Data User Guide

SBU Ceilometers IMPACTS

Introduction

The SBU Ceilometers IMPACTS dataset includes ceilometer cloud height measurements collected by the Vaisala CL51, Vaisala CT25K, and Lufft Ceilometer CHM 15k ceilometers operated by the State University of New York (SUNY) Stony Brook University. These data were collected during the Investigation of Microphysics and Precipitation for Atlantic Coast-Threatening Snowstorms (IMPACTS) field campaign, a three-year sequence of winter season deployments conducted to study snowstorms over the U.S. Atlantic coast. IMPACTS aimed to (1) Provide observations critical to understanding the mechanisms of snowband formation, organization, and evolution; (2) Examine how the microphysical characteristics and likely growth mechanisms of snow particles vary across snowbands; and (3) Improve snowfall remote sensing interpretation and modeling to significantly advance prediction capabilities. The ceilometer dataset files are available from January 1, 2020 through February 28, 2022 in netCDF-3 and netCDF-4 formats.

Note: It should be noted that the units within the 'time' variable in the *_MAN.nc files say 'days'; however, these are measured in 'seconds'.

Citation

Kollias, Pavlos and Mariko Oue. 2020. SBU Ceilometers IMPACTS [indicate subset used]. Dataset available online from the NASA Global Hydrometeorology Resource Center DAAC, Huntsville, Alabama, U.S.A. doi:
http://dx.doi.org/10.5067/IMPACTS/CEILOMETERS/DATA101

Keywords:

NASA, GHRC, IMPACTS, SBU, ceilometers, backscatter, U.S. Atlantic Coast, winter precipitation

Campaign

The Investigation of Microphysics and Precipitation for Atlantic Coast-Threatening Snowstorms (IMPACTS), funded by NASA's Earth Venture program, is the first comprehensive study of East Coast snowstorms in 30 years. IMPACTS will fly a complementary suite of remote sensing and in-situ instruments for three 6-week deployments (2020-2023) on NASA's ER-2 high-altitude aircraft and P-3 cloud-sampling aircraft. The first deployment began on January 17, 2020 and ended on March 1, 2020. IMPACTS samples U.S. East Coast winter storms using advanced radar, LiDAR, and microwave radiometer remote sensing instruments on the ER-2 and state-of-the-art microphysics probes and dropsonde capabilities on the P-3, augmented by ground-based radar and rawinsonde data, multiple NASA and NOAA satellites (including GPM, GOES-16, and other polar orbiting satellite systems), and computer simulations. IMPACTS addressed three specific objectives: (1) Provide observations critical to understanding the mechanisms of snowband formation, organization, and evolution; (2) Examine how the microphysical characteristics and likely growth mechanisms of snow particles vary across snowbands; and (3) Improve snowfall remote sensing interpretation and modeling to significantly advance prediction capabilities. More information is available from [NASA's Earth Science Project Office's IMPACTS field campaign webpage].

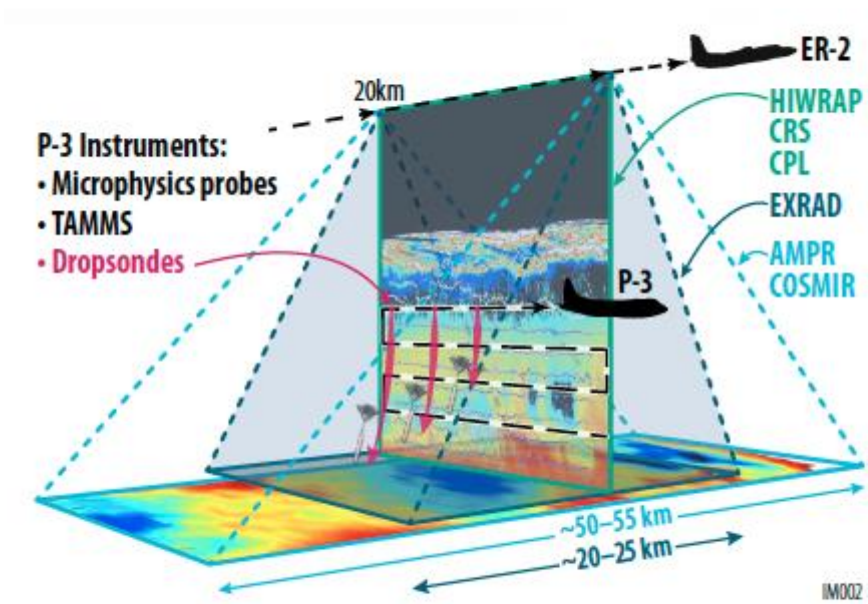

Figure 1: IMPACTS airborne instrument suite
(Image source: [NASA IMPACTS ESPO])

Instrument Description

The Vaisala Ceilometer CL51 and Vaisala Ceilometer CT25K are pulsed diode laser ceilometers operated by the State University of New York (SUNY) Stony Brook University. The CL51 and CT25K use Light Detection And Ranging (LiDAR) technology to detect cloud heights as well as other atmospheric targets. The ceilometer laser transmits pulses of light towards a volume of targets. When the light contacts the target, some of the light energy is absorbed and scattered while some is reflected back, or backscattered, towards the ceilometer's receiver. The time that it takes this reflected energy to return to the receiver indicates the targets' distance from the instrument (i.e., height), and the strength of the returned signal gives information regarding the type of targets. The ceilometers can detect and measure the height of various types of atmospheric targets including clouds, fog, precipitation, and aerosols.

The CL51 and CT25K both use a single lens which allows for more accurate measurement at lower altitudes. They are automatic and have self-diagnostic capabilities, allowing them to operate unaided for long periods of time. The CL51 has an altitude range of 15 km while the CT25K has an altitude range of 7.5 km. The CT25K is attached to a pedestal base and can be manually tilted to different tilt angles ranging from -15° to 90° from the vertical. The CL51 also has a tilting feature. These ceilometers can detect up to three cloud layers simultaneously as well as vertical visibility. Additional instrument specifications are listed in Table 1 below.

Figure 2: The SUNY Stony Brook Ceilometers: Vaisala CL51 (left) and Vaisala CT25K (right) (Image source: Stony Brook University)

Table 1: SUNY Stony Brook Ceilometer specifications

Field Name	CL51	CT25K
Measurement	Lidar backscatter, cloud base	Lidar backscatter, cloud base
Wavelength	910 nm	905 nm
Raw range resolution	10 m	7 m
Maximum range	15 km	7.5 km
Time resolution	6 s	15 s

The Lufft Ceilometer CHM 15K has a double-walled housing combined with integrated fan and automatic heating system. Thus it provides reliable protection against misting, precipitation, freezing or overheating. It uses LiDAR to measure aerosol backscatter profile, cloud base height, cloud penetration depth, aerosol layer height, cloud cover, vertical visibility, and the Sky Condition Index.

Figure 3: Lufft Ceilometer CGM 15K
(Image source: Lufft)

Additional information for each ceilometer is available below:
Vaisala CL51 Datasheet
Vaisala CT25K User's Guide
Lufft CHM15k Manual

Investigators

Pavlos Kollias
Stony Brook University School of Marine and Atmospheric Sciences
Stony Brook, New York

Mariko Oue
Stony Brook University School of Marine and Atmospheric Sciences
Stony Brook, New York

Data Characteristics

The SBU Ceilometers IMPACTS dataset contains cloud height measurements collected by the CL51, CHM15K, and CT25K ceilometers during the IMPACTS field campaign. These data are stored in netCDF-3 and netCDF-4 formats at a Level 2 processing level. More information about the NASA data processing levels are available on the [EOSDIS Data Processing Levels webpage](). The characteristics of this dataset are listed in Table 2 below.

Table 2: Data Characteristics

Characteristic	Description
Platform	Ground based
Instrument	Vaisala Ceilometer CL51 Vaisala Ceilometer CT25K Lufft Ceilometer CHM 15k
Spatial Coverage	N: 40.965, S: 40.897, E: -73.030, W: -73.128 (New York)
Spatial Resolution	30 m
Temporal Coverage	January 1, 2020 - February 28, 2022
Temporal Resolution	5 minutes-daily
Sampling Frequency	<15 seconds
Parameter	Cloud base height, backscatter, instrument parameters, cloud depth, aerosol layer, total cloud cover, boundary layer measurements
Version	1
Processing Level	2

File Naming Convention

The SBU Ceilometers IMPACTS dataset files are stored in netCDF-3 and netCDF-4 formats. The dataset files are named using the following convention:

Data files: IMPACTS_SBU_ceilo_YYYYMMDD_hhmm_<inst>.nc

Table 3: File naming convention variables

Variable	Description
YYYY	Four-digit year
MM	Two-digit month
DD	Two-digit day
hh	Two-digit hour in UTC
mm	Two-digit minute in UTC
<inst>	Name of instrument: chm15k_RT, cl51k_MAN, ct25k_BNL
.nc	netCDF-3 and netCDF-4 format data files

Data Format and Parameters

The SBU Ceilometers IMPACTS dataset consists of cloud height measurements collected by the Stony Brook CL51, CHM 15K, and CT25K ceilometers. The ceilometer data are stored in netCDF-3 and netCDF-4 formats. Each file type is described in detail below. It should be noted that the units within the 'time' variable in the *_MAN.nc files say 'days'; however, these are measured in 'seconds'.

CL51 data files

The CL51 data files are stored in netCDF-3 format. Each file contains backscatter measurements collected by CL51 along with the derived parameters of boundary layer height, cloud base height, number of cloud layers, and date/time/location information.

Table 4: Data Fields for CL51

Field Name	Description	Unit
algorithm_sensitivity	Algorithm sensitivity. Smaller values mean higher sensitivity	-
Algorithm_Method	Algorithm method: 0 = Merged gradient and profile fit 1 = Gradient 2 = Profile fit	-
bl_height	Boundary layer height	m
bl_height_length	Number of boundary layer height candidates found	-
bl_index	Quality indices for boundary layer height candidates	-
boundary_layer_max	Maximum height for a boundary layer height candidate	m
boundary_layer_min	Minimum height for a boundary layer height candidate	m
Bs_prof_length	Number of samples in ceilometer signal backscatter profile	-
Bs_profile_data	Ceilometer signal backscatter profile	m
cloud_data	Cloud bases or vertical visibility/highest signal detected	m
cloud_status	Cloud detection status (0=clear sky, 1= one layer, 2= two layers, 3= three layers, 4= vertical visibility reported, 5= some obscuration but determined to be transparent)	-
date_stamp	Measurement timestamp in textual form in YYYY-MM-DD hh:mm:ss	-
Ec_prof_length	Number of samples in ceilometer signal extinction coefficient profile	-
Ec_prof_opacity	Opacity or aerosol optical depth (AOD) of the extinction coefficient (EC) profile in units of 0.01; it is the integral of EC up to that range	-
Ec_prof_range	Range to which the extinction coefficient (EC) profile data is valid. Above that range data is 0	m
Ec_profile_data	Extinction coefficient (EC) profile	-

Height_averaging_param	Height averaging parameter. Used only if vrb_height_averaging = false	m
LevelTwoCount	Number of level 2 (L2) samples used to create level 3 (L3) sample	-
Location_latitude	Instrument latitude	Degrees North
Location_longitude	Instrument longitude	Degrees East
location_utc_offset	Location UTC offset	-
Mean_Layer_Calculation_Time	Mean layer calculation time	s
Mean_Layer_Height	Mean layer height	m
Mean_Layer_QuealityIndex	Mean layer quality index	-
name	Data identifier (ceilometer name)	-
Ng_prof_length	Number of samples in negative gradient profile	-
Ng_profile_data	Ceilometer signal backscatter profile	m
number_of_boundary_layers	Number of boundary layers	-
parameter_key	Parameter key	-
period	Sending frequency of ceilometer data message	s
range	range	m
sunrise_utc	Time when the sun rises	UTC
sunset_UTC	Time when the sun sets	UTC
time	Days since 1970-01-01 00:00:00.000	UTC
Time_averaging_period	Time averaging period. Used only if vrb_time_averaging = false	s
vrb_height_averaging	1 = True, use variable height averaging 0 = False, use user-defined constant height averaging	-
vrb_time_averaging	1 = True, use variable time averaging 0 = False, use user-defined constant time averaging	-

CT25K data files

The CT25K data files contain backscatter information and cloud base height measurements.

Table 5: Data Fields for CT25K

Field Name	Description	Unit
altitude	Height of instrument above mean sea level	m
background	This variable gives an indication of background light levels (noise)	mV
base1	Range of the first cloud base from the lidar	km
base2	Range of the second cloud base from the lidar	km

base3	Range of the third cloud base from the lidar	km
bases	Number of cloud bases	-
beta	Attenuated backscatter coefficient	1/m sr
beta_raw	Raw attenuated backscatter coefficient	1/m sr
elev	Elevation above horizon	degrees
flags	Instrument flags This is a bitfield of 6 bits that tracks several instrument modes and parameters, with 1 being the least significant bit 1 - Measurement mode (0 = normal, 1 = close range) 2 - Sampling rate (0 = 10 MHz, 1 = 20 MHz) 3 - Bandwidth (0 = narrow, 1 = wide) 4 - Gain level (0 = high, 1 = low) 5 - Pulse length (0 = long, 1 = short) 6 - Code check (0 = code understood, 1 = not understood)	-
laser_energy	Laser pulse energy	%
laser_temp	Laser temperature	Degrees C
latitude	Latitude of LiDAR	Degrees North
longitude	Longitude of LiDAR	Degrees East
pulse_per_profile	Number of laser pulses averaged per profile	-
range	Range from LiDAR	km
receiver_sens	Receiver sensitivity	%
scale	Measurement scale - should be 100%	%
stdn	Standard deviation of the backscatter coefficient background noise	1/m sr
time	Decimal hours UTC since midnight	UTC
wavelength	LiDAR wavelength	nm
window	Window contamination. This variable gives an indication of the laser reflection from the window of the instrument (measured by a photodiode)	mV

CHM15K data files

The CHM15K data files contain cloud base height and cloud depth measurements.

Table 6: Data Fields for CHM15K

Field Name	Description	Unit

altitude	Height of instrument above mean sea level	m
average_time	Average time per record	ms
azimuth	Laser direction of site	degrees
base	Baseline raw signal in photon per shot (b)	-
bcc	Base cloud cover	-
beta_raw	Normalized range corrected signal	-
beta_raw_hr	Normalized range corrected signal (high resolution)	-
cbe	Cloud base height variation	m
cbh	Cloud base height	m
cde	Cloud depth variation	m
cdp	Cloud depth	m
cho	Cloud height offset	m
error_ext	32 bit service code	-
laser_pulses	Number of laser pulses per record (lp)	-
latitude	Latitude of site	Degrees North
layer	Layer index	-
life_time	Laser lifetime	h
longitude	Longitude of site	Degrees East
mxd	Maximum detection height	m
p_calc	Calibration pulse in photon per shot	-
pbl	Aerosol layer in PBL	m
pbs	Quality score for aerosol layer in PBL	-
range	Distance from LiDAR	m
range_gate	Length of range gate, binwidth	m
range_gate_hr	Length of range gate with high resolution, binwidth	m
range_hr	High resolution distance from LiDAR	m
scaling	Scaling factor (cs)	-
sci	Sky condition index 0: nothing, 1: rain, 2: fog, 3: snow, 4: precipitation or particles on window	-
state_detector	Quality of detector signal	%
state_laser	Laser quality index	%
state_optics	Transmission of optics	%
stddev	Standard deviation raw signal in photons per shot	-
tcc	Total cloud cover	-
temp_det	Detector temperature	K
temp_ext	External temperature	K
temp_int	Internal temperature	K
temp_lom	Laser optic module temperature	K

time	Time	Seconds in UTC
voe	Vertical optical range error	m
vor	Vertical optical range	m
wavelength	Laser wavelength	nm
zenith	Laser direction of site	degrees

Algorithm

The Vaisala algorithm for retrieving cloud base heights is proprietary and details of it are not available. Atmospheric targets such as fog, precipitation, and clouds are detected by the laser signal that is transmitted and backscattered by these targets back to the ceilometer. Certain particles will return different magnitudes of backscatter. From this information, the type of target (aerosols, fog, precipitation, clouds) can be derived. More information about the ceilometer measurement process that applies to both systems is available in the Vaisala CT25K user's guide.

Quality Assessment

All data files have a Quality Flag parameter.

The variables beta, beta_raw, and stdn in the CT25k data files should be multiplied by the value in the scale_factor attribute. Speckle noise has been removed, but note that when speckle noise is strong/nits removal reduces the effective sensitivity of the instrument. Also, the instrument measures elevation in one direction only, with a precision of 1 degree.

The CL51 and CT25K are both low-power systems, for safety and economic purposes. This means that the strength of the transmitted laser signal is less than that of the noise from ambient light present during the daytime. To combat this issue, the ceilometers transmit multiple pulses and sum the return signals in order to distinguish the backscattered laser signal from the ambient light noise. More detail about the noise cancellation process that applies to both systems is available in the Vaisala CT25K user's guide.

It should be noted that the units within the 'time' variable in the *_MAN.nc files say 'days'; however, these are measured in 'seconds'.

Software

This dataset is in netCDF-3 and netCDF-4 formats and does not require any specific software to read. However, the netCDF-3 and netCDF-4 data files are easily readable and viewed in Panoply.

Known Issues or Missing Data

There are no known issues or missing data for this dataset.

References

Stony Brook University Radar Science Observatory. (2020). Ancillary Instruments. https://you.stonybrook.edu/radar/observatory/ancillary-instruments/

Vaisala. (2020). Ceilometer CL51. https://www.vaisala.com/sites/default/files/documents/CL51-Datasheet-B210861EN.pdf

Vaisala. (1999). Ceilometer CT25K User's Guide. https://ghrc.nsstc.nasa.gov/uso/ds_docs/gpmgv/gcpex/gpmceilgcpex/CEILOMETER_CT25K_UserGuide.pdf

Vaisala. (n.d.). Vaisala CT25K Laser Ceilometer. https://www.esrl.noaa.gov/psd/psd3/cruises/CT25K.pdf

Related Data

All other datasets collected as part of the IMPACTS campaign are considered related and can be located by searching the term "IMPACTS" in the Earthdata Search. The ceilometer instrument collected data for other field campaigns. These datasets are listed below.

CAMEX-4 MIPS Ceilometer (http://dx.doi.org/10.5067/CAMEX-4/CEILOMETER/DATA101)

GPM Ground Validation Vaisala Ceilometer IPHEx (http://dx.doi.org/10.5067/GPMGV/IPHEX/CEILOMETER/DATA101)

GPM Ground Validation Environment Canada (EC) VAISALA Ceilometer GCPEx (http://dx.doi.org/10.5067/GPMGV/GCPEX/CEILOMETERS/DATA201)

Contact Information

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

NASA Global Hydrometeorology Resource Center DAAC
User Services
320 Sparkman Drive
Huntsville, AL 35805
Phone: 256-961-7932
E-mail: support-ghrc@earthdata.nasa.gov
Web: https://ghrc.nsstc.nasa.gov/

Created: 8/27/20
Updated: 5/8/23