Precise Global Digital 3D Map "ALOS World 3D" (AW3D)

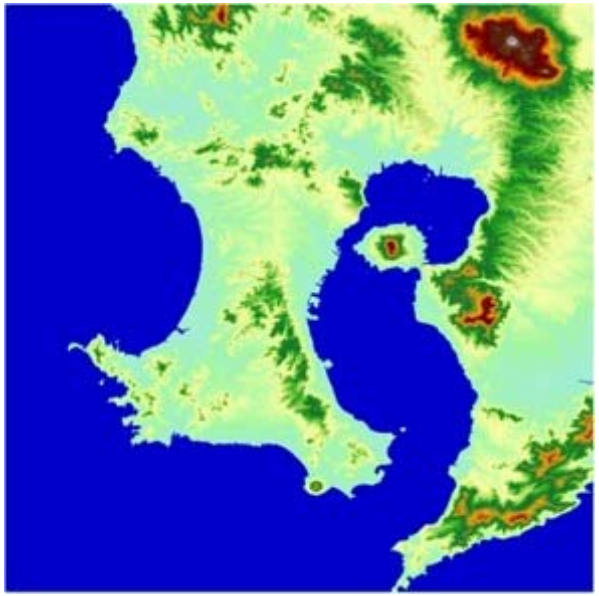
Processing Status and Initial Validation Results

December 4, 2014

Takeo Tadono
Earth Observation Research Center (EORC)
Japan Aerospace Exploration Agency (JAXA)
tadono.takeo@jaxa.jp

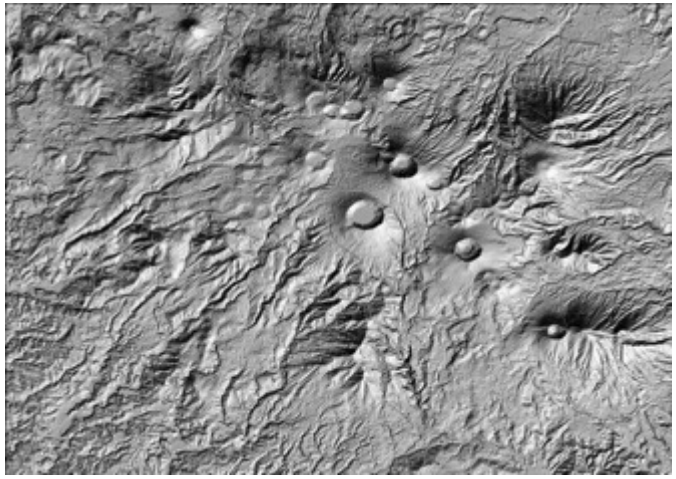
JAXA's "ALOS World 3D" (AW3D)

The Japan Aerospace Exploration Agency (JAXA) is starting to process the precise global digital 3D map using some 3 million data images acquired by the Panchromatic Remote sensing Instrument for Stereo Mapping (PRISM) onboard the Advanced Land Observing Satellite *"DAICHI"* (ALOS).



The digital 3D map consists of a DEM (or DSM) and ortho-rectified images (ORI) that indicate geolocation. DEM is compiled this time has a five meters in spatial resolution with five meters height accuracy (RMSE) that enables us to express land terrain all over the world. Hence its strong character will prove useful in various areas including mapping, damage prediction of a natural disaster, water resource research etc.

The global 3D map processing will be completed by March 2016. JAXA will commission the compiling work, and service provision to NTT DATA Corporation and Remote Sensing Technology Center of Japan (RESTEC).



In order to popularize the utilization of the 3D map data, JAXA is also preparing global DEM with lower spatial resolution (of about 30 meters under the current plan) to publish it as soon as it is ready. It will be available free of charge for any users. We expect that the 3D map will contribute to the expansion of satellite data utilizations and the industrial promotion, science and research activities as well as the Group on Earth Observations (GEO).

Related links

JAXA AW3D: http://www.eorc.jaxa.jp/ALOS/en/aw3d/index_e.htm

AW3D NTT DATA and RESTEC: http://alos-world3d.jp/en/index.html

Sample movies of the digital 3D map: http://www.youtube.com/watch?v=pZg78PXnlQc

Advanced Land Observing Satellite (ALOS, "DAICHI")

✓ **Operation**

24 Jan. 2006 by H-2A Rocket #8

12 May 2011 Mission ended

~22 Apr. 2011: Low Load Mode (LLM)

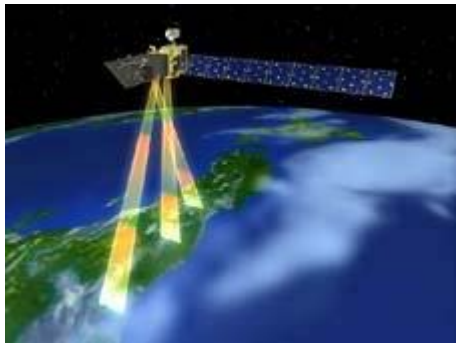
> 1,934 days=**5.3 years > 12 mil. scenes**

✓ **Objectives**

- Cartography (1/25,000 scale)
- Regional environmental monitoring
- Disaster monitoring, *etc.*

PRISM

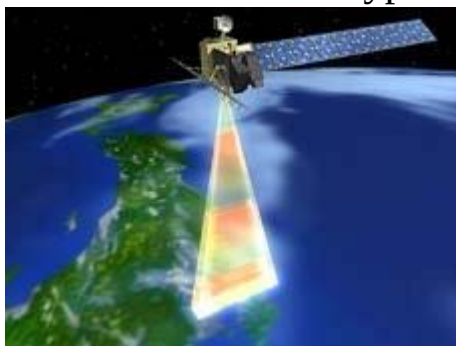
Panchromatic Remote sensing Instrument for Stereo Mapping



PRISM can acquire **triplet stereo** imageries by nadir-, forward-, and backward-radiometers with **2.5 m spatial resolution in 35 km swath**.

AVNIR-2

Advanced Visible and Near-Infrared Radiometer type 2



AVNIR-2 can observe with **10 m resolution in 70 km swath**, and it can be changed the observation area by pointing capability within +/-44 deg. in across track.

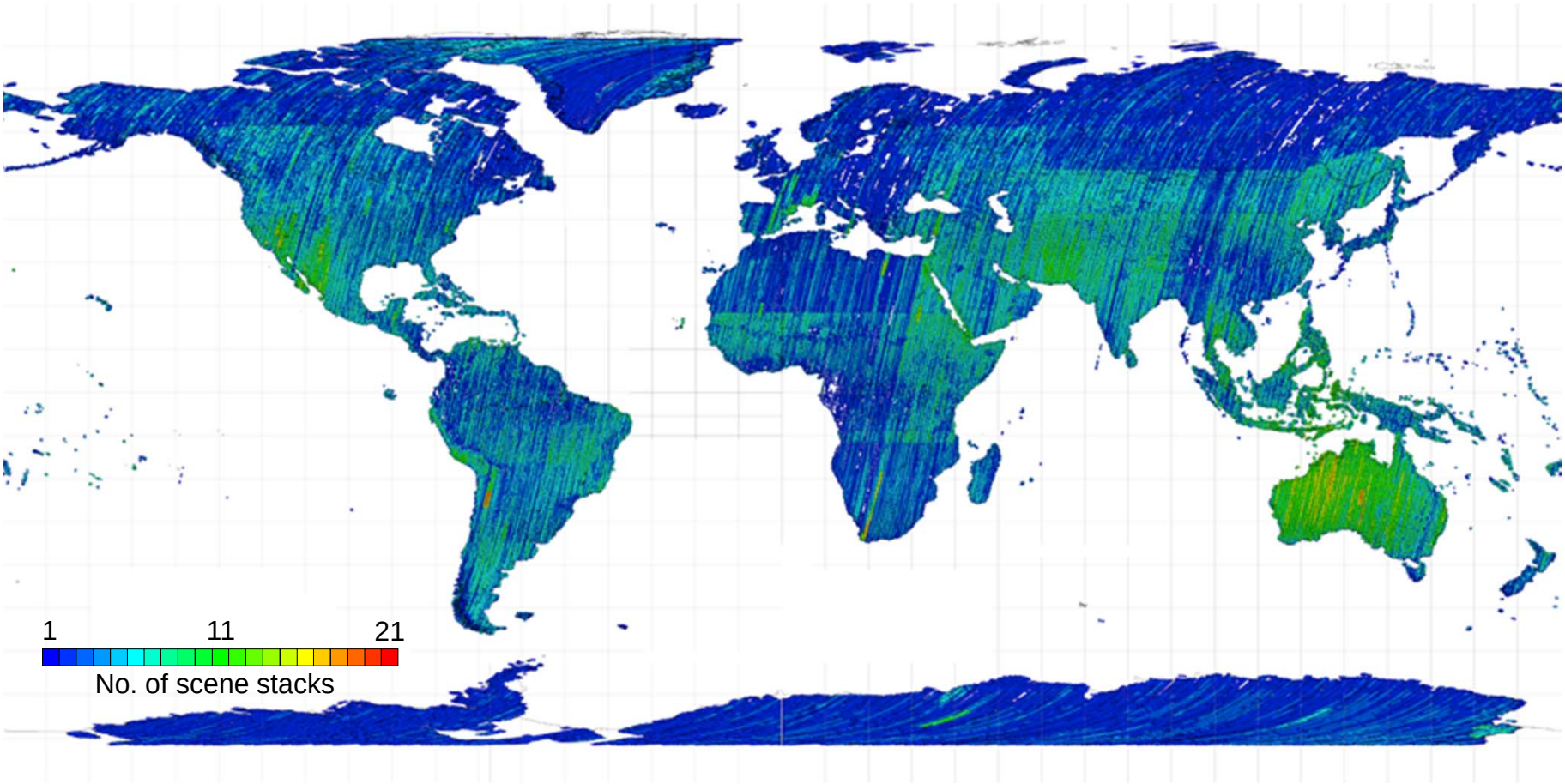
PALSAR

Phased Array type L-band Synthetic Aperture Radar

PALSAR can acquire the data in not only daytime but also nighttime as well as cloudy and rainy whether conditions.

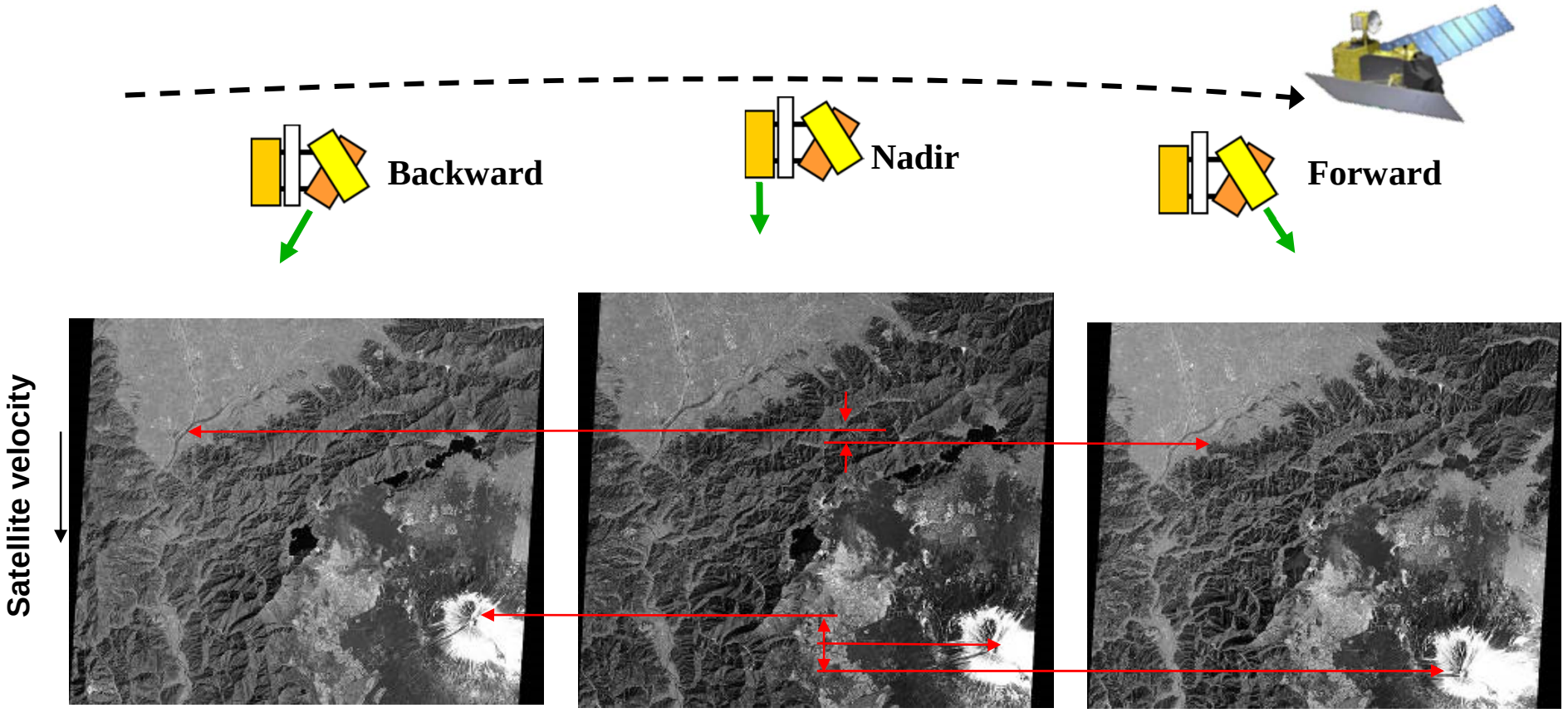
PRISM Data Acquisition Result

- **Global archive of PRISM stereo scenes (35km x 35km)**
  - Over 1 million stereo or triplet sets with cloud level < 30 % / scene in global
  - There are still remaining cloud covered areas



Distribution of PRISM stereo scene archives (cloud level < 30%)

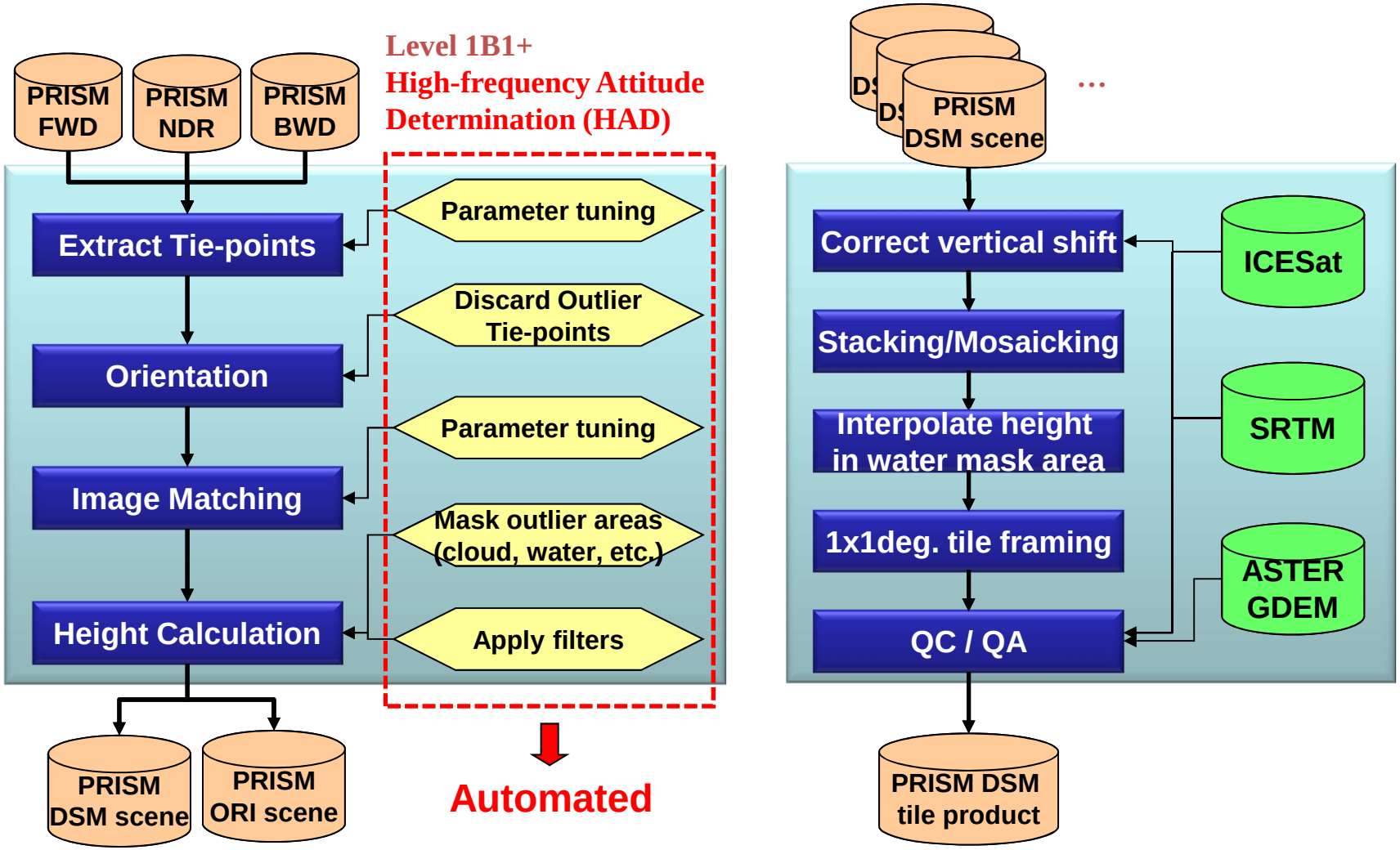
How to Measure Height from Stereo Image?



Location differences are depends on the terrain height.
> Derive digital elevation model (DEM)
or digital surface model (DSM)

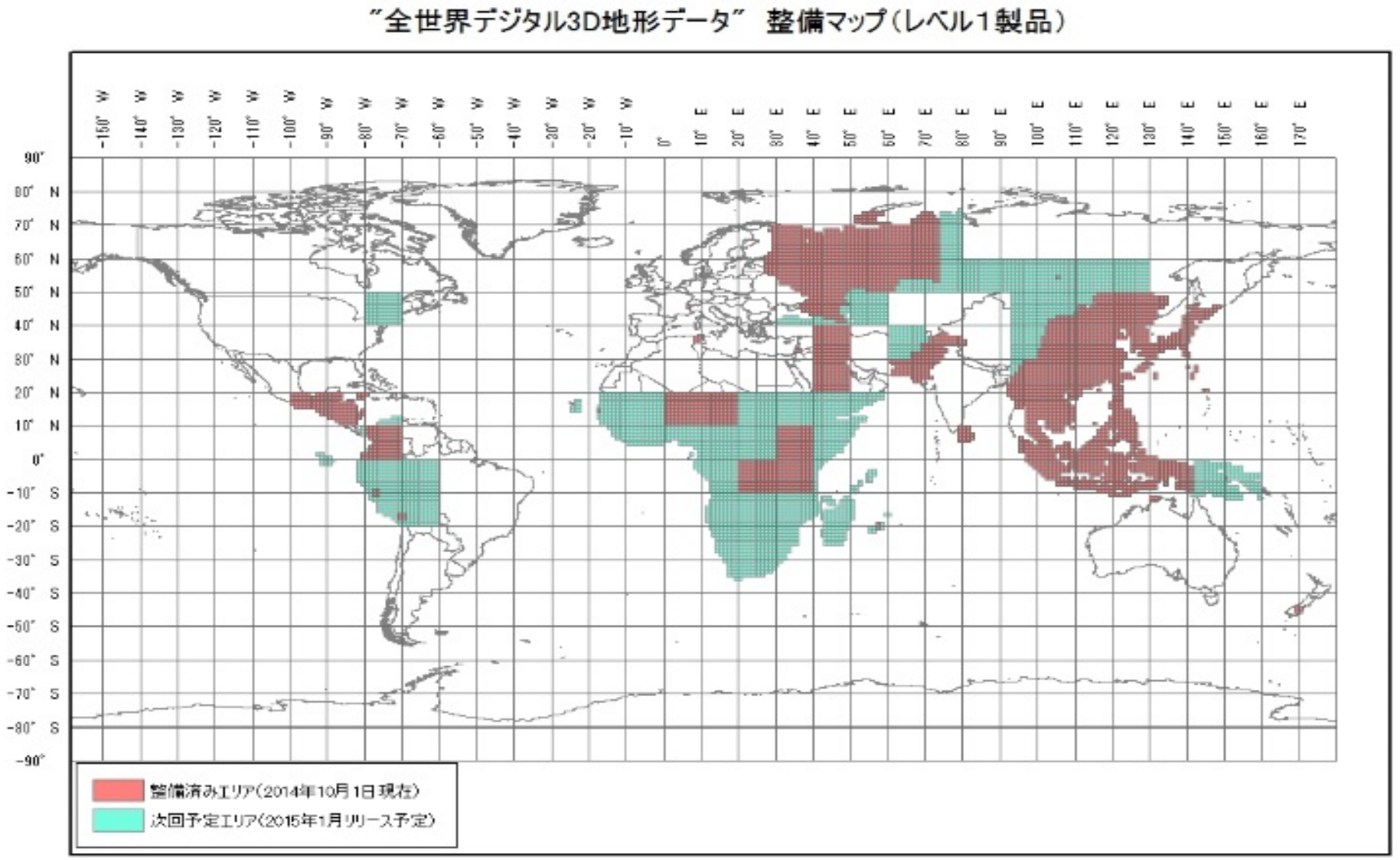
(on GRS80 ellipsoid height, ITRF97 coordination ≃ WGS84)

Automatic DSM and Ortho Image Generation Software for ALOS PRISM (Auto DOGS-AP)



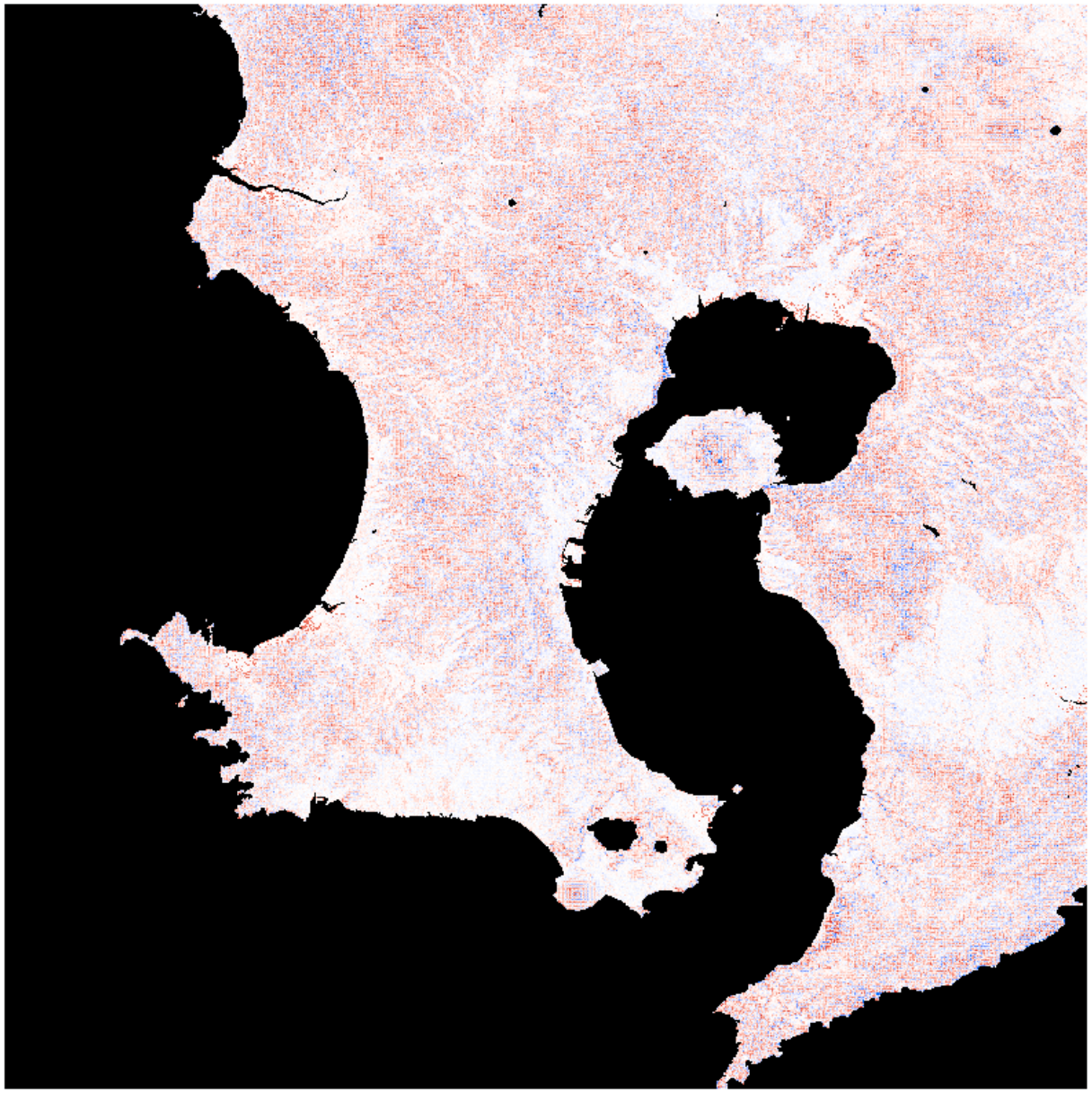
Schematic flowchart of the scene-process (left) and the mosaicking-process (right)

Processing Status of AW3D Product



Processing status of AW3D tiles (as of Oct. 1, 2014)

Validation of AW3D 5m DSM



Difference image (PRISM/DSM minus SRTM Ver.3 3-arcsec)

N031E130

Stats of height validation with 289 CPs

Dataset	Ave [m]	STDEV [m]	RMSE [m]
AW3D	-1.69	2.04	2.65
SRTM v.3	-1.68	8.23	8.39

Note

- No major issues
- Observation time differences (*i.e.* forest and vegetation changes)

■ Masks due to clouds, in-land water, and sea areas

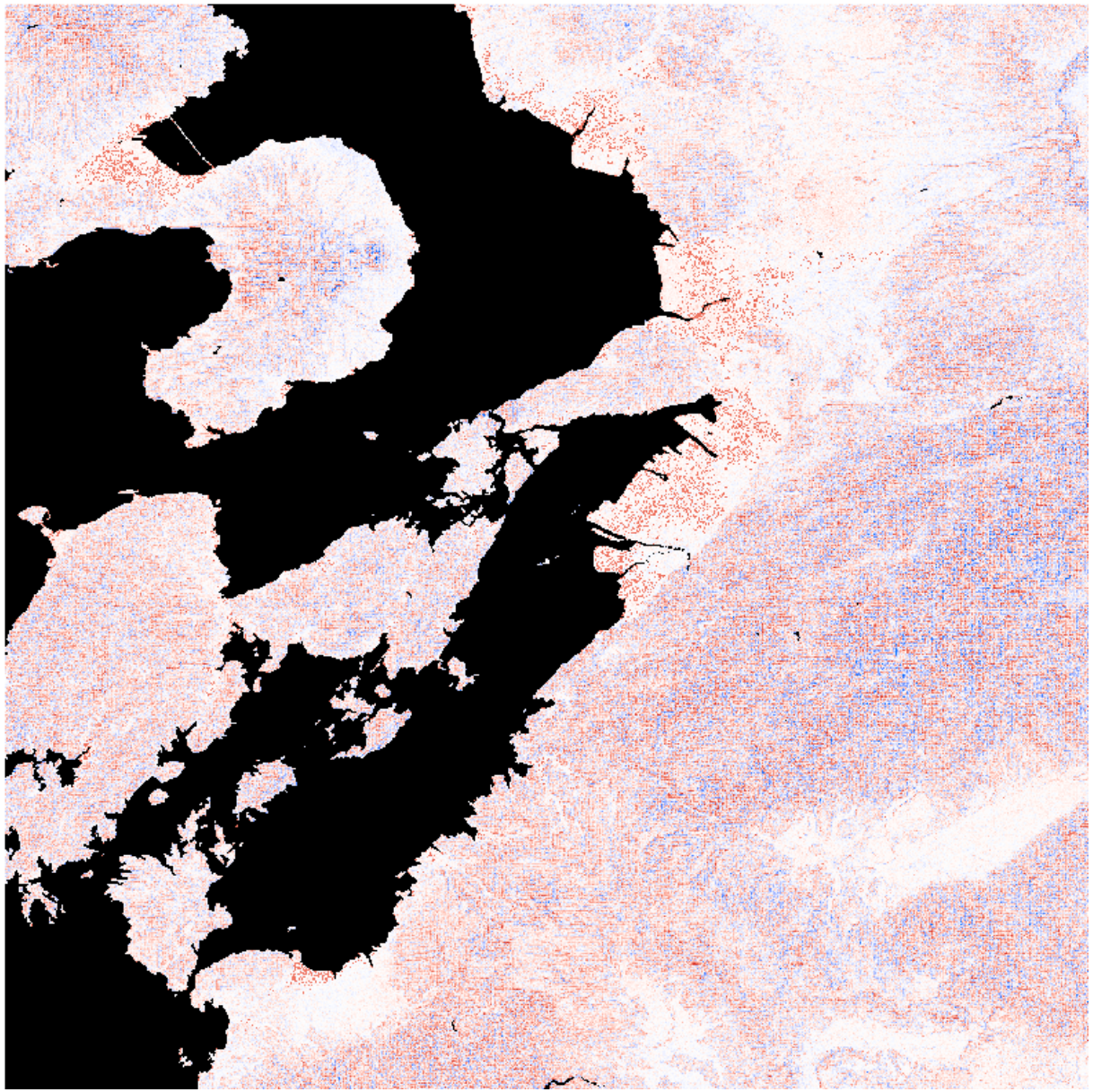
Difference

+50m

+/-0m

-50m

Validation of AW3D 5m DSM



Difference image (PRISM/DSM minus SRTM Ver.3 3-arcsec)

N032E130

Stats of height validation with 8 CPs

Dataset	Ave [m]	STDEV [m]	RMSE [m]
AW3D	-2.24	0.60	2.31
SRTM v.3	-4.12	0.90	4.20

Note

- No major issues
- Land use and land cover changes between observation times

■ Masks due to clouds, in-land water, and sea areas

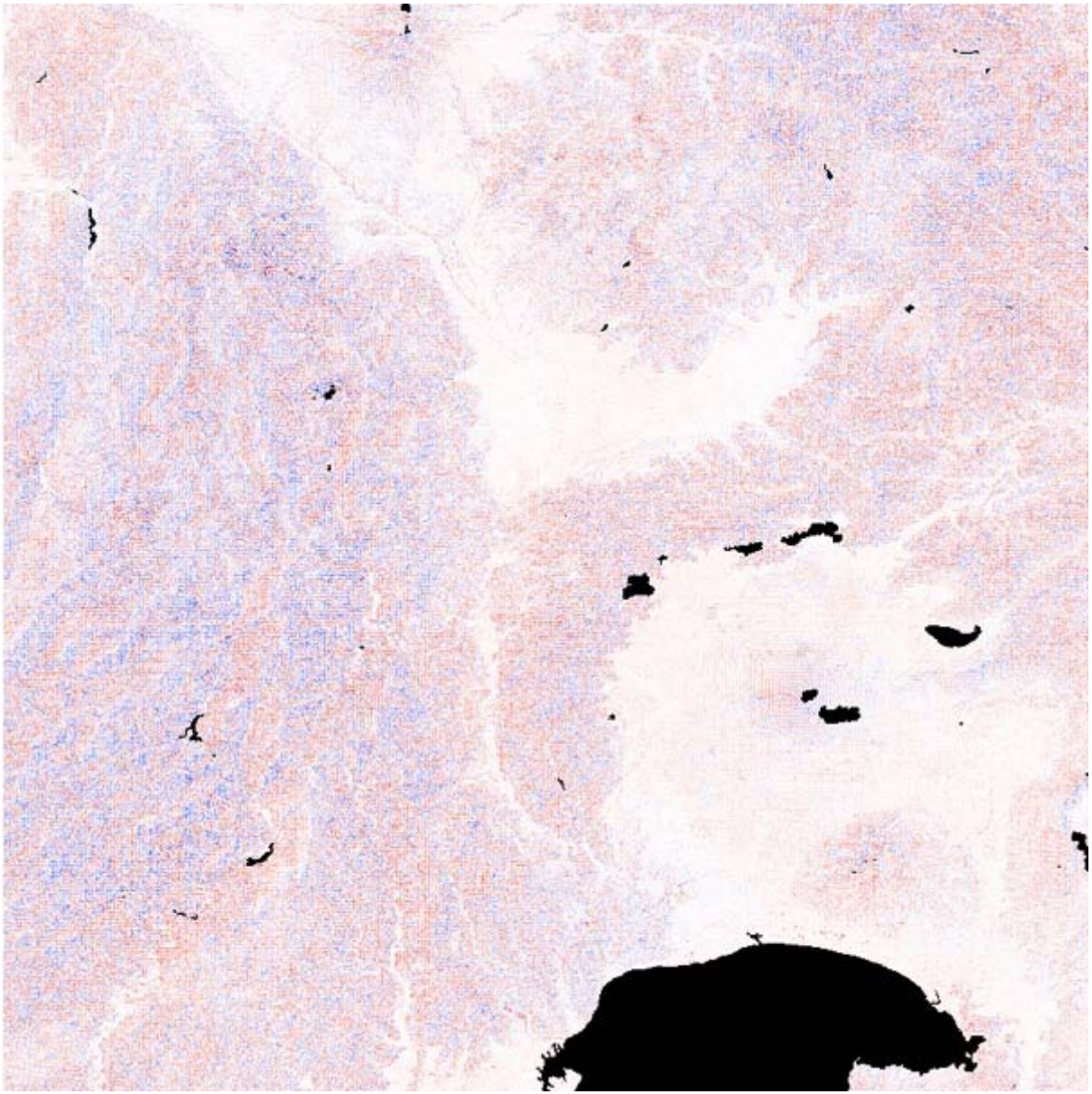
Difference

+50m

+/-0m

-50m

Validation of AW3D 5m DSM



Difference image (PRISM/DSM minus SRTM Ver.3 3-arcsec)

N035E138

Stats of height validation with 33 CPs

Dataset	Ave [m]	STDEV [m]	RMSE [m]
AW3D	-0.59	1.75	1.82
SRTM v.3	0.89	7.49	7.43

Note

- Small clouds remain
- Observation time differences (*i.e.* forest and vegetation changes)

■ Masks due to clouds, in-land water, and sea areas

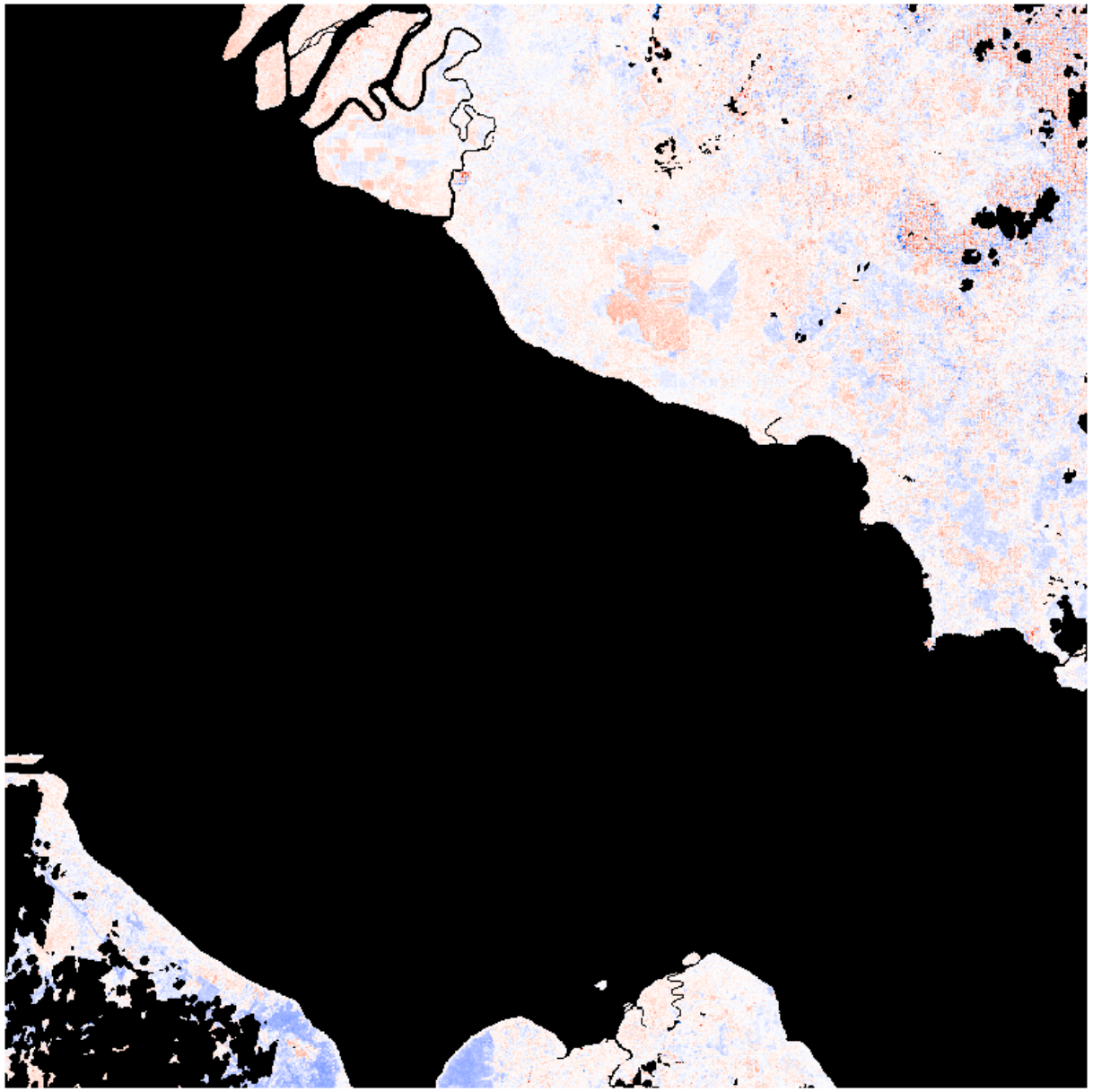
Difference

+100m

+/-0m

-100m

Validation of AW3D 5m DSM



Difference image (PRISM/DSM minus SRTM Ver.3 3-arcsec)

N002E101

Stats of height validation with 19 CPs

Dataset	Ave [m]	STDEV [m]	RMSE [m]
AW3D	4.94	3.70	6.12
SRTM v.3	5.36	5.73	7.74

Note

- Clouds are remaining
- Observation time differences (*i.e.* forest and vegetation changes) are showing as blue and red colors

■ Masks due to clouds, in-land water, and sea areas

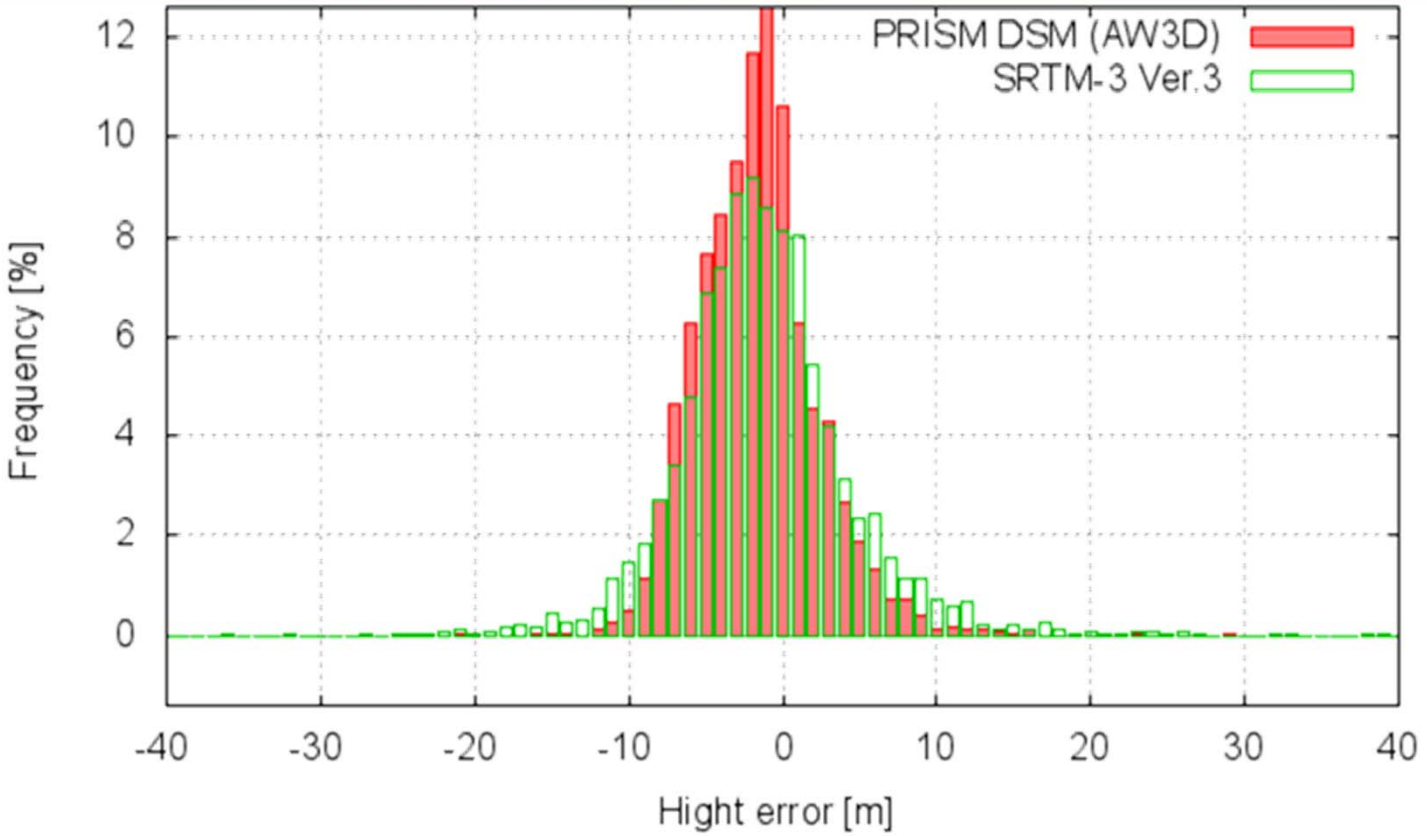
Difference

+50m

+/-0m

-50m

Initial Validation Result of AW3D 5m DSM



Histogram of height error evaluated by 466 CPs

Stats of height validation with 3,890 CPs in 85 tiles

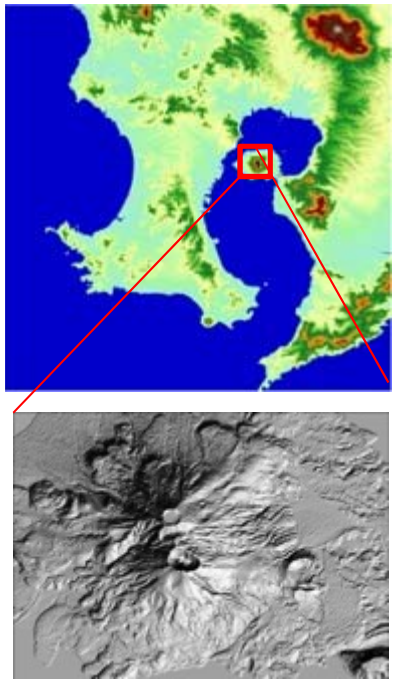
Dataset	Ave [m]	STDEV [m]	RMSE [m]
AW3D	-1.70	3.96	4.31
SRTM v.3*	-1.22	5.77	5.90

* reference

Conclusions

- Data processing status is on schedule
- The height accuracy achieved 4.31 m (RMSE)
- The remaining clouds are issues

Specification of “ALOS World 3D” Product



DSM (N031E130)
5 m spacing

Contents and definitions of “AW3D” Dataset (Level 1)

	Dataset Name	Contents
1	Precise DSM Dataset	Area: Global land area within 82 deg. of N/S latitudes Horizontal spacing: 0.15arcsec (approx. 5 m) Management: 1 deg. tile of lat/long, approx. 22,000 tiles in total Contents: – DSM file (DSM): 5 m (RMSE) in height accuracy – Mask file (MSK) – Stack number file (STK) – Header information (HDR) – Scene list (LST) – Quality assurance information (QAI)
2	ORI Dataset	Ortho rectified image of PRISM nadir-looking Horizontal spacing: 0.075arcsec (approx. 2.5 m) Management: Individual scene unit Contents: – Ortho rectified image for nadir (ORI): 5 m (RMSE) in geolocation accuracy – Header information (OHR)
3	Correlation Coefficient Image (CCI)*	The averaged correlation coefficient distribution image of available stereo pairs in scene-bases. Definition: The index shows image matching quality *e.g.* a correlation coefficient for the aerial correlation matching.

* An intermediate product

- A low-resolution DSM dataset (1 arcsec, ~30 m spacing) with same height accuracy (5 m) will be opened to the public free of charge as soon as it is ready (Jan. 2015).

“ALOS World 3D” Product Level

	Level 1	Level 2	Level 3
Type	DSM Digital Surface Model	DSM Digital Surface Model	DTM Digital Terrain model
Coverage	Global (land)		
Unit	Tile (1 degree x 1 degree) Mesh (0.2 degree x 0.2 degree) AOI*	AOI*	AOI*
Resolution	5m (Please ask for other resolution)		
Horizontal Accuracy	5m (RMSE)		
Vertical Accuracy	5m (RMSE)		
Coordinate system	Geographic Lat/Lon (ITRF97[GRS80]) (Please ask for UTM)		
Format	GeoTIFF		
Image files	DSM (elevation in meter, 16bit integer), Mask image	DSM (elevation in meter, 16bit integer**), Mask image	TBD
Height type	Ellipsoid height	Ellipsoid height or Elevation (height above sea level)	Ellipsoid height or Elevation (height above sea level)
Minimum sales area (AOI)	400km^2	400km^2	400km^2

***: Single polygon with 4 or more vertices. Each side: 10km or more. Each angle: 90degrees or more.**

****: Please ask for float.**

- Sample DSM datasets are available on **http://alos-world3d.jp/en/index.html**
- Contact by E-mail to: **data@restec.or.jp**