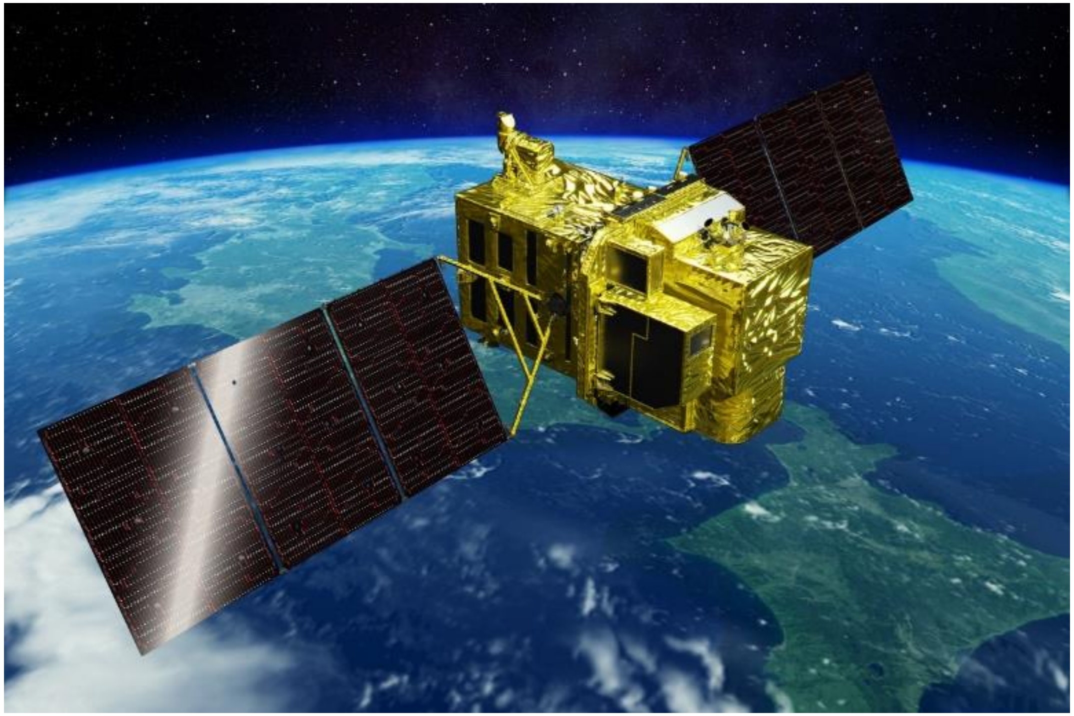
Advanced Optical Satellite (ALOS-3) Update



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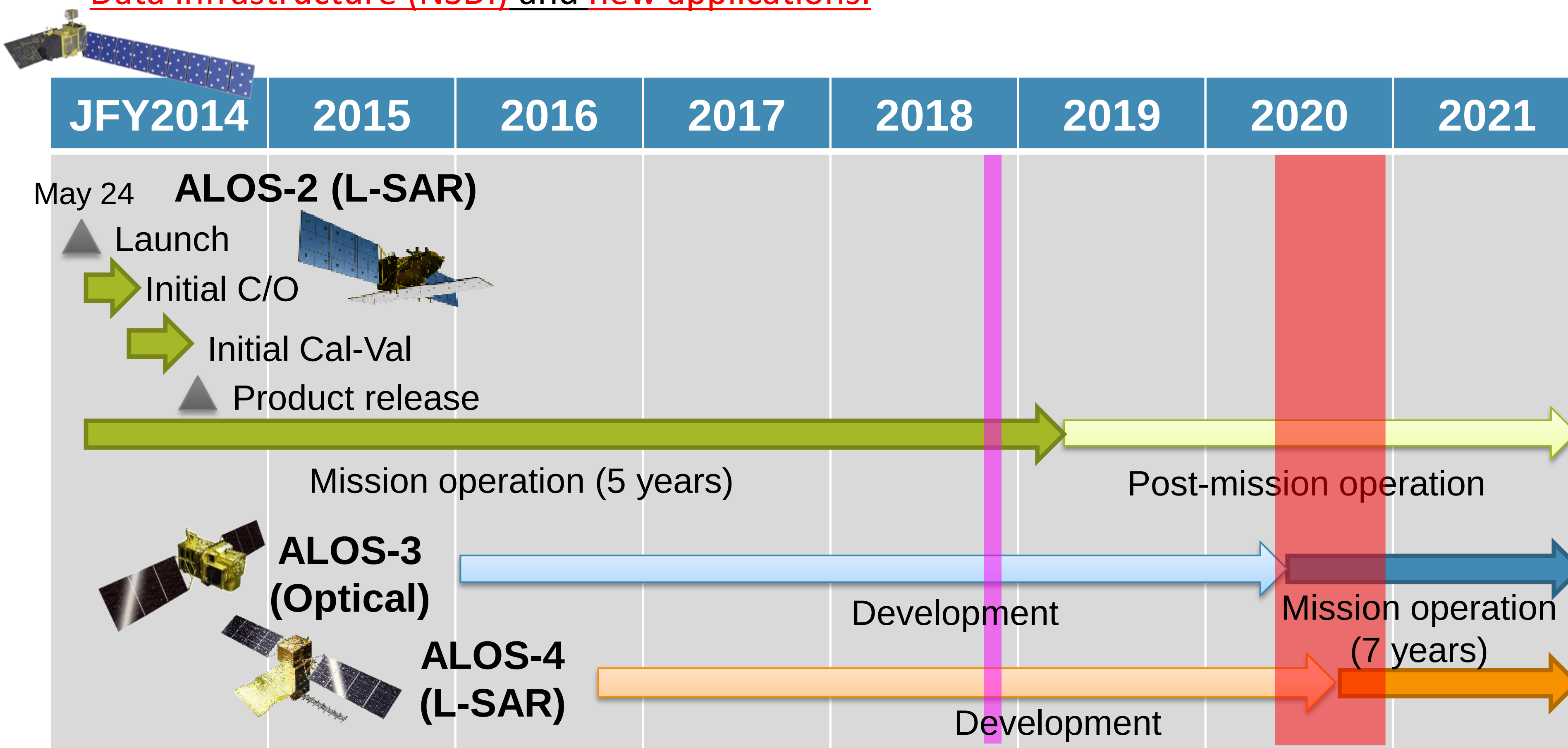
ALOS F/O Missions

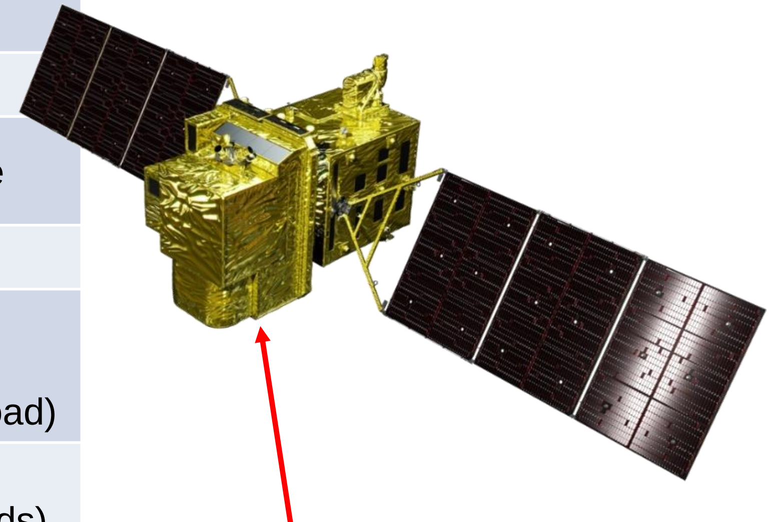
- Continuous observations successor *"Daichi" (ALOS)* from 2006 to 2011
  - Contribute to ensure the safety and security of citizens, *i.e.* disasters monitoring and management, land deformation monitoring, national developing management, foods and natural resources, environmental issues in global etc. as common issues.
  - Contribute to industrial development based on Earth observation data *i.e.* National Spatial Data infrastructure (NSDI) and new applications.



ALOS-3 Overview

Phase C

Items		Specifications
Orbit	Type	Sun-synchronous sub-recurrent
	Altitude	669 km at the equator
	Local Sun Time	10:30 am +/- 15 minutes at the descending node
	Revisit	35 days (Sub-cycle 3 days)
Instruments		- Wide-swath and high-resolution optical imager (WISH, as a tentative) - Dual-frequencies Infrared sensor (hosted payload)
Ground Sampling Distance (GSD)		- Panchromatic band of WISH (Pa): 0.8 m - Multispectral band of WISH (Mu): 3.2 m (6 bands)
Quantization		11 bit / pixel
Swath width		70 km at nadir
Mission data rate		Approx. 4 Gbps (after onboard data compression: 1/4 (Pa) and 1/3 (Mu))
Mission data downlink		- Direct Transmission: Ka and X-band - *via.* the Optical Data Relay Satellite
Mass		Approx. 3 tons at launch
Size		5 m × 16 m × 3.5 m on orbit
Duty		10 mins / recurrent
Design life time		Over 7 years

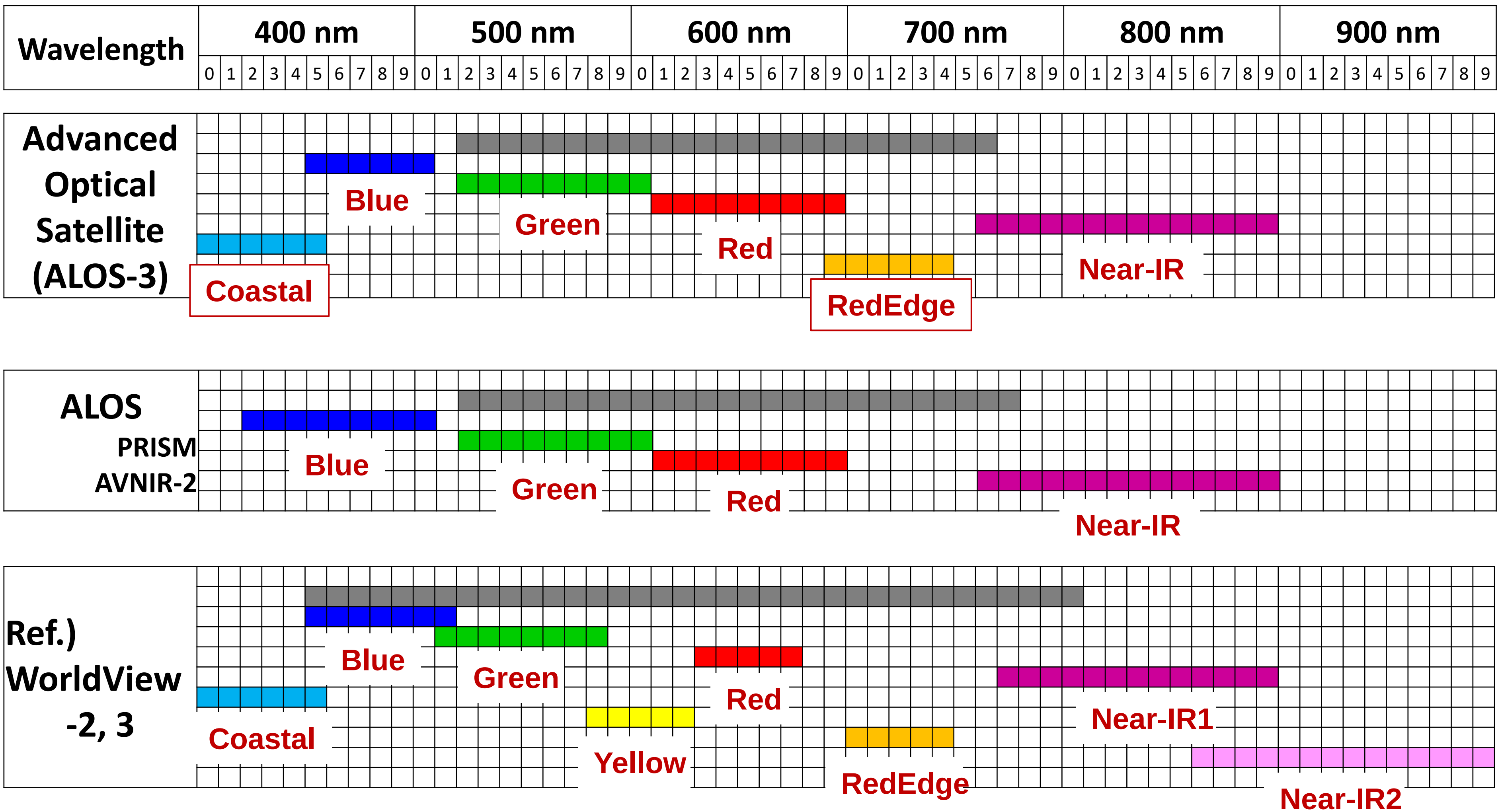


Wide-swath and high-resolution optical imager (WISH)

In-orbit configuration

Wide-Swath and High-Resolution Optical Imager

Observation channel band allocations among optical satellites (visible to near-infrared).

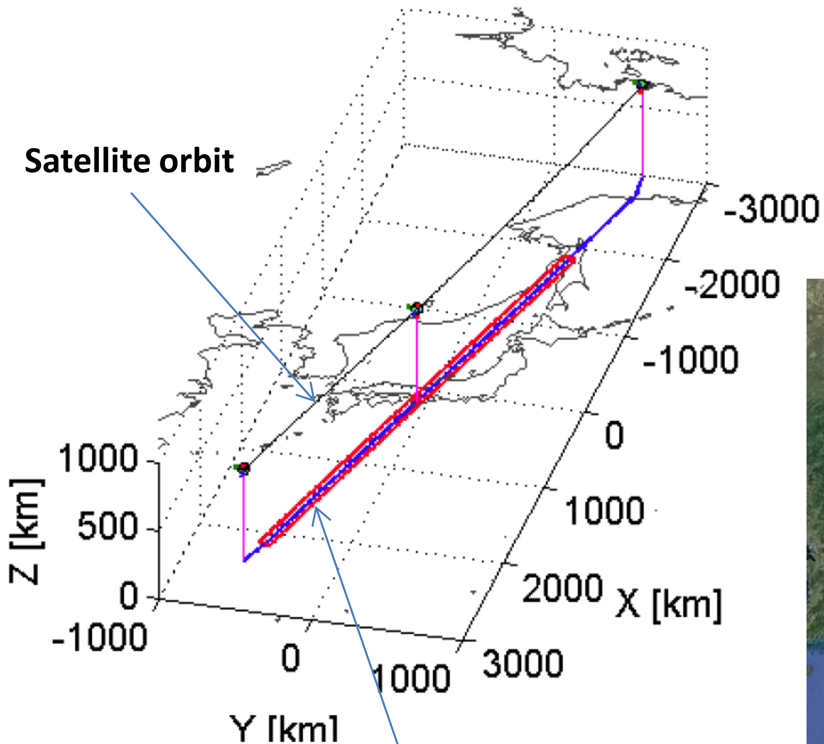


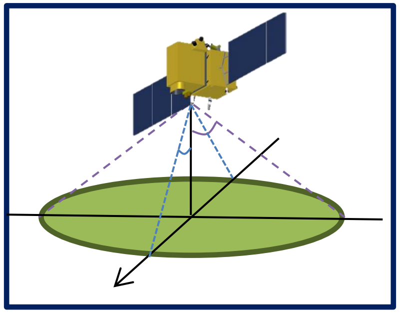
Observation Modes

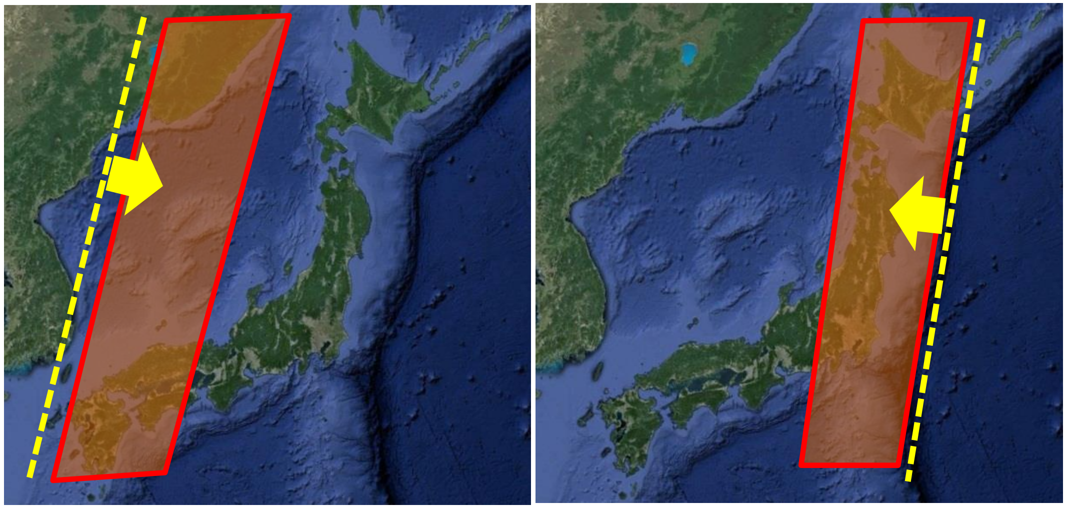
1	**Strip-map observation**	The satellite can normally perform observation covering 70 km in width and 4,000 km in along-track direction as the strip-map observation mode. To increase the acquisition frequency, the images will be taken by less than 25 deg. pointing angle in cross-track direction (GSD < 1m) when the satellite track is in oceans.
2	**Stereoscopic observation**	Two ways proposes to acquire stereo-pair image: 1) in single orbit path, and 2) combining two strip-map observations by nadir view and backward view in neighboring path after three days (sub-cycle revisit orbit). The way 1) will be however not sufficient base-to-height ratio (B/H) to derive terrain information. As the advantages of the way 2), that is possible to set suitable B/H, and can acquire images over large area. However, this will depend on weather conditions i.e. cloud covers, to success stereo image acquisition within short period as a disadvantage.
3	**Point observation**	If the user has a certain ground point or an area of interest (AOI), the satellite can observe there using pointing capability within 60 deg. This mode will be used for natural disaster monitoring, for example.
4	**Observation direction changing**	The satellite can observe any given point by the pointing capability up to 60 deg. in all direction against the satellite nadir. In the case of Japan, it can be activated within 24 hours after receiving the request. This will be used when the large natural disaster happens e.g. the expecting Nankai Trough large earthquake.
5	**Wide-area observation**	This mode can cover in wide-ranging area of 200 km (in along-track direction) x 100 km (in cross-track direction) by satellite's single orbital passage. This will be also used when the large natural disaster happens.

1 and 2 will be used in the basic observation.

Strip-Map Observation Mode



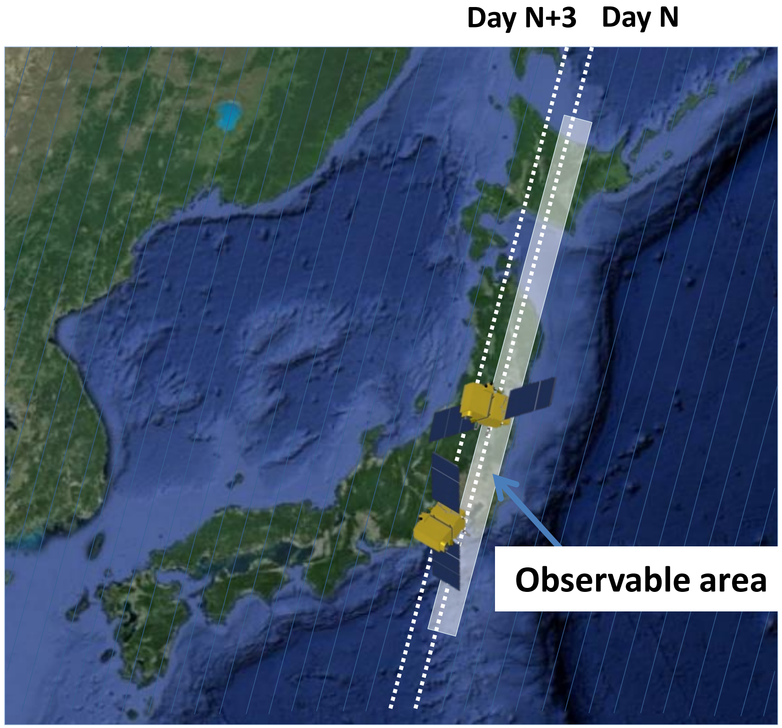




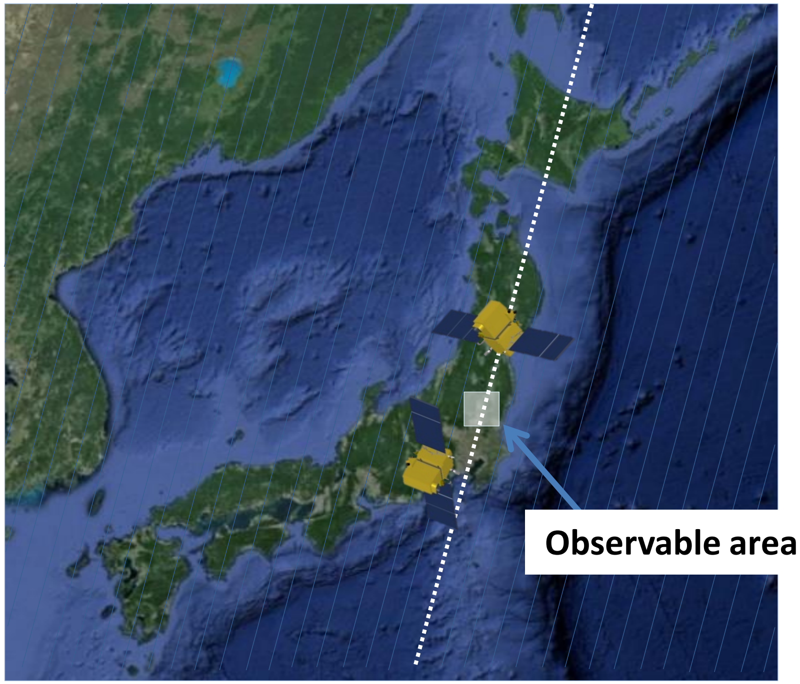
Example of nadir observation
70 km x 4000 km (10 mins/path).

The satellite can normally perform observation covering 70 km in width and 4,000 km in along-track direction as the strip-map observation mode. To increase the acquisition frequency, the images will be taken by less than 25 deg. pointing angle in cross-track direction (GSD < 1m) when the satellite track is in oceans.

Stereoscopic Observation Mode



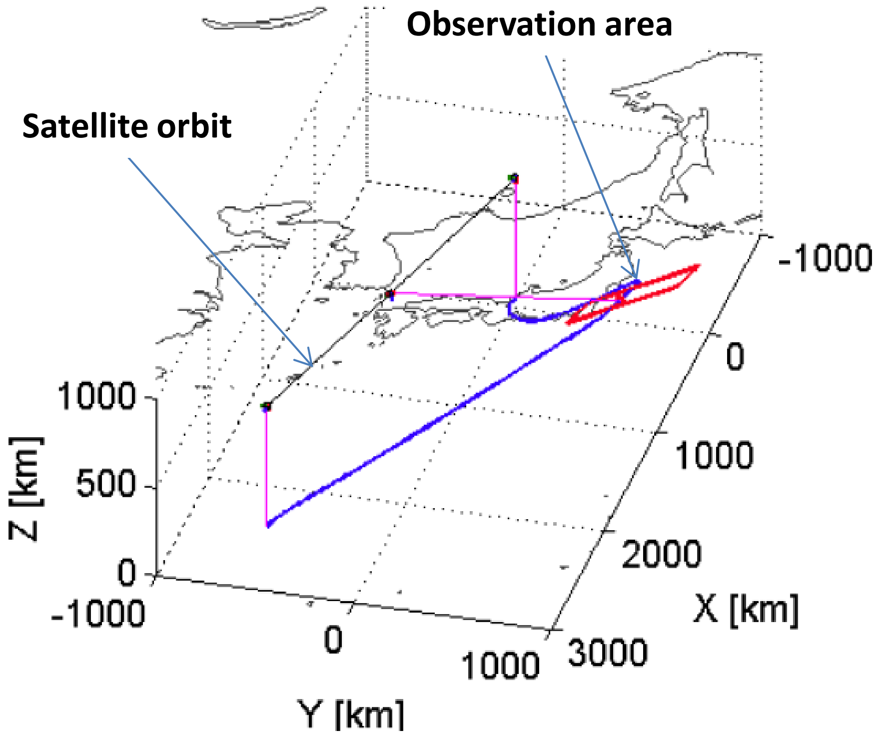
Combined two strip-map in neighboring paths after three days.



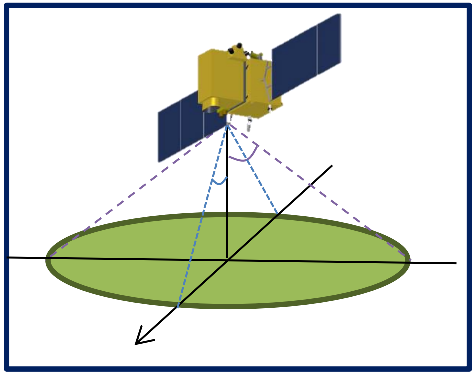
Single-path stereo.

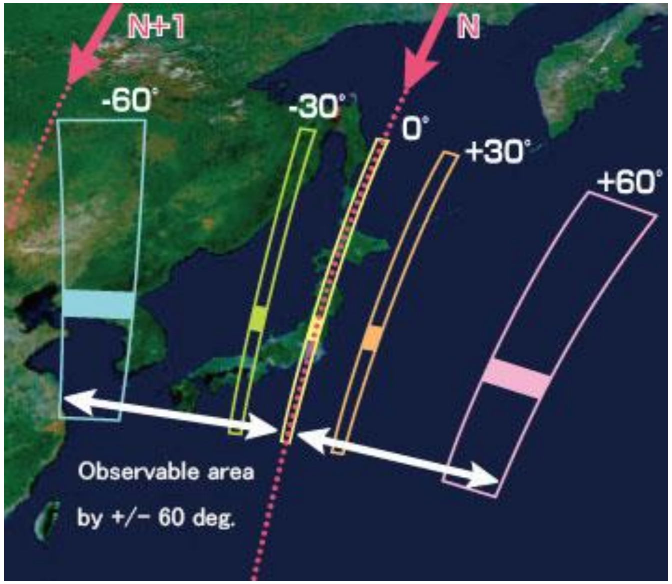
Two ways proposes to acquire stereo-pair image: 1) in single orbit path, and 2) combining two strip-map observations by nadir view and backward view in neighboring path after three days (sub-cycle revisit orbit). The way 1) will be however not sufficient base-to-height ratio (B/H) to derive terrain information. As the advantages of the way 2), that is possible to set suitable B/H, and can acquire images over large area. However, this will depend on weather conditions i.e. cloud covers, to success stereo image acquisition within short period as a disadvantage.

Point Observation Mode



Example of point observation
by pointing function.

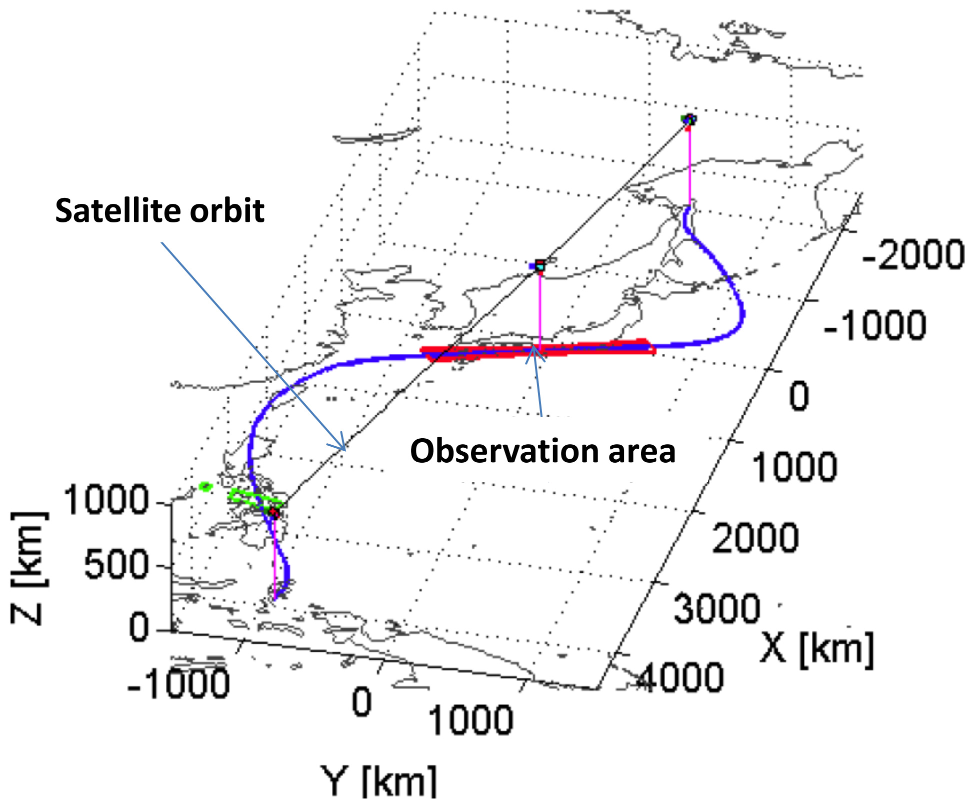




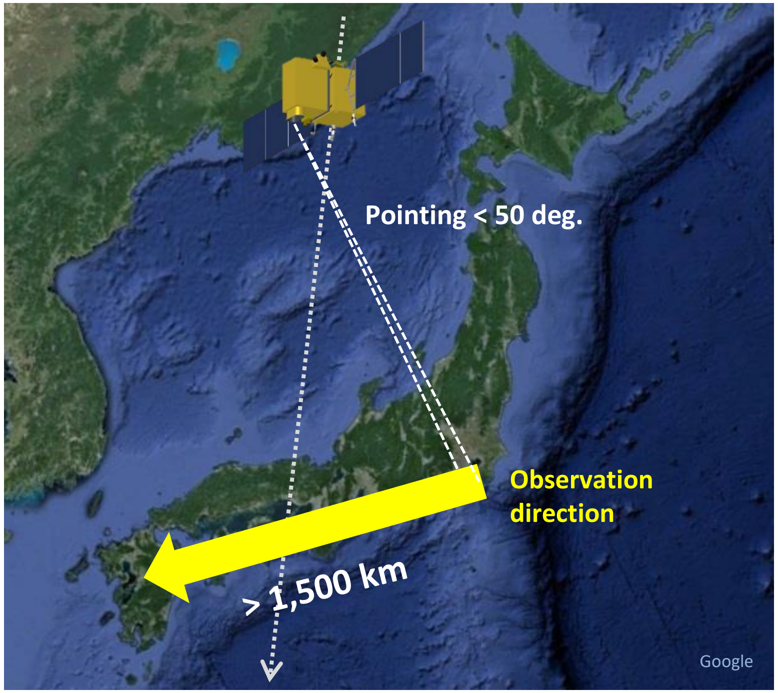
Example of coverage by
+/- 60 deg. pointing function.

If the user has a certain ground point or an area of interest (AOI), the satellite can observe there using pointing capability within 60 deg. This mode will be used for natural disaster monitoring, for example.

Observation Direction Changing Mode

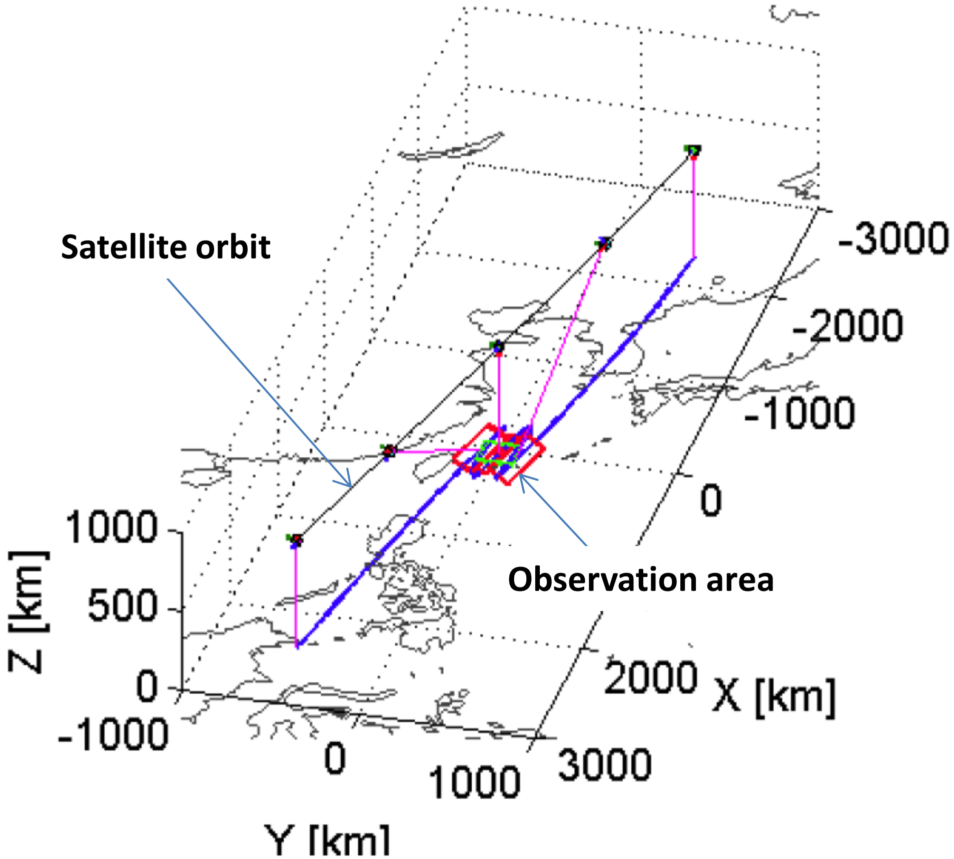


Example of observation direction changing mode.

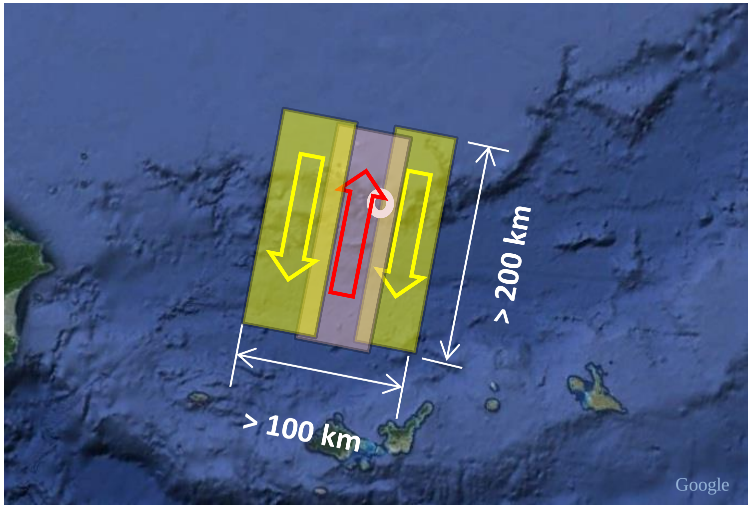


The satellite can observe any given point by the pointing capability up to 60 deg. in all direction against the satellite nadir. In the case of Japan, it can be activated within 24 hours after receiving the request. This will be used when the large natural disaster happens e.g. expecting the Nankai-Trough large earthquake.

Wide-Area Observation Mode



Example of wide-area observation mode.

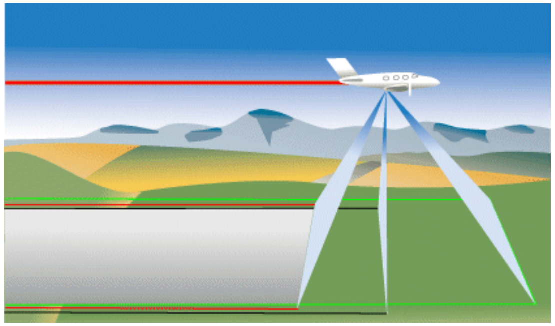


Example of three scans observation covered >200 x 100 km.

This mode can cover in wide-ranging area of 200 km (in along-track direction) x 100 km (in cross-track direction) by satellite's single orbital passage. This will be also used when the large natural disaster happens.

Simulated Image Generation

- The simulated images are generated as a part of pre-launch study to consider image utilizations by users in operational phase.
  - ✓ The latest or required specifications are reflected to them as much as possible, however it is impossible to create *"complete"* simulated image.
  - ✓ Such limitations and conditions are clarified to use them.
- Input data: two types of airborne images
  - ✓ ADS 80, Leica Geosystems AG: Three-line scanner, 20-30 cm GSD
    - Pointing simulation
    - *Strip-map* and *Direction Changing* modes simulation
    - Not enough GSD



Area	Obs. date	Band	Original GSD
Tsukuba, Japan	2013/04/22	Pa/R, G, B, NIR	30 cm
Tokyo, Japan	2013/03/16	Pa/R, G, B, NIR	20 cm

  - ✓ DMC II, Z/I Imaging Corp.: 8 cm GSD, only nadir image
    - Utilization of disaster monitoring and interpretation
    - *GSD in Strip-map* simulation
    - Use images captured actual natural disasters:
      - » Landslide in Hiroshima, Japan; Flooding in Ibaraki, Japan

Simulated Image Generation

ADS 80

DMC Ⅱ

- Geometric and pointing simulation
- Atmospheric degradation simulation
- Quantization
- Modulation Transfer Function (MTF)
- Signal-to-Noise Ratio (SNR)
- Data compression by JPEG2000
- Satellite attitude variation

Simulated image → **DSM generation simulation by multi-temporal WV2**

Processing flowchart.

Assumptions:

- ✓ The characteristics of input image is not affect to simulated image i.e. enough GSD, image noises and qualities.
- ✓ The simulated optics characteristics are based on the specifications.
- ✓ The onboard data compression introduces conventional JPEG 2000.

Limitations:

- Four bands for Multi available.
- Observation direction is different with the satellite.
- Target areas are limited.
- The input image characteristics sometime effected to simulated image.

List of Simulated Images by DMC II

■ Landslide sites, Hiroshima Pref., Japan: Aug. 27-28, 2014

	No	Contents	Roll	Pitch	Yaw	Band	File name
Strip-map	1	Nadir, site A	0.0°	0.0°	0.0°	Pa+RGB	HiroshimaA_Stripmap_000_000_PanSharpen.jpg
	2	Nadir, site B	0.0°	0.0°	0.0°	Pa+RGB	HiroshimaB_Stripmap_000_000_PanSharpen.jpg

■ Flooding sites, Kinu River, Joso, Ibaraki Pref., Japan: Sep. 11, 2015

	No	Contents	Roll	Pitch	Yaw	Band	File name
Strip-map	1	Nadir, site A	0.0°	0.0°	0.0°	Pa+RGB	KinugawaA_Stripmap_000_000_PanSharpen.jpg
	2	Nadir, site B	0.0°	0.0°	0.0°	Pa+RGB	KinugawaB_Stripmap_000_000_PanSharpen.jpg

ALOS-3 Simulated Image Generation

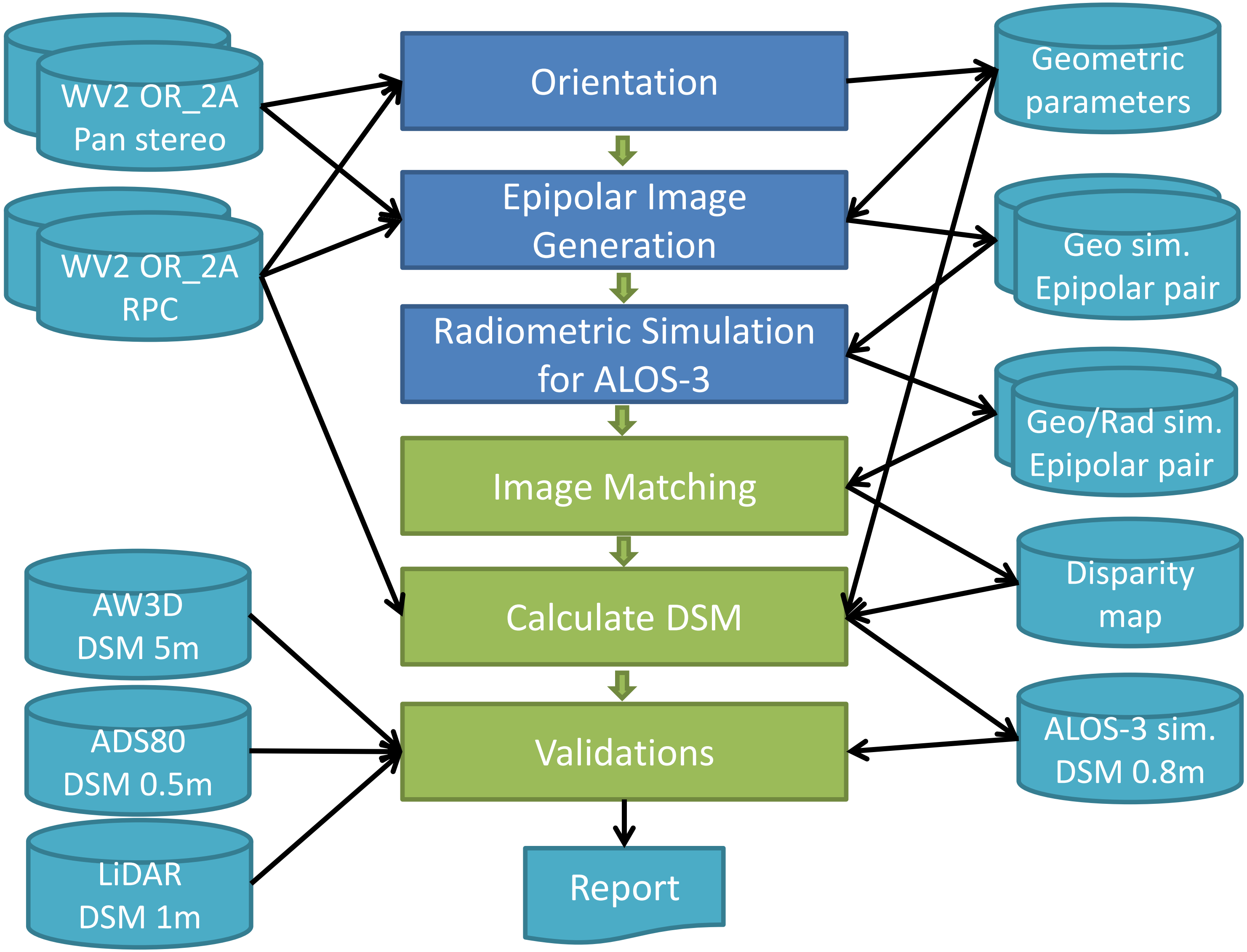
(a) Landslide sites, Hiroshima Pref., Japan on Aug. 27-28, 2014

(b) Flooding sites, Kinu River, Joso, Ibaraki Pref., Japan on Sep. 11, 2015

The radiometric and GSD simulated images.

Left: Simulated image using DMC II; right: ALOS pan-sharpen

Simulated Image Generation



Processing flowchart of DSM generation using simulated ALOS-3 image from WorldView-2 stereo pair.

ALOS-3 DSM Processing Simulation

WV-2 acquired different date and different angle: Stereo angle=26.7 (B/H=0.5)

ALOS-3 stereo simulated images on Dec 20, 2015 (left) and Jan. 5, 2016 (right).

0.8 m-mesh DSM using ALOS-3 simulated image.

50m height 150m

5 m-mesh DSM using ALOS PRISM.