ALOS-2 status and science project

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JAXA/EORC

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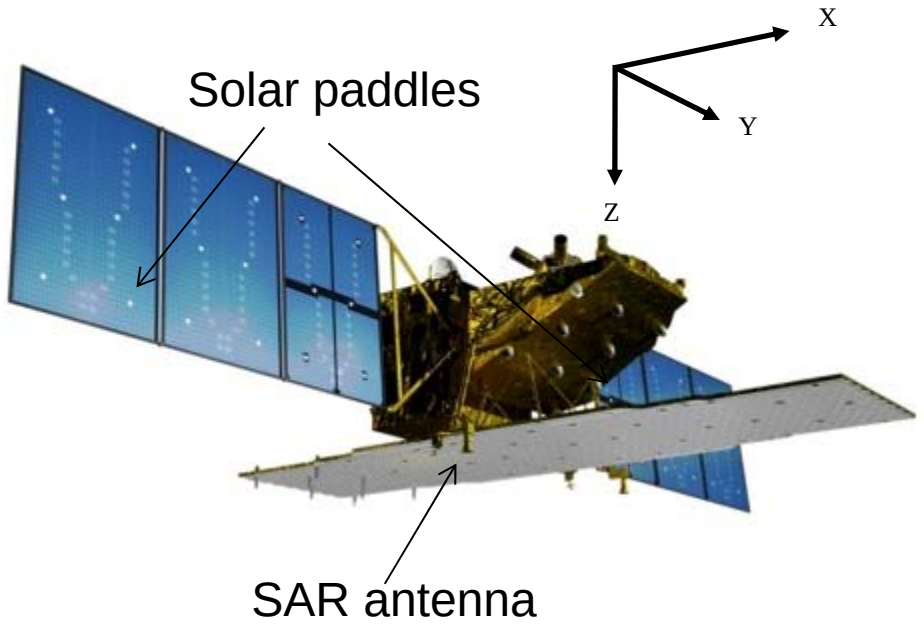
	ALOS	ALOS-2
Launch	Jan. 24, 2006	**JFY 2013 (by March 2014)**
Orbit type	Sun-synchronous	
Altitude	690 km	628 km +/- 500 m (for reference orbit)
Revisit time	46 days	14 days
LSDN	10:30	12:00 +/- 15 min
Sensor	PALSAR, PRISM, AVNIR-2	PALSAR-2



	PALSAR	**PALSAR-2**
Band	L-band Synthetic Aperture Radar	
Antenna	Active Phased Array Antenna type **one** dimensions scan (range)	Active Phased Array Antenna type **two** dimensions scan (range and azimuth)
Antenna size	3m(El) x 9m(Az)	3m(El) x 10m(Az)
Bandwidth	14/**28** MHz	14 – **84**MHz
Peak transmit Power	≥ 2000 W	5100W
Observation swath	35– **350**km	25 – **490**km
Resolution	Range : 10 m to 100 m Azimuth: 10 m to 100 m	Range : 3 m to 100 m Azimuth: 1 m to 100 m

PALSAR-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/QP/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 / DinSAR
ScanSAR (DP) : Rapid deforestation / wetlands / (ScanSAR)InSAR
Spotlight (SP) : Emergency observations
Ultra Fine (SP) : Global map, InSAR base mapping
High sensitive (QP) : Global map
ScanSAR wide (SP) : Polar ice

ALOS-2 Mission Objectives

- Disaster Monitoring
  (including the solid earth research)
- Environmental monitoring for sustainable Earth in Forestry, Cryospheric, and sea Ice
- Natural Resources
  (Agriculture, Ocean monitoring, and Resources)
- Technology Development for the Future Earth Remote sensing
  (satellite and sensor)

ALOS-2 Science Project

- CAL/VAL
- Geophysical parameters-1 & 2 (High-level and Science products)
- RA-4
- Kyoto and Carbon Project (REDD+)
- Pi-SAR-L2
- Ground Truth Data Collection
- AGAP-S

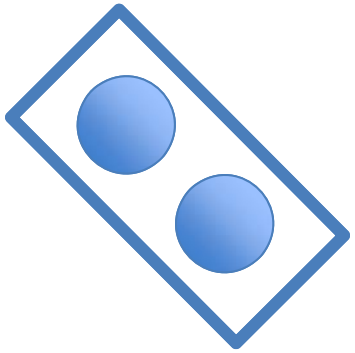
CAL/VAL

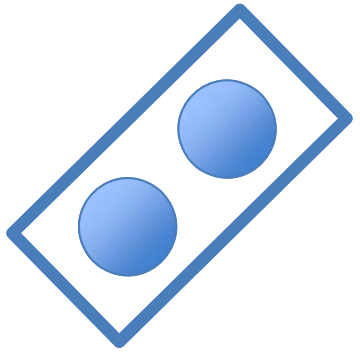
Items	Contents	Reference	Accuracy Requirement
Geometry	Geo-locations (SLC and Ortho)	CR, ARC	**Strip and Spotlight SLC: <5m** **Strip and Spotlight Ortho: < 10m** **ScanSAR<50m**
Radiometry	Calibration Factor Determination and Accuracy Antenna Pattern Estimation (Elevation and Azimuth) Polarimetric Calibration (Distortion, Cross talk, channel Imbalance) Noise Equivalent Sigma-Zero, Ambiguities	CR and Amazon Amazon CR + Amazon Natural Target	**NRCS < 1.0 dB** **Pol: VV/HH < 0.5 dB** **VV-HH<5 degrees**
Cal Site	Tomakomai-Hokkaido Brazil, several global sites		

JAXA Calibration Site in Tomakomai, Hokkaido, Japan

Transponder and Signal Evaluator

- Transportable Transponder (Geo-calibration)
- Position Accuracy : 1 cm – radar LOS
- Polarization selective

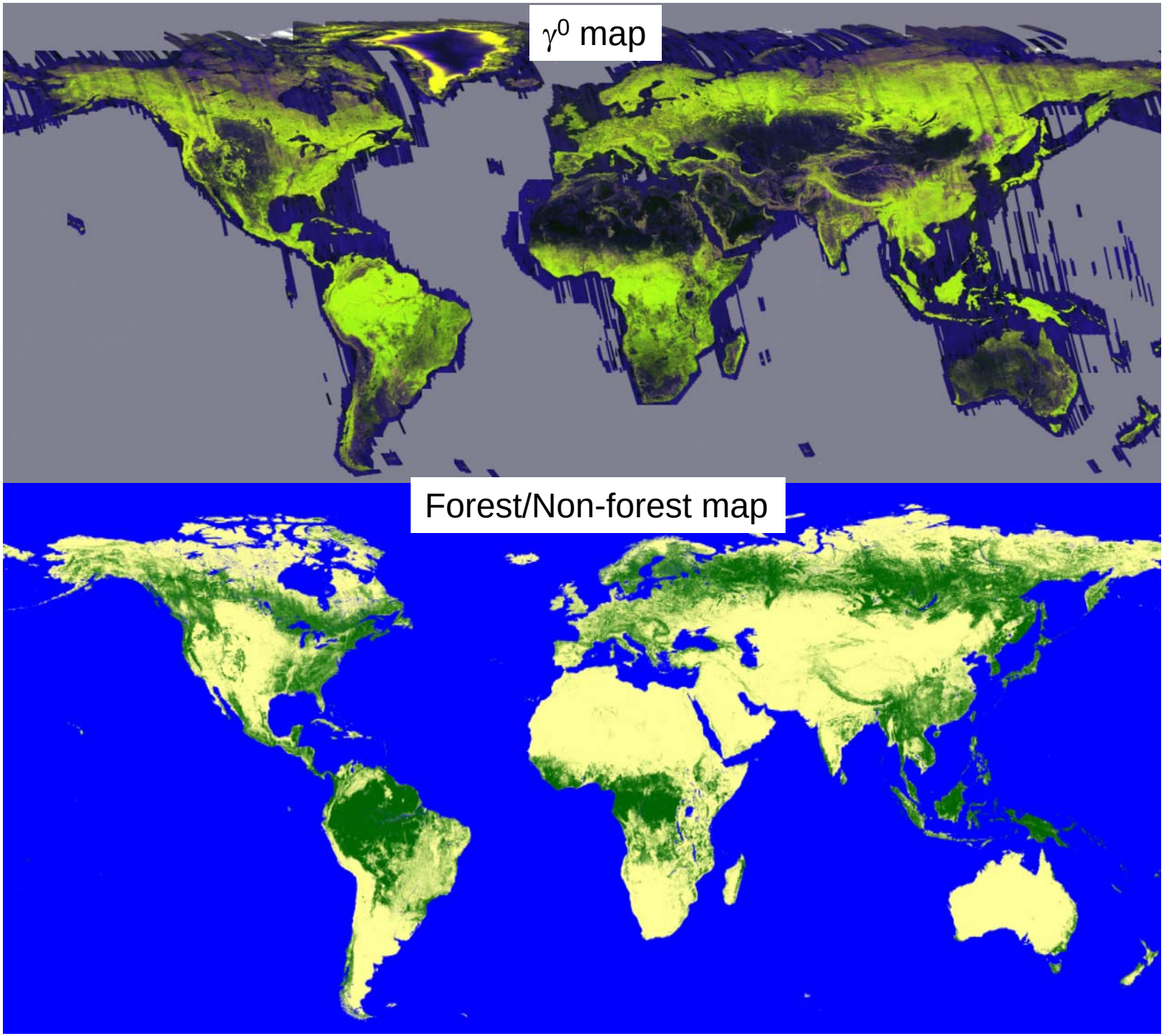




$$\begin{pmatrix} Z_{hh} & Z_{hv} \\ Z_{vh} & Z_{vv} \end{pmatrix} = Ae^{\frac{-4\pi r}{\lambda}} \begin{pmatrix} 1 & \delta_3 \\ \delta_4 & f_2 \end{pmatrix} \begin{pmatrix} S_{hh} & S_{hv} \\ S_{vh} & S_{vv} \end{pmatrix} \begin{pmatrix} 1 & \delta_1 \\ \delta_2 & f_1 \end{pmatrix} + \begin{pmatrix} N_{hh} & N_{hv} \\ N_{vh} & N_{vv} \end{pmatrix}$$

Geophysical Parameters-1

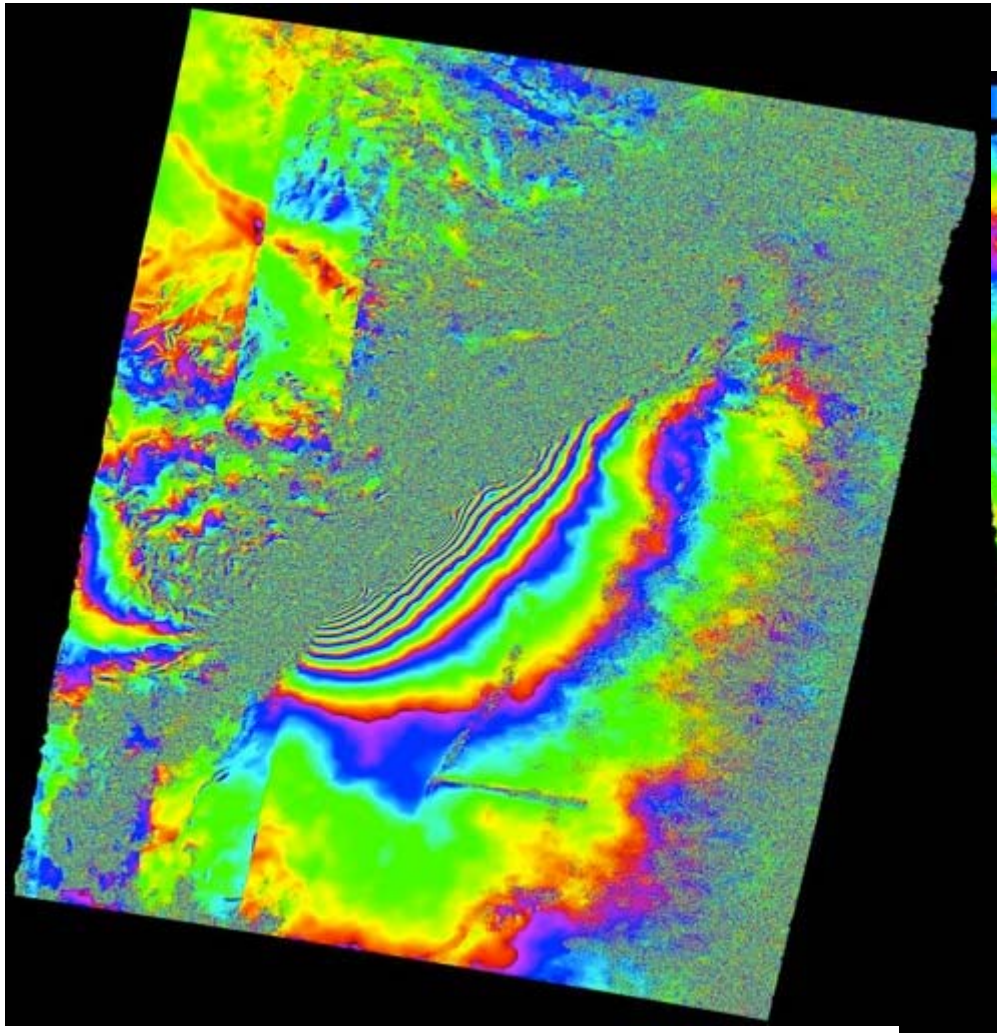
Product	Contents
Ortho-rectified (slope corrected) image	Produced using the DEM (DSM). **Global browse, 500m global browse mosaic, global 3-m resolution mosaic, ScanSAR ortho-slope corrected path for quasi deforestation monitoring at pan tropical regions, i.e., Brazil, Indonesia, are also included.**
Disaster information detection	Using the TIME SERIES SAR data including before and after the event, possible disaster area will be detected. The parameters will be amplitude, interferometric coherence, polarimetric coherence and the others.
Deformation detection	Using the DinSAR (Differential SAR interferometry) and Time Series Analysis, land surface deformation pattern caused by the Earthquake, Volcanic activities, subsidence, land slide, will be produced. Representative products are quick deformation pattern detection at the earthquake event, and the monitoring of the Japan Island annually.
Sea Ice Identification	Produces the Sea-Ice Identification using the ScanSAR Dual Polarizations.
Forest Classification	Generate the global forest map, i.e., Forest/Non-Forest or forest maps with more classes (Fig. 1 as the samples).
Biomass Estimation	Generate the biomass map using the gamma-naught-biomass, biomass-lidar, and biomass-classification method.

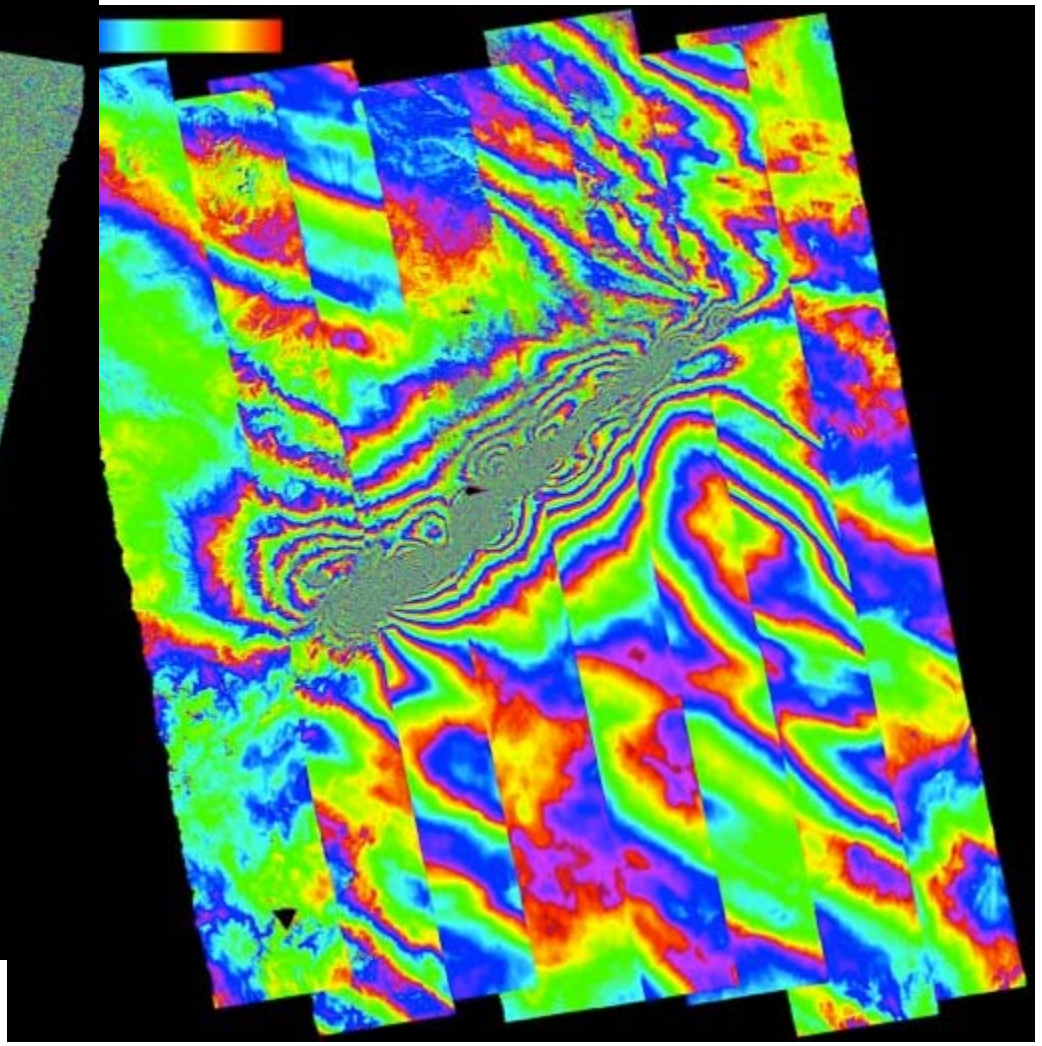

γ^0 map
Forest/Non-forest map

Shisen
RSP124

ScanSAR : descending

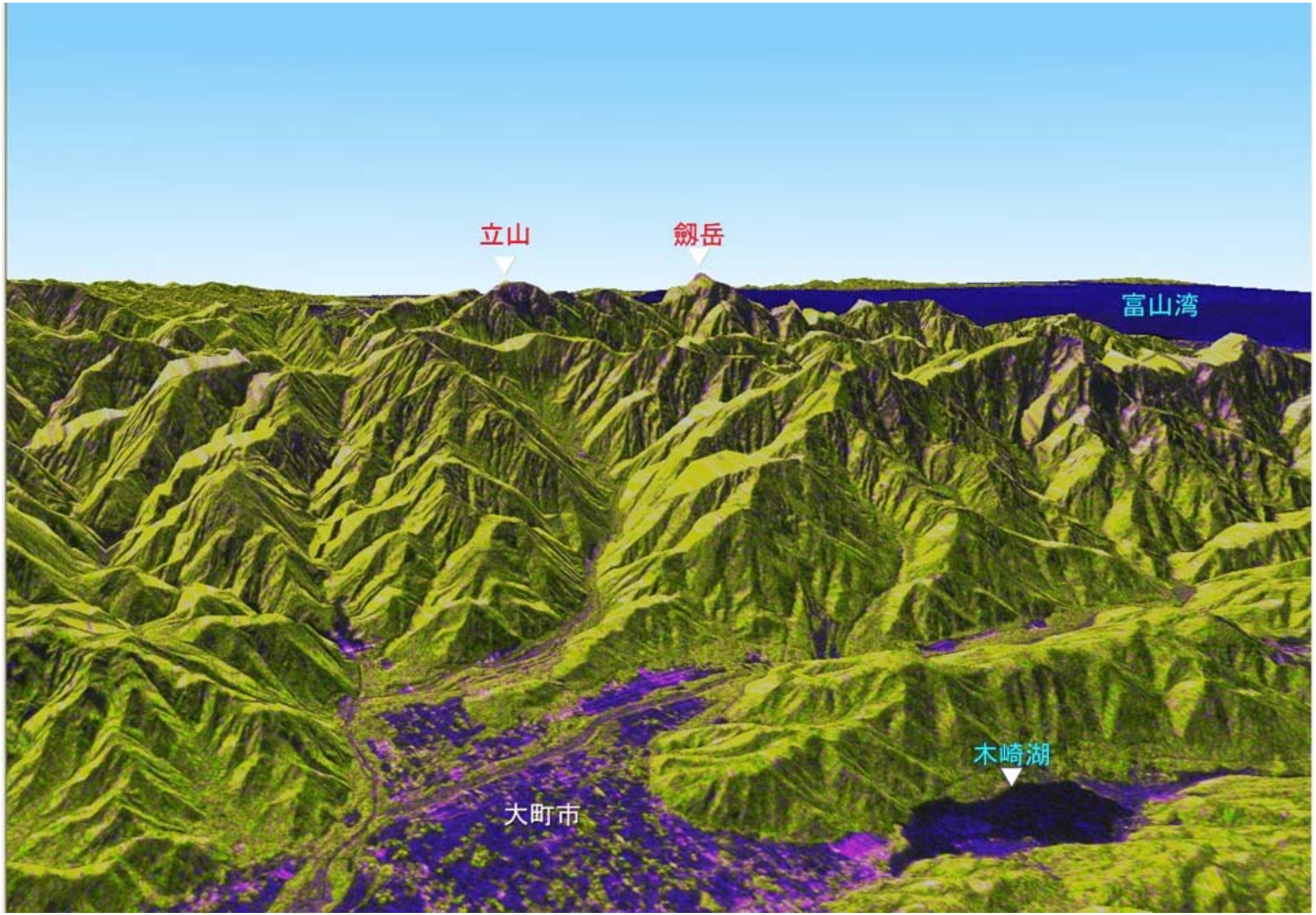
DinSAR: Ascending



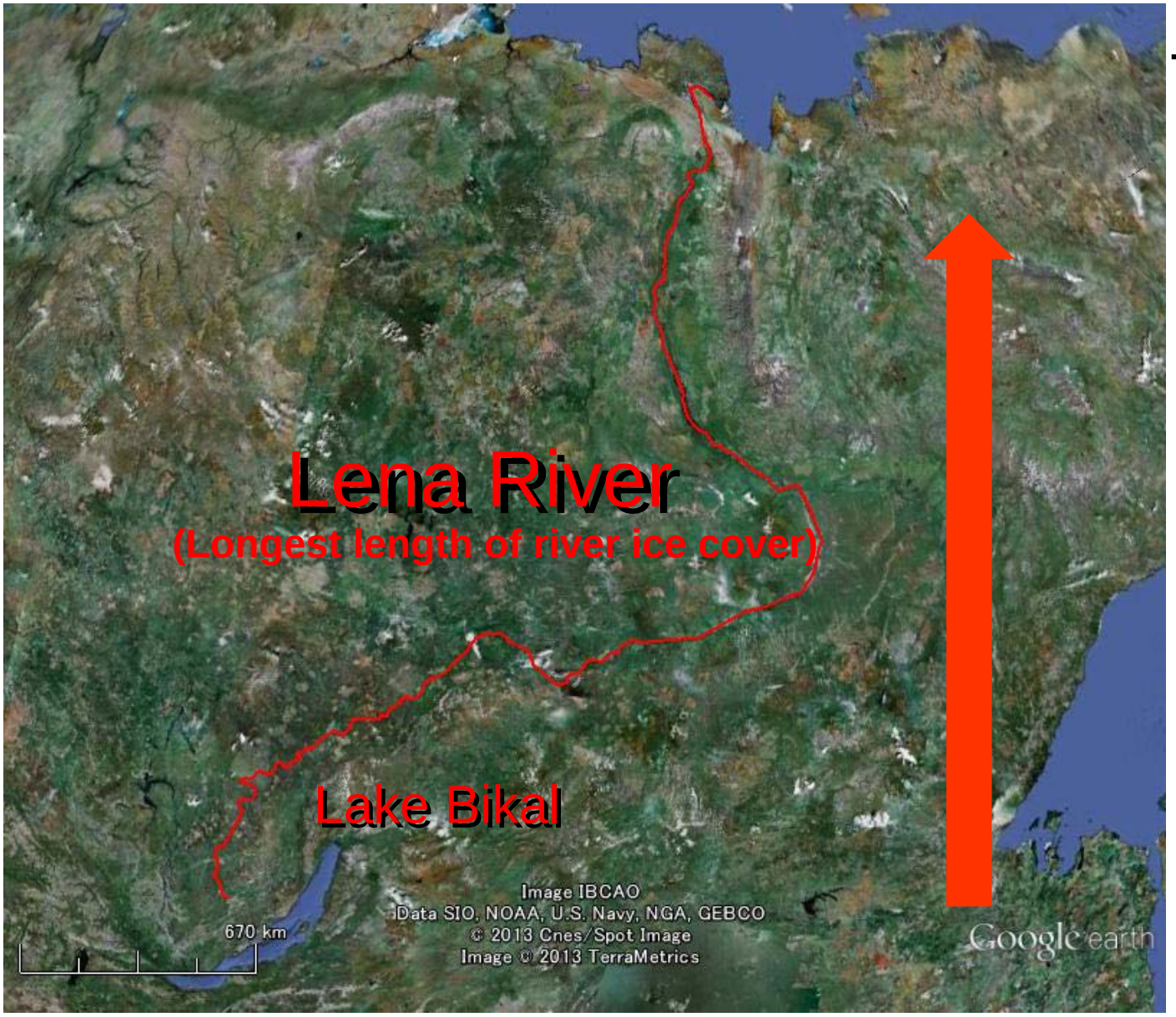


Geophysical Parameters-2

Product	Contents
Ship Detection	Detecting the ships on location and possibly the speed/direction.
DEM	DEM will be generated as stacking the InSAR data. Correction of Topographic and Ionospheric error is the issue.
Fire scare	Using the time-differentiation of the slope corrected HV, the fire scare area will be detected.
Wind speed distribution	LMOF (L-band Modulation Function) developed by PALSART will be improved by using the dual polarized PALSAR-2 data.
Land Use Classification	Land use will be classified by using the SAR data.
Soil Moisture	From the PolSAR data, the soil moisture will be generated.
Sensitivity Research for the disaster	Time series SAR data (amplitude), PolSAR and InSAR (coherence) will be combined to detect the best combination for each disaster. Flooding in the urban area is one of the targets.
Agriculture application	Crop monitoring using the SAR especially the biomass estimation will be the target.


立山
剱岳
富山湾
木崎湖
大町市

Ice jam flood



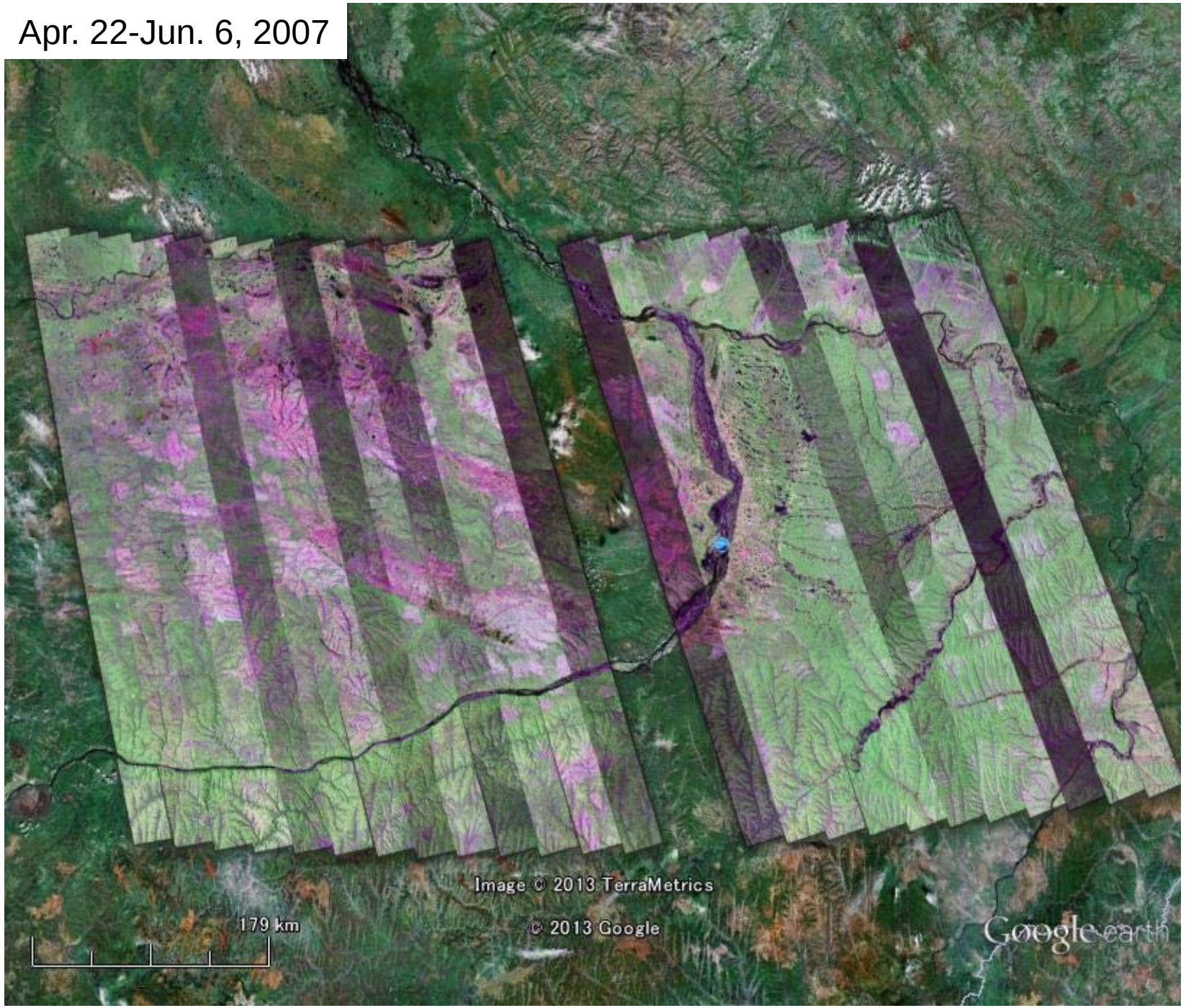
Thawing from south in spring time

Ice jam floods

More frequent & Larger scale recently

<u>Goal</u>
Understand the detailed mechanism

Apr. 22-Jun. 6, 2007

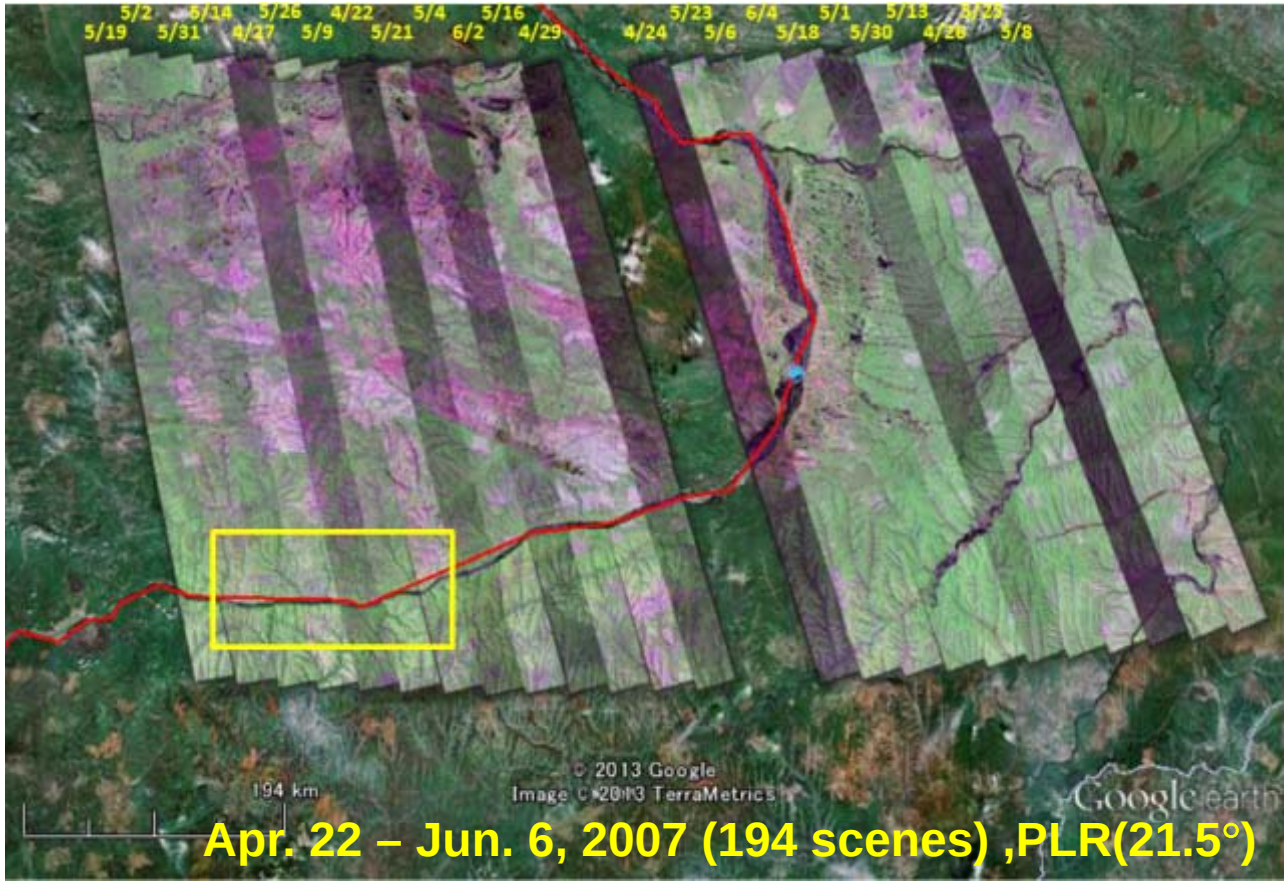



Mar. 7-Apr. 21, 2007
Image © 2013 TerraMetrics
© 2013 Google
179 km
Google earth

PALSAR full polarimetry mosaic image

(PALSAR : a unique systematic data observation strategy)

2007: Many floods
2009: Few floods



Apr. 22 – Jun. 6, 2007 (194 scenes) ,PLR(21.5°)

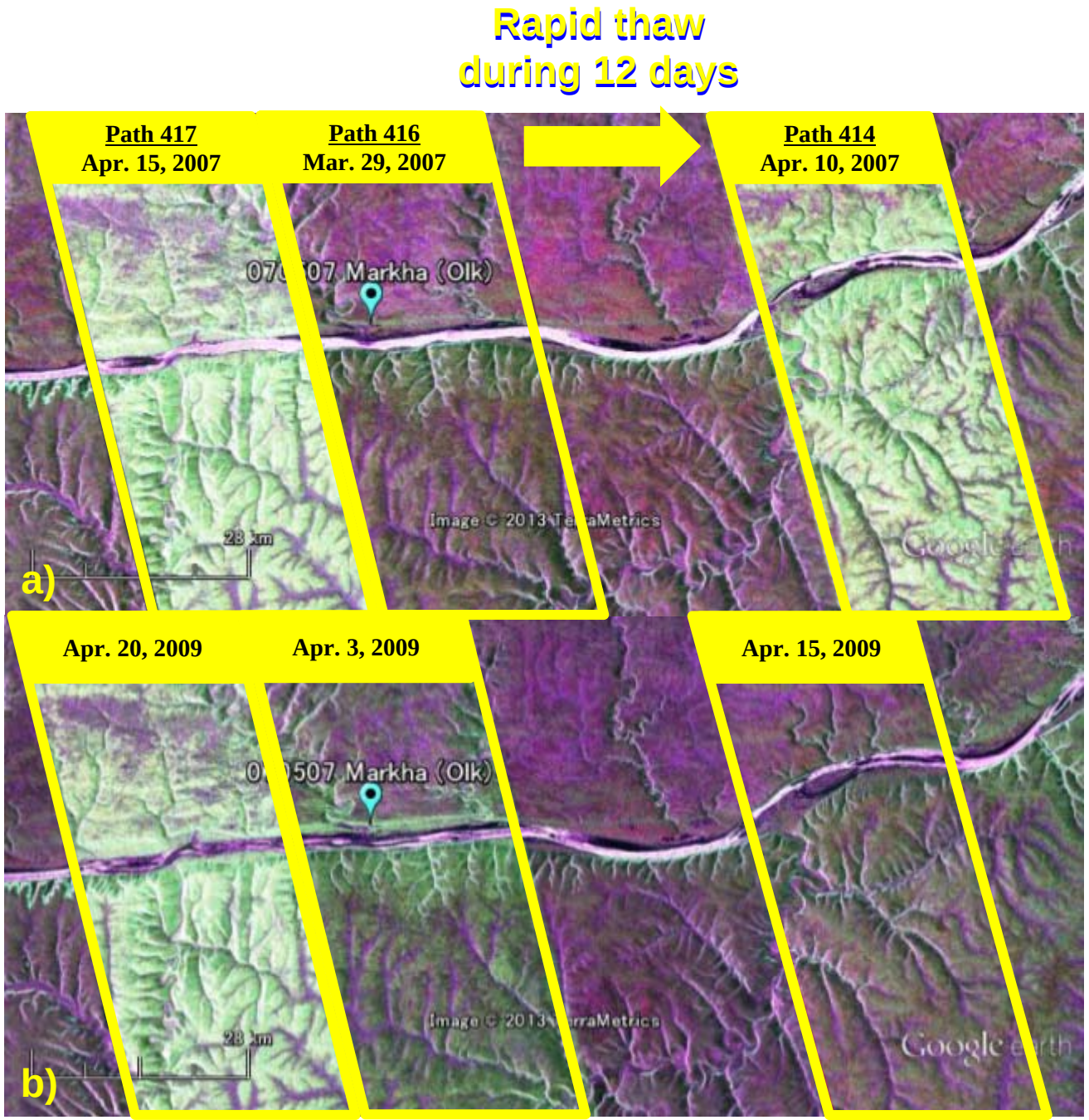
Interpretation of the color

	Frozen condition	Thawing condition
Forest	**Purple**	**Green**
Bare soil	Dark purple	Bright purple
Water	Purple or white	Black

Full polarimetry image
R: HH G: HV B : VV

2007
Many floods

2009
Few floods



M. Watanabe, et al., submitting

ALOS京都・炭素観測計画（ALOS Kyoto & Carbon Initiative）-3

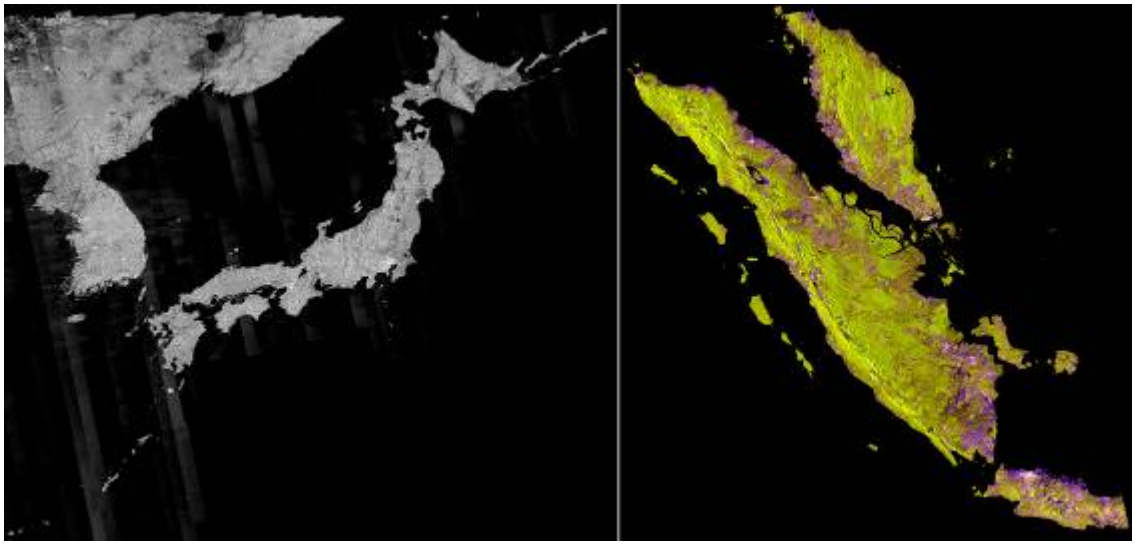
Abstract

・陸域観測技術衛星「だいち」（ALOS）に搭載しているLバンド合成開口レーダ（PALSAR）を用いて、世界の森林やその周辺、湿地帯や砂漠について、長期的・季節的な変動を観測し、データ解析や現地調査をもとに地球環境変化との関連を調べる。
・南米（アマゾン）、東南アジア、中央アフリカの熱帯雨林、シベリア、カナダ、アラスカに分布する北方林など世界規模の観測を行い、画像を3ヶ月以内にオンラインの専用回線経由で各機関に提供する。
- KC-3 will conduct the quantitative estimation and evaluation of the forest carbons based on the results of KC-1 and 2.

- ※K&C produces the global PALSAR data mosaic in 25, 50, or 100m resolutions multi-annually.

Participating Institutes

・マサチューセッツ大学（アメリカ）
・カリフォルニア大学サンタバーバラ校（アメリカ）
・地球観測科学シェフィールドセンター（イギリス）
・生物圏研究センター（フランス）
・ボルドー大学（フランス）
・ドイツ航空宇宙センター（ドイツ）
・フリードリッヒ・シラー大学（ドイツ）
・欧州連合共同研究センター（EU）
・Sarmap（スイス）
・スウェーデン農業科学大学（スウェーデン）
・ウェットランド・インターナショナル（オランダ）
・アプライド・ジオソリューション（オランダ）
・ヘルシンキ工科大学（フィンランド）
・地質科学コンサルティング社（オーストラリア）
・ヴィクトリア大学（カナダ）
・ブラジル環境及び再生可能天然資源院（ブラジル）
・国立宇宙研究所（ブラジル）
・ボルネオ・オランウータンサバイバル基金（ｲﾝﾄﾞﾈｼｱ）
>
37 institutes in KC-3

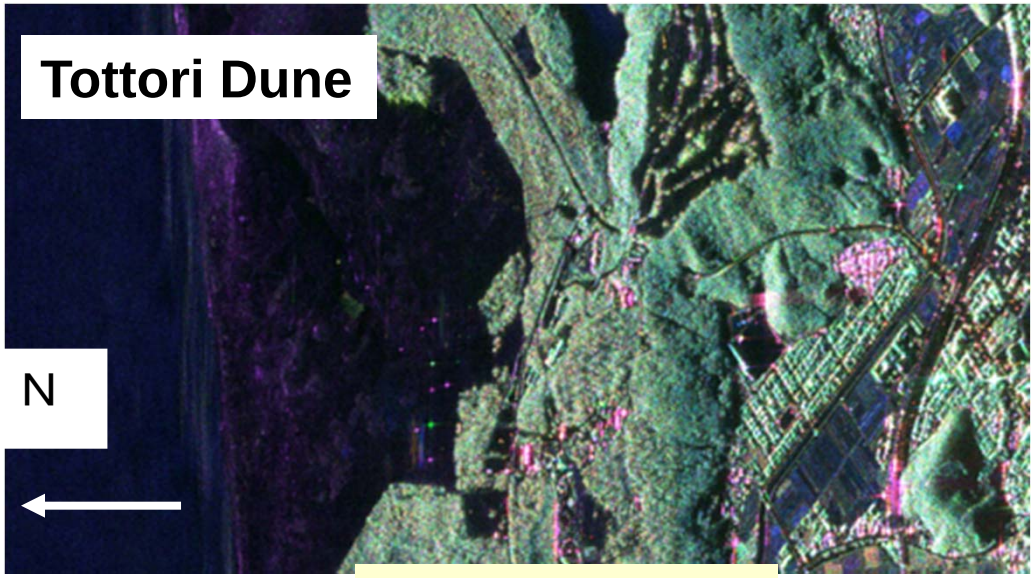


高分解能PALSARモザイク画像
左: 2007年 日本列島モザイク
右: 2007年 インドネシア、スマトラ島　カラー合成モザイク

Pi-SAR-L2

JAXA's L-band Airborne Polarimetric SAR
1st version: 1996~2012, 3
2nd version : April 2012~

All weather and High resolution sensor adequate for disaster and environmental monitoring.



R:HH,G:HV,B:VV

Specification

Items	**ALOS-2**	**Pi-SAR-L2**
Band width	14/28/42/85 MHz	**85MHz**
Sampling frequency		**100 MHz**
Height	628 km	**6~12 km**
Image width	25~490 km	**<=20 km**
AD(I/Q)		**8 bits I + Q**
ρ_R slant	1 m (Spot light) 3m (2 pol.) **6m (4. pol.)**	**1.76 m (4. pol)**
ρ_A 4look	3 m	**3.2 m**
NEsigma zero	-28 dB	**-35 dB**
Incidence Angle	8-70 deg.	**10-62 deg.**
Polarimetry	full	**full**
τ		**10~30 micro s**
Pt	5.1 KW	**3.5 KW**

Calibration of the Pi-SAR L band/Pi-SARl2

- •Calibration Factors: show some variation flit to flight (Pi-SAR-L)
- •Calibration Factors do not deviate so much for Pi-SAR-L2
- •PolCal was conducted using the two methods, shown below.

- •PolCal Method：
  - •Van Zyl Method(Pi-SAR-L2): Pi-SAR-L2 with radar reciprocal: 1st priority
  - •Forest and CR based method (Pi-SAR-L and L2)

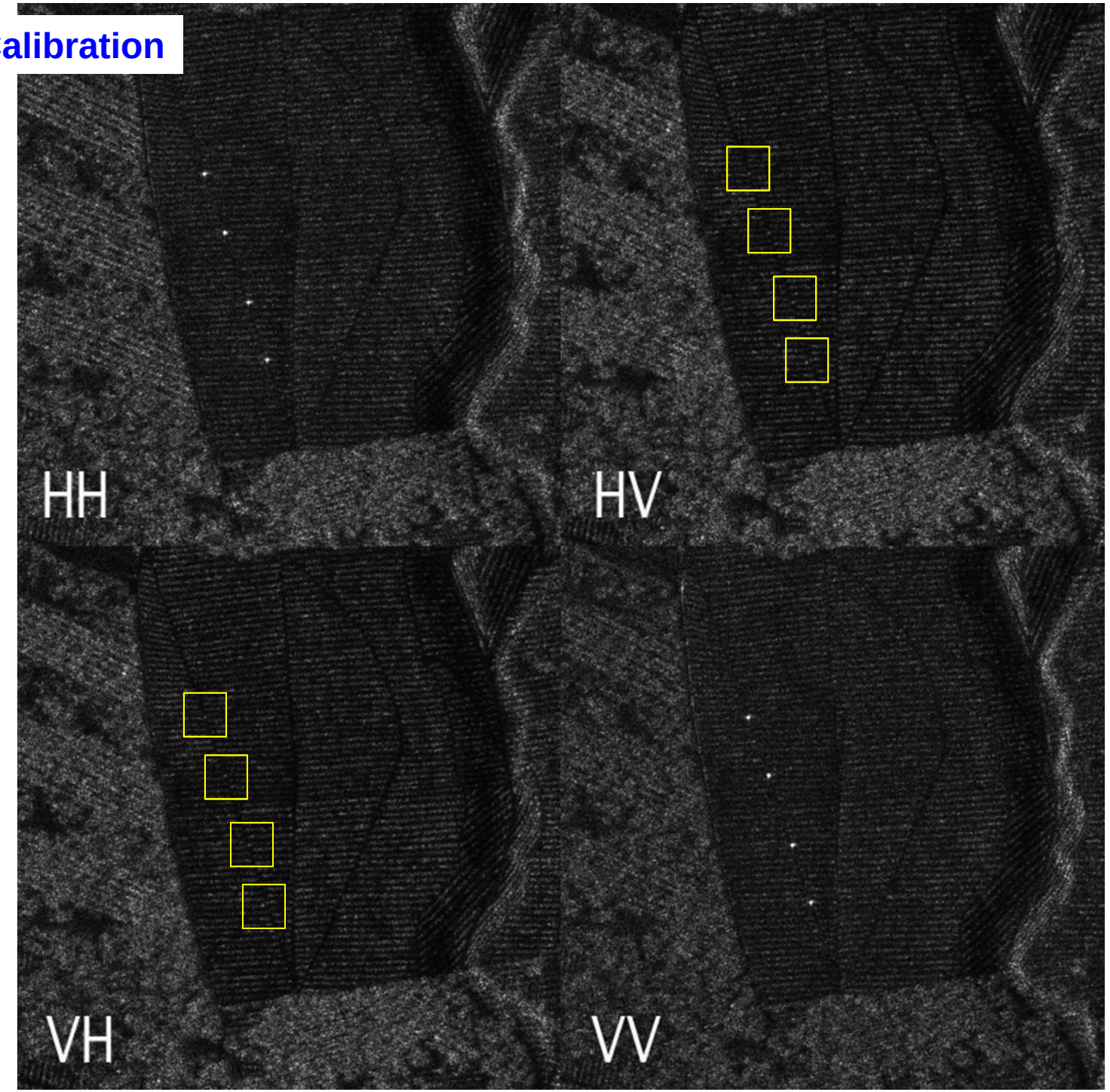
M-1)

$$\begin{pmatrix} Z_{hh} & Z_{hv} \\ Z_{vh} & Z_{vv} \end{pmatrix} = Ae^{\frac{-4\pi r}{\lambda}} \begin{pmatrix} 1 & \delta_2 \\ \delta_1 & f_1 \end{pmatrix} \begin{pmatrix} S_{hh} & S_{hv} \\ S_{vh} & S_{vv} \end{pmatrix} \begin{pmatrix} 1 & \delta_1 \\ \delta_2 & f_1 \end{pmatrix} + \begin{pmatrix} N_{hh} & N_{hv} \\ N_{vh} & N_{vv} \end{pmatrix}$$

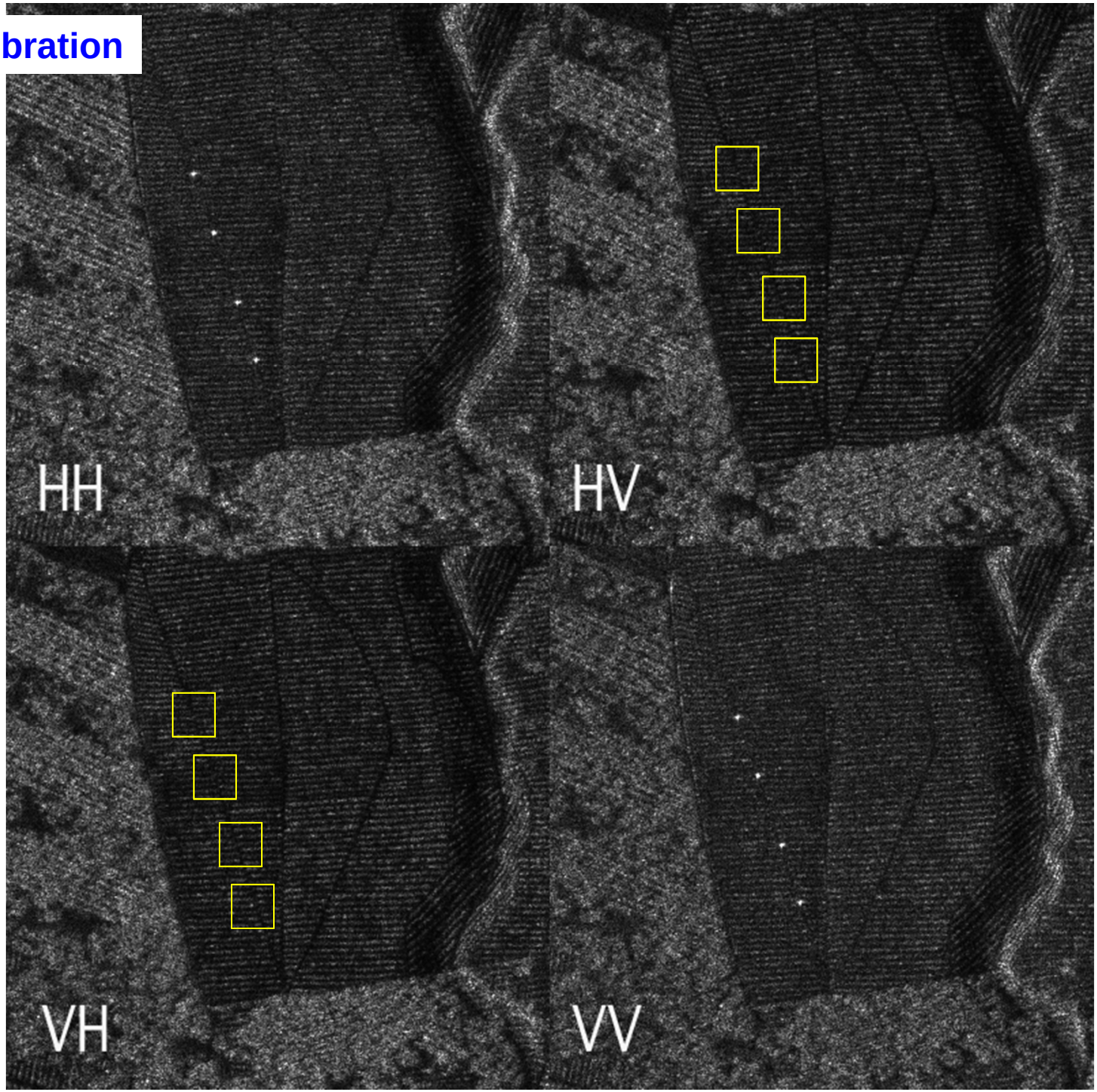
M-2)

$$\begin{pmatrix} Z_{hh} & Z_{hv} \\ Z_{vh} & Z_{vv} \end{pmatrix} = Ae^{\frac{-4\pi r}{\lambda}} \begin{pmatrix} 1 & \delta_3 \\ \delta_4 & f_2 \end{pmatrix} \begin{pmatrix} S_{hh} & S_{hv} \\ S_{vh} & S_{vv} \end{pmatrix} \begin{pmatrix} 1 & \delta_1 \\ \delta_2 & f_1 \end{pmatrix} + \begin{pmatrix} N_{hh} & N_{hv} \\ N_{vh} & N_{vv} \end{pmatrix}$$

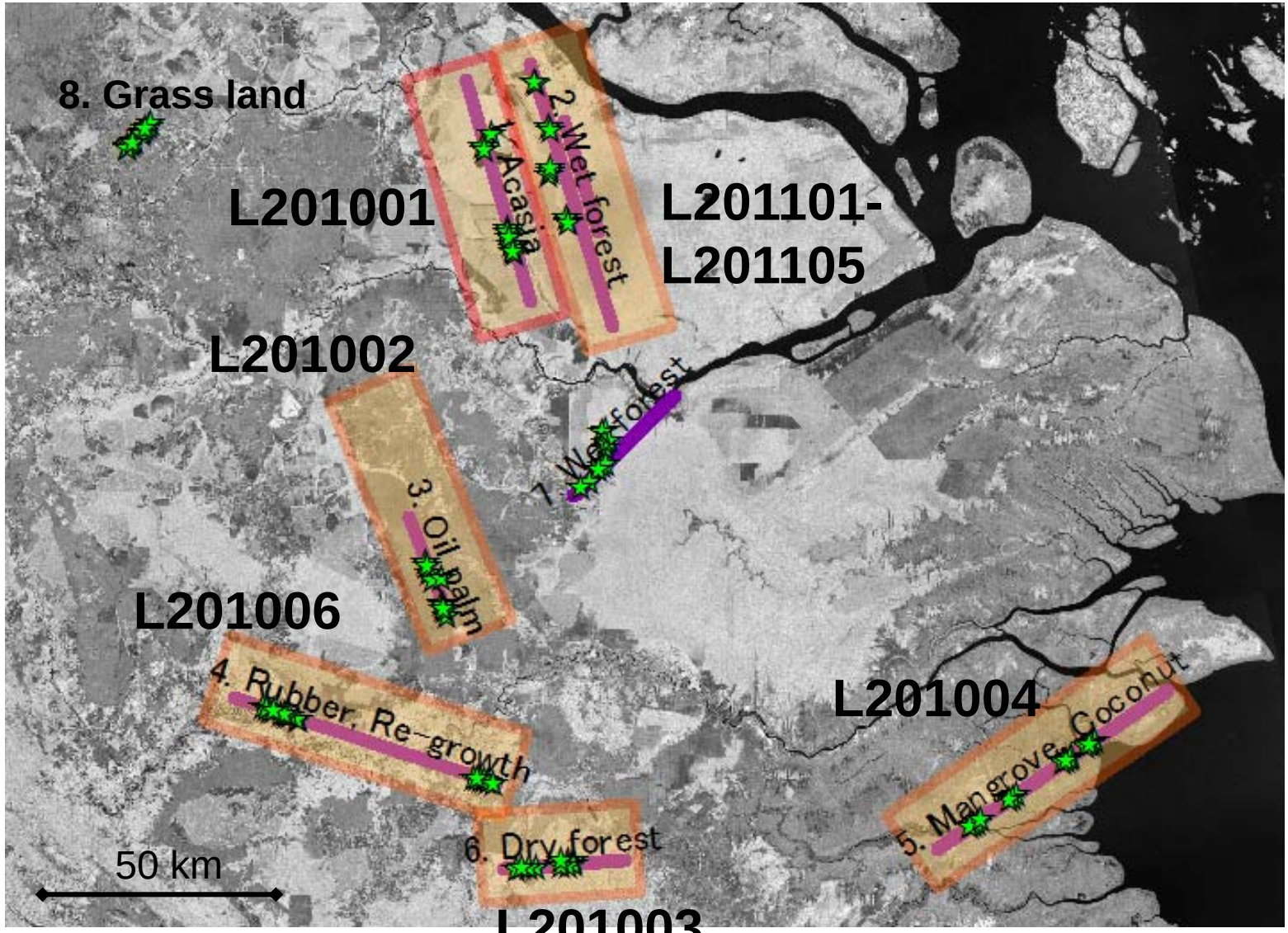
Before Calibration



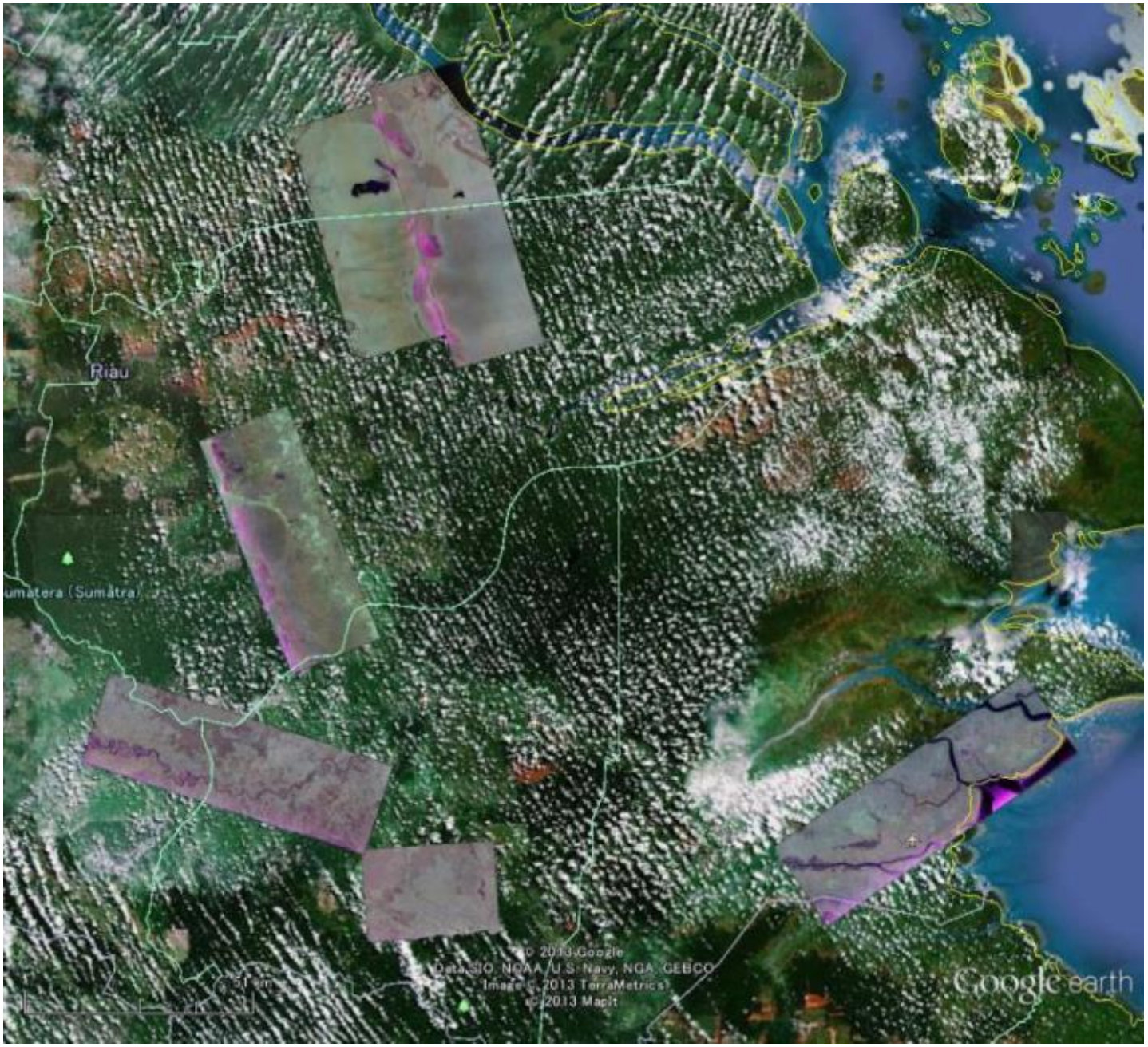
After Calibration



Pi-SAR-L2 Indonesia campaign



Pi-SAR-L2 observation



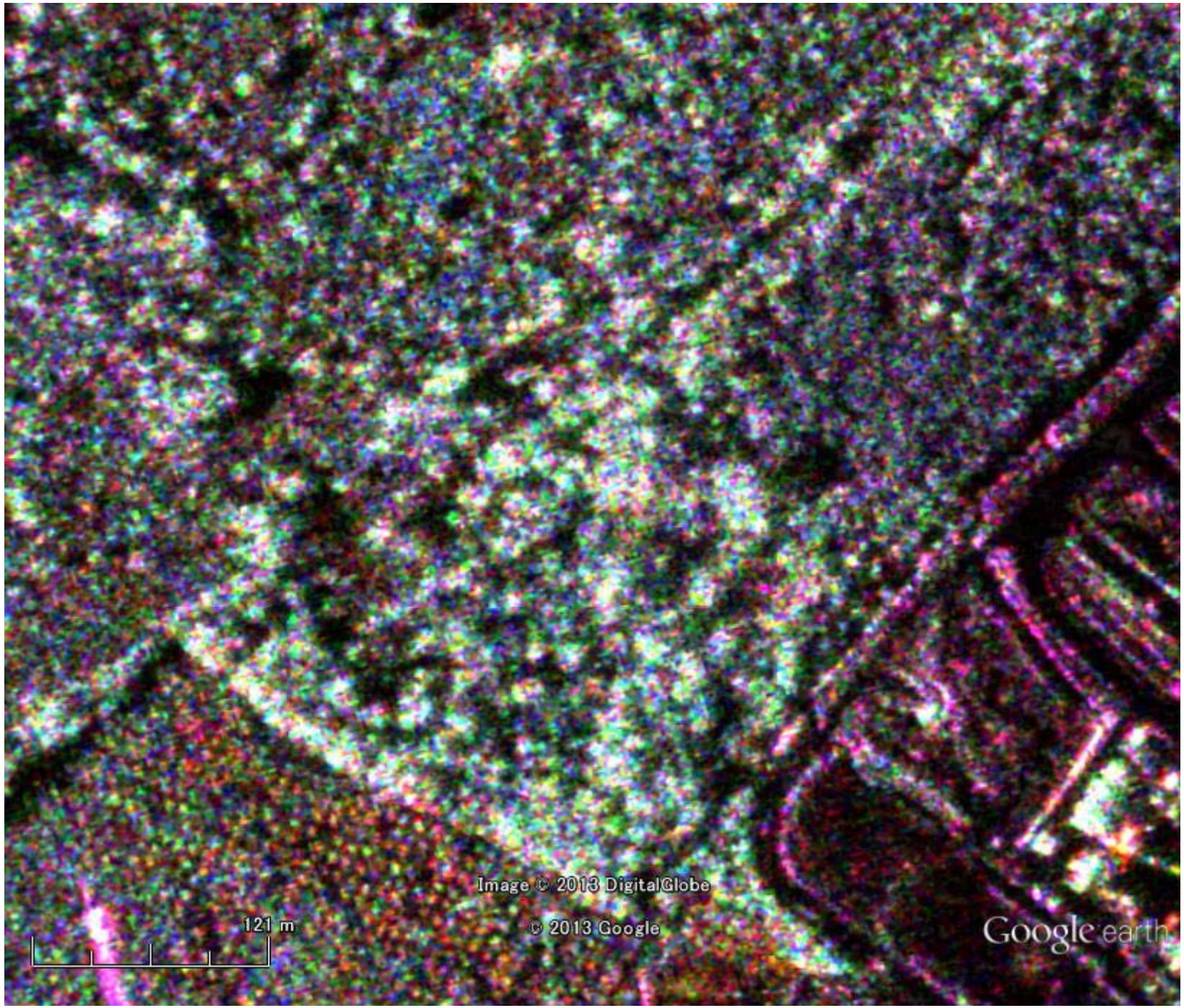
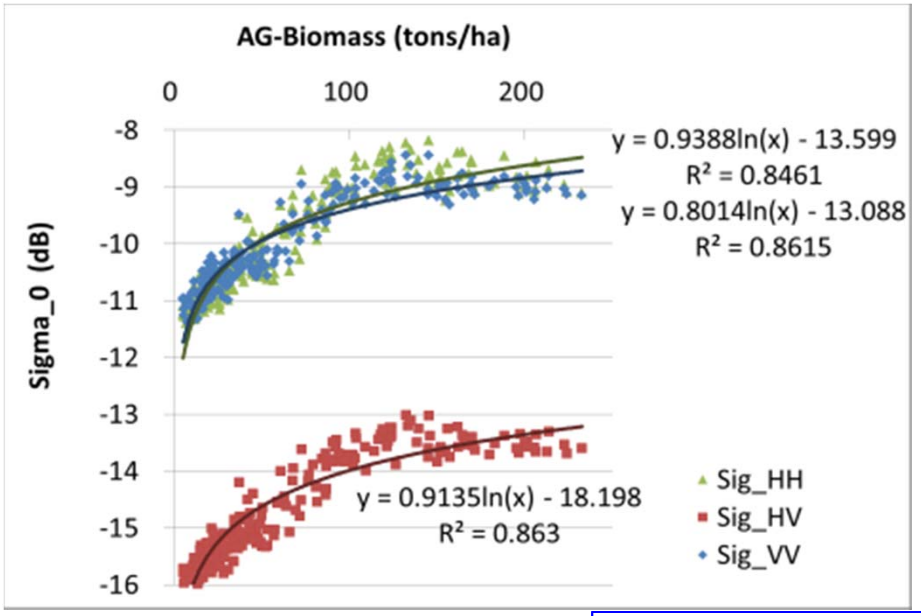
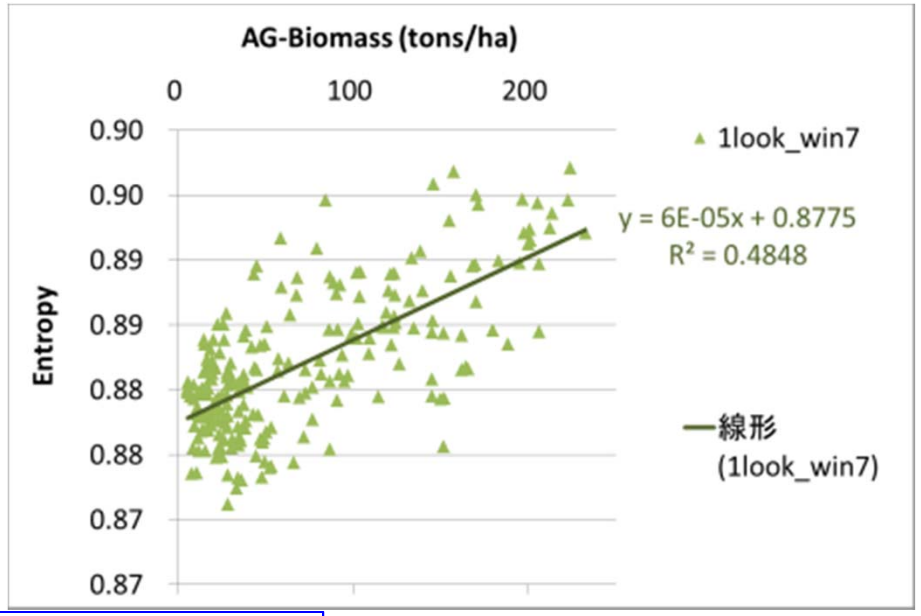


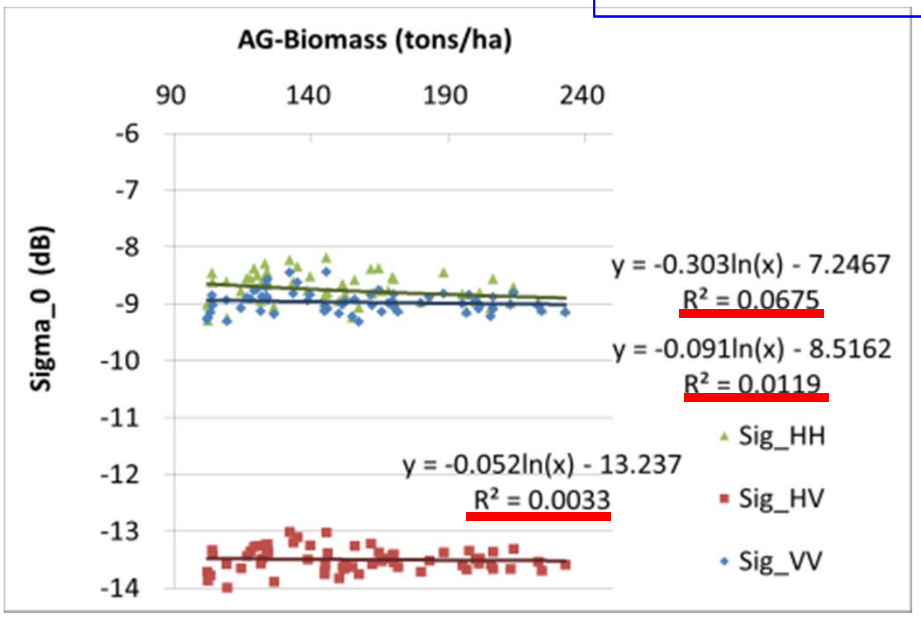
Image © 2013 DigitalGlobe
© 2013 Google
121 m
Google earth

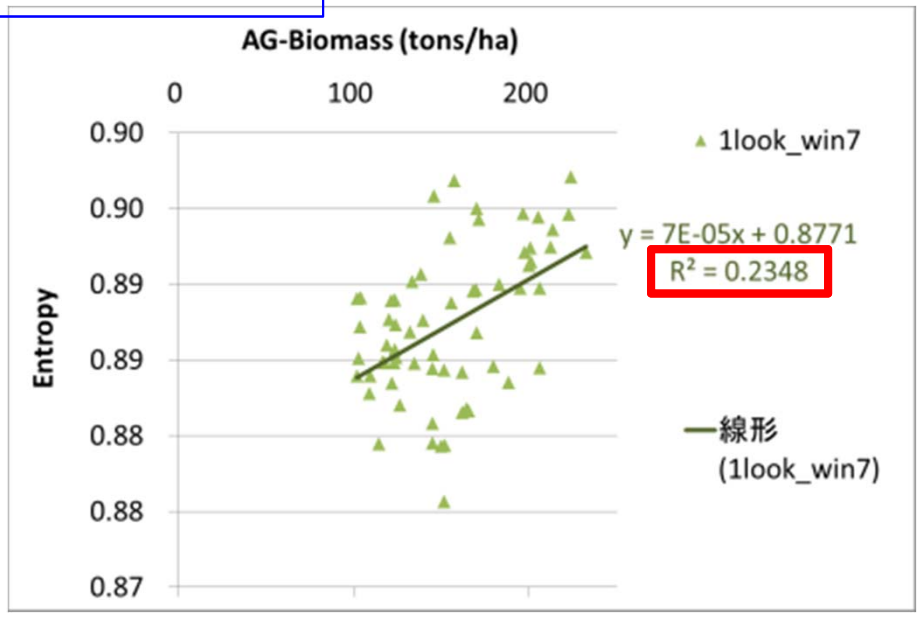

Image © 2013 DigitalGlobe
© 2013 Google
121 m
Google earth





AG-Biomass ≥ 100 tons/ha





σ^0: Saturation

Entropy: Week correlation

M. Watanabe, et al., IGARSS @ Melbourne

AGAP-S

Items	Contents
ALOS-2 Geoscience and application Processor (AGAP-S)	Linux system x 44 Set（704core） CPU: 2x Octet core 2.7GHz Sandy Bridge E5 Processor, MEM: 64GB（1600 MHz） SAN Disk 3.6PB Capacity Controller: Active/Active Disk Drive: 3TB SAS x1200 Storage Host: 16x FDR Infini Band(56GB/s)
Software	Sigma-SAR: Browsing all the PALSAR-2 data SAR imaging in range-Doppler and Specan InSAR processing (Strip and SCanSAR9 Mosaicking for strip/ScanSAR Ortho/slope corrected SAR data Applications (eCOG, etc.)

Within 24hrs
Raw data

Earth Observation
Center/JAXA

DRTS

ALOS

Within 24hrs
Raw data

PALSAR
Acquisition:3.5
hrs/day
350GB/day

110M scenes/
3 years

Earth Observation
Research Center/JAXA

Within 3~5days:
SCANSAR browse

IBAMA
The Brazilian Institute of Environment and
Renewable Natural Resources

Quick Forest Observation Chain

The ALOS-2

Basic Observation Scenario (BOS)

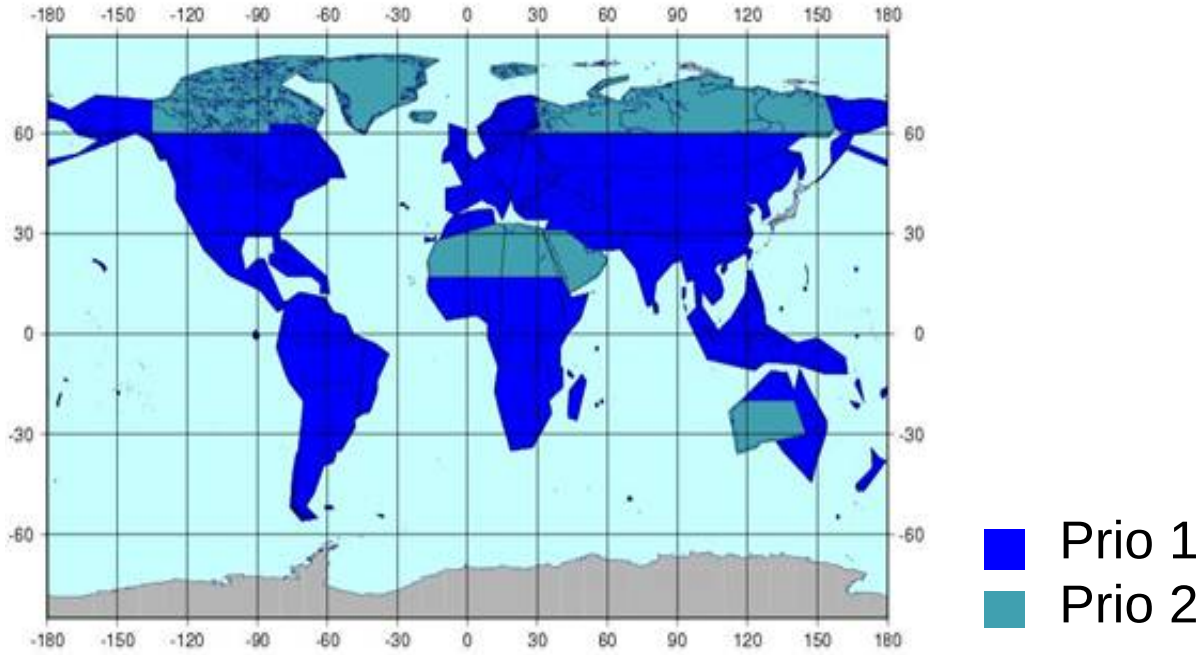
(as of September 2012)

Global land areas – baseline mapping

Temporal repeat: 2 cov/year

GSD: 10 m

Mode: Dual-pol (HH+HV)

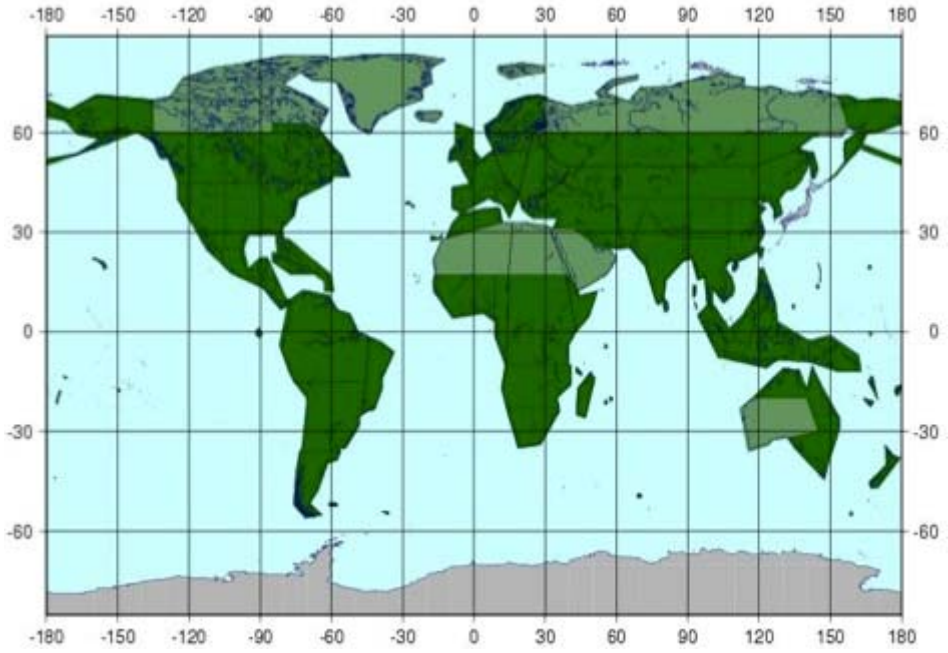


Global land areas – VHR baseline mapping

Temporal repeat: 1 cov/ 3 years

GSD: 3 m

Mode: Single-pol (HH or HV) (TBD)

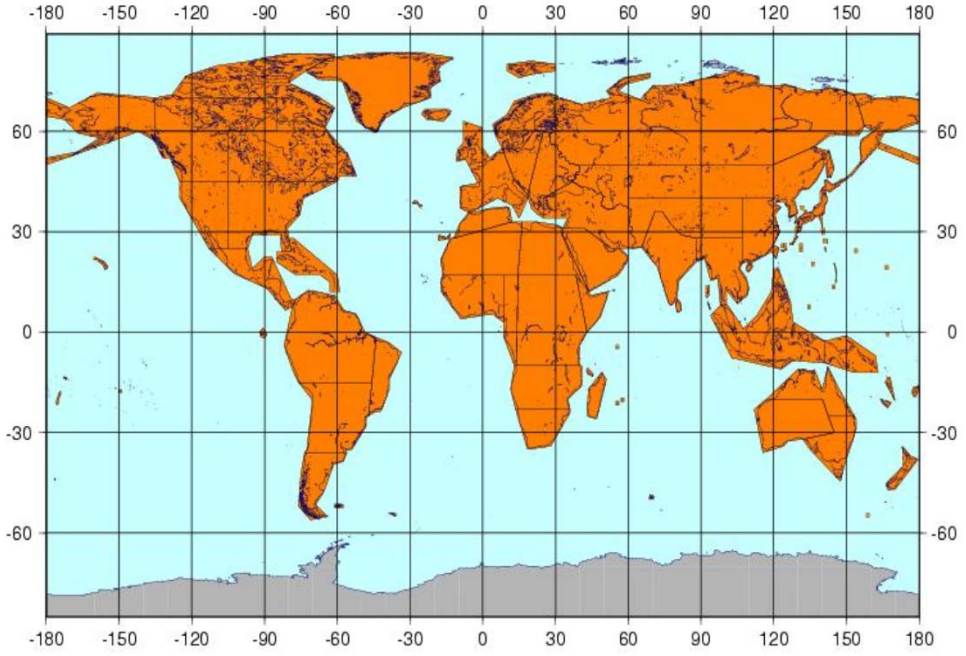


Global land areas – Polarimetric baseline

Temporal repeat: 1 cov/ 3 years

GSD: 6 m

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

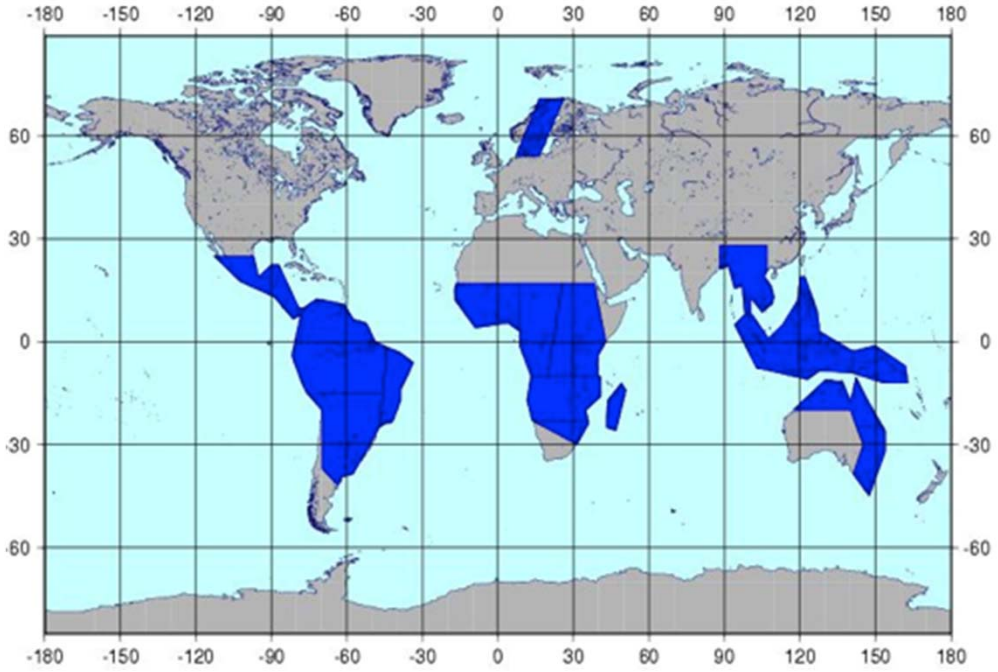


Forest monitoring

Temporal repeat: 2-6 cov/year (tropics 6 cov)

GSD: 10 m

Mode: Dual-pol (HH+HV)

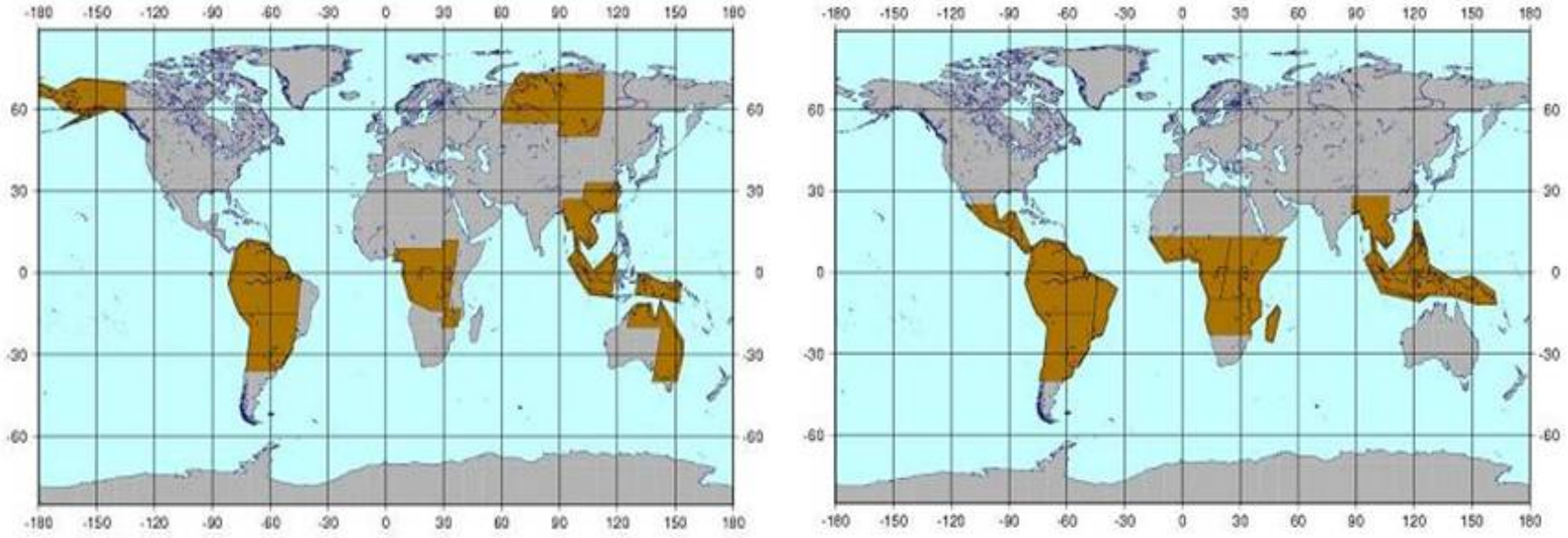


Wetlands & Rapid deforestation monitoring

Temporal repeat: 9 cov/year

GSD: 100 m

Mode: WB-350km (HH+HV)

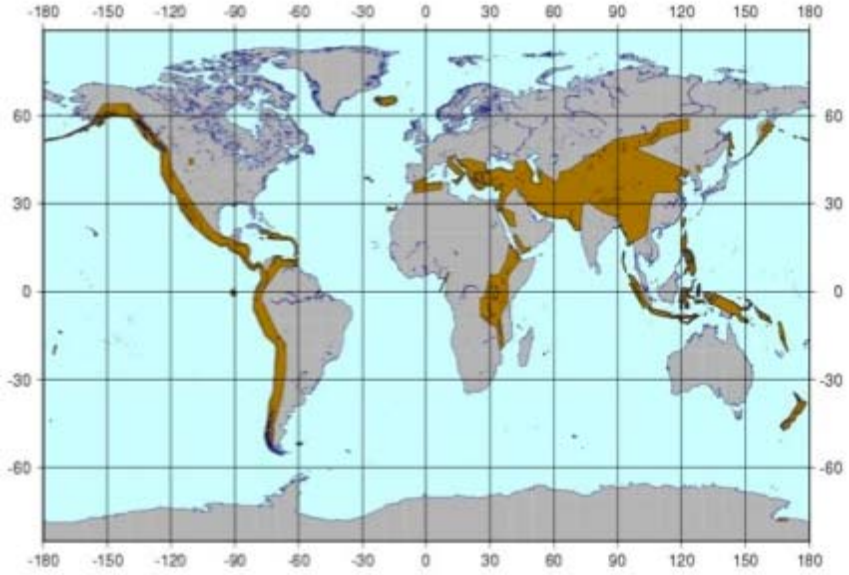


Crustal Deformation

Temporal repeat: 2-6 cov/year & 9 cov/year

GSD: 10 m & 100 m

Mode: Dual-pol (HH+HV) & WB-350km (HH+HV)

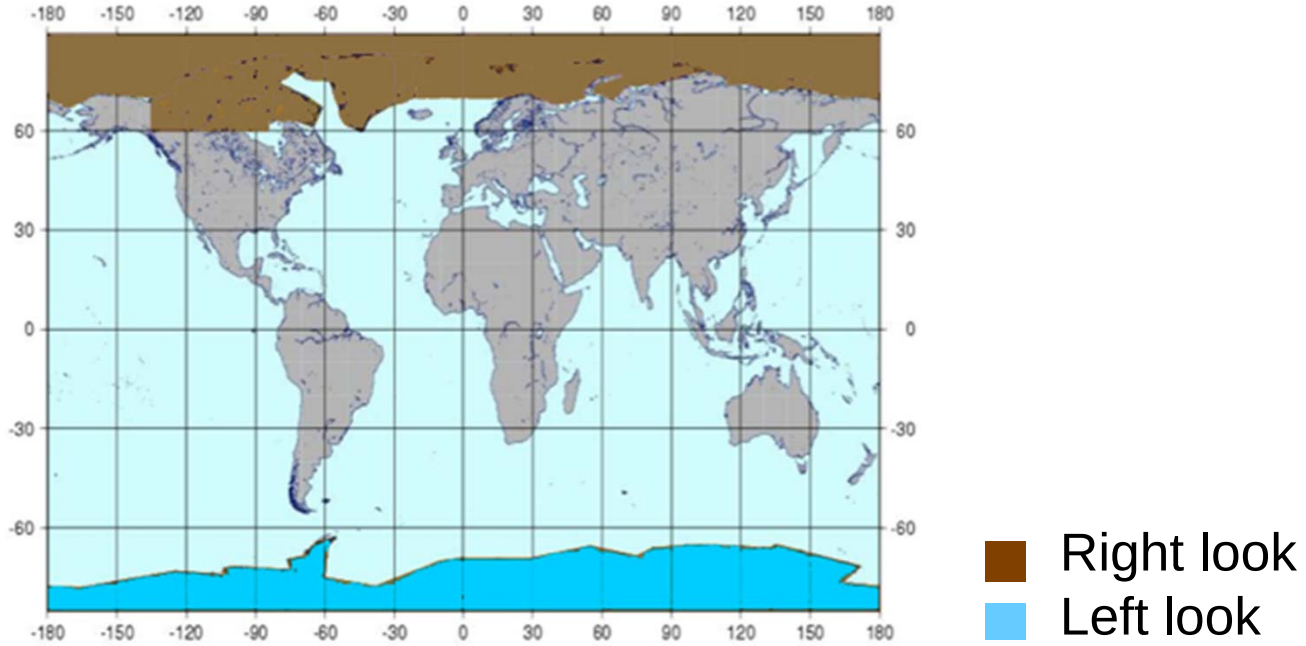


Polar Ice

Temporal repeat: 3 cov/year

GSD: 100 m

Mode: WB (HH or HH+HV) (TBD)

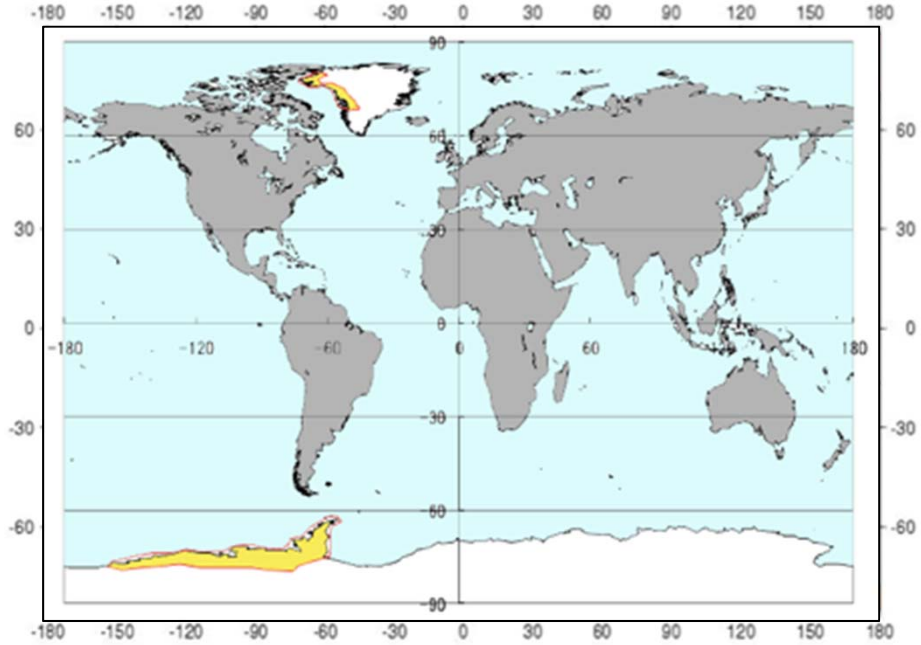


Glacier movement (Super Sites)

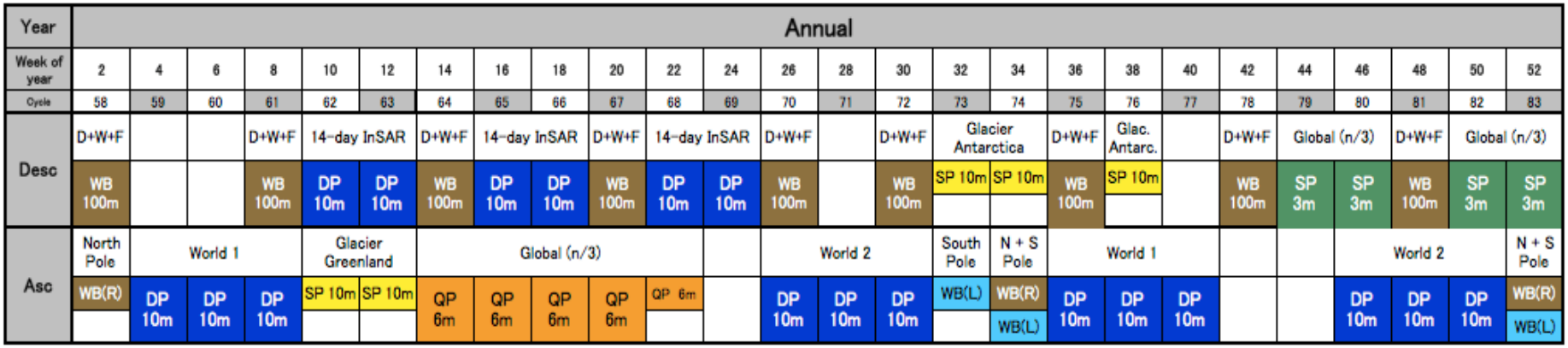
Temporal repeat: 2-3 cov/year

GSD: 10 m

Mode: SP (HH)



Observation pattern for annual acquisitions *



Year	Annual																								
Week of year	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52
Cycle	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83
Desc	D+W+F			D+W+F	14-day InSAR		D+W+F	14-day InSAR		D+W+F	14-day InSAR		D+W+F		D+W+F	Glacier Antarctica		D+W+F	Glac. Antarc.		D+W+F	Global (n/3)		D+W+F	Global (n/3)	
	WB 100m			WB 100m	DP 10m	DP 10m	WB 100m	DP 10m	DP 10m	WB 100m	DP 10m	DP 10m	WB 100m		WB 100m	SP 10m	SP 10m	WB 100m	SP 10m		WB 100m	SP 3m	SP 3m	WB 100m	SP 3m	SP 3m
Asc	North Pole	World 1			Glacier Greenland		Global (n/3)						World 2			South Pole	N + S Pole	World 1					World 2			N + S Pole
	WB(R)	DP 10m	DP 10m	DP 10m	SP 10m	SP 10m	QP 6m	QP 6m	QP 6m	QP 6m	QP 6m		DP 10m	DP 10m	DP 10m	WB(L)	WB(R)	DP 10m	DP 10m	DP 10m			DP 10m	DP 10m	DP 10m	WB(R)
																	WB(L)									WB(L)

DP 10m — 10m DP (HH+HV)

SP 3m — 3m SP (HH or HV)

WB 100m — 100m WB (HH+HV) (Right)

SP 10m — 10m SP (HH)

QP 6m — 6m QP (HH+HV+VV+VH)

WB (L) — 100m WB (HH+HV) (Left)

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

Pattern repeated on a 3-year basis

Year	2014年																								
Week of year	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52
Cycle	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
Desc	D+W+F			D+W+F	14-day InSAR		D+W+F	14-day InSAR		D+W+F	14-day InSAR		D+W+F		D+W+F	Glacier Antarctica		D+W+F	Glac. Antarc.		D+W+F	Global (1/3)		D+W+F	Global (1/3)	
	WB 100m			WB 100m	DP 10m	DP 10m	WB 100m	DP 10m	DP 10m	WB 100m	DP 10m	DP 10m	WB 100m		WB 100m	SP 10m	SP 10m	WB 100m	SP 10m		WB 100m	SP 3m	SP 3m	WB 100m	SP 3m	SP 3m
Asc	Def	World 1			Glacier Greenland		Global (1/3)						World 2			South Pole	N + S Pole	World 1					World 2			N + S Pole
	WB 100m	DP 10m	DP 10m	DP 10m	SP 10m	SP 10m	QP 6m	QP 6m	QP 6m	QP 6m	QP 6m		DP 10m	DP 10m	DP 10m	WB(L)	WB(R)	DP 10m	DP 10m	DP 10m			DP 10m	DP 10m	DP 10m	WB(R)
																	WB(L)									WB(L)

Year	2015年																								
Week of year	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52
Cycle	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
Desc	D+W+F			D+W+F	14-day InSAR		D+W+F	14-day InSAR		D+W+F	14-day InSAR		D+W+F		D+W+F	Glacier Antarctica		D+W+F	Glac. Antarc.		D+W+F	Global (2/3)		D+W+F	Global (2/3)	
	WB 100m			WB 100m	DP 10m	DP 10m	WB 100m	DP 10m	DP 10m	WB 100m	DP 10m	DP 10m	WB 100m		WB 100m	SP 10m	SP 10m	WB 100m	SP 10m		WB 100m	SP 3m	SP 3m	WB 100m	SP 3m	SP 3m
Asc	North Pole	World 1			Glacier Greenland		Global (2/3)						World 2			South Pole	N + S Pole	World 1					World 2			N + S Pole
	WB(R)	DP 10m	DP 10m	DP 10m	SP 10m	SP 10m	QP 6m	QP 6m	QP 6m	QP 6m	QP 6m		DP 10m	DP 10m	DP 10m	WB(L)	WB(R)	DP 10m	DP 10m	DP 10m			DP 10m	DP 10m	DP 10m	WB(R)
																	WB(L)									WB(L)

Year	2016年																								
Week of year	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52
Cycle	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83
Desc	D+W+F			D+W+F	14-day InSAR		D+W+F	14-day InSAR		D+W+F	14-day InSAR		D+W+F		D+W+F	Glacier Antarctica		D+W+F	Glac. Antarc.		D+W+F	Global (3/3)		D+W+F	Global (3/3)	
	WB 100m			WB 100m	DP 10m	DP 10m	WB 100m	DP 10m	DP 10m	WB 100m	DP 10m	DP 10m	WB 100m		WB 100m	SP 10m	SP 10m	WB 100m	SP 10m		WB 100m	SP 3m	SP 3m	WB 100m	SP 3m	SP 3m
Asc	North Pole	World 1			Glacier Greenland		Global (3/3)						World 2			South Pole	N + S Pole	World 1					World 2			N + S Pole
	WB(R)	DP 10m	DP 10m	DP 10m	SP 10m	SP 10m	QP 6m	QP 6m	QP 6m	QP 6m	QP 6m		DP 10m	DP 10m	DP 10m	WB(L)	WB(R)	DP 10m	DP 10m	DP 10m			DP 10m	DP 10m	DP 10m	WB(R)
																	WB(L)									WB(L)

Emergency observations
Emergency observations – such requested through the International Disaster Charter, by Japanese institutions or by JAXA itself – have highest priority and superseed the Basic Observation Scenario programming.

Cal/Val
Requests related to Cal/Val also have higher priority than the BOS, but are as far as possible already integrated into the BOS planning.

Top priority
Satellite house-keeping has top priority and superseed all the above.

ALOS-2 status

- ALOS-2 is planned for launch in **JFY 2013 (by March 2014)** with a design lifetime of 7 years.
- A global systematic acquisition strategy ("Basic Observation Scenario" – BOS) is under development.
- The ALOS-2 BOS builds on the ALOS acquisition strategy (2006-2011). It will provide continuity of key acquisitions but with enhanced image characteristics (spatial resolution, polarisations, radiometric sensitivity).
- The ALOS-2 Data Policy is yet to be determined.

Schedule

2011-2012: Observation plan development with associated software simulations to optimise data collection verses recording and downlink capacity and use of other system resources (power, etc.)

2013: BOS implementation and satellite launch

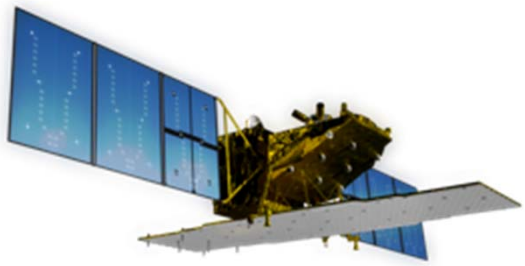
L + 2.5 m: BOS operations starting

L + 7 m: Start of distribution of standard products

2013+ The BOS plan will be reviewed on a regular basis (ALOS: 2 times/year) by JAXA and related Japanese institutions, and refined/modified as required.

ALOS-2 Research Announcement

- Release: July 20, 2012
- Window for proposal: ~ Oct. 31, 2012
- Peer review: Nov. 1 ~ Dec. E, 2012
- PI selection: Jan/E, 2013
- Agreements: Feb. 2013 ~ March 2013
- PI activities: April 2013-3 years:



(1) Calibration and Validation, (2) land use and land cover research, (3) topography and geology, (4) terrestrial (vegetation) ecosystem, agriculture and forestry research, (5) climate system, hydrological processes and water resources related research, (6) oceanography and coastal zone related research, (7) disaster and earthquakes, (8) resource exploration, (9) development of spatial data infrastructure, (10) basic studies on scattering and interferometric characteristics,, (11) Polar research, and (12) Ionospheric Researches.

The 1st PI Workshop for ALOS-2

Date : September 19 (Thursday) - 20 (Friday), 2013
Venue : Tsukuba International Congress Center, Epocal (Japan)

Registration deadline
July 31 , 2013

APSAR 2013

Date : September 23 (Monday) – 27(Friday), 2013
Venue : Tsukuba International Congress Center, Epocal (Japan)

Conclusion

- ALOS-2/PALSAR-2
- ALOS-2 Mission Objectives
- CAL/VAL
- Application (Geophysical Parameters, High level and Science Products)
- Kyoto and Carbon Project
- Pi-SAR-L2
- RA(RA-4)
- Basic Observation Scenario-2
- Conclusions