Polar Orbiter Product Environmental Applications: Part 1

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Hampton University Direct Broadcast Polar Orbiter Workshop

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Quick Review of Remote Sensing Basic Theory

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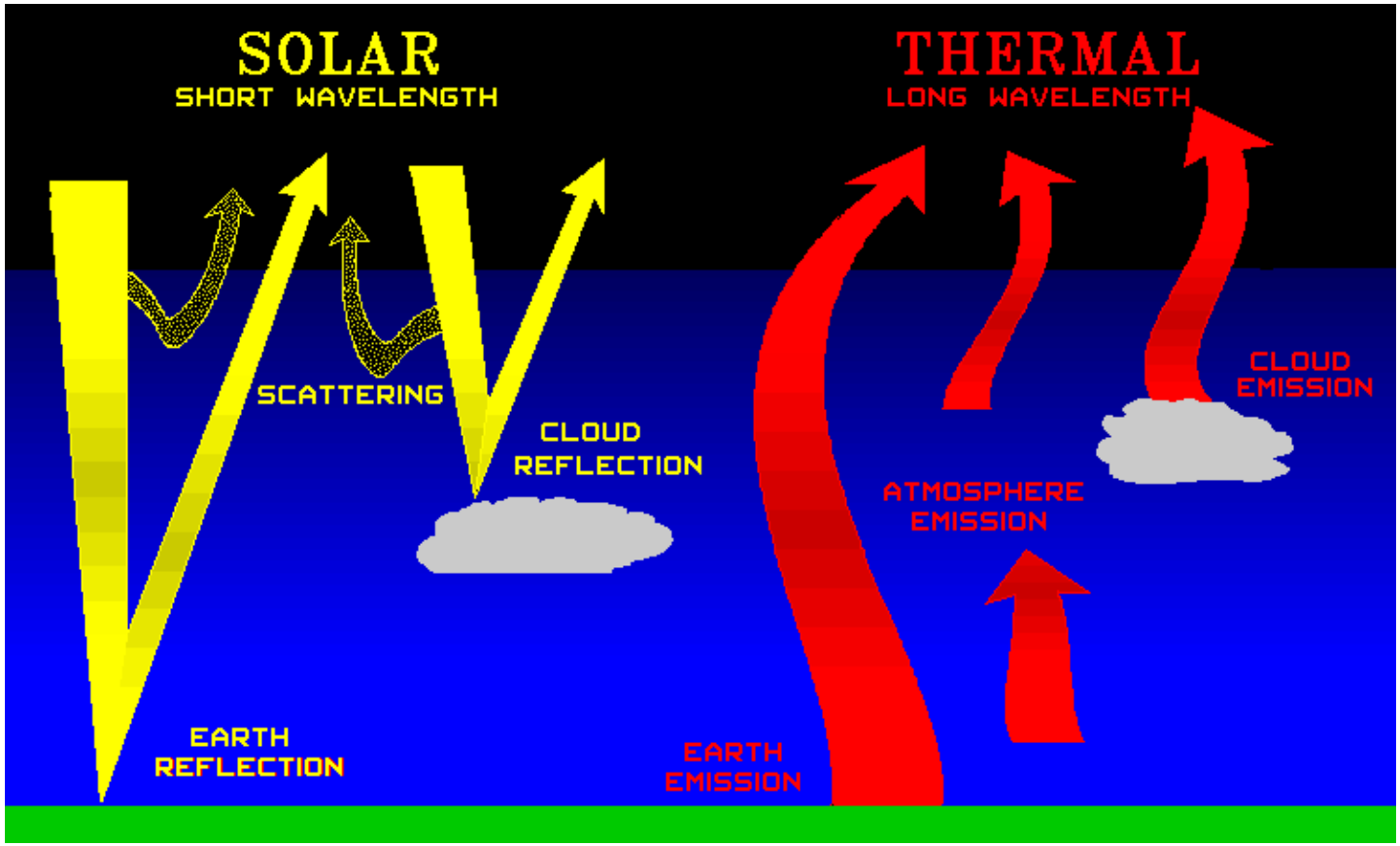
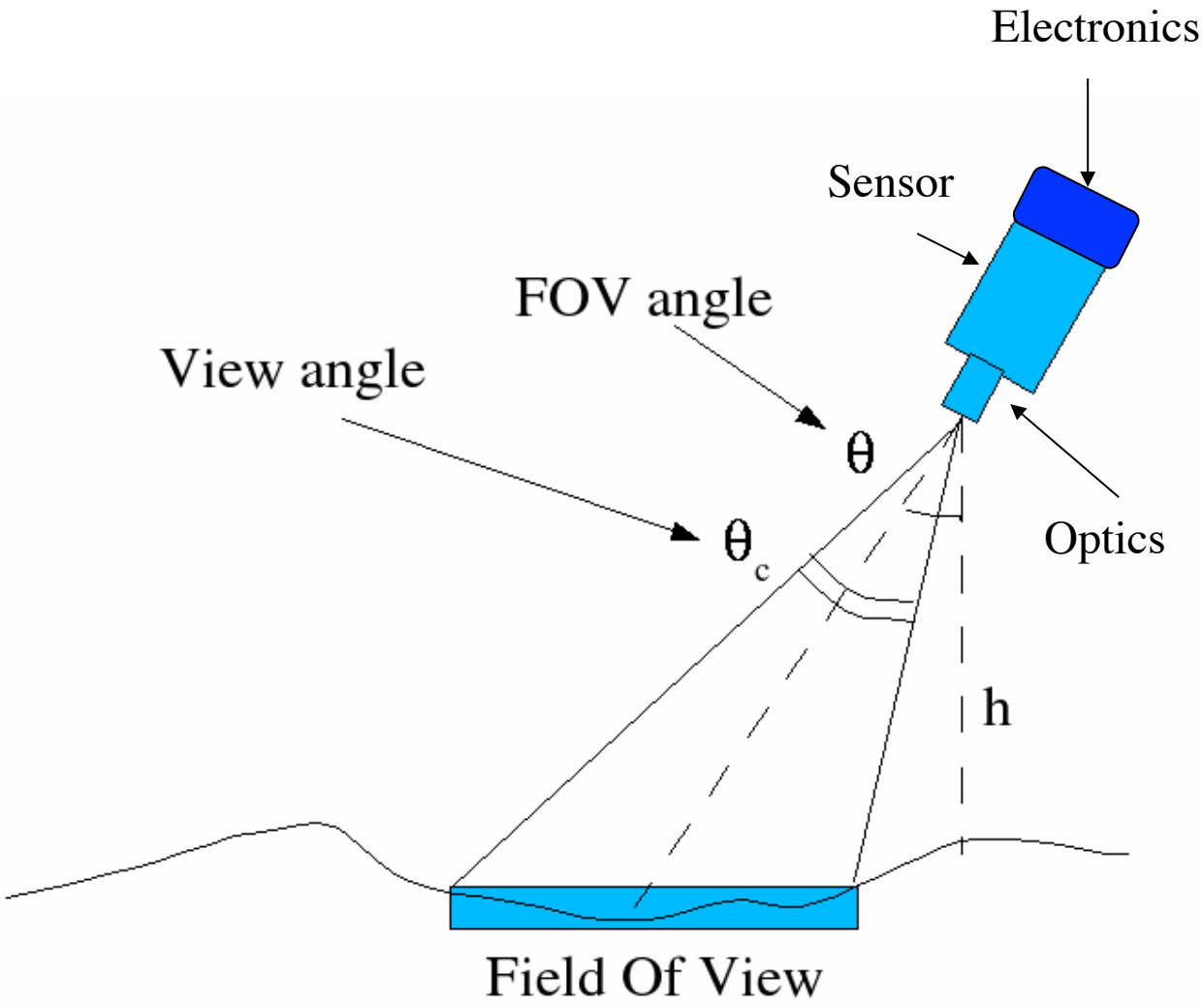
Visible
(Solar Reflective Bands)

Infrared
(Emissive Bands)



Sensor Geometry



Terminology of radiant energy

Energy from the Earth or Sun

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

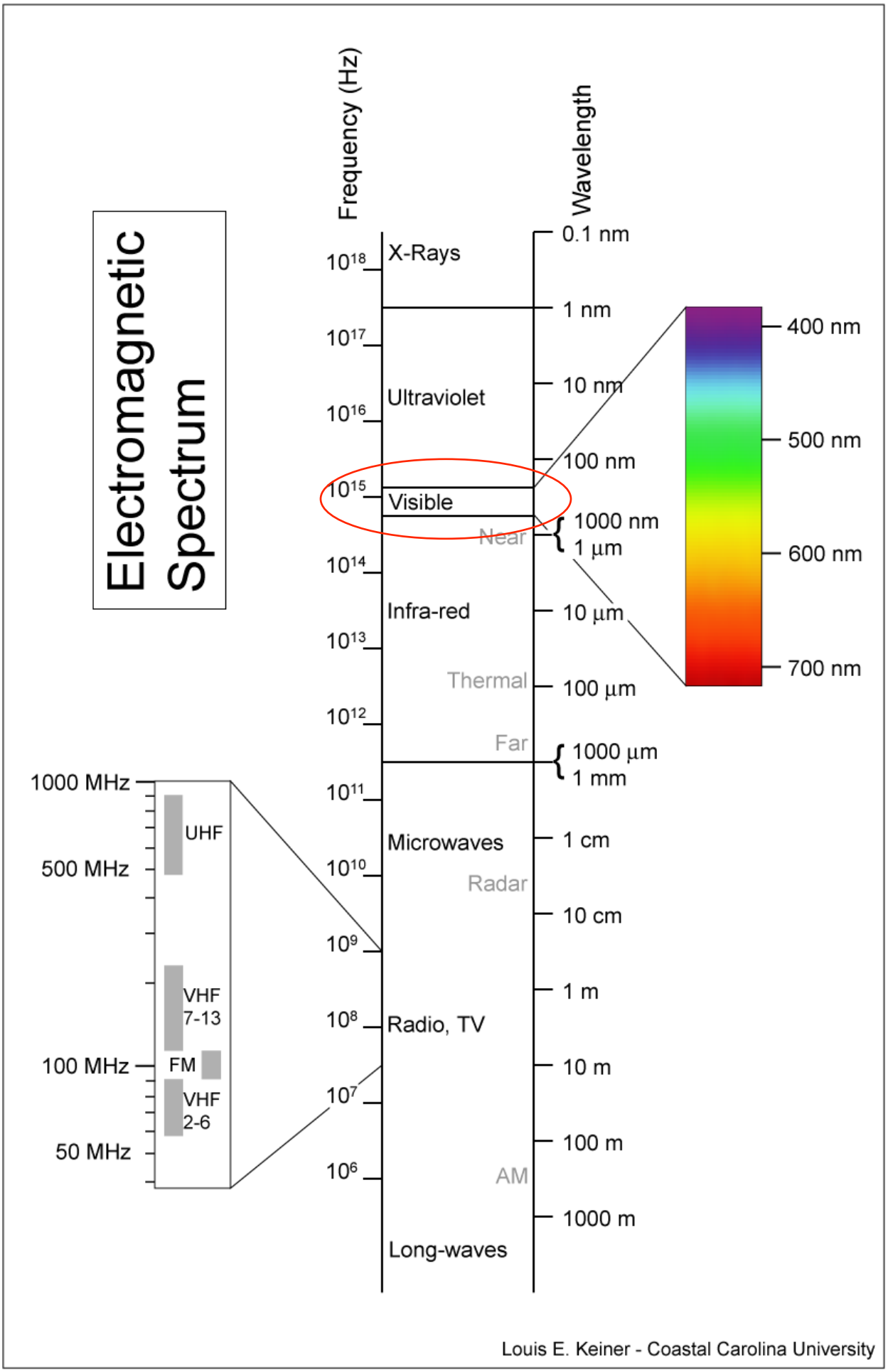
Solar: Reflective Bands

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


Electromagnetic Spectrum
Frequency (Hz)
Wavelength
10^{18}
X-Rays
0.1 nm
1 nm
10^{17}
Ultraviolet
10 nm
10^{16}
100 nm
10^{15}
Visible
400 nm
500 nm
600 nm
700 nm
Near
1000 nm
1 µm
10^{14}
Infra-red
10 µm
10^{13}
Thermal
100 µm
10^{12}
Far
1000 µm
1 mm
10^{11}
Microwaves
1 cm
10^{10}
Radar
10 cm
10^{9}
1 m
10^{8}
Radio, TV
10 m
10^{7}
100 m
10^{6}
AM
1000 m
Long-waves
1000 MHz
UHF
500 MHz
VHF
7-13
100 MHz
FM
VHF
2-6
50 MHz
Louis E. Keiner - Coastal Carolina University

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

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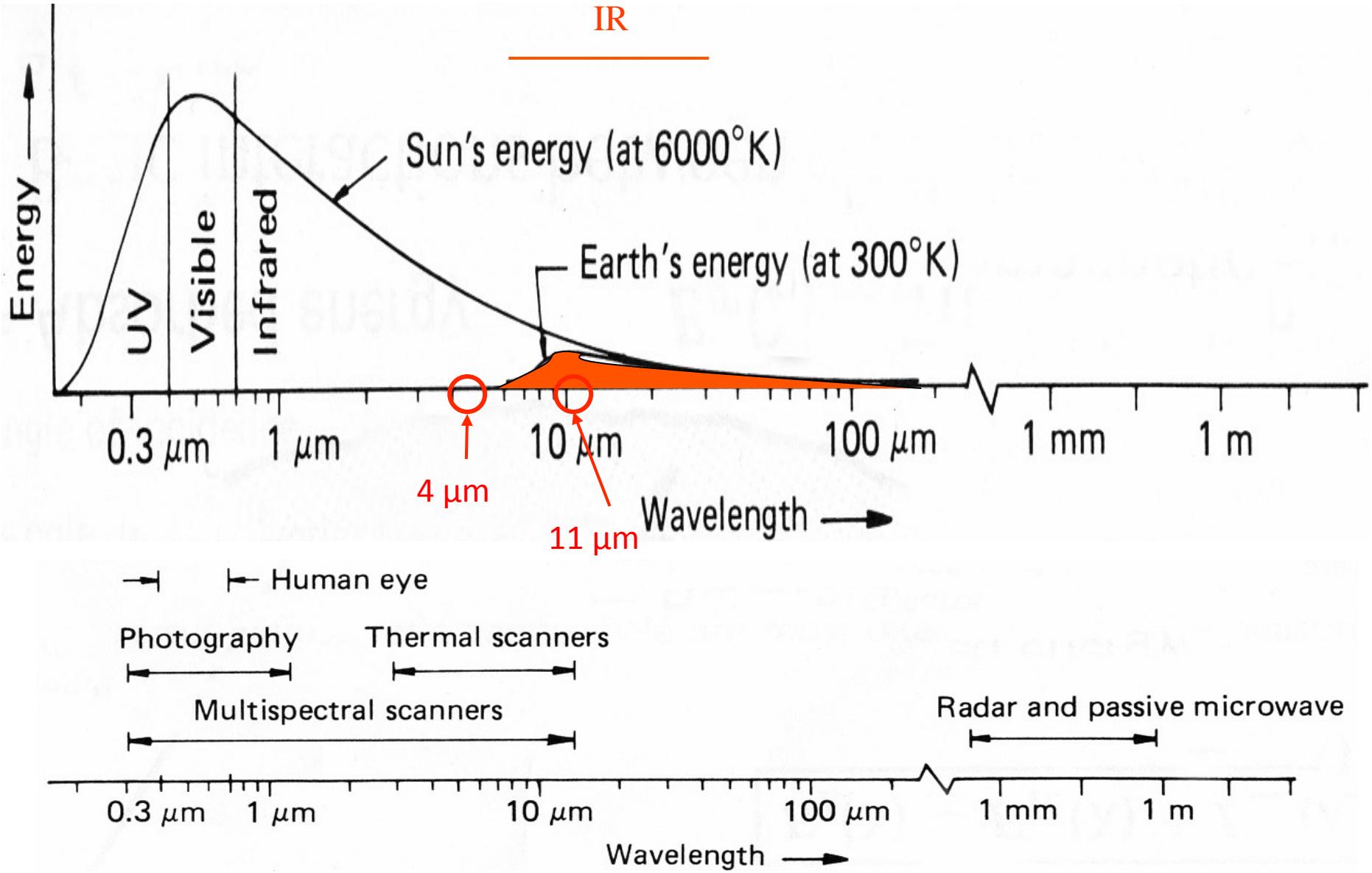
Spectral Characteristics of Energy Sources and Sensing Systems



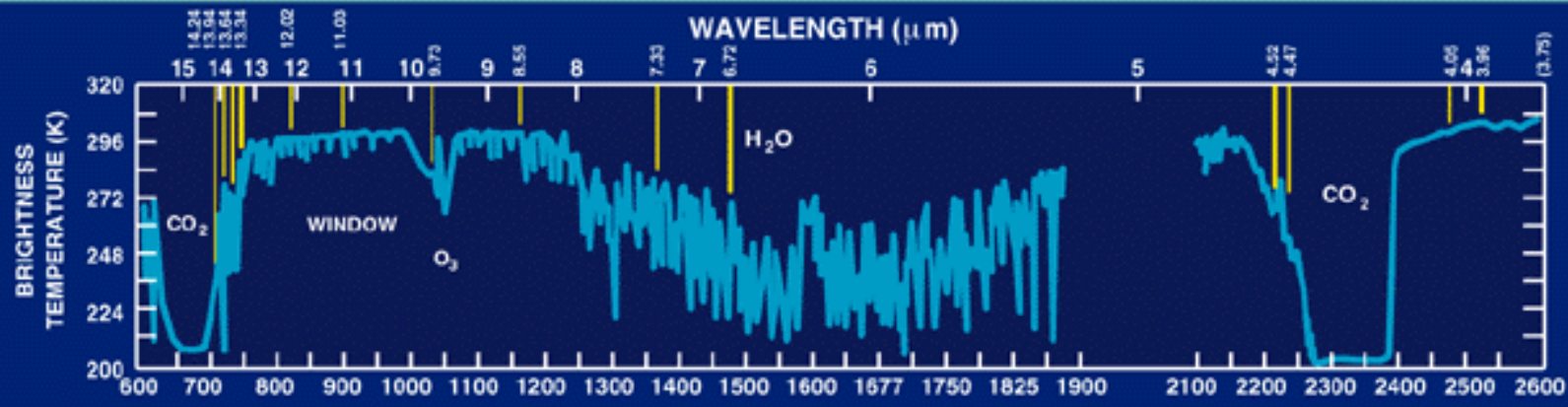
Brightness Temperature

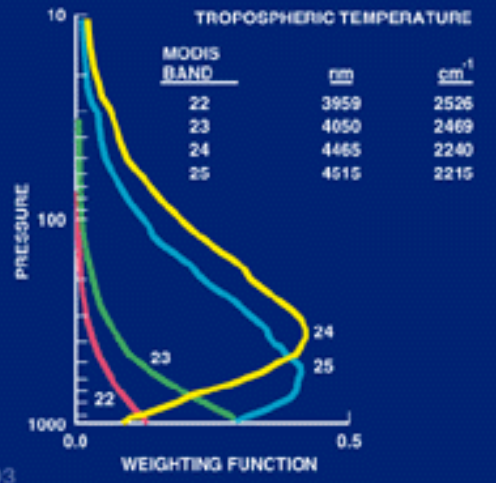
- To properly compare different emissive channels we need to convert observed radiance into a target physical property

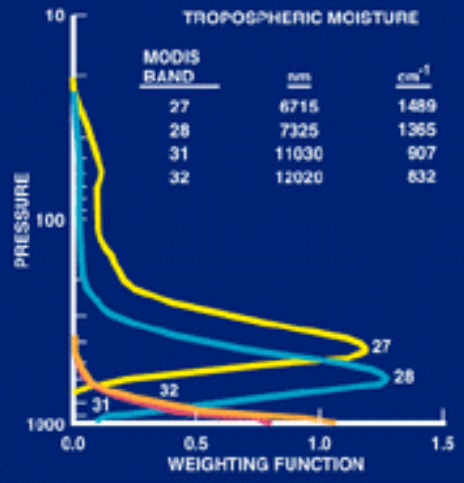
- In the Infrared this is done through the Planck function

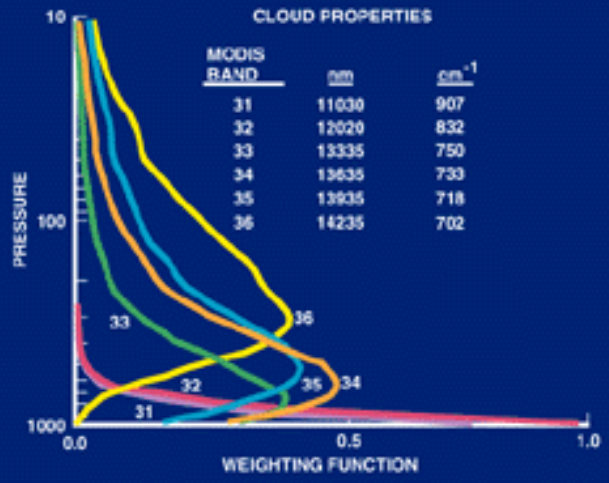
- The physical quantity is the Brightness Temperature i.e. the Temperature of a black body emitting the observed radiance

ATMOSPHERE - THERMAL RADIATION









E351.002 5/93

Observed BT at 4 micron
A very Special Spectral Region

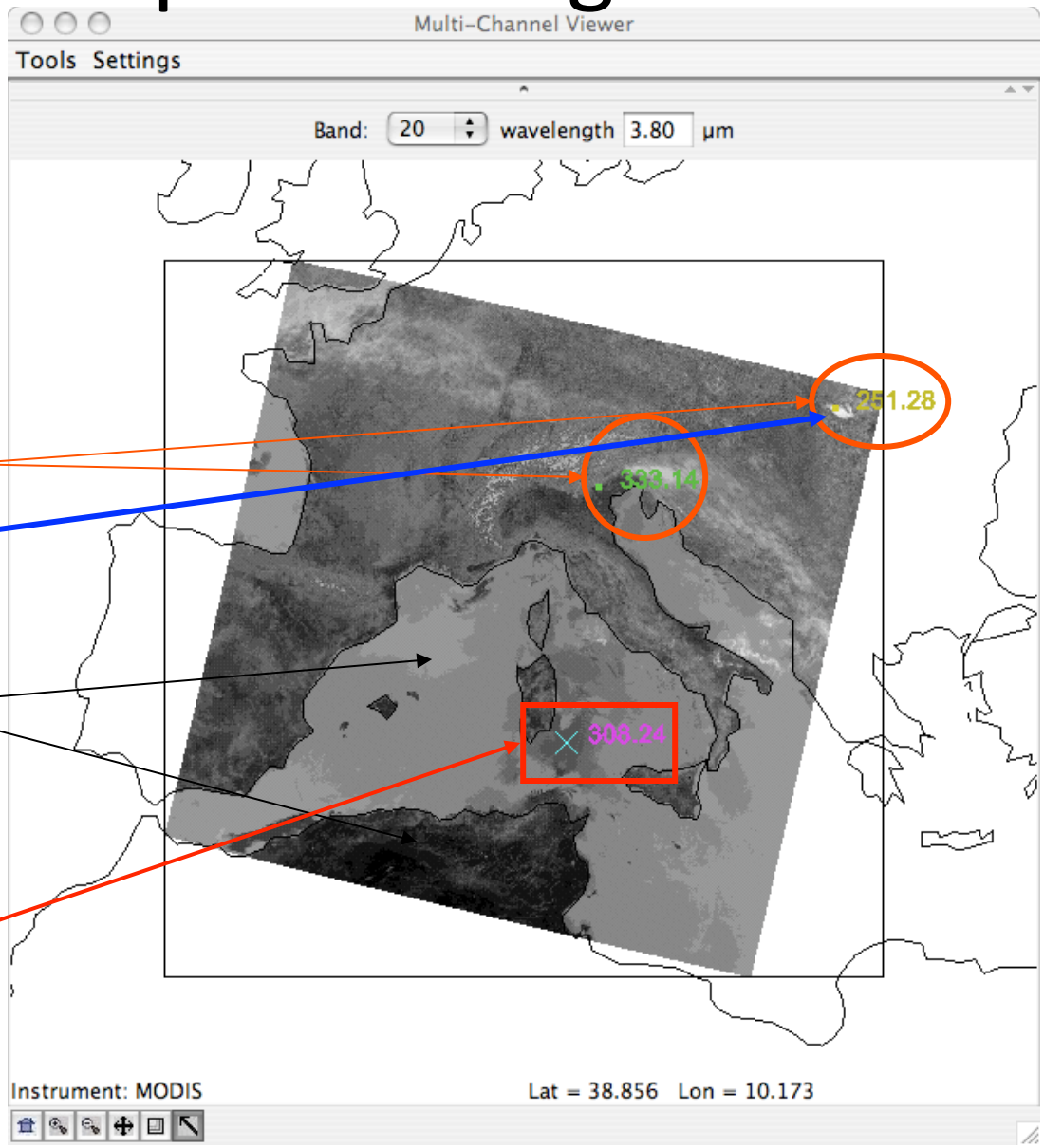
Window Channel:
- little atmospheric absorption
- surface features clearly visible

Range [250K 335K]
Celsius=Kelvin - 273.16

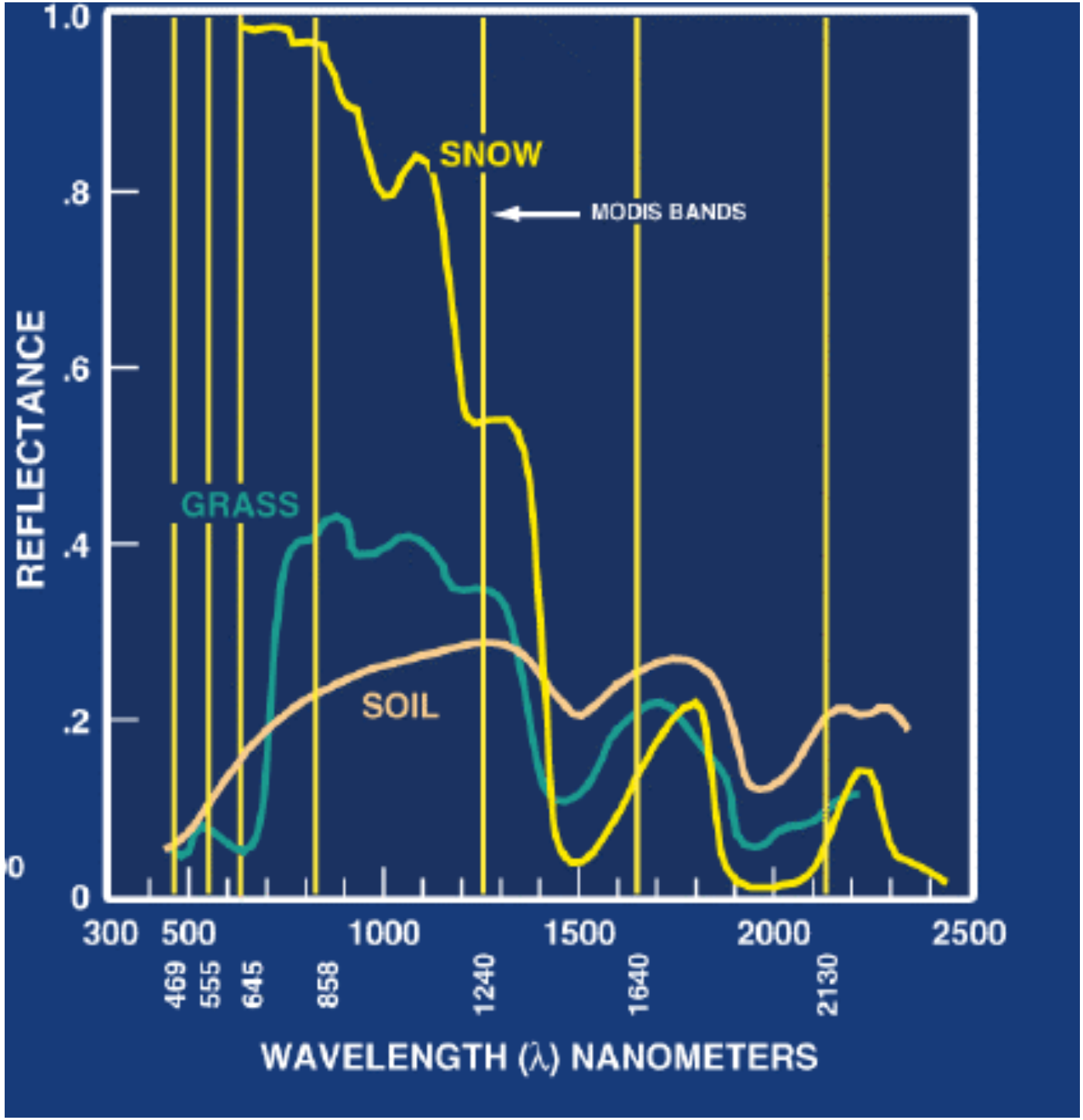
Clouds are cold

Values over land
Larger than over water

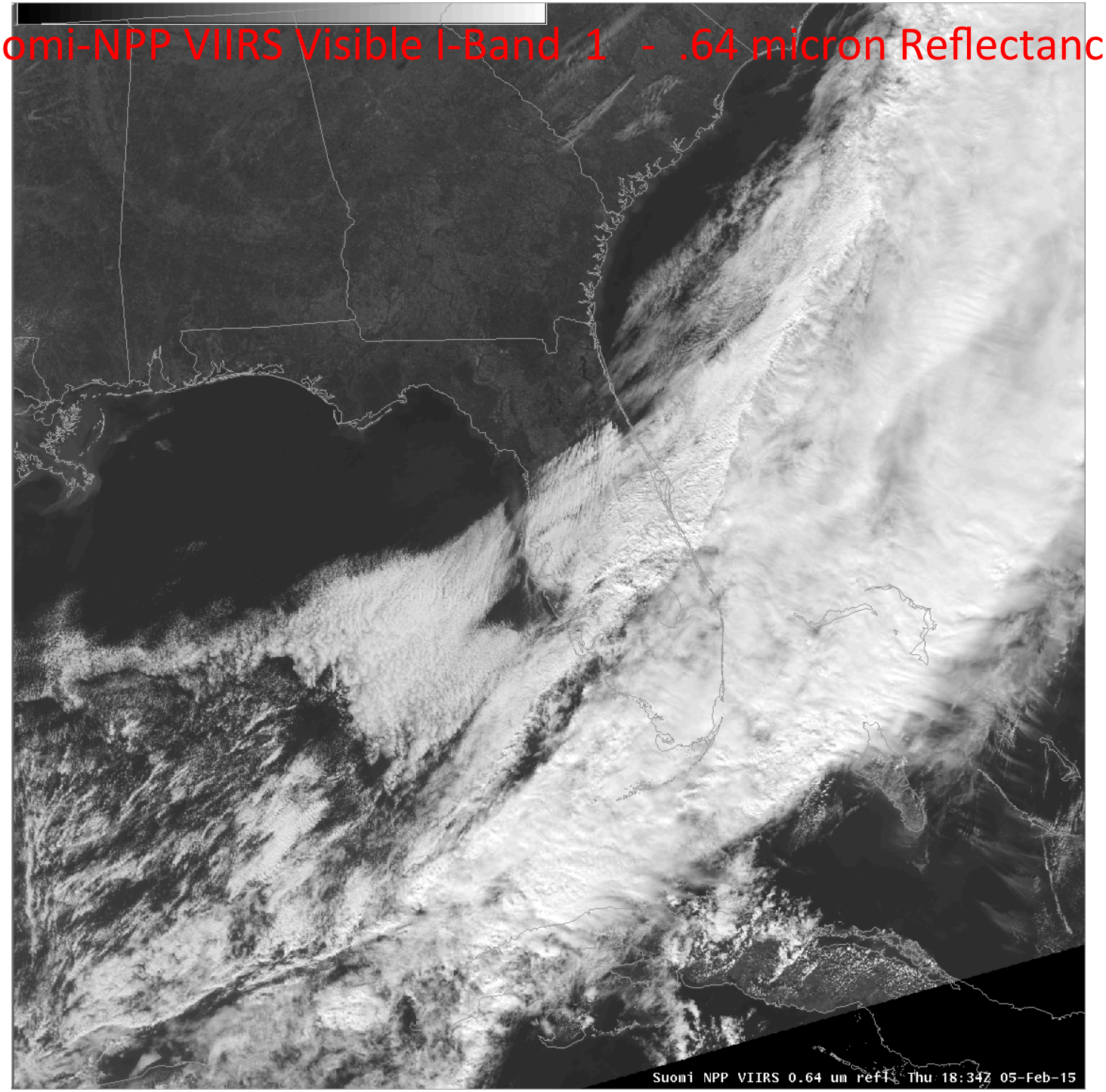
Reflected Solar everywhere
Stronger over Sunglint



VIIRS and MODIS observations and products (Examples using current AWIPS products)

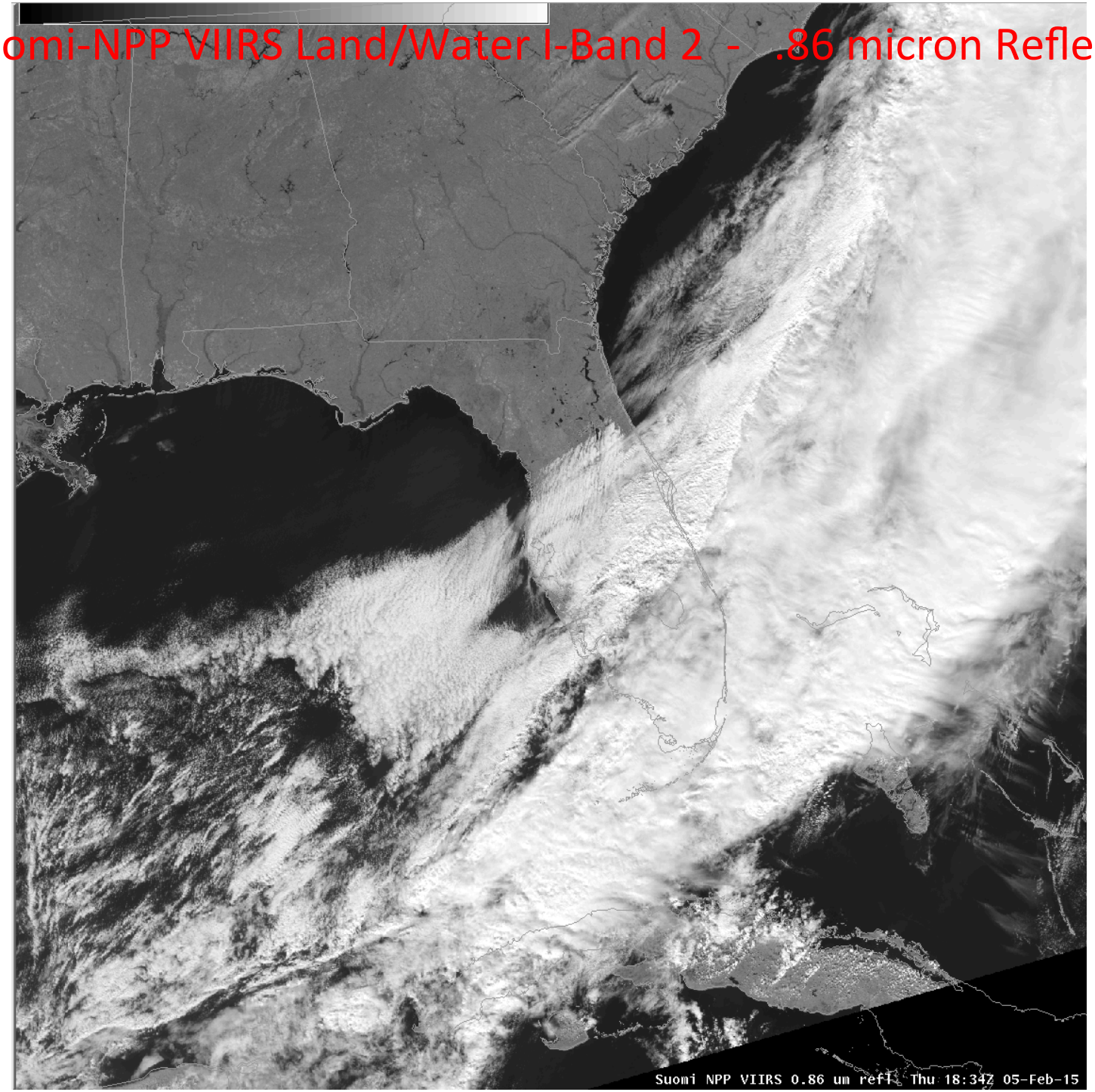

1.0
.8
.6
.4
.2
0
REFLECTANCE
SNOW
MODIS BANDS
GRASS
SOIL
300
500
1000
1500
2000
2500
469
555
645
858
1240
1640
2130
WAVELENGTH (λ) NANOMETERS

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



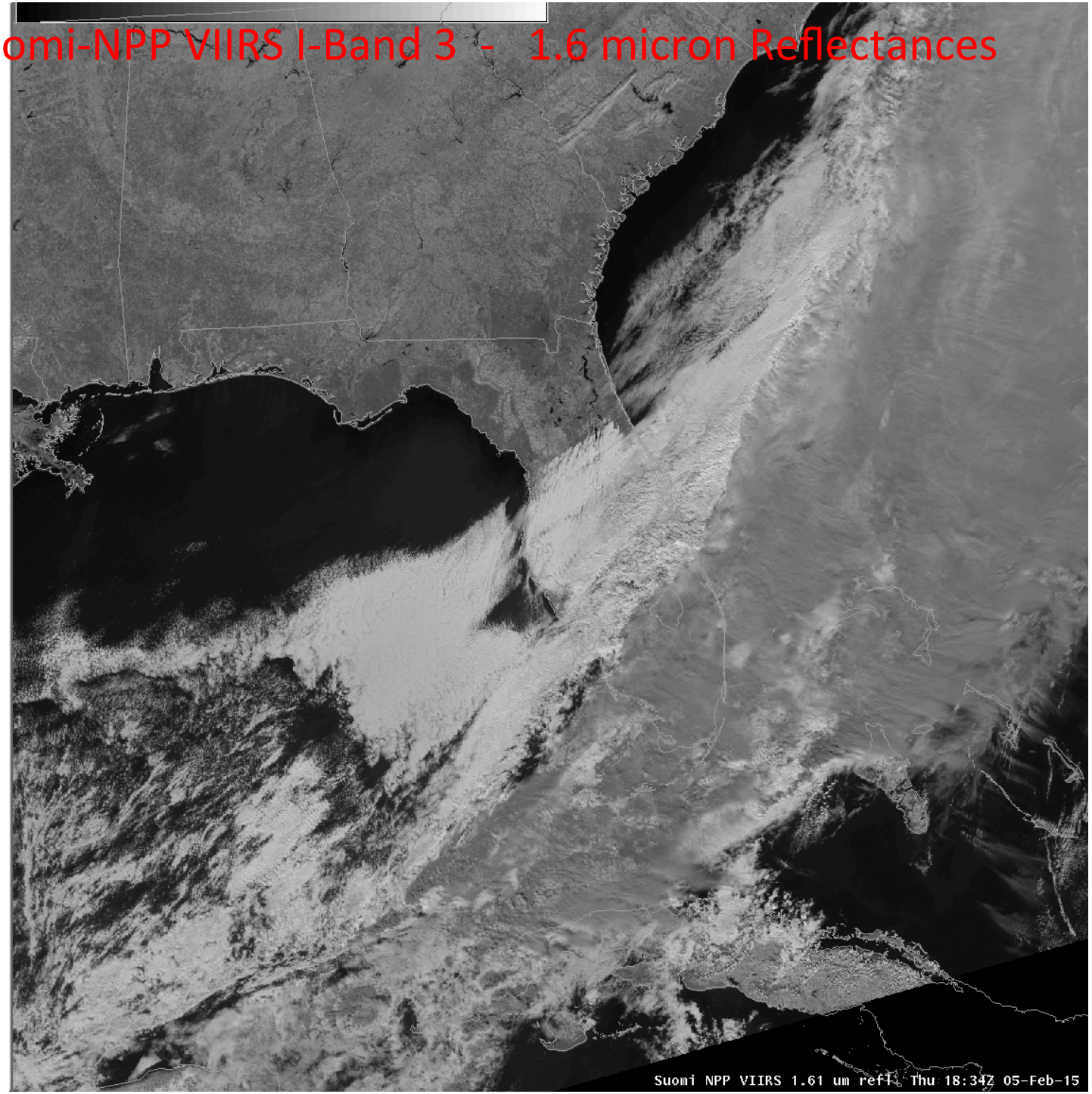
Day

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



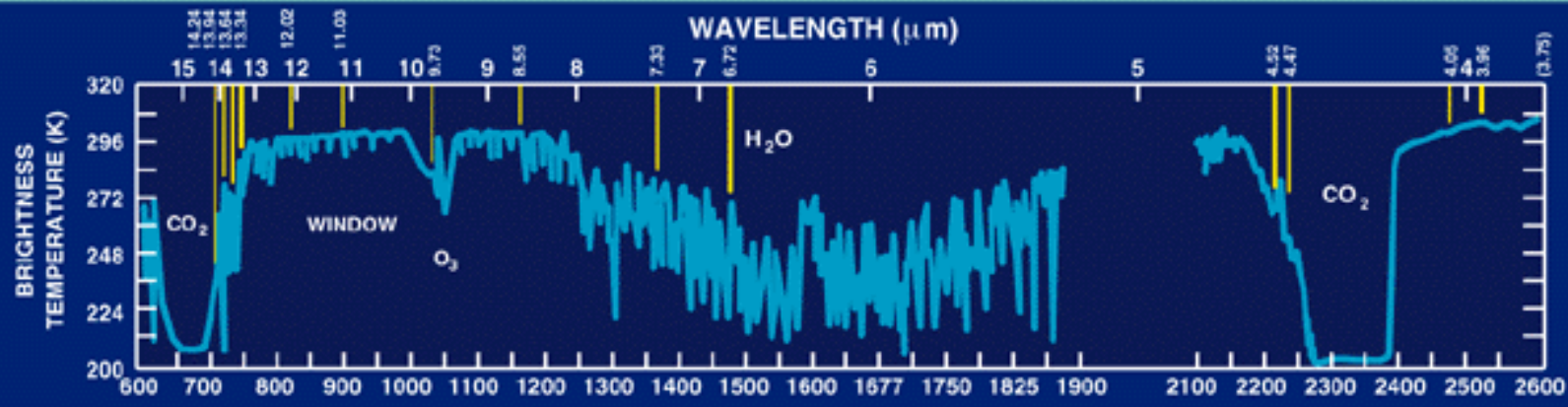
Day

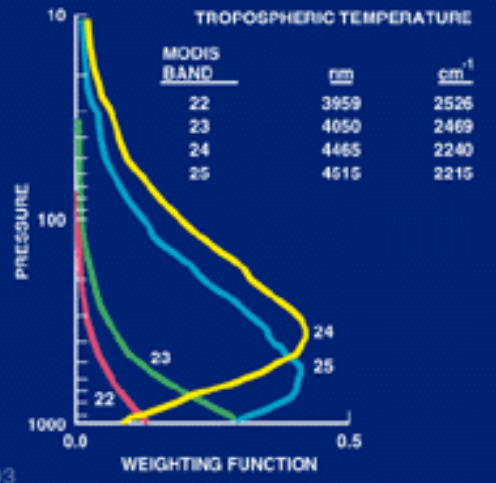
Suomi-NPP VIIRS I-Band 3 - 1.6 micron Reflectances

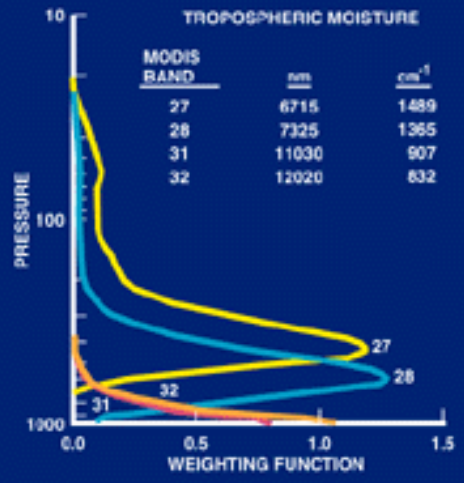


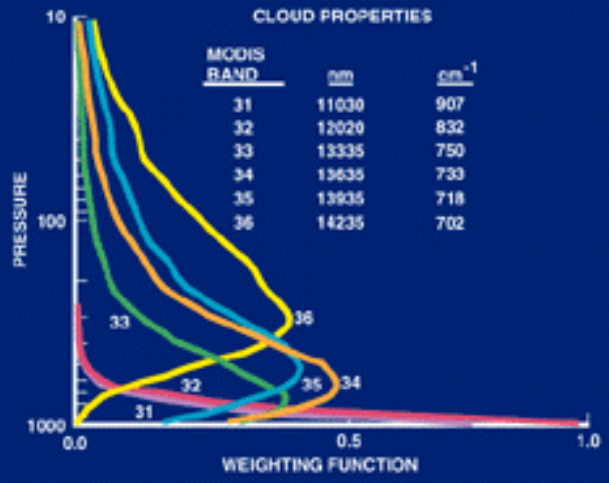
Day

ATMOSPHERE - THERMAL RADIATION









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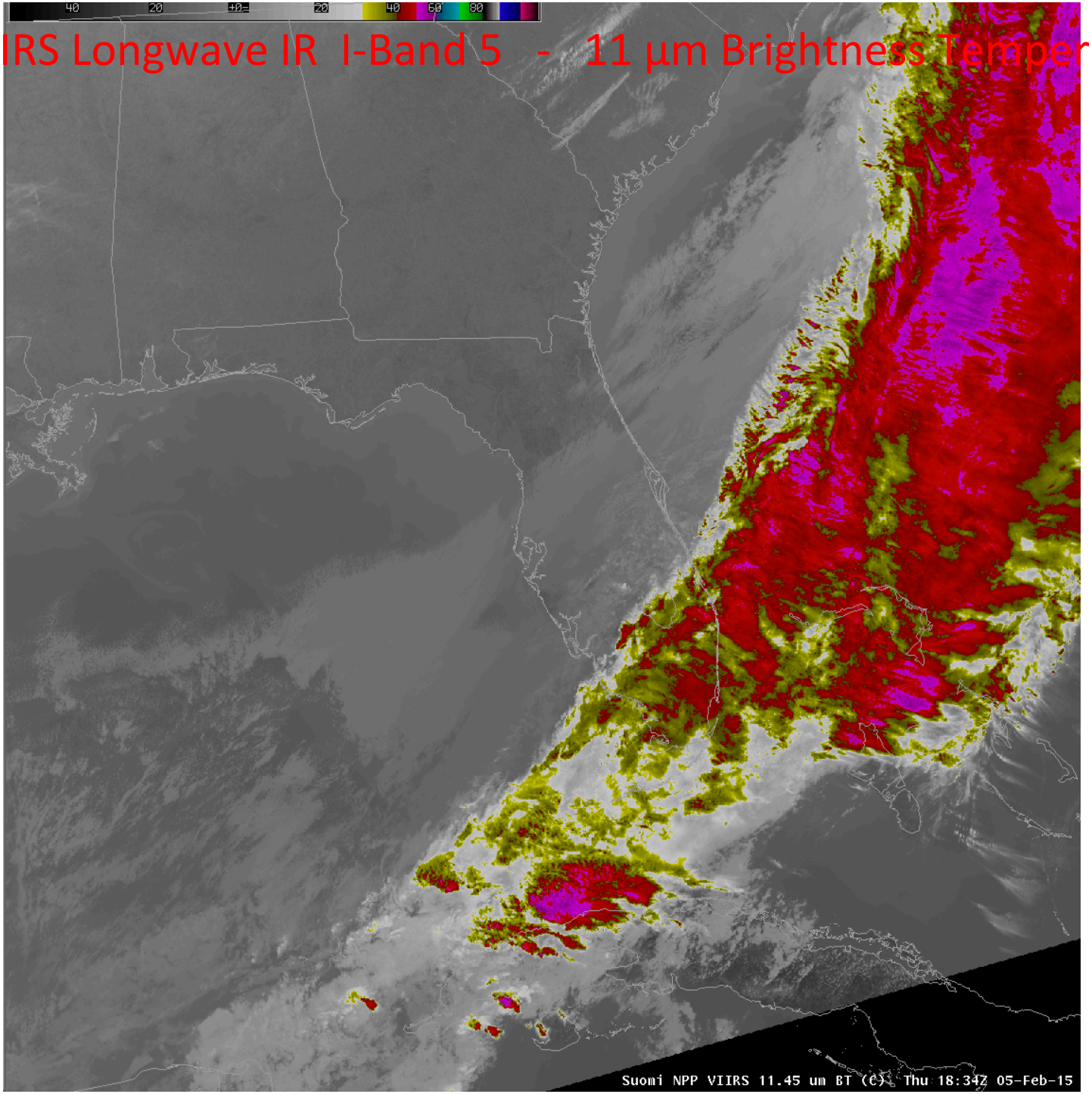
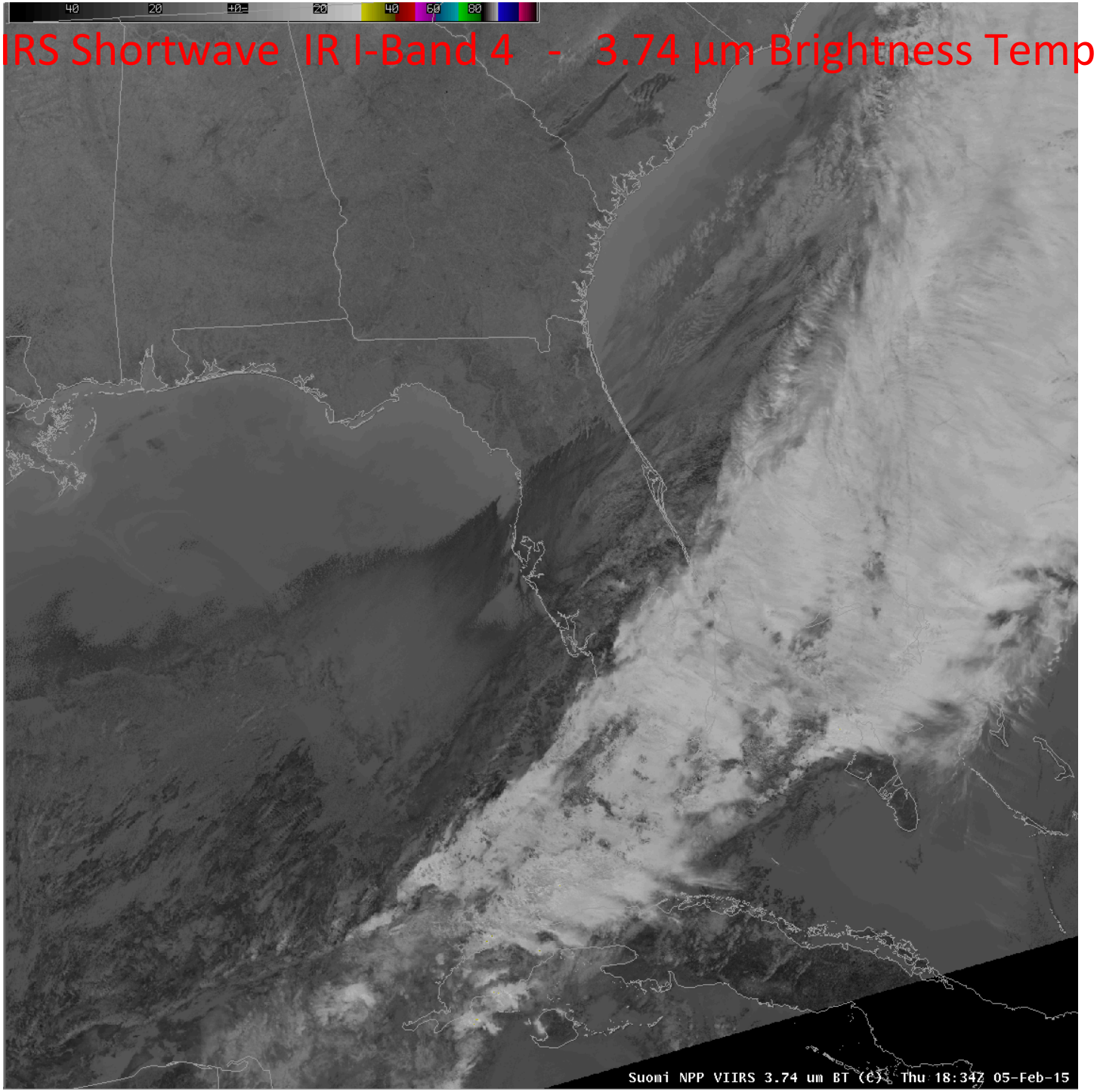
S-NPP VIIRS Longwave IR I-Band 5 - 11 µm Brightness Temperatures



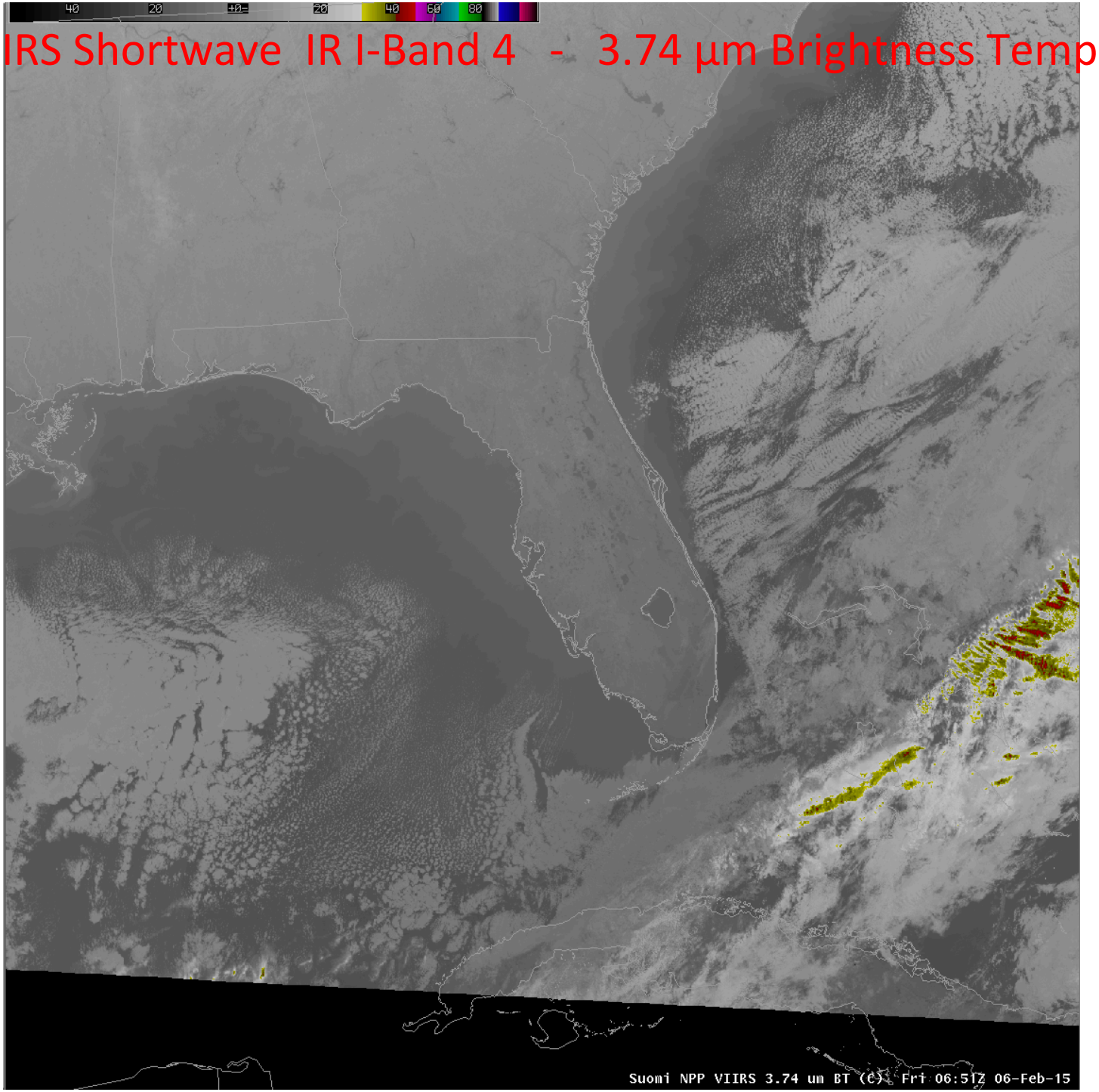
Day

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



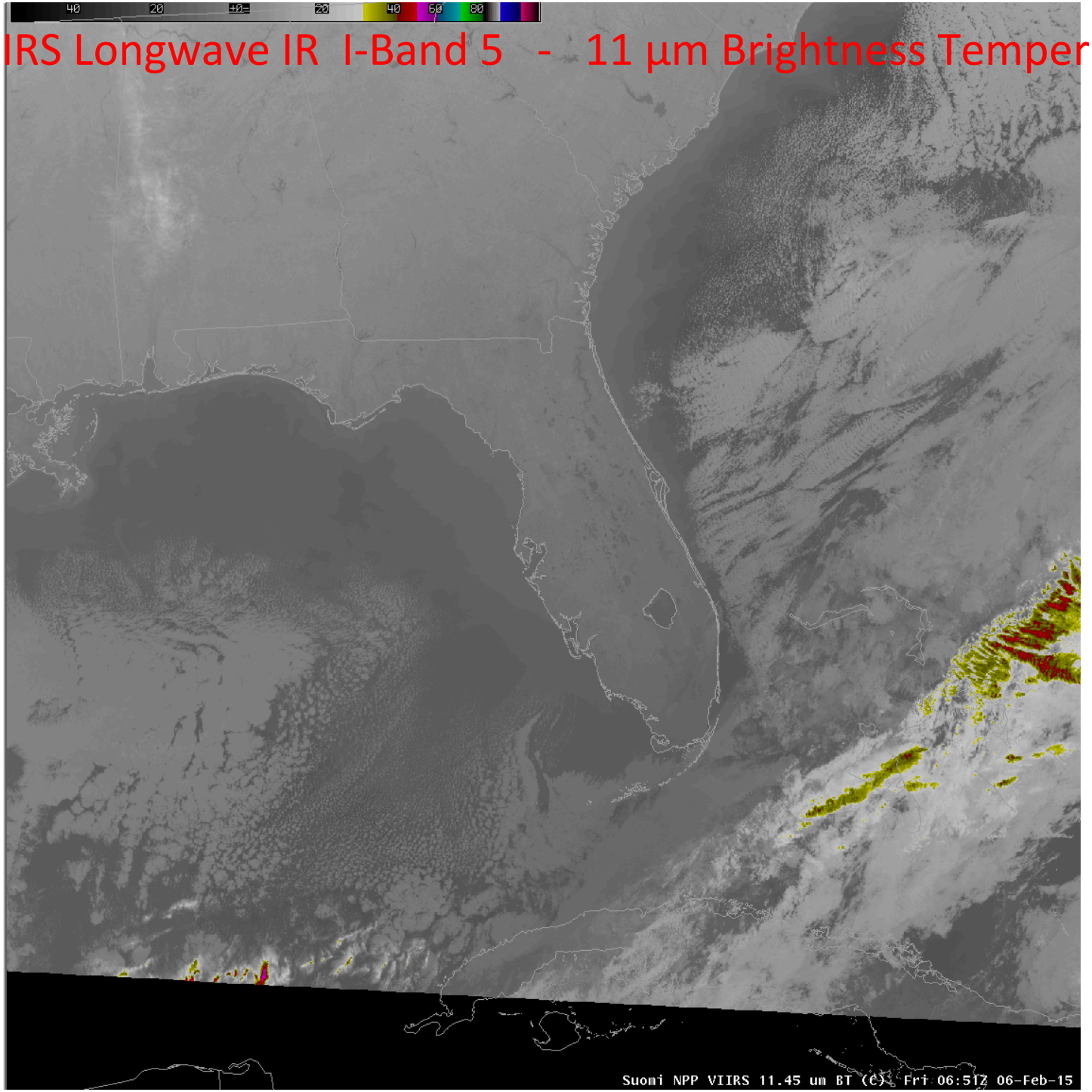
Day

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

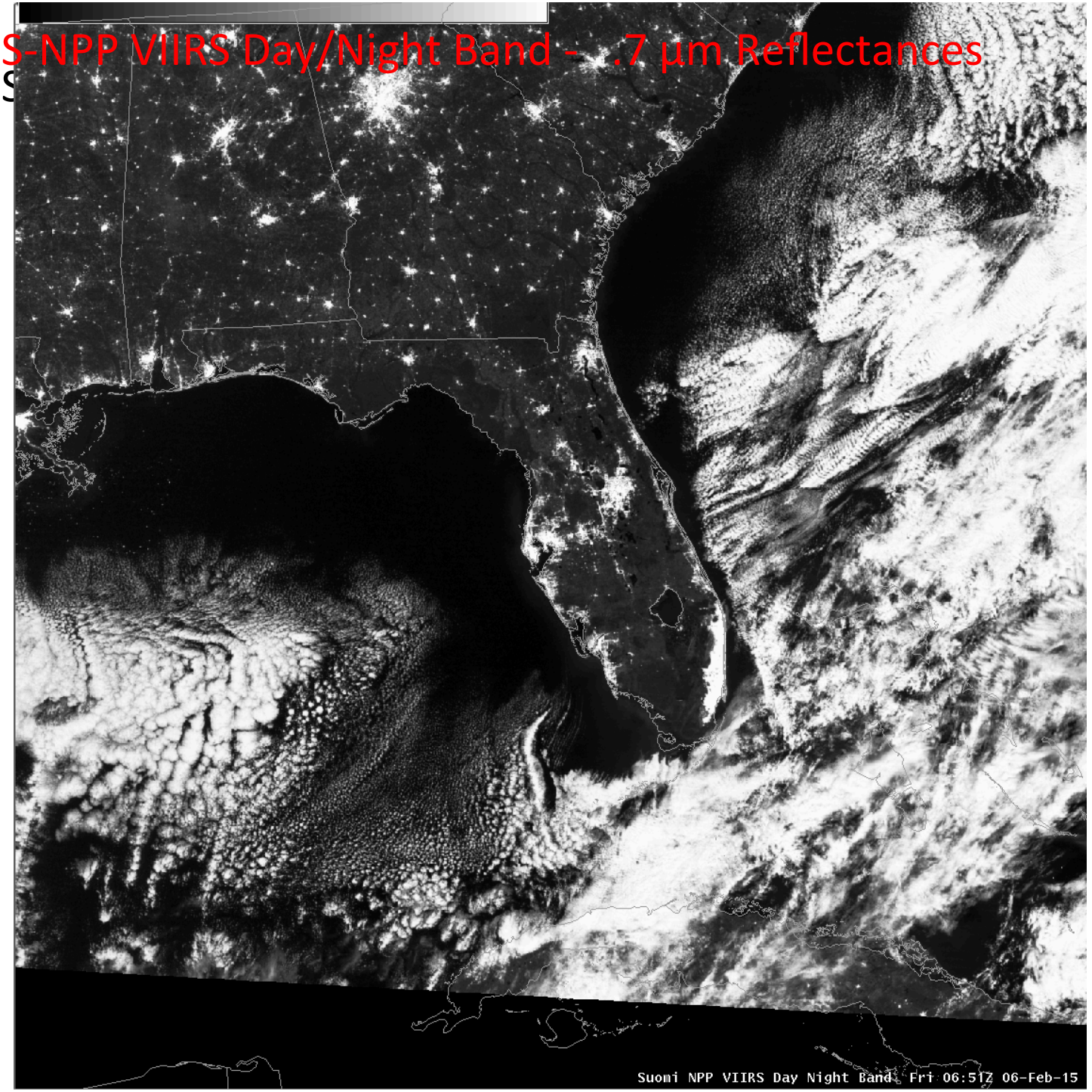


Night

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

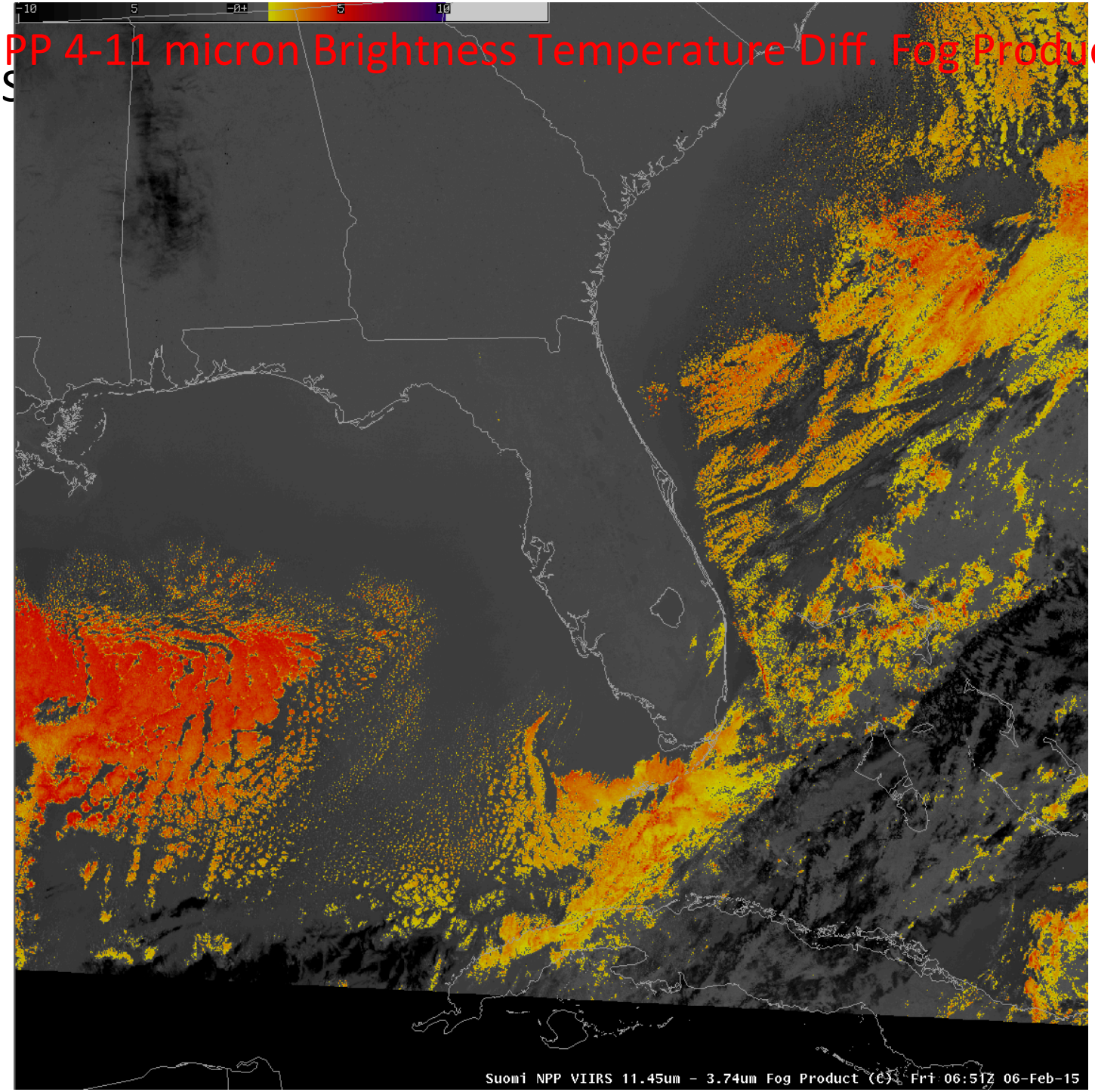


Night


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

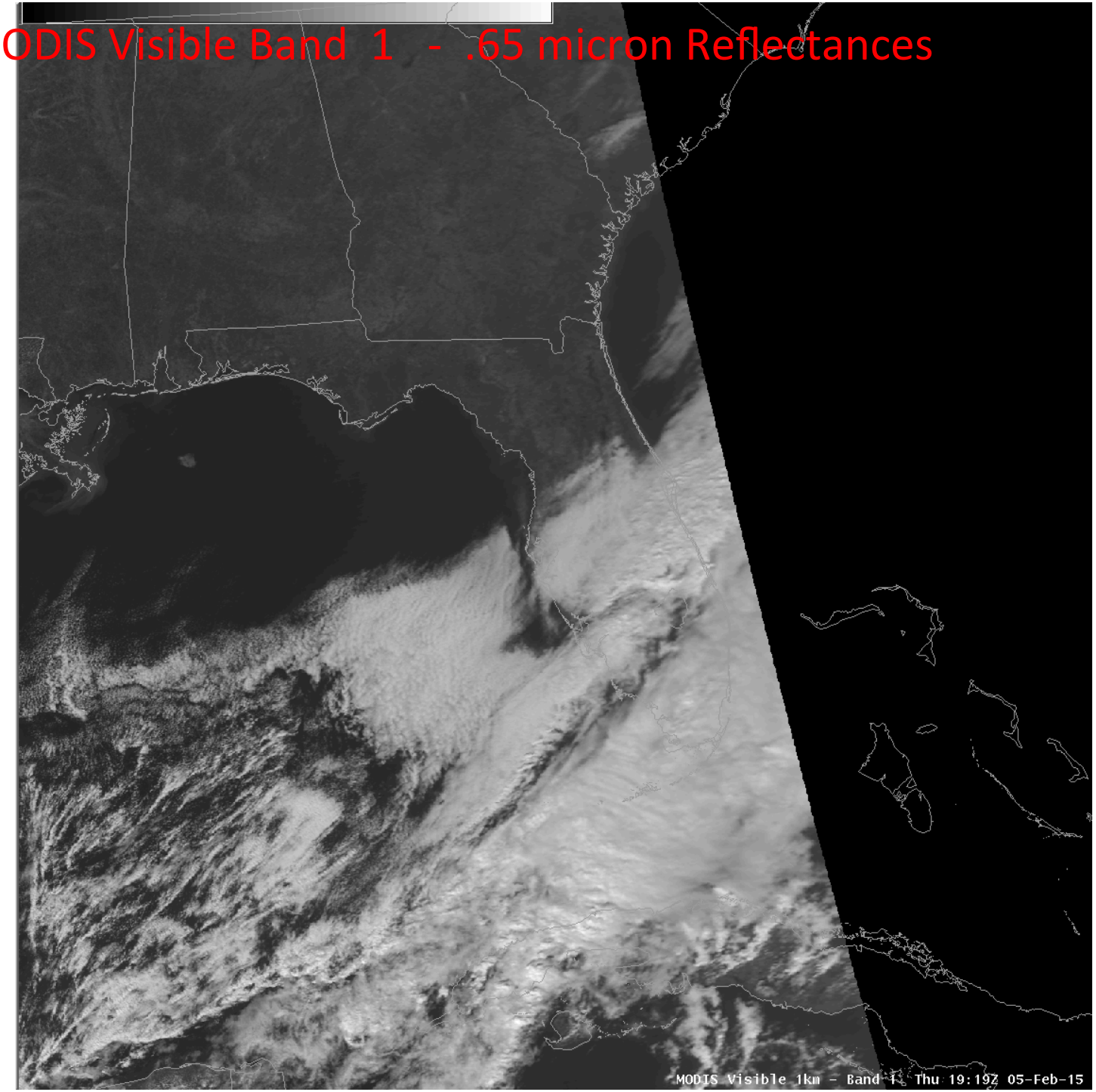
Night

S-NPP 4-11 micron Brightness Temperature Diff. Fog Product



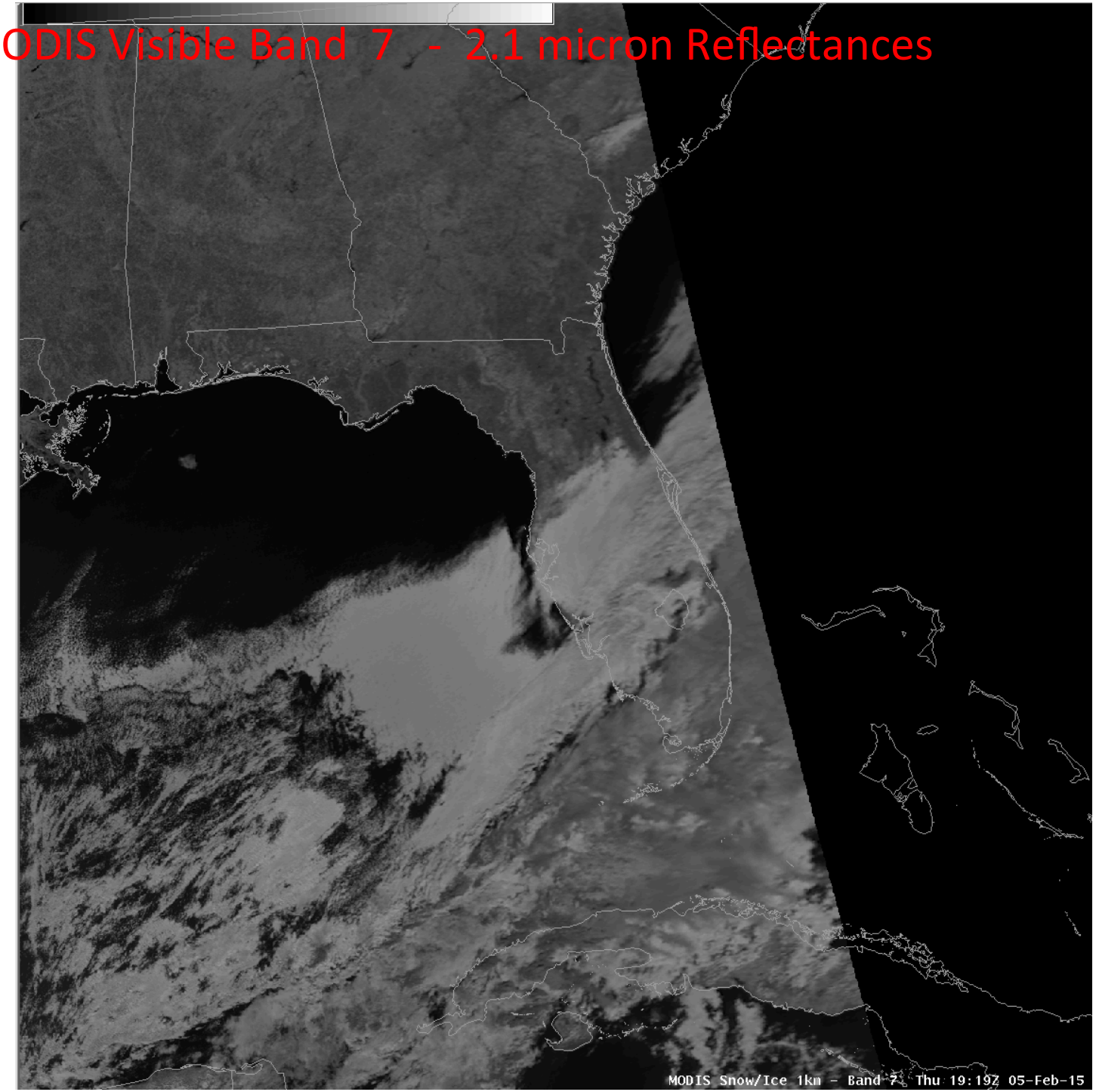
Night

MODIS Visible Band 1 - .65 micron Reflectances



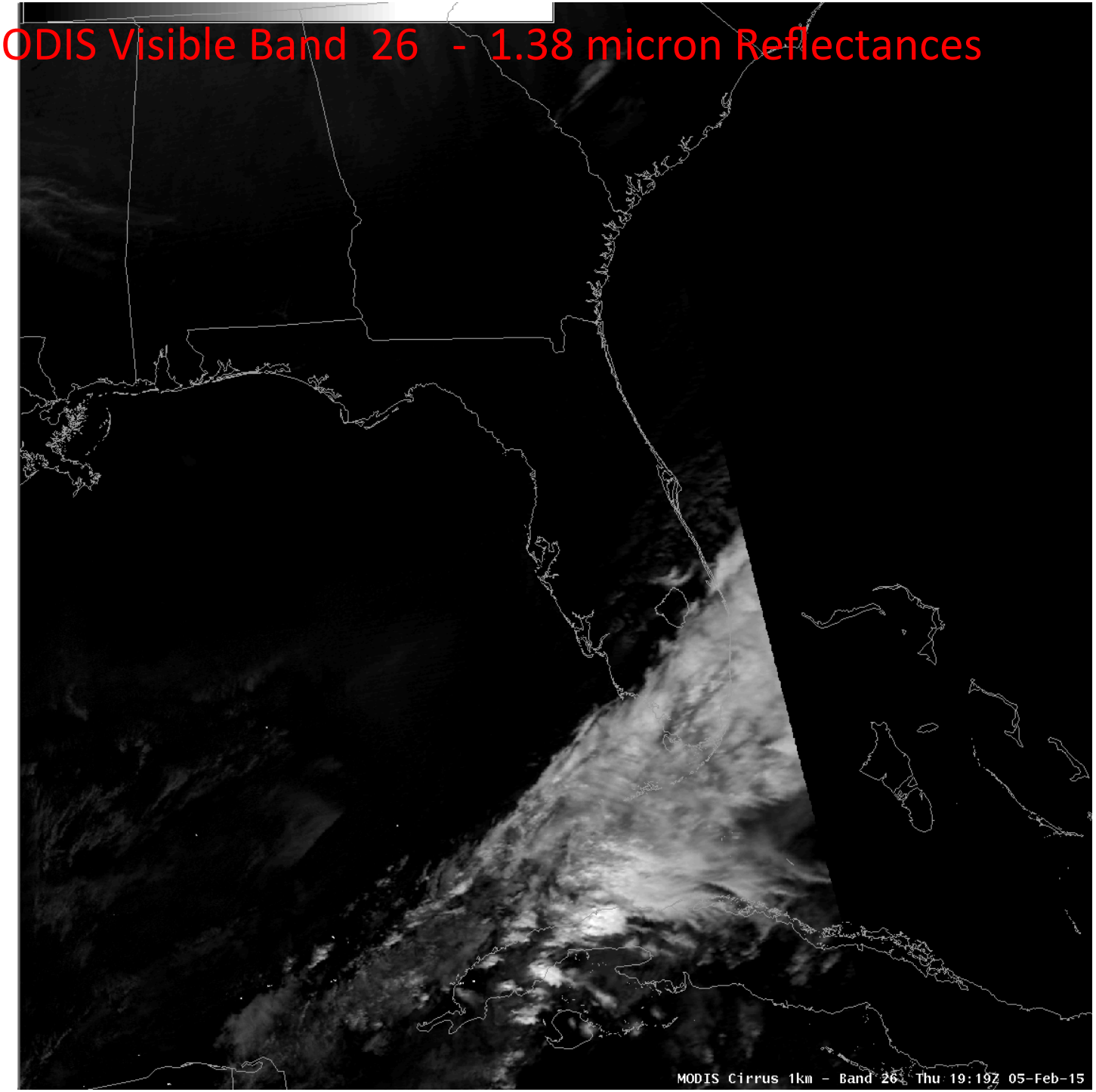
Day

MODIS Visible Band 7 - 2.1 micron Reflectances



Day

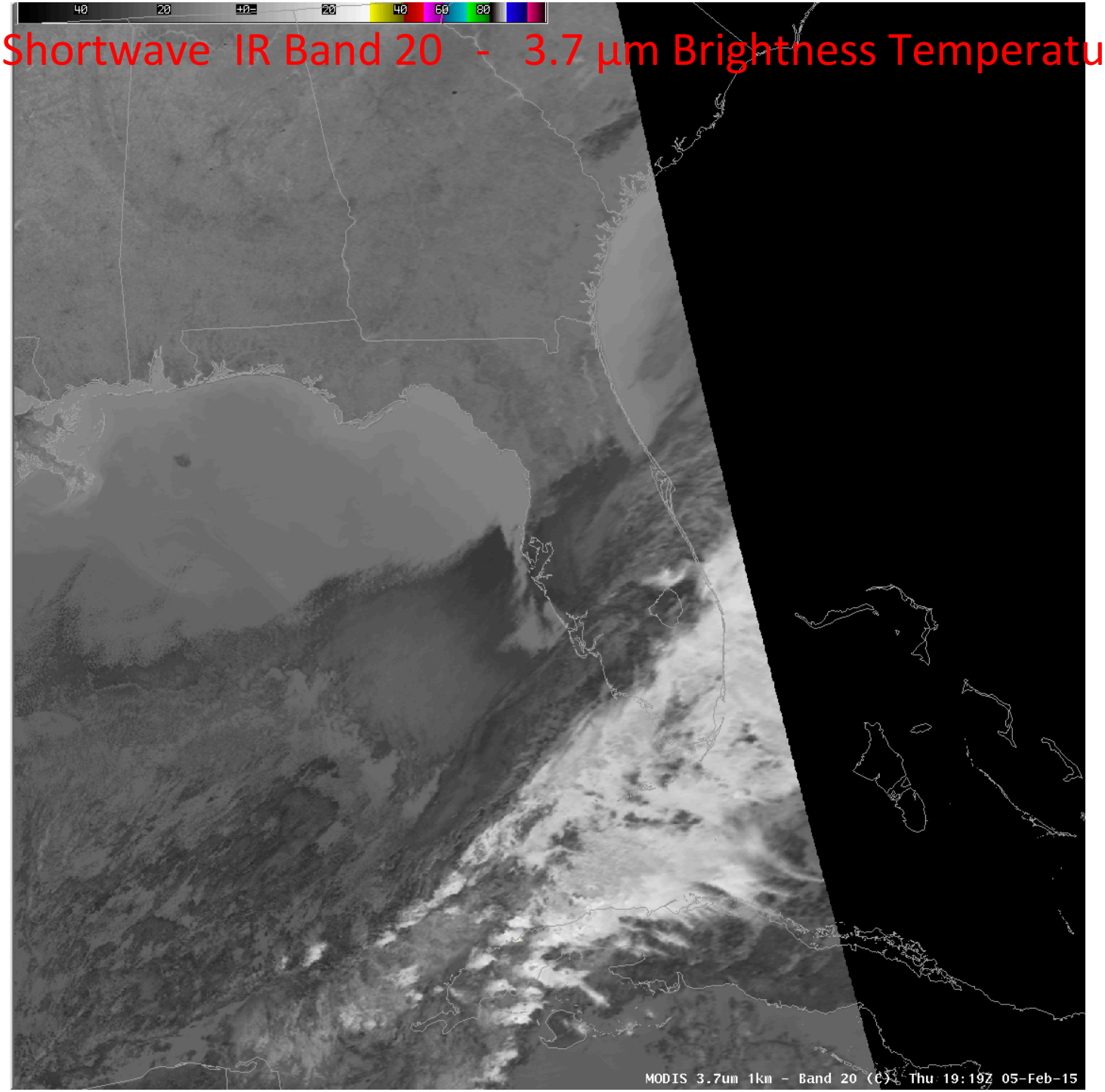
MODIS Visible Band 26 - 1.38 micron Reflectances



Day

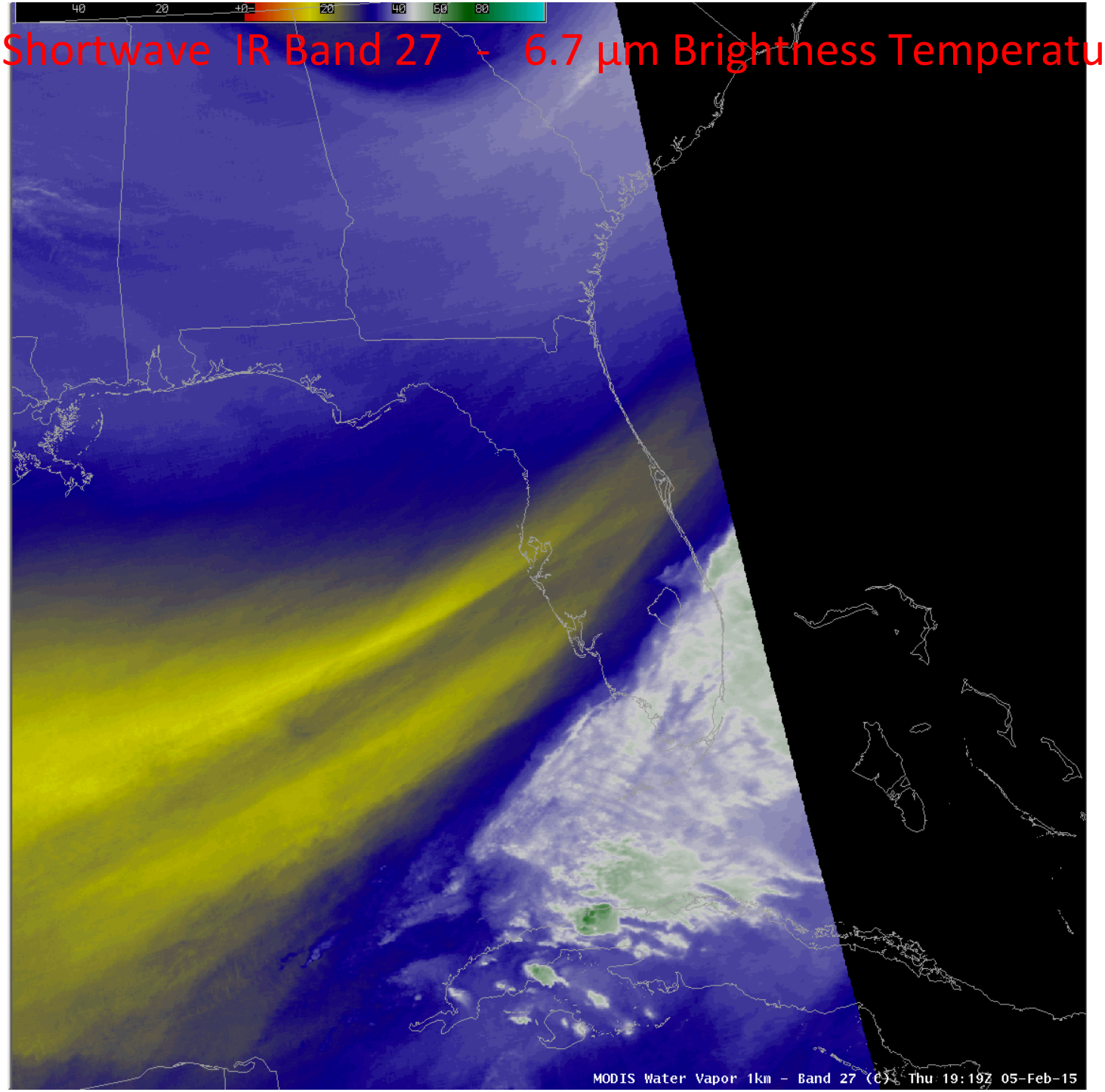
MODIS Shortwave IR Band 20 - 3.7 µm Brightness Temperatures

Day

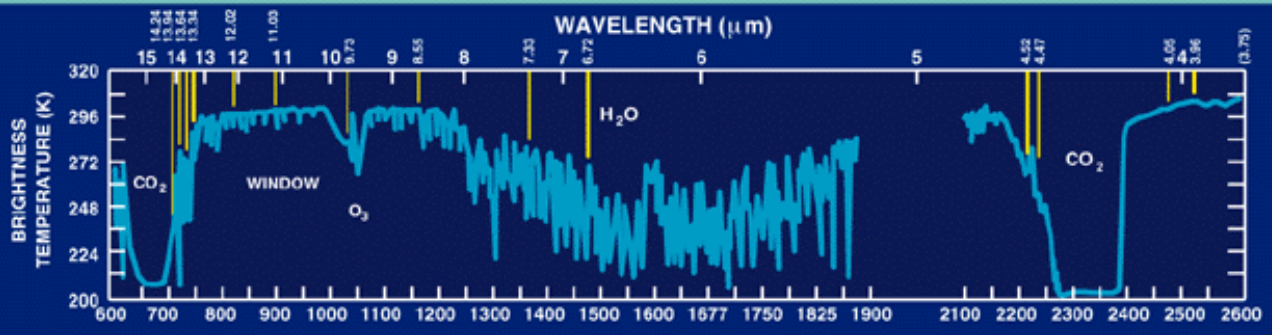


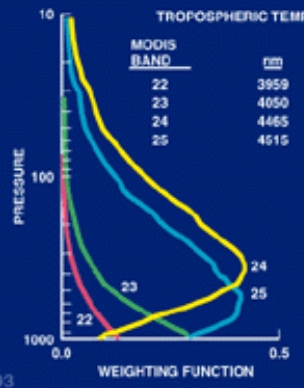
MODIS Shortwave IR Band 27 - 6.7 µm Brightness Temperatures

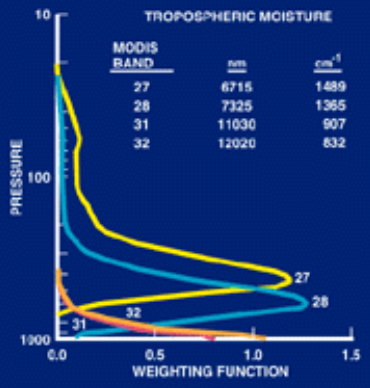
Day

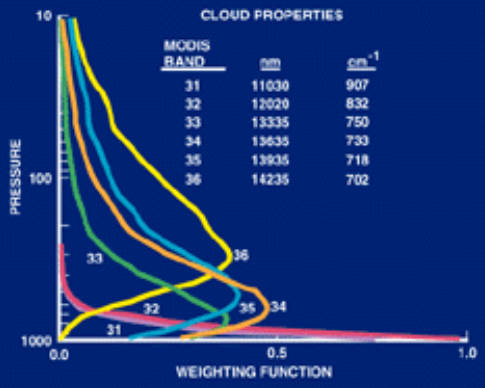


ATMOSPHERE - THERMAL RADIATION



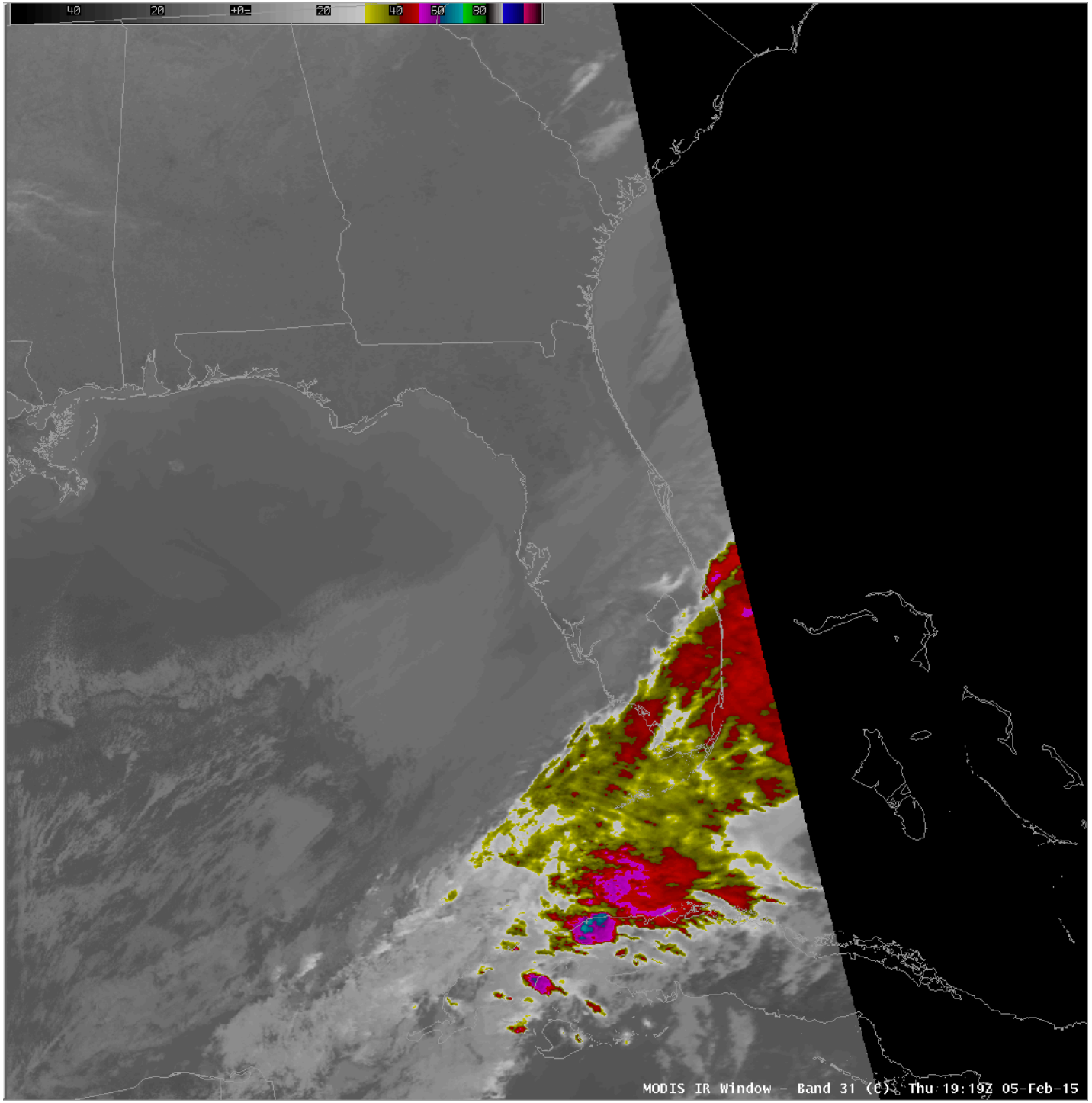




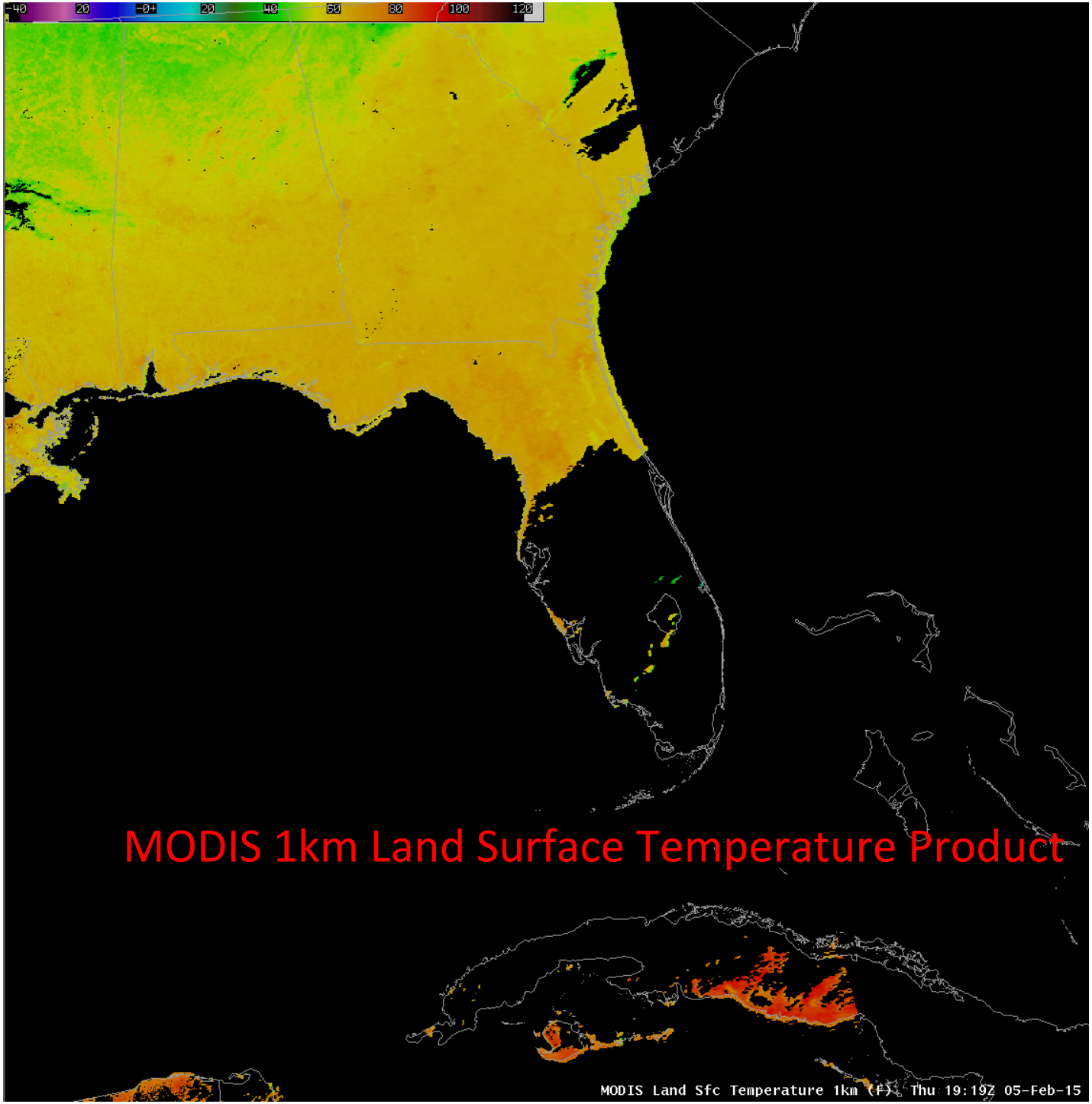


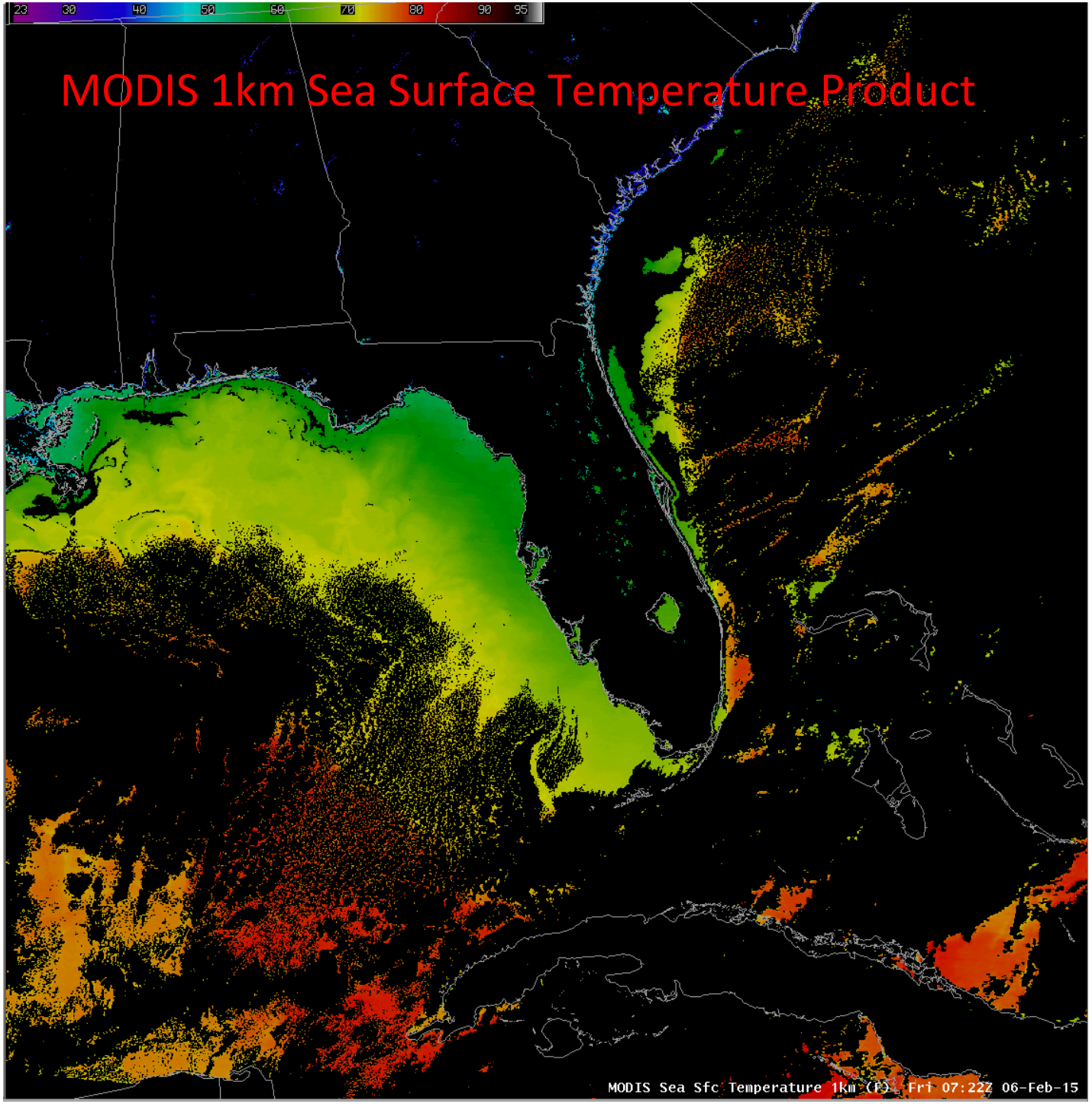
E351.002 5/93

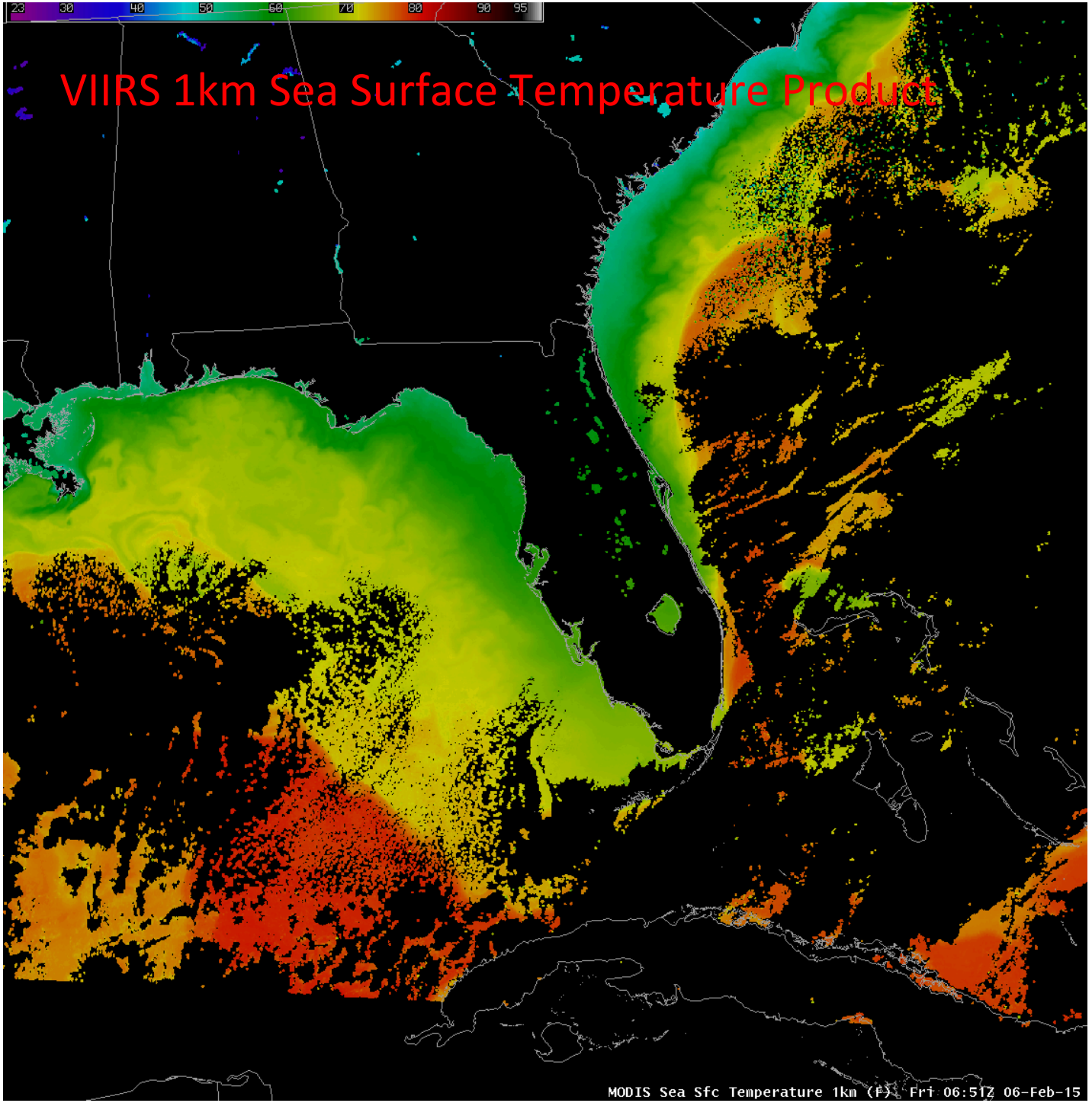
Day



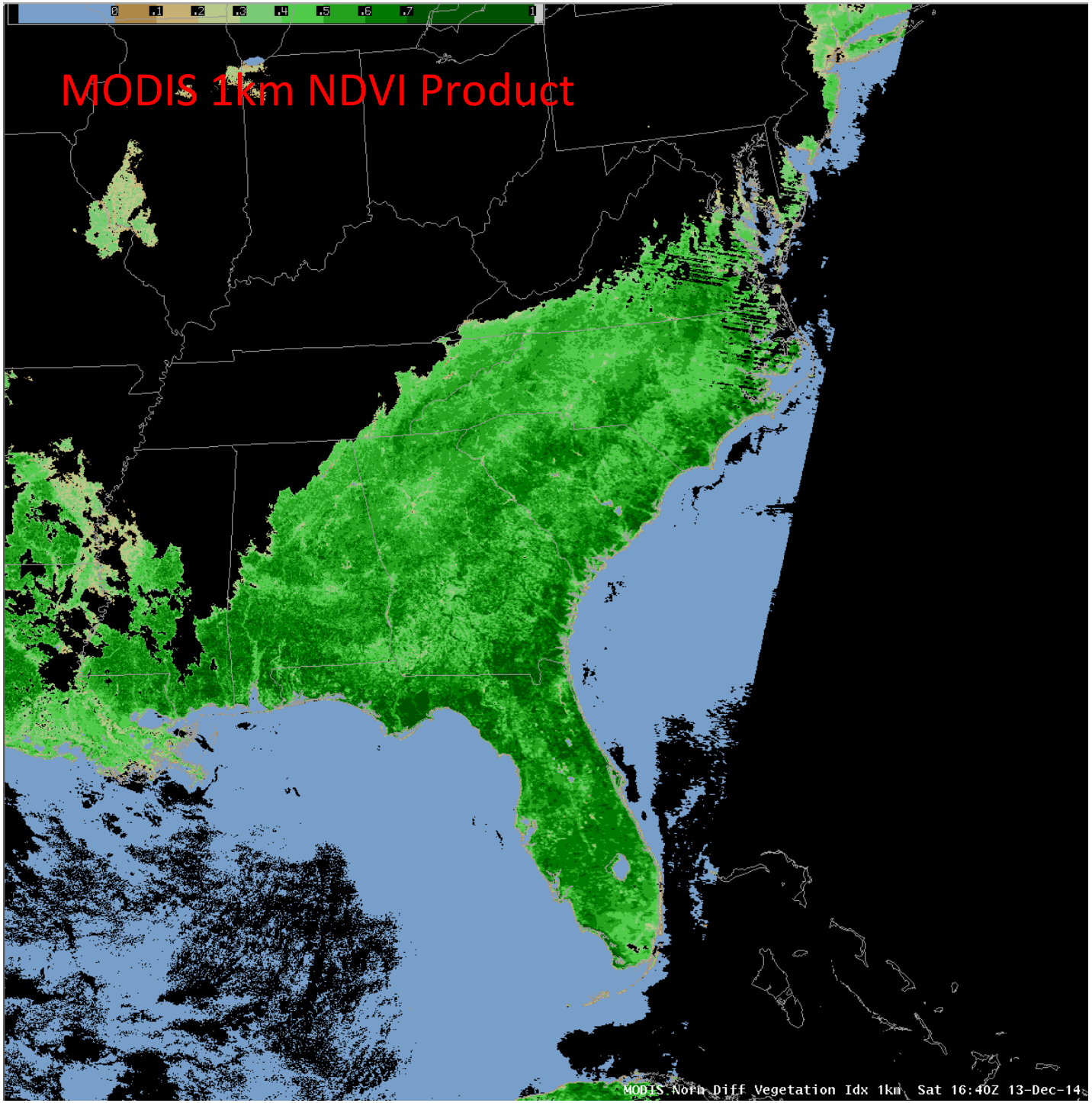
Day

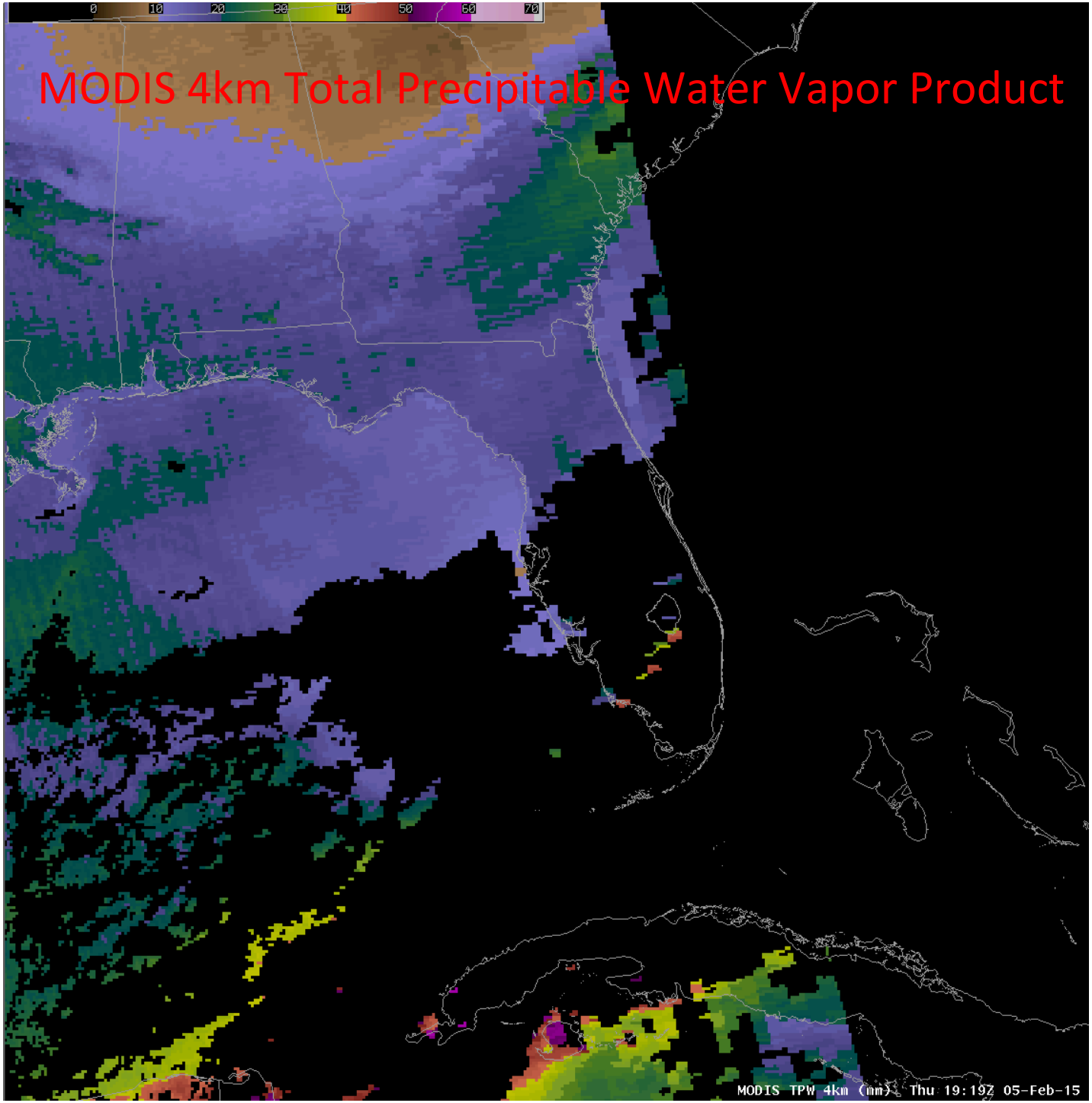

-40 20 -0+ 20 40 60 80 100 120
MODIS 1km Land Surface Temperature Product
MODIS Land Sfc Temperature 1km (F) Thu 19:19Z 05-Feb-15

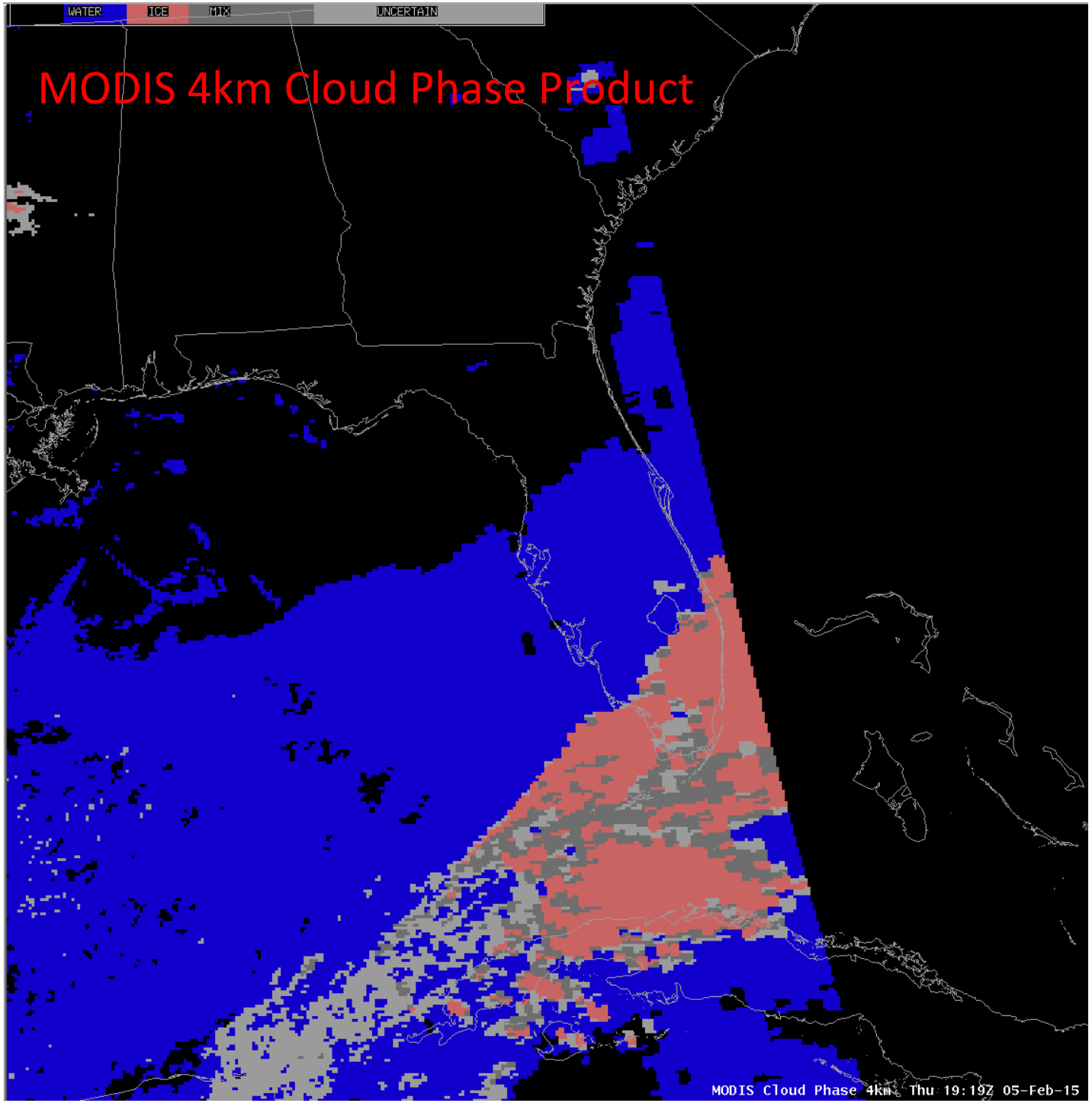

23 30 40 50 60 70 80 90 95
MODIS 1km Sea Surface Temperature Product
MODIS Sea Sfc Temperature 1km (F) Fri 07:22Z 06-Feb-15


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


0 10 20 30 40 50 60 70
MODIS 4km Total Precipitable Water Vapor Product
MODIS TPW 4km (mm) Thu 19:19Z 05-Feb-15


WATER
ICE
MIX
UNCERTAIN
MODIS 4km Cloud Phase Product
MODIS Cloud Phase 4km Thu 19:19Z 05-Feb-15

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

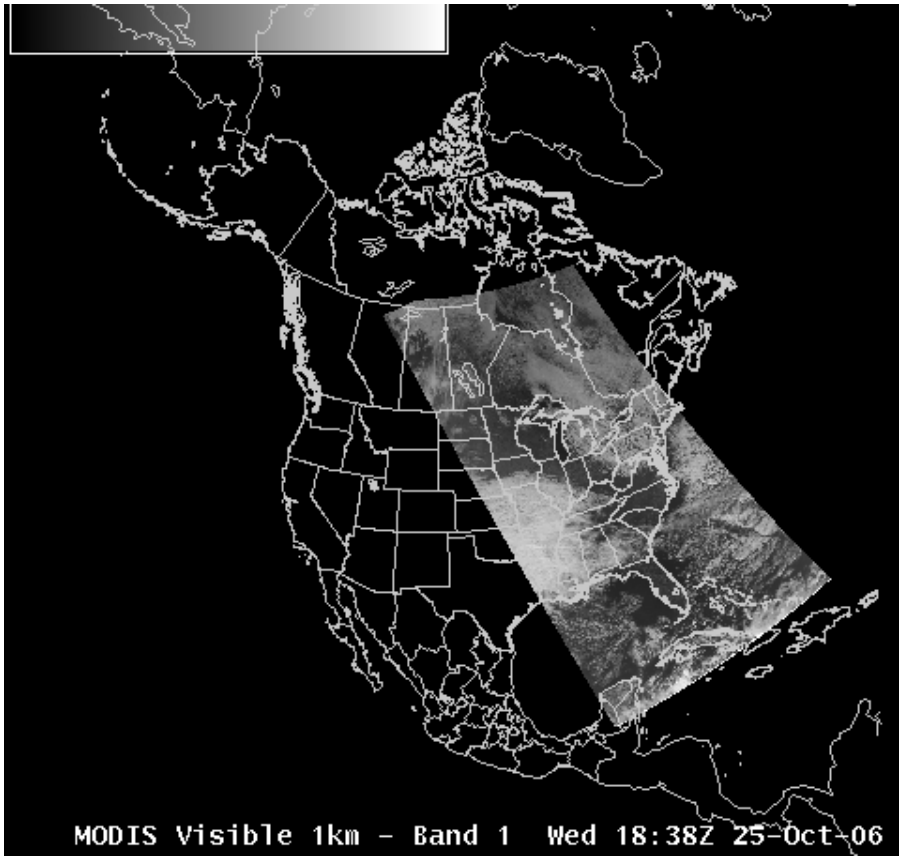
Weather and Forecasting

Complimentary to Geostationary

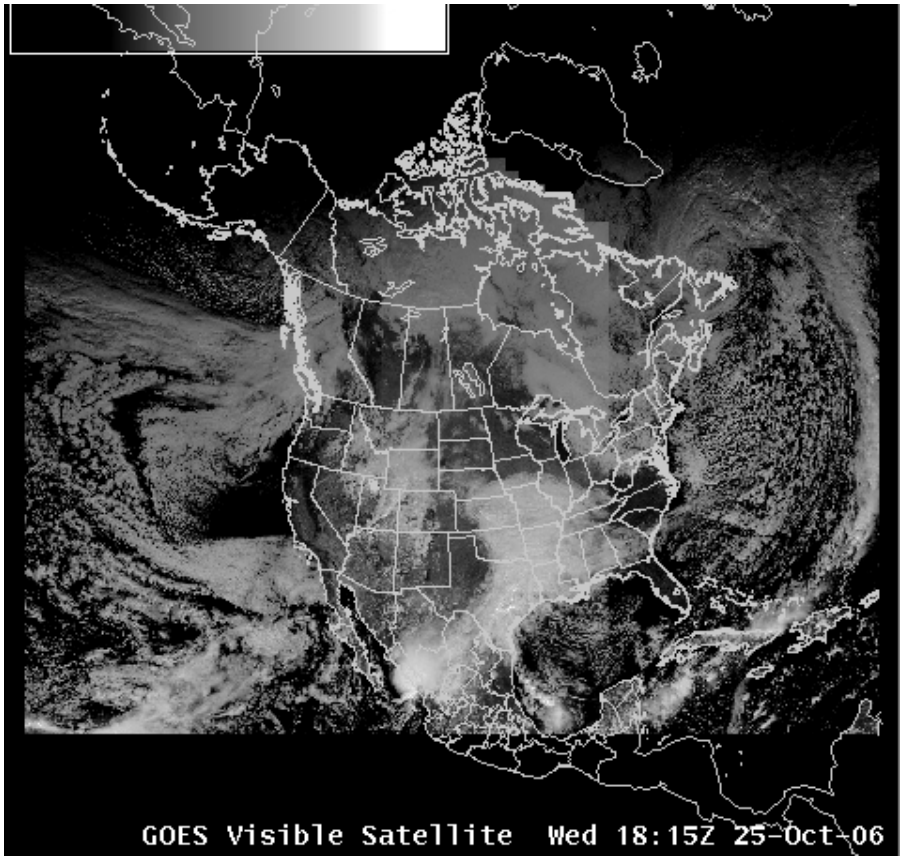
Example of Improved Spatial Resolution

MODIS Imagery in AWIPS

Band 1: Visible channel (0.6µm)



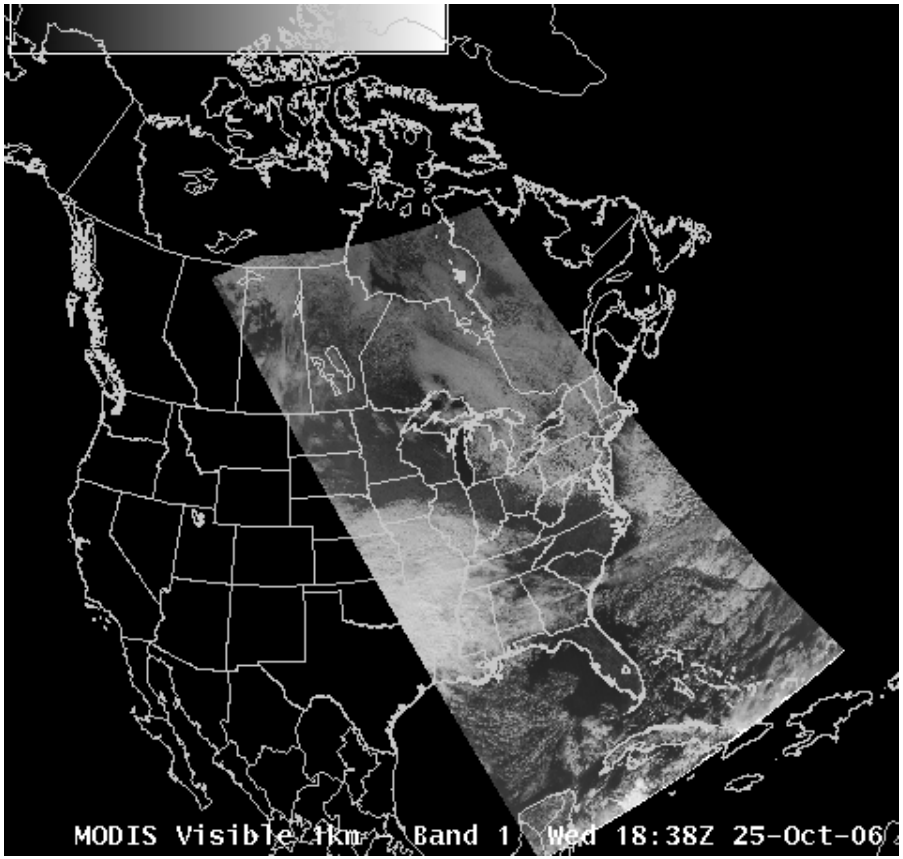
MODIS visible channel



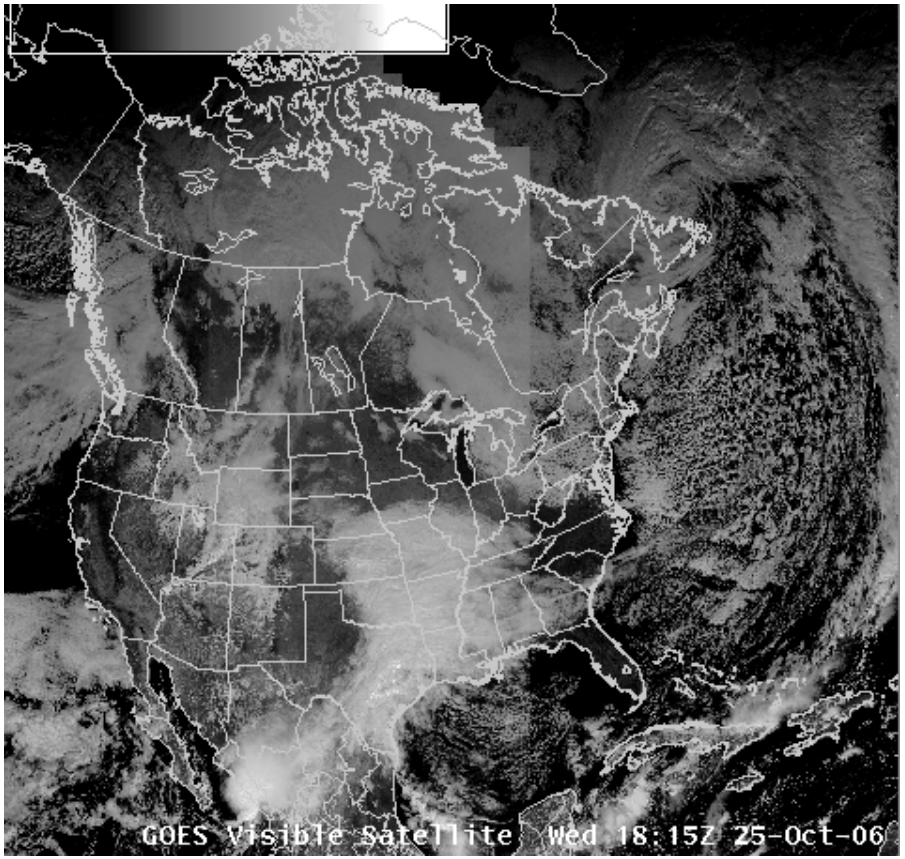
GOES visible channel

MODIS Imagery in AWIPS

Band 1: Visible channel (0.6µm)



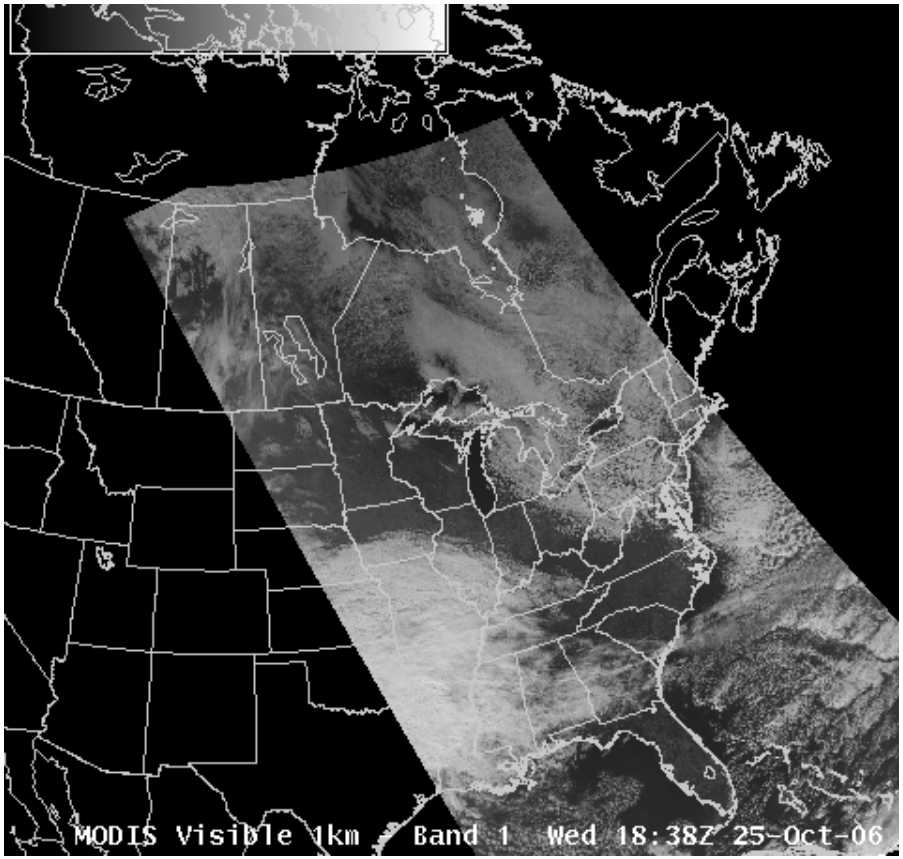
MODIS visible channel



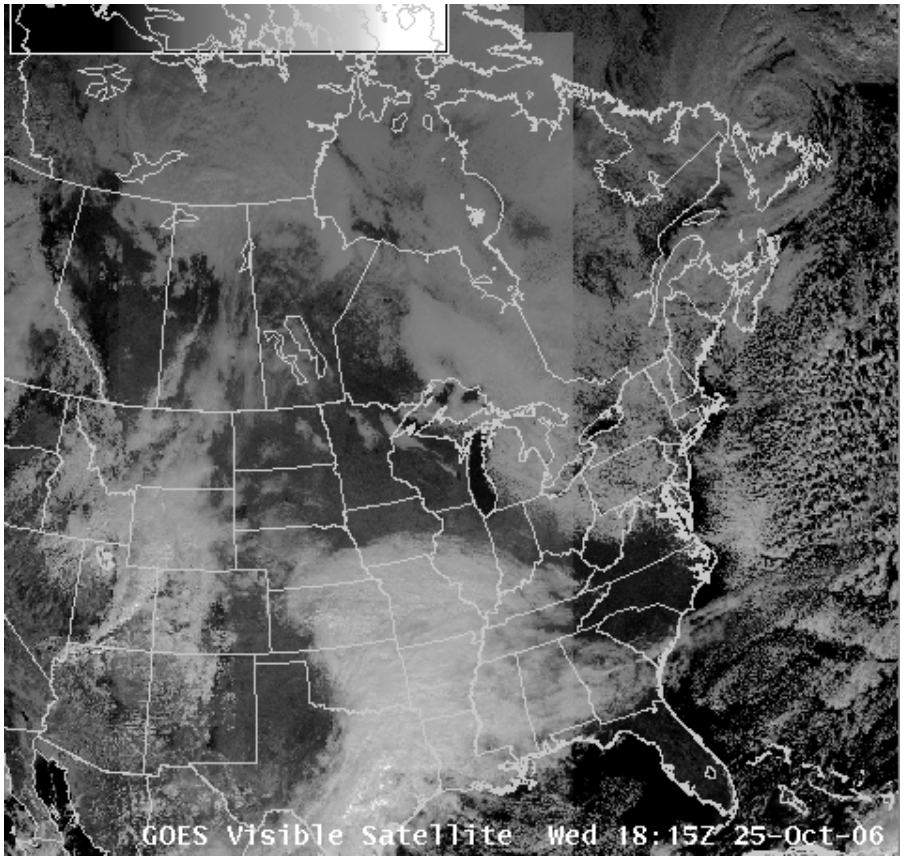
GOES visible channel

MODIS Imagery in AWIPS

Band 1: Visible channel (0.6µm)



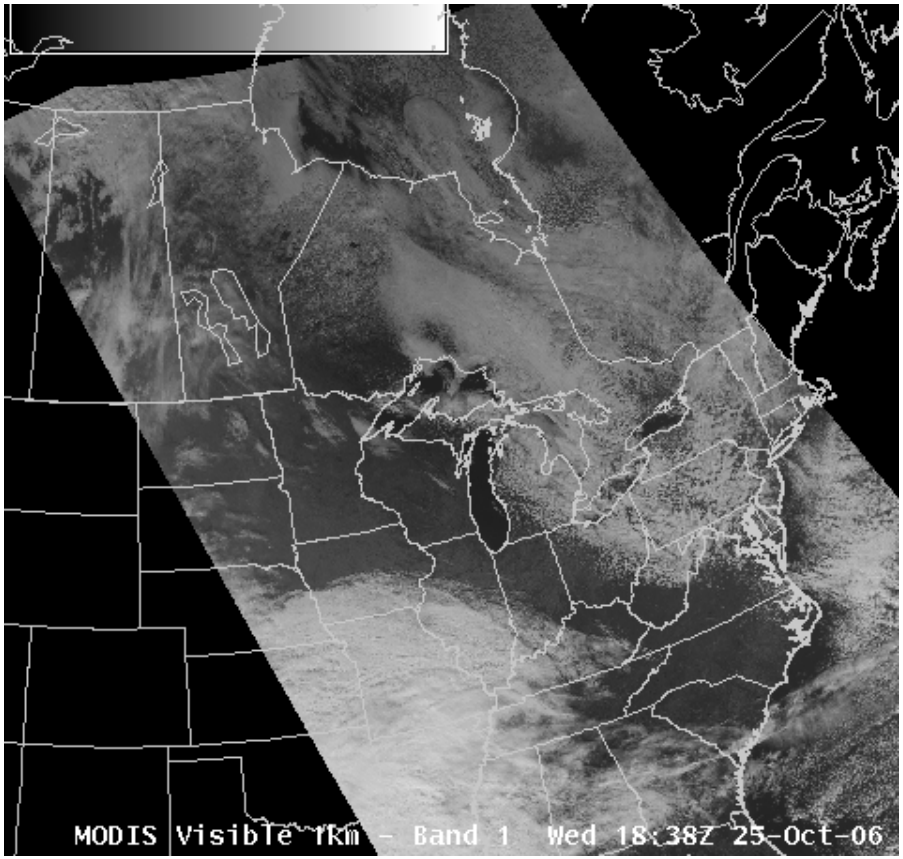
MODIS visible channel



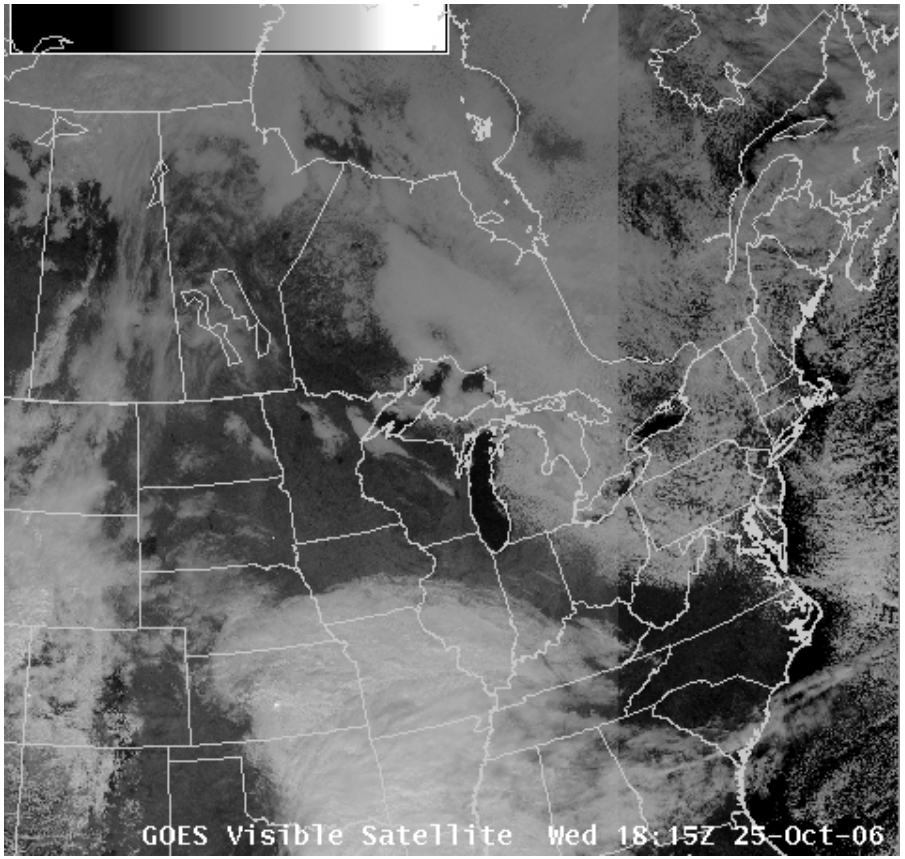
GOES visible channel

MODIS Imagery in AWIPS

Band 1: Visible channel (0.6µm)



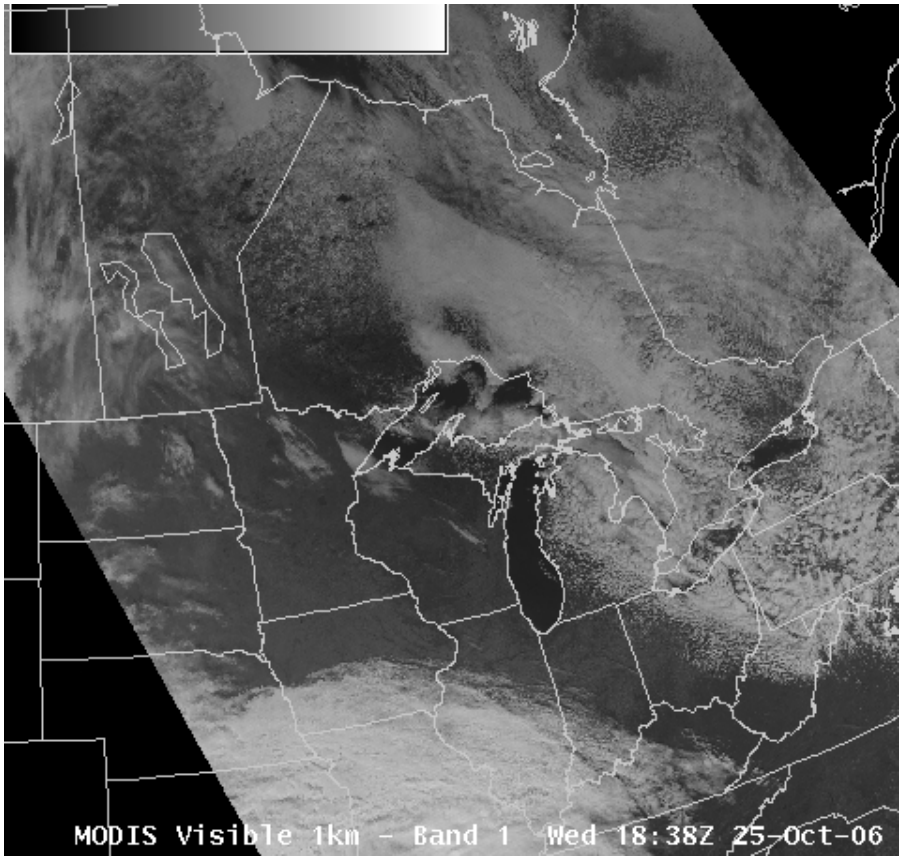
MODIS visible channel



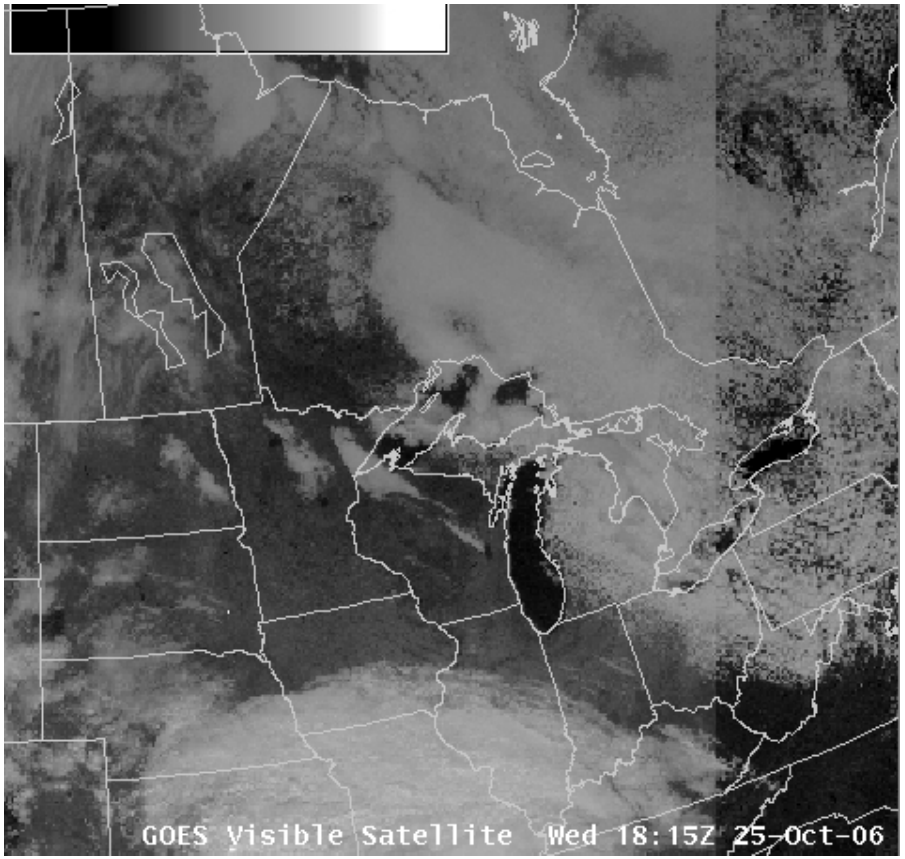
GOES visible channel

MODIS Imagery in AWIPS

Band 1: Visible channel (0.6µm)



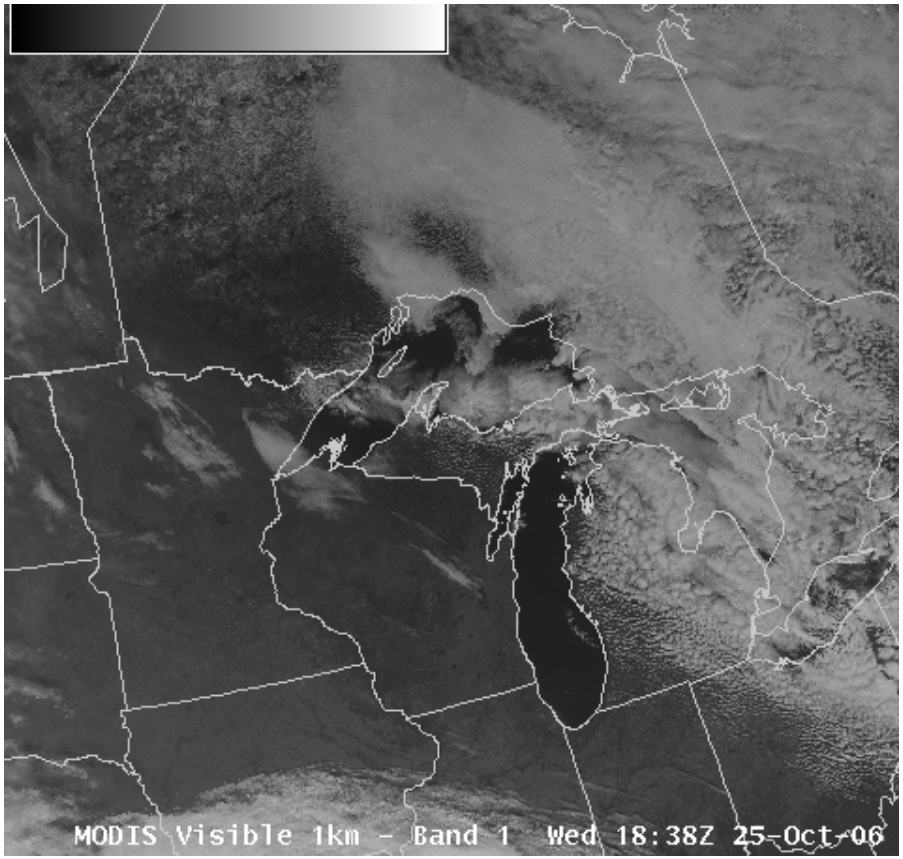
MODIS visible channel



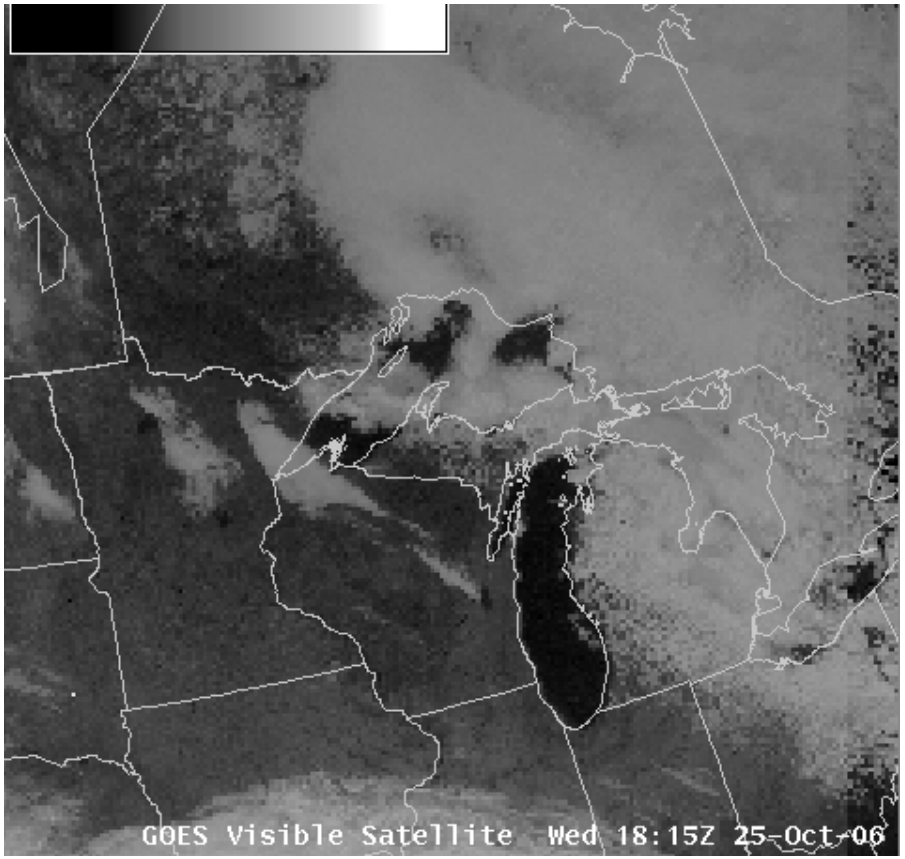
GOES visible channel

MODIS Imagery in AWIPS

Band 1: Visible channel (0.6µm)



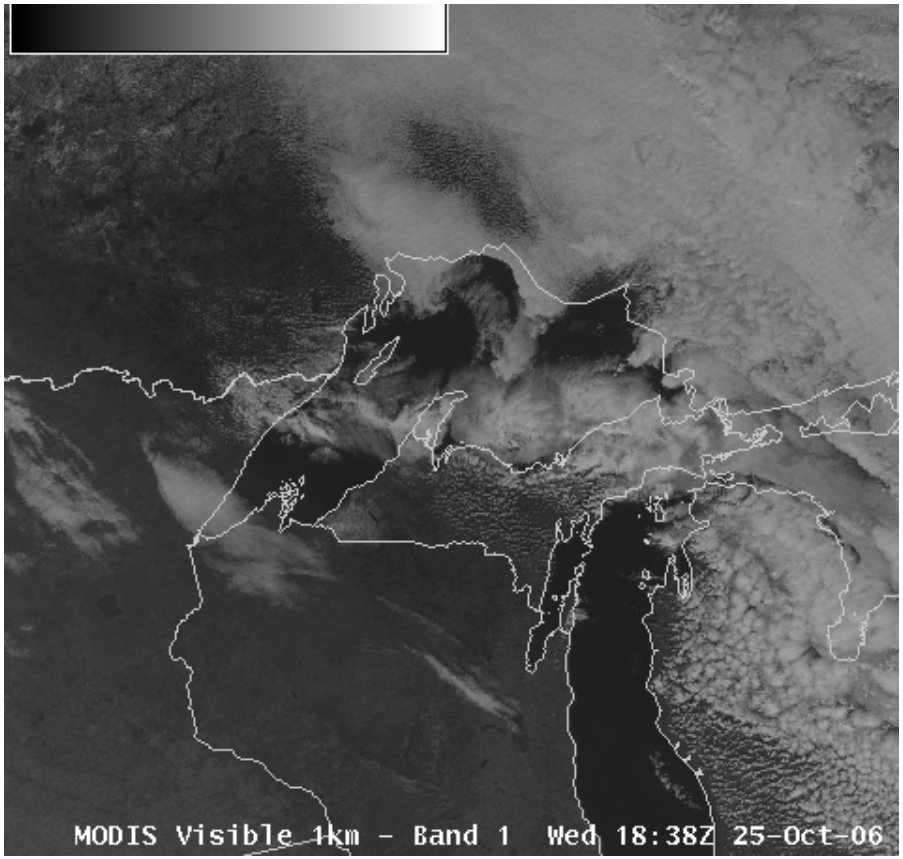
MODIS visible channel



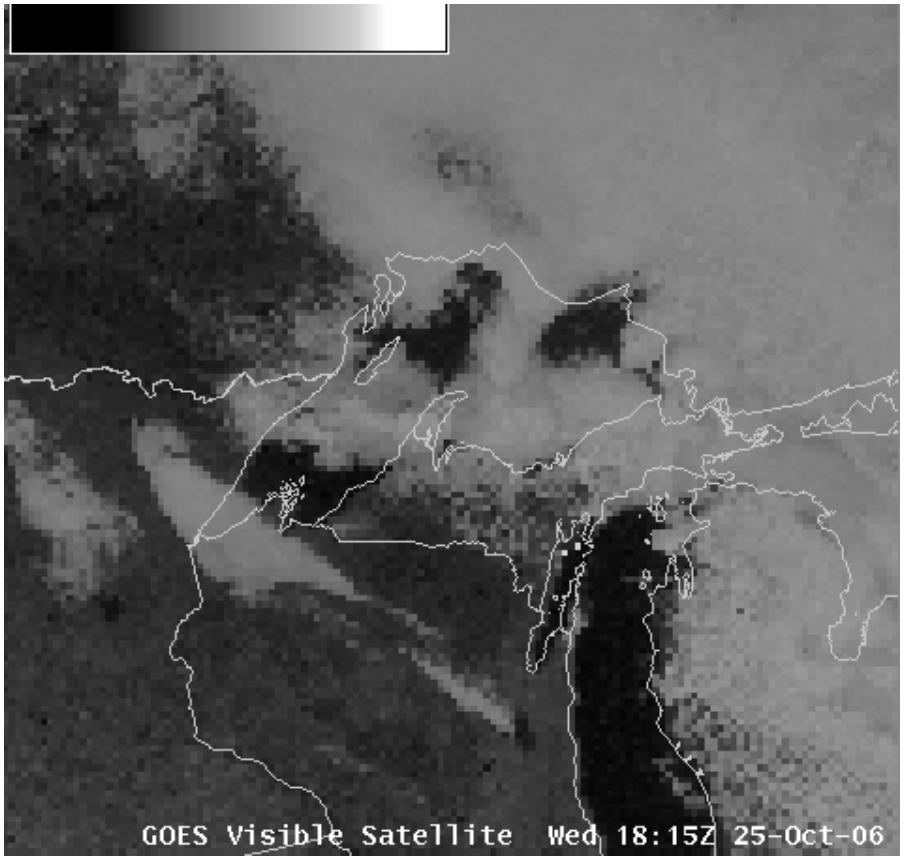
GOES visible channel

MODIS Imagery in AWIPS

Band 1: Visible channel (0.6µm)



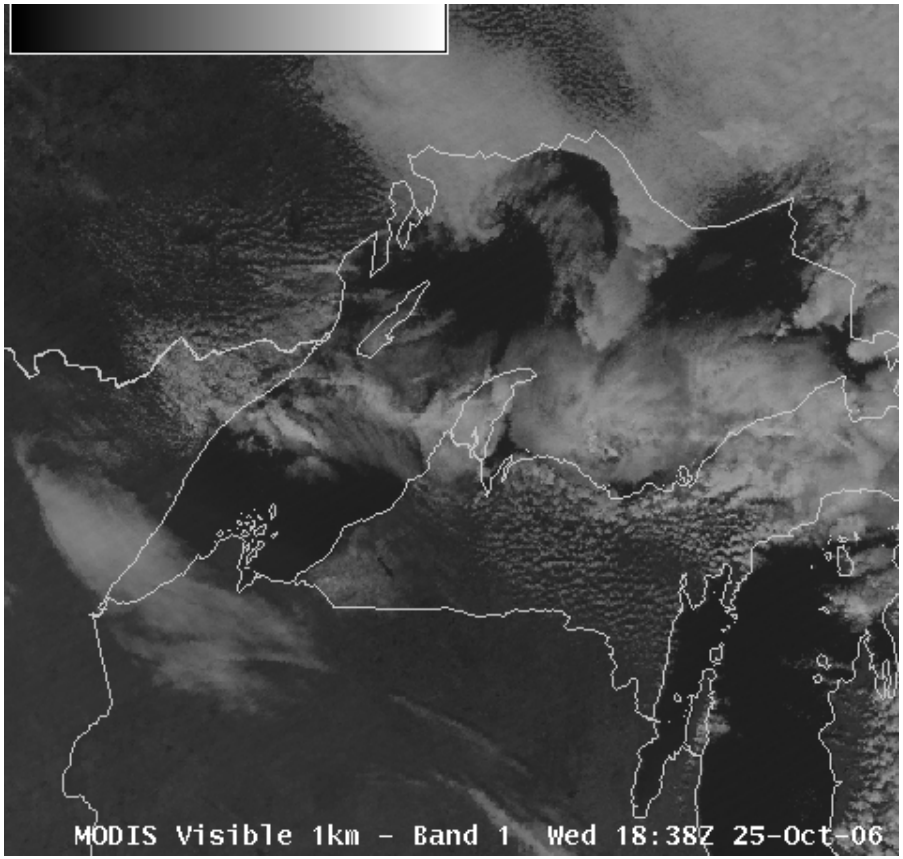
MODIS visible channel



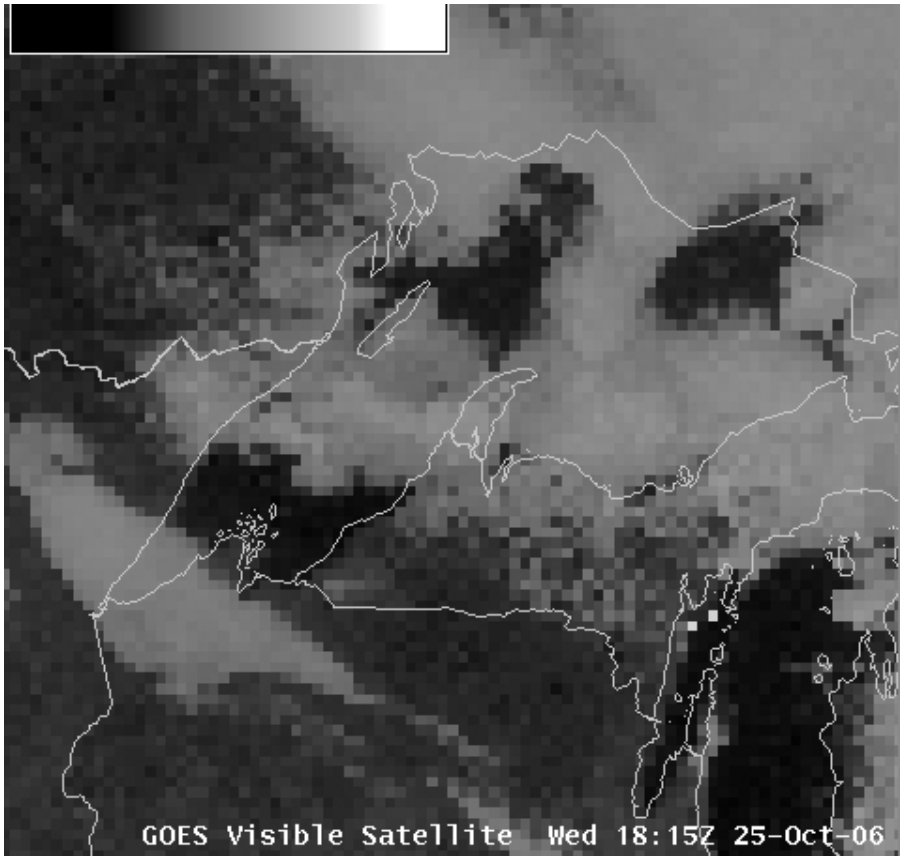
GOES visible channel

MODIS Imagery in AWIPS

Band 1: Visible channel (0.6µm)

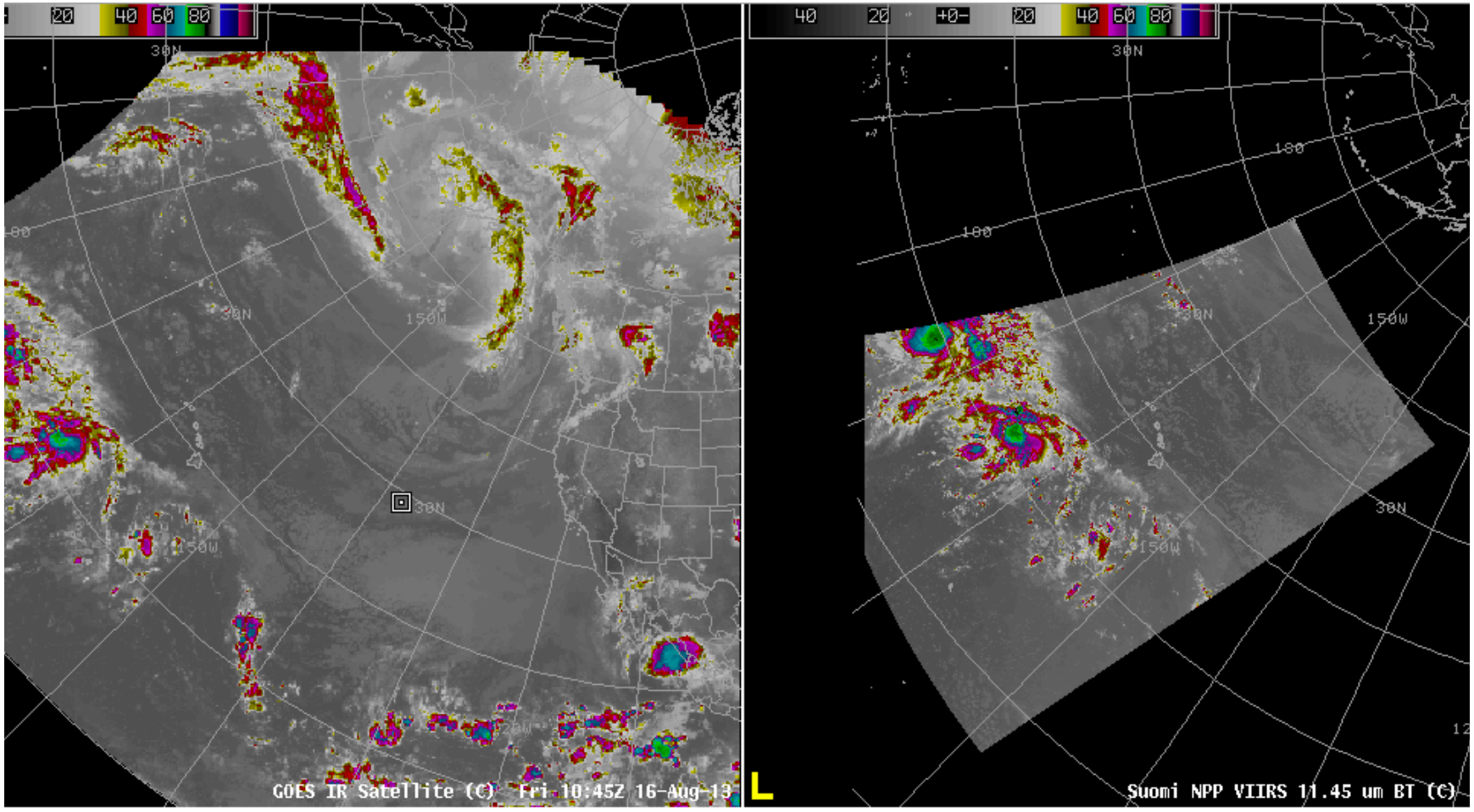


MODIS visible channel

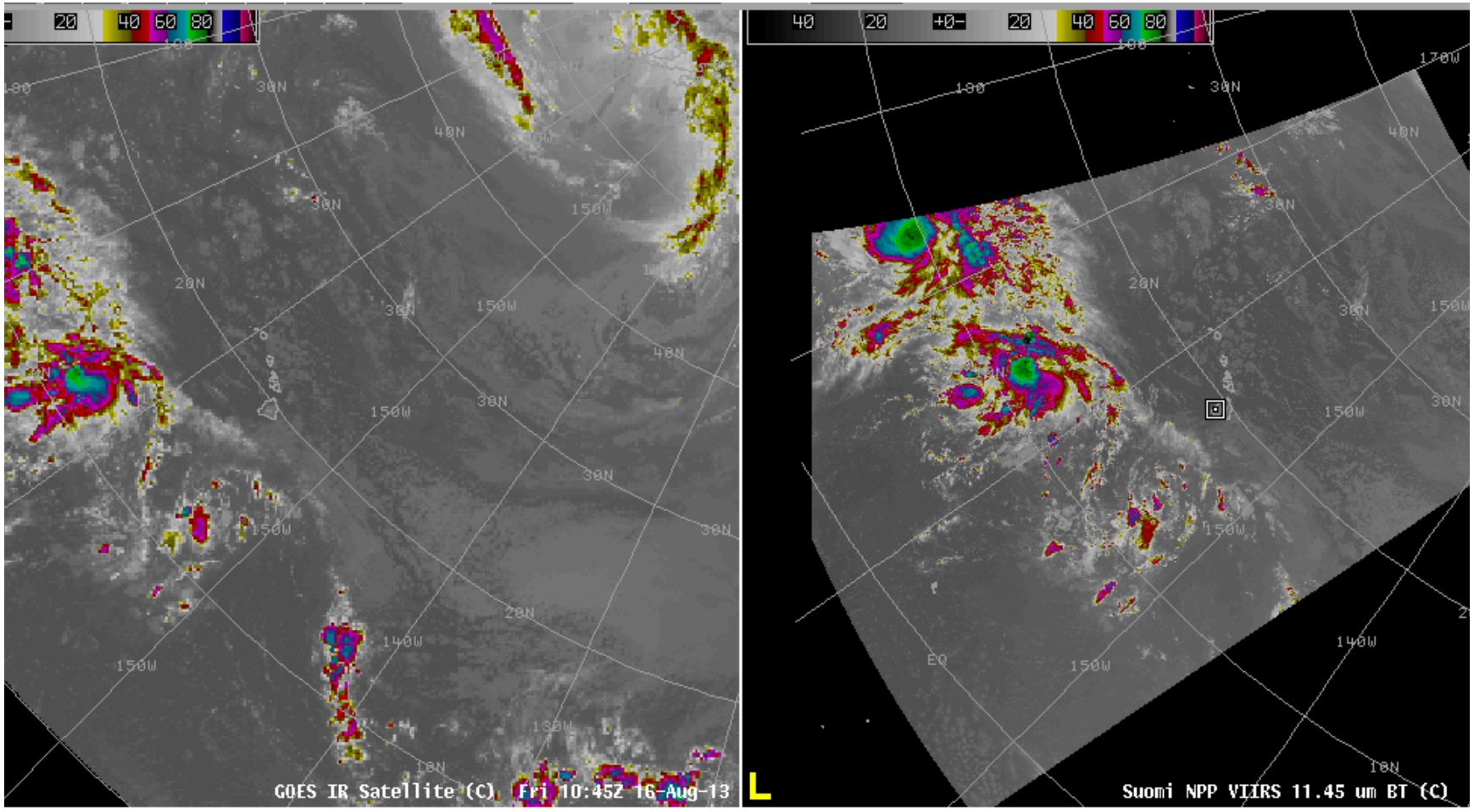


GOES visible channel

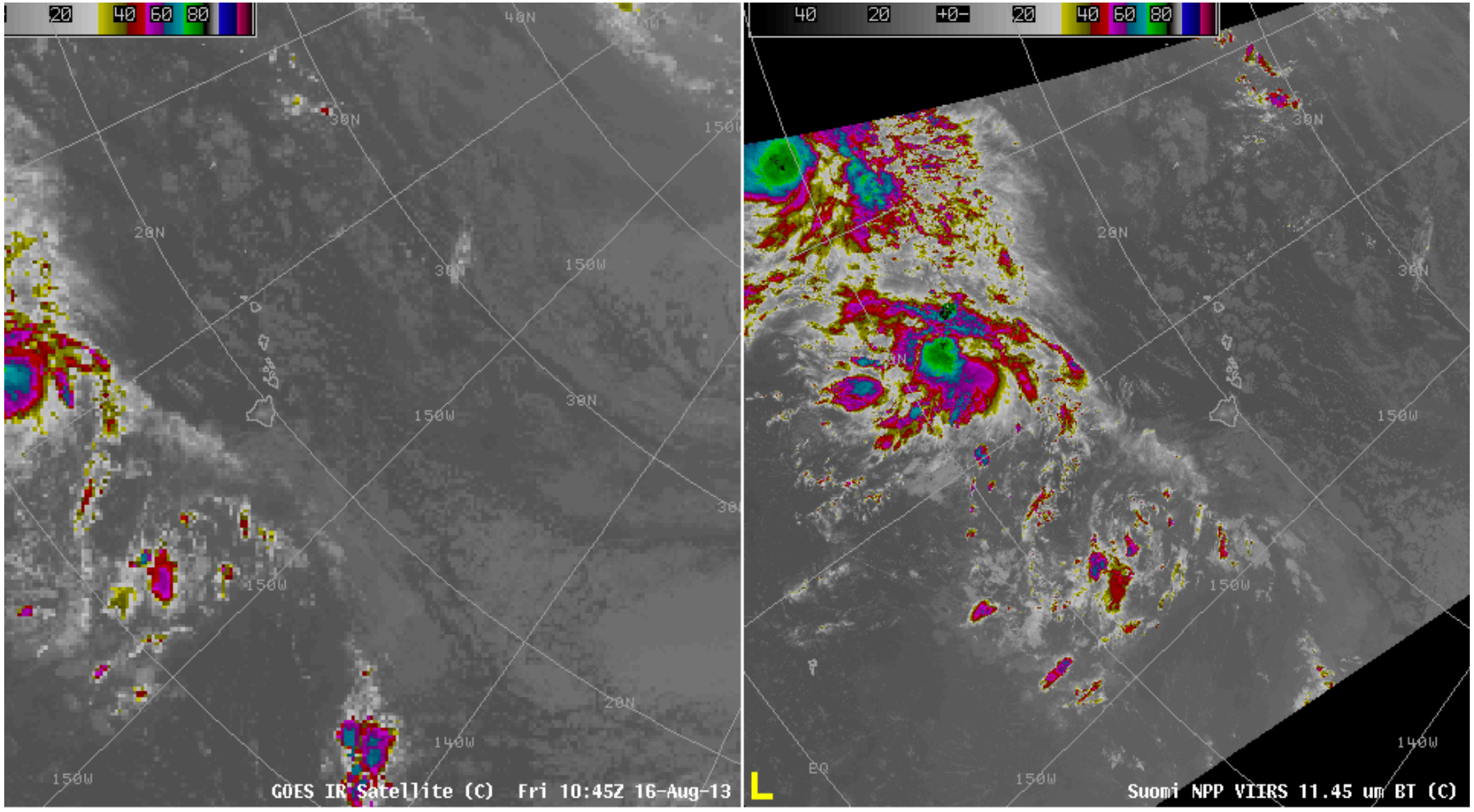
GEO versus LEO perspective



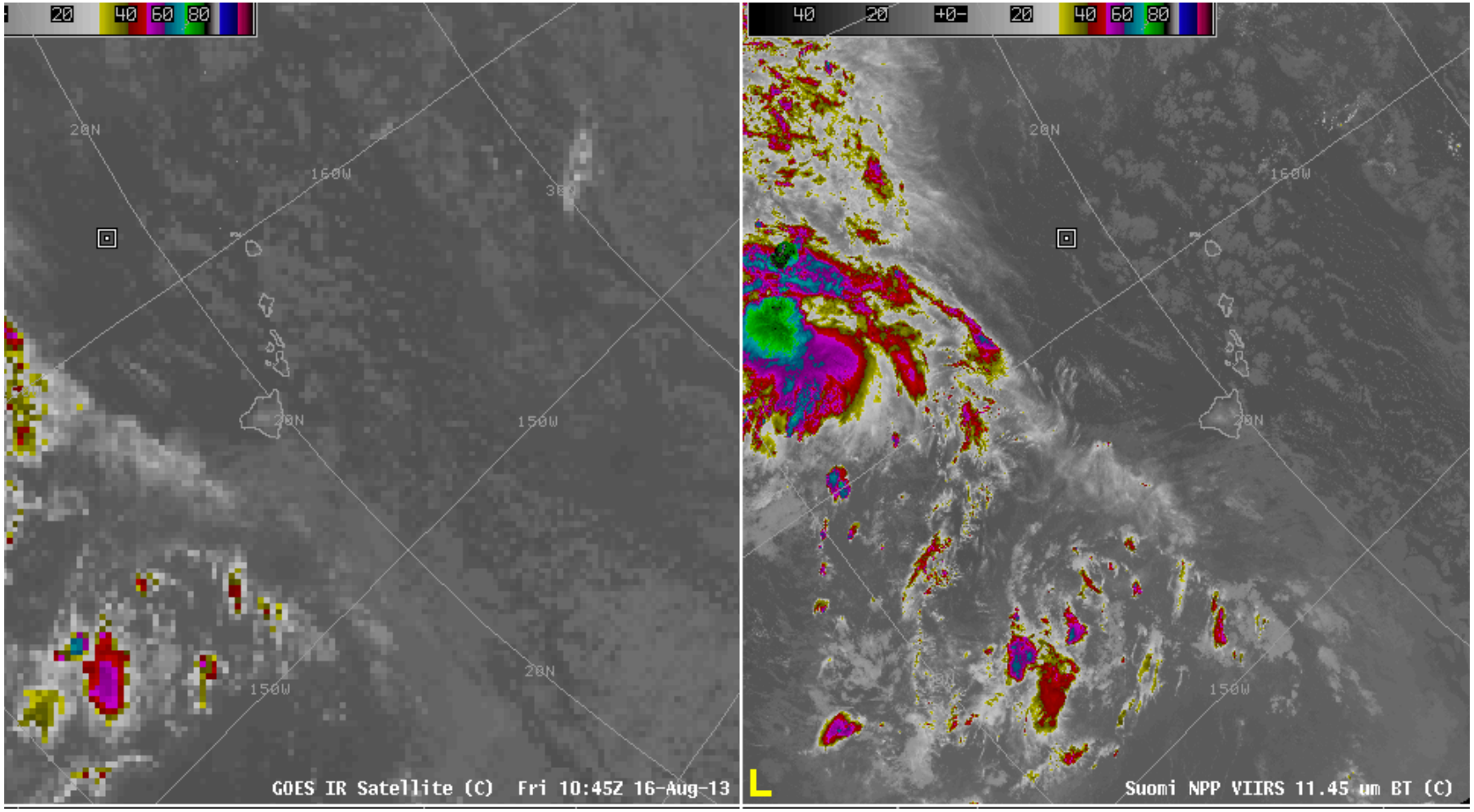
GEO versus LEO perspective



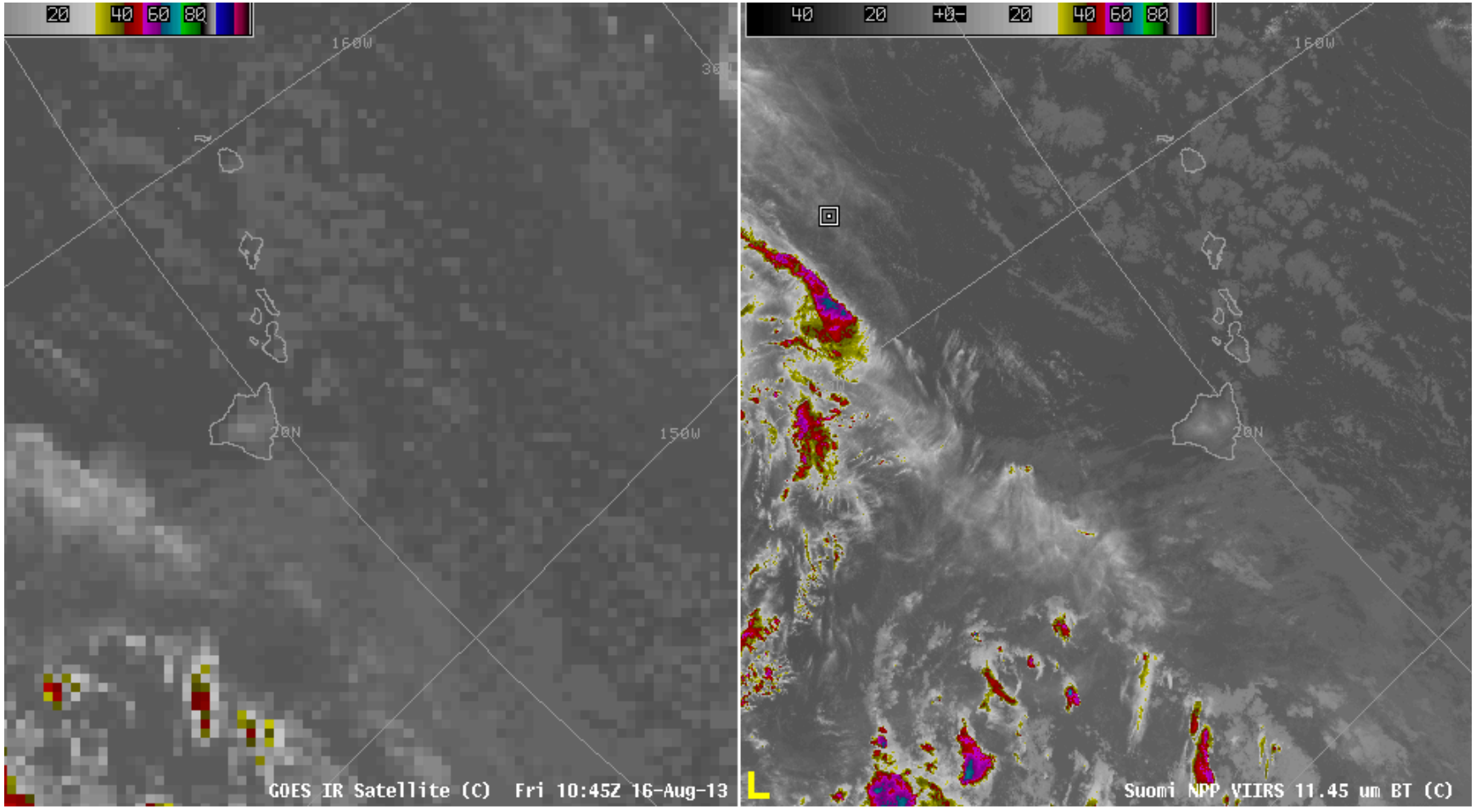
GEO versus LEO perspective



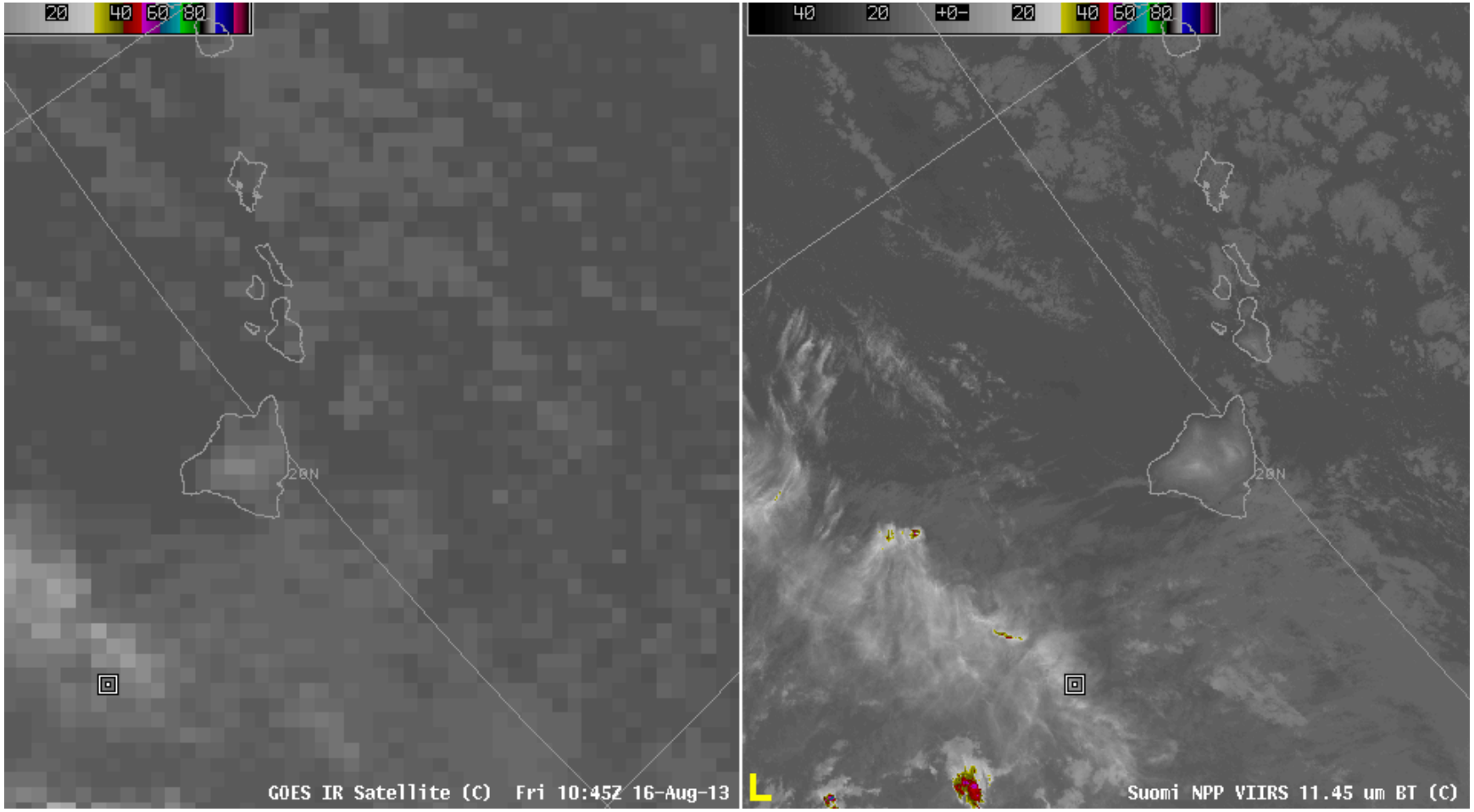
GEO versus LEO perspective



GEO versus LEO perspective



GEO versus LEO perspective



How Important Is Spatial Resolution?

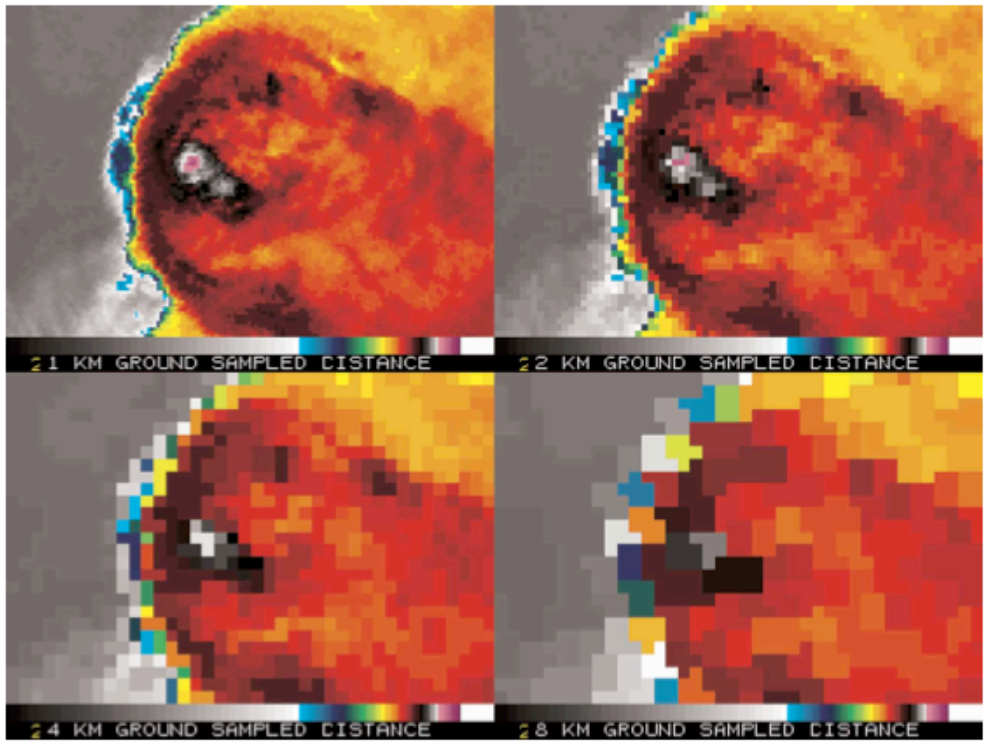
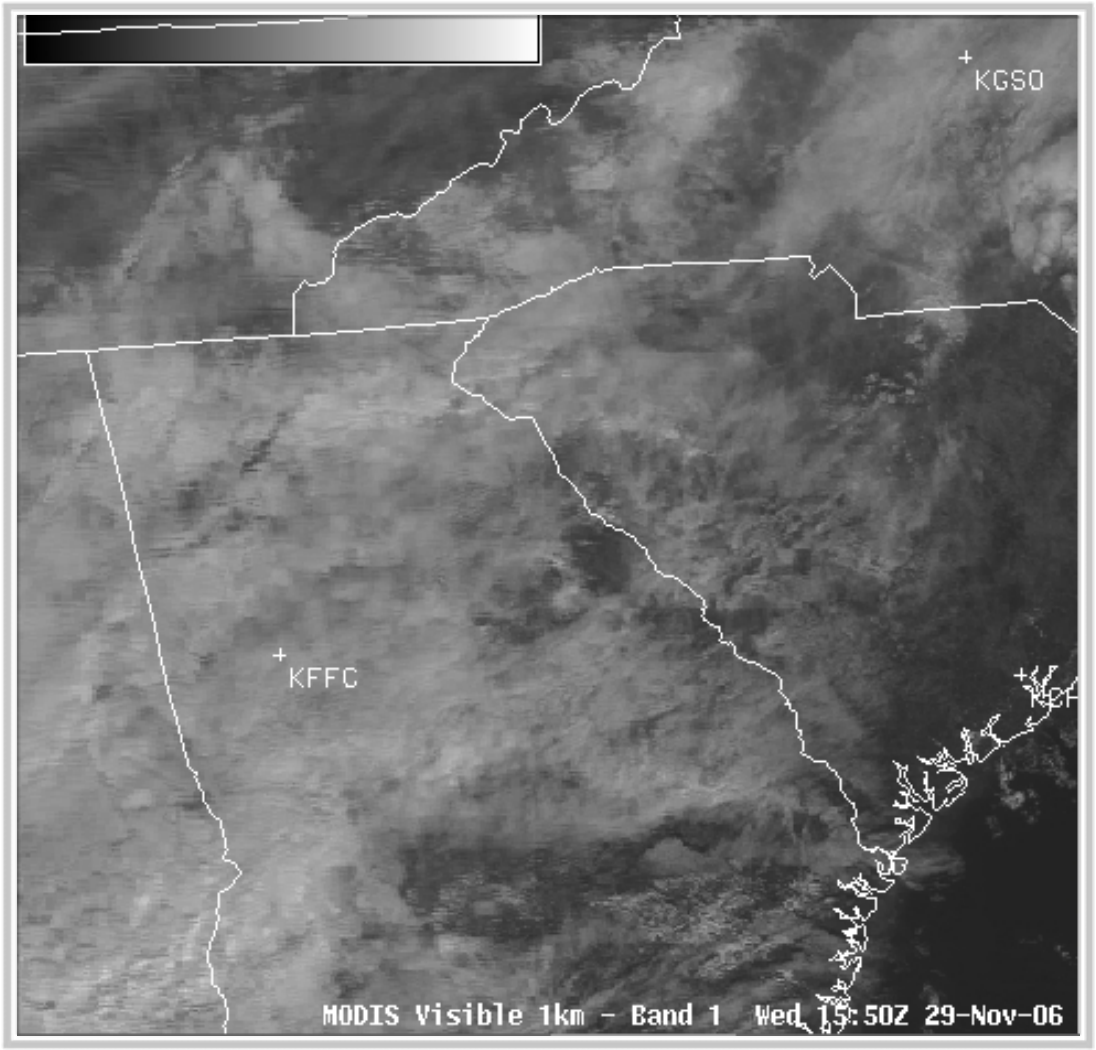


FIG. 3. Zoomed-in image of an enhanced-V feature located over northeast OK observed from enhanced LEO satellite imagery at 2218 UTC 6 May 2003 for 1-, 2-, 4-, and 8-km ground-sampled distances. The purple and white colors in the location of the updraft and overshooting top represent colder BTs, while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

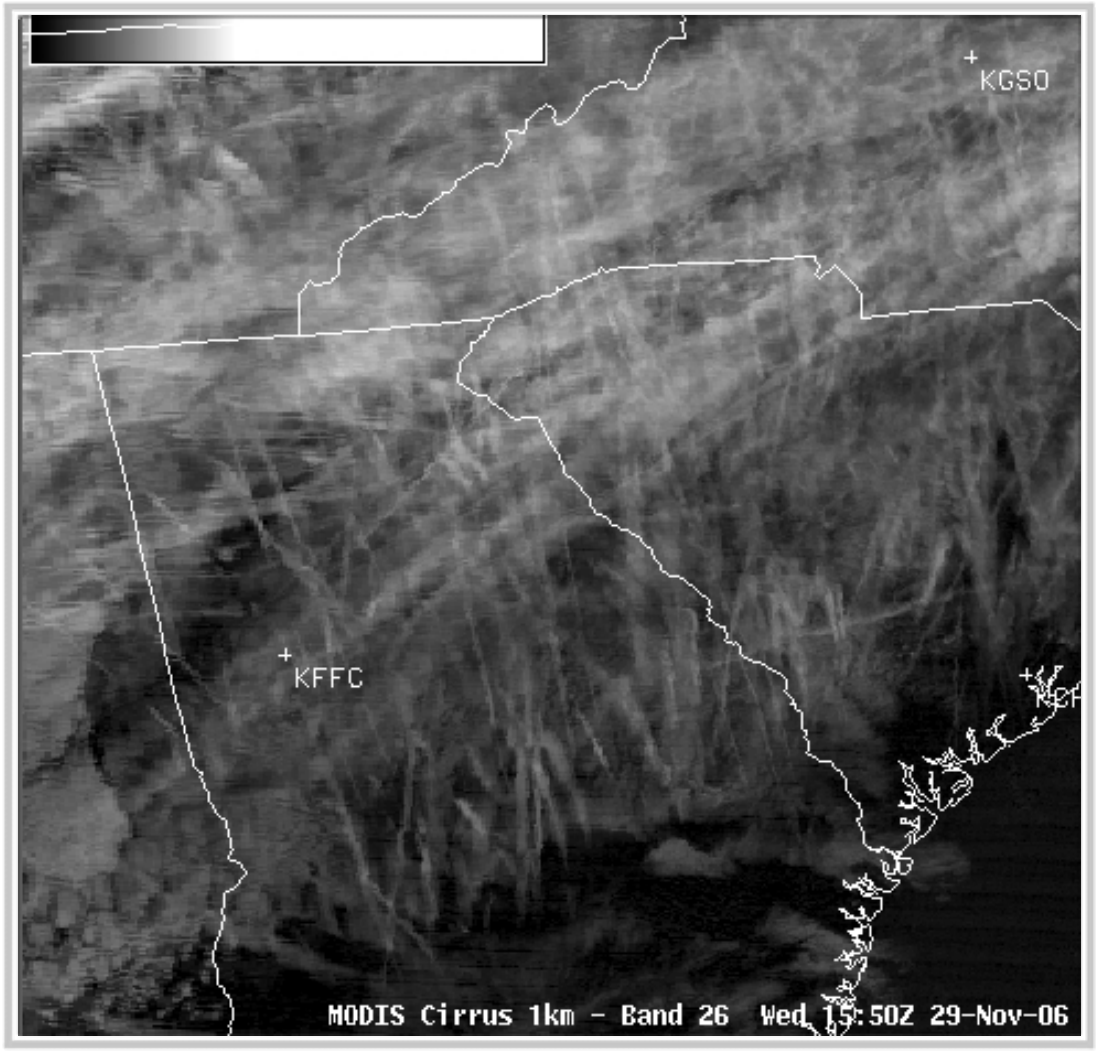
MODIS Imagery in AWIPS

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?

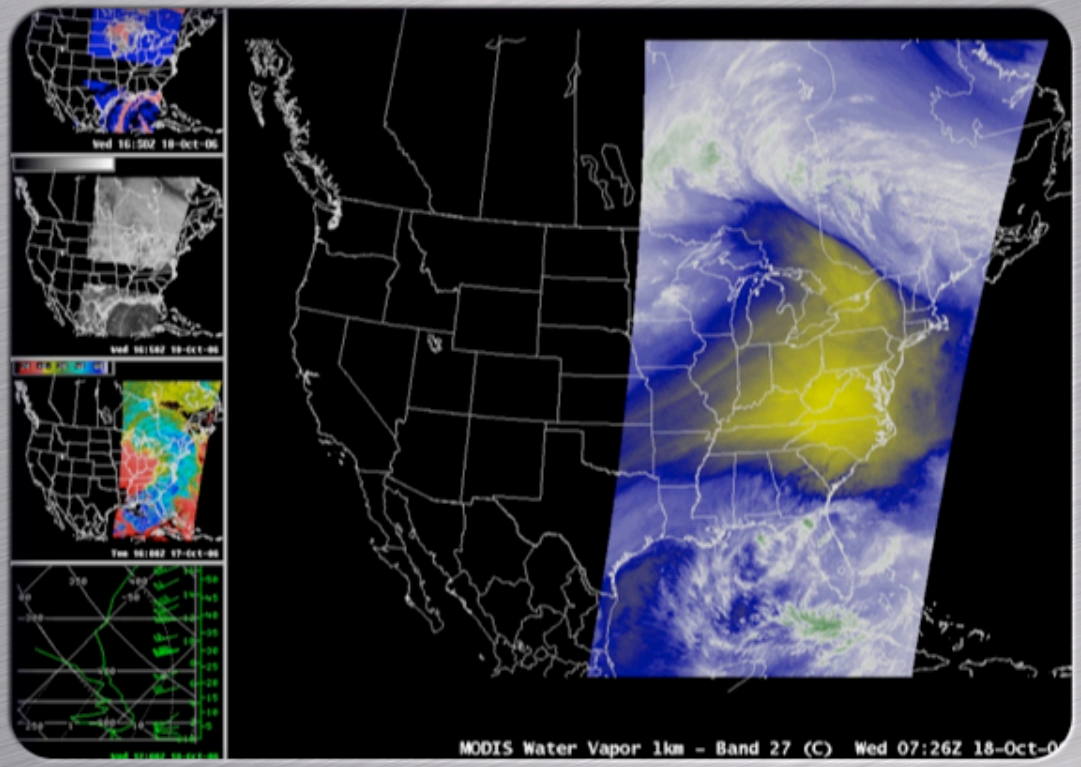
MODIS data to the NWS

- 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)

MODIS Products in AWIPS



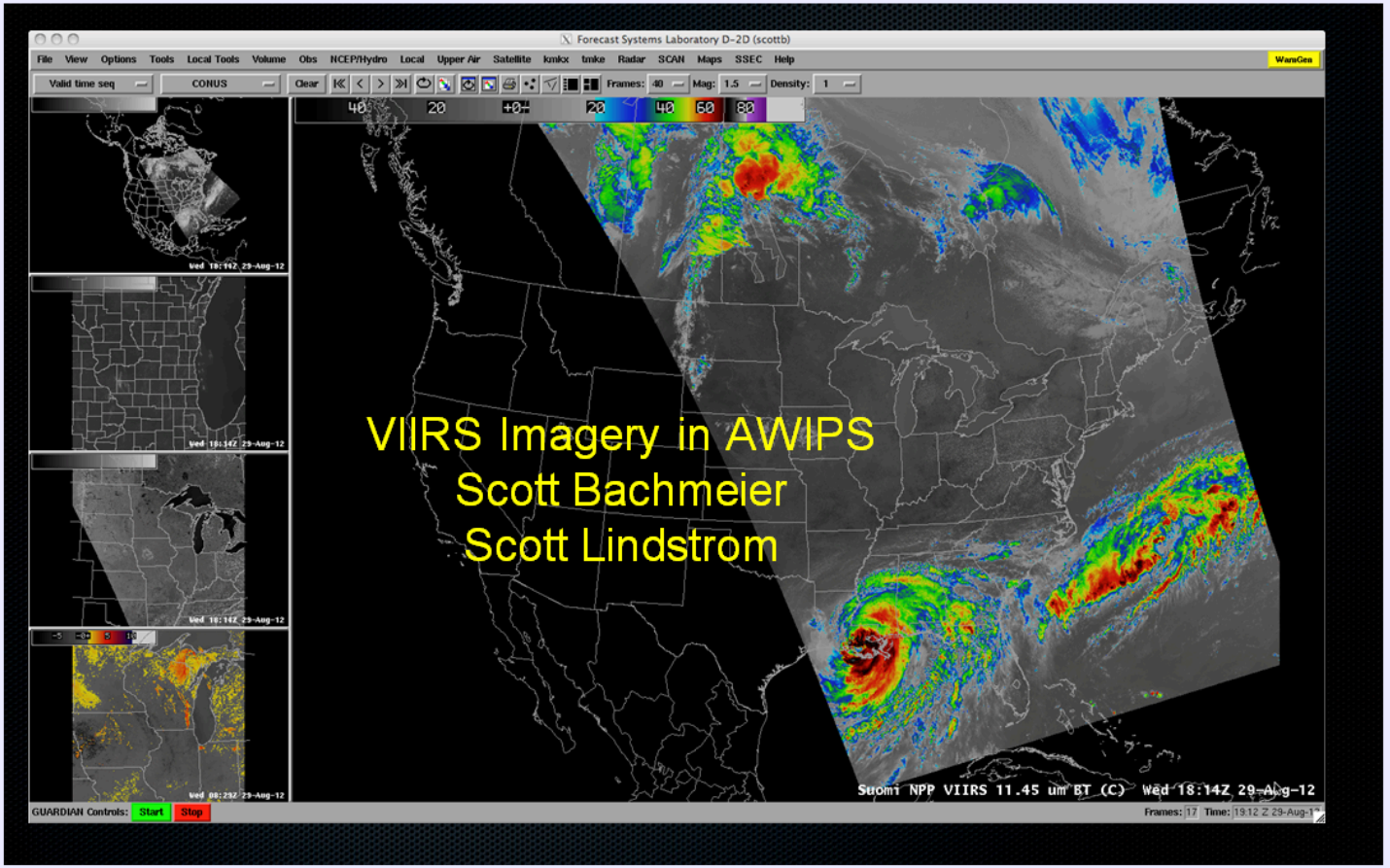
National Weather Service • Integrated Sensor Training Professional Development Series
Virtual Institute for Satellite Integration Training

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

VISIT

VIIRS Satellite Imagery in AWIPS

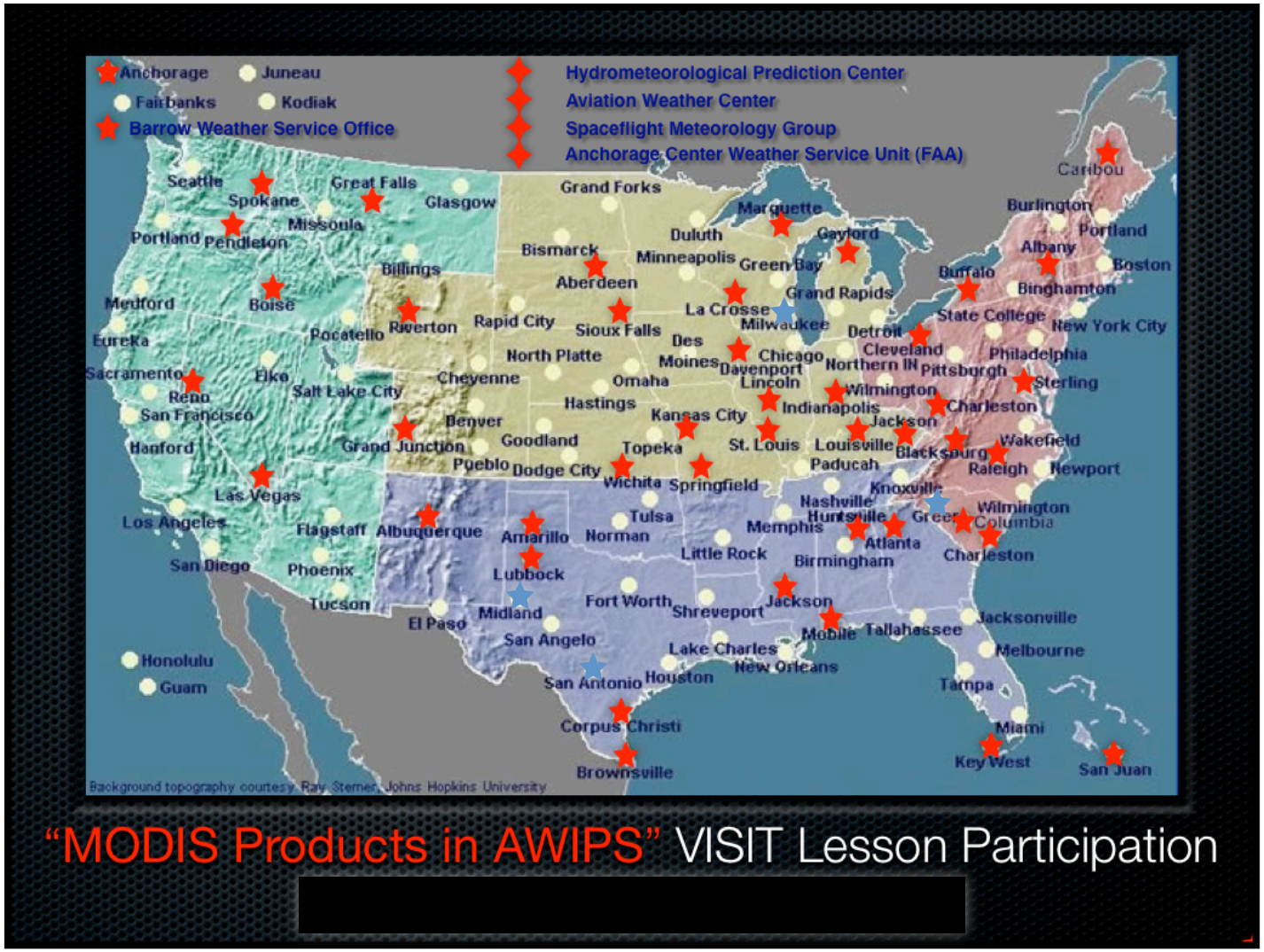
Scott Bachmeier and Scott Lindstrom



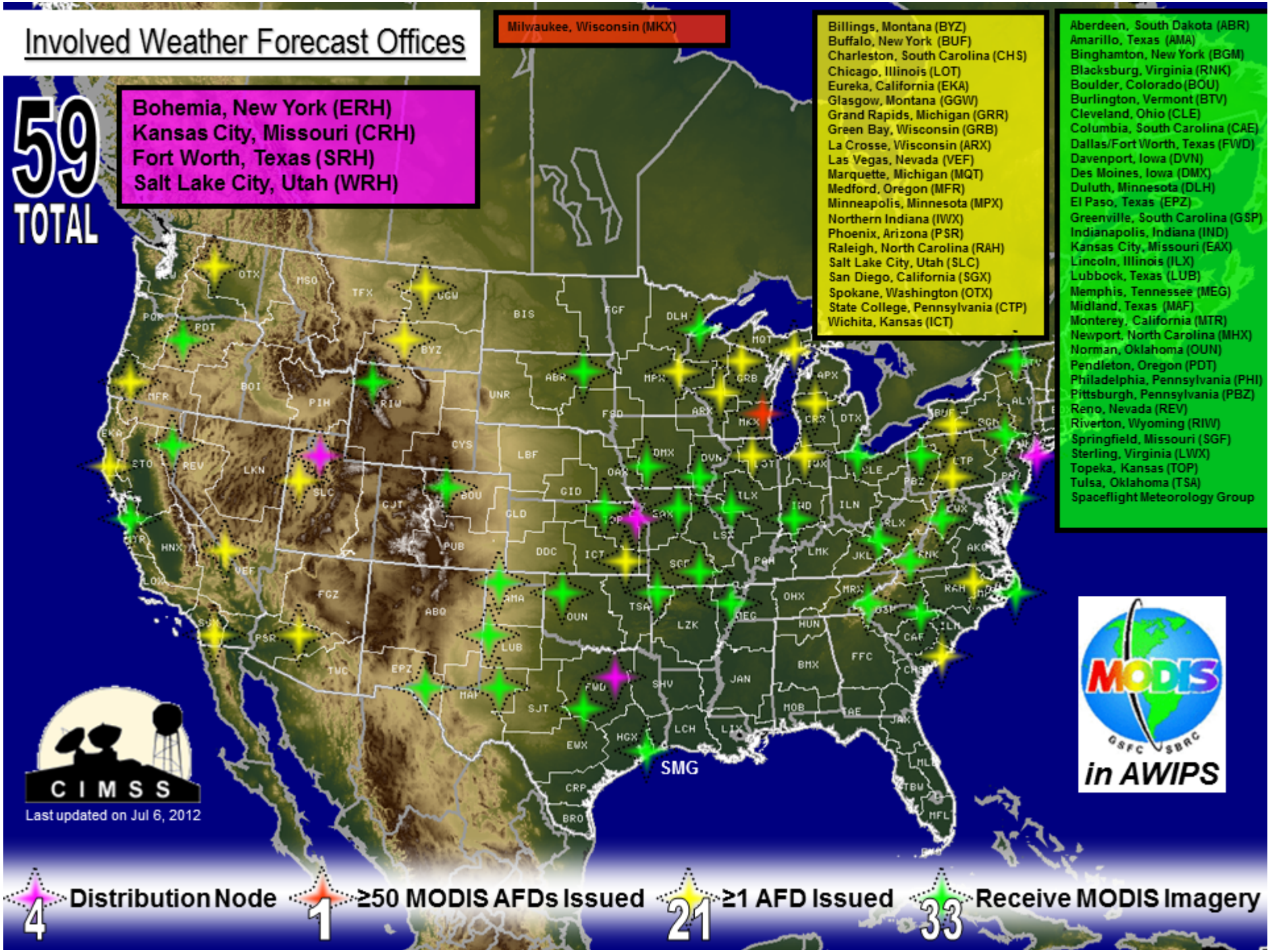
Introduction

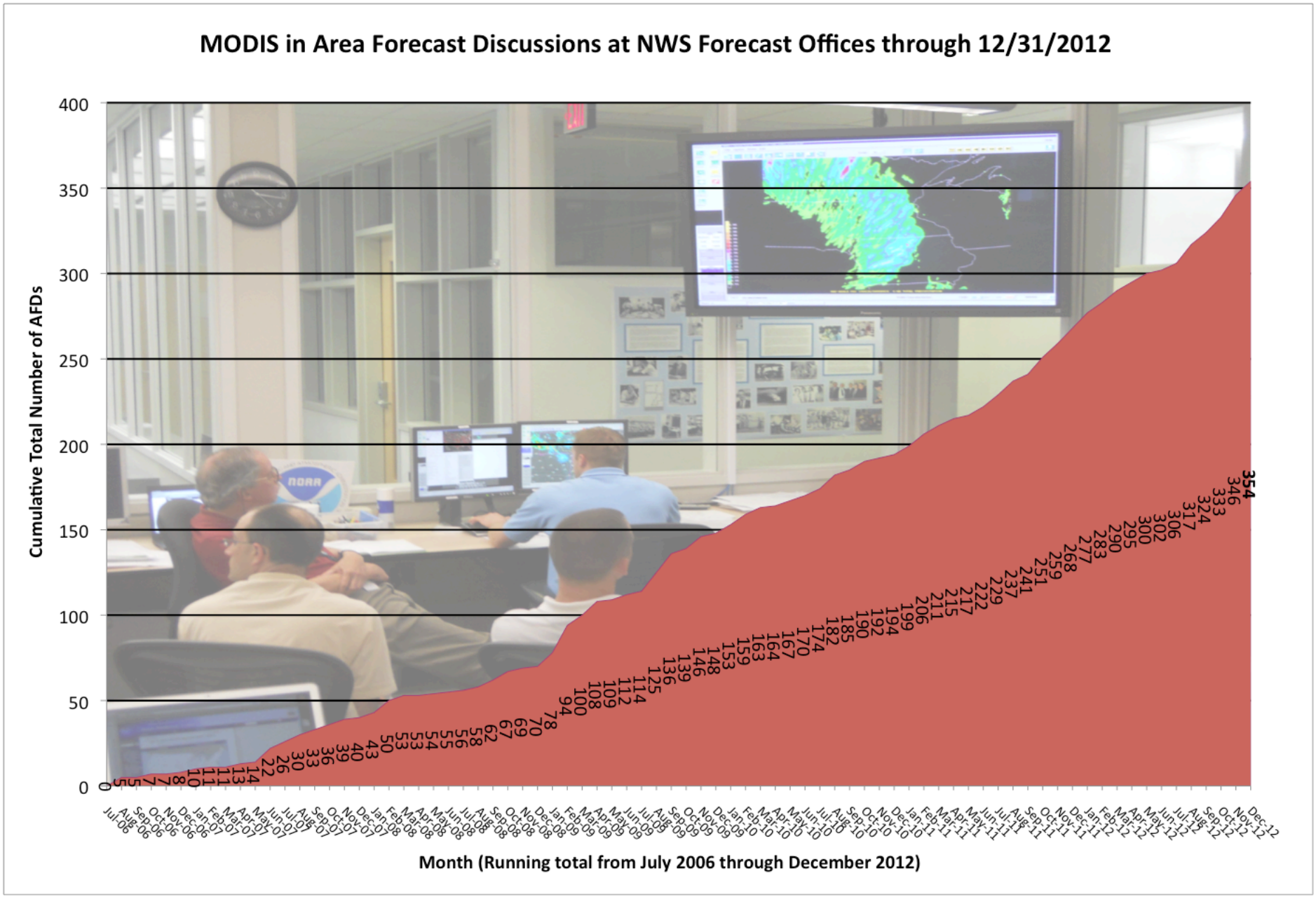
This basic-level VISIT teletraining lesson will describe the Visible Infrared Imaging Radiometer Suite (VIIRS) data from the Suomi/NPP (National Polar-orbiting Partnership) satellites that have recently been made available to the NWS Regional AWIPS servers (WFOs may add VIIRS imagery to their local AWIPS 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



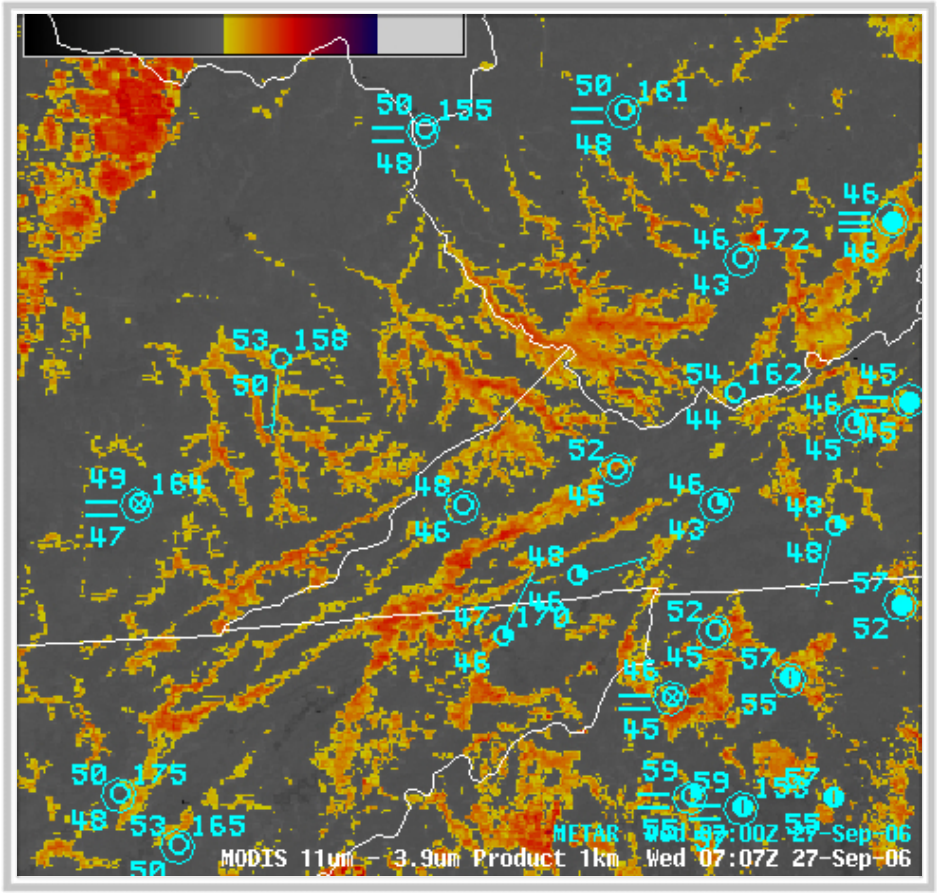
53 NWS forecast offices participating so far


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

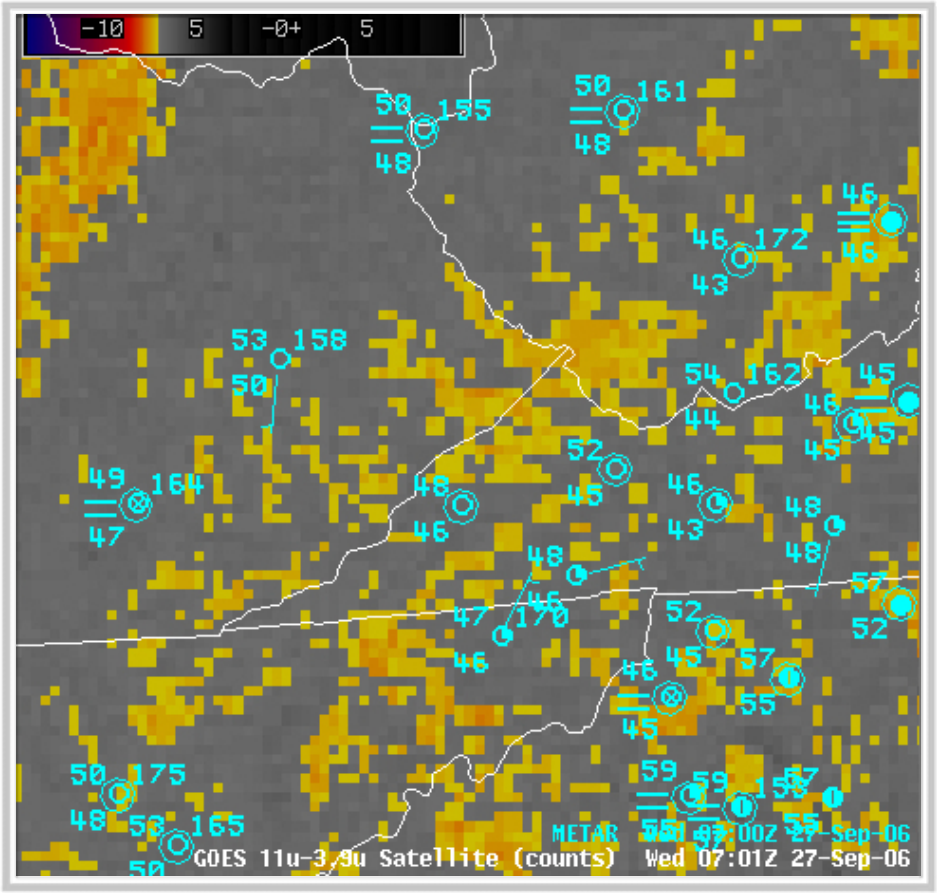

MODIS in Area Forecast Discussions at NWS Forecast Offices through 12/31/2012
Cumulative Total Number of AFDs
0
50
100
150
200
250
300
350
400
0 5 5 5 7 7 7 8 10 10 11 11 11 13 14 22 26 30 33 36 39 40 43 50 53 53 54 55 56 58 62 67 69 70 78 94 100 108 109 109 112 114 125 136 139 146 148 153 159 163 164 167 170 174 182 185 190 192 194 199 206 211 215 217 222 229 237 241 251 259 268 277 283 290 295 300 302 306 317 324 333 346 354
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

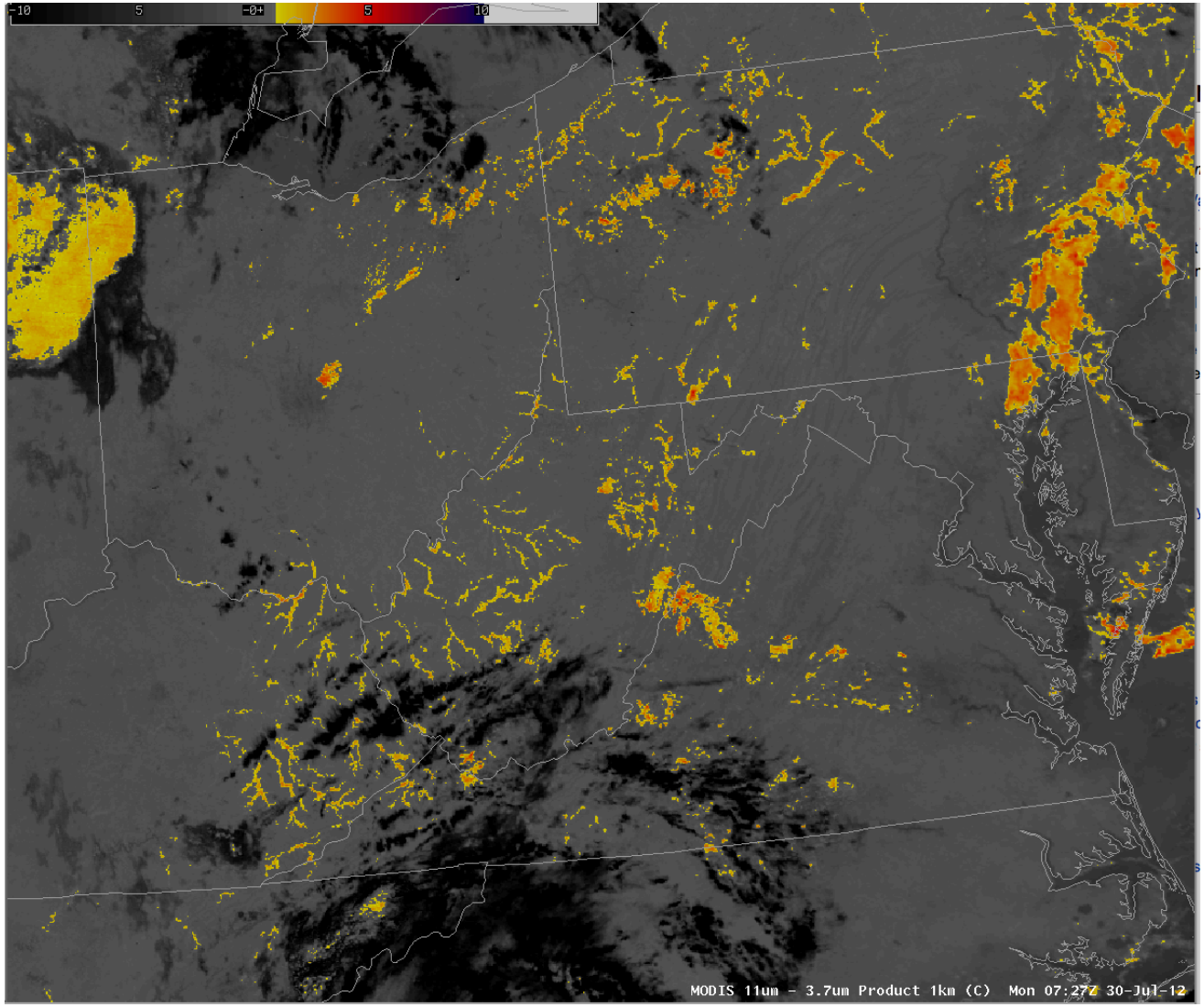
AREA FORECAST DISCUSSION
NATIONAL WEATHER SERVICE STATE COLLEGE PA
601 AM EDT TUE AUG 20 2013

.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
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Current Conditions
Observations
Radar
Satellite
Observed Precip

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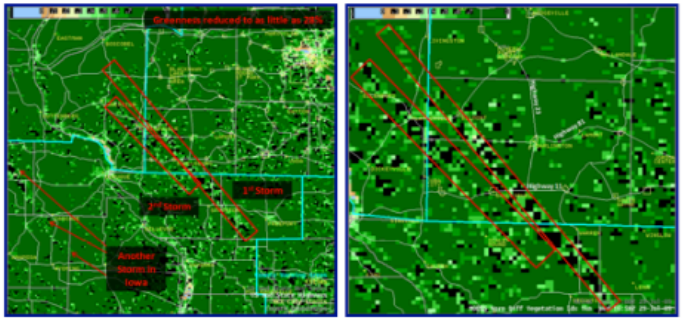
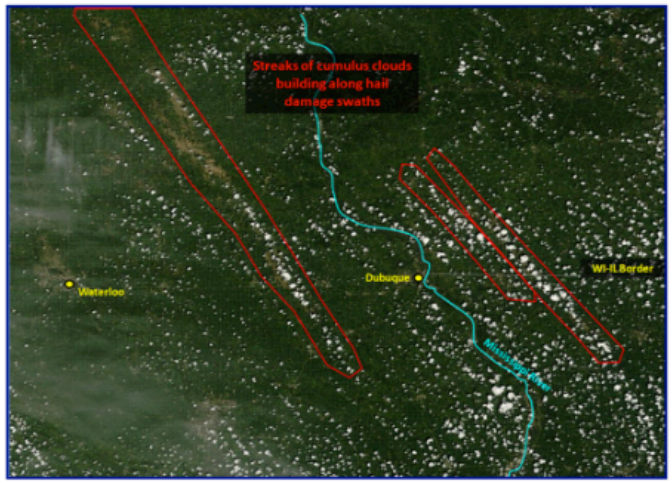
Hail Scars Visible On Satellite Imagery

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:

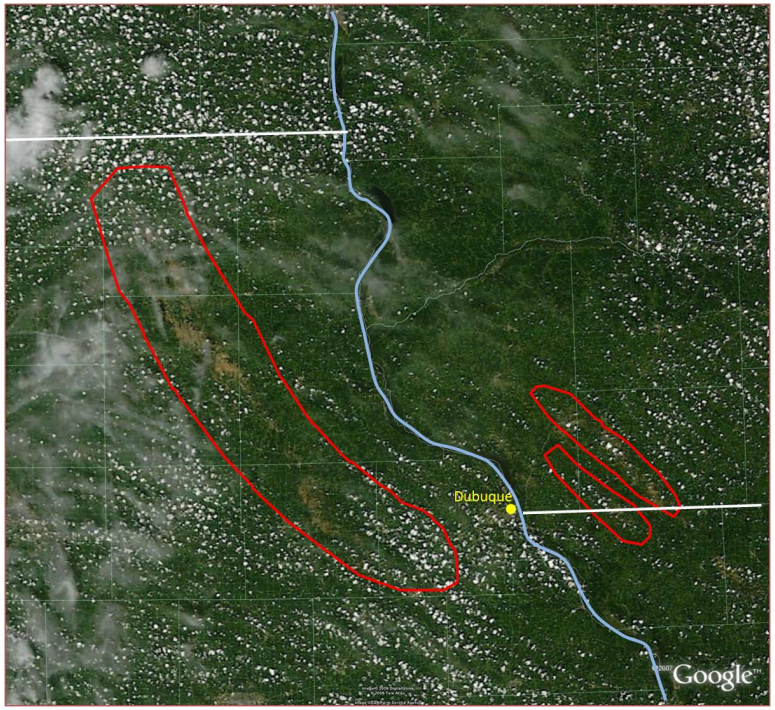


A minimum of about 28% greenness is evident just south-southeast of Belmont, which is not surprising given that is where some of the worst crop damage was observed. Corn stalks were completely stripped and sheared off to a height of less than 2 feet. These damaged areas of vegetation now absorb more 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



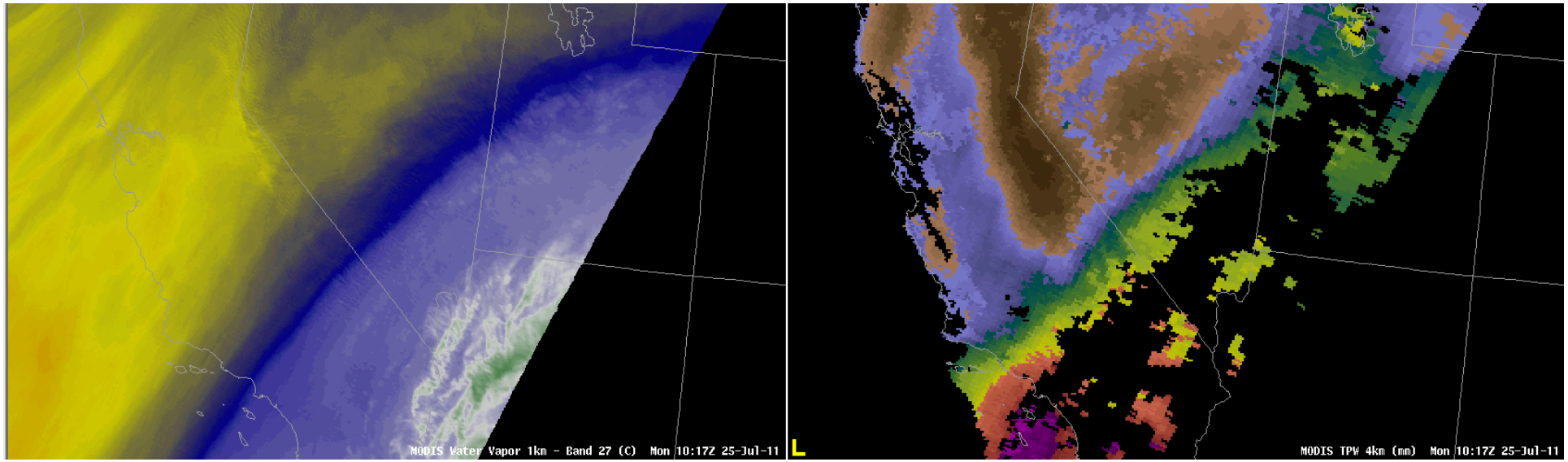
NASA

SSEC

Support for Fire Weather Forecasts

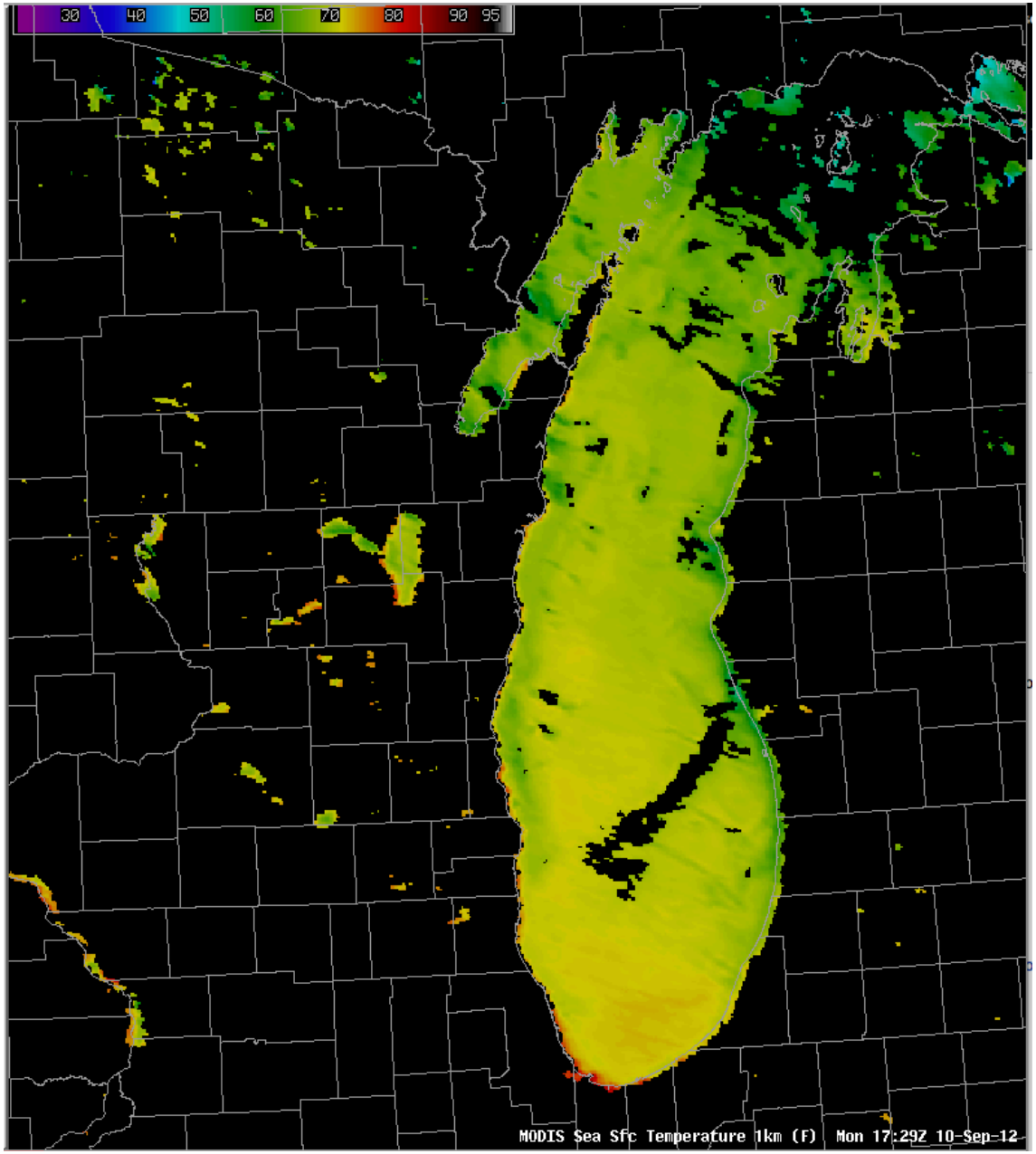
AREA FORECAST DISCUSSION
NATIONAL WEATHER SERVICE SALT LAKE CITY UT
1024 AM MDT MON JUL 25 2011

.FIRE WEATHER...MODIS WATER VAPOR IMAGERY INDICATES THAT PRECIPITABLE WATER VALUES APPROACHING ONE INCH HAVE PUSHED AS FAR NORTH AS THE SOUTHERN WASATCH FRONT THIS MORNING. THIS SURGE OF MOISTURE IS ALSO BRINGING EXTENSIVE CLOUD COVER TO CENTRAL AND NORTHERN UTAH THIS MORNING....WITH DEEP MOISTURE MOVING NORTH BELIEVE THAT RISK FOR DRY THUNDERSTORMS IS LIMITED PRIMARILY TO THE LEADING EDGE OF THE MOISTURE SURGE ACROSS NORTHERN UTAH...ALTHOUGH FEEL COVERAGE OF POTENTIAL DRY STORMS WOULD BE LIMITED



MODIS Imagery from UW SSEC Antenna 10:17 UTC 25 July 2011

MODIS SST supports Small Craft Advisory

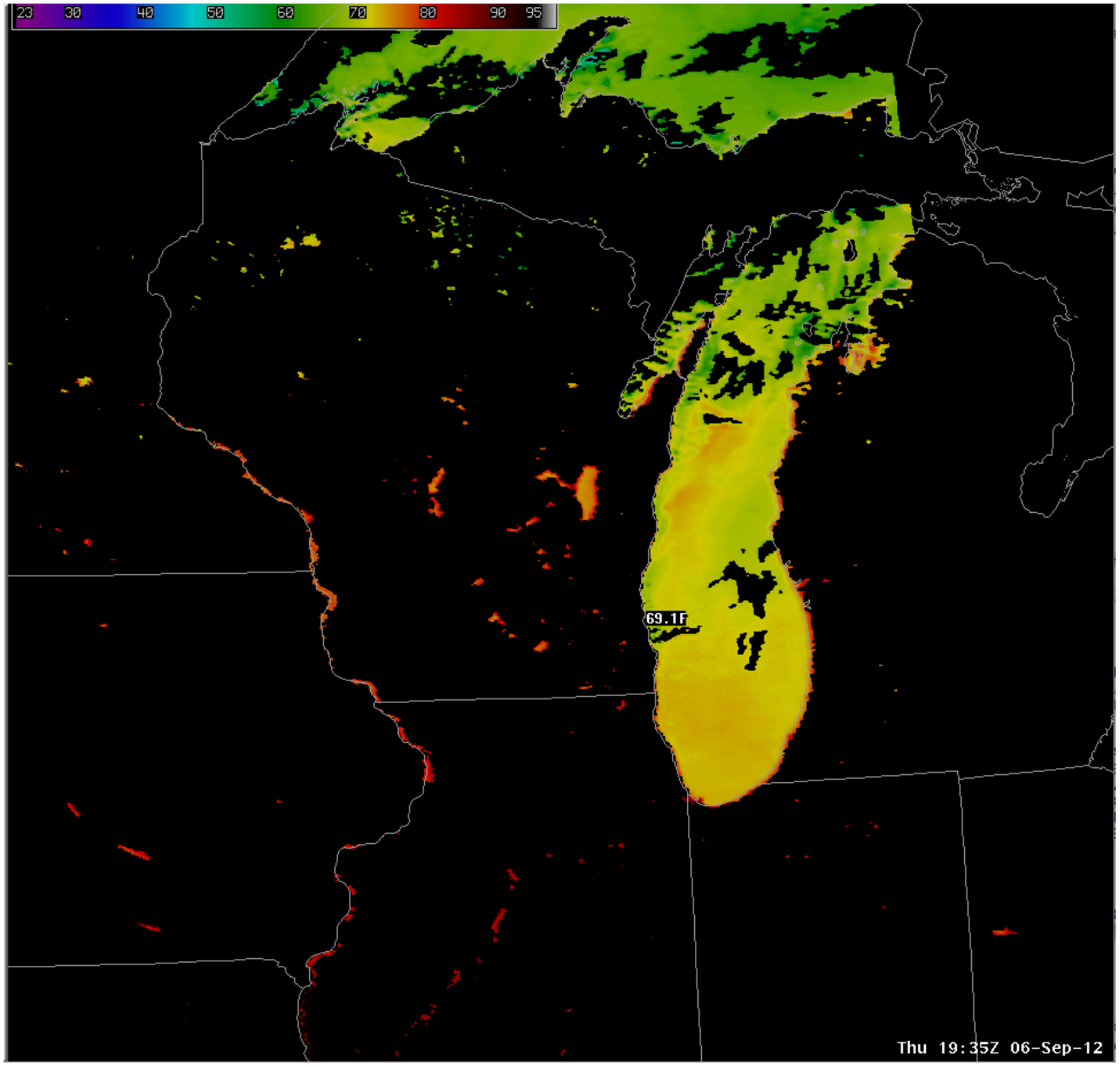


AREA FORECAST DISCUSSION
NATIONAL WEATHER SERVICE
MILWAUKEE/SULLIVAN WI
1056 PM CDT MON SEP 10 2012

.MARINE...TIGHTENING PRESSURE GRADIENT AND LOW LEVEL MIXING ENCROACHING ON THE VERY LOW LEVELS TO RESULT IN GUSTY WINDS PERSISTING THROUGH THE NIGHT ACROSS NORTHERN MARINE ZONES. OCCASIONAL GUSTS TO 25 KNOTS EXPECTED AT THE SHORE...MORE FREQUENT AWAY FROM THE SHORE DUE TO THE LOW LEVEL UNSTABLE AIR OVER THELAKE SURFACE. MODIS IMAGERY SHOWS THE LAKE TEMP IN THE NEAR SHORE WATERS AROUND 20C.

HENCE PUSHED UP START TIME OF SMALL CRAFT ADVISORY ACROSS NORTHERNTWO ZONES TO PRESENT TIME...AND ALSO EXPANDED ADVISORY TO INCLUDE WIND POINT TO WINTHROP HARBOR ZONE WHICH BEGINS TUESDAY MORNING.

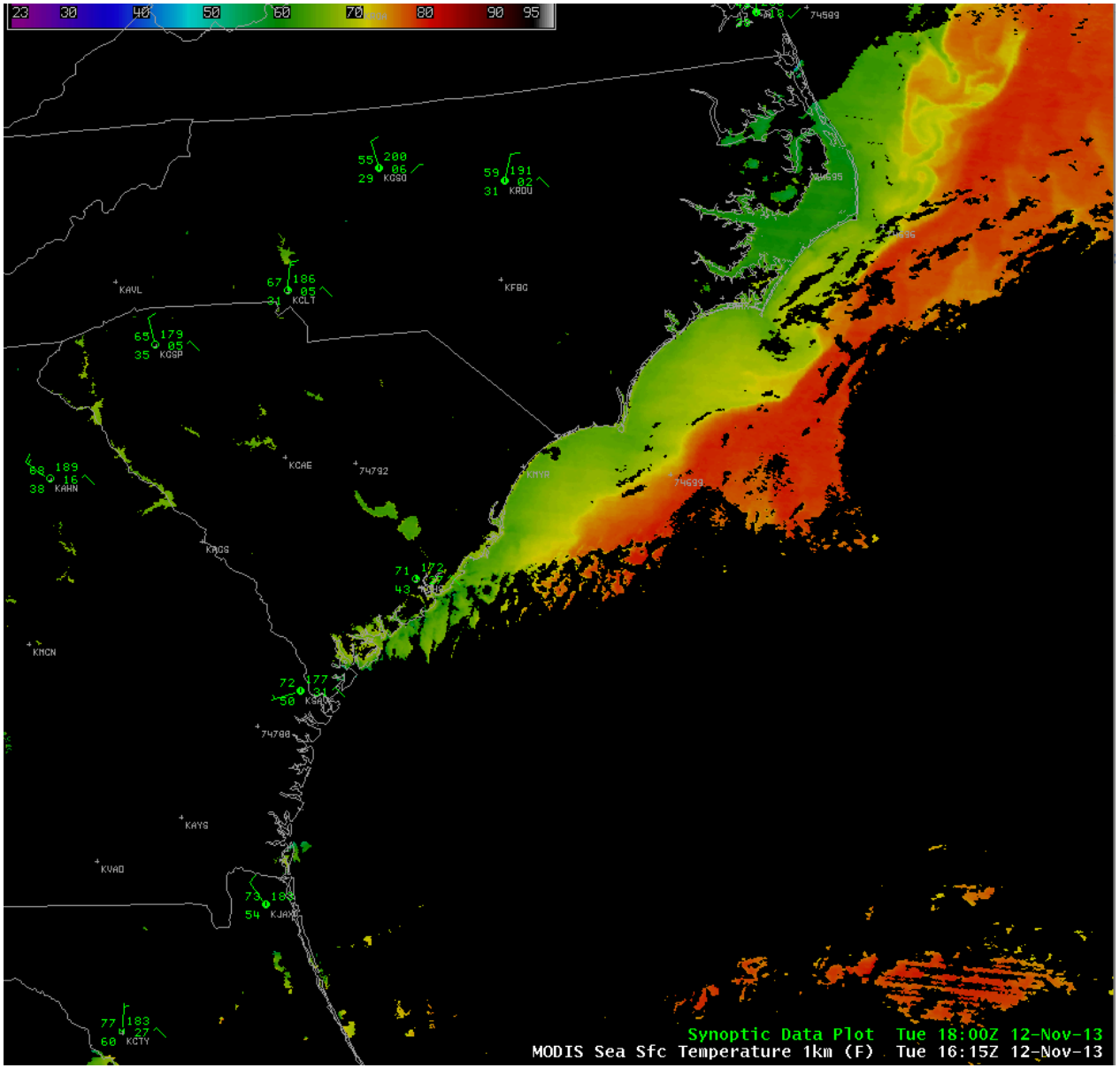
MODIS SST Supports Waterspout Forecasts



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.

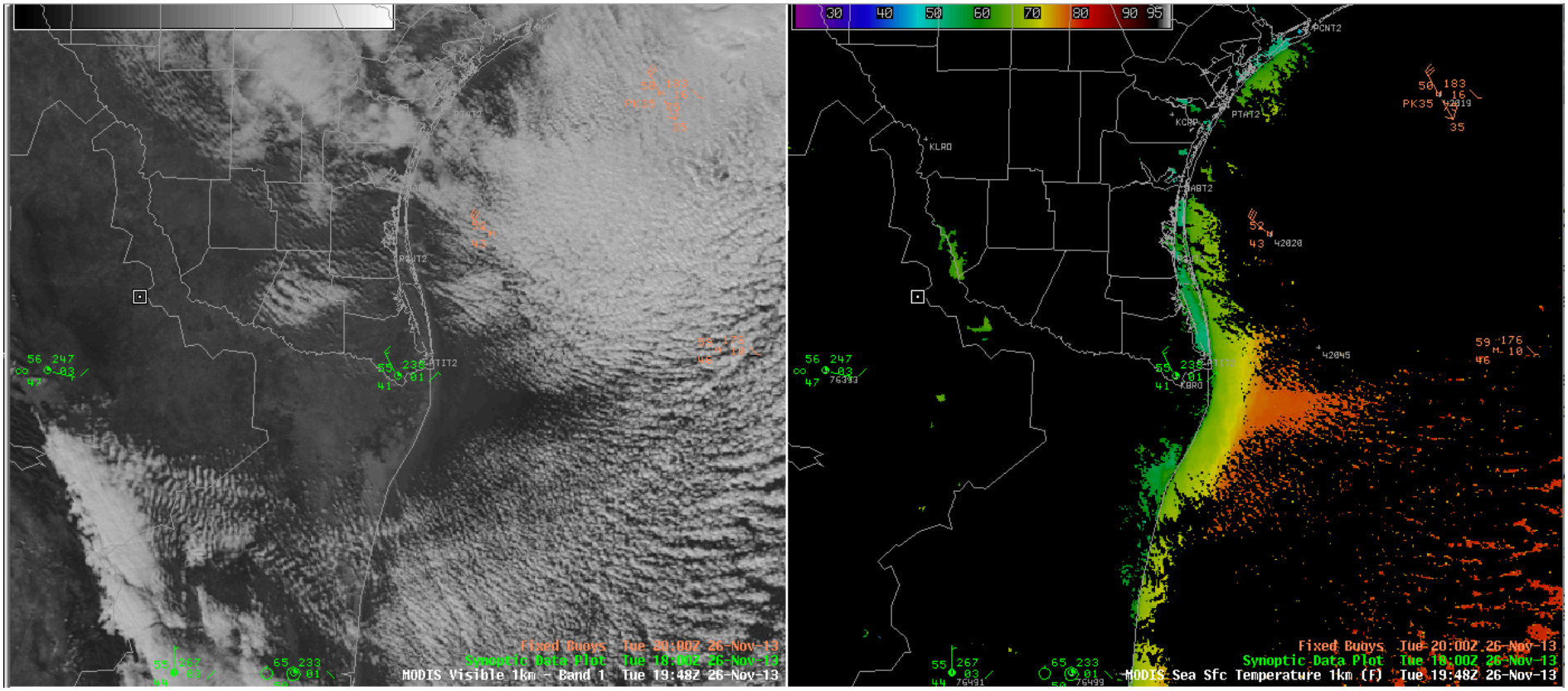
Marine Gale Force Wind Forecasts



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.***

Fog Formation Forecast



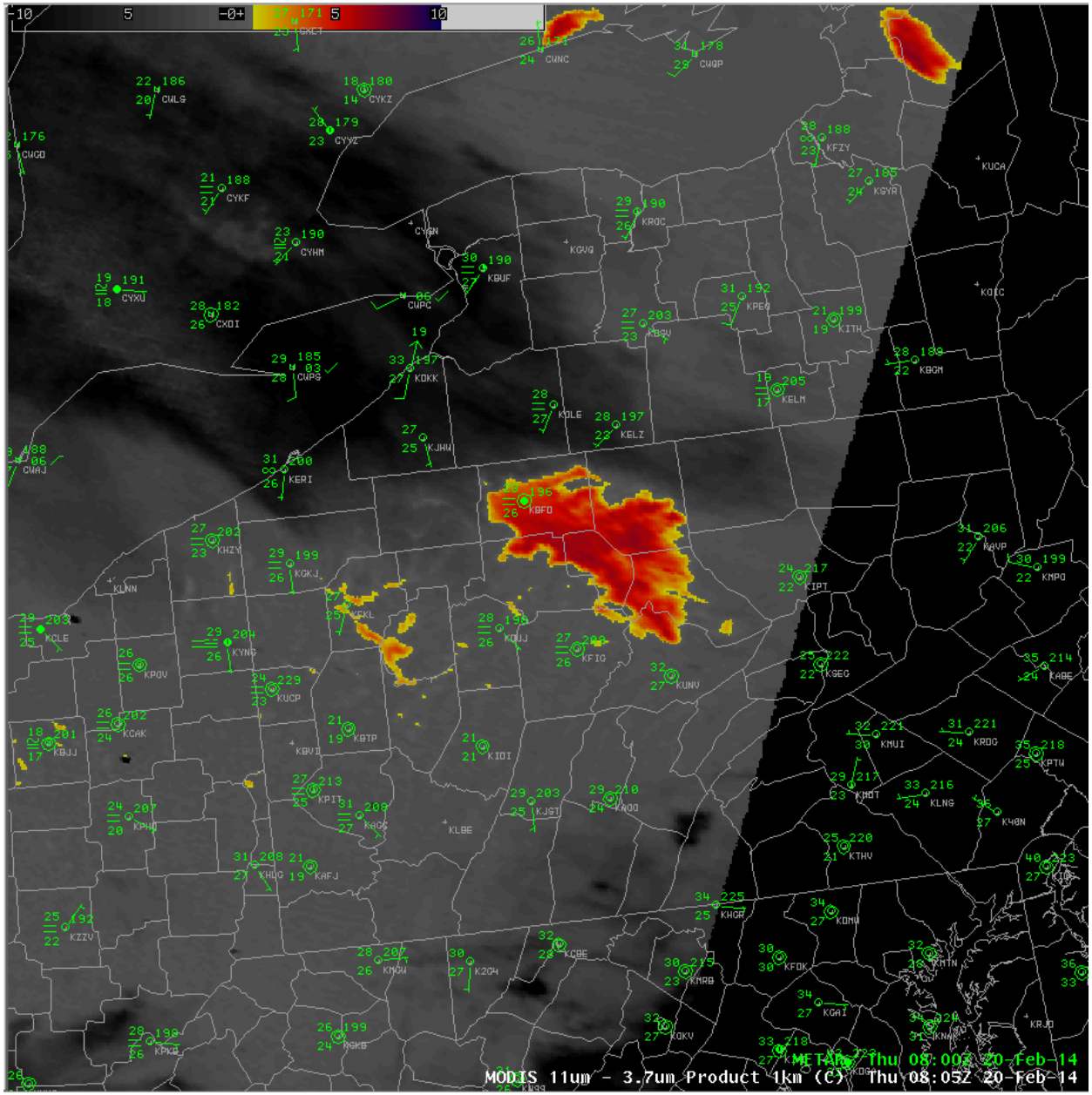
26 November 2013 Brownsville Texas

Fog Formation Forecast

AREA FORECAST DISCUSSION
NATIONAL WEATHER SERVICE BROWNSVILLE TX
238 PM CST TUE NOV 26 2013

DATA FROM A RECENT MODIS POLAR ORBITING SATELLITE PASS AND NEARSHORE TEMPERATURE OBSERVATIONS SHOW THE FRONT AND PERSISTENT NORTH WINDS HAVE DRASTICALLY REDUCED THE TEMPERATURE OF THE NEARSHORE GULF OF MEXICO DUE TO UPWELLING. THE SATELLITE SUGGESTS THE MORE DRASTIC DEPARTURE IS WITHIN 5 TO 15 MILES OF THE COASTLINE...WHICH IS FAIRLY TYPICAL. ***WITH EASTERLY WINDS PROJECTED TO FLOW OVER THE GRADIENT OF RELATIVELY WARM...76F ACCORDING TO BUOY 20...OFFSHORE WATER...TO THE RELATIVELY COLD NEARSHORE WATER...A SETUP FAVORABLE FOR SEA ADVECTION FOG EXISTS. ADDED FOG TO THE OVERNIGHT GROUP THURSDAY NIGHT INTO FRIDAY***...BUT IN LOCALIZED AREAS THE TIME OF DAY MAY NOT MAKE A SIGNIFICANT DIFFERENCE REGARDING FOG FORMATION WITH PARTS OF SOUTH PADRE ISLAND AND THE NEARSHORE WATERS POSSIBLY EXPERIENCING FOG FOR AN EXTENDED PERIOD OF TIME.

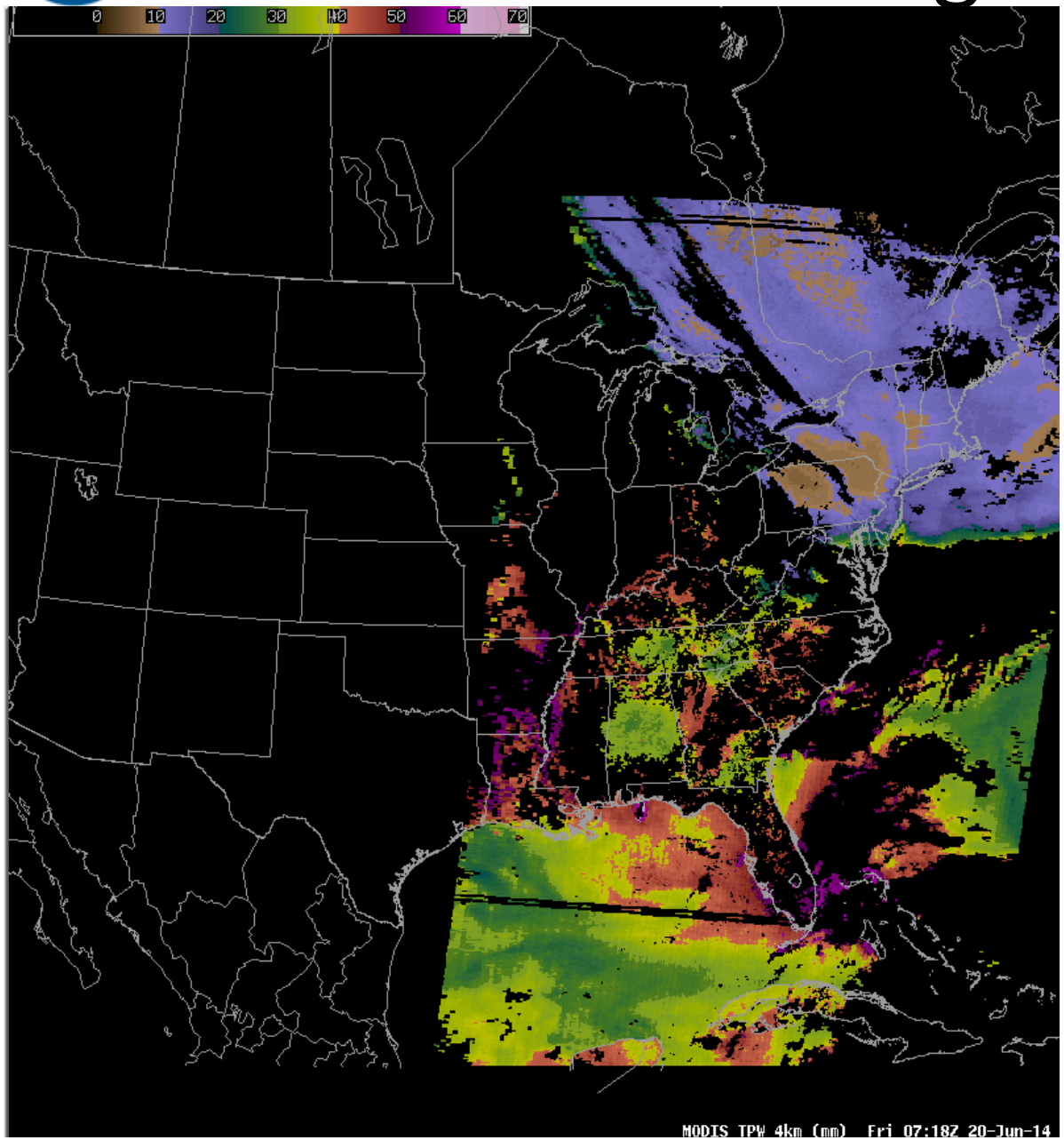
Location of Fog/Status



AREA FORECAST DISCUSSION
NATIONAL WEATHER SERVICE STATE COLLEGE PA
436 AM EST THU FEB 20 2014

.NEAR TERM /UNTIL 6 PM THIS EVENING/...
EARLY AM MODIS 11-3.7UM IMAGERY SHOWING EXTENSIVE VALLEY FOG AND STRATUS ACROSS NORTHWEST PA...THE RESULT OF CLEAR SKIES AND CALM WIND UNDER HIGH PRES SYSTEM. LAMP AND RAP DATA BOTH INDICATE AREAS OF FOG WILL LIFT BTWN 12Z-14Z. FOCUS WILL THEN BE ON BAND OF SHRA LIFTING NORTHEAST FROM THE OHIO VALLEY ALONG APPROACHING WARM FRONT. REGIONAL RADAR MOSAIC ALREADY SHOWING THIS DEVELOPING BAND OF RAIN ACROSS ILLINOIS/INDIANA...WHERE NOSE OF LL JET INTERSECTS RETREATING 8H BAROCLINIC ZONE. ALL NEAR TERM MDL DATA TIMES THIS FEATURE THRU CENTRAL PA BTWN 17Z-23Z. ENSEMBLE MFLUX VALUES AND QPF PROBS SUPPORT NEAR 100 PCT CHC OF RAIN ACROSS THE NWMTNS...WITH PROGRESSIVELY LOWER CHC OF SHOWERS FURTHER SE.

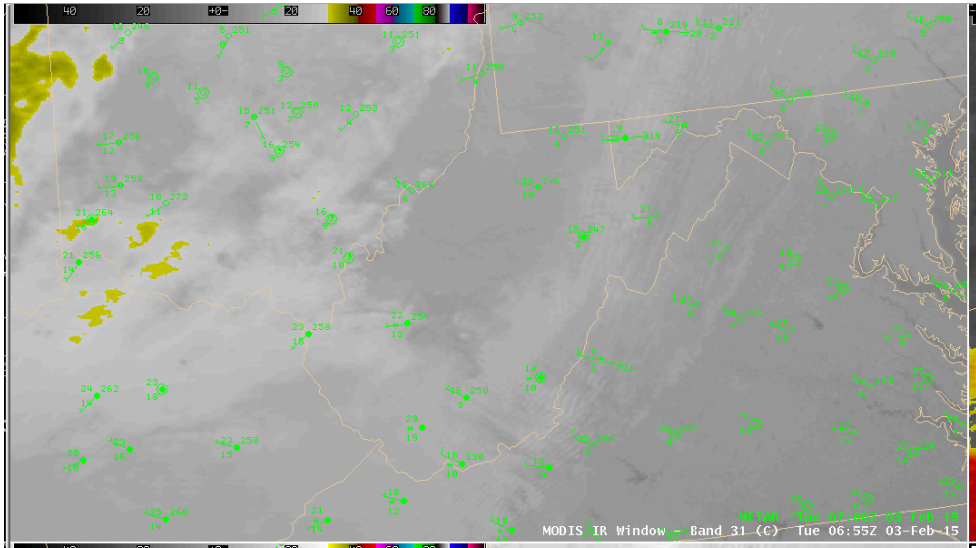
Forecasting POPs

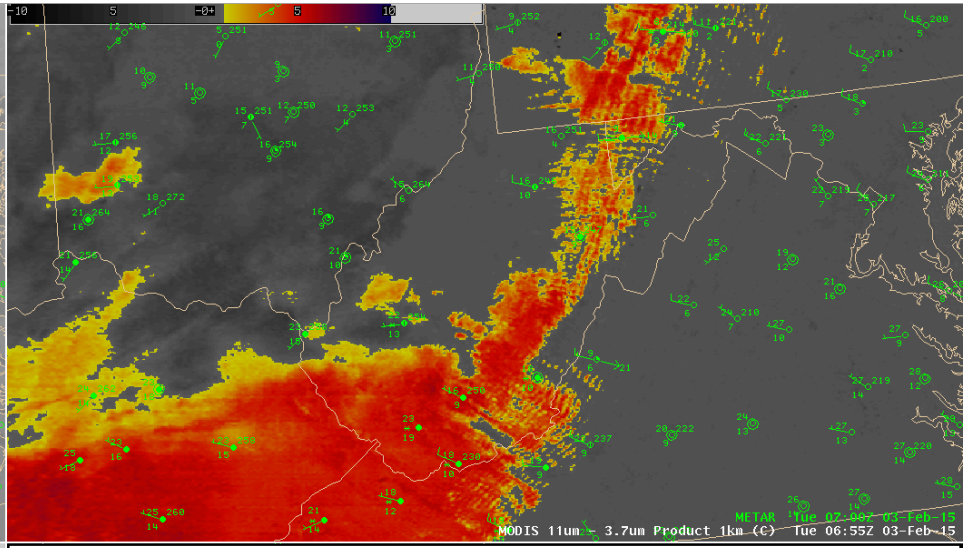


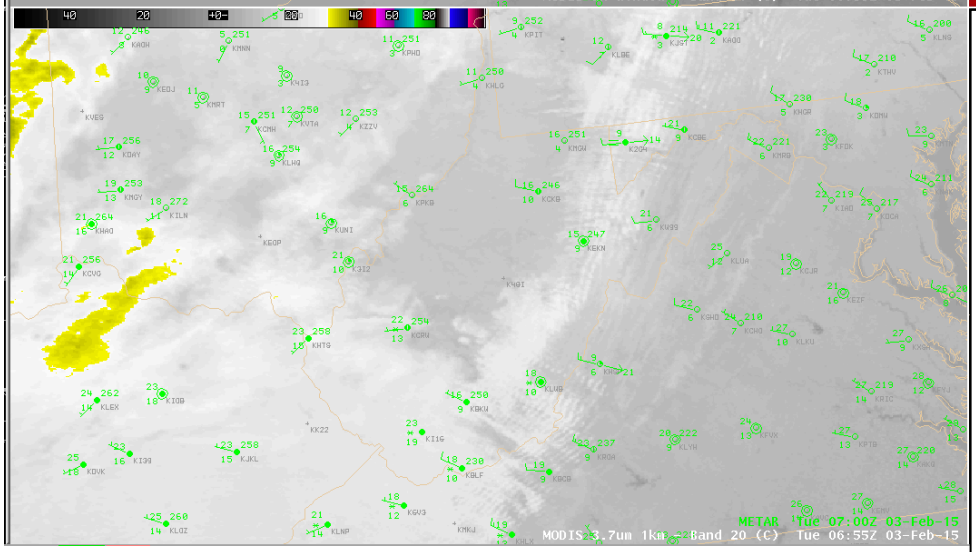
AREA FORECAST DISCUSSION
NATIONAL WEATHER SERVICE
BROWNSVILLE TX
359 AM CDT FRI JUN 20 2014

FOR THE FORECAST BASED IT AROUND A SCENARIO WHERE THE GULF TROUGHINESS IS NOT QUITE AS PRONOUNCED...BUT THE DEEP 30 KNOT EASTERLY WINDS IN THE 850/700MB LAYER DO NOT GET QUITE AS CARRIED AWAY EITHER. THE WAVES IN QUESTION ARE CLEARLY PRETTY PRONOUNCED ON SATELLITE IMAGERY BUT NOT ASSOCIATED WITH MUCH PRECIP AT THE MOMENT AND ***AMSU/SSMI AND MODIS TOTAL PRECIPITABLE WATER IMAGERY APPEAR TO SUGGEST THERE IS NOT AS MUCH AVAILABLE MOISTURE AS THE ECMWF INITIALIZED.*** EVEN IF THE SYNOPTIC ECMWF SOLUTION WERE TO VERIFY THE 40 AND 50 PCT POPS PRESENTED BY ECX MOS APPEAR FAR TOO HIGH AND THUNDER WOULD BE DIFFICULT/IMPOSSIBLE IN A ZONE WITH LAPSE RATES AS POOR AS SHOULD BE IN PLACE. SO PAINTED LOW GRADE POPS/SHOWERS STARTING IN THE MORNING ALONG THE COAST WORKING INLAND THROUGH THE DAY AND INTO THE MORE FAVORED SEABREEZE ZONES BY AFTERNOON WEDNESDAY AND THURSDAY AND HUGGED BACK TOWARDS A DRIER SOLUTION ON FRIDAY.

Identification of Stratus at Night





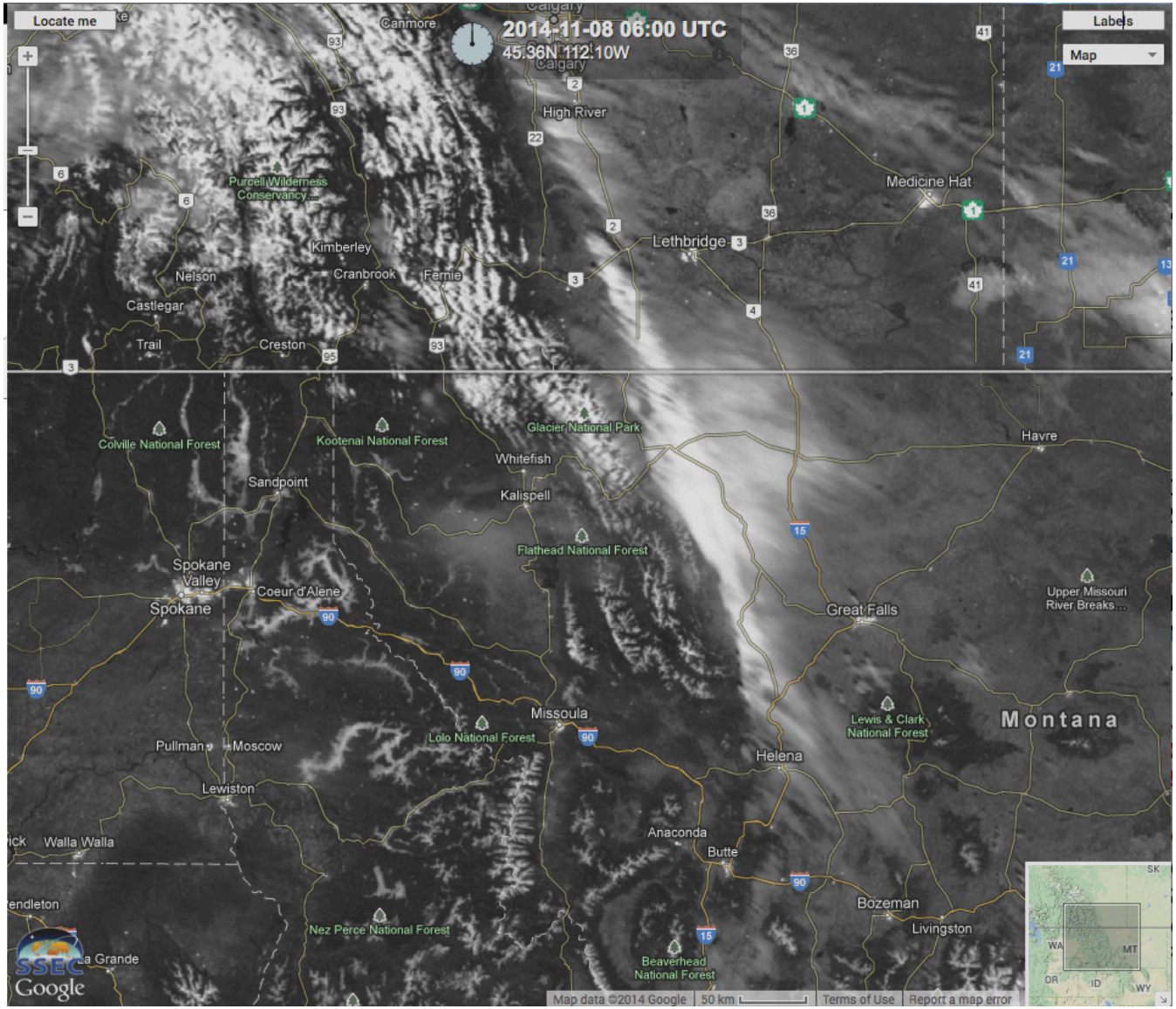


FXUS61 KRLX 030605
AFDRLX

AREA FORECAST DISCUSSION
NATIONAL WEATHER SERVICE CHARLESTON WV
105 AM EST TUE FEB 3 2015

.AVIATION /06Z TUESDAY THROUGH SATURDAY/...
LOW STRATO CU...EVIDENT IN MODIS SATELLITE IMAGES ...CONTINUING TO PRODUCE LIGHT SNOW SHOWERS OR FLURRIES ACROSS THE SOUTHERN HALF OF THE AREA. SOME CLEARING IS NOTED IN SATELLITE IMAGES AND SFC OBS ACROSS PORTIONS OF SOUTHEAST OHIO INCLUDING PKB. HOWEVER...ADDITIONAL CLOUDS ARE EXPECTED TO MOVE OVER THIS AREA FROM THE WEST. CODED MVFR CEILINGS UNDER LIGHT SNOW AT BKW...HTS...AND CRW. EXPECT SNOW SHOWERS TO END FROM WEST TO EAST THROUGH 09Z...PERHAPS PERSISTING OVER EKN AND BKW THROUGH 12Z. VERY LIGHT OR LITTLE ACCUMULATIONS EXPECTED WITH THESE SNOW SHOWERS.

Identification of Fog at Night

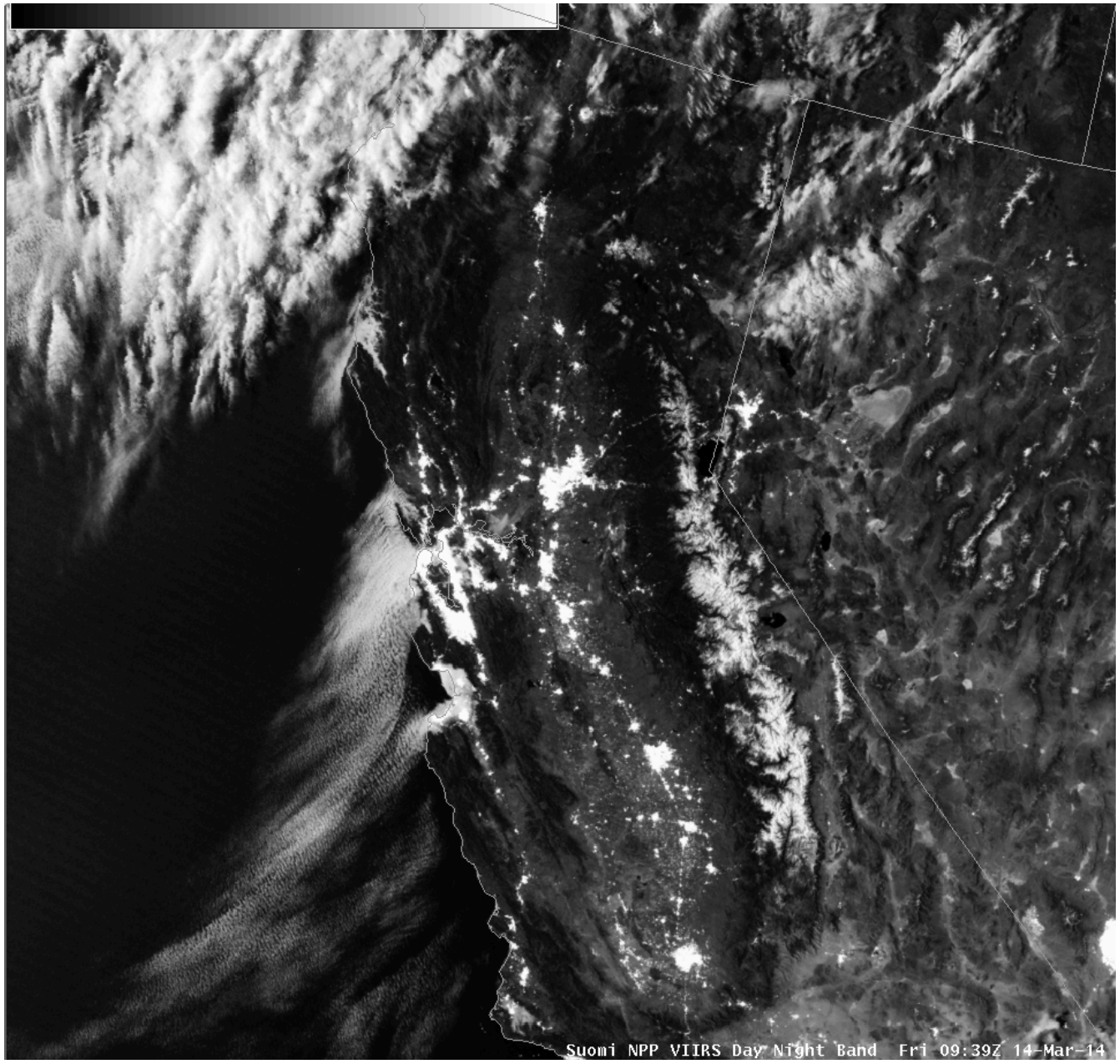


Area Forecast Discussion
National Weather Service
Missoula MT
334 AM MST SAT NOV 8 2014

…

.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.

Area Forecast Discussion
National Weather Service Milwaukee/Sullivan WI
949 AM CDT Thu Jun 1 2017

.MARINE...Light and variable winds over the nearshore waters will be turning onshore in the next 1-3 hours as lake breeze develops. Light pressure gradient due to nearby high pressure will result in wind speeds remaining mostly less than 10 knots. *Latest MODIS imagery shows Lake Michigan surface temperatures have warmed into the upper 40s to lower 50s in the near shore waters as well as to mid-lake. Average Lake Michigan surface water temperature running close to the long-term average for June 1st.*

Thunderstorms

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

How Important Is Spatial Resolution?

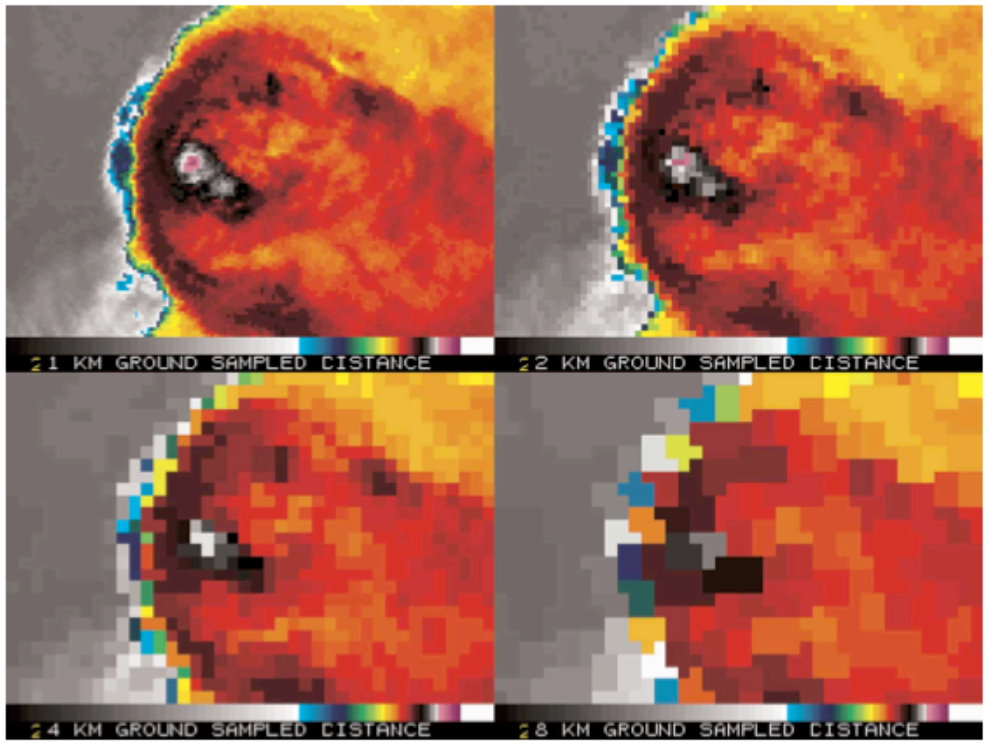
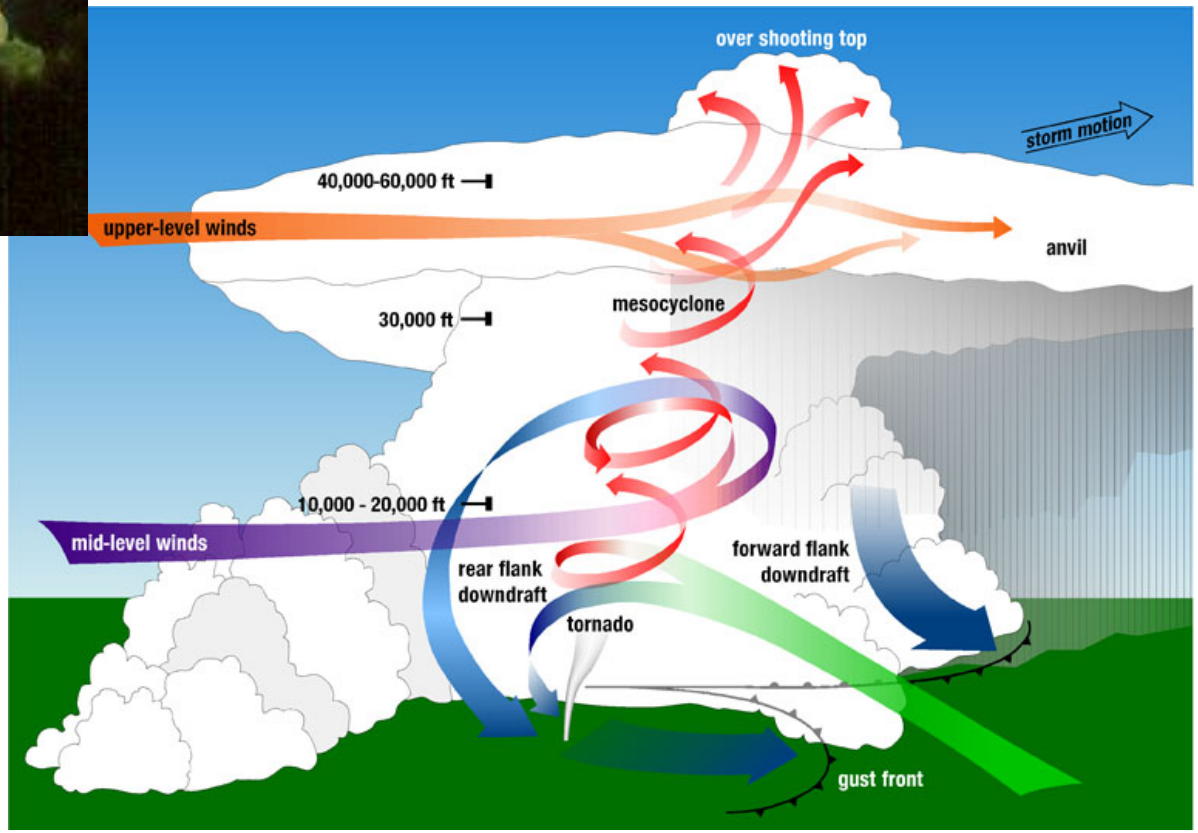


FIG. 3. Zoomed-in image of an enhanced-V feature located over northeast OK observed from enhanced LEO satellite imagery at 2218 UTC 6 May 2003 for 1-, 2-, 4-, and 8-km ground-sampled distances. The purple and white colors in the location of the updraft and overshooting top represent colder BTs, while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

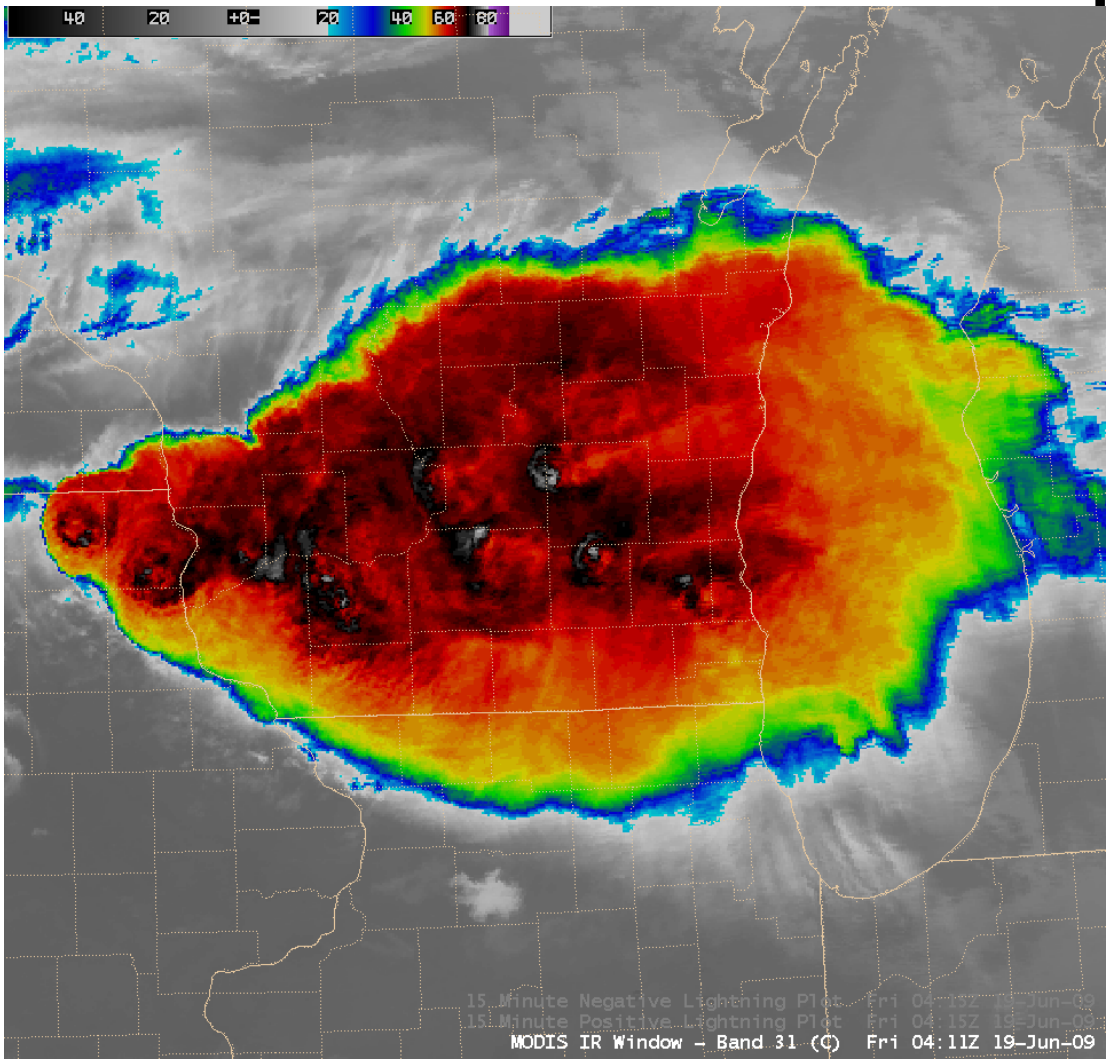
A Quantitative Analysis of the Enhanced-V Feature in Relation to Severe Weather Jason C. Brunner, Steven A. Ackerman, A. Scott Bachmeier, and Robert M. RabinWeather and Forecasting Volume 22, Issue 4 (August 2007) pp. 853–872

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

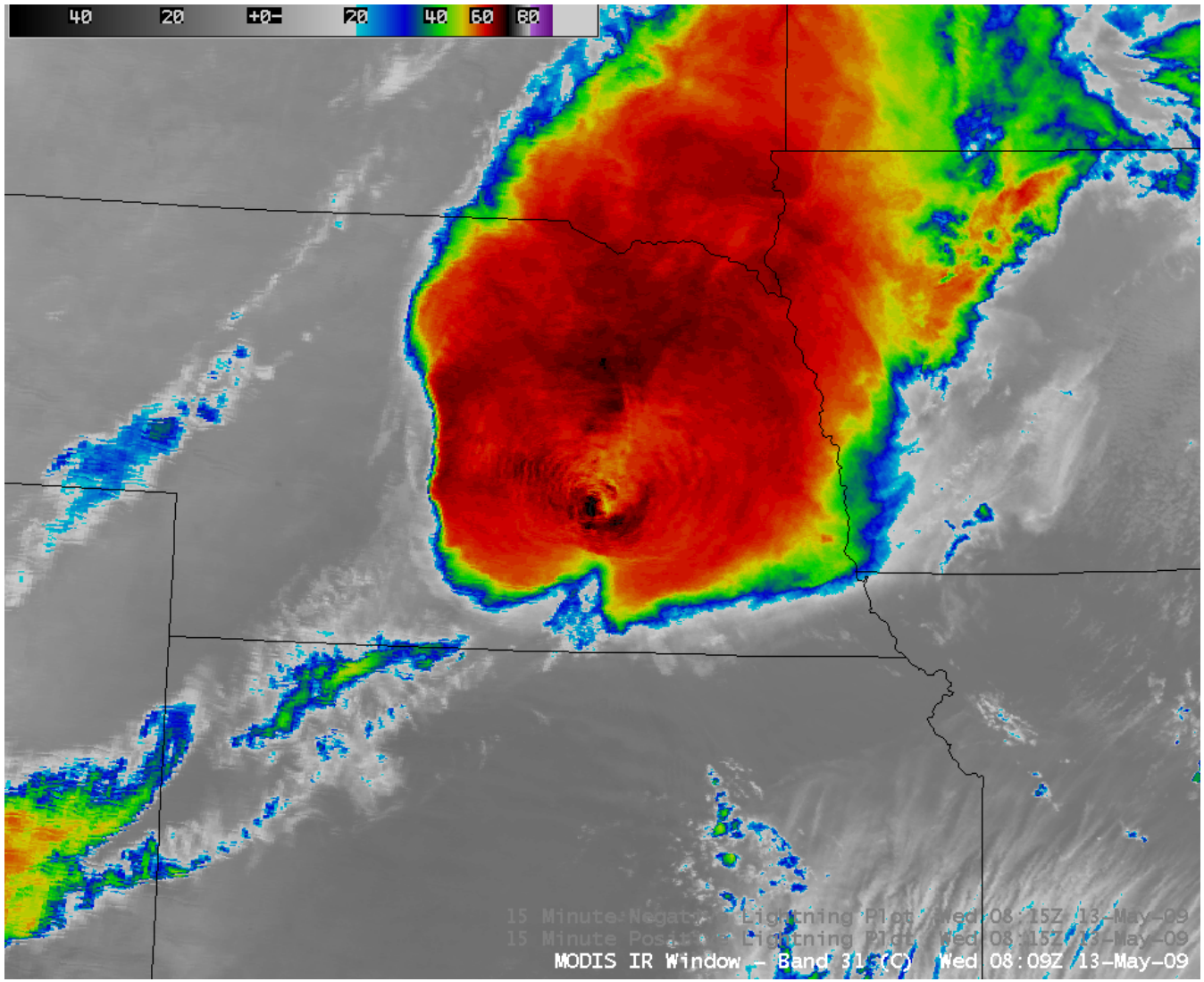


Including Lightning Detection

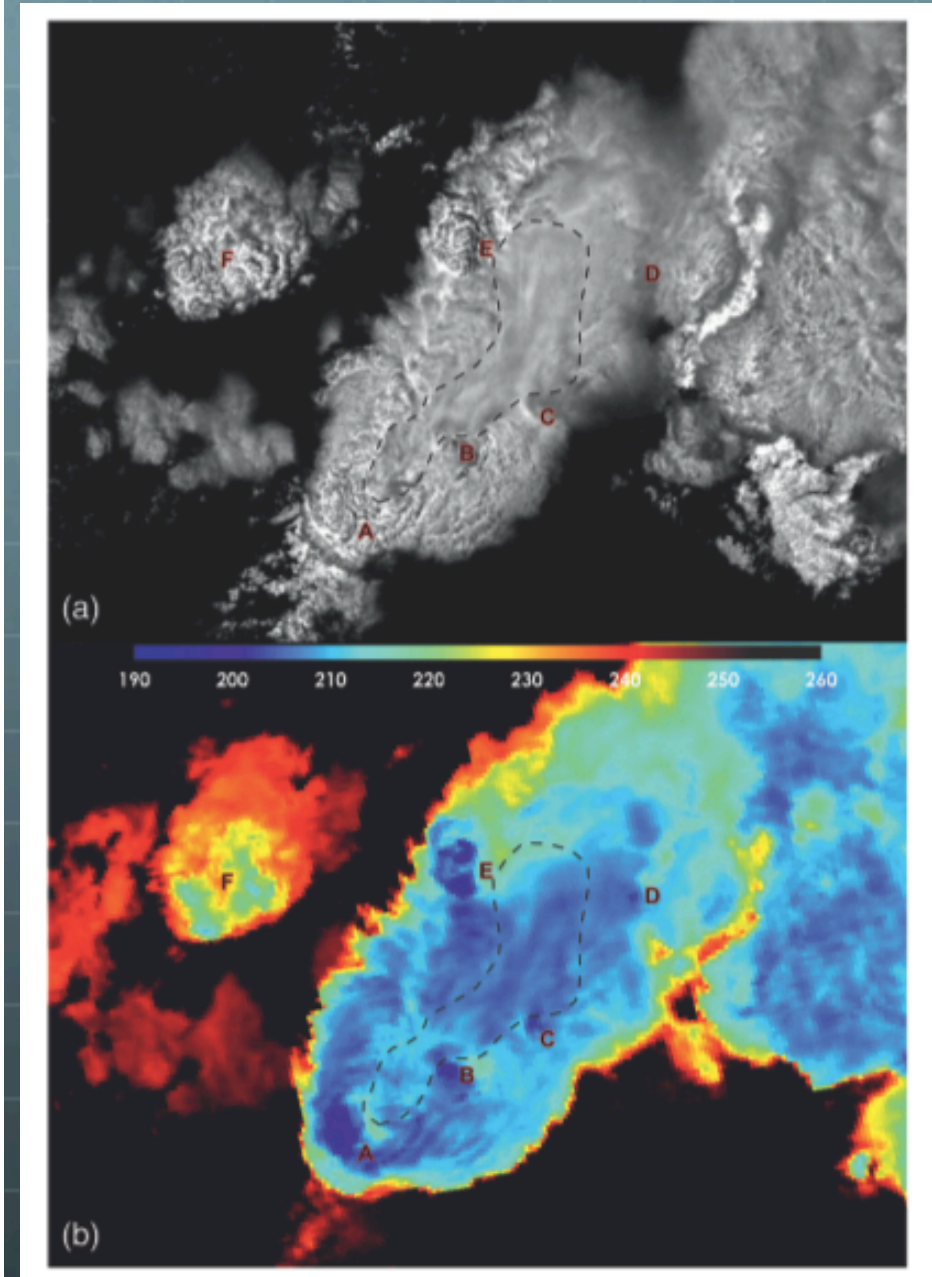
04:11 UTC
19 June 2009

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

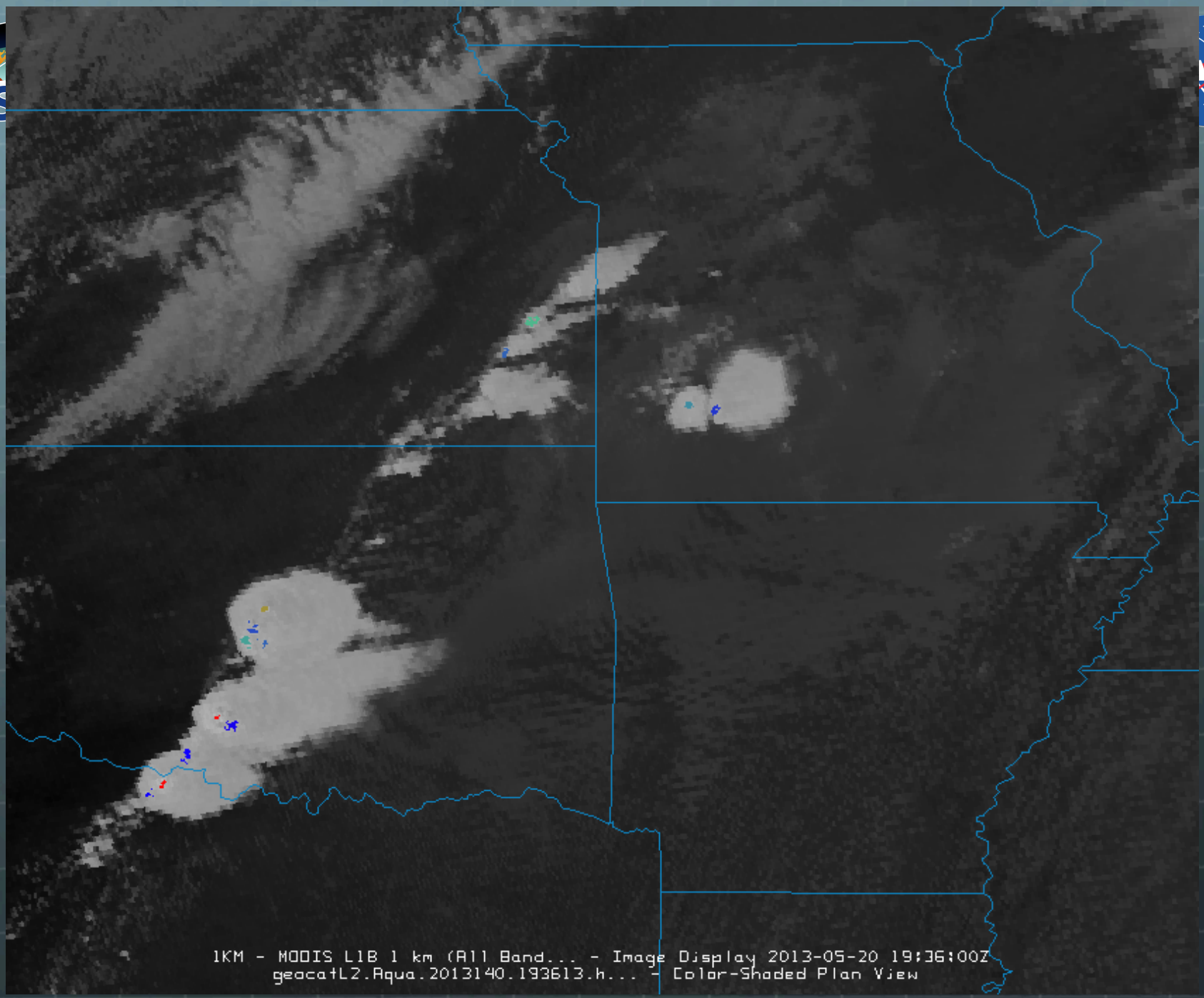


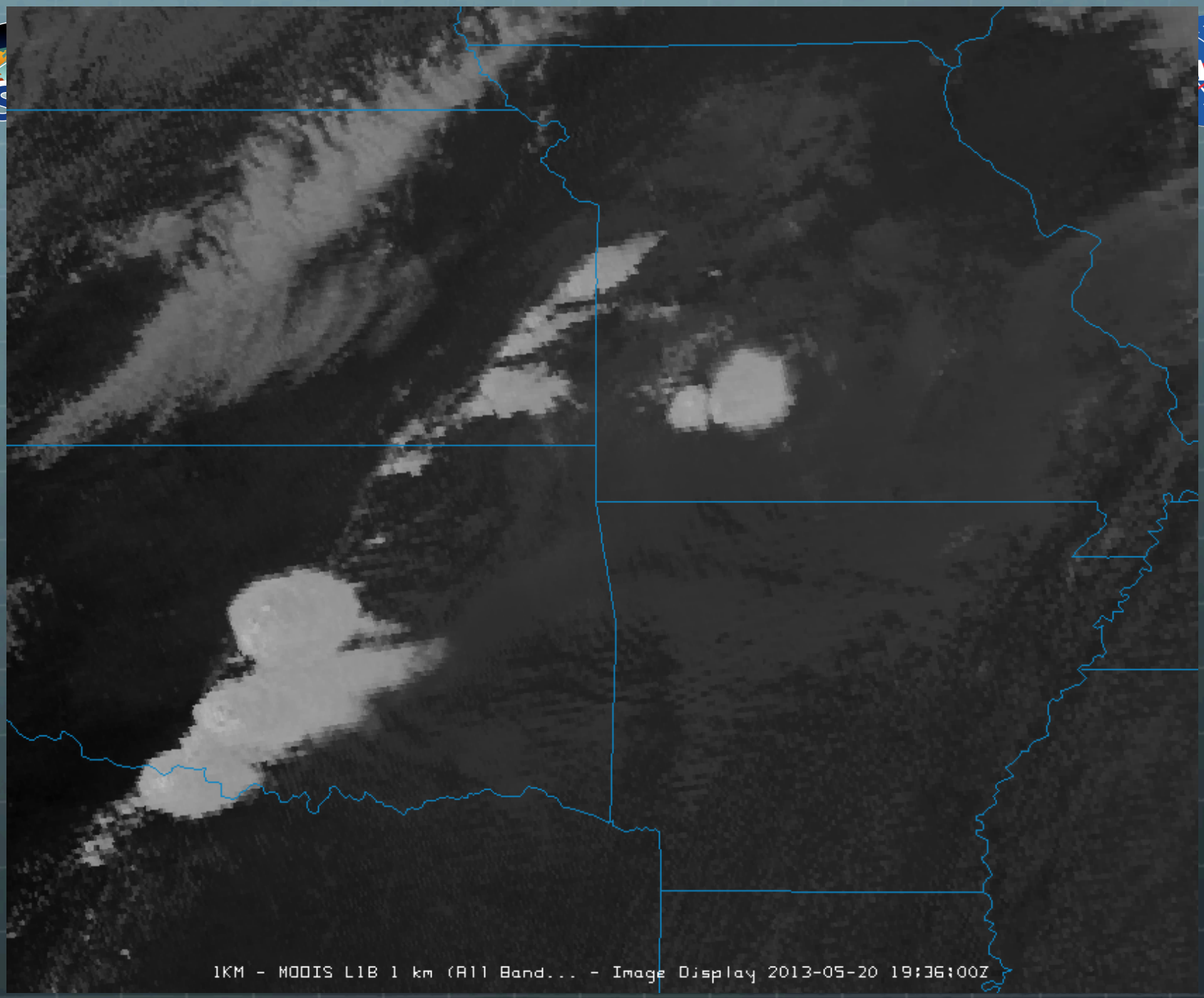
Bedka, K., Brunner, J., Dworak, Feltz, W., Otkin, J. and T. Greenwald: 2010. **Objective Satellite-Based Detection of Overshooting Tops Using Infrared Window Channel Brightness Temperature Gradients**, Journal of Applied Meteorology and Climatology, Vol. 49, pp. 181-202.

IMAPP OT GeoCAT Output HDF4 File

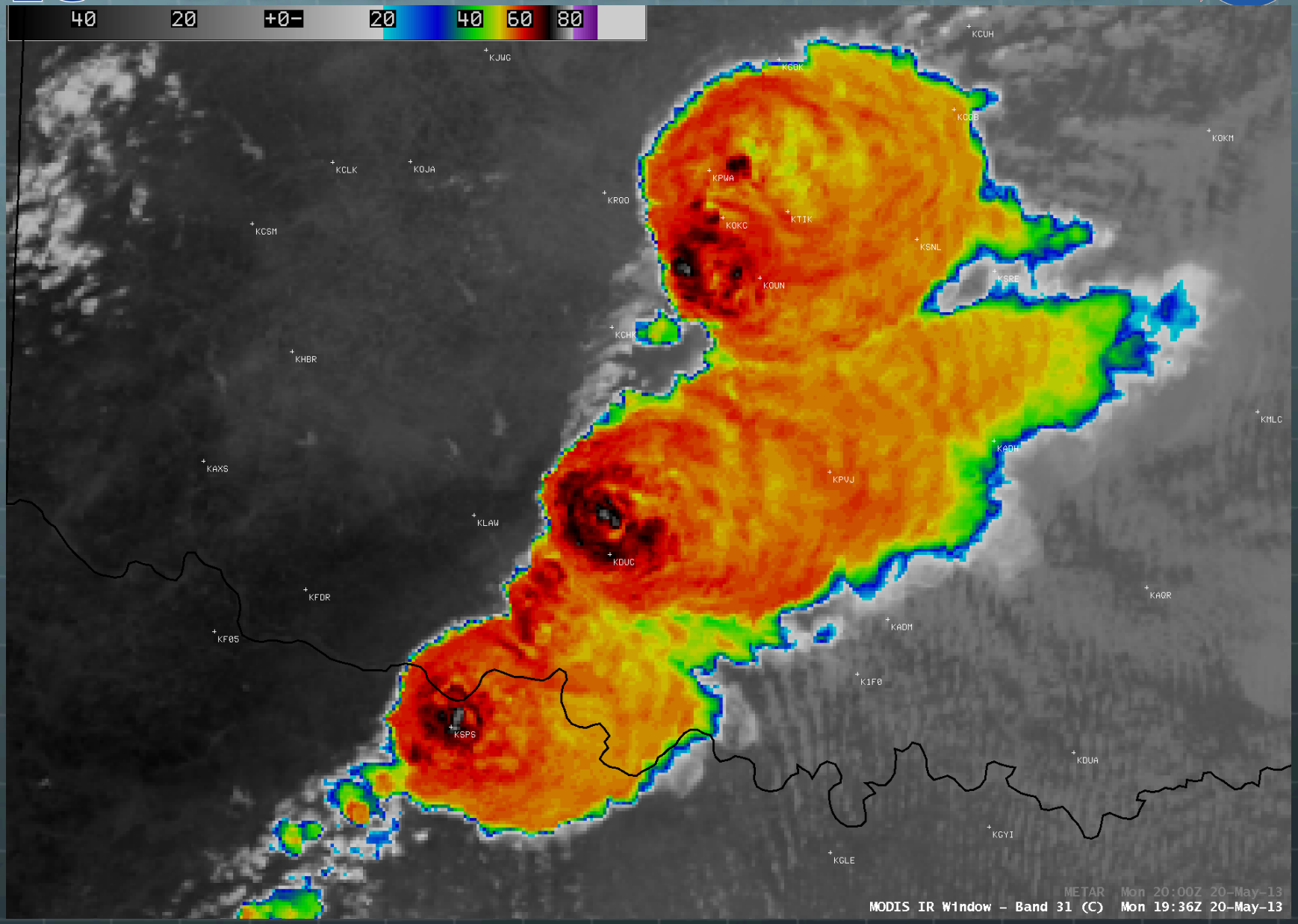
geocatL2.Terra.2013140.041735.hdf

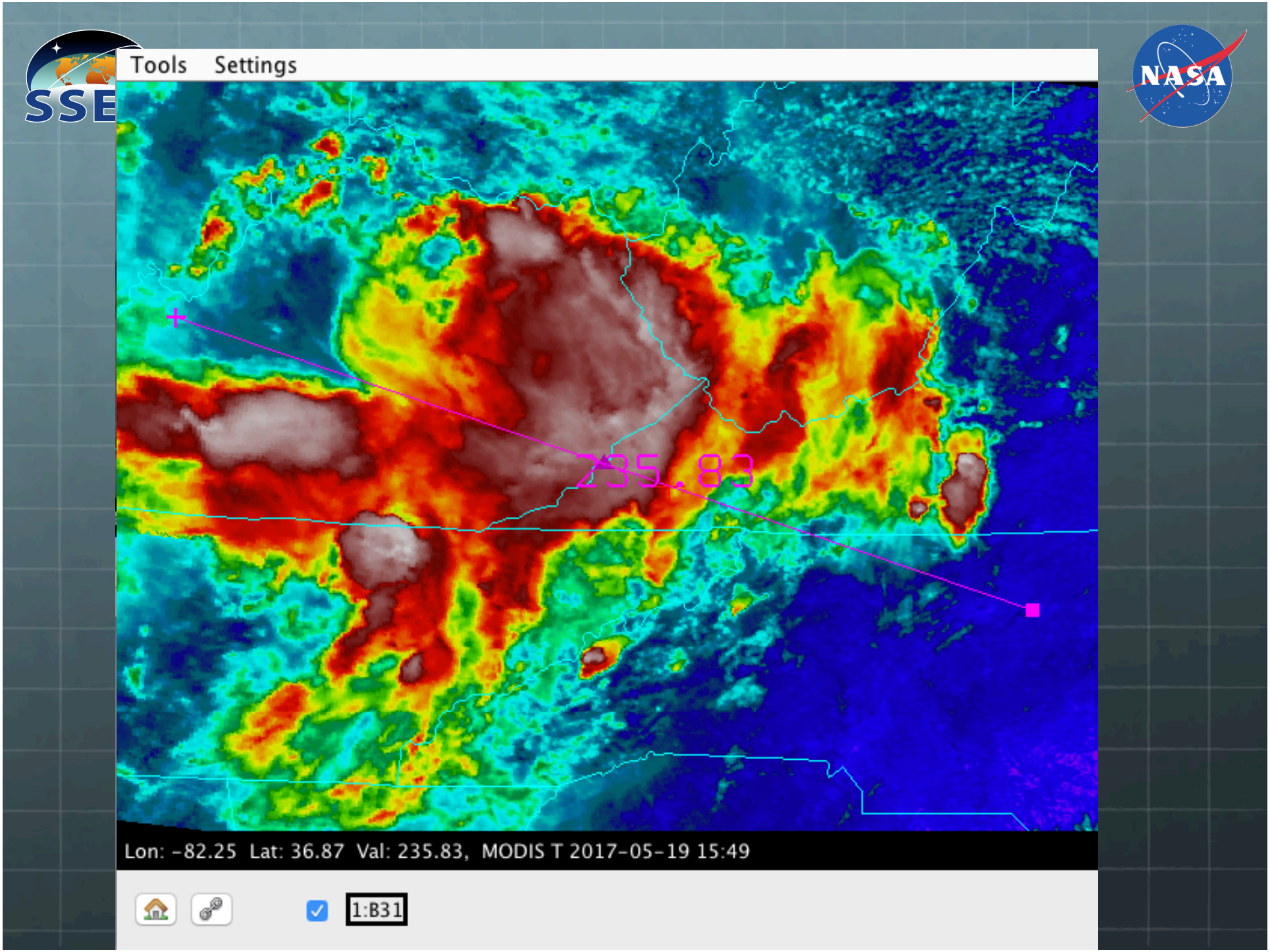
- Dimensions: lines = 4610, elements = 1354 ;
- 1 km resolution
- Variables:
  - short pixel_latitude(lines, elements) ;
  - short pixel_longitude(lines, elements) ;
  - short pixel_solar_zenith_angle(lines, elements) ;
  - short pixel_satellite_zenith_angle(lines, elements) ;
  - short pixel_relative_azimuth_angle(lines, 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) ;

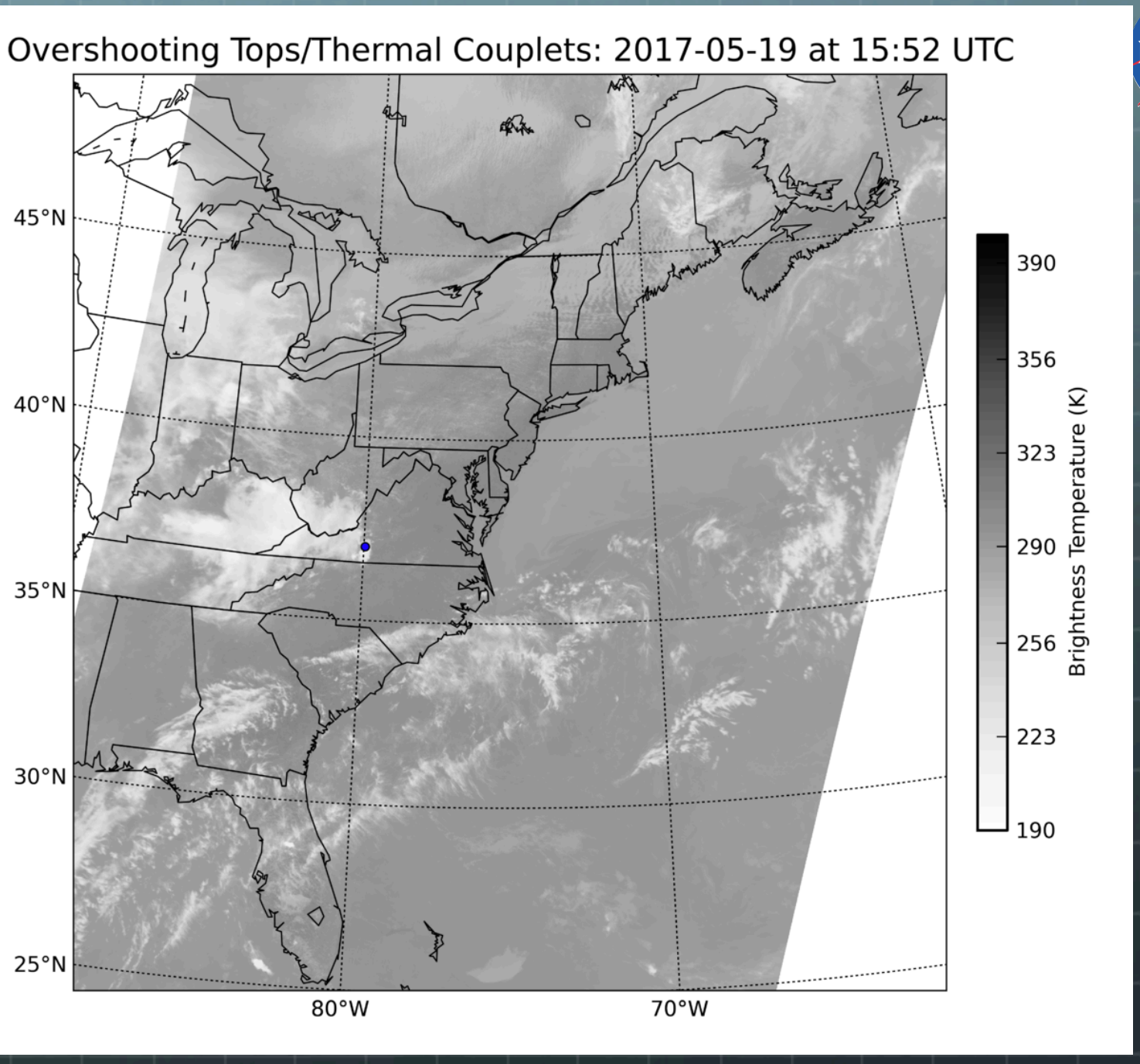

1KM - MODIS L1B 1 km (All Band... - Image Display 2013-05-20 19:36:00Z
geocatL2.Aqua.2013140.193613.h... - Color-Shaded Plan View


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

GOES versus MODIS

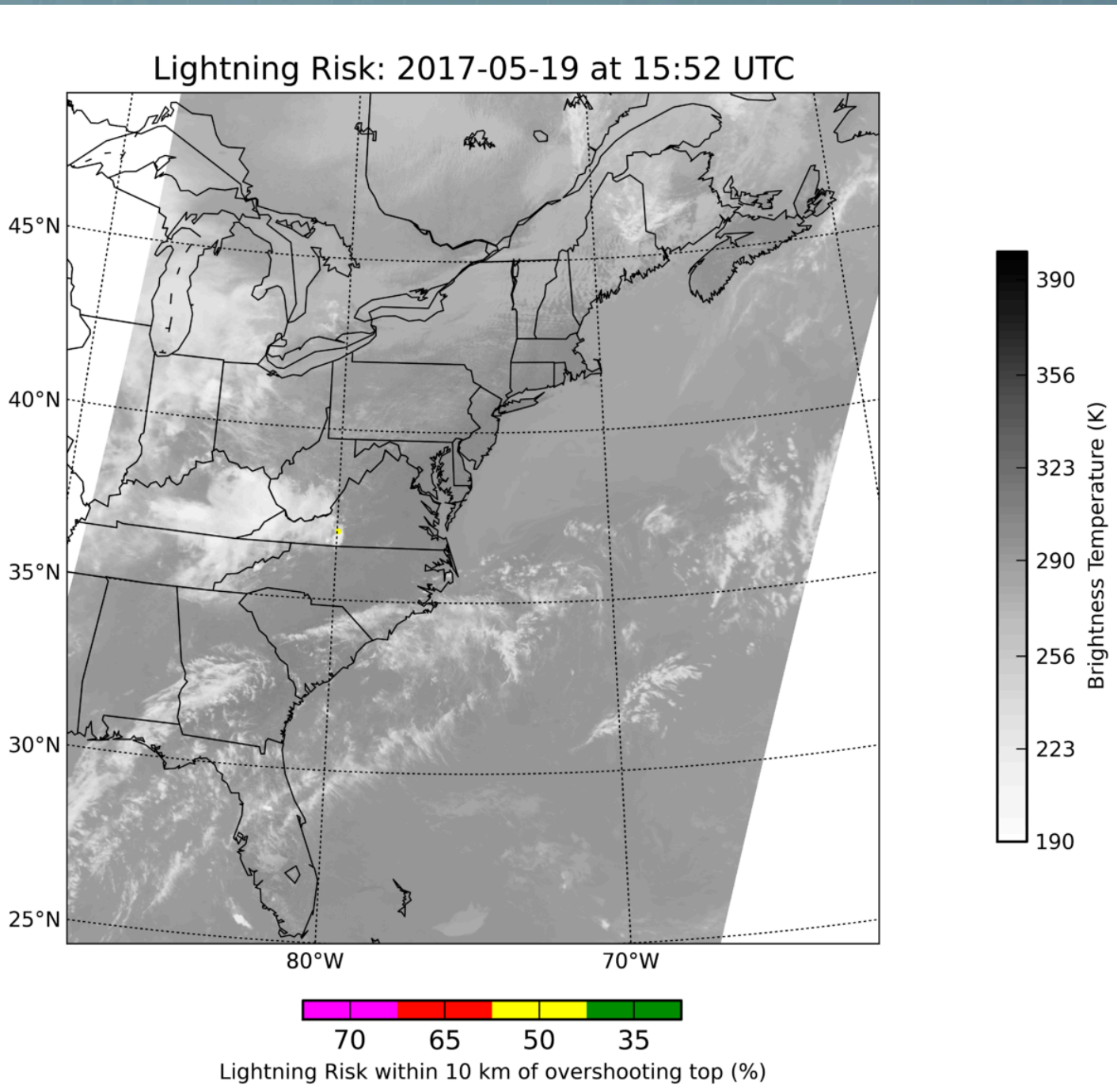



Tools
Settings
235.83
Lon: -82.25 Lat: 36.87 Val: 235.83, MODIS T 2017-05-19 15:49
1:B31


Overshooting Tops/Thermal Couplets: 2017-05-19 at 15:52 UTC
45°N
40°N
35°N
30°N
25°N
80°W
70°W
390
356
323
290
256
223
190
Brightness Temperature (K)

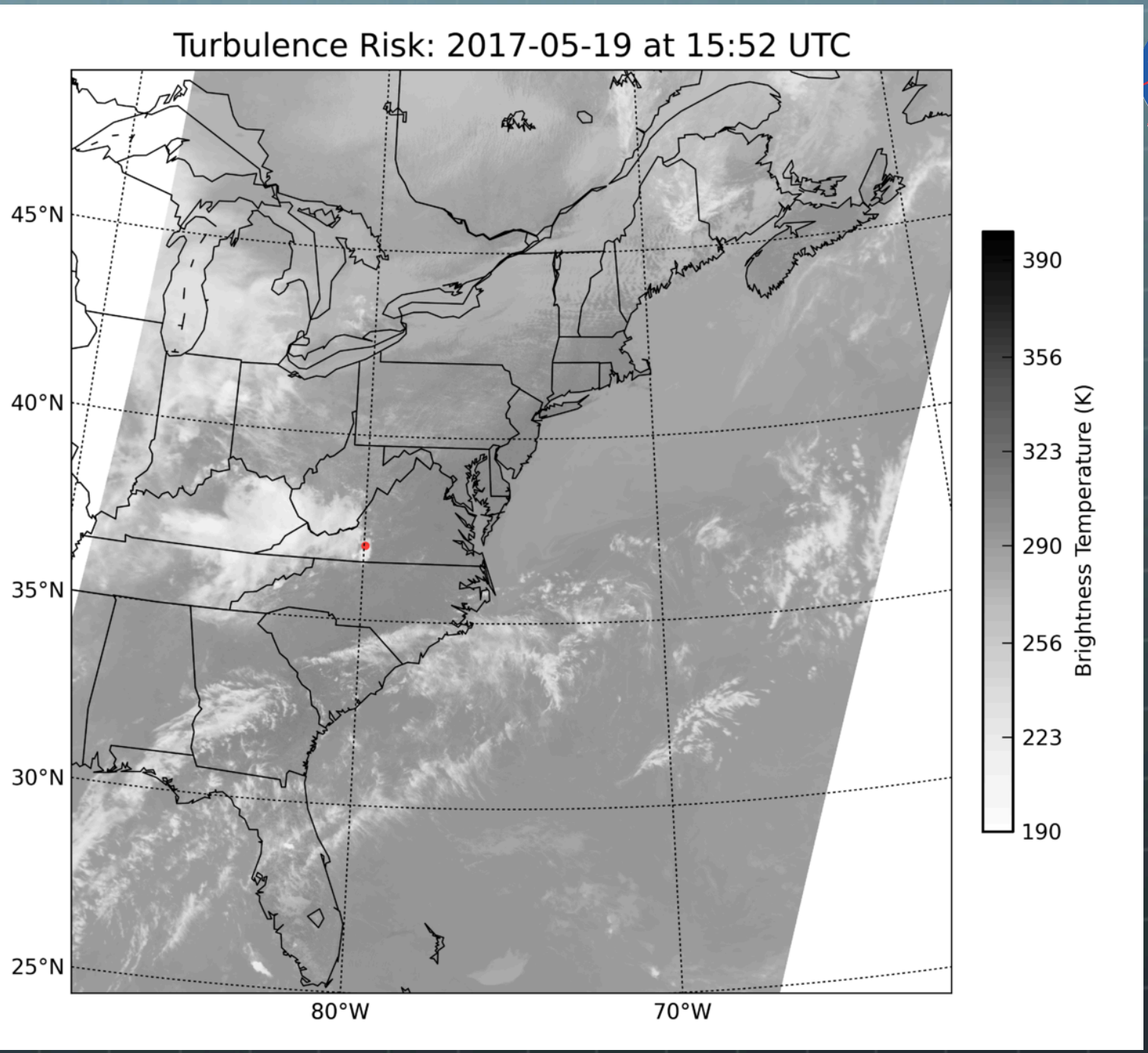
IMAPP Overshooting Top Lightning Risk Image

- 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: 2017-05-19 at 15:52 UTC
45°N
40°N
35°N
30°N
25°N
80°W
70°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: 2017-05-19 at 15:52 UTC
45°N
40°N
35°N
30°N
25°N
80°W
70°W
390
356
323
290
256
223
190
Brightness Temperature (K)