Beta (Provisional) Maturity Science Review For NOAA-21 VIIRS Active Fire Algorithm

Presented by Ivan Csiszar

Date: 06/01/2023

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.

Maturity Review - Entry Criteria

- Product Requirements
- Pre-launch Performance Matrix/Waivers
- Beta/Provisional Maturity Performance Validation
  - On-orbit instrument performance assessment
    - Identify all of the instrument and product characteristics you have verified/validated as individual bullets
    - Identify pre-launch concerns/waivers, mitigation and evaluation attempts with on-orbit data
- Users/Downstream-Products feedback
- Risks, Actions, Mitigations
  - Potential issues, concerns
- Path forward (to the next maturity stage)
- Summary

Maturity Review - Exit Criteria

- Beta/Provisional Maturity Performance is well characterized and meets/exceeds the requirements:
  - On-orbit instrument performance assessment
    - Provide summary for each identified instrument and product characteristic you have validated/verified as part of the entry criteria
    - Provide summary of pre-launch concerns/waivers mitigations/evaluation and address whether any of them are still a concern that raises any risk.
- Updated Maturity Review Slide Package addressing review committee's comments for:
  - Cal/Val Plan and Schedules
  - Product Requirements
  - Beta/Provisional Maturity Performance
  - Risks, Actions, Mitigations
  - Path forward (to the next maturity stage)

BETA/PROVISIONAL MATURITY REVIEW MATERIAL

Outline

- Algorithm Cal/Val Team Members
- Product Overview/Requirements
- Evaluation of algorithm performance to specification requirements
  - Algorithm version, processing environment
  - Evaluation of the effect of required algorithm inputs
  - Quality flag analysis/validation
  - Error Budget
- User Feedback
- Downstream Product Feedback
- Risks, Actions, and Mitigations
- Documentation (Science Maturity Checklist)
- Conclusion
- Path Forward

NOAA-21 VIIRS Algorithm Cal/Val Team

Name	Organization	Major Task
Ivan Csiszar	STAR	STAR SMCD Fire Science Team lead
Marina Tsidulko	IMSG	Baseline algorithm development and cal/val
Wei Guo	IMSG	Enterprise algorithm development and cal/val
Benjamin Marchant	IMSG	Product validation and algorithm improvements
Jason Brunner	IMSG	Product validation and algorithm improvements
Yingxin Gu	IMSG	Product evaluation
Wilfrid Schroeder	OSPO	Baseline algorithm main author
Hanjun Ding	OSPO	Product Area Lead
Shobha Kondragunta	STAR	Fire Emission Products, validation
Mike Pavolonis	STAR	NESDIS Wildland Fire Program Manager

Product Overview/Requirements (1/3)

NESDIS Product Baseline (NESDIS-REQ-1002.2)

5.2.13 Fires

Products in the Fires sub-category include fire detection and mapping, fire occurrence and hotspot characterization, smoke analysis, smoke plumes and concentration, etc.

Table 16: Product Specifications/Attributes in NLR Category: Fires

Baseline Products	Data Type	Geographic Coverage	Refresh	Latency
Fire Detection and Characterization	Granule	Global Land	12 hours	96 mins
Fire Detection and Characterization	Full Disk	Hemi US	10 mins	10 mins
Fire Detection and Characterization	Sectorized	CONUS	5 mins	5 mins
Fire Detection and Characterization	Sectorized	Targeted Mesoscale	1 min	1 min
Fire and Smoke Analysis	Analysis	US and Canada	60 mins	75 mins

From NESDIS LEVEL REQUIREMENTS (NESDIS-REQ-1001.1)

Product Category: Land and Surface Hydrology

Product Sub-Category: Fires

Products in the Fires sub-category include but are not limited to fire detection and mapping, smoke plumes and concentration and biomass burning and emissions, etc.

Product Overview/Requirements (2/3)

- The Active Fires product is based on the detection and analysis of the radiative signature of natural or anthropogenic surface fires as received by the sensor. The product includes the geolocation and fire radiative power of pixels for which fires are detected, and a full mask consisting of a two-dimensional array of values representing the fire and other relevant thematic classes (e.g., cloud) of each pixel in a swath data granule.

- DPS-32 The Active Fires product shall provide fire radiative power, with a measurement uncertainty of 50%, over the measurement range of the instrument.

  Product Name: Active Fires — Instrument: VIIRS
  Allocated To: ESPC Verification — Method: Analysis
  Verification Description: To be verified against truth data, selected at the discretion of the algorithm provider, demonstrating compliance over the range of production conditions.

- DPS-33 The Active Fires product shall provide a per-pixel fire mask and fire radiative power, calculated from infrared imager calibrated data, globally day and night, under clear sky conditions between clouds, at the refresh rates of the instrument.

  Product Name: Active Fires — Instrument: VIIRS
  Allocated To: ESPC Verification — Method: Demonstration

- Additional requirements attributes: DPS-568 (netCDF); DPS-569 and DPS-570 (Climate and Forecast Metadata Conventions); DPS-659 (long-term relative accuracy)

  These requirements are not addressed in this review

Product Overview/Requirements (3/3)

NESDIS FIVE-YEAR PRODUCT PLAN (NESDIS-PLN-1003.1)

B. Fire Detection and Characterization

1) VIIRS Active Fires

The VIIRS Active Fire products derived from the VIIRS M-band and I-band measurements are based on hybrid thresholding and contextual approaches that build on the heritage of the MODIS Fire and Thermal Anomalies algorithm, but including modifications and additional processing elements to account for VIIRS sensor characteristics.

User Impact-Driven Priority: 1

(...)

3) Enterprise Fire Algorithm (Potential R2O over 5 years)

The Enterprise Fire algorithm provides an enterprise approach for generating active fire products from all the user requested sensors including JPSS M-band Active Fire, JPSS I-band Active Fire, GOES-R ABI fire detection and characterization (including Mesoscale) and Meteosat-SG/SEVIRI Fire products. The Enterprise Fires System will share the I/O modules, Persistent Anomalies modules and underlying basic functions to make the software package easier to update and maintain in the future.

User Impact-Driven Priority: 1

VIIRS Baseline Product

- in NDE I&T production
- planned to continue NDE production until November 30, 2023
- **primary focus of this review**

Enterprise Fire (eFire) for VIIRS

- in the process of integrating into NCCF
- executes baseline science algorithm for VIIRS for continuity - minot changes in output and content
- **included in this review for demonstration purposes**

Product specifications and plans are being updated according to the new NESDIS Strategy to implement the Next Generation Fire System and associated new fire detection and characterization algorithm. Transition of the NGFS VIIRS capability is planned for 2025.

Processing Environment and Algorithms

- Description of processing environment and algorithms used to achieve the maturity stage:
  - Algorithm version: AF-Iband_v1r1_npp[j01,n21]
  - Version of LUTs used: TBD
  - Version of PCTs used: TBD
  - Effective date: October 18, 2022 (for SNPP and NOAA-20)
    - NOAA-21 data available from the NDE I&T stream since February 9, 2023
  - Evaluation periods are tied to NOAA-21 SDR Maturity dates:
    - NOAA-21 VIIRS SDR Beta: February 23, 2023
    - NOAA-21 VIIRS SDR Provisional: March 30, 2023

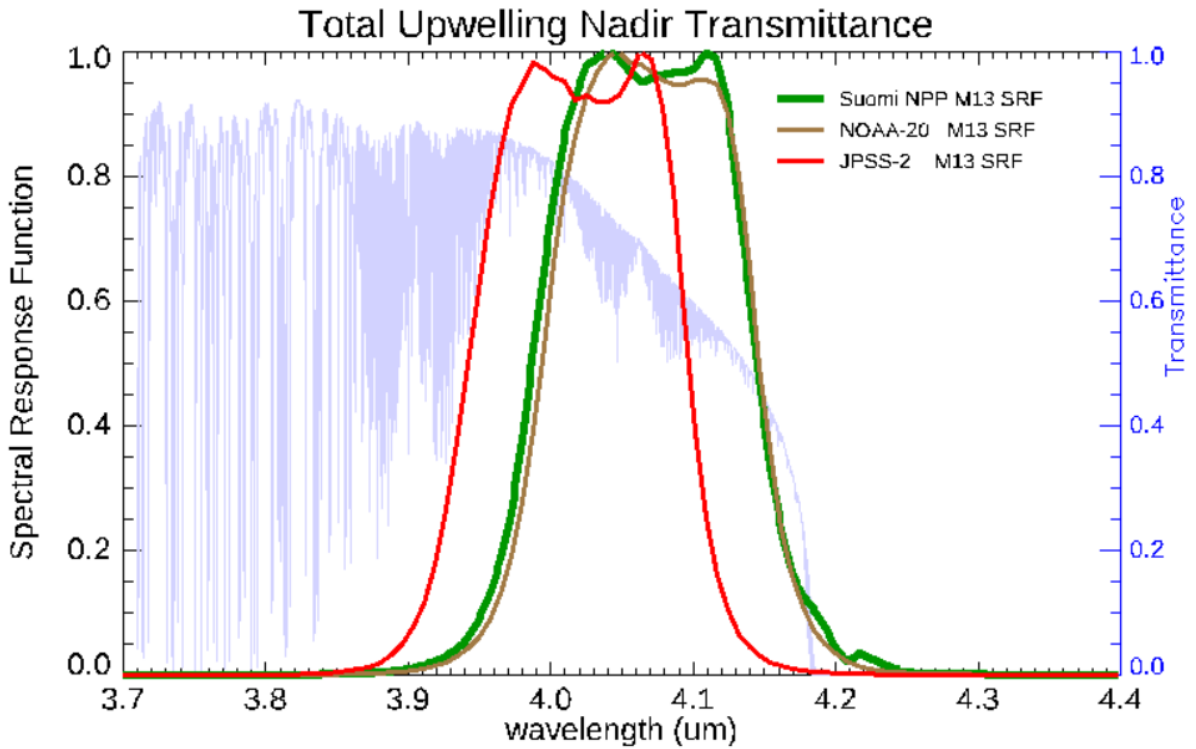
Evaluation of algorithm performance to specification requirements

- **Findings/Issues from last Review: N/A**
- **Improvements since last Review: N/A**
  - Algorithm Improvements: N/A
  - LUT / PCT updates: N/A
- **Algorithm performance evaluation**
  - Visual expert analysis
  - Validation data sets (type, periods, coverage)
    - opportunistic high resolution satellite and airborne imagery (e.g. MASTER during the FIREX-AQ campaign)
      - not available yet for NOAA-21
    - reference data must be within +- 15 minutes of the time of observation to provide representative validation statistics *(Csiszar and Schroeder, 2008)*
  - Validation strategies / methods
    - the simultaneous mapping of the presence and absence of actively burning fire within the entire pixel footprint at a spatial resolution much higher than VIIRS
    - the determination of detection probabilities as a function of sub-pixel fire activity summary statistics; and
    - the determination of omission rates based on the definition of minimum classification threshold for the fires of interest, as well as determination of commission error rates
    - combined with forward simulations and using scarce in-situ observations as anchor points
  - Validation results
    - no direct in-situ validation results available for NOAA-21
  - Long term monitoring readiness
    - long-term monitoring tools available (JSTAR Mapper, global quicklooks for STAR and OSPO monitoring)
- **Inter-sensor comparison**
  - Compare with SNPP and NOAA-20
  - Compare with other satellite product: Aqua MODIS

Evaluation of the effect of required algorithm inputs

- **Required Algorithm Inputs**
  - Primary Sensor Data:
    - VIIRS I-band SDR (all five bands), VIIRS M13 SDR, unaggreated dual-gain radiance (IVCDB), and geolocation
  - Ancillary Data: persistent anomaly database
  - Upstream algorithms: N/A
  - LUTs / PCTs: N/A
- **Evaluation of the effect of required algorithm inputs**
  - (from NOAA-21 VIIRS SDR Provisional Review Briefing)
  - Cold focal plane temperature (CFPA) lowered to 80 K on 3/3
    - Blackbody Warm-up cool-downs (WUCD) between 3/10 and 3/18 completed
  - TEB Nominal performance since 3/19/2023
    - Comparison with CrIS show 0.1 K agreement (M13: 0.2 K)
  - SWIR band degradation (may impact internal cloud mask)
  - Geolocation comparable to that of NOAA-20 VIIRS

NOAA-21 VIIRS M13 Spectral Response Function



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

Also shown is the total nadir upwelling 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 the ECMWF 83 training profile. Data courtesy Yong Chen, NOAA/NESDIS/STAR

Fire radiative power (FRP): rate of emitted radiative energy by the fire at the time of the observation.

$$FRP_{MIR} = \frac{A_{sample}\sigma}{a}\left(L_{MIR} - L_{B,MIR}\right)$$

(***Wooster et al., 2005***)

L_{MIR}	4 µm observed radiance
$L_{B,MIR}$	4 µm calculated background radiance
A_{sample}	area of pixel
a	constant (function of instrument SRF)

Chris Schmidt, UW-Madison

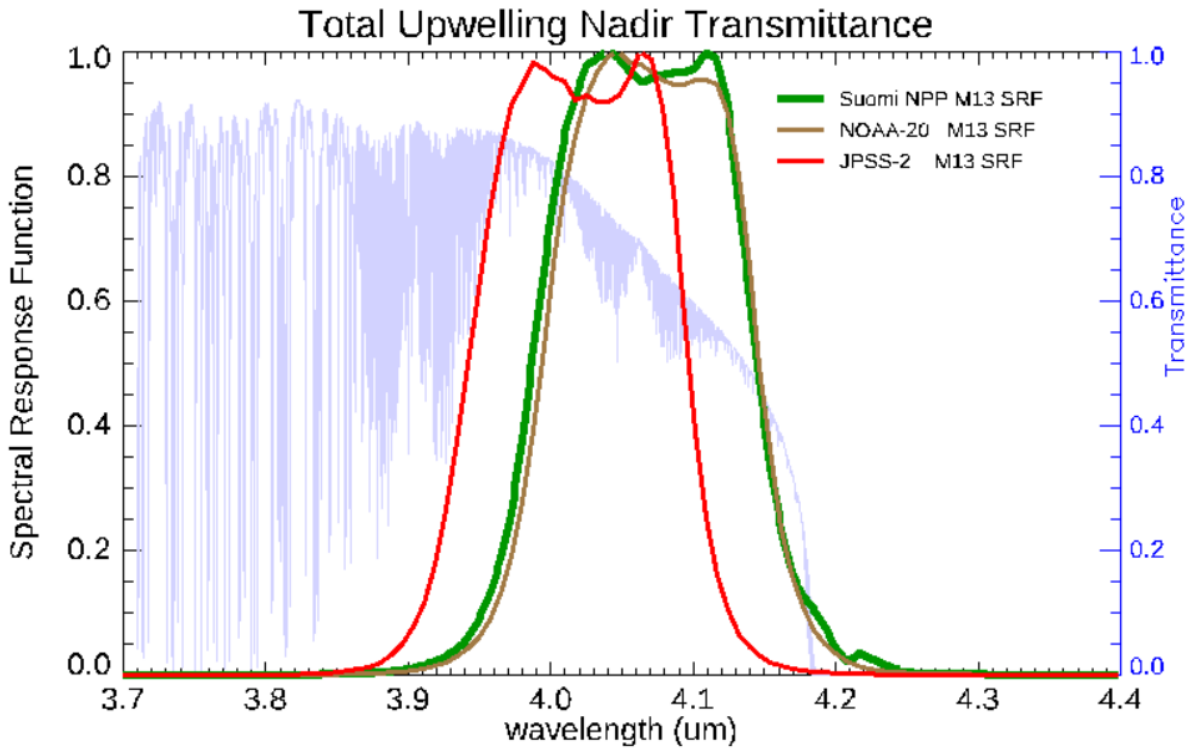
a [$Wm^{-2}sr^{-1}\mu m^{-1}K^{-4}$]:
2.88 (Suomi NPP, NOAA-20); 2.95 (JPSS-2)
~2.5% adjustment in FRP retrieval coefficient

Atmospheric transmittance

quantitative assessment is ongoing using CRTM
~ 5-10% difference in FRP signal

Wooster, M.J., Roberts, G., Perry, G.L.W., Kaufman, Y.J., 2005. Retrieval of biomass combustion rates and totals from fire radiative power observations: FRP derivation and calibration relationships between biomass consumption and fire radiative energy release. J. Geophys. Res. 110, D24311 https://doi.org/10.1029/

NOAA-21 VIIRS M13 Spectral Response Function



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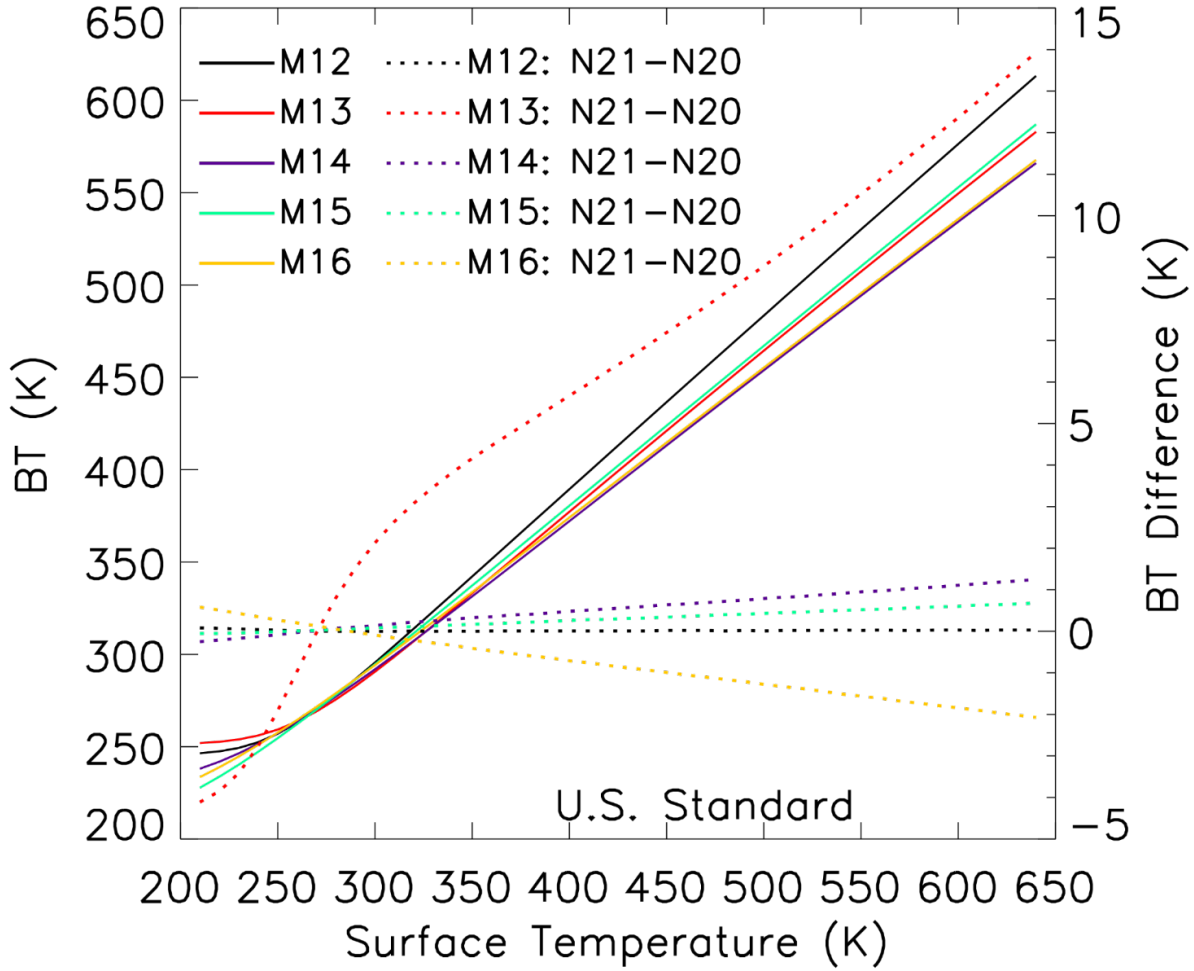
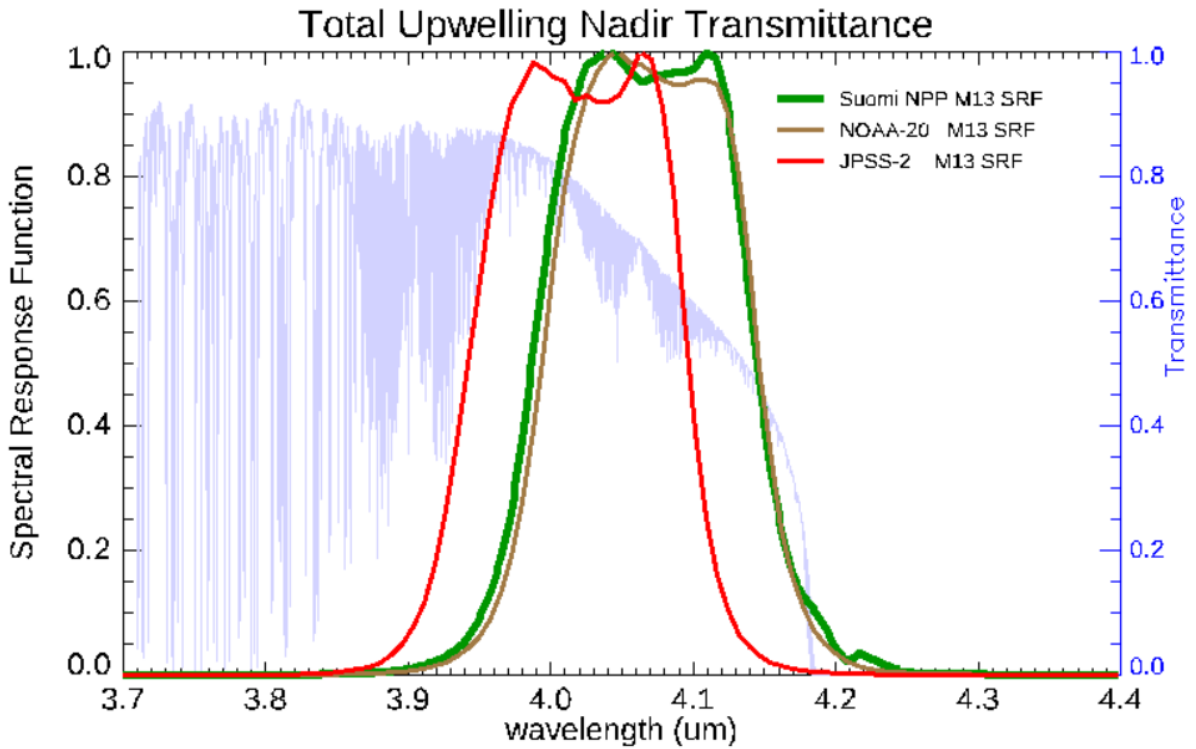


CRTM simulations courtesy Yong Chen, NOAA/NESDIS/STAR

NOAA-21 VIIRS M13 Spectral Response Function



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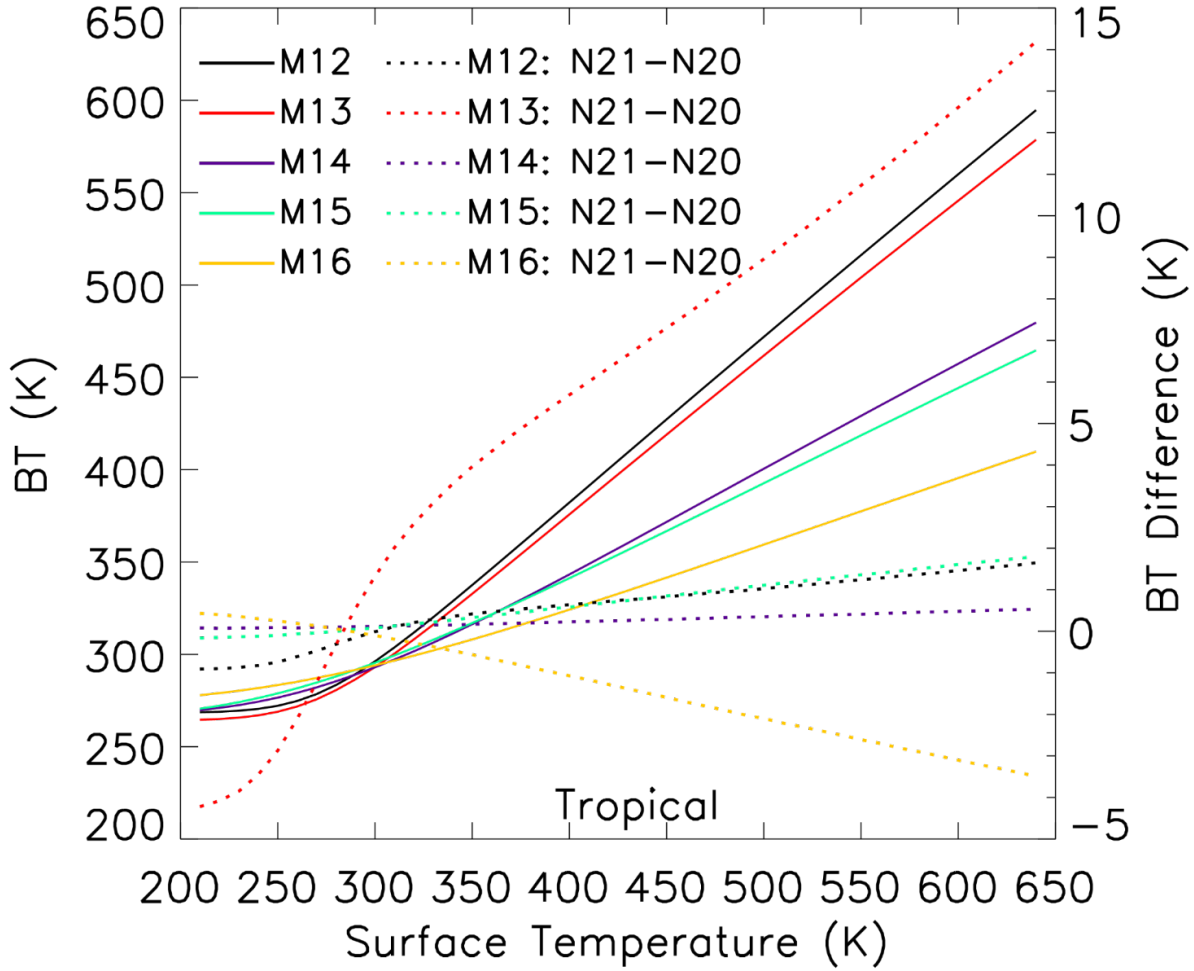
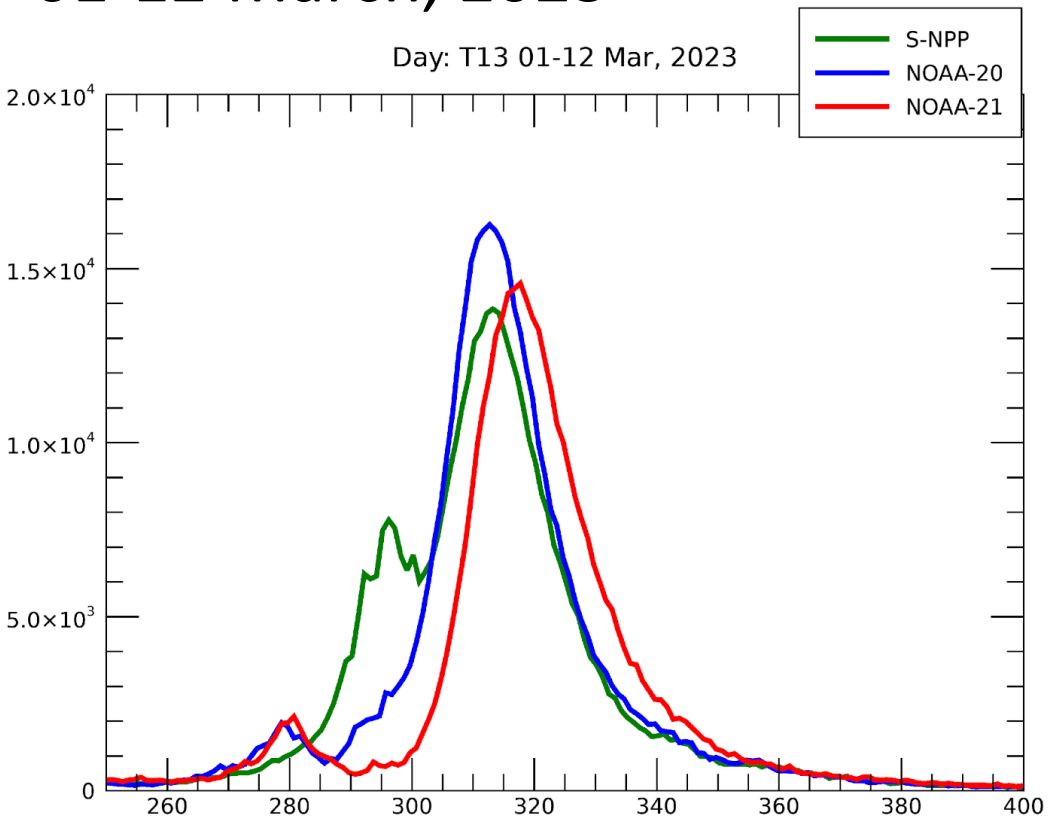
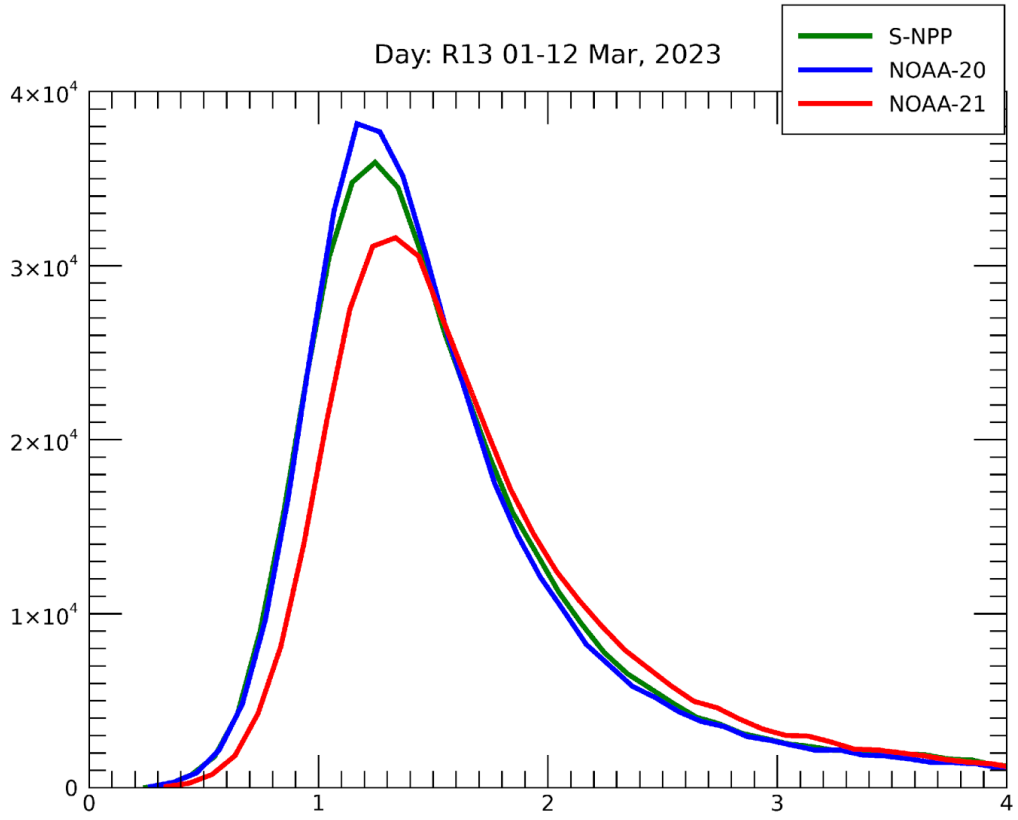


CRTM simulations courtesy Yong Chen, NOAA/NESDIS/STAR

01-12 March, 2023





SDR M13 brightness temperature of I-band fire pixels

SDR M13 radiance of I-band fire pixels

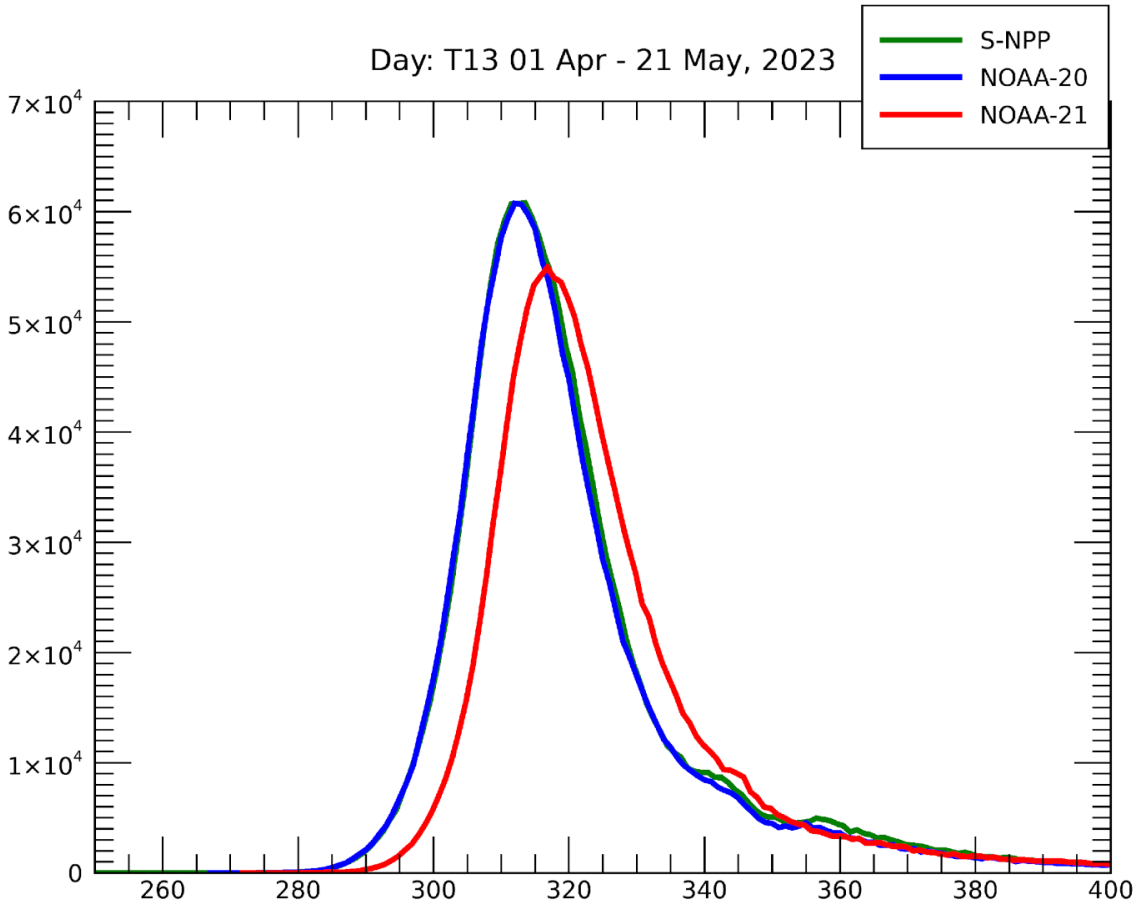
S-NPP fire pixels	430815	S-NPP T13 max	549.674
NOAA-20 fire pixels	425479	NOAA-20 T13 max	568.055
NOAA-21 fire pixels	395301	NOAA-21 T13 max	614.020

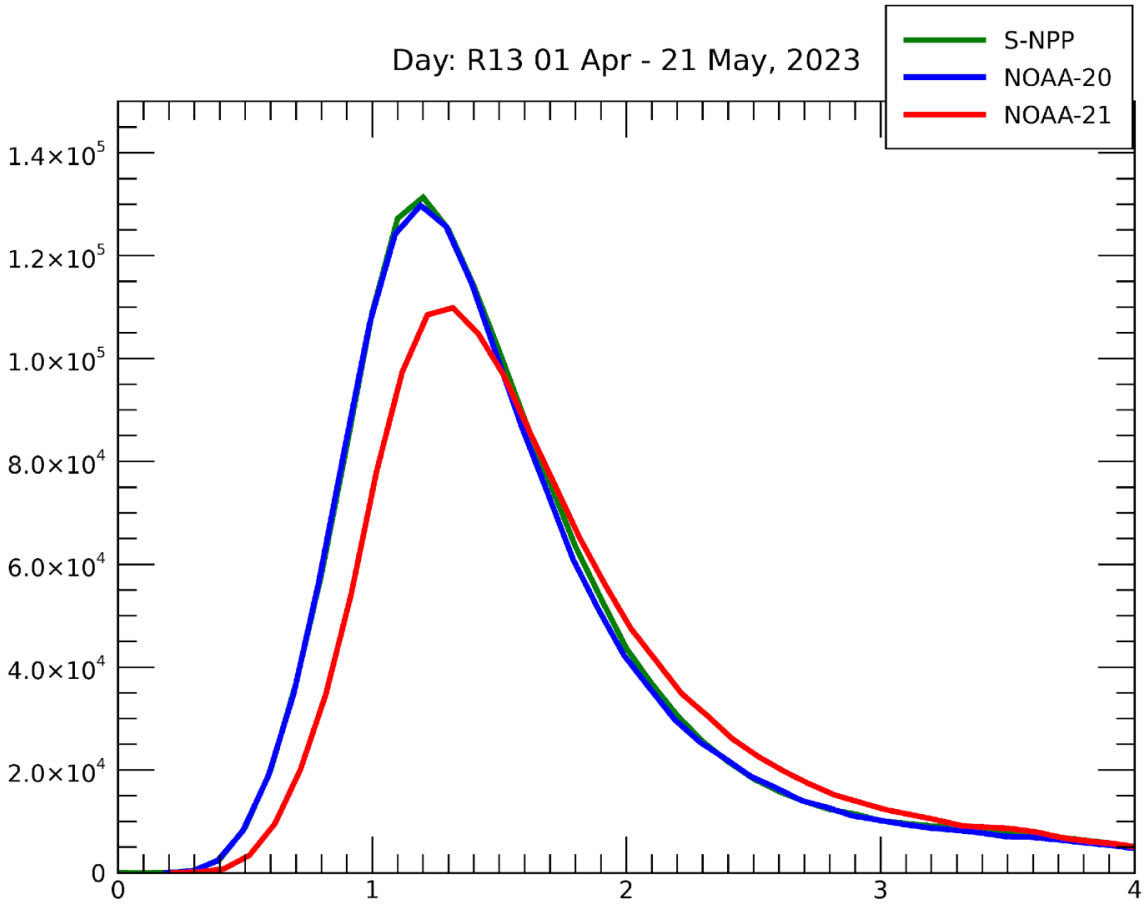
Day

NOAA-21 PRELIMINARY, NON-OPERATIONAL DATA

NOT APPROVED FOR PUBLIC RELEASE

01 Apr – 21 May, 2023





SDR M13 brightness temperature of I-band fire pixels

SDR M13 radiance of I-band fire pixels

Day

NOAA-21 PRELIMINARY, NON-OPERATIONAL DATA
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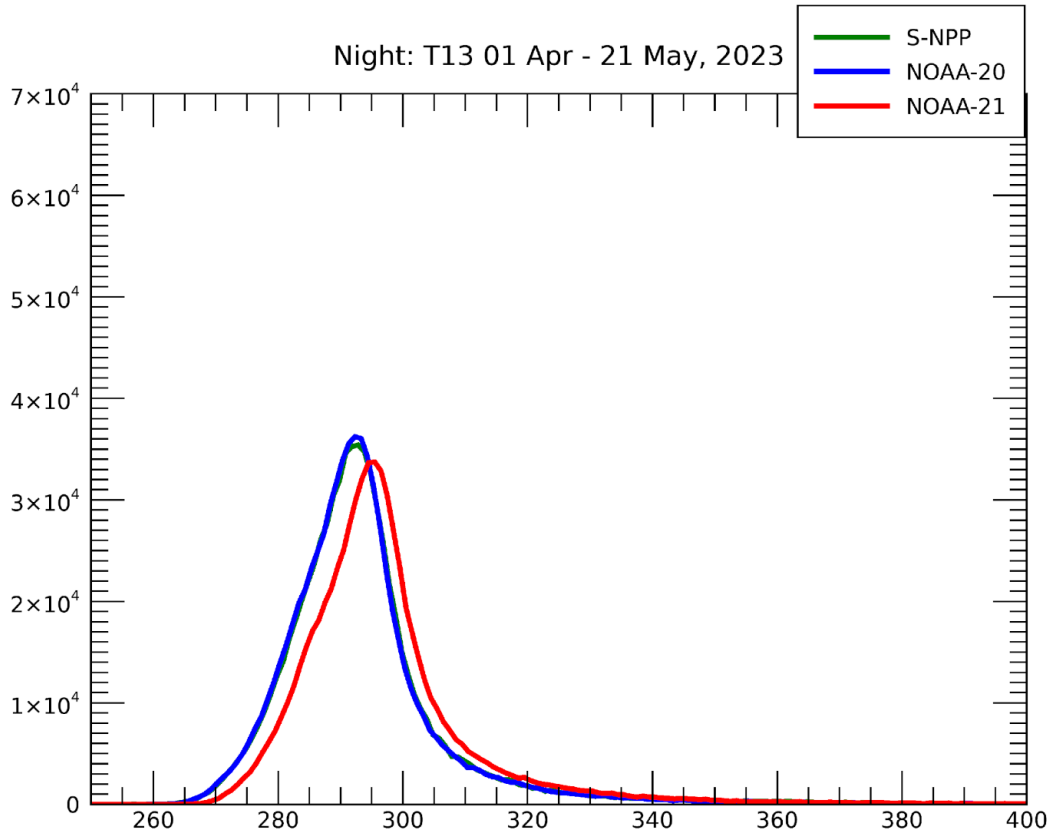
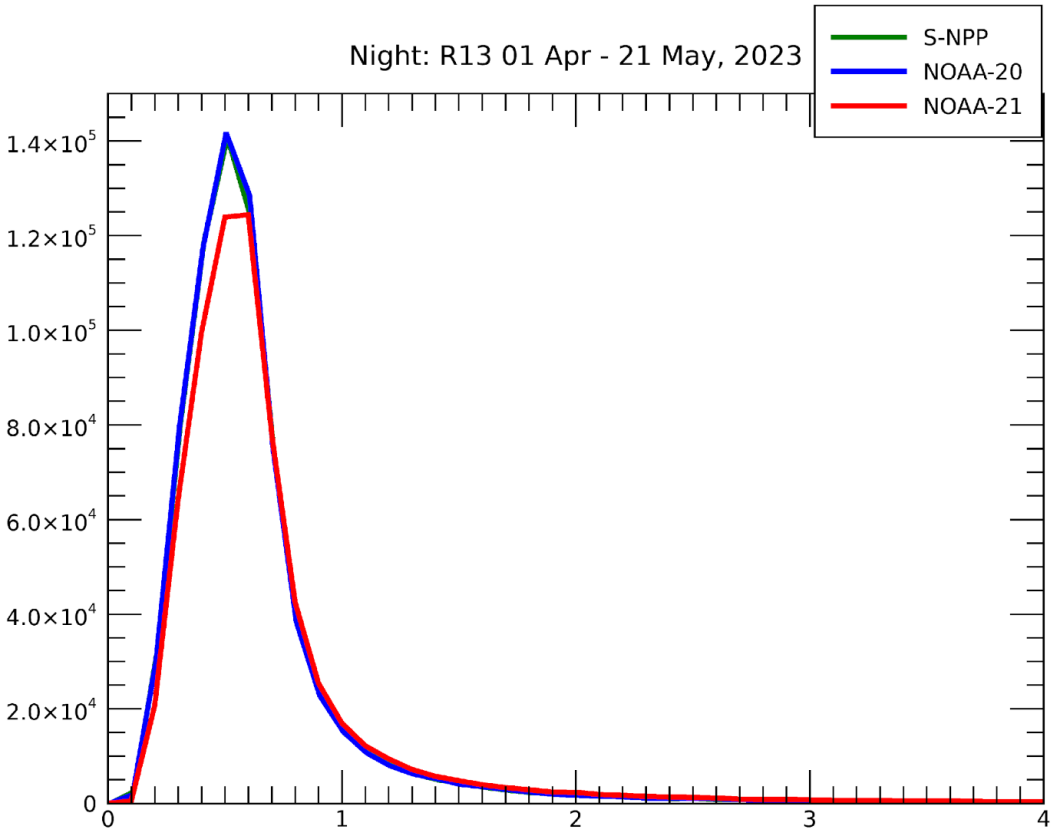
01 Apr – 21 May, 2023



SDR M13 brightness temperature of I-band fire pixels



SDR M13 radiance of I-band fire pixels

Night

NOAA-21 PRELIMINARY, NON-OPERATIONAL DATA
NOT APPROVED FOR PUBLIC RELEASE

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I4 saturation and folding (Chile fires)

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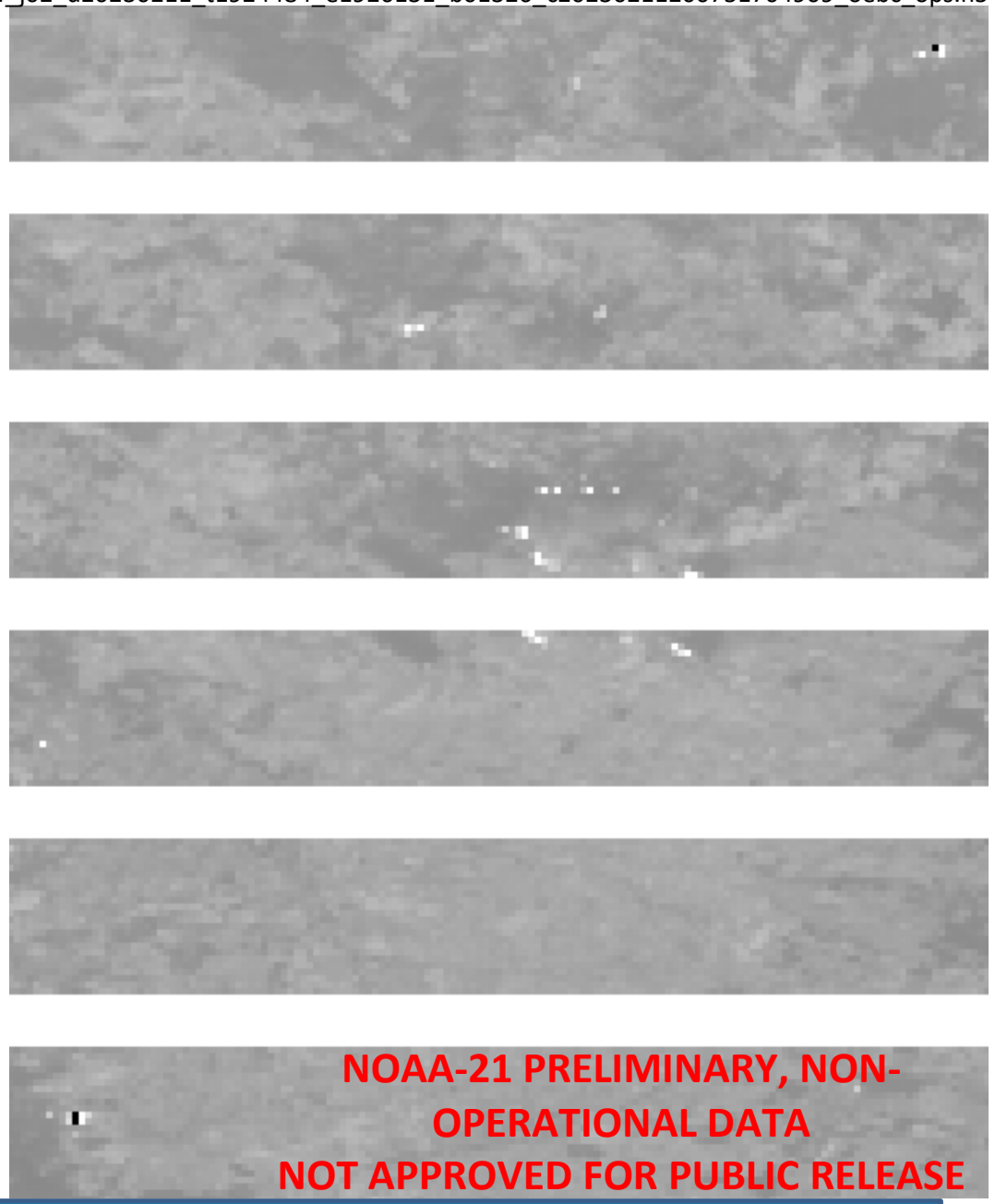

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M13 TB for comparison (Chile fires)

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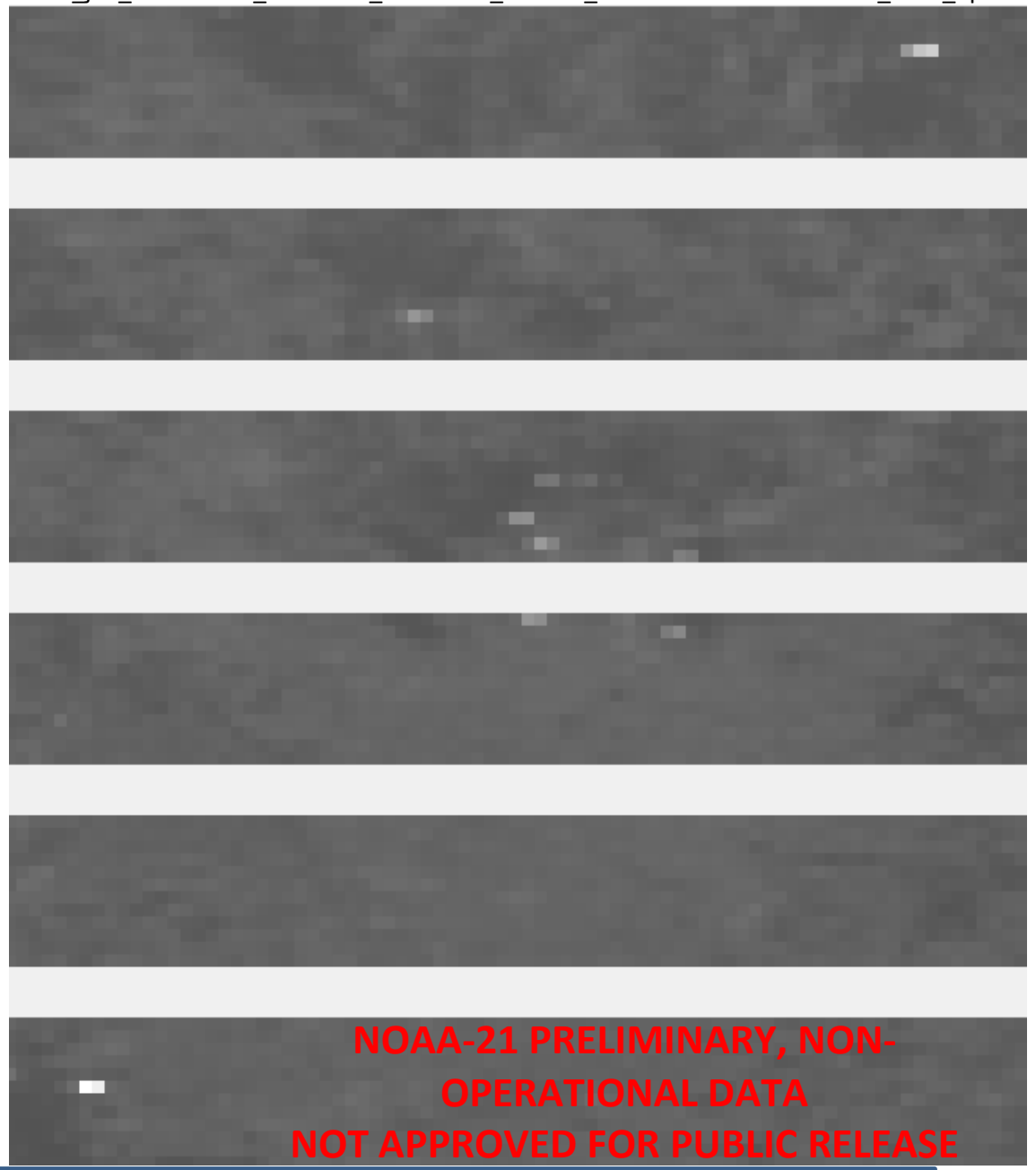
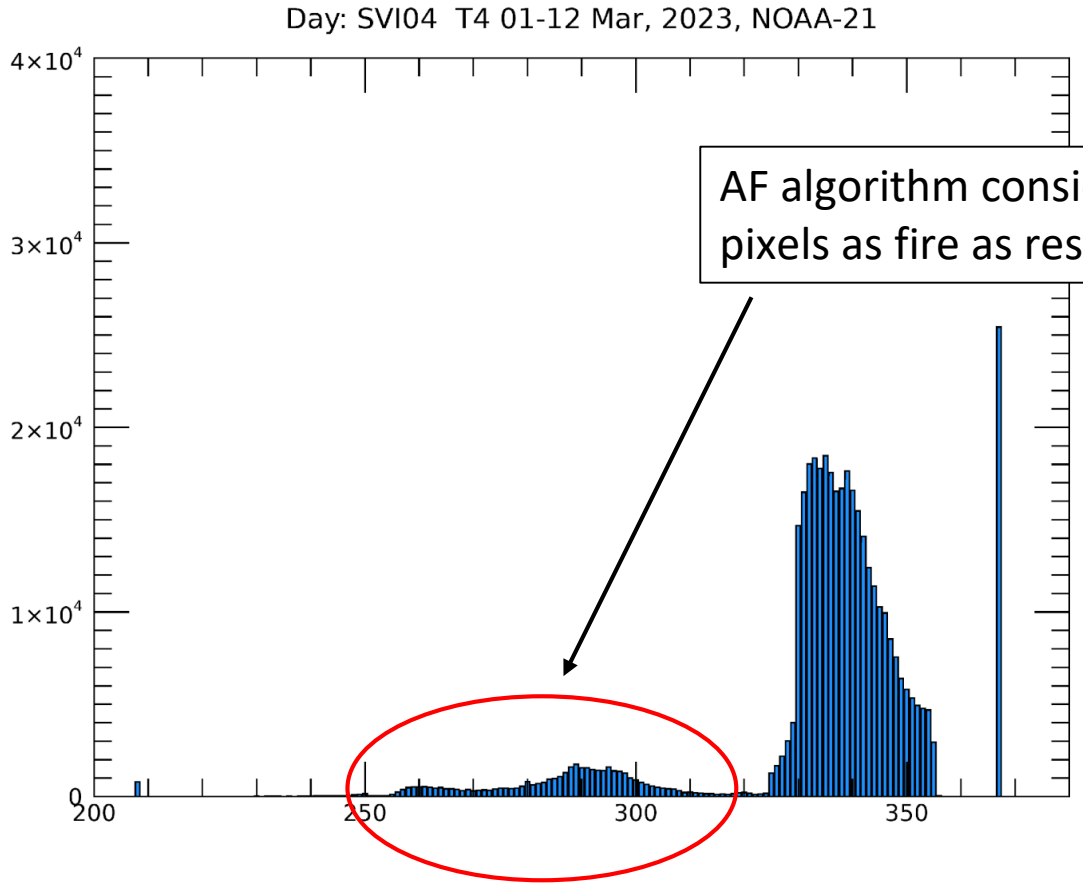
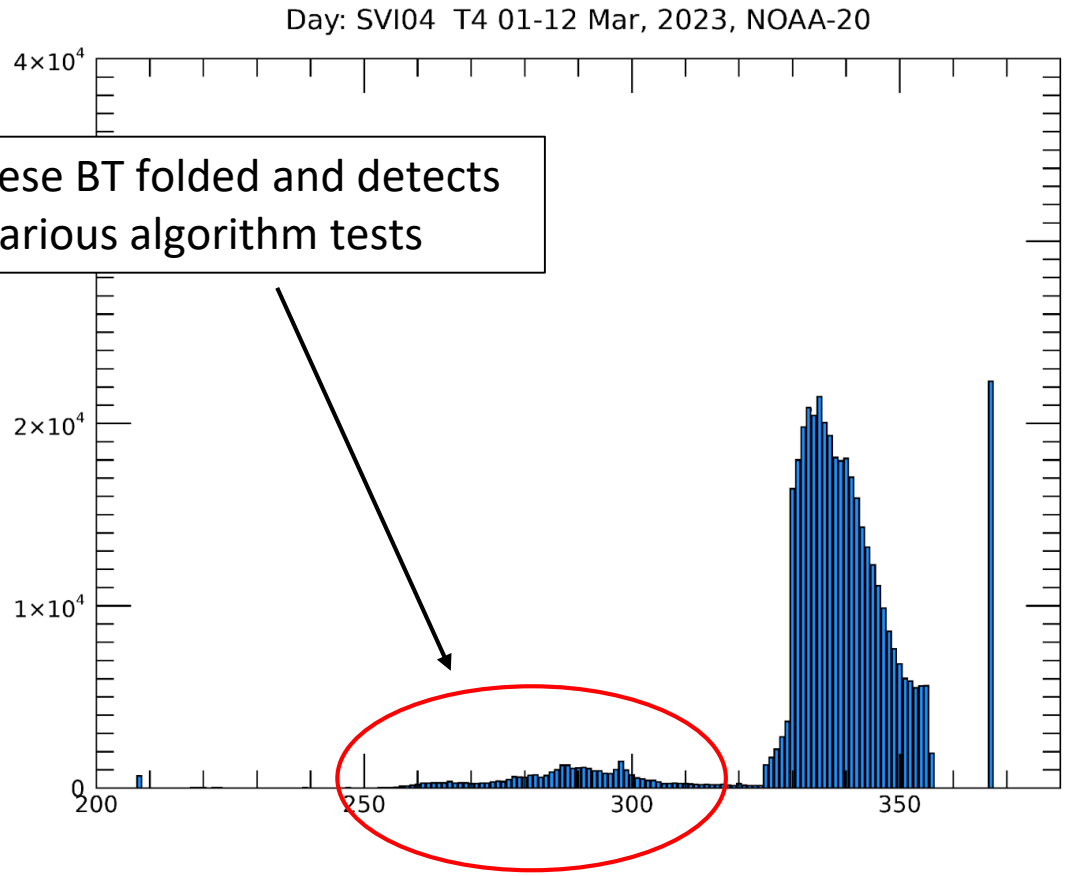


01-12 March, 2023



NOAA-21

AF algorithm considers these BT folded and detects pixels as fire as result of various algorithm tests



NOAA-20

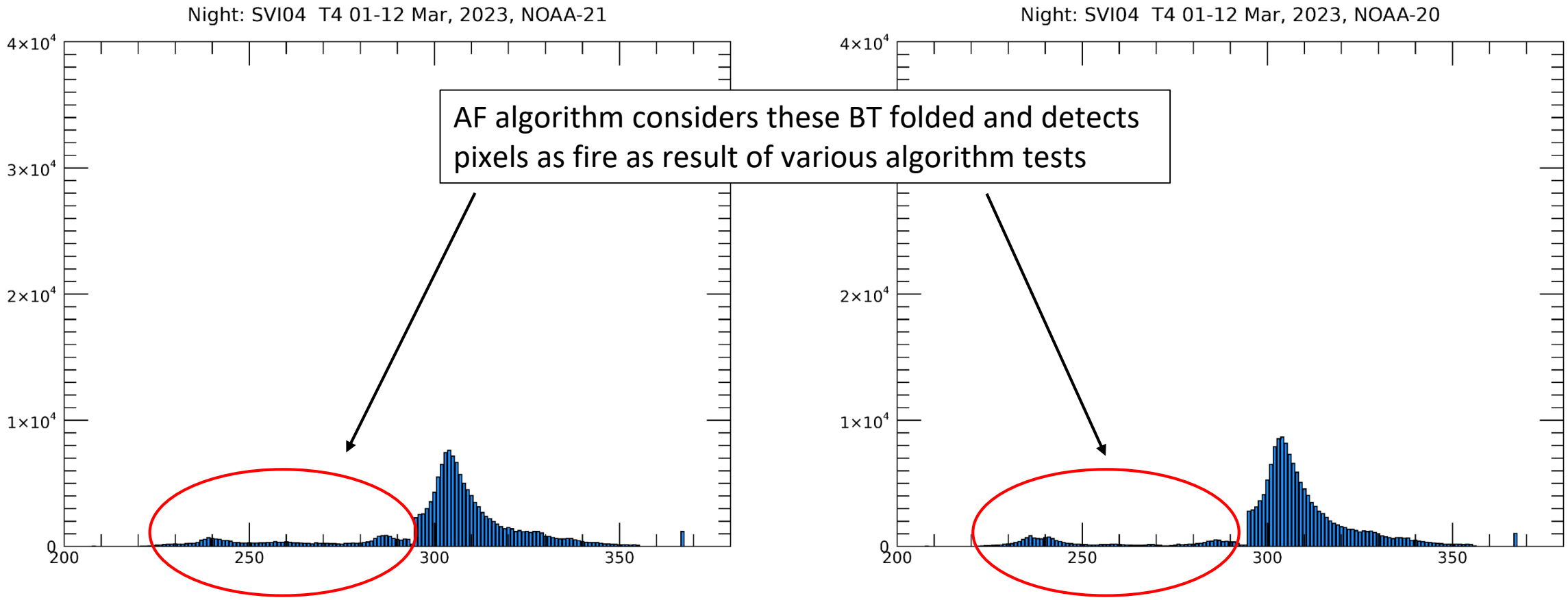
Day

SDR I04 brightness temperature of fire pixels

NOAA-21 PRELIMINARY, NON-OPERATIONAL DATA

NOT APPROVED FOR PUBLIC RELEASE

01-12 March, 2023



NOAA-21

NOAA-20

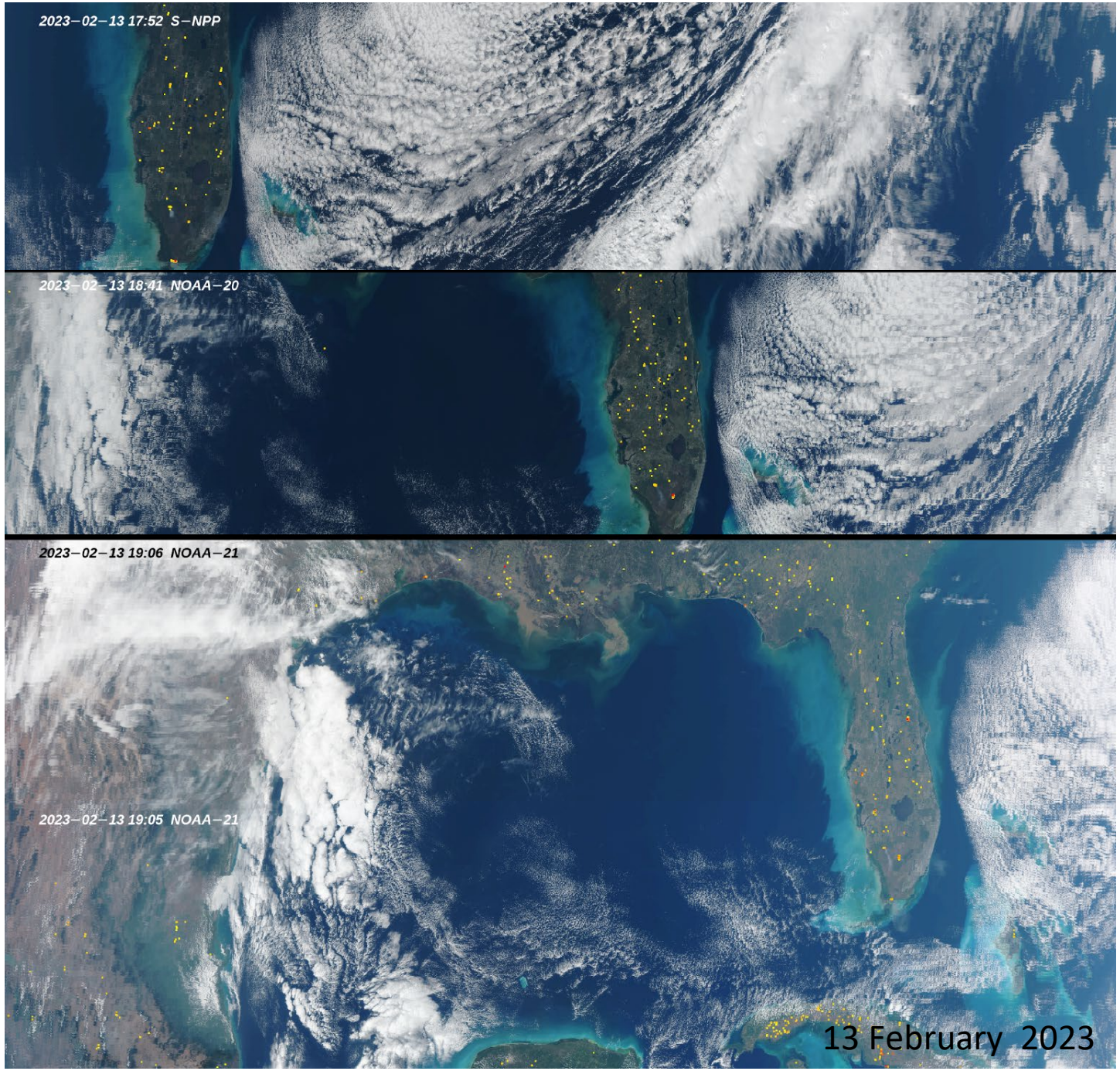
Night

SDR I04 brightness temperature of fire pixels

NOAA-21 PRELIMINARY, NON-OPERATIONAL DATA

NOT APPROVED FOR PUBLIC RELEASE

Visual expert analysis

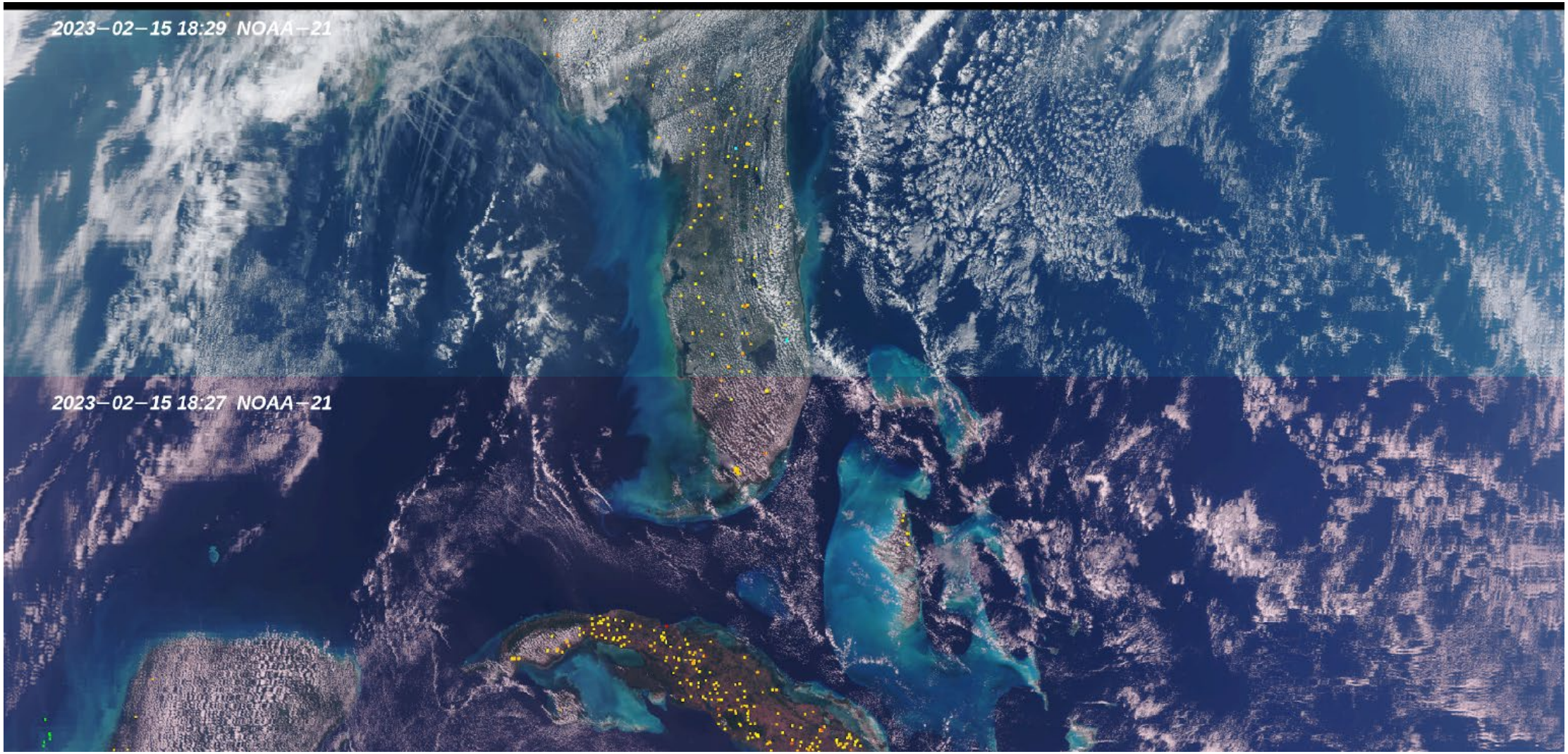


Suomi NPP

NOAA-20

NOAA-21

**NOAA-21 PRELIMINARY, NON-OPERATIONAL DATA
NOT APPROVED FOR PUBLIC RELEASE**



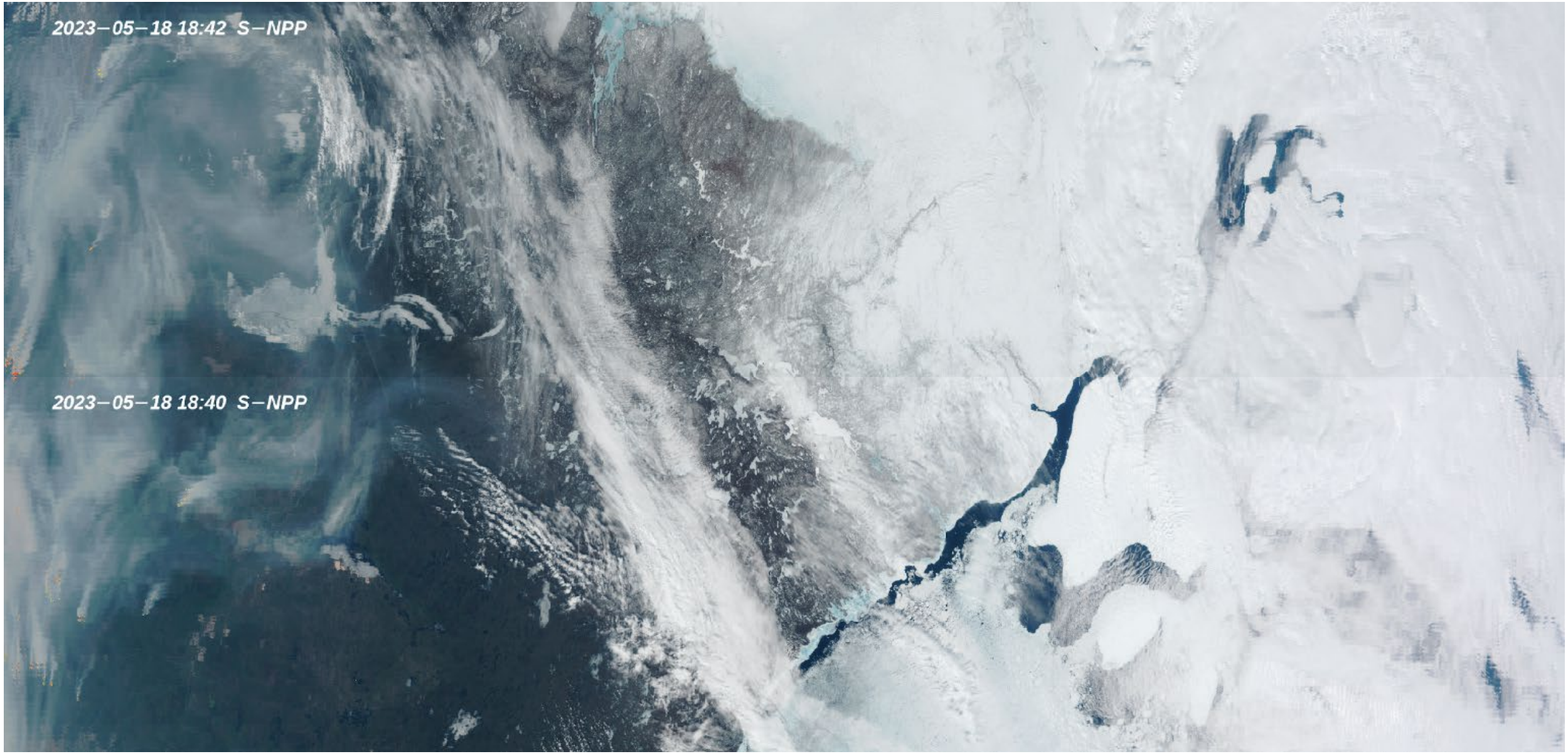
NOAA-21

15 February 2023

NOAA-21 PRELIMINARY, NON-OPERATIONAL DATA

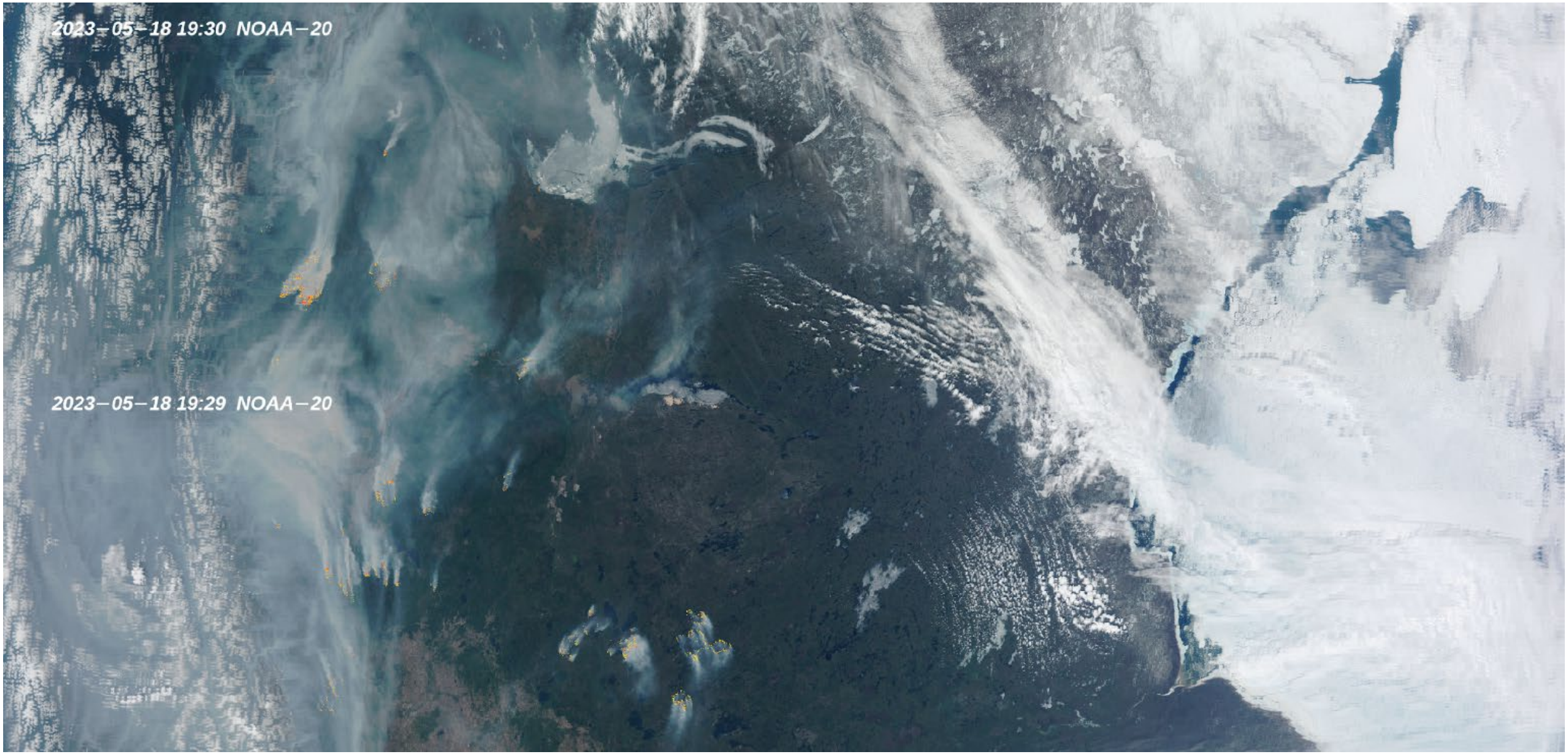
NOT APPROVED FOR PUBLIC RELEASE

S-NPP Canadian Fires



2023-05-18 18:40 UTC

NOAA-20 Canadian Fires

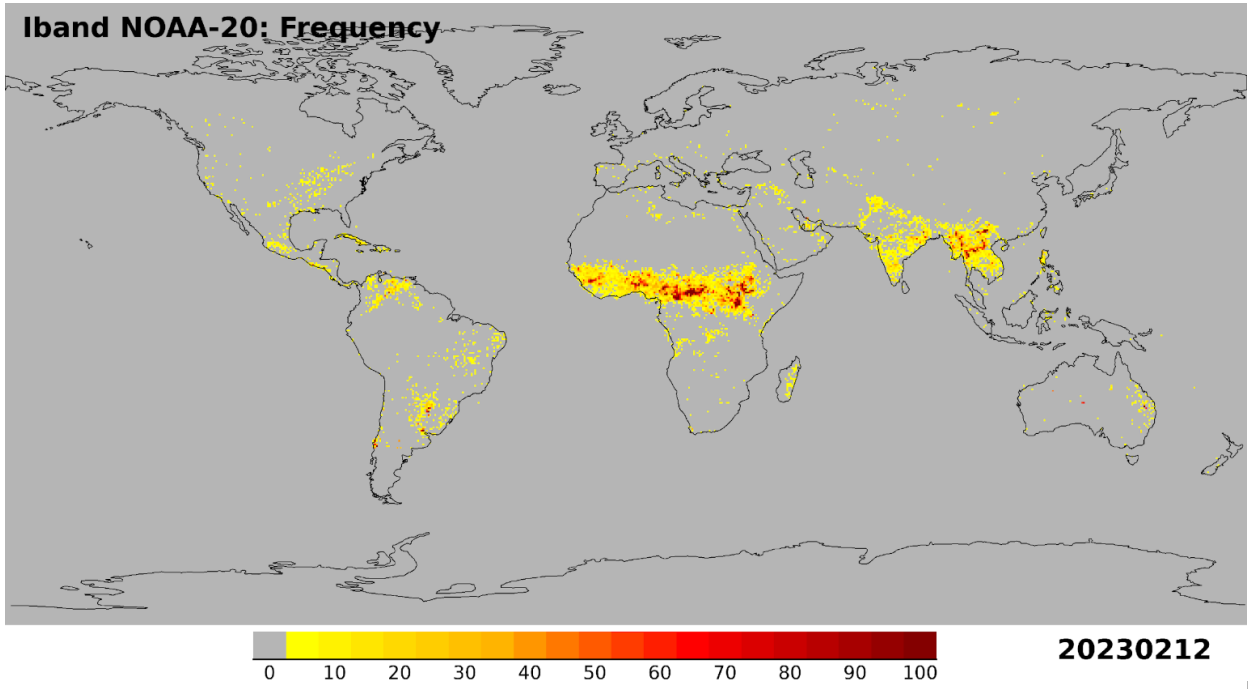


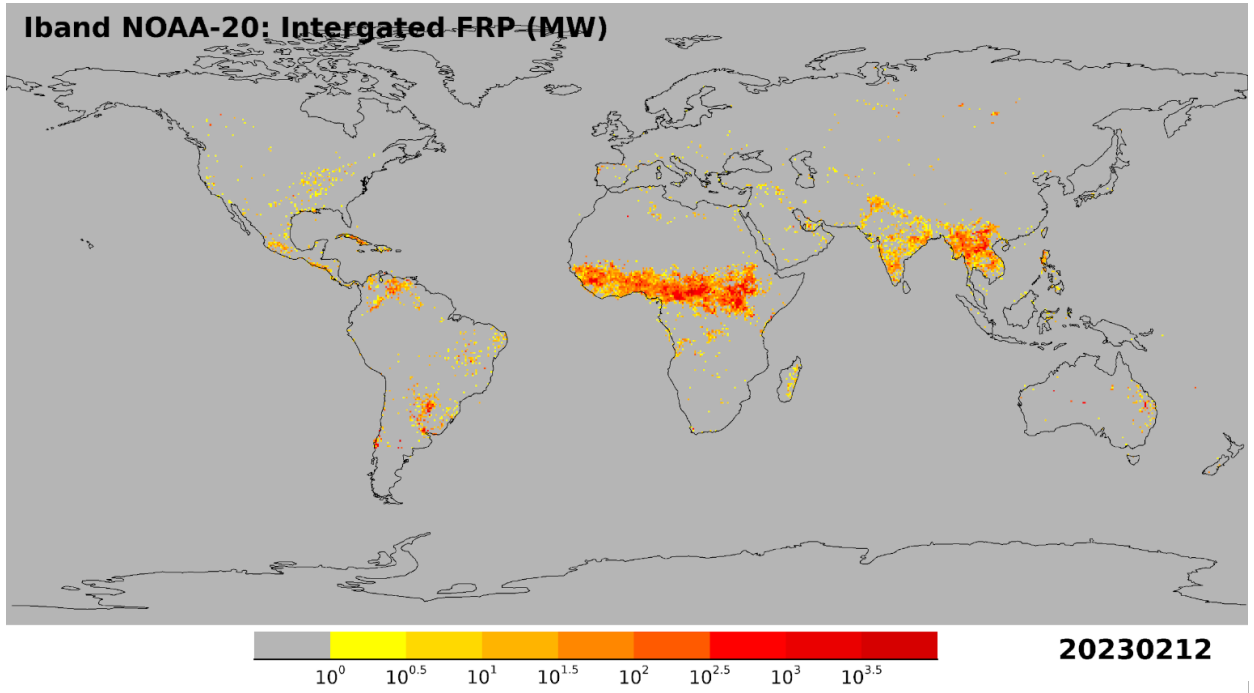
2023-05-18 19:29 UTC

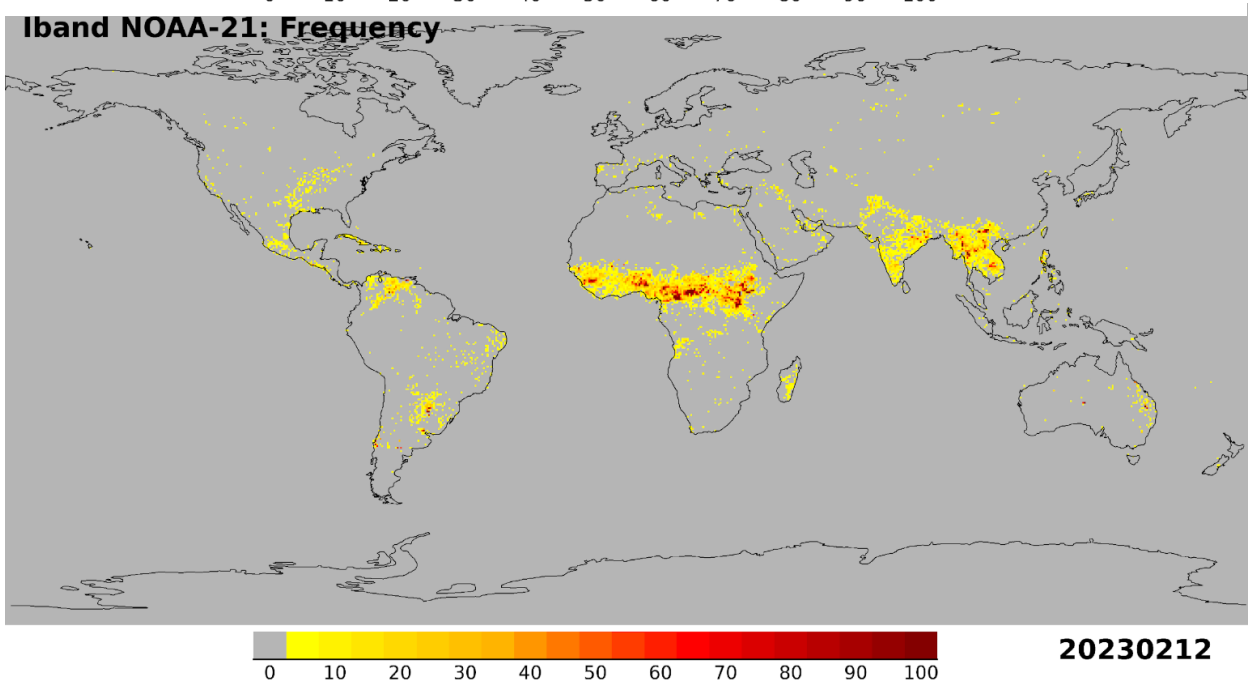
NOAA-21 Canadian Fires

2023-05-18 19:51 UTC

NOAA-21 PRELIMINARY, NON-OPERATIONAL DATA
NOT APPROVED FOR PUBLIC RELEASE


Iband NOAA-20: Frequency
0 10 20 30 40 50 60 70 80 90 100
20230212


Iband NOAA-20: Intergated FRP (MW)
10^0 $10^{0.5}$ 10^1 $10^{1.5}$ 10^2 $10^{2.5}$ 10^3 $10^{3.5}$
20230212


Iband NOAA-21: Frequency
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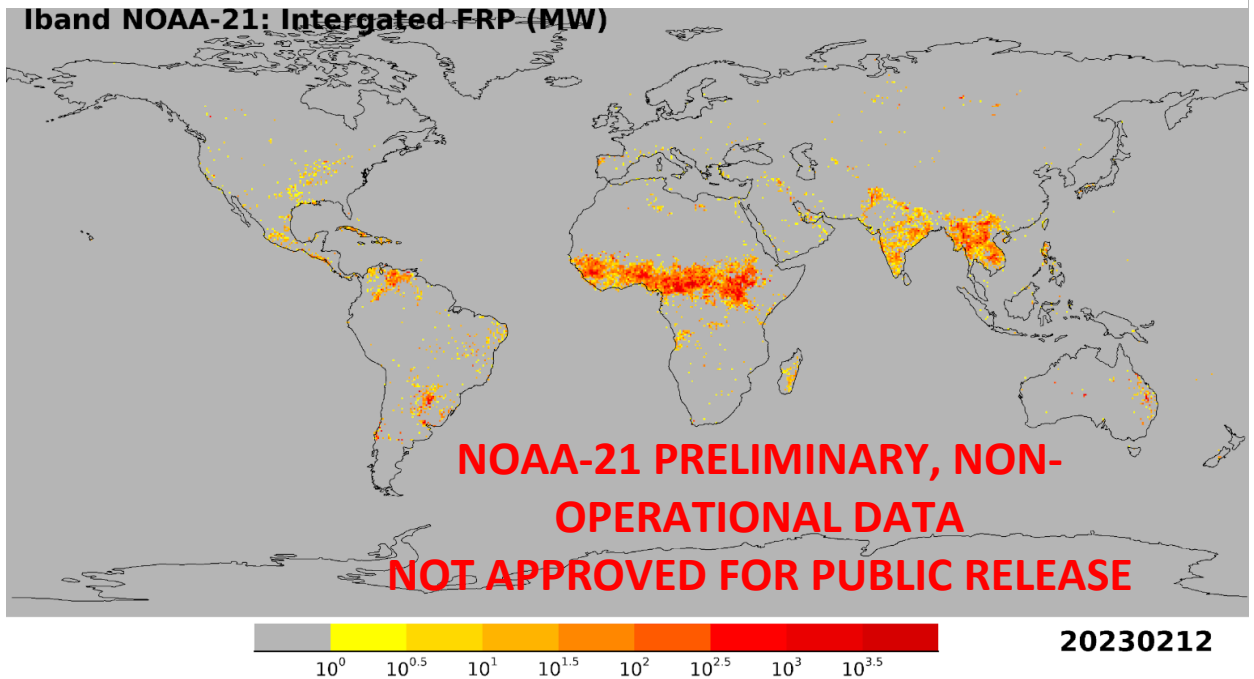
20230212


Iband NOAA-21: Intergated FRP (MW)
NOAA-21 PRELIMINARY, NON-OPERATIONAL DATA
NOT APPROVED FOR PUBLIC RELEASE
10^0 $10^{0.5}$ 10^1 $10^{1.5}$ 10^2 $10^{2.5}$ 10^3 $10^{3.5}$
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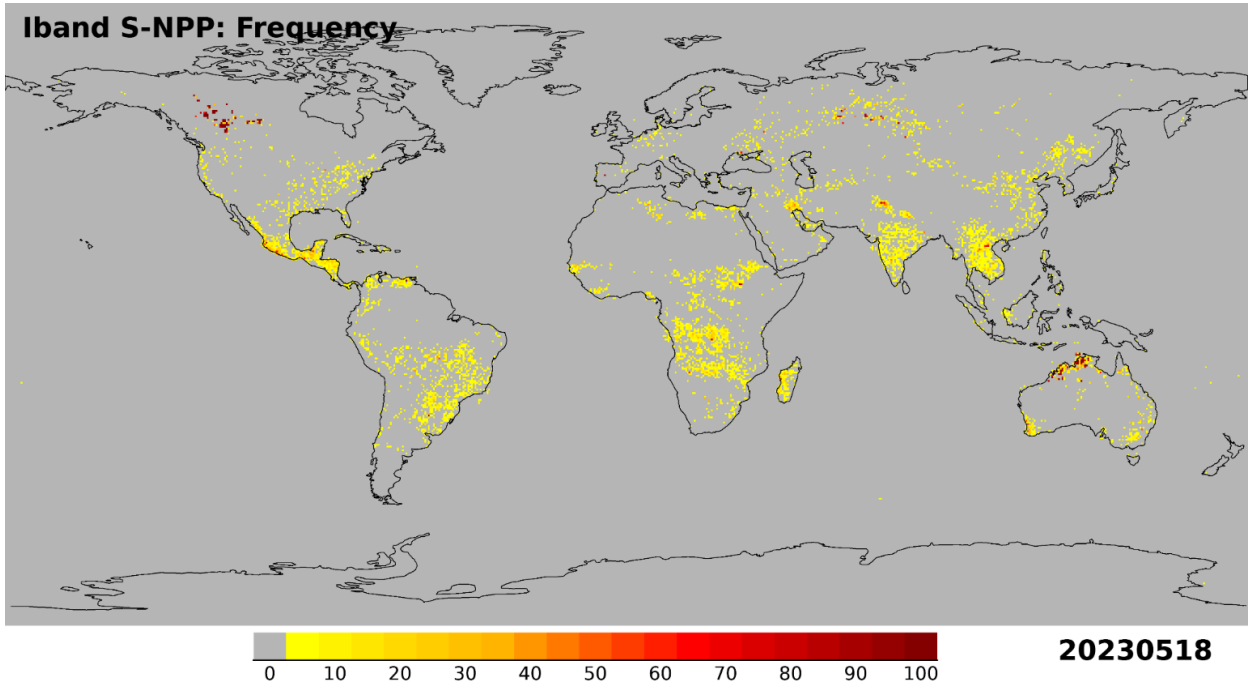
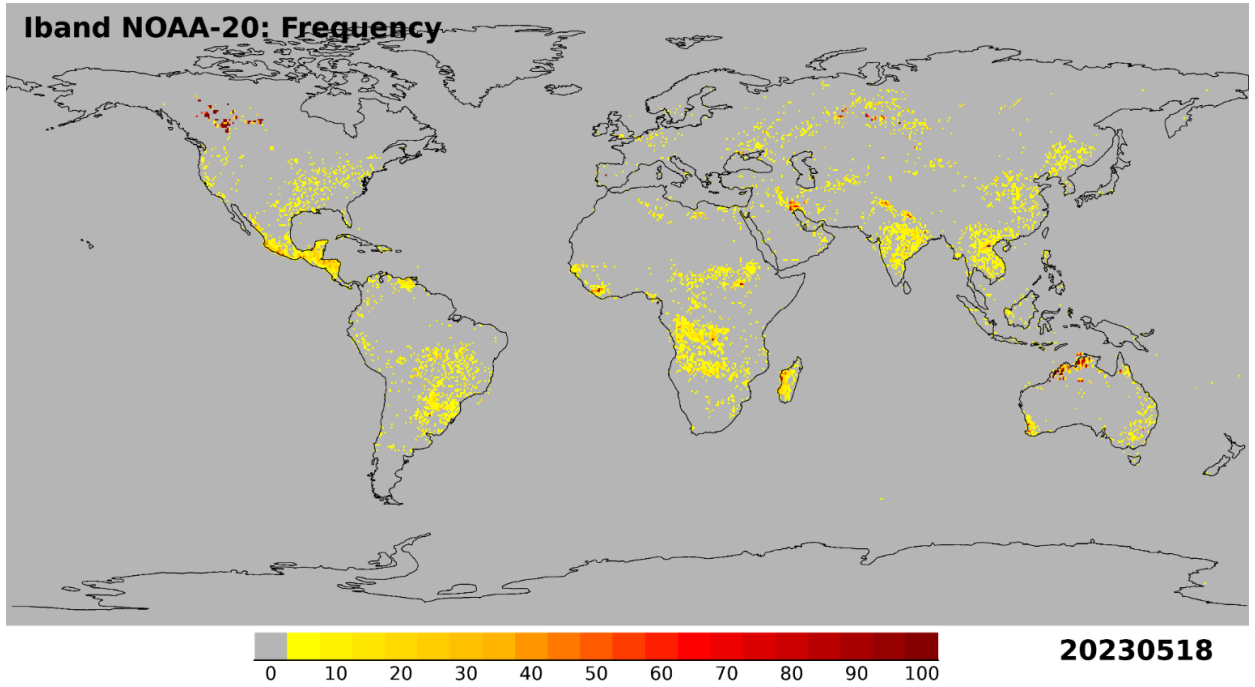
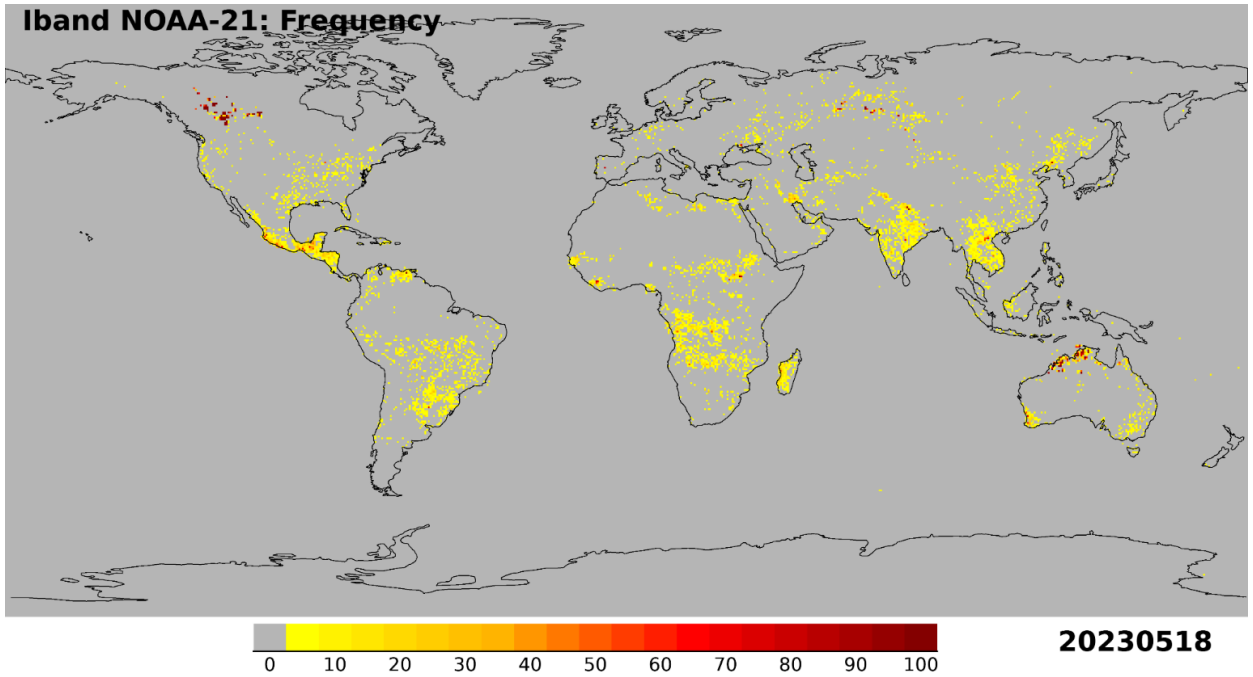
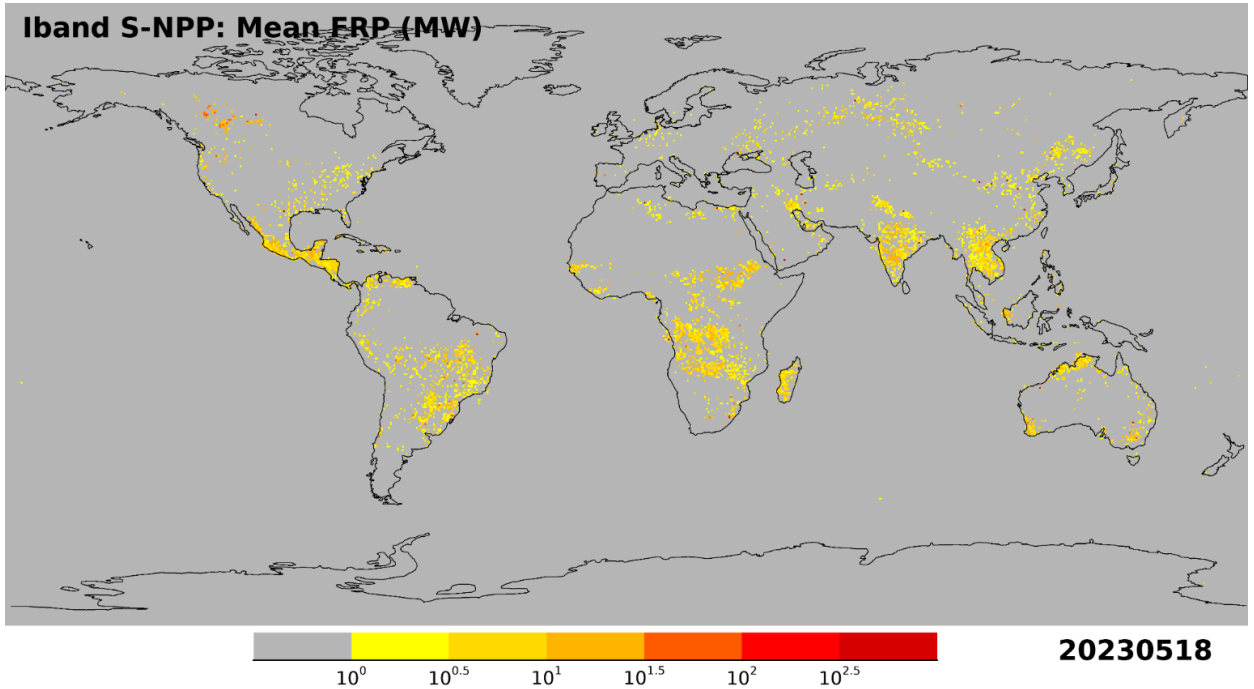


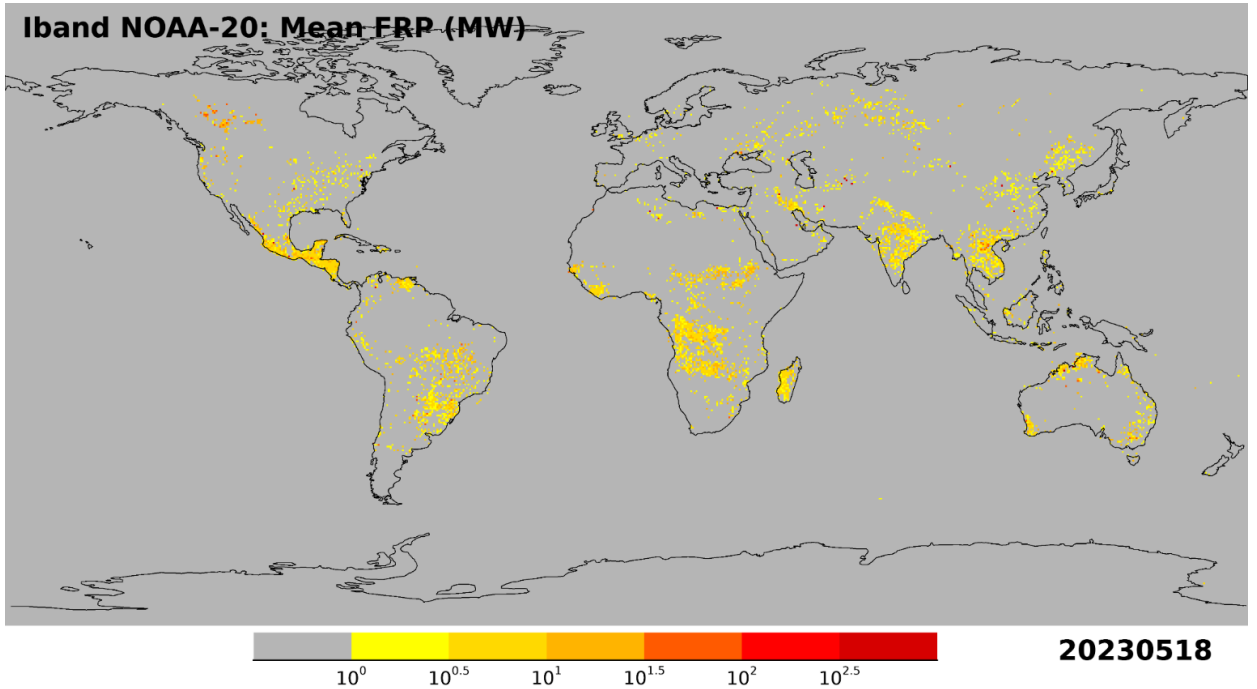


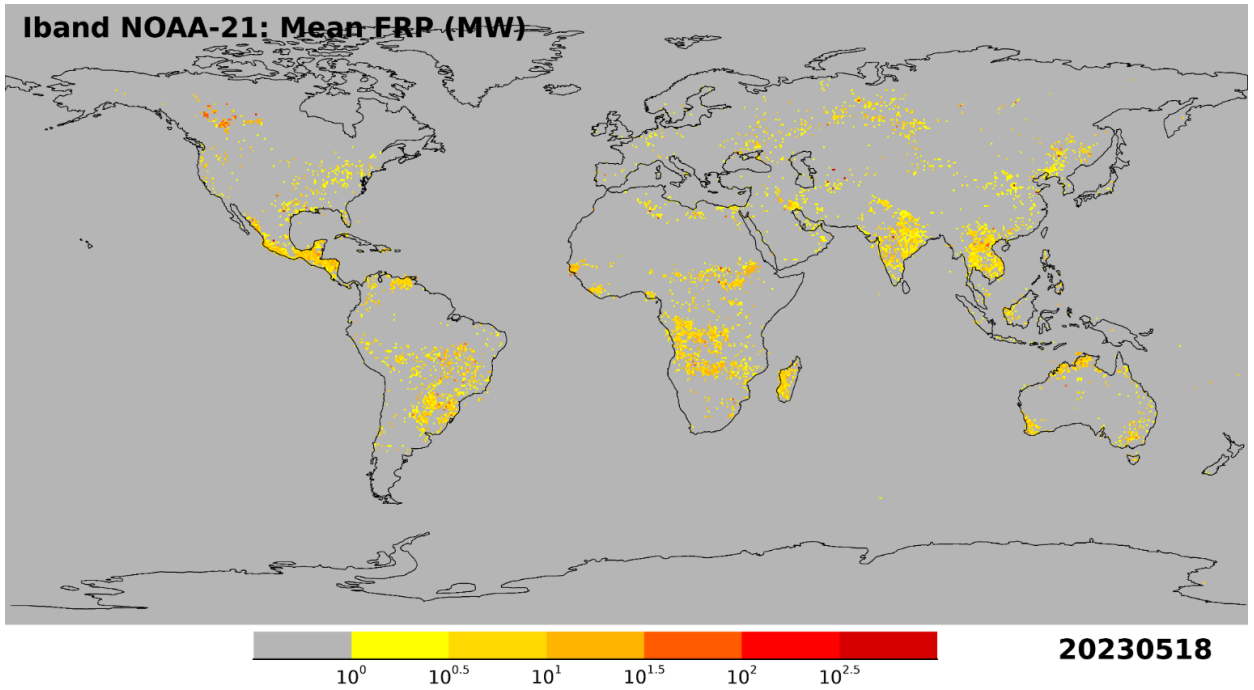


Daily number of fire detections
May 18, 2023

0.5 x 0.5 degree lat/lon grid

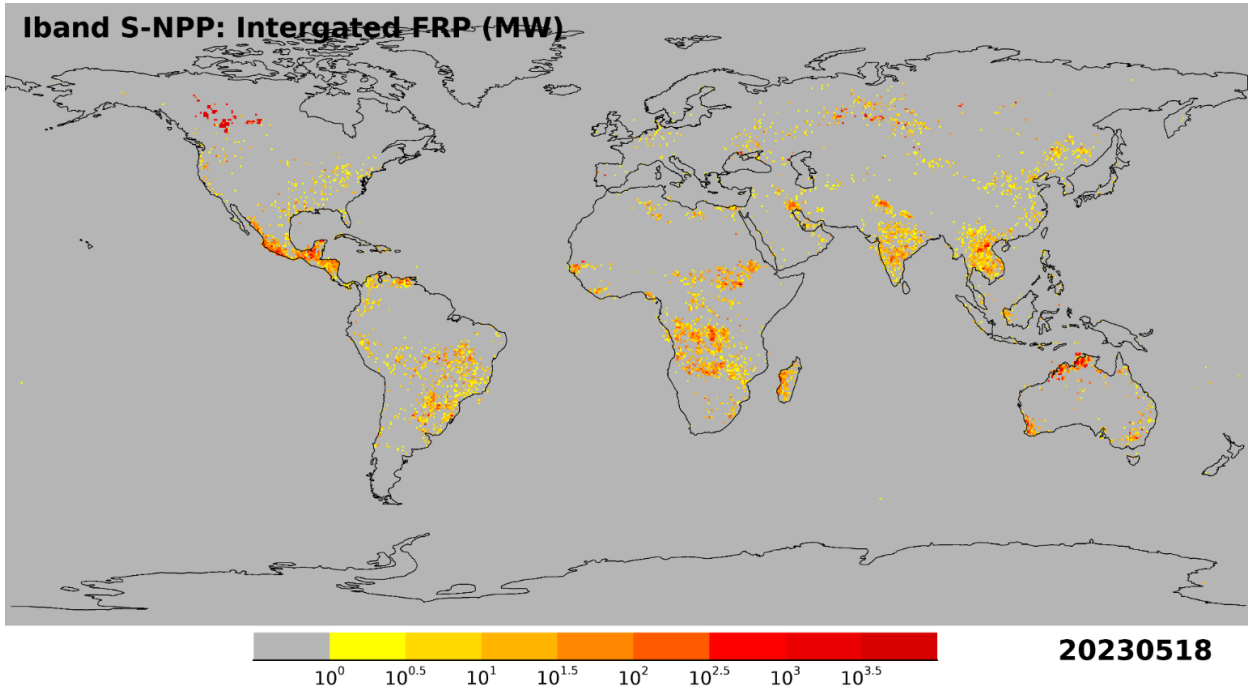


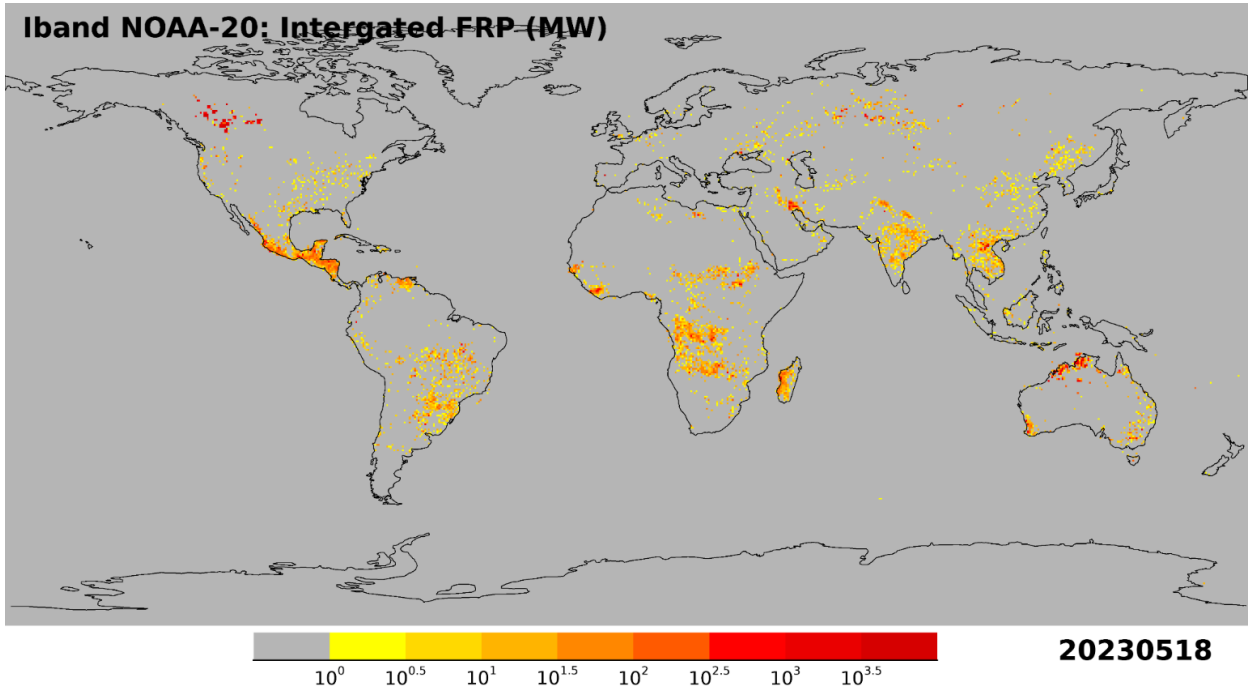


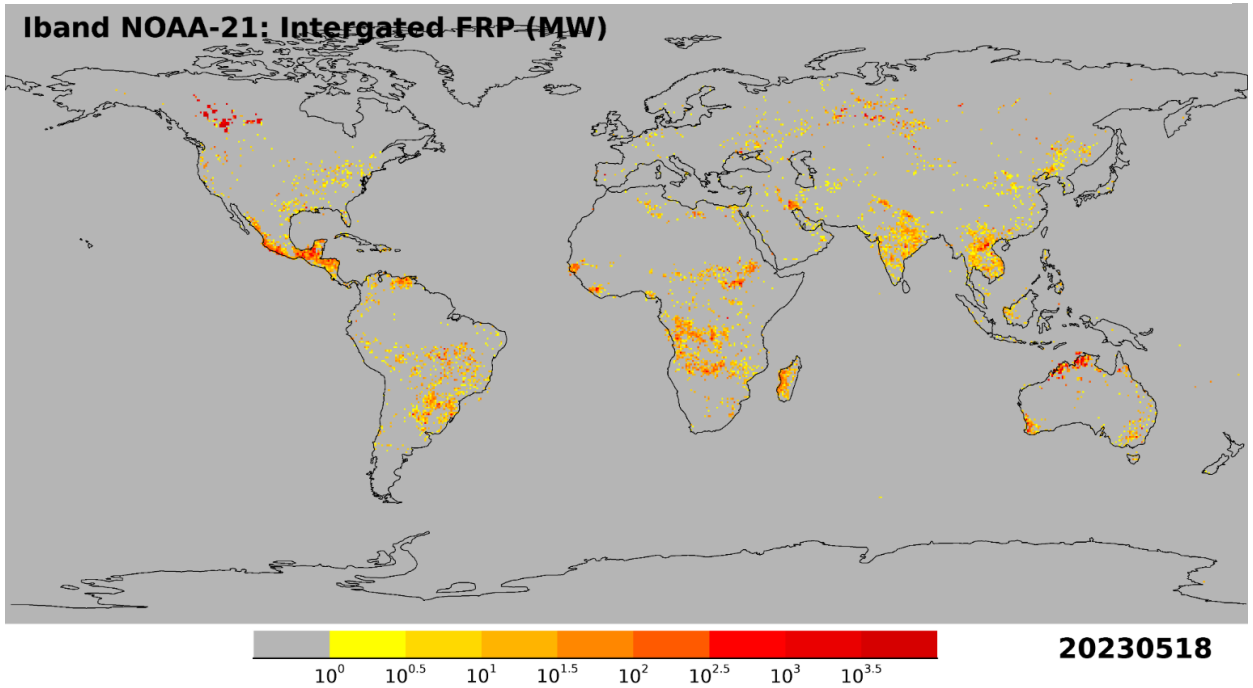


Daily mean fire radiative power (MW)
May 18, 2023

0.5 x 0.5 degree lat/lon grid

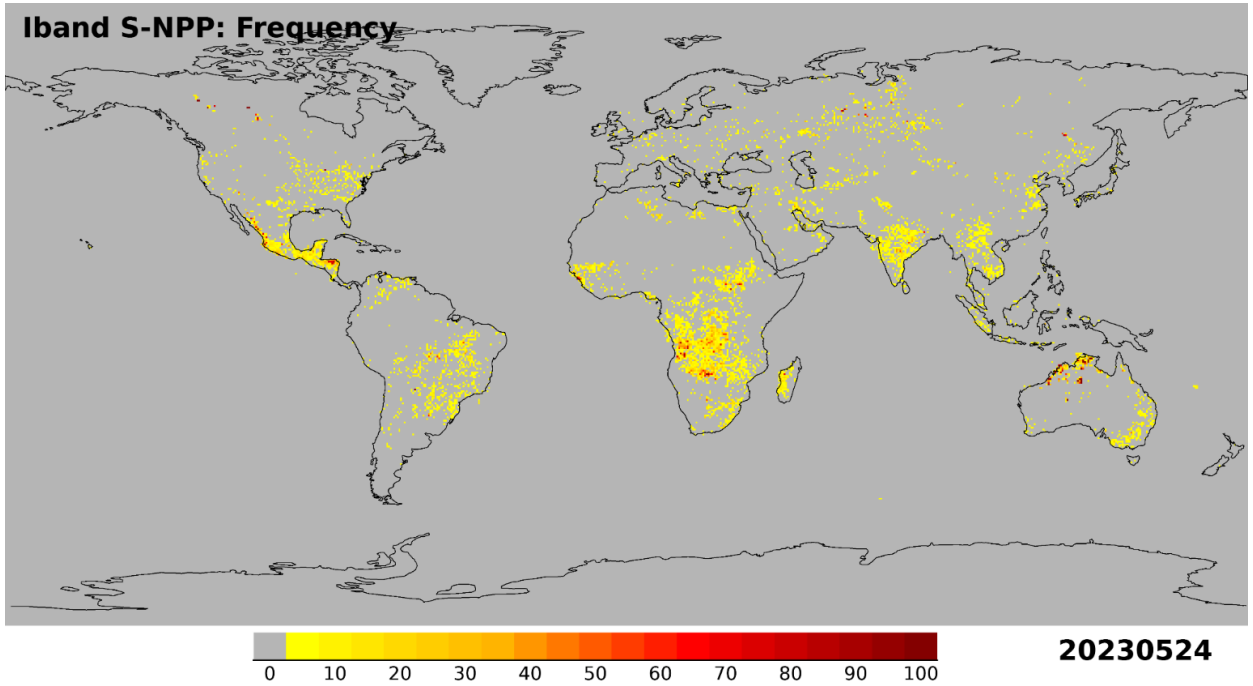


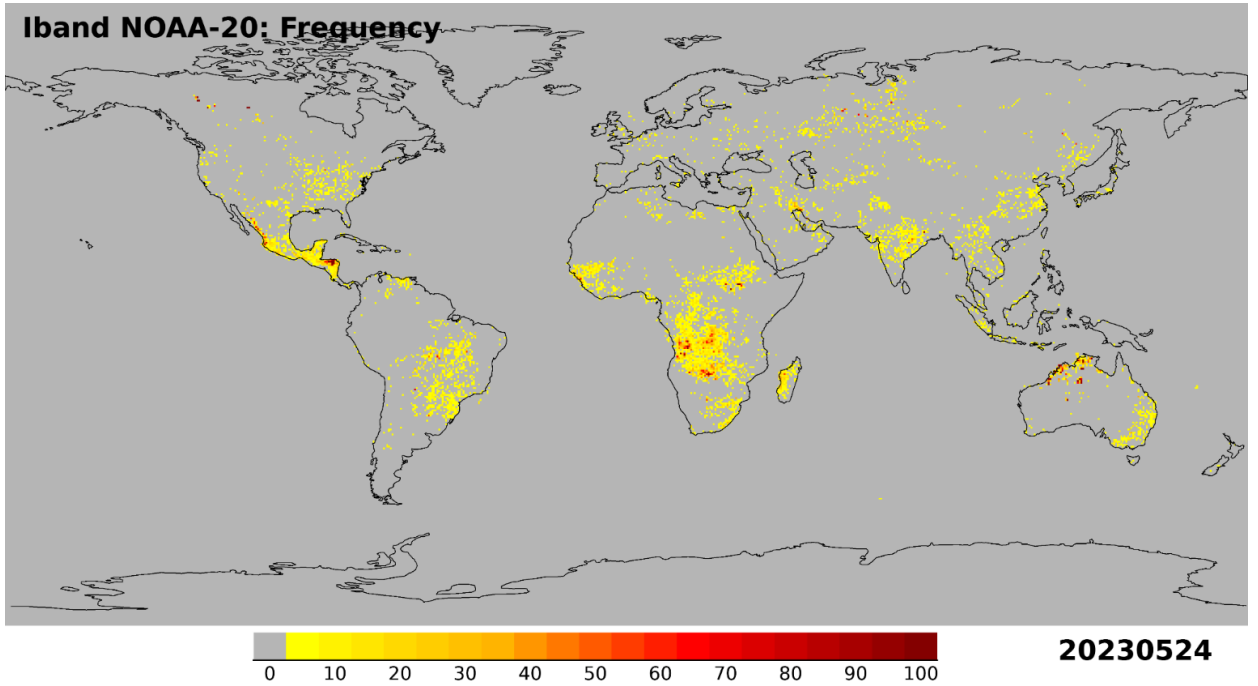


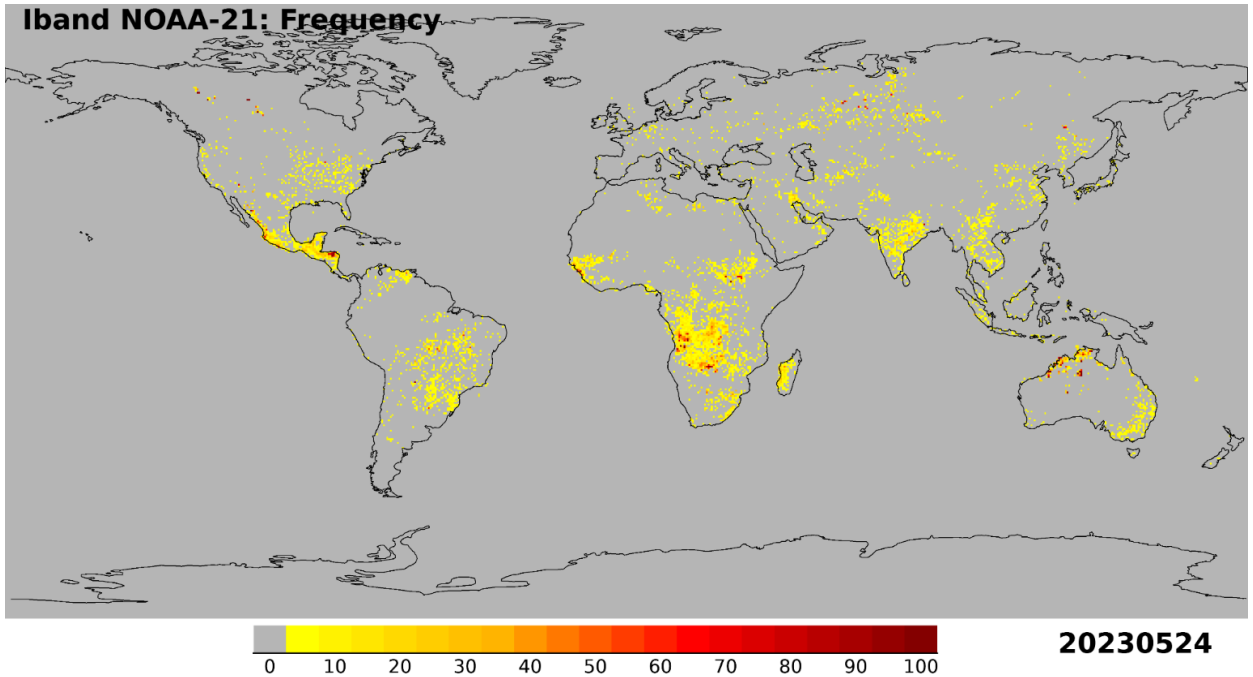


Daily total fire radiative power (MW)
May 18, 2023

0.5 x 0.5 degree lat/lon grid

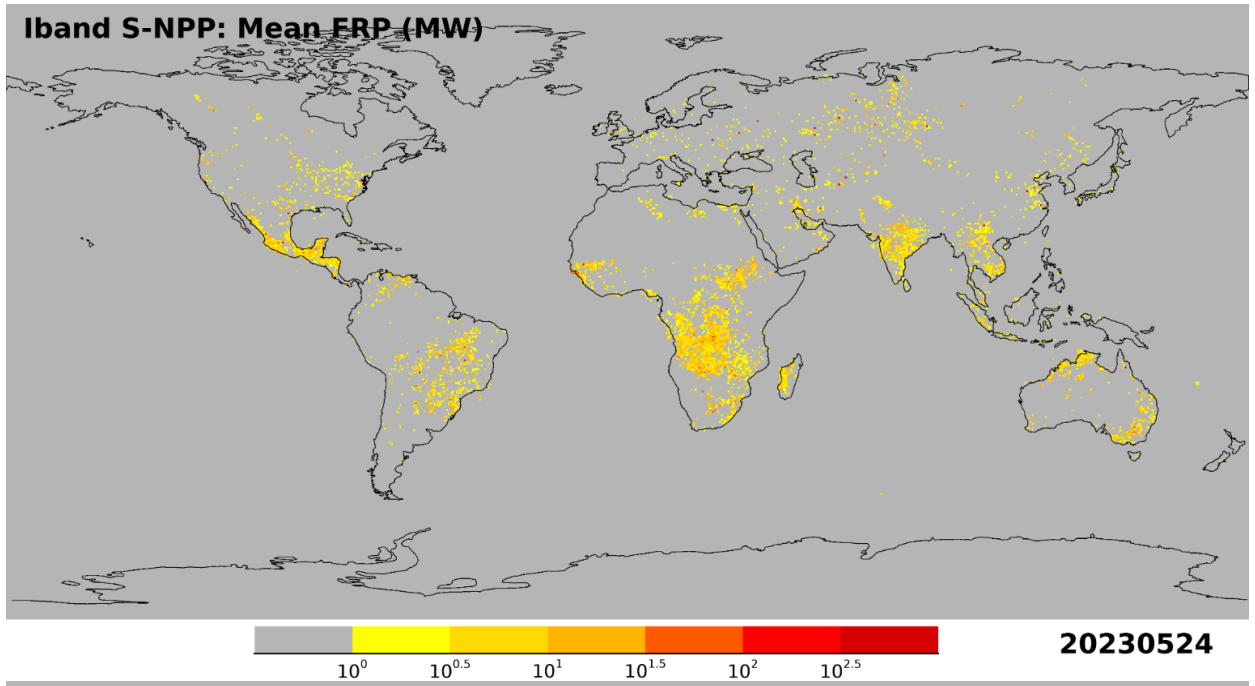


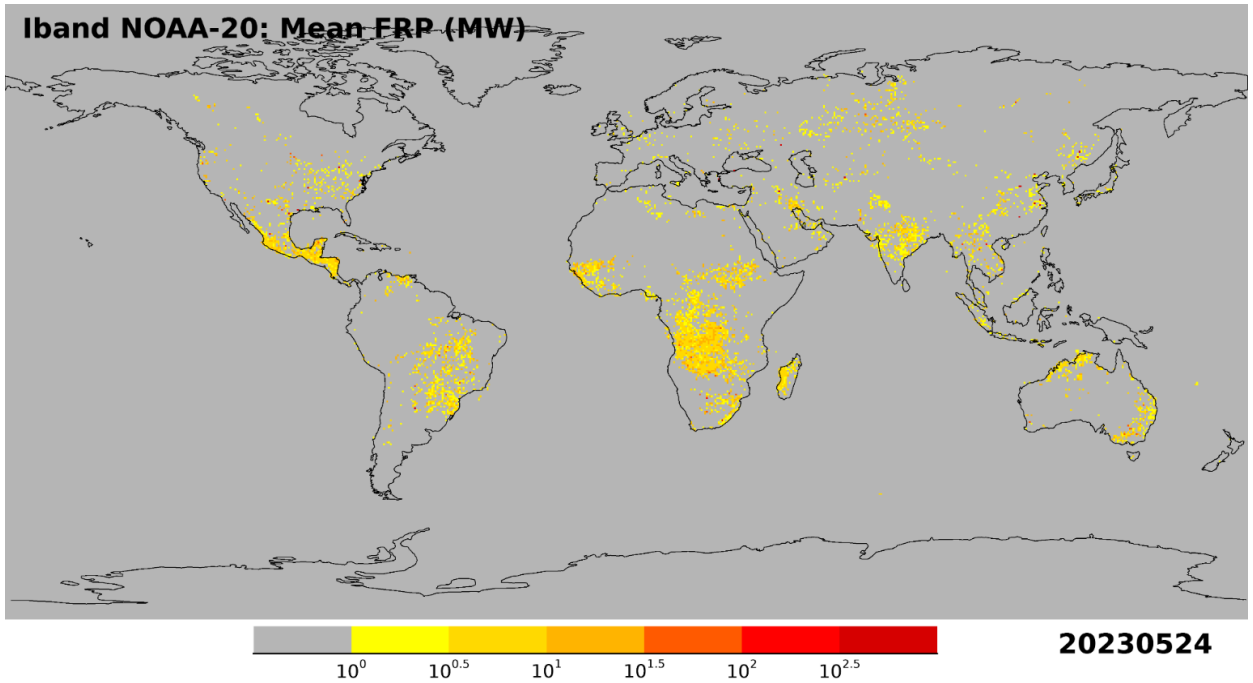


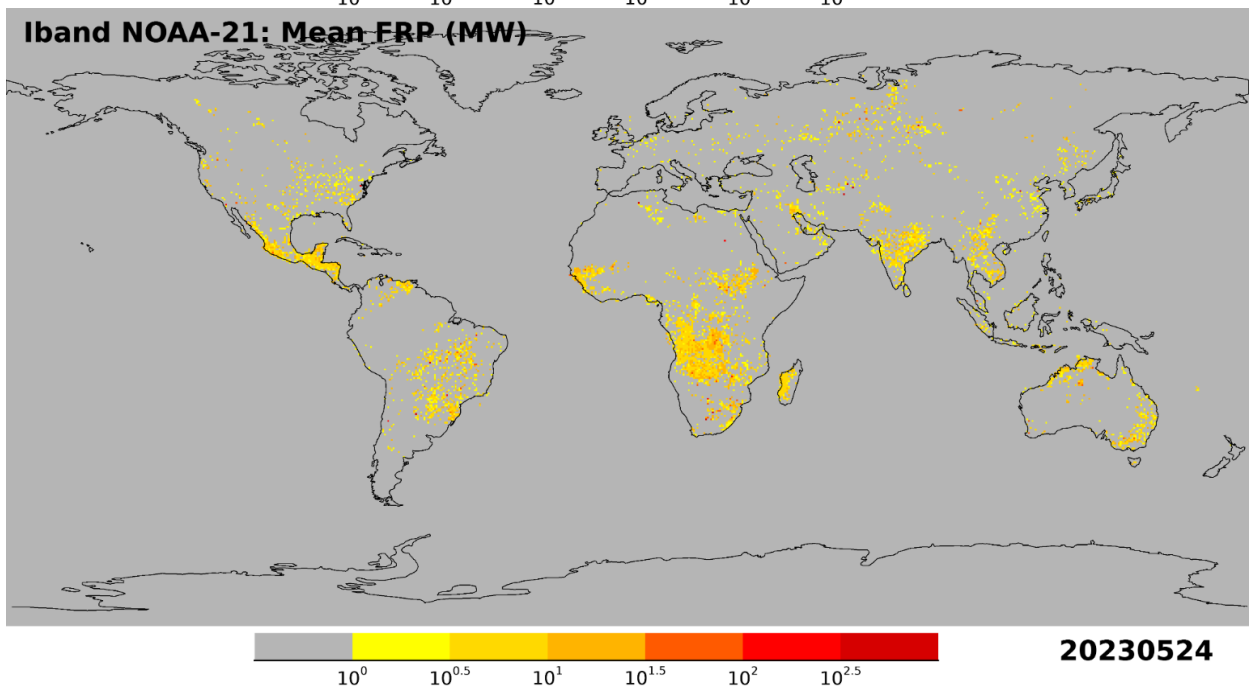


Daily number of fire detections
May 24, 2023

0.5 x 0.5 degree lat/lon grid

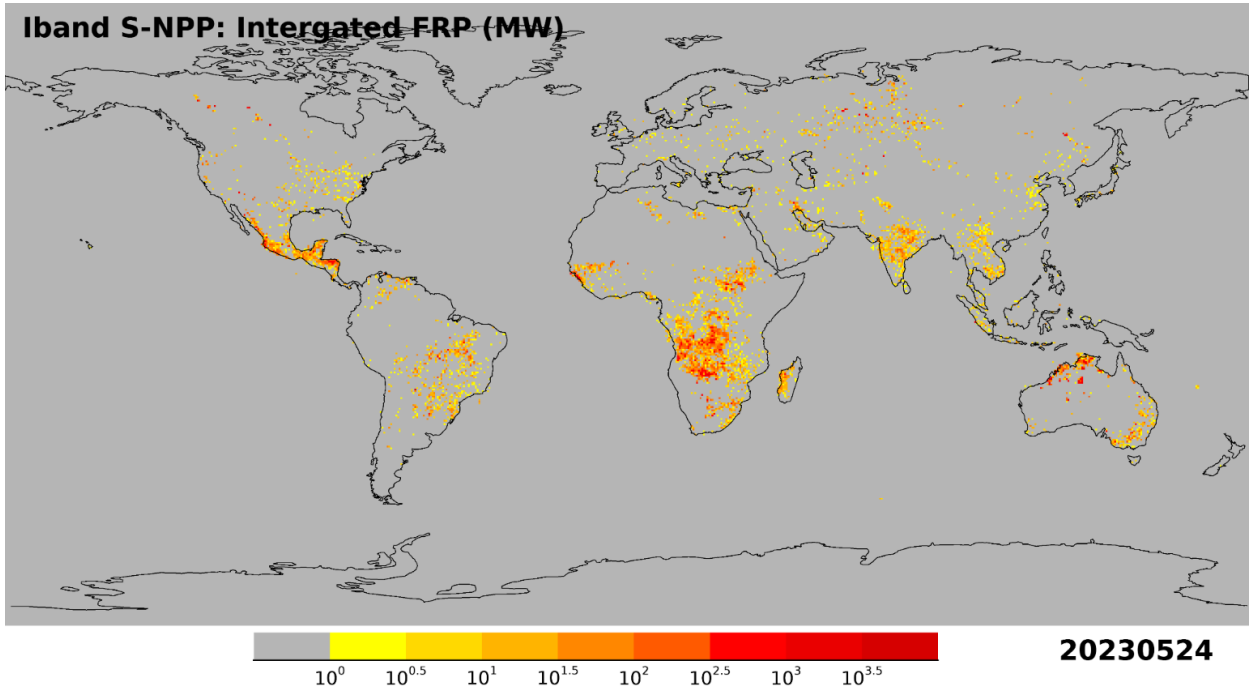


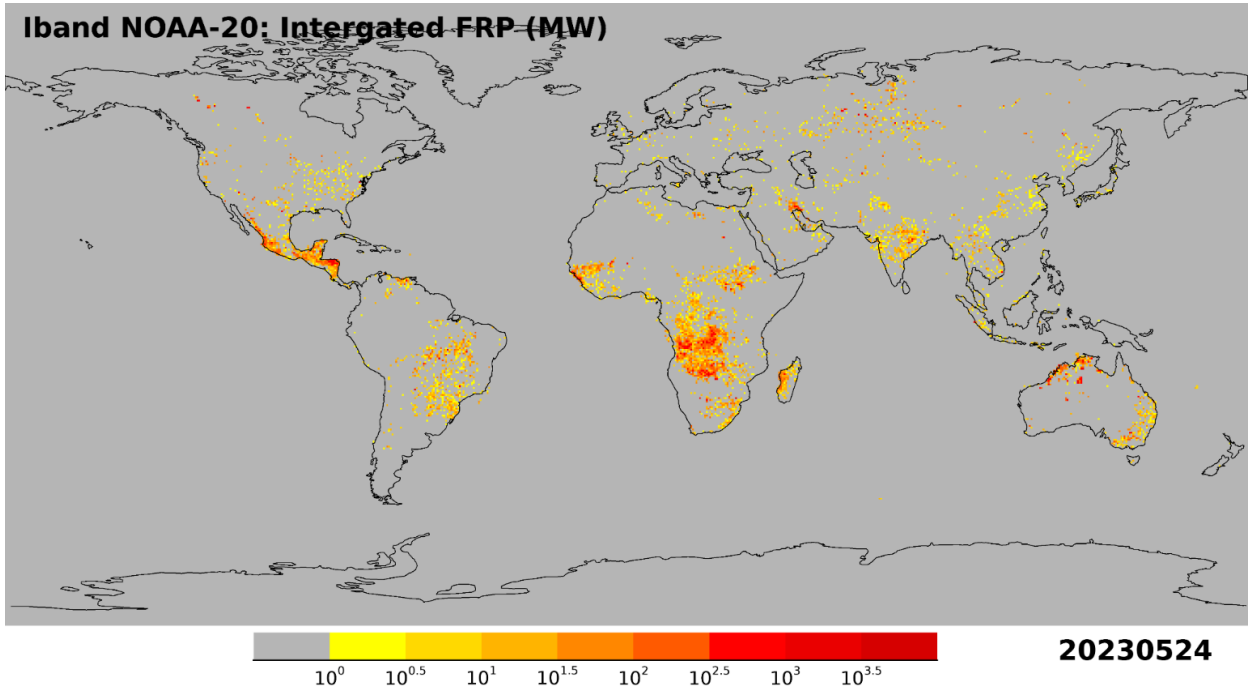


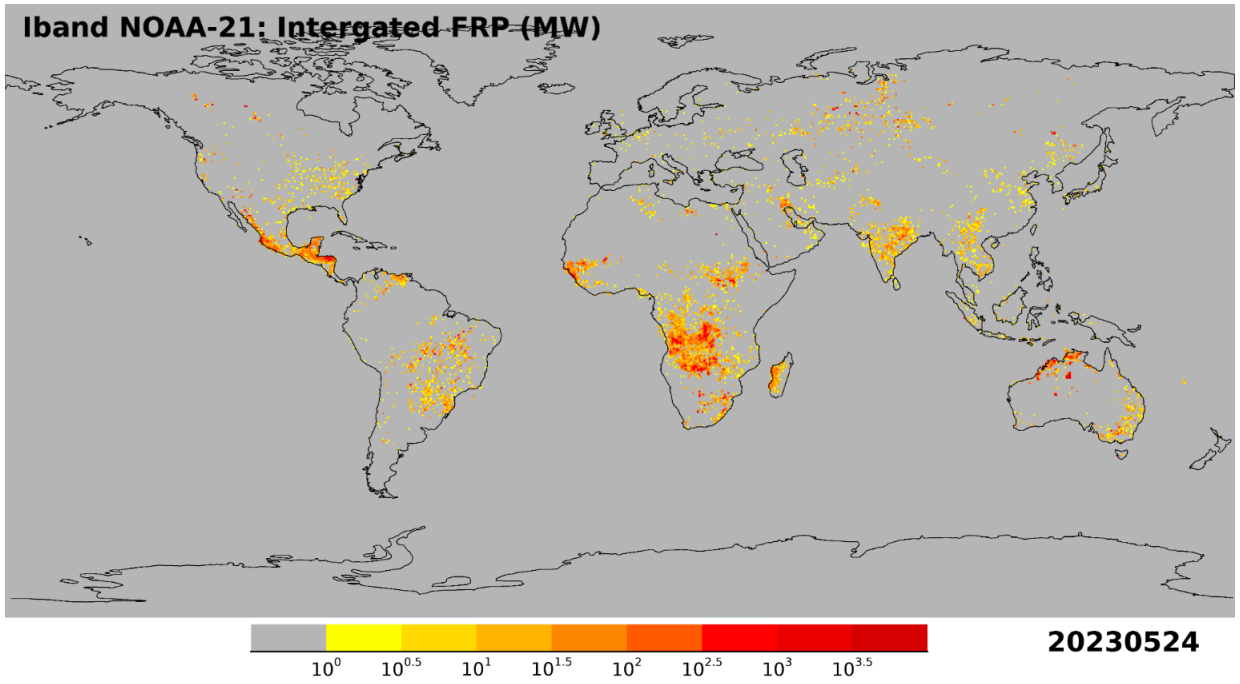


Daily mean fire radiative power (MW)
May 24, 2023

0.5 x 0.5 degree lat/lon grid





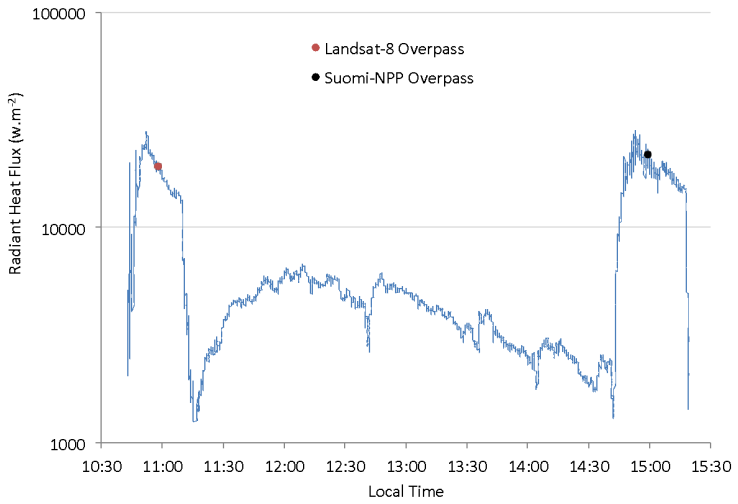


Daily total fire radiative power (MW)
May 24, 2023

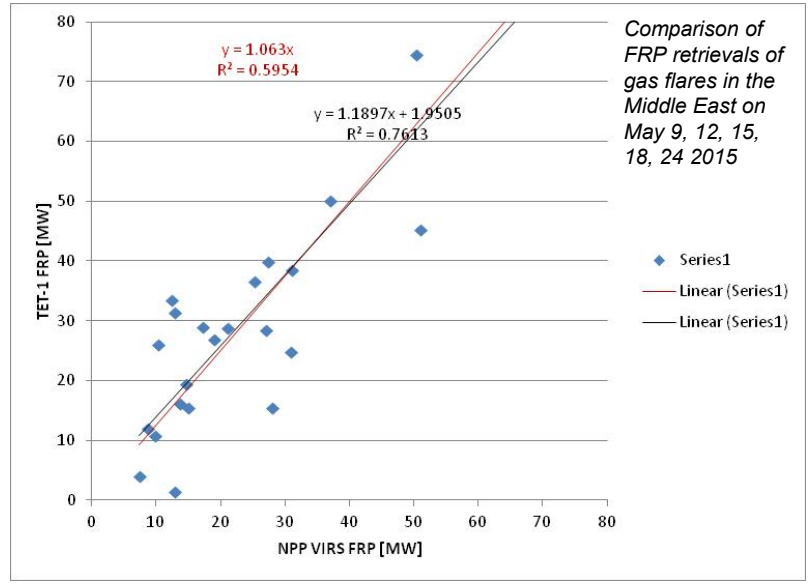
0.5 x 0.5 degree lat/lon grid

Tracing back NOAA-21 product performance to prior validation of SNPP and NOAA-20 products

Examples of previous validation against in-situ and high resolution reference data

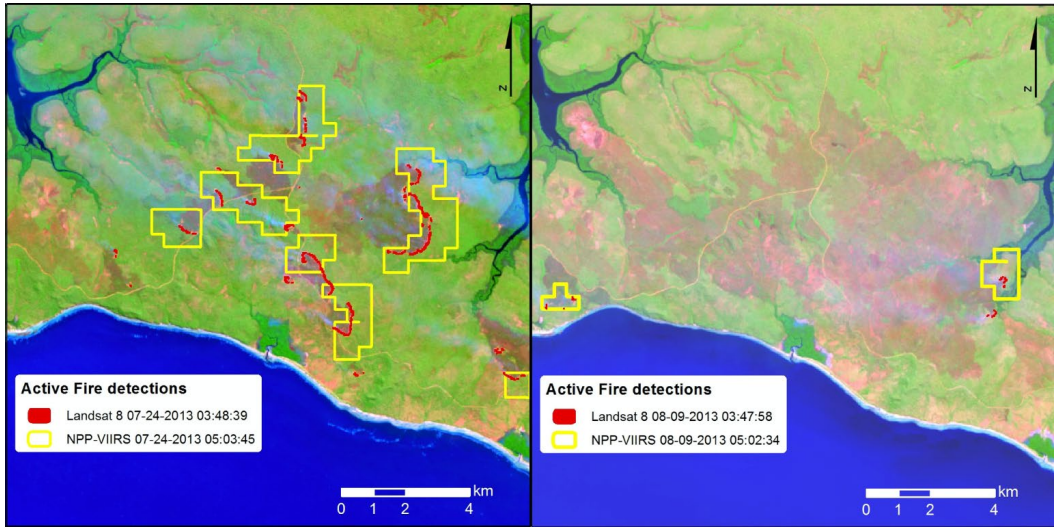


Small experimental fire implemented for the validation of same-day Landsat-8 and Suomi-NPP/VIIRS fire detection data in Brazil, Jan/2015. Tower-mounted radiometers provided 1Hz fire radiant flux data coincident with satellite overpasses.

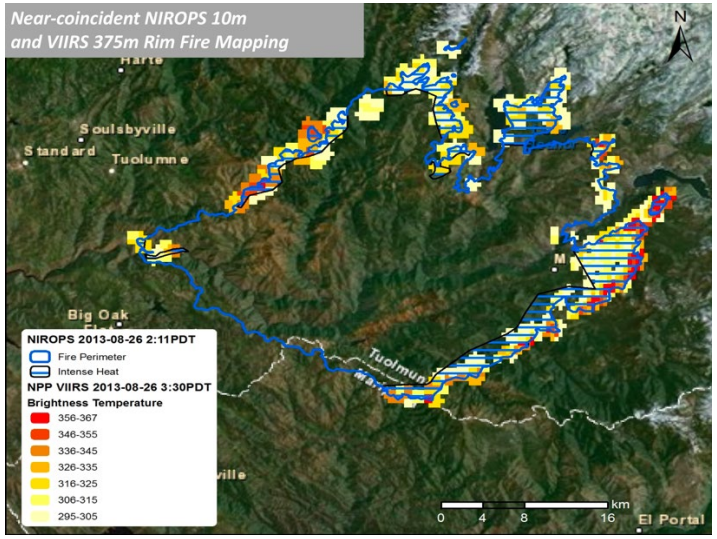


Comparison of FRP retrievals of gas flares in the Middle East on May 9, 12, 15, 18, 24 2015

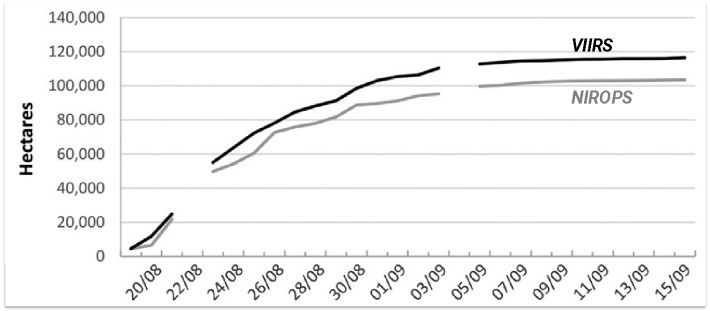
TET-1: Technology Experiment Carrier-1 by German Aerospace Agency DRL; dedicated 185m unsaturated measurements for hotspot characterization



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

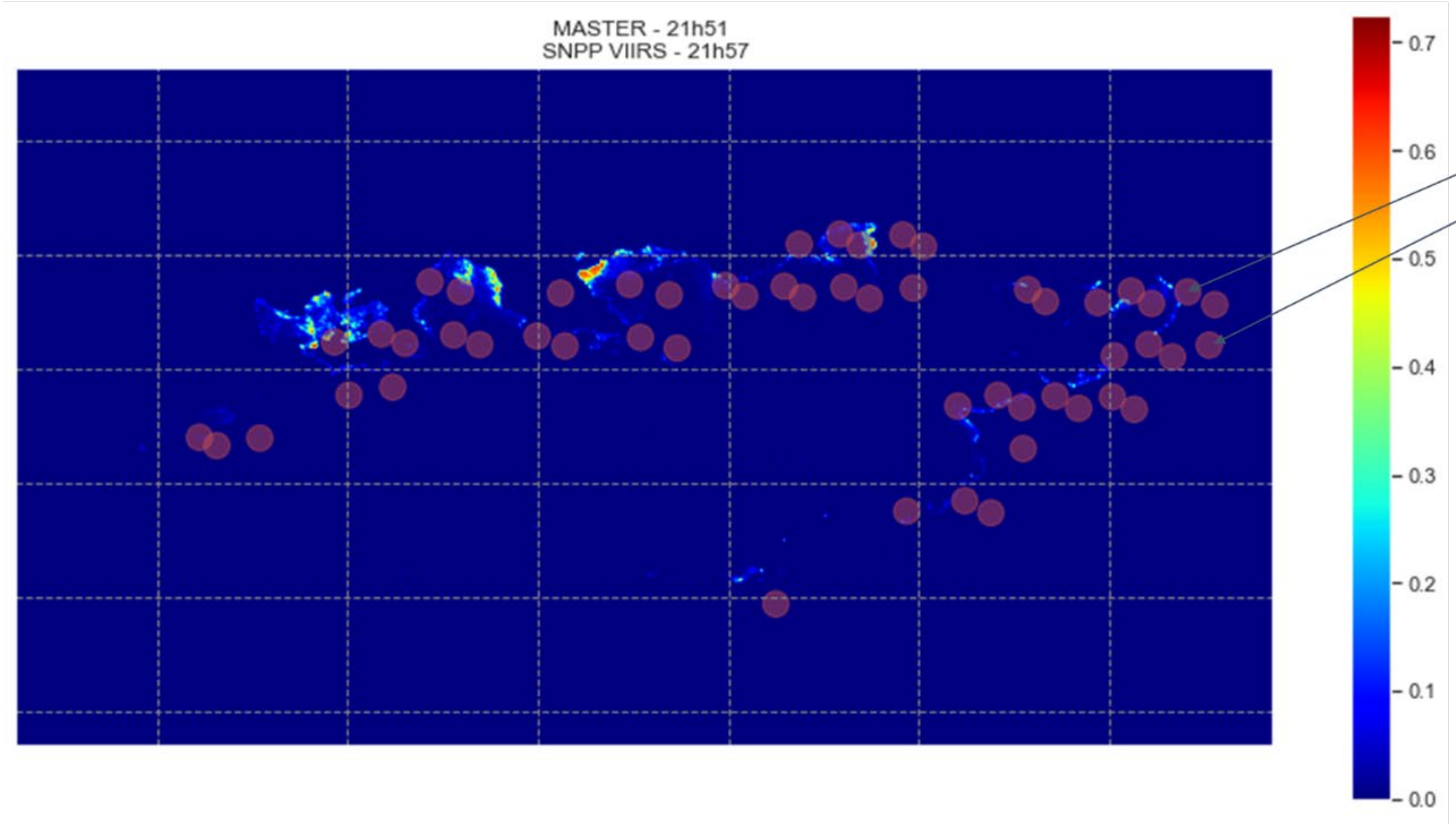


Instantaneous mapping of active fire line using near-coincident airborne and S-NPP/VIIRS data



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

MASTER vs NOAA VIIRS ACTIVE FIRE I-Band for Williams Flats Fire Case – 3 August 2019 2151 UTC

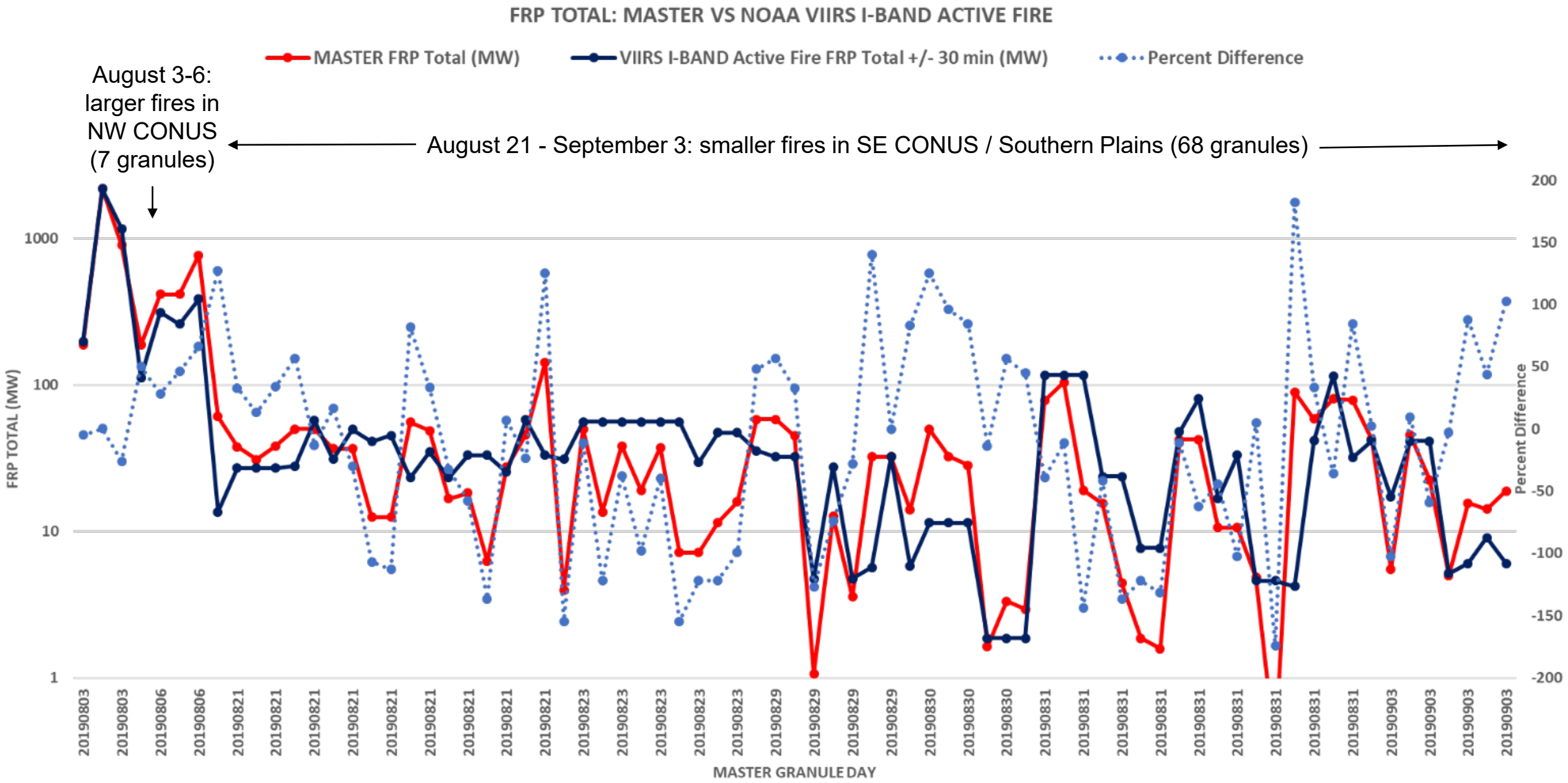


VIIRS AF Fire Pixels (Red Dots)

MASTER FRP: 2191.2 MW

VIIRS FRP: 2183.8 MW

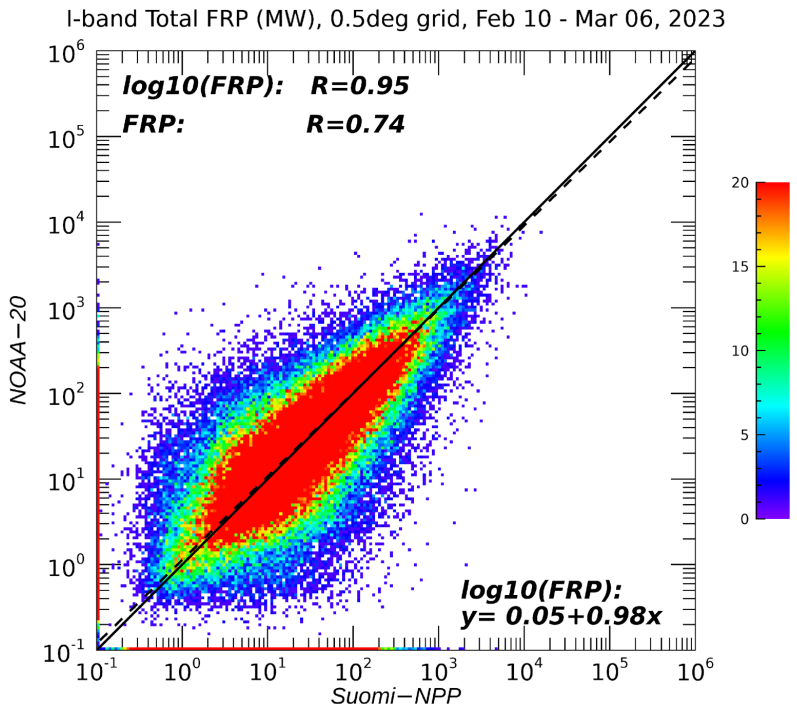
Really good agreement

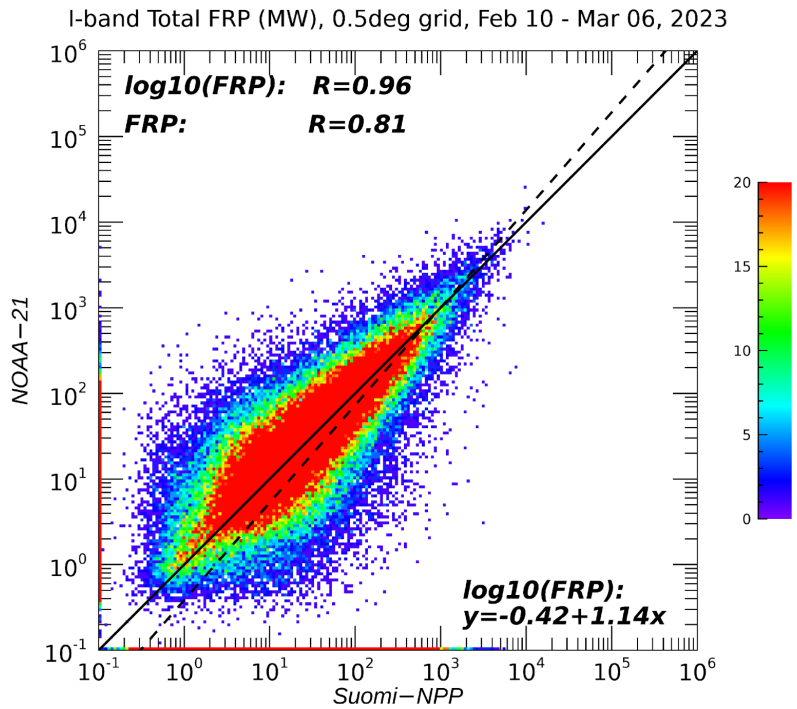


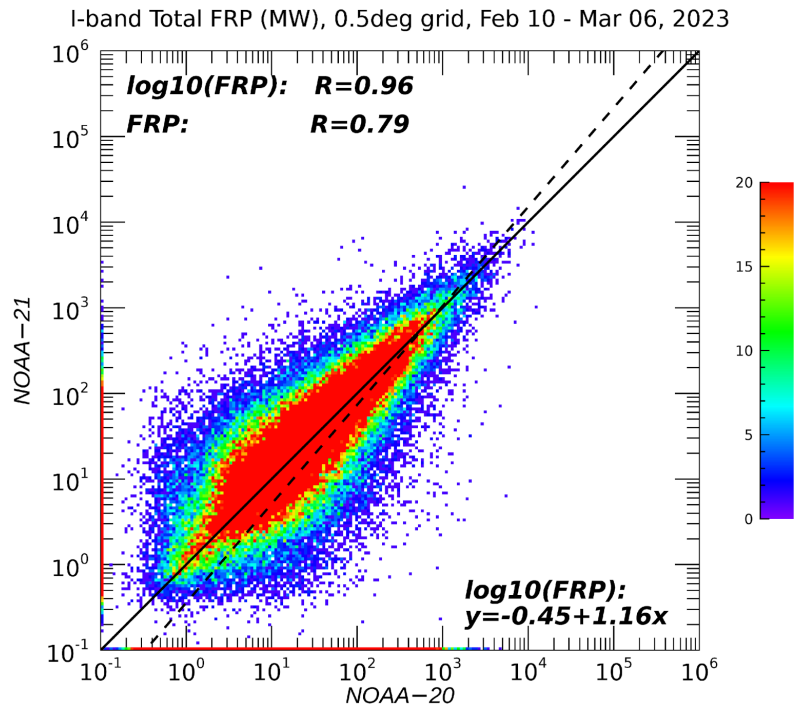
Insufficient sample for proper quantitative analysis

NOAA-21 product comparison to SNPP and NOAA-20

10 February – 06 March, 2023







Operational S-NPP, NOAA-20

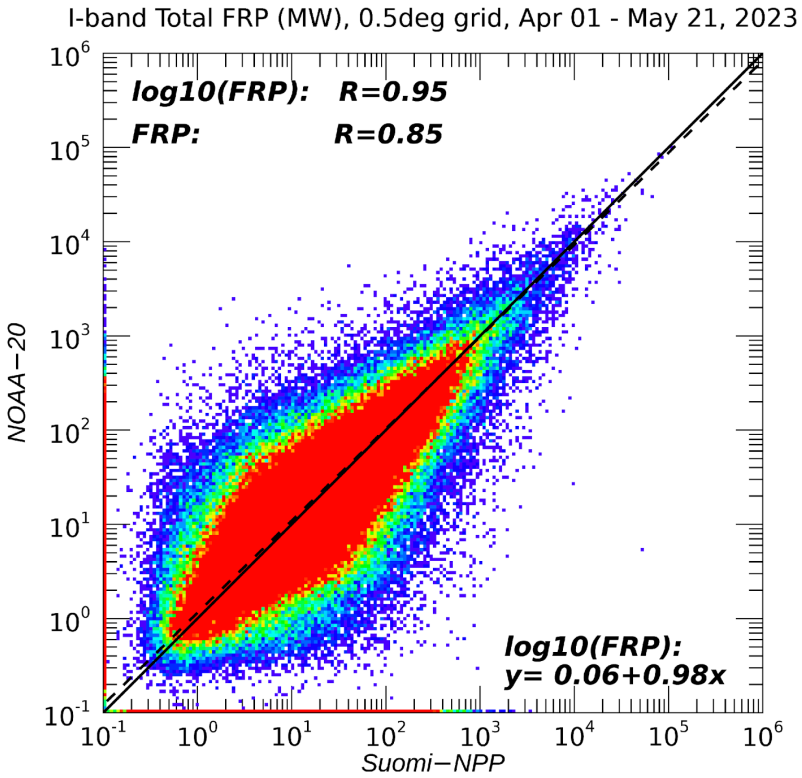
I&T NOAA-21

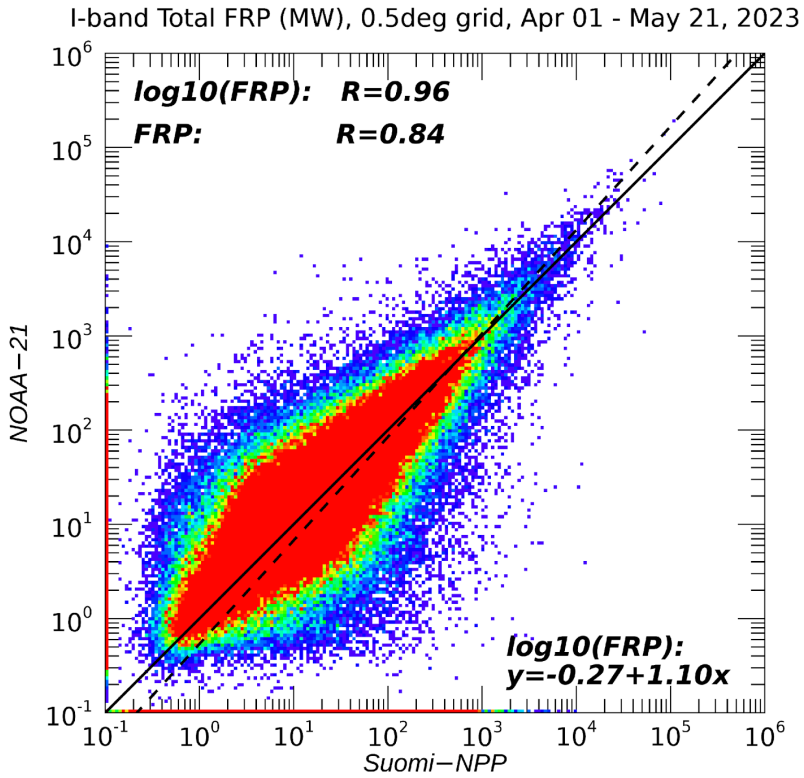
NOAA-21 PRELIMINARY, NON-OPERATIONAL DATA
NOT APPROVED FOR PUBLIC RELEASE

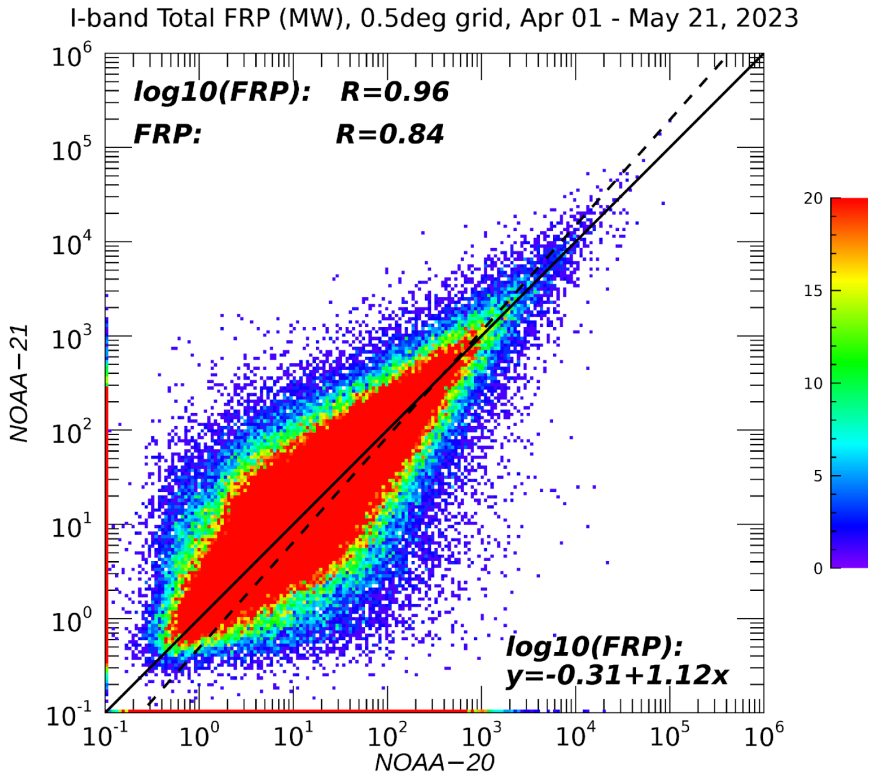
01 Apr – 21 May, 2023

Operational S-NPP, NOAA-20

NDE I&T NOAA-21







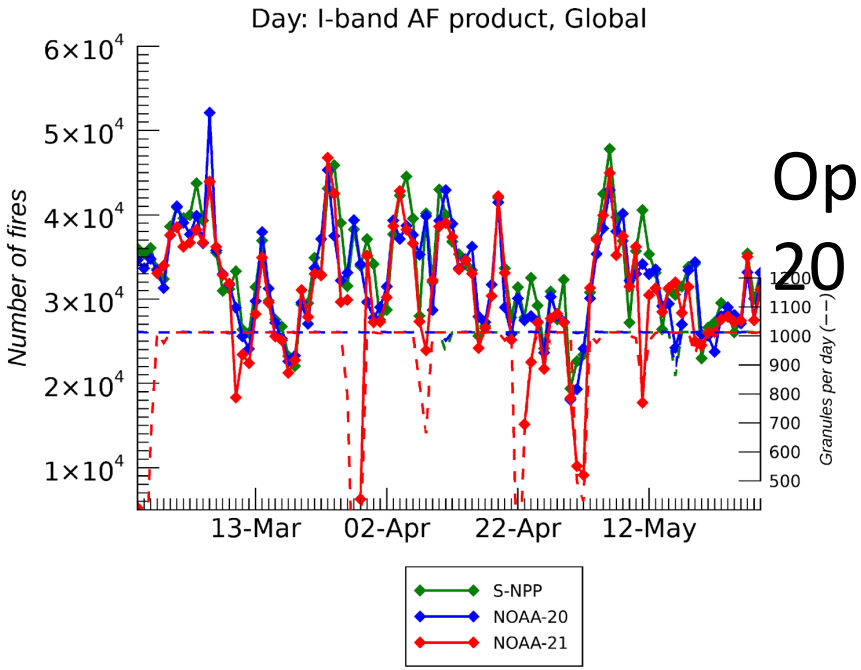
NOAA-21 PRELIMINARY, NON-OPERATIONAL DATA
NOT APPROVED FOR PUBLIC RELEASE

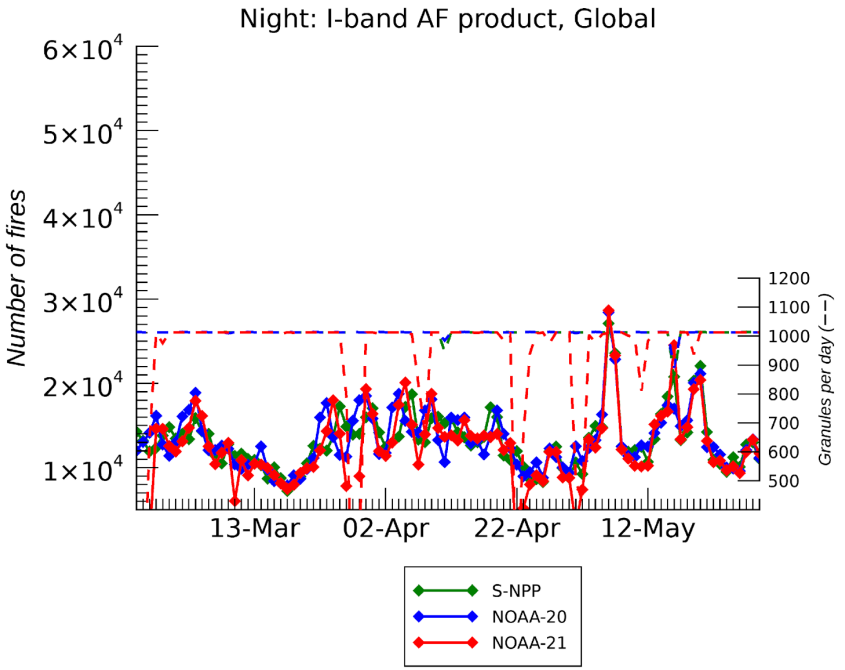
23 Feb – 29 May, 2023

Operational S-NPP, NOAA-20

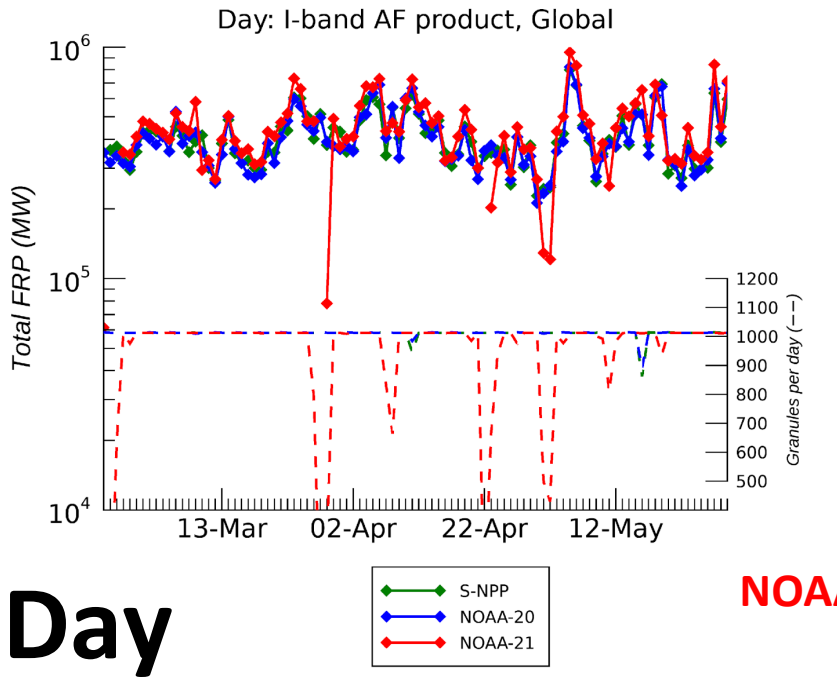
NDE I&T NOAA-21

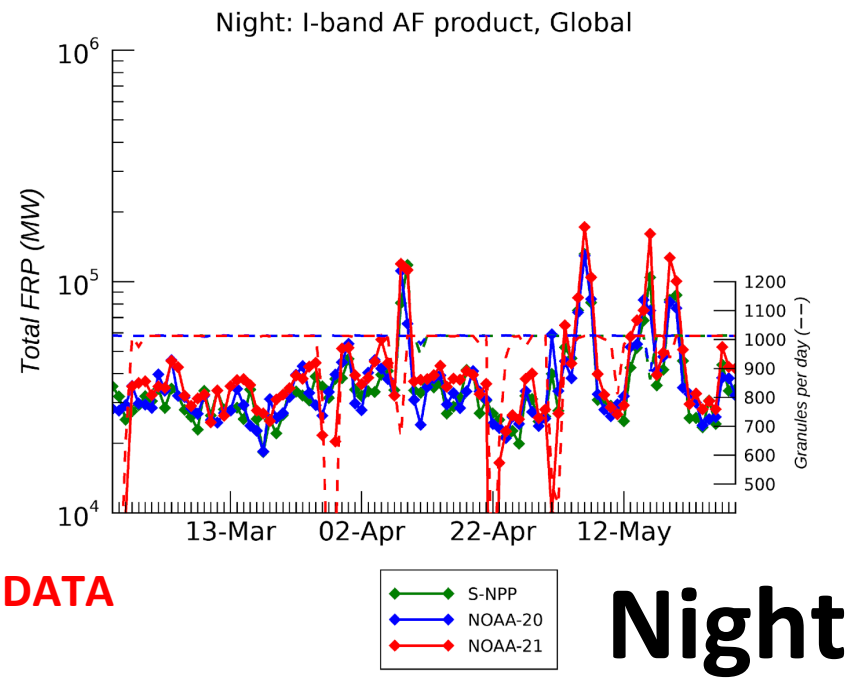
Number of fires, Global





FRP, Global





Day

NOAA-21 PRELIMINARY, NON-OPERATIONAL DATA
NOT APPROVED FOR PUBLIC RELEASE

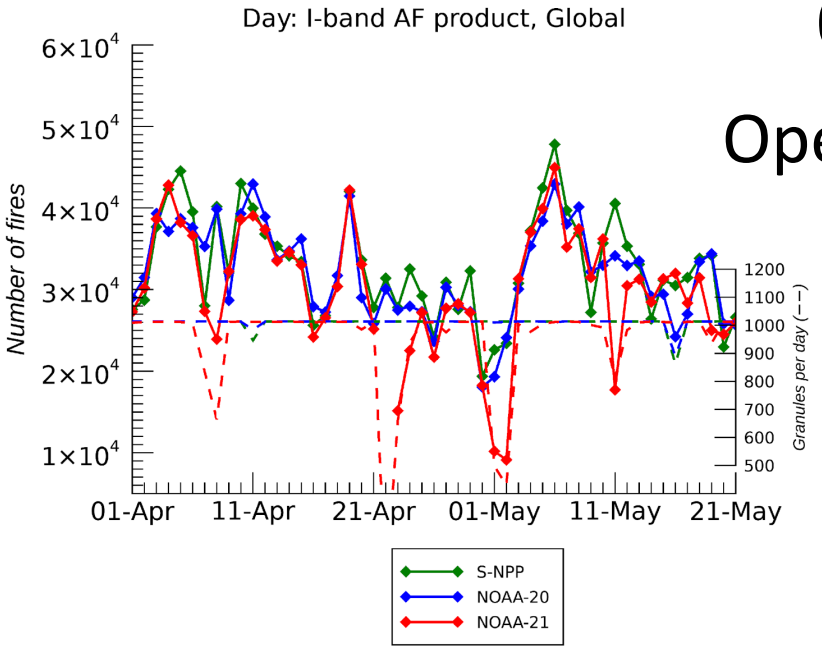
Night

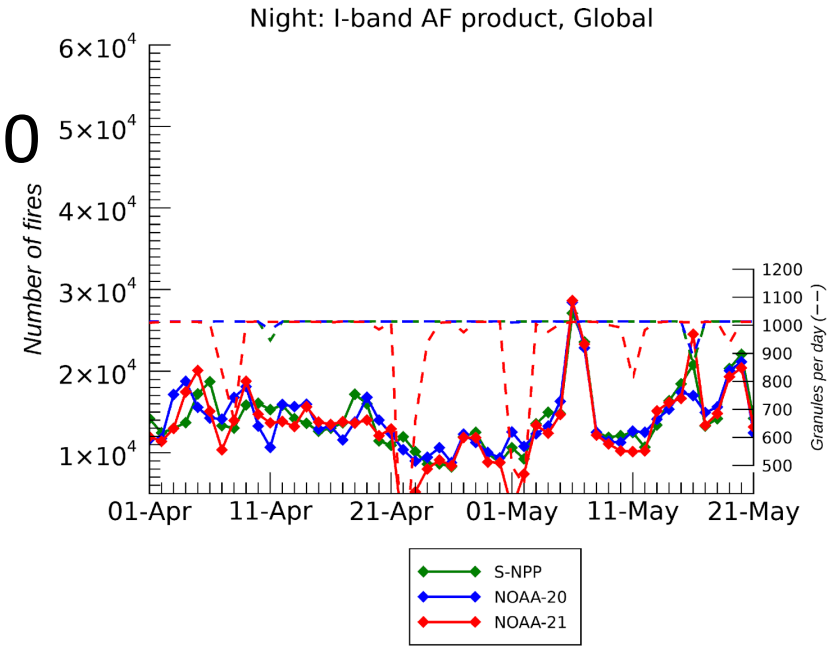
01 Apr – 21 May, 2023

Operational SNPP, NOAA-20

NDE I&T NOAA-21

Number of fires, global





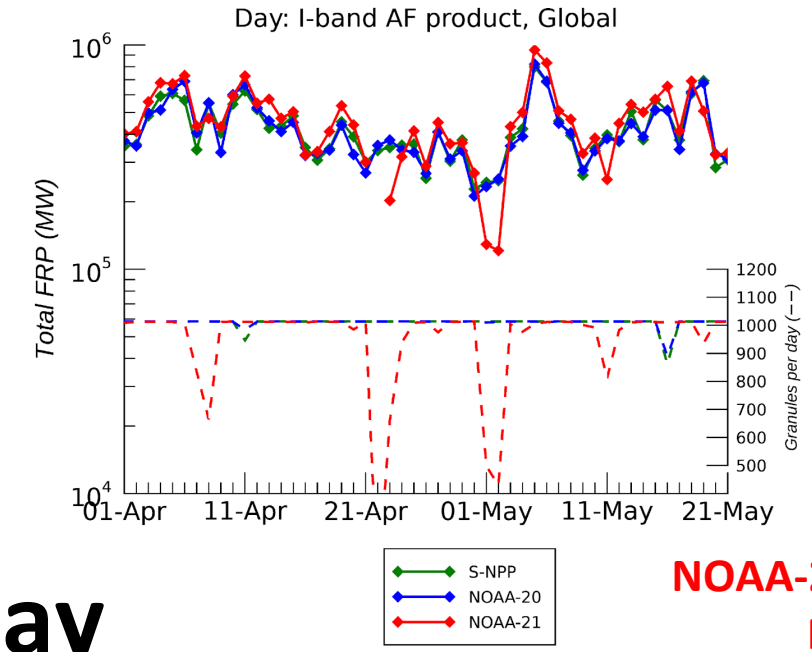
day

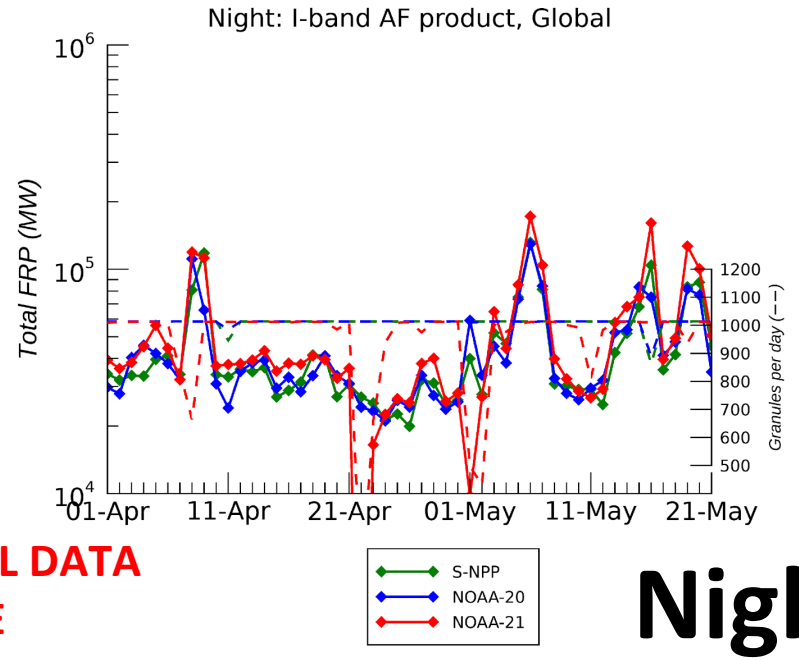
SNPP fire pixels
1674765
NOAA-20 fire pixels
1629451
NOAA-21 fire pixels
1502373

night

SNPP fire pixels
718453
NOAA-20 fire pixels
720049
NOAA-21 fire pixels
670173

FRP, global





Day

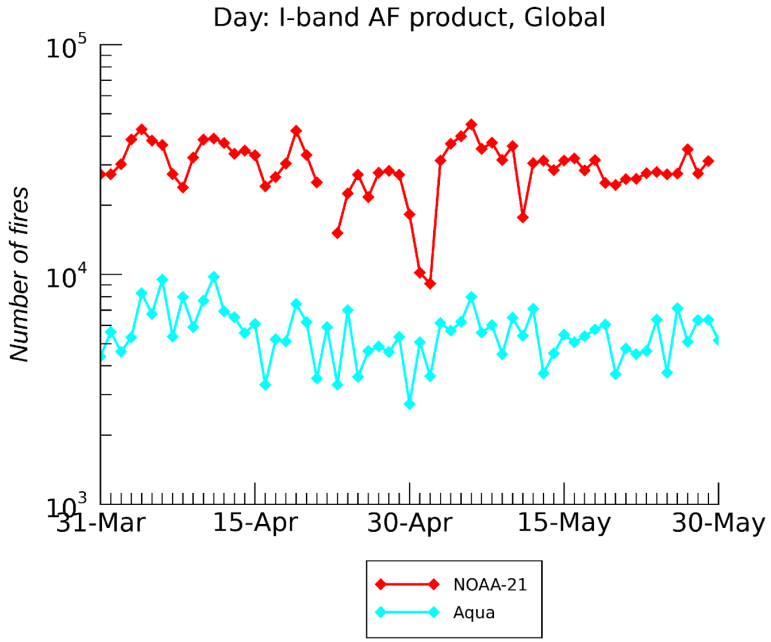
Night

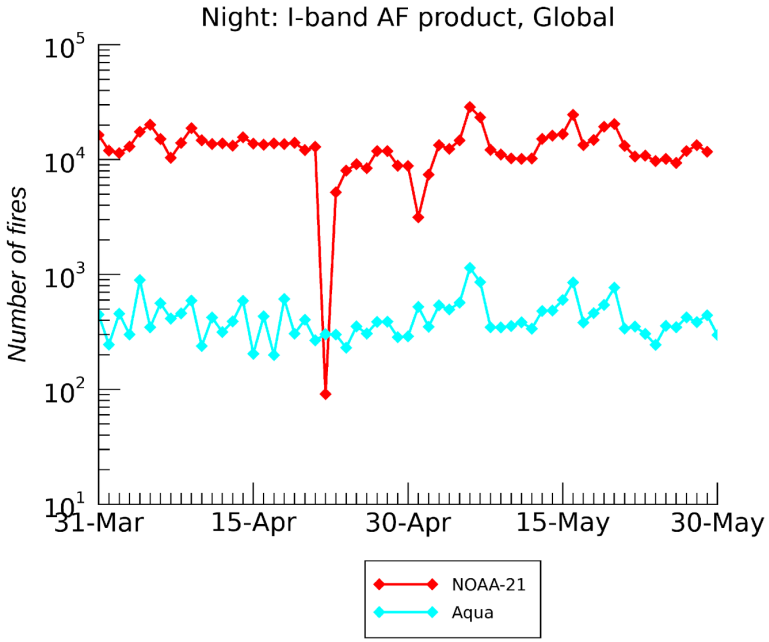
NOAA-21 PRELIMINARY, NON-OPERATIONAL DATA
NOT APPROVED FOR PUBLIC RELEASE

Apr – 29 May, 2023

Aqua/MODIS
NOAA-21/VIIRS

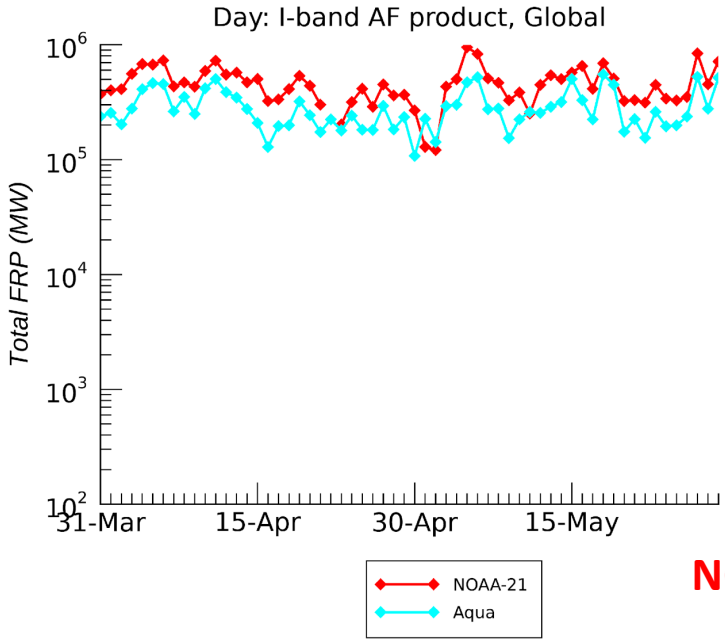
Number of fires, Global

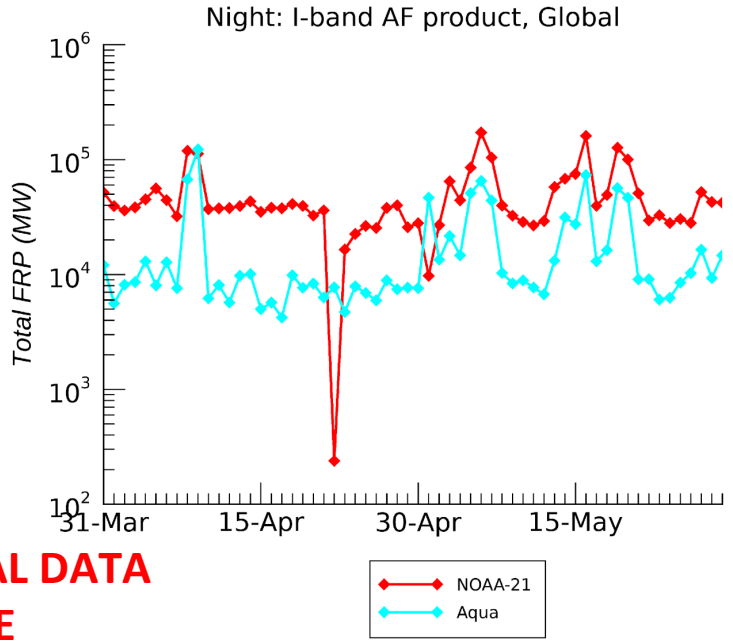




NOAA-21 data outages on 3/28, 4/12, 5/1 and 5/11.

FRP, Global





Note: The nighttime MODIS (and VIIRS M-band) algorithms are known to be relatively mode conservative than VIIRS I-band.

NOAA-21 PRELIMINARY, NON-OPERATIONAL DATA
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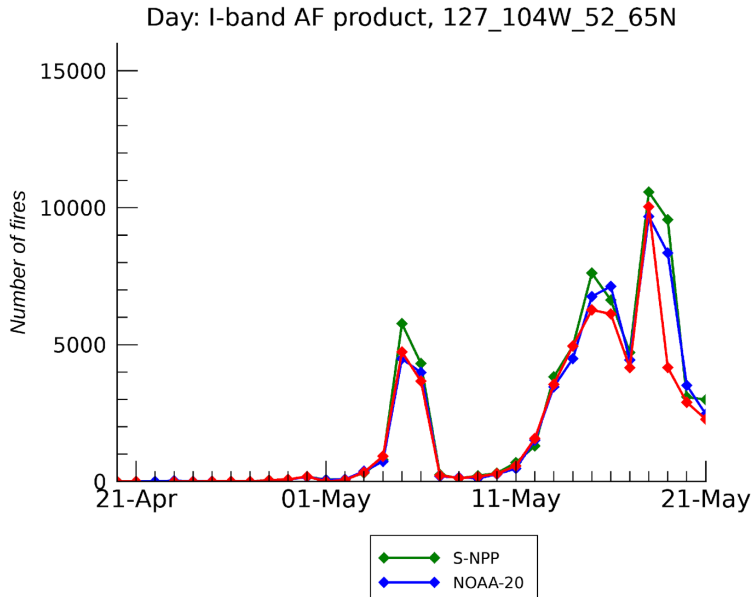
20 Apr – 21 May, 2023

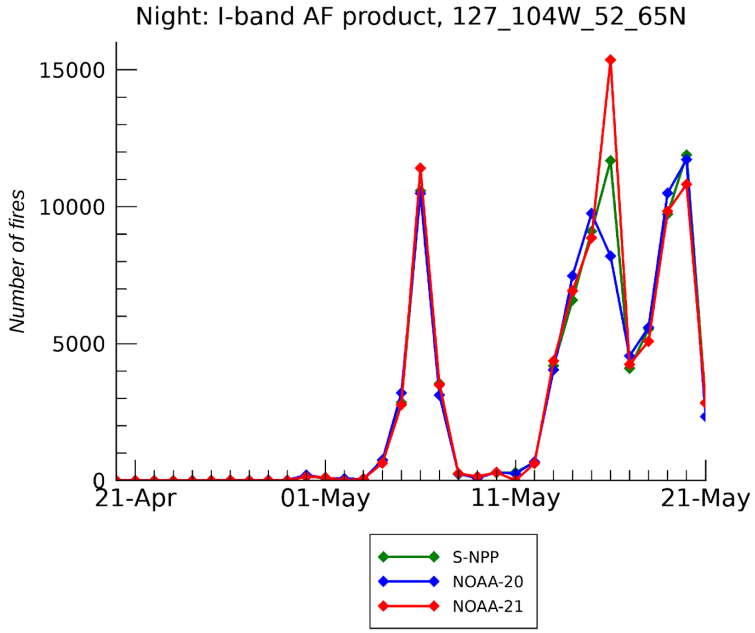
erational S-NPP, NOAA-

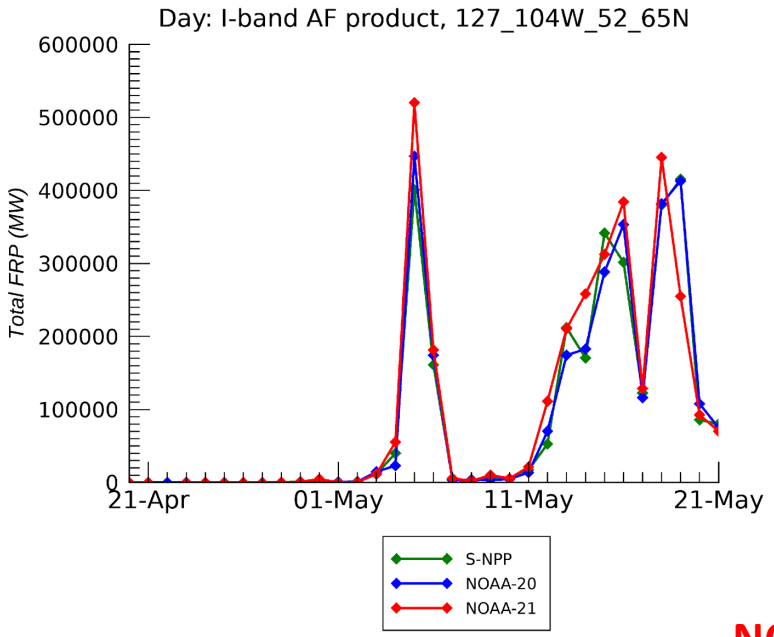
NDE I&T NOAA-21

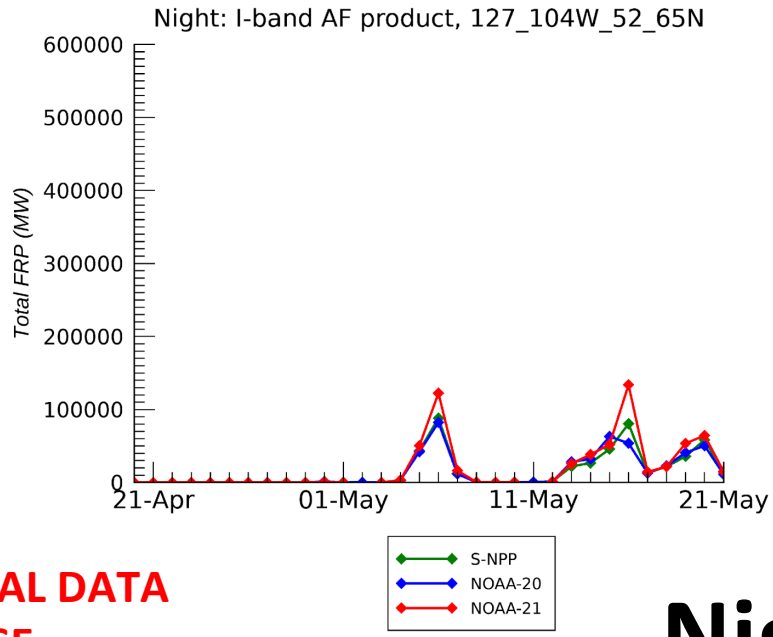
Number of fires, Canada 127-104W, 52-65N

FRP, Canada 127-104W, 52-65N









Day

NOAA-21 PRELIMINARY, NON-OPERATIONAL DATA
NOT APPROVED FOR PUBLIC RELEASE

Night

Quality flag analysis/validation

- Defined Quality Flags
  - Variable
  - Description
  - Value
- Quality flag analysis/validation
  - Test / example / ground truth data sets
  - Analysis / validation results
  - Analysis / validation plan

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 (M-band) 6400 x 1536 (I-band)	unitless	**0 - 9**
algorithm QA	32 bit Integer	Fire algorithm QA mask	3200 x 768 (M-band) 6400 x 1536 (I-band)	unitless	**0 - 31**
FP_line	16 bit Integer	Fire pixel line	Sparse data array 1 – N	unitless	**0 – 767 / 0-1535**
FP_sample	16 bit Integer	Fire pixel sample	Sparse data array 1 – N	unitless	**0 – 3199 / 0-6399**
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	8 bit Integer	Fire detection confidence	Sparse data array 1 – N	%	**0 – 100 / 7-9**
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: Fire Mask

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 (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 low confidence
		Fire Medium – 8	Fire pixel with medium confidence
		Fire High – 9	Fire pixel with high confidence
Fire Algorithm QA Mask	32-bit unsigned integer	See next slide for details	

M-band and I-band Active Fire Product content: QA Mask

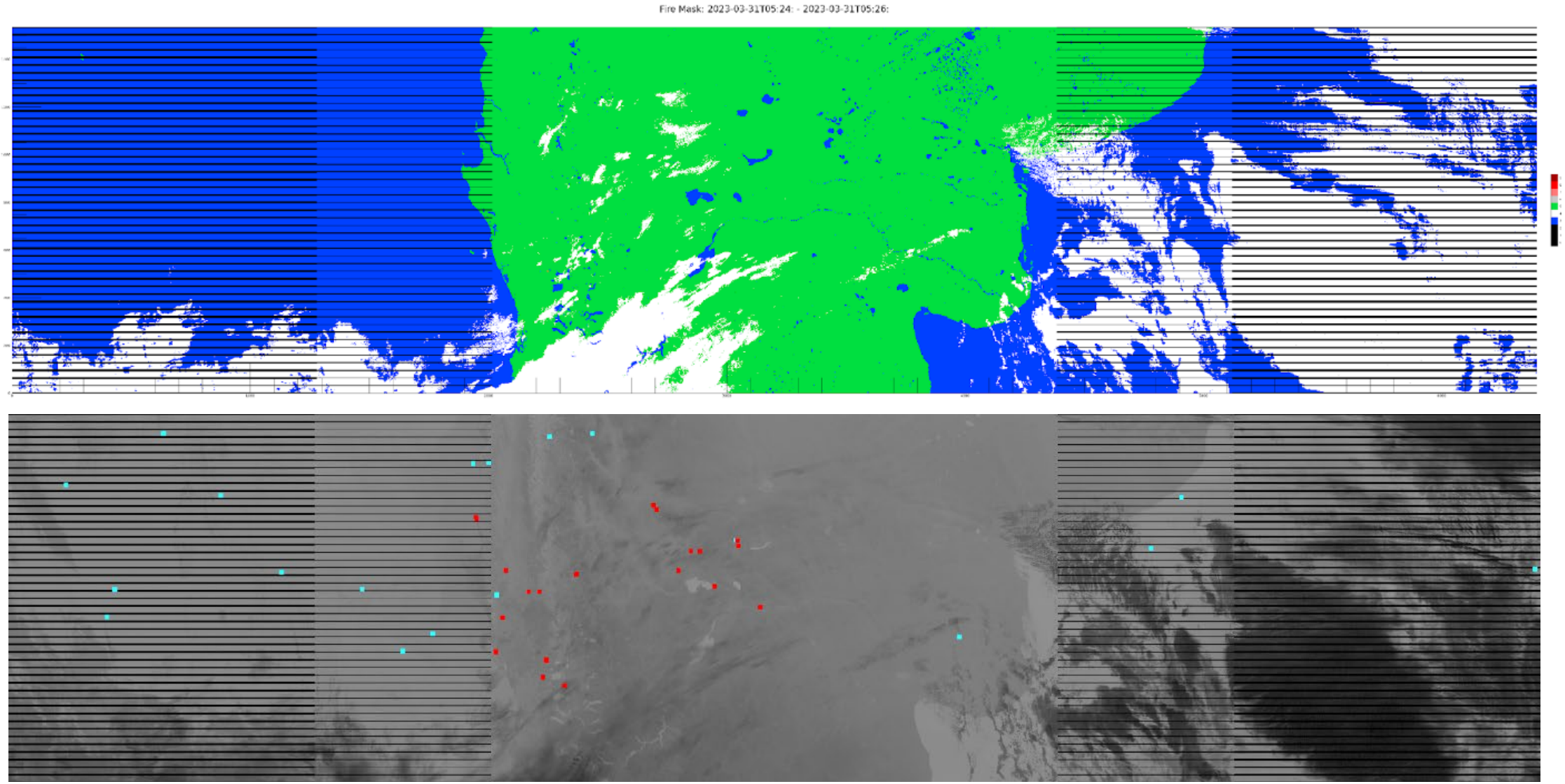
Bits	Description
0-1	Surface Type (water=0, coastal=1, land=2)
2	EDR ground bowtie deletion zone (0=false, 1=true)
3	Atmospheric correction performed (0=false, 1=true)
4	Day/Night (daytime = 1, nighttime = 0)
5	Potential fire (0=false, 1=true)
6	spare
7-10	Background window size parameter
11	Fire Test 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

Giglio, L., Schroeder, W., Csiszar, I., Tsidulko, M., Algorithm Theoretical Basis Document For NOAA NDE VIIRS Active Fire Version 2.6 June, 2016

Schroeder, W., Giglio, L., Csiszar, I., Tsidulko, M., Algorithm Theoretical Basis Document For NOAA NDE VIIRS I-band (375m) Active Fire Version 1.0 June, 2020

SAA: NOAA-21, 2023-03-31 05:24 UTC



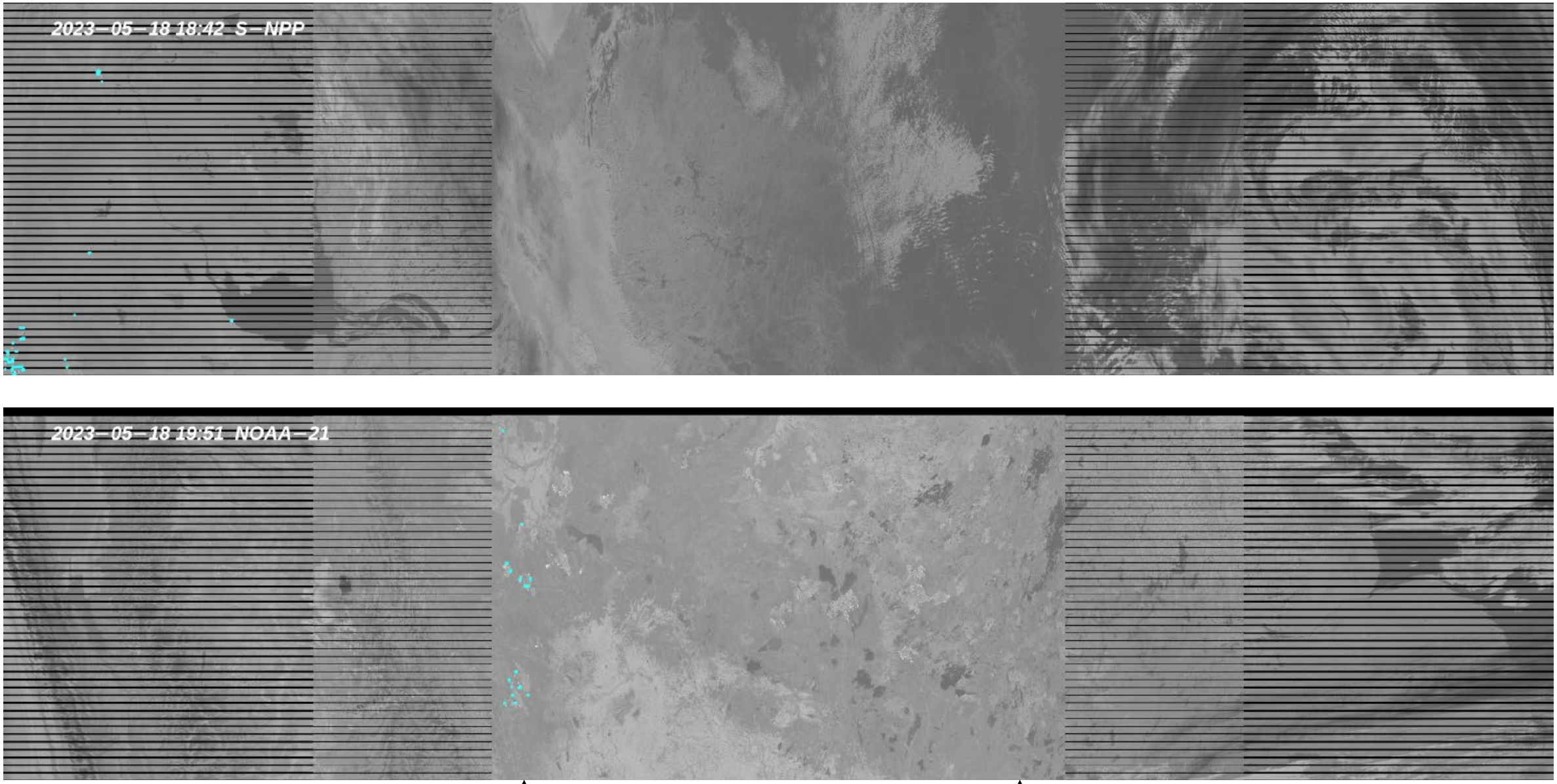
Blue: candidate fire pixels degraded by SAA filter; QA bit 18 = 1

Red: detected fire pixels

Canadian Fires

QA bit 22: on-ground bowtie deletion zone

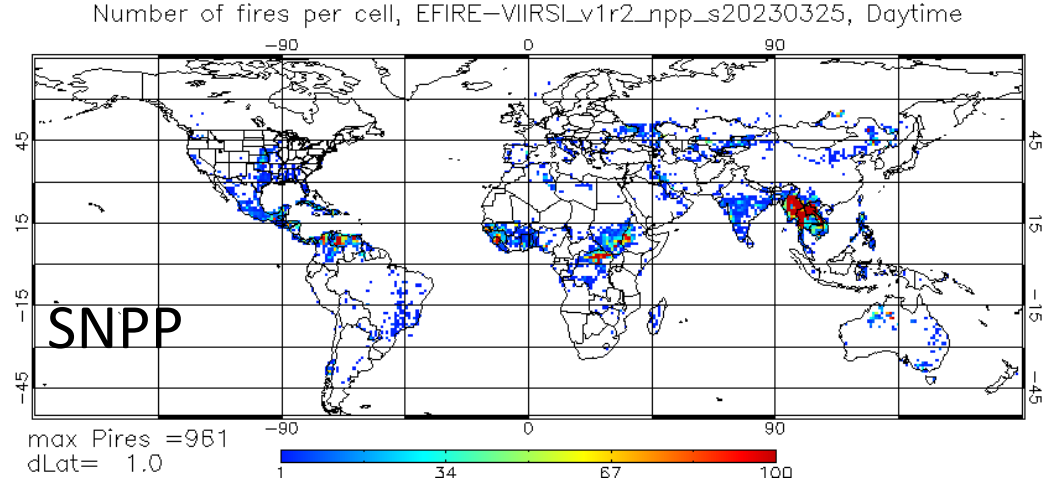
On-ground deletion zones are wider than on-board deletion zones (visible on the pictures) and start closer to the center of the granule

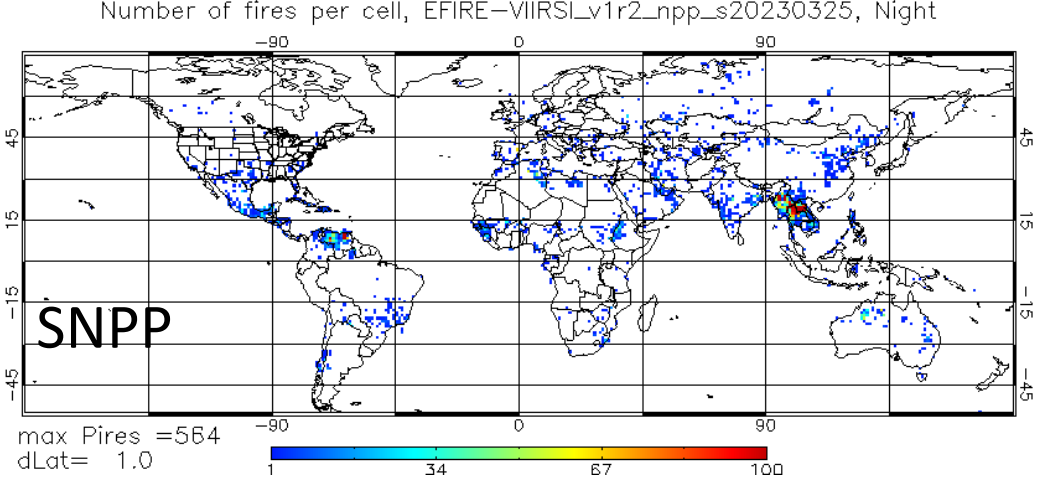


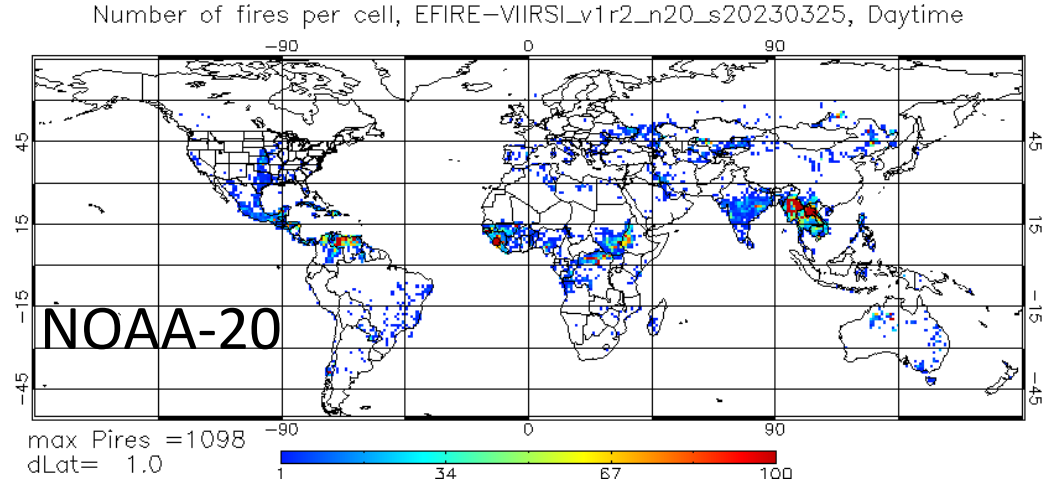
eFire for VIIRS I-band preliminary assessment

VIIRS I-band Active Fires from eFire

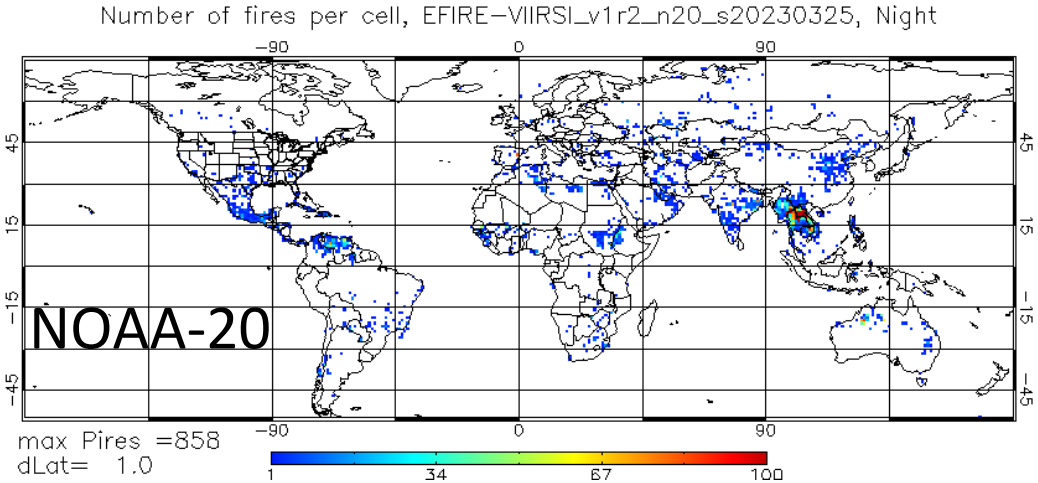
March 25, 2023



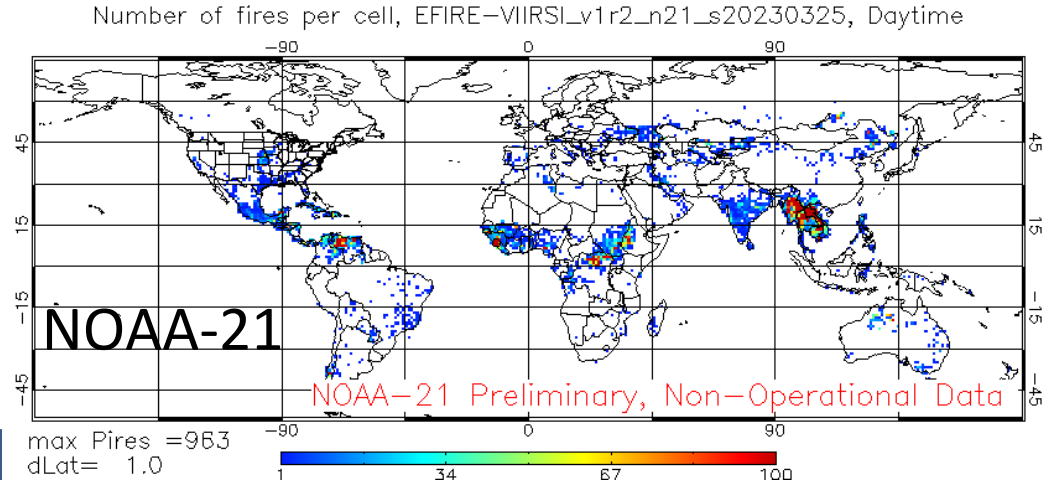




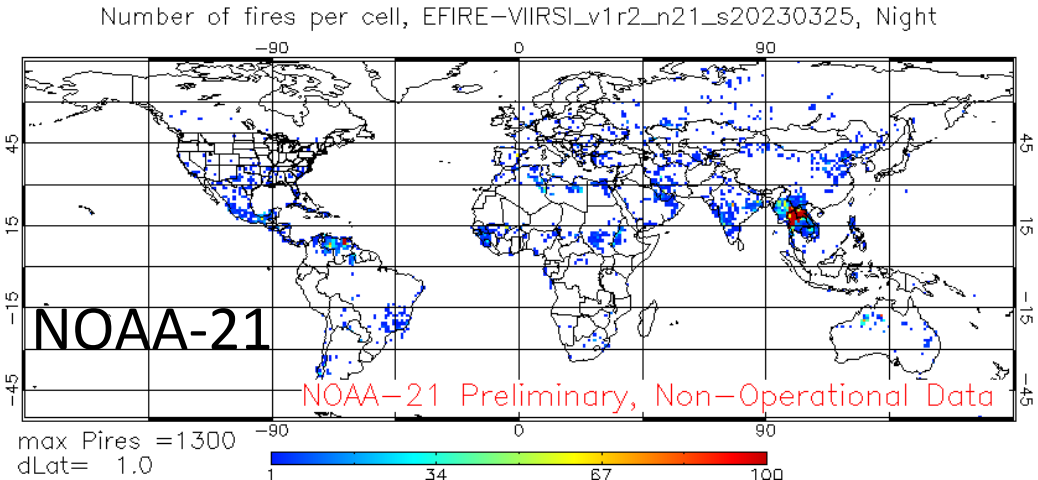
daytime



nighttime

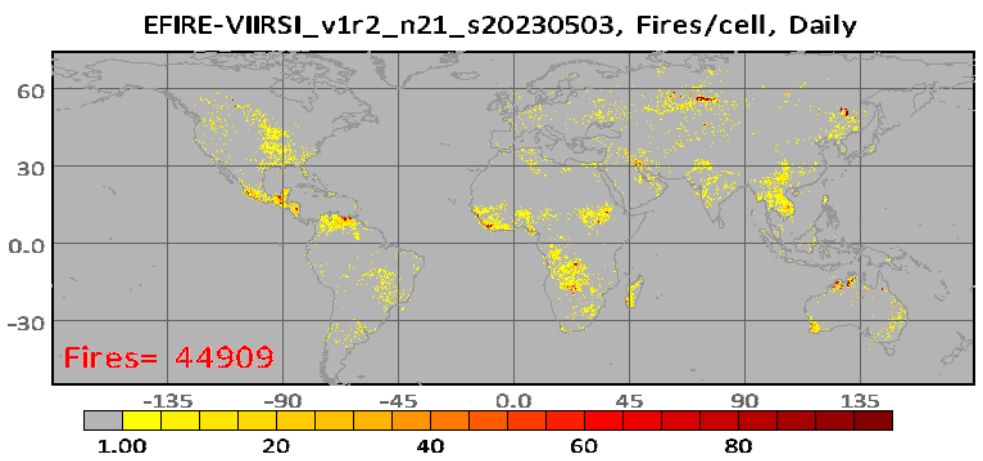


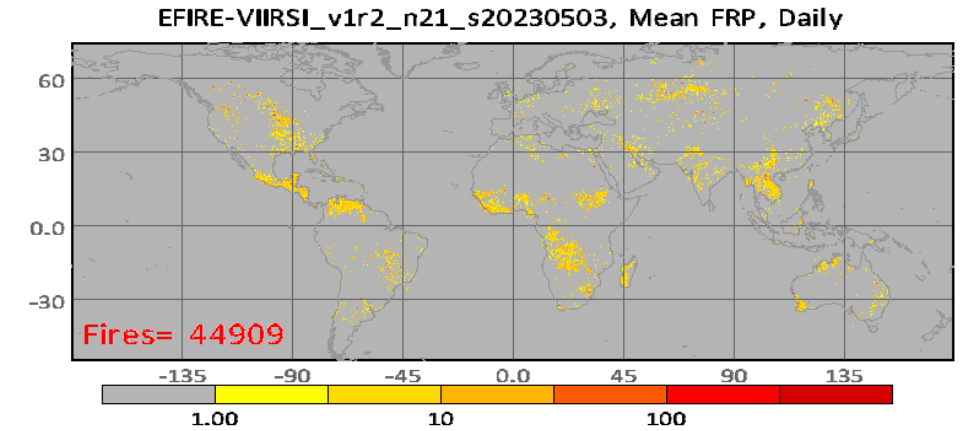
Number of fire pixels within 1x1 degree gridcells

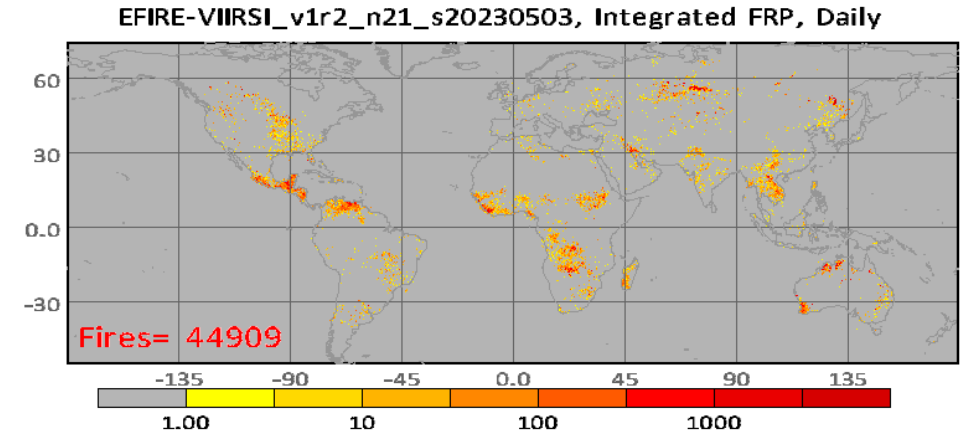


eFire vs. NDE VIIRS I-band Active Fires

May 5, 2023







eFire

NDE

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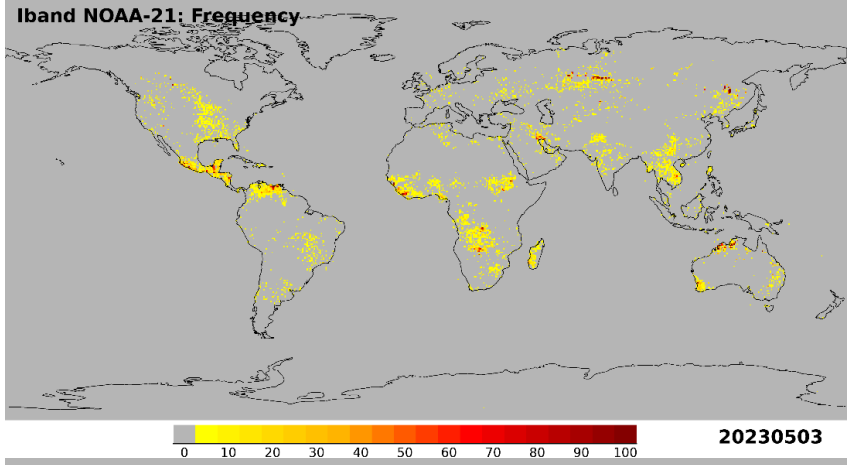
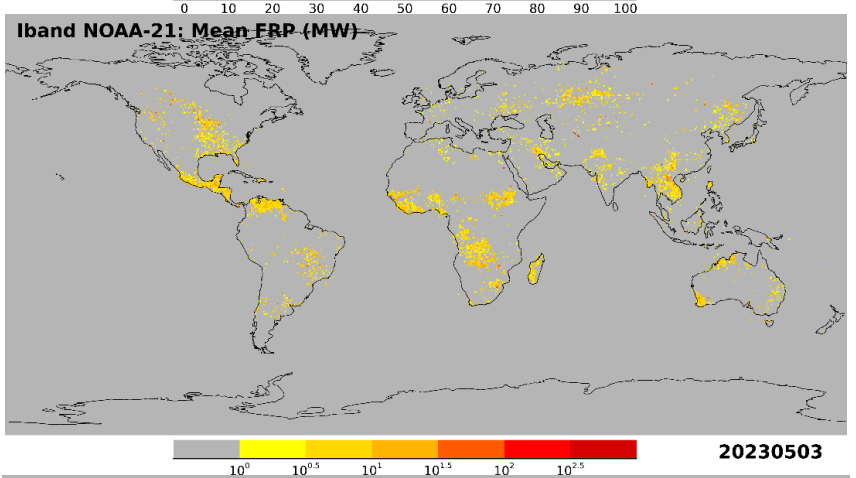
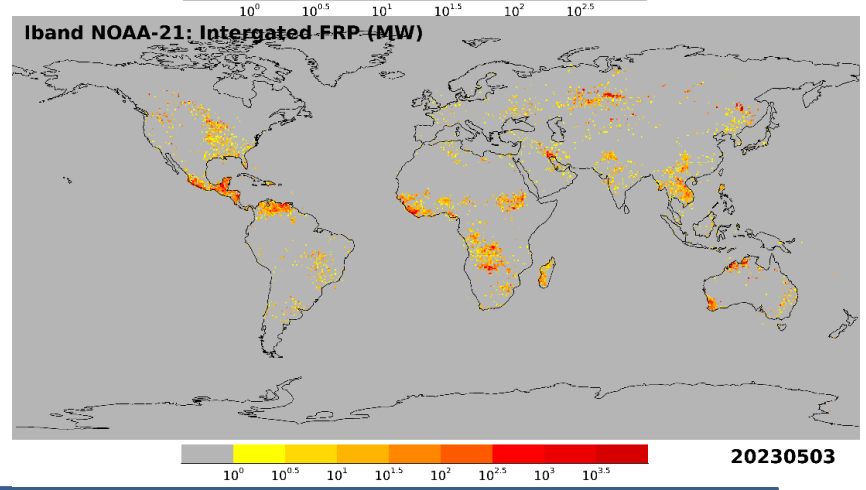
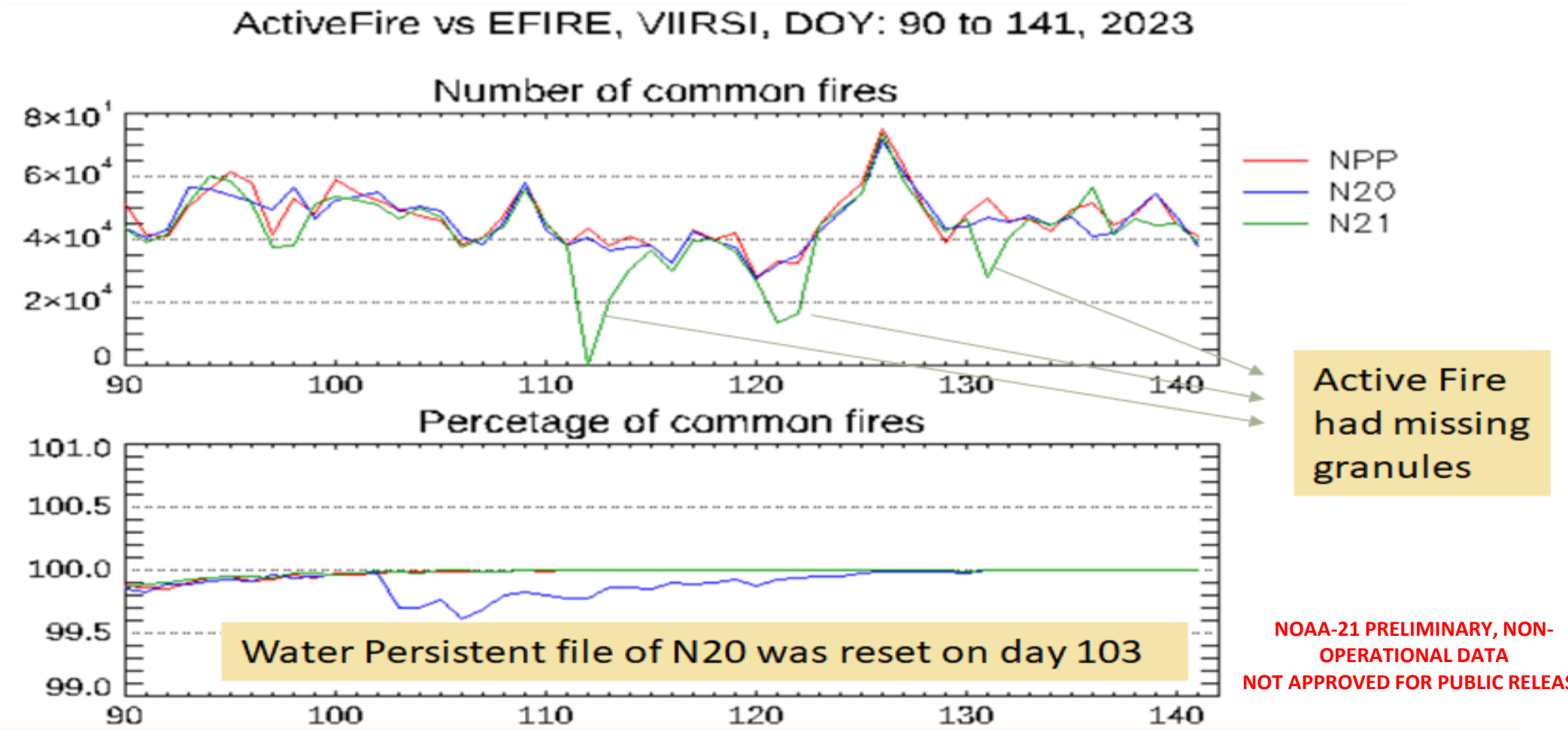






Summary on Comparison between Active Fire and EFIRE DOY 90 to 141, 2023



Daily Active Fire and EFIRE were compared for paired granules. The result are consistent (99.6% or more are common fire pixels.

Summary on Comparison between Active Fire and EFIRE

Active Fire of NOAA21 with Missing granules on day 102, 121 and 131

NOAA-21 PRELIMINARY, NON-OPERATIONAL DATA
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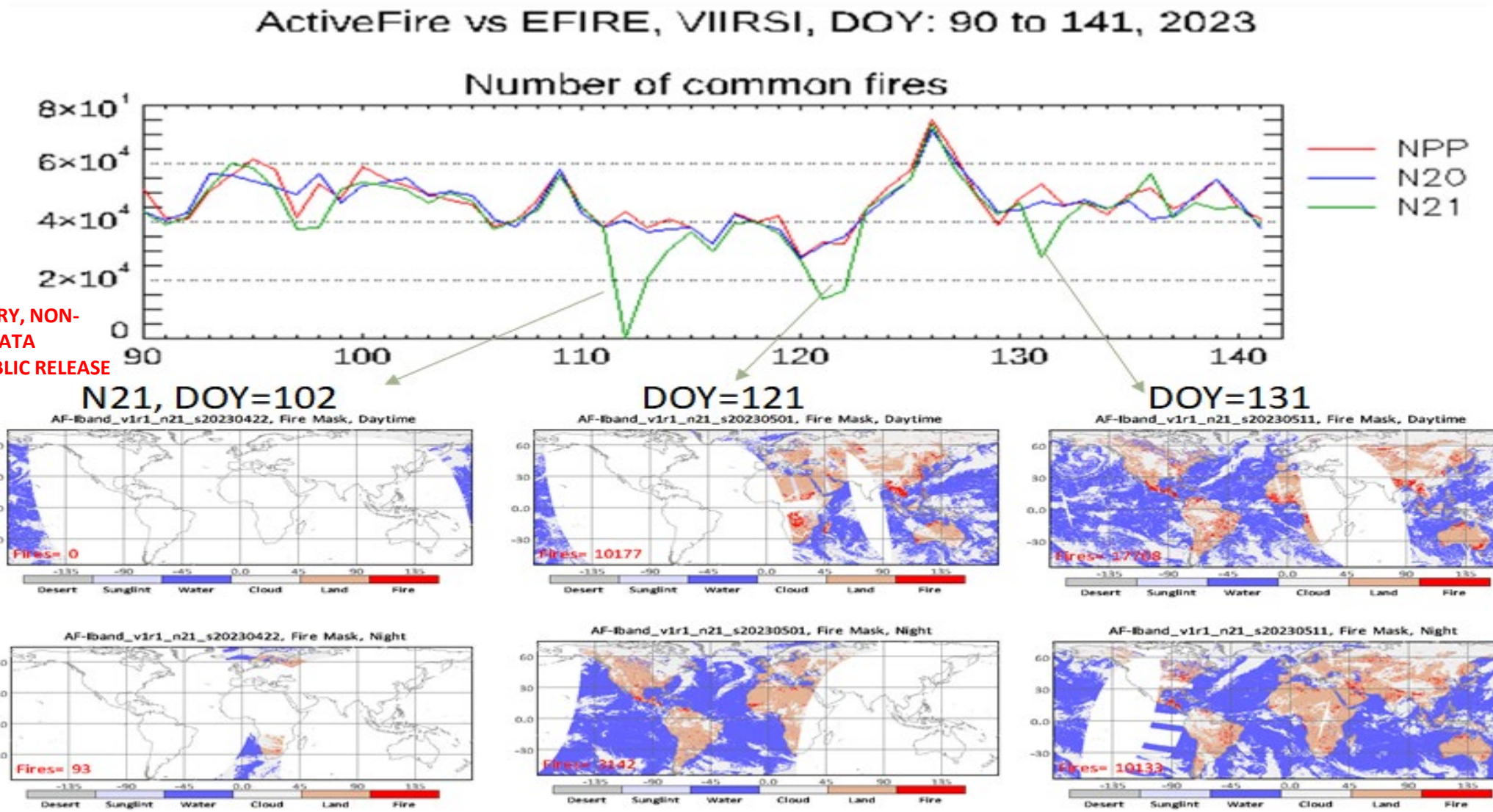


eFire vs. NCCF verification results

- eFIRE VIIRS-I products generated by STAR and NCCF were compared:
  - For the time period: day 66 to 81, 2023
  - For 3 satellites: SNPP, NOAA-20 and NOAA-21

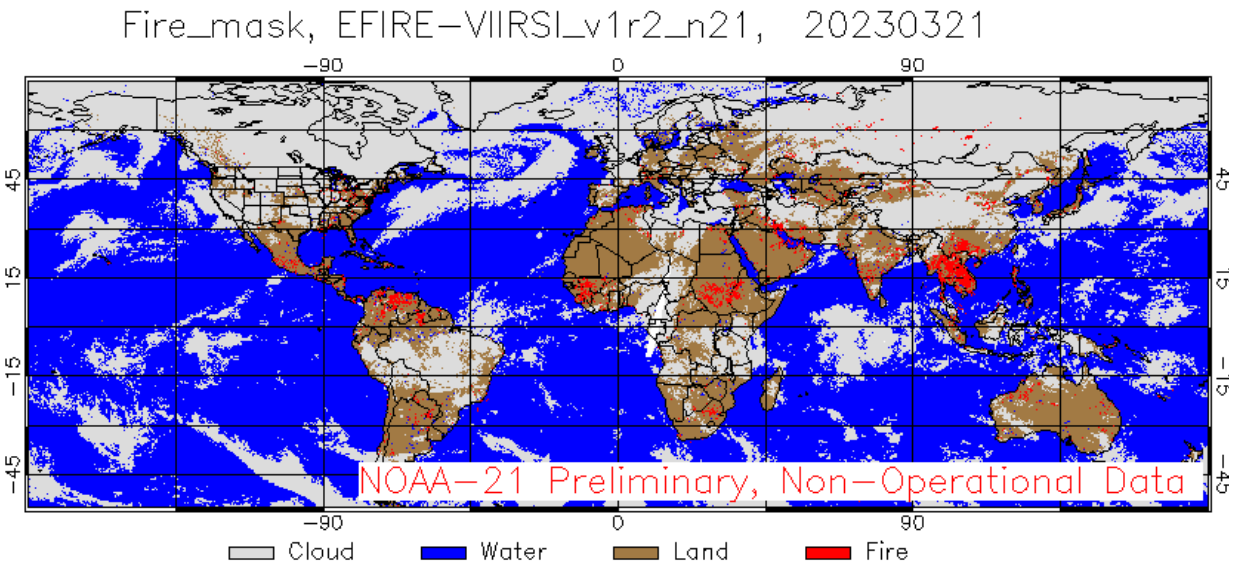
- Comparison plots include:
  - Daily fire mask image
  - Distribution map
  - FRP scatter plot for common points

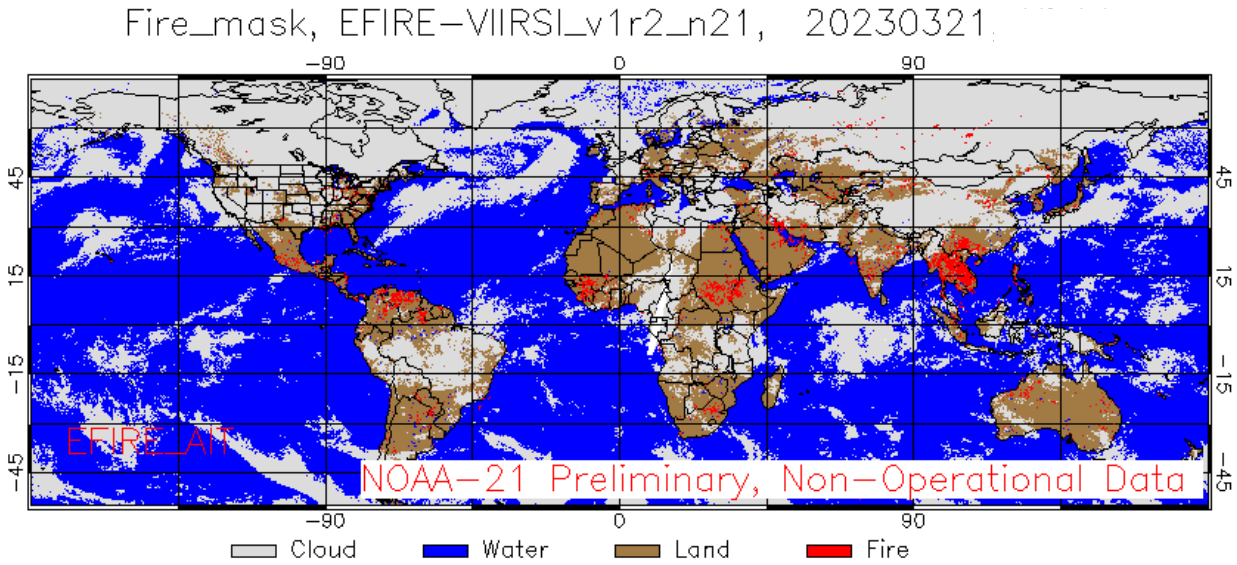
- Only NOAA-21 results are shown here

- Analysis for formal eFire maturity review will be performed using NCCF test output

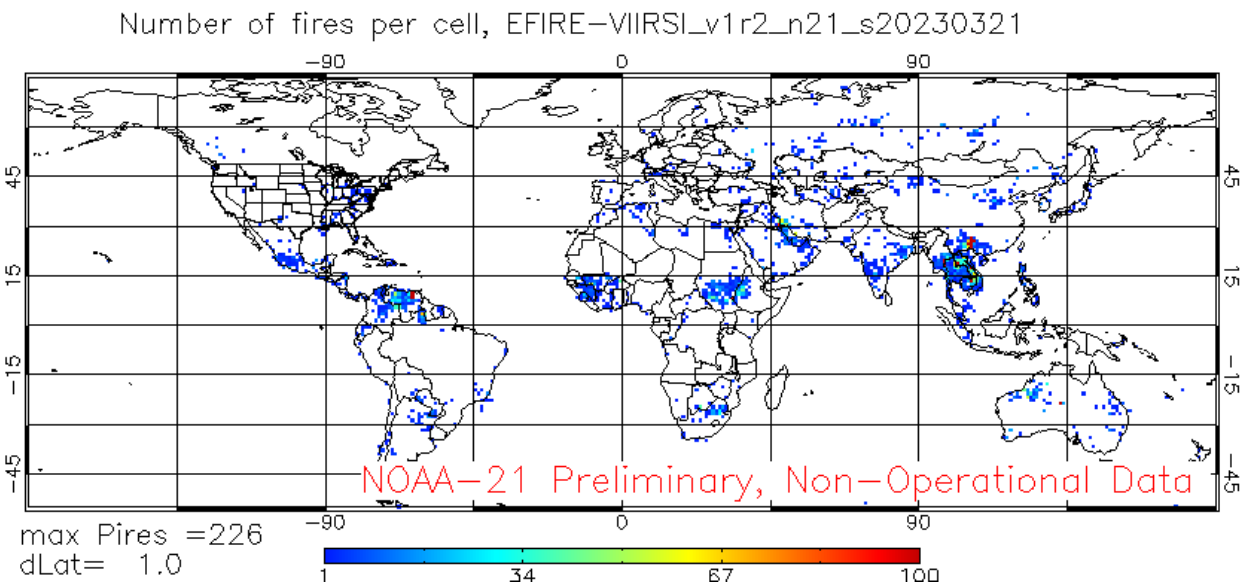
Fire Mask, N21,20230321

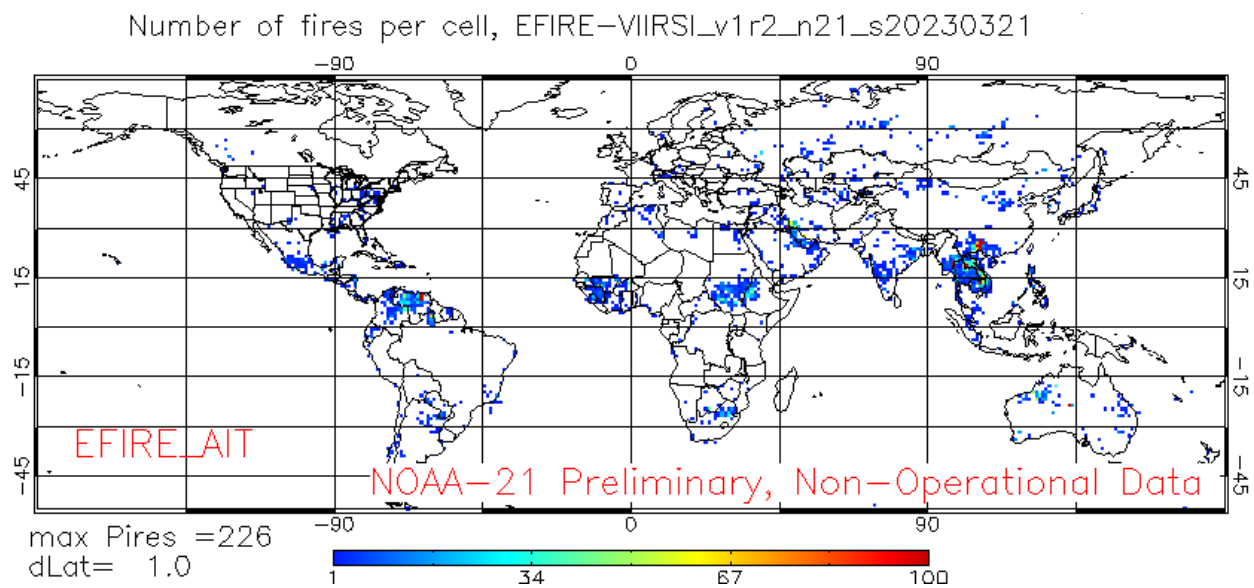
Daytime





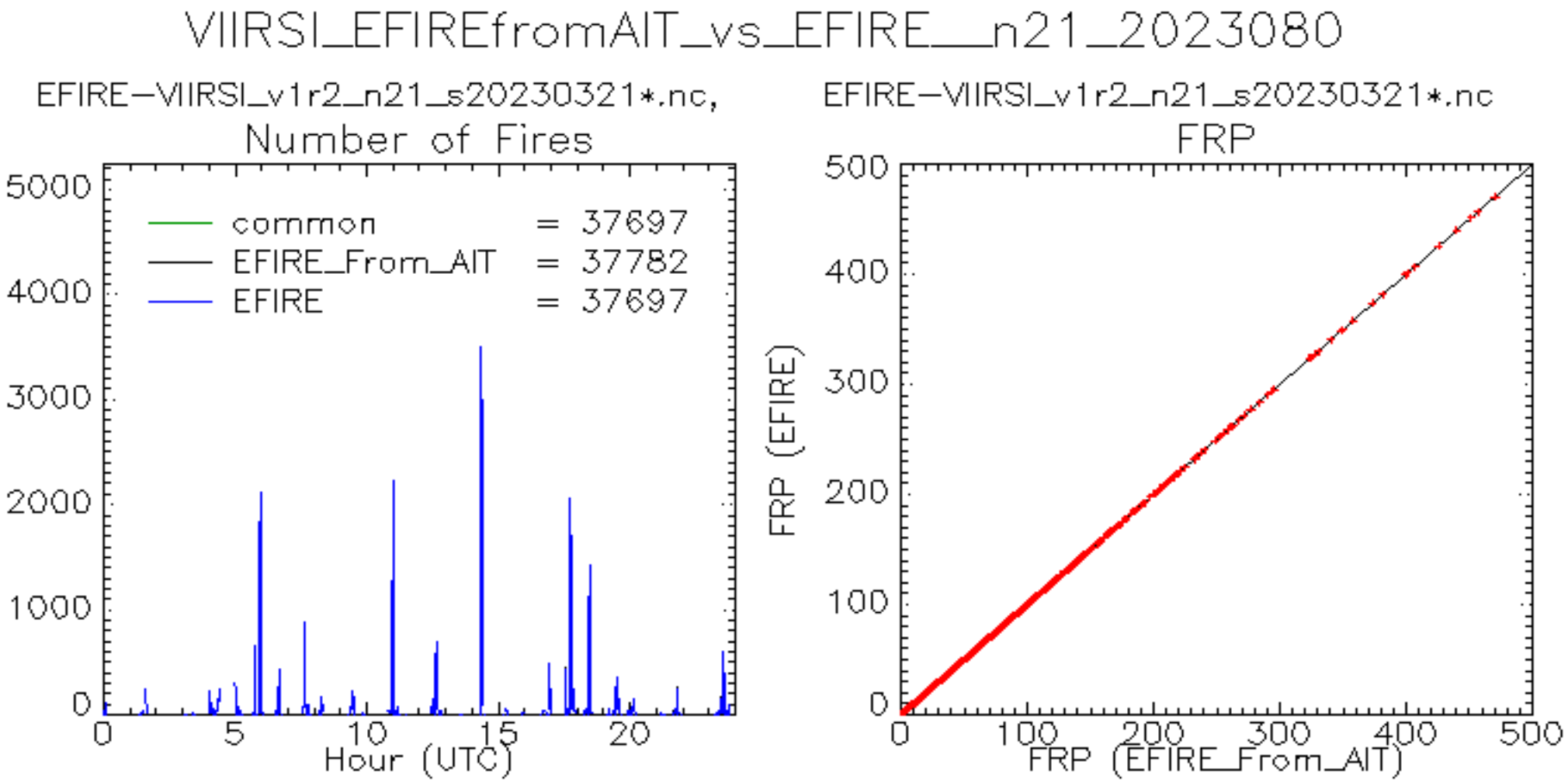
Nighttime





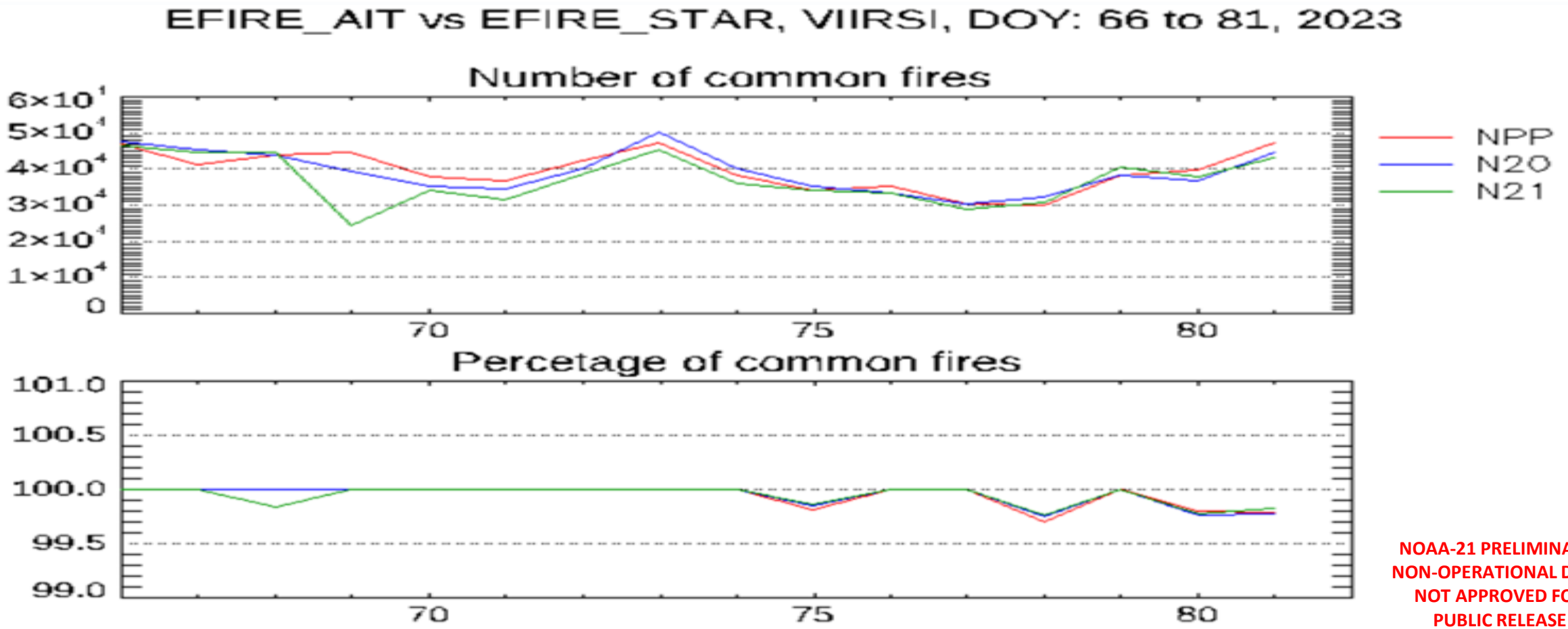
Top: eFIRE From STAR; Bottom: eFIRE from NCCF (or AIT)

eFire vs. NCCF verification results



99.9% fires are in common; For the common pixels, FRP are consistent.

eFire vs. NCCF verification results
Time series from March 7 to 23, 2023



NOAA-21 PRELIMINARY, NON-OPERATIONAL DATA NOT APPROVED FOR PUBLIC RELEASE

NCCF Integration team provided EFIRE data March 7 ~ 23, 2023. They were compared with EFIRE generated by STAR science team. It shows about 99.7% fires or more are common for each day.

Error Budget

Compare analysis/validation results against requirements, present as a table. Error budget limitations should be explained. Describe prospects for overcoming error budget limitations with future improvements of the algorithm, test data, and error analysis methodology.

Attribute Analyzed	DPS	Requirement/ Threshold	Pre-Launch Performance	On-orbit Performance			Meet Requirement?	Additional Comments
				NOAA-21	NOAA-20	S-NPP		
FRP Uncertainty	DPS-32	50%	<50% (est.)	<50% (est.)	<50% (est.)	<50% (est.)	Yes (est.)	Traced back to SNPP and NOAA-20
Detection and coverage	DPS-33	per-pixel fire mask and fire radiative power, globally day and night, under clear sky conditions between clouds, at the refresh rates of the instrument	confirmed	confirmed	confirmed	confirmed	Yes	

User Feedback

Name	Organization	Application	User Feedback - User readiness dates for ingest of data and bringing data to operations
Ravan Ahmadov	CERES@ERSL	HRRR-smoke; RAP-smoke	No format change in output text files. Working on smooth transition to operational NOAA-21 from eFire. Product performance is expected to be compatible to SNPP and NOAA-20.
Carl Dierking	GINA	Alaska Fire Service applications	"GINA has been receiving and evaluating NOAA-21 data for several months on a test system using CSPP 4.0. Our current assessment is that the VIIRS i-band imagery looks excellent and we plan to start processing NOAA-21 on our operational system beginning May 30th. We've been able to compare NOAA-21 VIIRS i04 (3.74um) imagery with NOAA-20 and SNPP for the extreme fires that have been occurring in Alberta and British Columbia and have found it to be equivalent with VIIRS imagery from the other satellites. The Alaska Fire Service (BLM) uses GINA direct broadcast products for fire management and they are anxious to include NOAA-21 data for fire monitoring this season.
Lee Byerle	NWS	AWIPS	"AF_Iband_VIIRS_EDR, are going to flow out to sites w/expected consistency given the current distribution path. We have configurations that are "sensor agnostic" in the sense that the instrument information will be picked up in the cursor sampling (after being processed, whether from S-NPP, N-20, N-21)."
Wilfrid Schroeder	OSPO SAB	Hazard Mapping System	At this time SAB is able and ready to ingest NOAA-21 L1B and L2 Active Fire data into its operational Hazard Mapping System (HMS), making it part of our routine fire monitoring application. The new data will complement the S-NPP, NOAA-20 and GOES-East/West data currently being used in HMS.

Downstream Product Feedback

Algorithm	Product	Downstream Product Feedback - Reports from downstream product teams on the dependencies and impacts
Fire emissions	RAVE, GBBEP-x	Systems are designed to use two satellites and are ready to ingest NOAA-21 data once they replace SNPP.

Risks, Actions, and Mitigations

- Provide updates for the status of the risks/actions identified during the previous maturity review(s); add new ones as needed

Identified Risk	Description	Impact	Action/Mitigation and Schedule
Baseline to eFire transition	Operational code base is transitioning to eFire as part of the NCCF migration.	Changes in output content and format.	Algorithm for VIIRS is compatible between the baseline and eFire to ensure continuity of operational downstream applications. Format change has been communicated to key downstream users (GBBEPx, RAVE, AWIPS). No format change in .txt output (used by HRRR-smoke and RAP-smoke).

Documentations

Science Maturity Checklist	Yes ?
ReadMe for Data Product Users	Yes
Algorithm Theoretical Basis Document (ATBD)	Yes
Algorithm Calibration/Validation Plan	Yes
(External/Internal) Users Manual	Yes
System Maintenance Manual (for ESPC products)	Yes
Peer Reviewed Publications (Demonstrates algorithm is independently reviewed)	Yes for SNPP
Regular Validation Reports (at least annually) (Demonstrates long-term performance of the algorithm)	N/A

Check List - Provisional Maturity

Provisional Maturity End State	Assessment
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 select locations, periods, and associated ground truth or field campaign efforts.	Over three months of global data were analyzed since the availability of the product, over the VIIRS SDR pre-beta, beta and provisional maturity periods. Compatible output to SNPP and NOAA-20 product. Performance also traced back to SNPP and NOAA-20 performance against in-situ airborne data (MASTER).
Product analysis is sufficient to communicate product performance to users relative to expectations (Performance Baseline).	NOAA-21 is the third satellite producing compatible VIIRS Active Fire products. The small change in FRP retrievals due to M13 band placement is being communicated and has low impact on downstream applications.
Documentation of product performance exists that includes recommended remediation strategies for all anomalies and weaknesses. Any algorithm changes associated with severe anomalies have been documented, implemented, tested, and shared with the user community.	Publications describing Suomi NPP and NOAA-20 performance issues apply. No specific anomalies observed in NOAA-21 performance.
Product is ready for operational use and for use in comprehensive cal/val activities and product optimization.	Performance has been determined to be compatible to Suomi NPP and NOAA-20 and thus ready for operational use.

Conclusion

- Cal/Val results summary:
  - –The team recommends algorithm Provisional maturity based on compatible performance to the corresponding Suomi NPP and NOAA-20 products
  - the proposed effective date is March 30, 2023 (VIIRS SDR Provisional)
  - –~3 months of global data analyzed; ~6 weeks over VIIRS SDR Provisional period
- Prelaunch waiver impacts
  - band M13 spectral response shift has minor impact on FRP retrievals, but it cannot be considered a negative impact
- Caveats
  - –Evaluation done over the slowest period of the annual cycle of global fire activity
  - –Explicit validation against independent in-situ measurements remains an issue

Path Forward

- Lessons learned for NOAA-21 Cal/Val
  - continuing issue of the lack of in-situ observations
    - reliance on comparison to other satellite data and tracing performance to previous validation efforts
- Planned improvements
  - ongoing work to develop detection method for solar farms and extend solar farm database to global
- Future Cal/Val activities / milestones
  - continue eFire implementation support and verification
    - perform NOAA-21 eFire provisional (NET July 2023)
  - ensure seamless transition of downstream applications to eFire
  - merge NGFS and JSTAR development and cal/val efforts
  - support CSPP update for NOAA-21 VIIRS I-band Active Fire