DOCUMENTATION FOR THE HARLIE IHOP VERSION 1.0 DATA SET

TITLE: HARLIE IHOP version 1.0 data set

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1.0 DATA SET OVERVIEW:

Introduction or abstract

HARLIE is a 1-micron wavelength elastic (aerosol) backscatter scanning lidar, located at the Homestead Site during IHOP. In scanning mode, the laser beam elevation angle is fixed at 45 degrees, and rotates continuously in azimuth, generating a conical scan pattern at speeds up to 30 rpm. For most of IHOP we used a scan rate of 30

degrees/second (12 second scan period). HARLIE is used to obtain high-resolution aerosol backscatter profiles, displayed in real-time. Aerosols (which are usually hygroscopic) are good tracers of atmospheric structure and humidity. The BL is usually clearly visible in the data, as are other vertical structures evidenced by gradients in the backscatter, that is proportional to both aerosol number density and size (a strong function of humidity). Clouds, even sub-visible cirrus, are clearly visible in the data images. We derive several data products during post-processing, some of which may become real-time data products in the future, the principal ones being BL height and variance, cloud coverage and heights, and horizontal winds derived from cloud motions. HARLIE was accompanied by a wide-angle visible camera, SKYCAM, pointed to zenith for the purpose of imaging clouds and studying their motions to compare with the HARLIE data.

Time period covered by the data:
24/7 from 18 May through 23 June (with the exception of occasional dropouts).

Physical location (including lat/lon/elev) of the measurement or platform: Homestead Site in the OK panhandle.

Any World Wide Web address references (i.e. additional documentation such as Project WWW site) The HARLIE quicklook backscatter data images are available at the HARLIE website, along with additional information at: http://harlie.gsfc.nasa.gov/

2.0 INSTRUMENT DESCRIPTION:

HARLIE[1] was developed as a technology demonstration of a new type of scanning lidar telescope that uses a 40 cm holographic optical element (HOE) to replace the conventional telescope primary optic and scanning mirror in order to make a much more compact package. Developed primarily for spaceborne lidar, the HARLIE technology is very advantageous for scanning airborne instruments as well because a much smaller window can be used to accommodate such a large scan angle and aperture size. HARLIE serves as an aerosol, cloud, and boundary layer backscatter lidar to augment the stable of lidars NASA uses in atmospheric research.

HARLIE generates a 45-degree conical scan pattern by rotating the transmission HOE at speeds up to 30 rpm. The entire transmitter/receiver package can be placed within centimeters from an aircraft instrument window so that a 52-cm clear aperture window allows for an unobstructed view with the 40-cm diameter HOE. The HOE serves both as the laser collimator lens as well as the receiver aperture. The HARLIE transmitter utilizes the fundamental output from a diode-pumped, Q-switched Nd:YAG laser to obtain high resolution aerosol backscatter profiles. The telescope is coupled to the receiver package via fiber optic, making it a simple matter to replace the receiver aft optical package with new configurations. It is particularly designed to be compatible with the Goddard Wind Van System components, sharing common module interfaces. The data system has a graphical user interface for real-time data display. For the IHOP field campaign, a second PC was added to generate quicklook data files that were posted to the IHOP Field Catalog every hour.

SKYCAM images were recorded on VHS video tape at a speed of 24 hours per 90 minute tape. To make this data more accessible, these were converted to digital AVI format files of manageable size for the periods during which cloud activity is visible on the videos.

Instrument Specifications:

Scan Modes: *Point and stare, 8 position step-stare, Continuous scan*

Transmitter: *200 μJ, 15 nsec pulse @ 5 kHz rep-rate, 1064nm wavelength, diode pumped Nd:YAG, divergence 180μrad*

Receiver: *40 cm diameter, f/2.5 volume phase HOE, 45° diffraction angle, effective collection area 1064 cm^2, 200 μradFOV, 0.5 nm bandpass*

Detector: *Geiger mode or analog Silicon APD, 10MHz max count rate, 2% Q.E.*

Data Acquisition: *ping-ponged scalers with 200 nsec (30 m range) bins, 30 km maximum range (20 km altitude), 100 ms minimum integration time.*

HARLIE data products:

Relative Aerosol Backscatter Profiles: 20 m height resolution, 100 msec intervals (in real-time)

Boundary Layer Height: ±~20 m, on 1 minute, 1-scan, or other time intervals.

Cloud Coverage vs. Height: ±~20 m averaged over 1-scan.

Cloud-tracked wind profiles: ±1.5 m/s averaged over 200 m altitude intervals and 15-30 min time intervals (for regions of strong aerosol scattering).

SKYCAM data products:

AVI format digital video files, and cloud-tracked winds.

3.0 DATA COLLECTION AND PROCESSING:

Description of data collection:

Aerosol backscatter data is collecting on 30 m range intervals (20 m in altitude) at a 5 KHz rep rate. Profiles are summed using photon counting scalers and stored 10 times per second. With a scan rate of 30 degrees/sec, the azimuth resolution is 3 degrees.

Description of derived parameters and processing techniques used

Height vs Time false-color images of relative backscatter are generated by summing all profiles in each scan, with background subtraction, range correction and signal logarithm applied. Data are also plotted as time series sequence of individual PPI scans on a polar axis in animated GIF file format (special product - on request only)

BL height:

Boundary layer height is determined via a Haar wavelet technique based on Davis et al. (2000) paper "An Objective Method for Deriving Atmospheric Structure from Airborne Lidar Observations". Briefly, a Haar wavelet is convoled with the profiles of atmospheric backscatter producing a covariance transform. The minimum in the covariance transform correspondes to the largest decrease in backscatter intensity. This decrease is considered to be the top of the boundary layer.

Cloud coverage vs height:
Cloud coverage is determined via a threshold technique. The profiles of atmospheric backscatter are examined for locations where the backscatter intensity exceeds the threshold. The values are then accumulated for each rotation of HARLIE and recorded.

Data intercomparisons: We are performing intercomparisons of BL data between HARLIE, FM-CW, and Raman Lidar. Wind intercomparisons are being done between HARLIE, SKYCAM, GLOW, sondes, and various other wind measurements.

4.0DATA FORMAT:

BL height:
There are four data products produced by the BL height algorithm: one backscatter image and three datafiles.

Backscatter image with BL height overlayed:
Image shows relative backscatter intensity with time on the abscissa and altitude on the ordinate. The derived BL height is overlayed as a white line.
Filename format: BL_image_*beginYYMMDDHH.MMH_endYYMMDDHH.MMH*.png
example: BL_image_02051800.00H_02051806.00H.png
begin: 05/18/02 at 00:00 UTC
end: 05/18/02 at 06:00 UTC

BL height datafiles:
Three datafiles are generated by the BL height algorithm: Per-profile, per-rotation, and per-minute. All three files are NetCDF files and have a common format. A brief description of the three datafiles:
Per-profile: the BL heights recorded are a mean of the heights calculated using a user-selected number of individual backscatter profiles.
Per-rotation: the BL heights recorded are a mean of each rotation of HARLIE.
Per-minute: the BL heights recorded are a mean of each minute of HARLIE data.

Filename format:
BL_(profile/rotation/minute)_beginYYMMDDHH.MMH_endYYMMDDHH.MMH.cdf
example: BL_profile_02051800.00H_02051806.00H.cdf
begin: 05/18/02 at 00:00 UTC
end: 05/18/02 at 06:00 UTC

Datafile format:

Variable Name	***Type***
Title	Character
File Generated	Character
Number of data bins	Short
Bin size (m)	Short
Laser repetition rate (Hz)	Short
Number of profiles per second	Short
HOE Rotation Rate (deg/s)	Short
Number of rotations in datafile	Short
Begin filename	Character
End filename	Character
Haar wavelet dilation	Short
Number of profiles averaged	Short
Year	Double
Month	Double
Day	Double
Hour	Double
Minute	Double
Second	Double
Azimuth angle of height measurement (deg)	Float
BL Height (m)	Float
Bad height flag	Short

Not all of the variables are applicable in each of the three datafiles. For example, the azimuth angle of the height measurement is not applicable in the *per-rotation* and the *per-minute* datafiles.
The bad height flag is 0 if the height is good, +1 if the upper search limit is reached, and -1 if the lower search limit is reached. Only data with a bad height flag of 0 should be used.

Cloud Coverage:
There are two data products produced by the cloud coverage routine: one image of cloud coverage as a function of time and altitude and a datafile containing the cloud coverge data. Both products encompass an entire day (24h).

Cloud coverage image:
Image shows cloud coverage with time on the abscissa and altitude on the ordinate.

Filename format: cld_cover_MMDD.png
example: cld_cover_0520.png
Cloud coverage image for 05/20/02

Cloud coverage datafile:
Datafile contains cloud coverage information for the respective day in NetCDF format.

Filename format: cld_cover_MMDD.cdf
example: cld_cover_0520.cdf
Cloud coverage datafile for 05/20/02

Datafile format:

Variable Name	***Type***
Title	Character
File Generated	Character
Begin filename	Character
End filename	Character
Number of bins	Short
Bin size (m)	Short
Laser repetition rate (Hz)	Short
Number of profiles per second	Short
Number of degrees per second	Short
Number of rotations in datafile	Short
Year	Double
Month	Double
Day	Double
Hour	Double
Minute	Double
Second	Double
Cloud coverage (0->1)	Float