

MODIS Calibration Workshop Summary

January 30, 2008

Attendance:

Jack Xiong, Michael King, Robert Wolfe, Chuck McClain, Steve Platnick (NASA-GSFC)
David Doelling (NASA-LaRC)
Vincent Salomonson (U. Utah)
Robert Evans, Peter Minnett (U. Miami)
Chris Moeller, Dan LaPorte (U. Wisc.)
Kurt Thome (U. Ariz.)
Eric Vermote (U. Md)
Jeff Myers (U. Calif.)
Ewa Kwiatkowska, Gene Eplee, Gary Toller, James Kuyper, Liqin Tan, Xu Geng (SAIC)
Gerhard Meister (Futuretech)
Mash Nishihama (Raytheon)
Gary Lin (INNOVIM)
Roy Yi (STG)
Brian Wenny, Junqiang Sun, Aisheng Wu, Amit Angal, Na Chen, Hongda Chen, Jenn Dodd, Vincent Chiang, Jason Choi, Sergey Marchenko, Tim Dorman, Sadashiva Devadgia (SSAI)

Scheduled Agenda

Instrument Status (J. Xiong): Both MODIS instruments continue to operate normally. No major spacecraft events occurred since the last Science Team Meeting (STM) on November 1, 2006. All on-board calibrators continue to perform designed functions. Instrument and Focal Plane Assembly temperatures have remained stable. Instrument and warm focal plane temperatures show drift of ~3K for Terra (8 years) and less than 2K for Aqua (~6 years).

Concerns: Decreased Aqua cooler margin for Cold Focal Plane assembly – unable to completely control the CFPA to the set temperature, may affect short-term stability. It has no immediate impact on TEB calibration as it is performed on a scan-by-scan basis. Frequency of Aqua Solar Diffuser (SD) calibration events may need to be changed to preserve SD door movements. Current frequency is tri-weekly. One proposed option is to perform the screened calibrations monthly and unscreened calibrations every other month.

Level 1B and LUT Status (J. Kuyper): The L1B code has been relatively stable, only 7 minor changes since the end of 2004. Near-monthly LUT updates for both MODIS forward processing. Several special LUTs were generated, tested and delivered since the last STM – for the Ocean Biology Processing Group (OBPG) and a special Collection 4 LUT for the Famine Early Warning Systems Network. Ongoing activities to prepare for a Collection 6 – some proposed improvements require code changes and some can be made with LUTs, collaborative effort with calibration analysts to implement and test proposed changes.

Concerns: The consensus opinion was that L1B for Collection 6 should not be ‘frozen’ too soon to allow science disciplines to make changes at late stages in the process. Land team has requested MCST complete its Collection 6 improvements by September 2008 time frame based on its current activities and schedule.

RSB Calibration Performance (J. Sun): Overall, the Reflective Solar Band (RSB) calibration has performed well since the last STM. No new noisy or inoperable RSB detectors. The Terra Solar Diffuser door has remained in a fixed open position (with screen in place) since July 2003, resulting in an increased degradation rate of the SD especially at shorter wavelengths (e.g. Band 8). The response for Terra Band 8 has decreased about 42% (mirror side 1) and 47% (mirror side 2) over the instrument lifetime and Aqua Band 8 has decreased about 20%. Mirror side differences exist on Terra particularly at the shorter wavelength bands. On Aqua, the mirror side differences are less than 1% for all RSB bands.

Concerns: There are many challenges to maintain the calibration quality for Terra MODIS VIS bands, especially Bands 8 and 9, which show increasingly lower signal levels due to the largest SD and mirror degradation.

TEB Calibration Performance (B. Wenny): Unlike the RSB, the Thermal Emissive Band (TEB) performance has been very stable over the lifetime of both MODIS instruments. The on-board Blackbody calibrator has demonstrated excellent stability, both short term and long-term (within ~20 mK of BB temperature set point). The Terra long-wave IR (LWIR) bands, B27-B36, have shown a (not unexpected) slight decrease in response of about 0.5% per year. Aqua response has been relatively stable long-term for all TEB. The noise performance is good for both instruments with only one new noisy detector on each MODIS since last STM. Concerns: 1) The loss of cooler margin for the AQUA CFPA. 2) The number of noisy detectors for Terra LWIR PV bands (B27-30).

Spatial and Spectral Performance (J. Xiong): The spatial performance on both instruments has remained stable. The Terra Band-to-Band Registration (BBR) meets specifications except along-scan between Band 30 and Band 32. On Aqua, there is a known problem with BBR between the cold FPA bands and warm FPA bands. All MTF parameters continue to exceed design requirements. With a few exceptions, the center wavelength and bandwidth (VIS/NIR bands only) changes are less than 0.5 nm.

Concerns: Loss of 30W lamps capability in SRCA on both Terra and Aqua MODIS (this is an old concern since last STM)

Geolocation Status (R. Wolfe): Several changes have been made to the Collection 5 Geolocation – incorporation of new ancillary data, updated ground control points based on GeoCover Landsat 7 products, a new flag identifying times near/after maneuvers, and a Terra northern/southern hemisphere difference correction. Collection 5 results for Terra are excellent – RMS error is better than accuracy goal, and sun angle fit corrects for N/S hemisphere differences. For Aqua, the RMS error is better than goal in track direction but slightly larger than goal in scan direction (although still better than specification). Handling of geolocation during/after spacecraft maneuvers has been re-examined and several changes have been implemented to improve the geolocation accuracy during these periods. A method for an enhanced terrain correction proposed for inclusion in Collection 6.

Concerns: NA

Challenging Issues – TEB: A0/A2 Update Strategy (A. Wu): The nonlinear and offset calibration coefficients for the TEB are derived on-orbit from the Blackbody warm-up/cool-down quarterly activities. Ideally, pre-launch characterization would provide the operational

coefficients, however post-launch configuration and gain changes (Aqua Bands 31 & 32, Terra bands 20 & 22-32) necessitated the use of the on-orbit derived values. For Aqua B31/32 a $\sim +1\text{K}$ bias for cold scenes (near 200K) was observed in a comparison with simultaneous AIRS measurements. Tests with different options of combinations of A0 & A2 (pre-launch, warm-up, cool-down, A0=0) were investigated. Setting A0=0 does eliminate the cold scene bias for Aqua B31/32 and AIRS, and is the recommended approach for Collection 6. Further investigation is underway to assess the science product impact of changing the Terra PV bands to A0=0. This has been, since the very beginning, a collaborative effort with C. Moeller (U. of Wisconsin).

Concerns: Need a careful assessment of impact on science products before a change from the current approach is made. The impact on typical scene temperatures is most important and needs to be considered.

MODIS L1B Radiometric Assessment A0=0 for all TEB (C. Moeller): The comparison of MODIS and MODIS Airborne Simulator (MAS) ER-2 underflights has provided useful validation of Collection 5 MODIS data. MCST produced a set of granules for specific ER2 flights using the proposed A0=0 Collection 6 strategy. The results show little impact on Aqua MODIS radiometry for typical clear sky scene temperatures. Terra bands 24, 25, 27, and 28 show significant changes (detrimental) from the Collection 5 comparison. There was no apparent impact on detector striping.

Concerns: The limited number of test cases and very small scene temperature range used are not entirely ideal in assessing the overall impact of the proposed A0 strategy. Careful consideration of possible improvements at scene temperature extremes (cold and hot) need to be balanced with the small changes likely to typical scene temperatures which may result in a decrease in quality of current validation datasets.

MODIS Aqua SST Residuals (R. Evans): Aqua SST retrievals show a slight AOI dependence, with the largest effect being at edge AOI. Will examine more data and work with MCST to address this.

Challenging Issues – RSB: Degradation of Scan Mirror Reflectance for VIS Bands (J. Xiong):

Issue 1) Terra mirror side (MS) differences have been a known issue since launch and are strongly wavelength dependent, with the largest impact on bands 8 and 9. The RVS and polarization parameters are expected to be affected. An increase in MS difference is seen in Terra bands 8 & 9 starting in 2003 and has become noticeable in the L1B reflectance/radiance images. This MS difference increases with time, has a seasonal oscillation, varies with angle of incidence (larger at large AOI), and varies with latitude (larger at polar regions). MCST concluded that this can be explained by the polarization effects and also indicates that polarization parameters of Terra MODIS are changing dramatically in the last two years. OBPG Terra MODIS data process appears to support this conclusion. No appreciable mirror side difference is observed thus far for Aqua MODIS.

Concerns: Deriving relative RVS properly is now a major challenge. The impact on the polarization parameters needs to be assessed. Corrections for some science data products are needed since L1B does not address the polarization issue.

Issue 2) Detector-to-Detector difference (D2D). This is closely related to issue 1). Changes of D2D difference started ~ 2004 for Terra MODIS bands 8 & 9, (related to mirror degradation). D2D difference varies with time and angle of incidence. No obvious changes in D2D difference in Aqua MODIS.

Concerns: Impact on RVS correction strategy needs to be assessed. A detector-dependent RVS is probably needed for Collection 6, at least for several VIS bands.

MODIS Terra Cross-calibration for Ocean Color Bands (E. Kwiatkowska):

Terra MODIS has a known mirror side difference issue at short wavelength bands which has made deriving Ocean Color products problematic. Collaborative efforts with MCST have identified RVS and polarization having the largest impact on the data. An approach using cross-calibration with SeaWiFS was developed to determine polarization coefficients to be applied on top of MCST LUT calibrations. Time-dependent polarization correction coefficients were derived. The coefficients will be validated and applied to the data and the impact on the Ocean Color products needs to be assessed.

Concerns: Derived polarization parameters are very large and require verification and validation.

Polarization Effect at 412nm Depending on Mirror Side for Terra (Band 8) (E. Vermote):

The impact of the polarization issue also became evident in certain Land products, particularly for Terra band 8. No impact was noted for Aqua data. A simulation of polarization demonstrated that the polarization of the incident light is geolocation dependent and thus could produce the mirror side ratio variation with latitude if the polarization parameters of the two mirrors sides are different. This is consistent with what MCST has observed in the trending of Terra and Aqua mirror side ratio.

Other Challenging Issues and Future Work (J. Xiong):

A number of challenging issues remain for MODIS, including:

- SD degradation - VIS band signals have dropped significantly in SD observations (SD degradation plus mirror degradation); Detector non-linearity may also impact calibration quality; SD degradation uniformity
- Noisy Detectors Terra LWIR PV bands
- RSB RVS Determination - Extremely challenging for Terra VIS bands due to large mirror degradation and changes of mirror polarization; NIR bands 13-16 (saturate during lunar observations)
- Improvement of band 21 calibration
- Calibration consistency (Terra versus Aqua, MODIS versus other sensors)
- MSCN impact on Terra PC bands 33-36

Issues to be addressed in Collection 6:

- Overall RVS improvement
- Detector dependent RSB RVS
- RVS for NIR bands 13-16 (work started with OBPG for quality assessment)
- B21 calibration improvements
- Noisy detector (sub-sample) QA flag impact on science data products
- a0/a2 update (due to potential change of update strategy)
- Band 2 (Terra) detector's sub-frame crosstalk correction (exist in 2 of 40 detectors)

- SWIR correction coefficients (update)
- Some code changes to improve data QA (e.g. DN=0 check) and to prepare for missing calibration telemetry (e.g. if any of the BB thermistor fails)
- Update on-orbit calibration uncertainty

Concerns: Several participants queried if it is possible to do another yaw maneuver for Terra as all the measurements of the SD BRDF were pre-SD door failure. FOT needs to be consulted to see if one can be scheduled. It was proposed that polarization corrections factors be made available in Collection 6 as metadata to the users. Ocean discipline will work with LIB on format and coordinate with Land & Atmosphere disciplines on what information to include.