ACT-America: HALO Lidar Measurements of AOP and ML Heights, 2019

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Dataset Version: 1

Summary

This dataset provides measurements from the High Altitude Lidar Observatory (HALO) instrument, an airborne multi-function Differential Absorption Lidar (DIAL) and High Spectral Resolution Lidar (HSRL), operating at 532 nm and 1064 nm wavelengths onboard a C-130 aircraft during the June and July 2019 ACT-America campaign. The flights took place over eastern and central North America based from Shreveport, Louisiana; Lincoln, Nebraska; and NASA Wallops Flight Facility located on the eastern shore of Virginia. HALO data were sampled at 0.5 s temporal and 1.25 m vertical resolutions. The data include profiles of aerosol optical properties (AOP), distributions of mixed layer heights (MLH), columns of tropospheric methane, and navigation parameters. The data are provided in HDF5 format along with PNG images and a companion files in Portable Document (*.pdf) format.

There are 561 data files included in this dataset: 17 files in Hierarchical Data Format Version 5 (HDF5; *.h5) format and 544 files in Portable Network Graphics (PNG; *.png) image format. Also included is one companion file in Portable Document (*.pdf) format.

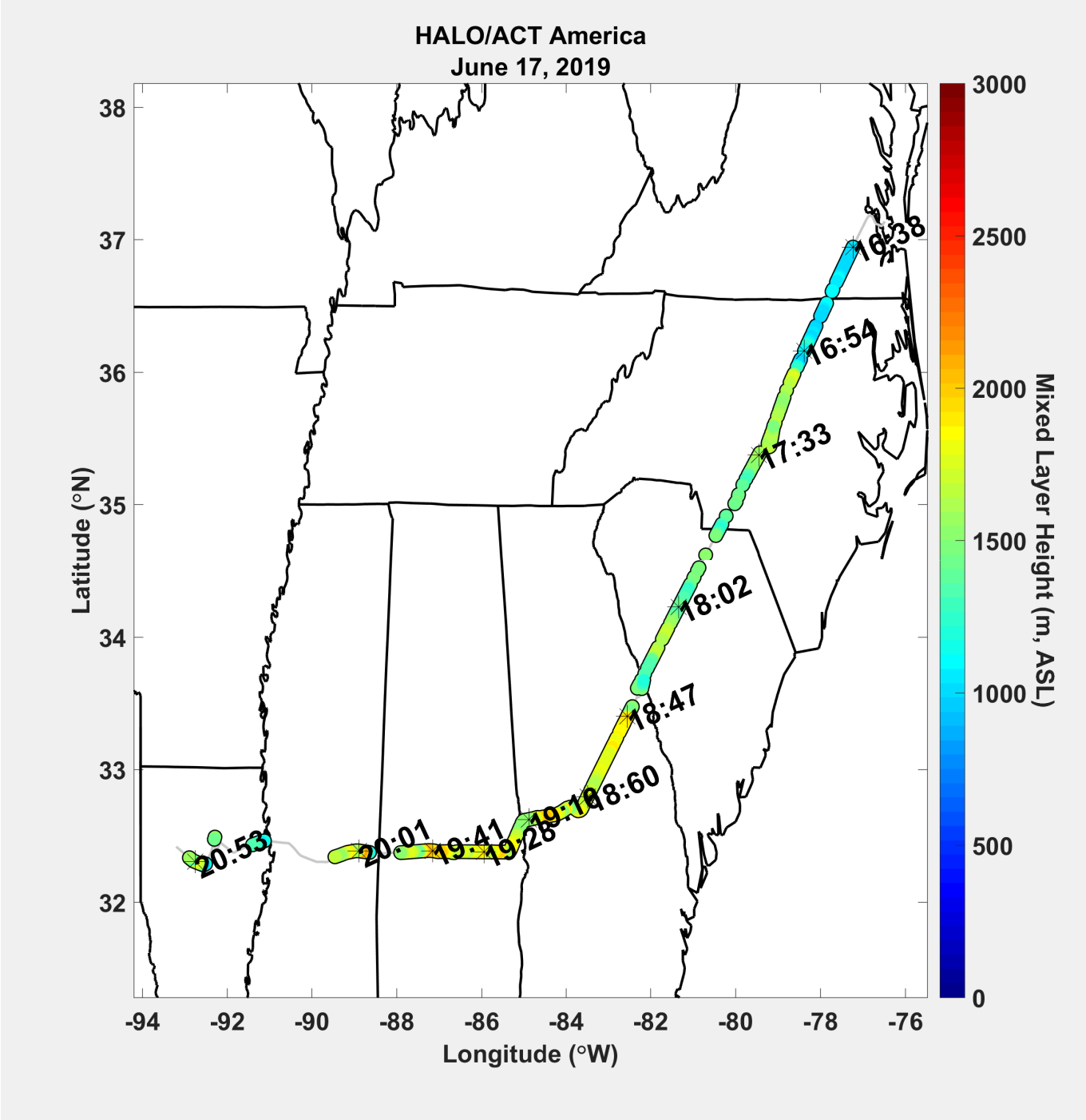

Figure 1. Map of mixing layer height across the sampling area. Source: 20190617_MixedLayerHeight_map.png

Citation

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1. Dataset Overview

This dataset provides measurements from the HALO instrument, an airborne multi-function Differential Absorption Lidar (DIAL) and High Spectral Resolution Lidar (HSRL), operating at 532 nm and 1064 nm wavelengths onboard a C-130 aircraft during the June and July 2019 ACT-America campaign. The flights took place over eastern and central North America based from Shreveport, Louisiana; Lincoln, Nebraska; and NASA Wallops Flight Facility located on the eastern shore of Virginia. HALO data were sampled at 0.5 s temporal and 1.25 m vertical resolutions. The data include profiles of aerosol optical properties, distributions of mixed layer heights (MLH), columns of tropospheric methane, and navigation parameters.

Project: Atmospheric Carbon and Transport - America

The ACT-America, or Atmospheric Carbon and Transport - America, project is a NASA Earth Venture Suborbital-2 mission to study the transport and fluxes of atmospheric carbon dioxide and methane across three regions in the eastern United States. Flight campaigns measured transport of greenhouse gases by continental-scale weather systems. Ground-based measurements of greenhouse gases were also collected. Project goals include better estimates of greenhouse gas sources and sinks which are required for climate management and for prediction of future climate.

2. Data Characteristics

Spatial Coverage: Central and eastern North America

Spatial Resolution: 1.3 km

Temporal Coverage: 2019-06-17 to 2019-07-28

Temporal Resolution: one-time

Study Area: Latitude and longitude are given in decimal degrees.

Region	Northernmost Latitude	Southernmost Latitude	Easternmost Longitude	Westernmost Longitude
North America	50	28	-73	102

Data File Information

There are 561 data files included in this dataset: 17 files in Hierarchical Data Format Version 5 (HDF5; *.h5) format and 544 files in Portable Network Graphics (PNG; *.png) image format. Also included is one companion file in Portable Document (*.pdf) format.

The HDF5 files are named *actamerica-HALO_C130_**YYYYMMDD**_R#.h5* (e.g., actamerica-HALO_C130_20190709_R0.h5), where **YYYYMMDD** is the sampling date and **R#** is the revision number.

The PNG files are named ***YYYYMMDD**_HALO_**<variable>**.png* (e.g., 20190617_532_aer_dep.png), where **YYYYMMDD** is the sampling date and **<variable>** is the data variable of interest (see Table 2).

Table 1. File names and descriptions.

File Names	Description
actamerica-HALO_C130_YYYYMMDD_R#.h5	Provides atmospheric state data including all variables for a given sampling date.
YYYYMMDD_<variable>.png	Provides images to describe selected variables that are described in the HDF5 files (see Table 2).
actamerica-HALO_C130_aerosol_description.pdf	A companion file that describes the data variables in detail.

Data File Details

The Coordinate Reference System is "WGS84" (EPSG:4326). Location information, including latitude, longitude, time, and aircraft altitude, is included in the *Nav_Data* folder of each HDF5 file.

All data have been interpolated to the same uniform altitude grid (*DataProducts/Altitude*) and horizontally averaged or interpolated to the GPS times (*Nav_Data/gps_time*).

Table 2. PNG file names and descriptions and corresponding variable names. The variable values are provided in the HDF files.

PNG File Name	Description	HDF Variable
YYYYMMDD_532_bsr_3D.png	3D representation of aerosol backscattering ratio at 532 nm	532_bsr
YYYYMMDD_ratio1064_532_aer_dep.png	plot of vertical profile as a function of time: the ratio of the aerosol depolarization ratios (1064 nm/532 nm)	1064_aer_dep, 532_aer_dep
YYYYMMDD_1064_aer_dep.png	plot of vertical profile as a function of time: the aerosol depolarization ratio at 1064 nm	1064_aer_dep
YYYYMMDD_1064_aer_dep_unc.png	plot of vertical profile as a function of time: the aerosol depolarization ratio uncertainty at 1064 nm	1064_aer_dep_unc

PNG File Name	Description	HDF Variable
YYYYMMDD_532_aer_dep.png	plot of vertical profile as a function of time: the aerosol depolarization ratio at 532 nm	532_aer_dep
YYYYMMDD_532_aer_dep_unc.png	plot of vertical profile as a function of time: the aerosol depolarization ratio uncertainty at 532 nm	532_aer_dep_unc
YYYYMMDD_Aerosol_ID.png	plot of vertical profile as a function of time: the aerosol type derived from HALO HSRL aerosol measurements	Aerosol_ID
YYYYMMDD_Angstrom_Dust.png	plot of vertical profile as a function of time: dust particle angstrom coefficient	Angstrom_Dust
YYYYMMDD_Angstrom_Spherical.png	plot of vertical profile as a function of time: spherical particle angstrom coefficient	Angstrom_Spherical
YYYYMMDD_532_AOT_hi_col.png	plot of vertical profile as a function of time: AOT at 532 nm	532_AOT_hi_col
YYYYMMDD_1064_bsc.png	plot of vertical profile as a function of time: aerosol backscatter at 1064 nm	1064_bsc
YYYYMMDD_1064_bsc_unc.png	plot of vertical profile as a function of time: aerosol backscatter uncertainty at 1064 nm	1064_bsc_unc
YYYYMMDD_532_bsc.png	plot of vertical profile as a function of time: aerosol backscatter at 532 nm	532_bsc
YYYYMMDD_532_bsc_unc.png	plot of vertical profile as a function of time: aerosol backscatter uncertainty at 532 nm	532_bsc_unc
YYYYMMDD_1064_bsr.png	plot of vertical profile as a function of time: aerosol backscattering ratio at 1064 nm	1064_bsr
YYYYMMDD_532_bsr.png	plot of vertical profile as a function of time: aerosol backscattering ratio at 532 nm	532_bsr
YYYYMMDD_1064_dep.png	plot of vertical profile as a function of time: total deploarization ratio at 1064 nm	1064_dep
YYYYMMDD_532_dep.png	plot of vertical profile as a function of time: total deploarization ratio at 532 nm	532_dep
YYYYMMDD_Dust_Mixing_Ratio.png	plot of vertical profile as a function of time: dust mixing ratio	Dust_Mixing_Ratio
YYYYMMDD_1064_ext.png	plot of vertical profile as a function of time: aerosol extinction at 1064 nm	1064_ext
YYYYMMDD_532_ext.png	plot of vertical profile as a function of time: aerosol extinction at 532 nm	532_ext
YYYYMMDD_532_ext_unc.png	plot of vertical profile as a function of time: aerosol extinction uncertainty at 532 nm	532_ext_unc
YYYYMMDD_MixedLayerHeight.png	time-series plot of mixing layer height as derived from aerosol backscatter at 532 nm	MixedLayerHeight
YYYYMMDD_532_AOT_hi_col_map.png	map of AOT at 532 nm	532_AOT_hi_col
YYYYMMDD_MixedLayerHeight_map.png	map of mixing layer height	MixedLayerHeight
YYYYMMDD_1064_bsc_Sa.png	plot of vertical profile as a function of time: aerosol extinction/backscatter ratio at 1064 nm	1064_bsc_Sa
YYYYMMDD_532_bsc_Sa.png	plot of vertical profile as a function of time: aerosol extinction/backscatter ratio at 532 nm	532_bsc_Sa
YYYYMMDD_532_bsc_Sa_unc.png	plot of vertical profile as a function of time: aerosol extinction/backscatter ratio uncertainty at 532 nm	532_bsc_Sa_unc
YYYYMMDD_1064_total_attn_bsc.png	plot of vertical profile as a function of time: total attenuated backscatter ratio at 1064 nm	1064_total_attn_bsc
YYYYMMDD_532_total_attn_bsc.png	plot of vertical profile as a function of time: total attenuated backscatter ratio at 532 nm	532_total_attn_bsc

PNG File Name	Description	HDF Variable
YYYYMMDD_WVD_1064_532.png	plot of vertical profile as a function of time: backscatter angstrom coefficient derived from 1064 nm 532 backscatter	WVD_1064_532
YYYYMMDD_WVD_1064_532_unc.png	plot of vertical profile as a function of time: uncertainty of backscatter angstrom coefficient derived from 1064 nm 532 backscatter	WVD_1064_532_unc

3. Application and Derivation

This dataset provides profiles of aerosol optical properties, distributions of mixed layer heights (MLH), and columns of tropospheric methane intended to support different NASA airborne science focus areas.

4. Quality Assessment

Information on uncertainty is provided within the HDF5 files.

5. Data Acquisition, Materials, and Methods

Overview

HALO is an airborne multi-function Differential Absorption Lidar (DIAL) and High Spectral Resolution Lidar (HSRL). HALO has multiple configurations intended to support different NASA airborne science focus areas. For ACT-America (summer 2019), HALO was configured in the methane DIAL/HSRL configuration to measure profiles of aerosol optical properties, distributions of mixed layer heights (MLH), as well as columns of tropospheric methane. This archive only contains the HSRL aerosol and MLH information as the methane retrievals are still under development. The HALO HSRL and backscatter aerosol channels operate at 532 nm and 1064 nm, respectively. The ACT-America summer 2019 campaign took place over eastern and central North America based in Shreveport, Louisiana; Lincoln, Nebraska; and NASA Wallops Flight Facility located on the eastern shore of Virginia.

The data are stored by profiles which are hardware averaged to 0.5 s (2Hz) native resolution. The vertical sampling resolution for the HALO raw data is 1.25 m. For aerosol profiling, these high vertical resolution bins are filtered and binned to 15 m to create a lower resolution and higher signal-to-noise ratio raw signal used to calculate the aerosol optical properties described below. Aerosol backscatter and depolarization products which include spectral depolarization ratios, angstrom exponents, and dust mixing ratio are averaged 10 s horizontally with a vertical resolution of 15 m, while aerosol extinction products are averaged 60 s horizontally and ~300 m vertically. Aerosol optical thickness (AOT) is reported. The *532_AOT_lo* data are based on 532 extinction data and have the same horizontal and vertical resolution. The variables *532_AOT_hi* and *532_AOT_hi_col* have a 10 s horizontal resolution but 300 m vertical averaging. *532_AOT_hi* is a single value for the AOT to the ground, while *532_AOT_hi_col* data are profiles of AOT. The polarization and HSRL gain ratios are calculated as described in Hair et al., 2008. Operational retrievals also provide the mixing ratio of non-spherical-to-spherical backscatter (Sugimoto and Lee, 2006), aerosol type (Burton et al., 2012), and aerosol mixed-layer height (Scarino et al., 2014).

The raw data were quality controlled by applying a cloud screening mask to remove attenuated signals below clouds. For the mixing layer height product, which is the principal lidar observable for ACT-America, the retrievals were quality controlled beyond the methods described in Scarino et al. (2014) by applying a user-defined and time-dependent threshold on the wavelet transform. To increase the precision of the mixing layer height retrievals, a ±3 point gliding or moving window (60 s window) was applied to 10 s resolution data. All data products are archived in an HDF5 file format with 10 s horizontal resolution and ranged reported data using an altitude array that is the same for all these data at ~15 m regardless of vertical averaging.

All of the aerosol data products were calculated from the 15 m interpolated altitudes. All averaging intervals (time and range) were recorded. The archived subset HDF5 files are the atmospheric files typically sub-sampled at 10 s intervals. Atmospheric products are located in the HDF5 file in the *DataProducts* directory.

Table 3. Parameter details that are included in the companion file actamerica-HALO_C130_aerosol_description.pdf.

Parameter	Wavelength (nm)	Approximate Precision	Horizontal Resolution	Vertical Resolution
Aerosol Backscatter	532 / 1064	0.2 Mm-1sr-1	10 s	15 m
Aerosol Extinction	532	0.01 km-1	60 s	300 m
Depolarization	532 / 1064	0.01	10 s	15 m
Aerosol Optical Thickness	532	0.01	60 s / 10 s	
Boundary Layer Height	532	varies with conditions	60 s	15 m
Aerosol Type (e.g., marine, dust, smoke)		qualitative	60 s	300 m

Reduced & Subset HDF5 Files

The 64 channels (not all channels are used depending on configuration) of raw data signal returns are gridded and stored along with the various data products at resolutions described previously. The engineering, navigation, gains, user input, and state parameter data are also saved in each file.

The HALO analyzed data files were sub-sampled for distribution due to the large file size associated with the full HDF5 files (~30.5 Gb/hour of flight for raw data files and ~2.5 Gb/hour of flight for the 15 m averaged data files). The subset file contains all of the calculated variables as well as atmospheric state, aircraft data, and relevant metadata, however, the engineering, gain, and raw data are not included. The data were also decimated to further reduce the file size. The amount of decimation depends on the backscatter product's temporal average, *532_bs_time_avg*, and was chosen so that only one profile in each time average is included in the subset. For example, if the raw HALO data were sampled at 0.5 s resolution and a 10 s average was applied in the backscatter calculation, the file was decimated by a factor of 20. The atmospheric extinction product, which typically has a longer temporal average than the backscatter and depolarization products, was decimated by the same amount as the other products to preserve the array size. Therefore, please note that the extinction product is over-sampled in the subset file. No sub-setting was performed along the height dimension of these products.

Data Sources

The source of the atmospheric state products used in the data reduction is identified in the attributes of the State directory. It is either MERRA2 data interpolated along the flight track (http://gmao.gsfc.nasa.gov/) or radiosonde data propagated along the flight track (http://weather.uwyo.edu/upperair/sounding.html). The Global Land One-kilometer Base Elevation (GLOBE) Digital Elevation Model, Version 1.0. provided surface elevation information (see http://www.ngdc.noaa.gov/mgg/topo/globe.html).

6. References

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