Global Hydrology Resource Center

Data User Guide

GOES-R PLT Cloud Physics LiDAR (CPL)

Introduction

The GOES-R PLT Cloud Physics Lidar (CPL) dataset consists of backscatter coefficient, lidar depolarization ratio, layer top/base height, layer type, particulate extinction coefficient, ice water content, and layer/cumulative optical depth data collected from the Cloud Physics LiDAR instrument flown aboard the NASA ER-2 high-altitude aircraft during the GOES-R Post Launch Test (PLT) field campaign. The GOES-R PLT field campaign supported post-launch L1B and L2+ product validation of the Advanced Baseline Imager (ABI) and the Geostationary Lightning Mapper (GLM). The CPL instrument is a multi-wavelength backscatter LiDAR that provides multi-wavelength measurements of cirrus clouds and aerosols with high temporal and spatial resolution. Data files are available from April 13, 2017 through May 14, 2017 in HDF-5 format with layer information in ASCII text files. Browse imagery files in GIF format are also available.

Notice: The ER-2 aircraft did not operate each day of the campaign, therefore, data are only available on flight days. There were some dates during the campaign when CPL signals were weak or noisy, prompting adjustments in data processing. See *Known Issues and Missing Data* section.

Citation

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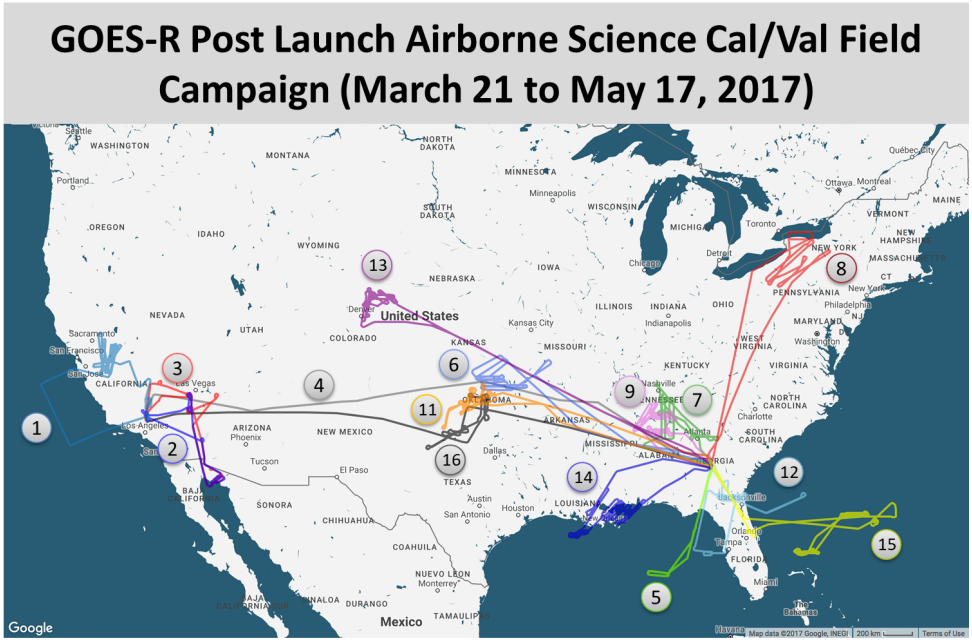
Keywords:

NASA, GHRC, GOES-R PLT, CPL, cirrus clouds, extinction profiles, depolarization ratio, layer optical depth, layer lidar ratio, aircraft parameters, aerosols

Campaign

The Geostationary Operational Environmental Satellites - R series (GOES-R) is a geostationary satellite program comprised of a four-satellite fleet including GOES-R, GOES-S, GOES-T, and GOES-U. The GOES-R Series Program is a collaborative development and acquisition effort between the National Oceanic and Atmospheric Administration (NOAA) and the National Aeronautics and Space Administration (NASA) to develop, launch and operate the satellites. The first satellite in the GOES-R series, GOES-R, launched on November 19, 2016 and became GOES-16 when it reached geostationary orbit. GOES-16 replaced GOES-13 as NOAA's operational GOES East satellite at 75.2 degrees west longitude on December 18, 2017. GOES-16 observes North and South America, as well as the Atlantic Ocean all the way to the west coast of Africa. GOES-16 provides high spatial and temporal resolution imagery of the Earth using its Advanced Baseline Imager (ABI). GOES-16's Geostationary Lightning Mapper (GLM) is the first operational lightning mapper flown in geostationary orbit. GOES-16 also includes four other scientific instruments for monitoring space weather and the Sun. More information about the GOES-R mission can be found at the GOES-R website.

The GOES-R Post Launch Test (PLT) field campaign took place between March 21 and May 17, 2017 in support of the post-launch validation of NOAA's new generation of geostationary Earth-observing instruments: ABI and GLM. The campaign was comprised of two phases: the first centered on the U.S. west coast, providing tests primarily for the ABI instrument, and the second focused on the central and eastern U.S. with tests primarily for the GLM instrument (Figure 1). The validation effort included targeted data collections from the NASA ER-2 high-altitude aircraft integrated with nine payloads (both passive and active instruments) coordinated with ground-based and low earth-orbit referenced data from several operational and research satellite missions. Sixteen ER-2 aircraft validation missions, totaling 105.1 mission flight hours, were conducted over ideal Earth validation targets, such as deserts and oceans, thunderstorms, active wildfires, and an expansive set of cloud and moisture phenomenology. Dedicated ABI 30-second mesoscale (MESO) imagery collections were conducted concurrently with the ER-2 high-altitude aircraft based sensors during each GLM mission. The GOES-R PLT field campaign provided critical reference data and new insights into the performance NOAA's new generation of geostationary Earth-observing instrument products. More information about the GOES-R PLT field campaign is available on the GOES-16 Field Campaign webpage.



*Flight #10 - April 27, 2017 - Huntsville, AL not shown due to aircraft navigation not reporting

Figure 1: The GOES-R PLT Field Campaign study area
(Image source: Frank Padula)

Instrument Description

The Cloud Physics LiDAR (CPL) instrument (Figure 2) is a multi-wavelength backscatter LiDAR that provides high-resolution measurements of aerosols and cirrus clouds, enabling the study of their radiative and optical properties. The instrument was flown aboard NASA's ER-2 high-altitude research aircraft during the GOES-R PLT field campaign. Light Detection and Ranging (LiDAR) is a remote-sensing technology in which a laser is used to gather 3-dimensional measurements of an object or environment. It works similarly to radar or sonar technology except that it uses light instead of radio or sound waves. LiDAR works by calculating the amount of time it takes the laser pulses to reach an object and return back to the scanner, allowing for spatial analysis. CPL uses three laser wavelengths (1064, 532, & 355 nm) that operate simultaneously. The instrument has the ability to detect visible and subvisible cirrus clouds and aerosols due to its laser's high pulse-repetition-frequency and low energy pulse, allowing for photon-counting detection. Due to the ER-2's high-altitude flight level, the CPL can simulate space-borne instrument measurements; hence, why the CPL and other instruments were used to validate the GOES-16 ABI and GLM instruments. More information about CPL can be found on the NASA Airborne Science CPL webpage and in the CPL Data Applications document.

Figure 2: The CPL in aircraft configuration
(Image source: NASA Airborne Science CPL webpage)

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Data Characteristics

The GOES-R PLT Cloud Physics LiDAR (CPL) dataset files are available in HDF-5 format at a Level 2 processing level with one file per ER-2 flight. More information about the NASA data processing levels is available on the EOSDIS Data Processing Levels webpage. ASCII text files describing layer locations for L2 data and browse image files in GIF format are also included. Table 1 lists the characteristics of this dataset.

Table 1: Data Characteristics

Characteristic	Description
Platform	NASA Earth Resources 2 (ER-2) aircraft
Instrument	Cloud Physics Lidar (CPL)
Spatial Coverage	N:43.57 , S:26.4 , E:-65.36 , W:-98.2 (United States of America)
Spatial Resolution	Horizontal: ~200m at 20km flight altitude; Vertical: 30m
Temporal Coverage	April 13, 2017 - May 14, 2017
Temporal Resolution	1 file per flight
Sampling Frequency	1/10 s raw data; 1 s processed data; 5 s L2 data
Parameter	Extinction profiles, layer optical depth, layer lidar ratio, aircraft parameters, aerosol layers, planetary boundary layer
Version	1
Processing Level	2

File Naming Convention

The GOES-R PLT Cloud Physics Lidar (CPL) dataset files are available in HDF-5, ASCII, and GIF format. There are two sets of validation data files, Level 1B (L1B) and Level 2 (L2), with the following naming convention:

L1B Data files:
goesrplt_CPL_[ATB|ATB-4sec]_L1B_<flight>_<YYYYMMDD>.hdf5

L1B Browse files:
goesrplt_cpl_[map|imgsum]_<flight>_<YYYYMMDD>[_<type>].gif

L2 Data files:
goesrplt_CPL_L2_V1-02_01km[Lay|Pro]_<flight>_<YYYYMMDD>.hdf5
goesrplt_CPL_layers_<flight>_<YYYYMMDD>.txt

L2 Browse files:
goesrplt_CPL_L2_01kmSum_<flight>_<YYYYMMDD>_[D1|D2][Top|Bot].gif

Table 2: File naming convention variables

Variable	Description
[map|imgsum]	map: ER-2 flight track map imgsum:Time-height summary curtain image
[ATB|ATB-4sec]	ATB: Attenuated backscatter data ATB-4sec: 4-sec resolution data file (due to degraded signal)*
flight	Flight number
type	Data type of image: 1064: 1,064nm wavelength

	532: 532nm wavelength 355: 355nm wavelength depol: depolarization ratio at 1,064nm
YYYY	Four-digit year
MM	Two-digit month
DD	Two-digit day
[Lay|Pro]	L2 data product type Lay: layer by layer product Pro: profile product
[D1|D2]	Plot display type D1: displays plots for layer type code, depolarization ratio, extinction coefficient, and extinction QC flag D2: displays plots for layer type code, particulate backscatter, ice water content, and cumulative optical depth
[Top|Bot]	Layer data type Top: CPL determined layer top Bot: CPL determined layer bottom
.hdf5	HDF-5 file format
.txt	ASCII text file format
.gif	GIF image file format

*See *Known Issues and Missing Data* section

Data Format and Parameters

The GOES-R PLT Cloud Physics LiDAR (CPL) dataset contains HDF-5 and ASCII data files, as well as GIF browse imagery. These files include backscatter coefficient, LiDAR depolarization ratio, layer top/base height, layer type, particulate extinction coefficient, ice water content and layer/cumulative optical depth data. Data products were produced for every wavelength, except the depolarization ratio which was only produced at 1,064 nm. The CPL data files are separated into two groups for the L1B and L2+ data product validation of GOES-16 instruments.

L1B CPL HDF-5 Files

The L1B HDF-5 files are calibrated attenuated backscatter profiles and associated products. These files are produced at 1-second averages under normal conditions. The L1B data fields are listed in Table 3 below.

Table 3: L1B Data Fields

Field Name	Description	Data Type	Unit

ATB_1064	Attenuated total backscatter profile for 1064 nm for each record	double	$km^{-1}\ sr^{-1}$
ATB_1064_PERP	Attenuated Total Backscatter profile at 1064 nm perpendicular channel	double	$km^{-1}\ sr^{-1}$
ATB_355	Attenuated total backscatter profile for 355 nm for each record	double	$km^{-1}\ sr^{-1}$
ATB_532	Attenuated total backscatter profile for 532 nm for each record	double	$km^{-1}\ sr^{-1}$
Bin_Alt	Altitude for each vertical bin	float	km
Bin_Width	Vertical resolution of the lidar	float	m
Cali_1064	Calibration constant at 1064 nm for each record	double	km^3 / Js^2
Cali_1064_Err	Calibration error at 1064 nm	double	km^3 / Js^2
Cali_355	Calibration constant at 355 nm for each record	double	km^3 / Js^2
Cali_355_Err	Calibration error at 355 nm	double	km^3 / Js^2
Cali_532	Calibration constant at 532 nm for each record	double	km^3 / Js^2
Cali_532_Err	Calibration error at 532 nm	double	km^3 / Js^2
Date	Date for flight	char	-
Dec_JDay	Decimal day of the year to 5 decimal places (second) for current profile	double	UTC
Depol_Ratio_1sec	Final depolarization ratio profile for 1064 nm, valid only inside layers	float	-
End_JDay	Decimal Julian day for the end time of the flight	double	UTC
Frame_Top	Top height of CPL reference frame (first bin)	float	km
Hori_Res	Horizontal resolution of the lidar profiles (typically 1 second or 200 m)	short	s
Hour	Hour of when profile was collected	short	UTC
Latitude	Latitude of profile, decimal degrees, S='-'	float	degrees
Longitude	Longitude of profile, decimal degrees, W='-'	float	degrees
Minute	Minute of when profile was collected	short	UTC
Mole_Back	Rayleigh backscatter profile of first record, currently used for whole flight for all 3 wavelengths	float	$km^{-1}\ sr^{-1}$
NumBins	Number of vertical lidar bins in the optical profiles	int	-
NumChans	Total number of lidar channels, including annulus channels if available, whereas nchan=4 always	short	-

NumRecs	Number of horizontal records (profiles)	int	-
NumWave	Number of wavelengths in lidar output -- Wavelength (wl) index: 0=355, 1=532, 2=1064nm	int	-
Plane_Alt	Height of the aircraft above mean sea level Missing = -999.0	float	km
Plane_Heading	Plane heading for current profile, clockwise from North	float	degrees
Plane_Pitch	Aircraft pitch, decimal degrees, down='-'	float	degrees
Plane_Roll	Aircraft roll, decimal degrees, left turn = '-'	float	degrees
Pressure	Atmospheric pressure profile of first record, currently used for whole flight float	float	hPa
Project	Field project name	char	-
RH	Atmospheric relative humidity profile of first record, currently used for whole flight	float	%
Saturate	Height where detector saturation occurred per channel No saturation = -5000.0	float	km
Second	Second of when profile was collected	short	UTC
Solar_Azimuth_Angle	Solar azimuth angle	float	degrees
Solar_Elevation_Angle	Solar elevation angle	float	degrees
Start_JDay	Decimal Julian day for the start time of the flight	double	UTC
Temperature	Atmospheric temperature profile of first record, currently used for whole flight	float	C

L2 CPL HDF-5 Files

The L2 HDF-5 files are organized into layer-by-layer products (*Lay_*.hdf), described in Table 4, and profile products (*Pro_*.hdf), described in Table 5. The L2 HDF-5 files are produced at 5-second averages under normal conditions and flag values for these data files are listed in Tables 6 - 8.

Table 4: L2 Layer by Layer Data Fields (*Lay_*.hdf)

Group	Field Name	Data Type
geolocation	CPL_Angle	double
	CPL_Latitude	float
	CPL_Longitude	float
	Index_Top_Bin	short
	Solar_Azimuth_Angle	double
	Solar_Zenith_Angle	float

layer_descriptor	Aerosol_Type	short
	Cloud_Phase	short
	Cloud_Phase_Score	short
	Constrained_Lidar_Ratio_Flag	short
	DEM_Surface_Altitude	float
	Extinction_QC_Flag_1064	float
	Extinction_QC_Flag_355	float
	Extinction_QC_Flag_532	float
	Feature_Type	short
	Feature_Type_Score	short
	Layer_Base_Altitude	float
	Layer_Base_Bin	short
	Layer_Base_Pressure	float
	Layer_Base_Temperature	float
	Layer_Effective_Multiple_Scattering_Factor_1064	float
	Layer_Effective_Multiple_Scattering_Factor_355	float
	Layer_Effective_Multiple_Scattering_Factor_532	float
	Layer_Top_Altitude	float
	Layer_Top_Bin	short
	Layer_Top_Pressure	float
	Layer_Top_Temperature	float
	Lidar_Ratio_Selection_Method_1064	float
	Lidar_Ratio_Selection_Method_355	float
	Lidar_Ratio_Selection_Method_532	float
	Lidar_Surface_Altitude	float
	Number_Layers	short
	Opacity	ushort
	Profile_Decimal_Julian_Day	double
	Sky_Condition	short
	Surface_Type	short
metadata_parameters	Bin_Altitude_Array	float
	Bin_Size	float
	File_Start_DateTime	char
	File_Start_Latitude	float
	File_Start_Longitude	float
	File_Stop_Latitude	float
	File_Stop_Longitude	float
	File_Stop_Time	char
	File_Year	char
	Horizontal_Resolution	float
	Max_Number_Layers	short
	Number_1km_Profiles	int

	Number_Bins	int
	Product_Creation_Date	char
	Product_Version_Number	char
optical_properties	Attenuated_Backscatter_Statistics_1064	float
	Attenuated_Backscatter_Statistics_355	float
	Attenuated_Backscatter_Statistics_532	float
	Attenuated_Total_Color_Ratio_Statistics	float
	Feature_Optical_Depth_1064	float
	Feature_Optical_Depth_355	float
	Feature_Optical_Depth_532	float
	Feature_Optical_Depth_Uncertainty_1064	float
	Feature_Optical_Depth_Uncertainty_355	float
	Feature_Optical_Depth_Uncertainty_532	float
	Ice_Water_Path_1064	float
	Ice_Water_Path_1064_Uncertainty	float
	Ice_Water_Path_355	float
	Ice_Water_Path_355_Uncertainty	float
	Ice_Water_Path_532	float
	Ice_Water_Path_532_Uncertainty	float
	Integrated_Attenuated_Backscatter_1064*	float
	Integrated_Attenuated_Backscatter_355*	float
	Integrated_Attenuated_Backscatter_532*	float
	Integrated_Attenuated_Backscatter_Uncertainty_1064*	float
	Integrated_Attenuated_Backscatter_Uncertainty_355*	float
	Integrated_Attenuated_Backscatter_Uncertainty_532*	float
	Integrated_Attenuated_Total_Color_Ratio	float
	Integrated_Attenuated_Total_Color_Ratio_Uncertainty	float
	Integrated_Volume_Depolarization_Ratio_1064	float
	Integrated_Volume_Depolarization_Ratio_Uncertainty_1064	float
	Lidar_Ratio_1064	float
	Lidar_Ratio_355	float
	Lidar_Ratio_532	float
	Measured_Two_Way_Transmittance_1064	float
	Measured_Two_Way_Transmittance_355	float
	Measured_Two_Way_Transmittance_532	float
	Measured_Two_Way_Transmittance_Uncertainty_1064	float
	Measured_Two_Way_Transmittance_Uncertainty_355	float
	Measured_Two_Way_Transmittance_Uncertainty_532	float
	Two_Way_Transmittance_Measurement_Region	float
	Volume_Depolarization_Ratio_Statistics_1064	float

*Note: The word ‘Attenuated’ in these field names is misspelled as ‘Attenauted’ in the data files

Table 5: L2 Profile Data Fields (*Pro_*.hdf)

Group	Field Name	Data Type
geolocation	CPL_Angle	double
	CPL_Latitude	float
	CPL_Longitude	float
	Index_Top_Bin	short
	Solar_Azimuth_Angle	double
	Solar_Zenith_Angle	float
metadata_parameters	Bin_Altitude_Array	float
	Bin_Size	float
	File_Start_DateTime	char
	File_Start_Latitude	float
	File_Start_Longitude	float
	File_Stop_Latitude	float
	File_Stop_Longitude	float
	File_Stop_Time	char
	File_Year	char
	Horizontal_Resolution	float
	Number_1km_Profiles	int
	Number_Bins	int
	Product_Creation_Date	char
	Product_Version_Number	char
profile	Aerosol_Optical_Depth_1064	float
	Aerosol_Optical_Depth_355	float
	Aerosol_Optical_Depth_532	float
	Aerosol_Optical_Depth_Uncertainty_1064	float
	Aerosol_Optical_Depth_Uncertainty_355	float
	Aerosol_Optical_Depth_Uncertainty_532	float
	Aerosol_Type	short
	Cloud_Optical_Depth_1064	float
	Cloud_Optical_Depth_355	float
	Cloud_Optical_Depth_532	float
	Cloud_Optical_Depth_Uncertainty_1064	float
	Cloud_Optical_Depth_Uncertainty_355	float
	Cloud_Optical_Depth_Uncertainty_532	float
	Cloud_Phase	short
	Cloud_Phase_Score	short
	Column_Optical_Depth_1064	float
	Column_Optical_Depth_355	float
	Column_Optical_Depth_532	float

	Column_Optical_Depth_Uncertainty_1064	float
	Column_Optical_Depth_Uncertainty_355	float
	Column_Optical_Depth_Uncertainty_532	float
	DEM_Surface_Altitude	float
	Extinction_Coefficient_1064	float
	Extinction_Coefficient_355	float
	Extinction_Coefficient_532	float
	Extinction_Coefficient_Uncertainty_1064	float
	Extinction_Coefficient_Uncertainty_355	float
	Extinction_Coefficient_Uncertainty_532	float
	Extinction_QC_Flag_1064	float
	Extinction_QC_Flag_355	float
	Extinction_QC_Flag_532	float
	Feature_Type	short
	Feature_Type_Score	short
	Ice_Water_Content_1064	float
	Ice_Water_Content_1064_Uncertainty	float
	Ice_Water_Content_355	float
	Ice_Water_Content_355_Uncertainty	float
	Ice_Water_Content_532	float
	Ice_Water_Content_532_Uncertainty	float
	Lidar_Surface_Altitude	float
	Mutiple_Scattering_Factor_1064	float
	Mutiple_Scattering_Factor_355	float
	Mutiple_Scattering_Factor_532	float
	Particulate_Backscatter_Coefficient_1064	float
	Particulate_Backscatter_Coefficient_355	float
	Particulate_Backscatter_Coefficient_532	float
	Particulate_Backscatter_Coefficient_Uncertainty_1064	float
	Particulate_Backscatter_Coefficient_Uncertainty_355	float
	Particulate_Backscatter_Coefficient_Uncertainty_532	float
	Profile_Decimal_Julian_Day	double
	Sky_Condition	short
	Surface_Type	short
	Total_Depolarization_Ratio_1064	float
	Total_Depolarization_Ratio_Uncertainty_1064	float

Table 6: CPL Optical Properties Flags

Parameter	Interpretation
Extinction_QC_Flag	-1 = calculation not attempted

	0 = non-opaque layer extinction analysis nominal 1 = layer hit earth's surface before layer bottom reached, adjusted bottom 2 = lowering lidar ratio thru iteration process successful 3 = raising lidar ratio thru iteration process successful 4 = # of iterations maxed out, analysis stopped 5 = signal inside layer saturated before bottom, analysis stopped 6 =layer is opaque, layer OD=-1, initial lidar ratio accepted* 7 = layer is opaque, layer OD=-1, lidar ratio iteration successful* 8 = layer OD out of bounder (invalid) OD= -999.9 9 = layer analysis invalid because final lidar ratio out of bounds
Lidar_Ratio_Selection_Method	0 = generic default 1 = aerosol GEOS5 lookup table 2 = cloud lookup table 3 = 1064 lidar ratio used 532 OD (for ice clouds only)* 4 = constrained result using clear zone just below layer 5 = constrained result with opaque layer 6 = lowered lidar ratio by a max of 15sr to reach layer bottom 7 = raised lidar ratio by a max of 15sr to reach layer bottom 8 = open slot (not used) 9 = missing
Constrained_Lidar_Ratio_Flag	0 = useful value using nominal "constrained" procedure 1 = useful value using opaque "constrained" procedure 2 = constrained lidar ratio outside thresholds 3 = below layer clear zone too small 4 = clear zone signal error > threshold 5 = Tp_sq < allowed min 6 = Tp_sq at or below 0.0 7 = useful 1064 lidar ratio using 532 OD (for ice clouds only)* 8 = Tp_sq at or below 0.0 in opaque cloud conditions 9 = missing

* Note: 'OD' stands for 'Optical Depth'

Table 7: CPL Surface Type Flags

Parameter	Interpretation
IGBP_Surface_Type	1 = evergreen needleleaf forest 2 = evergreen broadleaf forest 3 = deciduous needleleaf forest 4 = deciduous broadleaf forest 5 = mixed forest 6 = closed shrubland 7 = open shrublands 8 = woody savannas 9 = savannas 10 = grasslands

	11 = permanent wetlands 12 = croplands 13 = urban 14 = cropland/natural vegetation mosaic 15 = permanent snow and ice 16 = barren or sparsely vegetated 17 = water 18 = tundra

Table 8: CPL Vertical Feature Mask Parameters

Parameter	Interpretation
Sky_Condition	0 = clean skies (no clouds/aerosols) 1 = clear skies (no clouds) 2 = cloud skies (no aerosols) 3 = hazy/cloudy (both clouds/aerosols)
Feature_Type	0 = invalid 1 = cloud 2 = undetermined 3 = aerosol
Feature_Type_Score	| 10 | = high confidence | 1 | = low confidence 0 = zero confidence
Cloud_Phase	0 = invalid 1 = water cloud 2 = unknown cloud phase 3 = ice cloud
Cloud_Phase_Score	| 10 | = high confidence | 1 | = low confidence 0 = zero confidence
Aerosol_Type	0 = invalid 1 = marine 2 = polluted marine 3 = dust 4 = dust mixture 5 = clean/background 6 = polluted continental 7 = smoke 8 = volcanic

L2 CPL Layers ASCII Files

The *goesrplt_CPL_layers*.txt* files show geolocation, navigation, and layers found. The files also contain a header describing the data fields, listed in Table 6. These files are produced at 5-second averages under normal conditions.

Table 9: L2 ASCII Text File Data Fields

Column Number	Field Name	Description	Unit
1	Time	Observation UTC Time for ER-2 CPL	-
2	Lat	ER-2 Latitude	Degrees N
3	Lon	ER-2 Longitude	Degrees E
4	Alt	ER-2 Altitude	m
5	Angle	LiDAR Off-Nadir Angle	degrees
6	N	Number of detected layers of all types	-
7	GH	CPL determined ground height in meters above MSL	m
8-15	Layers 1-8	(Top Bot D) where: Top = CPL determined layer top in meters above MSL for each layer up to 10 layers Bot = CPL determined layer bottom in meters above MSL for each layer up to 10 layers D = Layer discriminator for each layer 1 ->PBL (planetary boundary layer); 2 ->Elevated aerosol; 3 ->Cloud; 4 ->Undetermined	m

L1B & L2 Browse Image Files

The L1B browse image files include time-series plots of CPL measurements and flight track maps. The time-series plots show attenuated backscatter curtain plots during the entire flight. There are four per flight: 355, 532, and 1064 nm wavelengths (1-second resolution) and depolarization ratio at 1064 nm (5-second resolution). The flight track maps include images of the ER-2 flight path during each mission. The track is marked with UTC timestamps along the path. The image also includes a geographic map behind the flight track.

The L2 browse images show various L2 products on two different displays (D1, D2) each containing 4 time-series plots. The 'D1' plots include layer type code, depolarization ratio, extinction coefficient, and extinction QC flag. The 'D2' plots include layer type code, particulate backscatter, ice water content, and cumulative optical depth. A legend is also included for the layer tye and extinction QC flag plots. The files also correspond to data from either the top (Top) or the bottom (Bot) of the layer.

Algorithm

The CPL measures the backscatter coefficient, or the amount of signal reflected back to the instrument by the target. The rest of the signal is either absorbed by the target or scattered.

Different layers can have different extinction-to-backscatter ratios (S-ratios), which is the total absorbed and scattered energy divided by the amount of backscattered energy, depending on the layer composition. Because of this, the processing algorithm must be able to discern aerosol types within each layer. More information about the processing algorithm is provided in McGill et al. (2002) and McGill, Hlavka, Hart, Welton, and Campbell (2003).

Quality Assessment

The CPL data processing algorithm calibrates each CPL measured profile by matching it to the profile of a calibration region, free of clouds and aerosols. Since the CPL instrument is a nadir-viewing system in the lower stratosphere, the altitude regime used for calibration is in the upper troposphere. After the calibrated 1-second averaged profiles are produced, they are averaged again to a 5-minute resolution. The 5-minute averaged profile data are fit to a curve to produce a polynomial calibration equation for each wavelength. More information about the CPL data calibration process can be found in McGill et al. (2003) and Vaughan, Liu, McGill, Hu, and Obland (2010).

Software

These data are available in HDF-5 and ASCII formats. No special software is required to view these data, however, Panoply can be used to easily view the HDF-5 data. In addition, the PI has provided IDL read routines for the L1B and L2 HDF files. Both routines are available on the GHRC public server.

Known Issues or Missing Data

The L1B HDF-5 files are normally produced at 1-second averages and 'layers' ASCII text files are normally produced at 5-second averages. Signals were weak and noisy on March 23, 2017 and March 28, 2017, so the L1B HDF-5 products and L2 'layers' text files were produced at 10-second averages for those two flights. No L2 HDF-5 or image products were produced for these flights and because of the degraded signals, these flights only have the L1B 1064nm and depolarization ratio browse images. Due to noisy signals on May 7, 2017, L1B HDF-5 files were produced at 4-second resolution and the flight lacks the 355nm browse image. Also, the ER-2 aircraft did not operate each day of the campaign, therefore, data are only available on flight days.

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Related Data

All datasets collected during the GOES-R PLT field campaign are considered related to this GOES-R PLT CPL dataset. They can be located using the GHRC HyDRO2.0 search tool and entering the term 'GOES-R PLT' in the search box. The CPL instrument was also used in other field campaigns. These datasets can be located by searching 'CPL' in HyDRO2.0 and are listed below.

GPM Ground Validation Cloud Physics Lidar (CPL) OLYMPEX dataset (http://dx.doi.org/10.5067/GPMGV/OLYMPEX/CPL/DATA101)

Hurricane and Severe Storm Sentinel (HS3) Global Hawk Cloud Physics Lidar (CPL) dataset (http://dx.doi.org/10.5067/HS3/CPL/DATA202)

Contact Information

To order these data or for further information, please contact:

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