-naught, classification, (biomass))**

Resolution: **10m-25m**
Sensor: JERS-1 SAR/ALOS-PALSAR
Reprocessing all the EORC/JAXA SAR archives
Dates: 1994-1996-1998~2007,2009, 2010
Products:**Horizon1/2 + Mosaic**
Classification method: SVM, Least distance, level slicing (under evaluation)

Key issues for generating the global satellite data

1. Collection of the same season data (Cloud free)
2. Stability and calibration (geo/radio) of the SAR
3. Effective SAR processing (strip processing)
4. Ortho-rectification
5. Radiometric normalization(slope correction)
6. Mosaicking and radiometric normalization
7. Classification (Forest/non-forest, land classification)

Geometry issue



Doppler frequency disturbance due to the height

Azimuth Shift

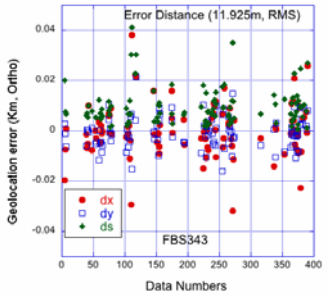
$$\Delta x = -\frac{\Delta f_D}{f_{DD}} v_g$$

Range Shift (1st order)

$$\Delta r_g \cong \frac{h}{\tan\theta_{inci}}$$

Geometric Evaluation Result

Geo error (ortho) > Geo error (slant)



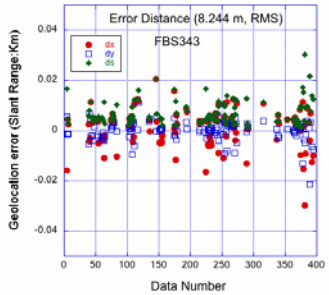


TABLE IV Geolocation Accuracy Measurement for the Ortho-rectification Image and Slant Range Image

Off-nadir Angle (°)	Geolocation Error (ortho: m)	Geolocation Error (Slant: m)
21.5	17.383 (7.211, 21)	13.19 (5.267, 28)
34.3	11.925 (7.266, 104)	8.244 (4.716, 124)
41.5	9.488 (5.127, 50)	7.286 (4.017, 56)
Total Value in RMSE	12.103 (6.718, 175)	8.885 (4.619, 208)

Note: Values in each element are RMSE defined Eq. (28) (standard deviation, number of samples)

G_err_ortho ~12.10m (RMSE)

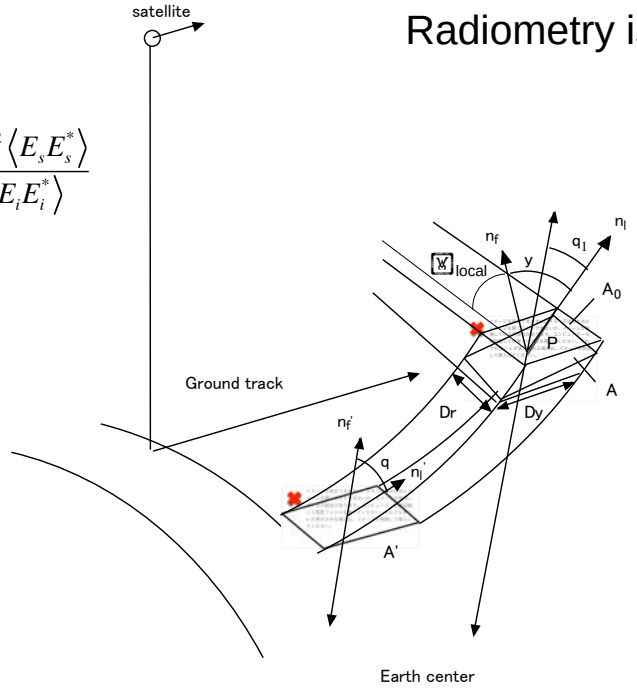
Radiometry issue

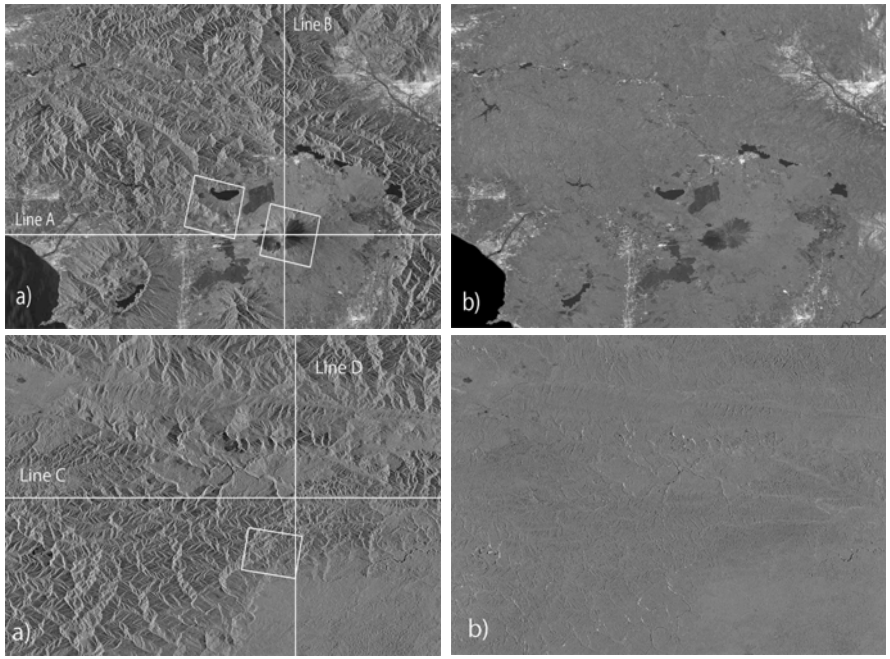
$$\sigma^0 = \lim_{R\to\infty} \frac{4\pi R^2 \langle E_s E_s^* \rangle}{A \langle E_i E_i^* \rangle}$$

$$= \frac{\sigma}{A}$$

$$\gamma^0 = \frac{\sigma^0}{\cos\theta}$$

$$\beta^0 = \frac{\sigma^0}{\sin\theta}$$





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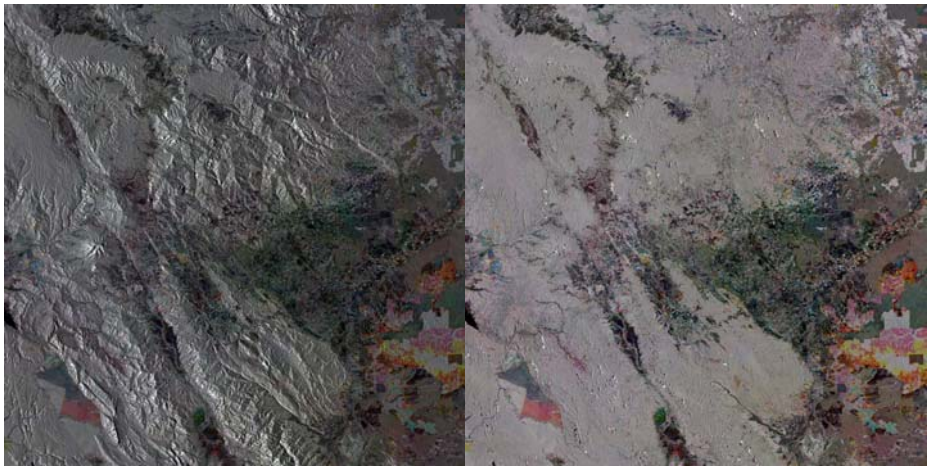

R:2007, G:2009:B:2010

R:2007, G:2009:B:2010

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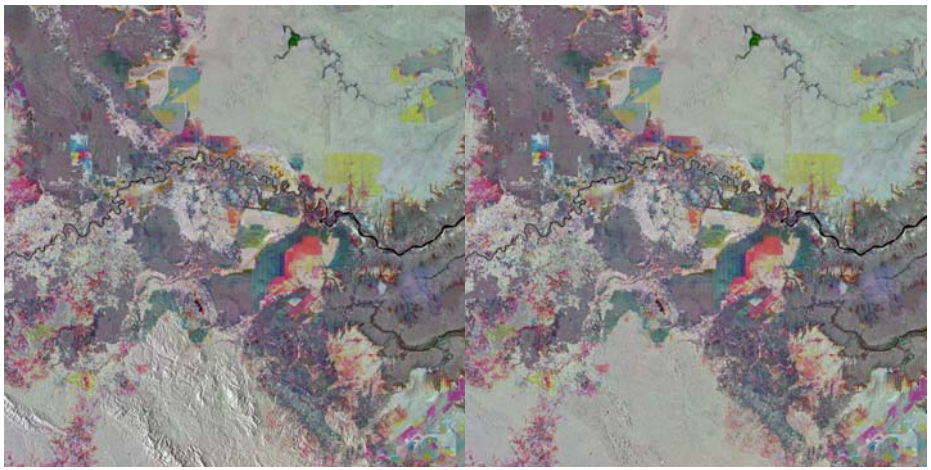


R:2007, G:2009:B:2010

R:2007, G:2009:B:2010

Radiometry: Slope corrections on γ^0 and σ^0

$$\tilde{\sigma}^0 = \sigma^0 \frac{\cos\psi}{\sin\theta} \frac{1}{LIAC}$$

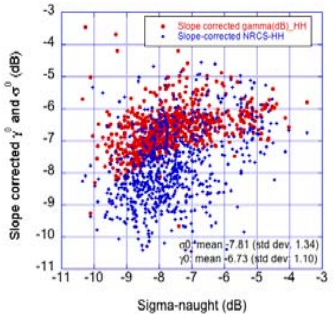
$$\theta_l = \cos^{-1}\left\{ \frac{(\mathbf{r}_s - \mathbf{r}_p)}{|\mathbf{r}_s - \mathbf{r}_p|} \cdot \mathbf{n}_l \right\}$$

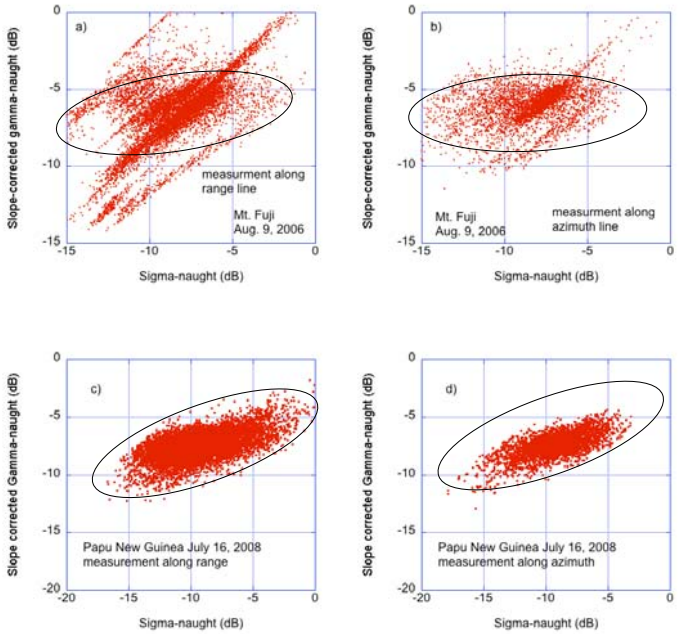
$$\mathbf{n}_l = \frac{1}{\sqrt{h_x^2 + h_y^2 + 1}} \begin{pmatrix} h_x & h_y & 1 \end{pmatrix}^t$$

$$\cos\psi = \mathbf{n}_f \cdot \mathbf{n}_l = \frac{\sin\theta_l - \cos\theta_l \cdot h_x}{\sqrt{h_x^2 + h_y^2 + 1}}$$

$$LIAC \sim 10^{d\theta_l}$$

$$\gamma^0 \equiv \frac{\sigma^0}{\cos\theta_{local}} \frac{\cos\psi}{\sin\theta_{inci}}$$





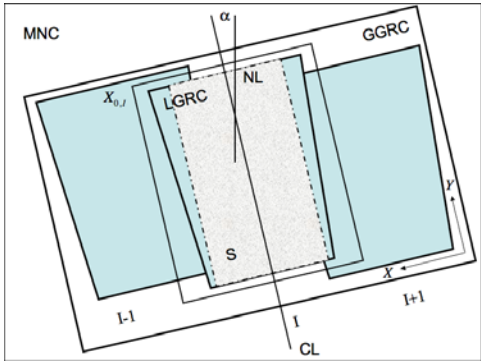
Mosaicking and SAR Strip Processing

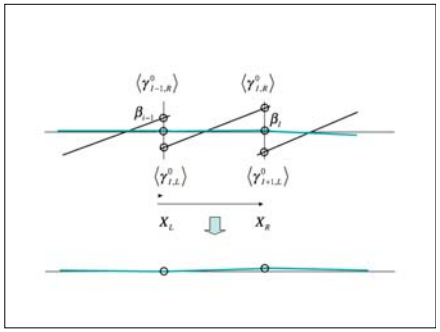
Advantages:

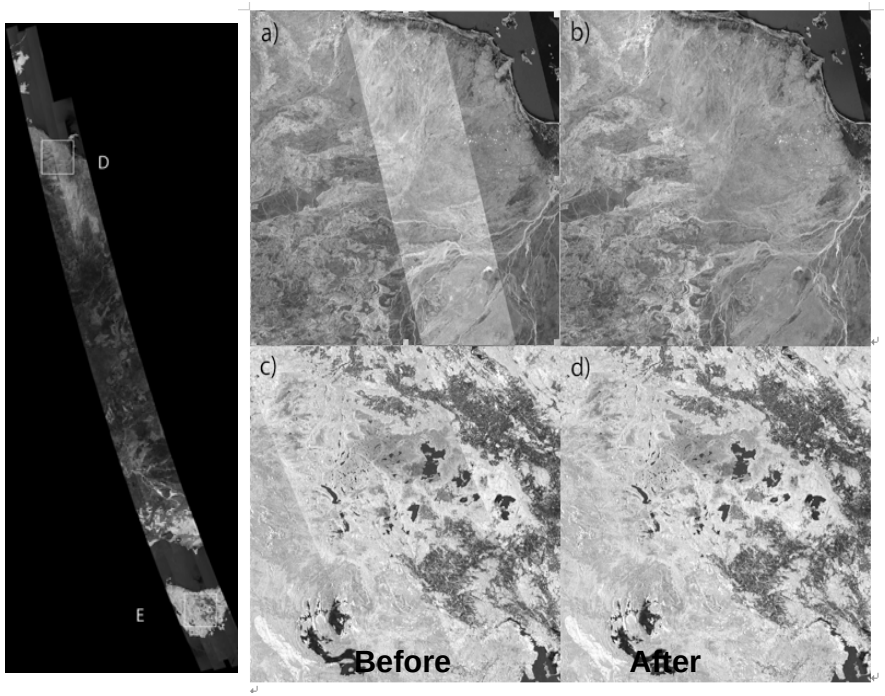
- Global researches
- Temporal variation
- Reduce the number of images : 86400 -> 1000

Requirements

- Geometric and radiometric collocations







Geometric accuracies

Co-registration: 0.261,0.277

Accuracy: 34.14: Landsat-mosaic
Accuracy: 11.00:CR-mosaic

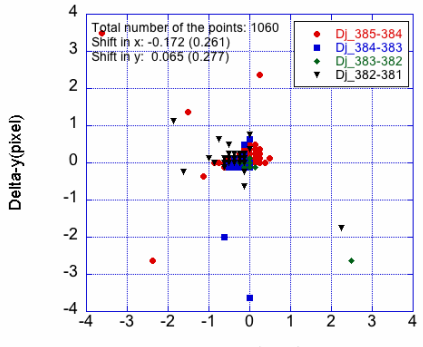


Table IV Summary of Geolocation RMSE of the JAXA PALSAR Mosaic

Area	Northing RMSE (m)	Easting RMSE (m)	Total RMSE (m)	No. of GCPs
Japan (2007)	22.81(-112.9,43.8)	34.20(-114.2,69.9)	41.11(0.0,119.3)	104
Borneo-Jawa (2007)	23.13(-76.7,71.1)	32.15(-94.5,49.4)	39.61(0.0,98.0)	104
Sumatra (2007)	27.98(-96.9,65.8)	30.03(-86.3,60.7)	41.05(0.0,129.8)	70
Philippine (2007)	17.19(-35.67,35.66)	16.86(-26.89,33.23)	24.08(0.48,43.56)	49
Philippine (2009)	22.83(-54.90,74.90)	29.34(-75.18,39.54)	37.17(0.02,98.39)	101
Borneo-Jawa (2009)	24.79(-62.75,71.95)	30.23(-79.32,26.33)	39.09(0.0,85.42)	83
Sumatra (2009)	26.42(-50.9,67.1)	32.99(-131.9,39.7)	42.26(0.0,131.9)	83
Japan (2009)	26.46(-55.8,52.3)	33.26(-90.0,61.3)	42.50(0.0,99.8)	69
Indochina (2009)	27.96(-52.5,72.9)	30.60(-92.8,75.5)	41.45(0.0,118.0)	89
Central Africa (2008)	24.30(-46.7,47.4)	21.16(-48.2,42.3)	32.22(2.9,63.0)	131
Central Africa (2009)	16.52(-35.17,30.81)	16.20(-39.16,35.88)	23.14(2.73,44.36)	147
Sulawesi (2007)	17.01(-35.14,31.79)	15.44(-30.68,37.59)	22.98(2.30,43.27)	68
Sulawesi (2009)	15.38(-33.76,33.74)	16.21(-41.20,34.76)	22.35(0.85,45.16)	67
Australia (2009)	19.66(-44.41,30.90)	18.91(-41.28,48.26)	27.28(2.35,58.44)	218
All	22.35	25.81	34.14	1393

Note: The numbers in brackets represent the minimum and maximum values respectively.

AGAP-F:ALOS Geoscience and Application Processor for Forest

Control Server

2 nodes

Processing Server

16 nodes
(32CPU 128Core)

Storage

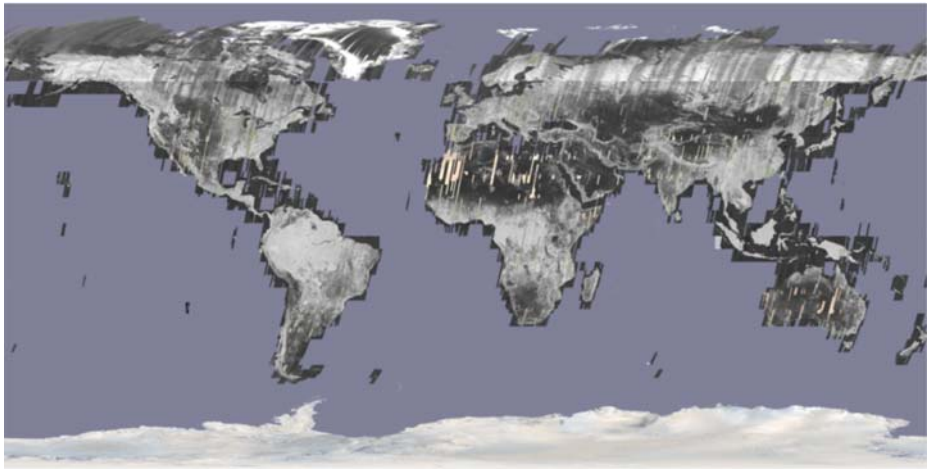
800TB
(2TB*40*10)

Item	Amount (1node)	Total (16nodes)	Description
CPU	2CPU (8Core)	32CPU (128Core)	Xenon E5540 (2.53GHz)
Memory	48GB	768GB	DDR3
Disk	-	800TB (RAID6)	DDN S2A9900

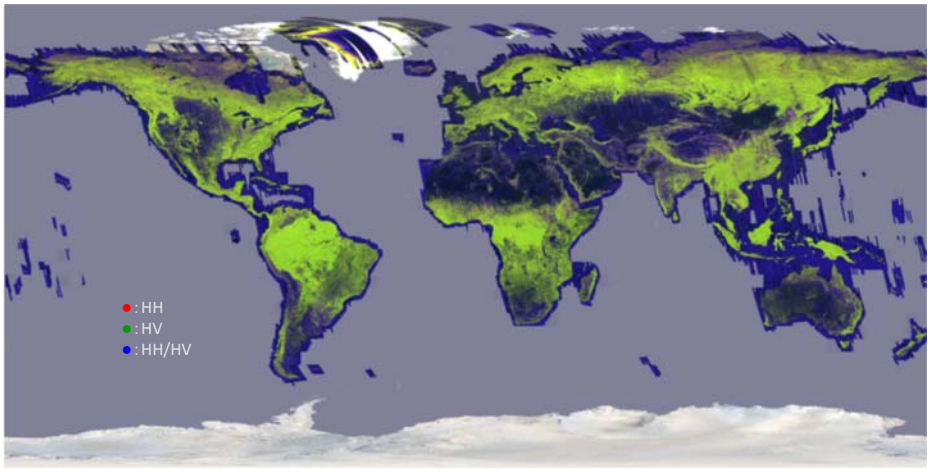
Features: Fast accesses by the parallel interface between HD and CPUs.

・eCognition Sever (7 licenses)

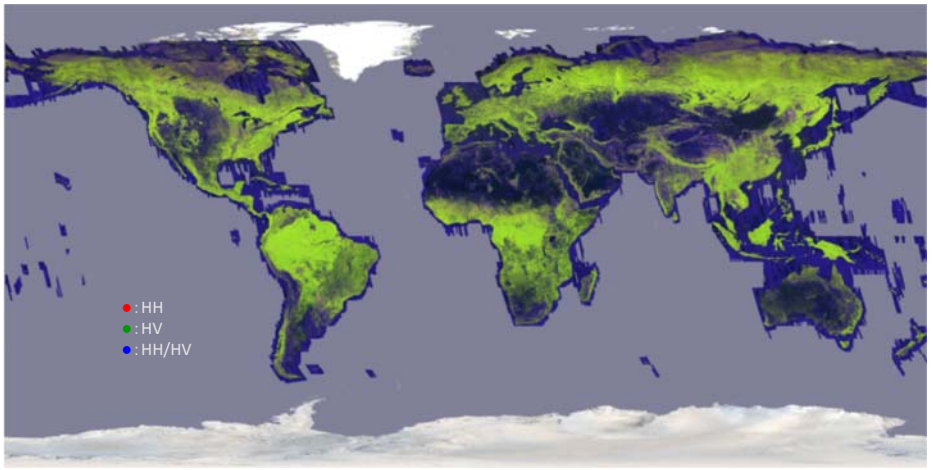
JERS-1 SAR 10m Mosaic- 1995 HH Image



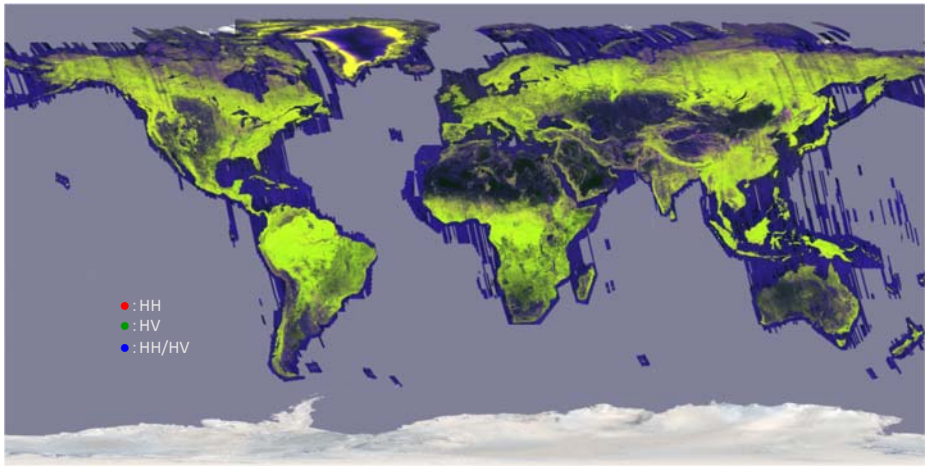
PALSAR 10m Mosaic 2007 RGB Composite Image



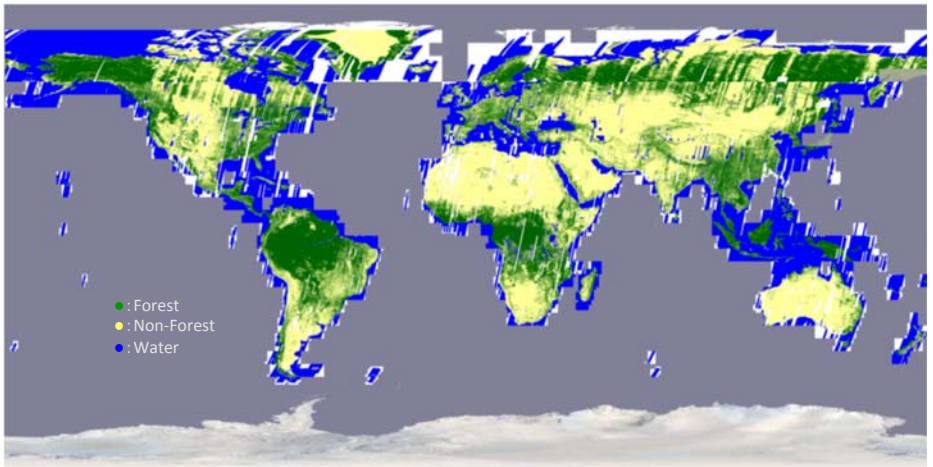
PALSAR 10m Mosaic 2009 RGB Composite Image



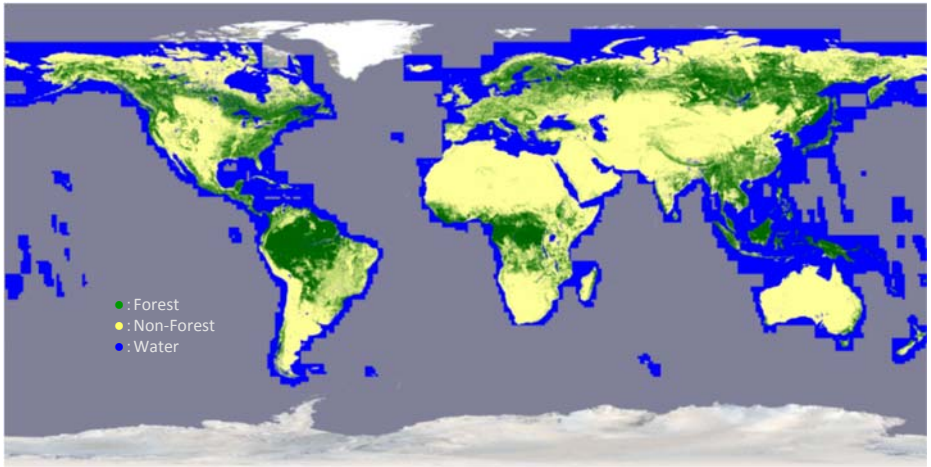
PALSAR 25m Mosaic 2010
RGB Composite Image



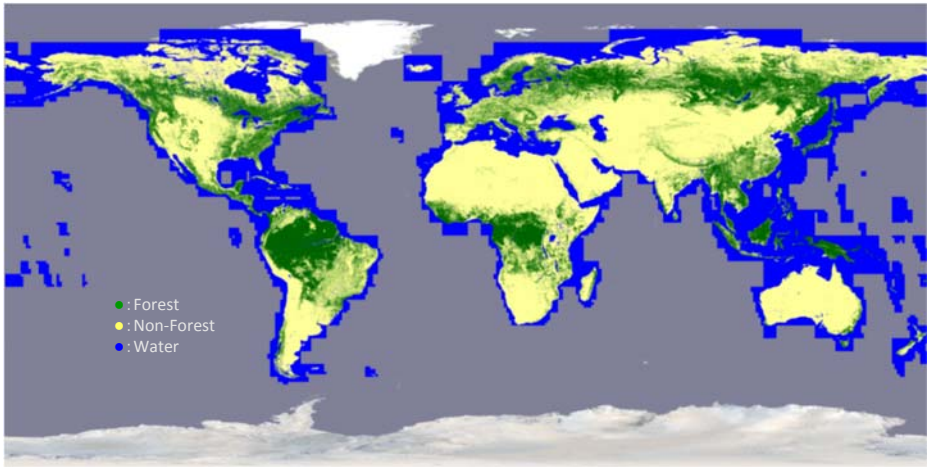
JERS-1 SAR 10m Mosaic 1995
Forest/ Non-Forest Map



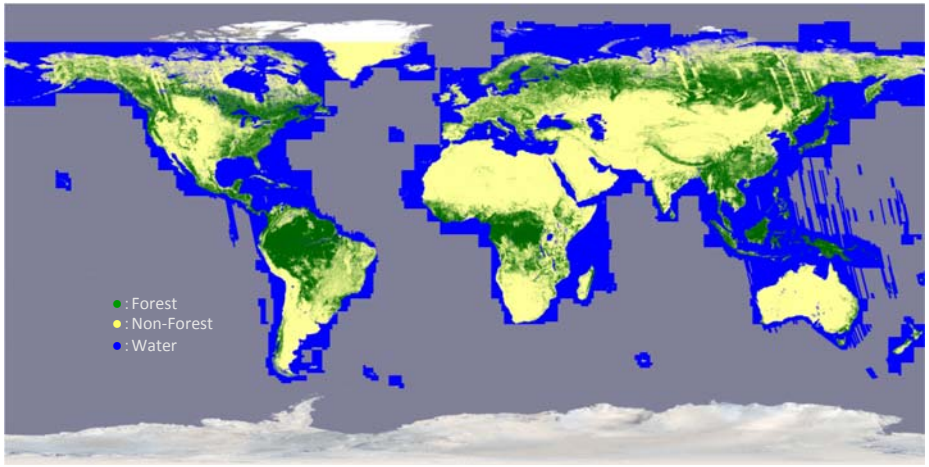
PALSAR 10m Mosaic 2007
Forest/Non-Forest Map



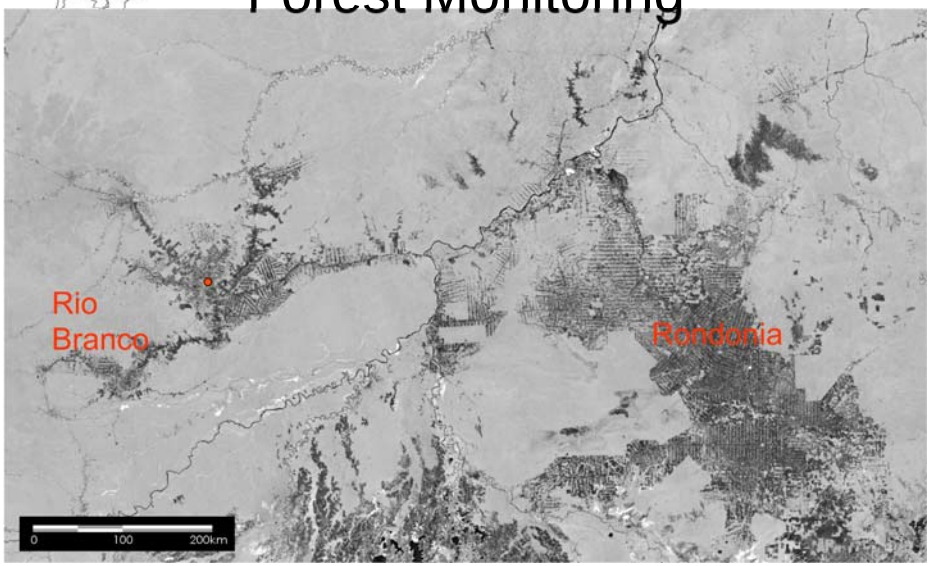
PALSAR 10m Mosaic 2009
Forest/Non-Forest Map



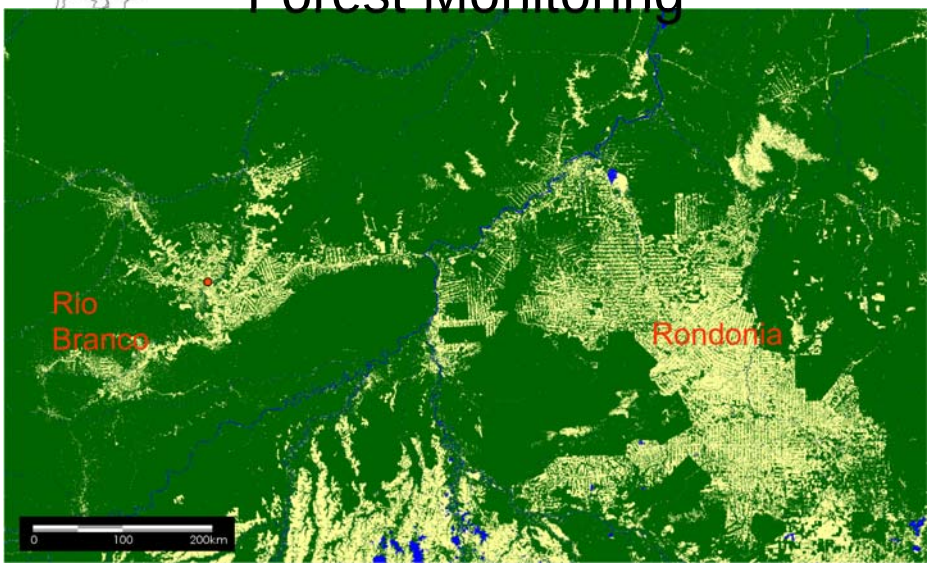
PALSAR 25m Mosaic 2010
Forest/Non-Forest Map



Forest Monitoring



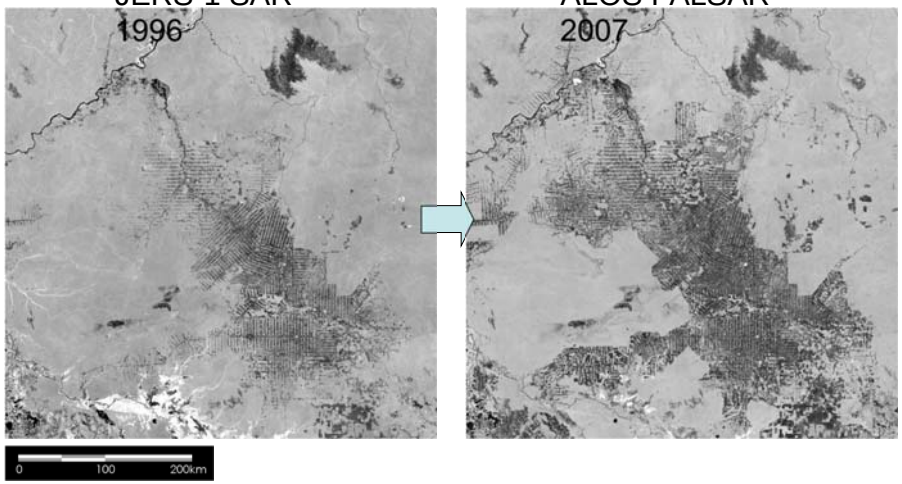
Forest Monitoring



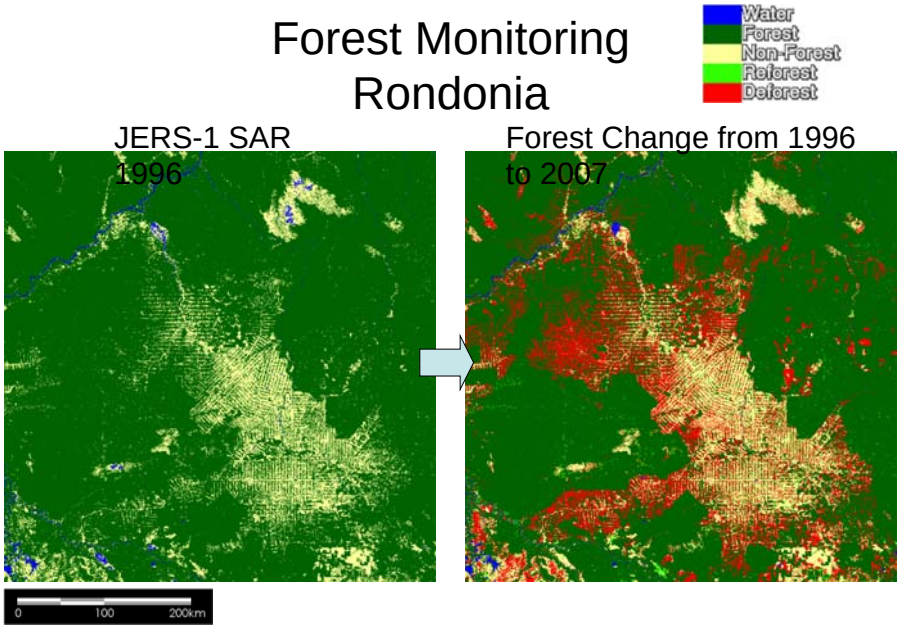
Forest Monitoring
Rondonia

JERS-1 SAR
1996

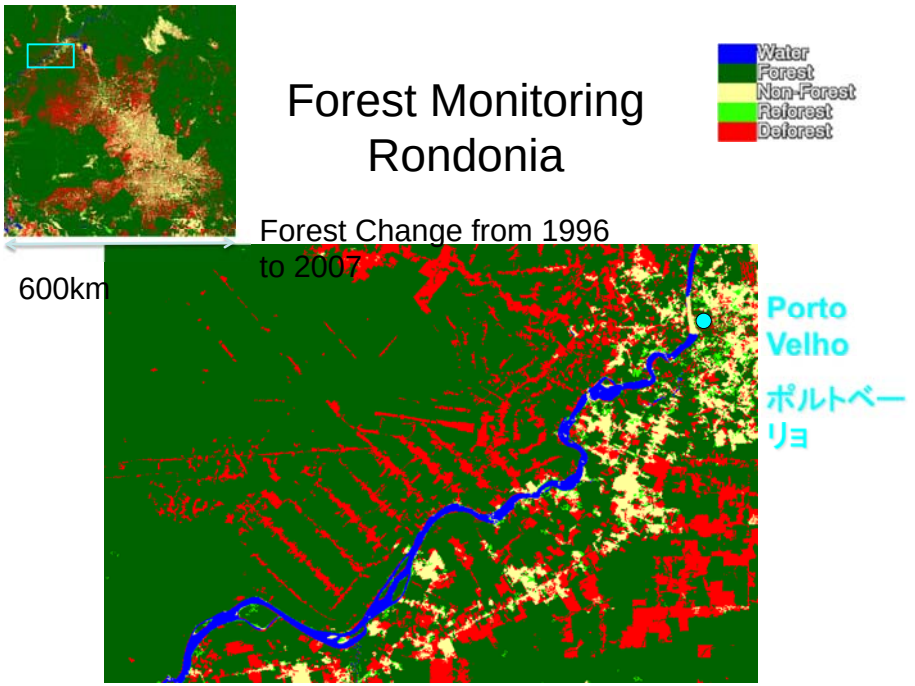
ALOS PALSAR
2007



Forest Monitoring Rondonia



Forest Monitoring Rondonia



Evaluation result using SACLA

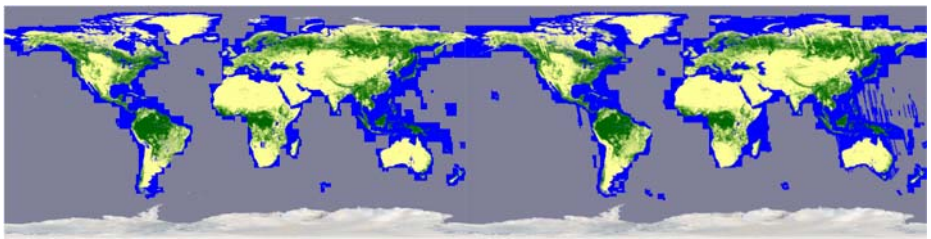
- PALSAR FNF 2010 および2007（25m分解能）について、SACLA(Site-based data for assessing Annual Change of Land cover)（名古屋大学がFLUXNETやDCPの現地データを元に土地被覆判別をしたもの）を用いた精度評価を行った。

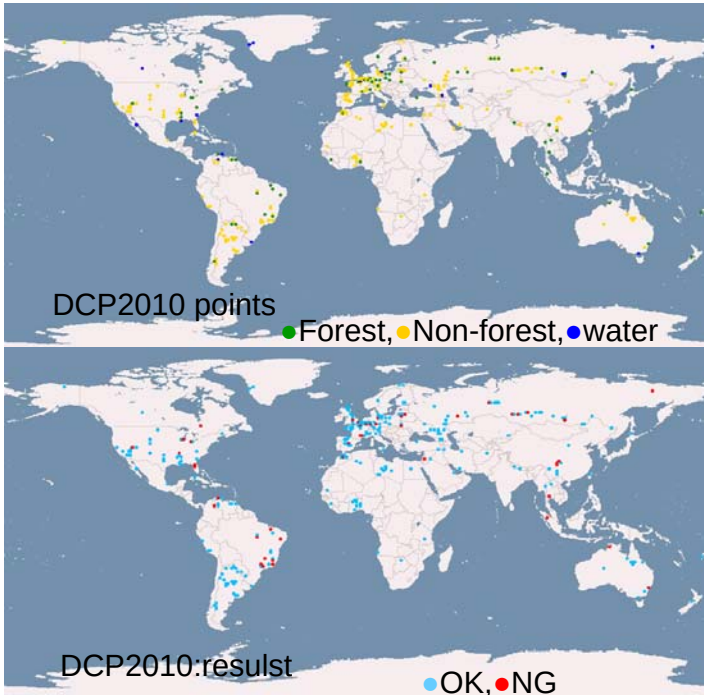
PALSAR FNF 2007

84.5% (1152 points)

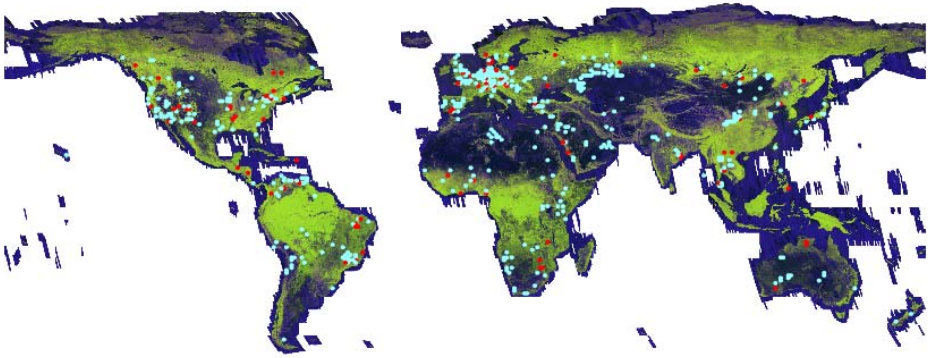
PALSAR FNF 2010

83.0% (611points)





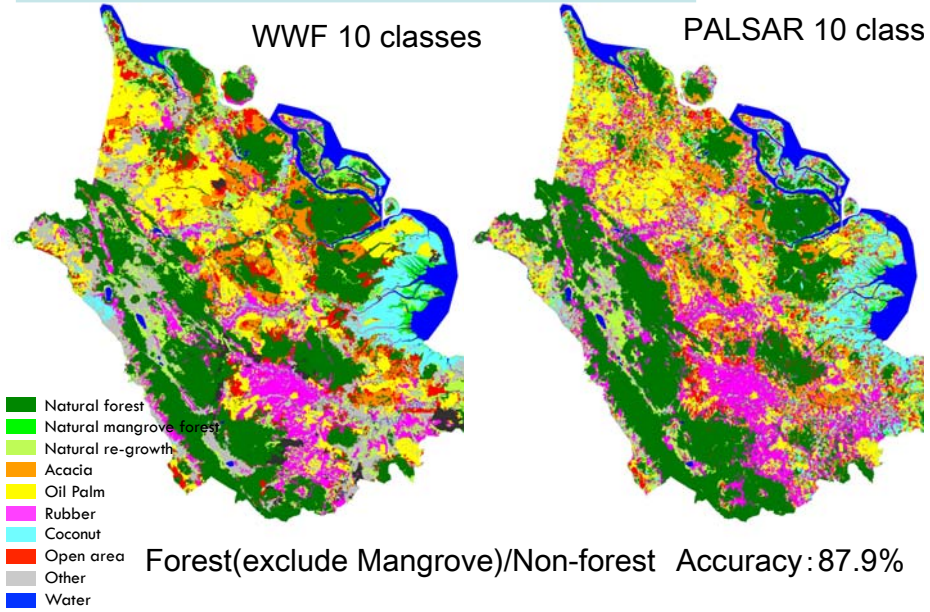
Evaluation result for 2009 using DCP



●Agree 443 (84%)
●Disagree 87 (16%)

分類	一致	不一致	合計	正解率	備考
森林	84	40	124	68%	1～5に対応
非森林	359	47	406	88%	0,6～16に対応
合計	443	87	530	84%	

Land Use Classification in Riau, Sumatra

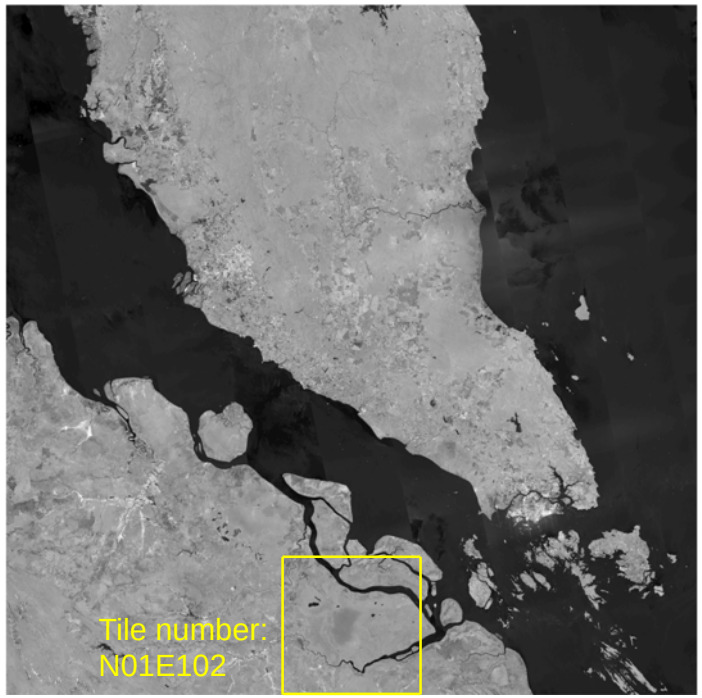


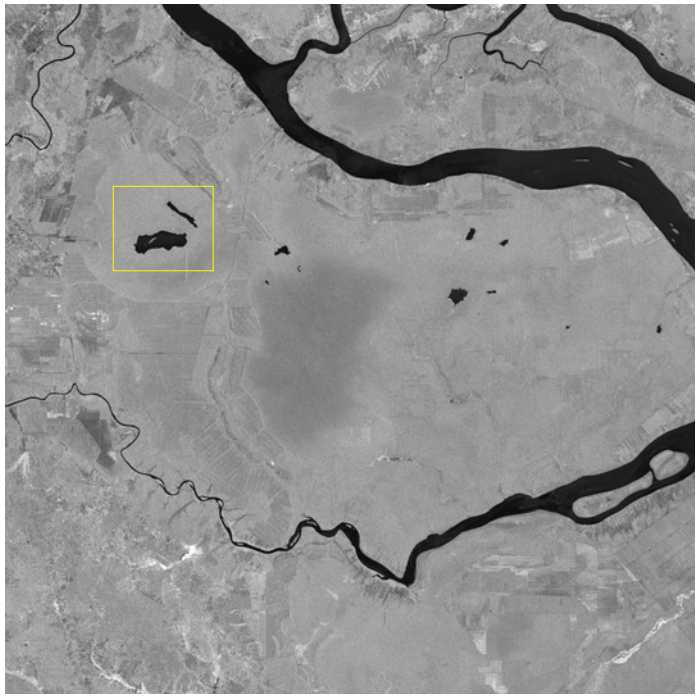
Forest(exclude Mangrove)/Non-forest Accuracy：87.9%

Conclusions

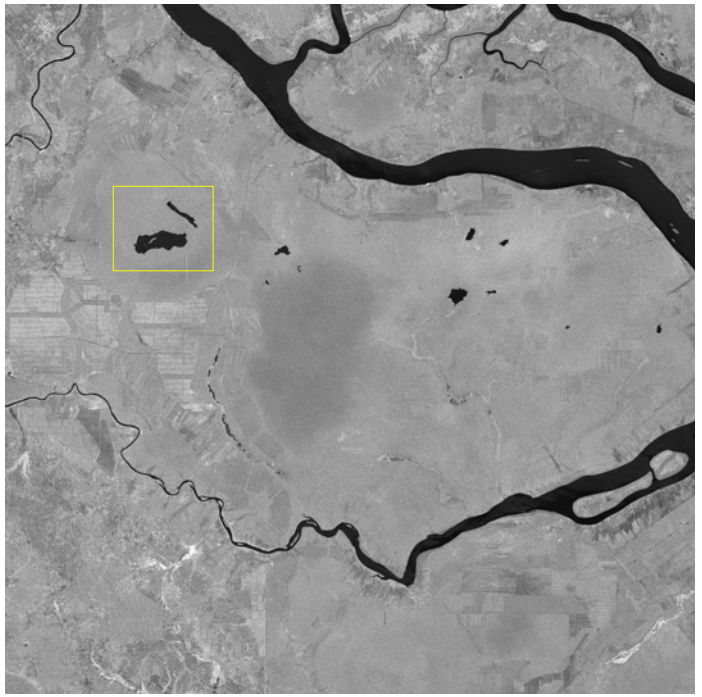
L-band SAR high resolution slope corrected ortho global products for 1995-2007-2009 and 2010 have been generated with well geometric accuracy of 11m.

Classification processes are under going. Using the test site in Riau, SVM shows the better accuracy of 89% for forest/non-forest. Level slicing shows some over and under estimates for the forest/non-forest information while the processing speed is acceptable.

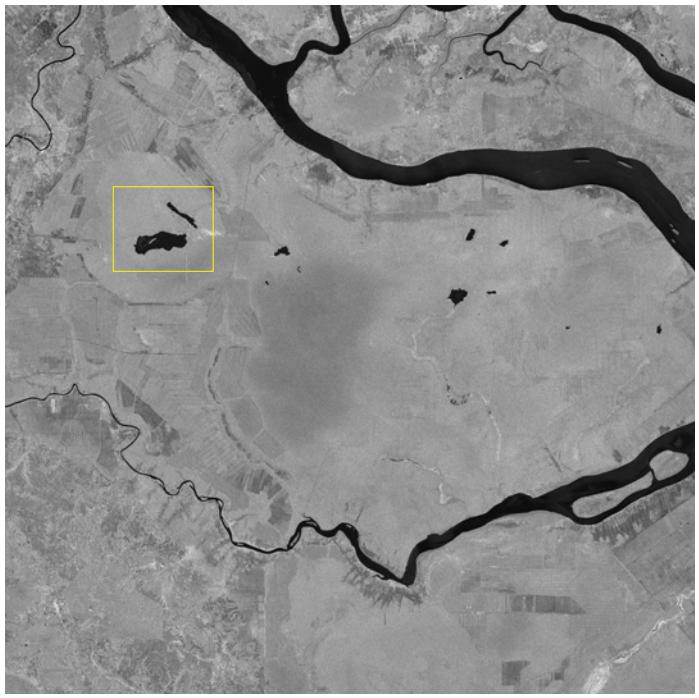




tile exsample
Tile:N01E10
Pol:sl_HH



tile exsample
Tile:N01E10
Pol:sl_HH



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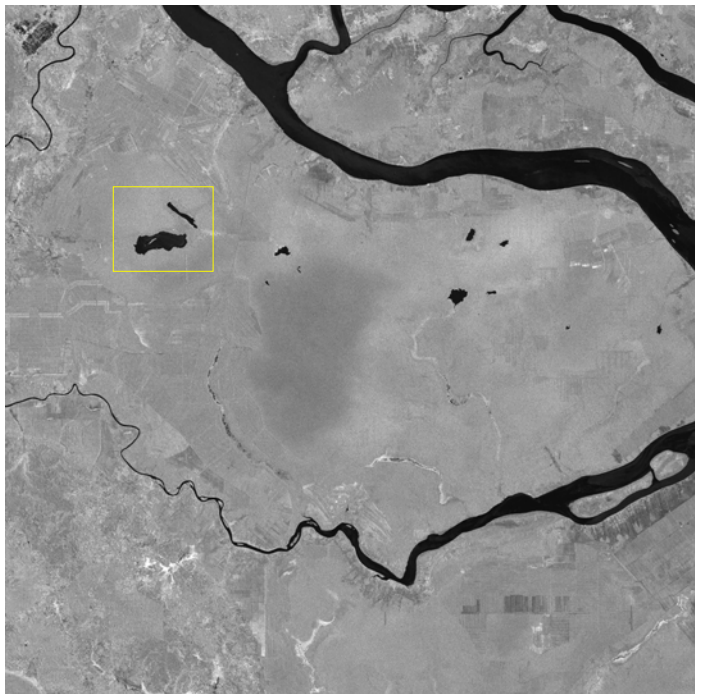

tile exsample
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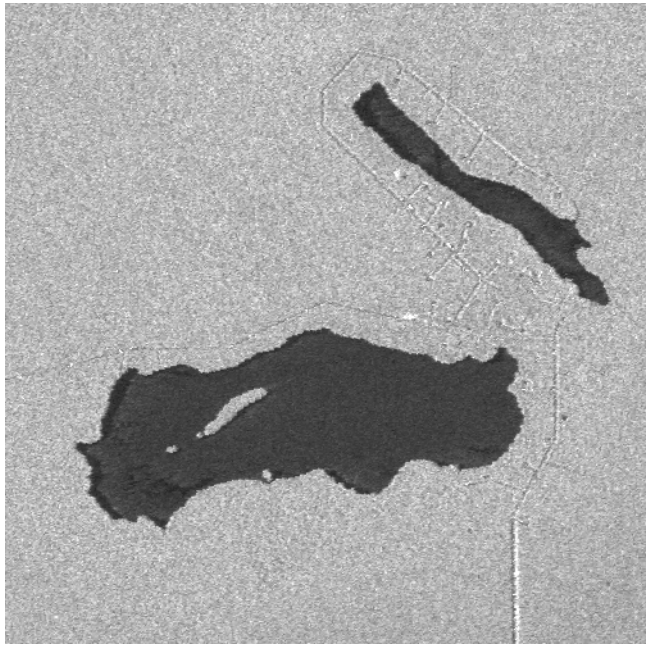
Year:2007

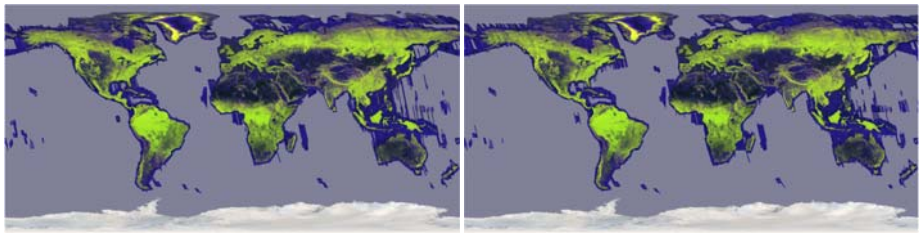


Year:2008

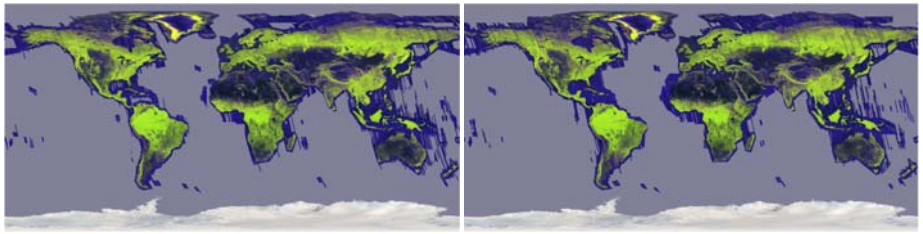
Year:2009

Year:2010

25m ortho-slopecorected mosaic

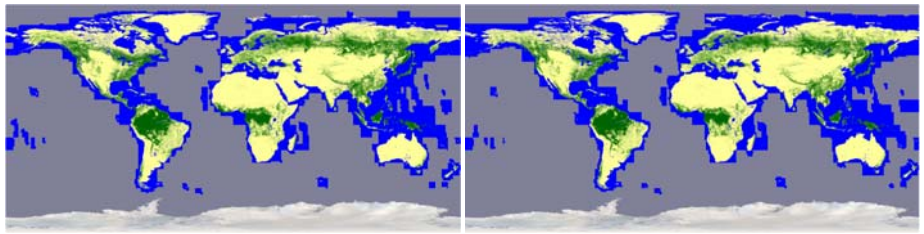


25m FBD mosaic, 2007　　25m FBD mosaic, 2008

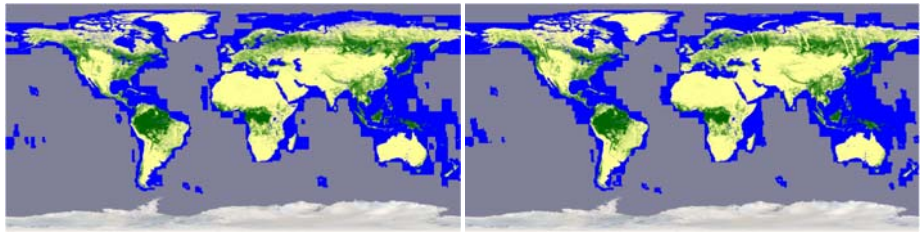


25m FBD mosaic, 2009　　25m FBD mosaic, 2010

Forest/Non-forest map



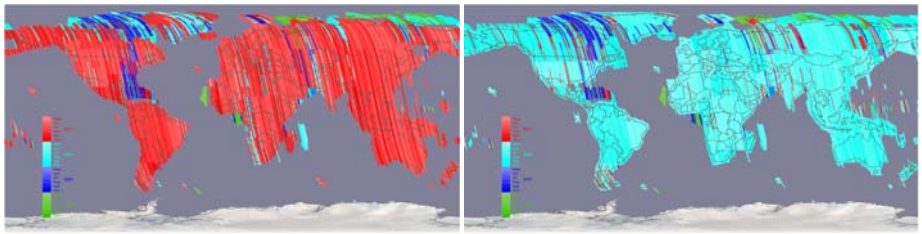
Forest/Non-forest map, 2007　　Forest/Non-forest map, 200



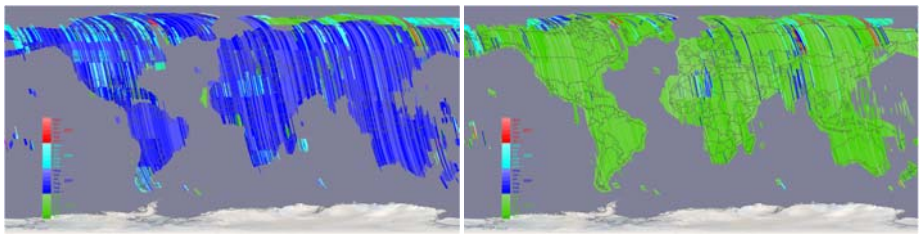
Forest/Non-forest map, 2009　　Forest/Non-forest map, 201

25m Data mosaic

2007: 87.98%　　2008: 93.19%
2009: 88.92%　　2010: 94.33%



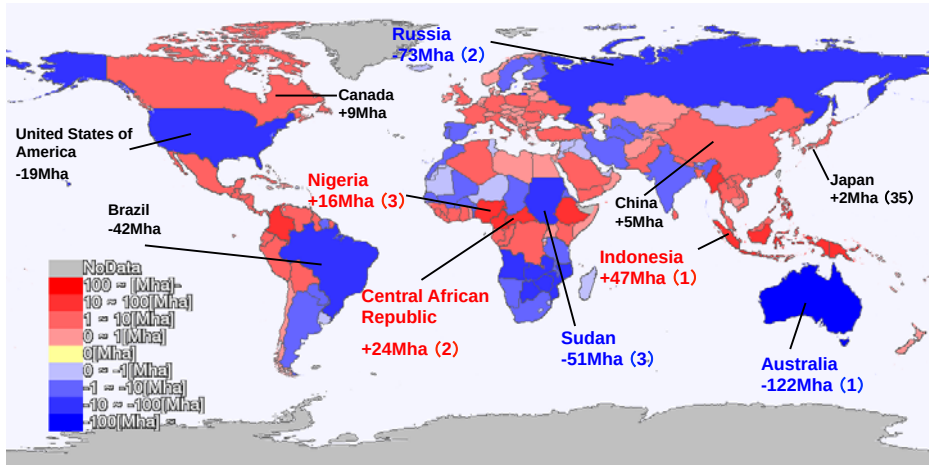
Date mosaic, 2007　　Date mosaic, 2008



Date mosaic, 2009　　Date mosaic, 2010

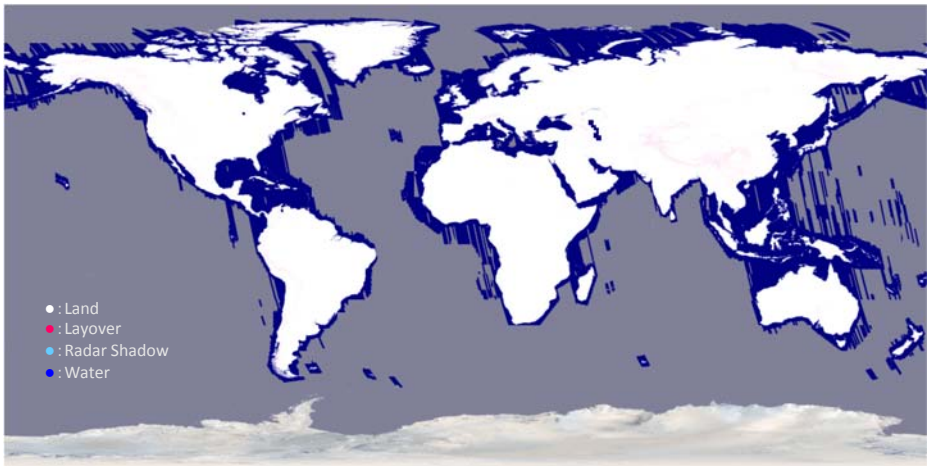
Accuracy of PALSAR FNF 2009
compared with FRA 2010

Difference in Forest Area

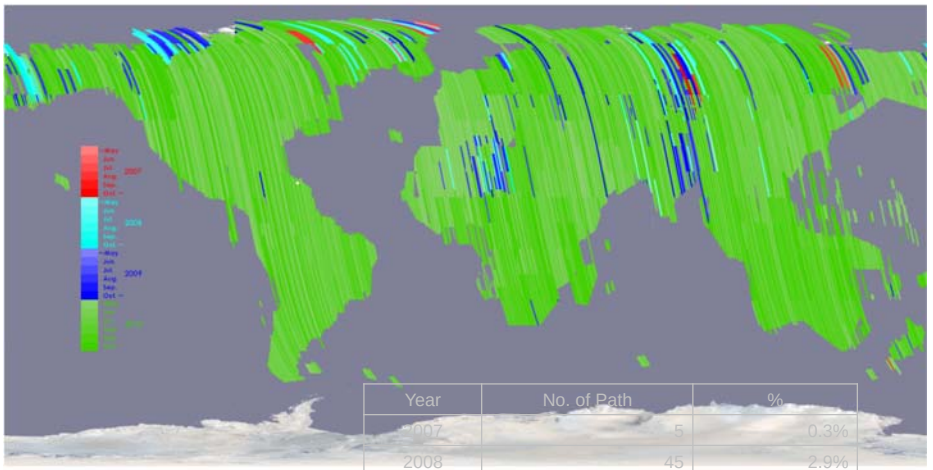


FRA 2010 = the Global Forest Resources Assessment 2010 by FAO

PALSAR 25m Mosaic 2010
Mask Information



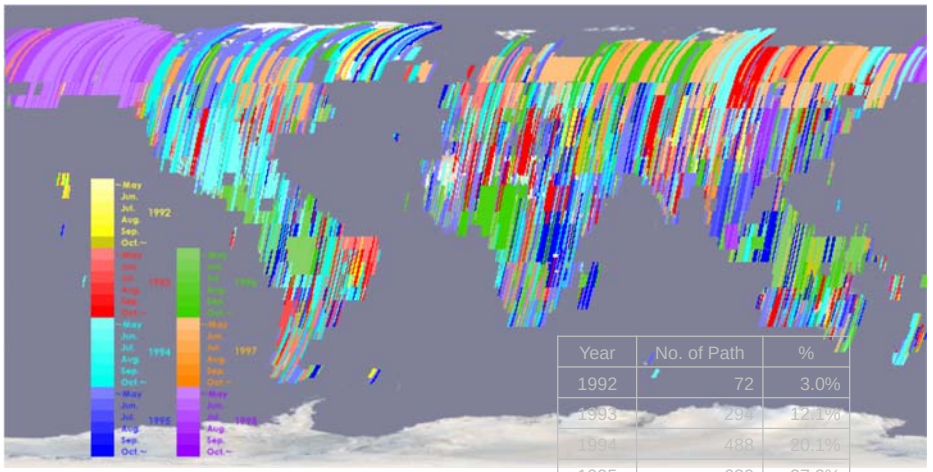
PALSAR 25m Mosaic 2010
Observation Date



Year	No. of Path	%
2007	5	0.3%
2008	45	2.9%
2009	96	6.2%
2010	1408	90.6%

PALSAR 25m Mosaic 2010
Local Incidence Angle

JERS-1 SAR 10m Mosaic
Observation Date



Year	No. of Path	%
1992	72	3.0%
1993	294	12.1%
1994	488	20.1%
1995	680	27.9%
1996	499	20.5%
1997	270	11.1%
1998	130	5.3%

ScanSAR Mosaic

- Four examples are shown below

- Ortho-rectified using SRTM DEM
- Slope correction using SRTM DEM