Provisional Maturity Science Review For NOAA-20 VIIRS Active Fire Algorithm

Presented by Ivan Csiszar

Date: 2018/04/18

Provisional Maturity Review - Entry Criteria

- Product Requirements
- Pre-launch Performance Matrix/Waivers
- 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/EDRs feedback
- Risks, Actions, Mitigations
  - Potential issues, concerns
- Path forward to Validated Maturity
- Summary

Provisional Maturity Review - Exit Criteria

- 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 Provisional Maturity Slide Package addressing review committee's comments for:
  - Cal/Val Plan and Schedules
  - Product Requirements
  - Provisional Maturity Performance
  - Risks, Actions, Mitigations
  - Path forward to Validated Maturity

PROVISIONAL MATURITY REVIEW MATERIAL

Outline

- Algorithm Cal/Val Team Members
- Product Requirements
- Evaluation of algorithm performance to specification requirements
  - Evaluation of the effect of required algorithm inputs
  - Quality flag analysis/validation
  - Error Budget
- Identification of Processing Environment
- User Feedback
- Downstream Product Feedback
- Documentation (Science Maturity Check List)
- Conclusion
- 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
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

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

Active Fires		
ATTRIBUTE	**THRESHOLD**	**OBJECTIVE**
a. Horizontal Cell Size		
1. Nadir	0.80 km	0.25 km
2. Worst case	1.6 km	
b. Horizontal Reporting Interval	HCS	
c. Horizontal Coverage	Global	Global
d. Mapping Uncertainty, 3 sigma	1.5 km	0.75 km
e. Measurement Range		
1. Fire Radiative Rower (FRP)	1.0 to 5.0 $(10)^3$ MW	1.0 to 1.0 $(10)^4$ MW
2. Sub-pixel Average Temperature of Active Fire	N/A	N/A
3. Sub-pixel Area of Active Fire	N/A	N/A
f. Measurement Uncertainty		
1. Fire Radiative Rower (FRP)	50%	20%
2. Sub-pixel Average Temperature of Active Fire	N/A	N/A
3. Sub-pixel Area of Active Fire	N/A	N/A
g. Refresh	At least 90% coverage of the globe every 12 hours (monthly average)	N/A

JPSS ESPC Requirements Document (JERD) Volume 2 - Science Requirements

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 (FRP) 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.

The algorithm shall produce an Active Fires …

JERD-2406 …product with a horizontal cell size of 0.80 km at nadir.

JERD-2407 ....product with a horizontal reporting interval of 0.80 km at nadir.

JERD-2408 …product globally (note 2).

JERD-2409 …product with a mapping uncertainty, 3 sigma, of 1.5 km.

JERD-2410 …Radiative Power product with a measurement range of 1.0 MW to 5.0×10^3 MW (note 3).

JERD-2411 …Radiative Power product with a measurement uncertainty of 50%.

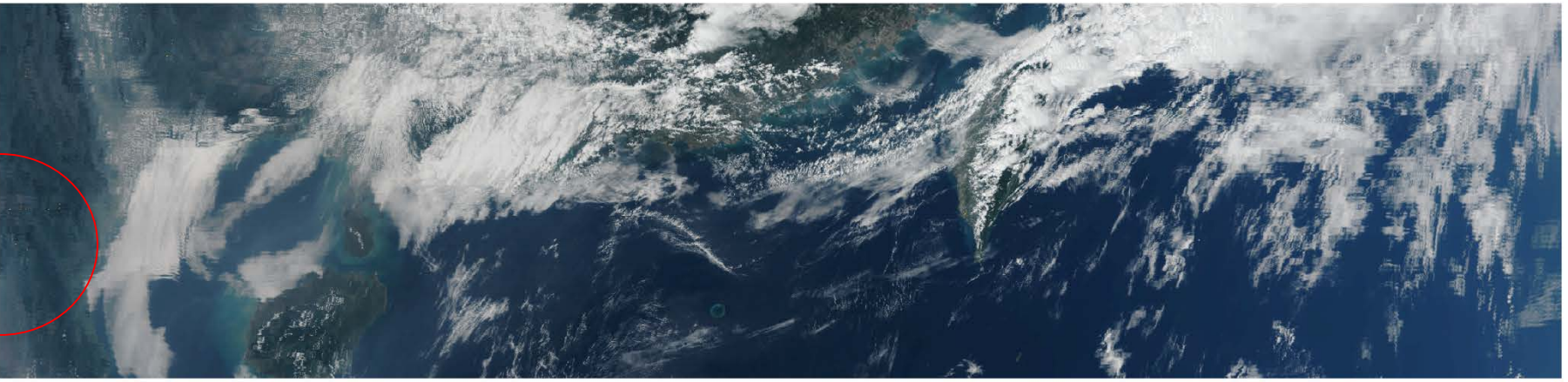
1. NOAA has endorsed the inclusion of an Active Fires EDR based on strong community interest in providing continuity of validated MODIS-based fire products (geolocation of fire detections, FRP, and a full fire mask) consistent with the recommendations of the NOAA-NASA Land Science Team. This change proposes the institution of Active Fires as an EDR with threshold requirements based on the demonstrated capabilities of the VIIRS F1 sensor and S-NPP spacecraft.

2. The requirement of global coverage is based on user community stated intentions to extend Active Fires product capabilities to non-land based targets (e.g., offshore gas flares).

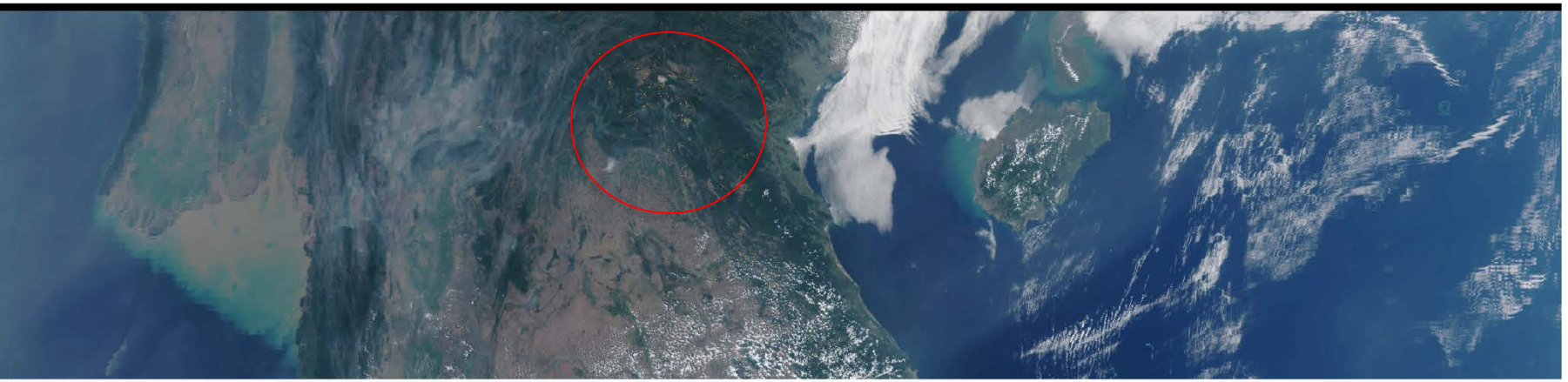
3. The high end of the FRP Measurement Range threshold requirement (5000 MW) is based on current design capabilities (i.e., the present 634 K saturation specification for the M13 Band on VIIRS) and the recommendation of the NOAA-NASA Land Science Team.

VIIRS 750m Fire Radiative Power
March 5, 2018

S-NPP Fire Radiative Power (FRP): 2018-03-05T05:20:17 - 2018-03-05T05:21:42

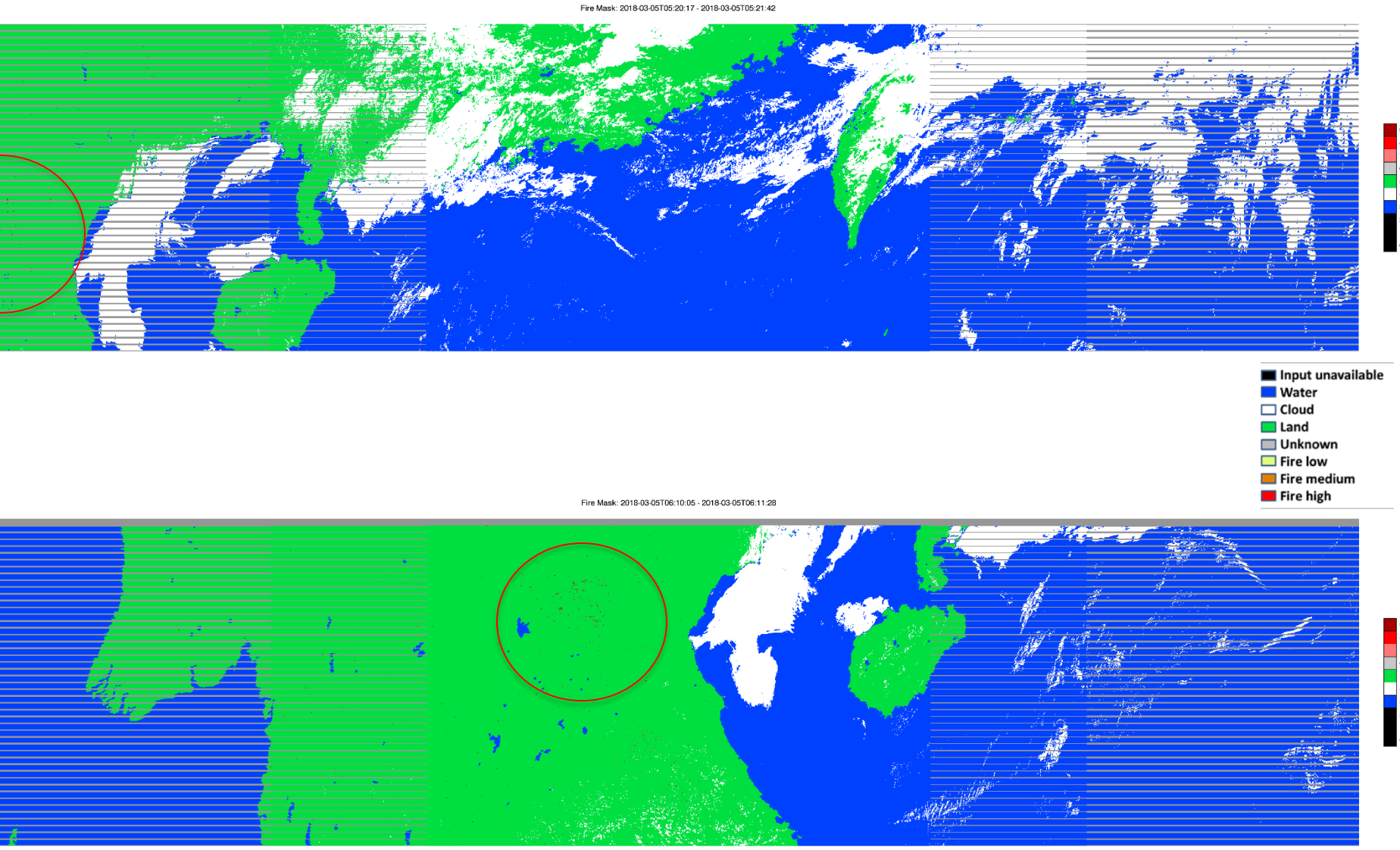


NOAA-20 Fire Radiative Power (FRP): 2018-03-05T06:10:05 - 2018-03-05T06:11:28



VIIRS 750m Fire Mask

March 5, 2018



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 of algorithm performance to specification requirements (3-5 slides)

- Findings/Issues from Beta Review
  - No spurious scanlines – no evidence of spurious detections due to M13 dual-gain calibration mismatch
  - Compatible detections counts and FRP retrievals between Suomi NPP and NOAA-20
- Improvements since Beta Review
  - No algorithm updates
  - Additional data monitoring and analysis
- Algorithm performance evaluation
  - Test data
    - NDE I&T and STAR processing environments
  - Validation strategies / methods
    - Cross-comparison with Suomi NPP
      - Relate NOAA-20 performance to previously validated product
    - Relative performance against the experimental I/M band “hybrid product
      - Performance assessment using semi-independent, higher quality data
  - Validation results

Beta review comments and actions

- *No precise match between Suomi NPP and NOAA-20*
  - These are comparisons from observations that are 50 minutes apart. Fire is a highly dynamic phenomenon spatially and temporally. This is why we did the analysis over a global spatial grid in a statistical sense. We were more concerned about the slope of the fit as an indicator of compatible FRP retrievals (and also M13 calibration) over the dynamic range.
- *Define effectivity date*
  - Use January 5th when the sensor reached normal operating temperature and the quality of the input VIIRS SDR is adequate. This is the date of our “first light” image as well. Readme updated accordingly.
- *Clarify whether the 750m or the 375m (or both) are being reviewed*
  - Beta briefing updated accordingly
- *Make labels on HMS slides clearer*
  - Added information on satellites, products etc.
- *Some documents do not exist for NOAA-20*
  - ATBD and EUM have been modified to include NOAA-20
- *Include reference circles etc. to guide audience to data to compare*
  - done

- ***Some of the updated slides are included in this briefing***

Evaluation of the effect of required algorithm inputs

- Required Algorithm Inputs
  - Primary Sensor Data
    - VIIRS bands M5, M7, M11, M13, M15, M16, geolocation
  - Ancillary Data
    - Granulated land/water mask
  - Upstream algorithms
    - none
  - LUTs / PCTs
    - none
- Evaluation of the effect of required algorithm inputs
  - VIIRS SDR performance monitoring through ICVS and maturity reviews
  - No effect of LWIR degradation observed in global analysis
    - Local and more quantitative effects possible
    - Users advised not to use March 12-15 2018 data

Quality flags and quality indicators

Output	Type	Description	
Fire Mask	8-bit unsigned integer	Missing – 0	Missing input data
		Scan – 1	On-board bowtie deletion
		Other – 2	Not processed (obsolete)
		Water – 3	Pixel classified as non-fire water
		Cloud – 4	Pixel classified as cloudy
		No Fire – 5	Pixel classified as non-fire land
		Unknown – 6	Pixel with no valid background pixels
		Fire Low – 7	Fire pixel with confidence strictly less than 20% fire
		Fire Medium – 8	Fire pixel with confidence between 20% and 80%
		Fire High – 9	Fire pixel with confidence greater than or equal to 80%
Fire Algorithm QA Mask	32-bit unsigned integer	Details in Table 1-5	

Bits	Description
0-1	Surface Type (water=0, coastal=1, land=2)
2	EDR ground bowtie deletion zone (0=false, 1=true)
3	Atmospheric correction performed (0=false, 1=true)
4	Day/Night (daytime = 1, nighttime = 0)
5	Potential fire (0=false, 1=true)
6	spare
7-10	Background window size parameter
11	Fire Test 1 valid (0 - No, 1 - Yes)
12	Fire Test 2 valid (0 - No, 1 - Yes)
13	Fire Test 3 valid (0 - No, 1 - Yes)
14	Fire Test 4 valid (0 - No, 1 - Yes)
15	Fire Test 5 valid (0 - No, 1 - Yes)
16	Fire Test 6 valid (0 - No, 1 - Yes)
17-19	spare
20	Adjacent clouds (0/1)
21	Adjacent water (0/1)
22-23	Sun Glint Level (0-3)
24	Sun Glint rejection
25	False Alarm (excessive rejection of legitimate background pixels)
26	False Alarm (rejection of land pixel due to water background)
27	Amazon forest-clearing rejection test
28	False alarm (rejection of water pixel due to land or coastal background)
29-31	spare

The following slides illustrate key fire mask / quality mask layers

NOAA-20 VIIRS 750m

March 3, 2018 (AF_v1r1_j01_s201803041311335*)

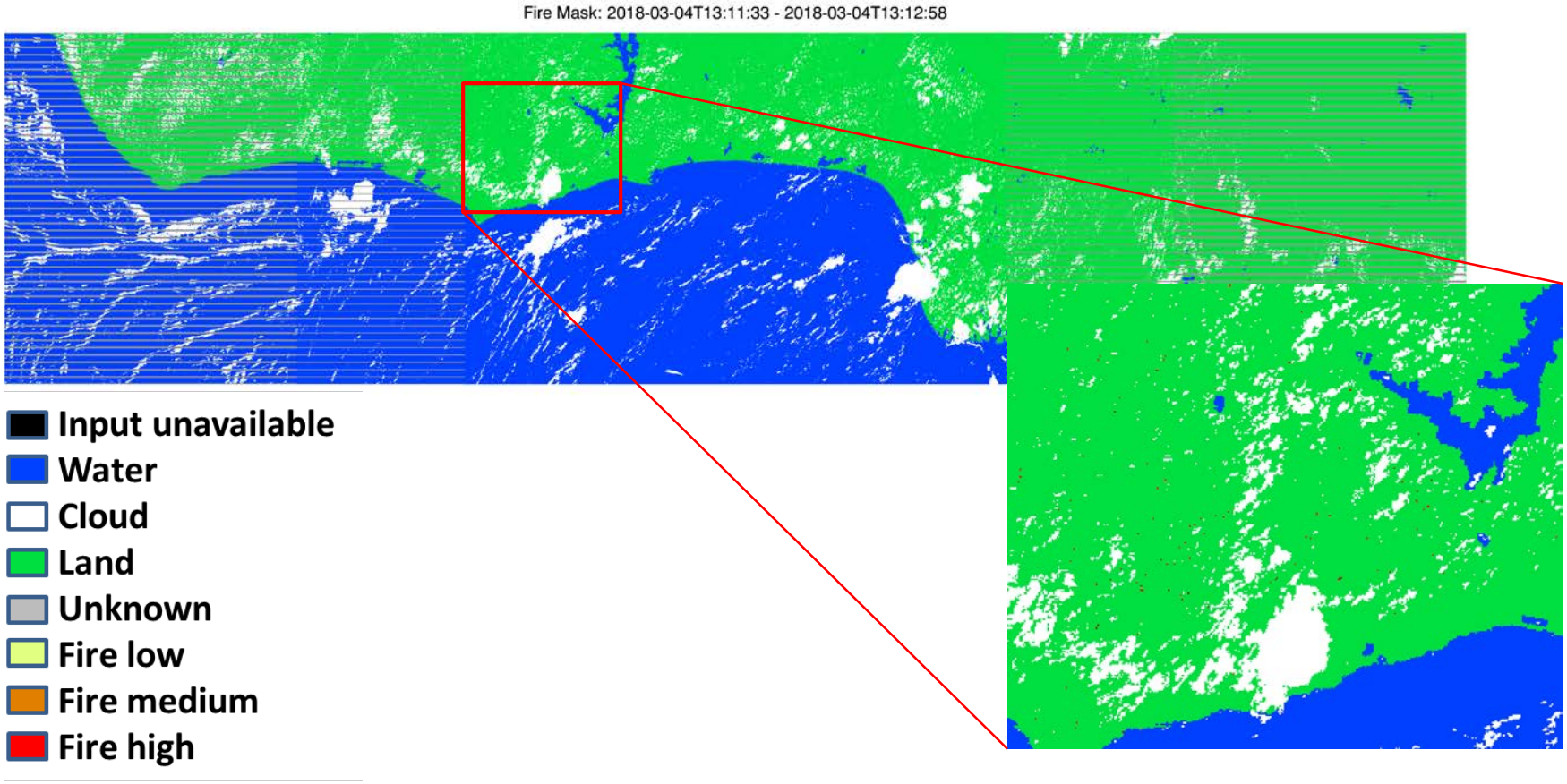
RGB image

2018-03-04T13:11:33 - 2018-03-04T13:12:58

NOAA-20 VIIRS 750m Fire Mask

March 3, 2018 (AF_v1r1_j01_s201803041311335*)

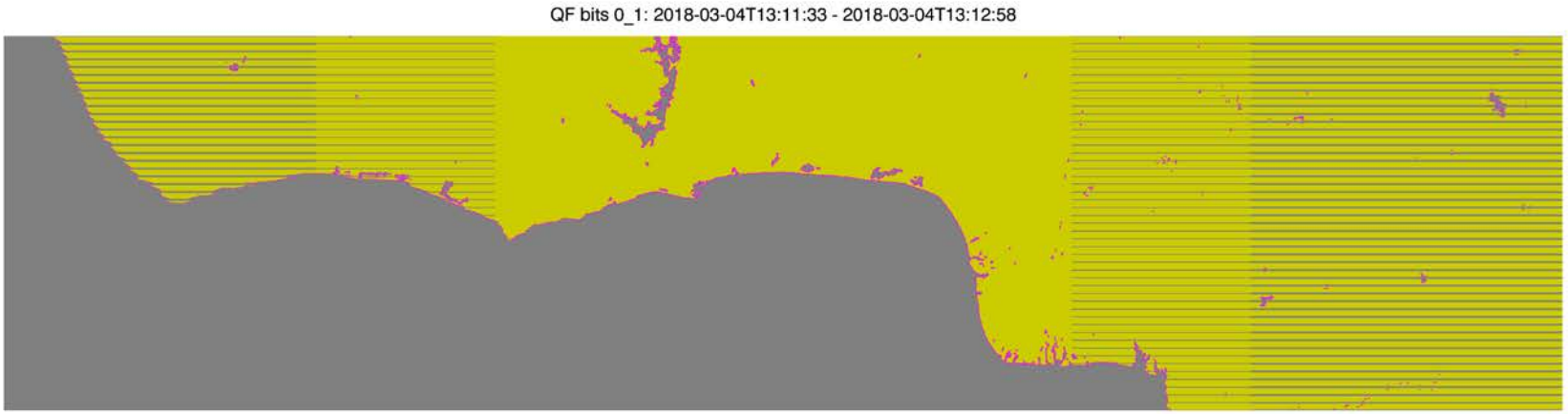
Fire Mask



NOAA-20 VIIRS 750m Fire Mask

March 3, 2018 (AF_v1r1_j01_s201803041311335*)

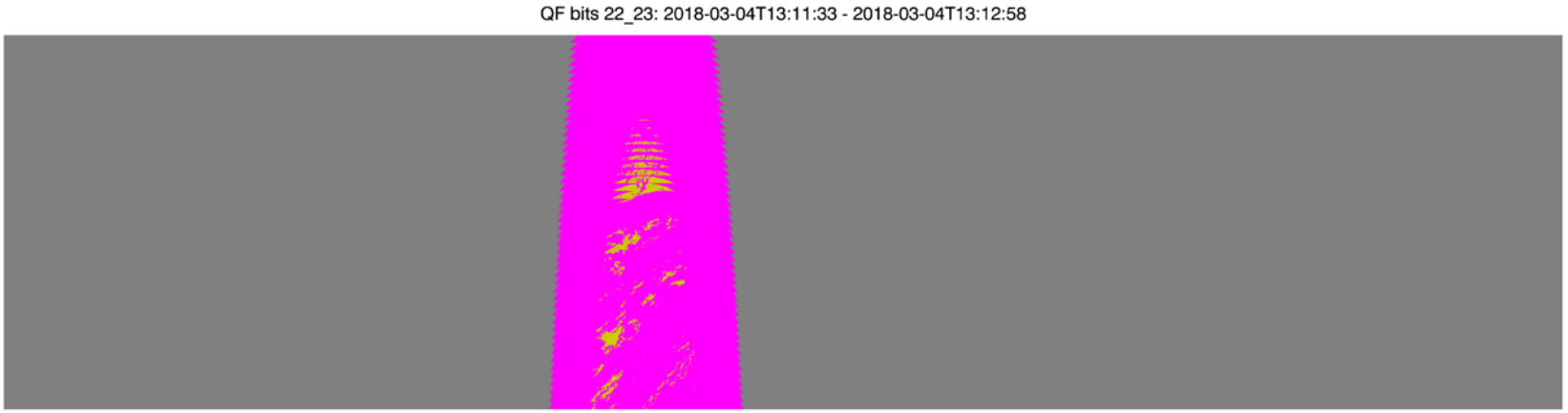
Surface Type (water: grey, coastal: red, land: yellow)



NOAA-20 VIIRS 750m Fire Mask

March 3, 2018 (AF_v1r1_j01_s201803041311335*)

Sun Glint Level (0-3)

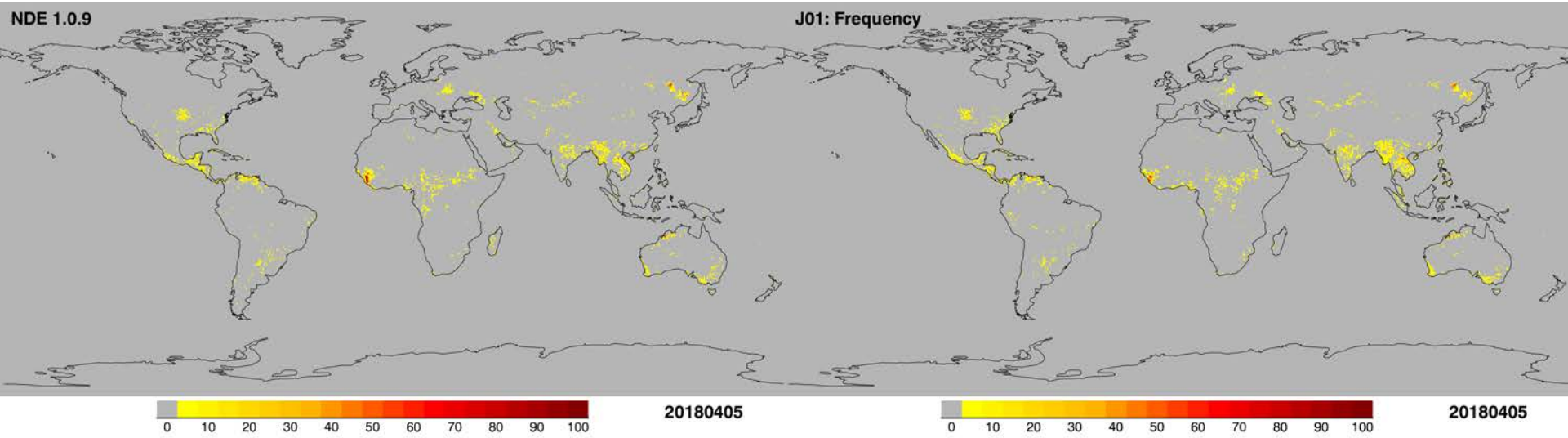


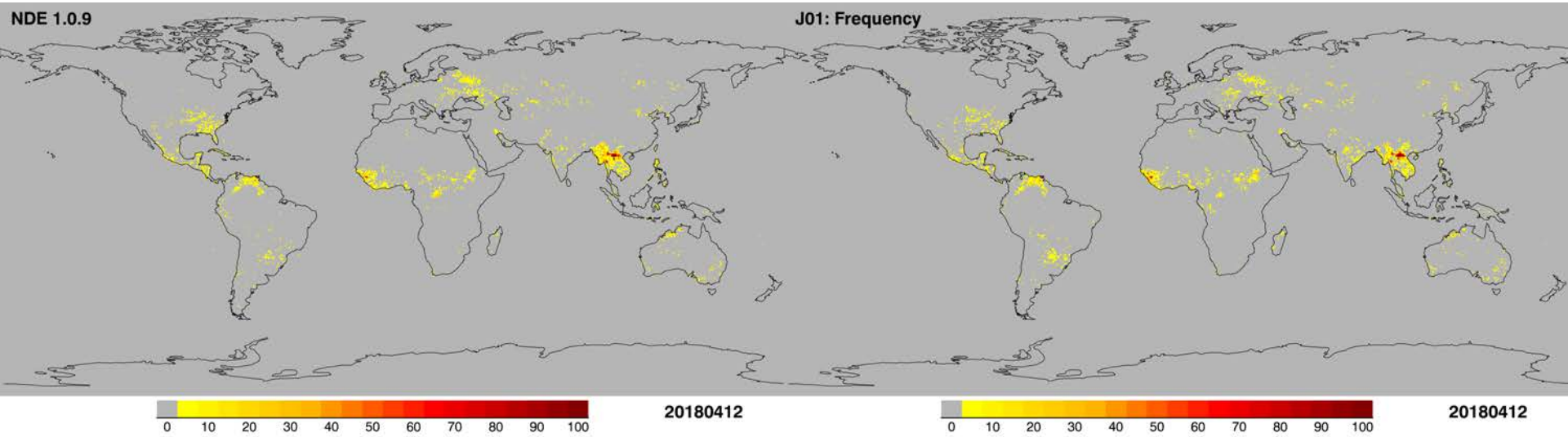
NOAA-20 VIIRS 750m Fire Mask

March 3, 2018 (AF_v1r1_j01_s201803041311335*)

EDR ground bowtie deletion zone (grey: false, purple: true)

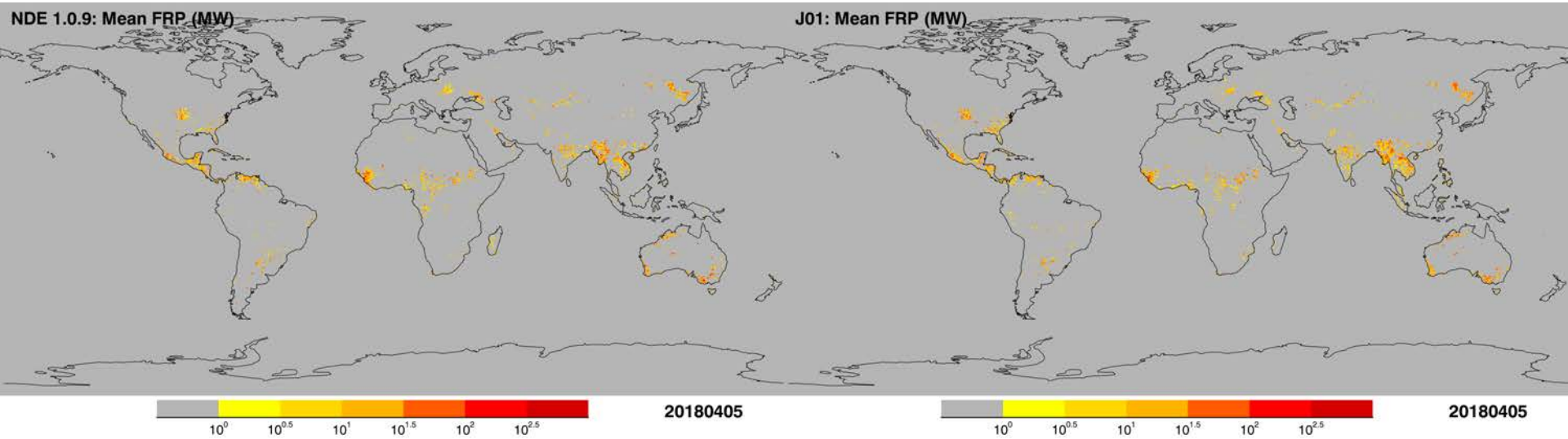
Suomi NPP vs. NOAA-20: 750m

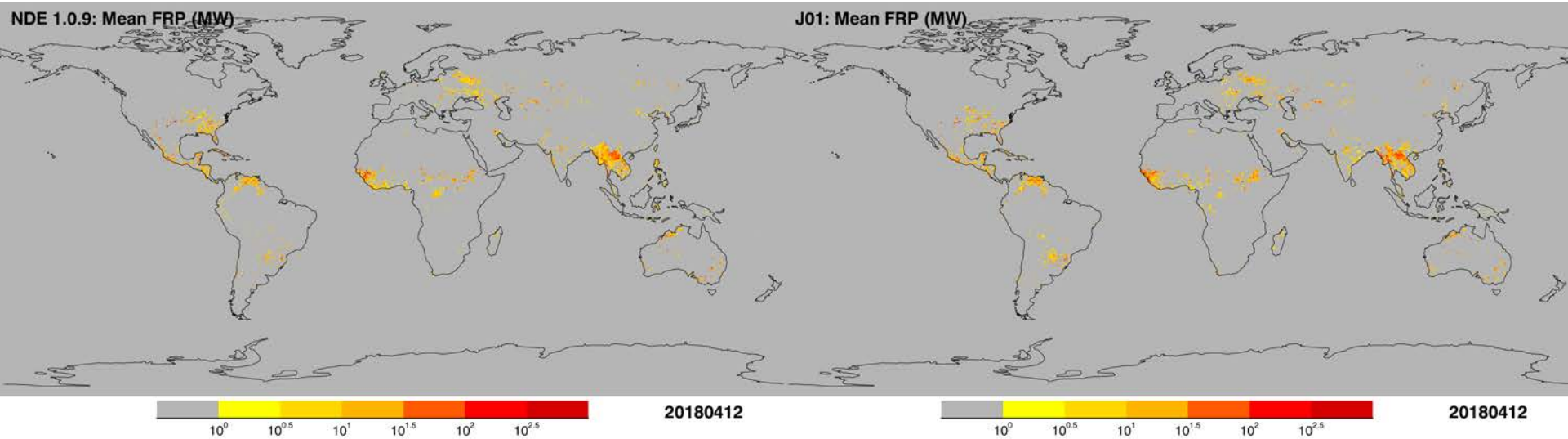




Good agreement. No "perfect" agreement is expected

Suomi NPP vs. NOAA-20: 750m





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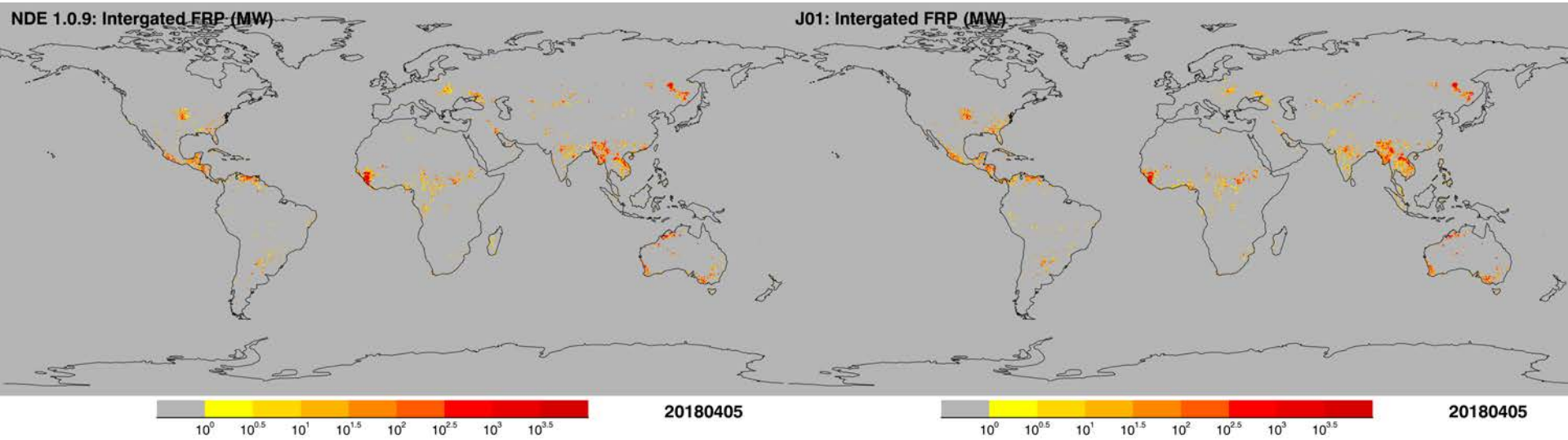
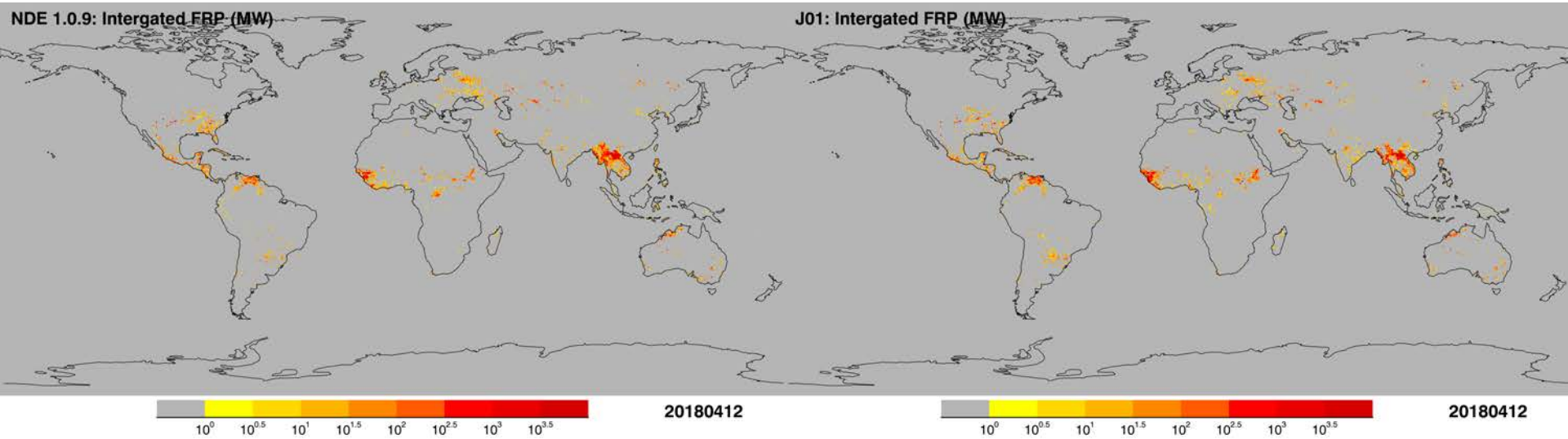
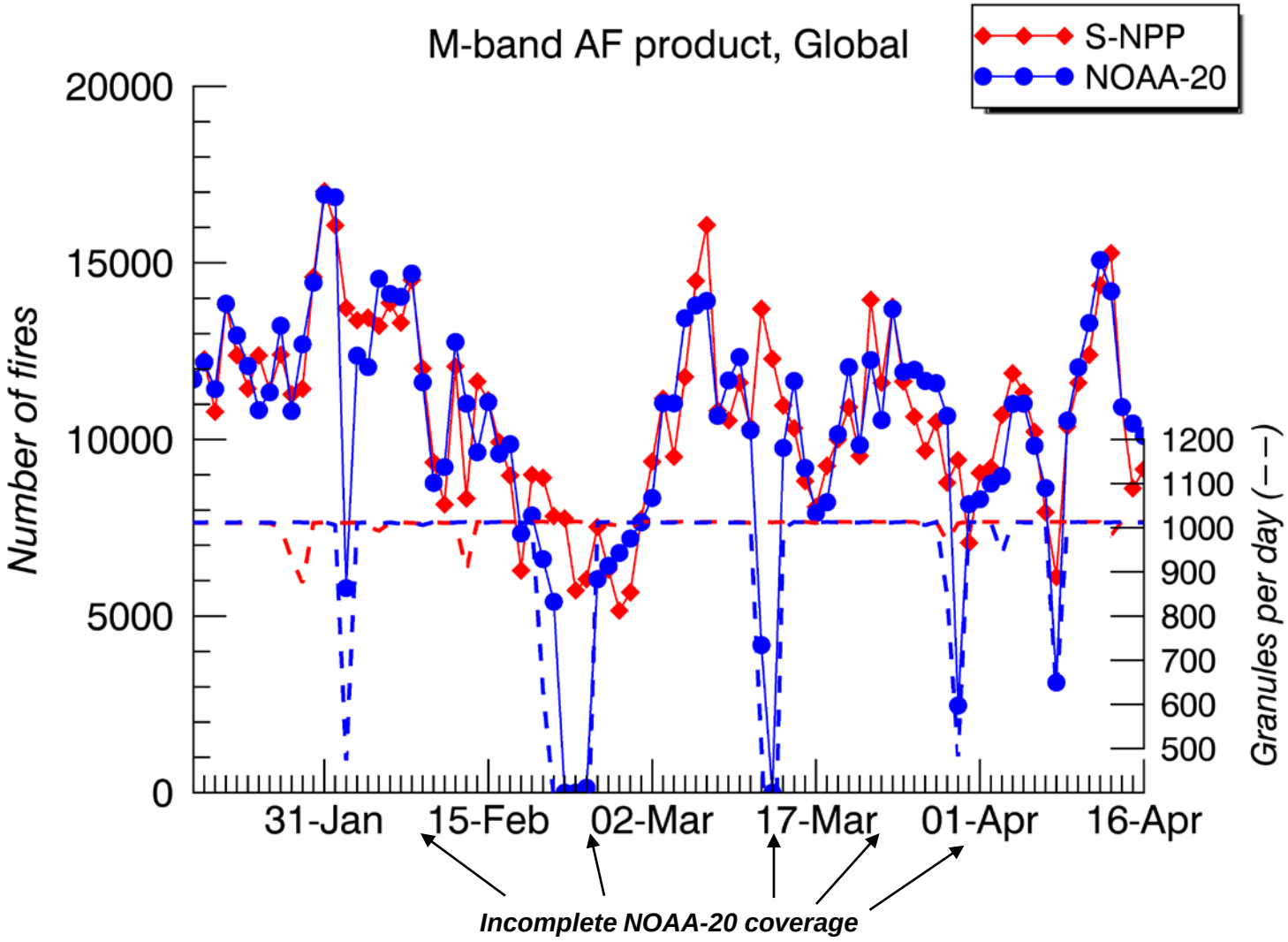
Suomi NPP vs. NOAA-20: 750m





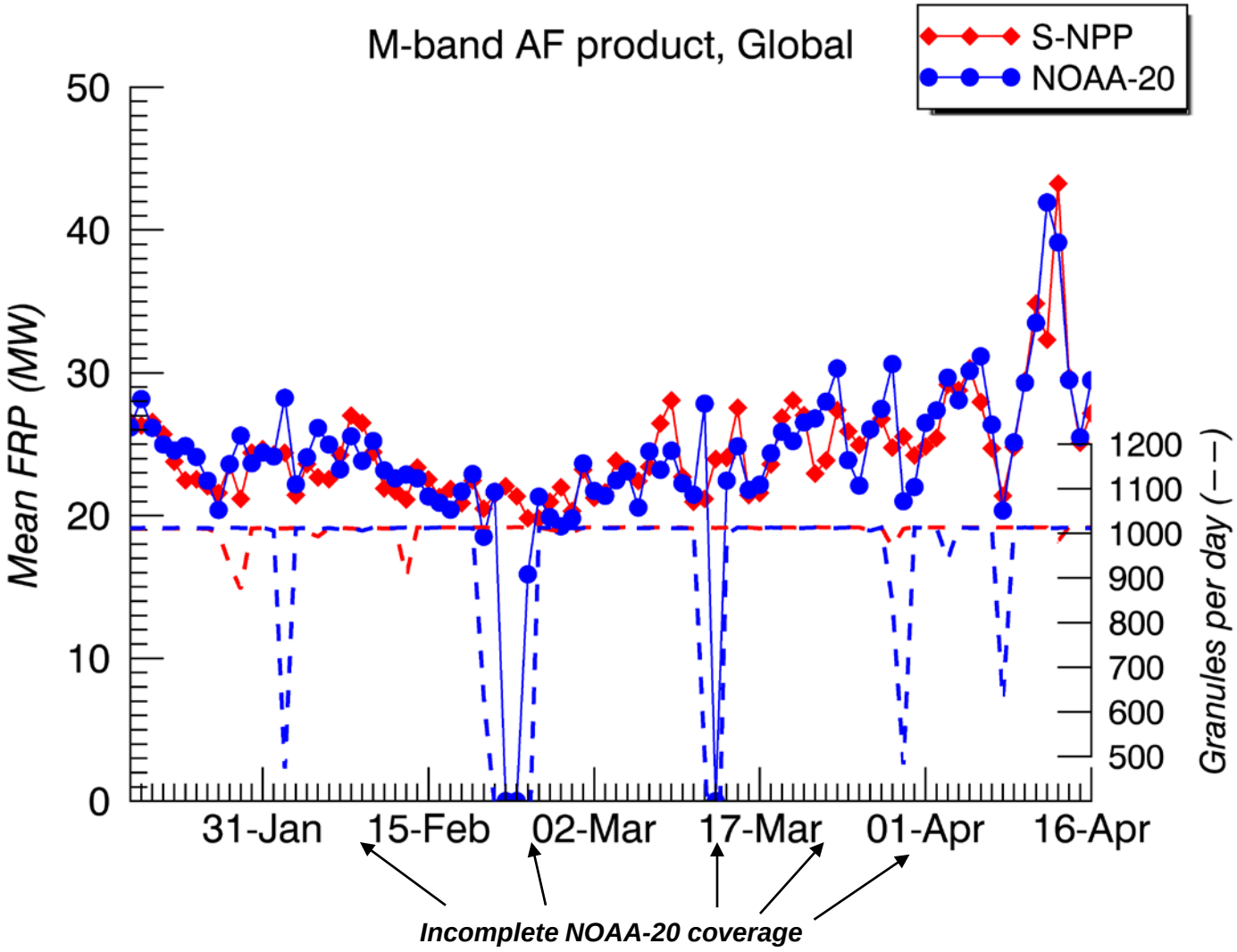
Good agreement. No "perfect" agreement is expected

Suomi NPP vs. NOAA-20: 750m



Good agreement. No "perfect" agreement is expected

Suomi NPP vs. NOAA-20: 750m



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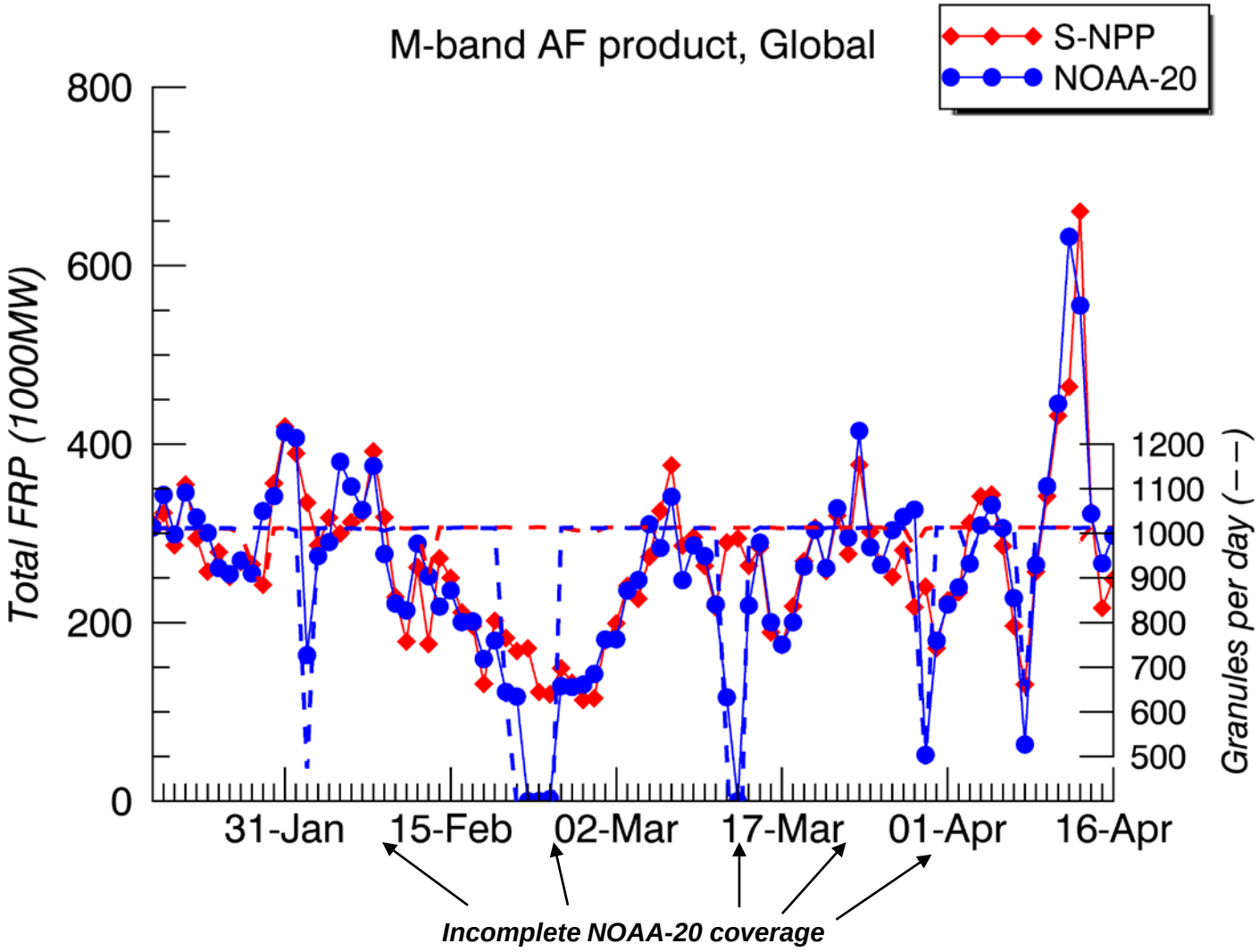
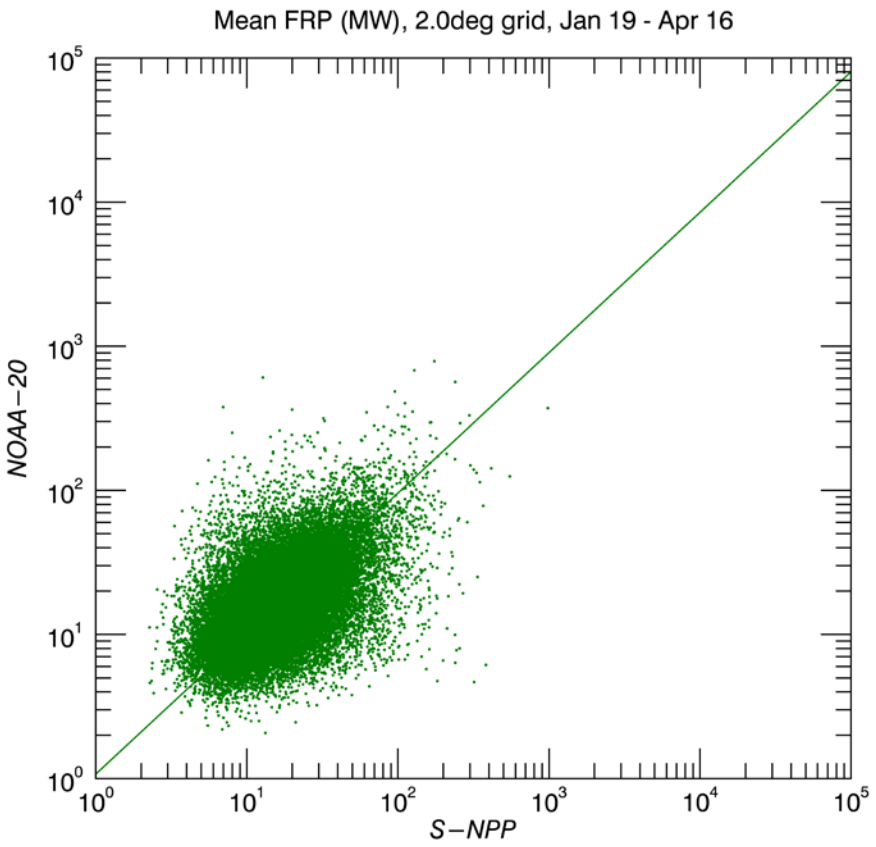
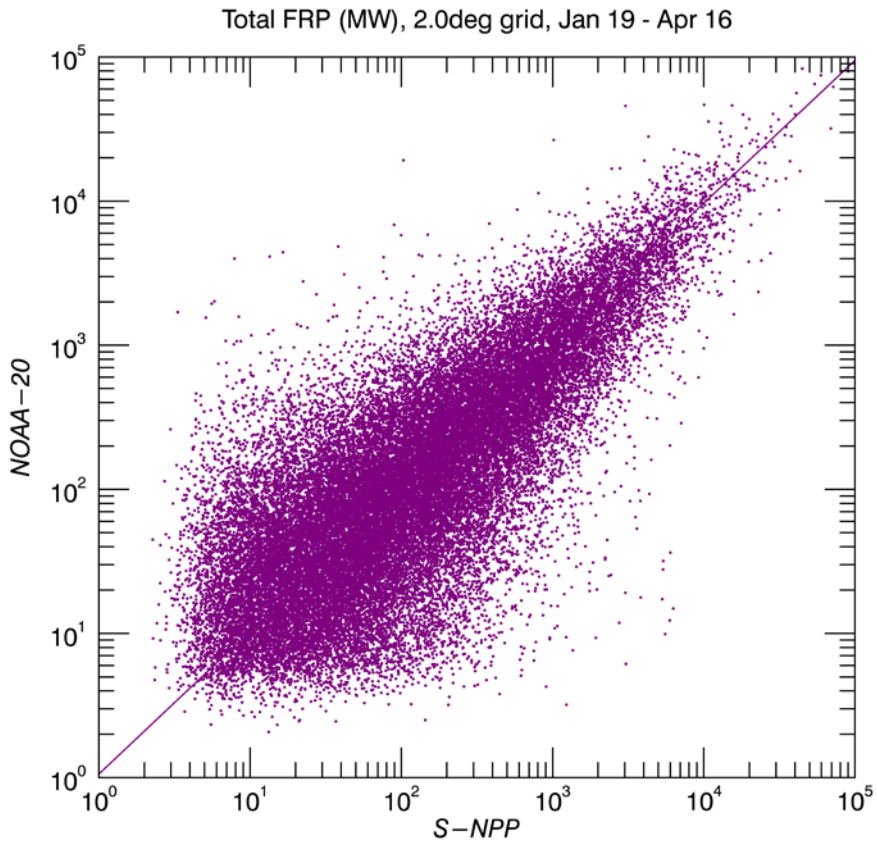
Suomi NPP vs. NOAA-20: 750m



Good agreement. No "perfect" agreement is expected

Suomi NPP vs. NOAA-20: 750m

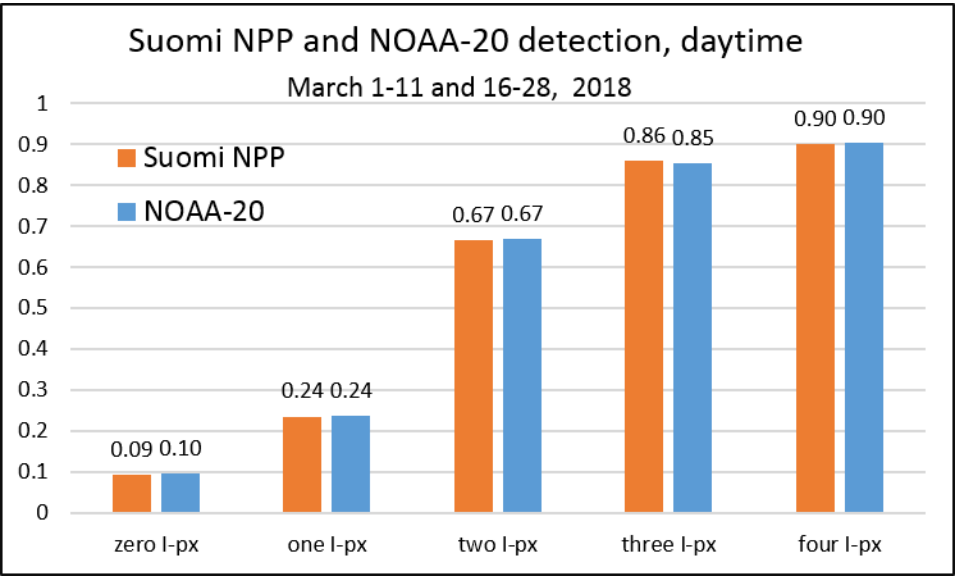


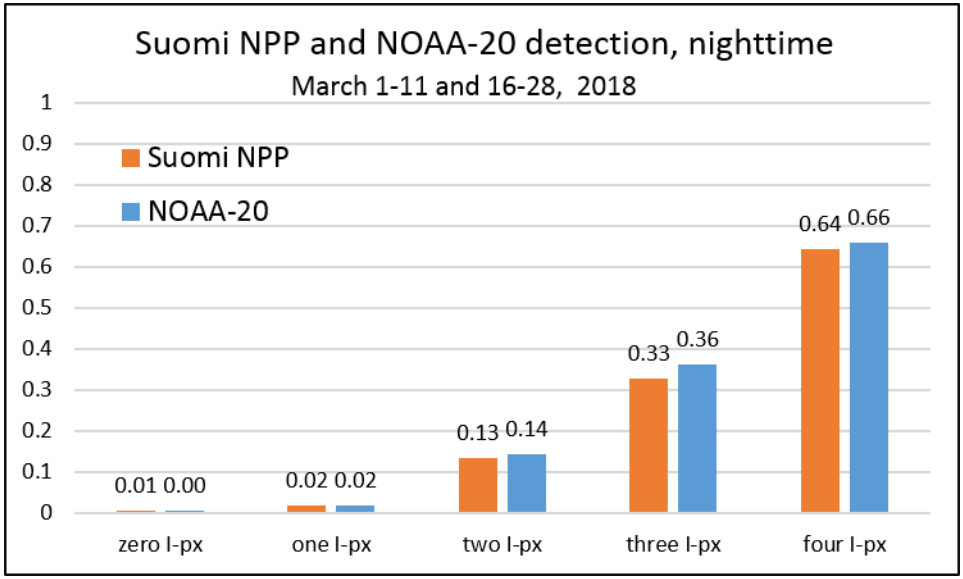


Good agreement. No "perfect" agreement is expected

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

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 improvement of the algorithm, test data, and error analysis methodology.

Attribute Analyzed	L1RD Threshold	Pre-Launch Perf.	On-orbit Perf.	Meet Req.?	Additional Comments
FRP	50%	N/A	Compatible with Suomi NPP	Yes	Performance traced to Suomi NPP

Mapping accuracy requirements traced back to SDR performance

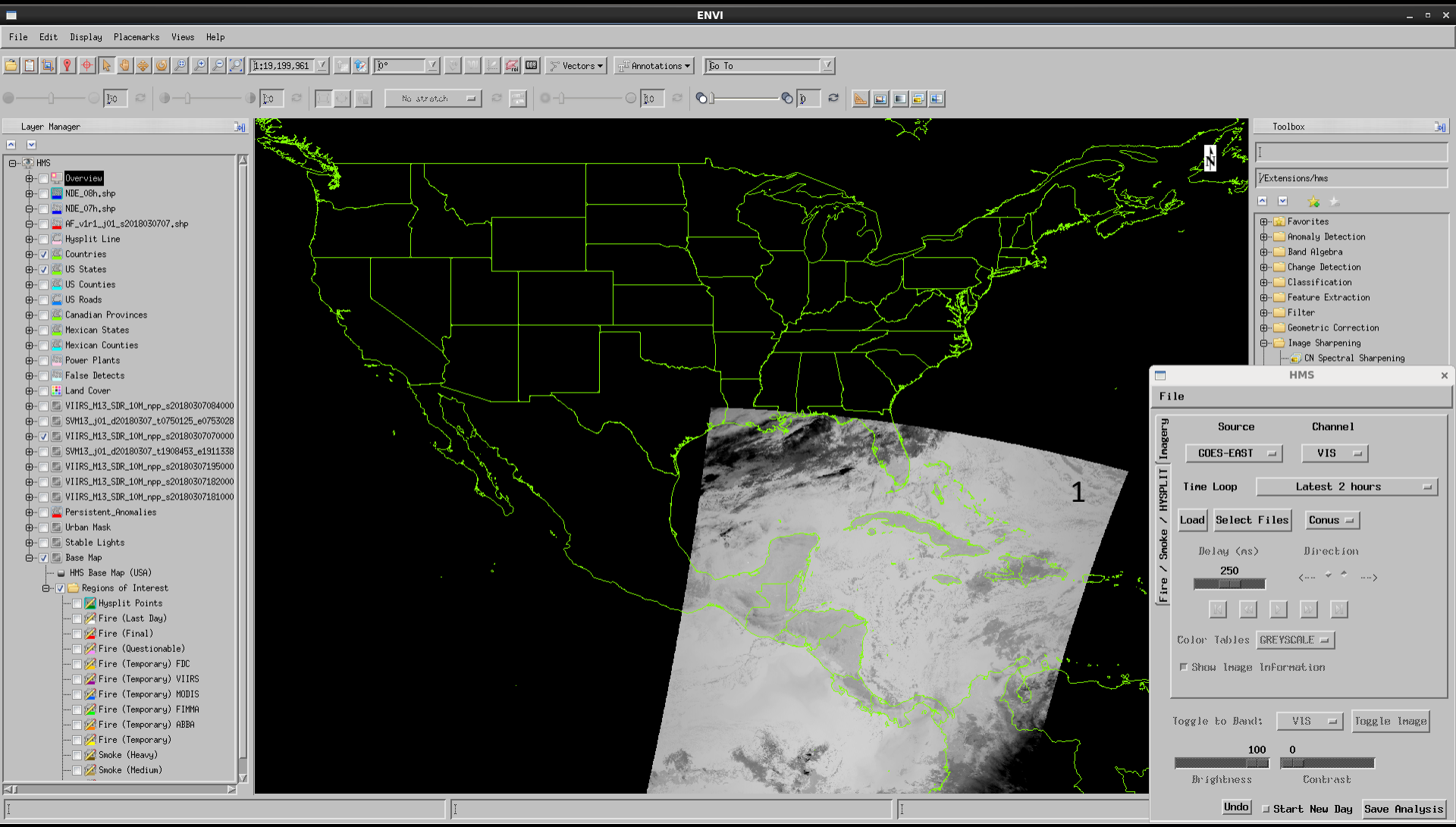
Identification of Processing Environment

- ESPC NDE 2.0.X
  - Implementation foreseen within the next few months
- Algorithm version
  - VIIRS Active Fires v1.1
- Version of LUTs used
  - none
- Version of PCTs used
  - none
- Description of environment used to achieve provisional maturity stage
  - STAR computing environment

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	Plans to use the NOAA-20 VIIRS FRP data in HRRR-Smoke forecasting. Working on sample files to modify prerprocessing tools.
John Simko	OSPO SAB	Hazard Mapping System	Working towards bringing the 375m I/M into experimental production.
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
	NCEP		TBC
	EUMETSAT		TBC

Hazard Mapping System
07 March 2018 – morning data

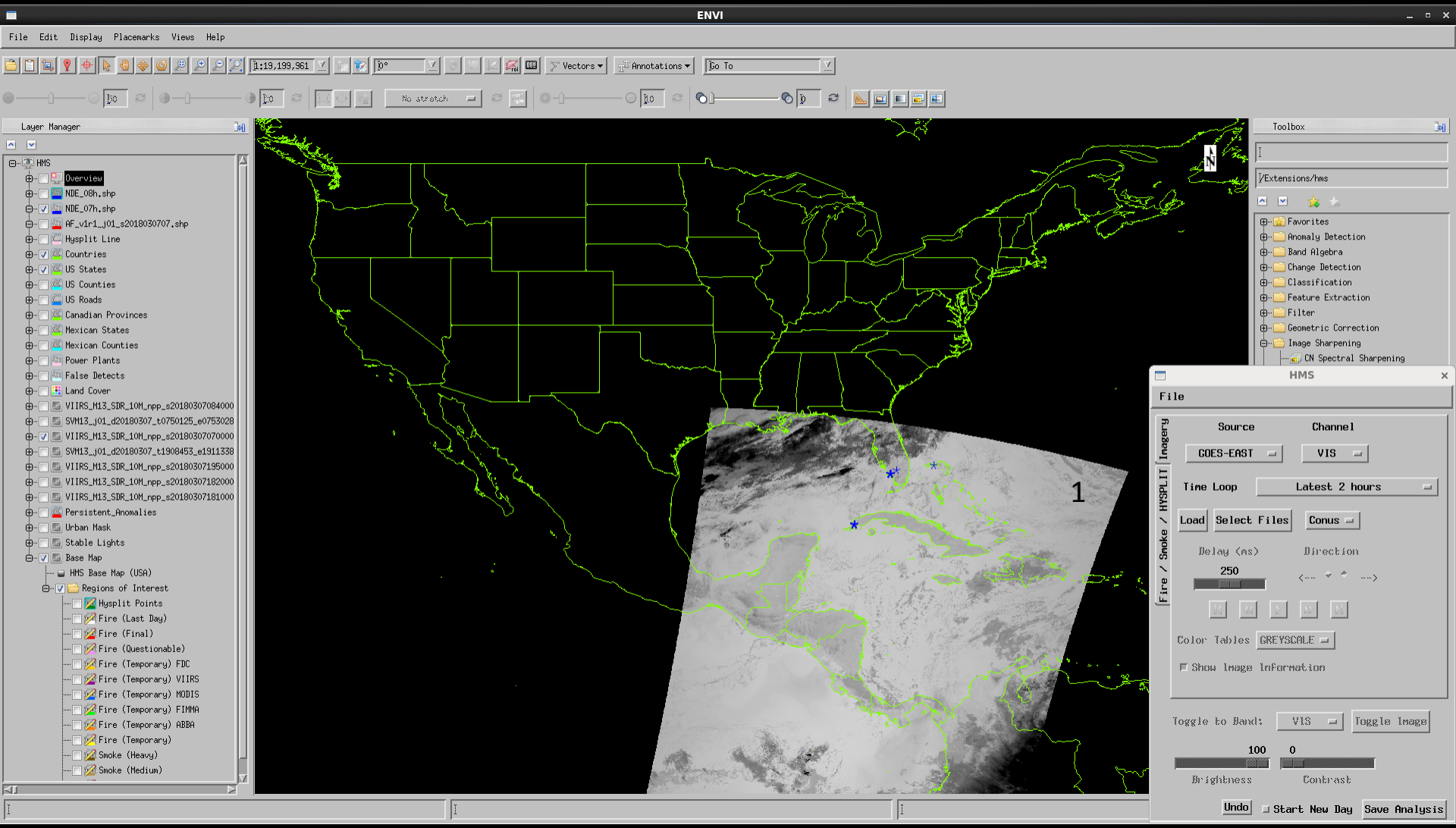


10-min granule

1: S-NPP/VIIRS 0700UTC

NOAA-20/VIIRS data display prepared for illustration purposes only.
Created by Wilfrid Schroeder (NOAA/NESDIS/OSPO/SPSD/SAB)

Hazard Mapping System
07 March 2018 – morning data

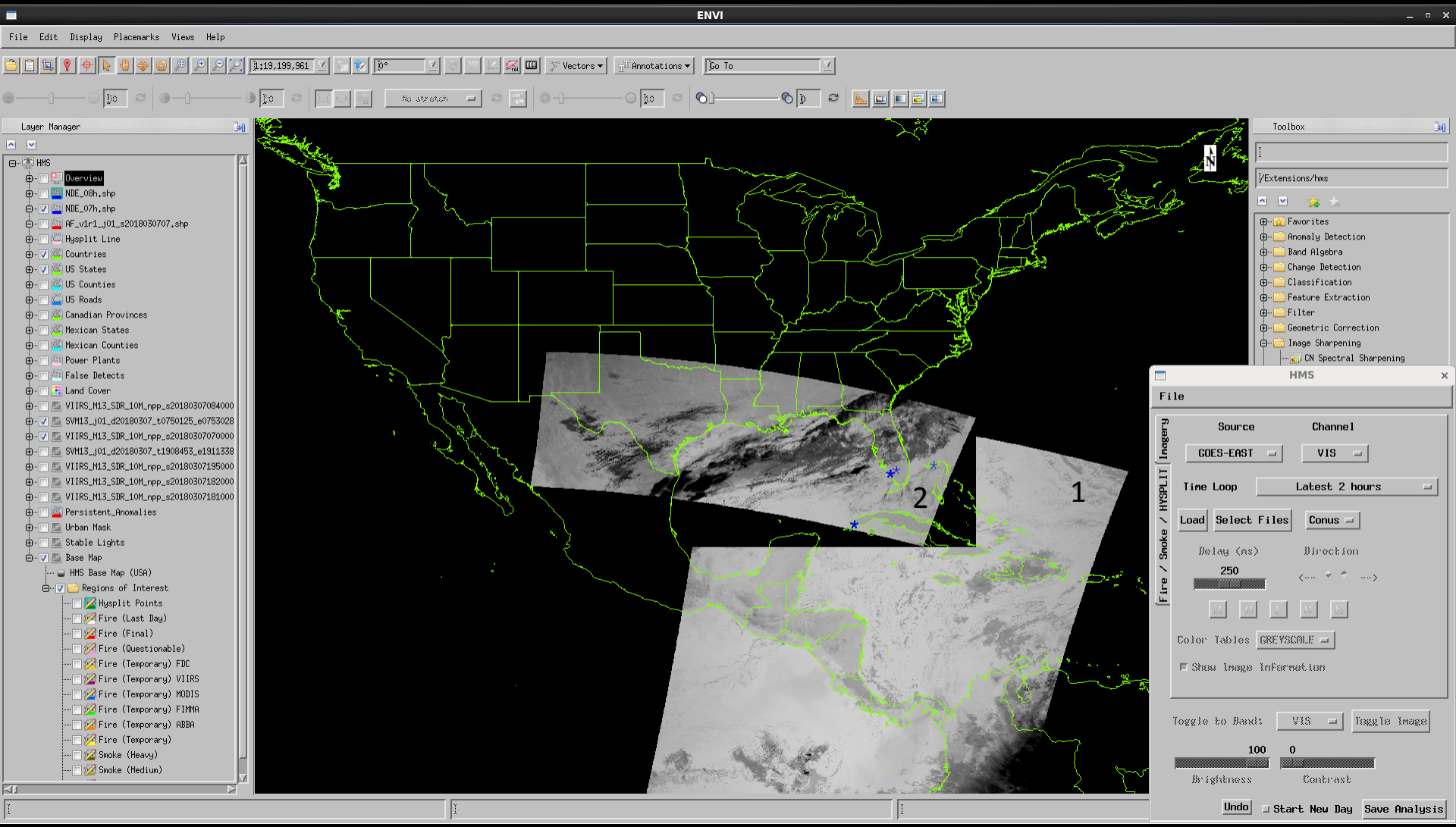


10-min granule

1: S-NPP/VIIRS 0700UTC

* S-NPP VIIRS 750m fire pixels

Hazard Mapping System
07 March 2018 – morning data

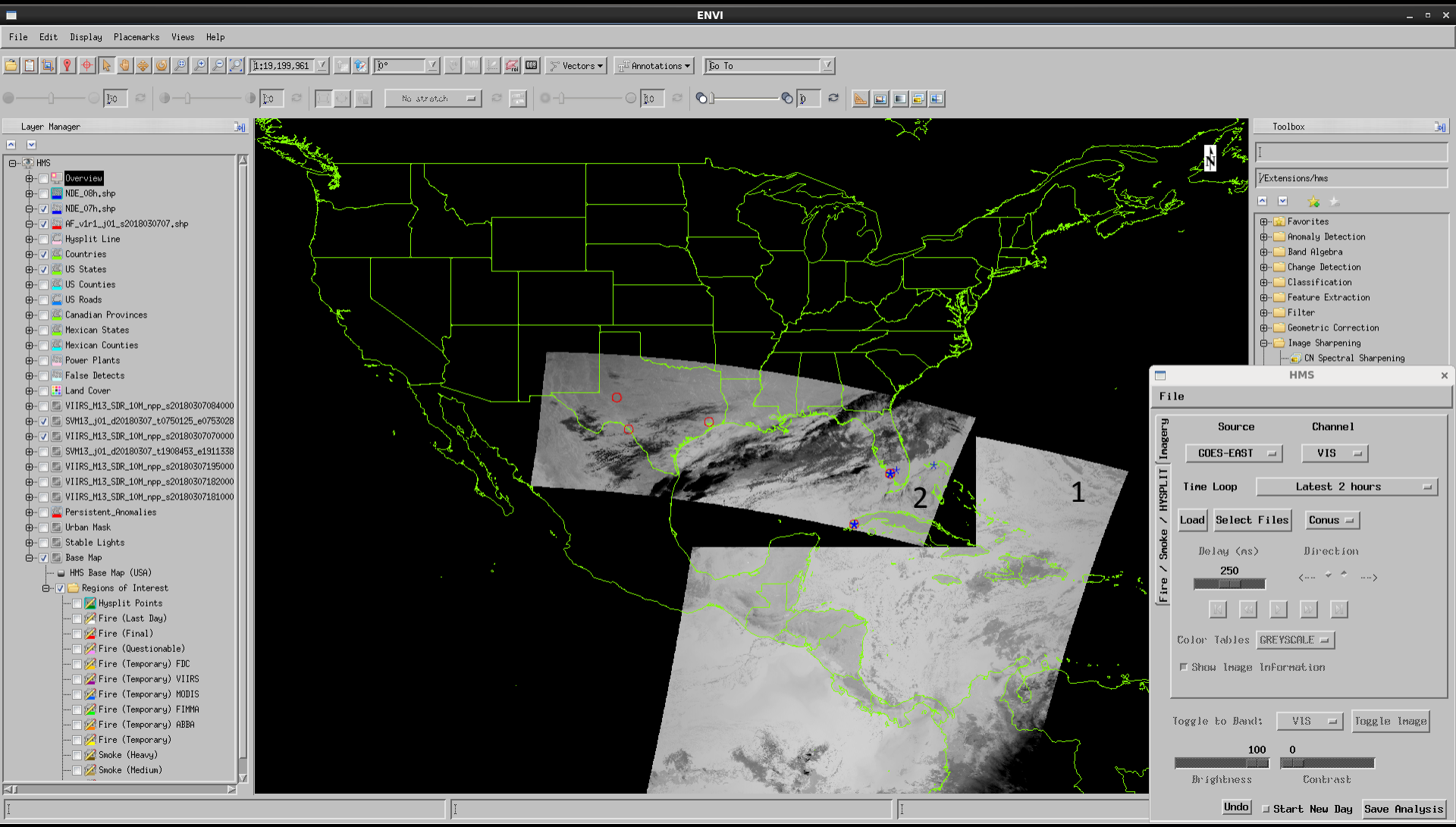


2x86sec granule

2: NOAA-20/VIIRS 0750UTC

* S-NPP VIIRS 750m fire pixels

Hazard Mapping System
07 March 2018 – morning data



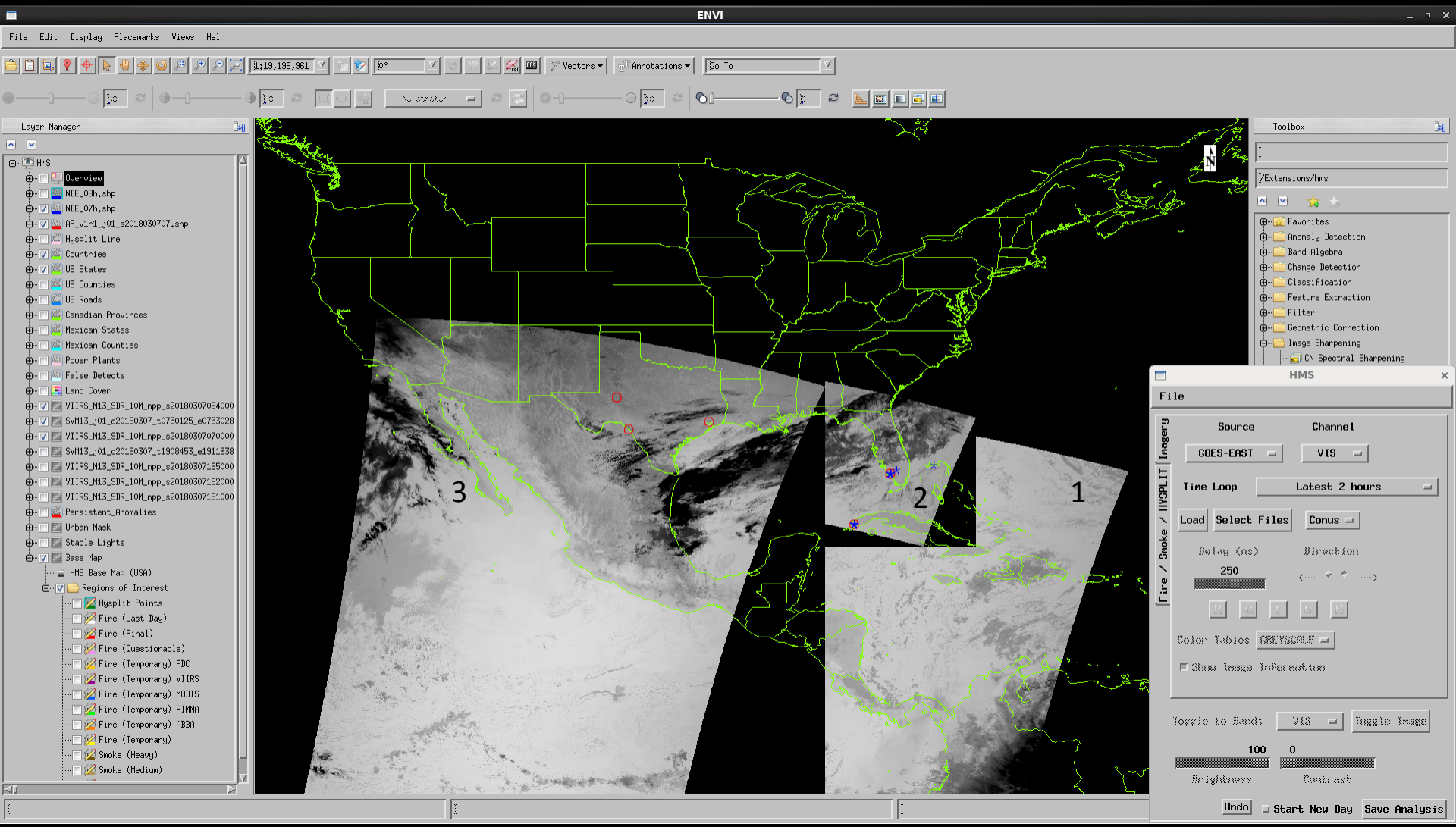
2x86sec granule

2: NOAA-20/VIIRS 0750UTC

* S-NPP VIIRS 750m fire pixels

o NOAA-20 VIIRS 750m fire pixels

Hazard Mapping System
07 March 2018 – morning data



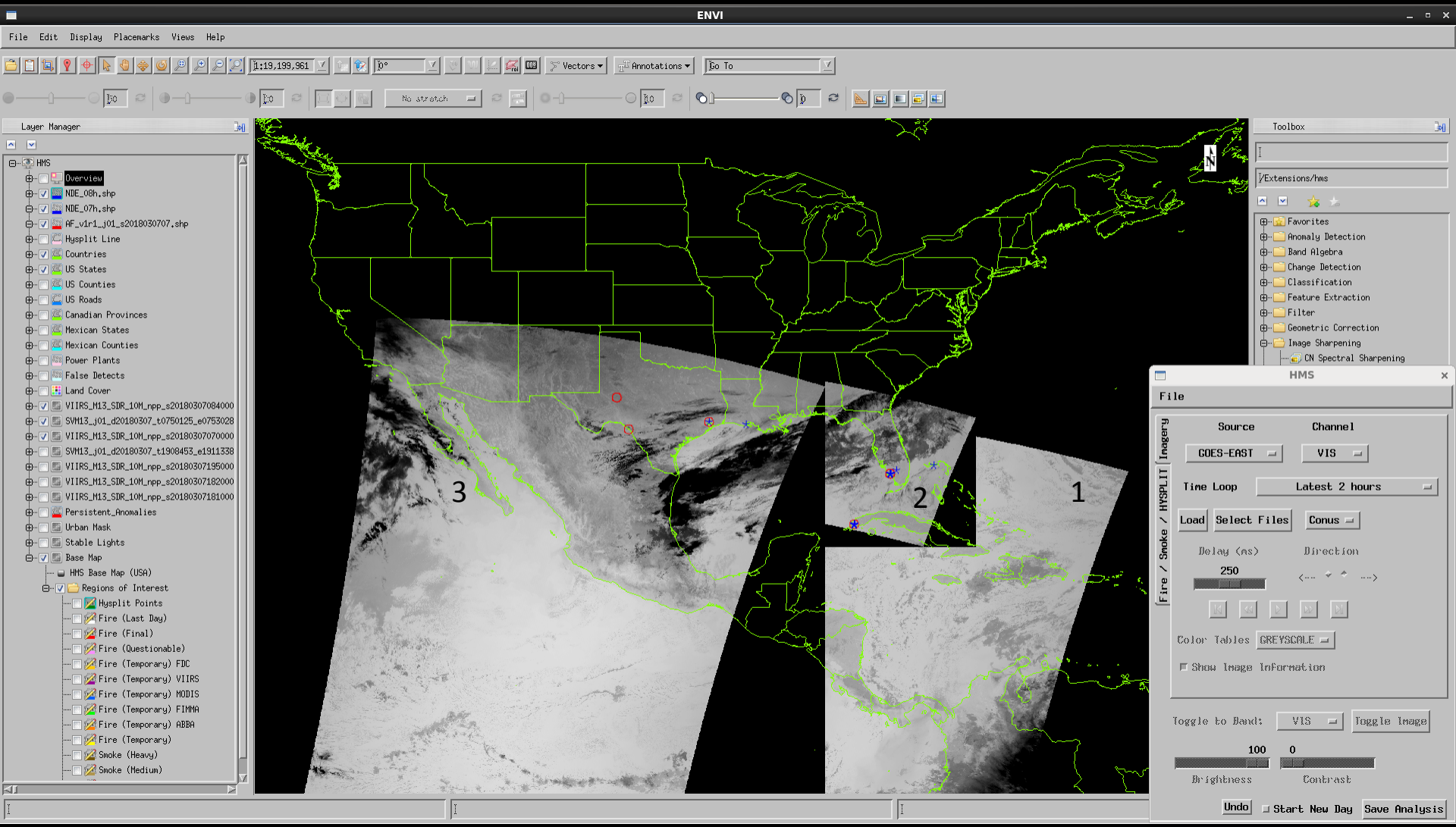
10-min granule

3: S-NPP/VIIRS 0840UTC

* S-NPP VIIRS 750m fire pixels

o NOAA-20 VIIRS 750m fire pixels

Hazard Mapping System
07 March 2018 – morning data



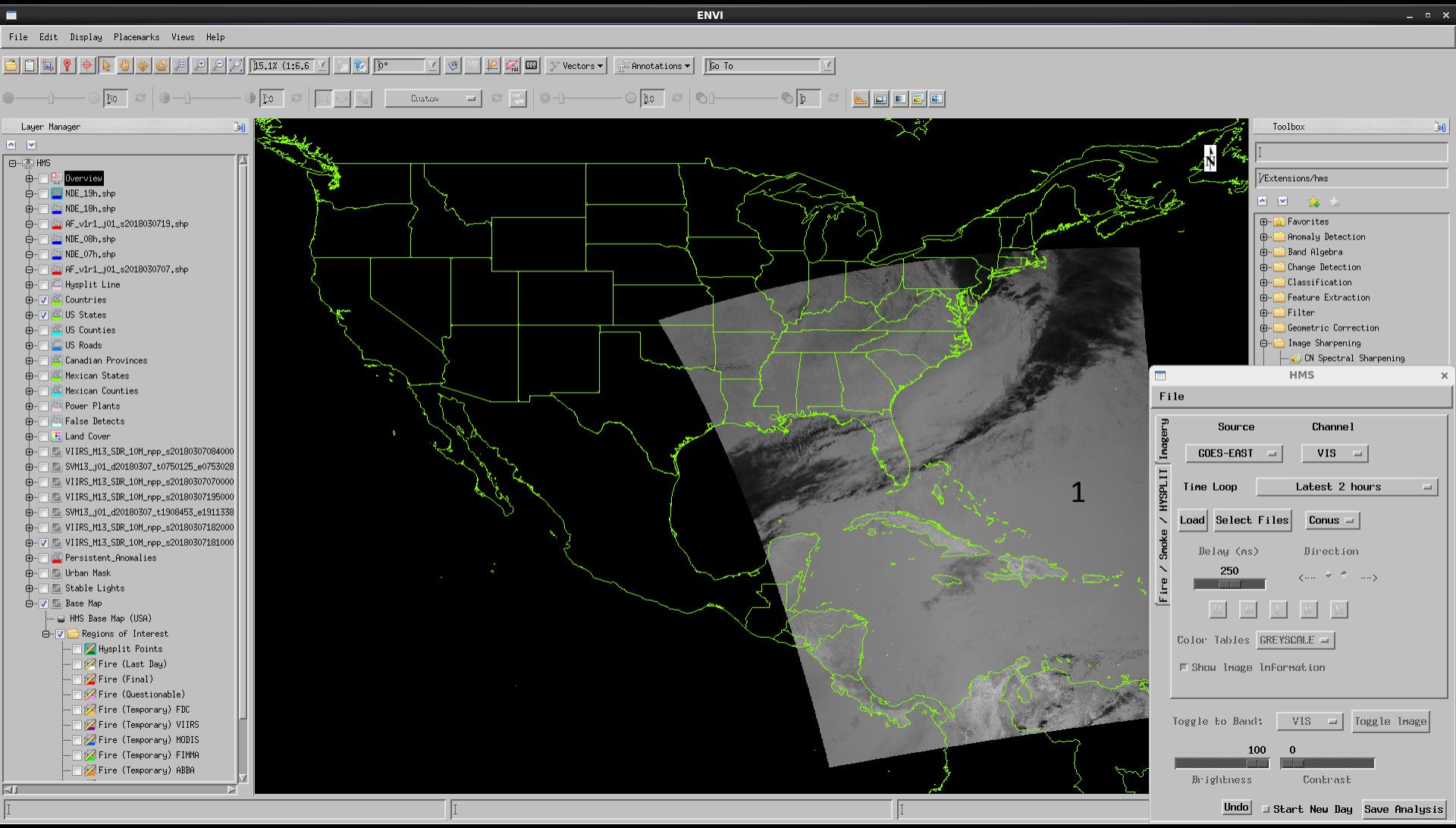
10-min granule

3: S-NPP/VIIRS 0840UTC

* S-NPP VIIRS 750m fire pixels

o NOAA-20 VIIRS 750m fire pixels

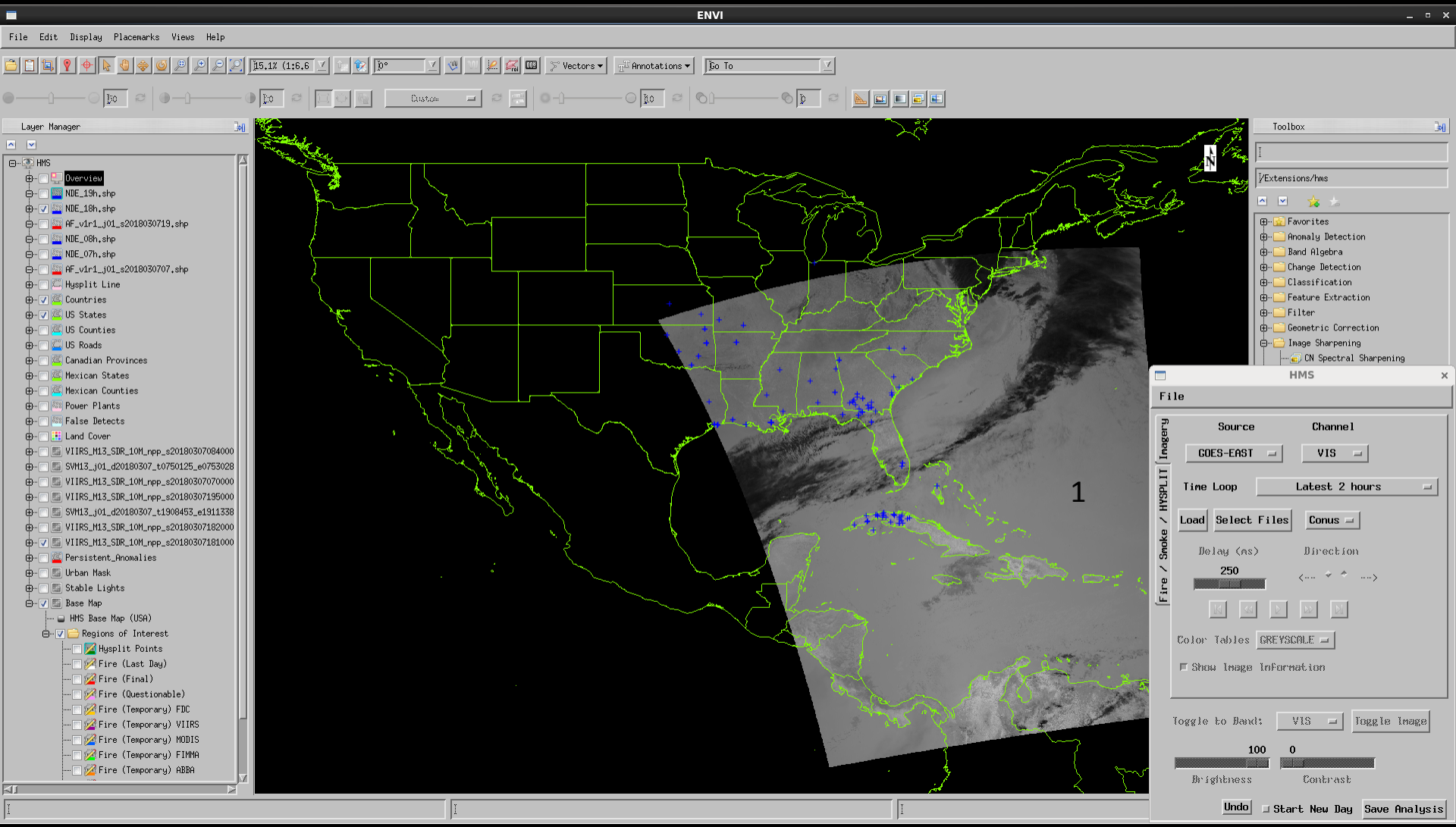
Hazard Mapping System
07 March 2018 – afternoon data



10-min granule

1: S-NPP/VIIRS 1810UTC

Hazard Mapping System
07 March 2018 – afternoon data

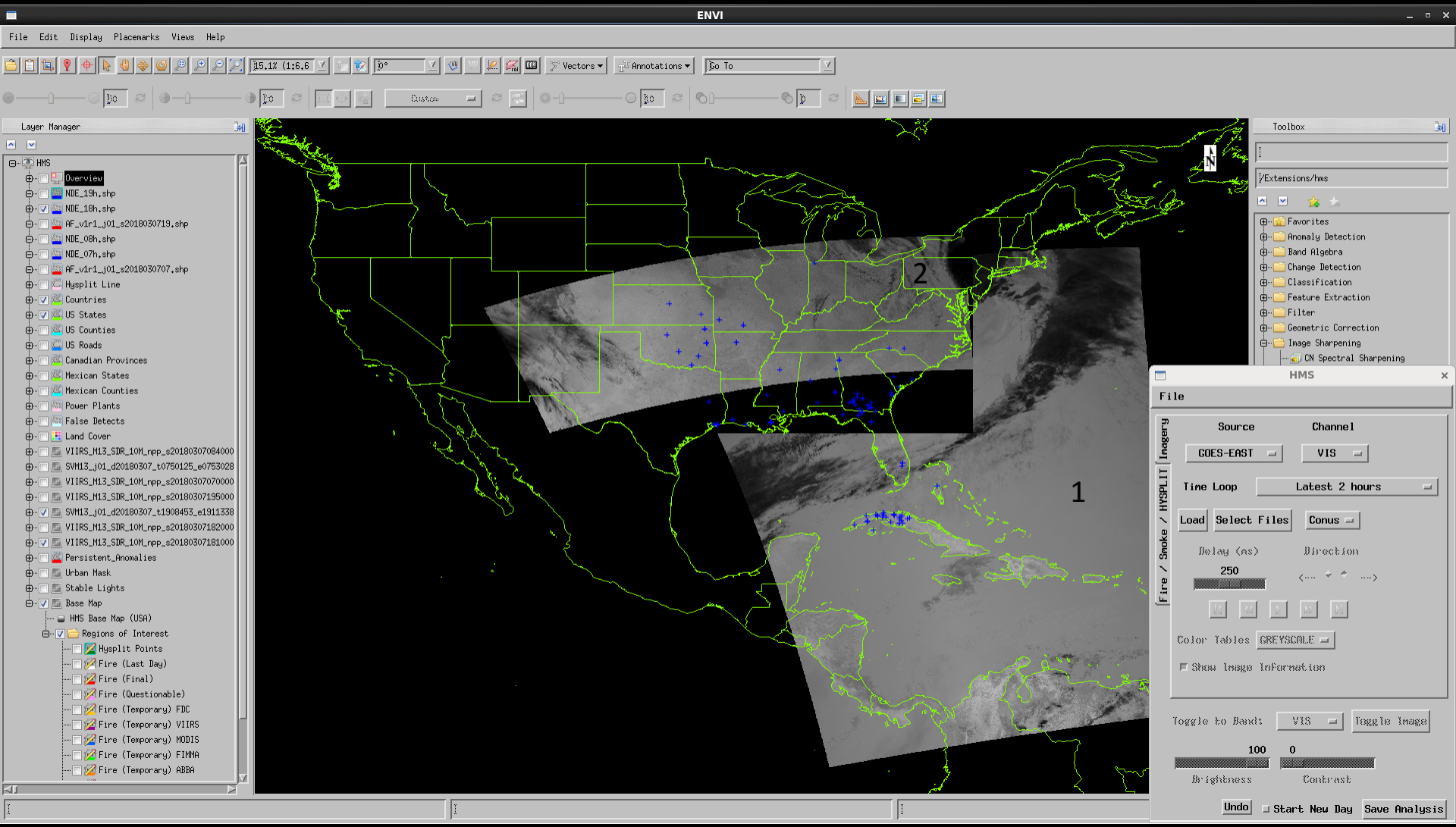


10-min granule

1: S-NPP/VIIRS 1810UTC

* S-NPP VIIRS 750m fire pixels

Hazard Mapping System
07 March 2018 – afternoon data



2x86sec granule

2: NOAA-20/VIIRS 1900UTC

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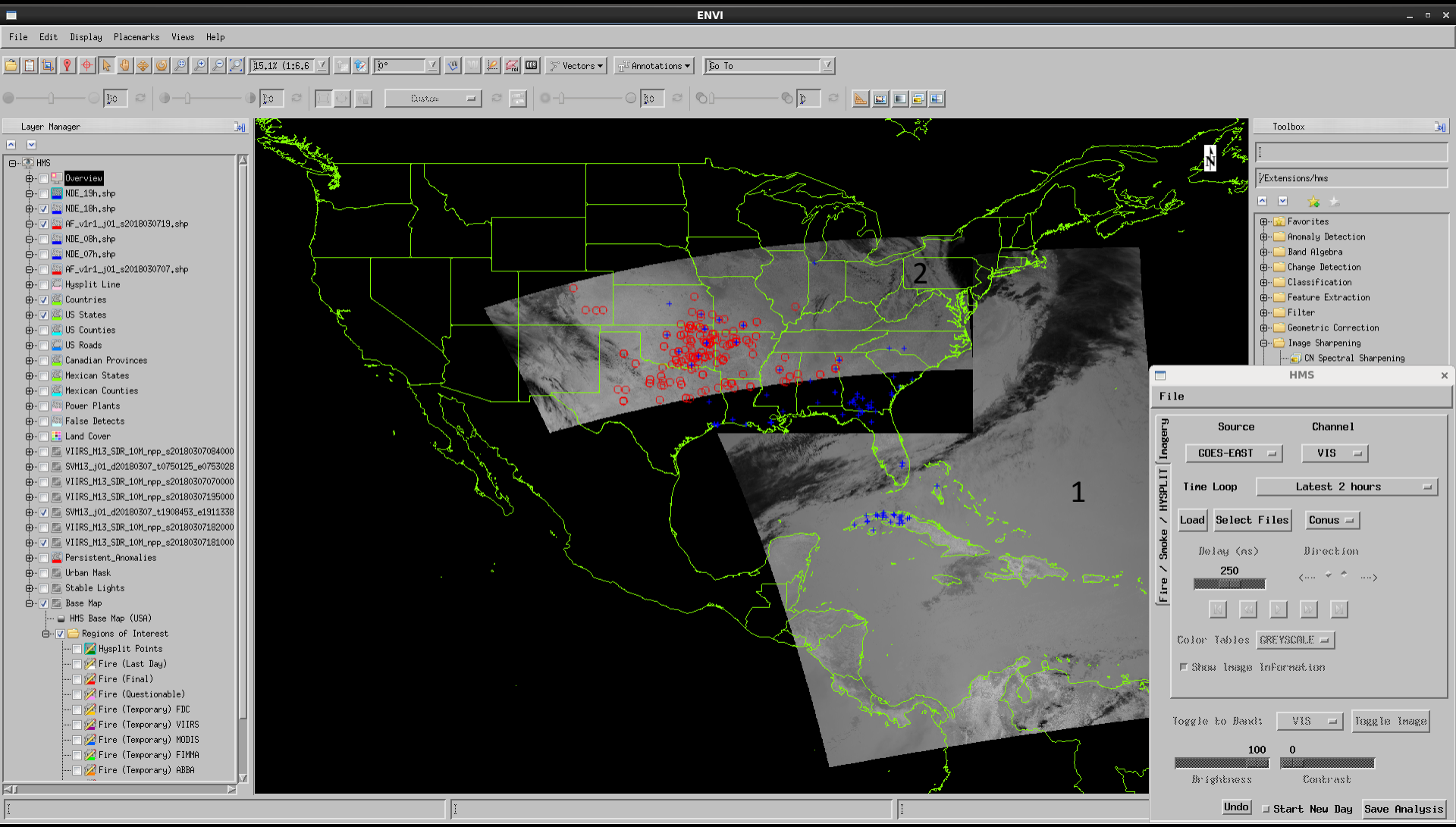

2x86sec granule

2: NOAA-20/VIIRS 1900UTC

* S-NPP VIIRS 750m fire pixels

o NOAA-20 VIIRS 750m fire pixels

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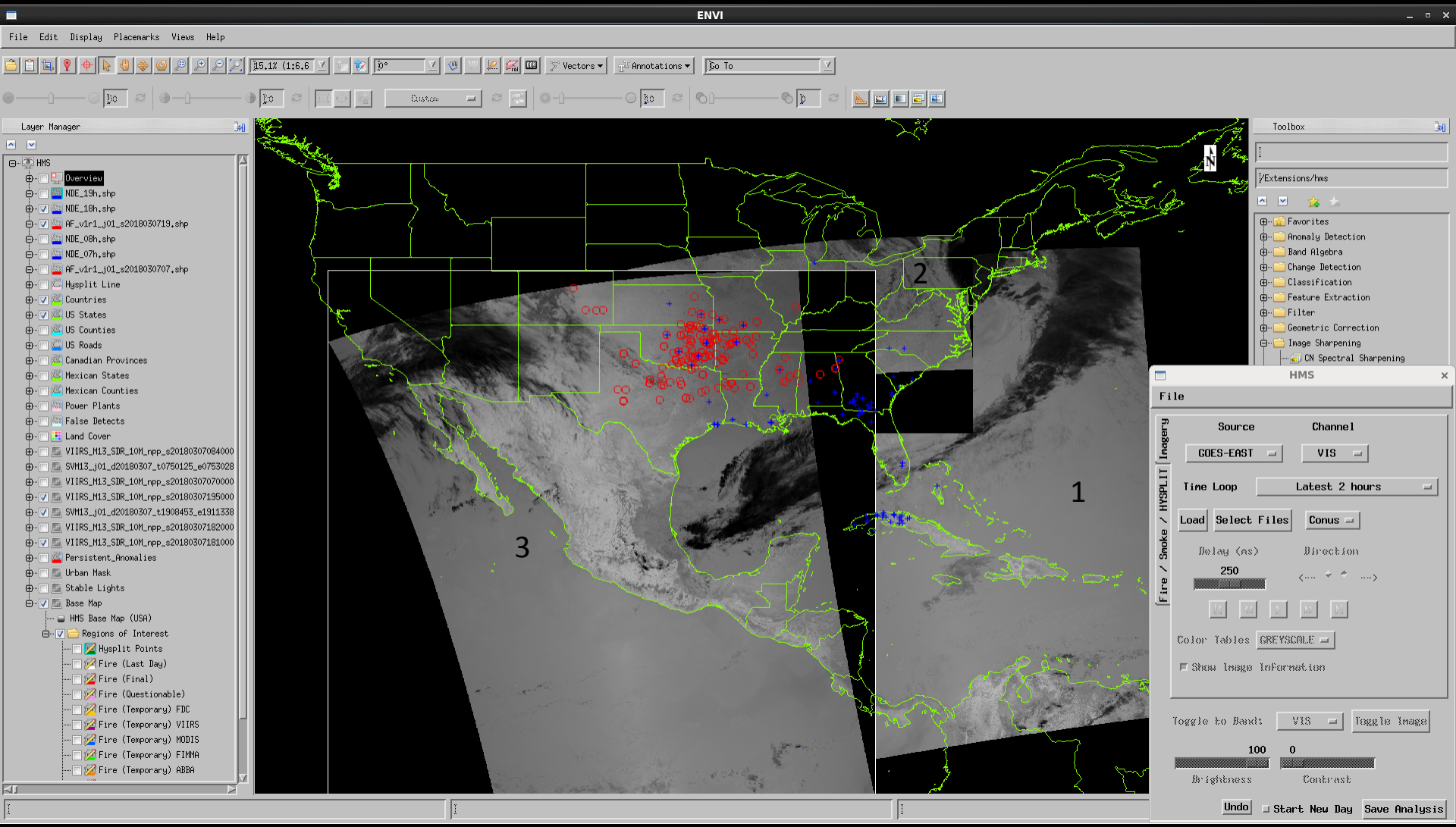
07 March 2018 – afternoon data



10-min granule

3: S-NPP/VIIRS 1950UTC

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o NOAA-20 VIIRS 750m fire pixels

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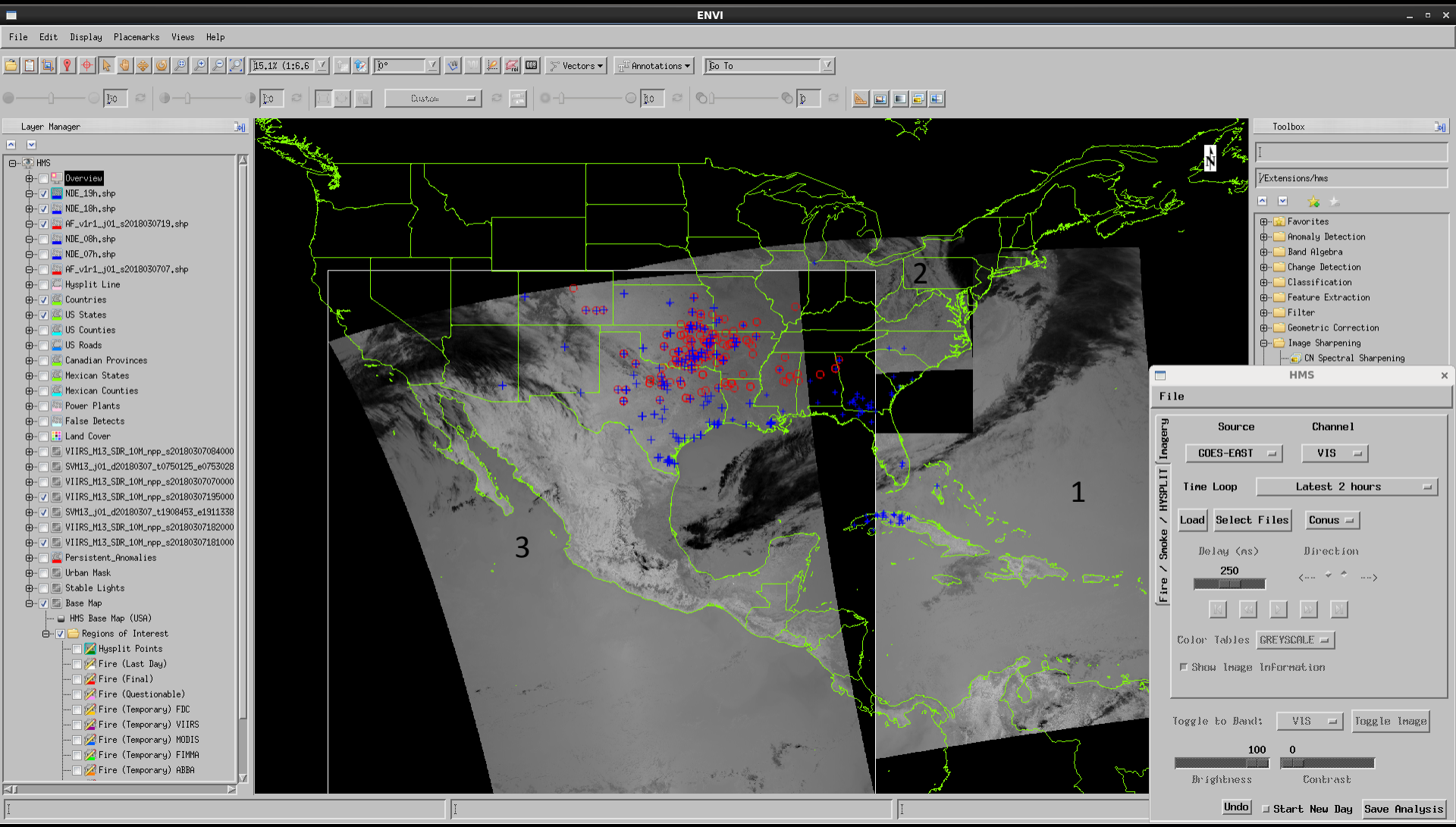
07 March 2018 – afternoon data



10-min granule

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Downstream Product Feedback

Algorithm	Product	Downstream Product Feedback - Reports from downstream product teams on the dependencies and impacts

No formal downstream products in the NDE / Enterprise system.

Risks, Actions, and Mitigations

Identified Risk	Action/Mitigation
Dependence on Risk Reduction package for granulated land-water mask	Ensure that NDE runs necessary components of the Risk Reduction package to avoid delay of operational implementation

Documentation

Science Maturity Check List	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)	In preparation
Peer Reviewed Publications (Demonstrates algorithm is independently reviewed)	Yes
Regular Validation Reports (at least. annually) (Demonstrates long-term performance of the algorithm)	

Conclusions

- Cal/Val results summary:
  - Team recommends algorithm Provisional maturity based on compatible performance to the corresponding Suomi NPP product
  - Larger sample (~3 months of global data) analyzed
- Prelaunch waiver impacts
  - No impact of pre-launch waivers foreseen and seen with in-orbit data
- 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

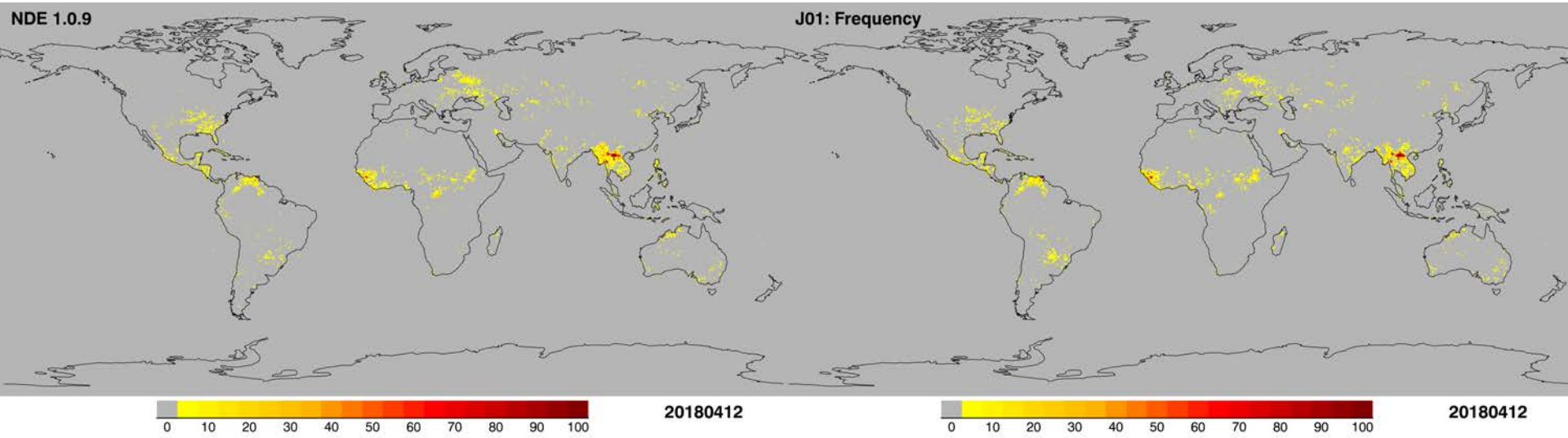
Path Forward (2/1)

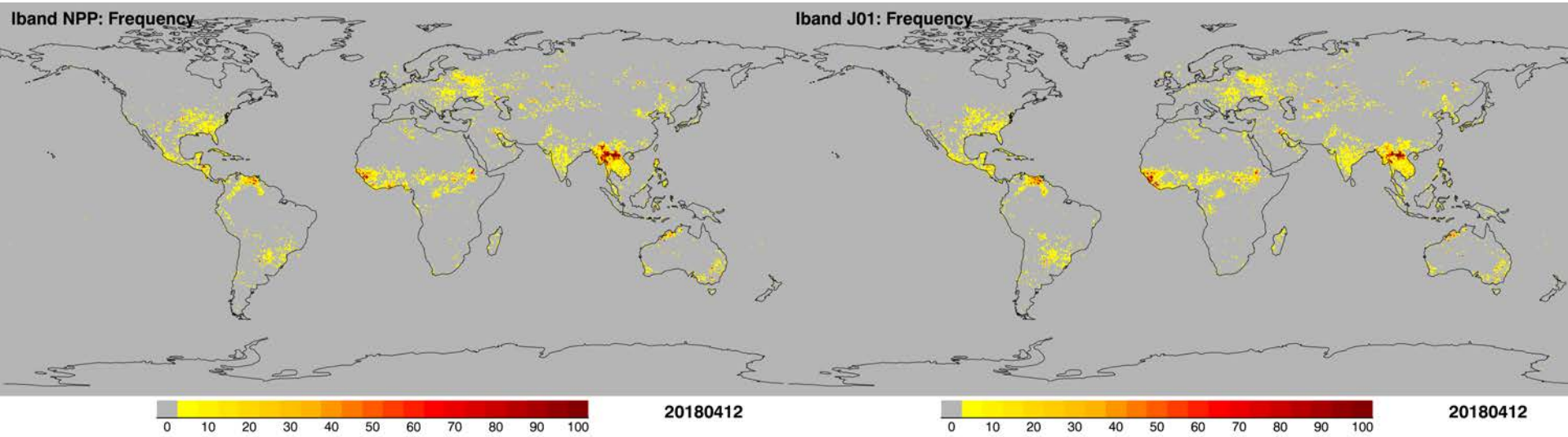
- 750m algorithm and product improvements
  - Edge effect (no complete windows for spatial heterogeneity test in first and last scan of the granule)
    - Re-configure processing to rolling triplets of granules
  - Conservative spatial heterogeneity tests
    - Further algorithm tuning
  - Conservative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

Path Forward (2/2)

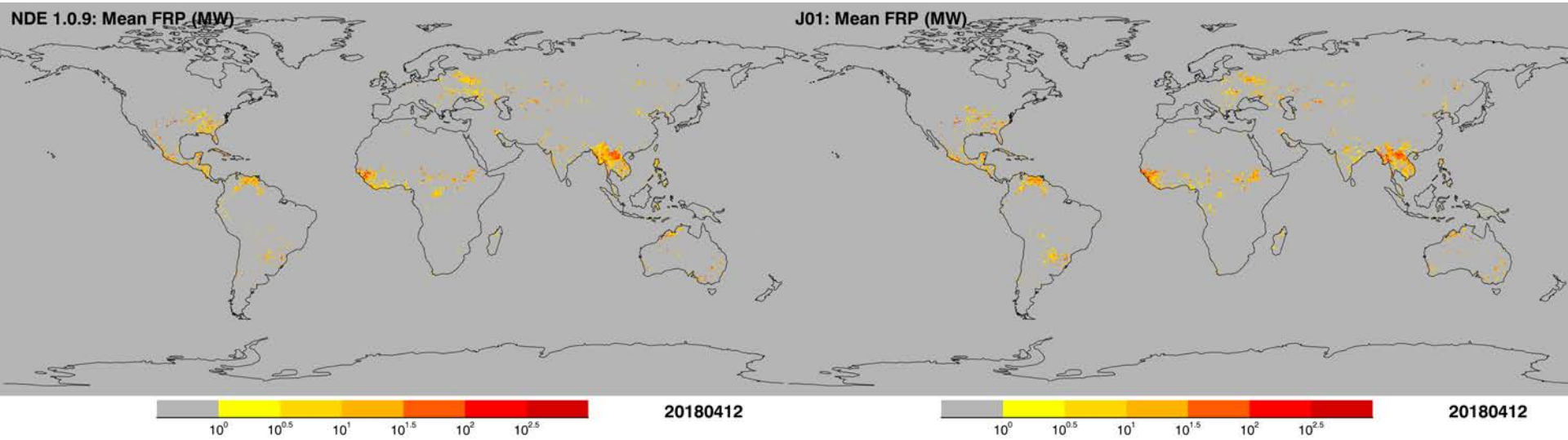
- 375m algorithm and product
  - Proven high quality performance
  - Continues to rely on M13 for FRP retrieval
  - Has been produced systematically in STAR's computing environment
  - CCR for requirement changed planned
    - Backed by NOAA Hazard Mapping System
    - HRRR-smoke evaluation ongoing
- Multi-satellite observing system
  - Enterprise algorithm elements
  - Leverage spatial and temporal coverage between polar and geostationary

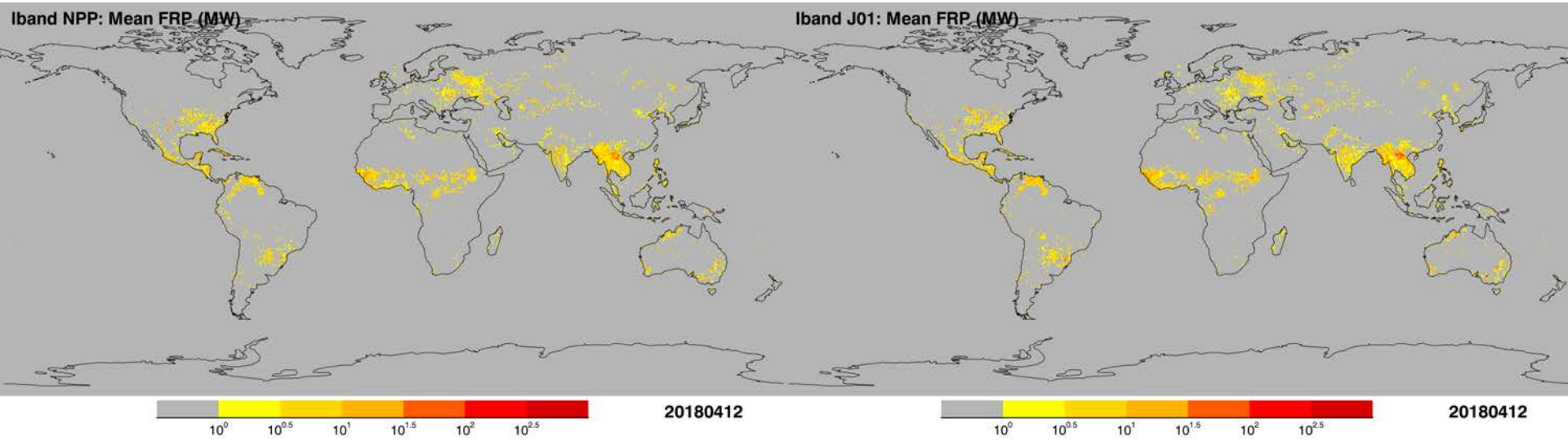
VIIRS 750m vs. 375m





Suomi NPP vs. NOAA-20: 750m





Suomi NPP vs. NOAA-20: 750m