ALOS-4 PALSAR-3 Initial Calibration/Validation Results

Japan Aerospace Exploration Agency
Earth Observation Research Center（EORC）

May 2025

Content

1. Summary
2. Calibration/validation plan for PALSAR-3 observation modes/beams
3. PALSAR-3 initial calibration/validation results
4. Image adjustments in the regular observation phase

Supplemental material

1. Summary

- In the initial calibration and validation operation (from Oct. 2024 to Mar. 2025), the following calibration[*1] and product evaluation were conducted for the observation modes/beams used in the basic observation scenario, and it was confirmed that there were no significant problems in providing the product. The details of the evaluation results are shown after P.5.

  - ✓ Geometric calibration
  - ✓ Antenna pattern calibration
  - ✓ Radiometric calibration
  - ✓ Polarimetric calibration
  - ✓ Image quality evaluation (point target characteristics, NESZ[*2], S/A[*3], etc.)
  - ✓ Ortho-rectified image evaluation (Level 2.1 product)
  - ✓ Higher-order processing evaluation (interferometry, global mosaics, forest/non-forest map, etc.)

*1: "calibration": Adjustment of observation systems and processing to correctly measure physical quantities
*2: "NESZ": Noise equivalent backscatter coefficient (an indicator of noise such as thermal noise)
*3: "S/A": Signal-to-ambiguity ratio (an indicator of the strength of false images caused by observation and processing)

- For other observation modes/beams potentially to be used, the calibration will be performed during regular observation operations after April 2025. See P. 4 for target modes.

- The following restrictions have occurred during the initial calibration and validation and will continue to be adjusted in the regular observation operation.
  - ✓ Noises (azimuth ambiguity) in observations in some areas (see details after P. 12)
  - ✓ Unable to operate ionospheric correction mode (onboard split-band option)

2. Calibration/validation plan for PALSAR-3 observation modes/beams

Calibration plan	Observation mode	Beam code	Purpose
Initinal cal./val. phase【completed】	Spotlight	SBD (incidence angle can be set arbitrarily)	Emergency/individual observation
	Stripmap 3 m/200 km swath	UWD01～03	Basic observation, emergency/individual observation
	Stripmap 6 m/100 km swath (full-polarimetry)	HBQ06, 08	
	Stripmap 10 m/200 km swath	FWD01	
	ScanSAR	XBD02	
Regular observation phase【on-going】	Stripmap 3 m/100 km swath	UBD01～05, UBD14～23	Emergency/individual observation
	Stripmap 3 m/100 km swath (full-polarimetry)	UBQ05～09	
	Stripmap 6 m/100 km swath (full-polarimetry)	HBQ05, 07, 09	
	Stripmap 10 m/200 km swath	FWD02～03	
	ScanSAR	XBD01, 03	
Not available (operational constraints)	Stripmap 10 m/200 km swath (ionospheric correction on-board)	FWD01	Basic observation, emergency/individual observation
No calibration plan	Others	Others	No plan for use

3. PALSAR-3 initial calibration/validation results

Evaluation result summary

Observation dates of the evaluated scenes: 2025/02/21 ~ 2025/04/30

Items		Results	Number of data	Requirement
Geometric accuracy		3.46 m (1σ) [L1.1] 6.26 m (1σ) [L2.1]	84 44	< 10 m
Radiometric accuracy	Evaluation using corner reflectors	0.46 dB (1σ) (mean CF: -82.86 dB)	12	< 1 dB
Polarimetry	VV/HH amplitude ratio	0.055 (1σ)	8	< 0.2
	VV/HH phase difference	4.448 deg (1σ)		< 5 deg.
	Cross talk	-36.7~-36.2 dB (σ=4.55~5.78)		< -30 dB
Resolution		Within spec. for each mode	48	-
Sidelobe	PSLR	-11.8 dB [range] -16.2 dB [azimuth]		< -11.26 dB
	ISLR	-8.16 dB		< -8.16 dB
NESZ		-25~-38 dB	>10	< -20 dB
Ambiguity	Range S/A	Not visible	>10	> 15 dB
	Azimuth S/A	20~35 dB [Fixed PRF] 10~25 dB [Valuable PRF] ※	>10	> 15 dB

※Some images are below the requirement and adjustment is continued in the next operation phase.

3. PALSAR-3 initial calibration/validation results

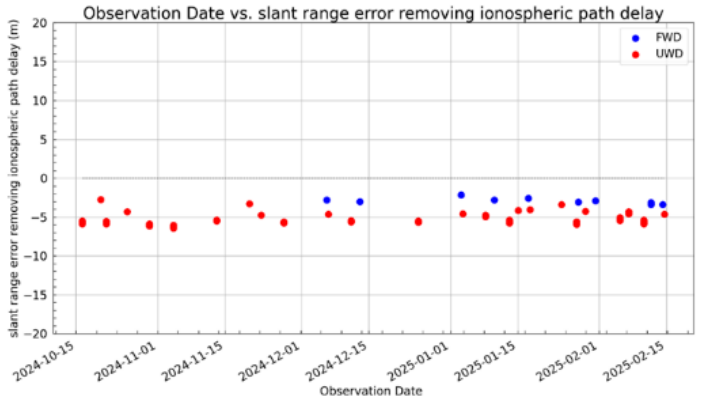
■ Geometric accuracy (L1.1 Single Look Complex)

Evaluation using corner reflectors

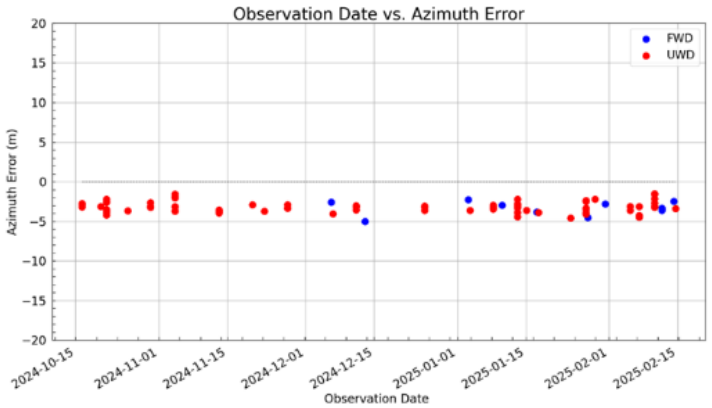
	Mean (m)	SD (m)	RMSE (m)	Points
Azimuth	-3.220	0.713	3.317	84
Slant range	-5.086	1.054	5.224	

Slant range error

(After ionospheric delay correction)



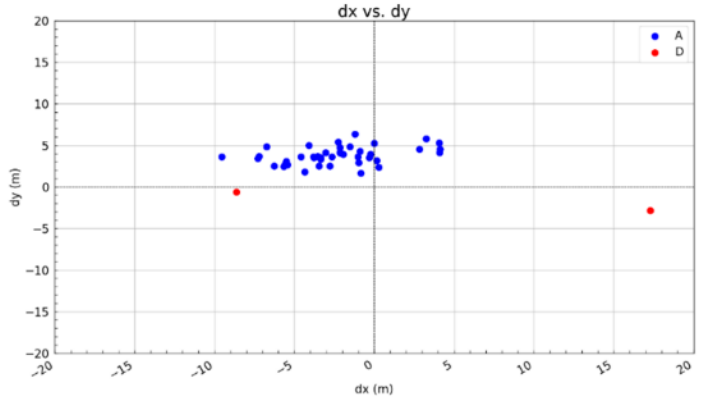
Azimuth error



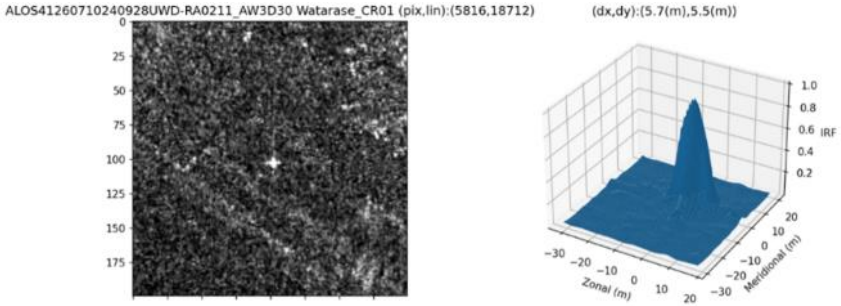
■ Geometric accuracy（L2.1 ortho-rectified image）

	Mean (m)	SD (m)	RMSE (m)	Points
East-west error	-2.097	4.419	4.902	44
South-north error	3.514	1.573	3.887	
Absolute error	5.685	2.464	6.256	

East/west error vs. North/south error



Example of point target image



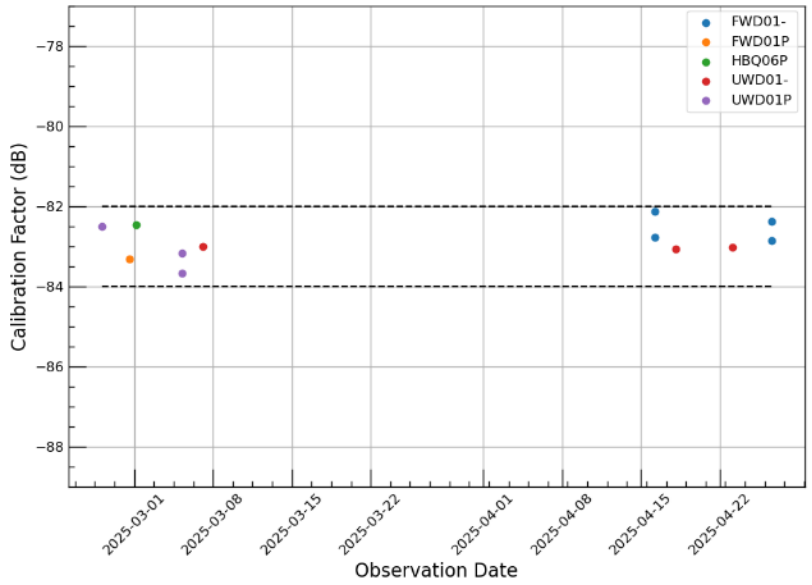
3. PALSAR-3 initial calibration/validation results

■ Radiometric accuracy

Evaluation using corner reflectors

Mode	Mean (dB)	SD (dB)	RMSE (dB) (reference -83 dB)	Points
UWD	-83.071	0.374	0.382	6
HBQ	-82.451	-	-	1
FWD	-82.690	0.460	0.576	5
ALL	-82.861	0.439	0.463	12

Radiometric calibration factor



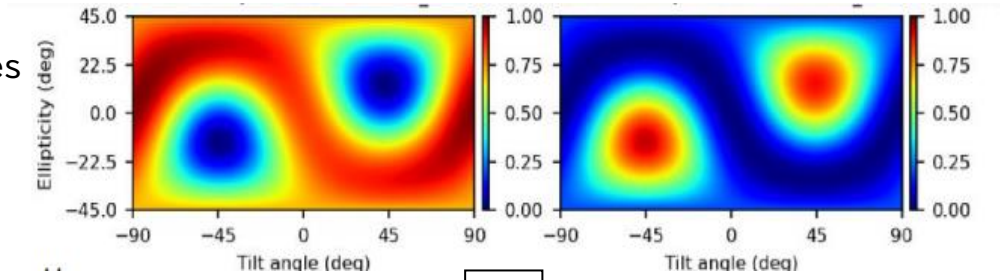
■ Polarimetric accuracy

Using corner reflectors and tropical forests

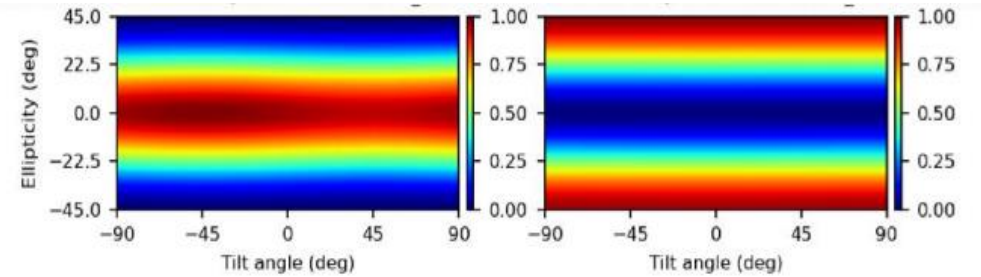
Num of scenes = 8	HH/VV amp. ratio	HH/VV phase diff. (deg.)	Cross talk (dB)			
			d1	d2	d3	d4
Mean	0.980	0.905	-36.2	-36.3	-36.3	-36.6
SD	0.055	4.448	5.38	4.55	4.55	5.78

Polarimetric signature images

Before calibration



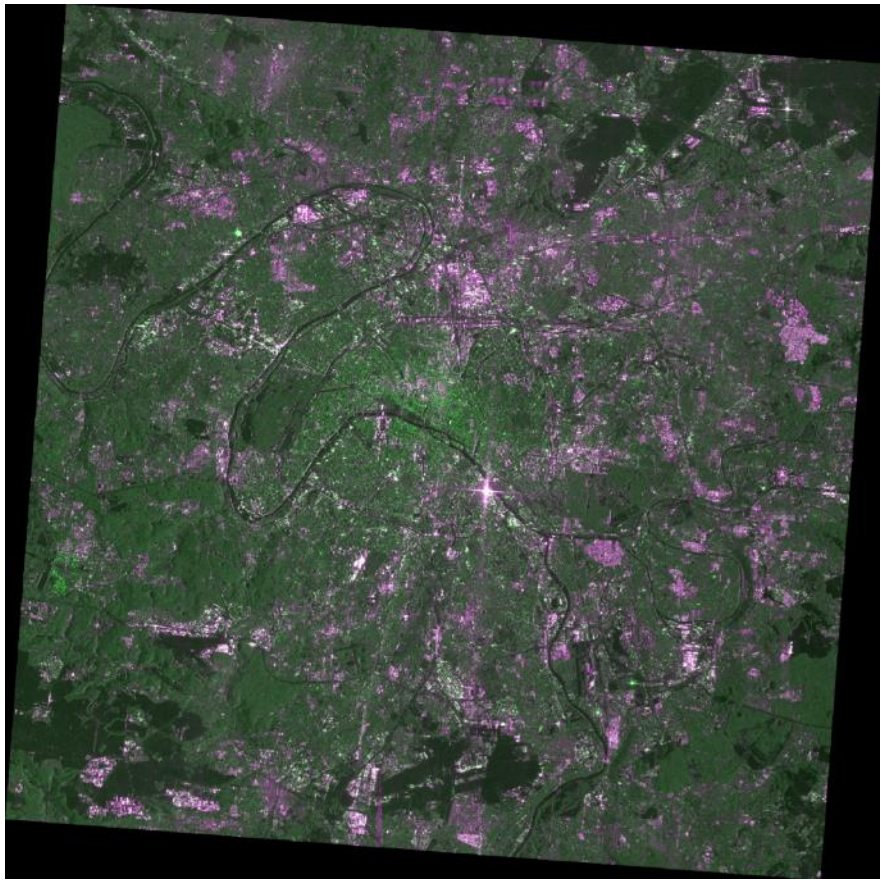
After calibration



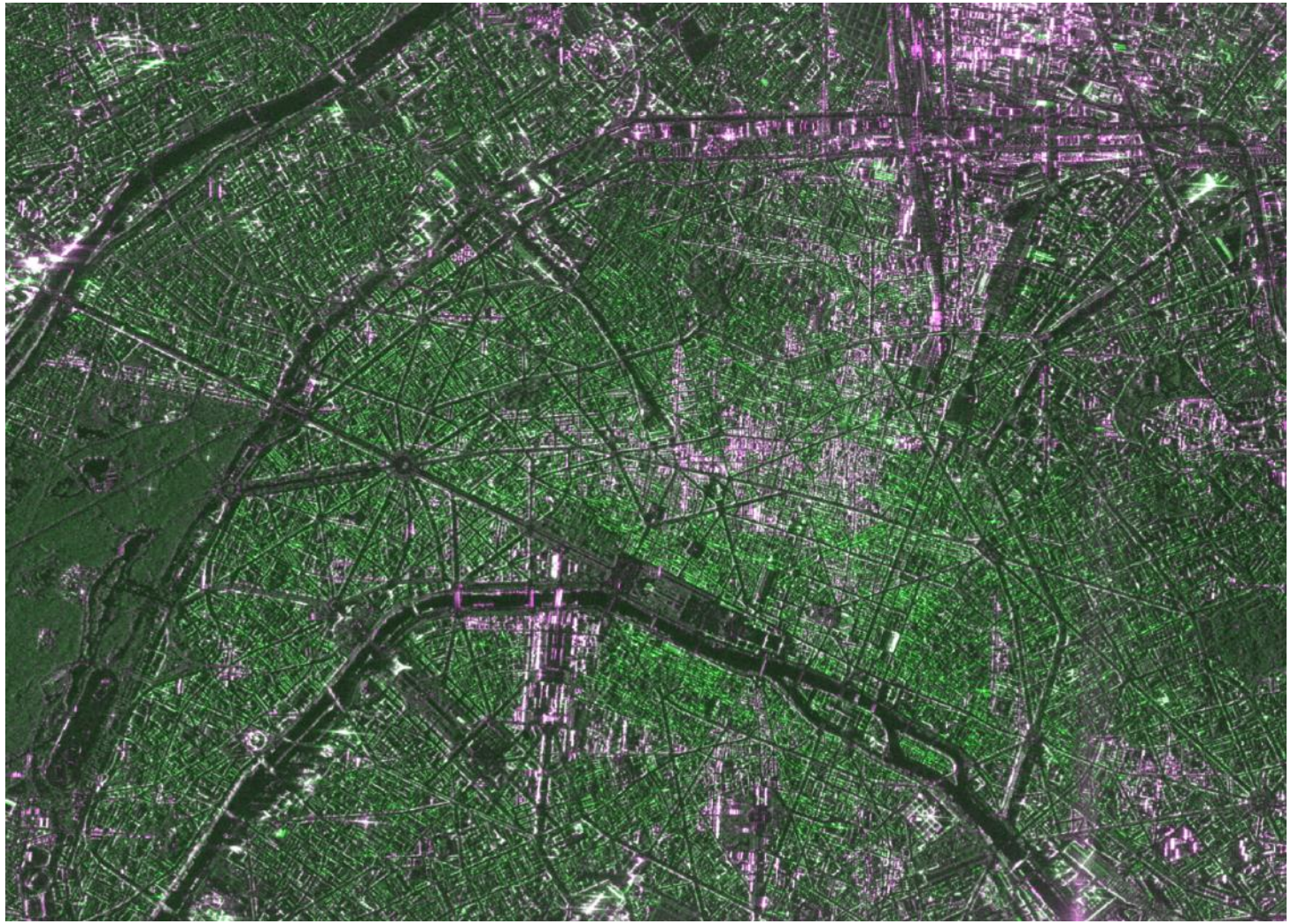
3. PALSAR-3 initial calibration/validation results

■ Example or Spotlight mode image

35 km x 35 km width
Feb. 23, 2025　Paris, France
R・B：HH-pol., G：HV-pol.



Zoom-up image

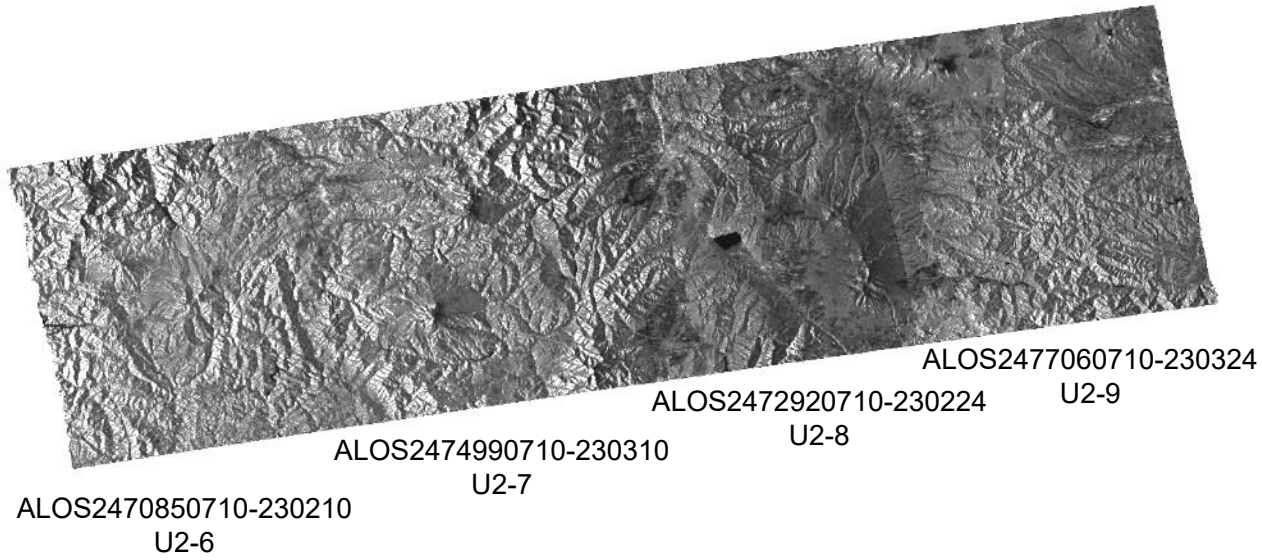


3. PALSAR-3 initial calibration/validation results

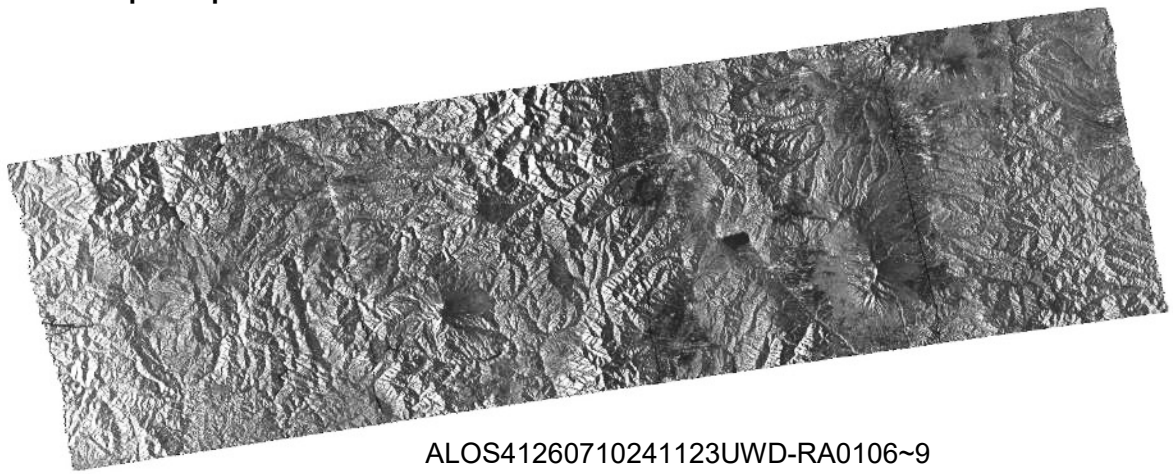
■ Example of L2.1 ortho-rectified images

Consistent images were obtained between ALOS-2 and ALOS-4

ALOS-2
DSM: AW3D DSM
Stripmap 3 m 50 km swath x 4 scenes



ALOS-4
DSM: AW3D DSM
Stripmap 3 m 200 km swath

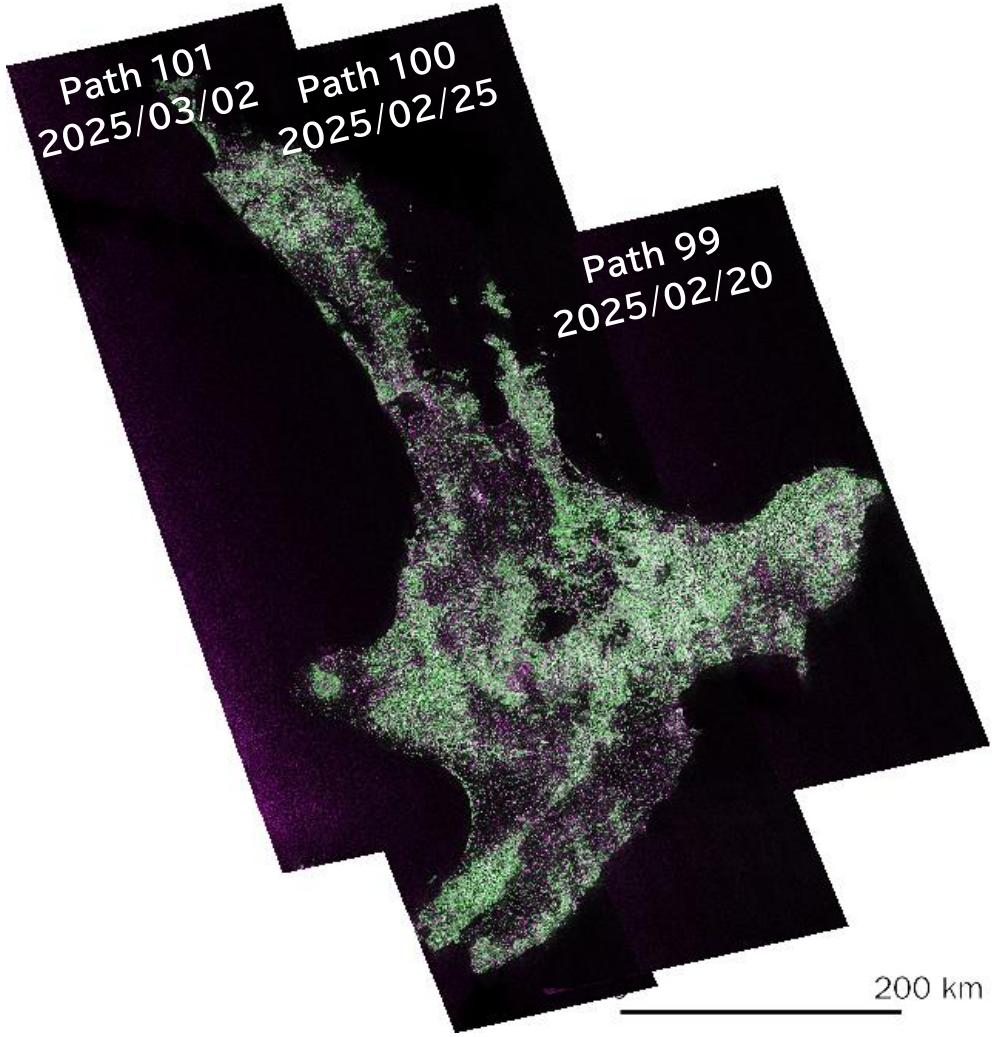


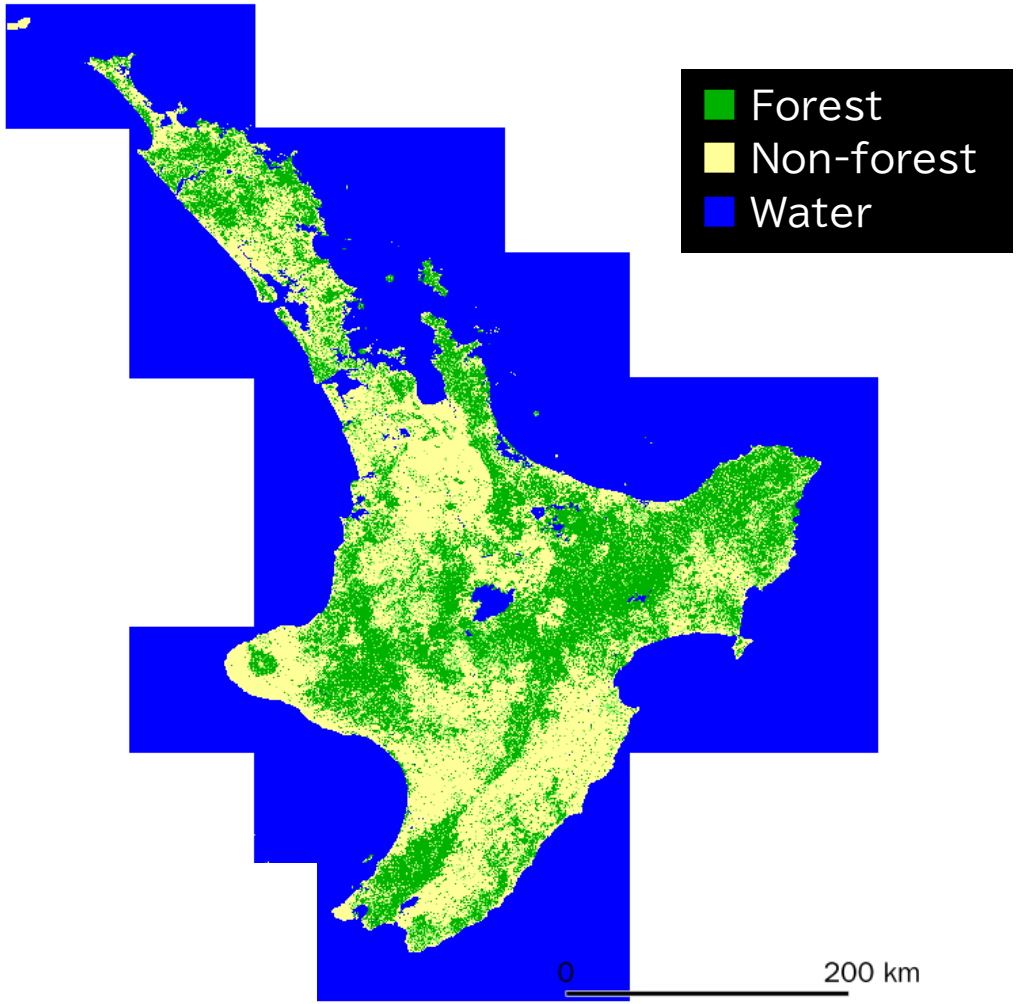
3. PALSAR-3 initial calibration/validation results

■ Test images of global mosaic and forest/non-forest map

New-Zealand

Seamless mosaic and classification are confirmed





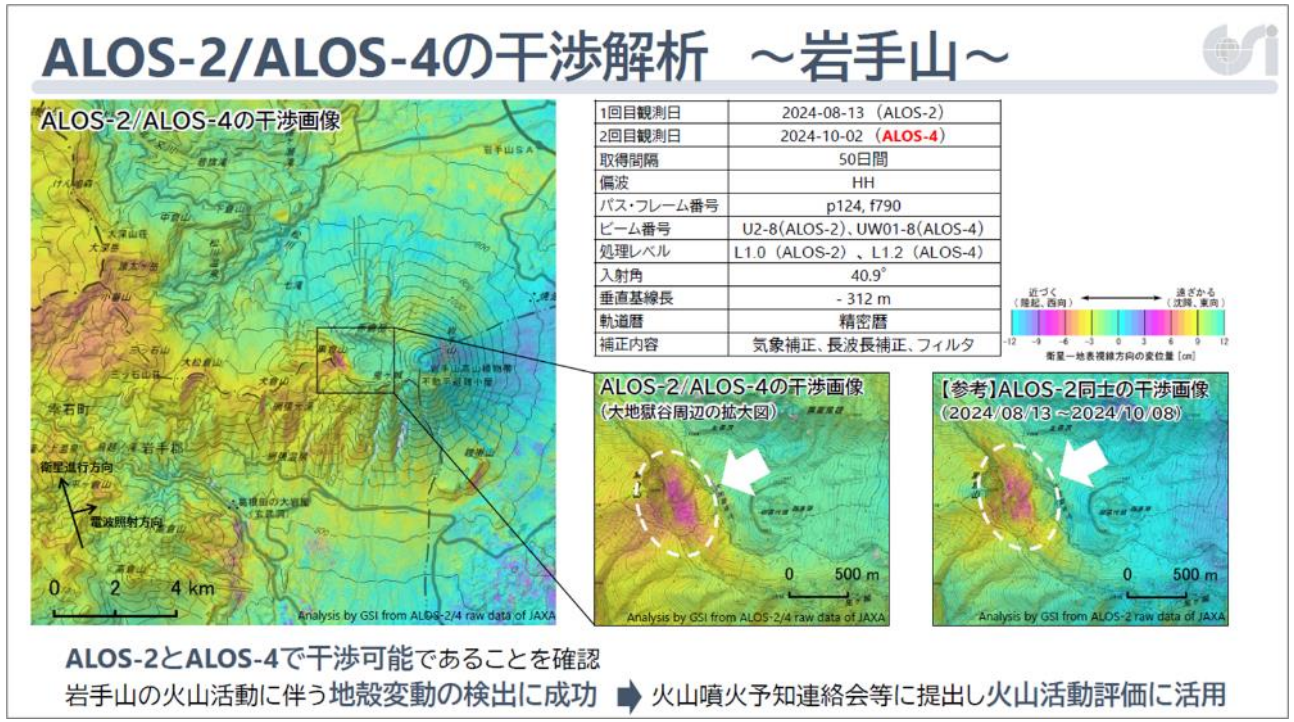
3. PALSAR-3 initial calibration/validation results

■ Example of Interferometric SAR analysis

Successful interferometric SAR analysis using ALOS-4 image pair and ALOS-2/-4 image pair

Results by Geospatial Information Authority of Japan

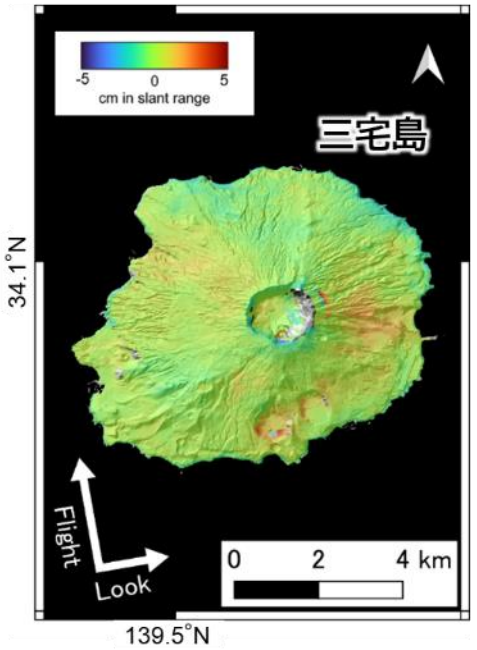
(Analysis for Mt. Iwate, in Japanese)



Results by JAXA

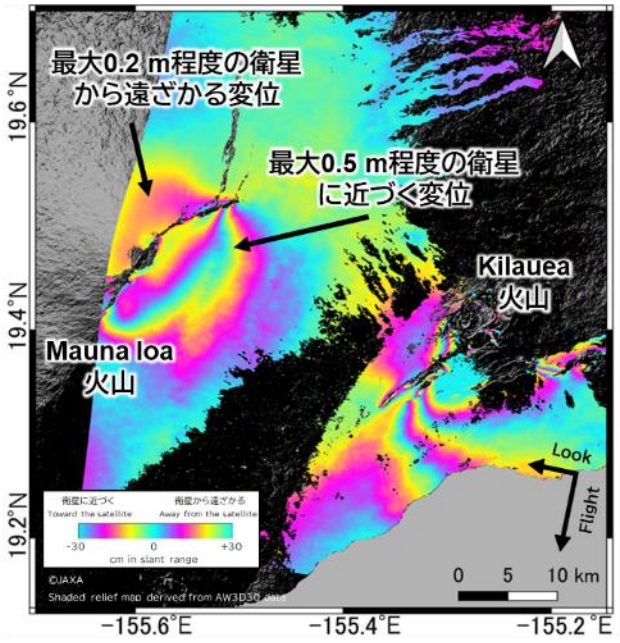
ALOS-2/4 Stripmap 3 m

2024/11/04 – 2024/11/10



Hawaii Mauna loa/Kilauea
ALOS-2/4 Stripmap 10 m

2014/11/15 – 2024/10/13



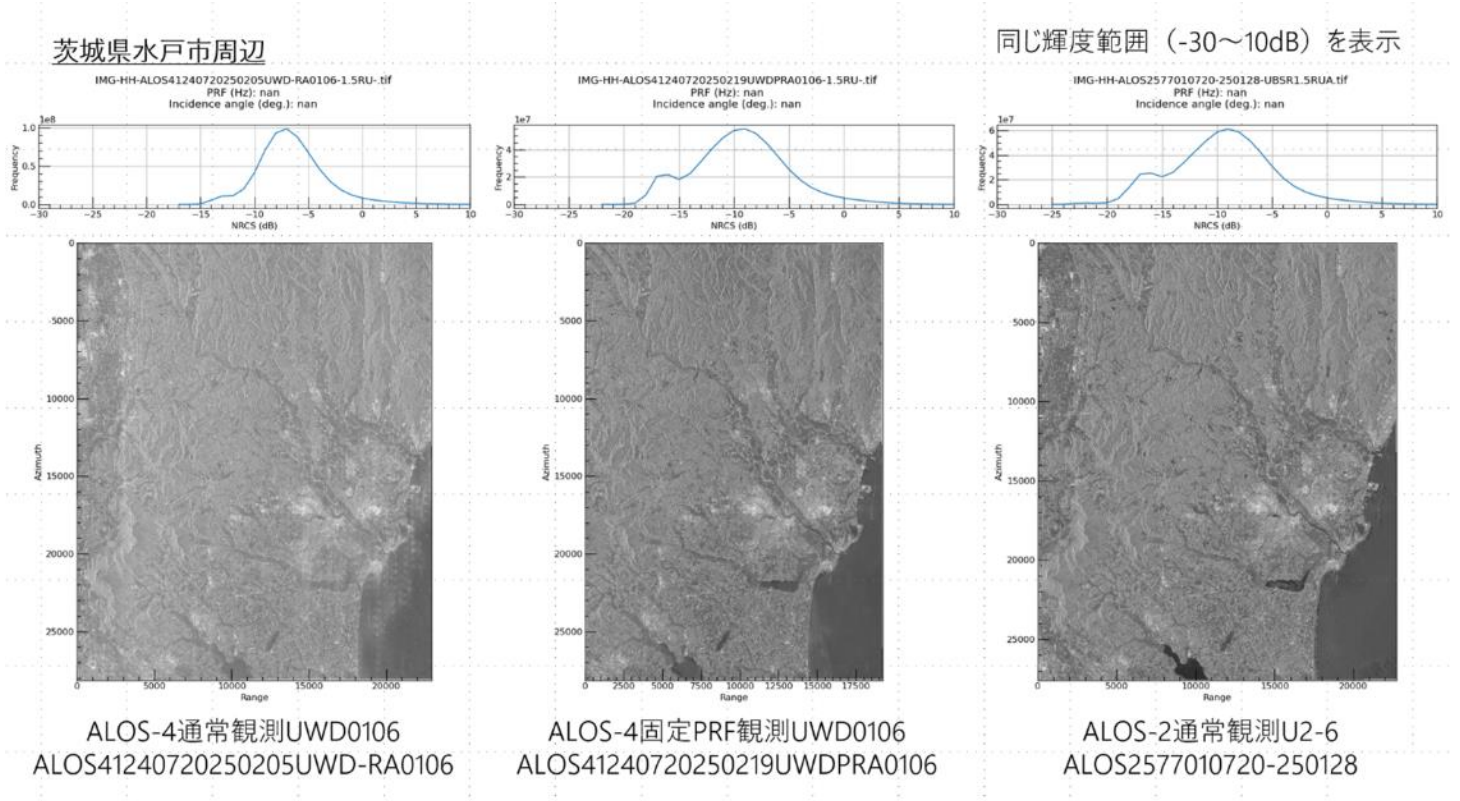
4. Image adjustment in the regular observation phase

■ Azimuth ambiguities (false image noises) in some areas

- JAXA confirmed noises in azimuth direction (=azimuth ambiguities) in some areas when operating the “variable PRF (pulse repetition frequency)” setting in the newly demonstrated DBF-SAR technology for making seamless images over a wide area. Continuous adjustment will be carried out in Japanese Fiscal Year 2025.
- In future operations, observations are sometimes operated with the “fixed PRF” setting in order to avoid azimuth ambiguities. In this case, there are blind (no data) areas of 10 to 20% of the observation width.

Comparison of ALOS-2/-4 images

（Left）ALOS-4 variable PRF
（Center）ALOS-4 fixed PRF
（Right）ALOS-2



4. Image adjustment in the regular observation phase

Comparison of variable/fixed PRF images

Stripmap 3 m

200 km swath

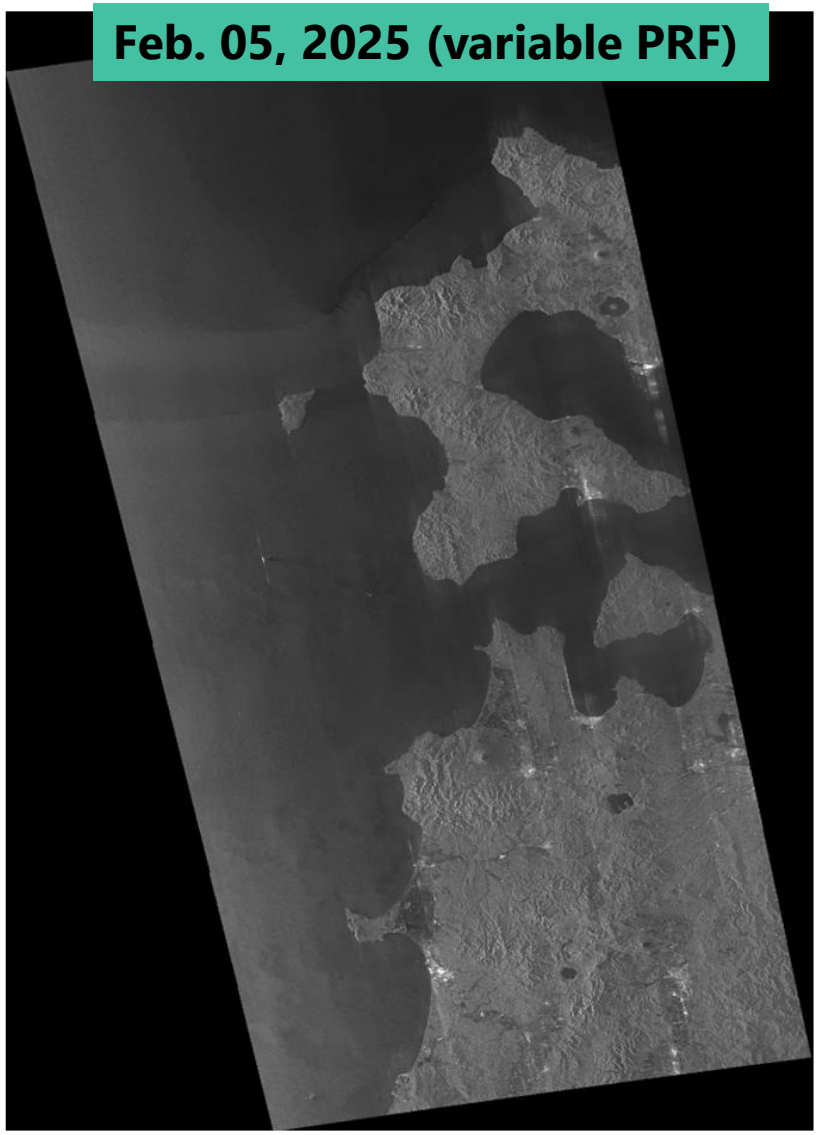
Beam 1 (UWD01)

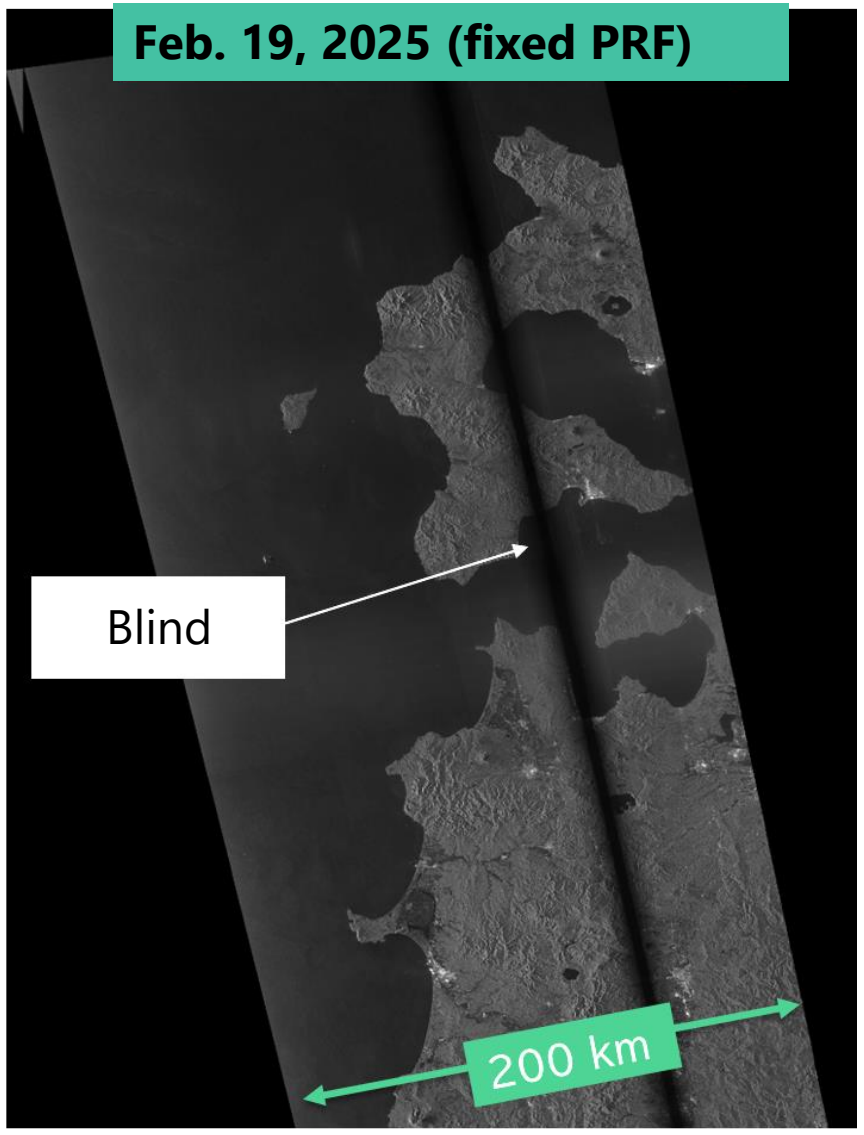
Japan

HH-pol.

Satellite direction (Azimuth)

Beam direction (Range)



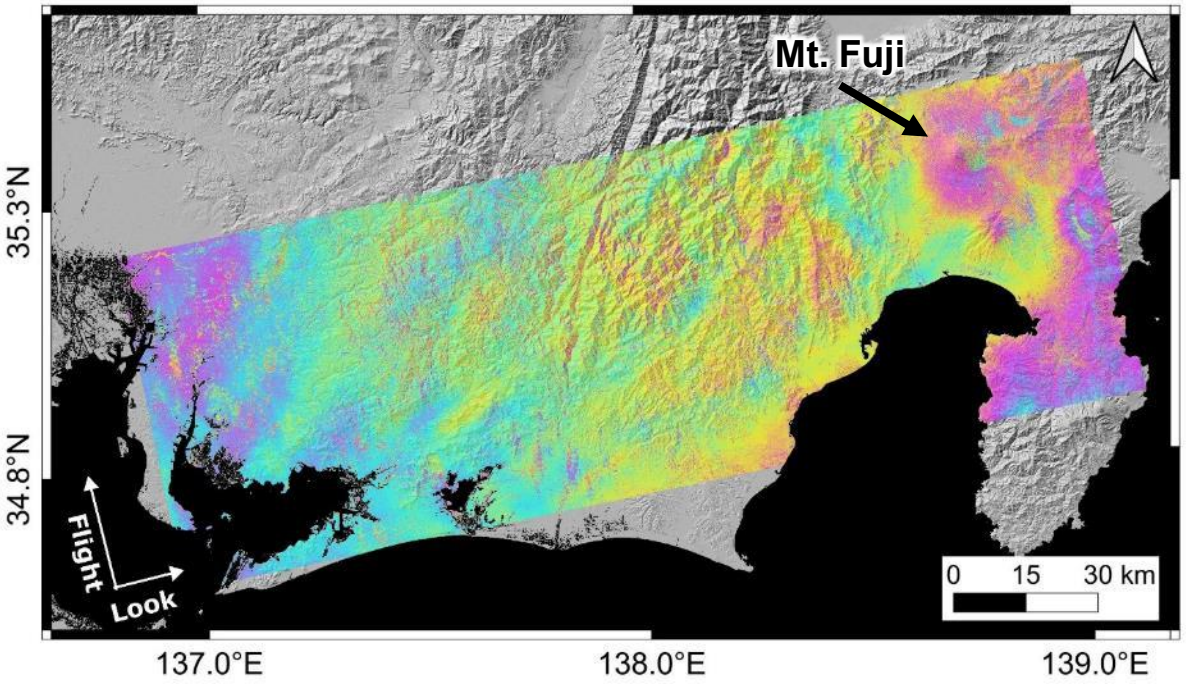


4. Image adjustment in the regular observation phase

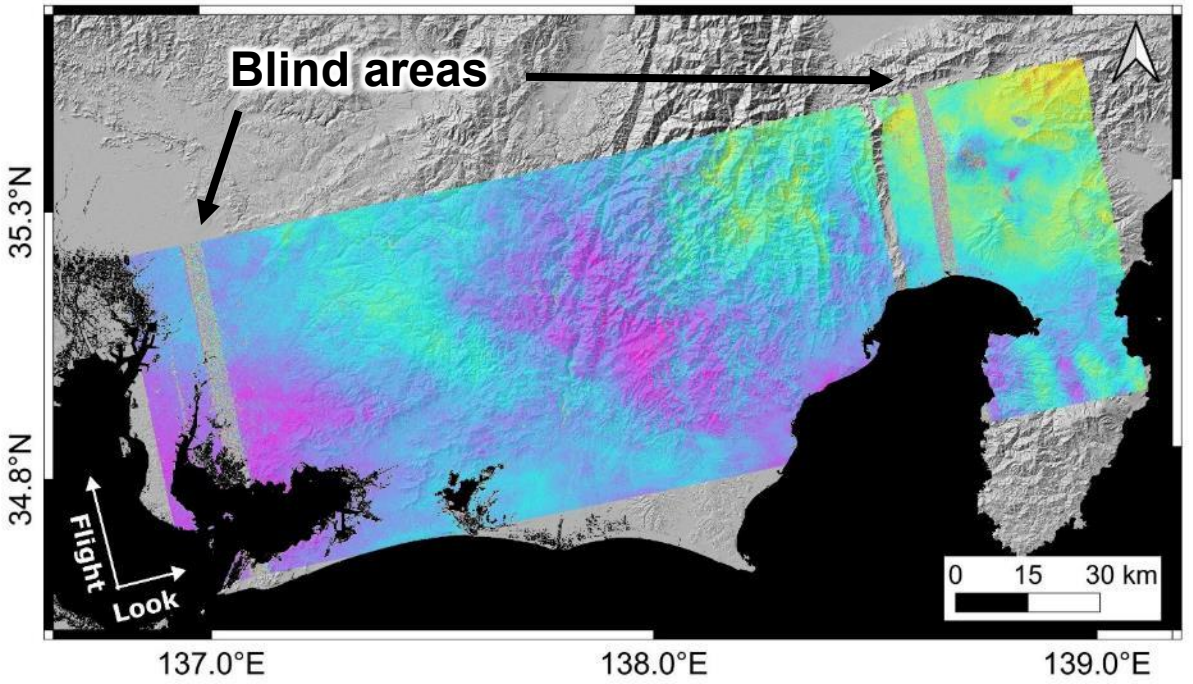
Interferometry using variable/fixed PRF (Stripmap 3 m, 200 km swath)

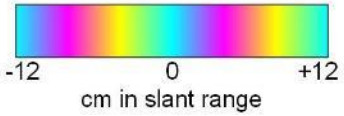
- Variable PRF pair: 200 km width can be analyzed seamlessly. Ambiguities cause reduced interferometric coherence in some locations.
- Fixed PRF pair: Interferometric analysis equivalent to that of ALOS-2 is possible. Blind areas cannot be observed.

ALOS-4 InSAR (variable PRF)
2024/12/21 – 2025/01/04（vertical baseline: -16 m）



ALOS-4 InSAR (fixed PRF)
2025/02/15 – 2025/03/01（vertical baseline: 86 m）



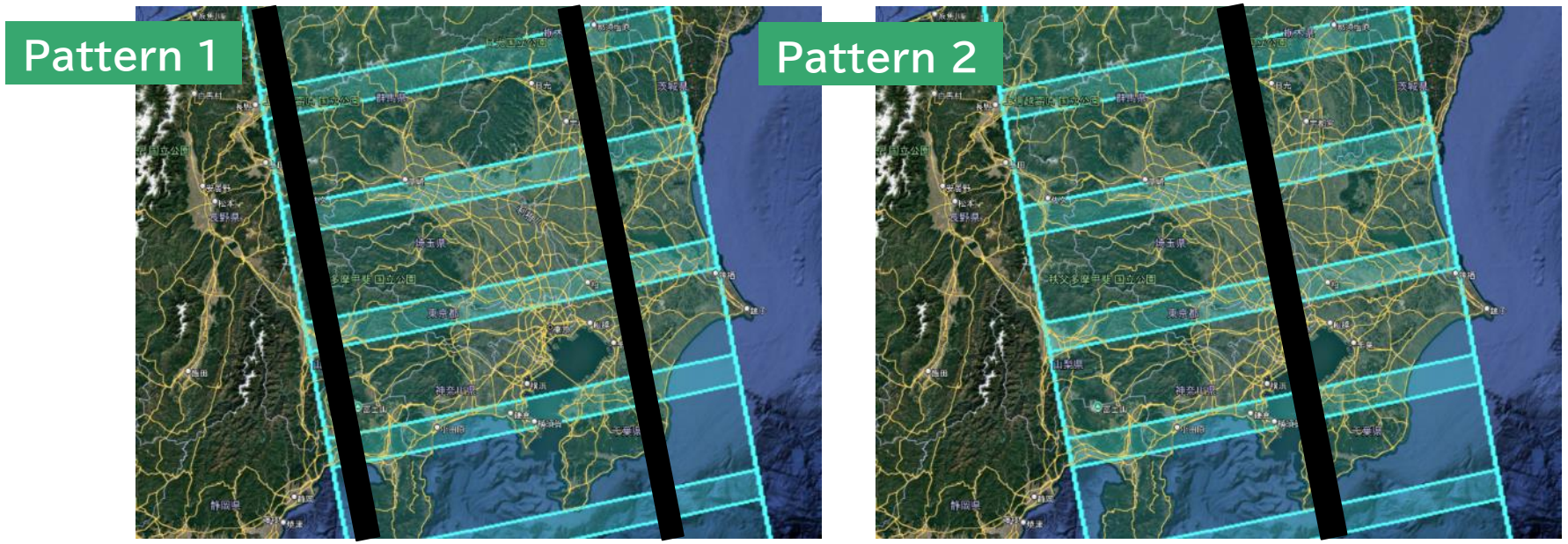


4. Image adjustment in the regular observation phase

Operation policy when using fixed PRF observations

- Part of the basic observations will be carried out using the fixed PRF setting. Two patterns of settings with different blind positions will be operated as follows.

Concept images of two fixed PRF patterns and blinds



Supplementally material

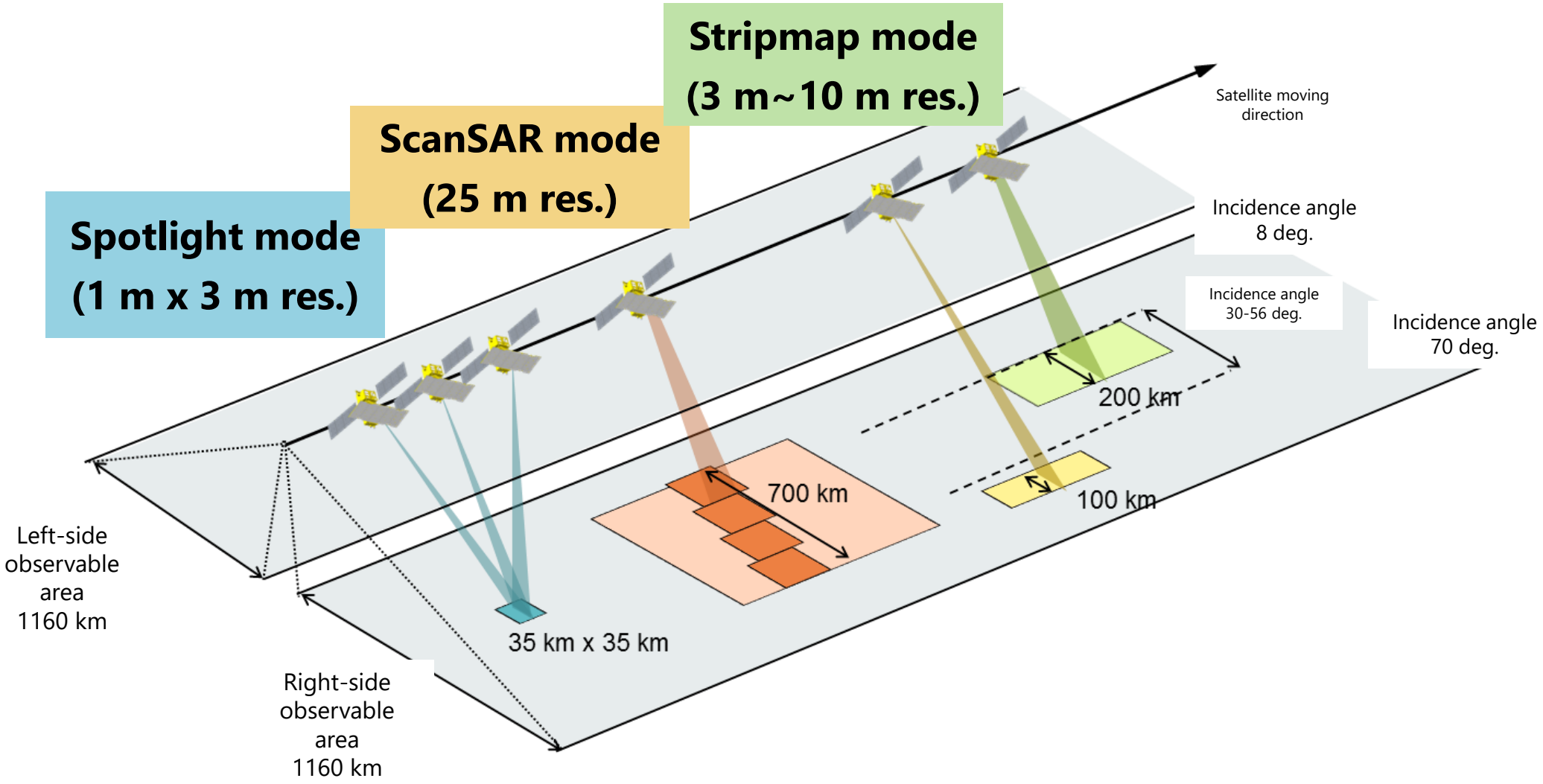
Specification of PALSAR-3 observation modes

Mode	Spotlight	Stripmap 3 m		Stripmap 6 m		Stripmap 10 m		ScanSAR
Beam code	SB	UW	UB	HW	HB	FW	FB	XB
Polarimetry	S, D	S, D	S, D, Q	S, D	S, D, Q	S, D	S, D, Q	S, D
Beam #	—	3	23	3	23	3	21	3
Resolution [m]	3 x 1 (Rg x Az)	3		6		10		25 (1 look)
Swath [km]	35 x 35	200	100	200	100	200	100	700 (4 scan)
Center frequency [MHz]	1257.5	1257.5		1236.5				
Bandwidth [MHz]	84	84		42		28		28
Incidence angles	8-70	30-56	8-70	30-56	8-70	29-56	8-70	8-70
NESZ	< -20 dB	< -20 dB		< -24 dB		< -28 dB		< -20 dB
Range S/A	> 15 dB	> 15 dB		> 15 dB		> 20 dB		> 15 dB
Azimuth S/A	> 15 dB	> 15 dB		> 15 dB		> 20 dB		> 15 dB
Pol. X-talk	＞ 30 dB							
Ionospheric correction option (on board split-band)	N/A	N/A	N/A	N/A	N/A	28+10 MHz	N/A	N/A

※Polarimetry: S = single, D = double, Q = quad/full

Supplementally material

Specification of PALSAR-3 observation modes



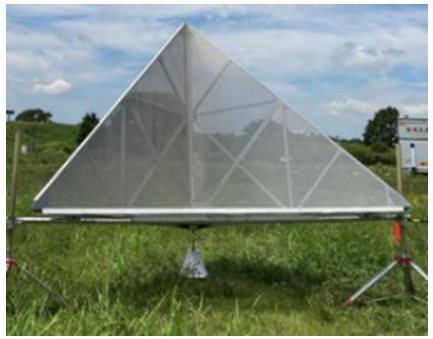
Supplementally material

Calibration sites

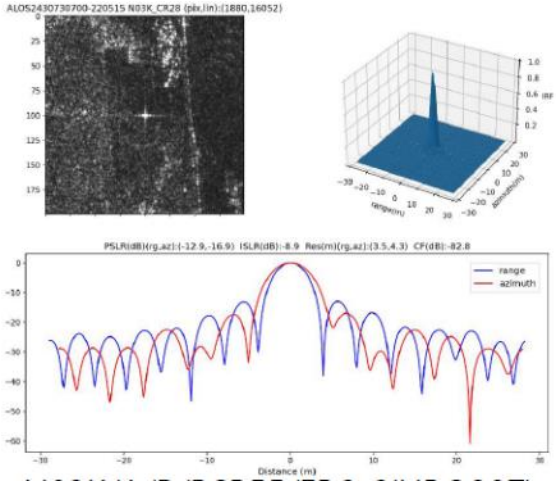
Corner reflector(CR) and Active Radar Calibrator (ARC、GC)

- Japan (using the same instruments and sites for ALOS-2)
  - Kanto area: temporary deployment of CRs/ARCs during satellite observations
  - Gotemba, Tomakomai: Permanent installation of CRs
- Overseas
  - Using sites managed by foreign space agencies (NASA, CONAE, CSA, etc.) or Research Announcement PIs (calibration and validation teams)

ARC



CR



Target response in ALOS-4 data at JPL Oklahoma site.

Natural calibration targets

- Wide areas with stable backscatter coefficients are used as calibration sites for radiometry, etc. … Amazon and African tropical forests.
- Use windless sea surface with low scattering coefficient for evaluation of NESZ (noise level), etc.