An Overview of MODIS Calibration and Characterization and Lessons Learned

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The Moderate Resolution Imaging Spectroradiometer (MODIS) is a key instrument for NASA's EOS missions. Two nearly identical copies have flown on the Terra and Aqua spacecraft for more than 9 years and 6 years since their launch in December 1999 and May 2002, respectively. MODIS observations and associated data products have been widely used by the science community and users worldwide for studies of Earth's system of land, oceans, and atmosphere. MODIS was developed based on the desire of the science community to extend and enhance heritage sensors' data records. It was designed with enhancements made over its heritage sensors in terms of its spectral, spatial, and radiometric characteristics. It is a cross-track scanning radiometer, that uses a two-sided scan mirror, collecting data in 36 spectral bands covering spectral regions of visible (VIS), near-infrared (NIR), short-wave infrared (SWIR), mid-wave infrared (MWIR), and long-wave infrared (LWIR). The VIS, NIR, and SWIR bands (bands 1-19 and 26), which make measurements of daytime surface reflected radiances, are referred to as the reflective solar bands (RSB). The MWIR and LWIR bands (20-25 and 27-36), which measure both the daytime and nighttime scene emissive radiances, are thus referred to as the thermal emissive bands (TEB).

In order to meet its stringent design requirements, MODIS was built with a complete set of on-board calibrators, including a solar diffuser (SD), a solar diffuser stability monitor (SDSM), a blackbody (BB), a spectroradiometric calibration assembly (SRCA), and a space view (SV) port. The SD/SDSM system is used together for RSB calibration. The BB, capable of being operated with its temperature varying from instrument ambient to 315K, is designed for TEB calibration. The SRCA is primarily responsible for sensor spatial (RSB and TEB) and spectral (RSB only) stability characterization. For both RSB and TEB, the SV port provides measurements for the sensor's background and offsets. In addition to its on-board calibrators, each MODIS makes near monthly lunar observations to monitor RSB radiometric calibration stability. In this paper, we

provide an overview of MODIS instrument calibration and characterization methodologies, activities, and results from pre-launch to post launch, with emphasis on the lessons learned from its design to on-orbit operation. Currently, both instruments are operated normally and all the on-orbit calibration activities are performed on a regular basis with some at slightly reduced frequencies. The TEB responses have been extremely stable with less than 0.3% change per year. For the RSB, the changes are wavelength and scan angle dependent with the largest changes in the VIS spectral bands. As both Terra and Aqua MODIS continue to operate beyond their prime missions, constant effort is still needed to maintain instrument and calibration and data product quality. This paper shows that the lessons from Terra MODIS design, test, and operation, have greatly benefitted Aqua MODIS. Because of this, Aqua MODIS overall performance is better than Terra MODIS. It is not surprising that lessons from MODIS calibration and characterization, from methodologies to on-orbit implementation, have also provided valuable information for the design and development of future earth observing missions/sensors, such as VIIRS on the NPP and NPOESS, ABI on GOES-R, OLI on LDCM, and the reflective solar sensor on CLARREO.