Fire and Smoke Initiative

Bill Sjoberg JPSS Program Office

28 August 2018

National Oceanic and Atmospheric Administration | Joint Polar Satellite System (JPSS)

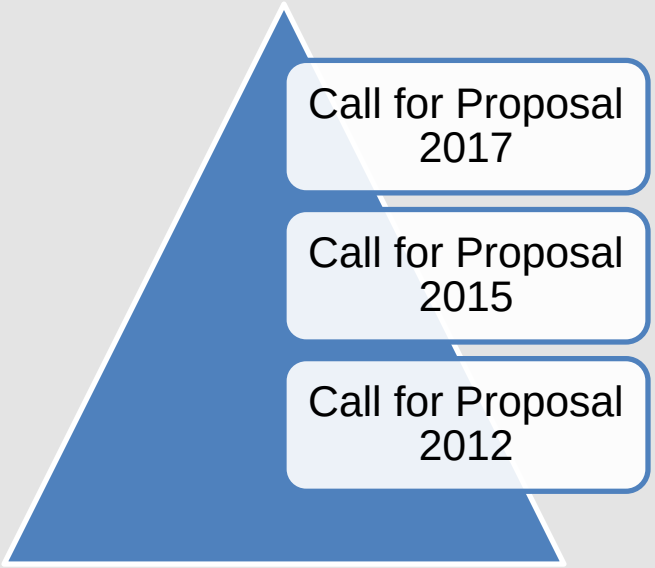
PGRR Background

JPSS PGRR Background Definitions

- **Proving Ground**
  - Demonstration and utilization of data products by the end-user operational unit, such as a NWS Weather Forecast Office or Modeling Center.
  - Promote outreach and coordination of new products with the end users, incorporating their feedback for product improvements
- **Risk Reduction**
  - Development of new research and applications to maximize the benefits of JPSS satellite data
    - Example - use of Day Night Band for improved fog and low visibility products at night, benefiting transportation industry.
  - Encourages fusion of data/information from multiple satellite, models and in-situ data
  - Primary work is done at the algorithm and application developer's institution.
  - Address potential risk in algorithms and data products by testing alternative algorithms.

JPSS PGRR Background

- The PGRR Program was established in early 2012, following the launch of the Suomi National Polar Partnership (SNPP) satellite on 28 Oct 2011



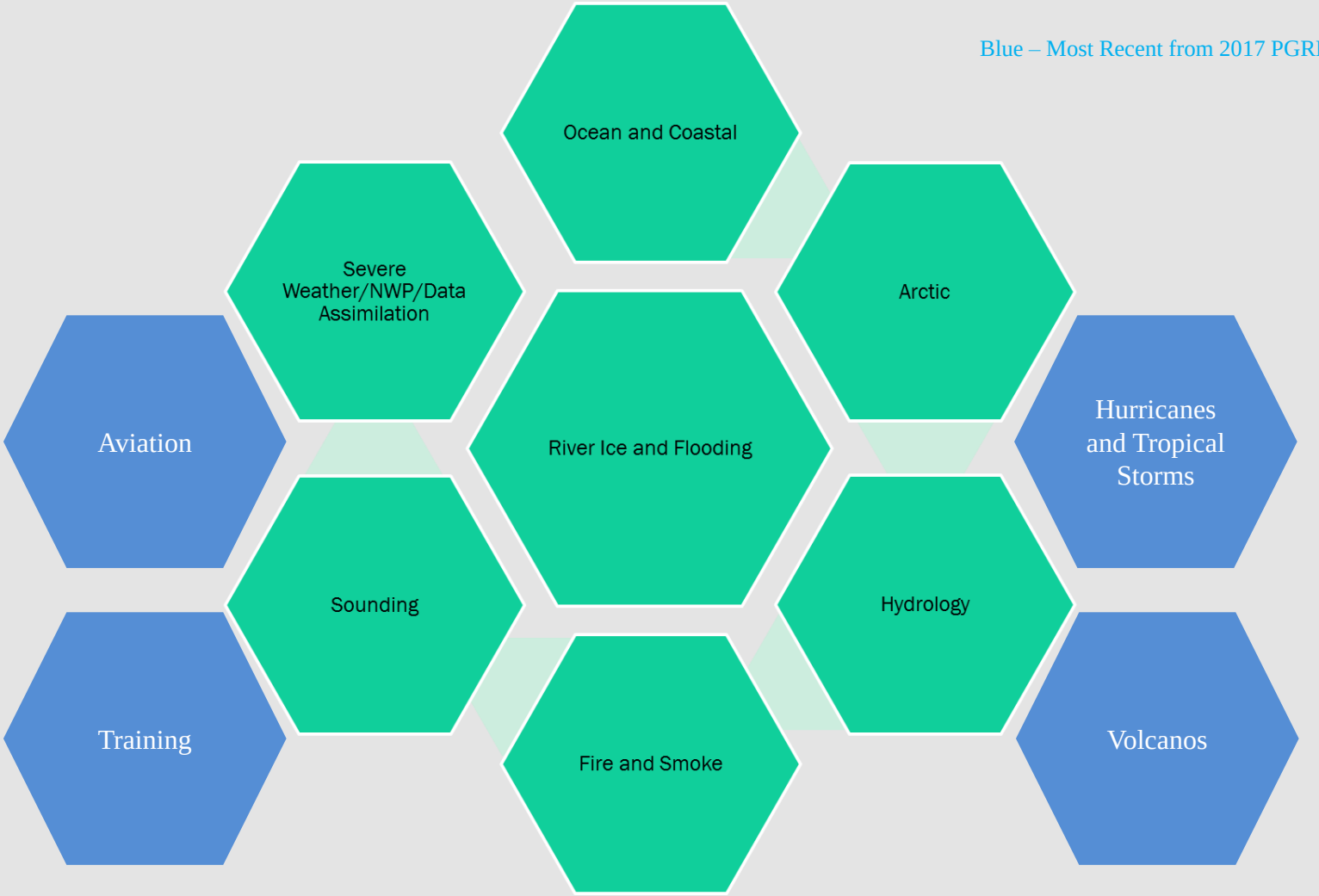
- CFP 2012: 100 teams providing Letters-of-Intent (LOIs) with nearly 40 projects selected for funding
- CFP 2015: PGRR Initiatives were used as a focus for the responses to this CFP. Over 130 LOIs were received.
- CFP 2017: Sent out in Oct 2017. Over 130 LOIs received and funding selections recently made

PGRR Proving Ground Initiatives Responding to User Feedback

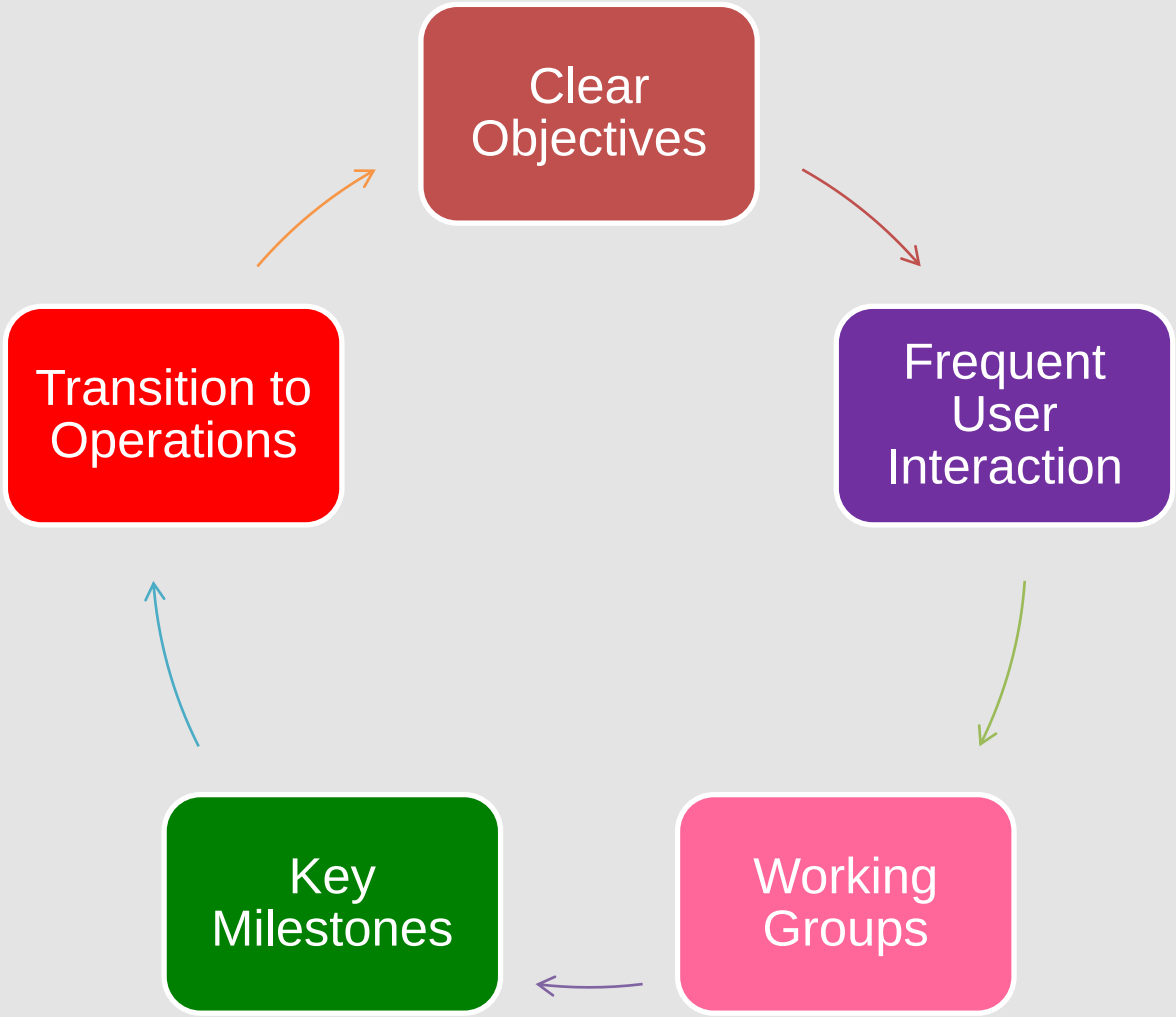
- The River Ice and Flooding Initiative was the first attempt at this new partnership and it was established in response to Galena AK flooding in May 2013.
- The Initiative included River Ice and River Flooding Project teams, direct broadcast SMEs, and National Weather Service River Forecast Center forecasters.
- The success of River Ice and Flooding Initiative led to creation of other initiatives that guided the 2014 PGRR CFP.
- Initiatives have proven to be critical forums where JPSS personnel, product developers, and users interact. The effort is to evaluate current and future JPSS Capabilities in operational environments to determine which of these capabilities should be transitioned to operations.

PGRR Initiatives List

Blue – Most Recent from 2017 PGRR CFP



PGRR Proving Ground Initiatives Best Practices



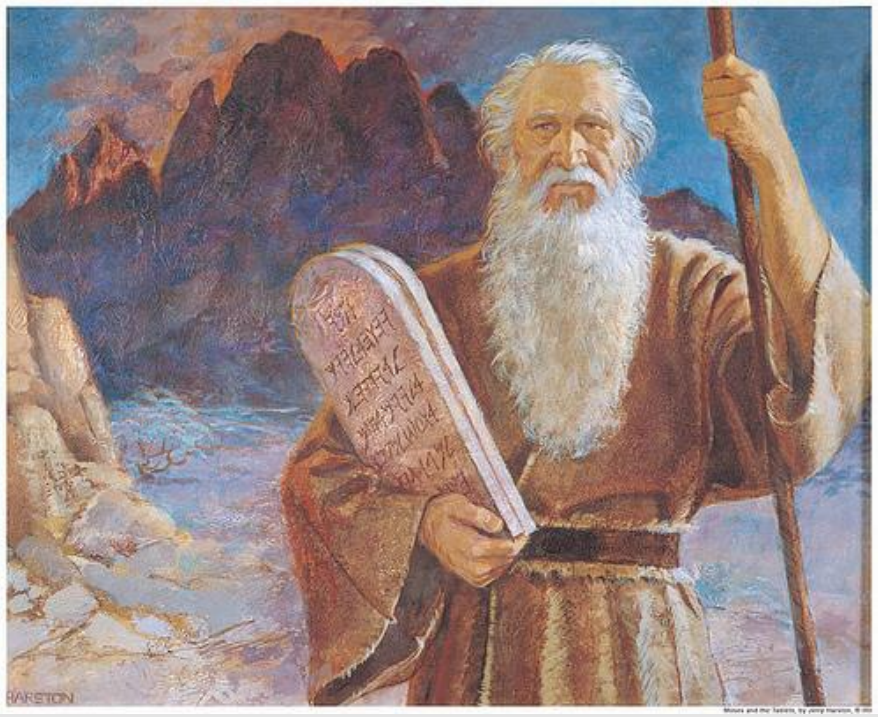
PGRR Proving Ground Initiatives Partners

PGRR Initiatives

Initiative	Start Date
River Ice and Flooding	November 2013
Fire and Smoke	May 2014
Sounding Applications NOAA Unique CrIS/ATMS Processing System (NUCAPS)	July 2014
Hydrology	July 2015
Ocean and Coastal	March 2016
Severe Weather/NWP/Data Assimilation	March 2016
Arctic Initiative	June 2016
Hurricanes and Tropical Storms Initiative	June 2018
Aviation Initiative	June 2018
Training Initiative	June 2018
Volcano Initiative	June 2018

JPSS and the Fire Mission

How the Fire and Smoke Initiative Began



We must find a way to deal effectively with fire events and smoke forecasts!

Andy Edman NWS WR SSD Chief

Fire and Smoke Initiative
Objectives

- Organize a forum to allow stakeholders supporting Fire and Smoke products development to interact with key users of the capabilities.
- Understand the current use of geostationary and polar orbiting satellite capabilities in support of Fire and Smoke detection and forecasting mission
- Identify current SNPP/JPSS and new GOES-R Fire and Smoke data and capabilities with the potential to improve support to this mission
- Establish methodologies and procedures for the operational demonstrations of these capabilities
- Following these operational demonstrations, identify the satellite capabilities whose operational impacts are sufficient to warrant transition from research to operations
- Determine required actions for an effective transition of these capabilities to operations that can be maintained over the long term.
- As the Initiative Team met over the months and years, actions were taken to implement these objectives, and new objectives were identified and worked.

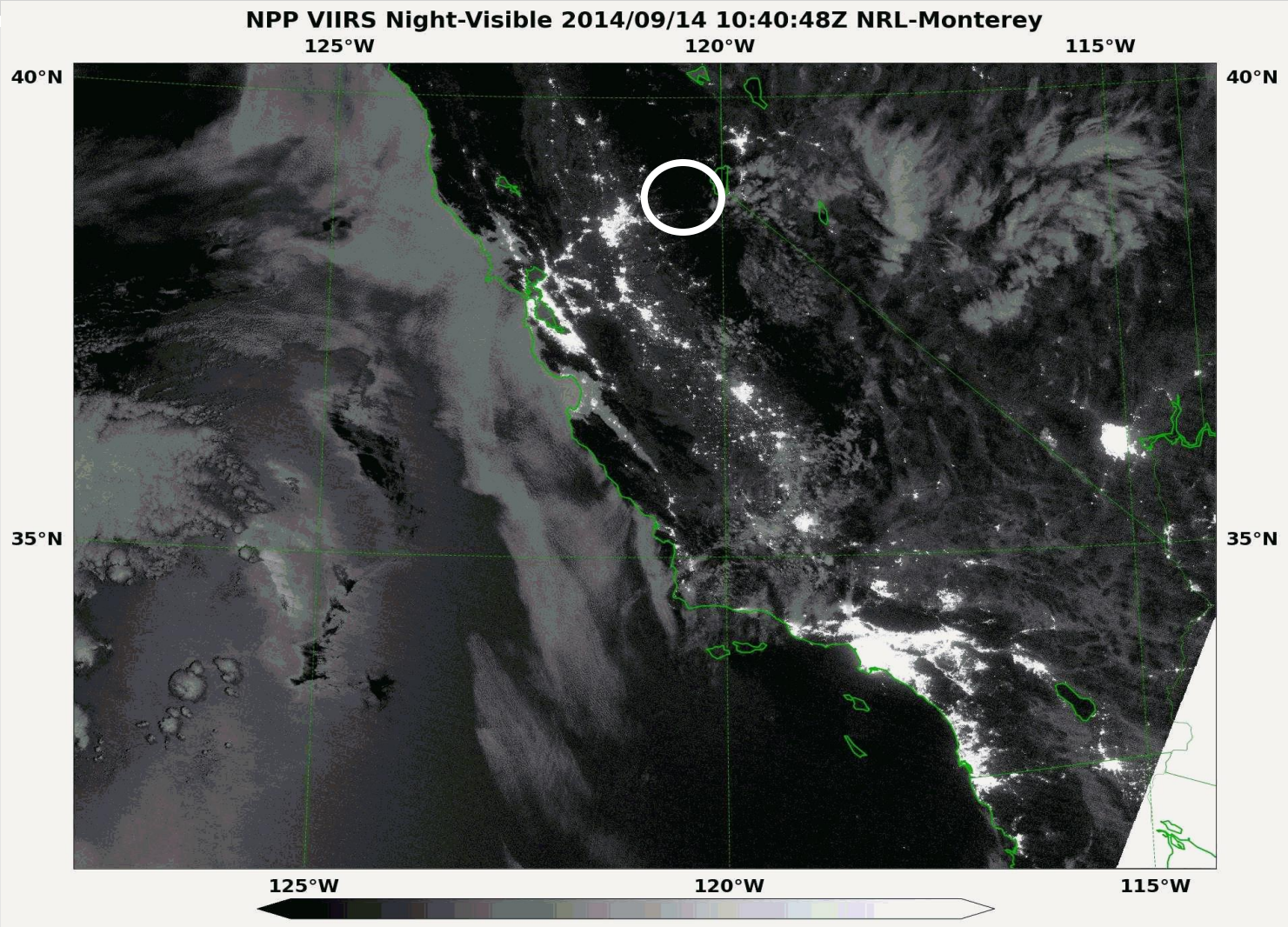
Typical Telecon Participants

Name	Organization	Name	Organization	Name	Organization
Raman Ahmadov	CIRA	Chad Kahler	NWS Western Region	Brad Pierce	STAR
Bret Anderson	US Forest Service	Hyun Kim	NOAA Air Resources Lab	Julie Price	JPSS
Nazmi Chowdhury	JPSS	Adam Kochanski	Univ of UT	Pete Roohr	NWS
Russell Dengel	CIMSS	Mark Loeffelbein	NWS – Western Region	Katherine Rowden	NWS – Service Hydro Spokane
Evan Ellicott	UofMD	Jan Mandel	Univ of CO - Denver	Scott Rudlosky	CICS
Rick Graw	US Forest Service	Jeff McQueen	NCEP	Bill Sjoberg	JPSS
Robyn Heffernan	NWS	Matt Mehle	NWS	Jebb Stewart	ESRL
Amy Huff	PSU	Brian Motta	NWS	William Straka	CIMSS
Eric James	CIRES	Susan O'Neill	USFS	Jason Taylor	NESDIS
Pedro Jimenez	UCAR	Li Pan	OAR	Jorel Torres	JPSS Training Liaison

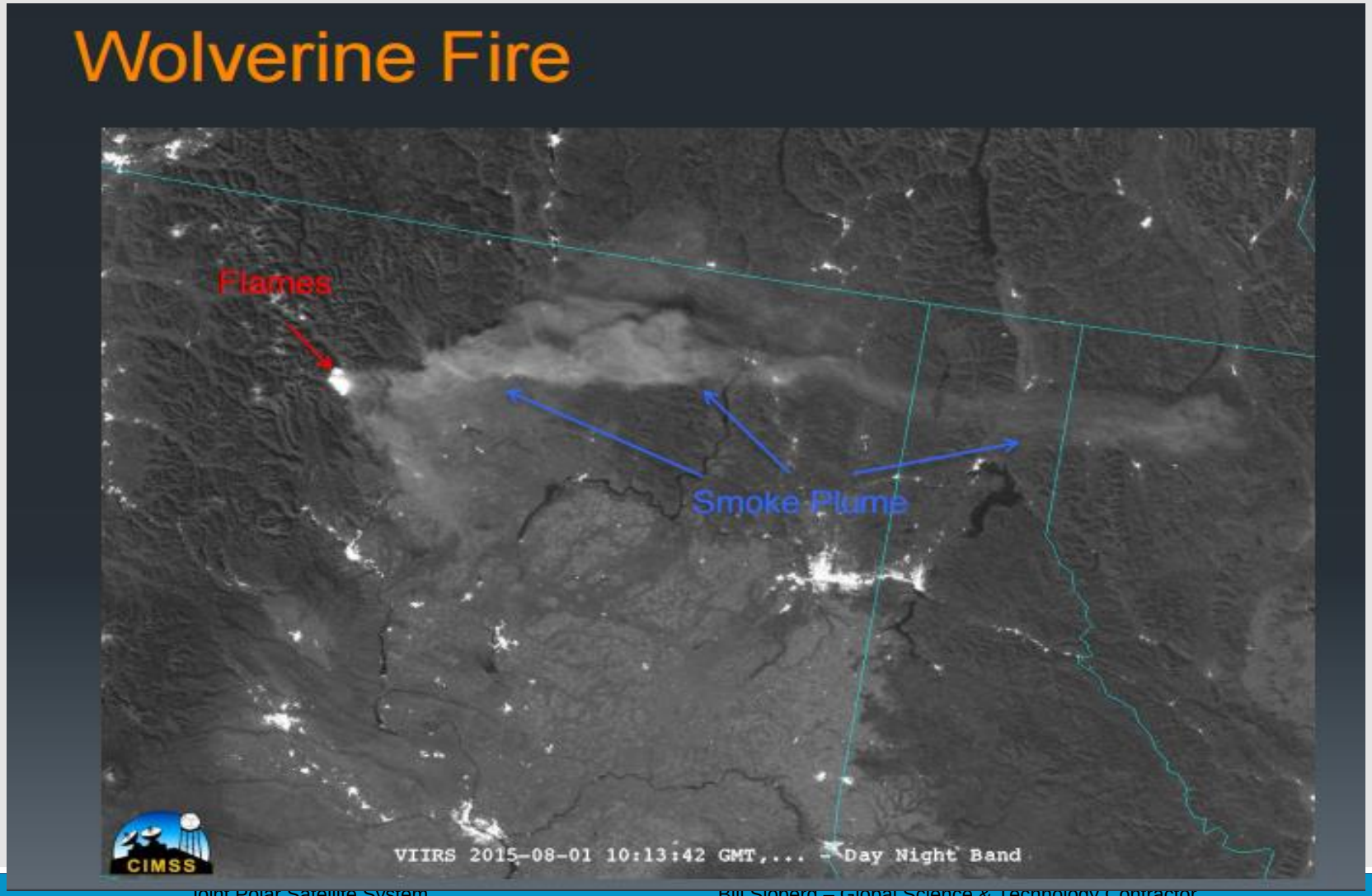
Initiative Activities

- Boots on the ground. Personnel visited fires to evaluate what environmental data is used and to provide info on JPSS fire support capabilities.
- Visited key stakeholders, Alaska Fire Service as an example, to help them access JPSS data and products consistently.
- Integrated VIIRS Active Fire and Fire Radiative Power as initial conditions for the HRRR Smoke Model.
- Integrated Air Quality (AQ) specialists into the Initiative Team to ensure AQ issues are addressed.
- Briefed at the last three NWS IMET Conferences to go through with participants the products available on AWIPS Thin Client and new initiatives.
- Evaluated JPSS Products during key fire events such as the Rim Fire in CA, the Fort McMurray Fire in Canada, and 2018 Western Region Fires.
- Welcomed developers for various smoke models, Blue Smoke as an example, to participate in the F&S Initiative Team to determine how VIIRS could be used in their models.
- And more……..

King Fire Sep 2014
Views via SNPP VIIRS DNB Night Time Visible



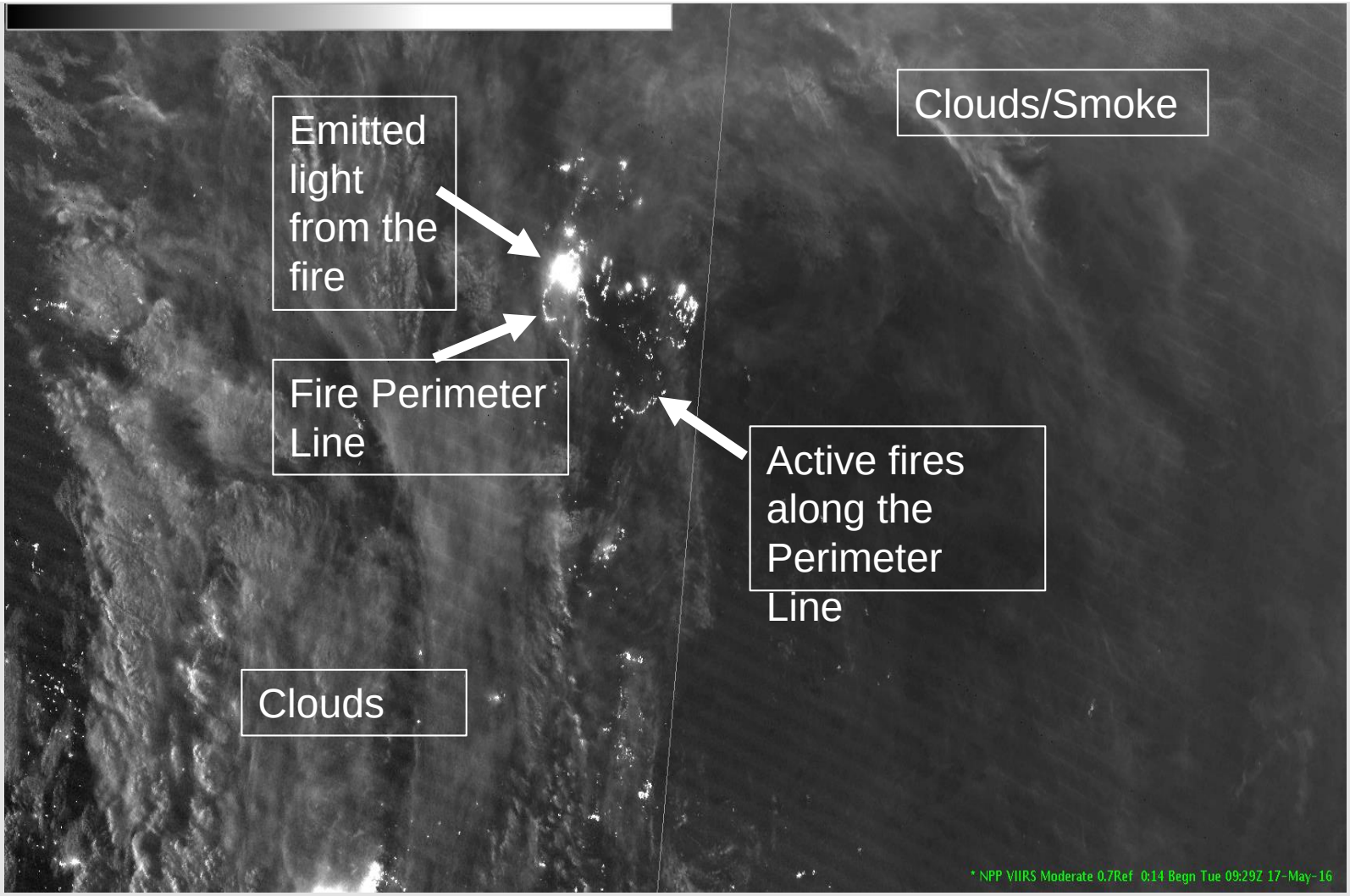
Western Washington State
1 Aug 2015



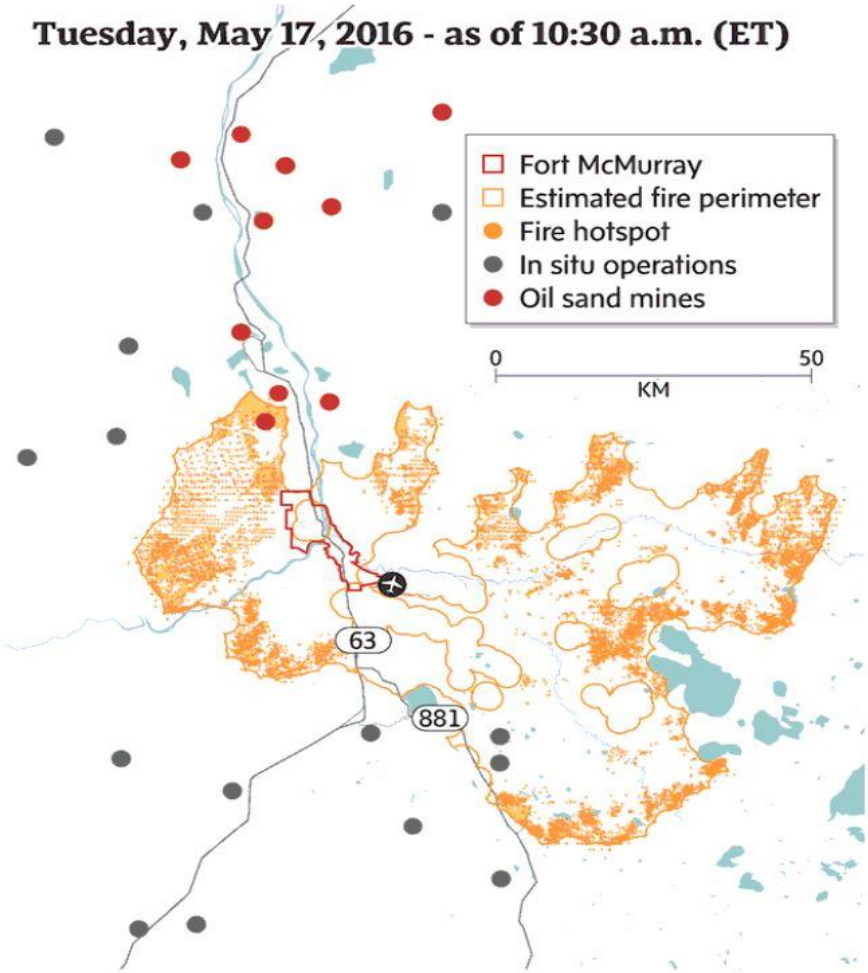
THE FORT MCMURRAY WILDFIRE MAY 2016

Image: Ft. McMurray Wildfire as it spreads across the Alberta landscape
Source: Public Service Alliance of Canada

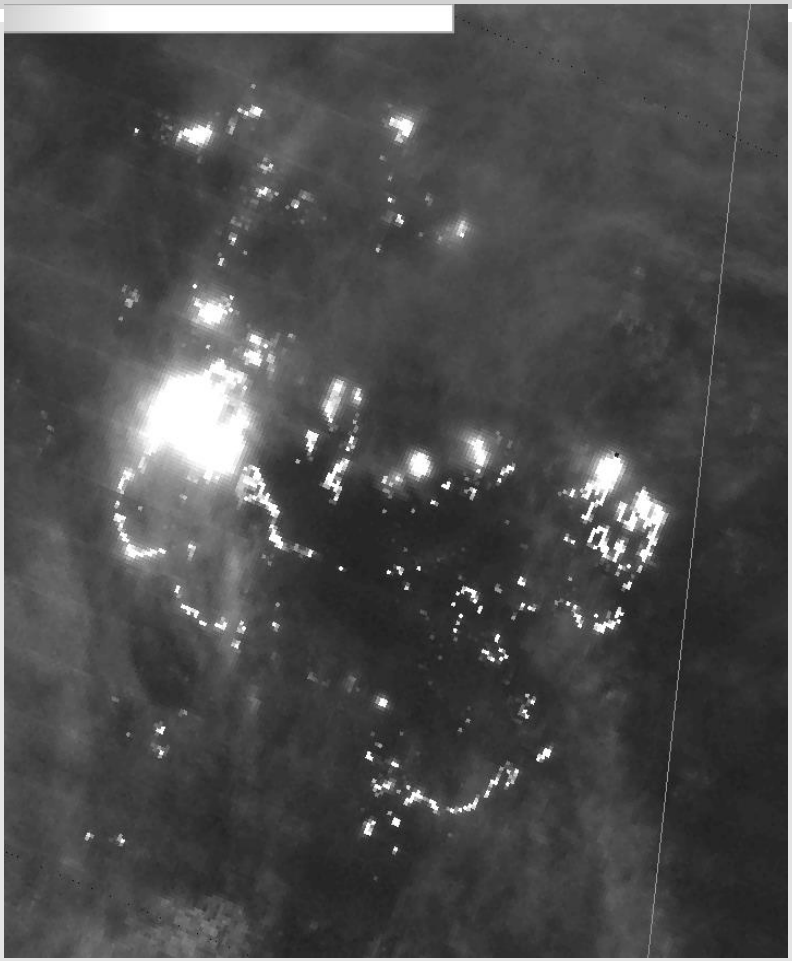
NCC Imagery of Ft McMurray Wildfire 17 May at 0930 UTC



NCC Imagery 17 May 2016 at 0929Z (i.e., 05:29 a.m. ET)

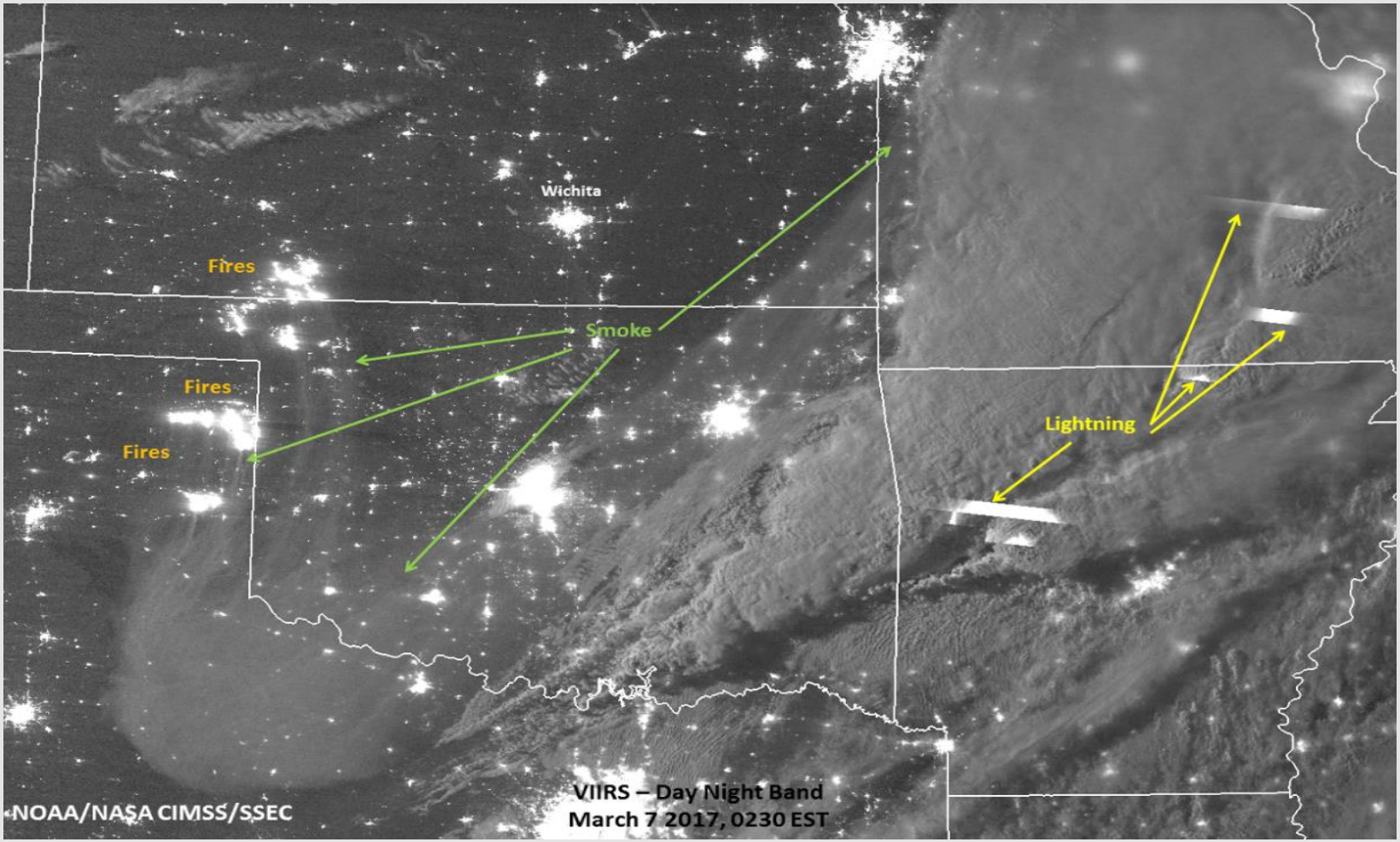


MURAT YÜKSELIR/THE GLOBE AND MAIL) SOURCES:
OIL SANDS COMMUNITY ALLIANCE; NATURAL RESOURCES CANADA

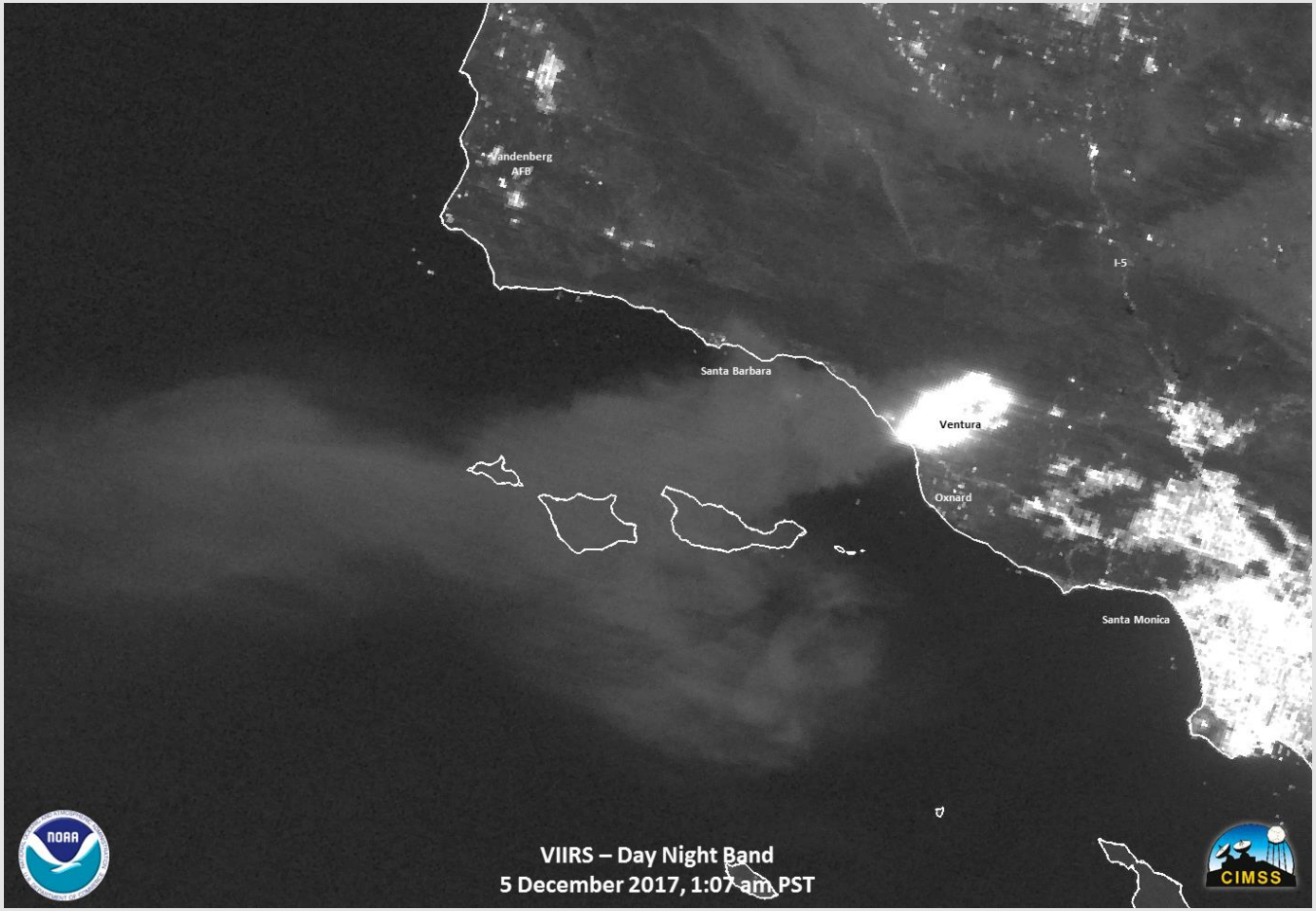


COMPARISON BETWEEN ESTIMATED FIRE PERIMETER AND NCC IMAGERY

Oklahoma Fires – 7 Mar 2017

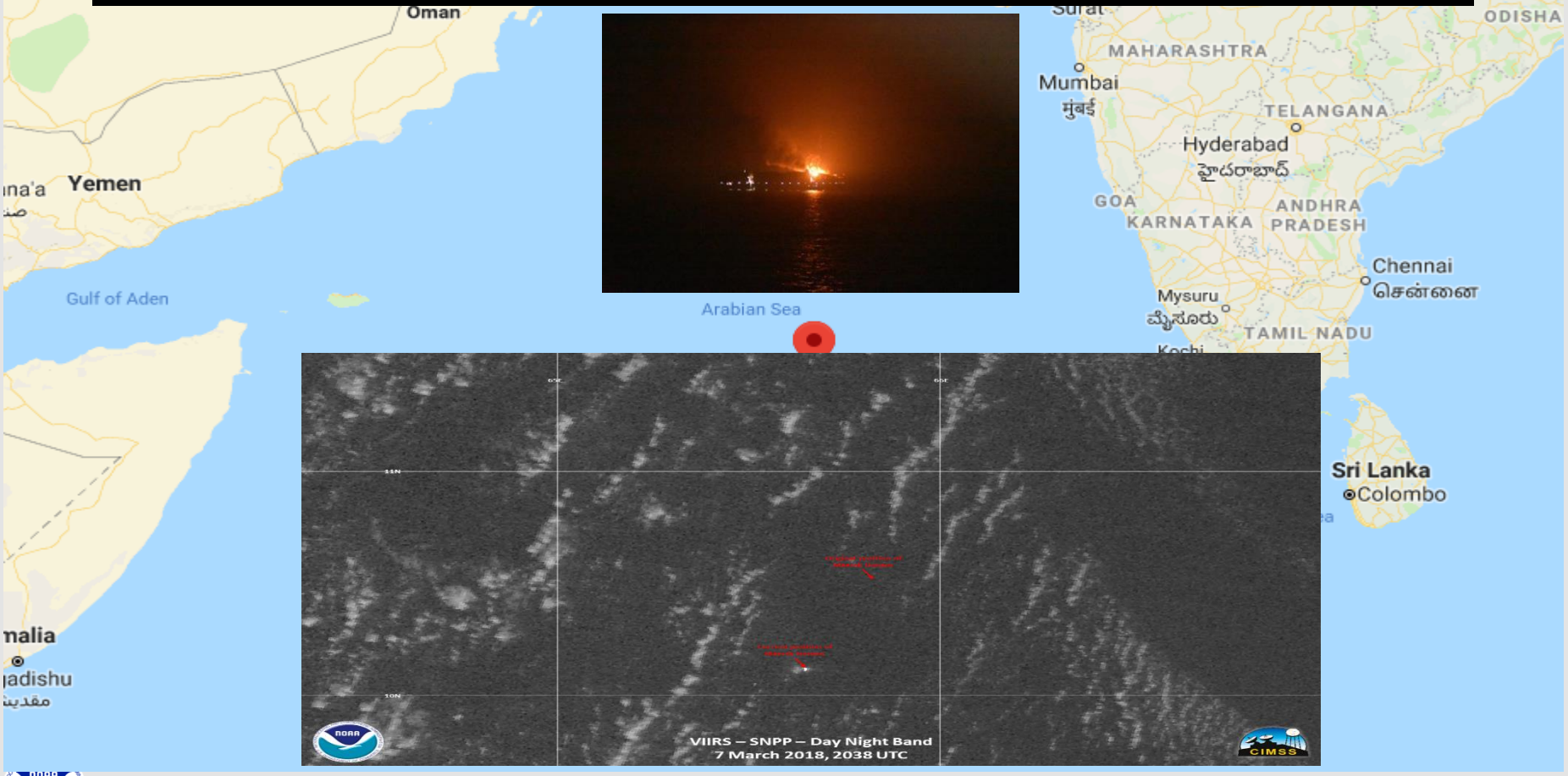


Thomas Fire – California
Day Night Band



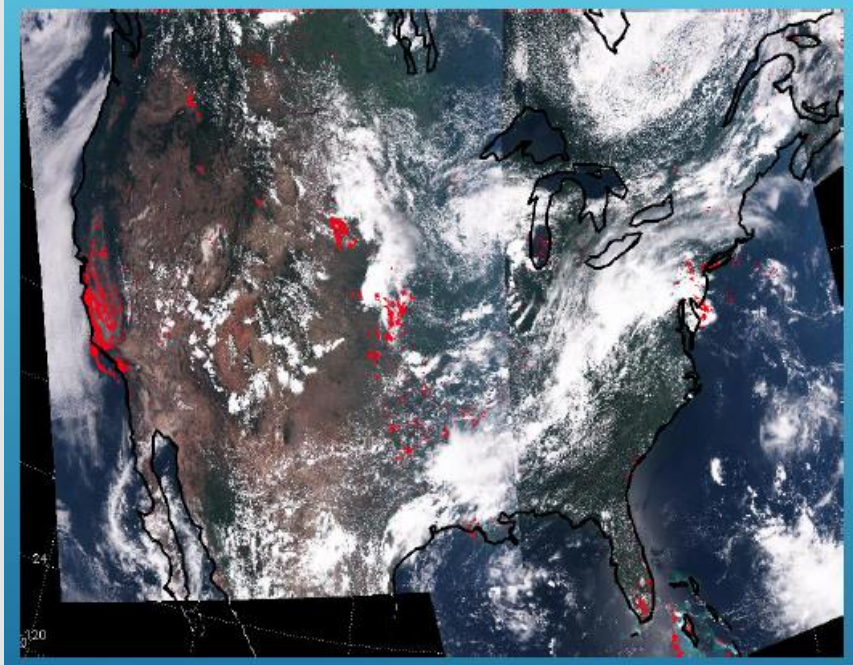
Container Ship Maersk Honam on Fire 7 Mar 2018

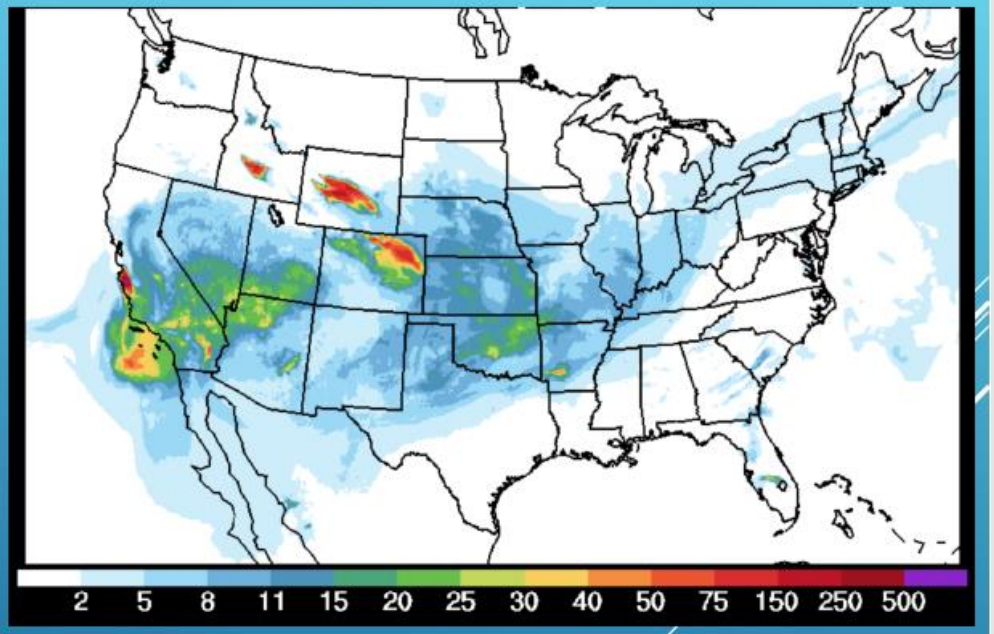
Major Fire on Ultra-Large Containership Maersk Honam in Arabian Sea
1 dead, 4 still missing



Early HRRR-Model Output

VIIRS smoke mask and HRRR-Smoke forecast for vertically integrated smoke, July 28 2016





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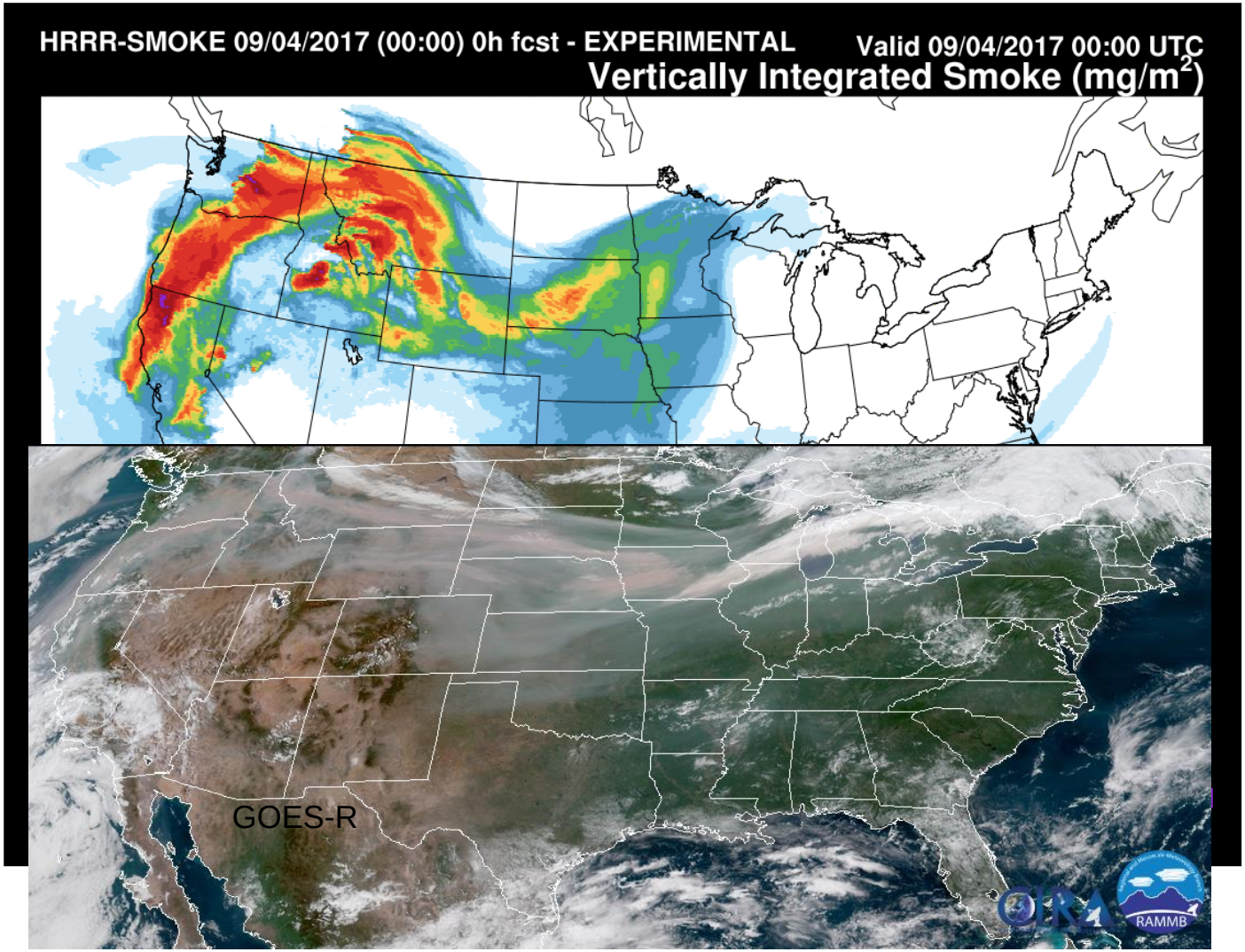
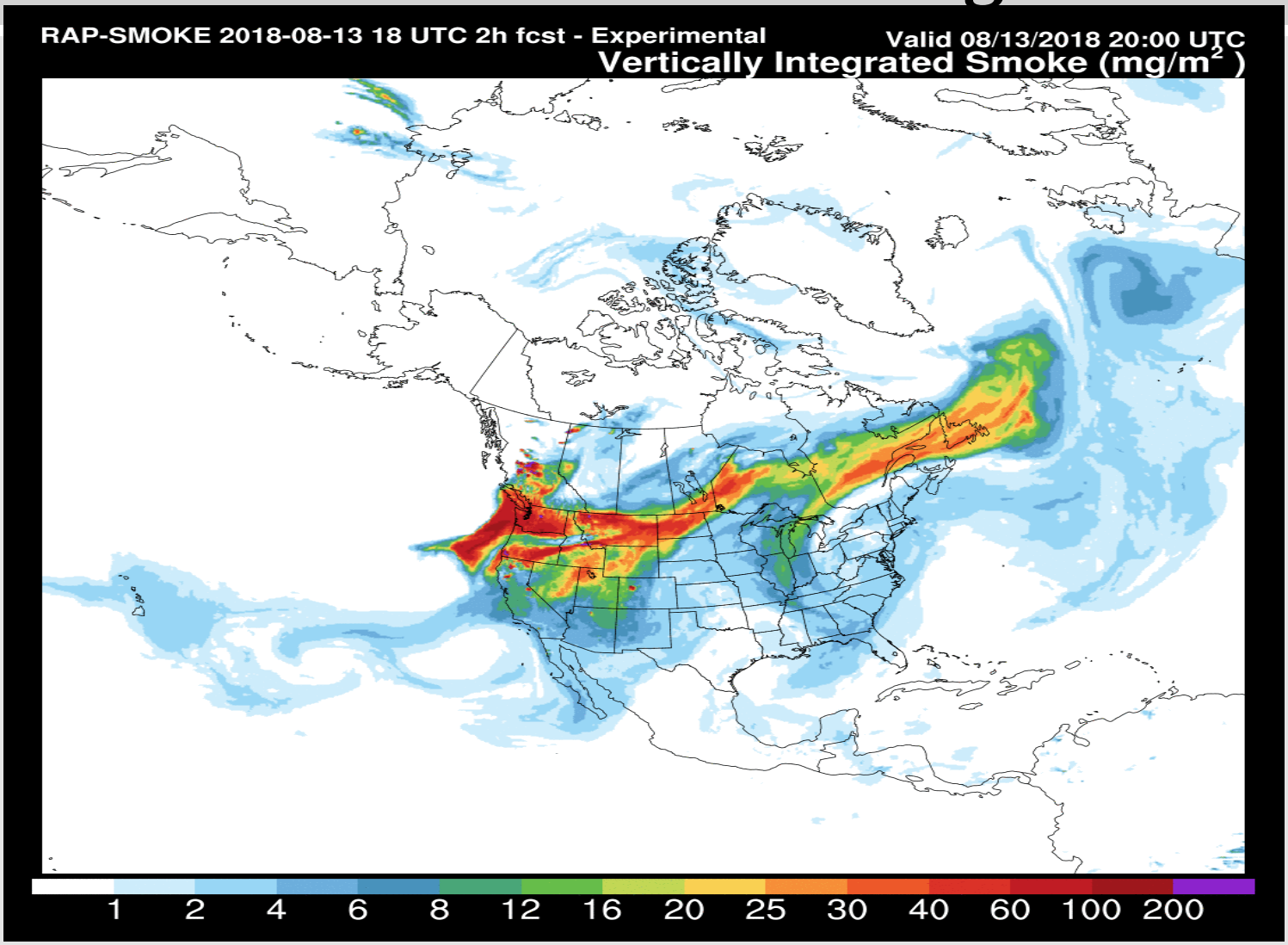
HRRR – Smoke Model Updated Version

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



RAP Model Provides More Smoke Forecast Coverage



Fire Smoke Models in Use
Rick Graw AQ Pgm Mgr
USDA Forest Service

Model Component	Blue Sky Daily Operational Runs (v3.5.1)	HRRR Smoke	FireWork	AIRPACT 5	NOAA/NWS National Air Quality Forecast	Comments
Purpose	Simulate the emissions, transport, and concentration of smoke from wildfire and prescribed fire.	Addresses the need for a coupled meteorological-wildfire smoke forecast model.	To provide numerical guidance (PM2.5 concentrations) to forecasters for inclusion of biomass burning.	Provide timely air quality information to people in the Pacific Northwest region.	Provide next day operational predications for ground level ozone, smoke, and dust	
Products	Surface levels of PM2.5: • hourly • 3-hr • 24-hour: • daily 1 hr max	• Fire radiative power • Near-surface smoke • Vertically-integrated smoke • 10m wind • 1hr precipitation • 2 m temperature	PM2.5 (from biomass burning emissions) Ground level: • 24 and 48 hour avg. • 1-hr max Total column	Surface PM2.5 Surface Ozone N and S Deposition	HYSPLIT Smoke and Dust • Surface • Vertical Integration CMAQ : • Surface Ozone (does not include gaseous emissions from wildfires). • 1-hr and 24-hr total PM2.5 (& bias corrected):	Daily average PM2.5 is helpful for comparison with EPA AQI which is also 24-hr avg.
Domain	Variable from Canada and CONUS, to sub-regions.	Continental US (CONUS)	North America	Washington, Oregon, Idaho, and parts of MT, CA, NV, UT, and WY	HYSPLIT smoke: North America CMAQ PM2.5 with smoke emissions: CONUS,	
Frequency of runs	Once a day for WRF. Twice a day for the NAM domains (00z and 12Z) Up to 4x/day for the NAM 1 km domains	Four times a day Every 6 hours (00, 06, 12 and 18 Z)	Twice daily: 00z and 12z	Once per day.	HYSPLIT: 1/day (06Z) CMAQ: 2/day (06Z, 12Z)	
Forecast period	36 hours (1 km variable) 60 hours (1.33 km PNW) 72 hours (4 km PNW) 84 hours (12 km CONUS) 48 hours (3 km CONUS) 5 days for 0.5 degrees	36 hours	48 hours	48 hours	48 hours	
Website	https://www.airfire.org/data/bluesky-daily/	https://rapidrefresh.noaa.gov/hrrr/HRRRsmoke/	http://weather.gc.ca/firework Development site (pw)	http://www.lar.wsu.edu/airpact/gmap/ap5/ap5smoke.html	http://airquality.weather.gov/ CMAQ PM: http://www.emc.ncep.noaa.gov/mmb/aq/	
Contact	Susan O'Neill (206) 73207851 smoneill@fs.fed.us	Ravan Ahmadov (303) 497-4314 ravan.ahmadov@noaa.gov	Radenko Pavlovic radenko.pavlovic@canada.ca Jack Chen (613) 991-9459 Jack.chen@canada.ca	Farren Herron-Thorpe (360) 407-7658 fher461@ecy.wa.gov	Ivanka Stajner ivanka.stajner@noaa.gov Jeff McQueen: jeff.mcqueen@noaa.gov	

Future Satellite Support to the Fire Mission

- *Fully implement GOES-17 and NOAA-20 Fire Products*
- *Continue to reach out to current users and potential users to work with them to evaluate satellite capabilities. User feedback to guide future decisions.*
- *Keep IMETs, Air Quality personnel, and others informed of continued work and provide training on products*
- *Respond to requests for satellite fire and smoke capabilities during fire events*
- *Look for additional opportunities to blend JPSS/GOES-R capabilities*
- *Smoke Modeling*
  - *Add other satellite (NOAA-20, GOES-R...) fire products to the HRRR-Smoke Model*
  - *Help transition the smoke parameterization into the global FV3 in the future in synergy with EMC and ARL*

For More Information on the JPSS Program (WWW.JPSS.NOAA.GOV)

VIIRS FIRE PRODUCT STATUS

Ivan Csiszar (STAR)
Marina Tsidulko (IMSG@STAR)
Wilfrid Schroeder (OSPO)
Zhaohui Cheng (OSPO)
and many other contributors

JPSS VIIRS Active Fire Algorithm Cal/Val Team

Algorithm Cal/Val Team Members and key stakeholders

Name	Organization	Major Task
Ivan Csiszar	NESDIS/STAR	Active Fire product lead
Marina Tsidulko	IMSG	STAR code development, data analysis
Wilfrid Schroeder	OSPO	I-band Algorithm development, validation; Hazard Mapping System user / developer
Mike Wilson	IMSG	STAR ASSIST integration
Louis Giglio	UMD	M-band Algorithm developer
Zhaohui Cheng	OSPO	Product Area Lead
Evan Ellicott	UMD	User outreach
Shobha Kondragunta	STAR	Smoke / aerosol user outreach and analysis
Ravan Ahmadov	ESRL	HRRR-smoke POC
Bill Sjoberg	NJO	Fire and Smoke Initiative coordinator

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	[illegible]	[illegible]			
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	[illegible]	[illegible]			
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 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

Requirements

- Product performance requirements from JPSS L1RD supplement (threshold) versus observed/validated

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 Rower (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 Rower (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

Current operational 750m NDE products

Target operational 375m NDE products

NDE/STAR VIIRS Active Fire Production Status

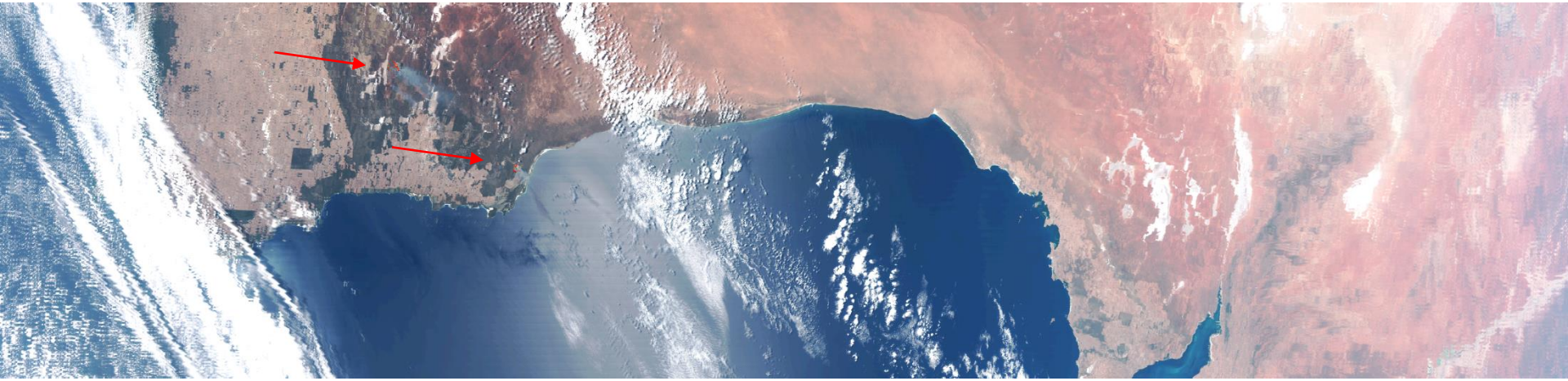
Algorithm	Suomi NPP	NOAA-20
750m M-band	NDE Operational since March 15, 2016	NDE Operational since August 13, 2018
375m/750m I/M-band	STAR Systematic production since January 30, 2018	STAR Systematic production since February 5, 2018

- **CSPP**
  - 750m product included
  - 375m product delivered to CSPP for integration
  - Both Suomi NPP and NOAA-20
- **HRRR-smoke**
  - Non-operational products provided through STAR ftp
  - Operational products through PDA

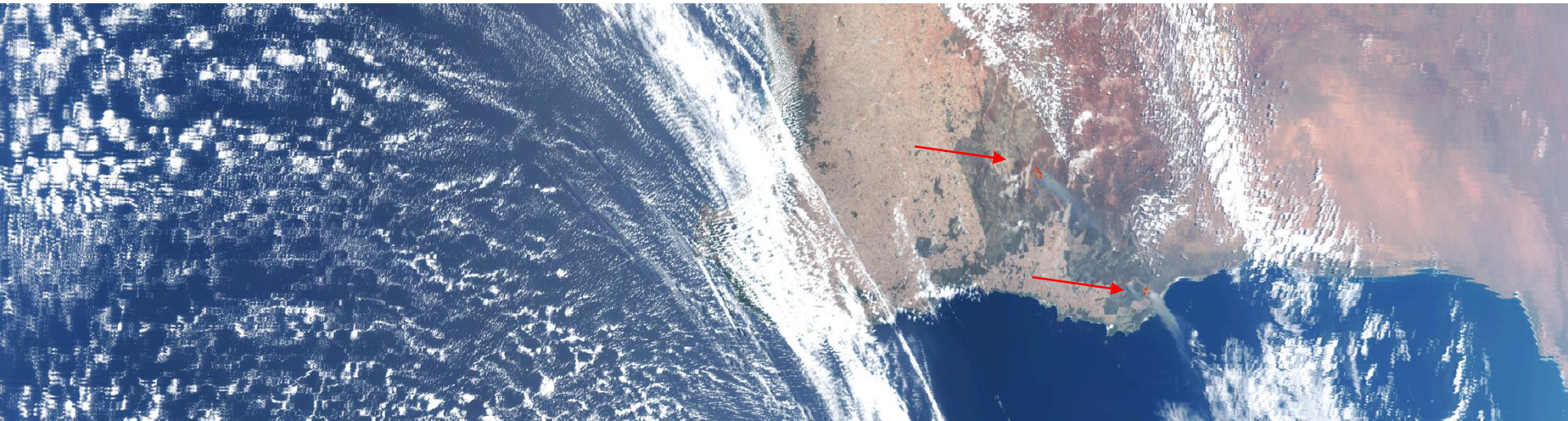
VIIRS 750m Active fires on January 5, 2018

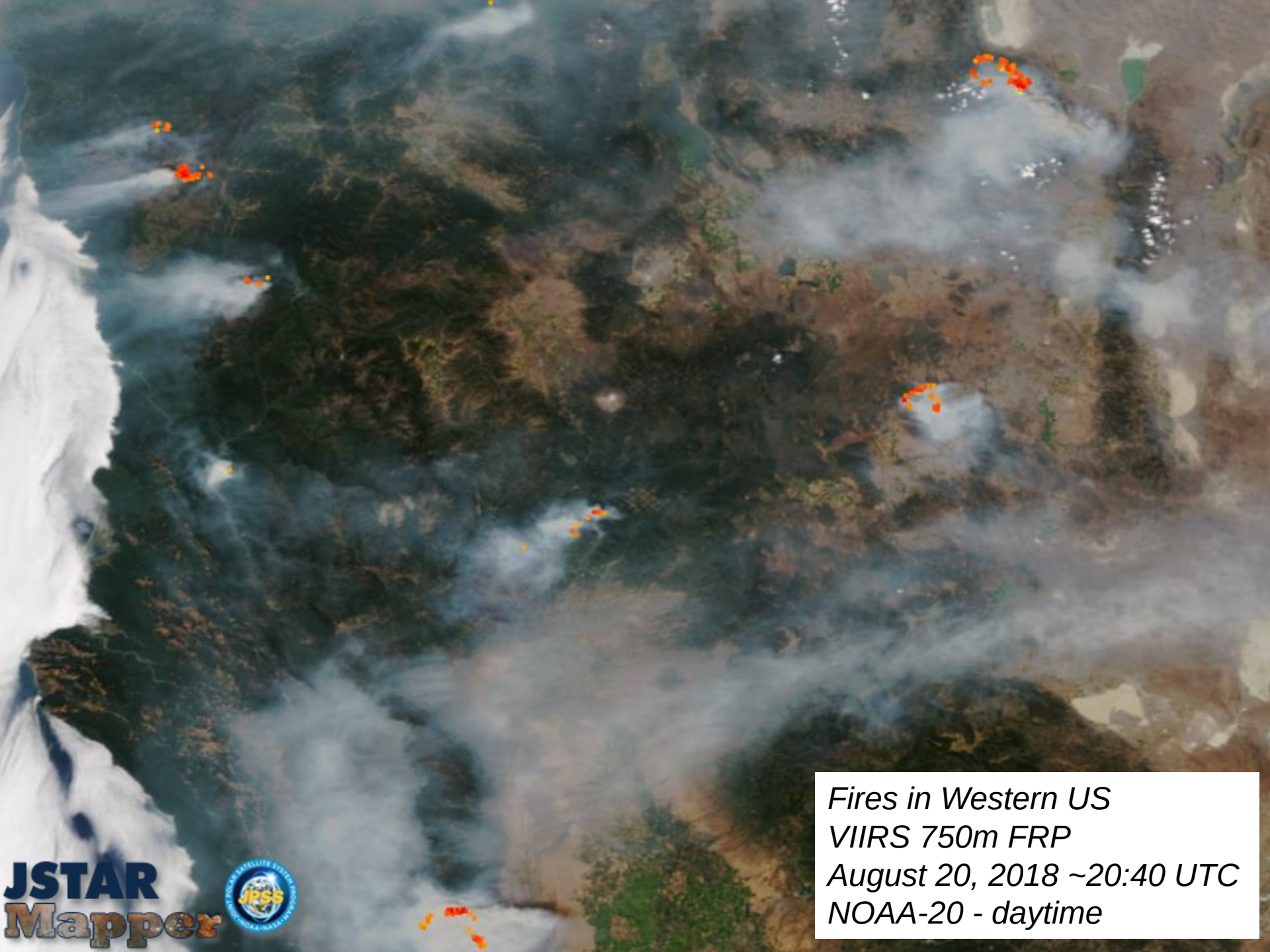
Suomi NPP 5:11 UTC (operational)

Level 2 product

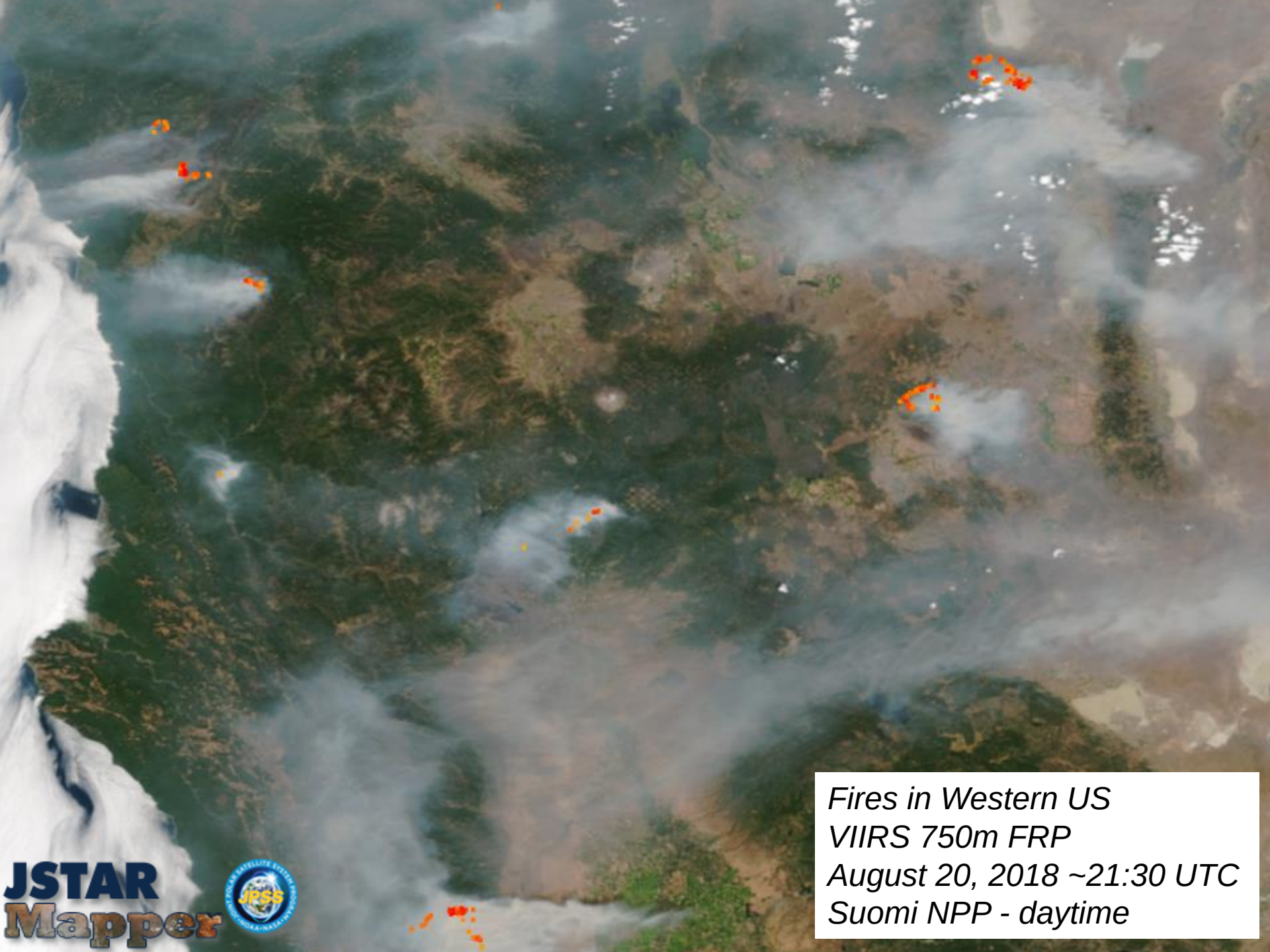


NOAA-20 6:01 UTC (early example – evaluation ongoing)



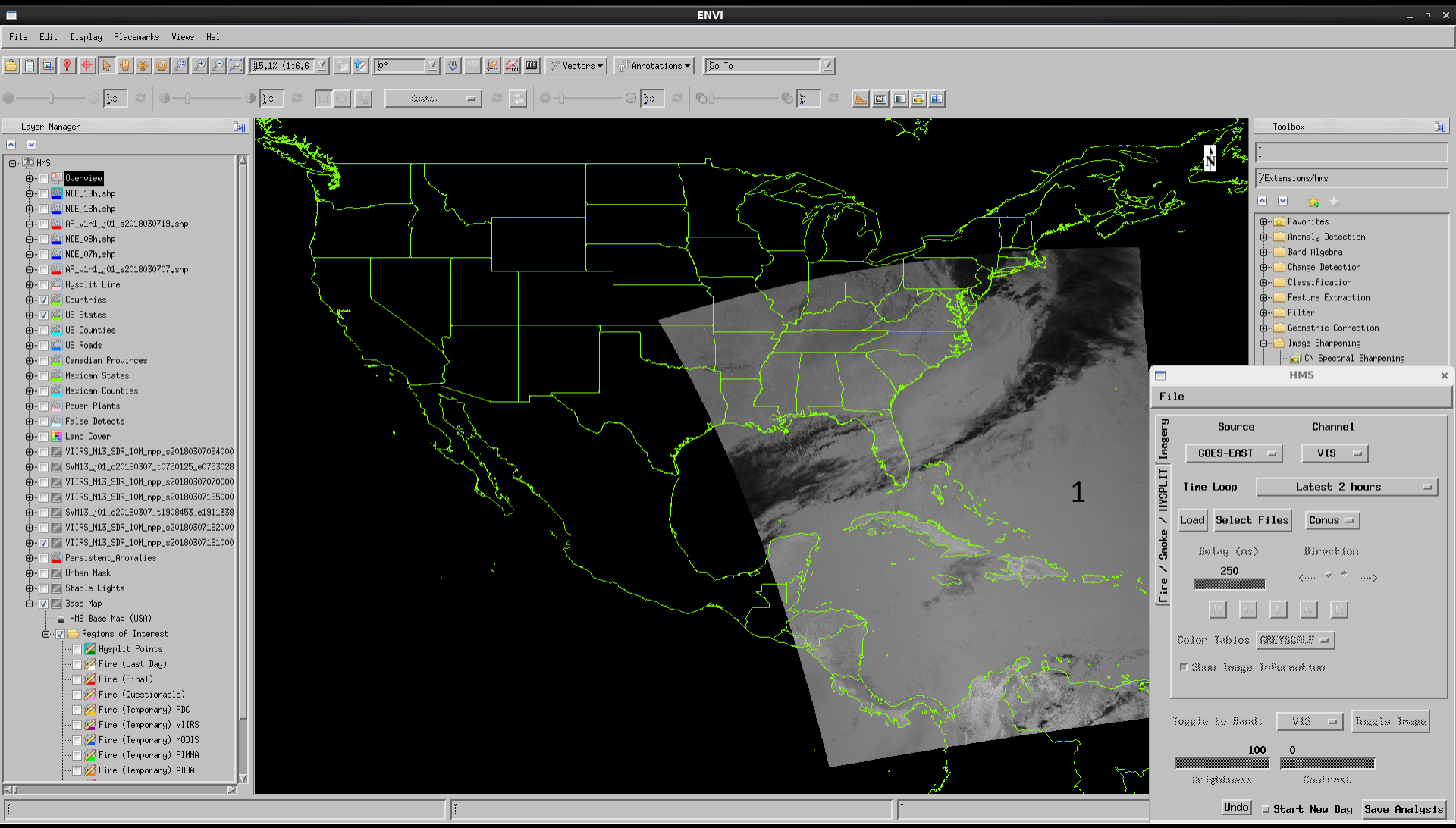


Fires in Western US
VIIRS 750m FRP
August 20, 2018 ~20:40 UTC
NOAA-20 - daytime



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

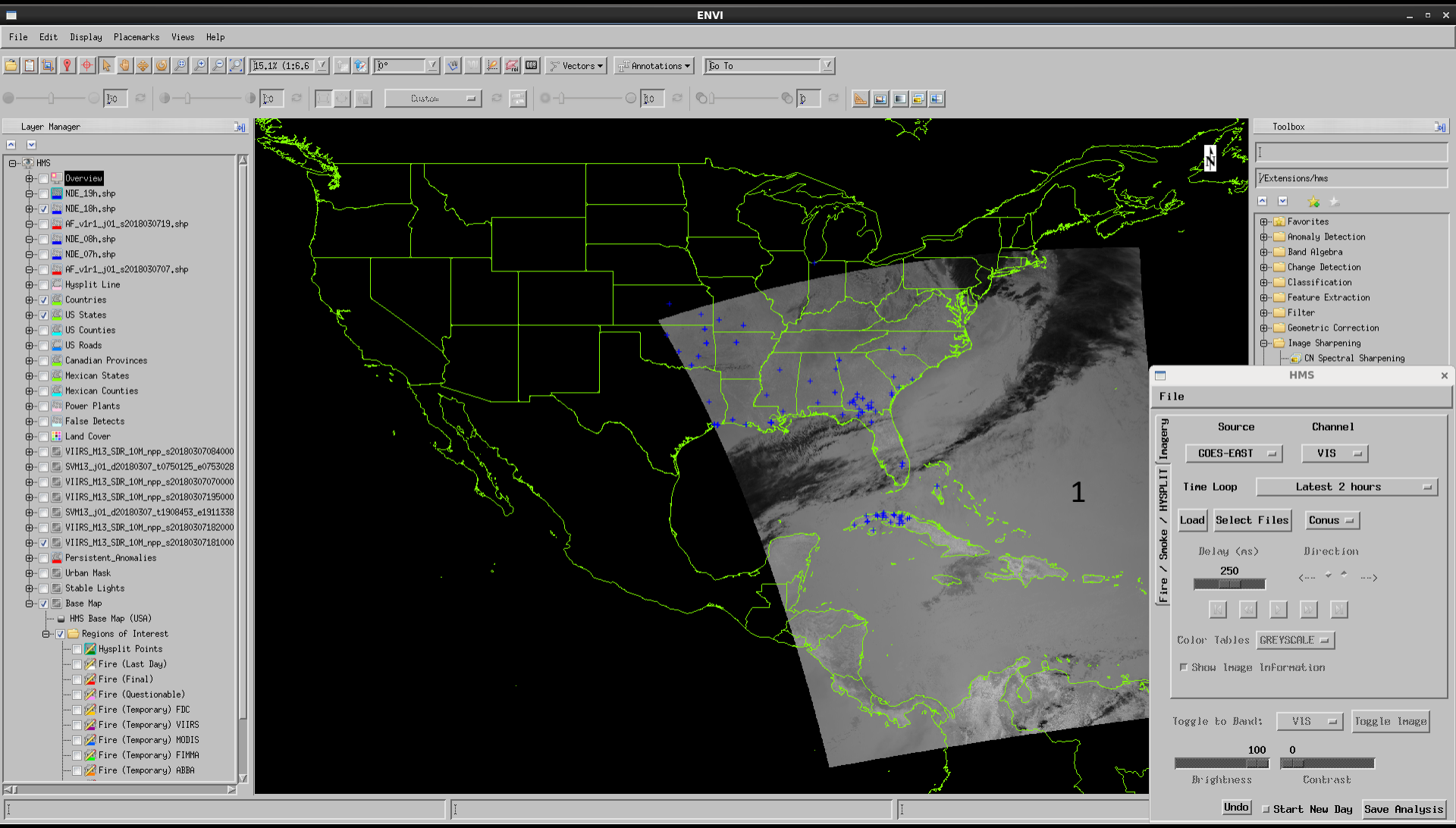
Hazard Mapping System
07 March 2018 – afternoon data



10-min granule

1: S-NPP/VIIRS 1810UTC

Hazard Mapping System
07 March 2018 – afternoon data

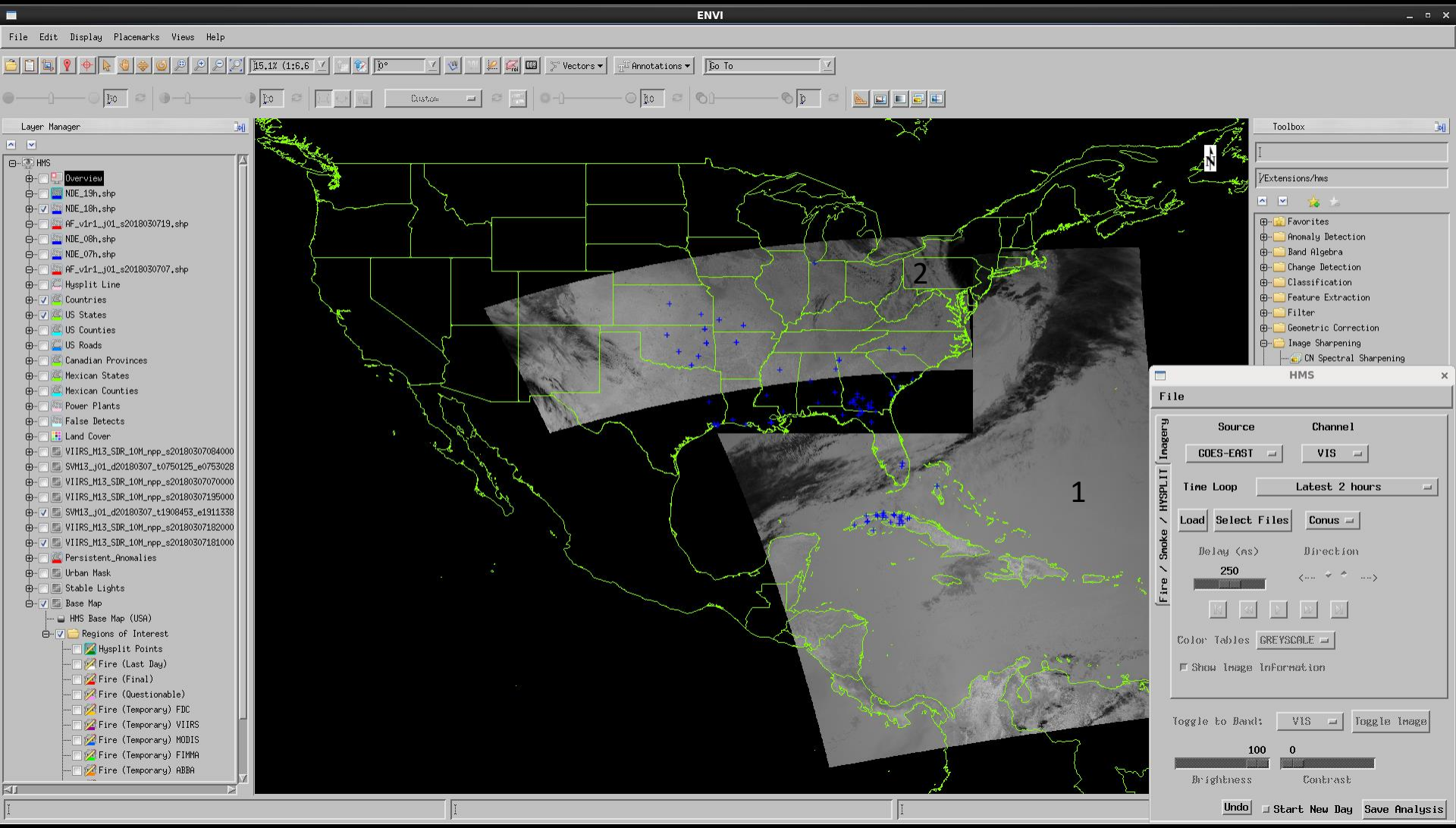


10-min granule

1: S-NPP/VIIRS 1810UTC

* S-NPP VIIRS 750m fire pixels

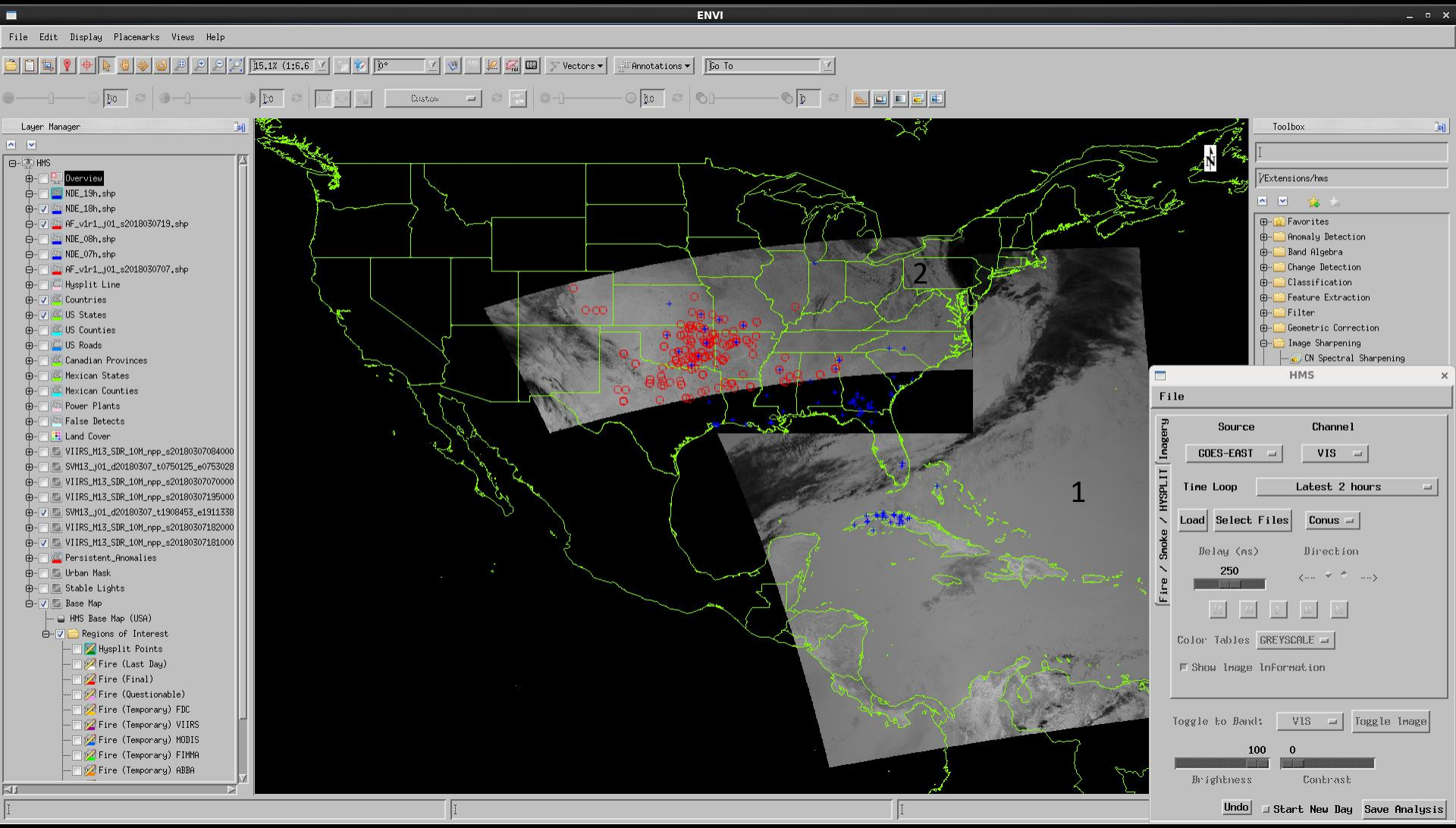
Hazard Mapping System
07 March 2018 – afternoon data



2x86sec granule

2: NOAA-20/VIIRS 1900UTC

Hazard Mapping System
07 March 2018 – afternoon data



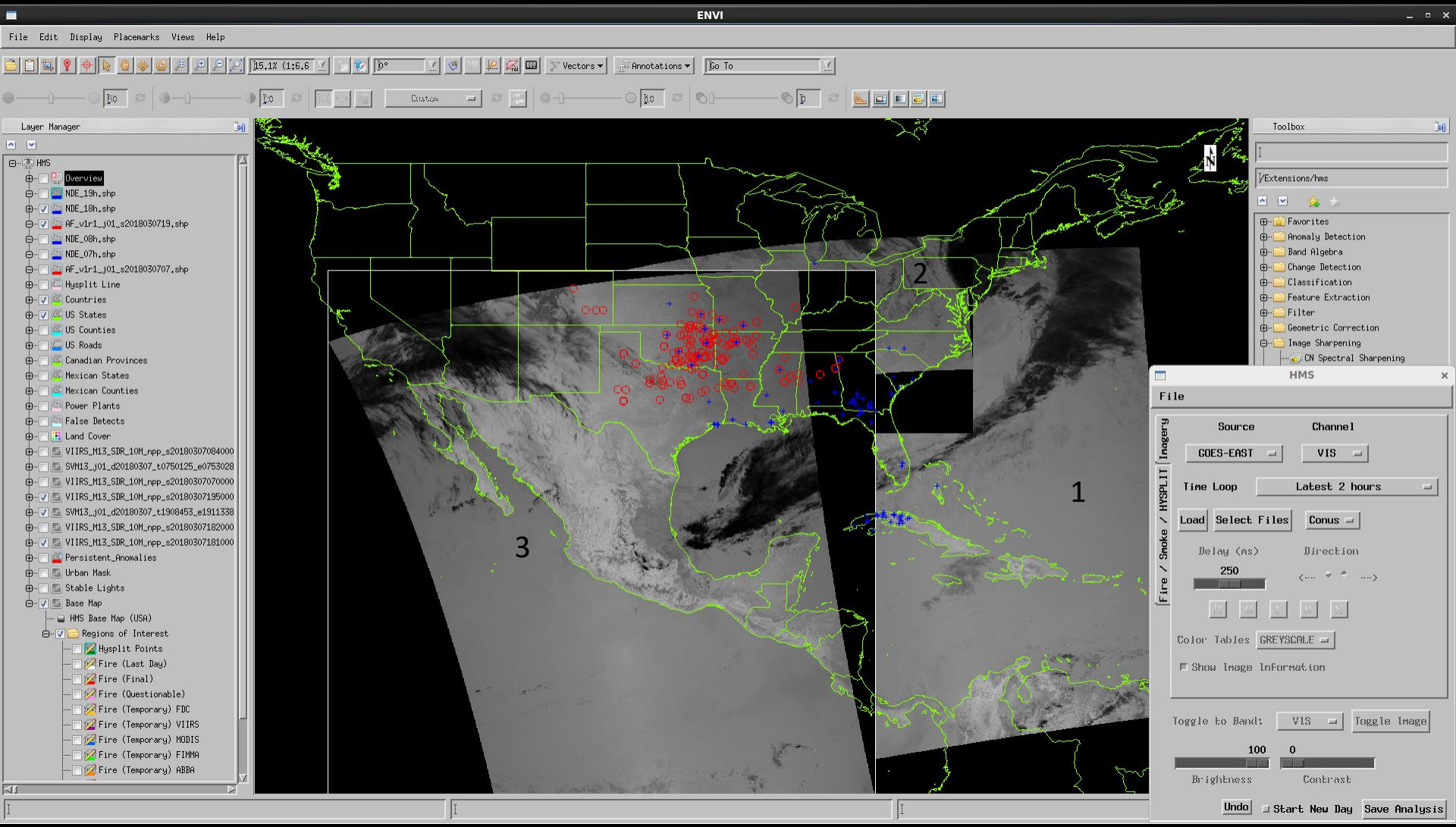
2x86sec granule

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



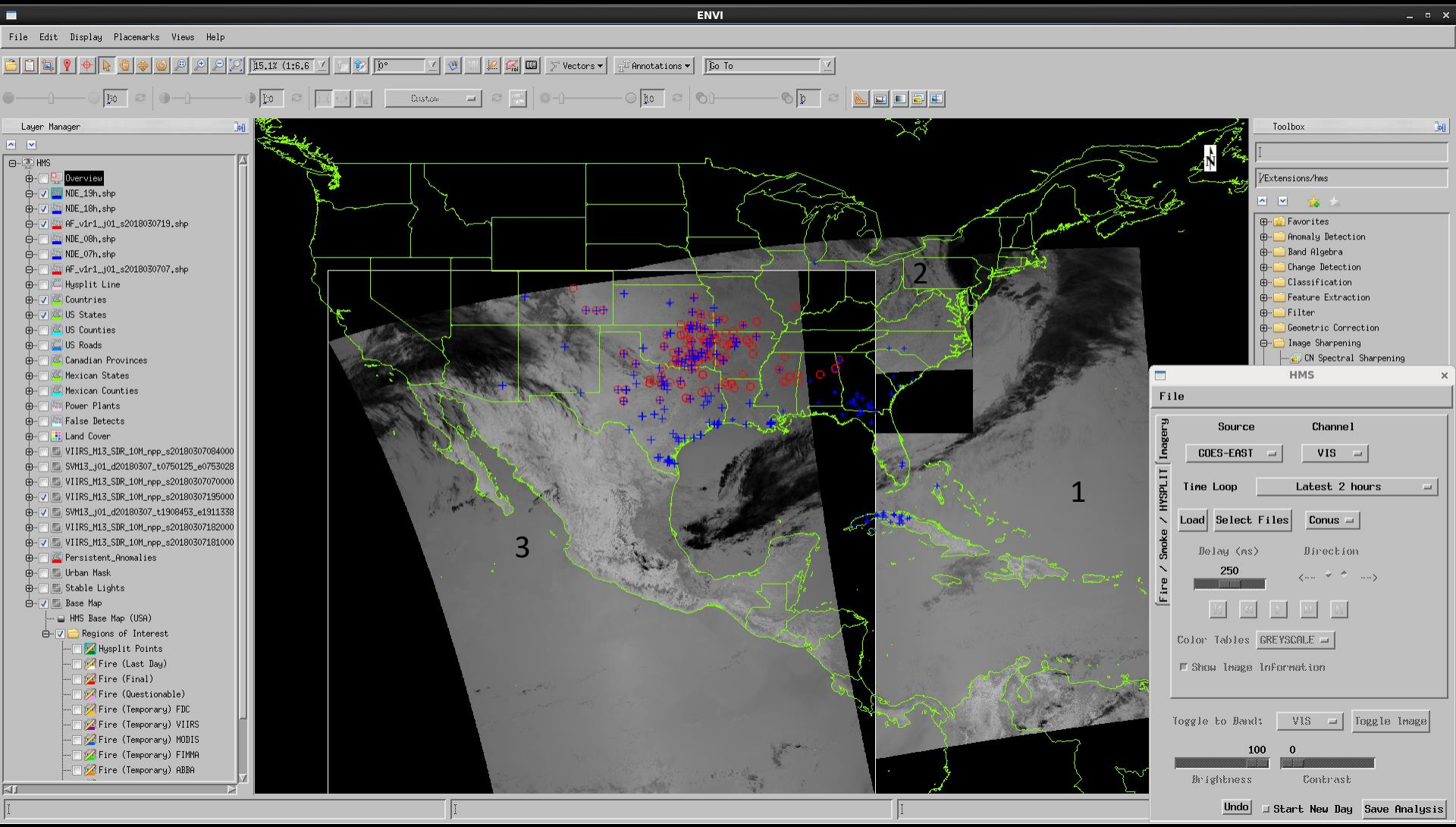
10-min granule

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



10-min granule

3: S-NPP/VIIRS 1950UTC

* S-NPP VIIRS 750m fire pixels

o NOAA-20 VIIRS 750m fire pixels

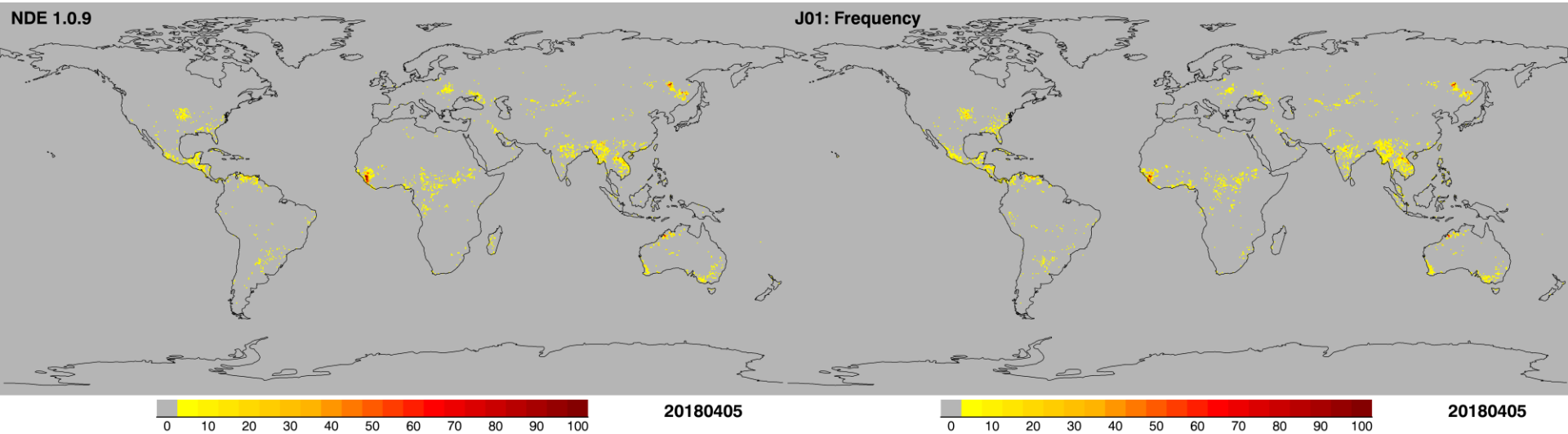
Quality flags and quality indicators

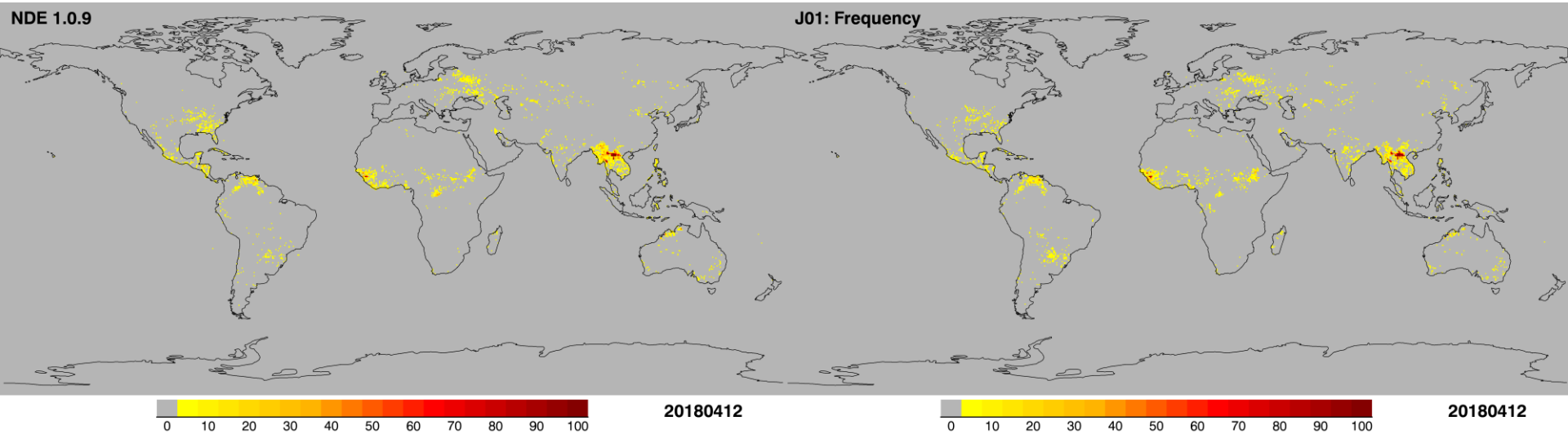
Output	Type	Description	
Fire Mask	8-bit unsigned integer	Missing – 0	Missing input data
		Scan – 1	On-board bowtie deletion
		Other – 2	Not processed (obsolete)
		Water – 3	Pixel classified as non-fire water
		Cloud – 4	Pixel classified as cloudy
		No Fire – 5	Pixel classified as non-fire land
		Unknown – 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.

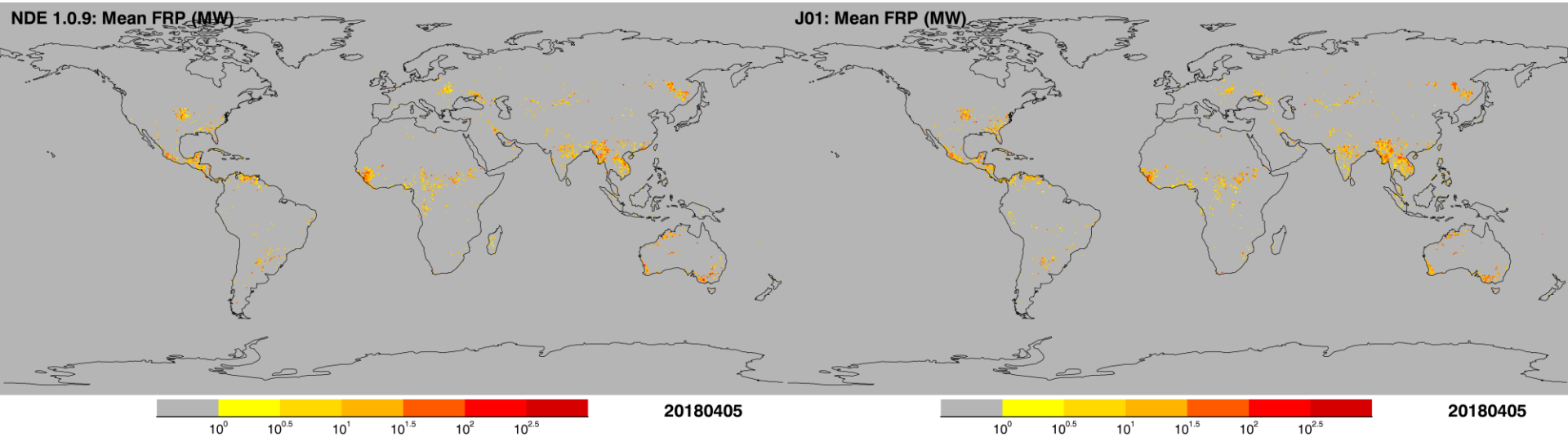
Suomi NPP vs. NOAA-20: 750m

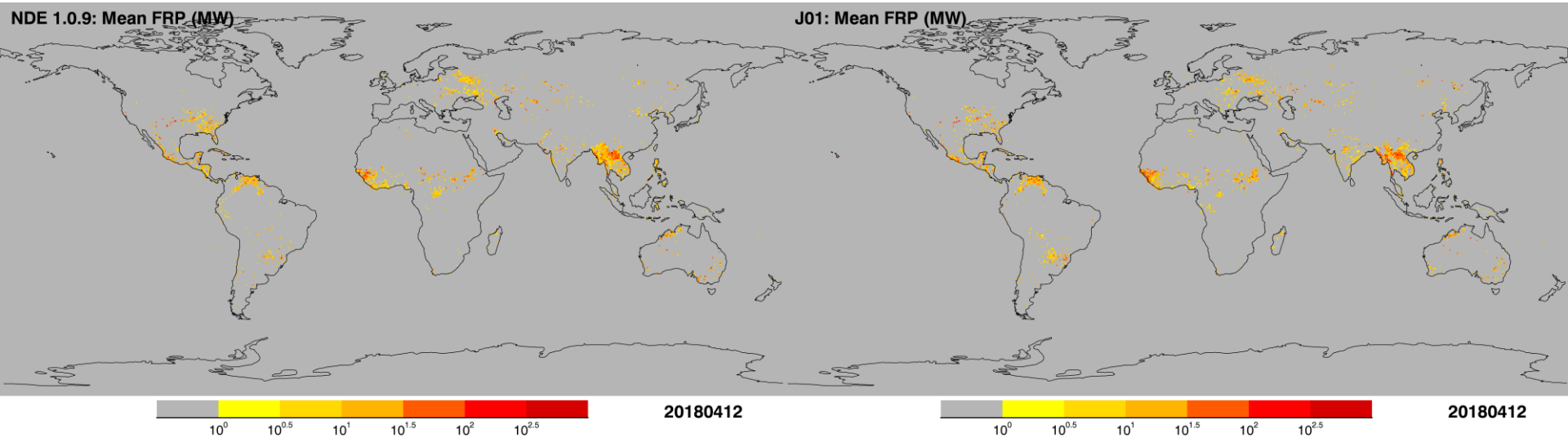




Good agreement. No "perfect" agreement is expected

Suomi NPP vs. NOAA-20: 750m





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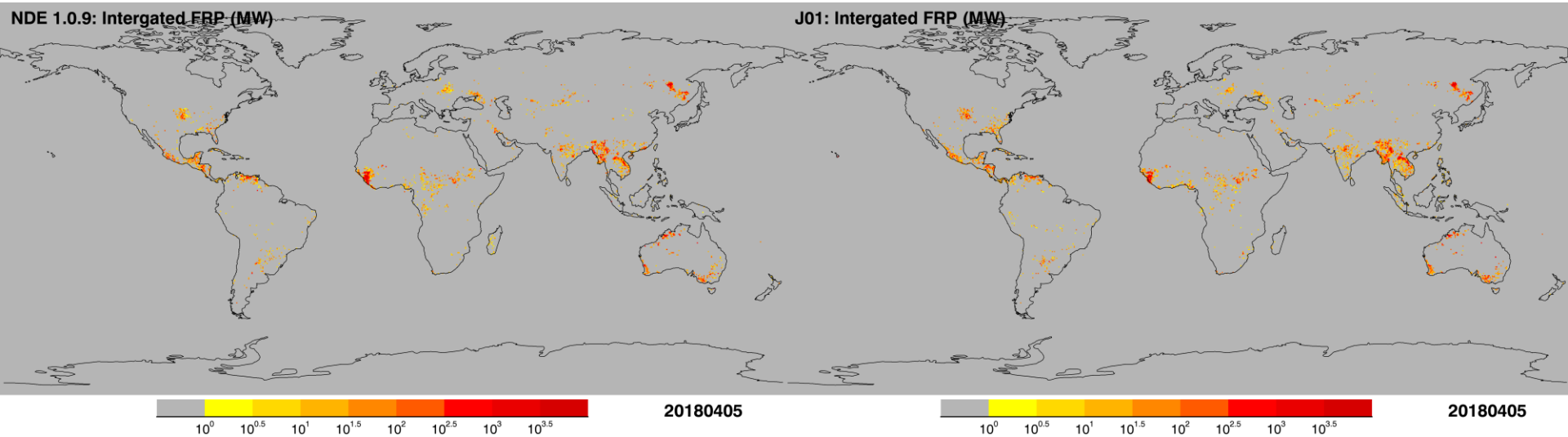
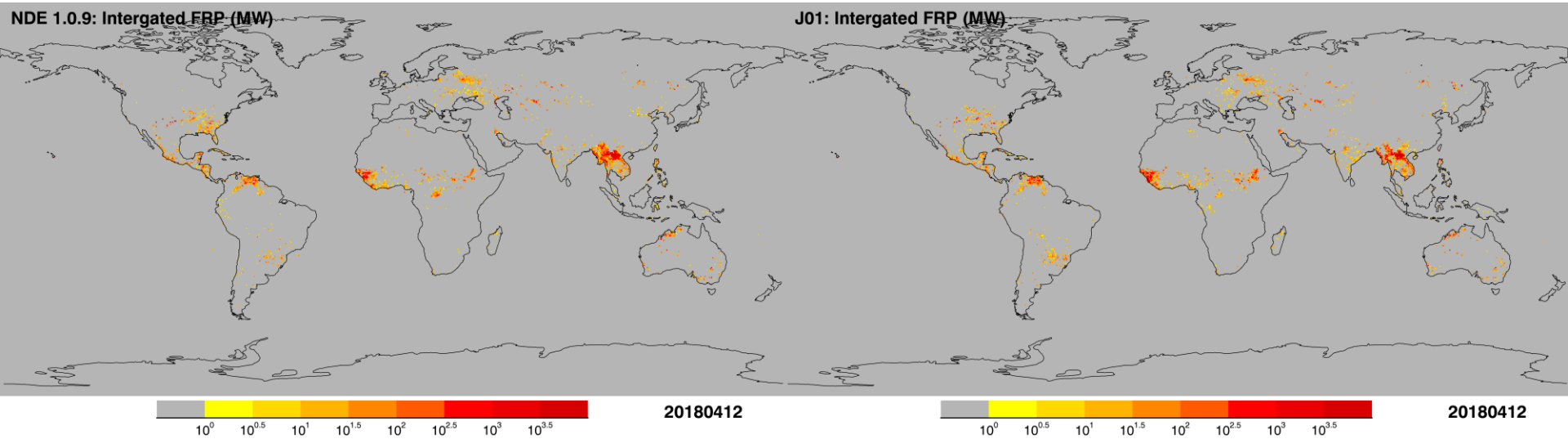
Suomi NPP vs. NOAA-20: 750m





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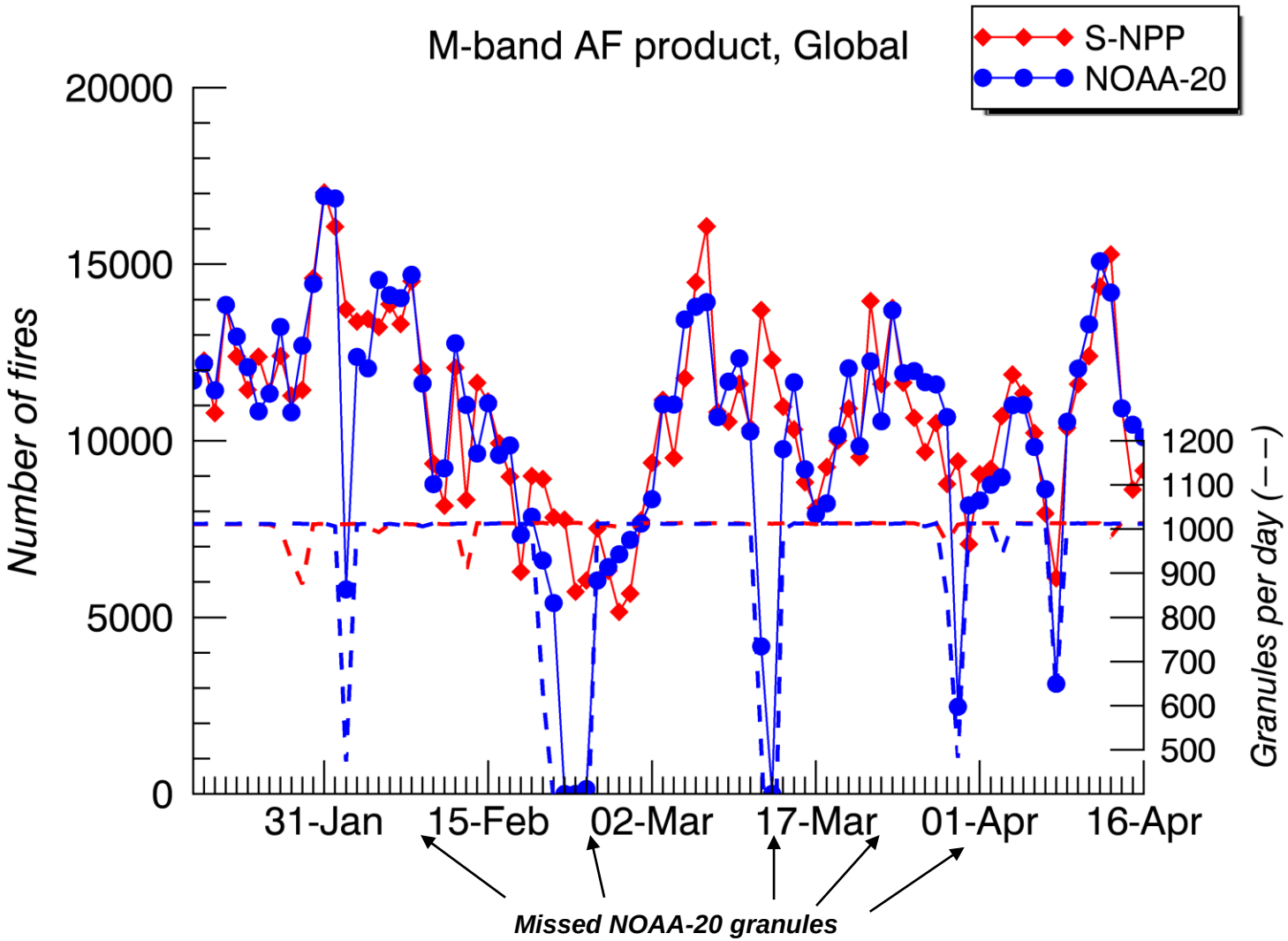
Suomi NPP vs. NOAA-20: 750m



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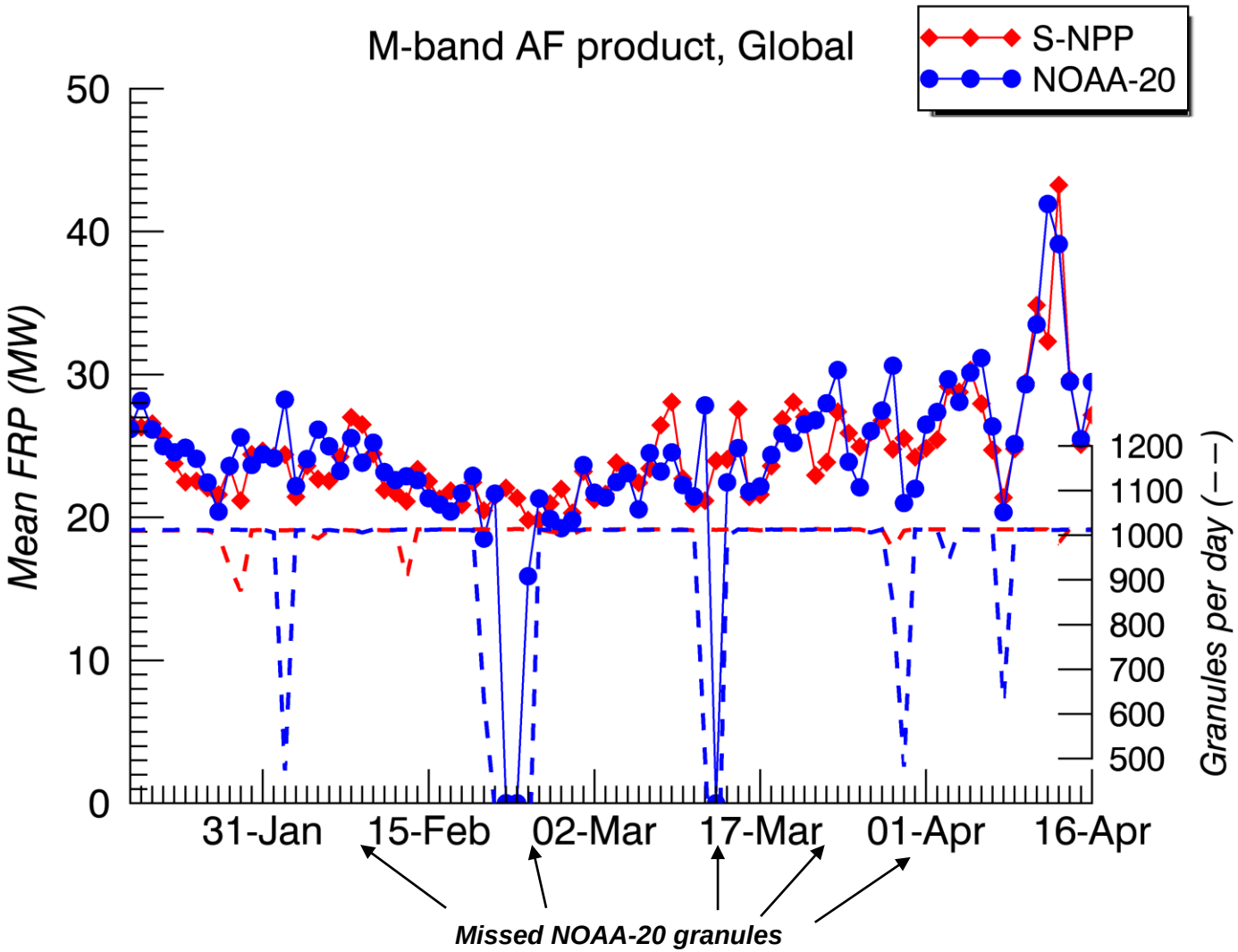
Suomi NPP vs. NOAA-20: 750m



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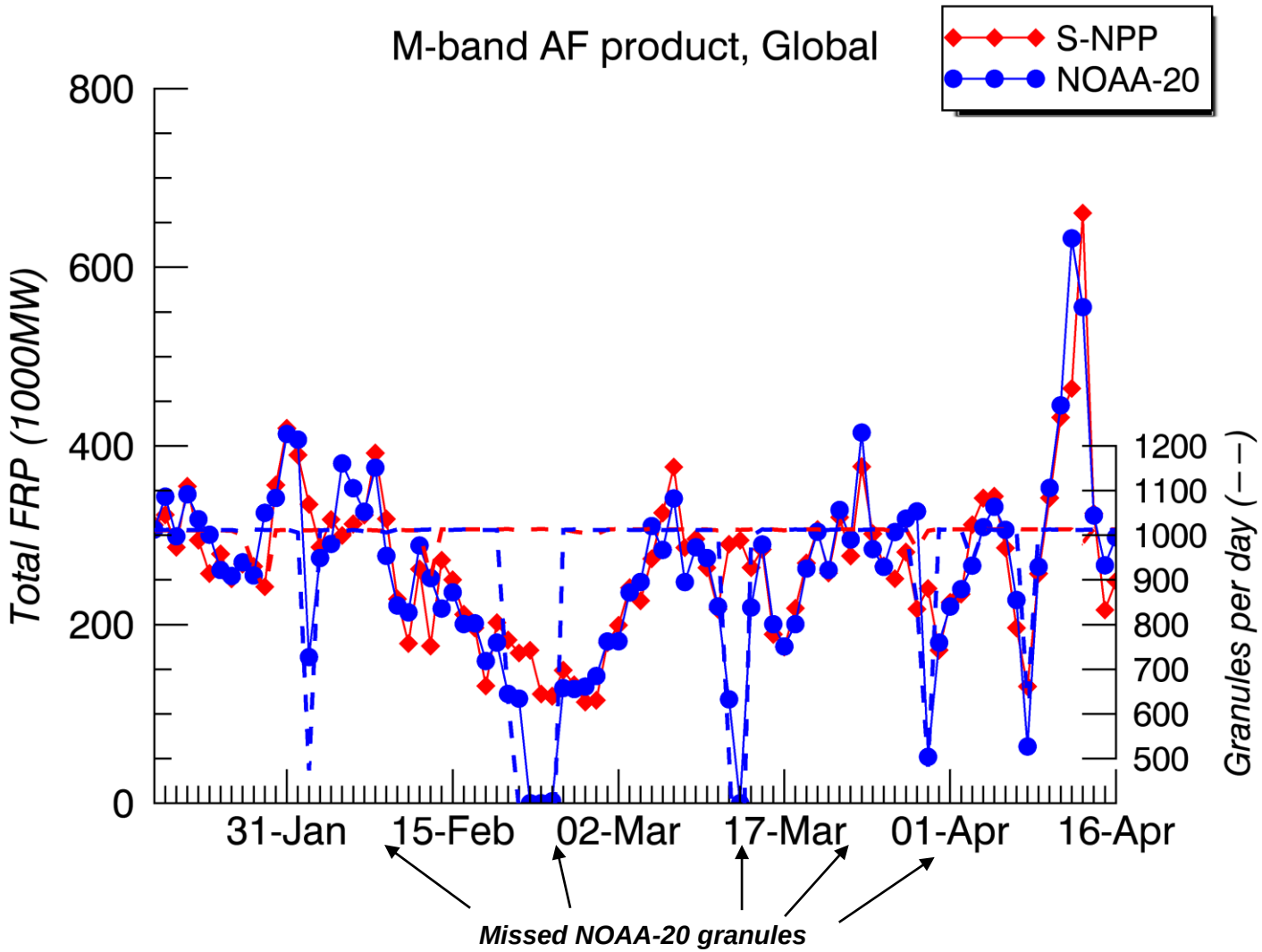
Suomi NPP vs. NOAA-20: 750m



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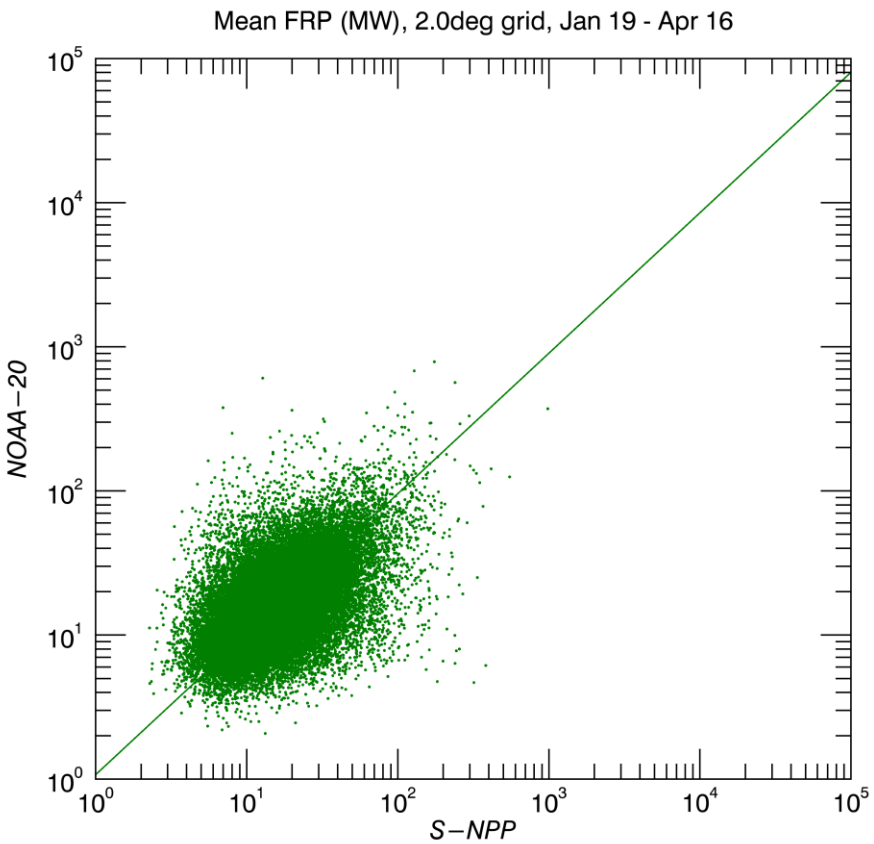
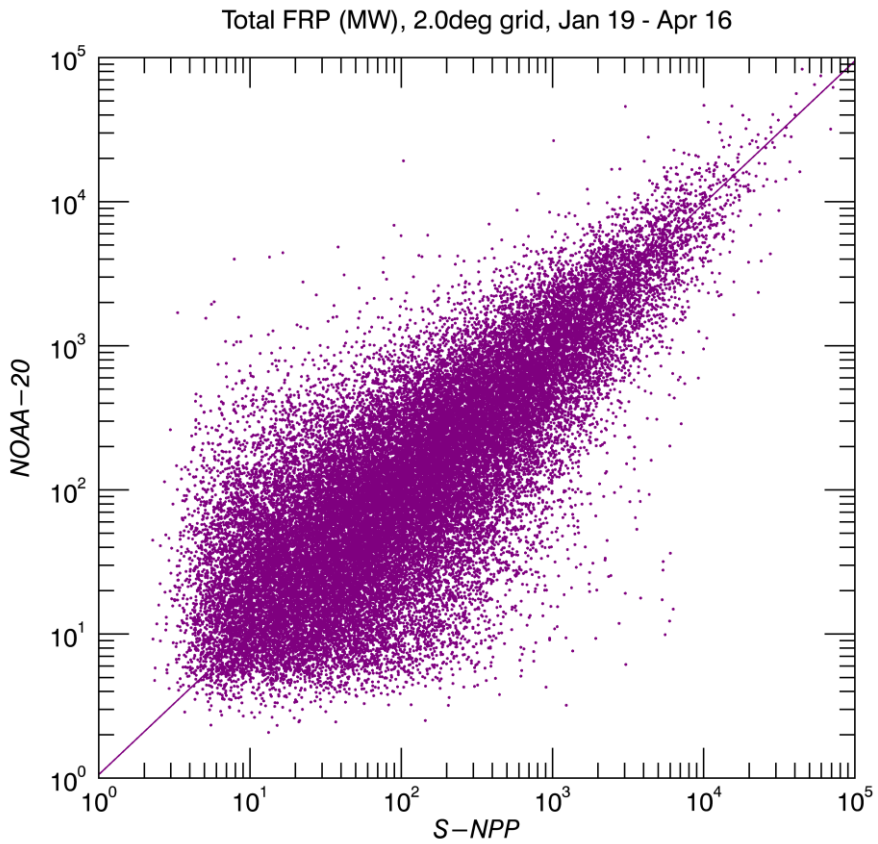
Suomi NPP vs. NOAA-20: 750m





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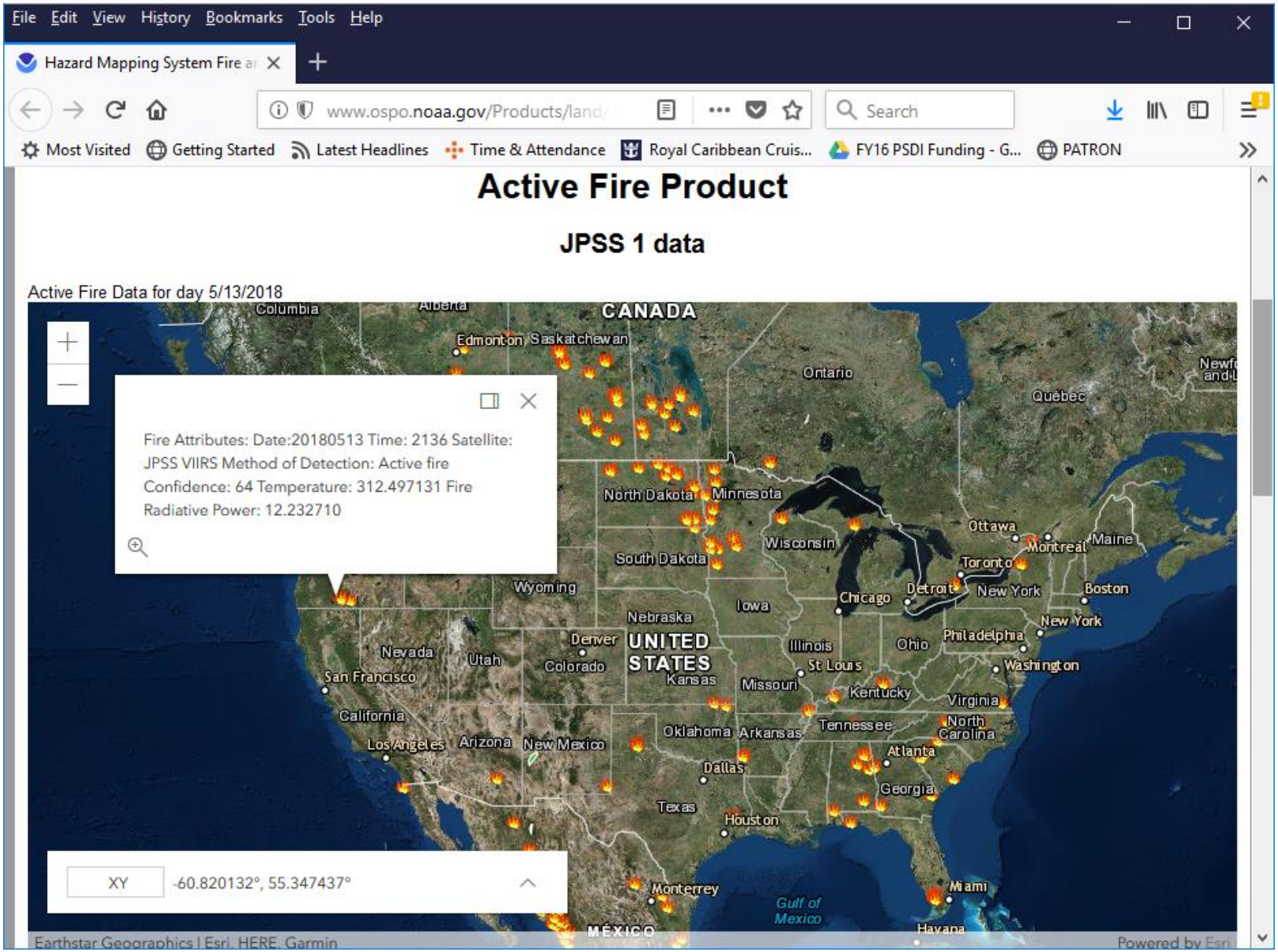
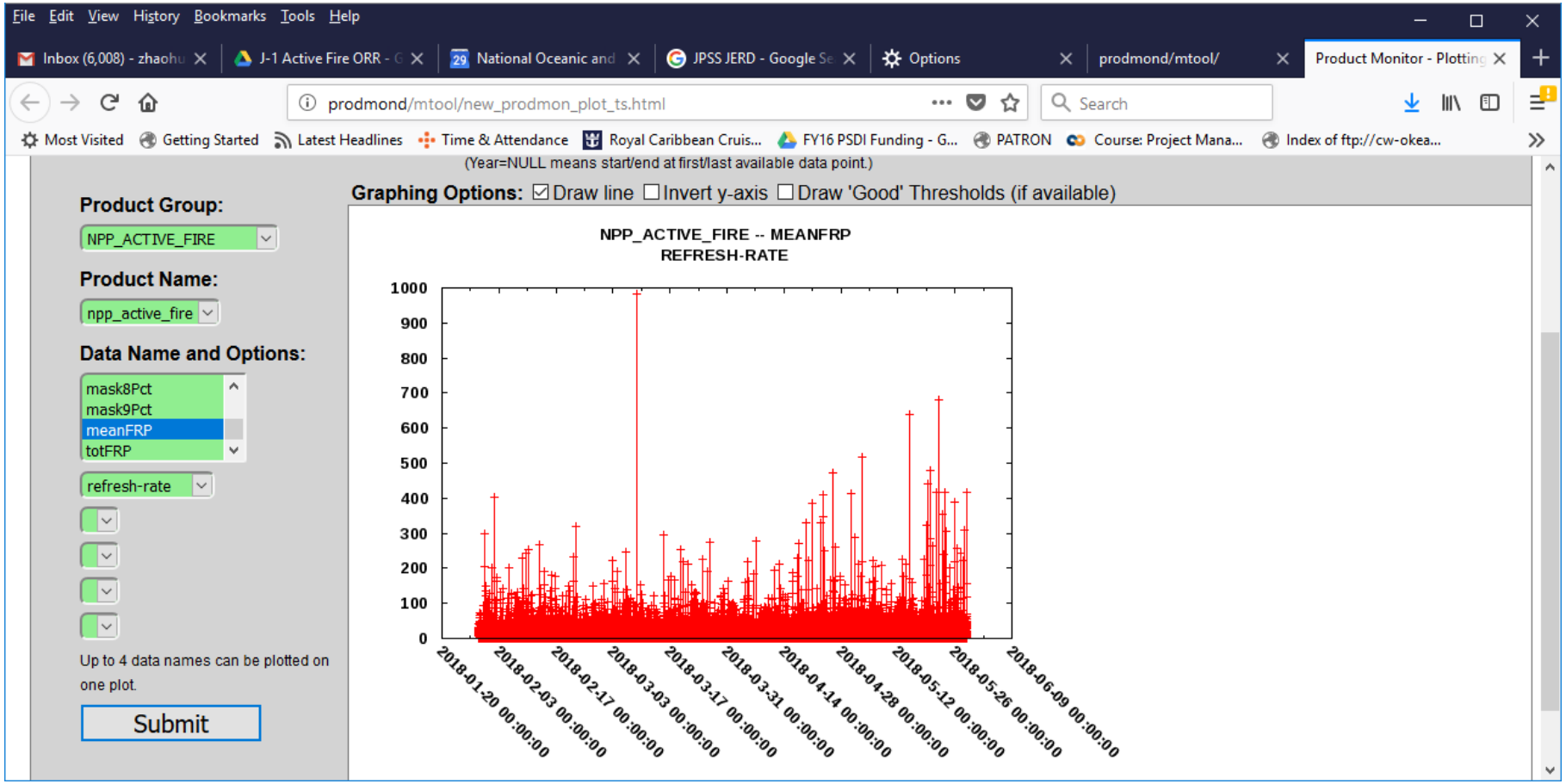
OSPO product monitoring



OSPO product monitoring

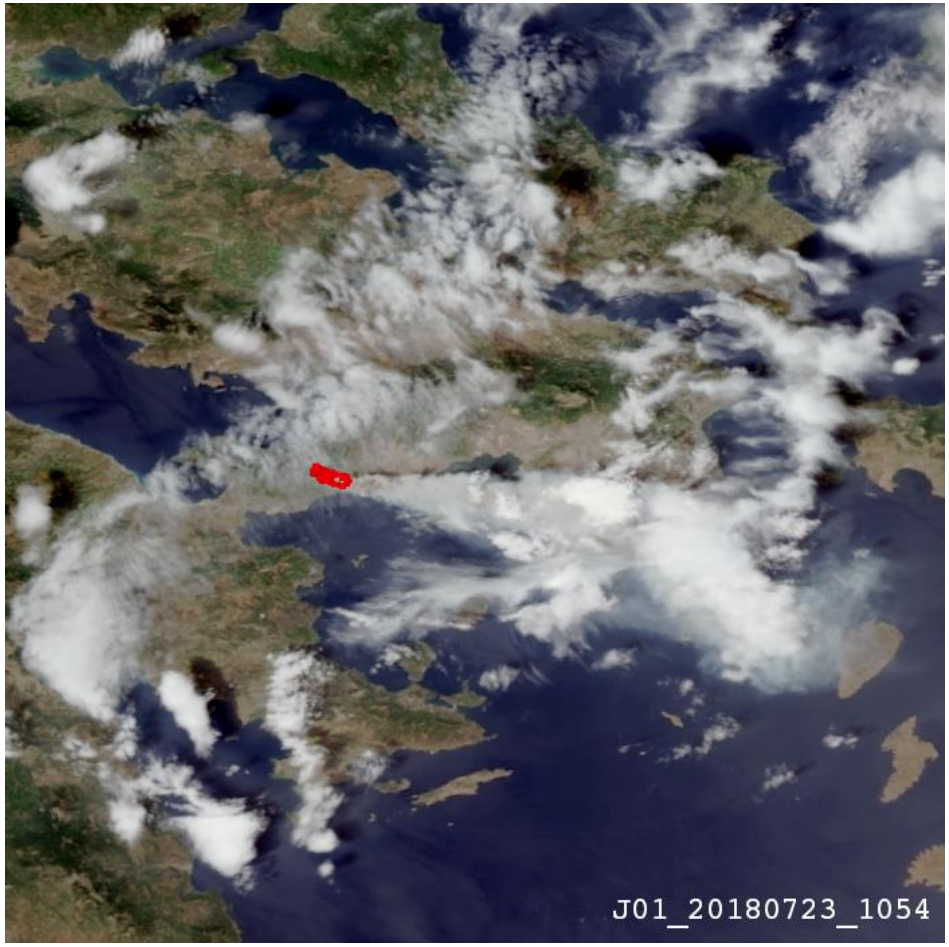


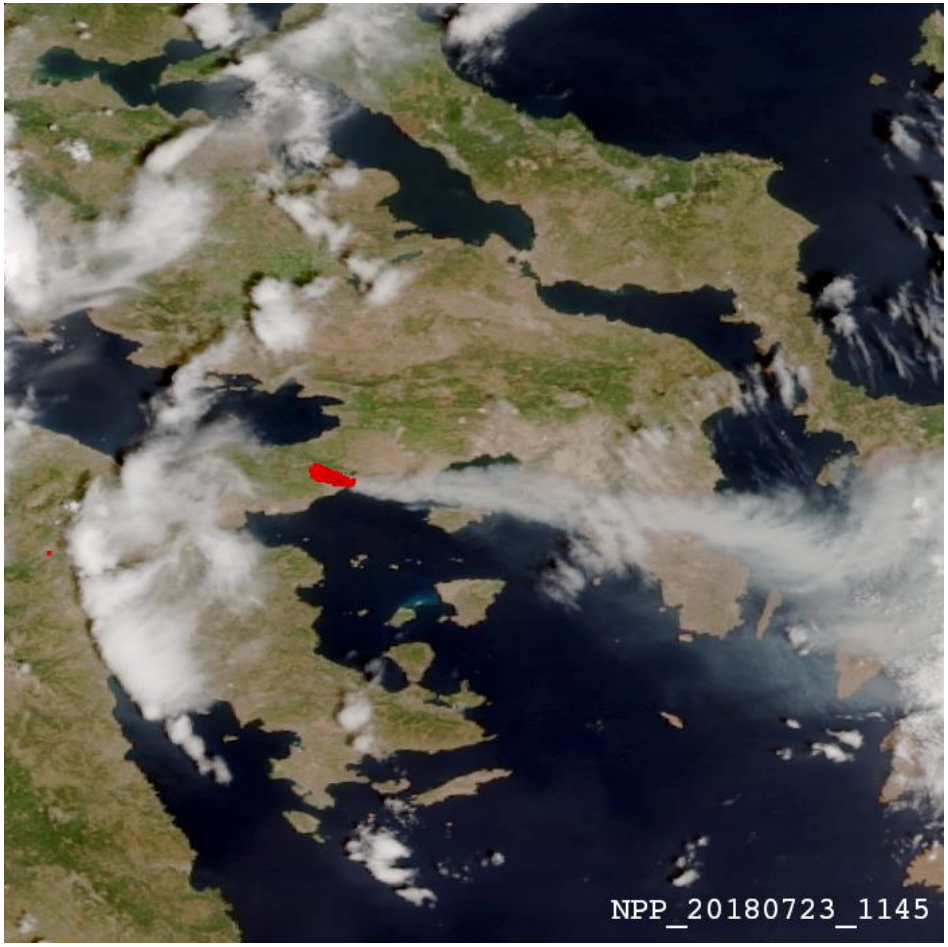
375m product status

- OSPO / Hazard Mapping System
  - VIIRS 375m fire data processing (including visualization by-products) is up an running at OSPO/SPSD/SAB
  - Final shake down taking place in HMS development environment
  - Full operational use to start in the next 1-2 weeks
  - New data will replace 750m fire product/imagery
- STAR
  - Systematic global production
  - Partnership with OSPO and ESRL for impact assessment / demonstration
  - Work towards NDE implementation

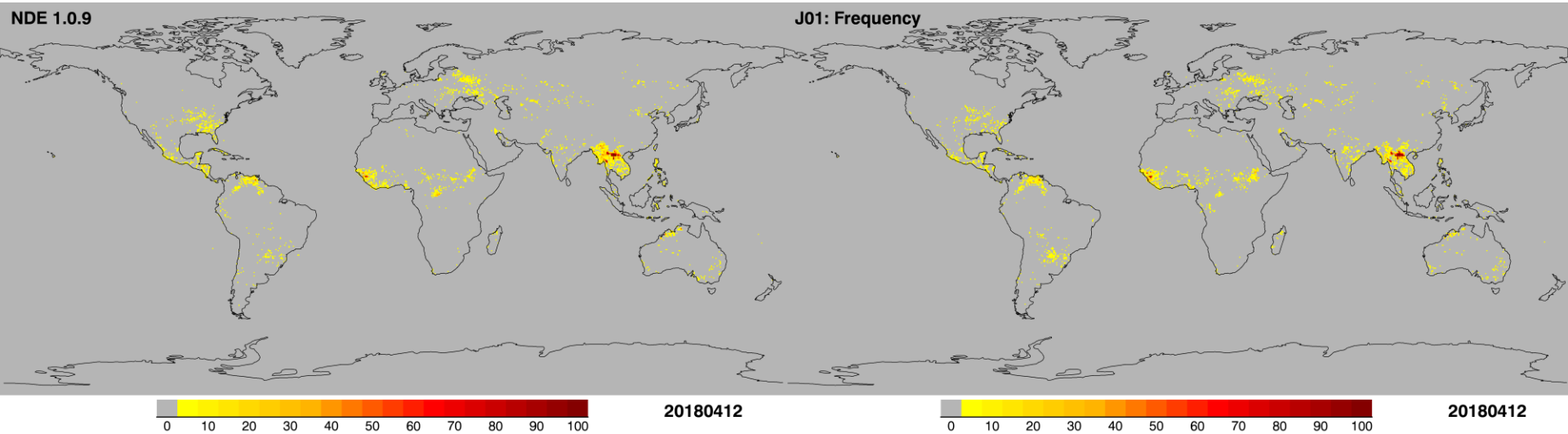
Fires in Greece on July 23, 2018

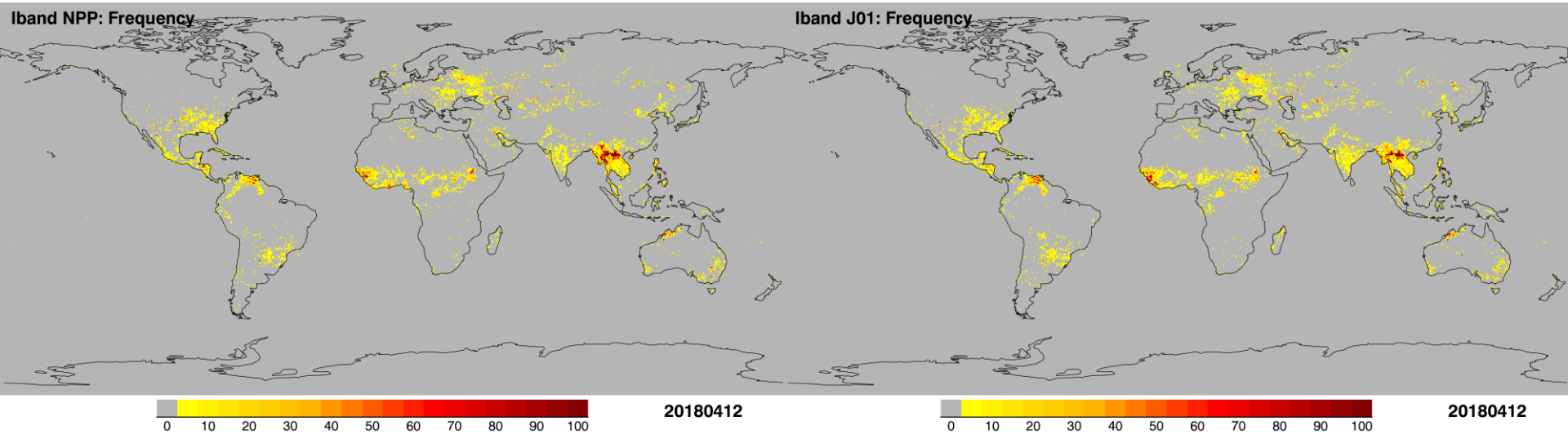
VIIRS 375m product generated at STAR



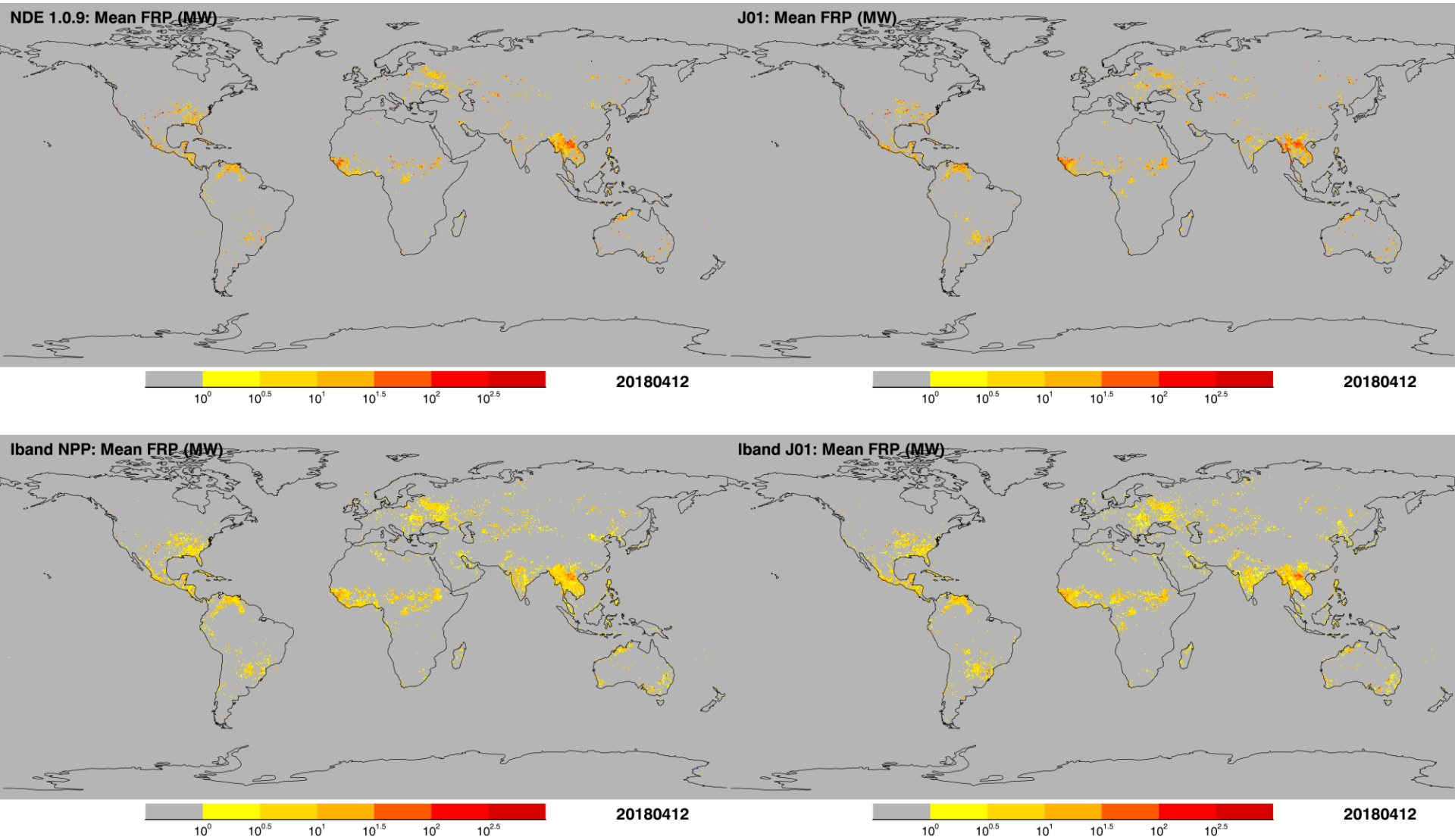


VIIRS 750m vs. 375m

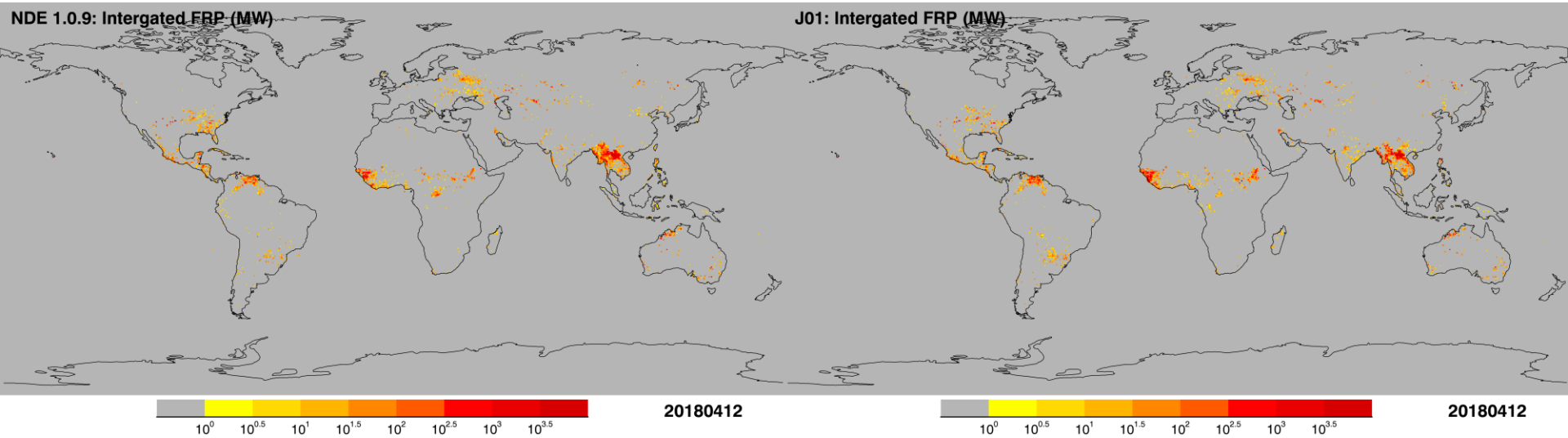


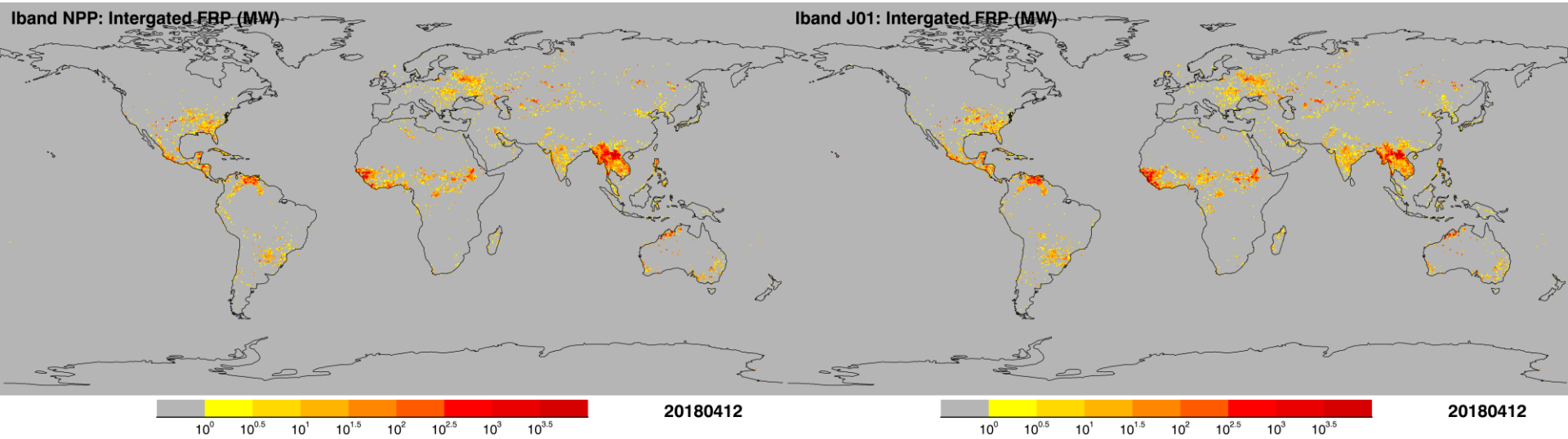


Suomi NPP vs. NOAA-20: 750m



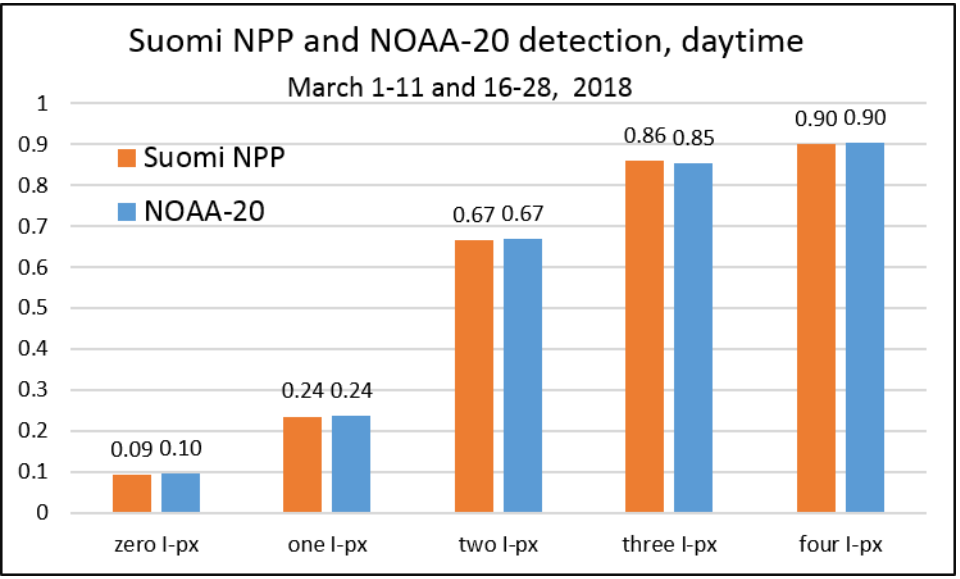
Suomi NPP vs. NOAA-20: 750m

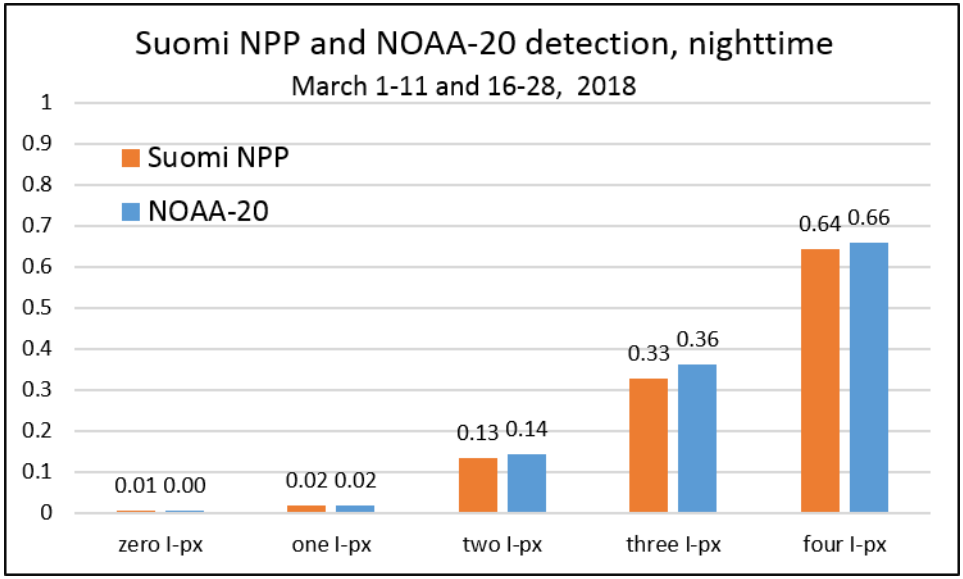




M-band vs. I-band detection rates

- 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

User Feedback

Name	Organization	Application	User Feedback
Ravan Ahmadov	NOAA ESRL	High Resolution Rapid Refresh-Smoke	Plans to use the NOAA-20 VIIRS FRP data in HRRR-Smoke forecasting. Working on sample files to modify preprocessing tools.
John Simko	OSPO SAB	Hazard Mapping System	Working towards bringing the 375m I/M into OSPO production over HMS domain
Shobha Kondragunta	STAR	eIDEA, GBBEP	Incorporate NOAA-20 products into eIDEA
Jerry Zhan	STAR	Surface Type Change	Plan to use NDE Active Fire information
Andy Edman	NWS	Fire weather	Increasing need for data with the onset of the fire season
Tony Salemi	NCEP		TBC
Natalia Donoho and HongmingQi	OSPO	GEONETCast	Plan to replace the SNPP Active Fire with N20 Active Fire
Tom Sheasby	EUMETSAT		Evaluating the sample files

Path Forward (2/1)

- 750m algorithm and product improvements
  - Edge effect (no complete windows for spatial heterogeneity test in first and last scan of the granule)
    - Re-configure processing to rolling triplets of granules
  - Conservative spatial heterogeneity tests
    - Further algorithm tuning
  - Conservative nighttime detection thresholds
    - Algorithm tuning
  - No atmospheric correction for FRP
    - Develop / implement atmospheric correction
- Future Cal/Val activities / milestones
  - Validated maturity
    - Including validation with new in-situ data
  - 375m (I-band) transition

Path Forward (2/2)

- 375m algorithm and product
  - Proven high quality performance
  - Continues to rely on M13 for FRP retrieval
  - Has been produced systematically in STAR's computing environment
  - **Needs operational data flow of unaggregated dual-gain M13 data into NDE**
  - OSPO limited operational processing also used for impact assessment
- Multi-satellite observing system
  - Enterprise algorithm elements
  - Leverage spatial and temporal coverage between polar and geostationary
  - Common physical basis; differences in current implementation between GEO and LEO

Fires, Smoke, and Air Quality

Shobha Kondragunta

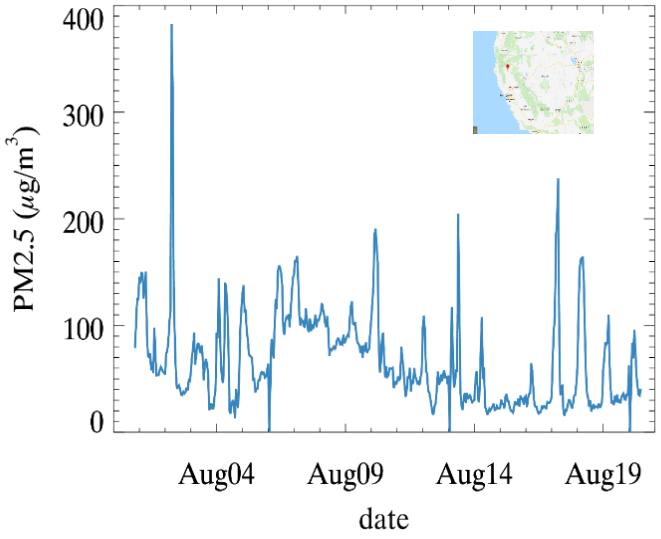
NOAA/NESDIS Center for Satellite Applications and Research

Chuanyu Xu and Hai Zhang

IMSG

Ravan Ahmadov

NOAA/ESRL



JPSS Annual Meeting
August 27-30, 2018

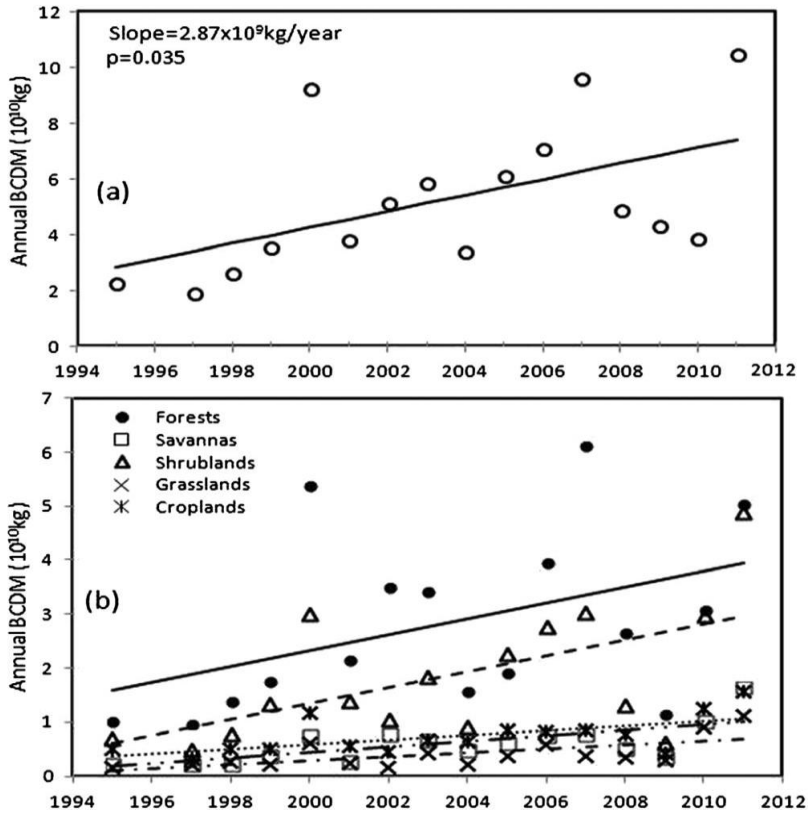
Biomass Burning

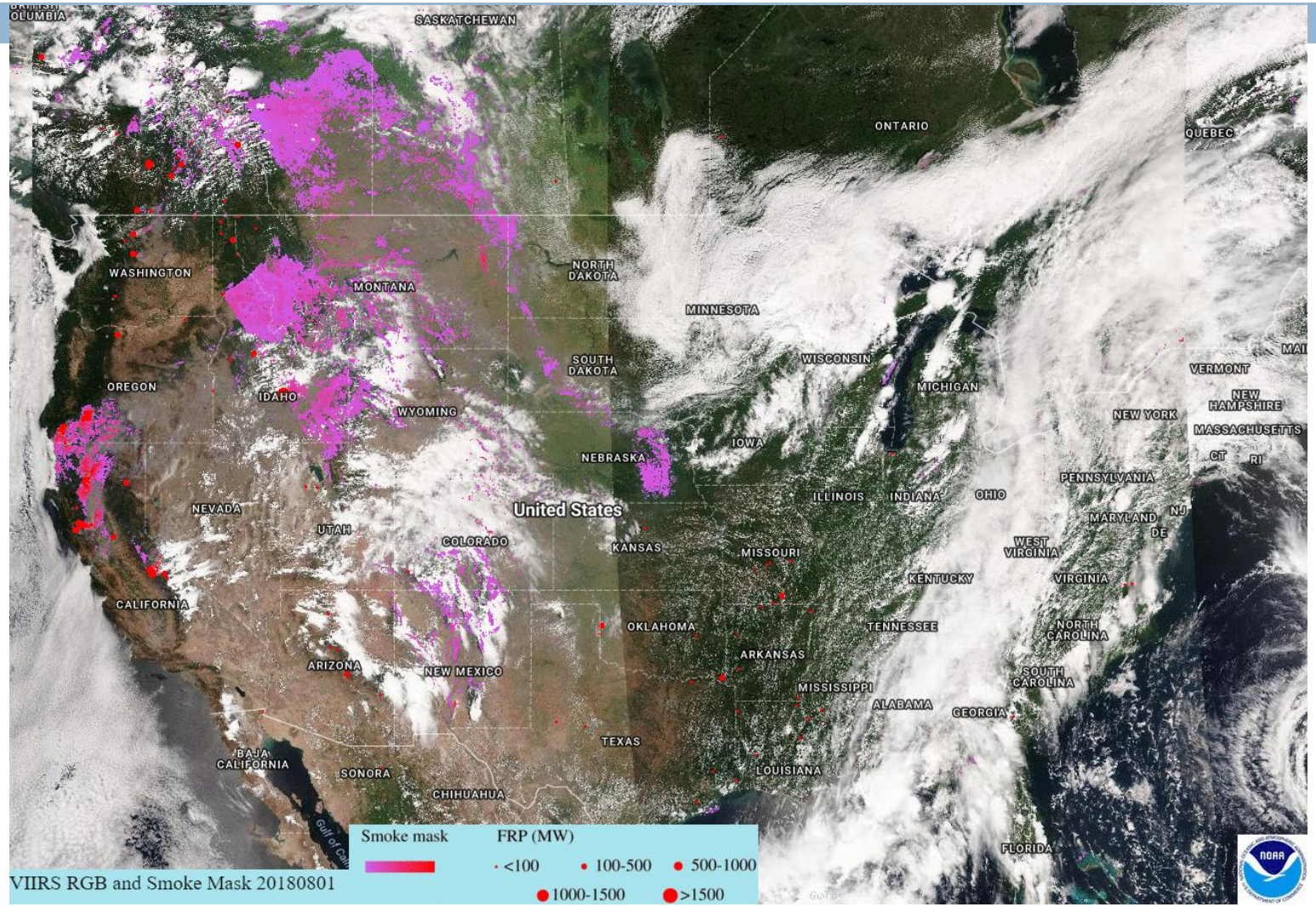
- Fires release large amounts of aerosols into the atmosphere that have adverse affects on human health and economy
  - Long range transport of smoke from fires impacts air quality in downwind regions. Worldwide 250,000 premature deaths per year (Jacobson, JGR, 2014).
  - Impacts national parks, monuments, and transportation due to reduced visibility.

Ft. McMurray Fire, Canada, May 2016

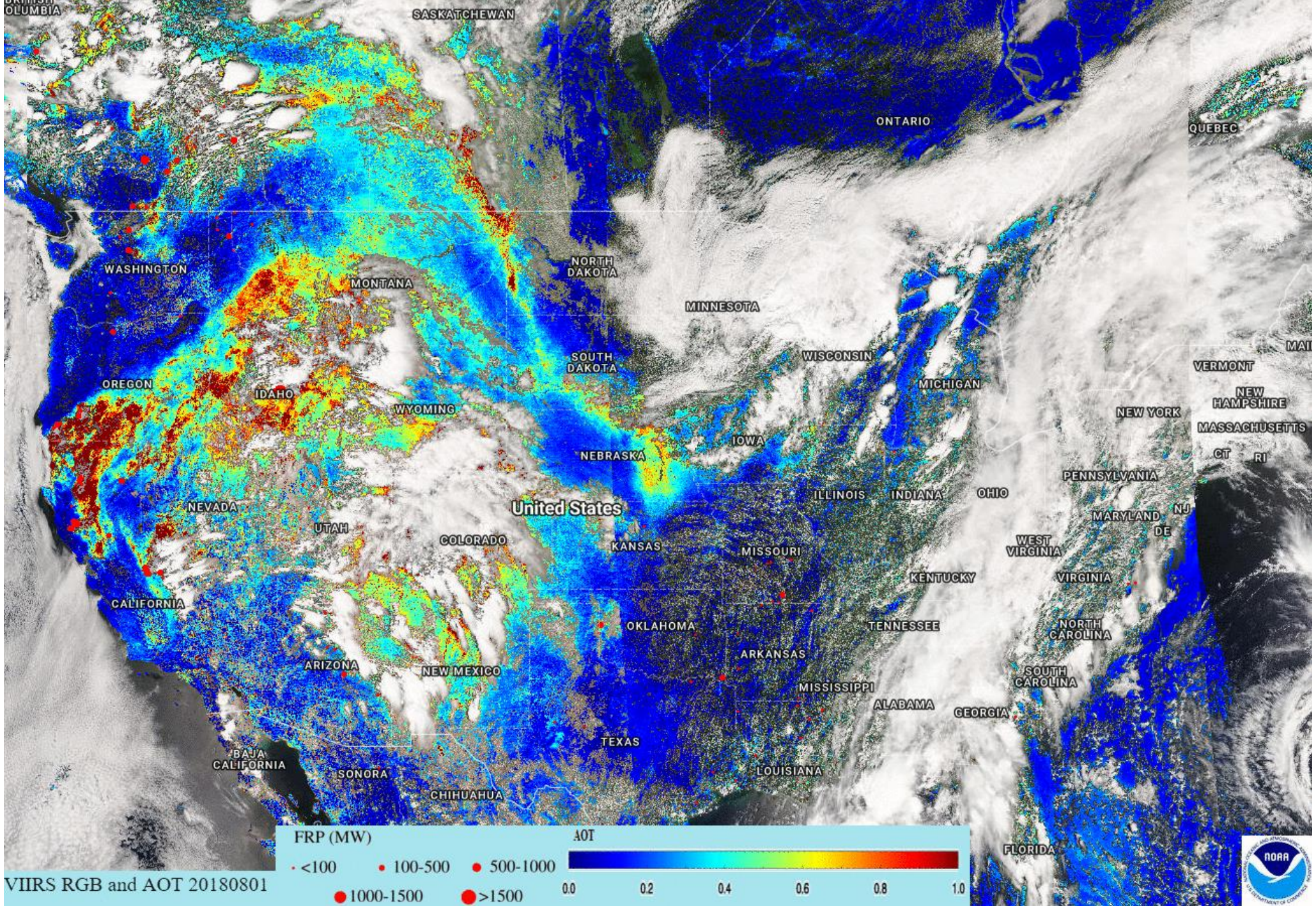
Types of Fires

Trends in Fire Activity





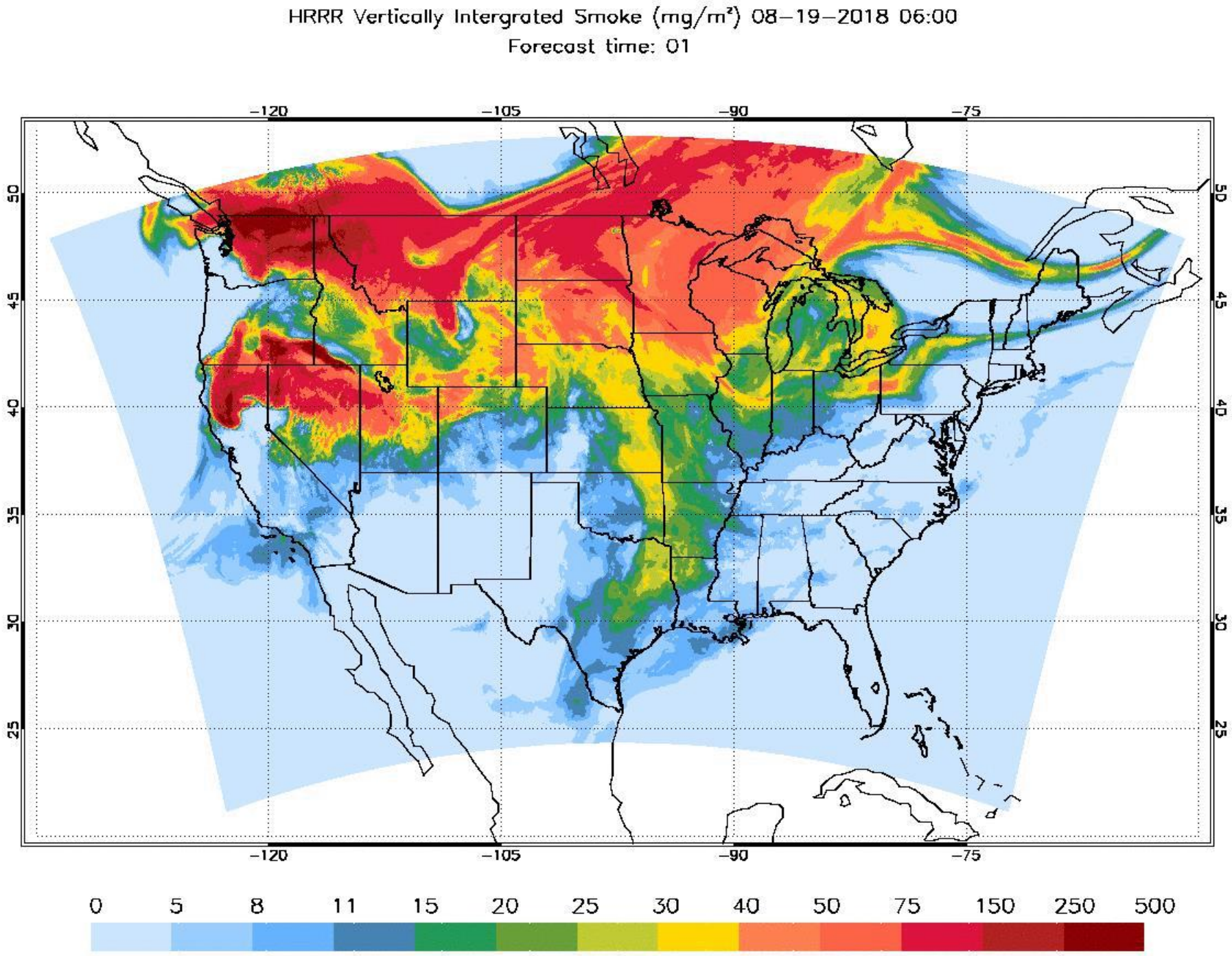
Zhang, X., Kondragunta, S., and Roy, D.P., 2014. Interannual variation in biomass burning and fire seasonality derived from geostationary satellite data across the contiguous United States from 1995 to 2011. *Journal of Geophysical Research-Biogeosciences*, http://dx.doi.org/10.1002/2013JG002518.


SASKATCHEWAN
ONTARIO
QUEBEC
WASHINGTON
MONTANA
NORTH DAKOTA
MINNESOTA
SOUTH DAKOTA
WISCONSIN
MICHIGAN
OREGON
IDAHO
WYOMING
NEW YORK
VERMONT
NEW HAMPSHIRE
MASSACHUSETTS
CT
RI
IOWA
NEBRASKA
PENNSYLVANIA
ILLINOIS
INDIANA
OHIO
NEVADA
United States
UTAH
MARYLAND
NJ
DE
COLORADO
KANSAS
MISSOURI
WEST VIRGINIA
KENTUCKY
VIRGINIA
CALIFORNIA
OKLAHOMA
TENNESSEE
NORTH CAROLINA
ARKANSAS
ARIZONA
NEW MEXICO
SOUTH CAROLINA
MISSISSIPPI
ALABAMA
GEORGIA
TEXAS
BAJA CALIFORNIA
SONORA
LOUISIANA
CHIHUAHUA
FLORIDA
FRP (MW)
<100
100-500
500-1000
1000-1500
>1500
AOT
0.0
0.2
0.4
0.6
0.8
1.0
VIIRS RGB and AOT 20180801

Air Quality Predictions

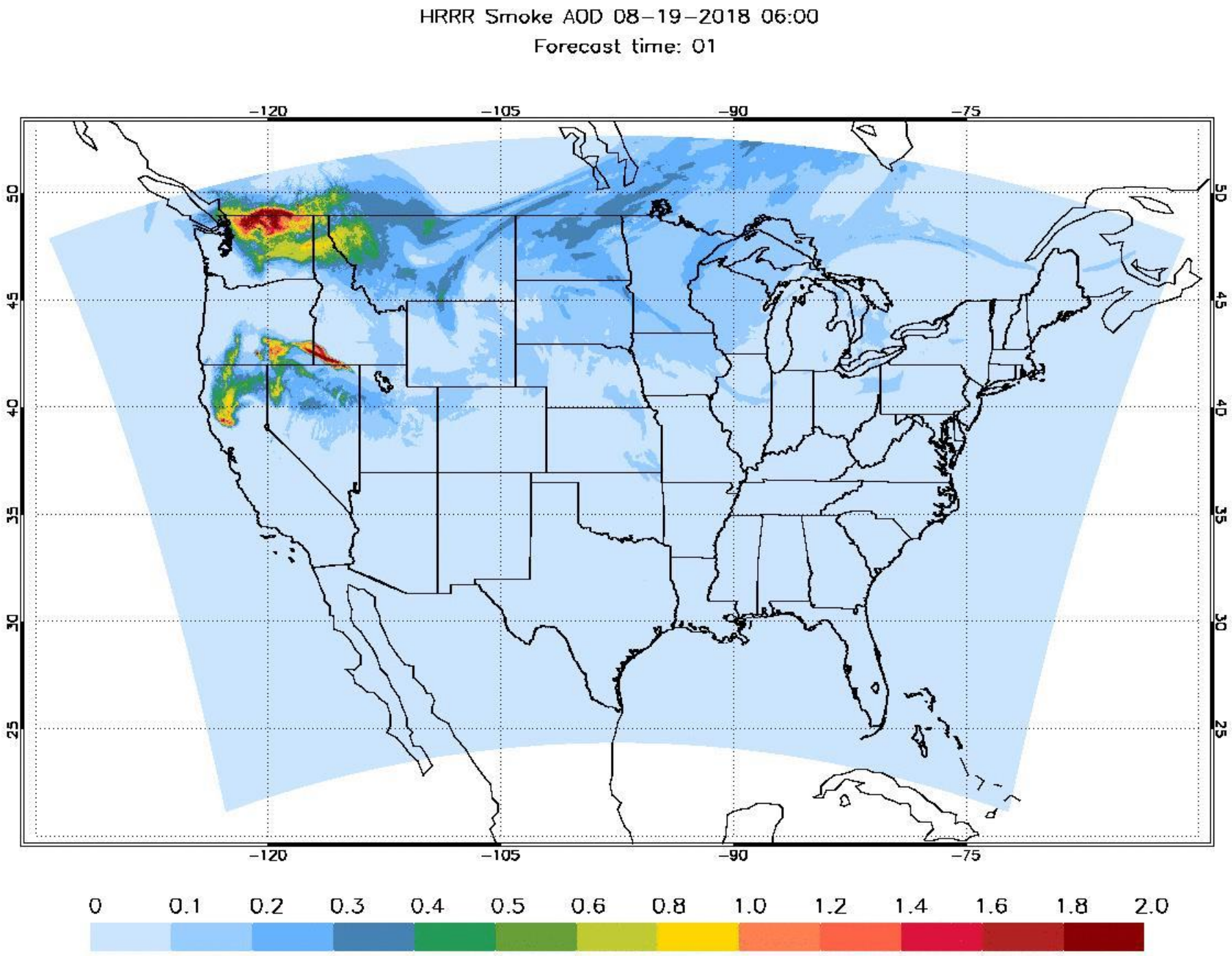
- Numerical models that predict air quality (ozone and PM2.5) need to know where the fires are located, how high is the aerosol loading being emitted, at what height is the plume injection, and the duration of the fire.
- Near real time information from satellites that models need
  - Fire location - ***yes***
  - Fire Radiative Power (a proxy to calculate emissions) - ***yes***
  - Fire duration (if satellite is in geostationary orbit) - ***yes***
  - Plume injection – ***no***
  - Aerosol composition - ***no***

High Resolution Rapid Refresh (HRRR-Smoke) Model



$$AOD = n_c \times \beta$$

n_c is column concentration (mg/m^2); β is mass extinction efficiency (m^2/g)



Evaluation of HRRR-Smoke using VIIRS AOD

Caveats – VIIRS AOD

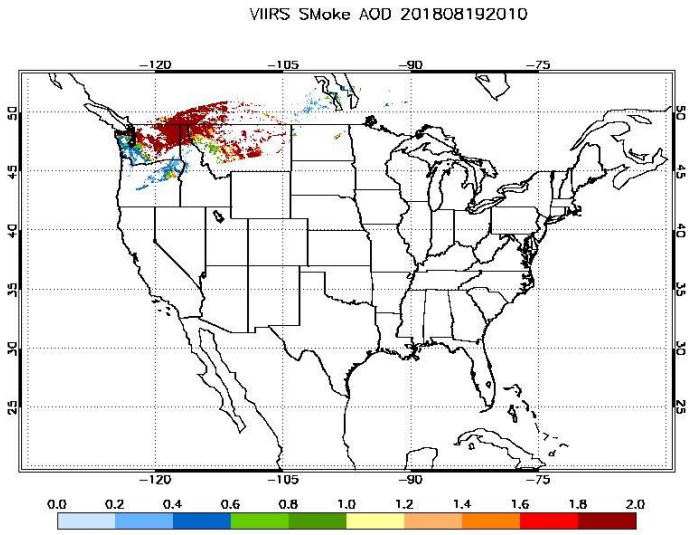
- VIIRS AOD has gaps
  - Clouds
  - Very thick smoke
    - Cloud mask calls smoke confidently cloudy
    - AODs are out of range (> 5.0)
- VIIRS smoke mask is qualitative indicator of smoke and only 80% accurate

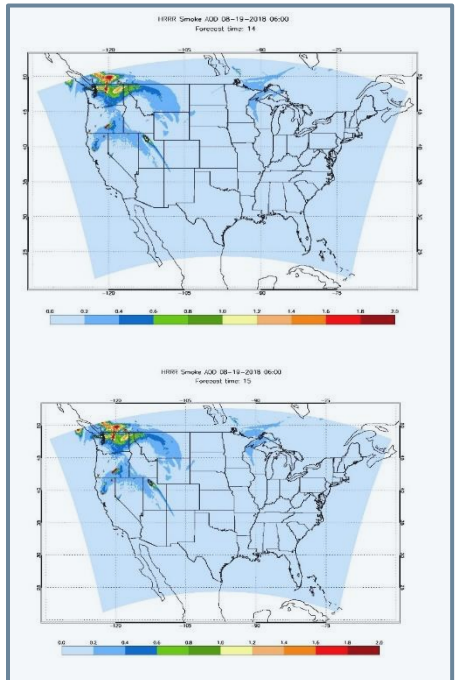
Caveats – HRRR Smoke

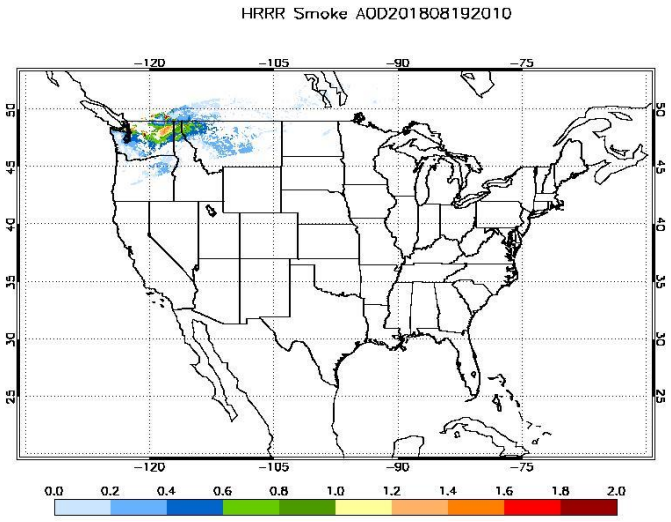
- Simple scaling of particle concentration to AOD
- No secondary aerosol formation
- No hygroscopic particle growth

Match-Up Criteria

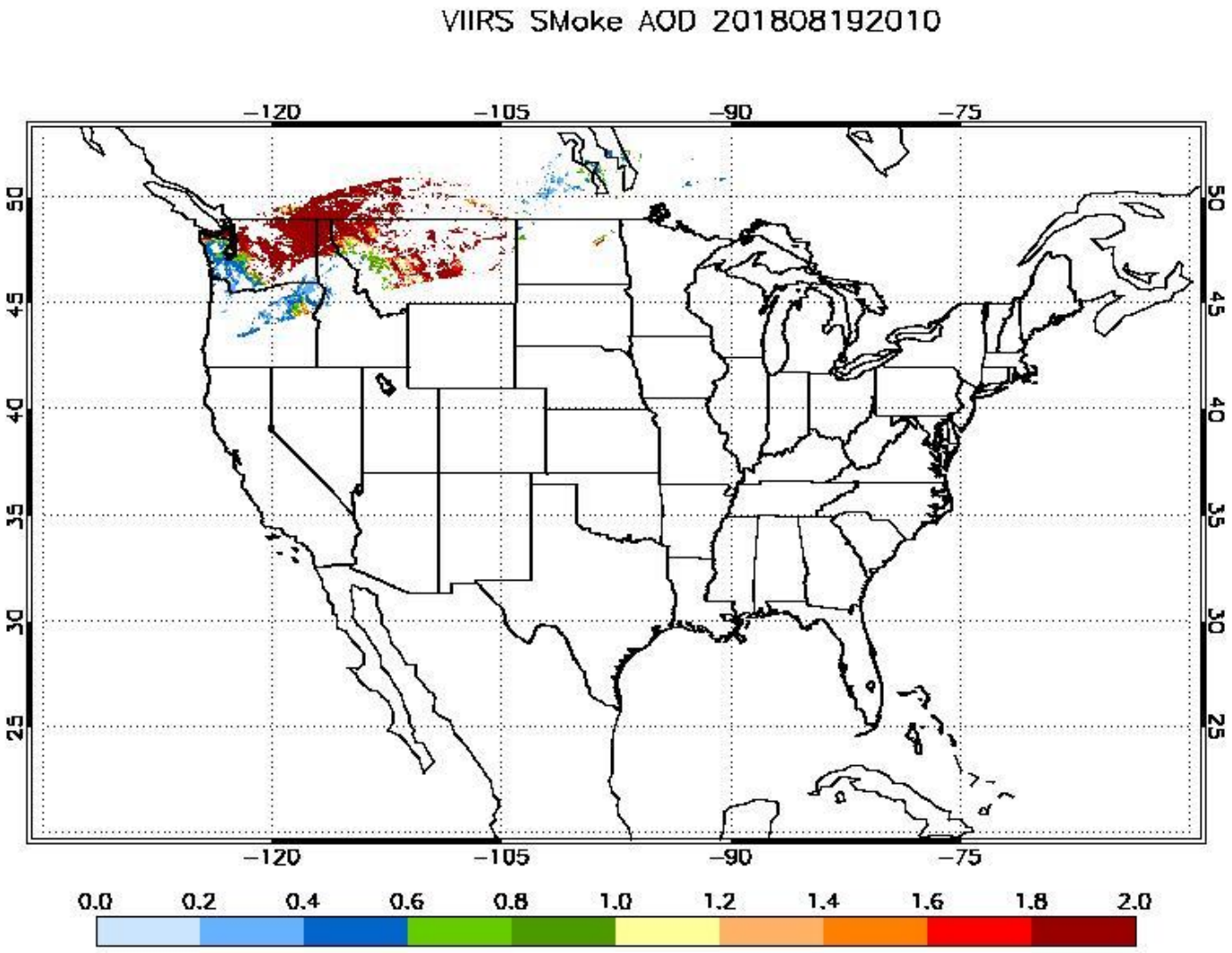
- VIIRS AOD pixels in a granule with co-existing VIIRS smoke mask are retained as “smoke AOD”
- VIIRS smoke AOD re-mapped to 0.05° x 0.05°
- HRRR smoke AOD re-mapped to 0.05° x 0.05°
- Each VIIRS granule matched to HRRR-Smoke ±30 minutes of VIIRS overpass time



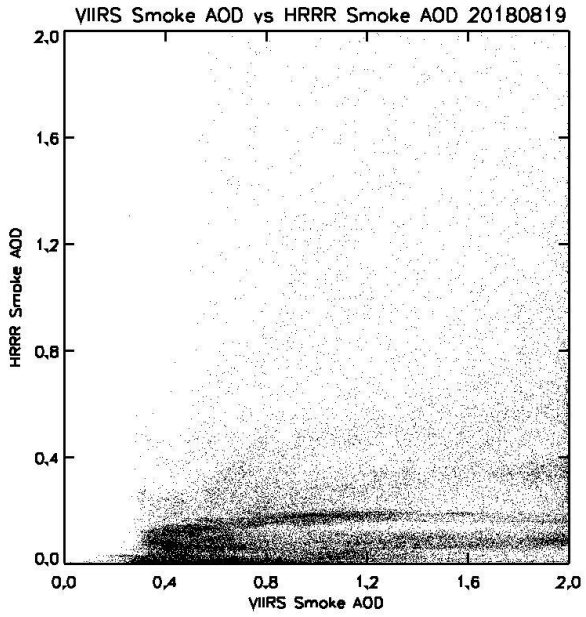


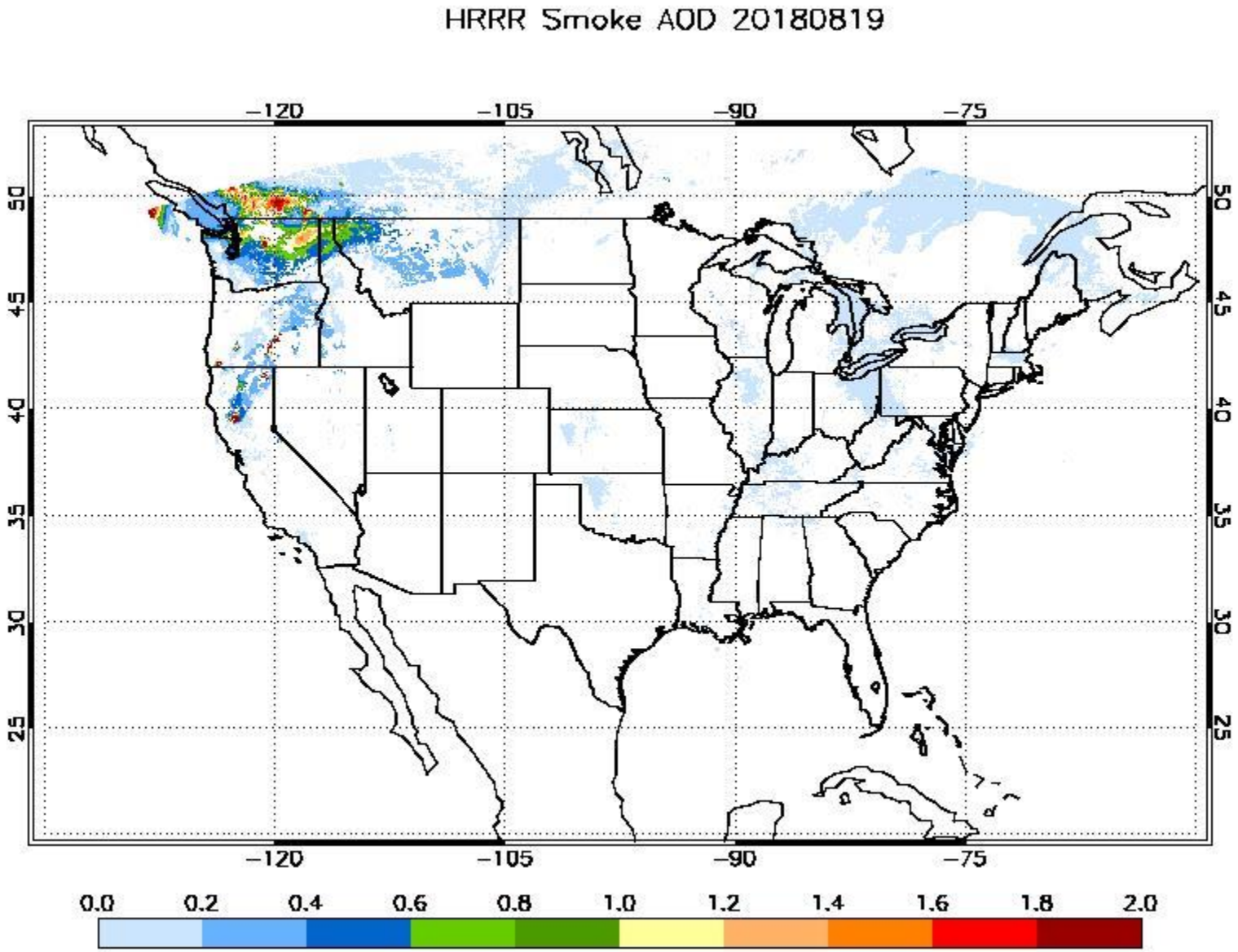


Match-Up Criteria



HRRR-Smoke vs. VIIRS Smoke AOD



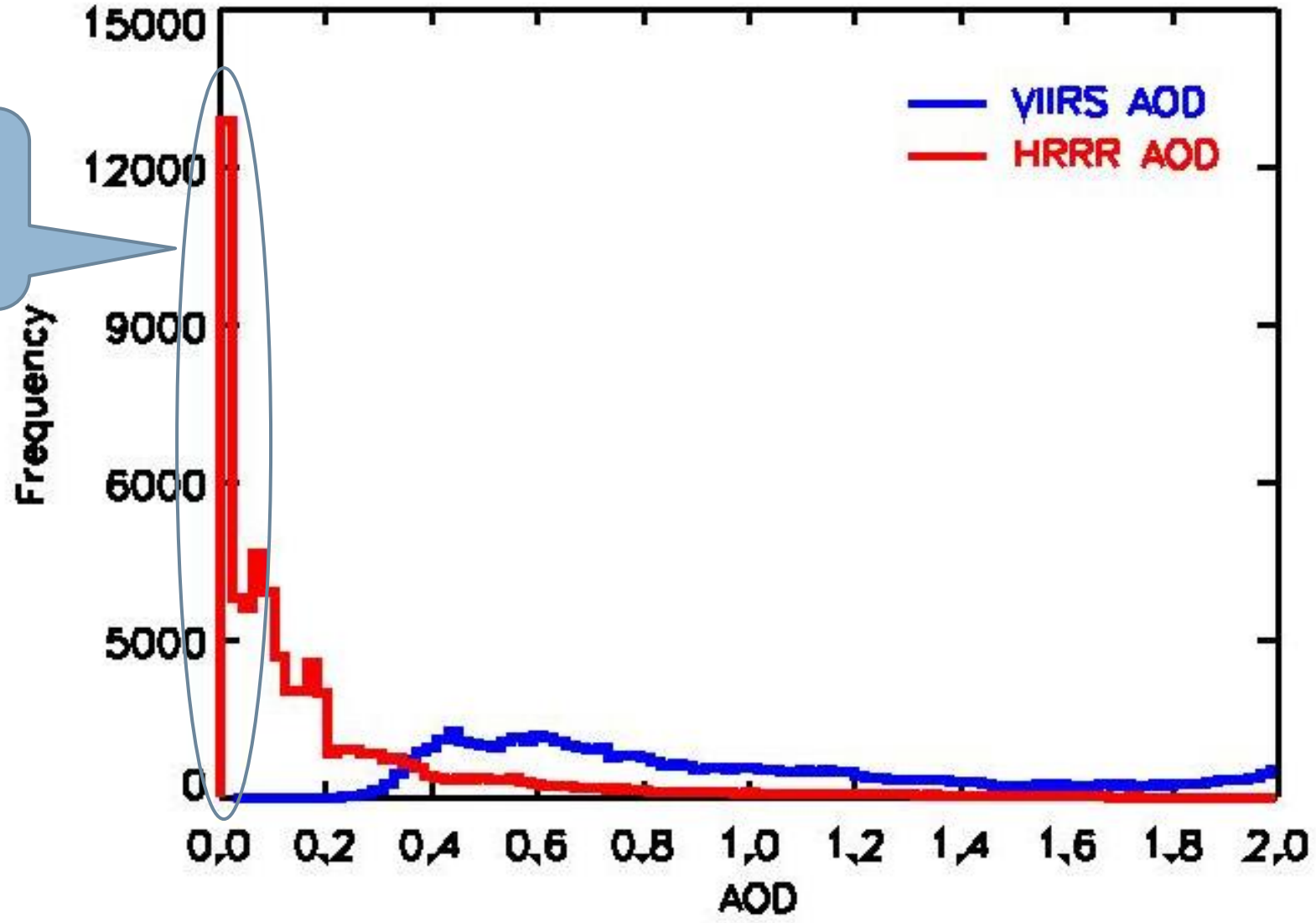


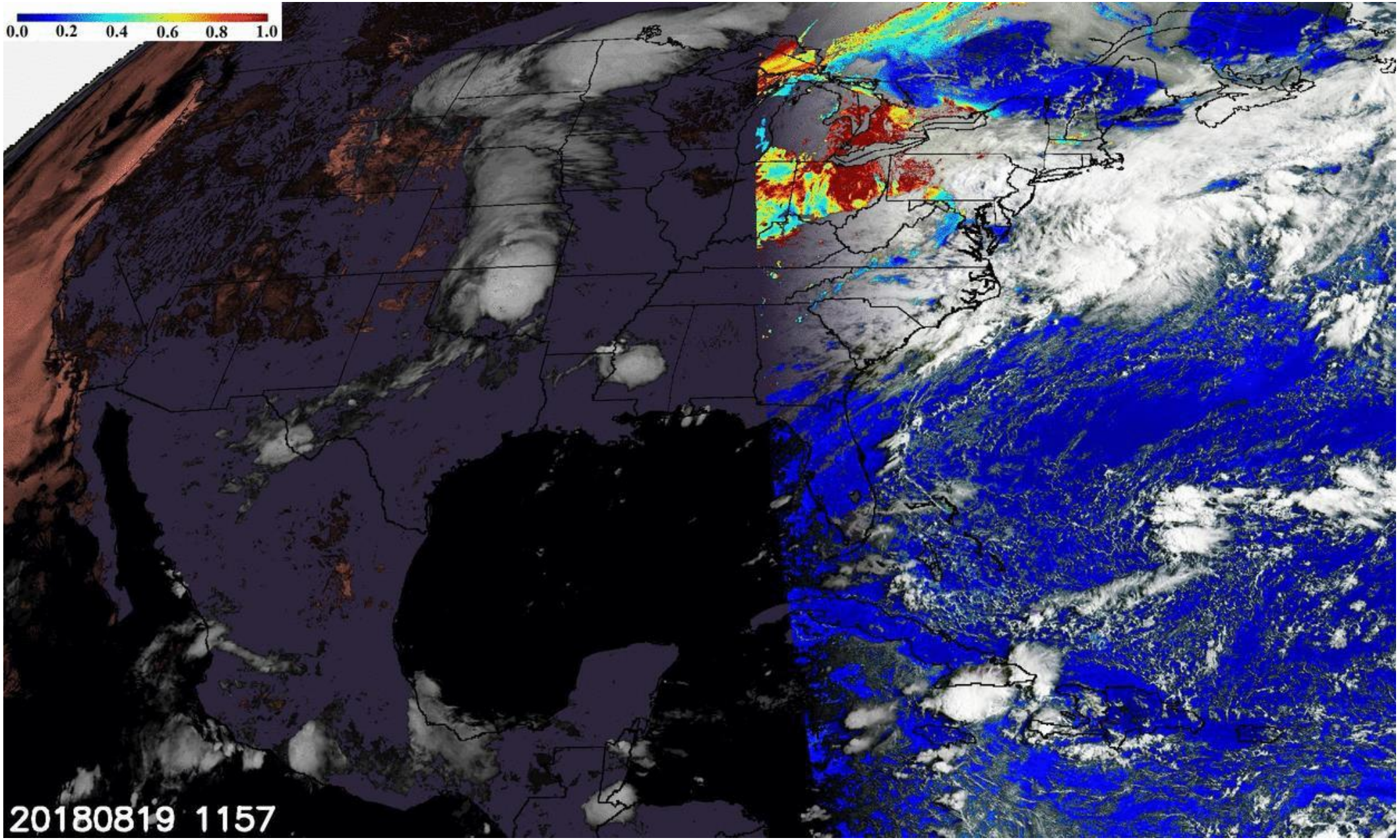
Likely source of bias:

- Transported smoke
- Fire emissions
- Matchup method

HRRR-Smoke vs. VIIRS Smoke AOD

Model background AOD




0.0 0.2 0.4 0.6 0.8 1.0
20180819 1157

Summary

- Analyzed one week of data but presented only one day of comparisons
- HRRR-Smoke model spatial patterns of smoke agree well with VIIRS observations matched up in space and time;
  - For qualitative applications such as informing field forecasters, IMETs et al. about locations of smoke, the model is performing very well.
- HRRR-Smoke model column aerosol concentrations are under-predicted and therefore AOD. HRRR-Smoke surface PM2.5 concentrations are likely correct
- The entire month of August data will be analyzed and stratified statistics will be generated to understand model performance for smoke events with smoke generated locally vs. transported smoke from Canada into the US domain;
- GOES-16 ABI AOD shows that smoke plume spatial patterns change rapidly
- Better matchups with GOES-16 ABI AOD expected to improve the matchups and results

Rapid Refresh and High-Resolution Rapid Refresh with Smoke (RAP/HRRR-Smoke experimental forecast models)

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Acknowledgement: E. James[1,2], G. Grell[2], C. Alexander[2], S.Benjamin[2], B.Jamison[1,2], M. Pagowski[1,2], J. Hamilton[1,2], S. Albers[7,2], J. Stewart[7,2], S. Freitas[3], G. Pereira[4], I. Csiszar[5], M. Tsidulko[8], W.Straka[6], B. Pierce[6], S. McKeen[1,2], S.Kondragunta[5], A. Edman[9], M. Goldberg[10], B. Sjoberg[10]

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[3] NASA Goddard Space Flight Center & USRA/GESTAR, Greenbelt, MD, USA

[4] Federal University of São João del-Rei, MG, Brazil

[5] Center for Satellite Applications and Research, NOAA/NESDIS, College Park, MD, USA,

[6] Advanced Satellite Products Branch, Center for Satellite Applications and Research, NOAA/NESDIS, Madison, WI, USA

[7] Cooperative Institute for Research in the Atmosphere, MD, USA

[8] I.M. Systems Group, Inc, Rockville, MD, USA

[9] National Weather Service, NOAA, USA

[10] NOAA's Joint Polar Satellite System Program Office

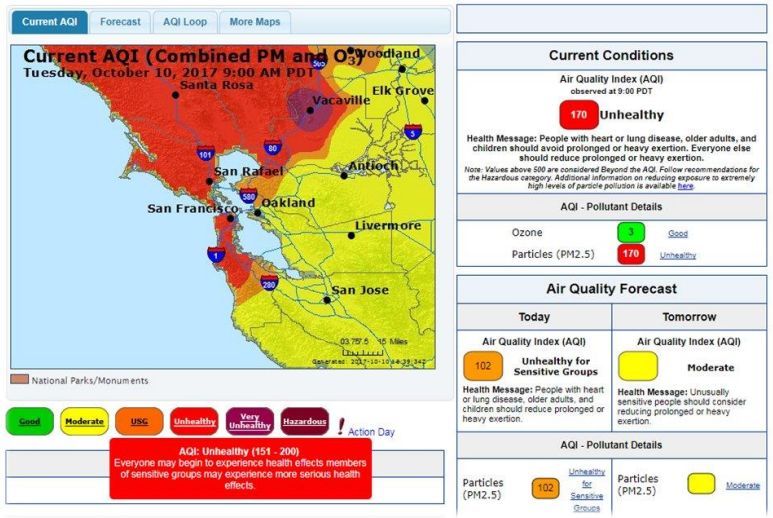
JPSS proving ground and risk reduction program

Western Region office, NWS

STAR JPSS annual conference
August 28, 2018

Smoke from wine country fires leads to 200 canceled flights, hazardous air quality.

Smoke and haze from wildfires hovers over the skyline Thursday, Oct. 12, 2017, in San Francisco. Gusting winds and dry air forecast for Thursday could drive the next wave of devastating wildfires. (Eric Risberg / Associated Press)



There is a high demand for high-resolution smoke forecasts over the US for different applications:

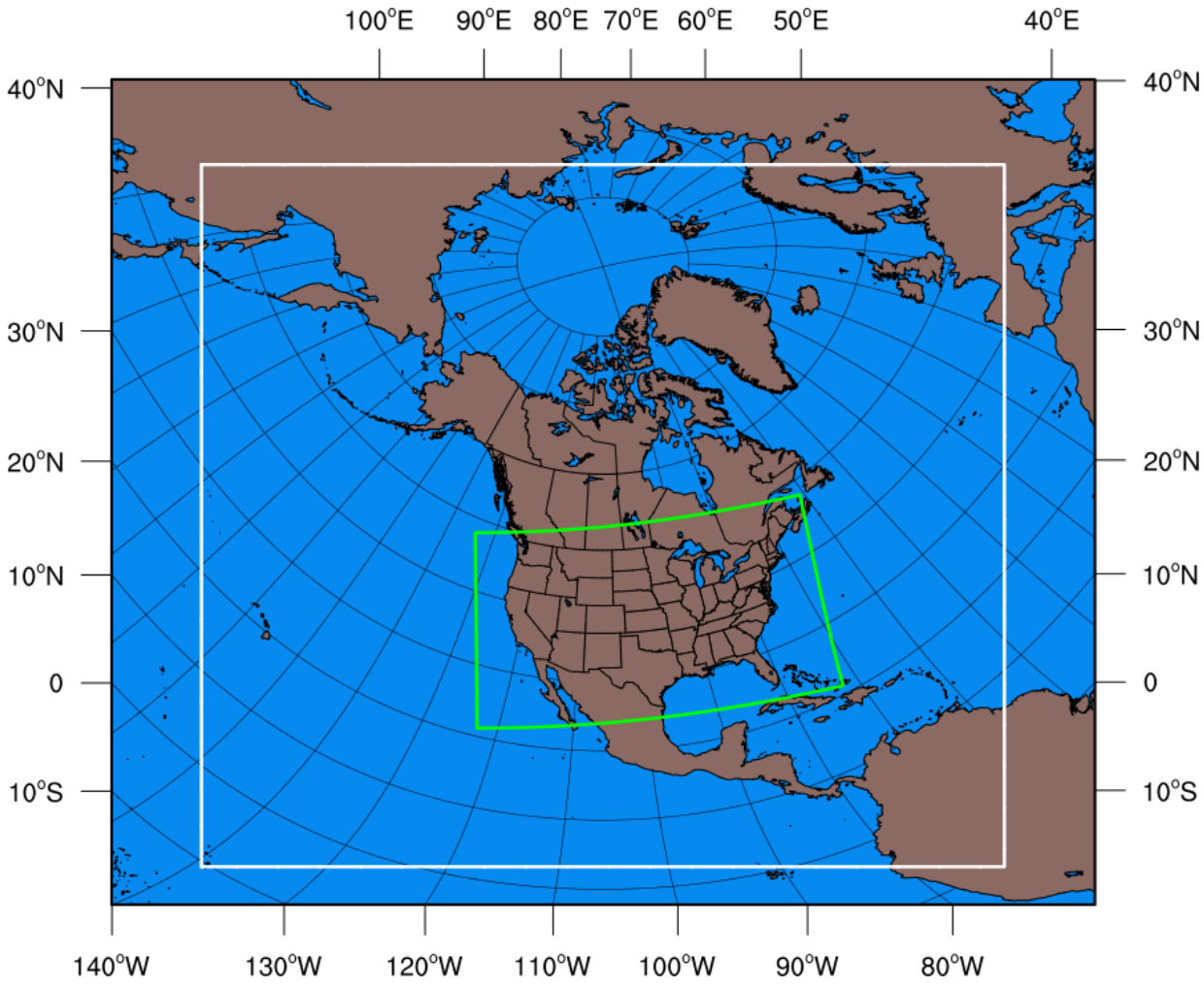
- **Air quality forecasting**
- **Visibility (transportation, aviation…)**
- **Smoke impact on meteorology to improve weather forecasting**

Fatal accident caused by a fire smoke Interstate 40 in Arizona, October, 2016

HRRR-Smoke model

The main strengths of the HRRR-Smoke modeling system:

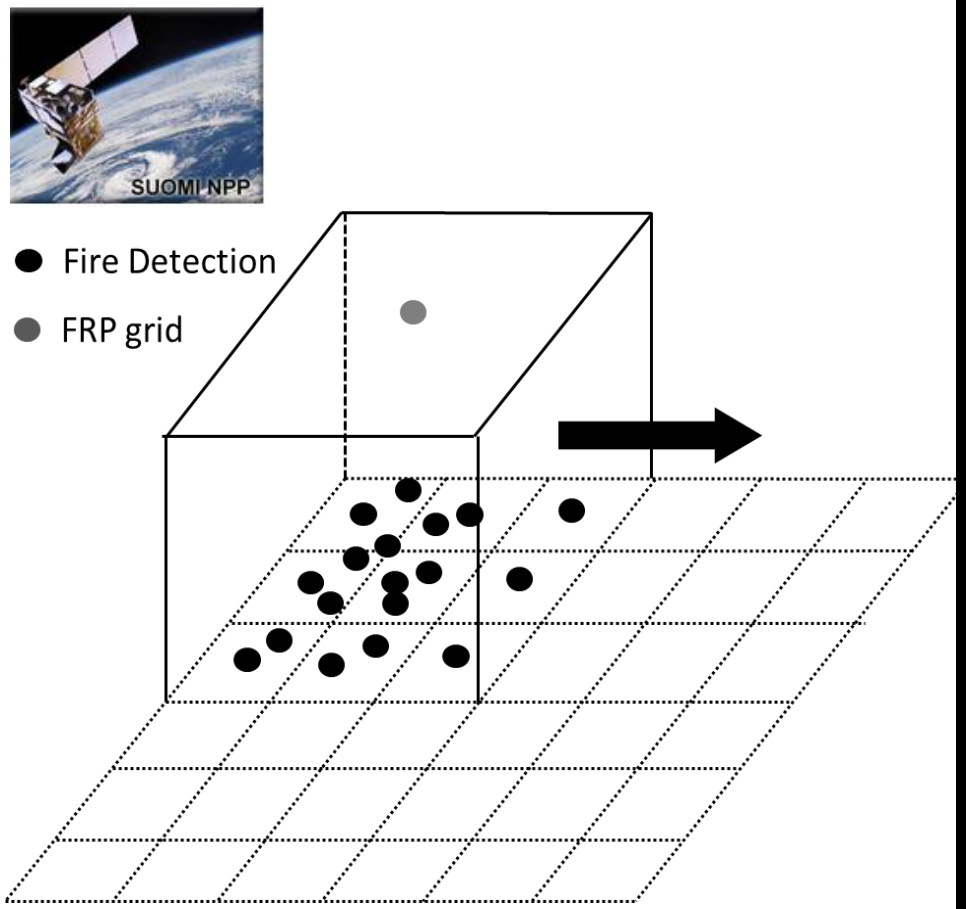
- First, we take advantage of the existing NWP systems by adding a **single tracer (smoke)** to GSD's HRRR model.
- It is a 3D model running on high spatial resolution (3km) to allow simulation of mesoscale flows and smoke dispersion over complex terrain.
- Full coupling between meteorology and smoke: feedback of smoke on predicted radiation, cloudiness, and precipitation.
- Biomass burning emissions and inline plume rise parameterization based on the satellite FRP data.
- A rapidly updating data assimilation cycle for meteorology;
- HRRR-Smoke uses meteorological input data prepared by the GSI data assimilation system and boundary conditions from Rapid Refresh (RAP).
- *Currently* the forecast lead time is 36 hours. Four times a day (00, 06, 12 and 18UTC) a new forecast starts. We plan to simulate smoke within HRRRX with hourly refresh cycle.



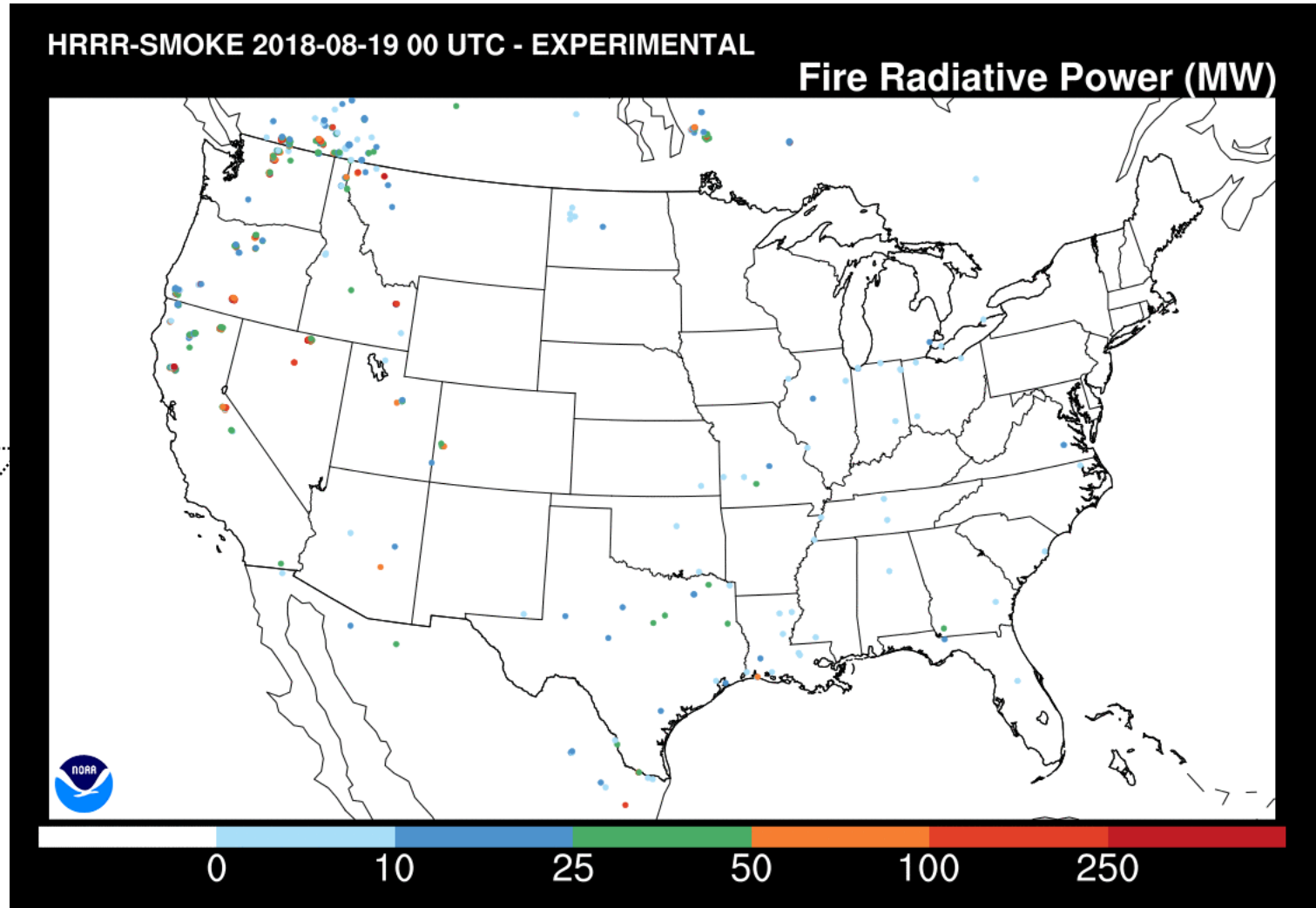
Operational weather forecast models at NWS:
RAP (white), 13km resolution
HRRR model domains (green), **3km** resolution
(https://rapidrefresh.noaa.gov/)

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.

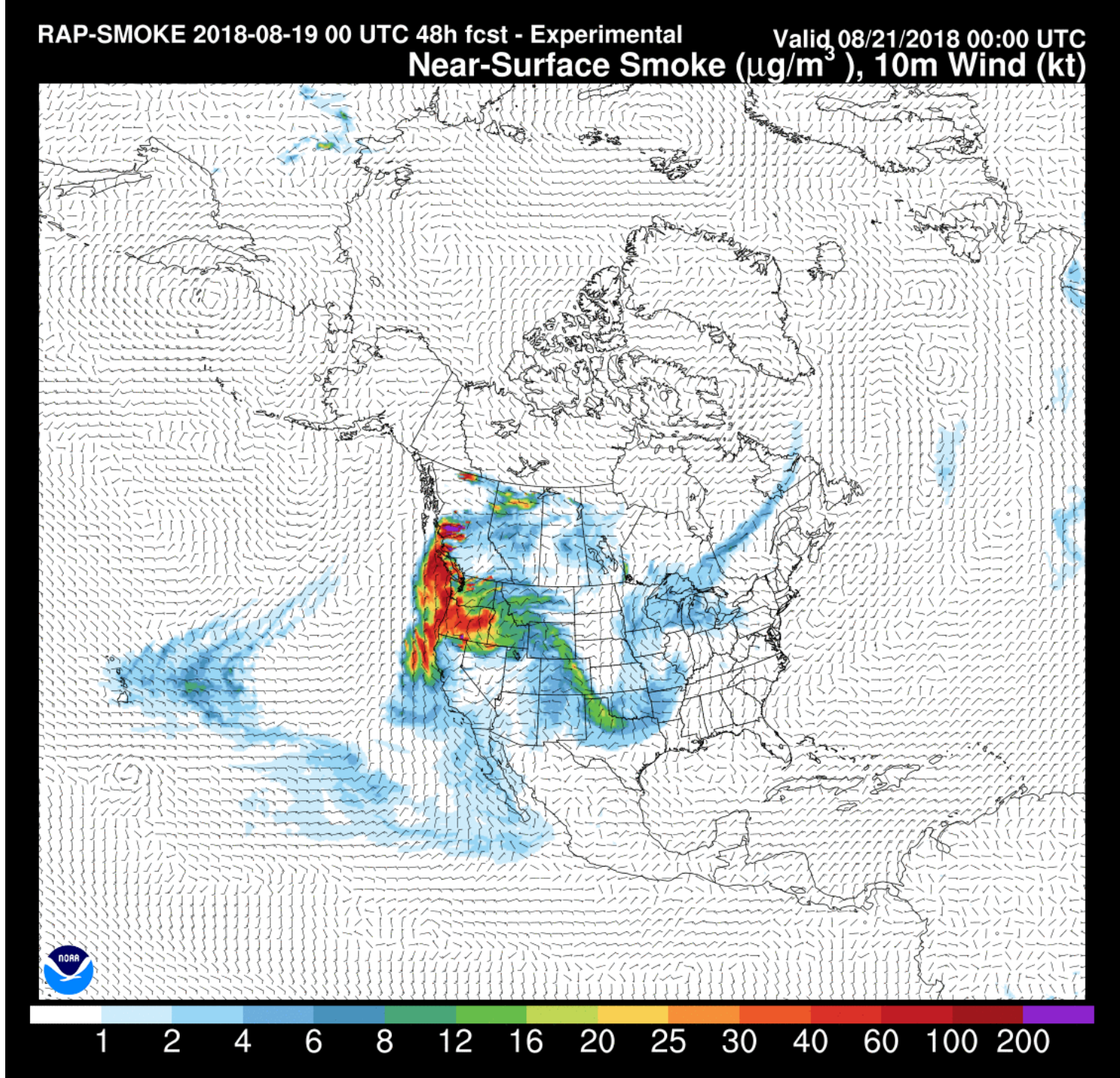


Averaged satellite FRP data mapped over 3x3km HRRR CONUS grid pixels for August 19, 2018



Experimental RAP-Smoke (13.5 km resolution) model development

- Covers the entire North America
- Taking advantage of the global satellite data from VIIRS and MODIS
- Feeds boundary conditions for smoke to the HRRR-Smoke over the CONUS domain
- Enables capturing smoke transport from Canada and Mexico to the CONUS domain
- Forecast lead time is **48** hours. A new forecast starts every 6 hours.
- The experimental smoke forecast products are displayed: https://rapidrefresh.noaa.gov/RAPsmoke/



The real-time HRRR-Smoke web-site for public access (rapidrefresh.noaa.gov/hrrr/HRRRsmoke/)

HRRR-Smoke Model Fields - Experimental

Model: HRRR-smoke (Experimental) Area: Full Date: 19 Aug 2018 - 00Z

***** Experimental forecast, use at your own risk *** - Quick Guide** **RAP-Smoke (North America domain, 13.5 km resolution)**

Visualization on Interactive Map

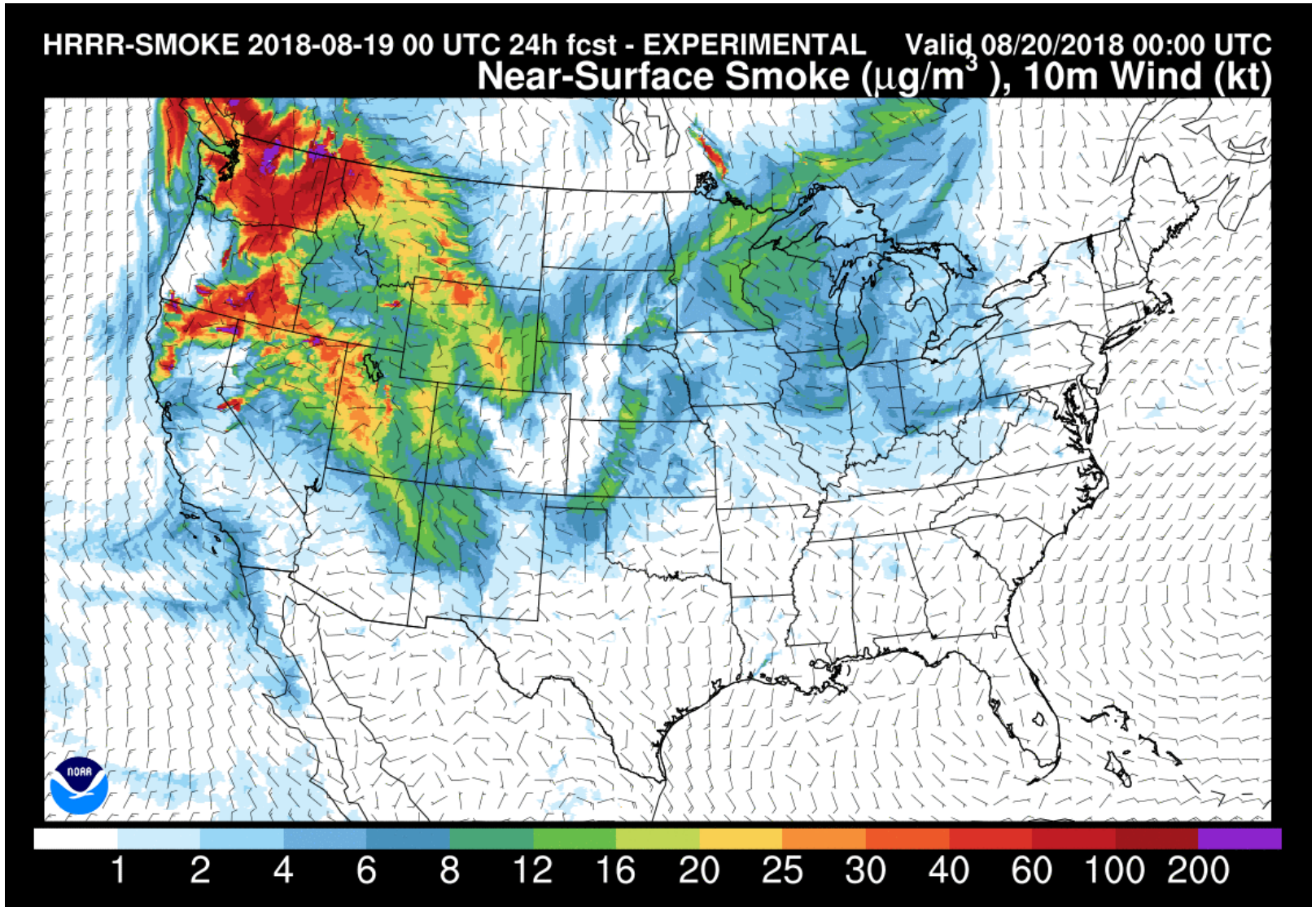
VIIRS Active fire quick guide

Model: HRRR-smoke (Experimental) **Domain:** Full **Date:** 19 Aug 2018 - 00Z

			Valid Time																																					
			Sun 00	Sun 01	Sun 02	Sun 03	Sun 04	Sun 05	Sun 06	Sun 07	Sun 08	Sun 09	Sun 10	Sun 11	Sun 12	Sun 13	Sun 14	Sun 15	Sun 16	Sun 17	Sun 18	Sun 19	Sun 20	Sun 21	Sun 22	Sun 23	Mon 00	Mon 01	Mon 02	Mon 03	Mon 04	Mon 05	Mon 06	Mon 07	Mon 08	Mon 09	Mon 10	Mon 11	Mon 12
	All times	Loop	Forecast																																					
			00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
all fields			00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
fire radiative power	✔	✔	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
near-surface smoke	✔	✔	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
1000 ft AGL smoke	✔	✔	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
6000 ft AGL smoke	✔	✔	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
vertically integrated smoke	✔	✔	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
10m wind	✔	✔	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
1h precip	✔	✔		01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
2m temperature	✔	✔	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
surface visibility	✔	✔	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	
cross section WE CAN SN1																																							

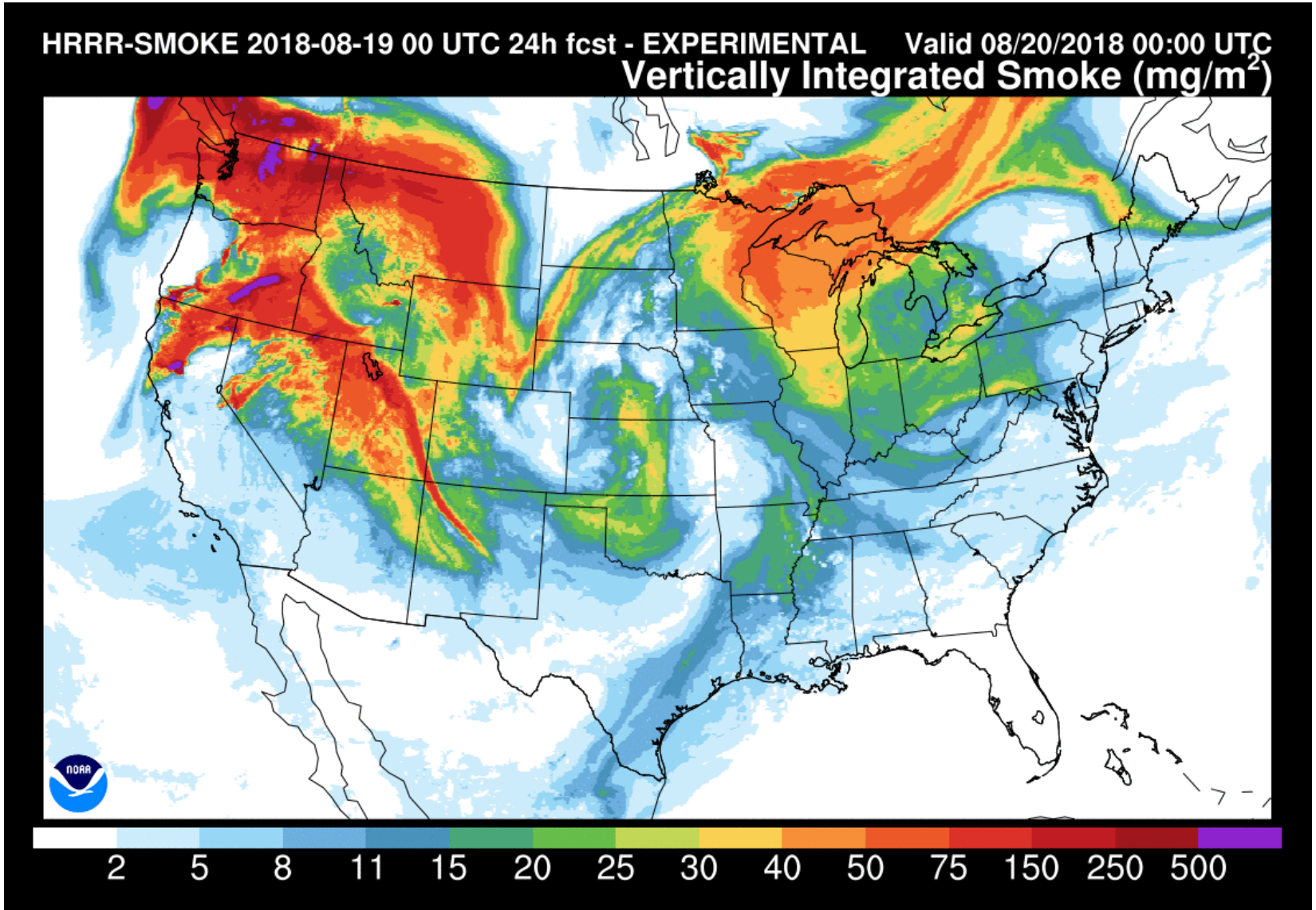
Experimental smoke forecast for August 19, 2018 (rapidrefresh.noaa.gov/hrrr/HRRRsmoke/)

This plot shows simulated fine particulate matter (PM2.5 or fire smoke) concentrations and wind at the first model level (~8m above ground). This is the experimental forecast of the near-surface fire smoke for August 19, 6pm EDT over the CONUS. This forecast is based on the model simulation of 24 hours from the model initialization time, which is 6pm EDT, August 18, 2018.

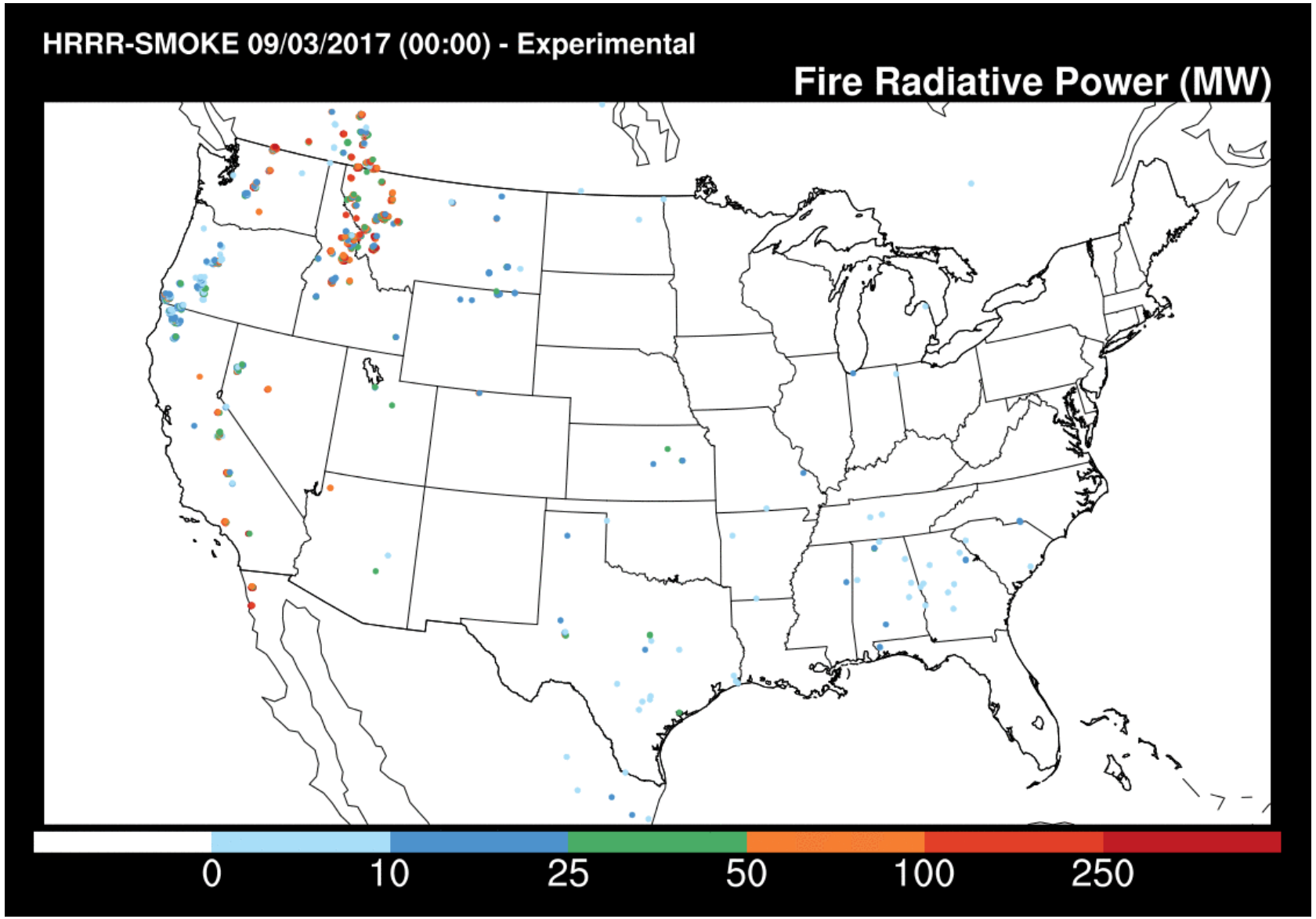


Experimental smoke forecast for August 19, 2018 (rapidrefresh.noaa.gov/hrrr/HRRRsmoke/)

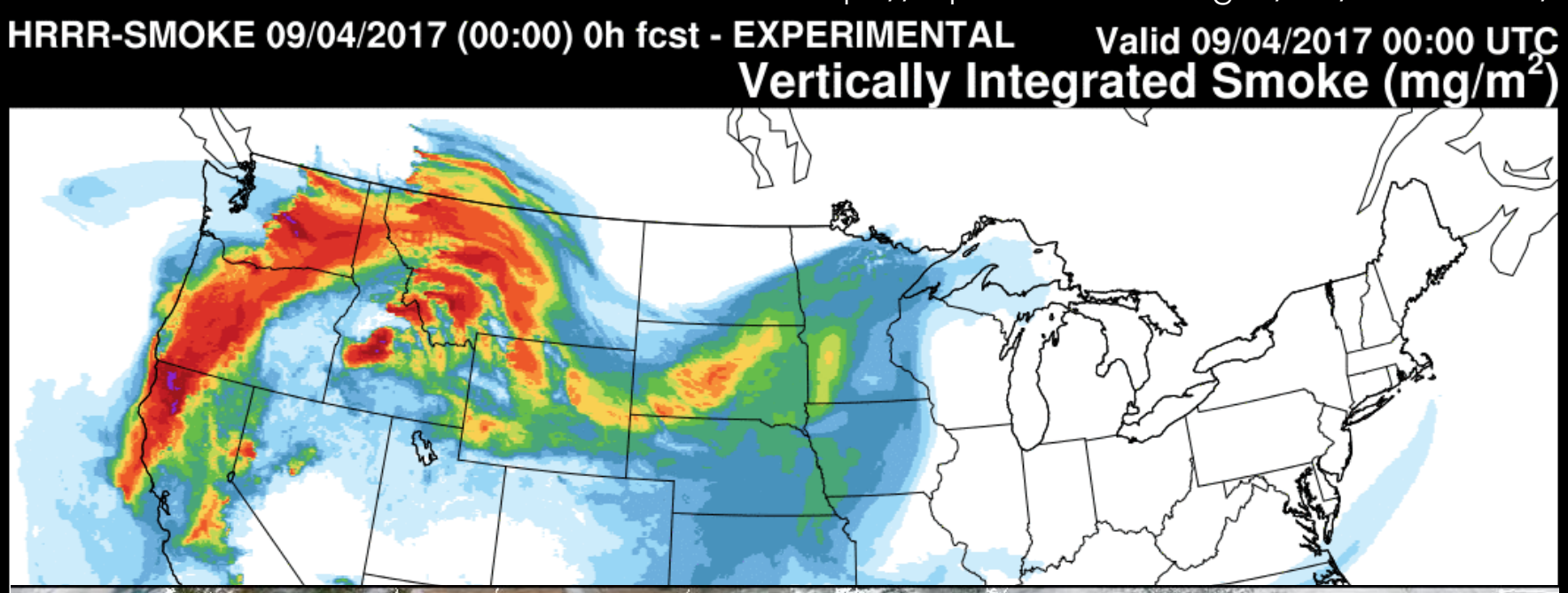
This plot shows simulated vertically integrated fire emitted fine particulate matter (PM2.5 or fire smoke) concentrations for the same forecast date/time as in previous slide.

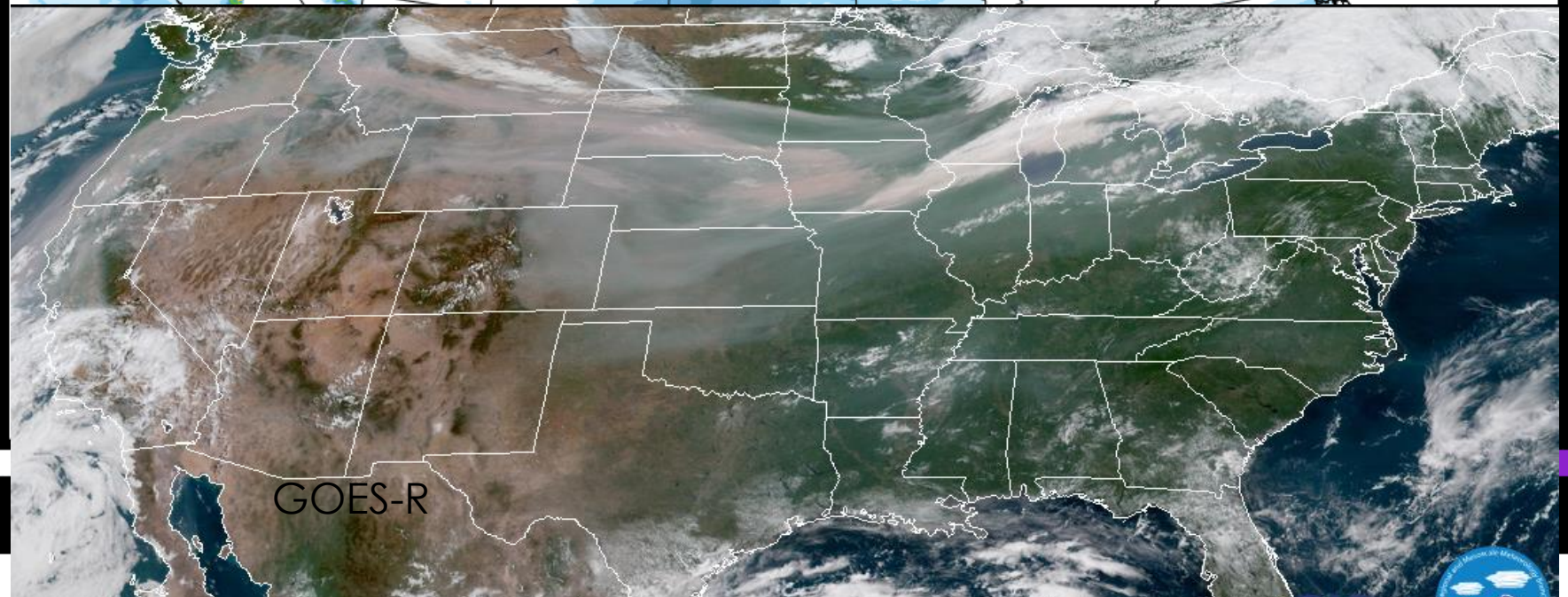


Numerous wildfires in the northwestern US last summer

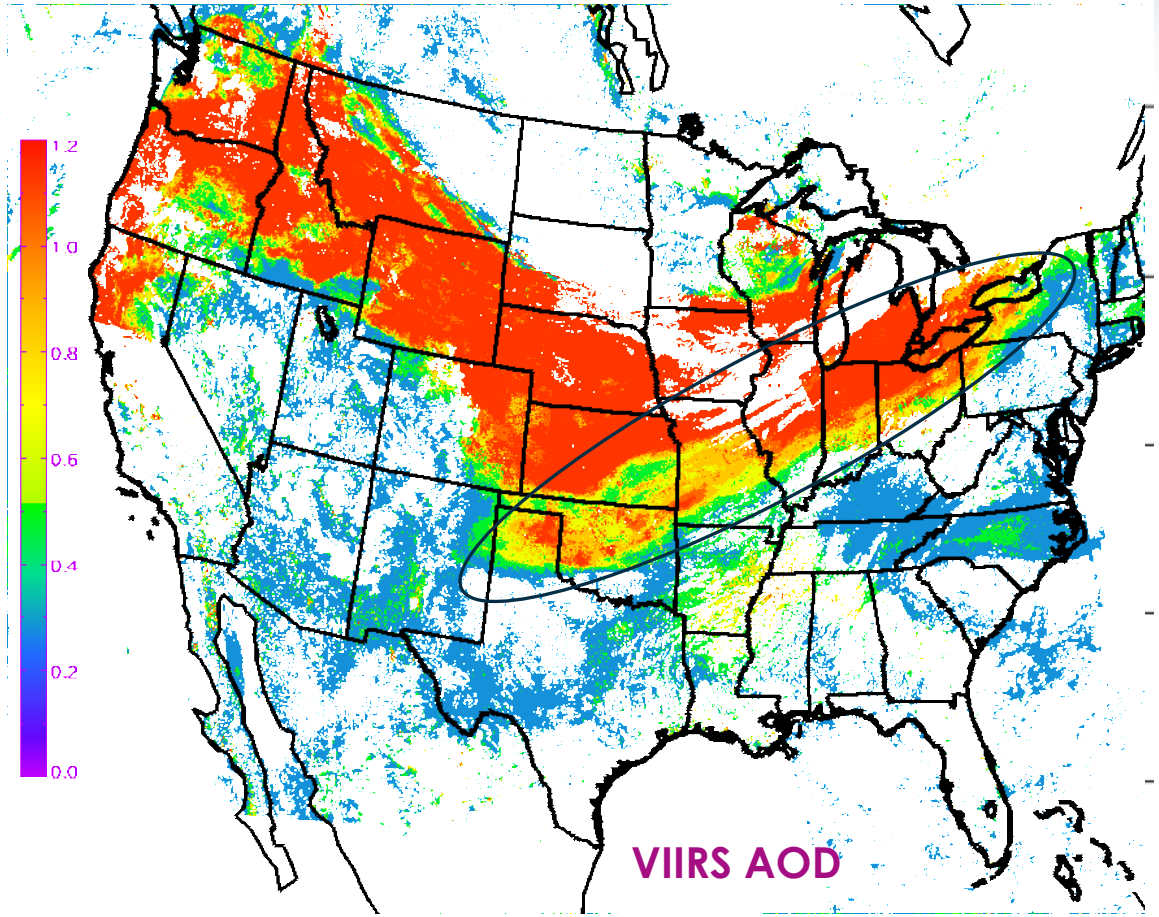


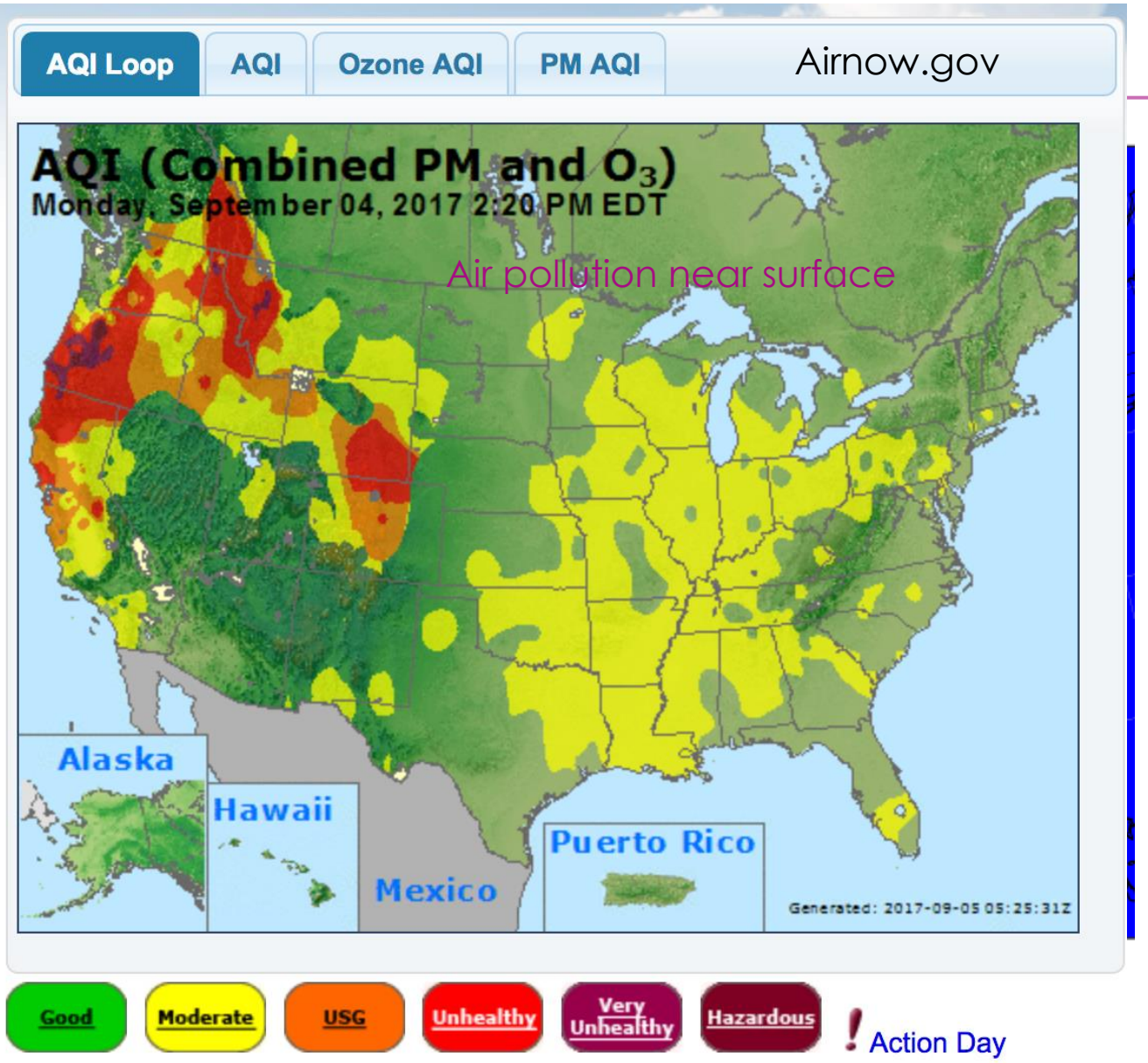
https://rapidrefresh.noaa.gov/hrrr/HRRRsmoke/





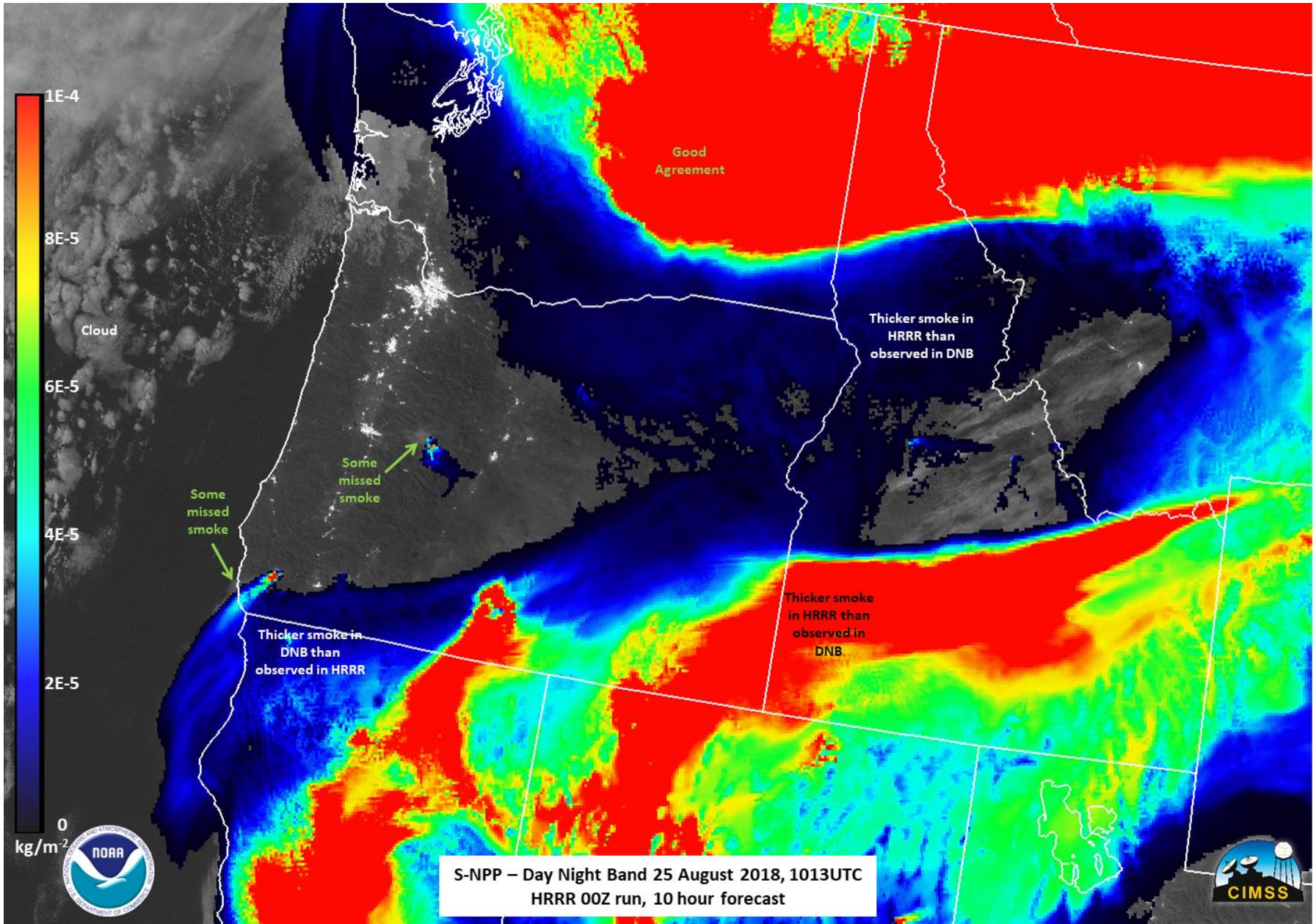
AOD from HRRR-Smoke



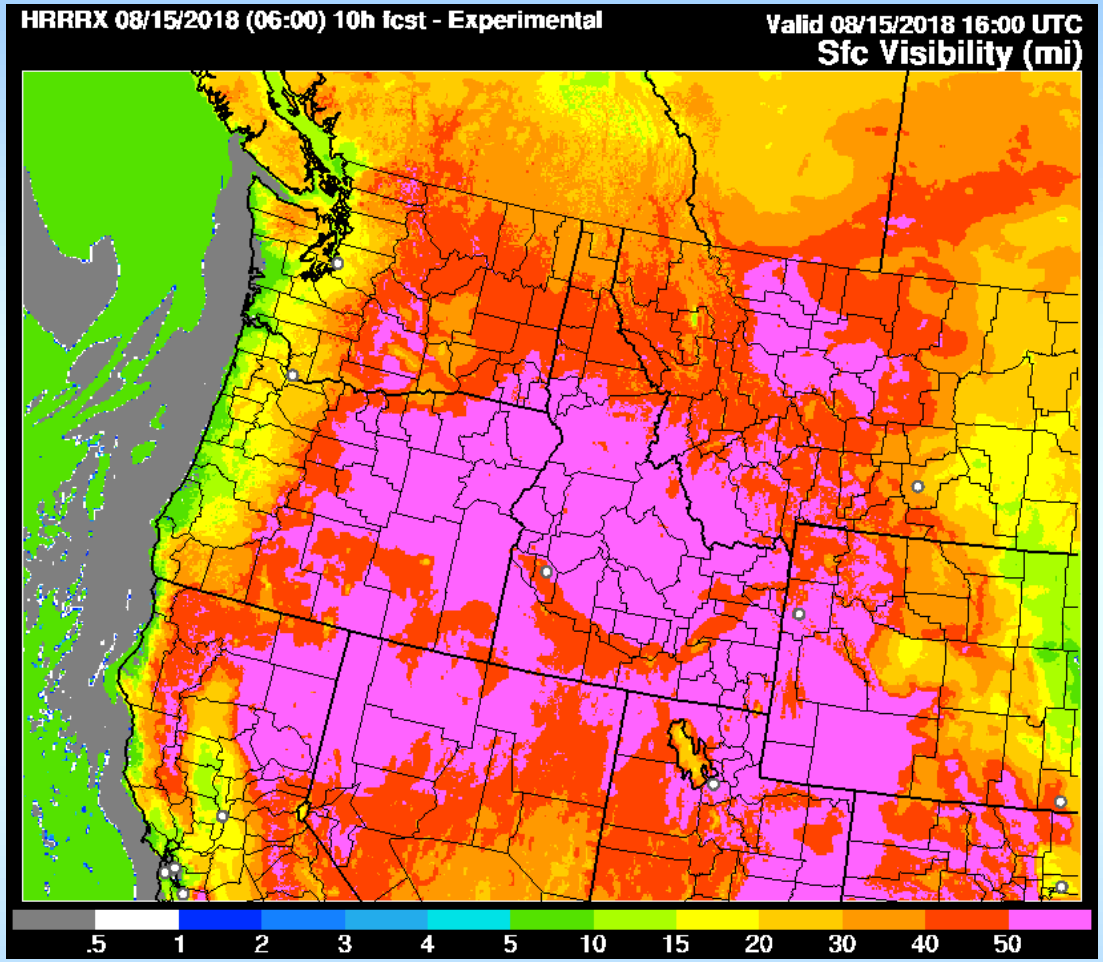


HRRR-Smoke does NOT assimilate the satellite AOD data.

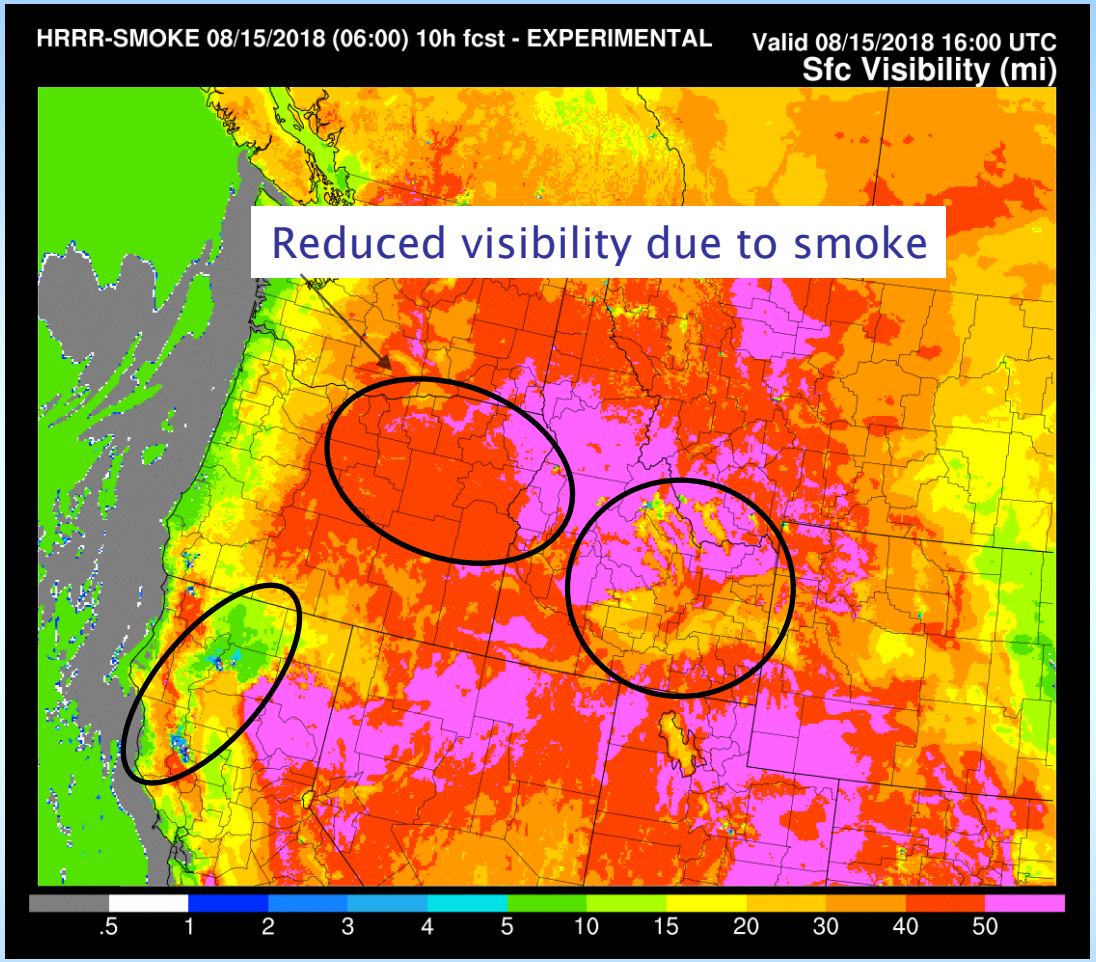
Qualitative verification of a recent HRRR-Smoke forecast using the S-NPP nighttime images



Experimental surface visibility forecasts



Experimental NWP system w/o smoke

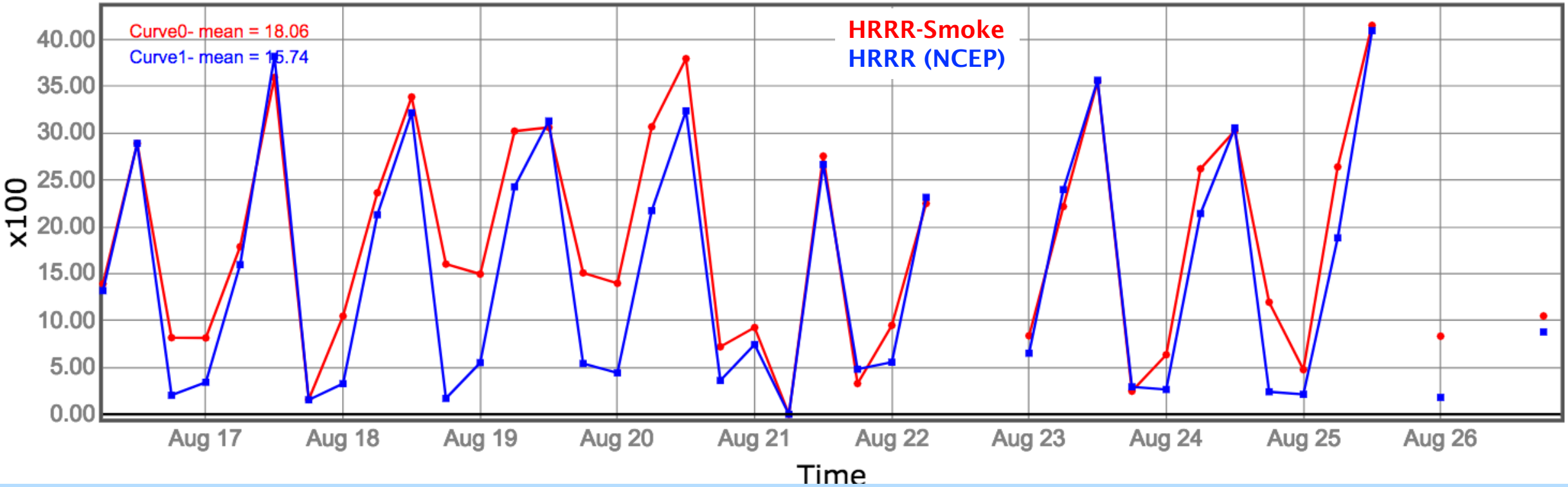


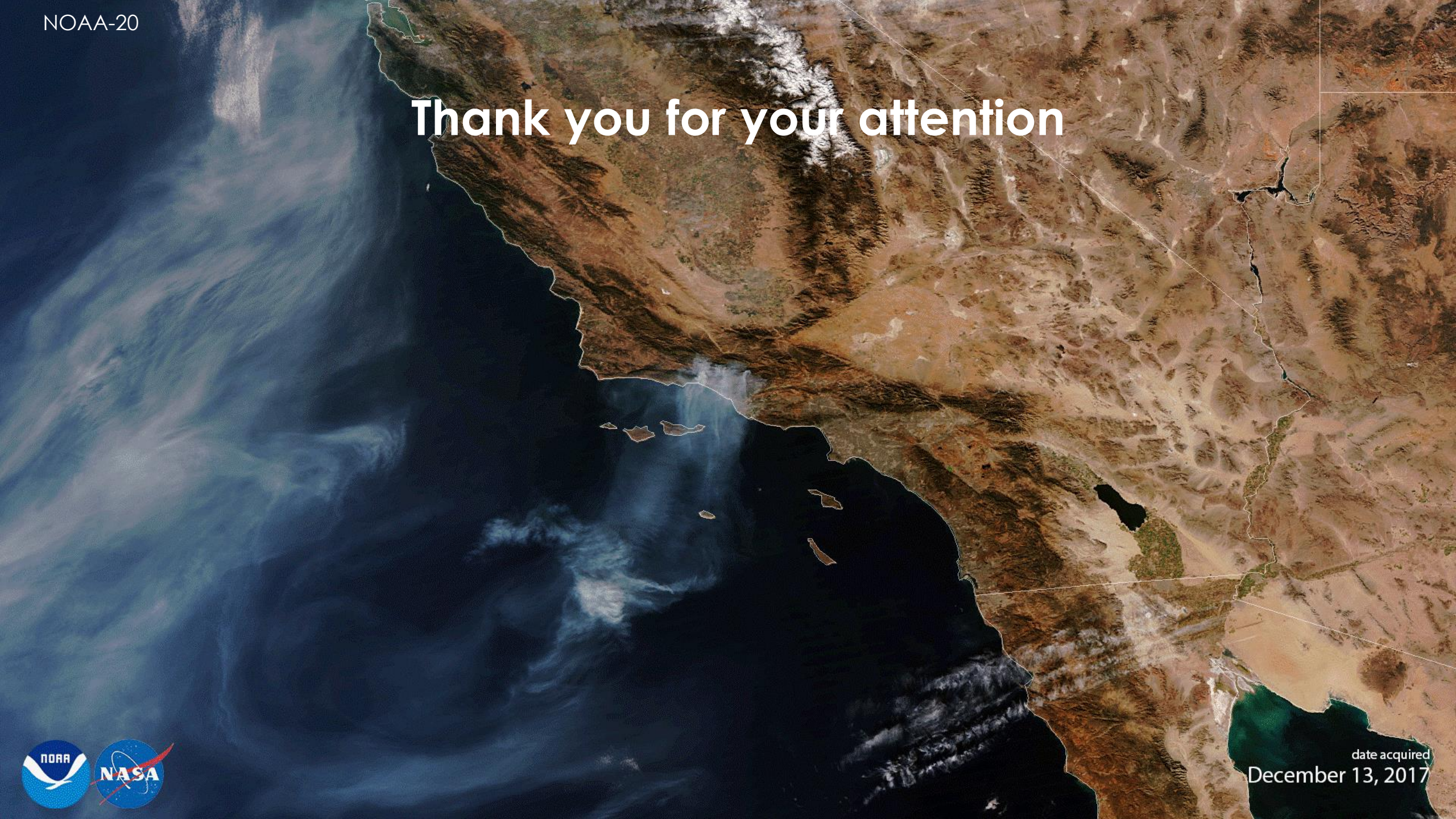
Experimental NWP system with smoke

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




NOAA-20
Thank you for your attention
date acquired
December 13, 2017

NWS/WR Science and Technology Infusion Division (STID)

Fire Weather/HRRR Smoke

Andy Edman
JPSS Conference
Aug 28, 2018

Fire Weather/HRRR Smoke

Key Points:

- Madison Sat Conf – world is changing
  - Value of sat obs based on their impact to modeling – this project is a good example
- Great teamwork
  - Improved FRP + HRRR upgraded with aerosols –> HRRR Smoke
- FY18 Summer fire season optimal for smoky fires
  - Deep unstable layers – weak transport winds
- R&D project – but WFO and Public acceptance very good
  - HRRR animations very successful

Fire Weather/HRRR Smoke

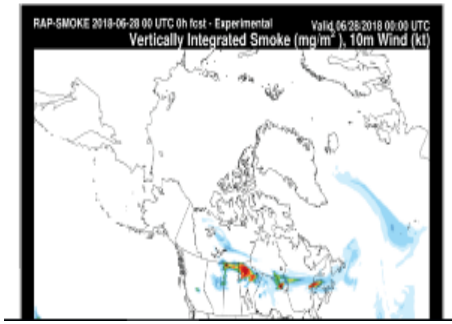
New Series – Highlight emerging new science tools to improve IDSS messaging and community impacts

Major upgrades to HRRR Smoke

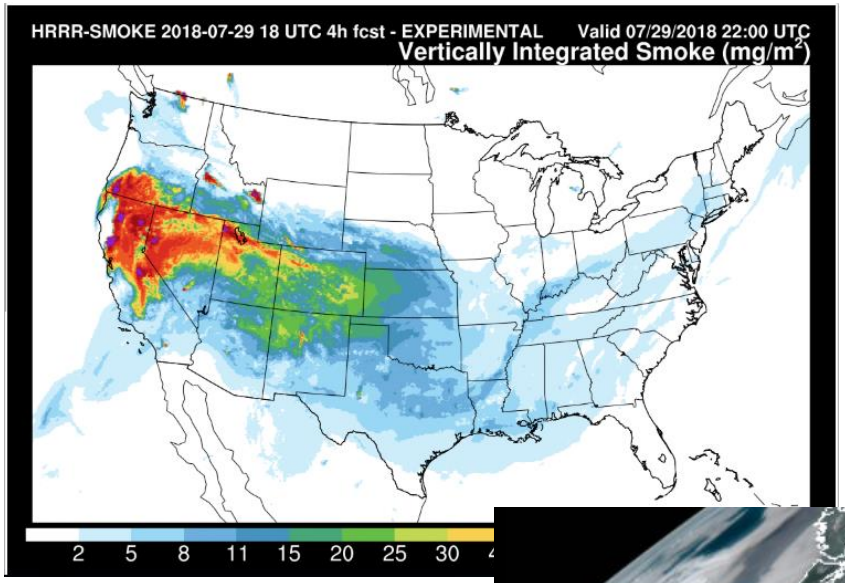
With the fire season starting, there are some important improvements to thw developmental HRRR smoke effort, based partially on WR Feedback.

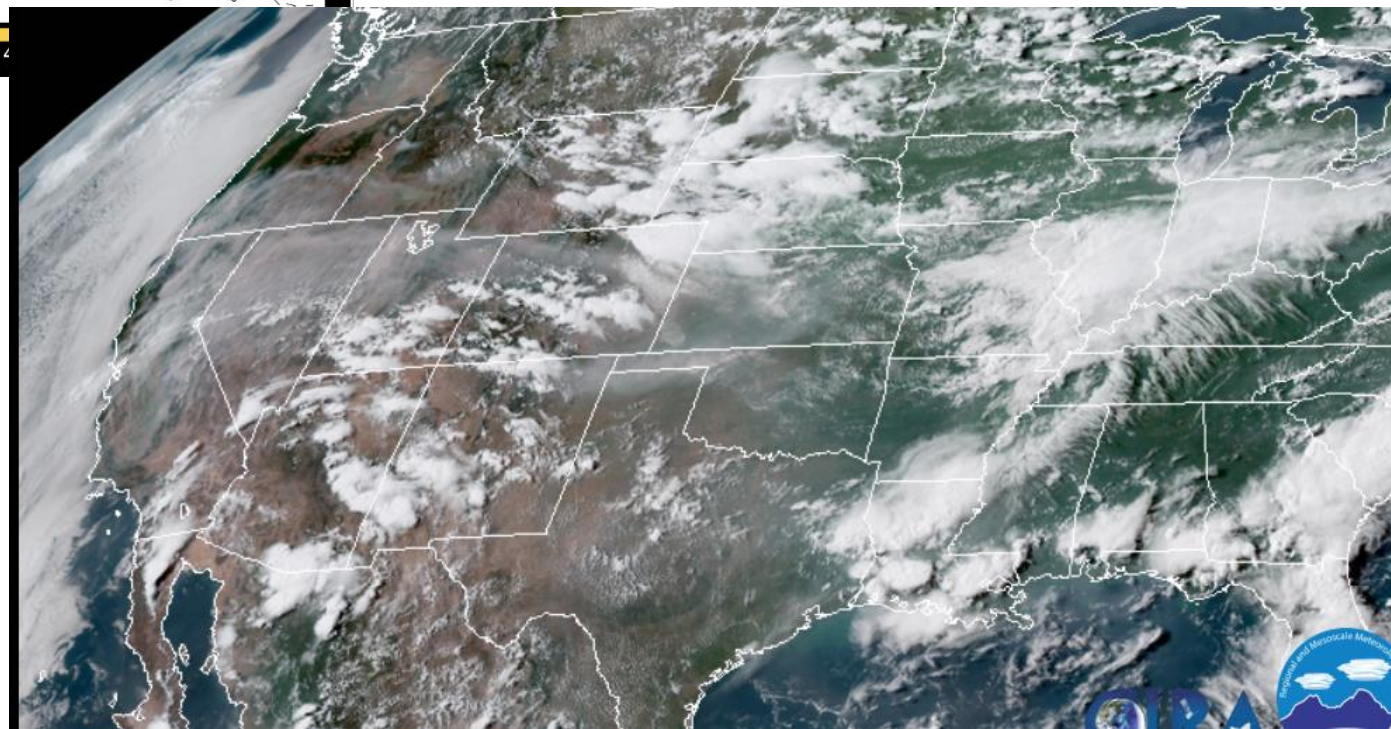
Key Points:

- The largest scale for smoke assimilation has been expanded to include Alaska, Canada and Mexico. This will better capture fire events over North America where the smoke drifts down into the CONUS - **see domain below**
  - Special thanks to Chris Gibson (SOO- Missoula) and Ron Miller (SOO-Spokane) for their feedback last year on this issue, it did have an impact!!
  - The EPA was also very interested in this capability as the HRRR represents the next generation aerosol modeling capability and smoke affects community air pollution attainment far downstream of the fires
- How does this work? As a reminder, the RAP model provides the background initial conditions to the hourly 3km CONUS HRRR
  - **Link to the RAP based smoke -** https://rapidrefresh.noaa.gov/RAPsmoke/
  - **Link to the HRRR Smoke CONUS -** https://rapidrefresh.noaa.gov/hrrr/HRRRsmoke/
- How does this capability compare with some of the other smoke options?
  - The HRRR Smoke uses the satellite based Fire Radiative Power (FRP) to acquire the location of active fires. Most other smoke models rely on the smoke being detected by ground aerosol observing systems. In essence the HRRR is the next generation approach to data assimilation and modeling -- much like how the HRRR data assimilates radar data to better capture thunderstorm activity. Both of these efforts are a work in progress!
  - ***Adding aerosol information will also improve other forecast elements, like temperature and precipitation forecasts***
  - The HRRR will be part of the NBM Blend
    - These changes are making their way into each HRRR operational upgrade -- first baby step this summer
    - These changes are also informing decisions about what physics will be included in the new NCEP FV3
- A special note: The Hawaiian volcano makes for an interesting test. The FRP relies on the size and intensity of the heat signature. **The FRP algorithm knows nothing about volcanic lava flows**, it just detects a very intense heat signature. So while the volcano is not producing that much smoke, it is useful test for an extreme high end heat event.
- Feedback requested: As we start another fire weather season your feedback is always appreciated and does have an impact

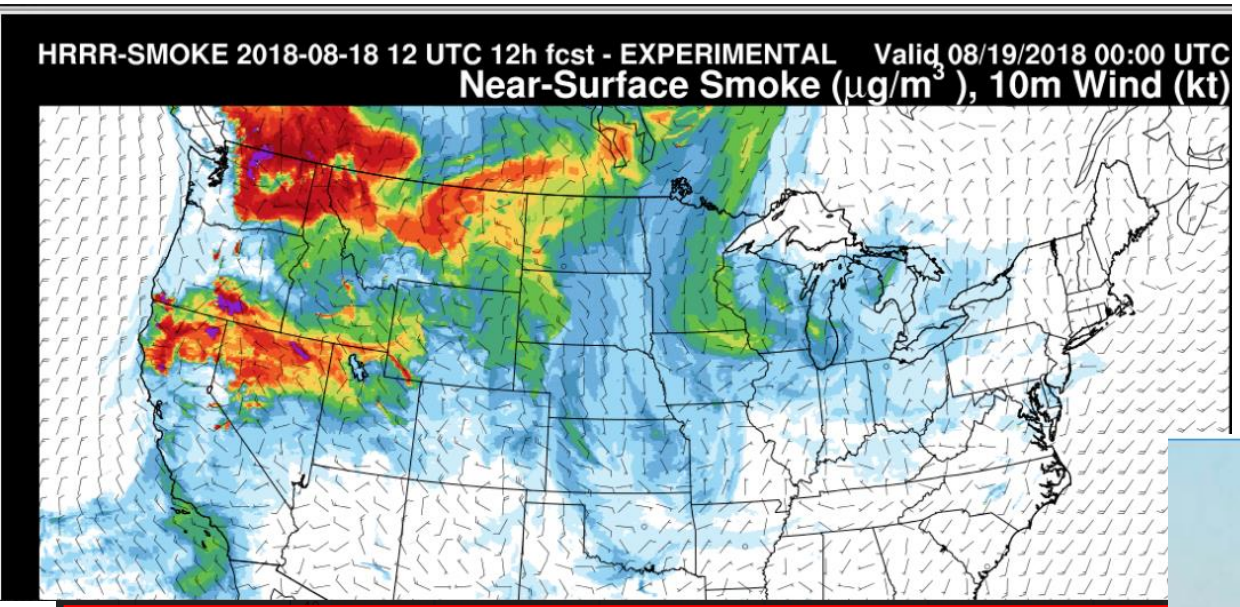


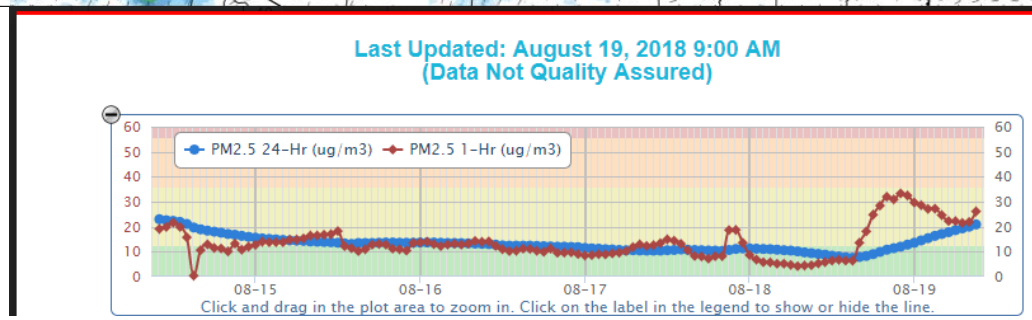
Fire Weather/HRRR Smoke

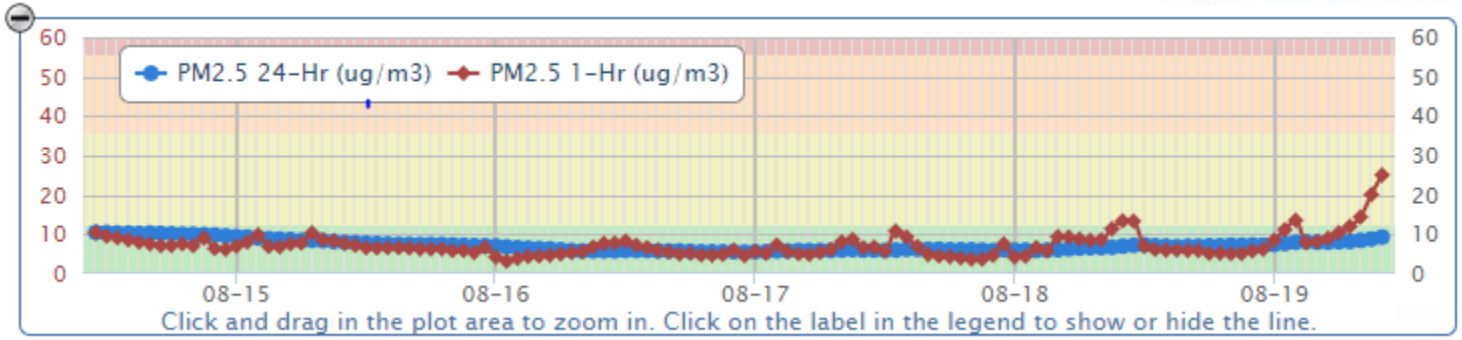




Fire Weather/HRRR Smoke







Fire Weather/HRRR Smoke

andye

HRRR smoke DSS messaging examples from last day(ish) -- note WAVE was used for many of the graphics

https://www.facebook.com/NWSSacramento/videos/1828276113875055/

https://www.facebook.com/NWSHanford/videos/2069315783143888/

https://www.facebook.com/207213322649399/posts/1759572954080087/

https://www.facebook.com/157117197683462/posts/1895621047166393/

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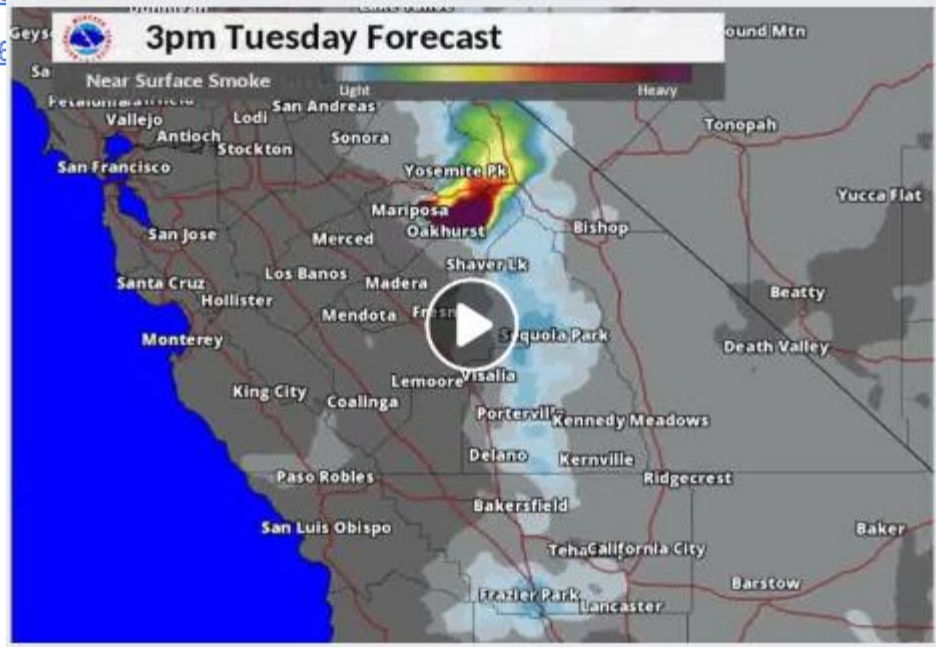
https://www.weather.gov/lkn/

https://www.weather.gov/rev/



US National Weather Service Hanford California
July 17

High resolution smoke model showing the likely areas to be affected by fire from the Ferguson Fire. It should be noted the model assumes the fire remains constant, producing a continuous supply of smoke.

7.7K Views

24 Likes 14 Comments 88 Shares

Fire Weather/HRRR Smoke

It just rained, so why is it so smoky?

By Lexi Nielsen, KSL.com | Posted - Aug 23rd, 2018 @ 5:44pm

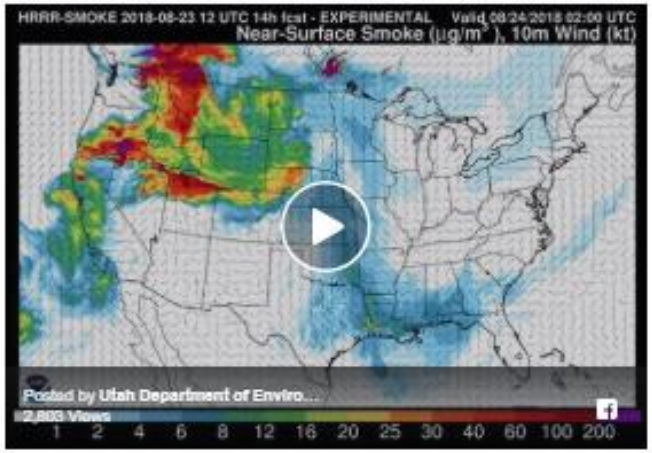
26

10PM: It just rained, so why is it so smoky?
KSL TV

Show 2 more videos

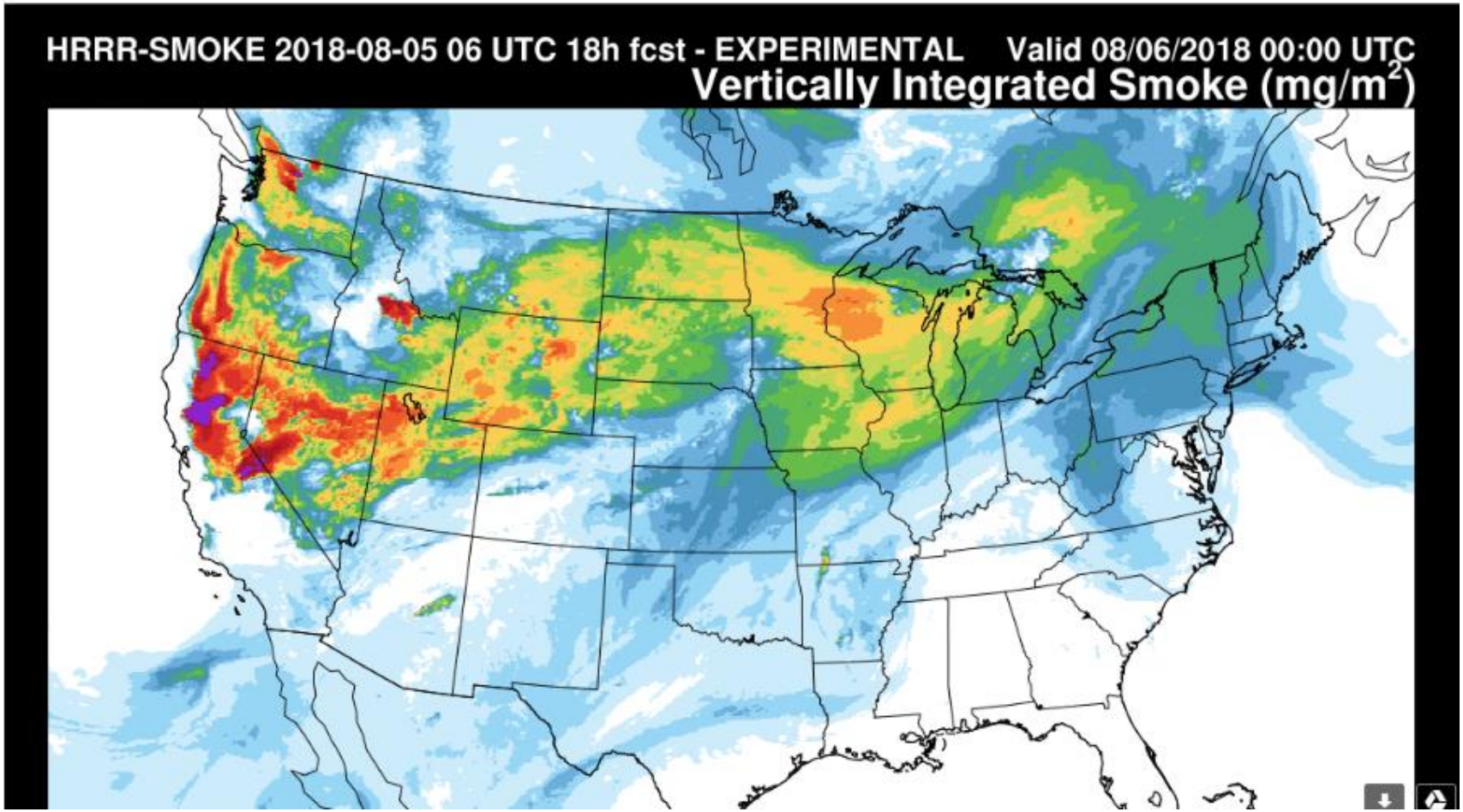
SALT LAKE CITY — Heavy August storms rolled through Utah Wednesday but left behind something a little puzzling: smoke.

Those hoping to finally see clear skies may have to wait a little longer. The front that brought the rain to the Beehive State also brought smoke from California and Oregon, according to a Facebook post from the Utah Department of Environmental Quality.



As the smoke plume settled, the air quality in most areas throughout the state remained moderate, but Tooele, Herriman, Rose Park and Weber County moved into the "unhealthy for sensitive groups" range. The department urged those with lung conditions to stay inside.

Fire Weather/HRRR Smoke



Fire Weather/HRRR Smoke

NOAA – National Weather Service
Interior Northern California – Sacramento CA
www.weather.gov/sacramento

Elevated Fire Weather; Poor Air Quality This Week

Updates are Highlighted

Impacts

- Potential rapid spread of fires
- Poor air quality for sensitive groups from wild fire smoke

Forecast Confidence

- High

Timing and Strength

- **Fire Weather**
  - Hot weather Thursday through Saturday evening
    - Increasing onshore flow will result in winds 15 to 20 mph (Updated)
    - Wind gusts up to 30 mph, mainly for canyons and ridges (See WindGusts.png)
    - Isolated thunderstorms possible over the Coastal Range Friday afternoon and evening (Updated)
- **Smoke** (See HRRR_Smoke.gif)
  - As fires continue to burn, smoke will continue to fill interior northern California
    - Areas of smoke will increase with fire activity from the Carr and Mendocino Complex fires
- **Temperatures** (See MaxT_Loop.gif)
  - Today-Thursday: Not as hot; temperatures return to near or slightly above normal

Weather Summary

Area wildfires continue to bring smoky conditions across northern California, especially in the vicinity of the Carr and Mendocino Complex fires.
Temperatures are expected be near or slightly above normal into the weekend. Critical fire weather concerns for ridges and canyons Thursday through Saturday evening as winds increase with onshore flow. Monsoonal moisture spreading north over the Coastal Range may cause isolated thunderstorms late afternoon and evening Friday.

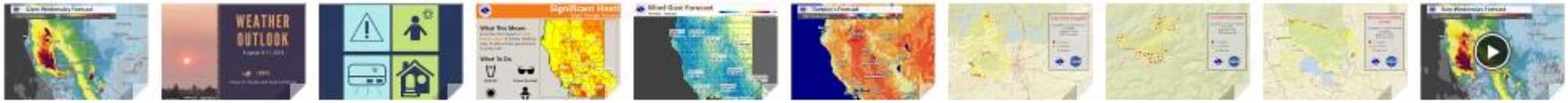
NWS will continue to provide updates as the situation develops.

Please do not reply to this email, rather contact NWS Sacramento at (916) 979-3045 for 24x7 forecaster assistance (please keep non-public)

Monitor NWS Sacramento Facebook, Twitter and Weather.gov for further updates.

You can help us by becoming a Weather Ready Nation Ambassador!
(Click the WRN icon below for more information)

10 Attachments



Fire Weather/HRRR Smoke

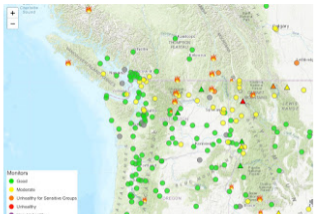
Cliff Mass Weather and Climate Blog

This blog discusses current weather, weather prediction, climate issues, and other topics

Sunday, August 26, 2018

Rain, Better Air Quality, And the End of Major Heat Waves for Perhaps the Rest of the Summer

With the upper level trough passage today, increasing onshore flow and rain has greatly cleaned up the air over the region. In fact, as shown in the figure, the air quality over the Northwest hasn't been this good in months (green is t

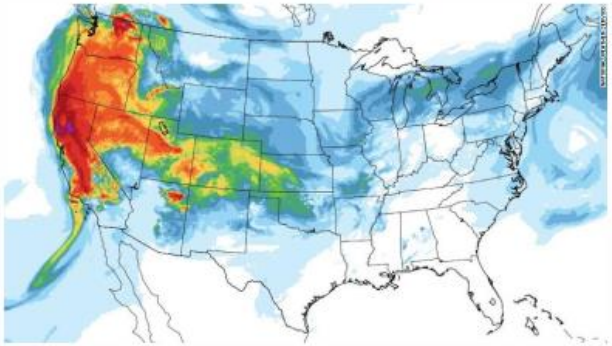


CNN U.S. • Crime + Justice | Energy + Environment | Extreme Weather | Space + Science Live TV U.S. Edition

Smoke from the California wildfires is spreading 3,000 miles to New York City

By Jessica Campisi and Haley Brink, CNN

Updated 8:33 AM ET, Fri August 10, 2018



More from CNN

Obama: Hawaii Little League world champions 'make America very...

North Carolina federal court throws out congressional map

(CNN) — Take a look at this forecast model from the National Weather Service. It shows how the smoke from the wildfires scorching California is traveling thousands of miles. In this case, all the way to New York City -- about 3,000 miles away.

The weather service uses an experimental model that forecasts the spread of smoke from wildfires across the country. It says winds lift the smoke up and carry it across the US. And it doesn't stop there -- some of the particles move even beyond the East Coast.

Eos - Earth and Space Science News • 17/08 09:20

How Forecasting Models Are Changing the Way We Fight Fires

Eos speaks with Andy Edman, western region chief of the Science and Technology Infusion Division at the National Weather Service, about how the agency is helping wildfire crews fight fires from space.

Fire Weather/HRRR Smoke

The WR large airports were busy yesterday due to weather issues.

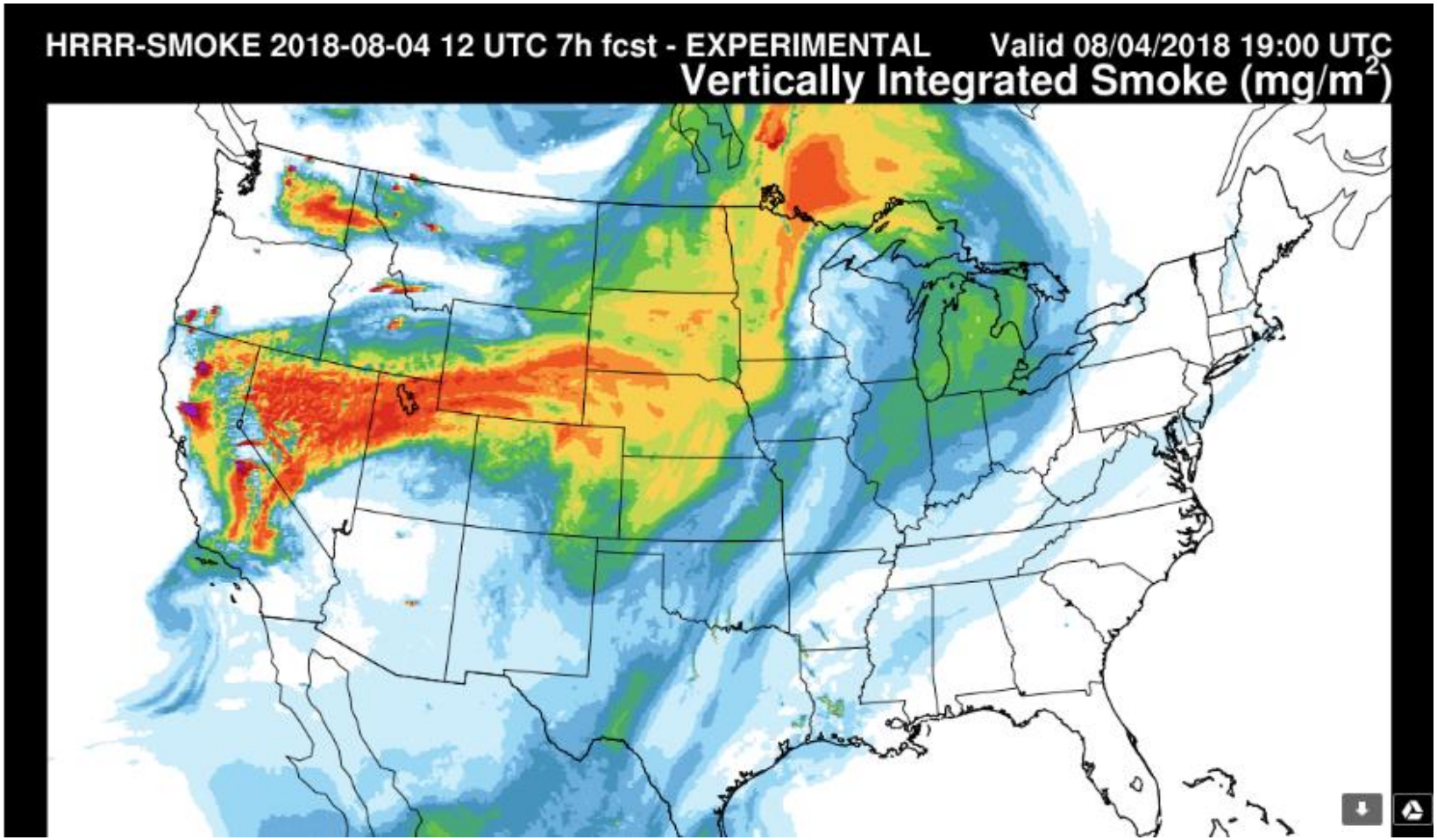
- SEA had 89 delays due to wildfire smoke and haze in the morning
- SFO had an all day GDP from low CIGs. 307 delays, 7 aircraft holds for 128 minutes and 37 diversions
- PHX had 53 delays and 5 diversions due to thunderstorms

Smoke and haze caused a 6.5 hour GDP at **SEA** that lasted until early afternoon. There were 158 delays.

PIREP BE99
Obs Time: 2018-08-23T01:15:00Z
Turb intensity: SEV
Weather: FU
Flight level: 070

PIREP: MFR UA /OV FISTA/TM 0115/FL070/TP BE99/SK FU/WX VIS 0/TB SEVERE/RM DURD ON ILS, PILOT REPORTED ENTERING SMOKE SO THICK IT FILLED THE COCKPIT, CREATED SEVERE TURBULENCE AND MADE THE PLANE SO HOT IT FELT LIKE HE WAS ON FIRE

Fire Weather/HRRR Smoke



Fire Weather/HRRR Smoke

NWS Forecast Office Salt Lake City, UT

Weather.gov > Salt Lake City, UT

Salt Lake City, UT
Weather Forecast Office

Current Hazards | Current Conditions | Radar | Forecasts | Rivers and Lakes | Climate and Past Weather | Local Programs

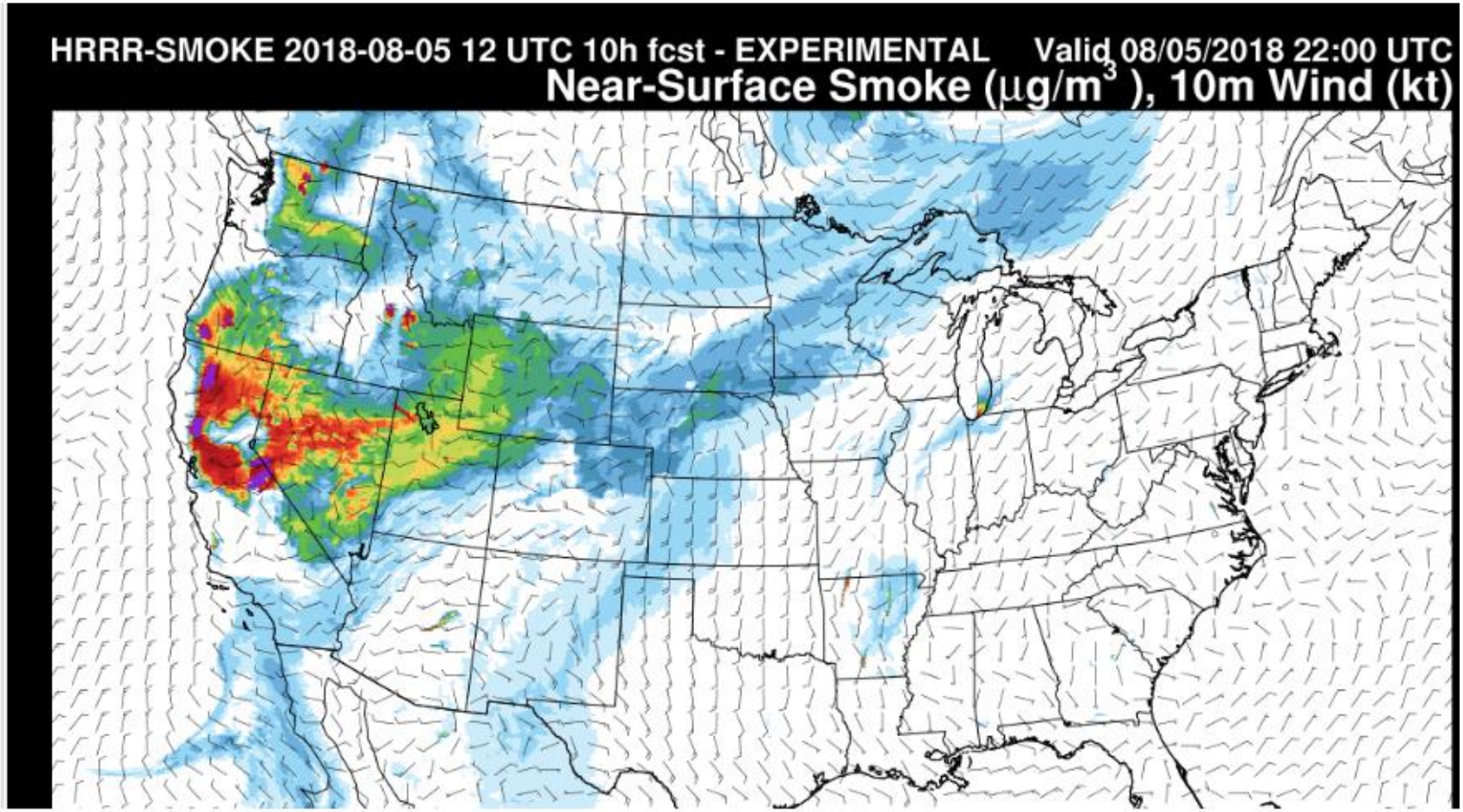
Smoky Conditions

Monday through Wednesday	• Smoke from California, Nevada and local fires will persist into midweek due to westerly flow • Little improvement in smoky conditions
Thursday into Friday	• Less additional smoke from California expected later in the week due to building high pressure • Smoke already present in the area will be slow to clear out • Some improvement in visibility and air quality possible

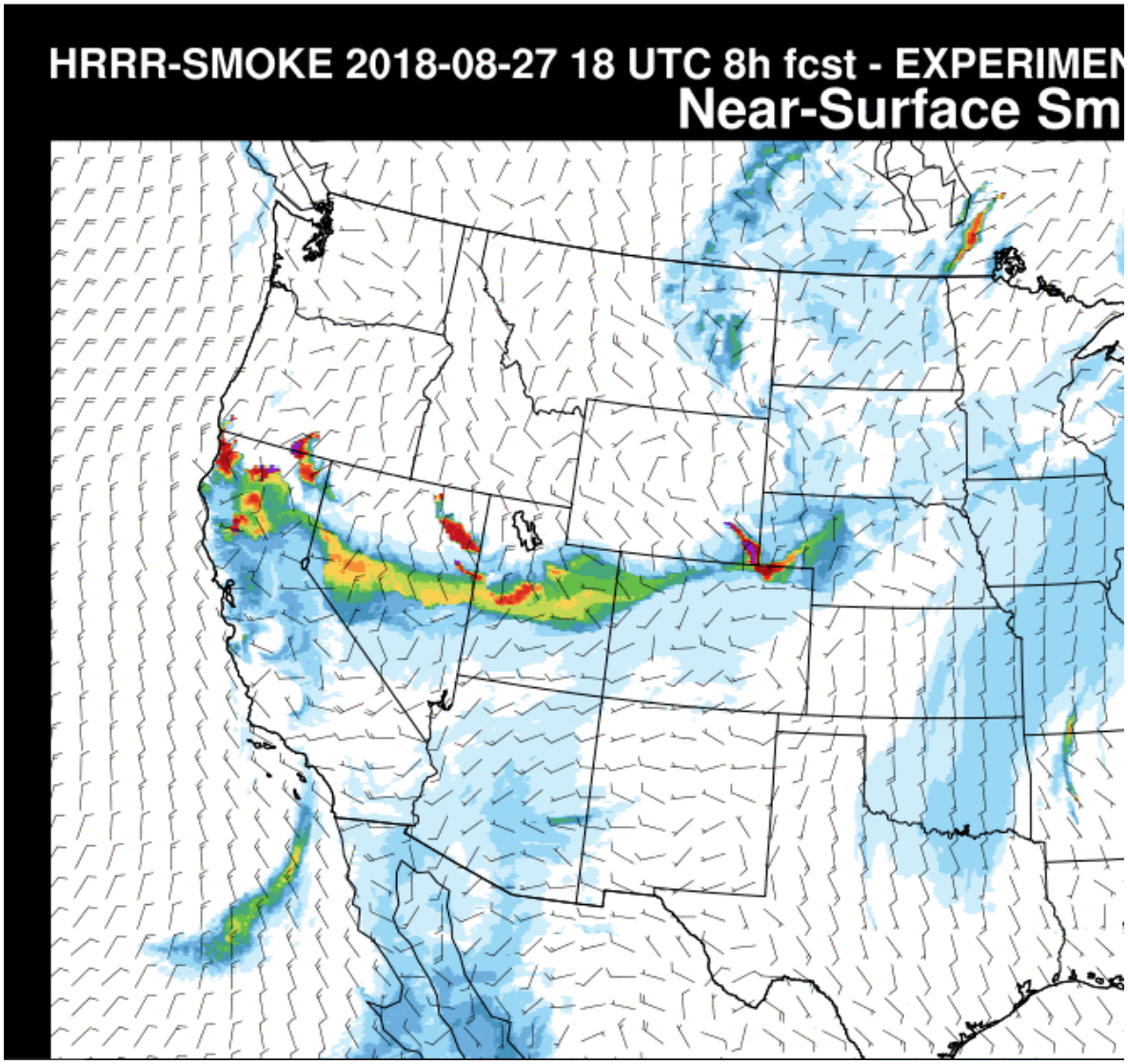
Photo: Brady Harris

Show Caption

Fire Weather/HRRR Smoke



Fire Weather/HRRR Smoke



Fire Weather/HRRR Smoke

- FRP and HRRR-Smoke enhancements were significant
  - 36 hour 3km animations are a huge selling point !!!!!
  - Fires from Mexico, Canada and Alaska in RAP really helped
  - Fire location/intensities were better
  - OAR many model improvements really helped
  - Reduced downtime helped with forecaster trust
  - Helped with FV3 physics planning
  - Used WAVE to make displays
- Still and R&D project
  - Smoke from Canadian fires a challenge
  - More verification and tuning

Fire Weather/HRRR Smoke

Summary

- Science
  - HRRR Smoke shows how event will evolve
    - Organizations/people interested
  - Smoke distribution is not uniform – either in horizontal and vertical – HRRR Smoke shows this well
    - Nearby fires – smoke under inversion
    - Distance – generally above inversion but can mix down far downstream – MN event
  - Impacts a number of forecast variables
- Societal
  - Affect health – both near fire and distant – EPA and local Air quality
  - Aircraft operations
  - Fire Operations
  - CALOES - transportation – Amtrak and highways
  - National Park Systems
  - Recreational and school sports
  - Visiual
- Educational opportunity
  - People are curious and want to know where smoke is coming from/when is it going to get better

Bottom-line: HRRR-Smoke is a foundational science change that helps everyone

Support for Burned Area Debris Flow Forecasting Using VIIRS NDVI

Sam Batzli, Dave Parker, Russ Dengel, Nick Bearson
Space Science & Engineering Center, University of Wisconsin-Madison
Ivan Csiszar
NOAA/NESDIS – STAR
Katherine Rowden
NOAA/NWS – Spokane WFO

Summary

The Problem: National Weather Service forecasters need timely burn intensity estimates to help forecast mud and debris flows following large wildland fires.

Landsat-derived Burned Area Reflectance Classification (BARC) maps from the US Forest Service and US Geological Survey are the gold standard for burn intensity estimates, *but they are often not available for forecasting* debris flows in a timely manner.

This project is intended to develop a semi-automated method for getting burn intensity information into the hands of forecasters sooner by:

- Using VIIRS data for a quicker, lower resolution estimation
- Automating processing to lower latency
- Providing forecasters a web-based tool to initiate processing and collect GIS-ready results

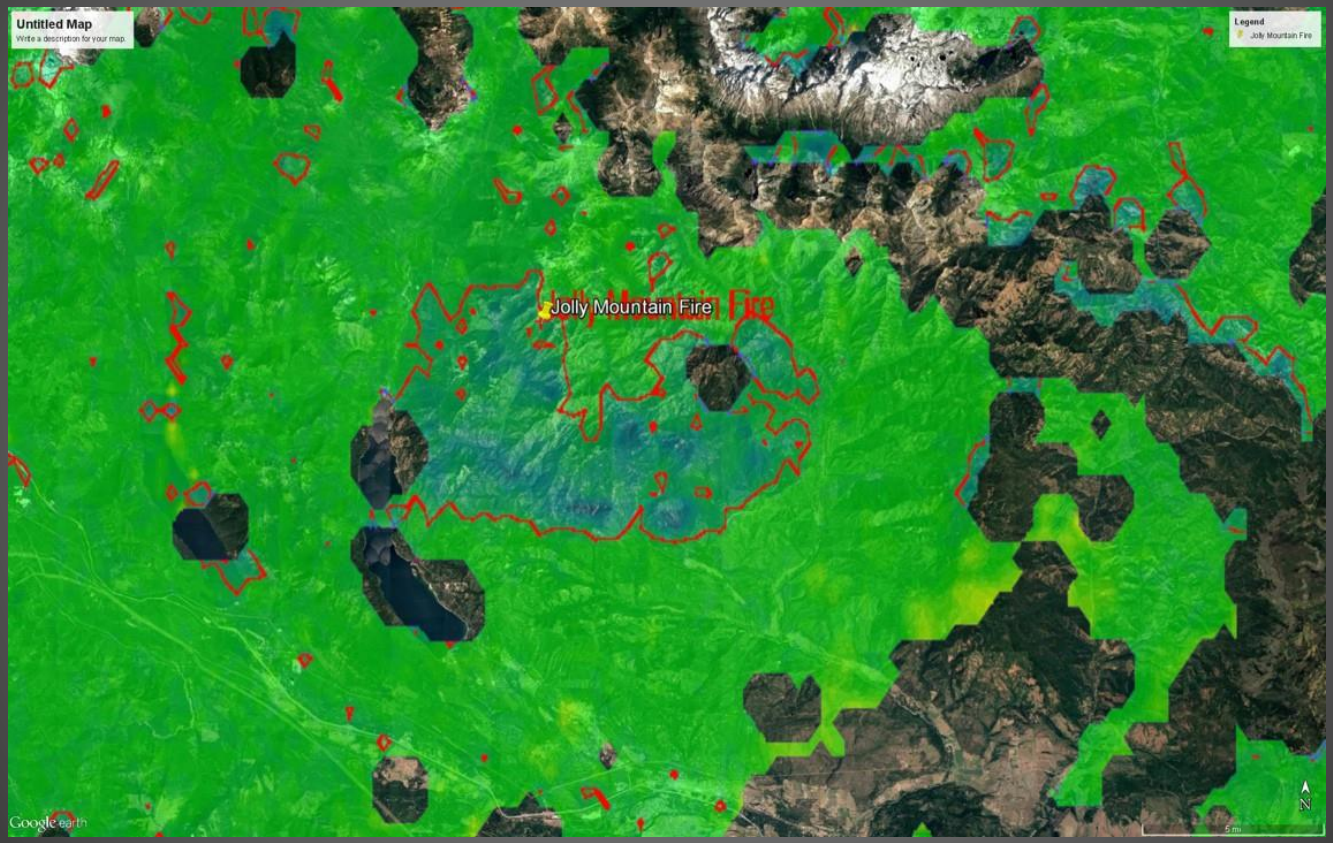
Results from Previous Research

Feasibility Studies: R. Bradley Pierce, Ivan Cisizar, Katherine Rowden

- Successful test of VIIRS Change in Normalized Difference Vegetation Index (Delta-NDVI) product to provide a rapid assessment of burn scars.
- The VIIRS Delta-NDVI imagery provided timely information when clear, high-resolution imagery was not available.
- Identified need for Esri shapefiles, suitable for GIS debris flow model processing.
- Desire to streamline, automate, extend, and ultimately operationalize production.

Results from Previous Research

Feasibility Studies: R. Bradley Pierce, Ivan Cisizar, Katherine Rowden



Jolly Mountain Fire: Difference between VIIRS NDVI on 20:43Z September 28, 2016 (pre-burn) and 20:41Z on September 26, 2017 (post-burn). Blue regions indicate reductions in NDVI following the Jolly Mountain Wildfire.

Results from Previous Research

Feasibility Studies: R. Bradley Pierce, Ivan Cisizar, Katherine Rowden

Norse Peak Fire: Difference between VIIRS NDVI on 20:43Z September 28, 2016 (pre-burn) and 20:41Z on September 26, 2017 (post-burn). Blue regions indicate reductions in NDVI following the Norse Peak Wildfire.

New Product

BRIDGE Maps: Burn Intensity Delta Greenness Estimation

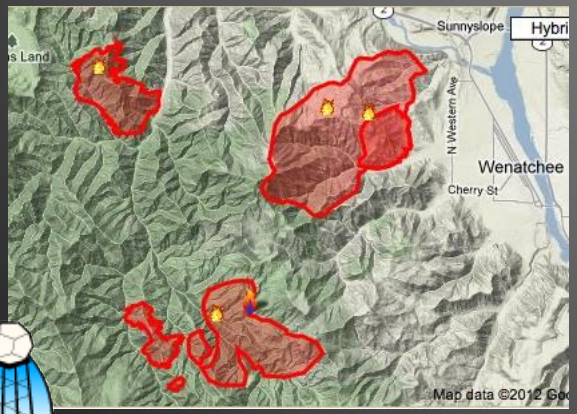
- BARC product is not intended to be used as an early warning tool.
- BRIDGE product will supplement, not replace BARC.
- BRIDGE product will evaluate NDVI from TOA (top of atmosphere), NDVI from TOC (top of canopy), and EVI (Enhanced Vegetation Index) from TOC in its production.
- BARC product is developed as a Delta NBR (Normalized Burn Ratio).
- NBR is not available as an operational and routinely produced VIIRS product at this time.
- This project will explore and test the potential for utilizing VIIRS NBR as well.

Integration of BRIDGE will result in improved situational awareness and will support decision making, especially before BAER assessment teams can deploy (typically at 80% containment) or before BARC maps are available.

Historical Analysis

We are testing BRIDGE maps for historical Washington debris flow events that followed fires and also mapping fires from the past two years.

- 6/29/2013 **2012 Peavine Fire**
  - year after, so there was a BAER assessment
- 8/4/2013 **2012 Wenatchee Fire**
  - year after, so there was a BAER assessment
- 8/13/2013 **2013 Colockum Tarps Fire**
  - fire was still active, no BARC or BAER
- 8/21/2014 **2014 Carlton Complex**
  - fire was still active, no BAER team yet, there was a BARC, but it was not widely shared



Workflow for Automated VIIRS Burn Intensity Estimation:

Satellite Inputs for Flash Flood and Debris Flow Situational Awareness and Modeling

Dashboard Displays:
- Satellite Active Fire Locations
- VIIRS Imagery/NDVI/EVI
- Embedded RealEarth Map

1

Web-Based Dashboard

NWS-WFO Initiates Action

NWS-WFO Staff:
- Chooses Fire(s) to Analyze
- Inspects Imagery
- Selects Before/After NDVI/EVI Pairs

4

NWS-WFO Integration

Adding VIIRS-Derived BRIDGE Product

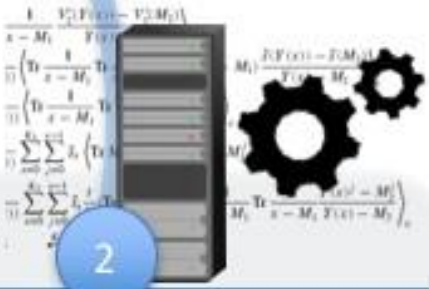
Decision Support:
- Integration for Situational Awareness
- NWS-WFO & IMETs Utilize BRIDGE for Decision Support and Warnings as Necessary

3

Results Visualized on Dashboard

Available for Download or Streaming

Dashboard Adds:
- BRIDGE Map
- Download/Streaming (multiple GIS formats)
- Added to Embedded RealEarth Map



2

Server Processing

Delta Greenness for Before and After Pairs

Processing:
- Before/After Pairs are Processed
- Burn Intensity Delta Greenness Estimation
- (BRIDGE) Map Produced in GIS Format

Summary of Tasks

Component 1: Web-Based Dashboard with RealEarth Map

Embedded map with True/False color VIIRS imagery, NDVI, Active Fires, Cloud Mask, Current Large Fires, Burn Scar Maps, drop-down menus and drawing tools for user to select area of interest for analysis.

Component 2: Historical Fire Analysis

Run protocol with historical fires/burn scars that led to debris flow events. Produce BRIDGE maps for large fires in recent years.

Component 3: Image Processing initiated by NWS-WFO

Automate Delta-NDVI BRIDGE map production. Link dashboard controls to automated processing on dedicated server at UW-CIMSS.

Component 4: Results Visualized on Dashboard

Automate process of scaling and converting raster output to polygon Shapefile and GeoJSON for use in GIS. Display in Dashboard.

Component 5: Results Integrated into NWS-WFO Models

Evaluate effectiveness of BRIDGE maps in debris flow forecast models.

Component 1 Progress