An Update on NOAA's Satellite Fire Product Development Activities

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NOAA National Environmental Satellite, Data, and Information Service

June 21, 2022

Operational NOAA satellites and imagers

Joint Polar Satellite System (JPSS)

- Suomi NPP (November 2011)
- NOAA-20 (November 2017)
- JPSS-2 launch planned 11/1/2022

Geostationary Operational Environmental Satellite – R (GOES-R)

- GOES-16 (East; November 2016)
- GOES-17 (West; March 2018)
- GOES-T March 1 2022

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

JPSS VIIRS product status

- **375m "I-band" product**
  - New NOAA Operational Product
  - Primary band is I4 for detection; M13 is used for characterization due to low I4 saturation
  - Much higher sensitivity than the 750m product
- **750m "M-band" product**
  - Heritage NOAA operational product
  - MODIS heritage
  - Primary band is VIIRS dedicated fire band (M13)
  - To be phased out after the transition of the downstream applications to the 375m "I-band" product
- **Both algorithms**
  - Work at daytime and nighttime
  - Process Suomi NPP and NOAA-20 (50 minutes apart on the 1:30 orbit)
  - Provide fire radiative power (FRP)
  - Provide full fire mask (fire detections, clear land, water, cloud, etc.)
  - Contain persistent anomaly flag (i.e. likely detection due to non-biomass burning related sources of signal)

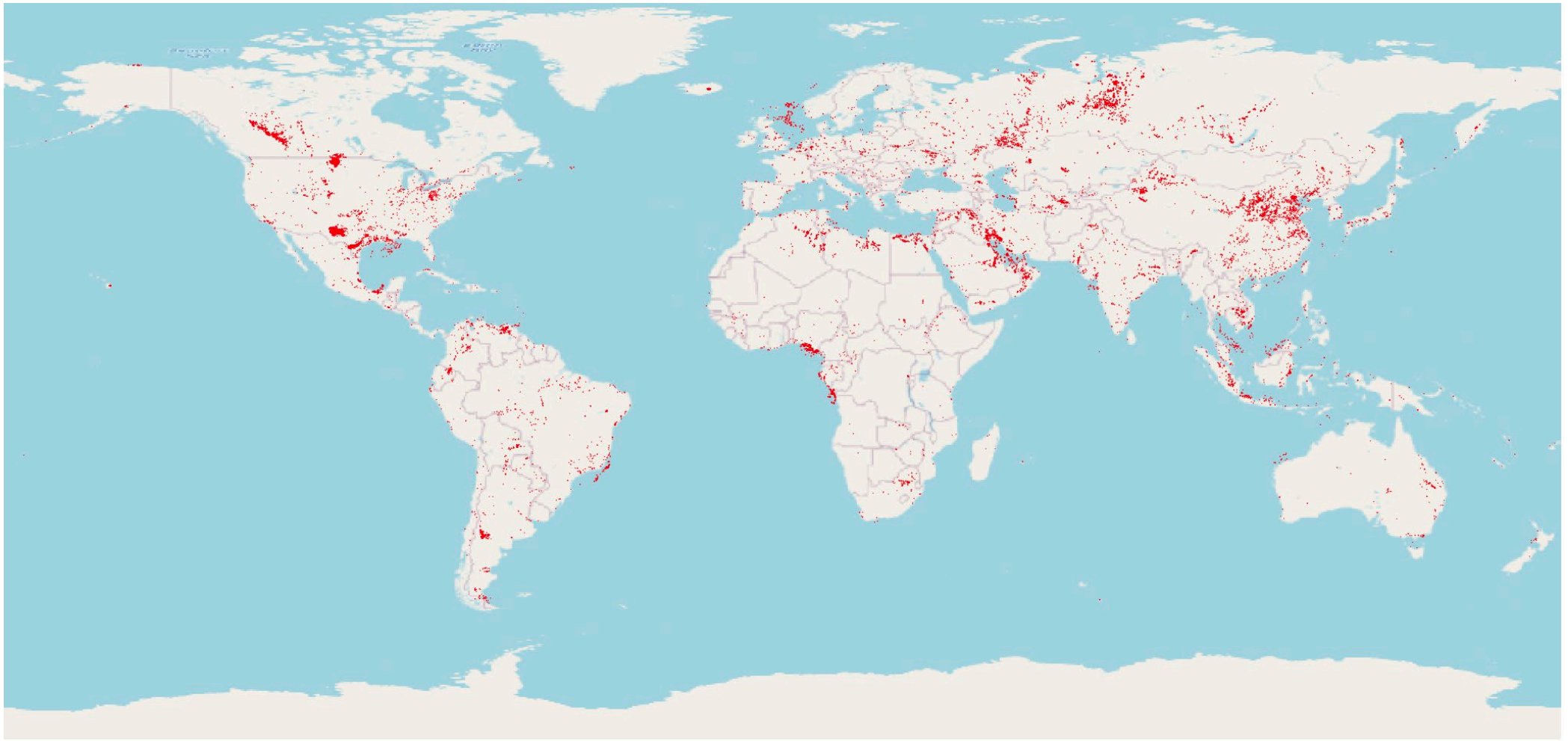
Algorithm	Suomi NPP	NOAA-20
750m (M-band)	IDPS: 1/2012 NDE: 3/15/2016	NDE: 8/13/2018
375m (I-band)	STAR: 1/30/2018 NDE: 9/30/2020	STAR: 2/5/2018 NDE: 9/30/2020

- **Global Near-real-time data**
  - 750m and 375m products from NDE ->PDA, CLASS
  - All included in JSTAR Mapper
  - Latest versions include persistent anomalies
- **Direct Broadcast: CSPP / CIMSS**
  - 750m and 375m product included
  - CIMSS processes and distributes DB data
  - Now included in RealEarth™
- **Used in emission modeling and smoke forecasting**
  - HRRR-smoke, GBBEPx etc.

Planned 375m Algorithm Improvements

- Still running the first version of the algorithm except for minor adjustments made to address bad L1b input data
- Recurring false alarms found over reflective sources (e.g., solar farms) – potential fix based on improved handling of bright pixel rejection tests. Use of persistent anomalies database has helped minimize the problem in the meantime
- Recurring omission errors found over snow-covered areas like Canada, US Midwest, Siberia, and under translucent clouds – potential fix based on revised cloud tests
- Recurring hot plume detection features impacting wildfires at times coinciding with explosive growth – ambiguous radiometric characteristics make it particularly challenging to avoid those. Thick and cooler plumes preventing detection in similarly large wildfires
- Atmospheric correction of FRP retrievals – work on MODTRAN-based transmittance LUTs could not be completed. Resuming effort exploring CRTM-based approach

Persistent Anomalies Database from Liu *et al* [2018] (includes updates to North America)



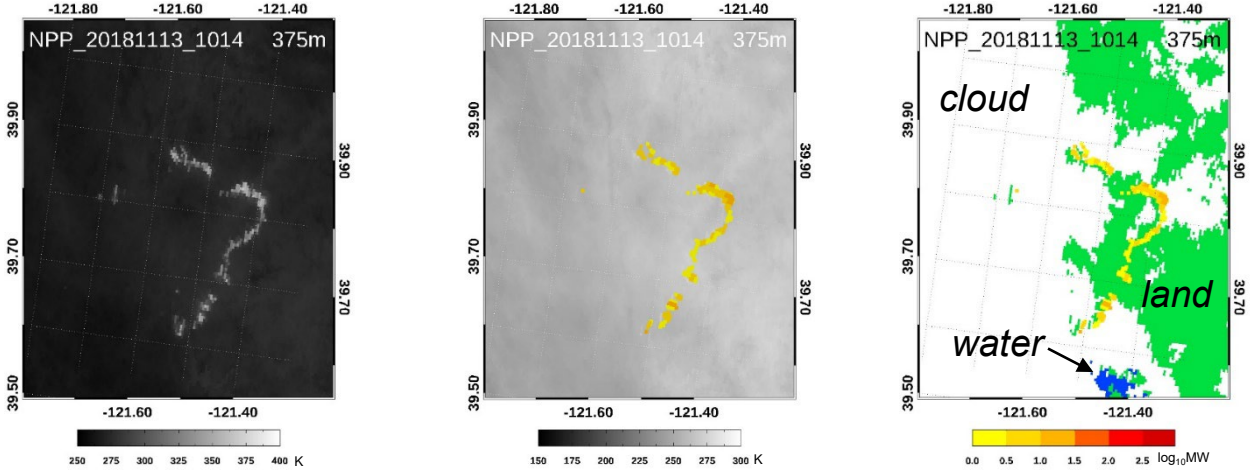
Detection and characterization under clouds and smoke

VIIRS I4 TB

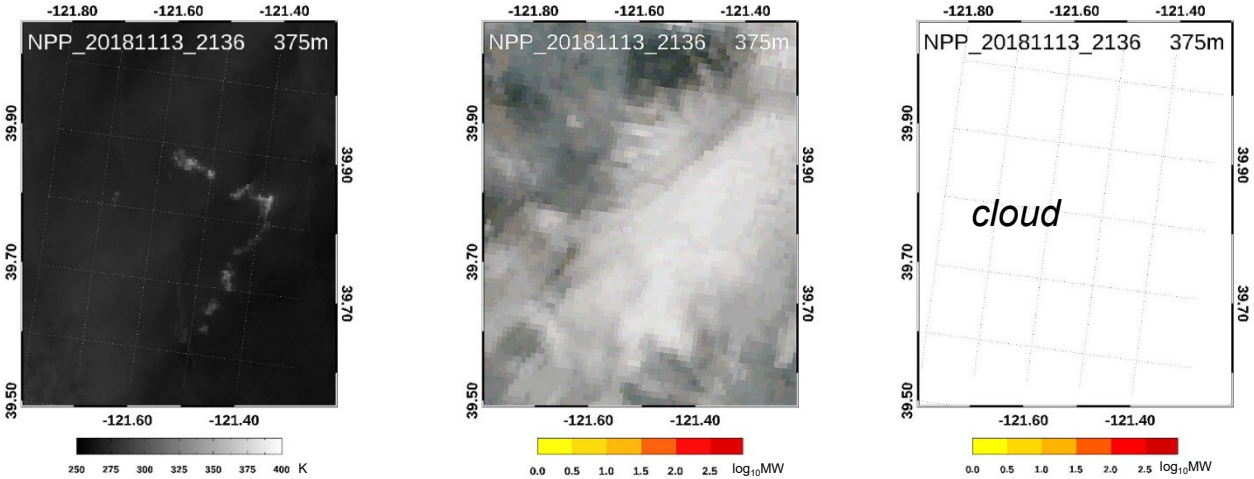
FRP over background image

VIIRS I-band fire mask

nighttime

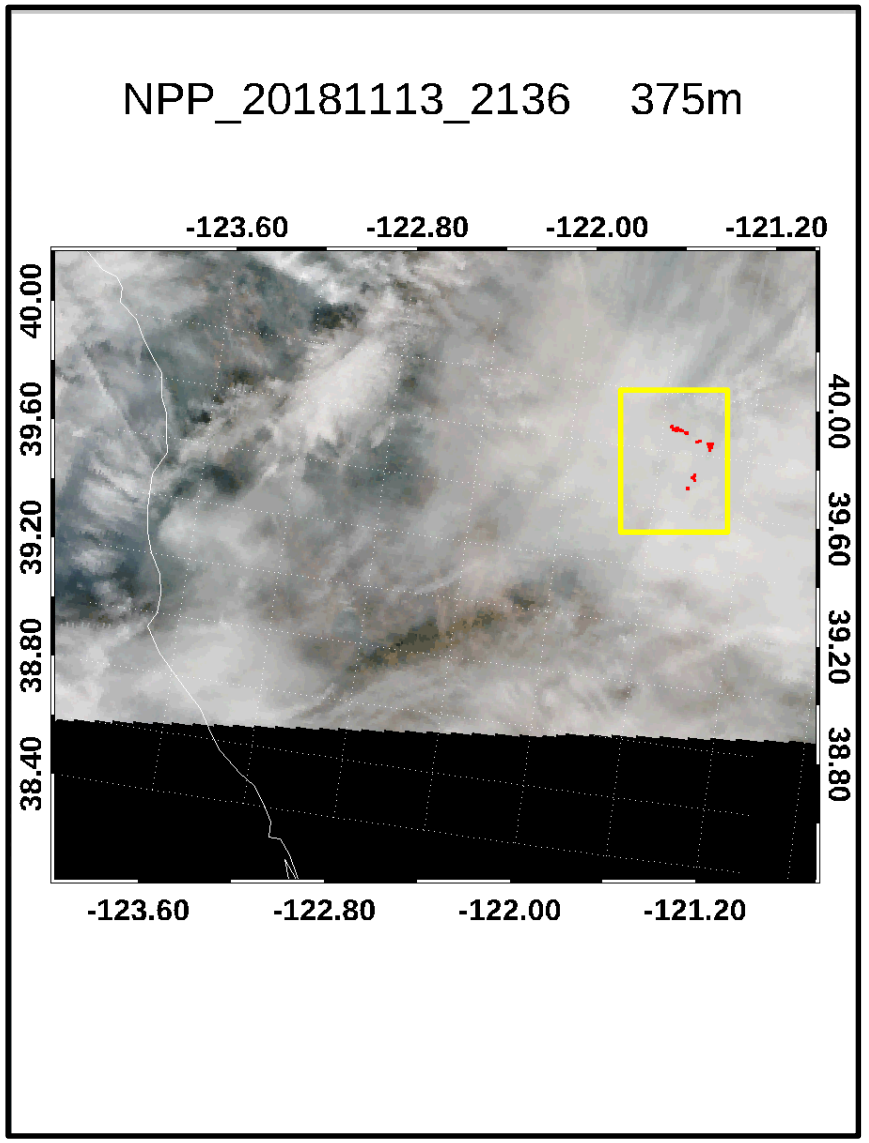


daytime



improved initial screening

relaxed internal cloud mask



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VIIRS I4 TB

FRP over background image

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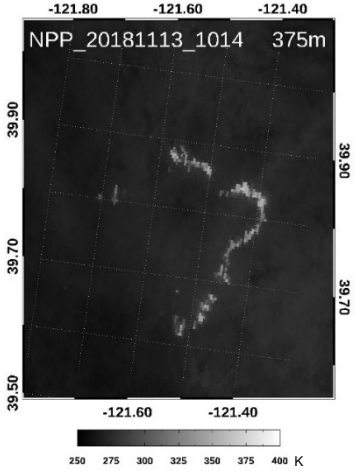
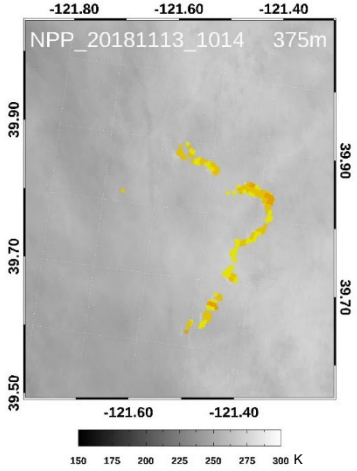
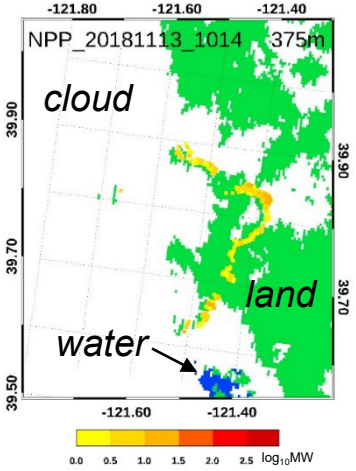
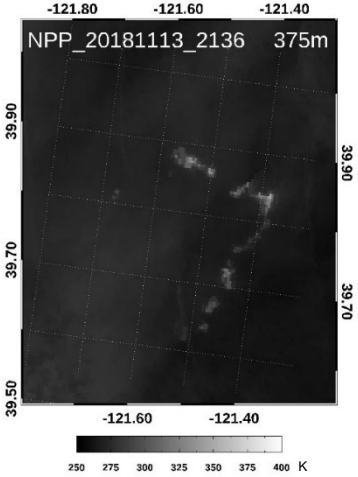
nighttime

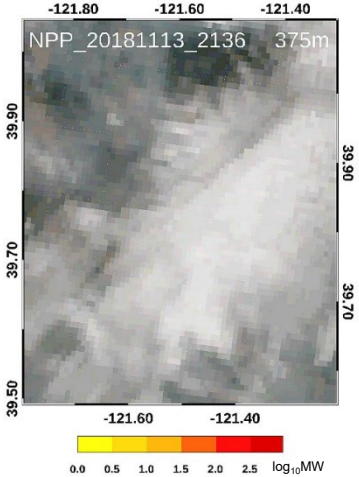


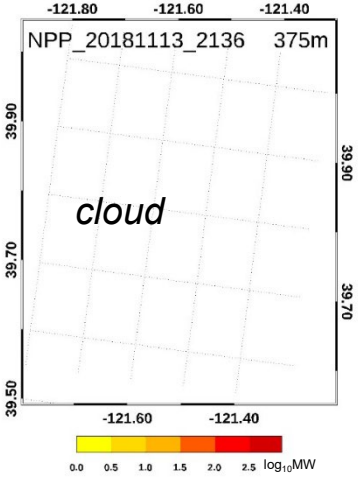




daytime



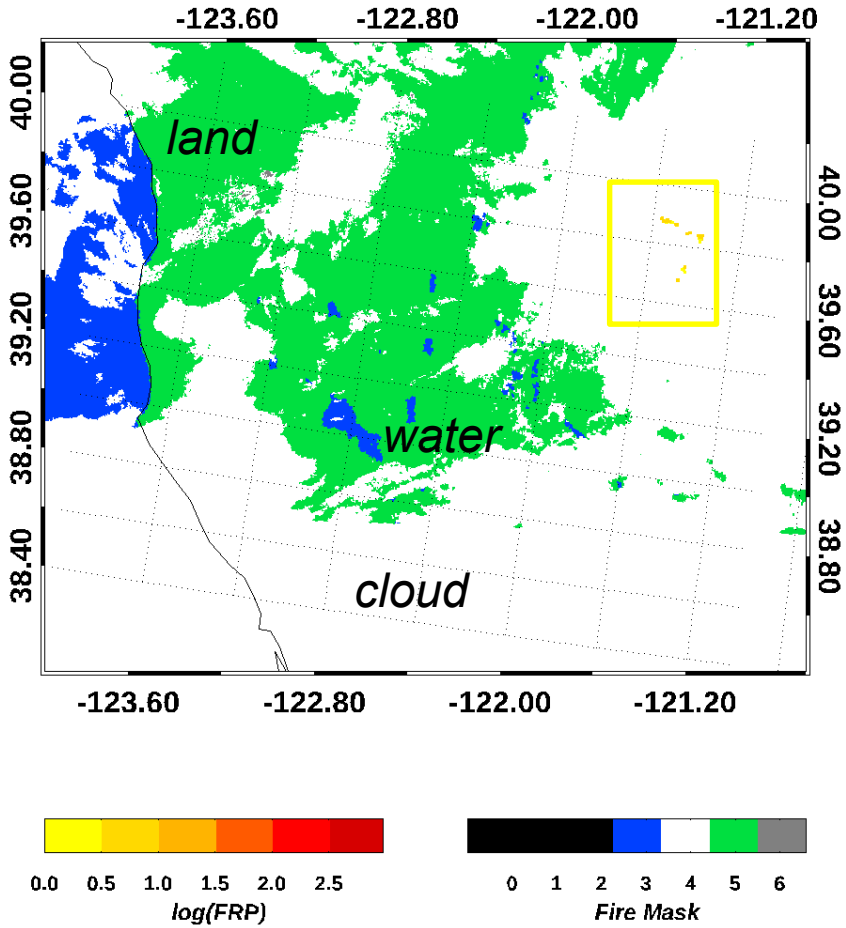




improved initial screening

relaxed internal cloud mask

NPP_20181113_2136 375m

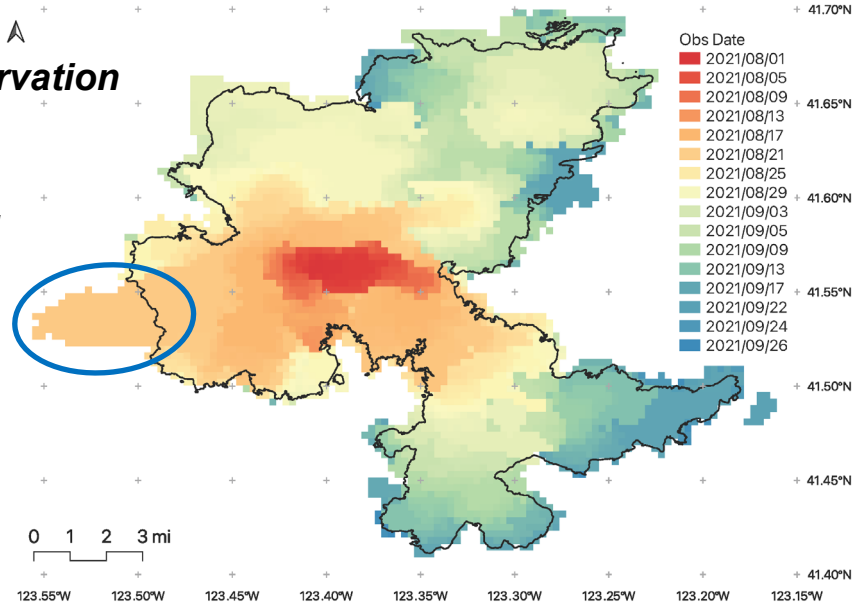


Hot Smoke Plume Detection Feature

VIIRS FRP and NIFC fire perimeter

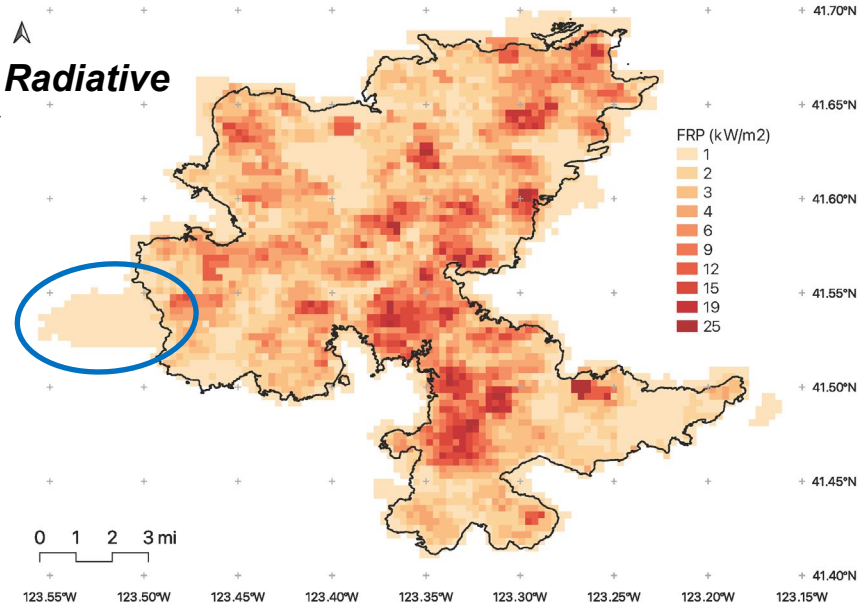
Date of observation

False signal from hot smoke plume



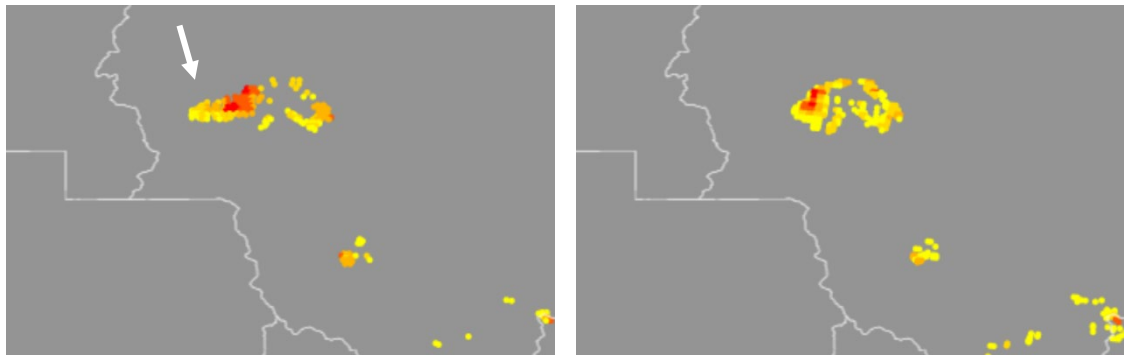
Cumulative Fire Radiative Power

False signal from hot smoke plume



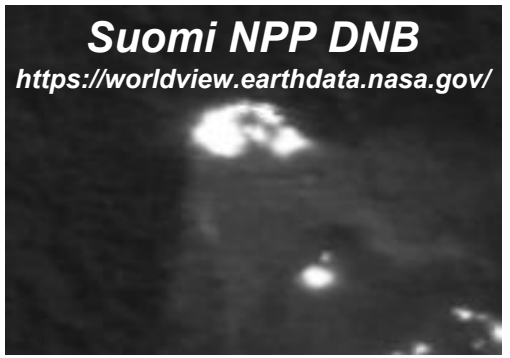
McCash Fire, CA
Aug-Sep 2021

Suomi NPP
8/21/2021
8:58 UTC
Scan angle ~55º



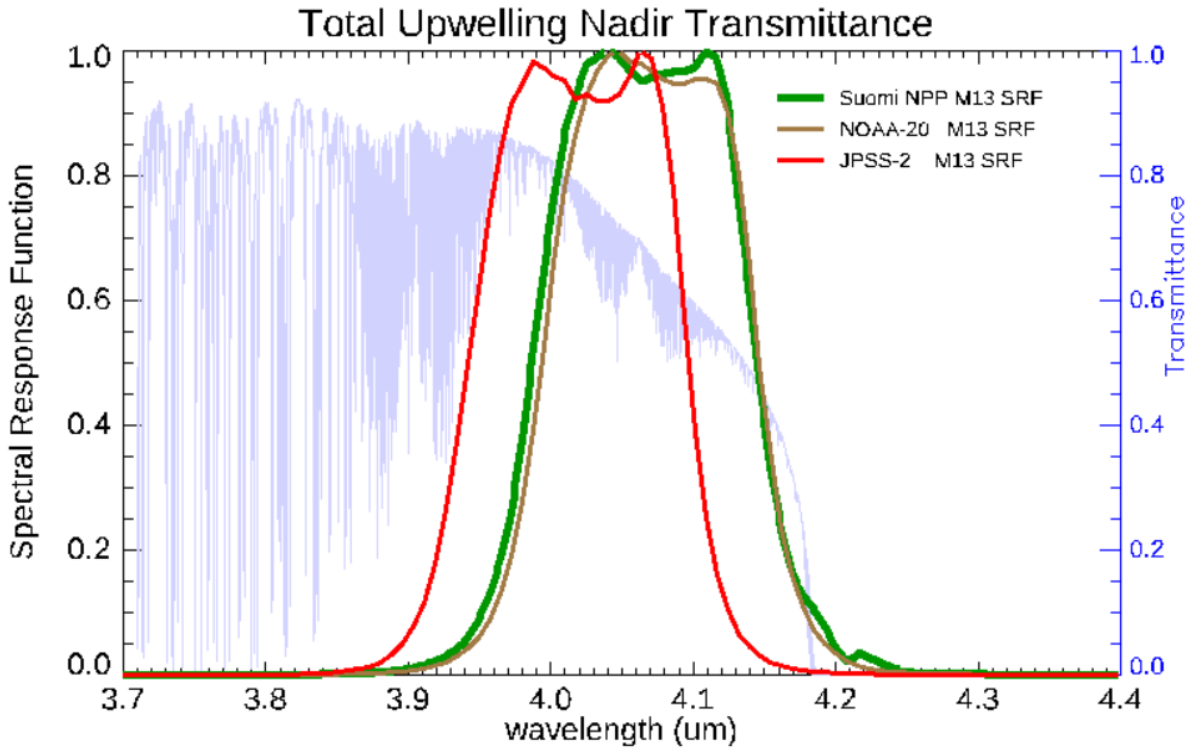
https://www.star.nesdis.noaa.gov/jpss/mapper/

NOAA-20
8/21/2021
9:49 UTC
Scan angle ~26º



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

Atmospheric correction and JPSS-2 Readiness



VIIIRS band M13 spectral response functions https://ncc.nesdis.noaa.gov/. Data courtesy JPSS Program and VIIRS Sensor Team, NOAA/NESDIS/STAR

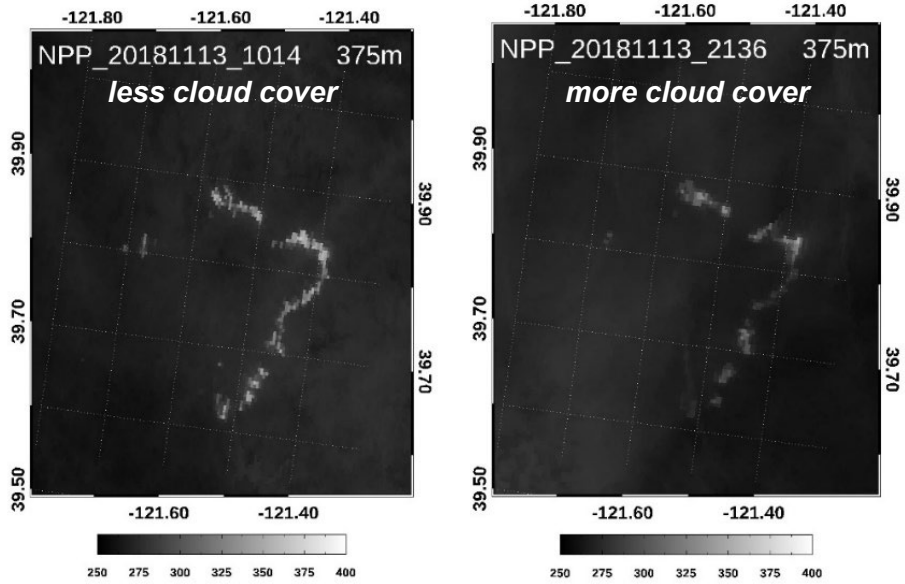
Also shown is an example of total atmospheric transmittance spectrum (H_2O, CO_2, O_3, N_2O, CO, CH_4, water continuum absorption) derived using the Community Radiative Transfer Model (CRTM) for a ECMWF training profile. Data courtesy Yong Chen, NOAA/NESDIS/STAR

FRP retrieval coefficient has been updated for J2 VIIRS M13

Ongoing work towards atmospheric correction

- **Atmospheric gases**
- **Atmospheric particles**

Camp Fire, November 13, 2018



Suomi NPP VIIRS I4 (~3.74 μm) brightness temperature

GOES-R ABI product status

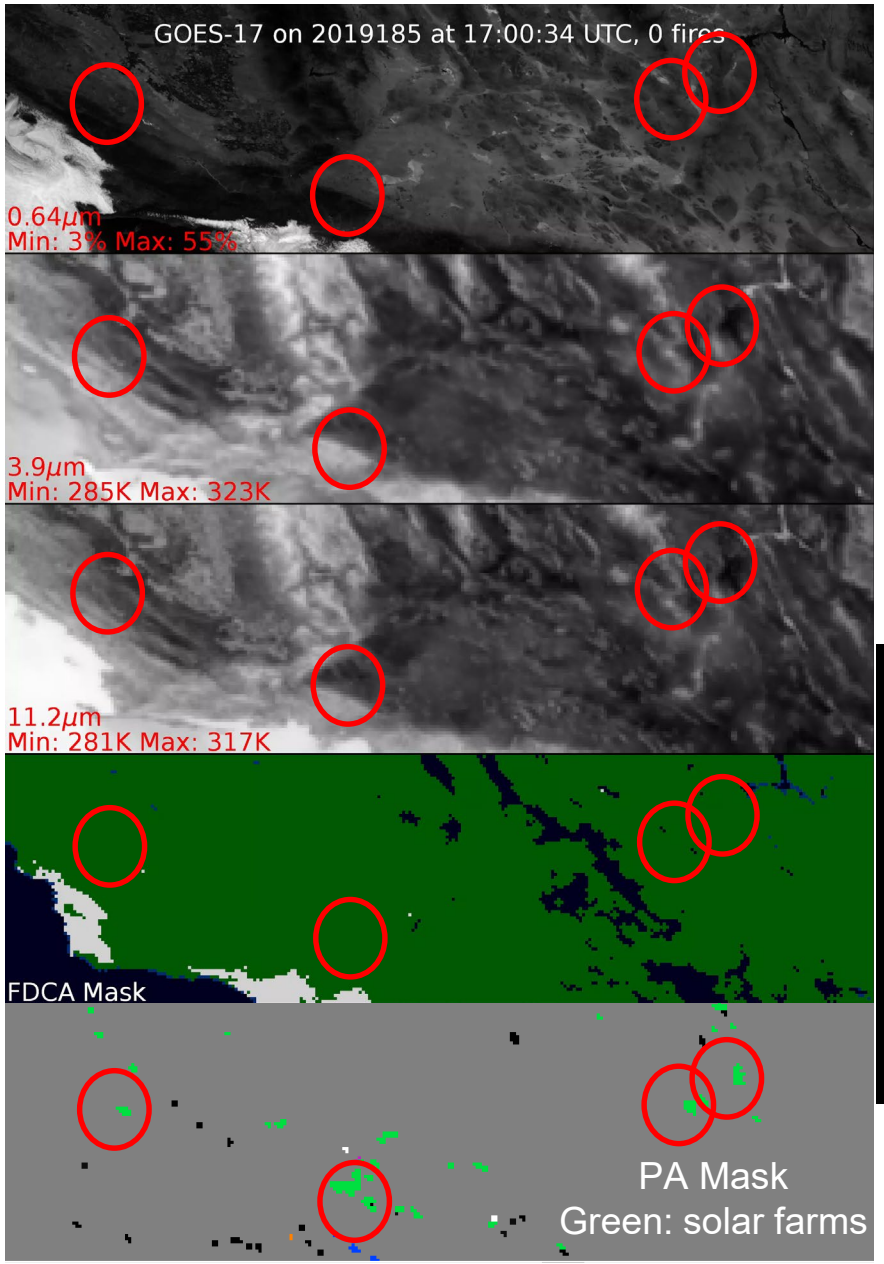
- **NOAA FDC product operational for GOES-East/West in all scanning modes**
  - Data processing expanded to include meso-scale high frequency (1min) sectors (04/2021), all available on AWS cloud
  - GOES-18 post-launch checkout is underway
- **Alternative AI-based algorithms are investigated**
  - focus on early detection, improved FRP
- **Upcoming algorithm improvements**
  - Nighttime sensitivity
  - Further reduction of false alarms
    - Clouds, bright surfaces, warm surfaces, sunglint
    - Flagging and detection of persistent anomalies
  - Updated surface type, terrain correction
  - Improved atmospheric corrections, cloud masking

Persistent anomalies (PA)

- Work is underway to incorporate PA flags into GOES-R processing systems
  - PA already in the operational VIIRS processing
  - a common PA module was implemented in the Enterprise Fire processing system (eFire)

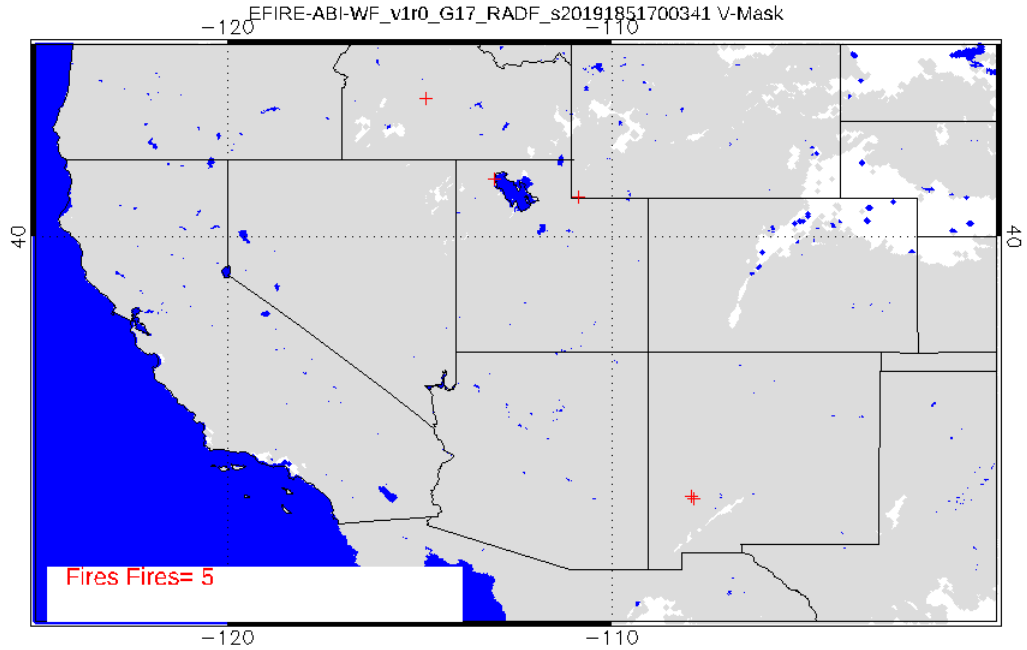
An example of a fire pixel flagged as solar farm:

```
from EFIRE-ABI-WF_v1r0_G17_RADF_s20191851840341_e20191851849408.txt
year, month, day, hh, mm, lon, lat, mask, confidence, BT4mu, FRP, line, sample, bowtie, PA_objectTime, PA_category
2019, 07, 04, 18,42, -120.0146, 35.3717, 8, 60, 406.504, 2290.530, 954, 3438, 0, 20180128, 3: Solar Panel
```



Baseline FDC product

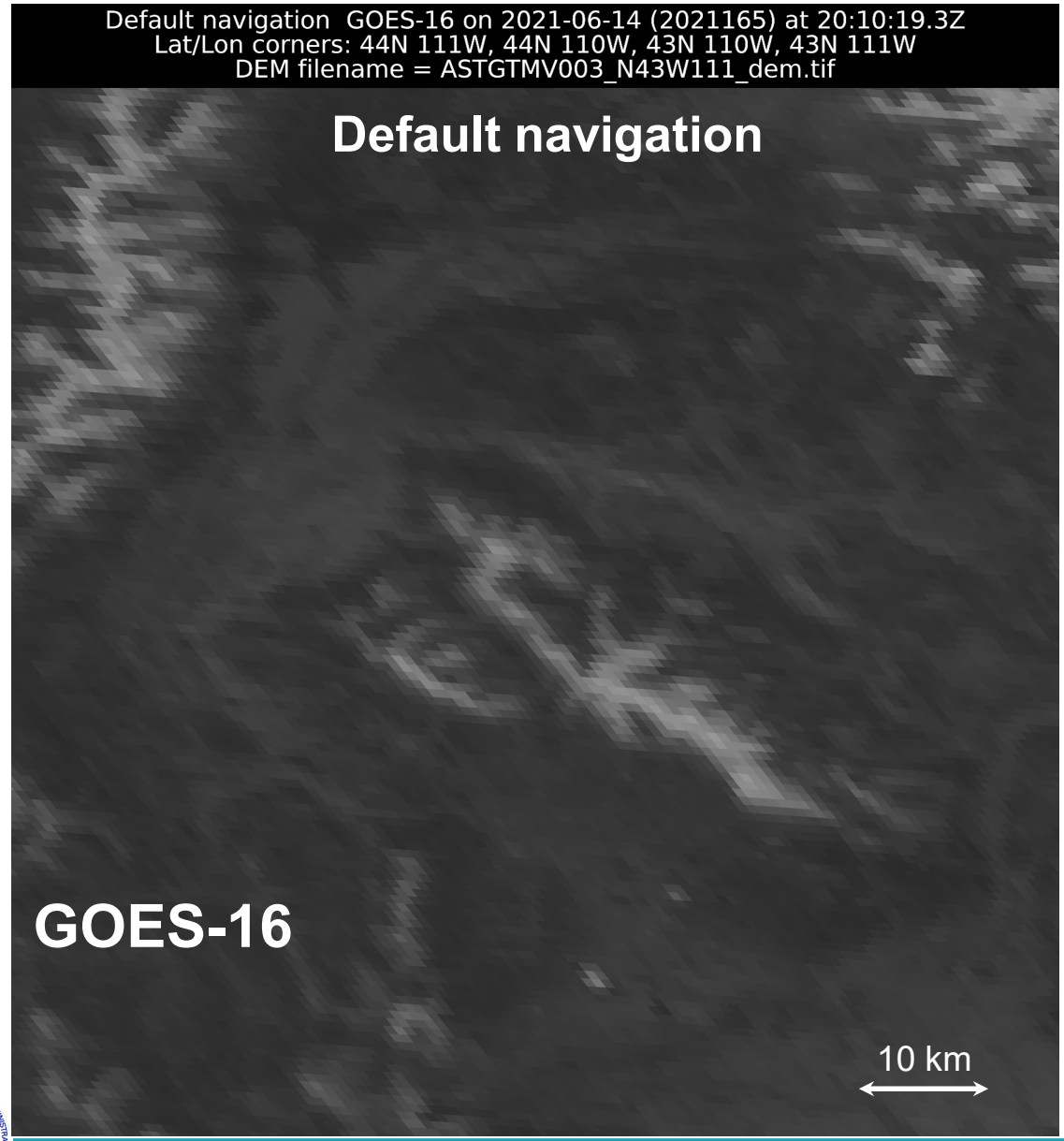
Fire Legend
- Processed Fire
- High Possibility Fire
- Saturated Fire
- Medium Possibility Fire
- Cloudy Fire
- Low Possibility Fire
- Fire-free ground
- Cold surface or cloud
- Cloudy (11 μm test)
- Cloudy (Albedo test, day)
- Cloudy (Rad Diff, night)
- Cloudy (Rad Diff, day)
- Background Calc Failed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

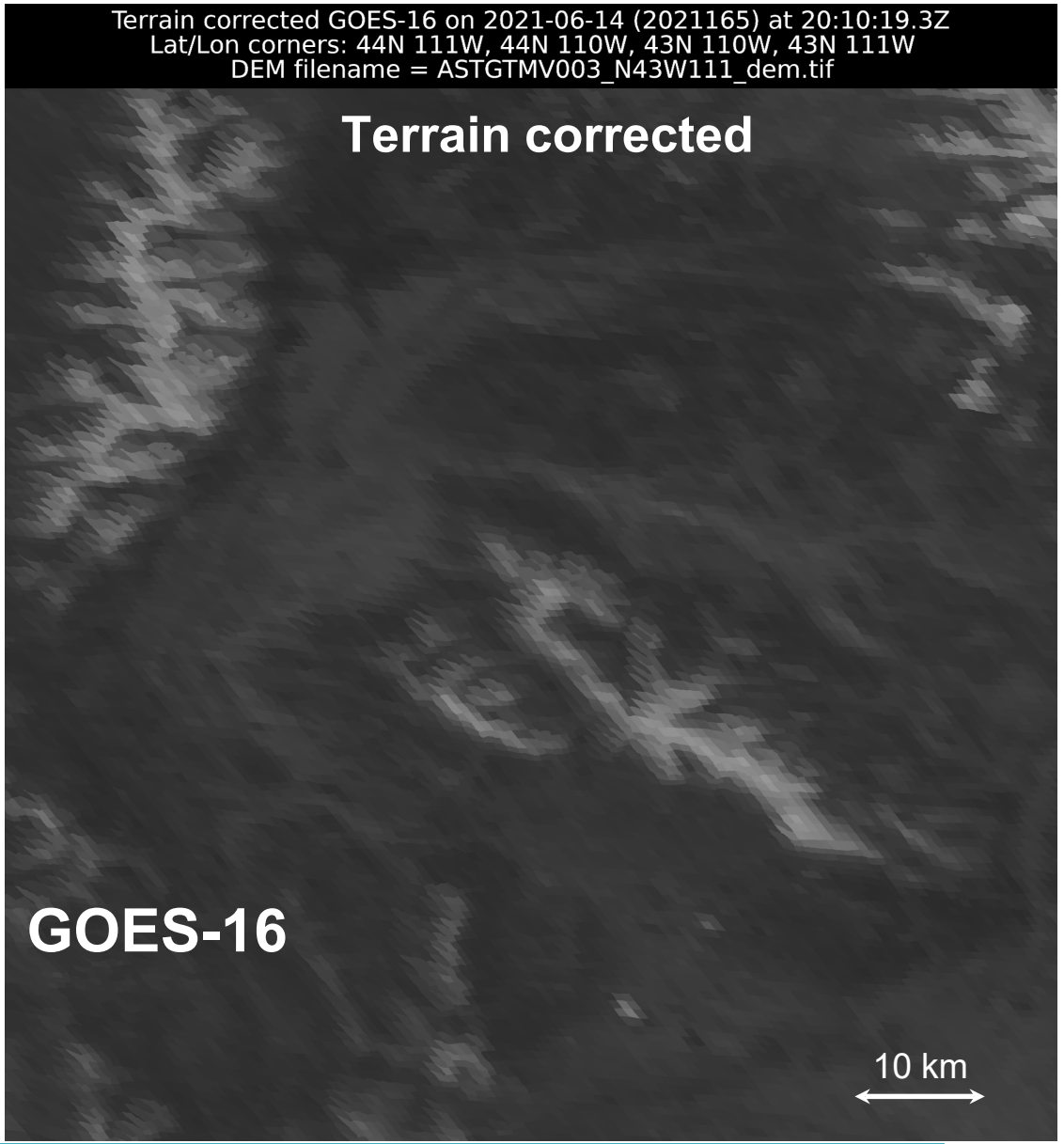


eFire GOES-R output

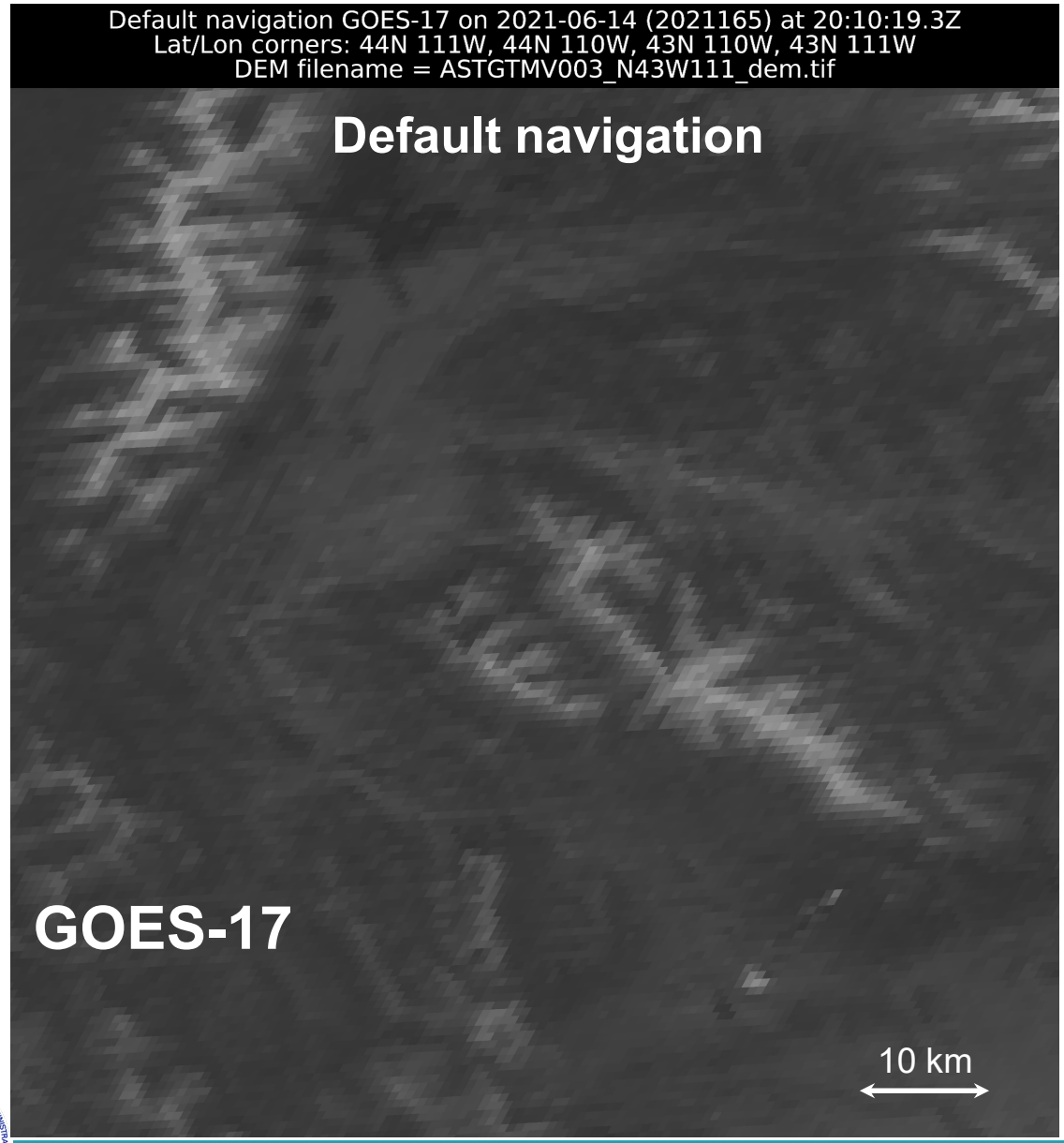
Wei Guo, IMSG@STAR and Chris Schmidt, CIMSS

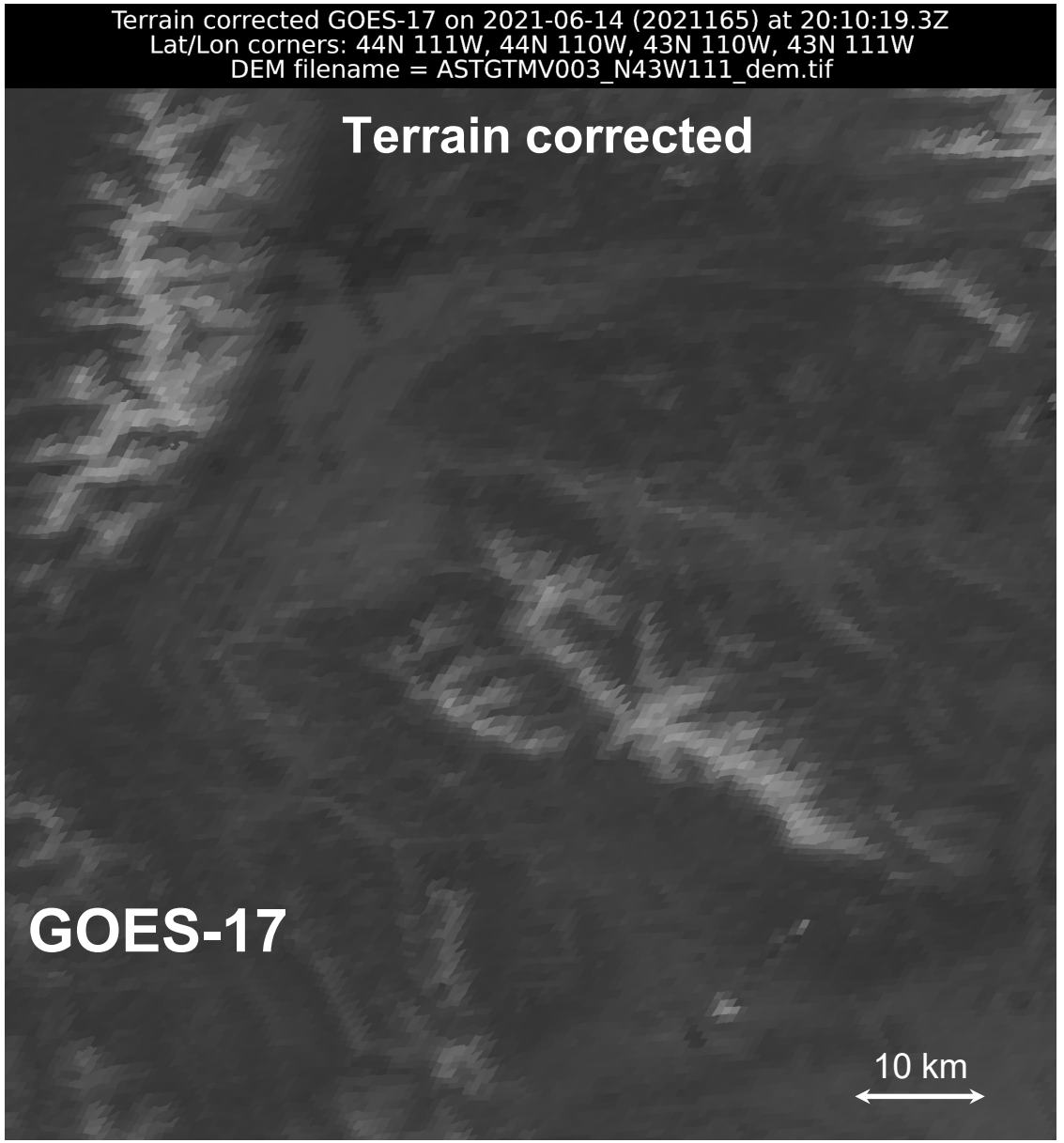
Terrain correction for GOES-R ABI





Terrain correction for GOES-R ABI



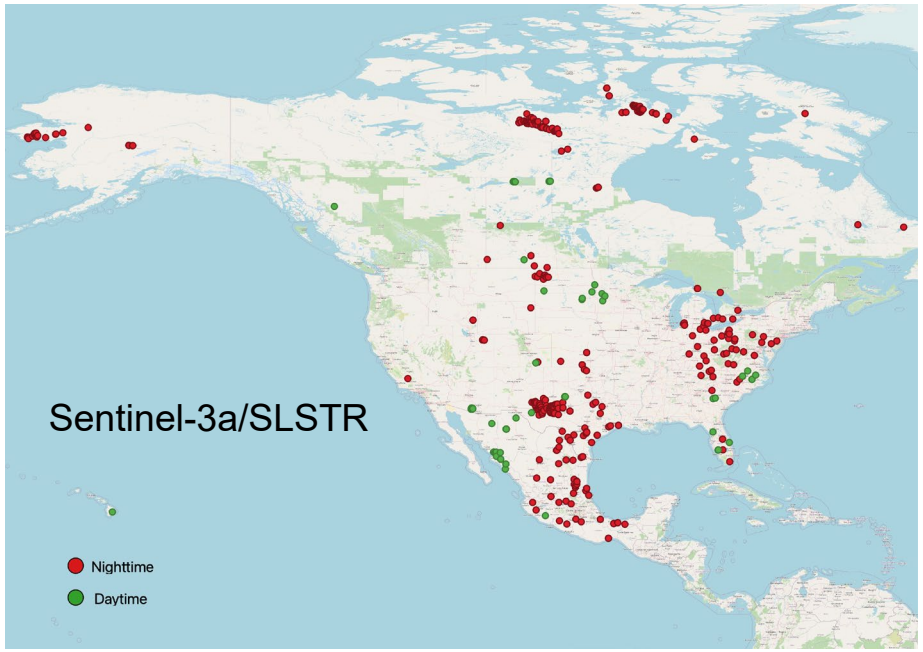


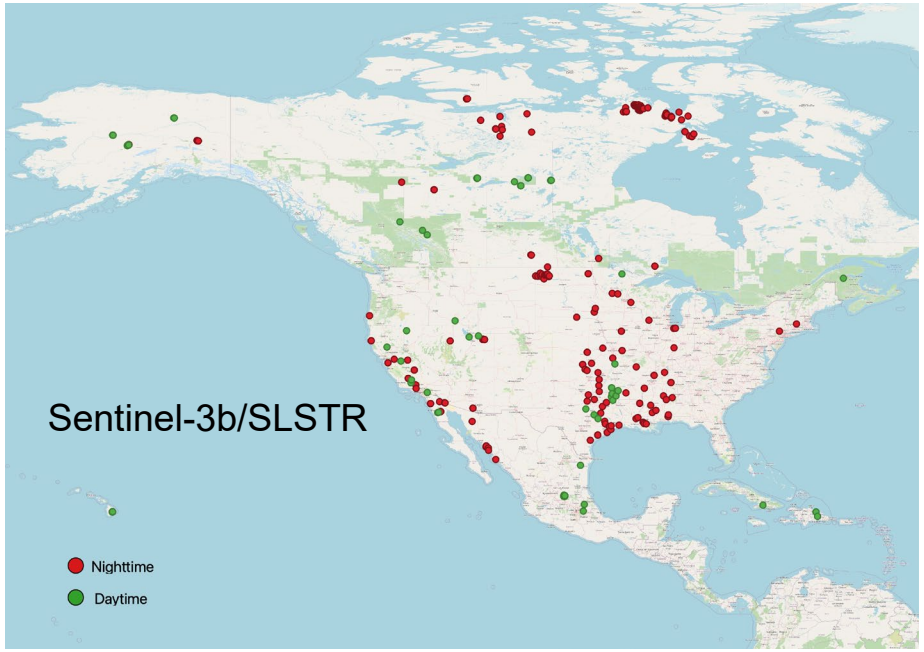
Sentinel-3/SLSTR

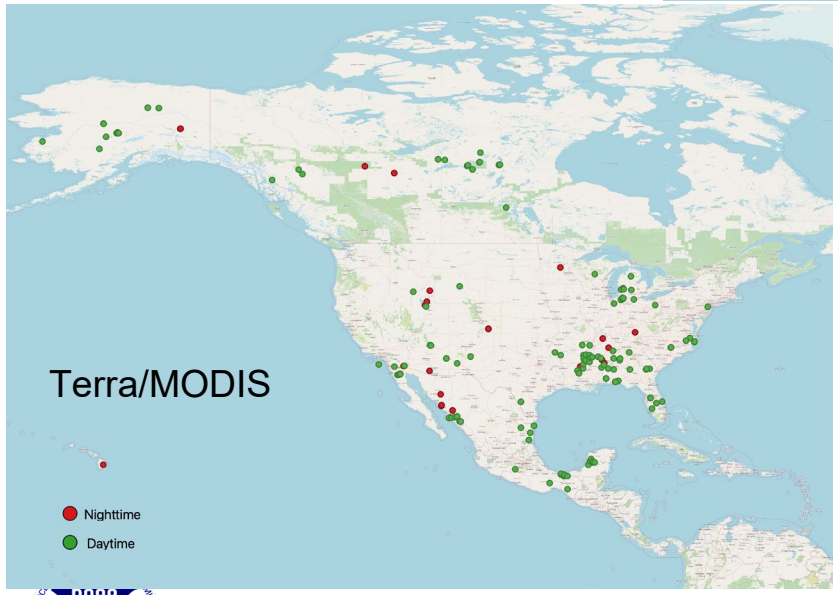
NOAA is routinely ingesting S3*_SL_2_FRP files

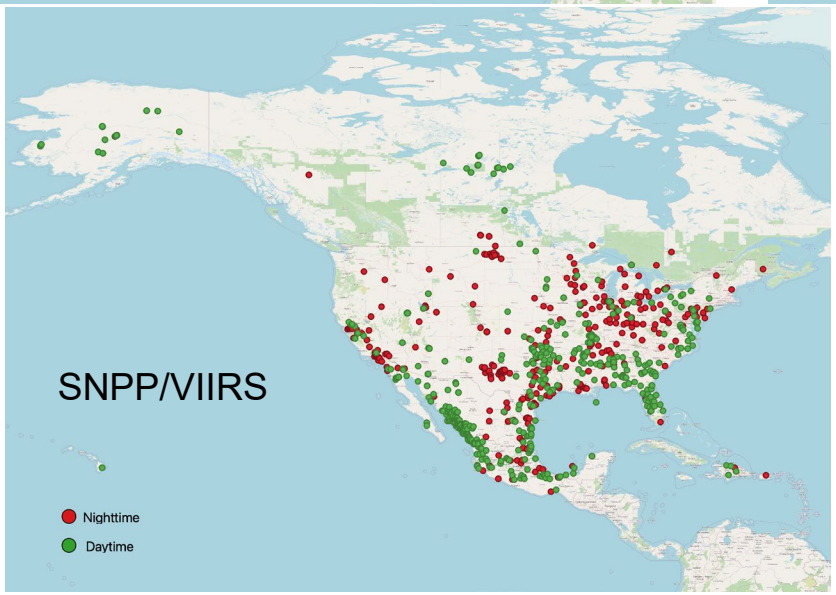
Despite improvements in overall data quality, detection artifacts continue to be observed delaying data adoption

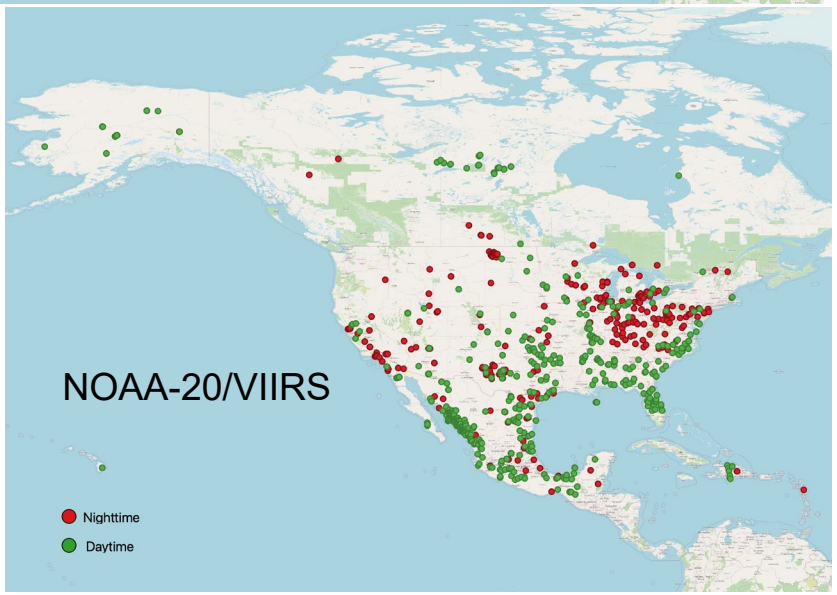
17 June 2022









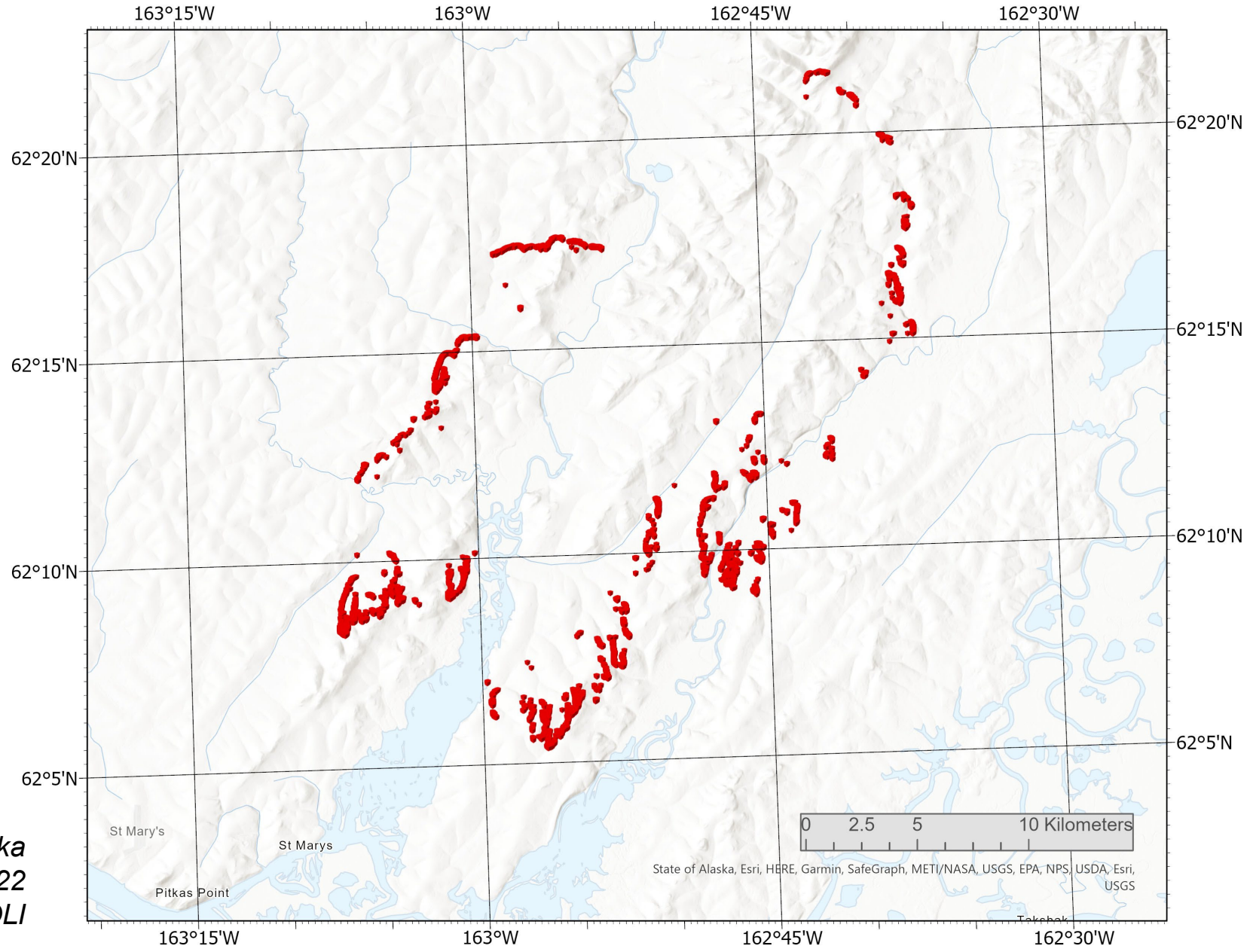


Landsat-class data

NOAA routinely processing Landsat-8 & 9 and Sentinel-2a & b active fire data for USA

Unmatched active fire line resolving capability

High data latency continues to prevent NRT applications

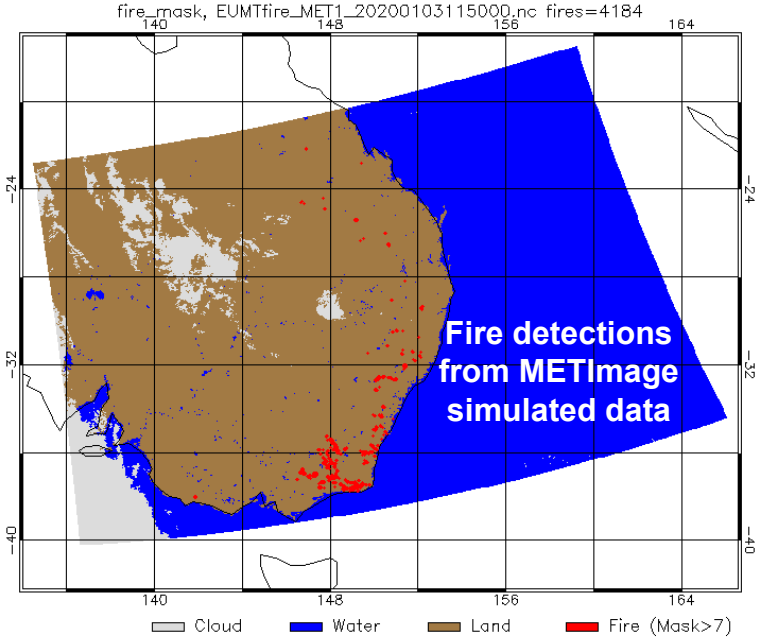


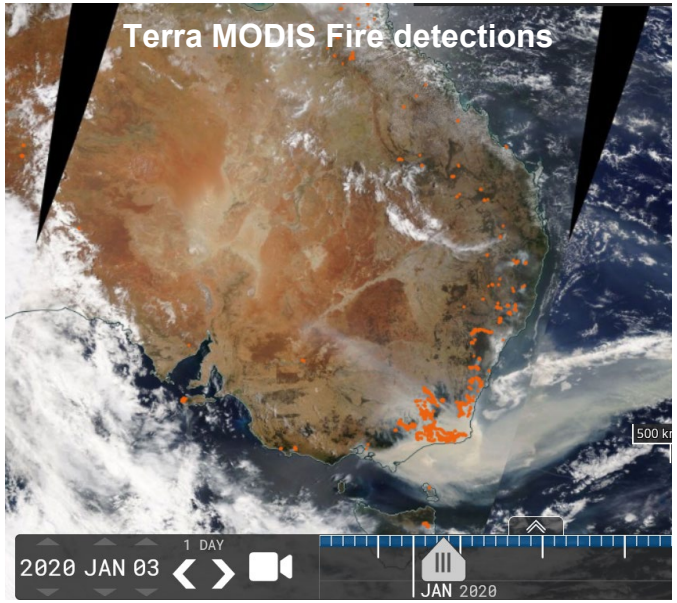
East Fork wildfire, Alaska
10 June 2022
Landsat-8/OLI

METImage fire product

Detection: heritage approach

Detection algorithm logic is based on VIIRS M-band / MODIS algorithm

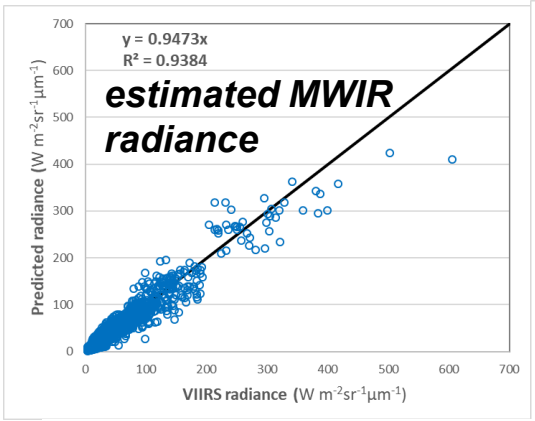


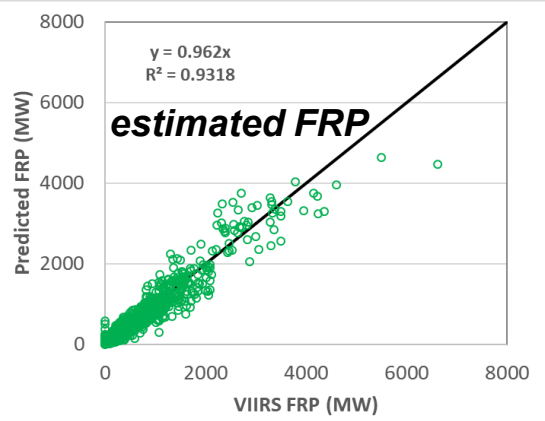


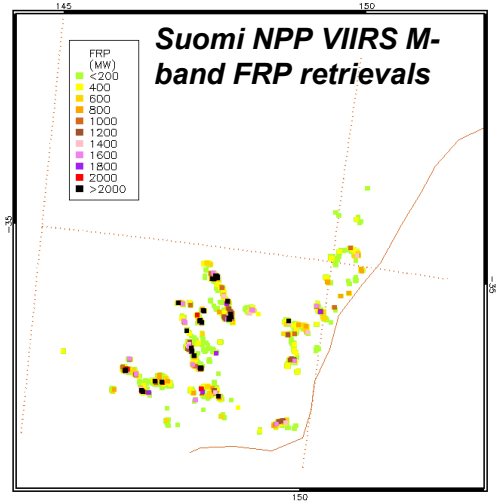
- *VIIRS M-band data are used as proxy to train a regression tree algorithm for FRP retrievals in saturated conditions*
- *Model has been tested for Australia, Western US, Central US*
- *FRP model performance averages at ~23% (daytime only)*
- *potential for nighttime retrievals is evaluated*

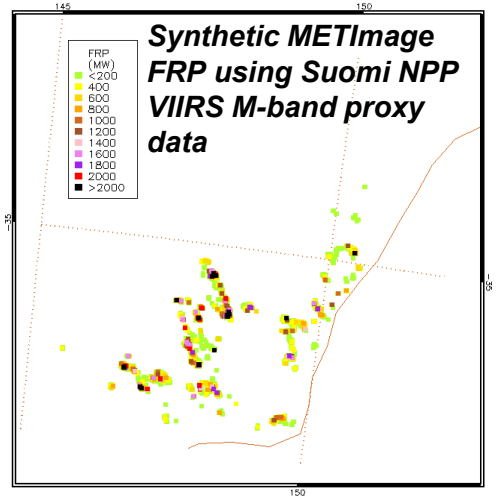
Fire Radiative Power: hybrid approach

*unsaturated MWIR measurements: heritage retrieval**
*saturated MWIR measurements: machine learning to estimate MWIR radiance -> heritage retrieval**
**Wooster et al., 2005; coefficient adjusted for METImage Spectral Response Function*









Key application areas

Fire emission / air quality modeling and forecasting

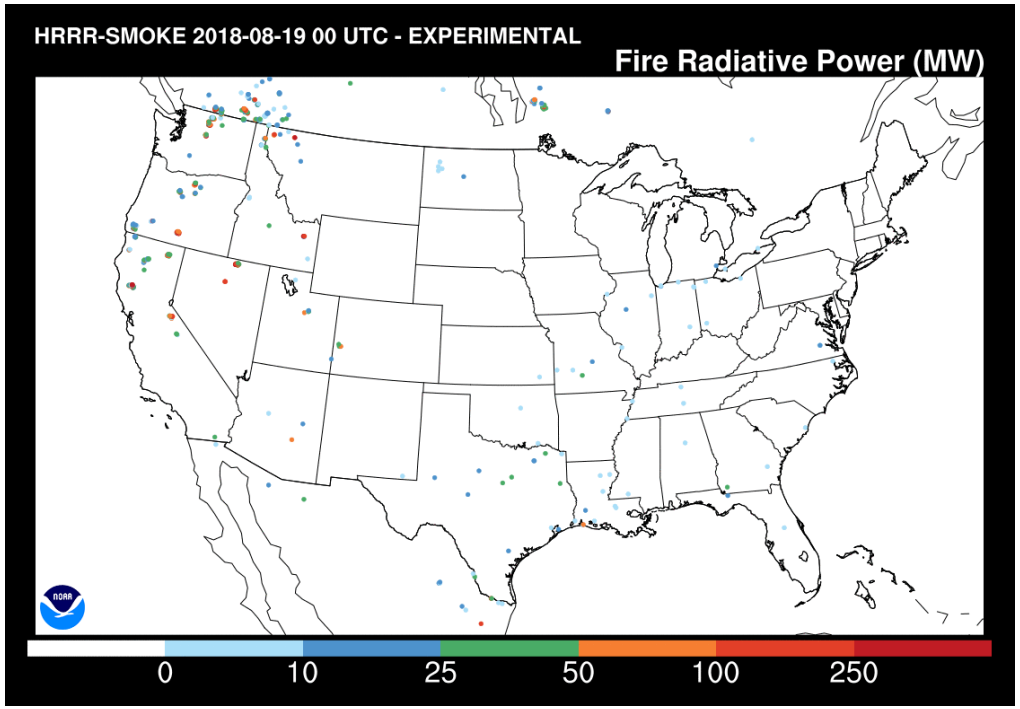
- Operational and experimental systems (see examples)

Fire behavior prediction models

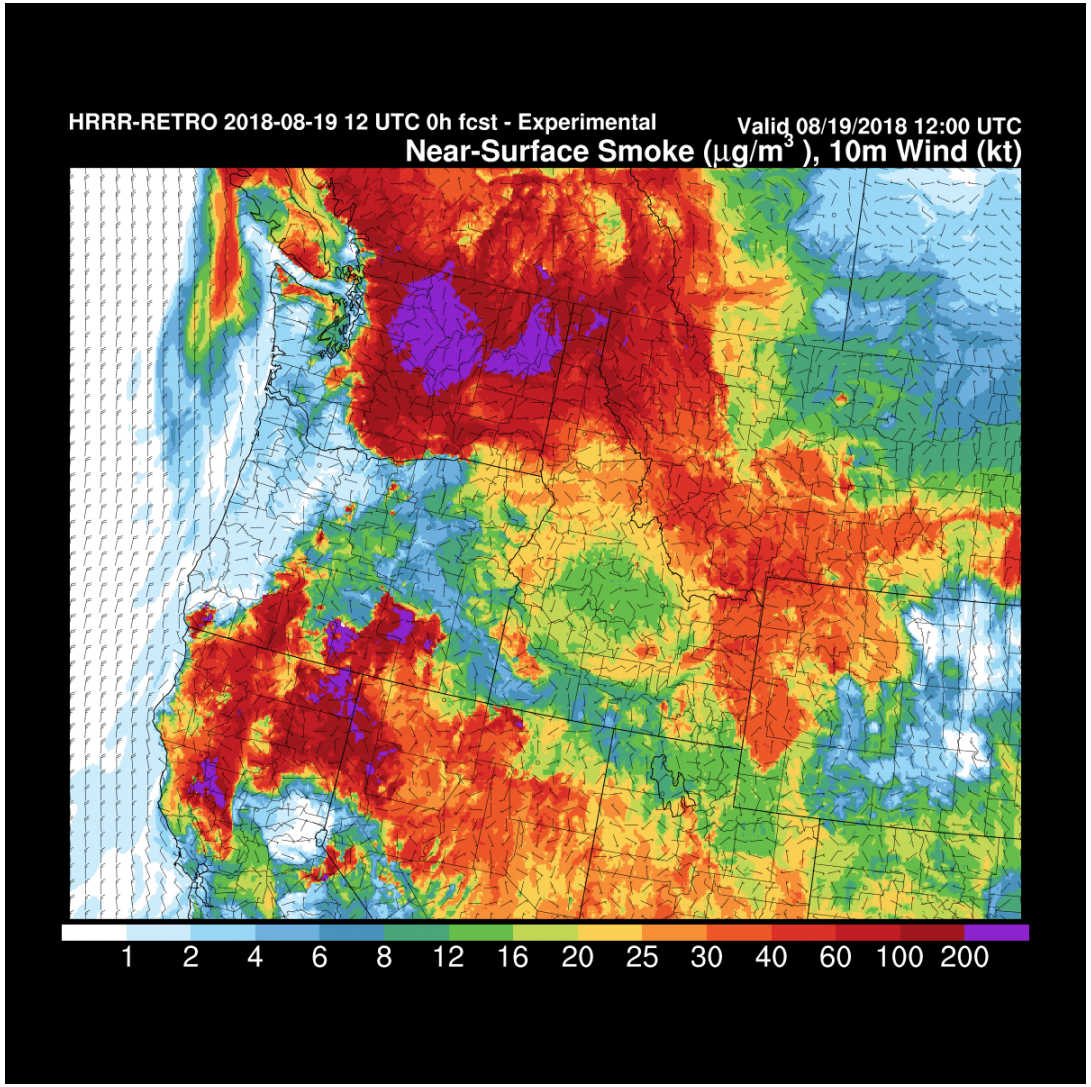
- Routine utilization is needed

Incident management

- incident-based customized products (reduce bandwidth, latency and increase information content)

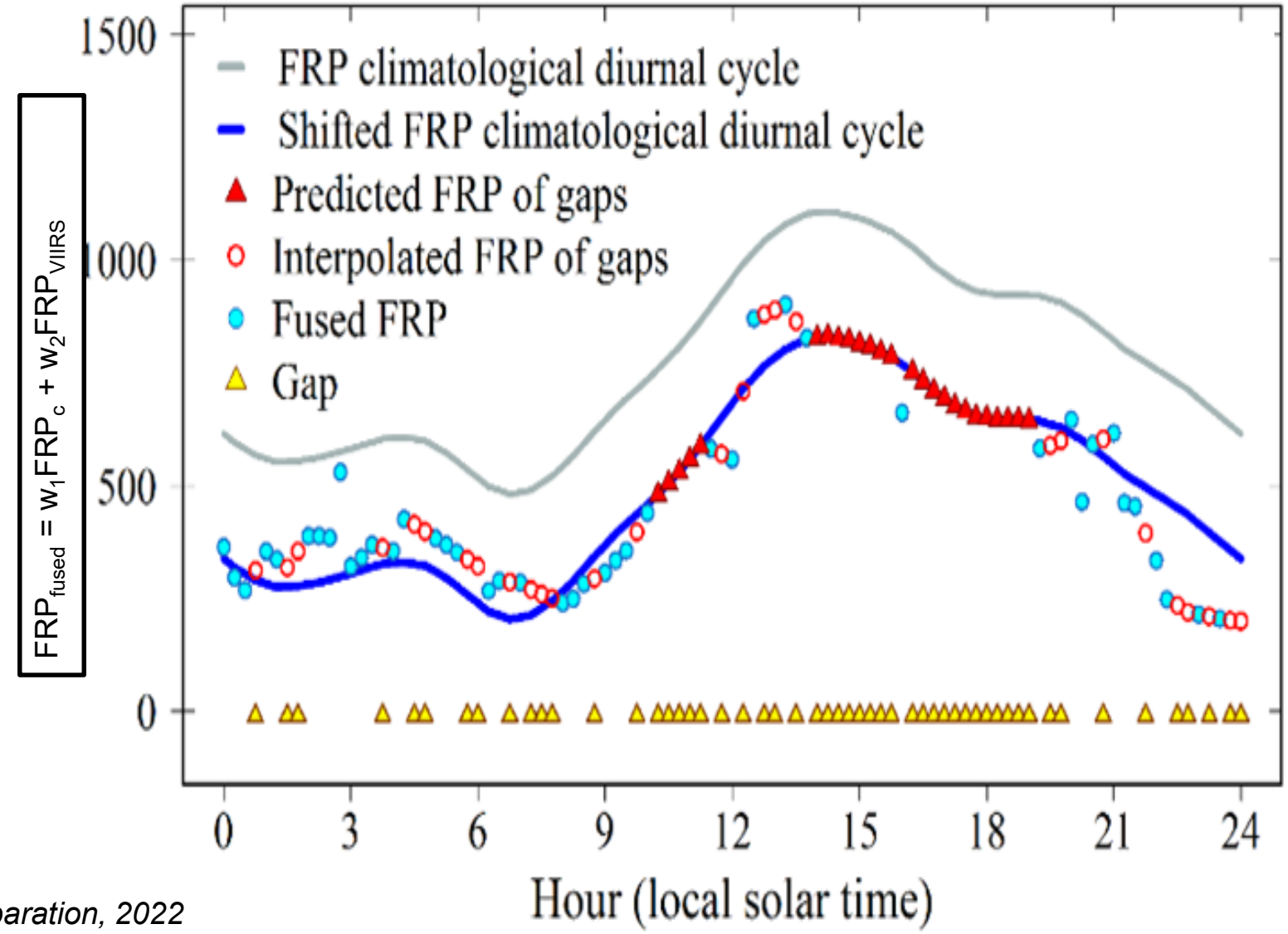


24hr average FRP data mapped over 3x3km HRRR CONUS grid pixels for August 19, 2018



Experimental HRRR-smoke model run
https://rapidrefresh.noaa.gov/hrrr/HRRRsmoke/

Regional Hourly ABI and VIIRS Emissions (RAVE) for NWS Air Quality Forecasting



Li et al., in preparation, 2022

Towards a Dedicated NESDIS Fire Information System and Storefront

Single or multi-source GEO or LEO satellite data + supplemental data

NESDIS Fire Information System:

- Source agnostic algorithms specially designed to support legacy needs and address gaps
- Includes higher-level information, such as alerts
- Enables blending of multiple sensors and information sources, including fire incident databases
- Cloud ready
- Modular, agile, and expandable (adhere to Agile/DevOps principles)
- OGC compliant product files

NESDIS Fire Storefront:

- Cloud-based
- Ease of access
- Seamless customer experience
- GIS friendly
- Event-based product distribution
- OSPO/SAB analyses

Summary and path forward

- The NESDIS active fire product suite has been expanding
- Incremental algorithm improvements and new capabilities are developed
- Focus areas are:
  - Improved detection and Fire Radiative Power for near-all-weather conditions
    - Critical in particular for emission monitoring and modeling
  - JPSS-2 readiness and GOES-18 post-launch evaluation
  - Continued push for Landsat-class NRT applications, commercial data exploitation
  - Further evaluation of the polar constellation for fires, including additional mission data (e.g. Sentinel-3/SLSTR, MetOp-SG METImage prototype detection and FRP retrieval)
- Coordination with and leveraging of inter-agency fire activities
  - Fomenting national and international partnerships (US Forest Service, NASA, DoD, ESA, Mexico, Canada, Brazil, Indonesia, industry) addressing fire problem