National Aeronautics and Space Administration Goddard Earth Science Data Information and Services Center (GES DISC)

README Document for

A Multi-Sensor Water Vapor Climate Data Record Using Cloud Classification

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Revision History

Revision Date	*Changes*	*Author*
2010-10-07	Added initial content.	Gerald Manipon
2011-02-22	Updated for latest version of the data.	Gerald Manipon
2011-02-28	Added an explanation for the naming at the start of section 2.3, on current p. 14. Added the text and table in Sections 2.3.1 and 2.3.2.	Eric Fetzer
2011-03-01	Mapped data types to s4pa short/long names and collection versions. Clarified AMSU, AIRS, CloudSat footprints.	Gerald Manipon
2011-10-07	Updated for v3.1.	Gerald Manipon
2012-03-19	Updated using the latest template. Updated for NetCDF4 data products.	Gerald Manipon
2013-06-20	Updated for v3.2 of NetCDF4 data products that now include quality flags. Updated all products with DOI metadata.	Gerald Manipon
2016-05-31	Updated for v4.0 of this software.	Gerald Manipon

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1.0 Introduction

This document provides basic information for using the WVCC (Water Vapor Cloud Climatology) AIRS-CloudSat merged dataset.

The WVCC AIRS-CloudSat merged dataset consists of products generated for the focus on multi-sensor water vapor climatology using cloud classification.

1.1 Dataset/Mission Instrument Description

The basic task is to bring together retrievals of water vapor and cloud properties from multiple "A-train" instruments (AIRS & CloudSat), classify each "scene" (instrument look) using the cloud information, and develop a merged, multi-sensor climatology of atmospheric water vapor as a function of altitude, stratified by the cloud classes. This is a large science analysis project that will require the use of the HySDS (Hybrid Cloud Science Data System) and SciFlo technologies to discover and organize all of the datasets, move and cache datasets as required, find space/time "matchups" between pairs of instruments, and scale up processing of years of satellite data to produce the climate data records.

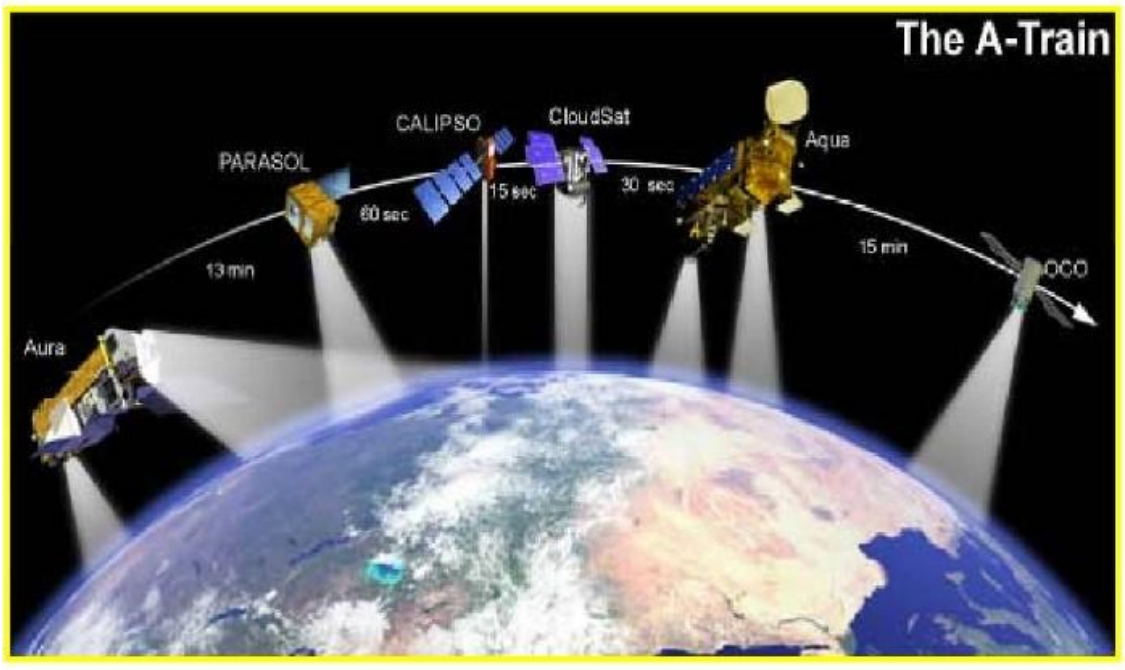


Figure 1.1: The A-train

1.1.1 AIRS & AMSU

AIRS is a continuously operating cross-track scanning sounder, consisting of a telescope that feeds an echelle spectrometer. The AIRS infrared spectrometer acquires 2378 spectral samples at resolutions, λ/Δλ, ranging from 1086 to 1570, in three bands: 3.74 m to 4.61 m, 6.20 m to 8.22 m, and 8.8 m to 15.4 m. The spatial footprint of the infrared channels is 1.1° in diameter, which corresponds to about 15x15 km in the nadir.

AMSU-A is a 15-channel microwave temperature sounder implemented as two independently operated modules. Module 1 (AMSU-A1) has 12 channels in the 50-58 GHz oxygen absorption band which provide the primary temperature sounding capabilities and 1 channel at 89 GHz which provides surface and moisture information. Module 2 (AMSU-A2) has 2 channels: one at 23.8 GHz and one at 31.4 GHz which provide surface and moisture information (total precipitable water and cloud liquid water). Like AIRS, AMSU-A is a cross-track scanner. AMSU-A scans three times as slowly as AIRS (once per 8 seconds), and its footprints are approximately three times as large as those of AIRS (45 km at nadir). This results in three AIRS scans per AMSU-A scans and nine AIRS footprints per AMSU-A footprint. Each AIRS/AMSU granule is six minutes in length (240 per day), and contains 30x45 AMSU and 90x135 AIRS footprints alongtrack x crosstrack.

1.1.2 CloudSat

The Cloud Profiling Radar (CPR) on CloudSat is a 94-GHz nadir-looking radar which measures the power backscattered by clouds as a function of distance from the radar. The CloudSat data footprint is approximately 1.7 km along-track by 1.3 km across-track. A granule is one orbit of data beginning at the first profile on or after the equator on the descending node. There are 125 vertical bins, each one approximately 240 m thick. There are approximately 36,383 profiles per granule.

1.1.3 SciFlo

SciFlo is a semantically-enabled ("smart") Grid Workflow system that ties together a peer-to-peer network of computers into an efficient engine for distributed computation. The SciFlo workflow engine enables scientists to do multi-instrument Earth Science by assembling remotely-invokable Web Services (SOAP or http GET URLs), native executables, command-line scripts, and Python codes into a distributed computing flow. SciFlo also deploys a variety of Data Grid services to: query datasets in space and time, locate & retrieve on-line data granules, and provide on-the-fly variable and spatial subsetting.

In processing AIRS-CloudSat matchups, the EOSService:geoRegionQuery() web service is used to query both CloudSat and AIRS datasets for granule identification and location (Figure 1.2).

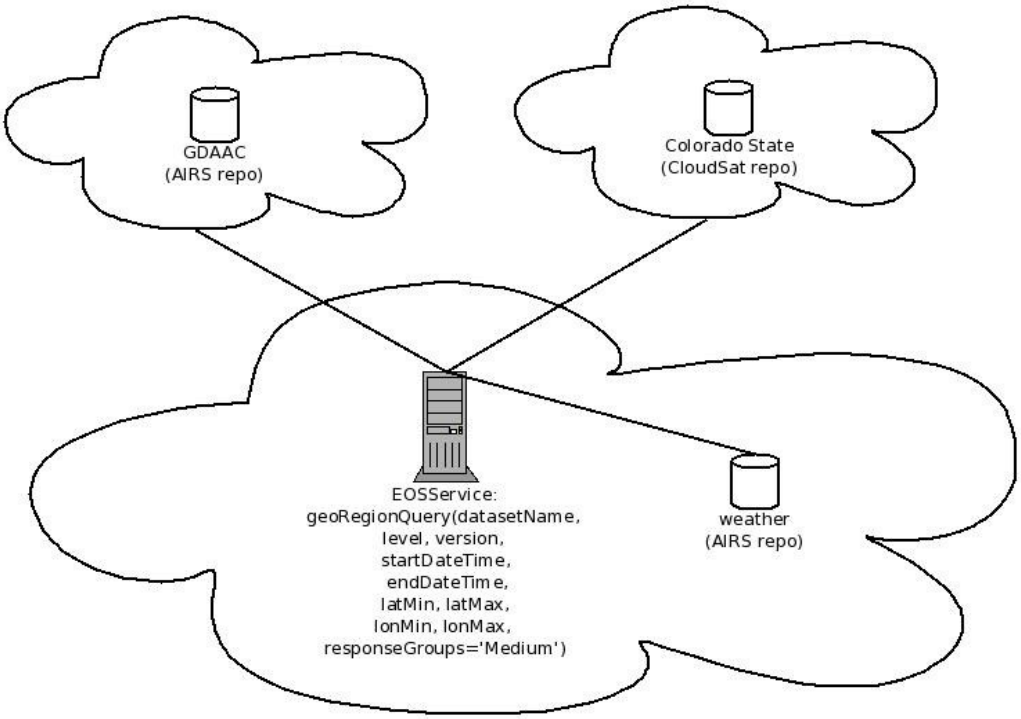


Figure 1.2: geoRegionQuery()

1.2 Algorithm Background

Production of the AIRS-CloudSat merged dataset is divided into two workflows producing the following intermediate and final products:

1) Footprint Matchups
    a. Matchup indices indexed by CloudSat granule (pickle & text)
    b. Matchup indices indexed by AIRS granule (pickle & text)
2) Variable Subsetting and Aggregation
    a. Subset AIRS and CloudSat variables indexed by AIRS granule (netCDF4)
    b. (optional) plots of AIRS, AMSU, & CloudSat granule and matched footprints (png)

Each workflow and its associated products are maintained as separate versions. As of this writing, the matchup and aggregation workflows are at version 4.0.

1.2.1 Footprint Matchup

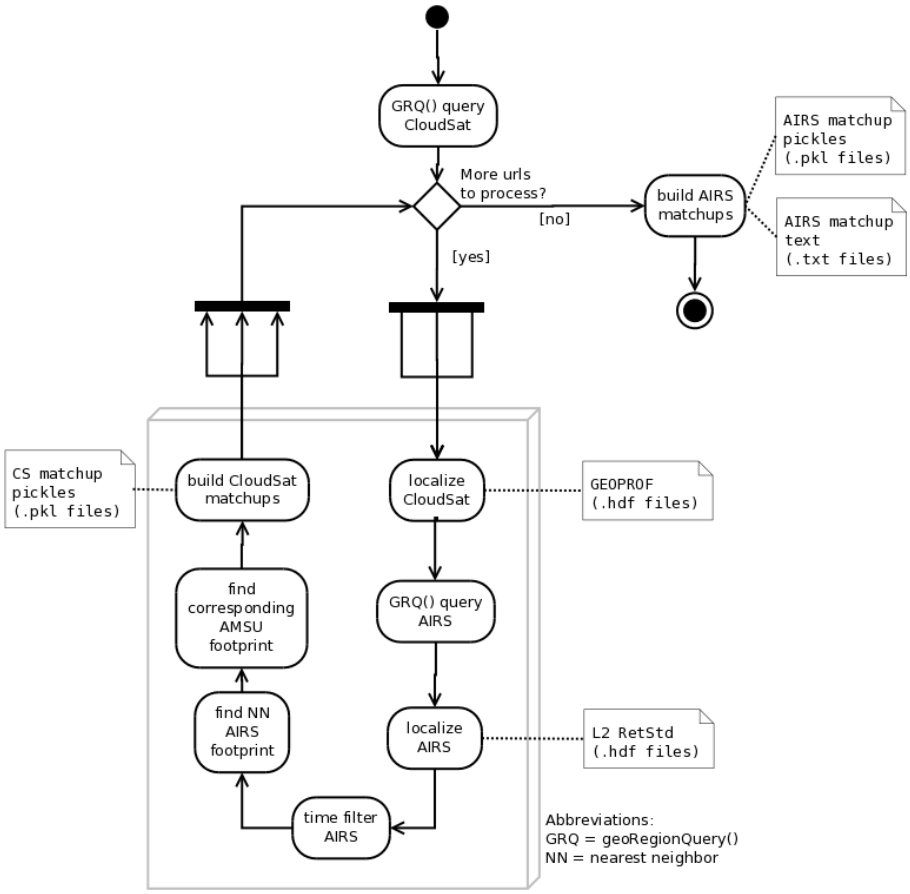


Figure 1.3: Footprint Matchup Activity Diagram

Figure 1.3 shows a high-level activity diagram of the footprint matchup workflow. The list of CloudSat granules drives the workflow and spawns concurrent SciFlo Work Units (workUnits hereafter) to handle each granule matchup. Note that aside from the products mentioned above, workUnit execution here results in the localization & caching of AIRS L2 RetStd and CloudSat GEOPROF granules.

The matchup indices for each CloudSat granule is collected by brute-force iteration over the CloudSat footprints and extracted from the nearest AIRS footprint. The AMSU footprint that

contains the matched AIRS footprint is also recorded. The following code snippet in Python implements the nearest neighbor algorithm used in the matchup:

```
import numpy as N

MAJOR_AXIS_RADIUS = 6378.137
MINOR_AXIS_RADIUS = 6356.7523142
RADIUS_EARTH = (2 * MAJOR_AXIS_RADIUS + MINOR_AXIS_RADIUS)/3.
DEG2RAD = N.pi/180.

def getDistance(lon1, lat1, lon2, lat2):
    """
    Return distance in kilometers between a point specified by
    lon1/lat1 and another point or array of points specified by lon2/lat2.
    """

    #calculate diffs
    dLat = lat2 - lat1
    dLon = lon2 - lon1

    #calculate distance using great circle
    return 2. * RADIUS_EARTH * \
        N.arcsin( N.sqrt( \
        (N.sin(dLat * DEG2RAD/2.))**2 \
        + N.cos(lat2 * DEG2RAD) \
        * N.cos(lat1 * DEG2RAD) \
        * (N.sin(dLon * DEG2RAD/2.))**2 \
    ))

...

#match AMSU footprint
amsuLon = a['Longitude']                                    #45x30 Longitude array from L2 RetStd
amsuLat = a['Latitude']                                     #45x30 Latitude array from L2 RetStd
amsuDist = getDistance(csLon, csLat, amsuLon, amsuLat)
closestAmsuIdx = N.unravel_index(amsuDist.argmin(), amsuDist.shape)    #get index of closest AMSU footprint

#match AIRS footprint
airsLon = a['lonAIRS']                                      #45x30x3x3 lonAIRS array from L2RetStd
airsLat = a['latAIRS']                                      #45x30x3x3 latAIRS array from L2RetStd
airsDist = getDistance(csLon, csLat, airsLon, airsLat)
closestAirsIdx = N.unravel_index(airsDist.argmin(), airsDist.shape)          #get index of closest AIRS footprint
```

After the CloudSat-AIRS matchup indices are collected and pickled, the matchup index text files, indexed by AIRS granules, are then generated.

The following example illustrates the matchups. Figure 1.4 shows a plot of the AIRS and AMSU footprints for AIRS granule AIRS.2006.11.08.227.L2.RetStd.v5.0.14.0.G07318121028.hdf and most of the CloudSat footprints for granule 2006312211510_02833_CS_2B-GEOPROF_GRANULE_P_R04_E02.hdf:

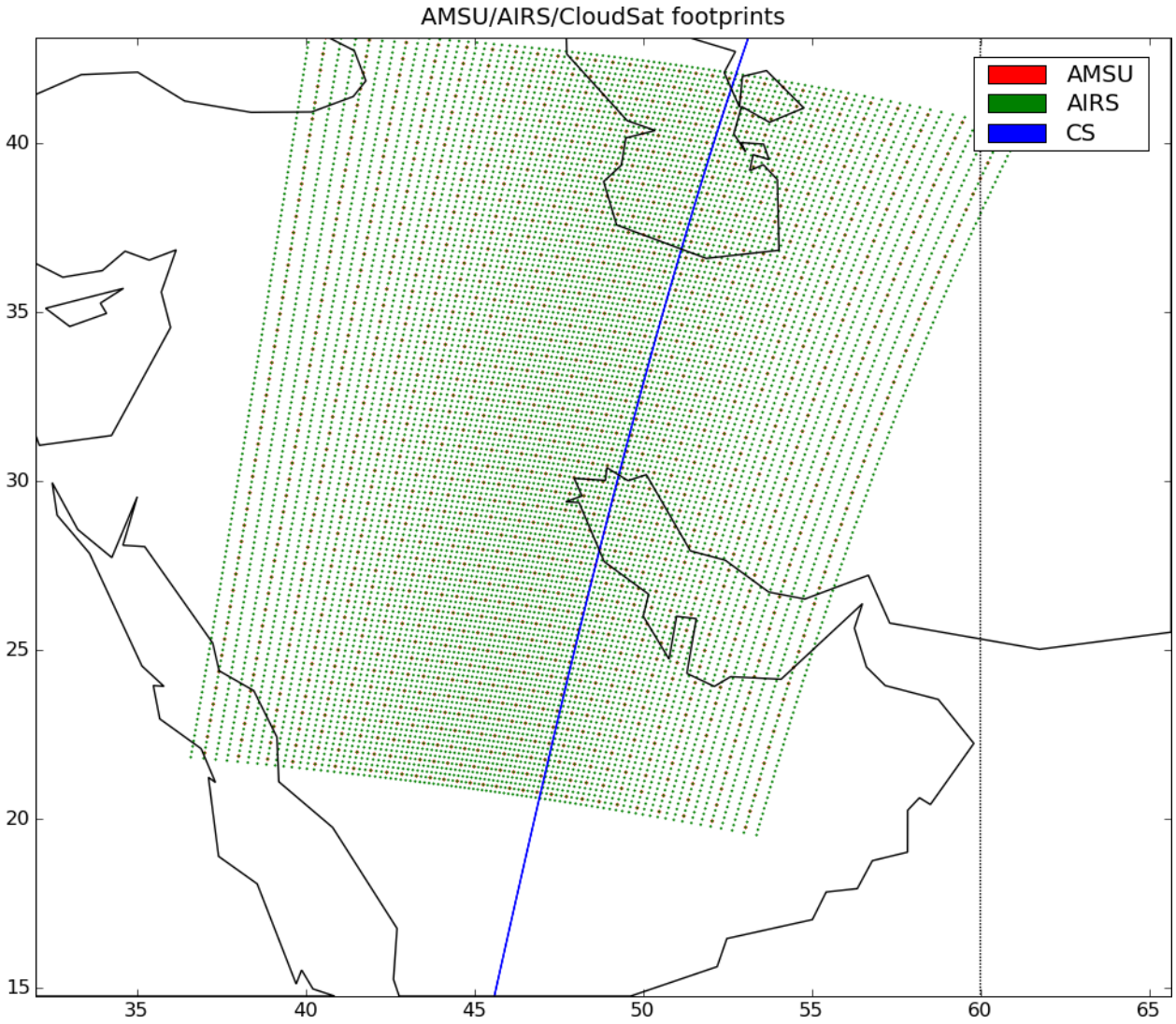


Figure 1.4: Footprint Plot

Figure 1.5 shows the resulting matched-up AIRS, AMSU, and CloudSat footprints:

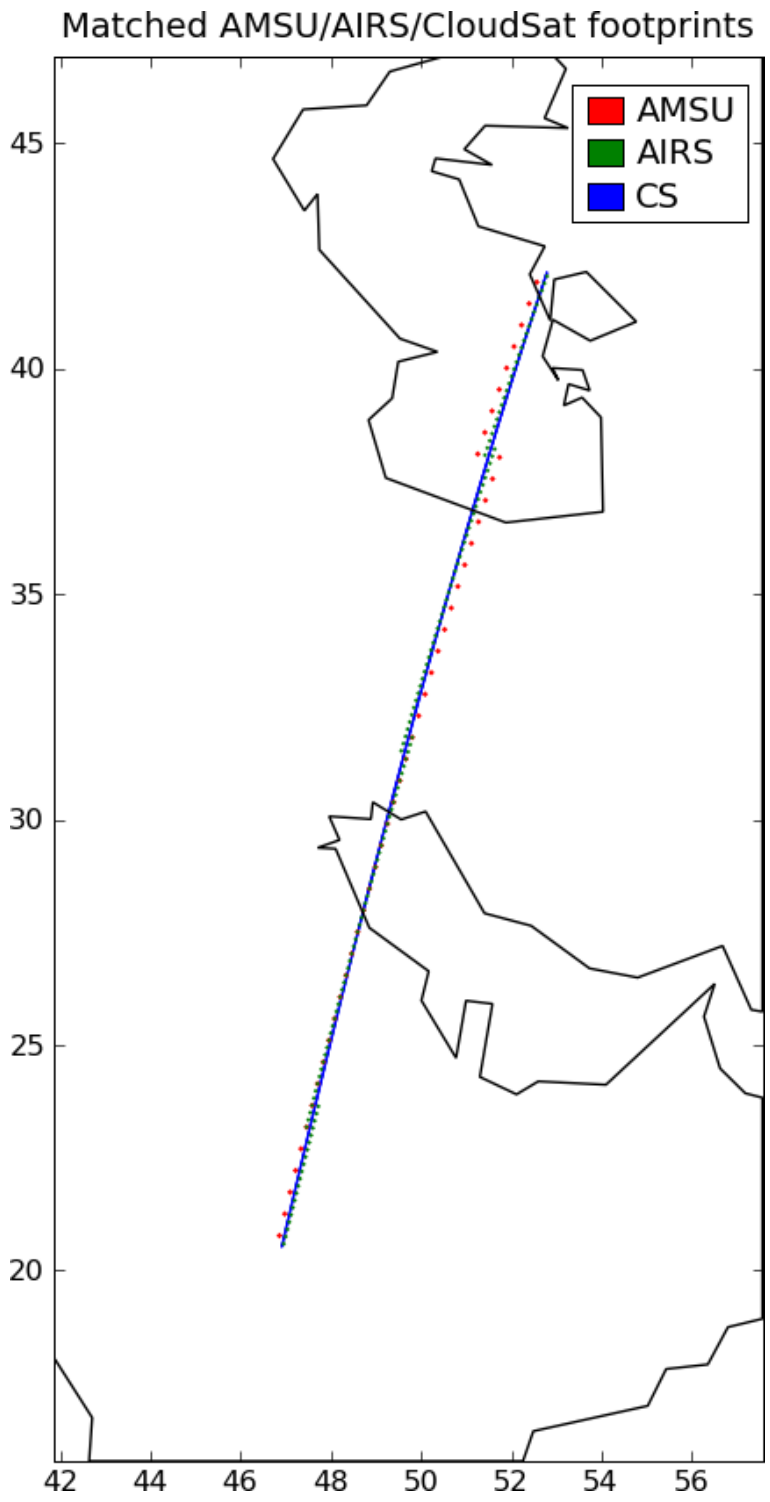


Figure 1.5: Matched Footprints Plot

1.2.2 Variable Subsetting and Aggregation

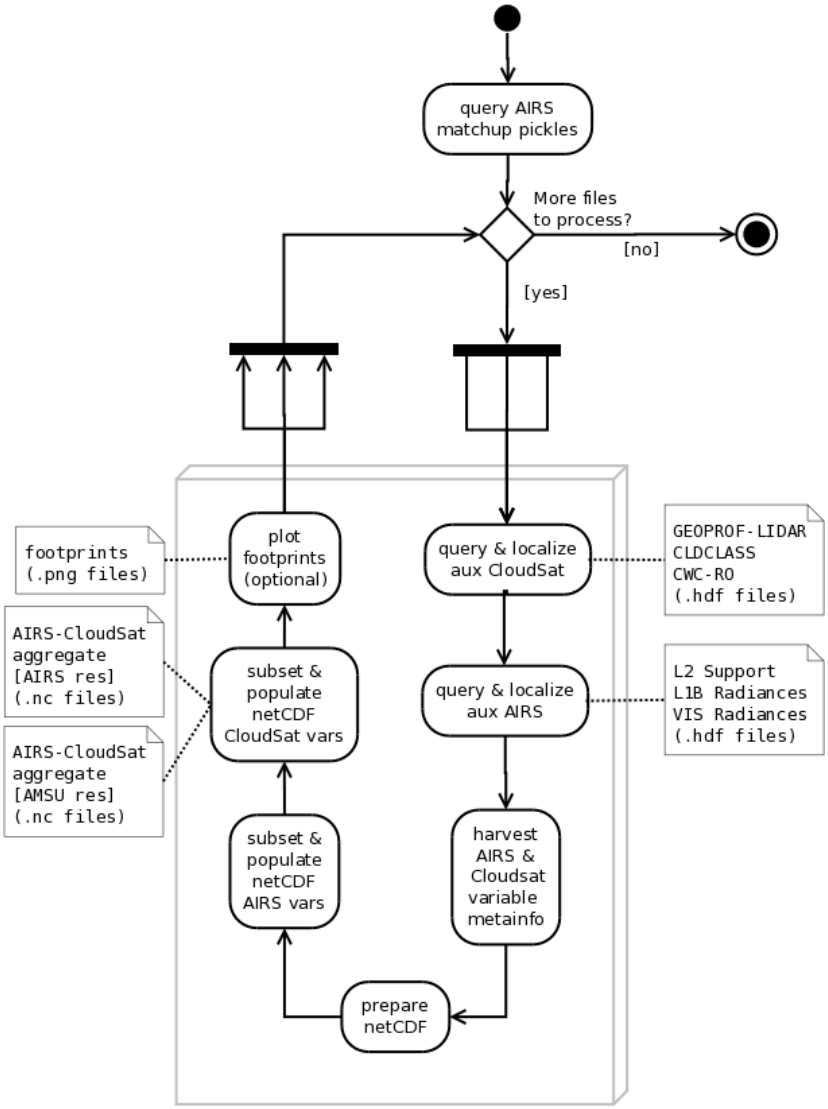


Figure 1.6: Variable Subsetting and Aggregation Activity Diagram

Figure 1.6 shows a high-level activity diagram of the subset & aggregation workflow. The list of AIRS matchups drives the workflow and spawns concurrent workUnits to handle these tasks. Note that execution of this workflow results in the localization & caching of additional AIRS (L2 Support, L1B Radiances, VIS Radiances) and CloudSat (GEOPROF-LIDAR, CLDLCLASS, CWC-RO) granules. Optionally, footprint plots may be generated to validate the matchup indices.

Which dataset (AIRS & CloudSat) product variables are included in the final merged product is driven by an xml configuration file generated as a result of the WVCC variable voting application (http://sciflo.jpl.nasa.gov/wsgi/wvc_varlister/).

1.3 Data Disclaimer

For any questions regarding this dataset, please contact Gerald Manipon at Geraldjohn.M.Manipon@jpl.nasa.gov.

For detailed information on the v6 AMSU/AIRS data, consult the documentation located at http://disc.sci.gsfc.nasa.gov/AIRS/documentation.

For detailed information on the R04 CloudSat data, consult the documentation located at http://www.cloudsat.cira.colostate.edu/dataHome.php.

For information on the directory structure and filename conventions used for the AIRS-CloudSat matchups, consult the documentation located at http://www.cloudsat.cira.colostate.edu/dataHome.php.

For information and access tools pertaining to NetCDF, consult the documentation at http://www.unidata.ucar.edu/software/netcdf/.

For information on the Python programming language, consult the documentation at http://www.python.org.

2.0 Data Organization

The data consists of:

1) the AIRS-CloudSat matchup index files in text and NetCDF4 formats
    - ShortName = AIRS_CPR_IND
    - LongName = AIRS-CloudSat cloud mask and radar reflectivities collocation indexes
    - VersionID = 040
    - DOI = 10.5067/MEASURES/WVCC/DATA204
    - DOI_Authority = http://dx.doi.org/
2) the AIRS-CloudSat matched variables in AIRS and AMSU resolutions aggregated in NetCDF4 files
    - ShortName = AIRS_CPR_MAT
    - LongName = AIRS-CloudSat cloud mask, radar reflectivities, and cloud classification matchups
    - VersionID = 040
    - DOI = 10.5067/MEASURES/WVCC/DATA205
    - DOI_Authority = http://dx.doi.org/

All products are indexed by AIRS granules thus for each day there are 240 files per product.

2.1 File Naming Convention

2.1.1 AIRS_CPR_IND (Matchup Index Text and NetCDF4 Files)

index-airs.aqua_cloudsat-*vm.m-yyyy.mm.dd.ggg*.(txt|nc4)

Where:
- m.m = algorithm version identifier is made up of major version and minor version, respectively.
- yyyy = 4 digit year number [2006 -].
- mm = 2 digit month number [01-12]
- dd = day of month [01-31]
- ggg = granule number [1-240]

Filename example: index-airs.aqua_cloudsat-v4.0-2006.06.15.167.txt, index-airs.aqua_cloudsat-v4.0-2006.06.15.167.nc4

2.1.2 AIRS_CPR_MAT (Aggregate AIRS/AMSU/CloudSat NetCDF4 Files)

matched-airs.aqua_cloudsat-*vm.m-yyyy.mm.dd.ggg*_airs.nc4

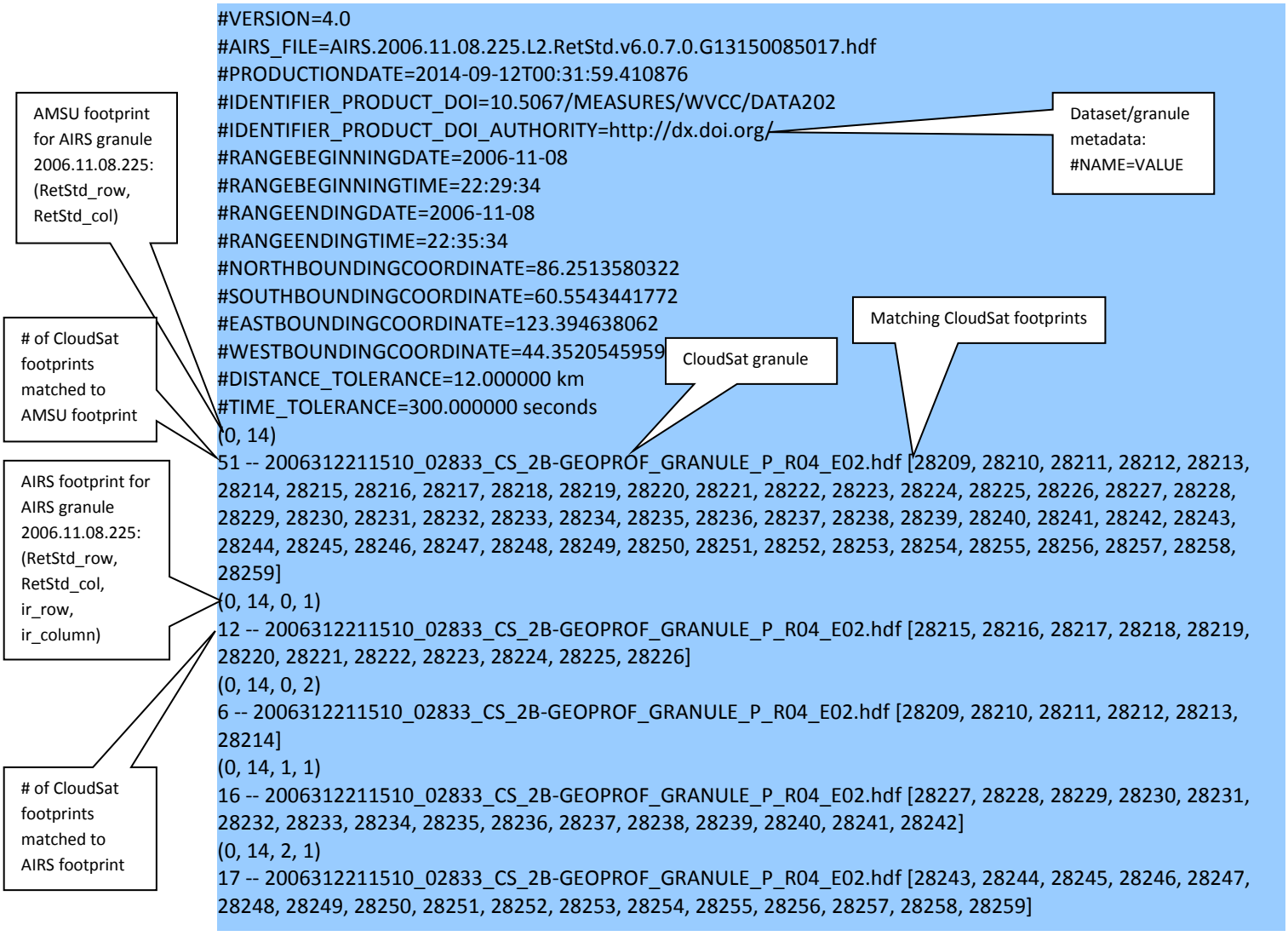
Where:

- m.m = algorithm version identifier is made up of major version and minor version, respectively.
- yyyy = 4 digit year number [2006 -].
- mm = 2 digit month number [01-12]
- dd = day of month [01-31]
- ggg = granule number [1-240]

Filename example: matched-airs.aqua_cloudsat-v4.0-2006.06.15.185_airs.nc4

2.2 File Format and Structure

The AIRS_CPR_IND (matchup index file) data type is in text and NetCDF4 format and contains the AIRS-CloudSat matchup indices in both AIRS and AMSU resolutions. An example from the following matchup file, index-airs.aqua_cloudsat-v4.0-2006.11.08.225.txt, will serve to explain its format:



The AIRS_CPR_MAT (aggregate AIRS/AMSU/CloudSat file) data type is in NetCDF4 format (http://www.unidata.ucar.edu/software/netcdf/) and contains the CloudSat and AIRS variables of interest sliced along the matched CloudSat-AIRS footprints and CloudSat-AMSU footprints.

In the aggregate product, the original variable names from each source's dataset are preserved along with the containing HDF group by utilizing the following HDF grouping structure:

/<dataset>/<resolution>/<product>/<variable name>

Where:

- dataset = either "AIRS" or "CloudSat"
- resolution = either "AIRS_resolution" or "AMSU_resolution"
- product = for AIRS either "L2_Standard_atmospheric&surface_product", "L1B_AIRS_Science", "L2_Support_atmospheric&surface_product"; for CloudSat either "2B-GEOPROF", "2B-GEOPROF-LIDAR", "2B-CLDCLASS", "2B-TAU", or "2B-CWC-RO"
- variable name = variable name in source dataset product

variable name examples: /AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/CldFrcStd, /AIRS/AIRS_resolution/L1B_AIRS_Science/radiances, /CloudSat/AMSU_resolution/2B-GEOPROF/MODIS_scene_var, /CloudSat/AIRS_resolution/2B-CLDCLASS/Data_status

2.3 Key Science Data Fields

Important notes on variable names

The variables listed below are replicated from AIRS, CloudSat or CALIPSO data products. Variable names indicate their sources; the leading field of the variable describes the instrument(s), the second field is the source file, and the third field is identical to the names in the corresponding source file.

Current instrument sources are AIRS, CloudSat and CALIPSO.

Current file sources are

L1B_AIRS_Science: AIRS/AMSU radiances products (Level 1b). All AIRS/AMSU variables are described in the document AIRS *Version 6.1 Processing Files Description*, January 2015.

L2_Standard_atmospheric&surfact_product: AIRS/AMSU Standard Product (Level 2 retrievals). All AIRS/AMSU variables are described in the document AIRS *Version 6.1 Processing Files Description*, January 2015.

L2_Support_atmospheric&surface_product: AIRS/AMSU Support Products (L2). All AIRS/AMSU variables are described in the document AIRS *Version 6.1 Processing Files Description*, January 2015.

2B-GEOPROF: CloudSat radar geolocation information. See *CloudSat Standard Data Products Handbook*, May 18, 2006.

2B-GEOPROF-LIDAR: CALIPSO lidar geolocation information. See *CloudSat Standard Data Products Handbook*, May 18, 2006.

2B-CLDCLASS: CloudSat cloud classes. See *Level 2 Cloud Scenario Classification Product Process Description and Interface Control Document*, Version: 4.0, March 1, 2005.

***Example**:* variable /AIRS/AIRS_resolution/L1B_AIRS_Science/Latitude

Source instruments: AIRS (designates the AIRS/AMSU instrument suite).

AIRS or AMSU resolution: designates the AIRS/AMSU variable resolution.

L2_Standard_atmospheric&surface_product: File source is AIRS/AMSU Standard Product (Level 2 retrievals).

Latitude: latitudes of AIRS spectral within an AMSU FOV (dimensioned 3 X 3).

The following table lists the variables in the AIRS_CPR_MAT (aggregate AIRS/AMSU/CloudSat file) data type:

Variable name	Long name (units)
/AIRS/spectral_freq	spectral_freq
/AIRS/glintlat	glintlat
/AIRS/glintlon	glintlon
/AIRS/pressH2O	pressH2O
/AIRS/pressStd	pressStd
/AIRS/sat_lat	sat_lat
/AIRS/sat_lon	sat_lon
/AIRS/pressSupp	pressSupp
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/CldFrcStd	Comment: This is a retrieved quantity, but reported at the same locations as the AIRS spectra. All other AIRS/AMSU retrieved quantities are reported at the AMSU resolution (see next table).
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/CldFrcStdErr	CldFrcStdErr
/AIRS/AIRS_resolution/L2_Support_atmospheric&surface_product/pseudo_lapse_rate	pseudo_lapse_rate
/AIRS/AIRS_resolution/L1B_AIRS_Science/Latitude	Latitude

/AIRS/AIRS_resolution/L1B_AIRS_Science/Longitude	Longitude
/AIRS/AIRS_resolution/L1B_AIRS_Science/dust_flag	dust_flag
/AIRS/AIRS_resolution/L1B_AIRS_Science/radiances	radiances
/AIRS/AIRS_resolution/L1B_AIRS_Science/topog	topog
/AIRS/AIRS_resolution/L1B_AIRS_Science/topog_err	topog_err
/AIRS/AMSU_resolution/L2_Standard_atmospheric&surface_product/GP_Height	GP_Height
/AIRS/AMSU_resolution/L2_Standard_atmospheric&surface_product/GP_Tropopause	GP_Tropopause
/AIRS/AMSU_resolution/L2_Standard_atmospheric&surface_product/H2OMMRSat	H2OMMRSat
/AIRS/AMSU_resolution/L2_Standard_atmospheric&surface_product/H2OMMRSat_liquid	H2OMMRSat_liquid
/AIRS/AMSU_resolution/L2_Standard_atmospheric&surface_product/H2OMMRStd	H2OMMRStd
/AIRS/AMSU_resolution/L2_Standard_atmospheric&surface_product/H2OMMRStdErr	H2OMMRStdErr
/AIRS/AMSU_resolution/L2_Standard_atmospheric&surface_product/H2O_verticality	H2O_verticality
/AIRS/AMSU_resolution/L2_Standard_atmospheric&surface_product/Latitude	Latitude (degrees_north)
/AIRS/AMSU_resolution/L2_Standard_atmospheric&surface_product/Longitude	Longitude (degrees_east)
/AIRS/AMSU_resolution/L2_Standard_atmospheric&surface_product/MWSurfClass	MWSurfClass
/AIRS/AMSU_resolution/L2_Standard_atmospheric&surface_product/O3VMRStd	O3VMRStd
/AIRS/AMSU_resolution/L2_Standard_atmospheric&surface_product/O3VMRStdErr	O3VMRStdErr
/AIRS/AMSU_resolution/L2_Standard_atmospheric&surface_product/PBest	PBest
/AIRS/AMSU_resolution/L2_Standard_atmospheric&surface_product/PGood	PGood
/AIRS/AMSU_resolution/L2_Standard_atmospheric&surface_product/PSurfStd	PSurfStd
/AIRS/AMSU_resolution/L2_Standard_atmospheric&surface_product/PTropopause	PTropopause
/AIRS/AMSU_resolution/L2_Standard_atmospheric&surface_product/TAirMWOnlyStd	TAirMWOnlyStd
/AIRS/AMSU_resolution/L2_Standard_atmospheric&surface_product/TAirStd	TAirStd
/AIRS/AMSU_resolution/L2_Standard_atmospheric&surface_product/TAirStdErr	TAirStdErr
/AIRS/AMSU_resolution/L2_Standard_atmospheric&surface_product/TSurfAir	TSurfAir
/AIRS/AMSU_resolution/L2_Standard_atmospheric&surface_product/TSurfAirErr	TSurfAirErr
/AIRS/AMSU_resolution/L2_Standard_atmospheric&surface_product/TSurfStd	TSurfStd
/AIRS/AMSU_resolution/L2_Standard_atmospheric&surface_product/Time	Time
/AIRS/AMSU_resolution/L2_Standard_atmospheric&surface_product/clrolr	clrolr
/AIRS/AMSU_resolution/L2_Standard_atmospheric&surface_product/emisIRStd	emisIRStd
/AIRS/AMSU_resolution/L2_Standard_atmospheric&surface_product/freqEmis	freqEmis
/AIRS/AMSU_resolution/L2_Standard_atmospheric&surface_product/landFrac	landFrac
/AIRS/AMSU_resolution/L2_Standard_atmospheric&surface_product/nBestStd	nBestStd
/AIRS/AMSU_resolution/L2_Standard_atmospheric&surface_product/nGoodStd	nGoodStd
/AIRS/AMSU_resolution/L2_Standard_atmospheric&surface_product/nSurfStd	nSurfStd
/AIRS/AMSU_resolution/L2_Standard_atmospheric&surface_product/olr	olr
/AIRS/AMSU_resolution/L2_Standard_atmospheric&surface_product/olr_err	olr_err
/AIRS/AMSU_resolution/L2_Standard_atmospheric&surface_product/satazi	satazi
/AIRS/AMSU_resolution/L2_Standard_atmospheric&surface_product/satzen	satzen
/AIRS/AMSU_resolution/L2_Standard_atmospheric&surface_product/solazi	solazi
/AIRS/AMSU_resolution/L2_Standard_atmospheric&surface_product/solzen	solzen

/AIRS/AMSU_resolution/L2_Standard_atmospheric&surface_product/totH2OMWOnlyStd	totH2OMWOnlyStd
/AIRS/AMSU_resolution/L2_Standard_atmospheric&surface_product/totH2OStdErr	totH2OStdErr
/AIRS/AMSU_resolution/L2_Support_atmospheric&surface_product/CldEmis	CldEmis
/AIRS/AMSU_resolution/L2_Support_atmospheric&surface_product/CldRho	CldRho
/AIRS/AMSU_resolution/L2_Support_atmospheric&surface_product/CO_VMR_eff	CO_VMR_eff
/AIRS/AMSU_resolution/L2_Support_atmospheric&surface_product/H2OCDSup	H2OCDSup
/AIRS/AMSU_resolution/L2_Support_atmospheric&surface_product/H2OCDSupErr	H2OCDSupErr
/AIRS/AMSU_resolution/L2_Support_atmospheric&surface_product/Latitude	Latitude (degrees_north)
/AIRS/AMSU_resolution/L2_Support_atmospheric&surface_product/Longitude	Longitude (degrees_east)
/AIRS/AMSU_resolution/L2_Support_atmospheric&surface_product/O3CDSup	O3CDSup
/AIRS/AMSU_resolution/L2_Support_atmospheric&surface_product/PCldTopStd	PCldTopStd
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/AIRS/AMSU_resolution/L2_Support_atmospheric&surface_product/TAirMWOnly	TAirMWOnly
/AIRS/AMSU_resolution/L2_Support_atmospheric&surface_product/TAirSup	TAirSup
/AIRS/AMSU_resolution/L2_Support_atmospheric&surface_product/TAirSupErr	TAirSupErr
/AIRS/AMSU_resolution/L2_Support_atmospheric&surface_product/TCldTopStd	TCldTopStd
/AIRS/AMSU_resolution/L2_Support_atmospheric&surface_product/TCldTopStdErr	TCldTopStdErr
/AIRS/AMSU_resolution/L2_Support_atmospheric&surface_product/TSurfStd	TSurfStd
/AIRS/AMSU_resolution/L2_Support_atmospheric&surface_product/TSurfStdErr	TSurfStdErr
/AIRS/AMSU_resolution/L2_Support_atmospheric&surface_product/T_Tropopause	T_Tropopause
/AIRS/AMSU_resolution/L2_Support_atmospheric&surface_product/numCloud	numCloud
/AIRS/AMSU_resolution/L2_Support_atmospheric&surface_product/totH2OStd	totH2OStd
/AIRS/AMSU_resolution/L2_Support_atmospheric&surface_product/tsurf_forecast	tsurf_forecast
/CloudSat/AIRS_resolution/2B-GEOPROF/CPR_Cloud_mask	CPR Cloud Mask
/CloudSat/AIRS_resolution/2B-GEOPROF/MODIS_Cloud_Fraction	MODIS 250m Cloud Fraction
/CloudSat/AIRS_resolution/2B-GEOPROF/MODIS_scene_char	MODIS scene characterizations
/CloudSat/AIRS_resolution/2B-GEOPROF/MODIS_scene_var	MODIS scene variability
/CloudSat/AIRS_resolution/2B-CLDCLASS/DEM_elevation	DEM_elevation
/CloudSat/AIRS_resolution/2B-CLDCLASS/Data_quality	Data Quality (--)
/CloudSat/AIRS_resolution/2B-CLDCLASS/Data_status	Data status flags (--)
/CloudSat/AIRS_resolution/2B-CLDCLASS/Data_targetID	CPR bus orientation (target ID) (--)
/CloudSat/AIRS_resolution/2B-CLDCLASS/Height	Height
/CloudSat/AIRS_resolution/2B-CLDCLASS/Latitude	Latitude (degrees_north)
/CloudSat/AIRS_resolution/2B-CLDCLASS/Longitude	Longitude
/CloudSat/AIRS_resolution/2B-CLDCLASS/cloud_scenario	Cloud scenario (none)
/CloudSat/AIRS_resolution/2B-GEOPROF-LIDAR/CloudFraction	Cloud Fraction
/CloudSat/AIRS_resolution/2B-GEOPROF-LIDAR/CloudLayers	Number of hydrometeor layers
/CloudSat/AIRS_resolution/2B-GEOPROF-LIDAR/Data_quality	Data Quality (--)
/CloudSat/AIRS_resolution/2B-GEOPROF-LIDAR/Data_status	Data status flags (--)

/CloudSat/AIRS_resolution/2B-GEOPROF-LIDAR/FlagBase	Flag of layer base
/CloudSat/AIRS_resolution/2B-GEOPROF-LIDAR/FlagTop	Flag of layer top
/CloudSat/AIRS_resolution/2B-GEOPROF-LIDAR/Height	Height
/CloudSat/AIRS_resolution/2B-GEOPROF-LIDAR/Latitude	Latitude (degrees_north)
/CloudSat/AIRS_resolution/2B-GEOPROF-LIDAR/LayerBase	Height of Layer Base (m)
/CloudSat/AIRS_resolution/2B-GEOPROF-LIDAR/LayerTop	Height of layer top (m)
/CloudSat/AIRS_resolution/2B-GEOPROF-LIDAR/Longitude	Longitude
/CloudSat/AIRS_resolution/2B-GEOPROF-LIDAR/UncertaintyCF	Uncertainty of Cloud Fraction
/CloudSat/AIRS_resolution/2B-CWC-RO/RO_ice_distrib_width_param	Radar-only Ice Distribution Width Parameter (--)
/CloudSat/AIRS_resolution/2B-CWC-RO/RO_ice_distrib_width_param_uncertainty	Radar-only Ice Distribution Width Parameter Uncertainty (%)
/CloudSat/AIRS_resolution/2B-CWC-RO/RO_ice_effective_radius	Radar-only Ice Effective Radius (um)
/CloudSat/AIRS_resolution/2B-CWC-RO/RO_ice_effective_radius_uncertainty	Radar-only Ice Effective Radius Uncertainty (%)
/CloudSat/AIRS_resolution/2B-CWC-RO/RO_ice_num_conc_uncertainty	Radar-only Ice Number Concentration Uncertainty (%)
/CloudSat/AIRS_resolution/2B-CWC-RO/RO_ice_number_conc	Radar-only Ice Number Concentration (L^{-1})
/CloudSat/AIRS_resolution/2B-CWC-RO/RO_ice_phase_fraction	Radar-only Ice Phase Fraction (--)
/CloudSat/AIRS_resolution/2B-CWC-RO/RO_ice_water_content	Radar-only Ice Water Content (mg m^{-3})
/CloudSat/AIRS_resolution/2B-CWC-RO/RO_ice_water_content_uncertainty	Radar-only Ice Water Content Uncertainty (%)
/CloudSat/AIRS_resolution/2B-CWC-RO/RO_ice_water_path	Radar-only Ice Water Path (g m^{-2})
/CloudSat/AIRS_resolution/2B-CWC-RO/RO_ice_water_path_uncertainty	Radar-only Ice Water Path Uncertainty (%)
/CloudSat/AIRS_resolution/2B-CWC-RO/RO_liq_distrib_width_param	Radar-only Liquid Distribution Width Parameter (--)
/CloudSat/AIRS_resolution/2B-CWC-RO/RO_liq_distrib_width_param_uncertainty	Radar-only Liquid Distribution Width Parameter Uncertainty (%)
/CloudSat/AIRS_resolution/2B-CWC-RO/RO_liq_effective_radius	Radar-only Liquid Effective Radius (um)
/CloudSat/AIRS_resolution/2B-CWC-RO/RO_liq_effective_radius_uncertainty	Radar-only Liquid Effective Radius Uncertainty (%)
/CloudSat/AIRS_resolution/2B-CWC-RO/RO_liq_num_conc_uncertainty	Radar-only Liquid Number Concentration Uncertainty (%)
/CloudSat/AIRS_resolution/2B-CWC-RO/RO_liq_number_conc	Radar-only Liquid Number Concentration (cm^{-3})
/CloudSat/AIRS_resolution/2B-CWC-RO/RO_liq_water_content	Radar-only Liquid Water Content (mg m^{-3})
/CloudSat/AIRS_resolution/2B-CWC-RO/RO_liq_water_content_uncertainty	Radar-only Liquid Water Content Uncertainty (%)
/CloudSat/AIRS_resolution/2B-CWC-RO/RO_liq_water_path	Radar-only Liquid Water Path (g m^{-2})
/CloudSat/AIRS_resolution/2B-CWC-RO/RO_liq_water_path_uncertainty	Radar-only Liquid Water Path Uncertainty (%)
/CloudSat/AMSU_resolution/2B-GEOPROF/CPR_Cloud_mask	CPR Cloud Mask
/CloudSat/AMSU_resolution/2B-GEOPROF/MODIS_Cloud_Fraction	MODIS 250m Cloud Fraction
/CloudSat/AMSU_resolution/2B-GEOPROF/MODIS_scene_char	MODIS scene characterizations
/CloudSat/AMSU_resolution/2B-GEOPROF/MODIS_scene_var	MODIS scene variability
/CloudSat/AMSU_resolution/2B-CLDCLASS/DEM_elevation	DEM_elevation

/CloudSat/AMSU_resolution/2B-CLDCLASS/Data_quality	Data Quality (--)
/CloudSat/AMSU_resolution/2B-CLDCLASS/Data_status	Data status flags (--)
/CloudSat/AMSU_resolution/2B-CLDCLASS/Data_targetID	CPR bus orientation (target ID) (--)
/CloudSat/AMSU_resolution/2B-CLDCLASS/Height	Height
/CloudSat/AMSU_resolution/2B-CLDCLASS/Latitude	Latitude (degrees_north)
/CloudSat/AMSU_resolution/2B-CLDCLASS/Longitude	Longitude
/CloudSat/AMSU_resolution/2B-CLDCLASS/cloud_scenario	Cloud scenario (none)
/CloudSat/AMSU_resolution/2B-GEOPROF-LIDAR/CloudFraction	Cloud Fraction
/CloudSat/AMSU_resolution/2B-GEOPROF-LIDAR/CloudLayers	Number of hydrometeor layers
/CloudSat/AMSU_resolution/2B-GEOPROF-LIDAR/Data_quality	Data Quality (--)
/CloudSat/AMSU_resolution/2B-GEOPROF-LIDAR/Data_status	Data status flags (--)
/CloudSat/AMSU_resolution/2B-GEOPROF-LIDAR/FlagBase	Flag of layer base
/CloudSat/AMSU_resolution/2B-GEOPROF-LIDAR/FlagTop	Flag of layer top
/CloudSat/AMSU_resolution/2B-GEOPROF-LIDAR/Height	Height
/CloudSat/AMSU_resolution/2B-GEOPROF-LIDAR/Latitude	Latitude (degrees_north)
/CloudSat/AMSU_resolution/2B-GEOPROF-LIDAR/LayerBase	Height of Layer Base (m)
/CloudSat/AMSU_resolution/2B-GEOPROF-LIDAR/LayerTop	Height of layer top (m)
/CloudSat/AMSU_resolution/2B-GEOPROF-LIDAR/Longitude	Longitude
/CloudSat/AMSU_resolution/2B-GEOPROF-LIDAR/UncertaintyCF	Uncertainty of Cloud Fraction
/CloudSat/AMSU_resolution/2B-CWC-RO/RO_ice_distrib_width_param	Radar-only Ice Distribution Width Parameter (--)
/CloudSat/AMSU_resolution/2B-CWC-RO/RO_ice_distrib_width_param_uncertainty	Radar-only Ice Distribution Width Parameter Uncertainty (%)
/CloudSat/AMSU_resolution/2B-CWC-RO/RO_ice_effective_radius	Radar-only Ice Effective Radius (um)
/CloudSat/AMSU_resolution/2B-CWC-RO/RO_ice_effective_radius_uncertainty	Radar-only Ice Effective Radius Uncertainty (%)
/CloudSat/AMSU_resolution/2B-CWC-RO/RO_ice_num_conc_uncertainty	Radar-only Ice Number Concentration Uncertainty (%)
/CloudSat/AMSU_resolution/2B-CWC-RO/RO_ice_number_conc	Radar-only Ice Number Concentration (L^{-1})
/CloudSat/AMSU_resolution/2B-CWC-RO/RO_ice_phase_fraction	Radar-only Ice Phase Fraction (--)
/CloudSat/AMSU_resolution/2B-CWC-RO/RO_ice_water_content	Radar-only Ice Water Content (mg m^{-3})
/CloudSat/AMSU_resolution/2B-CWC-RO/RO_ice_water_content_uncertainty	Radar-only Ice Water Content Uncertainty (%)
/CloudSat/AMSU_resolution/2B-CWC-RO/RO_ice_water_path	Radar-only Ice Water Path (g m^{-2})
/CloudSat/AMSU_resolution/2B-CWC-RO/RO_ice_water_path_uncertainty	Radar-only Ice Water Path Uncertainty (%)
/CloudSat/AMSU_resolution/2B-CWC-RO/RO_liq_distrib_width_param	Radar-only Liquid Distribution Width Parameter (--)
/CloudSat/AMSU_resolution/2B-CWC-RO/RO_liq_distrib_width_param_uncertainty	Radar-only Liquid Distribution Width Parameter Uncertainty (%)
/CloudSat/AMSU_resolution/2B-CWC-RO/RO_liq_effective_radius	Radar-only Liquid Effective Radius (um)
/CloudSat/AMSU_resolution/2B-CWC-RO/RO_liq_effective_radius_uncertainty	Radar-only Liquid Effective Radius Uncertainty (%)
/CloudSat/AMSU_resolution/2B-CWC-RO/RO_liq_num_conc_uncertainty	Radar-only Liquid Number Concentration Uncertainty (%)
/CloudSat/AMSU_resolution/2B-CWC-RO/RO_liq_number_conc	Radar-only Liquid Number

	Concentration (cm^{-3})
/CloudSat/AMSU_resolution/2B-CWC-RO/RO_liq_water_content	Radar-only Liquid Water Content (mg m^{-3})
/CloudSat/AMSU_resolution/2B-CWC-RO/RO_liq_water_content_uncertainty	Radar-only Liquid Water Content Uncertainty (%)
/CloudSat/AMSU_resolution/2B-CWC-RO/RO_liq_water_path	Radar-only Liquid Water Path (g m^{-2})
/CloudSat/AMSU_resolution/2B-CWC-RO/RO_liq_water_path_uncertainty	Radar-only Liquid Water Path Uncertainty (%)

2.3.1 Science Area 1: Atmospheric Moist Processes and Trends

The AIRS variables in the table below are particularly relevant to studies of atmospheric moist thermodynamics, including trending. The Level 3 products being created for this MEaSUREs project are based mostly on these variables. This table will be expanded to include MLS temperature and water vapor profiles and AMSR-E total precipitable water vapor; the L3 data will include them. Quantities in bold are fundamental observed quantities.

2.3.2 Science Area 2: Atmospheric Water Cycle

The comments immediately above also hold for studies of the atmospheric water cycle.

Variable name	Variable Descriptor
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/CldFrcStd	Retrieved quantity
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/TSurfAirErr	Error estimate on retrieved quantity
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/H2O_verticality	Retrieved quantity
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/TCldTopStdErr	Error estimate on retrieved quantity
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/nSurfStd	Retrieved quantity
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/Longitude	Independent geospatial coordinate
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/PBest	Quality flag or parameter
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/nStd_mid_top_bndry	Quality flag or parameter
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/TSurfStdErr	Error estimate on retrieved quantity
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/Qual_H2O	Quality flag or parameter
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/totH2OStd	**Retrieved total water vapor**
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/TAirMWOnlyStd	Retrieved quantity
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/GP_Height	Retrieved quantity
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/olr	Retrieved quantity
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/Qual_Temp_Profile_Bot	Quality flag or parameter
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/H2OMMRSat	Retrieved quantity
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/clrolr	Retrieved quantity
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/TSurfStd	Retrieved quantity
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/solazi	Independent geospatial coordinate

/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/numCloud	Retrieved quantity
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/Qual_Temp_Profile_Top	Quality flag or parameter
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/Qual_Temp_Profile_Mid	Quality flag or parameter
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/PCldTopStd	Retrieved quantity
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/clrolr_err	Error estimate on retrieved quantity
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/landFrac_err	Error estimate on retrieved quantity
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/PCldTopStdErr	Error estimate on retrieved quantity
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/PGood	Quality flag or parameter
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/TCldTopStd	Retrieved quantity
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/olr_err	Error estimate on retrieved quantity
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/PSurfStd	Provided by model forecast
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/totH2OStdErr	Error estimate on retrieved quantity
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/landFrac	Retrieved quantity / Independent geospatial coordinate
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/solzen	Independent geospatial coordinate
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/nStd_bot_mid_bndry	Quality flag or parameter
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/PTropopause	Retrieved quantity
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/GP_Tropopause	Retrieved quantity
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/TAirStdErr	Error estimate on retrieved quantity
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/TAirStd	**Retrieved atmospheric temperature**
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/H2OMMRSat_liquid	Retrieved quantity
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/Press_mid_top_bndry	Quality flag or parameter
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/Time	Independent geospatial coordinate
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/satzen	Independent geospatial coordinate
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/nGoodStd	Quality flag or parameter
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/nBestStd	Quality flag or parameter
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/TSurfAir	**Retrieved surface air temperature**
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/H2OMMRStd	**Retrieved water vapor profile**
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/Latitude	Independent geospatial coordinate
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/totH2OMWOnlyStd	**Total water vapor retrieved from microwave observations**
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/H2OMMRStdErr	Error estimate on retrieved quantity
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/Press_bot_mid_bndry	Quality flag or parameter
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/satazi	Independent geospatial coordinate
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/glintlon	Independent geospatial coordinate
/AIRS/AIRS_resolution/L2_Standard_atmospheric&surface_product/T_Tropopause	Retrieved quantity
/AIRS/AIRS_resolution/L2_Support_atmospheric&surface_product/TAirMWOnly	Retrieved quantity
/AIRS/AIRS_resolution/L2_Support_atmospheric&surface_product/H2OCDSup	**Retrieved water vapor profile at high vertical resolution**
/AIRS/AIRS_resolution/L2_Support_atmospheric&surface_product/pressSupp	Independent geospatial coordinate

/AIRS/AIRS_resolution/L2_Support_atmospheric&surface_product/H2OCDSupErr	Error estimate on retrieved quantity
/AIRS/AIRS_resolution/L2_Support_atmospheric&surface_product/TAirSup	**Retrieved temperature profiles at high vertical resolution**
/AIRS/AIRS_resolution/L2_Support_atmospheric&surface_product/TAirSupErr	Error estimate on retrieved quantity

3.0 Data Contents

3.1 Dimensions

3.1.1 AIRS_CPR_IND (Matchup Index File)

Name	Description
/matchup	Matchup index (unlimited dimension)
/airs_idx_size	GeoTrack, GeoXTrack, AIRSTrack, AIRSXTrack (4)

3.1.2 AIRS_CPR_MAT (Aggregate AIRS/AMSU/CloudSat Variables File)

Name	Description
/matchup	Matchup index (unlimited dimension)
/airs_idx_size	GeoTrack, GeoXTrack, AIRSTrack, AIRSXTrack (4)
/amsu_matchup	AMSU resolution matchup
/amsu_track_matchup	AMSU resolution track matchup
/airs_matchup	AIRS resolution matchup
/AIRS/GeoTrack_L1B_AIRS_Science	From AIRS L1B Radiances Product
/AIRS/GeoXTrack_L1B_AIRS_Science	From AIRS L1B Radiances Product
/AIRS/Channel_L1B_AIRS_Science	From AIRS L1B Radiances Product
/AIRS/VDFDim0_vdata_L1B_AIRS_Science_Data_Fields_spectral_freq_vdf_spectral_freq	From AIRS L1B Radiances Product
/AIRS/AIRSXTrack	3
/AIRS/GeoXTrack	30
/AIRS/GeoTrack	45
/AIRS/AIRSTrack	3
/AIRS/Cloud	numCloud from AIRS RetStd Product (2)
/AIRS/StdPressureLev	pressStd from AIRS RetStd Product (28)
/AIRS/H2OPressureLay	pressH2O from AIRS RetStd Product (14)
/AIRS/H2OFunc	num_H2O_Func from AIRS RetStd Product (11)
/AIRS/StdPressureLay	pressH2O from AIRS RetStd Product (28)
/AIRS/HingeSurf	HingeSurf from AIRS L1B Radiances Product (100)
/AIRS/H2OPressureLev	15
/AIRS/HingeCloud	7
/AIRS/COFunc	num_CO_Func from AIRS RetStd Product (9)

/AIRS/XtraPressureLay	100
/AIRS/XtraPressureLev	100
/CloudSat/nbin	nbin:2B-GEOPROF from CloudSat GEOPROF Product (125)
/CloudSat/nray	37083
/CloudSat/scalar	1
/CloudSat/ncloud	ncloud:2B-GEOPROF-LIDAR from CloudSat GEOPROF-LIDAR Product (5)
/CloudSat/AIRS_resolution/cs_idx	CloudSat footprint matchup index
/CloudSat/AMSU_resolution/cs_idx	CloudSat footprint matchup index

3.2 Global Attributes

Global metadata is also stored in the files. Some metadata are required by standard conventions, some are present to meet data provenance requirements and others as a convenience to users of the WVCC AIRS-CloudSat merged dataset. A summary of global attributes present in all netcdf files is shown in Table 3.3.

Global Attribute	Type	Description
AIRS_FILE	String	Specifies AIRS granule used for the matchup
PRODUCTIONDATE	String	Specifies production time in the format YYYYMMDDHHSS
RANGEBEGINNINGDATE	String	Start date of AIRS granule
RANGEBEGINNINGTIME	String	Start time of AIRS granule
RANGEENDINGDATE	String	Ending date of AIRS granule
RANGEENDINGTIME	String	Ending date of AIRS granule
NORTHBOUNDINGCOORDINATE	Float	North bounding coordinate of AIRS granule
SOUTHBOUNDINGCOORDINATE	Float	South bounding coordinate of AIRS granule
EASTBOUNDINGCOORDINATE	Float	East bounding coordinate of AIRS granule
WESTBOUNDINGCOORDINATE	Float	West bounding coordinate of AIRS granule
IDENTIFIER_PRODUCT_DOI	String	DOI identifier
IDENTIFIER_PRODUCT_DOI_AUTHORITY	String	URL for DOI authority
DISTANCE_TOLERANCE	String	Distance tolerance used for matchup
TIME_TOLERANCE	String	Time tolerance used for matchup
VERSION	String	Production version

Table 3.3: Global metadata attributes associated with each netcdf file

A list of key metadata fields can be found in Table 3.4 - Key Metadata Items. Not listed here are variable attributes from the source dataset granule that were carried over. Global attributes in a netcdf file can be viewed with *ncdump* software:
ncdump –h -c <WVCC AIRS-CloudSat netcdf file>

Name	Type	Description
missing |_FillValue	Float|Int	Floating-point value used to identify missing data. Will normally be set to -9999.. Required by CF.
long_name	String	Long name
units	String	Units

Table 3.4: Key Metadata Items

3.3 Products/Parameters

Refer to section 2.3 for product parameters.

4.0 Options for Reading the Data

4.1 Command Line Utilities

ncdump

The ncdump tool can be used as a simple browser for NetCDF data files, to display the dimension names and sizes; variable names, types, and shapes; attribute names and values; and optionally, the values of data for all variables or selected variables in a NetCDF file. The most common use of ncdump is with the –h option, in which only the header information is displayed.

ncdump [-c|-h] [-v ...] [[-b|-f] [c|f]] [-l len] [-n name] [-d n[,n]] filename
Options/Arguments:
[-c] Coordinate variable data and header information
[-h] Header information only, no data
[-v var1[,...]] Data for variable(s) <var1>,... only data
[-f [c|f]] Full annotations for C or Fortran indices in data
[-l len] Line length maximum in data section (default 80)
[-n name] Name for netCDF (default derived from file name)
[-d n[,n]] Approximate floating-point values with less precision filename File name of input netCDF file

Note: the ncdump tool will only display variables whose ranks are great than 1. In other words, you will not see one dimensional vectors such as *satheight* using this tool.
The ncdump program can be found in bin directory of the HDF installation area. Consult your local computer system administrator for the specifics.

4.2 Tools/Programming

Here we provide some python code snippets.

4.2.1 Read Variables

```
import os
import netCDF4


def walktree(top):
    for k,v in top.variables.iteritems():
        desc = "%s" % v.__dict__.get('long_name', '')
        if v.__dict__.get('units', None) is not None:
            desc += " (%s)" % v.__dict__.get('units', None)
        print("%s|%s" % (os.path.join(top.path, k), desc))
    for k,g in top.groups.iteritems():
        walktree(g)


ncFile = 'matched-airs.aqua_cloudsat-v4.0-2006.08.26.061.nc4'

f = netCDF4.Dataset(ncFile)

# print all variables in the file
walktree(f)

# pull out some variables
cloud_scen = f.groups['CloudSat'].groups['AIRS_resolution'].groups['2B-CLDCLASS'].variables['cloud_scenario'][:]
heigth = f.groups['CloudSat'].groups['AIRS_resolution'].groups['2B-CLDCLASS'].variables['Height'][:]
csLat = f.groups['CloudSat'].groups['AIRS_resolution'].groups['2B-CLDCLASS'].variables['Latitude'][:]
radiances = f.groups['AIRS'].groups['AIRS_resolution'].groups['L1B_AIRS_Science'].variables['radiances'][:]

f.close()
```

4.2.2 Plot Cloud Scene

```
import os, sys, netCDF4, matplotlib
matplotlib.use('Agg')

import numpy as N
from mpl_toolkits.basemap import Basemap
import matplotlib.pyplot as plt
import matplotlib.cm as cm
from pylab import linspace
from scipy import interpolate
from matplotlib.colors import LinearSegmentedColormap

'''
Run from command-line like this:
$ python plotCloudScene.py matched-airs.aqua_cloudsat-v3.2-2006.10.07.240_airs.nc test.png
$ display test.png
'''

def cmap_discretize(cmap, n):

   """Return a discrete colormap from the continuous colormap cmap.

      cmap: colormap instance, eg. cm.jet.
      n: number of colors.

   Example
      x = resize(arange(100), (5,100))
      djet = cmap_discretize(cm.jet, 5)
      imshow(x, cmap=djet)
   """

   cdict = cmap._segmentdata.copy()
   # n colors
   colors_i = linspace(0,1.,n)
   # n+1 indices
   indices = linspace(0,1.,n+1)
   for key in ('red','green','blue'):
      # Find the n colors
      D = N.array(cdict[key])
      I = interpolate.interp1d(D[:,0], D[:,1])
      colors = I(colors_i)
      # Place these colors at the correct indices.
      A = N.zeros((n+1,3), float)
      A[:,0] = indices
      A[1:,1] = colors
      A[:-1,2] = colors
      # Create a tuple for the dictionary.
      L = []
      for l in A:
         L.append(tuple(l))
      cdict[key] = tuple(L)
   # Return colormap object.
   return LinearSegmentedColormap('colormap',cdict,1024)

#set input and output files
ncFile = sys.argv[1]
plotFile = sys.argv[2]

#continued on next page
```

```
#continued from previous  page

#read in vars
f = netCDF4.Dataset(ncFile)
fig = plt.figure()
fig.clf()
cloud_scen = f.groups['CloudSat'].groups['AIRS_resolution'].groups['2B-CLDCLASS'].variables['cloud_scenario'][:]
height = f.groups['CloudSat'].groups['AIRS_resolution'].groups['2B-CLDCLASS'].variables['Height'][:]
csLat = f.groups['CloudSat'].groups['AIRS_resolution'].groups['2B-CLDCLASS'].variables['Latitude'][:]
radiances = f.groups['AIRS'].groups['AIRS_resolution'].groups['L1B_AIRS_Science'].variables['radiances'][:]
l1bLat = f.groups['AIRS'].groups['AIRS_resolution'].groups['L1B_AIRS_Science'].variables['Latitude'][:]

#get cloudsat latitude values range
csLat_range = list(set(csLat.flatten().tolist()))
csLat_range.sort()

#build cloudsat lat array with same shape as cloud_scenario
newCsLat = N.zeros(cloud_scen.shape)
for i in range(newCsLat.shape[2]): newCsLat[:,:,i] = csLat

#get cloud type bits (bits 1-4, little-endian)
cloud_scen_shift = N.right_shift(N.array(cloud_scen), 1) & int('1111', 2)

cloudTypes = {
   '0000': 'clear',
   '0001': 'Ci',
   '0010': 'As',
   '0011': 'Ac',
   '0100': 'St',
   '0101': 'Sc',
   '0110': 'Cu',
   '0111': 'Ns',
   '1000': 'DC'
}

#plot
sp = fig.add_subplot(111)
csPlot = sp.scatter(newCsLat.flatten(), height.flatten(),
                c=cloud_scen_shift.flatten(),
                vmin=int('0000', 2),
                vmax=int('1000', 2),
                edgecolors='none',
                cmap=cmap_discretize(cm.gist_ncar_r, 9))

#set x(lat) and y(height) limits
if csLat.max() > 90: sp.set_xlim(csLat.min(), csLat_range[-2])
else: sp.set_xlim(csLat.min(), csLat.max())
sp.set_ylim(0, height.max())

#set plot attrs
sp.set_xlabel('CloudSat Latitude')
sp.set_ylabel('CloudSat Height (m)')
plt.title("Cloud Scene")
cb = plt.colorbar(csPlot, ticks=range(9)) #set ticks
cb.ax.set_yticklabels([cloudTypes[N.binary_repr(i, 4)] for i in range(9)]) #set tick labels

#write file
fig.savefig(plotFile)
plt.close(fig)
```

A plot similar to the following will be generated:

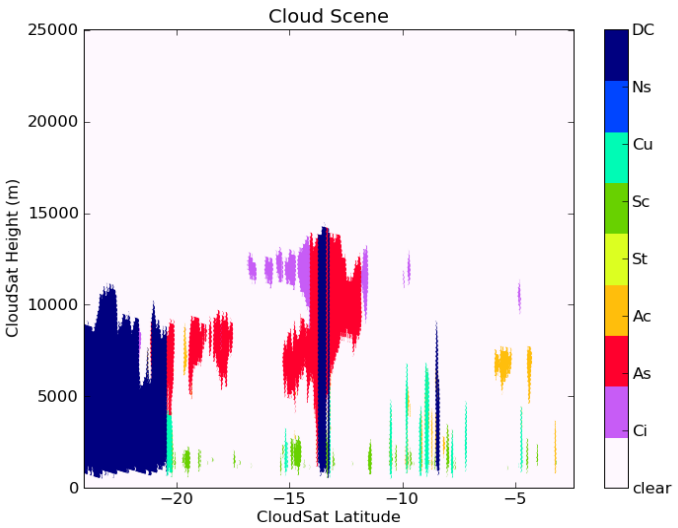

Figure 4.1: Cloud Scene

5.0 Data Services

GES DISC provides basic temporal and advanced (event) searches through its search and download engine, Mirador:
http://mirador.gsfc.nasa.gov/

Mirador offers various download options that suit users with different preferences and different levels of technical skills. Users can start from a point where they don't know anything about these particular data, its location, size, format, etc., and quickly find what they need by just providing relevant keywords, like "Cloud Classification". As the project progresses, more services will be added that will allow options for subsetting, format conversion, and previews using open source software such as OPeNDAP and Panoply.

If you need assistance or wish to report a problem:
Email: gsfc-help-disc@lists.nasa.gov
Voice: 301-614-5224
Fax: 301-614-5268
Address:
Goddard Earth Sciences Data and Information Services Center NASA Goddard Space Flight Center Code 610.2 Greenbelt, MD 20771 USA

6.0 More Information

All WVCC data types are published to the Global Change Master Directory:

http://gcmd.nasa.gov

This is a centralized depository of climate data information that is catalogued by popular keywords, which facilitate data discovery. Since the Directory is visited by a large number of people working on a broad range of research topics, it is an excellent forum to popularize data collections. It also serves as source of data type information for Mirador.

7.0 Acknowledgements

The creators for WVCC are:

Eric Fetzer, Brian Wilson, and Gerald Manipon.

References

AIRS Version 6.0 Processing Files Description:
https://disc.gsfc.nasa.gov/information/documents?title=AIRS Documentation

CloudSat Standard Data Products Handbook, May 18, 2006:
http://www.cloudsat.cira.colostate.edu/dataHome.php

Level 2 Cloud Scenario Classification Product Process Description and Interface Control Document, Version: 4.0, March 1, 2005.

NetCDF4: http://www.unidata.ucar.edu/software/netcdf/

For information on the Python programming language, consult the documentation:
http://www.python.org.