CALIPSO WFC Level 1 1km Data Description Document
Version 4.00

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Data Version: 4.00
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Data Date Range: June 13, 2006 to April 10, 2020

Introduction

The primary Wide Field Camera (WFC) Level 1B data products are calibrated radiance and bidirectional reflectance registered to an Earth-based grid centered on the Lidar ground track. During the normal operation, the WFC acquires science data only during the daylight portions of the CALIPSO orbits. For each orbit, three different data files are produced: 1 km Native Science grid, 125 m Native Science grid, and 1 km Registered Science grid. The 1 km Native Science grid covers the full 61 km swath centered on the Lidar track. The 125 m Native Science grid contains only the central 5 km wide high resolution portion of the WFC swath. The 1 km Registered Science grid provides WFC data on the identical grid as the CALIPSO IIR data and is produced to facilitate the use of the WFC data in the IIR retrievals. In addition to radiance and reflectance grids, the WFC Level 1 data products include two parameters that quantify the homogeneity of the cross track image frames: swath homogeneity and track homogeneity.

There are also two intermediate WFC Level 1B data products: Assembler and Calibration. The calibration data product contains geolocated nighttime digital count data. The calibration data is collected over a 25-second segment on the dark side of every orbit. The assembler data products contain geolocated nighttime daily digital count and daily statistical data which comes from the calibration product. The assembler algorithm takes the calibration data and calculates the statistics for each pixel (mean, standard deviation, maximum, and minimum).

This document will focus on the 1 km Native Science grid data product.

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Additional Documentation

- CALIPSO Data Management Team: CALIPSO Data Products Catalog, PC-SCI-503, Release 5.00.
- CALIPSO Algorithm Theoretical Basis Document, Wide Field Camera (WFC) Level 1 Algorithms (PC-SCI-205), Release 1.0, 25 October, 2005.

Data Product Descriptions

Scan_Time

Units: s

Format: Float_64

Valid Range: 4.203E8, 9.623E8

Description: Reports the International Atomic Time (TAI) in elapsed seconds from January 1, 1993.

Scan_UTC_Time

Units: yymmdd.ffffffff

Format: Float_64

Valid Range: 60428, 230701.0

Description: Reports the Coordinated Universal Time (UTC); format = yymmdd.ffffffff, where yy is a two digit data acquisition year number (06 to 23), mm is a month number (01 to 12), dd is a day number (1 to 31), and ffffffff is the elapsed fraction of the data acquisition day.

Latitude

Units: degrees_north

Format: Float_32

Valid Range: -90.0, 90.0

Description: Reports the latitude of the individual 1km WFC pixel on the surface.

Longitude

Units: degrees_east

Format: Float_32

Valid Range: -180.0, 180.0

Description: Reports the longitude of the individual 1km WFC pixel on the surface.

Radiance

Units: W/((m^2)*um*sr)

Format: Float_32

Typical Range: 0.0…2000.0

Description: The band-average spectral radiance of the scene averaged over the spectral range of the WFC (620-670 nm).

Reflectance

Units: No Units

Format: Float_32

Typical Range: 0.0…2.0

Description: The bi-directional reflectivity of the scene defined as the ratio of the intensity of the radiation reflected from the surface and atmosphere as observed by the WFC and the intensity of the incident solar radiation at the top of the atmosphere.

1km_Homogeneity

Units: No Units

Format: Float_32

Valid Range: 0.0, 2.0

Description: The 1 km swath homogeneity is simply the standard deviation in radiance over the full 61 km cross-track swath normalized by the swath mean. The spatial resolution of the swath homogeneity is 61 km cross-track and 1 km along-track.

Solar_Zenith

Units: degrees

Format: Float_32

Valid Range: 0.0, 90.0

Description: The angle between the zenith at the WFC pixel footprint on the surface and the line of sight to the sun.

Solar_Azimuth

Units: degrees

Format: Float_32

Valid Range: -180.0, 180.0

Description: The azimuth angle measured from north to the line of sight to the sun.

Viewing_Zenith

Units: degrees

Format: Float_32

Valid Range: 0.0, 90.0

Description: The angle between the WFC viewing vector and the zenith at the WFC pixel footprint on the surface.

Viewing_Azimuth

Units: degrees

Format: Float_32

Valid Range: -180.0, 180.0

Description: The azimuth angle measured from north to the WFC viewing vector.

CCD_Temperature

Units: degC

Format: Float_32

Typical Range: -100.0…100.0

Description: Temperature of the focal plane of the WFC Charge Coupled Device (CCD) array. The temperature of the WFC detector is actively controlled by a Thermoelectric Cooler (TEC). The set point is 0°C and the nominal range is about +/- 0.5°. Larger excursions have been observed with no impact on the data quality. However, if excursions exceed more than about +/- 5°, the data should be used with caution.

BasePlate_Temperature

Units: degC

Format: Float_32

Typical Range: -100.0…100.0

Description: Temperature of the feet of the WFC housing. Typically ranges between 10°C and 20°C. Primarily used as a diagnostic tool.

Reflectance_Bins

Units: No Units

Format: Int_32

Valid Range: 0, 20000

Description: Statistics on the observed WFC reflectance are produced for each orbit and reported here. The data are sorted into 5° solar zenith angle bins (0-5°, 5-10°, 10-15°, etc.). There are 72 reflectance bins within each solar zenith bin and the total number of occurrences per orbit is reported in each bin.

Pixel_QC_Flag

Units: No Units

Format: UInt_32

Valid Range: 0, 8

Description: This is a 32-bit integer to identify potential data quality issues. Only the first 5 bits are used as described below. Most data will have QC Flag values of zero; however, such as in the case of missing satellite ephemeris and attitude data, this will not always be true. If the QC Flag value is greater than 1, the data should be used with caution. If the QC Flag value is greater than 3, the data should not be used. Note, pixels with no geolocation will be identified with fill values in the position fields.

Table 1: interpretation of the Pixel QC Flag

Bit	Definition
1	Center pixel not defined in level 0 data
2	Radiance exceeds max count … saturated pixel
3	Cannot geolocate
4	Negative radiance
5	Negative reflectance

Metadata Parameter Descriptions

Product_ID

An 80-byte character string containing the product name. For the WFC Level 1 data, this parameter is “WFC_L1”.

Date_Time_at_Granule_Start

A 27-byte character string that specifies the granule start date and time. The format is yyyy-mm-ddThh:mm:ss.ffffffZ.

Date_Time_at_Granule_End

A 27-byte character string that specifies the granule end date and time. The format is yyyy-mm-ddThh:mm:ss.ffffffZ.

Date_Time_of_Production

A 27-byte character string that specifies the granule production. The format is yyyy-mm-ddThh:mm:ss.ffffffZ.

Number_of_Good_125m_Records

Reports the number of good 125 m records.

Number_of_Bad_125m_Records

Reports the number of bad 125 m records.

Number_of_Good_1km_Records

Reports the number of good 1 km records.

Number_of_Bad_1km_Records

Reports the number of bad 1 km records.

Initial_Subsatellite_Latitude

This field reports the first subsatellite latitude of the granule.

Initial_Subsatellite_Longitude

This field reports the first subsatellite longitude the granule.

Final_Subsatellite_Latitude

This field reports the last subsatellite latitude of the granule.

Final_Subsatellite_Longitude

This field reports the last subsatellite longitude the granule.

Orbit_Number_at_Granule_Start

Orbit_Number_at_Granule_Stop

Orbit_Number_Change_Time

Orbit Number consists of three fields that define the number of revolutions by the CALIPSO spacecraft around the Earth. This number is incremented each time the spacecraft passes the equator on the ascending node. To maintain consistency between the CALIPSO and CloudSat orbit parameters, the Orbit Number is keyed to the CloudSat orbit 2121 at 23:00:47 on 2006/09/20. Because the CALIPSO data granules are organized according to the day and night conditions, based on fixed Sun-Earth-Satellite angles, day/night boundaries do not coincide with transition points for defining orbit number. As such, three parameters are needed to describe the orbit number for each granule as:

- **Orbit Number at Granule Start:** orbit number at the granule start time.
- **Orbit Number at Granule End:** orbit number at the granule stop time.
- **Orbit Number Change Time:** time at which the orbit number changes in the granule.

Path_Number_at_Granule_Start

Path_Number_at_Granule_Stop

Path_Number_Change_Time

Path Number consists of three fields that define an index ranging from 1-233 that references orbits to the Worldwide Reference System (WRS). This global grid system was developed to support scene identification for LandSat imagery. Since the A-Train is maintained to the WRS grid within +/- 10 km, the Path Number provides a convenient index to support data searches, instead of having to define complex latitude and longitude regions along the orbit track. The Path Number is incremented after the maximum latitude in the orbit is attained and changes by a value of 16 between successive orbits. Because the CALIPSO data granules are organized according to the day and night conditions, based on fixed Sun-Earth-Satellite angles, day/night boundaries do not coincide with transition points for defining path number. As such, three parameters are needed to describe the path number for each granule as:

- **Path Number at Granule Start:** path number at the granule start time.
- **Path Number at Granule End:** path number at the granule stop time.
- **Path Number Change Time:** time at which the path number changes in the granule.

Ephemeris_Files_Used

A 160-byte character string that reports a maximum of two ephemeris files used in processing the spacecraft position and velocity.

Attitude_Files_Used

A 160-byte character string that reports a maximum of two attitude files used in processing the spacecraft attitude and attitude rate.

Vicarious_Calibration_File_Used

An 80-byte character string that reports the calibration file that contains the dark current offset, relative responsivity (calibration coefficients), quaternion rotations, and bad pixel map that is used in the processing of the data.

1km_Radiance_Calibration_Coefficients

A 61 element array that contains the coefficients used in the data calibration of the 1 km data.

125m_Radiance_Calibration_Coefficients

A 40 element array that contains the coefficients used in the data calibration of the 125 m data.

Column_Number_of_Center_Image_Pixel

Reports the CCD array center column used for this orbit.

Row_Number_of_Center_Image_Pixel

Reports the CCD array center row used for this orbit.

Frame_Time

Reports the total amount of time, in milliseconds, for a frame of data.

Integration_Time

Reports the total amount of time, in milliseconds, the CCD is exposed to light during a single data acquisition.

Total_Proc_Day_Packets

Reports the number of daytime packets processed.

Total_Proc_Night_Packets

Reports the number of nighttime packets processed.

Reflectance_Bins_Min

A 72 element array, which is the minimum value of each reflectance bin reported.

Reflectance_Bins_Max

A 72 element array, which is the maximum value of each reflectance bin reported.

Solar_Zenith_Bins_Min

A 15 element array, which is the minimum value of each solar zenith angle bin reported.

Solar_Zenith_Bins_Max

A 15 element array, which is the maximum value of each solar zenith angle bin reported.

Relevant External Documentation

Michael C. Pitts, Larry W. Thomason, Yongxiang Hu, and David M. Winker "An assessment of the on-orbit performance of the CALIPSO wide field camera", Proc. SPIE 6745, Remote Sensing of Clouds and the Atmosphere XII, 67450K (25 October 2007); https://doi.org/10.1117/12.737377.

Data Release Information

Table 2: dates, versions, and production strategy for all CALIPSO WFC level 1 data releases

WFC Lidar Level 1			
Release Date	**Version**	**Data Date Range**	**Production Strategy**
October 2025	4.00	June 13, 2006 to April 10, 2020	Standard
December 2011	3.02	November 11, 2011 to April 10, 2020	Validated Stage 1
May 2010	3.01	June 13, 2006 to October 29, 2009	Validated Stage 1

WFC Lidar Level 1			
Release Date	**Version**	**Data Date Range**	**Production Strategy**
December 2006	1.10	June 13, 2006 to September 21, 2010	Provisional

Data Quality Information

Data Quality Statement for the release of the CALIPSO WFC Level 1 Product Version 4.00

For the final release of the WFC data product two major changes were made.

Inclusion of Assembler and Calibration Files

Two intermediate products are generated as part of the WFC Level 1 processing that were previously not released, but for the final release will be. The calibration data product contains geolocated nighttime digital count data. The calibration data is collected over a 25-second segment on the dark side of every orbit. The assembler data products contain geolocated nighttime daily digital count and daily statistical data which comes from the calibration product. The assembler algorithm takes the calibration data and calculates the statistics for each pixel (mean, standard deviation, maximum, and minimum).

Update Format of CALIPSO HDF Files

The V4.0 WFC data products are distributed as Hierarchical Data Format Version 4 (HDF4) files, consistent with the EOS requirement in effect when CALIPSO launched in 2006. Since launch, there have been substantial technological advances in data discoverability and access resources. To make this data more readily accessible to the scientific community beyond the life of the mission and take advantage of newer data access capabilities, several modifications were made to the look and format of the WFC HDF files. These include:

- Update all units to conform to NetCDF Climate and Forecast (CF) metadata conventions.
- Verify all dimensions are named, to allow HDF to NCDF conversions using commercial off the shelf (COTS) tools that currently exist.
- Create/expand attributes and comments for all SDSs to make the data products more self-documenting.

Data Quality Statement for the release of the CALIPSO WFC Level 1 Product Version 3.02

The CALIPSO Team is releasing Version 3.02 which represents a transition of the Lidar, IIR, and WFC processing and browse code to a new cluster computing system. No algorithm changes were introduced, and very minor changes were observed between V 3.01 and V 3.02 as a result of the compiler and computer architecture differences. Version 3.02 is being released in a forward processing mode beginning November 1, 2011.

Data Quality Statement for the release of the CALIPSO WFC Level 1 Product Version 3.01

WFC Level 1B Scans Version 3.01 includes new metadata parameters and corrections to several minor software bugs. Specifically, the Orbit Number and Path Number metadata parameters are now included to facilitate improved sub-setting capabilities.

Data Quality Statement for the release of the CALIPSO WFC Level 1 Product Version 1.10

The WFC is currently fully functional and operating nominally. To date, the WFC data quality assessments have been focused on two primary areas: geolocation and radiometric accuracy. Post-launch checks of the WFC geolocation identified both along-track and cross-track biases in the reported WFC pixel locations. These systematic offsets were on the order of several 100 meters and were attributed to a small, uncharacterized misalignment of

the WFC relative to the spacecraft platform. Geolocation corrections have been implemented in the Level 1 ground processing to eliminate these biases. WFC geolocation accuracy for the V1.10 data release is estimated to be better than 50 m. The initial assessment of the WFC radiometric performance was based on comparisons with the well-calibrated Aqua MODIS Channel 1 data. Preliminary comparisons indicated that the WFC radiometric measurements were biased high relative to MODIS by about 10%. Further investigation revealed that an offset in the reported WFC exposure time was the likely cause of this bias. A review of pre-launch ground test data and results from diagnostic experiments performed on-orbit confirmed that the true WFC exposure time is about 0.4 ms longer than reported. Accounting for this exposure time offset results in about a 9% reduction in the magnitude of the WFC radiance values. This correction has been implemented in the Level 1 processing for the V1.10 data release. The WFC V1.10 radiometric measurements now exhibit excellent agreement with MODIS, with differences typically less than 2% over bright targets.