Polar Orbiter Product Environmental Applications: Part 1

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Direct Broadcast Polar Orbiter Workshop

University of Puerto Rico at Mayaguez

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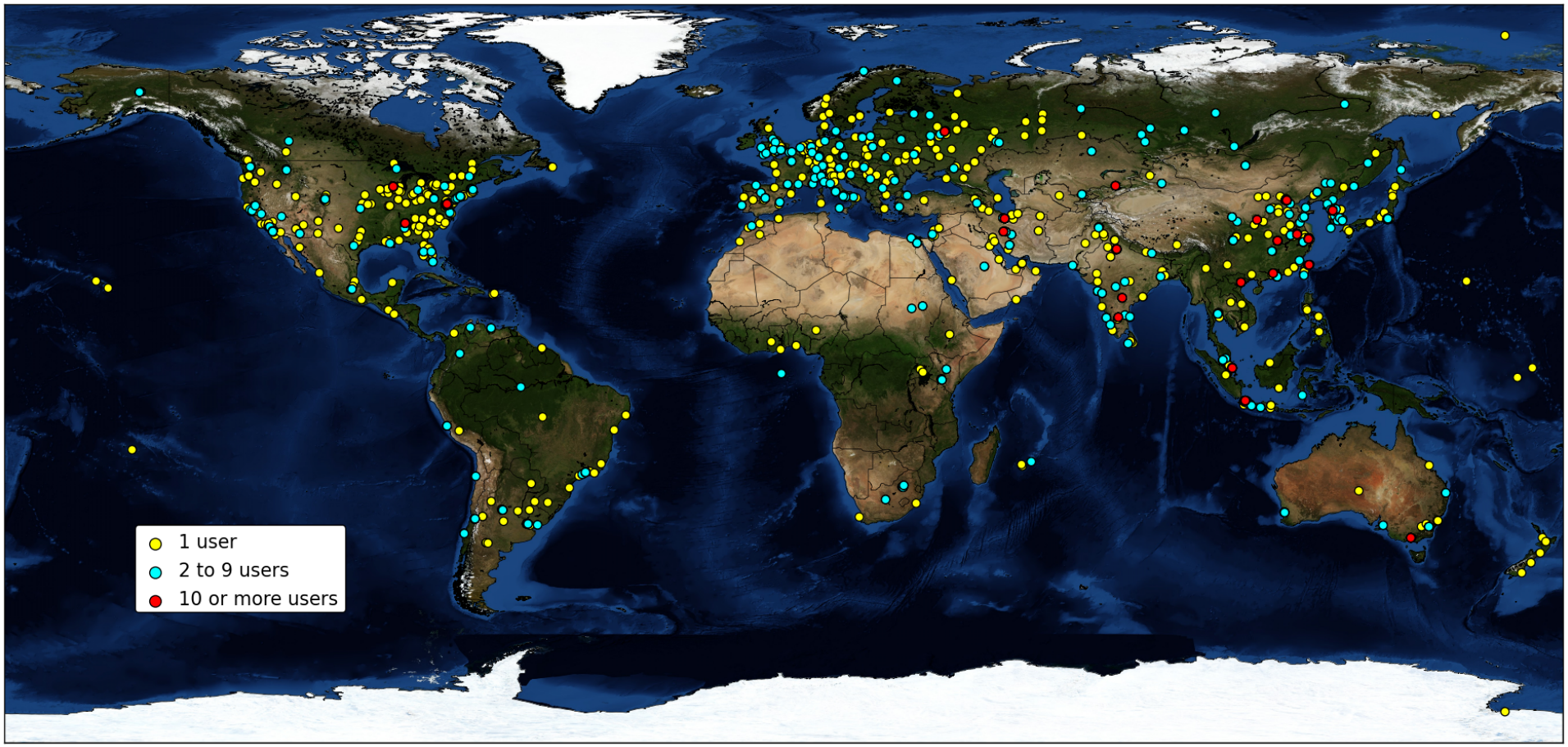
UPR Polar Orbiter DB Products

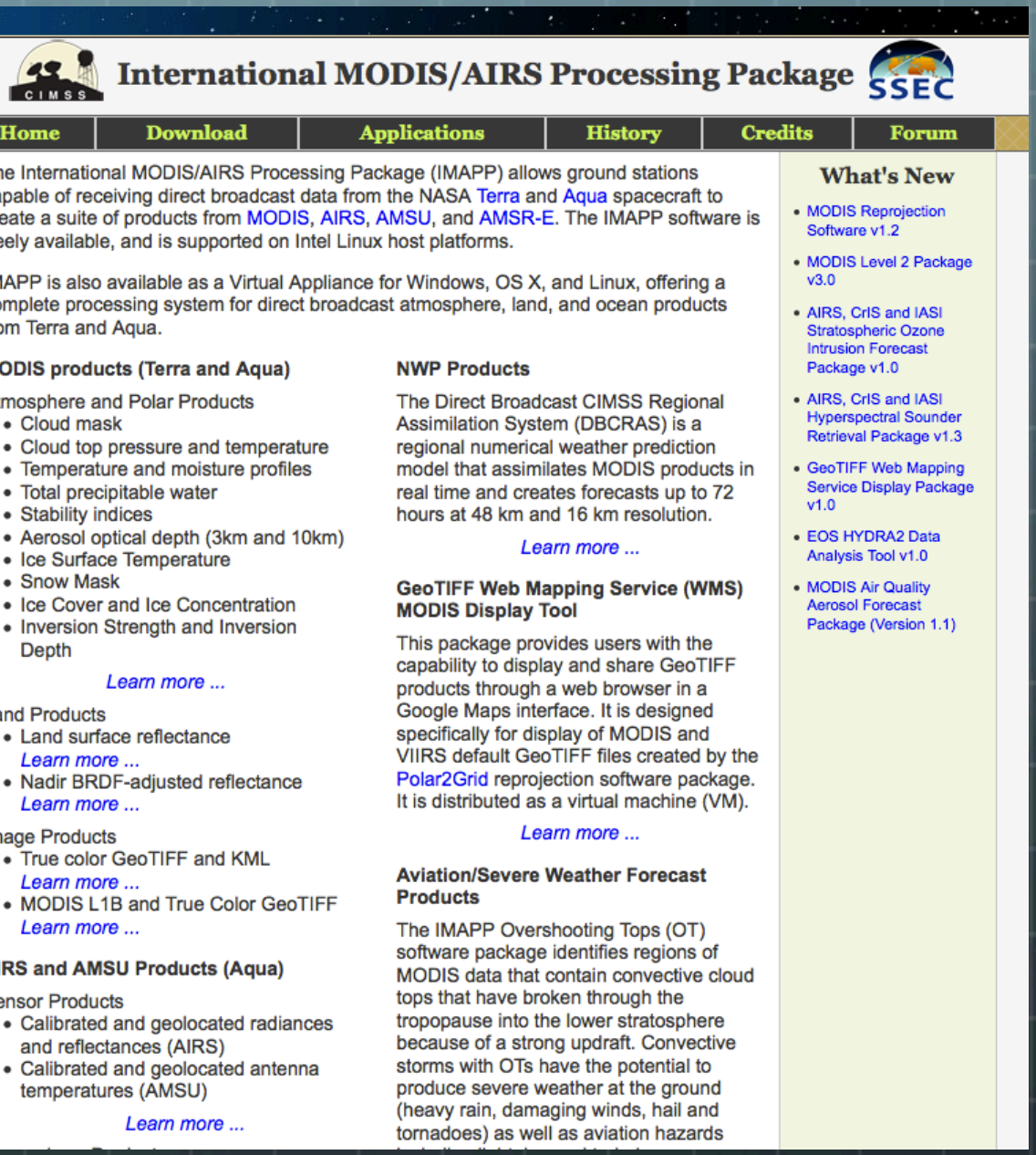
- Products Created from:
  - Community Satellite Processing Package (CSPP) supports VIIRS
  - International MODIS/AIRS Processing Package (IMAPP) – MODIS
  - SeaDAS – NASA Ocean Biology Group
    - http://seadas.gsfc.nasa.gov/
    - MODIS L1B software
    - Ocean products from MODIS and VIIRS
  - NASA science products distributed through the NASA Direct Readout Lab (DRL)
    - http://directreadout.sci.gsfc.nasa.gov/
    - Corrected reflectance (removes atmospheric Rayleigh scattering)
    - Simple NDVI
    - Land Surface Temperature

Global IMAPP Downloads



More than 2200 people have downloaded some part of the IMAPP suite of products representing 70+ different countries and all 7 continents (since 2007)

http://cimss.ssec.wisc.edu/imapp/



International MODIS/AIRS Processing Package

Home | Download | Applications | History | Credits | Forum

The International MODIS/AIRS Processing Package (IMAPP) allows ground stations capable of receiving direct broadcast data from the NASA Terra and Aqua spacecraft to create a suite of products from MODIS, AIRS, AMSU, and AMSR-E. The IMAPP software is freely available, and is supported on Intel Linux host platforms.

IMAPP is also available as a Virtual Appliance for Windows, OS X, and Linux, offering a complete processing system for direct broadcast atmosphere, land, and ocean products from Terra and Aqua.

MODIS products (Terra and Aqua)

Atmosphere and Polar Products
- Cloud mask
- Cloud top pressure and temperature
- Temperature and moisture profiles
- Total precipitable water
- Stability indices
- Aerosol optical depth (3km and 10km)
- Ice Surface Temperature
- Snow Mask
- Ice Cover and Ice Concentration
- Inversion Strength and Inversion Depth

Learn more ...

Land Products
- Land surface reflectance
  Learn more ...
- Nadir BRDF-adjusted reflectance
  Learn more ...

Image Products
- True color GeoTIFF and KML
  Learn more ...
- MODIS L1B and True Color GeoTIFF
  Learn more ...

AIRS and AMSU Products (Aqua)

Sensor Products
- Calibrated and geolocated radiances and reflectances (AIRS)
- Calibrated and geolocated antenna temperatures (AMSU)

Learn more ...

NWP Products

The Direct Broadcast CIMSS Regional Assimilation System (DBCRAS) is a regional numerical weather prediction model that assimilates MODIS products in real time and creates forecasts up to 72 hours at 48 km and 16 km resolution.

Learn more ...

GeoTIFF Web Mapping Service (WMS) MODIS Display Tool

This package provides users with the capability to display and share GeoTIFF products through a web browser in a Google Maps interface. It is designed specifically for display of MODIS and VIIRS default GeoTIFF files created by the Polar2Grid reprojection software package. It is distributed as a virtual machine (VM).

Learn more ...

Aviation/Severe Weather Forecast Products

The IMAPP Overshooting Tops (OT) software package identifies regions of MODIS data that contain convective cloud tops that have broken through the tropopause into the lower stratosphere because of a strong updraft. Convective storms with OTs have the potential to produce severe weather at the ground (heavy rain, damaging winds, hail and tornadoes) as well as aviation hazards

What's New
- MODIS Reprojection Software v1.2
- MODIS Level 2 Package v3.0
- AIRS, CrIS and IASI Stratospheric Ozone Intrusion Forecast Package v1.0
- AIRS, CrIS and IASI Hyperspectral Sounder Retrieval Package v1.3
- GeoTIFF Web Mapping Service Display Package v1.0
- EOS HYDRA2 Data Analysis Tool v1.0
- MODIS Air Quality Aerosol Forecast Package (Version 1.1)

IMAPP Software Suite

MODIS Atmosphere and Polar Products
- Cloud mask
- Cloud top pressure and temperature
- Cloud optical depth and effective radius
- Temperature and moisture profiles
- Total precipitable water
- Stability indices
- Aerosol optical depth
- Ice Surface Temperature
- Snow Mask
- Ice Cover and Ice Concentration
- Inversion Strength and Inversion Depth

MODIS Land Products
- Land Surface Reflectance
- BRDF

MODIS Image Software
- MODIS in Google Earth (true color)

AIRS Level 1B
- Calibrated and geolocated radiances and brightness temperatures (AIRS)
- Calibrated and geolocated antenna temperatures (AMSU)

AIRS Retrievals
- JPL 3x3 FOV
- Dual Regression Single FOV

AIRS Utilities
- Collocating AIRS/MODIS utility
- AIRS HDF to BUFR utility

AMSR-E Level 1B
- Calibrated and Geolocated Antenna Temperatures

AMSR-E Products
- Rain Rate, Soil Moisture, Snow Water Equilvalent

NWP Products
- Globally configurable regional numerical weather prediction model that assimilates MODIS DB products - DBCRAS

Aviation/Severe Weather Products
- Overshooting Tops Identification including turbulence and lightning potential

Complete DB Processing System
- VA for Mac, Windows and Linux

IMAPP Software Suite

Air Quality Forecast Product – IDEA-I

- 48 Hour Aerosol trajectory forecast
- Stratospheric Ozone Intrusions trajectory forecast

Visualization and Analysis Tools

- Polar2Grid MODIS reprojection software including true color images
- HYDRA-2 - a multi-spectral data analysis toolkit

Web Mapping Service (wms)

- Display and share GeoTIFFs through a web browser
- Can readily display Polar2Grid VIIRS/MODIS Imagery

http://cimss.ssec.wisc.edu/cspp/

Community Satellite Processing Package

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The Community Satellite Processing Package (CSPP) supports the Direct Broadcast (DB) meteorological and environmental satellite community through the packaging and distribution of open source science software. CSPP supports DB users of both polar orbiting and geostationary satellite data processing and regional real-time applications through distribution of free open source software, and through training in local product applications. CSPP is funded through NOAA JPSS.

Suomi National Polar-orbiting Partnership (NPP) Products

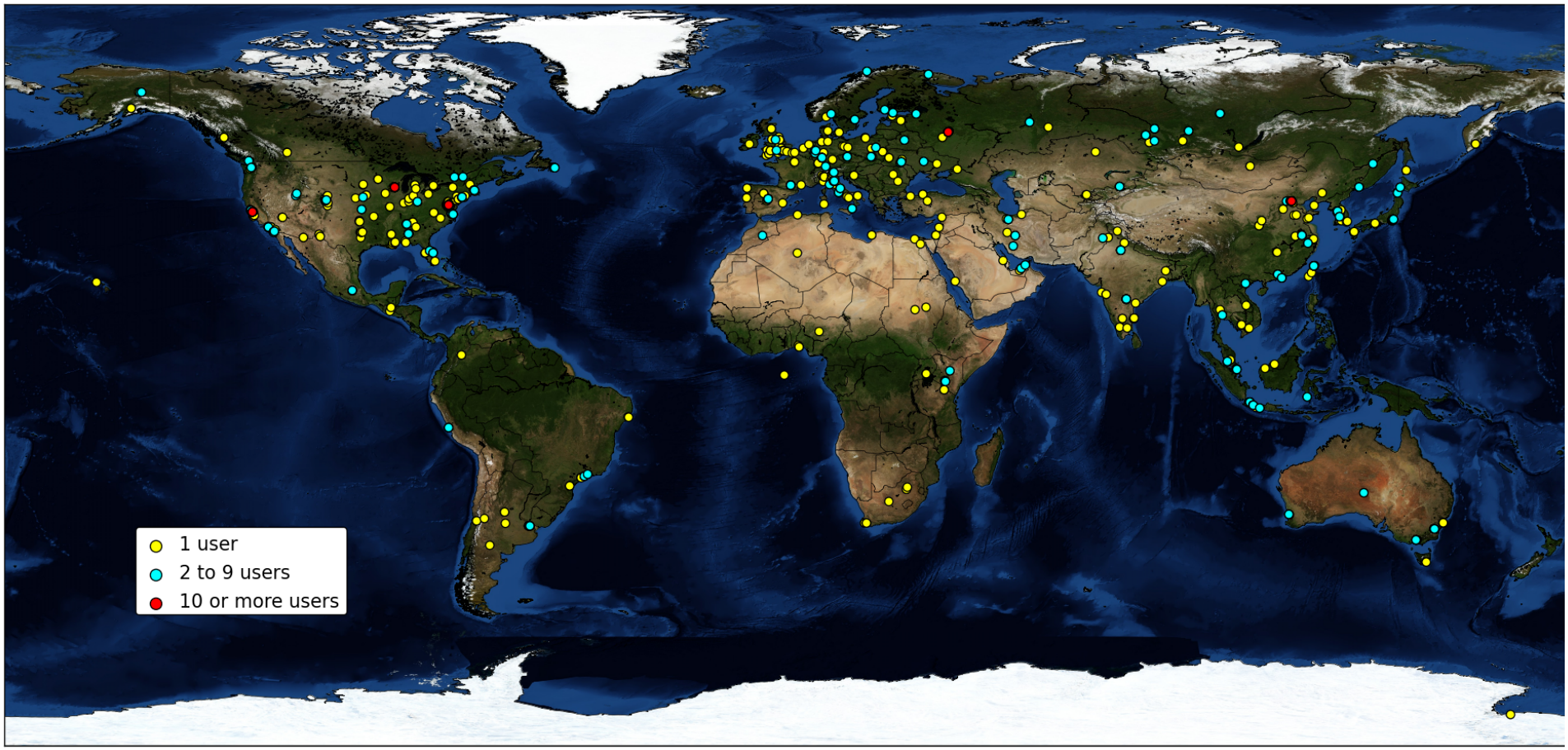
CSPP software to support Suomi NPP:

- VIIRS, ATMS and CrIS calibration and geolocation software (Raw Data Records (RDRs) to Sensor Data Records (SDRs));
  Learn more ...
- VIIRS Environmental Data Records (EDRs), including a subset of Land, Ocean and Atmosphere Products;
  Learn more ...
- VIIRS SDR reprojection software for the creation of GeoTIFFs and/or AWIPS NetCDF files;
  Learn more ...
- CrIS, AIRS and IASI University of Wisconsin dual regression single Field-of-View (FOV) Temperature, Moisture, Surface and Cloud Retrieval Environmental Data Record (EDR);
  Learn more ...
- S-NPP VIIRS, ATMS,CrIS and EOS Aqua and Terra HYDRA2 multispectral data analysis toolkit;
  Learn more ...
- NOAA/NESDIS/STAR Microwave Integrated Retrieval System (MIRS) supporting S-NPP ATMS, NOAA-18, 19 and MetOP-A, B AMSU-A and MHS instruments;
  Learn more ...
- VIIRS Imagery Environmental Data Records (EDRs).
  Learn more ...
- VIIRS, MODIS and AVHRR (POES and MetOP) Cloud and Land Surface Retrievals from CLAVR-x.
  Learn more ...

What's New

- VIIRS, ATMS, CrIS SDR Software v2.1
- VIIRS Reprojection Software v1.2
- VIIRS, ATMS, CrIS SDR Software v2.0
- VIIRS EDR Software v2.0
- VIIRS Imagery EDR Software v2.0
- CLAVRx VIIRS, MODIS and AVHRR Cloud Retrieval Package v1.0
- MIRS Microwave Retrieval Software v1.0

Global CSPP Registrants



More than 1000 people have registered since the first CSPP release in March 2012.

CSPP Software Suite

http://cimss.ssec.wisc.edu/cspp

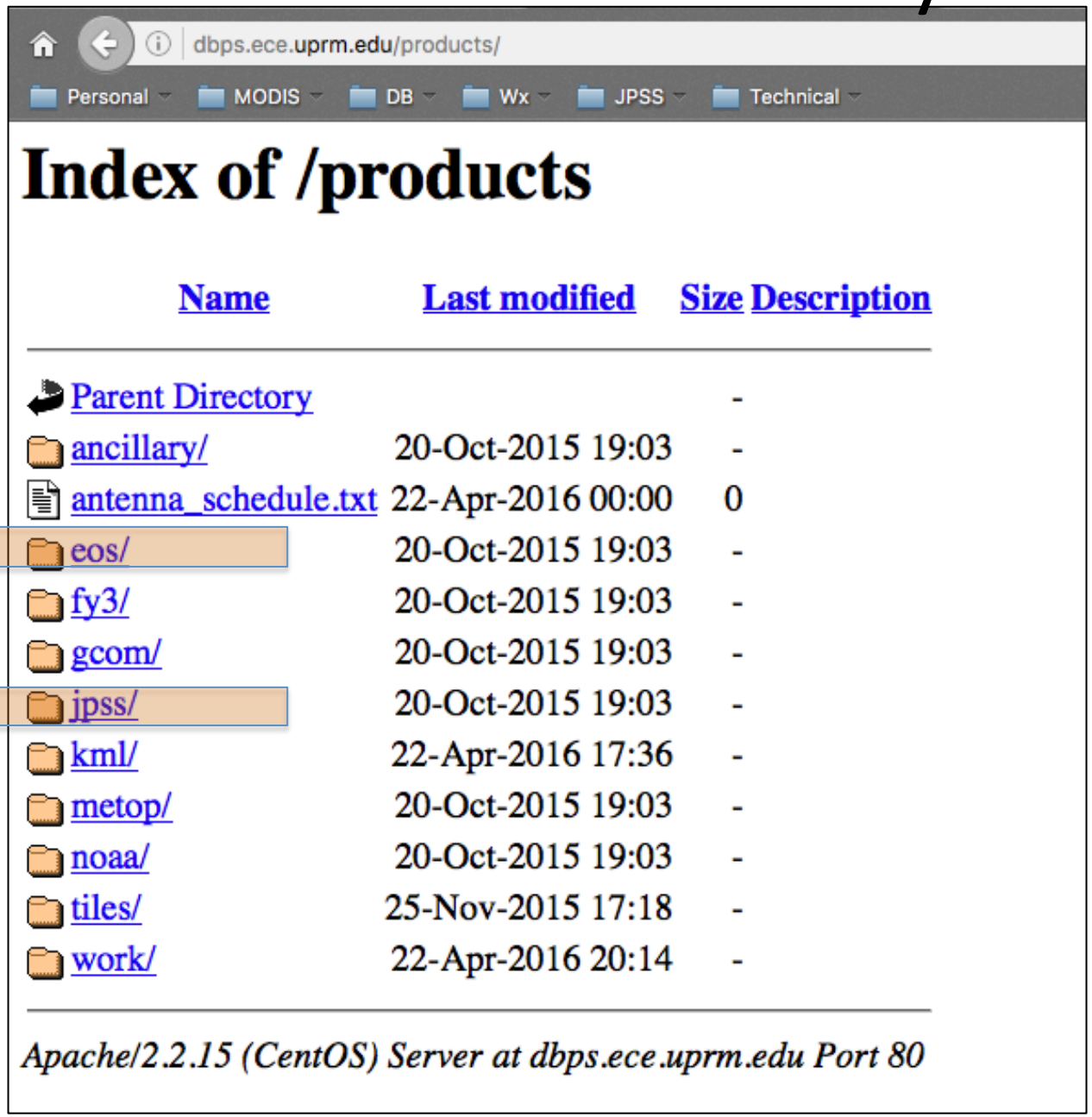
1. Suomi NPP CrIS, VIIRS and ATMS SDR (geolocation and calibration)
2. Suomi NPP VIIRS EDR (cloud mask, active fires, surface reflectance, NDVI, EVI, Surface Type, SST, Aerosol Optical Thickness, Suspended Matter, Land Surface Temperature)
3. CrIS, IASI, and AIRS Dual Regression Atmospheric Retrieval Softwae
4. VIIRS, MODIS and AVHRR GeoTIFF and AWIPS Reprojected Imagery
5. Microwave Integrated Retrieval System (MIRS)
6. Clouds from AVHRR Extended (CLAVR-x)
   - NOAA cloud product software supporting VIIRS, MODIS and AVHRR
7. HYDRA2 Multispectral Data Analysis Toolkit
8. VIIRS Imagery EDR (projected imagery for AWIPS)
9. ACSPO Sea Surface Temperatures
   - NOAA SST product supporting VIIRS, MODIS and AVHRR
10. NUCAPS atmospheric retrieval software for S-NPP CrIS/ATMS

Mayaguez antenna data site

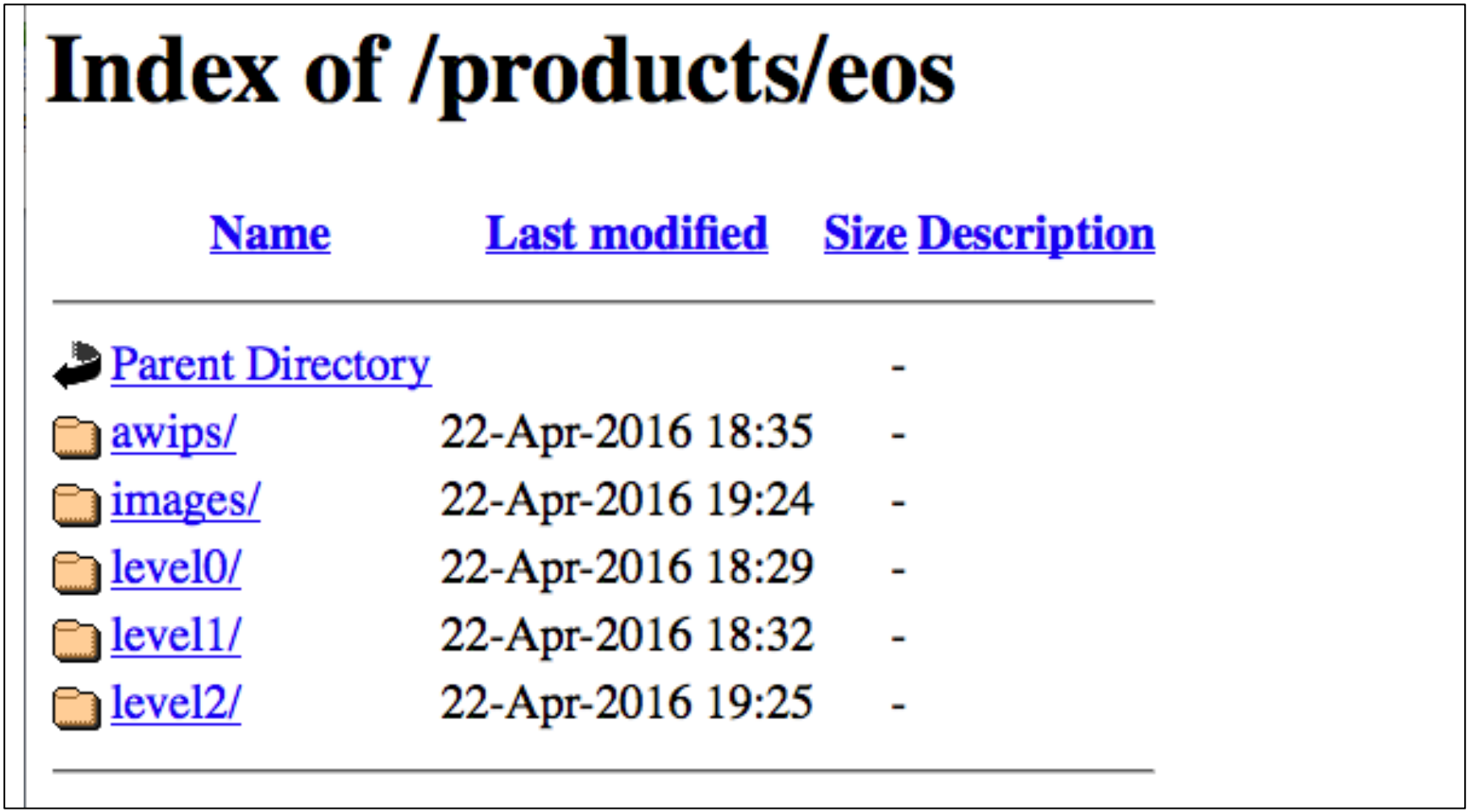
7 day product archive available at:

- http://dbps.ece.uprm.edu/products/

UPR DB Data Server Directory Structure



UPR MODIS DB Data Server Directory Structure



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level2/	22-Apr-2016 19:25	-	


dbps.ece.uprm.edu/products/eos/level2/
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MODIS
DB
Wx
JPSS
Technical
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a1.16105.1726.seadas.hdf 14-Apr-2016 18:32 372M
a1.16105.1726.wvnir.hdf 14-Apr-2016 18:07 25M
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a1.16105.1906.modlst.hdf 14-Apr-2016 19:18 19M
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dbps.ece.uprm.edu/products/eos/level2/a1.16105.1906.ndvi.1000m.hdf

UPR MODIS Standard Level 2 Products

a1.16105.1726.mod04.hdf – MODIS Aerosol Product file

a1.16105.1726.mod04_3k.hdf – MODIS Aerosol High Resolution Product file

a1.16105.1726.mod06ct.hdf – MODIS Cloud Top Properties file

a1.16105.1726.mod07.hdf – MODIS Atmospheric Profiles file

a1.16105.1726.mod14.hdf – MODIS Fire Product

a1.16105.1726.mod28.hdf – IMAPP MODIS SST file

a1.15039.1951.mod35.hdf – MODIS Cloud Mask file

a1.16105.1726.mask_byte1.hdf – MODIS Cloud Mask First Byte stripped file

a1.16105.1726.modlst.hdf – MODIS Land Surface Temperature file

a1.16105.1726.ndvi.1000.(500,250)m.hdf – MODIS NDVI 1km resolution file

a1.16105.1726.seadas.hdf – MODIS SeaDAS Ocean Color product file

a1.16105.1726.wvnir.hdf – MODIS Near-IR Atmospheric Water Vapor file

Other UPR MODIS Level 2 Products

CLAVRx.a1.16105.1726.1000m.level2.hdf

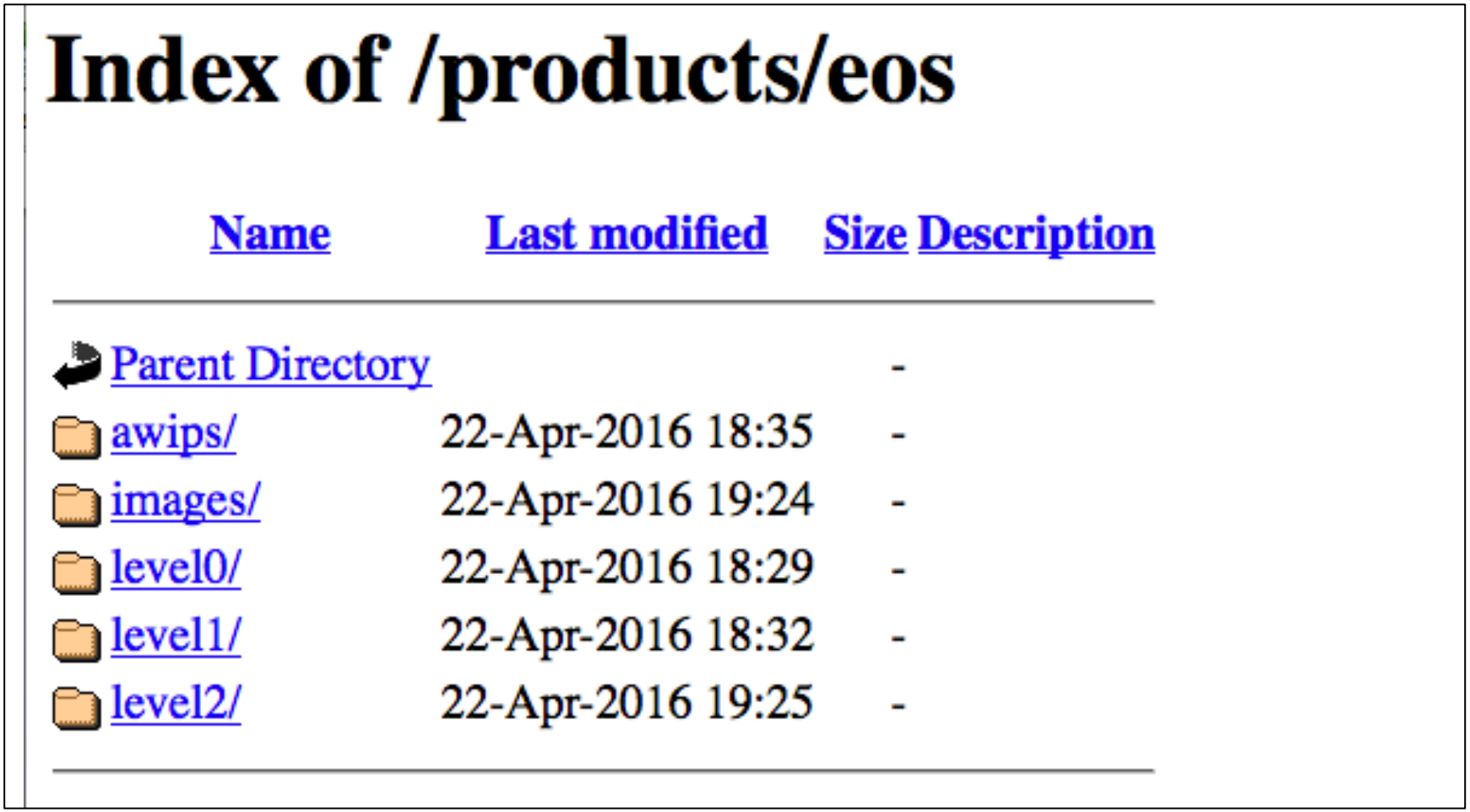
– NOAA Clouds from AVHRR Extended (CLAVR-x)

20160414172648-STAR-L2P_GHRSST-SST1m-MODIS_AQUA-v02.0-fv01.0.nc

ACSPO_V2.31_AQUA_MODIS_2016-04-14_1726-1737_20160414.183334.nc

- NOAA/STAR Advanced Clear-Sky Processor for Oceans (ACSPO)

UPR MODIS DB Data Server Directory Structure



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images/	22-Apr-2016 19:24	-	
level0/	22-Apr-2016 18:29	-	
level1/	22-Apr-2016 18:32	-	
level2/	22-Apr-2016 19:25	-	

Images Directory

- Contain Images of L1B reflectances and Brightness Temperatures
- Quick look product images
- Directory also contains GeoTiff files of almost every MODIS Band at about 600m resolution
- True color GeoTIFF

MODIS Product Images

Index of /products/eos/images

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Aqua_20160414_1726_CloudPhase.png	14-Apr-2016 18:13	228K	
Aqua_20160414_1726_CloudTopPressure.png	14-Apr-2016 18:13	299K	
Aqua_20160414_1726_SeaSurfaceTemperature.png	14-Apr-2016 18:14	282K	
Aqua_20160414_1726_TotalPrecipitableWater.png	14-Apr-2016 18:13	199K	
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Aqua_20160414_1906_AerosolOpticalDepth10km.png	14-Apr-2016 19:32	261K	
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Aqua_20160414_1906_Band7.png	14-Apr-2016 19:31	410K	
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Aqua_20160414_1906_Band27.png	14-Apr-2016 19:32	264K	
Aqua_20160414_1906_Band31.png	14-Apr-2016 19:32	263K	
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Aqua_20160414_1906_TotalPrecipitableWater.png	14-Apr-2016 19:32	264K	
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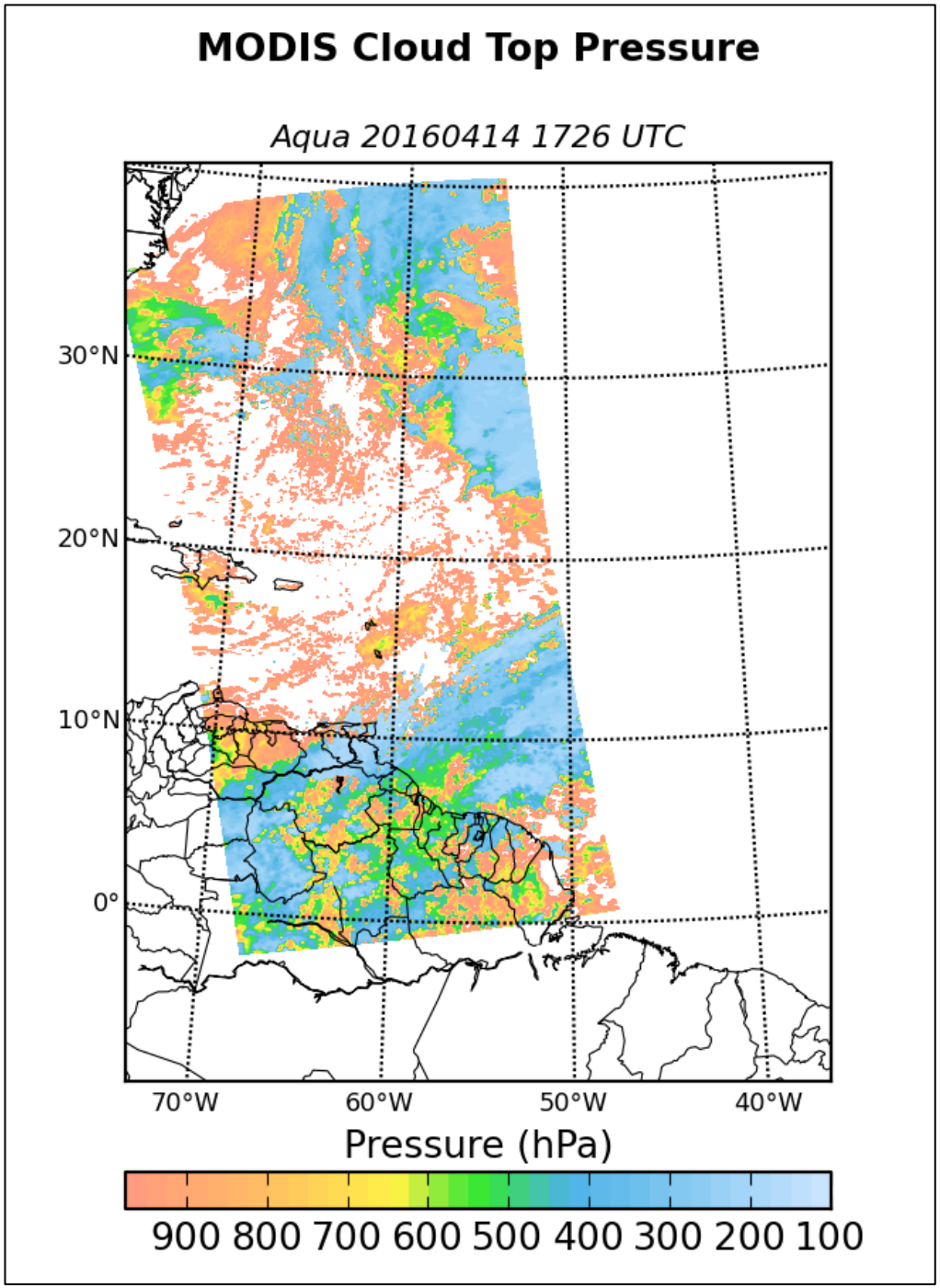
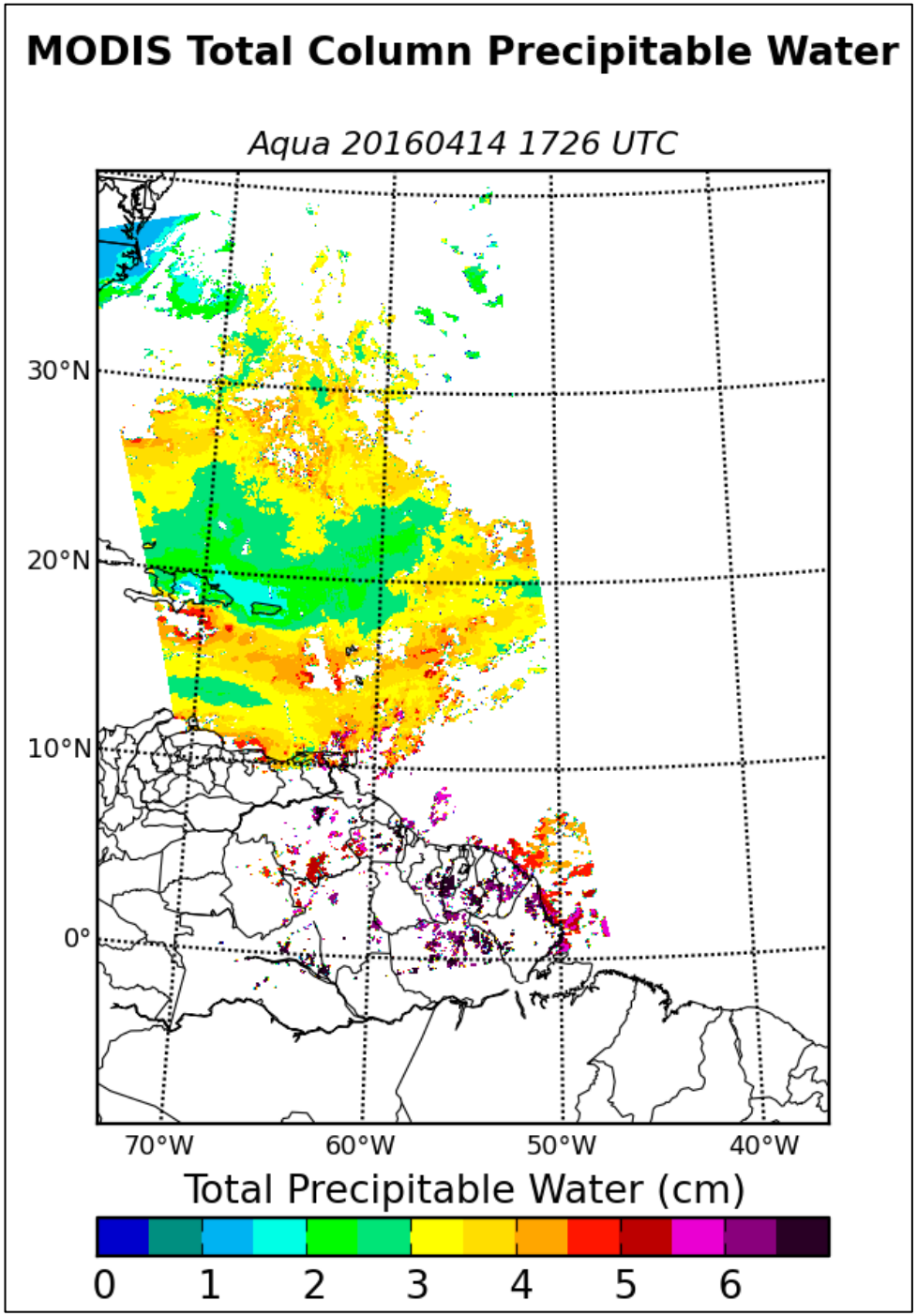
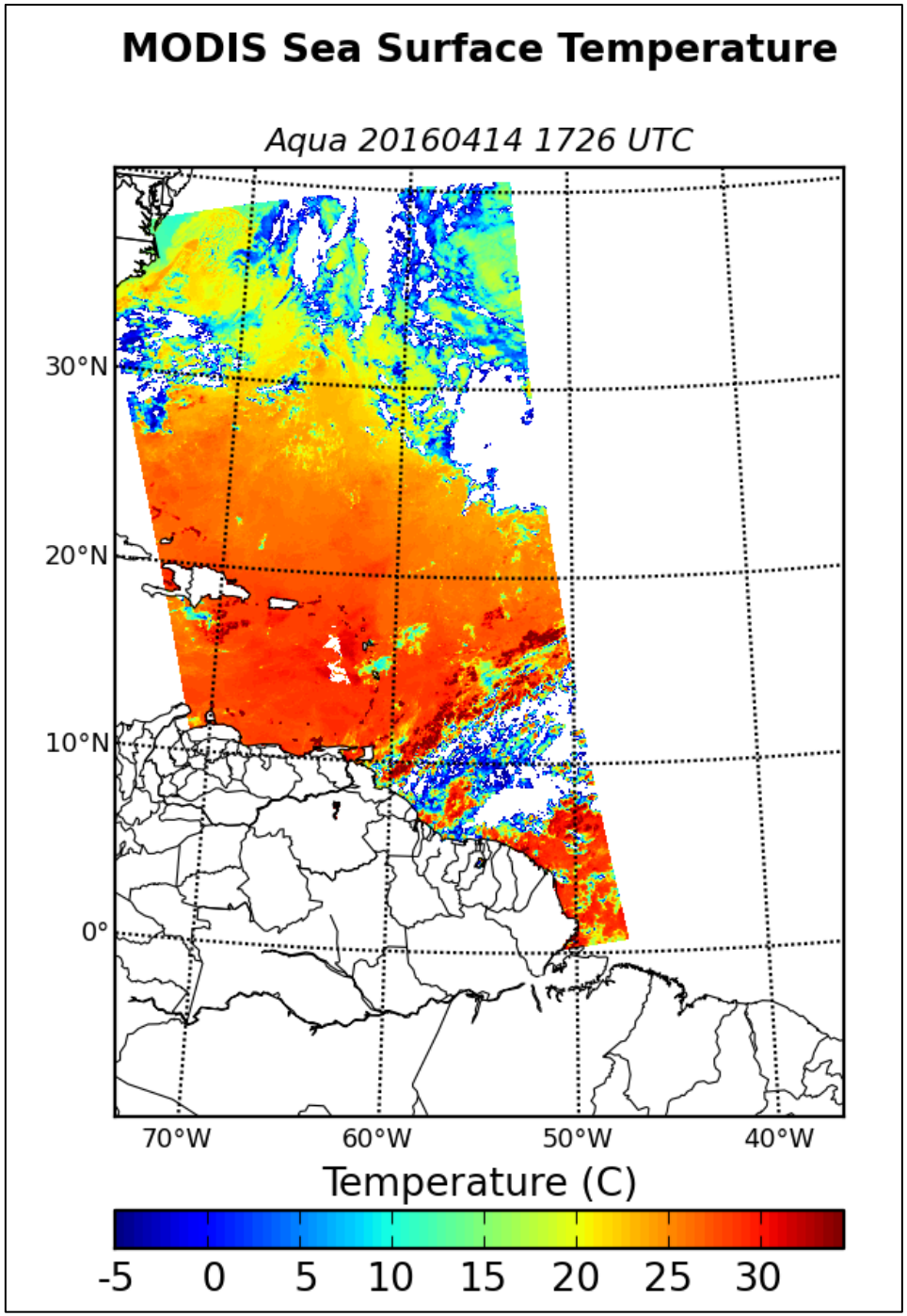
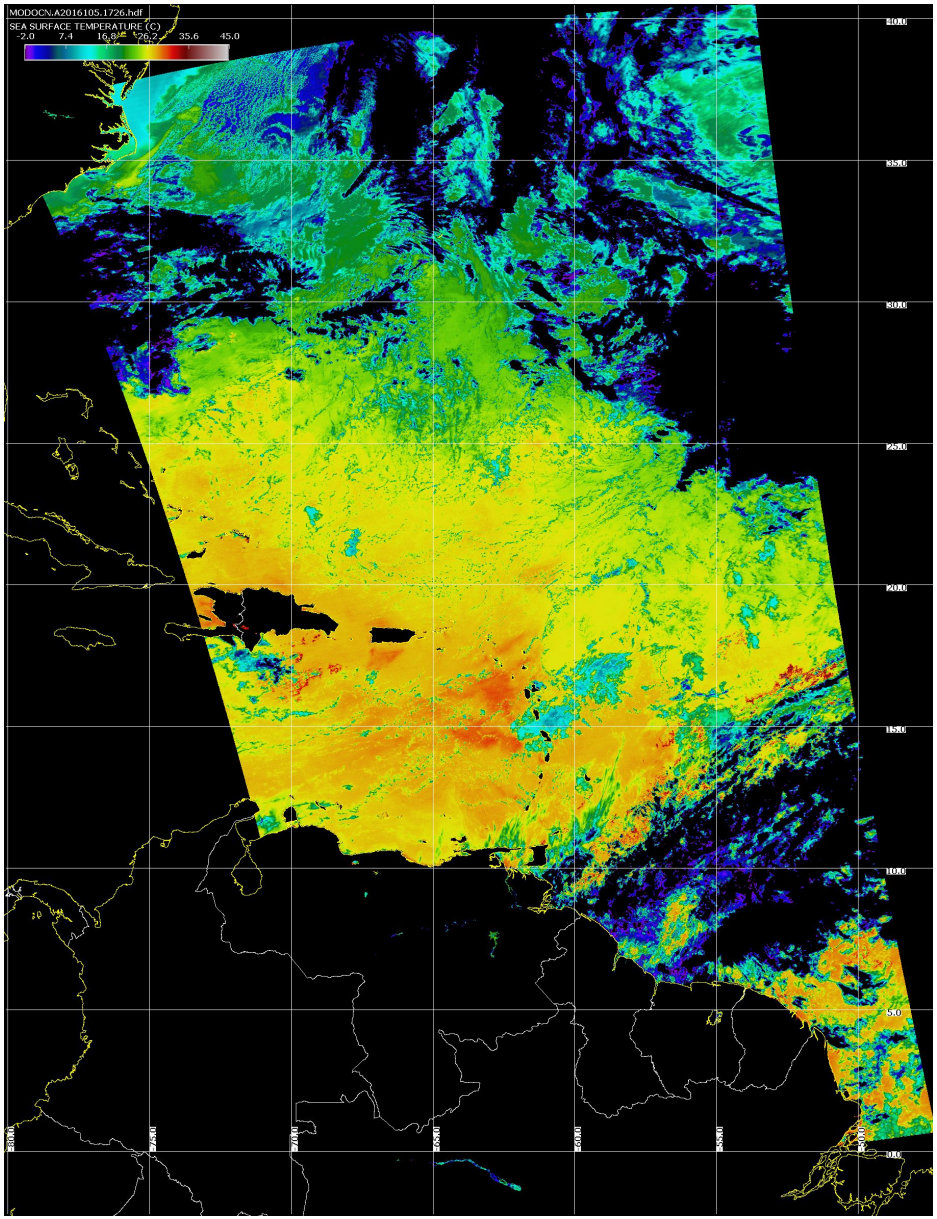

MODIS Cloud Top Pressure
Aqua 20160414 1726 UTC
30°N
20°N
10°N
0°
70°W
60°W
50°W
40°W
Pressure (hPa)
900 800 700 600 500 400 300 200 100


MODIS Total Column Precipitable Water
Aqua 20160414 1726 UTC
30°N
20°N
10°N
0°
70°W
60°W
50°W
40°W
Total Precipitable Water (cm)
0
1
2
3
4
5
6


MODIS Sea Surface Temperature
Aqua 20160414 1726 UTC
30°N
20°N
10°N
0°
70°W
60°W
50°W
40°W
Temperature (C)
-5
0
5
10
15
20
25
30

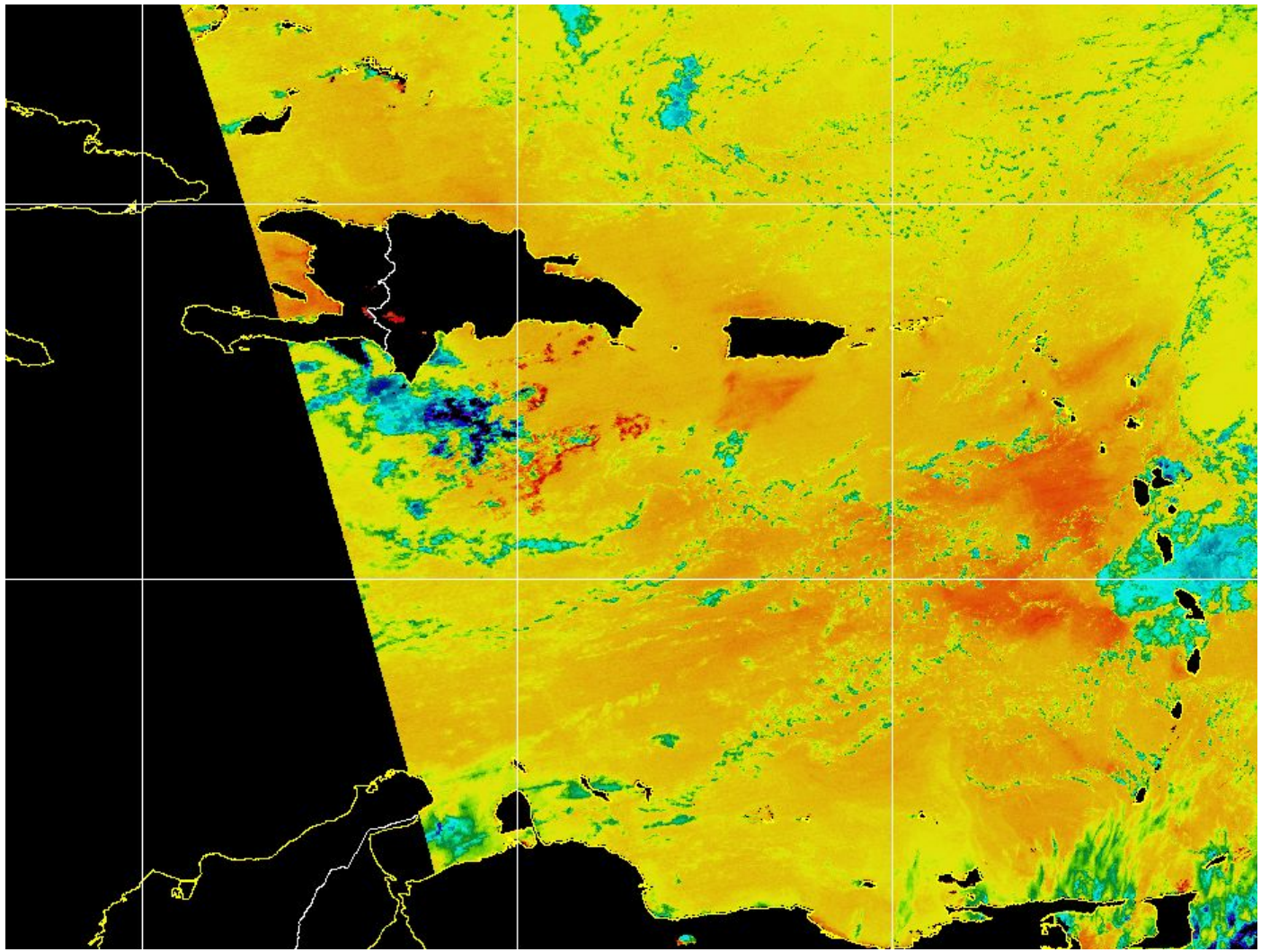
MODIS SeaDAS Sea Surface Temperature

Aqua 20160414 17:26 UTC



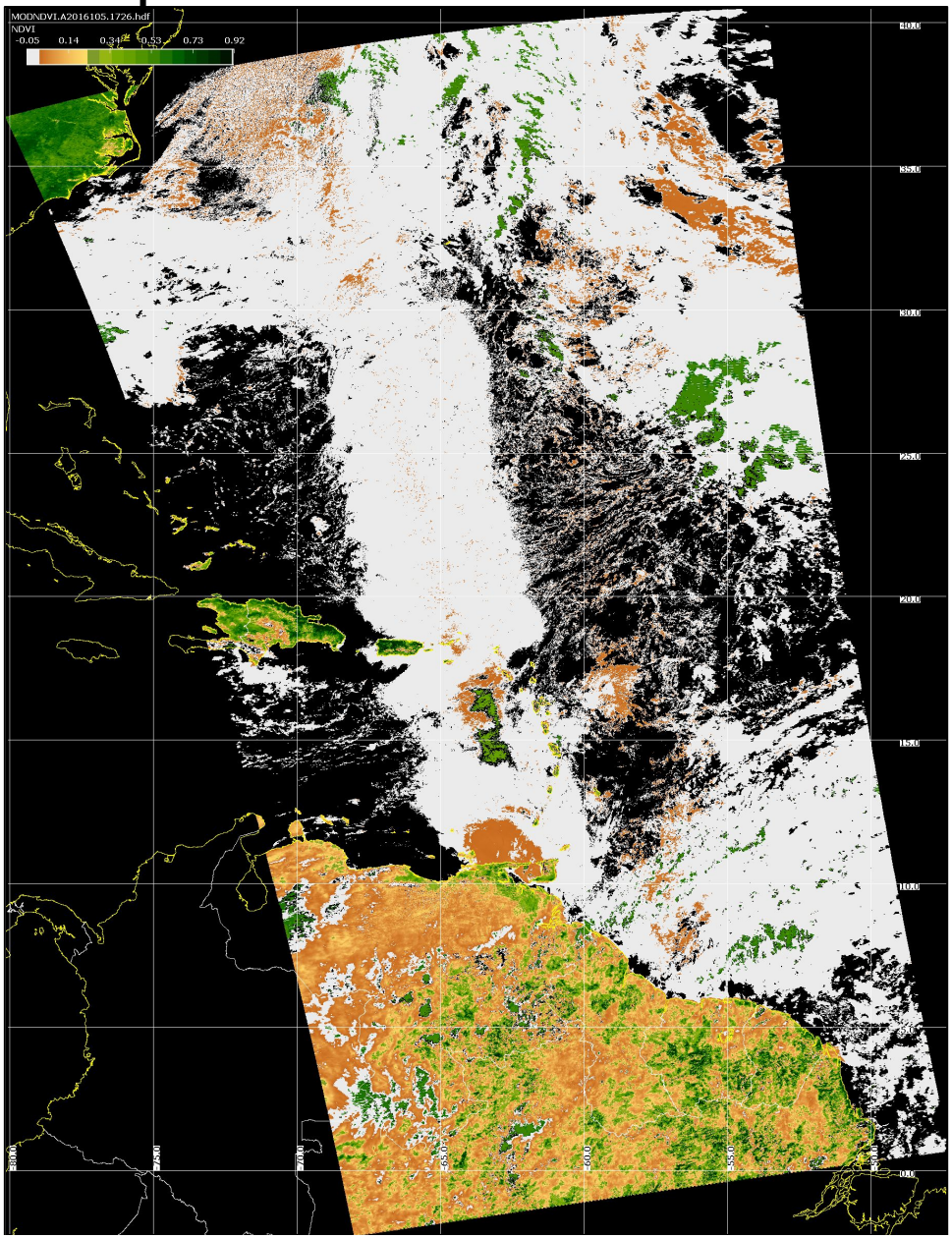
MODIS SeaDAS SST

Aqua 20160414 17:26 UTC



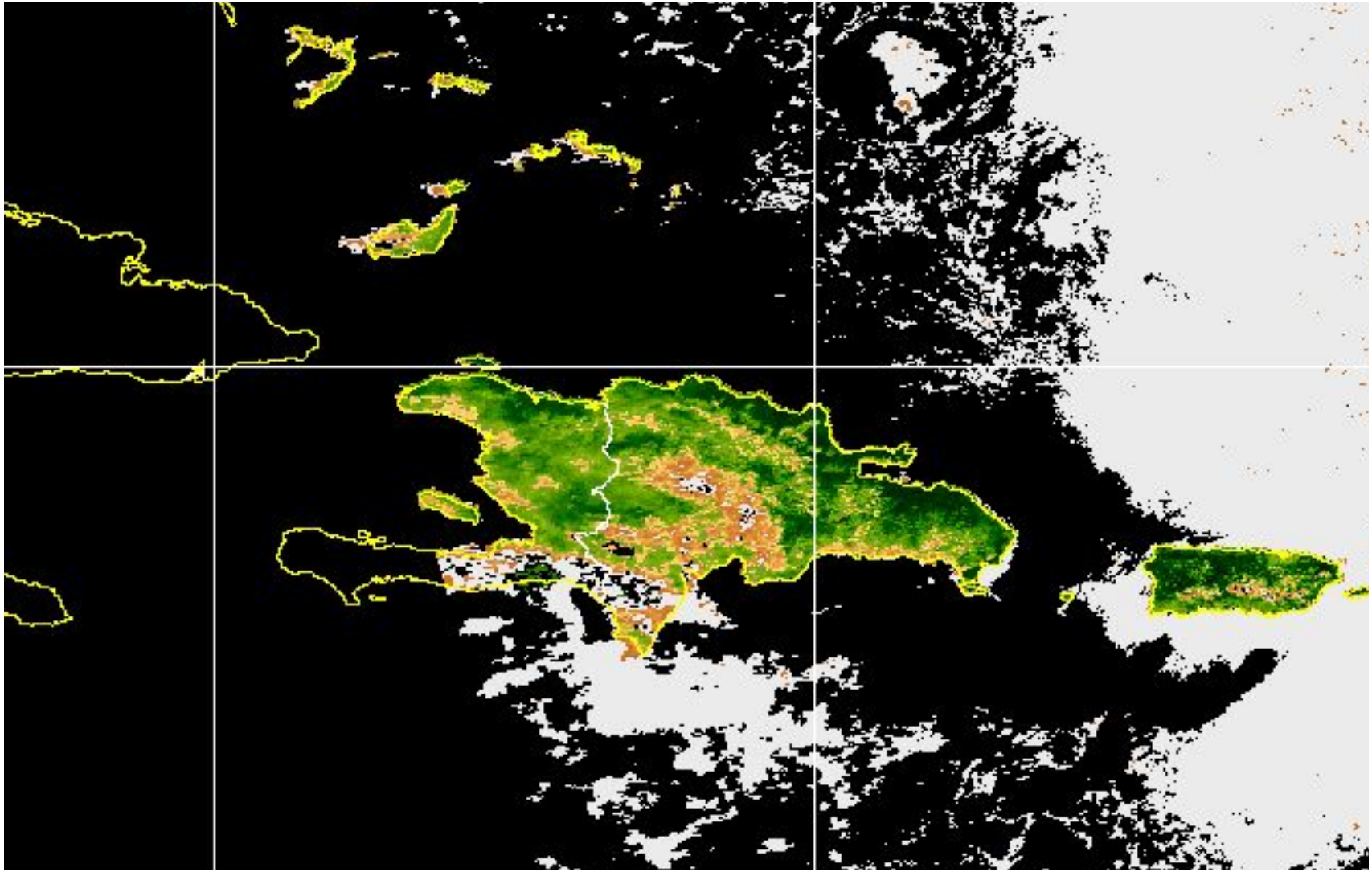
MODIS NDVI

Aqua 20160414 17:26 UTC

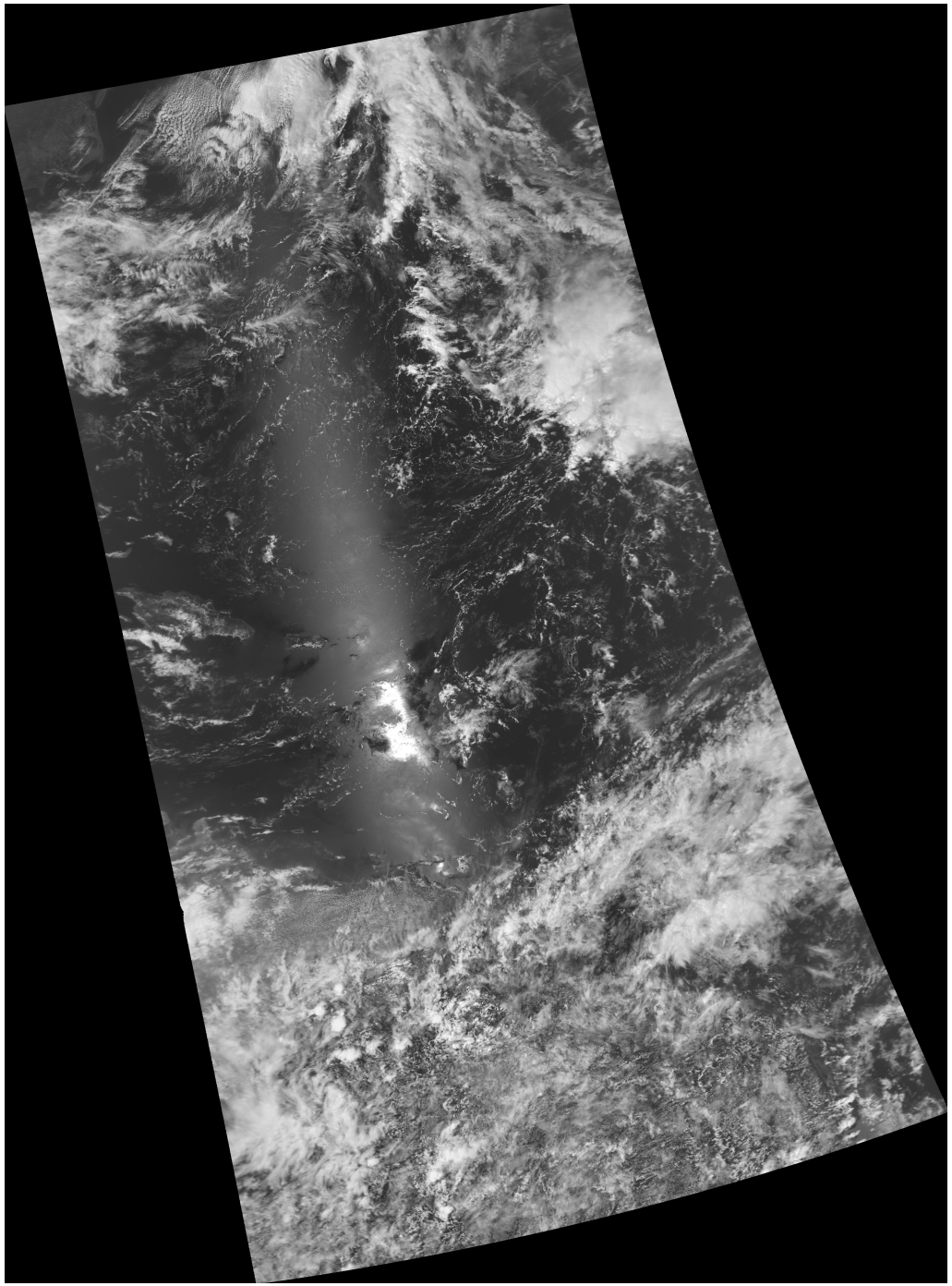


MODIS NDVI

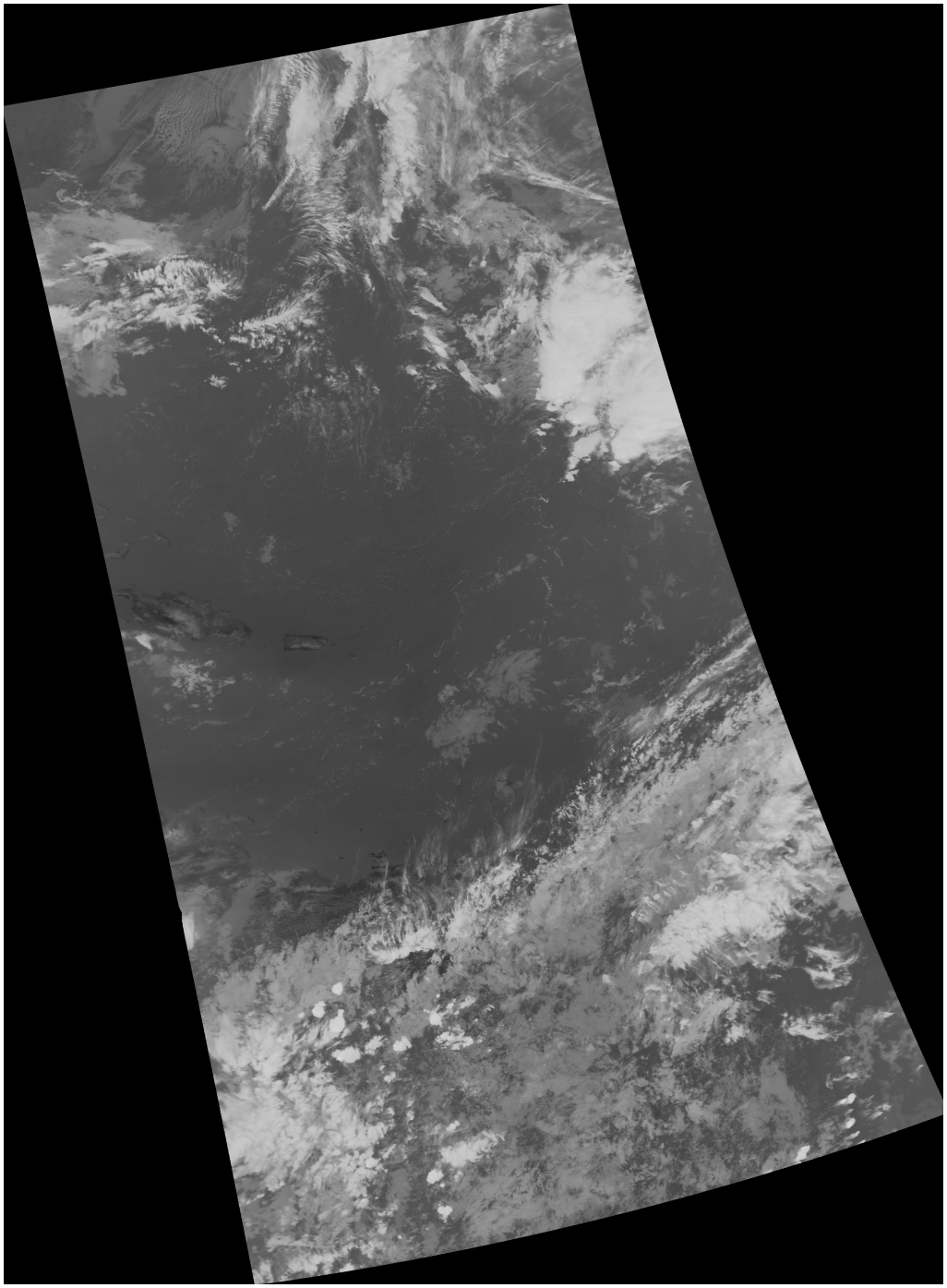
Aqua 20160414 17:26 UTC



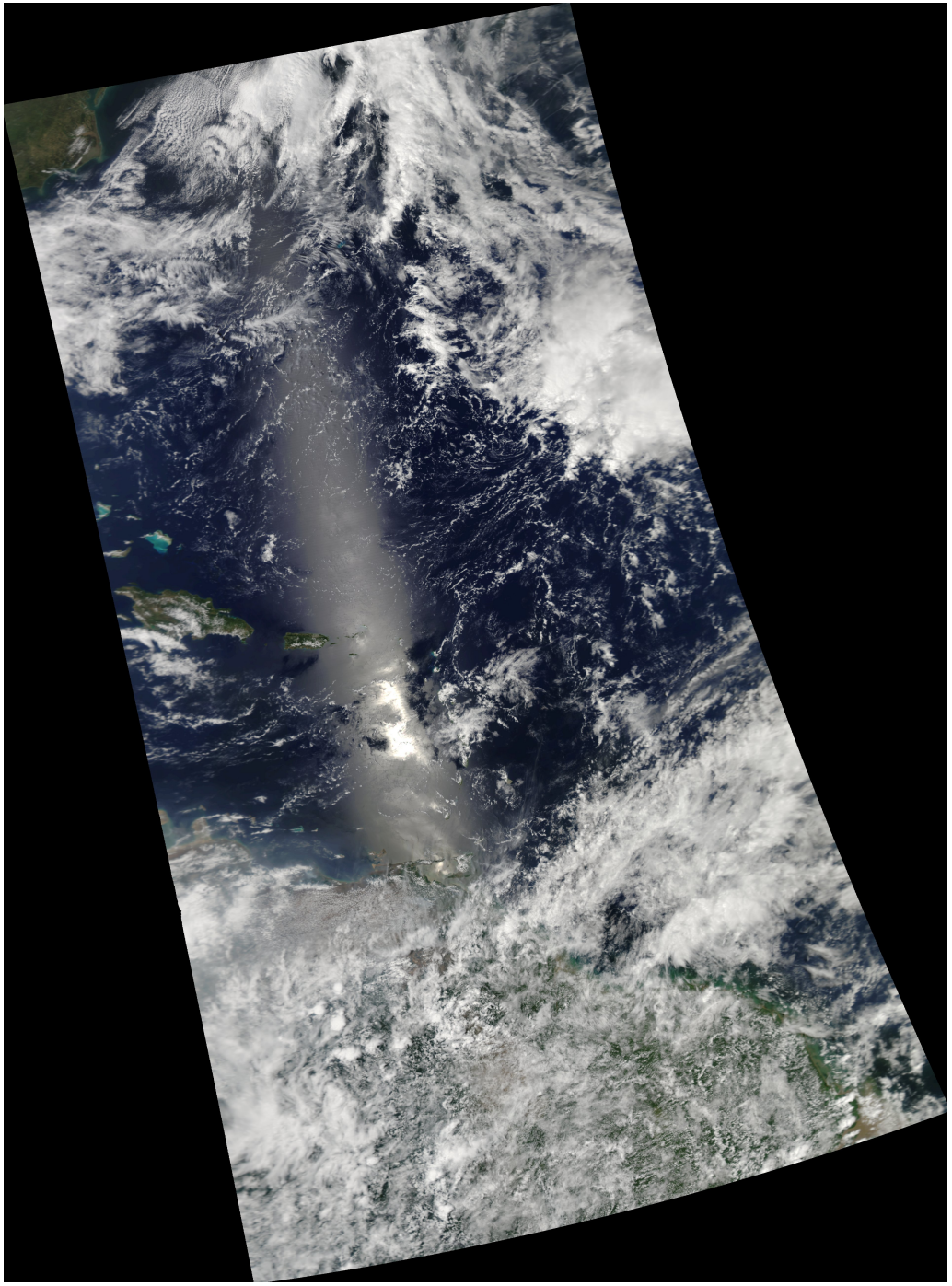
MODIS Band 1
Reflectances
(.65 micron)
20160414 17:26 UTC



MODIS Band 31
Brightness Temperatures
(11.0 micron)
20160414 17:26 UTC

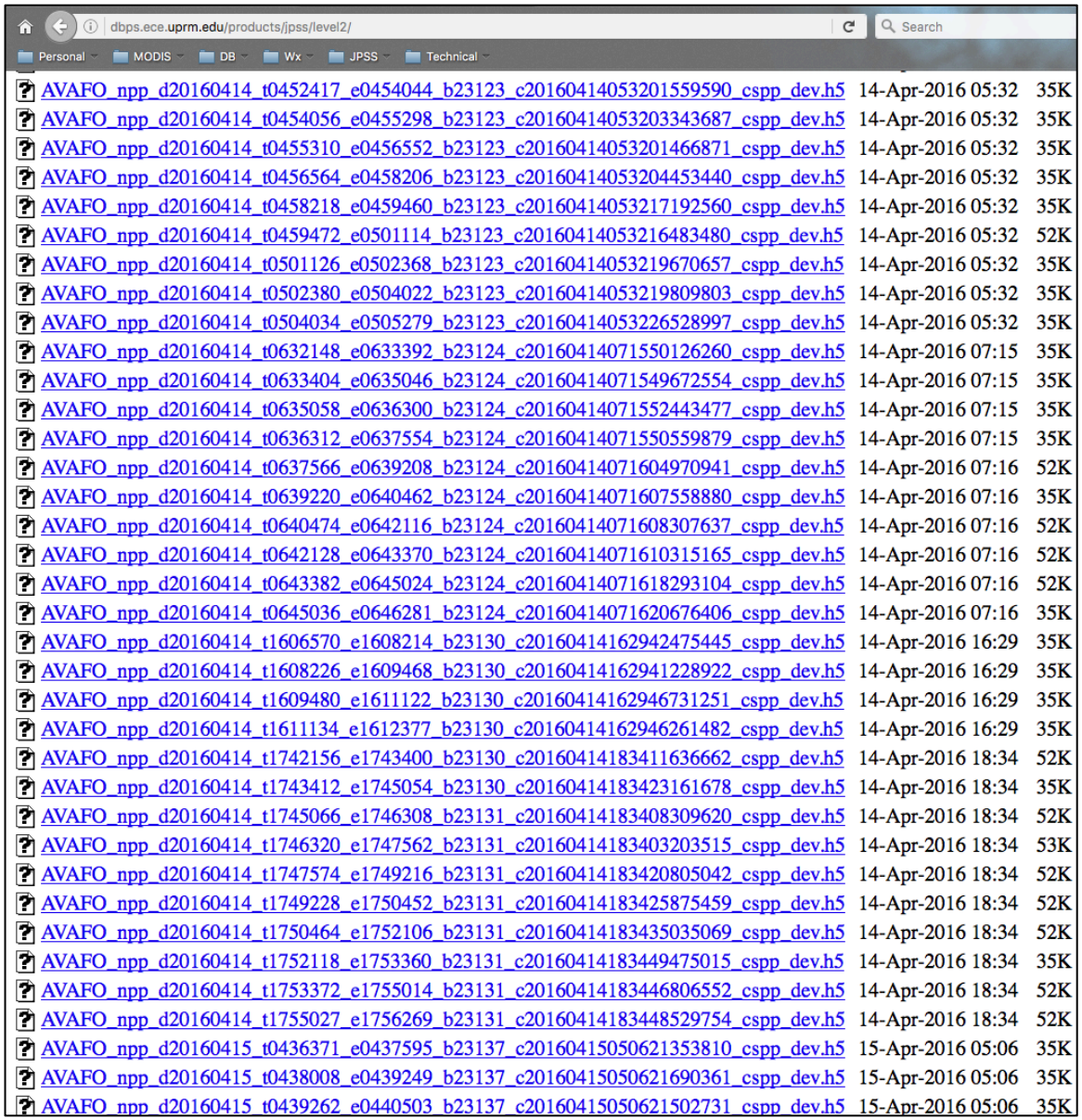


MODIS True Color Image
R: MODIS Band 1
.65 micron
G: MODIS Band 4
.55 micron
B: MODIS Band 3
.43 micron
Relfectances
20160414 17:26 UTC



UPR VIIRS DB EDR Data Server

Index of /products/jpss/level2



UPR VIIRS Standard Environmental Data Record (EDR) Products

- VIIRS EDR Products
  - Aerosol Optical Depth
    - VAOOO_npp*.h5 files
  - Sea Surface Temperatures
    - VSSTO_npp*.h5 files
  - Cloud Mask
    - IICMO_npp*.h5 files
  - Active Fires
    - AVAFO_npp*.h5 files
  - Surface Reflectance
    - IVISR*.h5
  - Vegetation Indices (NDVI and EVI)
    - VIVIO*.h5
  - Land Surface Temperature
    - VLSTO*.h5
  - Land Surface Type (17 surface types)
    - VSTYO*.h5

Other UPR VIIRS Level 2 Products

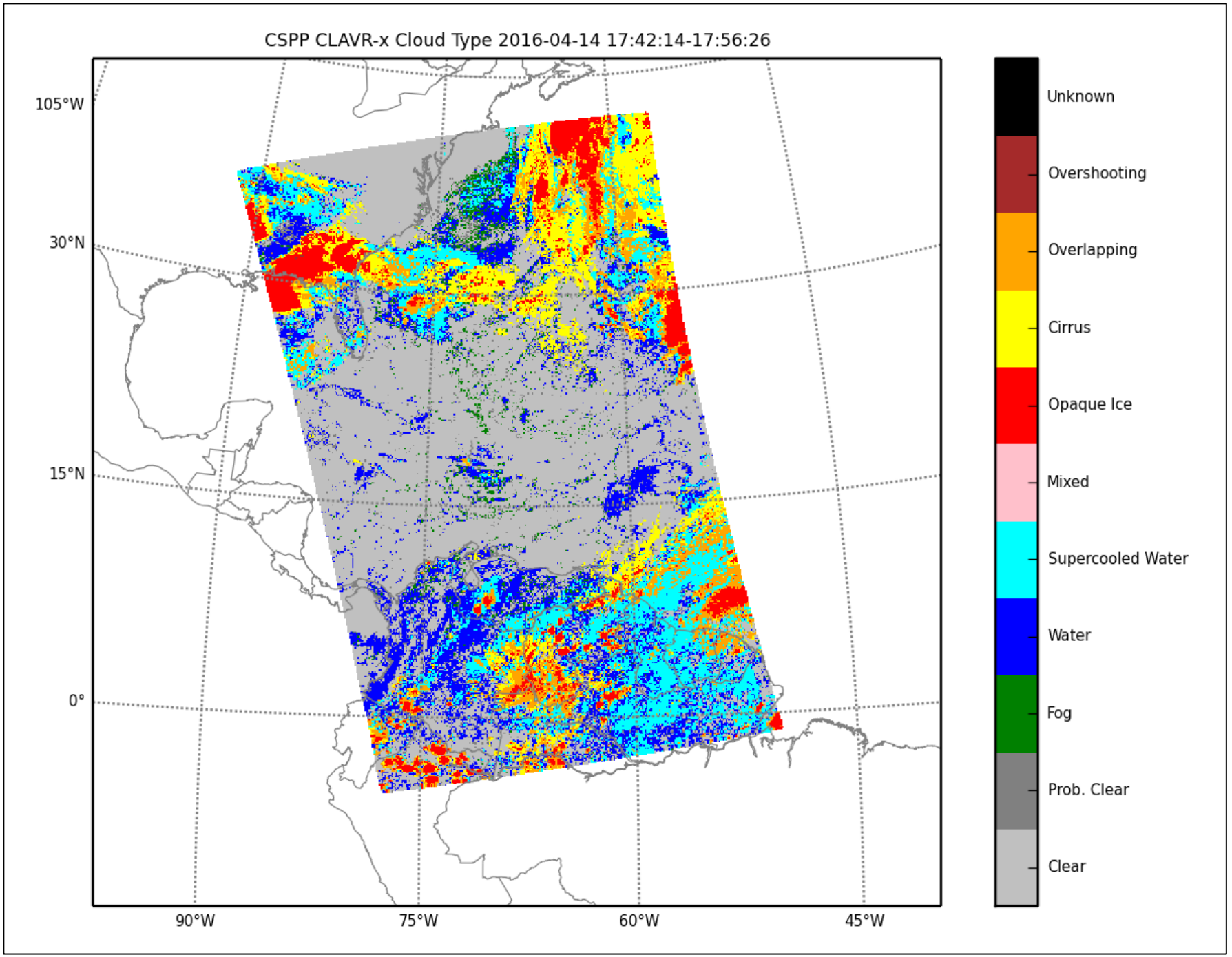
CLAVRx.npp_d20160414_t0452417_e0505279_b23123.level2.hdf
– NOAA Clouds from AVHRR Extended (CLAVR-x)

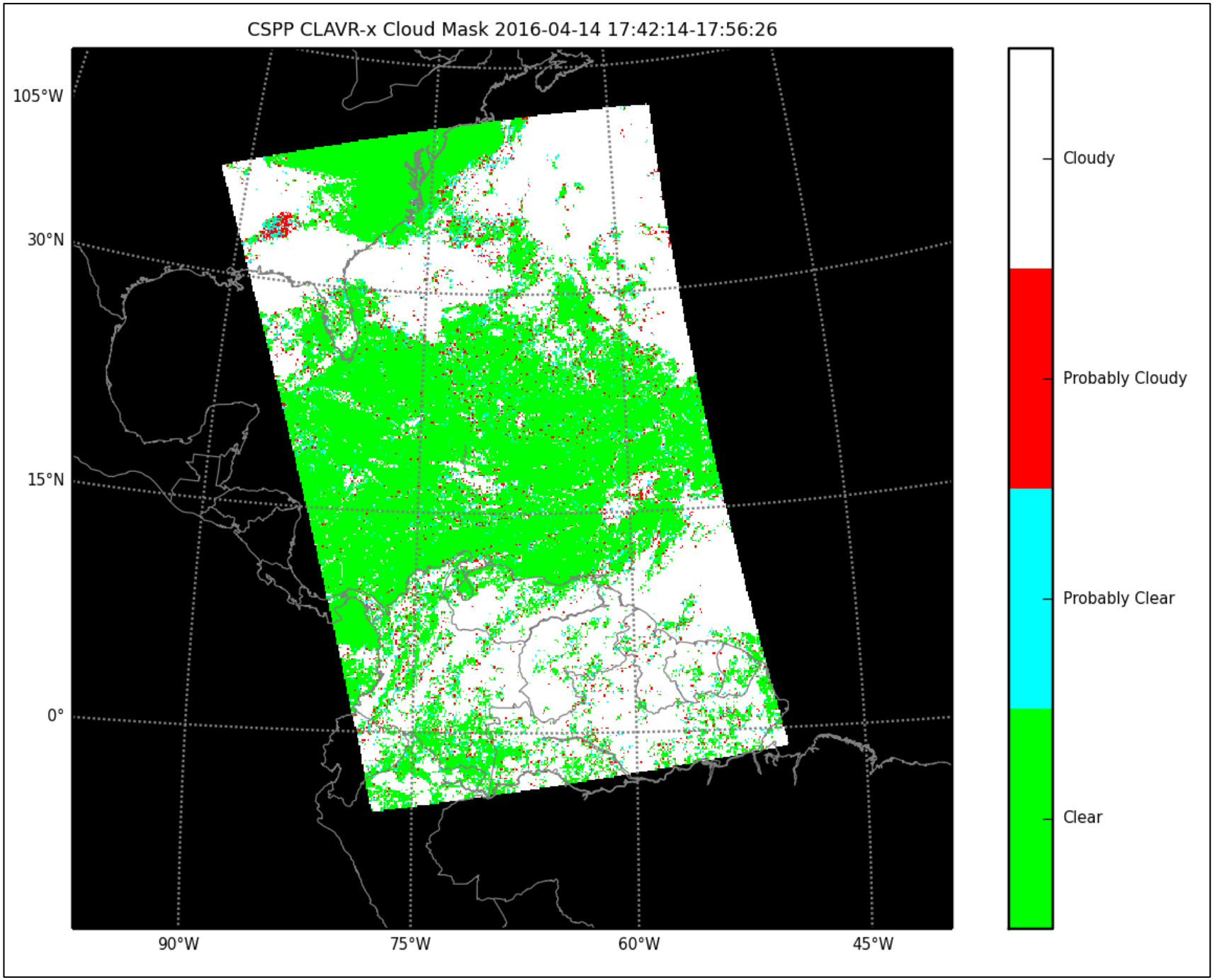
20160414045241-STAR-L2P_GHRSST-SST1m-VIIRS_NPP-v02.0-fv01.0.nc
ACSPO_V2.31_NPP_VIIRS_2016-04-14_0452-0505_20160414.055254.nc
- NOAA/STAR Advanced Clear-Sky Processor for Oceans (ACSPO)

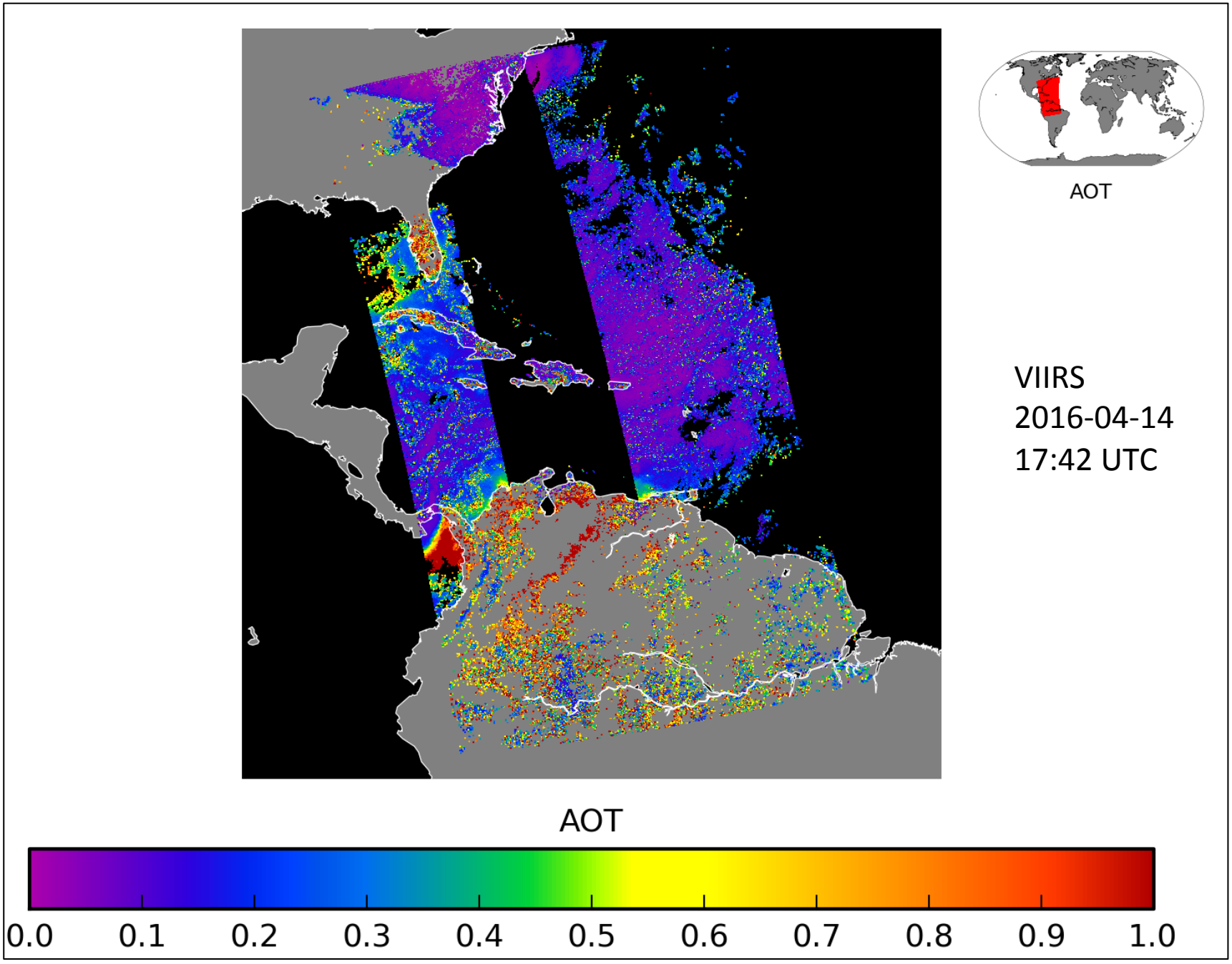
SEADAS_npp_d20160414_t1742156_e1756269.hdf - VIIRS SeaDAS Ocean Color product file

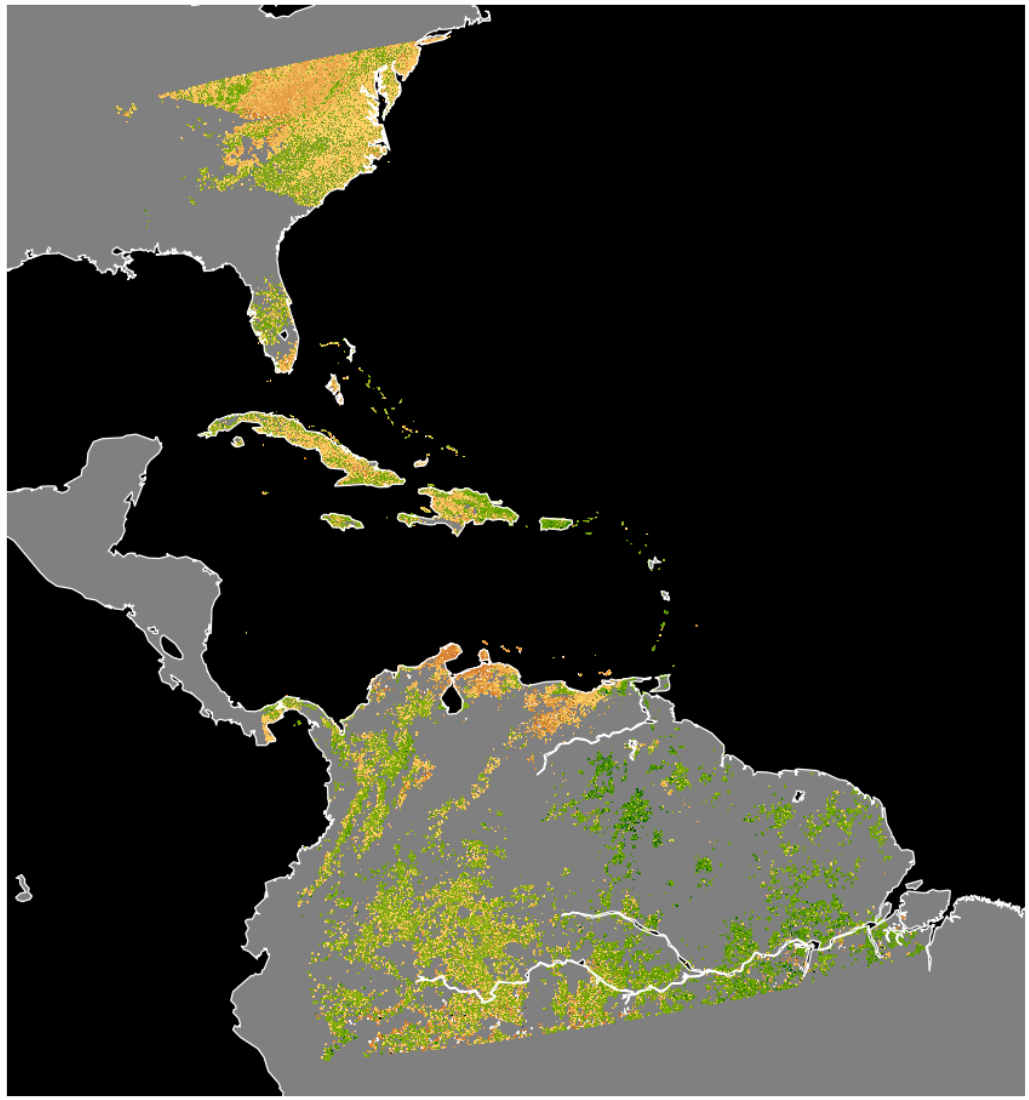
Images Directory

- Contain Images of L1B reflectances and Brightness Temperatures
- Quick look product images
- Directory also contains GeoTiff files of every VIIRS band, a subset of MODIS Bands
- True color GeoTIFF
- .0001 Radian Resolution (about 600m)


CSPP CLAVR-x Cloud Type 2016-04-14 17:42:14-17:56:26
105°W
30°N
15°N
0°
90°W
75°W
60°W
45°W
Unknown
Overshooting
Overlapping
Cirrus
Opaque Ice
Mixed
Supercooled Water
Water
Fog
Prob. Clear
Clear


CSPP CLAVR-x Cloud Mask 2016-04-14 17:42:14-17:56:26
105°W
30°N
15°N
0°
90°W
75°W
60°W
45°W
Cloudy
Probably Cloudy
Probably Clear
Clear

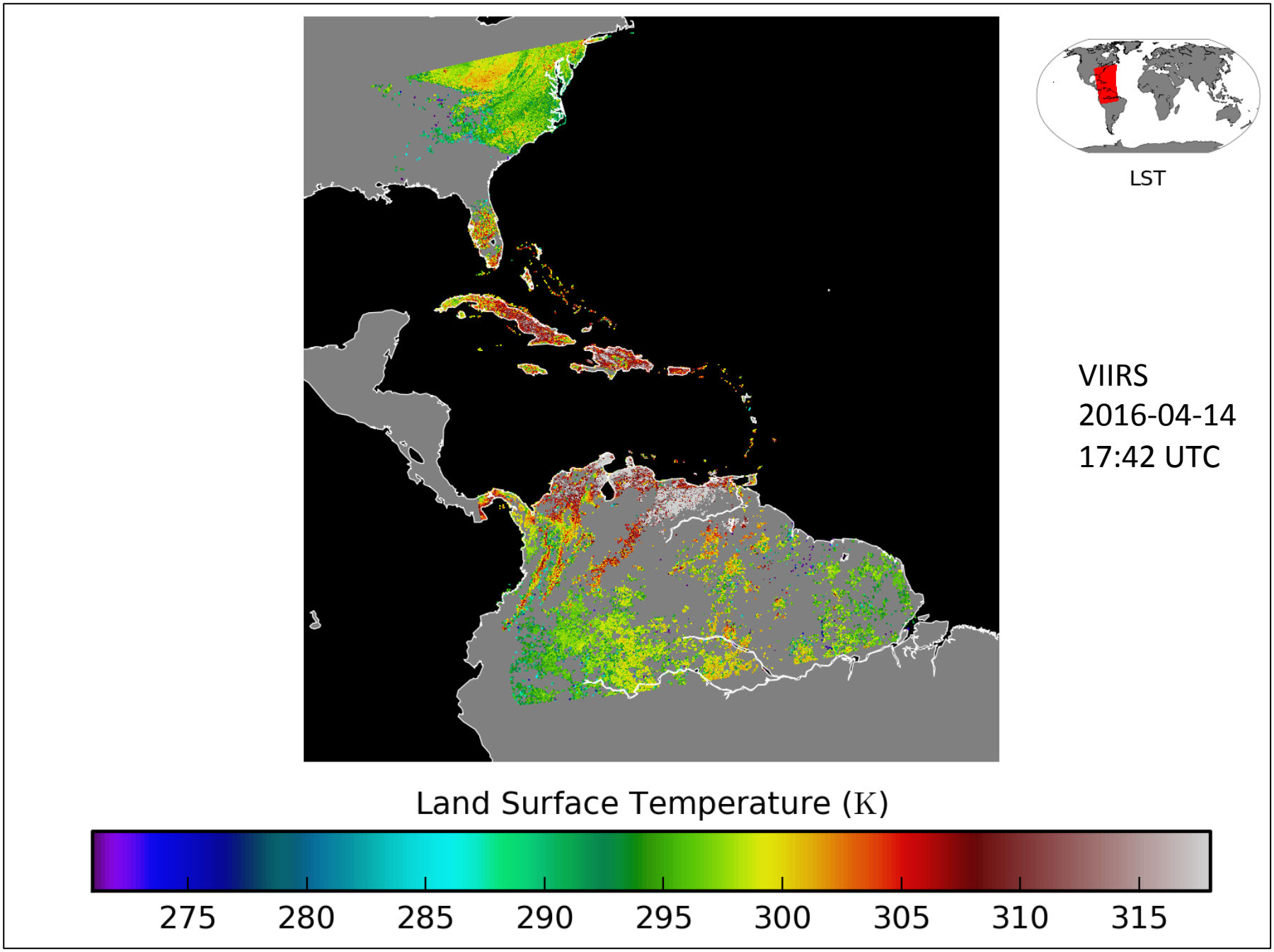

AOT
VIIRS
2016-04-14
17:42 UTC
AOT
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0

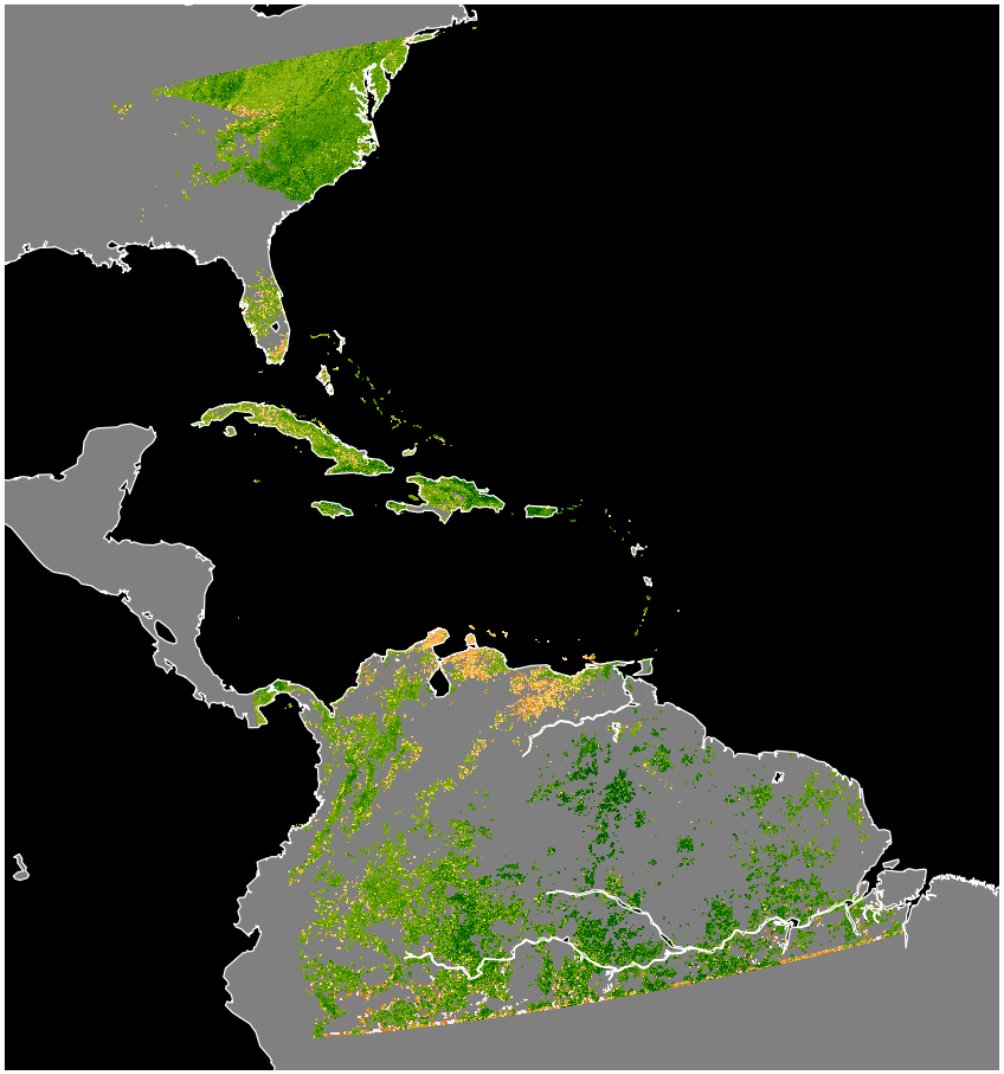


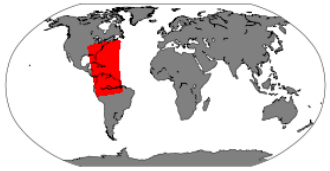
TOC EVI

VIIRS
2016-04-14
17:42 UTC

Vegetation Index


LST
VIIRS
2016-04-14
17:42 UTC
Land Surface Temperature (K)
275
280
285
290
295
300
305
310
315

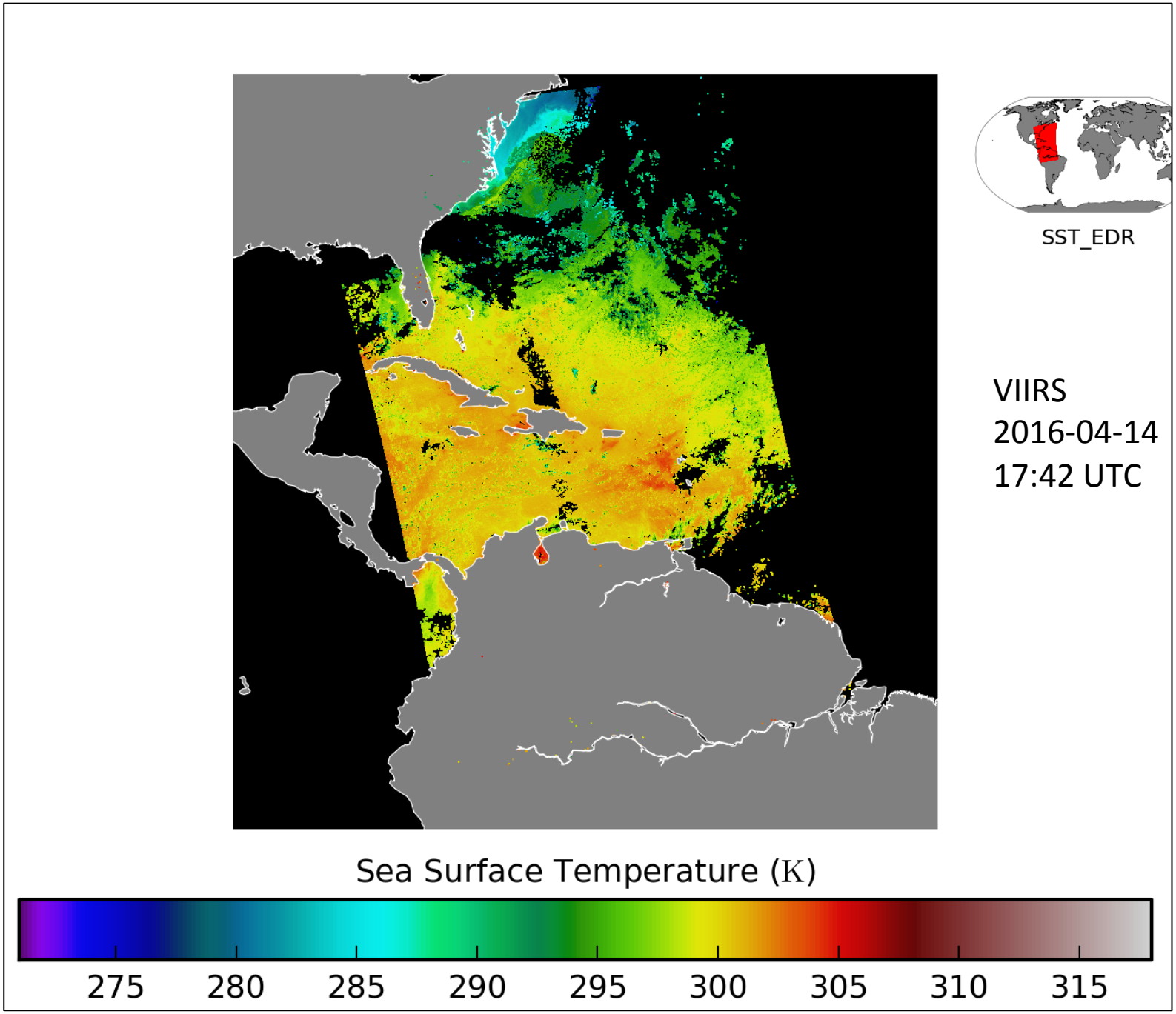




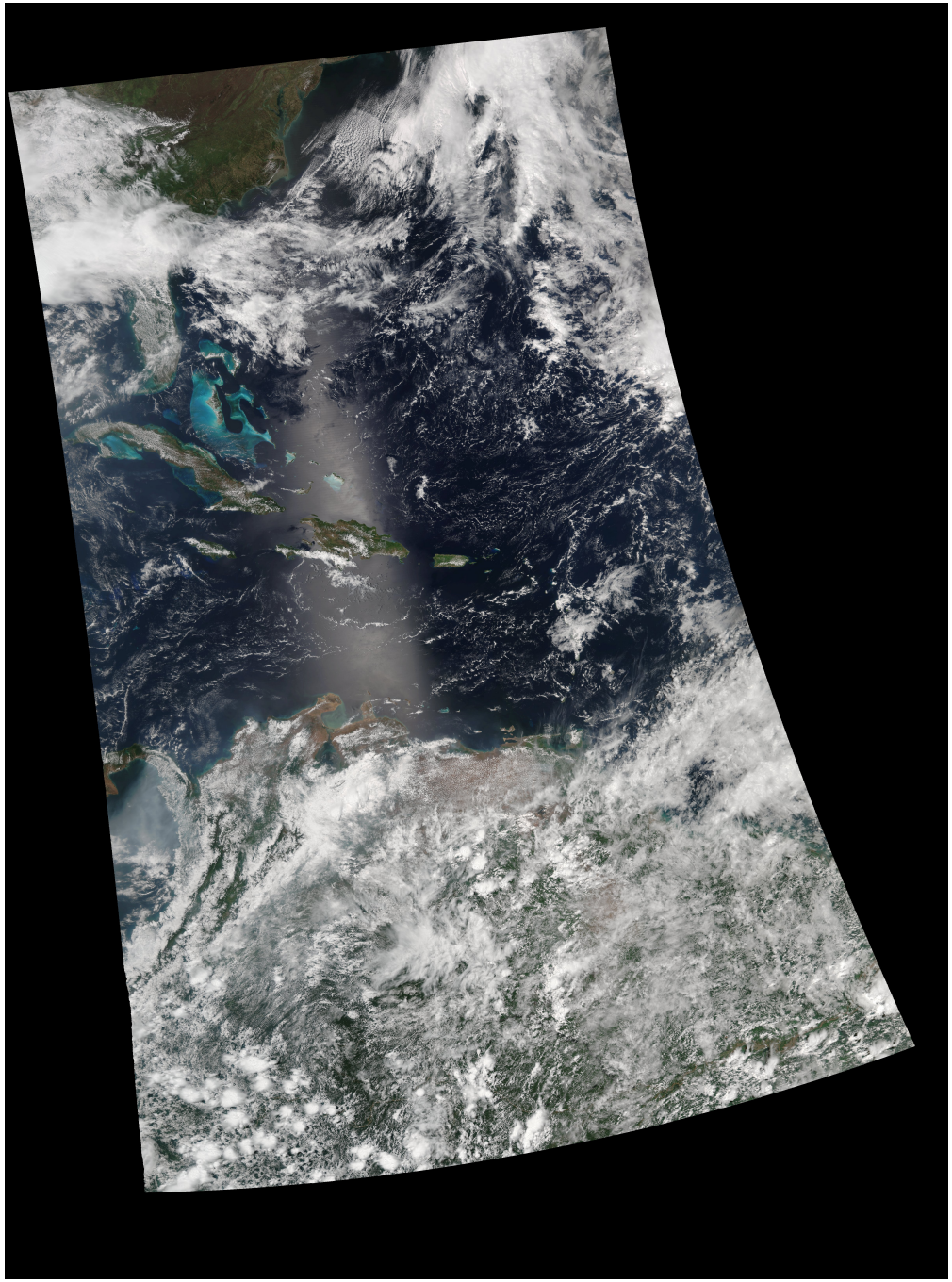
TOA NDVI

VIIRS
2016-04-14
17:42 UTC

Vegetation Index

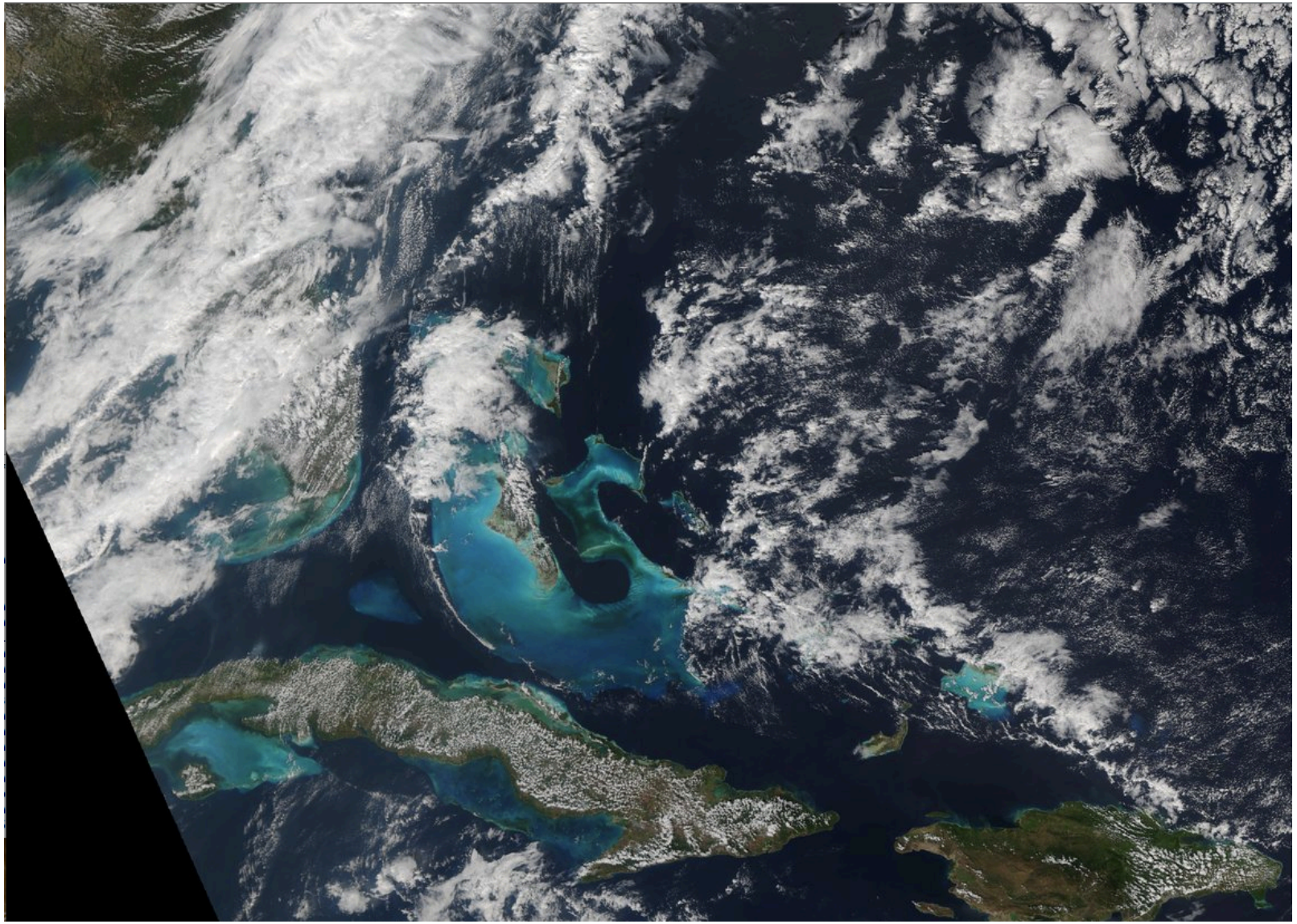

SST_EDR
VIIRS
2016-04-14
17:42 UTC
Sea Surface Temperature (K)
275
280
285
290
295
300
305
310
315

VIIRS True Color Image
R: MODIS Band 1
.65 micron
G: MODIS Band 4
.55 micron
B: MODIS Band 3
.43 micron
Relfectances
20160414 17:42 UTC

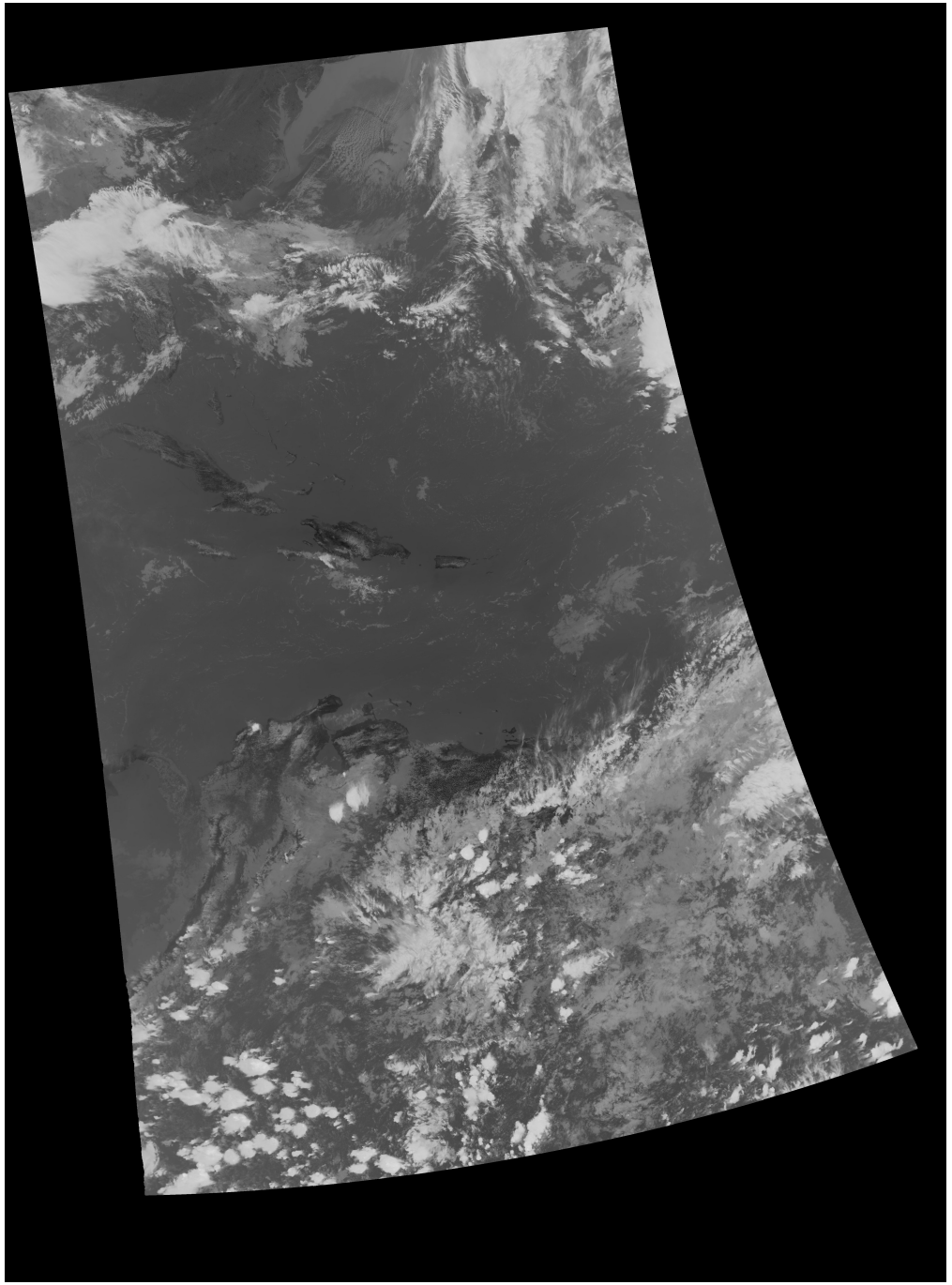


VIIRS True Color GeoTIFF

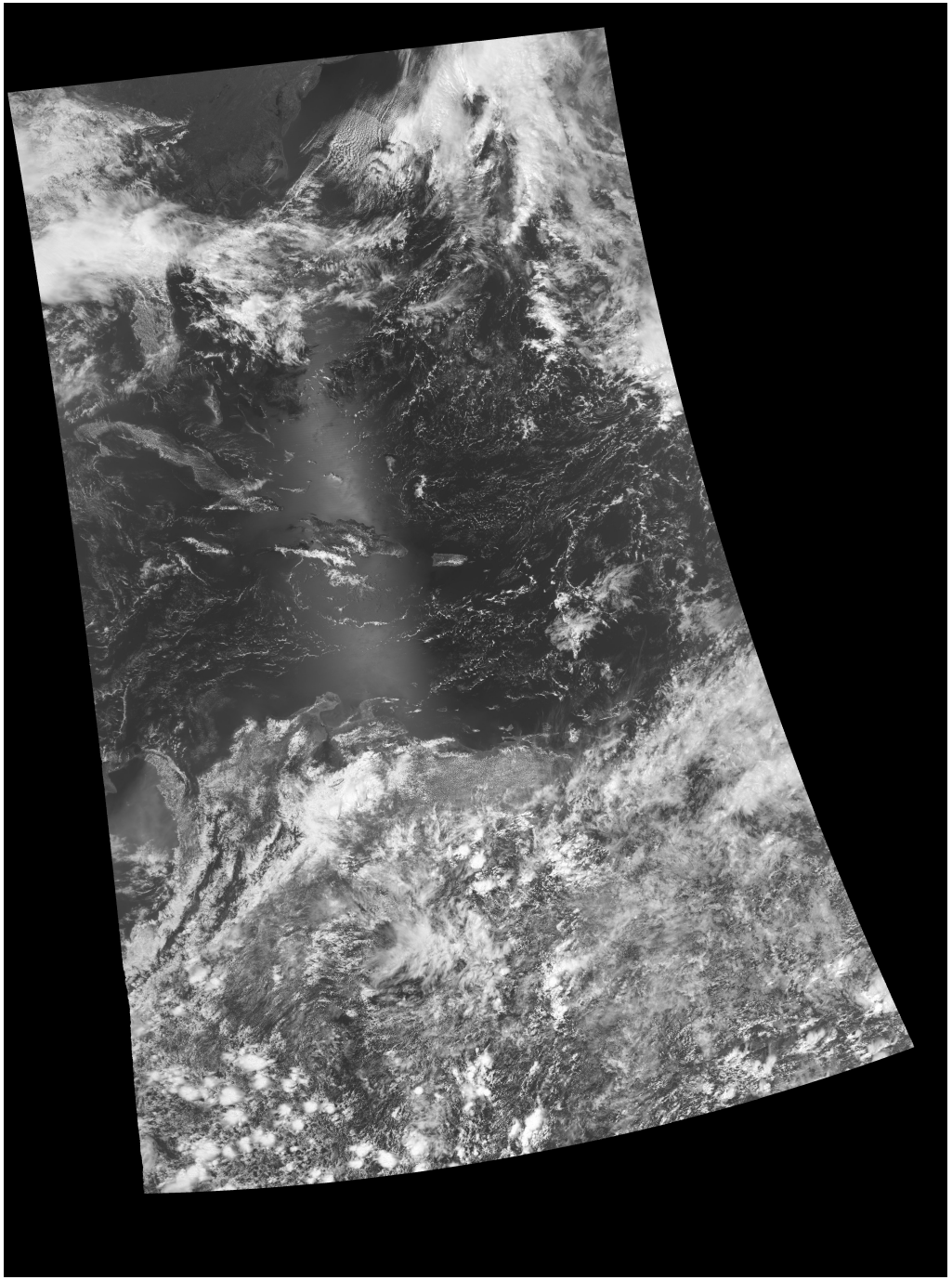
17:45 UTC 2 February 2015



VIIRS Band 14
Brightness Temperatures
(11.0 micron)
20160414 17:26 UTC



VIIRS Band 4
Reflectances
(.62 micron)
20160414 17:26 UTC



CSPP Polar2Grid Software

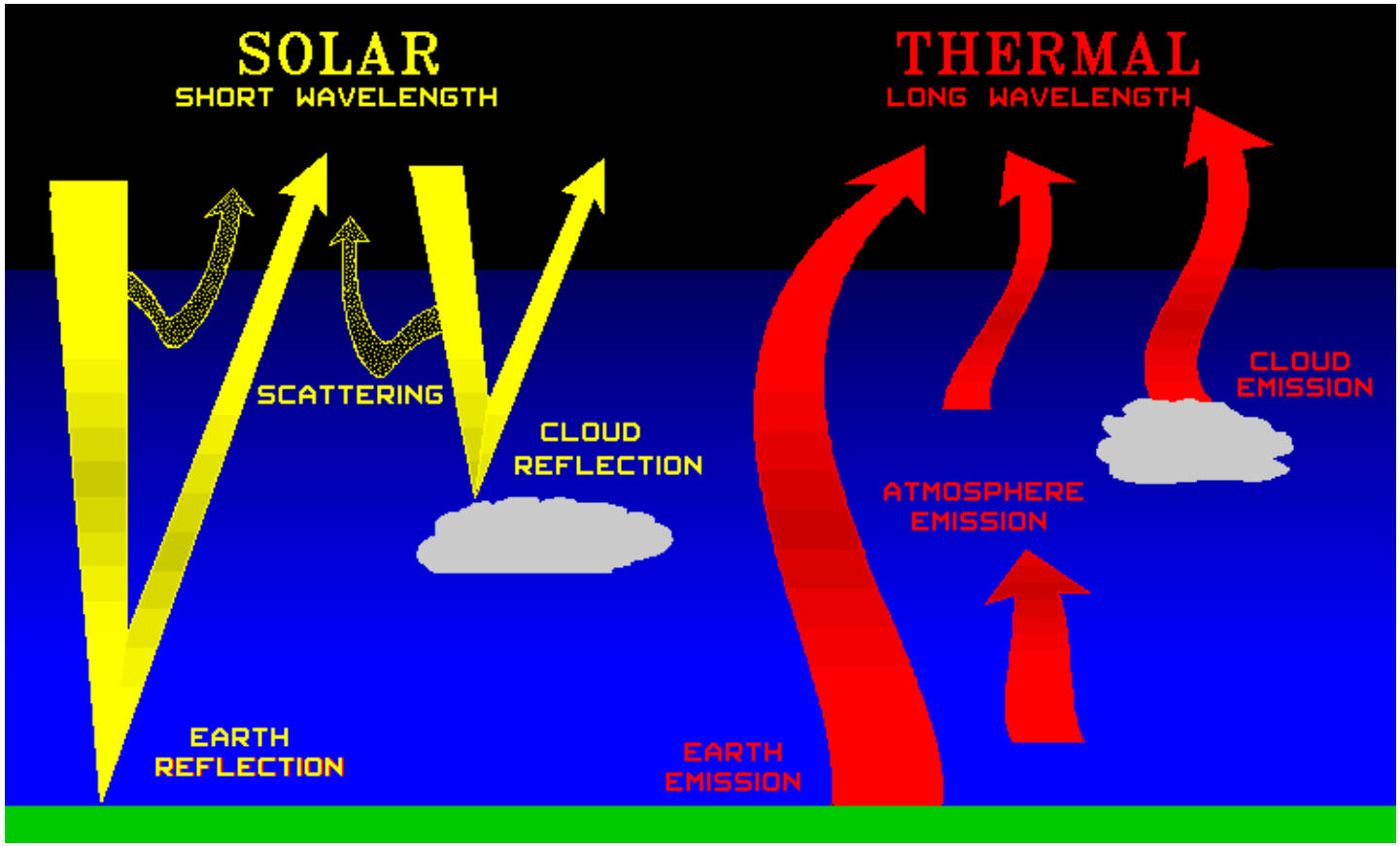
- Easy to use, efficient package to reproject MODIS L1B, VIIRS SDR an AVHRR L1B data onto user defined grid.
- Bash shell script interface to python.
- Runs corrected reflectance software as part of true color image generation (one command).
- Proj4 grids can be used.
- Default grid is Google projection.
- Github site:
  - http://github.com/davidh-ssec/polar2grid

Quick Review of Remote Sensing Basic Theory

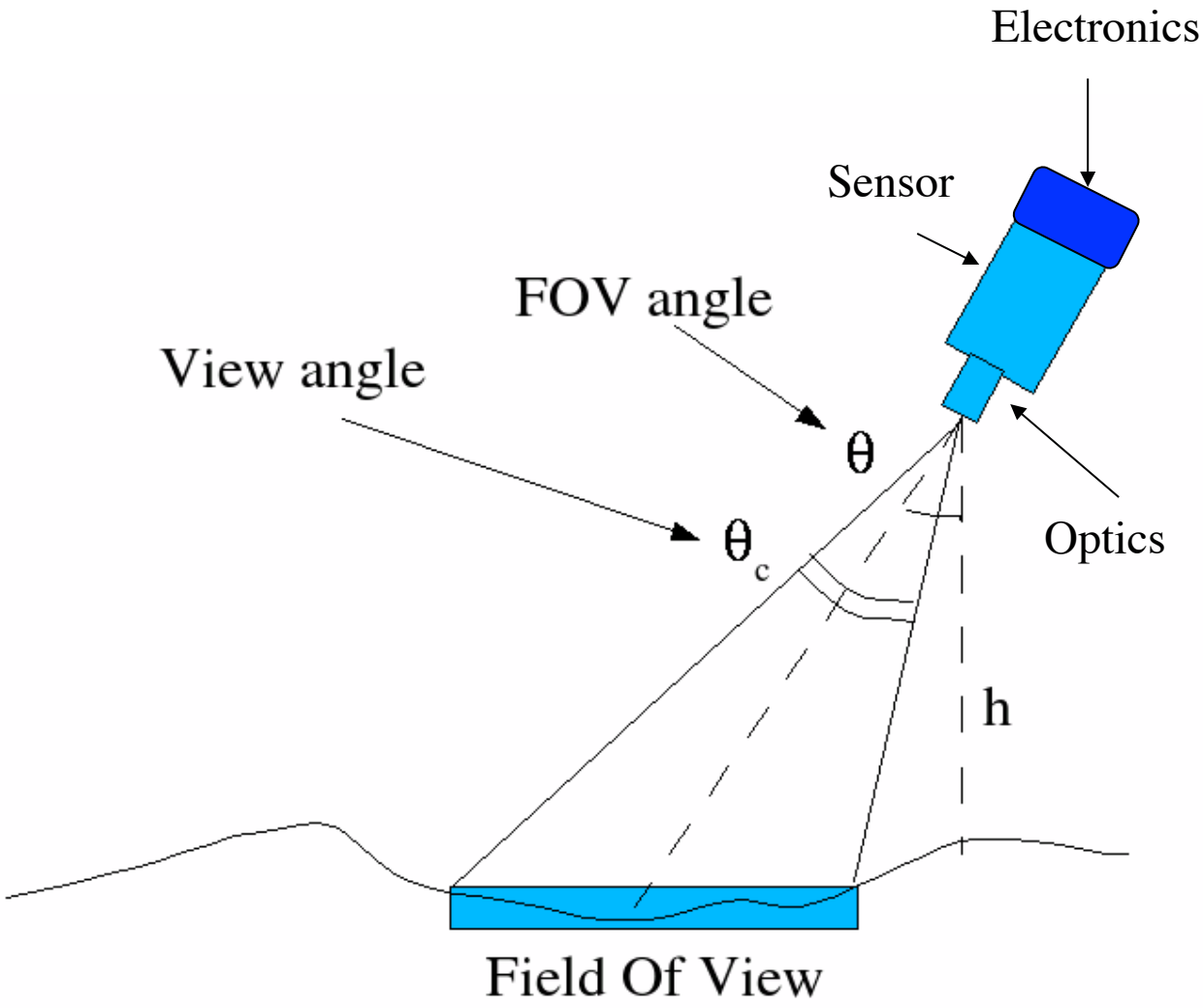
Paolo Antonelli
CIMSS
University of Wisconsin-Madison

Visible
(Solar Reflective Bands)

Infrared
(Emissive Bands)



Sensor Geometry



Terminology of radiant energy

Energy from the Earth Atmosphere

over time is

Flux

which strikes the detector area

Irradiance

at a given wavelength interval

Monochromatic Irradiance

over a solid angle on the Earth

Radiance observed by satellite radiometer

is described by

The Planck function

Can be converted to

Reflectance or Brightness Temperatures

Solar: Reflective Bands

Used to observe solar energy reflected by the Earth system in the:

- Visible between .4 and .7 μm
- NIR between .7 and 3 μm

About 99% of the energy observed between 0 and 4 μm is solar reflected energy

Only 1% is observed above 4 μm

MODIS Reflectance Bands

Primary Use	Band	Bandwidth[1]	Spectral Radiance[2]	Required SNR[3]
Land/Cloud/Aerosols Boundaries	1	620 - 670	21.8	128
	2	841 - 876	24.7	201
Land/Cloud/Aerosols Properties	3	459 - 479	35.3	243
	4	545 - 565	29.0	228
	5	1230 - 1250	5.4	74
	6	1628 - 1652	7.3	275
	7	2105 - 2155	1.0	110
Ocean Color/ Phytoplankton/ Biogeochemistry	8	405 - 420	44.9	880
	9	438 - 448	41.9	838
	10	483 - 493	32.1	802
	11	526 - 536	27.9	754
	12	546 - 556	21.0	750
	13	662 - 672	9.5	910
	14	673 - 683	8.7	1087
	15	743 - 753	10.2	586
	16	862 - 877	6.2	516
Atmospheric Water Vapor	17	890 - 920	10.0	167
	18	931 - 941	3.6	57
	19	915 - 965	15.0	250

VIIRS Instrument Characteristics

		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 NEΔT (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	Low	44.9	352	441	25%
						Aerosols	High	155	316	807	155%
		M2	0.445	0.742 x 0.259	1.60 x 1.58	Ocean Color	Low	40	380	524	38%
						Aerosols	High	146	409	926	126%
		M3	0.488	0.742 x 0.259	1.60 x 1.58	Ocean Color	Low	32	416	542	30%
						Aerosols	High	123	414	730	76%
		M4	0.555	0.742 x 0.259	1.60 x 1.58	Ocean Color	Low	21	362	455	26%
						Aerosols	High	90	315	638	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	Low	10	242	298	23%
						Aerosols	High	68	360	522	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	Low	6.4	215	388	81%
						Aerosols	High	33.4	340	494	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	Low	300 K	0.107	0.063	69%
						Fires	High	380 K	0.423	0.334	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%

Reflectance

- To properly compare different reflective channels we need to convert observed radiance into a target physical property

- In the visible and near infrared this is done through the ratio of the observed radiance divided by the incoming energy at the top of the atmosphere

- The physical quantity is the Reflectance i.e. the fraction of solar energy reflected by the observed target

Emissive Bands

Used to observe terrestrial energy emitted by the Earth system in the IR between 4 and 15 μm

- About 99% of the energy observed in this range is emitted by the Earth
- Only 1% is observed below 4 μm
- At 4 μm the solar reflected energy can significantly affect the observations of the Earth emitted energy

MODIS Emissive Bands

Primary Use	Band	Bandwidth[1]	Spectral Radiance[2]	Required NE[delta]T(K)[4]
Surface/Cloud Temperature	20	3.660 - 3.840	0.45(300K)	0.05
	21	3.929 - 3.989	2.38(335K)	2.00
	22	3.929 - 3.989	0.67(300K)	0.07
	23	4.020 - 4.080	0.79(300K)	0.07
Atmospheric Temperature	24	4.433 - 4.498	0.17(250K)	0.25
	25	4.482 - 4.549	0.59(275K)	0.25
Cirrus Clouds Water Vapor	26	1.360 - 1.390	6.00	150(SNR)
	27	6.535 - 6.895	1.16(240K)	0.25
	28	7.175 - 7.475	2.18(250K)	0.25
Cloud Properties	29	8.400 - 8.700	9.58(300K)	0.05
Ozone	30	9.580 - 9.880	3.69(250K)	0.25
Surface/Cloud Temperature	31	10.780 - 11.280	9.55(300K)	0.05
	32	11.770 - 12.270	8.94(300K)	0.05
Cloud Top Altitude	33	13.185 - 13.485	4.52(260K)	0.25
	34	13.485 - 13.785	3.76(250K)	0.25
	35	13.785 - 14.085	3.11(240K)	0.25
	36	14.085 - 14.385	2.08(220K)	0.35

VIIRS Instrument Characteristics

		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 NEΔT (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	Low	44.9	352	441	25%
						Aerosols	High	155	316	807	155%
		M2	0.445	0.742 x 0.259	1.60 x 1.58	Ocean Color	Low	40	380	524	38%
						Aerosols	High	146	409	926	126%
		M3	0.488	0.742 x 0.259	1.60 x 1.58	Ocean Color	Low	32	416	542	30%
						Aerosols	High	123	414	730	76%
		M4	0.555	0.742 x 0.259	1.60 x 1.58	Ocean Color	Low	21	362	455	26%
						Aerosols	High	90	315	638	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	Low	10	242	298	23%
						Aerosols	High	68	360	522	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	Low	6.4	215	388	81%
						Aerosols	High	33.4	340	494	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	Low	300 K	0.107	0.063	69%
						Fires	High	380 K	0.423	0.334	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%

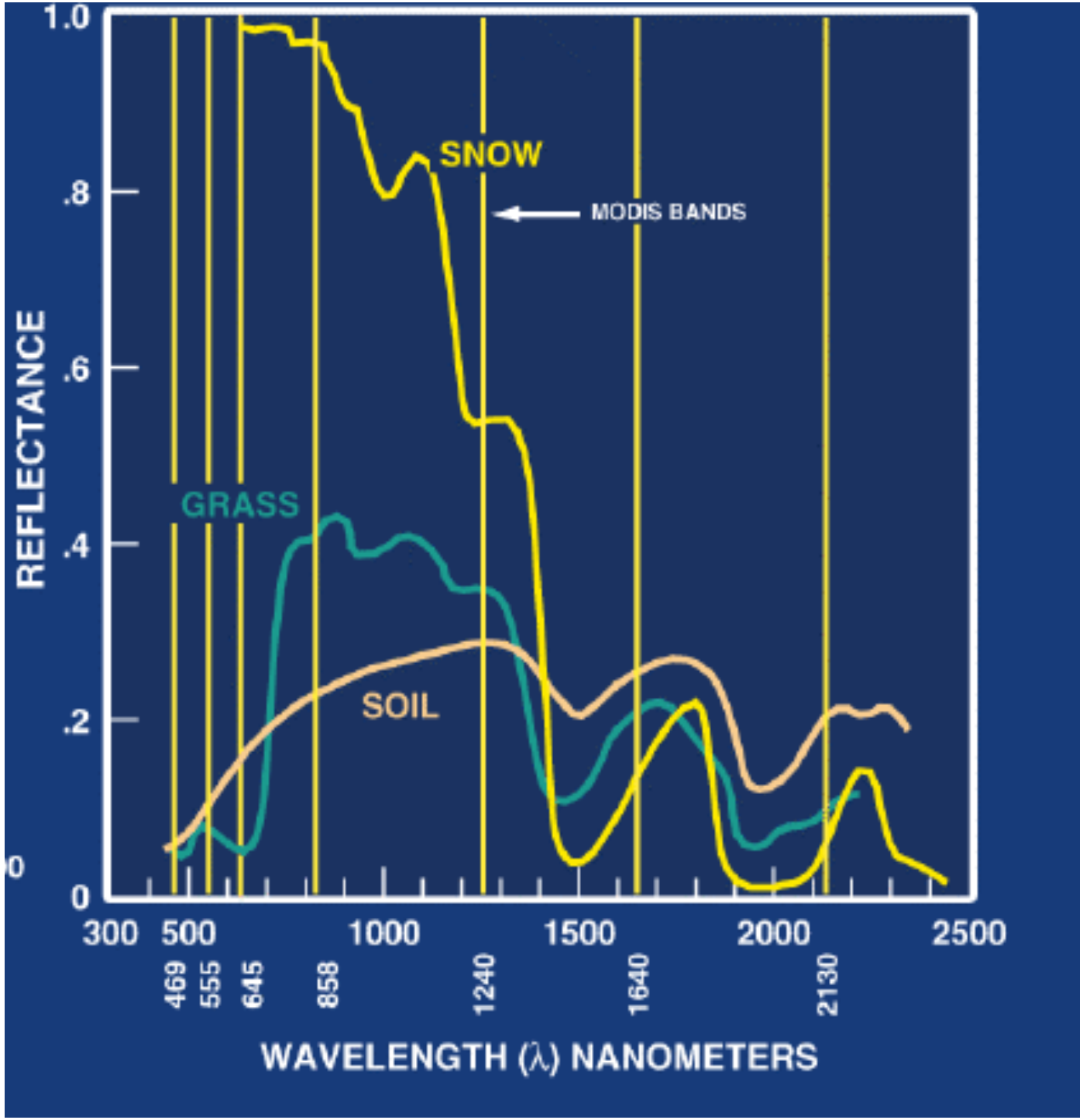
Brightness Temperature

- To properly compare different emissive channels we need to convert observed radiance into a target physical property

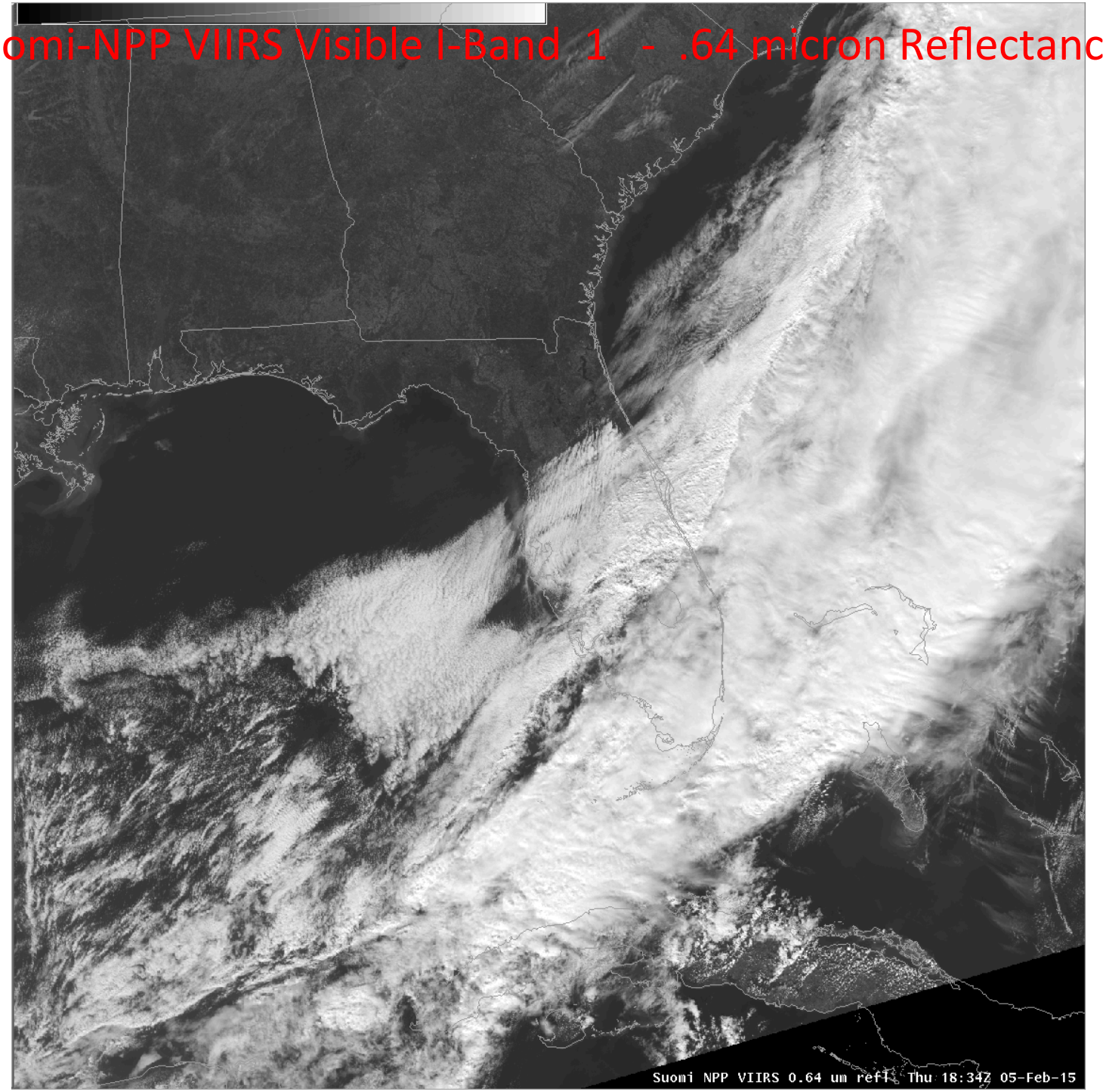
- In the Infrared this is done through the Planck function

- The physical quantity is the Brightness Temperature i.e. the Temperature of a black body emitting the observed radiance

VIIRS and MODIS observations and products

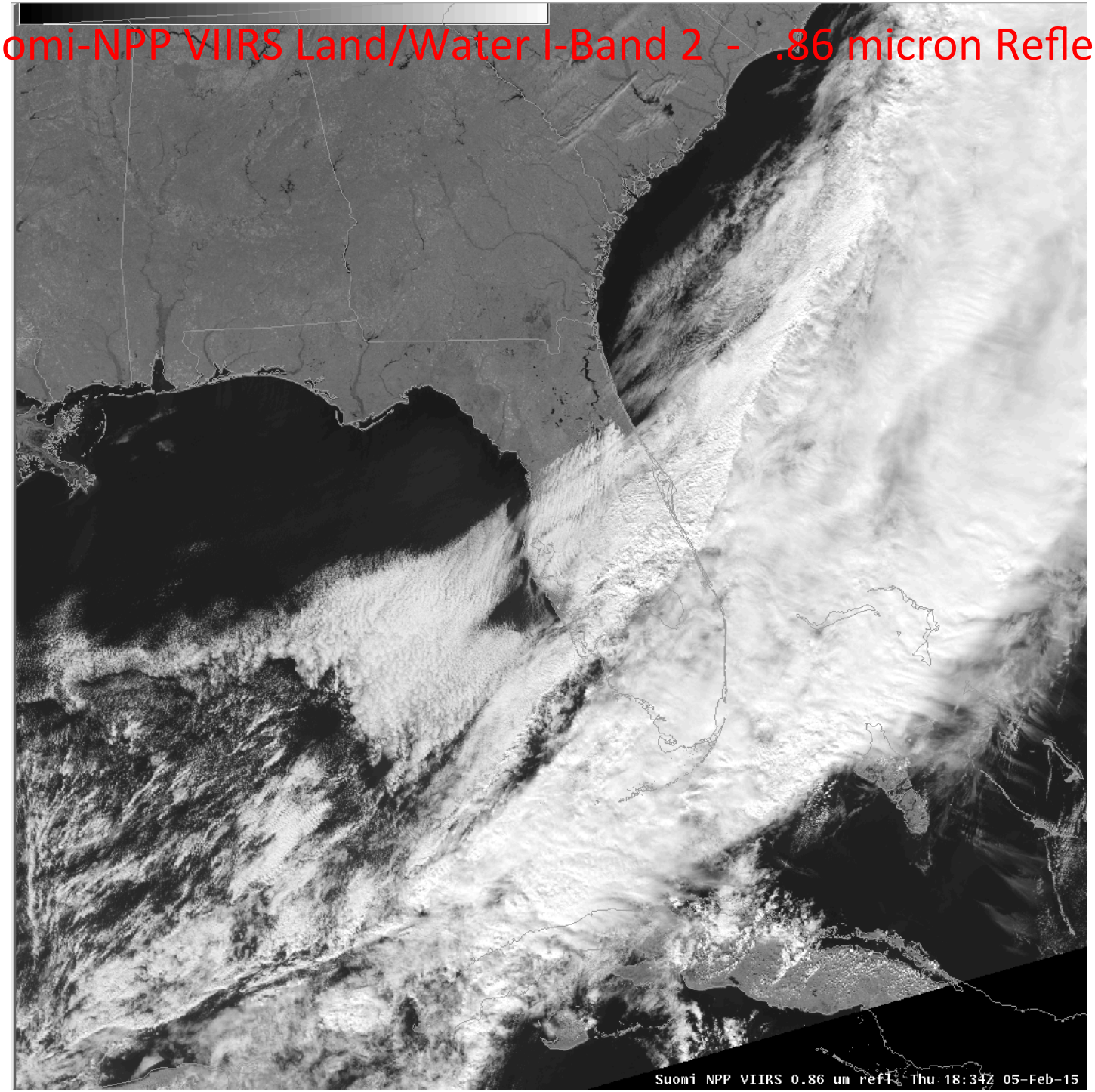

1.0
.8
.6
.4
.2
0
REFLECTANCE
SNOW
MODIS BANDS
GRASS
SOIL
300
500
1000
1500
2000
2500
469
555
645
858
1240
1640
2130
WAVELENGTH (λ) NANOMETERS

Suomi-NPP VIIRS Visible I-Band 1 - .64 micron Reflectances



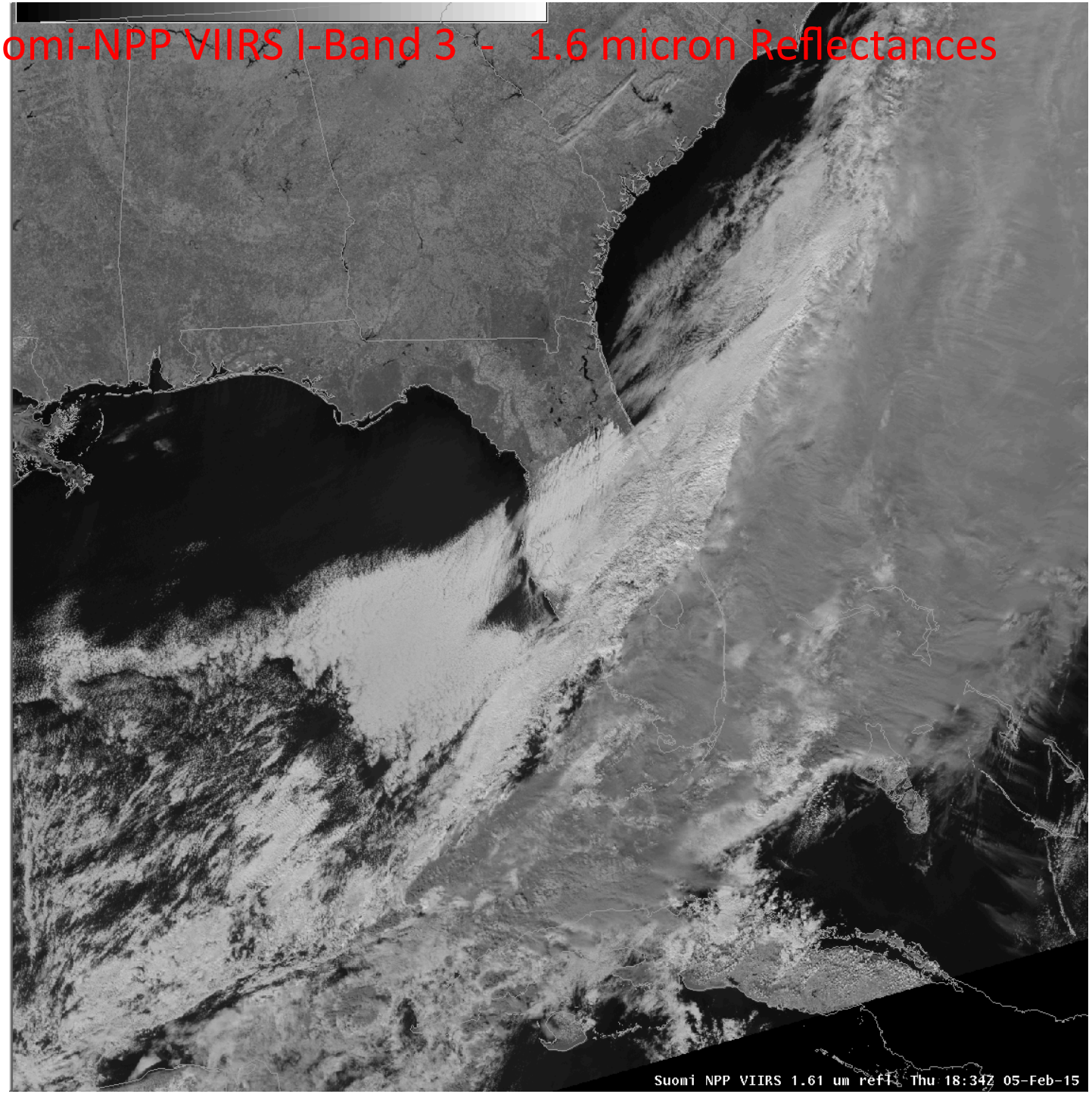
Day

Suomi-NPP VIIRS Land/Water I-Band 2 - .86 micron Reflectances



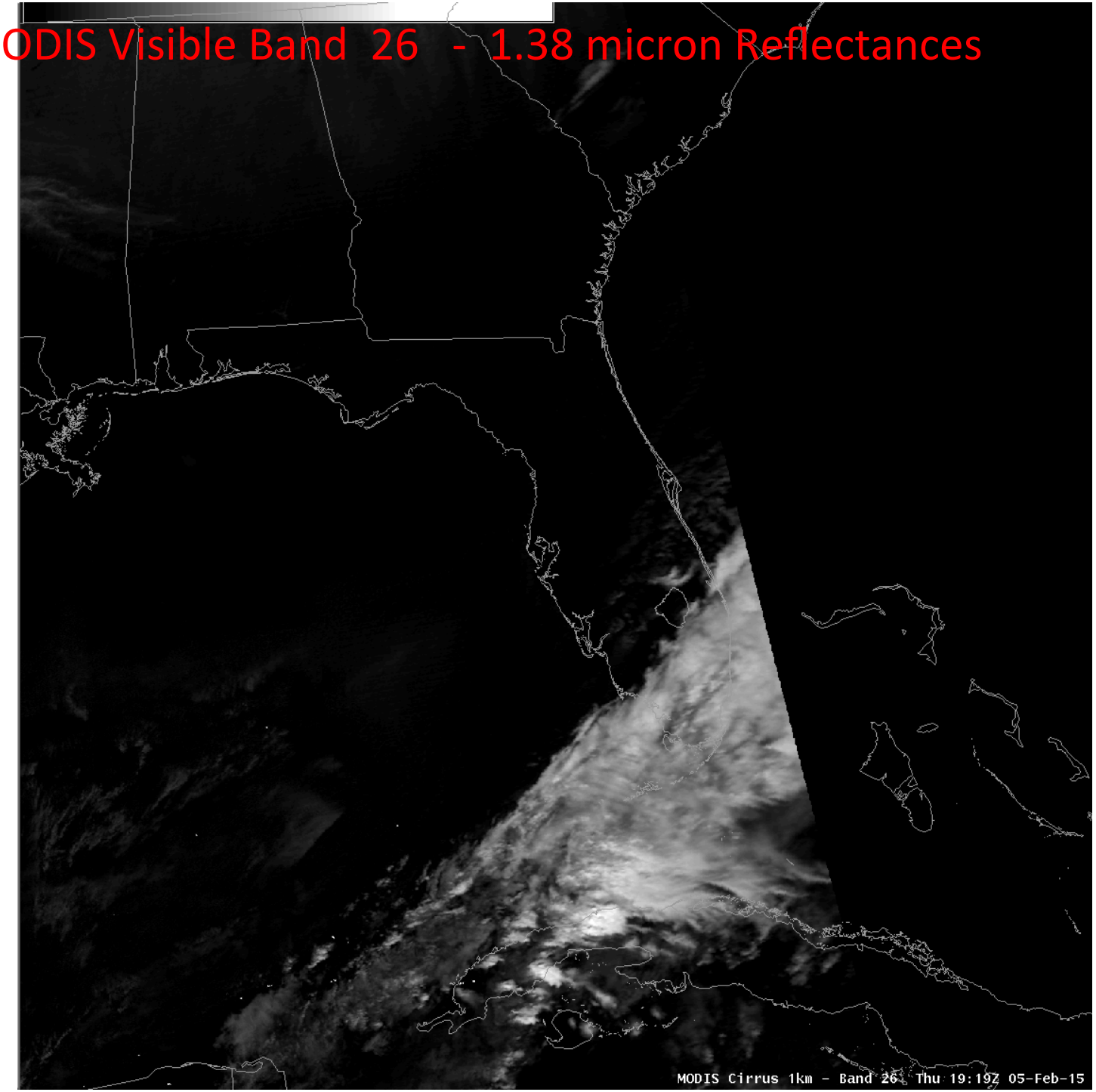
Day

Suomi-NPP VIIRS I-Band 3 - 1.6 micron Reflectances



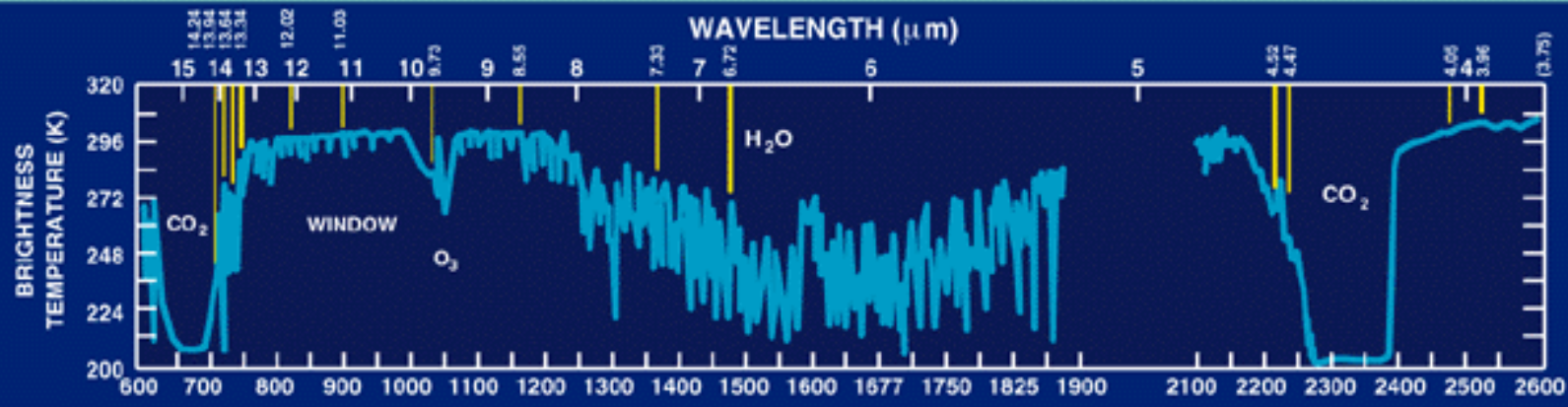
Day

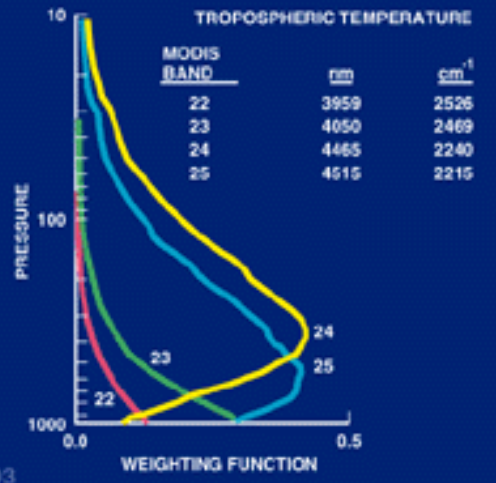
MODIS Visible Band 26 - 1.38 micron Reflectances

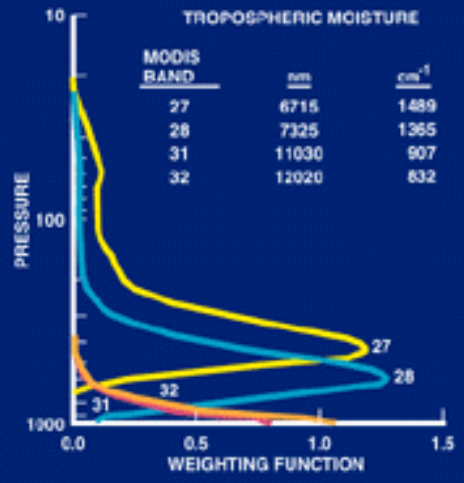


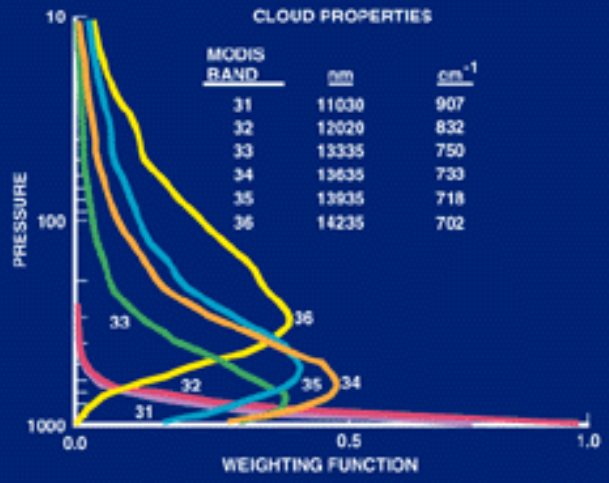
Day

ATMOSPHERE - THERMAL RADIATION





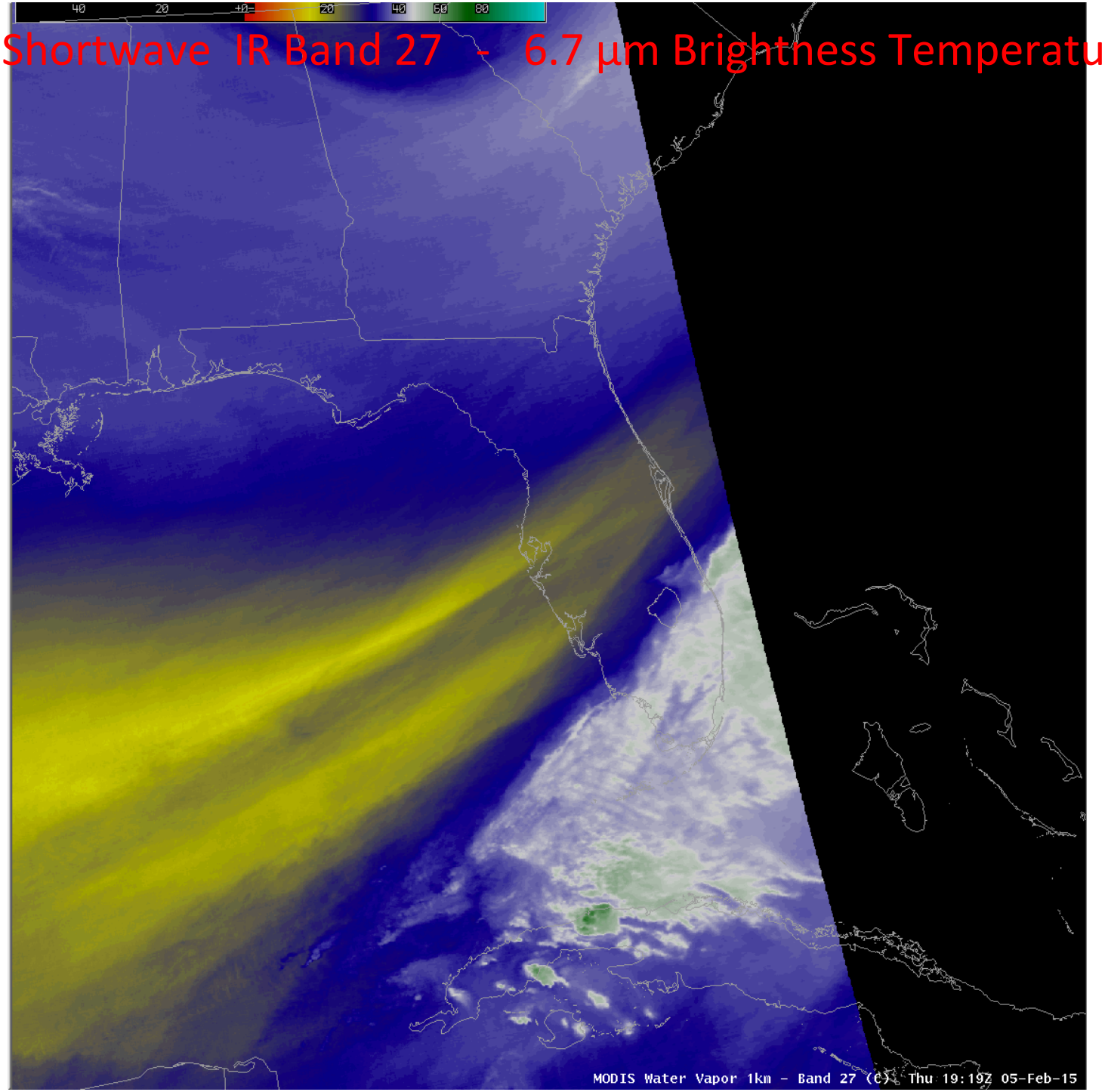




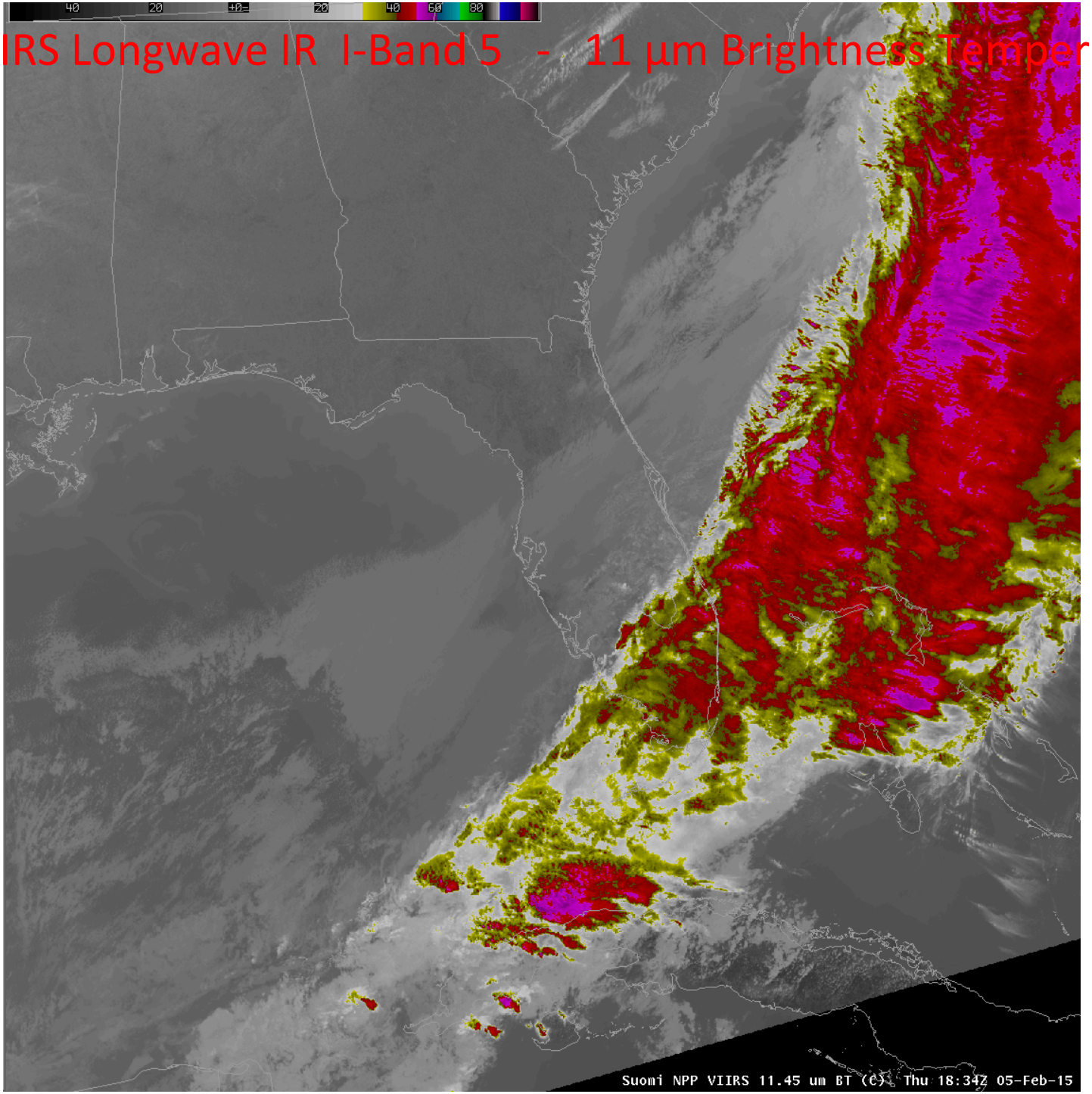
E351.002 5/93

MODIS Shortwave IR Band 27 - 6.7 µm Brightness Temperatures

Day

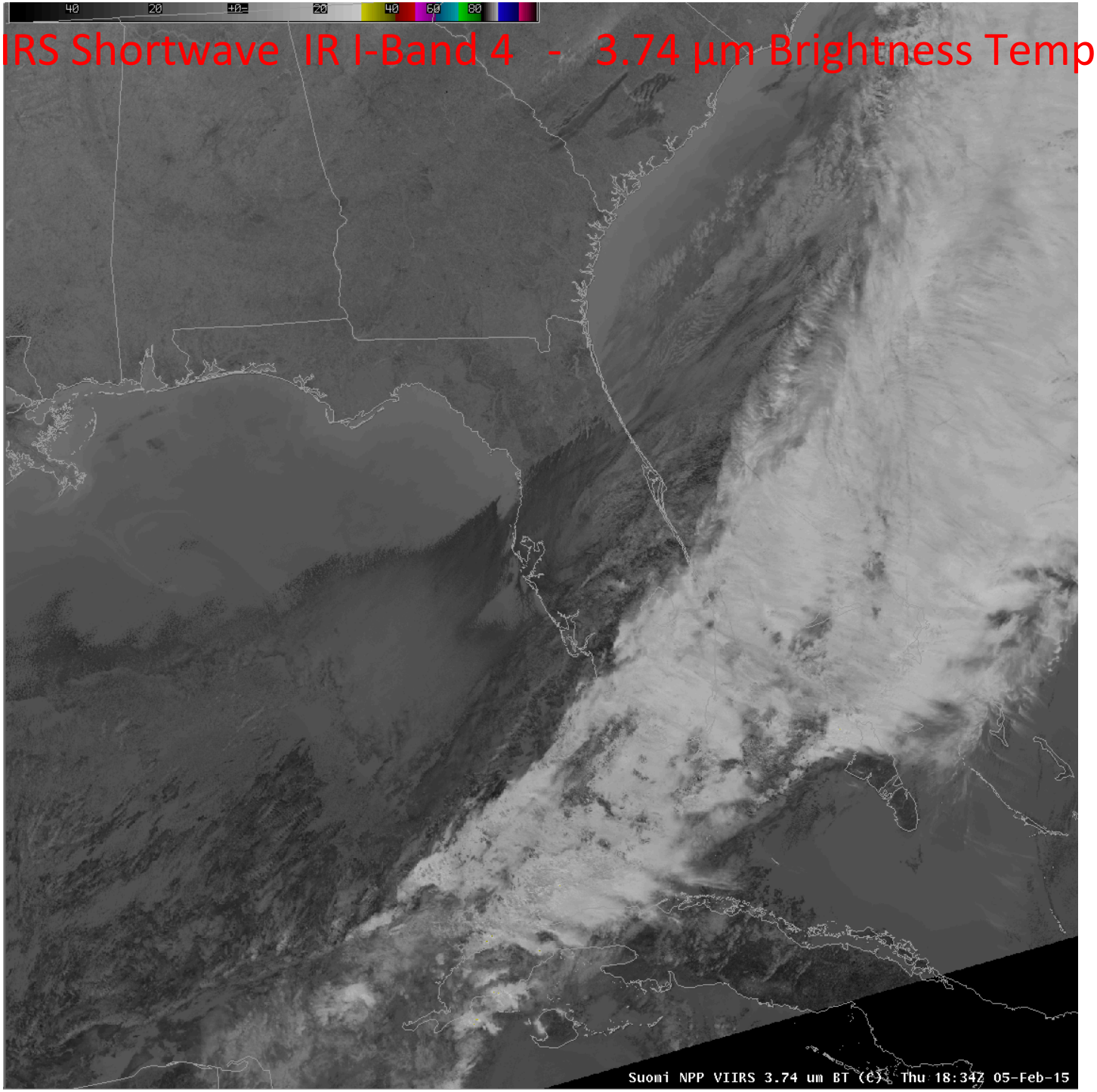


S-NPP VIIRS Longwave IR I-Band 5 - 11 µm Brightness Temperatures



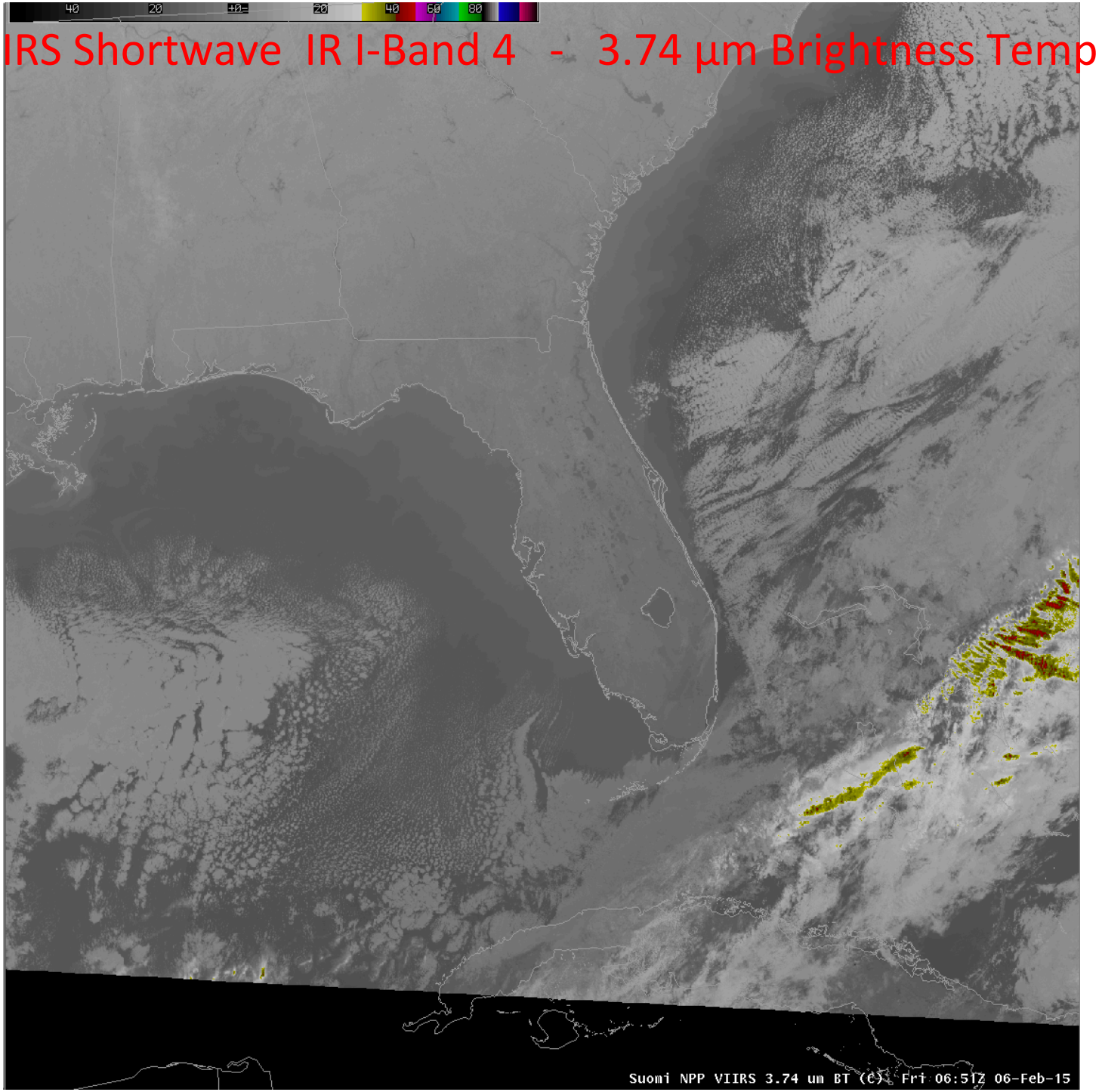
Day

S-NPP VIIRS Shortwave IR I-Band 4 - 3.74 µm Brightness Temperatures



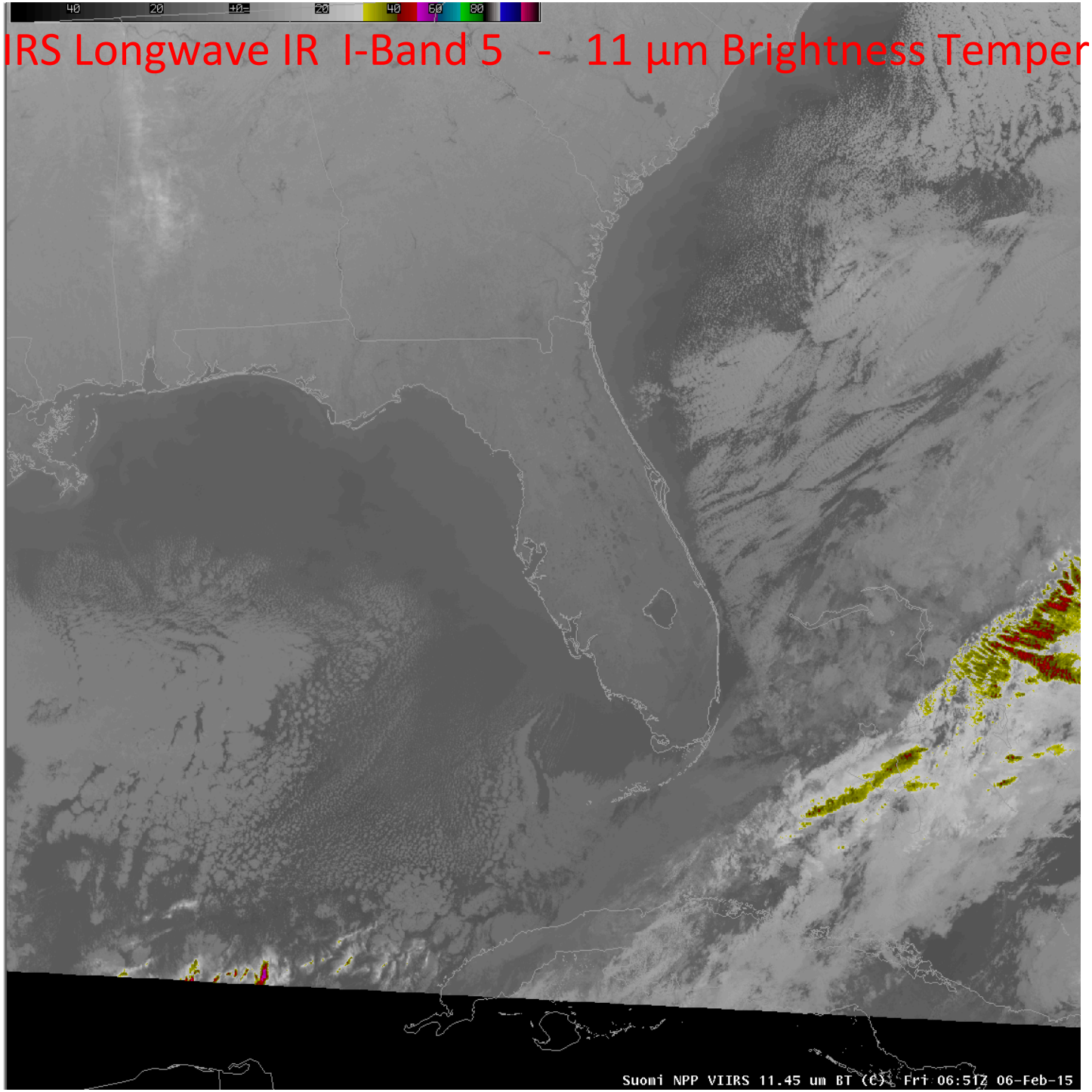
Day

S-NPP VIIRS Shortwave IR I-Band 4 - 3.74 µm Brightness Temperatures

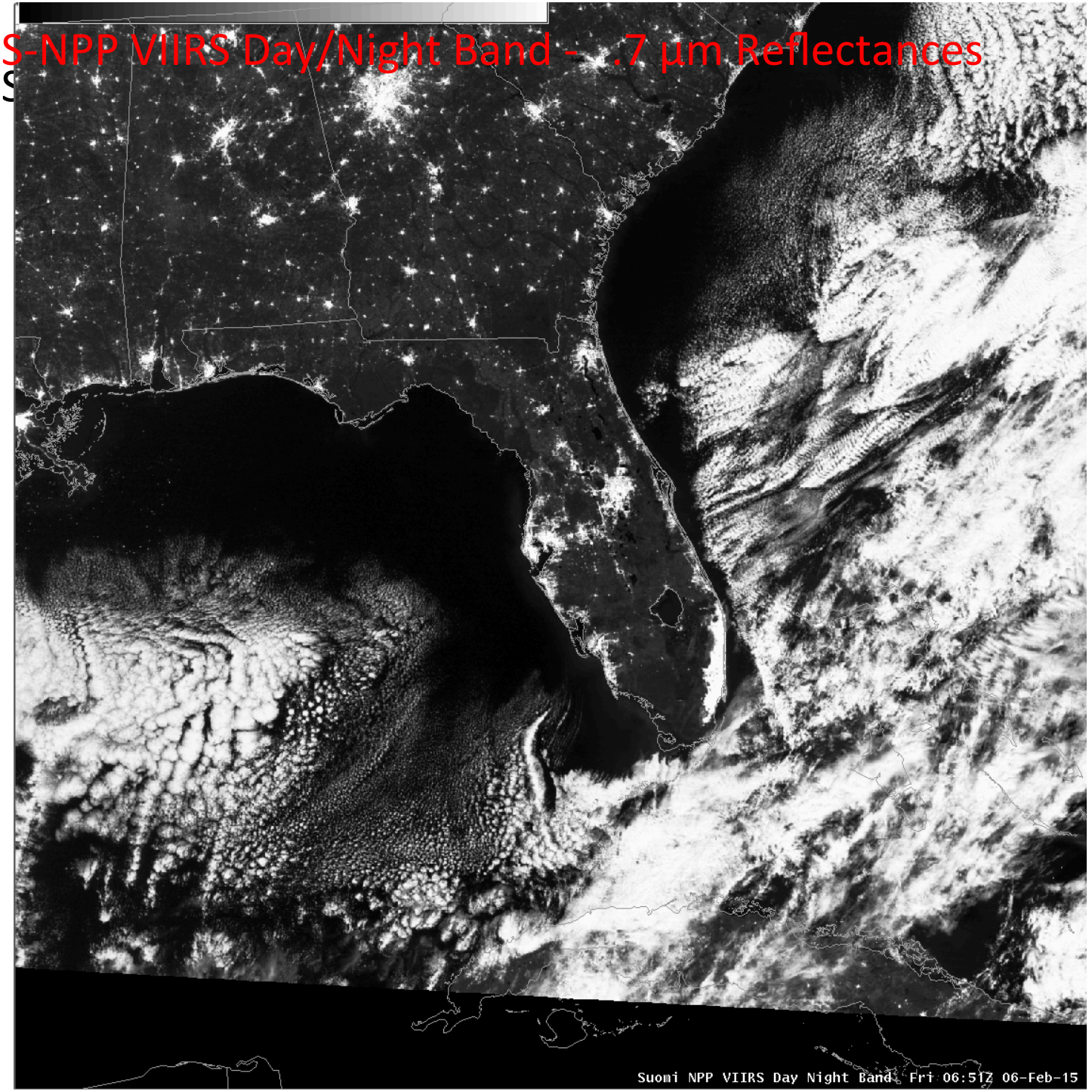


Night

S-NPP VIIRS Longwave IR I-Band 5 - 11 µm Brightness Temperatures

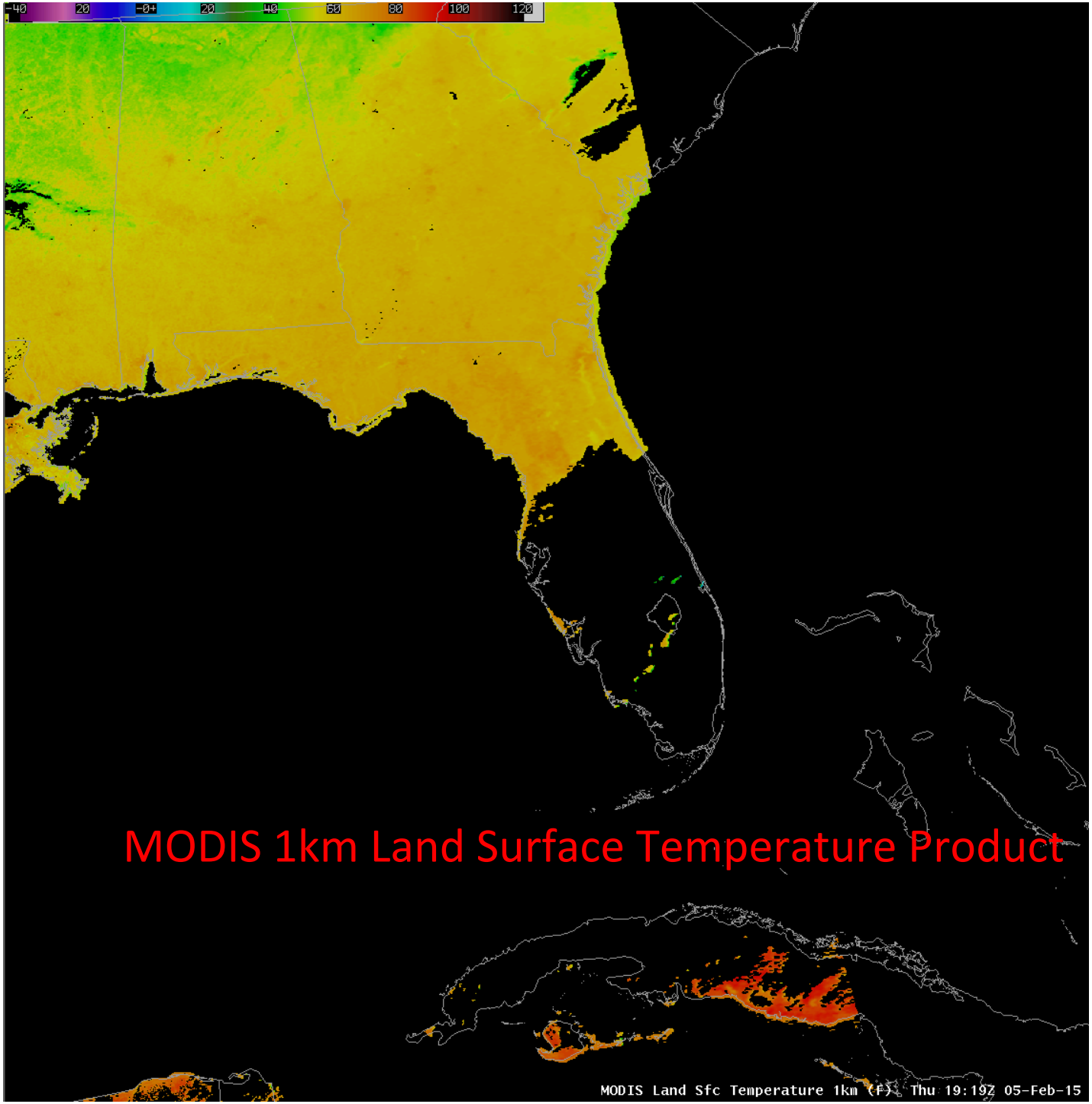


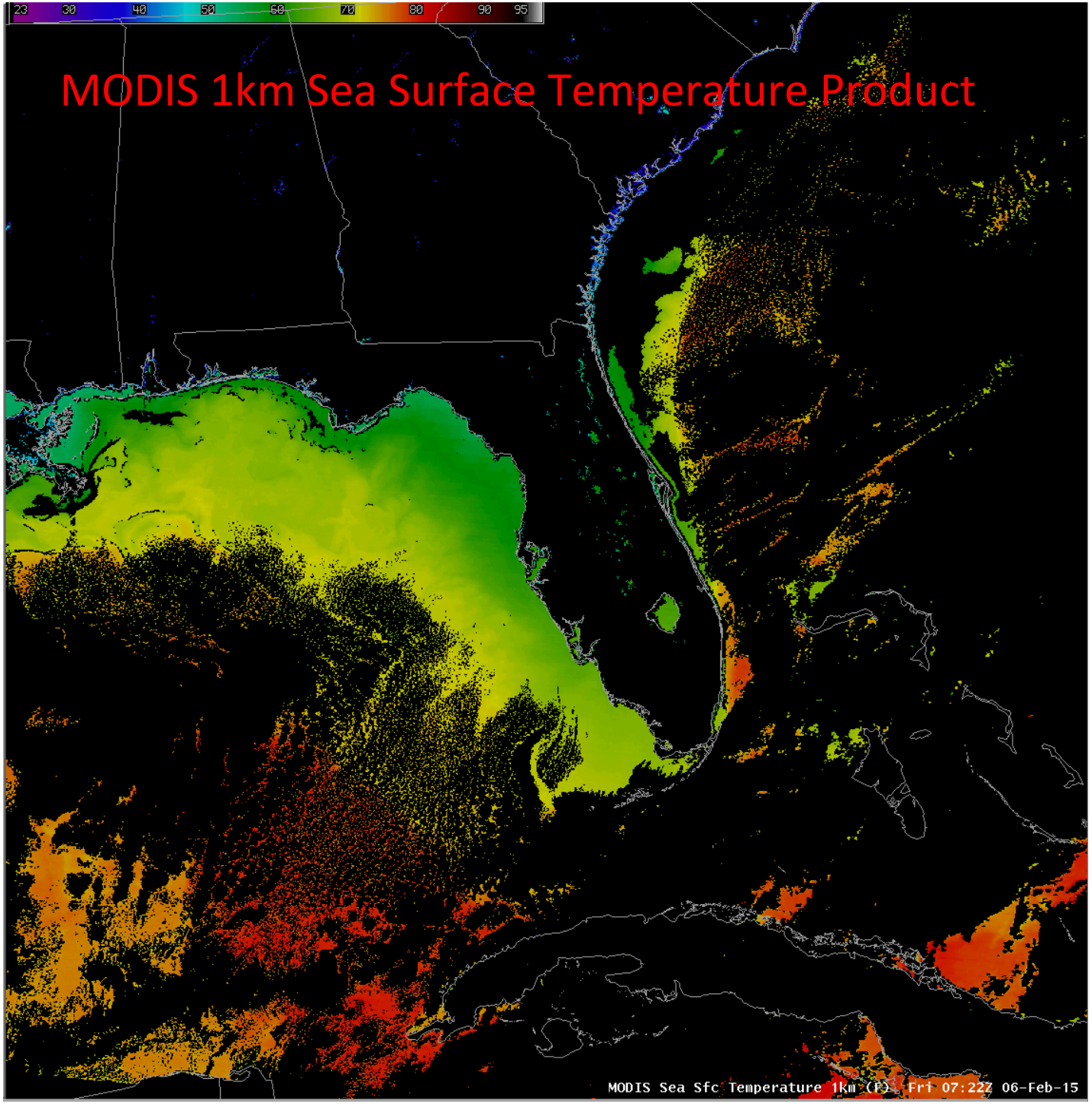
Night

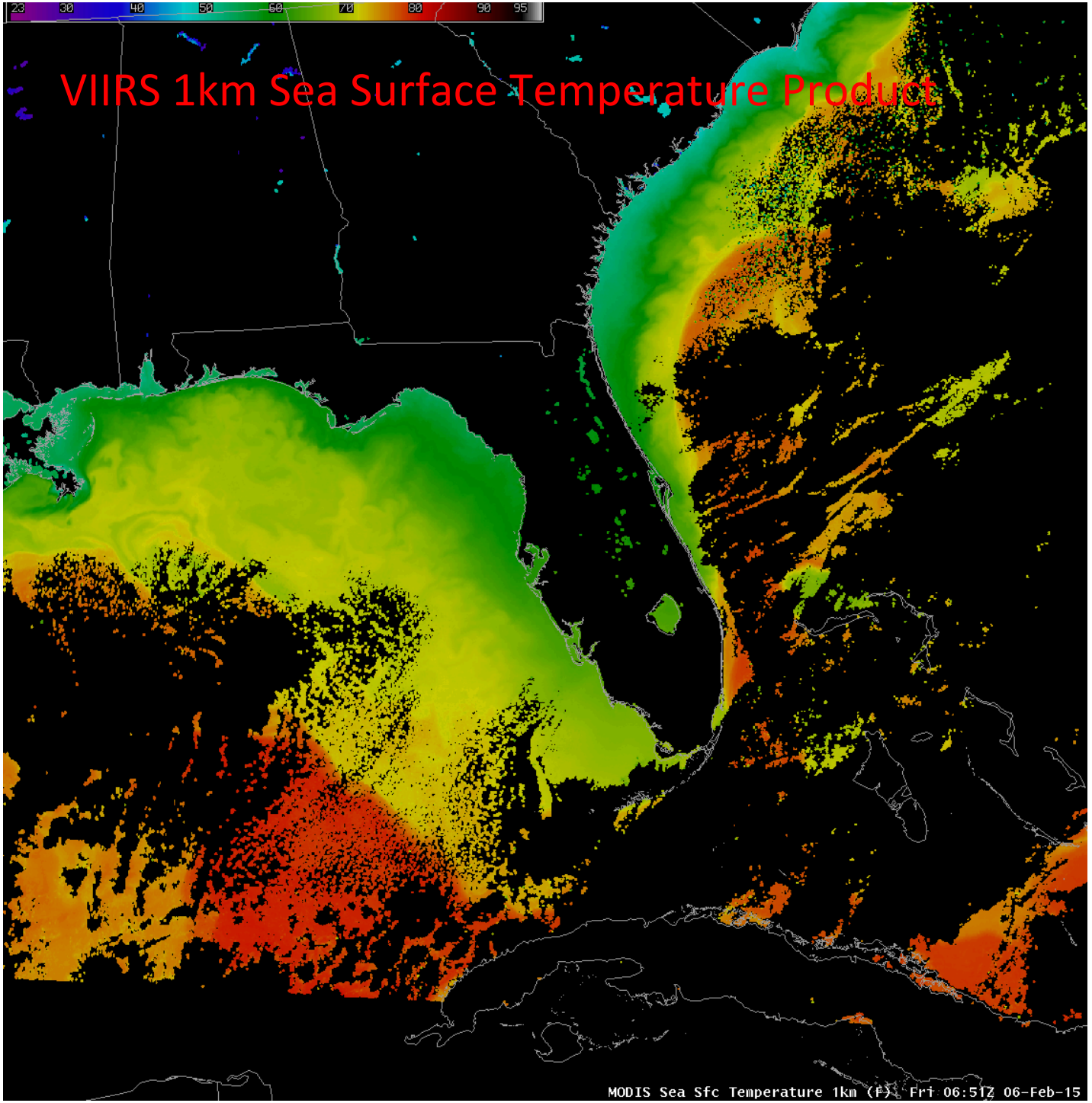

S-NPP VIIRS Day/Night Band - .7 µm Reflectances
Suomi NPP VIIRS Day Night Band Fri 06:51Z 06-Feb-15

Night

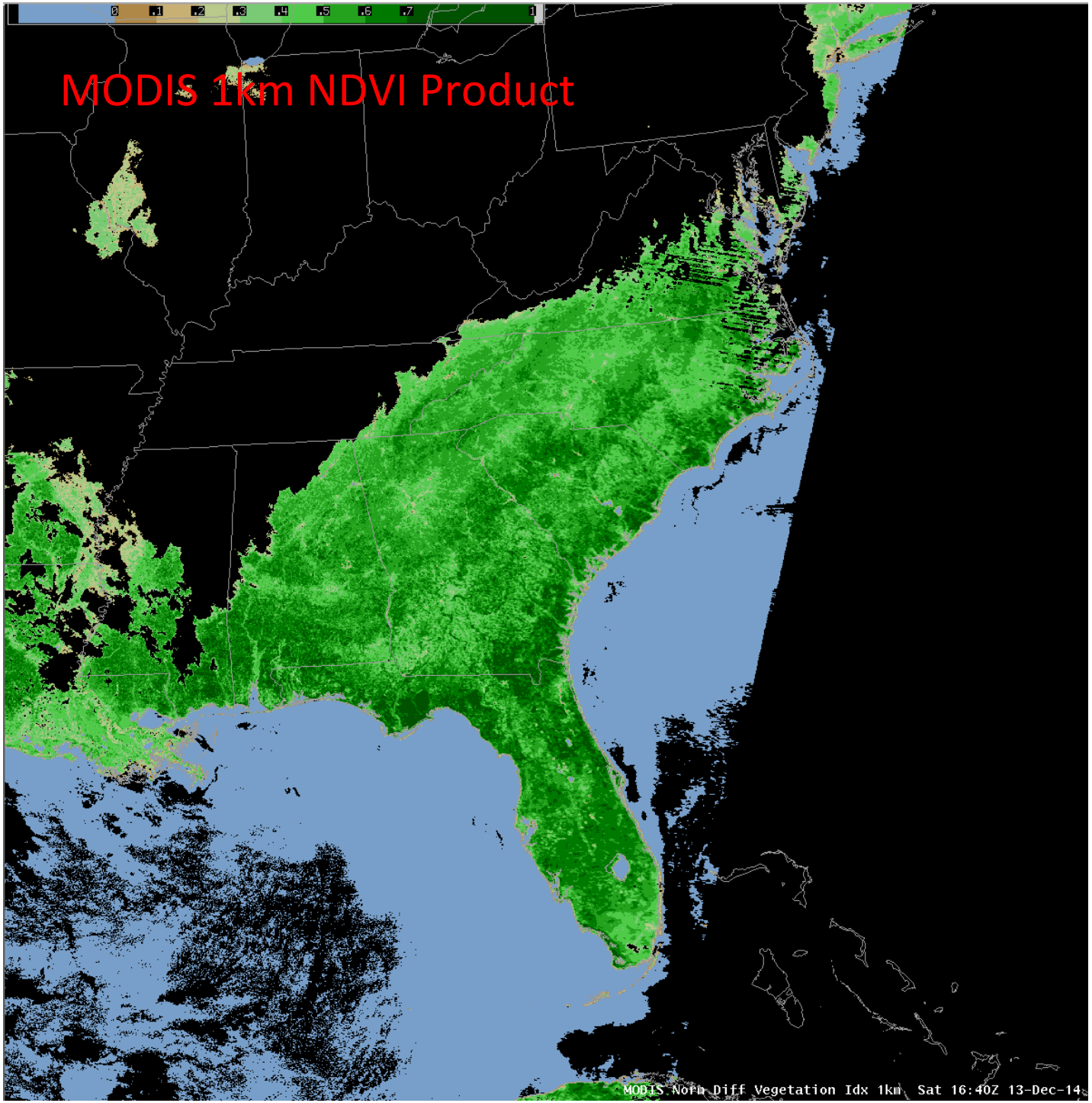
Day


-40 20 -0+ 20 40 60 80 100 120
MODIS 1km Land Surface Temperature Product
MODIS Land Sfc Temperature 1km (F) Thu 19:19Z 05-Feb-15

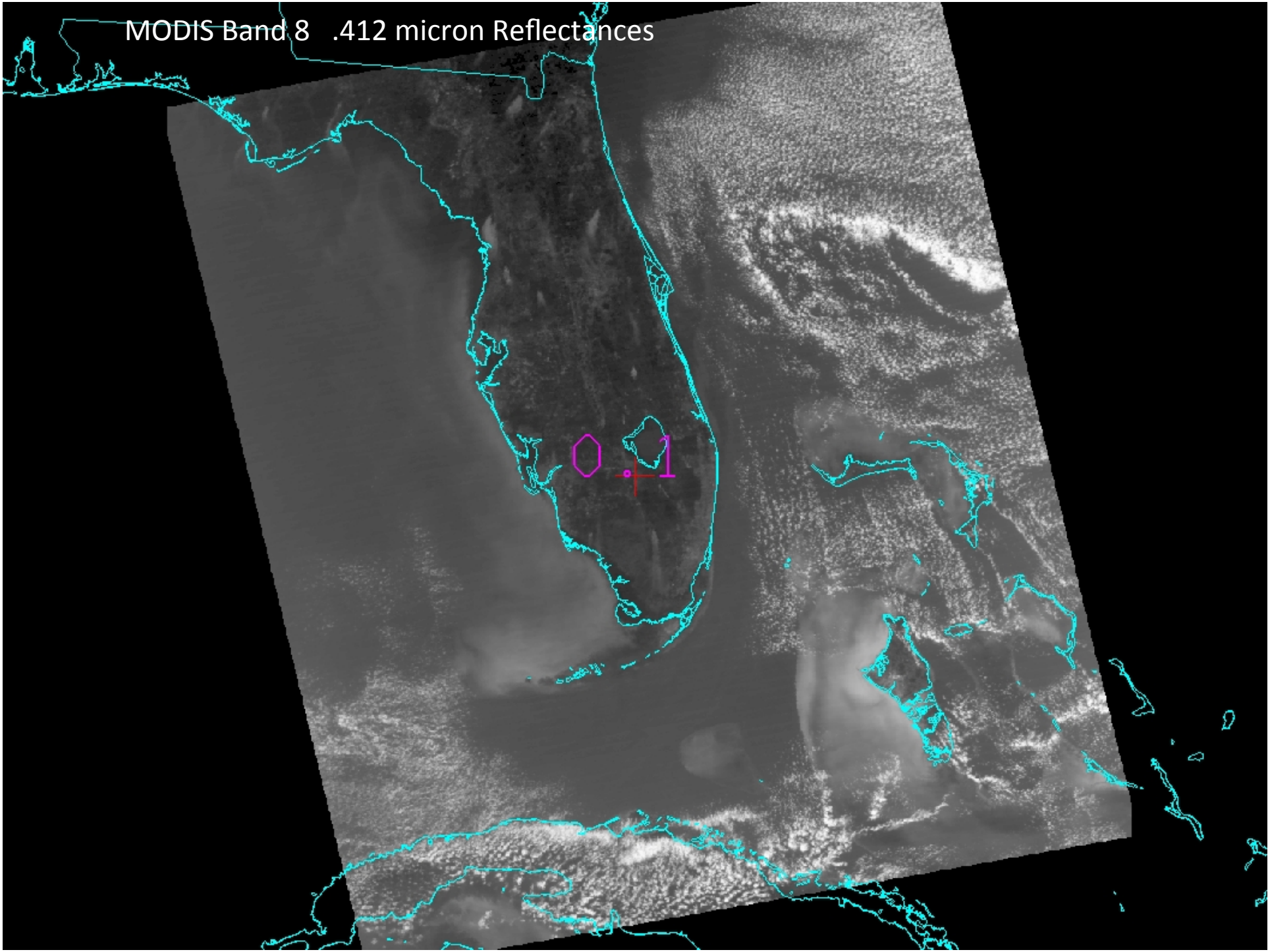

23 30 40 50 60 70 80 90 95
MODIS 1km Sea Surface Temperature Product
MODIS Sea Sfc Temperature 1km (F) Fri 07:22Z 06-Feb-15

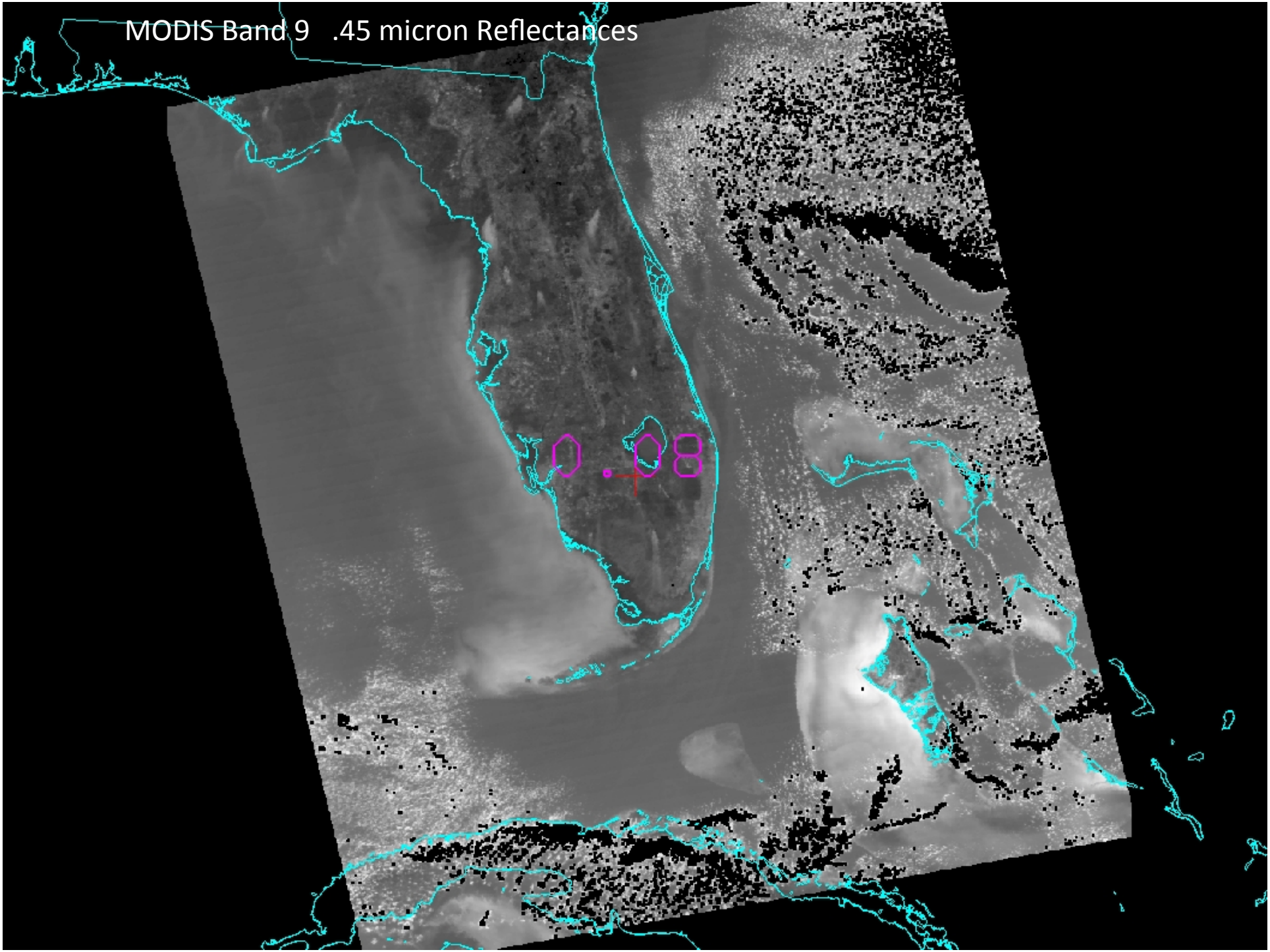

23 30 40 50 60 70 80 90 95
VIIRS 1km Sea Surface Temperature Product
MODIS Sea Sfc Temperature 1km (F) Fri 06:51Z 06-Feb-15

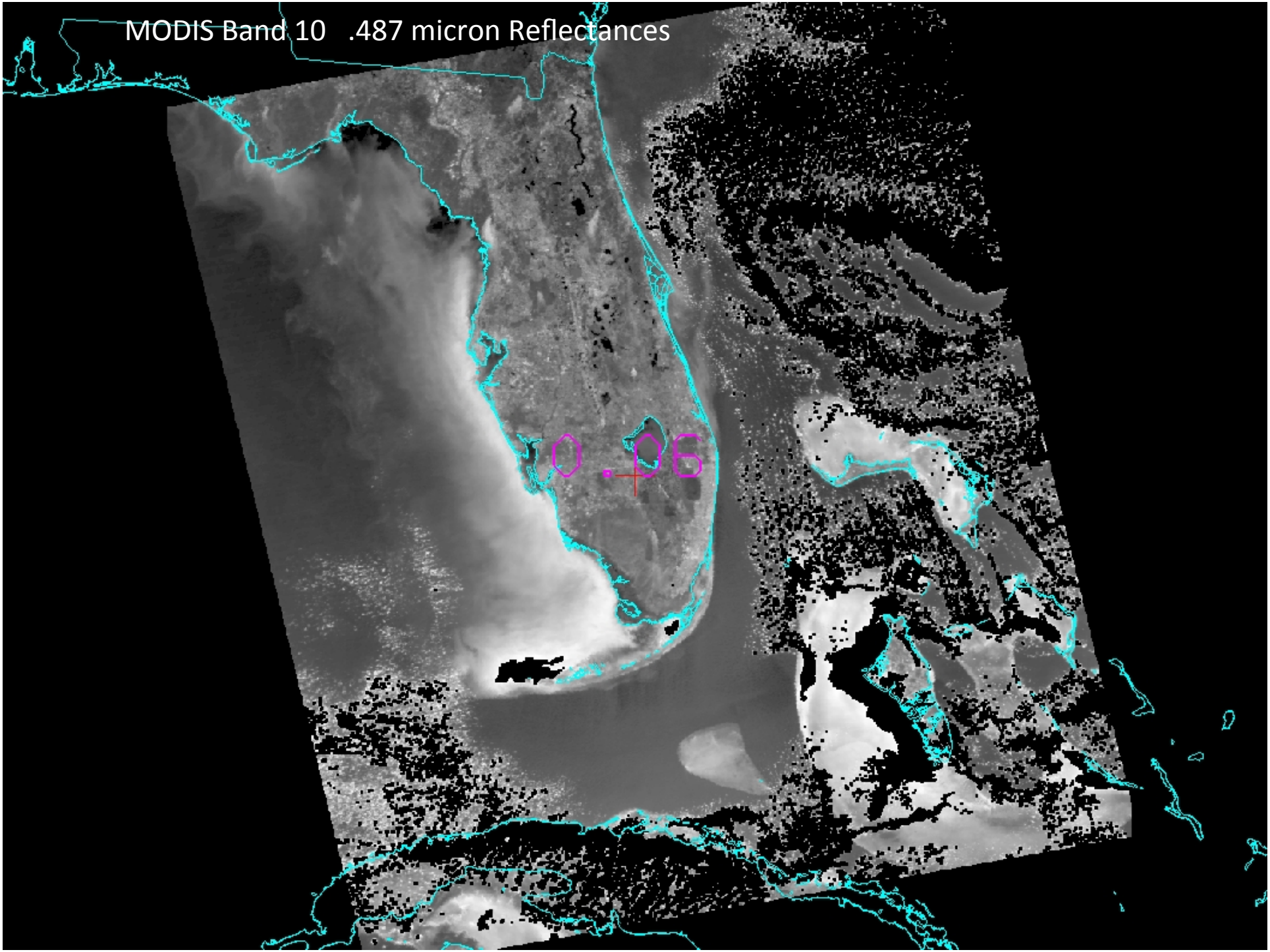
Day

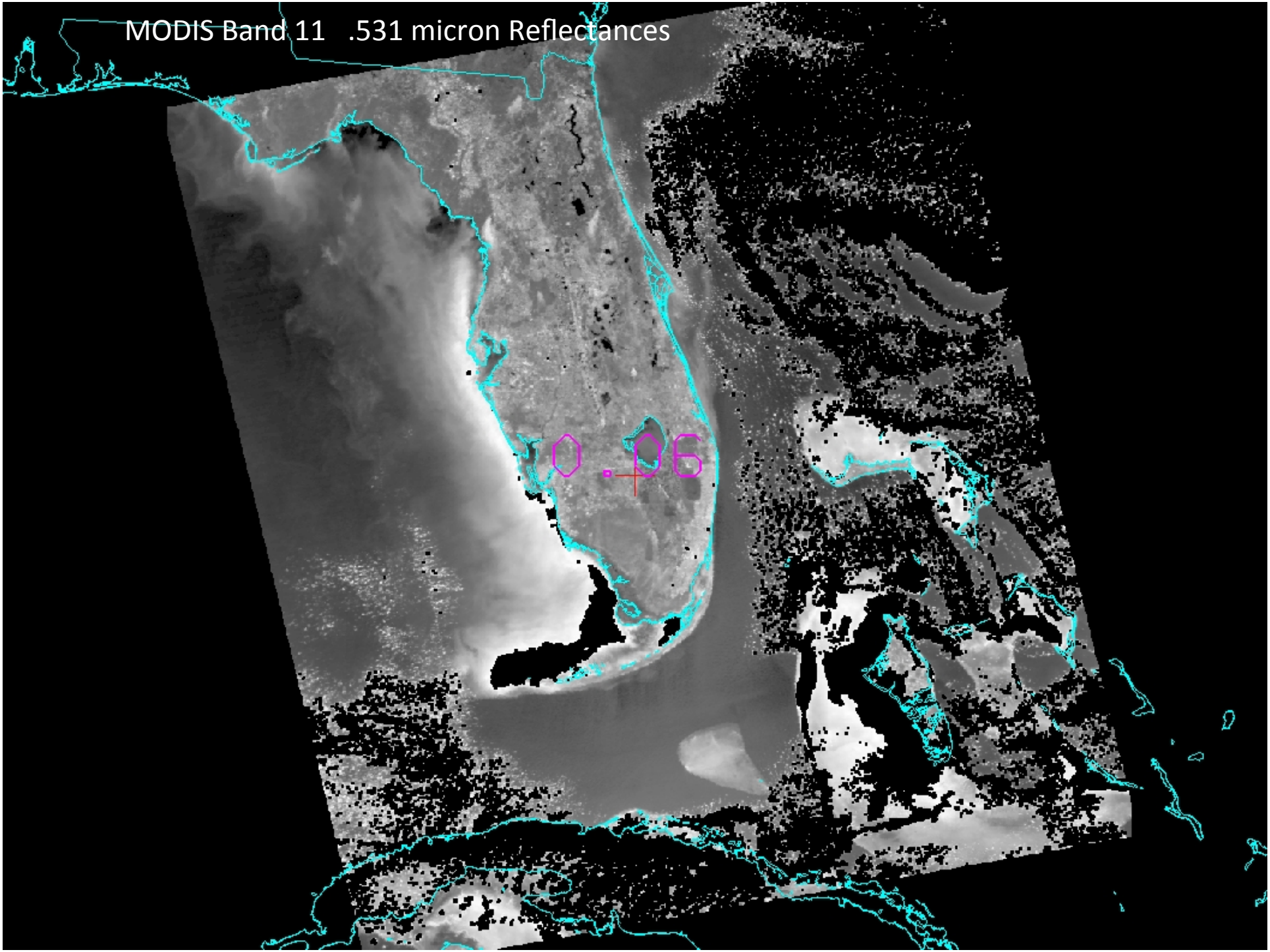

MODIS 1km NDVI Product
MODIS Norm Diff Vegetation Idx 1km Sat 16:40Z 13-Dec-14

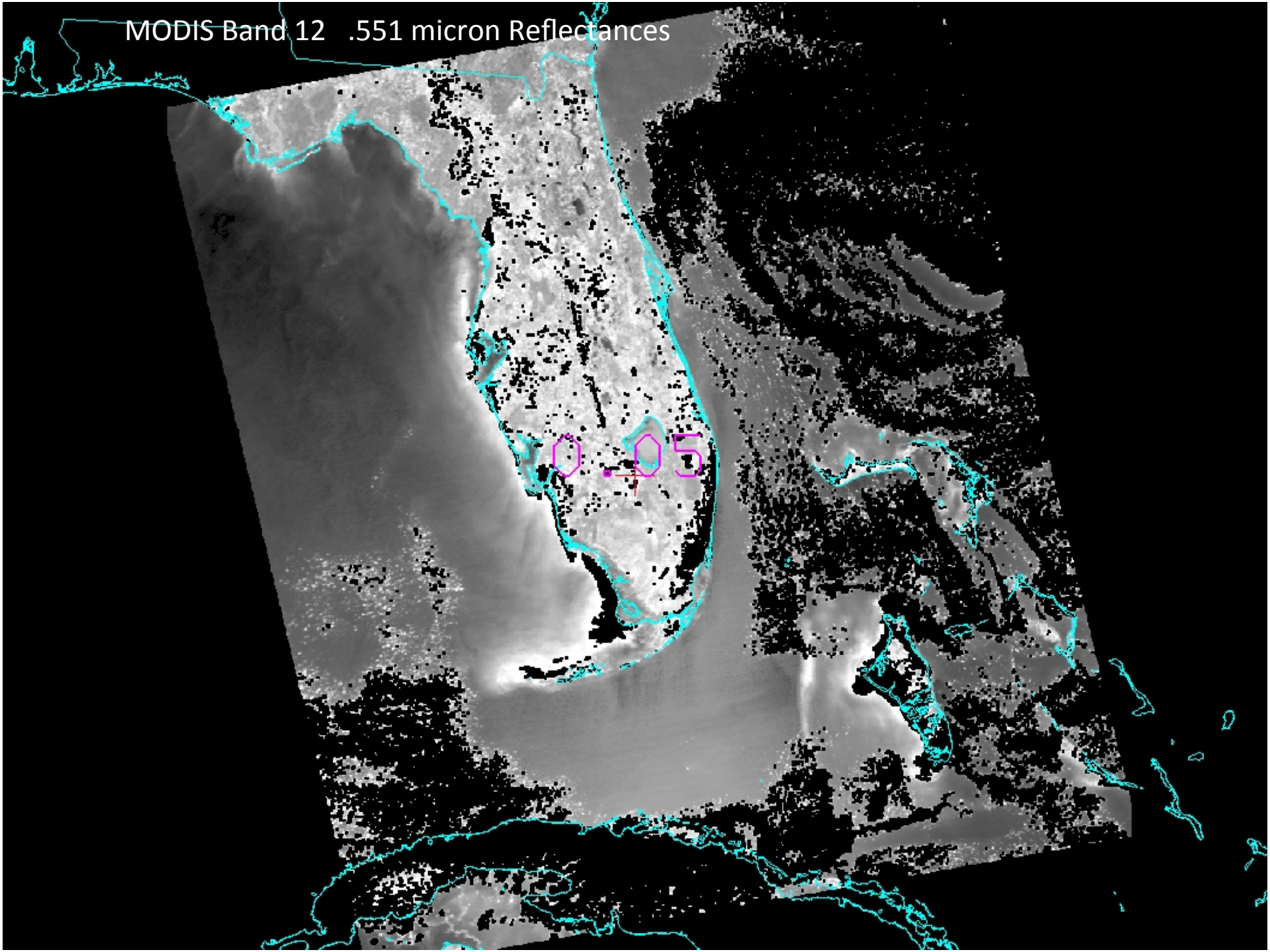
Primary Use	Band	Bandwidth[1]	Spectral Radiance[2]	Required SNR[3]
Land/Cloud/Aerosols Boundaries	1	620 - 670	21.8	128
	2	841 - 876	24.7	201
Land/Cloud/Aerosols Properties	3	459 - 479	35.3	243
	4	545 - 565	29.0	228
	5	1230 - 1250	5.4	74
	6	1628 - 1652	7.3	275
	7	2105 - 2155	1.0	110
Ocean Color/ Phytoplankton/ Biogeochemistry	8	405 - 420	44.9	880
	9	438 - 448	41.9	838
	10	483 - 493	32.1	802
	11	526 - 536	27.9	754
	12	546 - 556	21.0	750
	13	662 - 672	9.5	910
	14	673 - 683	8.7	1087
	15	743 - 753	10.2	586
	16	862 - 877	6.2	516
Atmospheric Water Vapor	17	890 - 920	10.0	167
	18	931 - 941	3.6	57
	19	915 - 965	15.0	250

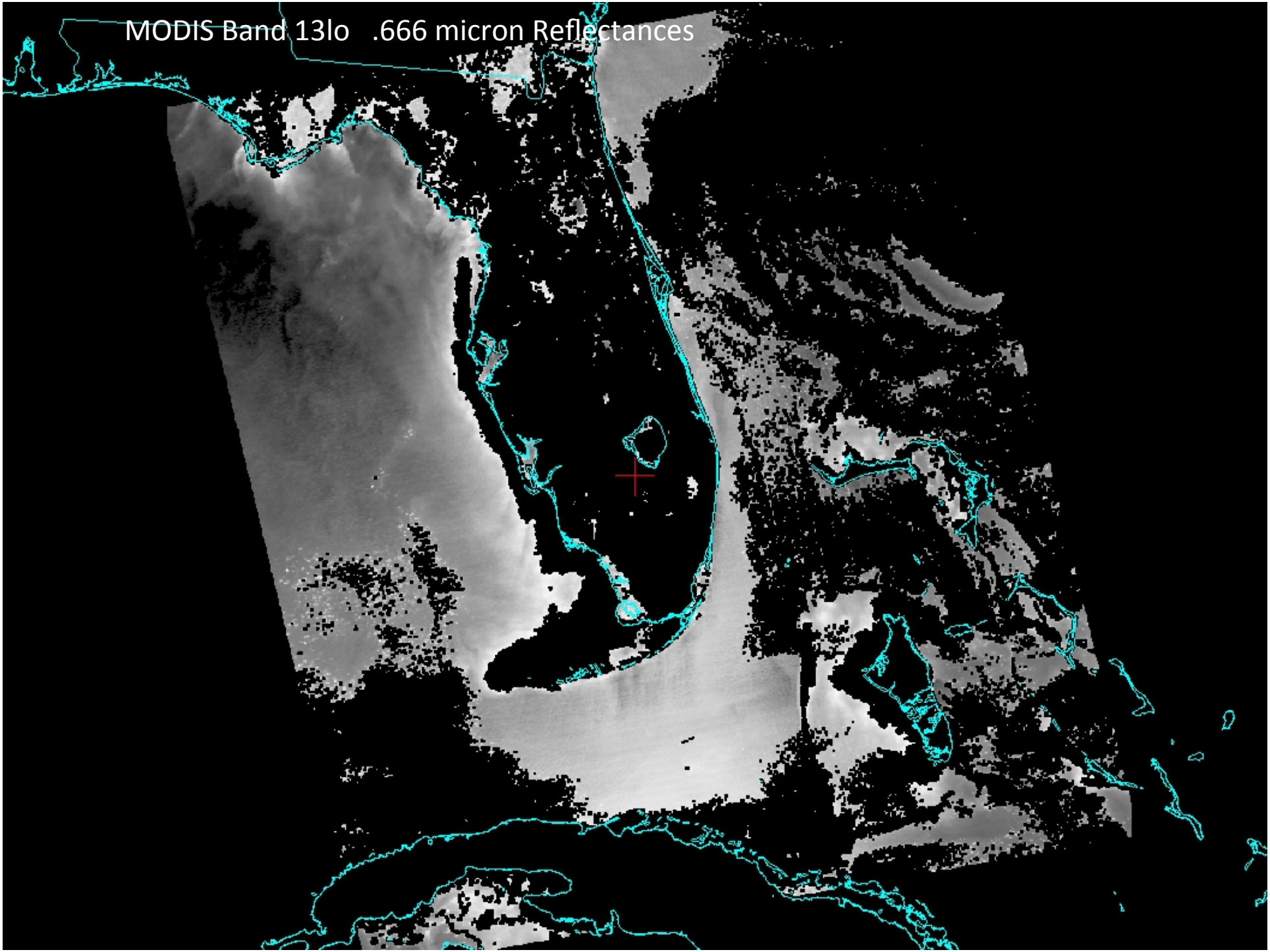

MODIS Band 8 .412 micron Reflectances

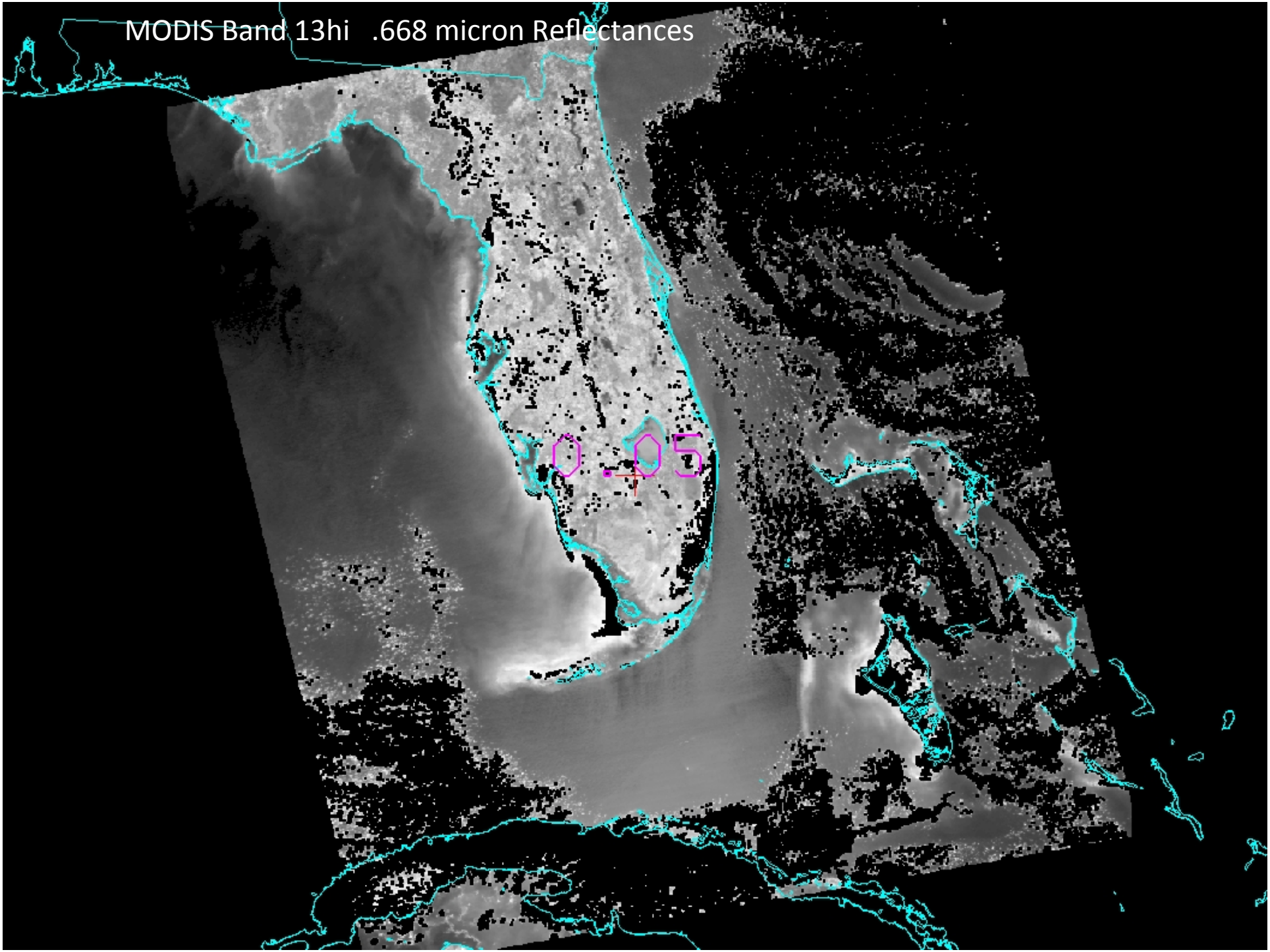

MODIS Band 9 .45 micron Reflectances

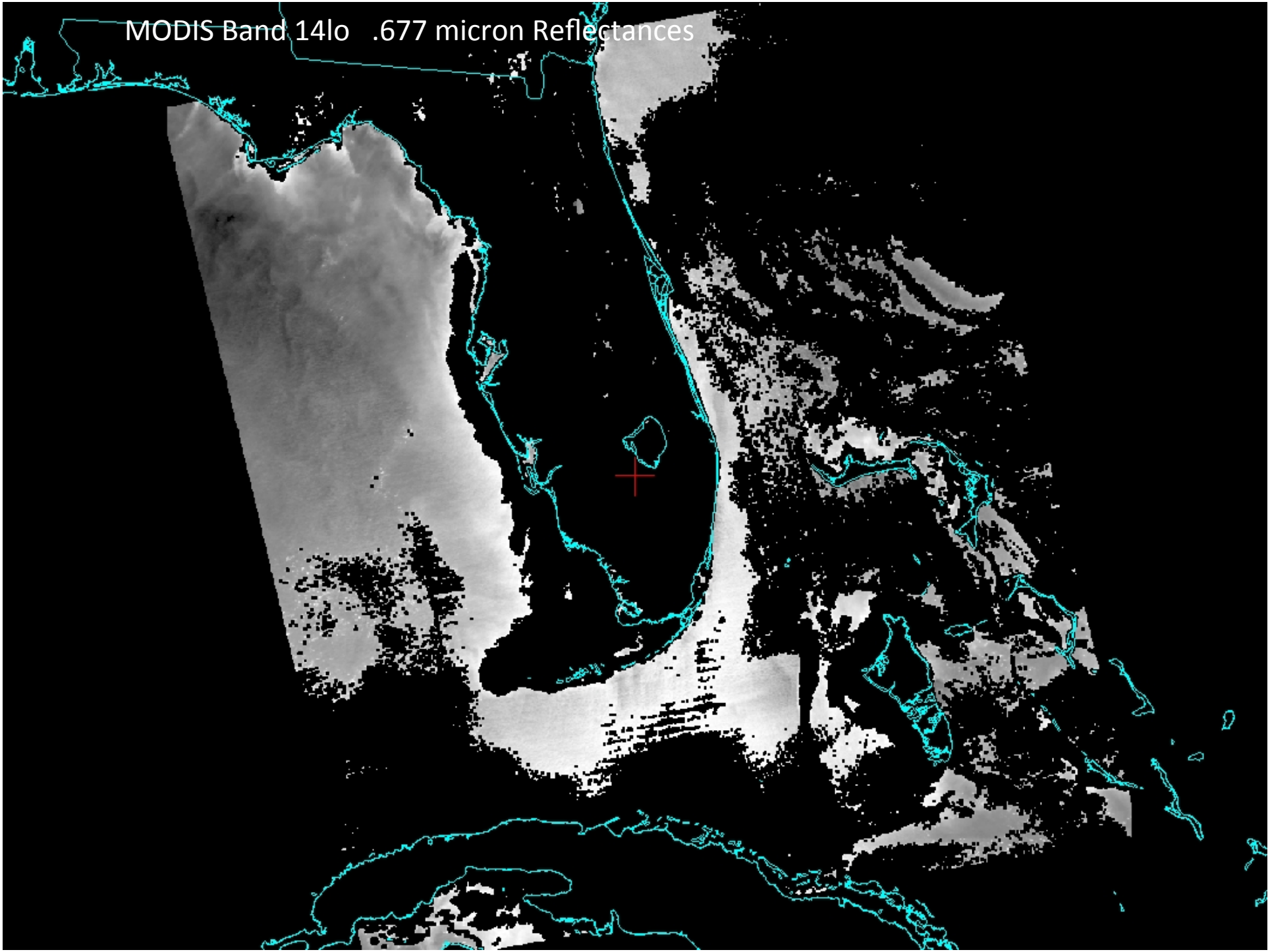

MODIS Band 10 .487 micron Reflectances
0.06

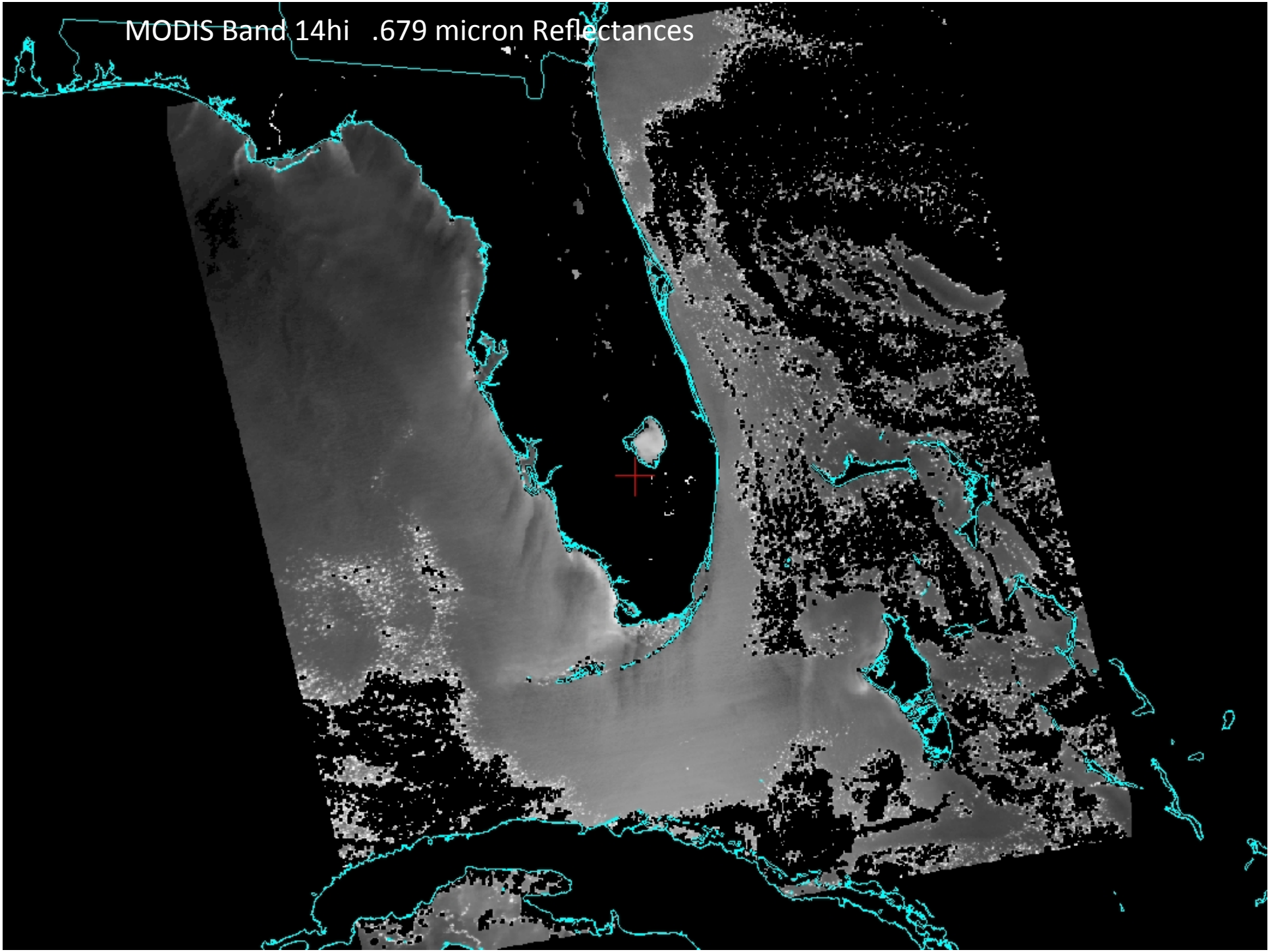

MODIS Band 11 .531 micron Reflectances
0.06

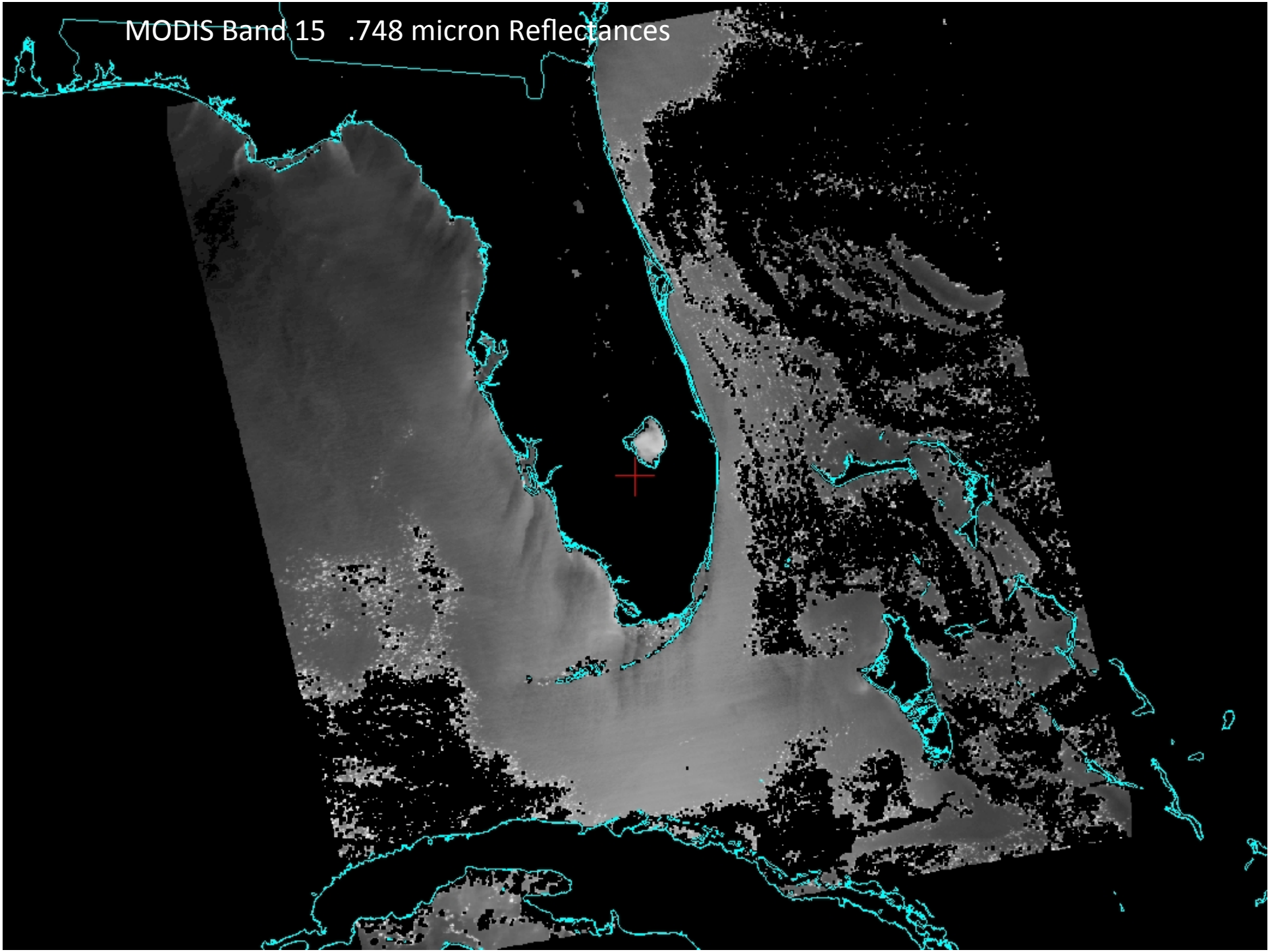

MODIS Band 12 .551 micron Reflectances

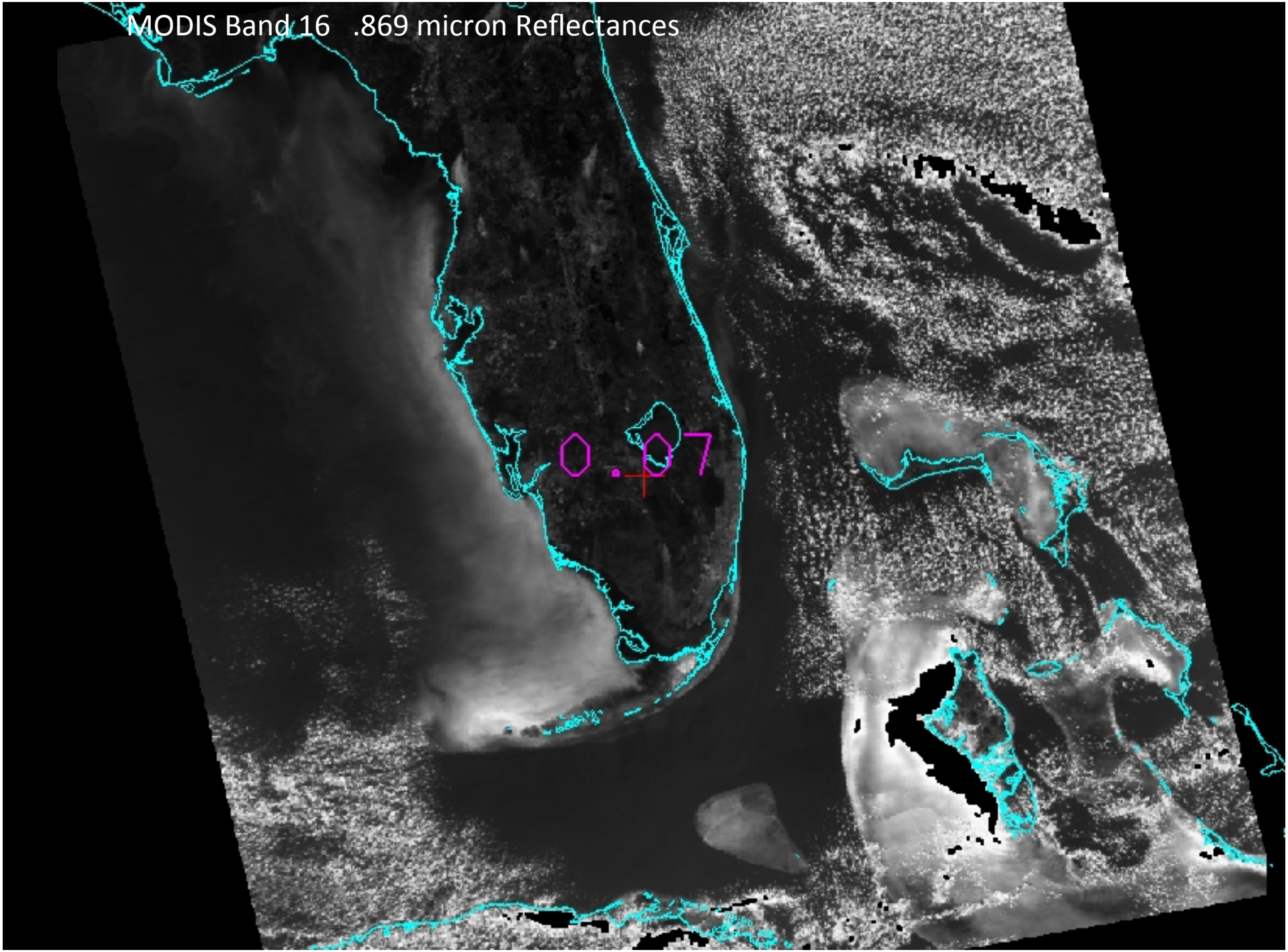

MODIS Band 13lo .666 micron Reflectances


MODIS Band 13hi .668 micron Reflectances


MODIS Band 14lo .677 micron Reflectances


MODIS Band 14hi .679 micron Reflectances


MODIS Band 15 .748 micron Reflectances


MODIS Band 16 .869 micron Reflectances
0.07

S-NPP, Aqua and Terra DB Applications

- Weather Observation and Forecasting
  - Often thought of as research satellites
  - Data is Complimentary to Geostationary
    - Higher Spatial Resolution (data at 250 m - 1 km, products at 250 m - 5 km)
    - Unique spectral bands (such as Day/Night band)
    - New products (such as true color imagery)
    - Preparation for next generation of geo instruments
  - Key for forecasts is timeliness of data
    - DB data and software allow processing and delivery of products to be usable
  - Temporal coverage is limiting

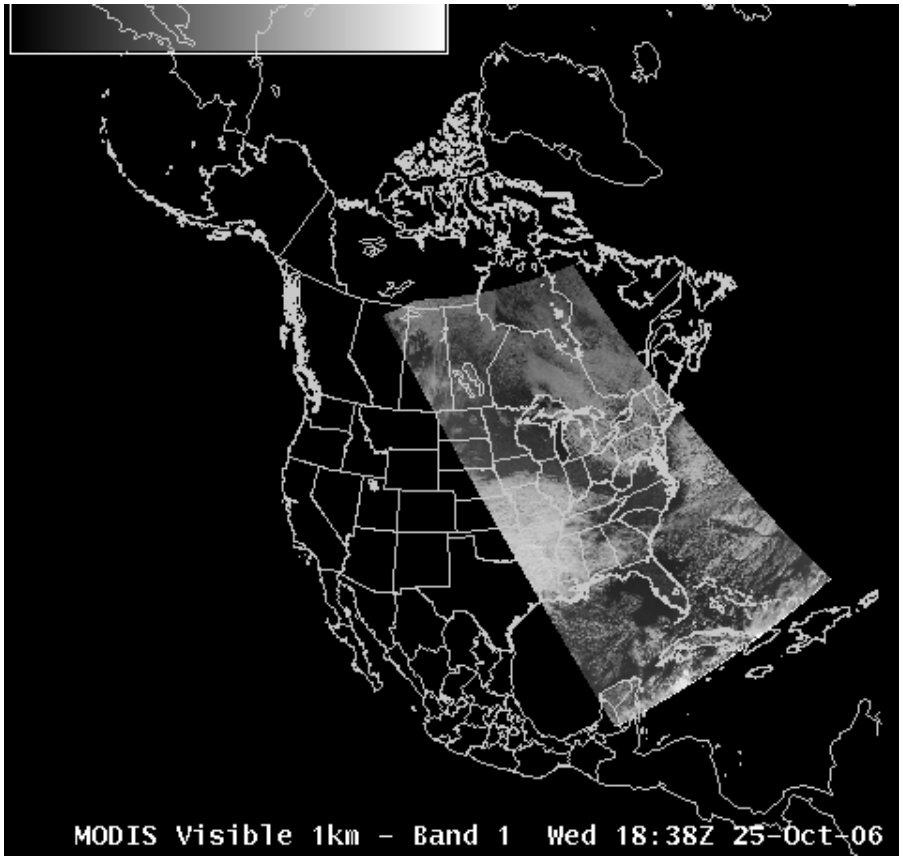
Weather and Forecasting

Complimentary to Geostationary

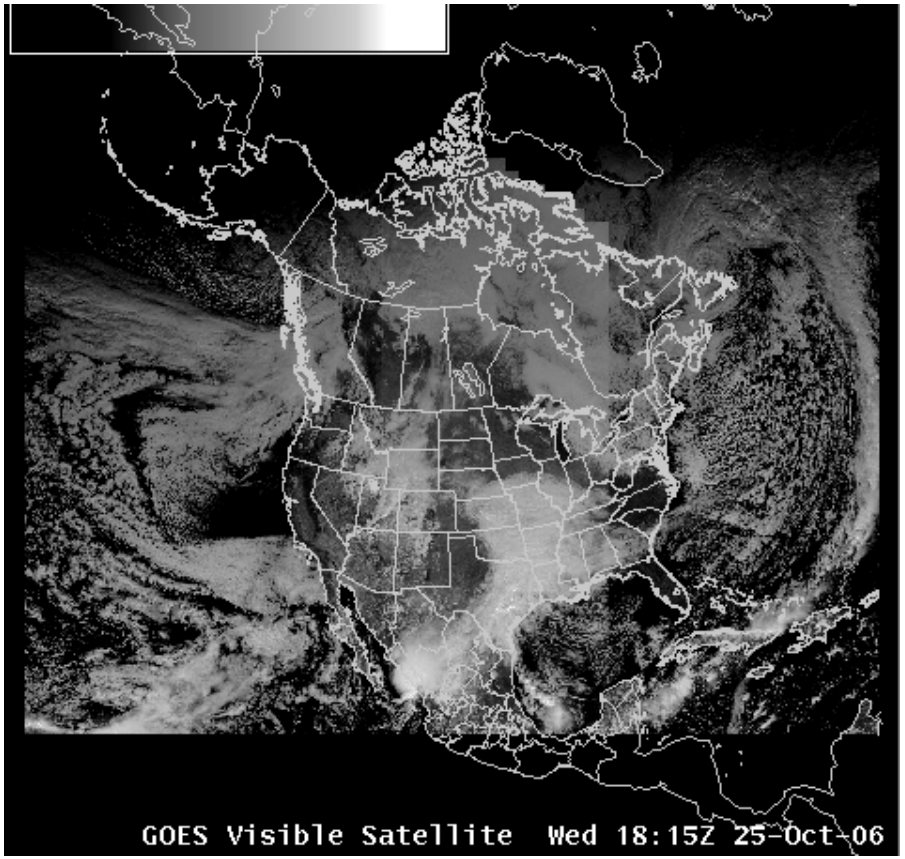
Example of Improved Spatial Resolution

MODIS Imagery in AWIPS

Band 1: Visible channel (0.6µm)



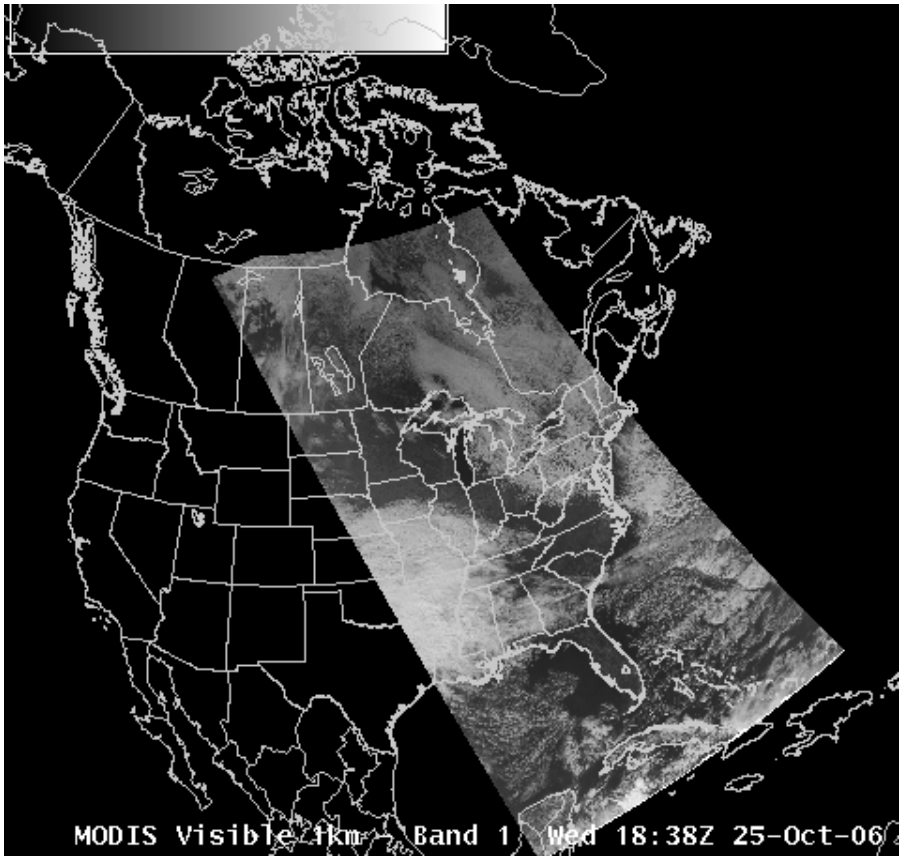
MODIS visible channel



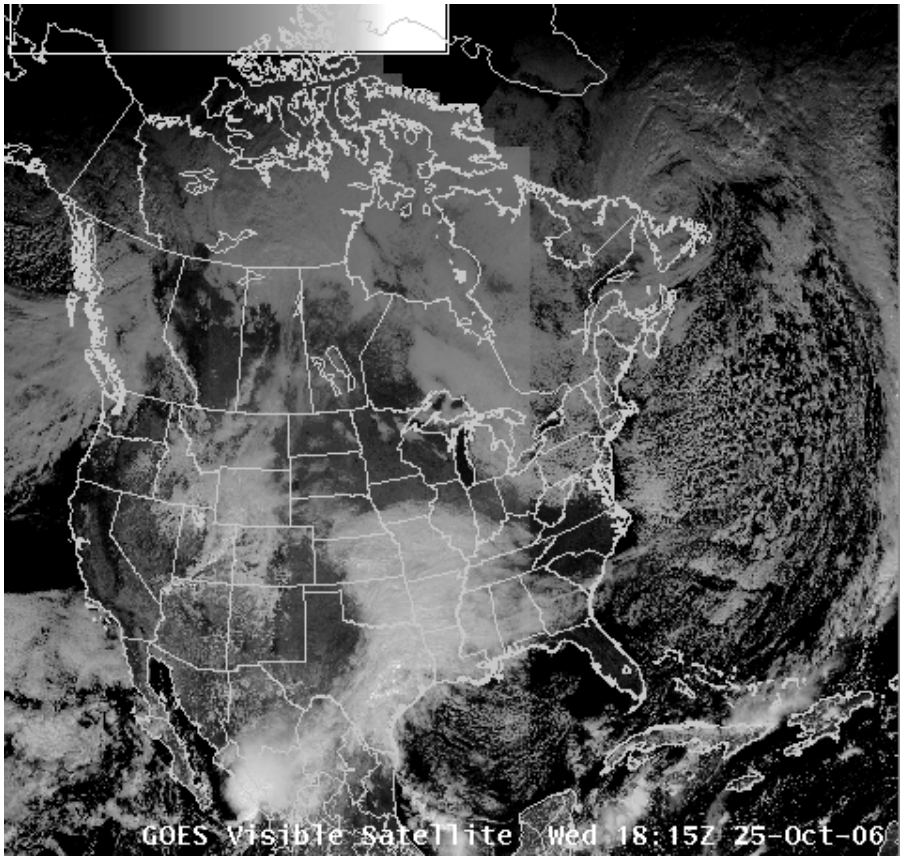
GOES visible channel

MODIS Imagery in AWIPS

Band 1: Visible channel (0.6µm)



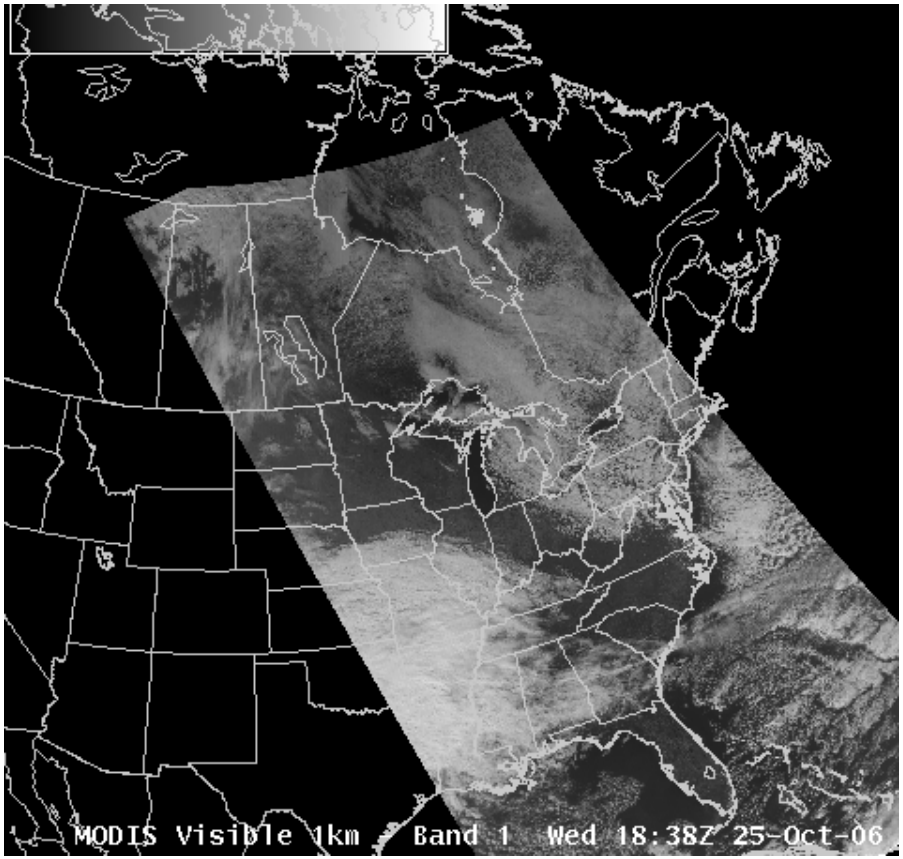
MODIS visible channel



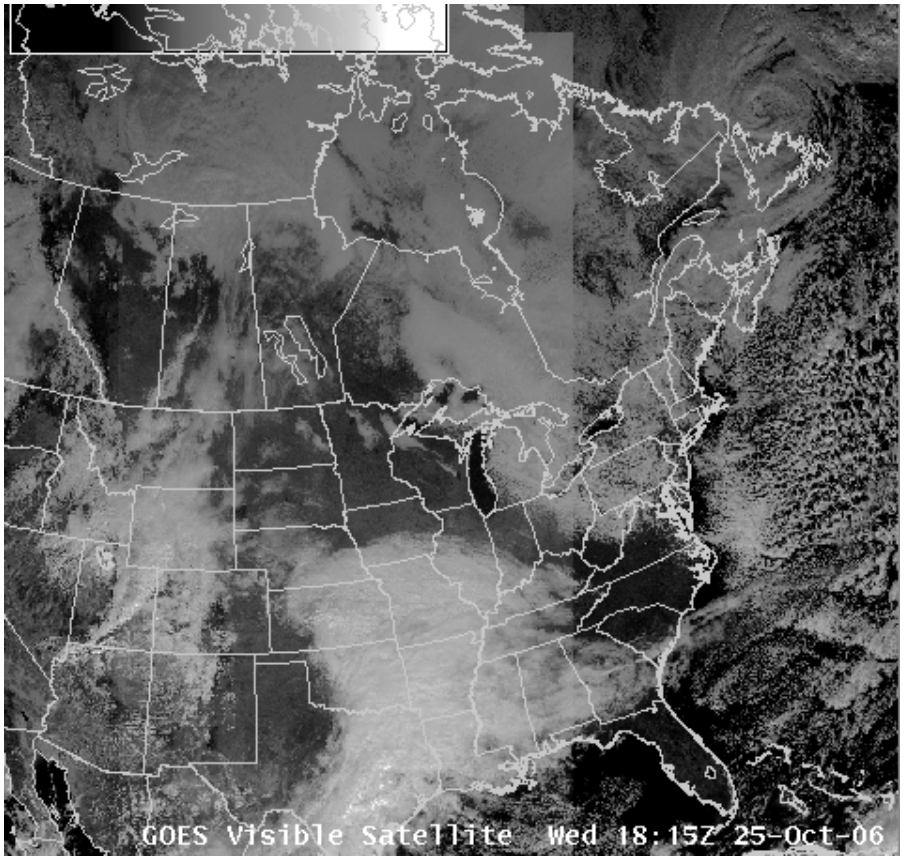
GOES visible channel

MODIS Imagery in AWIPS

Band 1: Visible channel (0.6µm)



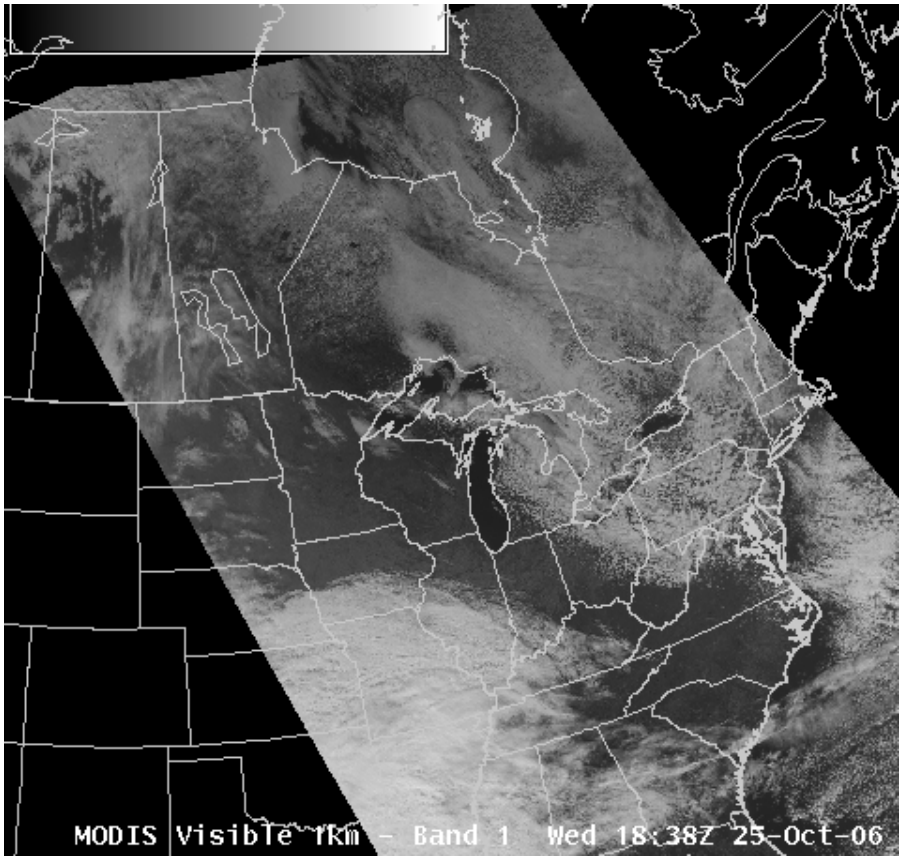
MODIS visible channel



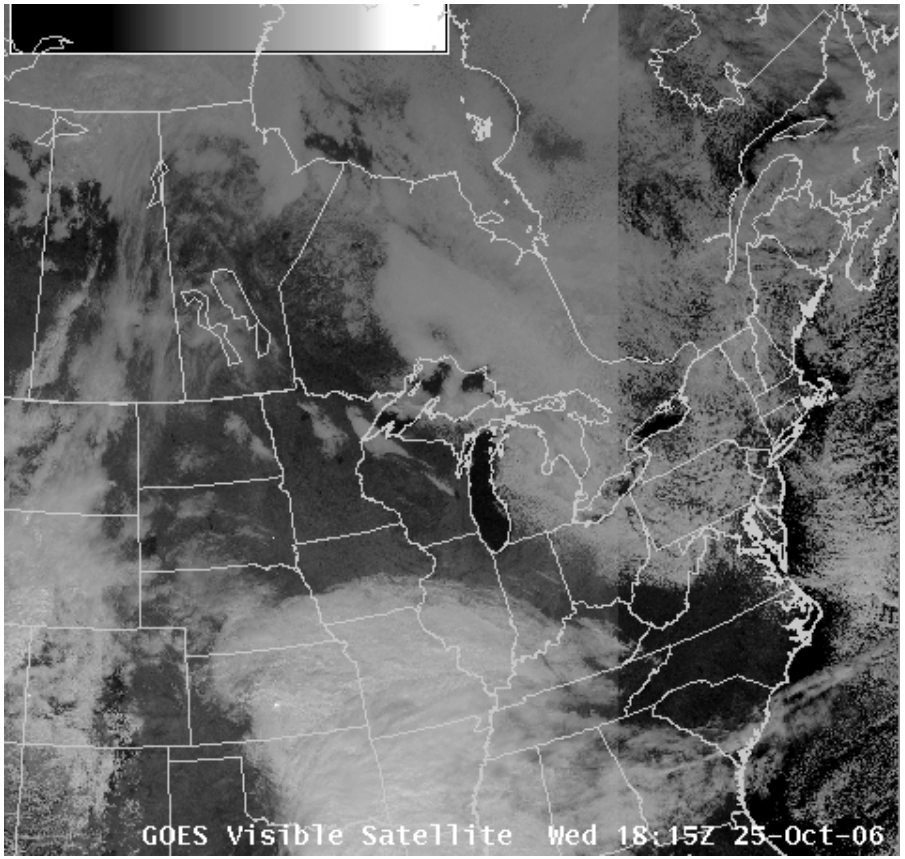
GOES visible channel

MODIS Imagery in AWIPS

Band 1: Visible channel (0.6µm)



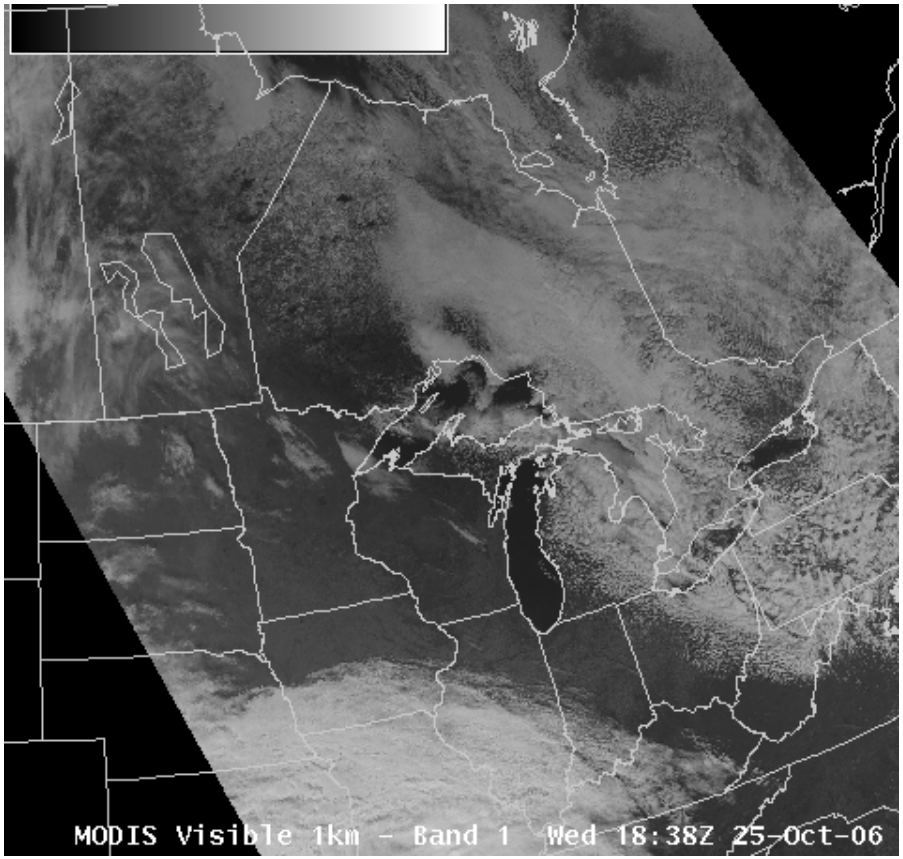
MODIS visible channel



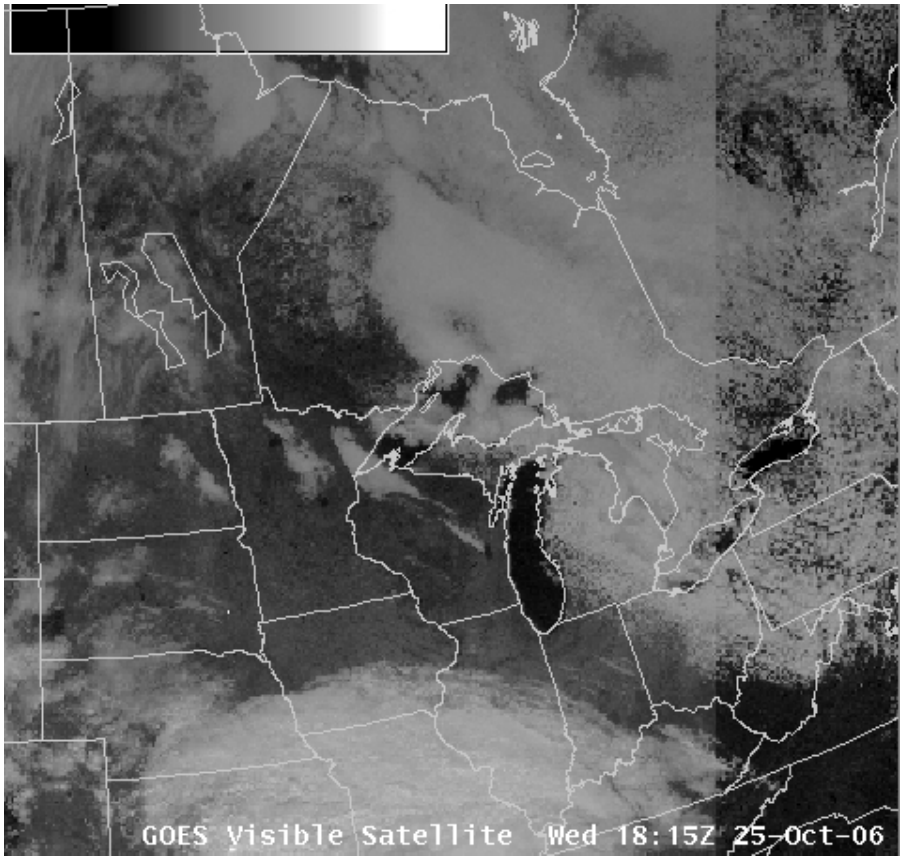
GOES visible channel

MODIS Imagery in AWIPS

Band 1: Visible channel (0.6µm)



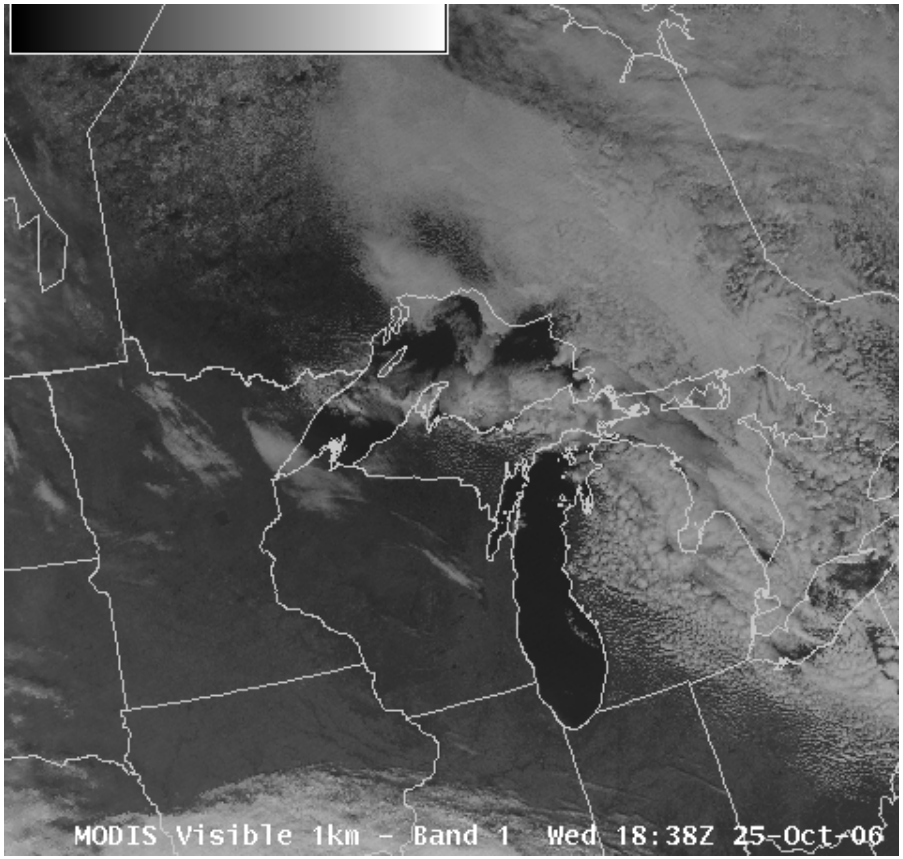
MODIS visible channel



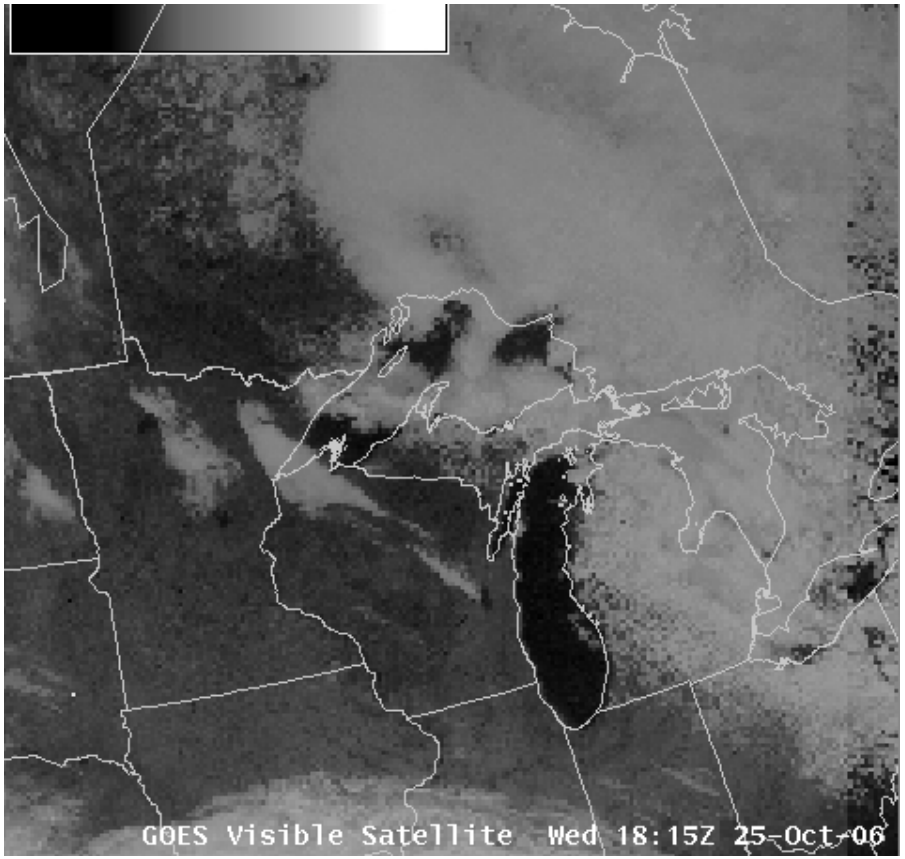
GOES visible channel

MODIS Imagery in AWIPS

Band 1: Visible channel (0.6µm)



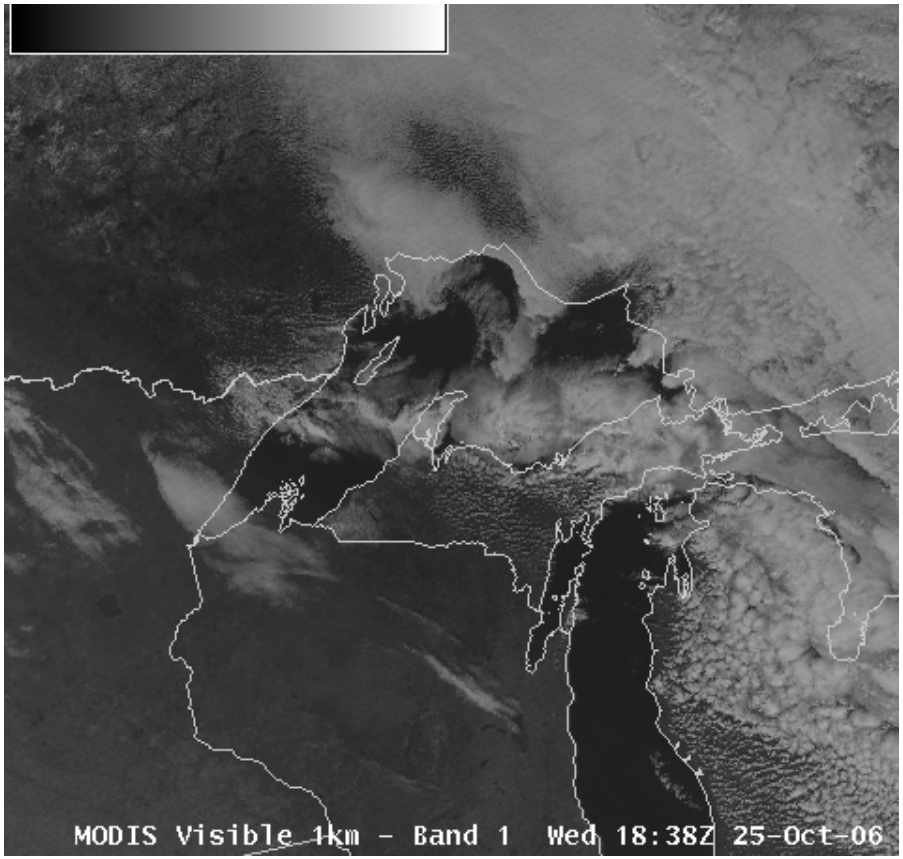
MODIS visible channel



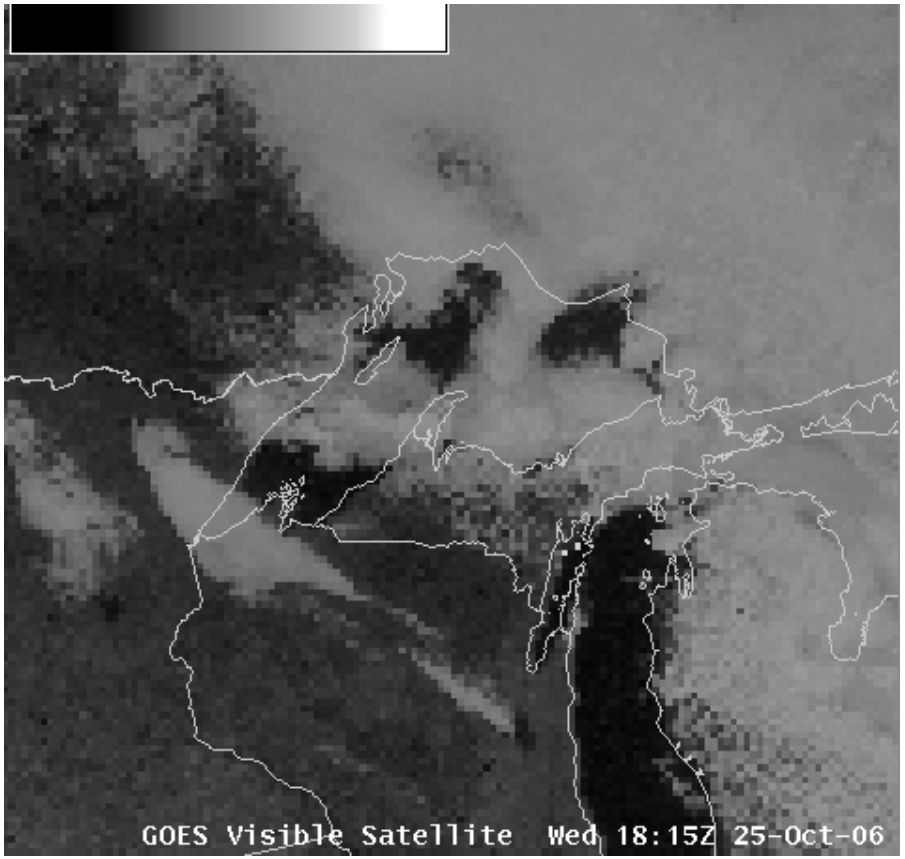
GOES visible channel

MODIS Imagery in AWIPS

Band 1: Visible channel (0.6µm)



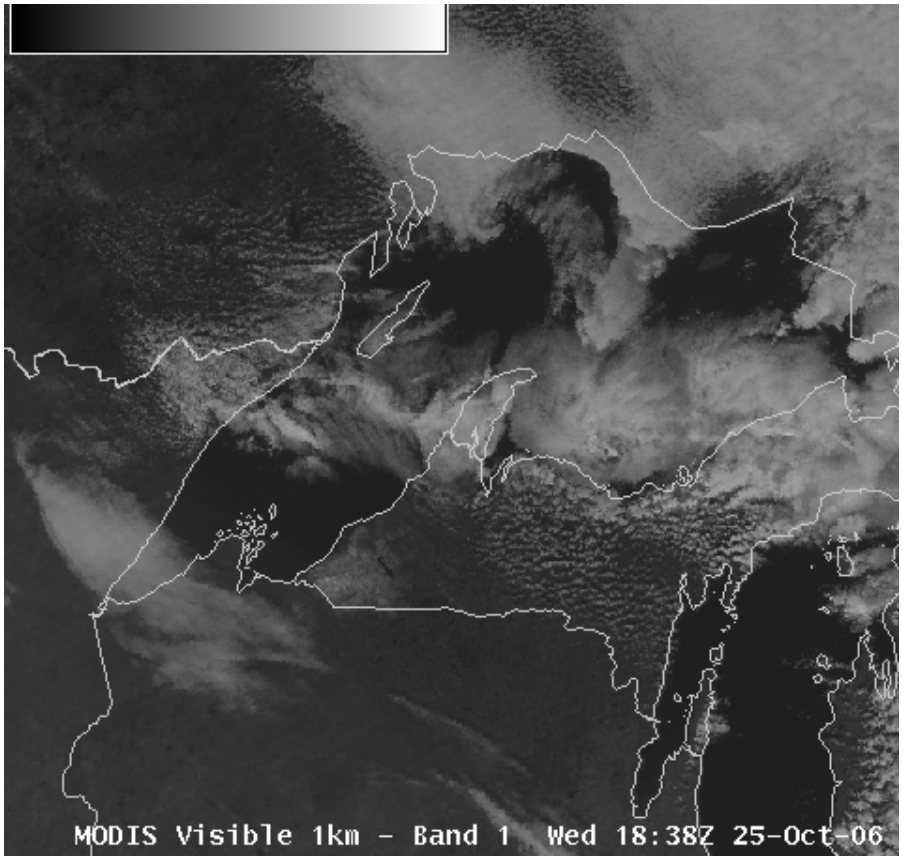
MODIS visible channel



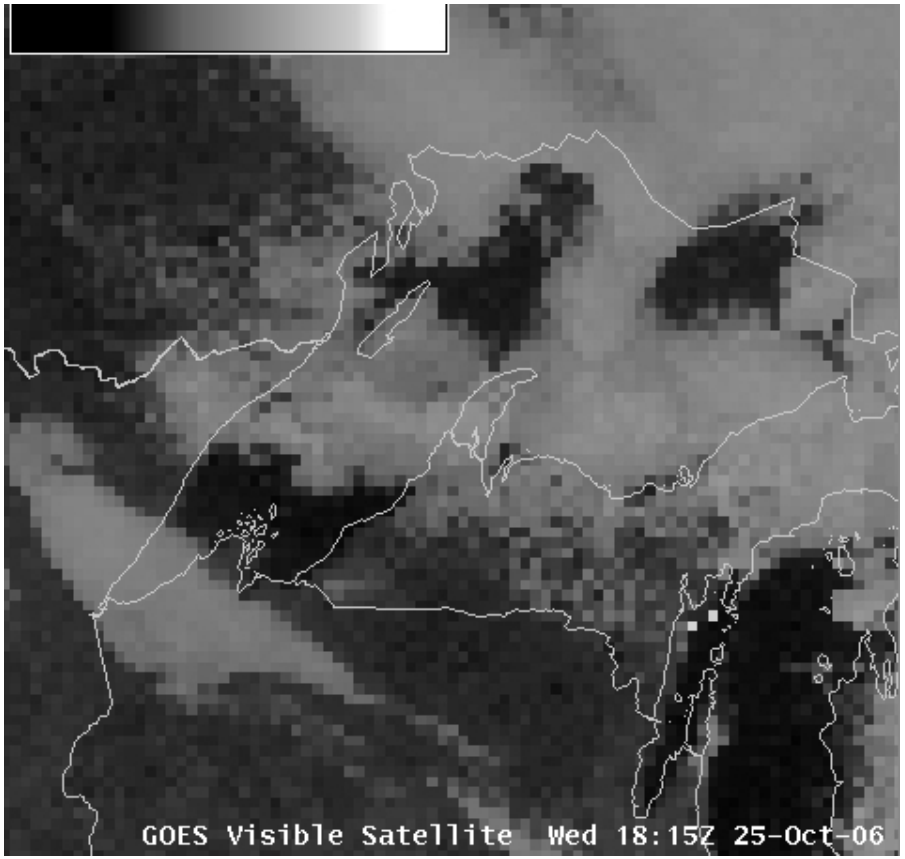
GOES visible channel

MODIS Imagery in AWIPS

Band 1: Visible channel (0.6µm)

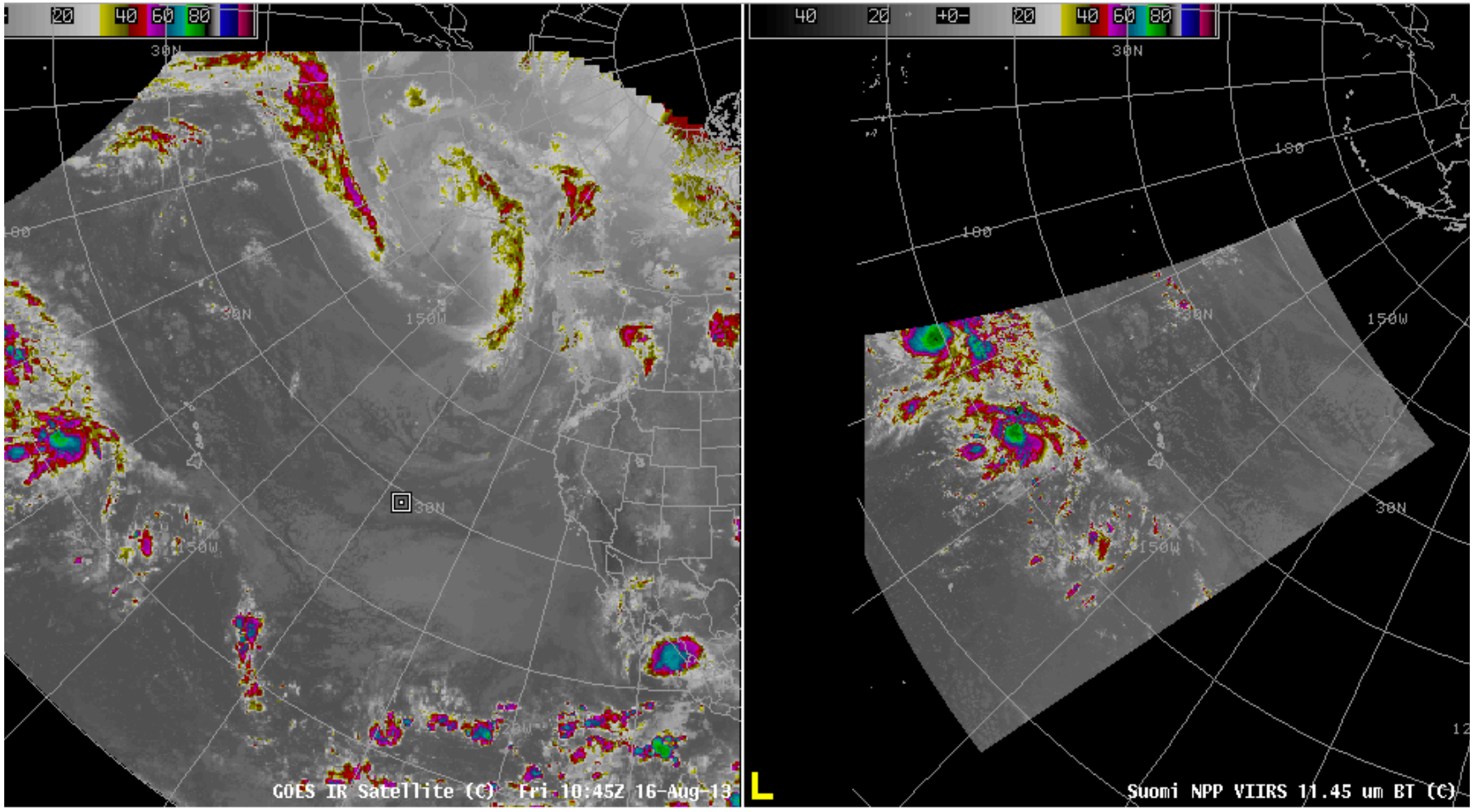


MODIS visible channel

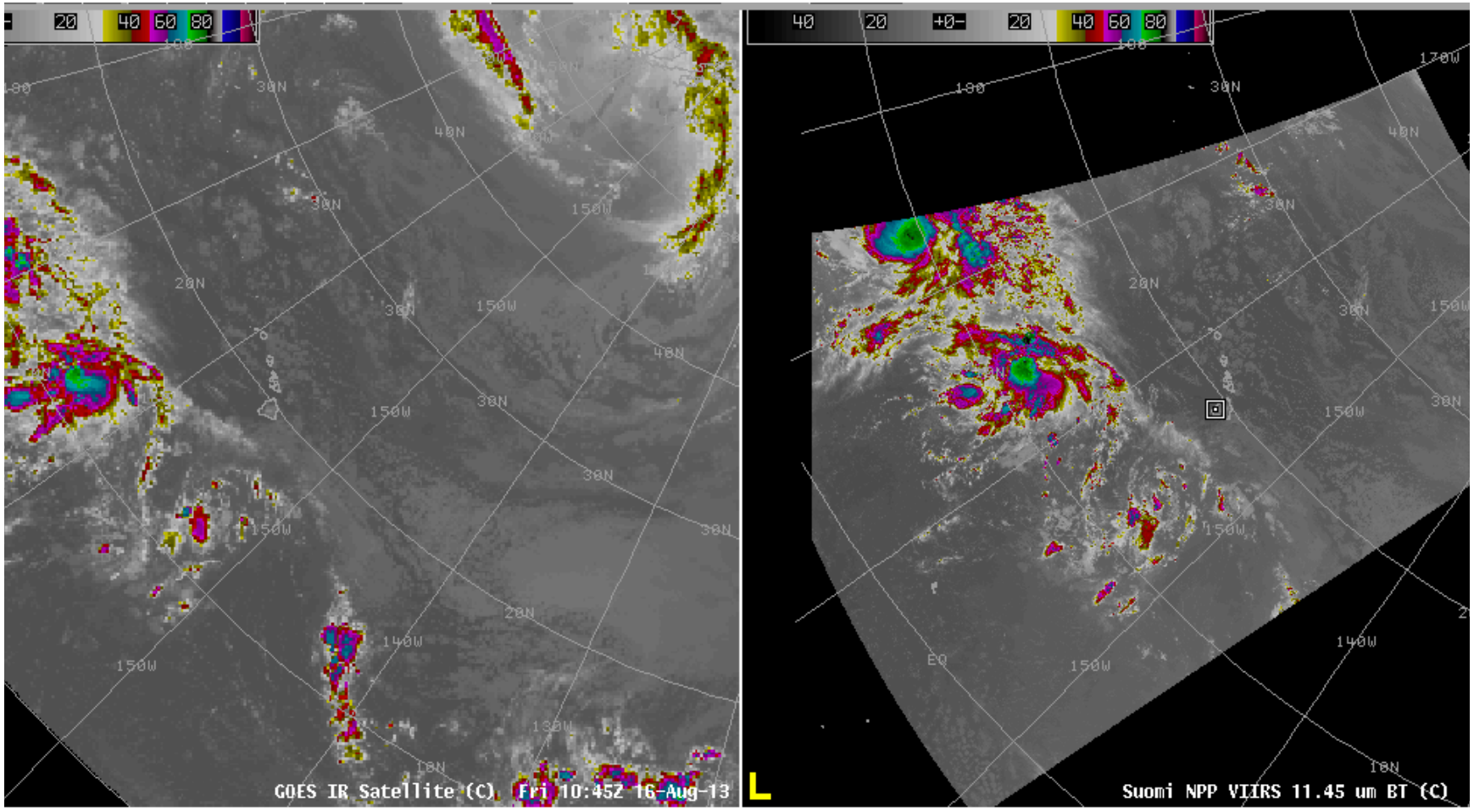


GOES visible channel

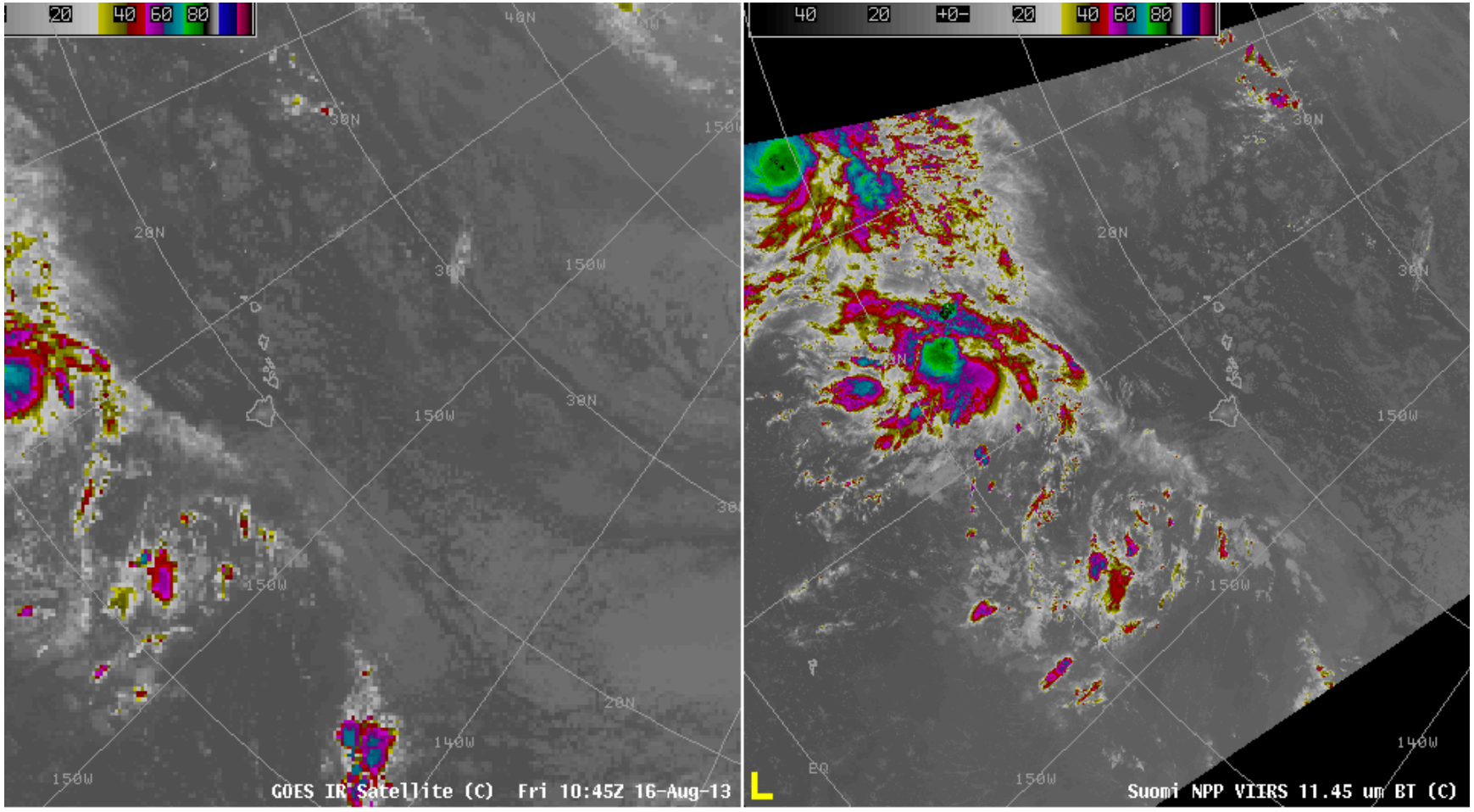
GEO versus LEO perspective



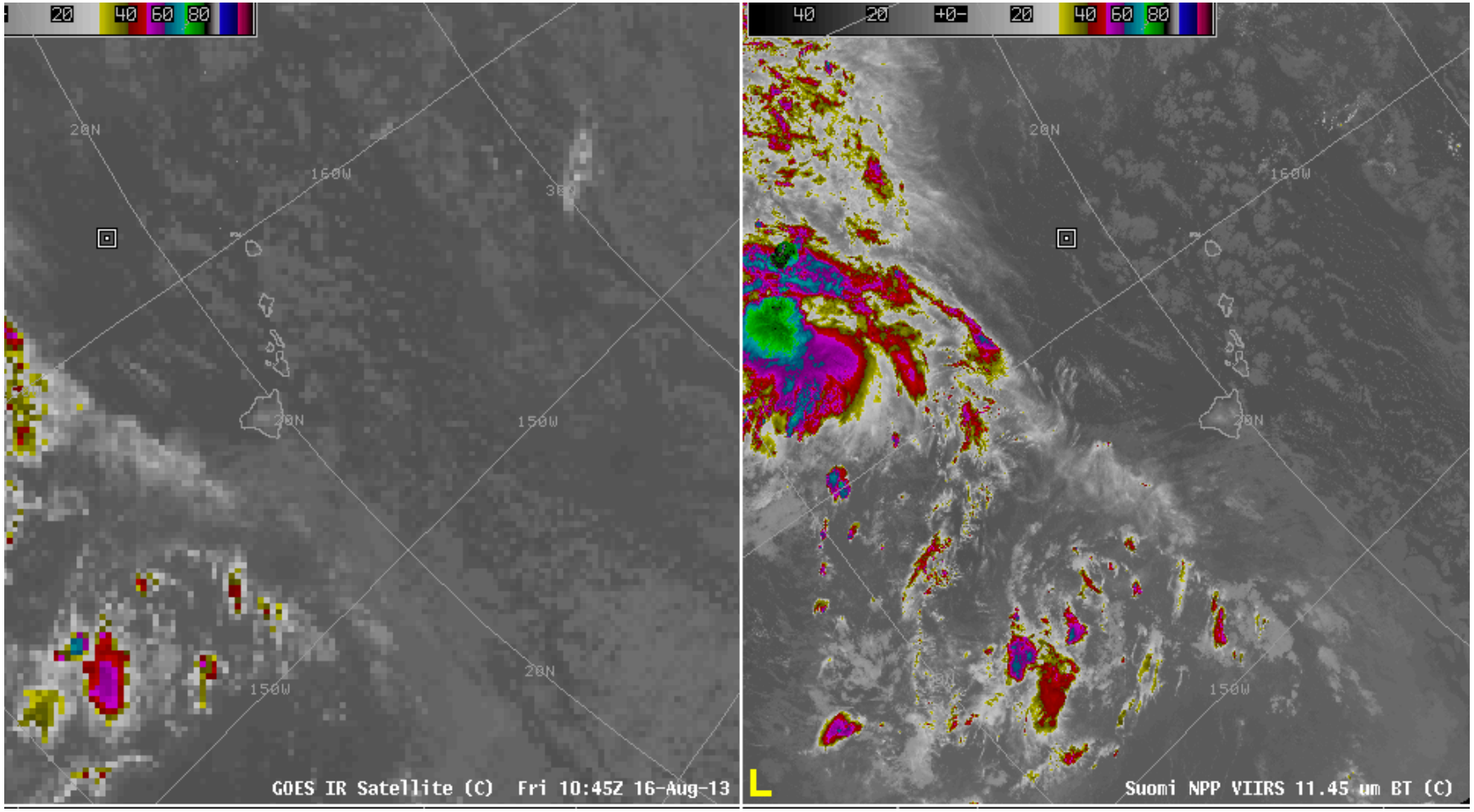
GEO versus LEO perspective



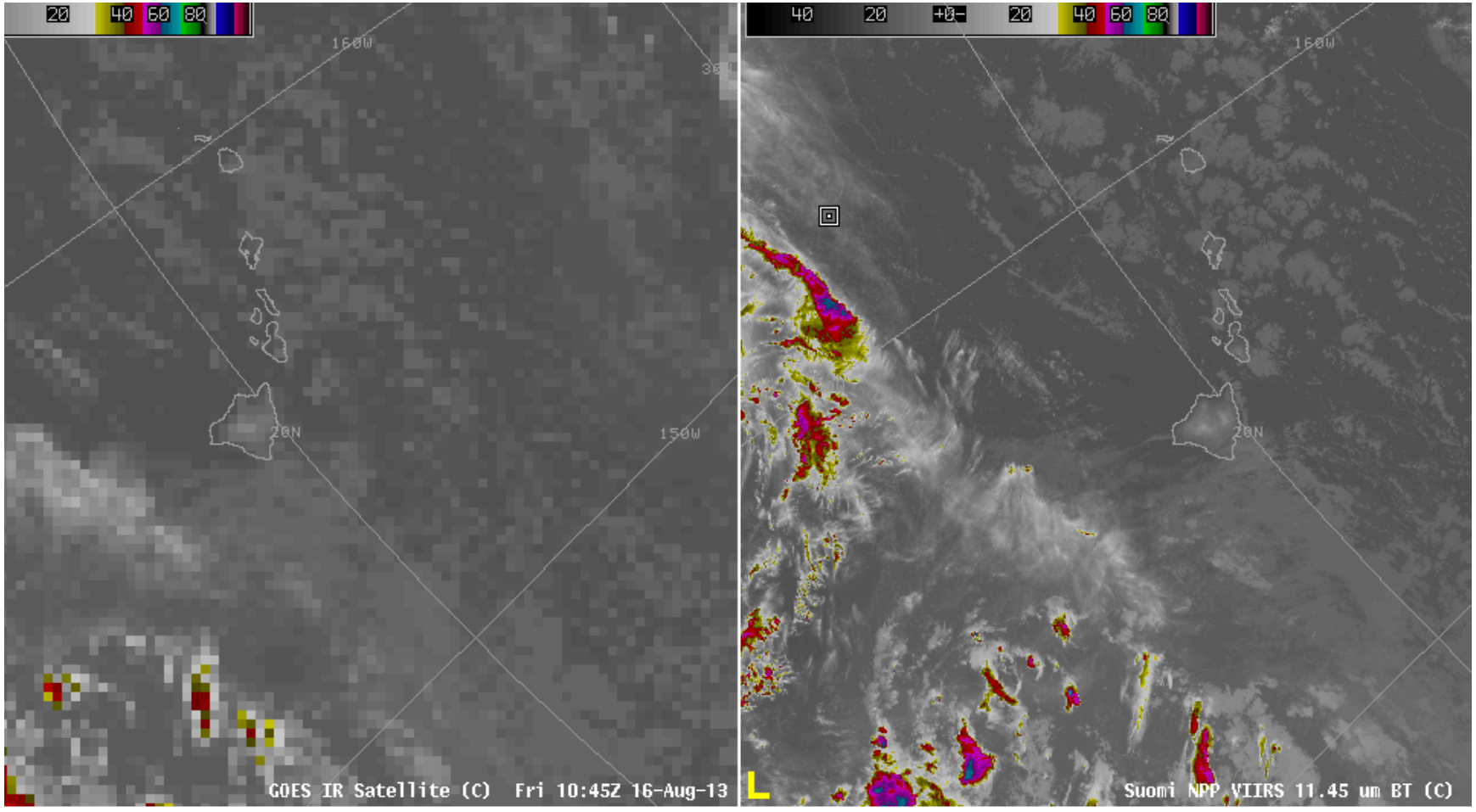
GEO versus LEO perspective



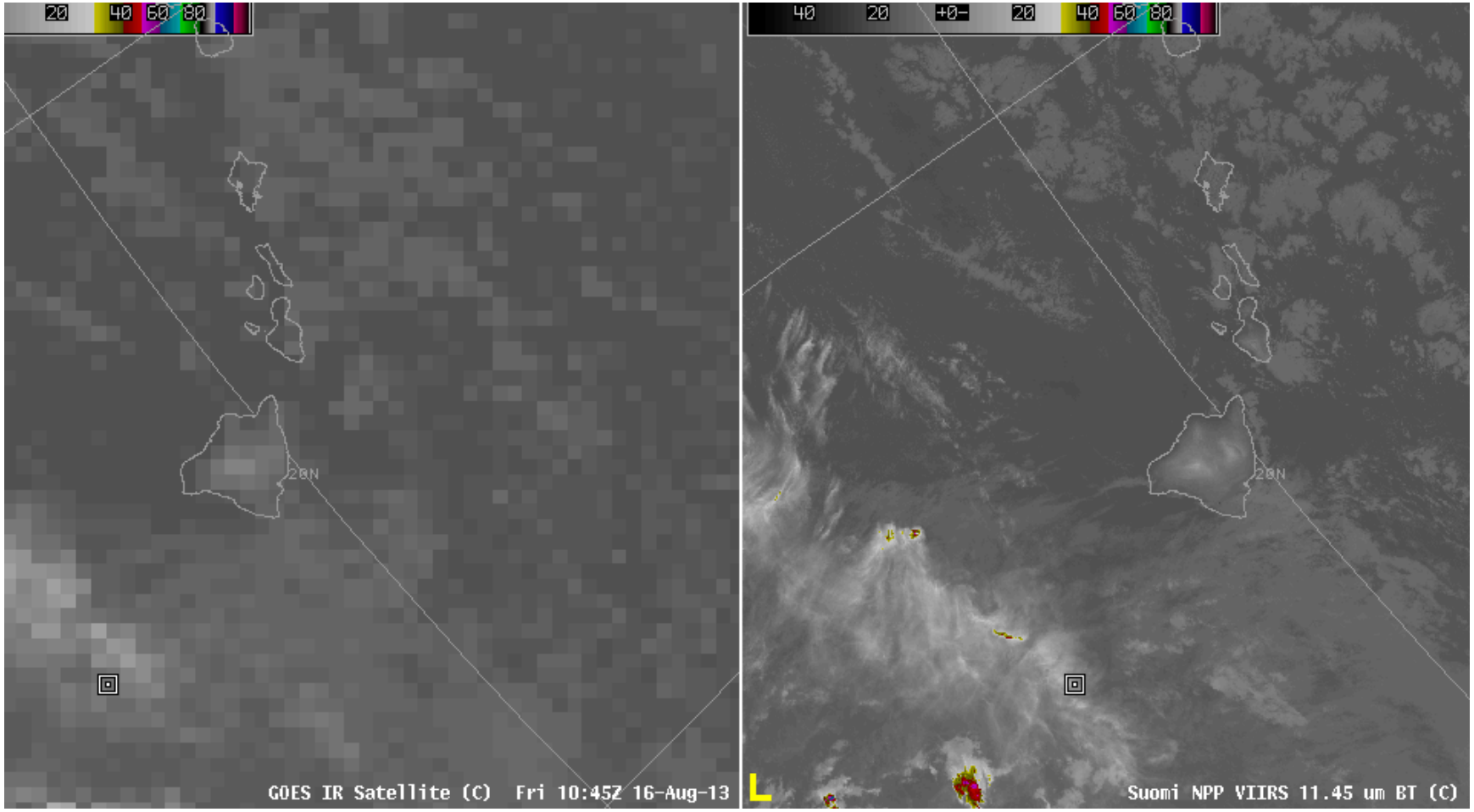
GEO versus LEO perspective



GEO versus LEO perspective



GEO versus LEO perspective



How Important Is Spatial Resolution?

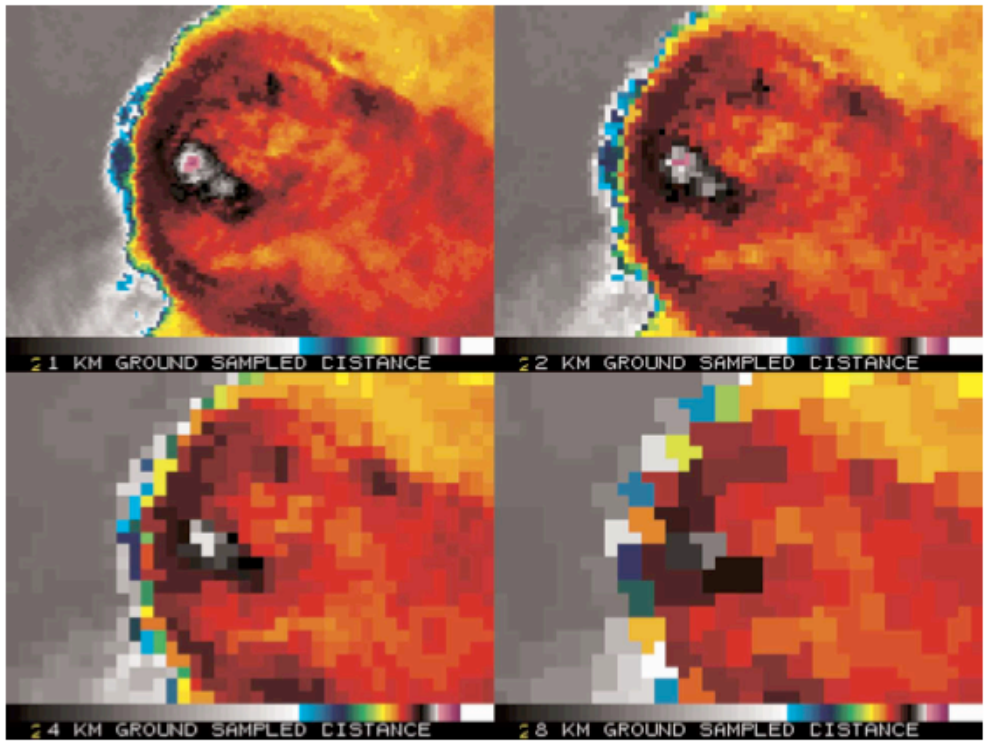
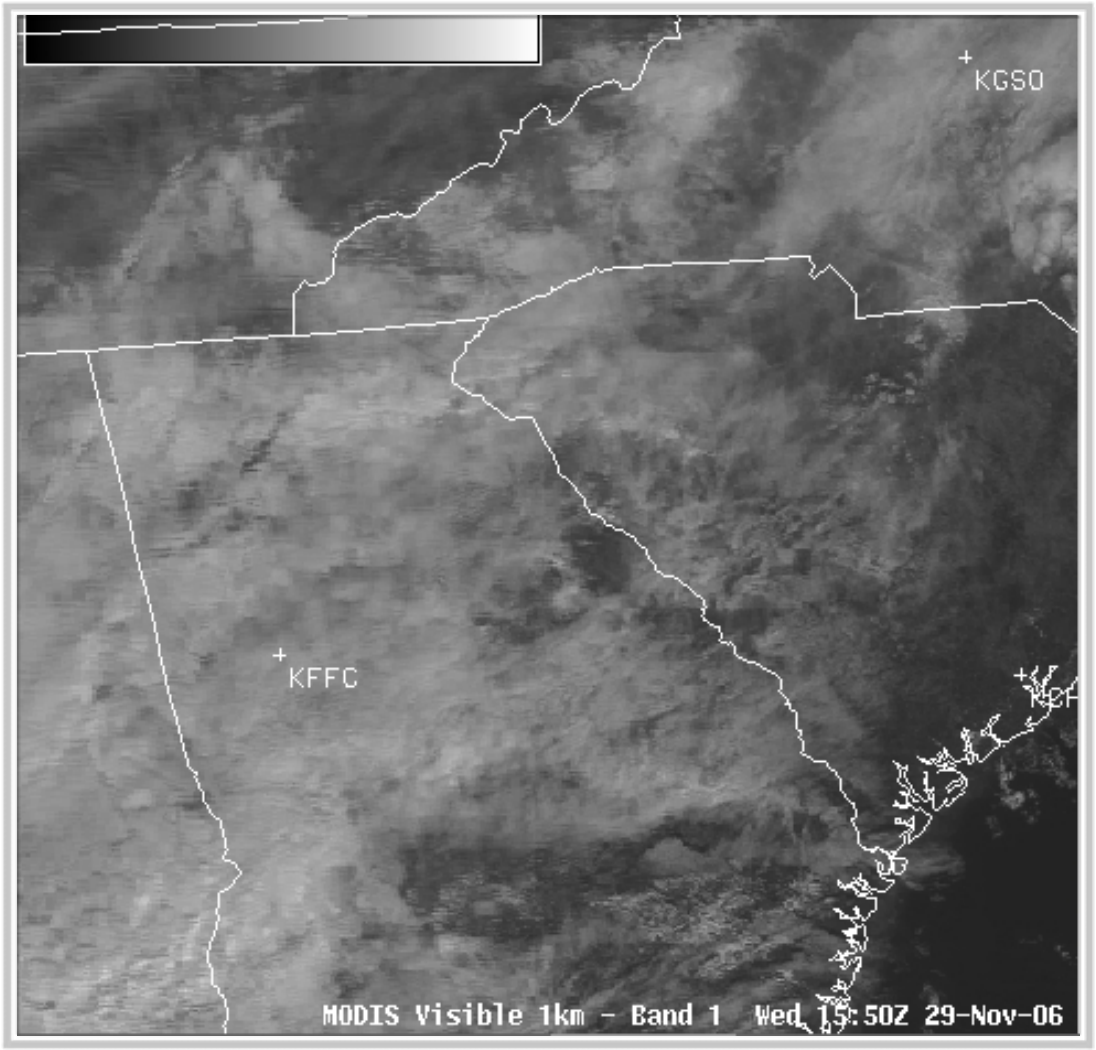


FIG. 3. Zoomed-in image of an enhanced-V feature located over northeast OK observed from enhanced LEO satellite imagery at 2218 UTC 6 May 2003 for 1-, 2-, 4-, and 8-km ground-sampled distances. The purple and white colors in the location of the updraft and overshooting top represent colder BTs, while the surrounding black and red colors represent warmer BTs.

A Quantitative Analysis of the Enhanced-V Feature in Relation to Severe Weather Jason C. Brunner, Steven A. Ackerman, A. Scott Bachmeier, and Robert M. RabinWeather and Forecasting Volume 22, Issue 4 (August 2007) pp. 853–872

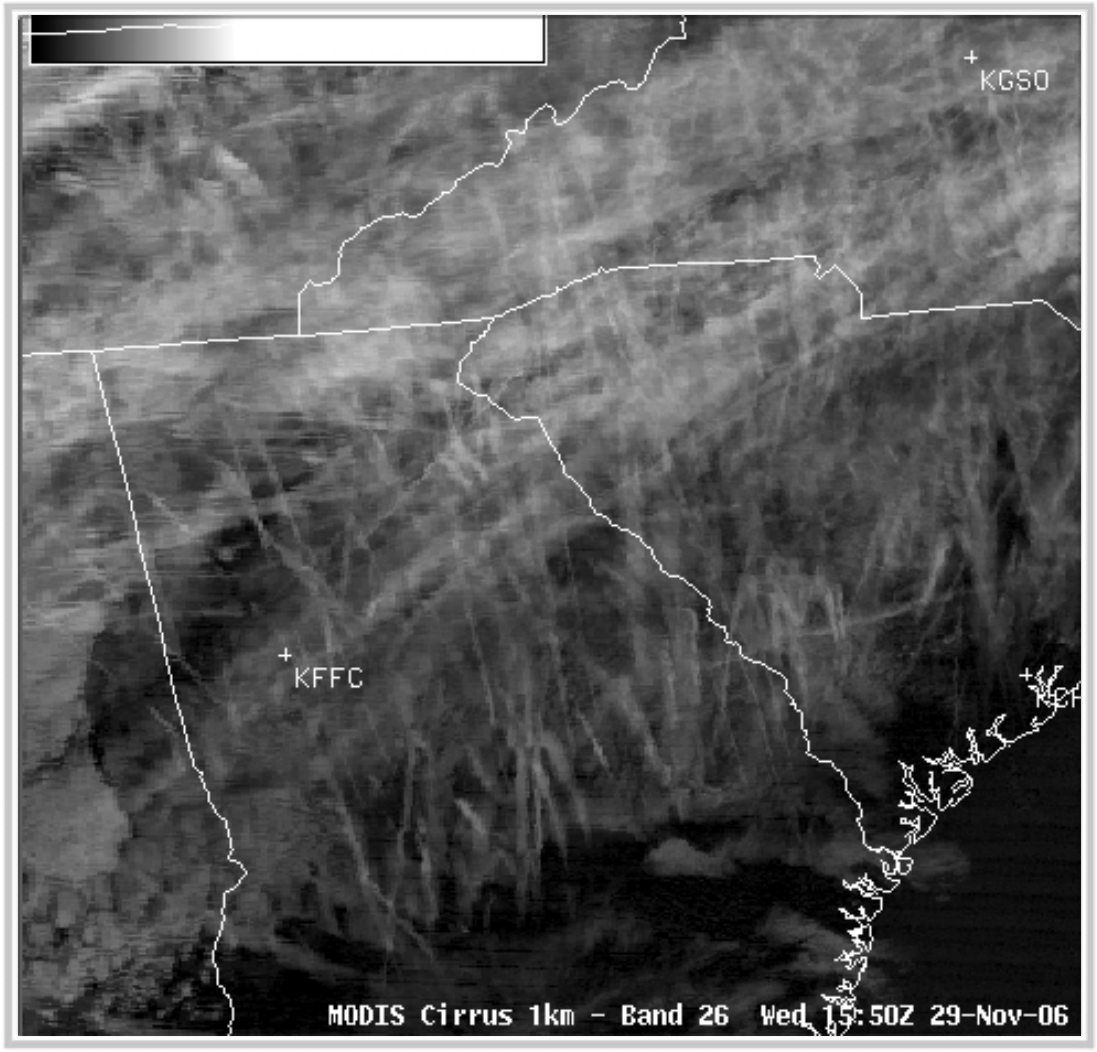
MODIS Imagery in AWIPS

Band 26: Cirrus detection (1.38 µm)



MODIS Imagery in AWIPS

Band 26: Cirrus detection (1.38 µm)



Can Polar Orbiter Data Really Be That Useful to Forecasters?

MODIS data to the NWS

- University of Wisconsin providing Direct Broadcast MODIS products to NWS since June 2006
- 1 km Reflectances and Brightness Temperatures
  - Bands 1 (.68 µm), Band 26 (1.38 µm), Band 7 (2.1 µm)
  - Band 20 (3.7 µm), Band 27 (6.7 µm), Band 31 (11 µm)
- Products
  - 1 km
    - Sea Surface Temperature, NDVI, Land Surface Temperature, Fog Product
  - 5 km
    - Cloud Top Pressure, Total Precipitable Water, Cloud Phase
- True Color 250 m Imagery

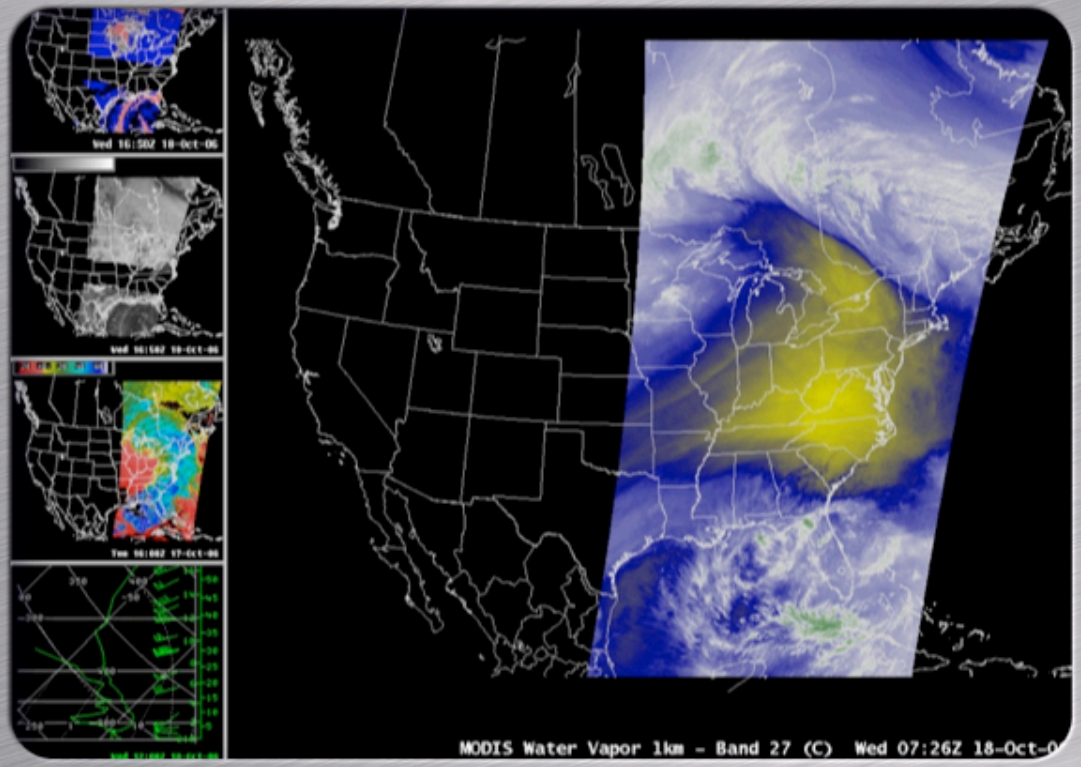
VIIRS data to the NWS

- University of Wisconsin providing Direct Broadcast VIIRS products to NWS in May 2012
- 1km Reflectances and Brightness Temperatures
  - M-Bands 5 (.67 µm), M-Band 7 (.86 µm), M-Band 10 (1.6 µm)
  - M-Band 12 (3.7 µm), M-Band 15 (11 µm)

VIIRS and MODIS for NWS

- Now in the process if upgrading to all VIIRS/ MODIS bands (selected by NWS)
- Corrected reflectances for creation of 24 bit true and false color imagery

MODIS Products in AWIPS



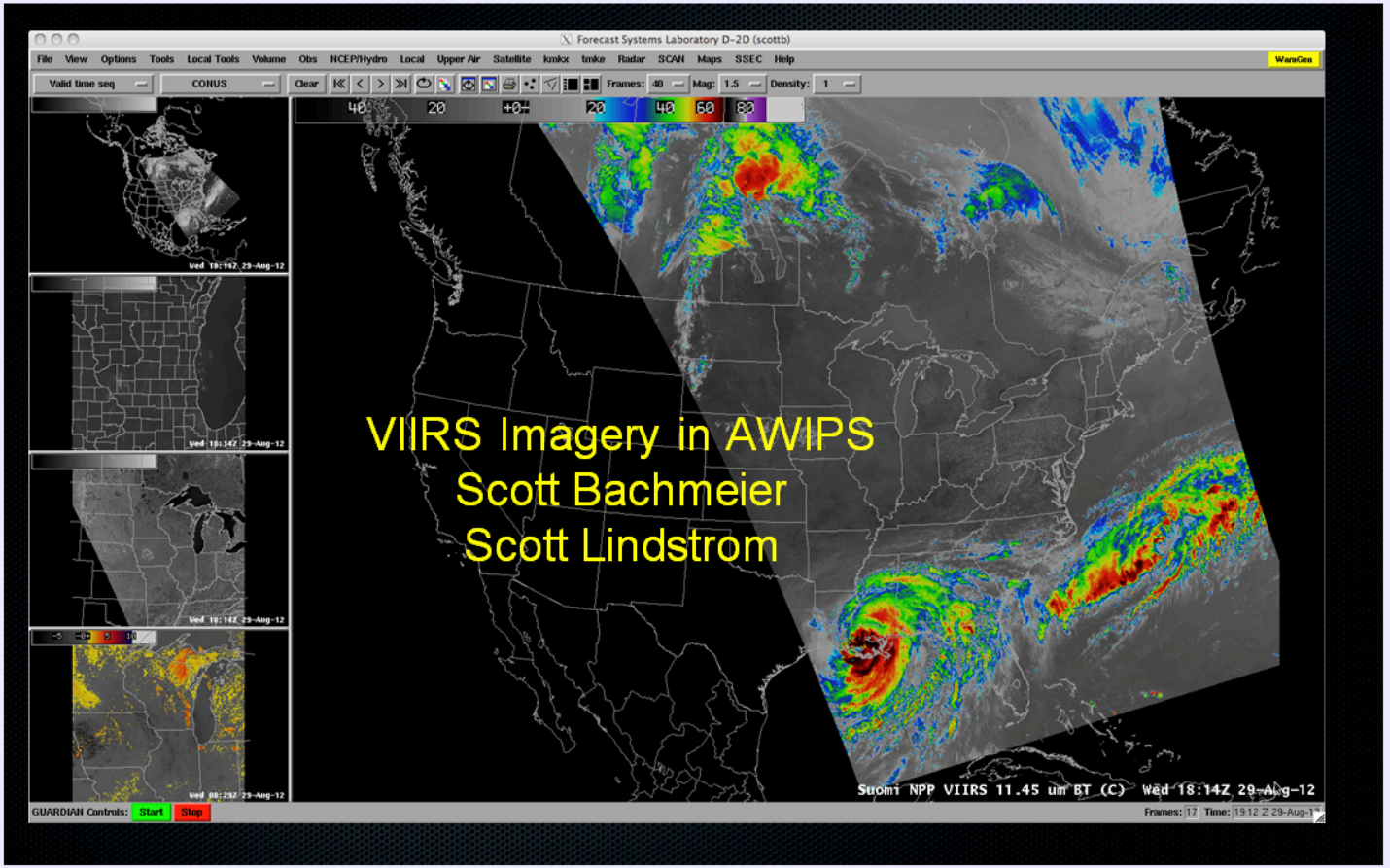
National Weather Service • Integrated Sensor Training Professional Development Series
Virtual Institute for Satellite Integration Training

Virtual Institute for Satellite Integration Training (VISIT) lesson - offered since October 2006

VISIT

VIIRS Satellite Imagery in AWIPS

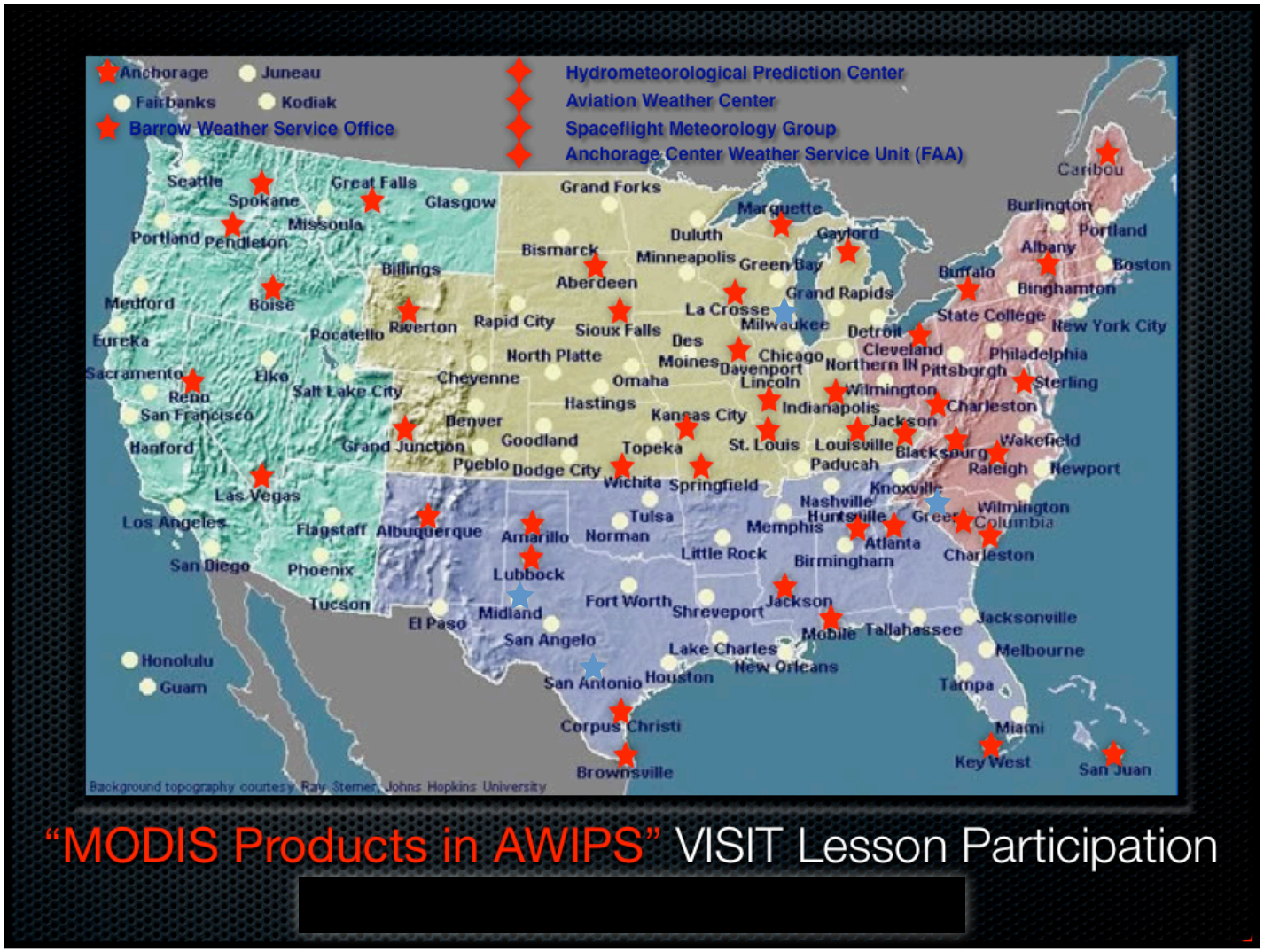
Scott Bachmeier and Scott Lindstrom



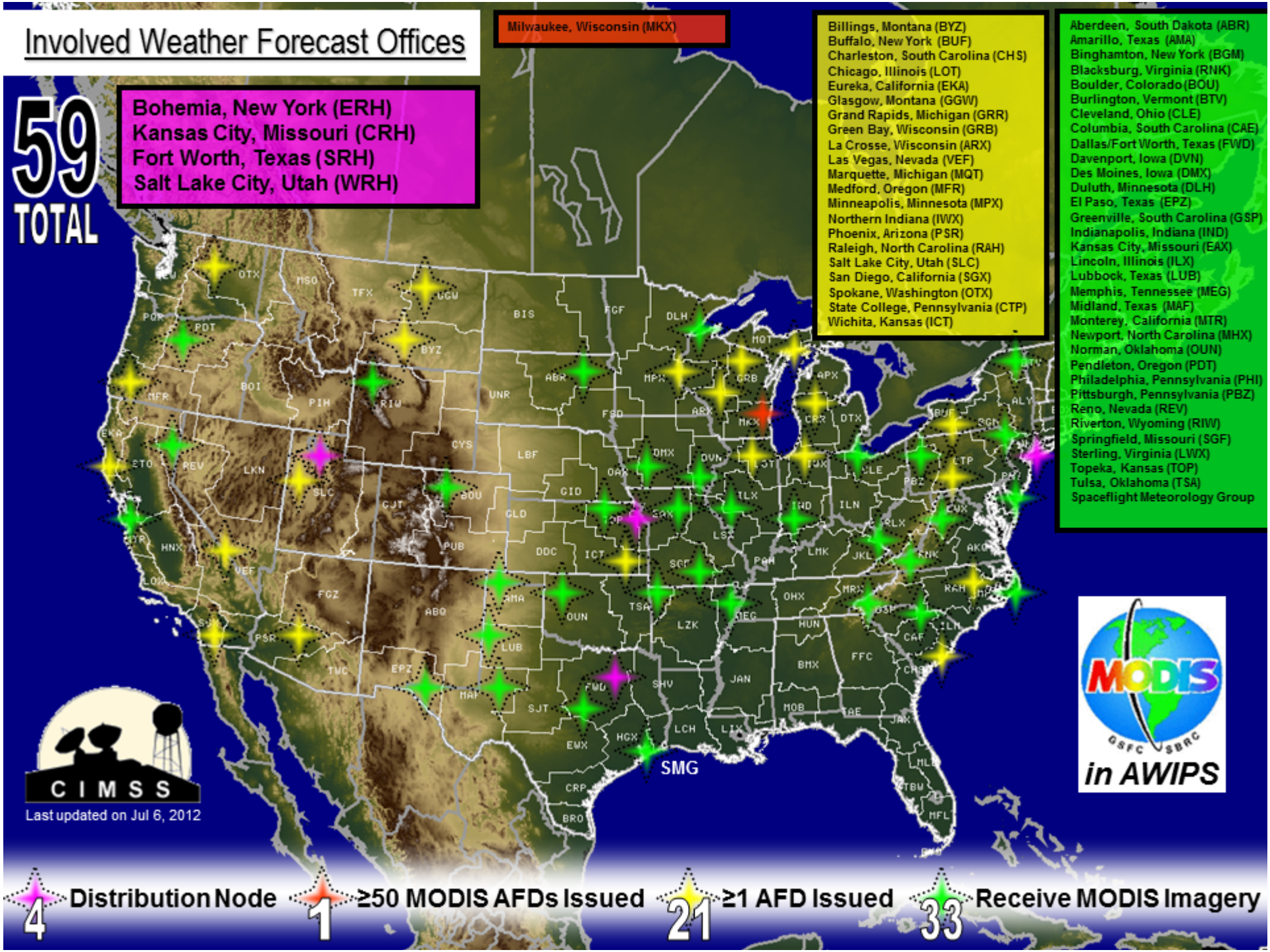
Introduction

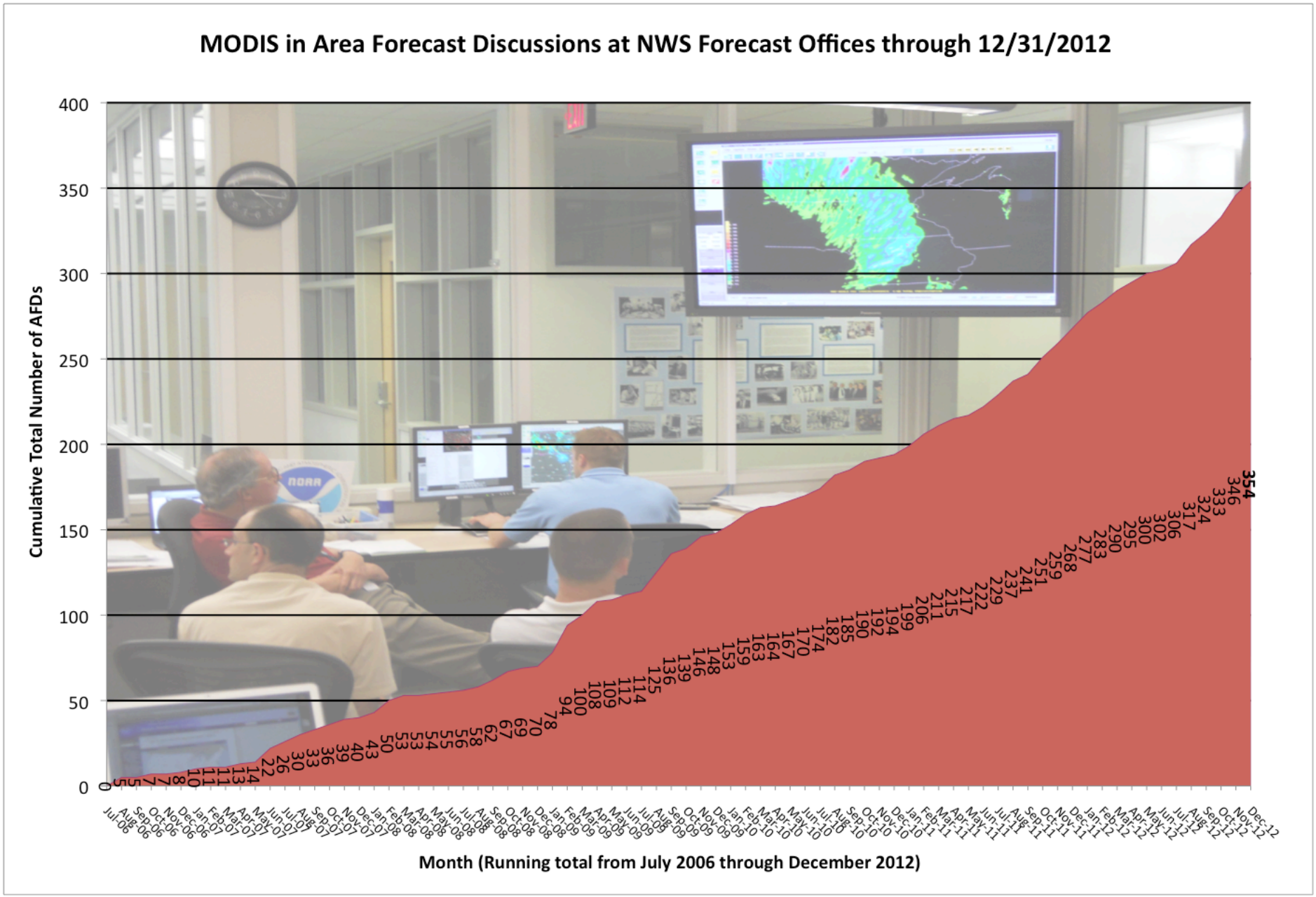
This basic-level VISIT teletraining lesson will describe the Visible Infrared Imaging Radiometer Suite (VIIRS) data from the Suomi/NPP (National Polar-orbiting Partnership) satellites that have recently been made available to the NWS Regional AWIPS servers (WFOs may add VIIRS imagery to their local AWIPS via LDM subscription). A variety of VIIRS examples will demonstrate the unique operational utility of these new satellite products, which will help forecasters prepare for new satellite channels and products coming in the JPSS and GOES-R era. (lesson created

MODIS Products in AWIPS



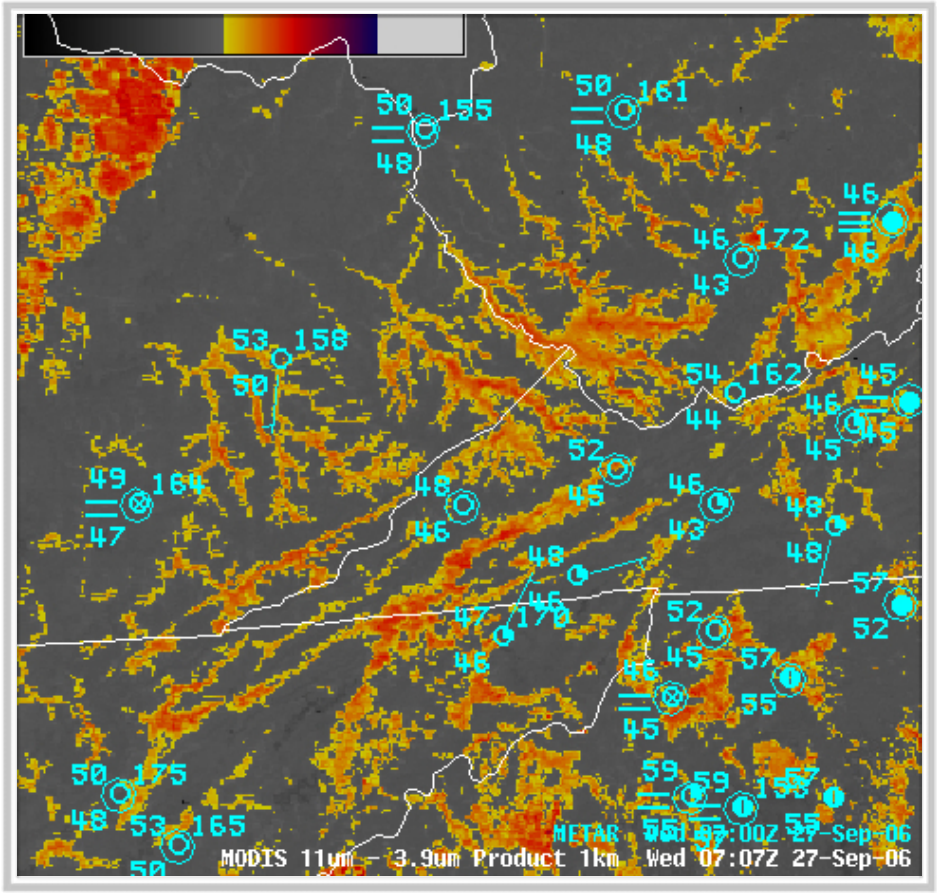
53 NWS forecast offices participating so far


Involved Weather Forecast Offices
59
TOTAL
Bohemia, New York (ERH)
Kansas City, Missouri (CRH)
Fort Worth, Texas (SRH)
Salt Lake City, Utah (WRH)
Milwaukee, Wisconsin (MKX)
Billings, Montana (BYZ)
Buffalo, New York (BUF)
Charleston, South Carolina (CHS)
Chicago, Illinois (LOT)
Eureka, California (EKA)
Glasgow, Montana (GGW)
Grand Rapids, Michigan (GRR)
Green Bay, Wisconsin (GRB)
La Crosse, Wisconsin (ARX)
Las Vegas, Nevada (VEF)
Marquette, Michigan (MQT)
Medford, Oregon (MFR)
Minneapolis, Minnesota (MPX)
Northern Indiana (IWX)
Phoenix, Arizona (PSR)
Raleigh, North Carolina (RAH)
Salt Lake City, Utah (SLC)
San Diego, California (SGX)
Spokane, Washington (OTX)
State College, Pennsylvania (CTP)
Wichita, Kansas (ICT)
Aberdeen, South Dakota (ABR)
Amarillo, Texas (AMA)
Binghamton, New York (BGM)
Blacksburg, Virginia (RNK)
Boulder, Colorado (BOU)
Burlington, Vermont (BTV)
Cleveland, Ohio (CLE)
Columbia, South Carolina (CAE)
Dallas/Fort Worth, Texas (FWD)
Davenport, Iowa (DVN)
Des Moines, Iowa (DMX)
Duluth, Minnesota (DLH)
El Paso, Texas (EPZ)
Greenville, South Carolina (GSP)
Indianapolis, Indiana (IND)
Kansas City, Missouri (EAX)
Lincoln, Illinois (ILX)
Lubbock, Texas (LUB)
Memphis, Tennessee (MEG)
Midland, Texas (MAF)
Monterey, California (MTR)
Newport, North Carolina (MHX)
Norman, Oklahoma (OUN)
Pendleton, Oregon (PDT)
Philadelphia, Pennsylvania (PHI)
Pittsburgh, Pennsylvania (PBZ)
Reno, Nevada (REV)
Riverton, Wyoming (RIW)
Springfield, Missouri (SGF)
Sterling, Virginia (LWX)
Topeka, Kansas (TOP)
Tulsa, Oklahoma (TSA)
Spaceflight Meteorology Group
SMG
CIMSS
Last updated on Jul 6, 2012
MODIS
GSFC SBRC
in AWIPS
4 Distribution Node
1 ≥50 MODIS AFDs Issued
21 ≥1 AFD Issued
33 Receive MODIS Imagery

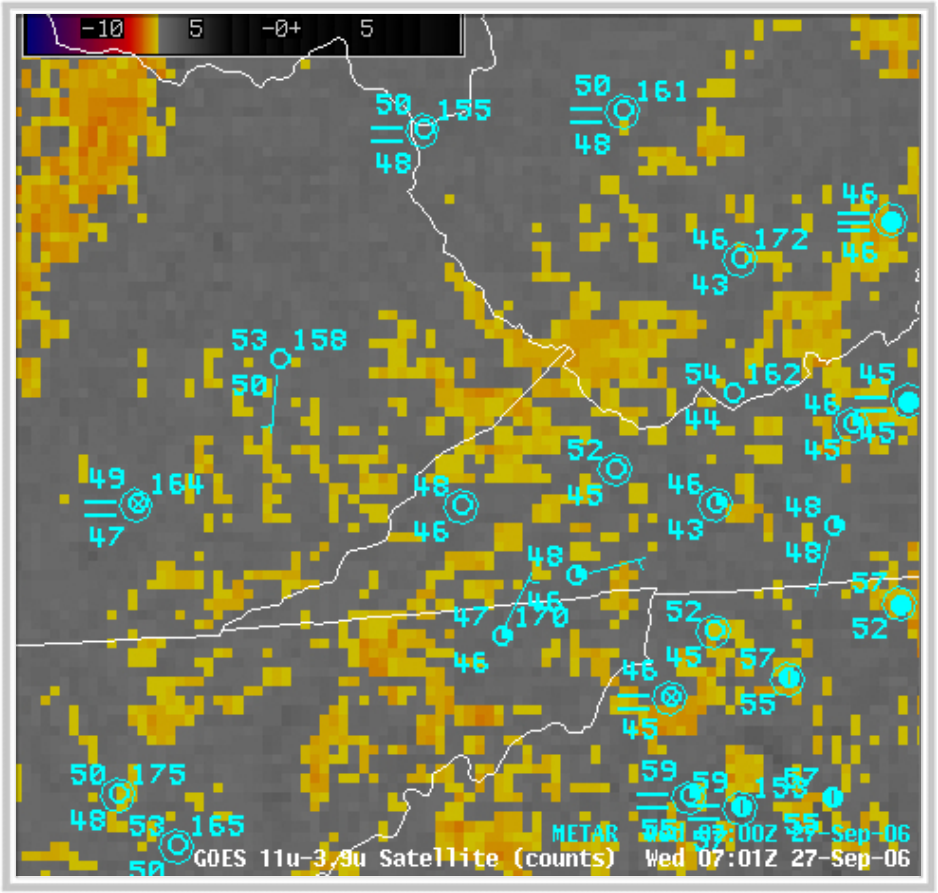

MODIS in Area Forecast Discussions at NWS Forecast Offices through 12/31/2012
Cumulative Total Number of AFDs
0
50
100
150
200
250
300
350
400
0 5 5 5 7 7 7 8 10 10 11 11 11 13 14 22 26 30 33 36 39 40 43 50 53 53 54 55 56 58 62 67 69 70 78 94 100 108 109 109 112 114 125 136 139 146 148 153 159 163 164 167 170 174 182 185 190 192 194 199 206 211 215 217 222 229 237 241 251 259 268 277 283 290 295 300 302 306 317 324 333 346 354
Jul-06 Aug-06 Sep-06 Oct-06 Nov-06 Dec-06 Jan-07 Feb-07 Mar-07 Apr-07 May-07 Jun-07 Jul-07 Aug-07 Sep-07 Oct-07 Nov-07 Dec-07 Jan-08 Feb-08 Mar-08 Apr-08 May-08 Jun-08 Jul-08 Aug-08 Sep-08 Oct-08 Nov-08 Dec-08 Jan-09 Feb-09 Mar-09 Apr-09 May-09 Jun-09 Jul-09 Aug-09 Sep-09 Oct-09 Nov-09 Dec-09 Jan-10 Feb-10 Mar-10 Apr-10 May-10 Jun-10 Jul-10 Aug-10 Sep-10 Oct-10 Nov-10 Dec-10 Jan-11 Feb-11 Mar-11 Apr-11 May-11 Jun-11 Jul-11 Aug-11 Sep-11 Oct-11 Nov-11 Dec-11 Jan-12 Feb-12 Mar-12 Apr-12 May-12 Jun-12 Jul-12 Aug-12 Sep-12 Oct-12 Nov-12 Dec-12
Month (Running total from July 2006 through December 2012)

MODIS Imagery in AWIPS

Fog/stratus product (11.0μm - 3.7μm)



1-km MODIS



4-km GOES

Improved fog/stratus detection capability

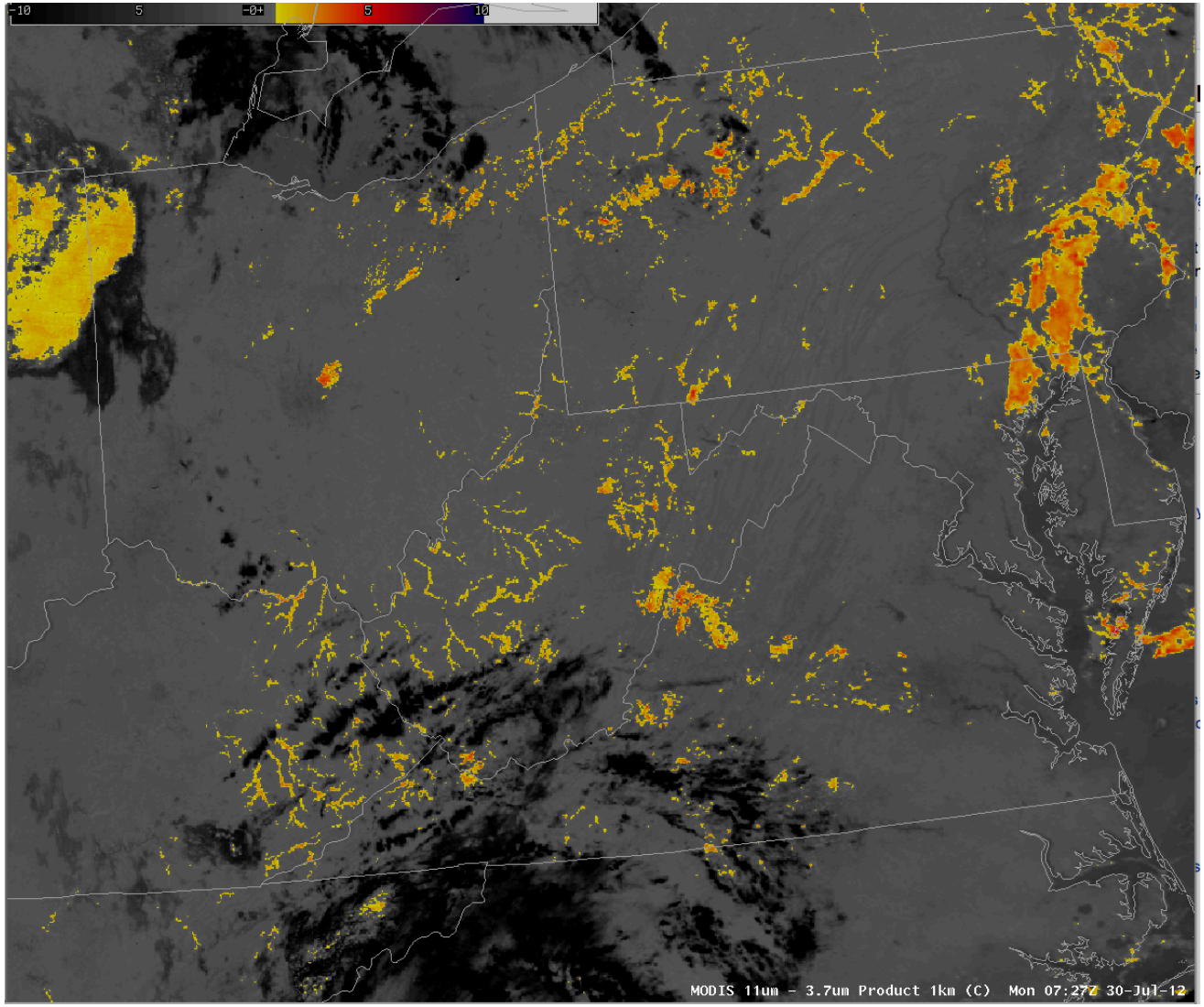
AREA FORECAST DISCUSSION
NATIONAL WEATHER SERVICE STATE COLLEGE PA
601 AM EDT TUE AUG 20 2013

.SYNOPSIS...
HIGH PRESSURE OFF OF THE EAST COAST WILL CONTROL THE WEATHER ACROSS PA THROUGH MIDWEEK. A COLD FRONT WILL PUSH THROUGH THE REGION LATE THURSDAY OR EARLY FRIDAY. CANADIAN HIGH PRESSURE WILL THEN BUILD SOUTHEAST INTO PENNSYLVANIA NEXT WEEKEND.

&&

.NEAR TERM /UNTIL 6 PM THIS EVENING/...
MODIS 11-3.7UM IMAGERY SHOWING WIDESPREAD VALLEY FOG ACROSS CENTRAL PA EARLY THIS AM. MANY LOCATIONS AOB 1/4SM VSBY AT 09Z...SO HAVE ISSUED A DENSE FOG ADVISORY THRU 13Z. 3KM HRRR SFC RH SUGGESTS THE FOG WILL BURN OFF IN MANY LOCATIONS BY ARND 12Z...BUT WILL LIKELY LINGER IN A FEW LOCATIONS UNTIL 14Z.

Supporting Visibility Forecasts



AREA FORECAST DISCUSSION
NATIONAL WEATHER SERVICE
STATE COLLEGE PA
543 AM EDT MON JUL 30 2012

.NEAR TERM /UNTIL 6 PM THIS EVENING/...

MODIS 11-3.7UM IMAGERY SHOWING DENDRITIC PATTERN OF VALLEY FOG ACROSS THE ALLEGHENIES EARLY THIS MORNING...THE RESULT OF A CALM WIND AND TEMPS MUCH COOLER THAN THE RIVER/STREAM WATER. ACROSS SOUTHEAST PA...A MOIST SERLY FLOW...COMBINED WITH RADIATIONAL COOLING...IS CAUSING LOW CLOUDS/FOG TO DEVELOP. LATEST MESOSCALE MDL DATA INDICATES THE ALLEGHENY VALLEY FOG WILL BURN OFF BY ARND 13Z. MDL SOUNDINGS SUGGEST THE LOW CLOUDS/FOG ACROSS THE SOUTHEASTCOUNTIES WILL LIFT INTO A SCT-BKN CU LYR BY LATE AM.

National Weather Service Weather Forecast Office

Milwaukee/Sullivan, WI

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Local forecast by "City, St" or Zip Code

City, St Go

XML RSS Feeds

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Watches/Warnings
Outlooks
Submit Report

Current Conditions
Observations
Radar
Satellite
Observed Precip

Forecasts
Forecast Discussion
Activity Planner
Aviation Weather
Fire Weather
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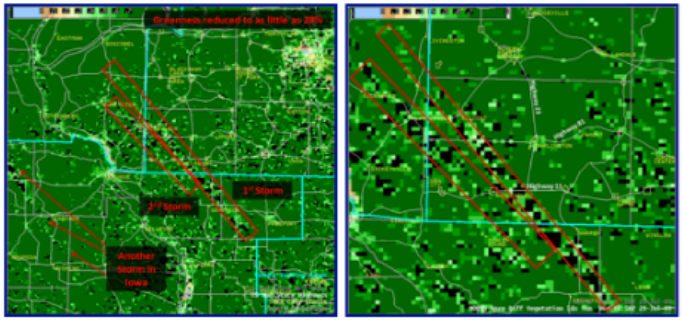
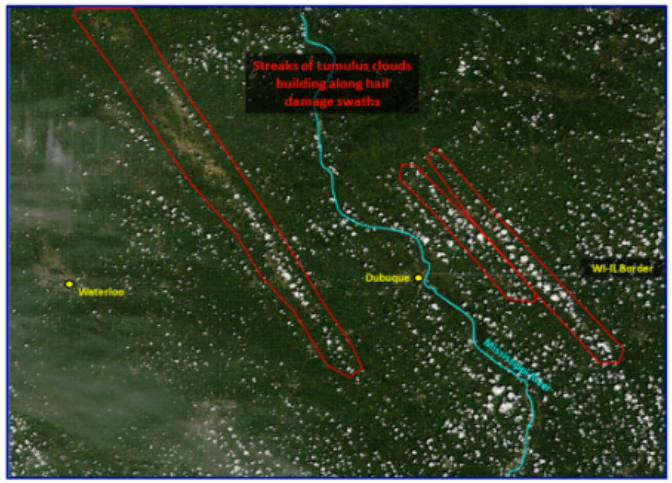
Hail Scars Visible On Satellite Imagery

On Friday July 24, 2009, multiple significant hail storms moved southeastward across northeast Iowa, southwest Wisconsin, and northwest Illinois. These hail storms produced extremely large hail, and copious amounts of hail, which led to some concentrated swaths of damage to vegetation. In some areas, most of the crops were severely damaged or destroyed. For a complete write-up on the situation, **click here**.

With a relatively clear day today, some of the scarring is visible on satellite images. First, the MODIS Vegetation Index which is a 1km resolution product designed to pick up on areas of greenness in the vegetation:

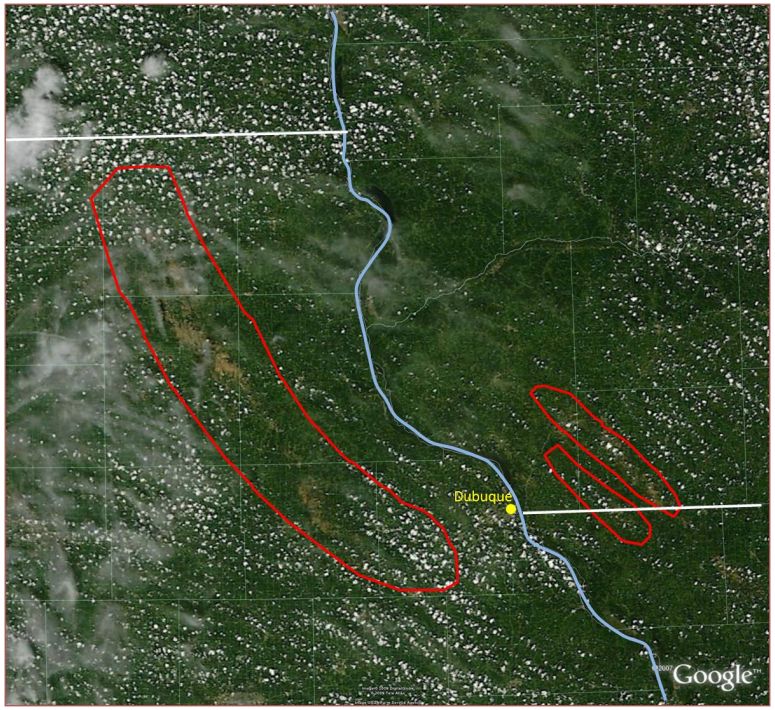


A minimum of about 28% greenness is evident just south-southeast of Belmont, which is not surprising given that is where some of the worst crop damage was observed. Corn stalks were completely stripped and sheared off to a height of less than 2 feet. These damaged areas of vegetation now absorb more radiation from the sun, thereby allowing the surface to heat faster. This phenomenon is evident in the MODIS 250m resolution satellite image from below. Cumulus clouds fired in greater abundance on the Wisconsin hail swaths, which makes them less distinguishable than the Iowa hail swath.



The below image is from a few days later, a little earlier in the day so fewer cumulus clouds. The hail scars are more clearly visible over southwest Wisconsin as well as in northeast Iowa.

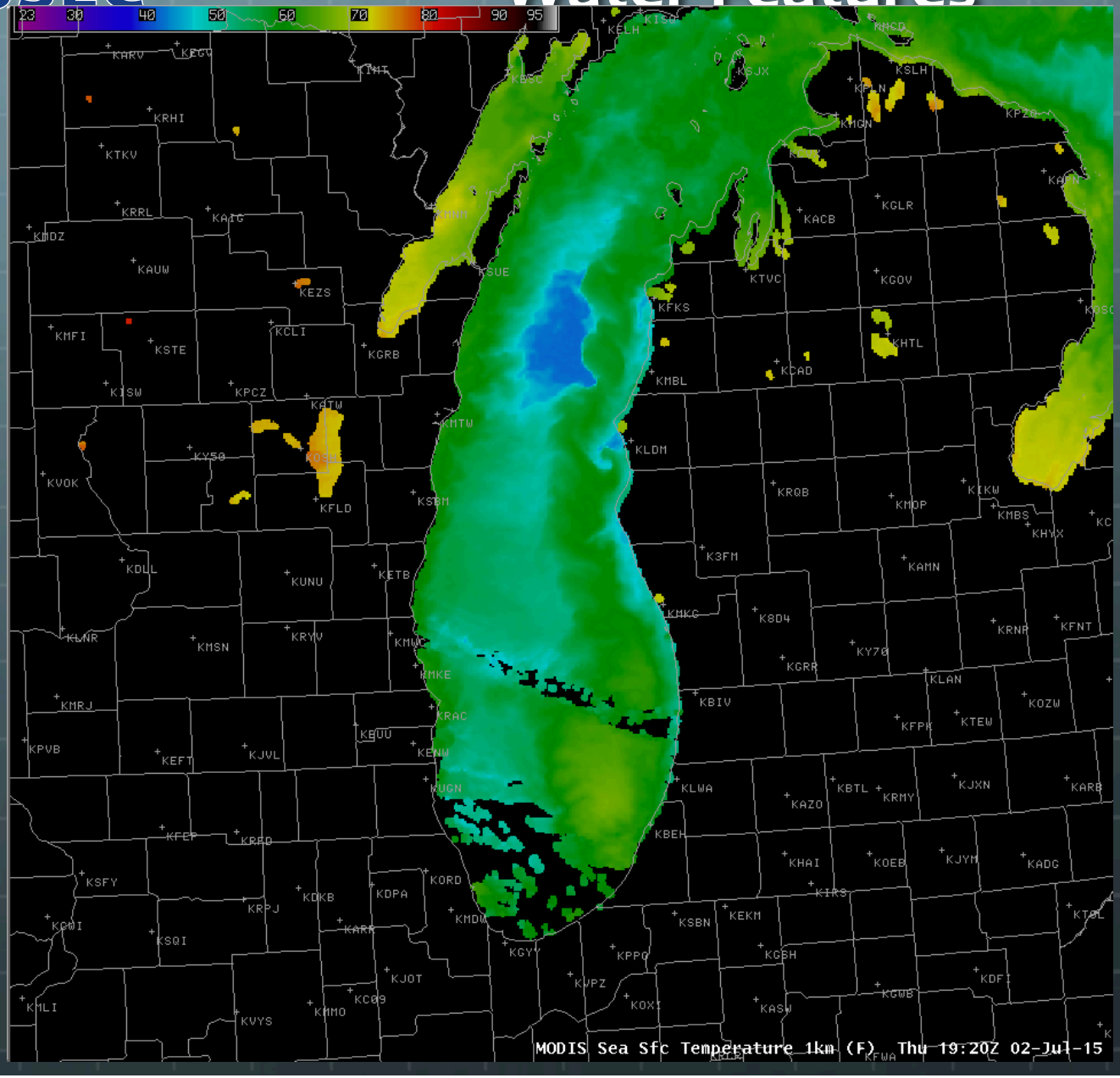
MODIS NDVI product used to determine extent of hail damage July 2008



NASA

SSEC

Identifying Fine Scale Water Features



AREA FORECAST DISCUSSION
NATIONAL WEATHER SERVICE
GRAND RAPIDS MI
326 PM EDT THU JUL 2 2015

LATEST UPDATE...

SYNOPSIS/SHORT TERM/LONG TERM/MARINE

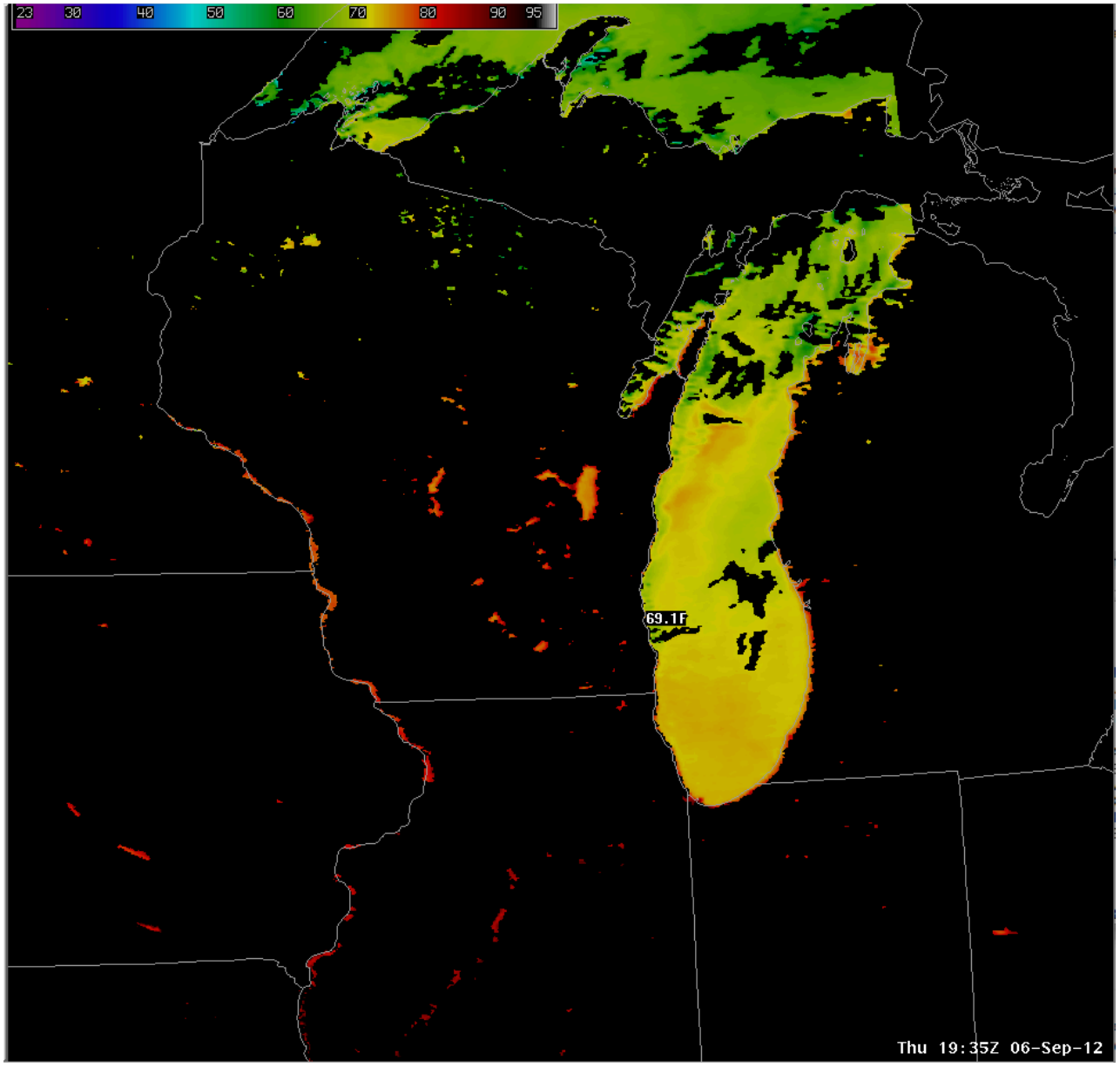
.MARINE...

ISSUED AT 326 PM EDT THU JUL 2 2015

....

ON ANOTHER NOTE...SOME UPWELLING HAS OCCURRED AT THE SHORELINE WITH THE NNE WINDS OVER THE LAST DAY. SOME WATER TEMPS HAVE DROPPED TO NEAR 40F ALONG THE SHORE PER LATEST WATER OBSERVATIONS FROM THE SITES ALONG THE COAST THIS MORNING AND MODIS SATELLITE IMAGERY.

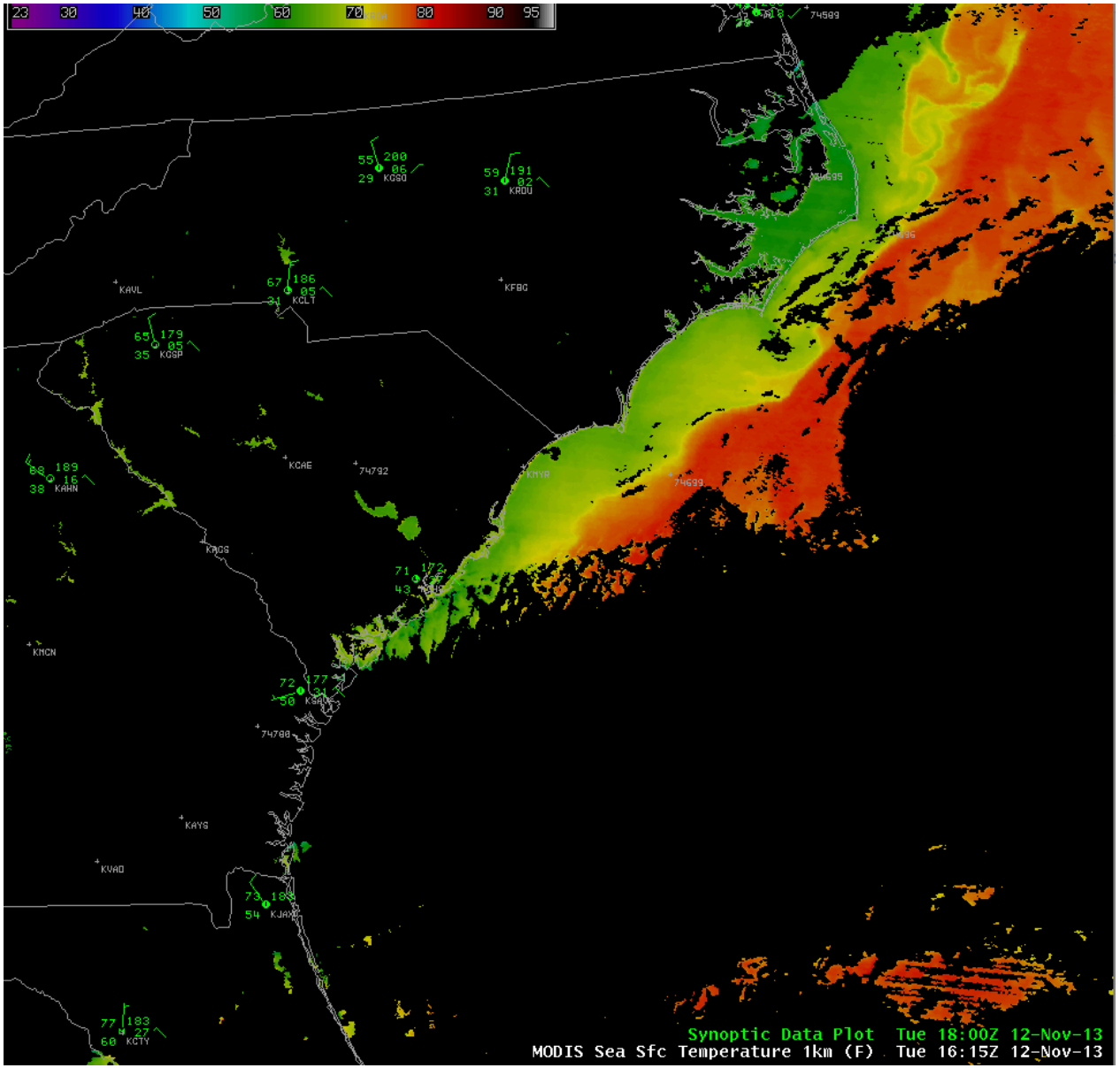
MODIS SST Supports Waterspout Forecasts



AREA FORECAST DISCUSSION
NATIONAL WEATHER SERVICE
MILWAUKEE/SULLIVAN WI
330 AM CDT FRI SEP 7 2012

.MARINE...TIGHTENING PRESSURE GRADIENT ASSOCIATED WITH DEEPENING LOW PRESSURE MOVING ALONG A FRONTAL BOUNDARY TO THE SOUTH OF LAKE MICHIGAN ALONG WITH A STEEPENING LOW LEVEL LAPSE RATE WILL RESULT IN GUSTY NORTH WINDS REACHING SMALL CRAFT ADVISORY LEVELS TONIGHT INTO SATURDAY. **LATEST MODIS IMAGERY SHOWS LAKE SURFACE TEMPERATURE IN THE NEARSHORE WATERS 68-70F. STRONG LOW LEVEL COLD AIR ADVECTION IS EXPECTED TO INCREASE THE DELTA-T OVER THE LAKE TO 12-13 DEGREES THIS EVENING WITH CONVECTIVE CLOUD DEPTH INCREASING TO 15 TO 20K. WATERSPOUT INDEX INCREASES TO 8 TO 10 UNITS. WL ADD MENTION OF WATERSPOUTS TO HWO FOR LATE AFTERNOON INTO THE EVENING.**

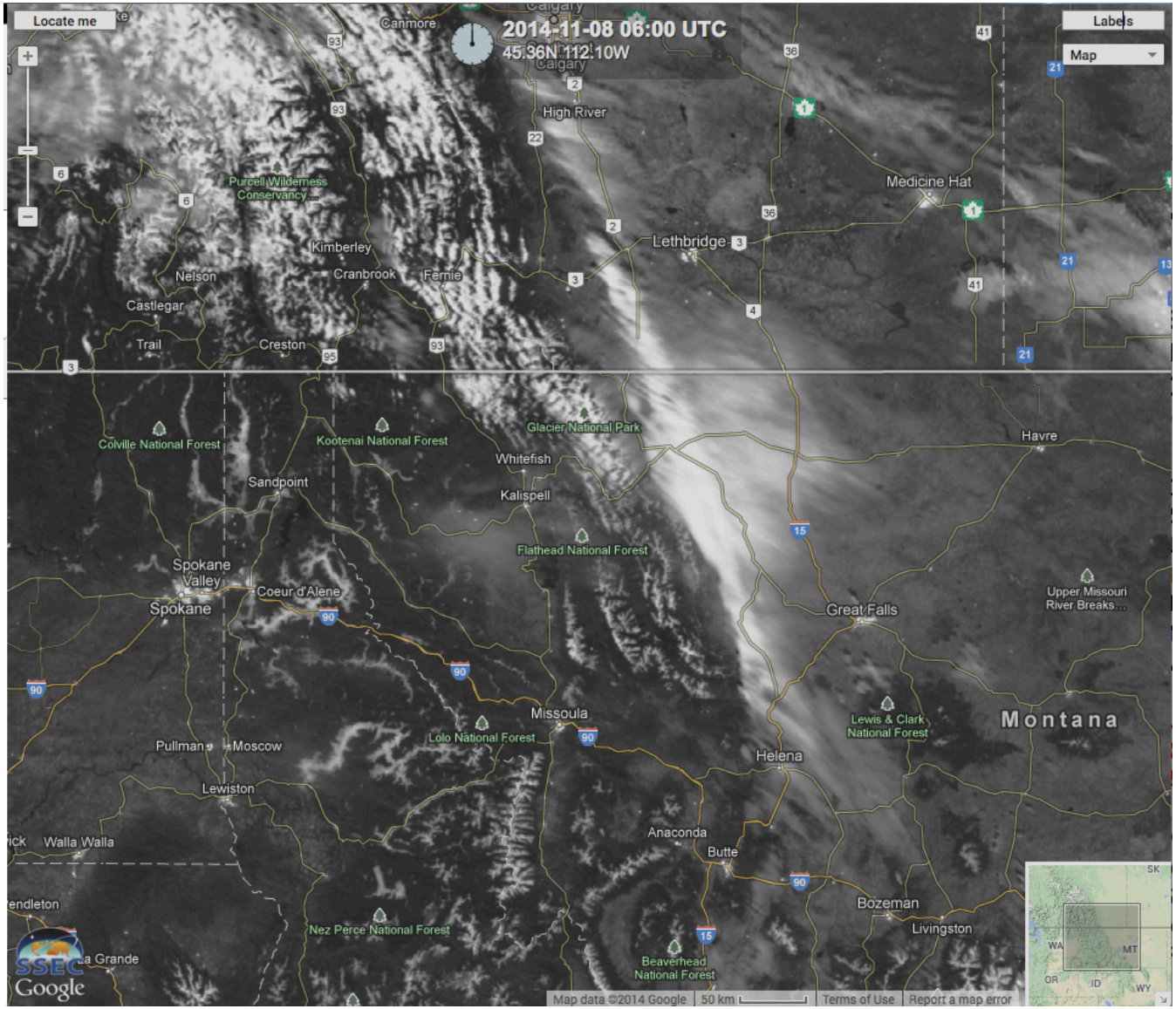
Marine Gale Force Wind Forecasts



AREA FORECAST DISCUSSION
NATIONAL WEATHER SERVICE
CHARLESTON SC
632 PM EST TUE NOV 12 2013

MARINE...
TONIGHT...CONDITIONS ARE SET FOR A DANGEROUS AND WIDESPREAD GALE EVENT. WINDS WILL INCREASE QUICKLY THIS EVENING AS THE ARCTIC FRONT PUSHES OFFSHORE AND STRONG COLD AIR ADVECTION ENSUES. SOLID GALES APPEAR LIKELY FOR ALL MARINE LEGS WITH WINDS TOPPING 30-35KT WITH GUSTS 40-45 KT NEARSHORE WATERS AND 35-40 KT WITH GUSTS TO 45 KT OVER THE GEORGIA OFFSHORE LEG. ALREADY SEEING WINDS GUSTING OVER 40 KT OFF THE NORTH CAROLINA OUTER BANKS. GALE WARNINGS ARE IN PLACE FOR ALL WATERS AND WILL WILL BE MAINTAINED. ***THERE IS CONCERN THAT FREQUENT GUSTS TO STORM FORCE COULD OCCUR ALONG THE EASTERN PORTIONS OF THE GEORGIA OFFSHORE WATERS WHERE 1KM MODIS SEA SURFACE TEMPERATURE DATA SHOWED THE WESTERN WALL STREAM IS LURKING.***

Identification of Fog at Night

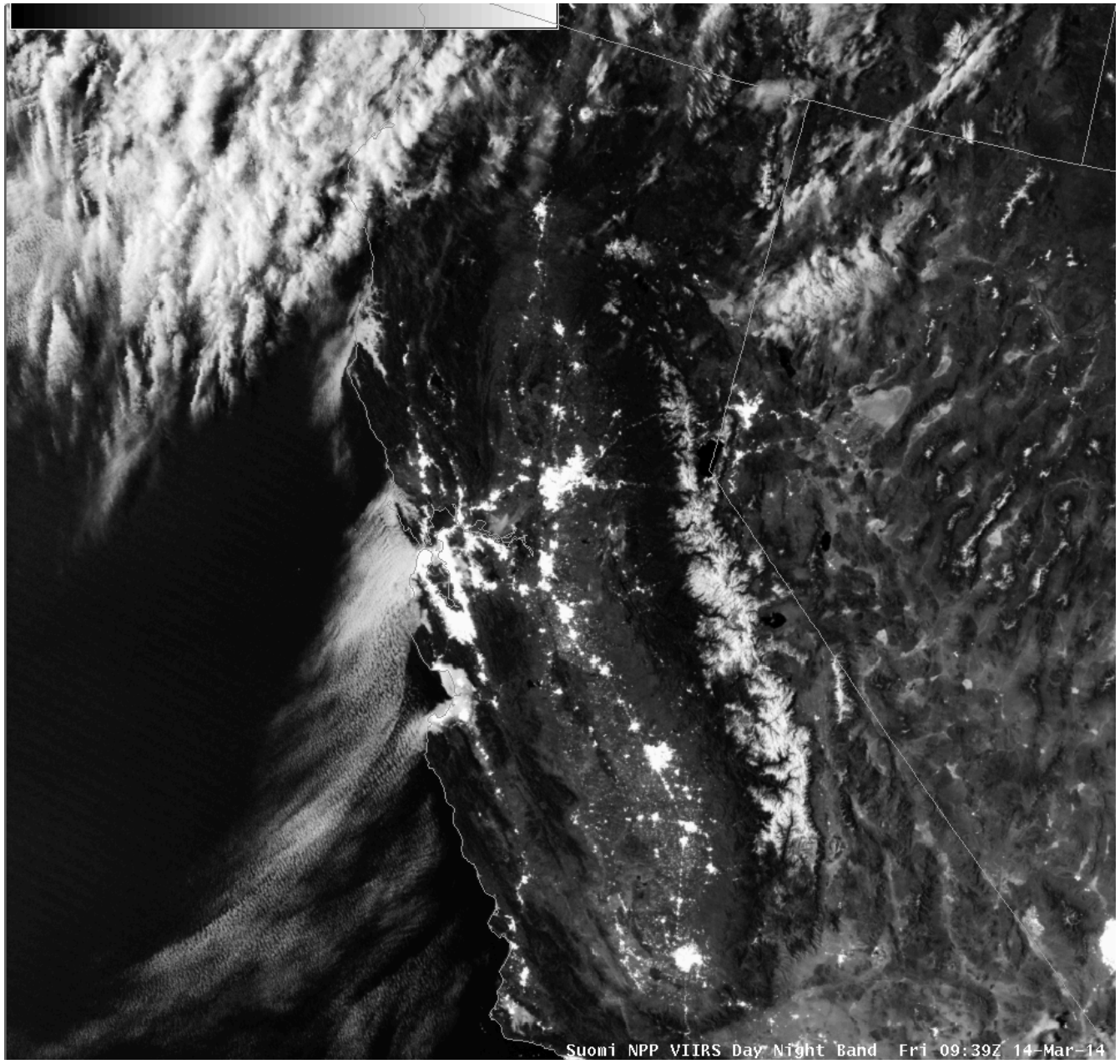


Area Forecast Discussion
National Weather Service
Missoula MT
334 AM MST SAT NOV 8 2014

…

.AVIATION...Moderate high pressure situated over the area will bring a chance for fog to develop at KGPI, KMSO and KSMN. ***The VIIRS night-time visible satellite image at 08/1010z revealed some valley fog across Clearwater County, Idaho and also north across the Idaho Panhandle.*** Any fog that develops near the aforementioned terminals will dissipate by noon. Expect light and variable surface winds at all the terminals.

Low Cloud/ Fog Identification at Night



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.

AREA FORECAST DISCUSSION
NATIONAL WEATHER SERVICE GRAND RAPIDS MI
1156 AM EST MON FEB 24 2014

ON A SIDE NOTE IT WILL BE INTERESTING TO SEE THE MODIS SAT PIC FROM TODAY AS THERE APPEARS TO BE SOME THIN ICE AGAIN IN PLACE ACROSS THE FAR SOUTH PART OF THE LAKE AND UP THE WESTERN SHORE TOWARDS MILWAUKEE. THIS WILL HAVE SOME AFFECT ON FETCH LENGTH IN A SOUTHWEST FLOW. OBVIOUSLY THE LAKE IS MUCH MORE OPEN THAN IT WAS A WEEK OR SO AGO. THE MODIS PASSES OVER LAKE MICHIGAN AT 1710Z TODAY OR IN ABOUT 15 MINS.

So we have gone from "Can Research Satellite be Used in Operations?" to forecasters knowing the MODIS orbit overpass times, and expecting the data to be useful.

Thunderstorms

- Characteristics of Severe Weather as Observed from Satellite
  - Overshooting Tops
  - Gravity Wave Generation

How Important Is Spatial Resolution?

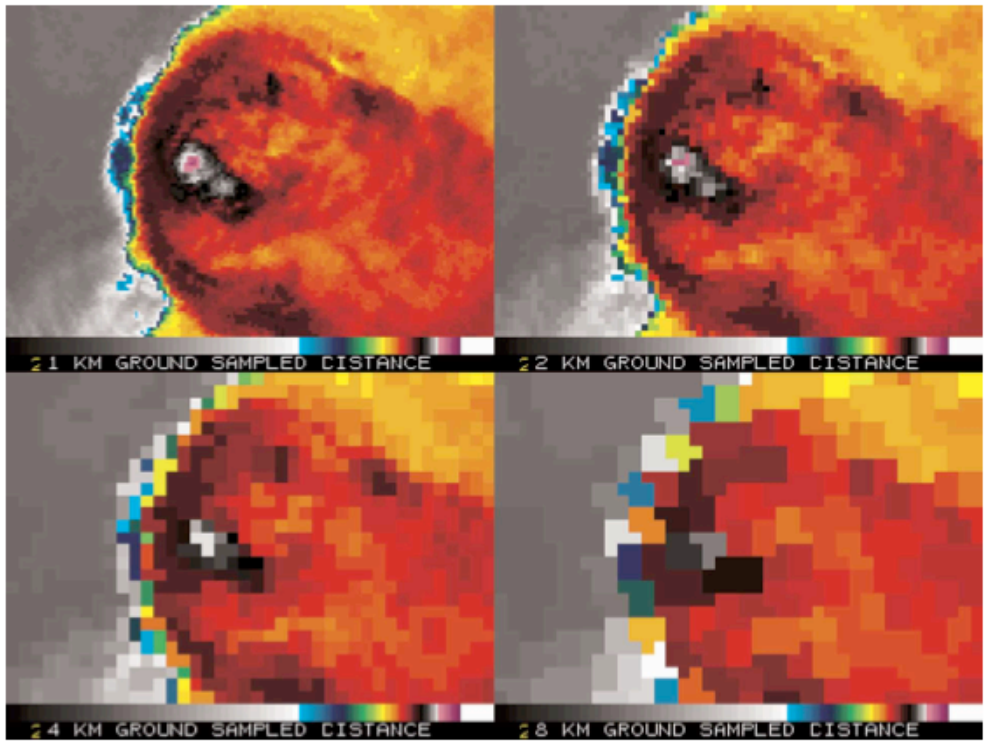
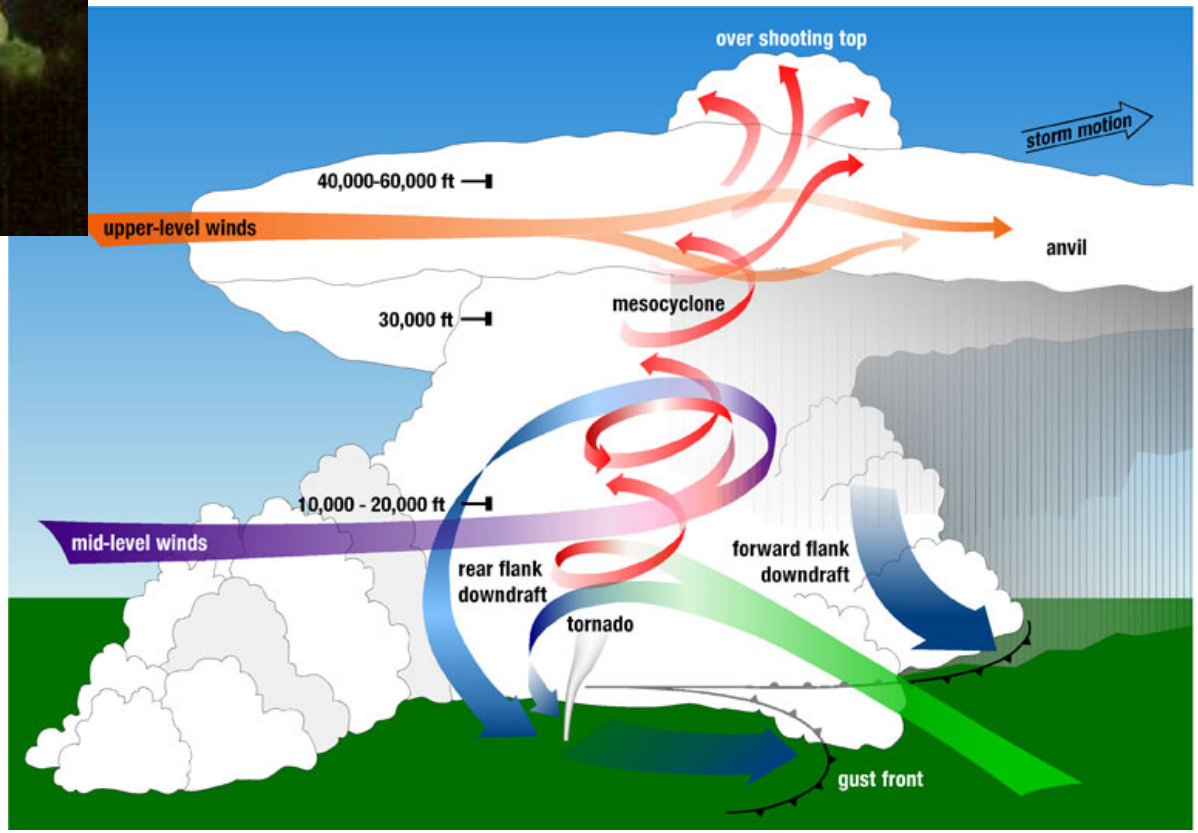


FIG. 3. Zoomed-in image of an enhanced-V feature located over northeast OK observed from enhanced LEO satellite imagery at 2218 UTC 6 May 2003 for 1-, 2-, 4-, and 8-km ground-sampled distances. The purple and white colors in the location of the updraft and overshooting top represent colder BTs, while the surrounding black and red colors represent warmer BTs.

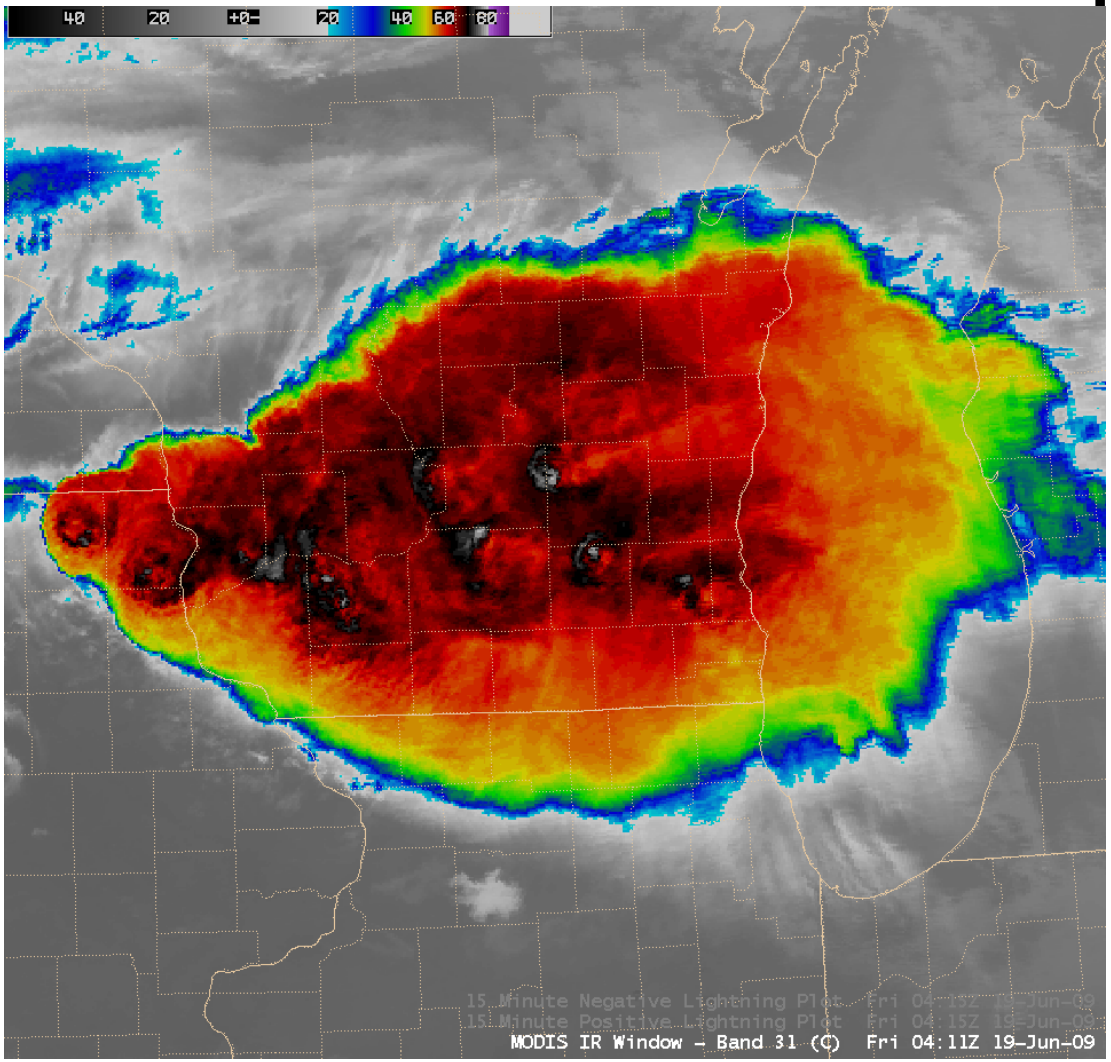
A Quantitative Analysis of the Enhanced-V Feature in Relation to Severe Weather Jason C. Brunner, Steven A. Ackerman, A. Scott Bachmeier, and Robert M. RabinWeather and Forecasting Volume 22, Issue 4 (August 2007) pp. 853–872

Overshooting Top

A dome-like protrusion above a thunderstorm anvil, representing a very strong updraft and hence a higher potential for severe weather with that storm. A persistent and/or large overshooting top often is present on a supercell.



Severe Thunderstorm Example 2

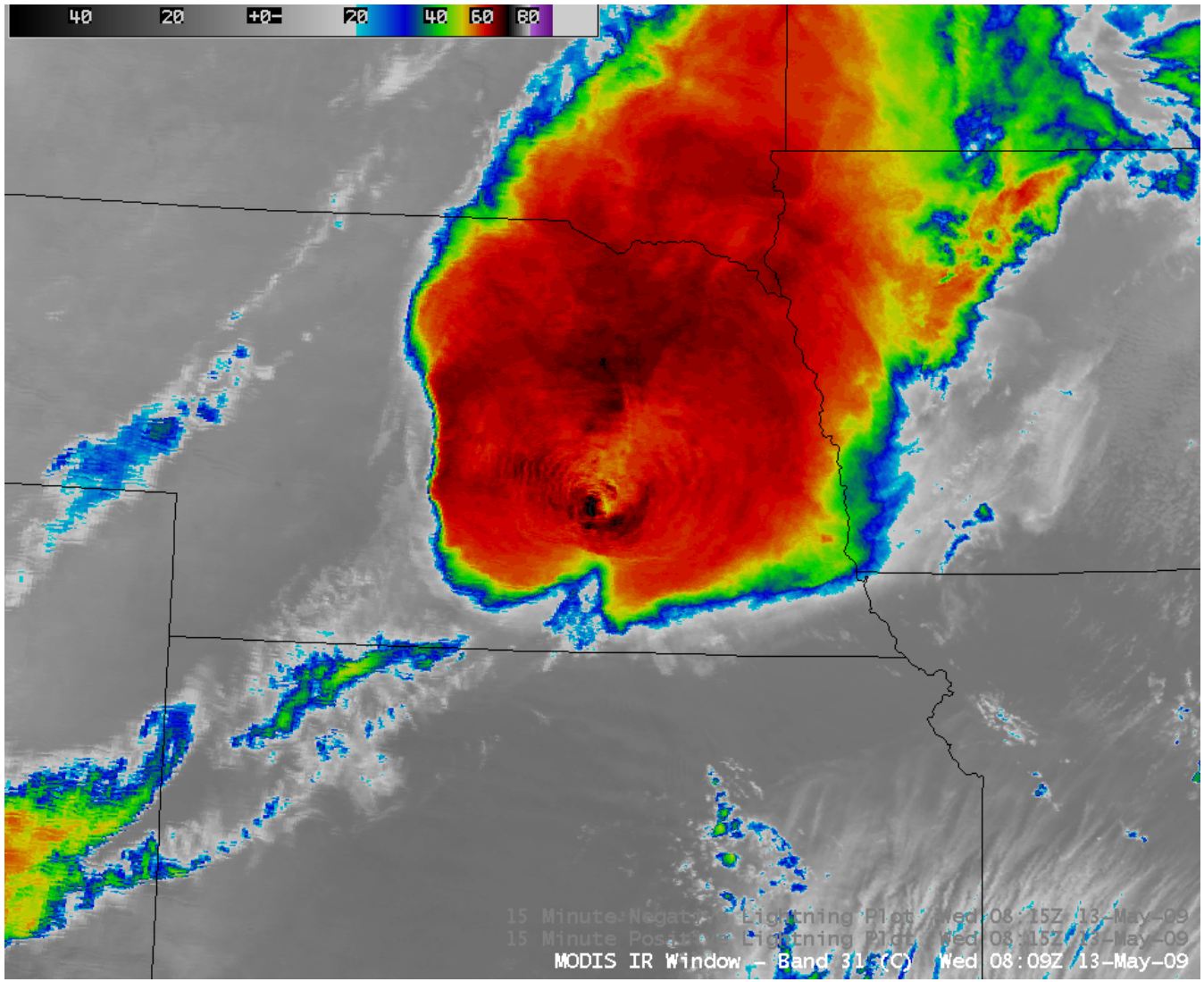


Including Lightning Detection

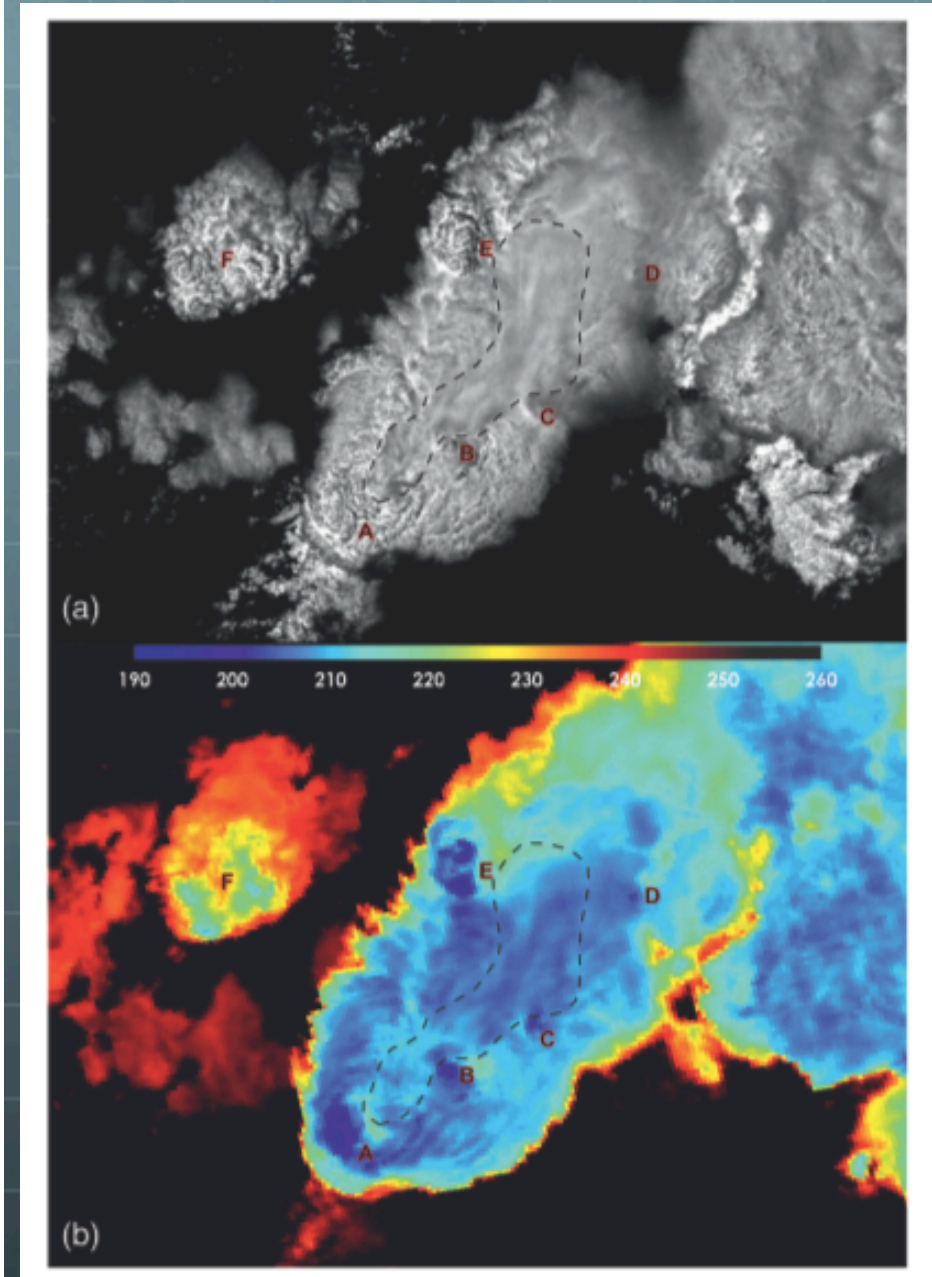
04:11 UTC
19 June 2009

During the 15-minute interval ending at 04:15 UTC this storm produced over 900 lightning strikes

Severe Thunderstorm Case 2



Including Lightning and Hail Reports 13 May 2009

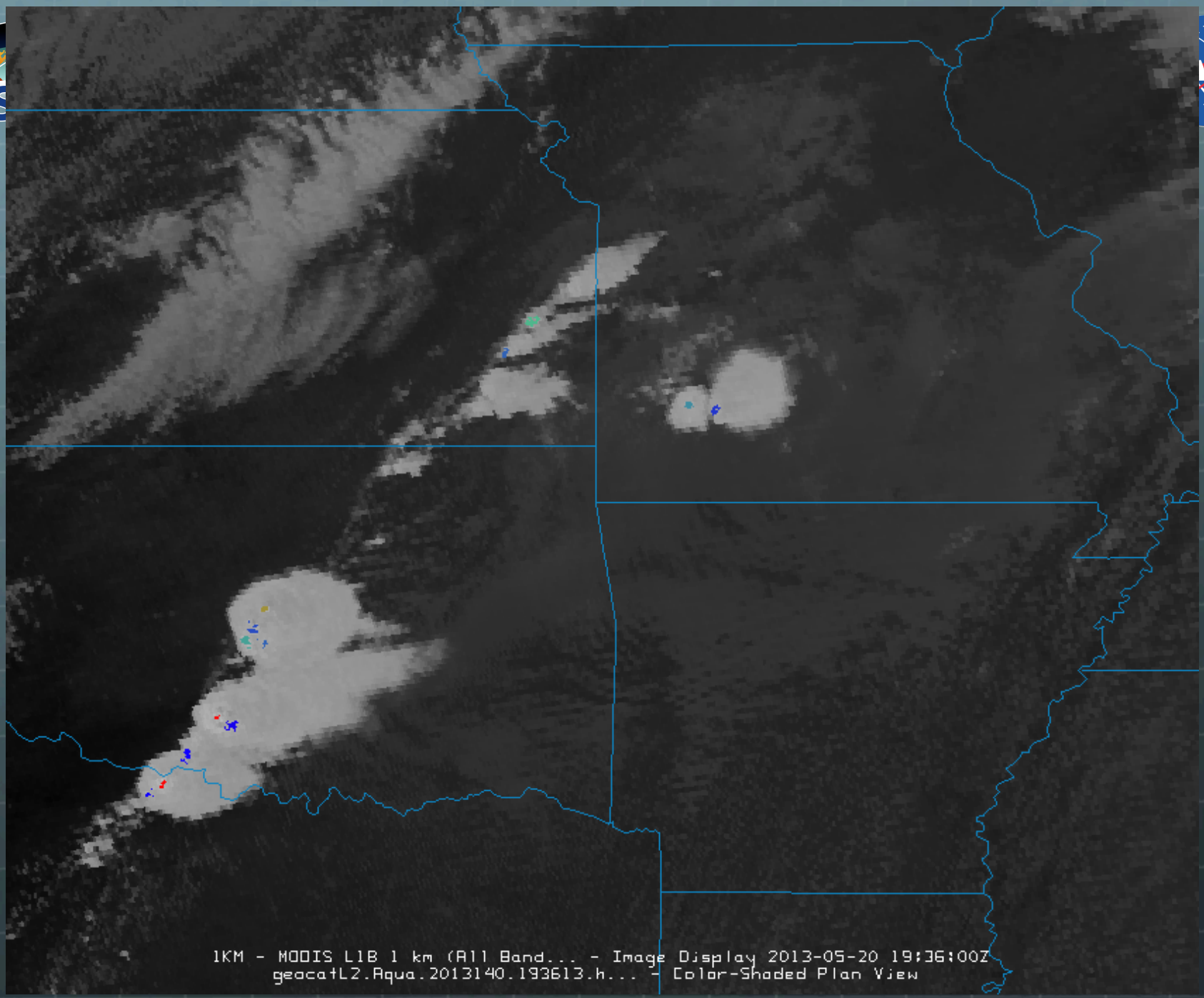


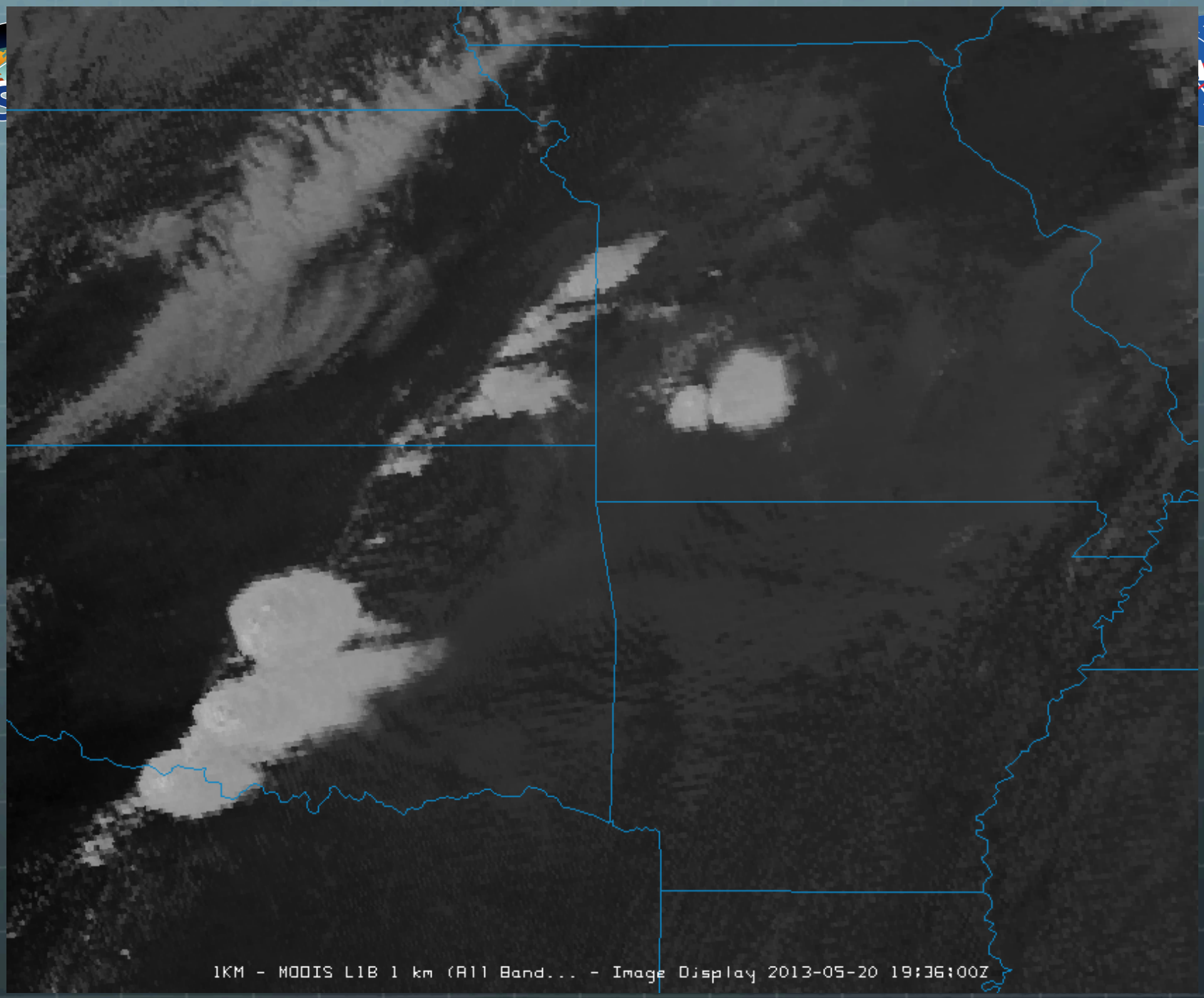
Bedka, K., Brunner, J., Dworak, Feltz, W., Otkin, J. and T. Greenwald: 2010. **Objective Satellite-Based Detection of Overshooting Tops Using Infrared Window Channel Brightness Temperature Gradients**, Journal of Applied Meteorology and Climatology, Vol. 49, pp. 181-202.

IMAPP GeoCAT Output HDF4 File

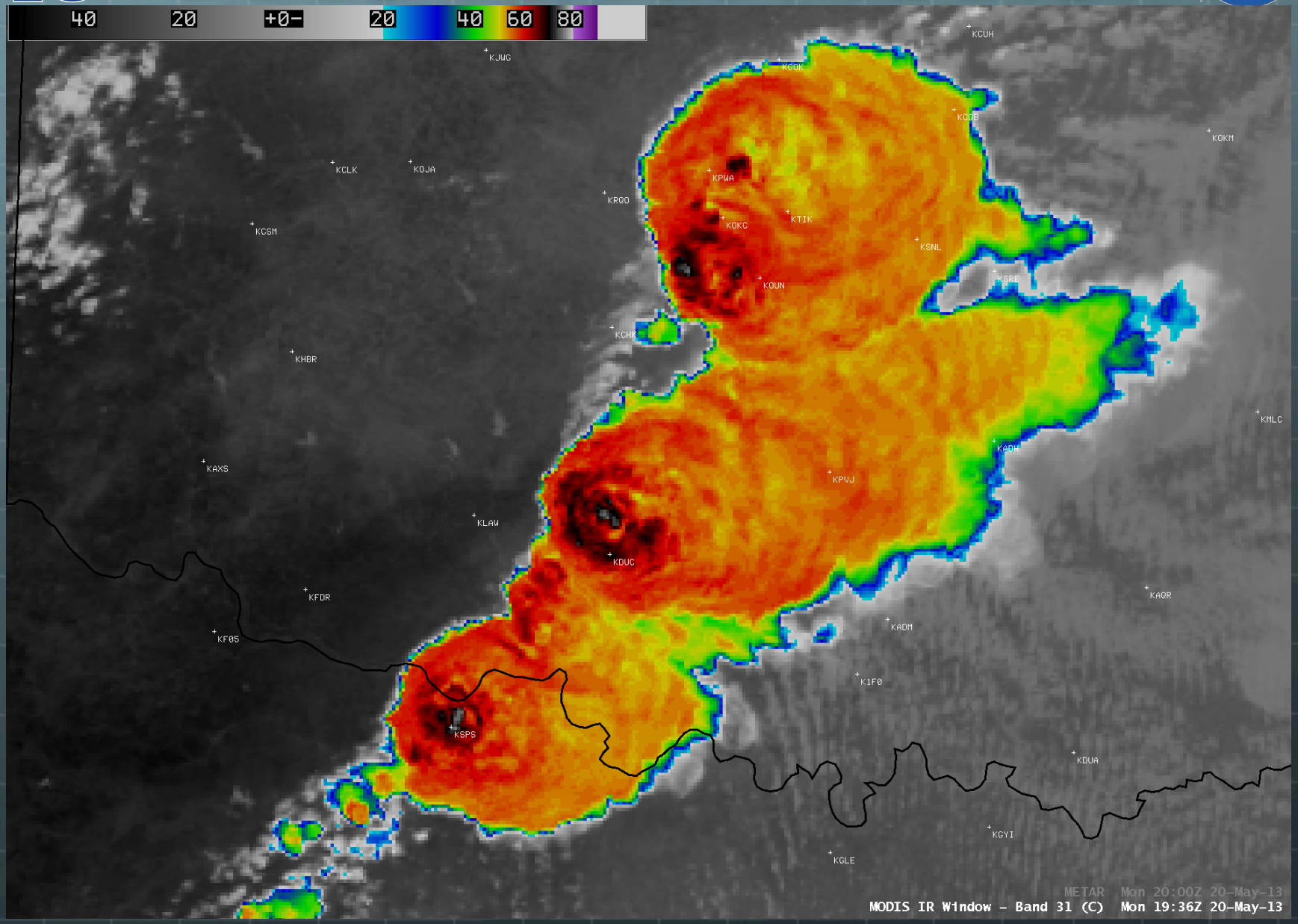
geocatL2.Terra.2013140.041735.hdf

- Dimensions: lines = 4610, elements = 1354 ;
- 1 km resolution
- Variables:
  - short pixel_latitude(lines, elements) ;
  - short pixel_longitude(lines, elements) ;
  - short pixel_solar_zenith_angle(lines, elements) ;
  - short pixel_satellite_zenith_angle(lines, elements) ;
  - short pixel_relative_azimuth_angle(lines, elements) ;
  - byte pixel_surface_type(lines, elements) ;
  - byte pixel_ecosystem_type(lines, elements) ;
  - float ot_overshooting_top_grid_magnitude(lines, elements) ;
  - short ot_overshooting_top_grid_number_of_anvil_pixels(lines, elements) ;


1KM - MODIS L1B 1 km (All Band... - Image Display 2013-05-20 19:36:00Z
geocatL2.Aqua.2013140.193613.h... - Color-Shaded Plan View

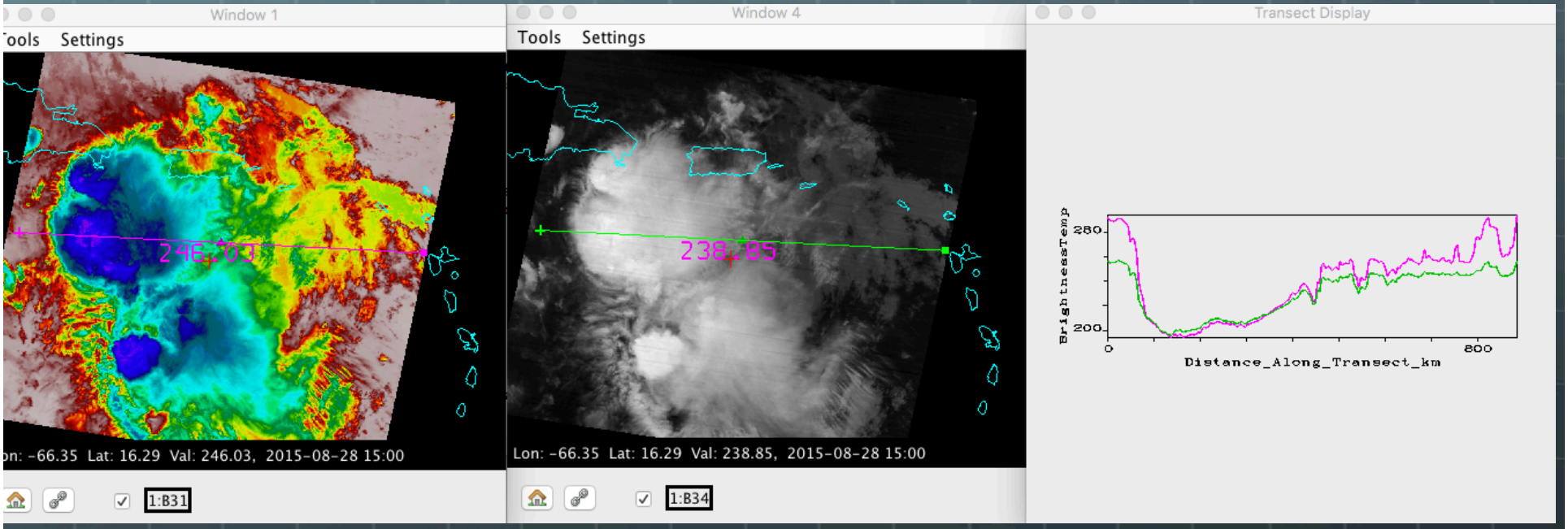

1KM - MODIS L1B 1 km (All Band... - Image Display 2013-05-20 19:36:00Z

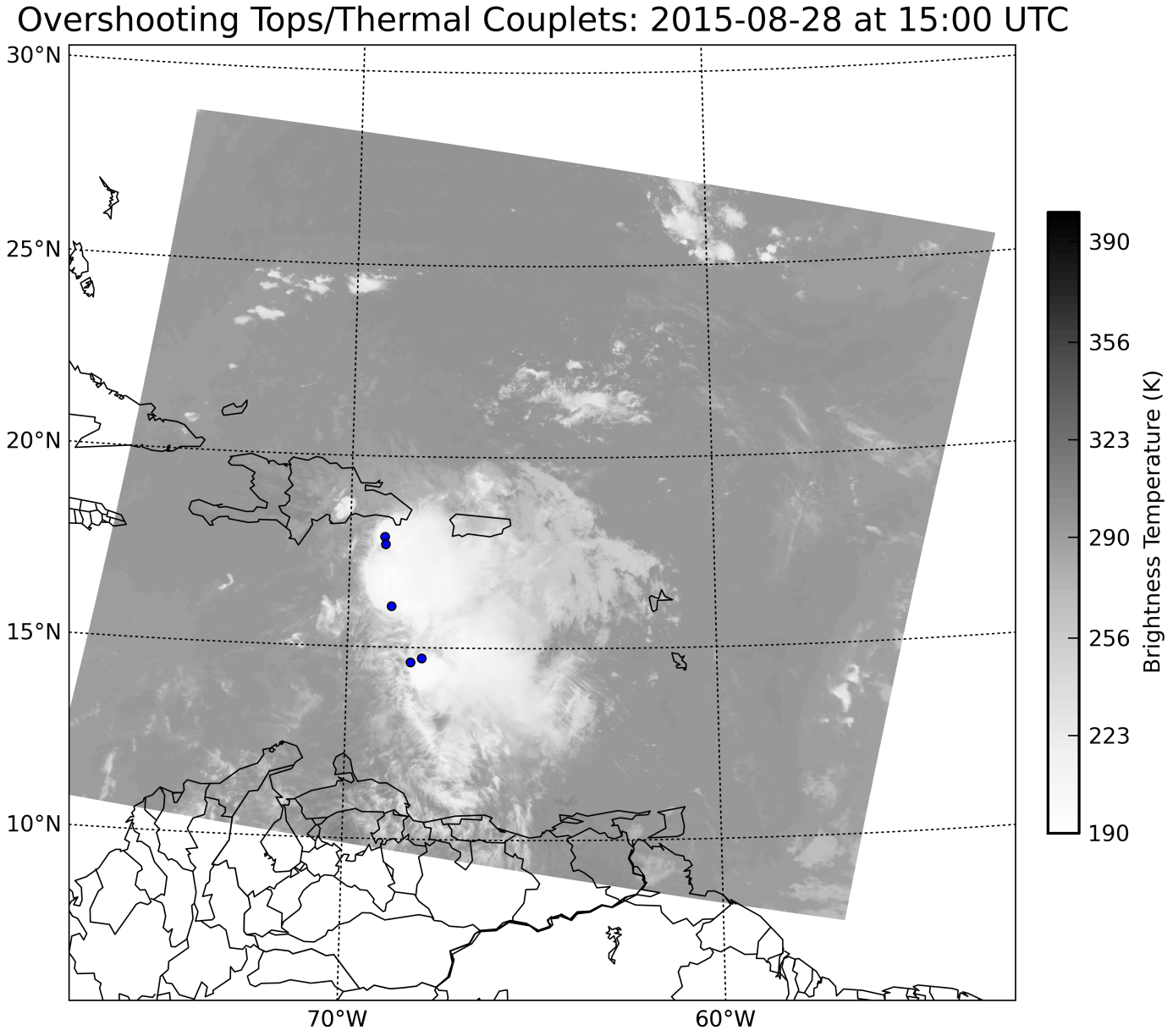
GOES versus MODIS



Tropical Storm Erika

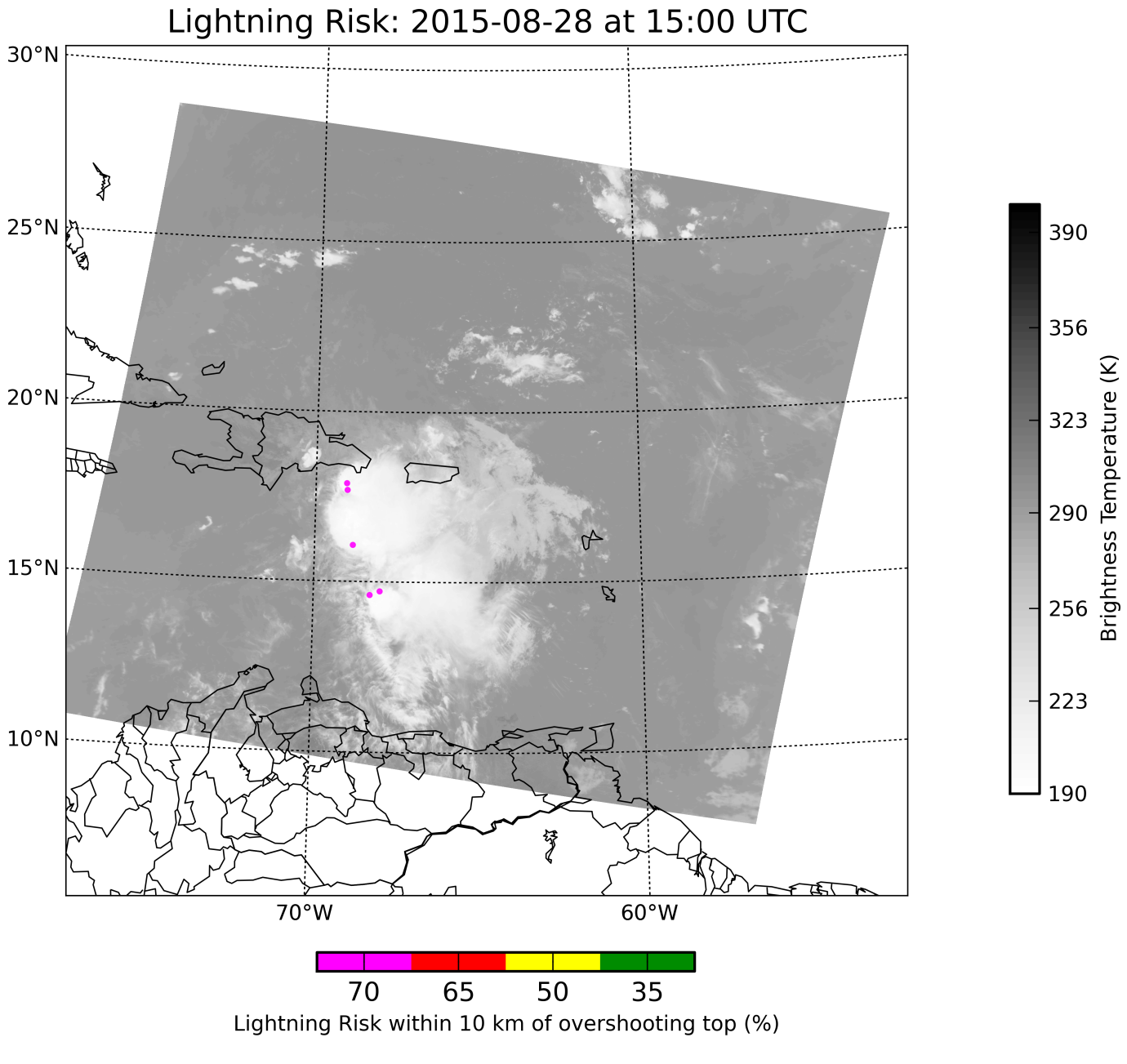
24 August 2015




Overshooting Tops/Thermal Couplets: 2015-08-28 at 15:00 UTC
30°N
25°N
20°N
15°N
10°N
70°W
60°W
390
356
323
290
256
223
190
Brightness Temperature (K)

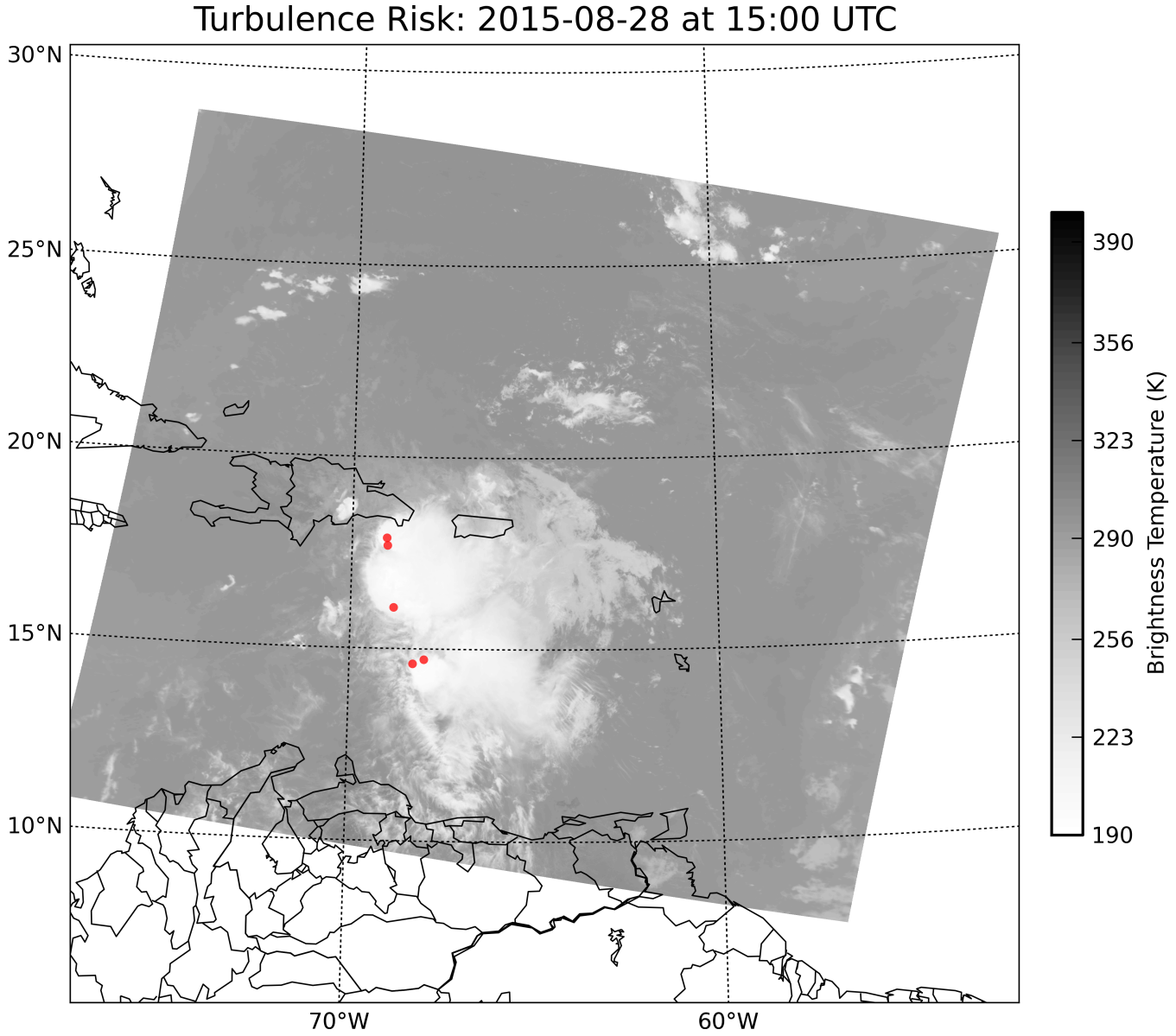
IMAPP Overshooting Top Lightning Risk Image

- According to the study by Bedka et al. 2010 (JAM), with the presence of an overshooting top, there is a 35% chance or greater, 50% chance or greater, 65% chance or greater, or 70% chance or greater of experiencing CG lightning within 10 km of the overshooting top center depending on the brightness temperature of the overshooting top. The colder the overshooting top brightness temperature is, the greater the chance of CG lightning. These relationships are shown on this image with each colored region identifying the area within a 10 km radius of the overshooting top center.


Lightning Risk: 2015-08-28 at 15:00 UTC
30°N
25°N
20°N
15°N
10°N
70°W
60°W
390
356
323
290
256
223
190
Brightness Temperature (K)
70
65
50
35
Lightning Risk within 10 km of overshooting top (%)

IMAPP Overshooting Top Turbulence Risk Image

- According to the study by Bedka et al. 2010 (JAM), with the presence of an overshooting top there is a 25% or greater chance of experiencing turbulence within 25 km of the overshooting top center. This relationship is shown on this image with each red region representing the area within a 25 km radius of the respective overshooting top center.


Turbulence Risk: 2015-08-28 at 15:00 UTC
30°N
25°N
20°N
15°N
10°N
70°W
60°W
390
356
323
290
256
223
190
Brightness Temperature (K)