

# Level-1B (L1B) Calibration

## Collection 6.0 and Collection 6.1 Changes

### Terra and Aqua MODIS

2 January 2018

To stay apprised of the latest Alerts and Issues:

MODIS data users may find an archive of LAADS DAAC MODIS Data Alerts and Issues at

<https://ladsweb.modaps.eosdis.nasa.gov/alerts-and-issues/>

The Level-1 and Atmosphere Archive & Distribution System (LAADS) Distributed Active Archive Center (DAAC) distributes data for Terra and Aqua MODIS (as well as several other instruments).

**Part 1.** The following information was released on the LAADS DAAC website on 11 August 2017 that provides a broad overview of the expected C61 changes to L1B calibration.

#### **MODAPS plans to generate Collection 6.1 MODIS data [11 August 2017 Release]**

The MODIS Adaptive Processing System (MODAPS) is currently generating an improved Collection 6.1 (061) for all MODIS Level-1 (L1) and higher-level Level-2 (L2) & Level-3 (L3) Atmosphere Team products. This decision to create a new improved Collection 6.1 (061) was driven by the need to address a number of issues in the current Collection 6 (006) Level-1B (L1B) data. These L1B issues had a negative impact in varying degrees in downstream products.

#### **A. Changes to Level-1B (L1B) Calibration:**

- **Change to Response-versus-Scan angle (RVS) approach that affects reflectance bands for Aqua and Terra MODIS:** A change in the RVS approach that uses fixed desert sites was implemented in C6 for Terra MODIS from the beginning of the Terra mission from 24 Feb 2000 onwards and for Aqua MODIS from 27 July 2016 onwards. (For more details see Process Change Request (PCR) #16-015 listed on page 5 and #17-xxx on page 7 of this document). **The C6.1 reprocessing will apply this change in RVS approach to calibration of reflectance bands from the beginning of the Aqua mission from 25 June 2002 onwards, as well.**
- **Correction to adjust for the optical crosstalk in Terra MODIS Infrared (IR) bands:** The C6 Terra MODIS products, especially cloud products were negatively impacted by the optical crosstalk in IR bands (B27 – B30). Though the crosstalk issue was present

from the beginning of the mission, its impact on the product wasn't significant, and not noticeable until after year-2009. The IR crosstalk effect became more significant following the MODIS Terra safe hold in February 2016. (For more details see PCR #16-008 on page 4 and #17-009 on page 6 of this document). **The C6.1 reprocessing implements an approach to correct this crosstalk in the calibration from the beginning of the mission through the safe hold period and into the forward processing period.**

For more detailed information see the Terra IR Bands Calibration Change Supplement at <https://modis-atmosphere.gsfc.nasa.gov/documentation/collection-61>

- **Correction to the Terra MODIS forward Look-Up Table (LUT) update for the period 2012 - 2017:** The C6 Terra L1B data products from the period 1 January 2012 (2012 001) through 11 February 2017 (2017 042) were generated using faulty calibration LUTs because of an error in the process generating the routine forward LUT updates by the MODIS Characterization Support Team (MCST). This error, which was fixed in January 2017, affected bands 1 and 2 only and had extremely minor impact on Atmosphere Team products. **The C6.1 reprocessing will fix this error.**

## **B. Schedule of the C61 Processing (Reprocessing and Forward Streams) for L1 and Atmosphere**

- The reprocessing of C6.1 Terra MODIS L1 and Atmosphere products, which is currently in progress, starts from the beginning of the mission in February 2000, and is expected to complete by the end of 2017. Reprocessed C6.1 Terra data began to be publically released on 15 October 2017.
- The forward-processing of Terra and Aqua MODIS L1 and Atmosphere products is expected to start in September 2017, but the start "data date" will be pushed back a few weeks so the forward processing streams will have a start data date of 1 September 2017 for both platforms. Forward C6.1 Terra and Aqua data began to be publically released on 15 October 2017.
- Following the completion of the Terra MODIS L1 and Atmosphere product reprocessing, the reprocessing of Aqua MODIS L1 and Atmosphere products will start (in early 2018).

**C. Collection 6.1 MODIS Processing and Release Schedule**

**MODIS Level-1 and MODIS Atmosphere Level-2 & Level-3**

<b>MODIS Platform &amp; Stream</b>	<b>Production Public Release Date</b> (for any part of stream)	<b>Production Completion Date</b> (for entire stream)	<b>Data Dates</b> (start to end)
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Terra and Aqua Forward Processing Streams

<b>Terra Forward</b>	15 Oct 2017	15 Oct 2017	1 Sep 2017 and forward
<b>Aqua Forward</b>	15 Oct 2017	15 Oct 2017	1 Sep 2017 and forward

Terra Historical or Reprocessing Stream

<b>Terra Historical</b>	15 Oct 2017	10 Dec 2017	25 Feb 2000 (Terra 1 <sup>st</sup> Day) to 31 Aug 2017
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Aqua Historical or Reprocessing Stream

<b>Aqua Historical</b>	28 Dec 2017	30 Mar 2018 (est.)	25 Jun 2002 (Aqua 1 <sup>st</sup> Day) to 31 Aug 2017
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Nominal processing is 50x corresponding to 4 years of MODIS L1B & ATM data for a single platform processed in 1 calendar month

**D. Retention of C6 MODIS Atmosphere Products:**

The Collection 6.0 (C6) forward-processing of Terra and Aqua MODIS atmosphere products will continue in parallel with Collection 6.1 (C6.1) through **April 2018**; at that time, the C6 forward-processing stream will be discontinued, with only the C6.1 forward-stream being produced. This end date of C6 was advanced 4 months so that a Complete Collection is always available to users. However, we will continue providing access to C6, via LAADS, for another six months, and likely schedule their decommissioning beyond that time. Please watch these alerts for further updates. <https://ladsweb.modaps.eosdis.nasa.gov/alerts-and-issues/>

**Part 2.** The following information was released in several Process Change Request (PCR) documents submitted during 2016 and 2017

## **Issue: Safe-Hold Recovery Feb 2016 (Terra IR bands 27 & 29)**

### **PCR Information:**

PCR Number:	16-008
PCR Date:	5 Apr 2016
Mission:	Terra
Collection:	Collection 6.0
Streams:	Forward & Reprocessing
Lead:	Bill Ridgway

### **Problem Statement:**

Recovery from the Feb 19, 2016 safe-hold resulted in degraded radiances in Terra Bands 27 & 29 (both bad and noisy detectors). Cloud mask, atmospheric profiles and some downstream products were seriously impacted by bad radiances in these thermal bands.

### **Description of Change:**

Updated PGE03 threshold tests for these bands. Two cloud detection tests (8.6-11 micron BT and 6.7 micron BT) in the Terra MODIS cloud mask algorithm have been effectively eliminated by modifying the test thresholds. The new thresholds are set in such a way as to prevent the corresponding tests from reporting any cloud, whether or not clouds actually exist in the scene, i.e., 1-km MODIS pixel. The 6.7 micron BT thresholds are set to non-physically low values, while the 8.6-11 micron BT thresholds are made unreasonably high. This change restores cloud mask quality to near pre-safe-hold levels.

Updated the de-striper that previously used Band 27 Detector 9 as a reference. This detector is no longer in family and is vulnerable to producing negative radiances (reason not yet clear). The de-striper has replaced detector 9 with detector 4 as the reference. This changes minimizes striping in the profile product.

### **Downstream Product Effects:**

Calibration changed after safe-hold requiring new LUTs from MCST and an updated IR de-striper from UW (University of Wisconsin). PGE03 thresholds were adjusted to get rid of spurious clouds coming from the Band 29 crosstalk issue (which was worse after safe-hold). Some detectors (B27) became unusable. Downstream products effected include MOD35\_L2 (Cloud Mask), MOD07\_L2 (Atm Profiles), MOD06\_L2 (Cloud), and downstream L3 products MOD08\_D3 (Daily), MOD08\_E3 (Eight Day), & MOD08\_M3 (Monthly). The forward processing is effective from data date 28 February 2016 (2016 059) onwards.

### **Product Improvement:**

Avoids unacceptable level of false positives in cloud detection, particularly over ocean. Avoids striping and bad average values in profile products.

## Issue: Top of Atmosphere (TOA) Reflectance Drift Jul 2016 (Aqua bands 1-4)

### PCR Information:

PCR Number:	16-015
PCR Date:	26 Jul 2016
Mission:	Aqua
Collection:	Collection 6.0
Streams:	Forward
Lead:	Xiaoxiong (Jack) Xiong

### Problem Statement:

A noticeable drift of Top-of-Atmosphere (TOA) reflectance is observed for Aqua bands 1-4. The on-board solar diffuser calibration cannot correctly capture the gain changes for those bands.

### Description of Change:

The Earth view (EV) reflectance trends from the Committee on Earth Observation Satellites (CEOS)-endorsed pseudo-invariant desert sites (Libya 1, 2 and 4) have been successfully used to derive the m1 (calibration coefficient) and Response-versus-Scan angle (RVS) for Aqua bands 8 and 9 from the start of Collection 6. This EV-based approach is extended to Aqua bands 1-4.

### Downstream Product Effects:

All Land and Atmosphere products that use MODIS bands 1 through 4. The forward processing is effective from day 2016 209 (27 July 2016) and onwards.

### Product Improvement:

The MCST and Land teams have evaluated test results, improvements were noted as expected.

## Issue: Crosstalk Contamination C6.1 Reprocessing (Terra IR bands 27-30)

### PCR Information:

PCR Number:	17-009
PCR Date:	03 Apr 2017
Mission:	Terra
Collection:	Collection 6.1
Streams:	Forward & Reprocessing
Lead:	Xiaoxiong (Jack) Xiong

### Problem Statement:

The contamination from electronic crosstalk in Terra MODIS longwave infrared photovoltaic (PV) bands (27-30) has been steadily increasing over the mission. Its impact on science products, especially the cloud mask product, is becoming significant in recent years. The crosstalk correction in L1B has been requested to support the Collection 6.1 reprocess.

### Description of Change:

1. A moon-based algorithm developed by MCST is used to identify the signal contamination for each detector in bands 27-30 from the scheduled Moon observations. The contribution to the contamination from all involved detectors can be quantified to derive the time-dependent crosstalk correction coefficients. A linear correction algorithm is implemented in the L1B using the derived coefficients to calculate the signal contamination and make corrections to the on-board calibrator (OBC) data and Earth-view (EV) data.
2. The uncertainty algorithm has to be updated for bands 27-30 to account for the effect of the crosstalk correction.
3. The detector quality can be greatly improved for some detectors in bands 27-30 after applying the crosstalk correction. The QA status also needs to be updated accordingly.
4. The m1 (calibration coefficient) and Response-versus-Scan angle (RVS) for bands 1 and 2 are also reprocessed between 2012 and 2016 as per NASA Land Team's request to improve the temporal stability.

### Downstream Product Effects:

All products that use Terra MODIS bands 27 through 30, as well as bands 1 and 2.

### Product Improvement:

The feedback from the science testing is very positive. The current crosstalk correction algorithm is very effective in reducing the impact from the crosstalk contamination. The quality of the Terra MODIS cloud mask product can be significantly restored. The reprocessed m1 and RVS for Terra bands 1 and 2 greatly improve the stability of the trending.

## Issue: LUT Updates for C6.1 Reprocessing (Aqua bands 1-4)

### PCR Information:

PCR Number:	17-xxx
PCR Date:	20 Aug 2017
Mission:	Aqua
Collection:	Collection 6.1
Streams:	Reprocessing
Lead:	Xiaoxiong (Jack) Xiong

### Problem Statement:

There is no calibration algorithm change in MOD\_PR02AQUA (PGE02). This delivery is to support the Aqua MODIS Collection 6.1 reprocess.

### Description of Change:

1. Update the processing version number to 6.2.1.
2. Update look-up-tables (LUT) for reprocessing. The major updates of look-up-tables (LUT) for 6.1 reprocess are, Earth-View (EV)-based Reflective Solar Bands (RSB) m1 and Response-versus-Scan angle (RVS) have been extended to entire mission for bands 1-4; Thermal Emissive bands (TEB) a0, a2 and default b1 are reprocessed for entire mission to mitigate the impact from the focal plane temperature change.

### Downstream Product Effects:

All products that use Aqua MODIS PGE02 Data (MYD021KM).

### Product Improvement:

The change in Aqua MODIS PGE02 is minimal. However this reprocess of Aqua for Collection 6.1 will remove the 1% to 2% discontinuity in some products that utilize MODIS bands 1 through 4. The discontinuity is noted in Collection 6 (C6) for products that use bands 1-4, with a step function transition at data date 27 July 2016. After reprocessing the entire Aqua data record with Collection 6.1, this step function discontinuity that appears at 27 July 2016 will disappear as the old C6 data previous to 27 July 2016 is replaced with C61 data.

**Part 3.** The following is a general background summary of Level-1B (L1B) for new users.

## **General Overview of Level-1B (L1B) for new users**

### **MOD021KM: Level-1B Calibrated Radiances – 1 km**

The MODIS Level-1B data set contains calibrated and geolocated at-aperture radiances for 36 discrete bands located in the 0.4  $\mu\text{m}$  to 14.4  $\mu\text{m}$  region of the electromagnetic spectrum. These data are generated from MODIS Level-1A scans of raw radiance, and in the process are converted to geophysical units of  $\text{W}/(\text{m}^2 \mu\text{m sr})$ . In addition, the Bidirectional Reflectance Distribution Function (BRDF) may be determined for the solar reflective bands (1-19, 26) through knowledge of the solar irradiance (e.g., determined from MODIS solar diffuser data, and from the target illumination geometry). Additional data are provided including quality flags, error estimates and calibration data.

Visible, shortwave infrared, and near infrared measurements are only made during the daytime, while radiances for the thermal infrared region (bands 20-25, 27-36) are measured continuously.

The resolution of channels 1 and 2 is 250 m, channels 3 through 7 are 500m resolution, and the rest are 1 km resolution. However, for the MODIS L1B 1 km product, the 250 m and 500 m band radiance data and their associated uncertainties have been aggregated to 1 km resolution. Thus, the entire channel data set is referenced to the same spatial and geolocation scales. Separate L1B products are available for just the 250 m channels (MOD02QKM) and the 500 m channels (MOD02HKM) that preserve the original resolution of the data.

Spatial resolution for pixels at nadir is 1 km, degrading to 4.8 km in the along-scan direction at the scan extremes. However, thanks to the overlapping of consecutive swaths and the respective pixels there, the resulting resolution at the scan extremes is about 2 km. A 55 degree scanning pattern at the EOS orbit of 705 km results in a 2330 km orbital swath width with global coverage every one to two days. A single MODIS Level-1B granule will nominally contain a scene built from 203 scans (or swaths) sampled 1354 times in the cross-track direction, corresponding to approximately 5 minutes worth of data. Since an individual MODIS scan (or swath) will contain 10 along-track spatial elements, the scene will be composed of 1354 by 2030 pixels, resulting in a spatial coverage of 2330 km by 2030 km. Due to the MODIS scan geometry, there will be increasing overlap occurring beyond about a 25 degree scan angle. Users requiring the full-resolution geolocation and solar/satellite geometry can obtain the separate MODIS Level-1 Geolocation product (MOD03) from LAADS (<https://ladsweb.modaps.eosdis.nasa.gov>).

## MODIS Spectral Bands:

Primary Use	Band	Bandwidth <sup>1</sup>	Spectral Radiance <sup>2</sup>	Required SNR <sup>3</sup>
Land Boundaries	1	620 - 670 nm	21.8	128
Cloud Boundaries	2	841 - 876 nm	24.7	201
Aerosols Boundaries				
	3	459 - 479 nm	35.3	243
Land Properties	4	545 - 565 nm	29.0	228
Cloud Properties	5	1230 - 1250 nm	5.4	74
Aerosols Properties	6	1628 - 1652 nm	7.3	275
	7	2105 - 2155 nm	1.0	110
	8	405 - 420 nm	44.9	880
	9	438 - 448 nm	41.9	838
	10	483 - 493 nm	32.1	802
Ocean Color	11	526 - 536 nm	27.9	754
Phytoplankton	12	546 - 556 nm	21.0	750
Biogeochemistry	13	662 - 672 nm	9.5	910
	14	673 - 683 nm	8.7	1087
	15	743 - 753 nm	10.2	586
	16	862 - 877 nm	6.2	516
	17	890 - 920 nm	10.0	167
Atmospheric Water Vapor	18	931 - 941 nm	3.6	57
	19	915 - 965 nm	15.0	250

Primary Use	Band	Bandwidth <sup>1</sup>	Spectral Radiance <sup>2</sup>	Required NE[Δ]T(K) <sup>4</sup>
	20	3.660 - 3.840 μm	0.45(300K)	0.05
Surface Temperature	21	3.929 - 3.989 μm	2.38(335K)	2.00
Cloud Temperature	22	3.929 - 3.989 μm	0.67(300K)	0.07
	23	4.020 - 4.080 μm	0.79(300K)	0.07
Atmospheric Temperature	24	4.433 - 4.498 μm	0.17(250K)	0.25
	25	4.482 - 4.549 μm	0.59(275K)	0.25
	26	1.360 - 1.390 μm	6.00	150(SNR)
Cirrus Clouds	27	6.535 - 6.895 μm	1.16(240K)	0.25
Water Vapor	28	7.175 - 7.475 μm	2.18(250K)	0.25
Cloud Properties	29	8.400 - 8.700 μm	9.58(300K)	0.05
Ozone	30	9.580 - 9.880 μm	3.69(250K)	0.25
Surface Temperature	31	10.780 - 11.280 μm	9.55(300K)	0.05
Cloud Temperature	32	11.770 - 12.270 μm	8.94(300K)	0.05
	33	13.185 - 13.485 μm	4.52(260K)	0.25
Cloud Top Height	34	13.485 - 13.785 μm	3.76(250K)	0.25
	35	13.785 - 14.085 μm	3.11(240K)	0.25
	36	14.085 - 14.385 μm	2.08(220K)	0.35

<sup>1</sup> Bands 1 to 19 are in nm; Bands 20 to 36 are in μm

<sup>2</sup> Spectral Radiance values are (W/m<sup>2</sup> - μm-sr)

<sup>3</sup> SNR = Signal-to-noise ratio

<sup>4</sup> NE(Δ)T = Noise-equivalent temperature difference