Status of ALOS-4 Initial Check-out and Calibration

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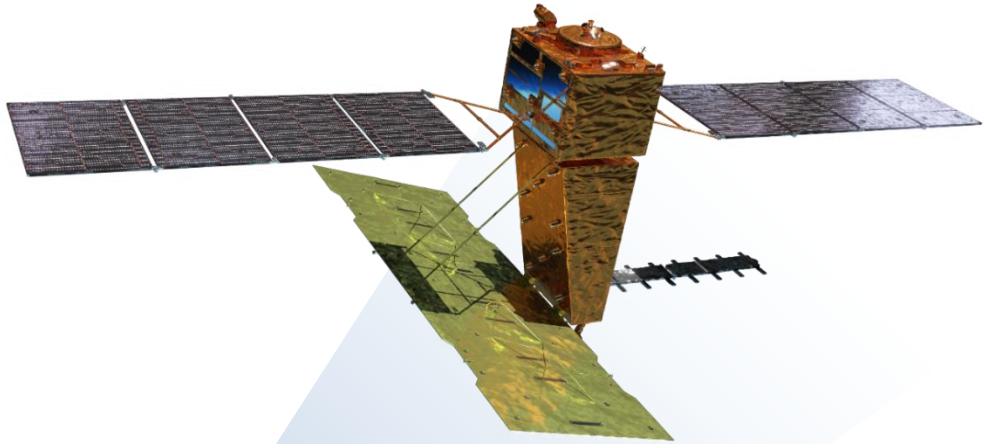
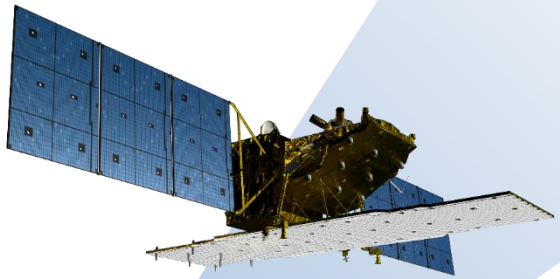
Japan Aerospace Exploration Agency (JAXA)

CEOS WGCV SAR Cal/Val Workshop 2024
ISRO, Ahmedabad, India
12-15 November, 2024

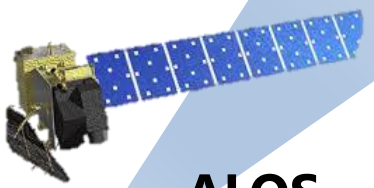
JAXA's ALOS-series L-band SAR



ALOS-4
(2024~ in operation)
PALSAR-3, SPAISE3



ALOS-2
(2014~ in operation)
PALSAR-2, SPAISE2



ALOS
(2006-2011)
PALSAR, AVNIR-2, PRISM

- The ALOS series satellites are continuously developed and operated by JAXA mainly for the purpose of land/ocean monitoring and technological development.
- L-band SAR has been developed and caried in the ALOS series.

Mission objectives of ALOS series:

Disaster damage assessment
Flood, Landslides, Building damage, Typhoon, etc.

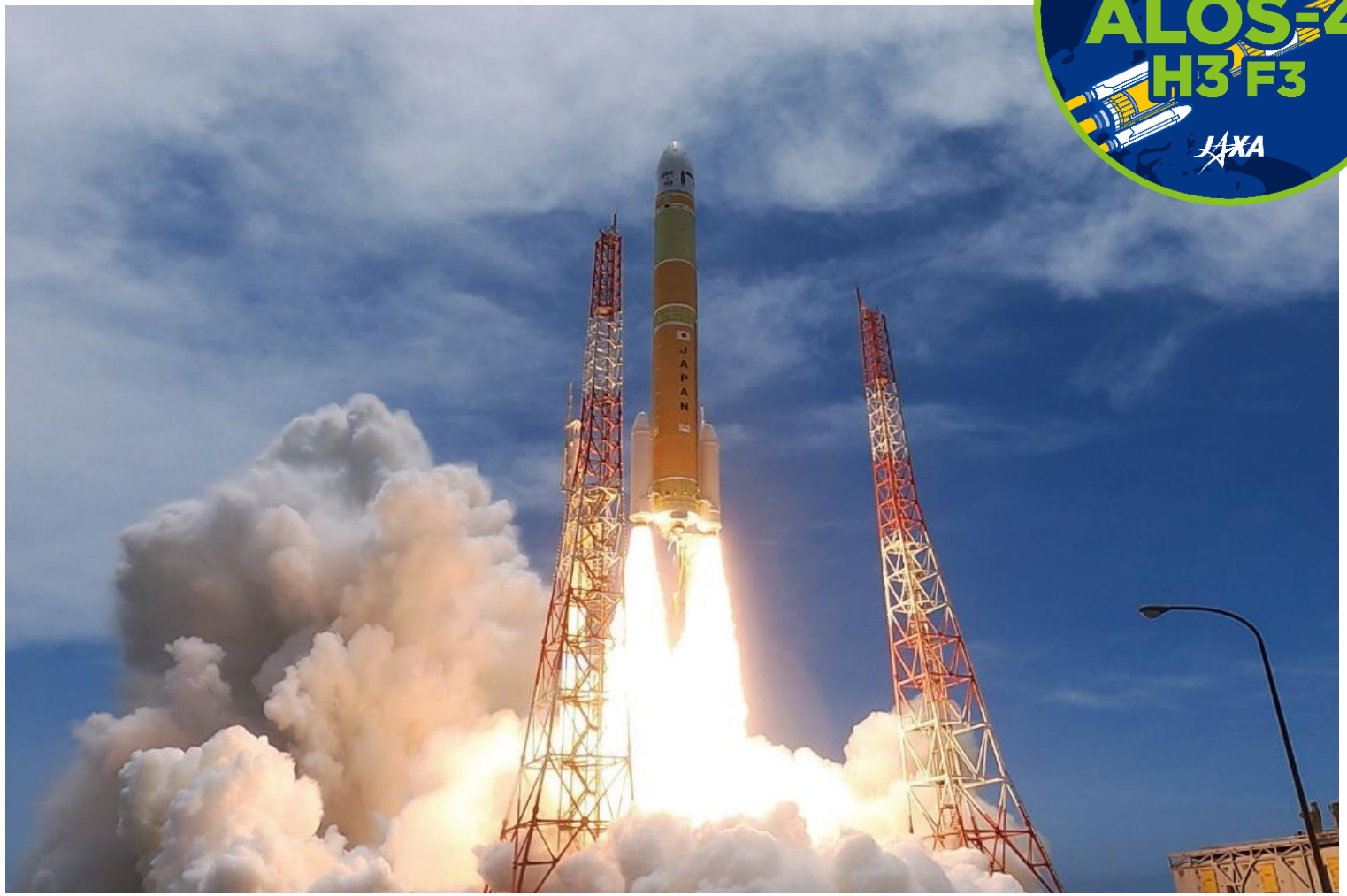
Land deformation
Volcano, Earthquakes, Landslides, Land subsidence, etc.

Maritime
Vessels, Ocean wind, Sea ice, etc.

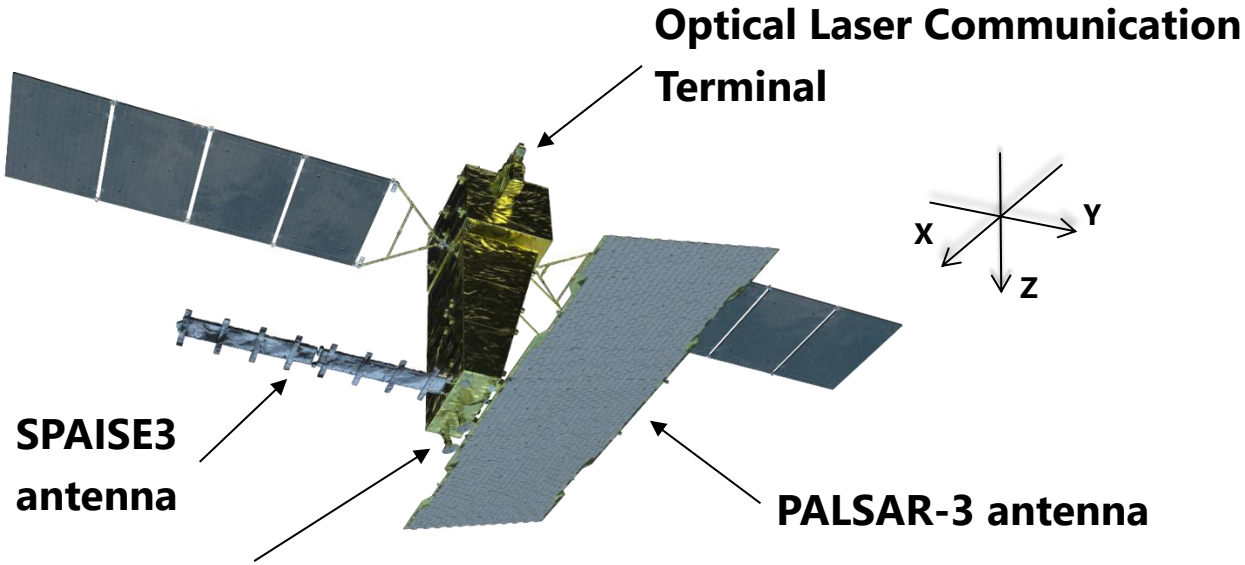
Global environment
Deforestation, Glacier, Agriculture, etc.

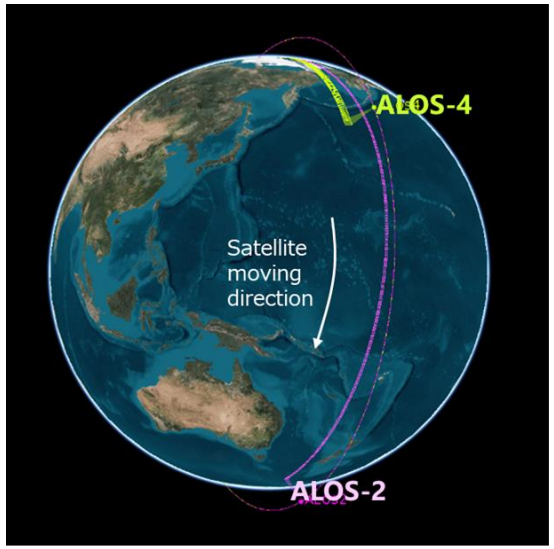
Launch of ALOS-4

ALOS-4 was launched aboard the third H3 Launch Vehicle at 12:06:42 (JST) on July 1, 2024, from the Tanegashima Space Center.



Overview of ALOS-4

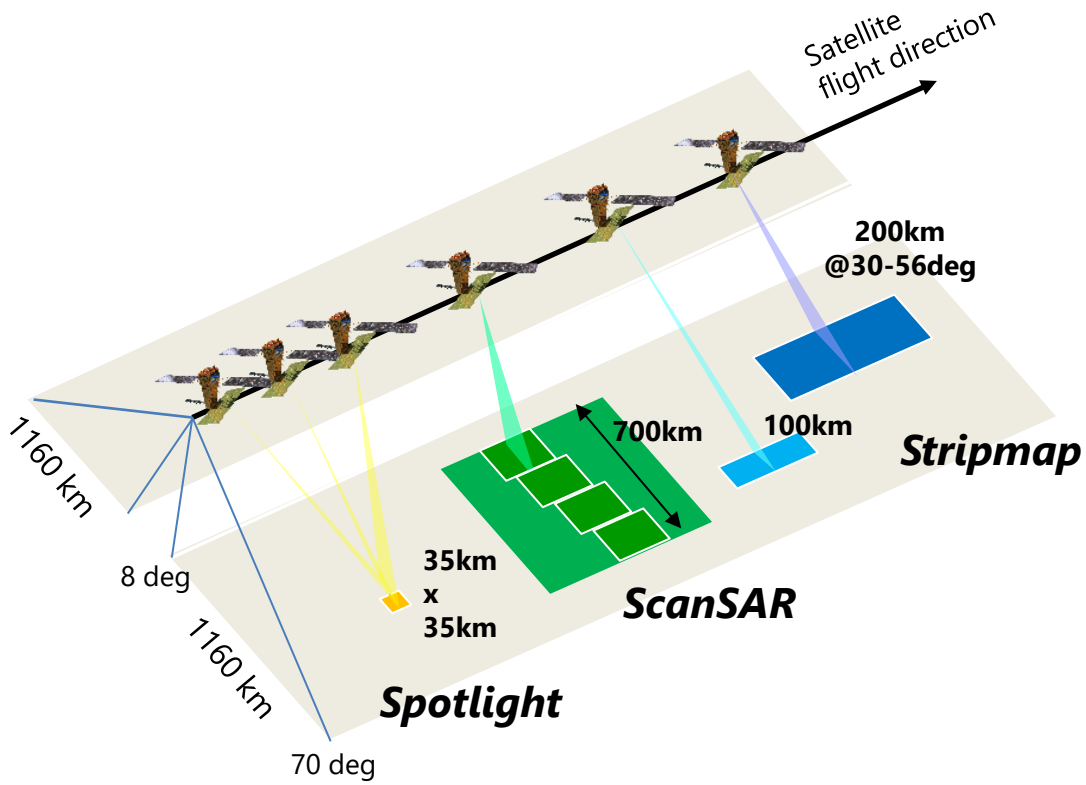




ALOS-4 flies on the same reference orbit as ALOS-2, enabling combined observations and data analysis by both.

Lifetime		7 years
Mission Instruments		PALSAR-3 (L-band SAR) SPAISE3 (AIS receiver)
Size (X, Y, Z)		10.0 m × 20.0 m × 6.4 m
Satellite Mass		Approx. 3,000 kg
Electrical Power	**Solar cells**	Approx. 7,000 W
	Battery	380 Ah
Data recorder		Approx. 1 Tbyte
Downlink		3.6 Gbps (Ka-band) 1.8 Gbps (Optical data relay)
Orbit (Same as ALOS-2)	**Type of orbits**	Sun-synchronous sub-recurrent orbit
	Altitude	628 km
	Local sun time at descending	12:00 ± 15 min
	Revisit time	14 day
	Inclination angle	97.9 deg.

PALSAR-3 Observation Mode



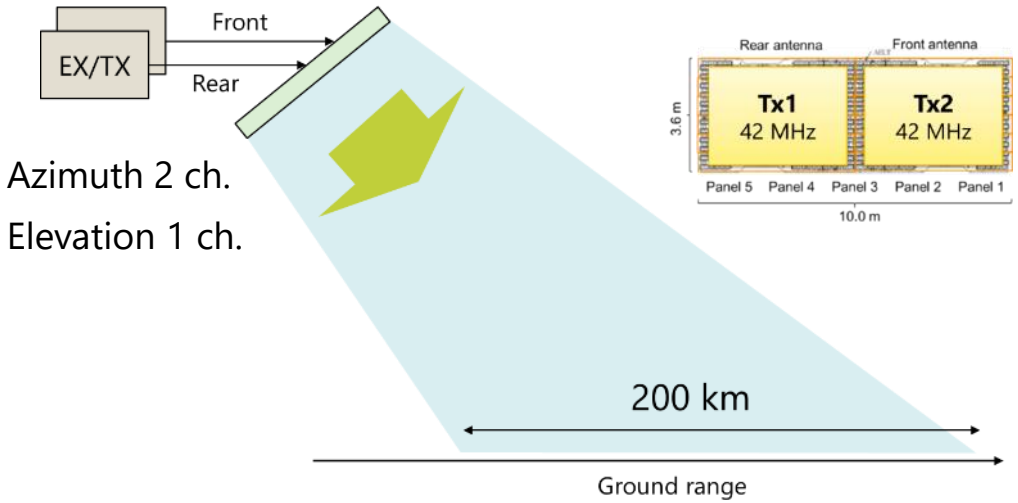
Observation mode	Spotlight	Stripmap		ScanSAR
Polarization*	Single/ **Dual**	Single/ Dual	Full	Single/ Dual
Resolution (m)	1 x 3 (Rg x Az)	3/6/10	**3**/6/10	25 (1 look)
Swath width (km)	**35 x 35** (Rg x Az) [25 x 25]*	**100-200** [50-70]*	**100** [40]*	**700** [350-490]*
NESZ (dB)	< -20			
S/A (dB)	> 15			
Pol. X-talk (dB)	< -30			
Split-band option	N/A	**28+10 MHz**	N/A	N/A

* [~]: ALOS-2 specifications

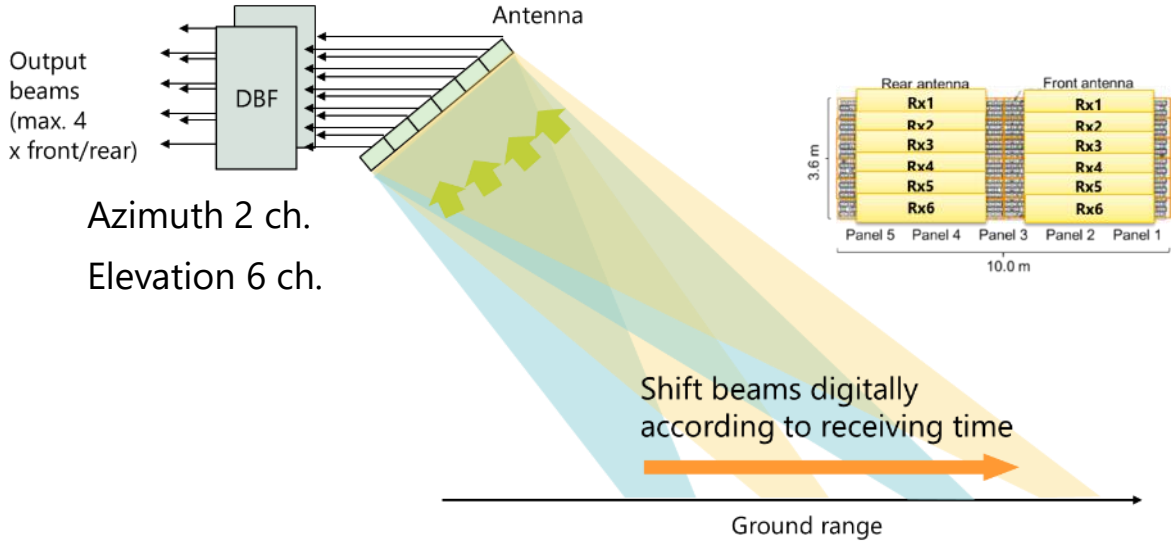
PALSAR-3 Observation Mode

Transmit

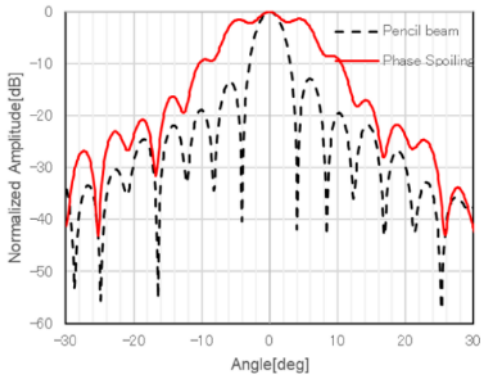
	ALOS-2	ALOS-4
Antenna size	3 m x 10 m	3.6 m x 10 m
Num. of TRMs	180	232



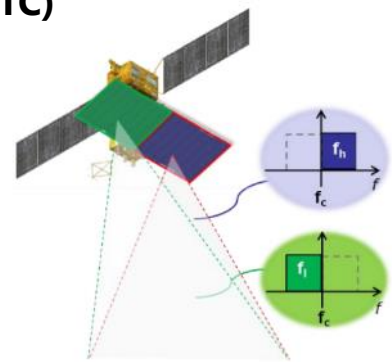
Receive



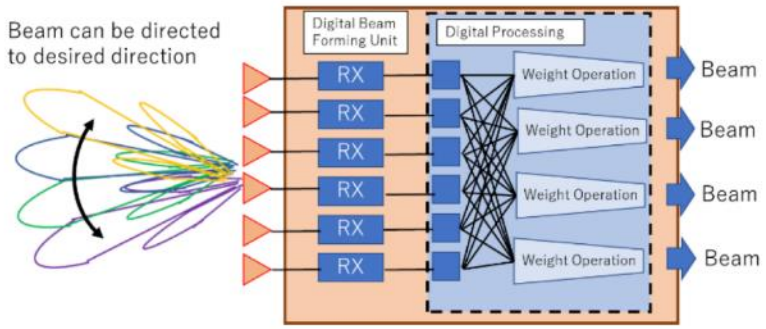
Phase Spoillng



Multiple Transmit Channels (MTC)



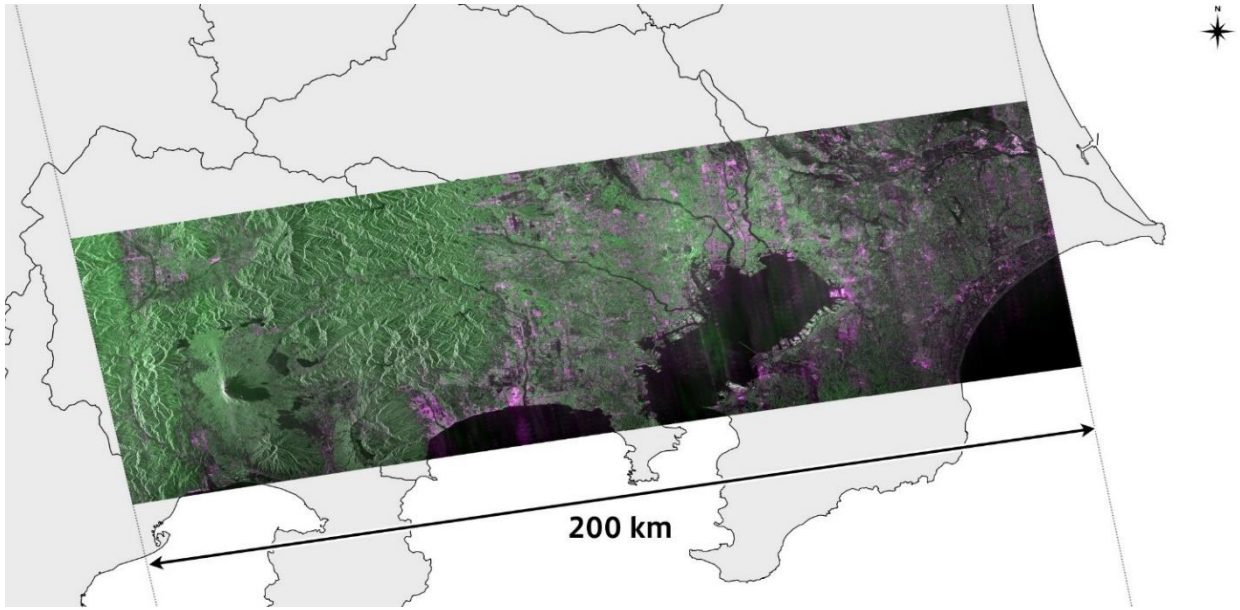
Digital Beam Forming (DBF)



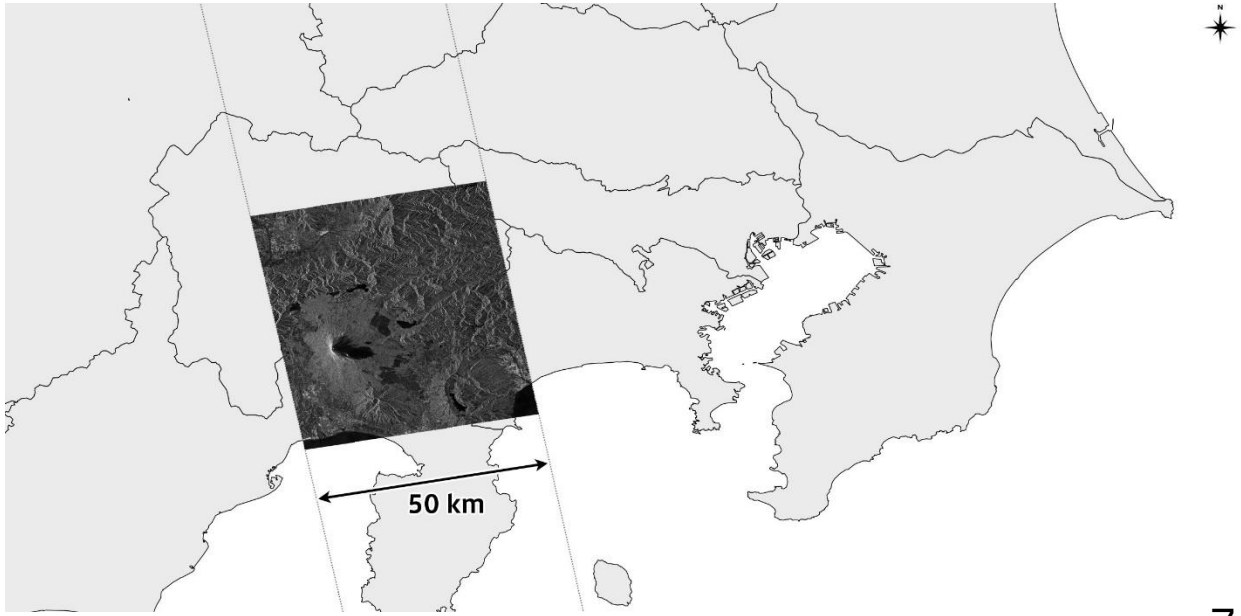
First images of PALSAR-3

- The first PALSAR-3 observation was conducted during July 15 to 17, 2024.
  - ✓ Successfully observed over a 200 km swath width with 3 m resolution. PALSAR-3 can observe 4 times wider than the 50 km swath of PALSAR-2.
  - ✓ Use of the new Ka-band data transmission enabling observations of large volumes of dual-polarization data. In PALSAR-2, the high-resolution 3 m mode is operated with one polarization.

PALSAR-3 image over Tokyo~Mt. Fuji, Japan
(200 km swath, HH and HV polarization)



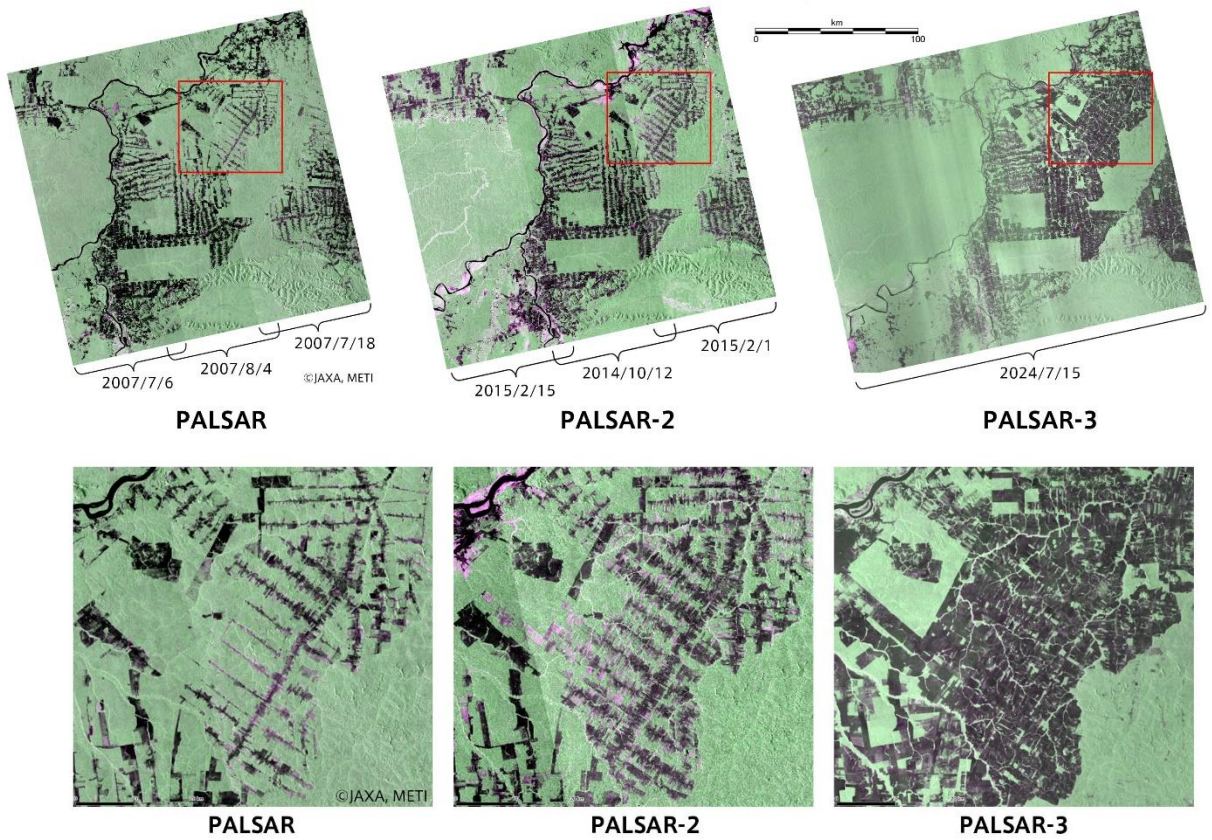
PALSAR-2 image
(50 km swath, HH-polarization)



First images of PALSAR-3

✓ Stripmap 10 m resolution and 200 km swath width

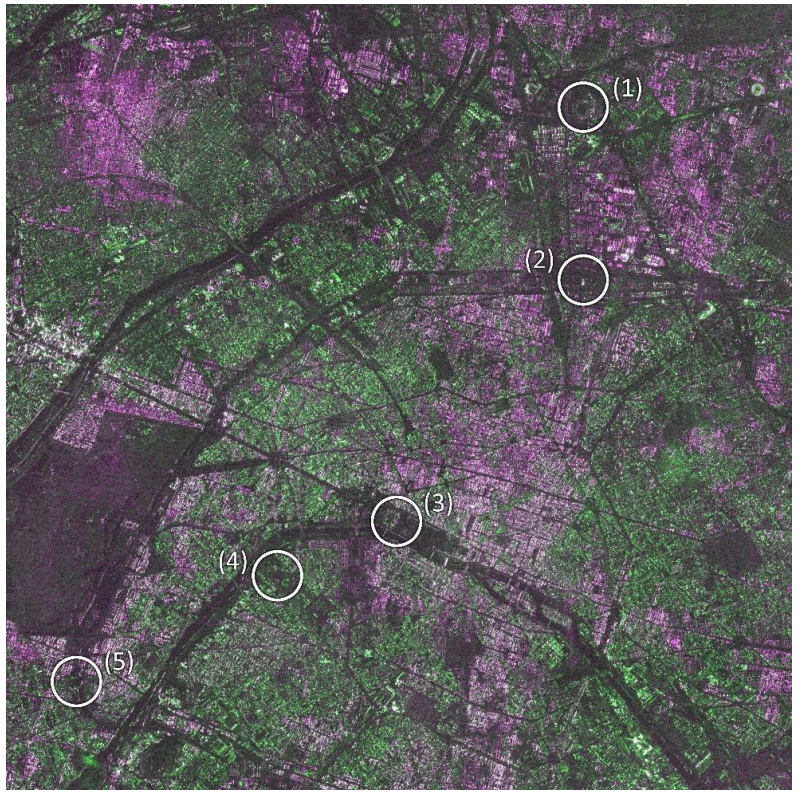
Amazon forest in the State of Rondonia, Brazil



✓ Spotlight mode 35 km x 35 km swath with 1m × 3 m resolution

Paris, France; Major venues for the Paris 2024 Olympics Games are marked with white circles

(1) Stade de France, the main venue, (2) Porte de la Chapelle Arena, (3) Place de la Concorde, (4) Eiffel Tower Stadium, and (5) Parc des Princes

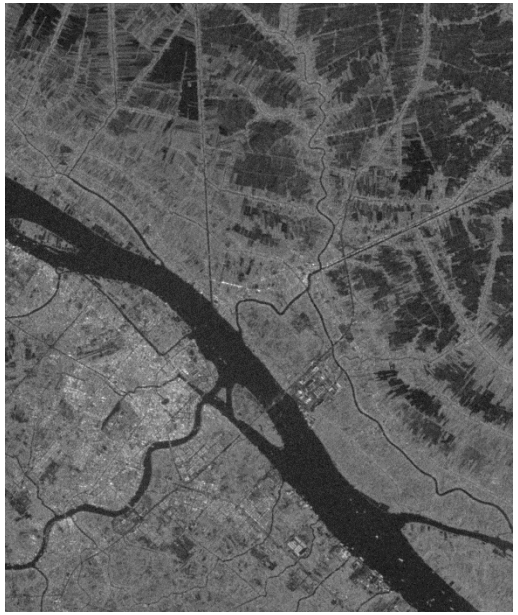


First images of PALSAR-3

✓ Full polarimetric SAR image with 6 m resolution

Urban and agricultural areas near Can Tho City, Vietnam

HH polarization



HV polarization

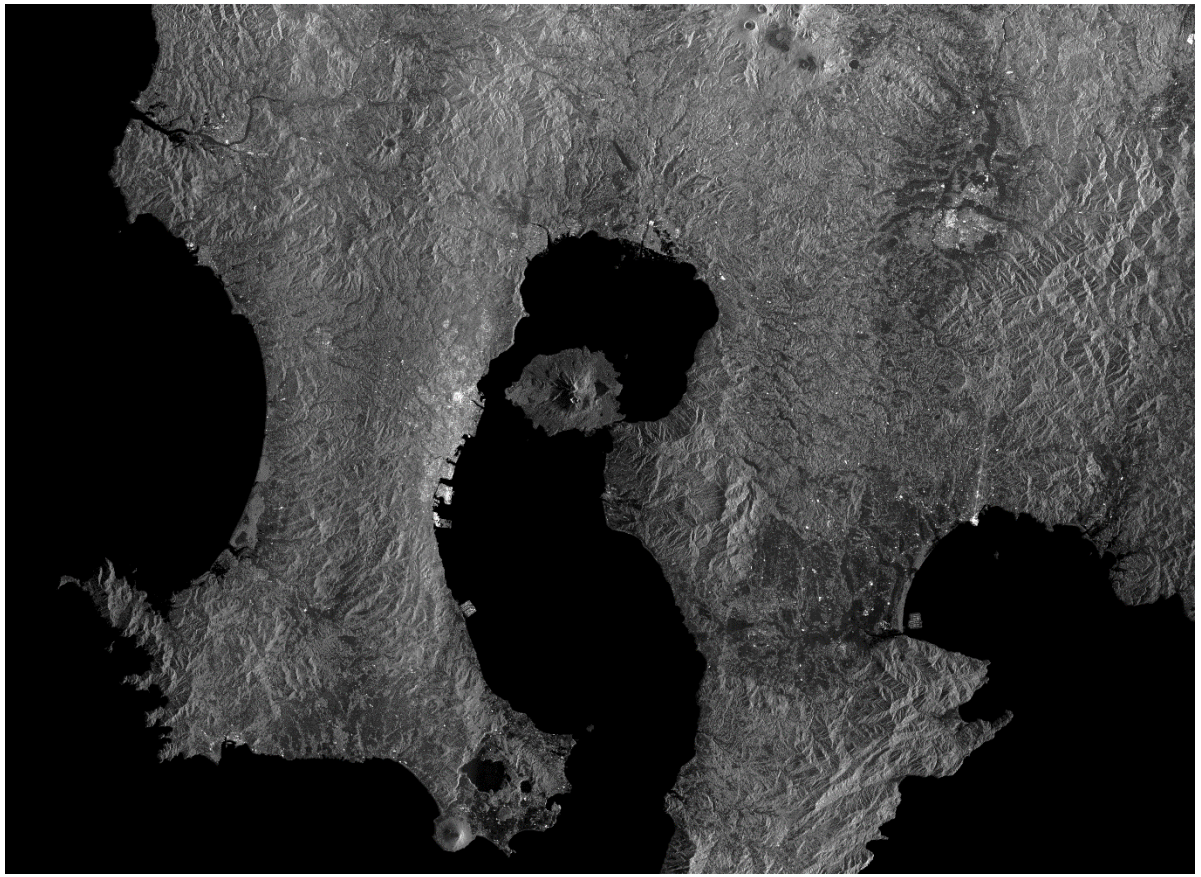
VV polarization

Color composite image
（R：HH、G：HV、B：VV）

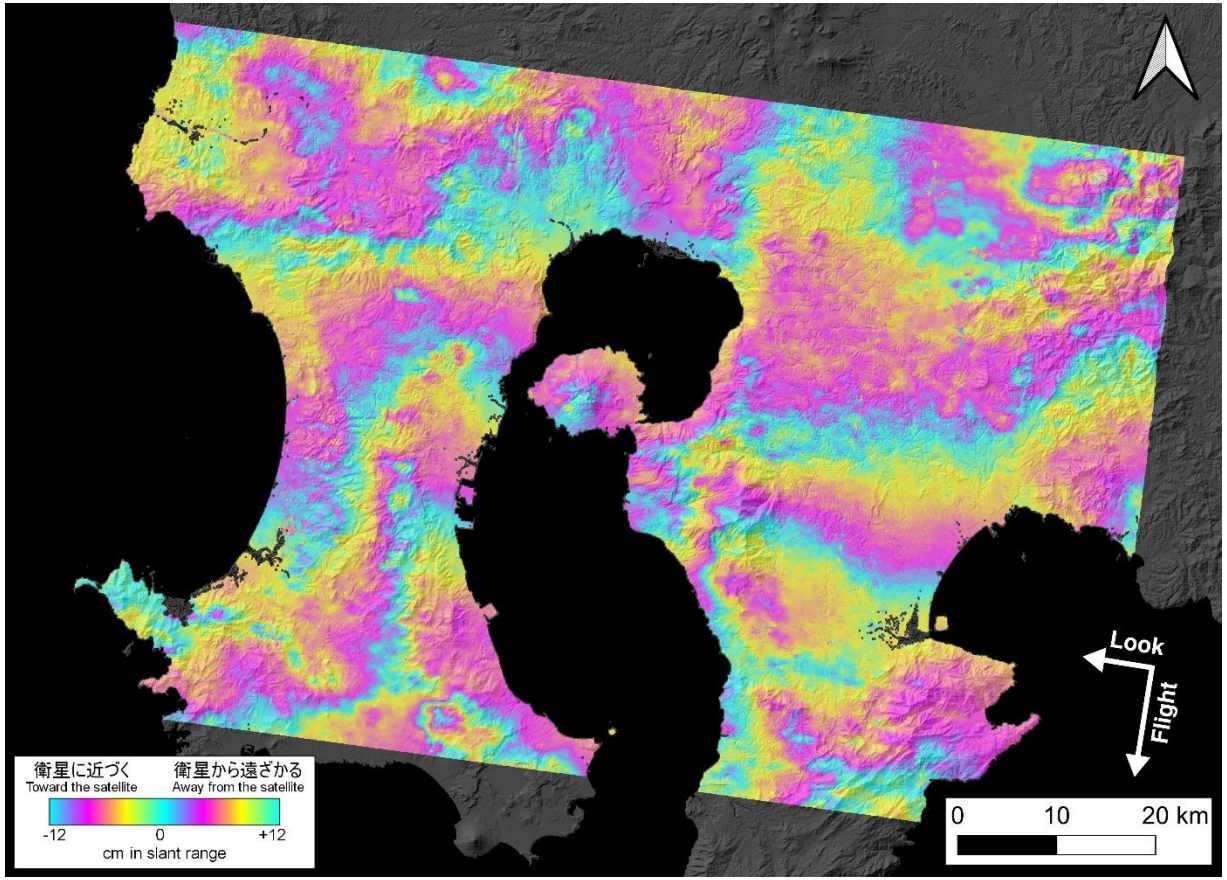
Initial results of InSAR

✓ Initial result of differential interferometry with 14 days repeat pass ALOS-4 observations

Amplitude image over Kagoshima, Japan on Aug. 10, 2024



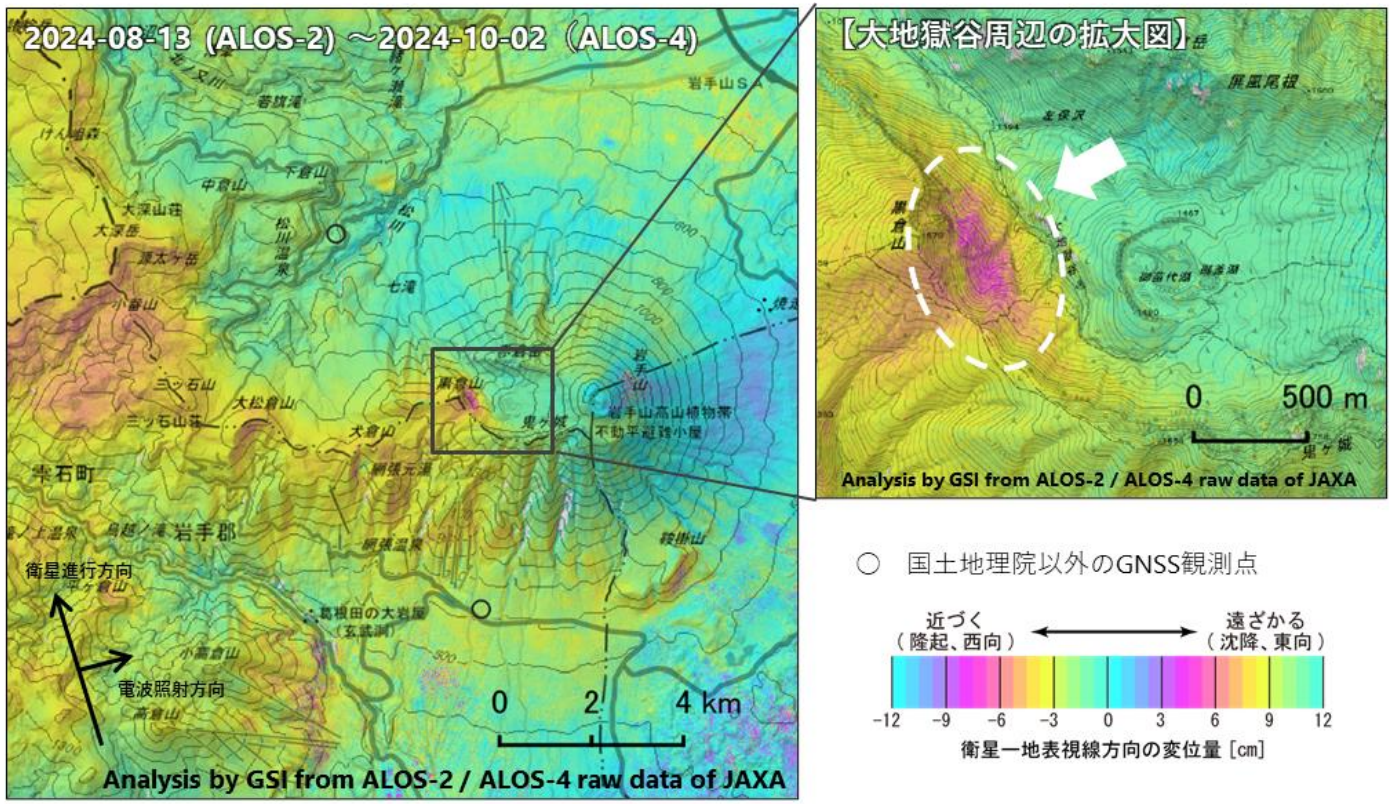
D-InSAR phase between Aug. 10 and Aug. 24, 2024



Initial results of InSAR

- InSAR between ALOS-2 and ALOS-4 observations had also successfully conducted.
- More frequent and long-term monitoring will be possible by combining with ALOS-2's future observations and its archived data for the past 10 years.

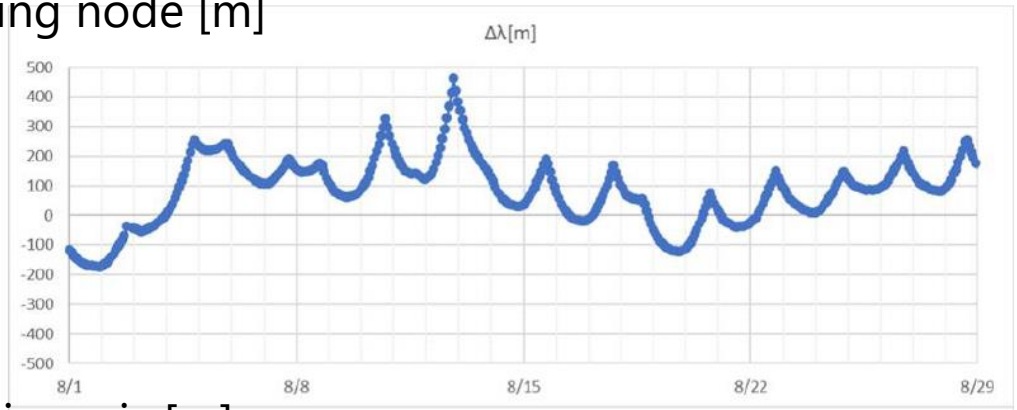
InSAR analysis results of PALSAR-2 and PALSAR-3 at Mt. Iwate, Japan by Geospatial Information Authority of Japan



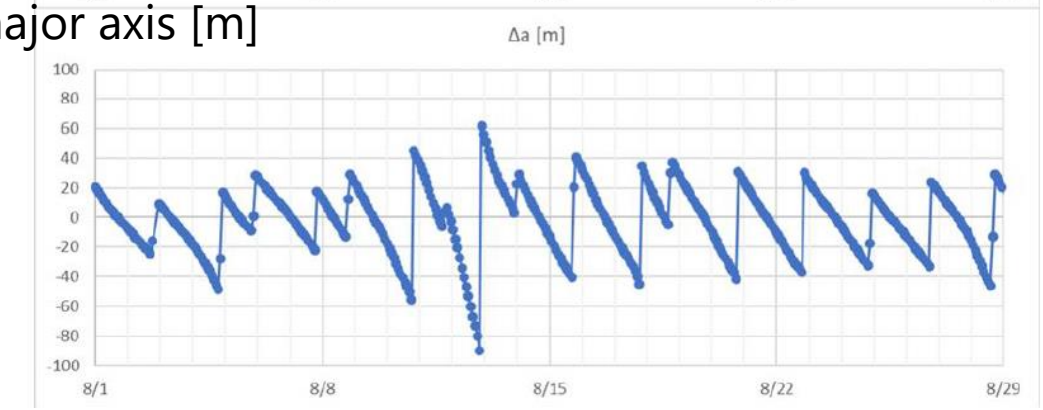
Orbit determination and control accuracy

- ✓ Autonomous orbit control started on 8/2, and orbit control is performed approximately every 1-2 days.
- ✓ Orbit control accuracy is satisfactory within ±500 m (3σ) tube.

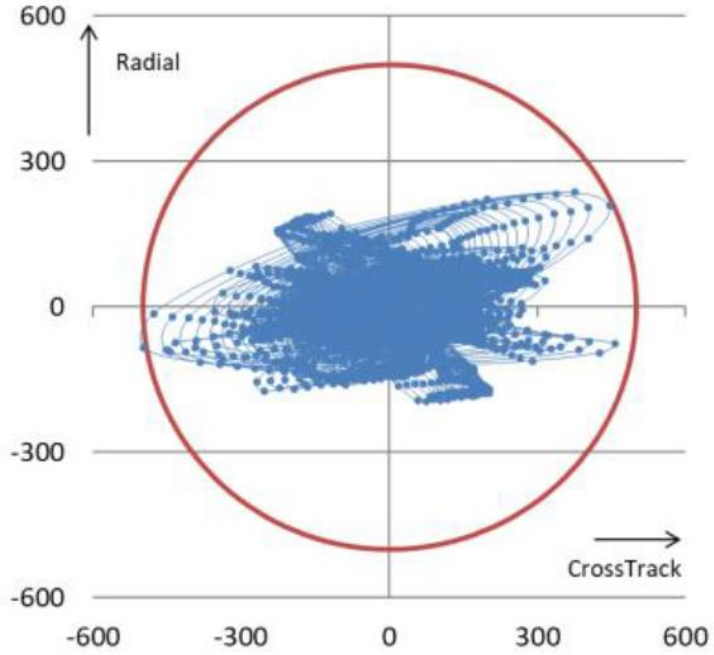
descending node [m]



semi-major axis [m]



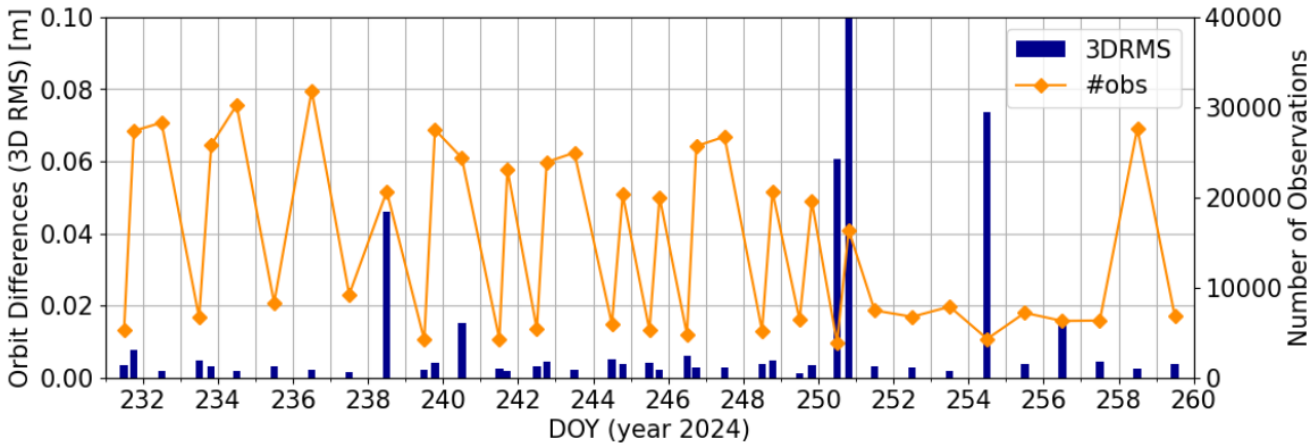
ALOS-4 orbit control accuracy during August, 2024



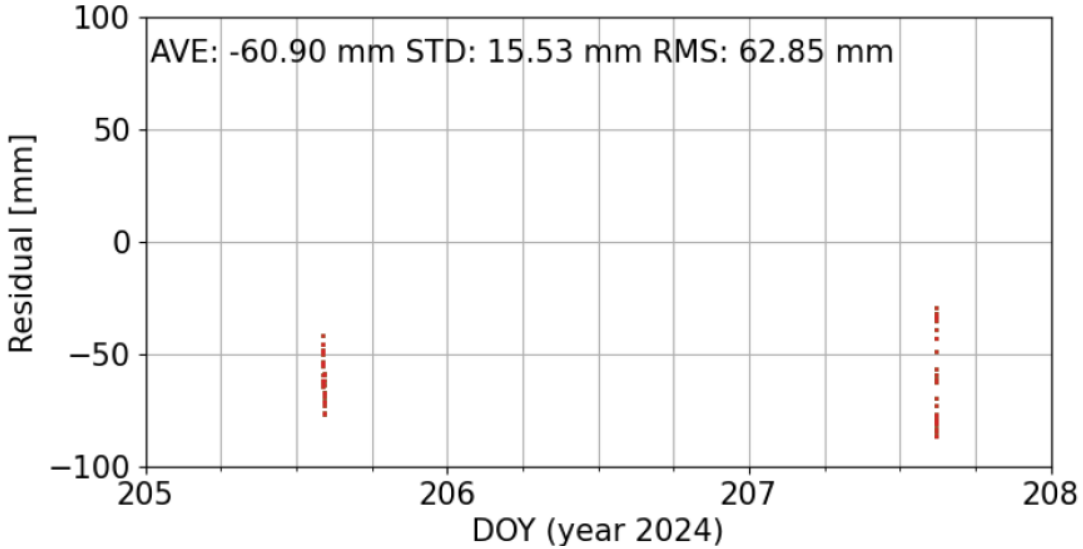
Orbit determination and control accuracy

- ✓ The accuracy of orbit determination was confirmed to be satisfactory within 10 cm RMS.
- ✓ Detailed accuracy evaluation will be conducted through a ranging campaign with the cooperation of international SLR stations.

Relative accuracy evaluation using the overlap of two orbit determination

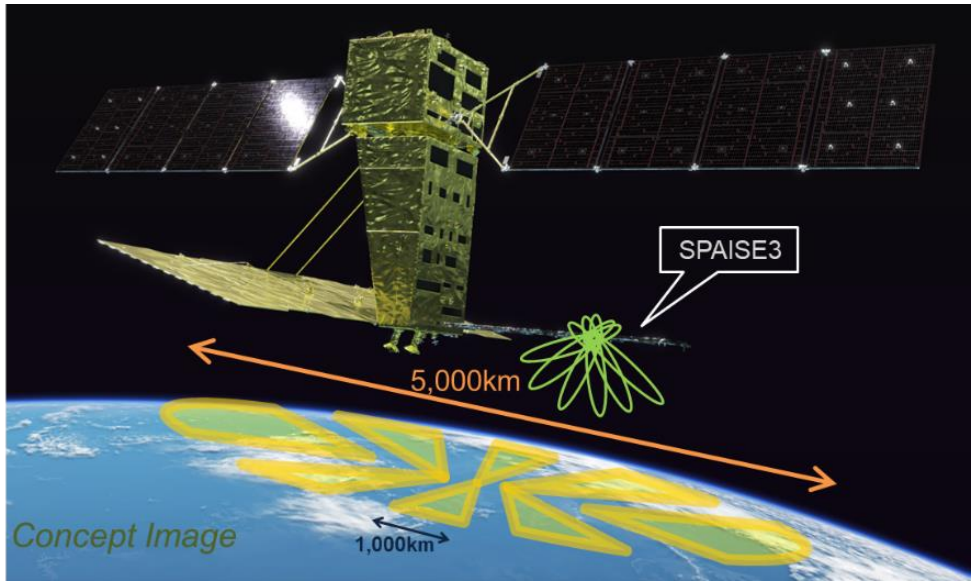


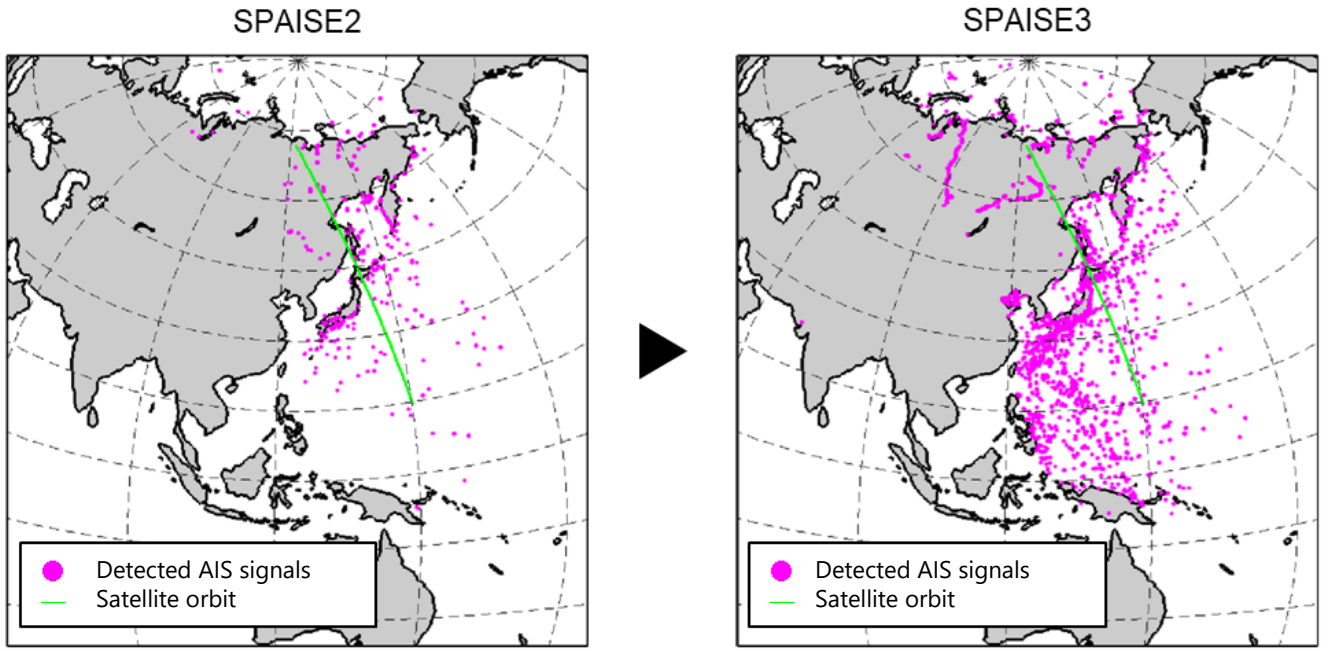
Absolute accuracy evaluation using SLR (Satellite Laser Ranging) observations



Initial check-out results of SPAISE3

- The purpose of SPAISE3 is to demonstrate the improvement of receiving performance of AIS signals in dense vessel areas using ground DBF processing.
- In the check-out results, SPAISE3 showed that improvements in detection rate compared to SPAISE2.





PALSAR-3 operation plan

Launch

Jul. 1

Critical operation (LEOP)	Initial check-out operation	Initial cal/val operation	Regular observation
After satellite separation, attitude establishment, solar array paddle deployment, followed by PALSAR-3 and SPAISE3 antenna deployment	Confirmation that the satellite system and mission equipment have the required functions and performance	Calibration and validation on PALSAR-3 products	Start providing PALSAR-3 standard products (*)
Completed Jul. 3	**Completed Oct. 18**	to around Jan. 2025 (about 3 months)	

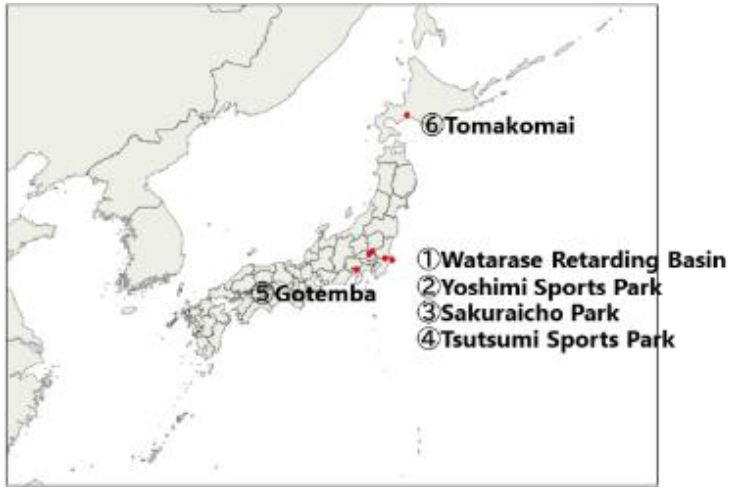
* JAXA plans to provide PALSAR-3 standard products to general users (all users other than those who have an agreement/arrangement with JAXA) from multiple private companies selected by JAXA.

JAXA is now calling for applications for this data and service providers.

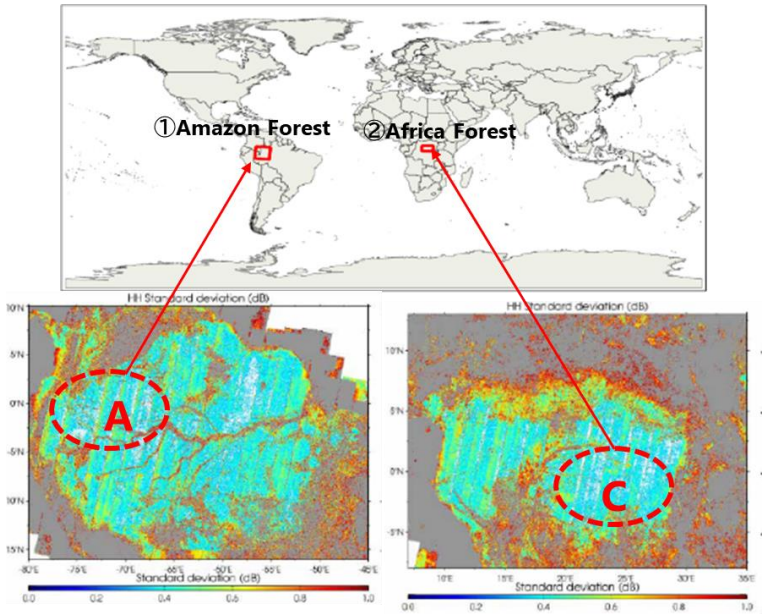
Observation plan for PALSAR-3 initial cal/val

- ✓ Permanent CR sites
  - Tomakomai (3 m Tri-CR x 2)
  - Gotenba (3 m Tri-CR x 1)
- ✓ Non-permanent CR sites (Kanto region)
  - 1 sites (1~2 CRs and 1 ARC) for 1 obs.
- ✓ Collaborative CR sites with CVST PIs
- ✓ Natural targets for checking antenna pattern, NESZ, S/A, ionospheric noise, RFI, interferometry, etc. (tropical forests, ocean, etc.)

CR sites in Japan



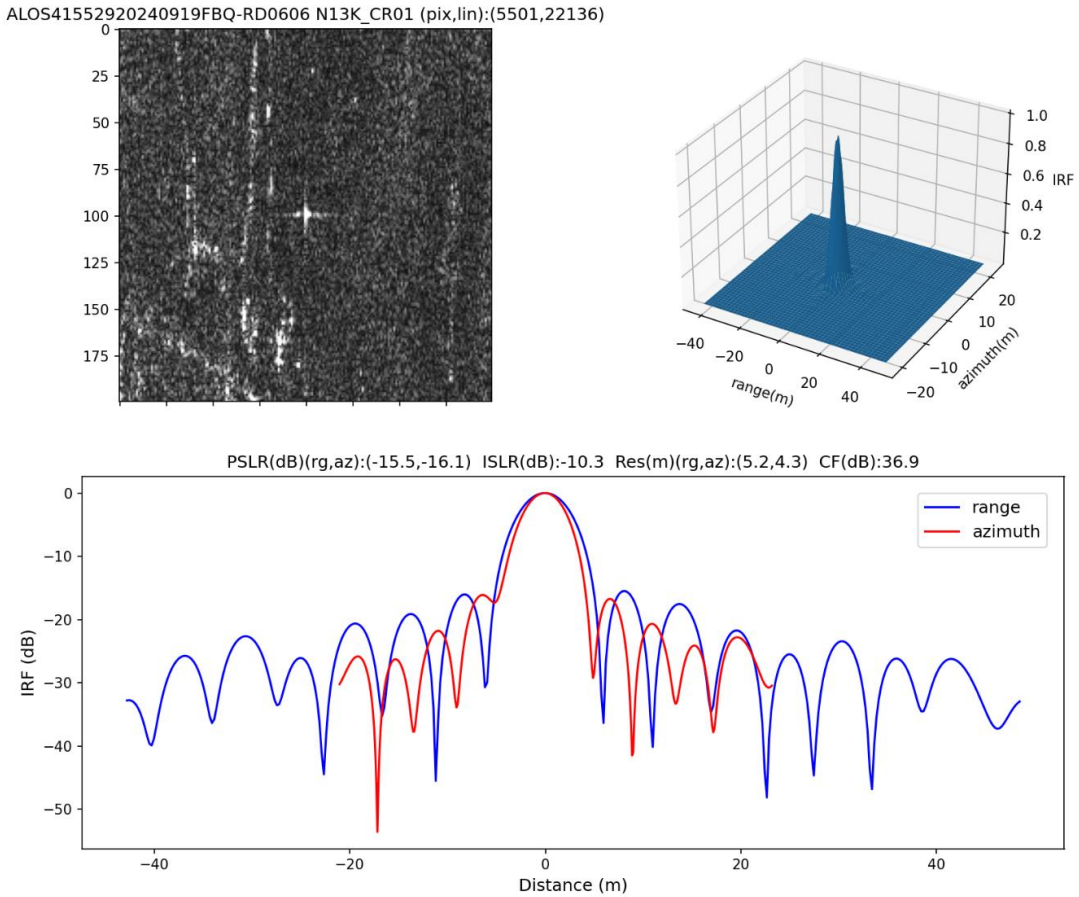
Tropical forest sites



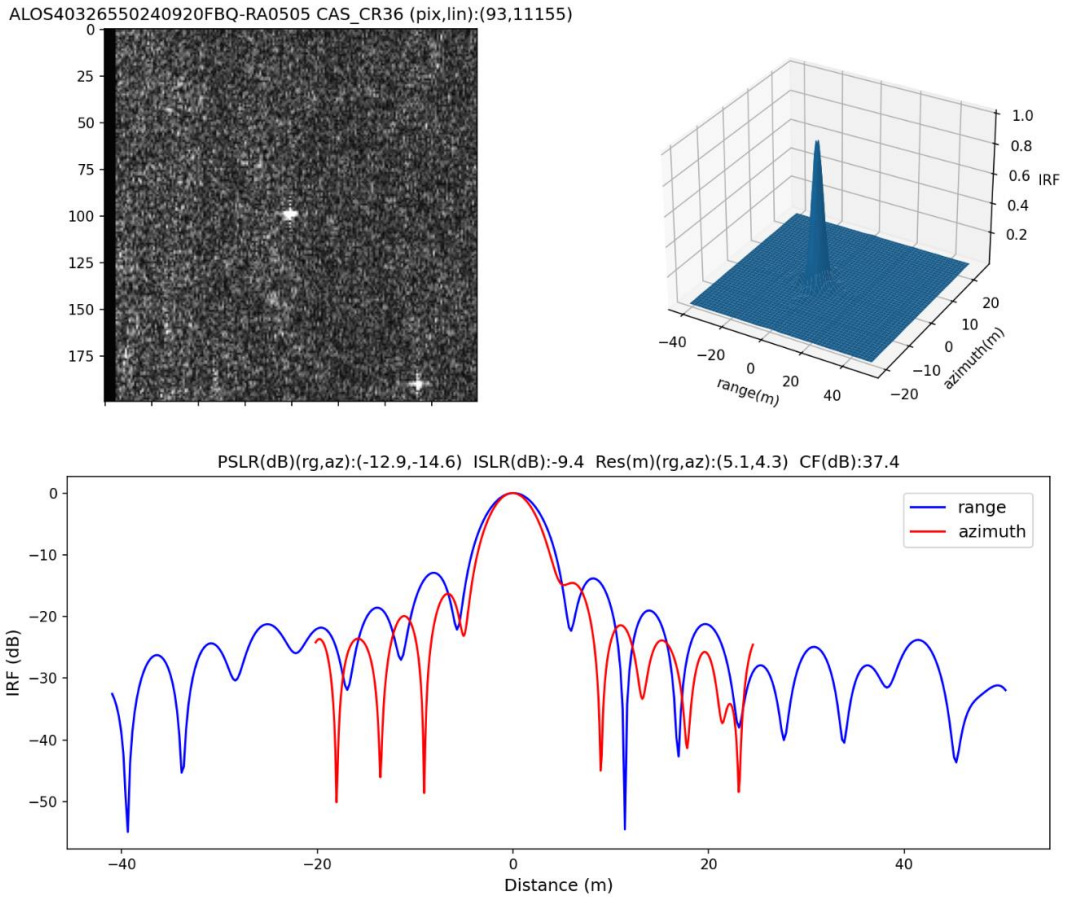
CVST (Cal/Val & Science Team) sites

Point targets evaluation

NASA/JPL Oklahoma CR
Sep. 19, 2024
Stripmap 10 m, 100 km-swath, full-pol



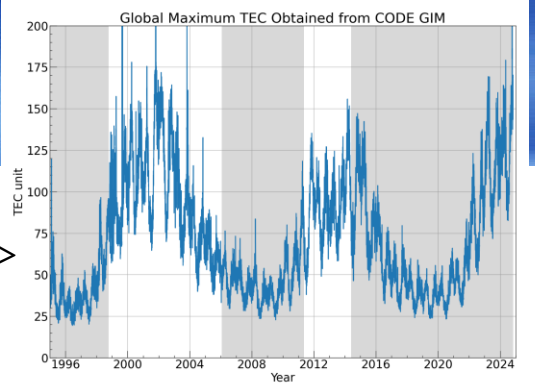
CONAE SAOCOM CR (CAS site)
Sep. 20, 2024
Stripmap 10 m, 100 km-swath, full-pol



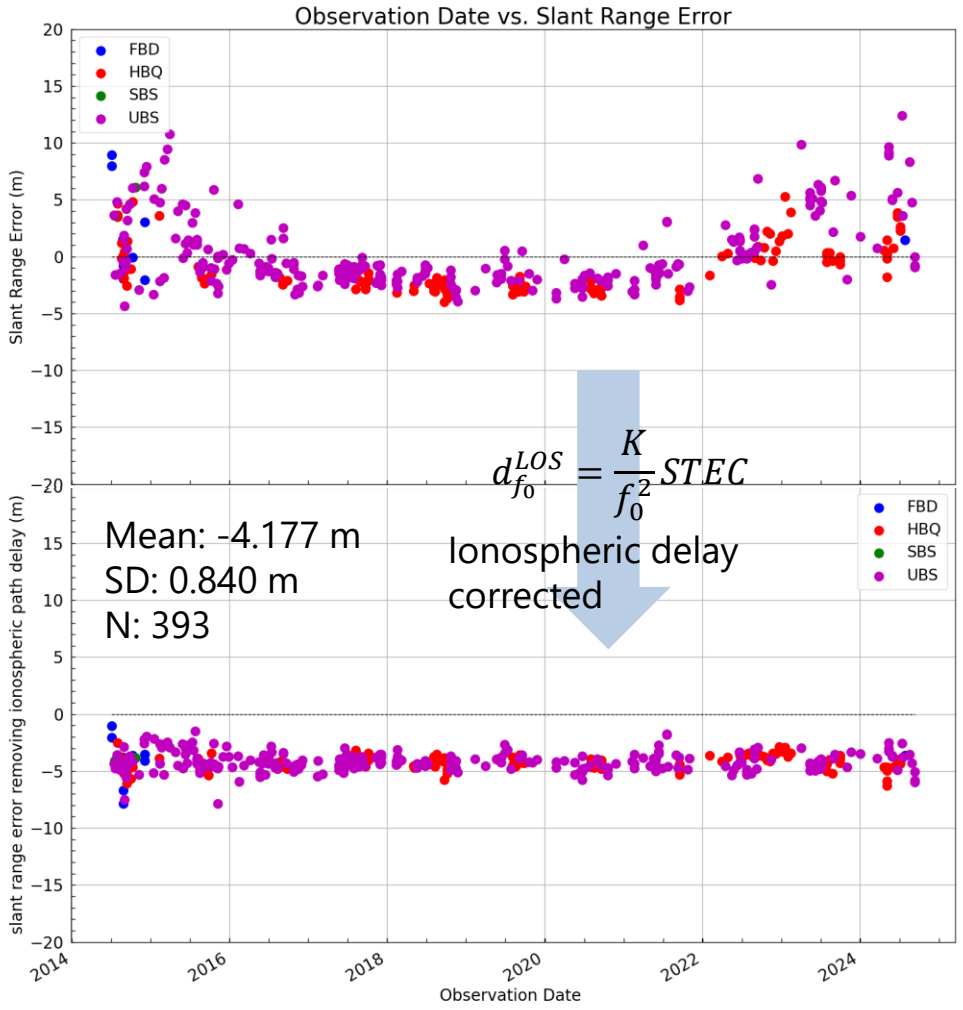
Point targets evaluation

✓ Slant range error at CR/ARC responses

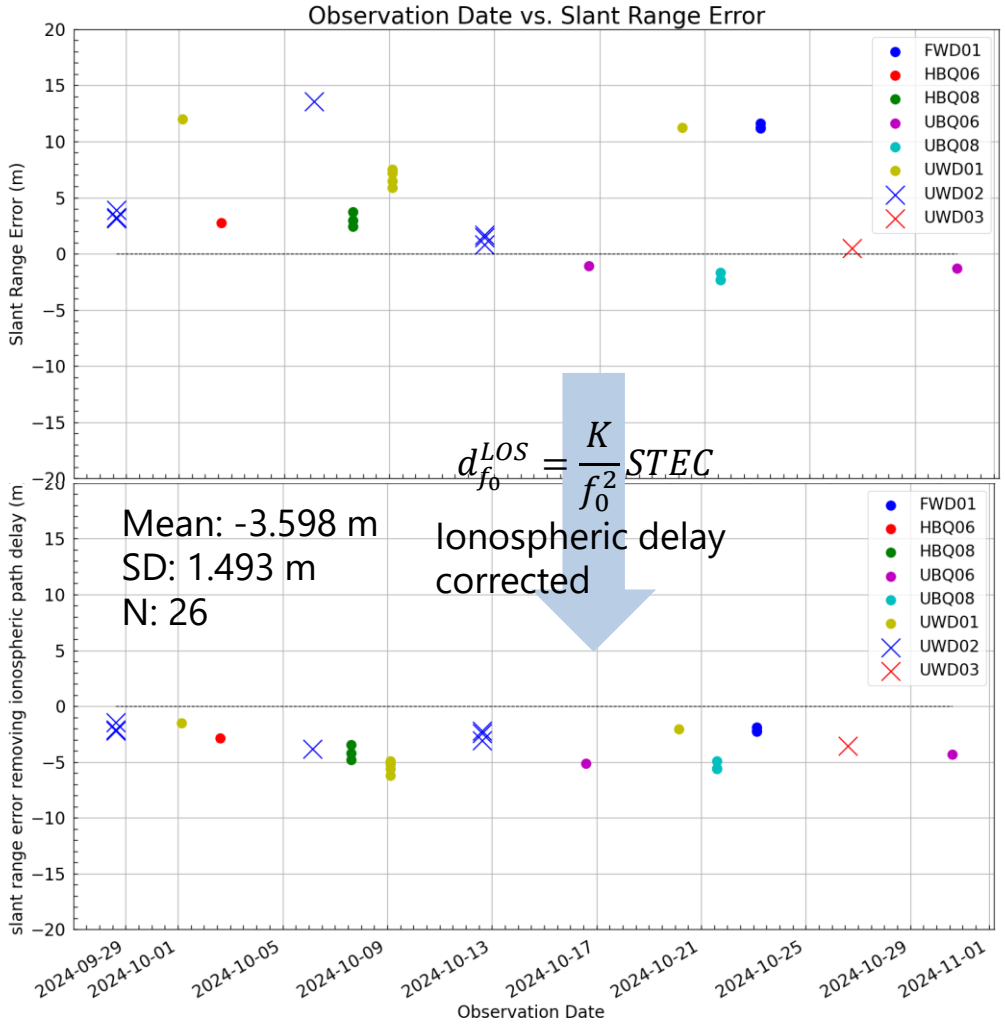
Global maximum TEC trends ->



ALOS-2

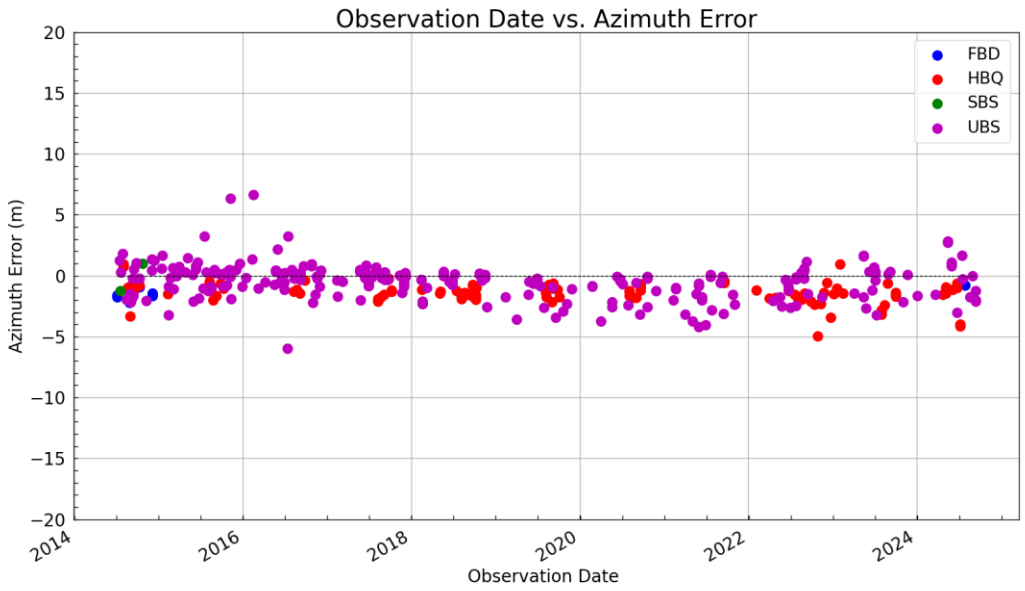


ALOS-4

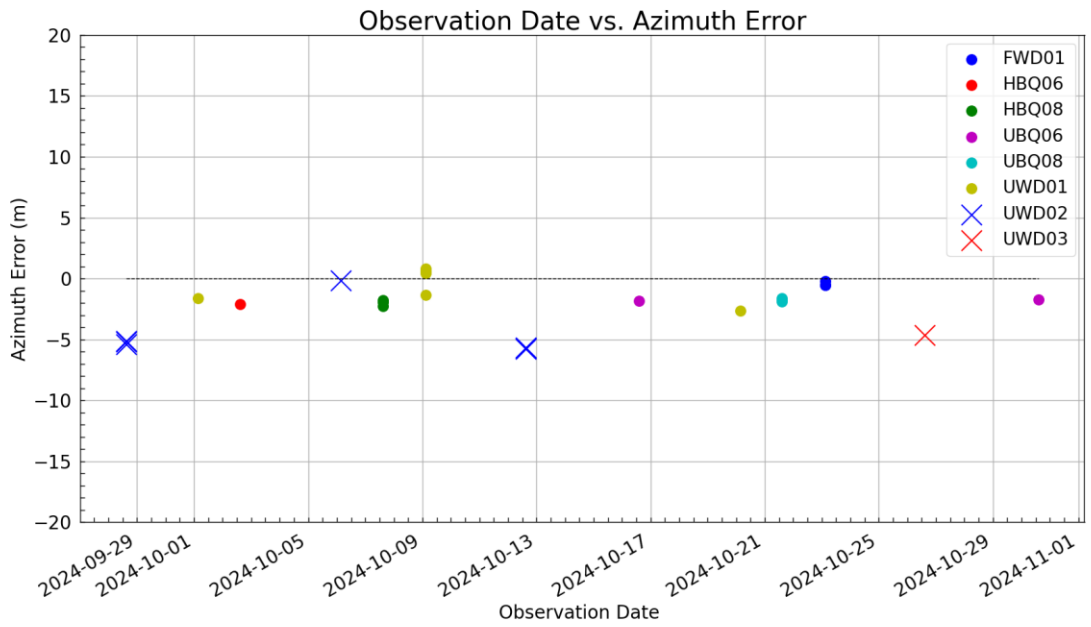


Point targets evaluation

✓ Azimuth position error at CR/ARC responses



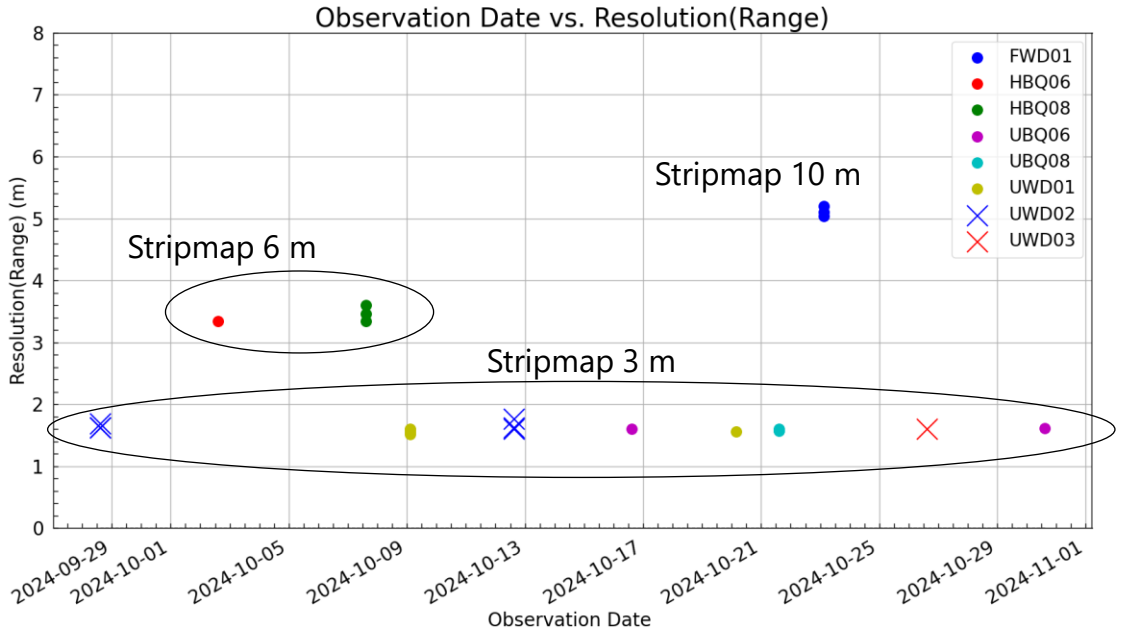
Mean (m)	S.D. (m)	RMSE (m)	Num of Data
-0.791	1.374	1.586	393

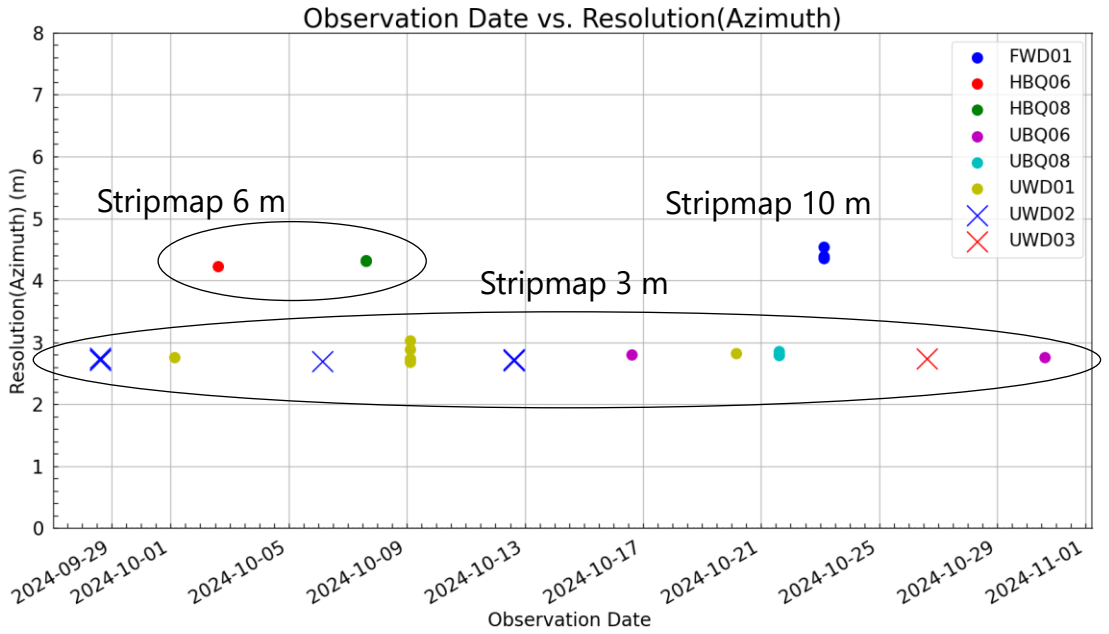


Mean (m)	S.D. (m)	RMSE (m)	Num of Data
-2.291	2.107	3.146	26

Point targets evaluation

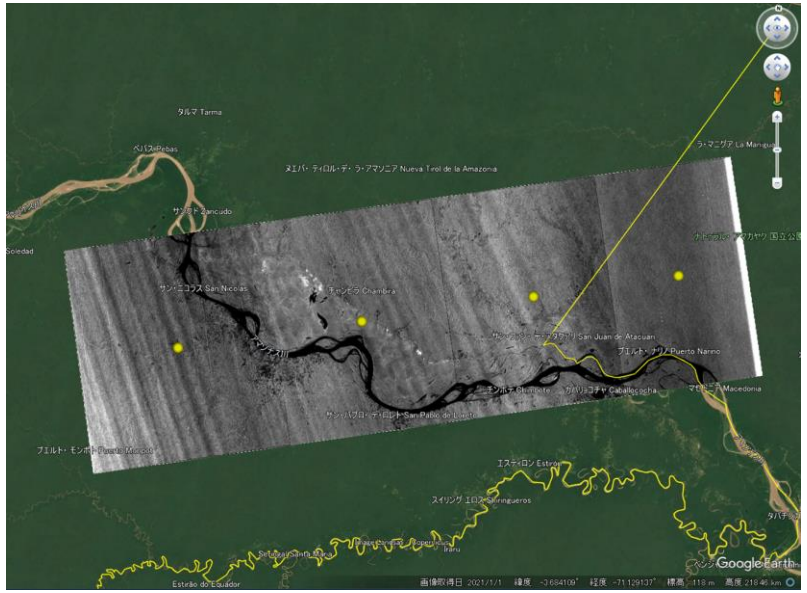
✓ Spatial resolution at CR/ARC responses

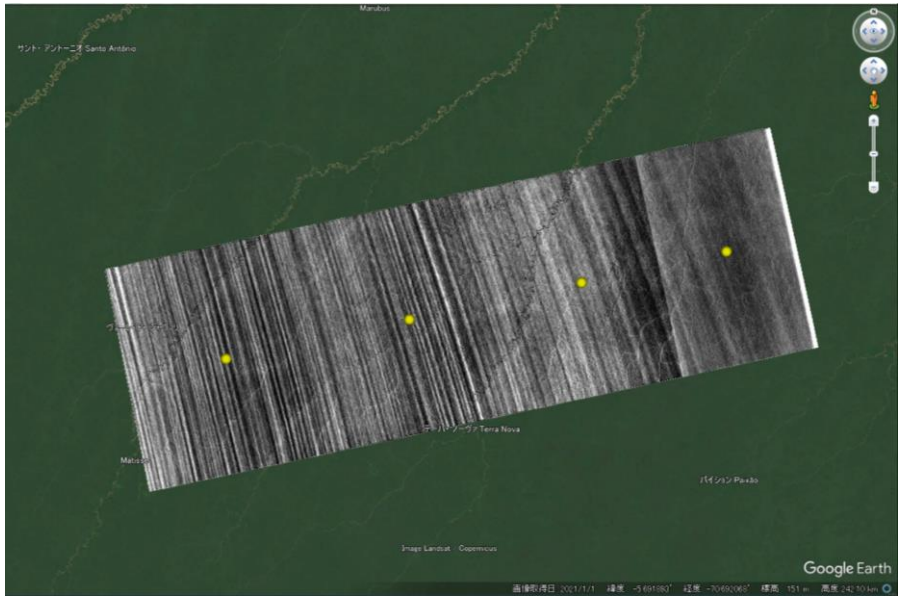




Plan of initial cal/val

- ✓ In the initial cal/val phase, the main modes/beams used in the basic observation scenario are evaluated.
- ✓ Many thanks to the availability of CR sites by collaborators, it is very helpful for quick check the performance.
- ✓ Antenna pattern, radiometric, and polarimetric calibrations will be performed after the improvement of ambiguities and image quality due to incomplete processing bug fixes and precise imbalance tuning between multiple Tx/Rx channels.
- ✓ Solar activity is at its maximum currently and it is a challenge to obtain enough images for antenna pattern estimation due to ionospheric disturbances.





PALSAR-3 Basic Observation Scenario

- For regular observations, PALSAR-3 observations will be performed according to the Basic Observation Scenario (BOS). The BOS will be continuously updated based on user feedback during operation.
- Global observations incorporate full polarimetry observations and observations of selected regions for several topics (forest, agriculture, polar/ice, land deformation, etc.).

Area	Theme	Observation			
		Mode	Pol.	Direction	Frequency
Japan	**Disaster basemap**	Stripmap 3 m/200 km swath, ScanSAR	Dual	Right and Left	1 year (left 30-44 deg. only),3 years (the others)
	Timeseries observations	Stripmap 3 m/200 km swath	Dual	Right	Around 20 times/year Reduced frequency is allowed during basemap acquisition.
Global	**Global basemap**	(Asc.) Stripmap 10 m/200 km swath (Des.) Stripmap 6 m/100 km swath	(Asc.) Dual (Des.) Full	Right	1 year
	Disaster basemap	ScanSAR 700 km swath, Stripmap 10 m/200 km swath	Dual	Right	Once every 3 years
	Thematic observations	Depends on theme	Depends on theme	Right	Depends on theme