Summary of HSRL Data File

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Overview:

This document provides information on the HSRL HDF data files. The data are stored in HDF4 format and contains all the raw data and processed data products for each flight or data session. The main purpose of this document is to provide a simple and brief overview of the variables that are contained in the file. This document does not contain any special conditions that may have been included for specific flights or data sessions. It is also recommend that users of the HSRL data products contact the HSRL team before performing their research. This document will periodically be updated and the user should request that last version available from the HSRL team. Contact Emails: Johnathan.W.Hair@nasa.gov; Richard.A.Ferrare@nasa.gov; Chris.A.Hostetler@nasa.gov.

The rawdata is stored in separate files that are saved periodically. This ensures that we do not have large data missing from a single corrupted file. This rawdata is stored in a separate binary format that is described in another document. The data is read via the analysis program and all the information is converted into the HDF format which this document describes. Note that there is a header for each rawdata file (see File Header Information) which is stored. These parameters can only be changed if a new rawdata file is created, although this is not typically the case.

For each rawdata file, the data is stored into two parts; the record header and the signal from each channel for a single profile. The data is stored by ***profiles*** which has typically been every 0.5 seconds. This includes the rawdata and the processed variables. The time average for each profile can be deduced from the pulse repetition rate and the number of shots in each profile (in File Header). The current laser is fixed at 200Hz. Therefore for the nominal average interval there is 100 shots in each profile. Note that shorter time averages are possible and have been made in some of the flights to date. The range sampling is also variable but to date all the data is stored at ~30m range ***bins***. The rawdata is interpolated to a standard set of altitude range bins that begins at -300m below sea level and extends to 150m above the highest altitude during the flight.

The interpolated rawdata and data products are stored at the same vertical and horizontal resolution as the binary rawdata. All averaging is done in a running (filtered) average which maintains the same number of profiles and interpolated range bins. Note that the averaged data products will not be statistically independent but all averaging intervals are recorded in the file (see User Input Parameters).

Raw, Analysis, and Subset HDF Files

Due to size limitations the 16 raw data channels are stored in a separate file from the analyzed products with filenames 'raw' and 'ana' denoting the difference. The engineering data are stored in both files.

The HSRL analyzed data are subset for distribution due to the large file size associated with the full 'ana' HSRL HDF files (~1-2 Gb). The subset file contains all of calculated variables as well relevant metadata, however the engineering data and raw data are not included. The data are 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 is chosen so that only one profile in each time average is included in the subset. For example if the raw HSRL data are sampled at 0.5 s resolution and a 10 s average is applied in the backscatter calculation, the file is decimated by a factor of 20. The extinction product, which has a longer temporal average than the backscatter and depolarization products, is decimated by the same amount as the other products to preserve the array size. *Please note that the extinction product is over sampled in the subset file.* No subset is preformed along the height dimension of these products.

The following tables have a column indicating the file(s) in which each variable is contained, denoted by R,A, or S for Raw, Analyzed, or Subset respectively.

Record Header Variables: System and data parameters recorded for each lidar profile.

Table 1 provides a description of record header information variables. For each lidar profile a set of record header information is obtained to provide aircraft attitude and position, system status and monitors, alignment conditions, detector gain settings, and background signal offsets and standard deviations.

Table 1

Variable Name	Units	LongName	Description/Comments	Containing Files
Record Header Information. System and data parameters recorded for each lidar profile.				
Beam_x (1xprofiles)	counts	Beam Steering X position	Encoded x-axis position of final beam steering mirror in digitizer counts. Provides record of changes in the beam position which is controlled via the boresight system.	R,A
Beam_y (1xprofiles)	counts	Beam Steering Y position	Encoded y-axis position of final beam steering mirror in digitizer counts. Provides record of changes in the beam position which is controlled via the boresight system.	R,A
bore_x (1xprofiles)	m	Boresight X DAQ control	Measured x-position based on boresight system. This parameter provides a record of the variability in pointing position.	R,A

		output		
bore_x (1xprofiles)	m	Boresight X DAQ control output	Measured y-position based on boresight system. This parameter provides a record of the variability in pointing position.	R,A
gps_alt (1xprofiles)	meters	gps altitude	Altitude read from aircraft GPS for each record.	R,A,S
gps_lat (1xprofiles)	deg	gps latitude	Latitude read from aircraft GPS for each record. (+North, -South)	R,A,S
gps_lon (1xprofiles)	deg	gps longitude	Longitude read from aircraft GPS for each record (+East, -West)	R,A,S
gps_gnd_speed (1xprofiles)	meters/sec	gps ground speed	Aircraft Ground Speed read from GPS for each record.	R,A,S
gps_time (1xprofiles)	Hrs UTC	gps time	UT time read from GPS for each record. This parameter is used for all synchronization of the data and is the most accurate time parameter on the aircraft. All data products are produced as a function of this parameters. This parameter is formatted to decimel hours.	R,A,S
gps_date (1xprofiles)	Date	gps date mm/dd/yyyy	Date for each record of data from the aircraft GPS. This parameter will change to a new value at 00:00 UT.	R,A,S
imu_heading (1xprofiles)	Deg	imu heading	Heading of aircraft from Inertial Measurement Unit for each record.	R,A,S
imu_pitch (1xprofiles)	Deg	imu pitch	Pitch of aircraft from Inertial Measurement Unit (IMU) for each record.	R,A,S
imu_roll (1xprofiles)	Deg	imu roll	Roll of aircraft from Inertial Measurement Unit (IMU) for each record.	R,A,S
imu_x_vel (1xprofiles)	m/s	imu x velocity	x velocity aircraft from Inertial Measurement Unit (IMU) for each record.	R,A
imu_y_vel (1xprofiles)	m/s	imu y velocity	y velocity aircraft from Inertial Measurement Unit (IMU) for each record.	R,A
imu_z_vel (1xprofiles)	m/s	imu z velocity	z velocity aircraft from Inertial Measurement Unit (IMU) for each record.	R,A
time (11xprofiles)	string	computer time string	Time determined from Laptop DAQ computer. This time is only used as a reference and is typically synchronized to other computers on the aircraft that do not have direct GPS input. This output is in a string format.	R,A
time_hr (1xprofiles)	Hrs UTC	computer time in UTC hours	Conversion of time string into UT hours. This variable is based on the laptop computer time as well.	R,A
telemetry_temp (6xprofiles)	Volts	telemetry values for system temperatures	Telemetry values to record temperature of the cabin and HSRL system at various locations. The temperature sensors can be moved to various locations but are typically placed as standard locations. There are typically XX monitors used to evaluate environmental and system conditions. 1 – locking I2 cell temperature (seed laser box for CHAPS) 2 – spectral purity I2 cell	R,A

			3 – laser baseplate (#1) 4 – detector box 5 – Main I2 cell 6 – aircraft window port 7 – 532nm etalon 8 – Main I2 cell (window) 9 – ambient 10 – laser baseplate (#2) 11 – aircraft window well area	
telemetry_volt (6xprofiles)	Volts	telemetry values for system voltage monitors	Telemetry values to record voltage monitors on the HSRL system. Conversion factors for these measurements are not recorded in the data file. This includes laser energy, frequency locking control etc. The number of telemetry volt parameters is given in the file header but currently there are 5 values. 1 – 532nm laser energy 2 – 1064 nm laser energy 3 – seed laser energy at 1064nm 4 – transmission through locking I2 cell. 5 – error signal for locking I2 cell	R,A
bkgnd (1xprofiles)	counts	background values calculated	Background values calculated for each data channel based on range provided in *bkgnd_begin* and *bkgnd_end* user input variables described below. The values for the array are order of the channels listed below in the rawdata channels section.	R,A
Bkgnd_std (16xprofiles)	counts	background std dev values calculated	Standard deviation values calculated for each data channel based on range provided in *bkgnd_begin* and *bkgnd_end* user input variables described below. The values for the array are order of the channels listed below in the rawdata channels section.	R,A
vga (32xprofiles)	counts	variable gain amp settings, gain, offset	Variable gain and offset settings in digitizer counts for each channel listed below in the rawdata channels section. The array is setup such that the first value is the gain and the next value is the offset. Therefore there are 2xnumber of channels with the odd array indices being the detector gain values and the even array indices being the offset detector values.	R,A
attn_waveplate (1xprofiles)	deg	Laser attenuation waveplate angle	Position of the laser attenuation waveplate. This is a relative position to the maximum value. The relative position is typically referenced to zero.	R,A
Cal_waveplate (1xprofiles)	deg	Laser output polarization waveplate relative angle	Position of the laser calibration waveplate. This waveplate is aligned relative to the receiver axis (typically referenced to zero) and is adjusted during depolarization gain calibrations.	R,A
shots (1xprofiles)	shots	Laser shots average per record	Number of laser shots averaged for each profile. This is typically constant for each flight data set.	R,A

shutters (1xprofiles)	index	Tranmit and receiver shutter positions	State of receiver and transmitter shutter (opened or closed). 0 – both closed, 1 – receiver shutter open only, 2 –transmitter shutter open only, 3 – both shutters open.	R,A
fileindex (1xprofiles)	index	Rawdata binary file number index	File index of binary files. This parameter is mainly used as a reference to record which rawdata binary file contains each lidar profile.	R,A
mode (1xprofiles)	index	run time mode for cals and boresight	The mode of data acquisition for the lidar system. Various modes are used during data acquisition.	R,A
ground_altitude (1xprofiles)	m	ground location altitude based 0n ground return	Estimate of the ground altitude based on the lidar signal. This currently is not fully developed and should be used cautiously.	R,A,S
DEM_altitude (1xprofiles)	m	ground location altitude based 0n DEM data	Ground altitude based on the GLOBE Digital Elevation Map dataset based on the GPS latitude and longitude values.	R,A,S

Altitude Profile: Interpolated Altitude Vector.

Table 2 provides a description of the Altitude vector that is used for all the raw data and science products in the HDF file. This is a single vector that has dimensions of *1 x altitude bins*. The altitude bins are separated by slightly less than 30m to match the native resolution of the digitized data which is at 5MHz sampling rates currently.

Table 2

Variable Name	**Units**	**LongName**	**Description/Comments**	**Containing Files**
Record Header Information. System and data parameters recorded for each lidar profile				
Altitude (altitude bins)	M	Interpolated Altitude	Altitude vector in which all the data is interpolated to in the raw data and science data products. This vector spans from -300m to about 100m above the highest altitude flown during the flight.	R,A,S

Raw Data Profiles: Recorded signal levels for all channels.

Table 3 provides a description of the raw lidar data signals. These signals are stored as background subtracted and range squared lidar profiles. The data is also interpolated to a uniform grid that covers the entire measurement range of the flight or data session. The data are stored in equal size 2-D arrays. One dimension is the exact same length as the record header information (number of lidar profiles) and the other dimension is set to the number of interpolated altitudes. The Altitudes vector is described in Table 2. Therefore all lidar raw data channels have the exact same dimension and are uniformly matched to time and altitude. For simplicity, the dimensions of all science data products have the same dimensions.

Table 3

Variable Name	**Units**	**LongName**	**Description/Comments**	**Containing Files**
Record Header Information. System and data parameters recorded for each lidar profile				
1064_5_parallel (altitude binsxprofiles)	counts*m^2	1064nm 5% parallel	1064nm parallel polarization 5% optical split channel. The 1064nm parallel polarization component is split into two optical channels to increase the dynamic range of the detector and digitizer. This channel is typically only required for large signals from clouds and is used to replace saturated values in the 1064nm parallel 95% channel. The data is background subtracted and multiplied by range squared. The data is interpolated to a uniform altitude grid.	R
1064_95_parallel (altitude binsxprofiles)	counts*m^2	1064nm 95% parallel	1064nm parallel polarization 95% optical split channel. The 1064nm parallel polarization component is split into two optical channels to increase the dynamic range of the detector and digitizer. A saturation routine is implemented to determine if the digitizer is saturated. In cases where the digitizer is saturated the 5% channel, properly scaled for detector gain and efficiency factors, is used to replace the data at those range bins. If the 5% optical channel is saturated the data is replaced with NaN. The data is background subtracted and multiplied by range squared. After the saturation routine this channel is exclusively used for the science products. The data is interpolated to a uniform altitude grid.	R
1064_95_perpendicular (altitude binsxprofiles)	counts*m^2	1064nm 95% perpendicular	1064nm perpendicular polarization 95% optical split channel. The 1064nm perpendicular polarization component is split into two optical channels to increase the dynamic range of the detector and digitizer. A saturation routine is implemented to determine if the digitizer is saturated. In cases where the digitizer is saturated the 5% channel, properly scaled for detector gain and efficiency factors, is used to replace the data at those range bins. If the 5% optical channel is saturated the data is replaced with NaN. The data is background subtracted and multiplied by range squared. After the saturation routine	R

			this channel is exclusively used for the science products. The data is interpolated to a uniform altitude grid.	
1064_5_perpendicular (altitude binsxprofiles)	counts*m^2	1064nm 5% perpendicular	1064nm perpendicular polarization 5% optical split channel. The 1064nm perpendicular polarization component is split into two optical channels to increase the dynamic range of the detector and digitizer. This channel is typically only required for large signals from clouds and is used to replace saturated values in the 1064nm perpendicular 95% channel. The data is background subtracted and multiplied by range squared. The data is interpolated to a uniform altitude grid.	R
532_5_parallel (altitude binsxprofiles)	counts*m^2	532nm 5% parallel	532nm parallel polarization 5% optical split channel. The 532nm parallel polarization component is split into two optical channels to increase the dynamic range of the detector and digitizer. This channel is typically only required for large signals from clouds and is used to replace saturated values in the 1064nm parallel 95% channel. The data is background subtracted and multiplied by range squared. The data is interpolated to a uniform altitude grid.	R
532_95_paralle (altitude binsxprofiles)l	counts*m^2	532nm 95% parallel	532nm parallel polarization 95% optical split channel. The 532nm parallel polarization component is split into two optical channels to increase the dynamic range of the detector and digitizer. A saturation routine is implemented to determine if the digitizer is saturated. In cases where the digitizer is saturated the 5% channel, properly scaled for detector gain and efficiency factors, is used to replace the data at those range bins. If the 5% optical channel is saturated the data is replaced with NaN. The data is background subtracted and multiplied by range squared. After the saturation routine this channel is exclusively used for the science products. The data is interpolated to a uniform altitude grid.	R
532_5_perpendicular (altitude binsxprofiles)	counts*m^2	532nm 5% perpendicular	532nm perpendicular polarization 5% optical split channel. The 532nm perpendicular polarization component is split into two optical channels to increase the dynamic range of the detector and digitizer. This channel is typically only required for large signals from clouds and is used to replace saturated values in the 1064nm perpendicular 95% channel. The data is background subtracted and multiplied by range squared. The data is interpolated to a uniform altitude grid.	R
532_95_perpendicular(altitude binsxprofiles)	counts*m^2	532nm 95% perpendicular	532nm perpendicular polarization 95% optical split channel. The 532nm perpendicular polarization component is split into two optical channels to increase the dynamic range of the detector and digitizer. A saturation routine is implemented to determine if the digitizer is saturated. In cases where the digitizer is saturated the 5% channel, properly scaled for detector gain and efficiency factors, is used to replace the data at those range bins. If the 5% optical channel is	R

			saturated the data is replaced with NaN. The data is background subtracted and multiplied by range squared. After the saturation routine this channel is exclusively used for the science products. The data is interpolated to a uniform altitude grid.	
532_low_gain_molecular (altitude binsxprofiles)	counts*m^2	532nm molecular high gain	532nm molecular low electronic gain channel. The molecular channel is filtered by the iodine vapor filter. Only a single detector is implemented due to the lower dynamic range of the signal in this channel. The detector electronic signal is split into two channels, *low* and *high* gain, to potentially reduce quantization noise of the digitizers. Currently the low gain channel is the only channel used for the science data products. The data is interpolated to a uniform altitude grid.	R
532_high_gain_molecular (altitude binsxprofiles)	counts*m^2	532nm molecular low gain	532nm molecular high electronic gain channel. The molecular channel is filtered by the iodine vapor filter. Only a single detector is implemented due to the lower dynamic range of the signal in this channel. The detector electronic signal is split into two channels, *low* and *high* gain, to potentially reduce quantization noise of the digitizers. Currently the low gain channel is the only channel used for the science data products. The data is interpolated to a uniform altitude grid.	R
open_channel_1 (altitude binsxprofiles)	counts*m^2	open channel_1	This channel is sometimes used for diagnostic purposes or special data acquisition modes. The data is interpolated to a uniform altitude grid.	R
open_channel_2 (altitude binsxprofiles)	counts*m^2	open channel 2	This channel is sometimes used for diagnostic purposes or special data acquisition modes. The data is interpolated to a uniform altitude grid.	R
boresight_channel_1 (altitude binsxprofiles)	counts*m^2	boresight channel 1	The system has four boresight channels to align the outgoing laser to the telescope field of view. This implements a quadrant detection scheme. The data is interpolated to a uniform altitude grid.	R
boresight_channel_2 (altitude binsxprofiles)	counts*m^2	boresight channel 2	The system has four boresight channels to align the outgoing laser to the telescope field of view. This implements a quadrant detection scheme. The data is interpolated to a uniform altitude grid.	R
boresight_channel_3 (altitude binsxprofiles)	counts*m^2	boresight channel 3	The system has four boresight channels to align the outgoing laser to the telescope field of view. This implements a quadrant detection scheme. The data is interpolated to a uniform altitude grid.	R
boresight_channel_4 (altitude binsxprofiles)	counts*m^2	boresight channel 4	The system has four boresight channels to align the outgoing laser to the telescope field of view. This implements a quadrant detection scheme. The data is interpolated to a uniform altitude grid.	R

Science Data Products: Analyzed data products

Table 4 provides a description of the retrieved data products. User inputs define the horizontal and vertical resolution of each data product. The 532nm and 1064nm data products can be averaged at different intervals and the variables in Table 8 below provide the user input averaging intervals for the data products listed in this table.

The backscatter ratios are defined to be the ratio of the backscatter coefficient to the Cabannes portion of the molecular backscatter coefficient. The total molecular backscatter coefficient is 2.5 % greater due to the rotational Raman signal as noted by She, 2001:

She, C. 2001, "Spectral Structure of Laser Light Scattering Revisited: Bandwidths of Nonresonant Scattering Lidars." Applied Optics LP, vol. 40, Issue 27, pp.4875-4884.

Table 4

Variable Name	Units	LongName	Description/Comments	Containing Files
Science Data Products: Analyzed data products				
532_ext (altitude binsxprofiles)	Km^-1	532nm aerosol extinction coefficient	Retrieved 532nm aerosol extinction coefficient. Values closer than 2500m to the aircraft are not calculated due to overlap.	A,S
532_bsr (altitude binsxprofiles)	ratio	532nm aerosol backscatter scattering ratio	Ratio of Aerosol backscatter coefficient to the molecular backscatter coefficient at 532nm. The total scattering ratio is calculated by adding one.	A,S
532_bsr_cloud_screened (altitude binsxprofiles)	ratio	532nm aerosol backscatter scattering ratio	Backscatter ratio with cloud mask applied.	A,S
532_bsc (altitude binsxprofiles)	Km^-1*sr-1	532nm aerosol backscatter coefficient	Aerosol volume backscatter coefficient at 532nm.	A,S
532_bsc_cloud_screened (altitude binsxprofiles)	Km^-1*sr-1	532nm aerosol backscatter coefficient	Aerosol volume backscatter coefficient at 532nm with cloud mask applied.	A,S
532_total_attn_bsc (altitude binsxprofiles)	Km^-1*sr-1	532nm attenuated backscatter	Attenuated backscatter coefficient = z^2*P(z) / k The data are normalized to the calculated aerosol backscatter + molecular in 1.0km to 1.5km from the aircraft altitude.	A,S

		coefficient		
532_total_attn_bsc_cloud_screened (altitude binsxprofiles)	Km^-1*sr-1	532nm attenuated backscatter coefficient	Attenuated backscatter coefficient with cloud mask applied	A,S
532_bsc_Sa (altitude binsxprofiles)	km^-1*sr-1	532nm aerosol backscatter coefficient	Aerosol volume backscatter coefficient at 532nm. This backscatter coefficient is different from above due to the fact that it is averaged to the same horizontal and vertical average as the extinction coefficient and is used to calculate extinction-to-backscatter ratio.	A,S
532_dep (altitude binsxprofiles)	ratio	532 nm total depolarization ratio ratio	Retrieved 532nm total (volume) depolarization ratio. This parameter includes both molecular and aerosol scattering and is calculated by taking the ratio of the perpendicular (cross polarized) and parallel *total* scattering channels. The parallel and perpendicular signals are corrected for optical and electronic gains via an internal calibration made during flight. $532\_dep = \frac{\beta^{\perp}_{mol.} + \beta^{\perp}_{aer.}}{\beta^{\parallel}_{mol.} + \beta^{\parallel}_{aer.}}$	A,S
532_aer_dep (altitude binsxprofiles)	ratio	532 nm aerosol depolarization ratio	Retrieved 532nm aerosol depolarization ratio. This parameter is calculated by taking the ratio of the perpendicular (cross polarized) and parallel *aerosol* backscatter coefficients. $532\_dep = \frac{\beta^{\perp}_{aer.}}{\beta^{\parallel}_{aer.}}$	A,S
1064_ext (altitude binsxprofiles)	Km^-1	1064nm aerosol extinction coefficient	Retrieved 1064 aerosol extinction coefficient using scaled Sa values from the 532 channel.	A,S
1064_bsr (altitude binsxprofiles)	ratio	1064 nm aerosol backscatter scattering ratio	Ratio of Aerosol backscatter coefficient to the molecular backscatter coefficient at 1064nm. The total scattering ratio is calculated by adding one.	A,S
1064_bsr_cloud_screened (altitude binsxprofiles)	ratio	1064 nm aerosol backscatter scattering ratio	1064 backscatter ratio with cloud mask applied.	A,S
1064_bsc (altitude binsxprofiles)	Km^-1 sr^-1	1064 nm aerosol backscatter coefficient	Aerosol volume backscatter coefficient at 1064nm.	A,S
1064_bsc_cloud_screened (altitude binsxprofiles)	Km^-1 sr^-1	1064 nm aerosol backscatter coefficient	Aerosol volume backscatter coefficient at 1064nm with cloud mask applied.	A,S
1064_total_attn_bsc	Km^-	1064 nm	1064 attenuated backscatter coefficient = z^2*P(z) / k	A,S

(altitude binsxprofiles)	1 sr^-1	attenuated backscatter coefficient		
1064_total_attn_bsc_cloud_screened (altitude binsxprofiles)	Km^-1 sr^-1	1064 nm attenuated backscatter coefficient	1064 attenuated backscatter coefficient with cloud mask applied.	A,S
1064_dep (altitude binsxprofiles)	ratio	1064 nm total depolarization ratio ratio	Retrieved 532nm total (volume) depolarization ratio. This parameter includes both molecular and aerosol scattering and is calculated by taking the ratio of the perpendicular (cross polarized) and parallel *total* scattering channels. The parallel and perpendicular signals are corrected for optical and electronic gains via an internal calibration made during flight. $1064\_dep = \frac{\beta_{mol.}^{\perp} + \beta_{aer.}^{\perp}}{\beta_{mol.}^{\parallel} + \beta_{aer.}^{\parallel}}$	A,S
1064_aer_dep (altitude binsxprofiles)	ratio	1064 nm aerosol depolarization ratio	Retrieved 1064nm aerosol depolarization ratio. This parameter is calculated by taking the ratio of the perpendicular (cross polarized) and parallel *aerosol* backscatter coefficients. $1064\_dep = \frac{\beta_{aer.}^{\perp}}{\beta_{aer.}^{\parallel}}$	A,S
Sa_532 (altitude binsxprofiles)	sr	532nm aerosol extinction to backscatter ratio	Retrieved Extinction-to-backscatter ratio at 532nm. The product is averaged to the same horizontal and vertical average as the extinction coefficient.	A,S
WVD_1064_532 (altitude binsxprofiles)	ratio	aerosol wavelength dependence	Retrieved wavelength dependence based on the aerosol backscatter coefficient at 1064 and 532nm. $WVD\_1064\_532 = -\ln\left(\frac{\beta_{aer.}^{1064nm}}{\beta_{aer.}^{1532nm}}\right) / \ln\left(\frac{1064nm}{532nm}\right)$	A,S
AOT_lo (1xprofiles)	None	Total Optical Thickness Method_1	532nm Aerosol optical thickness determined from the extinction profile and also using the backscatter and Sa value near the surface.	A,S
AOT_hi (1xprofiles)	None	Total Optical Thickness Method_2	532nm Aerosol optical thickness determined from the molecular channel near the aircraft and near the surface. The lower point uses a fit over a range of range bins to determine the signal level to reduce noise and the fit is extrapolated to the ground.	A,S
AOT_hi_col (altitude-binsxprofiles)	None	Layer Optical Thickness	532nm Aerosol optical thickness as a function of altitude as determined from the molecular signal. The AOT value in the lowest altitude bin is	A,S

		Method_2	filled with AOT_hi.	
AOT_flag (1xprofiles)	None	Flag for AOT	This flag indicates the reason for no AOT calculation. 0=no flag – AOT calculated 1 = not in normal data mode: shutters open, external trigger, cal wave plate < 10 2 = cloud NaN = outside of range of times considered	A,S
Cloud_top_height (1xprofiles)	km	Cloud flag and cloud height information	Cloud identification flag and cloud height information.	A,S
PBL (3xprofiles)	km	Planetary Boundary Layer Height.	Planetary boundary layer height. This will hold three heights, H1, H2, and H3, which represent three different wavelet dilations as discussed by Brooks, 2003.	A,S
Integrated_attn_bsc (1xprofiles)	Km^-1	Integrated Attenuated Backscatter.	Integrated Attenuated Backscatter or lidar reflectivity	A,S
mask_low (altitude binsxprofiles)	Index	Low gain signal limit data mask	Mask for all data products based on the molecular backscatter signal. A signal threshold over background light is used to determine when there is no signal to produce retrieved products.	A,S
Dust_Mixing_Ratio (altitude binsxprofiles)	none	Dust Mixing Ratio	Dust mixing ratio, X, calculated from Eq 7 of Sugimoto and Lee, Appl Opt 2006: $X = \left(\frac{(1+\delta_{d532}) \cdot \delta_{532}}{\delta_{d532} \cdot (1+\delta_{532})} \right)$ with assumed $\delta_{d532} = 0.35$	A,S
Angstrom_Dust (altitude binsxprofiles)	none	Angstrom coefficient of dust particles	Angstrom coefficient of dust particles calculated from Eq 17 of Sugimoto and Lee, Appl Opt 2006: $\gamma_d = \ln\left(\frac{A}{B}\right) \Big/ \ln(2)$ with A and B defined as in Eq 16	A,S
Angstrom_Spherical (altitude binsxprofiles)	none	Low gain signal limit data mask	Angstrom coefficient of spherical particles calculated from Eq 18 of Sugimoto and Lee, Appl Opt 2006: $\gamma_s = \ln\left(\frac{1-X}{R_\beta - XB/A}\right) \Big/ \ln(2)$ with R_β and R_β defined in Eq 12 and Eq 13	A,S

State Parameter Variables: Input data from balloon sondes or Meteorological Models (GSF,NAM,RUC)

State parameters used in the retrievals are input from either balloon sondes or meteorological models. Currently there are several model options and the filename is provided in the user input parameters in Table 8. Most preliminary analyses use the balloon data for the entire flight. Post processed data typically uses the North American Model state data interpolated to each altitude and latitude and longitude for each profile.

Table 5

Variable Name	Units	LongName	Description/Comments	Containing Files
State Parameters: Input Atmospheric State from Balloon Sondes or Meteorological Model (GSF,NAM,RUC)				
Temperature *(altitude binsxprofiles)*	K	Temperature	Temperature profiles	A,S
Pressure *(altitude binsxprofiles)*	atm	Pressure	Pressure profiles	A,S
Number_Density *(altitude binsxprofiles)*	m^-3	Molecular Number Density	Molecular Number Density of air	A,S
Sum_Number_Density_Above_HSRL (1xprofiles)	m^-3	Molecular Number Density above airplane	Integrated number density of air above HSRL.	A,S

File Header Information: System and Data parameters recorded only for each binary raw data file.

The file header information is a set of parameters that are stored with each raw data file. These parameters cannot be changed unless a new file is created. The raw data files are stored in a special binary format and are typically created on each operation that is performed during the flight. For example, a new file is created for each of the calibrations that are performed. A new file is also created after a certain time period to limit loss of data. Typically this is about 10 minutes a flight. A typical flight will have around 30-40 raw data files that are saved. Most of these parameters are rarely changed during a mission.

Table 6

Variable Name	Units	LongName	Description/Comments	Containing Files
File Header Information: System and Data parameters recorded only for each binary raw data file.				
Type	string	DAQ file format	File extension representing operation mode for raw data file. ‘stp’ = setup, ‘ntc’=not yet	R,A

		type	calibrated, ‘pgr’ = polarization gain ratio calibration, ‘i2c’ = backscatter calibration, ‘oac’ = polarization offset angle calibration, ‘dat’ = normal data mode.	
number_records	index	number of records in rawdata file	Provides number of profiles saved in particular raw data file.	R,A
date	string	date of file	Date file created. (date also stored from GPS record header inputs above)	R,A
telemetry1_volt	index	number telemetry	Number of voltage telemetry channels in file	R,A
telemetry2_number	index	number telemetry 2 channels	Number of temperature channels in file.	R,A
number_channels	index	number data channels	Number of digitizer channels in file (typically 16)	R,A
number_bins	index	number range bins	Number of range bins in raw data profile..	R,A
sample_rate	Hz	range bin sampling rate	Sampling rate used for range bins (typical 5 MHz)	R,A
PRF	Hz	laser pulse repition frequency	Laser pulse repetition frequency.	R,A
trigger_source	index	data acquistion trigger source	Trigger source for data acquisition computer, internal trigger, laser trigger, or spectral purity cell trigger.	R,A
FOV	mrad	receiver field of view	Telescope field of view.	R,A
DIV	mrad	laser beam divergence	Laser divergence estimate (may not always be updated)	R,A
lidar_acq_mode	index	lidar acquistion mode status bit	Internal status bit for data acquisition computer. Need to verify how this is implemented.	R,A

Calibration Ratios - backscatter and polarization gains

Table 7

Variable Name	**Units**	**LongName**	**Description/Comments**	**Containing Files**
Calibration Ratios - backscatter and polarization gains				
532_bs_gain_95_hi	ratio	532 nm channel backscatter gain ratio 95% para to hi molecular channel	532 nm channel backscatter gain ratio 95% para to hi molecular channel	R,A
532_bs_gain_95_lo	ratio	532 nm channel backscatter gain ratio 95% para to lo	532 nm channel backscatter gain ratio 95% para to lo molecular channel	R,A

		molecular channel		
532_bs_gain_5_hi	ratio	532 nm channel backscatter gain ratio 5% para to hi molecular channel	532 nm channel backscatter gain ratio 5% para to hi molecular channel	R,A
532_bs_gain_5_lo	ratio	532 nm channel backscatter gain ratio 5% para to lo molecular channel	532 nm channel backscatter gain ratio 5% para to lo molecular channel	R,A
532_depol_gain_95_95	ratio	532 nm channel depol gain ratio 95% perp to 95% para	532 nm channel depol gain ratio 95% perp to 95% para	R,A
532_depol_gain_95_5	ratio	532 nm channel depol gain ratio 95% perp to 5% para	532 nm channel depol gain ratio 95% perp to 5% para	R,A
532_depol_gain_5_95	ratio	532 nm channel depol gain ratio 5% perp to 95% para	532 nm channel depol gain ratio 5% perp to 95% para	R,A
532_depol_gain_5_5	ratio	532 nm channel depol gain ratio 5% perp to 5% para	532 nm channel depol gain ratio 5% perp to 5% para	R,A
1064_depol_gain_95_95	ratio	1064 nm channel depol gain ratio 95% perp to 95% para	1064 nm channel depol gain ratio 95% perp to 95% para	R,A
1064_depol_gain_95_5	ratio	1064 nm channel depol gain ratio 95% perp to 5% para	1064 nm channel depol gain ratio 95% perp to 5% para	R,A
1064_depol_gain_5_95	ratio	1064 nm channel depol gain ratio 5% perp to 95% para	1064 nm channel depol gain ratio 5% perp to 95% para	R,A
1064_depol_gain_5_5	ratio	1064 nm channel depol gain ratio 5% perp to 5% para	1064 nm channel depol gain ratio 5% perp to 5% para	R,A
bs_gain_index	index	backscatter gain calibration index	backscatter gain calibration index	R,A

dp_gain_index	index	depolarization gain calibration index	depolarization gain calibration index	R,A

User input parameters: input variables for data analysis

Table 8

Variable Name	Units	LongName	Description/Comments	**Containing Files**
			User Input Parameters	
filelist	string	filename of text file for filelist to process		R,A
aircraft_ground	index	aircraft=1 or ground=0 data toggle		R,A
range_offset	m	data acquisition range offset to first range bin		R,A
ground_altitude_offset	m	ground location altitude		R,A
bkgnd_type	index	background subtraction method		R,A
bkgnd_begin	km	begin range for average		R,A
bkgnd_end	km	end range for average		R,A
cal_begin	km	begin range for iodine and polarization calibrations		R,A
cal_end	km	end range for iodine and polarization calibrations		R,A
cal_start	index			R,A
cal_number	index	number of records for iodine and polarization calibration		R,A
filter_coeff	ratio	iodine filter Cabannes		R,A

		transmission coefficients		
state_filename	string	state parameter filename		R,A
filter_filename	string	filter function filename		R,A
state_type		type of state parameter data used		R,A
532_bs_time_avg	sec	time average for 532nm backscatter coefficient		R,A,S
532_bs_range_avg	m	range average for 532nm backscatter coefficient		R,A,S
1064_bs_time_avg	sec	time average for 1064nm backscatter coefficient		R,A,S
1064_bs_range_avg	m	range average for 1064nm backscatter coefficient		R,A,S
532_ext_time_avg	sec	average for 532nm extinction coefficient		R,A,S
532_ext_range_avg	m	average for 532nm extinction coefficient		R,A,S
532_depol_time_avg	sec	average for 532nm total depolarization ratio		R,A,S
532_depol_range_avg	m	average for 532nm total depolarization ratio		R,A,S
1064_depol_time_avg	sec	average for 1064nm total depolarization ratio		R,A,S
1064_depol_range_avg	m	average for 1064nm total depolarization ratio		R,A,S
1064_Sa_checkbox	none	Check box for 1064 Sa	Checkbox to use tabulated Sa values determined after first analysis	R,A
Low_limit_checkbox	none	Check box to limit	Checkbox to limit low signal levels (mask in mask_low variable	R,A

		low signals		
DEM_checkbox	none	Checkbox to use DEM altitude	Checkbox to use DEM data for ground altitude	R,A
Aircraft_checkbox	non	Aircraft/ground data checkbox	aircraft data (1) or ground data (0)	R,A

Version Control: date of analysis and code version

The date of analysis and version of the code are tracked in Table 9. The date of analysis is taken from the computer clock at time of analysis and each analyzed product has a version number as the product evolves. At the inclusion of version control on August 15, 2007 all of the version numbers were set to 2.

Table 9

Variable Name	Units	LongName	Description/Comments	**Containing Files**
		User Input Parameters		
extinction_date_version	none		Date of extinction analysis and version number	A,S
532_bsr_date_version	none		Date of 532 backscatter ratio analysis and version number	A,S
1064_bsr_date_version	none		Date of 1064 backscatter ratio analysis and version number	A,S
extinction_backscatter_date_version	none		Date of Sa analysis and version number	A,S
depol_ratio_date_version	none		Date of depol ratio analysis and version number	A,S
aerosol_depol_date_version	none		Date of aerosol depol analysis and version number	A,S
color_ratio_date_version	none		Date of wavelength dependence analysis and version number	A,S
AOT_date_version	none		Date of AOT analysis and version number	A,S
attn_backscatter_date_version	none		Date of attn backscatter analysis and version number	A,S
cloud_height_date_version	none		Date of cloud height analysis and version number	A,S

Maximum and minimum altitudes of calculated products

The maximum and minimum altitudes for the calculated variables are listed in Table 10

Table 10

Variable Name	*Minimum Altitude*	*Maximum Altitude*
532_ext	(filter window – 2 bins) above (ground + 2 bins).	2.5 km below aircraft
532_bsr	2 bins above ground	500 m below aircraft
532_bsc	2 bins above ground	500 m below aircraft
532_total_attn_bsc		1.5 km below aircraft
532_dep	2 bins above ground	500 m below aircraft
532_aer_dep	2 bins above ground	500 m below aircraft
1064_ext	2 bins above ground	750 m below aircraft
1064_bsr	2 bins above ground	750 m below aircraft
1064_bsc	2 bins above ground	750 m below aircraft
1064_total_attn_bsc		1.5 km below aircraft
1064_dep	2 bins above ground	500 m below aircraft
1064_aer_dep	2 bins above ground	500 m below aircraft
Sa_532	(filter window – 2 bins) above (ground + 2 bins).	2.5 km below aircraft
WVD_1064_532	2 bins above ground	500 m below aircraft
AOT_lo	2 bins above ground	2.5 km below aircraft
AOT_hi	Extrapolated to ground	2.5 km below aircraft
AOT_hi_col	Extrapolated to ground	2.5 km below aircraft