MISR Multi-angle Imaging Spectro-Radiometer

Jet Propulsion Laboratory **Interoffice Memorandum**

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Subject: On-Board Calibrator response functions used in Ancillary Radiometric Product In-flight Calibration version 4

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The purpose of this memorandum is to document the response functions of the MISR on-board calibrator (OBC) utilized in computing the camera gain coefficients for ARP Version 4. The response functions are the diode étendue or AΩ, the diode integrated solar-weighted spectral response, and the diode calibration correction factors. Also, included are the factors required to convert from ARP Version 3 radiances to ARP Version 4 radiances.

The diode integrated solar-weighted spectral response (Table 1) is defined in equation 1. Where $E_{0,\lambda}$ is the exo-atmospheric solar irradiance and R_λ is the diode spectral response.

$$= \int_{200nm}^{1200nm} E_{0,\lambda} R_\lambda \lambda \, d\lambda \qquad (1)$$

The diode étendue or AΩ is the area-projected solid angle product for the photodiode (Table 2).The diode calibration correction factors (Table 3) are multiplicative factors that are applied to the product of the diode AΩ and the diode integrated solar-weighted spectral response. The preflight calibration of the blue HQE diode is used as the standard to which the other photodiodes are calibrated. The D-diodes are calibrated using the goniometer to provide a transfer calibration. The OBC data collected during orbits 1259 and 1912 for Cal-North and Cal-South respectively were used. The calibration correction factors represent the average correction factor computed for Cal-North and Cal-South with the exception of the D-diode factors. For the D-diode factors, the north-south average is applied to the PIN-G for the transfer, but PIN-3 only views the south panel and PIN-4 only views the north panel.

The radiance measured by a given photodiode is computed following equation 2 where k is the calibration correction factor. The calibration correction factor is computed based upon the assumption that the Spectralon® calibration panels are spectrally flat, Lambertian targets. This implies that the ratio of one diode current to another should equal the ratio of étendue-response products, AΩ (equation 3). The calibration correction factors for the nadir viewing diodes are computed using the blue HQE diode and its preflight calibration as the standard, i.e., $k_{\mathrm{HQE,\ blue}} = 1$ (equation 4). The D-diodes, PIN-3 and PIN-4, are calibrated to the blue HQE diode using the goniometer, PIN-G, as a transfer standard. The goniometer calibration correction factor is computed using currents when the goniometer position is nadir-viewing. The D-diode bands are then calibrated to the goniometer diode bands as shown in equation 5.

$$L^{\mathrm{std,\ OBC}} = \frac{1.2395 i E_0^{std}}{(A\Omega \quad) \; k} \qquad (2)$$

$$\left[\frac{i_2}{(A\Omega)_2\;k_2}=\frac{L_2^{\text{std,OBC}}}{E_{0,2}^{std}}=\frac{L_1^{\text{std,OBC}}}{E_{0,1}^{std}}=\frac{i_1}{(A\Omega)_1\;k_1}\right]\qquad \left(\frac{i_2}{i_1}=\frac{(A\Omega)_2}{(A\Omega)_1}\;\frac{k_2}{k_1}\right) \tag{3}$$

$$k_{\text{diode, band}}=\frac{i_{\text{diode, band}}}{i_{\text{HQE, blue}}}\div\frac{(A\Omega)_{\text{diode, band}}}{(A\Omega)_{\text{HQE, blue}}} \tag{4}$$

$$k_{\text{D-diode,band}}=\frac{i_{\text{D-diode,band}}}{i_{\text{goni, band @D-angle}}}\div\frac{(A\Omega)_{\text{D-diode,band}}}{(A\Omega)_{\text{goni, band}}\;k_{\text{goni, band}}} \tag{5}$$

Table 1: diode integrated solar-weighted spectral response, [W m^{-1}]

diode		Band			
position	type	BLUE	GREEN	RED	NIR
+Y	PIN-1	13.0698	14.3526	8.7570	11.4217
-Y	PIN-2	13.0104	14.9508	8.7721	12.1682
Df	PIN-3	15.4890	14.5350	8.6580	11.5130
Da	PIN-4	16.0568	15.5577	10.8097	11.6961
goniometer	PIN-G	12.6824	14.2086	11.1406	10.9881
+Y (B, G), -Y (R, N)	HQE	17.3235	11.6565	12.5182	16.1813

Table 2: diode étendue or AΩ [m^2 sr]

Diode		Band			
position	type	BLUE	GREEN	RED	NIR
+Y	PIN-1	1.4806E-08	1.4829E-08	1.4755E-08	1.4653E-08
-Y	PIN-2	1.4803E-08	1.4813E-08	1.4766E-08	1.4674E-08
Df	PIN-3	1.4786E-08	1.4793E-08	1.4738E-08	1.4623E-08
Da	PIN-4	1.4752E-08	1.4783E-08	1.4786E-08	1.4783E-08
goniometer	PIN-G	1.4796E-08	1.4830E-08	1.4806E-08	1.4779E-08
+Y (B, G), -Y (R, N)	HQE	7.4541E-09	7.4495E-09	7.4719E-09	7.4730E-09

Table 3: diode calibration correction factors
computed using Orbits 1259 (Cal-North) and 1912 (Cal-South), HQE blue as standard

Diode		Band			
position	type	BLUE	GREEN	RED	NIR
+Y	PIN-1	0.8930	0.8871	0.9179	0.8943
-Y	PIN-2	0.8993	0.8472	0.8999	0.8543
Df	PIN-3	0.8637	0.8645	0.9119	0.8937
Da	PIN-4	0.8375	0.8268	0.8937	0.8660
goniometer	PIN-G	0.9030	0.8905	0.8953	0.8854
+Y (B, G), -Y (R, N)	HQE	1.0000	1.0337	0.9570	1.0792

To convert Version 3 radiances whose gain coefficients are based on the preflight diode response functions to Version 4 radiances which are based upon the diode response functions given here, one would multiply the Version 3 radiance by the appropriate factor from Table 4. The G_1 coefficient channel means are given in Tables 5 and 6 for each of the two versions. Table 7 shows the percent difference between them.

$$L_{v4} = L_{v3} \frac{G_{1,v3}}{G_{1,v4}} \quad (6)$$

Table 4: factors to convert from ARP version 3 radiances to version 4 radiances, $\frac{G_{1,v3}}{G_{1,v4}}$

Camera	Band			
	Blue	Green	Red	NIR
Df	0.9440	0.9579	0.9649	0.9347
Cf	1.0010	1.0164	0.9445	0.9287
Bf	1.0204	1.0401	1.0223	0.9872
Af	0.9987	0.9962	1.0001	0.9574
An	0.9284	0.9553	0.9812	0.9624
Aa	1.0309	1.0069	1.0495	0.9860
Ba	1.0501	0.9797	1.0392	0.9698
Ca	0.9905	1.0553	1.0309	0.9844
Da	1.0159	1.0714	1.0699	1.0057

Table 5: G1 coefficient, channel mean: MISR_AM1_ARP_INFLTCAL_F01_001.hdf ($G_{1,v3}$**)**

Camera	Band			
	Blue	Green	Red	NIR
Df	23.7327	23.5022	28.0790	44.1225
Cf	23.2061	24.0454	29.5118	44.9768
Bf	23.6779	22.6386	29.4522	45.6965
Af	23.4319	23.6168	29.2569	43.8165
An	20.9298	21.9385	30.2010	43.7020
Aa	23.1797	24.3174	28.9184	42.7098
Ba	26.0574	23.7955	27.5437	47.8591
Ca	23.0300	23.0991	27.9198	44.6848
Da	23.0859	22.7480	27.4547	42.3987

Table 6: G1 coefficient, channel mean: MISR_AM1_ARP_INFLTCAL_T002_F01_004c.hdf ($G_{1,v4}$)

Camera	Band			
	Blue	Green	Red	NIR
Df	25.1400	24.5340	29.1016	47.2038
Cf	23.1820	23.6575	31.2472	48.4285
Bf	23.2045	21.7657	28.8087	46.2912
Af	23.4616	23.7062	29.2541	45.7679
An	22.5434	22.9652	30.7784	45.4112
Aa	22.4853	24.1517	27.5552	43.3149
Ba	24.8146	24.2892	26.5047	49.3487
Ca	23.2513	21.8879	27.0821	45.3921
Da	22.7255	21.2316	25.6618	42.1603

Table 7: G1 coefficient, channel mean: Percent difference between v3 and v4, [%]

Camera	Band			
	Blue	Green	Red	NIR
Df	5.9	4.4	3.6	7.0
Cf	-0.1	-1.6	5.9	7.7
Bf	-2.0	-3.9	-2.2	1.3
Af	0.1	0.4	0.0	4.5
An	7.7	4.7	1.9	3.9
Aa	-3.0	-0.7	-4.7	1.4
Ba	-4.8	2.1	-3.8	3.1
Ca	1.0	-5.2	-3.0	1.6
Da	-1.6	-6.7	-6.5	-0.6