CLAVR-x in CSPP

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CLAVR-x is:

- CLAVR-x is the Clouds from AVHRR Extended Processing System.
- Operational in NESDIS on AVHRR since 2002.
- Responsible for AVHRR cloud products and other products at various times.
- Its geostationary clone (GSIP) also responsible for GOES-Imager cloud products, surface temperature and insolation.
- Serves as the PATMOS-x climate data set processing system.

CLAVR-x in CSPP will provide:

- NOAA/NESDIS (*aka GOES-R AWG*) Cloud Products
- Other NESDIS AVHRR Products (that we run on all sensors)
- Sensors supported by CLAVR-x in CSPP include:
  - AVHRR
  - S-NPP VIIRS
  - MODIS

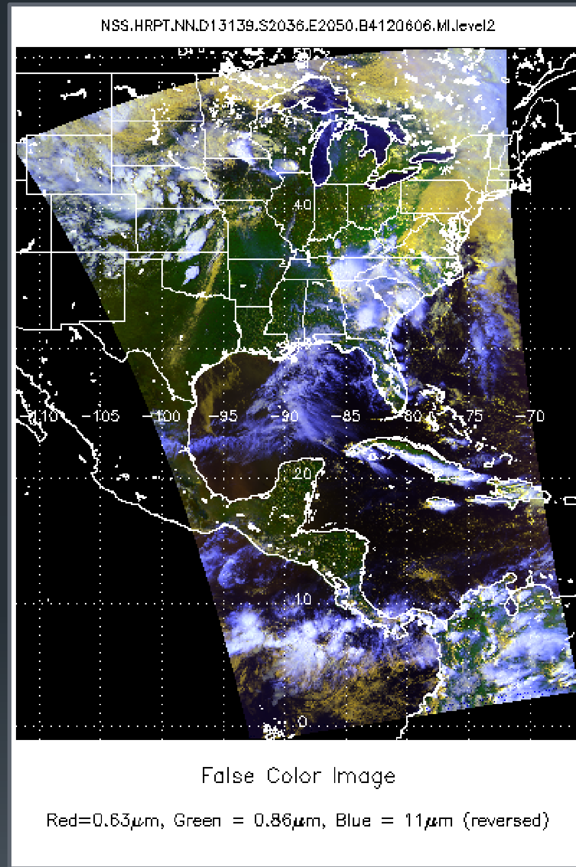
CLAVR-x Output

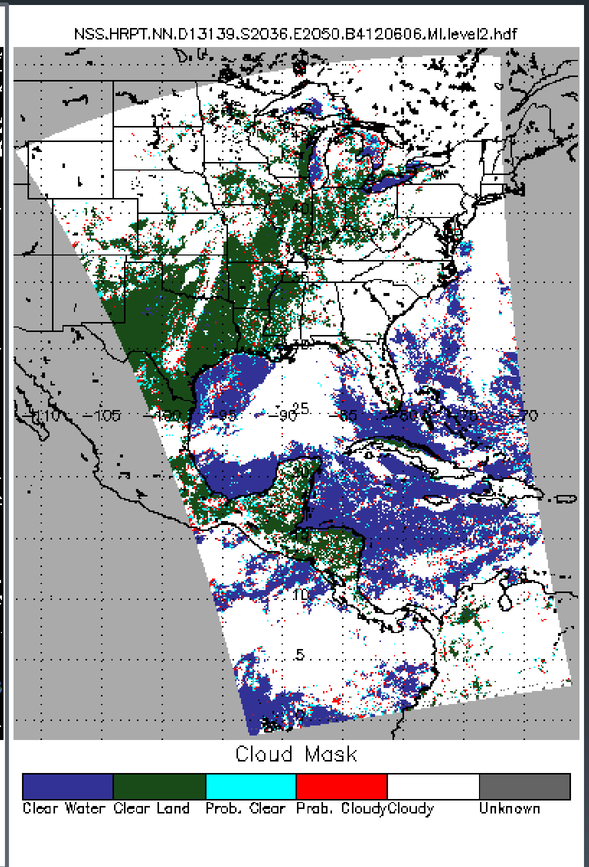
- Cloud: Mask, Probability, Phase, Type, Height, Pressure, Temperature, Emissivity, IR-Particle Size, Optical Depth, Particle Size, Ice/Liquid Water Path. Uncertainty Estimates.
- Surface: SST, TOC NDVI, Land Surface Temperature, Remote Sensing Reflectance (Oceanic Turbidity)
- Aerosol: Optical depths at 0.63, 0.86 and 1.6 μm.
- Fluxes: Solar Flux at Surface (Insolation) and Outgoing Longwave Radiation (OLR).
- Radiances: Calibrated Reflectance, Brightness Temperatures and some statistics useful for filtering products.

CLAVR-x Examples

Cloud Detection

- Naïve Bayesian formulation also used (Heidinger et al., 2012).
- Determination of test thresholds accomplished through an analysis of CALIPSO data.
- Compared against PPS and MAIA masks in CREW and other analysis. See Jan Musial's EUMETSAT 2012 paper.





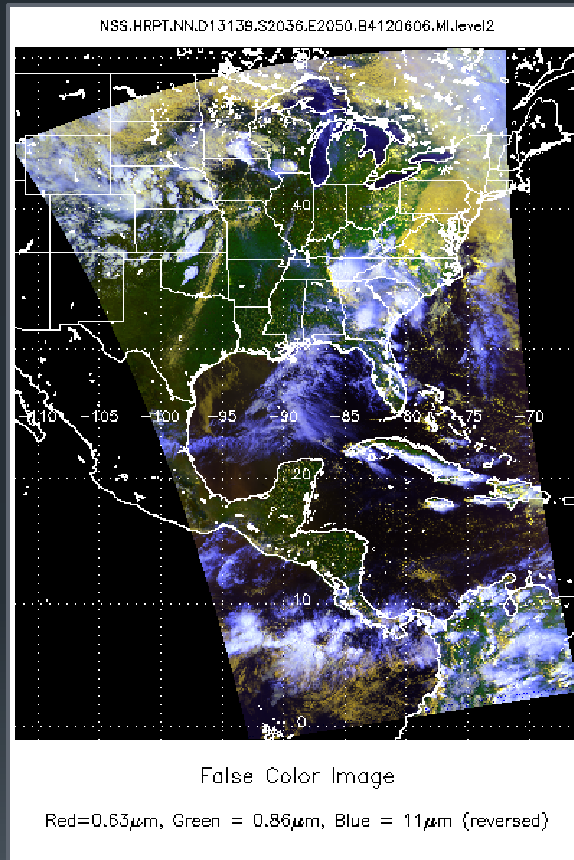
Heidinger, Andrew K.; Evan, Amato T.; Foster, Michael J. and Walther, Andi. A naive Bayesian cloud-detection scheme derived from CALIPSO and applied within PATMOS-x. Journal of Applied Meteorology and Climatology, Volume 51, Issue 6, 2012, 1129–1144.

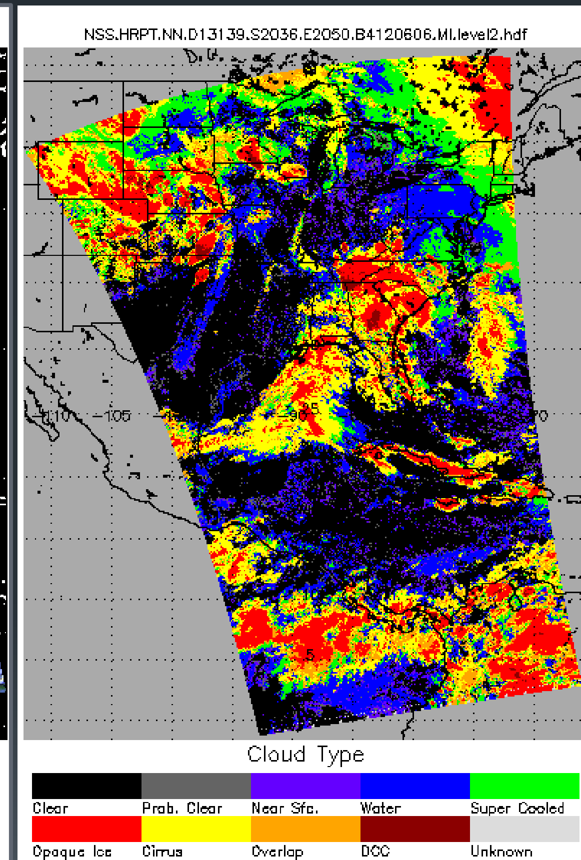
Cloud Type

- Derive 7 cloud types (less than PPS and MAIA)
- Algorithm based on pre-AWG approach.
- Operates on all sensors.

Cloud Types

1. Clear
2. Probably Clear
3. Near-surface cloud
4. Water cloud
5. Super Cooled Water
6. Opaque Ice
7. Cirrus
8. Overlapped Cirrus
9. Deep Convective
10. Unknown

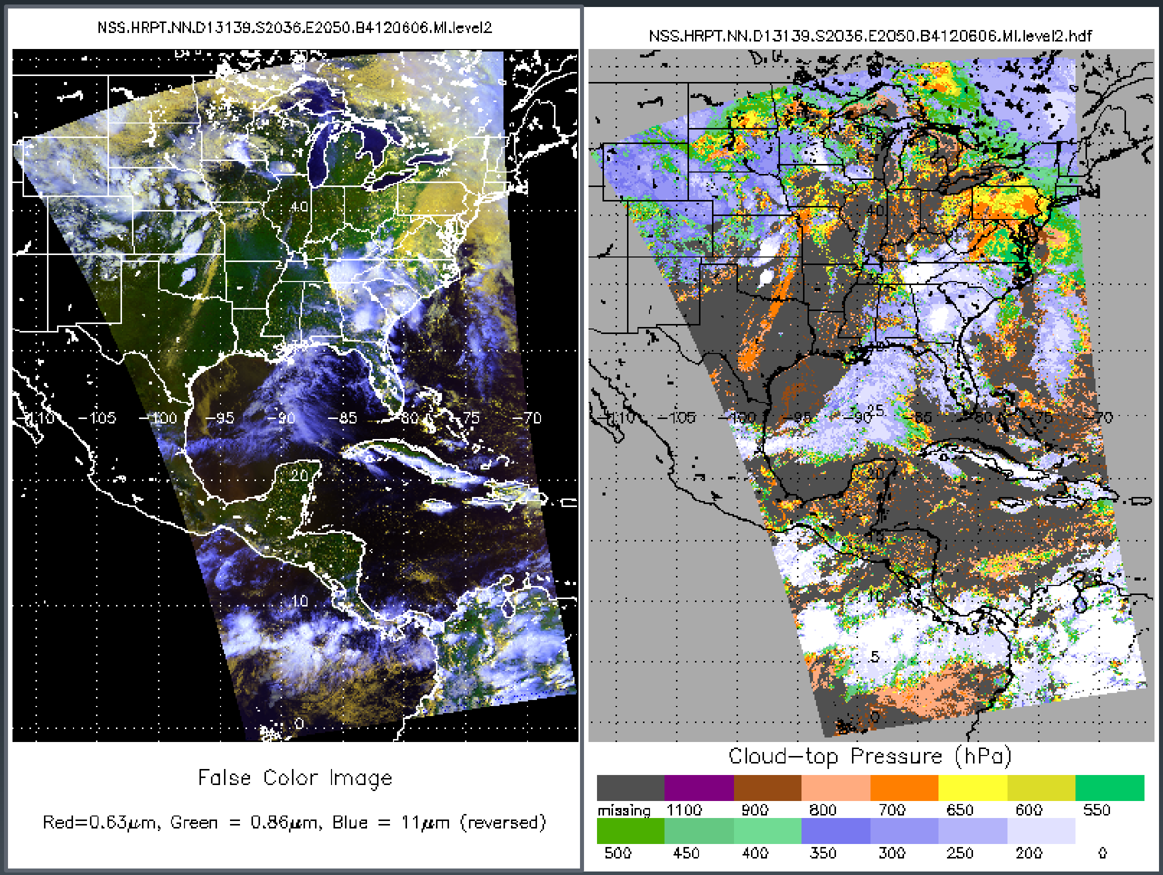




Pavolonis, Michael J.; Heidinger, Andrew K. and Uttal, Taneil. Daytime global cloud typing from AVHRR and VIIRS: Algorithm description, validation, and comparisons. Journal of Applied Meteorology, Volume 44, Issue 6, 2005, pp.804-826.

Cloud Height (ACHA)

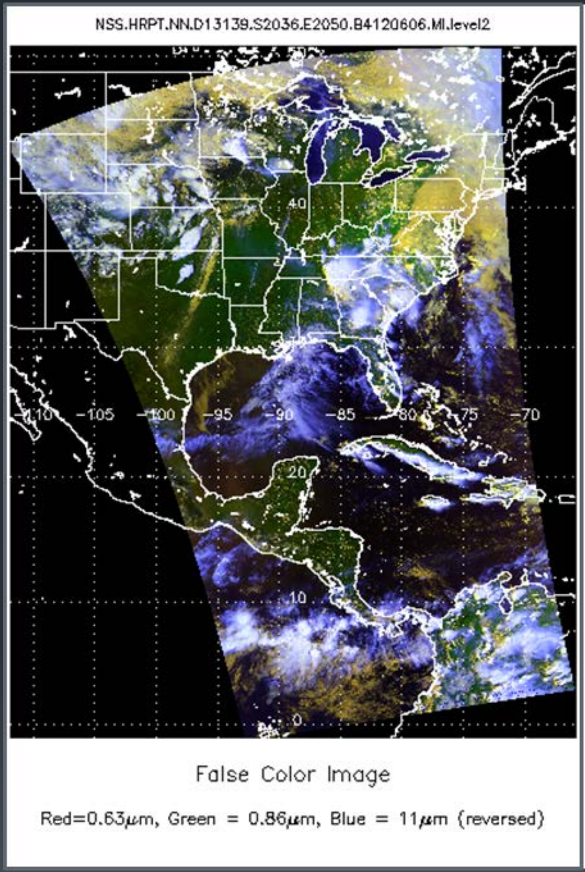
- We have a single code (The AWG Cloud Height Algorithm – ACHA) that works on all sensors.
- Optimal Estimation
- AVHRR = 11 & 12 μm
- MODIS = 11, 12 & 13.3 μm
- VIIRS = 8.5, 11 and 12 μm
- Products are height, temperature, pressure, optical depth and particle size.

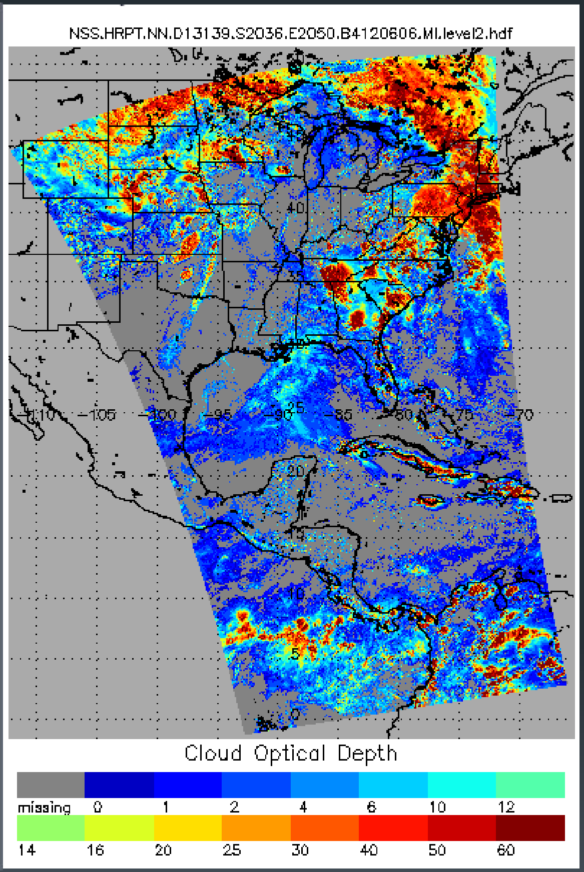


Heidinger, Andrew K. and Pavolonis, Michael J. Gazing at cirrus clouds for 25 years through a split window, part 1: Methodology. Journal of Applied Meteorology and Climatology, Volume 48, Issue 6, 2009, pp.1100-1116.

Daytime Cloud Optical Microphysical Properties (DCOMP)

- Cloud optical depth and particle radius are are fundamental products.
- Cloud Water Path and solar energy are derived.
- Uses 0.65 μm and 1.6 or 2.1 or 3.75 μm
- VIIRS and MODIS have more channels that improve performance over snow.

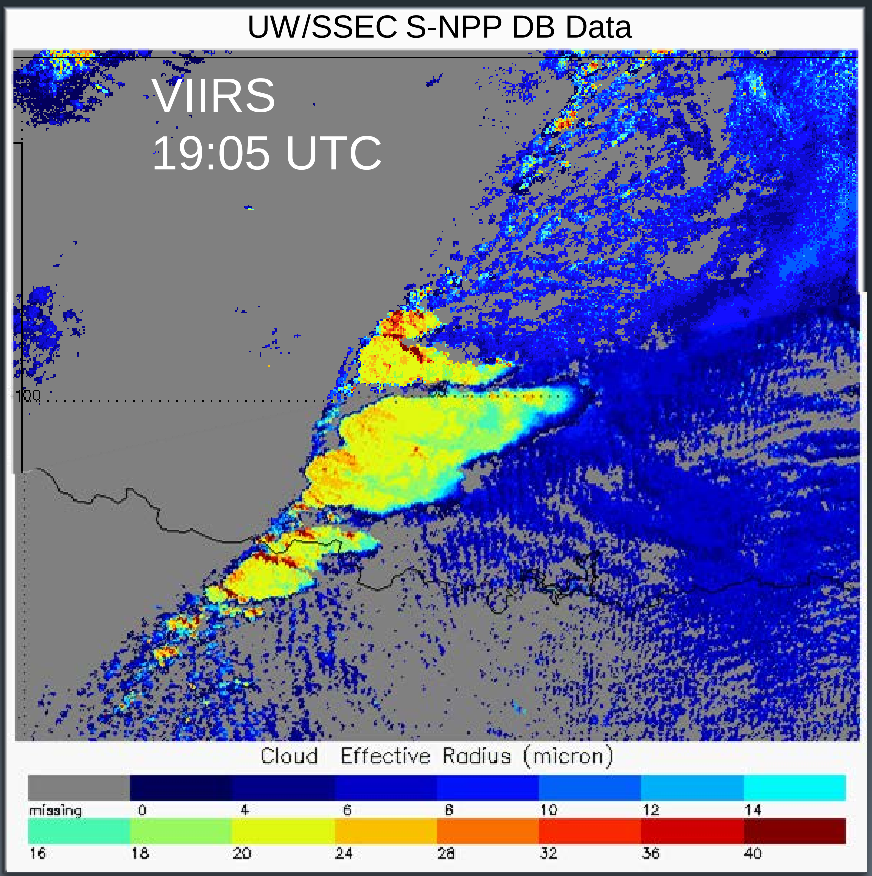


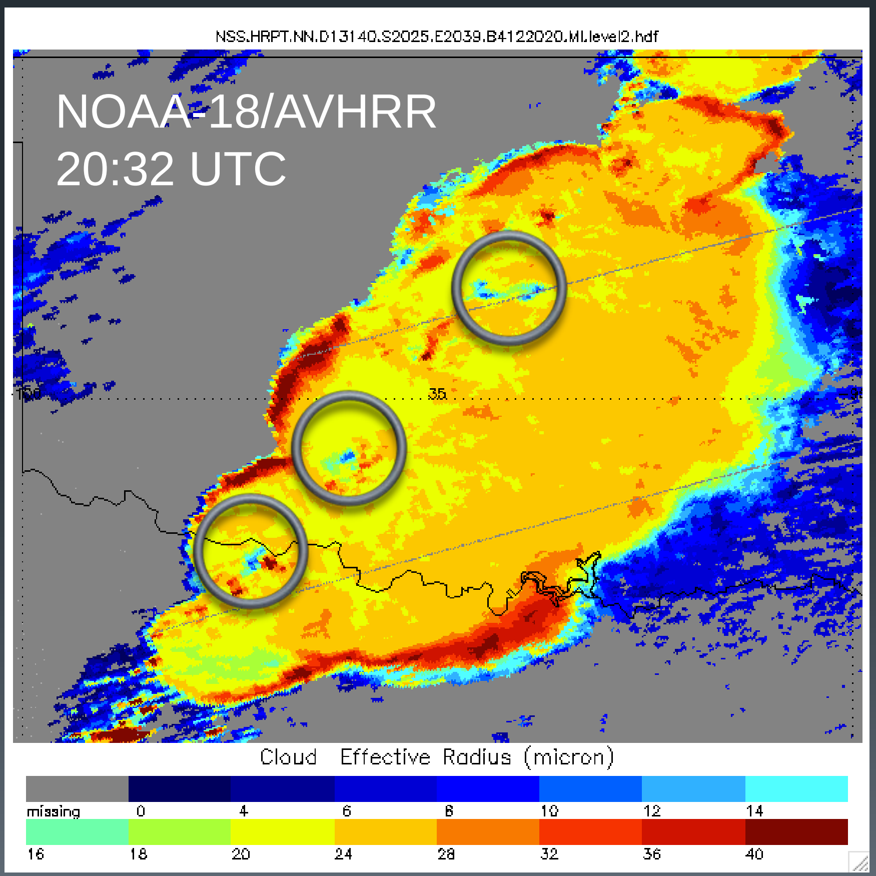


Walther, Andi and Heidinger, Andrew K. Implementation of the Daytime Cloud Optical and Microphysical Properties algorithm (DCOMP) in PATMOS-x. Journal of Applied Meteorology and Climatology, Volume 51, Issue 7, 2012, 1371–1390.

Cloud Effective Radius

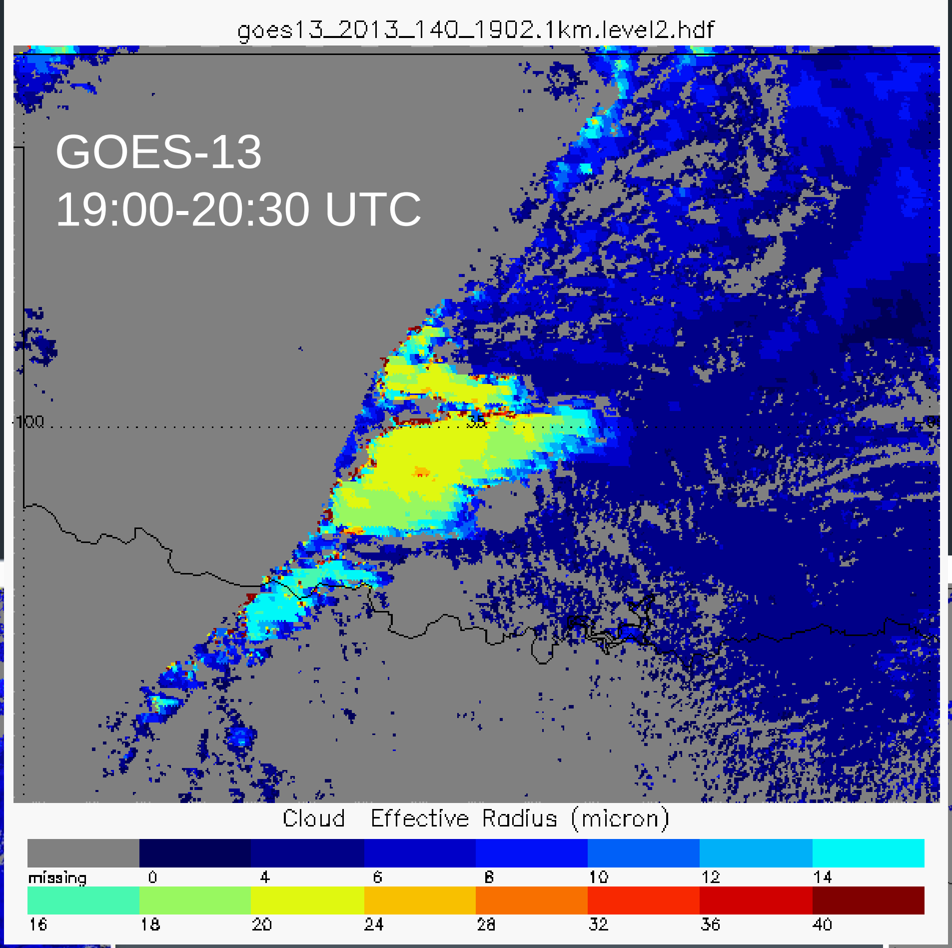
- Images below show NOAA Cloud Effective Radius Retrievals for DB data from VIIRS (left) and NOAA-18 (right).
- Small particle signatures are indicative of very strong updrafts
- VIIRS misses them at 19:05 UTC but NOAA-18/AVHRR sees them at 20:30 UTC.

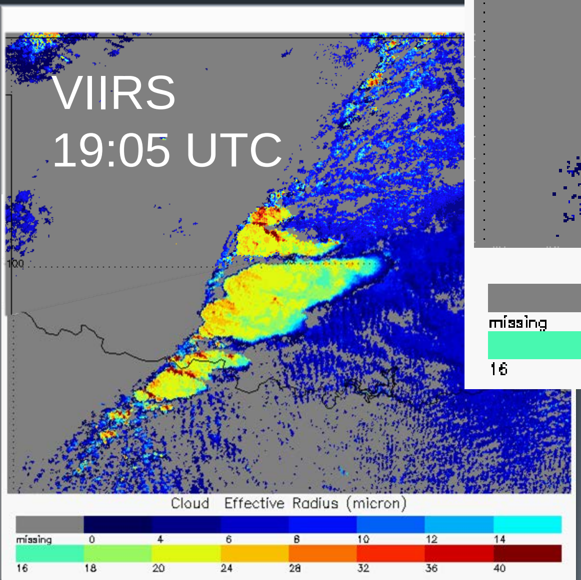


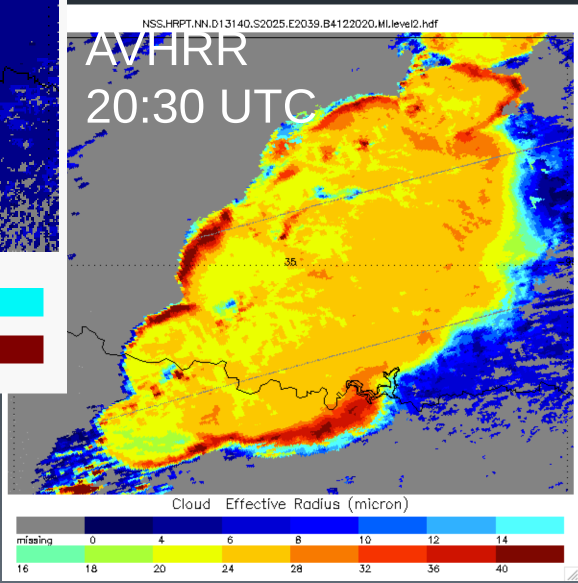


Cloud Effective Radius

- GOES-13 (Center) sees temporal evolution but spatial features harder to see.

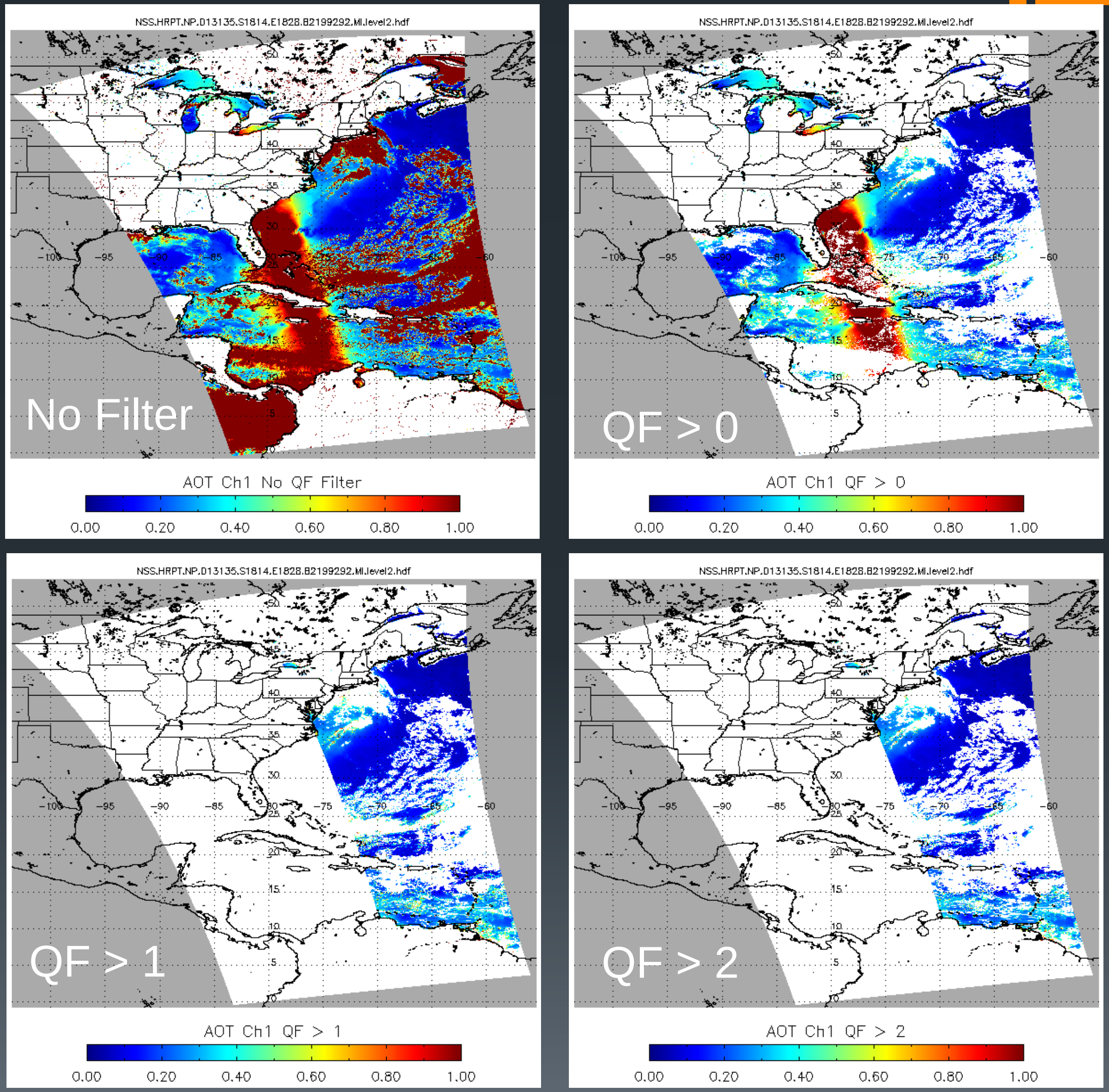






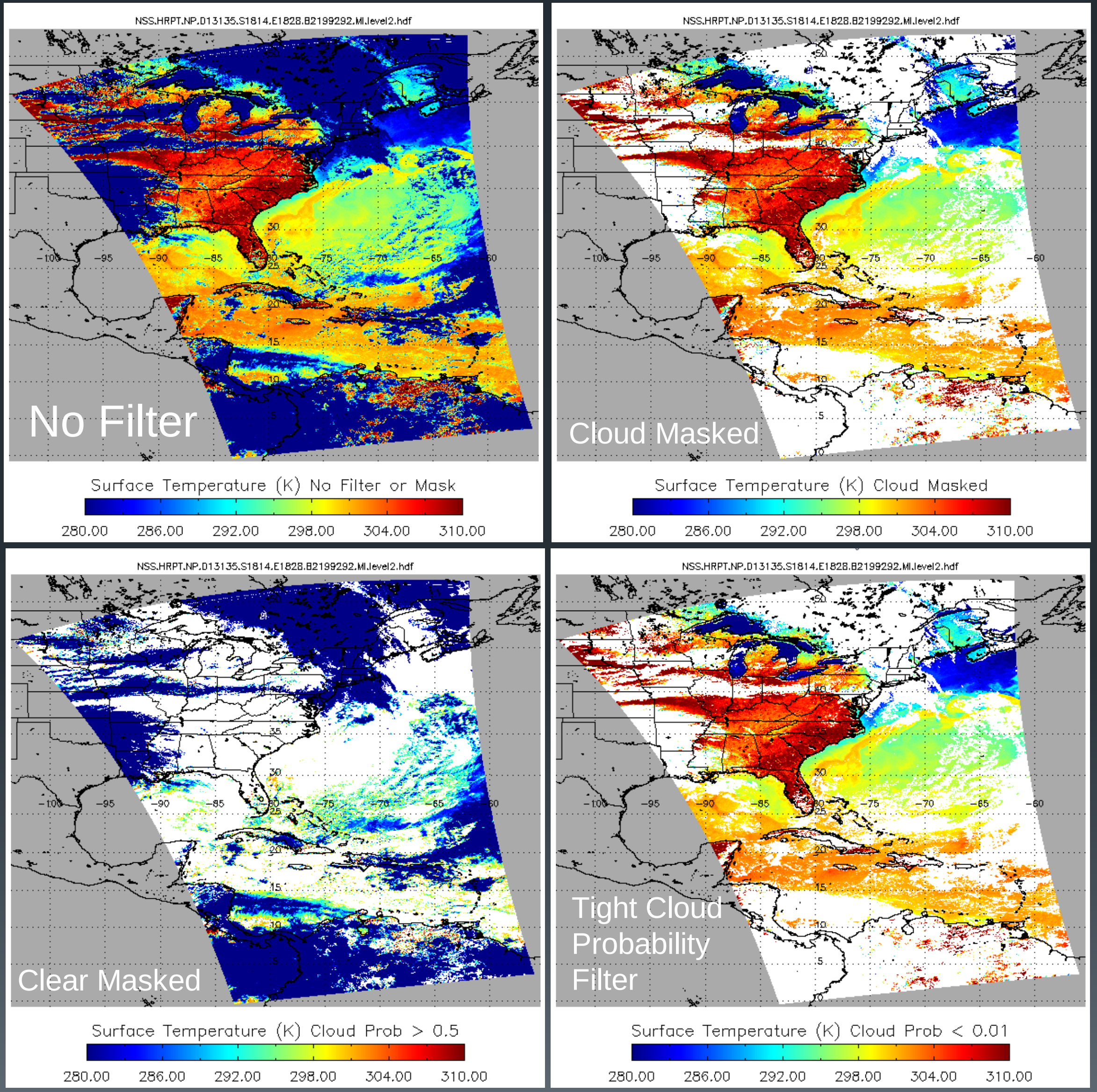
Aerosol Products

- We run the NESDIS Operational Aerosol over Ocean Algorithm (A. Ignatov, NOAA).
- Data is generated without regard to quality flags.
- Official quality flags are provided.
- Users can also add filters using cloud probability and other metrics.
- We do not run over-land approaches.



Surface Temperature

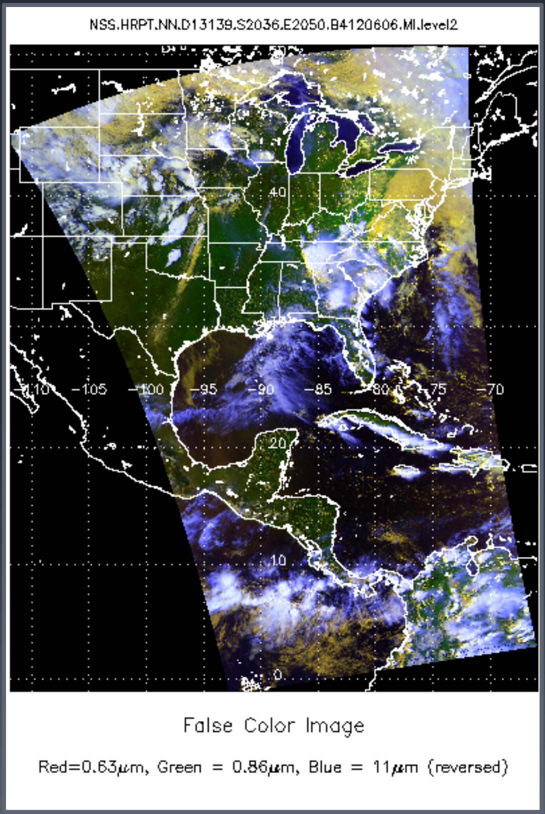
- We run the NESDIS Single Channel Algorithm over land and a split-window NLSST over Ocean.
- Data is generated without regard to quality flags.
- Cloud Mask is available to filter data
- Users can also add filters using cloud probability and other metrics.



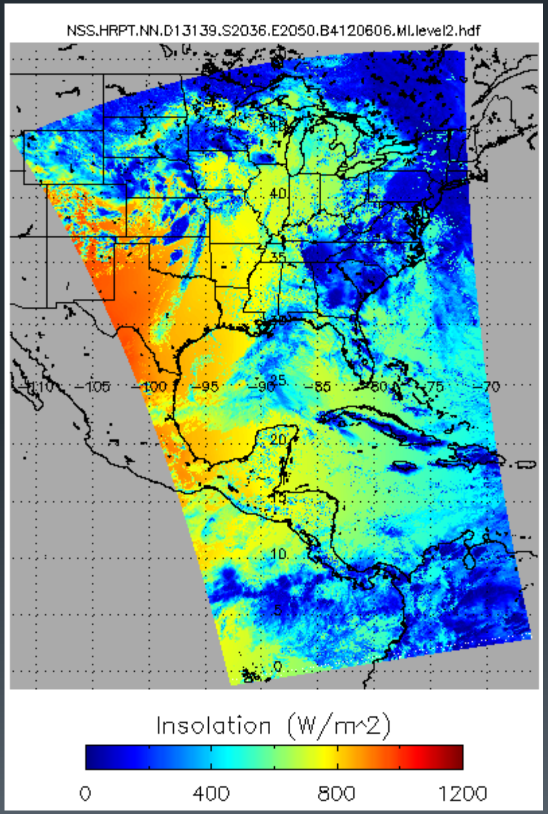
CLAVR-x Radiative Flux Products

Radiative flux algorithms are taken from PATMOS heritage (NESDIS Climate Project).

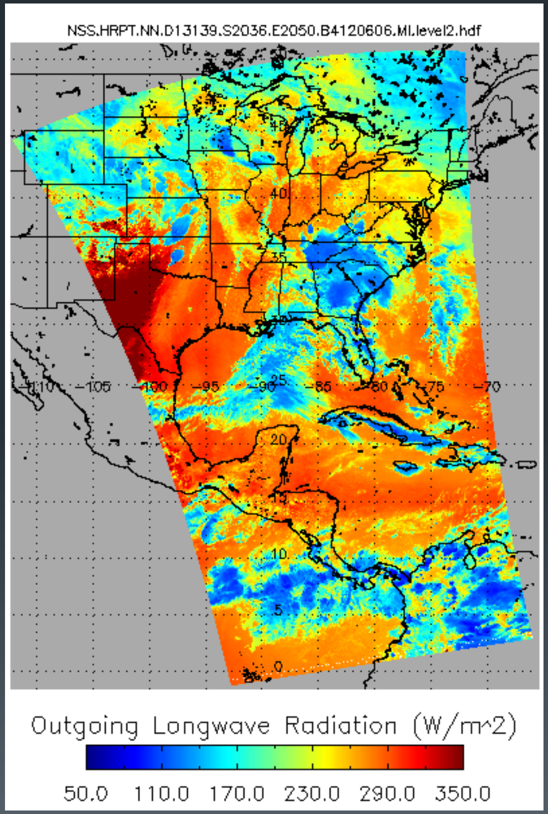
AVHRR False Color Image (0.63, 0.86, 11μm)



Downward Solar Flux at Surface (W/m^2)



Upward Longwave Flux at TOA (W/m^2)



CLAVR-x Future Changes

- Continue to make our algorithm into portable libraries.
- Adopt a fast Solar RTM from CRTM or RTTOVS
- Improve performance of cloud optical depth over snow.
- Finish VIIRS DNB Night Lunar Cloud Properties (NLCOMP)
- Implement GSICS corrections automatically.

Nick Bearson

Running CLAVR-x in CSPP

- Currently in testing – available soon on the CSPP website

- Easy to use! Five minute setup follows three familiar steps:
  - 1. Download & Extract
  - 2. Set up your directories
  - 3. Run!

Algorithm Options

- Begins with a default, kitchen-sink set of options, available to be configured to your preference (it’s just a text file.)

- A user can
  - Choose different modes of ACHA or DCOMP (Cloud Algorithms) that use different channels
  - Turn off Algorithms
  - Turn off the use of a channel.

Product Options

- CLAVR-x supports many applications including some climate-specific ones (PATMOS-x) and calibration studies.
- As a consequence, CLAVR-x has many potential output fields (our operational list at NESDIS includes 48 fields).
- There is a single include file with switches (0/1) that can be set to include output.
- Modification of this file requires recompilation.
- Algorithm and channel selections are automatically accounted for.

Source Code

- Bundled with source code and build instructions to recompile CLAVR-x without modifying the surrounding environment
- Bring your own HDF4 / HDF5

Relative Timing per Algorithm for NOAA-19 HRPT

- Level-1b Processing (sec) = 10.87646
- Ancil. Data Processing (sec) = 19.07158
- RTM Processing (sec) = 58.15201
- Spatial Processing (sec) = 41.41502
- Aerosol Retrieval (sec) = 1.520920
- Cloud Mask (sec) = 90.0040
- Cloud Type (sec) = 31.05698
- Cloud Height (sec) = 44.12727
- Cloud Opt/Micro (sec) = 103.9890
- Dust/Smoke Detection (sec) = 0.6935120
- Earth Radiation Budget (sec) = 0.0000000E+00
- Pixel-HDF Write (sec) = 32.36504
- Total Time for Processing This Orbit (sec) = 450.4861

Relative Timing as Function of Sensor

Results generated on the PEATE development machine (STORM):

- AVHRR NOAA19 GAC - 7m39.494s
- AVHRR M2 HRPT - 3m6.184s
- AVHRR M2 GAC - 5m2.507s
- MODIS Terra 1KM - 4m21.339s
- VIIRS M - 2m52.688s

Conclusions

- CLAVR-x will available in CSPP this summer

- CLAVR-x provides access to existing NOAA/NESDIS (AWG) Cloud + non-cloud AVHRR products

- We look forward to your feedback.

Thank You!

More information at cimss.ssec.wisc.edu/clavr

Ancillary Data

There are many ancillary data fields that can be included in the output, these include

- Surface: Temperature, Reflectance, Emissivity, Elevation, NDVI, Land Class, Vegetation Class.
- Atmosphere: TPW, K-Index, Wind at 10m, Wind at Cloud-top
- Cloud: Cloud Fraction, Cloud Water, Cloud Pressure from NWP if available.
- Example shown below of surface elevation (left), surface temp. (center) and veg. surface type (right)