The Clouds from AVHRR Extended User's Guide

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Introduction to CLAVR-x

The Clouds from AVHRR Extended System (CLAVR-x) is a processing system developed at NOAA/NESDIS and UW/CIMSS for generating quantitative cloud products in real-time from the Advanced Very High Resolution Radiometer (AVHRR). The CLAVR-x system has evolved into a climate processing system called the Pathfinder Atmospheres Extended (PATMOS-x). In addition, the NESDIS GOES Surface and Insolation Project (GSIP) processing system was initially based on CLAVR-x and remains linked. This document will provide users information needed to configure and run CLAVR-x and to interpret its output.

CLAVR-x is FORTRAN-90 code written in the early 2000's to meet the needs of NESDIS to provide cloudiness from the AVHRR to the National Centers for Environmental Prediction (NCEP). While it replaced the existing CLAVR system and products, the amount of code shared was minimal. CLAVR's main mission was cloud detection and CLAVR did not generate a full suite of cloud products and its operation was limited to the afternoon orbiting AVHRR sensors prior to the launch NOAA-L (NOAA-16).

CLAVR-x become operational in NESDIS in 2002 and was updated significantly in 2006 after the launch of METOP-A. In 2013, CLAVR-x was updated again to support the generation of higher spatial resolution output for NCEP and incorporated many algorithm improvements from the GOES-R AWG effort. As will be explained later, CLAVR-x algorithms are now designed to operate in several processing systems to support NESDIS's needs for cloud products in other applications and sensors.

Description of the CLAVR-x Processing System

The CLAVR-x system consists of several executables. The main executable is called clavrxorb and it operates on the Level-1b data and generates Level-2 products. Other executables operate on the Level-2 files and sample or average them in space and/or time to make the other product times required of CLAVR-x. Figure 1 gives a schematic, taken from the CLAVR-x ICD, of the input and output data flowing in and out of the CLAVR-x system.

CLAVR-x runs physical algorithms and therefore uses significant amounts of ancillary data to specify the atmospheric and surface conditions. Figure 1 shows the different types of ancillary data.

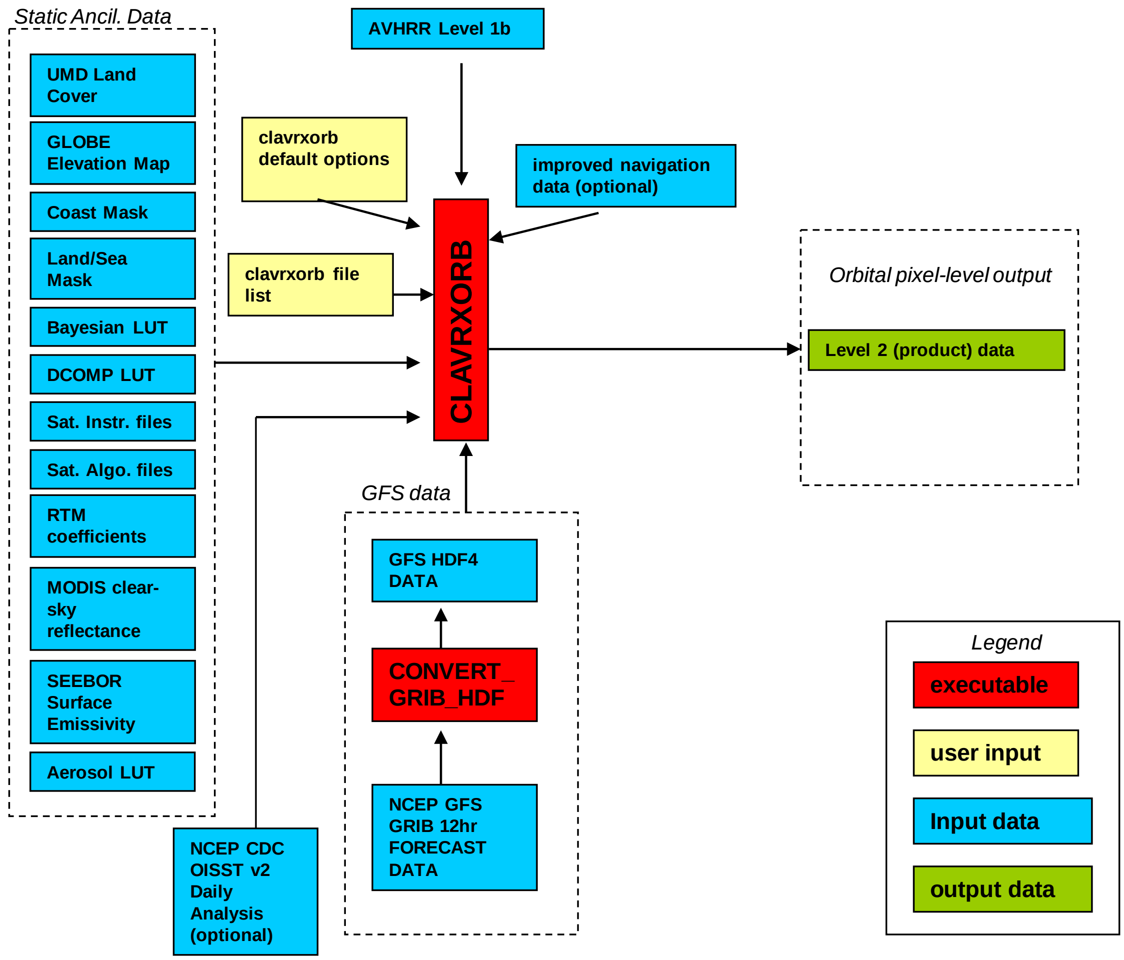

Figure 1 Schematic illustration of the input and output of CLAVR-x processing.

Installation of stable versions of CLAVR-x

The CLAVR-x software system is hosted on a subversion repository accessible over the internet. This offers the following advantages:

- All users have access to the same version of the software
- Updating to the latest version of the software is transparent and straightforward
- It is easy to go back to previous versions
- SVN can generate snapshots of software system.

One may use the simple **svn** command line client which is installed by default on many Linux systems (see http://subversion.tigris.org/getting.html#binary-packages).

We provide installer scripts within CLAVR-X to download the stable versions:

1. Create a local source code folder into which you want to download the software
2. Download the folder with installer scripts:

```
svn checkout -q https://svn.ssec.wisc.edu/repos/cloud_team_clavrx/tags/clavrx_current/clavrx_scripts ./
```

3. Run `./install_clavrx_stable.sh`, which downloads and compiles all needed modules. You may have to change hdf4 and hdf5 library paths in all config.mk files (in subdirectories **dcomp, nlcomp** and **main_src**)

4. The executable binary ***clavrxorb*** can be now found in clavrx_bin folder.

5. Older versions can be download with `./install_clavrx_stable.sh <version number>`

6.

Figure 2 Example session. Download and start running installer script.

Figure 3 Example session showing the result of successful installation with installer script.

Installation of trunk branch of CLAVR-x

Trunk and other development branches are solely for developers and advanced users. These versions of CLAVR-x may be not stable.

Users and developers may download trunk version by `./install_clavrx_trunk.sh` (see section "Installation of stable version "above)

Installer scripts for further development branches are not provided. Developers may adjust existing installer scripts for their need.

Getting needed Auxiliary data

The auxiliary data are stored on ftp sites at CIMSS.

DOMP LUTs:
ftp://ftp.ssec.wisc.edu/clavr/cld_ref_luts/

Ancil Data:
TBC

User Input in CLAVR-x

There are two ways for a user to pass information to CLAVRXORB. One way is through command line arguments and this is described in the Appendix 1. The most common ways users pass information is through the two run-controls files, which are the file-list and default-options files. The default name for the file-list is called "clavrxorb_file_list" and the default name for the default-options files is "clavrxorb_default_options". If CLAVRXORB is called without any arguments, it will expect these files to reside in the working directory. However, these files can be named arbitrarily and these names can be passed to CLAVRXORB through the command line arguments. Example of this would be as follows.

$> clavrxorb –filelist my_goes_level1b_data –default my_goes_options

The next two sections explain the contents of these files.

The CLAVRXORB File-List Run Control File

CLAVR-x processing requires a list of input/output directories and input files. By default the system is looking for a file named "clavrxorb_file_list". User can manually set the name from which the system would read required information by adding the following to the command line “ -filelist NAME_OF_THE_FILE”. File list should have the following structure (example in parentheses):

Table 1 Description of the clavrxorb file-list text file.

Line #	Description
1	Input directory location of Level 1b files (./level1b/)
2	Output directory location of Level 1b Prime files (./level1bx/)
3	Input directory location of Navigation files (./nav_in/)
4	Output directory location of Navigation files (./nav_out/)
5	Output directory location of CMR files (./cmr/)
6	Output directory location of SST files (./sst/)
7	Output directory location of Cloud files (./cld/)
8	Output directory location of Observation files (./obs/)
9	Output directory location of Geolocation files (./geo/)
10	Output directory location of RTM files (./rtm/)
11	Output directory location of Ash files (./ash/)
12	Output directory location of Level 2 files (./level2/)
13	Output directory location of Level 3 files (./level3/)
14	First Level-1b File Name *
15+	Subsequent File Names (one per line)

AVHRR Level-1b File Name Convention

When processing AVHRR, the user needs to provide the Level-1b name. The name can be arbitrary because no information is extracted from it. CLAVR-x assumes any file that ends in “.gz” or “.bz2” is compressed and any file without those suffixes is not compressed.

VIIRS Level-1b File Name Convention

When processing VIIRS, the expected file names in file-list are the terrain-corrected geolocation files that begin with GMTCO. The names of the other needed files are constructed based on information from the GMTCO file.

GOES, MSG, MTSAT, FY2D, COMS File Name Conventions

CLAVR-x uses band-separated "area" files when processing geostationary imager data. CLAVR-x expects the first file to be the name of the channel-1 file. It expects files of the following naming convention: satname_1_YYYY_DDD_HHMM.area where satname is the same of the satellite (e.g. goes13)

MODIS 1km Level1b File Name Conventions

When processing 1 km MODIS data (MOD02km and MYD021km), the file name in the file-list is the name of the Level-1b file. The MODIS 1km Level-1b files do not contain 1 km geolocation data. The relevant geolocation files (MOD03 and MYD03) should be located in the "navigation input" directory on line 3 of the file-list. The name of the MODIS files are arbitrary and the information of their date are extracted from the global attributes.

MODIS 5km Level1b File Name Conventions.

CLAVR-x processes the MODIS 5km subset files (MOD02SSH and MYD02SSH) generated by NASA GSFC and distributed by LAADSWEB. The geolocation information is imbedded in the files and therefore no separate file is needed.

The CLAVRXORB Default-Options Run-Control File

As its name implies, the default-options file passes the user-specified chooses for many options including ancillary data, algorithm modes and files output. Many of these choices are sensor specific and therefore most users employ a sensor-specific default-options file. The default-options file allows users to turn on and off the channels. CLAVRXORB can run with all channels turned on – even those not present on the sensor being processed. Turning off channels will remove them from the output stream and may result in CLAVRXORB modifying the ACHA and DCOMP algorithm modes.

The table below describes the contents and most common usage of each parameter in this file.

Table 2 Description of the contents of the clavrxorb default options file

Line #	Parameter	Type	Description/Options
1	ref_cal_1b	integer	Set to 0 to use the reflectance calibration information within the Level-1b data. Set to 1 to use the reflectance calibration information computed from parameters within the satellite instrument file. Set to 1 only for AVHRR climate

			processing (PATMOS-x)
2	therm_cal_1b	integer	Set to 0 to not use the thermal calibration information within the Level-1b data. Set to 1 to use the thermal calibration information computed from parameters within the satellite instrument file. Set to 1 only for AVHRR climate processing (PATMOS-x)
3	1bx	integer	AVHRR Only. Set to 1 to not make a AVHRR Level-1bx file. Set to 0 for all other cases
4	nav_flag	integer	AVHRR only. Set to 0 to use navigation in the Level-1b file (recommnend). Set to 1 to read in a pre-existing navigation file (clevernav.f90). Set to 2 to use Fred Nagle's repositioning routine (AVHRR climate processing only).
5	nav_file_flag	integer	Set to 0 to not write a navigation HDF4 file. Set to 1 to write navigation HDF4 file. The navigation HDF4 file includes pixel level latitude and longitude. Scan line numbers and scan line times are also included. The latitude and longitude variables may now be seen in the Level-2 HDF4 file. The "clavrxorb_file_list" file controls the output location. A normal user does not need this file. The flag should be set to 0.
6	cmr_file_flag	integer	This functionality has been removed from CLAVR-x. This flag should be set to 0.
7	obs_file_flag	integer	This functionality has been removed from CLAVR-x. The user can look to the Level-2 HDF4 file for the Level-1b information. Top of atmosphere reflectances at 0.65 µm and 3.75 µm, as well as brightness temperatures at 3.75 µm, 6.7 µm, 11 µm, and 13.3 µm are included in the Level-2 HDF4 file. This flag should be set to 0.
8	geo_file_flag	integer	This functionality has been removed from CLAVR-x. The user can look to the level2 HDF4 file for high-resolution ancillary data such as viewing angles, land cover, surface types, and surface elevation information. This flag should be set to 0.
8	cld_file_flag	integer	This functionality has been removed from CLAVR-x. The user can look to the Level-2 HDF4 file for the field of cloud properties information. The cloud mask, cloud type, cloud phase, cloud top temperature, cloud top pressure, cloud top height, and several others are included. This flag should be set to 0.
10	sst_file_flag	integer	This functionality has been removed from CLAVR-x. The user can look to the Level-2 HDF4 file for this information. This flag should be set to 0.
11	rtm_file_flag	integer	Set to 0 to not write a RTM HDF4 file. Set to 1 to write a RTM HDF4 file. The "clavrxorb_file_list" file controls the output

			location of the file. This file may still be generated, but the user should look to the Level-2 HDF4 file for modeled surface temperature, calculated clear sky reflectances and brightness temperatures, and emissivity. This flag should be set to 0.
12	ash_file_flag	integer	This functionality is unsupported in CLAVR-x, as it requires a specific branch of source code (VOLCAT). This flag should be set to 0.
13	level2_file_flag	integer	Set to 0 to not write a Level-2 CLAVR-x HDF4 file. Set to 1 to write a Level-2 CLAVR-x HDF4 file. The "clavrxorb_file_list" file controls the output location of the HDF4 file. This file will contain all of the output from the CLAVR-x run. The content of the HDF4 output is controlled at compile time by editing the level2.inc file. This flag needs to be set to 1.
14	level3_file_flag	integer	This functionality has been removed from CLAVR-x. This flag should be set to 0.
15	cld_mask_1b	integer	Set to 0 to not read in the cloud mask from a Level-1b file. Set to 1 to read in cloud mask from a Level-1b file and use in product derivation. Set to 2 to read in cloud mask from a Level-1b file, but do not use in product generation. In operations, it is set to zero for all satellites. However, it can be useful for testing official operational products such as the VIIRS IICMO (cloud mask). This flag should be set to 0.
16	cloud_mask_bayesian_flag	integer	Set to 0 to not use the Bayesian cloud mask software. If flag 0 is selected, the user must have a Level-1b cloud mask product available. Set to 1 to use the Bayesian cloud mask software. This flag should be set to 1.
17	sst_flag	integer	Set to 0 to not compute pixel level SST products. Set to 1 to compute pixel level SST products. This flag does not appear to be used, but is set to 1 in operations. This flag should be set to 1.
18	cld_flag	integer	Set to 0 to not compute pixel level cloud products. Set to 1 to compute pixel level cloud products. This flag should be set to 1.
19	aot_flag	integer	Set to 0 to not compute pixel level aerosol products. Set to 1 to compute pixel level aerosol products. In operations, this is set to 1 for all satellites. However, only the AVHRR satellite will return these products. For non-AVHRR satellites, the functions that calculate these products are commented out in the software. This flag should be set to 1.
20	erb_flag	integer	Set to 0 to not compute earth radiation budget properties. Set to 1 to compute earth radiation budget properties. Currently, there is no AVHRR algorithm. Along with the earth radiation budget, the insolation will also be

			calculated for the GOES, MTSAT, and Meteosat satellites. This flag should be set to 0 for AVHRR, and VIIRS. Set the flag to 1 for geostationary satellites.
21	ash_flag	integer	This functionality is unsupported in CLAVR-x, as it requires a specific branch of source code (VOLCAT). This flag should be set to 0.
22	oisst_flag	integer	Set to 0 not read in the daily NOAA Optimum Interpolation (OI) Sea Surface Temperature (SST) OISST analysis field. Set to 1 to read in the daily OISST analysis field. This flag should be set to 1.
23	oisst_option	integer	Set to 0 to allow the software look for the correct OISST analysis field. This flag should be set to 0.
24	gridcell_resolution	real	Number specifying grid resolution (degrees) of gridded Level-3 output. Values can be 0.25, 0.5, 1.0, or 2.5 degrees. This is an unsupported option as it pertains to the Level-3 gridded output. This can be set to 0.5.
25	gridcell_format	integer	Set to 0 for equal-area grid format. Set to 1 for equal-angle grid format. This is an unsupported option as it pertains to the Level-3 gridded output. This flag should be set to 0.
26	data_comp_flag	integer	Set to 0 to not use compression in the Level-2 output files. Set to 1 to use internal gzip compression in the output. Set to 2 for szip compression.
27	subset_pixel_hdf_flag	integer	Set to 0 to not subset pixels in the Level-2 HDF4 output file. Set to 1 to subset pixels in the Level-2 output using lat_min_diag and lat_max_diag (see below). In operations, this flag is set to 0.
28	nwp_flag	integer	Set to 0 to use no NWP (note, only OBS, NAV and GEO files will be produced). This option is not supported as the OBS, and GEO files are no longer created. Set to 1 to use NCEP GFS NWP fields. Set to 2 to use NCEP Reanalysis fields. Set to 3 to use NCEP Climate Forecast System Reanalysis (CFSR) fields. Set to 4 for GDAS reanalysis fields. In operations, the flag is set to 1. However, for case studies, option 3 is the preferred flag.
29	rtm_flag	integer	Set to 0 to use the CRTM. Set to 1 to Hal Woolf's PFAAST RTM. In operations, this is set to 1, as PFAAST is the only supported RTM at this time. This flag should be set to 1.
30	modis_clr_alb_flag	integer	Set to 0 to not use the MODIS clear sky albedo composite. Set to 1 to use the MODIS clear sky albedo composite. This flag should be set to 1.
31	prob_clear_res_flag	integer	Set to 0 to not restore the probably clear pixels. Set to 1 to restore probably clear pixels. This flag should be set to 1. Not sure this is a valid option anymore in the current version of

			CLAVR-x.
32	lrc_flag	integer	Set to 0 to not perform local radiative center computation (LRC). Set to 1 to perform LRC computation. This flag should be set to 1.
33	proc_undetected_cld_flag	integer	Set to 0 to not process cloud products on undetected cloud pixels or pixels that do not have a type set. Set to 1 to process cloud products on undetected cloud pixels or pixels that do not have a type. This flag should be set to 0.
34	diag_flag	integer	Set to 0 to not write out diagnostic files. Set to 1 to write out diagnostic files. This flag should be set to 0. I'm not sure this is supported in the current version of CLAVR-x.
35	asc_flag_diag	integer	Set to -1 to write out ascending and descending data to the diagnostic files. Set to 0 to write out ascending data to the diagnostic files. Set to 1 to write out descending data to the diagnostic files. This is for developer use only. This flag should be set to 0.
36	lat_min_diag	real	Value of minimum nadir latitude for diagnostic files. It is also used in conjunction with the subset_pixel_hdf_flag to trim the Level-2 HDF4 file. This flag should be set to -90.0.
37	lat_max_diag	real	Value of maximum nadir latitude for diagnostic files. It is also used in conjunction with the subset_pixel_hdf_flag to trim the Level-2 HDF4 file. This flag should be set to 90.0.
38	ancil_data_dir	char(128)	Directory where the CLAVR-X ancillary data files are to be read. An example directory listing is as follows: /data/Ancil_Data/clavrx_ancil_data/
39	gfs_data_dir	char(128)	Directory where the GFS data files are to be read. An example listing is as follows: /data/Ancil_Data/gfs/hdf/. The GFS data is converted from either GRIB1 or GRIB2 to a localized HDF4 file. This conversion takes place outside of CLAVR-x.
40	ncep_data_dir	char(128)	Directory where the NCEP Reanalysis data files are to be read. An example listing is as follows: /data/Ancil_Data/ncep-reanalysis/
41	cfsr_data_dir	char(128)	Directory where NCEP CFSR data files are to be read. An example listing is as follows: /data/Ancil_Data/cfsr/hdf_05/
42	oisst_data_dir	char(128)	Directory where the daily OISST data files are to be read. An example listing is as follows: /data/Ancil_Data/oisst_daily/
43	snow_data_dir	char(128)	Directory where ancillary daily snow map files are to be read. An example listing is as follows: /data/Ancil_Data/snow/
44	globsnow_data_dir	char(128)	Directory where the GlobSnow Snow Water Equivalent files are to be read. The data files encompass the years of 1979 to 2009. An example listing is as follows:

			/data/Ancil_Data/GlobSnow/
45	dsc_data_dir	char(128)	Directory where dark sky composite files are to be read (GOES only). An example listing is as follows: /data/Ancil_Data/goes_dark_sky_composites/
46	temp_dir	char(128)	A temporary files directory (ex. ./temporary_files) needs to be set up ahead of time. The CLAVR-x software creates temporary files within this directory. Most are deleted on completion.
47	smooth_nwp	integer	Smooth NWP data by linear interpolation. (0=no / 1= yes). This flag should be set to 1.
48	use_seebor	integer	Use SEEBOR Land Surface Emissivity database (0=no / 1= yes). This flag should be set to 1.
49	read_hires_sfc_type	integer	Read in the high-resolution surface type database (0=no [8km] / 1= yes [1km]). There are only 2 files available and both are hard coded into the CLAVR-x software. Each file is required to be within the sfc_data directory of the parent ancillary data directory (e.g. /data/Ancil_Data/sfc_data/). The 1 km file is named gl-latlong-1km-landcover.hdf. The 8 km file is named gl-latlong-8km-landcover.hdf. This flag should be set to 1.
50	read_land_mask	integer	Read in the land mask database (0=no / 1= yes). There is only 1 file available and it is hard coded into the CLAVR-x software. The land mask file is required to be within the sfc_data directory of the parent ancillary data directory (e.g. /data/Ancil_Data/sfc_data/). The filename is expected to be lw_geo_2001001_v03m.hdf. This flag should be set to 1.
51	read_coast_mask	integer	Read in the coast mask database (0=no / 1= yes). There is only 1 file available and it is hard coded into the CLAVR-x software. The coast mask file is required to be within the sfc_data directory of the parent ancillary data directory (e.g. /data/Ancil_Data/sfc_data/). The filename is expected to be coast_mask_1km.hdf. This flag should be set to 1.
52	read_surface_elevation	integer	Read in the surface elevation database (0=no / 1= read 1 km file / 2 = read 8 km file). There are only 2 files available and both are hard coded into the CLAVR-x software. Each file is required to be within the sfc_data directory of the parent ancillary data directory (e.g. /data/Ancil_Data/sfc_data/). The 1 km file is named GLOBE_1km_digelev.hdf. The 8 km file is named GLOBE_8km_digelev.hdf. This flag should be set to 1.
53	read_volcano_mask	integer	Read in volcano mask database(0=no / 1= yes). There is only 1 file available and it is hard coded into the CLAVR-x software. The volcano mask file is required to be within the sfc_data

			directory of the parent ancillary data directory (e.g. /data/Ancil_Data/sfc_data/). The filename is expected to be volcano_mask_1km.hdf. This flag should be set to 0.
54	solzen_min_limit, solzen_max_limit	2 reals	Value of minimum and maximum solar zenith angle (in degrees) to be processed. The two numbers must be separated by a space. These two values should be 0.0 and 180.0.
55	snow_mask_flag	integer	Determine which snow mask to use (0=NWP, 1=4km snow map, 2=GlobSnow). Using the NWP snow mask should be the last option. The 4km snow map files are located in the directory from the snow_data_dir defined above. The GlobSnow files are located in the directory from globsnow_data_dir defined above. Operationally, the 4km snow map files are use. The flag should be set to 1.
56	dsc_flag	integer	Read in dark sky composites for geostationary satellite insolation products. (0=no, 1=yes). This flag should be set to 0.
57	channel 1-6_flags	6 integers	Channel on flags of channels 1,2,3,4,5,6 (0=not present, 1=present) separated by a space. These are mapped to the MODIS band numbers. Other satellites are then mapped to the matching MODIS band by comparing the central wavelength of each band. It is easiest to simply use a flag of 1 for each channel. The software will determine if the channel exists.
58	channel 7-12_flags	6 integers	Channel on flags of channels 7,8,9,10,11,12 (0=not present, 1=present) separated by a space. See above for description. The user should set these to 1.
59	channel 13-18_flags	6 integers	Channel on flags of channels 13,14,15,16,17,18 (0=not present, 1=present) separated by a space. See above for description. The user should set these to 1.
60	channel 19-24_flags	6 integers	Channel on flags of channels 19,20,21,22,23,24 (0=not present, 1=present) separated by a space. See above for description. The user should set these to 1.
61	channel 25-30_flags	6 integers	Channel on flags of channels 25,26,27,28,29,30 (0=not present, 1=present) separated by a space. See above for description. The user should set these to 1.
62	channel 31-36_flags	6 integers	Channel on flags of channels 31,32,33,34,35,36 (0=not present, 1=present) separated by a space. See above for description. The user should set these to 1.
63	channel i1-i5,DNB	6 integers	Channel on flags of VIIRS channels i1,i2,i3,i4,i5,DNB (0=not present, 1=present) separated by a space. See above for description. The user should set these to 1.
64	dcomp_mode	integer	Set to 1 to use 0.6 μm/1.6 μm channel combination for the Daytime Cloud Optical

			Microphysical Parameters (DCOMP) Mode. Set to 2 to use 0.6 μm/2.2 μm DCOMP Mode. Set to 3 to use 0.6 μm/3.7 μm DCOMP Mode. DCOMP provides pixel level Cloud Optical Depth (COD) and Cloud effective Particle Size (CPS). In operations, GOES uses flag 3, AVHRR uses flag 1, MODIS uses 3, and VIIRS uses 1.
65	acha_mode	integer	Set to 0 to use 11 μm channel GOES-R ABI Cloud Height Algorithm (ACHA) Mode. Set to 1 to use 11 μm/12 μm channel combination ACHA Mode. Set to 2 to use 11 μm/13.3 μm ACHA Mode. Set to 3 to use 11 μm/12 μm/13 μm ACHA Mode. Set to 4 to use 8.5 μm/11 μm/12 μm ACHA Mode. Set to 5 to use 6.7 μm/11 μm/12 μm ACHA Mode. Set to 6 to use 6.7 μm/11 μm/12 μm ACHA Mode. In operations, GOES uses mode 6, AVHRR uses mode 1, MODIS uses mode 3, and VIIRS uses mode 4. The ACHA generates pixel level cloud-top height, cloud-top temperature, cloud-top pressure, and cloud layer products.
66	bayes_mask_file	char(128)	The naïve Bayesian cloud mask file. This file is satellite specific and is stored within the bayes directory of the parent ancillary data directory (e.g. /data/Ancil_Data/clavrx_ancil_data/). The Bayesian cloud mask files are kept up to date in the naive_bayes_mask CVS repository cvs.ssec.wisc.edu.

An example default options file for GOES processing is shown below.

```
0       !ref_cal_1b flag (0 = do not use reflectance cal in Level 1b)
0       !therm_cal_1b flag (0 = do not use thermal cal in Level 1b)
0       !1bx flag      (1 = fill in clavr-x bytes in Level 1b)
0       !nav flag  (0=level-1b,1 = clevernav)
0       !write nav out (1 = write to a nav file)
0       !cmr file flag  (0=no,1=make output file)
0       !obs file flag  (0=no,1=make output file)
0       !geo file flag  (0=no,1=make output file)
0       !cld file flag  (0=no,1=make output file)
0       !sst file flag  (0=no,1=make output file)
0       !rtm file flag  (0=no,1=make output file)
0       !ash file flag  (0=no,1=make output file)
1       !level2 file flag  (0=no,1=make output file)
0       !level3 file flag  (1 = make gridded output)
0       !cloud mask 1b (1 = read from 1b and don't recompute)
1       !bayesian cloud mask (0=no, 1 = yes)
1       !sst flag (0= no, 1 = yes)
1       !cld flag (0= no, 1 = yes)
1       !aot flag (0= no, 1 = yes)
1       !erb flag (0= no, 1 = yes)
0       !ash flag (0= no, 1 = yes)
1       !use oisst
0       !oisst option  (0 = determine file, 1 = use oisst.current)
```

```
0.5      !grid resolution
0        !grid format: eq. area (0) / eq. angle (1)
1        !output compression flag (0=no,1=gzip,2=szip)
0        !subset pixel hdf flag (0=no / 1= yes)
1        !nwp flag  (1=gfs,2=ncep reanalysis,3=cfsr)
1        !rtm flag  (0=crtm,1=pfast)
1        !use modis clear ref (0=no,1=yes)
1        !prob_clear_res_flag (0=no,1=yes)
1        !lrc_flag (0=no,1=yes)
0        !process undetected cloud (0=no,1=yes)
0        !diagnostic output flag
-1        !node for diagnostic output (0=asc,1=des)
-90.0     !minimum latitude for diagnostic output
90.0     !maximum latitude for diagnostic output
/data1/Ancil_Data/clavrx_ancil_data/
/data1/Ancil_Data/gfs/hdf/
/data1/Ancil_Data/ncep-reanalysis/
/data1/Ancil_Data/cfsr/hdf/
/data1/Ancil_Data/oisst_daily/
/data1/Ancil_Data/snow/
/data1/Ancil_Data/GlobSnow/
/data1/Ancil_Data/Dark_Composites/
./temporary_files/
1          !smooth nwp flag (0=no, 1 = yes)
1          !seebor emiss flag (0=no, 1 = yes)
1          !read hires sfc type flag (0=no-8km, 1 = yes-1km)
1          !read land mask flag (0=no, 1 = yes)
1          !read coast mask flag (0=no, 1 = yes)
1          !read surface elevation flag (0=no, 1 = yes)
0          !read volcano mask flag (0=no, 1 = yes)
0.0 180.0 !solar zenith angle limits
1          !read snow mask flag (0=NWP, 1 = IMS, 2 = GlobSnow)
1          !read dark composite flag (0=no, 1 = yes)
1 1 1 1 1 1    !chan on flags of channels 1,2,3,4,5,6
1 1 1 1 1 1    !chan on flags of channels 7,8,9,10,11,12
1 1 1 1 1 1    !chan on flags of channels 13,14,15,16,17,18
1 1 1 1 1 1    !chan on flags of channels 19,20,21,22,23,24
1 1 1 1 1 1    !chan on flags of channels 25,26,27,28,29,30
1 1 1 1 1 1    !chan on flags of channels 31,32,33,34,35,36
1 1 1 1 1 1  !chan on flags of channels i5,i2,i3,i4,i5,DNB (VIIRS ONLY)
3          ! DCOMP MODIS MODE (1 = 0.6/1.6 . 2 = 0.6/2.2 3 = 0.6/3.7  )
6          ! ACHA MODE (0=11;1=11/12;2=11/13.3;3=11,12,13;4=8.5/11/12;
                                    5=6.7,11,12;6=6.7,11,13.3)
goes_default_bayes_mask.txt
```

Level-1b Input Files

AVHRR

CLAVR-x operates on 16-bit packed binary AVHRR Level-1b files that are in official NESDIS format or in related AAPP format. CLAVR-x can process Global Area Coverage (GAC) data, Local Area Coverage (LAC) data, Full Resolution Area Coverage (FRAC) data or High Resolution Picture Transmission (HRPT) data. Data from every AVHRR is supported in CLAVR-x.

Level-1b AVHRR data is available from the NOAA CLASS site (www.class.noaa.gov). When ordering from CLASS, it is important to turn off the option of adding the header to the data set. If one makes this mistake, the 122 byte (pre NOAA-klm) or 512 byte (NOAA-klm and beyond) header must be stripped off before processing by CLAVR-x. CLAVR-x can read files that have been sub-setted in the scan-line dimension by CLASS.

GOES-Imager

CLAVR-x processed McIDAS Area file formatted data for GOES and all geostationary imagers (MTSAT, MSG, FY-2D and COMS). CLAVR-x requires band-separated area files with all channels having the same spatial resolution. Channels that are turned off are not read in. CLAVR-x can process any GOES-Imager band-separated data for any domain.

MODIS

CLAVR-x processes the standard HDF-EOS formatted MODIS Level-1b data from NASA. CLAVR-x can process 1km MODIS data (MYD021KM or MOD021KM) but requires the additional MYD03 or MOD03 geolocation file. CLAVR-x can also process the 5 km resolution MODIS data (MOD02SSH and MYD02SSH). CLAVR-x can also process the Direct Broadcast MODIS data as long as it conforms to the NASA format. In addition, CLAVR-x supports the MAST MODIS data which is MODIS data surrounding the CloudSat track.

VIIRS

CLAVR-x can process the standard HDF5 VIIRS SDR files from the IDPS. It also requires the terrain-corrected navigation files (GMTC0).

Level-2 Output File

All output from the CLAVR-x system goes into a single Level-2 file. Other output files, as controlled by the default options file, are also available but are not expected to be used by CSPP users.

The Level-2 Include File

The Level-2 file's contents are controlled by the flags set to off (0) or on (1) in the "level2.inc" file. Roughly 200 parameters can be included in the Level-2 output though the maximum number of parameters is considerably less for any given sensor. Each line in the level2.inc file consists of two values as shown below for the Ch1 (0.65 micron reflectance).

Sds_Num_Level2_Ch1 = 15 , Sds_Num_Level2_Ch1_Flag = 1

The value on the left shows the flag index assigned to this variable internally to CLAVR-x and should not be altered. This number may change as variables are removed or added to list of output options. The value on the right, the "flag" value, should be set to 0 (off) or 1(on). Level-2b is a sampled and remapped file format used in the generation of the PATMOS-x climate data set. Table 3 provides a list of those parameters that must be turned on (1) in order to make a Level-2b file. There is no further restriction on the number of Level-2 parameters needed to generate a Level-2b file. A table of the mapping of the flags in the Level2.inc file to the CLAVR-x parameter is given in Table 6 which is located in Appendix 1.

Table 3 List of Level2.inc flags that have to be turned on (set to 1) in the level2.inc file in order to be able to generate a Level-2b file.

Flag Name in Level2.inc	**Description**
Sds_Num_Level2_Lat_Flag	Latitude Flag
Sds_Num_Level2_Lon_Flag	Longitude Flag
Sds_Num_Level2_Zen_Flag	Sensor Zenith Angle Flag
Sds_Num_Level2_Solzen_Flag	Solar Zenith Angle Flag
Sds_Num_Level2_Ch1_Flag	Channel 1 (0.65μm Reflectance) Flag
Sds_Num_Level2_Ch31_Flag	Channel 31 (11 μm Brightness Temperature) Flag

Level-2 File Contents

As described above, the contents of the Level-2 file are defined by the user through the flags in the level2.inc file. Table 4 gives a listing of all of the current variables that could be written to a level-2 file.

Table 4 Description of the Level-2 output variables. The contents of any given Level-2 file are controlled by the flags set in the level2.inc file. The assuming missing value is -999. For un-scaled variables, the Range_Min and Range_Max are set to missing.

Index	Name	Units	Range Min	Range Max	Long Name
0	longitude	degrees _east	-999	-999	longitude
1	latitude	degrees	-999	-999	latitude

		_north			
2	scan_line_ time	hours	-999	-999	time for the scan line in fractional hours
3	scan_line_ number	none	-999	-999	scan line number
4	scan_ element_ number	none	-999	-999	scan element index of the pixel chosen for inclusion in level-2b
5	bad_scan_ line_flag	none	-999	-999	not specified
6	bad_pixel_ mask	none	-999	-999	mask that distinguishes good(0) from bad(1) pixels
7	gap_pixel_ mask	none	-999	-999	mask that distinguishes not in gap (0) from in-gap(1) pixels
8	diagnostic_1	unkno wn	-999	-999	First diagnostic variable (contents will change)
9	diagnostic_2	unkno wn	-999	-999	Second diagnostic variable (contents will change)
10	diagnostic_3	unkno wn	-999	-999	third diagnostic variable (contents will change)
11	packed_pixel _meta_data	none	-999	-999	order_and_depth: bad_pixel_mask(1),solar_contaminati on_mask(1),ch6_on_pixel_mask(1),Ba yes_Mask_Sfc_Type(3)
12	latitude_pc	degrees _north	-90.0	90.0	latitude_parallax_corrected_using_clo ud_height
13	longitude_pc	degrees _east	-180.0	180.0	longitude_parallax_corrected_using_cl oud_height
14	sensor_ zenith_angle	degrees	0.00	90.0	sensor zenith for each pixel measured in degrees from nadir
15	solar_zenith_ angle	degrees	0.00	180.0	solar zenith for each pixel measured in degrees away from the sun (0=looking at sun)
16	relative_ azimuth_ angle	degrees	0.00	180.0	relative azimuth angle in degrees. 0 is the principal plane looking towards sun
17	solar_ azimuth_ angle	degrees	-180.0	180.0	solar azimuth angle in degrees from north, pixel to sun, positive values are clockwise from north
18	sensor_	degrees	-180.0	180.0	sensor azimuth angle in degrees from

	azimuth_ angle				north, pixel to sensor, positive values are clockwise from north
19	glint_zenith_ angle	degrees	0.00	180.0	glint zenith for each pixel measured in degrees away from the specular image of sun
20	scattering_ zenith_angle	degrees	0.00	180.0	scattering zenith for each pixel measured in degrees away from direction of forward scattering
21	packed_land _cover	none	0.00	180.0	land cover, snow and coast values packed into one byte, see patmos-x docs to unpack
22	glint_mask	none	0.00	180.0	glint mask (0=no) (1=yes)
23	coast_mask	none	0.00	180.0	coast mask (0=no) (1=yes)
24	surface_type	none	0.00	180.0	UMD surface type: water=0,evergreen_needle=1,evergreen_broad=2,deciduous_needle=3,deciduous_broad=4,mixed_forest=5,woodlands=6,wooded_grass=7closed_shrubs=8,open_shrubs=9,grasses=10,croplands=11,bare=12,urban=13
25	land_class	none	0.00	180.0	land classes and values:shallow ocean=0,land=1,coastline=2,shallow inland water=3,ephemeral water=4,deep inland water=5,moderate ocean=6,deep ocean=7
26	snow_class	none	0.00	180.0	snow classes and values:no snow/ice=1,sea_ice=2,snow=3
27	surface_ elevation	meters	-500.0	10000.0	surface elevation above mean sea level
28	refl_0_65um _nom	%	-2.00	120.0	top of atmosphere reflectance at the nominal wavelength of 0.65 microns
29	refl_0_86um _nom	%	-2.00	120.0	top of atmosphere reflectance at the nominal wavelength of 0.86 microns
30	refl_1_60um _nom	%	-2.00	120.0	top of atmosphere reflectance at the nominal wavelength of 1.60 microns
31	refl_3_75um _nom	%	-20.0	80.0	top of atmosphere reflectance at the nominal wavelength of 3.75 microns
32	temp_ 3_75um_ nom	K	180.0	340.0	top of atmosphere brightness temperature at the nominal wavelength of 3.75 microns

33	temp_ 11_0um_ nom	K	180.0	340.0	top of atmosphere brightness temperature at the nominal wavelength of 11.0 microns
34	temp_ 12_0um_ nom	K	180.0	340.0	top of atmosphere brightness temperature at the nominal wavelength of 12.0 microns
35	refl_0_65um _nom_stddev _3x3	%	0.00	20.0	standard deviation of the 0.63 micron reflectance computed over a 3x3 pixel array
36	temp_ 11_0um_ nom_stddev_ 3x3	K	0.00	20.0	standard deviation of the 11 micron brightness temperature computed over a 3x3 pixel array
37	cloud_ probability	none	0.00	1.00	probability of a pixel being cloudy from the Bayesian cloud mask
38	cloud_mask	none	0.00	1.00	integer classification of the cloud mask including clear=0, probably-clear=1, probably-cloudy=2, cloudy=3
39	adj_pix_ cloud_mask	none	0.00	1.00	integer classification of the adjacent pixel cloud mask including clear=0, probably-clear=1, probably-cloudy=2, cloudy=3
41	cloud_mask_ 1b	none	0.00	1.00	integer classification of the cloud mask including clear=0, probably-clear=1, probably-cloudy=2, cloudy=3 from mask read from level-1b file
42	bayes_mask_ sfc_type	none	0.00	1.00	integer classification of the surface type assumed in constructed the Bayesian cloud mask, 1=deep water,2=shallow ocean,3=land,4=snow,5=arctic,6=antarctic+greenland,7=desert
43	cloud_type	none	0.00	1.00	integer classification of the cloud type including clear and aerosol type,0=clear,1=probably clear,2=fog,3=water,4=supercooled water,5=mixed,6=opaque_ice,7=cirrus,8=overlapping,9=overshooting,10=unknown,11=dust,12=smoke
44	cloud_phase	none	0.00	1.00	integer classification of the cloud phase including clear and aerosol type,0=clear,1=water,2=supercooled

					water,3=mixed,4=ice,5=unknown
45	cloud_type_ 1b	none	0.00	1.00	integer classification of the cloud type including clear and aerosol type read from level-1b file
46	cld_press_ acha	hPa	0.00	1100.00	cloud-top pressure computed using the AWG cloud height algorithm
47	cld_temp_ acha	K	180.0	320.0	cloud-top temperature computed using the AWG cloud height algorithm
48	cld_height_ acha	km	0.00	20.0	cloud height computed using the AWG cloud height algorithm
49	cld_height_ top_acha	km	0.00	20.0	estimate of actual cloud-top height computed using the AWG cloud height algorithm
50	cld_height_ base_acha	km	0.00	20.0	estimate of actual cloud-base height computed using the AWG cloud height algorithm
51	acha_ processing_ order	none	0.00	20.0	integer classification of the order of processing with ACHA
52	acha_ inversion_ flag	none	0.00	20.0	flag stating whether ACHA was processed assuming an inversion(1) or not(0)
53	cld_height_ h2o	km	0.00	20.0	cloud-top height computed using the two-point h2o intercept
54	cld_height_ opaque	km	0.00	20.0	cloud-top height computed using assuming the cloud is opaque
55	cld_emiss_ acha	none	0.00	1.00	cloud emissivity at the nominal wavelength of 11 microns, determined from the AWG cloud height algorithm
56	cld_beta_ acha	none	0.00	2.00	cloud 11/12 micron beta value determined from the split-window method
57	cld_height_ uncer_acha	km	0.00	10.0	cloud height uncertainty computed using the AWG cloud height algorithm
58	cld_temp_ uncer_acha	K	0.00	100.0	cloud temperature uncertainty computed using the AWG cloud height algorithm
59	cld_temp_ acha_qf	none	0.00	100.0	quality flag for cloud-top temperature from ACHA not attempted=0,

					failed=1, low quality=2, high quality=3
60	cld_emiss_ acha_qf	none	0.00	100.0	quality flag for 11.0 micron cloud emissivity from ACHA not attempted=0, failed=1, low quality=2, high quality=3
61	cld_beta_ acha_qf	none	0.00	100.0	quality flag for cloud 11.0/12.0 micron beta from ACHA not attempted=0, failed=1, low quality=2, high quality=3
62	cld_opd_acha	none	- 0.2000 00	8.00	cloud optical depth at the nominal wavelength of 0.65 microns, determined from ACHA
63	cld_reff_acha	micron	0.00	160.0	effective radius of cloud particles determined from ACHA; see attributes for channels used
64	acha_quality	none	0.00	160.0	quality flags for ACHA products 1:Processed (0=no,1=yes) 2:valid Tc retrieval (1=yes,0=no) 3:valid ec retrieval (1=yes,0=no) 4:valid beta retrieval (1=yes,0=no) 5:degraded Tc retrieval (1=yes,0=no) 6:degraded ec retrieval (1=yes,0=no) 7:degraded beta retrieval (1=yes,0=no)
65	acha_info	none	0.00	160.0	processing information for ACHA (0=no/1=yes) 1:Cloud Height Attempted 2:Bias Correction Employed 3:Ice Cloud Retrieval 4:Local Radiatve Center Processing Used 5:Multi-layer Retrieval 6:Lower Cloud Interpolation Used 7:Boundary Layer Inversion Assumed
66	cld_opd_ dcomp	none	- 0.2000 00	160.0	cloud optical depth at the nominal wavelength of 0.65 microns, determined from DCOMP
67	cld_reff_ dcomp	micron	0.00	160.0	effective radius of cloud particles determined from DCOMP; see attributes for channels used
68	cld_opd_ dcomp_unc	none	- 0.2000 00	160.0	uncertainty in the log10 cloud optical depth at the nominal wavelength of 0.65 microns, determined from DCOMP; see attributes for channels

					used
69	cld_reff_ dcomp_unc	micron	0.00	160.0	uncertainty in the log10 effective radius of cloud particle determined from DCOMP; see attributes for channels used
70	cld_opd_ dcomp_qf	none	0.00	160.0	quality flag for cloud optical depth from DCOMP not attempted=0, failed=1, low quality=2, high quality=3
71	cld_reff_ dcomp_qf	none	0.00	160.0	quality flag for cloud effective radius from DCOMP not attempted=0, failed=1, low quality=2, high quality=3
72	dcomp_ quality	none	0.00	160.0	quality flags for DCOMP products see documentation http://cimss.ssec.wisc.edu/clavr/ 1:Processed (0=no,1=yes) 2:valid COD retrieval (0=yes,1=no) 3:valid REF retrieval (0=yes,1=no) 4:degraded COD retrieval (0=no,1=degraded) 5:degraded REF retrieval (0=no,1=degraded) 6:convergency (0=no,1=yes) 7:glin
73	dcomp_info	none	0.00	160.0	processing flags for DCOMP see http://cimss.ssec.wisc.edu/clavr/ 1: info flag set ? (0=no,1=yes) 2: land/sea mask (0=land,1=sea) 3: day/night mask (0=Day,1=Night) 4: twilight (65-82 solar zenith) (0=no,1=yes) 5: snow (0=no,1= snow) 6: sea-ice (0=no,1=sea-ice) 7: phase (0=liquid,1=ice) 8: thick_cloud
74	insolation_ dcomp	W m-2	0.00	1500.00	surface downwelling shortwave flux computed from the DCOMP cloud properties
75	insolation_ diffuse_ dcomp	W m-2	0.00	1500.00	diffuse component of the surface downwelling shortwave flux computed from the DCOMP cloud properties
76	cld_opd_ nlcomp	none	-0.200000	160.0	cloud optical depth at the nominal wavelength of 0.65 microns, determined from NLCOMP

77	cld_reff_ nlcomp	micron	0.00	160.0	effective radius of cloud particles determined from NLCOMP; see attributes for channels used
78	cld_opd_ nlcomp_unc	none	-0.200000	160.0	uncertainty in cloud optical depth at the nominal wavelength of 0.65 microns, determined from NLCOMP
79	cld_reff_ nlcomp_unc	micron	0.00	160.0	effective radius of cloud particle determined from NLCOMP; see attributes for channels used
80	nlcomp_ quality	none	0.00	160.0	quality flags for NLCOMP products see documentation http://cimss.ssec.wisc.edu/clavr/ 1:Processed (0=no,1=yes) 2:valid COD retrieval (0=yes,1=no) 3:valid REF retrieval (0=yes,1=no) 4:degraded COD retrieval (0=no,1=degraded) 5:degraded REF retrieval (0=no,1=degraded) 6:convergency (0=no,1=yes) 7:gli
81	nlcomp_info	none	0.00	160.0	processing flags for NLCOMP see http://cimss.ssec.wisc.edu/clavr/ 1: info flag set ? (0=no,1=yes) 2: land/sea mask (0=land,1=sea) 3: day/night mask (0=Day,1=Night) 4: twilight (65-82 solar zenith) (0=no,1=yes) 5: snow (0=no,1= snow) 6: sea-ice (0=no,1=sea-ice) 7: phase (0=liquid,1=ice) 8: thick_clou
82	cloud_albedo _0_65um_ nom	none	0.00	1.00	cloud albedo at 0.65 microns nominal from DCOMP
83	cloud_ transmission _0_65um_ nom	none	0.00	1.00	cloud transmission 0.65 microns nominal from DCOMP
84	cloud_ fraction	none	0.00	1.00	cloud fraction computed over a 3x3 pixel array at the native resolution centered on this pixel
85	cloud_ fraction_ uncertainty	none	0.00	1.00	cloud fraction uncertainty computed over a 3x3 array
86	emissivity_	none	-	1.20000	emissivity at the nominal wavelength

	11um_ tropopause		0.5000 00		of 11 microns, assuming the cloud was located at the Tropopause
87	aot_0_65um_ nom	none	- 0.2000 00	5.00	optical thickness of atmosphere layer due to aerosol at the nominal wavelength of 0.65 microns
88	aot_0_86um_ nom	none	- 0.2000 00	5.00	optical thickness of atmosphere layer due to aerosol at the nominal wavelength of 0.86 microns
89	aot_1_6um_ nom	none	- 0.2000 00	5.00	optical thickness of atmosphere layer due to aerosol at the nominal wavelength of 1.6 microns
90	aot_qf	none	- 0.2000 00	5.00	quality flag for optical thickness of atmosphere layer
91	olr	W m-2	50.0	350.0	top of atmosphere outgoing longwave radiation
92	insolation_ sasrab	W m-2	0.00	1500.00	surface downwelling shortwave flux computed from the SASRAB routine
93	insolation_ diffuse_ sasrab	W m-2	0.00	1500.00	diffuse component of the surface downwelling shortwave flux computed from the SASRAB routine
94	ndvi_sfc	none	- 0.5000 00	1.00	normalized difference vegetation index, atmospherically corrected
95	ndvi_sfc_ white_sky	none	- 0.5000 00	1.00	normalized difference vegetation index, atmospherically corrected, modis white sky
96	surface_ temperature _retrieved	K	220.0	340.0	surface temperature retrieved using atmospherically corrected 11 micron radiance
97	surface_air_ temperature _nwp	K	220.0	340.0	surface air temperature from NWP ancillary data
98	surface_ radiation_ temperature _retrieved	K	220.0	340.0	surface radiation temperature retrieved using atmospherically corrected 11 micron radiance assuming a black surface
99	surface_ temperature _background	K	220.0	340.0	surface temperature assumed using ancillary data sources
100	surface_	%	0.00	110.0	near-surface relative humidity from

	relative_ humidity_ nwp				NWP ancillary data
101	surface_ pressure_ background	hPa	700.0	1100.00	surface pressure assumed using ancillary data sources
102	mean_ sealevel_ pressure_ background	hPa	850.0	1100.00	mean sealevel pressure assumed using ancillary data sources
103	k_index_nwp	K	-40.0	80.0	k index computed from NWP ancillary data sources
104	cloud_water_ path_nwp	g m-2	0.00	1200.00	cloud water path computed from NWP ancillary data sources
105	cloud_ fraction_nwp	none	0.00	1.00	cloud fraction computed from NWP ancillary data sources
106	cld_press_ nwp	none	0.00	1100.00	cloud-top pressure computed from NWP ancillary data sources
107	number_ cloud_layers _nwp	none	0.00	1100.00	number cloud layers in column from NWP ancillary data sources
108	cloud_type_ nwp	none	0.00	1100.00	cloud type from NWP ancillary data sources, see PATMOS-x documentation for key
109	tropopause_ temperature _nwp	K	160.0	260.0	tropopause temperature from NWP ancillary data
110	lcl_nwp	km	0.00	20.0	lifting condensation level from NWP ancillary data
111	ccl_nwp	km	0.00	20.0	convective condensation level from NWP ancillary data
112	remote_ sensing_ reflectance	none	-2.00	10.0	remote sensing reflectance (upward radiance/downward irradiance at surface)
113	quality_flags _1	none	-2.00	10.0	first set of packed quality flags, deprecated. Use *_qf variables.
114	quality_flags _2	none	-2.00	10.0	second set of packed quality flags, deprecated. Use *_qf variables.
115	refl_0_65um _nom_counts	none	-2.00	10.0	instrument counts for the nominal 0.65 micron channel

116	refl_0_86um _nom_counts	none	-2.00	10.0	instrument counts for the nominal 0.86 micron channel
117	refl_1_60um _nom_counts	none	-2.00	10.0	instrument counts for the nominal 1.6 micron channel
118	total_ precipitable_ water_nwp	cm	0.00	10.0	total precipitable water from NWP ancillary data
119	refl_3_75um _nom_atmos _corr	%	-20.0	80.0	observed pseudo-reflectance at the nominal wavelength of 3.75 microns, atmospherically corrected, expressed as a percentage using PATMOS-x calibration
120	refl_0_65um _nom_atmos _corr	%	-2.00	120.0	observed pseudo-reflectance at the nominal wavelength of 0.65 microns, atmospherically corrected, expressed as a percentage using PATMOS-x calibration
121	refl_0_86um _nom_atmos _corr	%	-2.00	120.0	observed pseudo-reflectance at the nominal wavelength of 0.85 microns, atmospherically corrected, expressed as a percentage using PATMOS-x calibration
122	refl_1_60um _nom_atmos _corr	%	-2.00	120.0	observed pseudo-reflectance at the nominal wavelength of 1.60 microns, atmospherically corrected, expressed as a percentage using PATMOS-x calibration
123	pixel_sst_ masked	K	265.0	315.0	sea surface skin temperature at the pixel with land mask and cloud mask applied
124	refl_0_65um _nom_unnor malized	%	-2.00	120.0	top of atmosphere reflectance at the nominal wavelength of 0.65 microns unnormalized to the cosine of the solar zenith angle
125	refl_0_86um _nom_unnor malized	%	-2.00	120.0	top of atmosphere reflectance at the nominal wavelength of 0.86 microns unnormalized to the cosine of the solar zenith angle
126	refl_1_60um _nom_unnor malized	%	-2.00	120.0	top of atmosphere reflectance at the nominal wavelength of 1.60 microns unnormalized to the cosine of the solar zenith angle

127	refl_0_65um_nom_clear_sky	%	-2.00	120.0	top of atmosphere bidirectional reflectance modeled assuming clear skies at the nominal wavelength of 0.65 microns
128	temp_3_75um_nom_clear_sky	K	180.0	340.0	top of atmosphere brightness temperature modeled assuming clear skies at the nominal wavelength of 11.0 microns
129	temp_11_0um_nom_clear_sky	K	180.0	340.0	top of atmosphere brightness temperature modeled assuming clear skies at the nominal wavelength of 11.0 microns
130	temp_12_0um_nom_clear_sky	K	180.0	340.0	top of atmosphere brightness temperature modeled assuming clear skies at the nominal wavelength of 12.0 microns
131	refl_0_65um_nom_mean_3x3	%	-2.00	120.0	mean of the 0.65 micron nominal reflectance computed over a 3x3 pixel array
132	pixel_sst_unmasked	K	265.0	315.0	sea surface skin temperature at the pixel with land mask applied and cloud mask not applied
133	wind_speed_10m_nwp	m/s	0.00	50.0	wind speed from the NWP ancillary data at 10m above ground level
134	wind_direction_10m_nwp	degrees	0.00	360.0	wind direction from the NWP ancillary data at 10m above ground level
135	refl_0_65um_nom_dark	%	-2.00	120.0	top of atmosphere reflectance at the nominal wavelength of 0.65 microns generated from a dark-sky compositing method
136	cloud_water_path	g m-2	0.00	1200.00	integrated total cloud water over whole column
137	rain_rate	mm h-1	0.00	32.0	derived rain rate
138	wind_speed_cloud_top_nwp	m/s	0.00	50.0	wind speed from the NWP ancillary data at cloud-top level
139	wind_direction_cloud_top_nwp	degrees	0.00	360.0	wind direction from the NWP ancillary data at cloud-top level

Level-2 Attributes.

In addition to the Scientific Data Sets (SDS) listed in Table 4, the Level-2 files also contain meta-data stored as global attributes. In a Level-2 file , there are over 60 attributes. These record many of the choices made in the default options file and provide information on the time-span, the sensor, its calibration and versions of the algorithms. Table 5 gives the complete list of these attributes.

Table 5 List and description of global attributes in a Level-2 fie.

Attr. #	Attribute Name	Description
1	SOURCE	Version of clavrxorb
2	CREATED	Time of file creation
3	PROCESSING_NOTE	Processing description string
4	HDF_LIB_VERSION	HDF4 library version
5	MACHINE	Machine name
6	PROGLANG	Version of FORTRAN used
7	CLOUD_MASK_VERSION	CVS ID string of cloud mask code
8	CLOUD_MASK_THRESHOLDS_VERSION	CVS ID string of cloud mask thresholds file
9	CLOUD_TYPE_VERSION	CVS ID string of cloud type code
10	ACHA_VERSION	CVS ID string of ACHA code
11	DCOMP_VERSION	CVS ID string of DCOMP code
12	FILENAME	Name of level-2 file
13	L1B	Name of level-1b file
14	RESOLUTION_KM	Approximate pixel resolution
15	START_YEAR	Year at start of data
16	START_DAY	Day of year at start of data
17	START_TIME	Time of day at start of data
18	END_YEAR	Year and end of data
19	END_DAY	Day of year at end of data
20	END_TIME	Time of day at end of data
21	ACHA_MODE	Mode used for ACHA products
22	DCOMP_MODE	Mode used for DCOMP products
23	WMO_SATELLITE_CODE	WMO code for this sensor
24	SENSOR_NAME	Name of this sensor
25	REFL_0_65UM_NOM_DARK_COMPOSITE_NAME	Name of dark sky composite used
26	NAIVE_BAYESIAN_CLOUD_MASK_NAME	Name of the naïve Bayesian threshold file
27	DATA_TYPE	The type of data (= pixel for level-2)
28	USE_1B_THERMAL_CALIBRATION_FLAG	Recorded from instrument file
29	USE_1B_REFLECTANCE_CALIBRATION_FLAG	Recorded from instrument file
30	RENAVIGATION_FLAG	Recorded from instrument file
31	USE_SST_ANALYSIS_FLAG	Recorded from instrument file
32	SST_ANALYSIS_SOURCE_FLAG	Recorded from instrument file

33	NWP_FLAG	Recorded from instrument file
34	MODIS_CLEAR_SKY_REFLECTANCE_FLAG	Recorded from instrument file
35	CH1_GAIN_LOW	Ch1 reflectance parameter (AVHRR only)
36	CH1_GAIN_HIGH	Ch1 reflectance parameter (AVHRR only)
37	CH1_SWITCH_COUNT	Ch1 reflectance parameter (AVHRR only)
38	CH1_DARK_COUNT	Ch1 reflectance parameter (AVHRR only)
39	CH2_GAIN_LOW	Ch2 reflectance parameter (AVHRR only)
40	CH2_GAIN_HIGH	Ch2 reflectance parameter (AVHRR only)
41	CH2_SWITCH_COUNT	Ch2 reflectance parameter (AVHRR only)
42	CH2_DARK_COUNT	Ch2 reflectance parameter (AVHRR only)
43	CH3A_GAIN_LOW	Ch3a reflectance parameter (AVHRR only)
44	CH3A_GAIN_HIGH	Ch3a reflectance parameter (AVHRR only)
45	CH3A_SWITCH_COUNT	Ch3a reflectance parameter (AVHRR only)
46	CH3A_DARK_COUNT	Ch3a reflectance parameter (AVHRR only)
47	SUN_EARTH_DISTANCE	Sun earth distance factor
48	C1	Planck Constant #1
49	C2	Planck Constant #2
50	A_20	Rad to Temp Coeff for Ch 20
51	B_20	Rad to Temp Coeff for Ch 20
52	NU_20	Equivalent width of Ch 20
53	A_31	Rad to Temp Coeff for Ch 31
54	B_31	Rad to Temp Coeff for Ch 31
55	NU_31	Equivalent width of Ch 31
56	A_32	Rad to Temp Coeff for Ch 32
57	B_32	Rad to Temp Coeff for Ch 32
58	NU_32	Equivalent width of Ch 32
59	SOLAR_20_NU	Mean solar energy in Ch20
60	TIME_ERROR_SECONDS	Clock error assumed (AVHRR only)
61	NUMBER_OF_ELEMENTS	Number of elements on a scan
62	NUMBER_OF_SCANS_LEVEL1B	Number of scans in level-1b
63	NUMBER_OF_SCANS_LEVEL2	Number of scans written to Level-2
64	PROCESSING_TIME_MINUTES	Total processing time in minutes
65	NONCONFIDENT_CLOUD_MASK_FRACTION	Fraction of pixels with probably-clear or probably-cloudy cloud mask
66	ACHA_SUCCESS_FRACTION	Fraction of relevant pixels with successful ACHA retrieval
67	DCOMP_SUCCESS_FRACTION	Fraction of relevant pixels with successful DCOMP retrieval

Reading SDS Data from Level-2 Files

IDL and fortran routines exist to read the contents of any parameter in a Level-2 file and are available on request and from the CLAVR-x web site (http://cimss.ssec.wisc.edu/clavr). The goal was the make CLAVR-x data easy to read and to comply where possible (and to the best of our understanding) the CF standards.

Reading Unscaled Data

The Level-2 SDS data are either un-scaled or scaled into one or two-byte integers. The scaling status is determined by reading the "SCALED" attribute for each SDS. A scaled value of 0 means the data are not scaled and 1 means that the data are scaled. The following text provides the variable information from the "hdp –h dumpsds "command for an un-scaled Level-2 variable (bad_pixel_mask). For un-scaled data, there are 7 attributes in addition to the ranks and dimensions of the data. The RANGE_MISSING value gives the value for the pixels whose value is missing and this value varies with the data type. The _FillValue and the RANGE_MISSING are the same for un-scaled data.

```
Variable Name = bad_pixel_mask
     Index = 4
     Type= 8-bit signed integer
     Ref. = 6
     Rank = 2
     Number of attributes = 8
     Dim0: Name=scan_lines_along_track_direction
          Size = 3906
          Scale Type = number-type not set
          Number of attributes = 0
     Dim1: Name=pixel_elements_along_scan_direction
          Size = 2048
          Scale Type = number-type not set
          Number of attributes = 0
     Attr0: Name = SCALED
          Type = 8-bit signed integer
          Count= 1
          Value = 0
     Attr1: Name = units
          Type = 8-bit signed char
          Count= 4
          Value = none
     Attr2: Name = standard_name
          Type = 8-bit signed char
          Count= 14
          Value = bad_pixel_mask
     Attr3: Name = long_name
          Type = 8-bit signed char
```

Count= 50
Value = mask that distinguishes good(0) from bad(
1) pixels
Attr4: Name = coordinates
Type = 8-bit signed char
Count= 18
Value = longitude latitude
Attr5: Name = RANGE_MISSING
Type = 32-bit floating point
Count= 1
Value = -128.000000
Attr6: Name = valid_range
Type = 8-bit signed integer
Count= 2
Value = -127 127
Attr7: Name = _FillValue
Type = 8-bit signed integer
Count= 1
Value = -128

Reading Scaled SDS Data

While CLAVR-x supports several scaling options, only SCALED=1 occurs in Level-2 files and this means the data is scaled linearly. For a scaled SDS, there are 14 attributes (as opposed to 7 for an un-scaled SDS). For a scaled SDS, RANGE_MIN, RANGE_MAX and RANGE_MISSING have the same units as the scaled data. The SCALED_MIN, SCALED_MAX and SCALED_MISSING refer to the scaled data. To be CF compliant, CLAVR-x added the _FillValue, add_offset and scale_factor attributes. For a scaled SDS, the _FILLVALUE is the same as the SCALED_MISSING value. The add_offset and scale_factor are derived from the RANGE and SCALED set of attributes. These allow the un-scaling equation to written simply as

un-scaled_data = scale_factor * scaled_data + add_offet

Due to CF compliance demands, the use of the add_offset and scale_factor are suggested as opposed to the other scaling parameters which will likely disappear in future CLAVR-x versions. An example “hdp –h dumpsds” output for a scaled SDS (solar zenith angle) is given below.

Variable Name = solar_zenith_angle
Index = 15
Type= 8-bit signed integer
Ref. = 45
Compression method = DEFLATE
Deflate level = 6
Compression ratio (original:compressed) = 17.35:1
Rank = 2
Number of attributes = 15
Dim0: Name=latitude index
Size = 700
Scale Type = number-type not set
Number of attributes = 0
Dim1: Name=longitude index
Size = 700

Scale Type = number-type not set
Number of attributes = 0
Attr0: Name = SCALED
Type = 8-bit signed integer
Count= 1
Value = 1
Attr1: Name = units
Type = 8-bit signed char
Count= 7
Value = degrees
Attr2: Name = standard_name
Type = 8-bit signed char
Count= 18
Value = solar_zenith_angle
Attr3: Name = long_name
Type = 8-bit signed char
Count= 84
Value = solar zenith for each pixel measured in degrees away from the sun (0=looking at sun)
Attr4: Name = coordinates
Type = 8-bit signed char
Count= 18
Value = longitude latitude
Attr5: Name = RANGE_MISSING
Type = 32-bit floating point
Count= 1
Value = -999.000000
Attr6: Name = valid_range
Type = 8-bit signed integer
Count= 2
Value = -127 0
Attr7: Name = _FillValue
Type = 8-bit signed integer
Count= 1
Value = -128
Attr8: Name = RANGE_MIN
Type = 32-bit floating point
Count= 1
Value = 0.000000
Attr9: Name = RANGE_MAX
Type = 32-bit floating point
Count= 1
Value = 180.000000
Attr10: Name = SCALED_MIN
Type = 32-bit signed integer
Count= 1
Value = -127
Attr11: Name = SCALED_MAX
Type = 32-bit signed integer
Count= 1
Value = 127
Attr12: Name = SCALED_MISSING
Type = 32-bit signed integer
Count= 1
Value = -128
Attr13: Name = scale_factor
Type = 32-bit floating point
Count= 1
Value = 0.708661
Attr14: Name = add_offset
Type = 32-bit floating point
Count= 1

Value = 90.000000

Algorithms

Cloud Detection

Heidinger et al. (2012) describes the cloud detection scheme employed in CLAVR-x. The CLAVR-x technique is a naïve Bayesian methodology. For the AVHRR, an analysis of co-located NOAA-18/AVHRR and CALIPSO/CALIOP observations was used to automatically derive the Bayesian classifiers globally. This methodology has been extended to all of the sensors supported by CLAVR-x. The resulting algorithm uses 12 Bayesian classifiers computed for 7 separate surface types. Relative to CALIPSO, the final AVHRR results show a probability of correct detection of roughly 90% over water, deserts and snow-free land, 75% over the Arctic and below 70% over the Antarctic. Comparisons of the AVHRR CLAVR-x results to those from ISCCP and MODIS GEWEX submissions indicate close agreement with zonal mean differences in cloud amount, being less than 5% over most zones. Most areas of difference coincide with regions where the Bayesian cloud mask reported elevated uncertainties. The ability to report uncertainties is a critical component of this approach though this information is not reported in the GEWEX data set.

Cloud Phase and Type Estimation

The cloud typing routine classifies each pixel into one of seven categories (0-clear, 1-fog, 2-liquid water cloud, 3-supercooled water cloud, 4-opaque ice, 5-cirrus, 6 – multilayer cirrus). These were chosen because they represent a minimum set of types evident in the spectral signatures provided by the AVHRR. The multi-layer cirrus type is restricted to semi-transparent cirrus that overlies a warmer and lower-level cloud. The actual technique is described in Pavolonis et al. (2005). The multi-layer detection is described in Pavolonis and Heidinger (2004) and global results are shown and compared to other estimates in Heidinger and Pavolonis (2005).

AWG Cloud Height Algorithm (ACHA)

Cloud temperature CT and emissivity CEM are retrieved by an optimal estimation approach based on split window observations (11 and 12 μm). This algorithm is described and evaluated in Heidinger and Pavolonis (2009). The relationship between brightness temperatures at 11 and 12 μm for a single layer cloud depends on cloud temperature (CT), cloud emissivity (CEM) and the cloud microphysics. We assume the cloud microphysics and estimate CT and CEM. Our choice for the assumed microphysical parameter has been guided by comparisons to MODIS CO2 slicing results. The a priori constraints are based on the cloud type classification and MODIS CO2 slicing results. For high, thin cirrus, we have found CT to be highly sensitive to the a priori constraint as well as CEM. Our analysis has also demonstrated that the CT accuracy allows for proper placement of ice clouds into the high cloud category. For low level cloud or optically thick high cloud, the method performs similar to a single channel 11 μm approach. Like TOVS Path-B, this approach allows for simultaneous estimation of CT and CEM day and night. This algorithm is one reason that PATMOS-x high cloud amounts show realistic day-night differences. CP and CZ are estimated from CT using the collocated NCEP Reanalysis profile.

The actual channel set used in ACHA varies with sensor. ACHA provides 7 modes of operation.

Table 6 Description of the Options for the AWG Cloud Height Algorithm (ACHA)

ACHA MODE	Channels Used (Wavelength and MODIS Band Number)	Relevant Sensors
0	11 μm (Ch 31)	All
1	11 and 12 μm (Ch31,32)	AVHRR, VIIRS, MODIS, MTSAT, COMS, FY2D, GOES I-L, MSG
2	11 and 13.3 μm (Ch31, 33)	MODIS, GOES-M-P, MSG
3	11,12 and 13 μm (Ch31,32,33)	MODIS, MSG
4	8.5, 11 and 12 μm (Ch29, 31 and 32)	MODIS, VIIRS, MSG
5	6.7, 11, 12 μm (Ch27, 31 and 32)	MODIS, MSG, GOES I-L, MTSAT, COMS, FY2D
6	6.7, 11, 13.3 μm (Ch27, 31 and 33)	MODIS, MSG, GOES M-P

Daytime Cloud Optical and Microphysical Properties (DCOMP)

The COD and effective cloud particle radius (CRE) are retrieved for daytime observations by an optimal estimation approach using the 0.63 and 3.75 micron channels (Walther and Heidinger 2012). The forward operator is based on Mie theory and an adding/doubling radiative transfer model. For ice phase functions we use ice crystal habit distributions as described by Baum et al. (2005). The forward simulation output is stored in look-up-tables to speed up the retrieval. The surface reflectance over land for 0.63 μm is taken from white-sky albedo maps generated by the MODIS-ST group. The 3.75 μm surface reflectance and emissivity over land is provided by the SEEBOR emissivity database (Seemann et al., 2008). Over ocean, fixed values of surface reflectance and emissivity are assumed.

Atmospheric correction is done in a two-level scheme separated into above cloud and below cloud corrections. The first part computes the reflectance observable at the top of the cloud level. Atmospheric transmission below the cloud is incorporated by adjusting the surface albedo to an effective value. Simplified algorithms based on forward simulations are used to compute atmospheric transmission values for ozone and for water vapor. MODTRAN v4 code is used to compute regression coefficients as a function of absorber amount, which is provided by NCEP. In a similar manner for the 3.75 µm channel, atmospheric transmission is provided by PFAAST – a fast infrared radiative transfer model that uses the NCEP profiles. Based on Optimal Estimation, DCOMP makes use of the uncertainty estimates of input parameters and the forward model and then propagates these into uncertainty estimates for the retrieved parameters.

We derive liquid water path and ice water path using COD and CRE by LWP = 5/9 *COD*CRE for liquid cloud phase (Wood; Hartmann 2006) and IWP = [COD**(1/0.84)]/0.065 for ice water path (Figure 7 in Heymsfield et al. 2003). The Heymsfield relationship was derived empirically from aircraft measurements. The motivation for this choice is that the cloud-top effective radius for thick ice clouds has little correlation with the effective radius deeper into the cloud. Our analysis indicates that this empirical relationship based solely on COD gives values higher than those predicted by the method employed for water clouds.

Table 7 Options for the AWG Daytime Cloud Optical and Microphysical Properties (DCOMP) Algorithm

DCOMP MODE	**Channels Used (Wavelength and MODIS Band Number)**	**Relevant Sensors**
0	N/A (turns off DCOMP)	All
1	0.65 and 1.6 µm (Ch1,6)	AVHRR, VIIRS, MODIS, MSG
2	0.65 and 2.2 µm (Ch1,7)	MODIS, MSG
3	0.65 and 3.75 µm (Ch1,20)	MODIS, MSG, GOES

Product Examples

Figure 2 shows an image from the 0.65 µm channel on the NOAA-19 AVHRR HRPT from September 8, 2013, 17:31 to 17:46 UTC. Level1B data are included in the CLAVR-x Level2 file. All subsequent images have been derived from the scene shown in Figure 2.

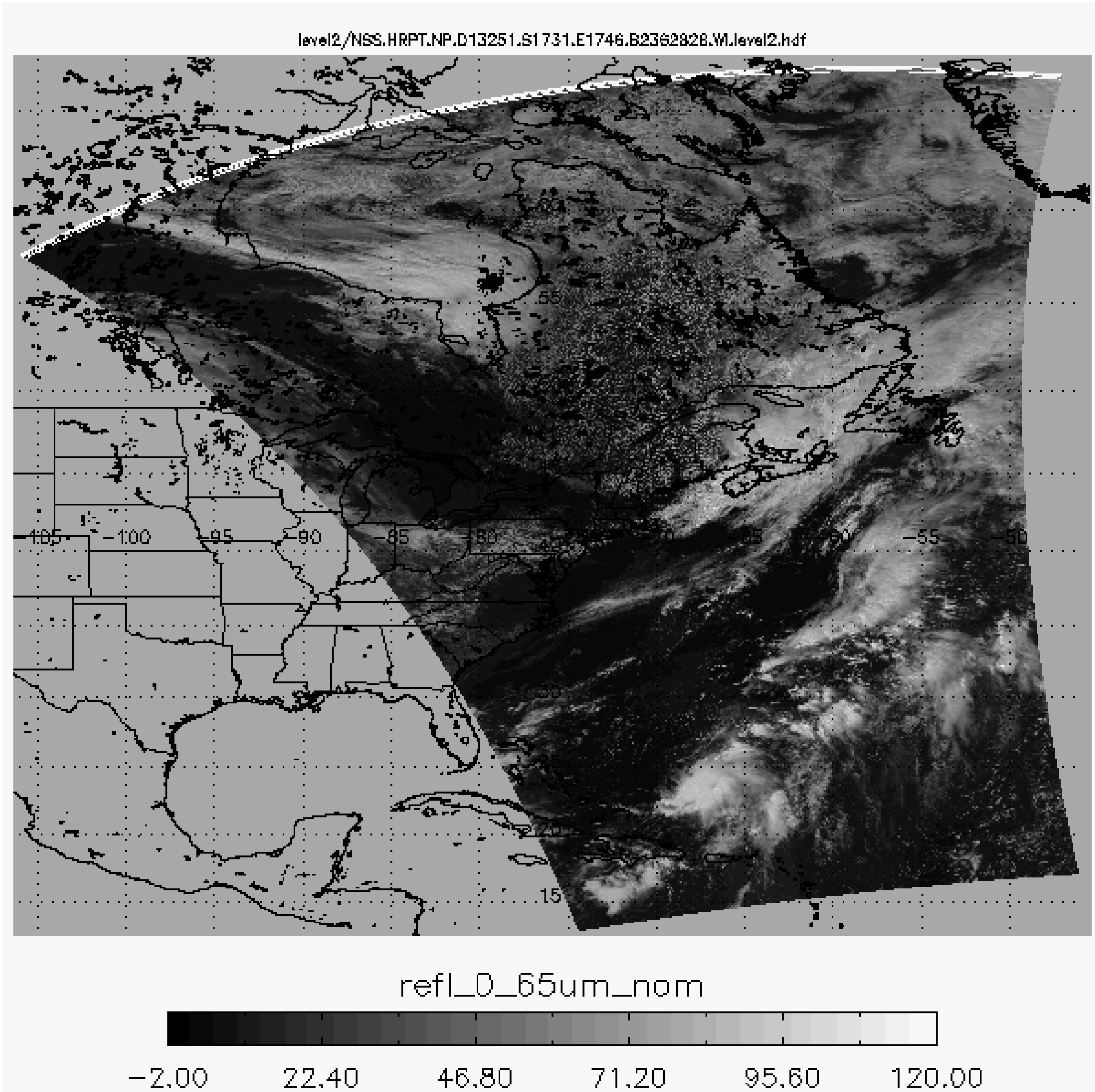

Figure 4 Example visible reflectance from NOAA-19 AVHRR HRTP from September 8, 2013. The time range of the image is from 17:31 to 17:46 UTC.

The following set of product images are generated from a CLAVR-x Level2 file derived the from NOAA-19 AVHRR HRPT data from September 8, 2013, 17:31 to 17:46 UTC. Figure 3 shows a false-color RGB image constructed from the 0.65 μm reflectance (refl_0_65um_nom variable in the Level2 file), the 0.86 μm reflectance (refl_0_86um_nom variable in the Level2 file) and the 11 μm brightness temperature (temp_11_0um_nom variable in the Level2 file).

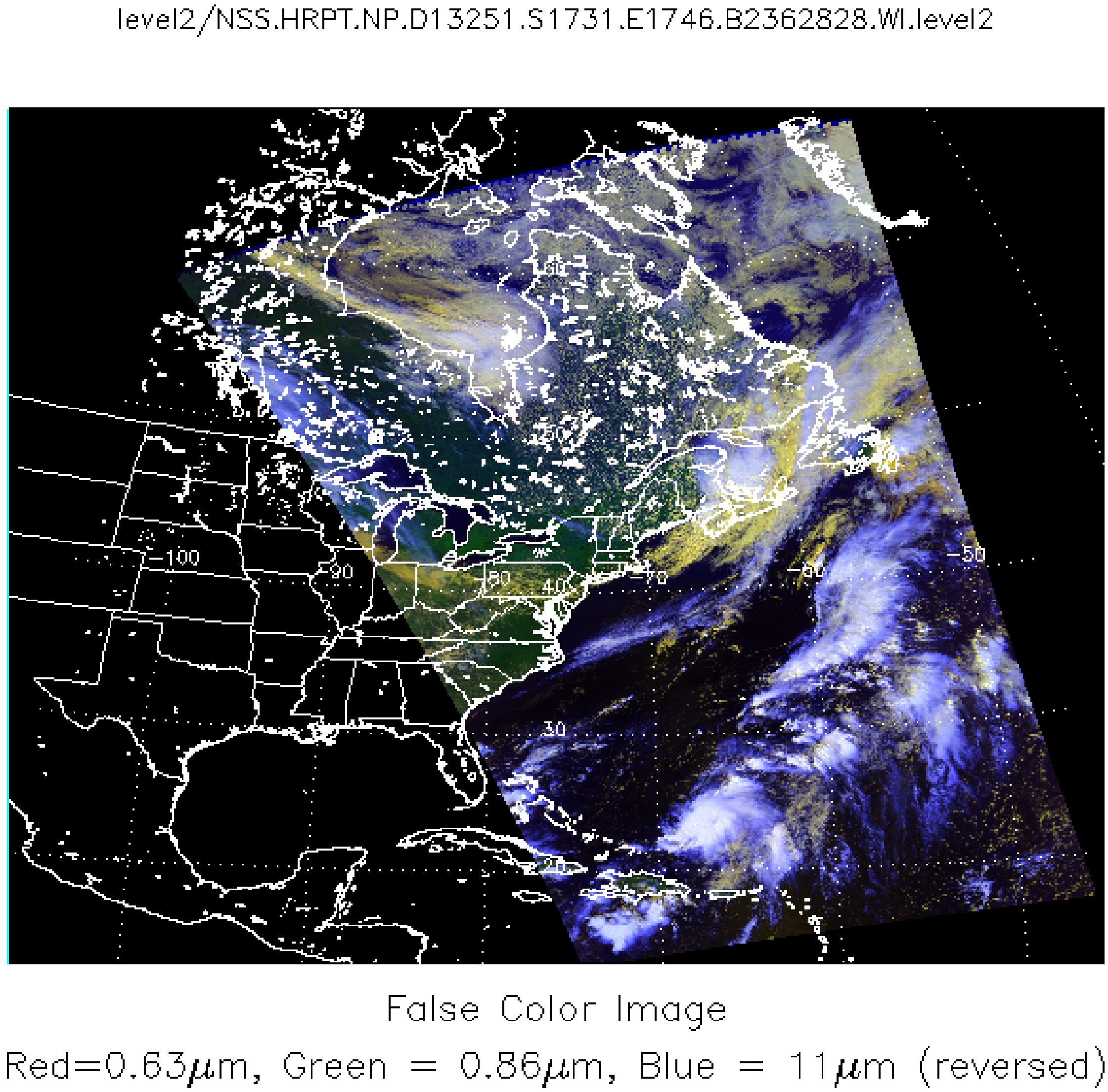

Figure 5 False-color RGB constructed from the 0.65 μm reflectance (refl_0_65um_nom), the 0.86 μm reflectance (refl_0_86um_nom) and the 11 μm brightness temperature (temp_11_0um_nom). Black regions represent pixels where no retrieval was performed (i.e. clear-sky), or where no data are present.

Figure 4 shows the CLAVR-x cloud mask for the scene in Figure 2. The cloud mask product (cloud_mask variable in the Level2 file) is a 4-level integer classification. However, the image below differentiates between clear land and clear water. The classifications from CLAVR-x are: CLEAR (value=0), PROBABLY-CLEAR (value=1), PROBABLY-CLOUDY (value=2), CLOUDY (value=3). The mask is derived from the cloud_probability variable, which is also output to the Level2 file. Users are encouraged to experiment with different thresholds of the cloud probability for their own application.

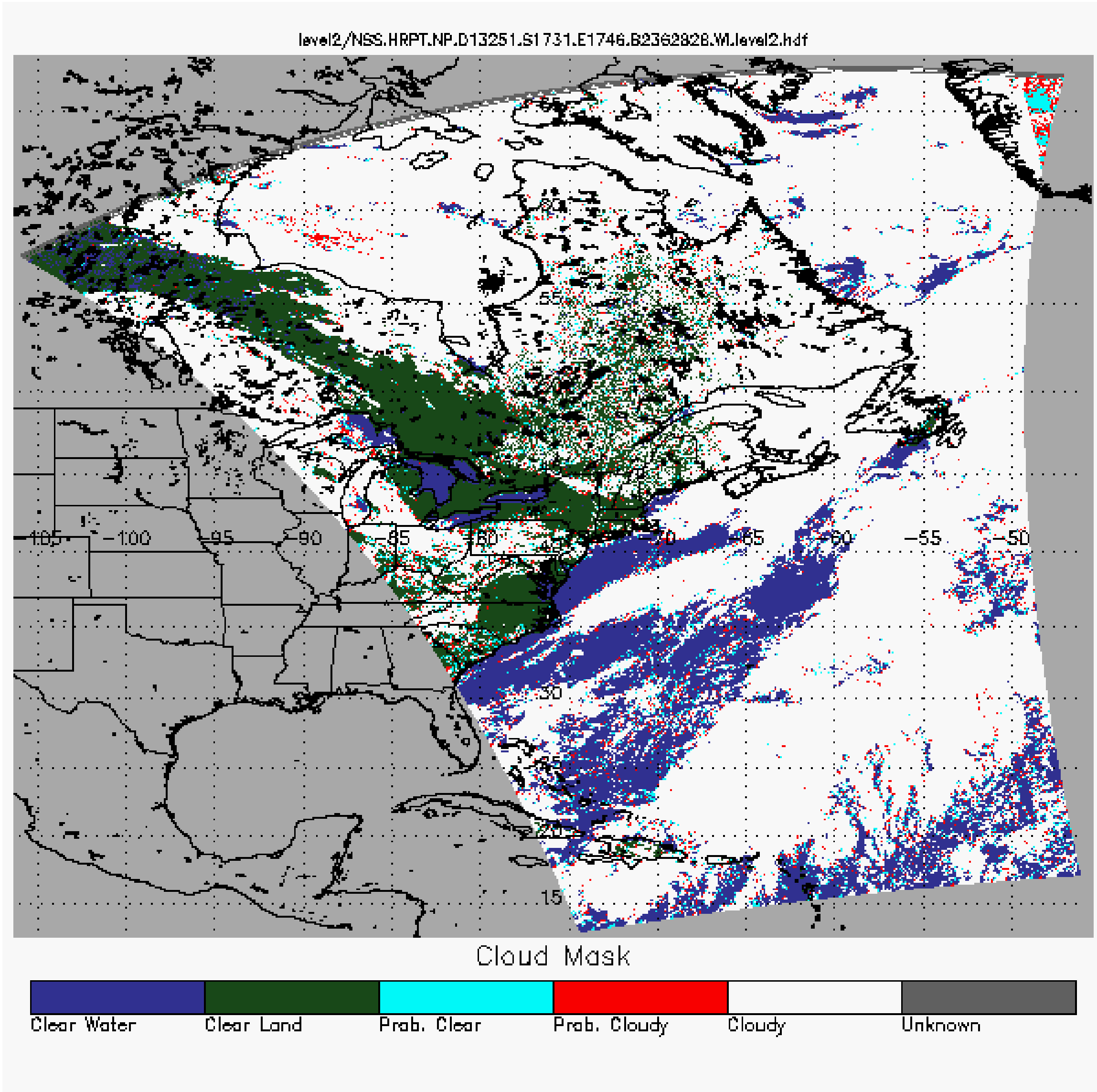

Figure 6 Example CLAVR-x cloud mask for the scene in Figure 2. The cloud mask (cloud_mask variable in the Level2 file) is a 4-level integer classification product. The classifications are: CLEAR (value=0), PROBABLY-CLEAR (value=1), PROBABLY-CLOUDY (value=2), CLOUDY (value=3).

Figure 5 shows the CLAVR-x cloud type classifications for the scene in Figure 2. The cloud type product (cloud_type variable in the Level2 file) is a 14-level integer classification. However, the image below shows only 10 designations. The integer cloud type classifications from CLAVR-x are: CLEAR=0, PROBABLY CLEAR=1, NEAR SURFACE CLOUD=2, WATER=3, SUPERCOOLED WATER=4, OPAQUE ICE=6, CIRRUS=7, MULTI-LAYER=8, DEEP CONVECTION=9, UNKNOWN=10, DUST=11, SMOKE=12, and FIRE=13. The current version of CLAVR-x does not support the generation of dust type, smoke type and fire type. SPEAK TO FUTURE CAPABILITY HERE!

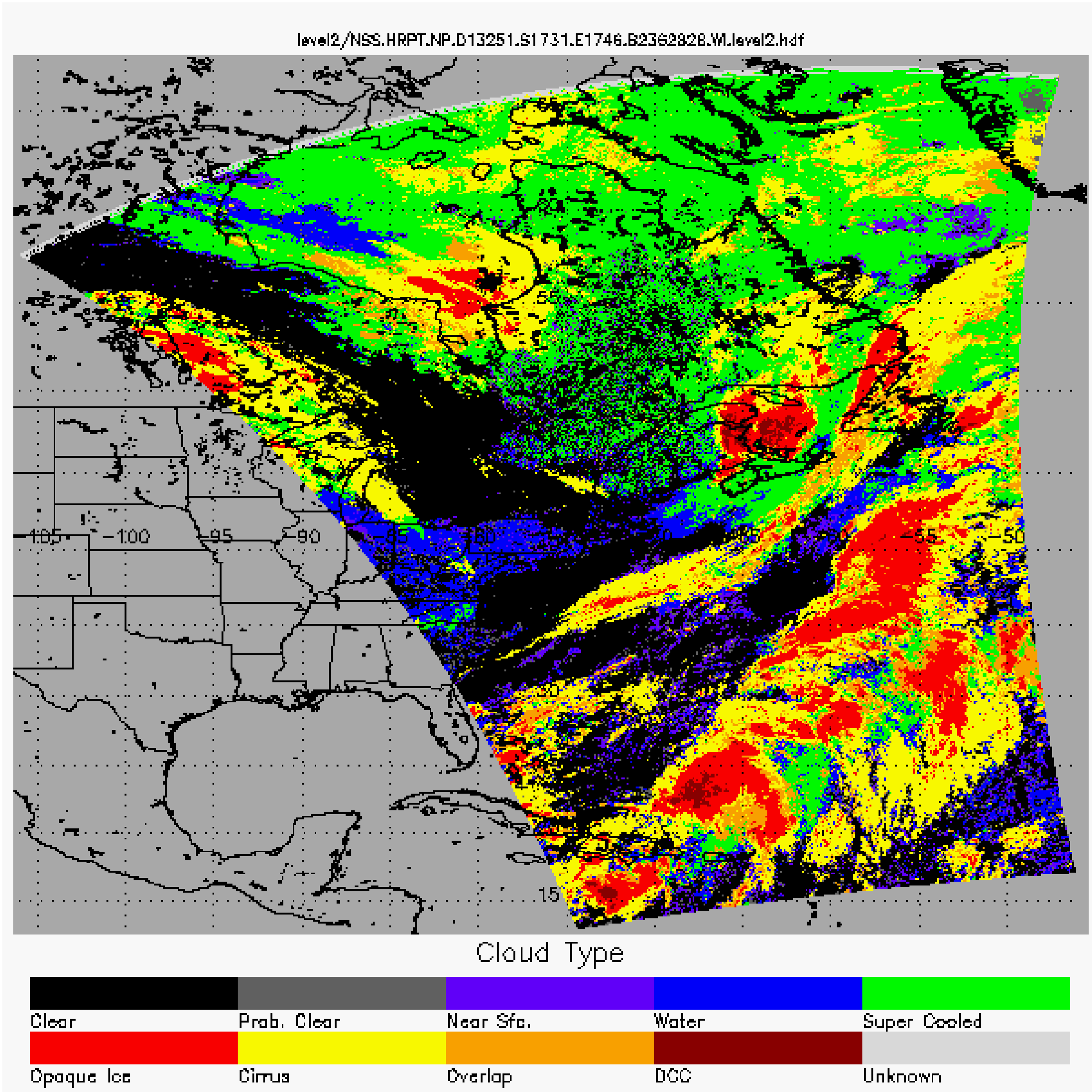

Figure 7 CLAVR-x cloud type products from the Level-2 file (cloud_type variable in the Level2 file). The integer cloud type classifications are: CLEAR=0, PROBABLY CLEAR=1, NEAR SURFACE CLOUD=2, WATER=3, SUPERCOOLED WATER=4, OPAQUE ICE=6, CIRRUS=7, MULTI-LAYER=8, DEEP CONVECTION=9, UNKNOWN=10, DUST=11, SMOKE=12 and FIRE=13.

Figure 6 shows the CLAVR-x cloud-top temperature product for the scene in Figure 2. The cloud-top temperature (cld_temp_acha variable in the Level2 file) is one of the directly retrieved products from the AWG Cloud Height Algorithm (ACHA).

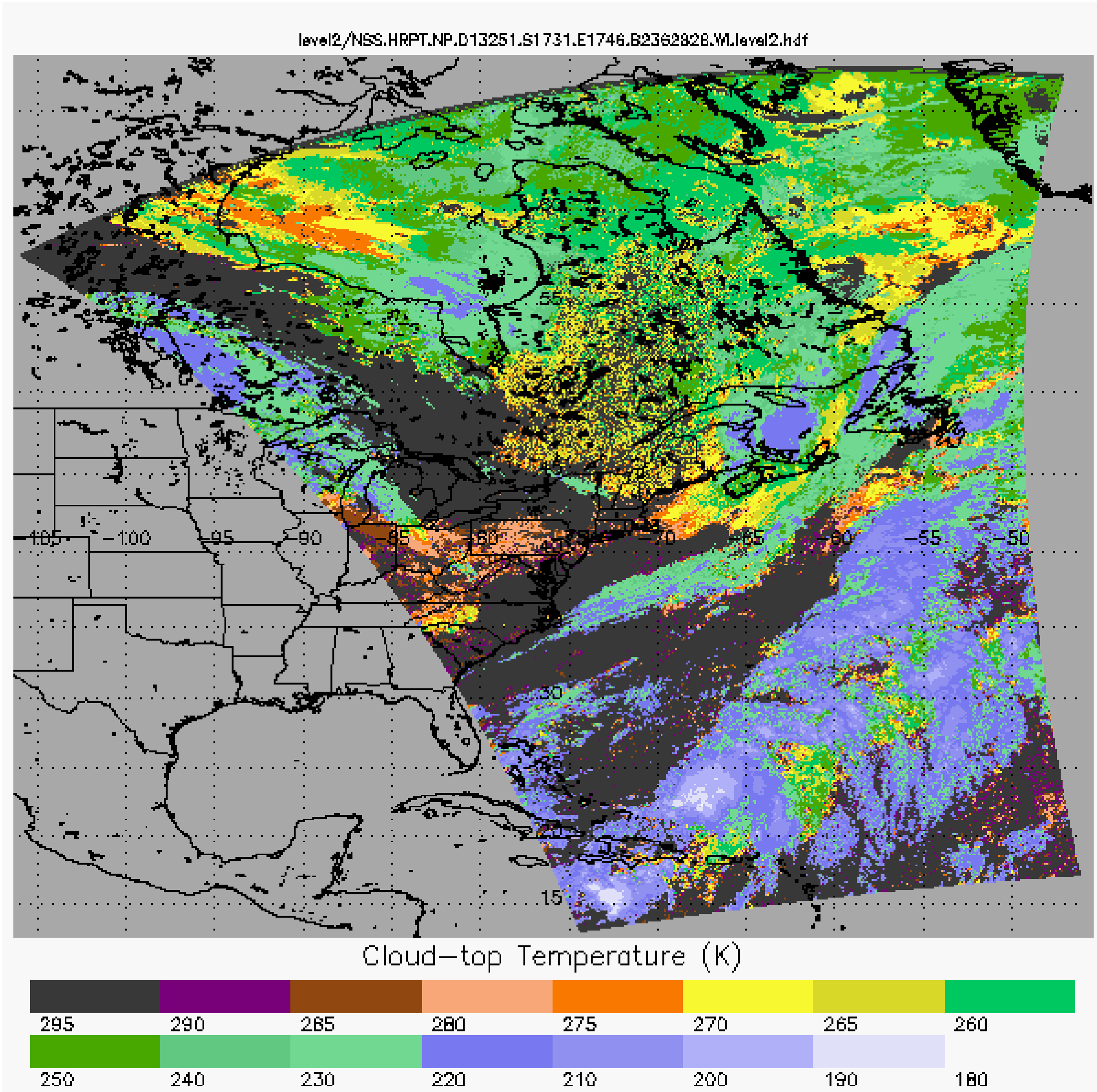

Figure 8 CLAVR-x cloud-top temperature (cld_temp_acha variable in the Level2 file) derived from the AWG Cloud Height Algorithm (ACHA). Dark grey regions represent pixels where no retrieval was performed (i.e. clear-sky).

Figure 7 shows the CLAVR-x cloud-top pressure product for the scene in Figure 2. The cloud-top pressure (cld_press_acha variable in the Level2 file) is derived from the cloud-top temperature and the atmospheric temperature profile provided by the background NWP model.

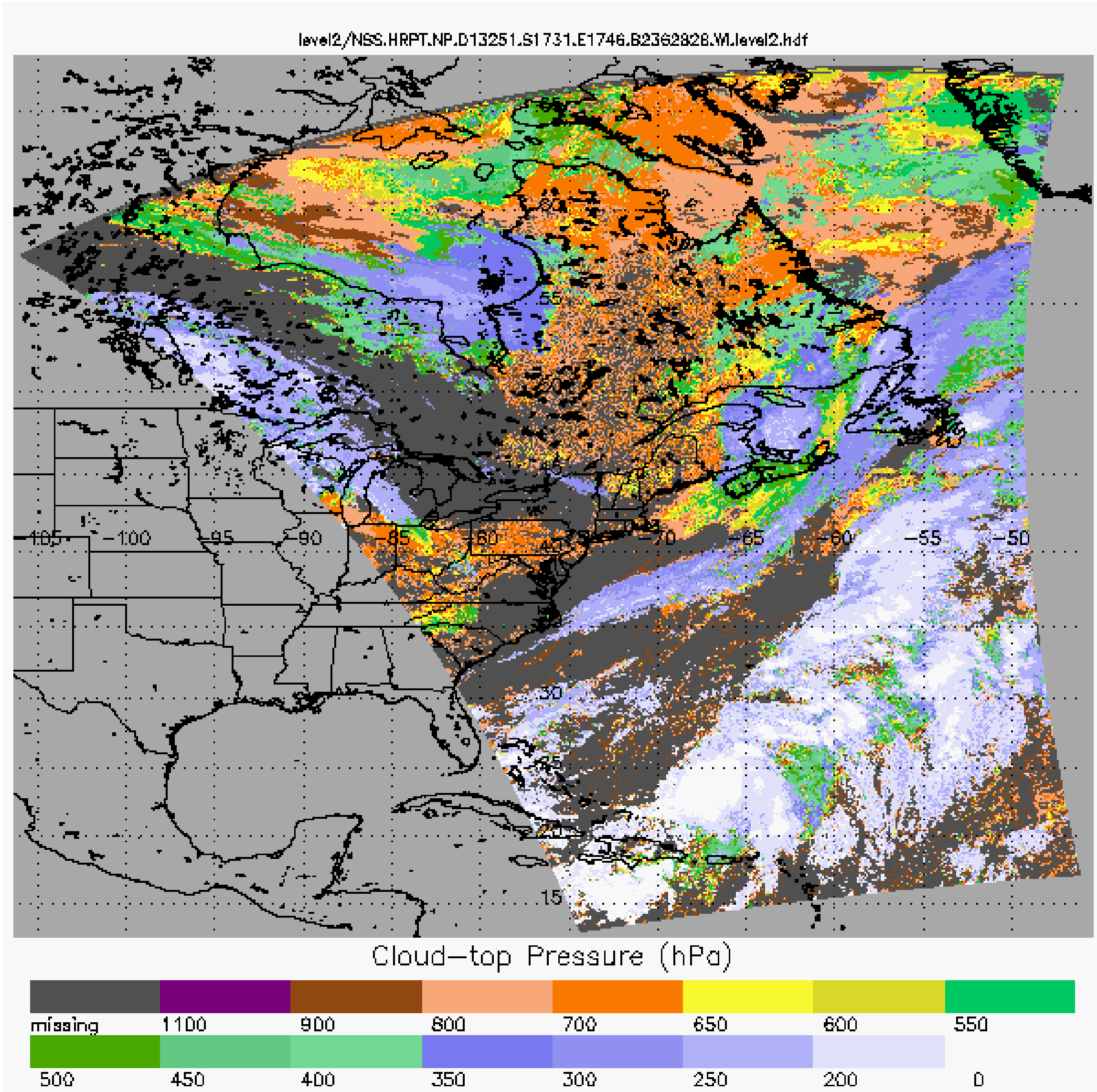

Figure 9 CLAVR-x cloud-top pressure (cld_press_acha variable in the Level2 file) derived from the AWG Cloud Height Algorithm (ACHA). Dark grey regions represent pixels where no retrieval was performed (i.e. clear-sky).

Figure 8 shows the CLAVR-x cloud-top height product for the scene in Figure 2. The cloud-top height (cld_height_acha variable in the Level2 file) is derived from the cloud-top temperature and the atmospheric temperature profile provided by the background NWP model.

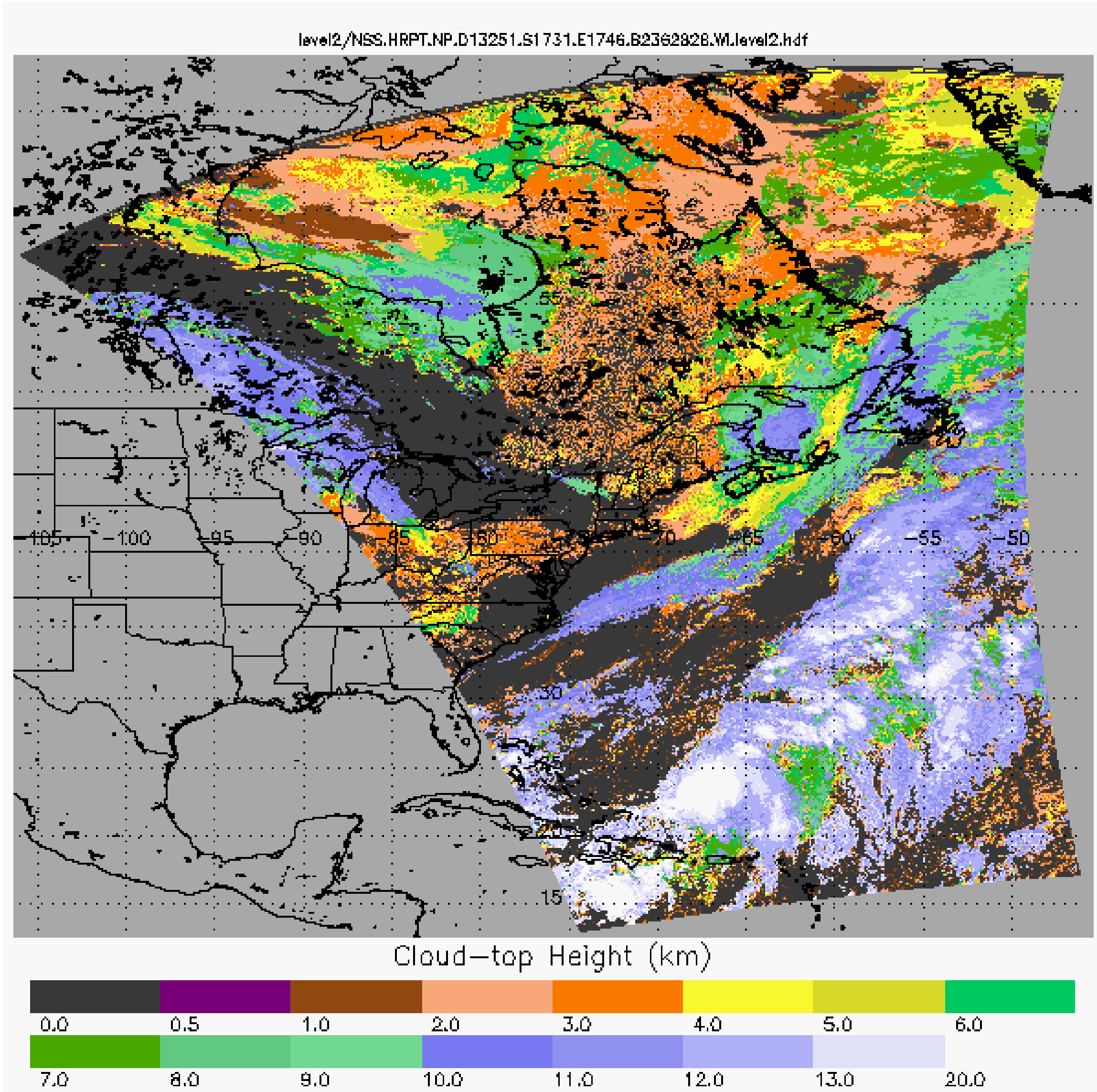

Figure 10 CLAVR-x cloud-top height (cld_height_acha variable in the Level2 file) derived from the AWG Cloud Height Algorithm (ACHA). Dark grey regions represent pixels where no retrieval was performed (i.e. clear-sky).

Figure 9 shows the CLAVR-x 11 μm cloud emissivity product for the scene in Figure 2. The cloud emissivity (cld_emiss_acha variable in the Level2 file) is one of the directly retrieved products from the AWG Cloud Height Algorithm (ACHA).

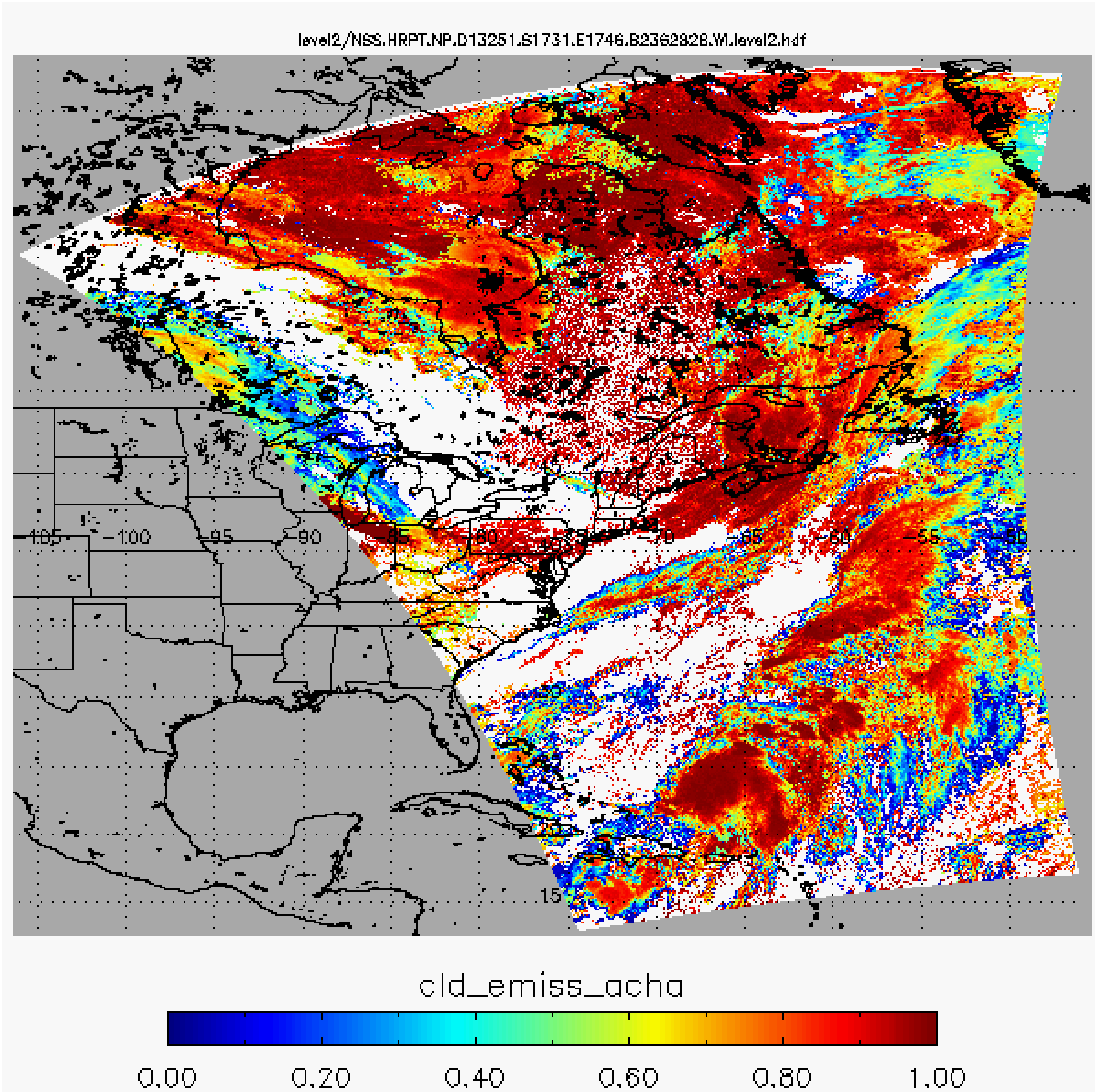

Figure 11 CLAVR-x 11 μm cloud emissivity (cld_emiss_acha variable in the Level2 file) derived from the AWG Cloud Height Algorithm (ACHA). White regions represent pixels where no retrieval was performed (i.e. clear-sky).

Figure 10 shows the CLAVR-x cloud optical depth (COD) for the scene in Figure 2. CLAVR-x uses the GOES-ABI daytime microphysical properties (DCOMP) algorithm to retrieve this product. The COD (cld_opd_dcomp variable in the Level2 file) is one of the directly retrieved products from DCOMP.

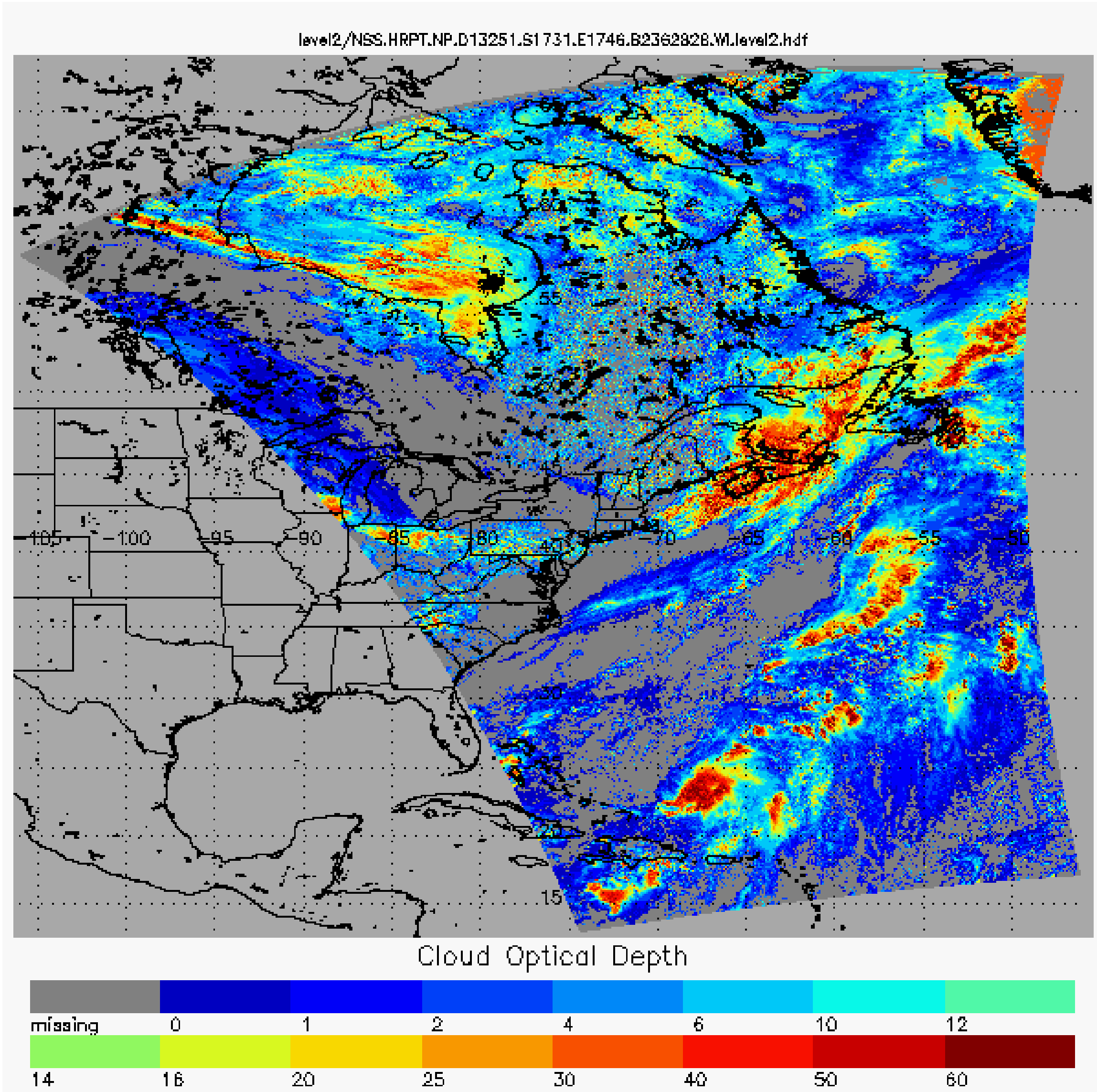

Figure 12 CLAVR-x cloud optical depth (COD) from the AWG Daytime Cloud Optical and Microphysical Properties (DCOMP). Dark grey regions represent pixels where no retrieval was performed (i.e. clear-sky).

Figure 11 shows the CLAVR-x cloud effective radius (REF) for the scene in Figure 2. CLAVR-x uses the DCOMP algorithm to retrieve this product. The REF (cld_reff_dcomp variable in the Level2 file) is one of the directly retrieved products from DCOMP. It may sometimes be referred to as the cloud particle size (CPS).

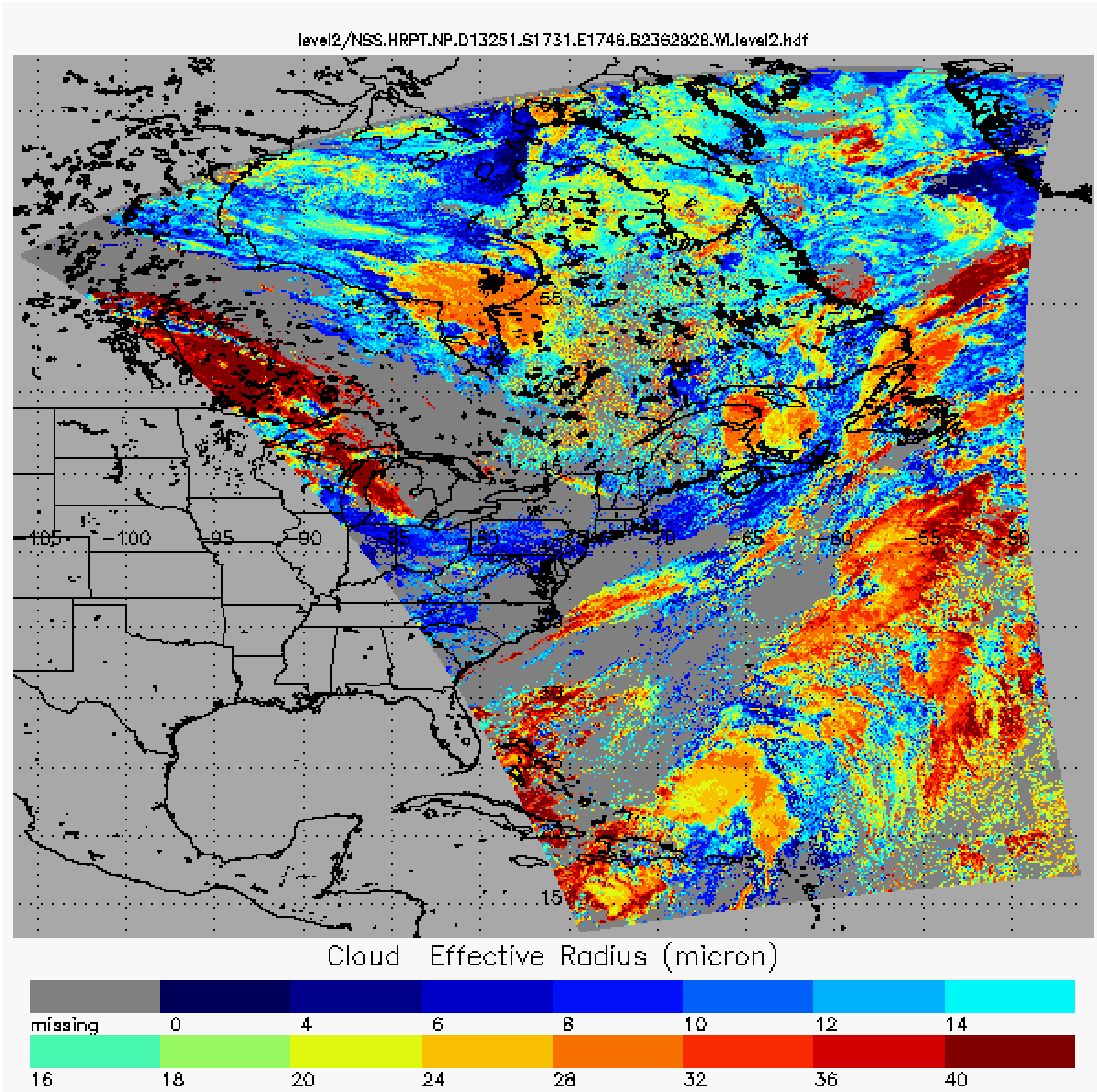

Figure 13 CLAVR-x cloud effective radius (REF) from the AWG Daytime Cloud Optical and Microphysical Properties (DCOMP). Dark grey regions represent pixels where no retrieval was performed (i.e. clear-sky).

Ancillary Data Sets

CLAVR-x reads in the following ancillary data-sets to provide additional information needed to process each pixel properly: NWP, SST, emissivity, surface type, land mask, coast mask, surface elevation, volcano mask, snow/ice mask.

NWP Data

The largest source of dynamic ancillary data comes from numerical weather prediction models (NWP). CLAVR-x supports 4 different types NWP data. CLAVR-x does not read Grib data directly. In order to increase portability, the GRIB or GRIB2 files are converted to HDF4 using a routine (convert_grib_hdf.f90) provided with CLAVR-x. This routine will place an ".hdf" suffix on the file names. NCEP_Reanalysis data is not reformatted into hdf. The choice of NWP data is controlled by the nwp_flag setting in the default options data. . If nwp_flag is "1", then the GFS fields are used. If nwp_flag is "2" then the NCEP Reanalysis is used. If nwp_flag is "3" then the CFSR Reanalysis is used. The path to these files is also a variable in the default options file.

GFS Grib Data

The GFS data used by CLAVR-x are the "pressure-layer grib files". To ensure real-time-access, CLAVR-x was designed to process the 12 hr forecasts made from each 6 hour cycle. The name of the files varies on different servers. One source of real-time data is the NOMADS described servers at http://nomads.ncdc.noaa.gov/. For example, from NOMADS a typical file would be named gfs.t00z.pgrbf12. This file is a 12 hour forecast from the 00Z model run and is therefore valid at 12Z. From the NOAA port server, this file would be called gblav.06062200_F012. Note, the NOAAPORT names include the date in the name where the NOMADS server identifies the date in the directory. Even if the naming convention changes, CLAVR-x does not need to be modified. The naming of the GFS files is taken care of in the grib2hdf converter. CLAVR-x expects these files to reside in the gfs_data_dir directory specified in the default options file.

CFSR Reanalysis

Another source for NWP data is provided by NCEP Climate Forecast System Reanalysis (CFSR) Data. The CFSR is the next generation of the NCEP Reanalysis (see below). CFSR data are very similar to the GFS data. For processing historical data, it is critical to have consistent ancillary data. For this reason, CLAVR-x can be run with reanalysis data. For generating PATMOS-x data, CFSR is used.

NCEP Reanalysis

CLAVR-x still supports the original (an on-going) NCEP Reanalysis data. These data are available at the NOAA Climate Diagnostic Center (CDC) at http://www.cdc.noaa.gov/cdc/reanalysis/reanalysis.shtml. The files needed are the following:

- Air temperature from the Pressure Level Data
- Geopotential height from the Pressure Level Data
- Relative humidity from the Pressure Level Data
- Air Temperature from the Surface Data
- Pressure from the Surface Data
- Precipitable Water from the Surface Data
- Relative Humidity from the Surface Data
- U-wind from the Surface Data
- V-wind from the Surface Data

These files are stored in NETCDF format but can be read using the CLAVR-x HDF libraries as-is. The files are stored per parameter per year and CLAVR-x expects the naming conventions to be the same as that used by the CDC server. CLAVR-x expects these files to reside in the ncep_data_dir directory specified in the "clavrxorb_default_options" file.

Daily SST Analysis Fields

To be able to produce a SST that is similar to the NESDIS operational SST, an SST analysis field is needed. CLAVR-x is designed to use the daily Reynolds OISST 100 km product. The weekly version of the OISST is described at http://www.esrl.noaa.gov/psd/data/gridded/data.noaa.oisst.v2.html, the daily is described at http://www.ncdc.noaa.gov/oa/climate/research/sst/papers/whats-new-v2.pdf . The data are available via ftp at ftp://eclipse.ncdc.noaa.gov/pub/OI-daily-v2/IEEE/. The data period is centered in the middle of the day (UTC) and is available the morning after.

For real-time operation, CLAVR-x uses the data from the previous day. For real-time operation the sst_analysis_option flag should be set to 1 and the latest OISST v2 analysis file should be named avhrr-only-v2.current in the OISST folder. Once a new OISST data-set is available, it should be renamed to avhrr-only-v2.current before being copied to the respective year folder in the OISST folder. For retrospective processing, the sst_analysis_option flag should be set to "0" and CLAVR-x will search the proper year subdirectory of oisst_data_dir specified in the "clavrxorb_default_options" file for the daily analysis that covers the time of the orbit.

Surface Emissivity

To calculate whether a pixel is cloudy or not, CLAVR-x uses average emissivity on a monthly basis. The data in these files were obtained from SeeBor (Seemann, S.W., E. E. Borbas, R. O. Knuteson, G. R. Stephenson, H.-L. Huang, 2008: Development of a global infrared land surface emissivity database for application to clear sky sounding retrievals from multi-spectral satellite radiance measurements. *J. Appl. Meteor. Climatol.*, **47**, 108-123). The twelve files have names global_emiss_intABI_2005*ddd*.hdf, where *ddd* is the day of year that each month begins with.

UMD Surface and Vegetation Type

The University of Maryland Surface Type system is used in CLAVR-x to classify each pixel into one of fifteen possible types. The resolution of the data is 1km, with the details of the dataset located here:

ftp://ftp.glcf.umiacs.umd.edu/glcf/Global_Land_Cover/Global/gl-latlong-1km-landcover/gl0500bs.txt

The original data file has only 14 surface types. A fifteenth surface type was added for regions that are snow covered all year round. The surface type file used by CLAVR-x is called gl-latlong-1km-landcover.hdf if read_hires_sfc_type=1 in clavrx_default_options. The file contains a 43200 by 21600 array of one byte numbers. The data start at the Date Line at the North Pole and move east and south. There is no scaling of the numbers. An 8km resolution version of this can also be used, called gl-latlong-8km-landcover.hdf, if read_hires_sfc_type=0 in clavrx_default_options.

The original data were obtained at the following URL.
ftp://ftp.glcf.umiacs.umd.edu/glcf/Global_Land_Cover/Global/gl-latlong-1km-landcover/

The follow citations describe the process of its generation:

Hansen, M., R. DeFries, J.R.G. Townshend, and R. Sohlberg (1998), UMD Global Land Cover Classification, 1 Kilometer, 1.0, Department of Geography, University of Maryland, College Park, Maryland, 1981-1994.

Hansen, M., R. DeFries, J.R.G. Townshend, and R. Sohlberg (2000), Global land cover classification at 1km resolution using a decision tree classifier, International Journal of Remote Sensing. 21: 1331-1365.

Land Mask

In addition to the surface type data-set, CLAVR-x also reads in a land mask from goge2_0ll.hdf. The resolution is 1km and starts at the Prime Meridian at the North Pole. The file contains a 43200 by 21600 array of 16 bit signed integers.

The land mask was obtained from NOAA Global Land One-kilometer Base Elevation (GLOBE) Project. The gridded tiles that make up the ancillary dataset can be obtained at the following URL:

http://www.ngdc.noaa.gov/mgg/topo/globe.html

The follow citations describe the process of its generation:

GLOBE Task Team and others (*Hastings, David A., Paula K. Dunbar, Gerald M. Elphingstone, Mark Bootz, Hiroshi Murakami, Hiroshi Maruyama, Hiroshi Masaharu, Peter Holland, John Payne, Nevin A. Bryant, Thomas L. Logan, J.-P. Muller, Gunter Schreier, and John S. MacDonald), eds., 1999. The Global Land One-kilometer Base Elevation (GLOBE) Digital Elevation Model, Version 1.0. National Oceanic and Atmospheric Administration, National Geophysical Data Center, 325 Broadway, Boulder, Colorado 80305-3328, U.S.A. Digital data base on the World Wide Web (URL: http://www.ngdc.noaa.gov/mgg/topo/globe.html) and CD-ROMs.*

Surface Elevation

Surface elevation is read from a file called GLOBE_1km_digelev.hdf if read_surface_elevation is set to 1 in clavrx_default_options; or GLOBE_8km_digelev.hdf if read_surface_elevation is set to 0. These data were derived from the GLOBE Project.

Coast Mask

A coast mask is read from a file called coast_mask_1km.hdf if read_coast_mask_flag is set to 1 in clavrx_default_options; or coast_mask_8km.hdf if read_coast_mask_flag is set to 0. These data were derived from the land mask data files taken from the GLOBE Project. The values in the coast mask give the distance in kilometers to the nearest coast and the values in the files range from 0 to 10. For AVHRR GAC data, a pixel is considered coastal if the coast distance is 10 km or less. For AVHRR HRPT/LAC or FRAC data, a pixel is considered coastal is the coast distance is less than 5 km.

Volcano Mask

A mask to pinpoint the location of volcanoes is read in by CLAVR-x if read_volcano_mask is set to 1 in clavrx_default_options. The file is named volcano_mask_1km.hdf. This file was produced using the Global Volcano List Excel Workbook from the Smithsonian Institution's Global Volcanism Program: www.volcano.si.edu/world/globallists.cfm.

Snow and Ice Mask

CLAVR-x has the option of reading one of two sources of snow and ice masks. For real-time use, read_snow_mask_flag is set to 1 in clavrx_default_options, and daily IMS snow mask files will be read in (e.g., snow_map_4km_120323.hdf). Data to create these files are obtained from the NOAA National Ice Center's Interactive Multisensor Snow and Ice Mapping System (IMS): www.natice.noaa.gov/ims/. If read_snow_mask_flag is set to 2 (historical analyses), daily GlobSnow files will be read (e.g., GlobSnow_SWE_L3A_20101231_v1.0.hdf). Data to create these files are obtained from the Finish Meteorological Institute: www.globsnow.info/index.php?page=Data.

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Walther, Andi; Heidinger, Andrew K. and Miller, Steven. The expected performance of cloud optical and microphysical properties derived from Suomi NPP VIIRS day/night band lunar reflectance. Journal of Geophysical Research-Atmospheres, Volume 118, Issue 23, 2013, doi:10.1002/2013JD020478.

Appendix 1

This table describes the command line arguments available when running clavrxorb.

Command line flag	**Meaning**
-filelist file_list_name	Clavrxorb operates on the file-list given by file_list_name. It will not use the default name of clavrxorb_file_list
-default default_options_name	Clavrxorb operates on the default options given by default_options_name. It will not use the default name of clavrxorb_default_options
-lines_per_seg N	Controls the number of lines per segment. The default is 240. N is an integer number. Making N too large may cause issues with memory.

Appendix 2

This table maps the flags in the level2.inc file to the actual level2 variable names in the level2 or level2b output files. More information on the meaning of the variables is contained in the long-name attribute for each variable.

	Level 2 Include File Flag	Level-2 Variable Name
1	Sds_Num_Level2_Scanline	scan_line_number
2	Sds_Num_Level2_Time	scan_line_time
3	Sds_Num_Level2_Bad_Scan	bad_scan_line_flag
4	Sds_Num_Level2_Bad_Pixel_Mask	bad_pixel_mask
5	Sds_Num_Level2_Gap_Pixel_Mask	gap_pixel_mask
6	Sds_Num_Level2_Asc_Flag	asc_des_flag
7	Sds_Num_Level2_Meta_Data	packed_pixel_meta_data
8	Sds_Num_Level2_Lat	latitude
9	Sds_Num_Level2_Lon	longitude
10	Sds_Num_Level2_Zen	Sensor_zenith_angle
11	Sds_Num_Level2_Solzen	Solar_zenith_angle
12	Sds_Num_Level2_Relaz	Relative_azimuth_angle
13	Sds_Num_Level2_Solaz	Solar_azimuth_angle
14	Sds_Num_Level2_Packed_Land	Packed_land_cover
15	Sds_Num_Level2_Ch1	refl_0_65um_nom
16	Sds_Num_Level2_Ch2	refl_0_86um_nom

17	Sds_Num_Level2_Ch3	refl_0_47um_nom
18	Sds_Num_Level2_Ch4	refl_0_55um_nom
19	Sds_Num_Level2_Ch5	refl_1_2um_nom
20	Sds_Num_Level2_Ch6	refl_1_60um_nom
21	Sds_Num_Level2_Ch7	refl_2_1um_nom
22	Sds_Num_Level2_Ch8	refl_0_41um_nom
23	Sds_Num_Level2_Ch9	refl_0_44um_nom
24	Sds_Num_Level2_Ch10	Not available in Level2
25	Sds_Num_Level2_Ch11	Not available in Level2
26	Sds_Num_Level2_Ch12	Not available in Level2
27	Sds_Num_Level2_Ch13	Not available in Level2
28	Sds_Num_Level2_Ch14	Not available in Level2
29	Sds_Num_Level2_Ch15	Not available in Level2
30	Sds_Num_Level2_Ch16	Not available in Level2
31	Sds_Num_Level2_Ch17	refl_0_95um_nom
32	Sds_Num_Level2_Ch18	refl_0_93um_nom
33	Sds_Num_Level2_Ch19	refl_0_94um_nom
34	Sds_Num_Level2_Ch20_Ref	refl_3_75um_nom
35	Sds_Num_Level2_Ch20_Bt	temp_3_75um_nom
36	Sds_Num_Level2_Ch21	Not available in Level2
37	Sds_Num_Level2_Ch22	temp_3_9um_nom
38	Sds_Num_Level2_Ch23	Not available in Level2
39	Sds_Num_Level2_Ch24	Not available in Level2
40	Sds_Num_Level2_Ch25	Not available in Level2
41	Sds_Num_Level2_Ch26	refl_1_38um_nom
42	Sds_Num_Level2_Ch27	temp_6_7um_nom
43	Sds_Num_Level2_Ch28	temp_7_3um_nom
44	Sds_Num_Level2_Ch29	temp_8_5um_nom
45	Sds_Num_Level2_Ch30	temp_9_7um_nom
46	Sds_Num_Level2_Ch31	temp_11_0um_nom
47	Sds_Num_Level2_Ch32	temp_12_0um_nom
48	Sds_Num_Level2_Ch33	temp_13_3um_nom
49	Sds_Num_Level2_Ch34	temp_13_6um_nom
50	Sds_Num_Level2_Ch35	temp_13_9um_nom
51	Sds_Num_Level2_Ch36	temp_14_2um_nom
52	Sds_Num_Level2_ChDNB	refl_sol_dnb_nom
53	Sds_Num_Level2_Tsfc_Back	surface_temperature_background
54	Sds_Num_Level2_Ch1_Std	refl_0_65um_nom_stddev_3x3
55	Sds_Num_Level2_Ch31_Std	temp_11_0um_nom_stddev_3x3
56	Sds_Num_Level2_Cldprob	cloud_probability
57	Sds_Num_Level2_Cld_Type	cloud_type
58	Sds_Num_Level2_Cld_Phase	cloud_phase
59	Sds_Num_Level2_Ctp	cld_press_acha
60	Sds_Num_Level2_Ctt	cld_temp_acha

61	Sds_Num_Level2_Cth	cld_height_acha
62	Sds_Num_Level2_Ec	cld_emiss_acha
63	Sds_Num_Level2_Beta	cld_beta_acha
64	Sds_Num_Level2_Cod_Acha	cld_opd_acha
65	Sds_Num_Level2_Ceps_Acha	cld_reff_acha
66	Sds_Num_Level2_Cod	cld_opd_dcomp
67	Sds_Num_Level2_Ceps	cld_reff_dcomp
68	Sds_Num_Level2_Cldalb	cloud_albedo_0_65um_nom
69	Sds_Num_Level2_Cldtrn	cloud_transmission_0_65um_nom
70	Sds_Num_Level2_Cldfrac	cloud_fraction
71	Sds_Num_Level2_Cldfrac_Uncer	cloud_fraction_uncertainty
72	Sds_Num_Level2_Etrop	emissivity_11um_tropopause
73	Sds_Num_Level2_Aot1	aot_0_65um_nom
74	Sds_Num_Level2_Olr	olr
75	Sds_Num_Level2_Ndvi	ndvi_sfc
76	Sds_Num_Level2_Tsfc	surface_temperature_retrieved
77	Sds_Num_Level2_Tair	surface_air_temperature_nwp
78	Sds_Num_Level2_Trad	surface_radiation_temperature_retrieved
79	Sds_Num_Level2_Rsr	remote_sensing_reflectance
80	Sds_Num_Level2_Qf1	quality_flags_1
81	Sds_Num_Level2_Qf2	quality_flags_2
82	Sds_Num_Level2_Cod_Dcomp_Uncer	cld_opd_dcomp_unc
83	Sds_Num_Level2_Ceps_Dcomp_Uncer	cld_reff_dcomp_unc
84	Sds_Num_Level2_Cth_Acha_Uncer	cld_height_uncer_acha
85	Sds_Num_Level2_Insol	insolation_sasrab
86	Sds_Num_Level2_Insol_Dif	insolation_diffuse_sasrab
87	Sds_Num_Level2_Ch1_Counts	refl_0_65um_nom_counts
88	Sds_Num_Level2_Ch2_Counts	refl_0_86um_nom_counts
89	Sds_Num_Level2_Ch6_Counts	refl_1_60um_nom_counts
90	Sds_Num_Level2_Tpw	total_precipitable_water_nwp
91	Sds_Num_Level2_Rh	surface_relative_humidity_nwp
92	Sds_Num_Level2_Ref_Ch20_Sfc	refl_3_75um_nom_atmos_corr
93	Sds_Num_Level2_Ref_Ch1_Sfc	refl_0_65um_nom_atmos_corr
94	Sds_Num_Level2_Ref_Ch2_Sfc	refl_0_86um_nom_atmos_corr
95	Sds_Num_Level2_Ref_Ch6_Sfc	refl_1_60um_nom_atmos_corr
96	Sds_Num_Level2_Sst_Masked	pixel_sst_masked
97	Sds_Num_Level2_Ch1_Unnorm	refl_0_65um_nom_unnormalized
98	Sds_Num_Level2_Ch2_Unnorm	refl_0_86um_nom_unnormalized
99	Sds_Num_Level2_Ch6_Unnorm	refl_1_60um_nom_unnormalized
100	Sds_Num_Level2_Ch1_Clear	refl_0_65um_nom_clear_sky
101	Sds_Num_Level2_Ch1_Mean	refl_0_65um_nom_mean_3x3
102	Sds_Num_Level2_Sst_Unmasked	pixel_sst_unmasked
103	Sds_Num_Level2_Wnd_Spd	wind_speed_10m_nwp

104	Sds_Num_Level2_Wnd_Dir	wind_direction_10m_nwp
105	Sds_Num_Level2_Ch1_Dark	refl_0_65um_nom_dark
106	Sds_Num_Level2_Cwp	cloud_water_path
107	Sds_Num_Level2_Wnd_Spd_Cld_Top	wind_speed_cloud_top_nwp
108	Sds_Num_Level2_Wnd_Dir_Cld_Top	wind_direction_cloud_top_nwp
109	Sds_Num_Level2_Temp_Tropo	tropopause_temperature_nwp
110	Sds_Num_Level2_Cld_Mask	cloud_mask
111	Sds_Num_Level2_Sfc_Type	Surface_type
112	Sds_Num_Level2_Coast_Mask	Coast_mask
113	Sds_Num_Level2_Land_Mask	Land_class
114	Sds_Num_Level2_Snow_Mask	Snow_class
115	Sds_Num_Level2_Cod_Dcomp_Qf	cld_opd_dcomp_qf
116	Sds_Num_Level2_Ceps_Dcomp_Qf	cld_reff_dcomp_qf
117	Sds_Num_Level2_Cth_Acha_Qf	cld_temp_acha_qf
118	Sds_Num_Level2_Ec_Acha_Qf	cld_emiss_acha_qf
119	Sds_Num_Level2_Beta_Acha_Qf	cld_beta_acha_qf
120	Sds_Num_Level2_Aot2	aot_0_86um_nom
121	Sds_Num_Level2_Aot6	aot_1_6um_nom
122	Sds_Num_Level2_Aot_QF	aot_qf
123	Sds_Num_Level2_Zsfc	Surface_height
124	Sds_Num_Level2_Cth_H2O	cld_height_h2o
125	Sds_Num_Level2_Cth_Opa	cld_height_opaque
126	Sds_Num_Level2_Cld_Mask_Aux	cloud_mask_1b
127	Sds_Num_Level2_Cld_Type_Aux	cloud_type_1b
128	Sds_Num_Level2_Ch20_Clear	temp_3_75um_nom_clear_sky
129	Sds_Num_Level2_Ch27_Clear	temp_6_7um_nom_clear_sky
130	Sds_Num_Level2_Ch28_Clear	temp_7_3um_nom_clear_sky
131	Sds_Num_Level2_Ch29_Clear	temp_8_5um_nom_clear_sky
132	Sds_Num_Level2_Ch30_Clear	temp_9_7um_nom_clear_sky
133	Sds_Num_Level2_Ch31_Clear	temp_11_0um_nom_clear_sky
134	Sds_Num_Level2_Ch32_Clear	temp_12_0um_nom_clear_sky
135	Sds_Num_Level2_Ch33_Clear	temp_13_3um_nom_clear_sky
136	Sds_Num_Level2_Glintzen	Glint_zenith_angle
137	Sds_Num_Level2_Scatzen	Scattering_angle
138	Sds_Num_Level2_Bayes_Sfc_Type	bayes_mask_sfc_type
139	Sds_Num_Level2_Acha_Order	acha_processing_order
140	Sds_Num_Level2_Acha_Inver	acha_inversion_flag
141	Sds_Num_Level2_Cth_Top	cld_height_top_acha
142	Sds_Num_Level2_Cth_Base	cld_height_base_acha
143	Sds_Num_Level2_Cld_Tests	cloud_mask_test_packed_results
144	Sds_Num_Level2_Ref_Max_ChI1	refl_0_65um_nom_iband_max
145	Sds_Num_Level2_Ref_Min_ChI1	refl_0_65um_nom_iband_min
146	Sds_Num_Level2_Ref_Mean_ChI1	refl_0_65um_nom_iband_mean
147	Sds_Num_Level2_Ref_Uni_ChI1	refl_0_65um_nom_iband_uni

148	Sds_Num_Level2_Ref_Max_ChI2	refl_0_86um_nom_iband_max
149	Sds_Num_Level2_Ref_Min_ChI2	refl_0_86um_nom_iband_min
150	Sds_Num_Level2_Ref_Mean_ChI2	refl_0_86um_nom_iband_mean
151	Sds_Num_Level2_Ref_Uni_ChI2	refl_0_86um_nom_iband_uni
152	Sds_Num_Level2_Bt_Max_ChI5	temp_11_0um_nom_iband_max
153	Sds_Num_Level2_Bt_Min_ChI5	temp_11_0um_nom_iband_min
154	Sds_Num_Level2_Bt_Mean_ChI5	temp_11_0um_nom_iband_mean
155	Sds_Num_Level2_Bt_Uni_ChI5	temp_11_0um_nom_iband_uni
156	Sds_Num_Level2_Ndvi_White	"ndvi_sfc_white_sky_nwp
157	Sds_Num_Level2_Glint_Mask	Glint_mask
158	Sds_Num_Level2_Psfc_Back	surface_pressure_background
159	Sds_Num_Level2_Pmsl_Back	mean_sealevel_pressure_background
160	Sds_Num_Level2_Kindex	k_index_nwp
161	Sds_Num_Level2_Cwp_Nwp	cloud_water_path_nwp
162	Sds_Num_Level2_Cfrac_Nwp	cloud_fraction_nwp
163	Sds_Num_Level2_Pc_Nwp	cld_press_nwp
164	Sds_Num_Level2_Ncld_Nwp	number_cloud_layers_nwp
165	Sds_Num_Level2_Cld_Type_Nwp	cloud_type_nwp
167	Sds_Num_Level2_Rain_Rate	rain_rate
168	Sds_Num_Level2_ChDNB_Lunar	refl_lunar_dnb_nom
169	Sds_Num_Level2_Adj_Pix_Cld_Mask	adj_pix_cloud_mask
170	Sds_Num_Level2_Dcomp_Quality	dcomp_quality
171	Sds_Num_Level2_Dcomp_Info	dcomp_info
172	Sds_Num_Level2_Acha_Quality	acha_quality
173	Sds_Num_Level2_Acha_Info	acha_info
174	Sds_Num_Level2_Diag1	Diagnostic_1
175	Sds_Num_Level2_Diag2	Diagnostic_2
176	Sds_Num_Level2_Diag3	Diagnostic_3
177	Sds_Num_Level2_Cod_Nlcomp	cld_opd_nlcomp
178	Sds_Num_Level2_Ceps_Nlcomp	cld_reff_nlcomp
179	Sds_Num_Level2_Cod_Nlcomp_Uncer	cld_opd_nlcomp_unc
180	Sds_Num_Level2_Ceps_Nlcomp_Uncer	cld_reff_nlcomp_unc
181	Sds_Num_Level2_Nlcomp_Quality	nlcomp_quality
182	Sds_Num_Level2_Nlcomp_Info	nlcomp_info
183	Sds_Num_Level2_Ctt_Acha_Uncer	cld_temp_uncer_acha
184	Sds_Num_Level2_Lunzen	Lunar_zenith_angle
185	Sds_Num_Level2_LunRelaz	Lunar_relative_azimuth_angle
186	Sds_Num_Level2_Lunaz	Luna_azimuth_angle
187	Sds_Num_Level2_Latpc	Latitude_pc
188	Sds_Num_Level2_Lonpc	Longitude_pc
189	Sds_Num_Level2_Sataz	Sensor_azimuth_angle
190	Sds_Num_Level2_CldInsol	insolation_dcomp
191	Sds_Num_Level2_CldInsol_Dif	insolation_diffuse_dcomp
192	Sds_Num_Level2_LCL_Nwp	lcl_nwp

193	Sds_Num_Level2_CCL_Nwp	ccl_nwp
194	Sds_Num_Level2_Alt	cld_altitude_acha
194	Sds_Num_Level2_Ch31_Rad_Atm	atmos_rad_11_0um_nom_nwp
195	Sds_Num_Level2_Ch31_Trans_Atm	atmos_trans_11_0um_nom_nwp
196	Sds_Num_Level2_Ch31_Sfc_Emiss	sfc_emiss_11_0um_nom_nwp
197	Sds_Num_Level2_Ch20_Sfc_Emiss	sfc_emiss_3_75um_nom_nwp
198	Sds_Num_Level2_Ch31_Rad_Atm_Dwn	atmos_rad_dwn_11_0um_nom_nwp
199	Sds_Num_Level2_Ozone	total_column_ozone_nwp
200	Sds_Num_Level2_Acha_Cost	cost_acha
201	Sds_Num_Level2_Hcld_Dcomp	hcld_dcomp
202	Sds_Num_Level2_Cdnc_Dcomp	cdnc_dcomp