CSET GV High Spectral Resolution Lidar (HSRL) data (CfRadial), Version 2.0

Changes from Version 1.0

This dataset is provided at higher temporal resolution (2Hz) than version 1.0. The raw photon counts were processed using Block Matching 3D (BM3D, see Azzari, 2016) to adaptively scale the photon count image resolution based on correlated structure in the image. Version 2.0 was processed using NCAR developed HSRL processing software where version 1.0 was processed using University of Wisconsin SSEC processing software.

Overview

This dataset contains High Spectral Resolution Lidar (HSRL) data collected aboard the NSF/NCAR GV HIAPER (Gulfstream-V High-performance Instrumented Airborne Platform for Environmental Research, HIAPER) (N677F) during the Cloud Systems Evolution in the Trades (CSET) field campaign. The data were collected during 16 research flights which took place between July 1 and August 12, 2015, between the US West Coast and Hawaii. For more information on CSET, see www.eol.ucar.edu/field_projects/cset.

Flight	Start date	Start time UTC	End date	End time UTC
RF01	20150701	17:37	20150701	22:22
RF02	20150707	14:58	20150707	21:19
RF03	20150709	16:29	20150709	23:41
RF04	20150712	15:10	20150712	21:33
RF05	20150714	16:44	20150715	00:22
RF06	20150717	14:57	20150717	21:45
RF07	20150719	16:25	20150720	00:04
RF08	20150722	15:02	20150722	22:08
RF09	20150724	16:26	20150725	00:25
RF10	20150727	15:00	20150727	22:10
RF11	20150729	16:31	20150730	00:06
RF12	20150801	14:54	20150801	22:38
RF13	20150803	16:26	20150803	23:42
RF14	20150807	15:00	20150807	22:06
RF15	20150809	16:30	20150809	23:47
RF16	20150812	15:27	20150812	22:03

Instrument description

The Gulfstream V High Spectral Resolution Lidar (GV-HSRL) is an eye-safe calibrated lidar system that measures backscatter coefficient and depolarization properties of atmospheric aerosols and clouds and cloud extinction coefficient. For more information, see www.eol.ucar.edu/instruments/gv-hsrl.

HSRL Specifications	
Parameter	**Specification**
Wavelength	532 nm
Pulse Repetition Rate	4000 Hz
Average Power	300 mW
Range Resolution - minimum	7.5 m
Telescope Diameter	40 cm
Field of View (FOV)	0.025°
Temporal Resolution - minimum	0.5 sec
Receiver Channels - 4	Molecular, Combined Hi, Combined Low, Cross-polarization
Iodine Blocking Filter Bandwidth	1.8 GHz
Etalon Filter Bandwidth	8.0 GHz

Data description

The 2 Hz time and 19 m range resolution moments data described here are available at http://data.eol.ucar.edu/dataset/487.016 in CfRadial format. For more information on CfRadial see www.ral.ucar.edu/projects/titan/docs/radial_formats/CfRadialDoc.pdf.

The primary data products for scientific use are listed in the table below.

Variable	Dimensions	Unit	Long Name
time	time	seconds	Time in seconds since volume start
range	time	meters	Range from instrument to center of gate
latitude	time	deg	Latitude
longitude	time	deg	Longitude
altitude	time	meters	Altitude of radar
Aerosol_Backscatter_Coefficient	time, range	m^{-1} sr^{-1}	Calibrated measurement of aerosol backscatter coefficient
Backscatter_Ratio	time, range		Ratio of combined to molecular backscatter
Particle_Depolarization	time, range		Propensity of particles to depolarize assuming random orientation
Particle_Linear_Depolarization_Ratio	time, range		Theoretically determined linear depolarization of particles assuming random particle orientation (molecular removed)
Volume_Depolarization	time, range		Propensity of Volume to depolarize assuming random orientation
Volume_Linear_Depolarization_Ratio	time, range		Theoretically determined linear depolarization of the volume, assuming random particle orientation
Merged_Combined_Channel	time, range	photon counts	Merged hi/lo gain combined channel
Raw_Molecular_Backscatter_Channel	time, range	photon counts	Parallel polarization molecular backscatter returns
Raw_Cross_Polarization_Channel	time, range	photon counts	Cross polarization combined aerosol and molecular returns
Optical_Depth	time, range		Total optical depth from aircraft altitude
Aerosol_Extinction_Coefficient	time, range	m^{-1}	Aerosol extinction coefficient
Raw_High_Gain_Total_Backscatter_Channel	time, range	photon counts	Parallel polarization high gain combined aerosol and molecular returns
Raw_Low_Gain_Total_Backscatter_Channel	time, range	photon counts	Parallel polarization low gain combined aerosol and molecular returns

Data processing

GV-HSRL makes four range-resolved backscatter observations:

(i) combined_hi - High receiver efficiency observation of parallel polarized total backscatter (clouds, aerosols, and molecules). Analogous to an elastic backscatter signal.

(ii) combined_lo - low receiver efficiency observation of parallel polarized total backscatter (clouds, aerosols, and molecules). Analogous to an elastic backscatter signal.
(iii) molecular - Molecular only parallel polarized backscatter channel. Aerosol and cloud signals are blocked using an iodine absorption filter which blocks the spectrally narrow particulate backscatter but passes the wings of the spectrally broad molecular backscatter.
(iv) cross - The cross-polarized total backscatter channel. HSRL transmits and receives circularly polarized light.

The primary data products of the GV-HSRL are:

Aerosol_Backscatter_Coefficient - Optical property of the scattering volume describing how strongly it scatters light at a 180 degree scattering angle. It is obtained through the relative ratio of total backscatter to molecular backscatter (B) then multiplying by the expected molecular backscatter coefficient (based on estimated temperature and pressure profiles).

$$\beta_a = B\tilde{\beta}_m$$

Particle_Linear_Depolarization_Ratio (δ_L) - When particles are randomly oriented, this is a measure of the tendency for particles in the scattering volume to reduce the degree of polarization of incident light upon backscattering. This is generally an indicator for asphericity of particles (d_a) This data product has molecular scattering effects removed. The linear depolarization ratio uses the volume_depolarization (obtained using combined parallel and cross-polarized returns) and the Backscatter_Ratio (the ratio of total to molecular scattering).

$$\delta_L = \frac{d_a}{2-d_a}$$

Note that the HSRL measures polarization using circular polarization, so the conversion to d_a and subsequently, δ_L is founded on the assumption that the particles are randomly oriented.

Optical_Depth (OD) - One-way optical depth measured from the lidar to the volume. Optical depth is the exponent of the atmospheric transmission to the scattering volume, and therefore an accumulation of extinction in each point up to the scattering volume. It is derived from the observed molecular backscatter (N_m) relative to the expected molecular backscatter coefficient.

$$OD = -\frac{1}{2}\ln\frac{N_m}{\tilde{\beta}_m}$$

Aerosol_Extinction_Coefficient (α)- The optical property describing the tendency of the volume to extinguish light by either scattering it or absorbing it. Extinction is the range derivative of the optical depth.

$$\alpha = \frac{\partial}{\partial z}OD$$

Other variable definitions used for the derived data products:

Volume depolarization - The propensity of the observation volume to depolarize including both aerosol and molecular contributions. The concept of "depolarization" in contrast to "depolarization ratio" is discussed in Gimmestad 2008.

$$d_v = \frac{N_{c\perp}}{N_{c\|} + N_{c\perp}}$$

Backscatter_Ratio (B) - the ratio of all scattering particles to only molecular scattering. This quantity is polarization independent.

$$B = \frac{N_{c\perp} + N_{c\|}}{N_m}$$

Particle_Depolarization - depolarization resulting from only particulate scatterers. The molecular contribution is removed.

$$d_a = \frac{Bd_V - d_m}{B - 1}$$

References

Lucio Azzari and Alessandro Foi, 2016: Variance Stabilization for Noisy+Estimate Combination in Iterative Poisson Denoising. IEEE Signal Processing Letters, 23(8), pp 1086-1090, DOI: 10.1109/LSP.2016.2580600.

Gimmestad, G, 2008: Reexamination of depolarization in lidar measurements. Appl. Opt., 47**(**21), pp. 3795-3802, doi:10.1364/AO.47.003795.

Citation

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