Preliminary Findings from the NWCG Satellite Data Task Team

NATIONAL WEATHER SERVICE

FEBRUARY 25, 2020 – Satellite Proving Ground Risk Reduction Summit

Presenter: Chad Gravelle, Tech Dev Met, NWS Southern Region HQ

National Wildfire Coordinating Group Task

Todd Lindley (Chair) – NOAA/NWS Norman, OK

NWCG Fire Environment Committee

Tasking Memorandum

Date: 6 June 2018

TO:	Satellite Data Task Team
FROM:	Robyn Heffernan, Fire Environment Committee Chair
SUBJECT:	Satellite data requirements for wildland fire.

Purpose: This memorandum tasks the Satellite Data Task Team to determine the raw and forecaster-improved data requirements for the new Geostationary Satellites (GOES) 16 &17 and the Joint Polar Satellite System (JPSS) for wildland fire purposes.

Action/Tasking: A satellite data task team will need to be created with representatives from operations, remote sensing, fire environment, and data management areas. These representatives should be familiar with remotely sensed data and its use on wildland fire incidents.

The task team will assess raw and post-processed satellite data from the new GOES16/17 and the JPSS platforms. Investigate pilot projects of forecaster improved services provided by the National Weather Service to the emergency management community with respect to fire related satellite services. Develop wildland fire requirements for access to raw and post-processed satellite data, as well as any forecaster improved services. Determine wildland fire capability (including IT-support) to utilize such data and services.

The scope of this tasking includes all fire utilities of satellite data including fire detections, burned area, fire progression and intensity, fire perimeter, vegetation information, weather information, and smoke data. Requirements must be supported with intended corresponding wildland fire or emergency management utility.

Resources available to support your assessment include the National Weather Service (NWS), NWS Operations Proving Ground (a test bed for operational ready projects), the National Environmental Satellite, Data, and Information Service (NESDIS, satellite experts), the U.S. Forest Service Geospatial Technology and Applications Center (GTAC, satellite experts), as well as any National Aeronautics and Space Administration (NASA) projects.

National Wildfire Coordinating Group Task

NWCG Fire Environment Committee

Tasking Memorandum

Date: 6 June 2018

TO:	Satellite Data Task Team
FROM:	Robyn Heffernan, Fire Environment Committee Chair
SUBJECT:	Satellite data requirements for wildland fire.

Purpose: This memorandum tasks the Satellite Data Task Team to determine the raw and forecaster-improved data requirements for the new Geostationary Satellites (GOES) 16 &17 and the Joint Polar Satellite System (JPSS) for wildland fire purposes.

Action/Tasking: A satellite data task team will need to be created with representatives from operations, remote sensing, fire environment, and data management areas. These representatives should be familiar with remotely sensed data and its use on wildland fire incidents.

The task team will assess raw and post-processed satellite data from the new GOES16/17 and the JPSS platforms. Investigate pilot projects of forecaster improved services provided by the National Weather Service to the emergency management community with respect to fire related satellite services. Develop wildland fire requirements for access to raw and post-processed satellite data, as well as any forecaster improved services. Determine wildland fire capability (including IT-support) to utilize such data and services.

The scope of this tasking includes all fire utilities of satellite data including fire detections, burned area, fire progression and intensity, fire perimeter, vegetation information, weather information, and smoke data. Requirements must be supported with intended corresponding wildland fire or emergency management utility.

Resources available to support your assessment include the National Weather Service (NWS), NWS Operations Proving Ground (a test bed for operational ready projects), the National Environmental Satellite, Data, and Information Service (NESDIS, satellite experts), the U.S. Forest Service Geospatial Technology and Applications Center (GTAC, satellite experts), as well as any National Aeronautics and Space Administration (NASA) projects.

Todd Lindley (Chair) – NOAA/NWS Norman, OK

Drew Daily – Oklahoma Forestry Services
Dr. Chad Gravelle – NOAA/NWS Southern Region HQ
Susan O'Neill – US Forest Service
Sean Triplett – NWCG Geospatial Subcommittee
Cole Belognie – NWCG Data Management Committee
Billy Gardunio – Predictive Services
Craig Thompson – Office of Wildland Fire
Dr. Wilfrid Schroeder – NOAA/NESDIS
Hal Bromley – Bureau of Indian Affairs (recused)

Preliminary Findings

29 Findings and 32 Recommendations that fit broadly into five categories…

Preparedness

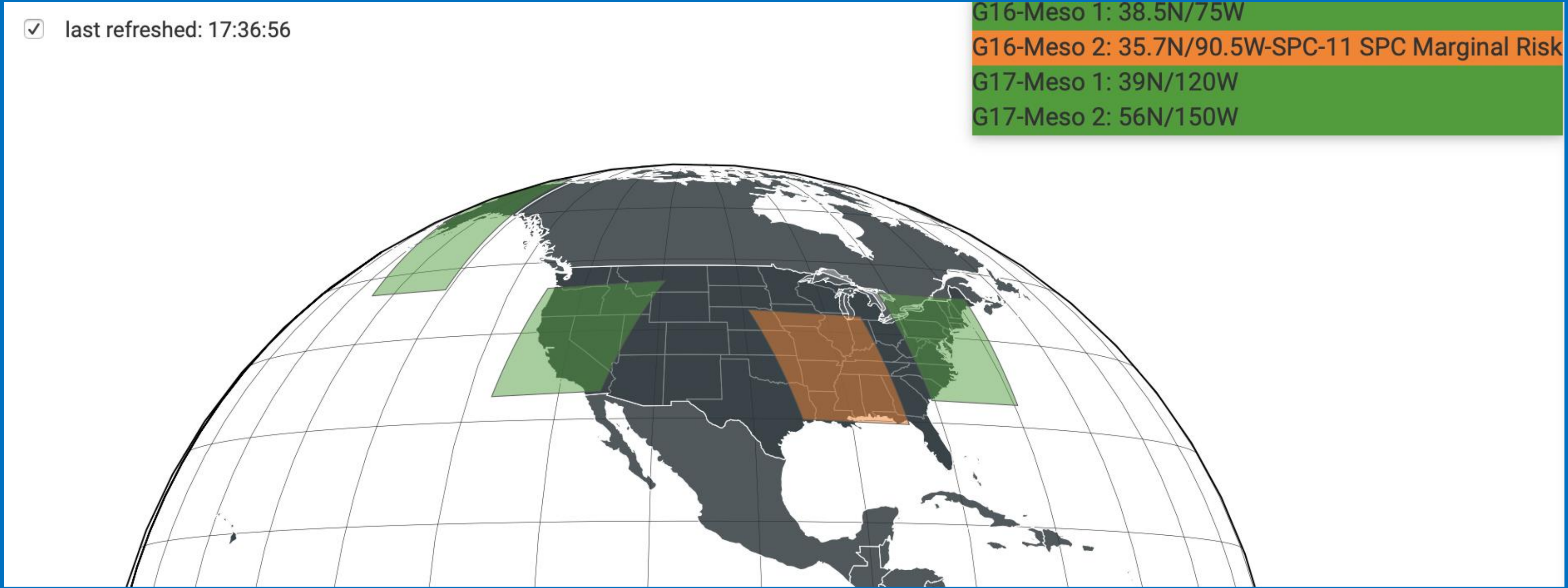
Support of Initial Attack

Support of Extended Attack

Smoke/Air Quality

Recovery

Preparedness



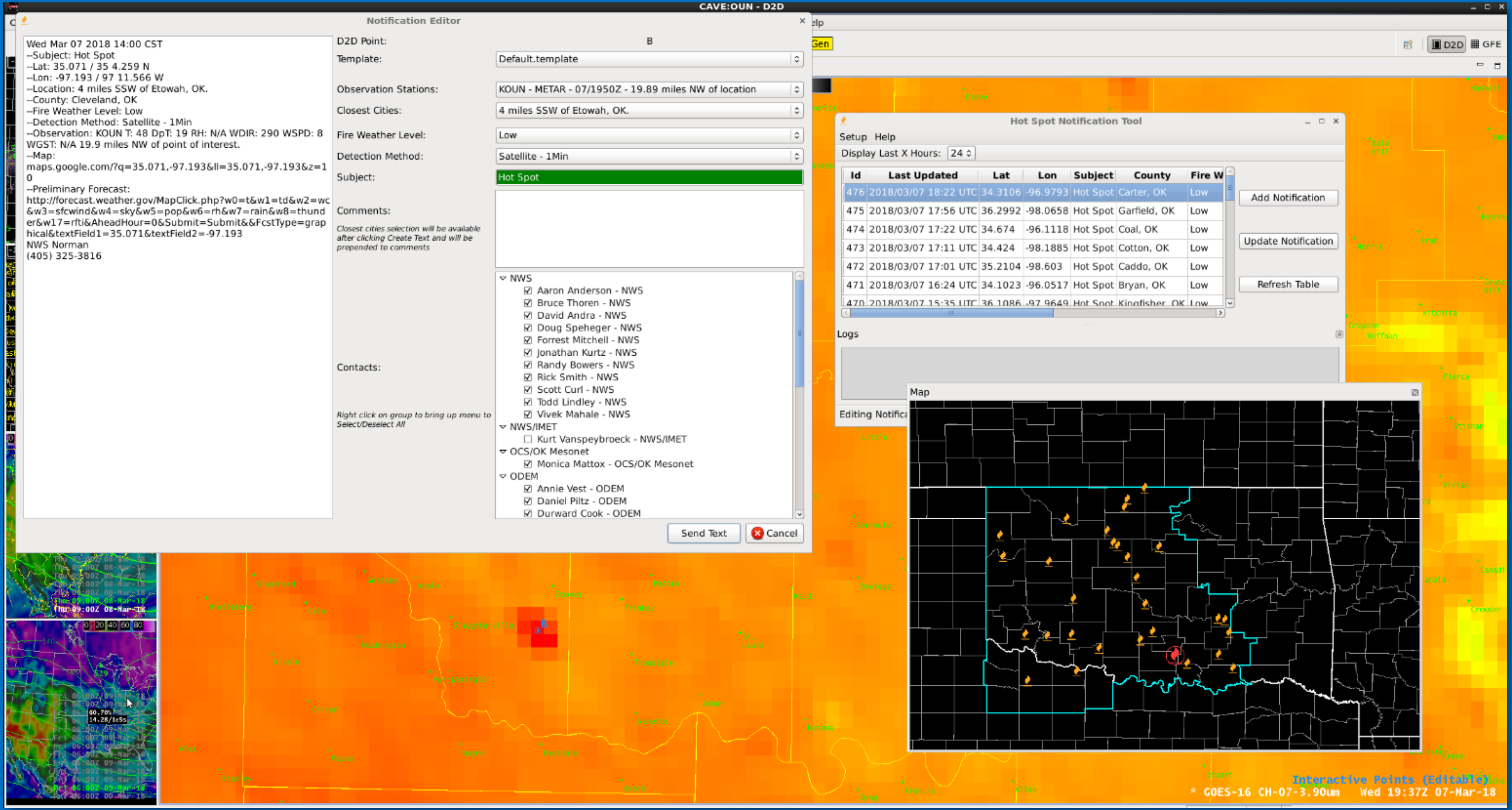
Finding: Applied wildland fire remote sensing research (Lindley et al. 2016) has shown 1-min satellite imagery provides critical information to wildland fire agencies.

Support of Initial Attack

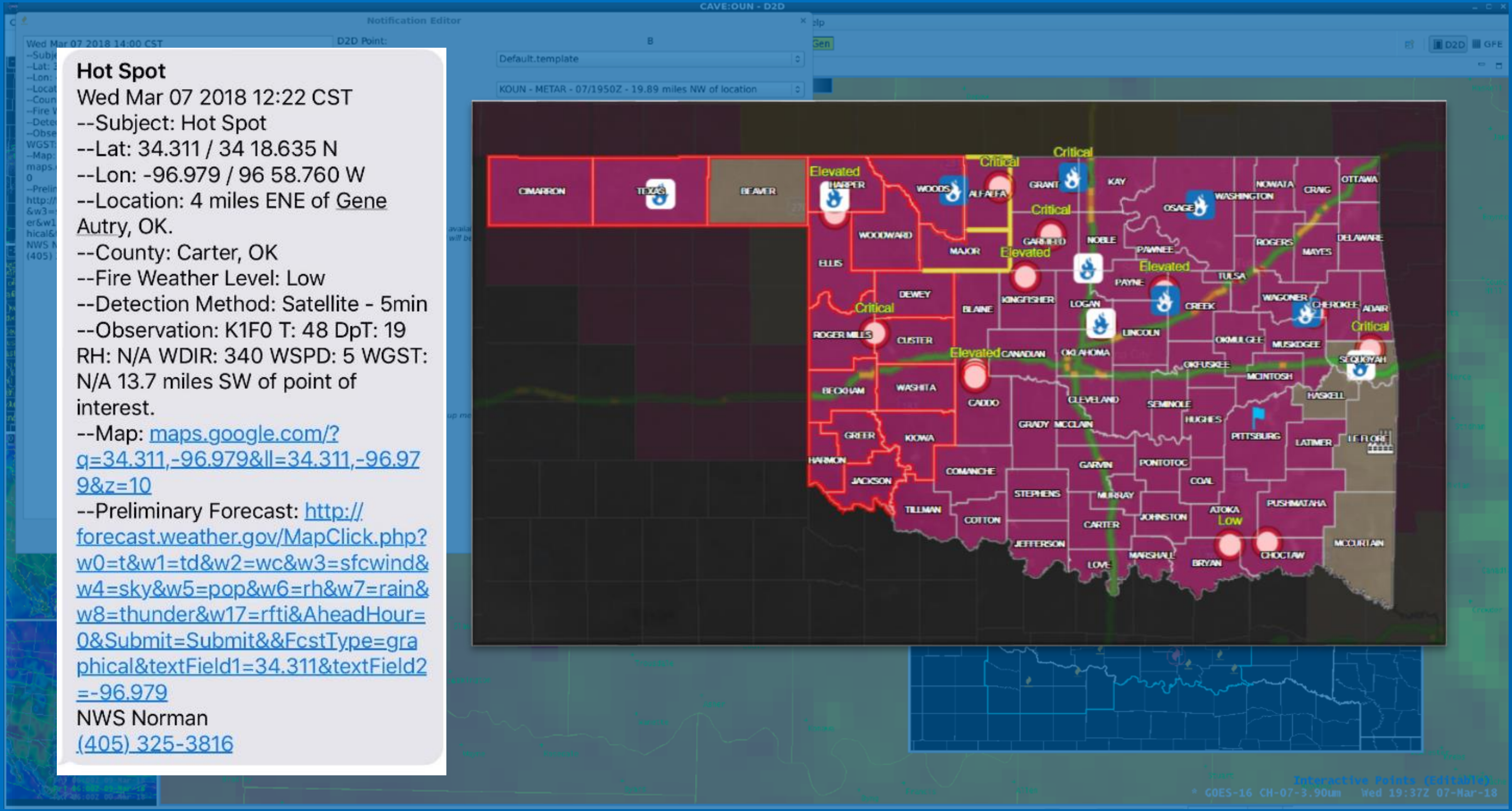
“Fact that never changes: The safest and least costly fires are the ones that receive strong initial attack and are suppressed while still small”....

Dr. Stephen J. Pyne, Between Two Fires

Support of Initial Attack



Support of Initial Attack



Support of Initial Attack

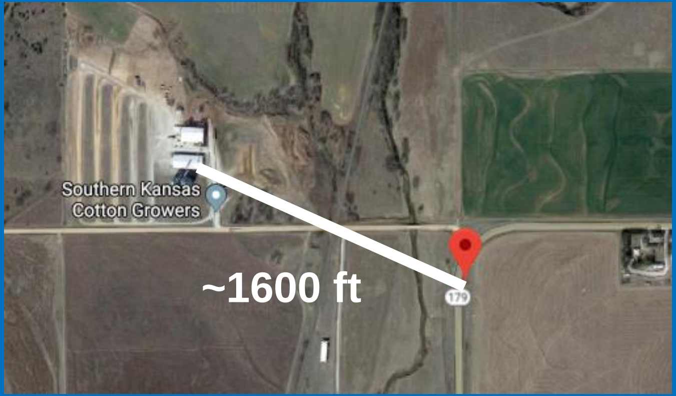
How good are NWS forecasters at identifying the locations of these wildfires?

Support of Initial Attack

2017

Support of Initial Attack

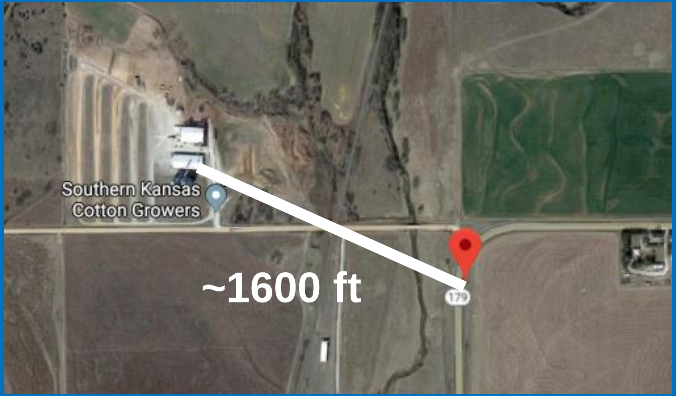
2017



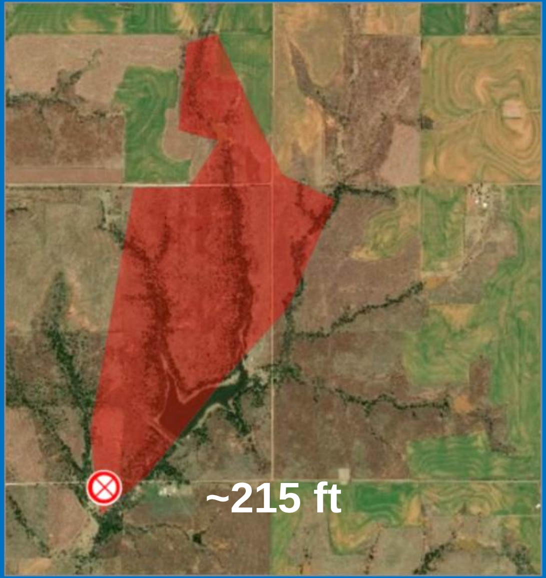
2018

Support of Initial Attack

2017

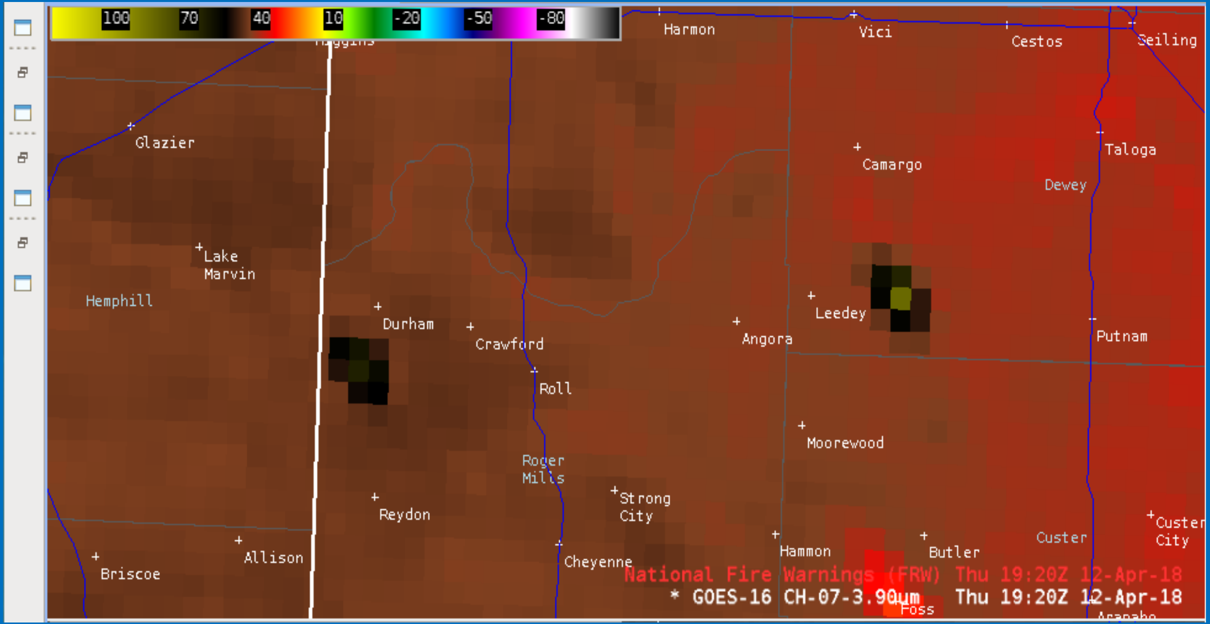


2018

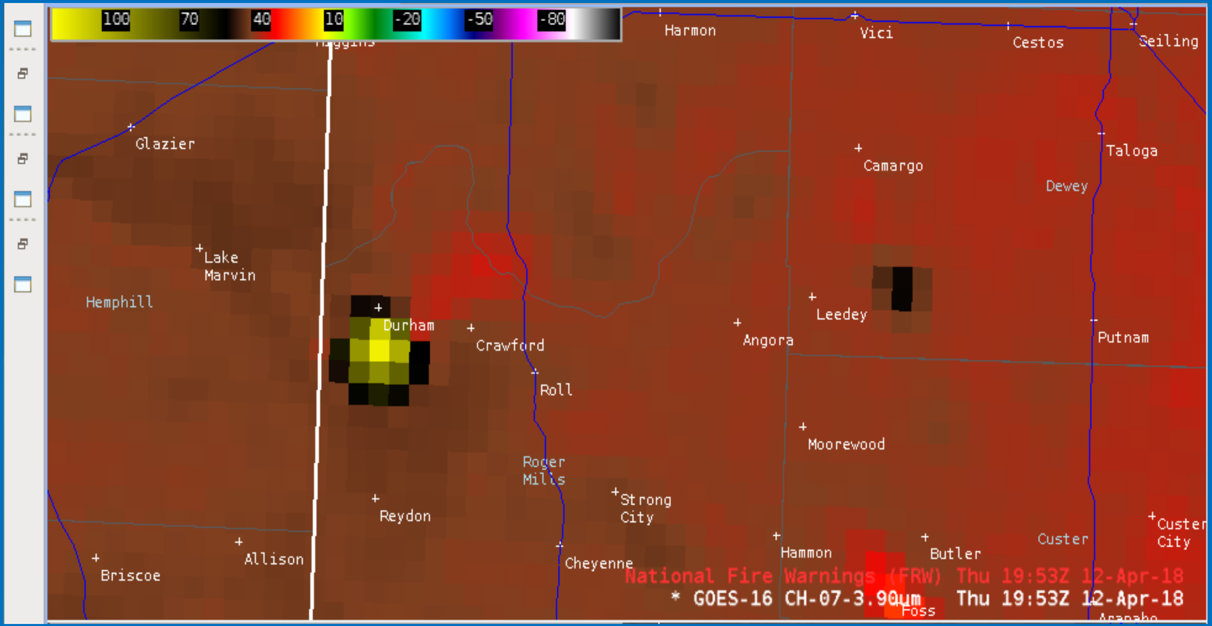


2019

Support of Initial Attack

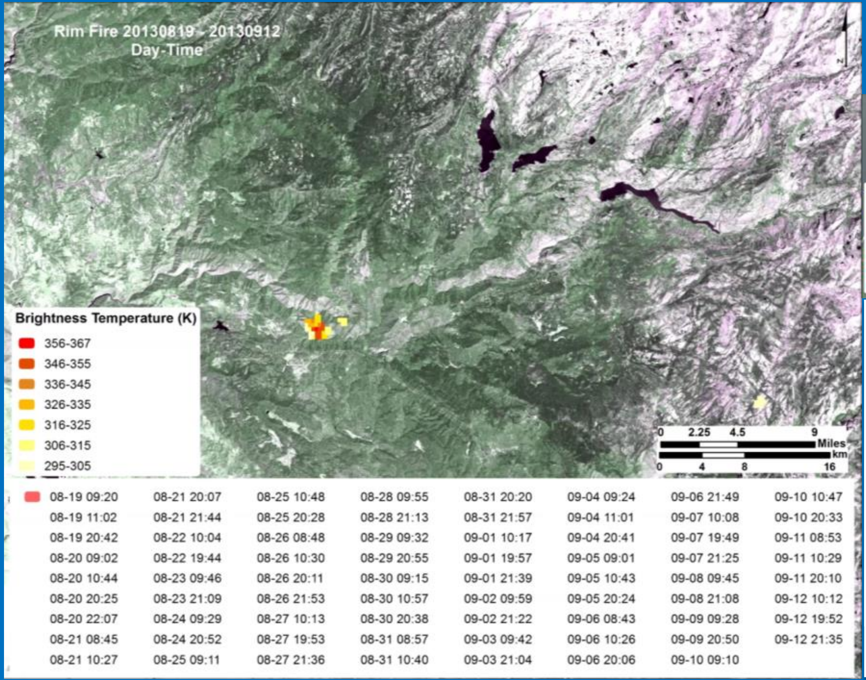


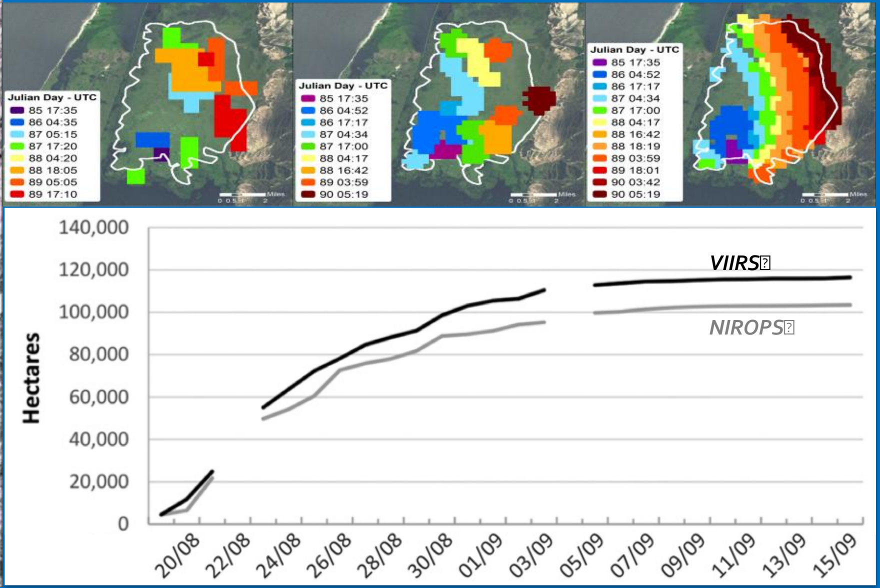
Support of Initial Attack



Finding: A LEO/GEO fused machine learning-based algorithm, analogous to ProbSevere, is needed that provides probabilistic characteristics of wildland fire (e.g., volatility, direction).

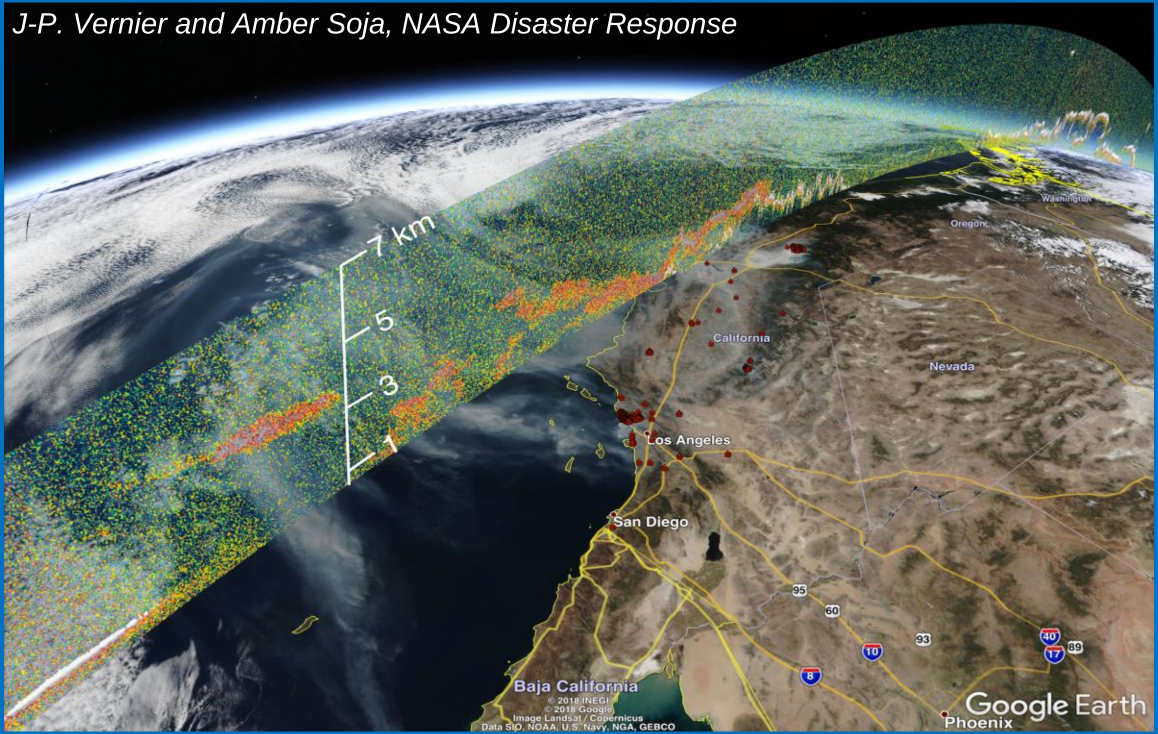
Support of Extended Attack





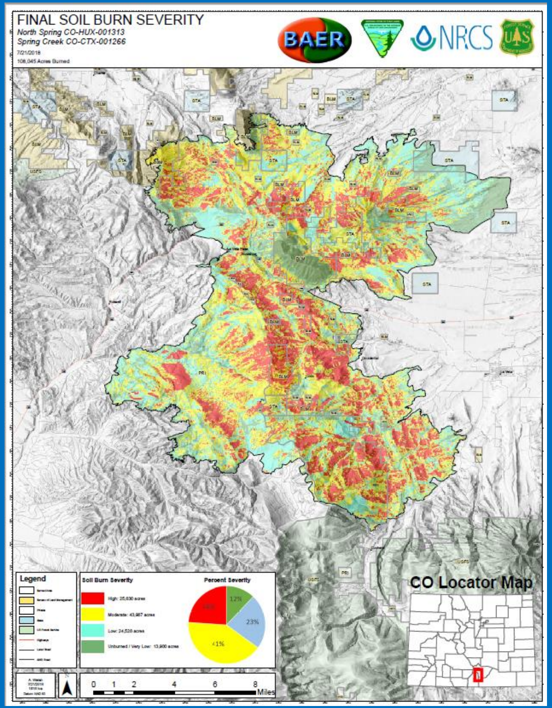
Finding: Wildland fire behavior intelligence (e.g., rate of spread, burn area, fire radiative power), based on polar orbiters, can provide added information to NIROPS.

Smoke/Air Quality



Finding: Information on the vertical distribution of smoke is unavailable from GEO/LEO satellites.

Recovery



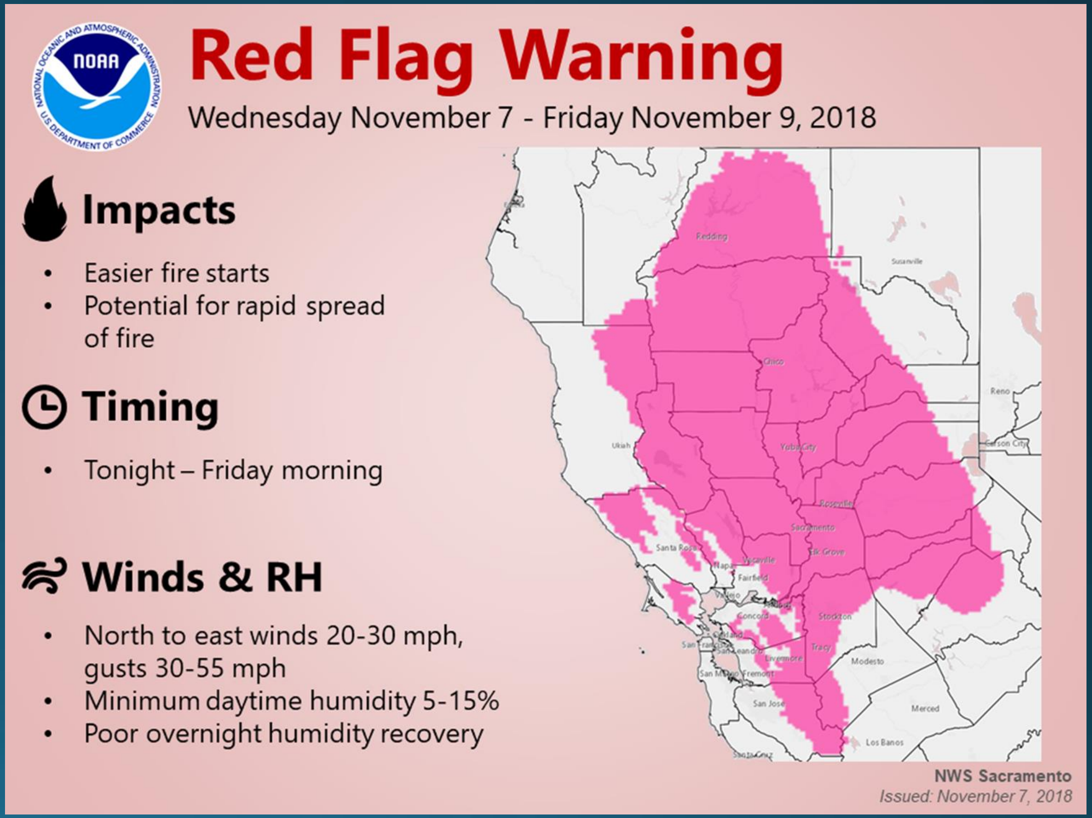
Finding: Polar orbiter wildland fire mapping information from the Burn Intensity Delta Greenness Estimate (BRIDGE) is critical for developing an initial burn scar polygon.

chad.gravelle@noaa.gov

NWS Southern Region HQ
Science Technology Services Division
Techniques Development Meteorologist

NWS Fire Weather Forecasters - Office

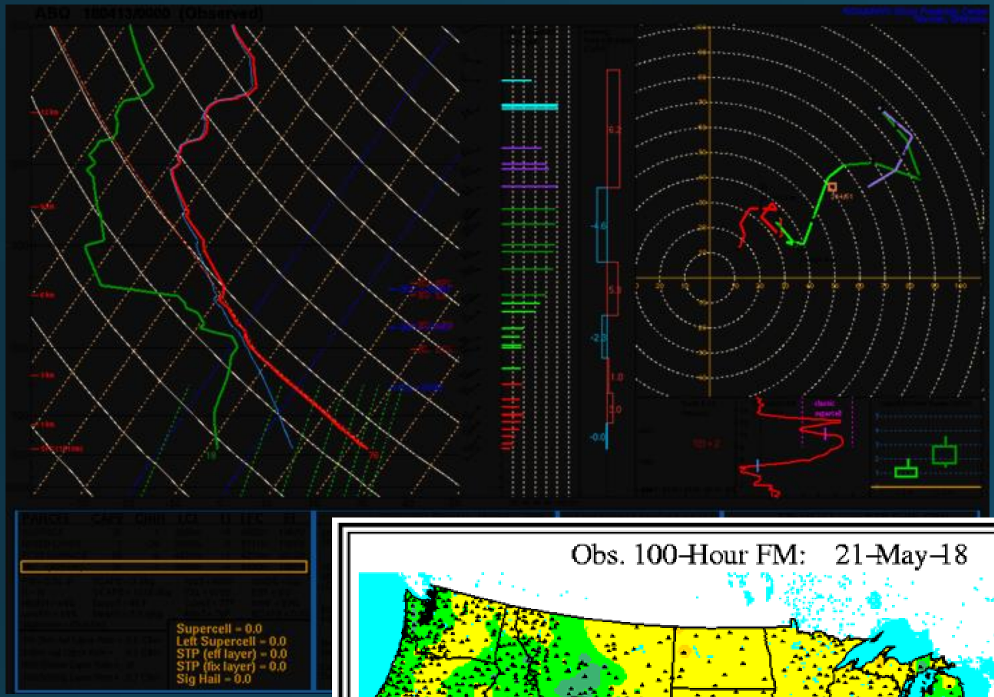
- Red Flag Warnings
- Fire Weather Watches
- Spot forecasts (updates)
- Daily fire weather forecasts
- Phone briefings
- NFDRS point forecasts
- Fire start notification (as able)

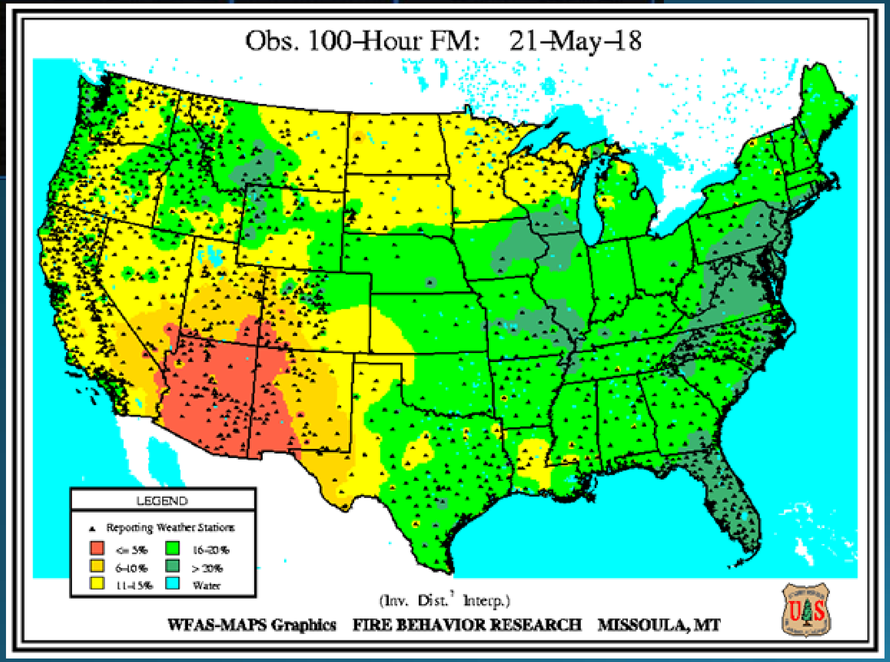


NWS Incident Meteorologists - Field

- Red Flag Warnings
- Incident Action Plan (IAP) Forecast
- Spot forecasts
- **Briefings**
  - Incident Command Staff
  - Field personnel
- Field updates
- 209 Weather

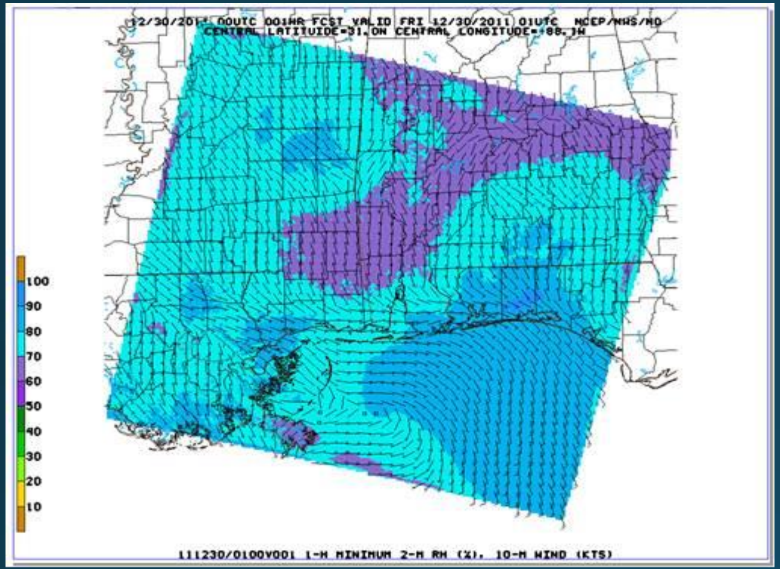
Forecast Process

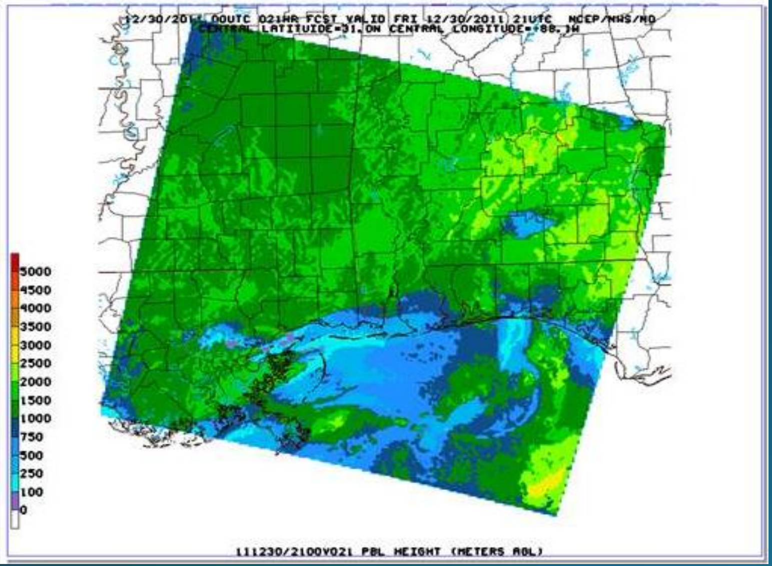




- Understand underlying climate regime
- Assess the atmospheric environment
  - Dry lines, frontal systems
  - Break down of upper level ridge
  - Thermal trough
  - Thunderstorm potential
  - Sea-breeze fronts
  - Hot, dry and unstable patterns
- Temperature, RH, Wind
- Evaluate fuel conditions
- Problem areas –current fires, new fires, anticipated emergence of fire

Issues and Challenges

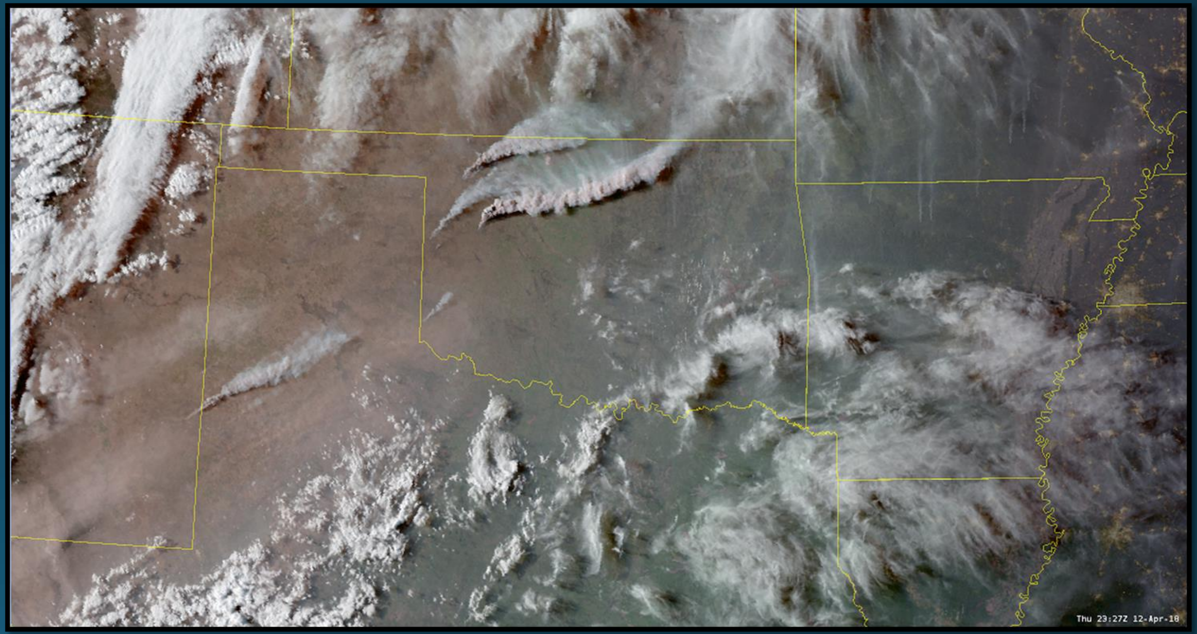




- Extreme fine scale forecasting – hundreds of meters, potential large domain
- Terrain influences create dynamic, chaotic environment
- High resolution data sets vs. low bandwidth, floating domain
- Data compression limitations
- Limited surface observing stations / field observations
- No fuels data in AWIPS

Satellite Data = Game Changer

- Fire structure, intensity and movement
- New fire occurrence
- Weather analysis and forecasting
- Thunderstorm development – GLM continuous current CG lightning data
- Smoke plume dynamics and extent



NATIONAL WEATHER SERVICE

Building a Weather-Ready Nation

JPSS in Western Region

Mike Stavish, SOO, NWS Medford

Question for Western Region Science and Operations Officers (SOOs)

“The ATMS and VIIRS are 2 primary instruments on NOAA-20 we are making use of - ATMS provides the NUCAPS imagery, and VIIRS includes the DNB imagery, SSTs, and Active Fires. How have you or any of your staff been making use of this data?”

“I don't think this gets used much here, especially during the winter. The passes are relatively infrequent, it's like we get a twice per day snap-shot so there's not much use in winter. I know a few will look at NUCAPS for pre-convective initiation soundings in the summer if we get a pass around 18-21z.”

“I would say NUCAPS is only used once every blue moon here. We don't use the VIIRS active fires here since GOES East/West works fairly well and being a geostationary satellite is a huge plus. “

“We're not using it operationally. We're currently not getting the Active Fires in AWIPS either. We've had some people take a look the DNB imagery and NUCAPS imagery early on, but it hasn't become part of the forecasters repertoire.“

“I think we've used the SSTs for a lake temperature program we use for the Great Salt Lake, but I didn't write the program and the forecaster who did is not in for several days. I have looked at the day-night band for geez-whiz factor but not for anything operational. Otherwise, I don't know of us using it. Our local satellite folks are cc'ed here.”

“We are getting the VIIRS active fire data into AWIPS. I can't say it's used a lot. We do use the HRRR Smoke forecasts, from they web and on AWIPS. I have a tool I'm experimenting with to create PotHaze/PotSmoke from HRRR smoke for the short term.”

Key Items

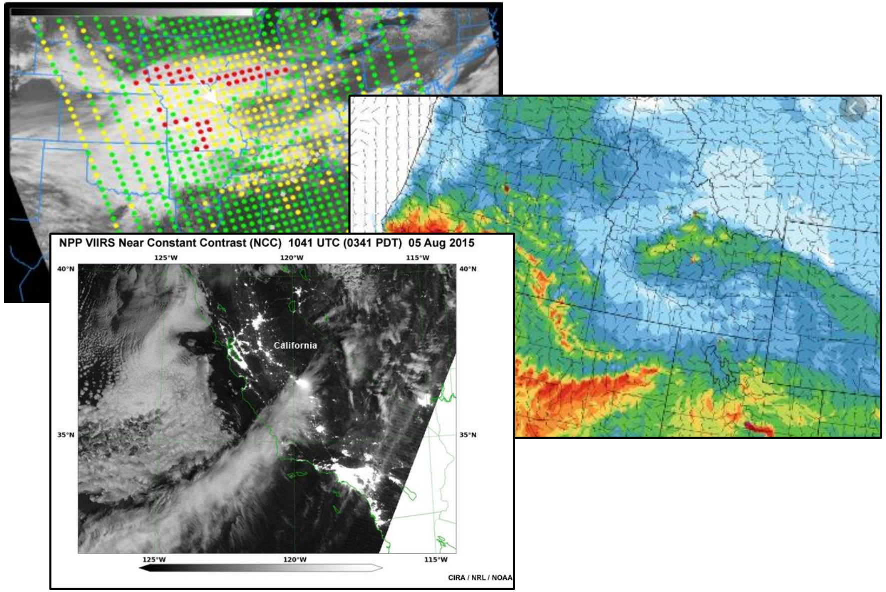
How are we using it? ...most common

<u>ATMS</u>

- NUCAPS

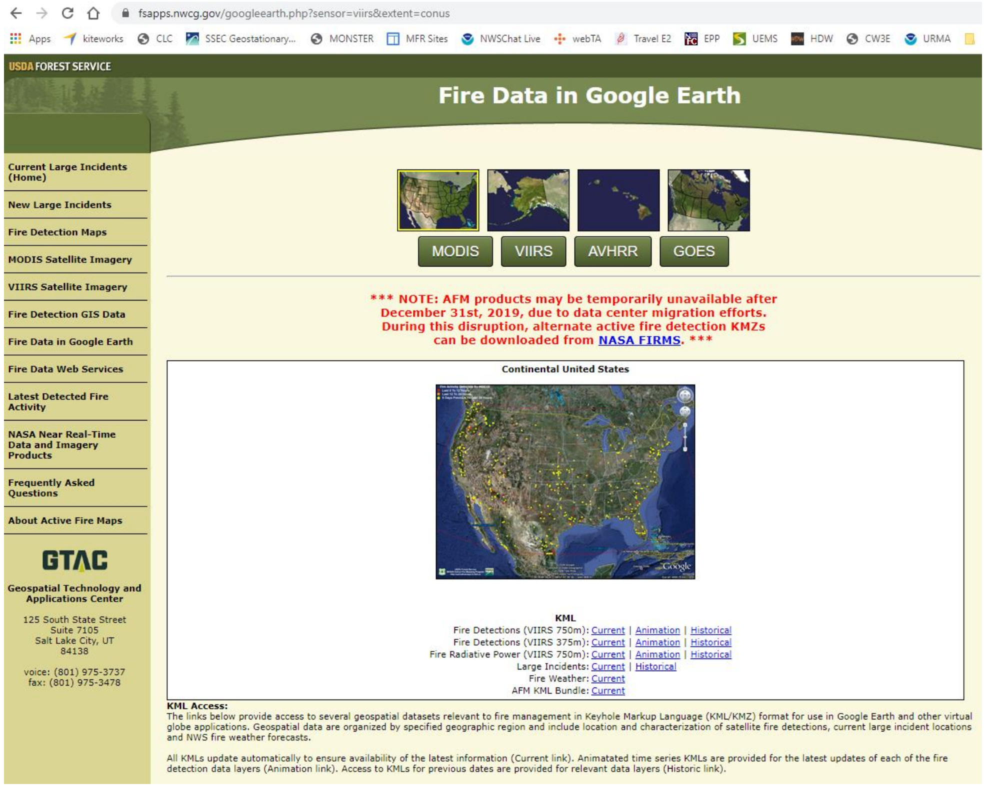
<u>VIIRS</u>

- Day Night Band (DNB) imagery
- SSTs
- Active Fires



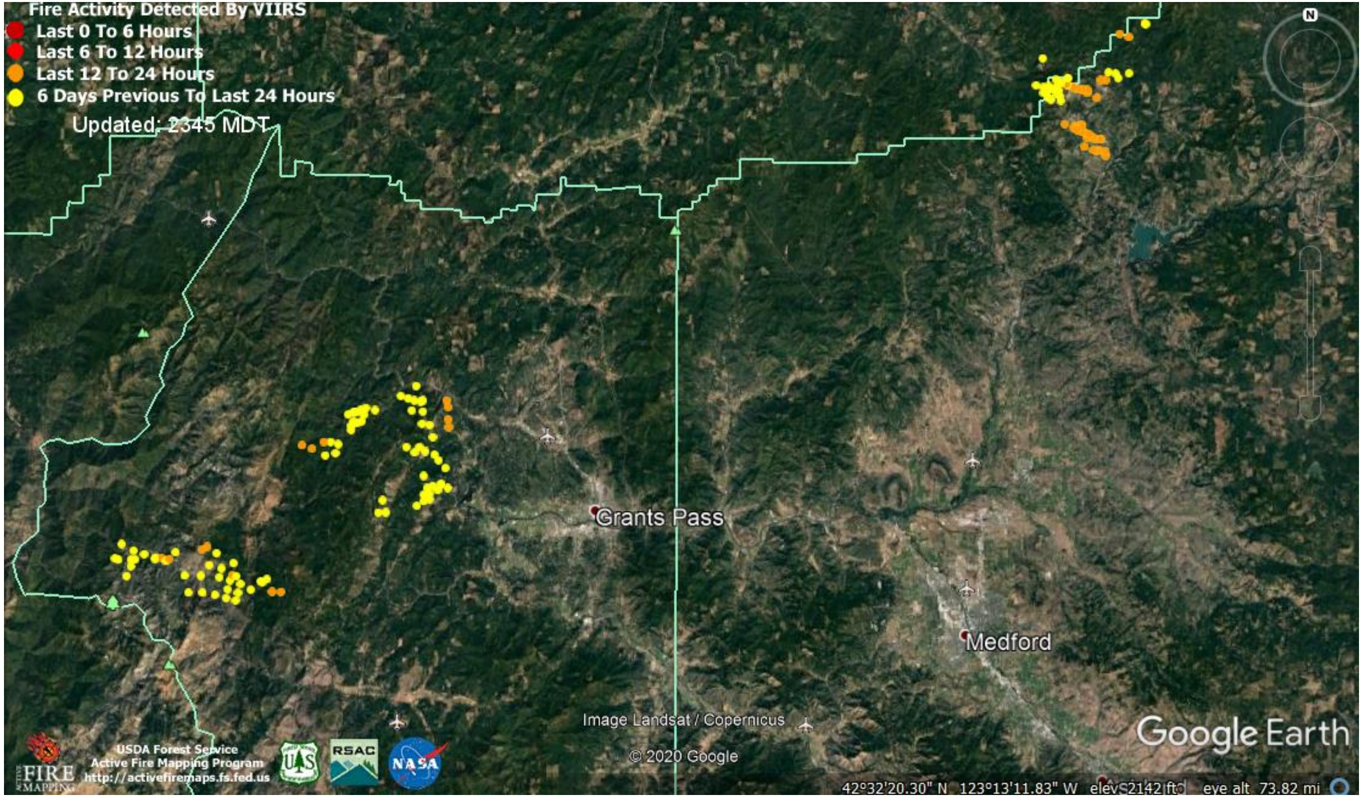
VIIRS Active Fires Online - NWCG

- NIROPS IR versus VIIRS for 1st morning update on fire progress



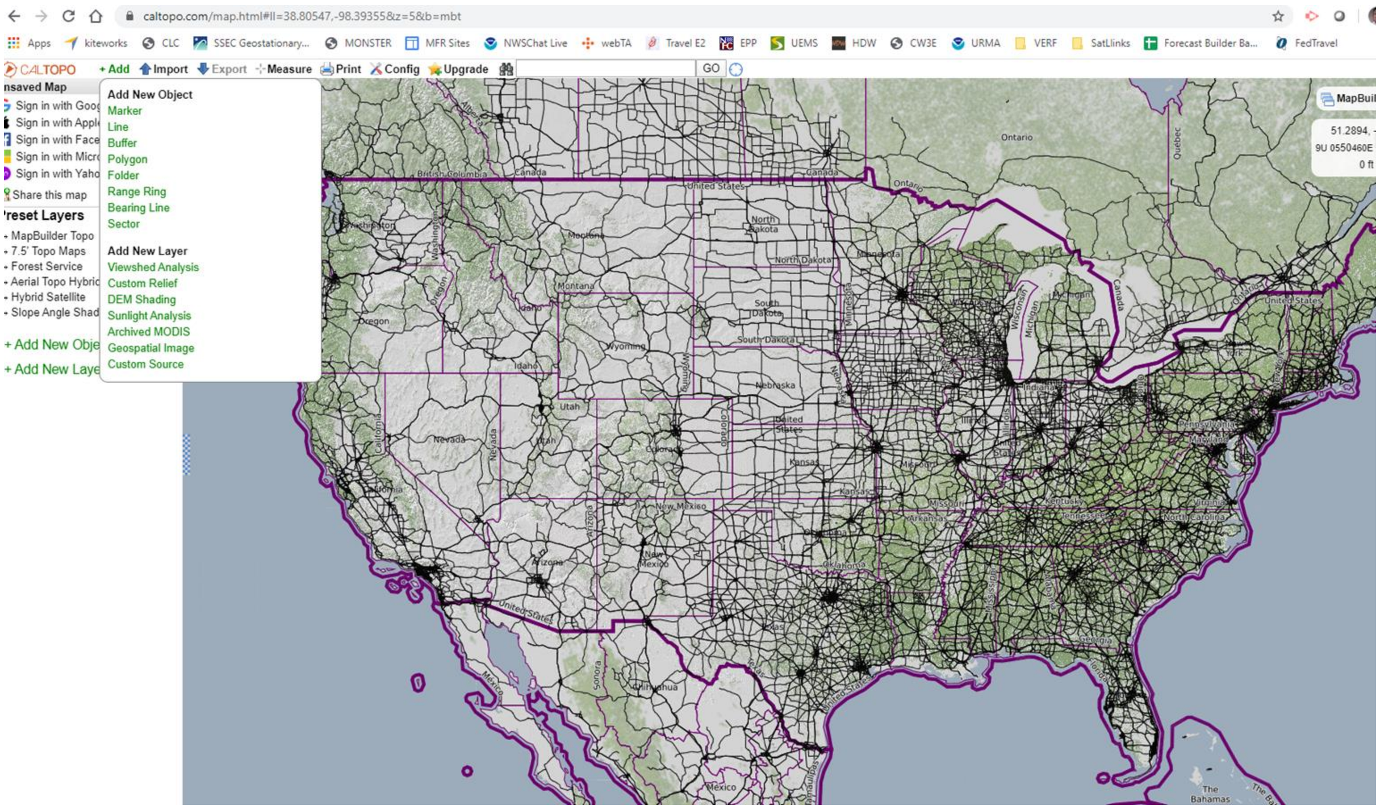
VIIRS Active Fires Online - NWCG

- **KMZ file download**
- **Dislays in Google Earth**
- **Useful for situational awareness, briefings, social media.**

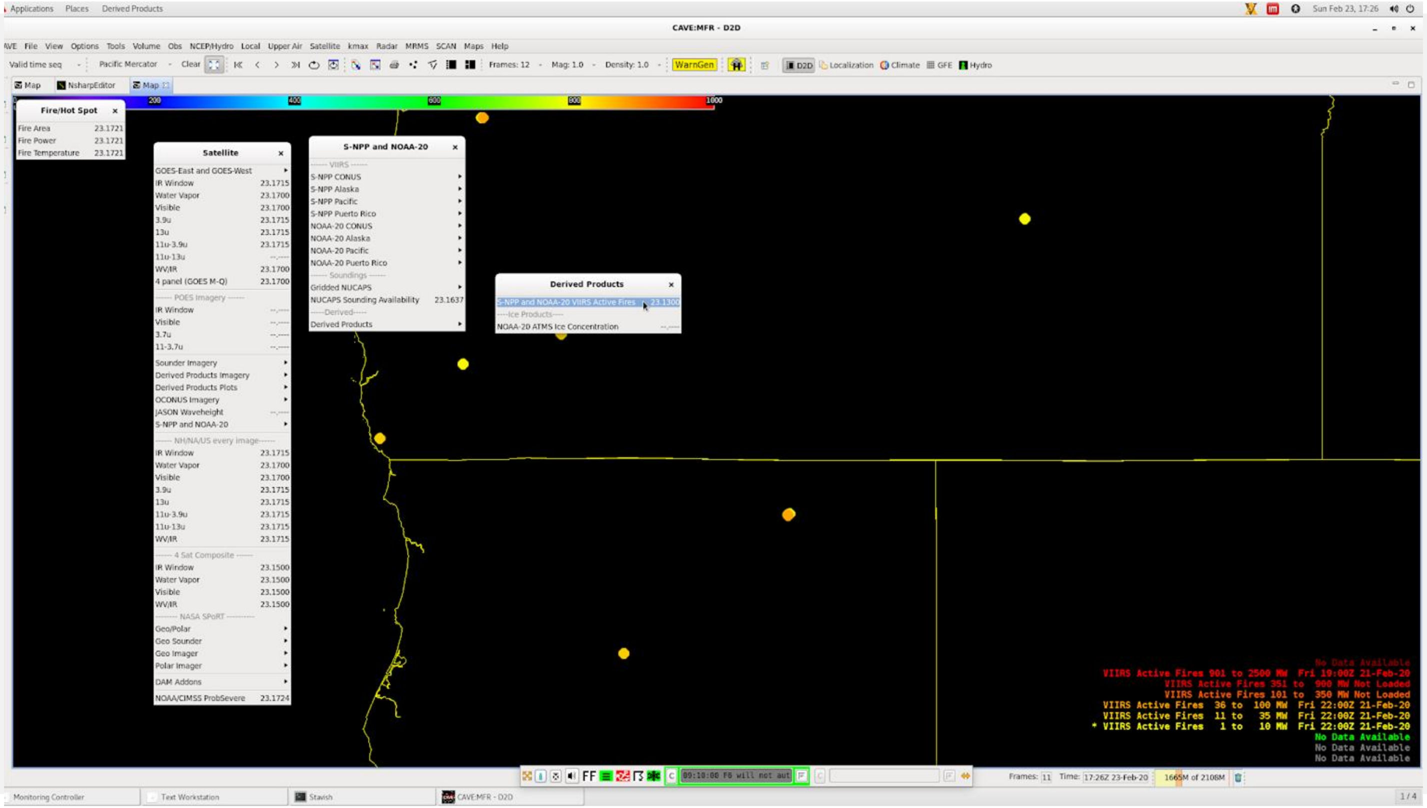


VIIRS Active Fires Online - NWCG

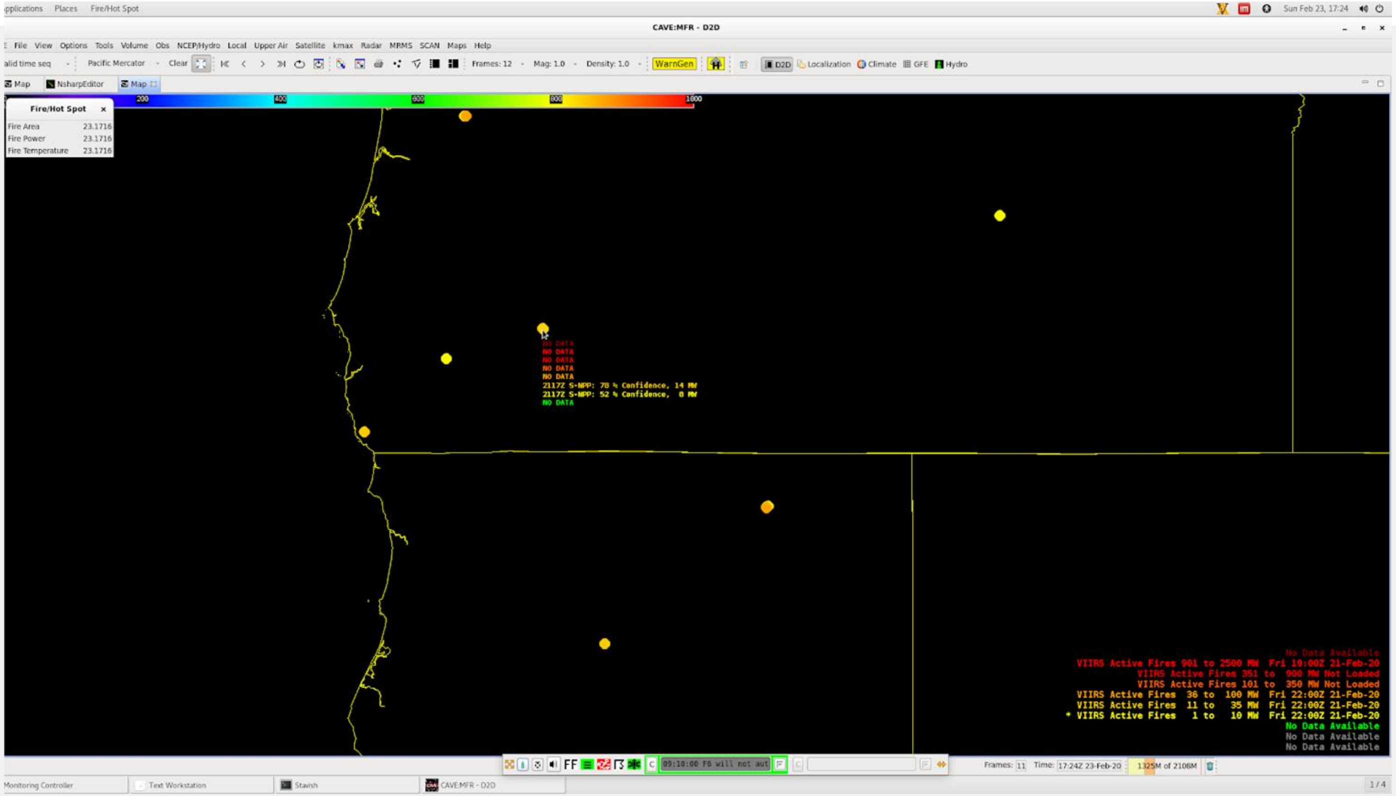
CalTopo


caltopo.com/map.html#ll=38.80547,-98.39355&z=5&b=mbt
Apps kiteworks CLC SSEC Geostationary... MONSTER MFR Sites NWSChat Live webTA Travel E2 EPP UEMS HDW CW3E URMA VERF SatLinks Forecast Builder Ba... FedTravel
CALTOPO + Add Import Export Measure Print Config Upgrade GO
Add New Object
Marker
Line
Buffer
Polygon
Folder
Range Ring
Bearing Line
Sector
Add New Layer
Viewshed Analysis
Custom Relief
DEM Shading
Sunlight Analysis
Archived MODIS
Geospatial Image
Custom Source
Share this map
MapBuilder Topo
7.5' Topo Maps
Forest Service
Hybrid Satellite
51.2894,
0 ft

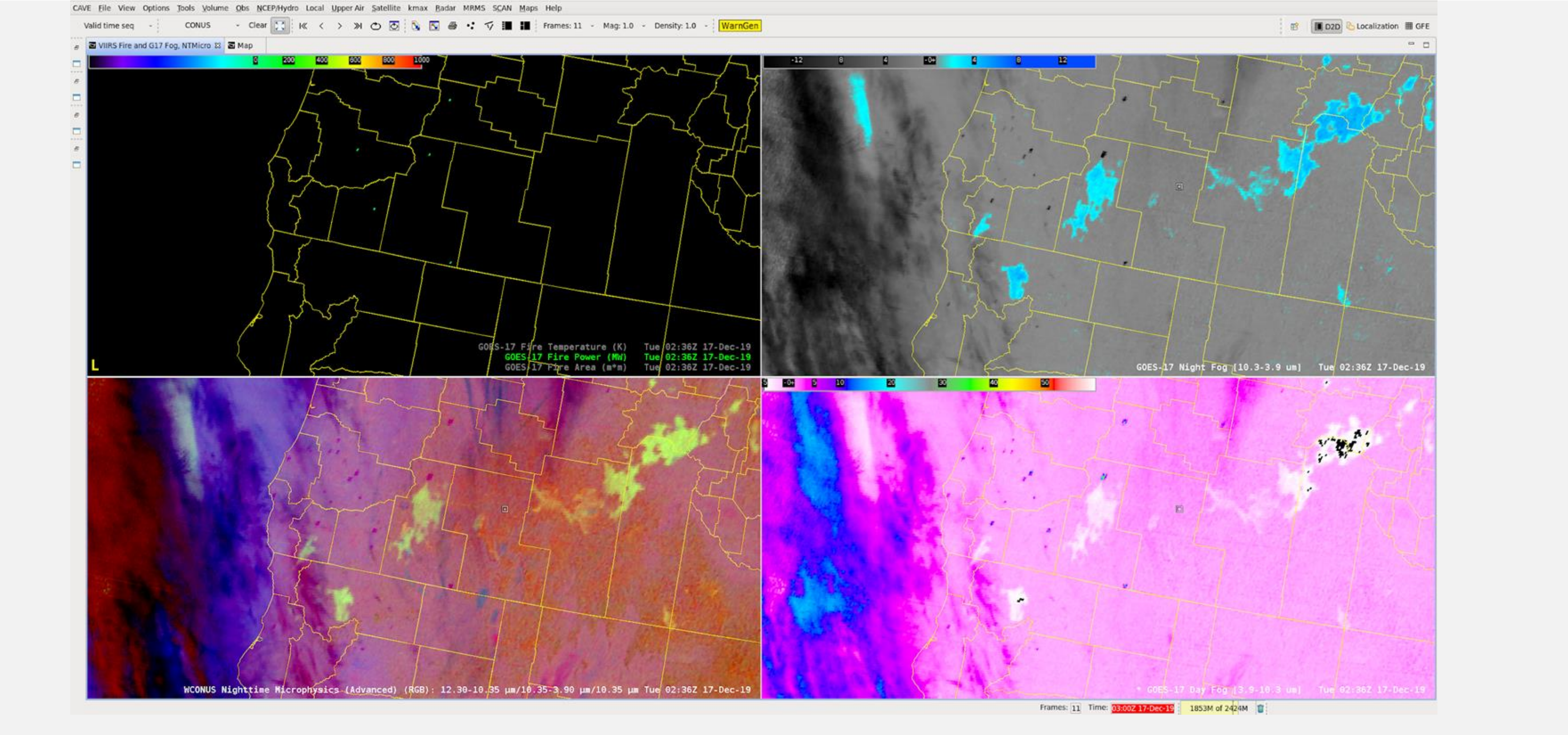
VIIRS Active Fires in AWIPS



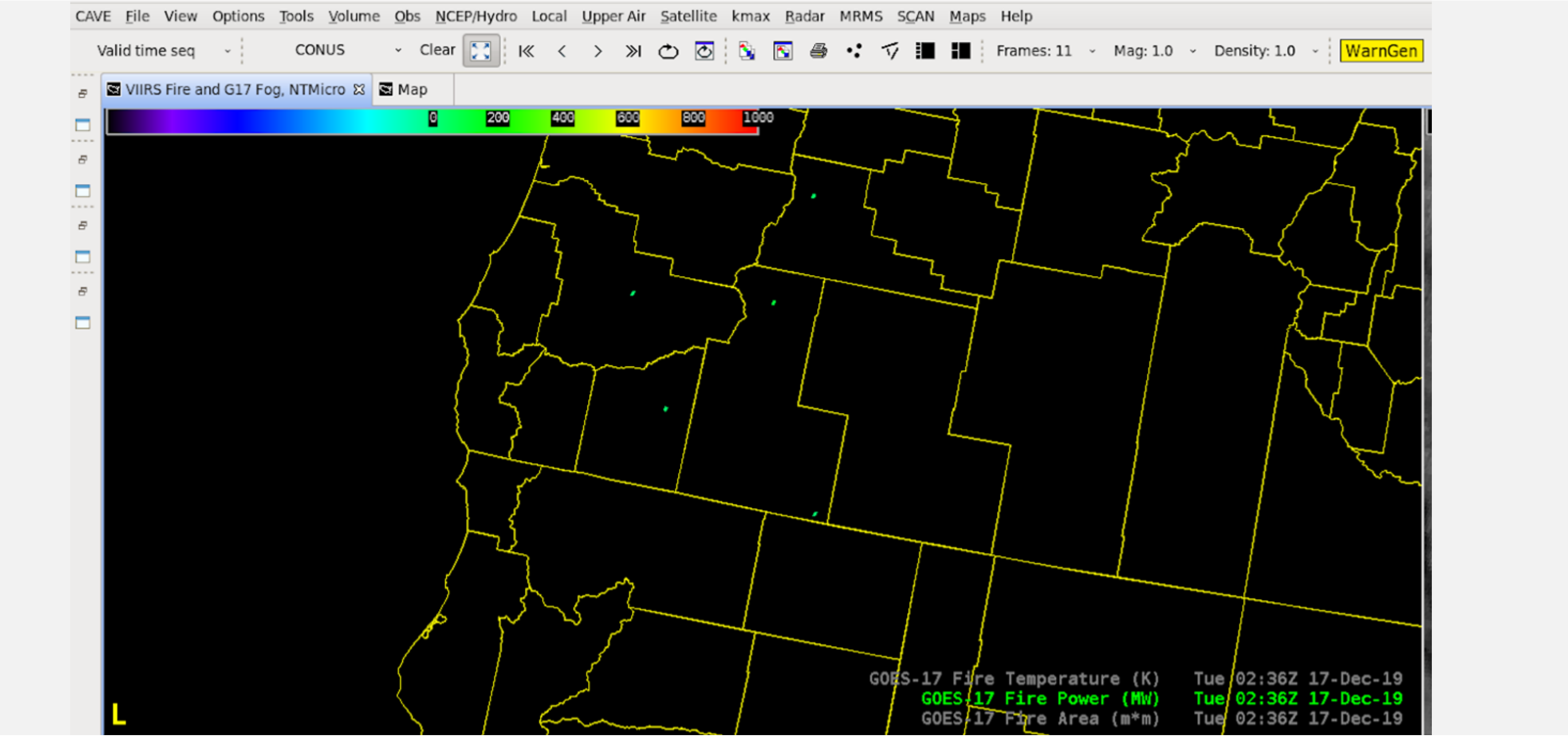
VIIRS Active Fires in AWIPS



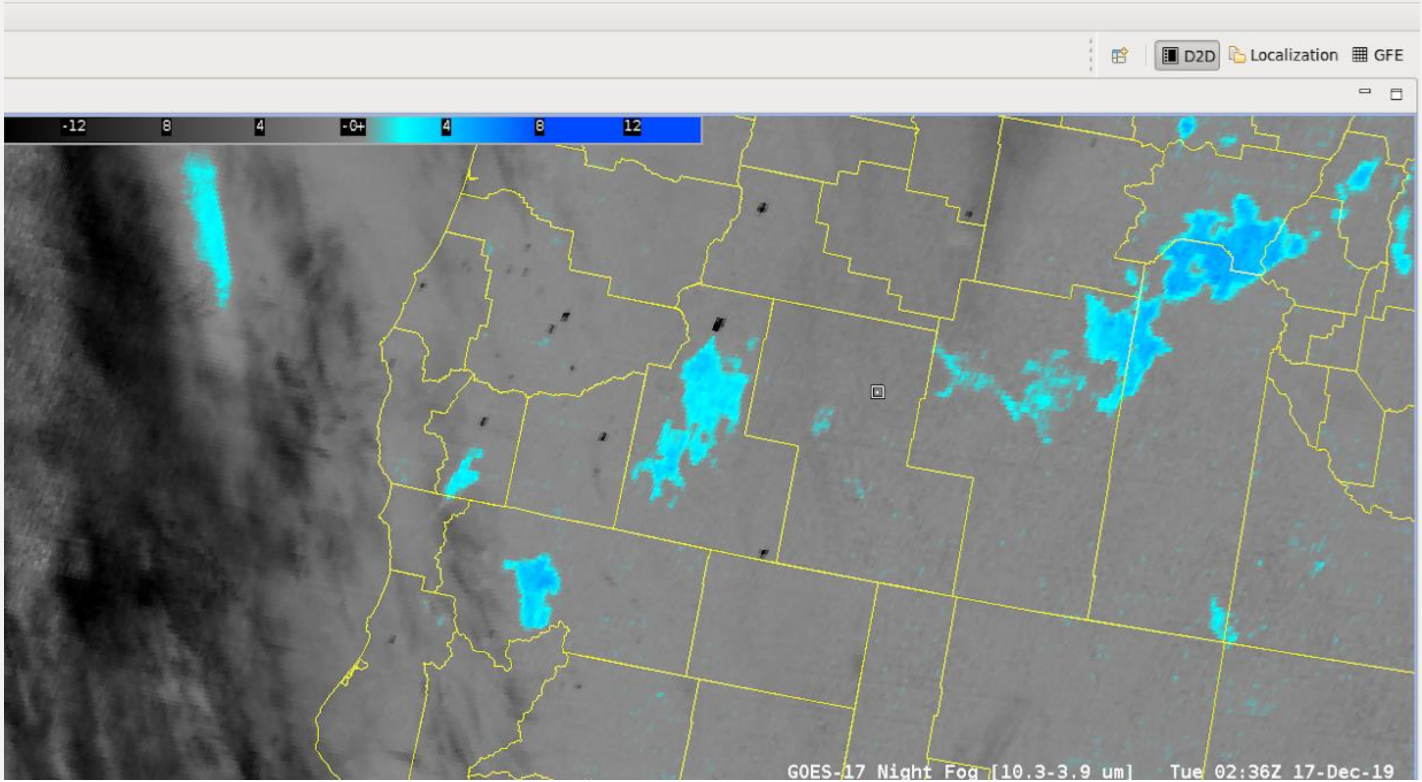
Prescribed Burns - GOES vs. VIIRS



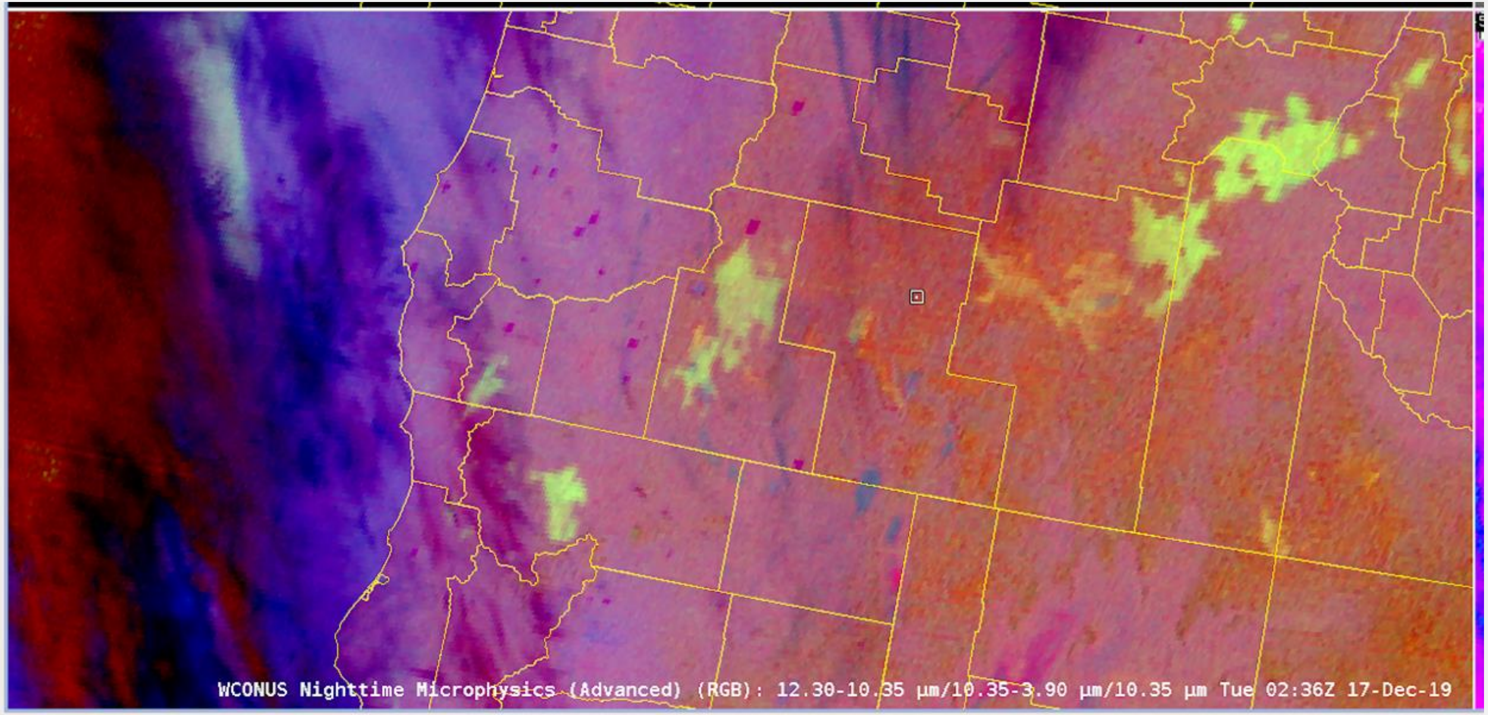
Prescribed Burns - GOES vs. VIIRS



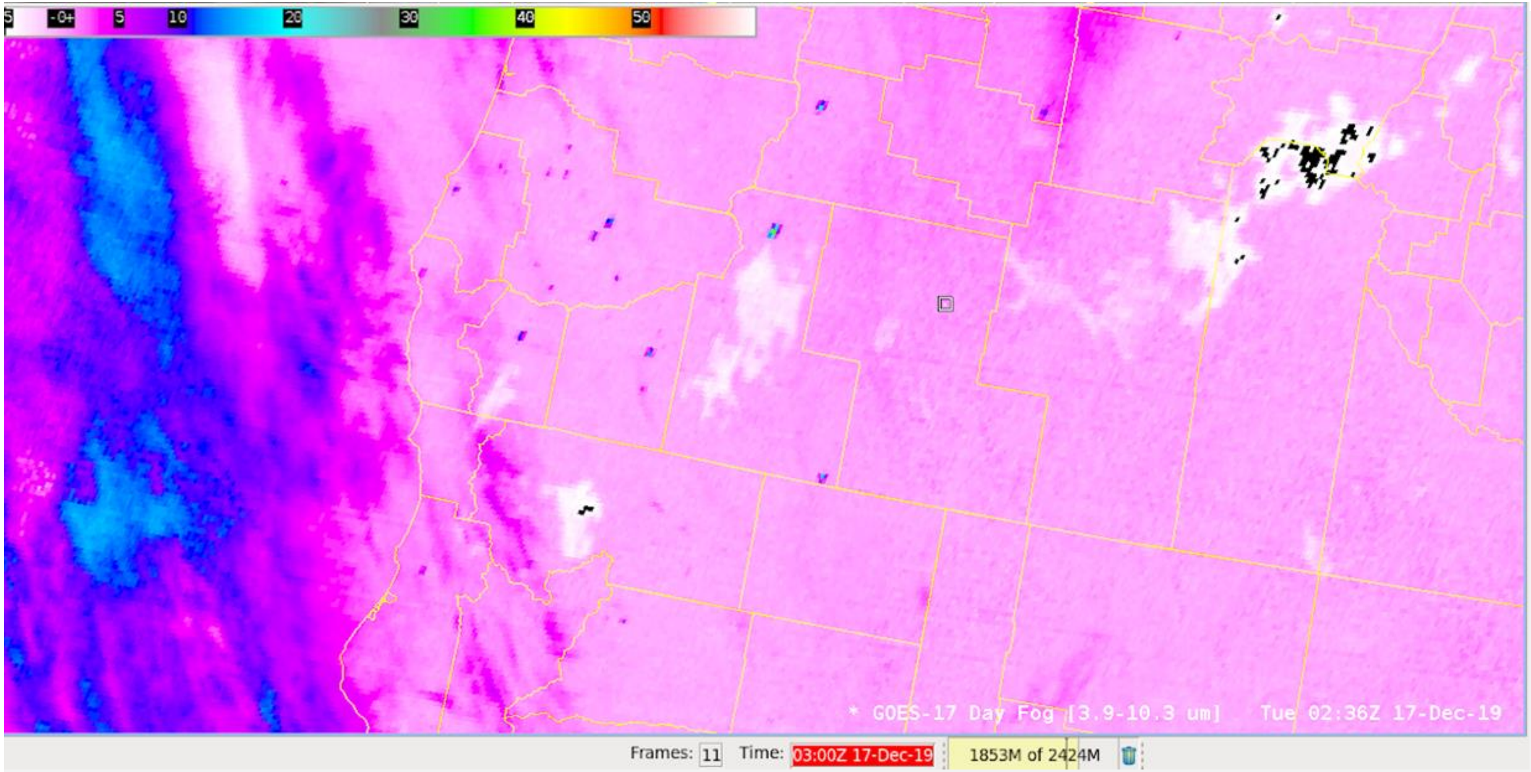
Prescribed Burns - GOES vs. VIIRS



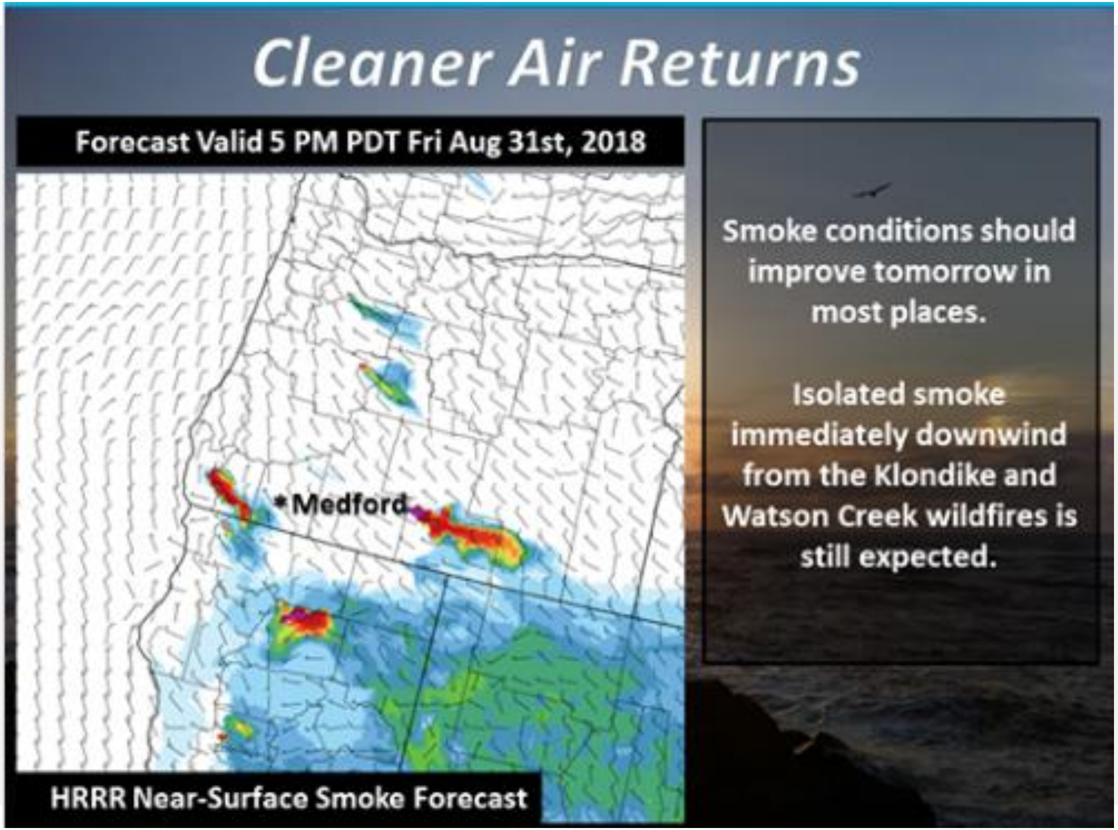
Prescribed Burns - GOES vs. VIIRS



Prescribed Burns - GOES vs. VIIRS



Fire Radiative Power (FRP) in HRRR SMOKE



Fire Radiative Power (FRP) in HRRR SMOKE

Mail Tribune

NEWS SPORTS OBITS LOCAL DEALS E-EDITION WATCH

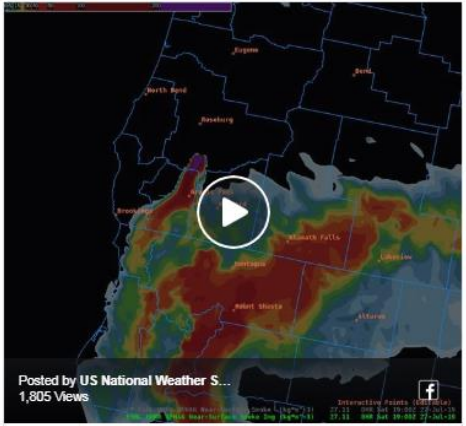
Consider it a smoke break

by Nick Morgan of the Mail Tribune | Saturday, July 27th 2019

Families take advantage of clear afternoon air to play at Don Jones Park Saturday in Central Point. Mail Tribune photo / Denise Baratta

The return to blue skies through Rogue Valley windows appeared to offer a glimmer of hope after two days of smoky skies, but meteorologists and public health officials see no end to smoke caused by a wildfire burning

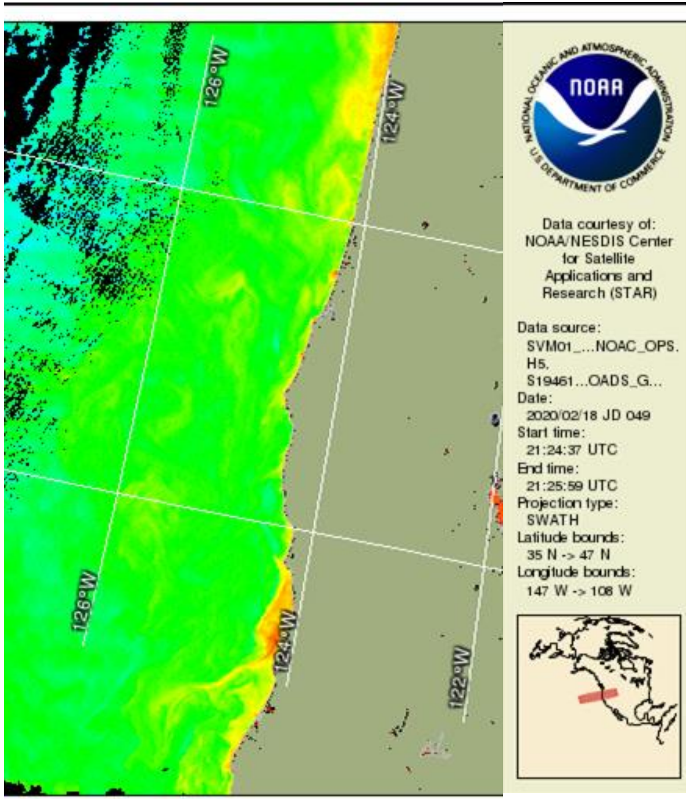
According to Keene, wind patterns and meteorologist predictions show that the smoke that's plagued Southern Oregon since Thursday will return late this afternoon between 3 and 7 p.m. Saturday and Sunday.



Here is a smoke forecast until Saturday evening. Again, north winds will carry new smoke into most of the valleys west of the Cascades. The purple

Sea Surface Temperatures

- SST use operationally is variable
- The prettier the better
- Mariners are savvy and appreciate this type of data



Thank You!

SATELLITE ANALYSIS BRANCH FIRE DETECTION PRODUCT: HAZARD MAPPING SYSTEM (HMS)

Davida Streett, John Simko, Wilfrid Schroeder

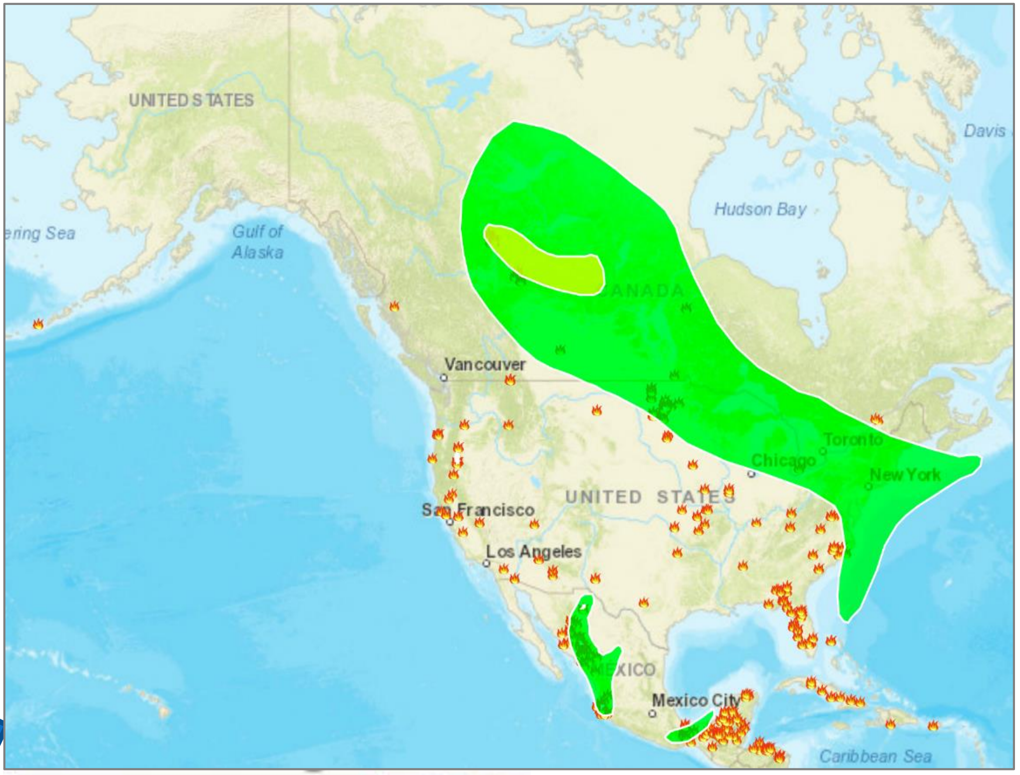
Satellites & Sensors

- S-NPP & NOAA-20 VIIRS
- GOES-16 & 17 ABI
- Terra MODIS
- Landsat-7/ETM+ & Landsat-8/OLI
- Sentinel-2/MSI

Coming soon: Sentinel-3/SLSTR

Fire Algorithms

- VIIRS AF (NOAA)
- ABI FDC (NOAA)
- MODIS MOD14 (NASA)



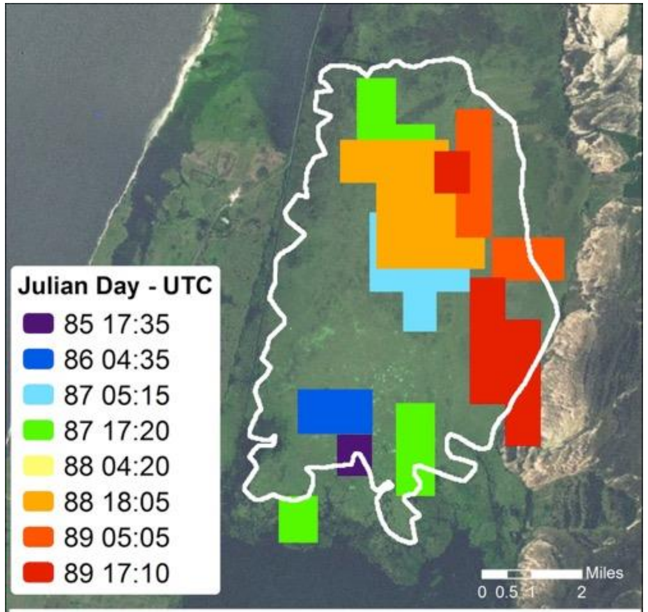
USERS include:

- NWS
- Forestry Service
- ARL
- EPA
- USGS
- BLM
- State/local land mngt
- State/local air quality
- FEMA
- DOD
- Fire responders
- Researchers
- Public

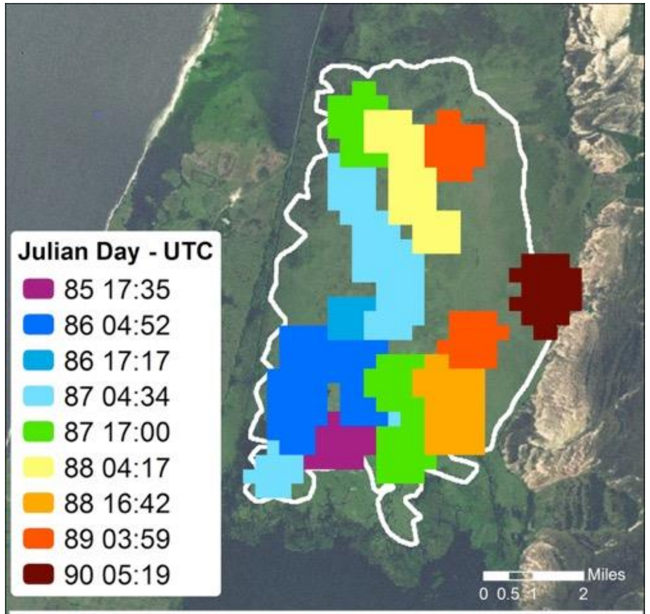
VIIRS Active Fire Detection Data

NDE’s baseline VIIRS 750m active fire detection data [Csiszar et al., 2014] was used in HMS until Fall/2018 when it was replaced with alternative VIIRS 375m algorithm [Schroeder et al., 2014]

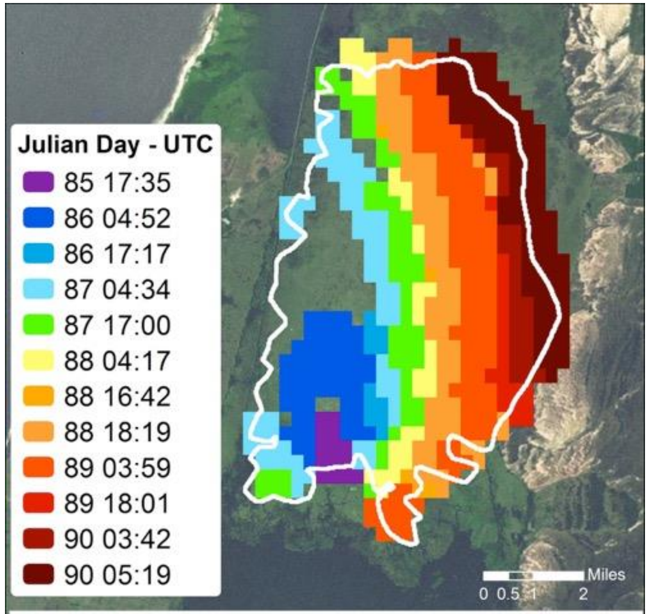
- Improved detection of small fires & mapping of large fires, very low commission error (<1% globally)
- S-NPP and NOAA-20 data being processed at OSPO/SAB, awaiting implementation in NDE



Aqua/MODIS 1 km



S-NPP/VIIRS 750 m



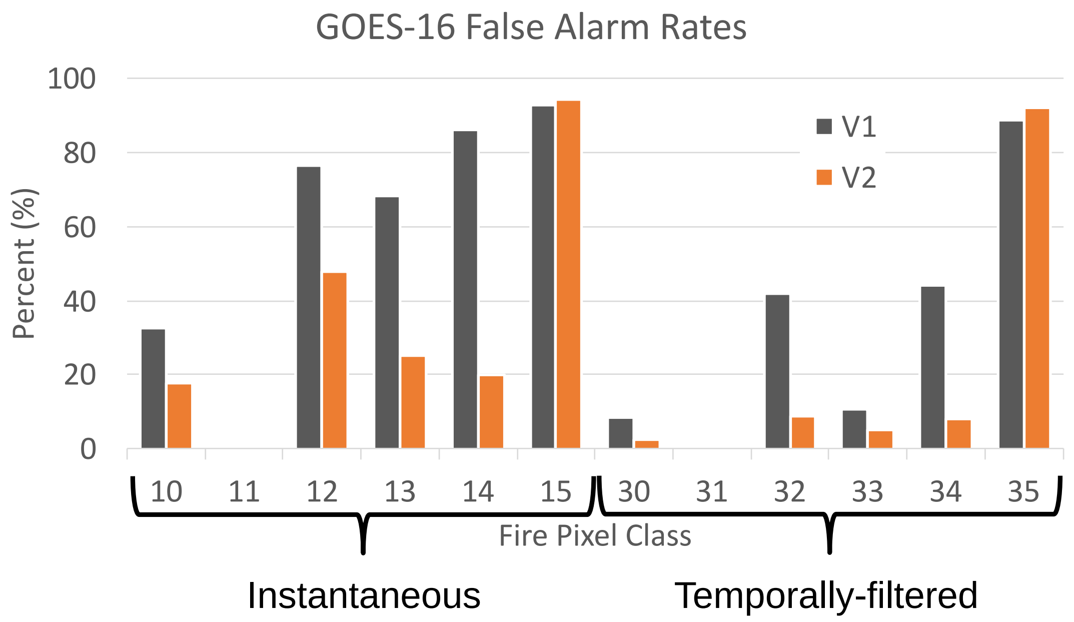
S-NPP/VIIRS 375 m

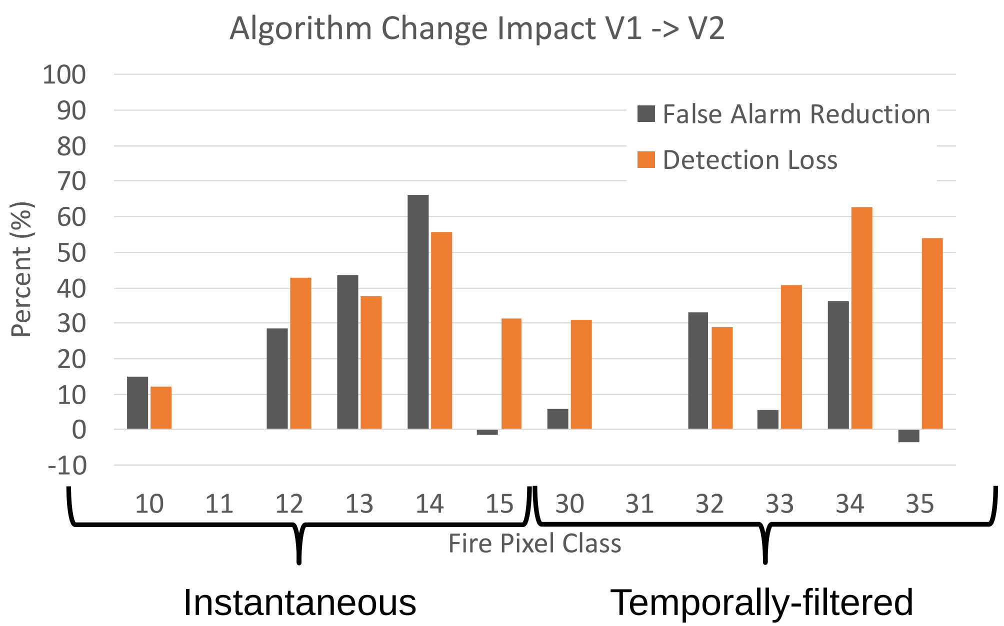
ABI Active Fire Detection Data

Baseline Fire Detection and Characterization (FDC) algorithm built on legacy Wildfire Automated Biomass Burning Algorithm (WF-ABBA) [Prins and Menzel, 1992]

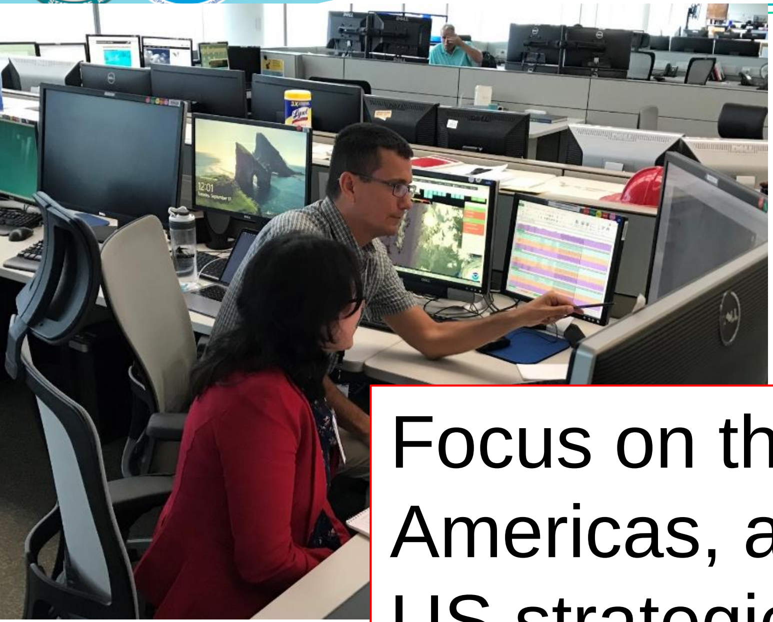
- Subpar performance leading to abnormally high omission and commission errors during *Beta* status review
- Algorithm changes implemented before/after *Provisional* status review
  - Commission errors were reduced, while still significantly higher than MODIS and VIIRS products
  - Noticeable increase in omission errors

SAB looking at alternatives to FDC (e.g., EUMETSAT's MSG, custom algorithm through NASA/NOAA proposal)

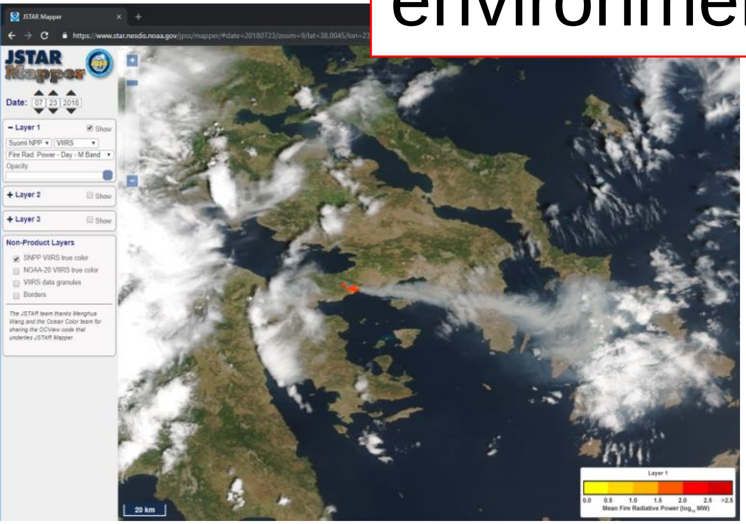




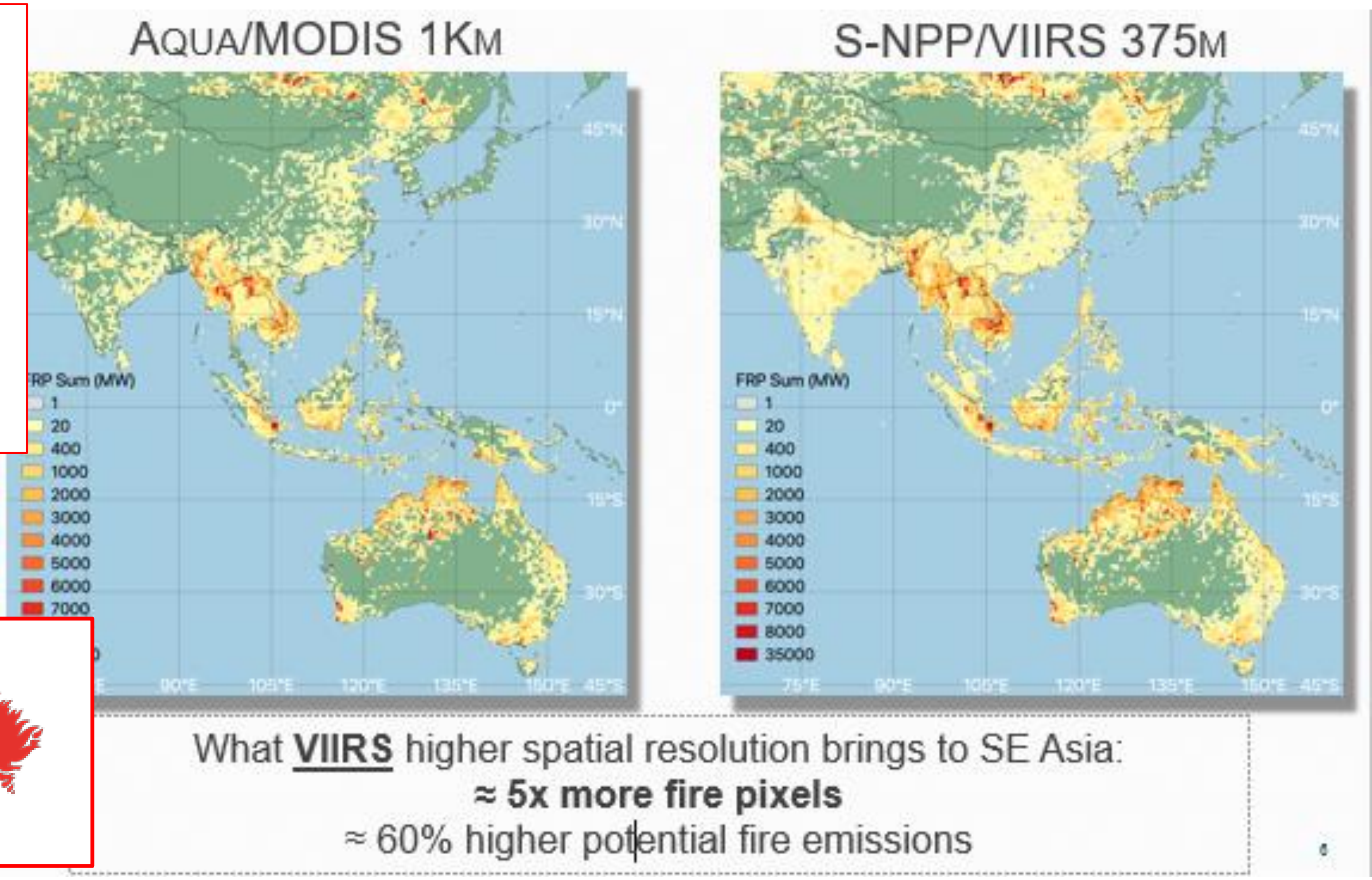
International Collaborations on Satellite Analysis of Fires Using NOAA satellite analysis techniques or satellite data



Focus on the Americas, areas of US strategic interest, or worldwide environmental impact



RedLaTIF
Red Latinoamericana de Teledetección e Incendios Forestales



CURRENT AND FUTURE DIRECTIONS

If we can free up staffing with better algorithms or in other ways, we could start or increasingly…

- Serve as a SME helping CalGuard and its successors, NWS personnel, and other govt agencies with satellite-based fire analysis expertise
- International Disaster Charter satellite analysis response
- Tailored, more strategic detailed fire analysis for disastrous fires
- Increased coordination with international satellite fire analysis community for mutual benefit

High-resolution (3km) forecasting of smoke, visibility and smoke-weather interactions for the US by ingesting the VIIRS and MODIS FRP data into the experimental HRRR-Smoke model

Ravan Ahmadov[1,2] (*ravan.ahmadov@noaa.gov*)

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

JPSS proving ground and risk reduction program

[1] Cooperative Institute for Research in Environmental Sciences, University of Colorado at Boulder, Boulder, CO, USA

[2] Earth System Research Laboratory, NOAA, Boulder, CO, USA

[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

Woolsey fire, CA

San Francisco skyline during the Camp fire, November 2018

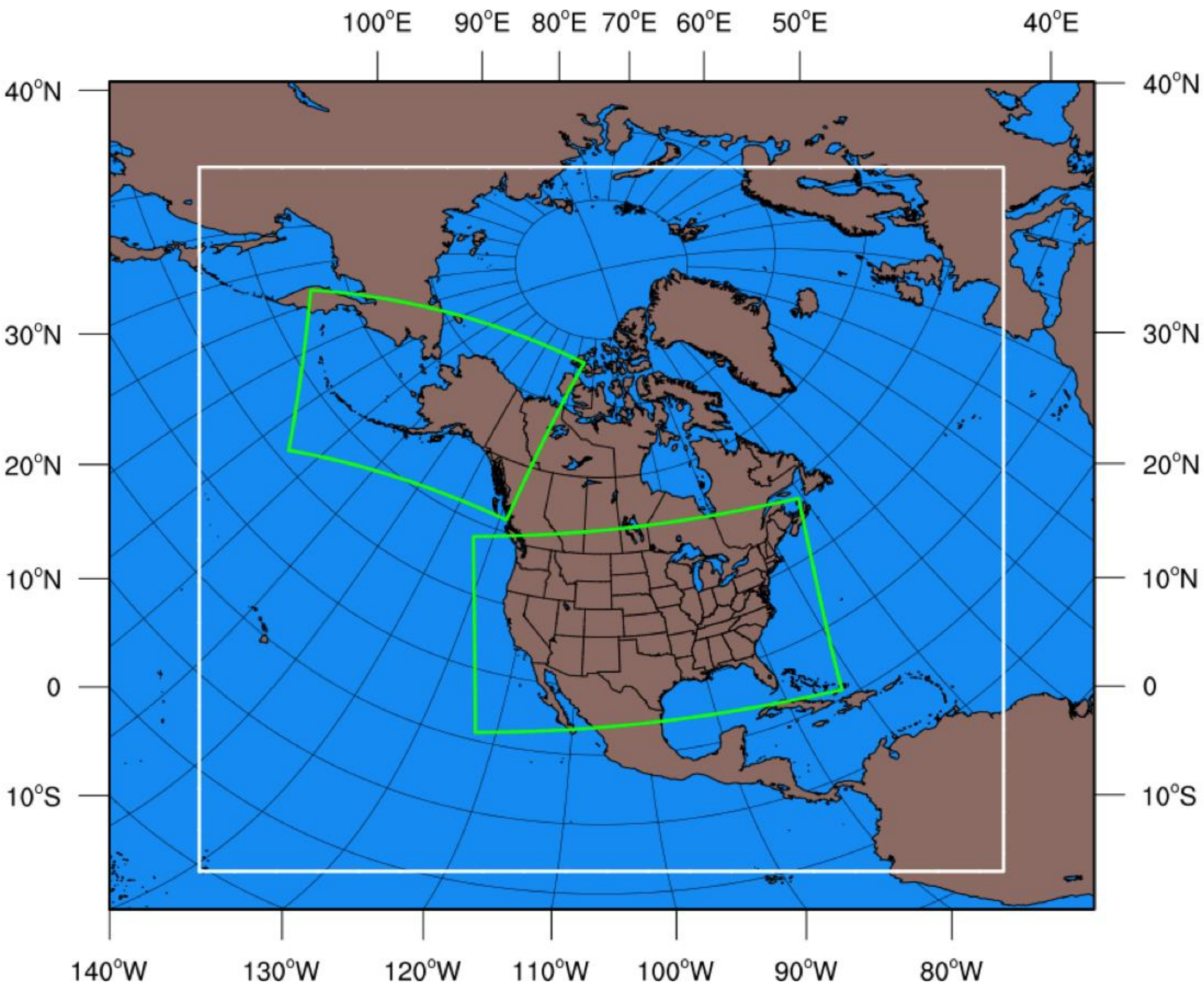
There is an increasing demand for high spatio-temporal resolution smoke forecasts over the US for various applications:

- Smoke/air quality alerts (impact on health and outdoor activities)
- Visibility (ground transportation, aviation…)
- Smoke impact on meteorology to improve weather forecasting
- Solar energy production

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

RAP/HRRR-Smoke models

- We take advantage of the existing NWP systems by adding a **single tracer (smoke)** to GSD's experimental RAP and HRRR weather forecasting models.
- We started in summer 2016 running HRRR-Smoke in real-time for CONUS. RAP-Smoke was started running in 2018;
- RAP-Smoke enables forecasting smoke from all the fires in North America. It provides boundary conditions for smoke to HRRR-Smoke.
- HRRR-Smoke is 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. The coupling also helps to improve the visibility forecasting.
- Biomass burning emissions and inline plume rise parameterization based on the satellite FRP data.
- **The smoke forecasting capability is a part of the next update of NOAA's operational RAP-Smoke, HRRR-Smoke-CONUS and HRRR-Smoke-Alaska models.**

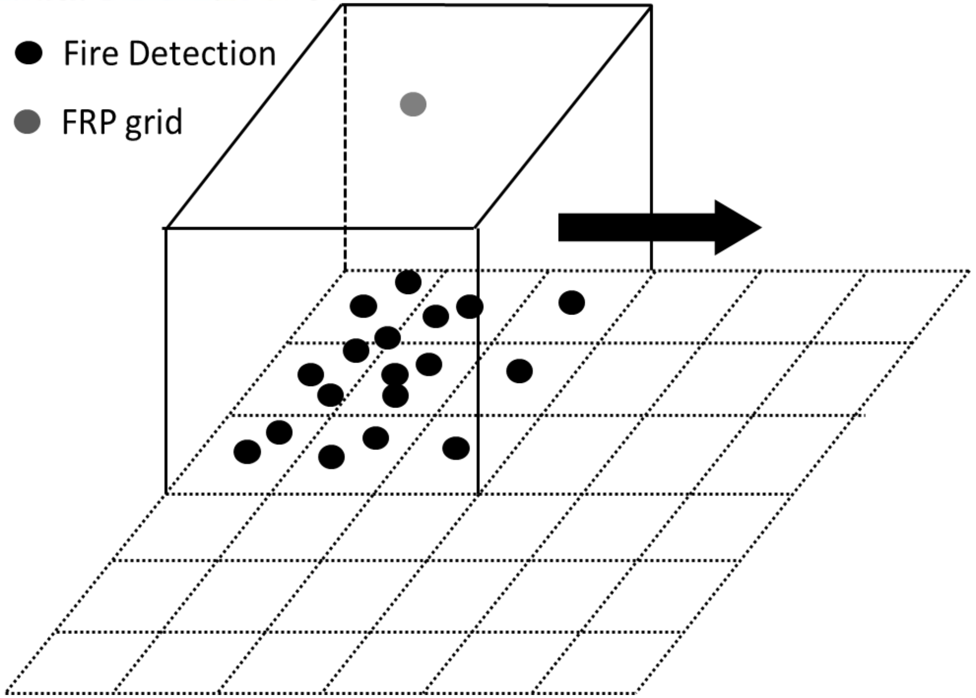


Operational weather forecast models at NCEP:
RAP (white), 13.5 km resolution
HRRR model domains (green), **3 km** resolution
(https://rapidrefresh.noaa.gov/)

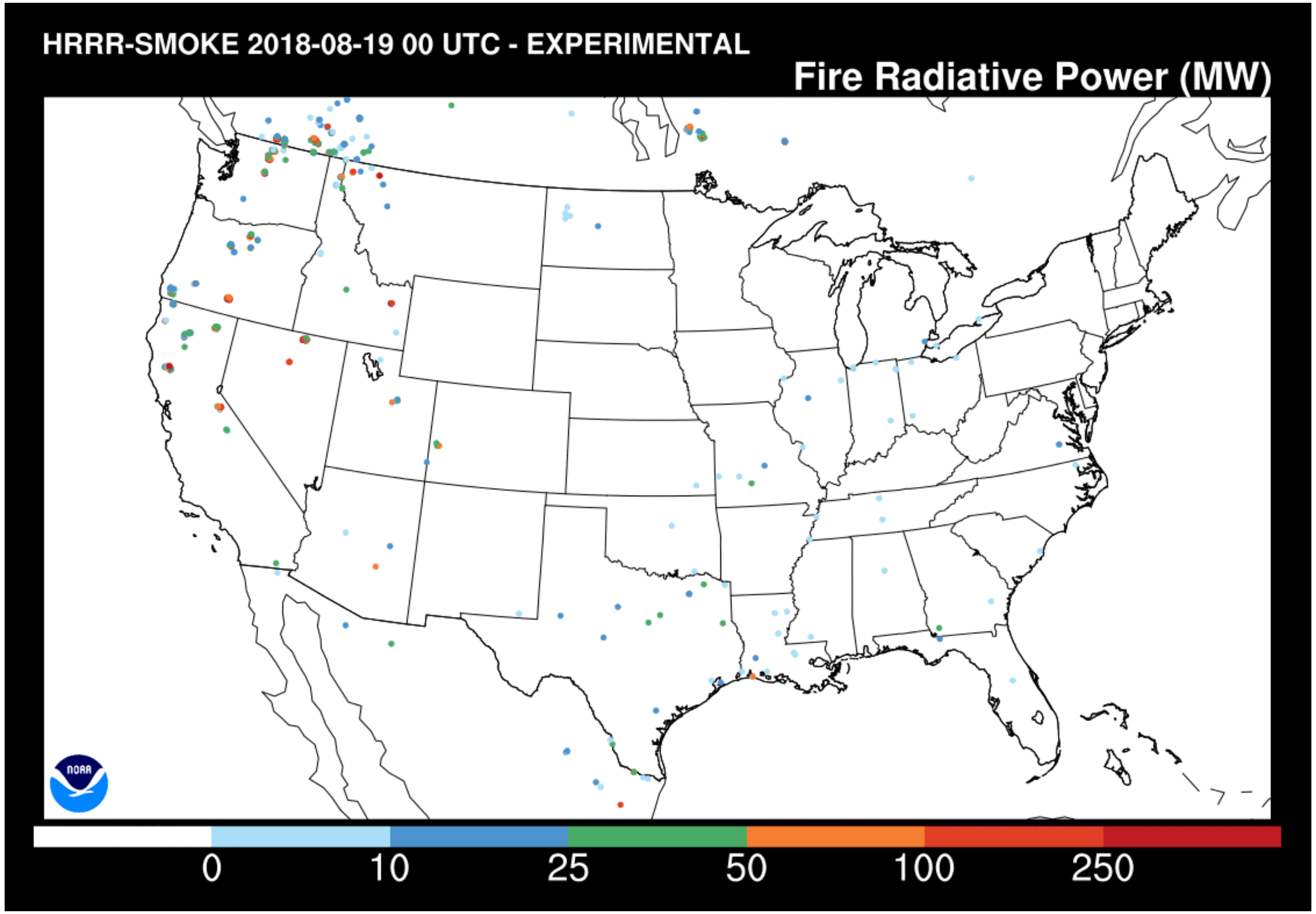
Mapping the satellite FRP data to the HRRR-Smoke CONUS grid

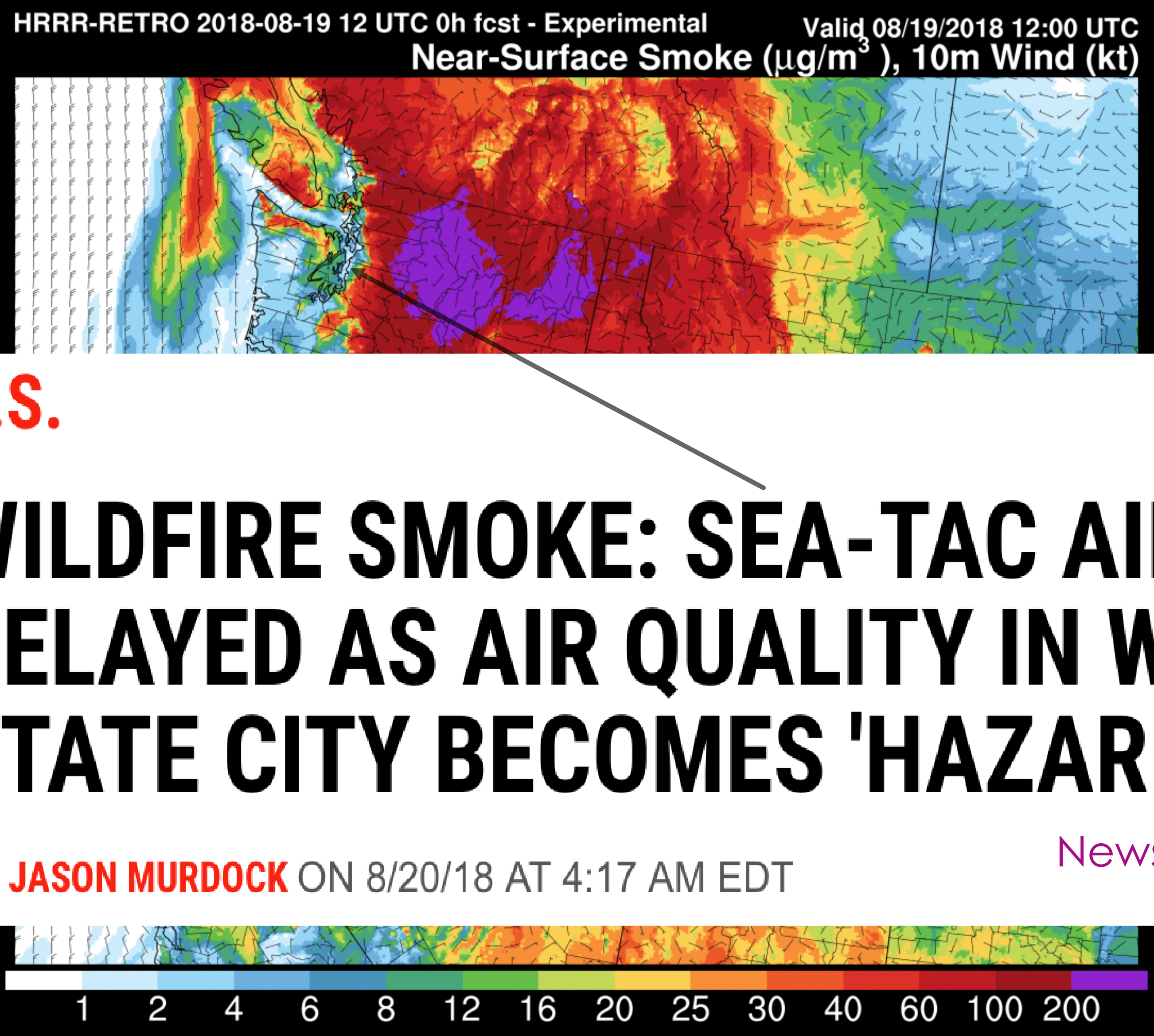
The clustering procedure performs a combination of all detected fires from VIIRS (S-NPP and NOAA-20) and MODIS (Terra and Aqua) according to the model spatial resolution and grid configuration

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

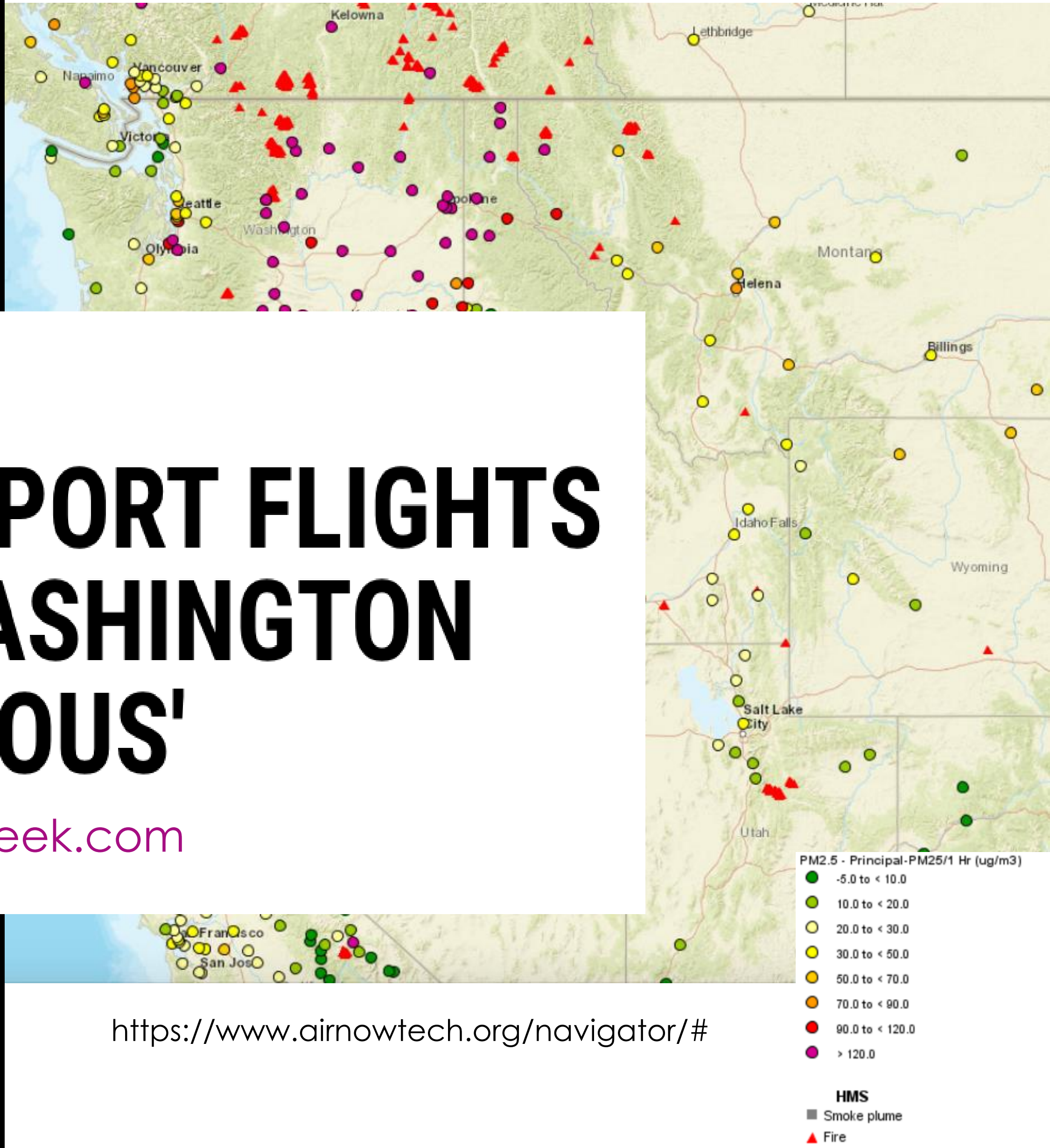


Averaged satellite FRP data mapped over 3x3km HRRR CONUS grid pixels for August 19, 2018





PM2.5 concentrations (AirNow network)
8pm PDT, August 19, 2018



U.S.

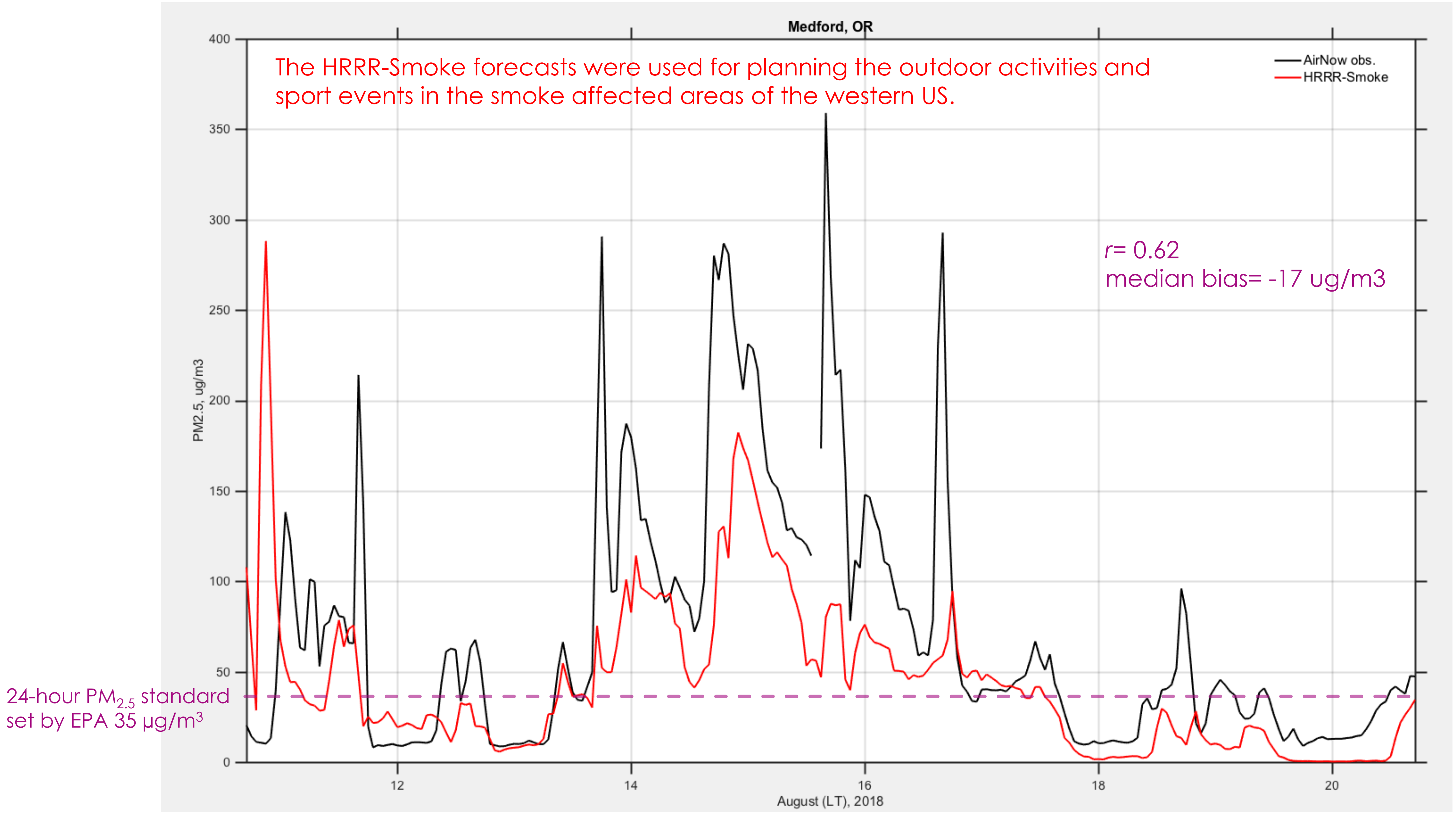
WILDFIRE SMOKE: SEA-TAC AIRPORT FLIGHTS DELAYED AS AIR QUALITY IN WASHINGTON STATE CITY BECOMES 'HAZARDOUS'

BY JASON MURDOCK ON 8/20/18 AT 4:17 AM EDT

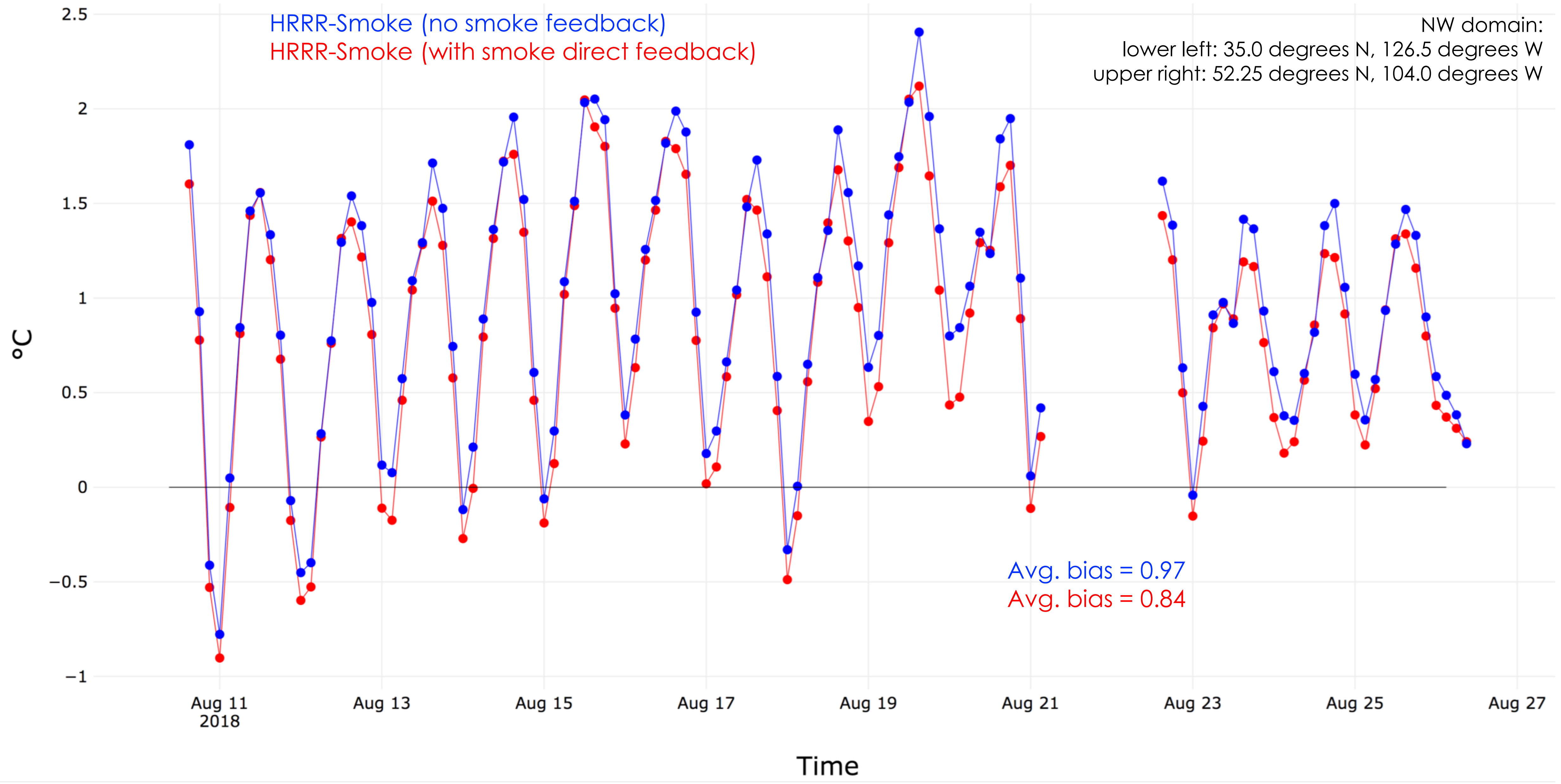
Newsweek.com

https://www.airnowtech.org/navigator/#

HRRR-Smoke vs. AirNow PM2.5 measurements (August 11-20, 2018)

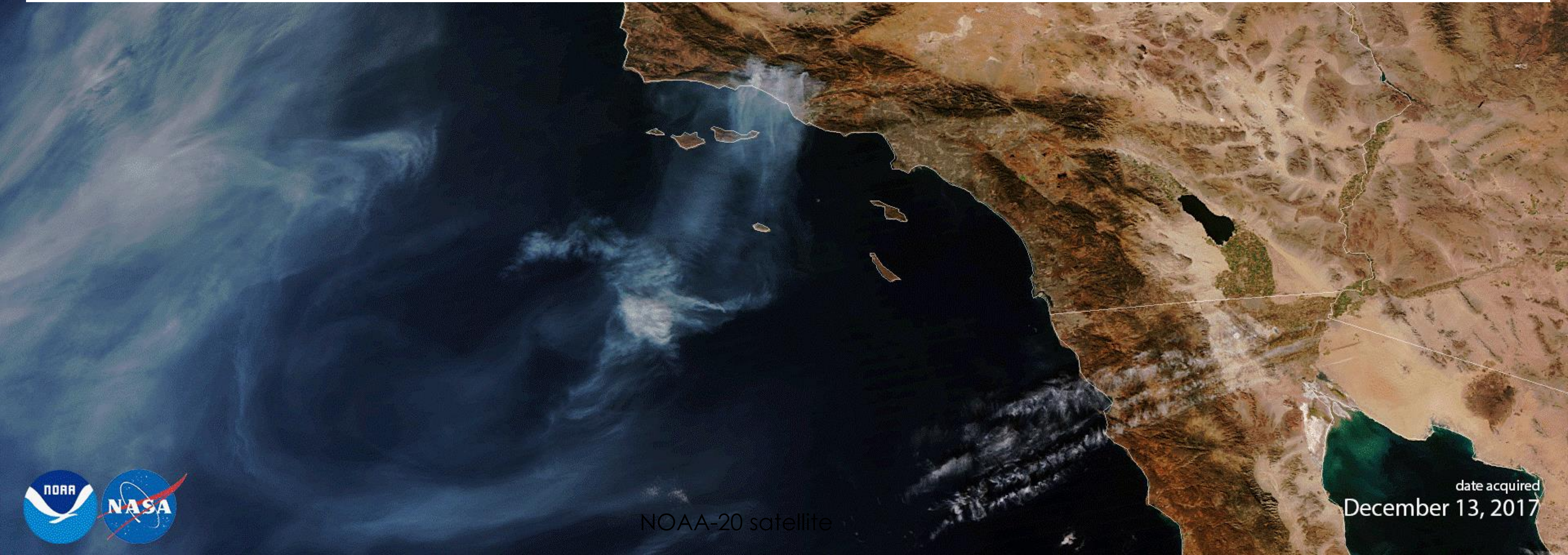


Verification of avg 2m temp bias (model-obs.) of 12 hour HRRR-Smoke forecasts over western US



Future plans

- *Ingest the high-frequency GOES-R/S FRP data into RAP/HRRR-Smoke;*
- *Transition HRRR-Smoke to the operational system at NCEP;*
- *Assimilate the VIIRS AOD in HRRR-Smoke;*
- *Transition to the FV3 based convection allowing model;*



NOAA Active Fire Product Status and Developer’s Perspective

presented by

Ivan Csiszar

NOAA/NESDIS Center for Satellite Applications and Research

Some lessons learned from the Fire and Smoke Initiative

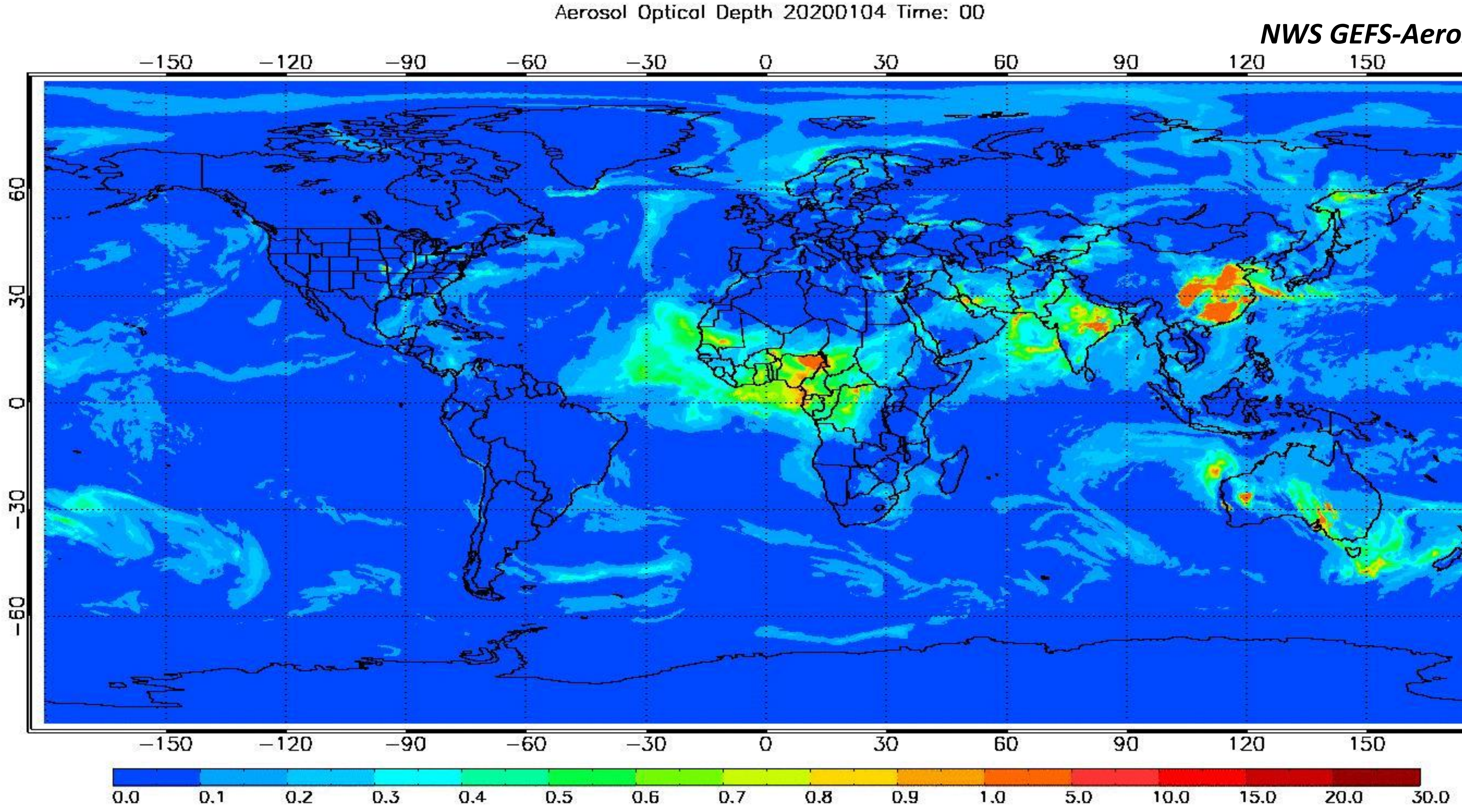
- Active (AF) fire information: distinct fundamental operational applications
  a. Early detection, monitoring, situational awareness, disaster and resource management
  b. Fire behavior / spread modeling
  c. Emission estimates for quantitative air quality monitoring and prediction
- A broad range of tailored AF products to meet specific user needs
  - Band imagery, band combinations, fire RGB, DNB etc.
    - Serve best a. above
  - Automated detection, fire radiative power (FRP), (+area / temperature) (i.e. current baseline products)
    - Serve best b. and c. above
- Need to develop / operationalize additional fire-related products
  - Fuels, fuel condition, burned area, recovery etc.
    - e.g. burned are for debris flow
- GEO-LEO distinction getting blurry
  - GEO: situational awareness – great temporal coverage and latency, but less sensitivity
  - LEO: model initialization – poor temporal coverage and latency, but great sensitivity

VIIRS baseline product status

Algorithm	Suomi NPP	NOAA-20
750m M-band: NDE v1r2*	Operational since March 15, 2016	Operational since August 13, 2018
375m/750m I/M-band: STAR v2r1	Systematic production since January 30, 2018	Systematic production since February 5, 2018

- **Global NRT data**
  - 750m product from NDE ->PDA
  - 375m product through STAR ftp
  - All included in JSTAR Mapper
  - *750m product upgraded to v1r2 with a post-processor to add persistent anomaly flag
- **CSPP / CIMSS (DB)**
  - 750m and 375m product included
  - CIMSS processes and distributes DB data
  - Now included in RealEarth™
- **HRRR-smoke**
  - Non-operational products provided through STAR ftp
  - Operational products through PDA
- **GBBEPx**
  - Uses operational M-band data

NWS GEFS-Aerosol



- SNPP and NOAA-20 VIIRS FRP used to estimate **near real time** Global Biomass Burning Emissions Product (GBBEPx) that is **operational** and used as input to NWS **operational** and experimental aerosol prediction models
- The above animation shows extremely high AODs due to emissions from fires in Australia on January 4, 2020

Shobha Kondragunta, STAR et al.

GOES-R FDCA Current Status

- Both GOES-16 and GOES-17 are operational

- The July 2019 update drastically reduced the number of false alarms and started providing Fire Radiative Power (FRP) for almost all detected fires (the ones excluded did not have a reliable background temperature).

- Known issues include:
  - Persistent/repeating heat sources – Solar farms, certain coastal and cloud edges, and other scenarios create recurring false positives.
  - Detection threshold – The minimum brightness temperature difference needed to consider a pixel as a fire is at least 4 K and can be higher, leading to delayed detection of fires and exclusion of small events.
  - Other false positives – Surface heterogeneities (ex: bare soil surrounded by vegetated land or small urban areas) and solar reflections off water clouds cause most other false positives.

- An update to mitigate focal plan heating is being implemented by PRO. The mitigation kicks in when the focal plane temperature (FPT) exceeds 90 K:
  - 12.3 µm band disabled – This band is optional and quickly goes bad as FPT increases
  - "Hybridize" 11.2 and 10.3 µm bands – Both bands are affected by the heating, but maximum impacts are at different times. For the purpose of fire detection, the bands can be used interchangeably. Each band is converted to the equivalent radiance in 3.9 µm space and the band with the smallest absolute difference in radiance units is chosen. The associated brightness temperature is then used for that pixel.

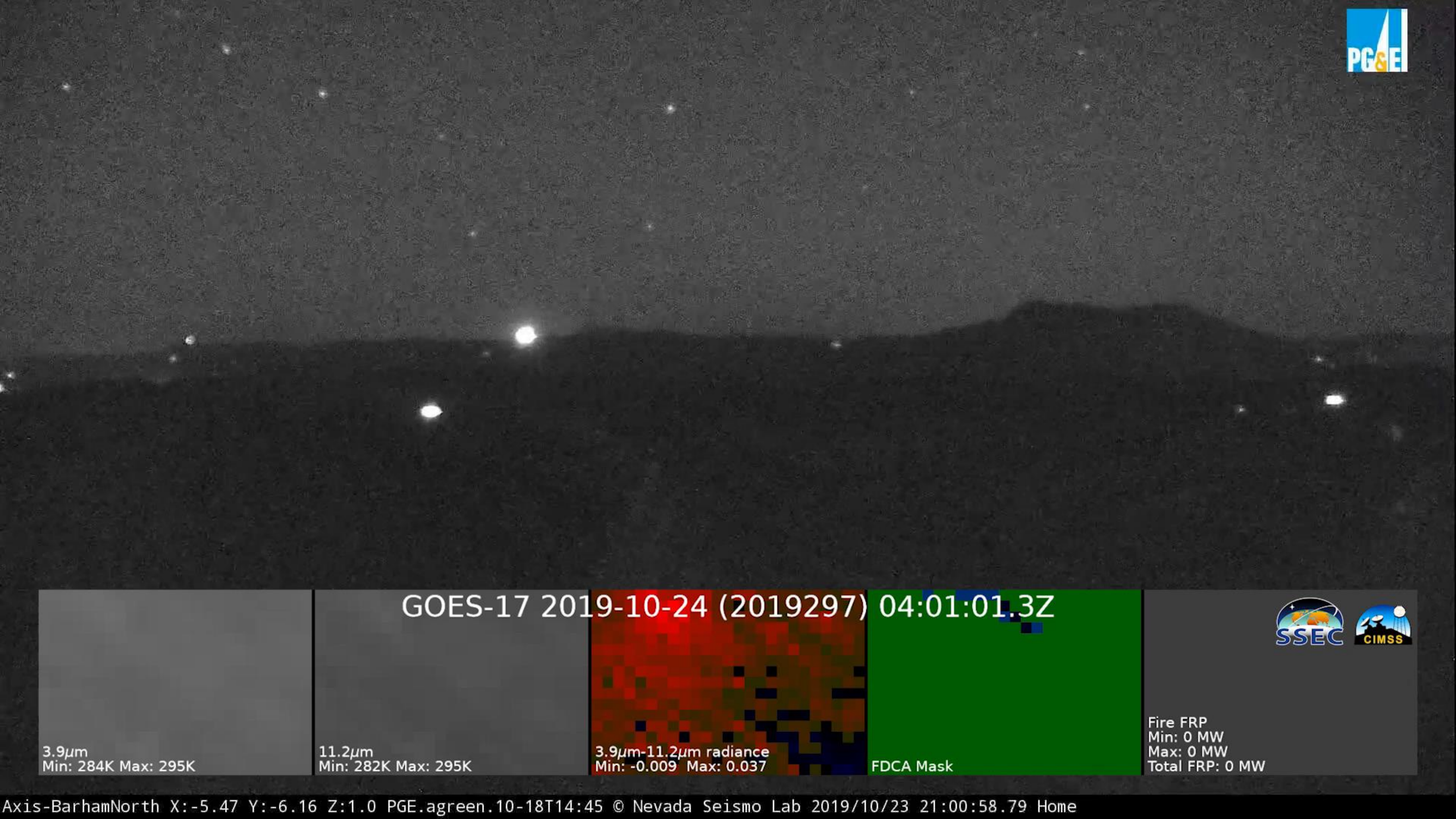
Chris Schmidt, CIMSS/SSEC/UW-Madison

The Kincade Fire

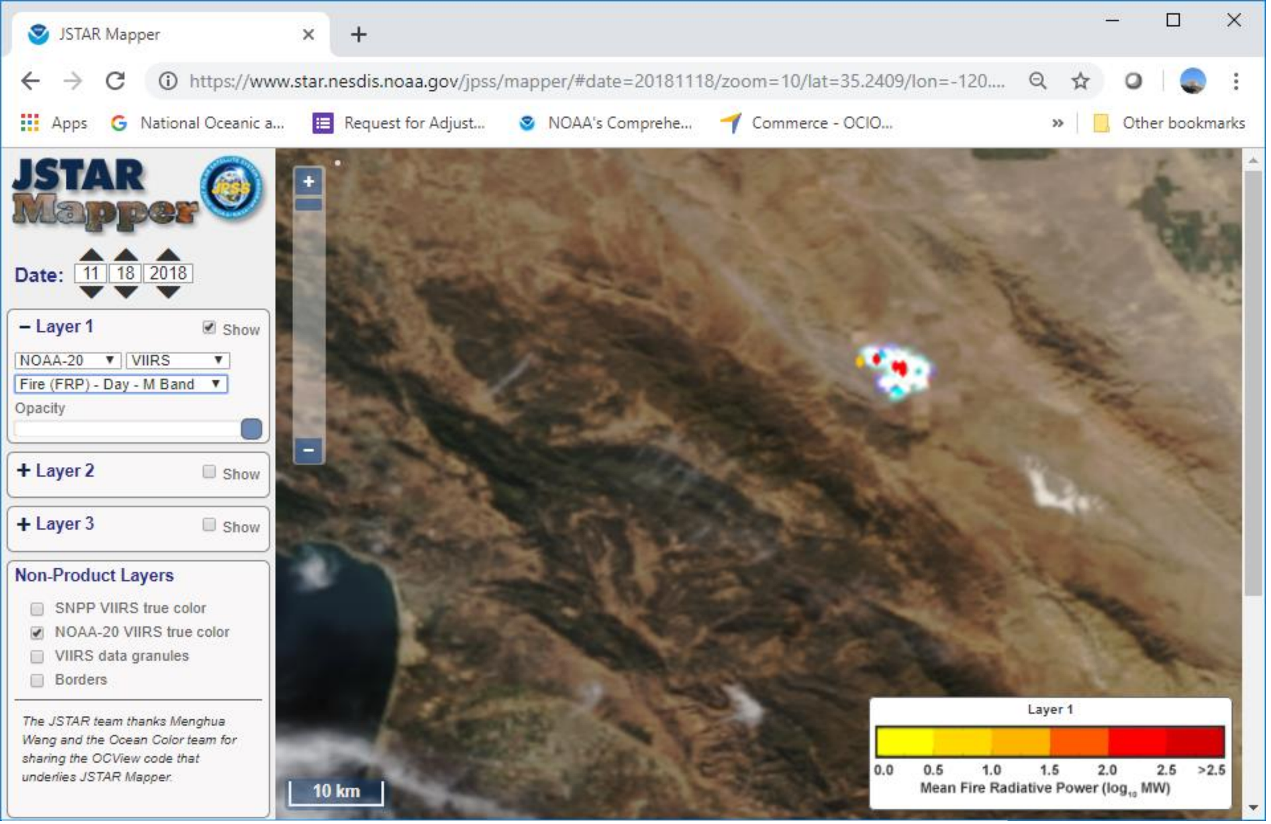
- On October 23, 2019, at about 9:20 pm PDT (4:20 UTC on 24 October 2019), the Kincade Fire started in Sonoma County. The ALERTWildfire camera at Barham near Santa Rosa, CA captured the start of the fire. It appears that a light on the horizon went out when a power line fell between 9:19:51 and 9:19:54 pm PDT. The same event may have started the fire. The fire intensified rapidly. GOES-17 picked up the first signs at in its Mesoscale sector scan 9:21 pm PDT, and by 9:25 pm PDT the FDCA had detected the fire.

- On the next slide, five panels from ABI and the FDCA are synchronized with the ALERTWildfire loop from 9-10 pm PDT. The min and max in the frame are listed on each panel. The GOES-17 Mesoscale sector data was processed at SSEC. From left to right:
    - 3.9 µm – midwave infrared window image (sees fires, clouds, and surface)
    - 11.2 µm – longwave infrared window image (sees clouds and surface)
    - “3.9 µm-11.2 µm radiance” – This is the radiance difference between the two key bands, but the 11.2 µm data has been converted to 3.9 µm “space” to make it directly comparable.
    - FDCA Mask – algorithm output indicating its decisions about each pixel, including detected fires
    - Fire FRP – algorithm output of FRP, for all detected fires (dynamically scaled)

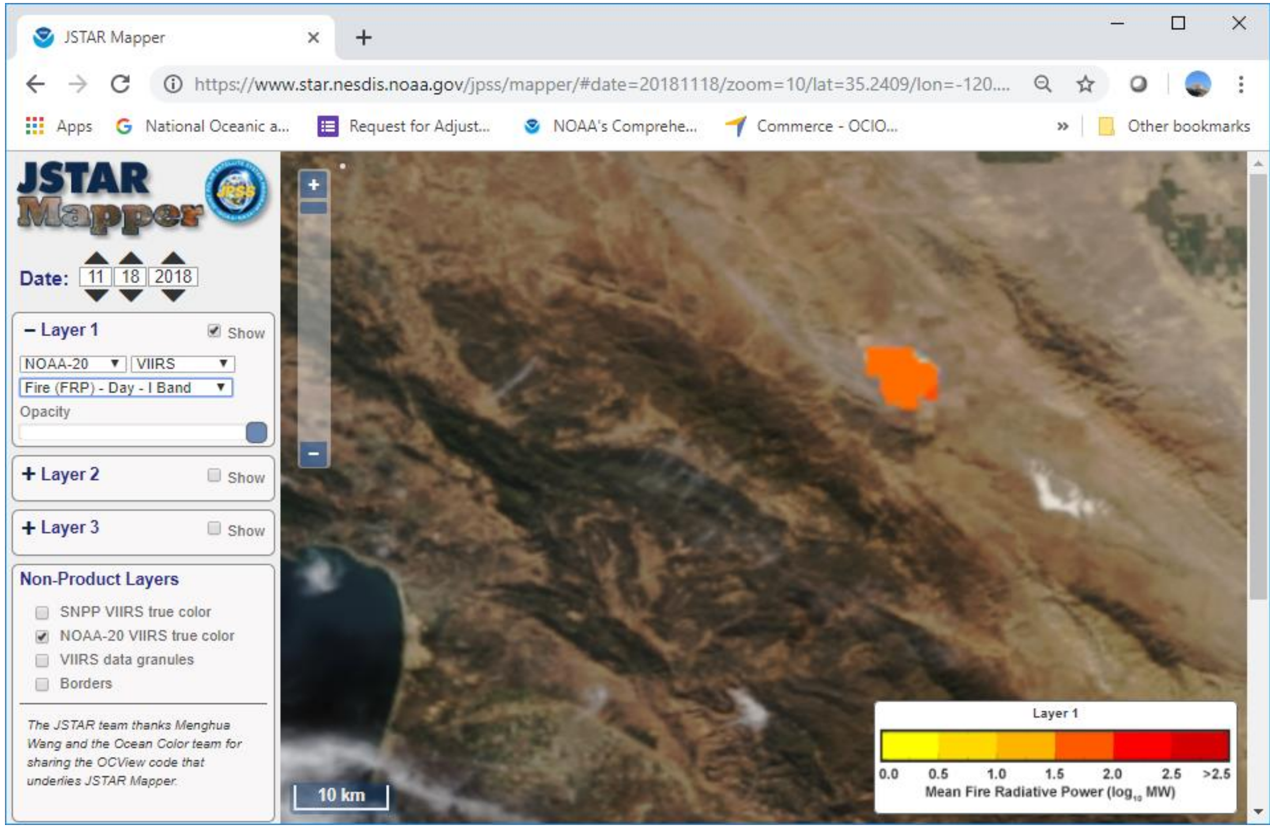
Chris Schmidt, CIMSS/SSEC/UW-Madison

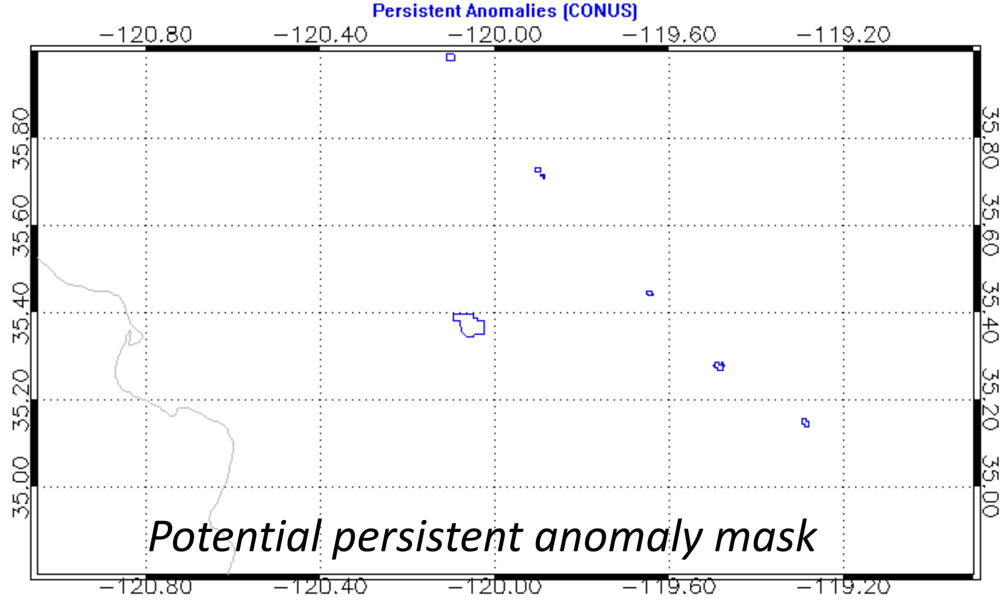

PG&E
GOES-17 2019-10-24 (2019297) 04:01:01.3Z
SSEC
CIMSS
3.9μm
Min: 284K Max: 295K
11.2μm
Min: 282K Max: 295K
3.9μm-11.2μm radiance
Min: -0.009 Max: 0.037
FDCA Mask
Fire FRP
Min: 0 MW
Max: 0 MW
Total FRP: 0 MW
Axis-BarhamNorth X:-5.47 Y:-6.16 Z:1.0 PGE.agreen.10-18T14:45 © Nevada Seismo Lab 2019/10/23 21:00:58.79 Home

Persistent anomalies and false alarms



An example of a false alarm caused by reflection from the Topaz Solar Farm in California. NOAA-20, 11/18/2018





Potential persistent anomaly mask

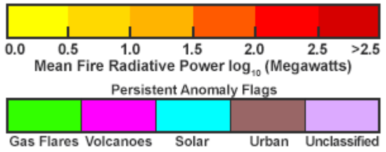
1. *Oil/gas*
2. *Volcanos*
3. *Solar farms (currently only for the HMS domain – extended North America)*
4. *Urban (currently a placeholder)*
5. *Everything else (industrial buildings, power plants, unknown etc.)*

Examples of the solar farm flag in the NDE 750m product

NOAA-20, 1/25/2020

Suomi NPP, 1/24/2020

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



Not Fires: Solar Farms

4 July 2019, Mode 6 FD, 17-20 UTC

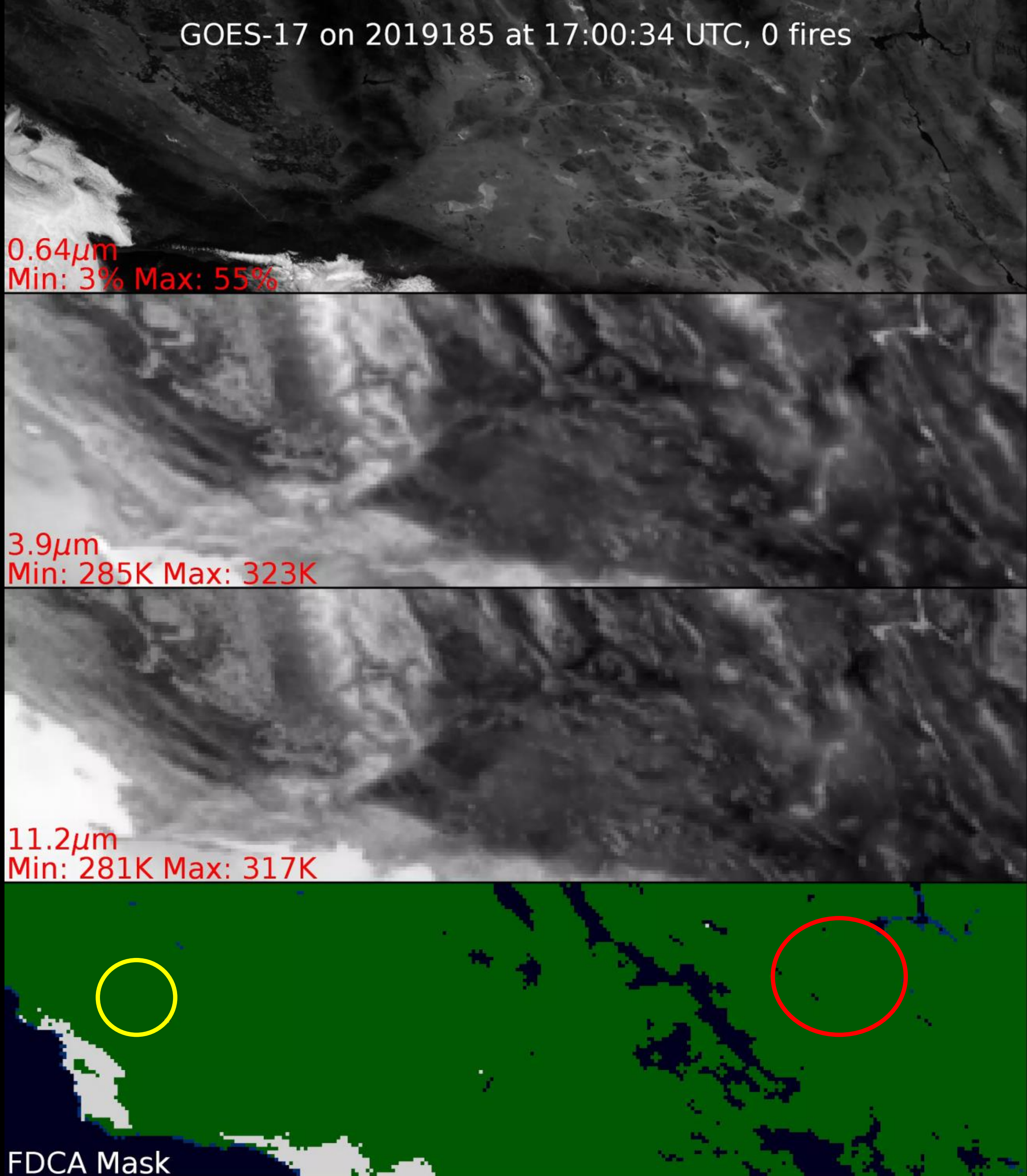
These images cover a swath of California and Nevada, from just north of Los Angeles east past Las Vegas.

Two of several solar farms are highlighted. The Topaz Solar Farm in the west (yellow circle) and solar facilities near Las Vegas (Ivanpah and others, red circle)

The extent in band 7 is much greater than in the shortwave bands, likely due to remapping and diffraction. Because the shortwave bands are not available at full resolution but instead averaged into their surroundings, using a threshold with them to screen these sites may be difficult.

Fire Legend

- Processed Fire
- High Possibility Fire
- Saturated Fire
- Medium Possibility Fire
- Cloudy Fire
- Low Possibility Fire
- Fire-free ground
- Cold surface or cloud
- Cloudy (11 μm test)
- Cloudy (Albedo test, day)
- Cloudy (Rad Diff, night)
- Cloudy (Rad Diff, day)
- Background Calc Failed
- Water



Chris Schmidt, CIMSS/SSEC/UW-Madison

Williams Flats VIIRS/MASTER comparison during FIREX-AQ

MASTER IR detection with 20m pixels from the DC8 at 21:57Z and ~8000 m AMSL altitude.

Fade in:
VIIRS fire detections: 20190803 at 21:57:30 Z

MASTER: MODIS/ASTER Airborne Simulator
https://master.jpl.nasa.gov/

Joshua Schwarz, NOAA ESRL

Williams Flats VIIRS/MASTER comparison during FIREX-AQ

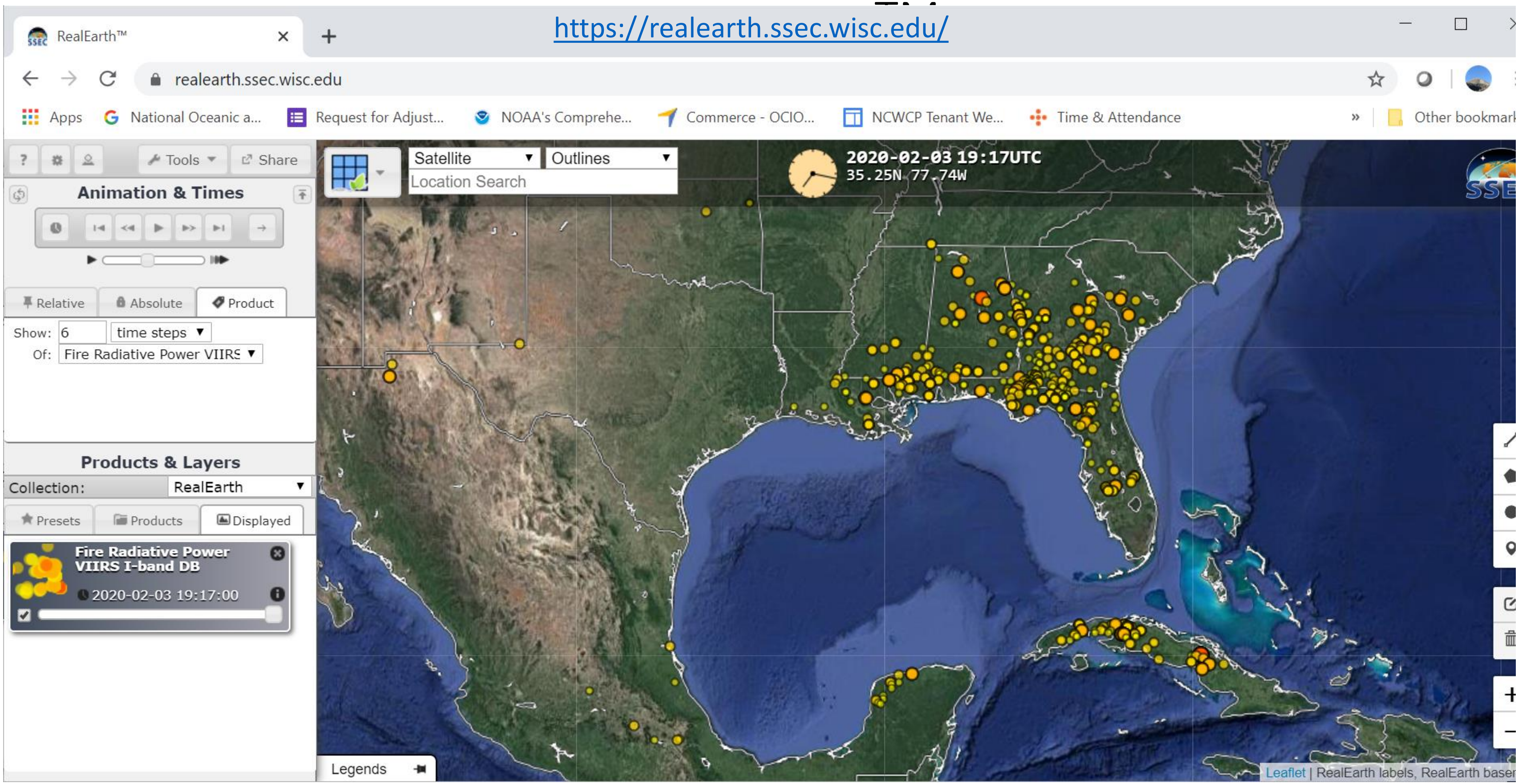
MASTER IR detection with 20m pixels from the DC8 at 21:57Z and ~8000 m AMSL altitude.

Fade in:
VIIRS fire detections: 20190803 at 21:57:30 Z

MASTER: MODIS/ASTER Airborne Simulator
https://master.jpl.nasa.gov/

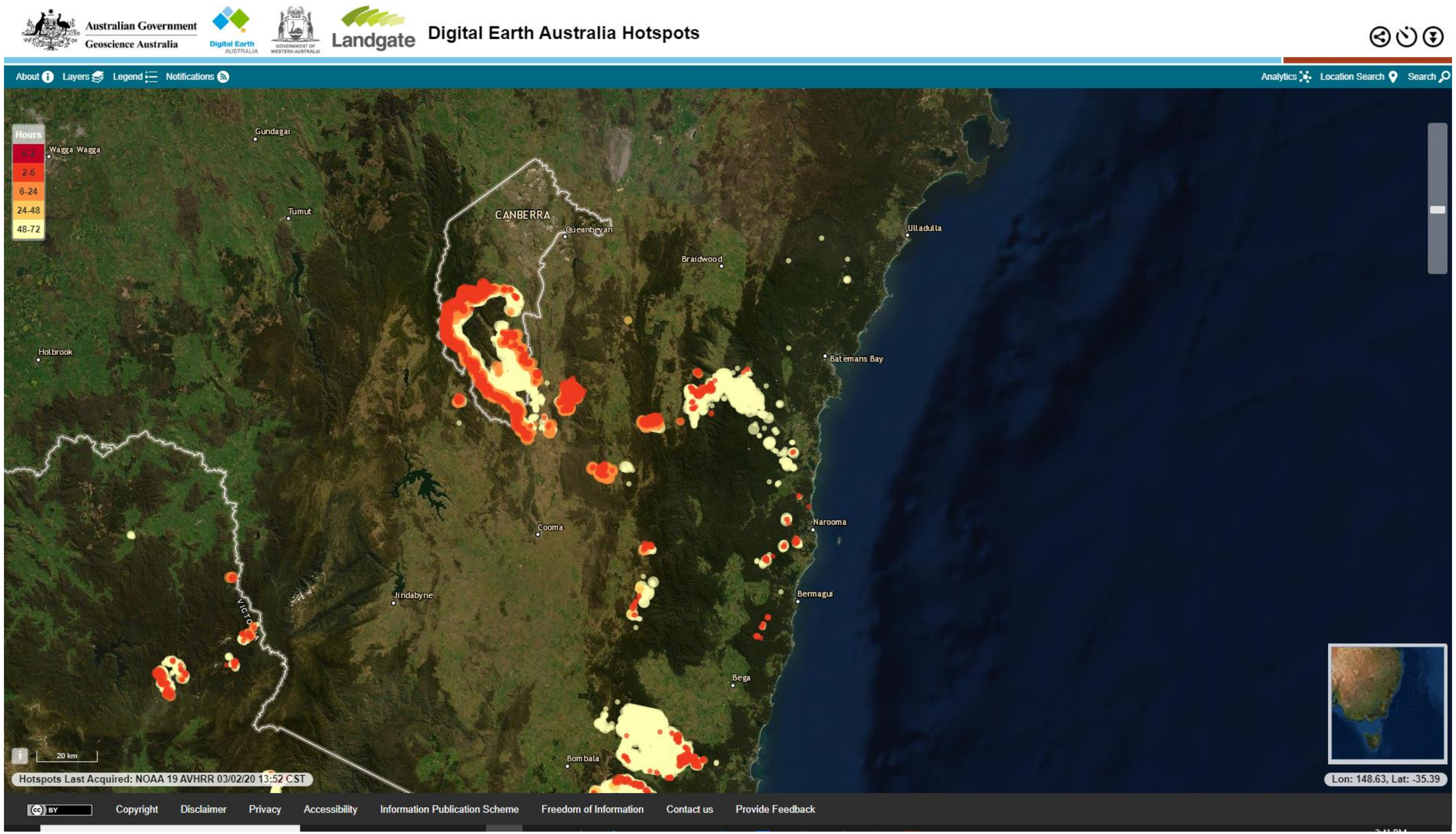
Joshua Schwarz, NOAA ESRL

VIIRS I-band data from Direct Broadcast in



VIIRS Active Fire Data to monitor fires in Australia

- we supported Charter Activation 613 in November by providing I-band data from our experimental STAR production.
- coordinated by William Straka (SSEC) and the JPSS Fire and Smoke Proving Ground Initiative.
- it was confirmed that Geoscience Australia had direct broadcast capabilities and thus our data feed was no longer needed.
- CSPP includes our NOAA versions of the VIIRS algorithms (750m M-band and 375m I-band).



https://hotspots.dea.ga.gov.au/

Unmet user needs

- GOES-R baseline algorithm performance and persistent anomalies
- GOES-R FRP in emission modeling
- GEO-LEO synergy
  - Data format, content, access
- Mid-morning polar coverage
  - Sentinel-3 SLSTR and Metop-SG METImage
- Agile, accurate, fast automated detection / characterization products
  - Current baseline products are optimized for performance over large domains (even with some algorithmic elements being adaptive)
  - Artificial Intelligence
    - Exploratory work ongoing in the community, including STAR
- Easy data access for all stakeholders
  - PDA limitations exclude key users who are outside of NOAA
  - Strengthen further access to DB data and products to reduce latency
  - Tailored formats beyond baseline requirements (i.e. netCDF4)
- Convergence towards a sensor-agnostic product suite
  - Enterprise product development
    - A balance between “one size fits all” and common processing elements and output format

FDCA Plans

- The "Enterprise" system for fires is currently being defined. The system would provide a unified framework for the fire detection algorithms for different platforms and a common set of output variables.

- Algorithm development plans include:
  - Inclusion of a priori information – Replacement for old (and now ineffective) temporal filtering, the new model would include information such as:
    - Known repeating sources: Solar farms and problematic surfaces, these heat sources will still be identified as heat sources but have their own flags. Solar farms can have wildfires, for example.
    - Ongoing fire events: from previous geo and leo processing runs
  - Creation of "fire events" – Take processing a step further and cluster detected fire pixels in space and time to create fire event records. This allows for fusion between platforms and easier dissemination of data about specific incidents. Fire event records would include outlines and tracking information about the individual pixels, as well as a composite FRP.
  - Use of additional bands – ABI bands 5 and 6, as well as some longwave bands, have information that can be used to improve detection performance and characterization.

Chris Schmidt, CIMSS/SSEC/UW-Madison

Backup slides

M-band and I-band Active Fire File content

Name	Type	Description	Dimension	Units	Range
fire mask	8 bit integer	Fire mask	3200 x 768	unitless	**0 - 9**
algorithm QA	32 bit Integer	Fire algorithm QA mask	3200 x 768	unitless	**0 - 31**
FP_line	16 bit Integer	Fire pixel line	Sparse data array 1 – N	unitless	**0 - 768**
FP_sample	16 bit Integer	Fire pixel sample	Sparse data array 1 – N	unitless	**0 – 3200**
FP_latitude	32 bit Float	Fire pixel latitude	Sparse data array 1 – N	degrees	**-90 - 90**
FP_longitude	32 bit Float	Fire pixel longitude	Sparse data array 1 – N	degrees	**-180 - 180**
FP_power	32 bit Float	Fire radiative power	Sparse data array 1 – N	MW	**0 - 5000**
FP_confidence (M-band only)	8 bit Integer	Fire detection confidence	Sparse data array 1 – N	%	**0 – 100**
FP_land	8 bit Integer	Land pixel flag	Sparse data array 1 – N	unitless	**1 – land** **0 – water**
FP_PersistentAnomalyCategory	8 bit Integer	Persistent industrial or natural source	Sparse data array 1 – N	unitless	**0: no persistent anomaly** **1: oil or gas flare** **2: volcano** **3: solar panel** **4: urban (currently not used)** **5: unclassified**
18 FP diagnostic variables	See netCDF4 metadata	Variables to describe observing and environmental conditions, and results of algorithm tests	Sparse data array 1 – N	See netCDF4 metadata	**See netCDF4 metadata**

*** N is a dimension of sparse data array; defined in “nfire” variable**

M-band and I-band Active Fire Product content

Output	Type	Description	
Fire Mask	8-bit unsigned integer	Missing – 0	Missing input data
		Scan – 1	On-board bowtie deletion
		Other – 2 (M-band) Sun glint – 2 (I-band)	Not processed (obsolete) (M-band) Pixel classified as sun glint (I-band)
		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	See next slide for details	

M-band and I-band Active Fire Product content

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	Persistent anomaly category (same as in sparse array)

Bits	Description
0	Channel I1 quality (0 = nominal (or nighttime), 1 = non-nominal)
1	Channel I2 quality (0 = nominal (or nighttime), 1 = non-nominal)
2	Channel I3 quality (0 = nominal (or nighttime), 1 = non-nominal)
3	Channel I4 quality (0 = nominal, 1 = non-nominal)
4	Channel I5 quality (0 = nominal, 1 = non-nominal)
5	Geolocation data quality (0 = nominal, 1 = non-nominal)
6	Channel M13 quality (0 = nominal, 1 = non-nominal)
7	Unambiguous fire (0 = false, 1 = true [night only])
8	Background pixel (0 = false, 1 = true)
9	Bright pixel rejection (0 = false, 1 = true)
10	Candidate pixel (0 = false, 1 = true)
11	Scene background (0 = false, 1 = true)
12	Test 1 (0 = false, 1 = true)
13	Test 2 (0 = false, 1 = true)
14	Test 3 (0 = false, 1 = true)
15	Test 4 (0 = false, 1 = true) (day)
16	Pixel saturation condition (0 = false, 1 = true) (day)
17	Glint condition (0 = false, 1 = true) (day)
18	Potential South Atlantic magnetic anomaly pixel (0 = false, 1 = true)
19	Fire pixel over water (0 = false, 1 = true)
20	Persistence test 1 (0 = false, 1 = true)
21	Persistence test 2 (0 = false, 1 = true)
22	Residual *bowtie* pixel (0 = false, 1 = true)
23-25	Persistent anomaly category
26-31	Reserved for future use

See ATBDs for details of deriving the various QA flags

Format of output text files

old

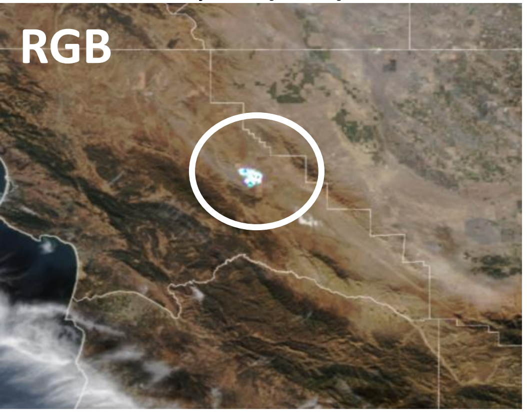
```
year,month,day,hh,mm,lon,lat,mask,confidence,bright_t13,frp,line,sample,bowtie;    nfire = 16
2018, 11, 18, 20, 50, -120.051445,   35.373226,   8,  75,  454.137024,  523.866943,   184,  1851,   0
2018, 11, 18, 20, 50, -120.053154,   35.379963,   7,   0,  458.887634,  568.377380,   185,  1851,   0
2018, 11, 18, 20, 50, -120.062065,   35.378429,   9,  87,  446.435364,  456.827118,   185,  1852,   0
2018, 11, 18, 20, 50, -120.083344,   35.388844,   8,  75,  488.237793,  911.507202,   187,  1854,   0
2018, 11, 18, 20, 50, -120.101158,   35.385788,   8,  39,  310.548340,    3.728809,   187,  1856,   0
2018, 11, 18, 20, 50, -118.601891,   36.226536,   7,  29,  300.670258,    3.968884,   274,  1661,   0
2018, 11, 18, 20, 50, -118.646439,   36.226280,   8,  35,  305.535767,    5.064438,   275,  1666,   0
2018, 11, 18, 20, 50, -118.622269,   36.236893,   9,  99,  357.488892,   53.261333,   276,  1663,   0
2018, 11, 18, 20, 50, -118.647957,   36.232841,   8,  45,  309.880249,    6.892451,   276,  1666,   0
2018, 11, 18, 20, 50, -118.640907,   36.240753,   9, 100,  398.086121,  155.975922,   277,  1665,   0
2018, 11, 18, 20, 50, -118.657928,   36.238068,   9,  84,  334.233887,   23.713444,   277,  1667,   0
2018, 11, 18, 20, 50, -118.739067,   36.395573,   7,  24,  300.086029,    4.420272,   302,  1671,   0
2018, 11, 18, 20, 50, -118.724632,   36.411800,   9,  96,  349.282104,   42.508846,   304,  1668,   0
2018, 11, 18, 20, 50, -118.726379,   36.418312,   9,  84,  326.054657,   18.055126,   305,  1668,   0
2018, 11, 18, 20, 50, -119.584526,   37.810020,   8,  74,  313.540253,   10.418139,   529,  1713,   0
2018, 11, 18, 20, 50, -119.593361,   37.808594,   8,  79,  319.367859,   13.668173,   529,  1714,   0
```

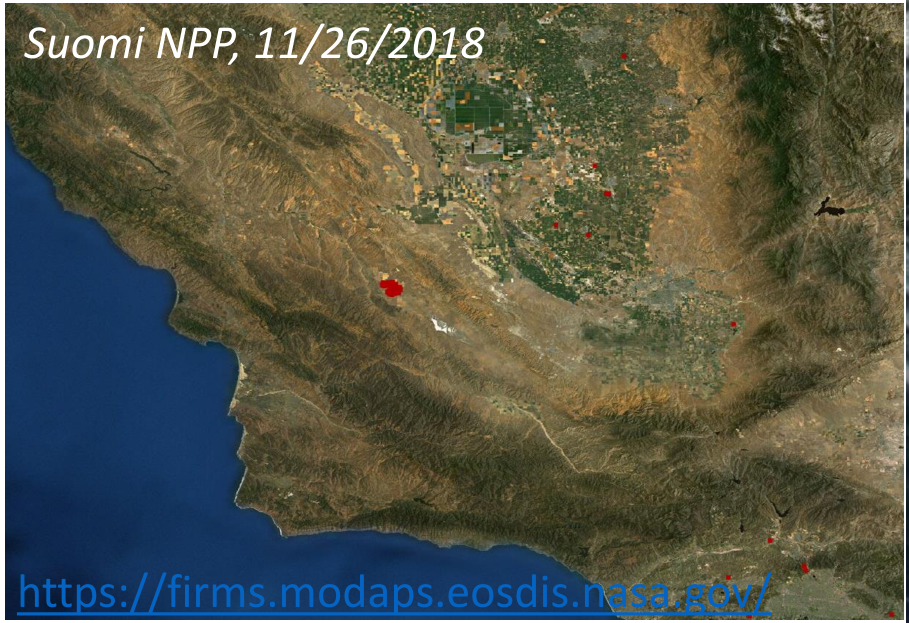
new

```
year,month,day,hh, mm,lon,lat,mask,confidence,bright_t13,frp,line,sample,bowtie,persist_anomaly;  nfire =
16
2018, 11, 18, 20, 50, -120.051445,   35.373226,   8,  75,  454.137024,  523.866943,   184,  1851,   0,   3
2018, 11, 18, 20, 50, -120.053154,   35.379963,   7,   0,  458.887634,  568.377380,   185,  1851,   0,   3
2018, 11, 18, 20, 50, -120.062065,   35.378429,   9,  87,  446.435364,  456.827118,   185,  1852,   0,   3
2018, 11, 18, 20, 50, -120.083344,   35.388844,   8,  75,  488.237793,  911.507202,   187,  1854,   0,   3
2018, 11, 18, 20, 50, -120.101158,   35.385788,   8,  39,  310.548340,    3.728809,   187,  1856,   0,   0
2018, 11, 18, 20, 50, -118.601891,   36.226536,   7,  29,  300.670258,    3.968884,   274,  1661,   0,   0
2018, 11, 18, 20, 50, -118.646439,   36.226280,   8,  35,  305.535767,    5.064438,   275,  1666,   0,   0
2018, 11, 18, 20, 50, -118.622269,   36.236893,   9,  99,  357.488892,   53.261333,   276,  1663,   0,   0
2018, 11, 18, 20, 50, -118.647957,   36.232841,   8,  45,  309.880249,    6.892451,   276,  1666,   0,   0
2018, 11, 18, 20, 50, -118.640907,   36.240753,   9, 100,  398.086121,  155.975922,   277,  1665,   0,   0
2018, 11, 18, 20, 50, -118.657928,   36.238068,   9,  84,  334.233887,   23.713444,   277,  1667,   0,   0
2018, 11, 18, 20, 50, -118.739067,   36.395573,   7,  24,  300.086029,    4.420272,   302,  1671,   0,   0
2018, 11, 18, 20, 50, -118.724632,   36.411800,   9,  96,  349.282104,   42.508846,   304,  1668,   0,   0
2018, 11, 18, 20, 50, -118.726379,   36.418312,   9,  84,  326.054657,   18.055126,   305,  1668,   0,   0
2018, 11, 18, 20, 50, -119.584526,   37.810020,   8,  74,  313.540253,   10.418139,   529,  1713,   0,   0
2018, 11, 18, 20, 50, -119.593361,   37.808594,   8,  79,  319.367859,   13.668173,   529,  1714,   0,   0
```

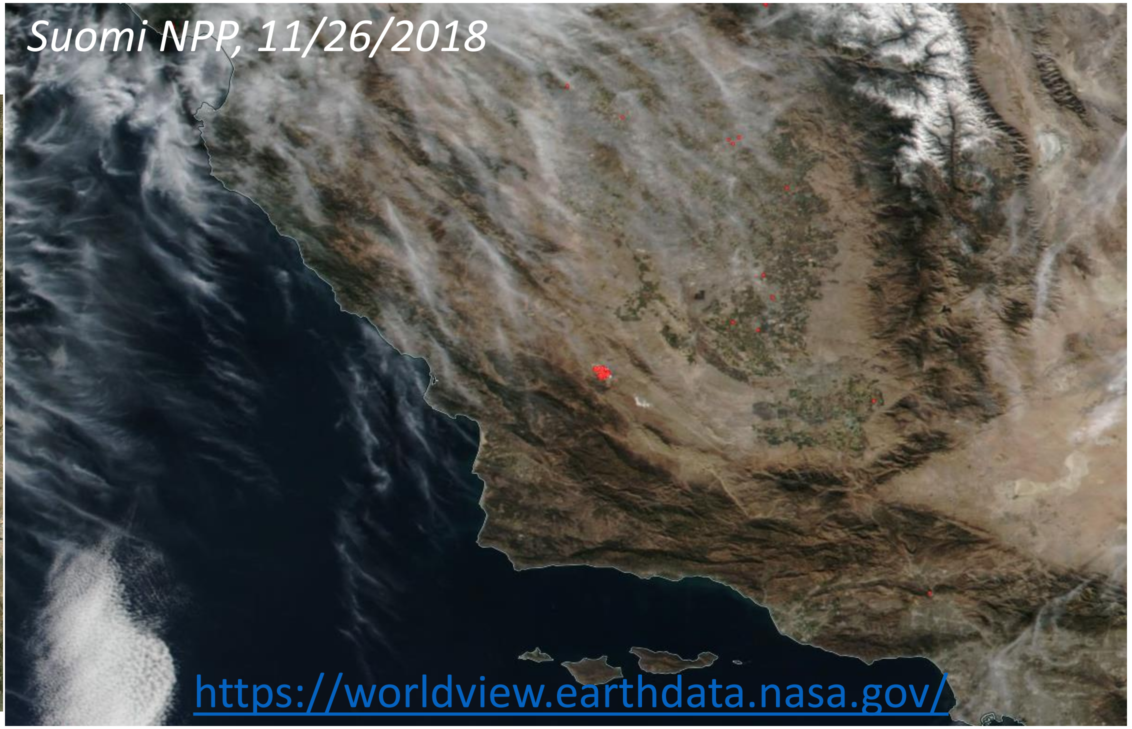
False fire detections from solar farms

NOAA-20, 11/18/2018



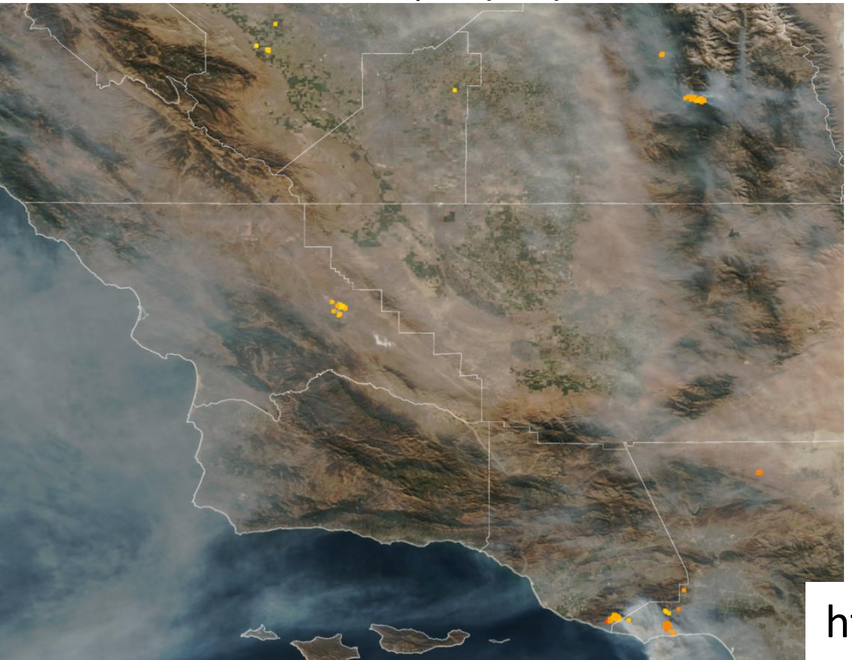


https://firms.modaps.eosdis.nasa.gov/

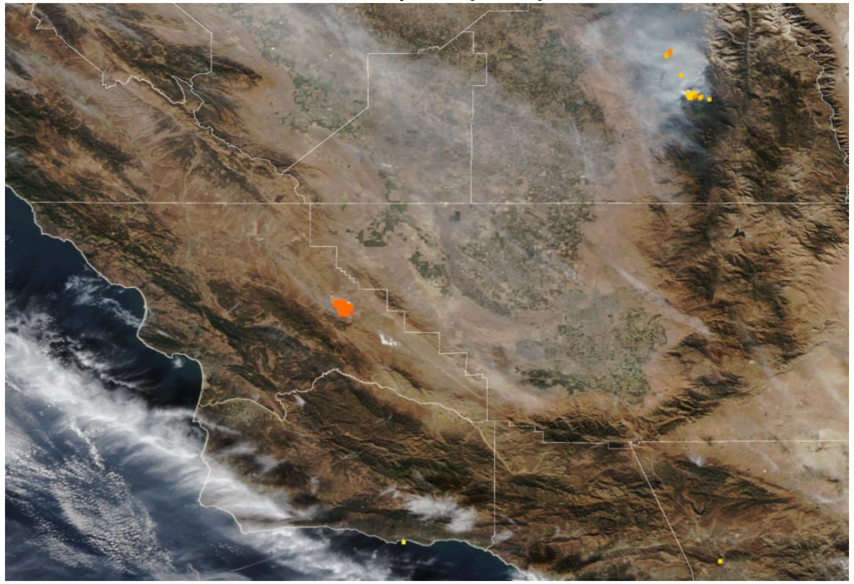


https://worldview.earthdata.nasa.gov/

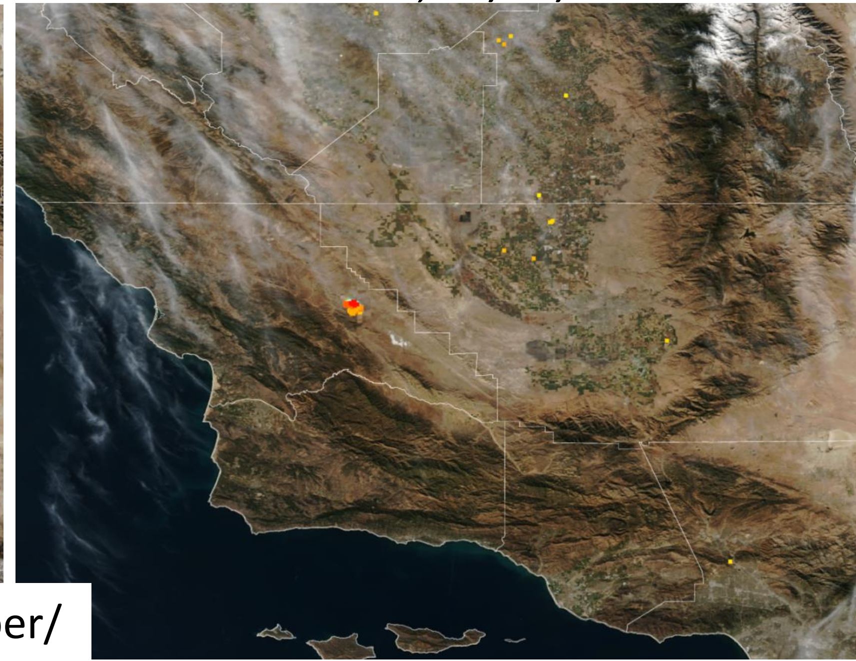
Suomi NPP, 11/10/2018



NOAA-20, 11/18/2018



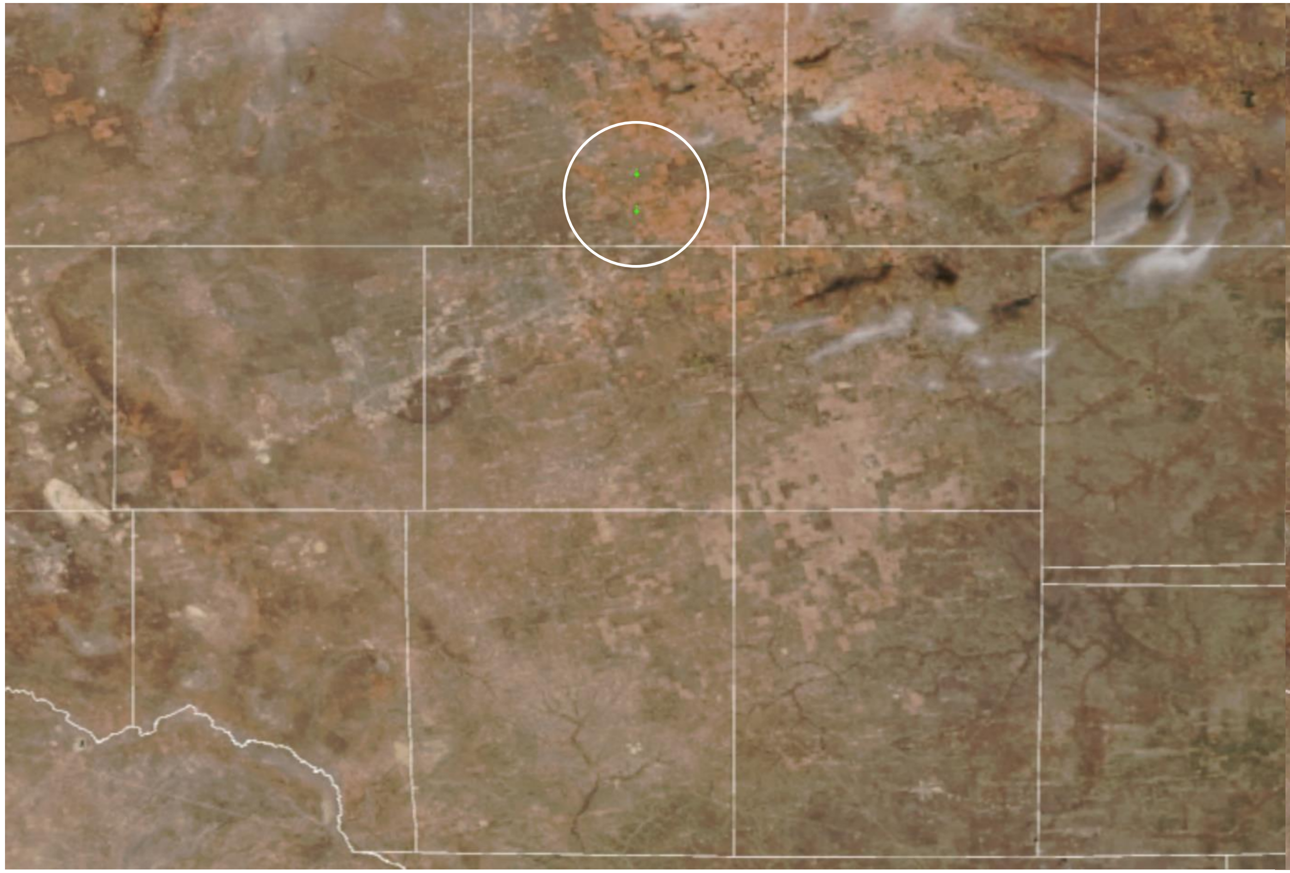
Suomi NPP, 11/26/2018



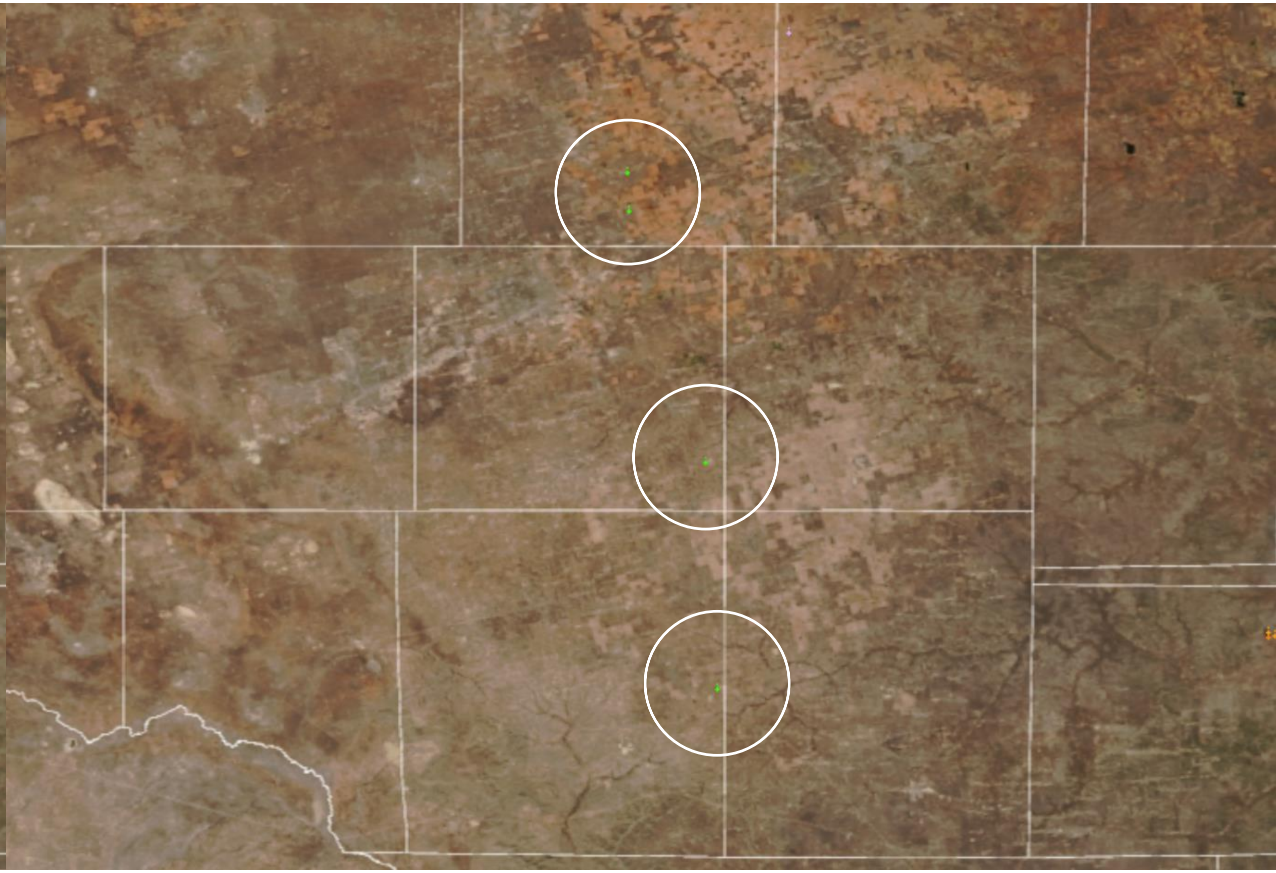
https://www.star.nesdis.noaa.gov/jpss/mapper/

Examples of the gas flare flag in the NDE 750m product

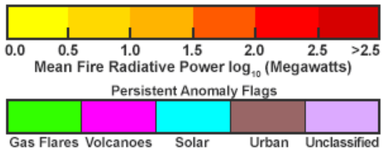
Suomi NPP, 1/23/2020



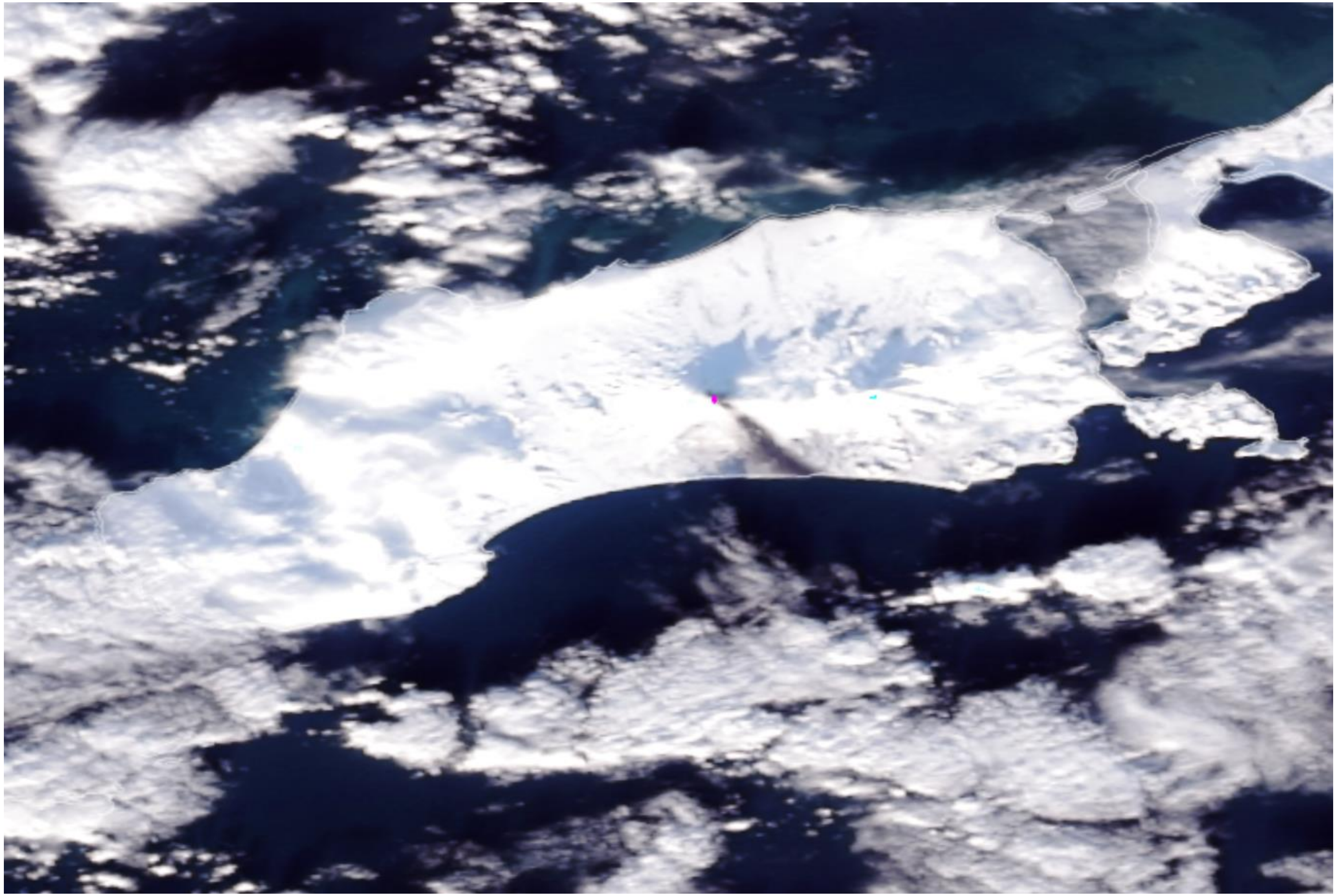
Suomi NPP, 1/24/2020



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



An example of the volcano flag in the NDE 750m product

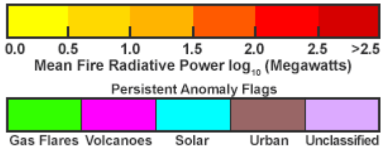


NOAA-20, 1/4/2020

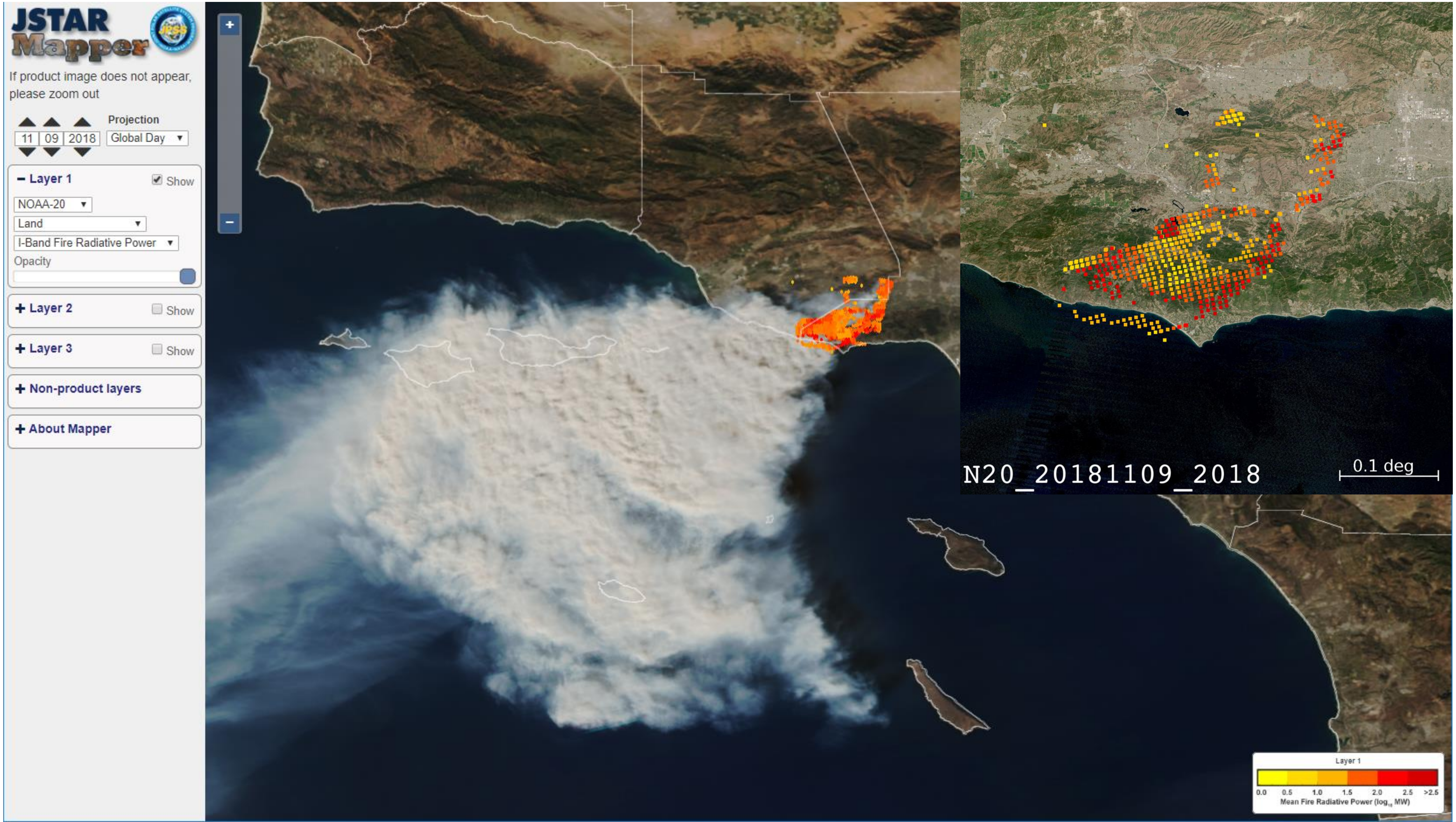
Shishaldin, Unimak Island, USA

Holocene Volcano Database obtained from

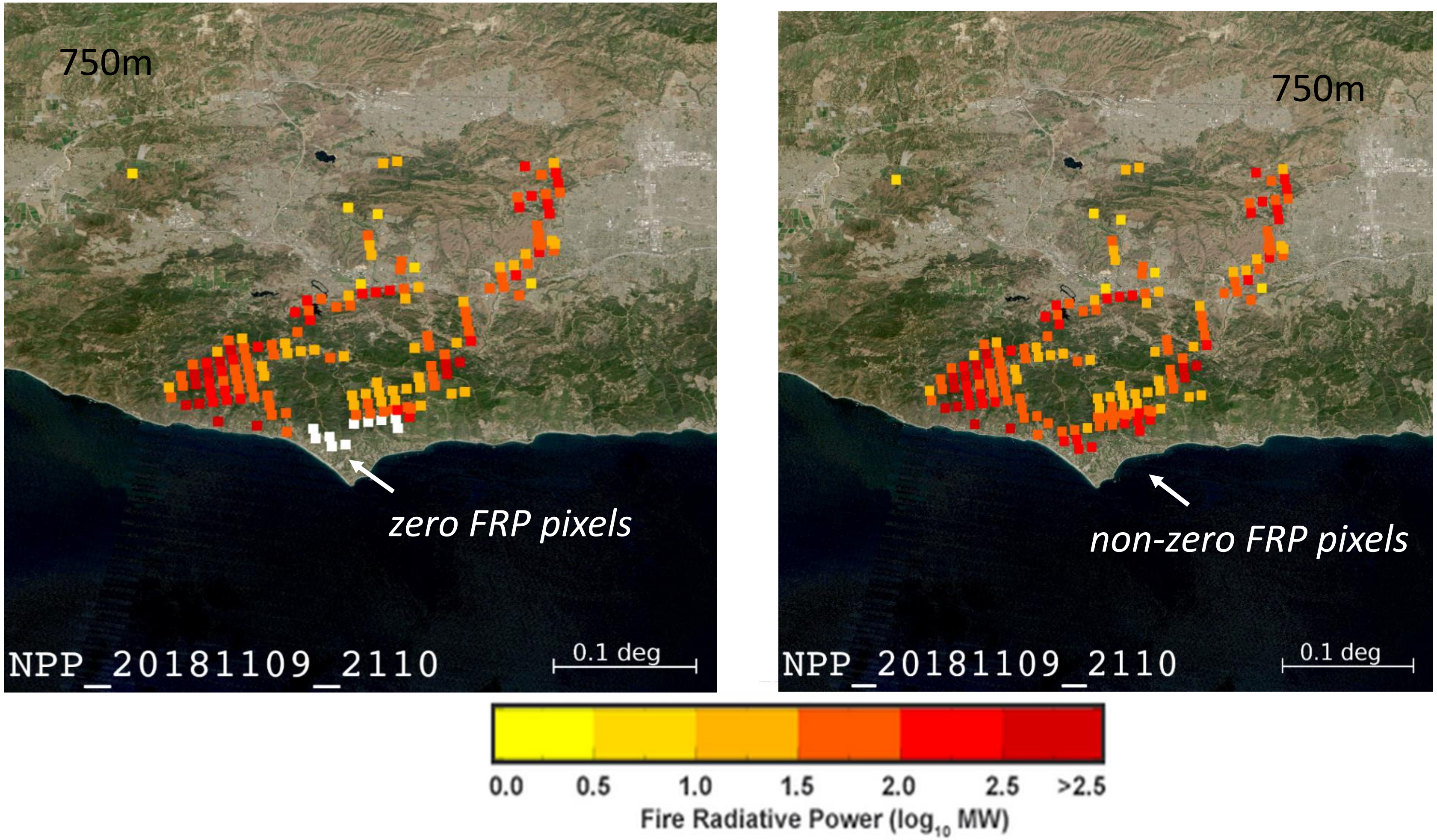
Global Volcanism Program, 2013. Volcanoes of the World, v. 4.8.5. Venzke, E (ed.). Smithsonian Institution. Downloaded 13 Nov 2019. https://doi.org/10.5479/si.GVP.VOTW4-2013



False detections from hot smoke plumes



Missing FRP retrievals from large fires



Some pixels have zero FRP due to lack of valid background pixels in FRP calculation

Increased background search window results in proper FRP in high confidence fire pixels