Polar Orbiter Product Environmental Applications: Part 3

Kathleen Strabala

UPR Direct Broadcast Polar Orbiter Workshop

27 April 2016

VIIRS Day/Night Band

- Visible wavelength available at night!
  - 735 m spatial resolution centered at about .7 microns
- What can now be seen at night?
  - Cities
  - Smoke, Dust, Ash
  - Low Clouds/Fog
  - Fires, Volcanoes (Lava)
  - Auroras
  - Lightning
- How much can be seen depends heavily on lunar illumination – Phase of moon, and rising setting times

VIIRS Day/Night Band

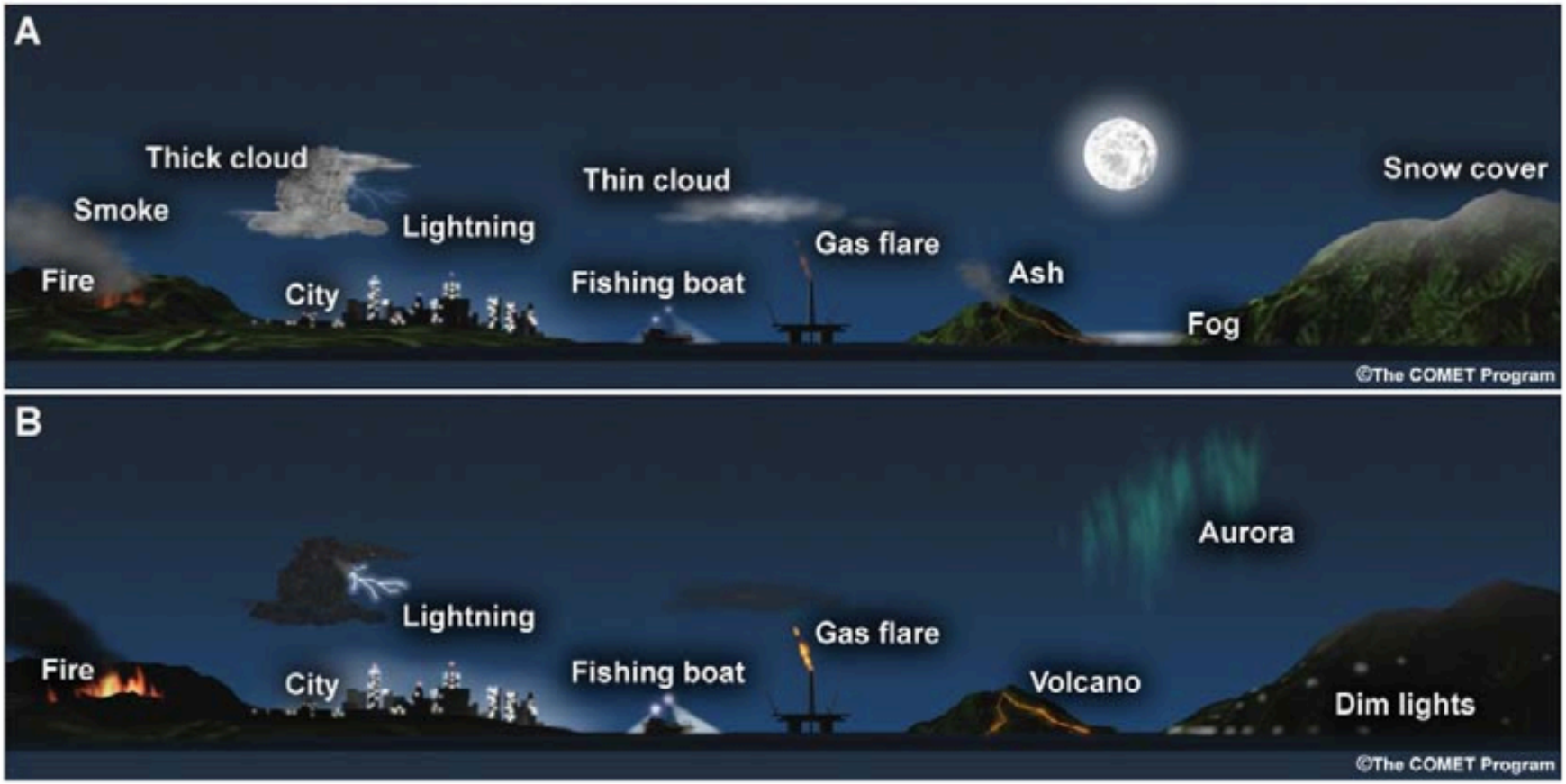


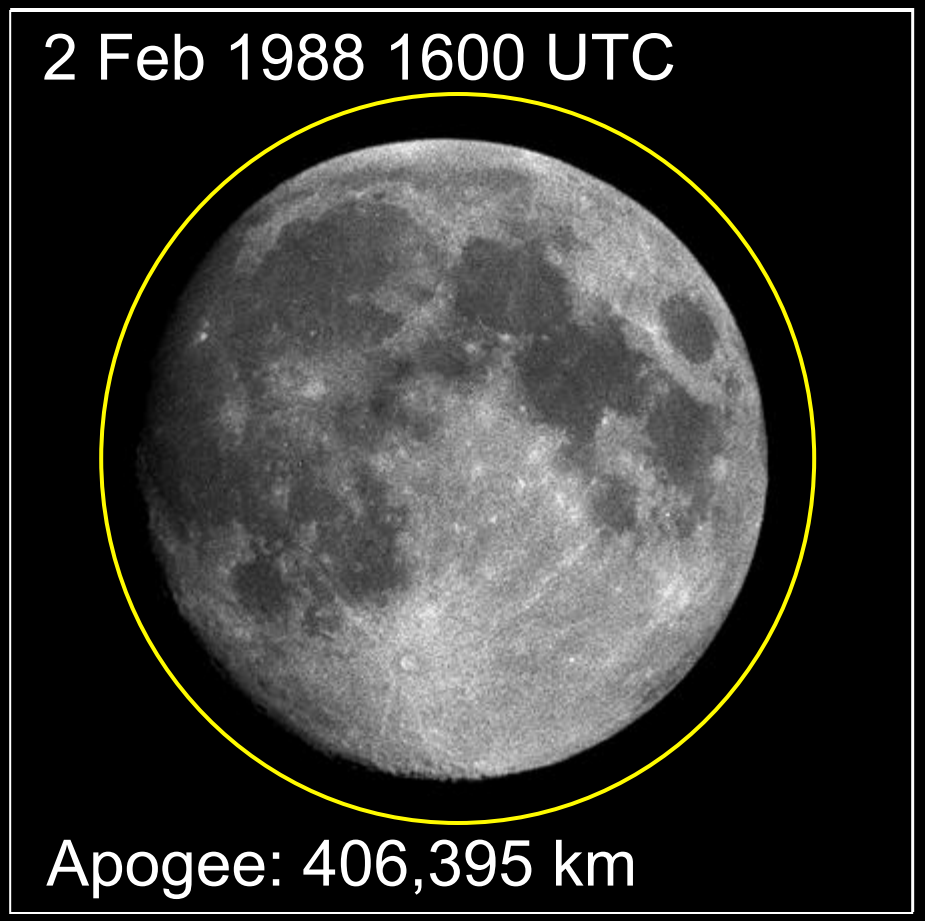
FIG. 1. Nighttime visible detection capabilities (a) with and (b) without lunar illumination.

Taken from: T., Miller, S. D., Turk, F. J., Schueler, C., Jullian, R., Deyo, S., Dills, P., and Wang, S., 2006: The NPOESS VIIRS Day/Night Visible Sensor, Bulletin Am. Met. Society, DOI:10.1175/BAMS-87-2-191, p. 191-199.

Currently Displaying Radiances

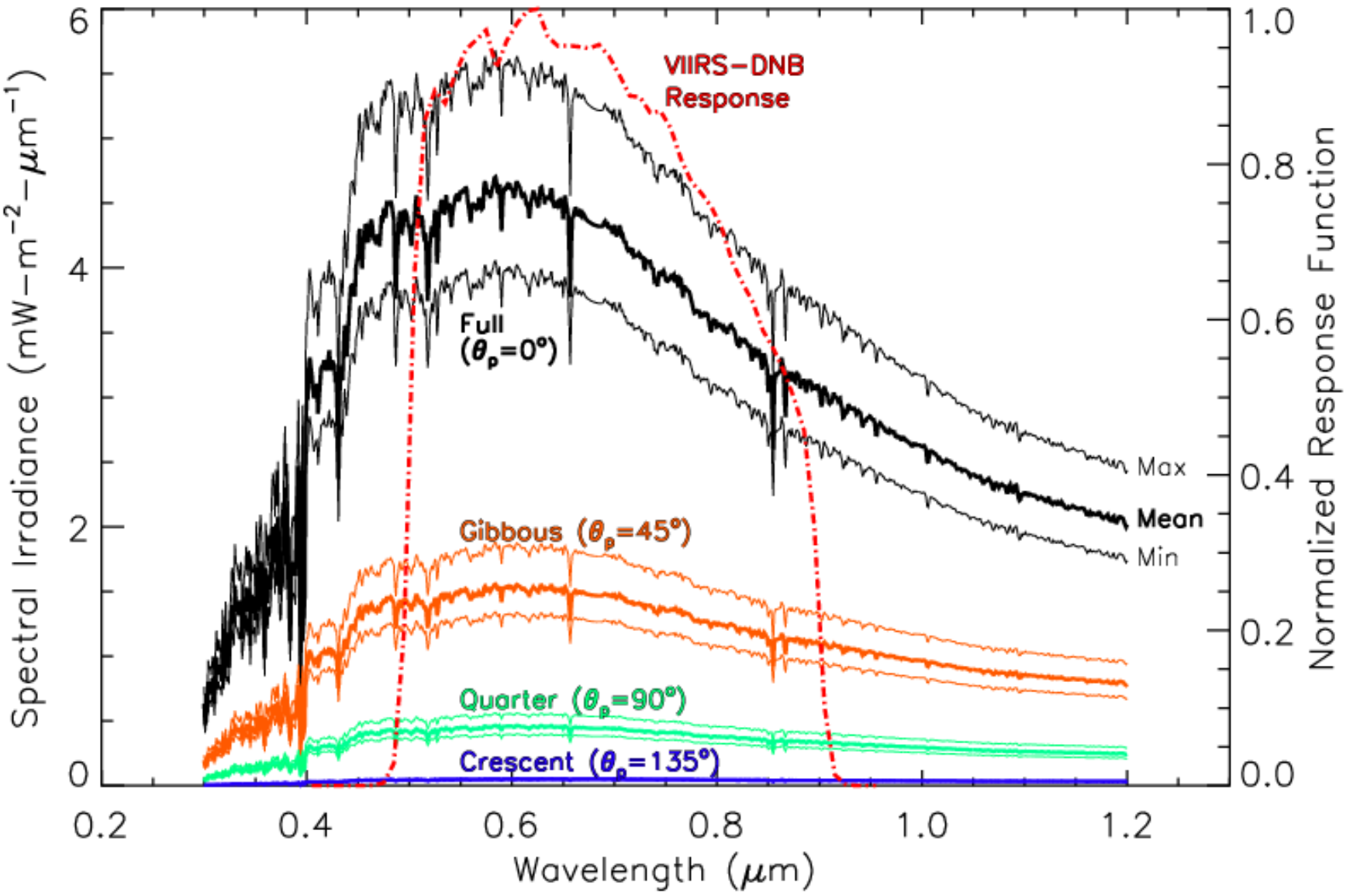
- Data spans 7 orders of magnitude
- We display it in terms of radiance units
  - Difficult to model the top of atmosphere incoming radiation from the moon, so no reflectance units in the Day/Night band VIIRS SDR file.
  - There is one as part of new release of CLAVRx cloud products.

Lunar Reflectance Model

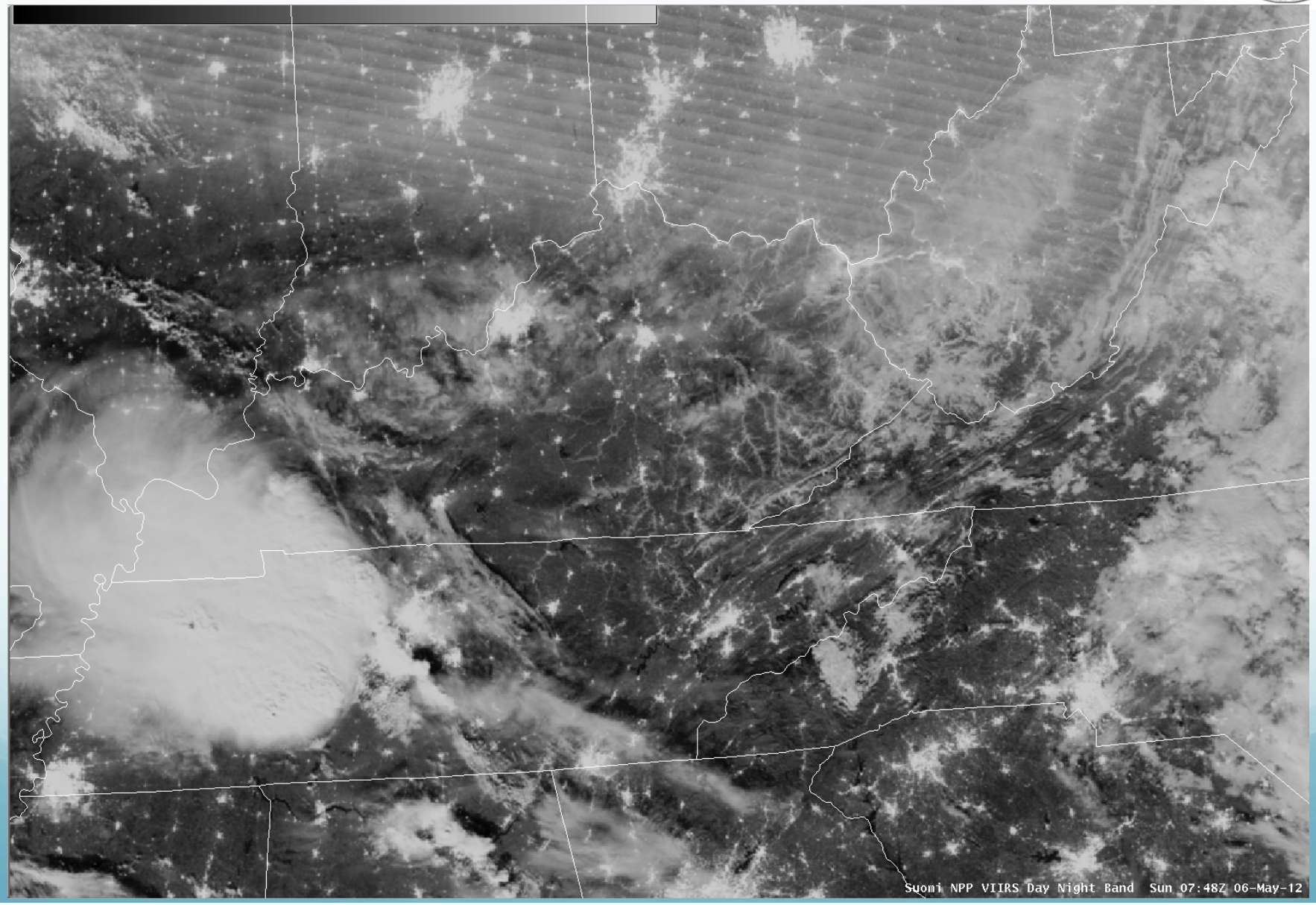


Mean Distance = 384,401 km

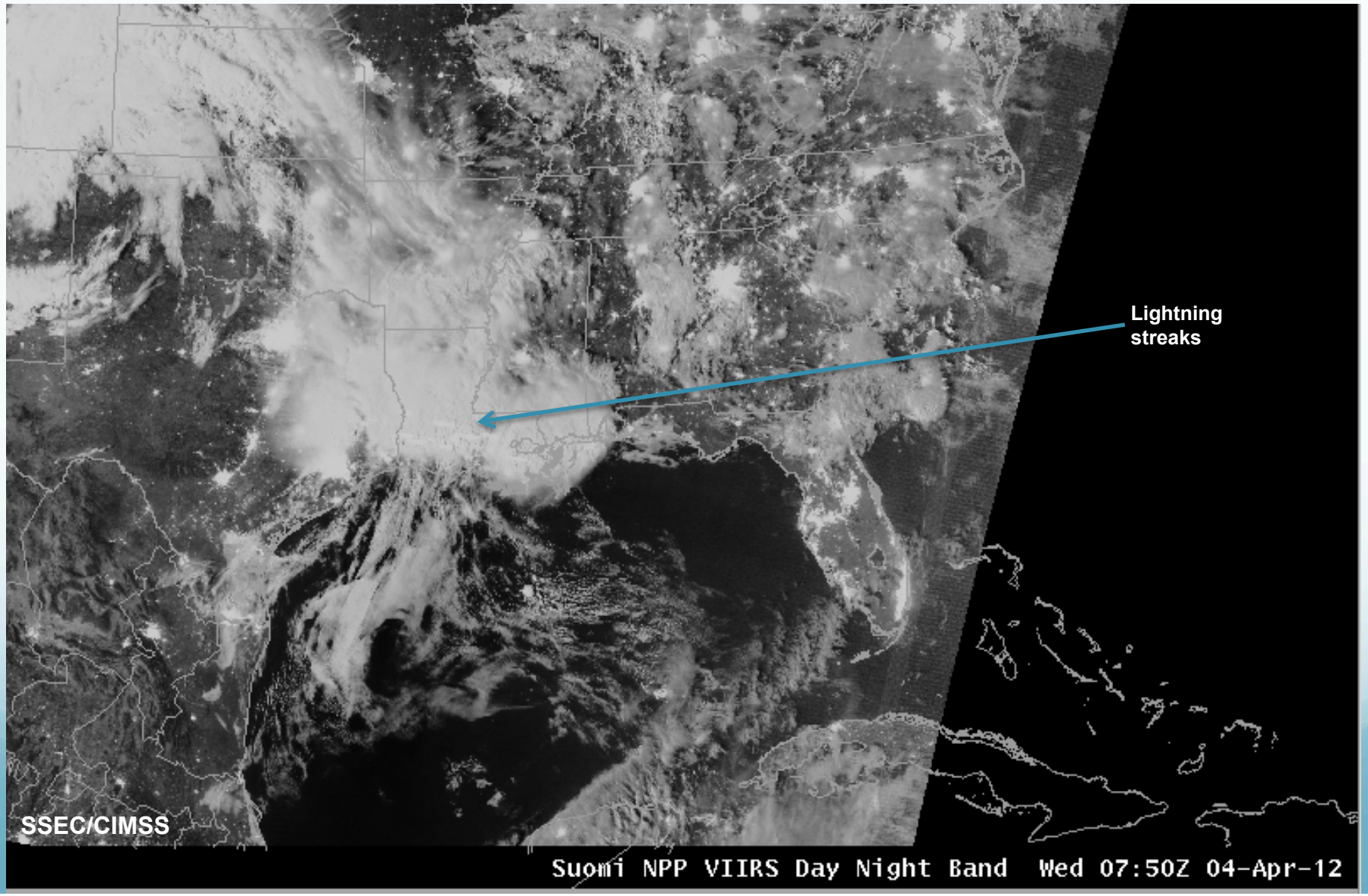
Lunar Reflectance Model



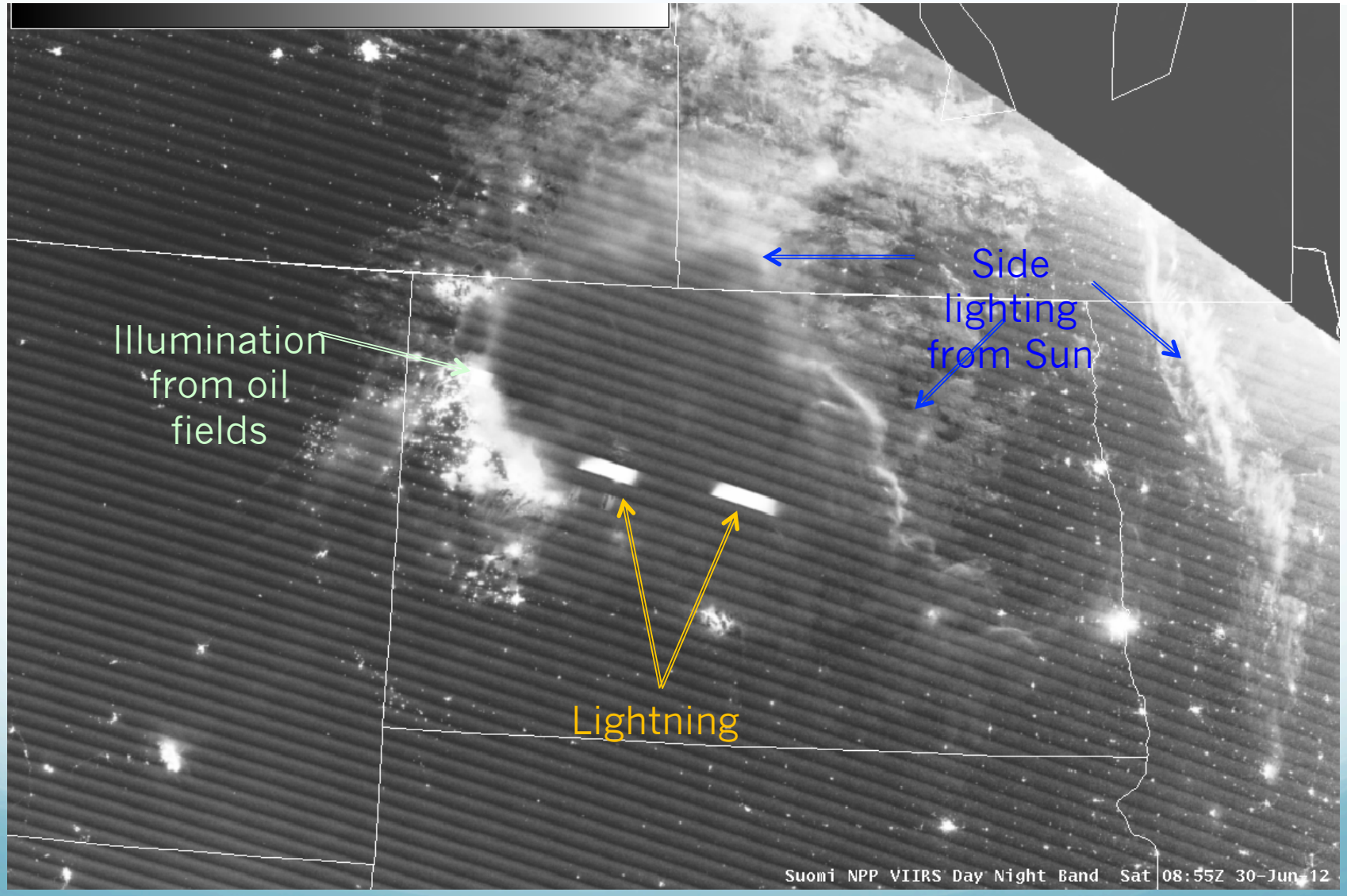
VIIRS Fog Detection Capability
Day/Night Band 6 May 2012



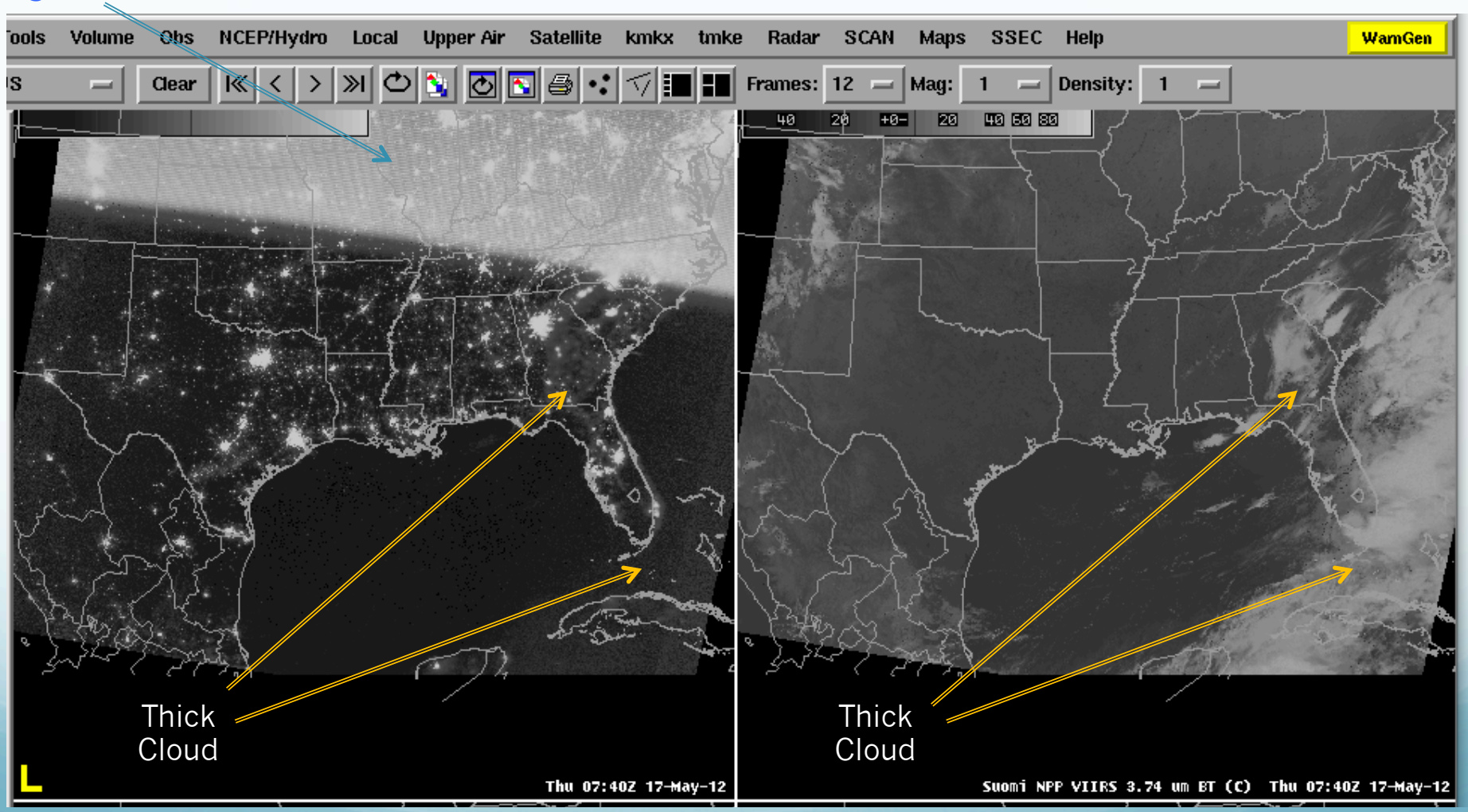
VIIRS in AWIPS Day/Night Band Lightning Detection 4 April 2012



VIIRS in AWIPS Day/Night Band Lightning Detection 30 June 2012



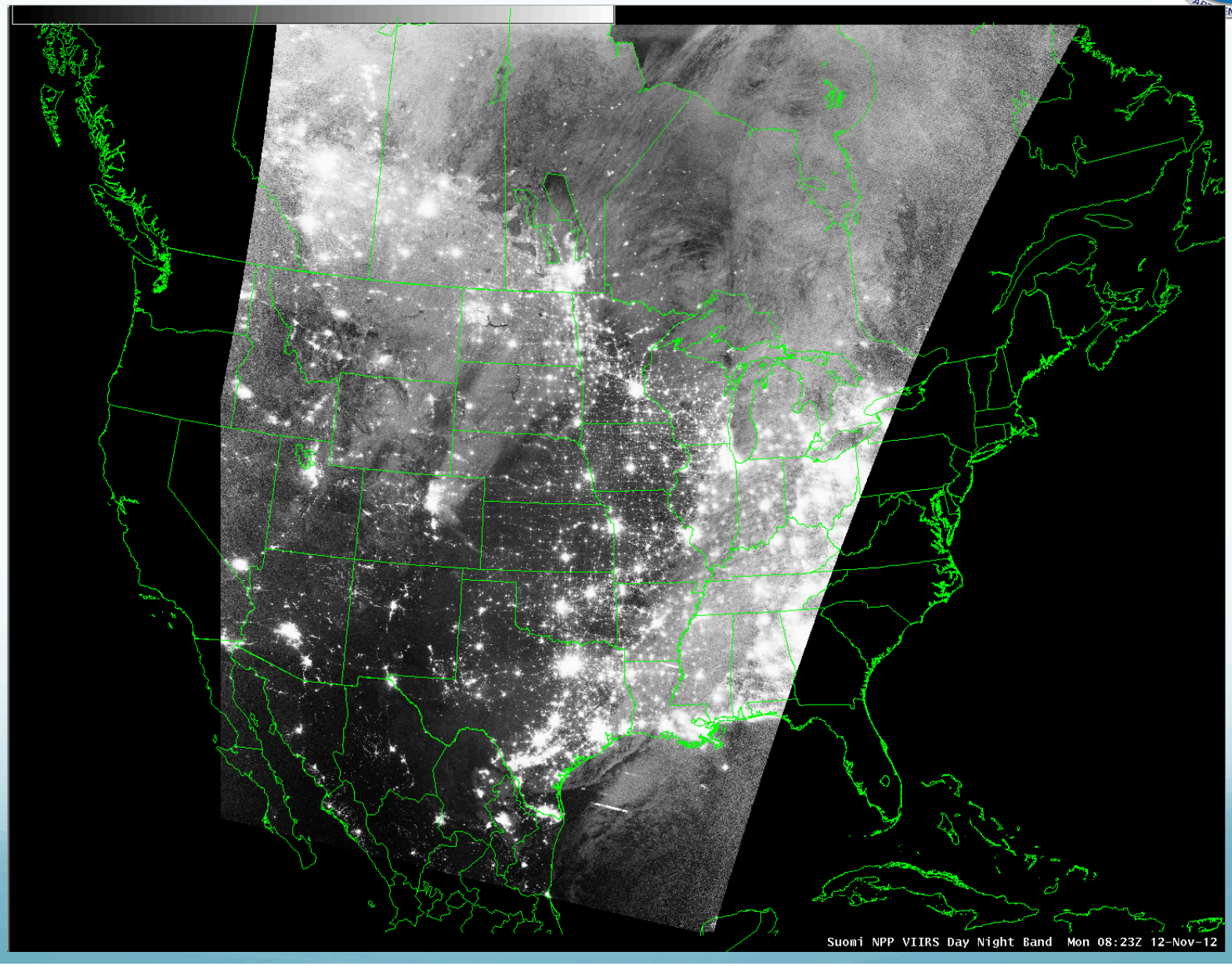
Moon Phase Affects How Much Can be Seen



Crescent moon means less illumination making it difficult to identify clouds

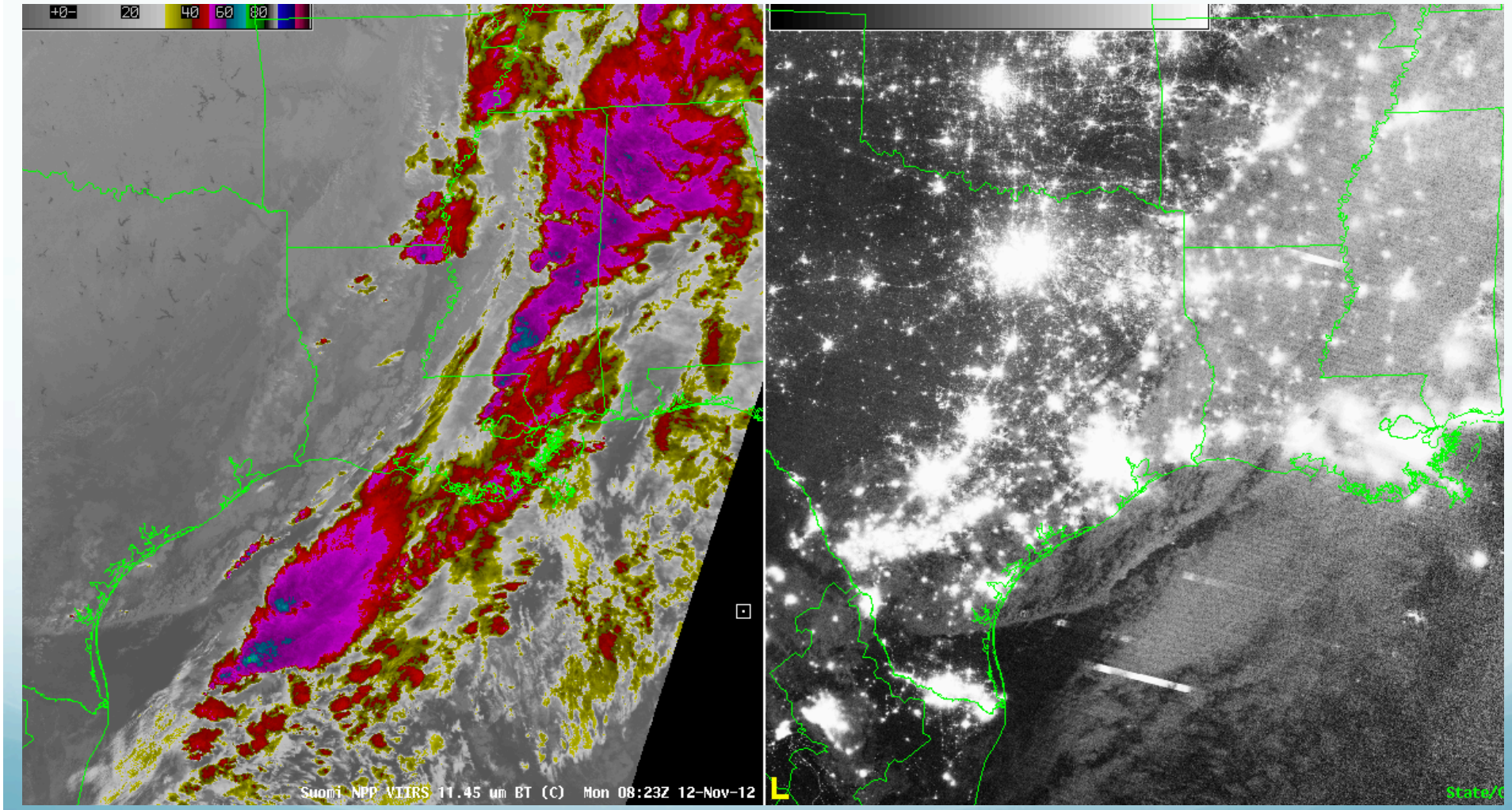
VIIRS Day/Night Band

New Moon



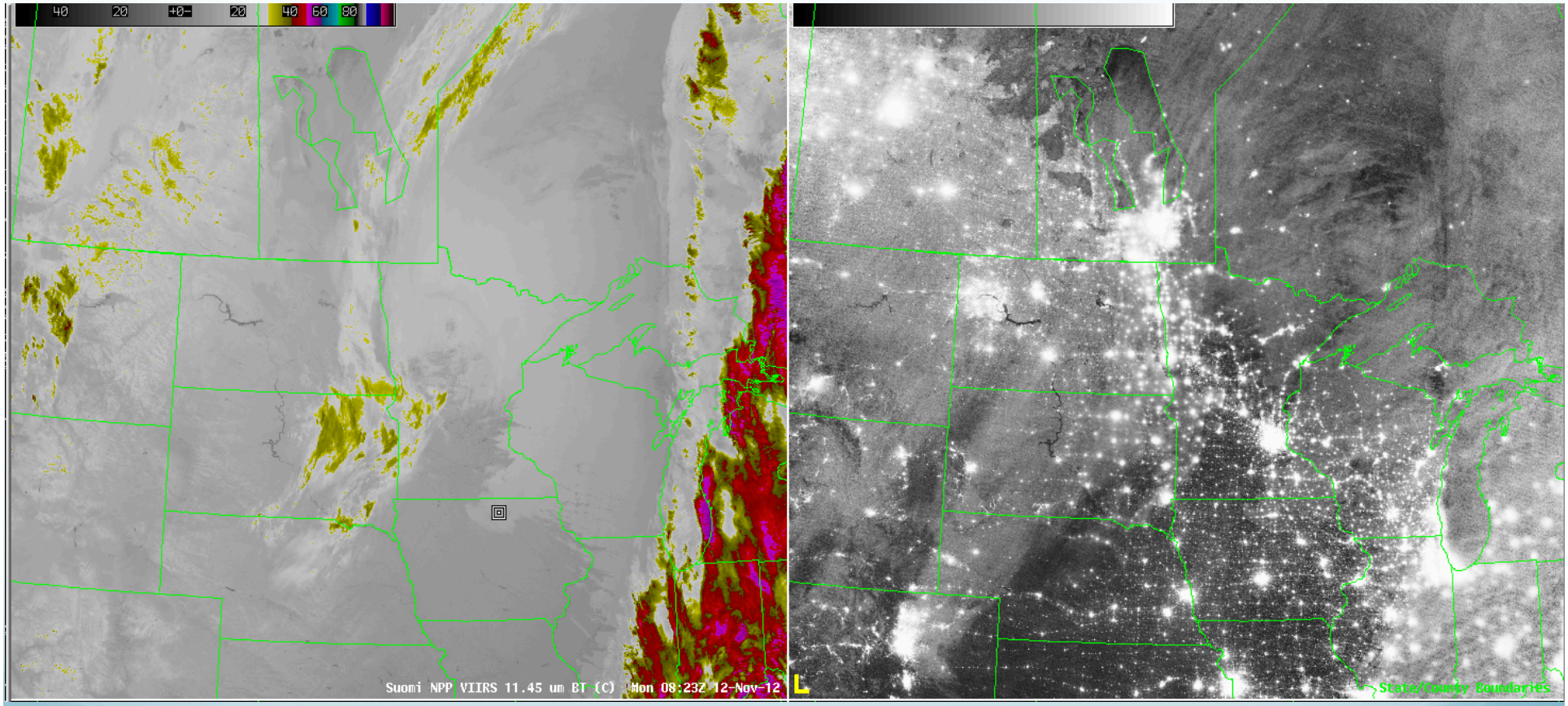
VIIRS Day/Night Band

New Moon

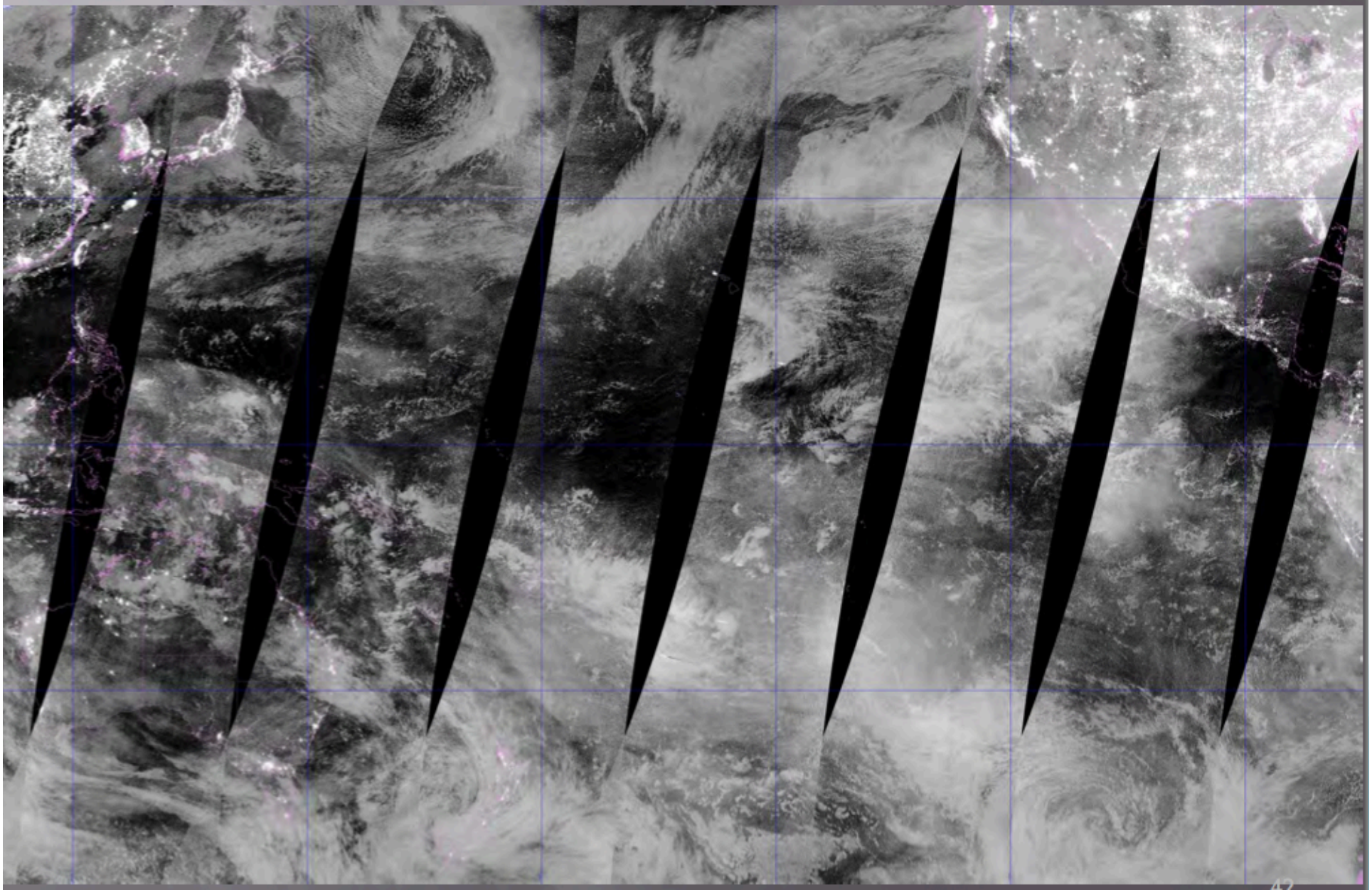


VIIRS Day/Night Band

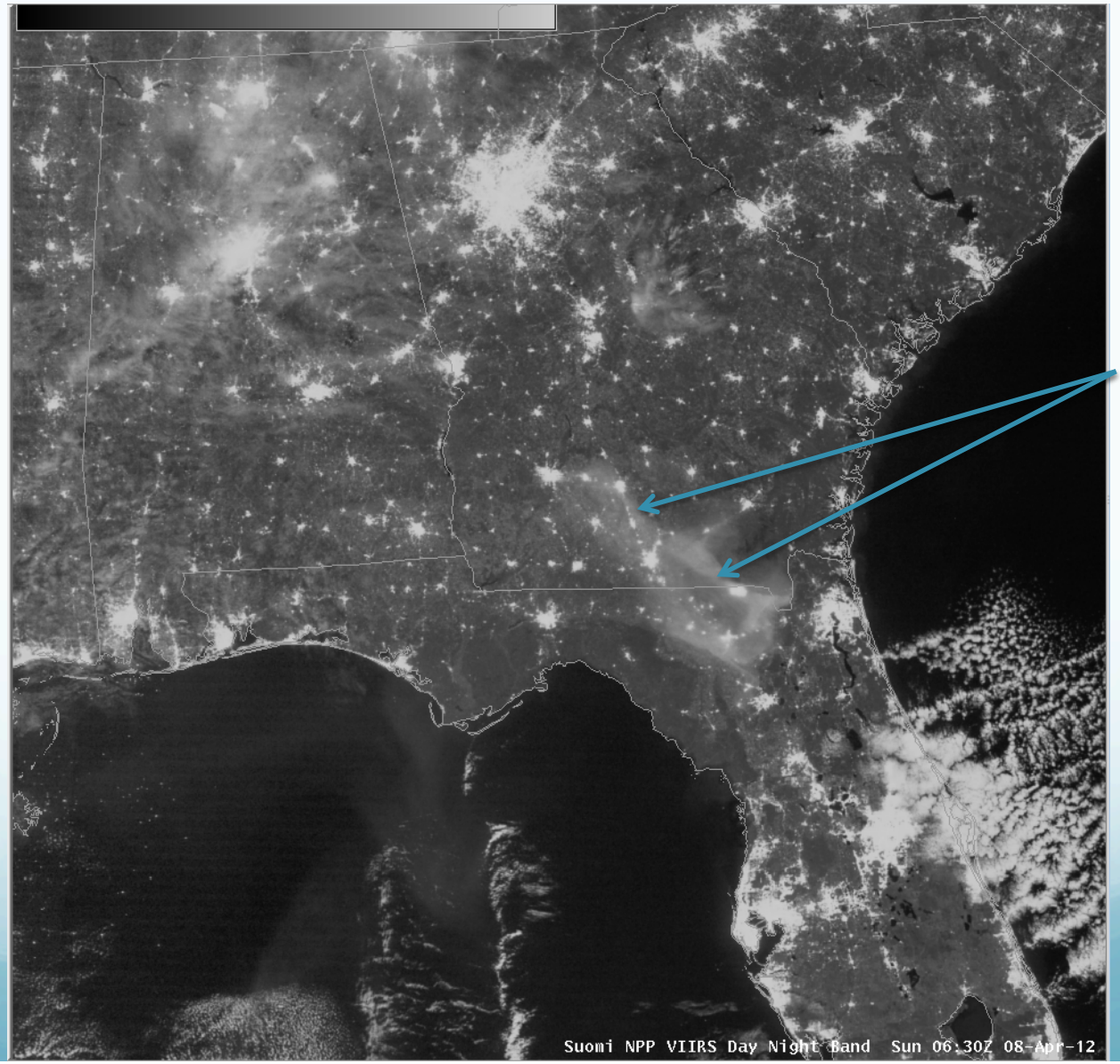
New Moon



Clouds Reflecting Airglow & Starlight



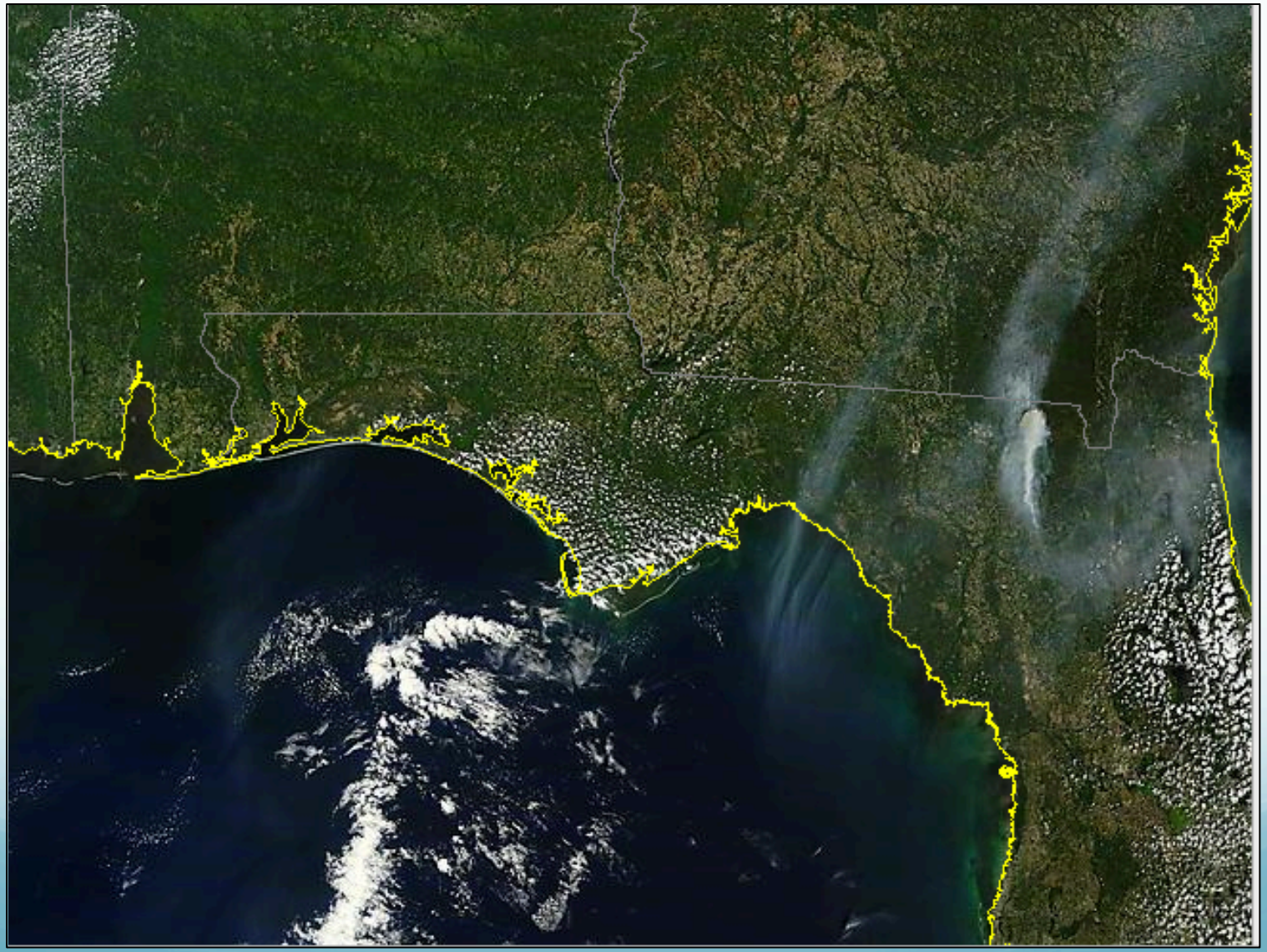
VIIRS in AWIPS Day/Night Band Smoke Detection 8 April 2012



Smoke from County Line Fire in northern Florida

SSEC/CIMSS

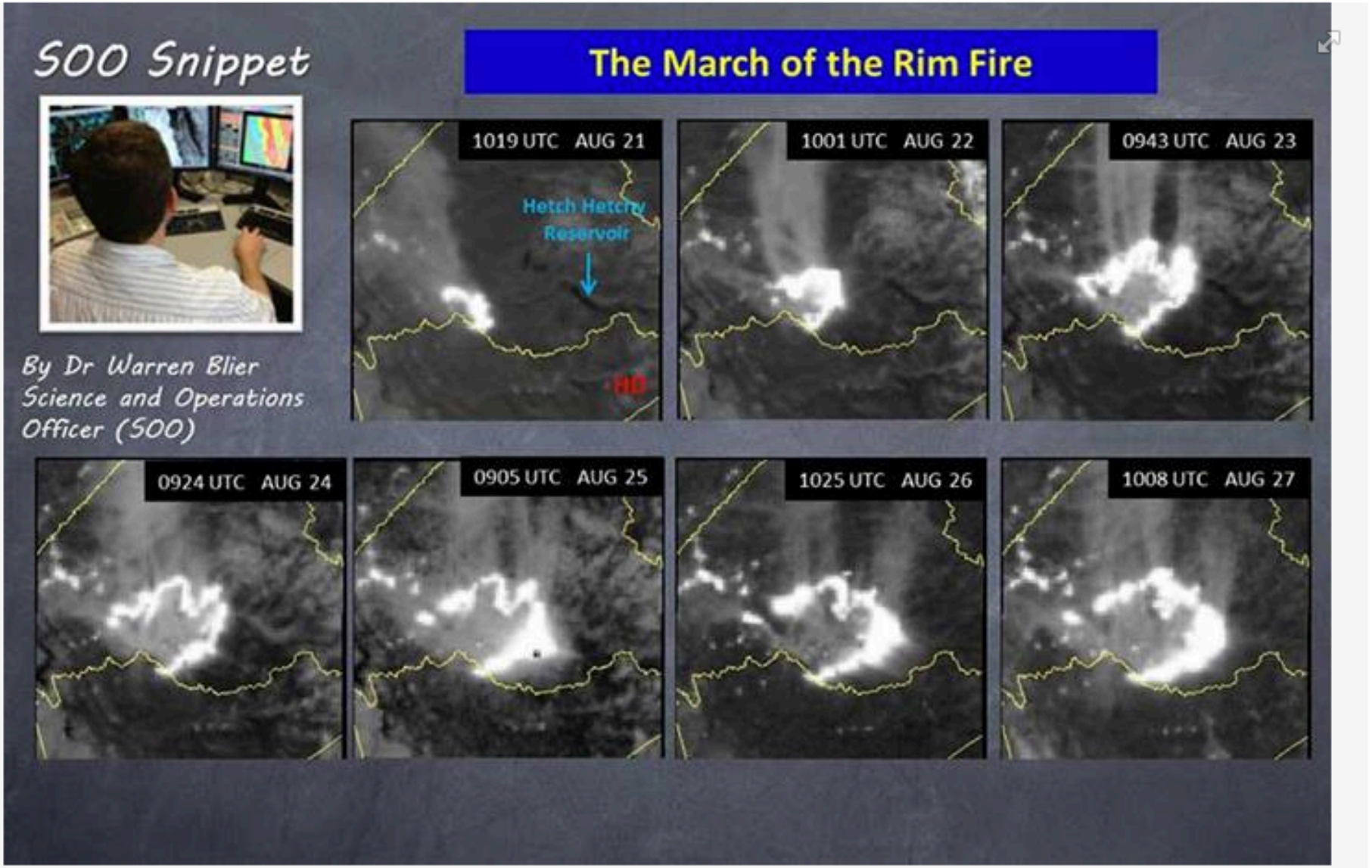
Terra MODIS 8 April 2012 16:15 UTC



Wildfires

VIIRS in AWIPS Fires

Timeline Photos

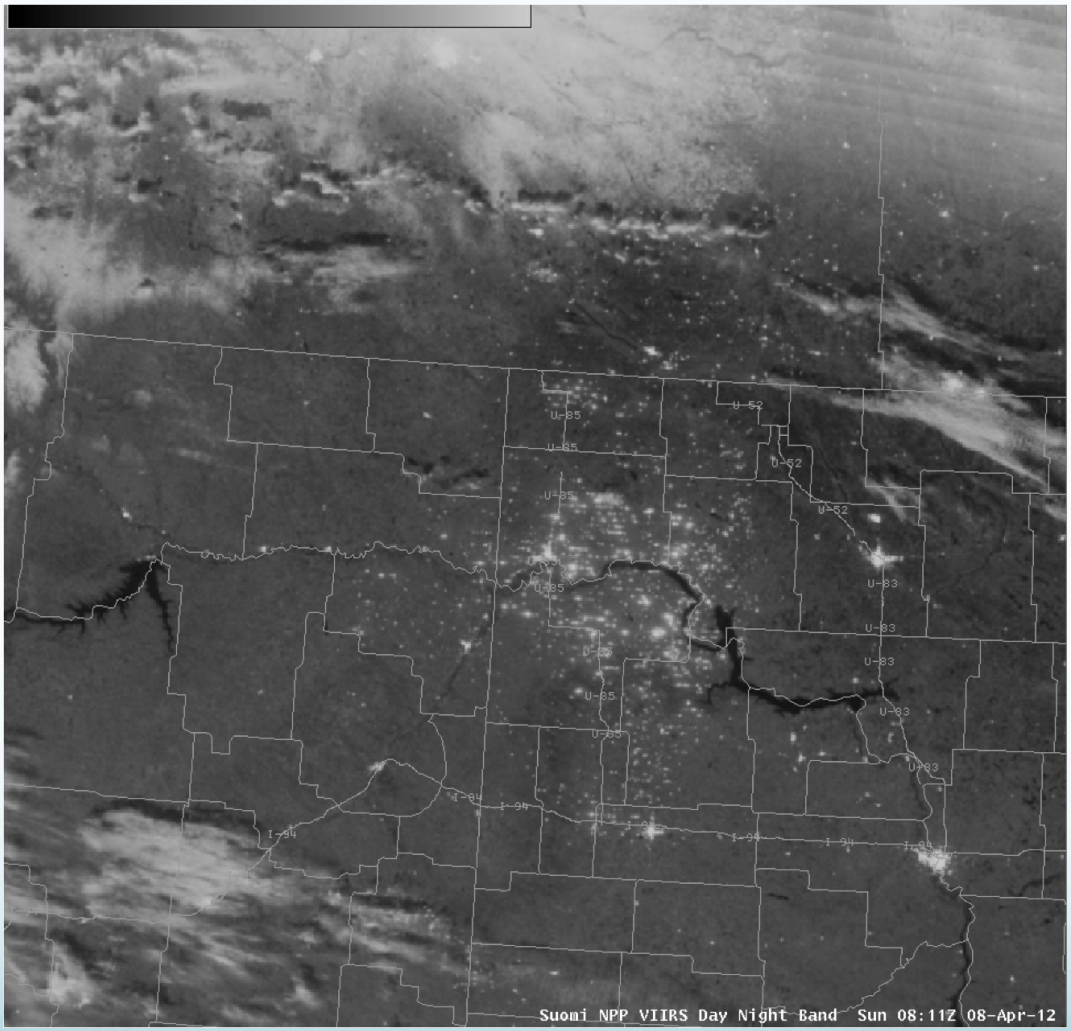


US National Weather Service San Francisco Bay Area/Monterey California

Album: Timeline Photos

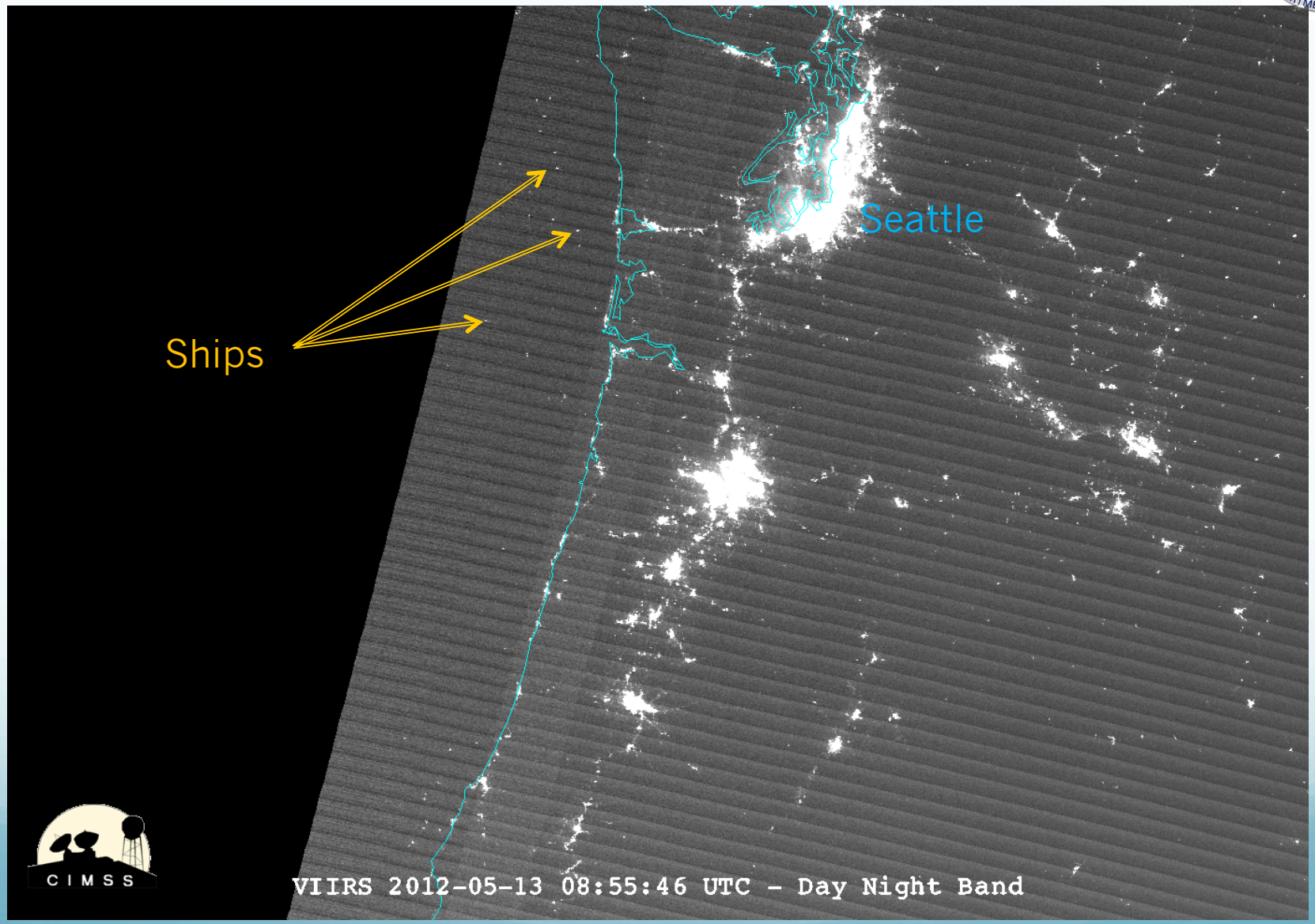
Shared with: Public

VIIRS in AWIPS Day/Night Band Mining Operations 8 April 2012

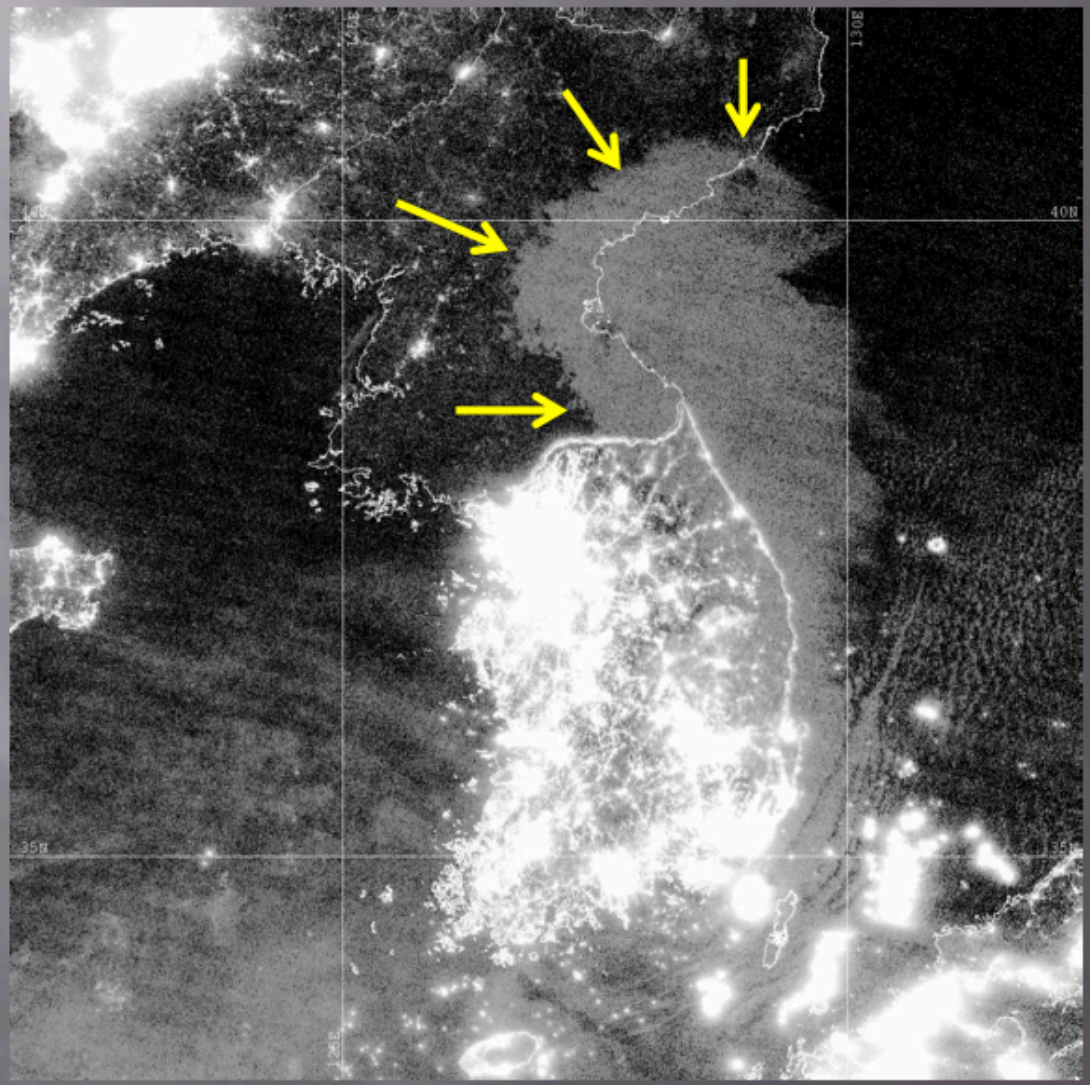


Another example of a Day/Night Band image from 08 April 2012 revealed a large number of natural gas flares and illuminated “man camps” associated with extensive drilling operations in the Bakken Shale Oil Field area of eastern Montana and western North Dakota.

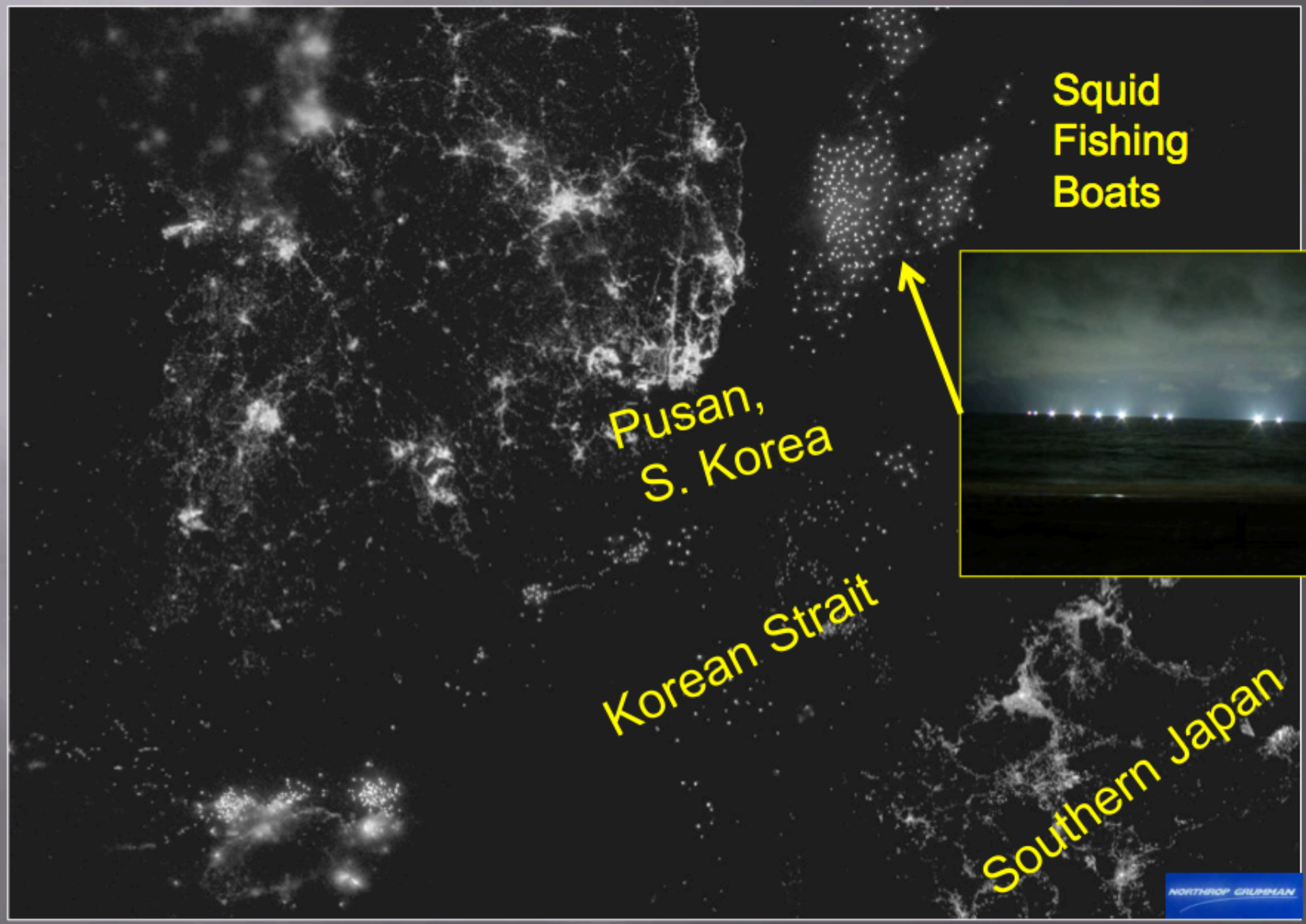
Examples Ships

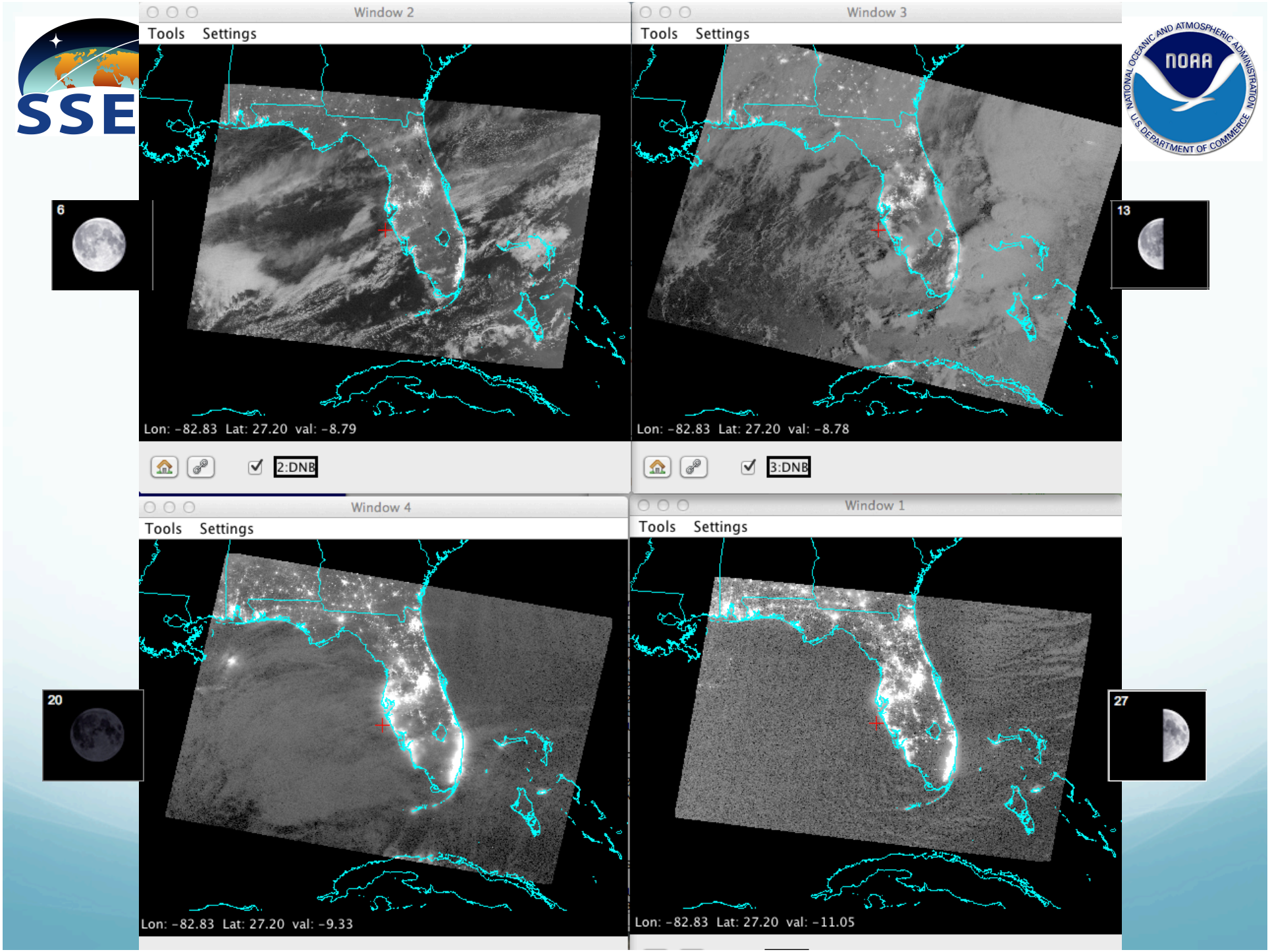


A New Way of Seeing Low Clouds

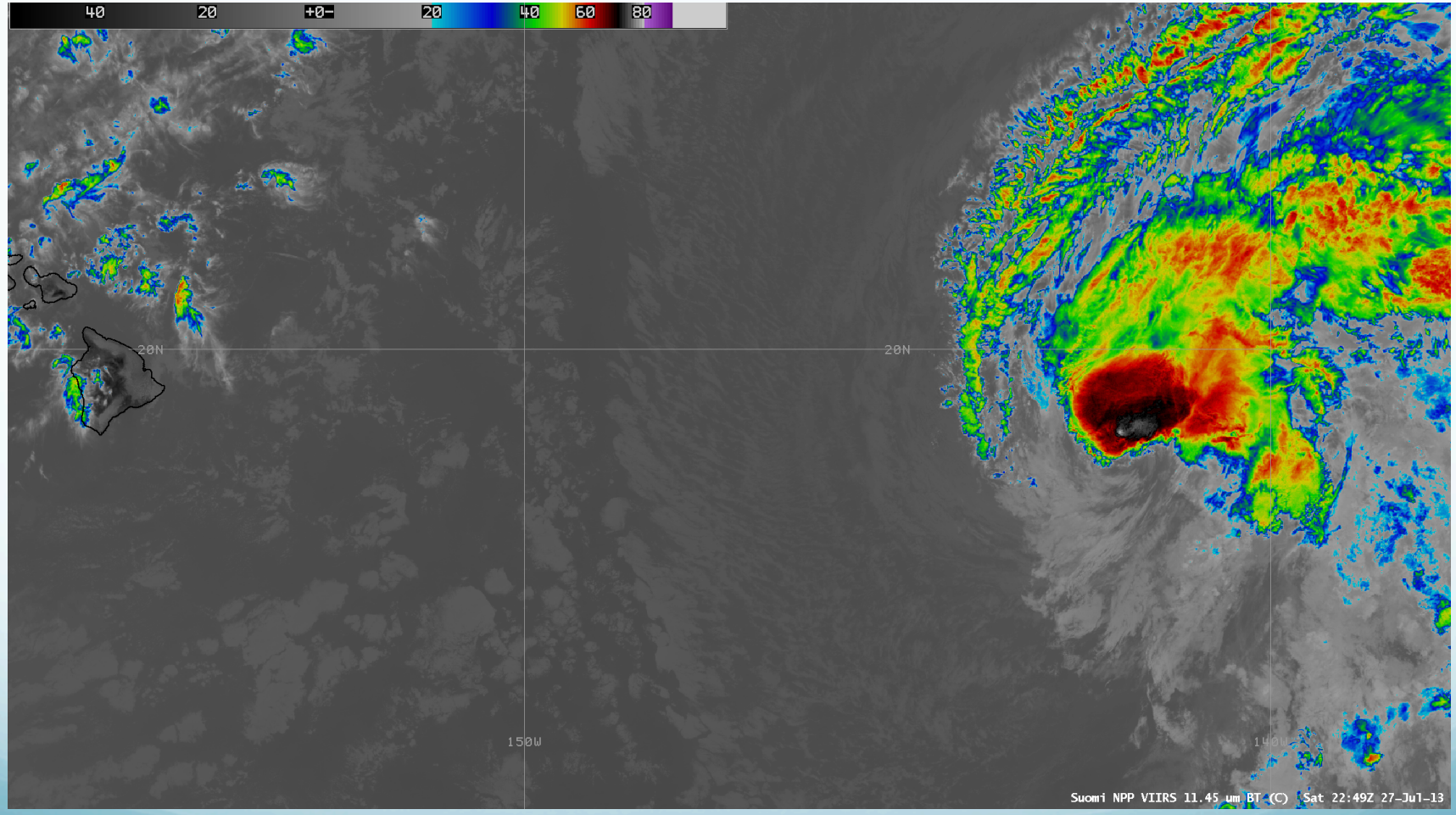


Korean Straight



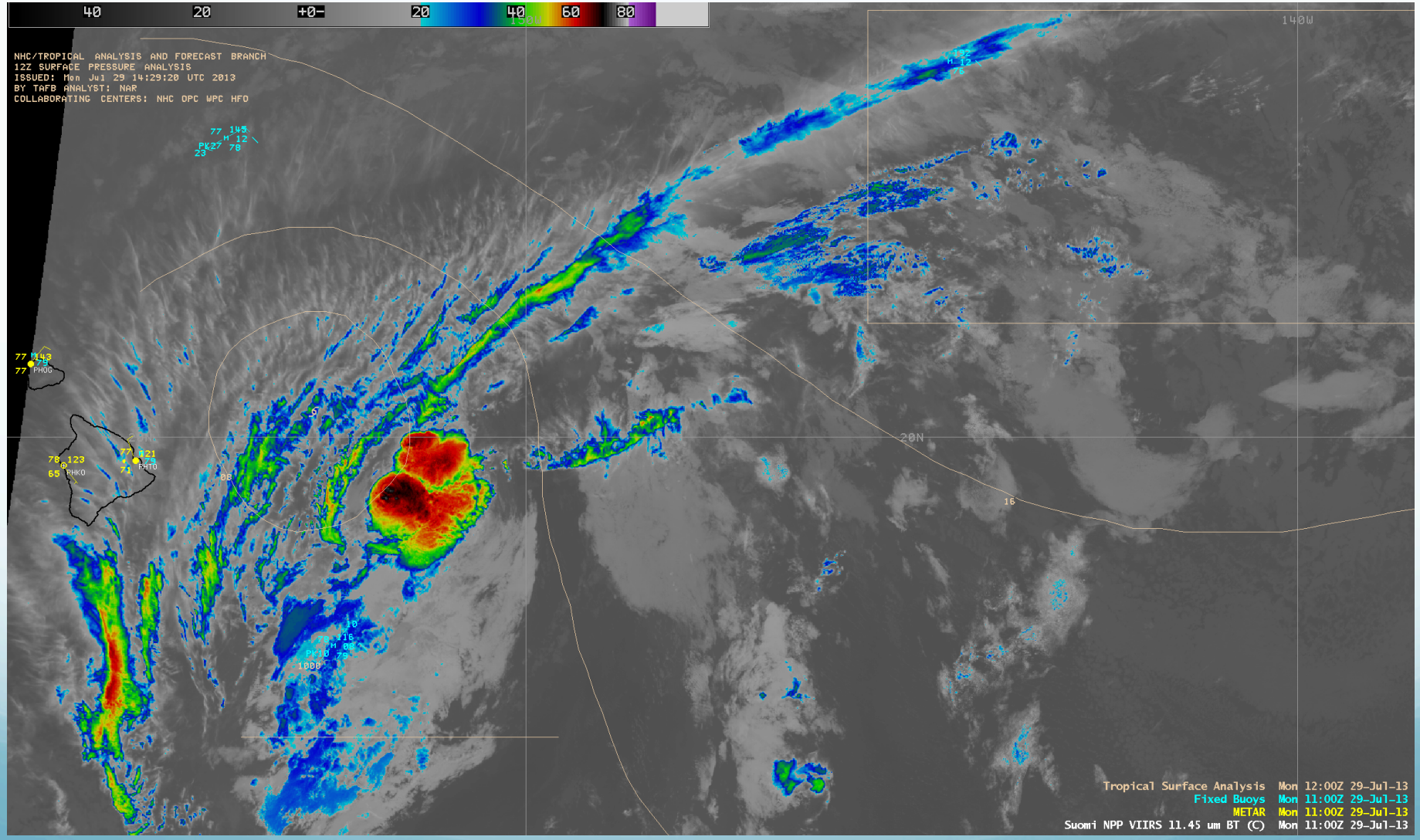

Window 2
Tools Settings
Lon: -82.83 Lat: 27.20 val: -8.79
2:DNB
Window 3
Tools Settings
Lon: -82.83 Lat: 27.20 val: -8.78
3:DNB
Window 4
Tools Settings
Lon: -82.83 Lat: 27.20 val: -9.33
Window 1
Tools Settings
Lon: -82.83 Lat: 27.20 val: -11.05
6
13
20
27
SSE
NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

Tropical Storm Flossie Approaching Hawaii
S-NPP VIIRS IR Window Loop
27-28 July 2013

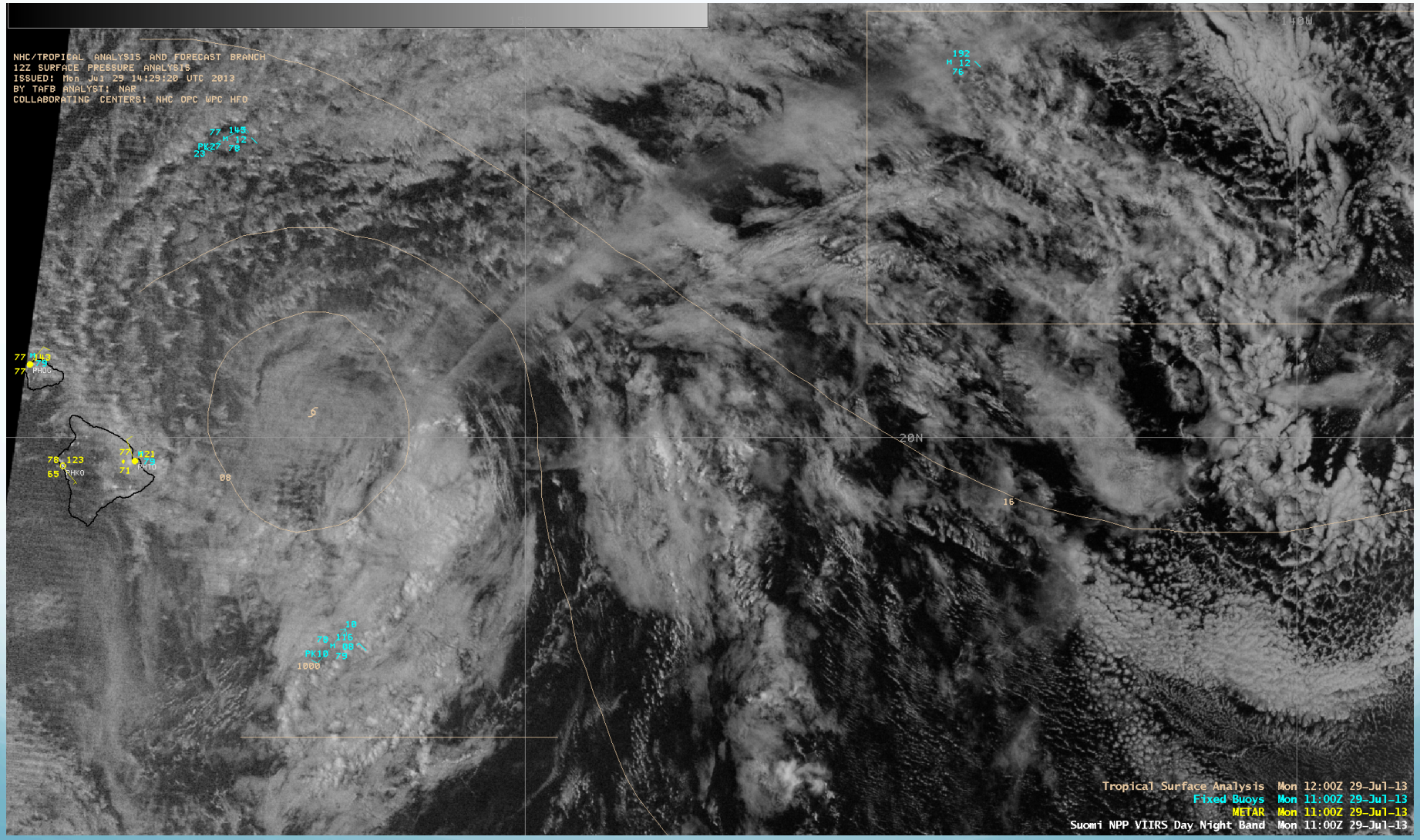


Data acquired by Honolulu Direct Broadcast Antenna
processed using CSPP software and displayed in AWIPS-I

Tropical Storm Flossie
VIIRS IR Window 29 July 2013



Tropical Storm Flossie VIIRS Day/Night Band 29 July 2013



S-NPP DB Data Used by NWS Central Pacific Hurricane Center

TROPICAL STORM FLOSSIE DISCUSSION NUMBER 19

NWS CENTRAL PACIFIC HURRICANE CENTER HONOLULU HI EP062013

500 AM HST MON JUL 29 2013

THE CENTER OF FLOSSIE WAS HIDDEN BY HIGH CLOUDS MOST OF THE NIGHT BEFORE VIRS NIGHTTIME VISUAL SATELLITE IMAGERY REVEALED AN EXPOSED LOW LEVEL CIRCULATION CENTER FARTHER NORTH THAN EXPECTED. WE RE-BESTED THE 0600 UTC POSITION BASED ON THE VISIBLE DATA. SUBJECTIVE DVORAK ANALYSES CONTINUED SHOW CURRENT INTENSITIES OF 3.0 BUT SATELLITE LOOPS SUGGEST A RAPID WEAKENING TREND WITH THE LOW LEVEL CENTER PULLING AWAY FROM A SMALL AREA OF CONVECTION SOUTHEAST OF THE CENTER. IT IS LIKELY THAT CONTINUED NORTHWEST SHEAR WILL MAINTAIN THIS WEAKENING TREND.

THE TRACK HAS BEEN SHIFTED NORTH TO REFLECT THE RE-LOCATED CENTER. THE TRACK GUIDANCE SHIFTED FOLLOWING THE TRACK CHANGE AND WAS CONSISTENT WITH A NEW TRACK FARTHER TO THE NORTH. THE TRACK NOW SHOWS FLOSSIE PASSING OVER MAUI TODAY...OVER OAHU TONIGHT...THEN PASSING SOUTH OF KAUAI EARLY TUESDAY MORNING. WE EXPECT FLOSSIE TO WEAKEN STEADILY AS IT TRACKS WEST NORTHWEST AND DISSPATE WITHIN 96 HOURS.

AREA FORECAST DISCUSSION

NATIONAL WEATHER SERVICE MARQUETTE MI

325 AM EST WED JAN 13 2016

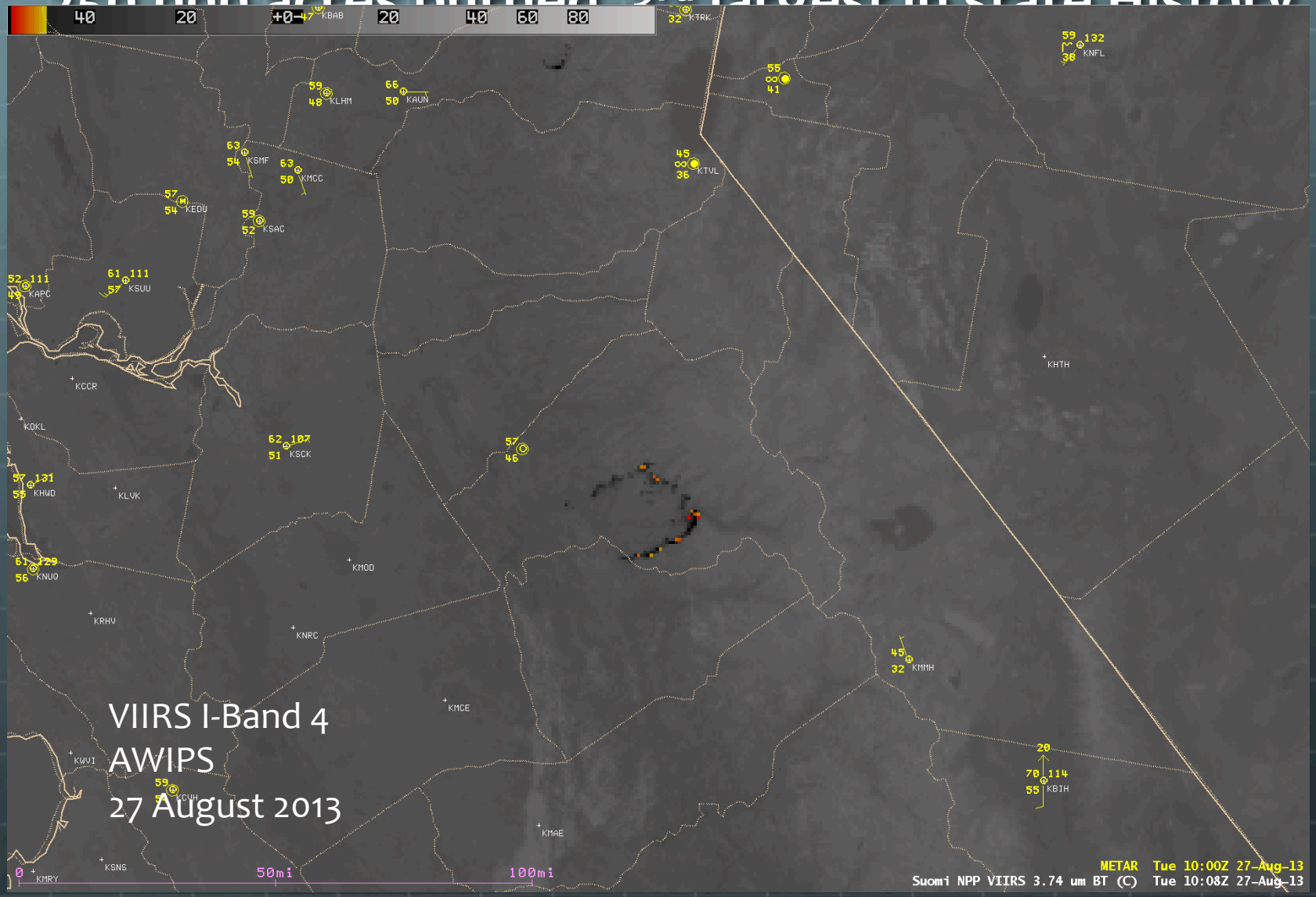
.SHORT TERM...(TODAY AND TONIGHT)

.....THE MAIN FOCUS WILL BE ALONG THE CONVERGENCE ZONE SETUP OVER NORTHERN HOUGHTON COUNTY. OFFICIAL OBSERVATIONS ARE LIMITED OUT WEST...BUT PERSONAL WEATHER STATIONS DO INDICATE THE CONVERGENCE BAND IS LOCATED OVER NORTHERN HOUGHTON COUNTY AND IN LINE WITH THE RADAR NORTH OF MARQUETTE COUNTY. THIS IS A LITTLE FARTHER NORTH THAN ORIGINALLY EXPECTED WITH SOME OF THE 00Z MODEL RUNS (ALTHOUGH IT WAS ICKED UP ON OUR LOCAL 6Z WRF RUN). ***WAS HOPING TO GET A VISUAL CONFORMATION FROM THE VIIRS DAY/NIGHT BAND BEFORE FINALIZING THE FORECAST...BUT WILL HAVE TO WAIT A LITTLE LATER THIS MORNING FOR THAT.***

Hot Spot Detection

Rim Fire in California

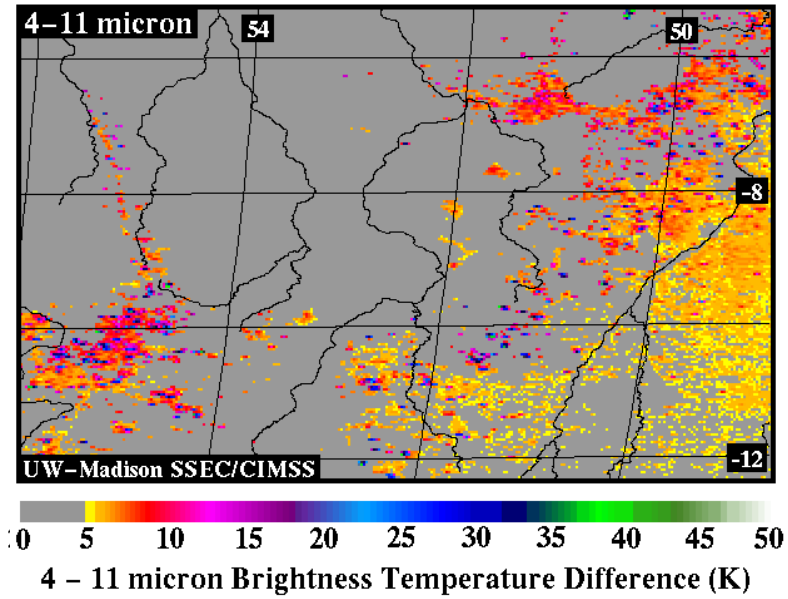
250,000 acres burned, 3rd largest in state History

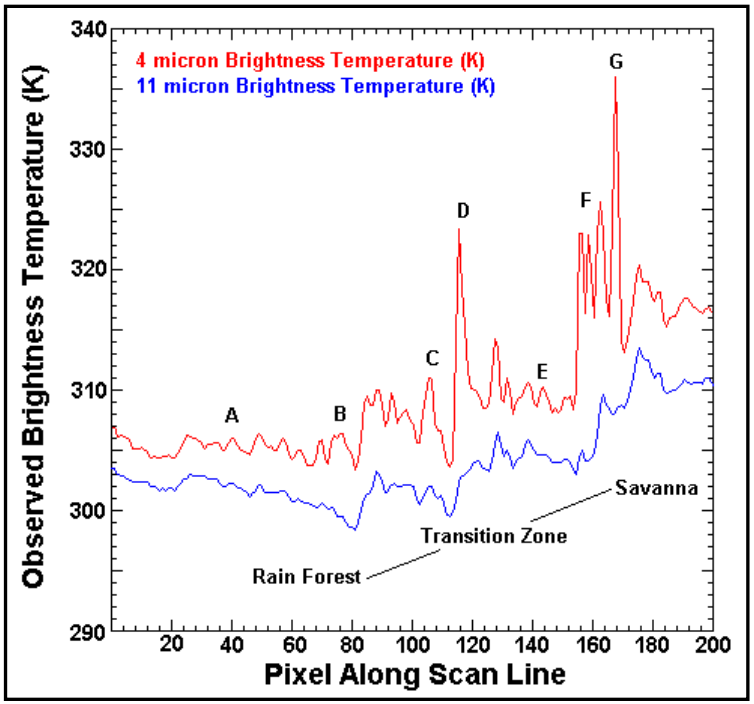


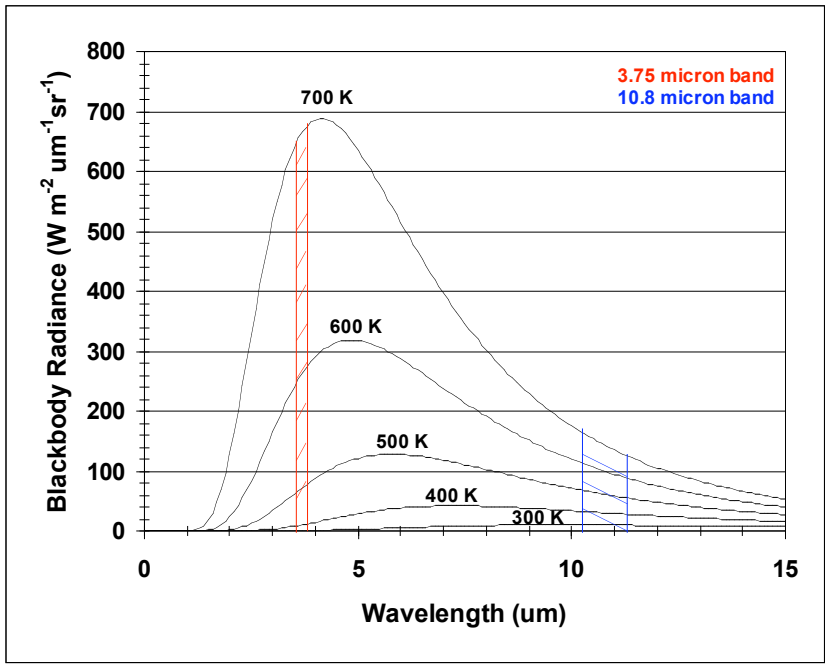
Hot Spot Detection
(Fire Product, Thermal anomolies)

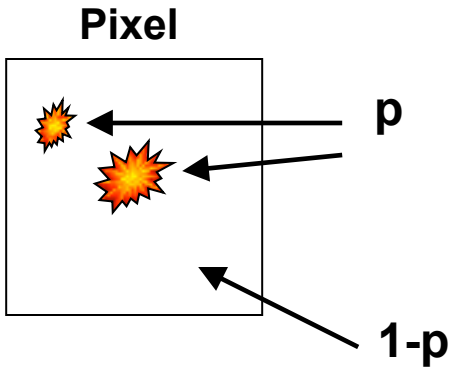
- Based upon the difference in Temperature Sensitivity between 4 and 11 microns
- Contextual Fire Detection Algorithm
  - Infrared static Brightness Temperature thresholds
  - Dynamic thresholds compare pixel to surrounding background

How are Meteorological Satellites Used to Monitor Fires?









$$B_4(T_4) = pB_4(T_{fire}) + (1-p)B_4(T_{bg})$$

$$B_{11}(T_{11}) = pB_{11}(T_{fire}) + (1-p)B_{11}(T_{bg})$$

Fire Output Parameters

1km resolution

- fire_mask 8 bit unsigned integer
  - 0 missing input data
  - 3 water
  - 4 cloud
  - 5 non-fire
  - 6 unknown
  - 7 fire (low confidence)
  - 8 fire (nominal confidence)
  - 9 fire (high confidence)
- Line and element of fire pixel
- Latitude and longitude of fire pixel
- Fire pixel confidence (one value for each fire detected per scene)

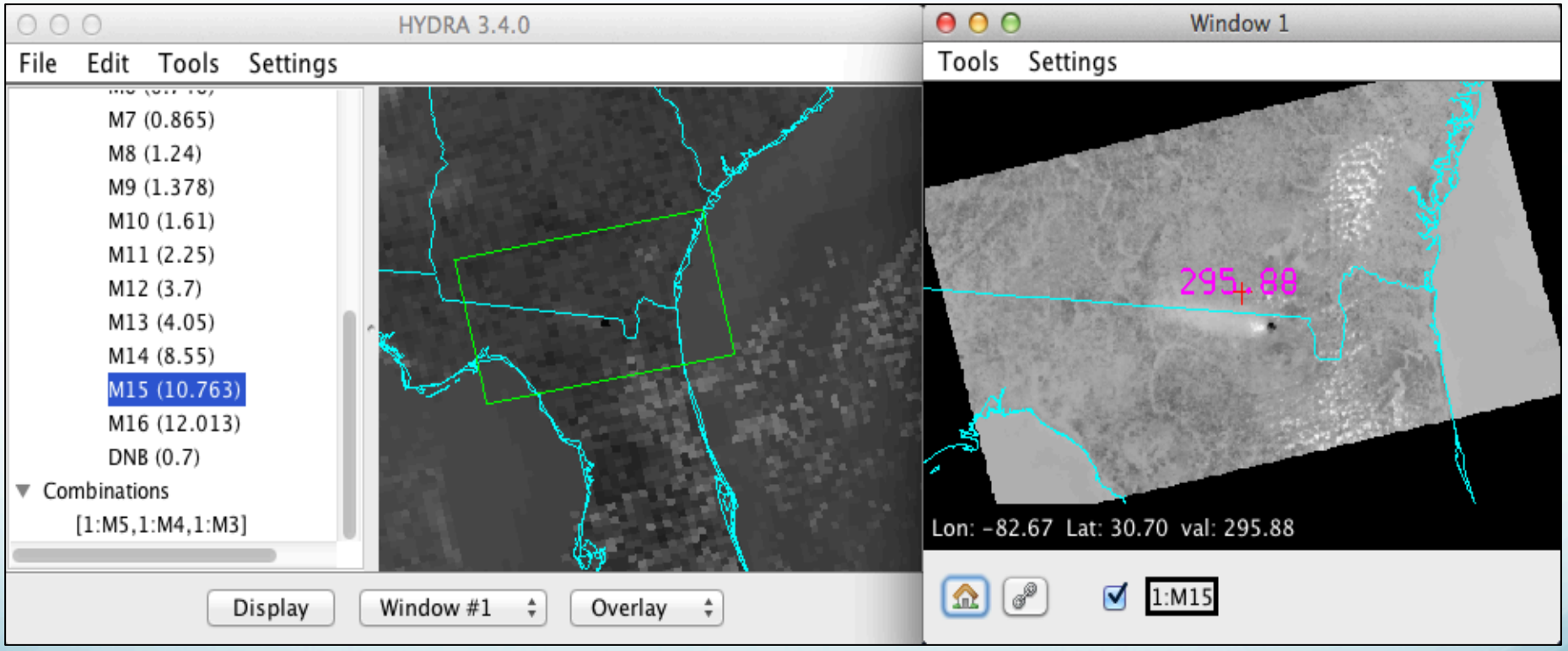
MODIS Emissive Bands

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

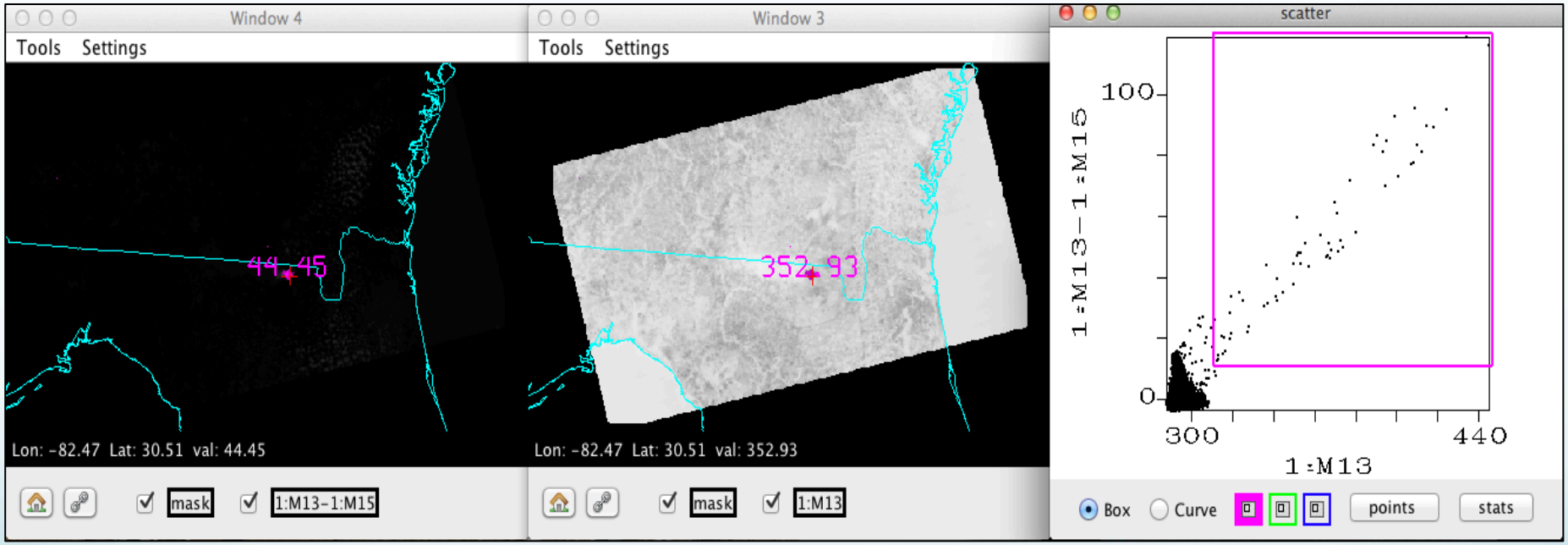
Algorithm Description

- MODIS bands 21 and 22 (3.99 micron)
  - Band 22 saturates at 331 K
  - Band 21 "fire channel" saturates at ~ 500 K
    - 12 bit range broader – less sensitive
    - The calibration of B21 uses fixed calibration coefficients and not using the scan-by-scan onboard black body (more noise)
    - So use Band 22 unless it is saturated
- MODIS band 31 (11 micron)
  - Saturates at ~ 400 K for Terra
  - Saturates at ~ 340 K for Aqua

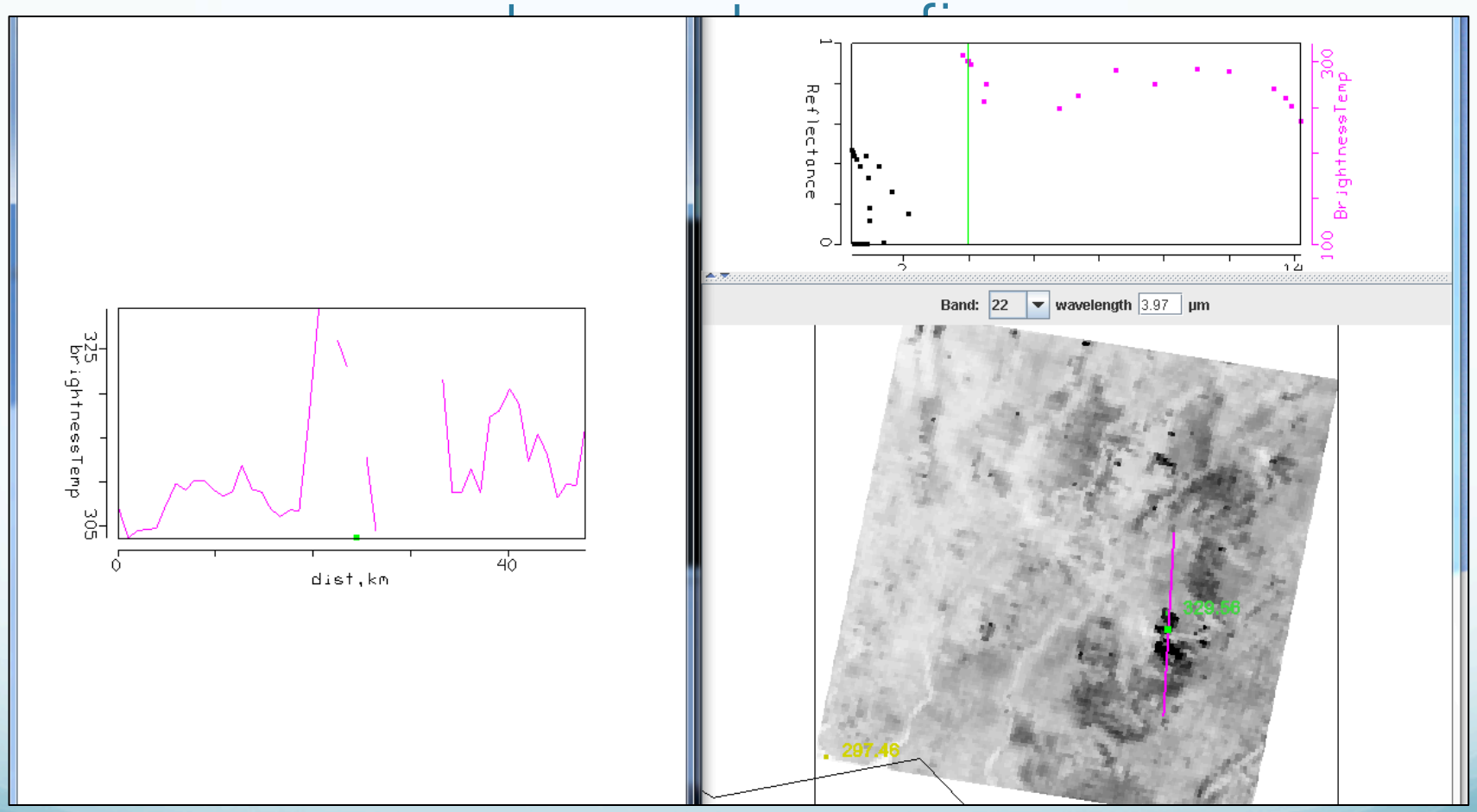
S-NPP Band 13
4.05 microns



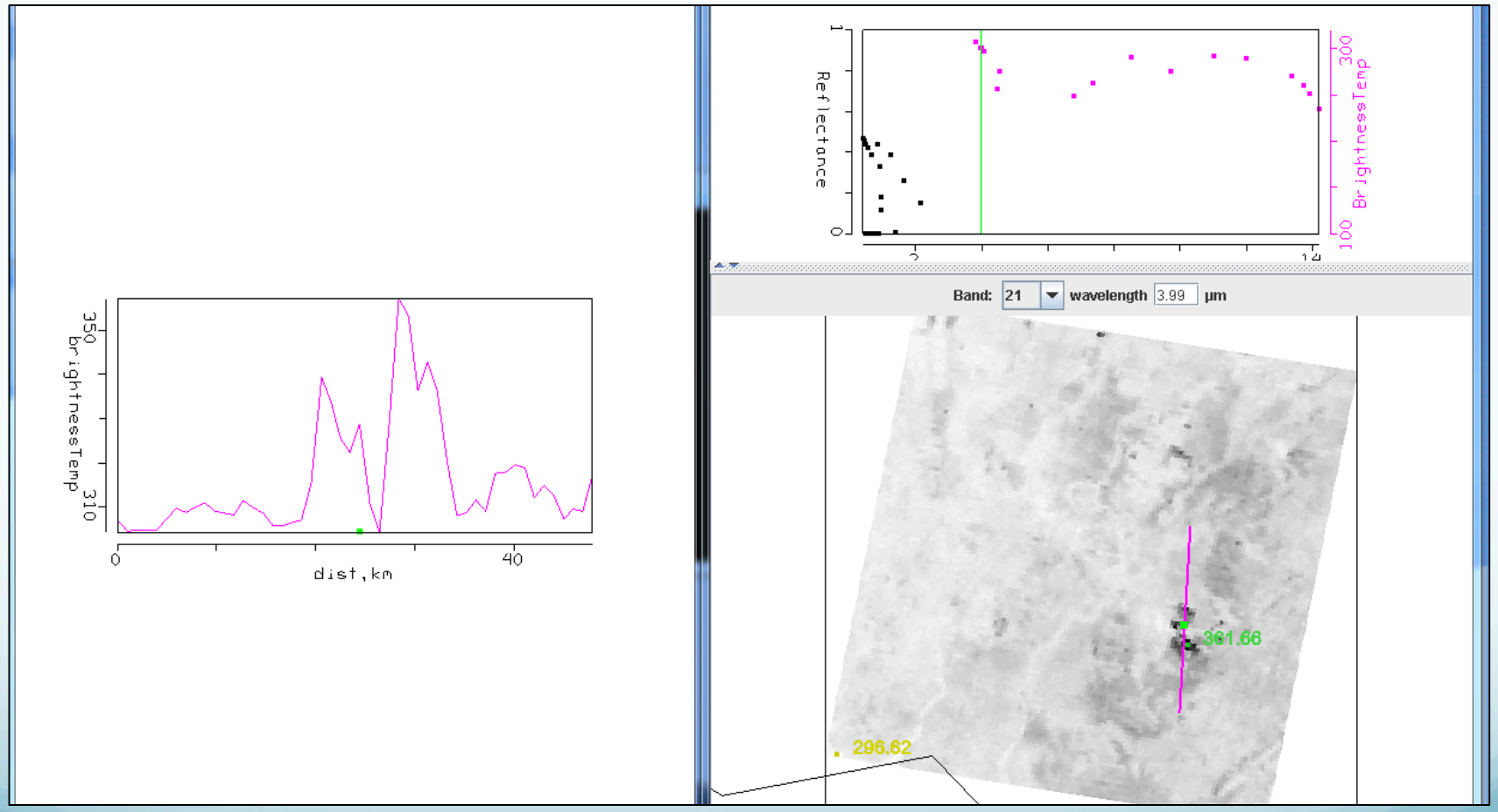
S-NPP IR Bands
11 August 2013



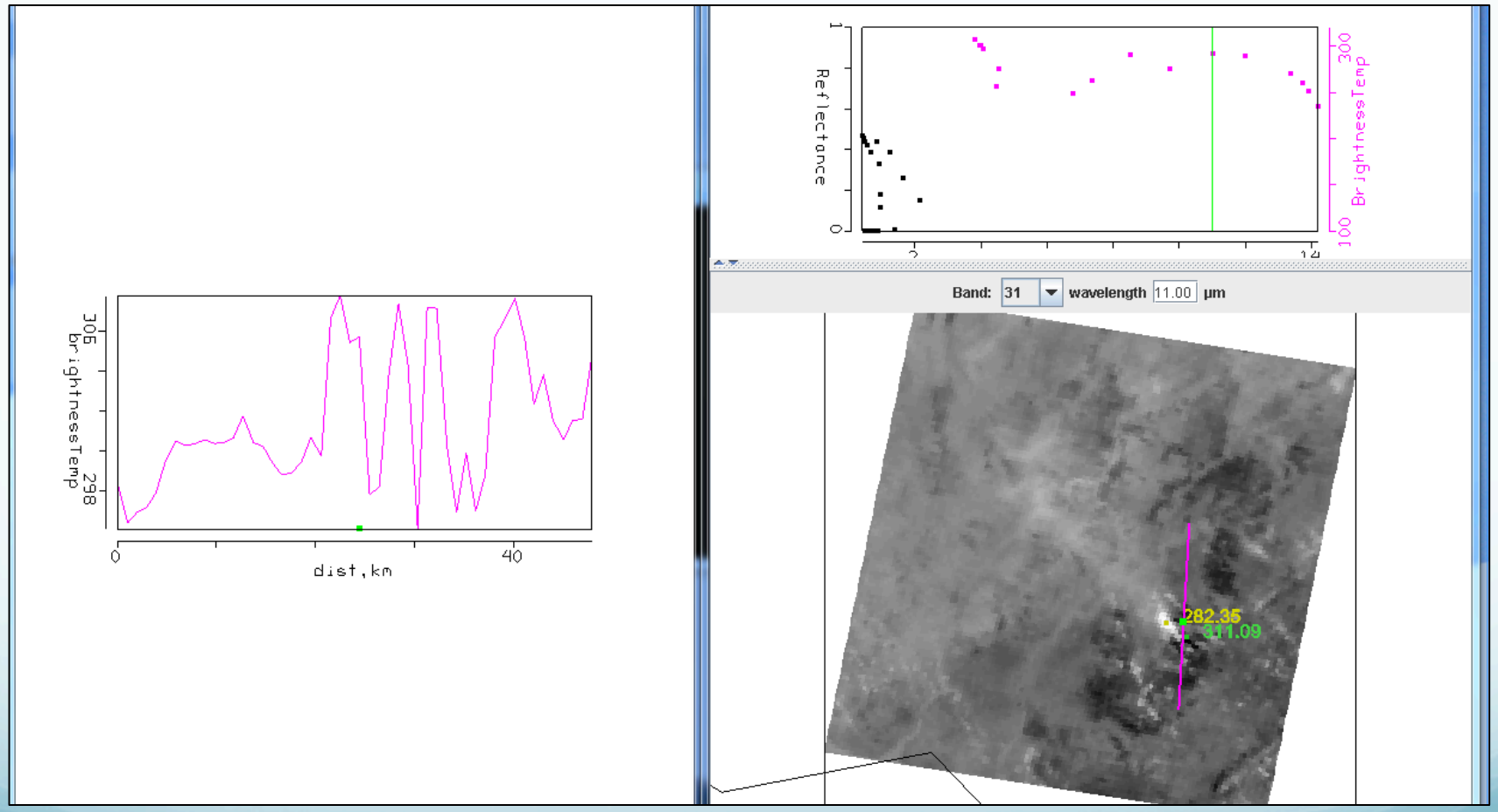
MODIS Terra Band 22 (3.99 micron)



MODIS Terra Band 21 (3.99 µm)
transect over fires



MODIS Terra Band 31 (11 μm)
transect over fires



Algorithm Description (cont.)

- Potential Fire Pixel identified
  - BT4 > 310 K (~37 C)
  - BT4-11 > 10 K
  - .86 micron reflectance < .3
- Otherwise flagged as non-fire pixel

Screening Potential Fire Pixels

(1) BT4 > 360 K (~87 C)

Contextual Tests: Performed on as many as 21 x 21 box surrounding potential fire pixel to separate out from background

(2) $$BT4-11 > \overline{BT4-11} + 3.5\partial_{BT4-11}$$

(3) $$BT4-11 > \overline{BT4-11} + 6K$$

(4) $$BT4 > \overline{BT4} + 3\partial_{BT4}$$

(5) $$BT11 > \overline{BT11} + \partial_{BT11} - 4K$$

(6) $$\partial'_4 > 5K$$

Where δ is the Mean Absolute Difference (MAD):

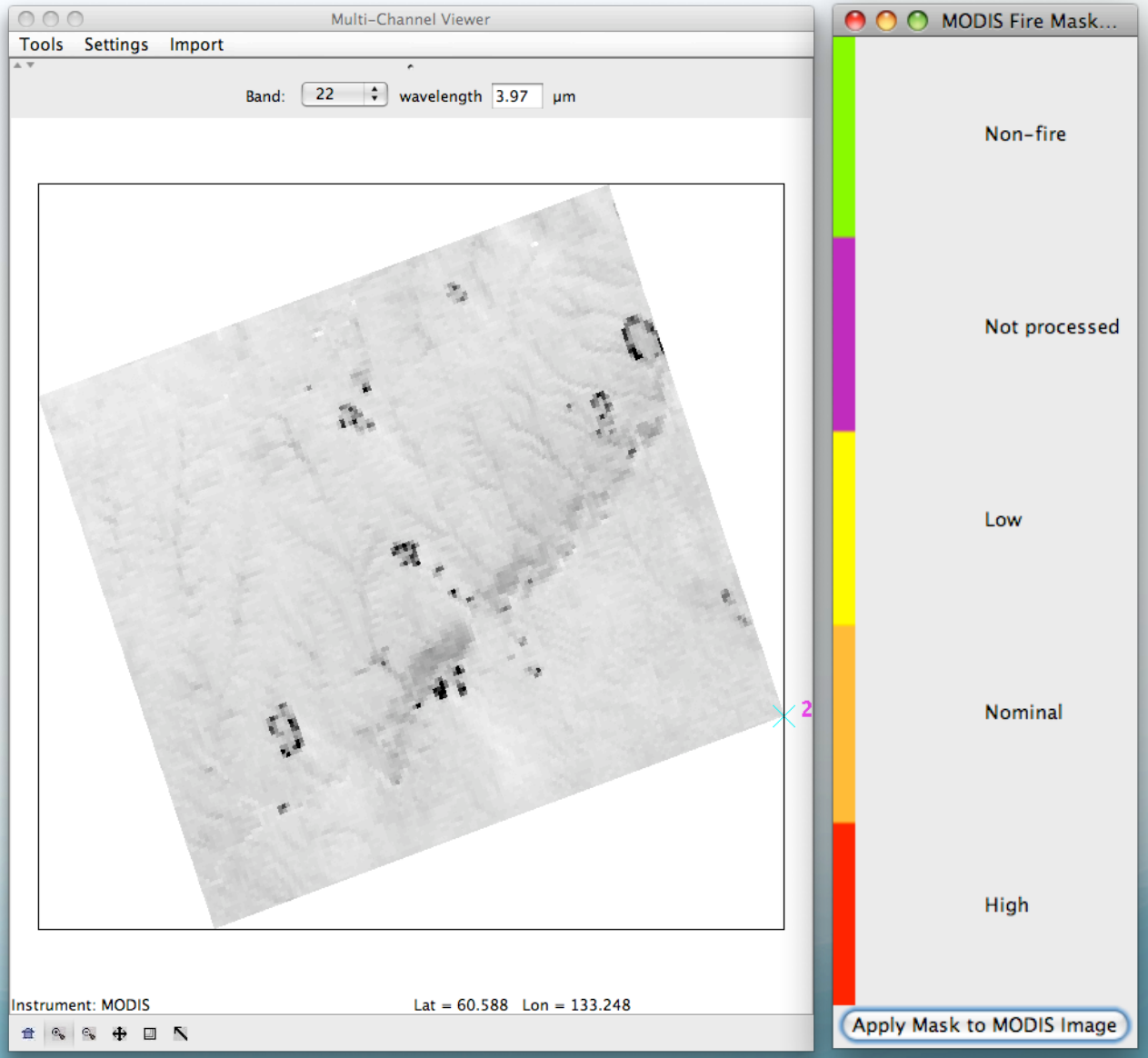
$$\text{MAD} = \frac{1}{N}\sum_i |x_i - \bar{x}|$$

Problem Areas

- If there are many fires – hard to get representative background temperature in max 21x21 pixel region
- Sunglint – Affects 4 micron band radiance
- Transition areas – contextual tests pick up boundaries
- Coastal areas – need really good geolocation so no mixed pixels are included
- Clouds – BT4-11 large over water and thick ice cloud

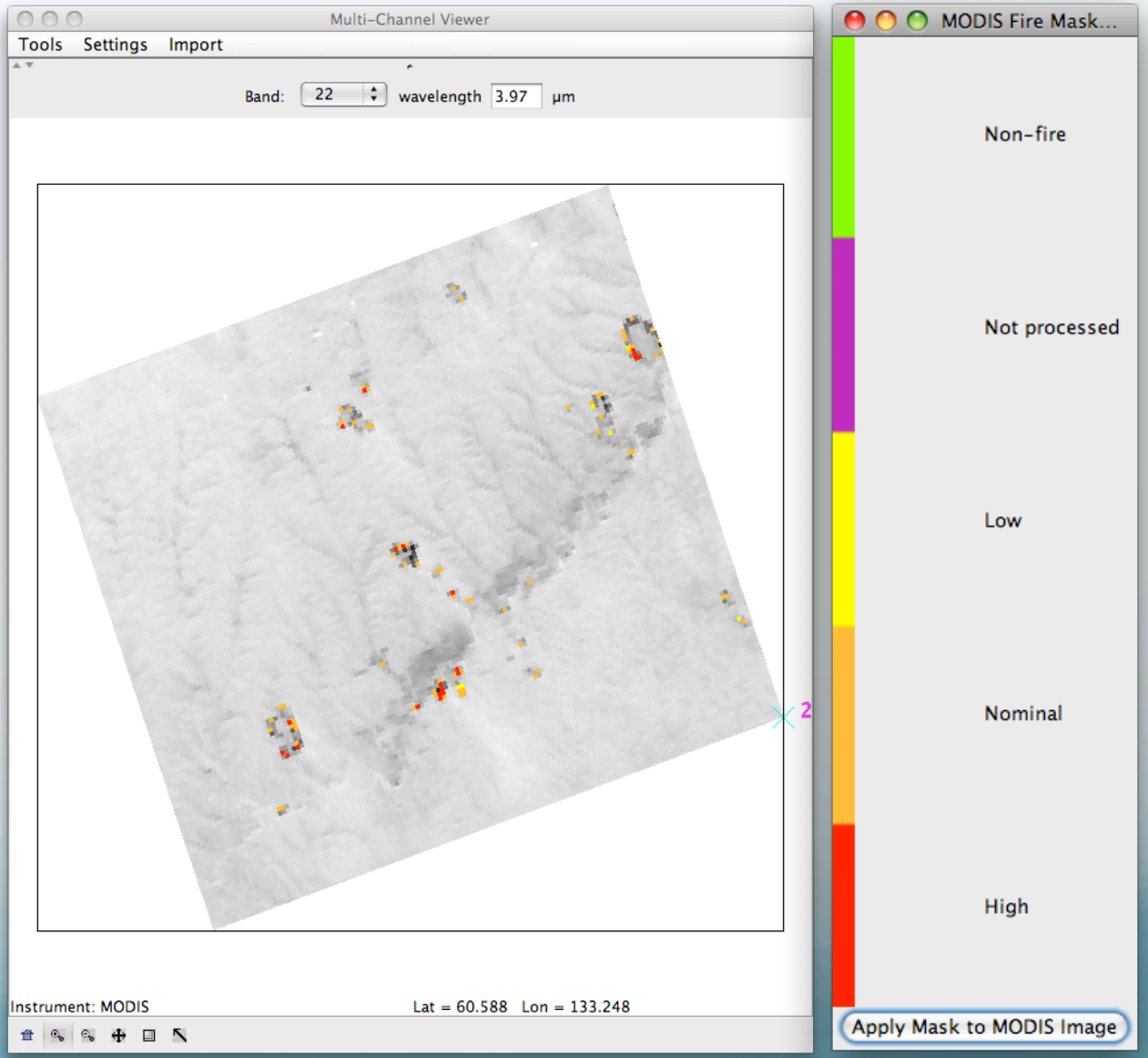
MODIS Fire Product

11 May 2011
03:40 UTC
Aqua MODIS



MODIS Fire Product

11 May 2011
03:40 UTC
Aqua MODIS



Fire Detection

AREA FORECAST DISCUSSION

NATIONAL WEATHER SERVICE LUBBOCK TX

315 PM CDT MON APR 11 2011

.FIRE WEATHER...*GOES 3.9 MICRON AND MODIS/POES 3.7 MICRON SATELLITE IMAGES SHOW ONLY ONE FIRE START SO FAR THIS AFTERNOON ALONG THE KENT/SCURRY COUNTY LINE. GOOD NEWS IS THAT THEY ARE NOT SHOWING ANY LARGE FLARE-UPS ON THE SWENSON/STONEWALL AND KING COUNTY FIRE.* DECREASING WIND SPEEDS WILL ALSO HELP WITH ANY CONTINUED FIREFIGHTING EFFORTS THROUGH TONIGHT. BY LATE TOMORROW MORNING...CONDITIONS CONTINUE TO LOOK MARGINAL TOMORROW FOR MEETING RED FLAG CRITERIA...BUT SOUTH WIND OF 15 TO 25 MPH AND RH VALUES BETWEEN 10 TO 15 PERCENT WILL RESULT IN AT LEAST AN INCREASED FIRE DANGER OVER THE REGION. WILL HOLD ONTO THE FIRE WEATHER WATCH FOR ANOTHER COUPLE OF SHIFTS TO MAKE SURE THE FORECAST REMAINS CONSISTENT IN THE COMPUTER MODELS FOR TOMORROW.

- Due to wildfires, the NWS WFO in Lubbock, Texas, is using the AWIPS alerting system, GUARDIAN, to inform forecasters of each new MODIS and AVHRR shortwave IR image that arrives.

Contact Information

Kathy Strabala

kathys@ssec.wisc.edu