DB Applications Workshop AOML: Practical Aspects of Real-Time Suomi NPP Imagery and Products

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VIIRS True Color, 2015/01/30

About Suomi NPP

Launched into a polar sun-synchronous orbit on Oct 28, 2011.

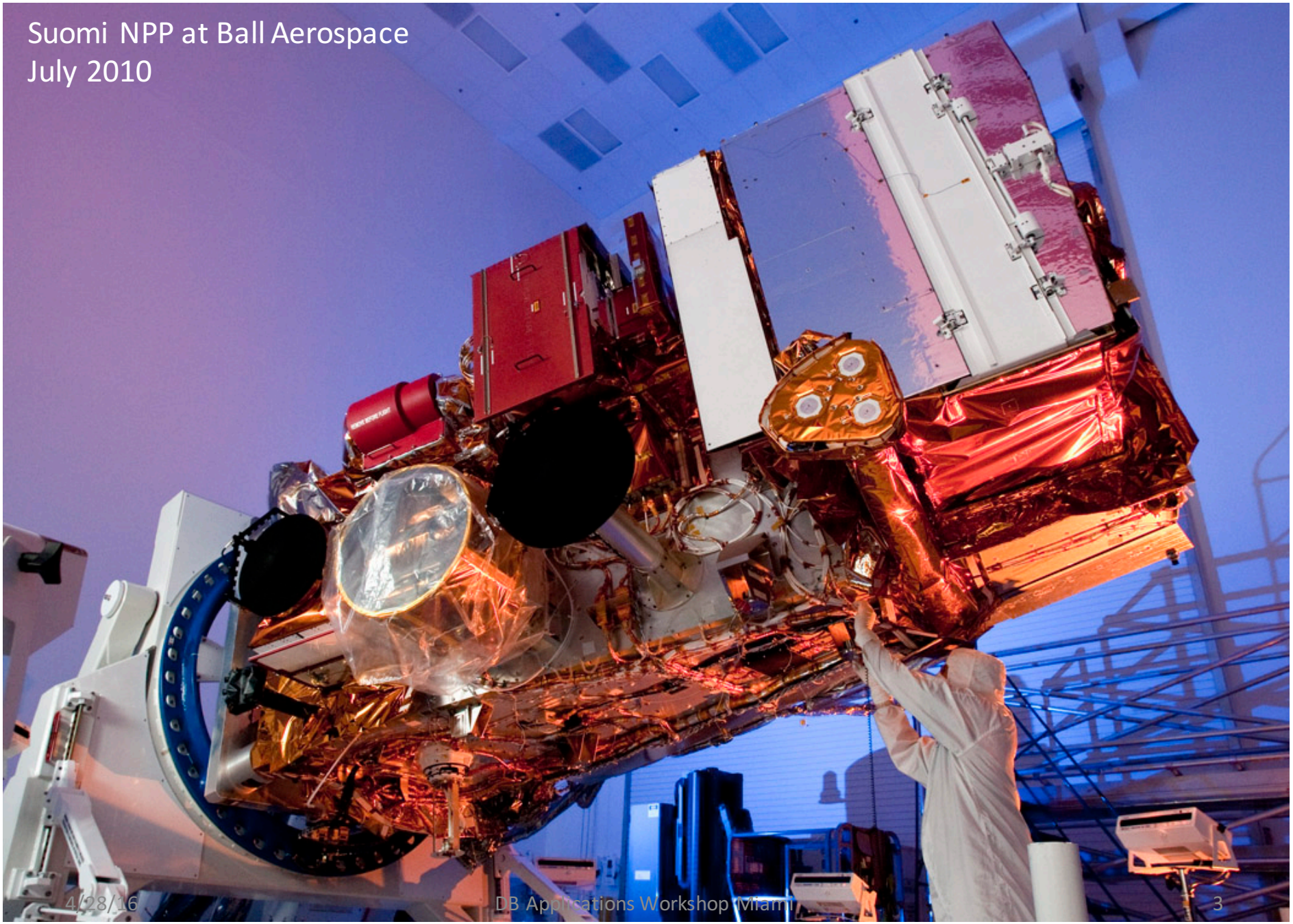
Developed by NASA and industry; operated by NOAA.

Spacecraft and sensors were developed by industry.

Science algorithms were also developed by industry.

Question: Can the science products (e.g., global cloudiness) continue the ***Climate Data Record*** established by previous NASA and NOAA satellites?

Climate Data Record = "A time series of measurements of sufficient length, consistency, and continuity to determine climate variability. and change."


Suomi NPP at Ball Aerospace
July 2010

Suomi NPP Sensor Suite

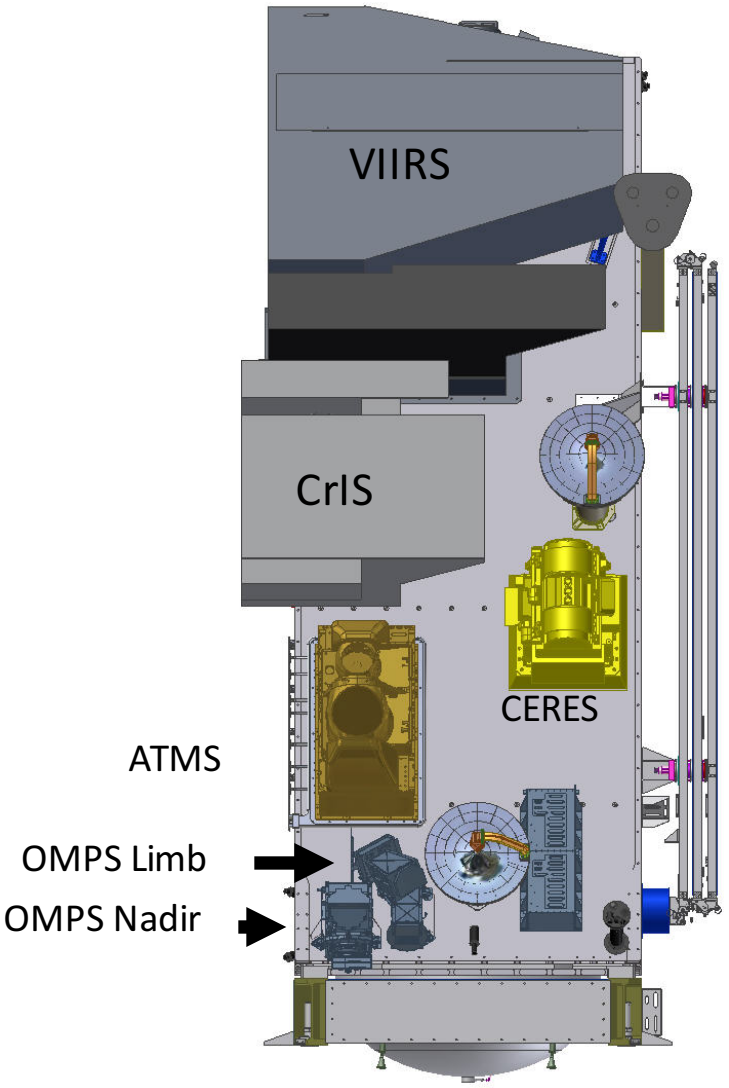
VIIRS – Medium Resolution Visible & Infra-red Imager

CrIS – Fourier Transform Spectrometer for IR Temperature and Moisture sounding

ATMS – Microwave sounding radiometer

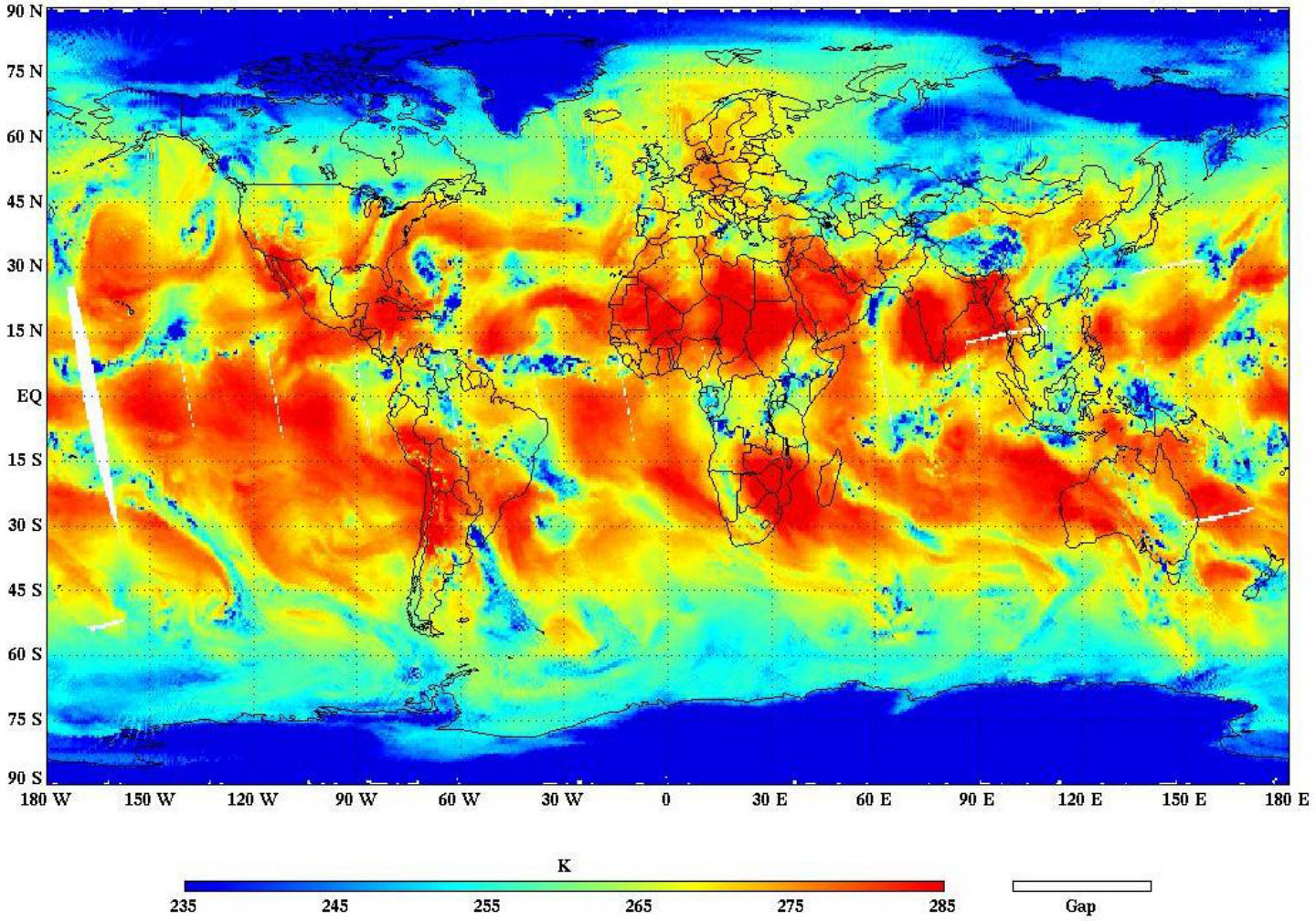
OMPS – Total Ozone Mapping and Ozone Profile measurements

CERES - Earth Radiation Budget



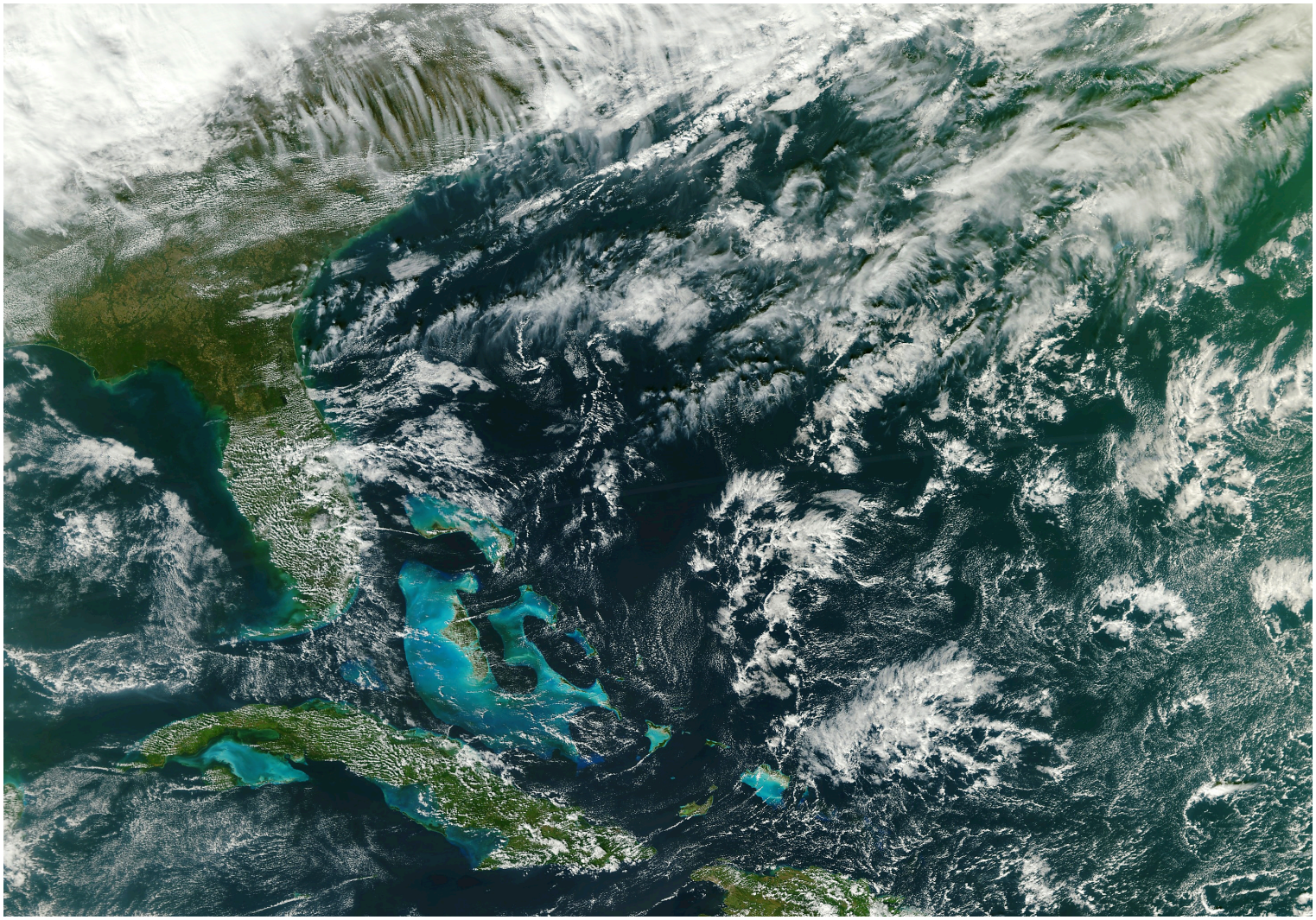
Suomi NPP Launch 2011/10/28

ATMS First Light image



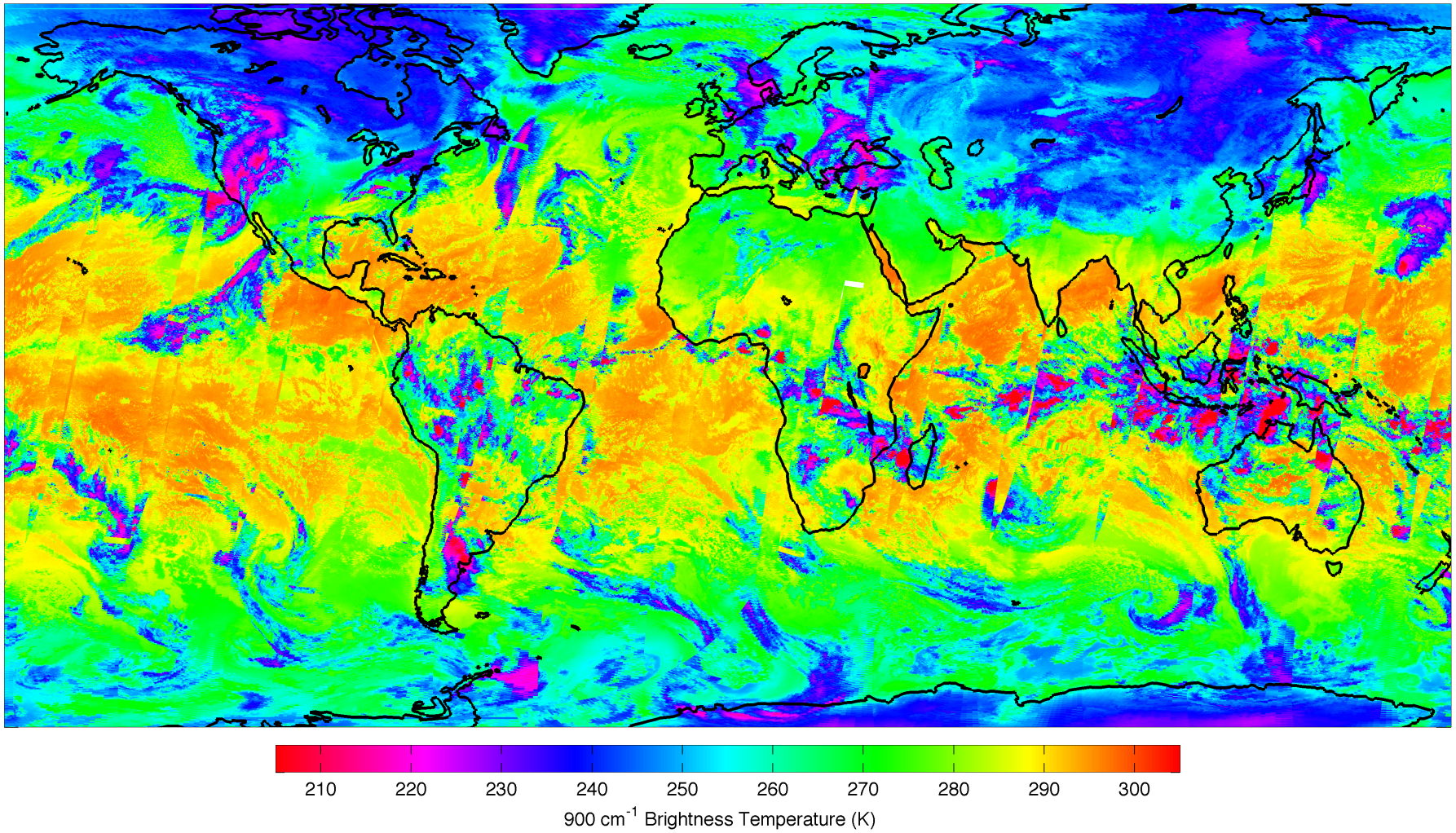
Suomi NPP ATMS channel 18 antenna temperature, 8 November 2011

VIIRS First Light Image



Suomi NPP VIIRS M-band True Color, 21 November 2011

CrIS First Light Image



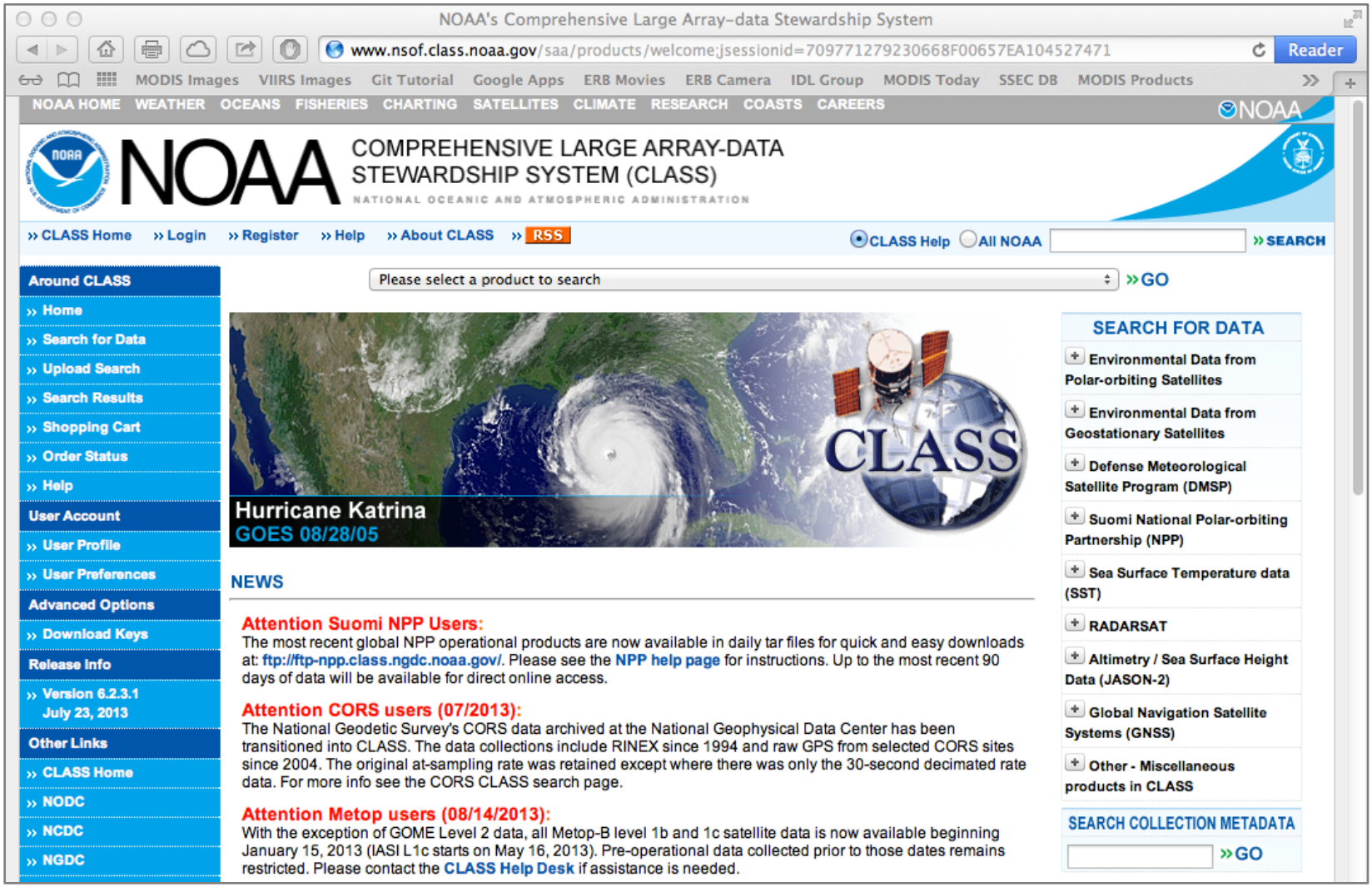
Suomi NPP CrIS thermal infrared, 21/23/25 January 2012

What is new about VIIRS?

- VIIRS native resolution is 375 and 750 meters (vs. 250 and 1000 meters for MODIS).
- VIIRS has 22 spectral bands while MODIS has 36 spectral bands.
- VIIRS has a thermal infrared band at 375 meter resolution.
- VIIRS has a Day/Night visible band.
- VIIRS has near constant FOV size across the scan.
- Redundant "bow-tie" pixels on VIIRS are not transmitted to the ground ("bowtie deletion").

Where To Obtain VIIRS Data

Suomi NPP Data Archive: NOAA CLASS



http://www.class.noaa.gov/

Notes about NOAA CLASS

- CLASS is the official archive for NPP and JPSS data.
- Ad-hoc orders are supported.
- Subscription orders are supported.
- A detailed tutorial on ordering Suomi NPP data is available.
- NASA Atmosphere PEATE at UW/SSEC also provides VIIRS SDRs.

VIIRS Scanner Characteristics

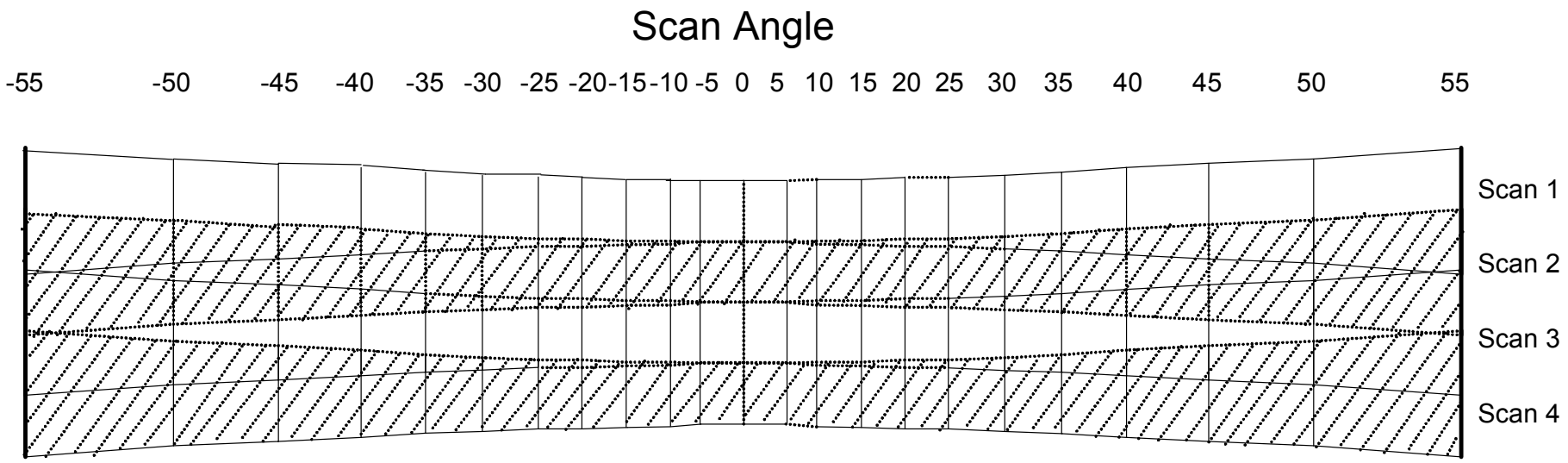
VIIRS Spectral Bands

		Band No.	Wave-length (μm)	Horiz Sample Interval (km Downtrack x Crosstrack)		Driving EDRs	Radi-ance Range	Ltyp or Ttyp	Signal to Noise Ratio (dimensionless) or $NE^{\Delta}T$ (Kelvins)		
				Nadir	End of Scan				Required	Predicted	Margin
VIS/NIR FPA	Silicon PIN Diodes	M1	0.412	0.742 x 0.259	1.60 x 1.58	Ocean Color Aerosols	Low High	44.9 155	352 316	441 807	25% 155%
		M2	0.445	0.742 x 0.259	1.60 x 1.58	Ocean Color Aerosols	Low High	40 146	380 409	524 926	38% 126%
		M3	0.488	0.742 x 0.259	1.60 x 1.58	Ocean Color Aerosols	Low High	32 123	416 414	542 730	30% 76%
		M4	0.555	0.742 x 0.259	1.60 x 1.58	Ocean Color Aerosols	Low High	21 90	362 315	455 638	26% 102%
		I1	0.640	0.371 x 0.387	0.80 x 0.789	Imagery	Single	22	119	146	23%
		M5	0.672	0.742 x 0.259	1.60 x 1.58	Ocean Color Aerosols	Low High	10 68	242 360	298 522	23% 45%
		M6	0.746	0.742 x 0.776	1.60 x 1.58	Atmospheric Corr'n	Single	9.6	199	239	20%
		I2	0.865	0.371 x 0.387	0.80 x 0.789	NDVI	Single	25	150	225	50%
		M7	0.865	0.742 x 0.259	1.60 x 1.58	Ocean Color Aerosols	Low High	6.4 33.4	215 340	388 494	81% 45%
CCD		DNB	0.7	0.742 x 0.742	0.742 x 0.742	Imagery	Var.	6.70E-05	6	5.7	-5%
S/MWIR	PV HgCdTe (HCT)	M8	1.24	0.742 x 0.776	1.60 x 1.58	Cloud Particle Size	Single	5.4	74	98	32%
		M9	1.378	0.742 x 0.776	1.60 x 1.58	Cirrus/Cloud Cover	Single	6	83	155	88%
		I3	1.61	0.371 x 0.387	0.80 x 0.789	Binary Snow Map	Single	7.3	6.0	97	1523%
		M10	1.61	0.742 x 0.776	1.60 x 1.58	Snow Fraction	Single	7.3	342	439	28%
		M11	2.25	0.742 x 0.776	1.60 x 1.58	Clouds	Single	0.12	10	17	66%
		I4	3.74	0.371 x 0.387	0.80 x 0.789	Imagery Clouds	Single	270 K	2.500	0.486	415%
		M12	3.70	0.742 x 0.776	1.60 x 1.58	SST	Single	270 K	0.396	0.218	82%
		M13	4.05	0.742 x 0.259	1.60 x 1.58	SST Fires	Low High	300 K 380 K	0.107 0.423	0.063 0.334	69% 27%
LWIR	PV HCT	M14	8.55	0.742 x 0.776	1.60 x 1.58	Cloud Top Properties	Single	270 K	0.091	0.075	22%
		M15	10.763	0.742 x 0.776	1.60 x 1.58	SST	Single	300 K	0.070	0.038	85%
		I5	11.450	0.371 x 0.387	0.80 x 0.789	Cloud Imagery	Single	210 K	1.500	0.789	90%
		M16	12.013	0.742 x 0.776	1.60 x 1.58	SST	Single	300 K	0.072	0.051	42%

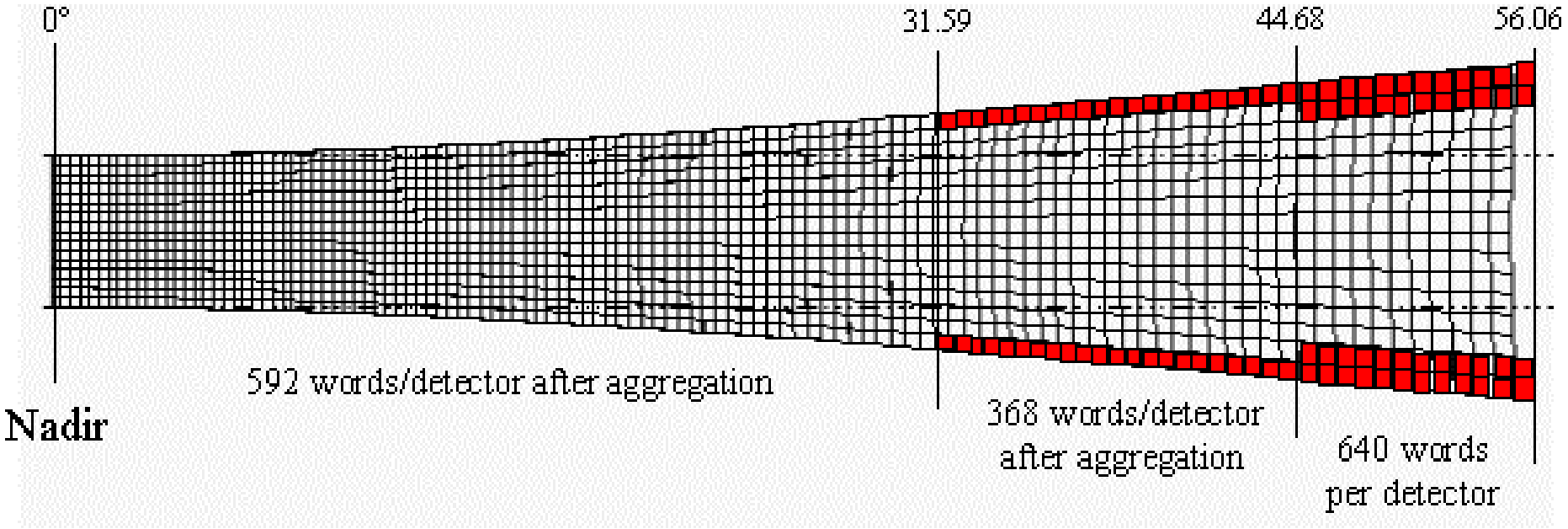
VIIRS Scan Details

- 16 detectors along track (M-bands)
- 32 detectors along track (I-bands)
- Swath width 3000 km
- Granule size 85.7 sec
- Usually 48 scans per granule (sometimes 47)
- Calibrated TOA reflectance is calculated using the terrain corrected solar zenith angle.

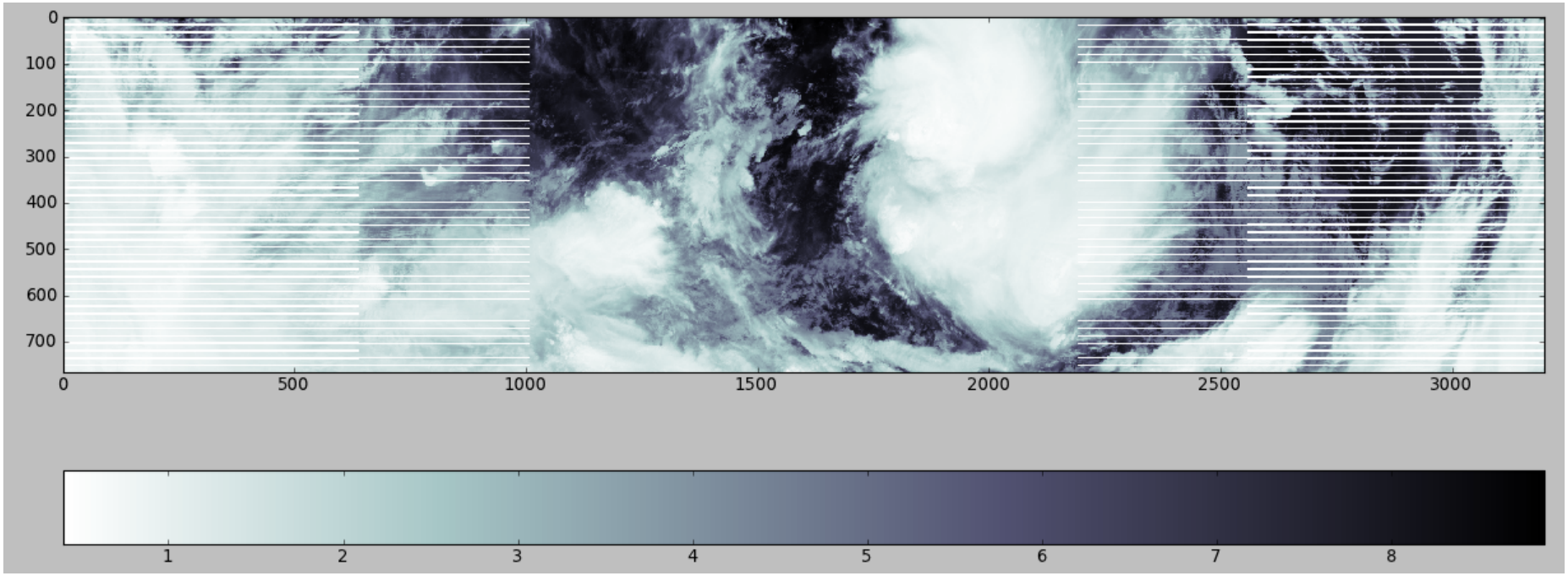
VIIRS Scan Overlap



VIIRS Bowtie Deletion Zones

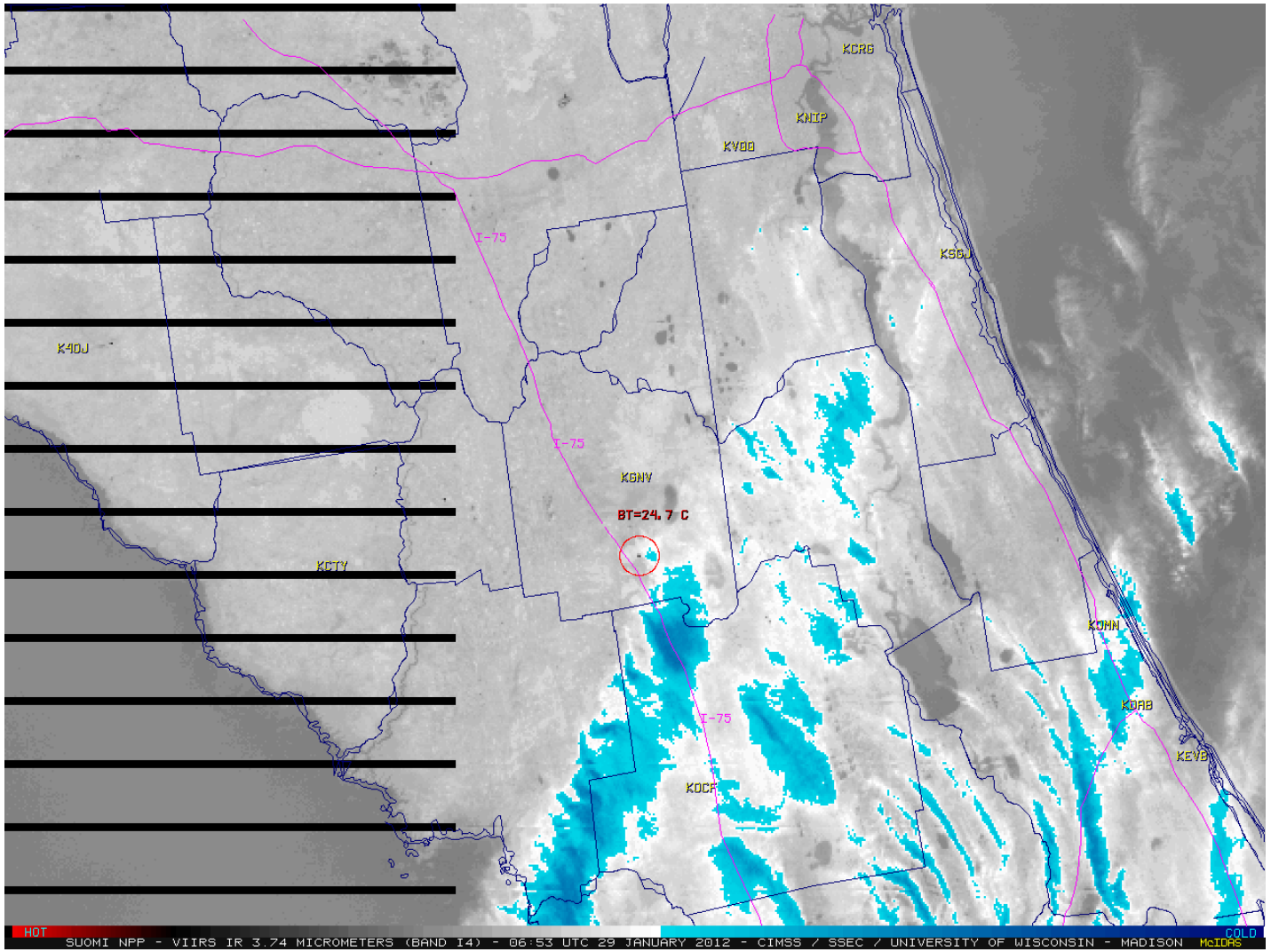


Visualization of a VIIRS M-band SDR granule (Python)



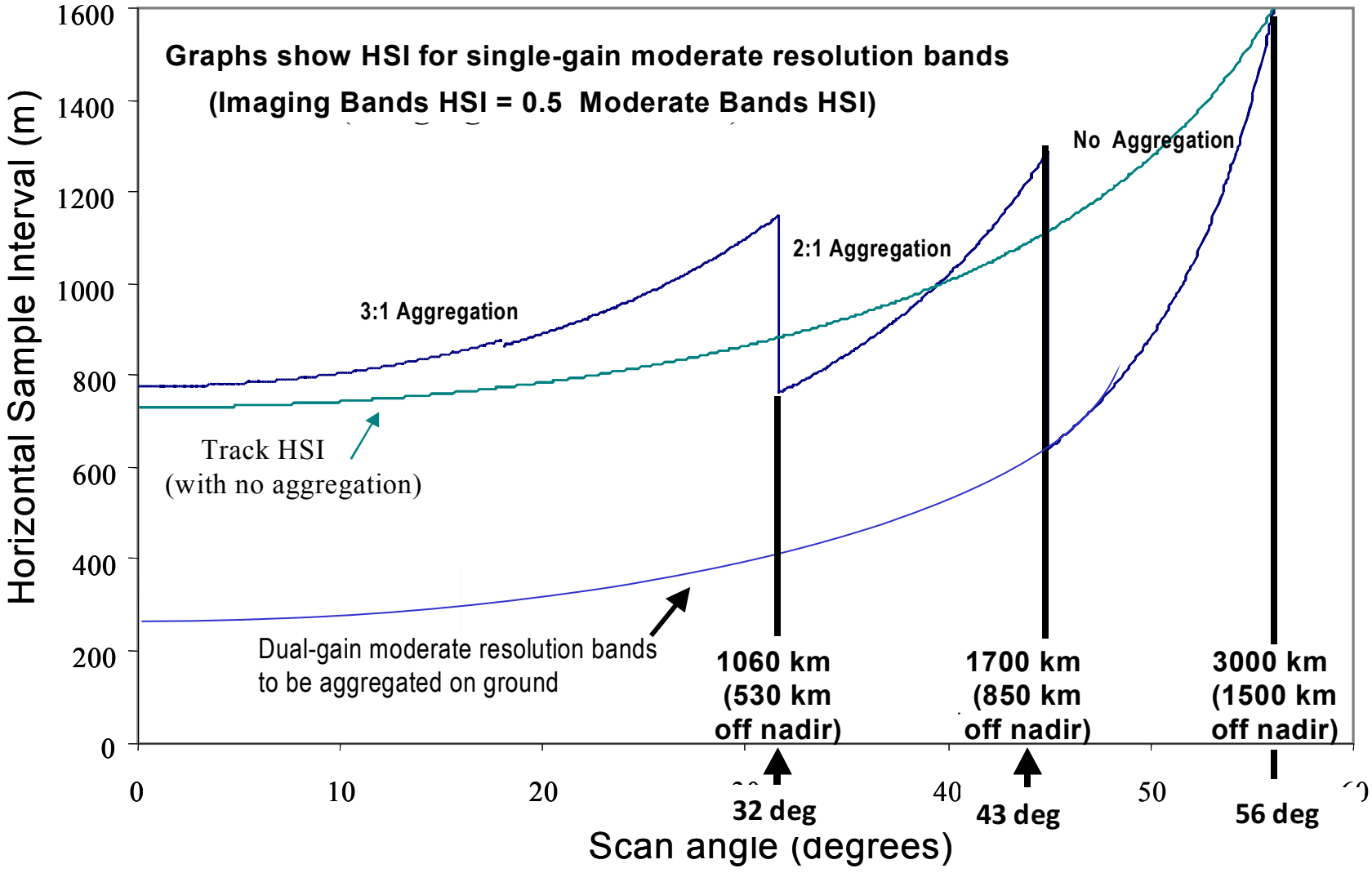
Dimensions are 3200x768 pixels
Note bowtie deletion zones
Fill value in these zones is 65533

Another example of bowtie deletion



McIDAS-X, served by VIIRS SDR ADDE

VIIRS aggregation zones (to maintain near constant FOV size)



VIIRS Calibration

- For thermal emissive (infrared) bands, a full aperture black body (BB) with accurately-known emissivity and temperature, and deep space, are viewed on every scan.
- For reflected solar (visible, near-infrared) bands, a full aperture solar diffuser (SD) providing precisely-attenuated sunlight in the visible region of the spectrum is viewed on every scan.
- Since the diffusing surface of the SD may degrade slightly over time on orbit, the sensor also includes a Solar Diffuser Stability Monitor (SDSM) to detect changes in the SD reflected radiance.
- SD and SDSM data are valid during a one minute window each orbit that occurs near the Earth's south pole when the sun illuminates the respective input ports.

Anatomy of a VIIRS File Name

GITCO_npp_d20120207_t0456502_e0458143_b01444_c20120207112240904333_noaa_ops.h5

GITCO	= product name (5 characters; GITCO = VIIRS I-band geolocation)
npp	= platform name (3 characters)
d20120207	= date of observation (yyyymmdd)
t0456502	= start time of granule (hhmmsss)
e0458143	= end time of granule (hhmmsss)
b01444	= orbit number
c20120207112240904333	= file creation date and time
noaa	= originator of the file (4 characters; noaa = NOAA/NESDIS/IDPS)
ops	= domain description (3 characters; ops = operational)

The file naming convention is described in detail in JPSS CDFCB External Volume 1: Overview, available at

http://npp.gsfc.nasa.gov/science/documents.html

VIIRS Detailed Information

For detailed information on VIIRS sensor data formats, scanning geometry, bowtie deletion, detector aggregation, etc., see

"NPOESS Common Data Format Control Book - External Volume VII – Part I – NPOESS Downlink Data Formats D34862-07-01 Rev C" from

http://npp.gsfc.nasa.gov/documents.html

VIIRS M-band SDR Contents

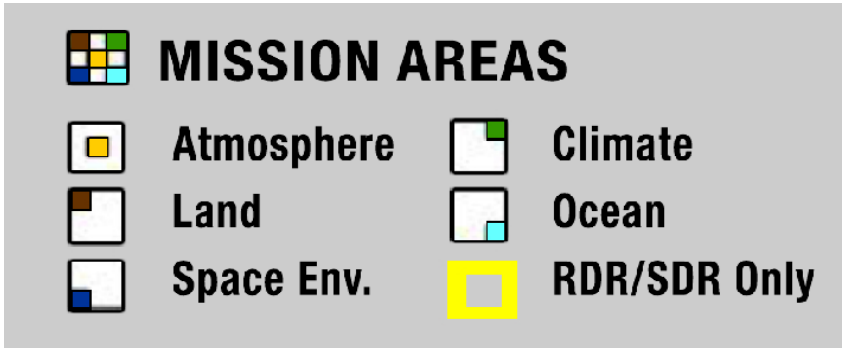
Name	Description	Data Type	Bands	Aggregate Dimensions (N = Number of Granules)	Granule Dimensions	Units
Radiance	Calibrated Top of Atmosphere (TOA) Radiance for each VIIRS pixel	32-bit floating point	M3-M5, M7, M13	[N*768, 3200]	[768,3200]	W/(m^2 sr μm)
		unsigned 16-bit integer	M1, M2, M6, M8-M12, M14-M16			
Reflectance	Calibrated TOA Reflectance for each VIIRS pixel	unsigned 16-bit integer	M1 – M11	[N*768, 3200]	[768,3200]	unitless
BrightnessTemperature	Calibrated TOA Brightness Temperature for each VIIRS pixel	32-bit floating point	M13	[N*768, 3200]	[768,3200]	kelvin
		unsigned 16-bit integer	M12, M14 – M16			

VIIRS M-band Geolocation Contents

Name	Description	Data Type	Aggregate Dimensions	Granule Dimensions	Units
StartTime	Starting Time of each scan in IET (1/1/1958)	64-bit integer	[N*48]	[48]	microsecond
MidTime	Mid-Time of each scan in IET (1/1/1958)	64-bit integer	[N*48]	[48]	microsecond
Latitude	Latitude of each pixel (positive North)	32-bit floating point	[N*768, 3200]	[768, 3200]	degree
Longitude	Longitude of each pixel (positive East)	32-bit floating point	[N*768, 3200]	[768, 3200]	degree
SolarZenithAngle	Zenith angle of sun at each pixel position	32-bit floating point	[N*768, 3200]	[768, 3200]	degree
SolarAzimuthAngle	Azimuth angle of sun (measured clockwise positive from North) at each pixel position	32-bit floating point	[N*768, 3200]	[768, 3200]	degree
SatelliteZenithAngle	Zenith angle to Satellite at each pixel position	32-bit floating point	[N*768, 3200]	[768, 3200]	degree
SatelliteAzimuthAngle	Azimuth angle (measured clockwise positive from North) to Satellite at each pixel position	32-bit floating point	[N*768, 3200]	[768, 3200]	degree

VIIRS Product Types

VIIRS Products



- Albedo (Surface)
- Cloud Base Height
- Cloud Cover/Layers
- Cloud Effective Part Size
- Cloud Optical Thickness
- Cloud Top Height
- Cloud Top Pressure
- Cloud Top Temperature
- Land Surface Temp 1
- Surface Type
- Ocean Color/Chlorophyll 2
- Suspended Matter
- Vegetation Index
- Aerosol Optical Thickness
- Aerosol Particle Size
- Ice Surface Temperature 3
- Imagery 3
- Sea Ice Characterization 3
- Snow Cover/Depth 3
- Sea Surface Temperature 3

VIIRS Product Types

Raw Data Record (RDR) = MODIS Level 0

Sensor Data Record (SDR) = MODIS Level 1B

Intermediate Product (IP) = MODIS Level 2

Environmental Data Record (EDR) = MODIS Level 2

Climate Data Record (CDR) = MODIS Level 3

Product format is ***HDF5***; described in CDFCB volumes available at

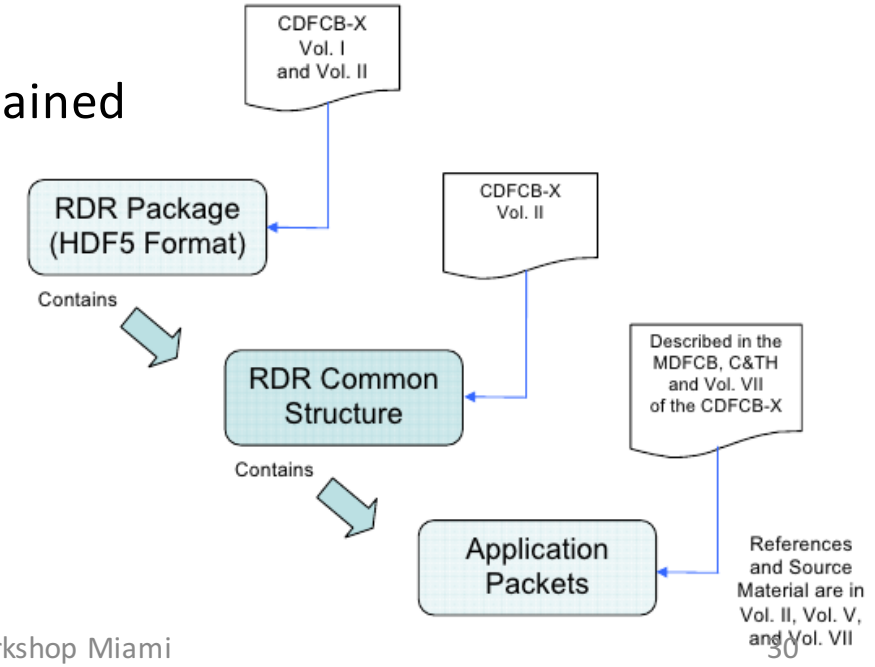
http://npp.gsfc.nasa.gov/science/documents.html

How many VIIRS SDR files per day?

- 16 M-bands, 5 I-bands, and 1 day/night band (16+5+1 = 22)
- Geoid and terrain corrected geolocation for M, I, and DNB (2x3 = 6)
- 85.7 sec per granule
- (86400 sec/day) / (85.7 sec/granule) = 1008 granules per day
- VIIRS SDR: (1008 granules/day) x (28 files/granule) = **28224 files/day**
- MODIS L1B: 288 granules/day x 4 files/granule = **1152 files/day**

Raw Data Record (RDR)

- The RDR is an accumulation of binary data generated by sensors on board the NPP spacecraft and assembled into groups called application packets (APs).
- The ground software collects one or more groups of related APs together into granules which are then assembled into common RDR structures and combined with metadata to create the delivered HDF5 file.
- Similar to MODIS Level 0
- CDFCB-X documents at right can be obtained from...



Sensor Data Record (SDR)

- The SDR is an accumulation of binary data generated by sensors on board the NPP spacecraft and assembled into groups called application packets (APs).

- Processing an RDR into an SDR involves unpacking and decommutating the Application Packet (AP) data, as necessary, applying calibration (radiometric, geometric, engineering), and finally geo-locating, as needed, using ephemeris and attitude information and earth model information.

- An SDR contains the following:
  - Calibrated sensor data
  - Geolocation data (where applicable)
  - Quality flags
  - Metadata at the granule and aggregation level

- Product names GMODO, GMTCO, GIMGO, GITCO, SVM[01-16], SVI[01-05]

Intermediate Product (IP)

- IPs are defined as a data subset or retrieval by-product that is required within another primary data product's generation sequence or is used as an input to secondary processing or analysis.
- Generally are pixel-level products like the SDRs (750m resolution).
- Certain IPs (Cloud Mask, Quarterly Surface Type) are packaged and delivered to the end-user, and are used to create further IPs (Cloud Optical Properties, Cloud Top Parameters, Aerosol etc...).
- Other IPs (Quarterly Surface Type/Land Water Mask [QSTLWM IP] are generated during the creation of IPs and EDRs but are not delivered.
- Atmosphere Product Names:
  - IICMO (Cloud Mask)
  - IVAOT (Aerosol Optical Thickness)
  - IVCOP (Cloud Optical Properties [COT, EPS])
  - IVCTP (Cloud Top Parameters [CTP, CTT, CTH])

Environmental Data Records (EDR)

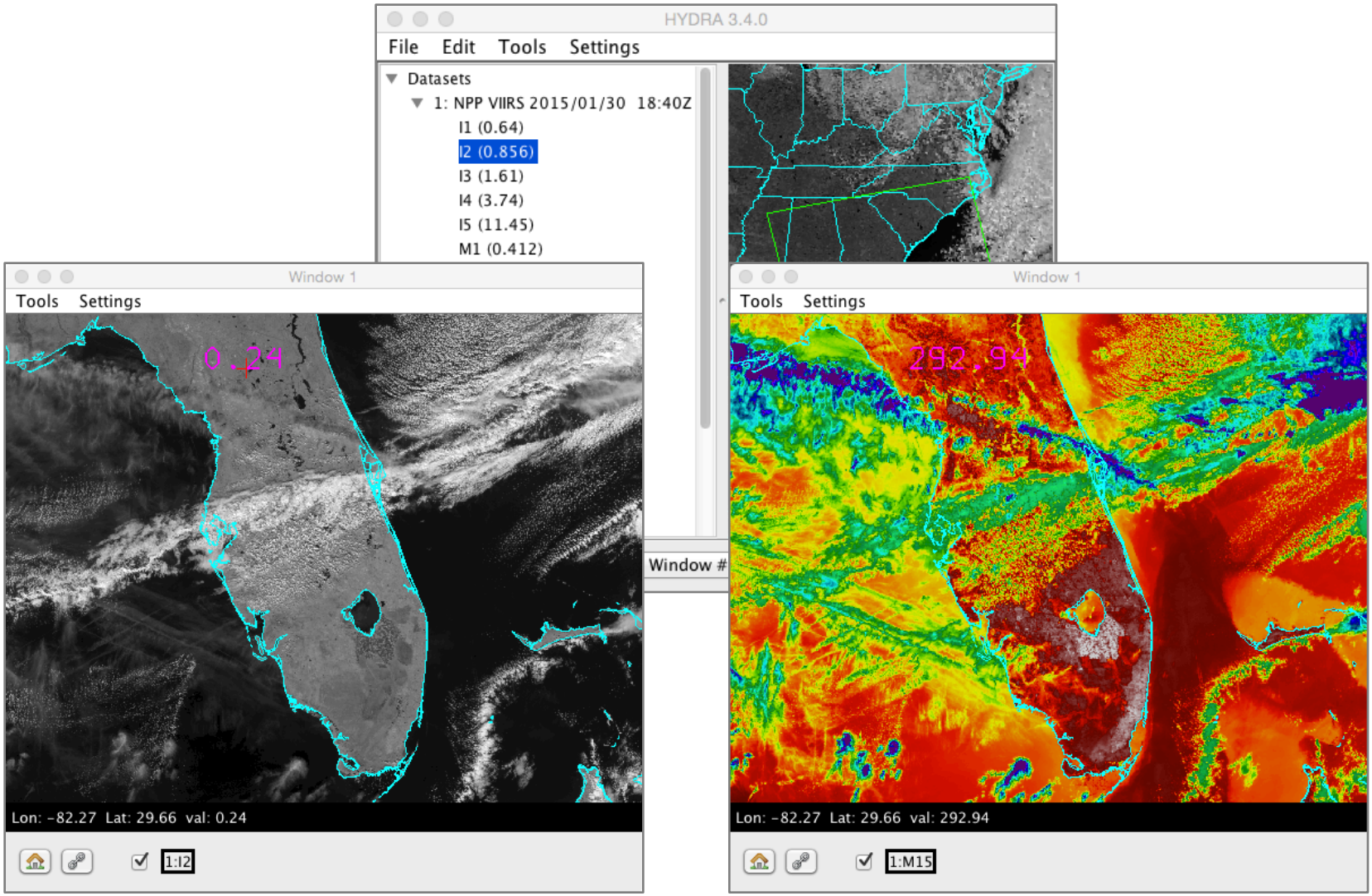
- Environmental Data Records (EDRs) are data records containing environmental parameters or imagery generated by the IDPS system as products deliverable to the user.
- An EDR contains the following:
  - EDR specific data
  - Appropriate geolocation values
  - Quality Flags
  - Metadata represented as Attributes in the HDF5 file that are provided at the granule and aggregation level
- Atmosphere Product names VAOOO (AOT), VCEPO (EPS), VCOTO (COT), VCTPO (CTP), VCTTO(CTT), VCTHO (CTH)...

Software to Read VIIRS Data

Hydra2

- Hydra2 is an interactive application for viewing and interrogating imager and sounder data.
- Supported satellites include Suomi NPP, Terra, Aqua, NOAA, Metop, FY-3.
- Supported sensors include:
  - Imagers VIIRS, MODIS, AVHRR, MERSI
  - IR Sounders CrIS, IASI, AIRS
  - MW Sounders ATMS, AMSU
- Software is free; runs on PC/Mac/Linux

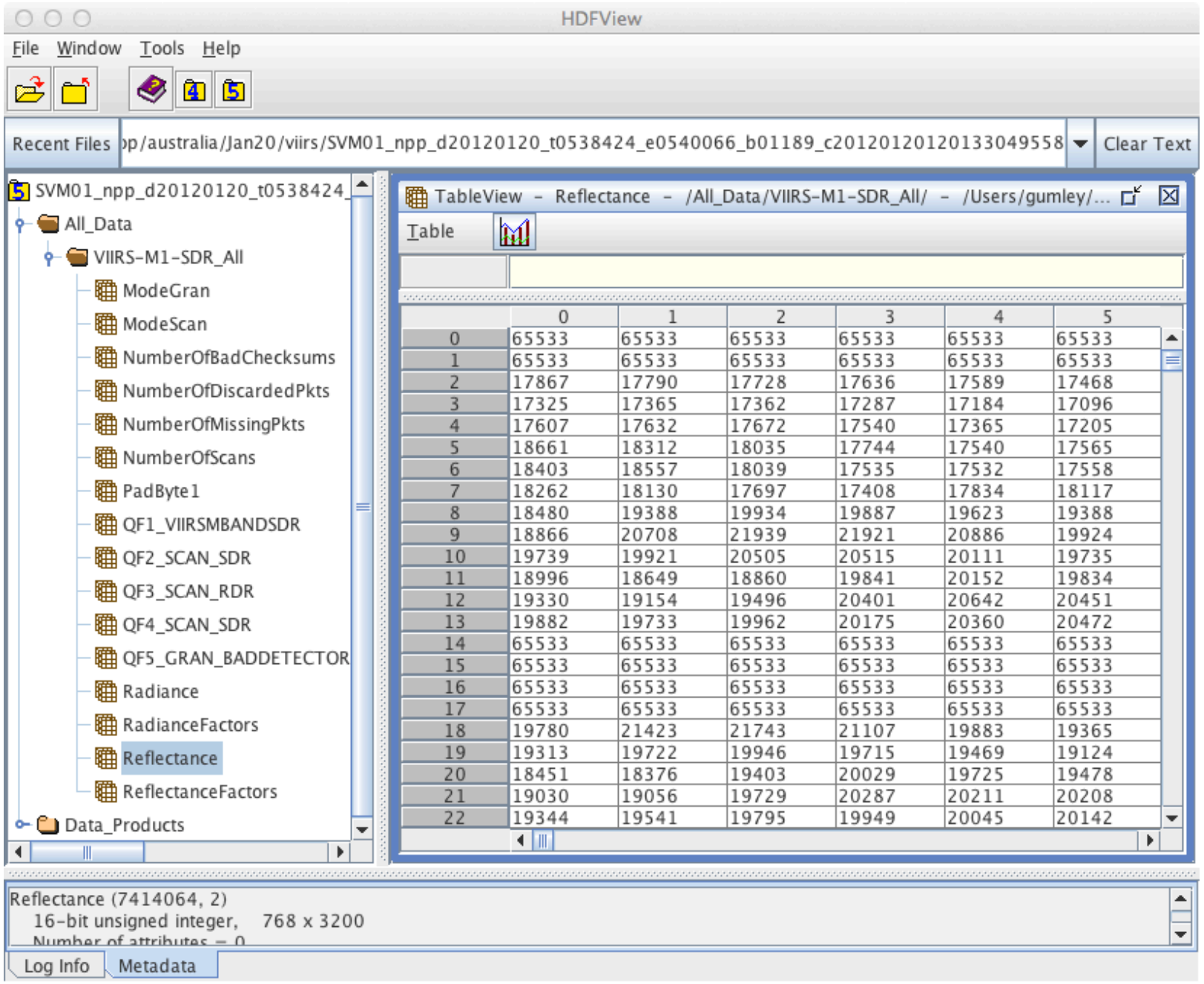
Hydra2


HYDRA 3.4.0
File Edit Tools Settings
Datasets
1: NPP VIIRS 2015/01/30 18:40Z
I1 (0.64)
I2 (0.856)
I3 (1.61)
I4 (3.74)
I5 (11.45)
M1 (0.412)
Window 1
Tools Settings
0.24
Lon: -82.27 Lat: 29.66 val: 0.24
1:I2
Window #
Window 1
Tools Settings
292.94
Lon: -82.27 Lat: 29.66 val: 292.94
1:M15

HDF5 Software

- http://www.hdfgroup.org/HDF5/
- Software library (API) for C, Fortran, Java
- Command line utilities (e.g., h5dump) for Windows, Mac, Linux
- HDFView interactive viewer

- IDL, Matlab, and Python all have well developed HDF5 APIs
- ENVI and other commercial software does not support VIIRS (yet)



	0	1	2	3	4	5
0	65533	65533	65533	65533	65533	65533
1	65533	65533	65533	65533	65533	65533
2	17867	17790	17728	17636	17589	17468
3	17325	17365	17362	17287	17184	17096
4	17607	17632	17672	17540	17365	17205
5	18661	18312	18035	17744	17540	17565
6	18403	18557	18039	17535	17532	17558
7	18262	18130	17697	17408	17834	18117
8	18480	19388	19934	19887	19623	19388
9	18866	20708	21939	21921	20886	19924
10	19739	19921	20505	20515	20111	19735
11	18996	18649	18860	19841	20152	19834
12	19330	19154	19496	20401	20642	20451
13	19882	19733	19962	20175	20360	20472
14	65533	65533	65533	65533	65533	65533
15	65533	65533	65533	65533	65533	65533
16	65533	65533	65533	65533	65533	65533
17	65533	65533	65533	65533	65533	65533
18	19780	21423	21743	21107	19883	19365
19	19313	19722	19946	19715	19469	19124
20	18451	18376	19403	20029	19725	19478
21	19030	19056	19729	20287	20211	20208
22	19344	19541	19795	19949	20045	20142

Interrogation of VIIRS files using h5dump

- VIIIRS RDR, SDR, EDR, CDR and IP files are in HDF5 format
- HDF5 format is hierarchical in nature, and HDF5 data structure shares a similarity with a UNIX file system. We can dump the basic file structure using "h5dump -n "...

```
h5dump -n SVM16_npp_d20120120_t0534262_e0535504_b01189_c20120120120117709679_noaa_ops.h5

HDF5 "SVM16_npp_d20120120_t0534262_e0535504_b01189_c20120120120117709679_noaa_ops.h5" {
FILE_CONTENTS {
 group      /
 group      /All_Data
 group      /All_Data/VIIRS-M16-SDR_All
 dataset    /All_Data/VIIRS-M16-SDR_All/BrightnessTemperature
 dataset    /All_Data/VIIRS-M16-SDR_All/BrightnessTemperatureFactors
 dataset    /All_Data/VIIRS-M16-SDR_All/ModeGran
 dataset    /All_Data/VIIRS-M16-SDR_All/ModeScan
 dataset    /All_Data/VIIRS-M16-SDR_All/NumberOfBadChecksums
 dataset    /All_Data/VIIRS-M16-SDR_All/NumberOfDiscardedPkts
 dataset    /All_Data/VIIRS-M16-SDR_All/NumberOfMissingPkts
 dataset    /All_Data/VIIRS-M16-SDR_All/NumberOfScans
 dataset    /All_Data/VIIRS-M16-SDR_All/PadByte1
 dataset    /All_Data/VIIRS-M16-SDR_All/QF1_VIIRSMBANDSDR
 dataset    /All_Data/VIIRS-M16-SDR_All/QF2_SCAN_SDR
 dataset    /All_Data/VIIRS-M16-SDR_All/QF3_SCAN_RDR
 dataset    /All_Data/VIIRS-M16-SDR_All/QF4_SCAN_SDR
 dataset    /All_Data/VIIRS-M16-SDR_All/QF5_GRAN_BADDETECTOR
 dataset    /All_Data/VIIRS-M16-SDR_All/Radiance
 dataset    /All_Data/VIIRS-M16-SDR_All/RadianceFactors
 group      /Data_Products
 group      /Data_Products/VIIRS-M16-SDR
 dataset    /Data_Products/VIIRS-M16-SDR/VIIRS-M16-SDR_Aggr
 dataset    /Data_Products/VIIRS-M16-SDR/VIIRS-M16-SDR_Gran_0
 }
}
```

Interrogation of VIIRS SDR files using h5dump

To examine the details about a particular dataset, say the M16 radiance…

```
h5dump -H -d  /All_Data/VIIRS-M16-SDR_All/Radiance
        SVM16_npp_d20120120_t0534262_e0535504_b01189_c20120120120117709679_noaa_ops.h5

HDF5 "SVM16_npp_d20120120_t0534262_e0535504_b01189_c20120120120117709679_noaa_ops.h5"  {
DATASET "/All_Data/VIIRS-M16-SDR_All/Radiance" {
DATATYPE  H5T_STD_U16BE
DATASPACE  SIMPLE { ( 768, 3200 ) / ( 768, 3200 ) }
}
}
```

Examining the data values in the radiance dataset…

```
h5dump -d  /All_Data/VIIRS-M16-SDR_All/Radiance
        SVM16_npp_d20120120_t0534262_e0535504_b01189_c20120120120117709679_noaa_ops.h5

HDF5 "SVM16_npp_d20120120_t0534262_e0535504_b01189_c20120120120117709679_noaa_ops.h5"  {
DATASET "/All_Data/VIIRS-M16-SDR_All/Radiance" {
DATATYPE  H5T_STD_U16BE
DATASPACE  SIMPLE { ( 768, 3200 ) / ( 768, 3200 ) }
DATA {
(0,0): 65533, 65533, 65533, 65533, 65533, 65533, 65533, 65533, 65533,
(0,9): 65533, 65533, 65533, 65533, 65533, 65533, 65533, 65533, 65533,
(0,18): 65533, 65533, 65533, 65533, 65533, 65533, 65533, 65533, 65533,
(0,27): 65533, 65533, 65533, 65533, 65533, 65533, 65533, 65533, 65533,
(0,36): 65533, 65533, 65533, 65533, 65533, 65533, 65533, 65533, 65533
...
...
```

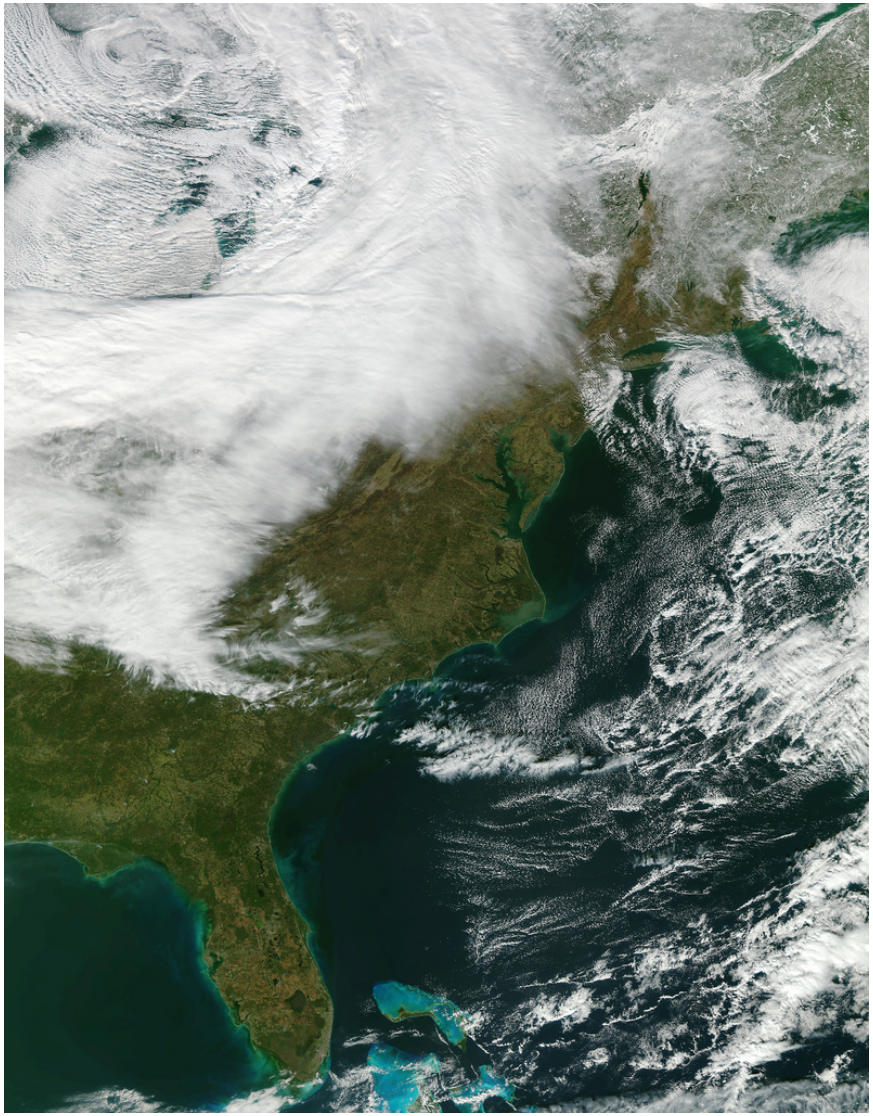
IDL code to read VIIRS SDR M15

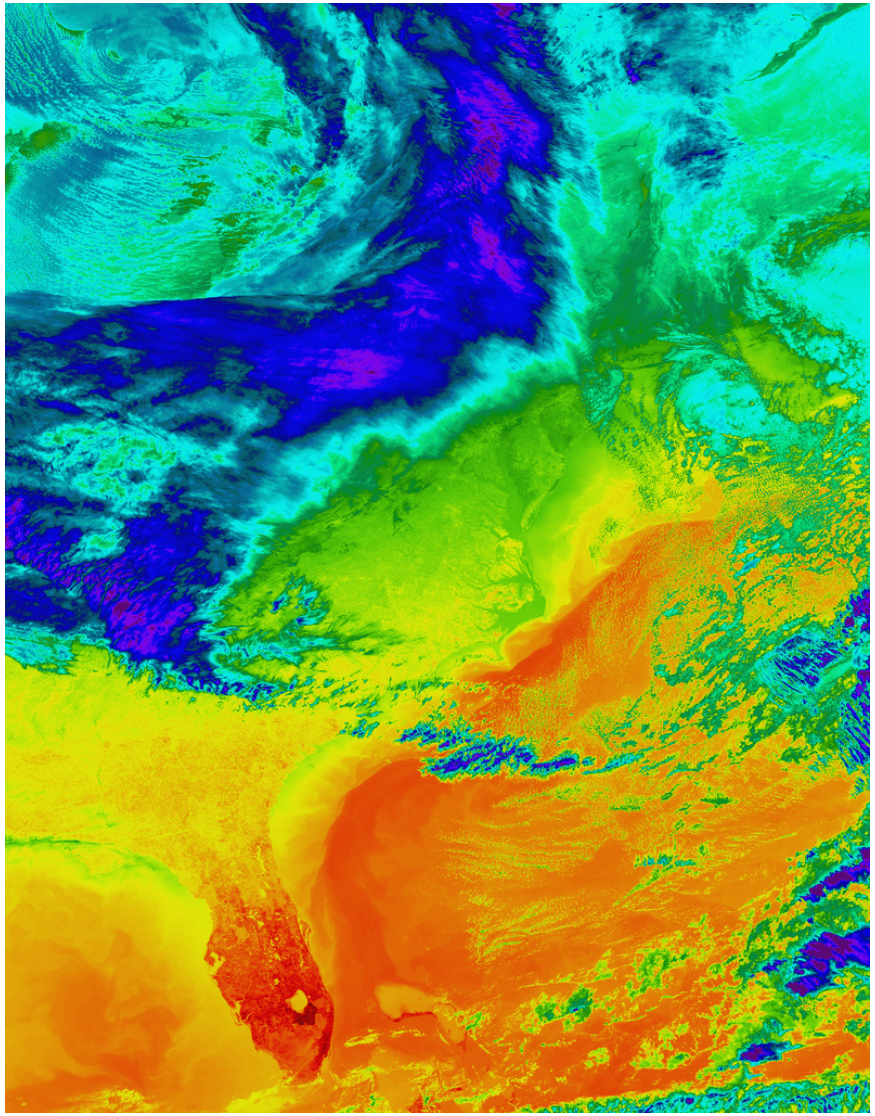
```
;- Open the file
file = 'SVM15_npp_d20120120_t0528446_e0530088_b01189_c20120120115158805940_noaa_ops.h5'
file_id = h5f_open(file)

;- Read the data array
data_id = h5d_open(file_id, '/All_Data/VIIRS-M15-SDR_All/BrightnessTemperature')
data = h5d_read(data_id)
h5d_close, data_id

;- Read the scale factors
data_id = h5d_open(file_id, '/All_Data/VIIRS-M15-SDR_All/BrightnessTemperatureFactors')
factors = h5d_read(data_id)
h5d_close, data_id

;- Apply the scale factors
data = data * factors[0] + factors[1]

;- Close the file
h5f_close, file_id
```

Software supporting HDF5

- IDL
- Matlab
- Python
- C/Fortran APIs
- Java
- ENVI (see VIIRS Conversion Toolkit)

VIIRS Projected Image Examples





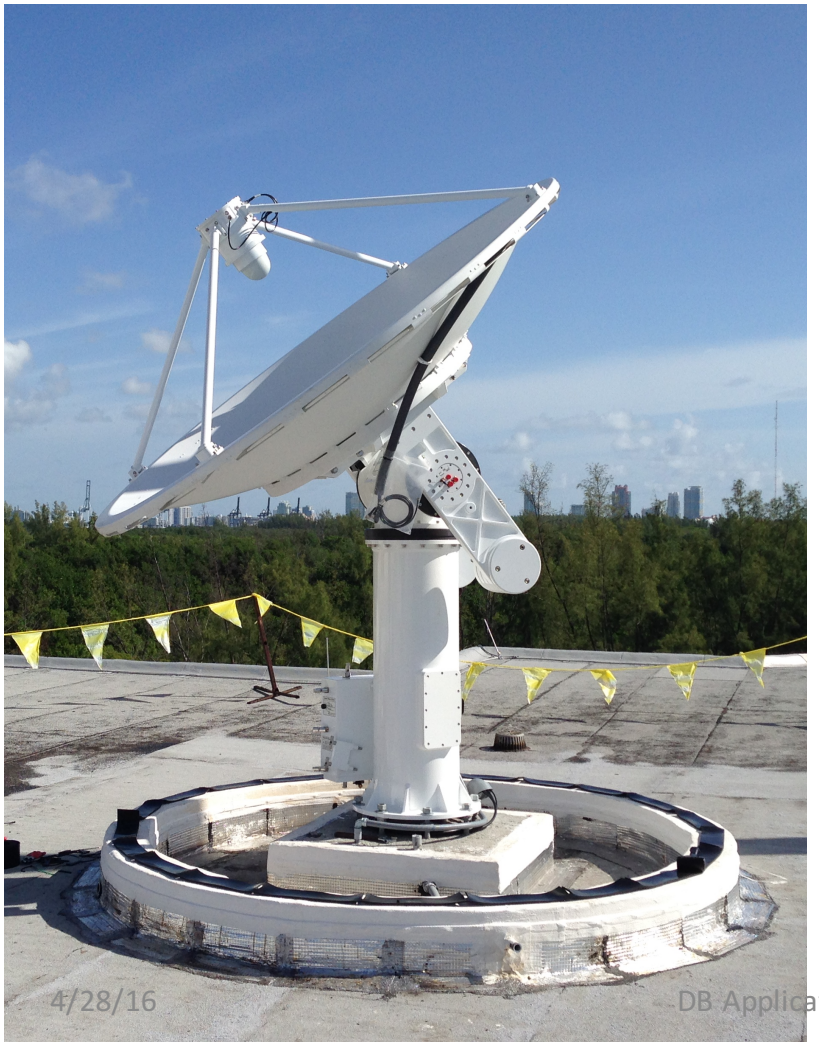
Suomi NPP Direct Broadcast and the Community Satellite Processing Package (CSPP)

Suomi NPP Direct Broadcast

- SNPP transmits VIIRS, CrIS, and ATMS data real-time via X-band direct broadcast.
- 7812 MHz, 13 Mbps.
- No encryption, licenses, or fees.
- Downlink format is described in CDFCB External Volume VII at

  http://npp.gsfc.nasa.gov/documents.html
- Software for real-time processing of SNPP DB data is available from SSEC and NASA.

Orbital Systems 2.4-meter X/L-band Antenna Installation at AOML Sep 2014



Suomi NPP Sensor Suite

Primary sensors on HRD direct broadcast

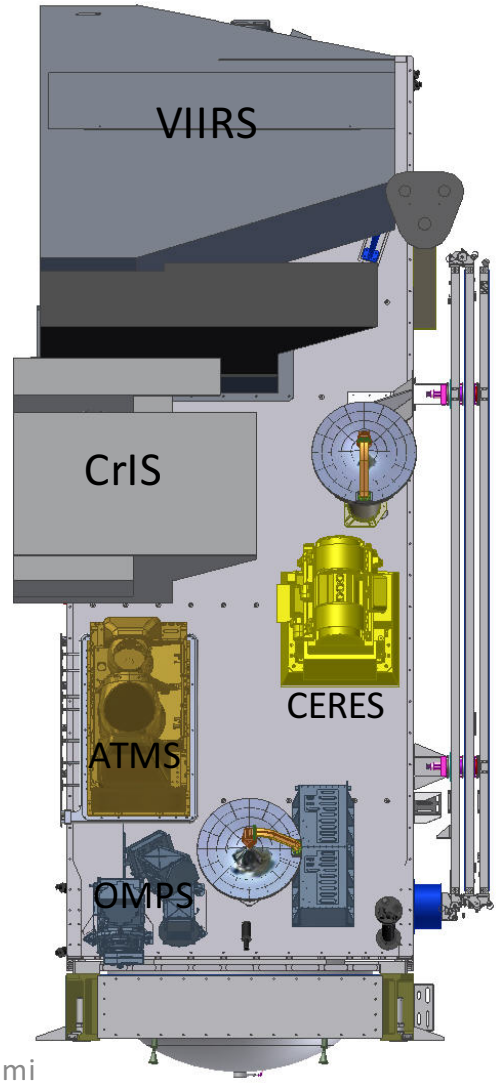
VIIRS – Medium Resolution Visible & Infra-red Imager

CrIS – Fourier Transform Spectrometer for IR Temperature and Moisture sounding

ATMS – Microwave sounding radiometer

OMPS – Total Ozone Mapping and Ozone Profile measurements

CERES - Earth Radiation Budget



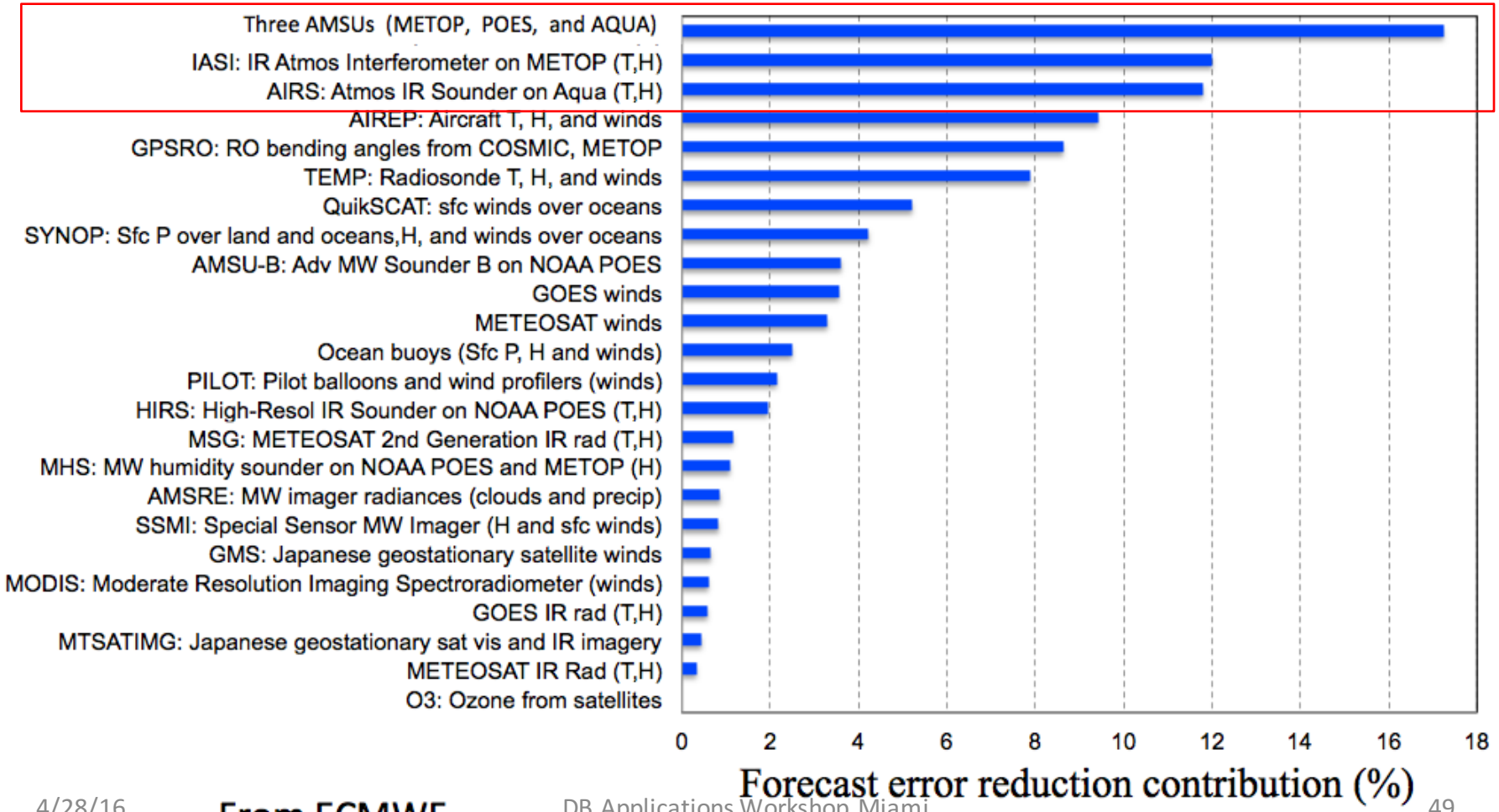
Real-Time Applications

- Numerical Weather Prediction: Infrared and Microwave Sounder Data
- Wildfire Detection for Disaster Management: Thermal Infrared Imager Data (e.g, GA Sentinel)
- Sea Ice Detection for Ship Navigation: Day/Night Band Imager Data
- Volcanic Ash Detection: Thermal Infrared Imager

Timeliness of the Data is Key

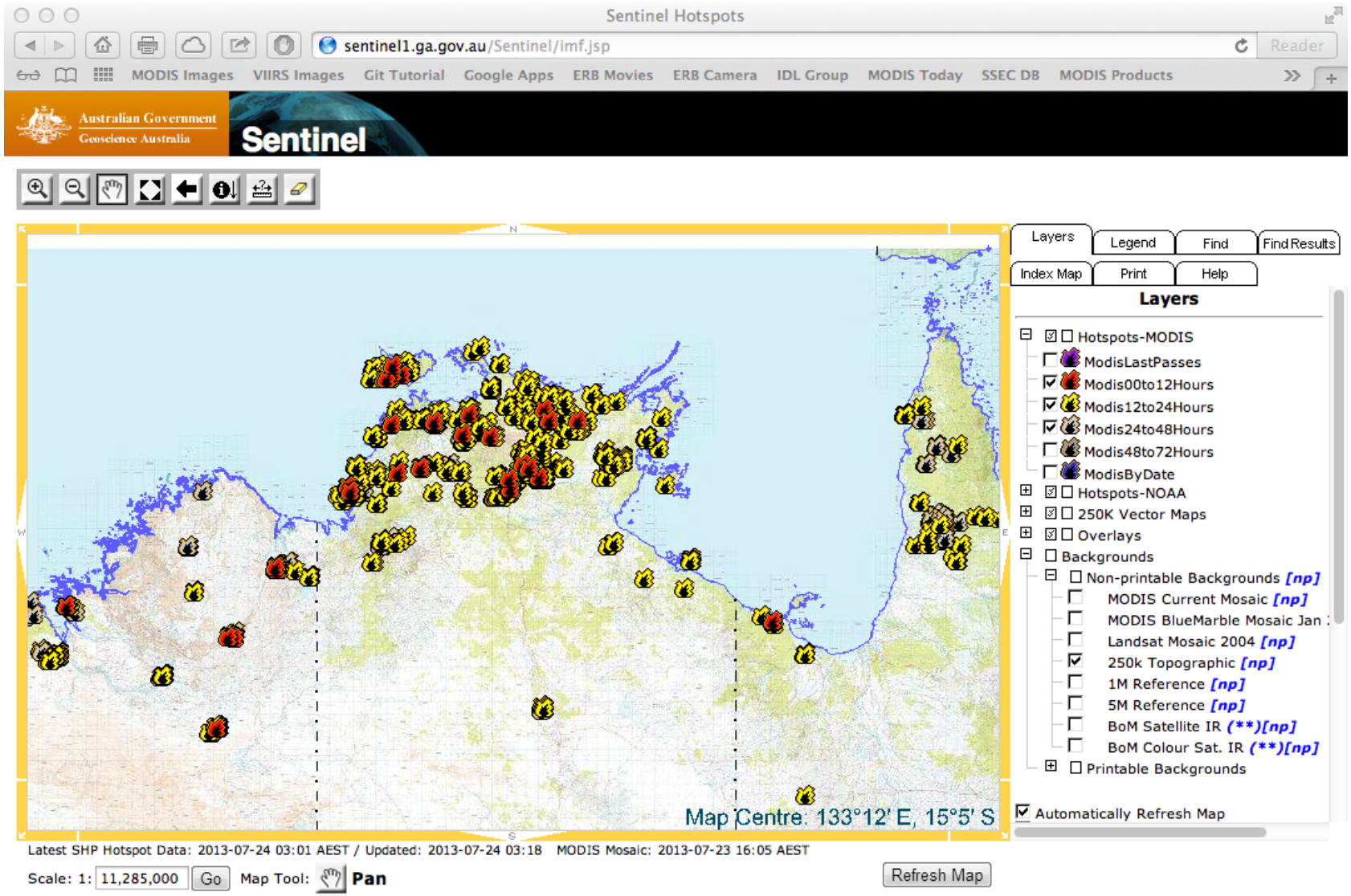
NWP Forecast Error Reduction

Infrared and Microwave Sounder data from polar orbiting satellites have the largest impact on improving NWP forecast skill



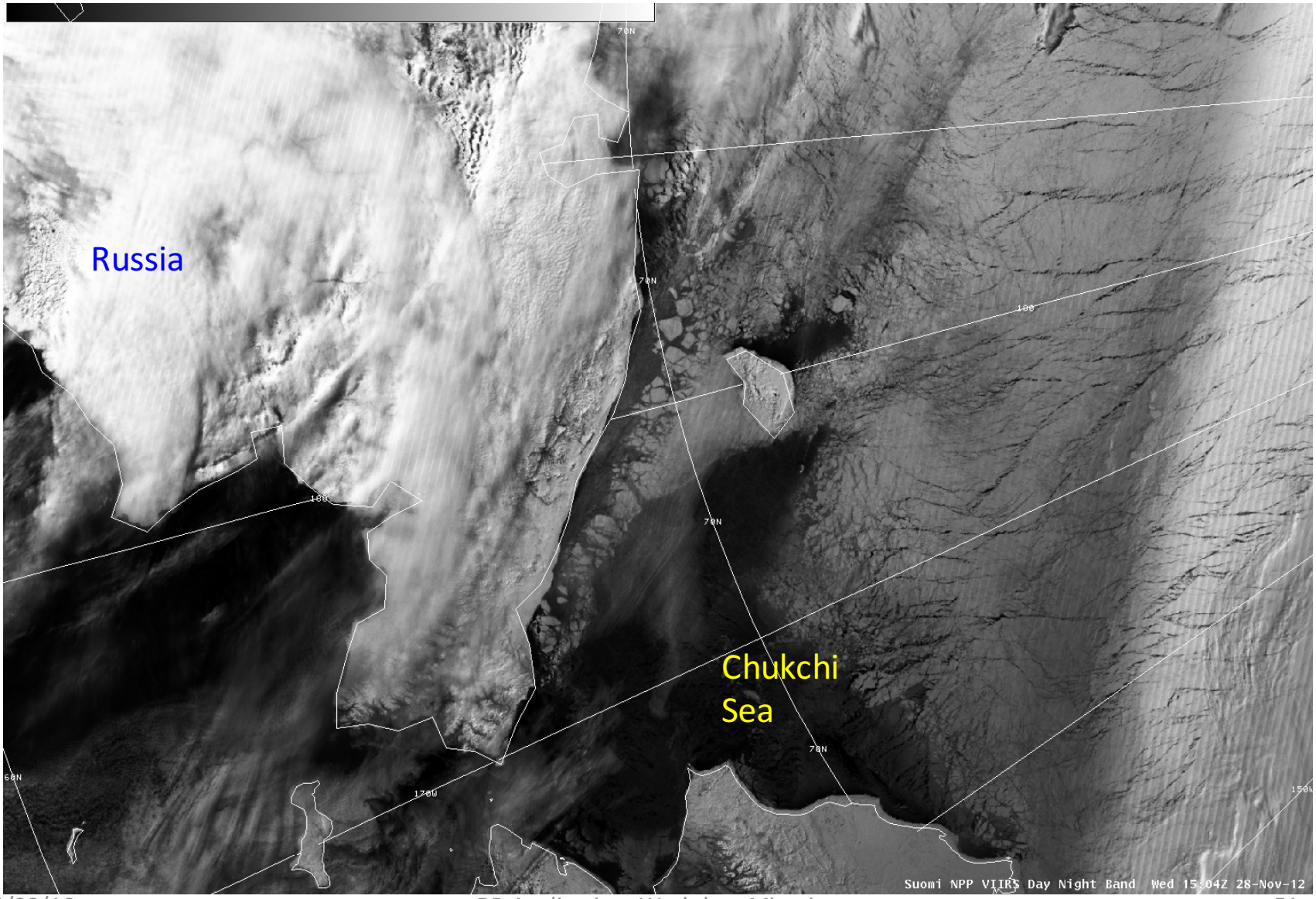
From ECMWF

Wildfire Detection



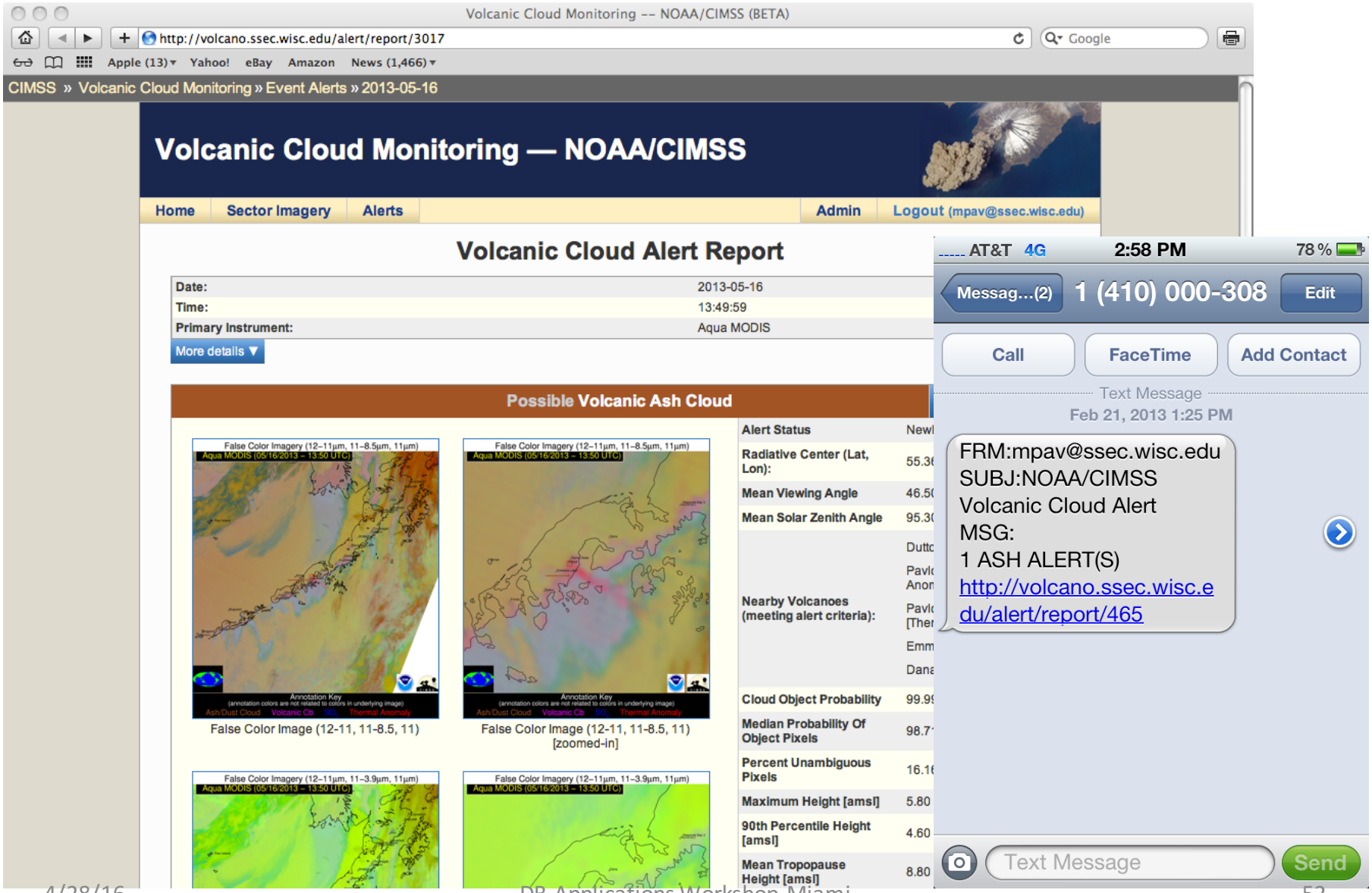
Sentinel Hotspot Detections Derived from MODIS Infrared Imagery

Sea Ice Mapping for Navigation



VIIRS Day/Night Band as seen by NWS Anchorage Ice Desk

Volcanic Ash Alert System



MODIS and VIIRS Infrared Imagery are used to Detect Volcanic Ash

Receiving Real-Time Data

Hardware Required:

- Tracking antenna with 2.4-3.0 meter reflector
- LNA, Downconverter, Demodulator

X-band: *Terra, Aqua, SNPP, FY-3*

L-band: *POES, Metop, FY-3*

Raw bitstream is captured from demodulator and framed to Level 0.

2.4-m X/L-band Antenna
NWS Honolulu

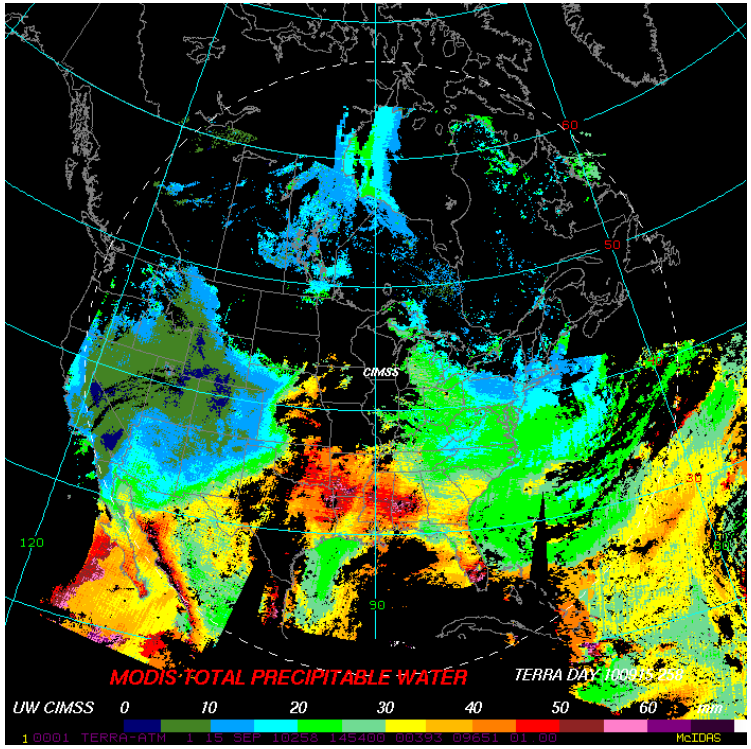
Worldwide X-band Sites

Direct Broadcast Software from SSEC

International ATOVS Processing Package (IAPP) heritage goes back to 1985. IAPP supports NOAA 15-19.

International MODIS/AIRS Processing Package (IMAPP) has been available since 2000 (funded by NASA). IMAPP supports Terra and Aqua.

Community Satellite Processing Package (CSPP) first released in 2012 (funded by JPSS).



IMAPP MODIS TPW

What is CSPP?

CSPP (Community Satellite Processing Package) is a collection of software systems for processing data from meteorological satellites.

The primary goal of CSPP is to support users who

- Receive satellite data via direct broadcast;
- Process it independently;
- Create higher level products and images in real time.

Funding is supplied by JPSS and NOAA.

CSPP Software Philosophy

CSPP software must:

- Create useful products for the DB community,
- Include up-to-date algorithms,
- Be pre-compiled for 64-bit Linux,
- Be easy to install and operate,
- Include test data for verification,
- Have prompt user support,
- Run efficiently on modest hardware.

CSPP LEO Satellites and Sensors

CSPP LEO includes support for Suomi NPP and JPSS, POES, Metop, Terra, and Aqua.

- For Suomi NPP, supported sensors include ***VIIRS, CrIS, ATMS***.
- For POES and Metop, supported sensors include ***AVHRR, IASI, AMSU-A/B, MHS*** (Level 2 products only; Level 1 processing provided by AAPP).
- For Aqua and Terra, supported sensors include ***MODIS, AIRS, and AMSU***.

CSPP Satellite/Sensor/Product Matrix

	Imager	Infrared Sounder	Microwave Sounder
SNPP	**VIIRS** *Level 1B, Images, Visualization, Atmosphere, Land, Ocean*	**CrIS** *Atmospheric Profiles, Clouds, Visualization*	**ATMS** *Atmospheric Profiles, Precipitation, Visualization*
Terra	**MODIS** *Images, Visualization*	**N/A**	**N/A**
Aqua	**MODIS** *Images, Visualization*	**AIRS** *Atmospheric Profiles, Clouds, Visualization*	**AMSU** *Atmospheric Profiles, Precipitation, Visualization*
Metop-A/B	**AVHRR** *Atmosphere, Cloud, Land, Visualization*	**IASI, HIRS** *Atmospheric Profiles, Clouds, Visualization*	**AMSU, MHS** *Atmospheric Profiles, Precipitation*
NOAA-18/19	**AVHRR** *Atmosphere, Cloud, Land, Visualization*	**HIRS** *Atmospheric Profiles*	**AMSU, MHS** *Atmospheric Profiles, Precipitation*

Other DB Software Packages

Software	Products	Developer
International MODIS/AIRS Processing Package (IMAPP)	MODIS Atmosphere and Cloud Products; Virtual Appliance; Google Earth Imagery; Forecast Model; Air Quality Model; Imagery	UW/SSEC and MODIS Science Team
Advanced ATOVS Processing Package (AAPP)	POES and Metop Level 1B, BUFR, and HDF5	UK Met Office, Meteo France
SeaDAS	MODIS, VIIRS, CZCZ Ocean Color and Sea Surface Temperature	NASA Ocean Biology Processing Group
Direct Readout Land Applications	MODIS and VIIRS Wild Fires and Vegetation Indices	NASA Direct Readout Laboratory

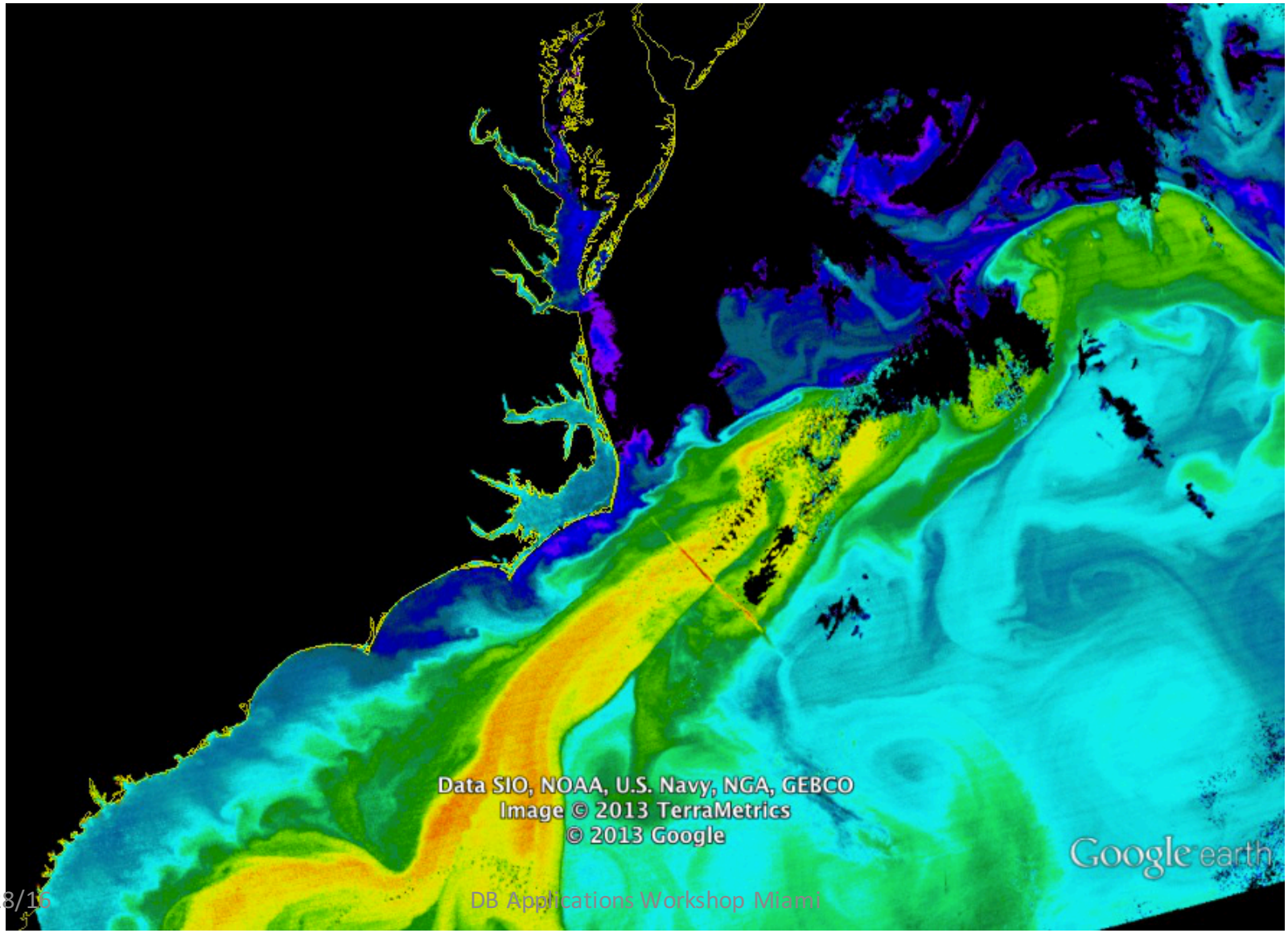
CSPP Users

- **EUMETSAT for EARS-NPP EUMETCast distribution**
- **UK Met Office**
- **Météo-France**
- **CSIR South Africa**
- **Swedish Met Service**
- **DWD – German Met Service**
- **Australia Bureau of Meteorology**
- **Taiwan Central Weather Bureau**
- **Belarus National Academy of Science**
- **Indonesia Government Space Agency (LAPAN)**
- **German Aerospace Center**
- **CONABIO Mexico**
- **EURAC Remote Sensing Institute Italy**
- **China National Satellite Meteorological Center**
- **Brazil INPE**
- **Danish Meteorological Institute**
- **Japanese Meteorological Agency**
- **Norwegian Meteorological Institute**
- **Swedish Met Institute**
- **Kazakhstan Space Investigation Institute**
- **UK Plymouth Marine Lab**
- **Naval Research Lab**
- **Vendors SeaSpace, ScanEx, SpaceTec and others.**
- **In addition, CSPP DB products are being used in the US NWS in HI, Alaska and CONUS**

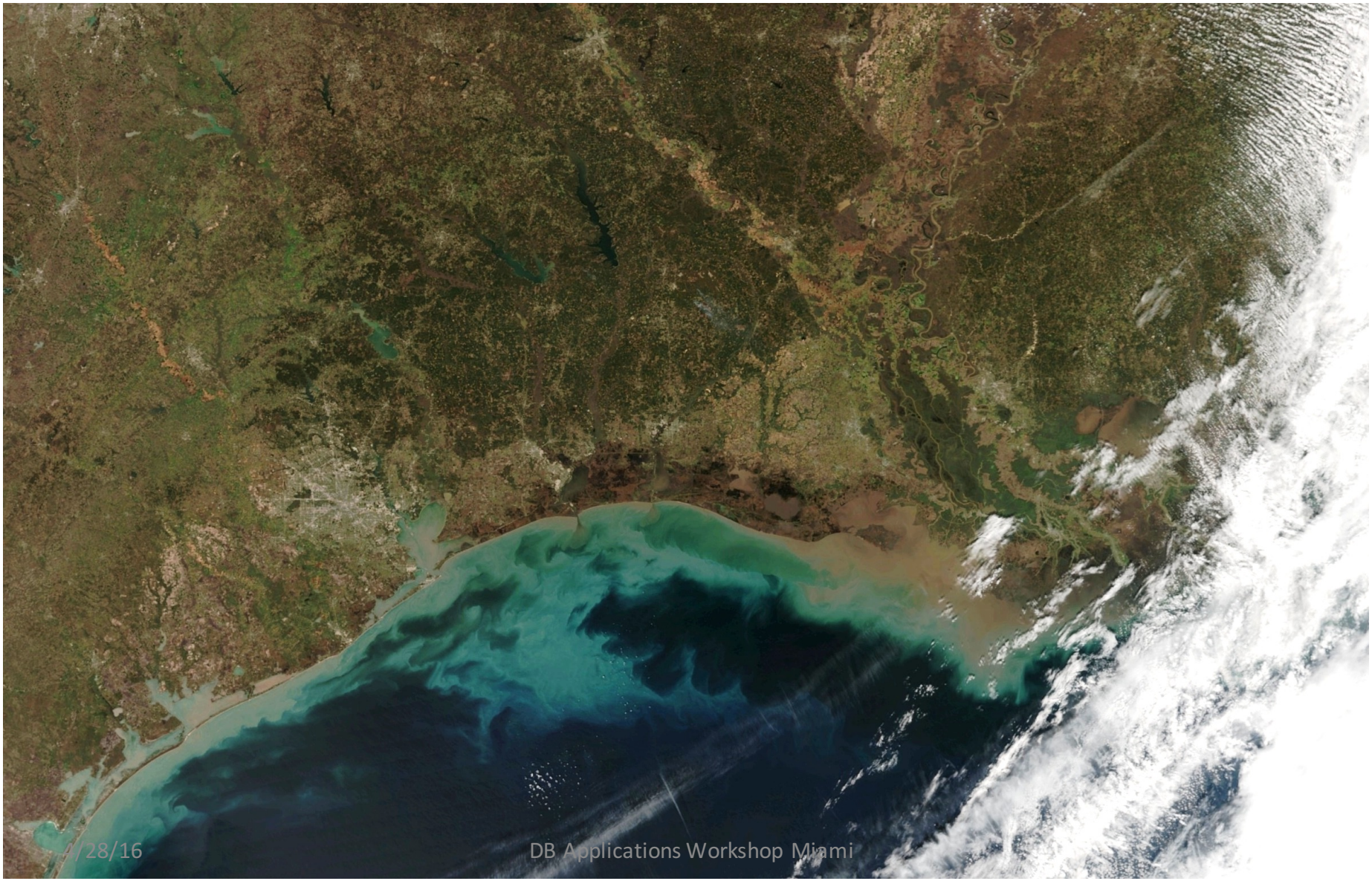
CSPP LEO Software (Jan 2015)

1. VIIRS, CrIS, and ATMS Level 1B / SDRs geolocation and calibration (***CSPP SDR***)
2. VIIRS Level 2 / EDRs cloud mask, active fires, surface reflectance, NDVI, EVI, SST, LST, AOT (***CSPP EDR***)
3. CrIS, IASI, and AIRS Temperature/Moisture Profiles (***HSRTV***)
4. VIIRS and MODIS Reprojected Imagery (***POLAR2GRID***)
5. ATMS, AMSU, and MHS Profile and Surface Retrievals (***MIRS***)
6. VIIRS, MODIS, and AVHRR Cloud Products (***CLAVR-x***)
7. VIIRS, MODIS, and MERSI Interactive Data Analysis (***HYDRA2***)

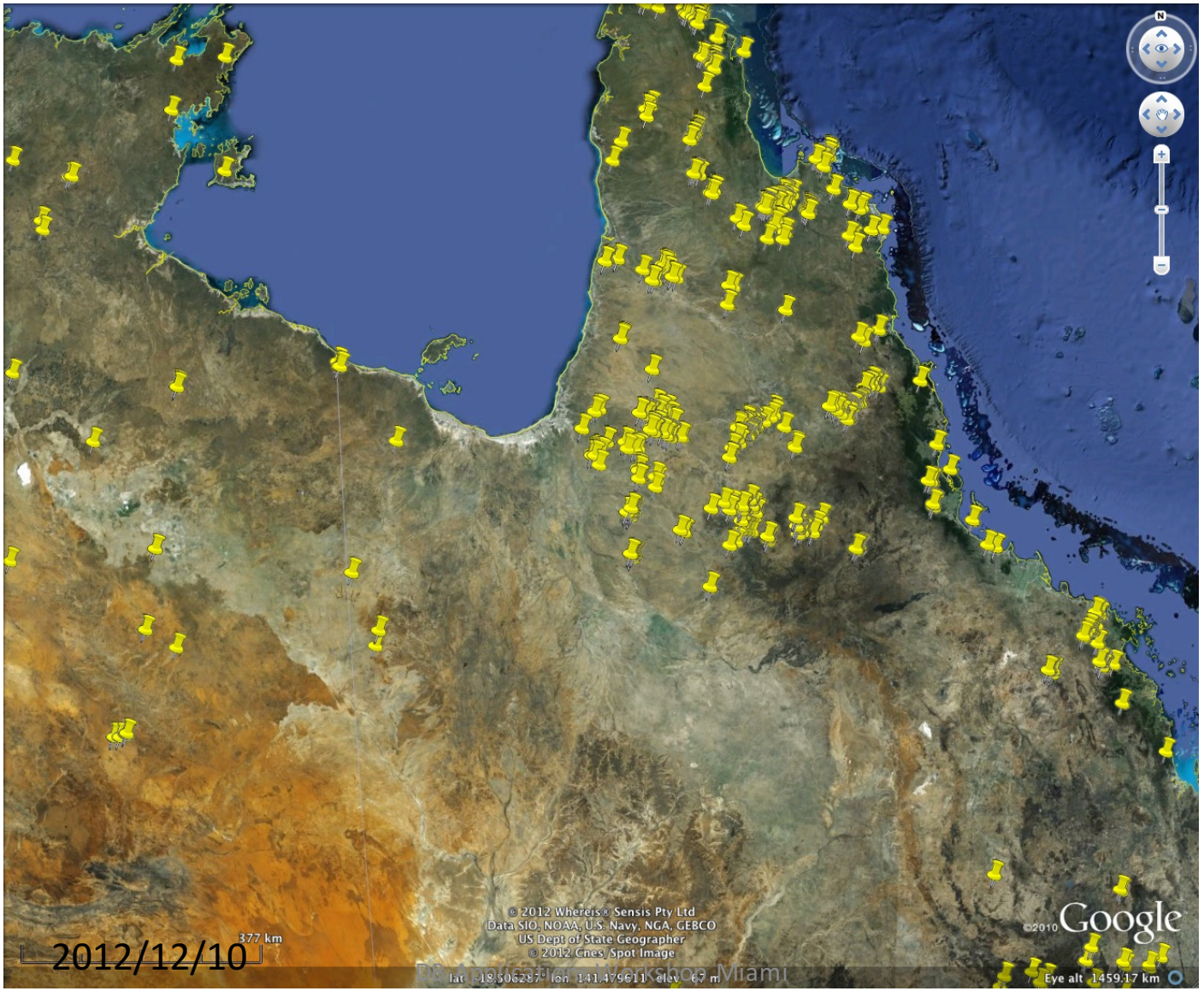
CSPP Product: VIIRS SST



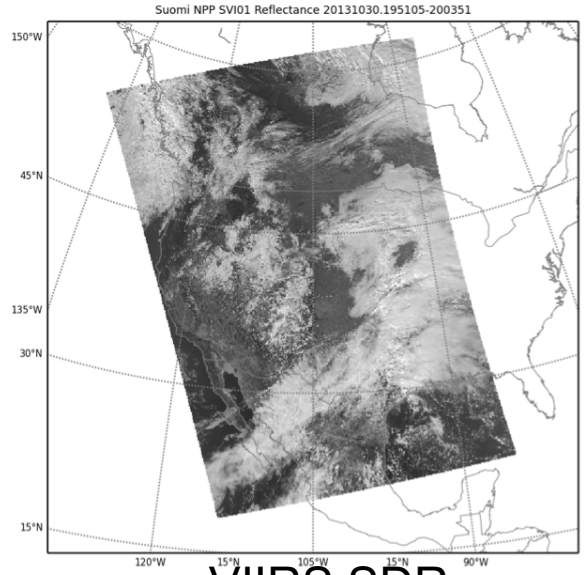
CSPP Product: VIIRS True Color



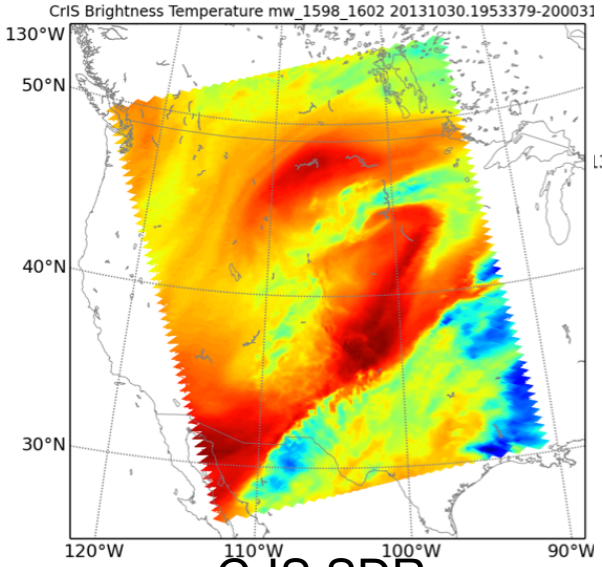
CSPP Product: VIIRS Active Fires



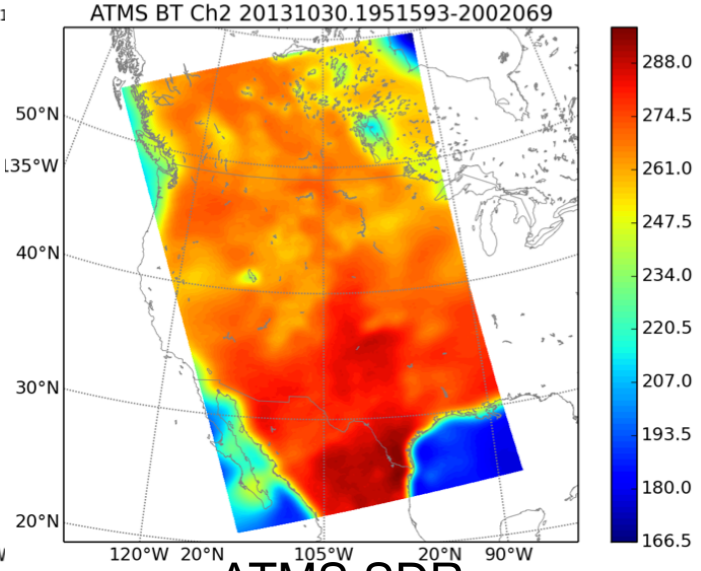
CSPP VIIRS SDR and EDRs



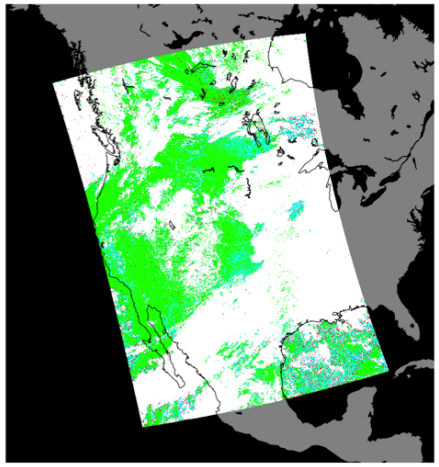
VIIRS SDR

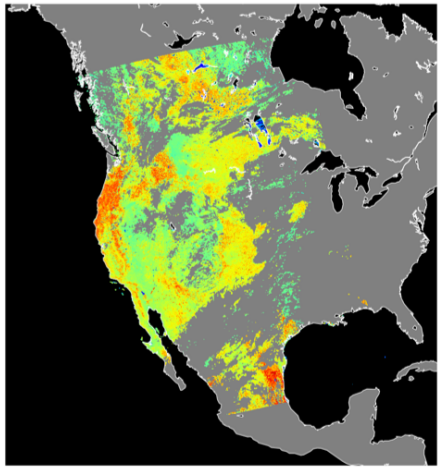


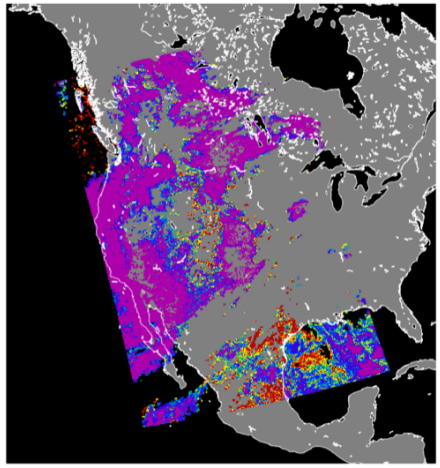
CrIS SDR



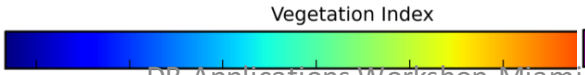
ATMS SDR



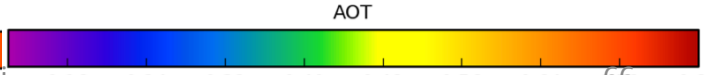




VIIRS Cloud Mask

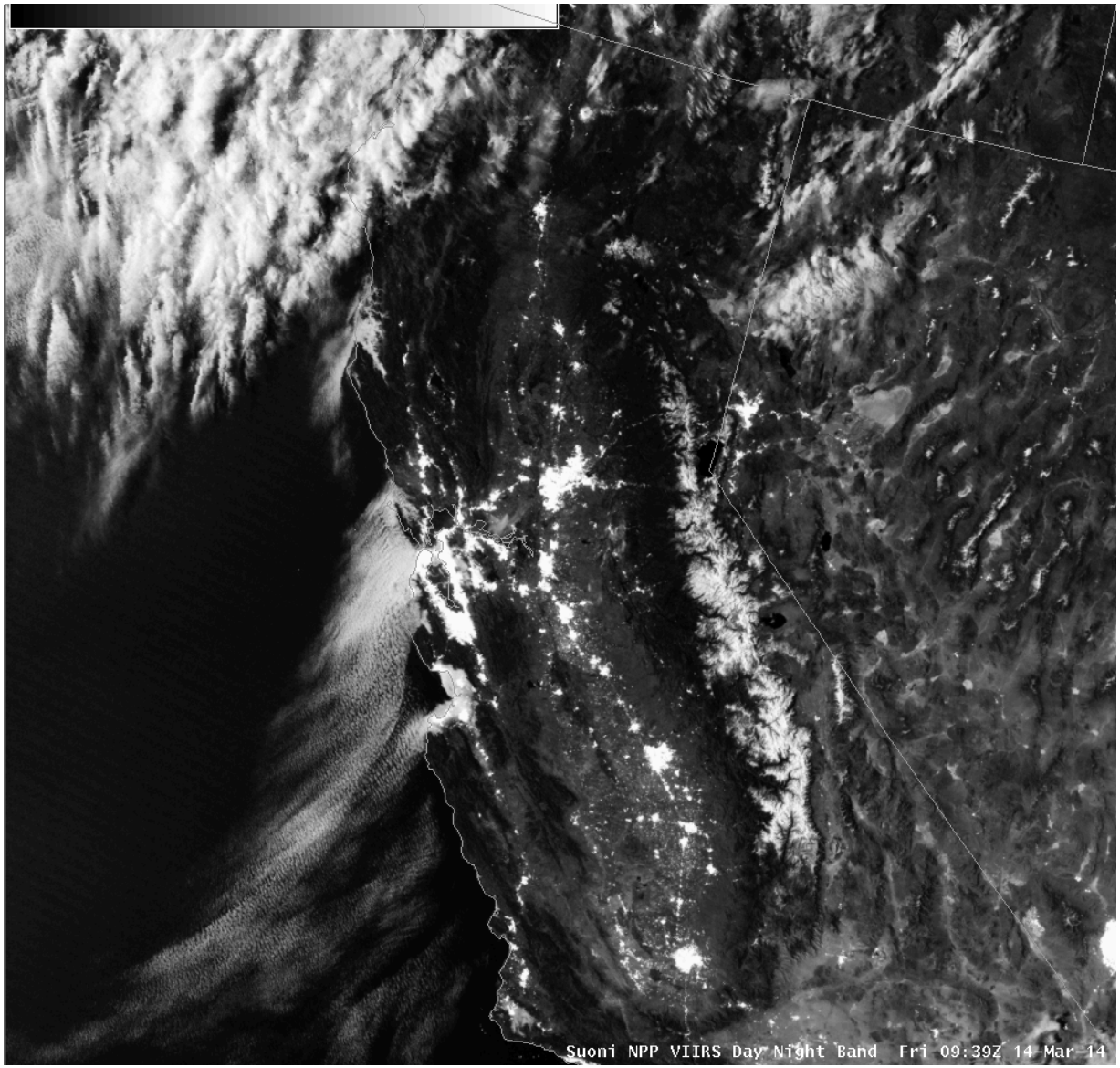


VIIRS NDVI



VIIRS AOT

CSPP VIIRS Projected Imagery (DNB)

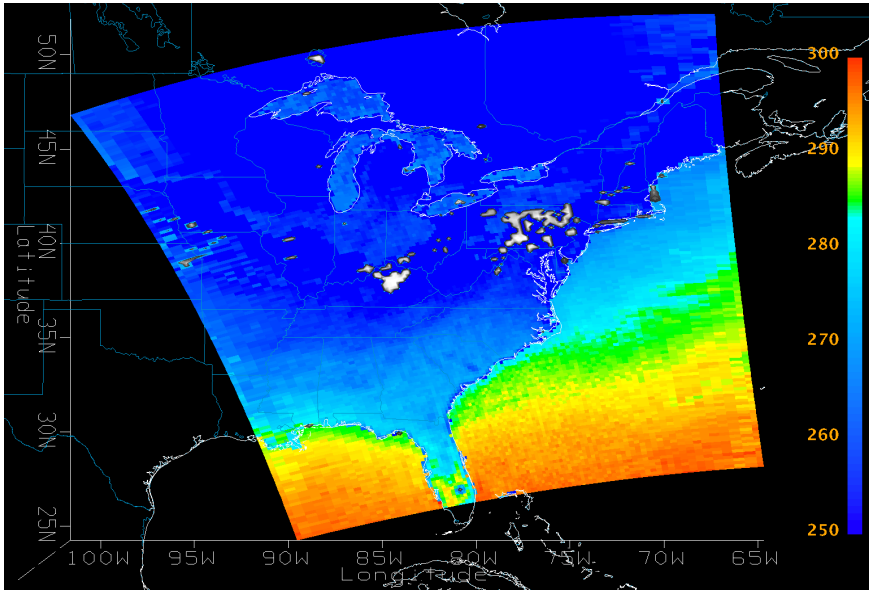


AREA FORECAST DISCUSSION
NATIONAL WEATHER SERVICE SAN FRANCISCO BAY AREA
443 AM PDT FRI MAR 14 2014

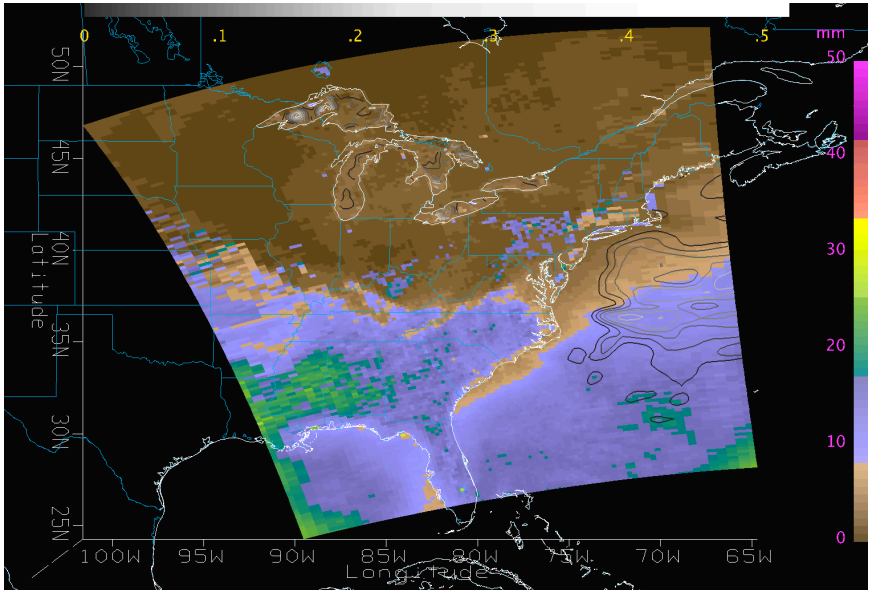
.DISCUSSION...AS OF 4:10 AM PDT FRIDAY...THE DRY TAIL END OF A WEATHER SYSTEM MOVING IN TO THE PACIFIC NORTHWEST IS APPROACHING OUR DISTRICT...AND RESULTING IN ENHANCEMENT OF THE MARINE LAYER AND ***A RETURN OF THE MARINE STRATUS. LATEST GOES FOG PRODUCT IMAGERY...AND IN RATHER SPECTACULAR DETAIL JUST REC'D SUOMI VIIRS NIGHTTIME HIGH RES VISUAL IMAGE...SHOW COVERAGE ALONG MUCH OF THE COAST FROM PT REYES SOUTH TO THE VICINITY OF THE MONTEREY PENINSULA...AND A BROAD SWATH EXTENDING INLAND ACROSS SAN FRANCISCO AND THROUGH THE GOLDEN GATE TO THE EAST BAY.*** LATEST BODEGA BAY AND FT ORD PROFILER DATA INDICATE A MARINE LAYER DEPTH OF ABOUT 1300 FT. SOME THIN HIGH CLOUDS ARE ALSO PASSING THROUGH ABOVE.

MIRS Products

Surface Temperature
with Rain Mass Profile

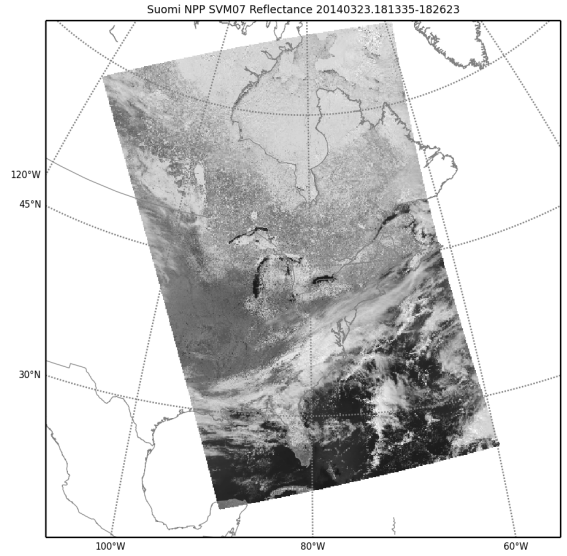


Total Precipitable Water
with contours of Cloud Liquid Water



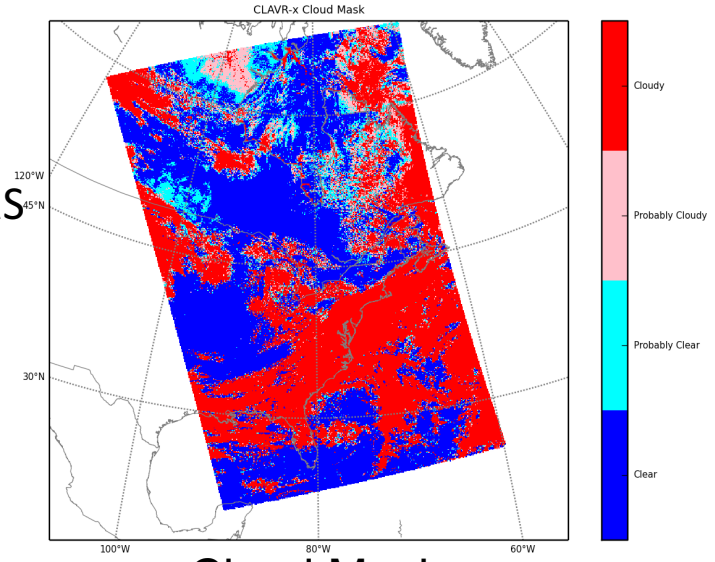
Suomi NPP ATMS
2014-01-23 18:19Z

CLAVR-X Products

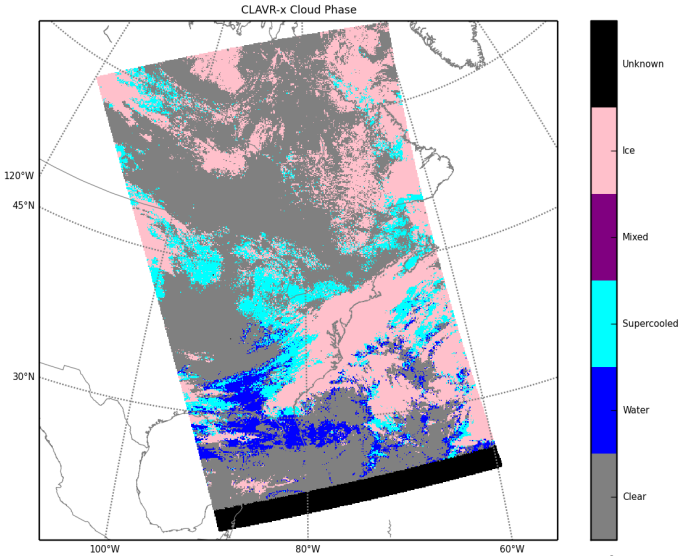


VIIRS SVM07

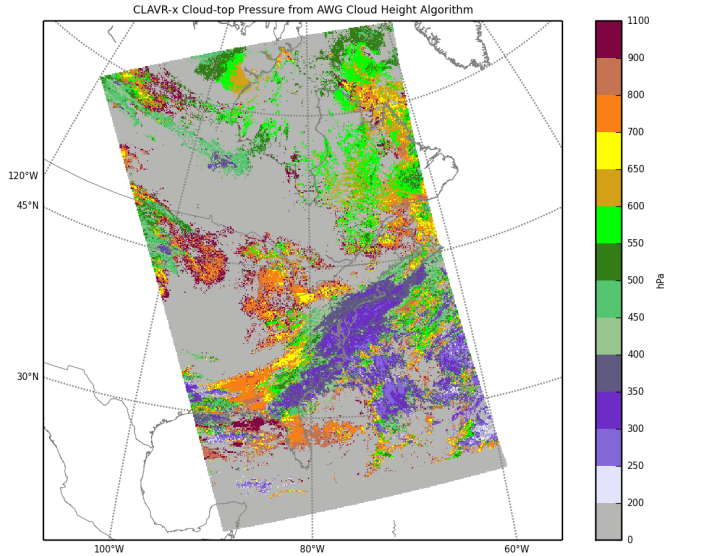
Suomi NPP VIIRS
2014/03/23
18:13 UTC



Cloud Mask



Cloud Phase



Cloud Top Pressure

CSPP LEO Upcoming Releases

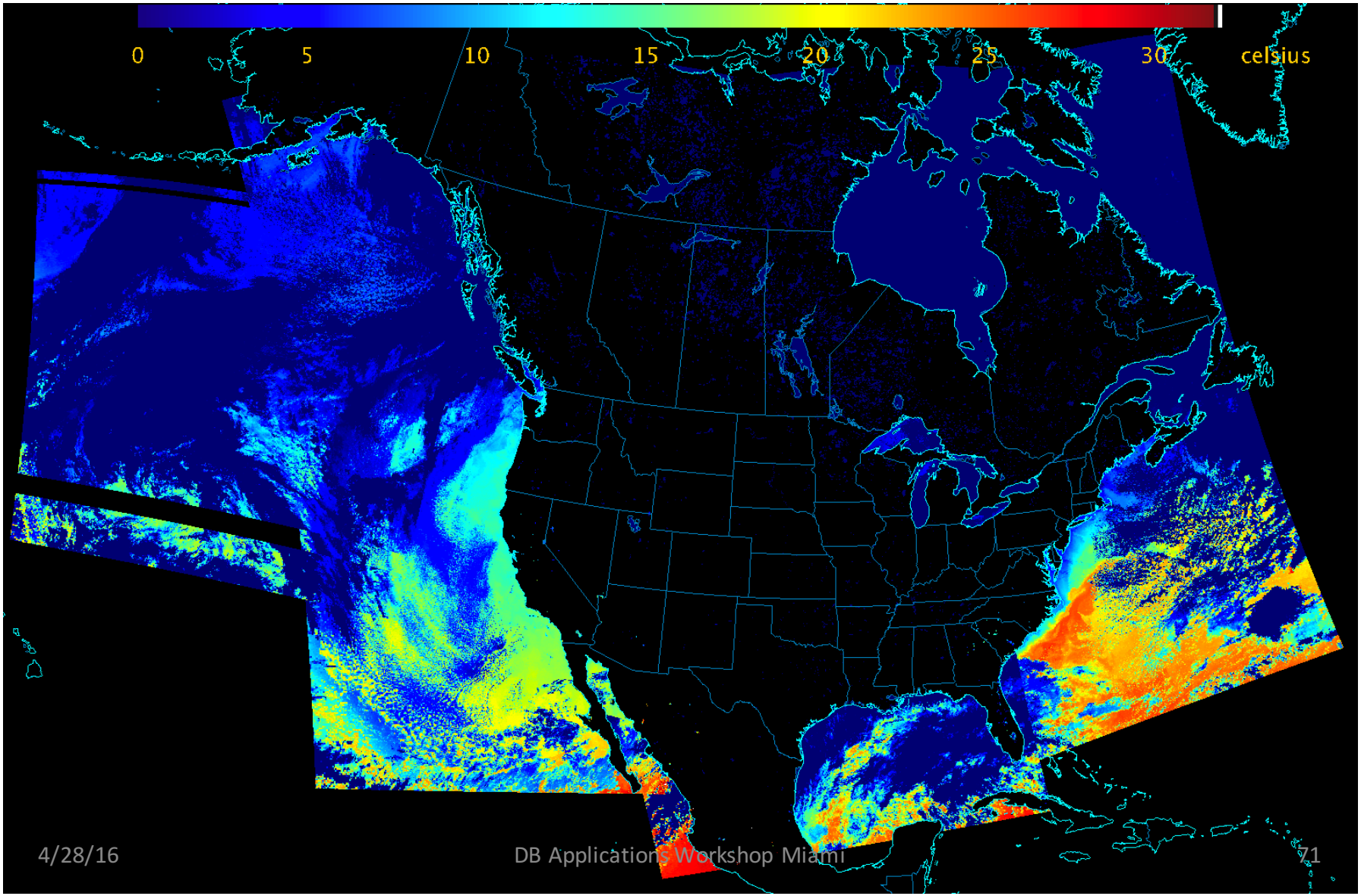
1. CrIS and ATMS Temperature and Moisture Profile Physical Retrieval (***NUCAPS*** *by C. Barnet et al.*). Future release will support IASI/AMSU and AIRS/AMSU.

2. VIIRS Sea Surface Temperature (***ACSPO*** *by A. Ignatov et al.*). Future release will support MODIS and AVHRR.

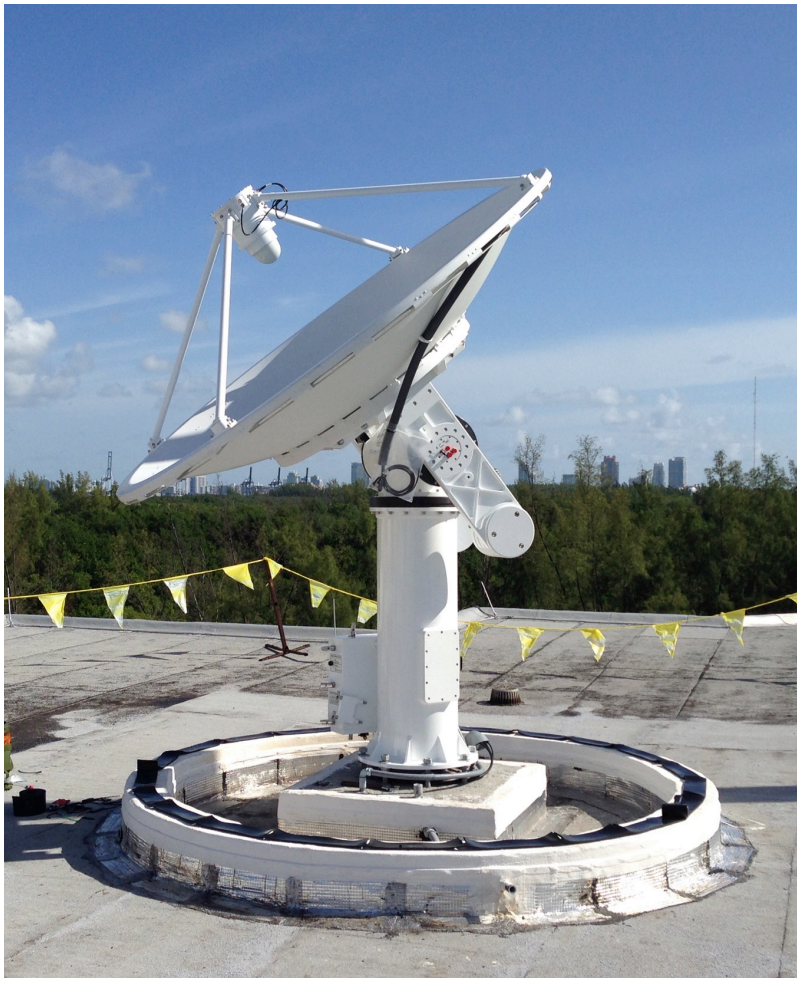
3. CrIS Full Spectral Resolution calibration based on NOAA calibration team version of ADL (*Yong Han et. al*).

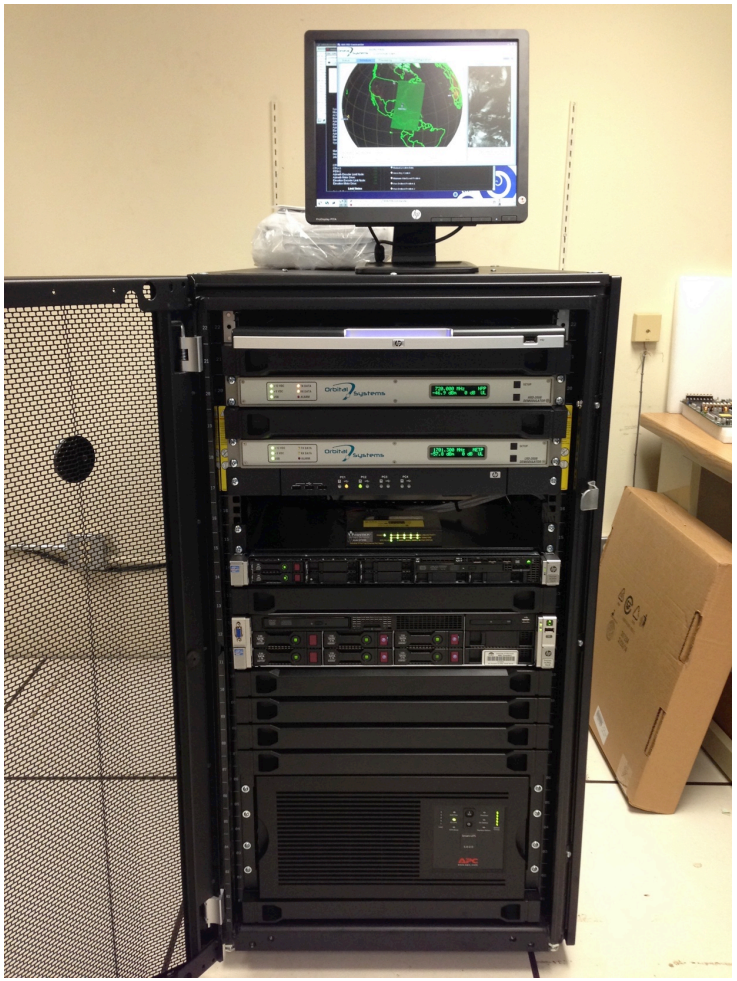
Items 1-3 above are in final testing and should be released by the end of 1st quarter 2015.

VIIRS SST from ACSPO
2015-01-01 SSEC Direct Broadcast



AOML X/L-Band Reception and Processing System





Reception System

- Satellite data scheduling and reception is handled by the EOS Front End Server (EOS-FES).
- The EOS-FES sends commands to the antenna positioner; schedules satellite passes; controls the demodulators; and saves decoded/framed satellite data (Level 0) to disk.
- Level 0 files are pushed via FTP to the Processing System.

Processing System

- Satellite data processing is handled by the Direct Broadcast Processing System (DBPS) server.
- The DBPS server ingests Level 0 satellite data delivered from the EOS-FES and creates Level 1 and Level 2 products.
- Products and images are saved to disk and are retained for 7 days.
- Products and images are served via this website:

http://dbps.aoml.noaa.gov/

Product Directories

- For each satellite series (eos, fy3, noaa, metop, jpss, gcom), the following directories contain the products:

  level0: framed uncalibrated data (binary, HDF5)

  level1: calibrated and geolocated sensor data (HDF4/5)

  level2: geophysical products (HDF4/5, netCDF4)

  images: projected imagery (JPEG, GeoTIFF, PNG, GIF)