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Cloud – Aerosol LIDAR and Infrared Pathfinder Satellite Observations (CALIPSO)

Data Description and Quality Summary

Imaging Infrared Radiometer Level 3 GEWEX Data

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CALIPSO IIR Level 3 GEWEX Cloud Data Description Document
Version 2.00

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Introduction

The IIR level 3 (L3) Global Energy and Water Cycle Experiment (GEWEX) Cloud product reports global distributions of IIR cloud effective radius and water path averages and histograms on a uniform 2-dimensional 1° latitude by 1° longitude spatial grid with a temporal averaging of one month. The product is designed to follow the general guidance of the GEWEX Cloud Assessment. Cloud amount, radiative temperature, effective emissivity, and optical depth characterize the cloud samples for which IIR microphysical retrievals are reported. Cloud properties are reported for ice clouds, liquid water clouds, and for high ice clouds of layer pressure lower than 440 hPa. For this release, the level 3 parameters are derived from the IIR level 2 Version 5.00 (V5) track products.

Though the averages and histograms are the same as in the IIR CALIPSO-ST cloud product provided to the GEWEX project, the data structure is slightly different. Instead of reporting each cloud property as yearly files, this product includes all cloud properties as monthly files, conforming to the CALIPSO format used for all other level 3 data releases.

Over the last seven years of the mission, the CALIOP laser experienced an increasing frequency of shots with low to zero energy, which were initially prevailingly located over the South Atlantic Anomaly and were then observed more globally at the end of the mission. The IIR level 2 V5 track products benefit from the low energy mitigation (LEM) algorithm (Tackett et al., 2025) implemented in the CALIOP level 1 and level 2 V5 products, which identifies level 1 backscatter data resulting from low energy pulses and, when appropriate, excludes it from the level 2 analyses. Therefore, this V2.00 release covers the full CALIPSO mission time-period whereas the previous V1.00 release, which was based on IIR level 2 V4.2 track products, was released for years 2006 to 2016.

The tables below summarize the dimensions of the various science data sets (1D, 2D, and 3D arrays).

Table 1: Name and dimension of the 1D array datasets of the IIR L3 GEWEX product

1D arrays		
Science Data Sets	**Dimension Length**	
	Description	**Value**
Longitude_Midpoint	Number of longitude bins	360
Latitude_Midpoint	Number of latitude bins	180
Cloud_Radiative_Temperature_Bin_Midpoint	Number of temperature bins	28
Cloud_Radiative_Temperature_Bin_Boundaries	Number of temperature bins + 1	29
Cloud_Effective_Emissivity_12_05_Bin_Midpoint	Number of emissivity bins	5
Cloud_Effective_Emissivity_12_05_Bin_Boundaries	Number of emissivity bins + 1	6
Ice_Cloud_Effective_Radius_Bin_Midpoint	Number of ice radius bins	31
Ice_Cloud_Effective_Radius_Bin_Boundaries	Number of ice radius bins + 1	32
Water_Cloud_Effective_Radius_Bin_Midpoint	Number of water radius bins	20
Water_Cloud_Effective_Radius_Bin_Boundaries	Number of water radius bins + 1	21
Cloud_Water_Path_Bin_Midpoint	Number of water path bins	22
Cloud_Water_Path_Bin_Boundaries	Number of water path bins + 1	23

Cloud_Optical_Depth_Bin_Midpoint	Number of optical depth bins	34
Cloud_Optical_Depth_Bin_Boundaries	Number of optical depth bins + 1	35

Table 2: Name and dimension of the 2D array datasets of the IIR L3 GEWEX product

2D arrays	
Science Data Sets	**Dimension Lengths**
Number_Of_Orbit_Tracks	Number of latitude bins x Number of longitude bins: 180 x 360
Number_Of_Valid_Pixels_IIR	
Number_Of_LEM_Rejected_Pixels_IIR	
Number_Of_Candidate_Clouds_IIR	
Mean values: *_Mean_*	

Table 3: Name and dimension of the 3D array datasets of the IIR L3 GEWEX product

3D arrays	
Science Data Sets	**Dimension Lengths**
Temperature histograms *_Temperature_Histogram_*	Number of latitude bins x Number of longitude bins x Number of temperature bins: 180 x 360 x 28
Emissivity_12_05 histograms *_Emissivity_12_05_Histogram_*	Number of latitude bins x Number of longitude bins x Number of emissivity bins: 180 x 360 x 5
Ice cloud radius histograms Ice*_Radius_Histogram_*	Number of latitude bins x Number of longitude bins x Number of ice radius bins: 180 x 360 x 31
Water cloud radius histograms *_Water_Path_Histogram_*	Number of latitude bins x Number of longitude bins x Number of water radius bins: 180 x 360 x 20
Water path histograms *_Water_Path_Histogram_*	Number of latitude bins x Number of longitude bins x Number of water path bins: 180 x 360 x 22
Optical Depth histograms *_Optical_Depth_Histogram_*	Number of latitude bins x Number of longitude bins x Number of optical depth bins: 180 x 360 x 34

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Additional Documentation

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Glossary and Acronym Dictionary

Term	Meaning
CALIOP	Cloud-Aerosol Lidar with Orthogonal Polarization
CALIPSO	Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation
GEWEX	Global Energy and Water Cycle Experiment

Term	Meaning
granule	continuous data segment in which all measurements were acquired while the lidar was configured for daytime data acquisition only or nighttime data acquisition only; each granule spans approximately one half of a full orbit, with daytime granules being slightly larger/longer than nighttime granules
HDF	Hierarchical Data Format
HOI	Horizontally Oriented Ice
LEM	low energy mitigation
netCDF	Network Common Data Form
ROI	Randomly Oriented Ice

Scientific Data Sets: Altitude and Position

Longitude_Midpoint

Units: degrees_east

Format: Float_32

Valid Range: -180, 180.0

Fill value: -9999.0

Description: Longitude at the grid cell midpoint.

Latitude_Midpoint

Units: degrees_north

Format: Float_32

Valid Range: -90.0, 90.0

Fill value: -9999.0

Description: Latitude at the grid cell midpoint.

Scientific Data Sets: Over-flight Parameters

Number_Of_Orbit_Tracks

Units: NoUnits

Format: Int_16

Valid Range: 0, 900

Fill value: -9999

Description: Number of CALIPSO orbital tracks in the grid cell. One granule pass is counted as one orbit track if there is at least one valid pixel. It corresponds to “n_tot” in a standard format GEWEX file.

Scientific Data Sets: Histogram Bin Boundaries

Cloud_Radiative_Temperature_Bin_Midpoint

Units: K

Format: Float_32

Valid Range: 165.0, 315.0

Fill value: -9999.0

Description: Temperature at the midpoint of each bin of the cloud radiative temperature histograms. It corresponds to “bin” in a standard format GEWEX file “CT*CALIPSO-ST*.nc”.

Cloud_Radiative_Temperature_Bin_Boundaries

Units: K

Format: Float_32

Valid Range: 150.0, 320.0

Fill value: -9999.0

Description: Temperature at the boundaries of each bin of the cloud radiative temperature histograms. It corresponds to “bin_bounds” in a standard format GEWEX file “CT*CALIPSO-ST*.nc”.

Cloud_Effective_Emissivity_12_05_Bin_Midpoint

Units: NoUnits

Format: Float_32

Valid Range: 0.1, 0.975

Fill value: -9999.0

Description: Effective emissivity at the midpoint of each bin of the cloud effective emissivity histograms. It corresponds to “bin” in a standard format GEWEX file “CEM*CALIPSO-ST*.nc”.

Cloud_Effective_Emissivity_12_05_Bin_Boundaries

Units: K

Format: Float_32

Valid Range: 0.0, 1.0

Fill value: -9999.0

Description: Effective emissivity at the boundaries of each bin of the cloud effective emissivity histograms. It corresponds to “bin_bounds” in a standard format GEWEX file “CEM*CALIPSO-ST*.nc”.

Ice_Cloud_Effective_Radius_Bin_Midpoint

Units: microns

Format: Float_32

Valid Range: 1.0, 175.0

Fill value: -9999.0

Description: Effective radius at the midpoint of each bin of the ice and high ice clouds effective radius histograms. It corresponds to “bin” in a standard format GEWEX file “CREI*CALIPSO-ST*.nc”.

Ice_Cloud_Effective_Radius_Bin_Boundaries

Units: microns

Format: Float_32

Valid Range: 0.0, 200.0

Fill value: -9999.0

Description: Effective radius at the boundaries of each bin of the ice and high ice clouds effective radius histograms. It corresponds to “bin_bounds” in a standard format GEWEX file “CREI*CALIPSO-ST*.nc”.

Water_Cloud_Effective_Radius_Bin_Midpoint

Units: microns

Format: Float_32

Valid Range: 1.0, 55.0

Fill value: -9999.0

Description: Effective radius at the midpoint of each bin of the liquid water clouds effective radius histograms. It corresponds to "bin" in a standard format GEWEX file "CREW*CALIPSO-ST*.nc".

Water_Cloud_Effective_Radius_Bin_Boundaries

Units: microns

Format: Float_32

Valid Range: 0.0, 60.0

Fill value: -9999.0

Description: Effective radius at the boundaries of each bin of the liquid water clouds effective radius histograms. It corresponds to "bin_bounds" in a standard format GEWEX file "CREW*CALIPSO-ST*.nc".

Cloud_Water_Path_Bin_Midpoint

Units: g/m^2

Format: Float_32

Valid Range: 2.5, 4000.0

Fill value: -9999.0

Description: Water path at the midpoint of each bin of the water path histograms for ice, high ice, and liquid water clouds. It corresponds to "bin" in a standard format GEWEX file "CIWP*CALIPSO-ST*.nc".

Cloud_Water_Path_Bin_Boundaries

Units: g/m^2

Format: Float_32

Valid Range: 0.0, 5000.0

Fill value: -9999.0

Description: Water path at the boundaries of each bin of the water path histograms for ice, high ice, and liquid water clouds. It corresponds to "bin_bounds" in a standard format GEWEX file "CIWP*CALIPSO-ST*.nc".

Cloud_Optical_Depth_Bin_Midpoint

Units: NoUnits

Format: Float_32

Valid Range: 0.05, 400.0

Fill value: -9999.0

Description: Optical depth at the midpoint of each bin of the cloud optical depth histograms. It corresponds to "bin" in a standard format GEWEX file "COD*CALIPSO-ST*.nc".

Cloud_Optical_Depth_Bin_Boundaries

Units: NoUnits

Format: Float_32

Valid Range: 0.0, 500.0

Fill value: -9999.0

Description: Optical depth at the boundaries of each bin of the cloud optical depth histograms. It corresponds to "bin_bounds" in a standard format GEWEX file "COD*CALIPSO-ST*.nc".

Scientific Data Sets: Number of Pixels - Cloud Amount

Number_Of_Valid_Pixels_IIR

Units: NoUnits

Format: Int_16

Valid Range: 0...32,767

Fill value: -9999

Description: Number of valid IIR pixels in the grid cell.

Number_Of_LEM_Rejected_Pixels_IIR

Units: NoUnits

Format: Int_16

Valid Range: 0...32,767

Fill value: -9999

Description: Number of IIR pixels in the grid cell rejected by the CALIOP Low Energy Mitigation (LEM) algorithm.

Number_Of_Candidate_Clouds_IIR

Units: NoUnits

Format: Int_16

Valid Range: 0...32,767

Fill value: -9999

Description: Number of IIR cloudy pixels in the grid cell accepted as a pre-requisite for meaningful microphysical retrievals, before microphysics and thermodynamic phase quality filters are applied.

Cloud_Amount_Mean_IIR

Units: NoUnits

Format: Float_32

Valid Range: 0.0, 1.0

Fill value: -9999.0

Description: Mean amount of candidate cloudy pixels with only ice or only liquid water clouds in the atmospheric column, regardless of the thermodynamic phase quality filters, and where IIR has confident microphysical retrievals. The mean amount in the grid cell is the average of the amounts in the individual CALIPSO orbital tracks.

Ice_Cloud_Amount_Mean_IIR

Units: NoUnits

Format: Float_32

Valid Range: 0.0, 1.0

Fill value: -9999.0

Description: Mean amount of pixels with only candidate ice clouds passing the phase quality filters in the column, and where IIR has confident microphysical retrievals. The mean amount in the grid cell is the average of the amounts in the individual CALIPSO orbital tracks. It corresponds to “a_CAI” in a standard format GEWEX file “CAI_IIR_CALIPSO-ST*.nc”.

Water_Cloud_Amount_Mean_IIR

Units: NoUnits

Format: Float_32

Valid Range: 0.0, 1.0

Fill value: -9999.0

Description: Mean amount of pixels with only candidate liquid water clouds passing the phase quality filters in the column, and where IIR has confident microphysical retrievals. The mean amount in the grid cell is the average of the amounts in the individual CALIPSO orbital tracks. It corresponds to “a_CAW” in a standard format GEWEX file “CAW_IIR_CALIPSO-ST*.nc”.

High_Ice_Cloud_Amount_Mean_IIR

Units: NoUnits

Format: Float_32

Valid Range: 0.0, 1.0

Fill value: -9999.0

Description: Mean amount of pixels with only candidate high ice clouds passing the phase quality filters in the column, and where IIR has confident microphysical retrievals. The mean amount in the grid cell is the average of the amounts in the individual CALIPSO orbital tracks. It corresponds to “a_CAIH” in a standard format GEWEX file “CAIH_IIR_CALIPSO-ST*.nc”.

Scientific Data Sets: Radiative Temperature

Ice_Cloud_Radiative_Temperature_Mean_IIR

Units: K

Format: Float_32

Valid Range: 150.0, 320.0

Fill value: -9999.0

Description: Mean cloud radiative temperature at grid cell in pixels with only candidate ice clouds passing the phase quality filters in the column, and where IIR has confident microphysical retrievals. It corresponds to “a_CTI” in a standard format GEWEX file “CTI_IIR_CALIPSO-ST*.nc”.

Ice_Cloud_Radiative_Temperature_Histogram_IIR

Units: NoUnits

Format: Int_32

Valid Range: 0...18,043,200

Fill value: 0

Description: Cloud radiative temperature histogram at grid cell in pixels with only candidate ice clouds passing the phase quality filters in the column, and where IIR has confident microphysical retrievals. It corresponds to “h_CTI” in a standard format GEWEX file “CTI_IIR_CALIPSO-ST*.nc”.

Water_Cloud_Radiative_Temperature_Mean_IIR

Units: K

Format: Float_32

Valid Range: 150.0, 320.0

Fill value: -9999.0

Description: Mean cloud radiative temperature at grid cell in pixels with only candidate liquid water clouds passing the phase quality filters in the column, and where IIR has confident microphysical retrievals. It corresponds to “a_CTW” in a standard format GEWEX file “CTW_IIR_CALIPSO-ST*.nc”.

Water_Cloud_Radiative_Temperature_Histogram_IIR

Units: NoUnits

Format: Int_32

Valid Range: 0...18,043,200

Fill value: 0

Description: Cloud radiative temperature histogram at grid cell in pixels with only candidate liquid water clouds passing the phase quality filters in the column, and where IIR has confident microphysical retrievals. It corresponds to “h_CTW” in a standard format GEWEX file “CTW_IIR_CALIPSO-ST*.nc”.

High_Ice_Cloud_Radiative_Temperature_Mean_IIR

Units: K

Format: Float_32

Valid Range: 150.0, 320.0

Fill value: -9999.0

Description: Mean cloud radiative temperature at grid cell in pixels with only candidate high ice clouds passing the phase quality filters in the column, and where IIR has confident microphysical retrievals. It corresponds to “a_CTIH” in a standard format GEWEX file “CTIH_IIR_CALIPSO-ST*.nc”.

High_Ice_Cloud_Radiative_Temperature_Histogram_IIR

Units: NoUnits

Format: Int_32

Valid Range: 0...18,043,200

Fill value: 0

Description: Cloud radiative temperature histogram at grid cell in pixels with only candidate high ice clouds passing the phase quality filters in the column, and where IIR has confident microphysical retrievals. It corresponds to “h_CTIH” in a standard format GEWEX file “CTIH_IIR_CALIPSO-ST*.nc”.

Scientific Data Sets: Effective Emissivity

Ice_Cloud_Effective_Emissivity_12_05_Mean_IIR

Units: NoUnits

Format: Float_32

Valid Range: 0.0, 1.0

Fill value: -9999.0

Description: Mean cloud effective emissivity at 12.05 µm at grid cell in pixels with only candidate ice clouds passing the phase quality filters in the column, and where IIR has confident microphysical retrievals. It corresponds to “a_CEMI” in a standard format GEWEX file “CEMI_IIR_CALIPSO-ST*.nc”.

Ice_Cloud_Effective_Emissivity_12_05_Histogram_IIR

Units: NoUnits

Format: Int_32

Valid Range: 0...18,043,200

Fill value: 0

Description: Cloud effective emissivity at 12.05 µm histogram at grid cell in pixels with only candidate ice clouds passing the phase quality filters in the column, and where IIR has confident microphysical retrievals. It corresponds to “h_CEMI” in a standard format GEWEX file “CEMI_IIR_CALIPSO-ST*.nc”.

Water_Cloud_Effective_Emissivity_12_05_Mean_IIR

Units: NoUnits

Format: Float_32

Valid Range: 0.0, 1.0

Fill value: -9999.0

Description: Mean cloud effective emissivity at 12.05 µm at grid cell in pixels with only candidate liquid water clouds passing the phase quality filters in the column, and where IIR has confident microphysical retrievals. It corresponds to “a_CEMW” in a standard format GEWEX file “CEMW_IIR_CALIPSO-ST*.nc”.

Water_Cloud_Effective_Emissivity_12_05_Histogram_IIR

Units: NoUnits

Format: Int_32

Valid Range: 0...18,043,200

Fill value: 0

Description: Cloud effective emissivity at 12.05 µm histogram at grid cell in pixels with only candidate liquid water clouds passing the phase quality filters in the column, and where IIR has confident microphysical retrievals. It corresponds to “h_CEMW” in a standard format GEWEX file “CEMW_IIR_CALIPSO-ST*.nc”.

High_Ice_Cloud_Effective_Emissivity_12_05_Mean_IIR

Units: NoUnits

Format: Float_32

Valid Range: 0.0, 1.0

Fill value: -9999.0

Description: Mean cloud effective emissivity at 12.05 µm at grid cell in pixels with only candidate high ice clouds passing the phase quality filters in the column, and where IIR has confident microphysical retrievals. It corresponds to “a_CEMIH” in a standard format GEWEX file “CEMIH_IIR_CALIPSO-ST*.nc”.

High_Ice_Cloud_Effective_Emissivity_12_05_Histogram_IIR

Units: NoUnits

Format: Int_32

Valid Range: 0...18,043,200

Fill value: 0

Description: Cloud effective emissivity at 12.05 µm histogram at grid cell in pixels with only candidate high ice clouds passing the phase quality filters in the column, and where IIR has confident microphysical retrievals. It corresponds to “h_CEMIH” in a standard format GEWEX file “CEMIH_IIR_CALIPSO-ST*.nc”.

Scientific Data Sets: Effective Radius

Ice_Cloud_Effective_Radius_Mean_IIR

Units: microns

Format: Float_32

Valid Range: 0.0, 200.0

Fill value: -9999.0

Description: Mean effective radius at grid cell in pixels with only candidate ice clouds passing the phase quality filters in the column, and where IIR has confident microphysical retrievals. It corresponds to "a_CREI" in a standard format GEWEX file "CREI_IIR_CALIPSO-ST*.nc".

Ice_Cloud_Effective_Radius_Histogram_IIR

Units: NoUnits

Format: Int_32

Valid Range: 0...18,043,200

Fill value: 0

Description: Effective radius histogram at grid cell in pixels with only candidate ice clouds passing the phase quality filters in the column, and where IIR has confident microphysical retrievals. It corresponds to "h_CREI" in a standard format GEWEX file "CREI_IIR_CALIPSO-ST*.nc".

Water_Cloud_Effective_Radius_Mean_IIR

Units: microns

Format: Float_32

Valid Range: 0.0, 60.0

Fill value: -9999.0

Description: Mean effective radius at grid cell in pixels with only candidate liquid water clouds passing the phase quality filters in the column, and where IIR has confident microphysical retrievals. It corresponds to "a_CREW" in a standard format GEWEX file "CREW_IIR_CALIPSO-ST*.nc".

Water_Cloud_Effective_Radius_Histogram_IIR

Units: NoUnits

Format: Int_32

Valid Range: 0...18,043,200

Fill value: 0

Description: Effective radius histogram at grid cell in pixels with only candidate liquid water clouds passing the phase quality filters in the column, and where IIR has confident microphysical retrievals. It corresponds to "h_CREW" in a standard format GEWEX file "CREW_IIR_CALIPSO-ST*.nc".

High_Ice_Cloud_Effective_Radius_Mean_IIR

Units: microns

Format: Float_32

Valid Range: 0.0, 200.0

Fill value: -9999.0

Description: Mean effective radius at grid cell in pixels with only candidate high ice clouds passing the phase quality filters in the column, and where IIR has confident microphysical retrievals. It corresponds to “a_CREIH” in a standard format GEWEX file “CREIH_IIR_CALIPSO-ST*.nc”.

High_Ice_Cloud_Effective_Radius_Histogram_IIR

Units: NoUnits

Format: Int_32

Valid Range: 0...18,043,200

Fill value: 0

Description: Effective radius histogram at grid cell in pixels with only candidate high ice clouds passing the phase quality filters in the column, and where IIR has confident microphysical retrievals. It corresponds to “h_CREIH” in a standard format GEWEX file “CREIH_IIR_CALIPSO-ST*.nc”.

Scientific Data Sets: Cloud Water Path

Ice_Water_Path_Mean_IIR

Units: g/m^2

Format: Float_32

Valid Range: 0.0, 3000.0

Fill value: -9999.0

Description: Mean ice water path at grid cell in pixels with only candidate ice clouds passing the phase quality filters in the column, and where IIR has confident microphysical retrievals. It corresponds to “a_CIWP” in a standard format GEWEX file “CIWP_IIR_CALIPSO-ST*.nc”.

Ice_Water_Path_Histogram_IIR

Units: NoUnits

Format: Int_32

Valid Range: 0…18,043,200

Fill value: 0

Description: Ice water path histogram at grid cell in pixels with only candidate ice clouds passing the phase quality filters in the column, and where IIR has confident microphysical retrievals. It corresponds to “h_CIWP” in a standard format GEWEX file “CIWP_IIR_CALIPSO-ST*.nc”.

Liquid_Water_Path_Mean_IIR

Units: g/m^2

Format: Float_32

Valid Range: 0.0, 3000.0

Fill value: -9999.0

Description: Mean liquid water path at grid cell in pixels with only candidate liquid water clouds passing the phase quality filters in the column, and where IIR has confident microphysical retrievals. It corresponds to “a_CLWP” in a standard format GEWEX file “CLWP_IIR_CALIPSO-ST*.nc”.

Liquid_Water_Path_Histogram_IIR

Units: NoUnits

Format: Int_32

Valid Range: 0…18,043,200

Fill value: 0

Description: Liquid water path histogram at grid cell in pixels with only candidate liquid water clouds passing the phase quality filters in the column, and where IIR has confident microphysical retrievals. It corresponds to "h_CLWP" in a standard format GEWEX file "CLWP_IIR_CALIPSO-ST*.nc".

High_Ice_Water_Path_Mean_IIR

Units: g/m^2

Format: Float_32

Valid Range: 0.0, 3000.0

Fill value: -9999.0

Description: Mean ice water path at grid cell in pixels with only candidate high ice clouds passing the phase quality filters in the column, and where IIR has confident microphysical retrievals. It corresponds to "a_CIWPH" in a standard format GEWEX file "CIWPH_IIR_CALIPSO-ST*.nc".

High_Ice_Water_Path_Histogram_IIR

Units: NoUnits

Format: Int_32

Valid Range: 0…18,043,200

Fill value: 0

Description: Ice water path histogram at grid cell in pixels with only candidate high ice clouds passing the phase quality filters in the column, and where IIR has confident microphysical retrievals. It corresponds to "h_CIWPH" in a standard format GEWEX file "CIWPH_IIR_CALIPSO-ST*.nc".

Scientific Data Sets: Optical Depth

Ice_Cloud_Optical_Depth_Mean_IIR

Units: NoUnits

Format: Float_32

Valid Range: 0.0, 400.0

Fill value: -9999.0

Description: Mean IIR-derived visible cloud optical depth at grid cell in pixels with only candidate ice clouds passing the phase quality filters in the column, and where IIR has confident microphysical retrievals. It corresponds to "a_CODI" in a standard format GEWEX file "CODI_IIR_CALIPSO-ST*.nc".

Ice_Cloud_Optical_Depth_Histogram_IIR

Units: NoUnits

Format: Int_32

Valid Range: 0…18,043,200

Fill value: 0

Description: IIR-derived visible cloud optical depth histogram at grid cell in pixels with only candidate ice clouds passing the phase quality filters in the column, and where IIR has confident microphysical retrievals. It corresponds to "h_CODI" in a standard format GEWEX file "CODI_IIR_CALIPSO-ST*.nc".

Water_Cloud_Optical_Depth_Mean_IIR

Units: NoUnits

Format: Float_32

Valid Range: 0.0, 400.0

Fill value: -9999.0

Description: Mean IIR-derived visible cloud optical depth at grid cell in pixels with only candidate liquid water clouds passing the phase quality filters in the column, and where IIR has confident microphysical retrievals. It corresponds to “a_CODW” in a standard format GEWEX file “CODW_IIR_CALIPSO-ST*.nc”.

Water_Cloud_Optical_Depth_Histogram_IIR

Units: NoUnits

Format: Int_32

Valid Range: 0…18,043,200

Fill value: 0

Description: IIR-derived visible cloud optical depth histogram at grid cell in pixels with only candidate liquid water clouds passing the phase quality filters in the column, and where IIR has confident microphysical retrievals. It corresponds to “h_CODW” in a standard format GEWEX file “CODW_IIR_CALIPSO-ST*.nc”.

High_Ice_Cloud_Optical_Depth_Mean_IIR

Units: NoUnits

Format: Float_32

Valid Range: 0.0, 400.0

Fill value: -9999.0

Description: Mean IIR-derived visible cloud optical depth at grid cell in pixels with only candidate high ice clouds passing the phase quality filters in the column, and where IIR has confident microphysical retrievals. It corresponds to “a_CODIH” in a standard format GEWEX file “CODIH_IIR_CALIPSO-ST*.nc”.

High_Ice_Cloud_Optical_Depth_Histogram_IIR

Units: NoUnits

Format: Int_32

Valid Range: 0…18,043,200

Fill value: 0

Description: IIR-derived visible cloud optical depth histogram at grid cell in pixels with only candidate high ice clouds passing the phase quality filters in the column, and where IIR has confident microphysical retrievals. It corresponds to “h_CODIH” in a standard format GEWEX file “CODIH_IIR_CALIPSO-ST*.nc”.

Ice_Cloud_Optical_Depth_Mean_LIDAR

Units: NoUnits

Format: Float_32

Valid Range: 0.0, 400.0

Fill value: -9999.0

Description: Mean CALIOP-derived visible cloud optical depth at grid cell in pixels with only candidate ice clouds passing the phase quality filters in the column, and where IIR has confident microphysical retrievals. It corresponds to “a_CODI” in a standard format GEWEX file “CODI_IIR-LIDAR_CALIPSO-ST*.nc”.

Ice_Cloud_Optical_Depth_Histogram_LIDAR

Units: NoUnits

Format: Int_32

Valid Range: 0…18,043,200

Fill value: 0

Description: CALIOP-derived visible cloud optical depth histogram at grid cell in pixels with only candidate ice clouds passing the phase quality filters in the column, and where IIR has confident microphysical retrievals. It corresponds to “h_CODI” in a standard format GEWEX file “CODI_IIR-LIDAR_CALIPSO-ST*.nc”.

High_Ice_Cloud_Optical_Depth_Mean_LIDAR

Units: NoUnits

Format: Float_32

Valid Range: 0.0, 400.0

Fill value: -9999.0

Description: Mean CALIOP-derived visible cloud optical depth at grid cell in pixels with only candidate high ice clouds passing the phase quality filters in the column, and where IIR has confident microphysical retrievals. It corresponds to “a_CODIH” in a standard format GEWEX file “CODIH_IIR-LIDAR_CALIPSO-ST*.nc”.

High_Ice_Cloud_Optical_Depth_Histogram_LIDAR

Units: NoUnits

Format: Int_32

Valid Range: 0…18,043,200

Fill value: 0

Description: CALIOP-derived visible cloud optical depth histogram at grid cell in pixels with only candidate high ice clouds passing the phase quality filters in the column, and where IIR has confident microphysical retrievals. It corresponds to “h_CODIH” in a standard format GEWEX file “CODIH_IIR-LIDAR_CALIPSO-ST*.nc”.

Metadata Descriptions

Product_ID

Units: NoUnits

Format: Char

Valid range: CAL_IIR_L3_GEWEX_Cloud

Definition: A character string (80-byte maximum) specifying the data product name.

Date_Time_of_Production

Units: NoUnits

Format: Char

Valid range: 4/2006 - 10/2025

Definition: A 27-byte character string that specifies the UTC date and time at which the data was generated. The format is yyyy-mm-ddThh:nn:ss.ffffffZ, where yyyy is the year, mm is the month, dd is the day, hh is the hour, nn is the minute, ss is the second, and ffffff is the fractional second. Date and time are separated by the character ‘T’. The ‘Z’ indicates that time is given in UTC.

Nominal_Year_Month

Units: NoUnits

Format: Char

Valid range: 200606 - 202306

Definition: A six-digit integer indicating the year and month when data within the level 3 file was measured by CALIPSO in the format yyyymm.

Day_Night_Flag

Units: NoUnits

Format: Char

Definition: A 2-byte character string indicating the lighting conditions in the IIR level 2 input granules. It is one of the following characters, D, N and A which represent daytime granules (D), nighttime granules (N) and all daytime and nighttime granules combined (A).

Program_Configuration

Units: NoUnits

Format: Char

Definition: This parameter contains the contents of the runtime program configuration file. The file controls the sizes of dimensions used by the program, the cloud quality filter parameters, and an input file check.

Number_of_Level2_Files_Analyzed

Units: NoUnits

Format: UInt_16

Valid range: 0, 900

Definition: Number of IIR level 2 granules analyzed to generate this L3 CALIPSO format IIR GEWEX cloud product file.

List_of_Input_Files

Units: NoUnits

Format: Char

Definition: List of included granules of IIR level 2 track product to generate this L3 CALIPSO format IIR GEWEX cloud product file.

Data Release Information

Table 4: Dates, versions, and production strategy for the CALIPSO IIR level 3 GEWEX data releases

Release Date	Version	Data Date Range	Production Strategy	Input Products and Versions
October 2025	2.00	June 13, 2006 to June 30, 2023	Standard	V5.00 IIR Level 2 Track
September 2021	1.00	June 13, 2016 to December 31, 2016	Standard	V4.20 IIR Level 2 Track

Data Quality Information

Data Quality Statement for the release of the CALIPSO IIR Level 3 GEWEX Cloud Product Version 2.00

For this release V2.00 release, the level 3 parameters are derived from the IIR level 2 Version 5.00 (V5) track products, whereas the previous V1.00 release was based on the IIR level 2 Version V4.2 track products.

The algorithm used to produce the level 3 parameters reported in this release is mostly unchanged compared to the one used for the previous V1.00 release. The only difference is in the definition of the valid IIR pixels, which has a subsequent impact on the cloud amounts. Over the last seven years of the mission, the CALIOP laser experienced an increasing frequency of shots with low to zero energy, which were initially prevailingly located over the South Atlantic Anomaly and were then observed more globally at the end of the mission. The IIR level 2 V5 track products benefit from the low energy mitigation (LEM) algorithm (Tackett et al., 2025) implemented in the CALIOP level 1 and level 2 V5 products, which identifies level 1 backscatter data resulting from low energy pulses and, when appropriate, excludes it from the level 2 analyses. For this V2.00 release, the five successive 1-km IIR pixels in 5-km columns that are rejected by the CALIOP LEM algorithm are excluded from the population of valid pixels, because no lidar data is available, so that the scene classification parameter is considered invalid. This number of pixels rejected by the LEM algorithm is reported.

The pixels in 5-km "affected" columns that include low energy shots and are accepted by the LEM algorithm are not distinguished from those in 5-km "unaffected" columns where low energy shots are absent. Indeed, according to Tackett et al. (2025), the layers in affected and unaffected columns have similar properties. In addition, the evaluation of "cloud-free" IIR pixels by comparison between observed and simulated brightness temperatures over ocean yields similar results for pixels in affected and unaffected 5-km columns (Tackett et al., 2025).

Candidate clouds or "candidate cloudy scenes" are selected as a pre-requisite for meaningful microphysical retrievals. One requirement is that there cannot be single shot cleared clouds in the 1-km column seen by the IIR pixel for scenes composed of semi-transparent layers. This is to prevent biases in the effective emissivity retrievals. As for the V1.00 release which was based on the IIR L2 V4.2 track product, this information is extracted from the Was_Cleared_Flag_1km parameter of the IIR L2 track product. The definition of the Was_Cleared_Flag_1km parameter was modified in the IIR L2 V5 track product to also report the number of single shot profiles rejected by the LEM algorithm. Because the presence of small-scale cloud(s) is unknown for these LEM rejected profiles, the pixels with at least one rejected profile are not included in the population of candidate cloudy scenes. In practice, this means that depending how the low energy shots are spread in the 5-km column, one to five IIR pixels of a 5-km affected column might be discarded.

For continuity with the V1.00 product and to ensure consistency between retrievals in semi-transparent and opaque ice clouds, the statistics are based on the standard IIR retrievals. Statistics based on the new "cirrus" properties reported in the IIR L2 V5 track products would have required the design of a product focused on semi-transparent ice clouds. However, the V5 radiative temperature in semi-transparent ice clouds corresponds to the radiance obtained from equation 5 in Garnier et al. (2021a), where the in-cloud temperature and extinction profiles are from the CALIOP V5 cloud profile product. In V4.2, this radiative temperature was estimated as the temperature at the centroid altitude of the 532-nm attenuated backscatter, further corrected to account for the difference in attenuation between visible and IR wavelengths, as described in section 3.4 of Garnier et al. (2021a). Initial analyses for April 2010 indicate [V5-V4.2] radiative temperature differences smaller than about 0.3 K with a standard deviation smaller than 1 K for single-layer clouds.

Besides the main expected differences discussed above, differences between the V1.00 and the V2.00 products (relevant for the 2006 to 2016 time-period) should be due to differences between the CALIOP V4.2 and V5 level 2 products.

Data Quality Statement for the release of the CALIPSO IIR Level 3 GEWEX Cloud Product Version 1.00

The IIR Level 3 (L3) Global Energy and Water cycle Experiment (GEWEX) Cloud Product reports IIR cloud effective radius and water path averages and histograms on a uniform 2-dimensional 1° latitude by 1° longitude spatial grid. This product is designed to follow the general guidance of the GEWEX Cloud Assessment. Cloud amount, radiative temperature, effective emissivity, and optical depth characterize the cloud samples for which IIR microphysical retrievals are reported. Cloud properties are provided for atmospheric columns containing only ice clouds, only liquid water clouds, and only high ice clouds of layer centroid pressure lower than 440 hPa. All level 3 parameters are derived from the IIR version 4.20 level 2 (L2) track products (Garnier at al., 2021a), with a temporal averaging of one month. The IIR algorithms take full advantage of the co-located characterization of the atmosphere provided in the CALIOP version 4.20 level 5-km layer products.

Though the averages and histograms are the same as in the IIR CALIPSO-ST cloud product provided to the GEWEX project, the data structure is slightly different. Instead of reporting each cloud property as yearly files, this product includes all cloud properties as monthly files. The product is represented as Hierarchical Data Format (HDF) 4 format instead of Network Common Data Form (netCDF) 4 format. The changes are made to keep consistency with other current L3 CALIPSO cloud and aerosol products.

The major categories of the IIR Level 3 GEWEX Cloud Product are:

- Cloud amount averages
- Cloud radiative temperature averages and histograms
- Cloud effective emissivity averages and histograms
- Cloud effective radius averages and histograms
- Cloud water path averages and histograms
- Cloud optical depth averages and histograms

Quality Filters Information

Though the averages and histograms are the same as in the IIR CALIPSO-ST cloud product provided to the GEWEX project, the data structure is slightly different. Instead of reporting each cloud property as yearly files, this product includes all cloud properties as monthly files.

- Valid IIR Pixels

  The valid IIR pixels are those with a valid radiance in each of the three channels centered at 8.65 µm, 10.6 µm, and 12.05 µm, and with a valid scene classification parameter.

- Candidate Clouds

  Candidate clouds or "candidate cloudy scenes" are selected as a pre-requisite for meaningful microphysical retrievals. The selection criteria, which are listed and described below, are implemented using the IIR scene classification and various quality flags reported in the IIR L2 product.

Table 5: Criteria for the selection of candidate clouds

Scene	Description
Cloudy Scene	The retrieved cloudy scene includes at least one cloud layer. At least one cloud layer has a low, medium, or high confidence in cloud feature type.

Scene	Description
	No mixed aerosols/clouds scenes with aerosols above clouds (scene types 63 and 66 excluded).
Pseudo mono layer	One cloud layer, or several layers separated by less than 1 km. No single shot cleared cloud in the column for scenes composed of semi-transparent layers.
Full column retrievals	The retrievals apply to all the clouds included in the column: the background reference used for emissivity retrievals is the surface
GEWEX requirements	Centroid altitude <= 20 km 150 K <= Radiative Temperature <= 320 K

- Microphysical Retrievals

  Following the rationale developed in Garnier et al. (2021a), we select the so-called confident retrievals, for which the two microphysical indices derived from the pairs of IIR channels 12.05/10.6 and 12.05/8.65 are within the expected range of values according to the look-up tables. These look-up tables are computed using ice habit models (Bi and Yang, 2017; Yang et al., 2013) and Lorenz-Mie theory for water clouds. In addition, we require Ice or Liquid Water Path to be reported, meaning that the scenes include only ice clouds or only water clouds with visible optical depth smaller than about 20.

- Ice and Water Clouds

  The cloud layer thermodynamic phase assignment is from the CALIOP version 4.20 level 5-km layer products. The CALIOP V4.20 algorithm (Avery et al., 2020) provides four phase assignments: Randomly Oriented Ice crystals (ROIs), Liquid water, Horizontally Oriented Ice crystals (HOIs), and unknown phase. The presence of HOIs is identified mostly from the beginning of the mission until November 2007, when the platform viewing angle was close to nadir (0.3°). In contrast, HOIs are rarely detected since December 2007 when the platform viewing angle was permanently changed to 3°. For this first version of the product, we chose to define "Ice" clouds as clouds classified as ROIs. We also require a high confidence in the phase assignment. Cloud layers are classified as ROIs more frequently at tilt angle of 3° than at 0.3°, because HOIs, if any, are typically not detected at 3°, and therefore possibly included in the population of clouds classified as ROIs. Differences between statistics derived from IIR observations conditioned by CALIOP measurements at near nadir and 3° viewing angles are thus to be expected.

Description of the Statistics

- Cloud Amount

  The cloud amounts are derived with respect to the number of valid IIR pixels. The mean cloud amounts in each grid point are the mean values of the cloud amounts derived from each individual orbit track. Cloud amounts are reported for all confident microphysical retrievals, regardless of the phase assignment, as well as for ice and water clouds as defined above. High ice clouds are those ice clouds with centroid pressure smaller than 440 hPa.

- Cloud Radiative Temperature

  For a meaningful characterization of the layer temperature, we chose to report the estimated cloud radiative temperature rather than the layer top temperature reported in the CALIOP L3 GEWEX products.

This radiative temperature is estimated as the temperature at the centroid altitude of the 532-nm attenuated backscatter, further corrected in case of ice clouds to account for the difference in attenuation between visible and IR wavelengths, as described in section 3.4 of Garnier et al. (2021a). Mean values and histograms are for the ice, water, and high ice pixels with confident microphysical retrievals.

- Cloud Effective Emissivity, Cloud Water Path, and Cloud Optical Depth

  The IIR parameters are from the IIR L2 track product, and they were derived as detailed in Garnier et al. (2021a). Note that the effective radii reported in this product are simply derived as half of the L2 effective diameters. Mean values and histograms are for the ice, water, and high ice pixels with confident microphysical retrievals.

  CALIOP optical depth (Young et al., 2018) means and histograms are provided for ice and high ice clouds. They are from the Version 4.20 CALIOP 5-km layer products used as input to the IIR algorithm.

Retrievals in liquid water clouds

Microphysical retrievals in the thermal infrared atmospheric window perform best for clouds that are sufficiently cold to ensure a sufficient radiative contrast with respect to the surface. Therefore, the population of liquid water clouds with microphysical retrievals is skewed toward supercooled water clouds.

References

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