

Update of the radiometric and polarimetric calibration for the PALSAR-2 standard product

1. Radiometric calibration factors (CF)
2. Polarimetric calibration

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1. Radiometric Calibration Factor (CF)

- In the update to the standard product processing software version 002.023 (scheduled for March 28, 2017), pixel values in the standard product are adjusted according to the CF evaluation results described below.
- The adjustment values are the difference from CF = -83 dB and is as shown in the right column of the table below.
- When performing quantitative analysis together with the product processed by the previous standard product processing software (~ version 002.022), please use the value of the "Mean" column as CF for the product by the previous version .

Evaluation results of the calibration factor (CF) and correction value
for the standard product update (version 002.023)

Mode	Evaluation result			Correction value [dB]
	Points	Mean [dB]	SD [dB]	
Spotlight	9	-81.058	0.729	+1.942
U2-6	29	-81.615	0.446	+1.385
U2-7	18	-81.237	0.812	+1.763
U2-8	14	-81.590	0.389	+1.411
U2-9	15	-81.668	0.329	+1.332
FP6-3	6	-81.040	0.369	+1.960
FP6-4	8	-81.733	0.572	+1.267
FP6-5	4	-82.770	0.495	+0.231
FP6-6	5	-82.477	0.851	+0.523
FP6-7	7	-80.812	0.404	+2.188
F2-5	23	-82.374	0.337	+0.626
F2-6	12	-82.351	0.424	+0.649
F2-7	7	-81.911	0.226	+1.089

2. Update of polarimetric calibration

- As a result of the polarimetric performance evaluation by corner reflector measurements so far, there is a bias of about 20 degrees in the phase difference between VV and HH for beam FP6-4 and FP6-6 (it should be 0 degrees).
- Therefore, in the update to standard product processing software version 002.023 (scheduled for March 28, 2017), polarimetric calibration is corrected.

Polarimetric evaluation result of PALSAR-2 standard product (**before update** of the polarimetric calibration)

Beam	FP6-3	FP6-4	FP6-5	FP6-6	FP6-7
Points	5	5	5	5	10
Amplitude ratio (VV/HH)	1.01 ($\sigma = 0.01$)	1.01 ($\sigma = 0.01$)	0.99 ($\sigma = 0.01$)	0.99 ($\sigma = 0.06$)	1.01 ($\sigma = 0.01$)
Phase difference (VV-HH) [deg.]	0.7 ($\sigma = 0.9$)	23.4 ($\sigma = 0.9$)	1.8 ($\sigma = 0.6$)	22.0 ($\sigma = 5.4$)	1.8 ($\sigma = 1.6$)
Cross-talk (VH/HH) [dB]	-46.9 ($\sigma = 4.7$)	-45.8 ($\sigma = 8.2$)	-44.4 ($\sigma = 3.2$)	-41.3 ($\sigma = 13.0$)	-43.2 ($\sigma = 6.5$)
Cross-talk (HV/VV) [dB]	-47.6 ($\sigma = 4.6$)	-39.8 ($\sigma = 5.4$)	-42.9 ($\sigma = 5.1$)	-38.8 ($\sigma = 12.7$)	-41.0 ($\sigma = 4.7$)

Polarimetric evaluation result of PALSAR-2 standard product (**after update** of the polarimetric calibration)

Beam	FP6-3	FP6-4	FP6-5	FP6-6	FP6-7
Scene observation date	2014/12/26	2015/01/09	2015/01/23	2015/02/06	2014/08/13
Amplitude ratio (VV/HH)	0.99	1.00	1.00	0.99	1.00
Phase difference (VV-HH) [deg.]	-0.02	-0.96	-0.21	-0.32	2.17
Cross-talk (VH/HH) [dB]	-52.4	-37.6	-47.4	-42.3	-44.3
Cross-talk (HV/VV) [dB]	-44.3	-41.2	-56.6	-41.9	-40.8

2. Update of polarimetric calibration

Notes for ordering/using products:

- The extent of influence is Stripmap [6 m] mode (full polarimetry, beams FP6-4 and FP6-6), processing level L1.1.
- In the update, the other beams are also re-calibrated, but there is no major change in these beams.
- Processing levels L1.5, L2.1, and L3.1 have no major impact.
- Products ordered before update can be corrected based on the equation of polarimetric calibration below. The values of polarimetric calibration factor (i.e., distortion matrices) are shown in the following pages.
 1. Calculate the signal before polarimetric calibration using the polarimetric calibration factor before update.
 2. Calculate the signal after correct polarimetric calibration using the updated calibration factor (inverse matrix).

Equation of polarimetric calibration

$$\begin{pmatrix} Z_{HH} & Z_{HV} \\ Z_{VH} & Z_{VV} \end{pmatrix} = \begin{pmatrix} 1 & \delta_3 \\ \delta_4 & f_2 \end{pmatrix} \begin{pmatrix} S_{HH} & S_{HV} \\ S_{VH} & S_{VV} \end{pmatrix} \begin{pmatrix} 1 & \delta_1 \\ \delta_2 & f_1 \end{pmatrix}$$

Measurement matrix (signal before calibration) True scattering matrix (signal after calibration)

Polarimetric calibration factors
Receive distortion matrix (RD) Transmit distortion matrix (TD)

Z_{pq} , S_{pq} : p is the reception polarization and q is the transmit polarization

(Notes: in the file name notation the order is reversed)

δ_n : Crosstalk

f_m : Channel imbalance

* The terms of absolute amplitude, Faraday rotation angle, system noise, etc. are ignored in the above.

2. Update of polarimetric calibration

Polarimetric calibration factor (TD and RD)

Before update (~ver. 002.022)

Beam		FP6-3	FP6-4	FP6-5	FP6-6	FP6-7	
TD	a11	Re	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000
		Im	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
	a12 (δ_1)	Re	0.0029780	-0.0182611	0.0030620	0.0017194	0.0006863
		Im	0.0026764	0.0161178	0.0041580	0.0033138	0.0052736
	a21 (δ_2)	Re	0.0027118	0.0203073	0.0017849	0.0014118	0.0066150
		Im	0.0016514	0.0020374	0.0024361	0.0011031	0.0028992
	a22 (f_1)	Re	0.9121158	0.8975634	0.8917574	0.9063899	0.9208093
		Im	-0.4840831	-0.4436239	-0.4805613	-0.4677647	-0.4478701
RD	b11	Re	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000
		Im	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
	b12 (δ_3)	Re	-0.0032790	0.0144252	-0.0073845	-0.0031506	-0.0009118
		Im	0.0026533	0.0033442	0.0038861	0.0019548	0.0041139
	b21 (δ_4)	Re	0.0047041	-0.0056287	0.0093964	0.0084732	0.0047211
		Im	0.0072861	0.0158646	0.0083342	0.0052384	0.0080605
	b22 (f_2)	Re	1.0681480	0.9642884	1.0300820	0.9589941	1.0500690
		Im	-0.0197118	-0.4042504	-0.0999592	-0.4188998	-0.0645943

After update (ver. 002.023)

Beam		FP6-3	FP6-4	FP6-5	FP6-6	FP6-7	
TD	a11	Re	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000
		Im	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
	a12 (δ_1)	Re	0.0025181	0.0018349	-0.0023059	-0.0002325	0.0006444
		Im	0.0027918	0.0033902	0.0052129	0.0033053	0.0040428
	a21 (δ_2)	Re	0.0020683	0.0029690	0.0062285	0.0040316	0.0061275
		Im	0.0016103	0.0017968	0.0015242	0.0014035	0.0020731
	a22 (f_1)	Re	0.9286370	0.9189993	0.8824115	0.9366146	0.9187411
		Im	-0.4808737	-0.4502332	-0.4916437	-0.4697279	-0.4642221
RD	b11	Re	1.0000000	1.0000000	1.0000000	1.0000000	1.0000000
		Im	0.0000000	0.0000000	0.0000000	0.0000000	0.0000000
	b12 (δ_3)	Re	-0.0033613	-0.0054863	-0.0012954	-0.0049808	-0.0038717
		Im	0.0025445	0.0028552	0.0030766	0.0021278	0.0032911
	b21 (δ_4)	Re	0.0046396	0.0063619	0.0003713	0.0055209	0.0063052
		Im	0.0078309	0.0078033	0.0075258	0.0067447	0.0073976
	b22 (f_2)	Re	1.0765140	1.0371440	1.0236590	1.0649200	1.0528850
		Im	-0.0192003	0.0048059	-0.0559726	-0.0017789	-0.0219815

*Re: real part, Im: imaginary part

2. Update of polarimetric calibration

Inverse matrices of TD and RD

Before update (~ver. 002.022)

Beam		FP6-3	FP6-4	FP6-5	FP6-6	FP6-7	
TD ⁻¹	c11	Re	0.9999976	0.9995104	0.9999890	0.9999959	0.9999733
		Im	0.0000121	0.0000810	0.0000108	0.0000052	0.0000279
	c12	Re	-0.0013323	0.0234729	-0.0007136	-0.0000080	0.0016516
		Im	-0.0036415	-0.0063453	-0.0050472	-0.0036602	-0.0049235
	c21	Re	-0.0015700	-0.0172721	-0.0004102	-0.0007341	-0.0045716
		Im	-0.0026438	-0.0108074	-0.0029529	-0.0015958	-0.0053757
	c22	Re	0.8554018	0.8949203	0.8690003	0.8712326	0.8781972
		Im	0.4539968	0.4424078	0.4683097	0.4496267	0.4271799
RD ⁻¹	d11	Re	0.9999676	0.9998040	0.9999045	0.9999676	0.9999627
		Im	-0.0000113	0.0001356	-0.0000336	-0.0000141	0.0000095
	d12	Re	0.0031145	-0.0114834	0.0074638	0.0035065	0.0011011
		Im	-0.0024265	-0.0082835	-0.0030482	-0.0005067	-0.0038545
	d21	Re	-0.0042766	0.0108302	-0.0082586	-0.0054160	-0.0040059
		Im	-0.0068999	-0.0119079	-0.0088912	-0.0078278	-0.0079215
	d22	Re	0.9358511	0.8817988	0.9616514	0.8756534	0.9486939
		Im	0.0172598	0.3698095	0.0932861	0.3824809	0.0583832

After update (ver. 002.023)

Beam		FP6-3	FP6-4	FP6-5	FP6-6	FP6-7	
TD ⁻¹	c11	Re	0.9999953	0.9999858	0.9999329	0.9999888	0.9999837
		Im	0.0000086	0.0000106	0.0000175	0.0000087	0.0000212
	c12	Re	-0.0009189	-0.0001339	0.0044888	0.0016182	0.0012097
		Im	-0.0034745	-0.0037668	-0.0034403	-0.0027161	-0.0037835
	c21	Re	-0.0010430	-0.0018516	-0.0046600	-0.0028310	-0.0044134
		Im	-0.0022786	-0.0028489	-0.0042874	-0.0029336	-0.0044726
	c22	Re	0.8491423	0.8775828	0.8647162	0.8529414	0.8670082
		Im	0.4396773	0.4297608	0.4817712	0.4279021	0.4377738
RD ⁻¹	d11	Re	0.9999647	0.9999330	0.9999568	0.9999549	0.9999389
		Im	-0.0000140	-0.0000218	-0.0000049	-0.0000206	-0.0000071
	d12	Re	0.0031683	0.0052836	0.0014368	0.0046904	0.0037155
		Im	-0.0023160	-0.0027776	-0.0029193	-0.0020005	-0.0030111
	d21	Re	-0.0041929	-0.0061639	0.0000268	-0.0051816	-0.0058208
		Im	-0.0073380	-0.0074893	-0.0073597	-0.0063359	-0.0071761
	d22	Re	0.9285700	0.9641269	0.9740176	0.9390646	0.9492665
		Im	0.0164865	-0.0045322	0.0532354	0.0016012	0.0197050

*Re: real part, Im: imaginary part