MODIS Collection 6
MCST Proposed Changes to L1B
Introduction

• MODIS Collection History
  – Collection 5 – Feb. 2005 - present
  – Collection 2 – Terra launch – June 2001
Collection 6 Issues

• RSB
  – Detector Dependent RVS
  – m1 correction
  – Reprocess m1 (using current algorithm)
  – New LUT containing Polarization correction information

• TEB
  – a0/a2 Strategy

• QA
  – Fill Values instead of Interpolation for Inoperable Detectors
  – New QA LUT: Subframe level QA flags
  – Minor formatting error in ASCII LUT

• Space view DN=0
# Collection 6 Issue Status

<table>
<thead>
<tr>
<th>#</th>
<th>Issue</th>
<th>Change Type</th>
<th>Change Status</th>
<th>Test Data Produced</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fill vs Interpolation for inoperable detectors</td>
<td>Code</td>
<td>Complete</td>
<td>Yes</td>
<td>Code changes complete 1-day ‘golden tile’ data produced and available.</td>
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<tr>
<td>2</td>
<td>Noisy/Inoperable Subframe</td>
<td>Code, LUT</td>
<td>Complete</td>
<td>Limited</td>
<td>L1B code changes and new QA LUT complete. Limited test data produced.</td>
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<tr>
<td>3</td>
<td>A0/A2 Strategy</td>
<td>LUT</td>
<td>Complete</td>
<td>Limited</td>
<td>Initial V6 LUT derived. Limited set of test data produced.</td>
</tr>
</tbody>
</table>
## Collection 6 Issue Status

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<tbody>
<tr>
<td>4</td>
<td>Reprocess m1</td>
<td>LUT</td>
<td>Complete</td>
<td></td>
<td>Mission m1 reprocessed using current algorithm</td>
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<tr>
<td>5</td>
<td>m1 correction</td>
<td>LUT</td>
<td>Complete</td>
<td>Limited</td>
<td>Initial v6 LUT derived</td>
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<tr>
<td>6</td>
<td>Detector dependent RVS</td>
<td>LUT</td>
<td>Complete</td>
<td>Limited</td>
<td>Initial v6 LUT derived</td>
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<tr>
<td>7</td>
<td>Polarization correction information</td>
<td>LUT</td>
<td>Pending</td>
<td></td>
<td>Provide information for users to correct L1B data for polarization effects</td>
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</table>
Fill Value vs Interpolation

- **Current v5 approach:** Interpolation using the adjacent good detectors has been used since beginning of mission
  - Originally introduced in v2.4.3 on 06/12/2000

- **Request from Land team to reconsider this decision and use fill values in v6**

- **Proposed change:** Fill value instead of interpolation for inoperable detectors
Fill Value vs Interpolation

• Bands impacted based on current QA LUT
  – Terra
    • B29 D6
  – Aqua
    • B5 D20
    • B6 D10, 12-16, 18-20
    • B36 D5
L1B Impact Example: Terra Band 29

Terra Band 29 Detector 6: currently flagged as inoperable in QA
Impact on Aggregate L1B Products

Test scenario with multiple inoperable detectors in Terra Band 2

Collection 5

Collection 6 (with test QA)
Impact on Aggregate L1B Products

Test scenario with multiple inoperable detectors in Terra Band 2

Collection 6 (with test QA)  Collection 6: 500m Aggregate
Impact on Aggregate L1B Products

Test scenario with multiple inoperable detectors in Terra Band 2

Collection 6 (with test QA)  Collection 6: 1km Aggregate
Fill Value vs Interpolation

• v6 L1B code changes completed

• Test data is available through lads
  – 1 day ‘Golden Tile’ granules (2007079)
  – At least one detector set as inoperable in each band
    • Multiple adjacent detectors in 250m & 500m bands
Subframe QA

• **Current v5 approach**
  – QA flags only set on a detector basis

• Terra B2 D29 & 30 subframe 1 have a known crosstalk issue.

• **Proposed change:**
  – Code change and new QA LUT to allow QA flag for noisy/inoperable to be set at subframe level
  – Noisy subframe – flag is set for user information, no impact on L1B
  – Inoperable subframe – Fill value in L1B
L1B Impact example: Terra Band 2

Collection 6 test data with Subframe 1, Detector 29 & 30 flagged as inoperable
L1B Impact Example: Terra Band 2

Collection 6 test data with Subframe 1, Detector 29 & 30 flagged as inoperable
Subframe QA

• Bands impacted:
  – Terra B2 D29 & 30 subframe 1
  – Subframes to be flagged as Noisy

• Initial v6 L1B code changes and new subframe QA LUT completed
Collection 6 A0/A2 Strategy

• Motivation
  – TEB Prelaunch BB calibration range 170-340 K
    • On-orbit BB calibration range 270-315 K
  – Issue: Aqua B31/32 & Terra TEB (gain change and config/elec changes mean we have no valid prelaunch calibration and have to rely on on-orbit calibration data from the warm-up/cool-down activities)
  – Historically, TEB has demonstrated good performance at typical scene temperatures.
  – A cold scene bias (~1K) has been observed and reported for Aqua B31 & 32 compared to AIRS for extreme low temperature scenes (~200K) using v5 data.

• Re-examination of A0/A2 strategy could yield improvements in temperature retrievals for low scene temperatures while minimizing impact at typical scene temperatures.
Proposed v6 A0/A2 Strategy

**Aqua**

<table>
<thead>
<tr>
<th>v4/v5*</th>
<th>v6</th>
</tr>
</thead>
<tbody>
<tr>
<td>B20, 22-30</td>
<td>PL a0/a2 no change</td>
</tr>
<tr>
<td>B21</td>
<td>a0 = 0 and a2 = 0 no change</td>
</tr>
<tr>
<td>B31-32</td>
<td>Warm-up a0/a2 a0 = 0, cool-down a2</td>
</tr>
<tr>
<td>B33-36</td>
<td>a0 = 0, PL a2 no change</td>
</tr>
</tbody>
</table>

**Terra**

<table>
<thead>
<tr>
<th>v4/v5*</th>
<th>v6</th>
</tr>
</thead>
<tbody>
<tr>
<td>B20, 22-30</td>
<td>Warm-up a0/a2 Cool-down a0/a2</td>
</tr>
<tr>
<td>B21</td>
<td>a0 = 0 and a2 = 0 no change</td>
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<tr>
<td>B31-32</td>
<td>Warm-up a0/a2 a0 = 0, cool-down a2</td>
</tr>
<tr>
<td>B33-36</td>
<td>a0 = 0, warm-up a2 a0 = 0, cool-down a2</td>
</tr>
</tbody>
</table>

*Changes in TEB between v4 & v5 included: On-orbit TEB RVS updated from Deep Space Maneuver (Terra), Cavity term average of 4 telemetry points instead of 1*
L1B Impact Assessment

• Compile new time dependent a0/a2 LUT using the v6 approach

Test Data Sets

• L1A granules with v5 & v6 LUT with EV data filled to cover entire dynamic range
• Specific L1B granules coinciding with the Univ. Wisconsin ER-2 flights (MODIS Airborne Simulator)
• One orbit of L1B data sets (Terra: June 21, 2007; Aqua June 20, 2006)
Aqua L1B Impact Assessment

Aqua TEB A0 & A2 Test (2008120.1250; Product Order; MS1)

\[
\text{Diff. in BT} = \text{BT(from avg}_\text{a0)} - \text{BT(from LUT a0); EV frames: 600 to 700}
\]

\[
T_{\text{0.3lltp};} \quad T_{\text{lltp};} \quad T_{\text{lmax};} \quad D1 \quad D2 \quad D3 \quad D4 \quad D5 \quad D6 \quad D7 \quad D8 \quad D9 \quad D10
\]
Aqua L1B Impact Assessment

• ER-2 MAS comparison

Aqua MODIS TIR Band Accuracy Assessment
Nov 21, 2002; 1940 UTC; SHISF2

Plot courtesy of Chris Moeller

Bands 31 & 32: nearly identical for this case with typical scene temperatures
One orbit of granules – June 20, 2006 – near nadir footprints
MODIS resampled to AIRS footprint, AIRS spectra convoluted with MODIS bandpass
Aqua L1B Impact Assessment

Scene temperature dependence of Aqua MODIS/AIRS difference (B31)
(near nadir AIRS footprints, one orbit)

Solid line: v5
Dashed line: v6
Terra L1B Impact Assessment

Terra TEB A0 & A2 Test (2001091.1635; Product Order; MS1)

Diff. in BT = BT(from avg_a0) - BT(from LUT a0); T_0.3Ltyp; T_Ltyp; T_Lmax; EV frames: 600 to 700; D1 D2 D3 D4 D5 D6 D7 D8 D9 D10
Terra L1B Impact Assessment

Terra TEB A0 & A2 Test (2001091.1635; Product Order; MS1)

Diff. in BT = BT(from avg_a0) - BT(from LUT a0); T_0.3Ltyp; T_Ltyp; T_Lmax;
EV frames: 600 to 700; D1 D2 D3 D4 D5 D6 D7 D8 D9 D10
Terra L1B Impact Assessment

- ER-2 MAS comparison analysis

Terra MODIS TIR Band Accuracy Assessment
April 1, 2001; 1635 UTC; SHISFRN

Plot courtesy of Chris Moeller
Terra L1B Impact Assessment

Terra TEB A0 & A2 Test (2004100.0600; Product Order; MS1)

Diff. in BT = BT(from avg_a0) - BT(from LUT_a0);
T_\_0.3Ltyp; T_\_Ltyp; T_\_Lmax;

EV frames: 600 to 700
D1 D2 D3 D4 D5 D6 D7 D8 D9 D10
Terra L1B Impact Assessment

Terra TEB A0 & A2 Test (2004100.0600; Product Order; MS1)

Diff. in BT = BT(from avg_a0) - BT(from LUT_a0);
T_0.3Ltyp; T_Ltyp; T_Lmax;

EV frames: 600 to 700
D1 D2 D3 D4 D5 D6 D7 D8 D9 D10
Terra L1B Impact Assessment

• ER-2 MAS comparison analysis

Terra MODIS TIR Band Accuracy Assessment
April 9, 2004; 0600 UTC; SHISF2

Plot courtesy of Chris Moeller
Terra L1B Impact Assessment

One orbit on June 21, 2007

Band 25

25% 70%

Band 29

15% 85%

Band 31

8% 90%

Band 35

98%
## Estimated L1B Impact

<table>
<thead>
<tr>
<th>Band</th>
<th>$T_{typ}$</th>
<th>Terra</th>
<th>Aqua</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\Delta T @ T(0.3L_{typ})$</td>
<td>$\Delta T @ T(L_{typ})$</td>
<td>$\Delta T @ T(0.9L_{max})$</td>
</tr>
<tr>
<td>20</td>
<td>300</td>
<td>- 0.10</td>
<td>+ 0.02</td>
</tr>
<tr>
<td>22</td>
<td>300</td>
<td>- 0.05</td>
<td>+ 0.02</td>
</tr>
<tr>
<td>23</td>
<td>300</td>
<td>- 0.08</td>
<td>+ 0.02</td>
</tr>
<tr>
<td>24</td>
<td>250</td>
<td>- 1.20</td>
<td>- 0.30</td>
</tr>
<tr>
<td>25</td>
<td>275</td>
<td>- 0.40</td>
<td>- 0.08</td>
</tr>
<tr>
<td>27</td>
<td>240</td>
<td>- 0.50</td>
<td>- 0.20</td>
</tr>
<tr>
<td>28</td>
<td>250</td>
<td>- 0.70</td>
<td>- 0.15</td>
</tr>
<tr>
<td>29</td>
<td>300</td>
<td>- 0.20</td>
<td>- 0.03</td>
</tr>
<tr>
<td>30</td>
<td>250</td>
<td>+ 0.40</td>
<td>+ 0.15</td>
</tr>
<tr>
<td>31</td>
<td>300</td>
<td>- 0.20</td>
<td>- 0.04</td>
</tr>
<tr>
<td>32</td>
<td>300</td>
<td>- 0.20</td>
<td>- 0.04</td>
</tr>
<tr>
<td>33</td>
<td>260</td>
<td>+ 0.10</td>
<td>+ 0.08</td>
</tr>
<tr>
<td>34</td>
<td>250</td>
<td>+ 0.10</td>
<td>+ 0.08</td>
</tr>
<tr>
<td>35</td>
<td>240</td>
<td>+ 0.10</td>
<td>+ 0.08</td>
</tr>
<tr>
<td>36</td>
<td>220</td>
<td>+ 0.08</td>
<td>+ 0.08</td>
</tr>
</tbody>
</table>
A0/A2 Summary

• Initial time dependent LUTs derived and tested
  – Results indicate improved performance for low temperature scenes.

• To be completed: Verification of v6 Terra LUTs by analysis of each cool-down dataset
  – Initial LUTs derived from average a0/a2 from all CD events within a given configuration
RSB LUTs Improvements in MODIS L1B Collection 6
Outline

• Introduction
• Correction for detector bias in the SD m1
  ▪ Algorithm
  ▪ Results
• Detector dependent RVS
  ▪ Algorithm
  ▪ Results
• V6 and V5 RVS comparison
• Application to the EV data
• Summary
Introduction

• m1:
  ▪ Approximations used in our SD calibration
  ▪ EV radiance detector difference trending at AOI of the SD

• RVS
  ▪ Current V5 RVS is detector independent and derived from the detector averaged SD m1, lunar m1, and mirror side ratios
  ▪ EV radiance detector difference trending at other AOI
Introduction
Introduction
Correction for detector bias in SD m1

- MODIS calibration coefficients

\[ m1' = m1 / R_{m1} \]

  - \( m1 \): Current calibration coefficients
  - \( m1' \): Corrected calibration coefficients
  - \( R_{m1} \): Correction for the calibration coefficients

- Correction:

\[ R_{m1} = \frac{L_{EV}}{\langle L_{EV} \rangle_d} \]

  - \( \langle \ldots \rangle_d \): Averaged over detectors in the band
Correction for detector bias in SD m1
Correction for detector bias in SD m1
Detector dependent RVS

• Algorithm
  ▪ For MS1, the detector dependent RVS is derived from the SD and lunar m1 with a linear approximation
  ▪ For MS2, the detector dependent RVS is derived from the EV, lunar, and SRCA dn mirror side ratios
  ▪ Data fitted to smooth functions
  ↪ The normalized detector dependent SD m1, lunar m1, and MS ratios are fitted to proper functions, which are, in general, composed of several of analytical functions smoothly connected
  ↪ The detector differences of the SD m1, lunar m1, and MS ratios are fitted to a properly chosen polynomial for each band and detector
Detector dependent RVS
Detector dependent RVS

Terra RVS for B8 mirror side 2

SV

Nadir
Detector dependent RVS

Terra RVS for B10 mirror side 1

SV

Nadir
Detector dependent RVS

Terra RVS for B10 mirror side 2

SV

Nadir

Day (Epoch 2000)
Terra RVS V5 and V6 Comparison

Terra RVS for B8 mirror side 1

SV
Red: V6
Green: V5

RVS Ratio (V5/V6)

Nadir
Red: V6
Green: V5

RVS Ratio (V5/V6)
Terra RVS V5 and V6 Comparison

Terra RVS for B10 mirror side 1

SV
Red: V6
Green: V5

RVS

0 500 1000 1500 2000 2500 3000

Nadir
Red: V6
Green: V5

RVS

0 500 1000 1500 2000 2500 3000

RVS Ratio (V5/V6)

0 500 1000 1500 2000 2500 3000

RVS Ratio (V5/V6)
Application to EV data

Band 8 at SD (50.25)

V5, MS1

Band 8 at SD (50.25)

V6, MS1
Application to EV data

V5, MS1

V6, MS1
Application to EV data

Band 8 at Moon (11.25)

V5, MS1

Band 8 at Moon (11.25)

V6, MS1
Application to EV data
Application to EV data

Frame 8

V6

V5
Summary

- Based on the EV radiance difference at AOI of the SD, correction for Terra RSB m1 detector bias is derived
  - The correction is within +/-0.5% for all bands early in the mission
  - The correction has increased by an additional +/-0.3% for Terra band 8, +/-0.2% for band 9
  - There are no obvious change for other bands
- Detector dependent RVS is derived for Terra RSB
  - Band 8 has the largest RVS detector difference, which increases with time and is now as large as 3.0% at the AOI of the SV
  - The largest RVS detector differences for bands 9, 3, and 10 are about 1.5%, 1.2%, and 0.8%, respectively, at the AOI of the SV
- Detector averaged V6 RVS matches the V5 RVS in general but it has corrected the errors in V5 due to various reasons occurred in the forward process
- The corrected m1 and detector dependent RVS greatly reduce the EV radiance detector difference and improve the MODIS L1B product quality.