10.2 **CLAVR-X INITIAL OPERATIONAL CAPABILITY AT NESDIS**

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1. INTRODUCTION

In 2004, the Clouds from AVHRR extended version (CLAVR-x) system achieved Initial Operational Capability (IOC) for NOAA-16 and NOAA-17. This IOC was implemented under the Computer Sciences Corporation's (CSC) Central Satellite Data Processing contract at the Information Processing Division (IPD) of NESDIS' Office of Satellite Data Processing and Distribution. The CLAVR-x system writes cloud mask information back to an AVHRR 1B level file, making it available to any product system that uses an AVHRR 1B level file as input. The CLAVR-x software was developed by the NESDIS Office of Research and Applications (ORA) and has been hosted on a production platform.

The current CLAVR-x system consists of essentially five subsystems: 1B processing; production of an orbital pixel-level cloud mask; orbital pixel-level retrievals (including sea surface temperature); orbital mapping of pixel-level quantities into grid cells; and synthesis of orbital grid cells into multi-orbit and/or multi-sensor global fields. The CLAVR-x orbital cloud mask is used as direct input to the radiation budget products generation system (RBPGS), while gridded products are being made available to NCEP, which is currently evaluating them for possible input into global forecast models.

Work is currently underway to generate the CLAVR-x pixel-level cloud mask within the MetOp era AVHRR 1B level preprocessing system.

2. BACKGROUND

Over the last several years, NESDIS scientists have developed the capability to derive cloud information from AVHRR data. This area of research has matured and led to code that is capable of producing AVHRR cloud products.

In 2001, ORA provided IPD with the CLAVRKLM processing software. Because of limited resources, the CLAVRKLM system was set up only for NOAA-16. The CLAVRKLM module read and processed NOAA-KLM-era level 1B AVHRR GAC data only, and produced a GAC "1C" data set data set containing a pixel-level cloud mask, as well as calibrated normalized albedos, brightness temperatures equivalent blackbody temperatures, and cloud codes determined for each GAC pixel. Additional output from the module was a modified 1B data set with cloud codes derived from the 1C data set.

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In 2002, the operational NOAA-16 RBPGS was modified to read the CLAVRKLM 1C file and use the 1C cloud code and CLAVR clear/overcast flag in determining the Earth Radiation Budget Experiment (ERBE) scene index and associated angular model used in the absorbed shortwave retrieval process. The CLAVR cloud mask allowed for the production of experimental clear-sky radiation budget retrievals for NOAA-16 (Donahue et al, 2004).

3. IMPROVEMENTS OVER CLAVR-1

CLAVR-x classification routines are similar to CLAVR-1 (Stowe et al, 1999), but CLAVR-x incorporates a number of upgrades. Both techniques use thresholds on spectral and contrast signatures, spatial tests to move pixels out of the confident clear and confident cloudy classes, as well as restoral tests to turn off those tests known to be falsely triggered under certain circumstances. By contrast, CLAVR-x is a more complicated mask. It replaces single value thresholds with lookup tables based on radiative transfer. It also uses more ancillary data. CLAVR-x separates partly cloudy from cloudy pixels in the derivation of cloudy radiances. This is a four-level mask, as opposed to the CLAVR-1three-level mask. Pixels previously assigned a classification of "mixed" are now classified as "partly clear" or "partly cloudy". As a result, CLAVR-x detects more cloud than CLAVR-1.

The bottom two panels of Figure 1 display RBPGS clear-sky retrievals of outgoing long-wave radiation for a NOAA-16 pass over Hurricane Frances. In the lower left, the CLAVR-1 clear/overcast flag was used to eliminate cloudy pixels from the 11 x 11 GAC target, while all pixels with a CLAVR-x cloud mask value other than "clear" were eliminated from the target in the lower right. When compared against the CLAVR-x cloud mask and all-sky outgoing long-wave retrievals in the upper two panels, CLAVR-x clearly does a much better job at detecting cloud contaminated pixels. All evidence so far indicates CLAVR-x global performance equaling or surpassing CLAVR-1.

Furthermore, the CLAVR-x system writes cloud mask information directly back to the AVHRR 1B level, eliminating the need for a 1C. Finally, for CLAVR-x all pixel level (except the 1B Prime) and gridcell output is converted into Hierarchical Data Format (HDF).

4. PIXEL LEVEL PRODUCTS

The CLAVR-x orbital processing module "clavrxorb" (Figure 2) runs on the IPD IBM SP node known as "North". As an AVHRR GAC, LAC, or HRPT file gets created on the Amdahl mainframe, it is automatically transferred to North. For each satellite, orbital scripts are submitted every five minutes on North that check to see if 1B input

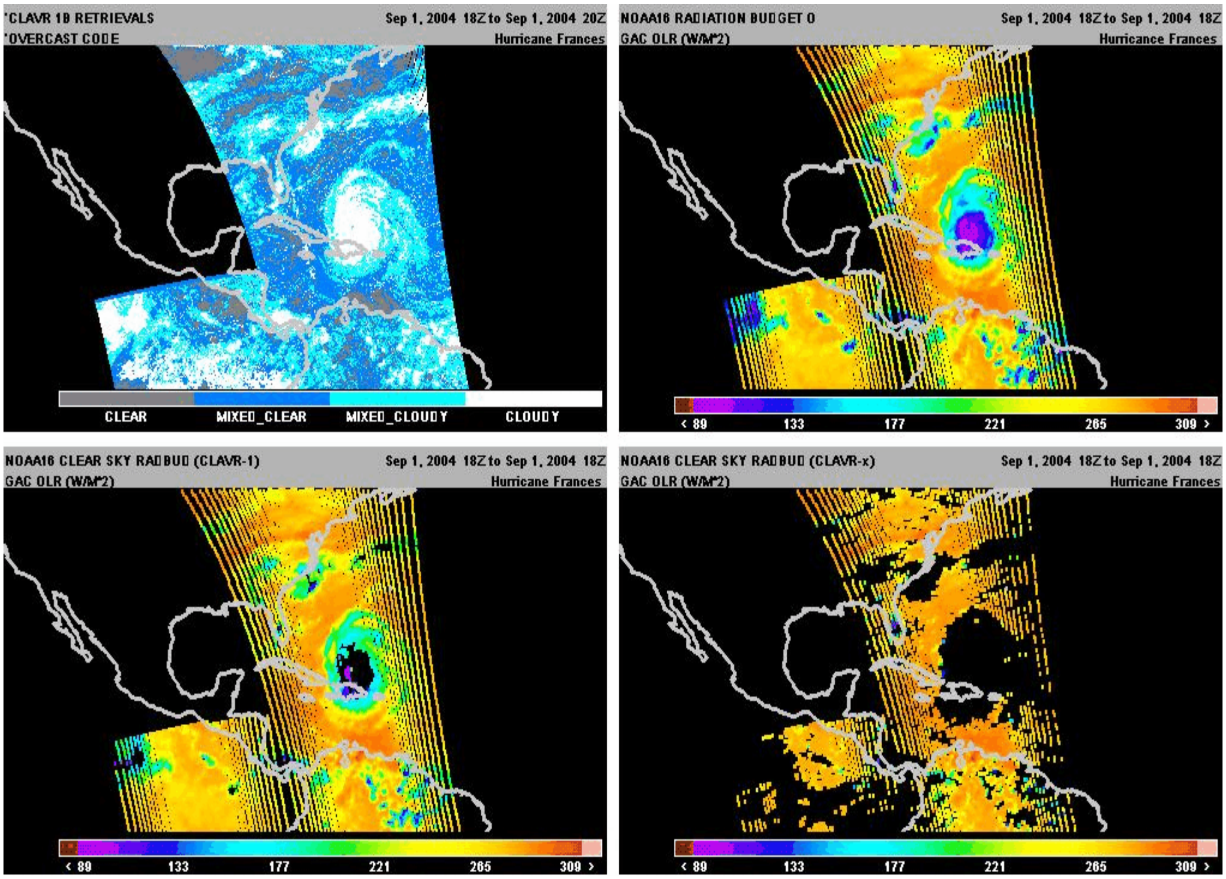

Figure 1. Comparison of CLAVR-x and CLAVR-1 Clear Sky Retrievals

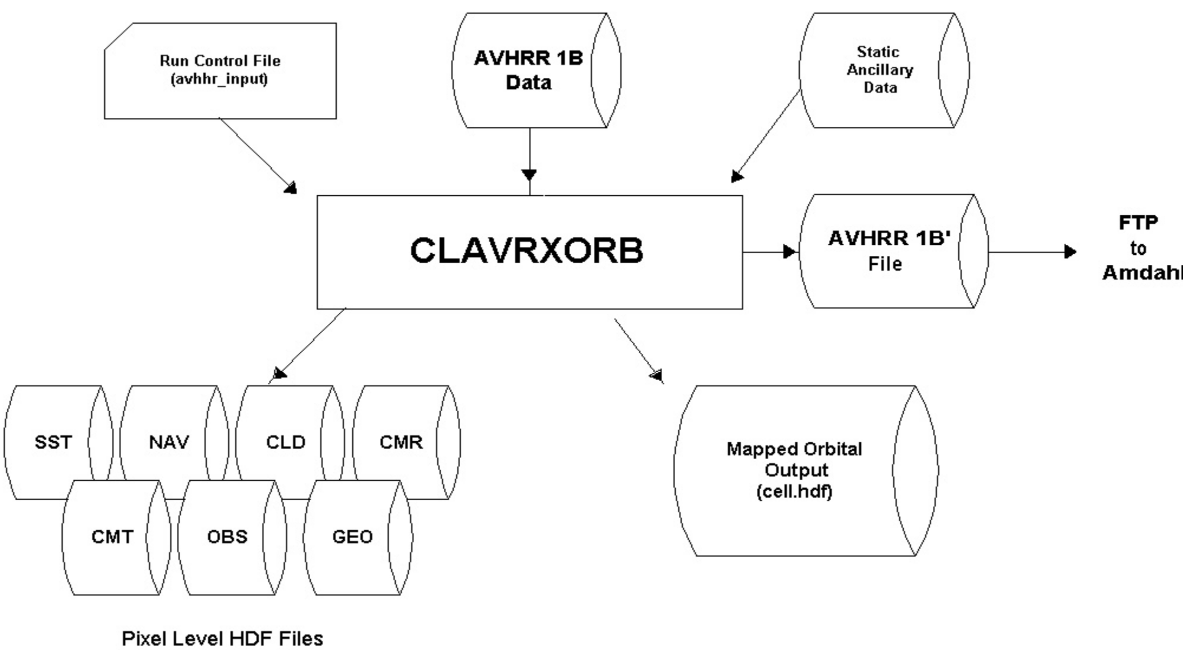

Figure 2. CLAVR-x Orbital Processing System

data sets are available for processing. If any data sets are present, one or more of the orbital scripts will be executed, in sequence, until all of the associated 1B files have been processed. Each orbital script creates a run control file that contains the values of all settings that require user modification and includes the list of all files to process. An optional SST analysis file can also be read in for proper sea surface temperature computation.

For GAC processing only, the 1B file with cloud mask or "1B prime" is the primary output file. Production of the 1B Prime is set in the run control file. The run control file can also be configured so that a 1B Prime is the primary input instead of a 1B. This option was added because IPD plans to incorporate computation of the CLAVR-x cloud mask into the MetOp Era AVHRR 1B preprocessor. At that point the 1B CLAVR cloud mask can be used directly by clavrxorb and the cloud mask code can be circumvented.

There are currently five types of pixel level HDF output files produced. The two files "nav" and "cmt" contain pixel latitudes and longitudes and their associated 24 bits of cloud mask information. The file "cmr" is the best source for a compact pixel level cloud mask. It holds the cloud mask, cloud type, the surface and type, and a couple of commonly requested other flags. The files "cld" and "sst" contain pixel level cloud and SST products, respectively. Finally, the "geo" file contains sensor and solar zenith angles, while the "obs" file holds calibrated channel observations.

GAC orbital processing is set to produce all pixel level HDF files, while HRPT and LAC processing only produce the sst and 24 bit cloud mask files (nav and cmt).

5. GRIDDED PRODUCTS

For GAC data, the current CLAVR-x orbital system also produces a mapped orbital gridded HDF "cell" output file of mapped parameters. The cell file holds gridded products derived from the pixel level products and typically the mean and standard deviations are generated. The resolution of the grid is controlled in the run control file and currently allowed values of 0.25, 0.5, 1.0 and 2.5 degrees. The resolution is currently set to 0.5 degrees. In addition, an equal-angle or equal-area grid is allowed and controlled through an option in the run control file. Current processing uses an equal-angle grid.

The grid-cell files contain a large number of parameters, including all radiances that went into the product generation. The dimension of each parameter is the number of gridcells with data in them. In the future, grid-cell files with fewer parameters may be produced for distribution or archiving.

The gridded output from CLAVR-x is meant to serve the National Centers for Environmental Prediction (NCEP)'s request for global and real-time cloudiness information. As such, the module "comp_time" (Figure 3) runs four times a day to collate all orbital cell files from all available satellites that fall within a specified time window (currently set at 3 hours), centered over one of the four synoptic initialization times (00Z, 06Z, 12Z, and 18Z). Each job currently runs 5½ hours after its synoptic time in order to capture all possible orbits. The data is combined and written to one file. The format of the output file is the same as the input files. The number of grid cells in the orbital files is variable, but the number of grid cells in the synoptic files is the maximum number (full global coverage). The synoptic files are made available to users via anonymous FTP. Figure 4 is an image of total cloud fraction created from the 18Z gridded synoptic file for September 1, 2004.

For long term global as well as satellite specific applications, the module "comp_asc_des" takes all the orbital grid cell files from the previous day for a specified satellite, combines them, and writes separate grid cell files for the ascending and descending nodes. As with the synoptic files, the format of the output files is the same as the input files, but the number of grid cells in the asc/des files is the maximum number (full global coverage). These files also are made available to users via anonymous FTP.

6. CONCLUSION

Implementation of the CLAVR-x operational system makes CLAVR-x cloud products from two of NOAA's operational polar satellites available to users, such as NCEP, in near real-time. CLAVR-x cloud classification and detection incorporates numerous algorithm and processing improvements over CLAVR-1. The pixel level and gridded products produced are now in Hierarchical Data Format, which provides an easy, straight-forward, and self-describing means of sharing scientific data among people, projects, and types of computers. CLAVR-x also allows for the operational production of improved clear-sky products for NESDIS polar satellites.

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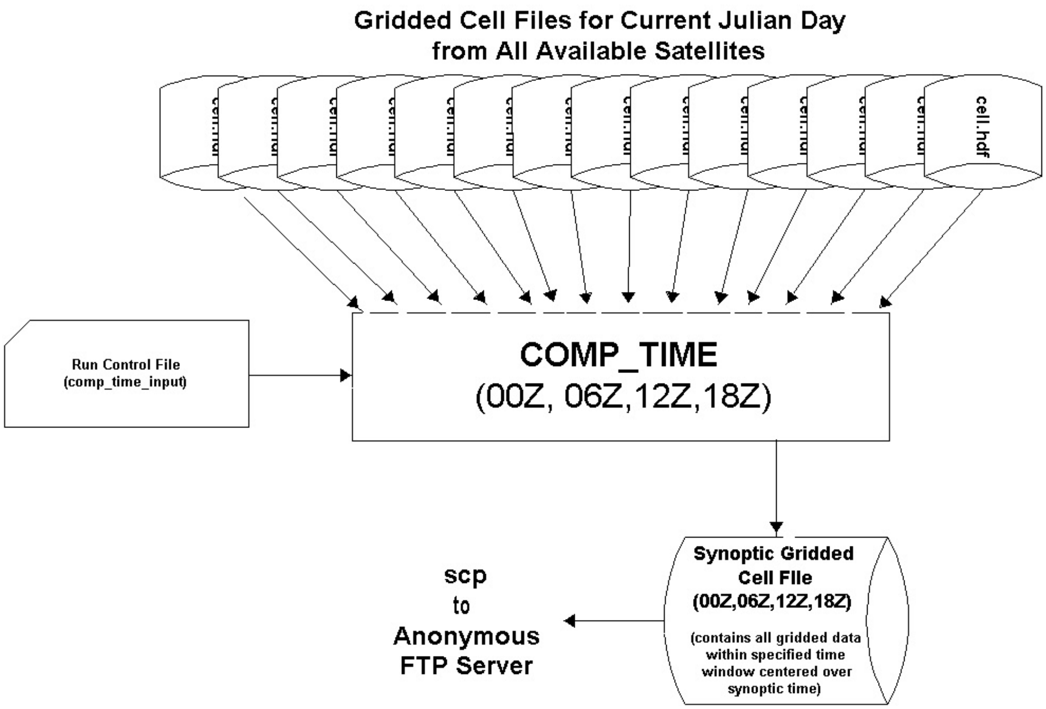

Figure 3. CLAVR-x Synoptic Processing System

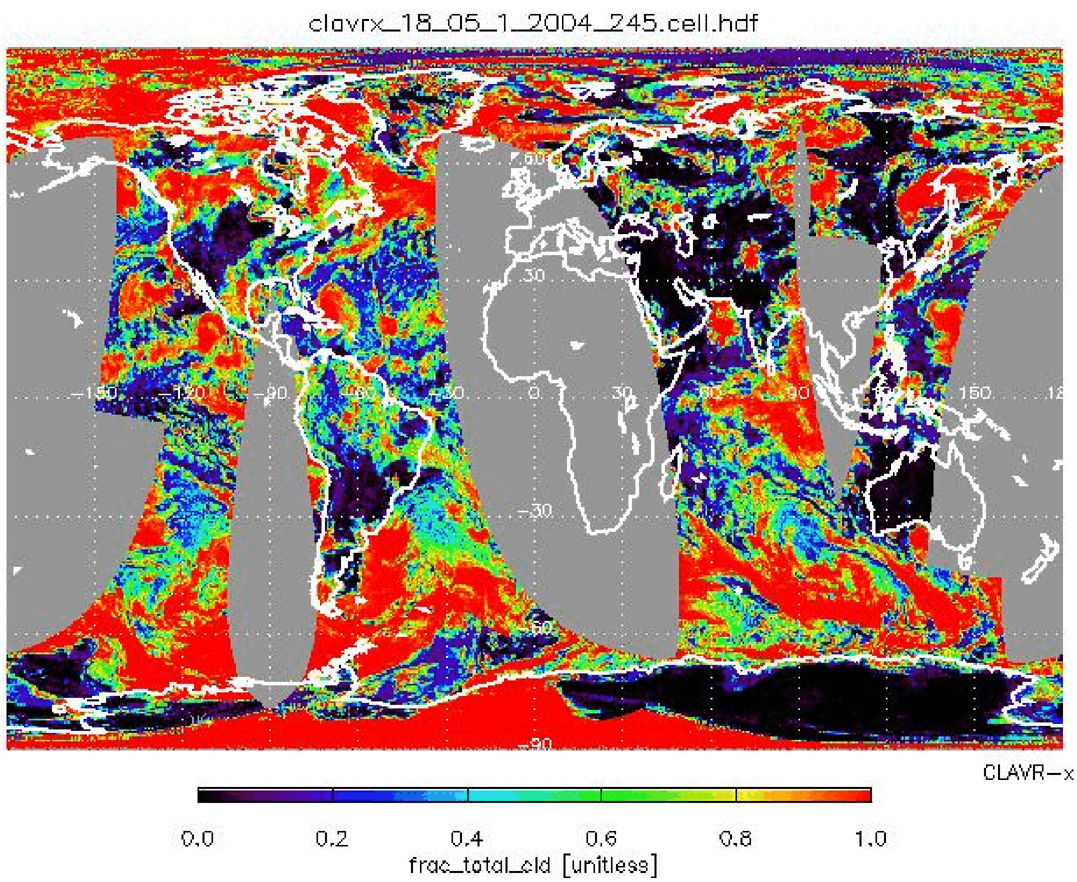

Figure 4. Total Cloud Fraction from 3 Hour Window Centered on 18Z