Updates on Suomi-NPP, JPSS and GOES-R Fire Data Products

Ivan Csiszar, Lihang Zhou, Jaime Daniels
NOAA NESDIS Center for Satellite Applications and Research

Marina Tsidulko
I.M. Systems Group, Inc.

Wilfrid Schroeder, Louis Giglio, Evan Ellicott
University of Maryland, Department of Geographical Sciences

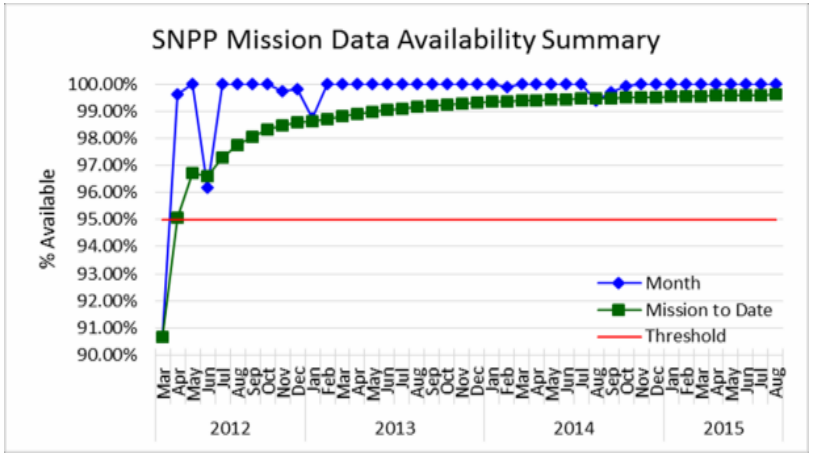
Chris Schmidt
University of Wisconsin - Madison

additional credits are given on select slides

JPSS Status Overview

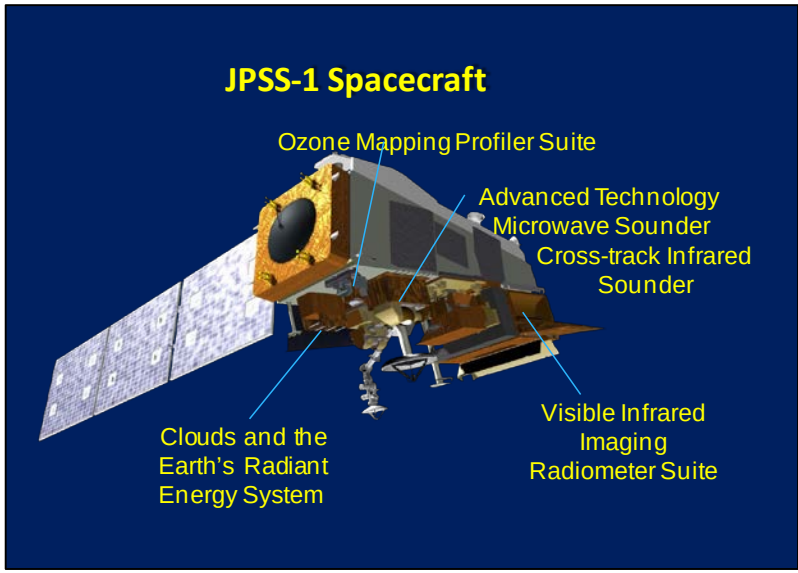
Suomi NPP

- Launched on October 28, 2011
- Primary PM for weather since May 1, 2014
- Excellent health and data availability



JPSS-1

- Integrated satellite in test phase
- On track for 2017 launch (NET March)
- 7-year mission lifetime
- 96-min mission data latency (photons -> NWS)
- Stored Mission Data capacity ~6 orbits



JPSS-2

- Instrument parts/assembly phase
- Spacecraft kick-off phase

JPSS-3/4 continuity until 2038

(Slide Curtsey of Lihan Zhou, STAR)

SNPP/JPSS-1/2/3/4 Carry Similar Instruments for Continuity of Observations

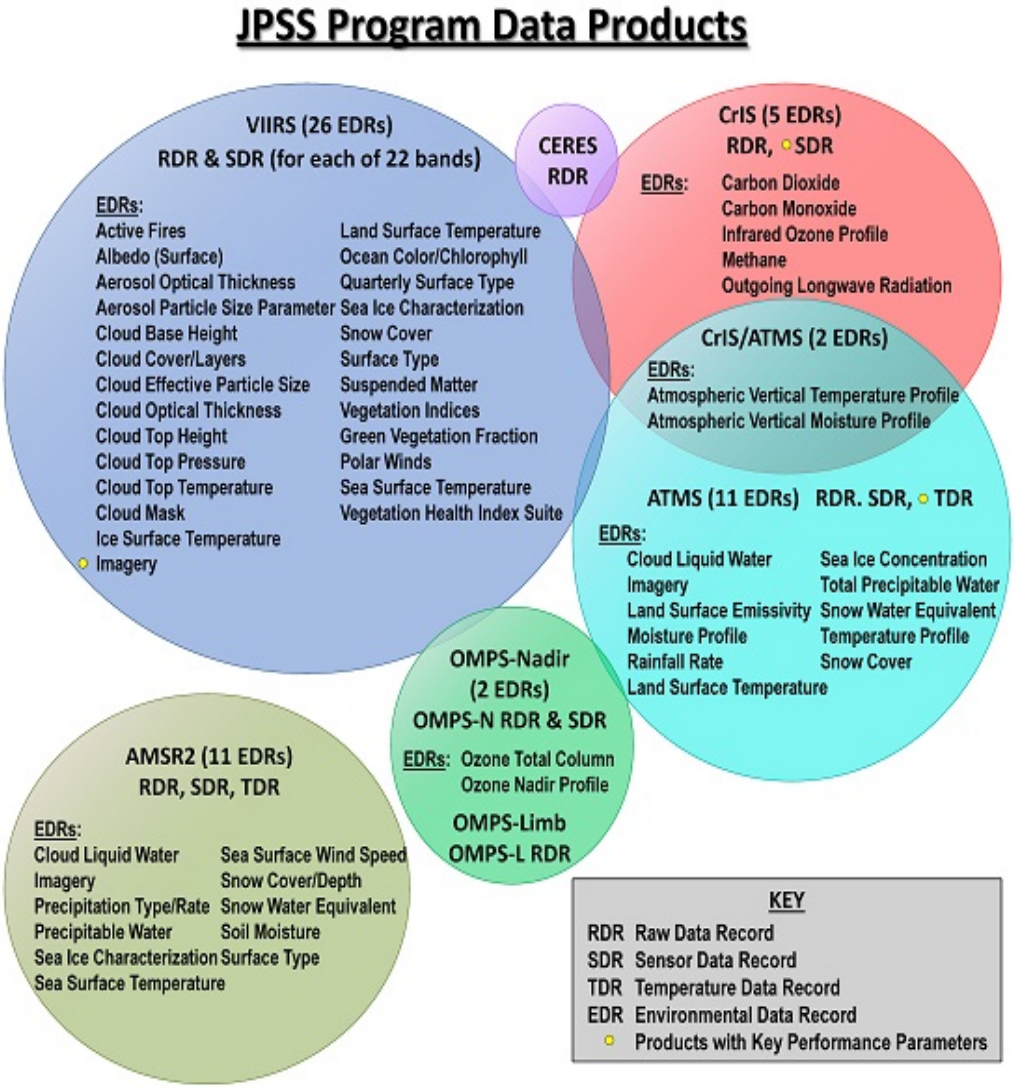
JPSS-1 status

- Launch expected NET mid-March 2017
- A larger ground system provides the following:
  - Half orbit dumps in both polar regions (Svalbard and McMurdo)
  - A full backup instantiation in Fairmont, WV for continuity of operations
  - Redundancy at the primary site (NSOF – Suitland, MD)
  - The ability to use TDRSS (Tracking and Data Relay Satellite System) for additional critical telemetry/command control and capability for receiving stored mission data
- Products/data will be made available in phases based on the calibration/validation schedule; emphasis is on KPP products first.

(Slide Curtsey of NESDIS/OSPO/Chris Sisco)

JPSS-1 Instruments and Products

JPSS Instruments	Measurements
ATMS - Advanced Technology Microwave Sounder	ATMS and CrIS together provide high vertical resolution temperature and water vapor information needed to maintain and improve forecast skill out to 5 to 7 days in advance for extreme weather events, including hurricanes and severe weather outbreaks
CrIS - Cross-track Infrared Sounder	
VIIRS – Visible Infrared Imaging Radiometer Suite	VIIRS provides many critical imagery products including snow/ice cover, clouds, fog, aerosols, fire, smoke plumes, vegetation health, phytoplankton abundance/chlorophyll
OMPS - Ozone Mapping and Profiler Suite	Ozone spectrometers for monitoring ozone hole and recovery of stratospheric ozone and for UV index forecasts
CERES - Clouds and the Earth's Radiant Energy System	Scanning radiometer which supports studies of Earth Radiation Budget (ERB)

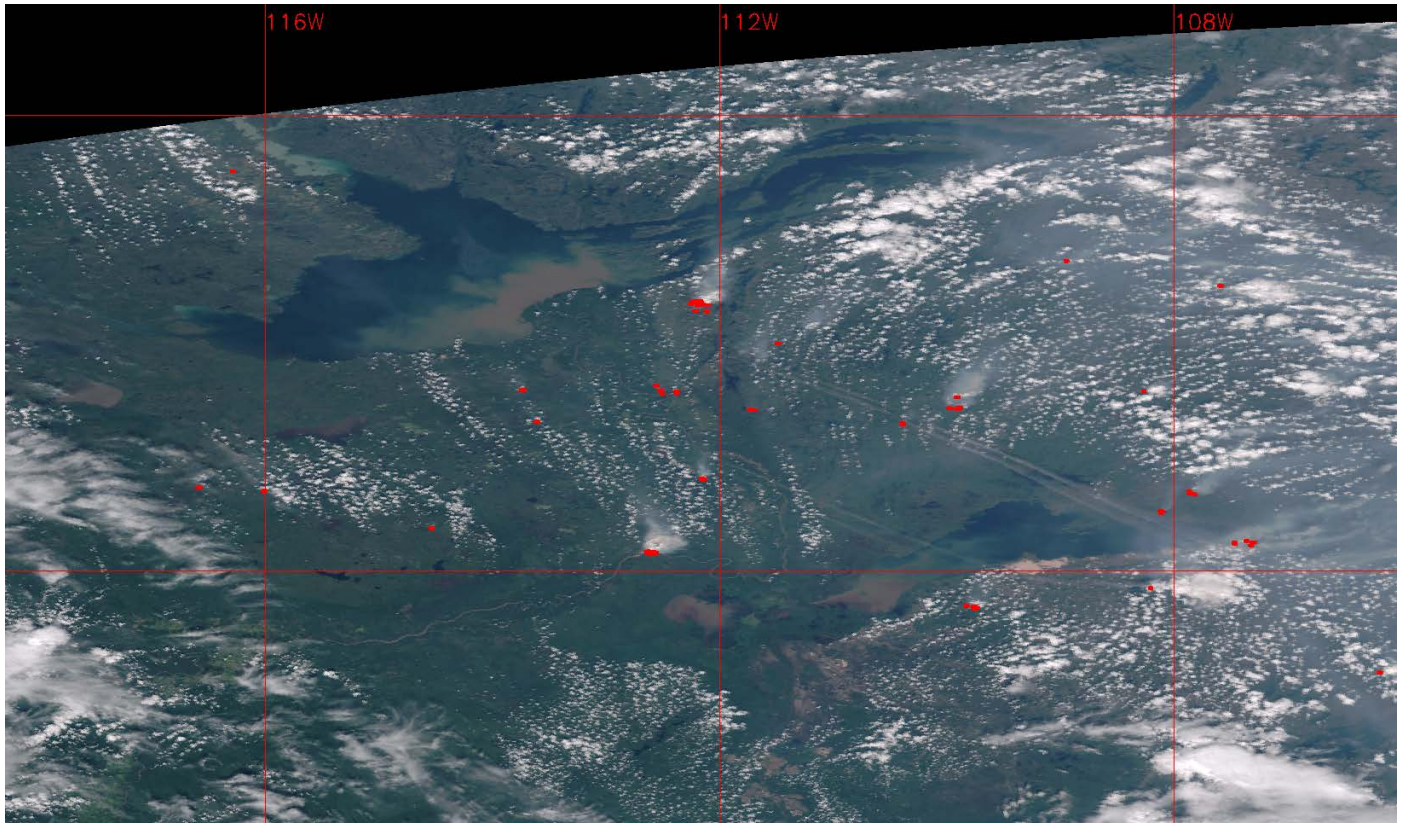


(Slide Curtsey of NJO / Lihan Zhou, STAR)

Data available through PDA , CLASS, and Direct Readout

Background of VIIRS IDPS* Active Fire Product

- VIIRS represents **continuity** with NASA EOS **MODIS** and NOAA POES **AVHRR** fire detection (and also international missions such as (A)ATSR
- VIIRS **design allows for radiometric measurements** to detect and characterize active fires over a wide range of observing and environmental conditions
- The VIIRS fire product is expected to be used by **real-time resource and disaster management; air quality monitoring; ecosystem monitoring; climate studies** etc.
- **IDPS product is a sparse array of lan/lon or fire pixels** and row/column and quality flag



*Interface Data Processing Segment (operational NOAA Production system; **only KPPs going forward**)

NW Canada
07 July 2013
20:14:55-20:20:34 UTC

NOAA Operational VIIRS Fire Product Status (2/1)

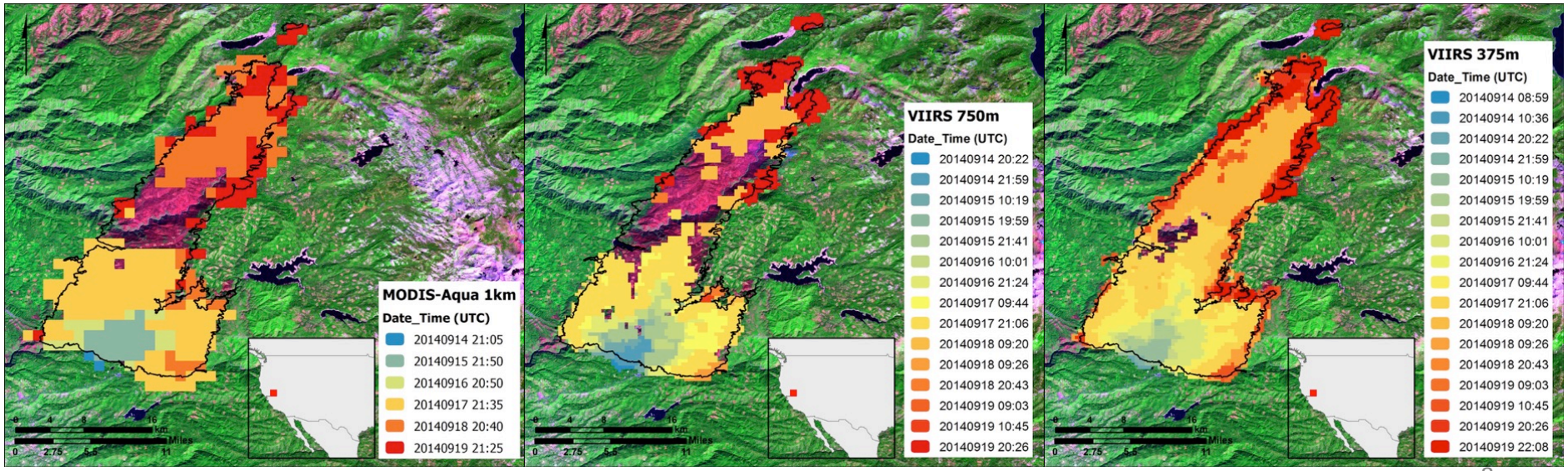
- Tailored version of the M-band UMD / NASA ST algorithm operational within the Suomi NPP Data Exploitation (NDE) system since March 15, 2016
  - includes fire mask and fire radiative power (FRP)
- Data available from OSPO in simplified text and other formats
  - ftp://satepsanone.nesdis.noaa.gov/FIRE/VIIRS/
- Data available from CLASS (http://www.class.ncdc.noaa.gov/)
  - ftp interface at ftp://ftp-npp.class.ngdc.noaa.gov/
    - pick the date, then to the folder NDE-L2/VIIRS-Active-Fire-EDR-NOAA-Enterprise-Algorithm/
  - ordering capability through the Web interface also available
  - all operational data from March 16, 2016 have been backfilled from the STAR archive
- Long-term quality monitoring ongoing (including both NDE and IDPS products)
    - https://www.star.nesdis.noaa.gov/jpss/EDRs/products_activeFires.php

NOAA Operational VIIRS Fire Product Status (2/2)

- Ongoing integration into NOAA operational and experimental systems e.g.
  - Hazard Mapping System
  - eIDEA – extended Infusing Satellite Data into Environmental Applications
    - http://www.star.nesdis.noaa.gov/smcd/spb/aq/eidea/
  - NWS Advanced Weather Interactive Processing System (AWIPS-II)
  - High Resolution Rapid Refresh (HRRR) http://rapidrefresh.noaa.gov/HRRRsmoke/
- IDPS production, long-term monitoring and maintenance until all downstream products in NDE / NOAA ESPC Enterprise system
- Other ongoing activities:
  - JPSS-1 testing / preparations
  - preparations for VIIRS SDR reprocessing
  - code integration into CSPP (Community Satellite Processing Package)
  - work towards UMD / NASA I-band / hybrid product transition to operations
  - end user interaction / support - NOAA JPSS Fire and Smoke Initiative
    - RealEarth™ – Google Maps etc.

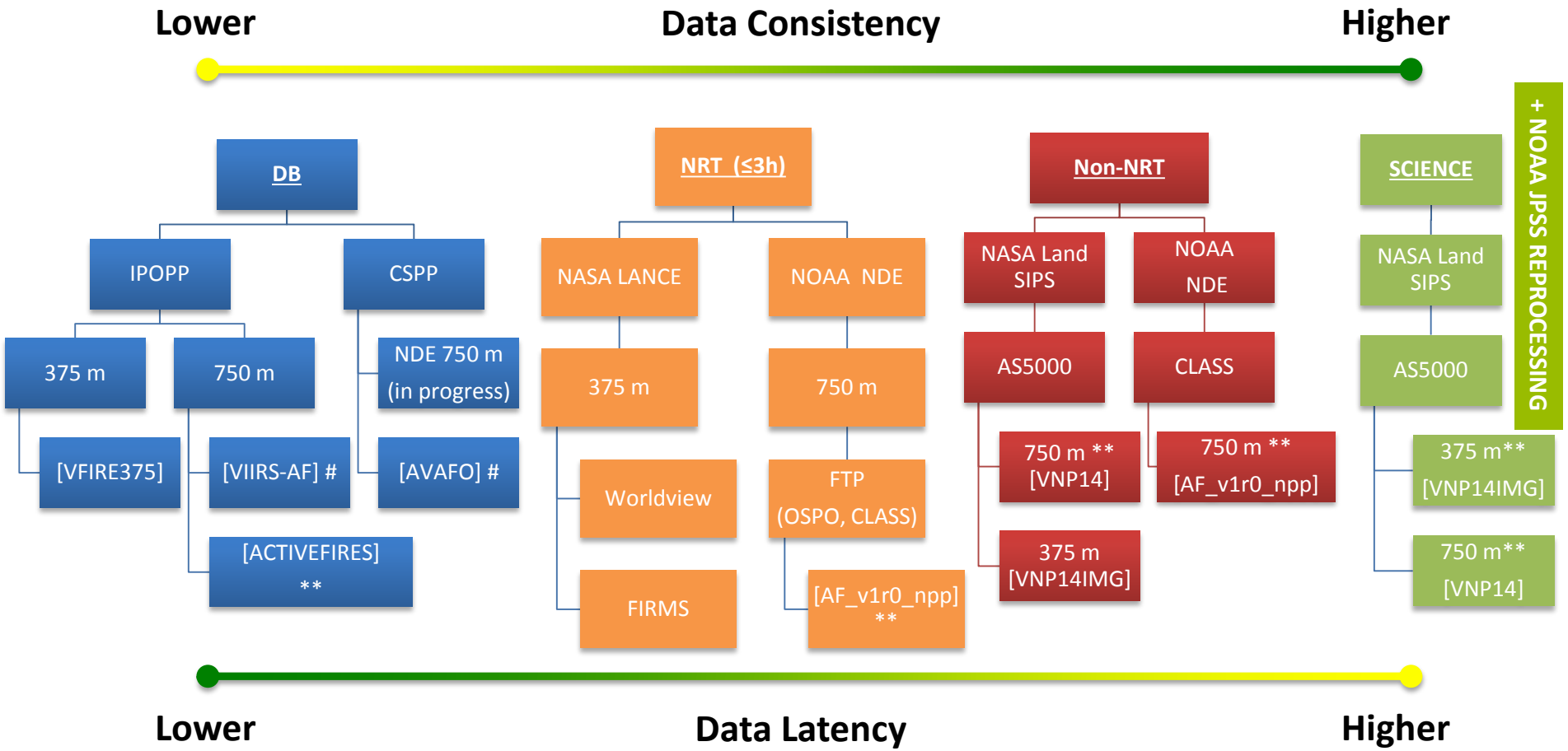
UMD/NASA VIIRS Active Fire Product Update

- Baseline **750 m active fire product** built on MODIS Collection 6 algorithm
  - L2 product basis for NOAA NDE
  - Small customization performed in order to account for unique L1B data
  - Fire detection and characterization (fire radiative power)
  - Output format supporting MODIS-VIIRS data continuity
- Alternative **375 m active fire product** developed
  - Unique algorithm optimizing use of channel I4 (MIR) data (frequent saturation, folding)
  - First version produced fire detections only
  - Latest version providing fire detection and FRP
    - Hybrid approach using 375 and 750 m data
  - Output format supporting MODIS-VIIRS data continuity



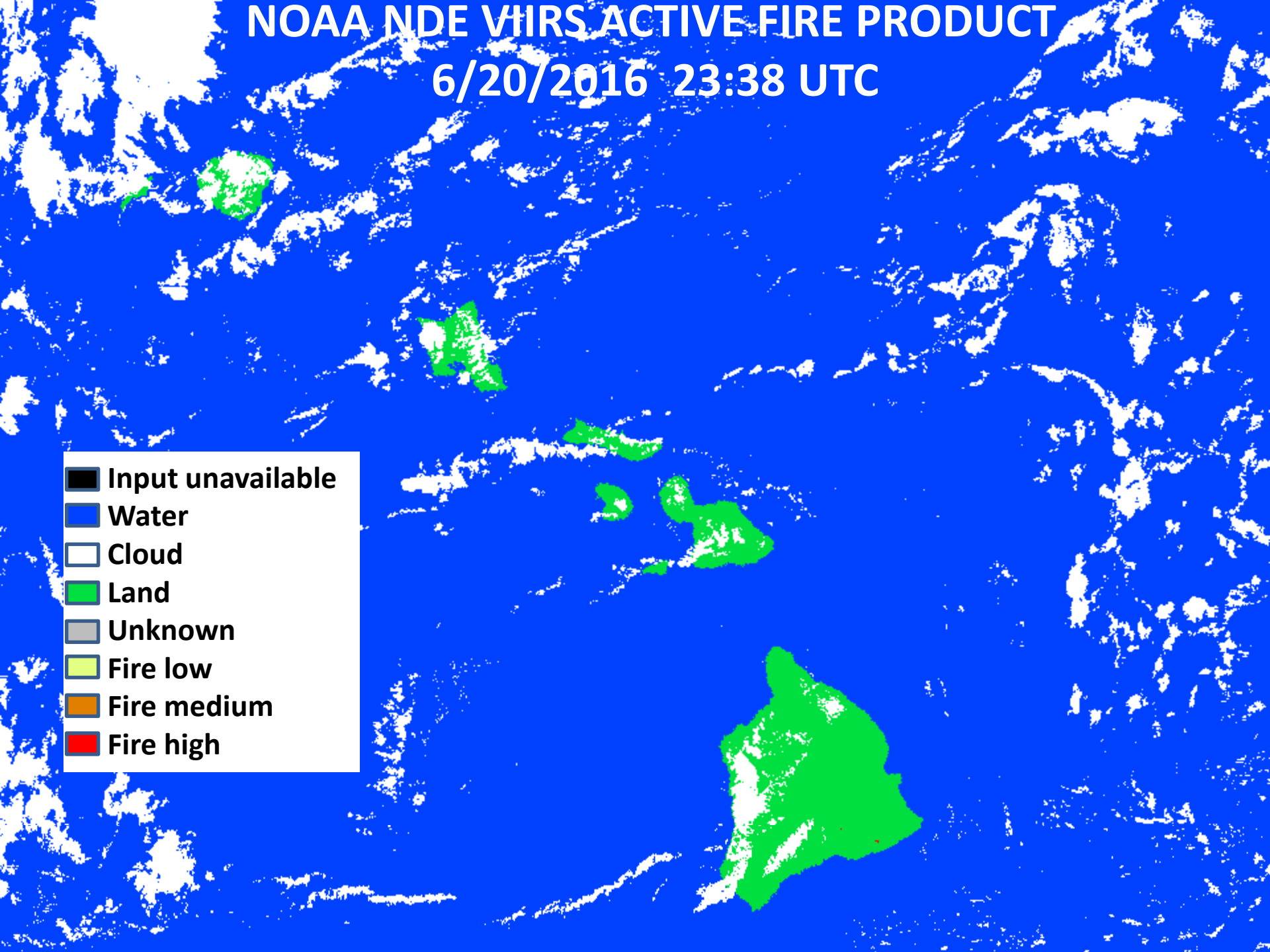
King Fire/CA, September 2014

VIIRS Active Fire Product Lineage



pattern indicates this directory is outdated
** marked products include FRP retrieval
# marked products describe discontinued algorithm
[ ] indicate official product name

Details soon to be available at:
http://viirsfire.geog.umd.edu/


NOAA NDE VIIRS ACTIVE FIRE PRODUCT
6/20/2016 23:38 UTC
Input unavailable
Water
Cloud
Land
Unknown
Fire low
Fire medium
Fire high

NDE output file content

Name	Description	Type
fire mask	Fire mask 2D array (unit-less)	8 bit int
algorithm QA	Fire algorithm QA mask 2D array (unit-less)	32 bit Int
FP_line	Fire pixel line Sparse data array	16 bit Int
FP_sample	Fire pixel sample Sparse data array	16 bit Int
FP_latitude	Fire pixel latitude Sparse data array (deg)	32 bit Float
FP_longitude	Fire pixel longitude Sparse data array (deg)	32 bit Float
FP_power	Fire radiative power Sparse data array (MW)	32 bit Float
FP_confidence	Fire detection confidence Sparse data array (%)	8 bit Int
FP_land	Land pixel flag Sparse data array	8 bit Int

Total output for one granule: 11.7 Mb
+ number of fires * 79 bytes

Missing – 0	Brightness temperatures for M13 or M15 unavailable
Scan – 1	Not processed (trim)
Other – 2	Not processed (other reason)
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%

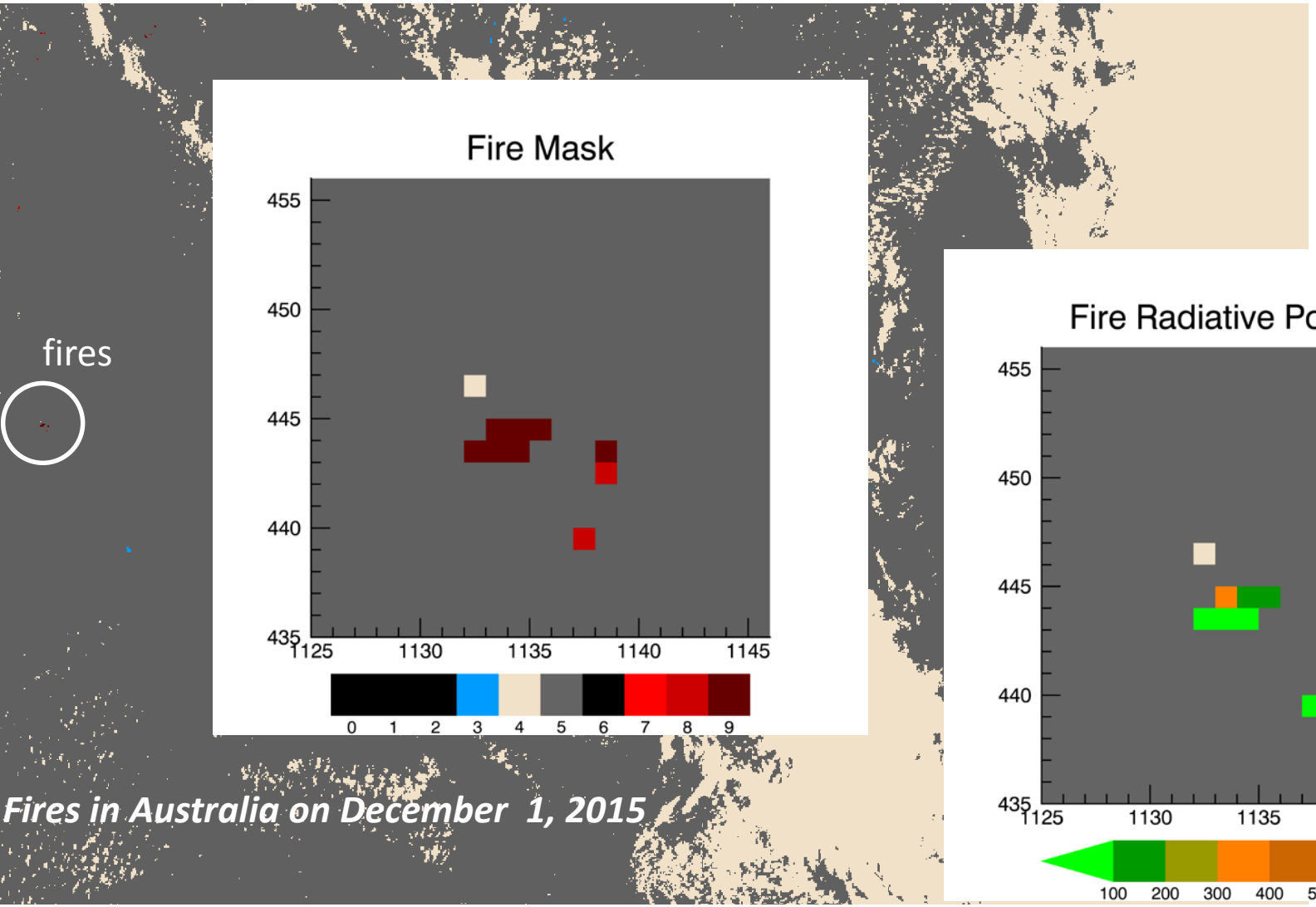
0-1	Surface Type (water=0, coastal=1, land=2)
2-3	Atmospheric correction (reserved for future use)
4	Day/Night (daytime = 1, nighttime = 0)
5	Potential fire (0/1)
6-10	Background window size parameter
11	Fire Test 1 valid (0 - No, 1 - Yes)
12	Fire Test 2 valid (0 - No, 1 - Yes)
13	Fire Test 3 valid (0 - 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	N/A
20	Adjacent clouds (0/1)
21	Adjacent water (0/1)
22-23	Sun Glint Level (0-3)
24	Sun glint rejection
25	False Alarm 1 (excessive rejection of legitimate background pixels)
26	False Alarm 2 (water pixel contamination)
27	Amazon forest-clearing rejection test
28-31	N/A

NDE VIIRS Fire Text Output* Example

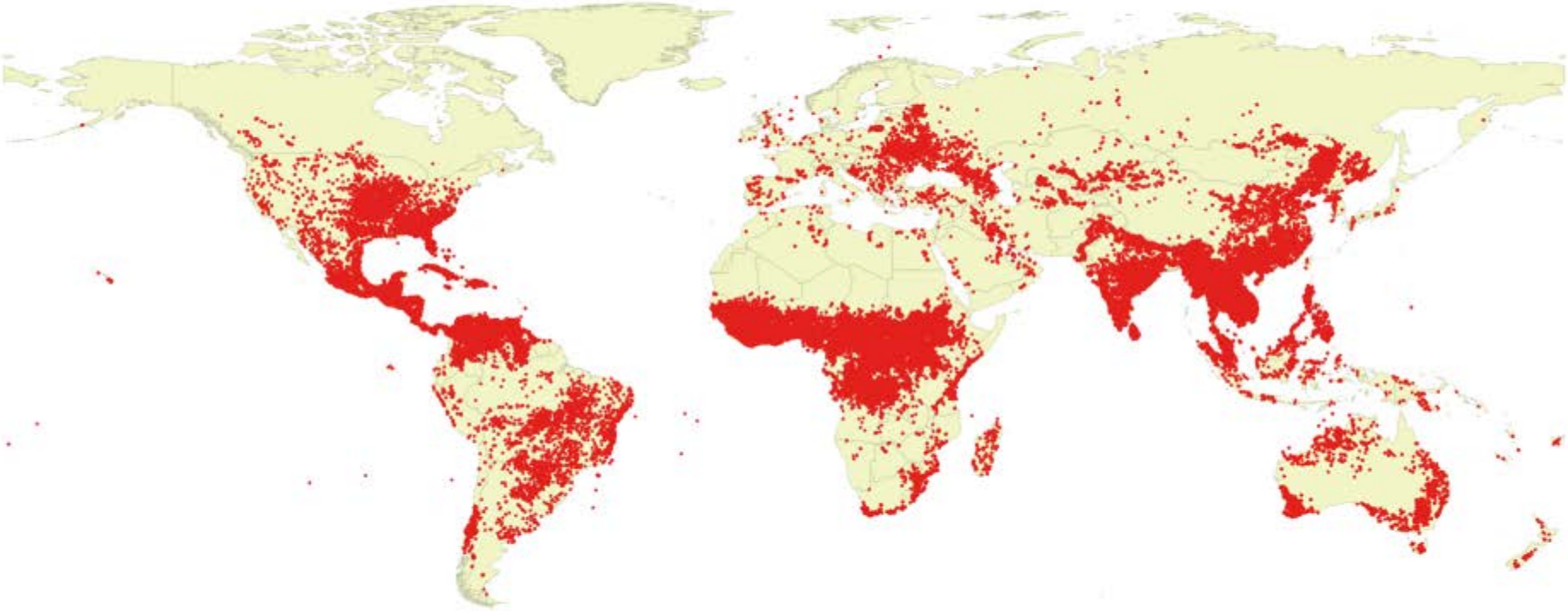
year,month,day,hh,mm,lon,lat,mask,confidence,bright_t13,frp,line,sample
2016, 06, 30, 13, 31, 14.393053, -16.983391, 8, 57, 316.378326, 28.955824, 75, 114
2016, 06, 30, 13, 31, 14.396797, -16.972019, 8, 53, 339.941559, 77.328888, 84, 113
2016, 06, 30, 13, 31, 14.384778, -16.974693, 8, 69, 344.900421, 97.380959, 84, 114
2016, 06, 30, 13, 31, 14.405772, -16.956085, 8, 44, 313.854004, 19.589737, 85, 112
2016, 06, 30, 13, 31, 14.393543, -16.958811, 8, 37, 321.766541, 32.511524, 85, 113
2016, 06, 30, 13, 31, 15.573229, -15.742855, 8, 49, 306.925323, 23.677296, 228, 4
2016, 06, 30, 13, 31, 14.185258, -15.916477, 8, 69, 310.967590, 21.830891, 246, 103
2016, 06, 30, 13, 31, 14.688642, -15.625280, 8, 64, 327.718658, 63.247353, 267, 60
2016, 06, 30, 13, 31, 14.691998, -15.618657, 8, 55, 321.560547, 41.713535, 276, 59
2016, 06, 30, 13, 31, 14.678295, -15.621688, 8, 75, 358.754883, 197.803665, 276, 60
2016, 06, 30, 13, 31, 14.688756, -15.604889, 8, 42, 314.810394, 27.194593, 277, 59
2016, 06, 30, 13, 31, 14.675403, -15.607850, 9, 88, 332.556183, 75.214859, 277, 60
2016, 06, 30, 13, 31, 14.976258, -14.989869, 8, 72, 312.135651, 30.420597, 358, 26
2016, 06, 30, 13, 31, 14.554691, -12.548762, 8, 56, 314.716003, 35.709991, 731, 5
2016, 06, 30, 13, 31, 14.559263, -12.547178, 8, 57, 314.763763, 35.436863, 740, 4
2016, 06, 30, 13, 31, 14.450356, -12.540216, 8, 74, 313.761322, 33.999859, 742, 11
2016, 06, 30, 13, 31, 14.410105, -12.396758, 8, 47, 311.148468, 25.756071, 761, 11

Text output files are not part of the core NDE production, but are generated by OSPO and STAR.

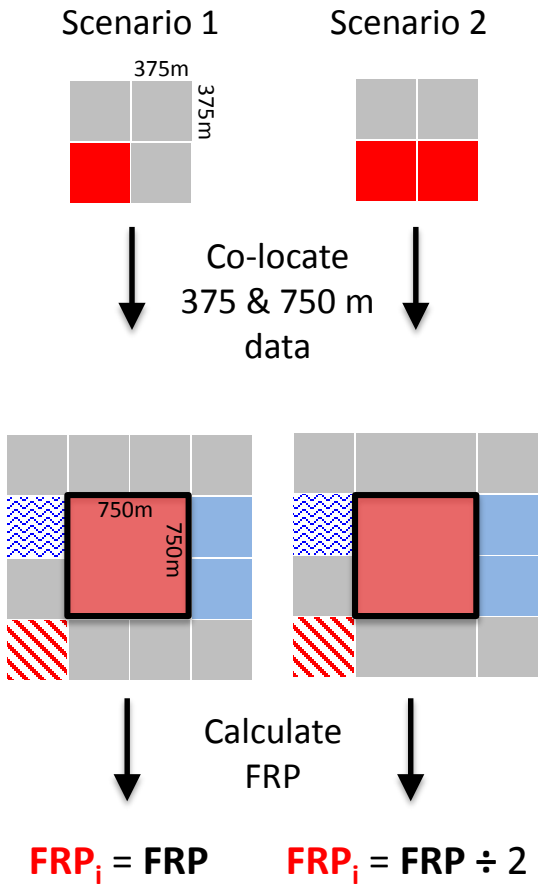
Characterizing Fires: confidence and radiative power

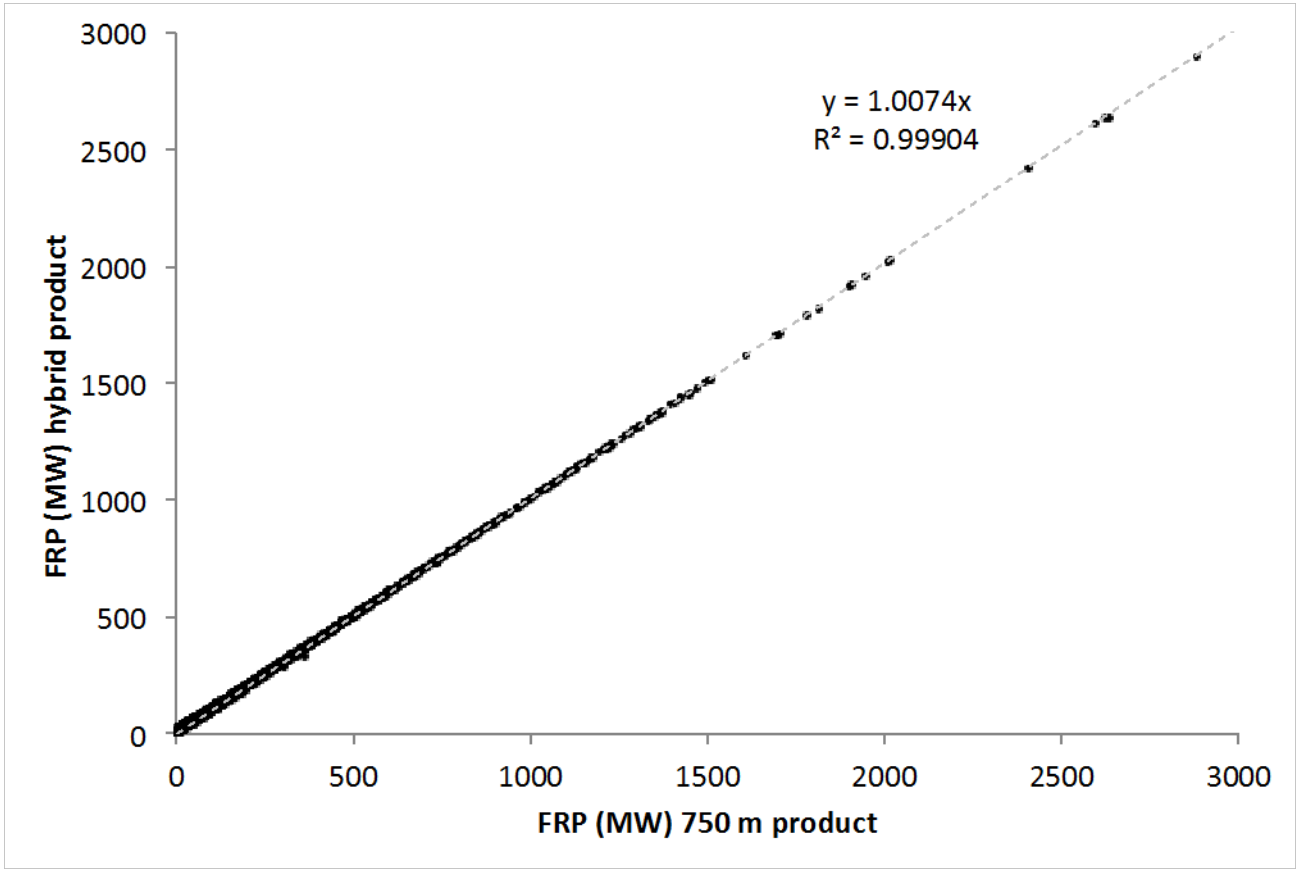


VIIRS 750 m Fire Pixels (March 2016)
VAFIRE_L2D (consistent with NOAA JPSS NDE)

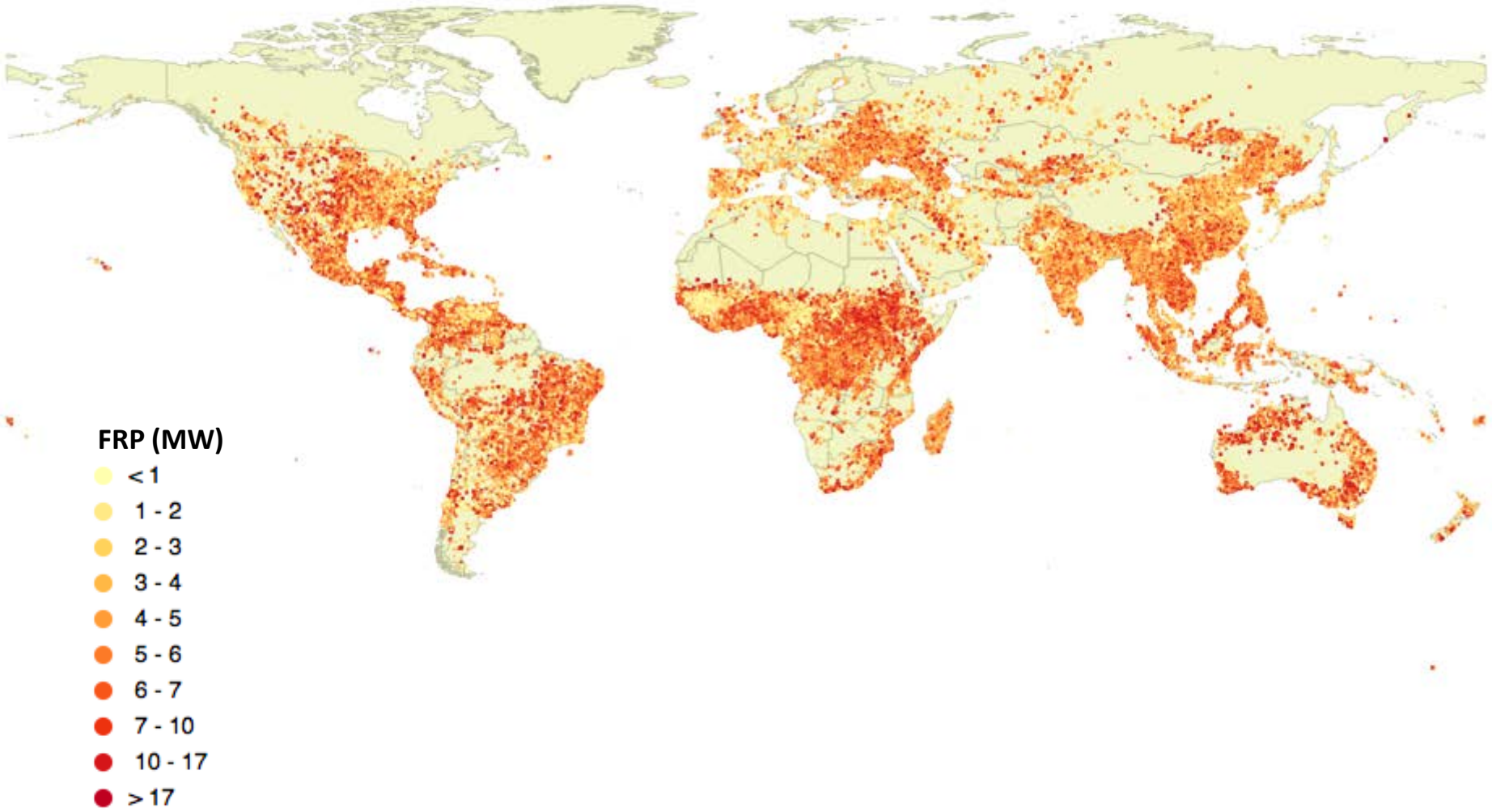


Hybrid (375+750m) FRP Retrieval





VIIRS 375m (hybrid) Fire Pixels (March 2016)
'Collection 2'

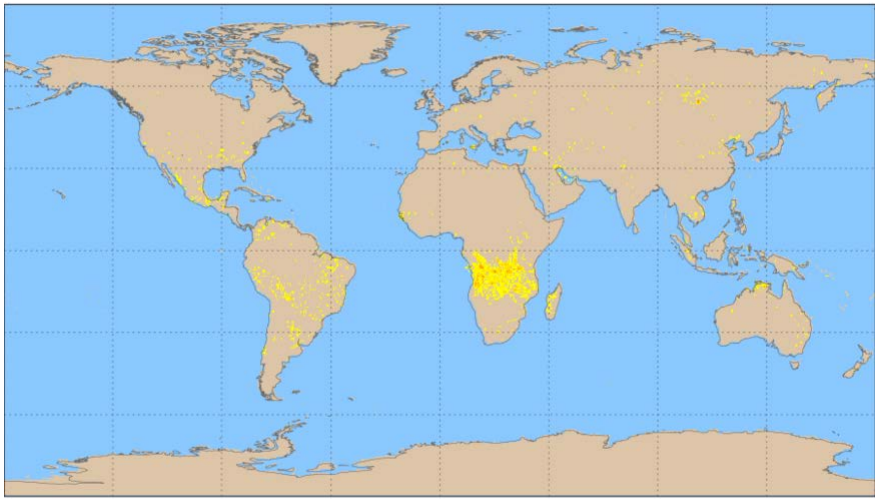


VIIRS Active Fire Long-term Monitoring

http://www.star.nesdis.noaa.gov/jpss/EDRs/products_activeFires.php

Suomi NPP - VIIRS - NDE - Active Fires

16 Jun 2016



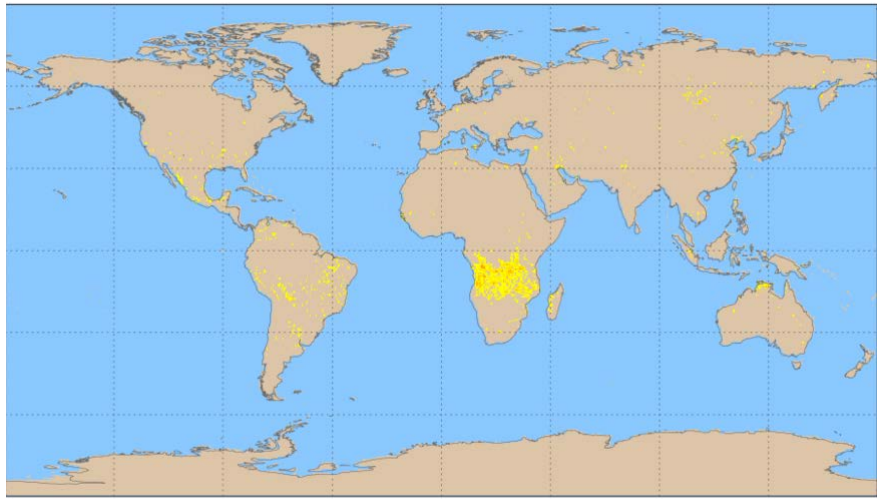
0 10 20 30 40 50 60 70 80 90 100

Fire Frequency

NOAA/NESDIS/STAR

Suomi NPP - VIIRS - IDPS - Active Fires

16 Jun 2016



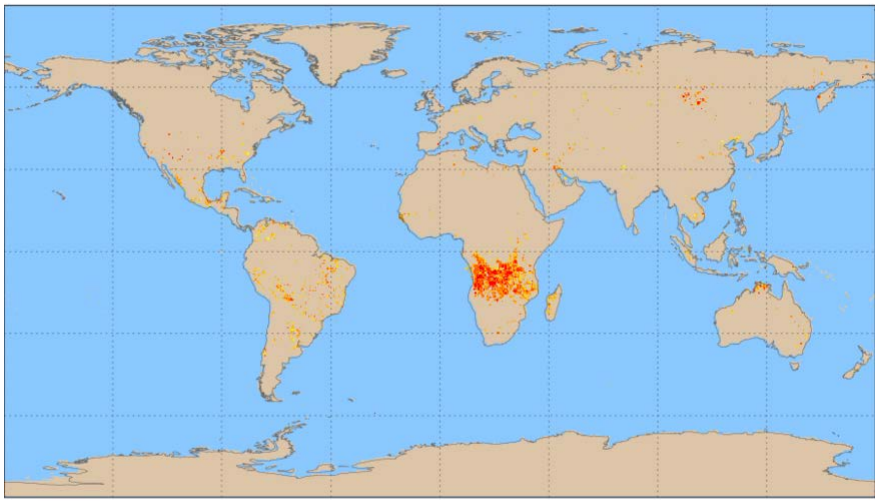
0 10 20 30 40 50 60 70 80 90 100

Fire Frequency

NOAA/NESDIS/STAR

Suomi NPP - VIIRS - NDE - Fire Radiative Power - Total

16 Jun 2016



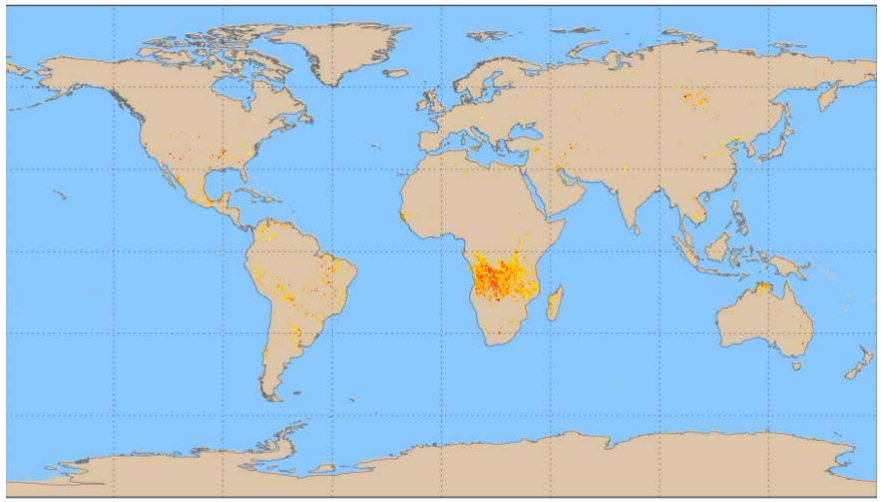
0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5

$\log_{10}$ (Megawatts)

NOAA/NESDIS/STAR

Suomi NPP - VIIRS - NDE - Fire Radiative Power - Mean

16 Jun 2016

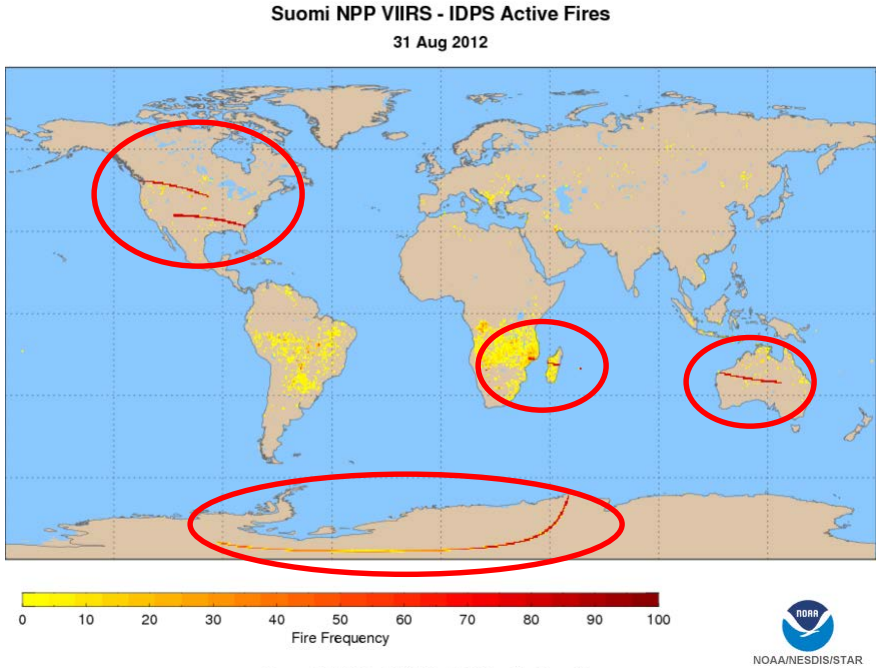


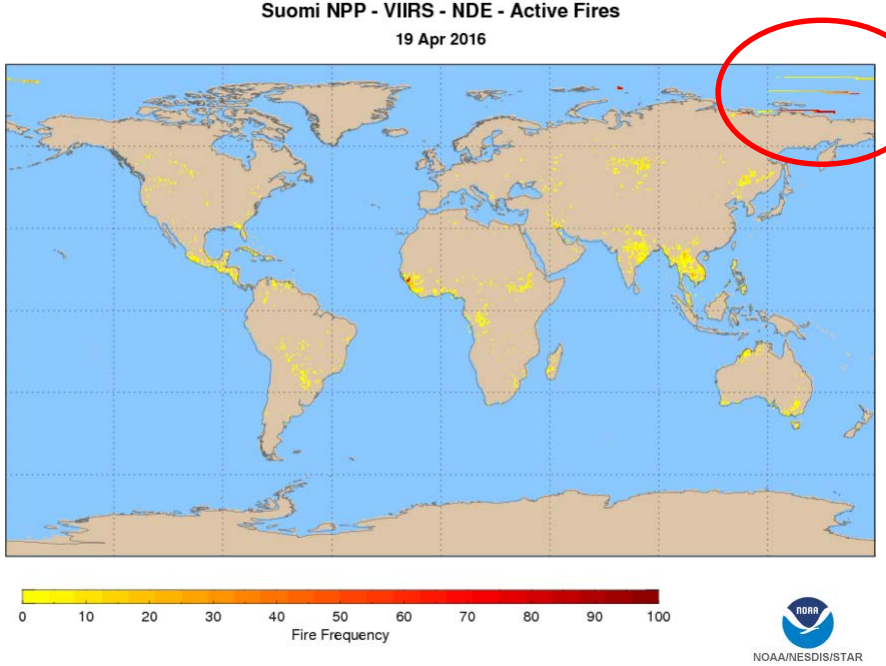
0.0 0.50 1.0 1.5 2.0 2.5

$\log_{10}$ (Megawatts)

NOAA/NESDIS/STAR

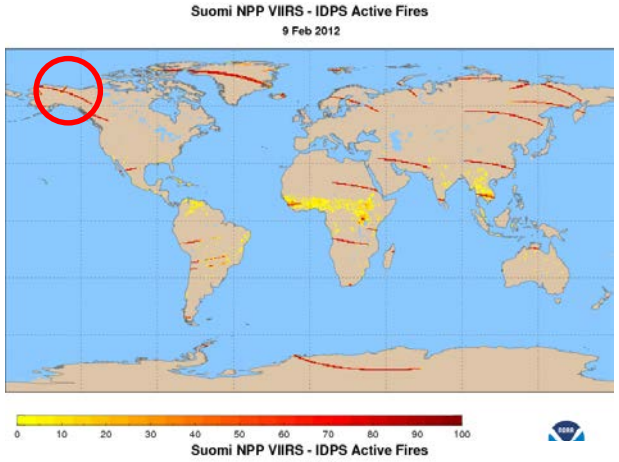
Examples of IDPS and NDE VIIRS fire product anomalies

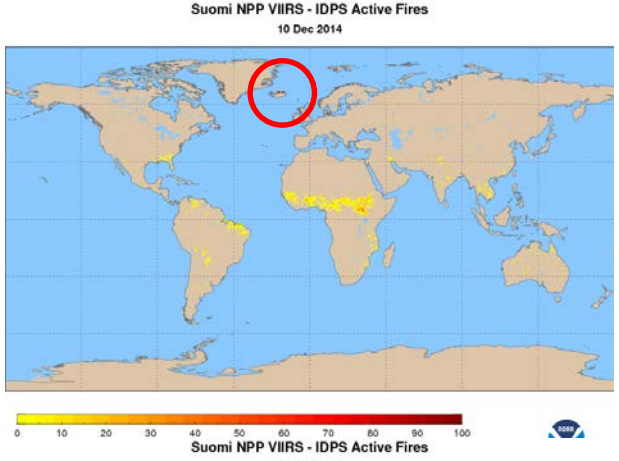


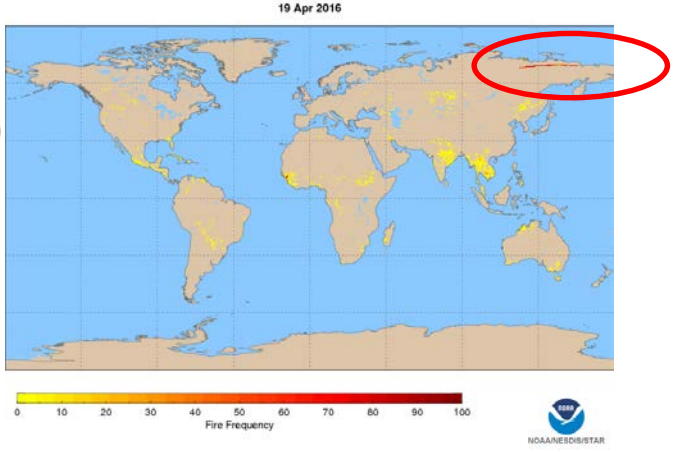


along-scan
(most anomalies)

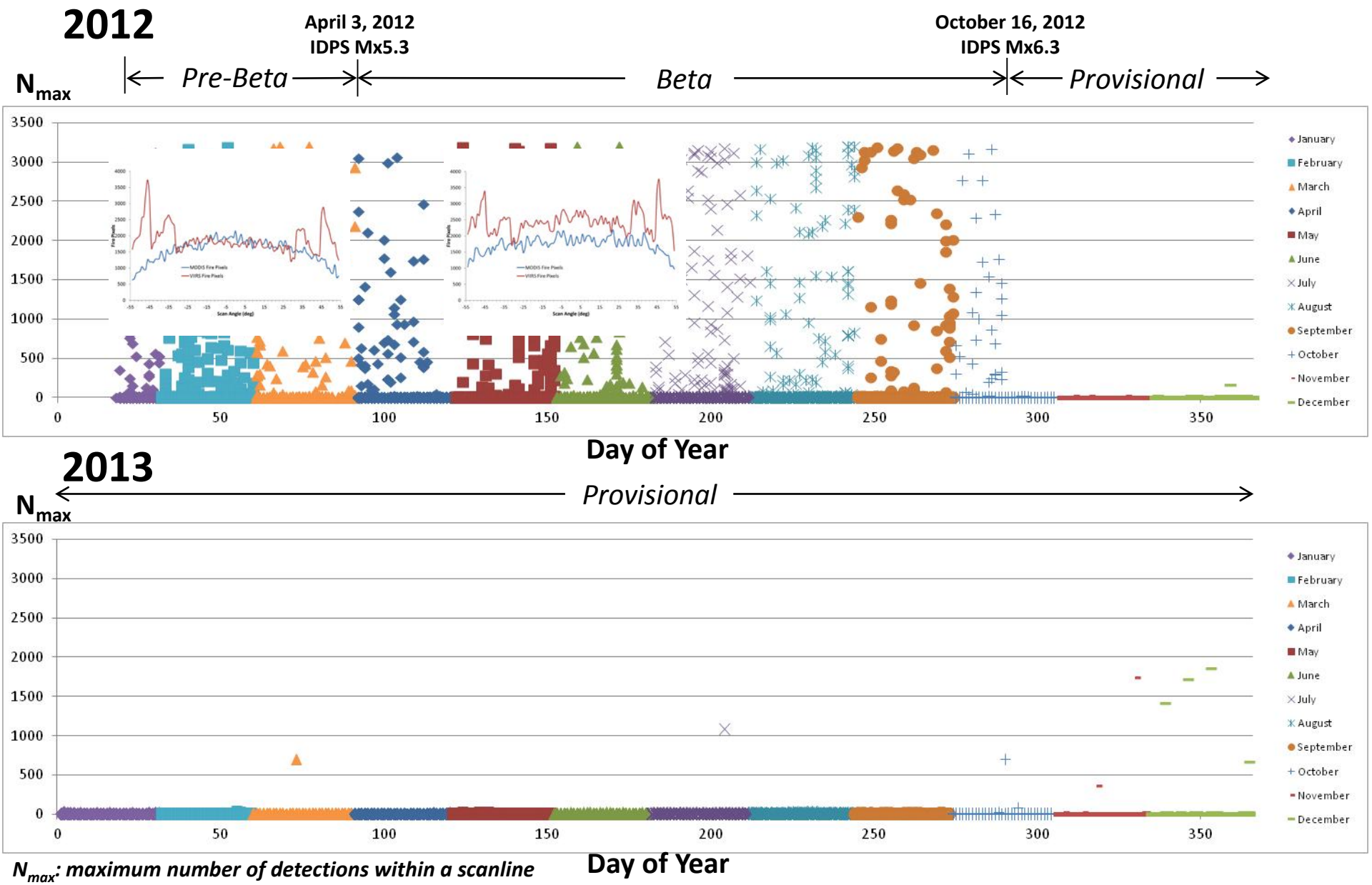
along-track
(a few anomalies)







IDPS Suomi NPP Active Fire Product history: data anomalies and product maturity (3/1)



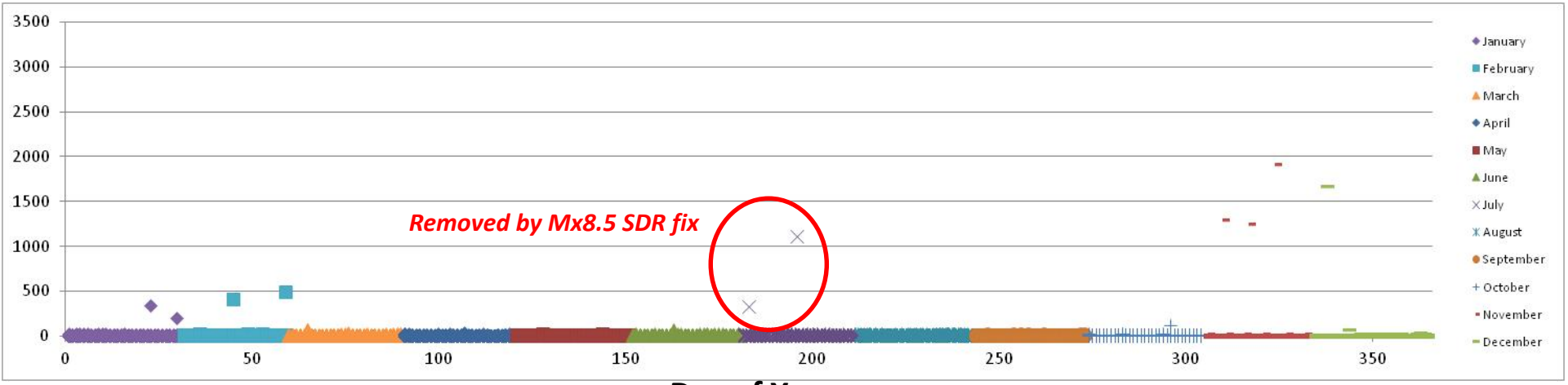
N_{max}: maximum number of detections within a scanline

IDPS Suomi NPP Active Fire Product history: data anomalies and product maturity (3/2)

2014

August 13, 2014
IDPS Mx8.5

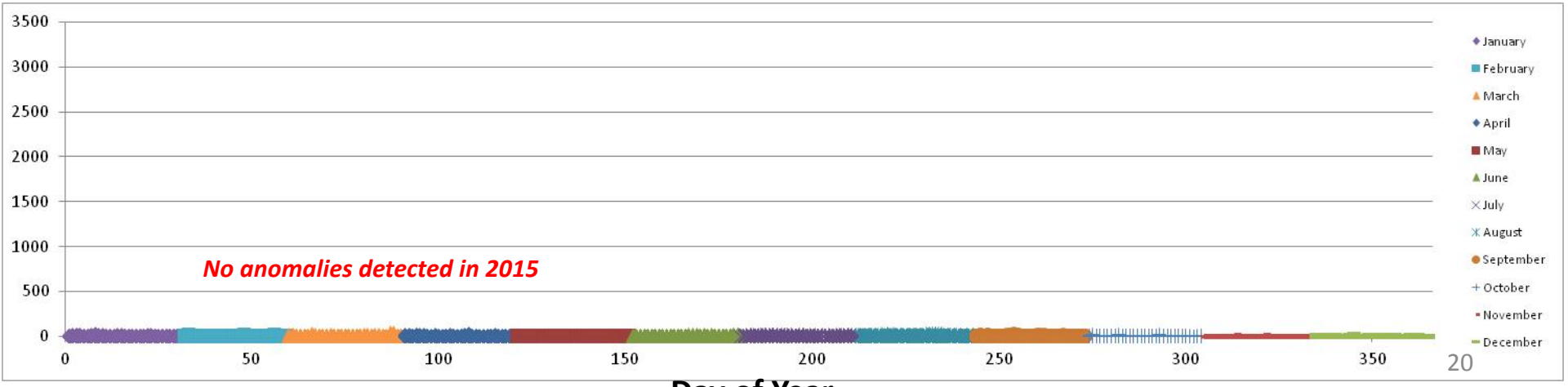
N_{max} ← *Provisional* → | ← *Validated stage 1* →



Day of Year

2015

N_{max} ← *Validated stage 1* →



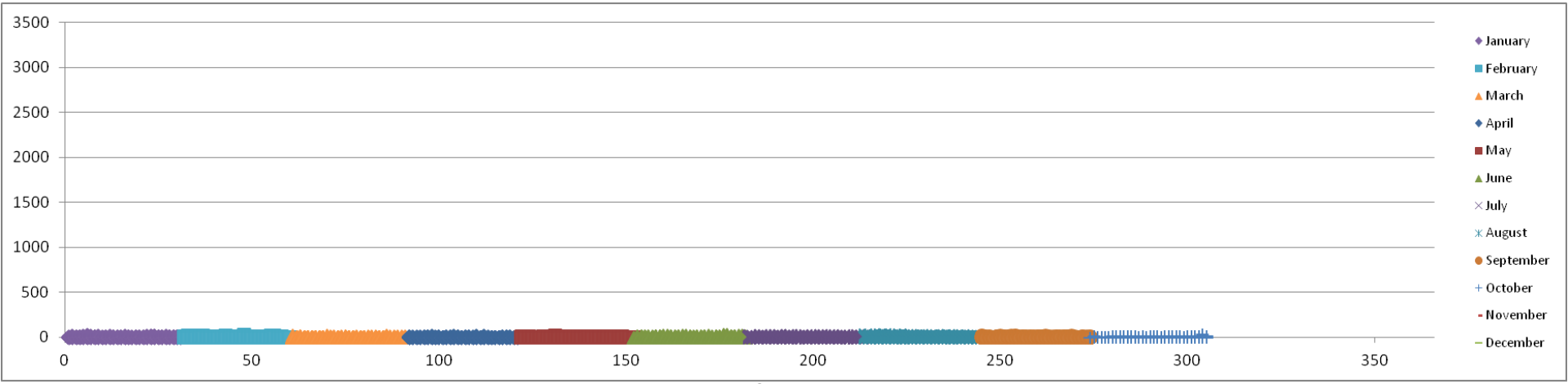
Day of Year

N_{max}: maximum number of detections within a scanline

IDPS Suomi NPP Active Fire Product history: data anomalies and product maturity (3/3)

2016

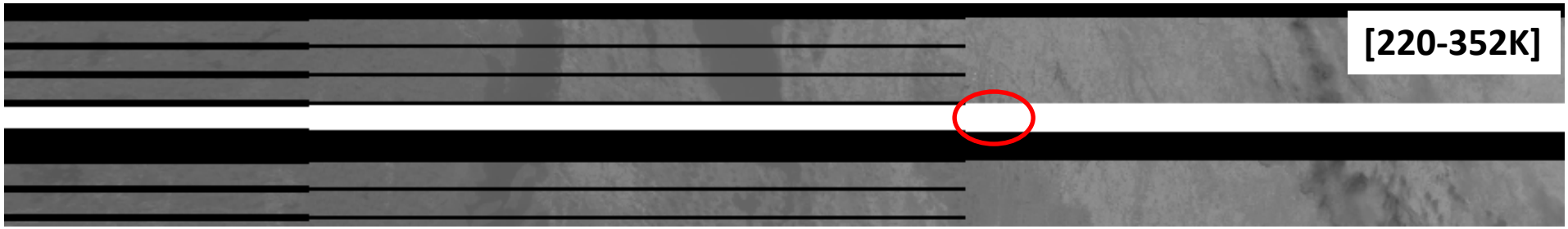
Validated stage 1



Day of Year

N_{max}: maximum number of detections within a scanline

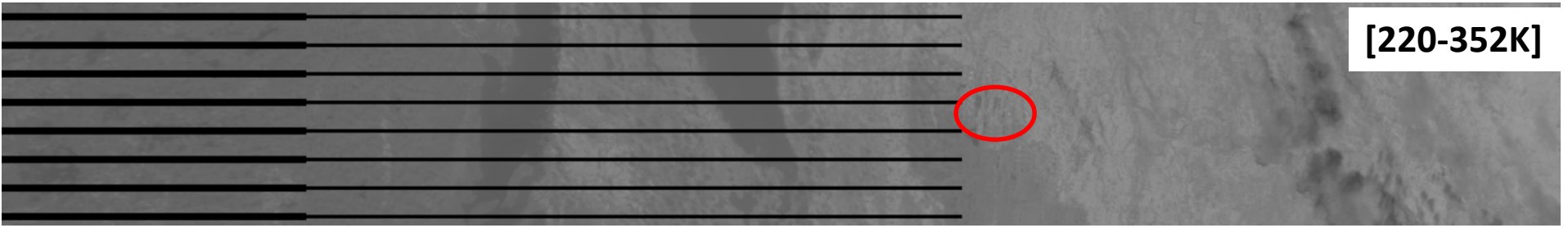
Reprocessing: missing or incorrectly calibrated scanlies



GMODO-SVM13_npp_d20120515_t1950411_e1956215_b02844_c20161008083807074331_noaa_ops

Original IDPS; current CLASS archive ↕

GMODO-SVM13_npp_d20120515_t1950411_e1956215_b02844_c20161008083807074331_noaa_ops



SVM13_npp_d20120515_t1950411_e1952053_b02844_c20160923181228410550_devl_dev

Reprocessed; repaired granule and latest SDR algorithm

Reprocessing: missing or incorrectly calibrated scanlies

GMODO-SVM13_npp_d20120515_t1808155_e1813559_b02843_c20161008070834377460_noaa_ops

[220-352K]

Original IDPS; current CLASS archive

GMODO-SVM13_npp_d20120515_t1808155_e1813559_b02843_c20161008070834377460_noaa_ops

[400-562K]

SVM13_npp_d20120515_t1808155_e1809397_b02843_c20160923170107206350_devl_dev

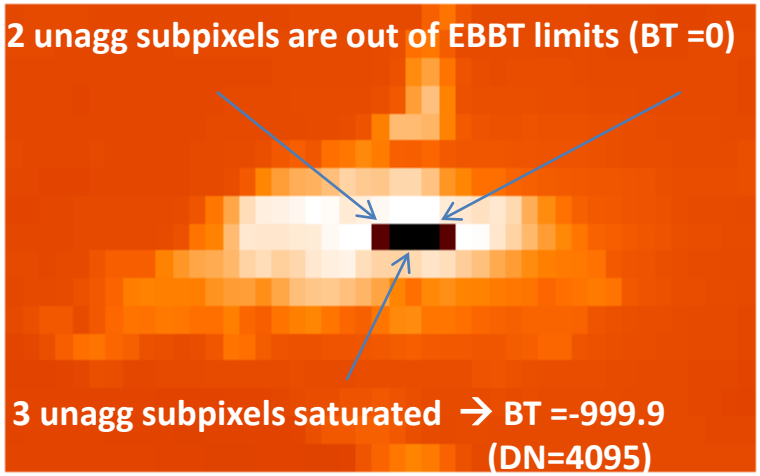
[220-352K]

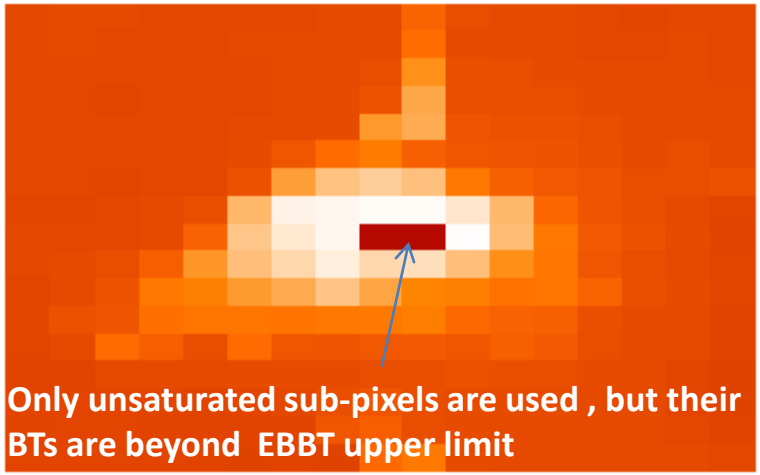
Reprocessed; repaired granule and latest SDR algorithm

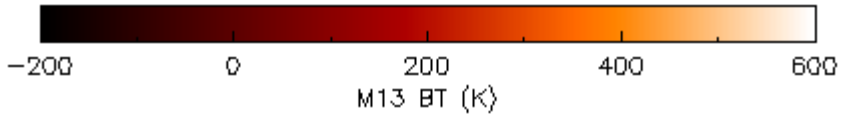
Reprocessing: M13 saturation handling

March 11, 2014

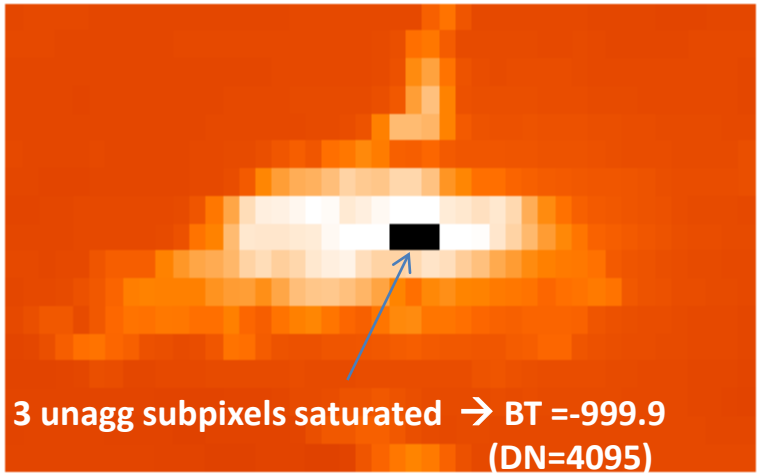
before

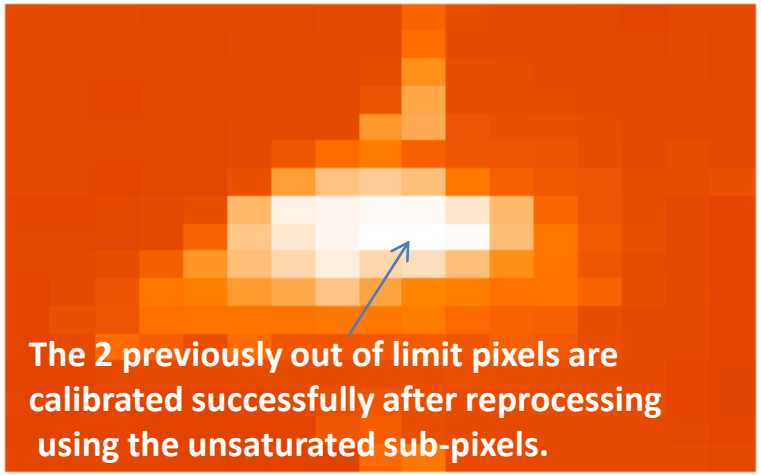


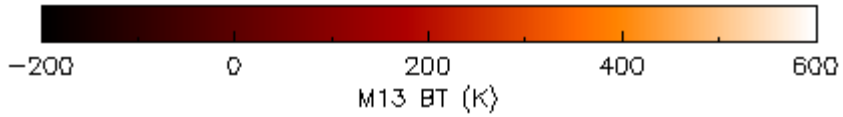


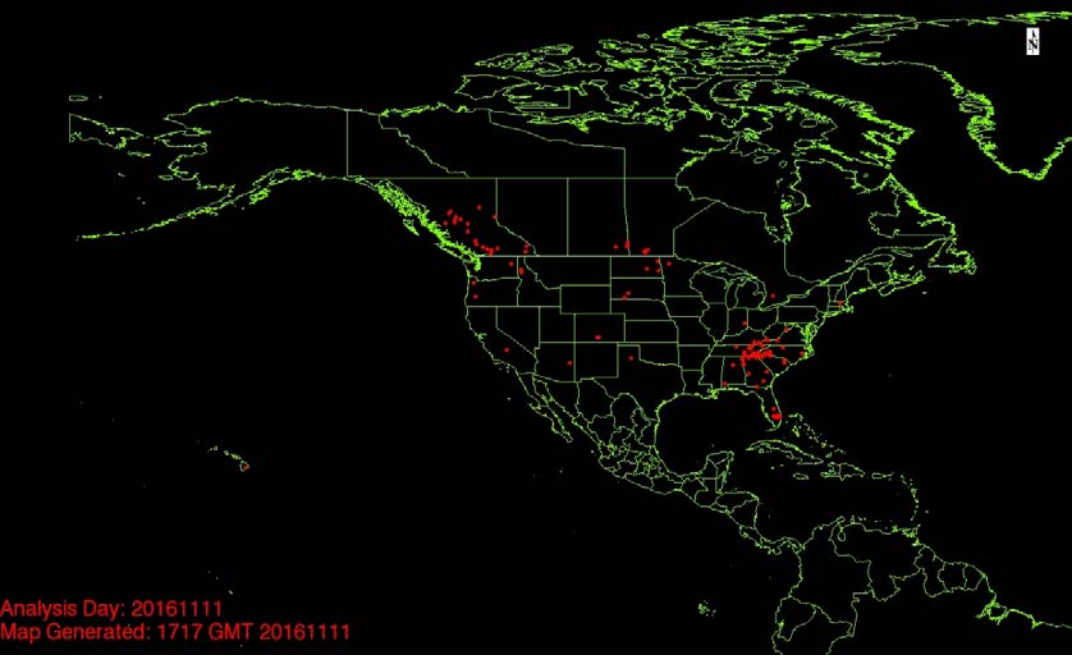


after





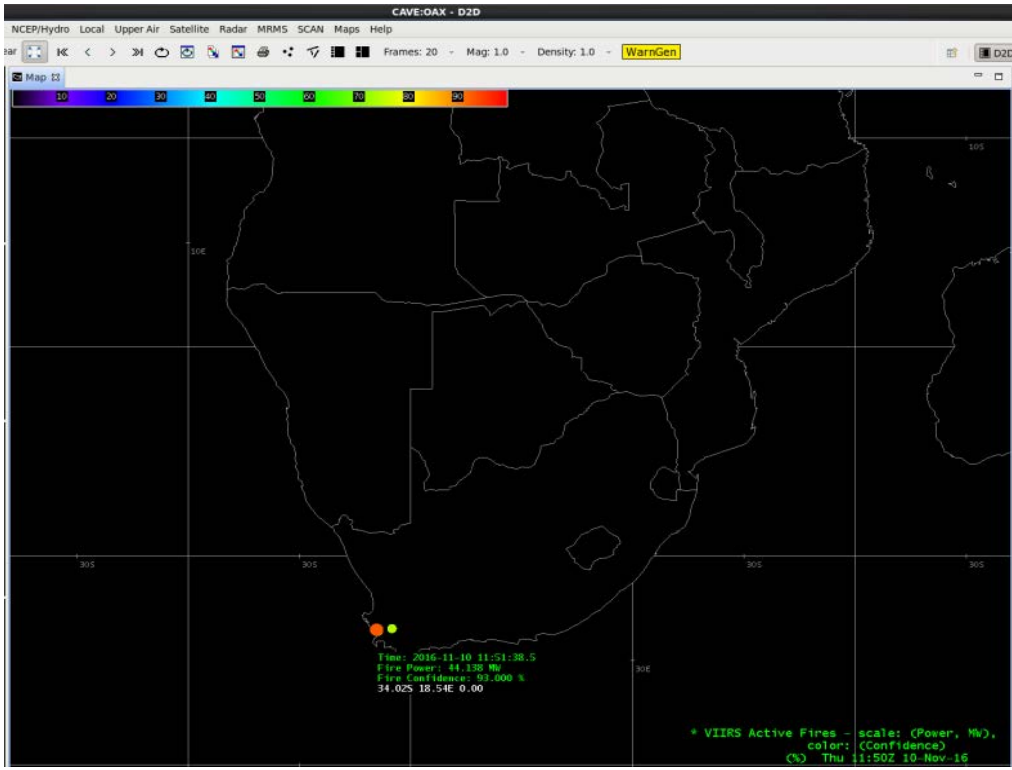




Hazard Mapping System and AWIPS-II status

- VIIRS data are included in operational HMS
  - http://www.ospo.noaa.gov/Products/land/hms.html
  - Global NDE data are available in text format
  - granule-based (.txt) : real-time
  - daily summary (.dat)
  - http://satepsanone.nesdis.noaa.gov/pub/FIRE/VIIRS/

- VIIRS data are included in new AWIFS-II release
  - Advanced Weather Interactive Processing System

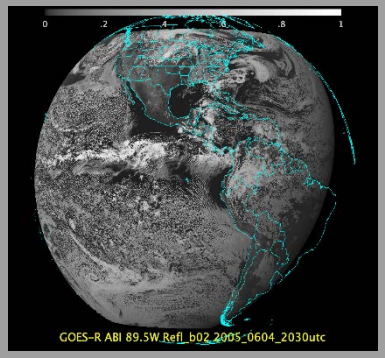


Expectations for GOES-R

(To be launched on November 19, 2016)

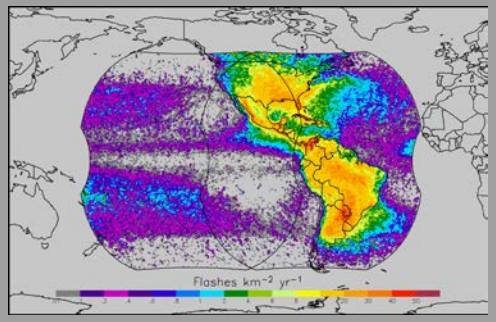
The GOES-R series will provide significant improvements in the detection and observation of meteorological phenomena that directly impact public safety, protection of property, and our Nation's economic health and prosperity

ABI



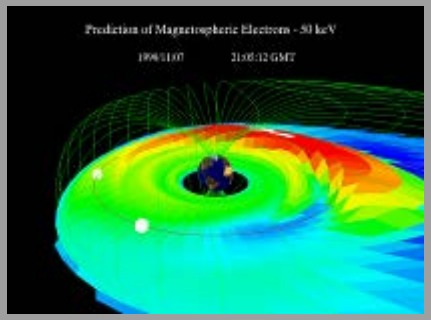
Visible & IR Imagery

GLM

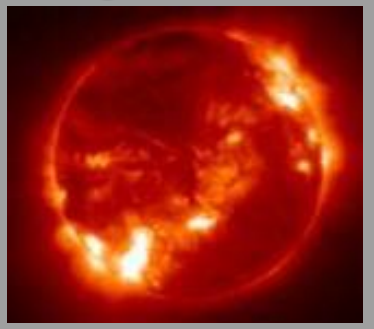


Lightning Mapping

SEISS, SUVI, EXIS, Magnetometer



Space Weather Monitoring



Solar Imaging

- ✓ Improves hurricane track & intensity forecasts
- ✓ Increases thunderstorm & tornado warning lead time
- ✓ Improves aviation flight route planning
- ✓ Data for long-term climate variability studies
- ✓ Low latency (30 sec ABI, 20 sec GLM)

- ✓ Improves solar flare warnings for communications and navigation disruptions
- ✓ More accurate monitoring of energetic particles responsible for radiation hazards to humans and spacecraft
- ✓ Better monitoring of Coronal Mass Ejections to improve geomagnetic storm forecasting

(Slide Curtsey of GOES-R Program, Product Readiness and Operations Team, Algorithm Working Group)

GOES-R Instrument & Product Suites

GOES-R PRODUCTS

Advanced Baseline Imager (ABI)

1. Aerosol Detection (Including Smoke and Dust)
2. Aerosol Optical Depth (AOD)
3. Clear Sky Masks
4. Cloud and Moisture Imagery (KPP)
5. Cloud Optical Depth
6. Cloud Particle Size Distribution
7. Cloud Top Height
8. Cloud Top Phase
9. Cloud Top Pressure
10. Cloud Top Temperature
11. Derived Motion Winds
12. Derived Stability Indices
13. Downward Shortwave Radiation: Surface
14. Fire/Hot Spot Characterization
15. Hurricane Intensity Estimation
16. Land Surface Temperature (Skin)
17. Legacy Vertical Moisture Profile
18. Legacy Vertical Temperature Profile
19. Radiances
20. Rainfall Rate/QPE
21. Reflected Shortwave Radiation: TOA
22. Sea Surface Temperature (Skin)
23. Snow Cover
24. Total Precipitable Water
25. Volcanic Ash: Detection and Height

Geostationary Lightning Mapper (GLM)

1. Lightning Detection: Events, Groups & Flashes

Space Environment In-Situ Suite (SEISS)

2. Energetic Heavy Ions
3. Magnetospheric Electrons & Protons: Low Energy
4. Magnetospheric Electrons: Med & High Energy
5. Magnetospheric Protons: Med & High Energy
6. Solar and Galactic Protons

Magnetometer (MAG)

7. Geomagnetic Field

Extreme Ultraviolet and X-ray Irradiance Suite (EXIS)

8. Solar Flux: EUV
9. Solar Flux: X-ray Irradiance

Solar Ultraviolet Imager (SUVI)

10. Solar Imagery (X-ray): coronal holes, solar flares, coronal mass ejection source regions

Baseline Products Are Our Post-Launch Priorities

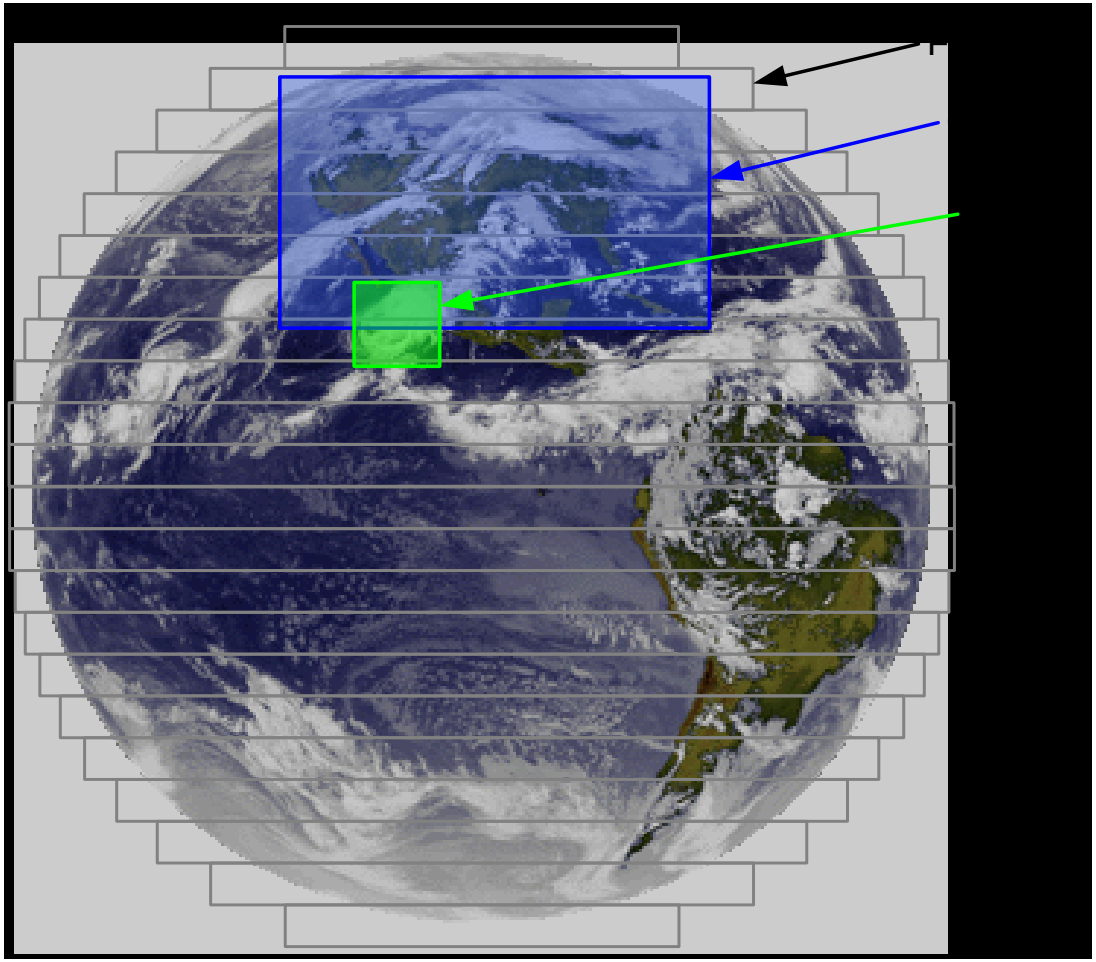
(Slide Curtsey of GOES-R Program, Product Readiness and Operations Team, Algorithm Working Group)

GOES-R vs. Current GOES

	ABI	Current GOES Imager
Spectral Coverage	16 bands	5 bands
Spatial resolution		
0.64 μm Visible	0.5 km	Approx. 1 km
Other Visible/near-IR	1.0 km	n/a
Bands (>2 μm)	2 km	Approx. 4 km
Spatial coverage		
Full disk	4 per hour	Scheduled (3 hrly)
CONUS	12 per hour	~4 per hour
Mesoscale	Every 30 sec	n/a
Visible (reflective bands)		
On-orbit calibration	Yes	No

(Slide Curtsey of GOES-R Program, Product Readiness and Operations Team, Algorithm Working Group)

Advanced Baseline Imager (ABI)



Scan modes for the ABI:

Mode 3 (default):

Full disk images every 15 minutes
CONUS images every 5 minutes
Mesoscale images (2) every 1 minute

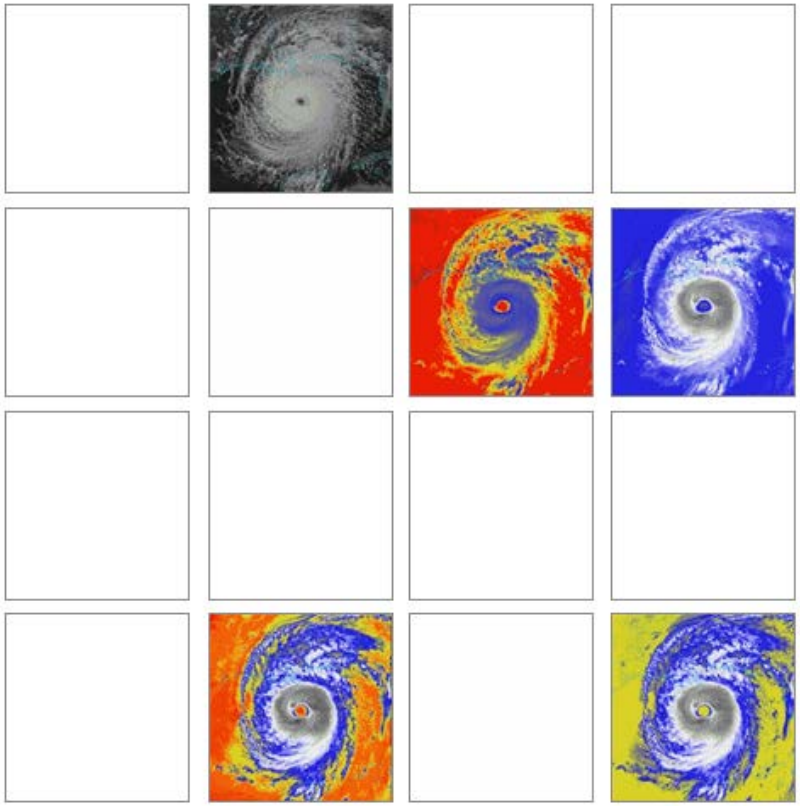
Mode 4 (per request):

Full disk images every 5 mins

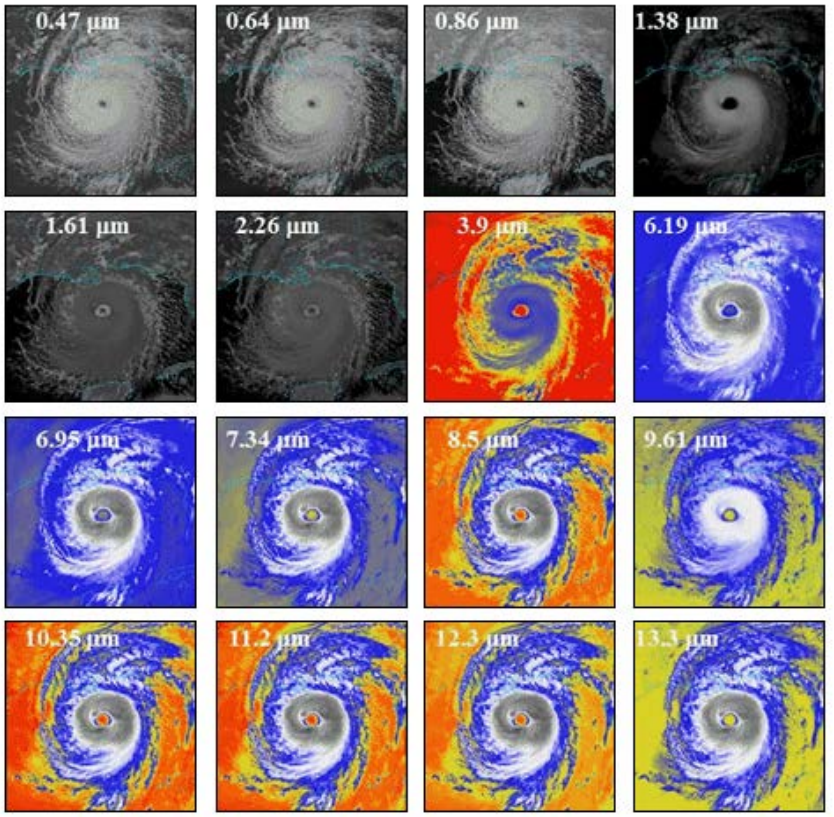
(Slide Curtsey of GOES-R Program, Product Readiness and Operations Team, Algorithm Working Group)

Three Times More Spectral Information

GOES-13/14/15 Spectral Bands



GOES-R Spectral Bands



(Slide Curtsey of GOES-R Program, Product Readiness and Operations Team, Algorithm Working Group)

Rim Fire

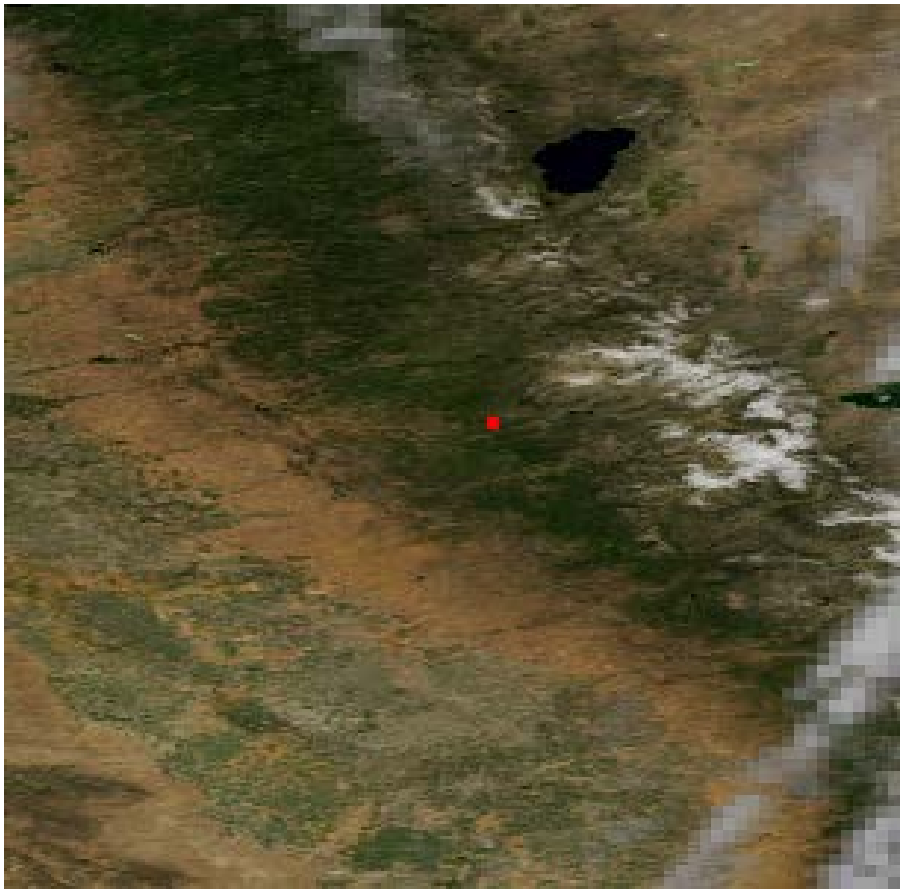
- GOES-14 was in a special mode during the summer of 2013 as a testbed for GOES-R
- The images were created using GOES visible and infrared (11 µm) clouds, WFABBA fires (yellow, red, magenta, blue), and the Blue Marble Second Generation from NASA
- They are centered on the Rim Fire's reported starting point and are in the GOES-14 native projection

(Slide Curtsey of GOES-R Program, Product Readiness and Operations Team, Algorithm Working Group)

Rim Fire (2013)

Imagery is typically available every 15 minutes today, but could be available every 30 seconds with GOES-R.

GOES-R Era (1-minute data)

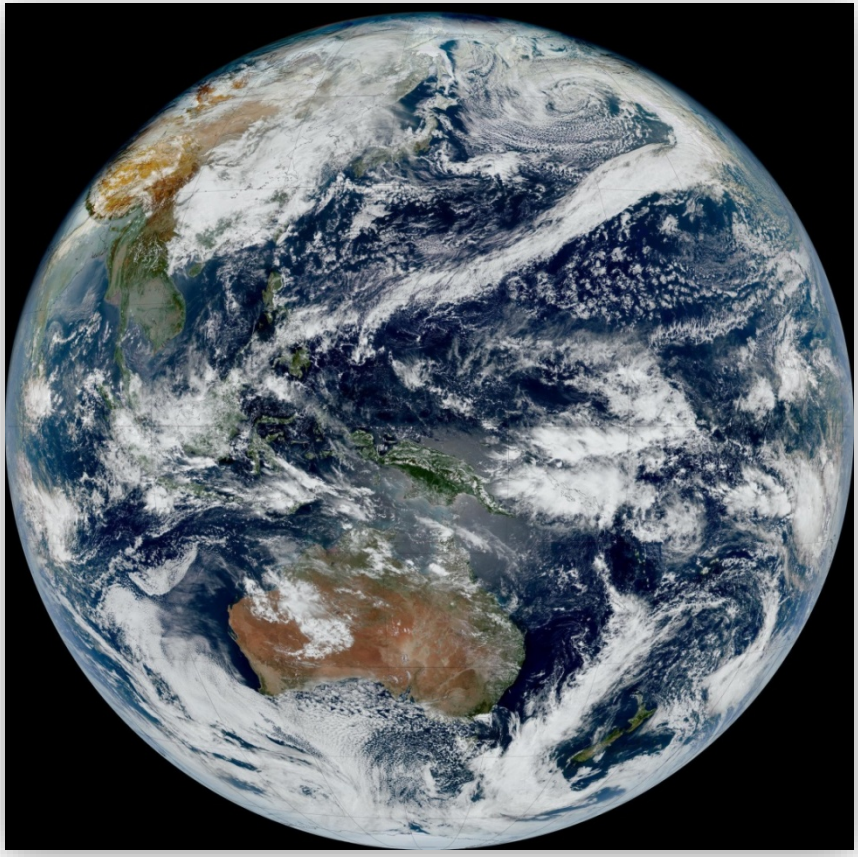


ABI's finer spectral, spatial, and temporal resolution will enable improvements in fire detection, characterization, monitoring, and forecasting.

We expect immediate and positive impacts on NWS Fire Operations

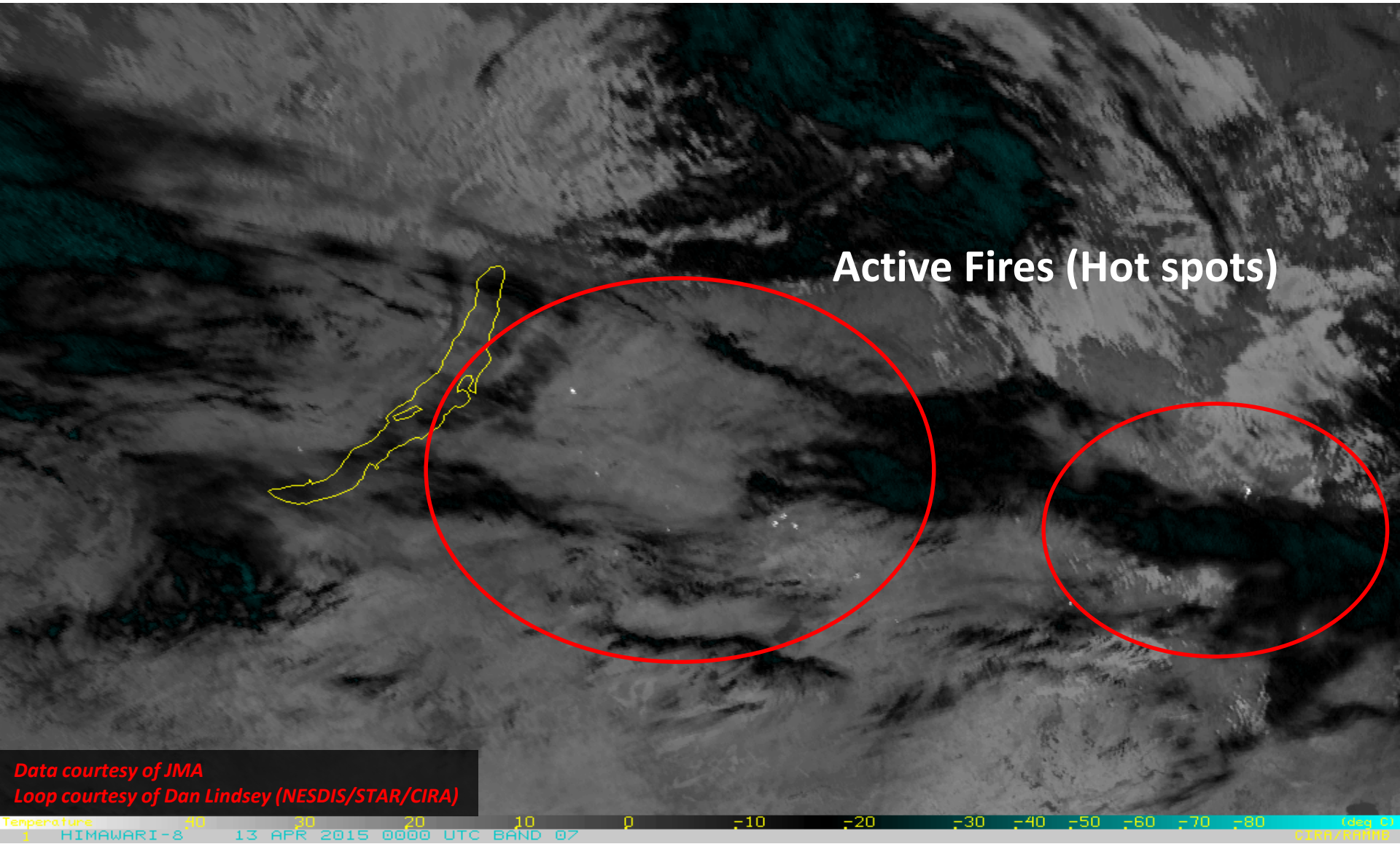
Leveraging Himawari-8/AHI for GOES-R Readiness

- Himawari-8 was successfully launched October 7, 2014 and carries the AHI which is an almost identical instrument to the ABI
- Availability of AHI datasets brings an unprecedented opportunity to
  - Use , demonstrate, and train with bands similar to ABI
  - Exercise the Level-2 algorithms developed for GOES-R
- NESDIS/STAR is routinely pulling full resolution AHI data (all bands) from JMA's Cloud Service and making it available to its Cooperative Institutes and other partners.
- Special thanks to JMA for sharing data and collaborating with NOAA and NASA during their post launch checkout



Blue Marble, Himawari 8 True Color Composite
25-January-2015 02:30 UTC
Steve Miller (CIRA) - GOES-R AWG Imagery Team

Himawari-8 Band 7 (3.9 µm; 2km) Loop, 4/13 @ 00 UTC through 4/15 @ 04 UTC



(Slide Curtsey of GOES-R Program, Product Readiness and Operations Team, Algorithm Working Group)

Fire/Hot Spot Characterization

- **Algorithm Highlights**
  - Heritage lies with the GOES operational Wildfire Automated Biomass Burning Algorithm (WF_ABBA)
  - Dynamic, multi-spectral, thresholding contextual algorithm
  - Utilizes the 0.64, 3.9, 11.2 and 12.3 mm channels
  - Leverages ABI's higher spatial and temporal resolution data
- **Operational Applications**
  - Fire weather monitoring and forecasting
  - Air quality forecasting

Fire Detections over Sumatra
3:15 UTC on 24 September 2015

Fires are sub-pixel features. ABI's higher spatial and temporal refresh rate will improve the detection and characterization of fires.

(Slide Curtsey of GOES-R Program, Product Readiness and Operations Team, Algorithm Working Group)

Fire Detection Using H-8/AHI

Case showing :

- Agreement between MODIS and GOES-R fire algorithm detects

MODIS Fire Detects:

- Red polygons

GOES-R Fire Algorithm FDCA:

- Red – processed fire
- Magenta – Cloud-covered fire
- Cyan – Medium probability fire

Fire Detections over Sumatra
3:15 UTC on 24 September 2015

(Slide Curtsey of GOES-R Program, Product Readiness and Operations Team, Algorithm Working Group)

Summary

- JPSS VIIRS and GOES-R ABI are excellent assets for fire monitoring
  - JPSS-1 launch probably in mid-2017
    - three more missions to follow with similar VIIRS sensors
  - GOES-R launch on November 19, 2016
    - compatible with Himawari AHI
- VIIRS fire product development and distribution is done by various key stakeholders
  - Products are now mature
  - Concerted effort to assist users to find the most appropriate product
  - NOAA, NASA, USDA Forest Service products and activities
  - reprocessing is ongoing
    - Improved SDR/L1, latest granules, latest algorithms
- GOES-R fire product a critical component
  - a baseline product, available soon after spacecraft checkout