Quality of MISR Radiometric Calibration
January 10, 2018

Calibration Process

MISR has challenging radiometric specifications of 3% absolute, and 1% band and camera-relative calibration. The radiometric calibration is facilitated by use of an on-orbit calibrator (OBC) experiment, which is used at bi-monthly intervals. During these experiments a diffuse panel reflects solar light into the cameras. The intensity of this light is measured with on-board photodiode "detector standards." With the measured incident radiance and output DN, radiometric calibration coefficients are computed. Following each experiment the coefficients are packaged into a file called the Ancillary Radiometric Product (ARP). This new ARP file is used for the next two months to produce the MISR Level 1B1 radiance product, and in turn the Level 1B2 geo-located product.

Because of the challenging radiometric requirements, the calibration team at JPL has been researching various procedures for reducing the calibration data and producing coefficients. Calibration-algorithm changes have occurred over time, and thus the initial ARP time-series files have not been produced using a common algorithm. The full history of this activity is reported in Table 2 below.

It is desirable to generate all reprocessed data at a uniform quality level, which reflects the most current and accurate approach available to calibrating the instrument. To this end, the ARP time-series files have been regenerated twice during the mission with fixed algorithms. The first regeneration effort, conducted in January of 2004, and described in Table 3 below, was used to produce reprocessing Collection 4 data. The second and final ARP regeneration effort, described in Table 1 below, was conducted in November of 2004. The user must pay attention to the version number portion of the ARP_INFLTCAL filename in order to determine the uncertainty of the resulting data. Users are advised to obtain data products generated with the ARP file version specified in table 1.

Table 1. Active in-flight ARP data files (Uniform Quality. Used in reprocessing Collections 5 and greater.)

ARP ID	File Version*	Radiometric uncertainty (for uniform targets)
T002-T111	F02_0010	Same as T029, described in Table 2.

* Filename conventions:
Txxx = Time window, defined in Table 2.
Fxx = Format version
xxxx = revision number of this Time window file

Table 2. Initial Releases of in-flight ARP data files (Incremental Quality Improvements Since Launch)

ARP ID	Valid For Data Acquired On/After:	Time	Orbit	Filename*	Calibration algorithm updates	Radiometric uncertainty (for uniform targets)
T111	09 Jan 2018	23:15:30	96078	T111_F02_0010	Same algorithm as T055.	Same as T018
T110	24 Oct 2017	23:46:27	94957	T110_F02_0010	Same algorithm as T055.	Same as T018
T109	28 Aug 2017	23:52:56	94127	T109_F02_0010	Same algorithm as T055.	Same as T018
T108	11 Jul 2017	23:52:31	93428	T108_F02_0010	Same algorithm as T055.	Same as T018
T107	03 May 2017	23:33:59	92423	T107_F02_0010	Same algorithm as T055.	Same as T018
T106	08 Mar 2017	22:44:23	91607	T106_F02_0010	Same algorithm as T055.	Same as T018
T105	17 Jan 2017	22:56:46	90879	T105_F02_0010	Same algorithm as T055.	Same as T018
T104	08 Nov 2016	23:34:00	89860	T104_F02_0010	Same algorithm as T055.	Same as T018

T103	07 Sep 2016	23:21:54	88957	T103_F02_0010	Same algorithm as T055.	Same as T018
T102	18 Jul 2016	22:51:31	88214	T102_F02_0010	Same algorithm as T055.	Same as T018
T101	10 May 2016	22:32:38	87209	T101_F02_0010	Same algorithm as T055.	Same as T018
T100	14 Mar 2016	22:38:24	86379	T100_F02_0010	Same algorithm as T055.	Same as T018
T099	19 Jan 2016	22:32:34	85578	T099_F02_0010	Same algorithm as T055.	Same as T018
T098	17 Nov 2015	23:15:58	84661	T098_F02_0010	Same algorithm as T055.	Same as T018
T097	29 Sep 2015	22:32:22	83947	T097_F02_0010	Same algorithm as T055.	Same as T018
T096	21 Jul 2015	23:10:25	82928	T096_F02_0010	Same algorithm as T055.	Same as T018
T095	02 Jun 2015	22:26:36	82214	T095_F02_0010	Same algorithm as T055.	Same as T018
T094	24 Mar 2015	23:03:23	81195	T094_F02_0010	Same algorithm as T055.	Same as T018
T093	03 Feb 2015	23:58:49	80482	T093_F02_0010	Same algorithm as T055.	Same as T018
T092	02 Dec 2014	23:03:13	79564	T092_F02_0010	Same algorithm as T055.	Same as T018
T091	30 Sep 2014	23:46:44	78647	T091_F02_0010	Same algorithm as T055.	Same as T018
T090	02 Sep 2014	23:22:08	78239	T090_F02_0010	Same algorithm as T055.	Same as T018
T089	10 Jun 2014	23:46:51	77016	T089_F02_0010	Same algorithm as T055.	Same as T018
T088	08 Apr 2014	22:50:41	76098	T088_F02_0010	Same algorithm as T055.	Same as T018
T087	04 Feb 2014	23:33:42	75181	T087_F02_0010	Same algorithm as T055.	Same as T018
T086	16 Dec 2013	23:45:58	74453	T086_F02_0010	Same algorithm as T055.	Same as T018
T085	21 Oct 2013	22:56:37	73637	T085_F02_0010	Same algorithm as T055.	Same as T018
T084	21 Aug 2013	23:27:57	72749	T084_F02_0010	Same algorithm as T055.	Same as T018
T083	11 Jun 2013	23:21:40	71715	T083_F02_0010	Same algorithm as T055.	Same as T018
T082	16 Apr 2013	22:32:35	70899	T082_F02_0010	Same algorithm as T055.	Same as T018
T081	13 Feb 2013	23:58:22	69997	T081_F02_0010	Same algorithm as T055.	Same as T018
T080	02 Jan 2013	23:21:40	69386	T080_F02_0010	Same algorithm as T055.	Same as T018
T079	25 Oct 2012	23:02:39	68380	T079_F02_0010	Same algorithm as T055.	Same as T018
T078	27 Aug 2012	23:21:32	67521	T078_F02_0010	Same algorithm as T055.	Same as T018
T077	01 Jul 2012	00:23:26	66677	T077_F02_0010	Same algorithm as	Same as T018

T076	30 Apr 2012	23:15:22	65788	T076_F02_0010	Same algorithm as T055.	Same as T018
T075	29 Feb 2012	23:46:15	64900	T075_F02_0010	Same algorithm as T055.	Same as T018
T074	04 Jan 2012	22:56:44	64084	T074_F02_0010	Same algorithm as T055.	Same as T018
T073	01 Nov 2011	22:56:27	63153	T073_F02_0010	Same algorithm as T055.	Same as T018
T072	07 Sep 2011	22:50:14	62351	T072_F02_0010	Same algorithm as T055.	Same as T018
T071	13 Jul 2011	23:39:55	61536	T071_F02_0010	Same algorithm as T055.	Same as T018
T070	11 May 2011	22:44:21	60618	T070_F02_0010	Same algorithm as T055.	Same as T018
T069	14 Mar 2011	23:46:04	59774	T069_F02_0010	Same algorithm as T055.	Same as T018
T068	11 Jan 2011	23:33:29	58871	T068_F02_0010	Same algorithm as T055.	Same as T018
T067	21 Nov 2010	23:02:51	58128	T067_F02_0010	Same algorithm as T055.	Same as T018
T066	14 Oct 2010	23:39:50	57575	T066_F02_0010	Same algorithm as T055.	Same as T018
T065	28 Jul 2010	23:27:37	56439	T065_F02_0010	Same algorithm as T055.	Same as T018
T064	26 May 2010	22:32:13	55521	T064_F02_0010	Same algorithm as T055.	Same as T018
T063	23 Mar 2010	22:32:15	54589	T063_F02_0010	Same algorithm as T055.	Same as T018
T062	25 Jan 2010	22:38:16	53759	T062_F02_0010	Same algorithm as T055.	Same as T018
T061	01 Dec 2009	22:32:23	52958	T061_F02_0010	Same algorithm as T055.	Same as T018
T060	30 Sep 2009	23:58:44	52056	T060_F02_0010	Same algorithm as T055.	Same as T018
T059	27 Jul 2009	23:15:41	51109	T059_F02_0010	Same algorithm as T055.	Same as T018
T058	03 Jun 2009	23:53:13	50323	T058_F02_0010	Same algorithm as T055.	Same as T018
T057	08 Apr 2009	23:04:04	49507	T057_F02_0010	Same algorithm as T055.	Same as T018
T056	04 Feb 2009	23:47:13	48590	T056_F02_0010	Same algorithm as T055.	Same as T018

T055	21 Jan 2009	23:34:51	48386	T055_F02_0010	CALFACT, the precursor to ARPGEN which calculates the calibration factors contained in the calfactor file, was modified to remove any dependencies on goniometer movement. Calibration sequences T054 and prior computed Pin3_cal and Pin4_cal based on the goniometer movement. Due to the MISR anomaly during the T054 calibration sequence on September 30, 2008, the MISR calibration sequences were modified to exclude any goniometer movement. Therefore, the algorithm which calculates the Pin3_cal and Pin4_cal calibration factors was changed to use predictions derived from historical goniometer calibration data through T054. For Pin4_cal a south_Pin2 / north_Pin2 ratio was also used to compensate for panel variations. Calibration sequences from T055 on will use this new algorithm.	Same as T018
T054	16 Oct 2008	17:54:17	46970	T054_F02_0010	Same algorithm as T031.	Same as T018
T053	06 Aug 2008	22:44:45	45939	T053_F02_0010	Same algorithm as T031.	Same as T018
T052	11 Jun 2008	23:34:21	45124	T052_F02_0010	Same algorithm as T031.	Same as T018
T051	04 May 2008	22:32:21	44570	T051_F02_0010	Same algorithm as T031.	Same as T018
T050	19 Feb 2008	22:50:44	43478	T050_F02_0010	Same algorithm as T031.	Same as T018
T049	16 Dec 2007	23:46:09	42532	T049_F02_0010	Same algorithm as T031.	Same as T018
T048	30 Oct 2007	22:50:45	41847	T048_F02_0010	Same algorithm as T031.	Same as T018

T047	29 Aug 2007	22:38:38	40944	T047_F02_0010	Same algorithm as T031.	Same as T018
T046	28 Jun 2007	01:00:34	40028	T046_F02_0010	Same algorithm as T031.	Same as T018
T045	01 May 2007	00:23:28	39183	T045_F02_0010	Same algorithm as T031.	Same as T018
T044	28 Feb 2007	00:11:21	38280	T044_F02_0010	Same algorithm as T031.	Same as T018
T043	15 Jan 2007	01:25:13	37640	T043_F02_0010	Same algorithm as T031.	Same as T018
T042	15 Nov 2006	00:16:38	36751	T042_F02_0010	Same algorithm as T031.	Same as T018
T041	06 Sep 2006	00:54:00	35732	T041_F02_0010	Same algorithm as T031.	Same as T018
T040	21 Jul 2006	01:37:18	35048	T040_F02_0010	Same algorithm as T031.	Same as T018
T039	18 May 2006	01:36:55	33819	T039_F02_0010	Same algorithm as T031.	Same as T018
T038	21 Mar 2006	00:59:46	33271	T038_F02_0010	Same algorithm as T031.	Same as T018
T037	20 Jan 2006	00:34:26	32397	T037_F02_0010	Same algorithm as T031.	Same as T018
T036	10 Nov 2005	00:25:18	31363	T036_F02_0010	Same algorithm as T031.	Same as T018
T035	26 Sep 2005	00:56:43	30707	T035_F02_0010	Same algorithm as T031.	Same as T018
T034	21 Jul 2005	00:26:35	29732	T034_F02_0010	Same algorithm as T031.	Same as T018
T033	01 Jun 2005	00:39:31	29004	T033_F02_0010	Same algorithm as T031.	Same as T018
T032	21 Mar 2005	01:28:20	27956	T032_F02_0010	Same algorithm as T031.	Same as T018
T031	31 Jan 2005	00:47:05	27242	T031_F02_0010	Subsequent to the overall band-to-band calibration adjustments made in ARP T024, camera-by-camera radiometric calibration refinements were made based on the combined analysis of multiple calibration techniques (Diner et al., 2004; Kahn et al., 2005). They amounted to 1% or less in all cases except the near-infrared channel of the Bf camera, which was reduced by 2.5%.	Same as T018
T030	19 Nov 2004	00:27:53	26237	T030_F02_0001	Same algorithm as T024.	Same as T018

T029	28 Sep 2004	00:22:20	25436	T029_F02_0001	Same algorithm as T024.	Same as T018
T028	29 Jul 2004	00:10:15	24533	T028_F02_0001	Same algorithm as T024.	Same as T018
T027	16 Jun 2004	23:46:38	23921	T027_F02_0001	Same algorithm as T024.	Same as T018
T026	30 Mar 2004	00:17:39	22771	T026_F02_0001	Same algorithm as T024.	Same as T018
T025	20 Jan 2004	10:48:50	21758	T025_F02_0001	Same algorithm as T024.	Same as T018
T024	05 Dec 2003	01:08:28	21023	T024_F02_0002	Band-to-Band Adjustment: The red band calibration was reduced by 3% relative to the calibration in use since the year 2000. The NIR band was reduced by 1.5% (Bruegge et al., 2004). Blue and Green band relative calibrations were not changed. Additional bug fixes amounting to roughly a 1% change include: calibrating the G1 coefficients over the slowly-changing clear atmosphere portion of the cal acquisition and fixing some minor time and angle problems in the ARP generation software.	Same as T018
T023	21 Oct 2003	00:19:32	20441	T023_F02_0001	Same algorithm as T022.	Same as T018
T022	20 Aug 2003	01:03:31	19524	T022_F02_0001	Minor Bug Fix to T018 algorithm. Solar Angles on the diffuse panel are computed at the correct time, removing a 1.5 degree error; and the aft-camera BRF scale factors have been adjusted appropriately. The resulting change in the calibration is less than 1%.	Same as T018
T021	09 Jun 2003	00:14:54	18475	T021_F02_0001	Same algorithm as	Same as T018

T020	22 Apr 2003	00:15:25	17776	T020_F02_0001	Same algorithm as T018.	Same as T018
T019	18 Feb 2003	01:08:38	16859	T019_F02_0001	Same algorithm as T018.	Same as T018
T018	12 Jan 2003	00:41:19	16320	T018_F02_0001	Same off-axis corrected algorithm as used to generate T017, but an additional bug fix regarding sun angles on the calibration panel was made to the code which calculates BRF.	Absolute: 4% Camera and band relative: 2% Pixel relative: 0.5%
T017	24 Oct 2002	00:42:14	15155	T017_F02_0001	Off-axis corrected algorithm. An error in the BRF database indexing was corrected in the code used to process MISR calibration coefficients.	Absolute: 4% Camera and band relative: 2% Pixel relative: 0.5%
T016	06 Sep 2002	00:42:47	14456	T016_F02_0001	Linear. A linear calibration equation is again implemented. The DN versus radiance curve is constrained to go through zero. This algorithm gives more consistent calibrations among data collected over the North and South poles.	Exceptions to the 4% absolute uncertainty are: AN camera western edge is 10% too bright; AN camera eastern edge is 5% too dim. Error varies between these values for other pixels, with best radiometry at the swath center. Relative uncertainties: Same as most recent ARP.
T015	26 Jun 2002	01:33:03	13408	T015_F02_0001	No algorithm change.	
T014	25 Apr 2002	01:21:24	12505	T014_F02_0001	No algorithm change.	
T013	25 Feb 2002	00:05:41	11645	T013_F02_0001	No algorithm change.	

T012	22 Dec 2001	01:02:27	10699	T012_F02_0001	BRF correction algorithm. Data from the on-board goniometer have been used to update the North calibration panel reflectance data base. The D-pin photodiodes are used to calibrate all but the nadir camera; the -yn-pn photodiode was used for the An camera only. We believe this to correct an aft-to-fore camera bias; camera-relative uncertainties using this algorithm are believed to be less than 2%. Level 1 data produced using this ARP are Provisional Data Quality.	Absolute: Larger than current algorithm. See T016. Camera relative: 4% Band and pixel: Same as most recent ARP (2% and 0.5% respectively).
T011	19 Nov 2001	00:19:10	10218	T011_F02_0001	D-PIN photodiodes used to calibrate C and D cameras; HQE for all other cameras.	
T010	26 Sep 2001	00:56:52	9432	T010_F02_0001	In an effort to study camera-to-camera relative calibrations, the D-PIN photodiodes were used to calibrate the C and D cameras (HQE photodiodes were used for other cameras). An evaluation of the camera-relative calibrations followed.	

T009	11 Jul 2001	01:27:11	8311	T009_F02_0001	A 5% aft-to-fore camera-relative bias was discovered. This bias is present for all data products produced through T011 (T012 has applied the final correction algorithm). For ARP T009, separate calibration coefficients have been developed for the photodiodes as they view the North panel (used for aft and AN-red, nir channels) and the South panel (used for the fore- and AN-blue, green channels). This change was expected to improve fore-aft camera biases. In practice, several additional updates were made in T010 though T012 to correct this problem. Photodiodes used for T009: D-PIN for D camera, HQE for others.	Absolute: Larger than current algorithm. See T016. Camera relative: 5% Band and pixel: Same as most recent ARP (2% and 0.5% respectively).
T008	17 May 2001	01:19:09	7510	T008_F02_0001	Beginning with this delivery, a quadratic calibration equation is being used to convert the sensor data from DN to radiances values. This algorithm may change the radiances reported over dark, or ocean targets, by a few percent. Radiances reported over bright scenes are believed to be invariant with algorithm. Photodiodes used: HQE only.	
T007	07 Mar 2001	01:17:44	6476	T007_F02_0001	Use was made of	Absolute:

T006	19 Dec 2000	19:29:18	5351	T006_F02_0001	the June 11th Vicarious Calibration experiment to validate the Blue HQE photodiode. As a result of this study all radiances computed for MISR have been adjusted upwards by a factor of 1.10, irrespective of data acquisition time. The Linear Algorithm is used both to convert DN to Radiance and to generate ARP coefficients.	Radiances are increased to remove a 10% bias from previous data products. Errors are still larger than the current algorithm. See T016. Camera relative: 5% Band and pixel: Same as most recent ARP (2% and 0.5% respectively)
T005	01 Nov 2000	21:06:26	4653	T005_F02_0001		
T004	29 Aug 2000	14:25:43	3717	T004_F02_0001		
T003	12 Jun 2000	4:16:43	2575	T003_F02_0001		
T002	24 Feb 2000	16:41:00	995	T002_F02_0005		
* Filename convention: Txxx = Time window Fxx = Format version xxxx = revision number of this Time window file						

Table 3 below describes ARPs that were used to create MISR reprocessing collection 4. These products were widely distributed. Collection 4 products will eventually be replaced by another reprocessing collection. This set of ARPs was generated with uniform quality in January 2004, before the camera-by-camera adjustment was available.

Table 3. Historical Group of in-flight ARP data files used for reprocessing Collection 4

ARP ID	File Version*	Radiometric uncertainty (for uniform targets)
T025-T026	F02_0001	Same as T024, described in Table 2.
T024	F02_0002	Same as T024, described in Table 2.
T019, T020, T022, T023	F02_0003	Same as T024, described in Table 2.
T021, T018	F02_0004	Same as T024, described in Table 2.
T017	F02_0005	Same as T024, described in Table 2.
T015	F02_0004	Same as T024, described in Table 2.
T002-T014, T016	F02_0003	Same as T024, described in Table 2.
* Filename conventions: Txxx = Time window, defined in Table 2. Fxx = Format version xxxx = revision number of this Time window file		

Warning: Do not use MISR Level 1 radiance products with the version number F03_0021. Products with this version number were generated with ARP files containing an error in the band-to-band calibration. This error resulted in Red band radiances that were 6% too high and Near-Infrared band radiances that were 2% high. All data products containing this error have been removed from the Langley DAAC archive. The first ARP to include the erroneous correction was T024_F02_0001, but T017-T023 were redelivered with the error at the same time. The Langley DAAC used these bad ARPs between December 5, 2003 and January 23, 2004.

Table 4. Bad in-flight ARP data files, producing Red radiances that are 6% high and NIR radiances that are 2% high.

ARP ID	File Version*	Radiometric uncertainty (for uniform targets)
T024	F02_0001	N/A
T018	F02_0003	N/A
T017, T019-T023	F02_0002	N/A

* Filename conventions:
Txxx = Time window, defined in Table 2.
Fxx = Format version
xxxx = revision number of this Time window file

Further information can be found in the following papers:

- Bruegge, Carol J., Wedad A. Abdou, David J. Diner, Barbara J. Gaitley, Mark C. Helmlinger, Ralph A. Kahn, and John V. Martonchik (2004). Validating the MISR radiometric scale for the ocean aerosol science communities. In Post-launch calibration of satellite sensors, Stanley A. Morain and Amelia M. Budge, editors. A.A. Balkema Publishers, Leiden, Netherlands, pp.103-115.
- Kahn, R., W-H. Li, J. Martonchik, C. Bruegge, D. Diner, B. Gaitley, W.Abdou, O. Dubovik, B. Holben, S. Smirnov, Z. Jin, and D. Clark, 2005. MISR low-light-level calibration, and implications for aerosol retrieval over dark water, J. Atmosph, Sci., in press.
- Diner, D.J., R.A. Kahn, C.J. Bruegge, J.V. Martonchik, W.A. Abdou, B.J. Gaitley, M.C. Helmlinger, O.V. Kalashnikova, and W-H. Li (2004). Refinements to MISR's radiometric calibration and implications for establishing a climate-quality aerosol observing system. Proc. SPIE 5652, 57-65.
- Bruegge, Carol J., Nadine L. Chrien, Robert R. Ando, David J. Diner, Wedad A. Abdou, Mark C. Helmlinger, Kurtis Thome. Validation of Multi-angle Imaging SpectroRadiometer (MISR) radiometric data products IEEE Trans. Geosci. Remote Sens., 40 (7), pp. 1477-1492, July 2002.
- Chrien, Nadine, L, Carol J. Bruegge, and Robert R. Ando (2001). Multi-angle Imaging SpectroRadiometer (MISR) On-Board Calibrator (OBC) In-flight Performance Studies. IEEE Trans. Geosci. Remote Sens., 40 (7), pp. 1493-1499, July 2002.
- Abdou, Wedad A., Carol J. Bruegge, Mark C. Helmlinger, James E. Conel, Stuart H. Pilorz, William Ledeboer, Barbara J. Gaitley, and Kurtis J. Thome. Vicarious calibration experiment in support of the Multi-angle Imaging SpectroRadiometer. IEEE Trans. Geosci. Remote Sens., 40 (7), pp. 1500-1511, July 2002.

The MISR Data and Information page contains a link to the MISR Home Page for those who desire more details.