CALIPSO Quality Statements Summary: Lidar Level 1B Profiles

Lidar Level 1B Profiles Information Half orbit (Night and Day) geolocated, calibrated Lidar Profiles and Viewing Geometry Products					
Release Date	**Version**	**Data Date Range**	**Product Quality Statement**	**Detailed Quality Statement**	**Maturity Level**
December 2011	3.02	November 1, 2011 to present	3.02 Version Summary	QS 3.01, 3.02	Validated Stage 1
November 2009	3.01	June 13, 2006 to February 16, 2009 March 17, 2009 to October 31, 2011	3.01 Version Summary	QS 3.01, 3.02	Validated Stage 1
June 2009	3.00	June 13, 2006 to December 31, 2006 March 12, 2009 to June 10, 2009 No longer orderable	3.00 Version Summary	QS 3.00	Validated Stage 1
October 2008	2.02	September 14, 2008 to February 16, 2009	2.02 Version Summary	QS 2.01, 2.02	Provisional
December 2007	2.01	June 13, 2006 to September 13, 2008	2.01 Version Summary		Provisional
August 12, 2007	1.22	August 12, 2007 to December 5, 2007	1.22 Version Summary	QS 1.22, 1.20, 1.11, 1.10	Provisional
March 1, 2007	1.20	March 1, 2007 to August 11, 2007	1.20 Version Summary		Provisional
January 6, 2007	1.11	January 6, 2007 to February 28, 2007	1.11 Version Summary		Provisional
December 8, 2006	1.10	June 13, 2006 to January 5, 2007	1.10 Version Summary		Provisional

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Data Release Date: December 2011
Version: 3.02
Data Date Range: November 1, 2011 to present

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 Release Date: November 2009
Version: 3.01
Data Date Range: June 13, 2006 to February 16, 2009 and March 17, 2009 to October 31, 2011

Incorrect 532 nm and 1064 nm extinction, backscatter, and ozone cross-sections were applied in the recent release of Lidar Level 1B Version 3.00. The data were reprocessed using the corrected values and are being released as Version 3.01.

Data Release Date: June 2009 - No longer orderable
Version: 3.00
Data Date Range: June 13, 2006 to December 31, 2006 and March 12, 2009 to June 10, 2009

Version 3.00 includes algorithm improvements, modifications to existing data parameters, and new data parameters. Algorithm improvements were implemented for the 532-nm daytime calibration, laser energy calculations, signal normalization by laser energy, and the interpolation of GMAO gridded data products to the CALIPSO orbit tracks. The modified parameters include the Met_Data_Altitude array and quality flags QC_Flag and QC_Flag_2. The new data parameters describe the orbit and path number and are included in the file metadata.

The revised 532-nm daytime calibration algorithm produces improved corrections to the thermally-induced drift in signal level that occurs over the course of the daytime orbit segment. In Version 3.00, the empirically determined correction factors are applied using a 34-point linear approximation as compared to the 5-point linear approximation implemented in Versions 2.01 and 2.02. This allows for better characterization of the small scale changes in signal level that take place over the daytime orbit segment. Comparisons of nighttime and newly calibrated daytime clear-air, attenuated scattering ratios over 8-12 km in altitude were made for multiple seasons and between LOM 1 (backup laser) and LOM 2 (first laser). In all cases the agreement between night and day was within 5% for the entire orbit segment.

Two updates to the 532-nm and 1064-nm laser energy calculation algorithm were implemented in Version 3.00 in order to reduce errors in both calibration and the processing of signal profiles for low energy laser shots. The first update uses new laser energy conversion coefficients to improve the accuracy of the laser energy calculation. In the second update, the signal normalization by laser energy is changed to normalize by averaging region instead of by shot. That is, for each averaging region, normalize all averaged shots by the corresponding average energy for that region. Data are averaged on-board over 15, 5, 3, or 1 shot(s) before downlink, with the amount of averaging depending upon the altitude. Application of the new normalization scheme improves the signal normalization for frames with low energy laser shots and has little effect on frames with nominal laser energies. The quality flags QC_Flag and QC_Flag_2 were updated to identify the profiles that were normalized using low energy.

Corrections were made to the code used to interpolate the GMAO gridded data products to the CALIPSO orbit tracks. In Versions 2.01 and 2.02, two bracketing GMAO files were used to derive meteorological parameters. In some cases, the CALIPSO measurement times fell outside of the bracketing file times causing parameters to be extrapolated. In Version 3.00, this problem was rectified by selecting three GMAO files for each orbit track segment. This assures the orbit track times are completely contained within the GMAO data file times.

The altitudes reported in the parameter Met_Data_Altitude were modified so they are now coincident with an altitude reported in the Lidar_Data_Altitude array.

The new parameters that were added contain orbit and path number information and are stored in the file metadata. The following six parameters were added: Orbit_Number_at_Granule_Start, Orbit_Number_at_Granule_End, Orbit_Number_Change_Time, Path_Number_at_Granule_Start, Path_Number_at_Granule_End, Path_Number_Change_Time.

Data Release Date: October 2008
Version: 2.02
Data Date Range: September 14, 2008 to February 16, 2009

Version 2.02 of the CALIOP Level 1 data products is a maintenance release that implements the following changes.

- Corrections were made to the code used to interpolate the GMAO gridded data products to the CALIPSO orbit tracks. As a result, the magnitudes of the molecular and ozone number densities used in the Level 1 calibration algorithms can be different from the values used in the version 2.01 processing by as much as ±0.5%. The exact magnitude of the changes encountered will vary according to latitude, longitude, altitude, and season.
- A small (~0.8%) error was corrected in the calculation of the Cabannes backscattering cross-sections used to derive the molecular scattering models used for the Level 1 532 nm parallel channel calibration algorithm.

Combined, these two changes yield 532 nm calibration constants that are larger, on average, by ~1%, with a corresponding decrease in the magnitudes of the 532 nm attenuated backscatter coefficients. Similar effects occur in the 1064 nm data. Implementing these changes increases the agreement between collocated measurements of "clear air" acquired by CALIPSO and NASA's high spectral resolution lidar (HRSL) by ~1%.

Data Release Date: December 2007
Version: 2.01
Data Date Range: June 13, 2006 to present

Version 2.01 includes revised algorithms for the 532 nm daytime calibration and the 1064 nm daytime and nighttime calibration. The 532 nm daytime calibration coefficients are now scaled relative to systematic variations in the measured backscatter signal that occur over the course of the daytime orbit segments. The Version 2.01 532 nm daytime calibration corrections produce significant improvements to the overall quality of both the Lidar Level 1 and 2 daytime data products, particularly in the northern hemisphere where the Level 1 data contain significant daytime calibration biases. It is recommended to use the Version 2.01 for all analyses of the 532 nm daytime data.

The Version 2.01 1064 nm calibration coefficients also vary as a function of orbit elapsed time, in the same manner and for the same reasons as the 532 nm calibration constants. In all previous versions, a single value for the 1064 nm calibration coefficient was computed and applied for each daytime and nighttime orbit granule. The revised calibration procedures produce substantial improvements in the quality of the 1064 nm measurements. These changes are most noticeable in the daytime granules. Use of the Version 2.01 data products is recommended for all analyses that rely on the 1064 nm measurements.

Data Release Date: August 12, 2007
Version: 1.22
Data Date Range: August 12, 2007 to November 11, 2007

Beginning with Version 1.22, the lidar altitude array is calculated as a function of the spacecraft off-nadir angle. The off-nadir parameter used

during processing is determined by the tilt of the CALIPSO lidar relative to nadir and is limited to 0.3 degrees or 3.0 degrees. In Versions prior to 1.22, the off-nadir parameter was set to a constant 0.3 degrees. The lidar altitude array is stored in the HDF metadata field named "Lidar Data Altitude".

Since the beginning of operations in June 2006, CALIPSO has been operating with the lidar pointed at 0.3 degrees off-nadir (along track in the forward direction) with the exception of November 7-17, 2006 and August 21 to September 7, 2007. During these periods, CALIPSO operated with the lidar pointed at 3.0 degrees off nadir. Beginning November 28, 2007, the off-nadir angle will be permanently changed to 3.0 degrees.

When comparing data acquired at 3.0 degrees and 0.3 degrees, the altitude difference between two adjacent samples is relatively insignificant, but when summed over the entire backscatter region, the difference is significant. The total span at 3.0 degrees is 57 meters less than it is at 0.3 degrees. It is therefore important to retrieve the altitude array stored within the HDF metadata field in order to maintain the correct altitude registration between data acquired at different off-nadir angles.

The method used to register the 532 nm and 1064 nm backscatter coefficients to the lidar altitude array is changed beginning with Version 1.22. In previous versions, altitude registration was performed by interpolating the lidar profile data to the lidar altitude array. Beginning with Version 1.22, the lidar altitude registration is performed without interpolation.

For the altitude registration with interpolation (Versions 1.0 through 1.21), the highest altitude bin for each profile specific altitude array is matched to the corresponding altitude bin in a fixed altitude array. Profile specific altitude arrays are computed as a function of the actual spacecraft off-nadir angle, which varies slightly from the commanded spacecraft off-nadir angle. The fixed altitude array is computed using the commanded spacecraft off-nadir angle (0.3 or 3.0 degrees). The vertical resolution for both the profile specific and fixed altitude arrays is 30 meters. The attenuated backscatter coefficients are linearly interpolated between the two altitude arrays. The interpolation is performed from highest altitude to lowest altitude.

For altitude registration without interpolation (Versions 1.22 and forward), the lowest altitude bin for the profile specific altitude arrays are matched to the corresponding altitude bin in the fixed altitude array. The attenuated backscatter coefficients are then assigned to the fixed altitude array bins one-by-one from the lowest bin to the highest bin.

The final step averages the lidar profiles stored at the fixed 30 meter resolution altitude to the downlink resolution.

Two surface parameters are added in Version 1.22. The parameter named Surface_Altitude_Shift contains the altitude difference between the profile specific 30 meter altitude array and the fixed 30 meter altitude array at the array element that includes mean sea level. The units are in kilometers and the values may be positive or negative. The difference is calculated as: Surface_Altitude_Shift = altitude (profile specific 30 meter mean sea level bin) - altitude (fixed 30 meter mean sea level bin).

The parameter named Number_Bins_Shift contains the number of 30 meter bins the profile specific 30-meter array elements are shifted to match the lowest altitude bin of the fixed 30 meter altitude array. The profile specific array elements may be shifted up or down.

Four column reflectance parameters are added in Version 1.22. The parameters named Parallel_Column_Reflectance_532 and Perpendicular_Column_Reflectance_532 contain the 532 nm parallel and perpendicular bi-directional column reflectance values derived from the lidar background measurements, respectively. The parameters named Parallel_Column_Reflectance_Uncertainty_532 and Perpendicular_Column_Reflectance_Uncertainty_532 are the 532 nm parallel and perpendicular column reflectance uncertainties, respectively.

Data Release Date: March 1, 2007
Version: 1.20
Data Date Range: March 1, 2007 to August 11, 2007

The Global Modeling and Assimilation Office (GMAO) next generation global atmospheric model, Goddard Earth Observing System Model, Version 5 (GEOS-5), was implemented within the CALIPSO Data Processing System on March 1, 2007. The CALIOP Level 1B data products obtained from the GEOS-5 assimilation model include Molecular Number Density, Ozone Number Density, Temperature, and Pressure.

The four GMAO-5 meteorological parameters are used to compute the CALIOP Level 1B data for the 532 nm and 1064 nm calibration constants and their associated uncertainties. The CALIOP Level 1B calibration constant data products are named Calibration Constant 532 and Calibration Constant 1064. The CALIOP Level 1B calibration constant data product uncertainties are named Calibration Constant Uncertainty 532 and Calibration Constant Uncertainty 1064. The CALIOP Level 1B 532 nm total and perpendicular and 1064 nm attenuated backscatter profiles are derived from the calibrated (divided by calibration constant), range-corrected, laser energy normalized, baseline subtracted lidar return signal. Thus, the following CALIOP Level 1B data products are also affected by the GEOS-5 transition: Total Attenuated Backscatter 532, Perpendicular Attenuated Backscatter 532, and Attenuated Backscatter 1064.

Version 1.20 is a provisional data release. A preliminary comparison of the CALIOP Level 1B calibration constants and uncertainties computed using GEOS-4 and 5 was performed and revealed small differences. Uncertainties and possible biases will be documented when the data are validated.

The CALIOP Level 1B data products prior to March 1, 2007 (June 13, 2006 to February 28, 2007) were processed using GEOS-4. These data will be reprocessed using GEOS-5 and are planned to be released in the Fall of 2007.

Data Release Date: January 6, 2007
Version: 1.11
Data Date Range: January 6, 2007 to February 28, 2007

A software fix was applied to the Lidar Level 1B Profile code to correct a memory allocation error that caused jobs to terminate prematurely. The science algorithm and code did not change. Because this version update has no impact on the data products being generated, the Data Quality Statement for Version 1.11 is the same as for Version 1.10, Initial Release.

Data Release Date: January 6, 2007
Version: 1.10 - Initial Release of Data
Data Date Range: June 13, 2006 to January 5, 2007

Geolocation and altitude registration have been checked and appear to have uncertainties of less than the sampling resolution (333 m for geolocation and 30 m for altitude). Random uncertainties in the 532 nm parallel calibration have been assessed and are reported. Potential biases in the calibration appear to be small but are still under investigation. The calibration of the 532 nm perpendicular channel relative to the 532 nm parallel appears to be quite accurate. Thus, volume depolarization ratios should be quite reliable. Uncertainties in the 1064 nm channel calibration have not been studied as thoroughly. There do not appear to be gross errors in 1064 nm calibration, but biases on the order of 10% are not unexpected. Any calibration biases will have significant impacts on the volume color ratio, so these values should be viewed skeptically.