Beta Maturity Science Review for the VIIRS 375m Active Fire Algorithm

Presented by Ivan Csiszar

Date: 2019/05/16

Outline

- Active Fire Cal/Val Team Members
- Product Requirements
- Findings/Issues for Beta maturity
- Documentation (Science Maturity Check List)
- Conclusions
- Path Forward

NOAA-20 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
Wei Guo	IMSG	Algorithm development support
Yingxin Gu	IMSG	Algorithm development support
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

Requirements

- Data Product Objective Capabilities Document (DPOCD) JPSS-REF-5110 – Section 2.7.1 (*From L1RDS-273, L1RD-S section 5.5.1)*

SENSOR

Current Sensor: VIIRS
Current refresh: At least 90% coverage of the globe every 12 hours (monthly average)
Objective refresh: NS

ALGORITHM

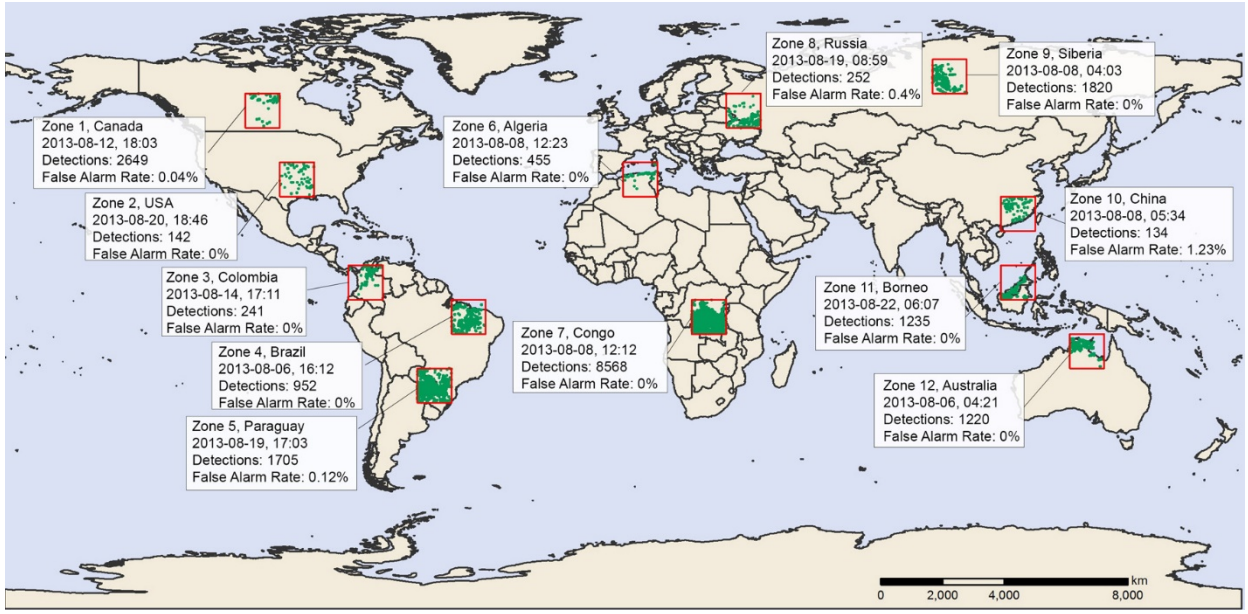
Applicable Conditions: Delivered in daytime and night-time regimes under clear-sky conditions and within the clear areas between scattered and broken clouds.
Current horizontal cell size: 0.80 km nadir 1.6 km worst case
Objective horizontal cell size: 0.25 km nadir NS worst case
Current horizontal reporting interval: HCS
Objective horizontal reporting interval: NS
Current horizontal coverage: Global
Objective horizontal coverage: Global
Current 3σ mapping uncertainty at nadir: 1.5 km
Objective 3σ mapping uncertainty at nadir: 0.75 km
Current measurement range: 1.0 MW to 5.0 $(10)^3$ MW Fire radiative power (FRP)
Objective measurement range: 1.0 MW to 1.0 $(10)^4$ MW Fire radiative power (FRP)
Current measurement uncertainty: 50% Fire radiative power (FRP)
Objective measurement uncertainty: 20% Fire radiative power (FRP)

Algorithm Status and Approach

- The algorithm has been published
  - Schroeder, W., Oliva, P., Giglio, L. and Csiszar, I. (2014),The New VIIRS 375 m Active Fire Detection Data Product: Algorithm Description and Initial Assessment. Remote Sensing of Environment, doi: 10.1016/j.rse.2013.12.008.
- Expected performance
  - The I-band product has shown to detect multiple times the number of fires compared to the 750m product
- Overview of technical approach of the algorithm and its implementation
  - A hybrid thresholding-contextual algorithm for detection; a single-band approach for FRP retrievals
  - Requires land-water mask
  - Concept of operations
    - for each orbit level granule VIIRS SDR radiances are read, granulated land-water mask is acquired, algorithm is applied to SDR, generated output is converted to netCDF4 and text, output sent to server for distribution
- Validation concept
  - Limited amount of higher resolution spaceborne or airborne reference data
  - Detection rates and omission/commission errors for detection; APU for FRP
  - User feedback on performance has been positive

VIIRS 375m Active Fire Algorithm

- First version of algorithm (using S-NPP/VIIRS data) was completed in 2013-2014 and implemented at **NASA LANCE in 2015**
- Algorithm was subsequently implemented at **NASA LandSIPS in 2016**, where the entire S-NPP/VIIRS record was **reprocessed in 2017**
- Overall, VIIRS 375m fire data show significantly improved detection rates compared to VIIRS 750m (M-band) and MODIS 1km active fire products
  - 3-4x more daytime fire pixels
  - +20x more nighttime fire pixels
  - Mid-infrared channel (I4) saturation has little/no impact on detection performance. Fire radiative power retrievals are calculated using co-located and unsaturated M-band (M13) radiance data
  - Low (<2%) false alarm rates



VIIRS 375m global fire data assessment

Adapted from: Schroeder et al., 2014

Current NDE/STAR VIIRS Active Fire Production Status

Algorithm	Suomi NPP	NOAA-20
750m M-band: NDE	Operational since March 15, 2016	Operational since August 13, 2018
375m/750m I/M-band: STAR	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
  - SPSRB briefed on April 17, 2019
- **CSPP / CIMSS (DB)**
  - 750m and 375m product included
  - Both Suomi NPP and NOAA-20
  - CIMSS processes and distributes DB data
- **HRRR-smoke**
  - Non-operational products provided through STAR ftp
  - Operational products through PDA

JPSS Data Products Maturity Definition

JPSS/GOES-R Data Product Validation Maturity Stages – COMMON DEFINITIONS (Nominal Mission)

1. Beta

- Product is minimally validated, and may still contain significant identified and unidentified errors.
- Information/data from validation efforts can be used to make initial qualitative or very limited quantitative assessments regarding product fitness-for-purpose.
- Documentation of product performance and identified product performance anomalies, including recommended remediation strategies, exists.

2. Provisional

- Product performance has been demonstrated through analysis of a large, but still limited (i.e., not necessarily globally or seasonally representative) number of independent measurements obtained from selected locations, time periods, or field campaign efforts.
- Product analyses are sufficient for qualitative, and limited quantitative, determination of product fitness-for-purpose.
- Documentation of product performance, testing involving product fixes, identified product performance anomalies, including recommended remediation strategies, exists.
- Product is recommended for potential operational use (user decision) and in scientific publications after consulting product status documents.

3. Validated

- Product performance has been demonstrated over a large and wide range of representative conditions (i.e., global, seasonal).
- Comprehensive documentation of product performance exists that includes all known product anomalies and their recommended remediation strategies for a full range of retrieval conditions and severity level.
- Product analyses are sufficient for full qualitative and quantitative determination of product fitness-for-purpose.
- Product is ready for operational use based on documented validation findings and user feedback.
- Product validation, quality assurance, and algorithm stewardship continue through the lifetime of the instrument.

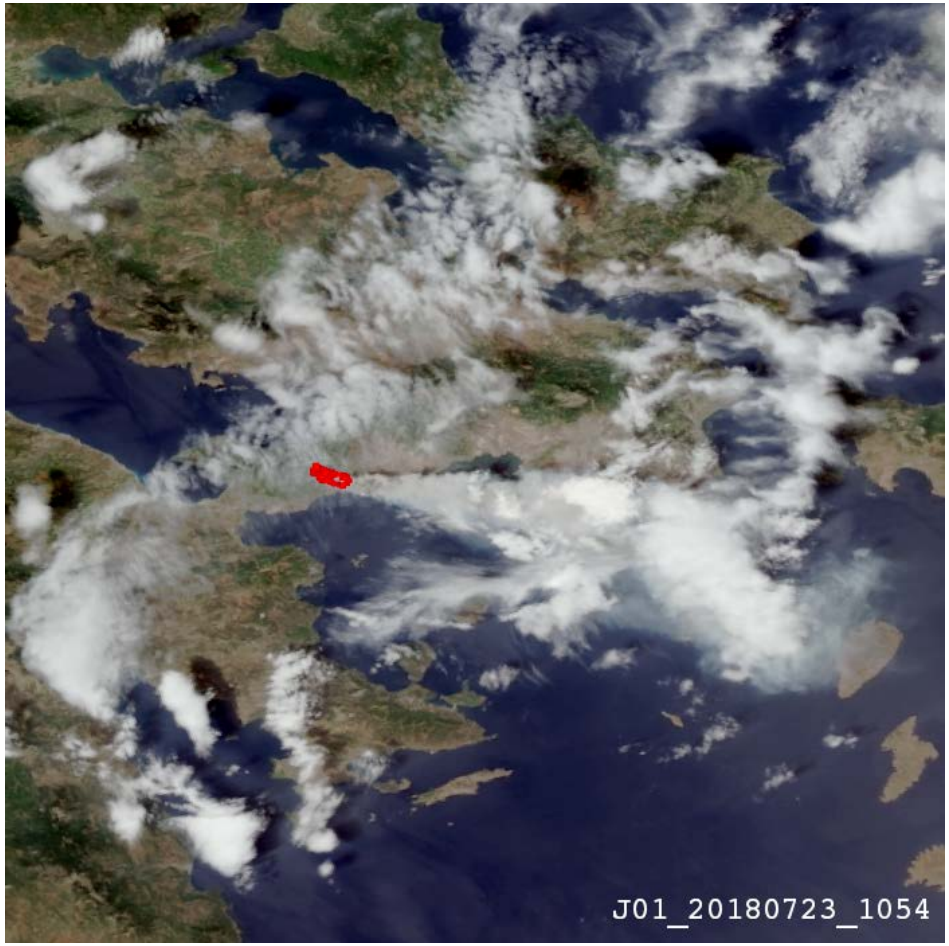
Evaluation methodology

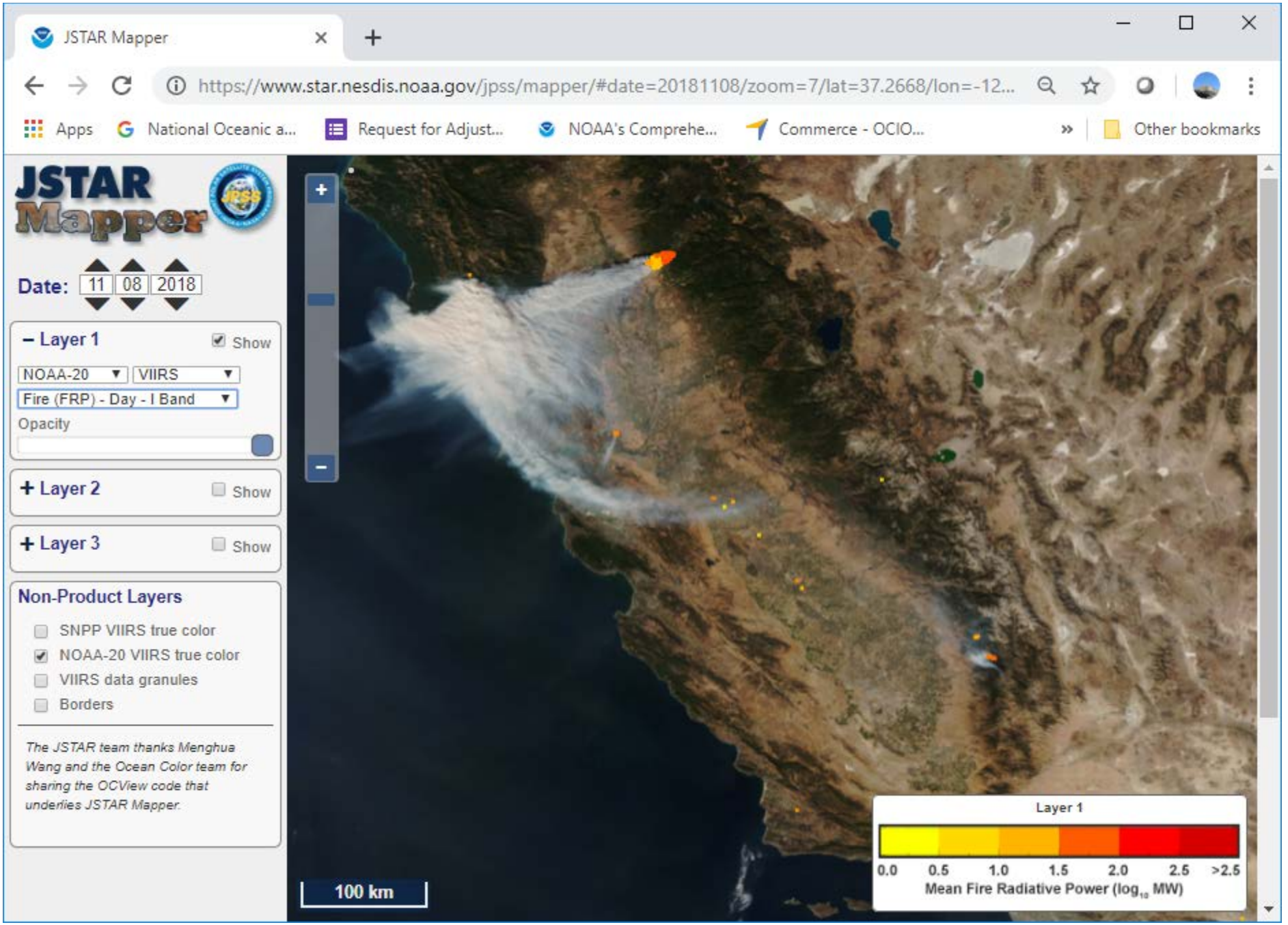
For Beta evaluation the operational M-band Suomi NPP and NOAA-20 products are used as reference. Evaluation also includes intercomparison between the Suomi NPP and NOAA-20 I-band products.

- Visual comparison between Suomi NPP and NOAA-20 fire products on a granule basis
  - Fire location, fire radiative power (FRP)
  - I4 saturation handling (as a result of low I4 saturation)
- Visual comparison of global maps of Suomi NPP and NOAA-20 fire products
  - Global fire dynamics
  - Presence of “bad” scanlines
- Comparison of global fire statistics from Suomi NPP and NOAA-20
  - Fire location, fire radiative power (FRP)
- Gridcell-based statistical comparison of Suomi NPP and NOAA-20 FRP retrievals

Fires in Greece on July 23, 2018

VIIRS 375m product generated at STAR




JSTAR Mapper
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Date: 11 08 2018
Layer 1
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NOAA-20
VIIRS
Fire (FRP) - Day - I Band
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Layer 3
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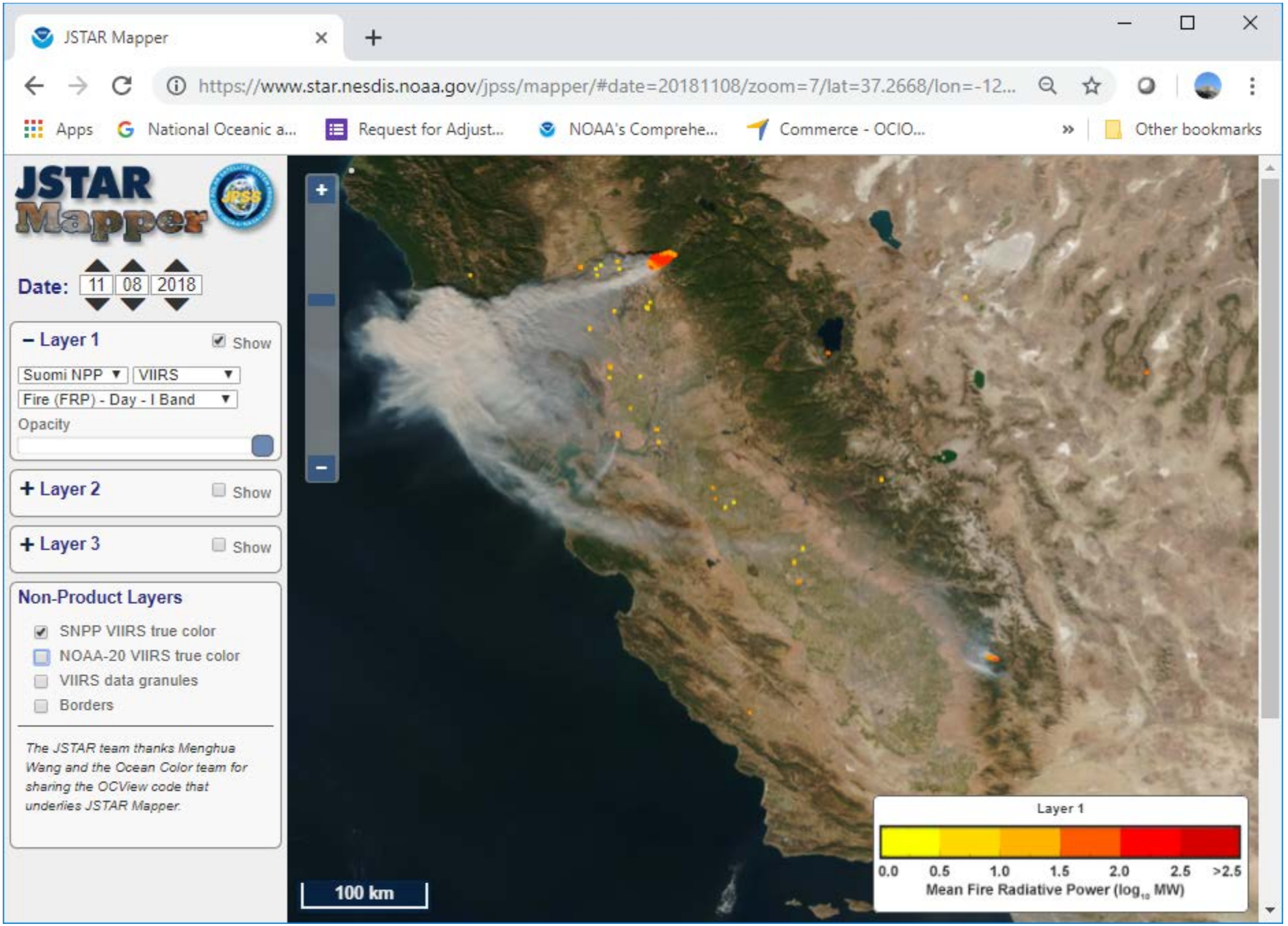
SNPP VIIRS true color
NOAA-20 VIIRS true color
VIIRS data granules
Borders
The JSTAR team thanks Menghua Wang and the Ocean Color team for sharing the OCView code that underlies JSTAR Mapper.
100 km
Layer 1
0.0 0.5 1.0 1.5 2.0 2.5 >2.5
Mean Fire Radiative Power (log10 MW)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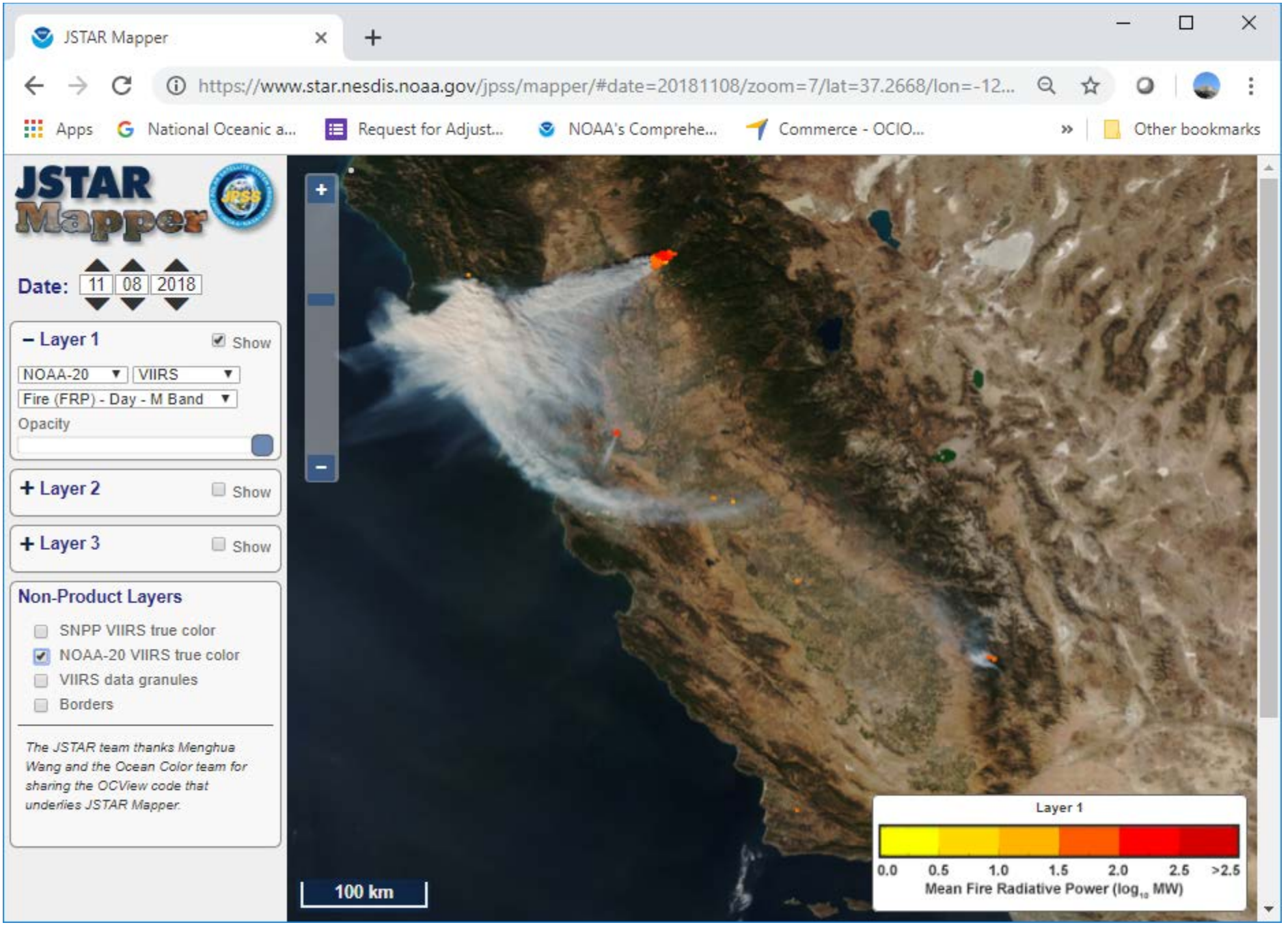
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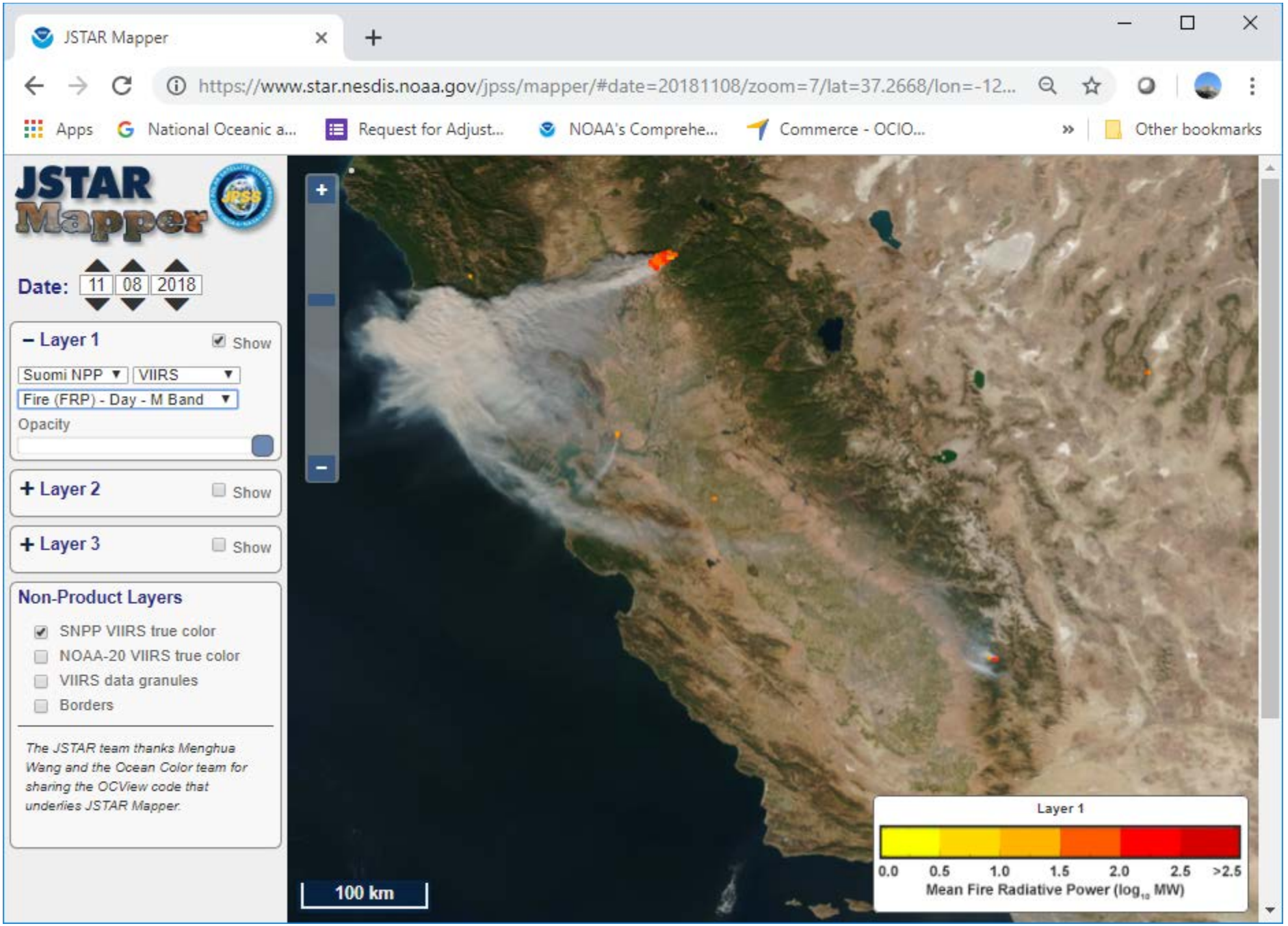
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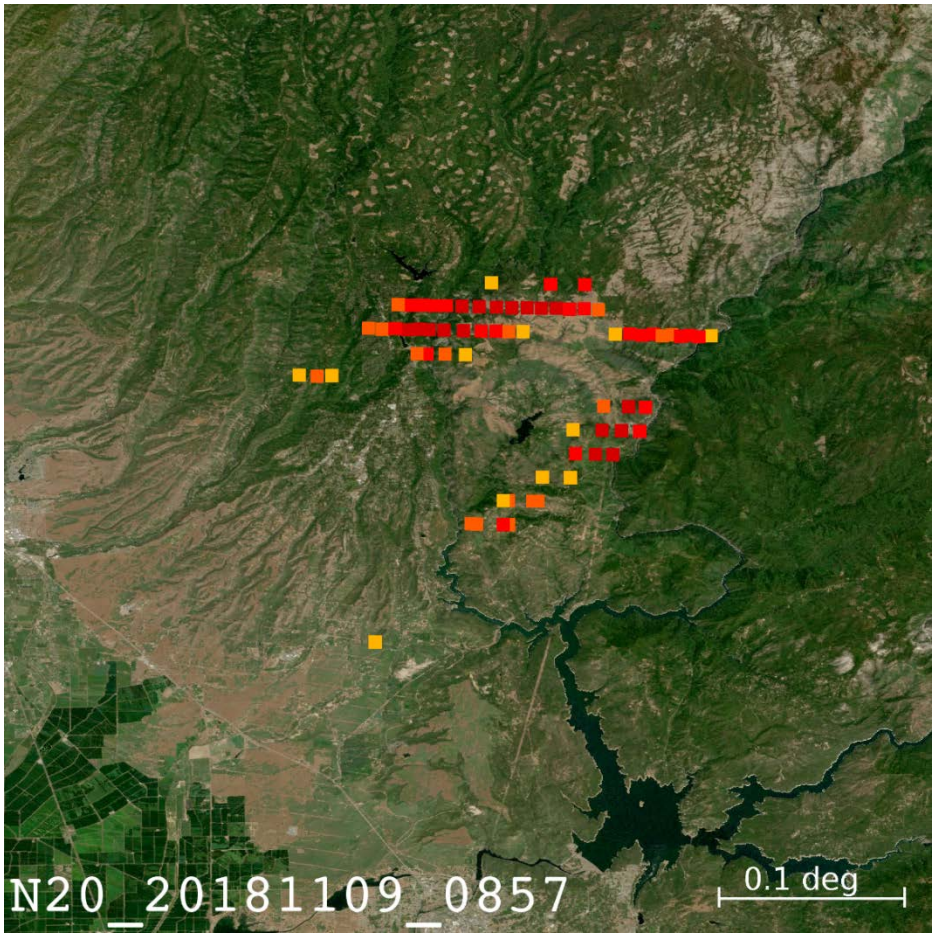
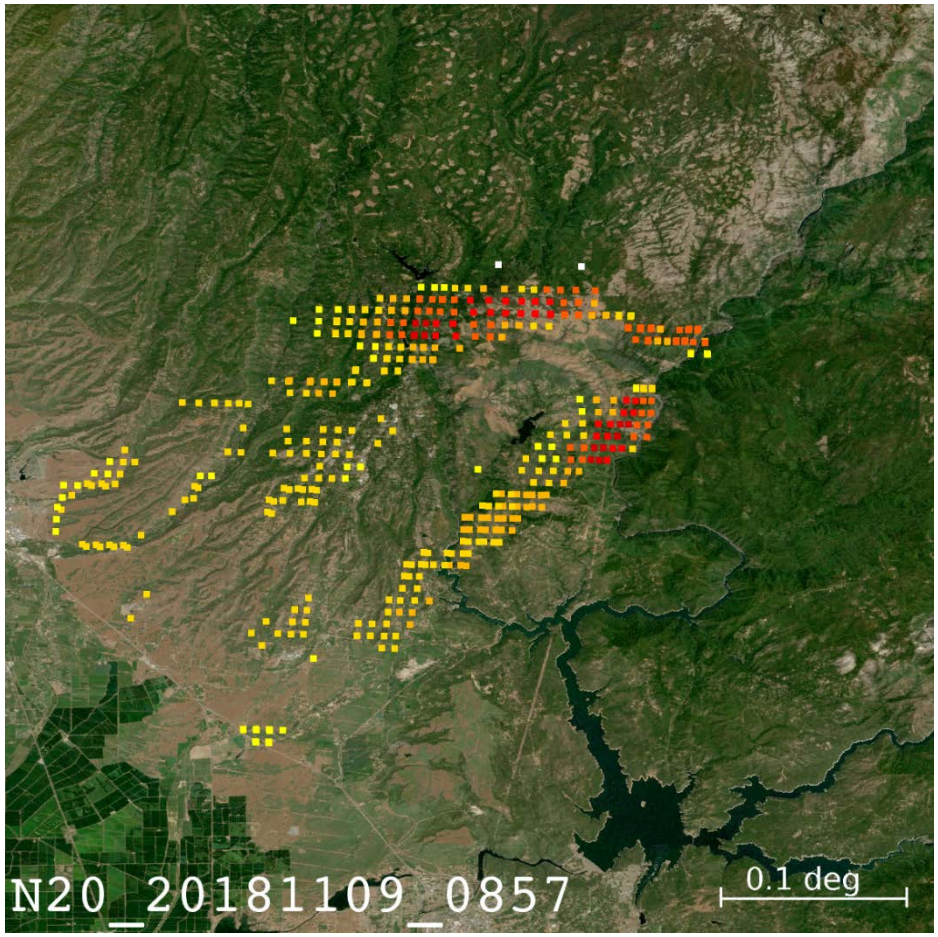
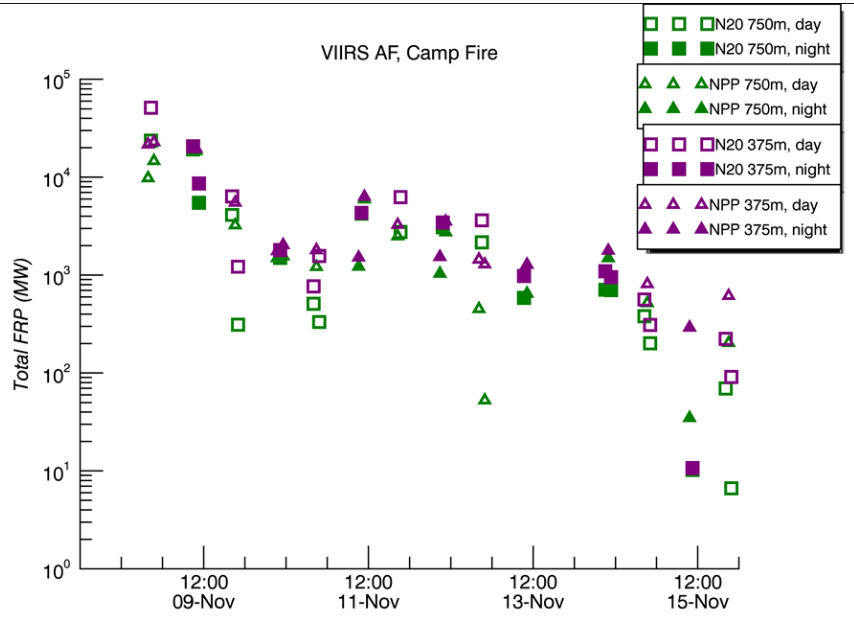
Camp Fire, CA M-band vs. I-band

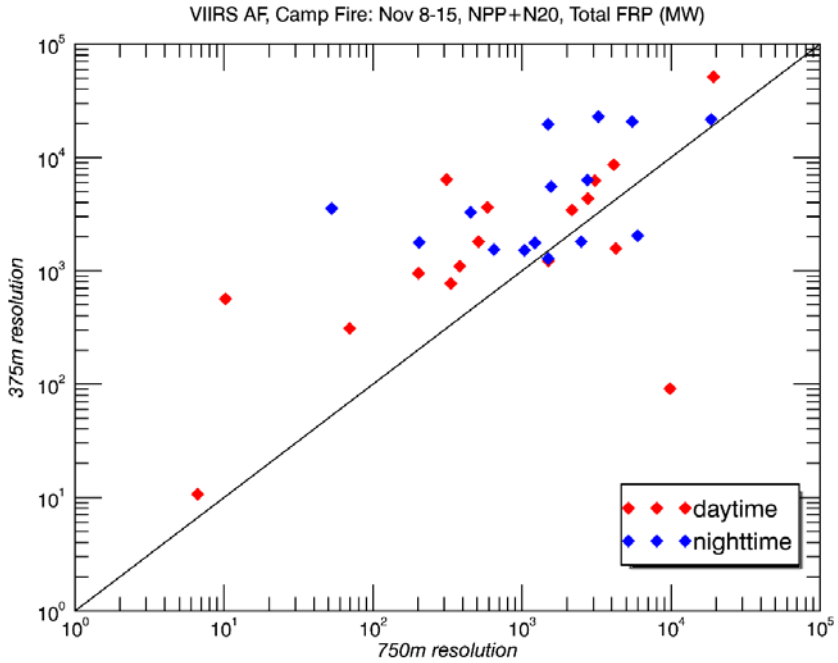




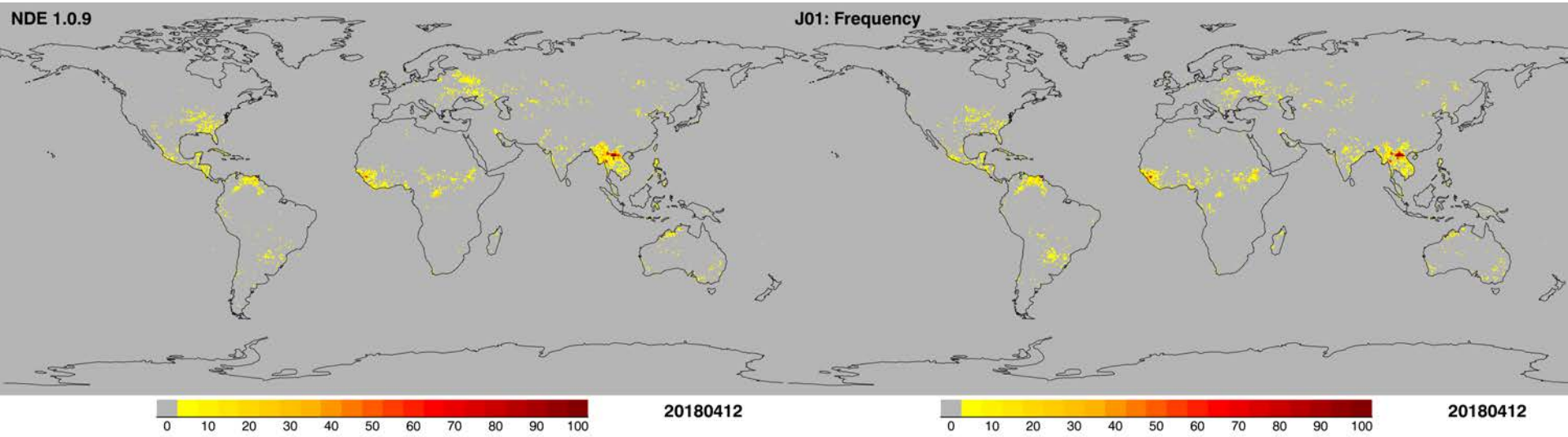
FRP signal from Camp fire, CA

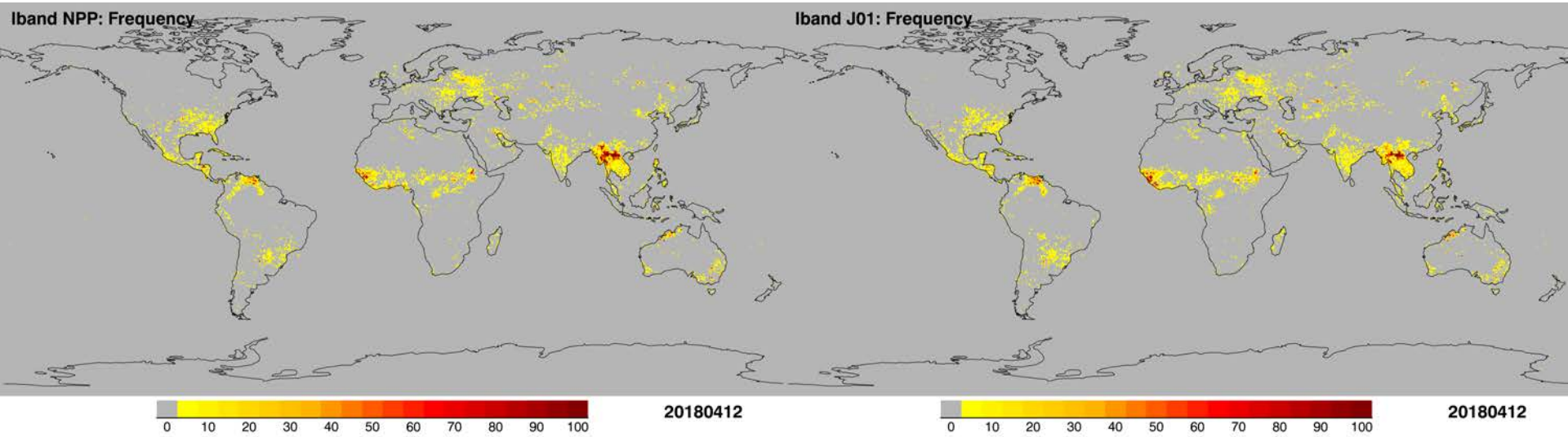


0.5x0.5 degree area centered at 121.43W, 39.81N



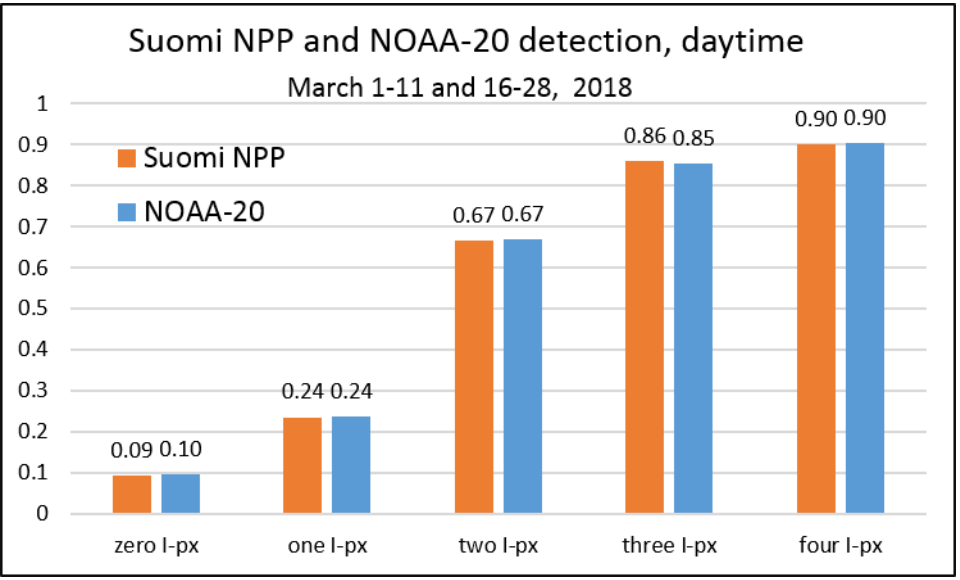
VIIRS 750m vs. 375m

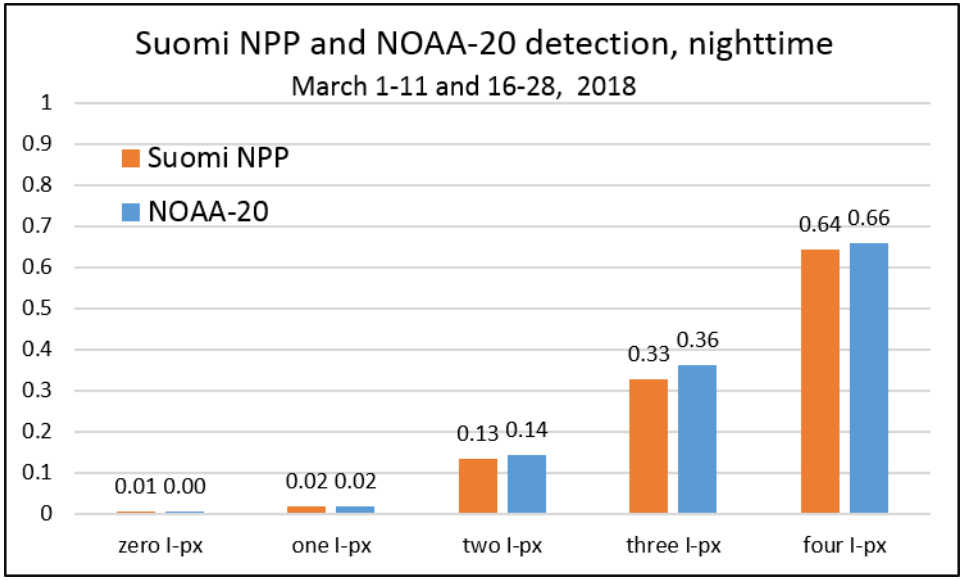




M-band vs. I-band detection rates

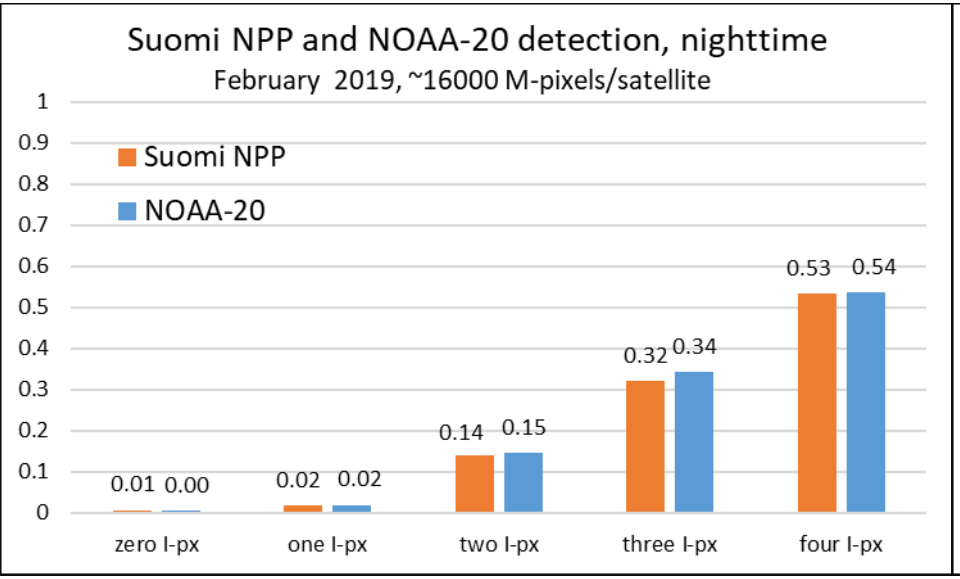
- Detection rates relative to the experimental 375m I/M "hybrid" product as a function of the number of I-band resolution detections within the M-band pixel footprint
- Frequency of M-band detections without a single I-band detection were used as a proxy for commission errors
- Increase of detection 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

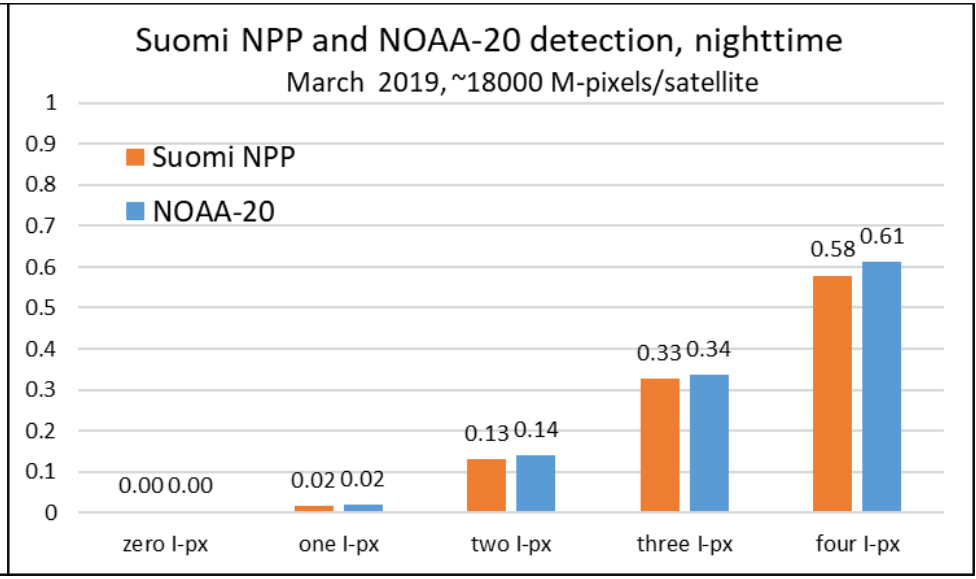


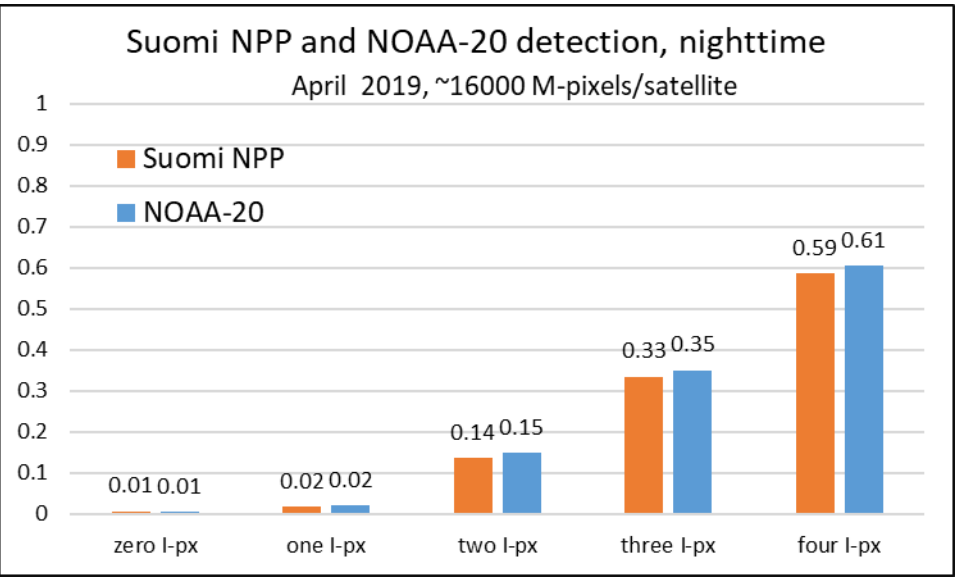


Daytime (left) and nighttime (right) relative detection performance between the operational 750m M-band and the experimental 375m I/M-band VIIRS active fire products

M-band vs. I-band detection rates

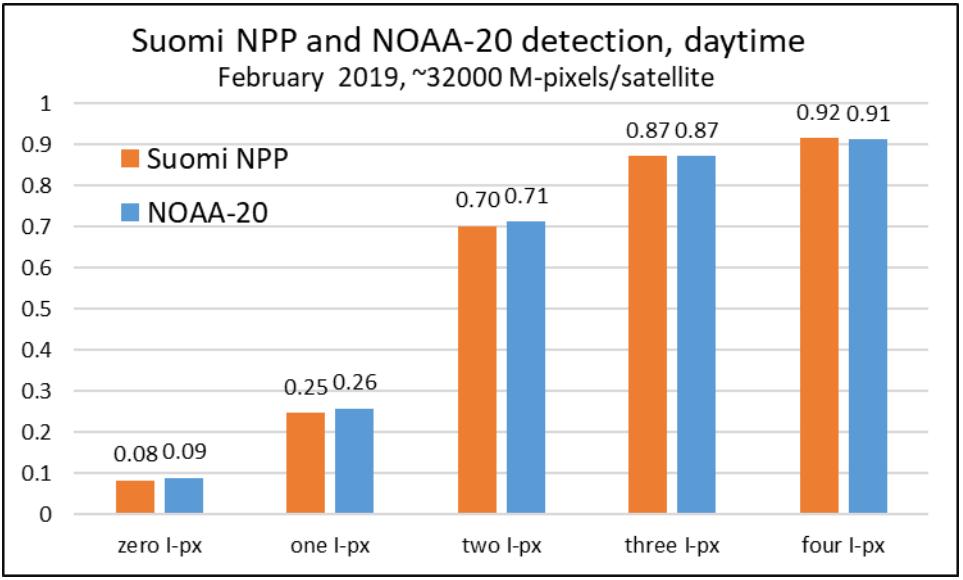


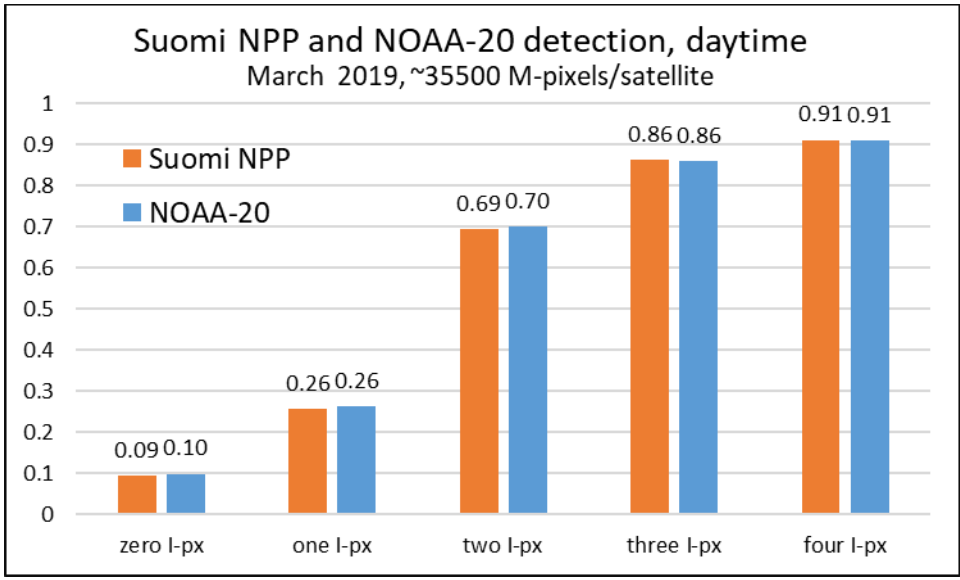


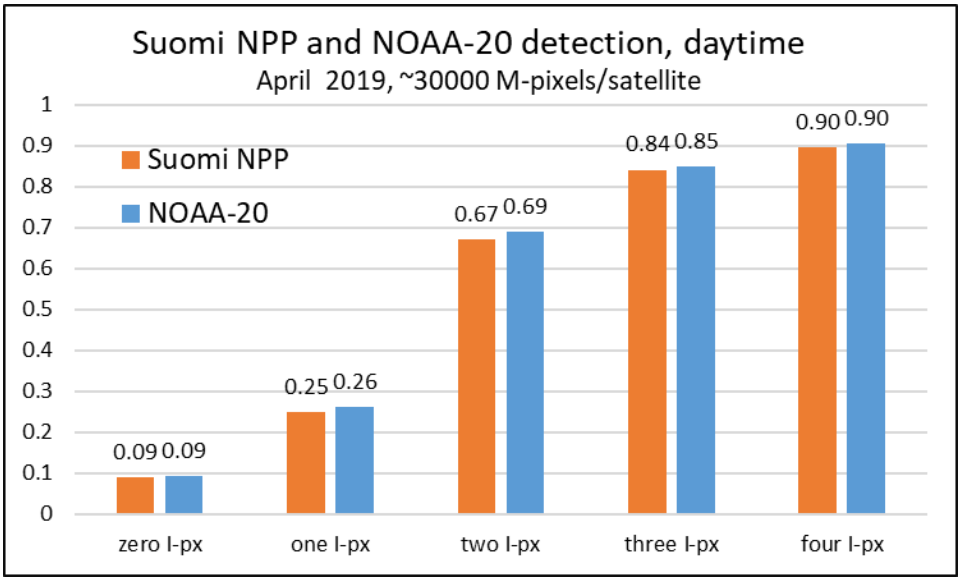


Nighttime relative detection performance between the operational 750m M-band and the experimental 375m I/M-band VIIRS active fire products

M-band vs. I-band detection rates





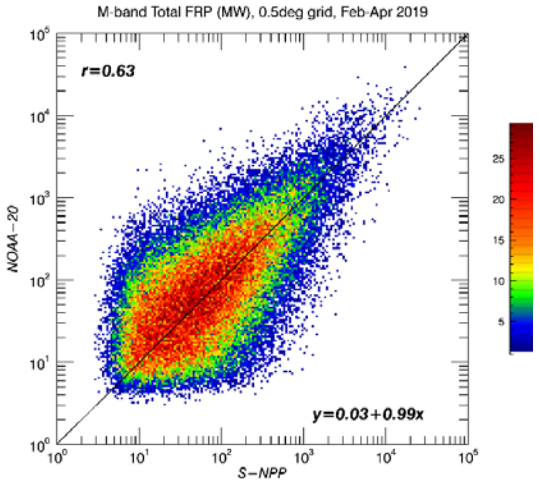


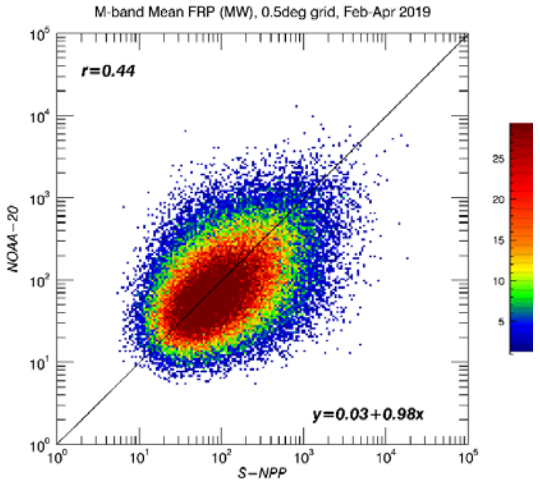
Daytime relative detection performance between the operational 750m M-band and the experimental 375m I/M-band VIIRS active fire products

Suomi NPP vs. NOAA-20 FRP: 0.5 degree grid

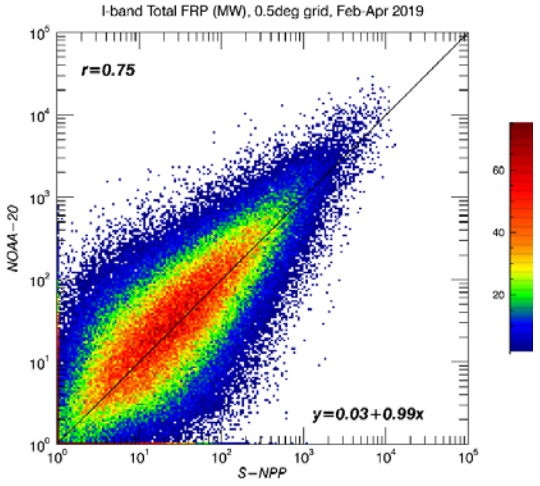
Feb – Apr 2019

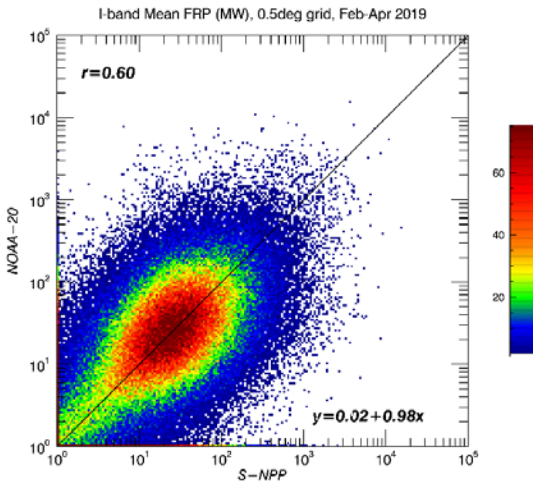
M-band





I-band

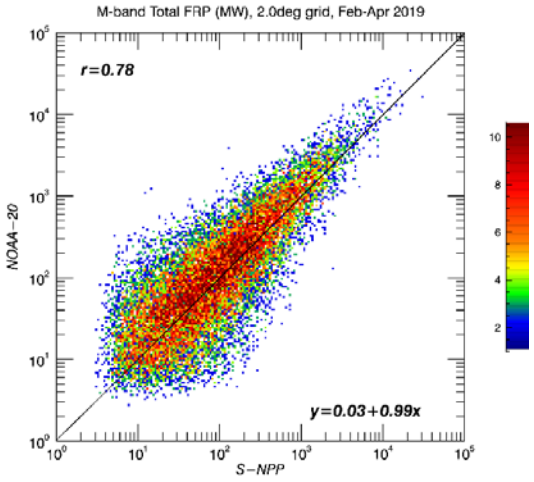


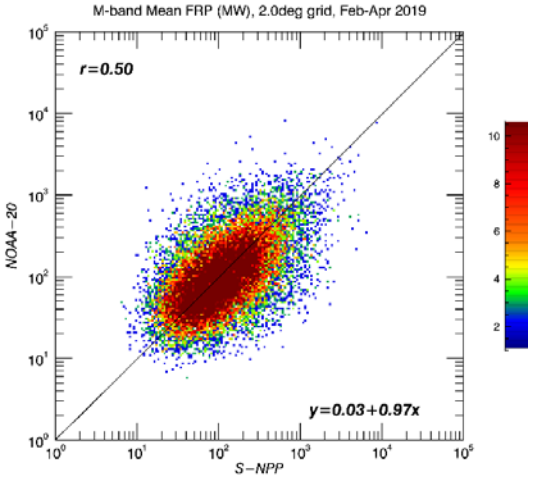


Suomi NPP vs. NOAA-20 FRP: 2-degree grid

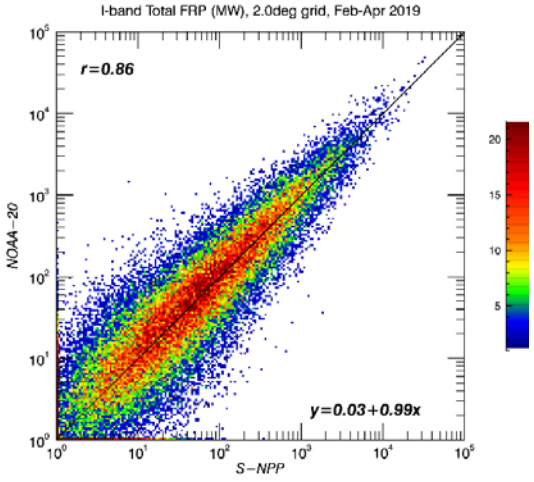
Feb – Apr 2019

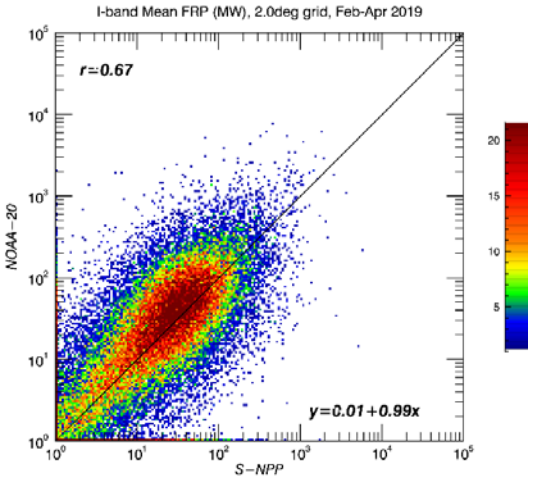
M-band



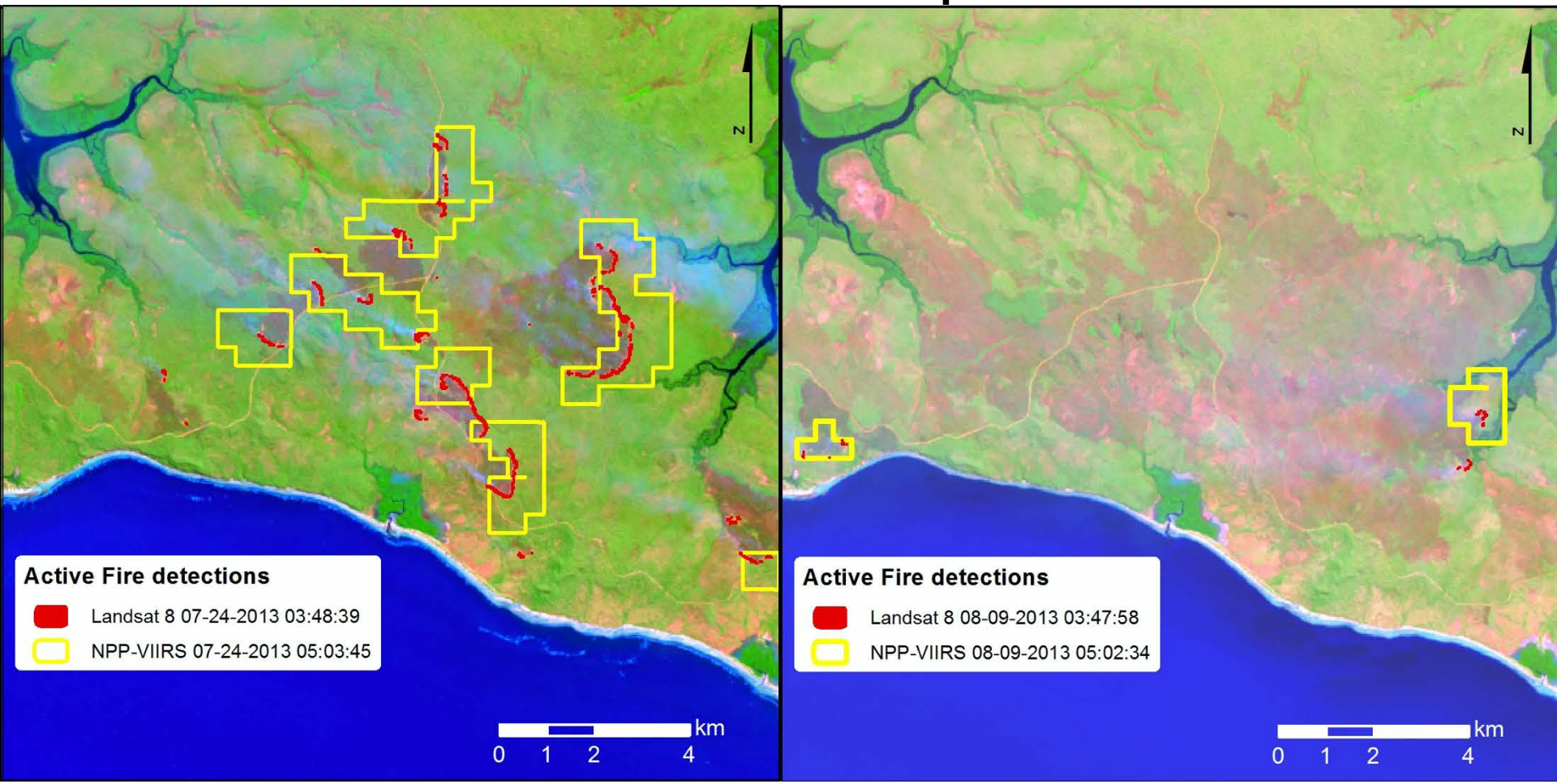


I-band



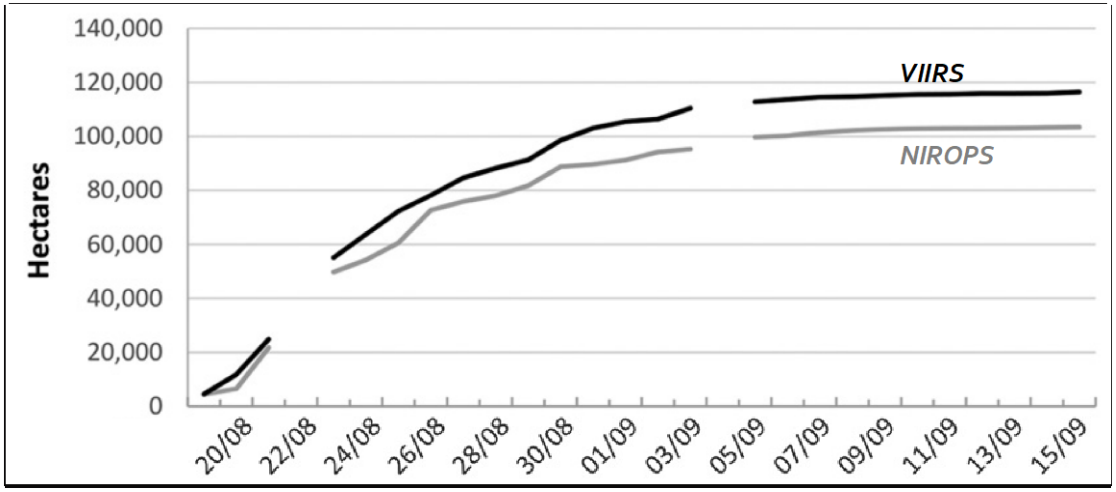


Landsat-8/OLI 30m × VIIRS 375 m Fire Data Intercomparison

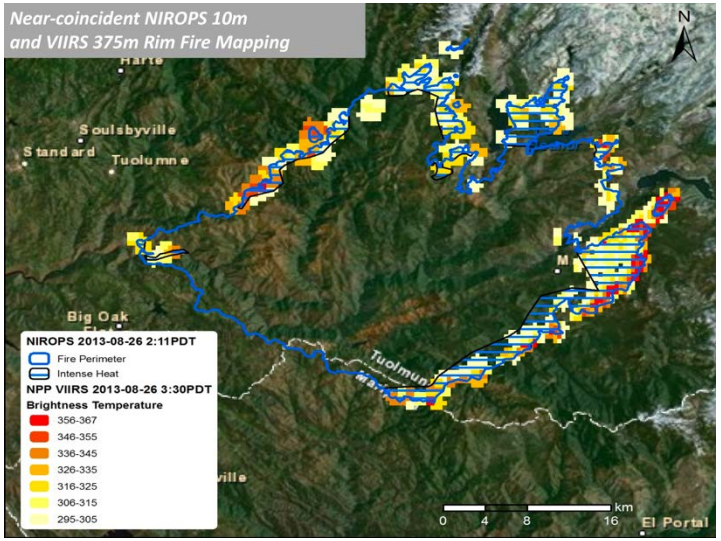


Active fires in Australia

NIROPS (airborne) 10m x VIIRS 375 m Fire Data Intercomparison (Rim Fire/CA 2013)

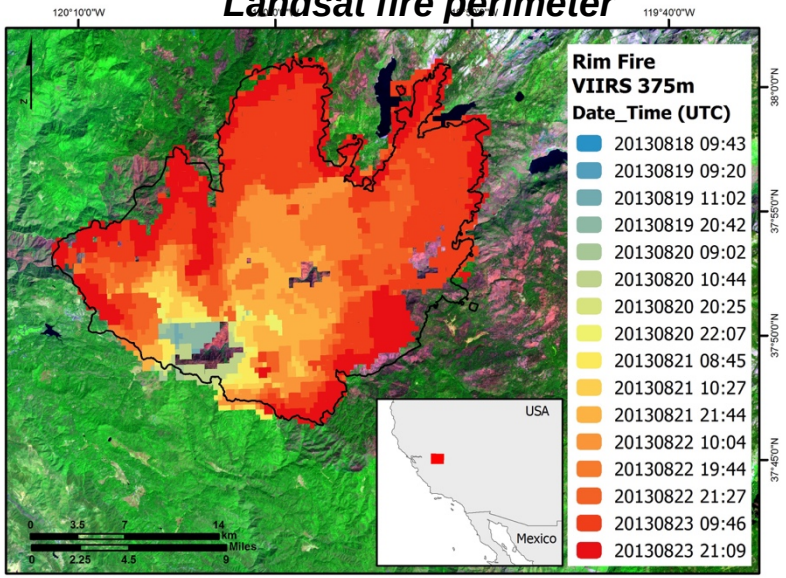


Daily mapping of fire-affected area using airborne and S-NPP/VIIRS data

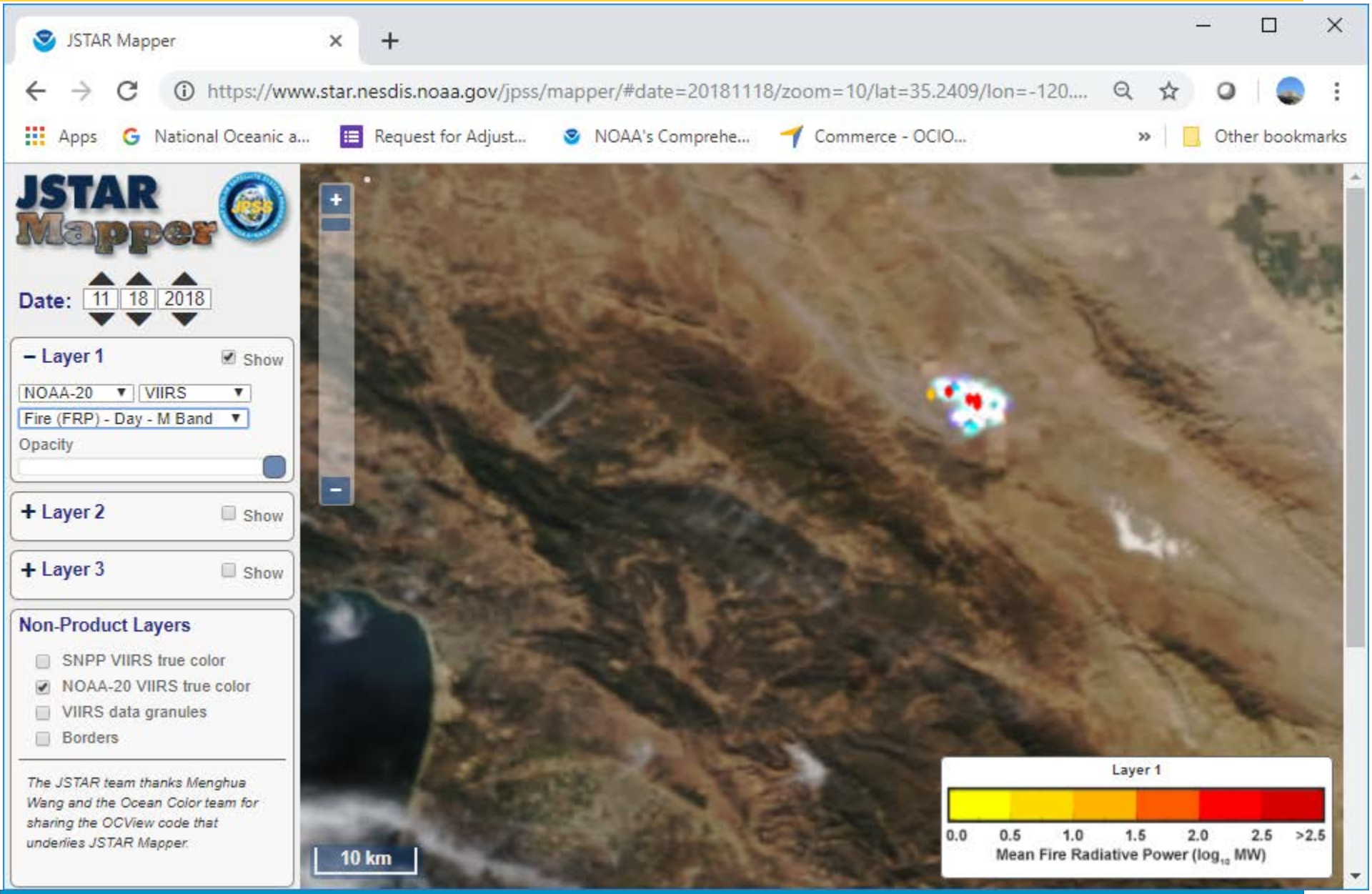


Instantaneous mapping of active fire line using near-coincident airborne and S-NPP/VIIRS data

Cumulative map of S-NPP/VIIRS fire pixels + Landsat fire perimeter



Persistent anomalies



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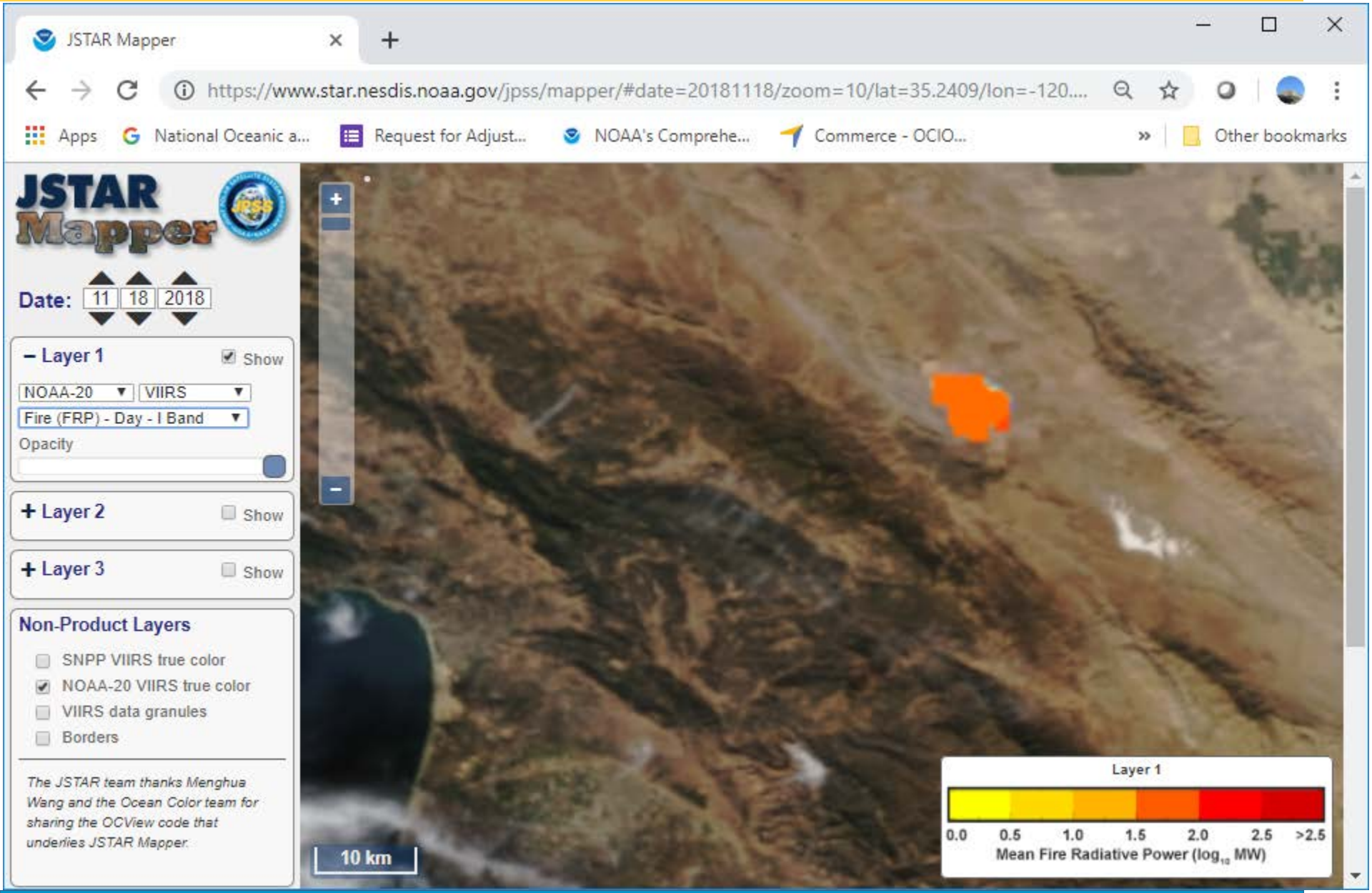

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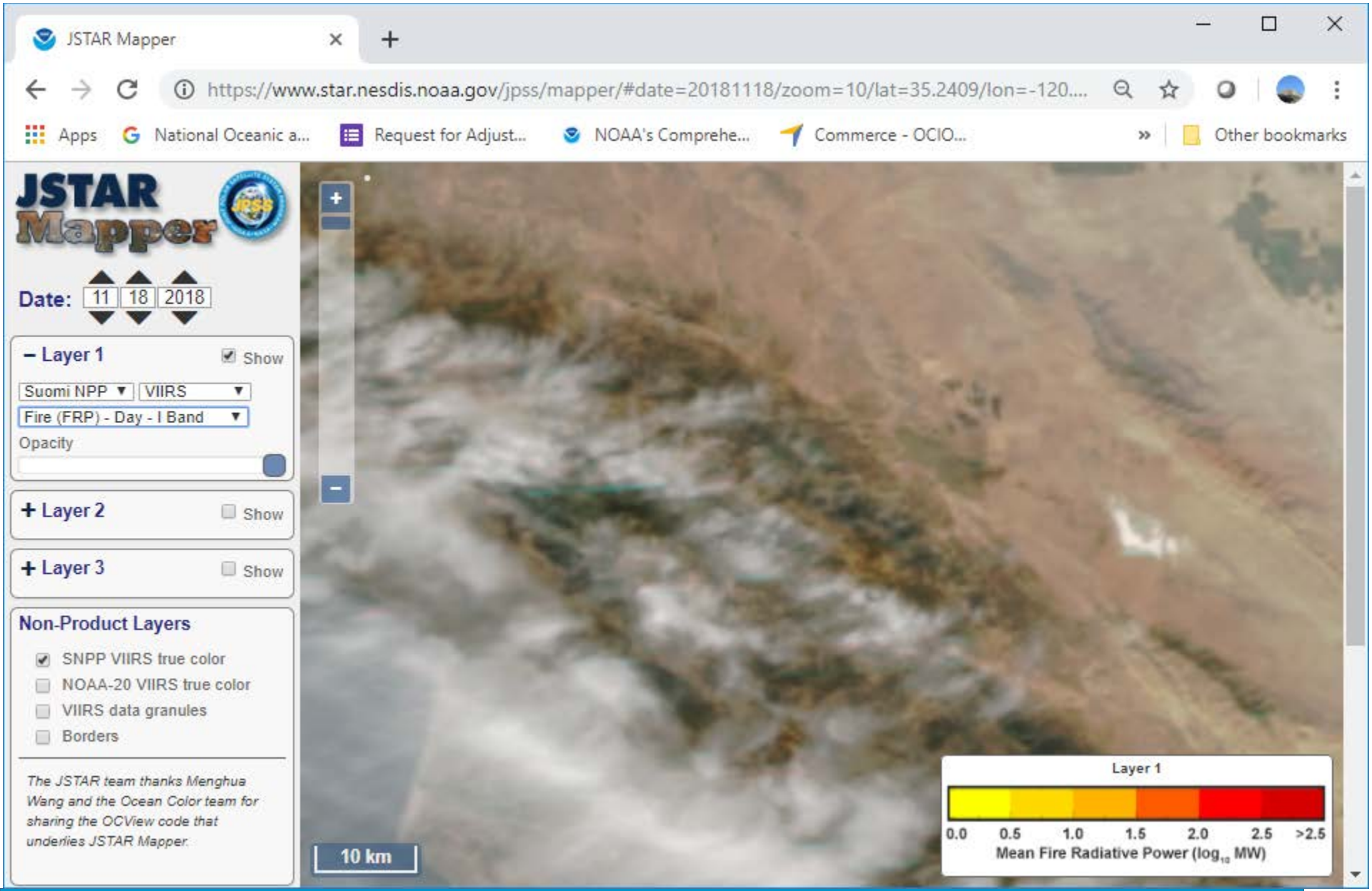

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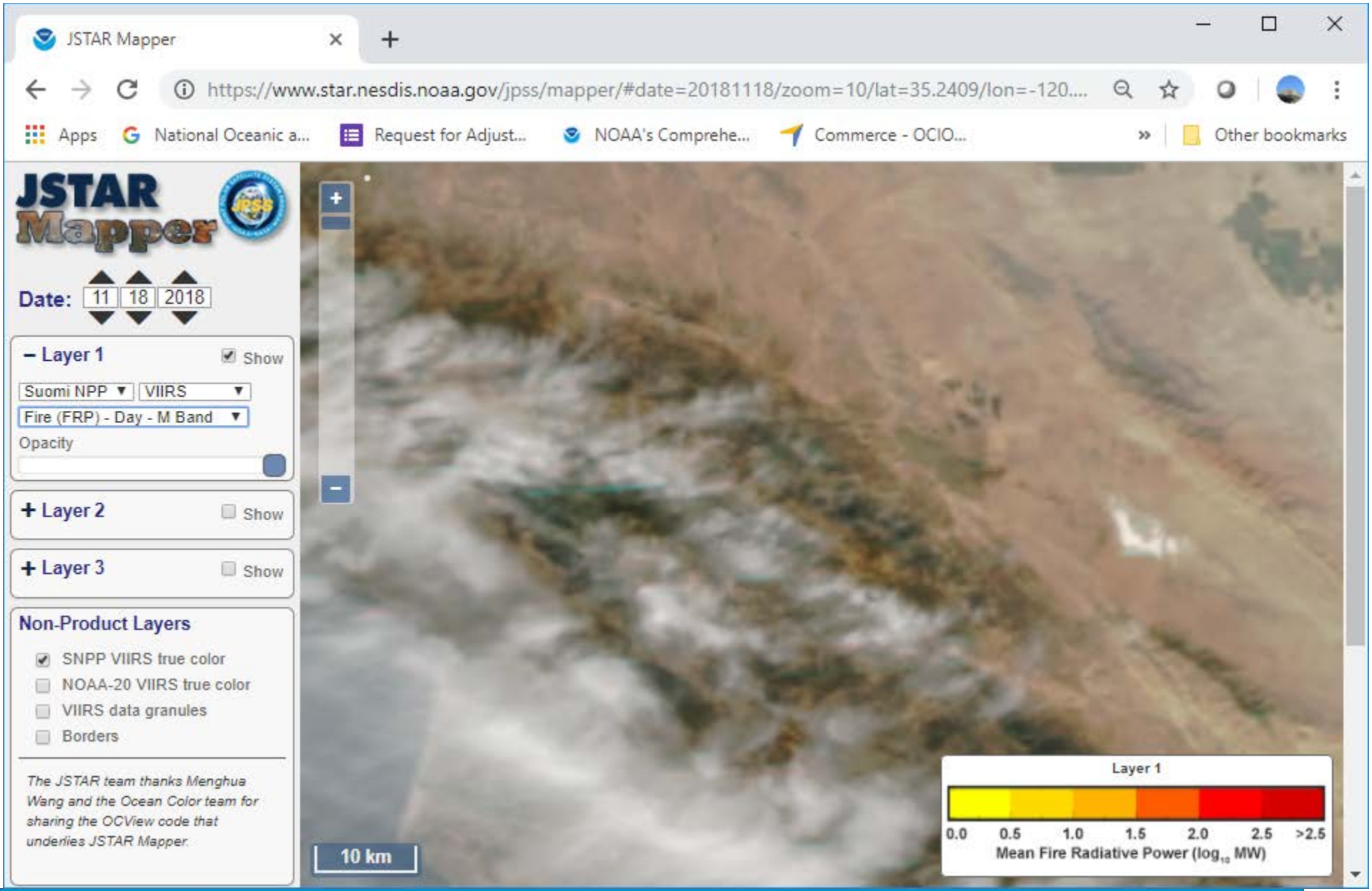
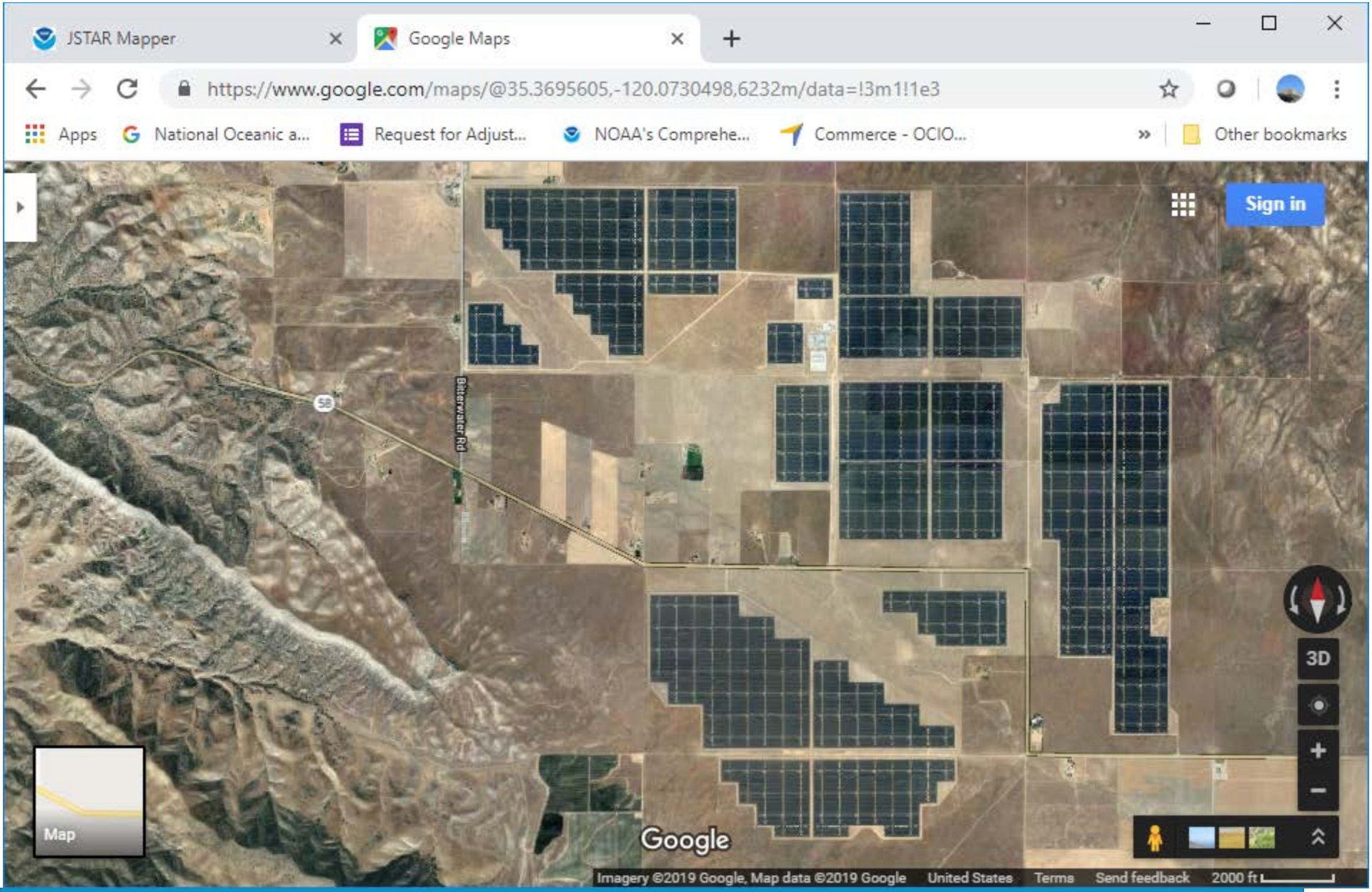
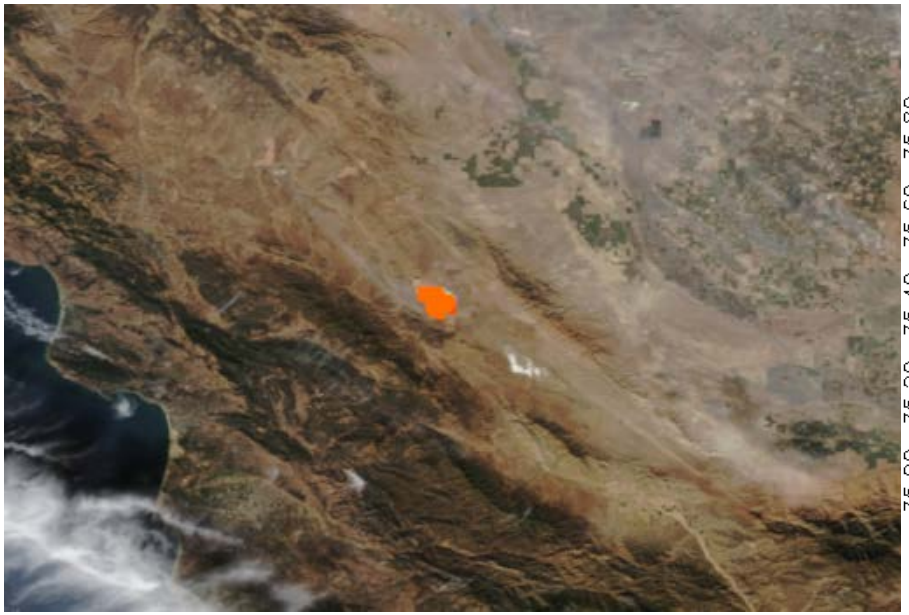


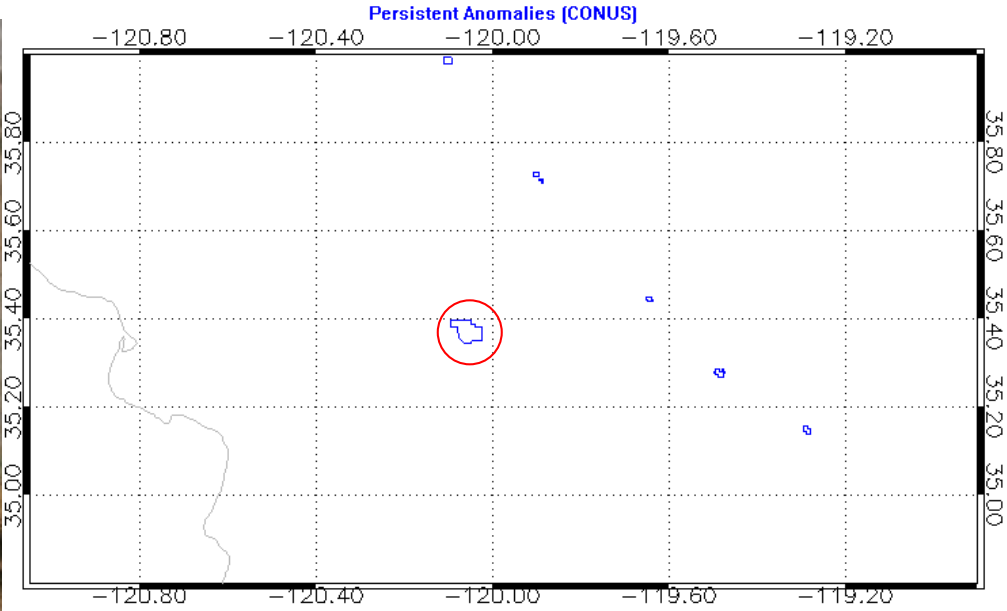
Persistent anomalies



Persistent anomalies

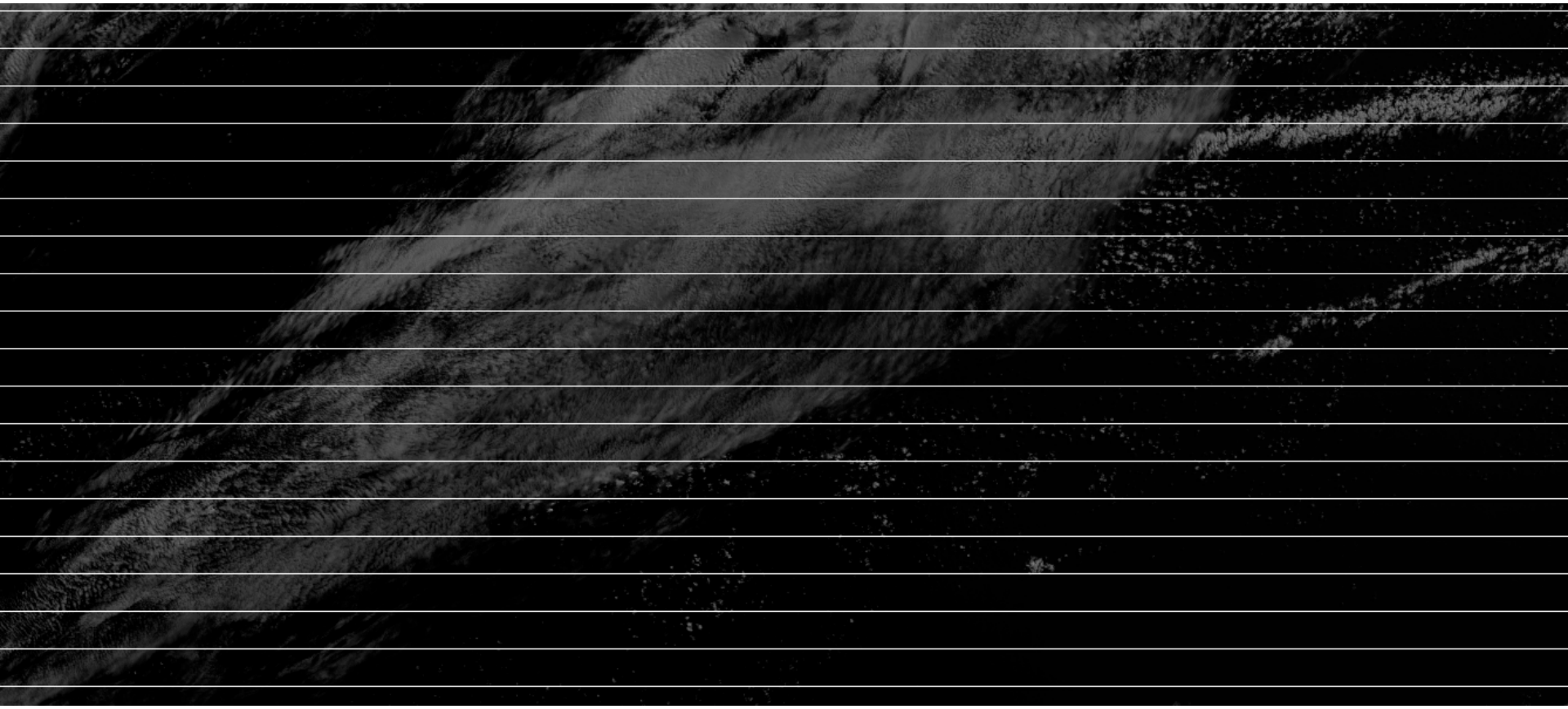
- Four classes of potential false alarms
  1. Oil/gas
  2. Volcanos
  3. Solar farms (currently only for the HMS domain – extended North America)
  4. Everything else (industrial buildings, power plants, unknown etc.)
- Information included in the product
  1. netCDF: included in QA array and sparse array for fire pixels
  2. Text files: additional variable with the four classes (or 0)





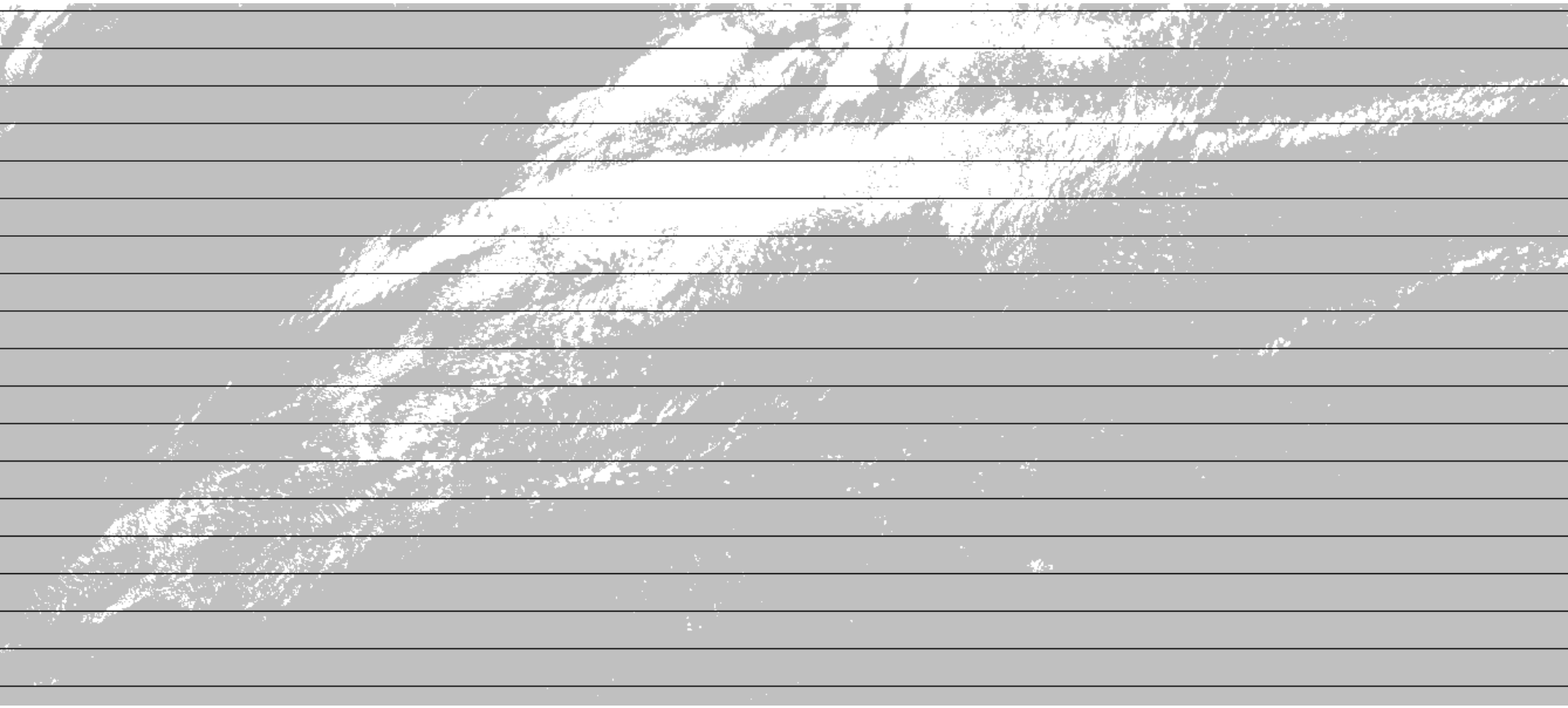
Data Artifacts - NOAA-20/VIIRS

Channel I3 - Dead detector #29 (out of 32)



Radiance -> 65531 = fill value

Data Artifacts - NOAA-20/VIIRS Fire Data



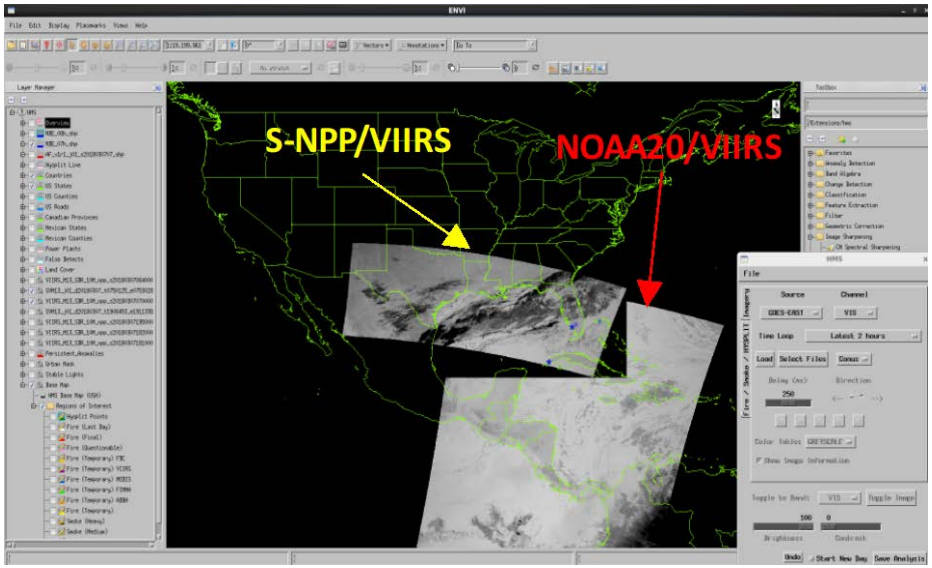
Impact on Level 2 fire mask -> missing data leading to omission errors
Channel 3 is secondary input to fire detection (used to mask out water/clouds)
Algorithm fix being developed based on data interpolation using nearest neighbors

Evaluation of algorithm performance to specification requirements

- Findings/Issues
  - No spurious scanlines – no evidence of spurious detections due to I4 calibration issues
  - Small percentage of missed detections due to I3 bad detector
  - Compatible detections counts and FRP retrievals between Suomi NPP and NOAA-20
  - False alarms from persistent anomalies
- Improvements
  - Persistent anomaly information included
  - I3 bad detector fix
- Algorithm performance evaluation
  - Test data
    - STAR processing environments
  - Validation strategies / methods
    - Cross-comparison with Suomi NPP and M-band products
    - Relative performance against the experimental I/M band “hybrid product
      - Performance assessment using semi-independent, higher quality data
  - Limited validation results using in-situ data

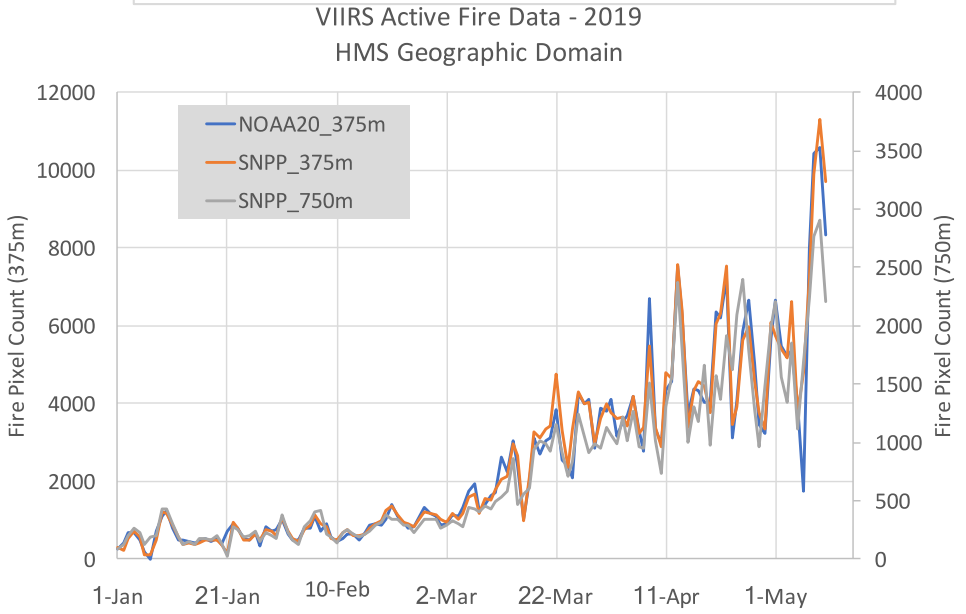
VIIRS 375m Fire Data Application at OSPO/SAB/HMS

- VIIRS 375m algorithm implemented for **OSPO/SAB/HMS on Fall of 2018**
- Currently **S-NPP and NOAA-20** data are being processed at SAB and ingested into HMS where it is integrated to other satellite data (e.g., GOES/ABI, EOS/MODIS, Metop/AVHRR)
- Its use has **boosted the detection of small fires**, and improved mapping of large fires



VIIRS 375m data respond to largest (up to +80%) share of daily fire detection locations in SAB/HMS

3.25x increase in fire pixel counts between S-NPP/VIIRS 750m -> 375m
Highly consistent fire detection patterns



User Feedback

Name	Organization	Application	User Feedback - User readiness dates for ingest of data and bringing data to operations
Ravan Ahmadov	NOAA ESRL	High Resolution Rapid Refresh-Smoke	Working on testing I-band input and enabling the code to ingest persistent anomaly infiormation
John Simko	OSPO SAB	Hazard Mapping System	375m I/M product is used in production and analysis.
Shobha Kondragunta	STAR	eIDEA, GBBEP	Working on revisions to fold 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
HRRR group	NCEP		Working with ESRL, STAR and OSPO on operational implementation
	EUMETSAT		TBC

Documents (Check List)

Science Maturity Check List	Yes ?
ReadMe for Data Product Users	Yes
Algorithm Theoretical Basis Document (ATBD)	In preparation
Algorithm Calibration/Validation Plan	Yes (NOAA-20)
(External/Internal) Users Manual	In preparation
System Maintenance Manual (for ESPC products)	In preparation
Peer Reviewed Publications (Demonstrates algorithm is independently reviewed)	Yes (Suomi NPP)
Regular Validation Reports (at least annually) (Demonstrates long-term performance of the algorithm)	JPSS Annual Meeting presentations

Summary and path forward

- The quality of the I-band VIIRS Active Fire product indicates that product has reached at least Beta maturity
  - No spurious scanlines – no evidence of spurious detections due to I4 calibration / saturation issues
  - Main performance issues identified
- Path forward
  - Algorithm changes for persistent anomalies and NOAA-20 I3 bad detector
  - Further detailed Suomi NPP vs. NOAA-20 comparisons for the entire possible range of FRP retrievals
  - Validation against independent reference data (hi-res imagery)
- Ensuring smooth transition into operations
  - Including HRRR-smoke