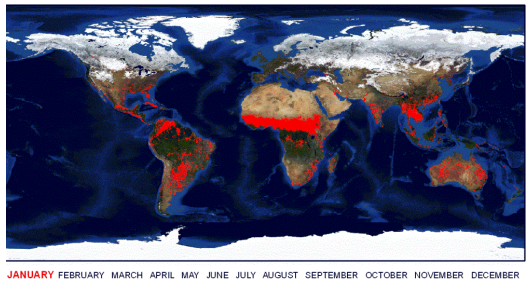
NOAA Fire Products from New Generation Polar and Geostationary Satellite Missions

- Ivan Csiszar

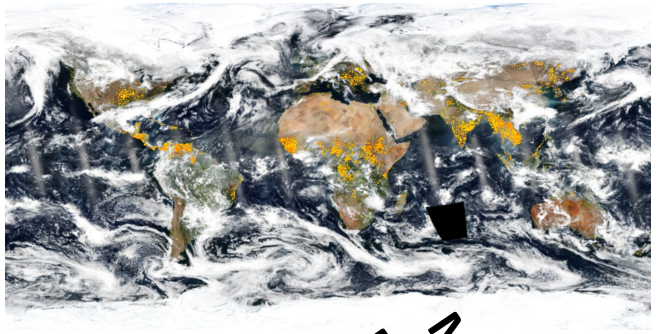
NOAA/NESDIS Center for Satellite Applications and Research (STAR)

- with contributions from the NOAA JPSS and GOES-R Programs and Science Teams
- see slides for individual credits

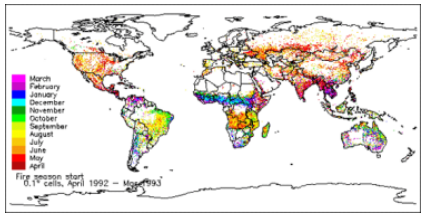
MODIS (MOD14/MYD14)



VIIRS



GLOBAL (AVHRR) FIRE PRODUCT (1992-93)



bioval.jrc.ec.europa.eu/

1980s

AVHRR production

AVHRR global analyses

1990s

GOES production

GOFC-GOLD Fire

MODIS production

MODIS validation

2000s

GCOS Fire ECV

MODIS CMG

GOES reprocessing

2010s

GOES-R ABI

NPP VIIRS

Suomi

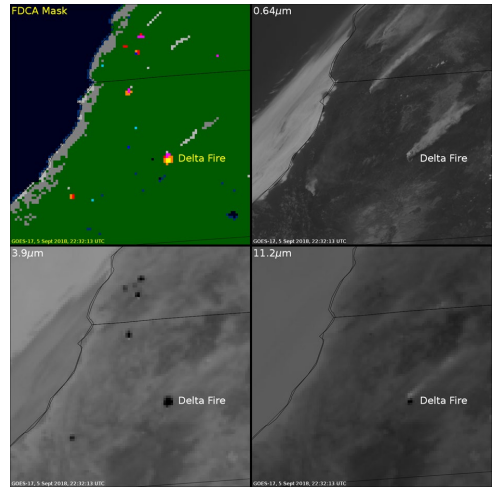
JPSS VIIRS

PRESENT

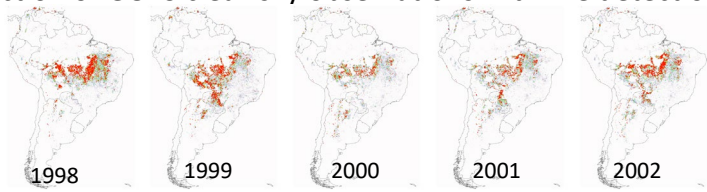
polar

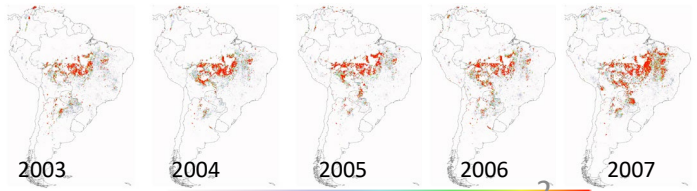
geostationary

GOES-16 fire



Fraction of GOES clear-sky observations with fire detections





New generation of operational NOAA satellites and sensors used for fire detection

Joint Polar Satellite System (JPSS)

- Suomi NPP (November 2011)
- NOAA-20 (November 2017)

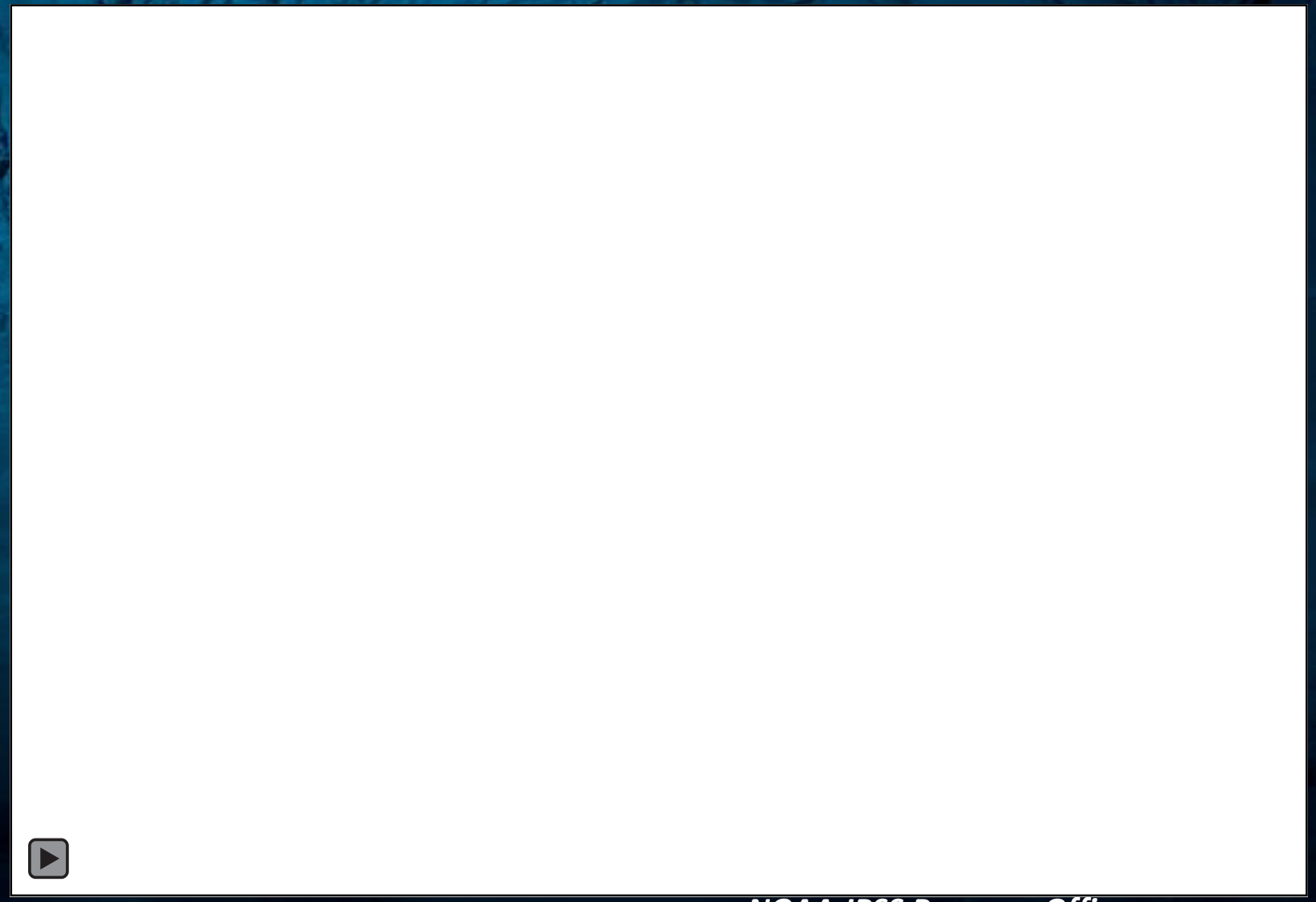
Geostationary Operational Environmental Satellite – R (GOES-R)

- GOES-16 (East; November 2016)
- GOES-17 (West; March 2018)

	JPSS Visible Infrared Imaging Spectrorariometer (VIIRS)	GOES-R Advanced Baseline Imager (ABI)
Spectral Coverage	22 bands 0.41 ~ 12.01 µm	16 bands 0.47 ~ 13.3 µm
Spatial Resolution	M-band: 750 m at nadir I-band: 375 m at nadir	0.64 µm Visible: 0.5 km Other visible/near-IR: 1.0 km Bands (>2 µm): 2 km
Spatial Coverage	at least every 12 hours	Full Disk: 10 minutes Conterminous US (CONUS): 5 minutes Mesoscale: 30 or 60 sec

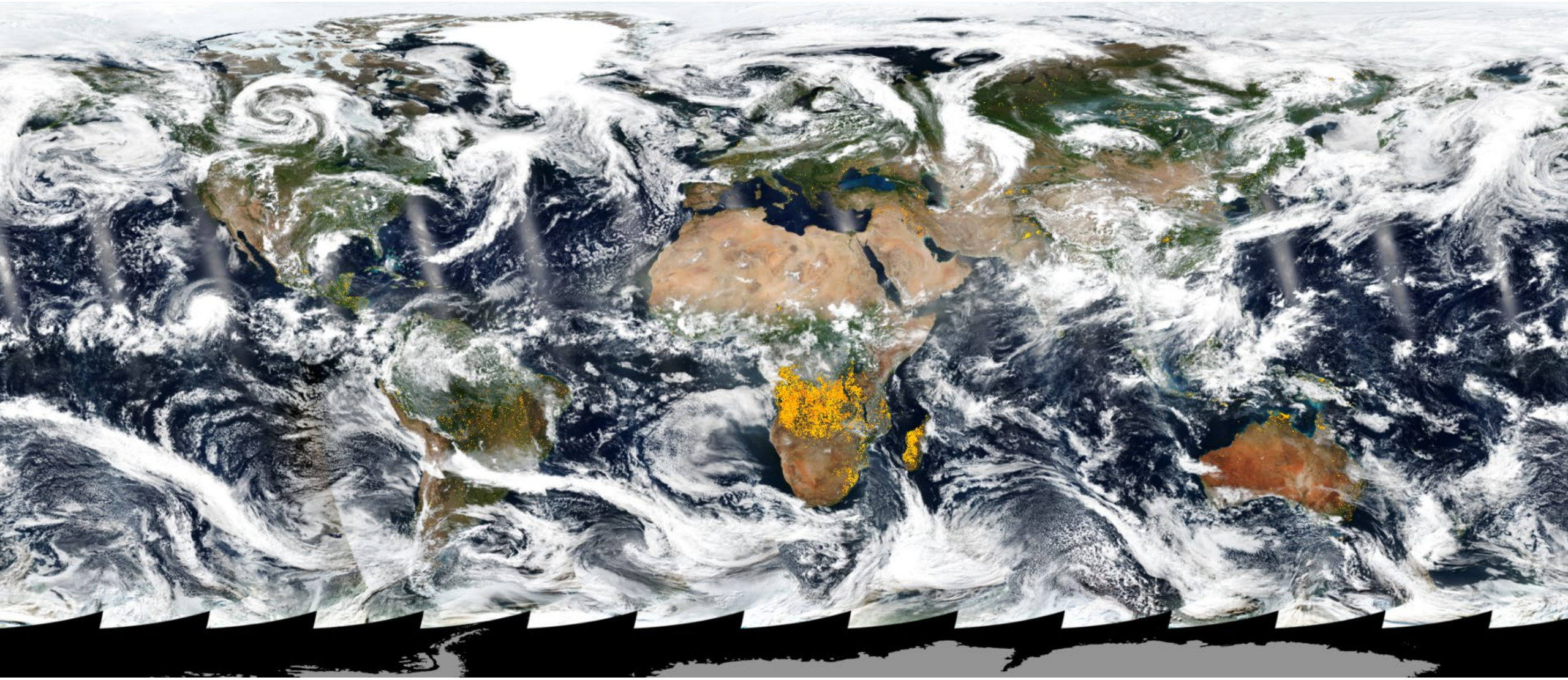
NOAA-20 is Now Operational!

- Launched into Low Earth Orbit—512 miles
- **14x** Orbits Earth 14 times pole-to-pole with Suomi NPP
- **2x** Images entire globe twice a day
- State of the art instrumentation to collect data on Earth's atmosphere, land surface, and oceans
- Sends more than 2,000 gigabytes of data to Earth every day
- Flies in the same orbit as Suomi NPP, 50 minutes apart



NOAA JPSS Program Office

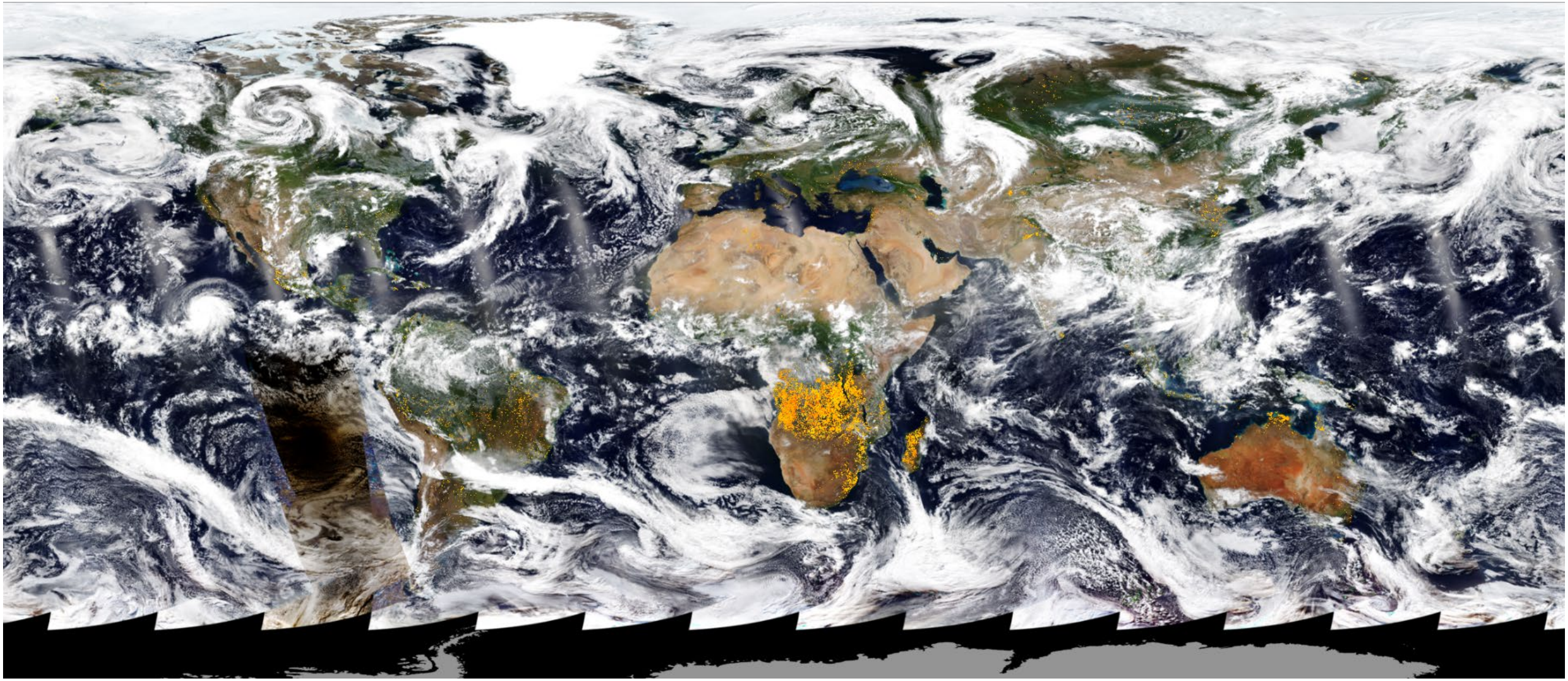
Suomi NPP



July 2, 2019

https://www.star.nesdis.noaa.gov/jpss/mapper/

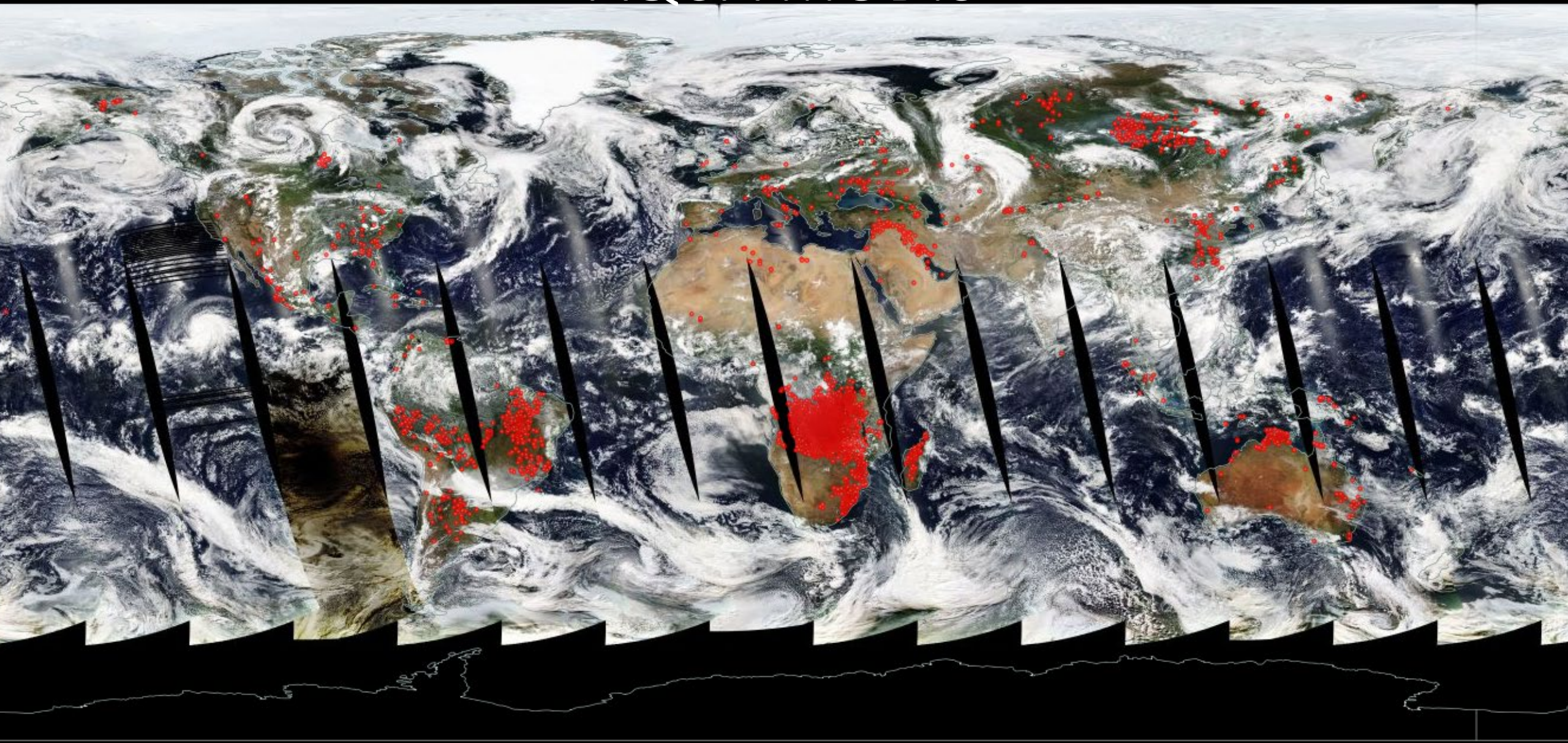
NOAA-20 VIIRS



July 2, 2019

https://www.star.nesdis.noaa.gov/jpss/mapper/

AQUA MODIS



July 2, 2019

https://worldview.earthdata.nasa.gov/

Primary VIIRS bands used for heritage MODIS / AVHRR – like active fire algorithms

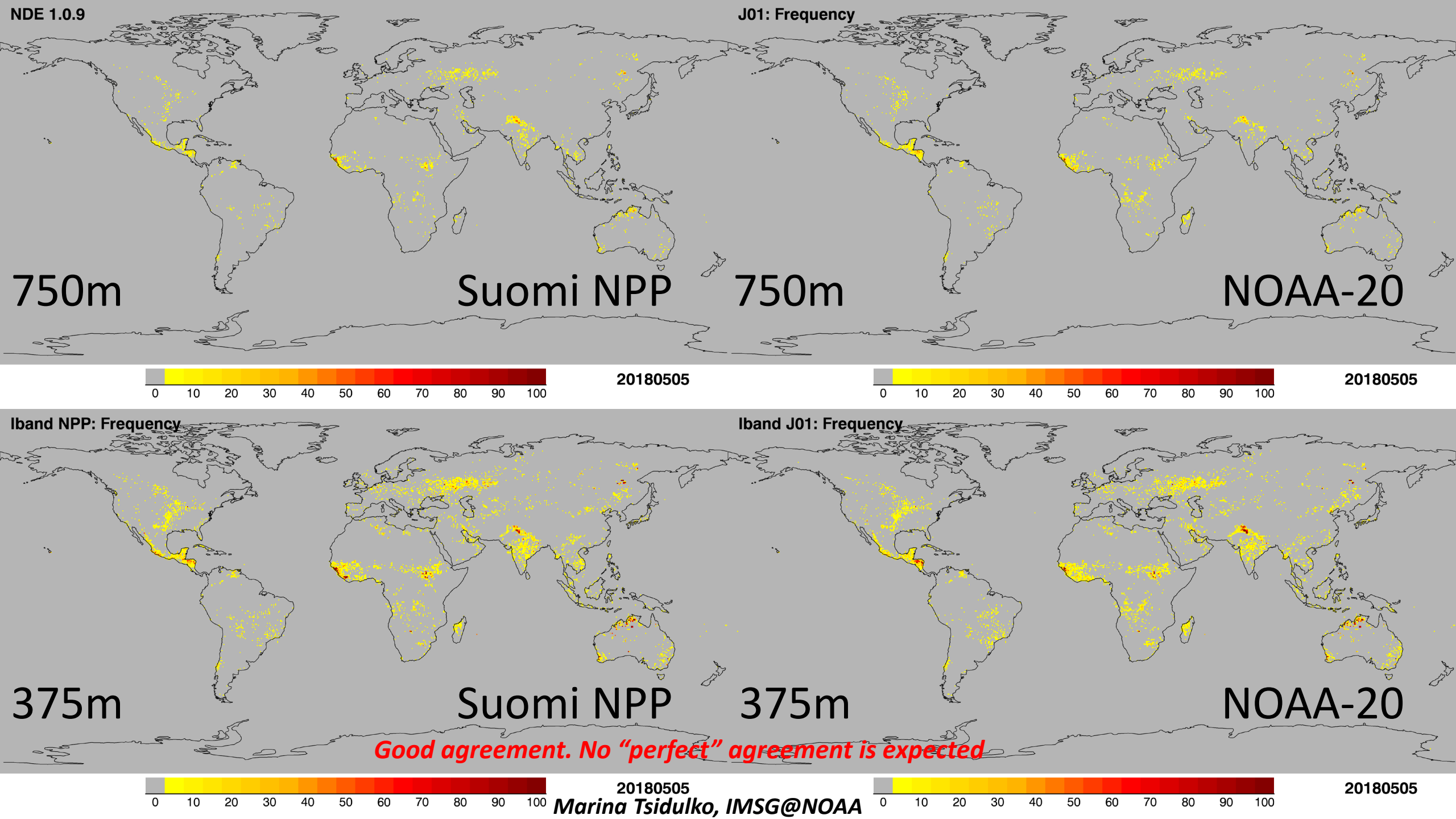
VIIRS			MODIS Equivalent			AVHRR-3 Equivalent			OLS Equivalent		
Band	Range (um)	HSR (m)	Band	Range	HSR	Band	Range	HSR	Band	Range	HSR
DNB	0.500 - 0.900								HRD PMT	0.580 - 0.910 0.510 - 0.860	550 2700
M1	0.402 - 0.422	750	8	0.405 - 0.420	1000						
M2	0.436 - 0.454	750	9	0.438 - 0.448	1000						
M3	0.478 - 0.498	750	3 10	0.459 - 0.479 0.483 - 0.493	500 1000						
M4	0.545 - 0.565	750	4 12	0.545 - 0.565 0.546 - 0.556	500 1000						
I1	0.600 - 0.680	375	1	0.620 - 0.670	250	1	0.572 - 0.703	1100			
M5	0.662 - 0.682	750	13 14	0.662 - 0.672 0.673 - 0.683	1000 1000	1					
M6	0.739 - 0.754	750	15	0.743 - 0.753	1000						
I2	0.846 - 0.885	375	2	0.841 - 0.876	250	2					
M7	0.846 - 0.885	750	16	0.862 - 0.877	1000	2					
M8	1.230 - 1.250	750	5	SAME	500						
M9	1.371 - 1.386	750	26	1.360 - 1.390	1000						
I3	1.580 - 1.640	375	6	1.628 - 1.652	500						
M10	1.580 - 1.640	750	6	1.628 - 1.652	500	3a					
M11	2.225 - 2.275	750	7	2.105 - 2.155	500						
I4	3.550 - 3.930	375	20	3.660 - 3.840	1000	3b	SAME	1100			
M12	3.660 - 3.840	750	20	SAME	1000	3b	3.550 - 3.930	1100			
M13	3.973 - 4.128	750	21 22 23	3.929 - 3.989 3.929 - 3.989 4.020 - 4.080	1000 1000 1000						
M14	8.400 - 8.700	750	29	SAME	1000						
M15	10.263 - 11.263	750	31	10.780 - 11.280	1000	4	10.300 - 11.300	1100			
I5	10.500 - 12.400	375	31 32	10.780 - 11.280 11.770 - 12.270	1000 1000	4 5	10.300 - 11.300 11.500 - 12.500	1100 1100	HRD	10.300 - 12.900	550
M16	11.538 - 12.488	750	32	11.770 - 12.270	1000	5	11.500 - 12.500	1100			

M-band: 750m resolution
high 4 µm (M13) saturation
good signal for FRP

Hybrid: I-band for detection
M-band for FRP

I-band: 375m resolution
low 4 µm (I4) saturation
poor signal for FRP

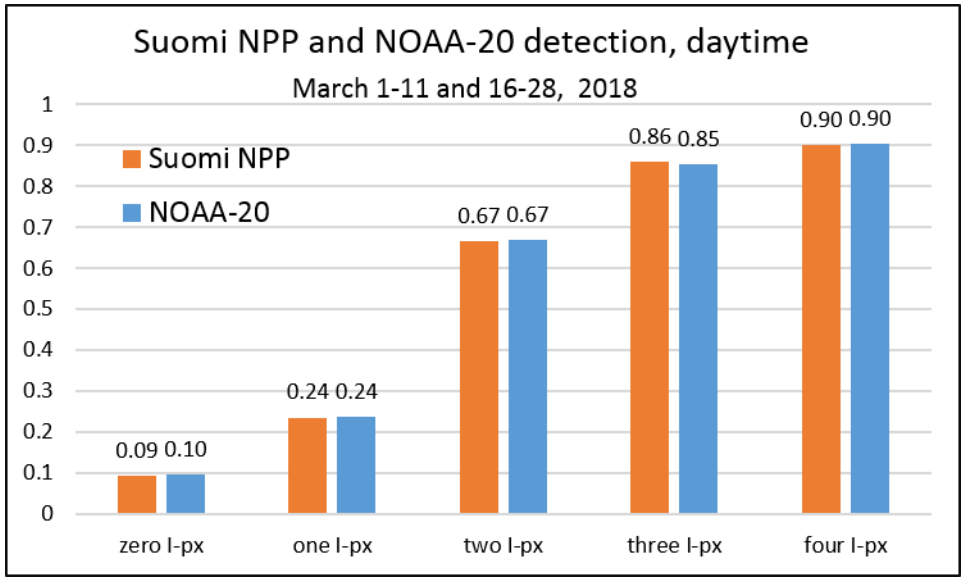
There are many approaches for fire detection and visualization from VIIRS

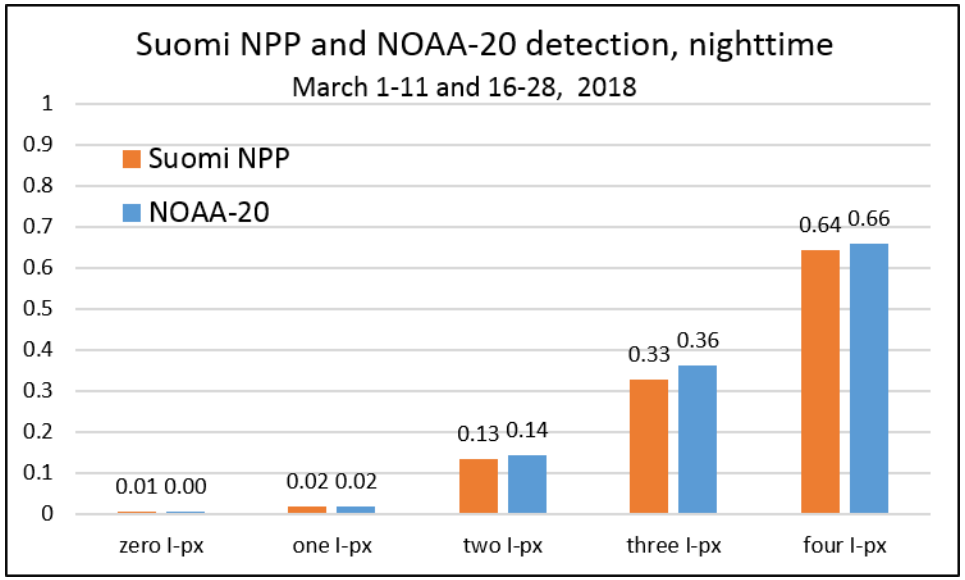

NDE 1.0.9
750m
Suomi NPP
J01: Frequency
750m
NOAA-20
0 10 20 30 40 50 60 70 80 90 100
20180505
0 10 20 30 40 50 60 70 80 90 100
20180505
Iband NPP: Frequency
375m
Suomi NPP
Iband J01: Frequency
375m
NOAA-20
Good agreement. No "perfect" agreement is expected
0 10 20 30 40 50 60 70 80 90 100
20180505
Marina Tsidulko, IMSG@NOAA
0 10 20 30 40 50 60 70 80 90 100
20180505

M-band vs. I-band detection rates

- Detection rates relative to the experimental 375m I/M “hybrid” product as a function of the number of I-band resolution detections within the M-band pixel footprint
- Frequency of M-band detections without a single I-band detection were used as a proxy for commission errors
- Increase of detection rates with increasing number of I-band detections
- Good consistency of detection rates between Suomi NPP and NOAA-20
- Significant differences between daytime and nighttime detection rates, indicating a more conservative performance of the nighttime M-band algorithm

Daytime (left) and nighttime (right) relative detection performance between the operational 750m M-band and the experimental 375m I/M-band VIIRS active fire products

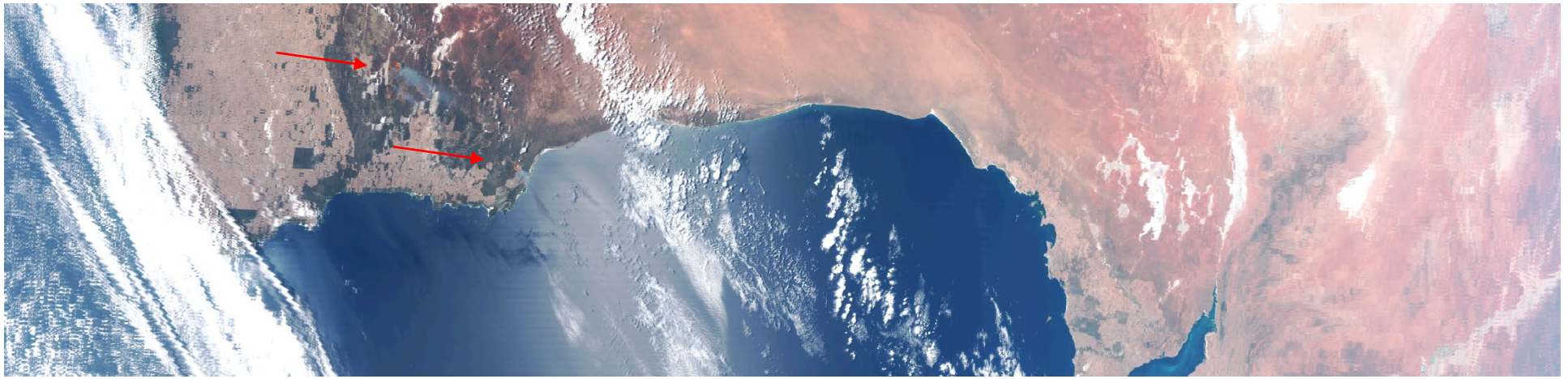




Marina Tsidulko, IMSG@NOAA

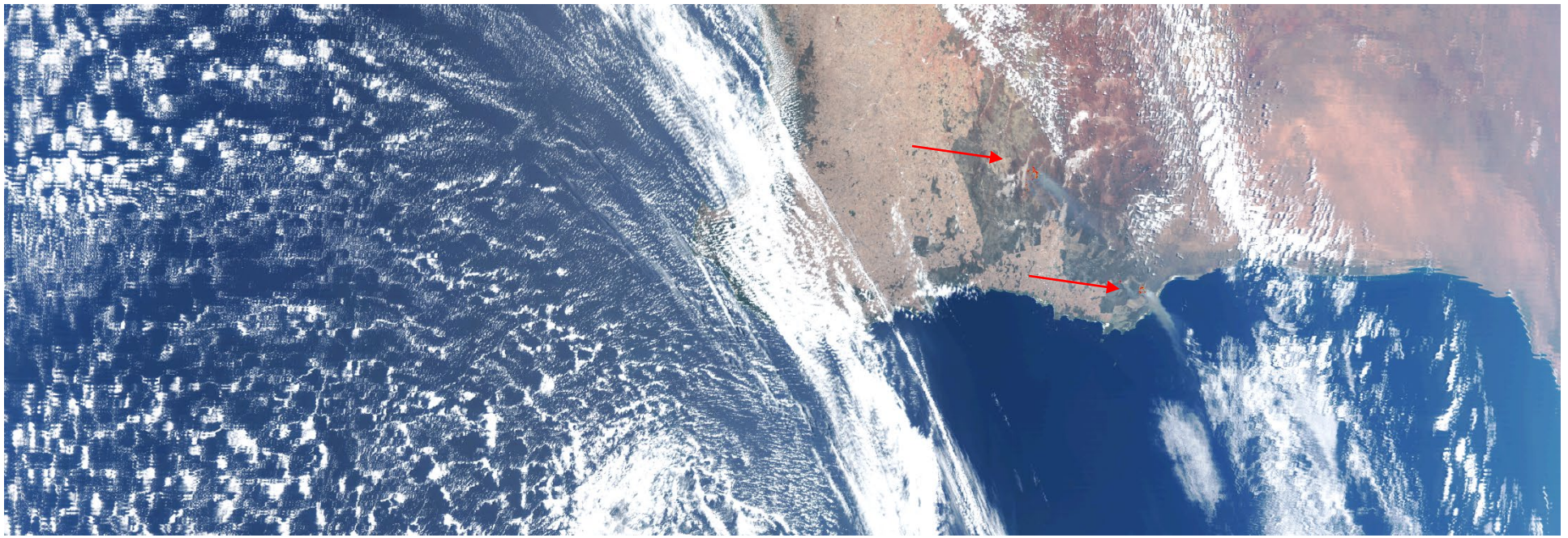
Fires: disasters, emissions, air quality

Suomi NPP 5:11 UTC



VIIRS 750m
Active fires on
January 5, 2018

NOAA-20 6:01 UTC



"first light" NOAA-20 fire image by the Science Team

Level 2 product

Carr fire, California, July 23, 2018

Suomi NPP, 20:14 UTC

NPP_20180723_2014

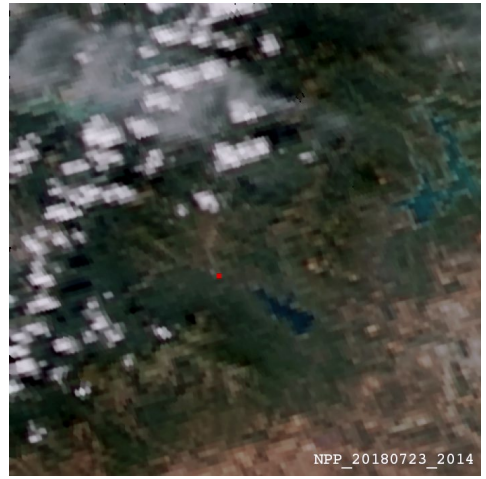
NOAA-20, 21:04 UTC

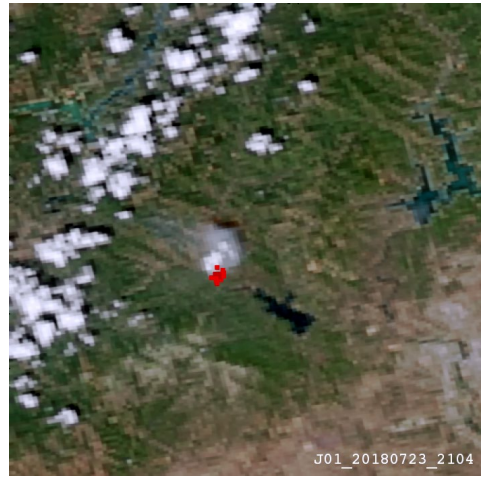
J01_20180723_2104

Suomi NPP, 21:55 UTC

NPP_20180723_2155

Marina Tsidulko, IMSG@NOAA

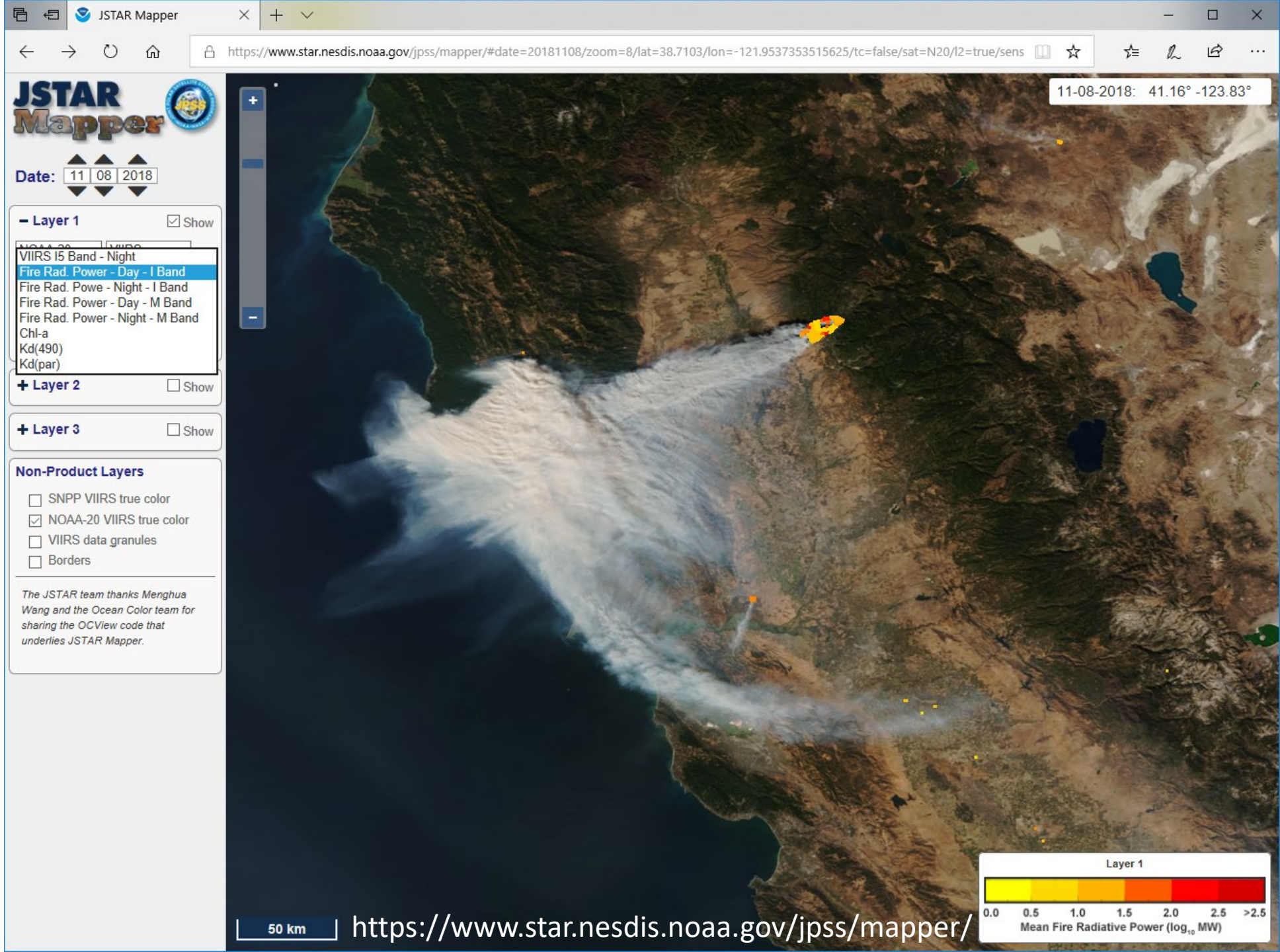




NOAA/NESDIS/STAR JSTAR Mapper

- ***Integrated monitoring and visualization system for a number of JPSS products (including fire, aerosol and air quality information)***
- ***Data from Suomi NPP and NOAA-20 available with moderate latency***

NOAA-20 ~20:37 UTC



NOAA/NESDIS/STAR JSTAR Mapper

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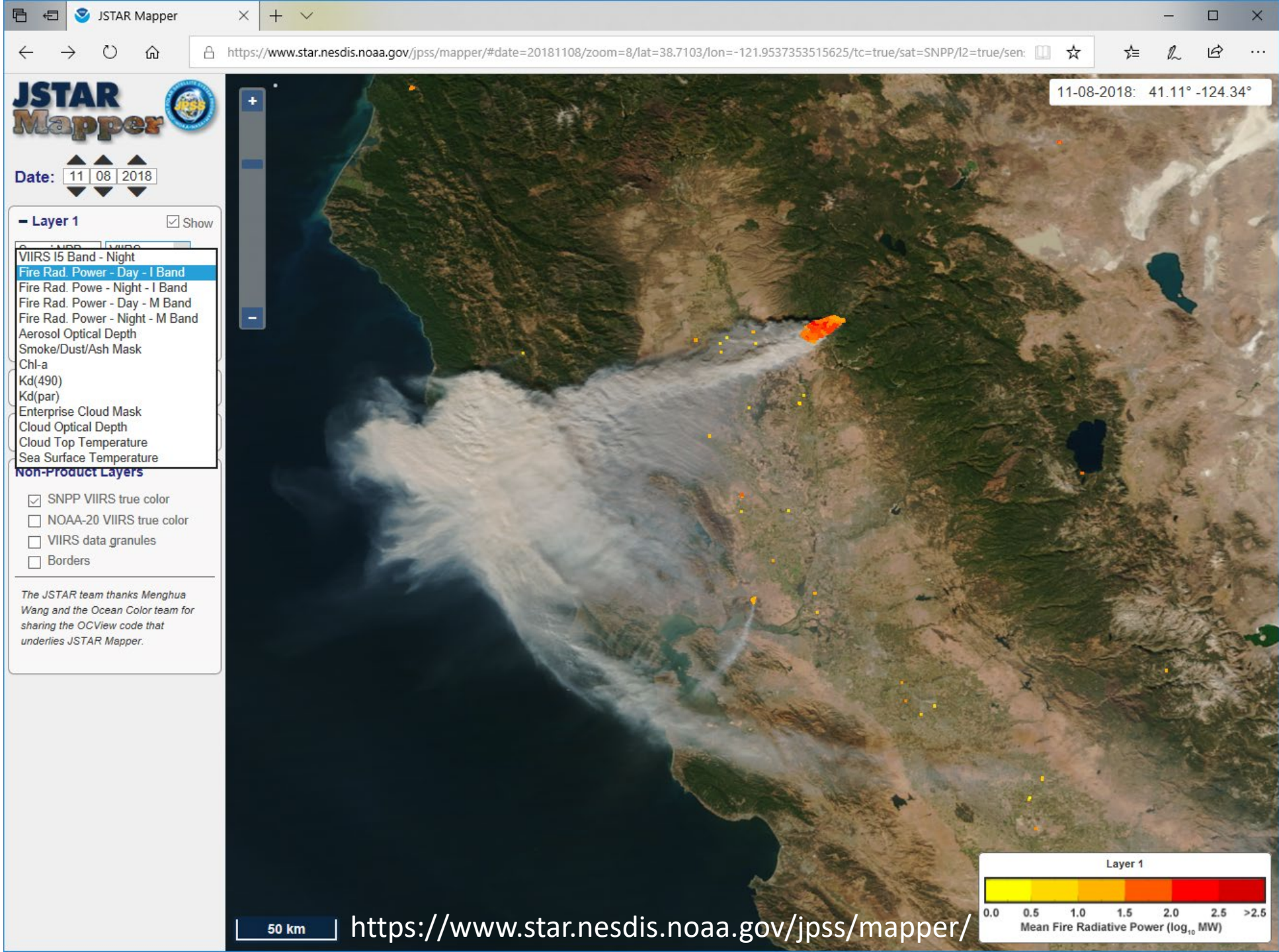
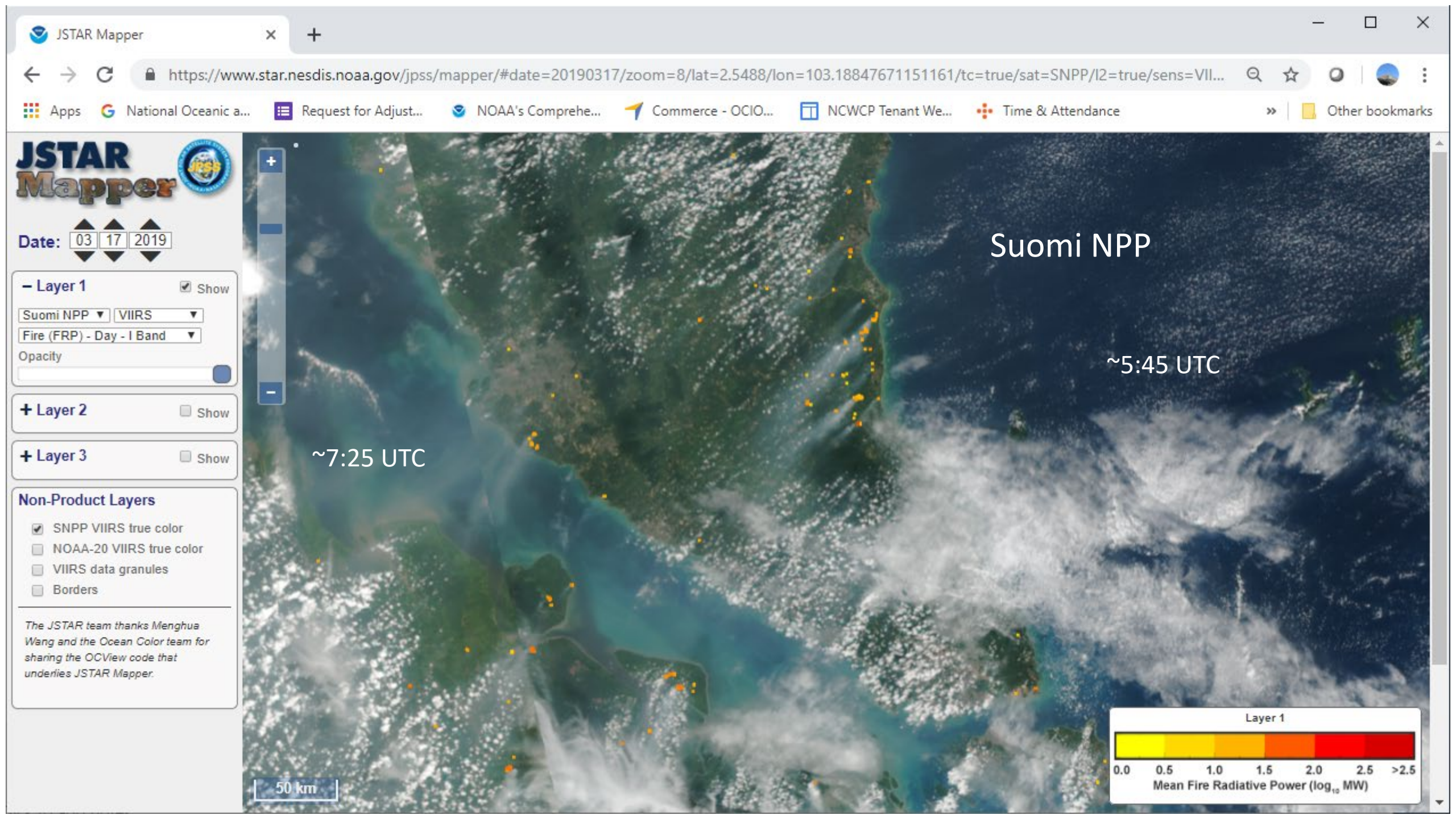
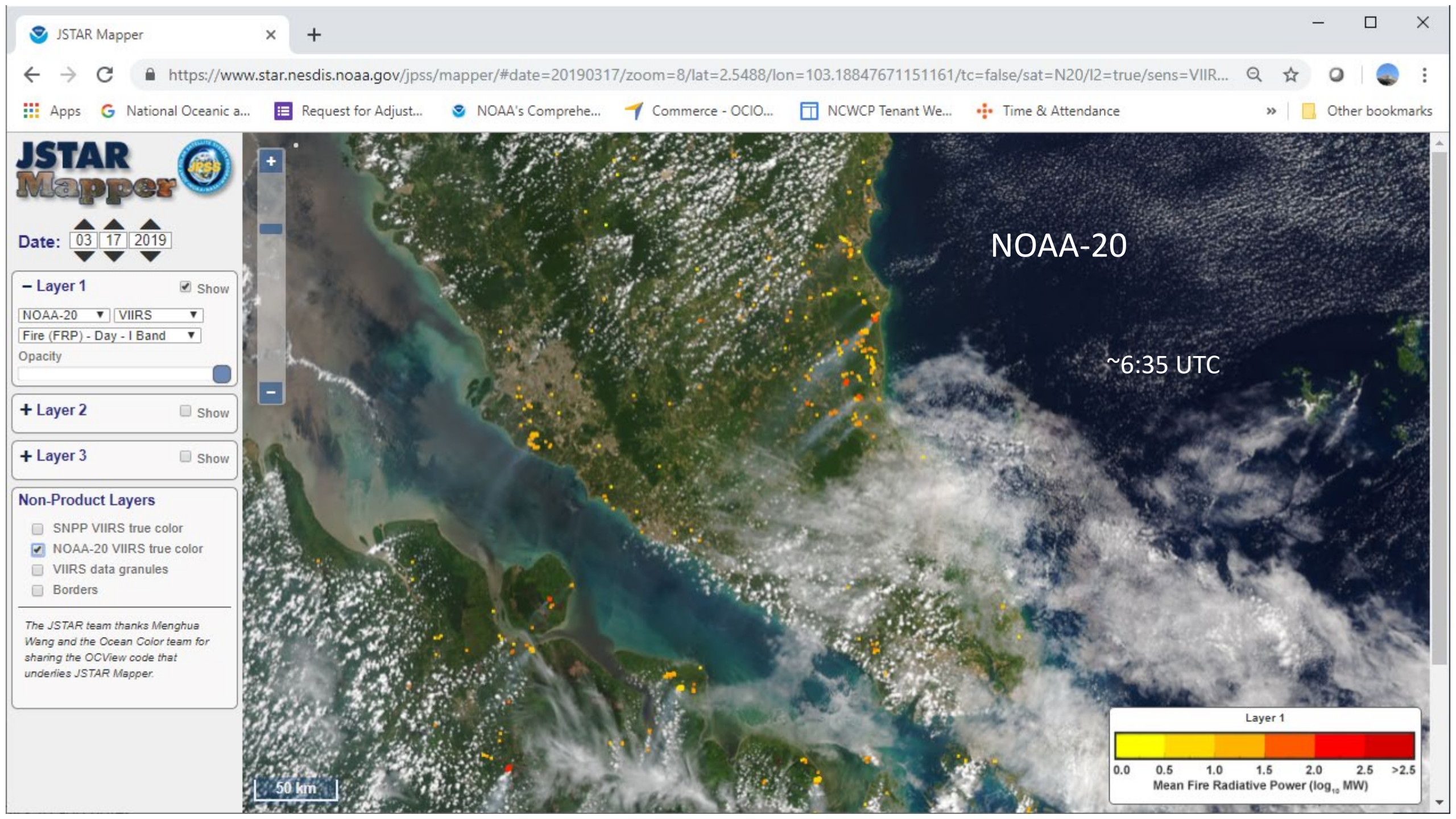
Suomi NPP ~21:27 UTC




JSTAR Mapper
https://www.star.nesdis.noaa.gov/jpss/mapper/#date=20190317/zoom=8/lat=2.5488/lon=103.18847671151161/tc=true/sat=SNPP/l2=true/sens=VII...
Apps
National Oceanic a...
Request for Adjust...
NOAA's Comprehe...
Commerce - OCIO...
NCWCP Tenant We...
Time & Attendance
Other bookmarks
JSTAR Mapper
Date: 03 17 2019
Layer 1
Show
Suomi NPP
VIIRS
Fire (FRP) - Day - I Band
Opacity
Layer 2
Show
Layer 3
Show
Non-Product Layers
SNPP VIIRS true color
NOAA-20 VIIRS true color
VIIRS data granules
Borders
The JSTAR team thanks Menghua Wang and the Ocean Color team for sharing the OCView code that underlies JSTAR Mapper.
Suomi NPP
~5:45 UTC
~7:25 UTC
50 km
Layer 1
0.0 0.5 1.0 1.5 2.0 2.5 >2.5
Mean Fire Radiative Power (log10 MW)


JSTAR Mapper
https://www.star.nesdis.noaa.gov/jpss/mapper/#date=20190317/zoom=8/lat=2.5488/lon=103.18847671151161/tc=false/sat=N20/l2=true/sens=VIIR...
Apps
National Oceanic a...
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VIIRS data granules
Borders
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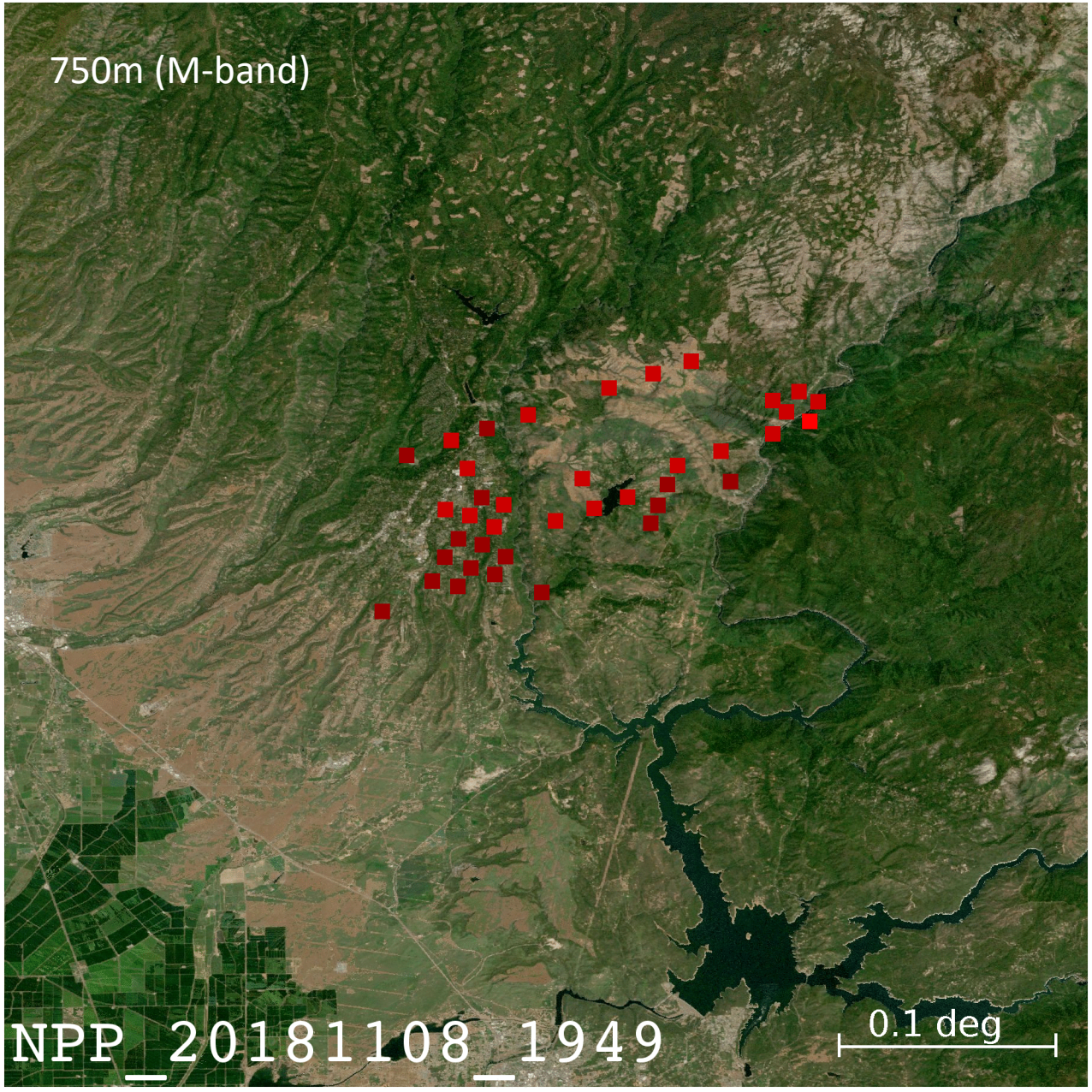
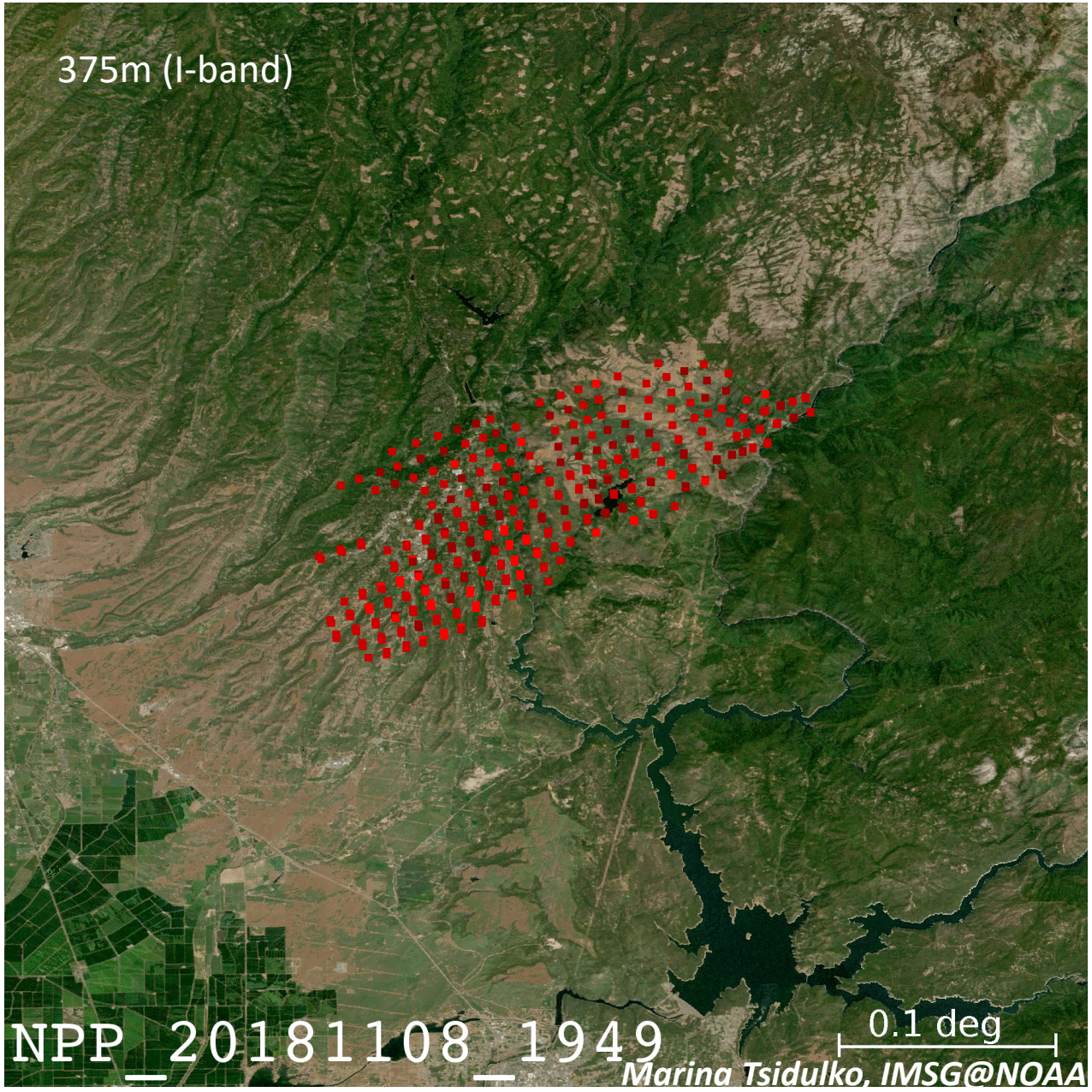
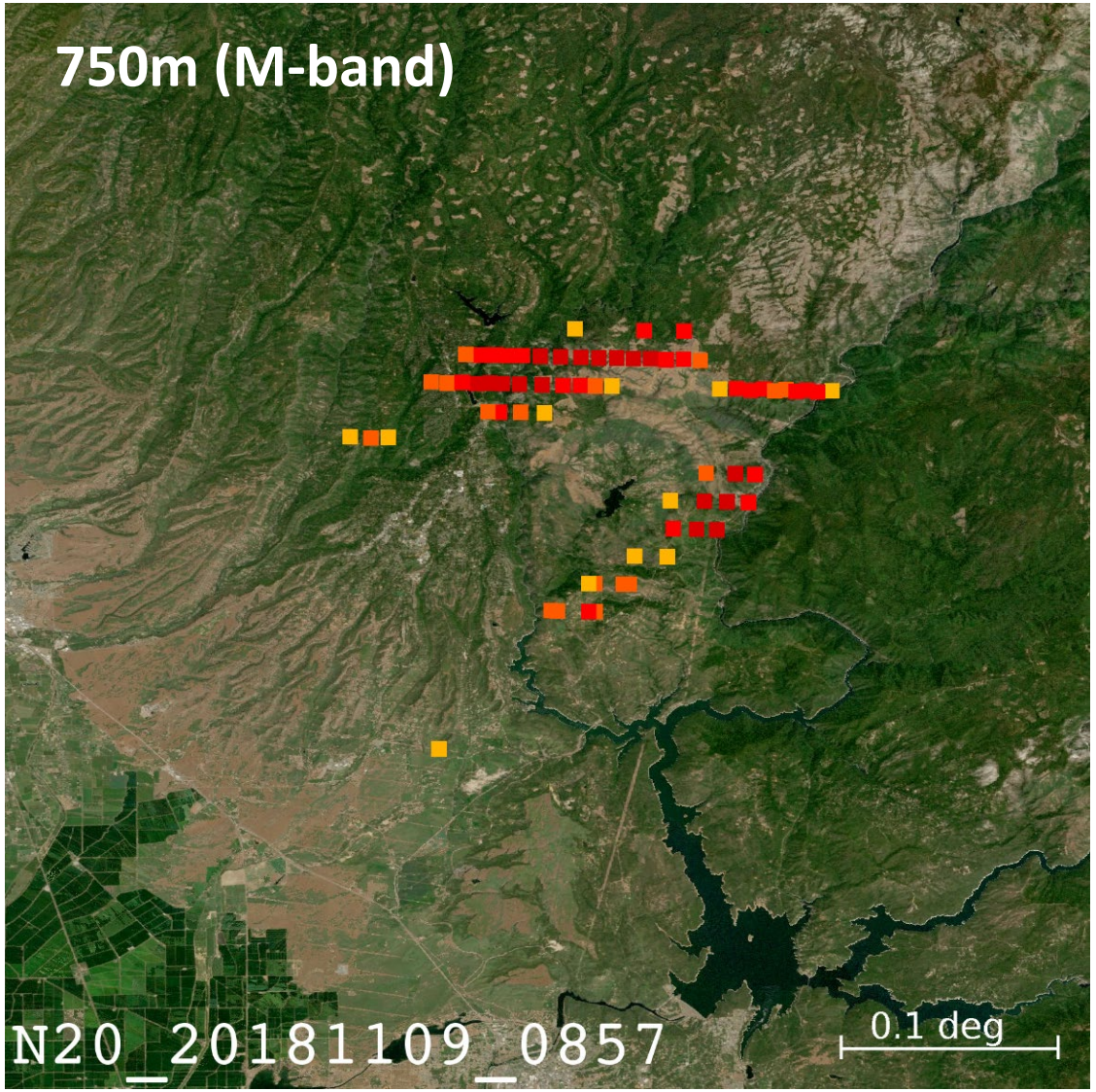
NOAA-20
~6:35 UTC
50 km
Layer 1
0.0 0.5 1.0 1.5 2.0 2.5 >2.5
Mean Fire Radiative Power (log10 MW)

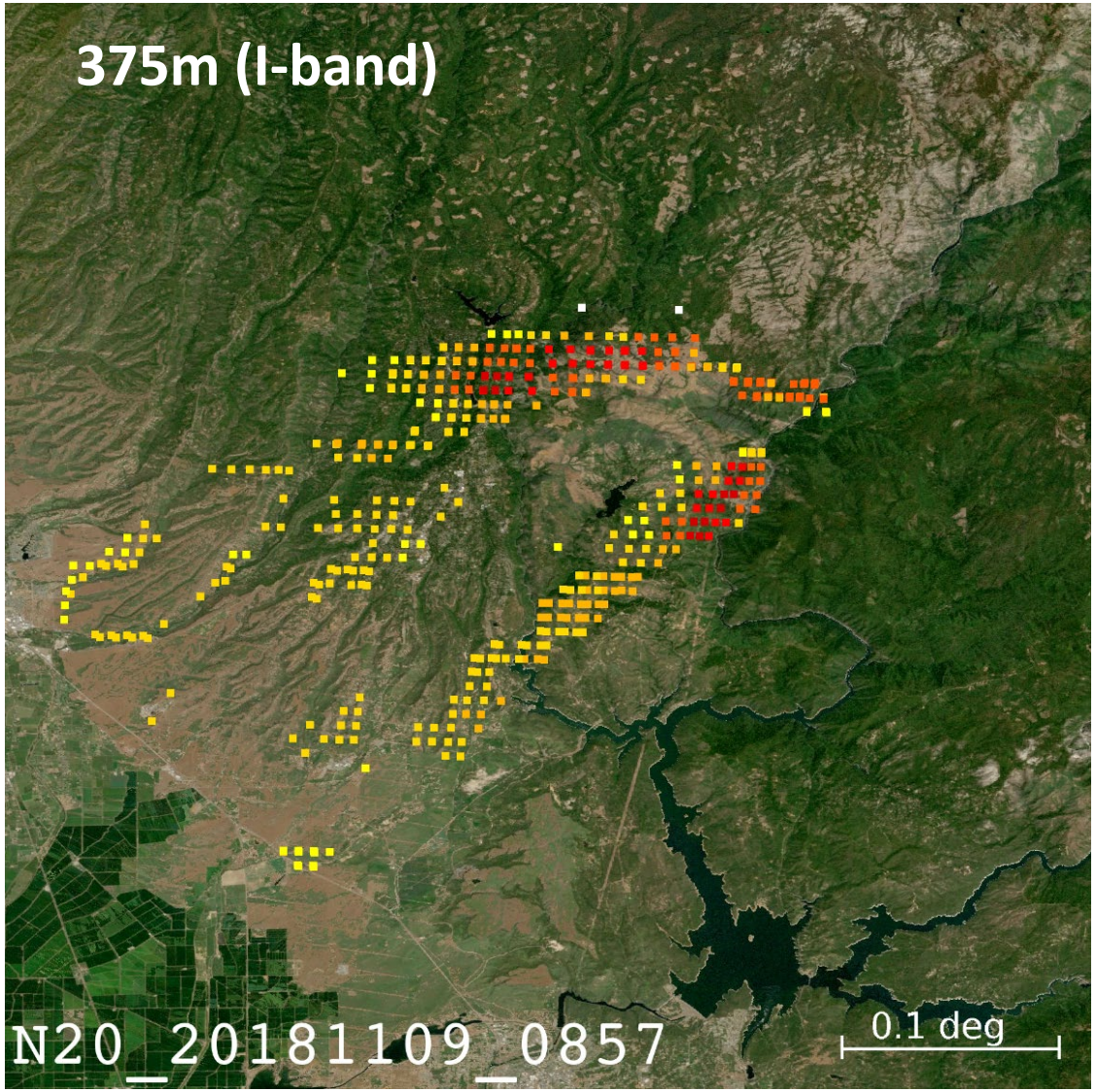
VIIRS detections of Camp fire (CA) on November 8-15, 2018

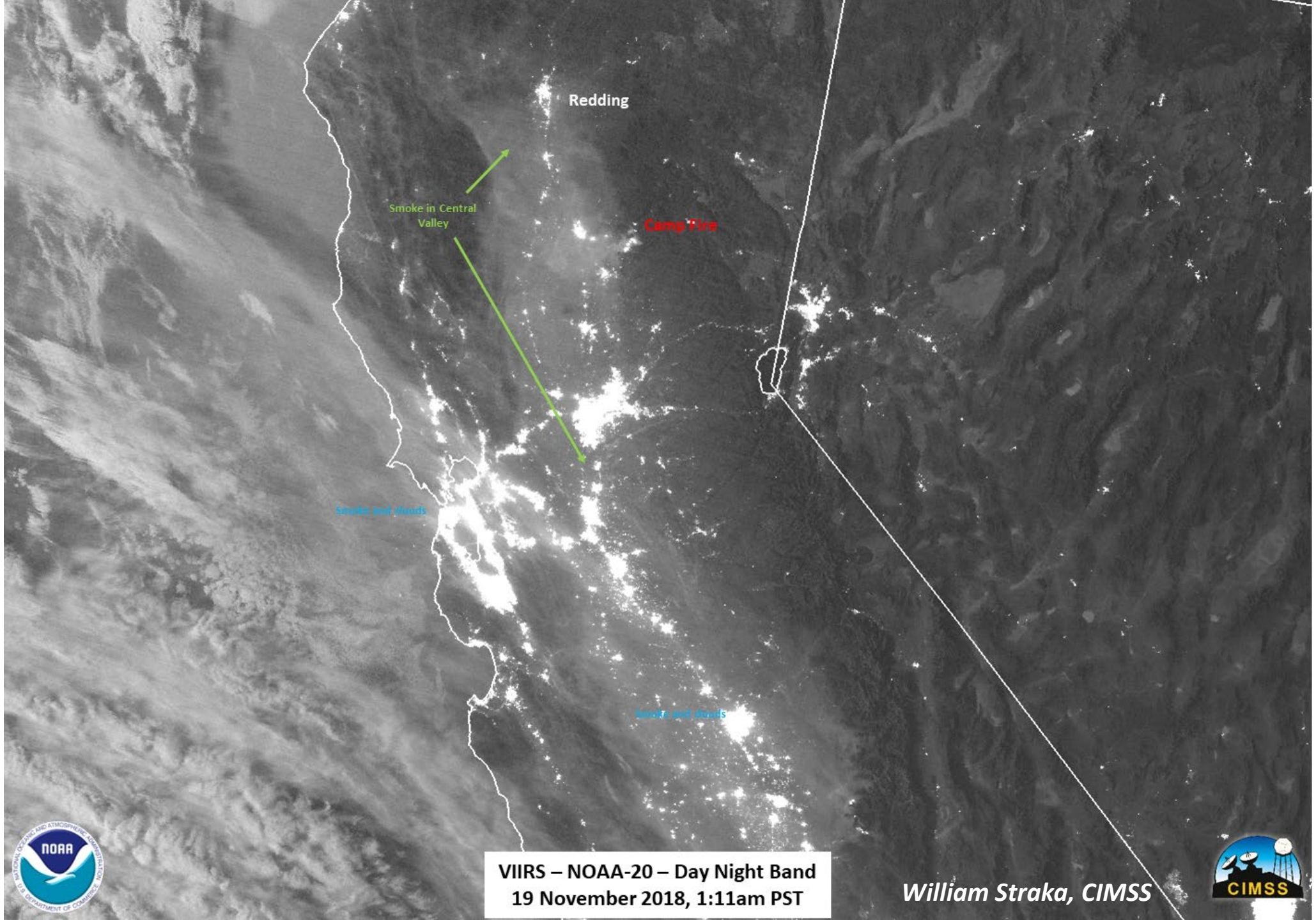




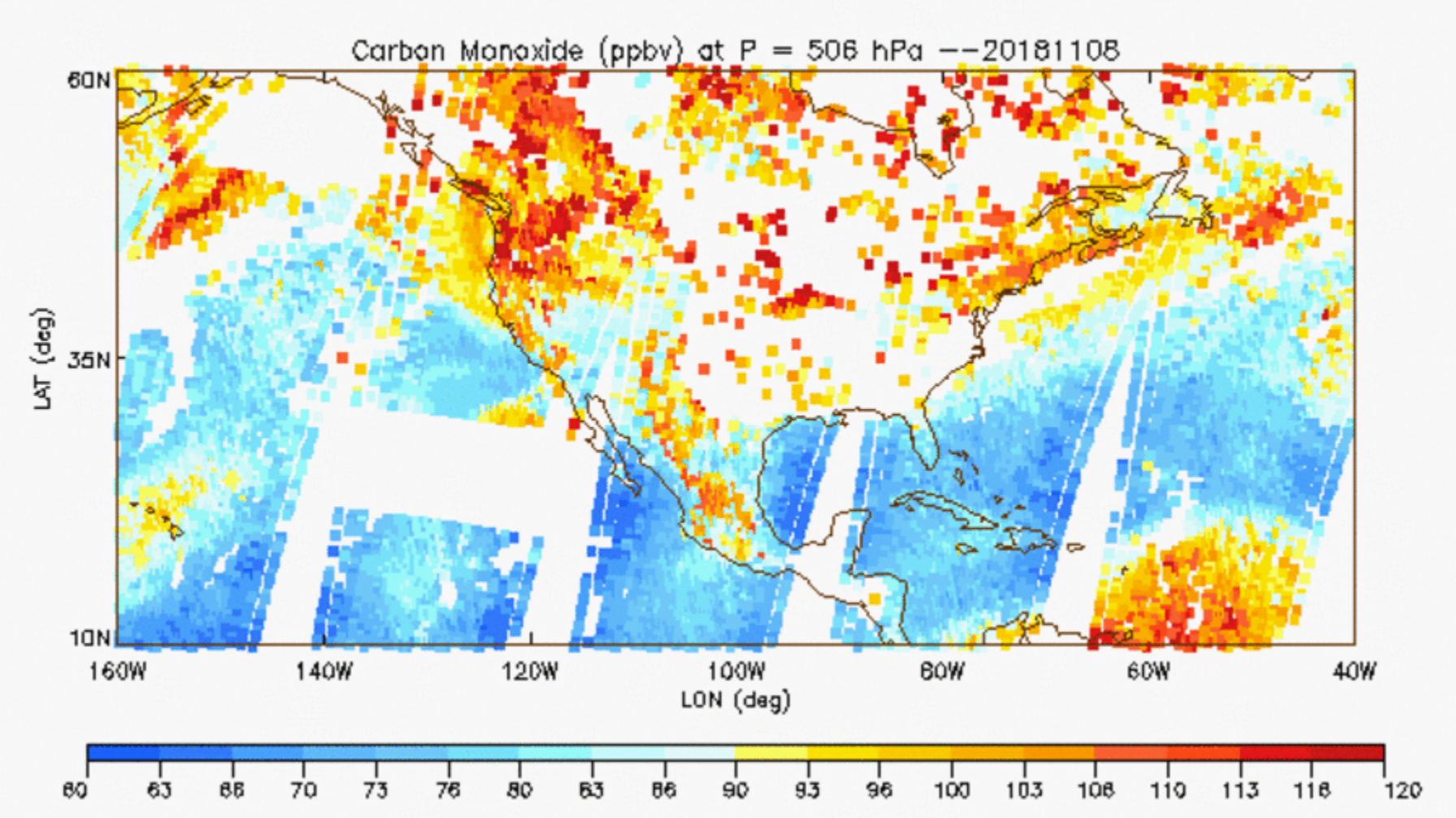
Camp Fire, CA M-band vs. I-band






Redding
Smoke in Central Valley
Camp Fire
Smoke and clouds
Smoke and clouds
VIIRS – NOAA-20 – Day Night Band
19 November 2018, 1:11am PST
William Straka, CIMSS

Suomi NPP NUCAPS CO on November 8-18, 2018



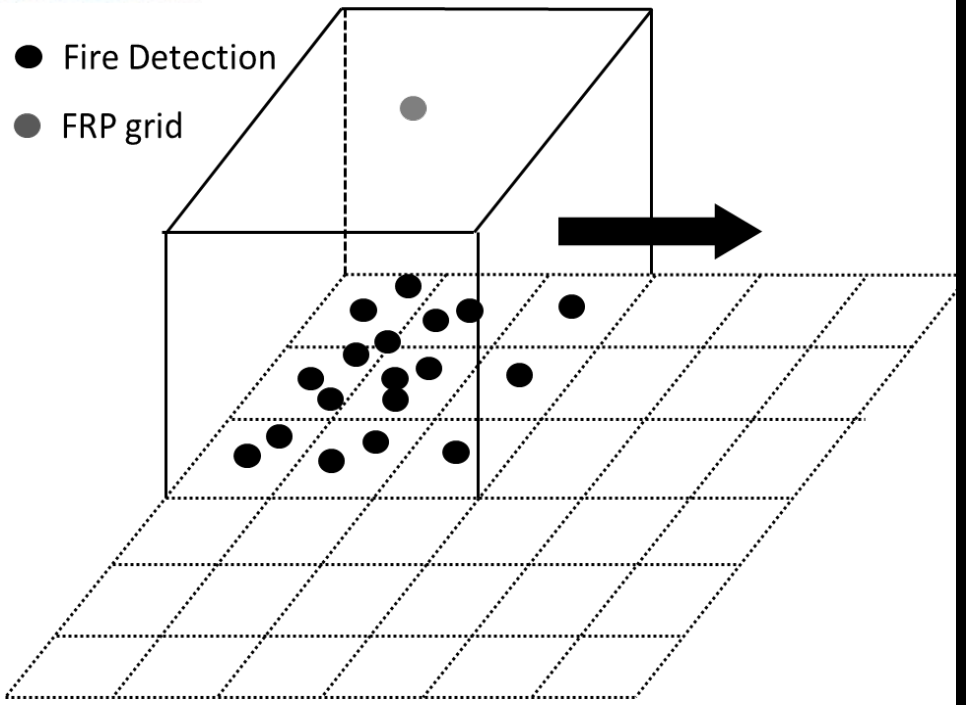
NUCAPS: NOAA Unique Combined Atmospheric Processing System

Antonia Gambacorta, IMSG@NOAA

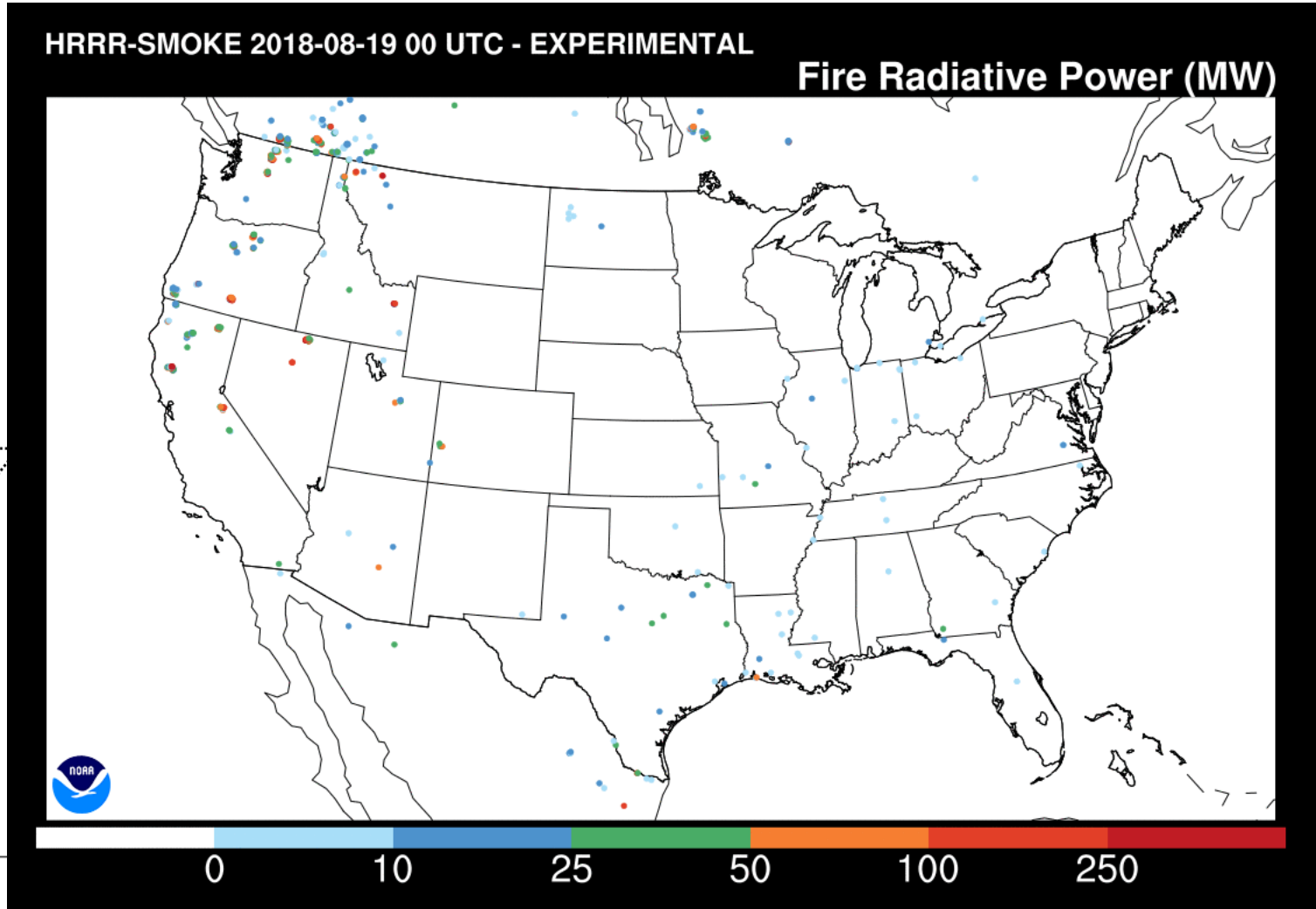
Mapping the VIIRS and MODIS FRP data to the HRRR-Smoke CONUS grid

The clustering procedure performs a combination of all detected fires from VIIRS and MODIS according to the model spatial resolution and grid configuration.

$$M^{[\epsilon]} = FRE_{grid_{(lon,lat)}} \cdot \gamma . EF^{[\epsilon]}$$

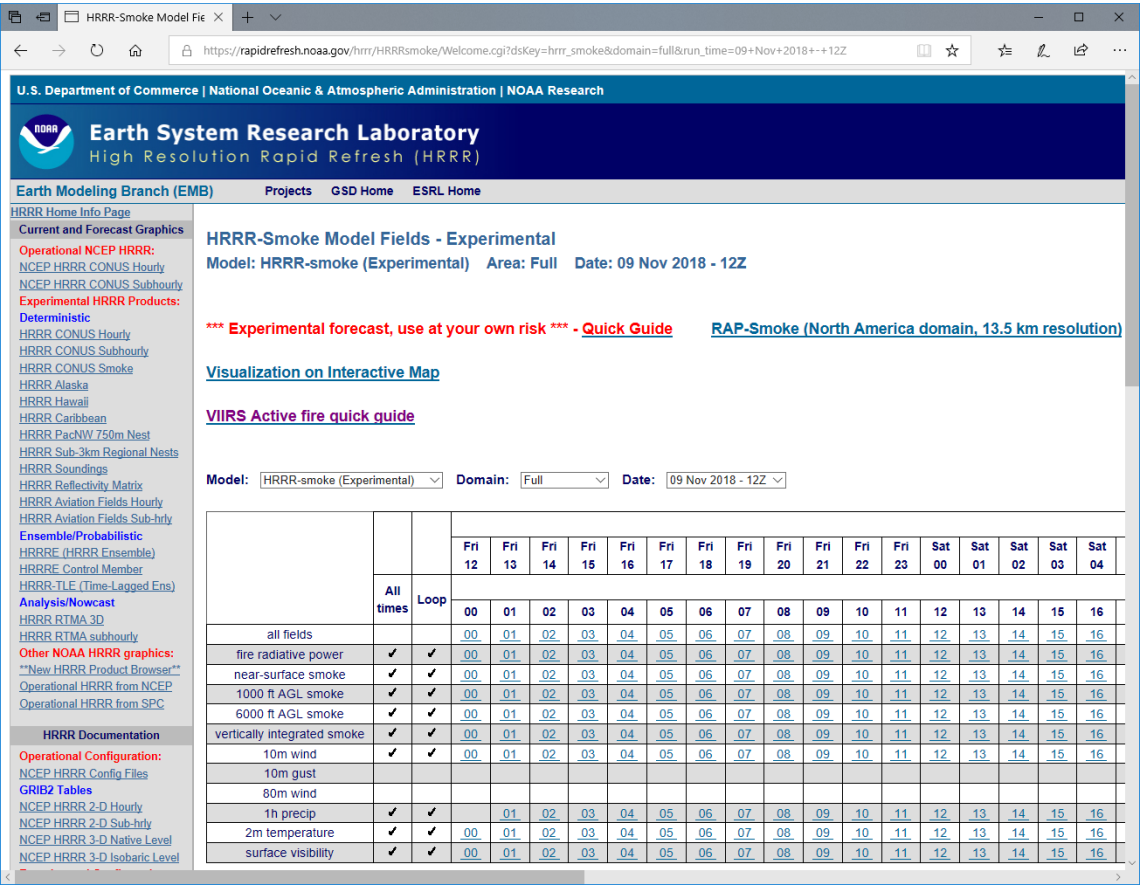


Averaged satellite FRP data mapped over 3x3km HRRR CONUS grid pixels for August 19, 2018



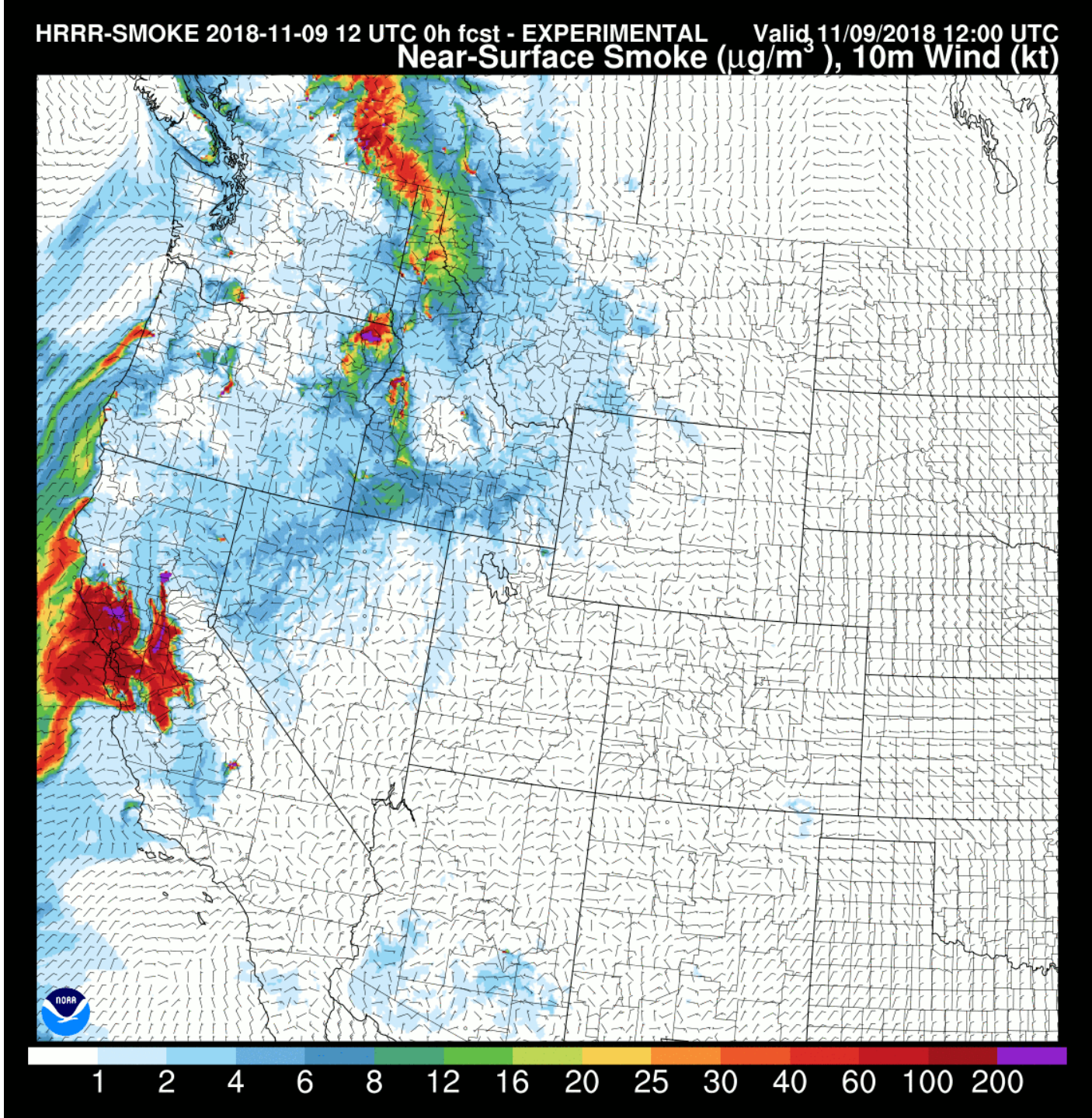
Ravan Ahmadov, CIRES@NOAA

High Resolution Rapid Refresh (HRRR) - smoke

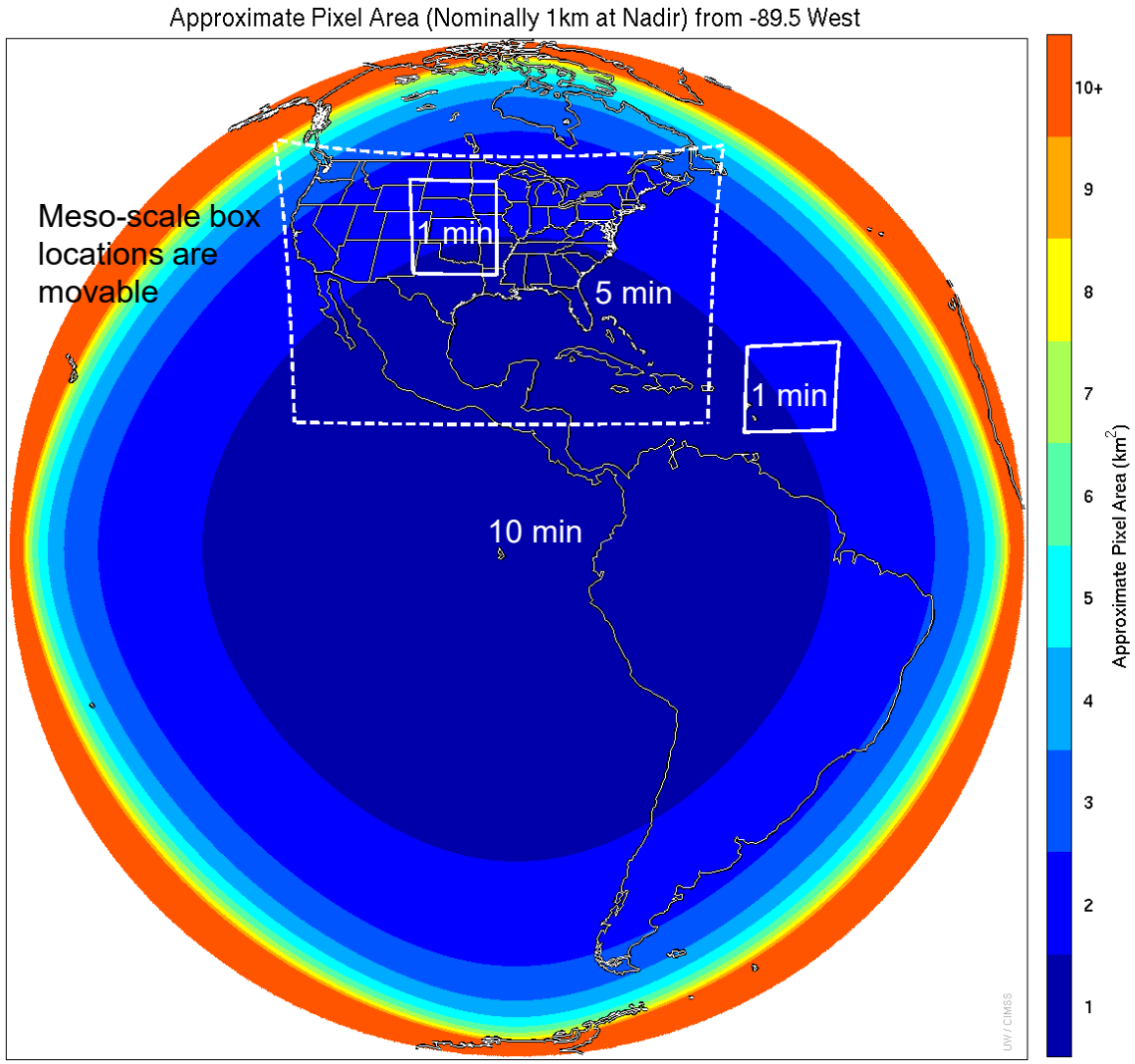


https://rapidrefresh.noaa.gov/hrrr/HRRRsmoke/

Ravan Ahmadov, CIRES@NOAA



GOES-R ABI



Default Operational Mode:

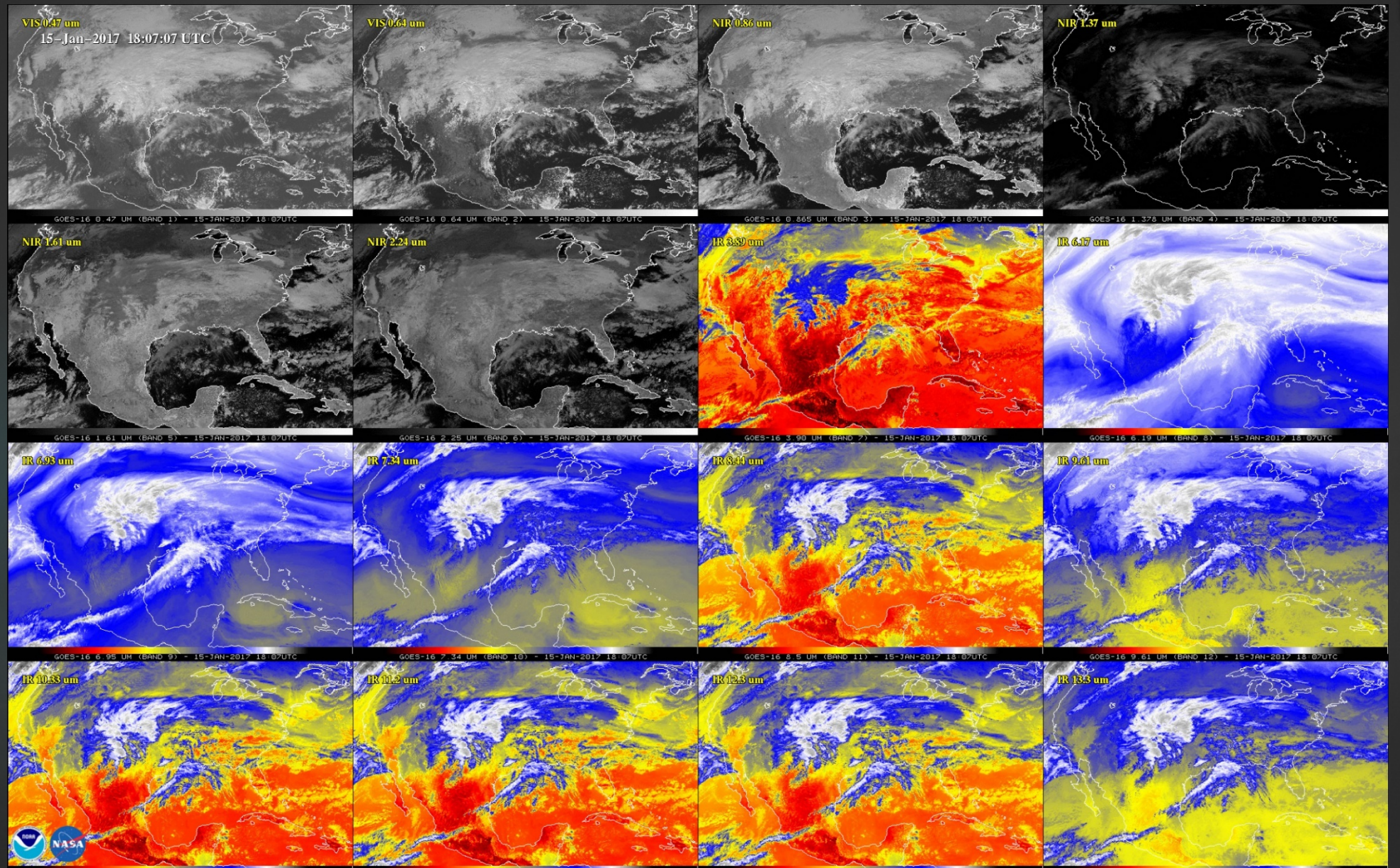
Full Disk 10 min

CONUS 5 min

Mesoscale 1 min (2 movable locations)

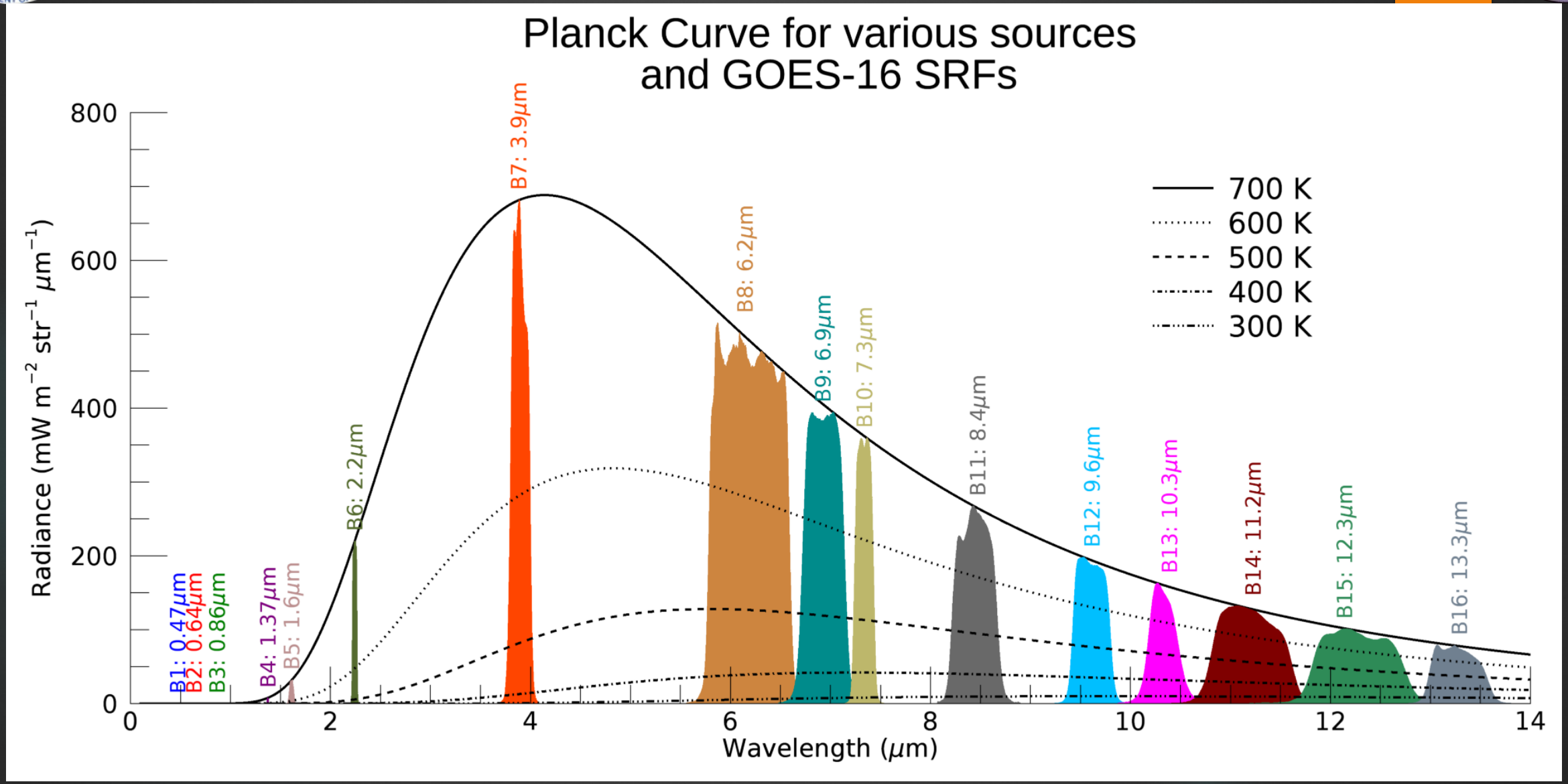
Tim Schmit, NOAA; Mat Gunshor, CIMSS

All 16 Bands of CONUS



Tim Schmit, NOAA;
Mat Gunshor, CIMSS

The Physics of How ABI Sees Fires



Chris Schmidt, CIMSS

GOES-16 Band 7 imagery

(from 5-minute CONUS data)

November 8, 2018

12:02 – 23:57 UTC (4:02 – 15:57 PST)

Camp fire: 6:29 PST

Woolsey fire: 14:24 PST

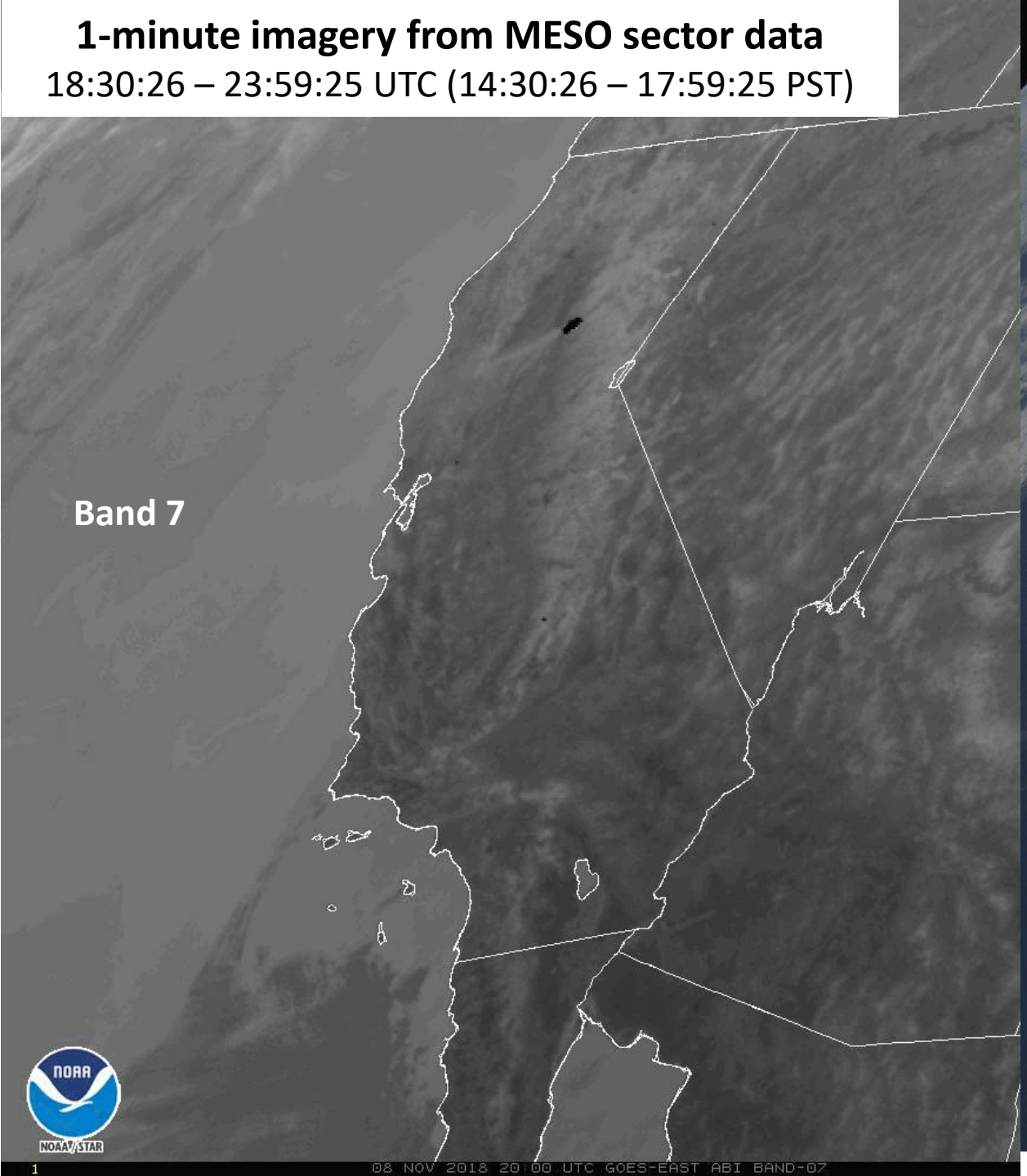
(http://www.fire.ca.gov)

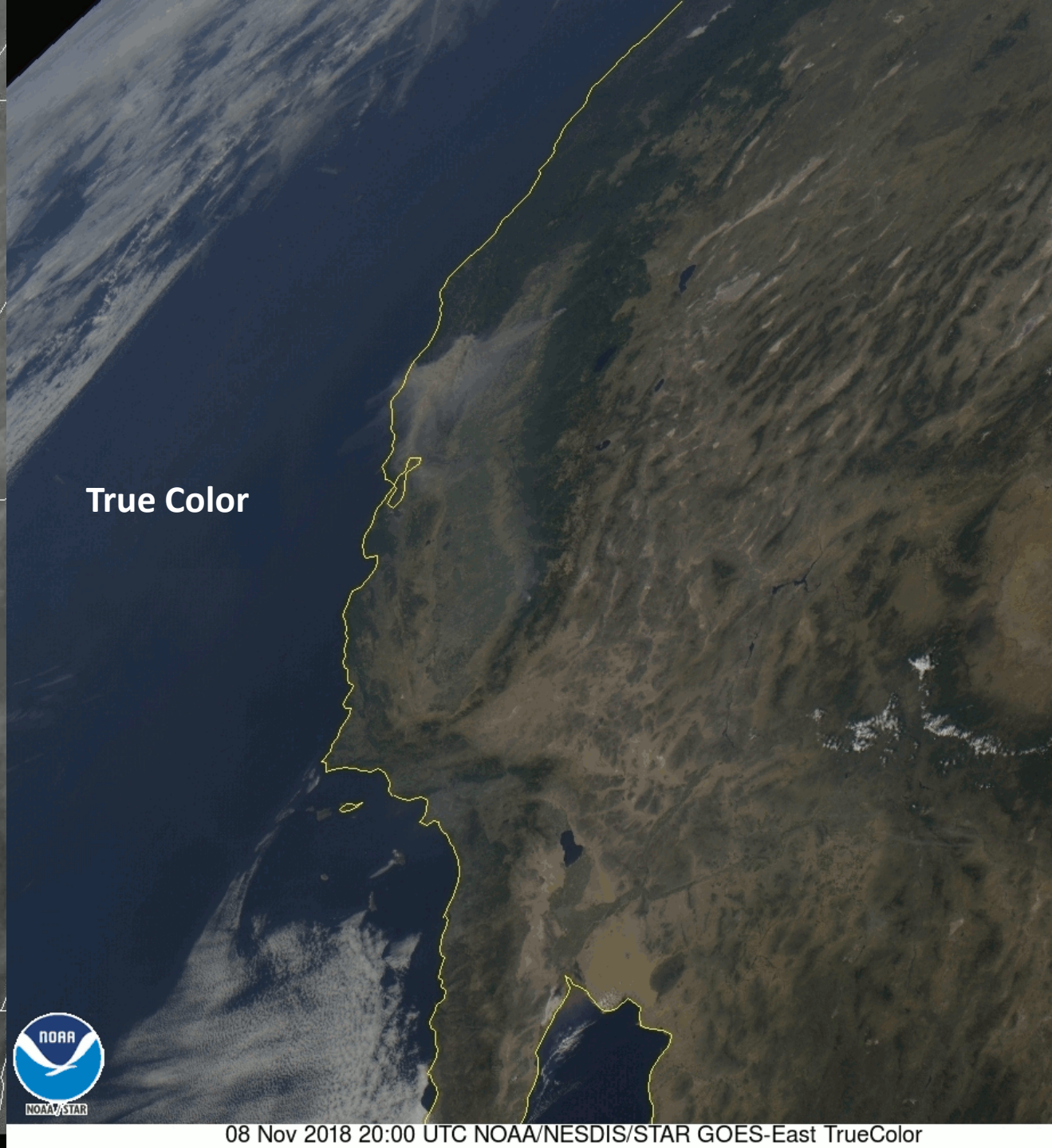
Band 7: 3.9 µm (primary band for hot spot / fire detection and characterization)

https://www.star.nesdis.noaa.gov/GOES/index.php

1-minute imagery from MESO sector data

18:30:26 – 23:59:25 UTC (14:30:26 – 17:59:25 PST)



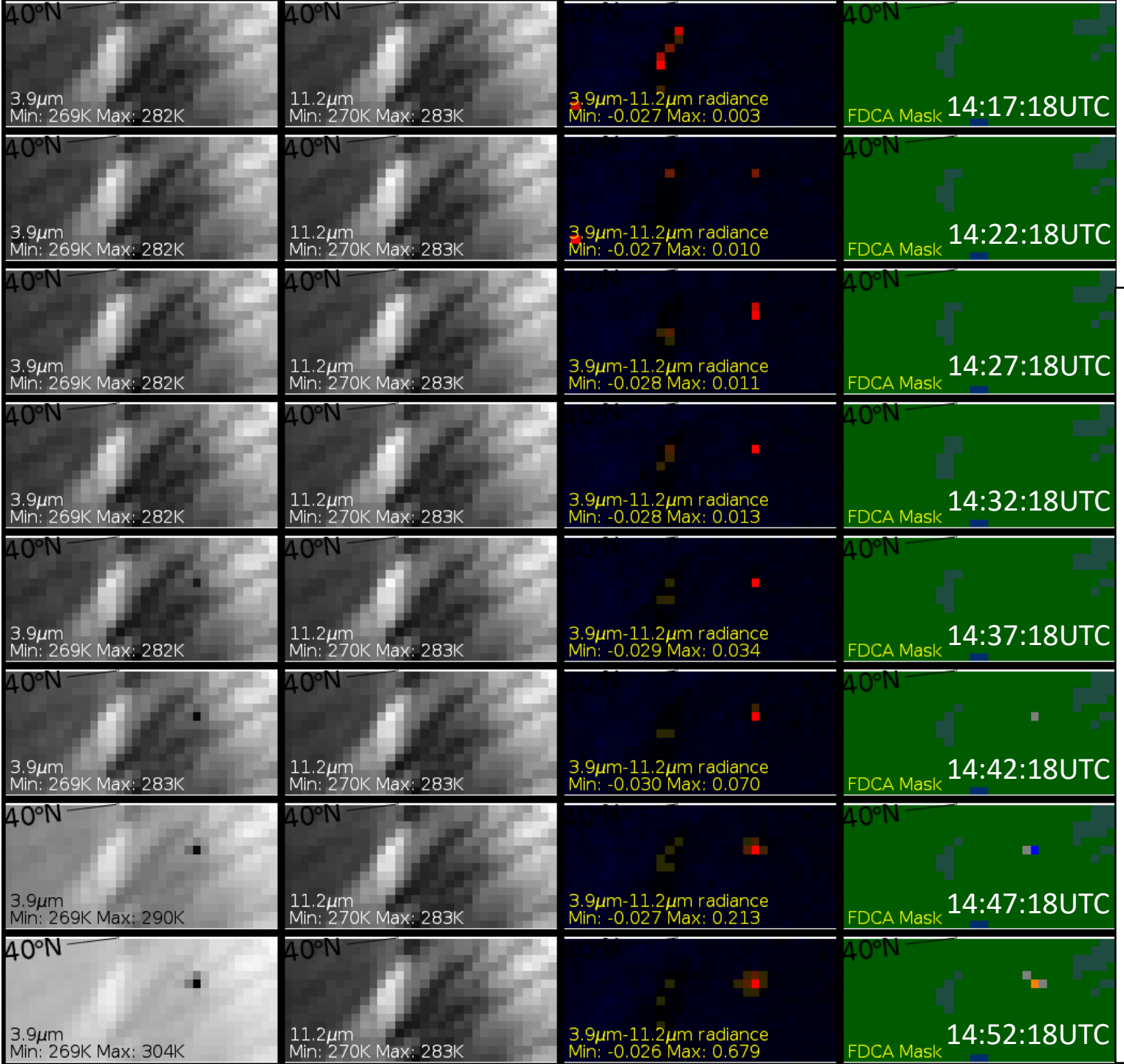


A close-up look at the onset of Camp fire from GOES-16 ABI

based on 5-minute CONUS data

November 8, 2018

Christopher Schmidt, CIMSS



GOES-16 ABI Fire Temperature RGB

November 8, 2018
12:02:18 – 23:57:18 UTC

similar RGB products are also generated from JPSS VIIRS data

Red: 3.9 µm (band 7)
Green: 2.2 µm (band 6)
Blue: 1.6 µm (band 5)

Curtis Seaman, CIRA

Himawari AHI

Fire Temperature RGB

March 15-18, 2019

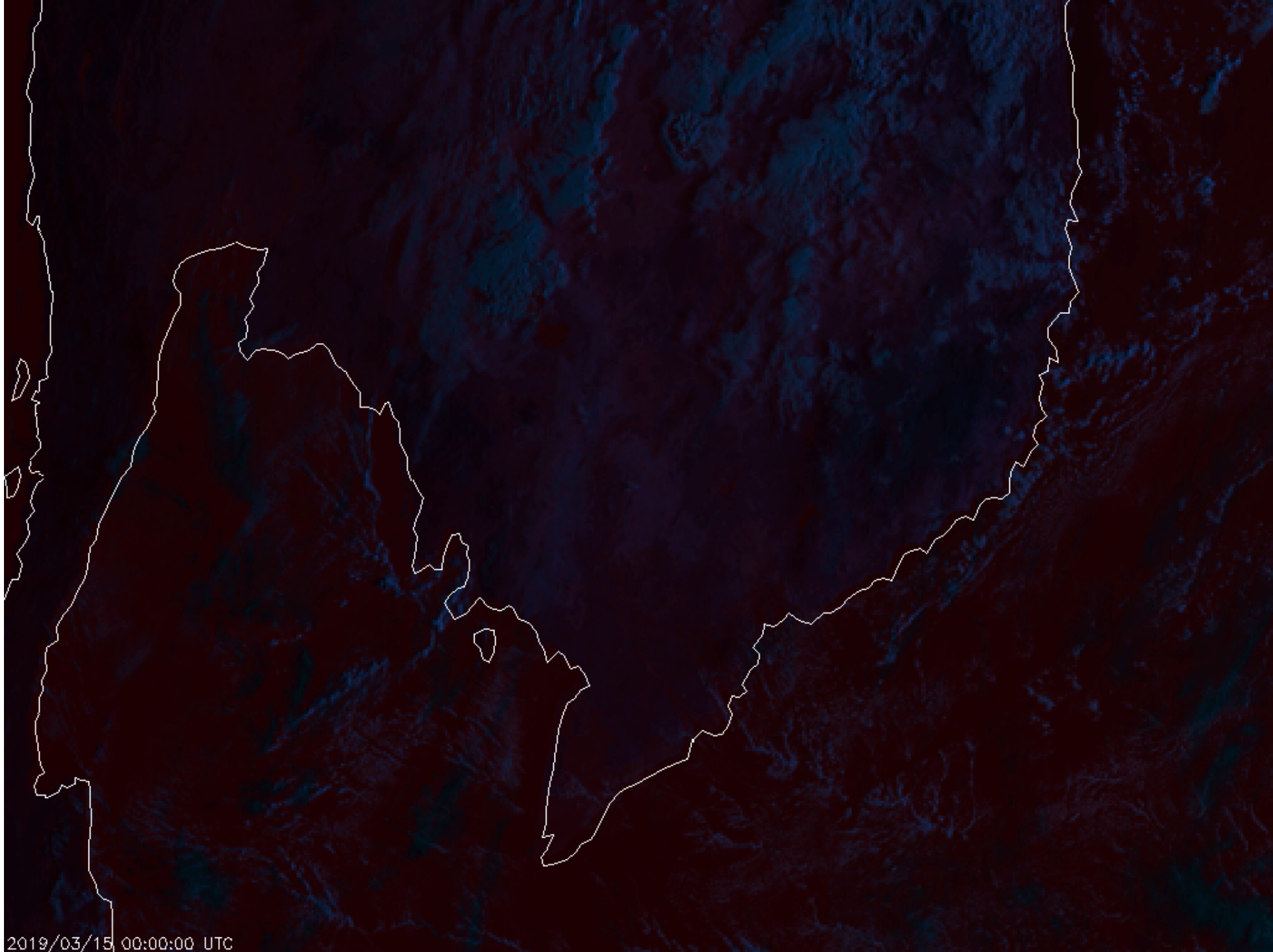
Curtis Seaman, CIRA

Himawari AHI

Fire Temperature RGB

March 15-18, 2019

Curtis Seaman, CIRA

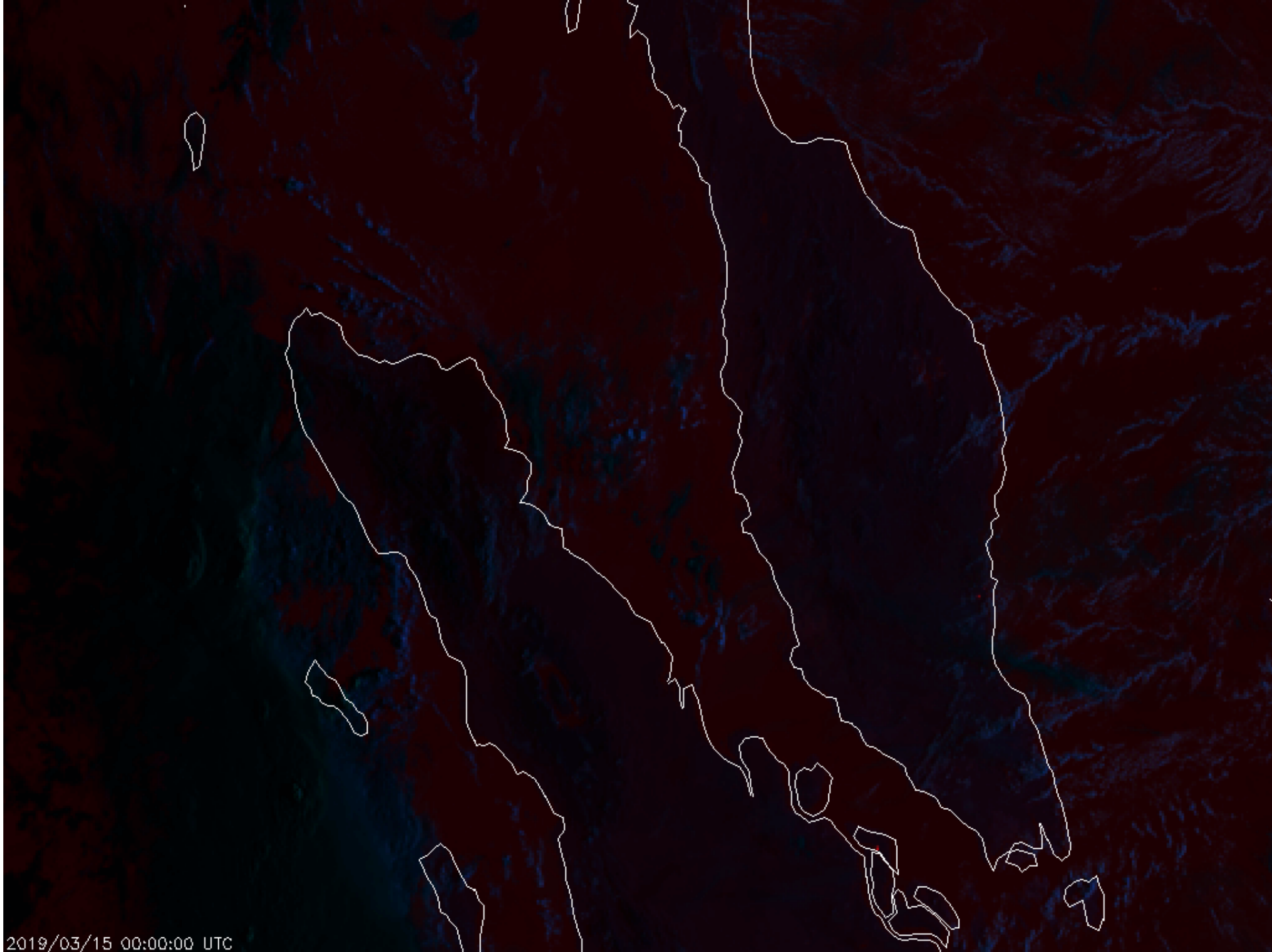


Himawari AHI

Fire Temperature RGB

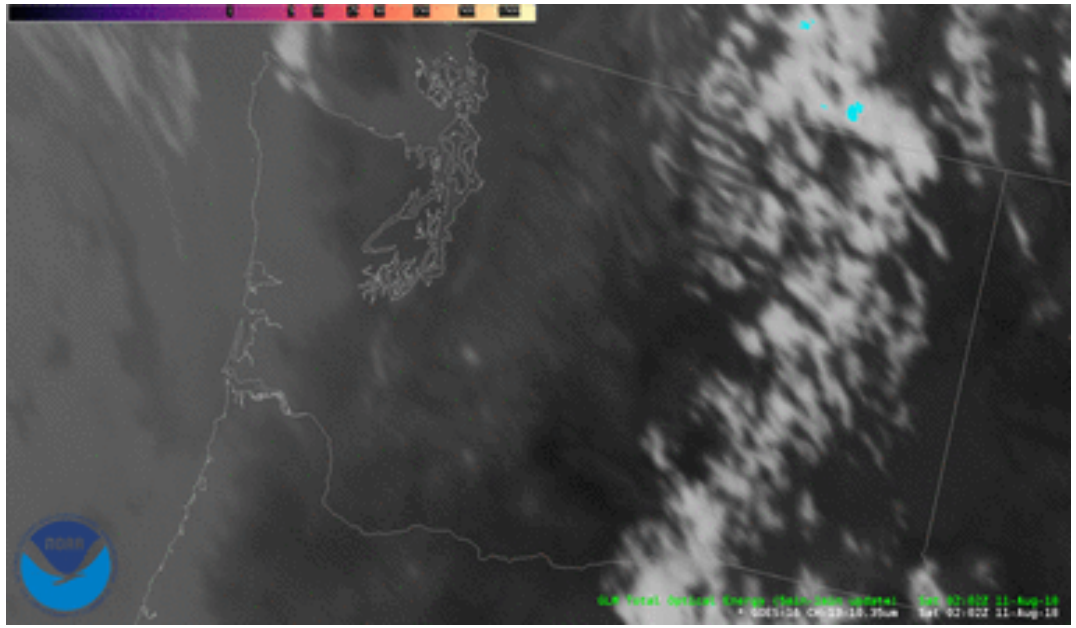
March 15-18, 2019

Curtis Seaman, CIRA

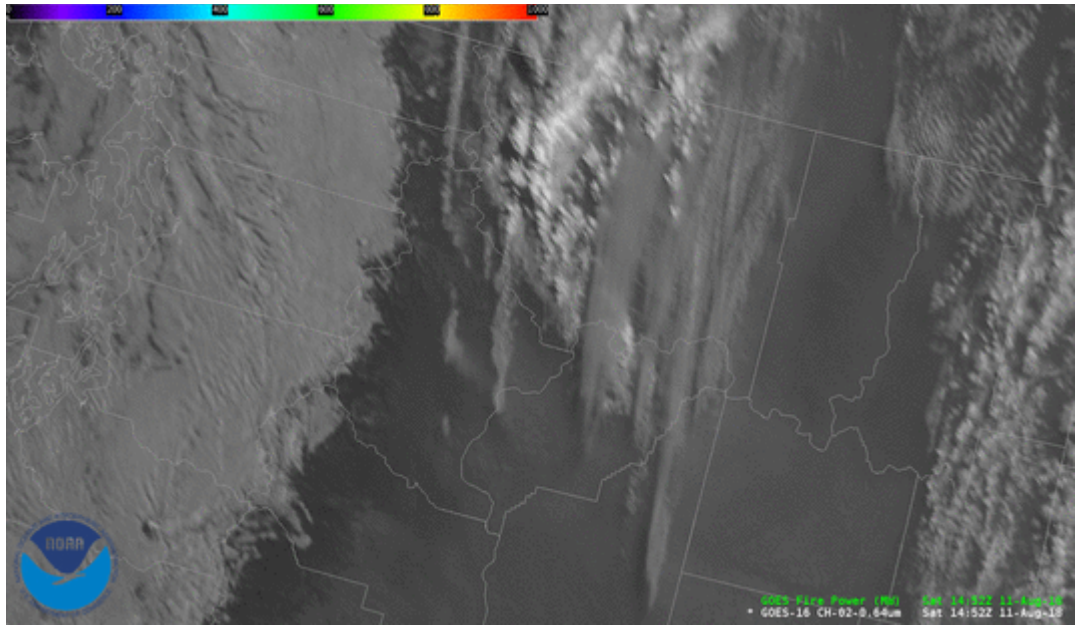


GOES-16 GLM and ABI Fire

August 11-12, 2018



GLM: Geostationary Lightning Mapper



ABI: Advanced Baseline Imager

Scott Rudloski, NOAA/NESDIS/STAR

Examples of fire data access and visualization systems

- NOAA AerosolWatch: https://www.star.nesdis.noaa.gov/smcd/spb/aq/AerosolWatch/
- NOAA JSTAR Mapper: https://www.star.nesdis.noaa.gov/jpss/mapper/
- NOAA Hazard Mapping System: https://www.ospo.noaa.gov/Products/land/hms.html
- CIMSS RealEarth™: http://realearth.ssec.wisc.edu
- CIRA RAMSDIS: http://rammb.cira.colostate.edu/ramsdis/online/
- NOAA GOES-East Image Viewer: https://www.star.nesdis.noaa.gov/GOES/index.php
- NASA WorldView: https://worldview.earthdata.nasa.gov/
- NASA LANCE: https://earthdata.nasa.gov/earth-observation-data/near-real-time
- USFS Active Fire Mapping: https://fsapps.nwcg.gov/

Summary

- Even in more densely populated area satellite data are needed for early detection and monitoring
- Geostationary satellites are more likely to detect new fires due to high frequency of observations
  - visual interpretation of tailored imagery provides most timely detection
- JPSS satellites provide better spatial detail and higher sensitivity
  - automated algorithms more likely to detect small / early fires
  - day-night-band provides new capability for nighttime smoke detection and high sensitivity for nighttime fire detection
- The new generation sensors are sensitive enough to be able provide first detections of fires – timely delivery of satellite information is critical
- The new generation sensors provide critical quantitative input to smoke / air quality models to help improve forecast accuracy
- The JPSS and GOES-R missions provide multiple data products to help comprehensive monitoring of fire events

For more information visit

- NOAA JPSS at https://www.jpss.noaa.gov/
- STAR JPSS at https://www.star.nesdis.noaa.gov/jpss/
- VIIRS Active Fire product info at https://www.star.nesdis.noaa.gov/jpss/fires.php
- VIIRS Active Fire science team at http://viirsfire.geog.umd.edu/
- GOES-R Program, Products etc. https://www.goes-r.gov/
- NOAA STAR GOES-R Algorithm Working Group https://www.star.nesdis.noaa.gov/goesr/
- GOES-R Fire and Hot Spot Characterization Product https://www.star.nesdis.noaa.gov/goesr/product_land_fire.php
- NOAA's Comprehensive Large Array-data Stewardship System (CLASS) at https://www.bou.class.noaa.gov/saa/products/welcome