



MODIS Reflective Solar Bands Calibration Performance and Major Improvements in C6



MODIS Characterization Support Team*

Introduction

- MODIS is a key instrument for NASA's Earth Observing System. It is onboard both the Terra (launched on December 18, 1999) and Aqua (launched on May 4, 2002) spacecrafts.
- MODIS uses a 2-sided paddle wheel scan mirror to provide ± 55 degree scans of Earth view (EV) covering 10 km (nadir) along track by 2330 km along scan swath.
- MODIS has 20 reflective solar bands (RSB) ranging from 0.41 to 2.3 μm , with spatial resolution of 250 m (bands 1-2), 500 m (bands 3-7) and 1 km (bands 8-19,26).
- RSB are calibrated on-orbit using the Solar Diffuser (SD), the Spectro-Radiometric Calibration Assembly (SRCA), lunar observations and EV mirror side ratios.

RSB Key Specifications

Band	CW (nm)	BW (nm)	I FOV (m)	Ltyp (W/m ² /sr/ μ)	Lmax (W/m ² /sr/ μ)	Lcloud (W/m ² /sr/ μ)	SNR
1	645	50	250	21.8	685	457	128
2	858	35	250	24.7	285	293	201
3	469	20	500	35.3	593	570	243
4	555	20	500	29.0	518	559	228
5	1240	20	500	5.4	110	138	74
6	1640	24	500	7.3	70	68	275
7	2130	50	500	1.0	22	27	110
8	412	15	1000	44.9	175	573	880
9	443	10	1000	41.9	133	585	838
10	488	10	1000	32.1	101	539	802
11	531	10	1000	27.9	82	538	754
12	551	10	1000	21.0	64	528	750
13L	667	10	1000	9.5	32	471	910
14L	678	10	1000	8.7	31	440	1087
15	748	10	1000	10.2	26	373	586
16	869	15	1000	6.2	16	286	516
17	905	30	1000	10.0	185	252	167
18	936	10	1000	3.6	256	267	57
19	940	50	1000	15.0	189	244	250
26	1375	30	1000	6.0	90	113	150
13H	667	10	1000	9.5	32	471	910
14H	678	10	1000	8.7	31	440	1087

On-Orbit Calibration Algorithms

Retrieval Algorithm

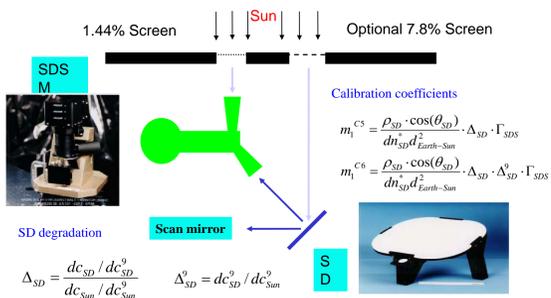
$$R_{EV} = \rho_{EV} \cdot \cos(\theta_{EV}) = m_1 \cdot dn_{EV}^* \cdot d_{Earth-Sun}^2$$

$$dn_{EV}^* = dn_{EV} \cdot (1 + k_{INST} \cdot \Delta T_{INST}) / RVS_{EV}$$

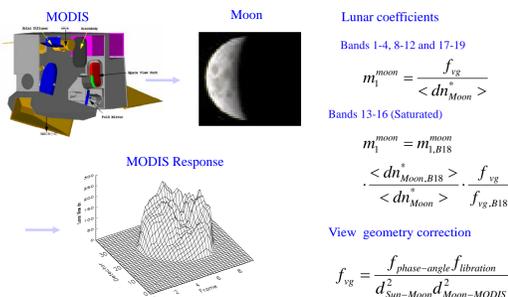
$$R_{Sun} = m_1 \cdot dn_{EV}^* \cdot E_{Sun} / \pi$$

E_{Sun} : 0.4-0.8 μm Thuillier et al., 1998; 0.8-1.1 μm Neckel and Labs, 1984; Above 1.1 μm Smith and Gottlieb, 1974

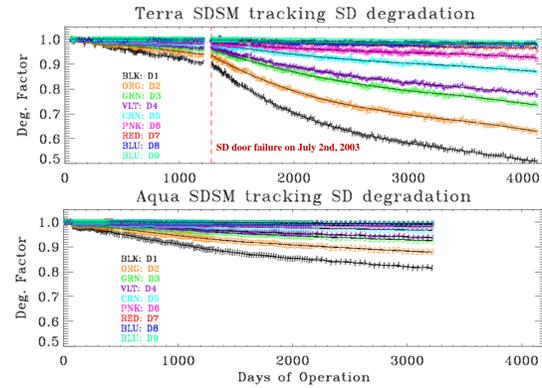
RSB SD Calibration



RSB lunar calibration

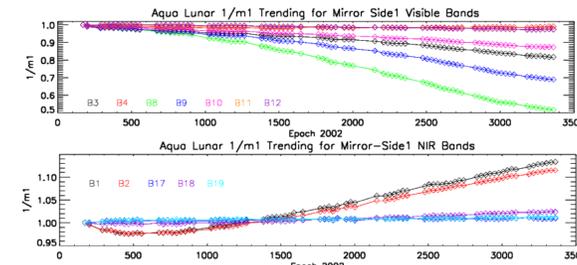
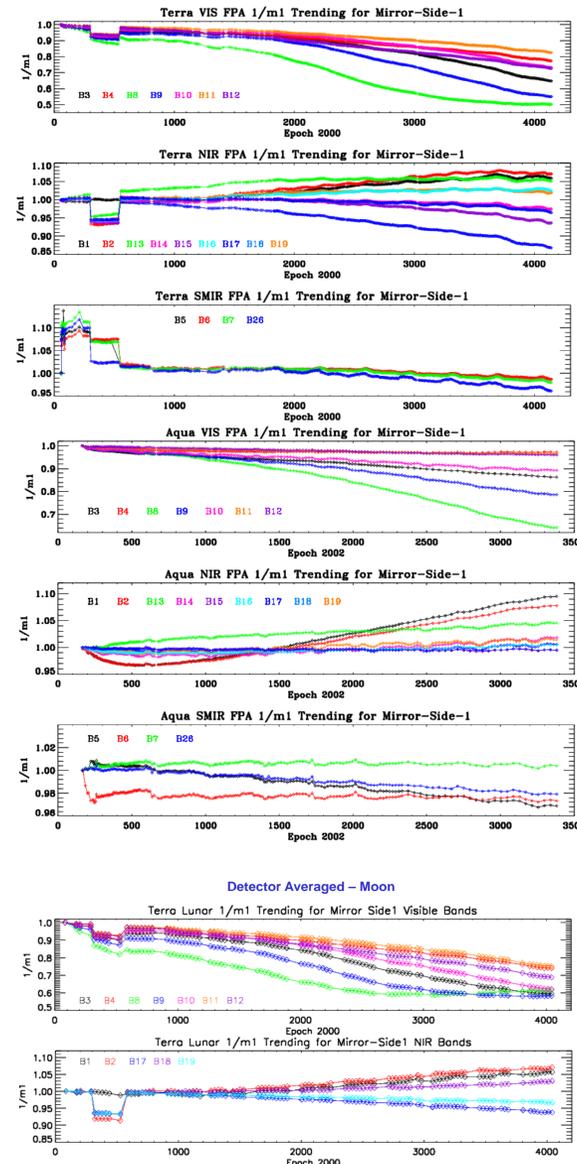


SD Degradation Performance

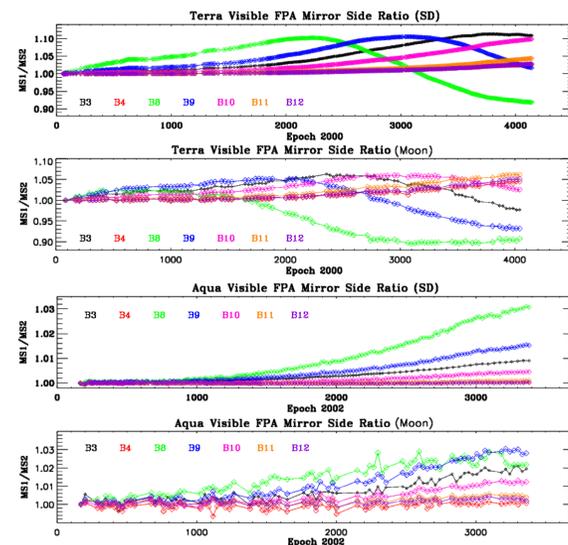


On-Orbit Performance

MODIS RSB Response Trending



Mirror Side Differences



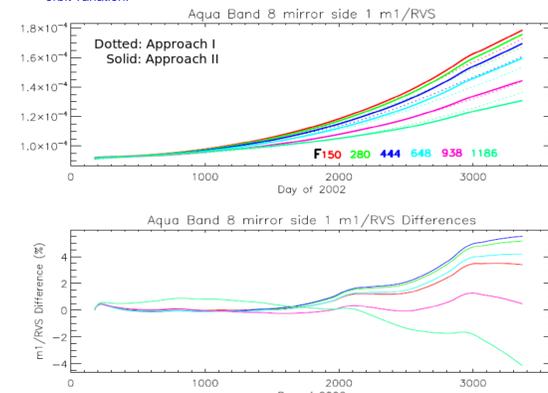
Major Improvements in Collection-6

Approach I

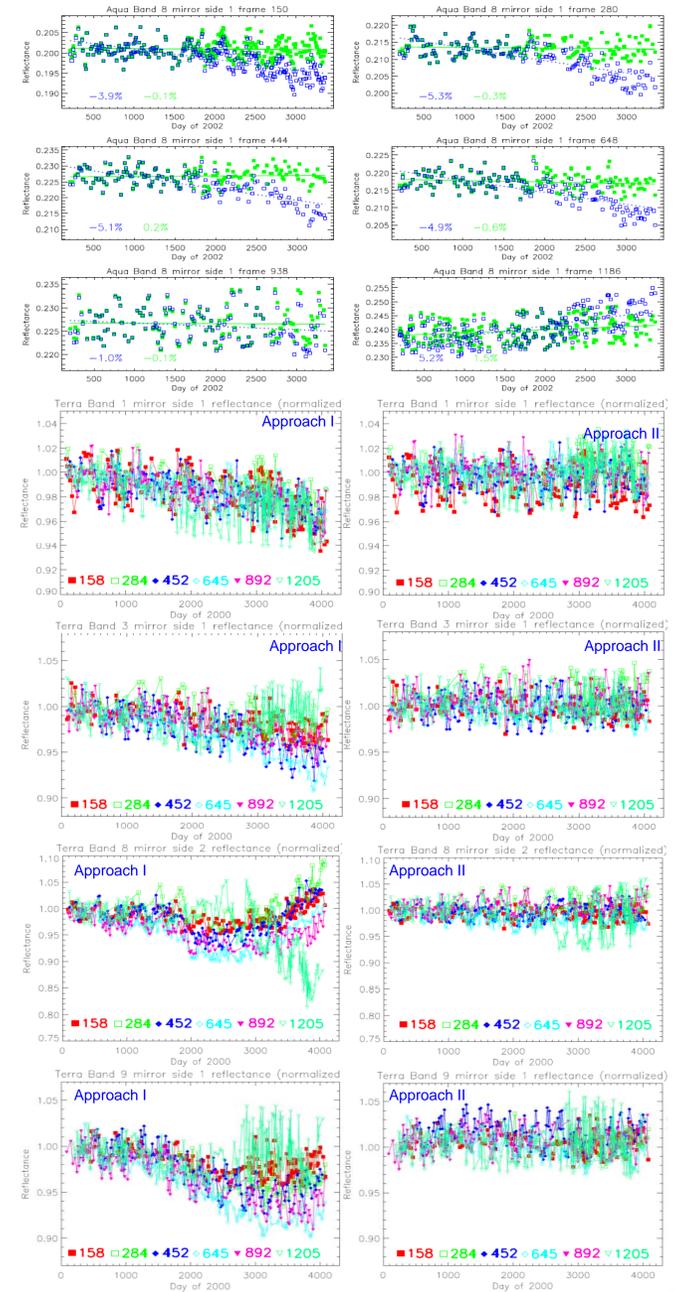
- m1 and RVS are generated based on SD and lunar calibrations with EV and SRCA mirror side (MS) ratios.
- MS1 RVS on-orbit variation is tracked using SD and lunar calibration coefficients with a linear approximation for its angle of incidence (AOI) dependence.
- MS2 RVS on-orbit variations is derived from the mirror side ratio of the instrument response (SD, Moon, EV, and SRCA) with a quadratic approximation for the AOI dependence and using MS1 RVS as reference.
- Detector-dependent RVS for bands 1-4,8-12, and time-dependent RVS for bands 13-16.
- No time-dependent RVS applied to bands 5-7 and 26.

Approach II

- m1 and RVS are generated based on the lunar calibration, SD calibration (absolute calibration at beginning of the mission, detector difference for entire mission, and short-term calibration), and EV instrument response trending at selected AOI.
- Detector differences in both m1 and RVS are identical to the Approach I, which are obtained from SD and lunar calibration coefficients.
- The lunar m1 is used to track the gain change at the AOI of the SV.
- The EV dn trending at 11 or 10 selected AOI are used to track the detector averaged m1 and RVS change on-orbit.
- A quartic approximation is applied for both MS1 and MS2 AOI dependence of the RVS on-orbit variation.



TOA Reflectance Validations



Summary

- MODIS has successfully operated for more than 11 and 9 years for Terra and Aqua, respectively.
- Both Terra and Aqua SDSM operations are scheduled every three weeks.
- RSB SD calibrations are carried out daily for Terra and tri-weekly for Aqua.
- Both Terra and Aqua view the Moon approximately monthly to track the RVS change.
- Terra has much larger mirror side difference than Aqua. Terra Band-3,8,9,10 experience more than +/-10%, however all Aqua bands are within 3%.
- Terra Band 8 has about 50% gain change, and Aqua Band 8 has about 35% gain change.
- Terra has 1 noisy RSB detector, and Aqua has 1 noisy and 13 inoperable RSB detectors.
- Two approaches have been developed for RVS calculations in C6.
 - Approach I: based on SD and lunar calibrations with EV and SRCA mirror side ratios.
 - Approach II: based on the lunar calibration, SD calibration, and EV instrument responses.
- Major improvements in C6
 - Detector dependent RVS for bands 1-4,8-12, and time dependent RVS for bands 13-16 are implemented.
 - Long term reflectance drifts are significantly reduced in Aqua bands 8,9, and Terra bands 1-4,8,9.

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