STATUS OF TERRA AND AQUA MODIS INSTRUMENTS

X. Xiong[1], B. Wenny[2], T. Chang[2], J. Sun[2], H. Chen[2], A. Wu[2], W. Barnes[3], and V. Salomonson[4]

[1]Sciences and Exploration Directorate, NASA/GSFC, Greenbelt, MD 20771, USA
[2]Sigma Space Co., 10210 Greenbelt Road, Lanham, MD 20706, USA
[3]University of Maryland, Baltimore County, 1000 Hilltop Circle, Baltimore, MD 21250, USA
[4]University of Utah, Salt Lake City, UT 84112, USA

1. INTRODUCTION

Terra MODIS has successfully operated for over 10 years and Aqua MODIS 8 years since their launch in 1999 and 2002, respectively. Together, they have generated an unprecedented amount of science data products, which are extensively used by the worldwide science and user community for studies of changes in the Earth's land, ocean, and atmospheric properties, and their impact on climate and the environment [1]. Improved over its heritage sensors in terms of its overall spectral, spatial, and radiometric characteristics, MODIS collects data in 36 spectral bands from the visible (VIS) to long-wave infrared (LWIR) and at 3 spatial resolutions (0.25, 0.5, and 1km). 20 of the 36 spectral bands (bands 1-19, and 26) are the reflective solar bands (RSB) and the remaining 16 (bands 20-25 and 27-36) are the thermal emissive bands (TEB). In order to maintain sensor on-orbit calibration and data product quality, MODIS was designed with a set of on-board calibrators (OBC), including a solar diffuser (SD) and solar diffuser stability monitor (SDSM) system for RSB calibration, a blackbody (BB) for TEB calibration, and a spectroradiometric calibration assembly (SRCA) for sensor spectral and spatial calibration [2]. MODIS OBC are operated either constantly or on a regular basis, generating time-dependent calibration coefficients for the level 1B (L1B) production code. Since launch, both MODIS instrument have provided satisfactory performance over their entire missions. In a number of areas, however, Aqua MODIS has demonstrated better performance than its predecessor, Terra MODIS [3, 4]. This paper provides an overview of MODIS operation and calibration activities. It illustrates each instrument and its OBC on-orbit performance and summarizes results derived from sensor radiometric, spectral, and spatial calibration and characterization.

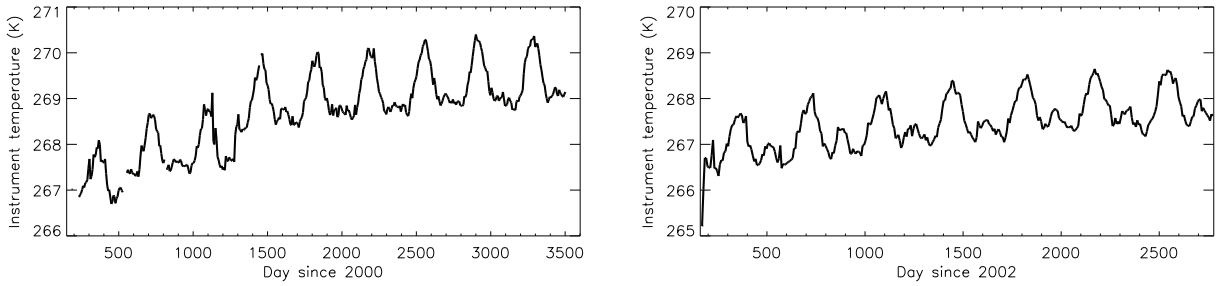
2. OPERATION AND CALIBRATION ACTIVITIES

For each instrument, there are approximately 30 operation and calibration activities. These activities are built into commands and executed by the MODIS Characterization Support Team (MCST) at NASA/GSFC in order to safely operate, constantly monitor, and accurately calibrate both Terra and Aqua MODIS. Key calibration activities include regular SD/SDSM operations, constant BB temperature control (290K for Terra MODIS and 285K for Aqua MODIS) and periodic BB warm-up and cool-down (WUCD) cycles (between 272K and 315K), and different SRCA operations. Special activities have also been planned in conjunction with spacecraft maneuvers. For example, spacecraft roll maneuvers are performed on a near-monthly basis, allowing MODIS to make lunar observations at the same phase angle. Excluding operations executed for function and configuration tests, there have been a total of 299 SD/SDSM operations, 53 BB WUCD cycles, and 92 scheduled lunar observations for Terra MODIS. Apart from monthly SRCA radiometric calibration events, Terra MODIS has also made 36 spectral and 53 spatial calibrations. As expected, these numbers are slightly lower for Aqua MODIS. With both missions continuing to operate beyond their design lifetime of 6 years, some operation and calibration frequencies have been slowly reduced without effecting the existing calibration and data product quality.

3. INSTRUMENT AND CALIBRATION PERFORMANCE

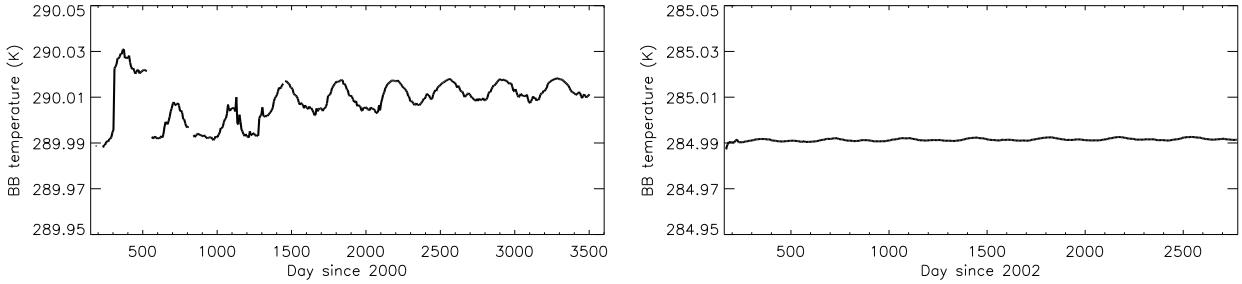
Since launch, Terra MODIS has operated using different configurations, including A-side configuration, B-side configuration, and the current cross strapping of A-side electronics and B-side formatter. On the other hand, Aqua MODIS has been using its B-side configuration from the mission beginning to present. Figure 1 shows Terra and Aqua MODIS instrument temperatures (weekly averaged) over their entire missions. In addition to expected periodic or seasonal oscillations, the changes in Terra MODIS instrument temperatures during a 10-year period have been less than 3.0K. A small but noticeable step of temperature increase (around day 1300) is due to a change in the SD door configuration, when the SD door was permanently fixed at its open position. The changes in Aqua MODIS instrument temperatures over a period of nearly 8 years have been less than 1.5K. In general, the operational conditions of both instruments have been and continue to be stable. MODIS TEB calibration is performed on a scan-by-scan basis using its on-board BB, which is normally set at 290K for Terra MODIS and 285K for Aqua MODIS. Figure 2 illustrates Terra and Aqua MODIS BB temperature trends over their respective missions. BB temperatures during periodic BB WUCD operations are excluded from these trends. Small step-wise changes in Terra MODIS BB temperatures are due to telemetry setting point differences under different operational configurations. Ignoring changes caused by different configurations, the drift of Terra MODIS BB temperatures has been less than 0.03K. Small seasonal variations of BB temperatures (±0.1K), which are closely coupled with the seasonal oscillations of instrument temperatures, also exist. In comparison, the temporal drifts

and seasonal variations of Aqua MODIS BB temperatures are extremely small. In general, Aqua MODIS instrument is more stable than Terra MODIS.



(a) (b)

Figure 1 MODIS instrument temperatures: (a) Terra MODIS; (b) Aqua MODIS



(a) (b)

Figure 2 MODIS BB temperatures: (a) Terra MODIS; (b) Aqua MODIS

MODIS SD on-orbit degradation is monitored by the SDSM. The degradation rate is wavelength dependent with larger changes occurring at shorter wavelengths. MODIS RSB calibration is reflectance based with coefficients derived from SD observations and changes in SD bi-directional reflectance factor (BRF) must be removed. As the Terra MODIS SD door is currently fixed in an open position, its SD degradation rates are much faster than Aqua MODIS due to the increased solar exposure. For MODIS RSB responses, larger changes are also observed at shorter wavelengths. In general, changes in TEB responses are much smaller as the optics degradation is wavelength dependent and primarily affects the RSB. In addition, the TEB detectors are located on the cold focal plane assemblies which are constantly controlled at 83K via a passive cooler. Details of sensor response changes will be discussed in this paper. The 36 MODIS spectral bands have a total of 490 detectors. Currently, there are 44 noisy detectors (30 from pre-launch) and no inoperable detectors in Terra MODIS and there are 6 noisy detectors (2 from pre-launch) and 13 inoperable detectors (10 from pre-launch) in Aqua MODIS. Most inoperable detectors are in band 6 at 1.64μ. For both Terra and Aqua MODIS, on-orbit changes in sensor spectral and spatial characteristics, such as center wavelengths (CW) and bandwidths (BW), and band-to-band registrations (BBR), have been very small. It is expected that, with constant and dedicated calibration efforts, both Terra and Aqua

MODIS will continue to function well and make significant contributions to many scientific studies and applications.

4. REFERENCES

[1] V. Salomonson, W. Barnes, X. Xiong, S. Kempler, and E. Masuoka, "An Overview of the Earth Observing System MODIS Instrument and Associated Data Systems Performance," *Proceedings of IGARSS 2002*.

[2] X. Xiong, K. Chiang, J. Esposito, B. Guenther, and W. Barnes, "MODIS On-orbit Calibration and Characterization," *Metrologia* 40, 89-92, 2003.

[3] X. Xiong, B. Wenny, A. Wu, W. Barnes, and V. Salomonson, "Aqua MODIS Thermal Emissive Bands On-orbit Calibration, Characterization, and Performance," *IEEE Trans. Geosci. Remote Sens.*, 47(3), 803-814, 2009.

[4] X. Xiong, J. Sun, X. Xie, W. Barnes, and V. Salomonson, "On-Orbit Calibration and Performance of Aqua MODIS Reflective Solar Bands," *IEEE Trans. Geosci. Remote Sens.*, 47(10), 2009.