CALIPSO Quality Statement: Wide Field Camera Level 1B Scans Data Release Versions: 3.01, 3.02

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Introduction

This document provides a high-level quality assessment of the CALIPSO Level 1B Wide Field Camera (WFC) data products, as described in Section 2.3 of the CALIPSO Data Products Catalog (Version 3.2) (PDF). As such, it represents the minimum information needed by scientists and researchers for appropriate and successful use of these data products. We strongly suggest that all authors, researchers, and reviewers of research papers review this document for the latest status before publishing any scientific papers using these data products.

The purpose of these data quality summaries is to inform users of the accuracy of CALIOP data products as determined by the CALIPSO Science Team and Wide Field Camera Science Working Group. This document is intended to briefly summarize key validation results; provide cautions in those areas where users might easily misinterpret the data; supply links to further information about the data products and the algorithms used to generate them; and offer information about planned algorithm revisions and data improvements.

Additional Documentation and References

Algorithm Theoretical Basis Documents (ATBDs)

- PC-SCI-205 - WFC Level 1 ATBD (PDF)

General References

- PC-SCI-503 : CALIPSO Data Products Catalog (Version 3.2) (PDF)
- Additional peer-reviewed publications (journal articles and conference proceedings about CALIPSO science, algorithms, and data processing)
- CALIPSO Data Read Software

Standard and Expedited Data Set Definitions

Standard Data Sets:
Standard data processing begins immediately upon delivery of all required ancillary data sets. The ancillary data sets used in standard processing (e.g., GMAO meteorological data and data from the National Snow and Ice Data Center) must be spatially and temporally matched to the CALIPSO data acquisition times, and thus the time lag latency between data onboard acquisition and the start of standard processing can be on the order of several days.
The data in each data set are global, but are produced in files by half orbit, with the day portion of an orbit in one file and the night portion of the orbit in another.

Expedited Data Sets:
Expedited data are processed as soon as possible after following downlink from the satellite and delivery to LaRC. Latency between onboard acquisition and analysis expedited processing is typically on the order of 6 to 28 hours. Expedited processing uses the most recently current available set of ancillary data (e.g., GMAO meteorological profiles) and calibration coefficients available, which may lag the CALIPSO data acquisition time/date by several days.
Expedited data files contain at the most, 90 minutes of data. Therefore, each file may contain both day and night data.
NOTE: Users are strongly cautioned against using Expedited data products as the basis for research findings or journal publications. Standard data sets only should be used for these purposes.

The differences between expedited processing and standard processing are explained in more detail in "Adapting CALIPSO Climate Measurements for Near Real Time Analyses and Forecasting" (PDF).

CALIPSO WFC Level 1B Data Product Description

The primary Wide Field Camera 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. The major categories of WFC Level 1B data in each file type are:

- WFC 1 km x 1 km Native Science Data (full 61 km swath)
  - Radiance
  - Reflectance
  - Swath Homogeneity
  - Position Data
  - Viewing Geometry
- WFC 125 m x 125 m Native Science Data (central 5 km swath only)
  - Radiance
  - Reflectance
  - Track Homogeneity
  - Position Data
  - Viewing Geometry
- WFC 1 km x 1 km Registered Science Data (IIR grid)
  - Radiance
  - Reflectance
  - Swath Homogeneity
  - Position Data
  - Viewing Geometry

For the convenience of the user, we describe the contents of each of the three major file types separately below. Note, in isolated cases satellite ephemeris and attitude data may be missing for a portion of an orbit. In these cases, the geolocation process will fail and fill values (-9999) will be reported in all position and viewing geometry fields. In addition, the Pixel QC Flag (see below) will also be set appropriately for no geolocation.

WFC 1 km Native Science Data

(see Table 20 in CALIPSO Data Products Catalog (Version 3.2) (PDF))

The 1 km Native Science data product provides WFC radiance and reflectance measurements across the full 61 km swath at 1 km resolution. The 125 m data in the central 5 km swath have been averaged to the 1 km resolution to fill in this portion of the swath. No additional spatial interpolation is performed.

Scan Time
This field reports the International Atomic Time (TAI) for each WFC scan, in seconds, starting from January 1, 1993.

Scan UTC Time
This field reports the Coordinated Universal Time (UTC) for each WFC scan with a format 'yymmdd.ffffffff', where 'yy' is the last two digits of year, 'mm' and 'dd' represent month and day, respectively, and 'ffffffff' is the fractional of the day.

Latitude
This field reports the latitude of the individual 1 km WFC pixel on the surface.

Longitude
This field reports the longitude of the individual 1 km WFC pixel on the surface.

Radiance
The band-average spectral radiance of the scene averaged over the spectral range of the WFC (620-670 nm). Units are $Wm^{-2}sr^{-1}\mu m^{-1}$.

Reflectance
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. It is has no units.

1 km Homogeneity
The 1 km or swath homogeneity is defined as the variance 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 Angle
The angle between the zenith at the WFC pixel footprint on the surface and the line of sight to the sun.

Solar Azimuth Angle
The azimuth angle measured from north to the line of sight to the sun.

Viewing Zenith Angle
The angle between the WFC viewing vector and the zenith at the WFC pixel footprint on the surface.

Viewing Azimuth Angle
The azimuth angle measured from north to the WFC viewing vector.

CCD Temperature
Temperature of the focal plane of the WFC CCD array. The temperature of the WFC detector is actively controlled by a 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.

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

Reflectance Bins
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
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 0, the data should be used with caution. If the QC Flag value is greater than 3, the data should not be used.

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

WFC 125 m Native Science Data

(see Table 21 in CALIPSO Data Products Catalog (Version 3.2))

The 125 m Native Science data product provides WFC radiance and reflectance measurements across just the central 5 km swath at 125 m resolution. No spatial interpolation is performed.

Scan Time
This field reports the International Atomic Time (TAI) for each WFC scan, in seconds, starting from January 1, 1993.

Scan UTC Time
This field reports the Coordinated Universal Time (UTC) for each WFC scan with a format 'yymmdd.ffffffff', where 'yy' is the last two digits of year, 'mm' and 'dd' represent month and day, respectively, and 'ffffffff' is the fractional of the day.

Latitude
This field reports the latitude of the individual 125 m WFC pixel on the surface.

Longitude
This field reports the longitude of the individual 125 m WFC pixel on the surface.

Radiance
The band-average spectral radiance of the scene averaged over the spectral range of the WFC (620-670 nm). Units are $Wm^{-2}sr^{-1}\mu m^{-1}$.

Reflectance
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. It is has no units.

125 m Homogeneity
The 125 m or track homogeneity is simply as the standard deviation in radiance over the central 5 km high-resolution portion of the WFC image frame normalized by the mean.

Reflectance Bins 125 m

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

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 0, the data should be used with caution. If the QC Flag value is greater than 3, the data should not be used.

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

WFC 1 km Registered Science Data

(see Table 18 in CALIPSO Data Products Catalog (Version 3.2) (PDF))

To facilitate the use of the WFC data in IIR retrievals, the WFC radiometric data is also registered to the same Earth-based geometric grid as the IIR data. This grid projection has been defined as follows:

- Grid lines are orthogonal to the lidar track
- Center point in each grid line is aligned with the lidar track
- Center point is registered with a lidar shot
- Grid lines are separated by about 1 km, but exact sampling is determined by translation of sub-satellite point during a time Δt equivalent to 3 lidar shots (i.e. ~148 ms)

The WFC data are registered to the IIR grid by interpolation of the "native grid" data using a bilinear interpolation scheme.

Lidar Shot Time

This field reports the International Atomic Time (TAI) for each Lidar shot that defines a grid line, in seconds, starting from January 1, 1993.

Lidar Shot UTC Time

This field reports the Coordinated Universal Time (UTC) for each Lidar shot that defines a grid line, with a format 'yymmdd.ffffffff', where 'yy' is the last two digits of year, 'mm' and 'dd' represent month and day, respectively, and 'ffffffff' is the fractional of the day.

Latitude

This field reports the latitude of the individual 1 km WFC grid points on the surface.

Longitude

This field reports the longitude of the individual 1 km WFC grid points on the surface.

Radiance

The band-average spectral radiance of the scene averaged over the spectral range of the WFC (620-670 nm). Units are $Wm^{-2}sr^{-1}\mu m^{-1}$.

Reflectance

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. It is has no units.

1 km Homogeneity

The 1 km or swath homogeneity is defined as the variance 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 Angle

The angle between the zenith at the WFC grid point on the surface and the line of sight to the sun.

Solar Azimuth Angle

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

Viewing Zenith Angle

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

Viewing Azimuth Angle
The azimuth angle measured from north to the WFC viewing vector.

Pixel QC Flag
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 0, the data should be used with caution. If the QC Flag value is greater than 3, the data should not be used.

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

File Metadata Parameters

Product ID
an 80-byte (max) character string specifying the data product name. The values for the Wide Field Camera data products will be "WFC_Native_125m", "WFC_Native_1Km", and "WFC_IIR_Registered_1km".

Date Time at Granule Start
a 27-byte character string that reports the date and time at the start of the file orbit segment (i.e., granule). The format is yyyy-mm-ddThh:mm:ss.ffffffZ.

Date Time at Granule End
a 27-byte character string that reports the date and time at the end of the file orbit segment (i.e., granule). The format is yyyy-mm-ddThh:mm:ss.ffffffZ.

Date Time at Granule Production
This is a 27-byte character string that defines the date at granule production. The format is yyyy-mm-ddThh:mm:ss.ffffffZ.

Number of Good 125 m Records
This field reports the number of good 125m records.

Number of Bad 125 m Records
This field reports the number of bad 125m records.

Number of Good 1 km Records
This field reports the number of good 1 Km records.

Number of Bad 1 km Records
This field 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 of 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 of the granule.

Orbit Number at Granule Start
This field reports the orbit number at the granule start time.

Orbit Number at Granule End
This field reports the orbit number at the granule stop time.

Orbit Number Change Time
This field reports the time at which the orbit number changes in the granule.

Path Number at Granule Start
This field reports the path number at the granule start time.

Path Number at Granule End
This field reports the path number at the granule stop time.

Path Number Change Time
This field reports the time at which the path number changes in the granule.

Ephemeris Files Used
This is a 160-byte character that reports a maximum of two ephemeris files used in processing the spacecraft position and velocity.

Attitude Files Used
This is a 160-byte character that reports a maximum of two attitude files used in processing the spacecraft attitude and attitude rate.

Vicarious Calibration File Used
This is an 80-byte character that reports the calibration file that contains the dark current offset, relative responsitivity (calibration coefficients), quaternion rotations, and bad pixel map that is used in the processing of the data.

1km Radiance Calibration Coefficients
This is a 61 element array that contains the coefficients used in the data calibration of the 1 Km data.

125m Radiance Calibration Coefficients
This is a 40 element array that contains the coefficients used in the data calibration of the 125 m data.

Column Number of Center Image Pixel
This field reports the CCD array center column used for this granule.

Row Number of Center Image Pixel
This field reports the CCD array center row used for this granule.

Frame Time
This field reports the total amount of time for a frame of data.

Integration Time
This field reports the amount of time the CCD is exposed to light during a single data acquisition.

Total Poss Day Packets
This field reports the possible number daytime packets that could be processed.

Total Proc Day Packets
This field reports the number of daytime packets processed.

Total Proc Night Packets
This field reports the number of nighttime packets processed.

Reflectance Bins Min
This is a 72 element array, which is the minimum value of each reflectance bin reported.

Reflectance Bins Max
This is a 72 element array, which is the maximum value of each reflectance bin reported.

Solar Zenith Bins Min
This is a 15 element array, which is the minimum value of each solar zenith angle bin reported.

Solar Zenith Bins Max
This is a 15 element array, which is the maximum value of each solar zenith angle bin reported.

Data Release Versions

Wide Field Camera (WFC) Level 1B Scans Information Half orbit (Day) geolocated data radiances			
Release Date	**Version**	**Data Date Range**	**Maturity Level**
December 2011	3.02	November 1, 2011 to present	Validated Stage 1
November 2010	3.01	June 13, 2006 to October 31, 2011	Validated Stage 1

Data Quality Statement for the release of the CALIPSO WFC Level 1B Products Version 3.02, December 2011

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 Product WFC Level 1B Scans Version 3.01, November 2010

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 subsetting capabilities.

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. WFC geolocation accuracy is estimated to be better than 50 m. There is no on-orbit radiometric calibration capability for the WFC. Therefore, we must rely on vicarious approaches to verify and monitor the WFC radiometric calibration. Since the WFC bandpass is matched to the well-calibrated Aqua MODIS Channel 1, direct comparisons with nearly coincident MODIS Channel 1 measurements provide an excellent means of assessing the WFC radiometric performance. On-orbit performance assessments of the WFC radiometric products are refularly performed-based on analysis of coincident WFC and MODIS data. Using deep convective clouds as vicarious calibration targets, direct comparisons of WFC and MODIS radiance measurements from the first four years of the CALIPSO mission indicate that the WFC radiance tracks the MODIS data very closely with daily absolute mean differences never exceeding 1.5% and typically less than 1%. Analysis of WFC and MODIS deep convective cloud reflectance distributions also indicate that the WFC has exhibited very good radiometric stability during the four years of operation with at most a <1% drift relative to MODIS. For more details, please see Pitts et al. (2007) (PDF).