Precise Global Digital 3D Map “ALOS World 3D” (AW3D)
Processing Status and Initial Validation Results

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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
Sample movies of the digital 3D map: http://www.youtube.com/watch?v=pZg78PXnlQc
**Advanced Land Observing Satellite (ALOS, “DAI CHI”)**

- **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.

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**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.

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Global archive of PRISM stereo scenes (35km x 35km)
- Over 1 million stereo or triplet sets with cloud level < 30% per 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 \(\approx\) 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)

Level 1B1+
High-frequency Attitude Determination (HAD)

Extract Tie-points
Orientation
Image Matching
Height Calculation

Correct vertical shift
Stacking/Mosaicking
Interpolate height in water mask area
1x1deg. tile framing
QC / QA

Automated

PRISM FWD
PRISM NDR
PRISM BWD

Parameter tuning
Discard Outlier Tie-points
Parameter tuning
Mask outlier areas (cloud, water, etc.)
Apply filters

PRISM DSM scene
PRISM ORI scene

ICESat
SRTM
ASTER GDEM

PRISM DSM tile product
PRISM DSM scene
PRISM ORI scene
...
Processing status of AW3D tiles (as of Oct. 1, 2014)
Validation of AW3D 5m DSM

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

<table>
<thead>
<tr>
<th>Dataset</th>
<th>Ave [m]</th>
<th>STDEV [m]</th>
<th>RMSE [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>AW3D</td>
<td>-1.69</td>
<td>2.04</td>
<td>2.65</td>
</tr>
<tr>
<td>SRTM v.3</td>
<td>-1.68</td>
<td>8.23</td>
<td>8.39</td>
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</table>

Difference image (PRISM/DSM minus SRTM Ver.3 3-arcsec)
Validation of AW3D 5m DSM

N032E130
Stats of height validation with 8 CPs

<table>
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<tr>
<th>Dataset</th>
<th>Ave [m]</th>
<th>STDEV [m]</th>
<th>RMSE [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>AW3D</td>
<td>-2.24</td>
<td>0.60</td>
<td>2.31</td>
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<tr>
<td>SRTM v.3</td>
<td>-4.12</td>
<td>0.90</td>
<td>4.20</td>
</tr>
</tbody>
</table>

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

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

Masks due to clouds, inland water, and sea areas

Difference
- +50m
- +/-0m
- -50m
Validation of AW3D 5m DSM

N035E138
Stats of height validation with 33 CPs

<table>
<thead>
<tr>
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<th>Ave [m]</th>
<th>STDEV [m]</th>
<th>RMSE [m]</th>
</tr>
</thead>
<tbody>
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<td>-0.59</td>
<td>1.75</td>
<td>1.82</td>
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<tr>
<td>SRTM v.3</td>
<td>0.89</td>
<td>7.49</td>
<td>7.43</td>
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</table>

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

- Masks due to clouds, inland water, and sea areas

Difference image (PRISM/DSM minus SRTM Ver.3 3-arcsec)
Validation of AW3D 5m DSM

Stats of height validation with 19 CPs

<table>
<thead>
<tr>
<th>Dataset</th>
<th>Ave [m]</th>
<th>STDEV [m]</th>
<th>RMSE [m]</th>
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</thead>
<tbody>
<tr>
<td>AW3D</td>
<td>4.94</td>
<td>3.70</td>
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<tr>
<td>SRTM v.3</td>
<td>5.36</td>
<td>5.73</td>
<td>7.74</td>
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</tbody>
</table>

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

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

<table>
<thead>
<tr>
<th>Dataset</th>
<th>Ave [m]</th>
<th>STDEV [m]</th>
<th>RMSE [m]</th>
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</thead>
<tbody>
<tr>
<td>AW3D</td>
<td>-1.70</td>
<td>3.96</td>
<td>4.31</td>
</tr>
<tr>
<td>SRTM v.3*</td>
<td>-1.22</td>
<td>5.77</td>
<td>5.90</td>
</tr>
</tbody>
</table>

* reference

Conclusions
- Data processing status is on schedule
- The height accuracy achieved 4.31 m (RMSE)
- The remaining clouds are issues
### Contents and definitions of “AW3D” Dataset (Level 1)

<table>
<thead>
<tr>
<th>Dataset Name</th>
<th>Contents</th>
</tr>
</thead>
</table>
| 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

<table>
<thead>
<tr>
<th></th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
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<tbody>
<tr>
<td><strong>Type</strong></td>
<td>DSM Digital Surface Model</td>
<td>DSM Digital Surface Model</td>
<td>DTM Digital Terrain model</td>
</tr>
<tr>
<td><strong>Coverage</strong></td>
<td>Global (land)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Unit</strong></td>
<td>Tile (1 degree x 1 degree) Mesh (0.2 degree x 0.2 degree) AOI*</td>
<td>AOI*</td>
<td>AOI*</td>
</tr>
<tr>
<td><strong>Resolution</strong></td>
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<td>5m (Please ask for other resolution)</td>
<td></td>
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<tr>
<td><strong>Horizontal Accuracy</strong></td>
<td></td>
<td>5m (RMSE)</td>
<td></td>
</tr>
<tr>
<td><strong>Vertical Accuracy</strong></td>
<td></td>
<td>5m (RMSE)</td>
<td></td>
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<tr>
<td><strong>Coordinate system</strong></td>
<td></td>
<td>Geographic Lat/Lon (ITRF97[GRS80])</td>
<td>(Please ask for UTM)</td>
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<tr>
<td><strong>Format</strong></td>
<td></td>
<td>GeoTIFF</td>
<td></td>
</tr>
<tr>
<td><strong>Image files</strong></td>
<td>DSM (elevation in meter, 16bit integer), Mask image</td>
<td>DSM (elevation in meter, 16bit integer**), Mask image</td>
<td>TBD</td>
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<tr>
<td><strong>Height type</strong></td>
<td>Ellipsoid height</td>
<td>Ellipsoid height or Elevation (height above sea level)</td>
<td>Ellipsoid height or Elevation (height above sea level)</td>
</tr>
<tr>
<td><strong>Minimum sales area (AOI)</strong></td>
<td>400km²</td>
<td>400km²</td>
<td>400km²</td>
</tr>
</tbody>
</table>

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

**: Please ask for float.

- Contact by E-mail to: data@restec.or.jp