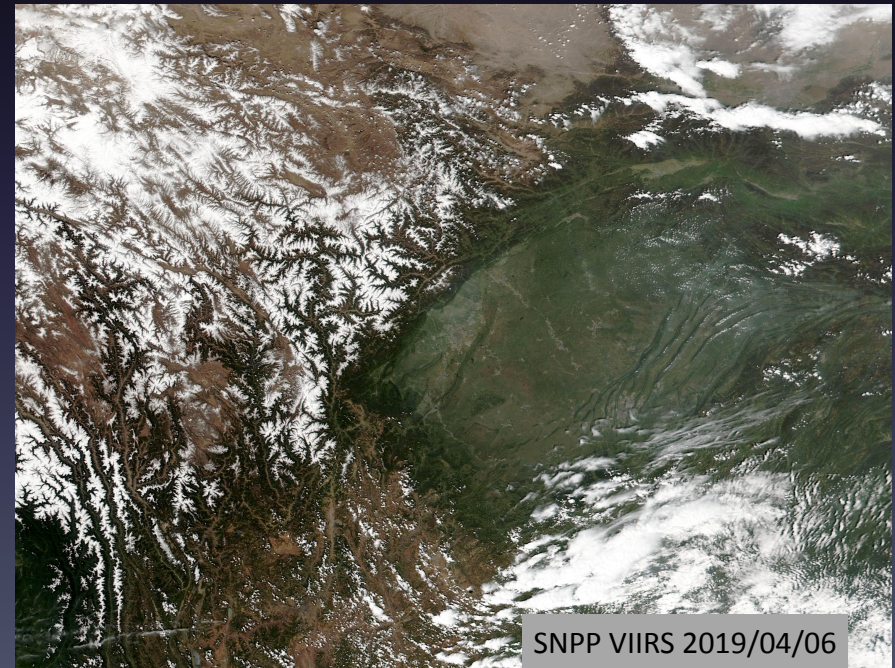


CSPP LEO: Status and Recent Enhancements

Liam Gumley, Allen Huang, Scott Mindock, Kathy Strabala,
Jessica Braun, Geoff Cureton, Nick Bearson, James Davies, Ray
Garcia, Graeme Martin, David Hoesle

CIMSS/SSEC
University of Wisconsin-Madison, USA

CSPP Users' Group Meeting
25-27 June 2019, Chengdu, China



Outline



- Overview of CSPP LEO
- Software packages, sensors, and satellites supported by CSPP LEO
- Recent enhancements
- New features coming soon

What is CSPP LEO?



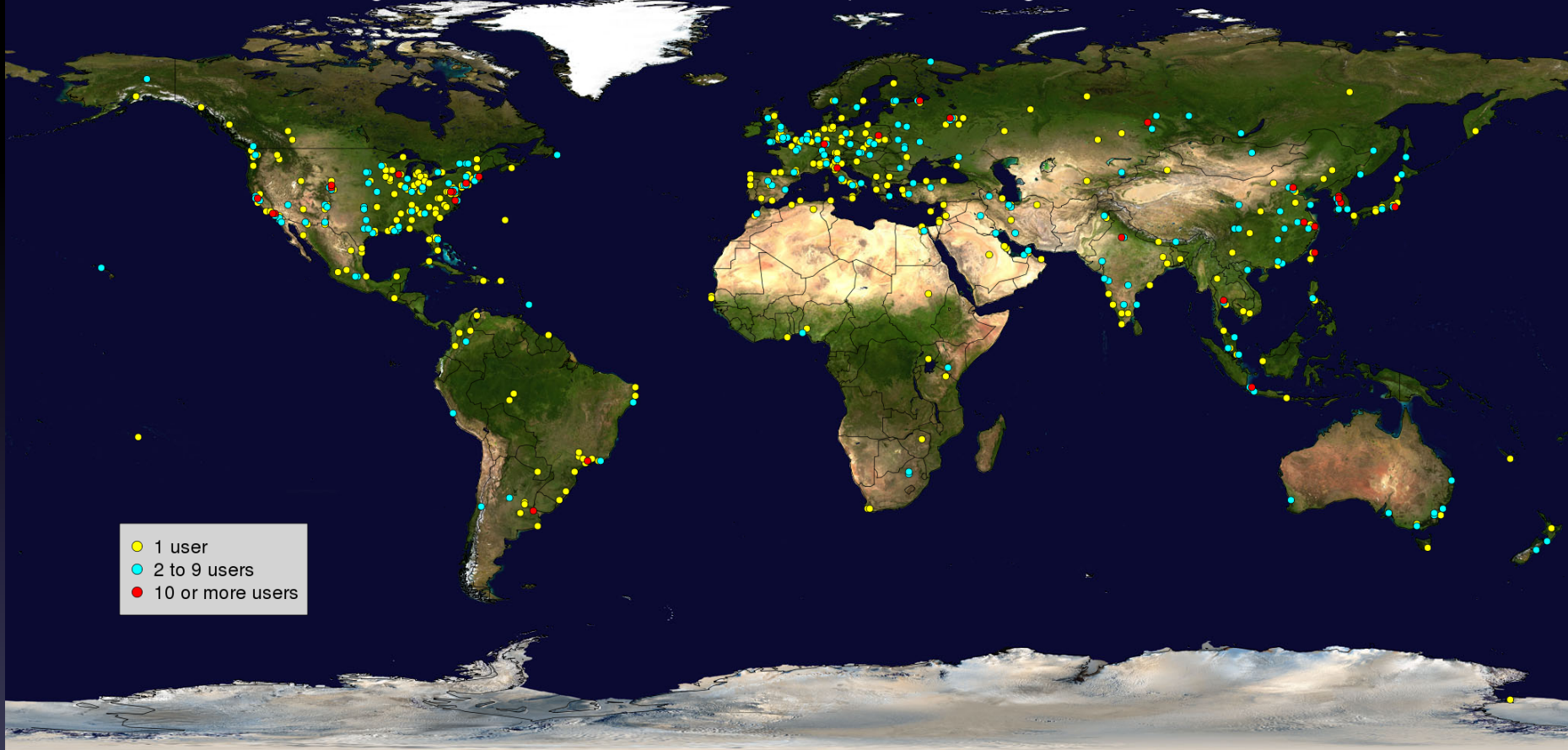
- The Community Satellite Processing Package (CSPP) is a collection of freely available software for processing data from Low Earth Orbit (LEO) meteorological satellites.
- CSPP LEO supports the creation of calibrated observational data, geophysical derived products, and images from visible, infrared, and microwave sensors.
- CSPP LEO is funded by NOAA JPSS Program Office.

<https://cimss.ssec.wisc.edu/cspp/>

Who uses CSPP LEO?



CSPP registration database on 2019-06-16 comprises 2235 registrants in 94 countries



- 1 user
- 2 to 9 users
- 10 or more users



Honolulu, HI



Mayaguez, PR

Guam



Typical LEO DB reception system



2.4-m X/L-band Antenna
Kwajalein Atoll

X-band and L-band demodulators
Control computer and Processing server

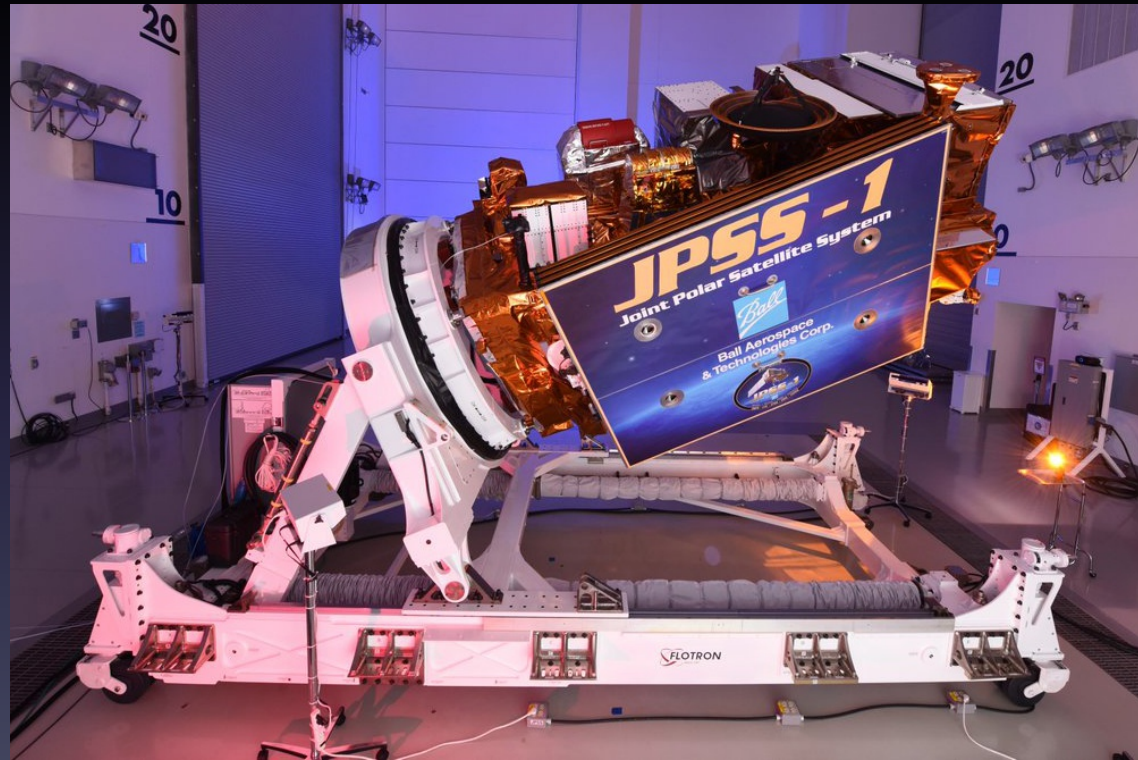


The CSPP software

- Is freely available,
- Includes up-to-date algorithms,
- Ready to run on 64-bit Intel Linux (CentOS 6/7),
- Is easy to install and operate,
- Includes test data for verification,
- Runs efficiently on modest hardware,
- Has prompt expert user support.

NOAA-20

Launched November 18, 2017



Main updates since last CSPP Meeting



- Support for NOAA-20 and Metop-C
- Imagery for SST and Cloud Products (VIIRS, MODIS, AVHRR)
- Fire detection for VIIRS
- Flood detection for VIIRS
- Combined infrared/microwave retrievals for IASI/AMSU
- Updated microwave retrievals for ATMS, AMSU/MHS
- Updated infrared/microwave retrievals for CrIS/ATMS and IASI/AMSU
- Aerosol, snow, cloud, ice, and volcanic ash for VIIRS

Supported satellites and sensors:

- NOAA-20 and Suomi NPP (VIIRS, CrIS, ATMS)
- Metop-A/B/C (IASI, AMSU-A, MHS, HIRS, AVHRR)
- NOAA-18/19 (AMSU-A, MHS, HIRS)
- Terra and Aqua (MODIS, AIRS)
- GCOM-W1 (AMSR-2)
- FY-3B/C/D (VIRR, MERSI-2)

Supported products:

- Geolocated and calibrated reflectances and brightness temperatures
- Georeferenced imagery
- Cloud properties
- Sea Surface Temperature
- Temperature and Moisture Profile Retrievals
- Flood and Active Fire Detection
- Aerosol, Snow, Ice, and Volcanic Ash Properties
- Interactive Visualization

CSPP LEO Software Packages



CSPP Software Package	Product Description
SDR	VIIRS, CrIS, and ATMS geolocated and calibrated earth observations (NOAA algorithm).
Polar2grid	Reprojected imagery (single and multi-band) in GeoTIFF and AWIPS formats.
Hydra	Interactive visualization and interrogation of multispectral imagery and hyper spectral soundings.
VIIRS ASCI	VIIRS imager aerosol optical depth, cloud properties, sea ice, and volcanic ash (NOAA algorithm).
VIIRS Active Fires	VIIRS imager wildfire detection (NOAA algorithm).
VIIRS Flood Detection	VIIRS imager flood detection (NOAA algorithm).
HSRTV	Hyperspectral infrared sounder retrievals of temperature and moisture profiles, cloud properties, total ozone, and surface properties.
MIRS	Microwave sounder retrievals of temperature and moisture profiles; surface properties; snow and ice cover; rain rate; and cloud/rain water paths (NOAA algorithm).
CLAVR-x	Multispectral imager retrievals of cloud properties; aerosol optical depth; surface properties; ocean properties (NOAA algorithm).
NUCAPS & NUCAPS-IASI	Combined hyperspectral infrared sounder and microwave sounder retrievals of temperature and moisture profiles, cloud cleared radiances, and trace gases (NOAA algorithm).
IAPP	Combined infrared sounder and microwave sounder retrievals of temperature and moisture profiles, water vapor, total ozone, and cloud properties.
ACSPO	Multispectral imager retrievals of sea surface temperature (NOAA algorithm).
Sounder Quicklook	Projected 2D maps of temperature and water vapor retrievals, and Skew-T profiles for individual atmospheric profiles.

CSPP LEO Supported Sensors



CSPP Software	SNPP	NOAA-20	Metop-A/B/C	NOAA-18/19	Terra	Aqua
SDR	VIIRS, CrIS, ATMS	VIIRS, CrIS, ATMS	Provided by AAPP & OPS-LRS	Provided by AAPP	Provided by SeaDAS	Provided by SeaDAS
Polar2Grid	VIIRS, CrIS, ATMS	VIIRS, CrIS, ATMS	AVHRR, AMSU, MHS	AVHRR, AMSU, MHS	MODIS	MODIS, AIRS
Hydra	VIIRS, CrIS, ATMS	VIIRS, CrIS, ATMS	AVHRR, IASI	AVHRR	MODIS	MODIS, AIRS
VIIRS ASCI	VIIRS	VIIRS	N/A	N/A	N/A	N/A
VIIRS Active Fires	VIIRS	VIIRS	N/A	N/A	N/A	N/A
VIIRS Flood Detection	VIIRS	VIIRS	N/A	N/A	N/A	N/A
HSRTV	CrIS	CrIS	IASI	N/A	N/A	AIRS
MIRS	ATMS	ATMS	AMSU, MHS	AMSU, MHS	N/A	N/A
CLAVR-x	VIIRS	Coming soon	AVHRR	AVHRR	MODIS	MODIS
NUCAPS & NUCAPS-IASI	CrIS, ATMS	CrIS, ATMS	IASI, AMSU	N/A	N/A	N/A
IAPP	N/A	N/A	HIRS, AMSU, MHS	HIRS, AMSU, MHS	N/A	N/A
ACSPO	VIIRS	Coming soon	AVHRR	AVHRR	MODIS	MODIS
Sounder Quicklook	CrIS, ATMS	Coming soon	IASI, AMSU, MHS	AMSU, MHS	N/A	AIRS

CSPP SDR (Sensor Data Record) creates calibrated and geolocated earth observation products (Level 1B).

Heritage	Developed by Raytheon and released as part of Algorithm Development Library (ADL).
Satellites/ Sensors	NOAA-20, Suomi NPP (VIIRS, CrIS, ATMS).
Products	VIIRS: M-band, I-band, and Day/Night Band SDR calibrated sensor data and geolocation files in HDF5 format. CrIS: Calibrated spectra and geolocation in HDF5 format. ATMS: Calibrated antenna temperatures and geolocation in HDF5 format.
Features	<ul style="list-style-type: none">• Multi-core support for faster processing.• Optional product aggregation and compression.• Automated download and installation of calibration LUTs.• Quicklook images

CSPP SDR v3.1 Features

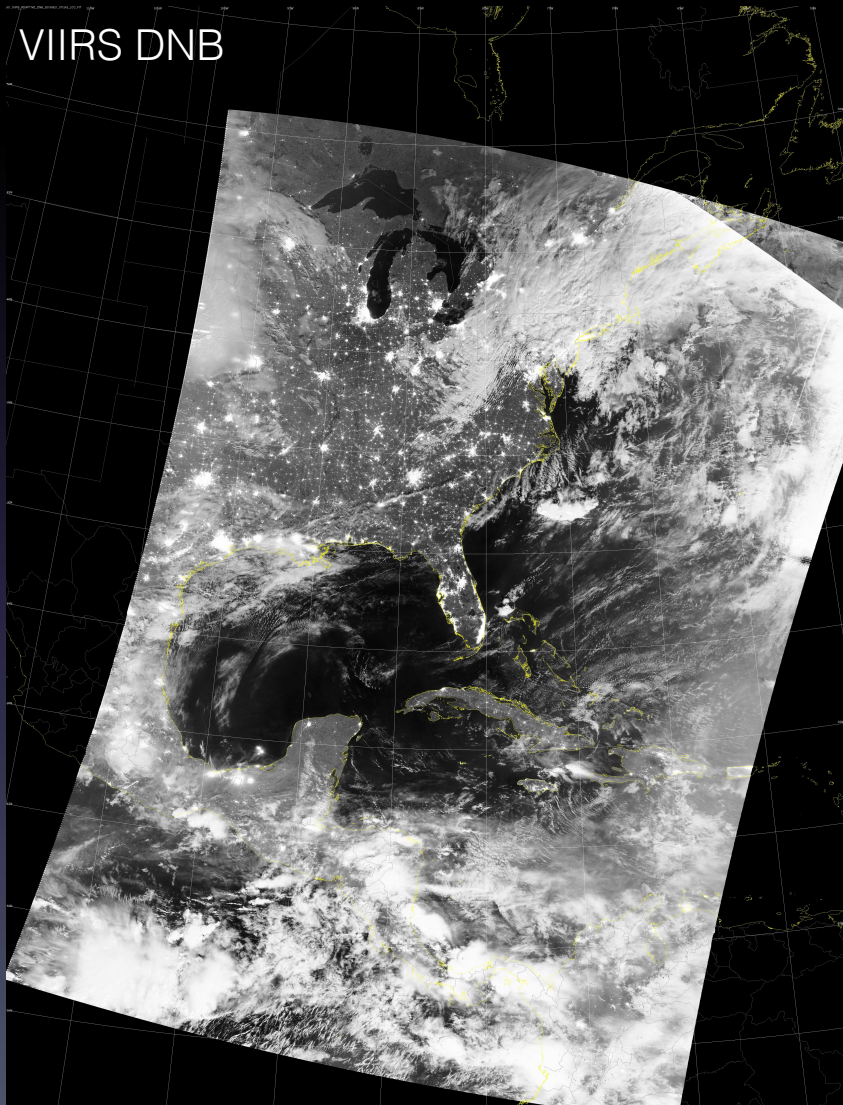


- Supports multi-core processing for reduced runtimes (e.g., 13-minute VIIRS pass processed in 8 minutes using 8 cores). **Critical for low latency.**
- CrIS can be processed at Normal Spectral Resolution (NSR) or Full Spectral Resolution (FSR).
 - Default mode for SNPP CrIS is NSR.
 - Default mode for JPSS-1 CrIS is FSR.
- Supports offline downloads of required ancillary data and calibration lookup tables.
- Users' Guide includes information on BUFR conversion for DBNet station operators.

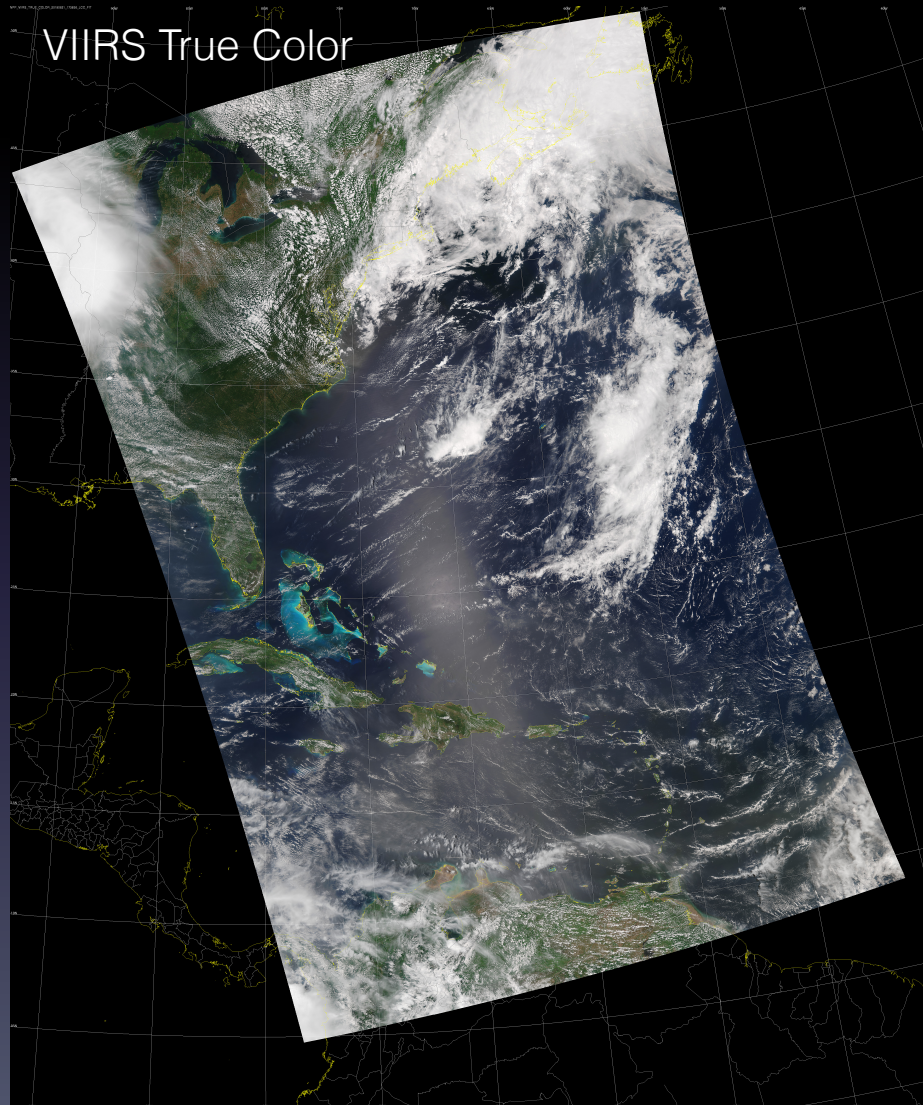
CSPP SDR Examples

NOAA-20 Direct Broadcast data from Miami antenna 2019/06/21

VIIRS DNB



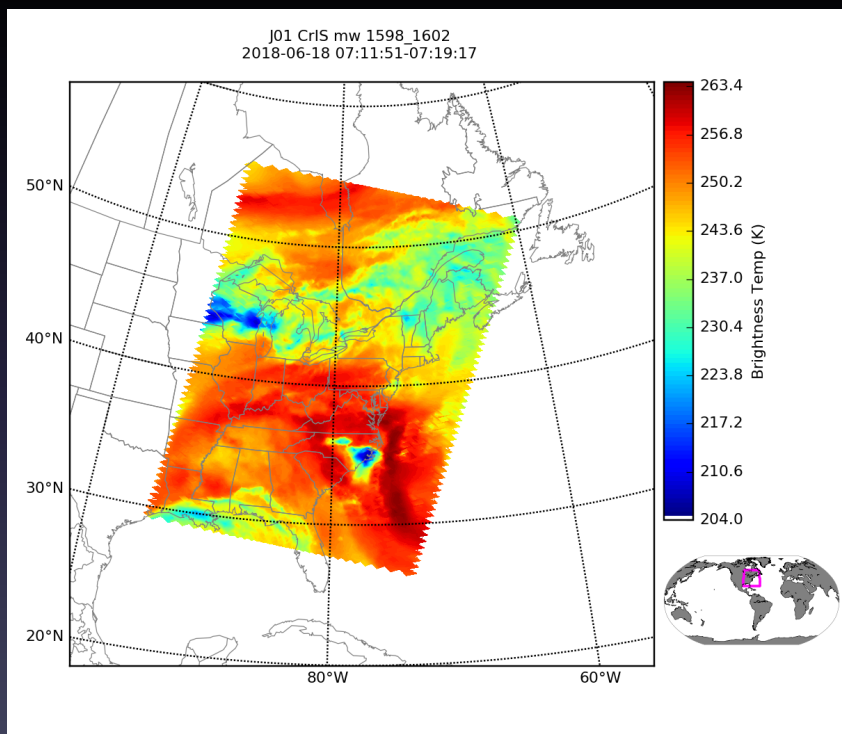
VIIRS True Color



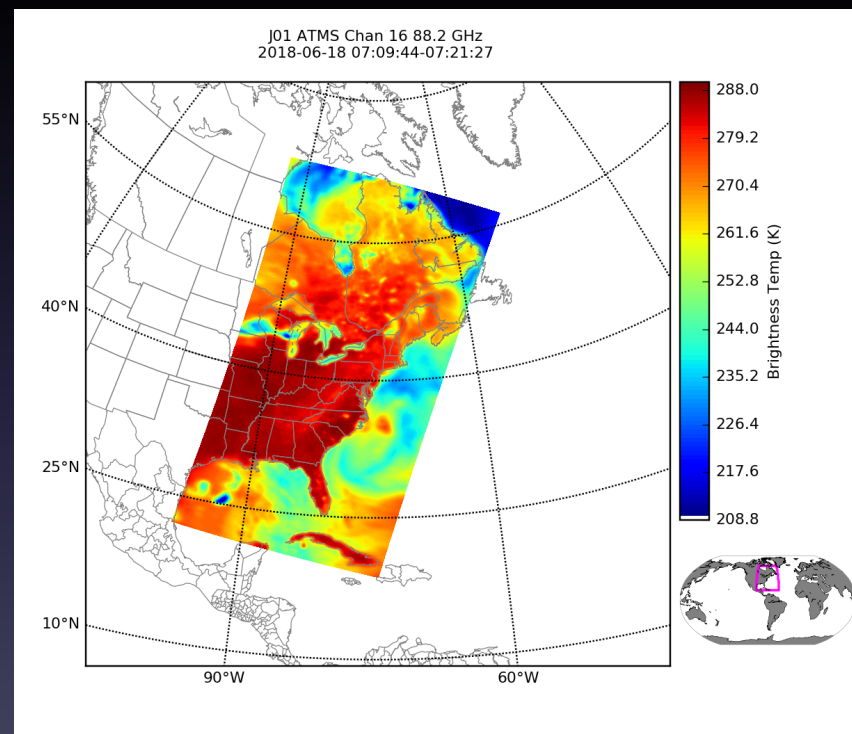
CSPP SDR Examples

NOAA-20 Direct Broadcast data from Madison antenna
2018/06/18 07:10 UTC

CrIS 1600 cm^{-1}



ATMS 89 GHz



HSRTV (High Spectral Resolution Retrieval) creates temperature, moisture, and trace gas profiles, and cloud products.

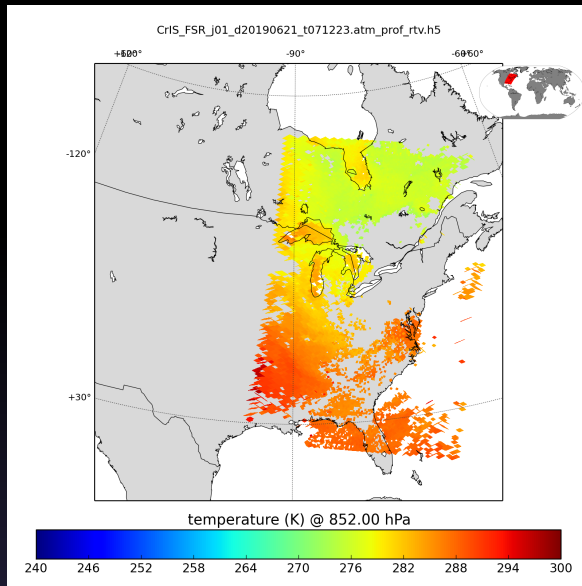
Heritage	Developed at CIMSS/SSEC by Bill Smith, Elisabeth Weisz, and Nadia Smith.
Satellites/ Sensors	NOAA-20 and Suomi NPP (CrIS); Metop-A/B/C (IASI); Aqua (AIRS).
Products	Temperature, moisture, and ozone at 101 pressure levels; surface skin temperature and emissivity; total column water vapor and ozone; CO ₂ amount; cloud mask; cloud top pressure and temperature; and cloud optical thickness in HDF5 format
Features	<ul style="list-style-type: none">• Common multi-sensor algorithm.• Single field of view retrievals.• Fast regression algorithm.

HSRTV Examples

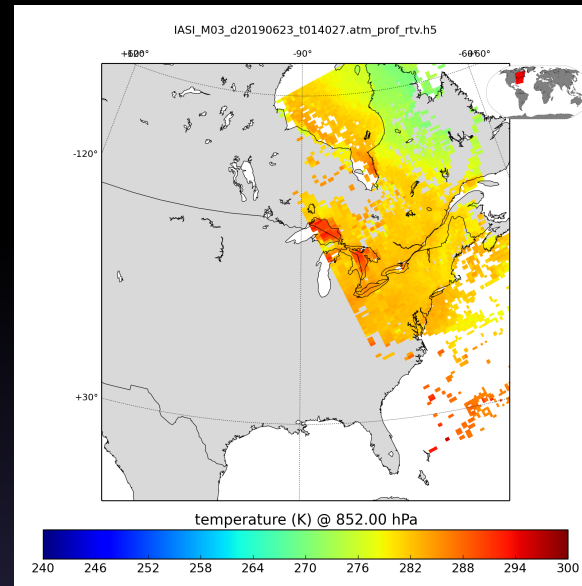
NOAA-20 2019/06/21 07:12 UTC
Metop-C 2019/06/23 01:40 UTC



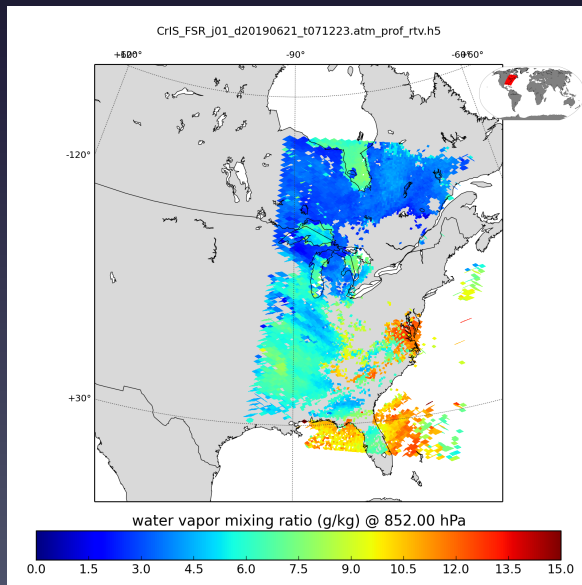
CrIS
Temperature
850 hPa



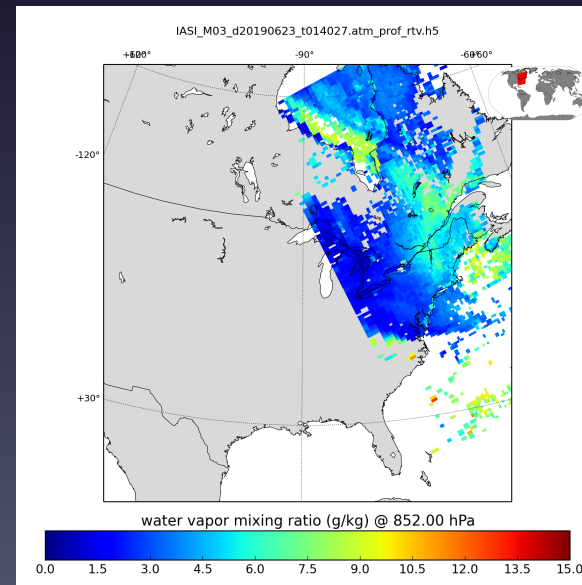
IASI
Temperature
850 hPa



CrIS
Mixing ratio
850 hPa



IASI
Mixing ratio
850 hPa



MIRS (Microwave Integrated Retrieval System) creates atmospheric profile, precipitation, and surface products from microwave sounder data.

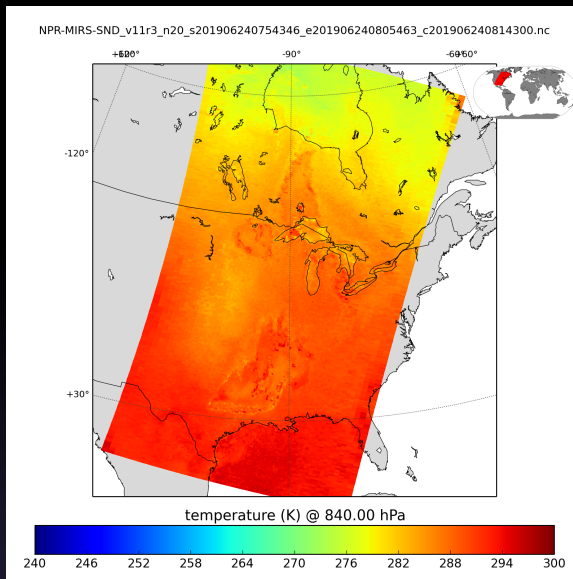
Heritage	Developed at NOAA/NESDIS by Sid Boukabara, Chris Grassotti, et al.
Satellites/ Sensors	NOAA-20 and Suomi NPP (ATMS); Metop-A/B (AMSU, MHS); NOAA-18/19 (AMSU, MHS).
Products	Temperature and moisture profiles, total precipitable water, surface skin temperature and emissivity, rain rate, cloud liquid water, rain water path, ice water path, liquid water path, sea ice concentration, snow water equivalent, and snow cover.
Features	<ul style="list-style-type: none">• Multi-sensor common algorithm.• Physics-based retrieval.• Retrieves land and ocean products in all sky conditions.• Extensively validated and documented.

MIRS Examples



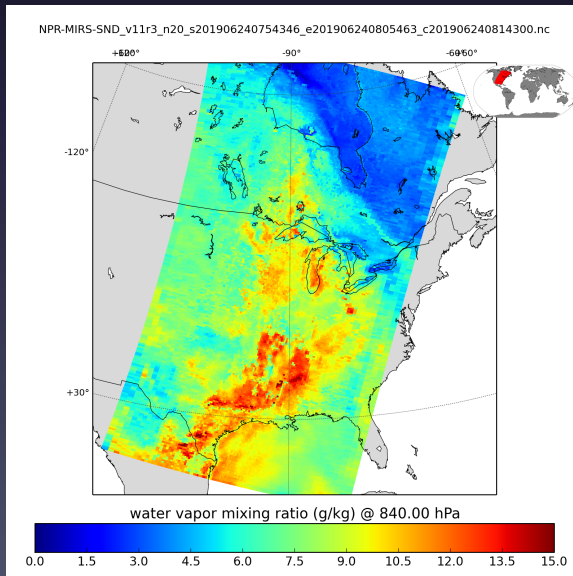
NOAA-20
2019/06/24
07:54 UTC

Atmospheric
Temperature
840 hPa



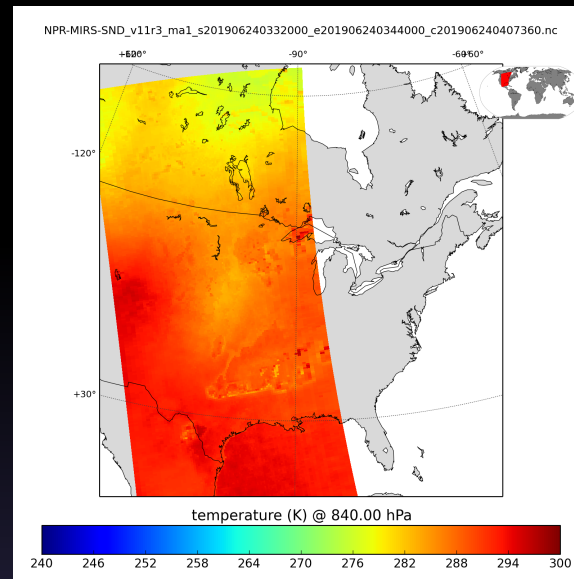
NOAA-20
2019/06/24
07:54 UTC

Water vapor
Mixing ratio
840 hPa



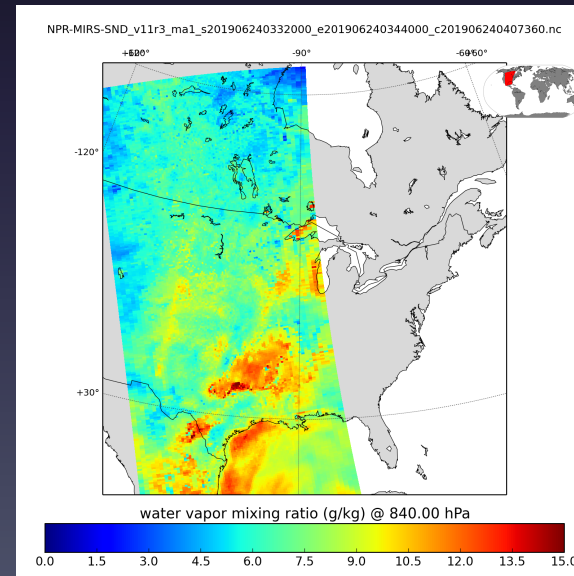
Metop-B
2019/06/24
03:32 UTC

Atmospheric
Temperature
840 hPa



Metop-B
2019/06/24
03:32 UTC

Water vapor
Mixing ratio
840 hPa



NUCAPS and NUCAPS-IASI



NUCAPS (NOAA Unique CrlS/ATMS Processing System) retrieves atmospheric temperature, moisture, and trace gases from combined infrared and microwave observations.

Heritage	Developed at NOAA/NESDIS/STAR by Chris Barnet, Antonia Gambacorta, Tom King, Walter Wolf, Mark Liu et al.
Satellites/ Sensors	NOAA-20 and Suomi NPP (CrIS, ATMS); Metop-A/B (IASI, AMSU)
Products	Temperature, water vapor, and ozone profiles; trace gas profiles including ozone, carbon monoxide, methane, carbon dioxide, nitrous oxide, sulphur dioxide; infrared and microwave surface emissivity; cloud cleared radiances.
Features	<ul style="list-style-type: none">• Multi-sensor common physical retrieval algorithm.• NUCAPS is the official NOAA sounding product for JPSS.• Future version will support Metop-C (IASI/AMSU).

NUCAPS Examples



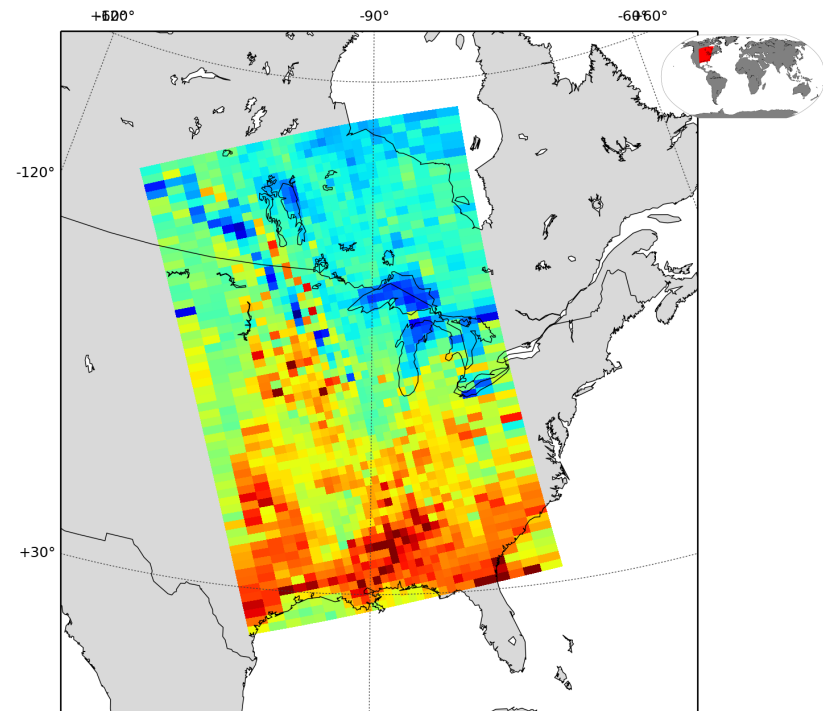
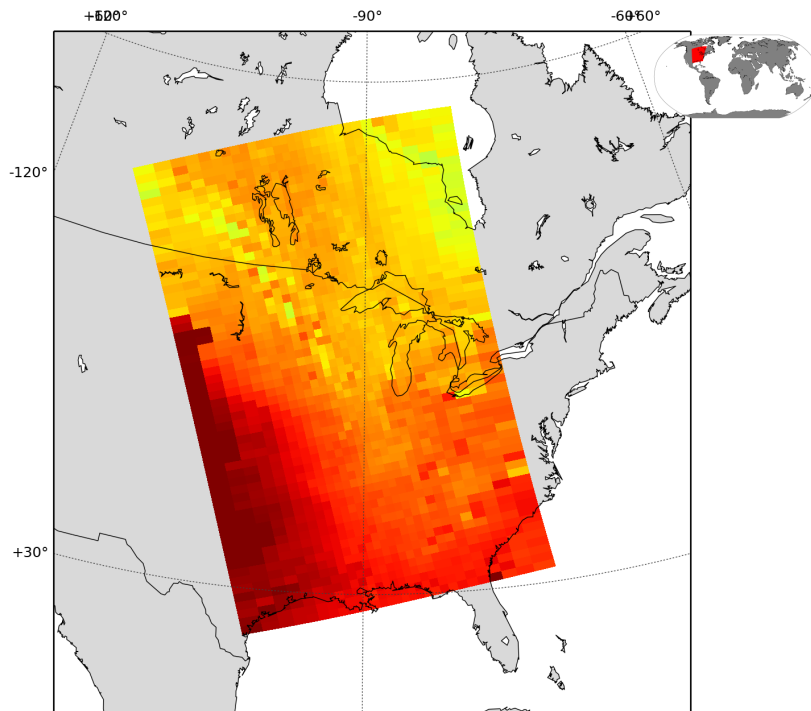
NOAA-20 2019/06/20 18:55 UTC

Temperature at 852 hPa

Water Vapor Mixing Ratio at 852 hPa

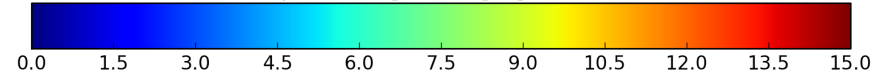
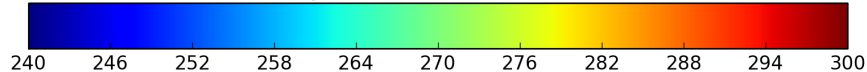
NUCAPS-EDR_v2r0_j01_s201906201855199_e201906201855497_c201906201915040.nc

NUCAPS-EDR_v2r0_j01_s201906201855199_e201906201855497_c201906201915040.nc



temperature (K) @ 852.00 hPa

water vapor mixing ratio (g/kg) @ 852.00 hPa



NUCAPS-IASI Examples



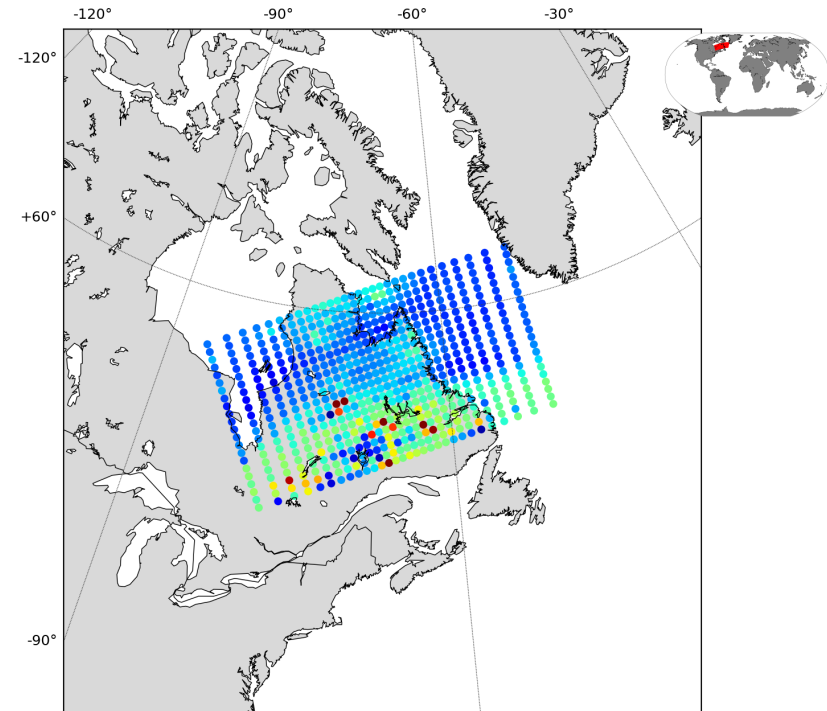
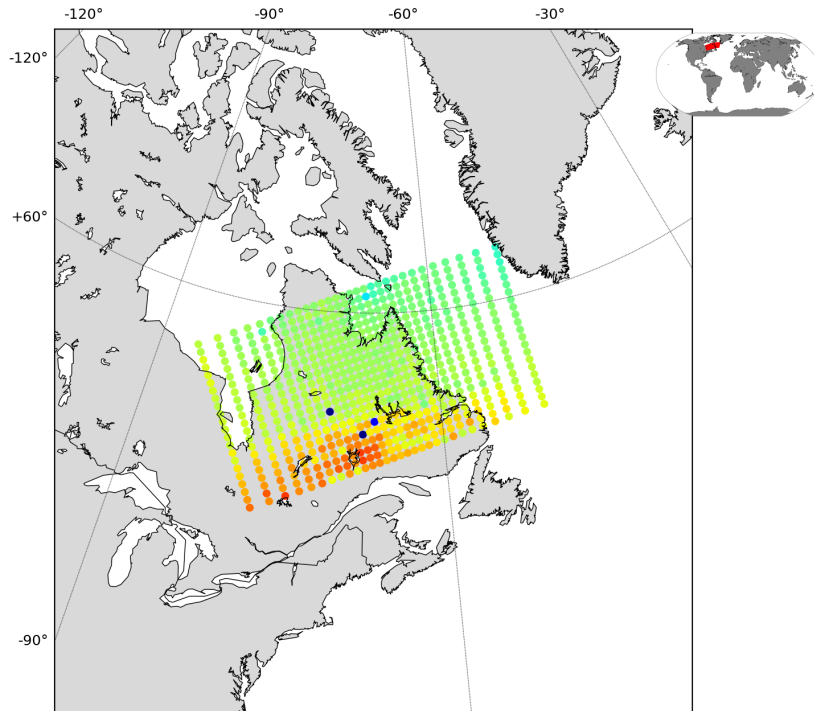
Metop-B 2018/08/02 01:02 UTC

Temperature at 852 hPa

Water Vapor Mixing Ratio at 852 hPa

IASI_L02_M01_V140606_20180802010239Z_20180802010535Z.nc

IASI_L02_M01_V140606_20180802010239Z_20180802010535Z.nc



temperature (K) @ 852.00 hPa

water vapor mixing ratio (g/kg) @ 852.00 hPa

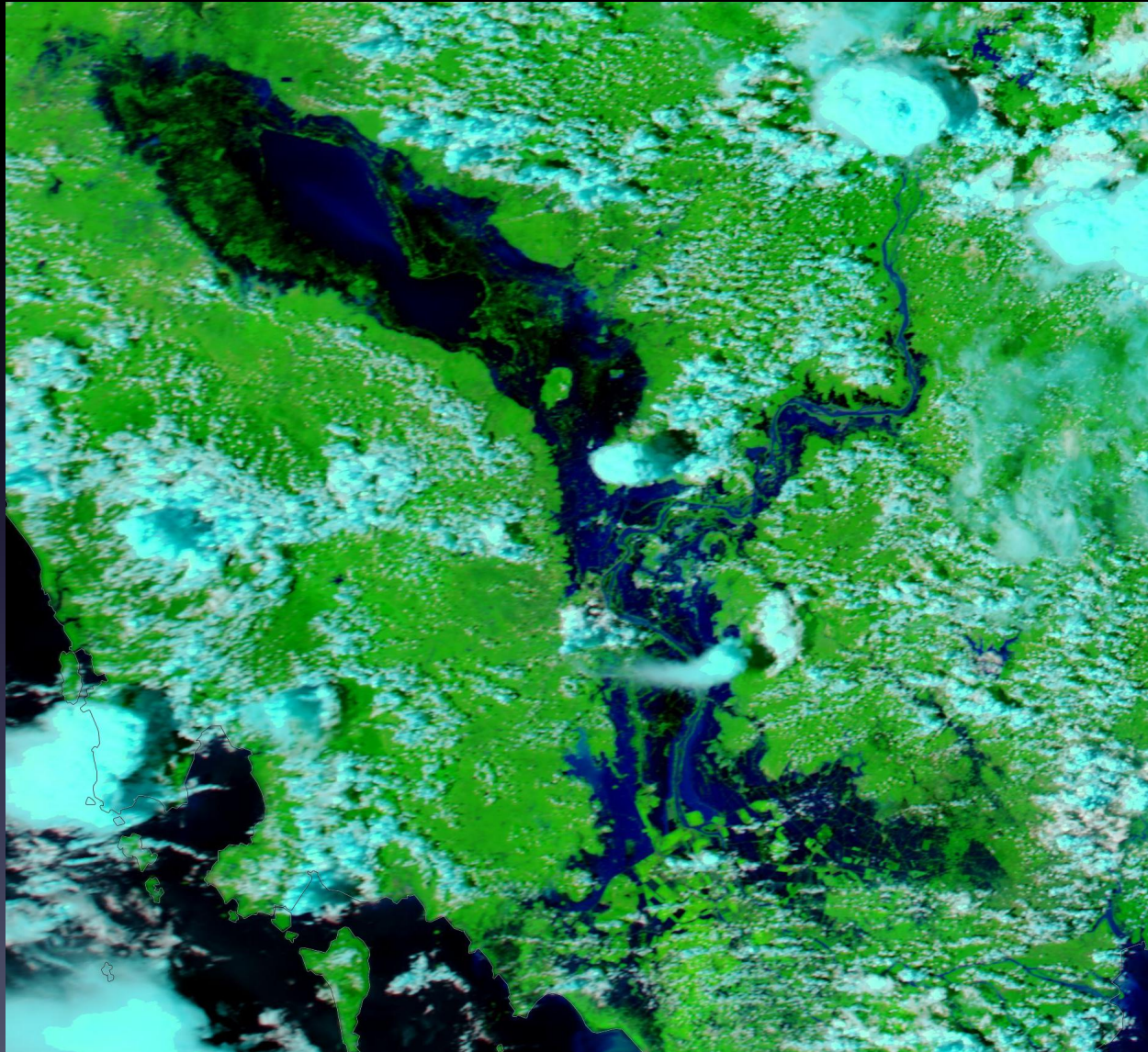


Algorithm developed by Sanmei Li at George Mason University

- Daytime algorithm using VIIRS I-bands at 375 meter resolution.
- Includes built-in tests for detecting clouds, snow, ice, and shadows from clouds and terrain.
- Uses static global water database to identify “normal water”.
- Supports SNPP and NOAA-20 VIIRS

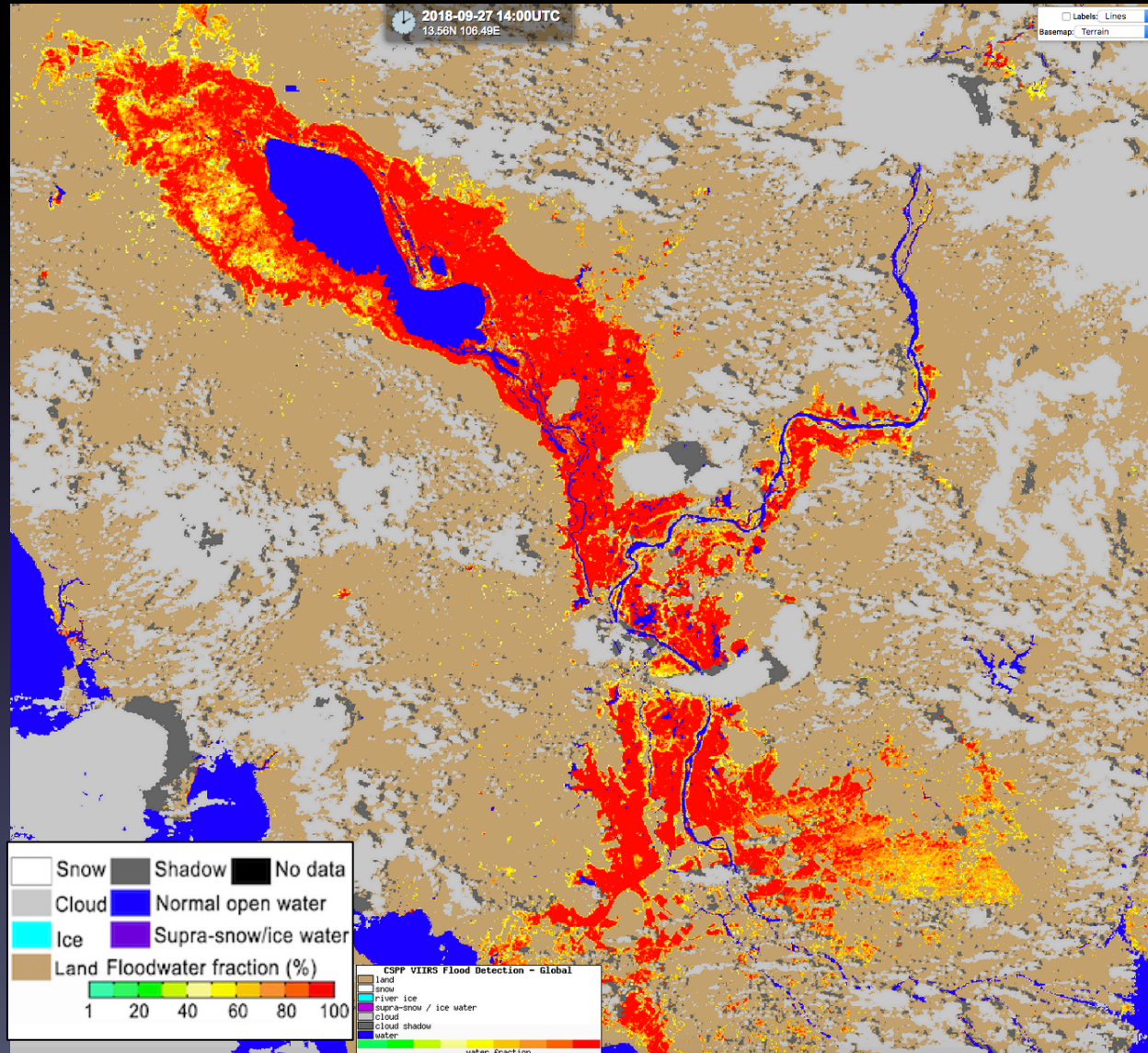
VIIRS flood detection

SNPP VIIRS False Color 2018/09/27 CAMBODIA



VIIRS flood detection

SNPP VIIRS Flood Detection 2018/09/27 CAMBODIA

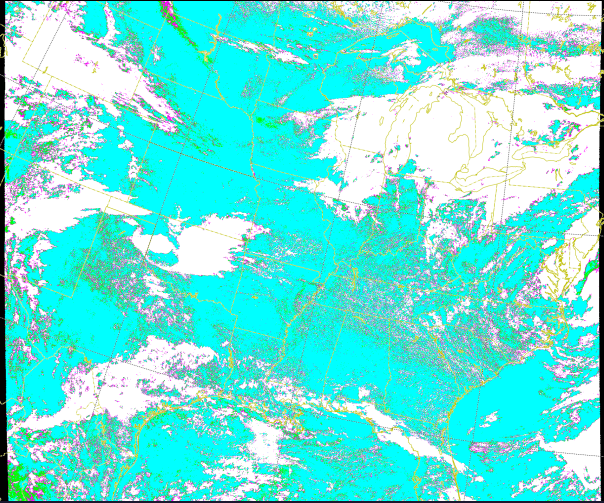


VIIRS Aerosol, Snow/Ice, Cloud and Volcanic Ash.

Heritage	Developed at NOAA/NESDIS
Satellites/ Sensors	NOAA-20 and Suomi NPP (VIIRS)
Products	Cloud Mask, Cloud Top Properties, Cloud Phase, Cloud Base Height, and Cloud Optical Depth; Aerosol Optical Depth and Aerosol Detection Product; Snow Mask, Snow Fraction, Ice Age, Ice Thickness, Ice Concentration, and Ice Surface Temperature; Volcanic Ash Confidence, Ash Height, Ash Top Temperature, Ash Effective Radius and Ash Optical Depth.
Features	<ul style="list-style-type: none">• Multi-core acceleration• Automated download of ancillary data

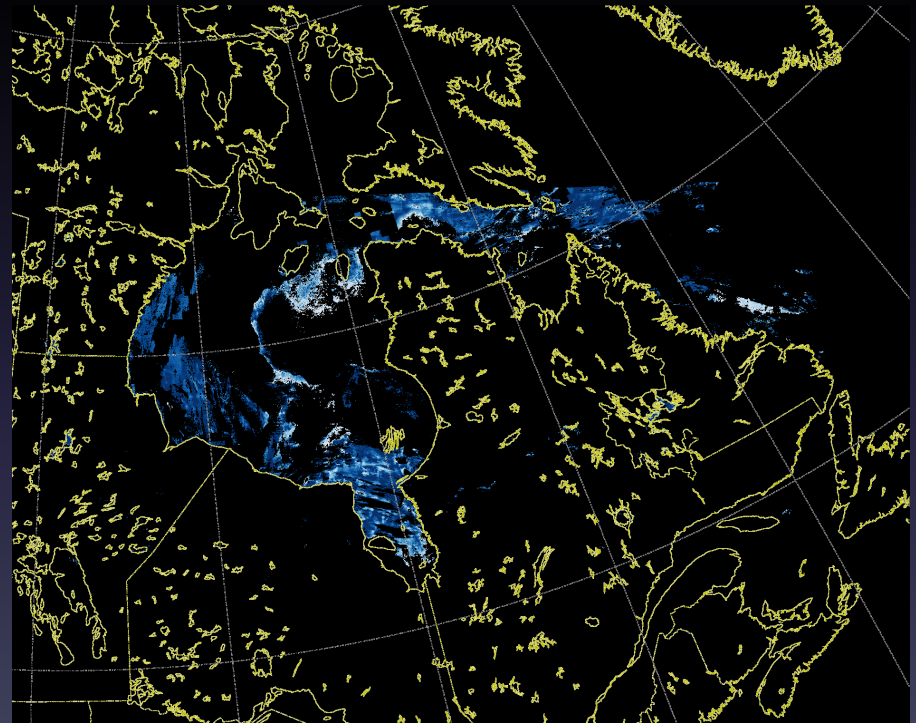
VIIRS ASCI Examples

SNPP 2019/06/01 18:58 UTC

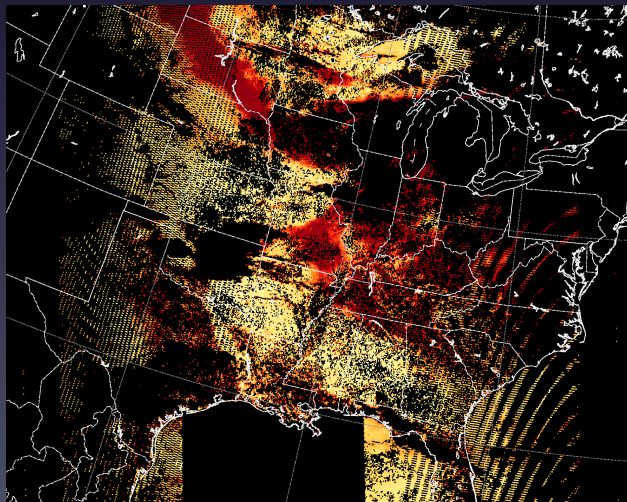


Cloud Mask

SNPP 2019/06/02 07:15 UTC



Ice Concentration



Aerosol Optical Thickness

VIIRS Active Fires



Algorithm developed by Ivan Csiszar and Wilfrid Schroeder at NOAA.

Heritage	Developed at NOAA/NESDIS
Satellites/ Sensors	NOAA-20 and Suomi NPP (VIIRS)
Products	<ul style="list-style-type: none">• I-Band (375m) and M-Band (750m) resolutions.• Fire Mask, Detection Confidence, Fire Radiative Power.• netCDF and text file product formats.
Features	<ul style="list-style-type: none">• Multi-core acceleration

VIIRS Active Fires Example



NOAA-20 2019/05/28 19:42 UTC British Columbia

New features coming soon in CSPP LEO

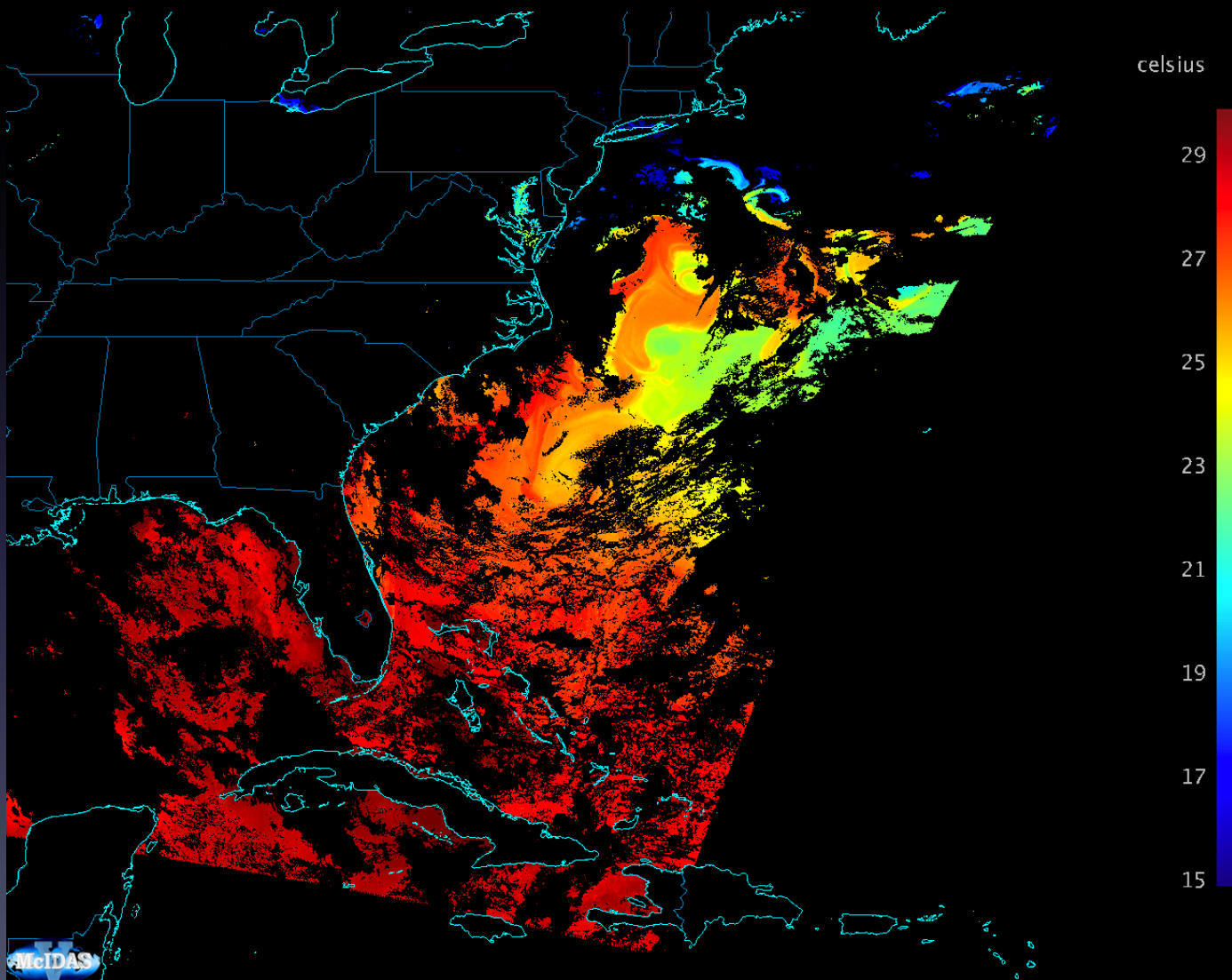


- VIIRS SST support for NOAA-20
- Cloud product support for NOAA-20, Metop-C, FY-3D
- GAASP microwave products
- Polar2Grid imagery from FY-3D MERIS-2, FY-3B/C VIRR, VIIRS Flood, VIIRS Fires
- VIIRS Land Surface Reflectance and Land Surface Temperature

VIIRS SST support for NOAA-20 (ACSP0)



NOAA-20 VIIRS SST 2019/06/06



NOAA-20 VIIRS Cloud Products (CLAVR-x)



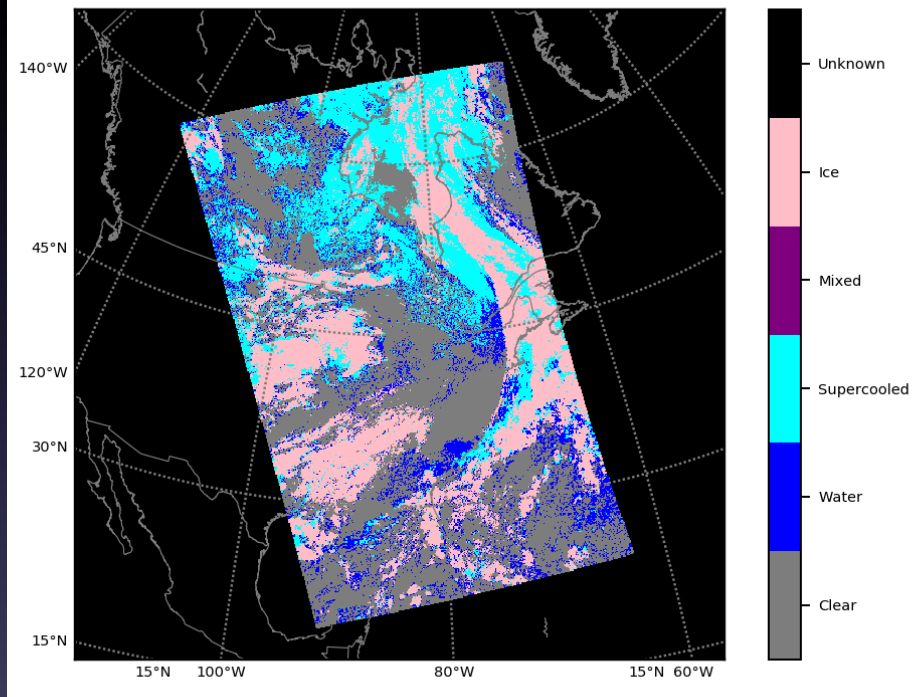
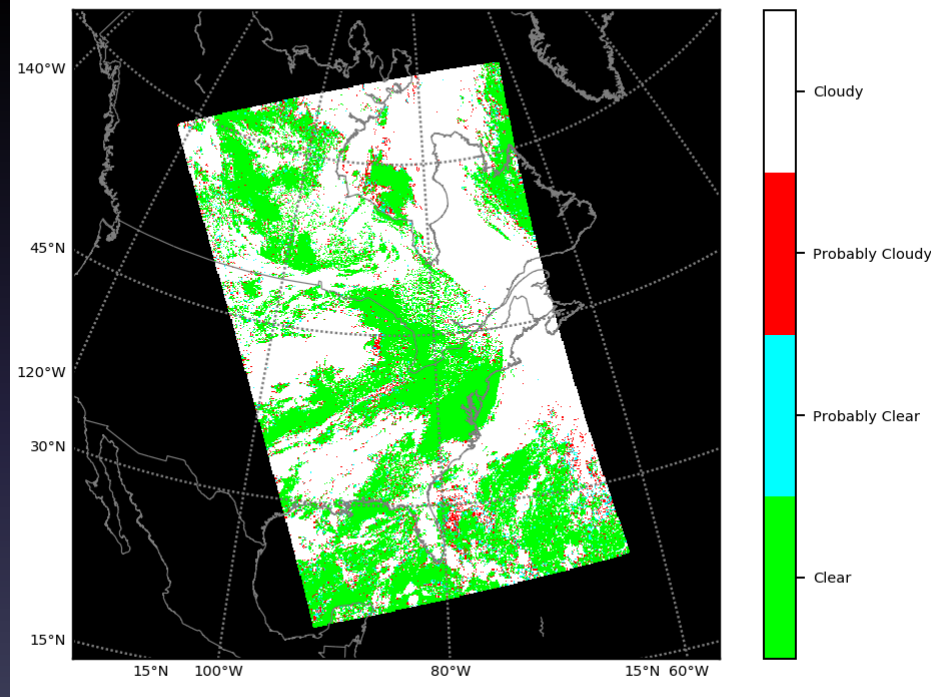
NOAA-20 2019/06/11 18:21 UTC

Cloud Mask

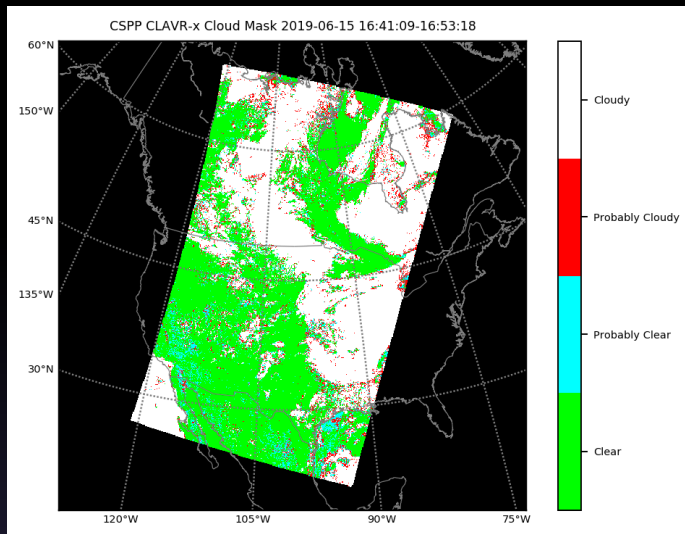
Cloud Phase

CSPP CLAVR-x Cloud Mask 2019-06-11 18:21:17-18:35:30

CSPP CLAVR-x Cloud Phase 2019-06-11 18:21:17-18:35:30

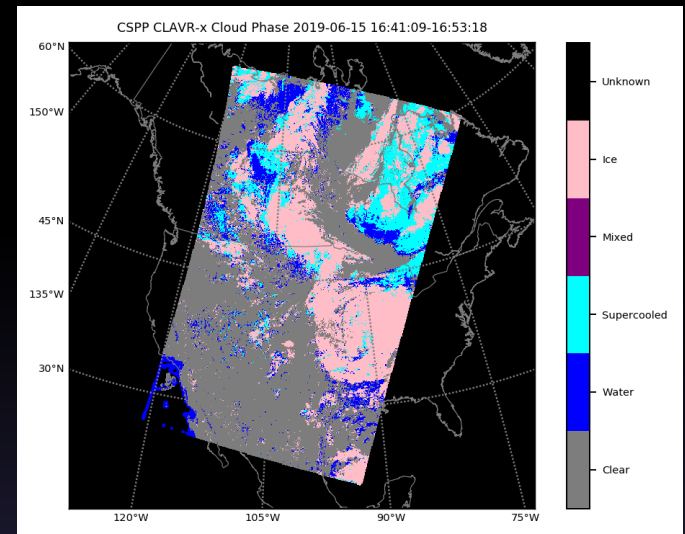


Metop-C & FY-3D Cloud Products (CLAVER-x)

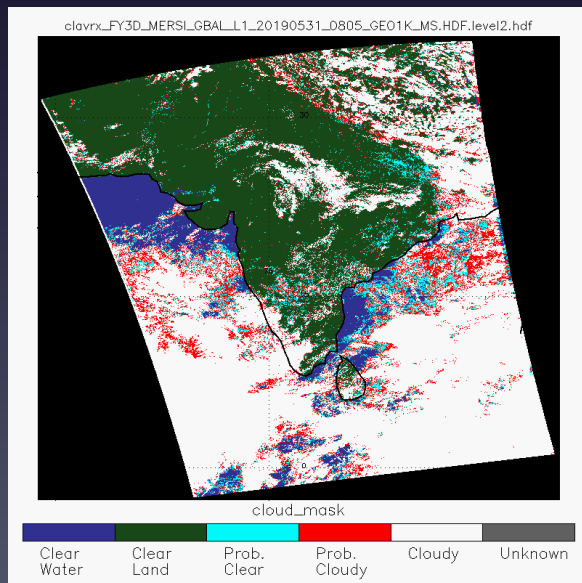


Cloud Mask

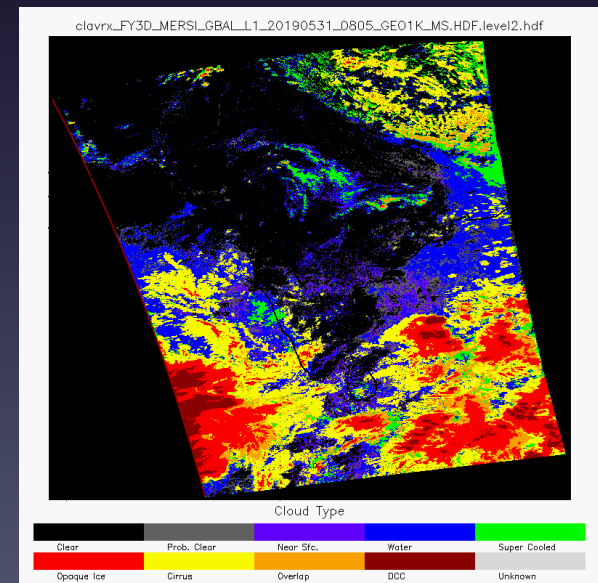
Metop-C
2019/06/15
16:41 UTC



Cloud Type



FY-3D
2019/05/31
08:00 UTC



GAASP for GCOM-W1 AMSR2



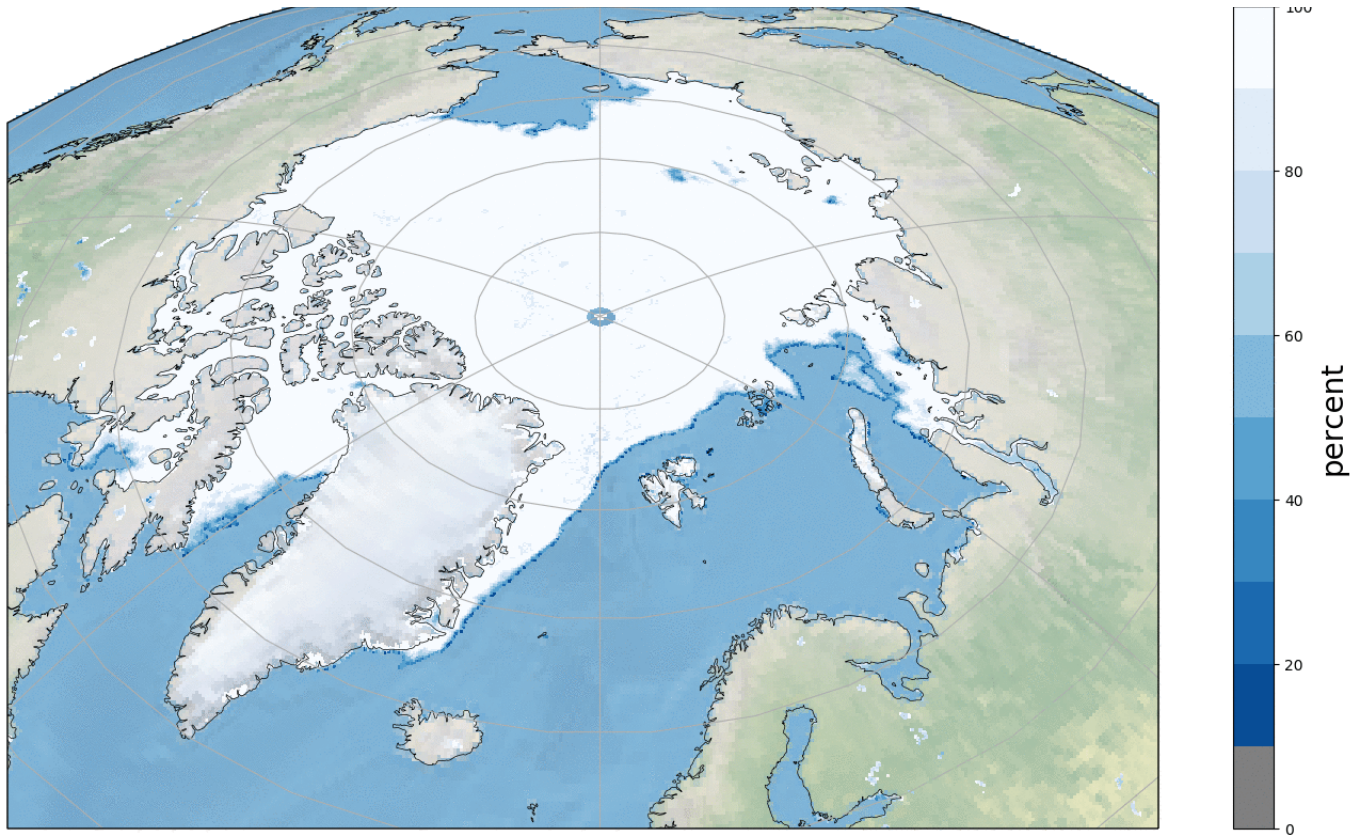
GCOM-W1 AMSR2 Algorithm Software Package (GAASP) was developed at NOAA/NESDIS/STAR.

GAASP products include:

Precipitation Rate (PR), Sea Surface Temperature (SST), Sea Surface Winds (SSW), Total Precipitable Water (TPW), Cloud Liquid Water (CLW), Soil Moisture (SM), Surface Type (ST), Snow Cover (SC), Snow Depth (SD), Snow Water Equivalent (SWE), and Sea Ice Cover (SIC).

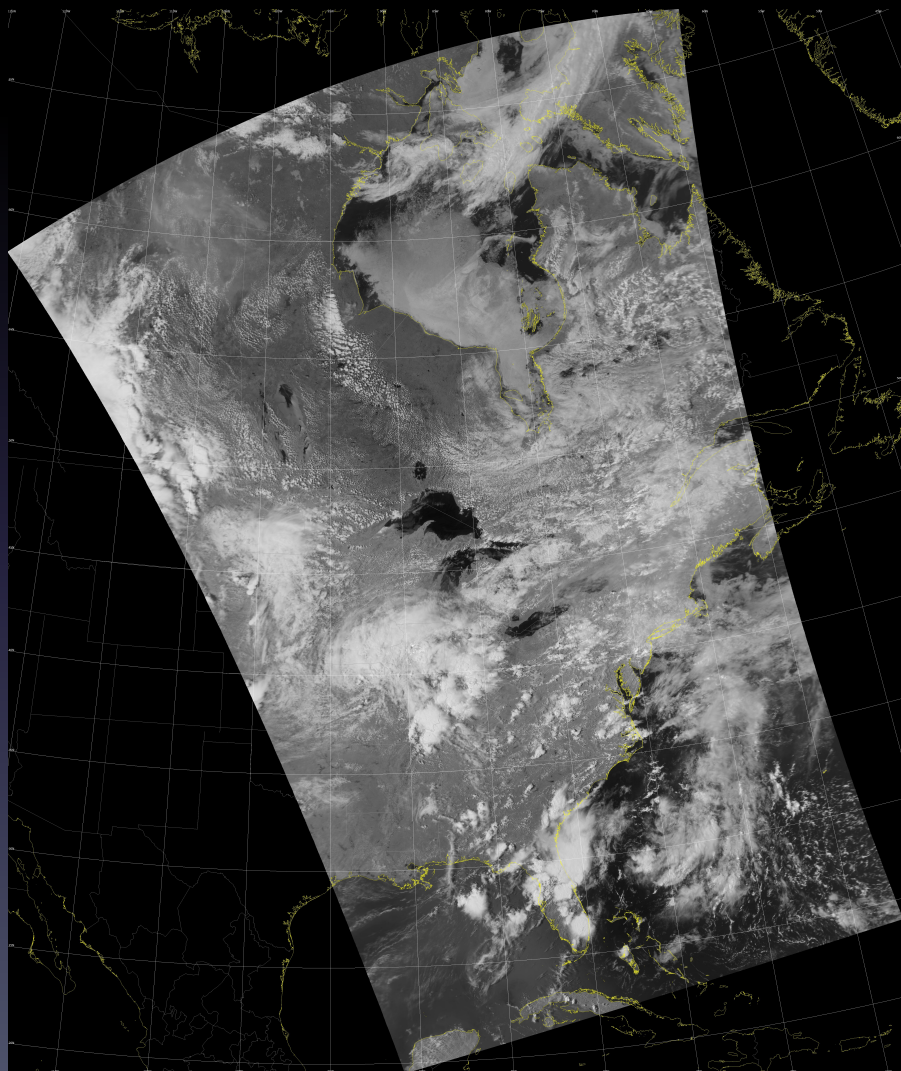
GAASP Example: Sea Ice

GAASP Ice Concentration 2018-11-04 to 2018-11-05

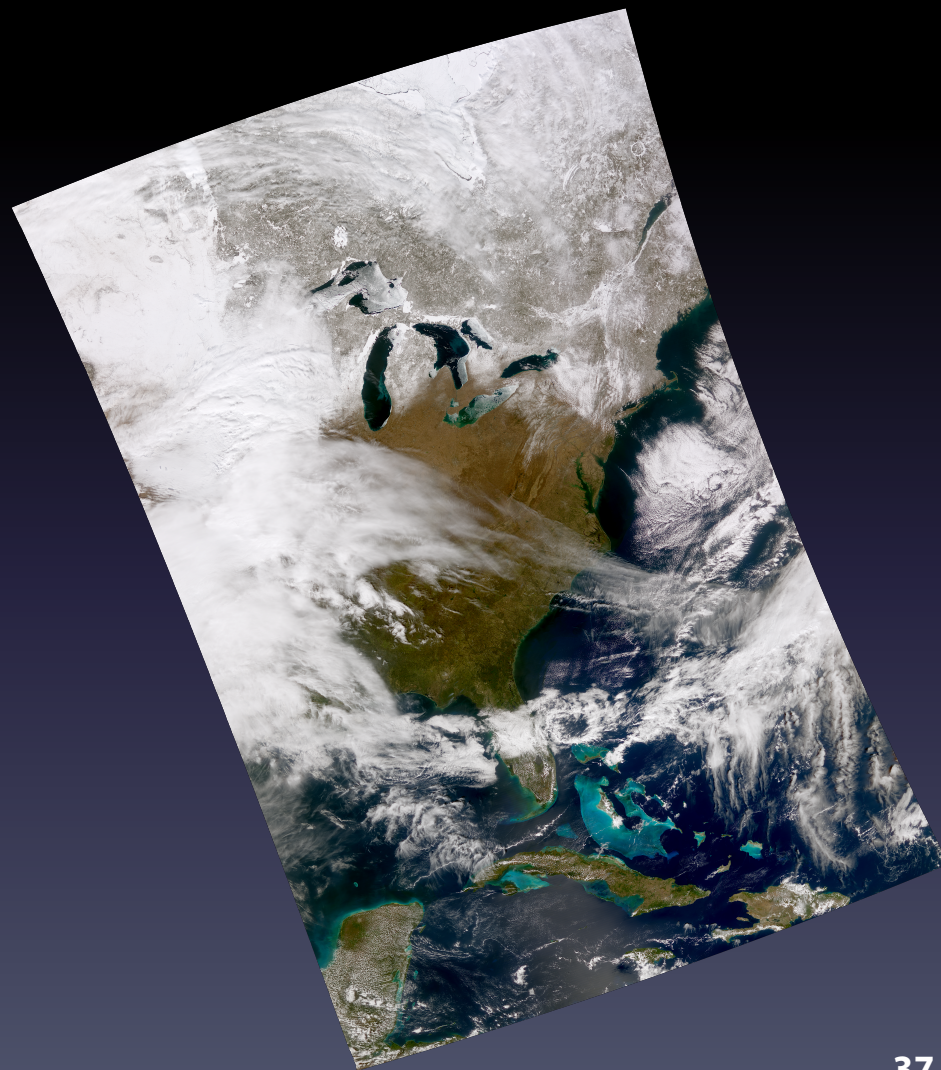


Polar2Grid Examples

FY-3B VIRR
2019/06/19



FY-3D MERSI-2
2019/03/12



Summary

- CSPP LEO continues to support the global DB community with updated software and new products.
- Support for NOAA-20, Metop-C, and FY-3D has been added.
- We look forward to supporting JPSS-2 launch in 2022.

<https://cimss.ssec.wisc.edu/cspp/>

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