Calibration Result of JAXA standard products (As of Sep. 6, 2011)

High resolution satellite imageries demonstrate the effective performance when they are used on the Geographical Information System (GIS). Three instruments onboard ALOS were to observe the Earth surface in detail, and their geometric and radiometric accuracies are important not only for showing the instruments performance themselves, but also for utilizing the images and products in several applications. ALOS was operated from January 24, 2006 to May 12, 2011, and the products were continuously calibrated and validated by JAXA for all through the time. The following calibration results show the accuracies of the standard products for PRISM, AVNIR-2 and PALSAR. Some of the performances reached to the world records. These knowledge and experiences are able to take over for ALOS follow on missions i.e. ALOS-2 and ALOS-3.

PRISM Level 1B2 data products

- Geometric calibration accuracy
    1. 1) Absolute accuracy

        The products were re-processed using the latest pointing alignment parameters, and were evaluated with the worldwide ground control points (GCPs). This evaluation is valid for whole mission period of the ALOS. The evaluated products were acquired from Aug. 27, 2007 to Apr. 18, 2011.

	Pixel direction (m)	Line direction (m)	Error distance (m)	No of points	No of scenes
Nadir	3.5	5.0	6.1	5,154	584
Forward	3.3	5.0	5.9	1,572	216
Backward	3.5	6.8	7.6	4,077	475

        - Evaluation method: The absolute accuracy is defined here as the root mean square error (RMSE). The location difference between GCPs

measured on the GRS 80 ellipsoid and their points identified on the PRISM images that were also produced on the GRS 80 ellipsoid and corrected for the height is calculated.

∗ For reference: CE90 (Circular error with 90 % confidence)
Nadir 9.4 m, Forward 9.1 m, and Backward 12.1 m

2. 2) Relative accuracy

	Pixel direction (m)	Line direction (m)	Distance (m)
Nadir	1.5	1.5	2.1
Forward	1.3	1.6	2.1
Backward	1.5	1.8	2.3

– Evaluation method: The relative geometric accuracy is defined as the averaged standard deviations (STDEV) of the geometric errors within a scene.

- Radiometric calibration accuracy
    1. 1) Absolute accuracy (Nadir-looking radiometer)

        Similar to that of AVNIR-2 (better than 3 %, RMSE)

        – Evaluation method: The comparison between PRISM image and AVNIR-2' one as cross calibration in homogeneous targets (e.g. deserts, salt lakes, ocean)

    2. 2) Relative accuracy (Three radiometers)

        Better than 0.4 % (1 DN)(STDEV)

Reference: T. Tadono, M. Shimada, H. Murakami, and J. Takaku, "Calibration of PRISM and AVNIR-2 Onboard ALOS "Daichi"," IEEE Trans. Geoscience and Remote Sensing, Vol. 47, No. 12, pp.4042-4050, Dec. 2009.

AVNIR-2 Level 1B2 data products

- Geometric calibration accuracy
    1. 1) Absolute accuracy

    Regarding to commonly used seven pointing angles (0, +/-21.5, +/-34.3, +/-41.5 degrees) of AVNIR-2, the products were re-processed using the latest sensor alignment parameters, and were evaluated with the worldwide GCPs. This evaluation is valid for whole mission period of the ALOS. The evaluated products were acquired from Feb. 11, 2008 to Apr. 18, 2011.

Pointing angle (deg)	Pixel direction (m)	Line direction (m)	Distance (m)	No of points	No of scenes
All seven	31.3	14.1	34.3	1,329	118
-41.5	60.5	28.5	66.8	128	14
-34.3	32.1	13.5	34.8	231	21
-21.5	15.4	10.9	18.8	215	17
0	19.8	9.4	21.9	382	30
+21.5	27.8	13.1	30.8	208	14
+34.3	40.3	10.3	41.6	117	11
+41.5	28.6	15.4	32.4	48	9

    - Evaluation method: The absolute accuracy is defined as the root mean square error (RMSE). The location difference between GCPs on the GRS 80 ellipsoid and those points identified on the AVNIR-2 images that were also produced on the GRS80 is calculated.

    - Other pointing angles of AVNIR-2 may have similar accuracy with previous evaluation result (offset error may become better than it).

＊ For reference: CE90

All seven pointing angle 51.9 m, 0 degree pointing 37.7 m

2. 2) Relative accuracy

Pointing angle (deg)	Pixel direction (m)	Line direction (m)	Distance (m)	Distance (pixel)
All seven	8.8	3.3	9.9	0.7
-41.5	24.5	3.3	25.0	1.2
-34.3	13.2	3.8	14.5	1.0
-21.5	4.1	3.0	5.2	0.5
0	3.2	2.6	4.2	0.4
+21.5	3.9	2.9	5.0	0.5
+34.3	11.8	5.0	13.3	0.9
+41.5	5.8	3.8	7.0	0.5

－ Evaluation method: The relative geometric accuracy is defined as the averaged standard deviations (STDEV) of the geometric errors within a scene. The error distance in meter looks not good as that of in pixel because it relatively becomes larger with pointing angle.

- Radiometric accuracy
  1. 1) Absolute accuracy

     Band 1-3   3 %
     Band 4   7 %

     － Evaluation method: The comparison between AVNIR-2 and MODIS onboard NASA's TERRA/AQUA satellites as cross calibration in homogeneous targets (e.g. deserts, salt lakes, ocean). The absolute radiometric accuracy is not much changed during 5.3 years of the mission life (within 5 %).

  2. 2) Relative accuracy

Better than 0.4 % (1 DN) (STDEV)

Reference: T. Tadono, M. Shimada, H. Murakami, and J. Takaku, "Calibration of PRISM and AVNIR-2 Onboard ALOS "Daichi"," IEEE Trans. Geoscience and Remote Sensing, Vol. 47, No. 12, pp.4042-4050, Dec. 2009.
H. Murakami, T. Tadono, H. Imai, J. Nieke, and M. Shimada, "Improvement of AVNIR-2 Radiometric Calibration by Comparison of Cross-Calibration and Onboard Lamp Calibration," IEEE Trans. Geoscience and Remote Sensing, Vol. 47, No. 12, pp.4051-4059, Dec. 2009.

PALSAR level1.1/1.5Product

- Radiometric calibration accuracy (common for all the off-nadir angles)

Absolute accuracy		0.76 dB (1σ) : Corner reflector
		0.22 dB (1σ): Amazon Forest *
Noise equivalent sigma-naught		-34 dB (FBD-HV)
		-32 dB (FBD-HH)
		-29 dB (FBS-HH)
Amplitude ratio of VV/HH (PLR)		1.013 (0.062:1σ)
Phase difference of VV and HH (PLR)		0.612 deg (2.66deg:1σ)
Cross talk (PLR)		-31.7 ~ -40 dB
Resolution	Single look in azimuth	4.49 m
	Range	9.6 m (FBD, PLR, DSN)
	Range	4.8 m (FBS)
Sidelobes	In azimuth	-16.6 dB
	In range	-12.6 dB
	Two-dimensional	-8.6 dB

- Measurement: Impulse response of the corner reflectors (CR) at the calibration sites and the responses from the Amazon rainforest were statistically evaluated.

* Standard deviation of the incidence angle dependence of the gamma-naught** measured for five off-nadirs (e.g., 9.9, 21.5, 34.3, 41.5, and 50.8 degrees) using the Amazon Rainforest were calculated as the stability measure.

** Gamma-naught: the normalized radar cross section (NRCS or sigma-naught) divided by the cosine of (local) Incidence angle.

- Ambiguity

Range	23 dB
Azimuth	Un-measurable

- Geometric accuracy (common for all the incidence angles)

7.8 m	FBS, FBD, PLR, DSN
70 m	WB1, WB2

-Measurements: Location difference between the CR positions corrected for the height (in range shift and azimuth shift due to the Doppler) in the slant range coordinate and the CR image in the SAR slant range image were calculated for globally depoyed CRs in total 572, and their root mean square error (RMSE) is shown in the above table..

Reference: M. Shimada, O. Isoguchi, T. Tadono, and K. Isono, "PALSAR Radiometric and Geometric Calibration," IEEE Trans. Geoscience and Remote Sensing, Vol. 47, No. 12, pp.3915-3932, Dec. 2009.