

# CloudSat Project

A NASA Earth System Science Pathfinder Mission

## **CloudSat MODIS-AUX Auxiliary Data Process Description and Interface Control Document**

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## Document Revision History

<b>Date</b>	<b>Revision</b>	<b>Description</b>	<b>Section(s) Affected</b>
March 2017	0	Initial Release	All
November 2017	1	1. Fixed minor typos 2. Clarified application of scales and offsets to Reflective Solar Bands Scaled Integers to calculate radiance and reflectance	1. All 2. Section 4, Data Product Output Specifications

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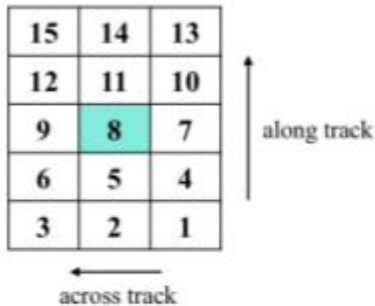
## 1 Introduction

The MODIS-AUX data set is an intermediate product that contains a subset of ancillary MODIS radiance and cloud mask data that overlaps and surrounds each CloudSat cloud profiling radar (CPR) footprint. Input data are obtained from the 1B-CPR and AN-MODIS products, and the MODIS-AUX data are used as input to the 2B-GEOPROF, 2B-CLDCLASS, 2B-TAU, 2B-FLXHR-LIDAR, and 2B-FLXHR-LIDAR-ERB algorithms in the CloudSat data processing system. This document describes the input product specifications, the subset process, and the format of the MODIS-AUX product.

## 2 Description of the Subset Process

The AN-MODIS data contain selected Collection 6 MODIS data fields and geolocation at a one-kilometer resolution (see Section 3.2 for a more detailed description). To produce the MODIS-AUX product, the geolocation data from the 1B-CPR product are used as the reference dataset. Operating one CloudSat ray at a time and using a great-circle nearest-neighbor scheme, the closest AN-MODIS pixel is located and a 3-pixel across-track by 5-pixel along-track grid of each AN-MODIS parameter of interest is extracted and stored in a 15-element vector associated with that ray (see Figure 1). If the CloudSat geolocation for a particular ray is missing or the closest AN-MODIS pixel is more than 0.95 km from the CloudSat ray, the resulting MODIS geolocation data and the associated data vectors are filled with a missing value flag. Note that this maximum distance threshold was derived empirically and deviates from the idealized value of 0.707 km to ensure that there is the possibility of a matched pixel even as the MODIS viewing geometry changes within the width of the swath.

a) Physical Representation of Subset Data



b) Data Vector in MODIS-AUX Product



Figure 1. Visualization of subset MODIS-AUX data in physical space (a) and within the data product (b). Pixel 8 (highlighted in teal) is the closest pixel to the CPR footprint.

### 3 Algorithm Inputs

Input data for the MODIS-AUX algorithm includes CloudSat 1B-CPR and AN-MODIS data sets. Each 1B-CPR data file contains data for one orbit of the CloudSat spacecraft, whereas each AN-MODIS file contains 5 minutes of MODIS data. The AN-MODIS data set is provided by the A-Train Data Depot (<http://disc.sci.gsfc.nasa.gov/atdd>) at the Goddard Earth Sciences (GES) DAAC. The swath is 11 km wide, centered on the CloudSat ground track. The data are provided in HDF-EOS2 format

#### 3.1 1B-CPR

Fields available in the 1B-CPR P\_R05 data set used by this algorithm include

**(1) Seconds since the start of the granule.**

<b>Name in file:</b> Profile_time	<b>Range:</b> 0 to 6000
<b>Source:</b> 1B-CPR P_R05	<b>Missing value:</b> N/A
<b>Field type:</b> REAL(4)	<b>Missing value operator:</b> N/A
<b>Dimensions:</b> nray	<b>Units:</b> seconds

Seconds since the start of the granule for each profile. The first profile is 0.

**(2) Spacecraft Latitude**

<b>Name in file:</b> Latitude	<b>Range:</b> -90 to 90
<b>Source:</b> 1B-CPR P_R05	<b>Missing value:</b> -999
<b>Field type:</b> REAL(4)	<b>Missing value operator:</b> ==
<b>Dimensions:</b> nray	<b>Units:</b> degrees

Spacecraft Geodetic Latitude.

**(3) Spacecraft Longitude**

<b>Name in file:</b> Longitude	<b>Range:</b> -180 to 180
<b>Source:</b> 1B-CPR P_R05	<b>Missing value:</b> -999
<b>Field type:</b> REAL(4)	<b>Missing value operator:</b> ==
<b>Dimensions:</b> nray	<b>Units:</b> degrees

Spacecraft geodetic longitude.

### 3.2 AN-MODIS

The AN-MODIS dataset is made up of individual Aqua MODIS products that have been subset by the A-Train Data Depot to an 11 km wide swath around the CloudSat ground track. The HDF-EOS2 format files contain the following fields from the specified products:

- Geodetic 1-kilometer resolution Latitude and Longitude (MAC03S0.002, subset from MYD03).
- Collection 6 radiances and associated scale factors and offsets, radiance uncertainty indexes and associated specified uncertainty and scaling factors: bands 1-7, 17-20, and 26-36, 1 km resolution (MAC021S0.002, subset from MYD02\_1KM\_L1B).
- Collection 6 cloud mask and spectral test results, 1 km resolution (MAC35S0.002, subset from MYD35\_L2).

The radiance channels for each band are:

<u>Band</u>	<u>WaveLength</u>	<u>IFOV</u>	<u>Bandwidth</u>	<u>Example Usage</u>
1	645nm	250m	50nm	Veg. Chlorophyll Absorp.
2	858nm	250m	35nm	Cloud/Veg. Land Cover
3	469nm	500m	20nm	Soil & Veg. Differences
4	555nm	500m	20nm	Green Vegetation
5	1240nm	500m	20nm	Leaf/Canopy Differences
6*	1640nm	500m	24.6nm	Snow/Cloud Differences
7	2130nm	500m	50nm	Land/Cloud Properties
17	905nm	1000m	30nm	Cloud/Atmos Properties
18	936nm	1000m	10nm	Cloud/Atmos Properties
19	940nm	1000m	50nm	Cloud/Atmos Properties
20	3.75µm	1000m	0.18µm	Sea Surface Temp Fraction
26	1375nm	1000m	30nm	Cinfraredrus Cloud Detect
27	6.72µm	1000m	0.36µm	Mid-Tropospheric Humidity
28	7.33µm	1000m	0.30µm	Upper-Tropospheric Humidity
29	8.55µm	1000m	0.30µm	Surface Temperature
30	9.73µm	1000m	0.30µm	Total Ozone
31	11.03µm	1000m	0.50µm	Cloud/Surface Temp
32	12.02µm	1000m	0.50µm	Cloud Height & Surface Temp
33	13.34µm	1000m	0.30µm	Cloud Height & Fraction
34	13.64µm	1000m	0.30µm	Cloud Height & Fraction
35	13.94µm	1000m	0.30µm	Cloud Height & Fraction
36	14.24µm	1000m	0.30µm	Cloud Height & Fraction

\*Aqua/MODIS Band 6 failed before launch.

More information about the radiance and cloud mask fields can be found their respective MODIS Collection 6 product ATBDs.

## 4 Data Product Output Specifications

Each HDF-EOS2 product file is built for the orbit specified by the input 1B-CPR data. Within each file, the Geolocation Fields contain the MODIS geolocation of the subset pixels along with the time information for the CloudSat ray. The Data Fields contain the MODIS science data for the subset pixels as well as information tracing back to the input AN-MODIS files. As discussed in Section 2, all information for the 3-pixel across-track by 5-pixel along-track grid of subset pixels is stored in the MODIS-AUX product file as a 15-element vector for each CPR ray and data dimension. As depicted in Figure 1, the first element in the vector corresponds to the lower right corner of the 3x5 pixel grid (assuming the along-track dimension points up). The element count increases across the MODIS track to the left. Element 4 in the vector is the first pixel of the second along-track row in the 3x5 grid. The pixel in the middle of the 3x5 grid (vector element 8) is the closest pixel to the CPR footprint for that grid. The specifications for the MODIS-AUX product are as follows:

### (1) Geodetic latitude of MODIS pixels

<b>Name in file:</b> MODIS_latitude	<b>Range:</b> -90 to 90
<b>Source:</b> MODIS-AUX P_R05	<b>Missing value:</b> -999
<b>Field type:</b> REAL(4)	<b>Missing value operator:</b> ==
<b>Dimensions:</b> mod_1km,nray	<b>Units:</b> degrees

This array contains the vector of latitudes for the closest 15 pixels to the CloudSat CPR footprint in a 3x5 (across track x along track) grid.

### (2) Geodetic longitude of MODIS pixels

<b>Name in file:</b> MODIS_longitude	<b>Range:</b> -180 to 180
<b>Source:</b> MODIS-AUX P_R05	<b>Missing value:</b> -999
<b>Field type:</b> REAL(4)	<b>Missing value operator:</b> ==
<b>Dimensions:</b> mod_1km,nray	<b>Units:</b> degrees

This array contains the vector of longitudes for the closest 15 pixels to the CloudSat CPR footprint in a 3x5 (across track x along track) grid.

### (3) Seconds since the start of the granule

<b>Name in file:</b> Profile_time	<b>Range:</b> 0 to 6000
<b>Source:</b> 1B-CPR P_R05	<b>Missing value:</b> N/A
<b>Field type:</b> REAL(4)	<b>Missing value operator:</b> N/A
<b>Dimensions:</b> nray	<b>Units:</b> seconds

Seconds since the start of the granule for each profile. The first profile is 0.

**(4) UTC seconds since 00:00 Z of the first profile**

<b>Name in file:</b> UTC_start	<b>Range:</b> 0 to 86400
<b>Source:</b> 1B-CPR P_R05	<b>Missing value:</b> N/A
<b>Field type:</b> REAL(4)	<b>Missing value operator:</b> N/A
<b>Dimensions:</b> <scalar>	<b>Units:</b> seconds

The UTC seconds since 00:00 Z of the first profile in the data file.

**(5) TAI time for the first profile**

<b>Name in file:</b> TAI_start	<b>Range:</b> 0 to 6e+008
<b>Source:</b> 1B-CPR P_R05	<b>Missing value:</b> N/A
<b>Field type:</b> REAL(8)	<b>Missing value operator:</b> N/A
<b>Dimensions:</b> <scalar>	<b>Units:</b> seconds

The TAI timestamp for the first profile in the data file. TAI is International Atomic Time: seconds since 00:00:00 Jan 1, 1993.

**(6) MODIS granule index of each pixel**

<b>Name in file:</b> MODIS_granule_index	<b>Range:</b> 1 to 25
<b>Source:</b> MODIS-AUX P_R05	<b>Missing value:</b> -99
<b>Field type:</b> INT(1)	<b>Missing value operator:</b> ==
<b>Dimensions:</b> mod_1km,nray	<b>Units:</b> N/A

Key to the granule index dimension in data fields associating each field with a MODIS granule and corresponding scales and offsets.

**(7) MODIS Across-Track Pixel Index**

<b>Name in file:</b> MODIS_pixel_index_across_track	<b>Range:</b> 1 to 1354
<b>Source:</b> MODIS-AUX P_R05	<b>Missing value:</b> -999
<b>Field type:</b> INT(2)	<b>Missing value operator:</b> ==
<b>Dimensions:</b> mod_1km,nray	<b>Units:</b> N/A

Across-track pixel index of the data point in the original AN-MODIS file. This is primarily used for consistency checks between AN-MODIS and MODIS-AUX.

**(8) MODIS Along-Track Pixel Index**

<b>Name in file:</b> MODIS_pixel_index_along_track	<b>Range:</b> 1 to 2040
<b>Source:</b> MODIS-AUX P_R05	<b>Missing value:</b> -999
<b>Field type:</b> INT(2)	<b>Missing value operator:</b> ==
<b>Dimensions:</b> mod_1km,nray	<b>Units:</b> N/A

Along-track pixel index of the data points in the original AN-MODIS file. This is primarily used for consistency checks between AN-MODIS and MODIS-AUX.



**(9) Solar zenith angle at the MODIS pixel**

<b>Name in file:</b> Solar_zenith	<b>Range:</b> 0 to 18000
<b>Source:</b> MODIS-AUX P_R05	<b>Missing value:</b> -32767
<b>Field type:</b> INT(2)	<b>Missing value operator:</b> ==
<b>Dimensions:</b> mod_1km,nray	<b>Units:</b> degrees

This is the solar zenith angle as measured at the location of the MODIS pixel. It is stored in a 2-byte signed integer and must be divided by 100 before use.

**(10) Solar azimuth angle at the MODIS pixel**

<b>Name in file:</b> Solar_azimuth	<b>Range:</b> -18000 to 18000
<b>Source:</b> MODIS-AUX P_R05	<b>Missing value:</b> -32767
<b>Field type:</b> INT(2)	<b>Missing value operator:</b> ==
<b>Dimensions:</b> mod_1km,nray	<b>Units:</b> degrees

This is the solar azimuth angle as measured at the location of the MODIS pixel. It is stored in a 2-byte signed integer and must be divided by 100 before use.

**(11) Sensor zenith angle at the MODIS pixel**

<b>Name in file:</b> Sensor_zenith	<b>Range:</b> 0 to 18000
<b>Source:</b> MODIS-AUX P_R05	<b>Missing value:</b> -32767
<b>Field type:</b> INT(2)	<b>Missing value operator:</b> ==
<b>Dimensions:</b> mod_1km,nray	<b>Units:</b> degrees

This is the zenith angle as measured from the MODIS pixel in the direction of the MODIS instrument. It is stored in a 2-byte signed integer and must be divided by 100 before use.

**(12) Sensor azimuth angle at the MODIS pixel**

<b>Name in file:</b> Sensor_azimuth	<b>Range:</b> -18000 to 18000
<b>Source:</b> MODIS-AUX P_R05	<b>Missing value:</b> -32767
<b>Field type:</b> INT(2)	<b>Missing value operator:</b> ==
<b>Dimensions:</b> mod_1km,nray	<b>Units:</b> degrees

This is the sensor azimuth angle as measured at the location of the MODIS pixel. It is stored in a 2-byte signed integer and must be divided by 100 before use.

**(13) MODIS Cloud Mask Subset**

<b>Name in file:</b> Cloud_Mask	<b>Range:</b> 0 to 1
<b>Source:</b> MODIS-AUX P_R05	<b>Missing value:</b> 0
<b>Field type:</b> INT(1)	<b>Missing value operator:</b> ==
<b>Dimensions:</b> mod_1km,nray,Byte_Segment	<b>Units:</b> N/A

The MODIS cloud mask is a bit field that contains information about clouds observed in each pixel including type and height. A full description of the cloud mask can be found at the MODIS web site from the AN-MODIS document or the MODIS website: [http://modis-atmos.gsfc.nasa.gov/MOD35\\_L2/index.html](http://modis-atmos.gsfc.nasa.gov/MOD35_L2/index.html). The full MODIS data has been subset to the closest 15 pixels around the CloudSat CPR footprint.

**(14) MODIS Earth View 1KM Reflective Solar Bands Scaled Integers Subset**

<b>Name in file:</b> EV_1KM_RefSB	<b>Range:</b> 0 to 32767
<b>Source:</b> MODIS-AUX P_R05	<b>Missing value:</b> 32768
<b>Field type:</b> UINT(2)	<b>Missing value operator:</b> >=
<b>Dimensions:</b> mod_1km,nray,Band_1KM_RefSB	<b>Units:</b> N/A

This data array contains radiances for MODIS band numbers 17-19 and 26. The full MODIS data has been subset to the closest 15 pixels around the CloudSat CPR footprint. More information can be obtained from the AN-MODIS ICD or from the MODIS web site at <http://mest.gsfc.nasa.gov>.

Floating point values can be obtained using the following formulas:

$$\text{Radiance [Wm}^{-2}\text{sr}^{-1}\text{um}^{-1}] = \text{EV\_1KM\_RefSB\_rad\_scales} * (\text{EV\_1KM\_RefSB} - \text{EV\_1KM\_RefSB\_rad\_offsets})$$

$$\text{Reflectance [Unitless]} = \text{EV\_1KM\_RefSB\_ref\_scales} * (\text{EV\_1KM\_RefSB} - \text{EV\_1KM\_RefSB\_ref\_offsets})$$

**(15) Radiance scales for EV\_1KM\_RefSB**

<b>Name in file:</b> EV_1KM_RefSB_rad_scales	<b>Range:</b> N/A
<b>Source:</b> MODIS-AUX P_R05	<b>Missing value:</b> -999
<b>Field type:</b> REAL(4)	<b>Missing value operator:</b> ==
<b>Dimensions:</b> mod_granules,Band_1KM_RefSB	<b>Units:</b> N/A

Radiance scales needed to convert unscaled radiance data to scientific values.

**(16) Radiance offsets for EV\_1KM\_RefSB**

<b>Name in file:</b> EV_1KM_RefSB_rad_offsets	<b>Range:</b> N/A
<b>Source:</b> MODIS-AUX P_R05	<b>Missing value:</b> -999
<b>Field type:</b> REAL(4)	<b>Missing value operator:</b> ==
<b>Dimensions:</b> mod_granules,Band_1KM_RefSB	<b>Units:</b> N/A

Radiance offsets needed to convert unscaled radiance data to scientific values.

**(17) Reflectance scales for EV\_1KM\_RefSB**

<b>Name in file:</b> EV_1KM_RefSB_ref_scales	<b>Range:</b> N/A
<b>Source:</b> MODIS-AUX P_R05	<b>Missing value:</b> -999
<b>Field type:</b> REAL(4)	<b>Missing value operator:</b> ==
<b>Dimensions:</b> mod_granules,Band_1KM_RefSB	<b>Units:</b> N/A

Reflectivity scales needed to convert unscaled radiance data to scientific values.

**(18) Reflectance offsets for EV\_1KM\_RefSB**

<b>Name in file:</b> EV_1KM_RefSB_ref_offsets	<b>Range:</b> N/A
<b>Source:</b> MODIS-AUX P_R05	<b>Missing value:</b> -999
<b>Field type:</b> REAL(4)	<b>Missing value operator:</b> ==
<b>Dimensions:</b> mod_granules,Band_1KM_RefSB	<b>Units:</b> N/A

Reflectivity offsets needed to convert unscaled radiance data to scientific values.

**(19) MODIS Earth View 1KM Reflective Solar Bands Uncertainty Indexes Subset**

<b>Name in file:</b> EV_1KM_RefSB_Uncert_Indexes	<b>Range:</b> 0 to 15
<b>Source:</b> MODIS-AUX P_R05	<b>Missing value:</b> 255
<b>Field type:</b> UINT(1)	<b>Missing value operator:</b> ==
<b>Dimensions:</b> mod_1km,nray,Band_1KM_RefSB	<b>Units:</b> N/A

Uncertainty indexes corresponding to the EV\_1KM\_RefSB radiances. The radiance uncertainty is calculated with:

$$\text{uncertainty(\%)} = \text{specified\_uncertainty} * \exp(\text{uncertainty\_index} / \text{scaling\_factor})$$

**(20) MODIS Earth View 1KM Reflective Solar Bands Specified Uncertainty**

<b>Name in file:</b> EV_1KM_RefSB_spec_uncert	<b>Range:</b> N/A
<b>Source:</b> MODIS-AUX P_R05	<b>Missing value:</b> -999
<b>Field type:</b> REAL(4)	<b>Missing value operator:</b> ==
<b>Dimensions:</b> mod_granules,Band_1KM_RefSB	<b>Units:</b> N/A

The specified uncertainty is used along with the uncertainty indexes and scale factors to calculate the radiance uncertainty in % (see uncertainty indexes description).

**(21) MODIS Earth View 1KM Reflective Solar Bands Uncertainty Scaling Factor**

**Name in file:** EV\_1KM\_RefSB\_scaling\_factor      **Range:** N/A  
**Source:** MODIS-AUX P\_R05      **Missing value:** -999  
**Field type:** REAL(4)      **Missing value operator:** ==  
**Dimensions:** mod\_granules,Band\_1KM\_RefSB      **Units:** N/A

The scaling factor is used along with the uncertainty indexes and specified uncertainty to calculate the radiance uncertainty in % (see uncertainty indexes description).

**(22) MODIS Earth View 1KM Emissive Bands Scaled Integers Subset**

**Name in file:** EV\_1KM\_Emissive      **Range:** 0 to 32767  
**Source:** MODIS-AUX P\_R05      **Missing value:** 32768  
**Field type:** UINT(2)      **Missing value operator:** >=  
**Dimensions:** mod\_1km,nray,Band\_1KM\_Emissive      **Units:** W/(m<sup>2</sup> str um)

This data array contains radiances for MODIS band numbers 20 and 27-36. The full MODIS data has been subset to the closest 15 pixels around the CloudSat CPR footprint. More information can be obtained from the AN-MODIS ICD or from the MODIS web site at <http://mcst.gsfc.nasa.gov>.

**(23) Radiance scales for EV\_1KM\_Emissive**

**Name in file:** EV\_1KM\_Emissive\_rad\_scales      **Range:** N/A  
**Source:** MODIS-AUX P\_R05      **Missing value:** -999  
**Field type:** REAL(4)      **Missing value operator:** ==  
**Dimensions:** mod\_granules,Band\_1KM\_Emissive      **Units:** N/A

Radiance scales needed to convert unscaled radiance data to scientific values.

**(24) Radiance offsets for EV\_1KM\_Emissive**

**Name in file:** EV\_1KM\_Emissive\_rad\_offsets      **Range:** N/A  
**Source:** MODIS-AUX P\_R05      **Missing value:** -999  
**Field type:** REAL(4)      **Missing value operator:** ==  
**Dimensions:** mod\_granules,Band\_1KM\_Emissive      **Units:** N/A

Radiance offsets needed to convert unscaled radiance data to scientific values.

**(25) MODIS Earth View 1KM Emissive Bands Uncertainty Indexes Subset**

**Name in file:** EV\_1KM\_Emissive\_Uncert\_Indexes      **Range:** 0 to 15  
**Source:** MODIS-AUX P\_R05      **Missing value:** 255  
**Field type:** UINT(1)      **Missing value operator:** ==  
**Dimensions:** mod\_1km,nray,Band\_1KM\_Emissive      **Units:** N/A

Uncertainty indexes corresponding to the EV\_1KM\_Emissive radiances. The radiance uncertainty is calculated with:

$$\text{uncertainty(\%)} = \text{specified\_uncertainty} * \exp(\text{uncertainty\_index} / \text{scaling\_factor})$$

**(26) MODIS Earth View 1KM Emissive Bands Specified Uncertainty**

**Name in file:** EV\_1KM\_Emissive\_spec\_uncert      **Range:** N/A  
**Source:** MODIS-AUX P\_R05      **Missing value:** -999  
**Field type:** REAL(4)      **Missing value operator:** ==  
**Dimensions:** mod\_granules,Band\_1KM\_Emissive      **Units:** N/A

The specified uncertainty is used along with the uncertainty indexes and scale factors to calculate the radiance uncertainty in % (see uncertainty indexes description).

**(27) MODIS Earth View 1KM Reflective Solar Bands Scaling Factor**

**Name in file:** EV\_1KM\_Emissive\_scaling\_factor      **Range:** N/A  
**Source:** MODIS-AUX P\_R05      **Missing value:** -999  
**Field type:** REAL(4)      **Missing value operator:** ==  
**Dimensions:** mod\_granules,Band\_1KM\_Emissive      **Units:** N/A

The scaling factor is used along with the uncertainty indexes and specified uncertainty to calculate the radiance uncertainty in % (see uncertainty indexes description).

**(28) MODIS Earth View 250M Aggregated 1km Reflective Solar Bands Scaled**

**Integers Subset**

**Name in file:** EV\_250\_RefSB      **Range:** 0 to 32767  
**Source:** MODIS-AUX P\_R05      **Missing value:** 32768  
**Field type:** UINT(2)      **Missing value operator:** >=  
**Dimensions:** mod\_1km,nray,Band\_250M      **Units:** N/A

This data array contains radiances for MODIS band numbers 1 and 2 aggregated to 1 km. The full MODIS data has been subset to the closest 15 pixels around the CloudSat CPR footprint. More information can be obtained from the AN-MODIS ICD or from the MODIS web site at <http://mcst.gsfc.nasa.gov>.

Floating point values can be obtained using the following formulas:

$$\text{Radiance } [Wm^{-2}sr^{-1}um^{-1}] = EV\_250\_RefSB\_rad\_scales * (EV\_250\_RefSB - EV\_250\_RefSB\_rad\_offsets)$$

$$\text{Reflectance } [Unitless] = EV\_250\_RefSB\_ref\_scales * (EV\_250\_RefSB - EV\_250\_RefSB\_ref\_offsets)$$

**(29) Radiance scales for EV\_250\_RefSB**

**Name in file:** EV\_250\_RefSB\_rad\_scales      **Range:** N/A  
**Source:** MODIS-AUX P\_R05      **Missing value:** -999  
**Field type:** REAL(4)      **Missing value operator:** ==  
**Dimensions:** mod\_granules,Band\_250M      **Units:** N/A

Radiance scales needed to convert unscaled radiance data to scientific values.

**(30) Radiance offsets for EV\_250\_RefSB**

<b>Name in file:</b> EV_250_RefSB_rad_offsets	<b>Range:</b> N/A
<b>Source:</b> MODIS-AUX P_R05	<b>Missing value:</b> -999
<b>Field type:</b> REAL(4)	<b>Missing value operator:</b> ==
<b>Dimensions:</b> mod_granules,Band_250M	<b>Units:</b> N/A

Radiance offsets needed to convert unscaled radiance data to scientific values.

**(31) Reflectance scales for EV\_250\_RefSB**

<b>Name in file:</b> EV_250_RefSB_ref_scales	<b>Range:</b> N/A
<b>Source:</b> MODIS-AUX P_R05	<b>Missing value:</b> -999
<b>Field type:</b> REAL(4)	<b>Missing value operator:</b> ==
<b>Dimensions:</b> mod_granules,Band_250M	<b>Units:</b> N/A

Reflectivity scales needed to convert unscaled radiance data to scientific values.

**(32) Reflectance offsets for EV\_250\_RefSB**

<b>Name in file:</b> EV_250_RefSB_ref_offsets	<b>Range:</b> N/A
<b>Source:</b> MODIS-AUX P_R05	<b>Missing value:</b> -999
<b>Field type:</b> REAL(4)	<b>Missing value operator:</b> ==
<b>Dimensions:</b> mod_granules,Band_250M	<b>Units:</b> N/A

Reflectivity offsets needed to convert unscaled radiance data to scientific values.

**(33) MODIS Earth View 250M Aggregated 1KM Reflective Solar Bands**

**Uncertainty Indexes Subset**

<b>Name in file:</b> EV_250_RefSB_Uncert_Indexes	<b>Range:</b> 0 to 15
<b>Source:</b> MODIS-AUX P_R05	<b>Missing value:</b> 255
<b>Field type:</b> UINT(1)	<b>Missing value operator:</b> ==
<b>Dimensions:</b> mod_1km,nray,Band_250M	<b>Units:</b> N/A

Uncertainty indexes corresponding to the EV\_250\_Aggr1km\_RefSB radiances. The radiance uncertainty is calculated with:

$$\text{uncertainty}(\%) = \text{specified\_uncertainty} * \exp(\text{uncertainty\_index} / \text{scaling\_factor})$$

**(34) MODIS Earth View 250M Aggregated 1KM Reflective Solar Bands Specified**

**Uncertainty**

<b>Name in file:</b> EV_250_RefSB_spec_uncert	<b>Range:</b> N/A
<b>Source:</b> MODIS-AUX P_R05	<b>Missing value:</b> -999
<b>Field type:</b> REAL(4)	<b>Missing value operator:</b> ==
<b>Dimensions:</b> mod_granules,Band_250M	<b>Units:</b> N/A

The specified uncertainty is used along with the uncertainty indexes and scale factors to calculate the radiance uncertainty in % (see uncertainty indexes description).

**(35) MODIS Earth View 250M Aggregated 1KM Reflective Solar Bands Scaling Factor**

**Name in file:** EV\_250\_RefSB\_scaling\_factor                      **Range:** N/A  
**Source:** MODIS-AUX P\_R05    **Missing value:** -999  
**Field type:** REAL(4)    **Missing value operator:** ==  
**Dimensions:** mod\_granules,Band\_250M                              **Units:** N/A

The scaling factor is used along with the uncertainty indexes and specified uncertainty to calculate the radiance uncertainty in % (see uncertainty indexes description).

**(36) MODIS Earth View 500M Aggregated 1km Reflective Solar Bands Scaled Integers Subset**

**Name in file:** EV\_500\_RefSB    **Range:** 0 to 32767  
**Source:** MODIS-AUX P\_R05    **Missing value:** 32768  
**Field type:** UINT(2)    **Missing value operator:** >=  
**Dimensions:** mod\_1km,nray,Band\_500M                              **Units:** N/A

This data array contains radiances for MODIS band numbers 3-7 aggregated to 1 km. The full MODIS data has been subset to the closest 15 pixels around the CloudSat CPR footprint. More information can be obtained from the AN-MODIS ICD or from the MODIS web site at <http://mcst.gsfc.nasa.gov>.

Floating point values can be obtained using the following formulas:

$$\text{Radiance [Wm}^{-2}\text{sr}^{-1}\text{um}^{-1}] = \text{EV\_500\_RefSB\_rad\_scales} * (\text{EV\_500\_RefSB} - \text{EV\_500\_RefSB\_rad\_offsets})$$

$$\text{Reflectance [Unitless]} = \text{EV\_500\_RefSB\_ref\_scales} * (\text{EV\_500\_RefSB} - \text{EV\_500\_RefSB\_ref\_offsets})$$

**(37) Radiance scales for EV\_500\_RefSB**

**Name in file:** EV\_500\_RefSB\_rad\_scales                              **Range:** N/A  
**Source:** MODIS-AUX P\_R05    **Missing value:** -999  
**Field type:** REAL(4)    **Missing value operator:** ==  
**Dimensions:** mod\_granules,Band\_500M                              **Units:** N/A

Radiance scales needed to convert unscaled radiance data to scientific values.

**(38) Radiance offsets for EV\_500\_RefSB**

**Name in file:** EV\_500\_RefSB\_rad\_offsets                              **Range:** N/A  
**Source:** MODIS-AUX P\_R05    **Missing value:** -999  
**Field type:** REAL(4)    **Missing value operator:** ==  
**Dimensions:** mod\_granules,Band\_500M                              **Units:** N/A

Radiance offsets needed to convert unscaled radiance data to scientific values.

**(39) Reflectance scales for EV\_500\_RefSB**

<b>Name in file:</b> EV_500_RefSB_ref_scales	<b>Range:</b> N/A
<b>Source:</b> MODIS-AUX P_R05	<b>Missing value:</b> -999
<b>Field type:</b> REAL(4)	<b>Missing value operator:</b> ==
<b>Dimensions:</b> mod_granules,Band_500M	<b>Units:</b> N/A

Reflectivity scales needed to convert unscaled radiance data to scientific values.

**(40) Reflectance offsets for EV\_500\_RefSB**

<b>Name in file:</b> EV_500_RefSB_ref_offsets	<b>Range:</b> N/A
<b>Source:</b> MODIS-AUX P_R05	<b>Missing value:</b> -999
<b>Field type:</b> REAL(4)	<b>Missing value operator:</b> ==
<b>Dimensions:</b> mod_granules,Band_500M	<b>Units:</b> N/A

Reflectivity offsets needed to convert unscaled radiance data to scientific values.

**(41) MODIS Earth View 500M Aggregated 1KM Reflective Solar Bands**

**Uncertainty Indexes Subset**

<b>Name in file:</b> EV_500_RefSB_Uncert_Indexes	<b>Range:</b> 0 to 15
<b>Source:</b> MODIS-AUX P_R05	<b>Missing value:</b> 255
<b>Field type:</b> UINT(1)	<b>Missing value operator:</b> ==
<b>Dimensions:</b> mod_1km,nray,Band_500M	<b>Units:</b> N/A

Uncertainty indexes corresponding to the EV\_500\_Aggr1km\_RefSB radiances. The radiance uncertainty is calculated with:

$$\text{uncertainty(\%)} = \text{specified\_uncertainty} * \exp(\text{uncertainty\_index} / \text{scaling\_factor})$$

**(42) MODIS Earth View 500M Aggregated 1KM Reflective Solar Bands Specified**

**Uncertainty**

<b>Name in file:</b> EV_500_RefSB_spec_uncert	<b>Range:</b> N/A
<b>Source:</b> MODIS-AUX P_R05	<b>Missing value:</b> -999
<b>Field type:</b> REAL(4)	<b>Missing value operator:</b> ==
<b>Dimensions:</b> mod_granules,Band_500M	<b>Units:</b> N/A

The specified uncertainty is used along with the uncertainty indexes and scale factors to calculate the radiance uncertainty in % (see uncertainty indexes description).



### **(43) MODIS Earth View 500M Aggregated 1KM Reflective Solar Bands Scaling Factor**

<b>Name in file:</b> EV_500_RefSB_scaling_factor	<b>Range:</b> N/A
<b>Source:</b> MODIS-AUX P_R05	<b>Missing value:</b> -999
<b>Field type (in file):</b> REAL(4)	<b>Missing value operator:</b> ==
<b>Dimensions:</b> mod_granules,Band_500M	<b>Units:</b> N/A

The scaling factor is used along with the uncertainty indexes and specified uncertainty to calculate the radiance uncertainty in % (see uncertainty indexes description).

### **5 Changes Since Algorithm Version P\_R04**

- 1B-CPR P\_R05 inputs are now used.
- Version P\_R04 used MODIS Collection 5.1 up until 1 May 2014 and Collection 6 afterward. The current version uses Collection 6 for the entire mission.
- There were no updates to the algorithm.

### **6 Acronym List**

ATBD	Algorithm Theoretical Basis Document
CORE	CloudSat Operational and Research Environment
CPR	Cloud Profiling Radar
DAAC	Distributive Active Archive Center
DPC	Data Processing Center
EOS	Earth Observing System
GES	Goddard Earth Sciences (DAAC)
HDF	Hierarchical Data Format
MODIS	MOderate-Resolution Imaging Spectrometer