Derived GV High Spectral Resolution Lidar (HSRL) data (CfRadial), Version 1.0

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) (N677F) during SOCRATES (Southern Ocean Clouds, Radiation, Aerosol Transport Experimental Study). The data was collected during 15 research flights which took place between January 15 and February 24, 2018, over the Southern Ocean south of Australia. For more information on SOCRATES, see www.eol.ucar.edu/field_projects/socrates.

Flight	Start date	Start time	End date	End time
RF01	20180115	21:50	20180116	05:30
RF02	20180119	00:00	20180119	07:15
RF03	20180122	19:25	20180123	03:45
RF04	20180123	21:20	20180124	06:10
RF05	20180125	21:55	20180126	05:30
RF06	20180128	21:25	20180129	06:10
RF07	20180130	23:30	20180131	07:50
RF08	20180203	21:40	20180204	06:45
RF09	20180204	22:10	20180205	06:55
RF10	20180207	19:25	20180208	05:00
RF11	20180216	23:35	20180217	06:20
RF12	20180217	22:10	20180218	07:45
RF13	20180219	21:25	20180220	06:25
RF14	20180221	22:10	20180222	06:40
RF15	20180224	01:50	20180224	08:35

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. The instrument can also be used to detect the presence of oriented scatters in the atmosphere and determine the full (Mueller) backscatter phase matrix. For more information, see www.eol.ucar.edu/instruments/gv-hsrl.

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 HSRL data set described here is available at http://data.eol.ucar.edu/dataset/552.021 in CfRadial format with a 0.5s time and 7.5m range resolution. The data is also available in NetCDF format at http://data.eol.ucar.edu/dataset/552.035. The NetCDF data is in a range centered format similar to that of the CfRadial data. However, the NetCDF contains data processing variables that are not necessarily needed by end users and does not have all its variables and metadata in line with the current CfRadial standard and cannot be read by display programs such as HawkEye. A data set which contains only the primary HSRL variables with a 0.5s time and ~19m range resolution (and also data from the HIAPER Cloud Radar (HCR)) which is geared towards the general user is available at http://data.eol.ucar.edu/dataset/552.034. In general, data users should use the HSRL only CfRadial data described here or the HSRL-HCR merged data unless there is need for the underlying signals (and in those instances users are still strongly encouraged to contact EOL Data Support eol-datahelp@ucar.edu to ensure observational data provided is meeting the criteria of the user).

The primary data products for scientific use are listed in the table below. For a full list of variables see Appendix A.

Variable	Unit	Description
time	s since start of file	
range	m	
Aerosol_Backscatter_Coefficient	$m^{-1}sr^{-1}$	Calibrated measurement of aerosol/cloud backscatter coefficient
Particle_Linear_Depolarization_Ratio		Theoretically determined linear depolarization of particles (molecular removed). Depolarization is measured using circular polarizations and converted to the linear depolarization ratio assuming the volume consists of randomly oriented particles.
Aerosol_Extinction_Coefficient	m^{-1}	Aerosol extinction coefficient
Optical_Depth		Total optical depth from aircraft altitude
Temperature	K	Ideal atmosphere temperature in K
Pressure	Pa	Ideal atmosphere pressure in Pa

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)- 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).

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

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.

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

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

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

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

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

References

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

Contact

EOL Data Support eol-datahelp@ucar.edu

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Gulfstream-V High Spectral Resolution Lidar (HSRL)
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Appendix A

Variable	Unit	Description
time	s since start of file	
range	m	
Aerosol_Backscatter_Coefficient	$m^{-1}sr^{-1}$	Calibrated measurement of aerosol/cloud backscatter coefficient
Aerosol_Backscatter_Coefficient_variance	$m^{-2}sr^{-2}$	Estimate of the square error of the aerosol backscatter coefficient
Aerosol_Backscatter_Coefficient_mask	1 = masked 0 = not masked	
Particle_Depolarization		Propensity of particles to depolarize
Particle_Depolarization_variance		
Particle_Depolarization_mask	1 = masked 0 = not masked	
Volume_Depolarization		Propensity of volume to depolarize
Volume_Depolarization_variance		
Volume_Depolarization_mask	1 = masked 0 = not masked	
Backscatter_Ratio		Ratio of combined (cloud/aerosol and molecular) to molecular backscatter
Backscatter_Ratio_variance		
Backscatter_Ratio_mask	1 = masked 0 = not masked	
Molecular_Backscatter_Coefficient	$m^{-1}sr^{-1}$	Ideal atmosphere molecular backscatter coefficient
Molecular_Backscatter_Coefficient_variance		

Temperature	K	Ideal atmosphere temperature in K
Temperature_variance	K^2	
Pressure	Pa	Ideal atmosphere pressure in Pa
Pressure_variance	Pa^2	
Particle_Linear_Depolarization_Ratio		Theoretically determined linear depolarization of particles (molecular removed). Depolarization is measured using circular polarizations and converted to the linear depolarization ratio assuming the volume consists of randomly oriented particles.
Particle_Linear_Depolarization_Ratio_variance		Estimated square error of the particle linear depolarization ratio
Volume_Linear_Depolarization_Ratio		Theoretically determined linear depolarization of the volume. Depolarization is measured using circular polarizations assuming the volume consists of randomly oriented particles.
Volume_Linear_Depolarization_Ratio_variance		Estimated square error of the volume linear depolarization ratio
Low_Gain_Total_Backscatter_Channel	photon counts	Parallel polarization, low gain, combined aerosol and molecular returns
Low_Gain_Total_Backscatter_Channel_variance		
range_Raw_Low_Gain_Total_Backscatter_Channel	m	
Raw_Low_Gain_Total_Backscatter_Channel	photon counts	Parallel polarization, low gain, combined aerosol and molecular returns
Raw_Low_Gain_Total_Backscatter_Channel_variance		
High_Gain_Total_Backscatter_Channel	photon counts	Parallel polarization, high gain, combined aerosol and molecular returns
High_Gain_Total_Backscatter_Channel_variance		
range_Raw_High_Gain_Total_Backscatter_Channel	m	
Raw_High_Gain_Total_Backscatter_Channel	photon counts	Parallel polarization, high gain, combined aerosol and molecular returns
Raw_High_Gain_Total_Backscatter_Channel_variance		

Molecular_Backscatter_Channel	photon counts	Parallel polarization molecular backscatter returns
Molecular_Backscatter_Channel_variance		
range_Raw_Molecular_Backscatter_Channel	m	
Raw_Molecular_Backscatter_Channel	photon counts	Parallel polarization molecular backscatter returns
Raw_Molecular_Backscatter_Channel_variance		
Cross_Polarization_Channel	photon counts	Cross polarization combined aerosol and molecular returns
Cross_Polarization_Channel_variance		
range_Raw_Cross_Polarization_Channel	m	
Raw_Cross_Polarization_Channel	photon counts	Cross polarization combined aerosol and molecular returns
Raw_Cross_Polarization_Channel_variance		
Merged_Combined_Channel	photon counts	Merged hi/lo gain combined channel
Merged_Combined_Channel_variance		
Merged_Combined_Channel_mask	1 = masked 0 = not masked	
Aerosol_Extinction_Coefficient	m^{-1}	Aerosol extinction coefficient
Aerosol_Extinction_Coefficient_variance	m^{-2}	
Aerosol_Extinction_Coefficient_mask	1 = masked 0 = not masked	
Optical_Depth		Total optical depth from aircraft altitude
Optical_Depth_variance		
polarization	radians	System quarter waveplate orientation
TelescopeDirection	1 = lidar pointing up 0 = lidar pointing down	
TASX	m/s	Airspeed
PSXC	hPa	Ambient pressure
PITCH	degrees	Aircraft pitch angle

GGLON	degrees	Longitude
GGALT	m	Altitude
THDG	degrees	Aircraft heading
GGLAT	degrees	Latitude
ROLL	degrees	Aircraft roll angle
ATX	C	Ambient temperature
lidar_pointing		Lidar pointing vector in global coordinate frame. Positive axis is directed: index 0 = North, index 1 = East, index 2 = Down
time_offset_deriv	s	Estimated time offset between aircraft and HSRL data systems based on derivative of aircraft attitude signal. **This is accounted for in data processing and does not need to be applied to the data.**
est_bin0	MCS bin number	Estimated MCS bin corresponding to t=0 on the lidar pulse
time_offset_lms	s	Estimated time offset between aircraft and HSRL data systems based on combined_hi aircraft attitude signal. **This is accounted for in data processing and does not need to be applied to the data.**
time_offset_total	s	Estimated time offset between aircraft and HSRL data systems based on combined aircraft attitude and derivative of aircraft attitude signals. **This is accounted for in data processing and does not need to be applied to the data.**
time_offset	s	Time offset between aircraft and HSRL data systems used in processing this dataset. **This is accounted for in data processing and does not need to be applied to the data.**
bin0	MCS bin number	Actual MCS bin corresponding to t=0 on the lidar pulse used in this processing. **This is accounted for in data processing and does not need to be applied to the data.**