



VIIRS Active Fire Products from Suomi NPP and NOAA-20

Ivan Csiszar, Shobha Kondragunta

NOAA NESDIS Center for Satellite Applications and Research

Wilfrid Schroeder

NOAA/NESDIS Office of Satellite and Product Operations

Marina Tsidulko, Yingxin Gu

I.M. Systems Group, Inc.



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

There are many approaches for fire detection and visualization from VIIRS

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	0.580 - 0.910	550
									PMT	0.510 - 0.860	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	0.459 - 0.479	500						
			10	0.483 - 0.493	1000						
M4	0.545 - 0.565	750	4	0.545 - 0.565	500						
			12	0.546 - 0.556	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	0.662 - 0.672	1000	1					
			14	0.673 - 0.683	1000						
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	0.720 - 1.000	1100			
M7	0.846 - 0.885	750	16	0.862 - 0.877	1000	2	0.720 - 1.000	1100			
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	3.929 - 3.989	1000						
			22	3.929 - 3.989	1000						
			23	4.020 - 4.080	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	10.780 - 11.280	1000	4	10.300 - 11.300	1100	HRD	10.300 - 12.900	550
			32	11.770 - 12.270	1000	5	11.500 - 12.500	1100			
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

Requirements and Production Status

Active Fires		
ATTRIBUTE	THRESHOLD	OBJECTIVE
a. Horizontal Cell Size		
1. Nadir	0.80 km	0.25 km
2. Worst case	1.6 km	
b. Horizontal Reporting Interval	HCS	
c. Horizontal Coverage	Global	Global
d. Mapping Uncertainty, 3 sigma	1.5 km	0.75 km
e. Measurement Range		
1. Fire Radiative Power (FRP)	1.0 to 5.0 (10) ³ MW	1.0 to 1.0 (10) ⁴ MW
2. Sub-pixel Average Temperature of Active Fire	N/A	N/A
3. Sub-pixel Area of Active Fire	N/A	N/A
f. Measurement Uncertainty		
1. Fire Radiative Power (FRP)	50%	20%
2. Sub-pixel Average Temperature of Active Fire	N/A	N/A
3. Sub-pixel Area of Active Fire	N/A	N/A
g. Refresh	At least 90% coverage of the globe every 12 hours (monthly average)	N/A

Algorithm	Suomi NPP	NOAA-20
750m M-band	NDE Operational since March 15, 2016	NDE Operational since August 13, 2018
375m/750m I/M-band	STAR Systematic production since January 30, 2018	STAR Systematic production since February 5, 2018

Algorithms are NOAA implementations of those also generated by NASA

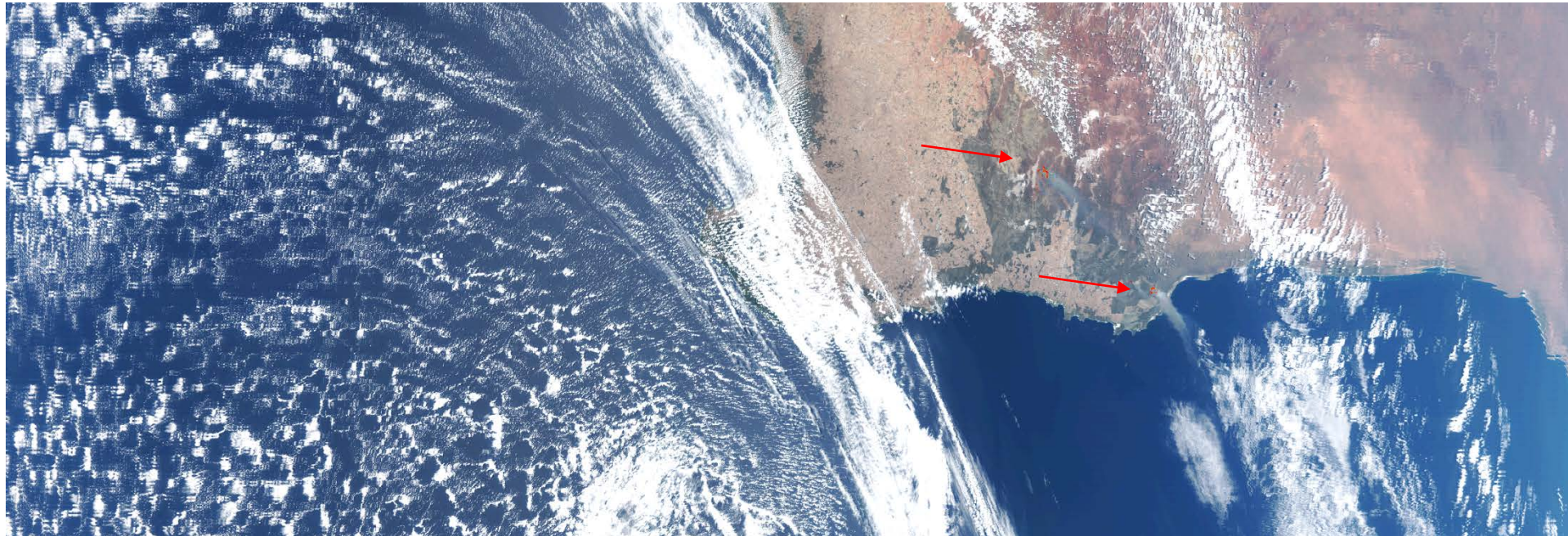
Suomi NPP 5:11 UTC (operational)

Level 2 product



**VIIRS 750m
Active fires on
January 5, 2018**

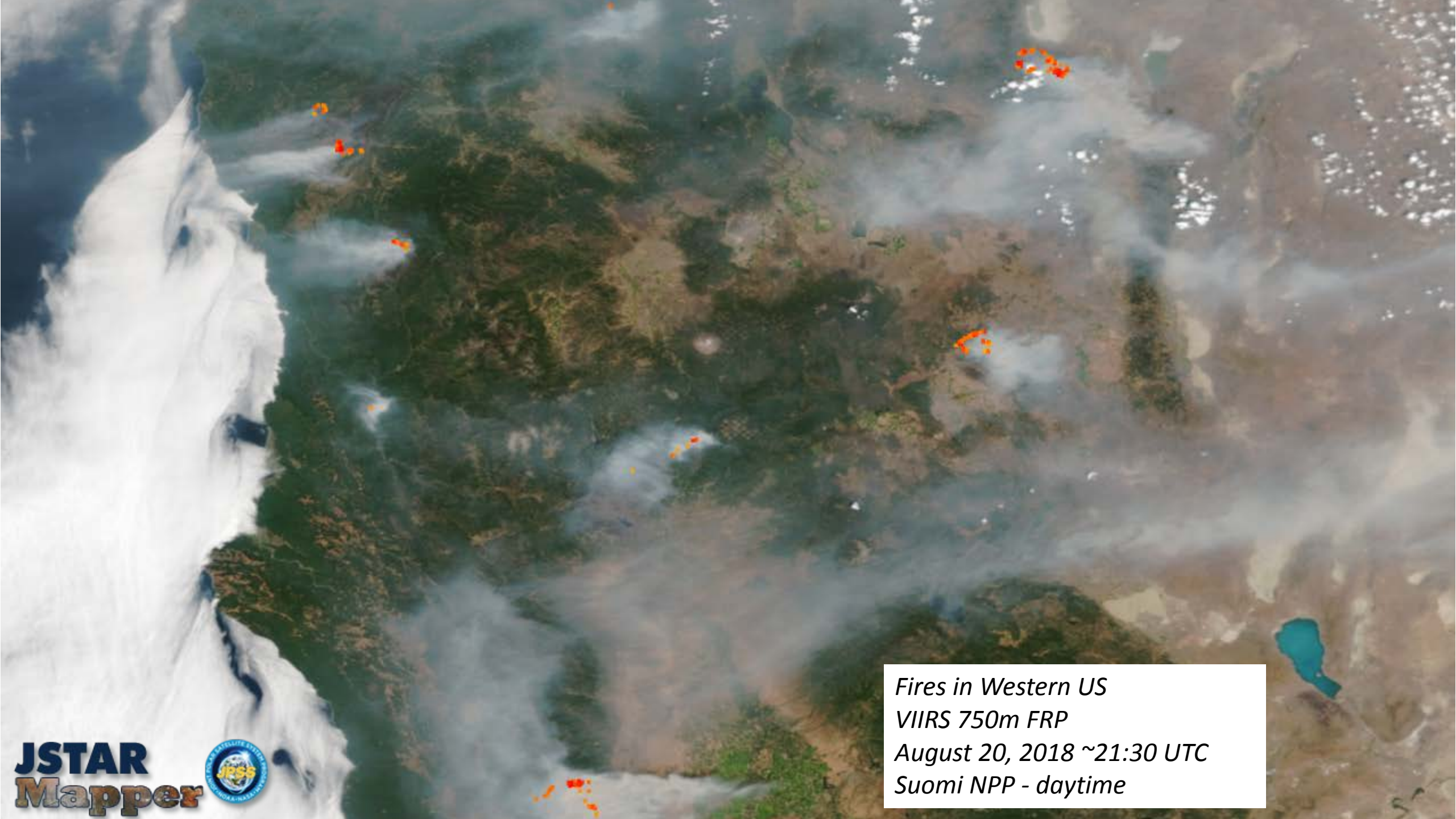
NOAA-20 6:01 UTC



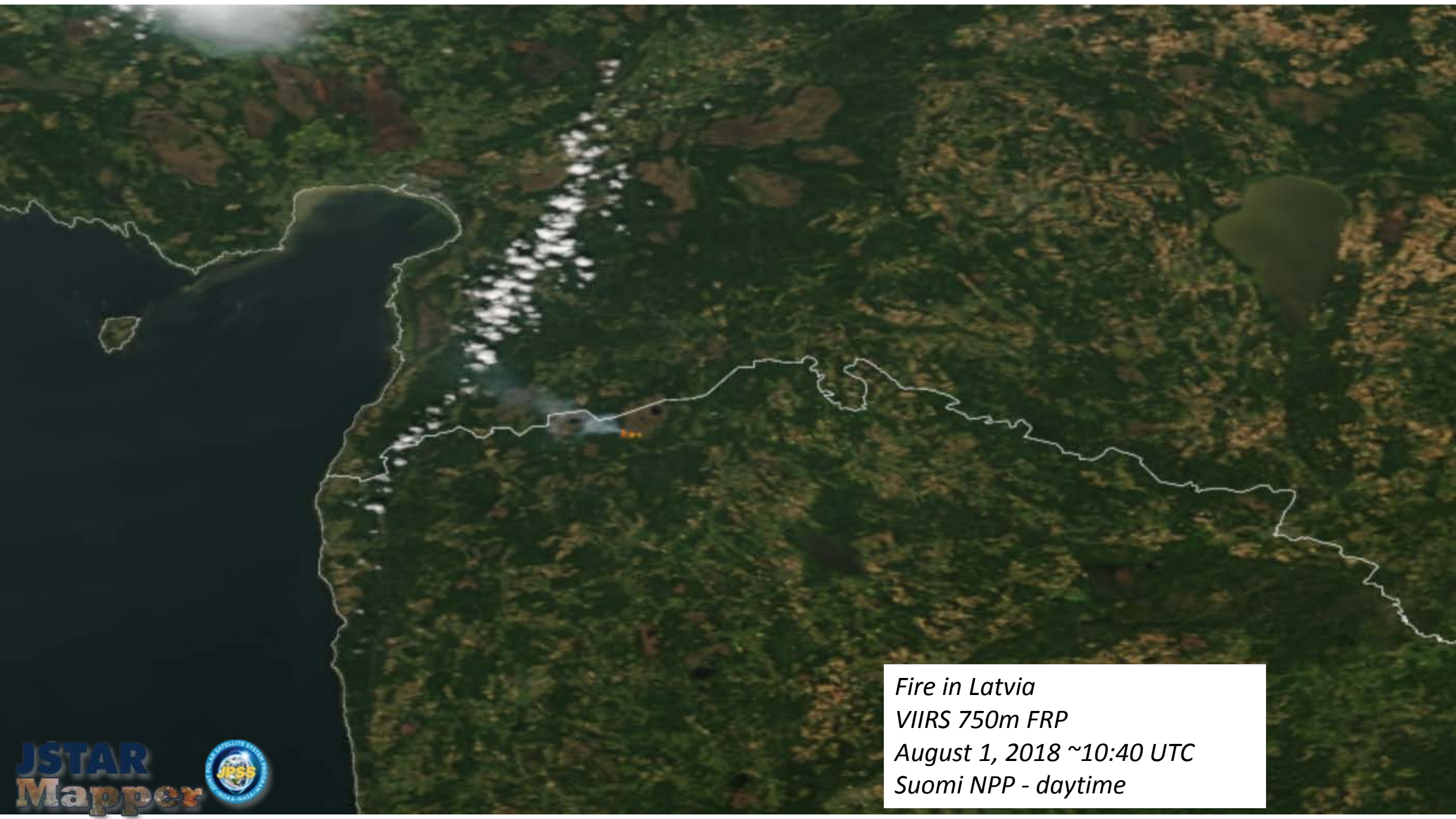
***“first light”
NOAA-20 fire
image by the
Science Team***



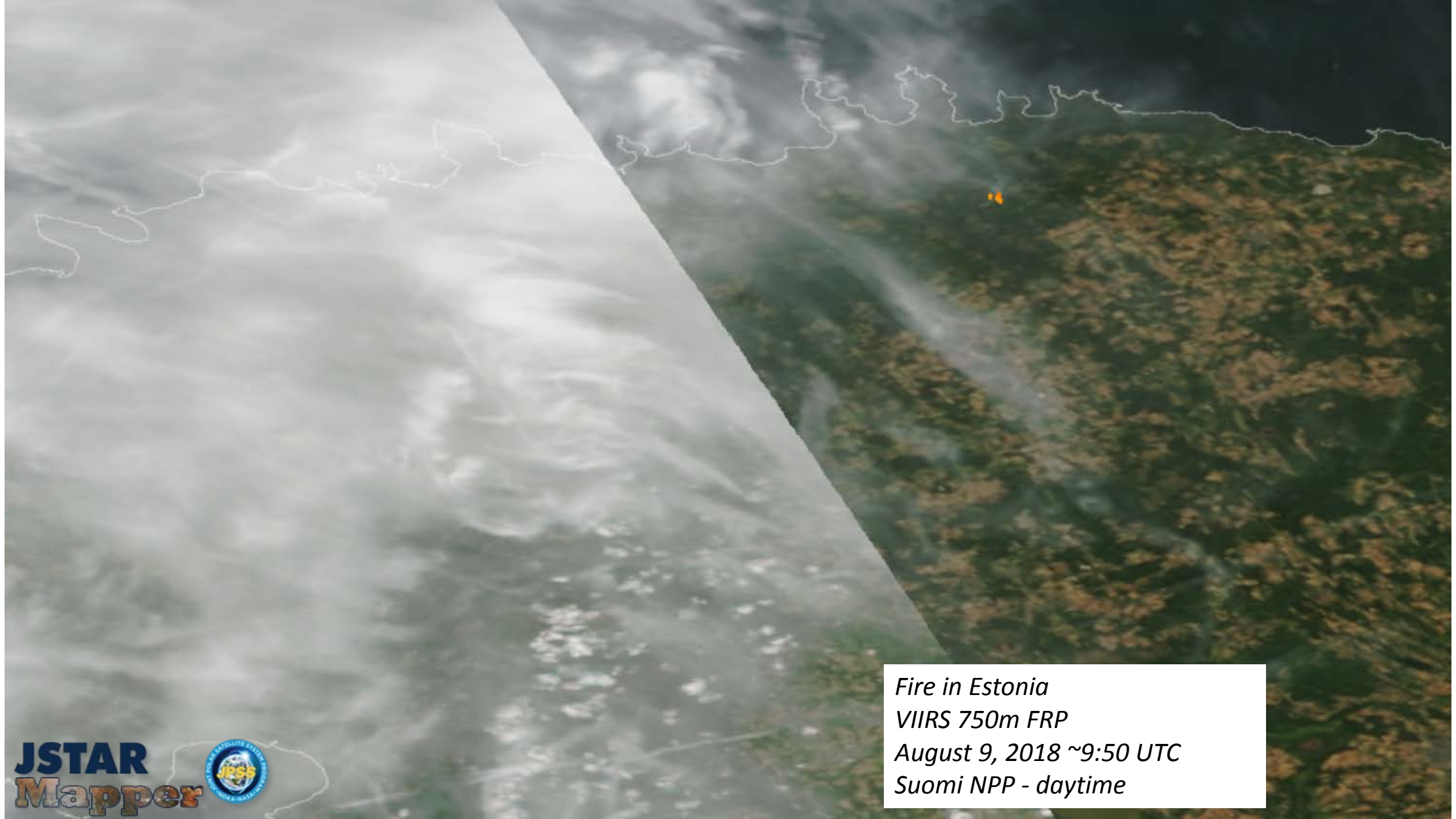
*Fires in Western US
VIIRS 750m FRP
August 20, 2018 ~20:40 UTC
NOAA-20 - daytime*



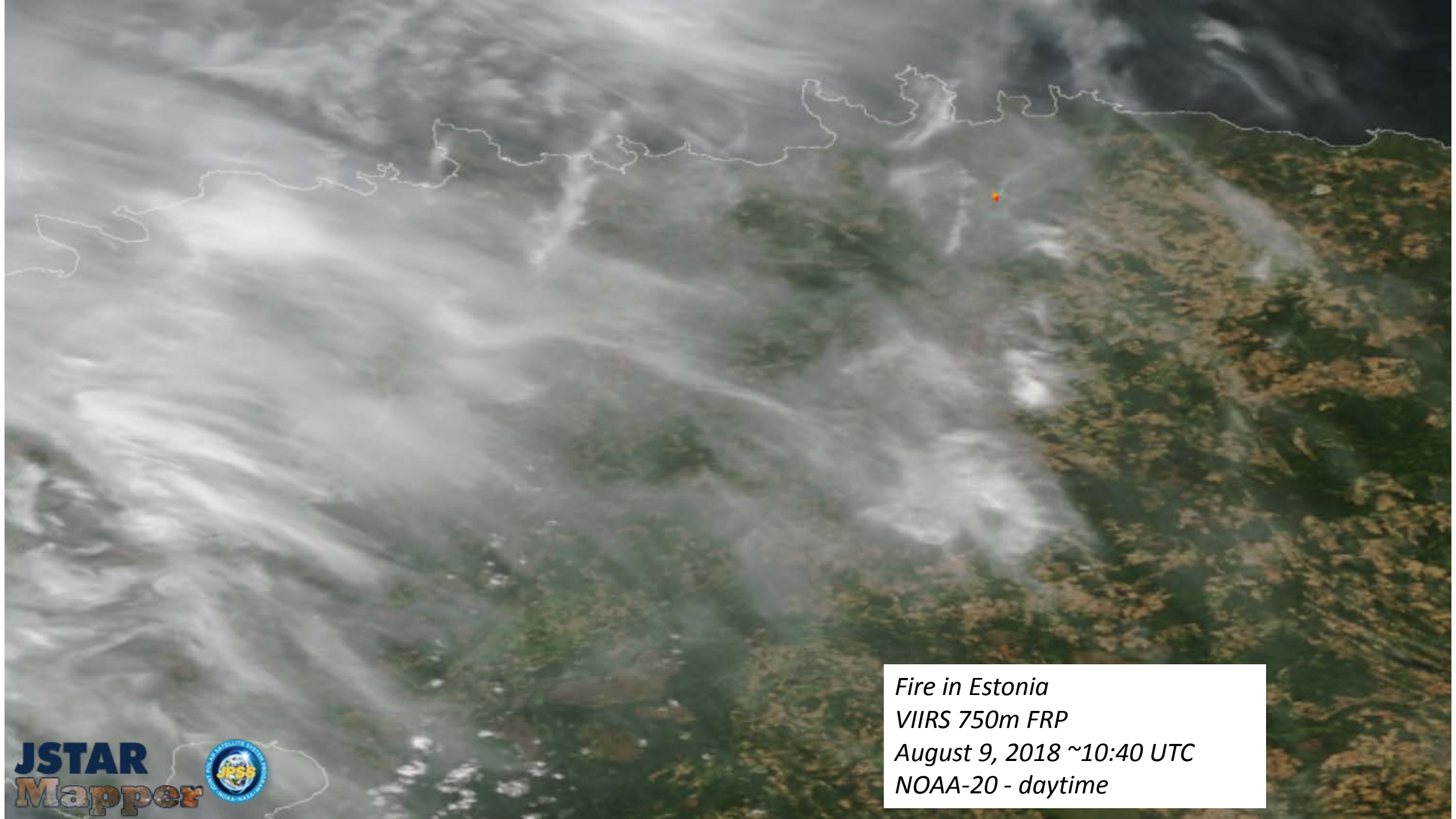
*Fires in Western US
VIIRS 750m FRP
August 20, 2018 ~21:30 UTC
Suomi NPP - daytime*



*Fire in Latvia
VIIRS 750m FRP
August 1, 2018 ~10:40 UTC
Suomi NPP - daytime*



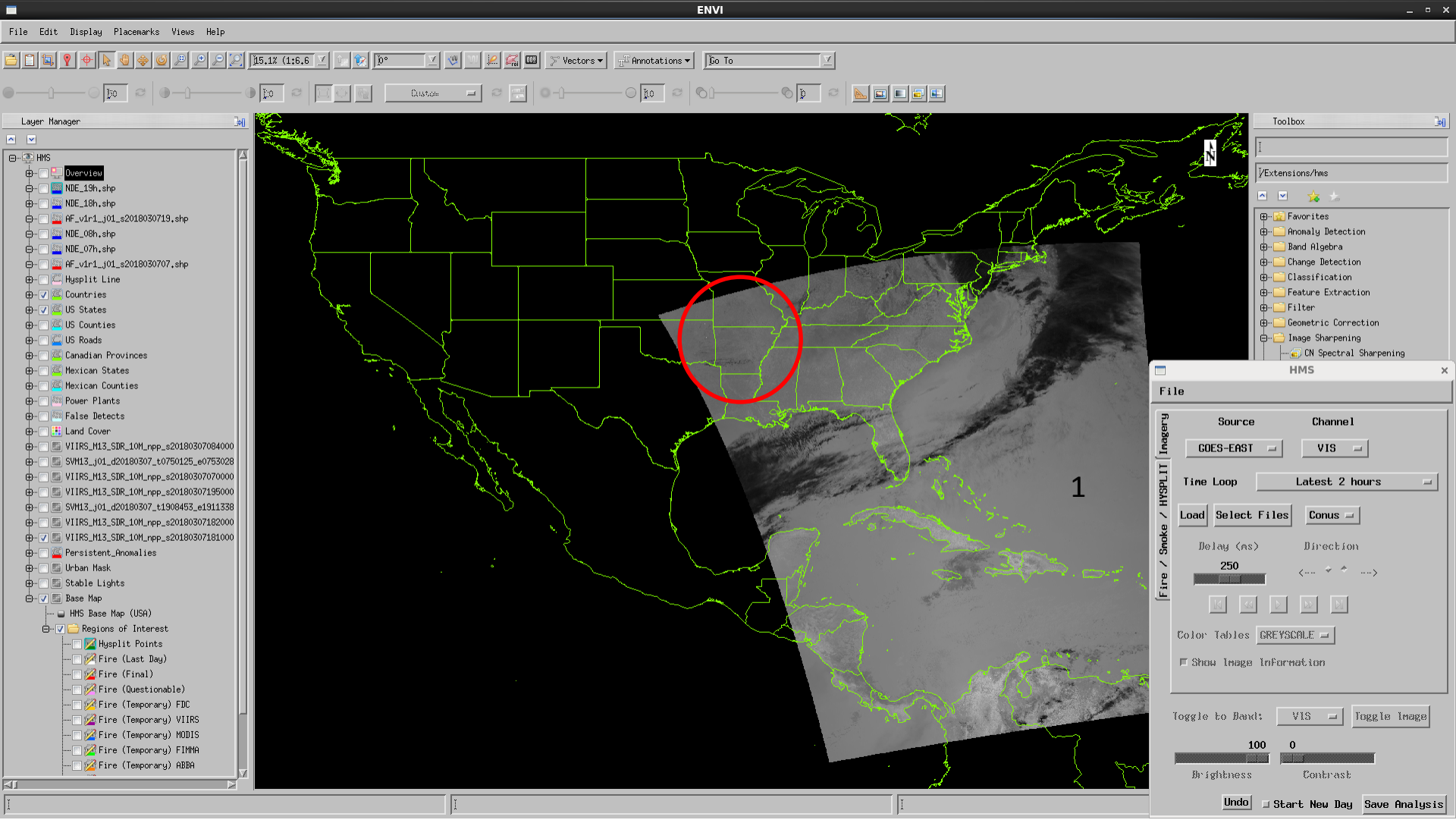
*Fire in Estonia
VIIRS 750m FRP
August 9, 2018 ~9:50 UTC
Suomi NPP - daytime*



*Fire in Estonia
VIIRS 750m FRP
August 9, 2018 ~10:40 UTC
NOAA-20 - daytime*

Hazard Mapping System

07 March 2018 – afternoon data



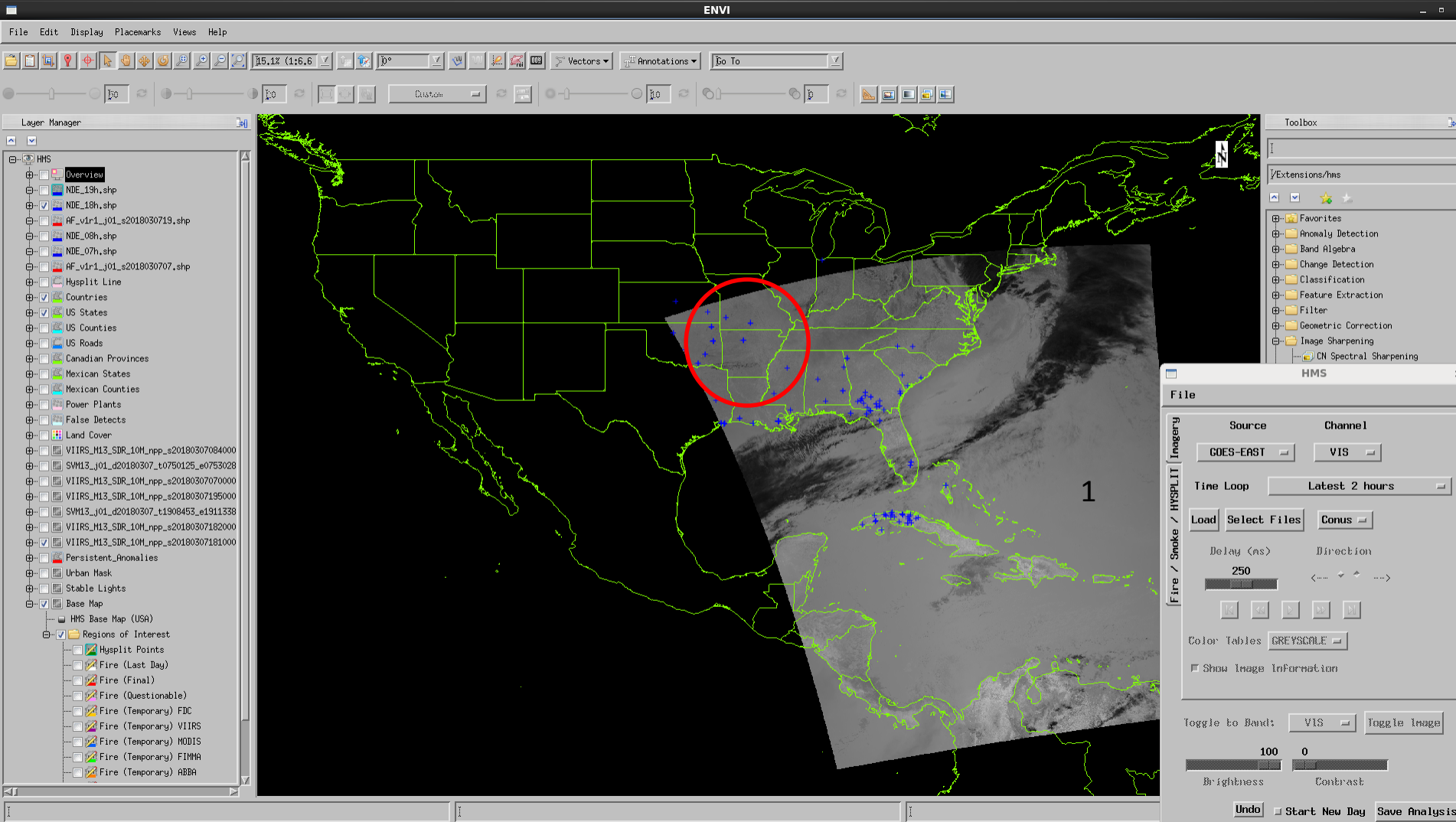
VIIRS swath overlaps allow for multiple looks by the two-satellite configuration even at mid-latitudes!

10-min granule

1: S-NPP/VIIRS 1810UTC

Hazard Mapping System

07 March 2018 – afternoon data



VIIRS swath overlaps allow for multiple looks by the two-satellite configuration even at mid-latitudes!

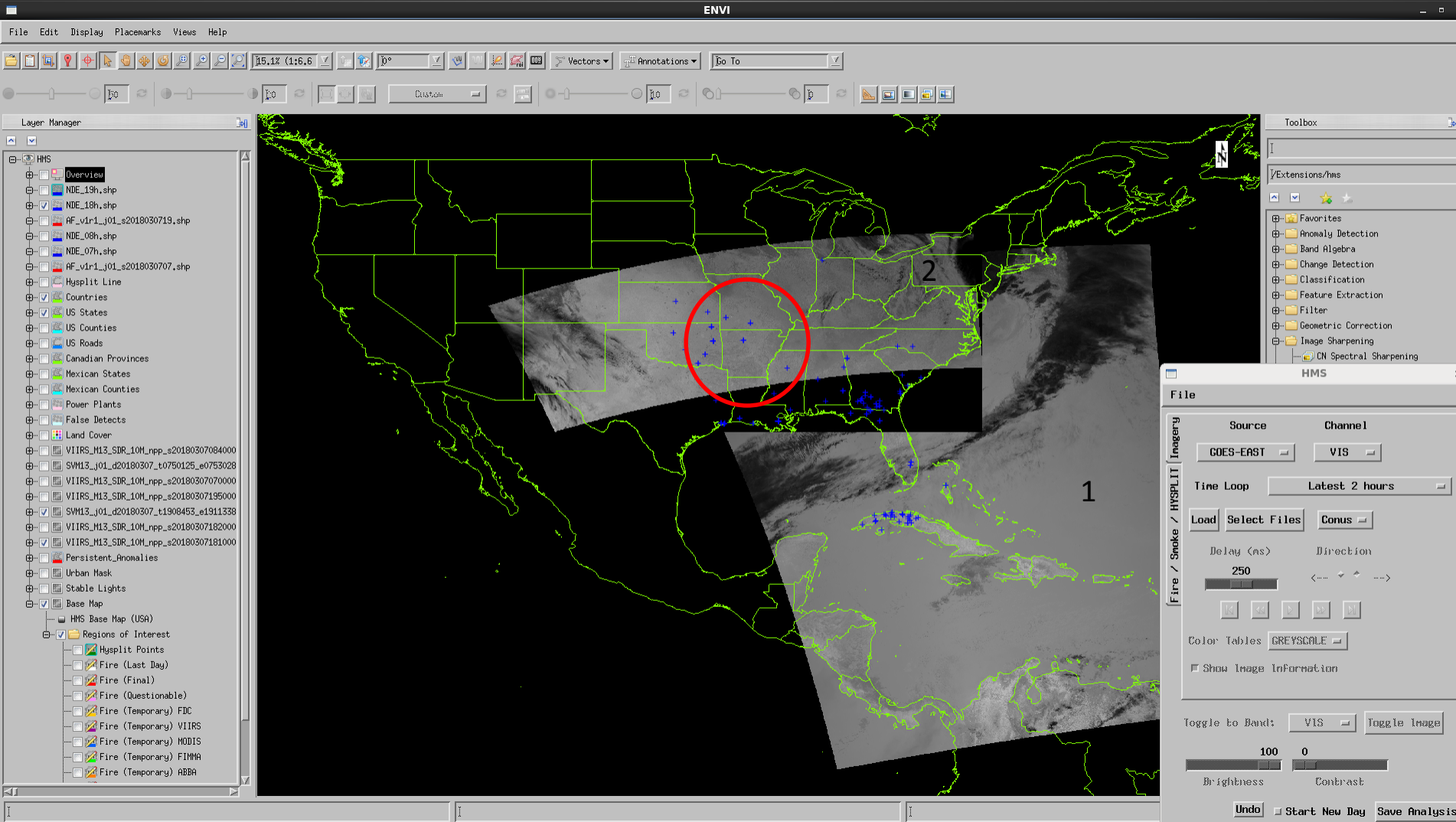
10-min granule

1: S-NPP/VIIRS 1810UTC

* S-NPP VIIRS 750m fire pixels

Hazard Mapping System

07 March 2018 – afternoon data



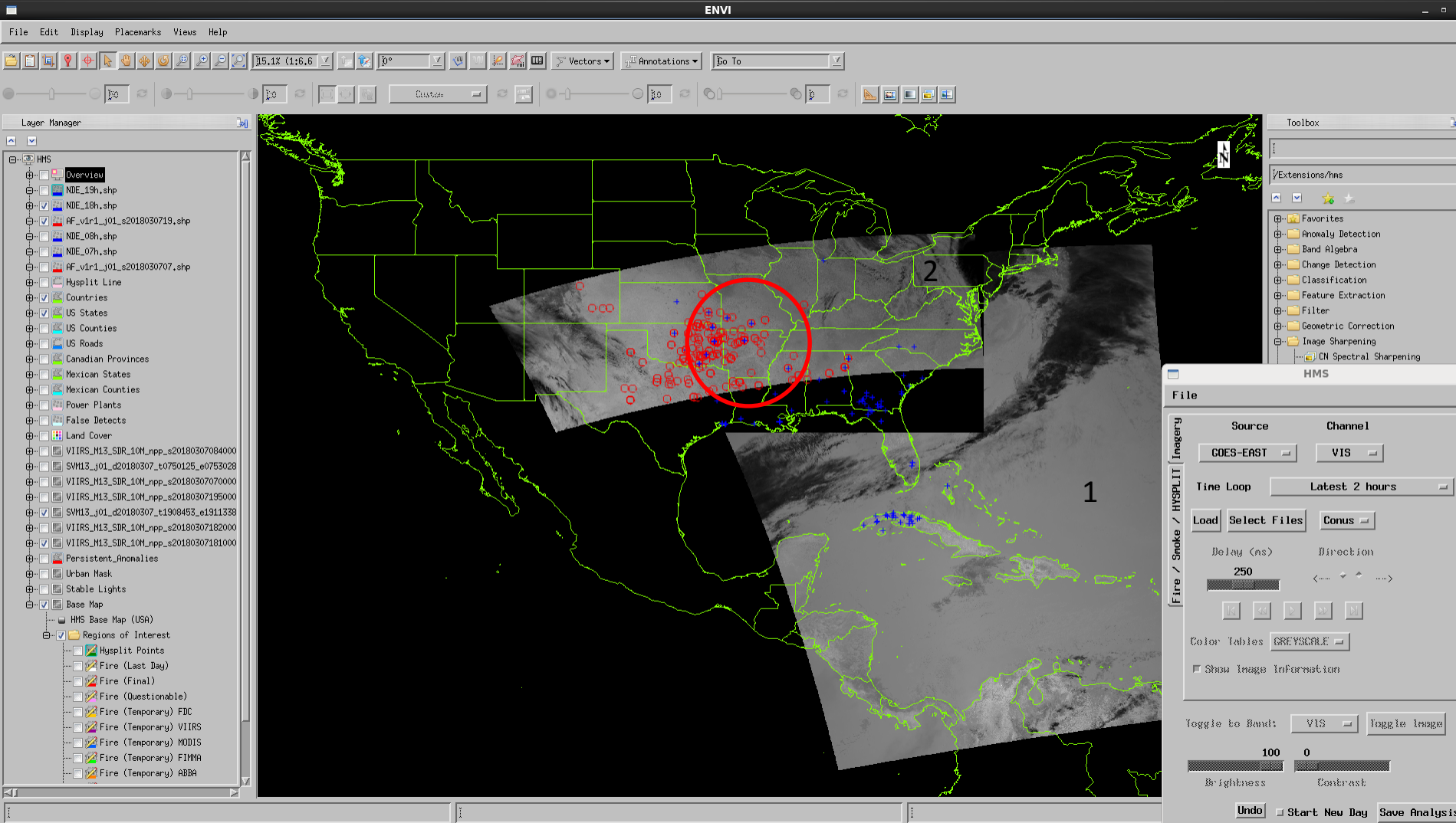
VIIRS swath overlaps allow for multiple looks by the two-satellite configuration even at mid-latitudes!

2x86sec granule

2: NOAA-20/VIIRS 1900UTC

Hazard Mapping System

07 March 2018 – afternoon data



VIIRS swath overlaps allow for multiple looks by the two-satellite configuration even at mid-latitudes!

2x86sec granule

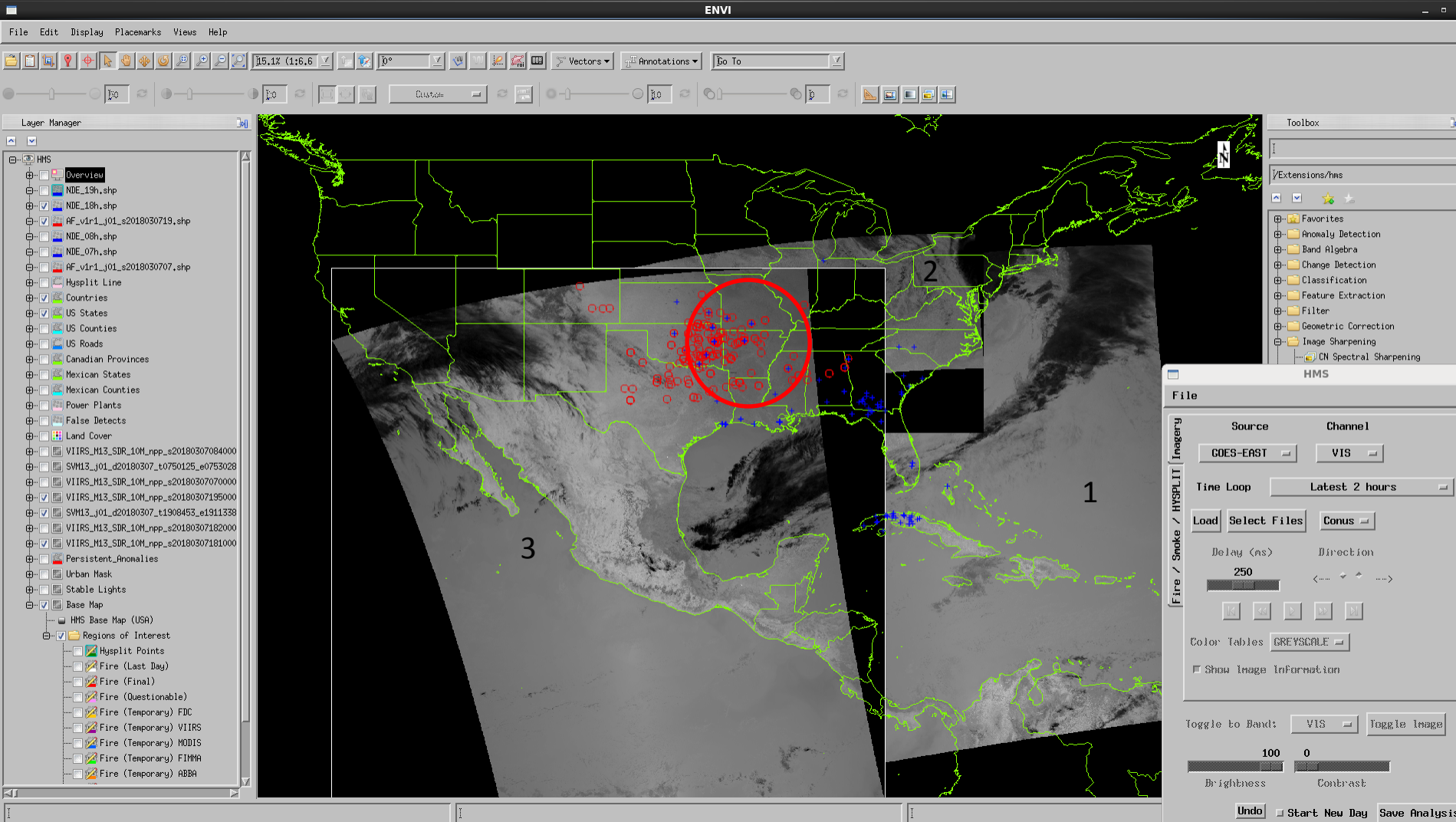
2: NOAA-20/VIIRS 1900UTC

* S-NPP VIIRS 750m fire pixels

o NOAA-20 VIIRS 750m fire pixels

Hazard Mapping System

07 March 2018 – afternoon data



VIIRS swath overlaps allow for multiple looks by the two-satellite configuration even at mid-latitudes!

10-min granule

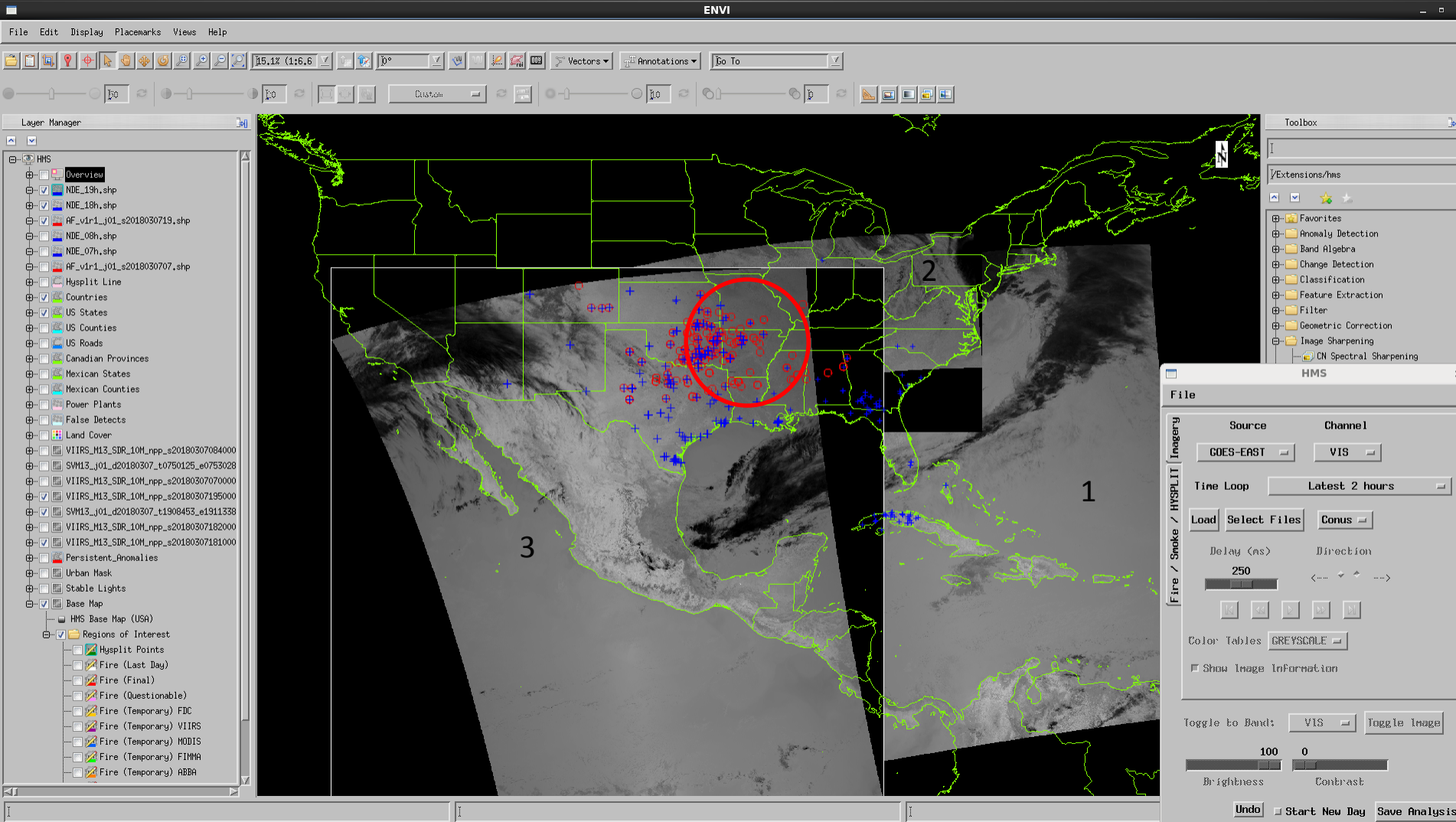
3: S-NPP/VIIRS 1950UTC

* S-NPP VIIRS 750m fire pixels

o NOAA-20 VIIRS 750m fire pixels

Hazard Mapping System

07 March 2018 – afternoon data



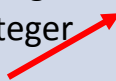
VIIRS swath overlaps allow for multiple looks by the two-satellite configuration even at mid-latitudes!

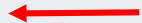
10-min granule

3: S-NPP/VIIRS 1950UTC

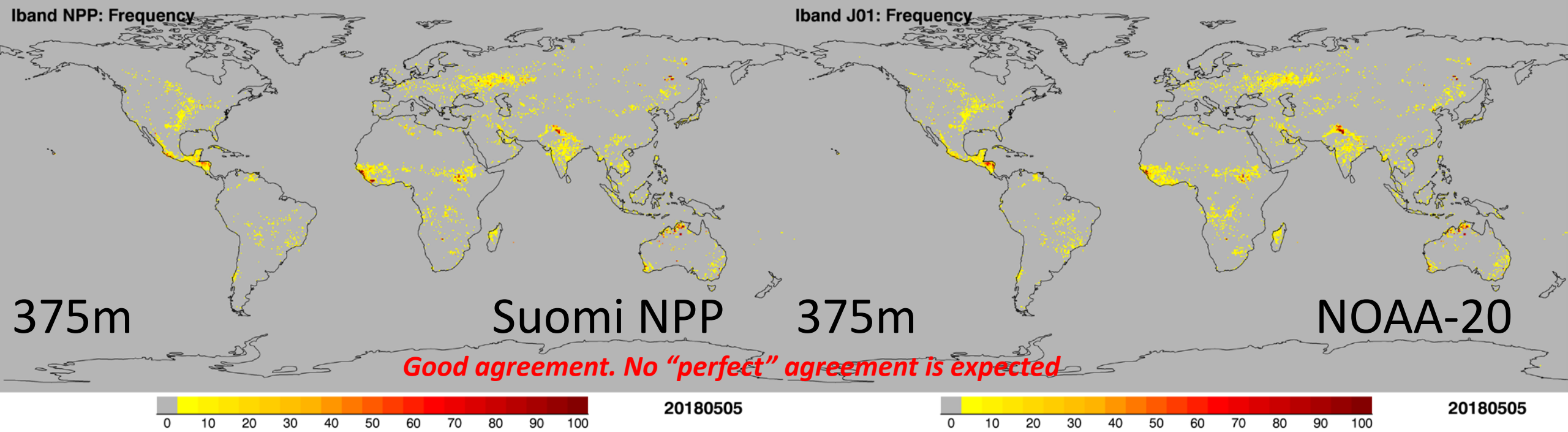
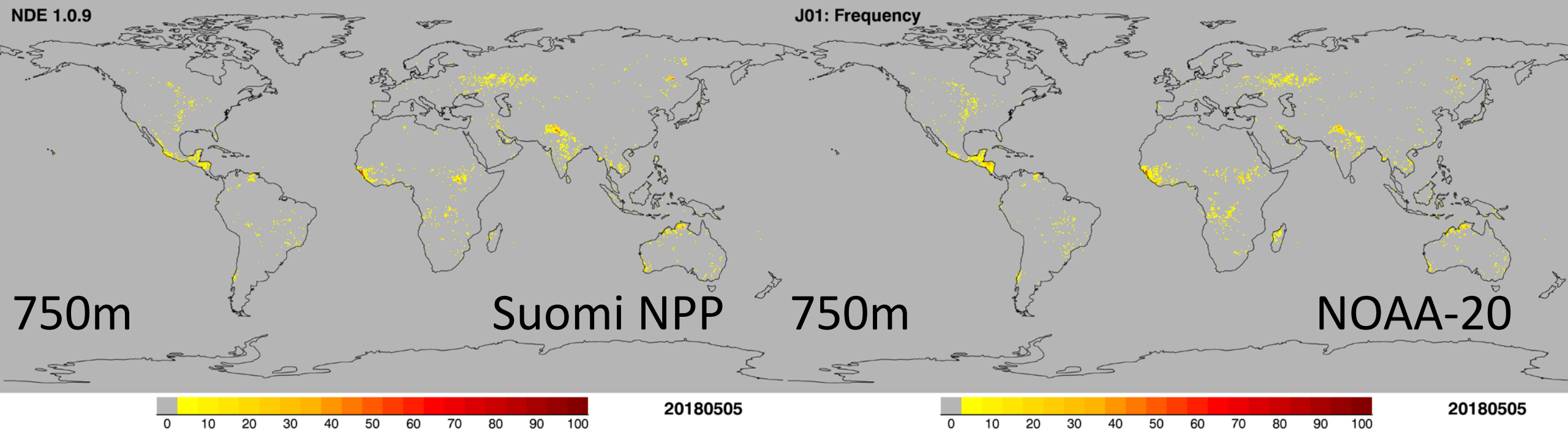
* S-NPP VIIRS 750m fire pixels
o NOAA-20 VIIRS 750m fire pixels

750m VIIRS NDE Product content

Output	Type	Description	
Fire Mask	8-bit unsigned integer 	Missing – 0	Missing input data
		Scan – 1	On-board bowtie deletion
		Other – 2	Not processed (obsolete)
		Water – 3	Pixel classified as non-fire water
		Cloud – 4	Pixel classified as cloudy
		No Fire – 5	Pixel classified as non-fire land
		Unknown – 6	Pixel with no valid background pixels
		Fire Low – 7	Fire pixel with confidence strictly less than 20% fire
		Fire Medium – 8	Fire pixel with confidence between 20% and 80%
		Fire High – 9	Fire pixel with confidence greater than or equal to 80%
Fire Algorithm QA Mask	32-bit unsigned integer	Details in Table 1-5	

Bits	Description
0-1	Surface Type (water=0, coastal=1, land=2)
2	EDR ground bowtie deletion zone (0=false, 1=true) 
3	Atmospheric correction performed (0=false, 1=true)
4	Day/Night (daytime = 1, nighttime = 0)
5	Potential fire (0=false, 1=true)
6	spare
7-10	Background window size parameter
11	Fire Test 1 valid (0 - No, 1 - Yes)
12	Fire Test 2 valid (0 - No, 1 - Yes)
13	Fire Test 3 valid (0 - No, 1 - Yes)
14	Fire Test 4 valid (0 - No, 1 - Yes)
15	Fire Test 5 valid (0 - No, 1 - Yes)
16	Fire Test 6 valid (0 - No, 1 - Yes)
17-19	spare
20	Adjacent clouds (0/1)
21	Adjacent water (0/1)
22-23	Sun Glint Level (0-3)
24	Sun Glint rejection
25	False Alarm (excessive rejection of legitimate background pixels)
26	False Alarm (rejection of land pixel due to water background)
27	Amazon forest-clearing rejection test
28	False alarm (rejection of water pixel due to land or coastal background)
29-31	spare

New information has been added on bow tie deletion.



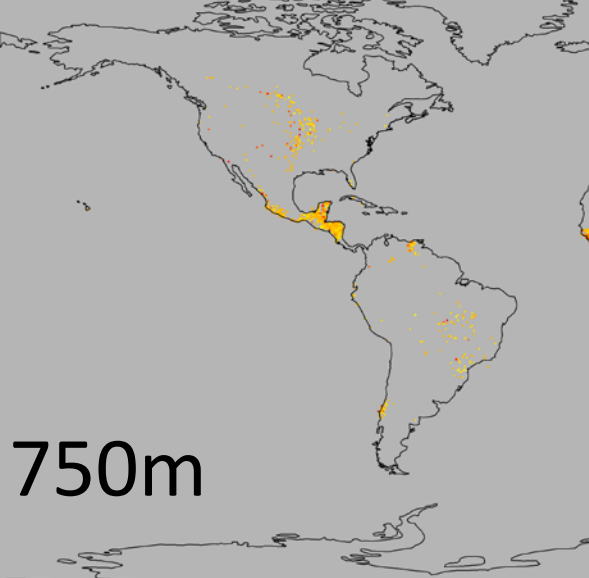
NDE 1.0.9: Mean FRP (MW)



750m

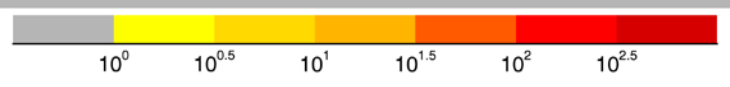
Suomi NPP

J01: Mean FRP (MW)

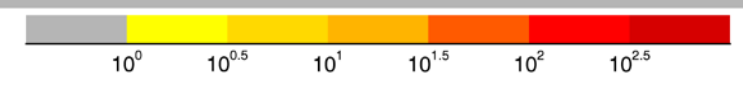


750m

NOAA-20

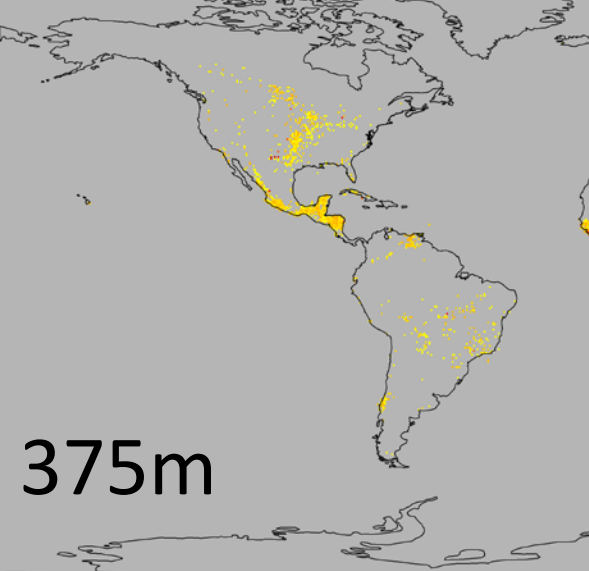


20180505



20180505

Iband NPP: Mean FRP (MW)



375m

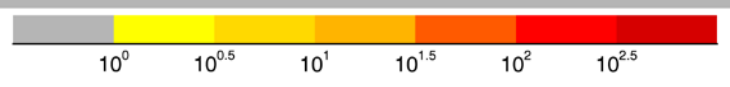
Suomi NPP

Iband J01: Mean FRP (MW)

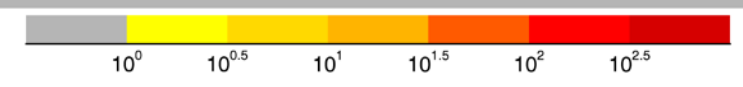


375m

NOAA-20



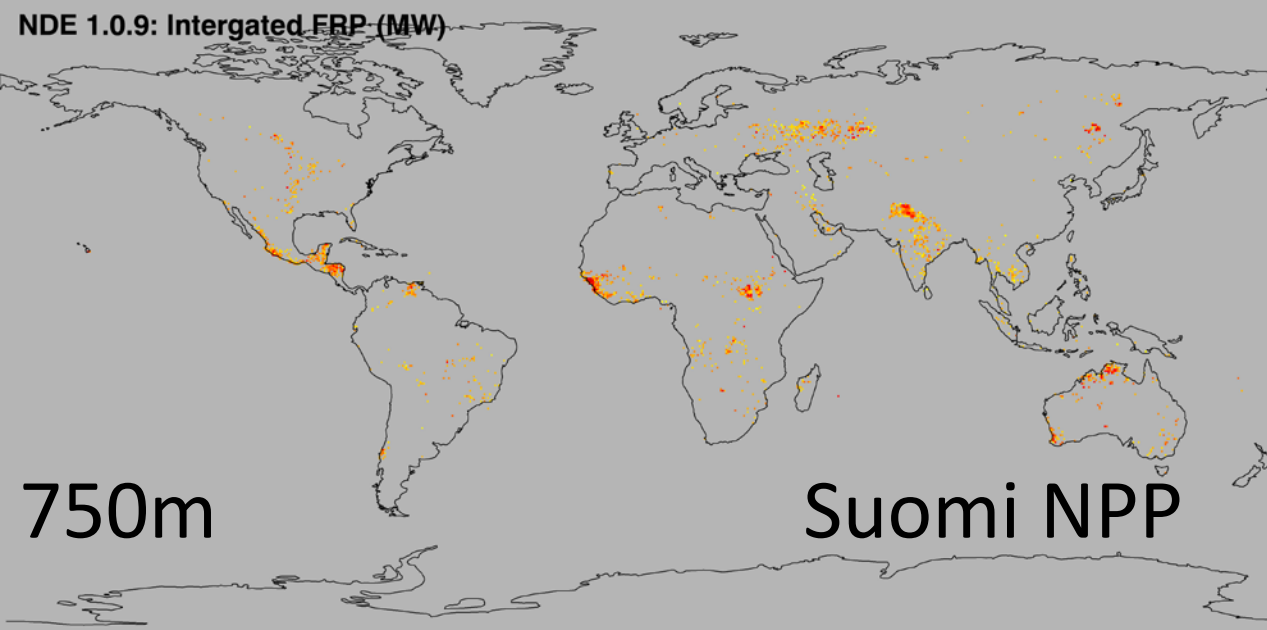
20180505



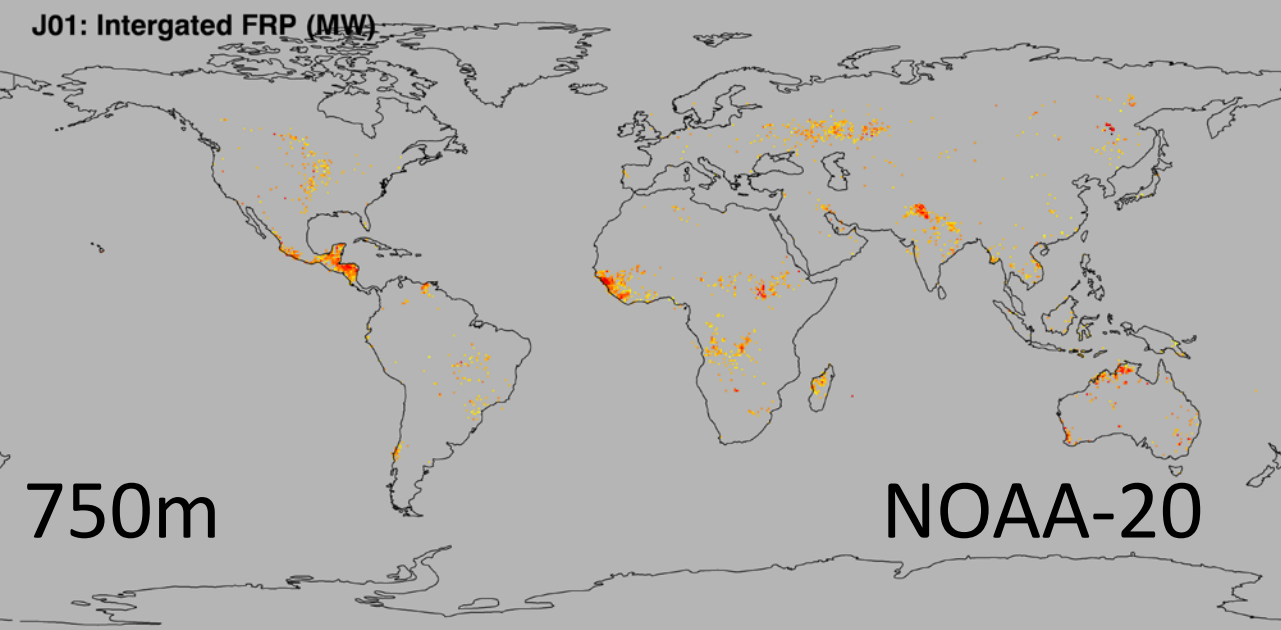
20180505

Good agreement. No "perfect" agreement is expected

NDE 1.0.9: Intergated FRP (MW)



J01: Intergated FRP (MW)

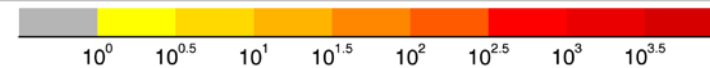


Suomi NPP

NOAA-20

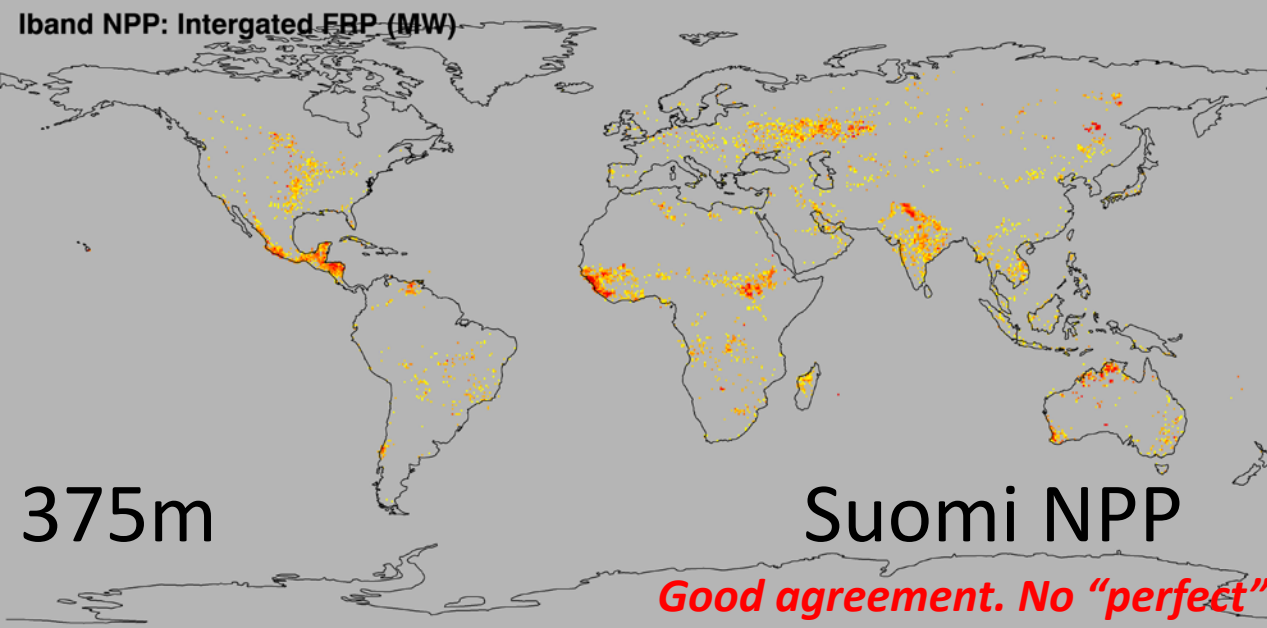


20180505

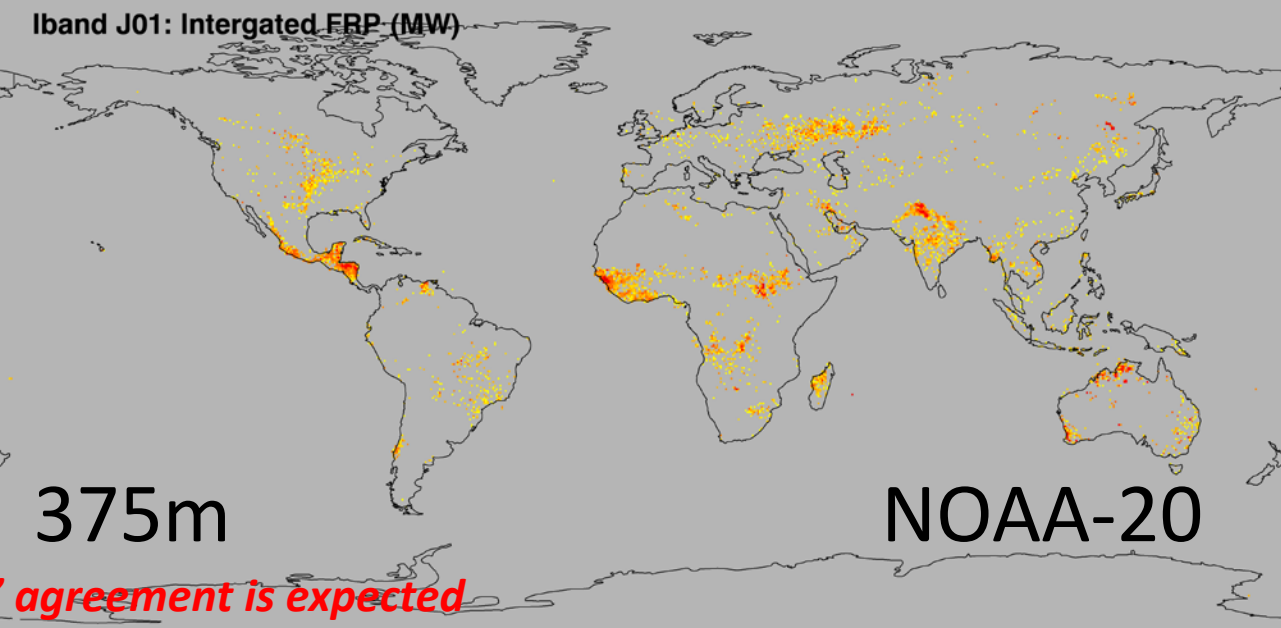


20180505

Iband NPP: Intergated FRP (MW)



Iband J01: Intergated FRP (MW)



Suomi NPP

NOAA-20

Good agreement. No "perfect" agreement is expected

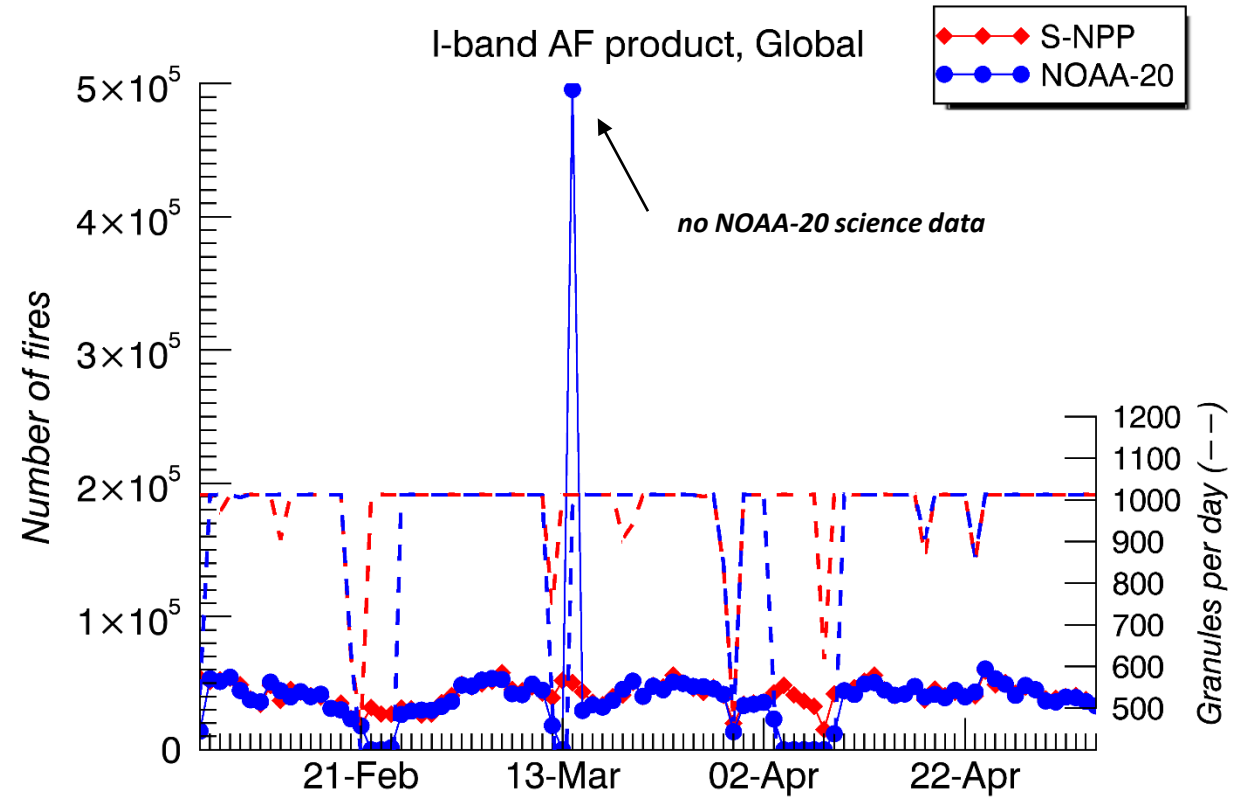
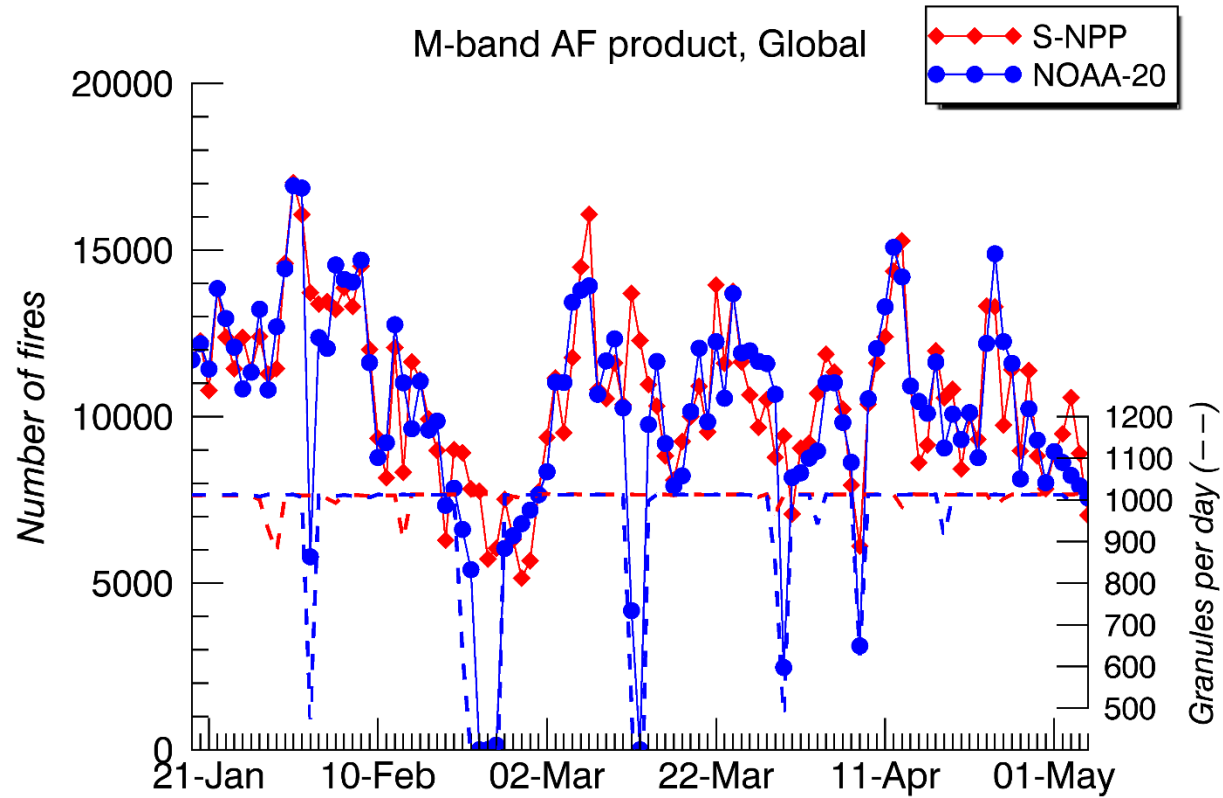


20180505



20180505

Suomi NPP vs. NOAA-20 global fire statistics

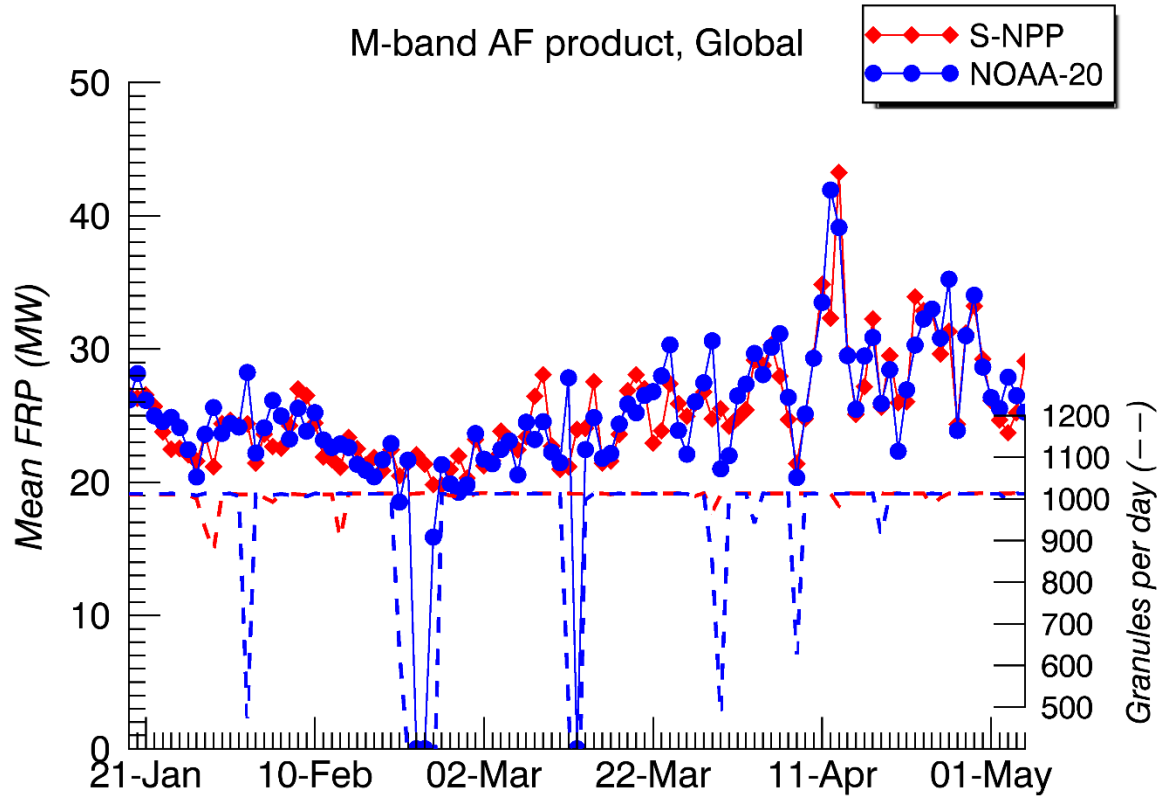


←
←
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↘
Unprocessed granules

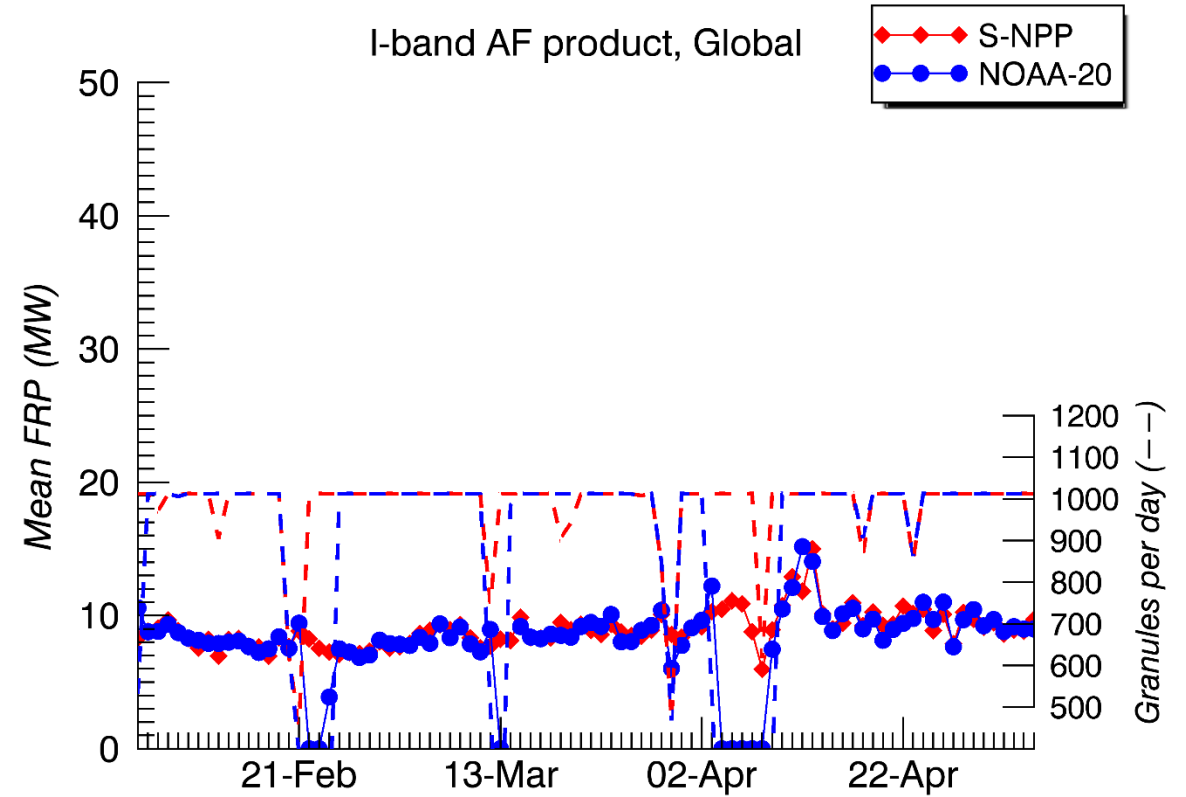
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Unprocessed granules

Good agreement. No "perfect" agreement is expected

Suomi NPP vs. NOAA-20 global fire statistics



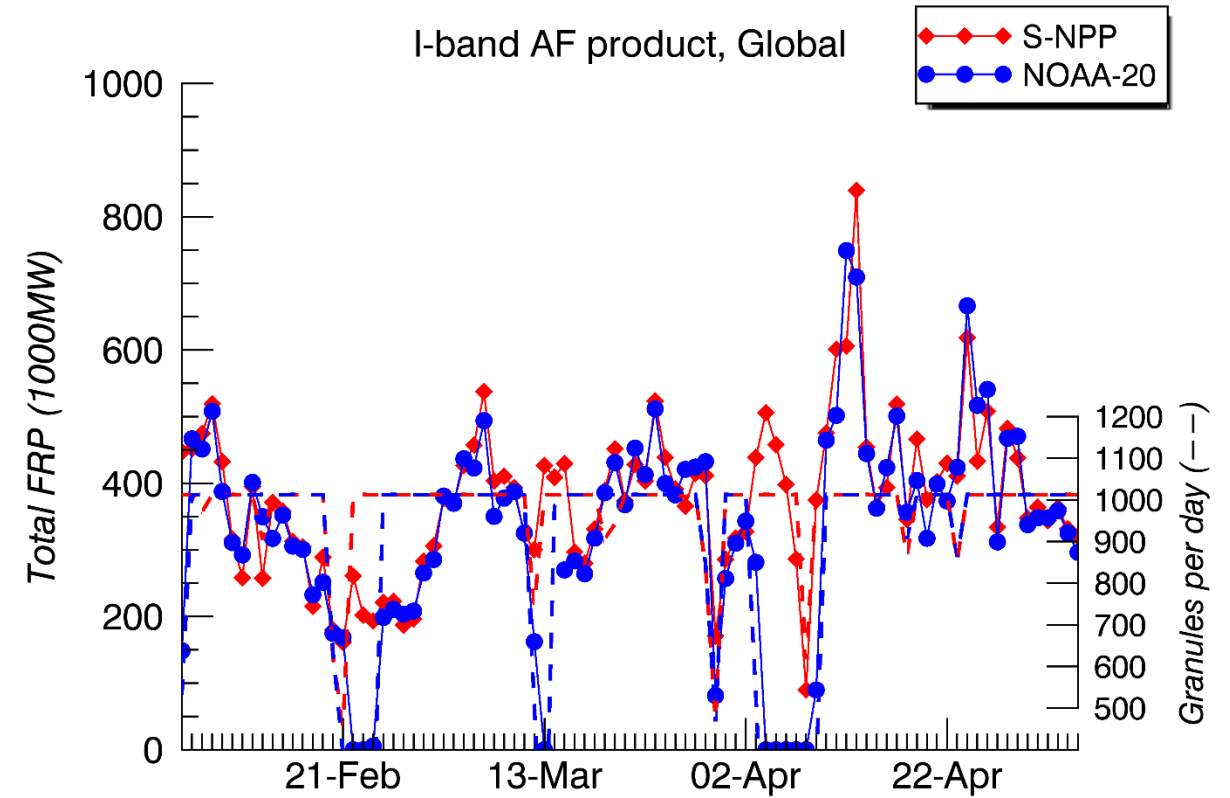
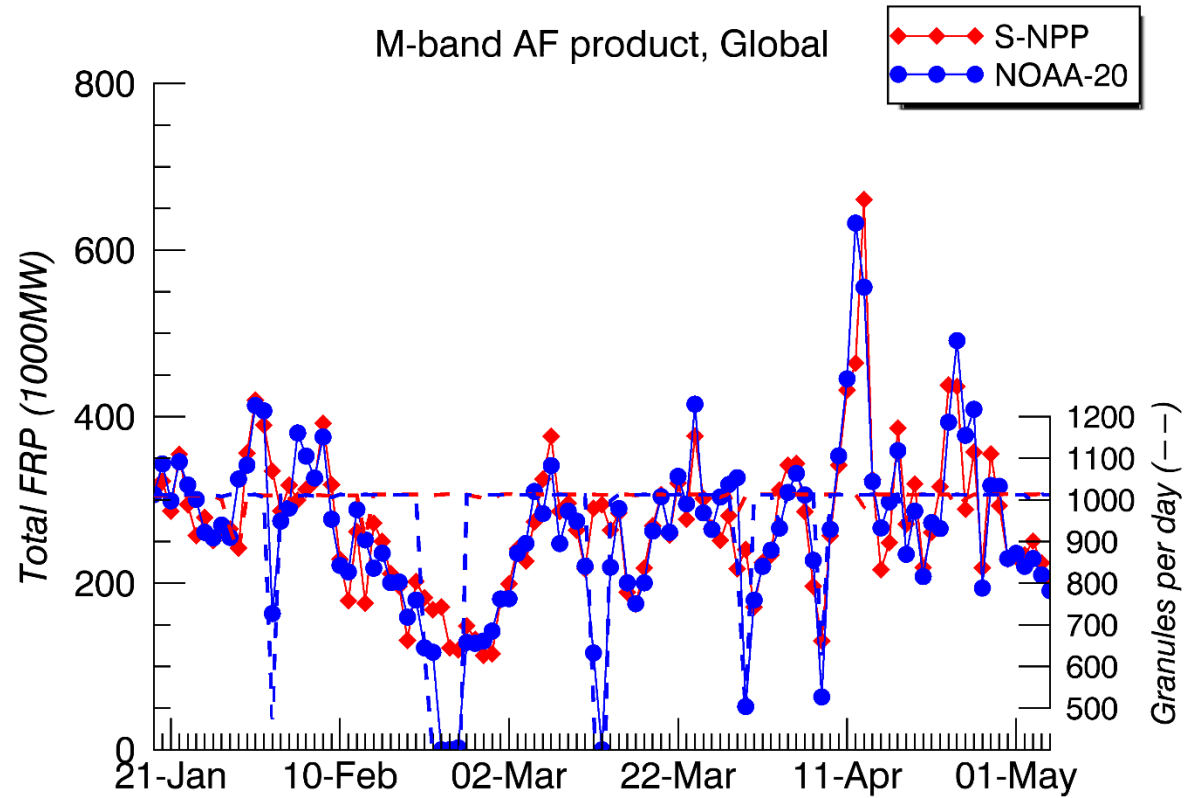
Unprocessed granules



Unprocessed granules

Good agreement. No "perfect" agreement is expected

Suomi NPP vs. NOAA-20 global fire statistics

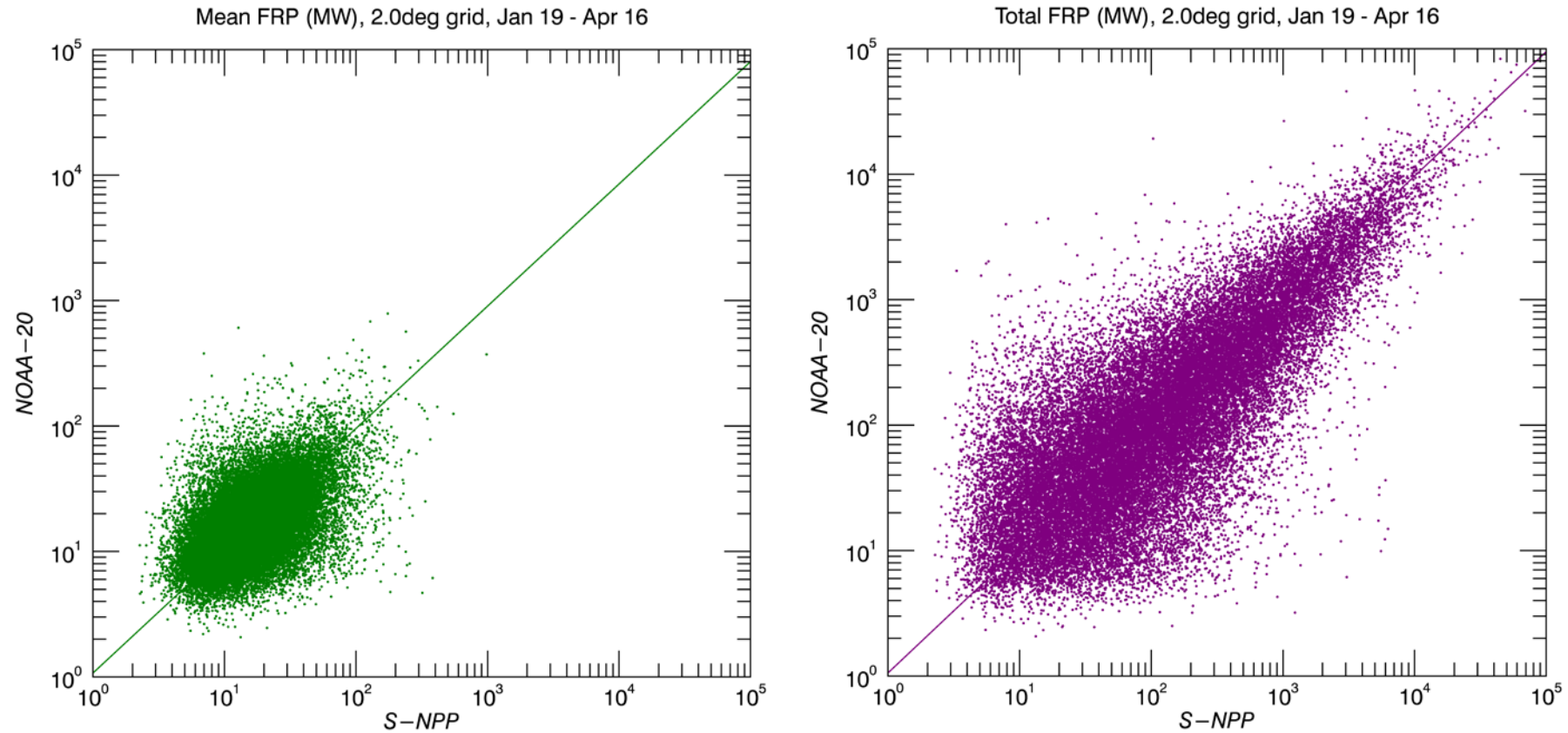


← ↑ ↗ ↘
Unprocessed granules

← ↑ ↗ ↘
Unprocessed granules

Good agreement. No "perfect" agreement is expected

Suomi NPP vs. NOAA-20: 750m

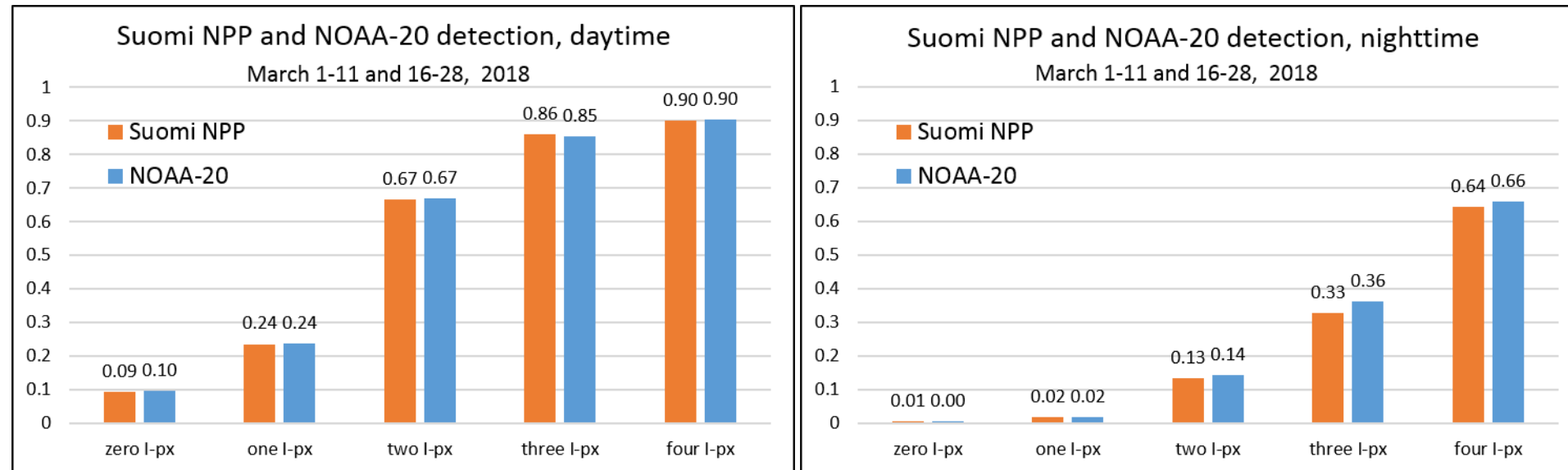


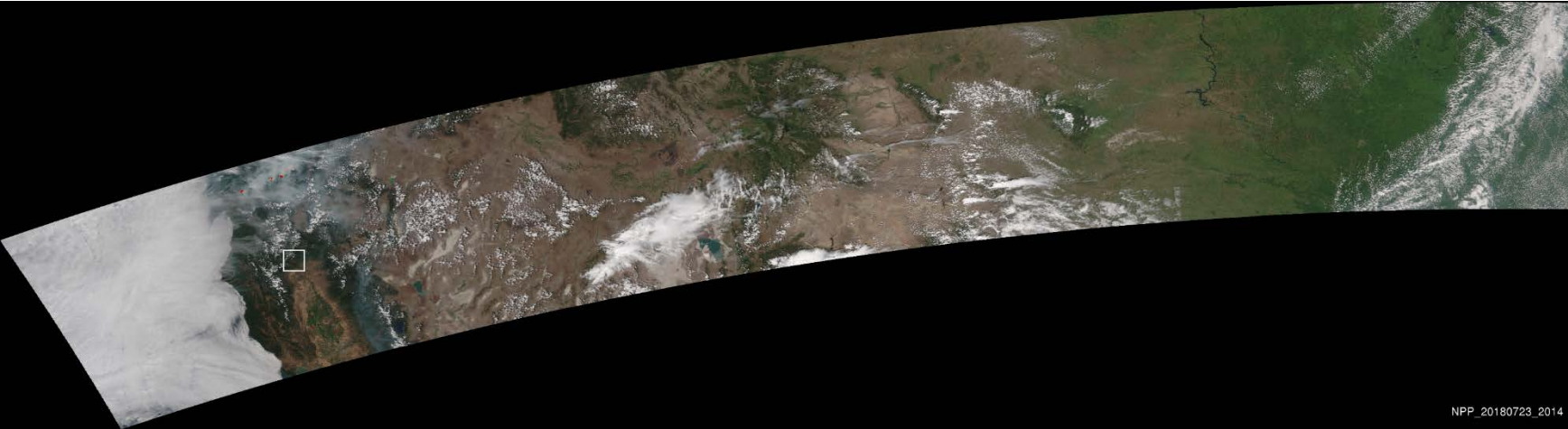
Good agreement. No "perfect" agreement is expected

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

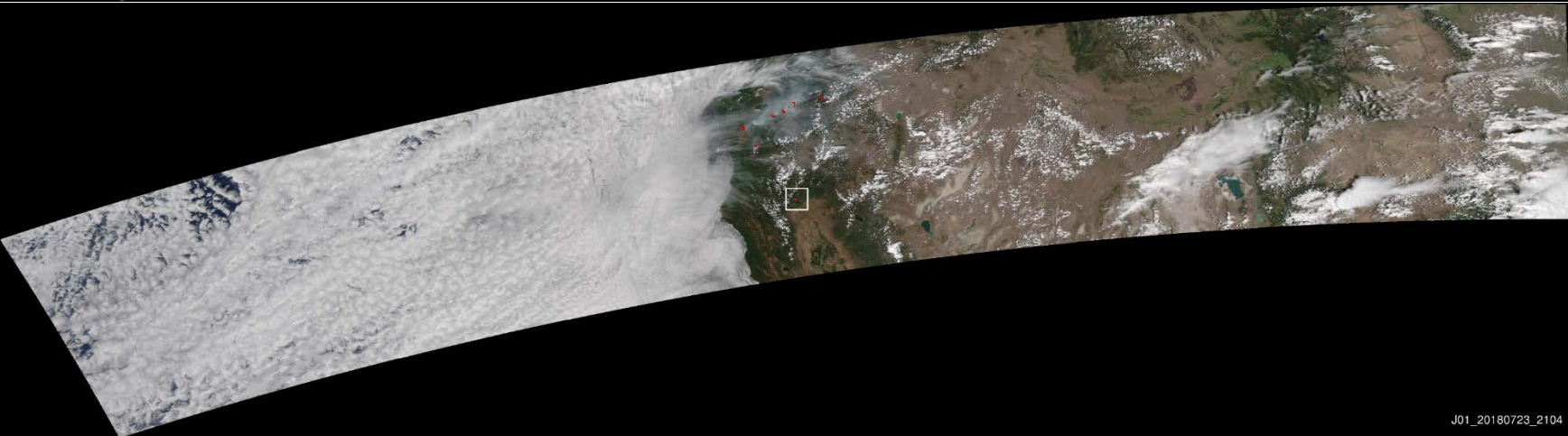




NPP_20180723_2014



NPP_20180723_2014



J01_20180723_2104



J01_20180723_2104



NPP_20180723_2155



NPP_20180723_2155

Carr fire, California, July 23, 2018

Carr Fire in California as seen by Suomi NPP VIIRS and GOES-16 ABI

First detection by Suomi NPP VIIRS at 20:14 UTC

First detection by GOES-16 at 20:37 UTC

GOES-16 filled in the gap and detection the fast
growth of the fire

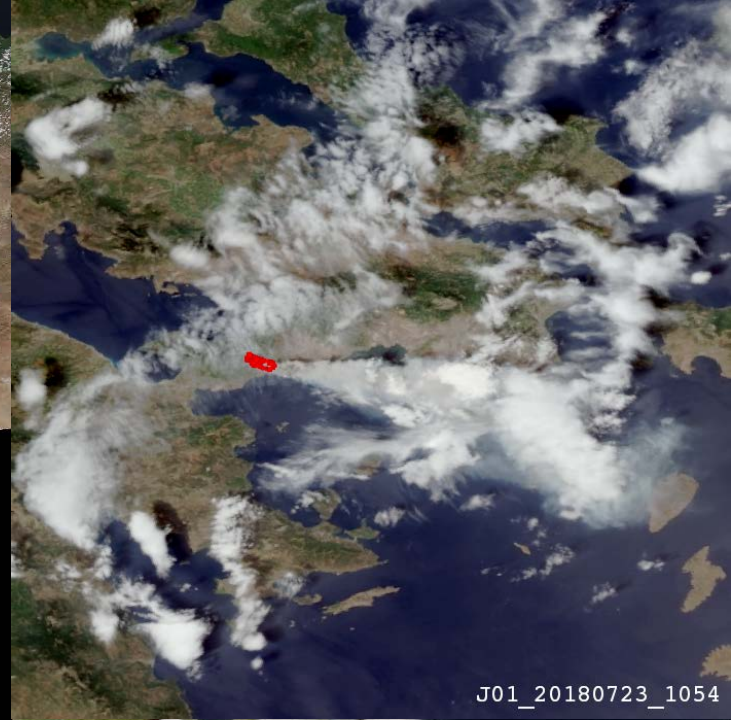
NOAA-20 VIIRS detected again at 21:04 UTC as a
larger fire

GOES-16 continued monitoring the growth of
the fire complex

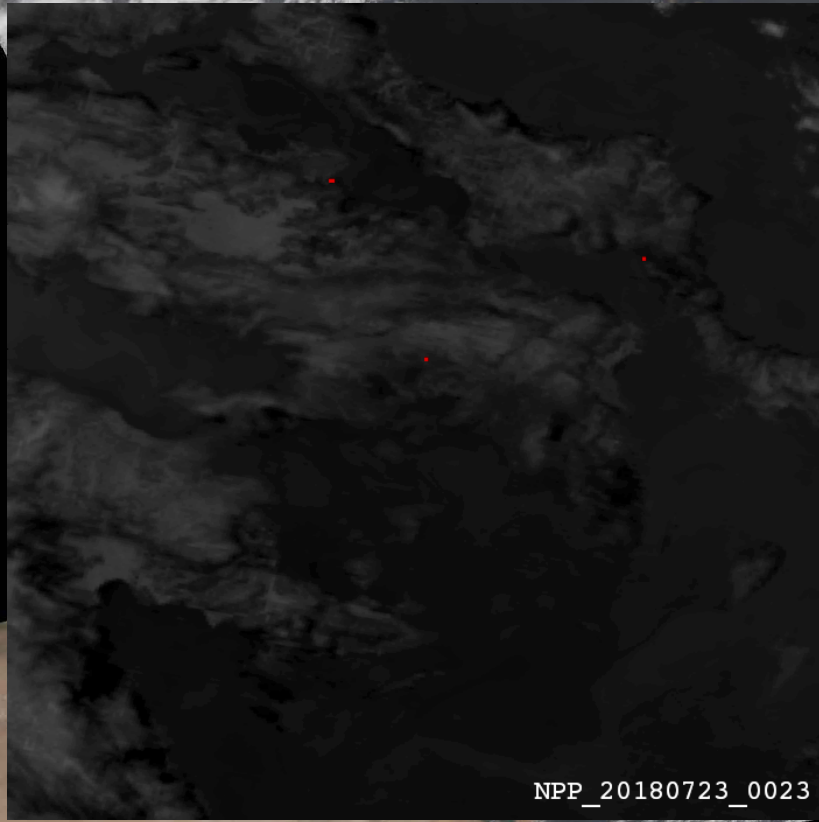
Suomi NPP detected again at 21:55 UTC



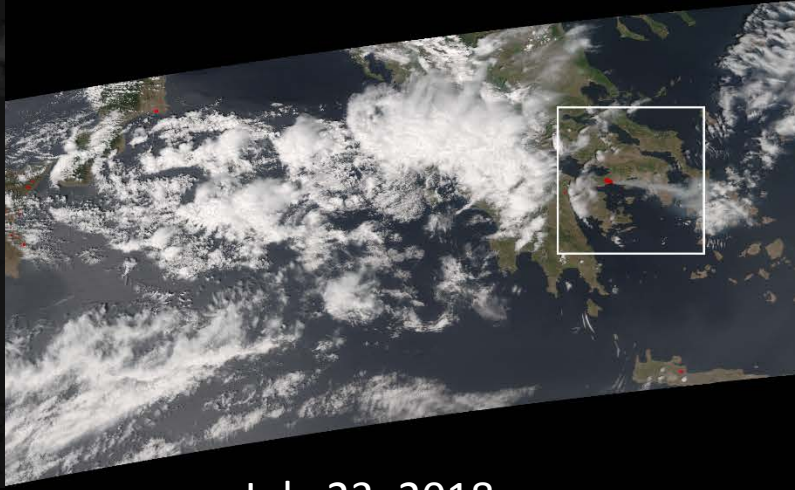
G16_20180723_2002



J01_20180723_1054

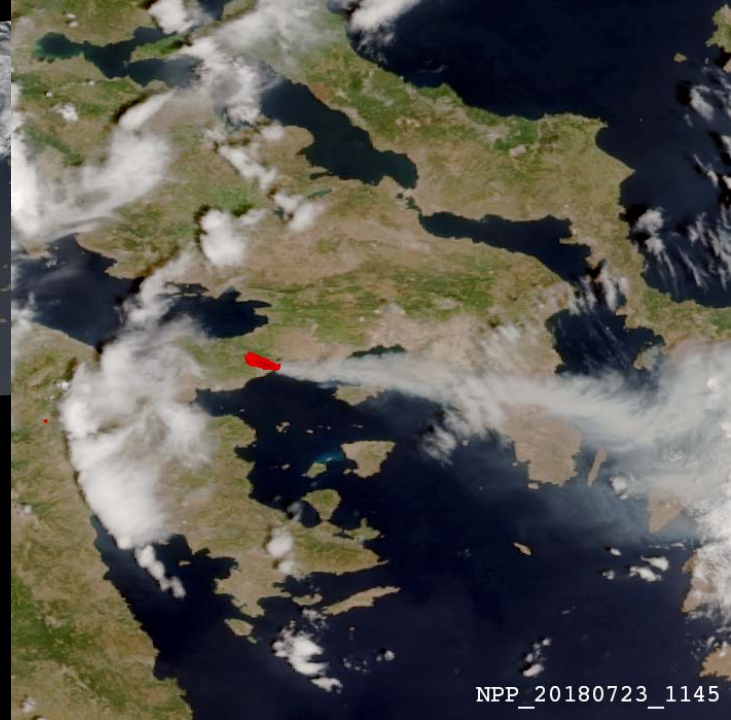


NPP_20180723_0023



July 23, 2018

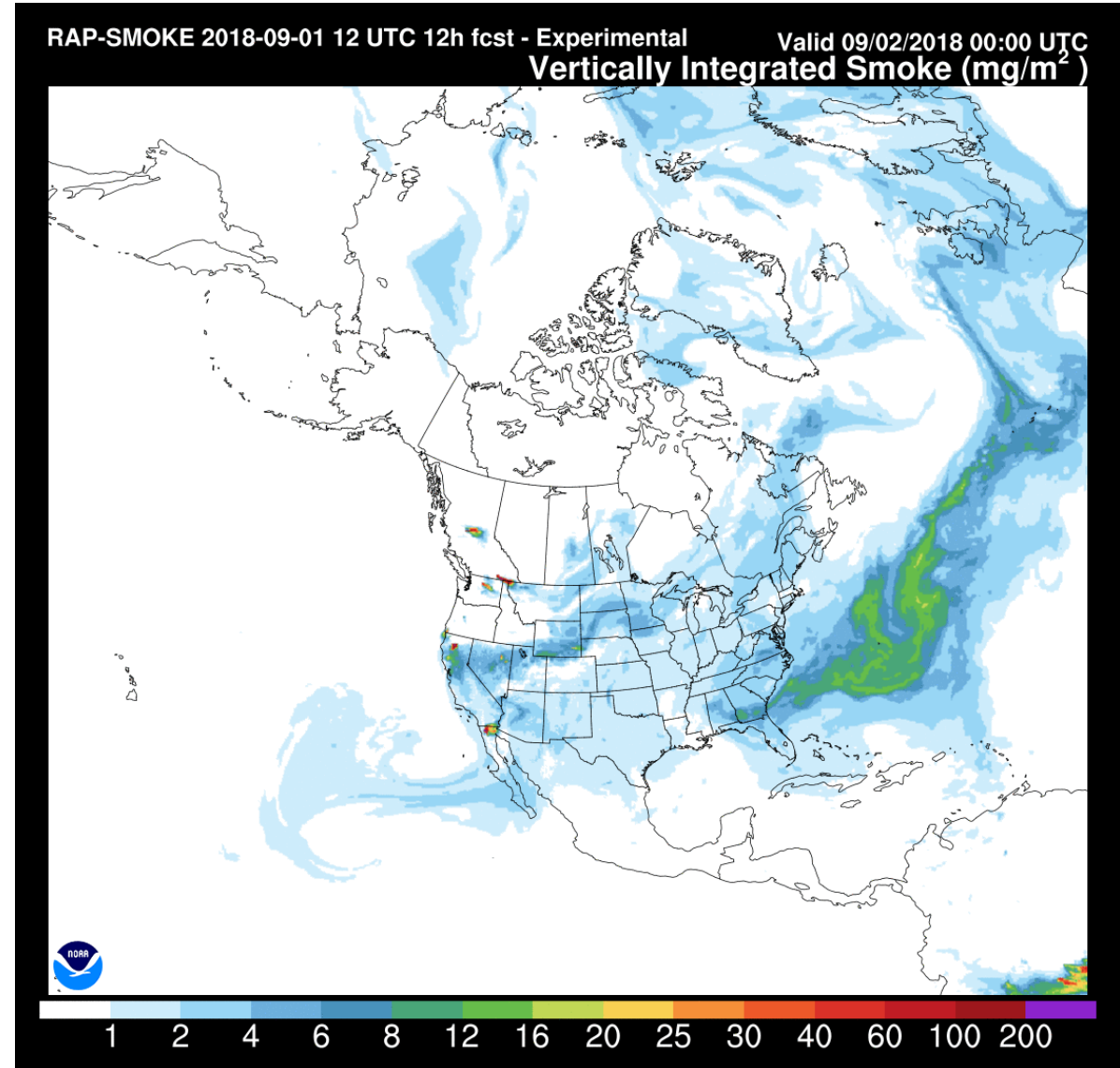
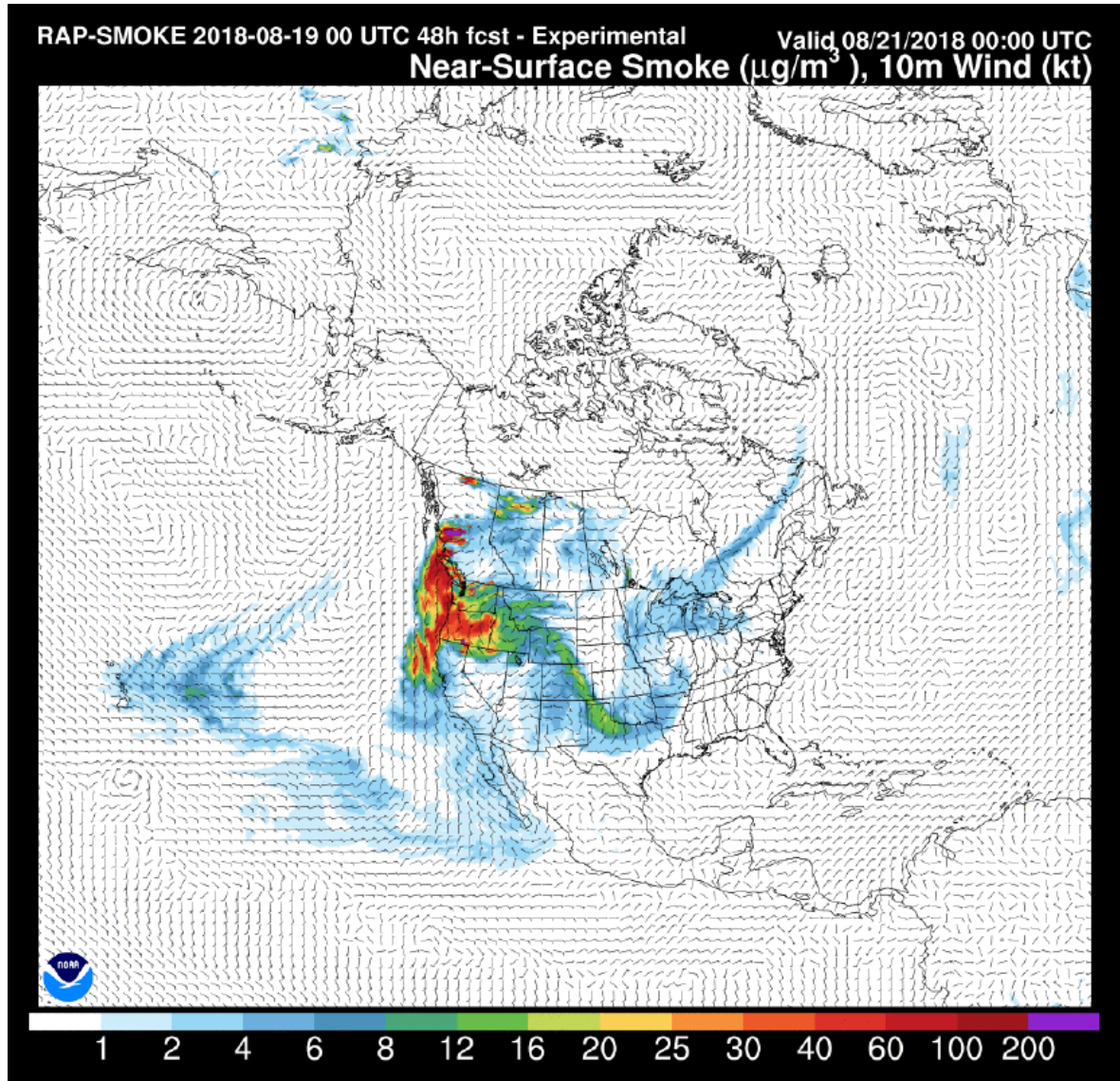
VIIRS 375m product generated at STAR



NPP_20180723_1145

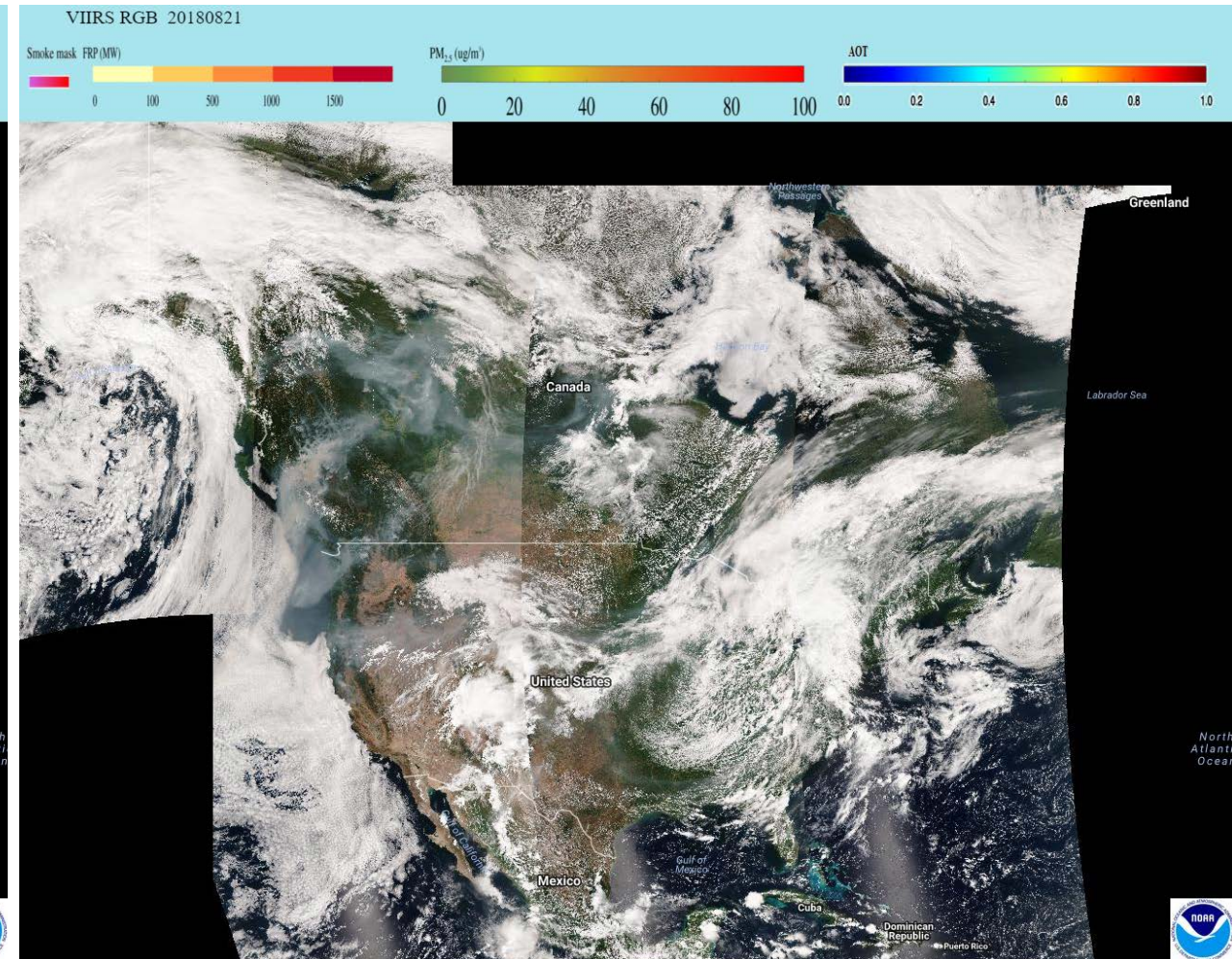
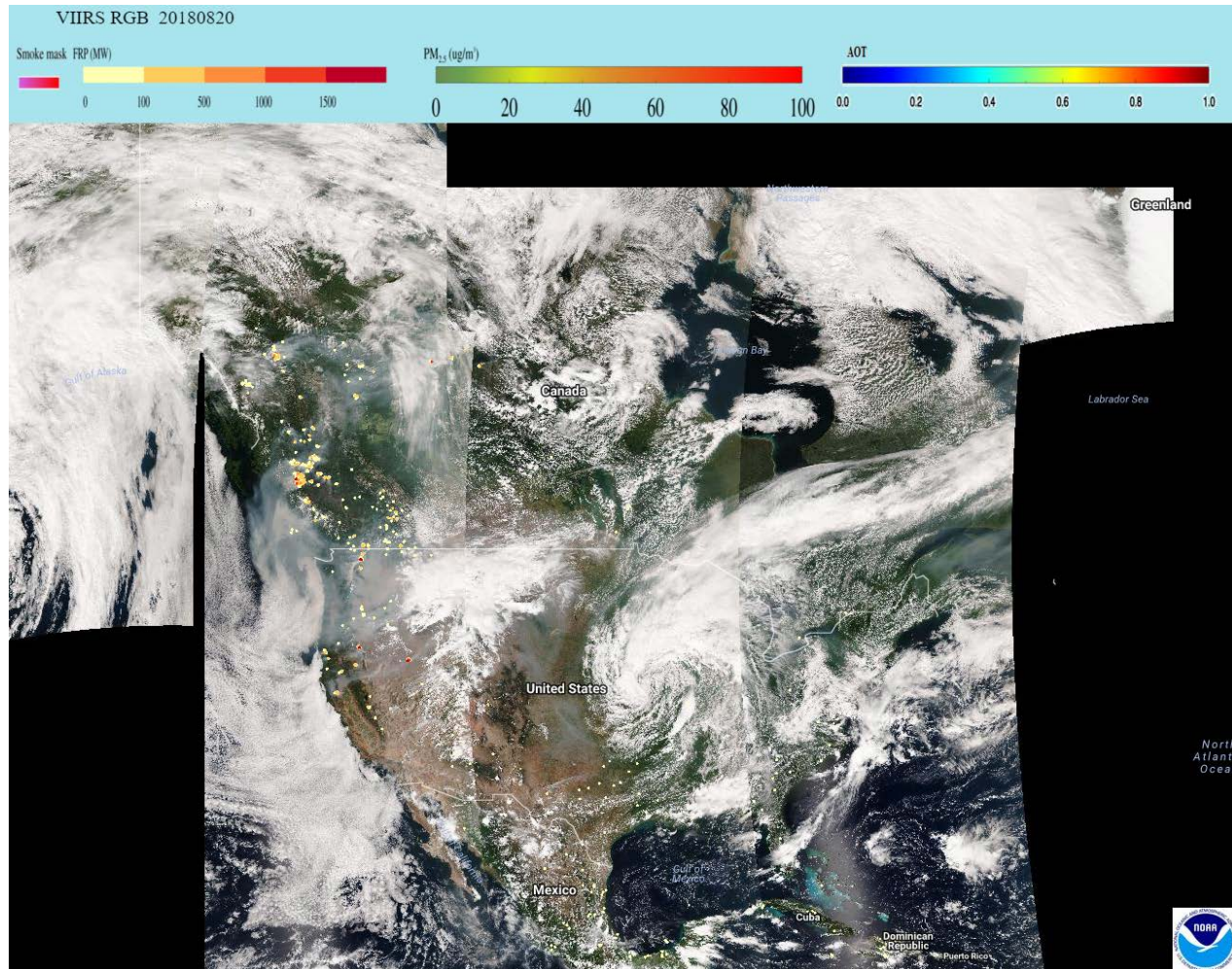
VIIRS FRP in Rapid Refresh (RAP) - Smoke

<https://rapidrefresh.noaa.gov/RAPsmoke/>



VIIRS FRP in eIDEA

<https://www.star.nesdis.noaa.gov/smcd/spb/aq/eidea/>



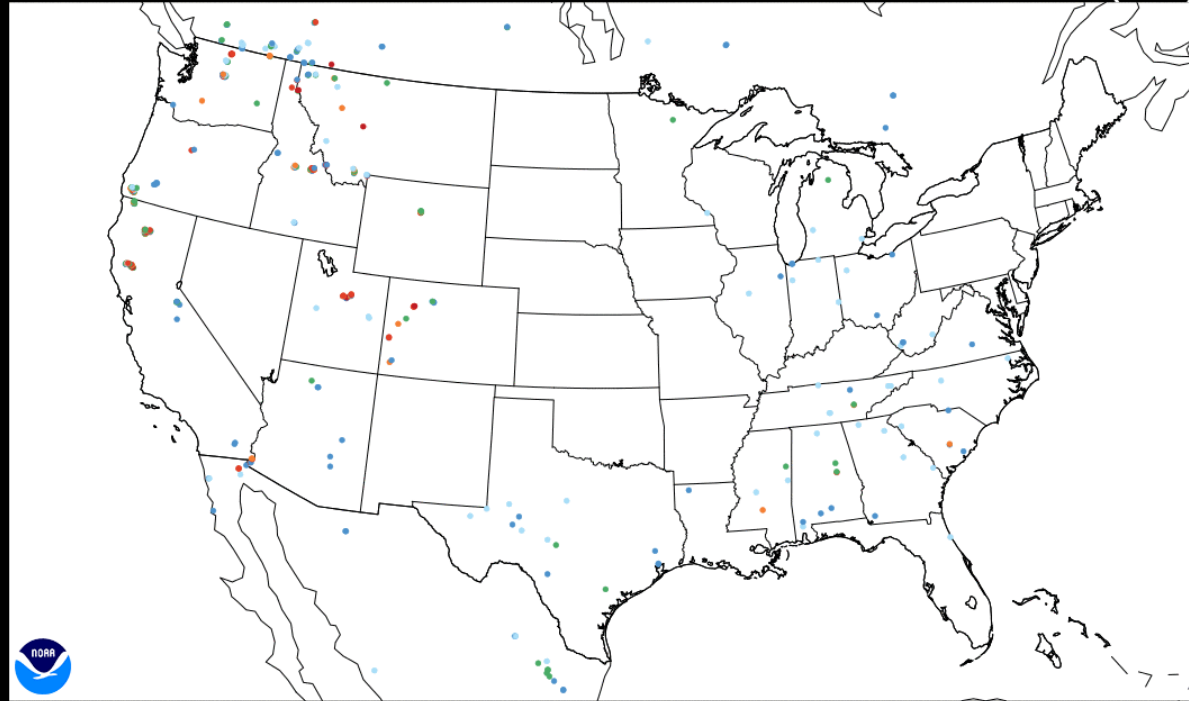
eIDEA: enhanced Infusing satellite Data into Environmental Applications

High Resolution Rapid Refresh(HRRRR) - Smoke

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

HRRR-SMOKE 2018-08-15 06 UTC - EXPERIMENTAL

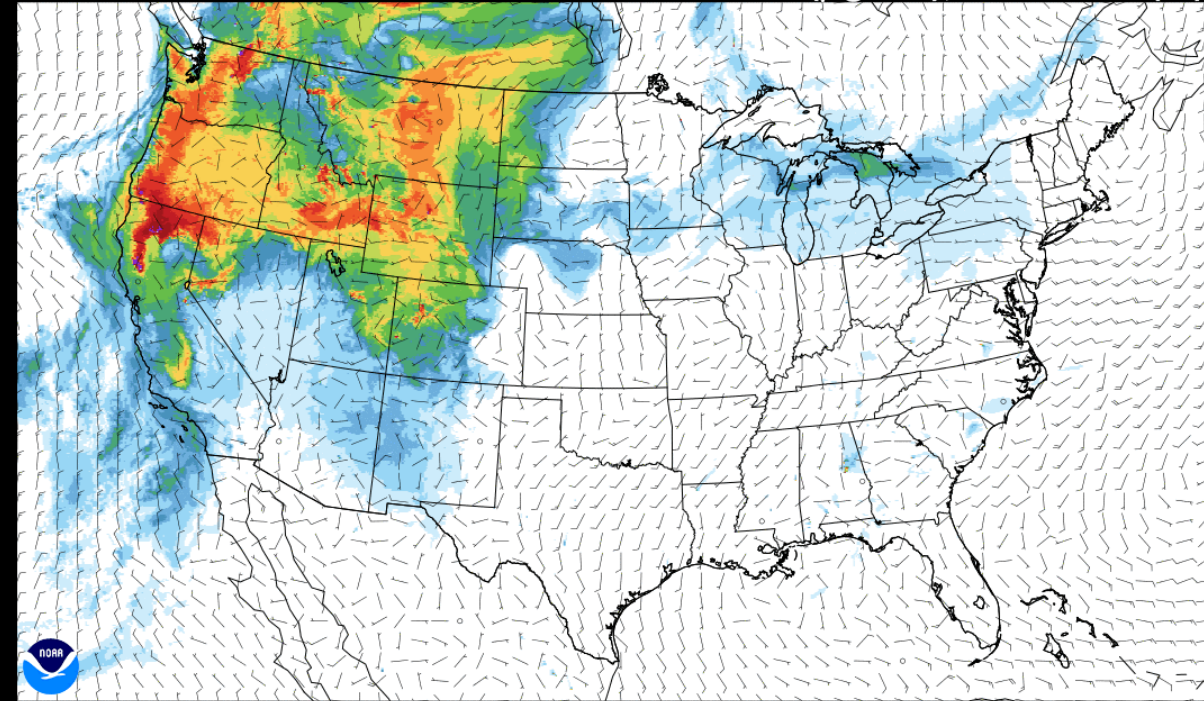
Fire Radiative Power (MW)



0 10 25 50 100 250

Fire Radiative Power

HRRR-SMOKE 2018-08-15 06 UTC 10h fcst - EXPERIMENTAL Valid 08/15/2018 16:00 UTC
Near-Surface Smoke ($\mu\text{g}/\text{m}^3$), 10m Wind (kt)



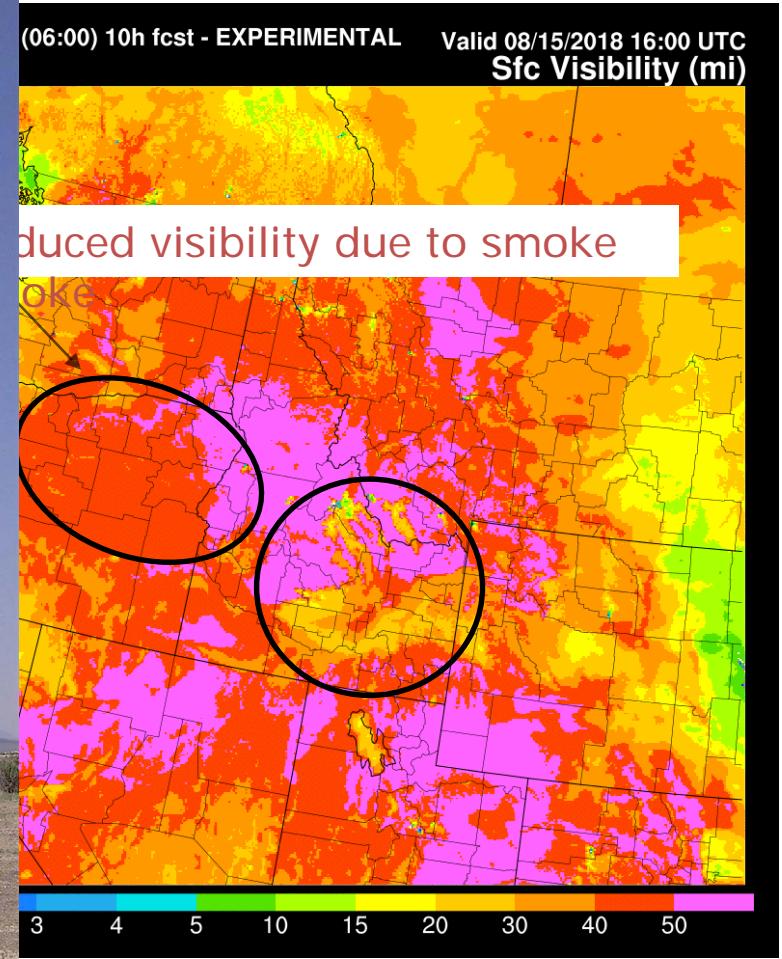
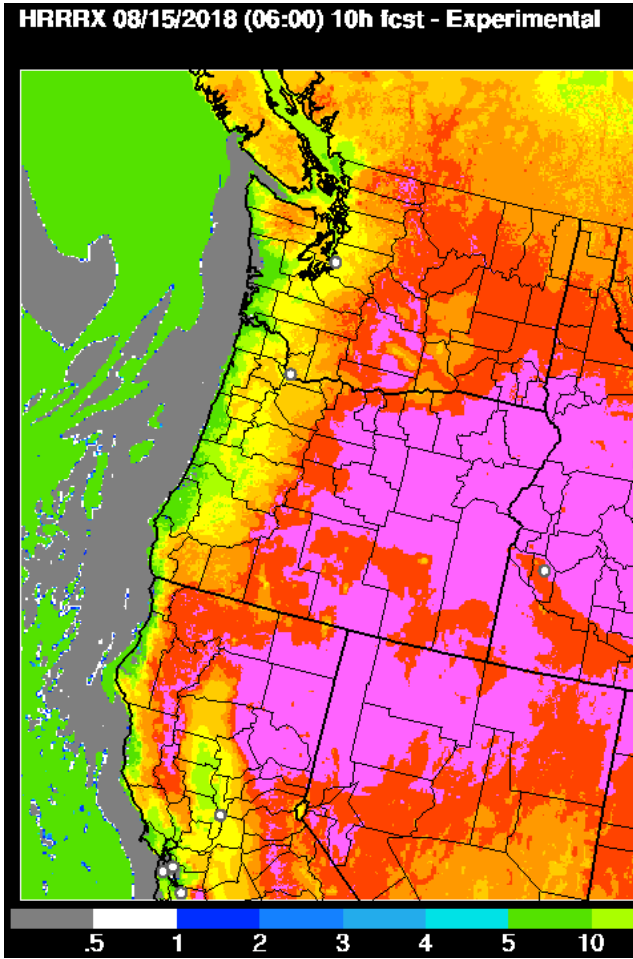
1 2 4 6 8 12 16 20 25 30 40 60 100 200

10-hour forecast of Near-Surface Smoke

Now VIIRS FRP data from both Suomi NPP and NOAA-20!

Ex ASOS visibility sensor

Forecast forecasts



Experimental NWP system

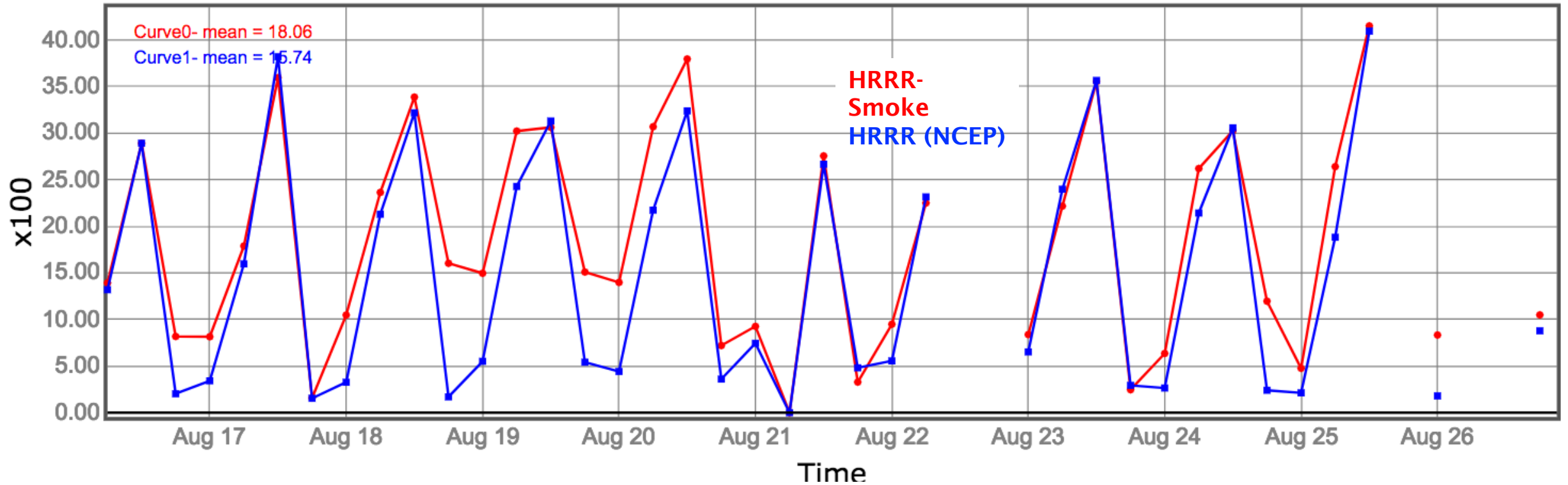
ASOS: Automated Surface Observing Systems

Experimental NWP system with smoke

Visibility is an important forecast product (traffic, aviation...)

Verification of the surface visibility forecasts over the western US

CSI (Critical Success Index), (visibility < 10 mi), forecast length: 12h, average over the domain



CSI = $X / (X + Y + Z)$ X- true alarm, Y- miss, Z- false alarm

CSI is an indicator of warning skill used in weather forecasting

Summary and conclusions

- Both Suomi NPP and NOAA-20 750m VIIRS active fire products are operational
- Testing / evaluation / transition to operations of the 375m I/M-band product is ongoing
- The two-satellite configuration provides improved coverage
- The VIIRS active fire product has been used successfully in particular for smoke and air quality monitoring and forecasting
- Work is ongoing towards a multi-sensor integrated observing system
 - Synergistic use of JPSS and GOES-R data
 - Enterprise algorithms for consistency and improved processing efficiency
 - Sentinel-3 SLSTR and EPS-SG METImage are critical for mid-morning polar observations



For more information visit

- NOAA JPSS at <https://www.jpss.noaa.gov/>
- STAR JPSS at <https://www.star.nesdis.noaa.gov/jpss/>
- Active Fire product info at <https://www.star.nesdis.noaa.gov/jpss/fires.php>
- NOAA's Comprehensive Comprehensive Large Array-data Stewardship System (CLASS) at <https://www.bou.class.noaa.gov/saa/products/welcome>
- VIIRS Active Fire science team at <http://viirsfire.geog.umd.edu/>

