CALIPSO Lidar Level 0 Payload Instrument Verification and Block (PIVB) Data Description Document
Version 1.00

Last Updated: August 25, 2025

Data Version: 1.00
Data Release Date: August 1, 2024
Data Date Range: August 23, 2016 to June 6, 2023

Introduction

The CALIPSO payload flight software creates Raw and Post-Processed packets for data from all three channels; 532 nm parallel, 532 nm perpendicular, and 1064 nm. These payload instrument verification block (PIVB) data are reported in the Lidar Level 0 (L0) PIVB data product.

The L0 PIVB reports raw and backscatter signals from the high and low gain channel prior to being merged on-board into a single profile. Capturing of this data is outside the nominal science operations and requires special commanding of this instrument, so because of that the PIVB data are only episodically produced through the latter half of the mission. Also, given the large amount of data and the limitations of the on-board recorder only a portion of an orbit is generated in this mode.

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Additional Documentation

- CALIPSO Data Management Team: CALIPSO Data Products Catalog, PC-SCI-503, Release 5.00.
- Hostetler, C. A., Z. Liu, J. Reagan, M. A. Vaughan, D. M., Winker, M. Osborn, W. A. Hunt, K. A. Powell, and C. Trepte, 2006: CALIOP Algorithm Theoretical Basis Document: Calibration and Level 1 Data Products, PC-SCI-201.01, https://ntrs.nasa.gov/citations/20250006623.

Data Product Descriptions

Profile_Time

Units: TAI seconds

Format: Float_64

Valid Range: 4.203E8, 9.623E8

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

Profile_UTC_Time

Units: yymmdd.ffffffff

Format: Float_64

Valid Range: 60428.0…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.

Day_Night_Flag

Units: No Units

Format: Int_8

Valid Range: 0, 1

Range Value: 0 = day; 1 = night

Description: As CALIPSO approaches the terminator, the lidar is automatically reconfigured to adapt to changing lighting conditions that directly impact signal-to-noise (SNR) levels. These changes occur at Sun-Earth-Satellite (SES) angles of 95° (day to night) and 265° (night to day), corresponding to changes in lighting conditions at an altitude of ∼24 km above mean sea level. 0 indicates daytime conditions, 1 indicates nighttime.

Lidar_Mode

Units: No Units

Format: Int_16

Valid Range: 1, 6

Description: Lidar operations mode, as defined in Table 1.

Table 1: interpretation of the lidar operations mode values

Value	Operations Mode
1	Safe

Value	Operations Mode
2	Standby
3	autonomous data collection
4	built in test system (BITS)
5	special operations
6	Diagnostic

Lidar_Submode

Units: No Units

Format: Int_16

Valid Range: 1, 25

Description: Lidar operations sub-mode, as defined in Table 2.

Table 2: interpretation of the lidar operations submode values

Value	Operations Submode		Value	Operations Submode
1	safe		14	baseline measurement
2	warm-up		15	polarization calibration
3	standby		16	extended background measurement
4	normal		17	boresight alignment
5	BITS profile #1, no background		18	manual boresight operation
6	BITS profile #2, no background		19	boresight search
7	BITS profile #3, no background		20	build on-board baseline profiles
8	BITS profile #4, no background		21	baseline corrected high gain channel
9	BITS profile #1, with background		22	baseline corrected low gain channel
10	BITS profile #2, with background		23	uncorrected high gain channel
11	BITS profile #3, with background		24	uncorrected low gain channel
12	BITS profile #4, with background		25	diagnostic
13	no baseline removal		26–32	unused

Frame_Number

Units: No Units

Format: Int_16

Valid Range: 1, 11

Description: The number of current frame (5 km horizontal segment = 15 consecutive laser pulses) within the sequence of 11 frames within a Payload Data Acquisition Cycle (PDAC). A PDAC specifies the minimum time interval over which each of the three CALIPSO instruments (CALIOP, IIR, and WFC) can collect an integer number of measurements (165 laser pulses, ~55 km along track).

Parallel_Amplifier_Gain_532

Perpendicular_Amplifier_Gain_532

Units: V/V

Format: Float_32

Typical Range: 26.0…178.0

Description: Gain of the variable gain amplifier for the 532 nm parallel and perpendicular channels. The nighttime gains are substantially higher than the daytime gains.

Amplifier_Gain_1064_High

Amplifier_Gain_1064_Low

Units: V/V

Format: Float_32

Typical Range: 102.0…195.0

Description: Gain of the high and low gain amplifiers for the 1064 nm perpendicular channel.

Laser_Energy_Monitor_532

Units: J

Format: Float_32

Typical Range: 0.003…0.135

Description: 532 nm laser energy measured for each laser pulse by a dedicated onboard laser energy monitor.

Laser_Energy_Monitor_1064

Units: J

Format: Float_32

Typical Range: 0.038…0.12

Description: 1064 nm laser energy measured for each laser pulse by a dedicated onboard laser energy monitor.

Parallel_Background_Monitor_532

Perpendicular_Background_Monitor_532

Units: counts

Format: Float_32

Typical Range: 120.0…6000.0

Description: Magnitudes of the background signals, in science digitizer counts, for, respectively, the 532 nm parallel and 532 nm perpendicular channels. Background signals are measured for each laser pulse at very high altitudes (97-112 km), where laser backscatter from atmospheric constituents is essentially zero. Background signals include such things as detector dark current and background radiation signals (e.g., from daytime sunlight). CALIPSO lidar signals measured onboard the satellite include both an atmospheric

backscatter component and a background contribution, with the background signal being subtracted during the onboard data processing prior to data downlink.

Quality_Flags_532_Par

Quality_Flags_532_Per

Quality_Flags_1064

Units: No Units

Format: UInt_16

Description: 532 nm parallel and perpendicular and 1064 nm channel quality assurance flags; most significant bit = 15.

Table 3: 532nm and 1064nm quality assurance flag interpretations

Bit	Interpretation	Values
15	Configuration Suspect	True = 1, False = 0
14	Shutter Position Unconfirmed	True = 1, False = 0
13	High Gain Upper FIFO Empty	Empty = 0, Not Empty = 1 (nominal state = empty)
12	High Gain Lower FIFO Empty	Empty = 0, Not Empty = 1 (nominal state = empty)
11	Low Gain Upper FIFO Empty	Empty = 0, Not Empty = 1 (nominal state = empty)
10	Low Gain Lower FIFO Empty	Empty = 0, Not Empty = 1 (nominal state = empty)
09	Remove Baseline Algorithm Failed	True = 1, False = 0
08	Dynamic Gain Used	True = 1, False = 0 (nominal state = false)
07	Gain Calculation Status	Successful = 1, Unsuccessful = 0
06	Suspect Filter Wait Time	True = 1, False = 0
05	Suspect Old Table Data	True = 1, False = 0
04	Suspect GPS Data Points Ignored	True = 1, False = 0
03	Suspect Filter Performance	True = 1, False = 0
02	Suspect Old GPS Data	True = 1, False = 0
01	Suspect No Geolocation Solution	True = 1, False = 0
00	Suspect Attitude	True = 1, False = 0

Laser_Latitude

Units: degrees_north

Format: Float_32

Valid Range: -90.0, 90.0

Fill Value: -9999.0

Description: Geodetic latitude of the laser footprint on the Earth's surface.

Laser_Longitude

Units: degrees_east

Format: Float_32

Valid Range: -180.0, 180.0

Fill Value: -9999.0

Description: Longitude of the laser footprint on the Earth's surface.

Region_6_Low_Gain_Raw_Mean_532_Par

Region_6_Low_Gain_Raw_Mean_532_Per

Region_6_Low_Gain_Raw_Mean_1064

Units: counts

Format: Float_32

Description: The mean of 15000 samples of raw data collected on the 532 nm parallel, 532 nm perpendicular, and 1064 nm low gain channels within region 6 (high) of the defined backscatter regions.

Region_6_Low_Gain_Frame_RMS_Noise_532_Par

Region_6_Low_Gain_Frame_RMS_Noise_532_Per

Region_6_Low_Gain_Frame_RMS_Noise_1064

Units: counts

Format: Float_32

Description: The root-mean-square (RMS) noise of 15000 samples of raw data collected on the 532 nm parallel, 532 nm perpendicular, and 1064 nm low gain channels within region 6 (high) of the defined backscatter regions.

Region_6_Low_Gain_Overflows_532_Par

Region_6_Low_Gain_Overflows_532_Per

Region_6_Low_Gain_Overflows_1064

Units: No Units

Format: UInt_16

Description: The number of overflows in 15000 samples of raw data collected on the 532 nm parallel, 532 nm perpendicular, and 1064 nm low gain channels within region 6 (high) of the defined backscatter regions.

Region_6_Low_Gain_Underflows_532_Par

Region_6_Low_Gain_Underflows_532_Per

Region_6_Low_Gain_Underflows_1064

Units: No Units

Format: UInt_16

Description: The number of underflows in 15000 samples of raw data collected on the 532 nm parallel, 532 nm perpendicular, and 1064 nm low gain channels within region 6 (high) of the defined backscatter regions.

Region_2_Low_Gain_Overflows_532_Par

Region_2_Low_Gain_Overflows_532_Per

Region_2_Low_Gain_Overflows_1064

Units: No Units

Format: UInt_16

Description: The number of overflows in 8700 samples in Normal Processing or 9900 samples in Atmospheric Test Processing of raw data collected on the 532 nm parallel, 532 nm perpendicular, and 1064 nm low gain channels within region 2 of the defined backscatter regions.

Region_1_Low_Gain_Overflows_532_Par

Region_1_Low_Gain_Overflows_532_Per

Region_1_Low_Gain_Overflows_1064

Units: No Units

Format: UInt_16

Description: The number of overflows in 1500 samples in Normal Processing or 9900 samples in Atmospheric Test Processing of raw data collected on the 532 nm parallel, 532 nm perpendicular, and 1064 nm low gain channels within region 1 of the defined backscatter regions.

Region_0_Low_Gain_Raw_Mean_532_Par

Region_0_Low_Gain_Raw_Mean_532_Per

Region_0_Low_Gain_Raw_Mean_1064

Units: counts

Format: Float_32

Description: The mean of 7500 samples in Normal Processing or 15000 samples in Atmospheric Test Processing of raw data collected on the 532 nm parallel, 532 nm perpendicular, and 1064 nm low gain channels within region 0 (low) of the defined backscatter regions.

Region_6_High_Gain_Raw_Mean_532_Par

Region_6_High_Gain_Raw_Mean_532_Per

Region_6_High_Gain_Raw_Mean_1064

Units: counts

Format: Float_32

Description: The mean of 15000 samples of raw data collected on the 532 nm parallel, 532 nm perpendicular, and 1064 nm high gain channels within region 6 (high) of the defined backscatter regions.

Region_6_High_Gain_Frame_RMS_Noise_532_Par

Region_6_High_Gain_Frame_RMS_Noise_532_Per

Region_6_High_Gain_Frame_RMS_Noise_1064

Units: counts

Format: Float_32

Description: The root-mean-square (RMS) noise of 15000 samples of raw data collected on the 532 nm parallel, 532 nm perpendicular, and 1064 nm high gain channels within region 6 (high) of the defined backscatter regions.

Region_6_High_Gain_Overflows_532_Par

Region_6_High_Gain_Overflows_532_Per

Region_6_High_Gain_Overflows_1064

Units: No Units

Format: UInt_16

Description: The number of overflows in 15000 samples of raw data collected on the 532 nm parallel, 532 nm perpendicular, and 1064 nm high gain channels within region 6 (high) of the defined backscatter regions.

Region_6_High_Gain_Underflows_532_Par

Region_6_High_Gain_Underflows_532_Per

Region_6_High_Gain_Underflows_1064

Units: No Units

Format: UInt_16

Description: The number of underflows in 15000 samples of raw data collected on the 532 nm parallel, 532 nm perpendicular, and 1064 nm high gain channels within region 6 (high) of the defined backscatter regions.

Region_3_High_Gain_Overflows_532_Par

Region_3_High_Gain_Overflows_532_Per

Region_3_High_Gain_Overflows_1064

Units: No Units

Format: UInt_16

Description: The number of overflows in 12000 samples in Normal Processing or 7200 samples in Atmospheric Test Processing of raw data collected on the 532 nm parallel, 532 nm perpendicular, and 1064 nm high gain channels within region 3 of the defined backscatter regions.

Region_2_High_Gain_Overflows_532_Par

Region_2_High_Gain_Overflows_532_Per

Region_2_High_Gain_Overflows_1064

Units: No Units

Format: UInt_16

Description: The number of overflows in 8700 samples in Normal Processing or 9900 samples in Atmospheric Test Processing of raw data collected on the 532 nm parallel, 532 nm perpendicular, and 1064 nm high gain channels within region 2 of the defined backscatter regions.

Region_6_Merged_Background_Mean_532_Par

Region_6_Merged_Background_Mean_532_Per

Region_6_Merged_Background_Mean_1064

Units: counts

Format: Float_32

Description: The mean of 15000 samples of data after baseline removal, offset removal, merging and scaling, and residual offset removal, collected on the 532 nm parallel, 532 nm perpendicular, and 1064 nm combined gain channel within region 6 (high) of the defined backscatter regions.

Region_6_Merged_Shot_RMS_Noise_532_Par

Region_6_Merged_Shot_RMS_Noise_532_Per

Region_6_Merged_Shot_RMS_Noise_1064

Units: counts

Format: Float_32

Description: The root-mean-square (RMS) noise of 15000 samples of data after baseline removal, offset removal, merging and scaling, and residual offset removal, collected on the 532 nm parallel, 532 nm perpendicular, and 1064 nm combined gain channel within region 6 (high) of the defined backscatter regions.

Region_0_Merged_Background_Mean_532_Par

Region_0_Merged_Background_Mean_532_Per

Region_0_Merged_Background_Mean_1064

Units: counts

Format: Float_32

Description: The mean of 7500 samples in Normal Processing or 15000 samples in Atmospheric Test Processing of data after baseline removal, offset removal, merging and scaling, and residual offset removal, collected on the 532 nm parallel, 532 nm perpendicular, and 1064 nm combined gain channel within region 0 (low) of the defined backscatter regions.

Gain_Coeff_A_532_Par

Gain_Coeff_A_532_Per

Gain_Coeff_A_1064

Units: No Units

Format: Float_32

Description: The 532 nm parallel, 532 nm perpendicular, and 1064 nm gain coefficient A used by the combined gain channel algorithm for this frame of data.

Gain_Coeff_B_532_Par

Gain_Coeff_B_532_Per

Gain_Coeff_B_1064

Units: No Units

Format: Float_32

Description: The 532 nm parallel, 532 nm perpendicular, and 1064 nm gain coefficient B used by the combined gain channel algorithm for this frame of data.

Gain_Coeff_C_532_Par

Gain_Coeff_C_532_Per

Gain_Coeff_C_1064

Units: No Units

Format: Float_32

Description: The 532 nm parallel, 532 nm perpendicular, and 1064 nm gain coefficient C used by the combined gain channel algorithm for this frame of data.

Gain_Coeff_D_532_Par

Gain_Coeff_D_532_Per

Gain_Coeff_D_1064

Units: No Units

Format: Float_32

Description: The 532 nm parallel, 532 nm perpendicular, and 1064 nm gain coefficient D used by the combined gain channel algorithm for this frame of data.

Backscatter_532_Parallel_Averaged

Backscatter_532_Perpendicular_Averaged

Backscatter_1064_Averaged

Units: counts

Format: Float_32

Description: The 532 nm parallel, 532 nm perpendicular, and 1064 nm raw backscatter measurements.

Altitude_532_Averaged

Units: km

Format: Float_32

Valid Range: -1.86, 39.84

Description: Altitudes (above mean sea level) that specify the vertical midpoints of the 583 ranges bins in the profile backscatter measurements from the 532 nm channel.

Altitude_1064_Averaged

Units: km

Format: Float_32

Valid Range: -1.86, 29.94

Description: Altitudes (above mean sea level) that specify the vertical midpoints of the 405 ranges bins in the profile backscatter measurements from the 1064 nm channel.

Frame_Shot_Number

Units: No Units

Format: Int_32

Valid Range: 1, 15

Description: Indicates laser pulse position with the frame of data collected to form the PIVB.

Altitude_Raw_Data

Units: km

Format: Float_32

Valid Range: -18.48, 80.0

Description: Raw lidar data altitudes, totaling 4800 range bins, at 15 m resolution. Bins 1-1000 (80 to 65 km, upper baseline background measurement), bins 1001-4300 (47.5 to -1.95 km backscatter measurement bins), bins 4301-4800 (-11 to -18.48 km lower baser background measurement).

Raw_Data_532_Par_High_Gain

Raw_Data_532_Per_High_Gain

Raw_Data_1064_High_Gain

Units: counts

Format: Float_32

Description: Raw data collected on the 532 nm parallel, 532 nm perpendicular, and 1064 nm high gain channels. Data are unprocessed, range-resolved backscatter measurements acquired at 15 m resolution onboard the satellite in 5 non-contiguous backscatter regions beginning at 80 km above mean sea level extending to -18.48 km below the surface.

Raw_Data_532_Par_Low_Gain

Raw_Data_532_Per_Low_Gain

Raw_Data_1064_Low_Gain

Units: counts

Format: Float_32

Description: Raw data collected on the 532 nm parallel, 532 nm perpendicular, and 1064 nm low gain channels. Data are unprocessed, range-resolved backscatter measurements acquired at 15 m resolution onboard the satellite in 5 non-contiguous backscatter regions beginning at 80 km above mean sea level extending to -18.48 km below the surface.

High_Offset_532_Par

High_Offset_532_Per

High_Offset_1064

Units: counts

Format: Float_32

Description: The average of the first 1000 samples of raw 532 nm parallel, 532 nm perpendicular, and 1064 nm high gain backscatters from the upper baseline background measurement region (80 to 65 km).

Low_Offset_532_Par

Low_Offset_532_Per

Low_Offset_1064

Units: counts

Format: Float_32

Description: The average of the first 1000 samples of raw 532 nm parallel, 532 nm perpendicular, and 1064 nm low gain backscatters from the upper baseline background measurement region (80 to 65 km).

Metadata Descriptions

Product_ID

An 80-byte character string containing the product name. For the L0 data, this parameter is “L0_LIDAR”.

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.

Data Release Information

Table 4: dates, versions, and production strategy for all CALIPSO lidar level 0 PIVB data releases

Lidar Level 0 PIVB Profile			
Release Date	**Version**	**Data Date Range**	**Production Strategy**
August 2024	1.00	August 23, 2016 to June 6, 2023	Standard

References

Hunt, W. H, D. M. Winker, M. A. Vaughan, K. A. Powell, P. L. Lucker, and C. Weimer, 2009: CALIPSO Lidar Description and Performance Assessment, *J. Atmos. Oceanic Technol.*, **26**, 1214–1228, https://doi.org/10.1175/2009JTECHA1223.1.