**Description of the Cloud Physics Lidar (CPL) netCDF data format**

 **7/9/2015**

**Overview**

The Cloud Physics Lidar (CPL) instrument is a multi-wavelength backscatter LIDAR which provides multi-wavelength measurements of cirrus and aerosols with high temporal and spatial resolution; it was originally designed to fly on the NASA ER-2 aircraft, and it was first deployed in 2000 for the Southern African Regional Science Initiative (SAFARI) campaign in southern Africa. A duplicate CPL was constructed for the NASA Global Hawk UAV; this CPL was used for the HS3 campaign. The CPL operates simultaneously at three wavelengths (355, 532, and 1064 nm) and has a small field of view, which eliminates multiple scattering; it offers 30 m vertical resolution and 200 m horizontal resolution. The CPL instrument measures the total (aerosol plus Rayleigh) attenuated backscatter as a function of altitude at each wavelength.

CPL utilizes a high repetition rate, low pulse energy transmitter and photon-counting detectors. It is designed specifically for three-wavelength operation and maximum receiver efficiency. An off-axis parabola is used for the telescope, allowing 100% of the laser energy to reach the atmosphere. CPL measures the total (aerosol plus Rayleigh) attenuated backscatter as a function of altitude at each wavelength. For transmissive cloud/aerosol layers, using optical depth measurements determined from attenuation of Rayleigh and aerosol scattering, and using the integrated backscatter, the extinction-to-backscatter parameter (S-ratio) can be directly derived. This permits unambiguous analysis of cloud optical depth since only the LIDAR data is required. Using the derived extinction-to-backscatter ratio, the internal cloud extinction profile can then be obtained. This approach to directly solving the LIDAR equation without assumption of aerosol climatology is a standard analysis approach for backscatter LIDAR (McGill et al 2003).

The CPL netCDF files are direct translations from the CPL HDF5 files with data arrays copied directly without modification with additional file-level and variable-level metadata added to make the files CF-compliant. There are two types of files, ATB and OP, as is the case with the HDF5 versions. Variable-wise, the contents are identical to the HDF5 versions.

**ATB Contents**

The contents of the ATB files are shown in the following table. The variables in the netCDF file are also fully attributed and self describing.

|  |  |  |
| --- | --- | --- |
| **Variable Name** | **Variable Description** | **Variable Dimensions** |
| ATB\_1064 | Attenuated Total Backscatter at 1064 micrometers 1010641010610641064mimicrmicrometers | NumRecsDim, NumBinsDim |
| ATB\_355 | Attenuated Total Backscatter at 355 micrometers 1010641010610641064mimicrmicrometers | NumRecsDim, NumBinsDim |
| ATB\_532 | Attenuated Total Backscatter at 532 micrometers 1010641010610641064mimicrmicrometers | NumRecsDim, NumBinsDim |
| Bin\_Alt | Altitude of each vertical bin | NumBinsDim |
| Bin\_Width | Vertical bin size | Scalar |
| Cali\_1064 | Calibration coefficients at 1064 micrometers | NumRecsDim |
| Cali\_355 | Calibration coefficients at 355 micrometers | NumRecsDim |
| Cali\_532 | Calibration coefficients at 532 micrometers | NumRecsDim |
| Dec\_JDay | Decimal day of year for current profile | NumRecsDim |
| Depol\_Ratio | Depolarization ratio at 1064 micrometers | NumRecsDim, NumBinsDim |
| End\_JDay | End time in decimal day of year for the flight | Scalar |
| Frame\_Top | Frame Top Height | Scalar |
| Gnd\_Hgt | Lidar Ground Return Height | NumRecsDim |
| Hori\_Res | Horizontal Resolution | Scalar |
| Hour | Hour component of time for current profile | NumRecsDim |
| Latitude | Profile Latitude | NumRecsDim |
| Layer\_Bot\_Alt | Layer bottom height | NumRecsDim, MaxLayersDim |
| Layer\_Top\_Alt | Layer top height | NumRecsDim, MaxLayersDim |
| Longitude | Profile longitude | NumRecsDim |
| MaxLayers | Maxijmum number of layers/profiles | Scalar |
| Minute | Minute component of time for current profile | NumRecsDim |
| Mole\_Back | Molecular Backscatter Profile | NumWaveDim, NumBinsDim |
| NumBins | Number of bins | Scalar |
| NumChans | Number of channels | Scalar |
| NumLayers | Number of layers | NumRecsDim |
| NumRecs | Number of profiles | Scalar |
| NumWave | Number of wavelengths | Scalar |
| Plane\_Alt | Plane Altitude | NumRecsDim |
| Plane\_Heading | Plane heading | NumRecsDim |
| Plane\_Pitch | Plane pitch angle | NumRecsDim |
| Plane\_Roll | Plane Roll Angle | NumRecsDim |
| Pressure | Air pressure at each bin | NumBinsDim |
| RH | Relative humidity at each bin | NumBinsDim |
| Saturate | Saturation height | NumRecsDim, NumChansDim |
| Second | Second component of time for current profile | NumRecsDim |
| Solar\_Azimuth\_Angle | Solar azimuth angle | NumRecsDim |
| Solar\_Elevation\_Angle | Solar elevation angle | NumRecsDim |
| Start\_JDay | Start time in decimal day of year for the flight | Scalar |
| Temperature | Air temperature at each bin | NumBinsDim |

**OP Contents**

The contents of the OP files are shown in the following table. The variables in the netCDF file are also fully attributed and self describing.

|  |  |  |
| --- | --- | --- |
| **Variable Name** | **Variable Description** | **Variable Dimensions** |
| Bin\_Alt | Altitude of each vertical bin | NumBinsDim |
| Bin\_Width | Vertical bin size | Scalar |
| Dec\_JDay | Decimal day of year for current profile | NumRecsDim |
| Depol\_Ratio | Depolarization ratio at 1064 micrometers | NumRecsDim, NumBinsDim |
| Depol\_Ratio\_Err | Depolarization ratio standard deviation at 1064 nanomaters | NumRecsDim, NumBinsDim |
| Direct\_OD | Direct Optical Depth estimate | NumRecsDim, NumWaveDim, MaxLayersDim |
| End\_JDay | End time in decimal day of year for the flight | Scalar |
| Extinction | Extinction profile | NumRecsDim, NumWaveDim, NumBinsDim |
| Extinction\_Err | Extinction error profile | NumRecsDim, NumWaveDim, NumBinsDim |
| Frame\_Top | Frame Top Height | Scalar |
| Gnd\_Hgt | Lidar Ground Return Height | NumRecsDim |
| Hori\_Res | Horizontal Resolution | Scalar |
| Hour | Hour component of time for current profile | NumRecsDim |
| Latitude | Profile Latitude | NumRecsDim |
| Layer\_Bot\_Alt | Layer bottom height | NumRecsDim, MaxLayersDim |
| Layer\_OD | Later Optical Depth | NumRecsDim, NumWaveDim, MaxLayersDim |
| Layer\_OD\_Err | Later Optical Depth Error | NumRecsDim, NumWaveDim, MaxLayersDim |
| Layer\_Top\_Alt | Layer top height | NumRecsDim, MaxLayersDim |
| Layer\_Type | Type of the layer | NumRecsDim, NumWaveDim, MayLayersDim |
| Lidar\_Ratio | Lidar Ratio | NumRecsDim, NumWaveDim, MaxLayersDim |
| Lidar\_Ratio\_Err | Lidar Ratio Error | NumRecsDim, NumWaveDim, MaxLayersDim |
| Longitude | Profile longitude | NumRecsDim |
| LRatio\_Source | Lidar ratio source | NumRecsDim, NumWaveDim, MaxLayersDim |
| MaxLayers | Maxijmum number of layers/profiles | Scalar |
| Minute | Minute component of time for current profile | NumRecsDim |
| Mol\_Ext\_Prof | Molecular Extinction Profile | NumWaveDim, NumBinsDim |
| NumBins | Number of bins | Scalar |
| NumChans | Number of channels | Scalar |
| NumLayers | Number of layers | NumRecsDim |
| NumRecs | Number of profiles | Scalar |
| NumWave | Number of wavelengths | Scalar |
| PGR | Polarization gain ratio | Scalar |
| Plane\_Alt | Plane Altitude | NumRecsDim |
| Plane\_Pitch | Plane pitch angle | NumRecsDim |
| Plane\_Roll | Plane Roll Angle | NumRecsDim |
| Second | Second component of time for current profile | NumRecsDim |
| Start\_JDay | Start time in decimal day of year for the flight | Scalar |
| T\_Loss\_Stats | Layer transmission loss technique statistics | NumRecsDim, NumWaveDim, MaxLayersDim |

**CPL ATB netCDF Header Dump**

netcdf HS3\_CPL\_ATB\_12203a\_20120906 {

dimensions:

 NumRecsDim = 11699 ;

 NumBinsDim = 900 ;

 MaxLayersDim = 10 ;

 NumWaveDim = 3 ;

 NumChansDim = 4 ;

variables:

 double ATB\_1064(NumRecsDim, NumBinsDim) ;

 ATB\_1064:long\_name = "Attenuated Total Backscatter Profile at 1064 nanometers" ;

 ATB\_1064:units = "km-1 sr-1" ;

 ATB\_1064:coordinates = "Dec\_JDay Longitude Latitude Bin\_Alt" ;

 double ATB\_355(NumRecsDim, NumBinsDim) ;

 ATB\_355:long\_name = "Attenuated Total Backscatter Profile at 355 nanometers" ;

 ATB\_355:units = "km-1 sr-1" ;

 ATB\_355:coordinates = "Dec\_JDay Longitude Latitude Bin\_Alt" ;

 double ATB\_532(NumRecsDim, NumBinsDim) ;

 ATB\_532:long\_name = "Attenuated Total Backscatter Profile at 532 nanometers" ;

 ATB\_532:units = "km-1 sr-1" ;

 ATB\_532:coordinates = "Dec\_JDay Longitude Latitude Bin\_Alt" ;

 float Bin\_Alt(NumBinsDim) ;

 Bin\_Alt:standard\_name = "height" ;

 Bin\_Alt:long\_name = "Altitude of each vertical bin" ;

 Bin\_Alt:units = "km" ;

 Bin\_Alt:positive = "up" ;

 float Bin\_Width ;

 Bin\_Width:long\_name = "Vertical bin size" ;

 Bin\_Width:units = "m" ;

 double Cali\_1064(NumRecsDim) ;

 Cali\_1064:long\_name = "Calibration coefficients at 1064 nanometers" ;

 Cali\_1064:comment = "calibration applied for current profile at 1064 nanometers" ;

 Cali\_1064:units = "km3 J-1 s-2" ;

 Cali\_1064:coordinates = "Dec\_JDay Longitude Latitude" ;

 double Cali\_355(NumRecsDim) ;

 Cali\_355:long\_name = "Calibration coefficients at 355 nanometers" ;

 Cali\_355:comment = "calibration applied for current profile at 355 nanometers" ;

 Cali\_355:units = "km3 J-1 s-2" ;

 Cali\_355:coordinates = "Dec\_JDay Longitude Latitude" ;

 double Cali\_532(NumRecsDim) ;

 Cali\_532:long\_name = "Calibration coefficients at 532 nanometers" ;

 Cali\_532:comment = "calibration applied for current profile at 532 nanometers" ;

 Cali\_532:units = "km3 J-1 s-2" ;

 Cali\_532:coordinates = "Dec\_JDay Longitude Latitude" ;

 double Dec\_JDay(NumRecsDim) ;

 Dec\_JDay:standard\_name = "time" ;

 Dec\_JDay:long\_name = "Decimal day of year for current profile" ;

 Dec\_JDay:units = "days since 2012-01-01T00:00:00Z" ;

 float Depol\_Ratio(NumRecsDim, NumBinsDim) ;

 Depol\_Ratio:long\_name = "Depolarization Ratio at 1064 nanometers" ;

 Depol\_Ratio:comment = "1064 nanometer depolarization ratio profiles, valid only inside layers" ;

 Depol\_Ratio:units = "1" ;

 Depol\_Ratio:coordinates = "Dec\_JDay Longitude Latitude Bin\_Alt" ;

 Depol\_Ratio:missing\_value = -0.999f ;

 double End\_JDay ;

 End\_JDay:long\_name = "End time in decimal day of year for the flight" ;

 End\_JDay:units = "day" ;

 float Frame\_Top ;

 Frame\_Top:long\_name = "Frame Top Height" ;

 Frame\_Top:units = "km" ;

 float Gnd\_Hgt(NumRecsDim) ;

 Gnd\_Hgt:long\_name = "Lidar Ground Return Height" ;

 Gnd\_Hgt:comment = "height of Lidar ground return (km), missing = -0.999" ;

 Gnd\_Hgt:units = "km" ;

 Gnd\_Hgt:coordinates = "Dec\_JDay Longitude Latitude" ;

 Gnd\_Hgt:missing\_value = -0.999f ;

 short Hori\_Res ;

 Hori\_Res:long\_name = "Horizontal Resolution" ;

 Hori\_Res:comment = "horizontal resolution, 1 sec = approx. 0.200 km" ;

 Hori\_Res:units = "seconds" ;

 short Hour(NumRecsDim) ;

 Hour:long\_name = "Hour component of time for current profile" ;

 Hour:comment = "hour at which the measurement is made for the current profile" ;

 Hour:units = "hour" ;

 float Latitude(NumRecsDim) ;

 Latitude:standard\_name = "latitude" ;

 Latitude:long\_name = "Profile latitude" ;

 Latitude:comment = "latitude for current profile" ;

 Latitude:units = "degrees\_north" ;

 float Layer\_Bot\_Alt(NumRecsDim, MaxLayersDim) ;

 Layer\_Bot\_Alt:standard\_name = "height" ;

 Layer\_Bot\_Alt:long\_name = "Layer bottom height" ;

 Layer\_Bot\_Alt:comment = "height of the bottom of the layer" ;

 Layer\_Bot\_Alt:units = "km" ;

 Layer\_Bot\_Alt:coordinates = "Dec\_JDay Longitude Latitude" ;

 float Layer\_Top\_Alt(NumRecsDim, MaxLayersDim) ;

 Layer\_Top\_Alt:standard\_name = "height" ;

 Layer\_Top\_Alt:long\_name = "Layer top height" ;

 Layer\_Top\_Alt:comment = "height of the top of the layer" ;

 Layer\_Top\_Alt:units = "km" ;

 Layer\_Top\_Alt:coordinates = "Dec\_JDay Longitude Latitude" ;

 short Layer\_Type(NumRecsDim, MaxLayersDim) ;

 Layer\_Type:long\_name = "Type of the layer" ;

 Layer\_Type:comment = "Type of the layer (0=dummy, 1=PBL, 2=elevated aerosol, 3=cloud, 4=indeterminate)" ;

 Layer\_Type:units = "1" ;

 Layer\_Type:coordinates = "Dec\_JDay Longitude Latitude" ;

 Layer\_Type:flag\_values = 0s, 1s, 2s, 3s, 4s ;

 Layer\_Type:flag\_meanings = "0\_dummy 1\_PBL 2\_elevated\_aerosol 3\_cloud 4\_indeterminate" ;

 float Longitude(NumRecsDim) ;

 Longitude:standard\_name = "longitude" ;

 Longitude:long\_name = "Profile longitude" ;

 Longitude:comment = "longitude for current profile" ;

 Longitude:units = "degrees\_east" ;

 int MaxLayers ;

 MaxLayers:long\_name = "Maximum number of layers/profiles" ;

 MaxLayers:units = "1" ;

 short Minute(NumRecsDim) ;

 Minute:long\_name = "Minute component of time for current profile" ;

 Minute:comment = "minute at which measurement is made for current profile; need to combine with Hour variable for use" ;

 Minute:units = "minute" ;

 float Mole\_Back(NumWaveDim, NumBinsDim) ;

 Mole\_Back:long\_name = "Molecular Backscatter Profile" ;

 Mole\_Back:comment = "Molecular backscatter profile (km-1 sr-1) for the three wavelengths" ;

 Mole\_Back:units = "km-1 sr-1" ;

 Mole\_Back:coordinates = "Bin\_Alt" ;

 int NumBins ;

 NumBins:long\_name = "Number of bins" ;

 NumBins:comment = "Number of vertical bins in frame" ;

 NumBins:units = "1" ;

 short NumChans ;

 NumChans:long\_name = "Number of channels" ;

 NumChans:comment = "Number of channels (355, 532, 1064 parallel and 1064 perpendicular)" ;

 NumChans:units = "1" ;

 int NumLayers(NumRecsDim) ;

 NumLayers:long\_name = "Number of layers" ;

 NumLayers:comment = "Number of layers for current profile" ;

 NumLayers:units = "1" ;

 NumLayers:coordinates = "Dec\_JDay Longitude Latitude" ;

 int NumRecs ;

 NumRecs:long\_name = "Number of profiles" ;

 NumRecs:comment = "Total number of profile records" ;

 NumRecs:units = "1" ;

 int NumWave ;

 NumWave:long\_name = "Number of wavelengths" ;

 NumWave:comment = "Number of wavelengths (355, 532, and 1064 nanometers)" ;

 NumWave:units = "1" ;

 float Plane\_Alt(NumRecsDim) ;

 Plane\_Alt:long\_name = "Plane altitude" ;

 Plane\_Alt:comment = "Plane altitude at which current profile is measured" ;

 Plane\_Alt:units = "km" ;

 Plane\_Alt:coordinates = "Dec\_JDay Longitude Latitude" ;

 float Plane\_Heading(NumRecsDim) ;

 Plane\_Heading:long\_name = "Plane heading" ;

 Plane\_Heading:comment = "Plane heading for current profile, clockwise from north" ;

 Plane\_Heading:units = "degrees" ;

 Plane\_Heading:coordinates = "Dec\_JDay Longitude Latitude" ;

 float Plane\_Pitch(NumRecsDim) ;

 Plane\_Pitch:long\_name = "Plane pitch angle" ;

 Plane\_Pitch:comment = "Plane pitch angle for current profile, downward is negative" ;

 Plane\_Pitch:units = "degrees" ;

 Plane\_Pitch:coordinates = "Dec\_JDay Longitude Latitude" ;

 float Plane\_Roll(NumRecsDim) ;

 Plane\_Roll:long\_name = "Plane Roll Angle" ;

 Plane\_Roll:comment = "Plane roll angle, left turn is negative" ;

 Plane\_Roll:units = "degrees" ;

 Plane\_Roll:coordinates = "Dec\_JDay Longitude Latitude" ;

 float Pressure(NumBinsDim) ;

 Pressure:standard\_name = "air\_pressure" ;

 Pressure:long\_name = "Air pressure at each bin" ;

 Pressure:units = "hPa" ;

 Pressure:coordinates = "Bin\_Alt" ;

 float RH(NumBinsDim) ;

 RH:standard\_name = "relative\_humidity" ;

 RH:long\_name = "Relative humidity at each bin" ;

 RH:units = "percent" ;

 RH:coordinates = "Bin\_Alt" ;

 float Saturate(NumRecsDim, NumChansDim) ;

 Saturate:long\_name = "Saturation height" ;

 Saturate:comment = "Height where detector saturation first occurs per channel (if any)" ;

 Saturate:units = "km" ;

 Saturate:coordinates = "Dec\_JDay Longitude Latitude" ;

 short Second(NumRecsDim) ;

 Second:long\_name = "Second component of time for current profile" ;

 Second:comment = "second at which measurement is made for current profile; need to combine with Hour and Minute variables for use" ;

 Second:units = "second" ;

 float Solar\_Azimuth\_Angle(NumRecsDim) ;

 Solar\_Azimuth\_Angle:standard\_name = "solar\_azimuth\_angle" ;

 Solar\_Azimuth\_Angle:long\_name = "Solar azimuth angle" ;

 Solar\_Azimuth\_Angle:units = "degrees" ;

 Solar\_Azimuth\_Angle:coordinates = "Dec\_JDay Longitude Latitude" ;

 float Solar\_Elevation\_Angle(NumRecsDim) ;

 Solar\_Elevation\_Angle:standard\_name = "solar\_elevation\_angle" ;

 Solar\_Elevation\_Angle:long\_name = "Solar Elevation Angle" ;

 Solar\_Elevation\_Angle:units = "degrees" ;

 Solar\_Elevation\_Angle:coordinates = "Dec\_JDay Longitude Latitude" ;

 double Start\_JDay ;

 Start\_JDay:long\_name = "Start time in decimal day of year for the flight" ;

 Start\_JDay:units = "day" ;

 float Temperature(NumBinsDim) ;

 Temperature:standard\_name = "air\_temperature" ;

 Temperature:long\_name = "Air temperature at each bin" ;

 Temperature:comment = "air temperature at each bin" ;

 Temperature:units = "degree\_Celsius" ;

 Temperature:coordinates = "Bin\_Alt" ;

// global attributes:

 :Conventions = "CF-1.6" ;

 string :Project = "UAV-HS3\_12" ;

 string :Date = "06sep12" ;

}

**CPL OP netCDF Header Dump**

netcdf HS3\_CPL\_OP\_12203a\_20120906 {

dimensions:

 NumRecsDim = 11699 ;

 NumBinsDim = 900 ;

 MaxLayersDim = 10 ;

 NumWaveDim = 3 ;

 NumChansDim = 4 ;

variables:

 float Bin\_Alt(NumBinsDim) ;

 Bin\_Alt:standard\_name = "height" ;

 Bin\_Alt:long\_name = "Altitude of each vertical bin" ;

 Bin\_Alt:units = "km" ;

 Bin\_Alt:positive = "up" ;

 float Bin\_Width ;

 Bin\_Width:long\_name = "Vertical bin size" ;

 Bin\_Width:units = "m" ;

 double Dec\_JDay(NumRecsDim) ;

 Dec\_JDay:standard\_name = "time" ;

 Dec\_JDay:long\_name = "Decimal day of year for current profile" ;

 Dec\_JDay:units = "days since 2012-01-01T00:00:00Z" ;

 float Depol\_Ratio(NumRecsDim, NumBinsDim) ;

 Depol\_Ratio:long\_name = "Depolarization Ratio at 1064 nanometers" ;

 Depol\_Ratio:comment = "1064 nanometer depolarization ratio profiles, valid only inside layers" ;

 Depol\_Ratio:units = "1" ;

 Depol\_Ratio:coordinates = "Dec\_JDay Longitude Latitude Bin\_Alt" ;

 Depol\_Ratio:ancillary\_variables = "Depol\_Ratio\_Err" ;

 Depol\_Ratio:missing\_value = -0.999f ;

 float Depol\_Ratio\_Err(NumRecsDim, NumBinsDim) ;

 Depol\_Ratio\_Err:long\_name = "Depolorization Ratio standard deviation at 1064 nanometers" ;

 Depol\_Ratio\_Err:comment = "Depolarization ratio standard deviation, valid only inside layers" ;

 Depol\_Ratio\_Err:units = "1" ;

 Depol\_Ratio\_Err:coordinates = "Dec\_JDay Longitude Latitude Bin\_Alt" ;

 Depol\_Ratio\_Err:missing\_value = -0.999f ;

 float Direct\_OD(NumRecsDim, NumWaveDim, MaxLayersDim) ;

 Direct\_OD:long\_name = "Direct Optical Depth estimate" ;

 Direct\_OD:comment = "Optical Depth estimate from transmission loss method per layer per wavelength (-8.8 = layer not processed, -9.9 = invalid)" ;

 Direct\_OD:units = "1" ;

 Direct\_OD:coordinates = "Dec\_JDay Longitude Latitude" ;

 Direct\_OD:missing\_value = -9.9f ;

 double End\_JDay ;

 End\_JDay:long\_name = "End time in decimal day of year for the flight" ;

 End\_JDay:units = "day" ;

 float Extinction(NumRecsDim, NumWaveDim, NumBinsDim) ;

 Extinction:long\_name = "Extinction profile" ;

 Extinction:comment = "Extinction profile (1/km) for the 3 wavelengths (0.0 = not processed (no layer), -9900 = invalid)" ;

 Extinction:units = "km-1" ;

 Extinction:coordinates = "Dec\_JDay Longitude Latitude Bin\_Alt" ;

 Extinction:ancillary\_variables = "Extinction\_Err" ;

 float Extinction\_Err(NumRecsDim, NumWaveDim, NumBinsDim) ;

 Extinction\_Err:long\_name = "Extinction error profile" ;

 Extinction\_Err:comment = "Extinction error profile (1/km) for the 3 wavelengths" ;

 Extinction\_Err:units = "km-1" ;

 Extinction\_Err:coordinates = "Dec\_JDay Longitude Latitude Bin\_Alt" ;

 float Frame\_Top ;

 Frame\_Top:long\_name = "Frame Top Height" ;

 Frame\_Top:units = "m" ;

 float Gnd\_Hgt(NumRecsDim) ;

 Gnd\_Hgt:long\_name = "Lidar Ground Return Height" ;

 Gnd\_Hgt:comment = "height of Lidar ground return (km), missing = -0.999" ;

 Gnd\_Hgt:units = "km" ;

 Gnd\_Hgt:coordinates = "Dec\_JDay Longitude Latitude" ;

 Gnd\_Hgt:missing\_value = -0.999f ;

 short Hori\_Res ;

 Hori\_Res:long\_name = "Horizontal Resolution" ;

 Hori\_Res:comment = "horizontal resolution, 1 sec = approx. 0.200 km" ;

 Hori\_Res:units = "seconds" ;

 short Hour(NumRecsDim) ;

 Hour:long\_name = "Hour component of time for current profile" ;

 Hour:comment = "hour at which the measurement is made for the current profile" ;

 Hour:units = "hour" ;

 short Inver\_Type(NumRecsDim, NumWaveDim, MaxLayersDim) ;

 Inver\_Type:long\_name = "Lidar Inversion Type" ;

 Inver\_Type:comment = "Type of Lidar Inversion used, 0=backward, 1=forward" ;

 Inver\_Type:units = "1" ;

 Inver\_Type:coordinates = "Dec\_JDay Longitude Latitude" ;

 Inver\_Type:flag\_values = 0s, 1s ;

 Inver\_Type:flag\_meanings = "0\_backward 1\_forward" ;

 short LRatio\_Source(NumRecsDim, NumWaveDim, MaxLayersDim) ;

 LRatio\_Source:long\_name = "Lidar ratio source" ;

 LRatio\_Source:comment = "Key signifying source of Lidar ratio value per layer:\nAEROSOLS>\n0= pre-defined generic default based on geographic grid\n1= educated guess based on recent history at location (PBL)\n2= calculated from available column AOD at location and time(PBL)\n3= pre-calculated from AERONET, etc for location and time (PBL)\n4= retrieved using technique calculating layer transmission loss\n6= lowered by a maximum of 15.0sr in order to process down to layer bottom\n9= missing\nCLOUDS>\n0= water phase determination based on met temperature profile only, then for ice used S-ratio eq. based on mean layer temperature\n1= water phase determ. based on depolarization ratio and temper., then for ice used S-ratio eq. based on mean layer temperature\n3= 1064nm S ratio calculated from 532nm optical depth using transmission loss technique\n4= retrieved directly using technique calculating layer trans. loss\n5= calculated setting bottom transmission to reflect extinquished signal\n6= lowered by a maximum of 15.0sr in order to process down to layer bottom\n9= missing\n" ;

 LRatio\_Source:units = "1" ;

 LRatio\_Source:coordinates = "Dec\_JDay Longitude Latitude" ;

 LRatio\_Source:flag\_values = 0s, 1s, 2s, 3s, 4s, 5s, 6s, 9s ;

 LRatio\_Source:flag\_meanings = "0\_aerosol\_pre-defined\_generic\_default\_based\_on\_geographic\_grid\_or\_cloud\_water\_phase\_determined\_based\_on\_met\_temperature\_profile\_only\_ice\_phase\_used\_S-ratio\_eq\_based\_on\_mean\_layer\_temperature 1\_aerosol\_educated\_guess\_based\_on\_recent\_history\_at\_location\_PBL\_cloud\_water\_phase\_determined\_based\_on\_depolarization\_ratio\_and\_temperature\_ice\_phase\_used\_S-ratio\_eq\_based\_on\_mean\_layer\_temperature 2\_calculated\_from\_available\_column\_AOD\_at\_location\_and\_time\_PBL 3\_aerosols\_pre-calculated\_from\_AERONET\_etc\_for\_location\_and\_time\_PBL\_or\_clouds\_1064nm\_S\_ratio\_calculated\_from\_532nm\_optical\_depth\_using\_transmission\_loss\_technique 4\_aerosols\_retrieved\_using\_technique\_calculating\_layer\_transmission\_loss\_or\_clouds\_retrieved\_directly\_using\_technique\_calculating\_layer\_transmission\_loss 5\_calculated\_setting\_bottom\_transmission\_to\_reflect\_extinquished\_signal 6\_lowered\_by\_a\_maximum\_of\_15.0sr\_in\_order\_to\_process\_down\_to\_layer\_bottom 9\_missing" ;

 float Latitude(NumRecsDim) ;

 Latitude:standard\_name = "latitude" ;

 Latitude:long\_name = "Profile latitude" ;

 Latitude:comment = "latitude for current profile" ;

 Latitude:units = "degrees\_north" ;

 float Layer\_Bot\_Alt(NumRecsDim, MaxLayersDim) ;

 Layer\_Bot\_Alt:standard\_name = "height" ;

 Layer\_Bot\_Alt:long\_name = "Layer bottom height" ;

 Layer\_Bot\_Alt:comment = "height of the bottom of the layer" ;

 Layer\_Bot\_Alt:units = "km" ;

 Layer\_Bot\_Alt:coordinates = "Dec\_JDay Longitude Latitude" ;

 float Layer\_OD(NumRecsDim, NumWaveDim, MaxLayersDim) ;

 Layer\_OD:long\_name = "Layer Optical Depth" ;

 Layer\_OD:comment = "Optical Depth per layer per wavelength (-8.8 = layer not processed, -9.9 = invalid" ;

 Layer\_OD:units = "1" ;

 Layer\_OD:coordinates = "Dec\_JDay Longitude Latitude" ;

 Layer\_OD:ancillary\_variables = "Layer\_OD\_Err" ;

 Layer\_OD:missing\_value = -9.9f ;

 float Layer\_OD\_Err(NumRecsDim, NumWaveDim, MaxLayersDim) ;

 Layer\_OD\_Err:long\_name = "Layer Optical Depth Err" ;

 Layer\_OD\_Err:comment = "Optical Depth error profile per layer per wavelength" ;

 Layer\_OD\_Err:units = "1" ;

 Layer\_OD\_Err:coordinates = "Dec\_JDay Longitude Latitude" ;

 Layer\_OD\_Err:missing\_value = -9.9f ;

 float Layer\_Top\_Alt(NumRecsDim, MaxLayersDim) ;

 Layer\_Top\_Alt:standard\_name = "height" ;

 Layer\_Top\_Alt:long\_name = "Layer top height" ;

 Layer\_Top\_Alt:comment = "height of the top of the layer" ;

 Layer\_Top\_Alt:units = "km" ;

 Layer\_Top\_Alt:coordinates = "Dec\_JDay Longitude Latitude" ;

 short Layer\_Type(NumRecsDim, MaxLayersDim) ;

 Layer\_Type:long\_name = "Type of the layer" ;

 Layer\_Type:comment = "Type of the layer (0=dummy, 1=PBL, 2=elevated aerosol, 3=cloud, 4=indeterminate)" ;

 Layer\_Type:units = "1" ;

 Layer\_Type:coordinates = "Dec\_JDay Longitude Latitude" ;

 Layer\_Type:flag\_values = 0s, 1s, 2s, 3s, 4s ;

 Layer\_Type:flag\_meanings = "0\_dummy 1\_PBL 2\_elevated\_aerosol 3\_cloud 4\_indeterminate" ;

 float Lidar\_Ratio(NumRecsDim, NumWaveDim, MaxLayersDim) ;

 Lidar\_Ratio:long\_name = "Lidar Ratio" ;

 Lidar\_Ratio:comment = "Lidar (S) Ratio (sr) per layer per wavelength (-8.8 = layer not processed, -9.9 = invalid)" ;

 Lidar\_Ratio:units = "1" ;

 Lidar\_Ratio:coordinates = "Dec\_JDay Longitude Latitude" ;

 Lidar\_Ratio:ancillary\_variables = "Lidar\_Ratio\_Err" ;

 Lidar\_Ratio:missing\_value = -9.9f ;

 float Lidar\_Ratio\_Err(NumRecsDim, NumWaveDim, MaxLayersDim) ;

 Lidar\_Ratio\_Err:long\_name = "Lidar Ratio error" ;

 Lidar\_Ratio\_Err:comment = "Lidar Ratio (sr) from error profile per layer per wavelength" ;

 Lidar\_Ratio\_Err:units = "1" ;

 Lidar\_Ratio\_Err:coordinates = "Dec\_JDay Longitude Latitude" ;

 Lidar\_Ratio\_Err:missing\_value = -9.9f ;

 float Longitude(NumRecsDim) ;

 Longitude:standard\_name = "longitude" ;

 Longitude:long\_name = "Profile longitude" ;

 Longitude:comment = "longitude for current profile" ;

 Longitude:units = "degrees\_east" ;

 int MaxLayers ;

 MaxLayers:long\_name = "Maximum number of layers/profiles" ;

 MaxLayers:units = "1" ;

 short Minute(NumRecsDim) ;

 Minute:long\_name = "Minute component of time for current profile" ;

 Minute:comment = "minute at which measurement is made for current profile; need to combine with Hour variable for use" ;

 Minute:units = "minute" ;

 float Mol\_Ext\_Prof(NumWaveDim, NumBinsDim) ;

 Mol\_Ext\_Prof:long\_name = "Molecular Extinction Profile" ;

 Mol\_Ext\_Prof:comment = "Molecular Extinction profile (1/km) for the 3 wavelengths" ;

 Mol\_Ext\_Prof:units = "km-1" ;

 Mol\_Ext\_Prof:coordinates = "Bin\_Alt" ;

 int NumBins ;

 NumBins:long\_name = "Number of bins" ;

 NumBins:comment = "Number of vertical bins in frame" ;

 NumBins:units = "1" ;

 short NumChans ;

 NumChans:long\_name = "Number of channels" ;

 NumChans:comment = "Number of channels (355, 532, 1064 parallel and 1064 perpendicular)" ;

 NumChans:units = "1" ;

 short NumLayers(NumRecsDim) ;

 NumLayers:long\_name = "Number of layers" ;

 NumLayers:comment = "Number of layers for current profile" ;

 NumLayers:units = "1" ;

 NumLayers:coordinates = "Dec\_JDay Longitude Latitude" ;

 int NumRecs ;

 NumRecs:long\_name = "Number of profiles" ;

 NumRecs:comment = "Total number of profile records" ;

 NumRecs:units = "1" ;

 int NumWave ;

 NumWave:long\_name = "Number of wavelengths" ;

 NumWave:comment = "Number of wavelengths (355, 532, and 1064 nanometers)" ;

 NumWave:units = "1" ;

 float PGR ;

 PGR:long\_name = "Polarization gain ratio" ;

 PGR:comment = "Polarization gain ratio at 1064 nanometers" ;

 PGR:units = "1" ;

 float Plane\_Alt(NumRecsDim) ;

 Plane\_Alt:long\_name = "Plane altitude" ;

 Plane\_Alt:comment = "Plane altitude at which current profile is measured" ;

 Plane\_Alt:units = "km" ;

 Plane\_Alt:coordinates = "Dec\_JDay Longitude Latitude" ;

 float Plane\_Pitch(NumRecsDim) ;

 Plane\_Pitch:long\_name = "Plane pitch angle" ;

 Plane\_Pitch:comment = "Plane pitch angle for current profile, downward is negative" ;

 Plane\_Pitch:units = "degrees" ;

 Plane\_Pitch:coordinates = "Dec\_JDay Longitude Latitude" ;

 float Plane\_Roll(NumRecsDim) ;

 Plane\_Roll:long\_name = "Plane Roll Angle" ;

 Plane\_Roll:comment = "Plane roll angle, left turn is negative" ;

 Plane\_Roll:units = "degrees" ;

 Plane\_Roll:coordinates = "Dec\_JDay Longitude Latitude" ;

 short Second(NumRecsDim) ;

 Second:long\_name = "Second component of time for current profile" ;

 Second:comment = "second at which measurement is made for current profile; need to combine with Hour and Minute variables for use" ;

 Second:units = "second" ;

 double Start\_JDay ;

 Start\_JDay:long\_name = "Start time in decimal day of year for the flight" ;

 Start\_JDay:units = "day" ;

 short T\_Loss\_Stats(NumRecsDim, NumWaveDim, MaxLayersDim) ;

 T\_Loss\_Stats:long\_name = "Layer transmission loss technique statistics" ;

 T\_Loss\_Stats:comment = "Layer transmission loss technique statistics,\n0= ok\n1= no grd after this final layer\n2= no lower layer or grd\n3= clear zone below layer too small\n4= clear zone SNR below min\n5= trans^2 of bin below min\n6= trans^2 of layer <= 0\n7= 1064 S used 532 optical depth" ;

 T\_Loss\_Stats:units = "1" ;

 T\_Loss\_Stats:coordinates = "Dec\_JDay Longitude Latitude" ;

 T\_Loss\_Stats:flag\_values = 0s, 1s, 2s, 3s, 4s, 5s, 6s, 7s ;

 T\_Loss\_Stats:flag\_meanings = "0\_OK 1\_no\_grd\_after\_this\_final\_layer 2\_no\_lower\_layer\_or\_grd 3\_clear\_zone\_below\_layer\_too\_small 4\_clear\_zone\_SNR\_below\_min 5\_trans\_square\_of\_bin\_below\_min 6\_trans\_square\_of\_layer\_less\_or\_equal\_than\_zero 7\_1064nanometer\_scattering\_used\_532nanometer\_optical\_depth" ;

// global attributes:

 :Conventions = "CF-1.6" ;

 string :Project = "UAV-HS3\_12" ;

 string :Date = "06sep12" ;

}

**References**

McGill, M.J., D.L. Hlavka, W.D. Hart, E.J. Welton, and J.R. Campbell, "Airborne lidar measurements of aerosol optical properties during SAFARI-2000",  J. Geophys. Res., 108, doi: 10.1029/2002JD002370, 2003.

Yorks, J. E., M. McGill, D. Hlavka and W. Hart (2011), Statistics of Cloud Optical Properties from Airborne Lidar Measurements, J. Atmos. Oceanic Technol., 28, 869-883, doi:10.1175/2011JTECHA1507.1.

Yorks, J. E., D. L. Hlavka, M. A. Vaughan, M. J. McGill, W. D. Hart, S. Rodier, and R. Kuehn (2011), Airborne validation of cirrus cloud properties derived from CALIPSO lidar measurements: Spatial properties, J. Geophys. Res., 116, D19207, doi:10.1029/2011JD015942.

Hlavka, D. L., J. E. Yorks, S. Young, M. A. Vaughan, R. Kuehn, M. J. McGill, and S. Rodier (2012), Airborne validation of cirrus cloud properties derived from CALIPSO lidar measurements: Optical properties, submitted to J. Geophys. Res.