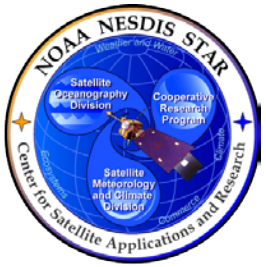
Algorithm Validation

Presented by

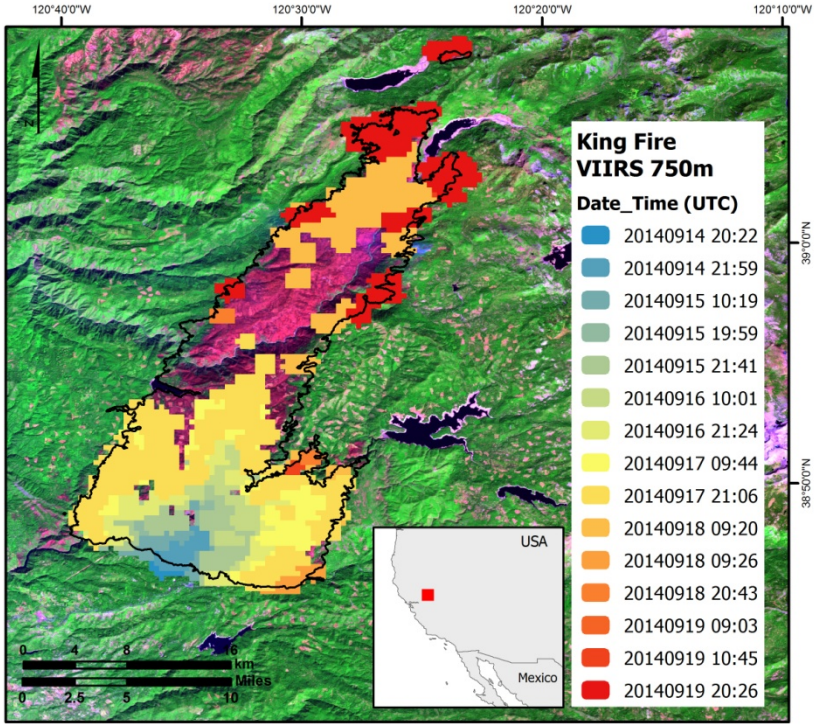
Ivan Csiszar
NOAA/NESDIS/STAR

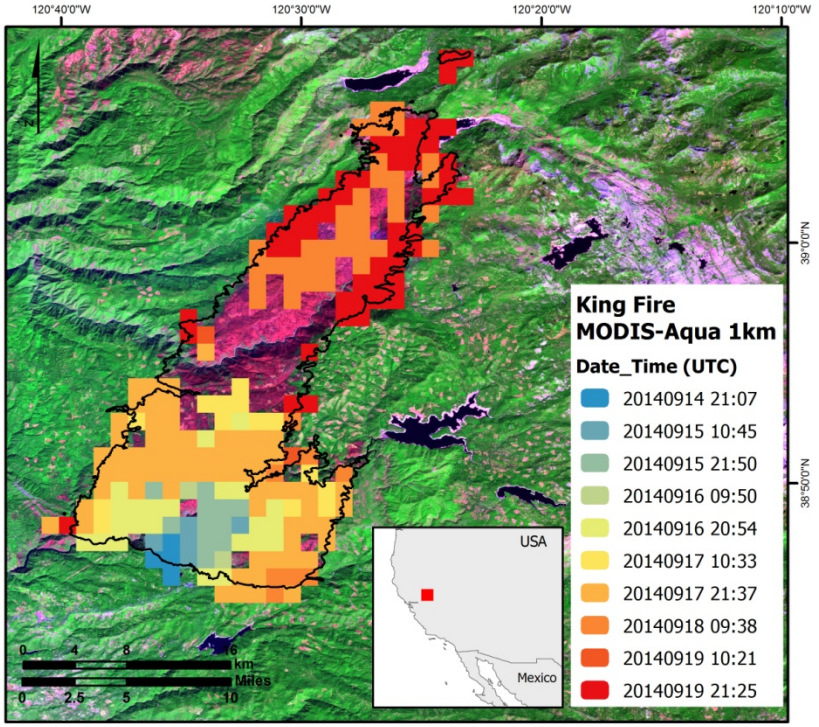
Algorithm validation and verification approaches



- Tracing back to MODIS product accuracy
  - Common algorithm
  - Terra MODIS explicitly validated using ASTER
- Use of independent reference data
  - In situ (validation)
  - Airborne (validation)
  - Spaceborne (30m: validation; 185m: consistency check)
- Visual evaluation and consistency with IDPS
  - for detections only
- Consistency between research (NASA) and NRT operational (NOAA) code output
- Consistency between STAR and NDE (SADIE) output

VIIRS vs. MODIS active fire

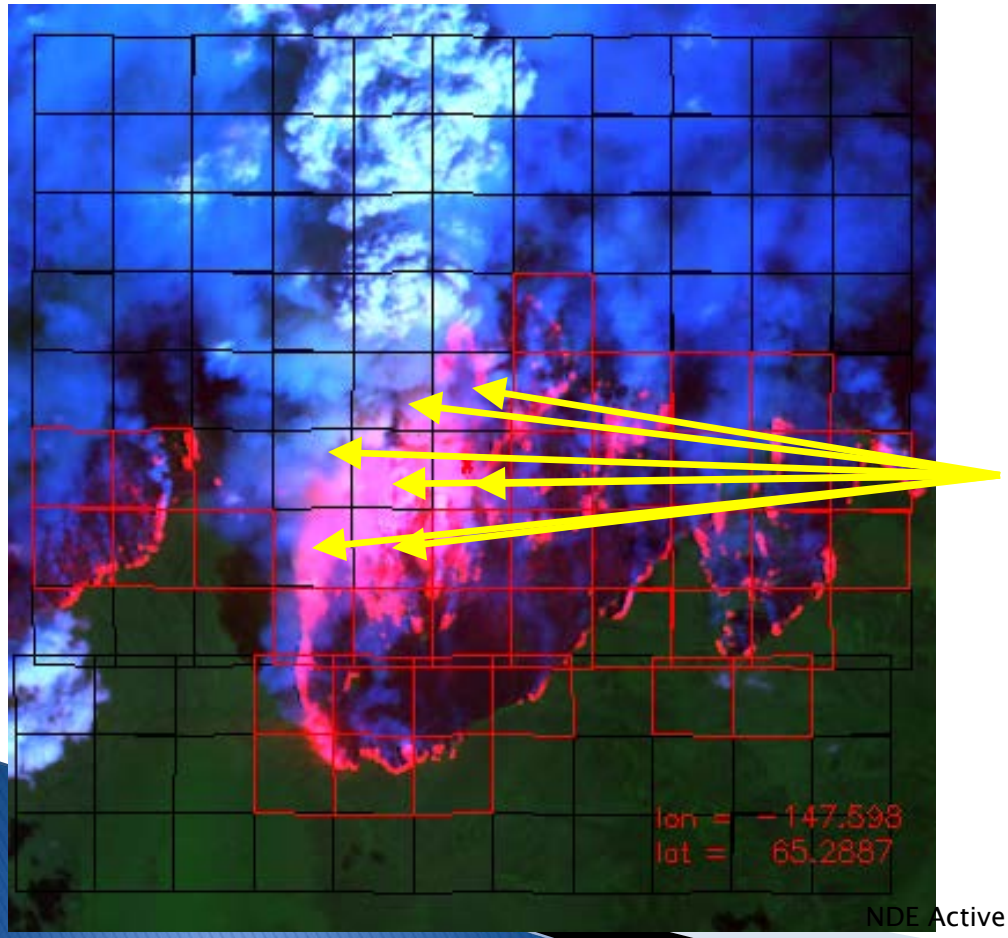




Suomi NPP/VIIRS AF and Aqua/MODIS MYD14 fire detection data produced for the King fire/California on 14-19 September 2014

VIIRS Fire Product Validation: tracing back to MODIS

- 2D fire mask and QA data required for proper consideration of viewing conditions and error quantification

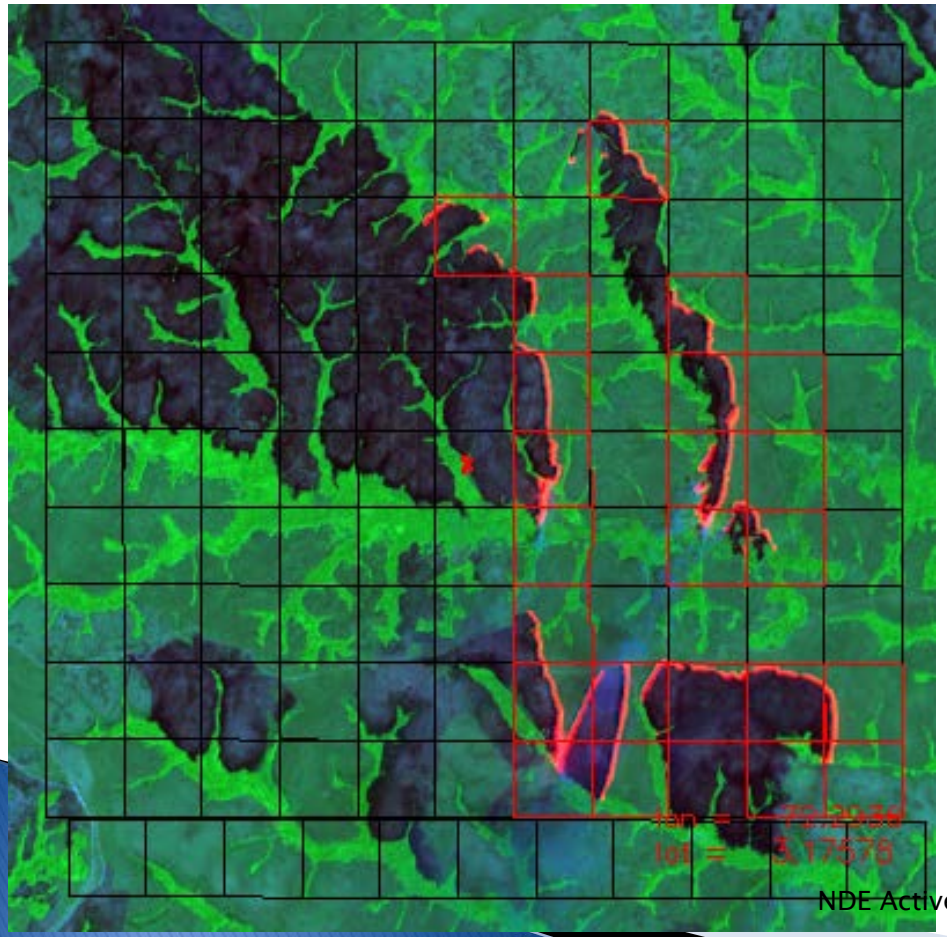


MODIS (1km) omission error of core fire area due to thick smoke column

(from CDR)

VIIRS Fire Product Validation: tracing back to MODIS

- Detected fires are predominantly sub-pixel in size
  - *Higher spatial resolution reference data sets required*



MODIS (1 km grid) and ASTER (30 m) coincident mapping of fires in Colombia (72.2936W 3.17578N) 01 Feb 2004 15:18:49 UTC

Time separation between VIIRS and Landsat-class data (>2h) prevents use of those reference data sets for active fire validation

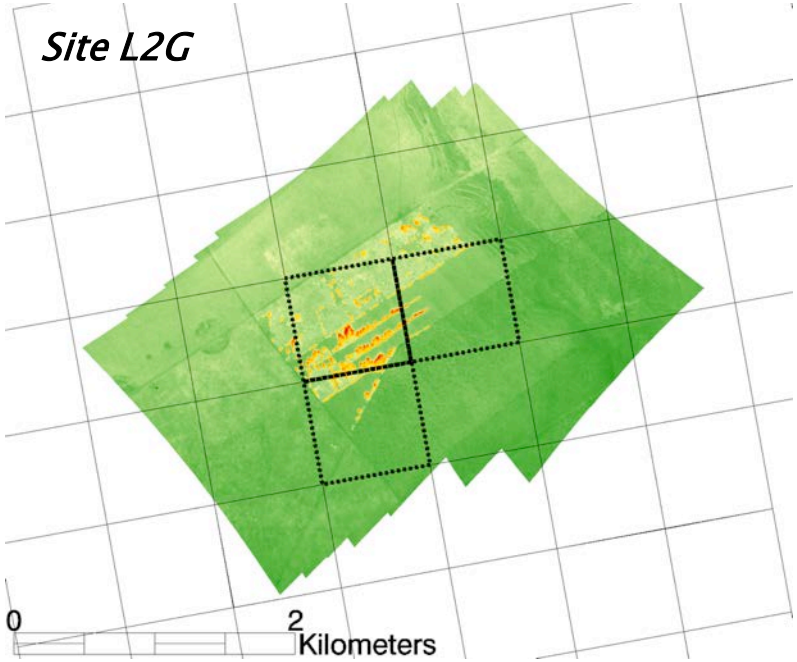
(from CDR)

Key relevant publications

- Morisette, J.T., Giglio, L., Csiszar, I. , Justice, C.O. 2005. Validation of the MODIS active fire product over Southern Africa with ASTER data. International Journal of Remote Sensing , 26:4239-4264.
- Morisette, J.T., Giglio, L., Csiszar, I., Setzer, A., Schroeder, W., Morton, D., Justice, C.O. 2005.
- Validation of MODIS active fire detection products derived from two algorithms. Earth Interactions, 9:1-23.
- Csiszar, I., J. Morisette and L. Giglio, 2006. Validation of active fire detection from moderate resolution satellite sensors: the MODIS example in Northern Eurasia. IEEE Transactions on Geoscience and Remote Sensing , vol. 44, no. 7, 1757-1764.
- Schroeder, W., Prins, E., Giglio, L., Csiszar, I., Schimdt, C., Morisette, J., Morton, D. 2008. Validation of GOES and MODIS active fire detection products using ASTER and ETM+ data. Remote Sensing of Environment 112 (2008) 2711-2726.
- Schroeder, W., M. Ruminski, I. Csiszar, L. Giglio, E. Prins, C. Schmidt, J. Morisette,2008: Validation Analyses of and Operational Fire Monitoring Product: the Hazard Mapping System. International Journal of Remote Sensing, Vol. 29, No. 20, 6059-6066, DOI: 10.1080/01431160802235845.
- Csiszar, I. and W. Schroeder, 2008: Short-Term Observations of the Temporal Development of Active Fires from Consecutive Same-Day ETM+ and ASTER Imagery in the Amazon: Implications for Active Fire Product Validation. IEEE Journal of Selected Topics in Earth Observations and Remote Sensing Vol. 1, No. 4, 248-253. DOI: 10.1109/JSTARS.2008.2011377.
- Csiszar, I., W. Schroeder, L. Giglio, E. Ellicott, K. P. Vadrevu, C. O. Justice, B. Wind, 2014: Active fires from the Suomi NPP Visible Infrared Imaging Radiometer Suite: Product status and first evaluation results, *J Geophys Res Atmos*, 119, doi:10.1002/2013JD020453.

VIIRS Fire Product Validation: Initial Results from airborne data

Prescribed Fire Combustion and Atmospheric Dynamics Research (RxCadre) experiment in Eglin Air Force Base, FL Nov 2012.

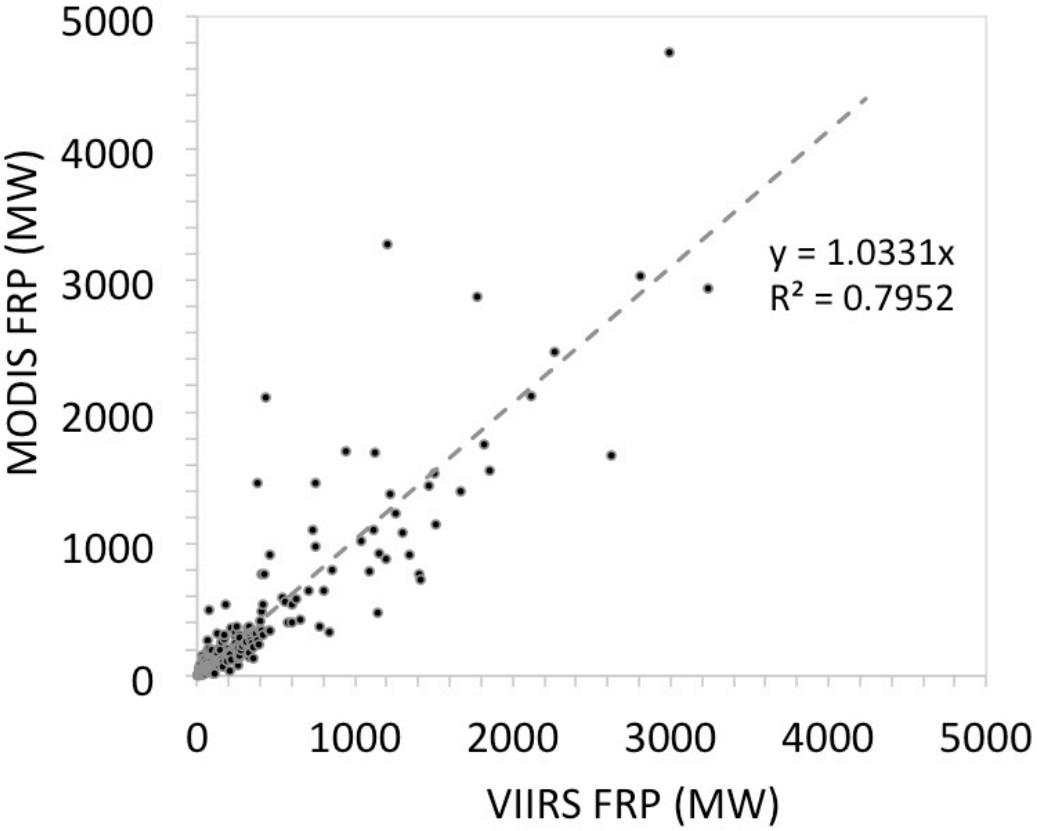


VIIRS (750 m) mapping of 2012 prescribed fire in Florida using airborne reference data (WASP sensor)

		FRP (MW)				Time (UTC)		
Satellite	Fire	WASP	MODIS	Diff	Cloud	WASP	MODIS	Diff (s)
MODIS	L1G	148	143	5	Yes	19:19:47	19:18:58	49
	L2G	111	167	-55	No	18:42:26	18:42:01	25
	L2F	119	199	-79	No	19:25:56	19:25:05	51
			Mean (SD)	-43 (44)				
VIIRS	L1G	414	158	256	Yes	18:59:24	18:59:54	30
	L2G	152	151	1	No	18:49:08	18:47:22	106
	L2F	487	237	250	Yes	18:29:47	18:28:34	73
			Mean (SD)	169 (146)				

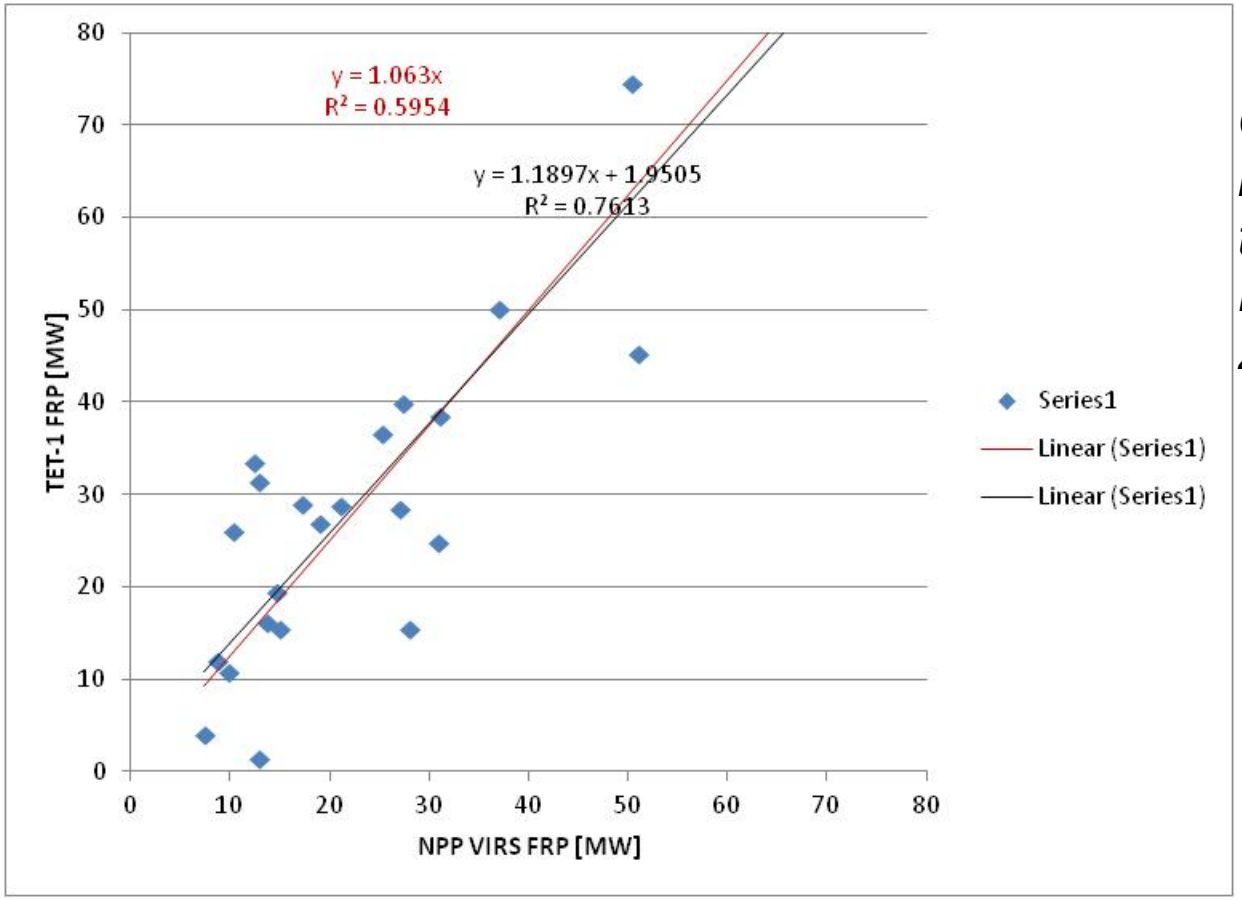
Dickinson et al. [2014]

FRP evaluation using MODIS



MODIS/VIIRS gridded data (0.5 degree) of near-coincident fires (<1km from each other) over different parts of the globe including atmospheric correction of both data sets.

FRP evaluation using DRL TET-1

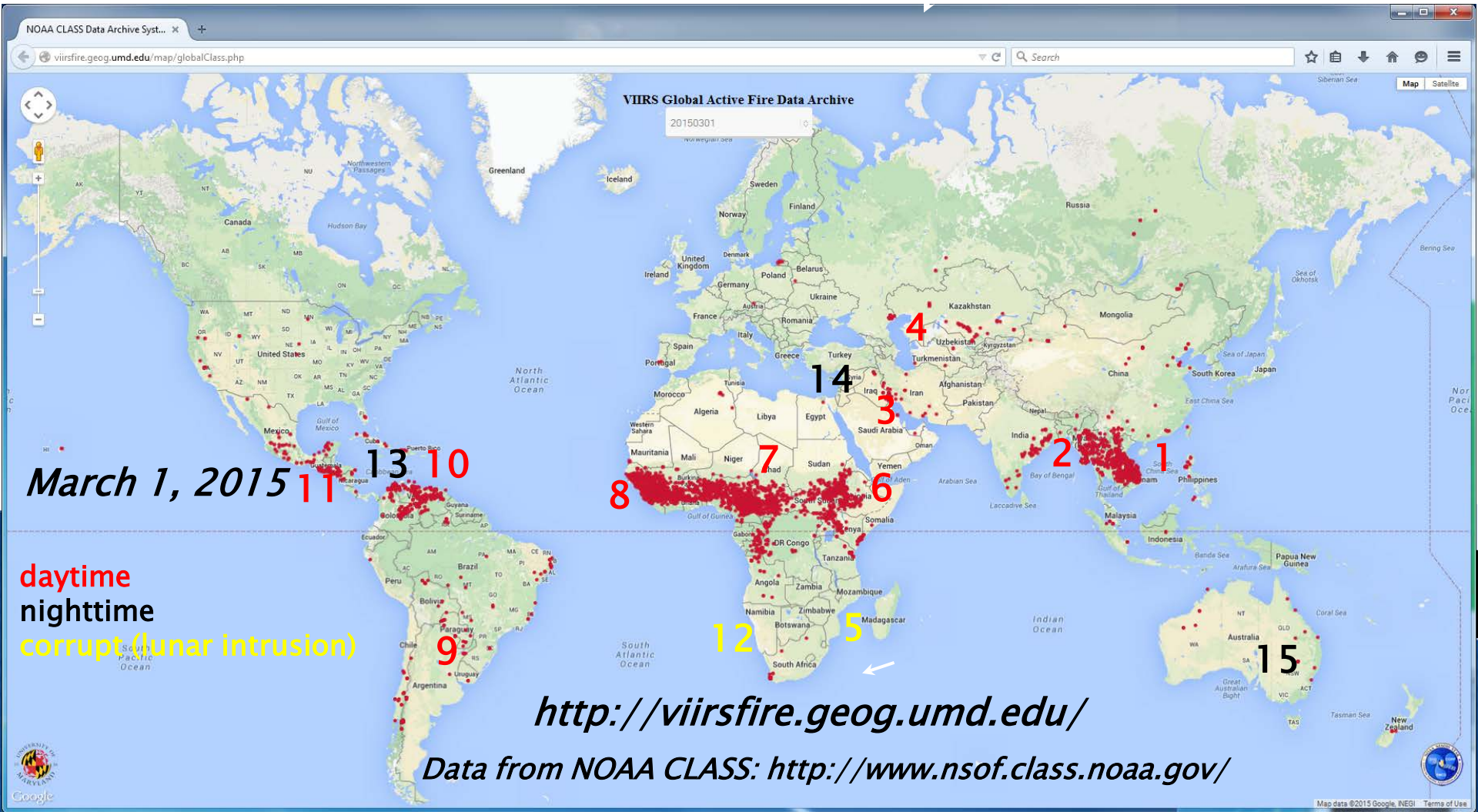


Comparison of FRP retrievals of gas flares in the Middle East on May 9, 12, 15, 18, 24 2015

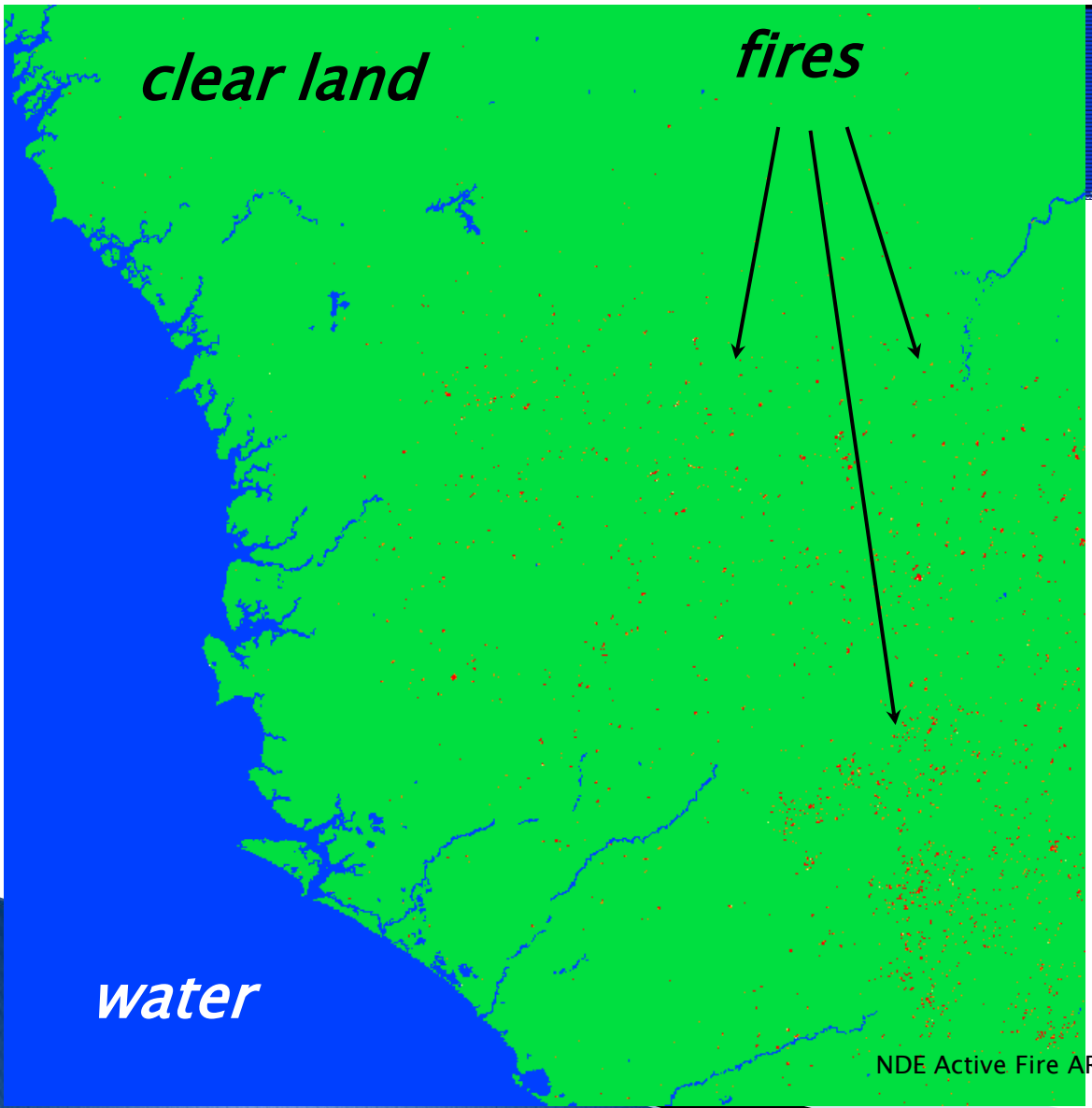
TET-1: Technology Experiment Carrier-1by German Aerospace Agency DRL; dedicated 185m unsaturated measurements for hotspot characterization

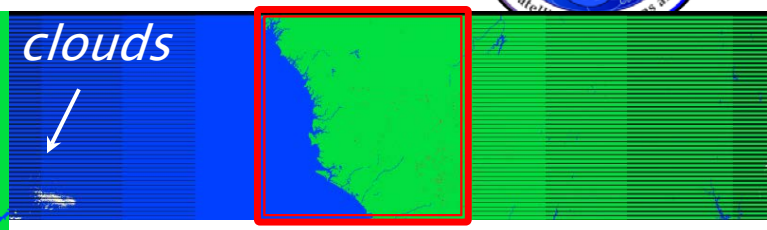
NOAA NDE VIIRS Active Fire Product testing

15 granules covering daytime (1-12), nighttime (13-15), land, water and corrupt (5,12) data were tested for overall performance and consistency between the NOAA and NASA output. The global map shown for reference is the current IDPS product.



NOAA NDE Active Fire Product





VIIRS fire mask over West Africa on 3/1/2015 at 14:15 UTC, generated by the STAR Algorithm Integration Team (AIT) from IDPS input data and the NOAA version of the VIIRS fire replacement code

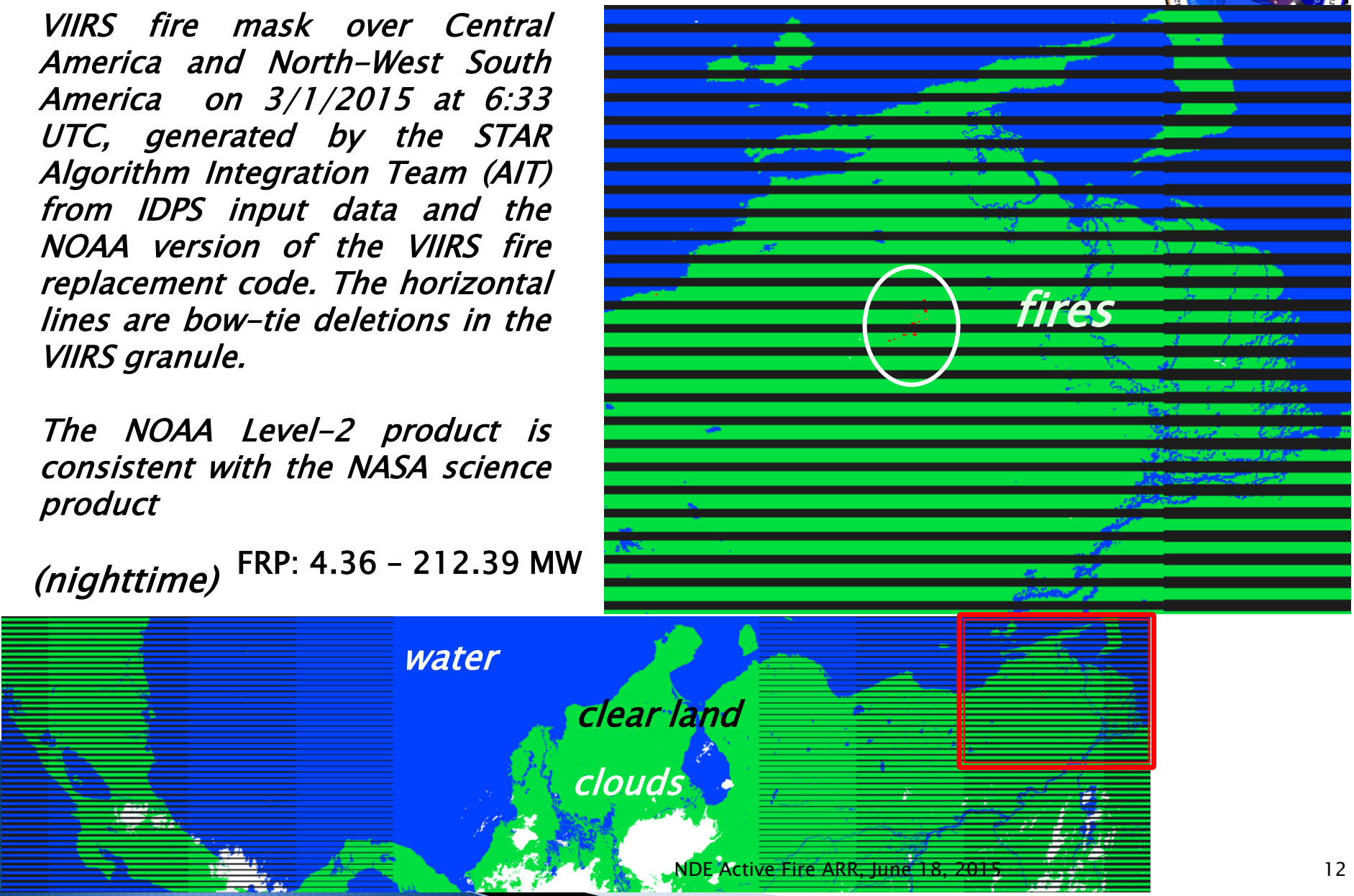
The NOAA Level-2 product is consistent with the NASA science product

NOAA NDE Active Fire Product

VIIRS fire mask over Central America and North-West South America on 3/1/2015 at 6:33 UTC, generated by the STAR Algorithm Integration Team (AIT) from IDPS input data and the NOAA version of the VIIRS fire replacement code. The horizontal lines are bow-tie deletions in the VIIRS granule.

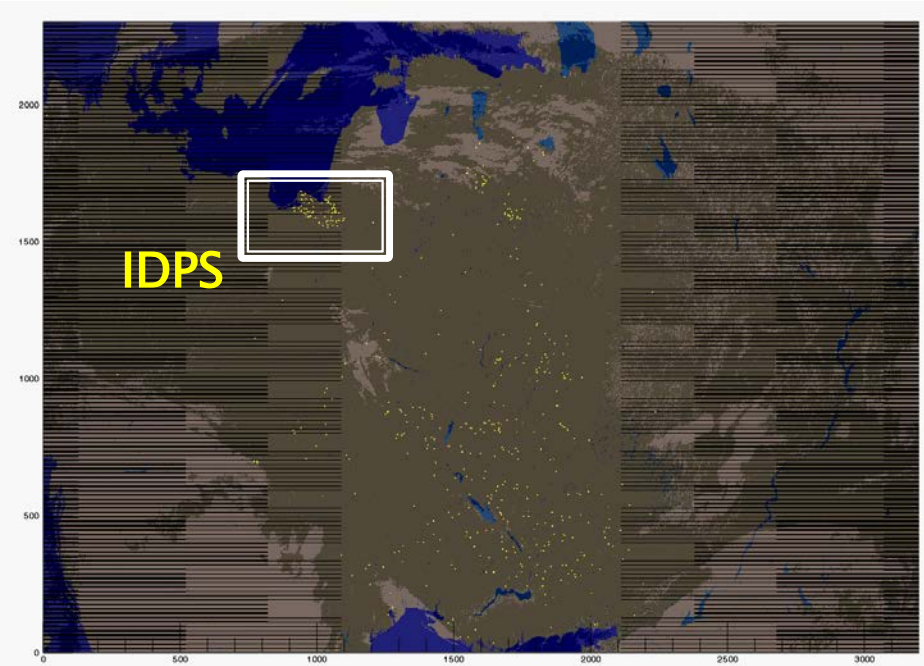
The NOAA Level-2 product is consistent with the NASA science product

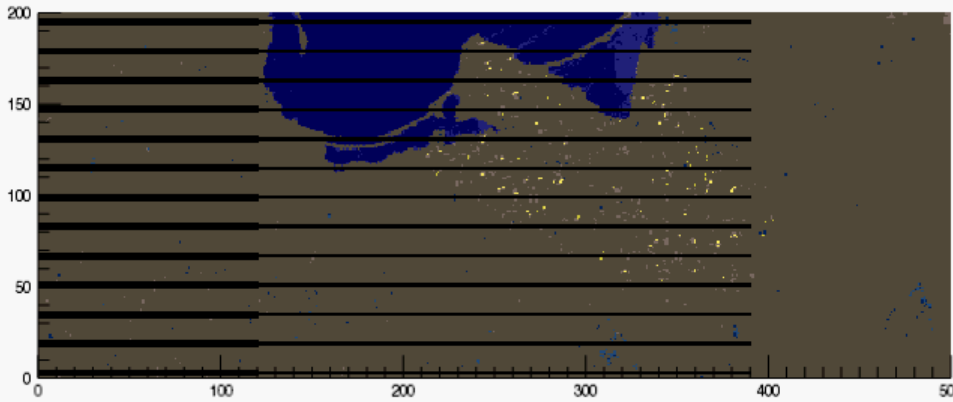
(nighttime) FRP: 4.36 - 212.39 MW

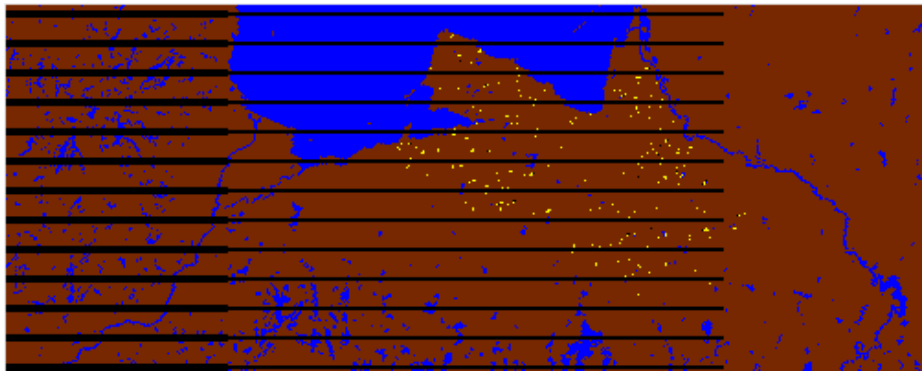


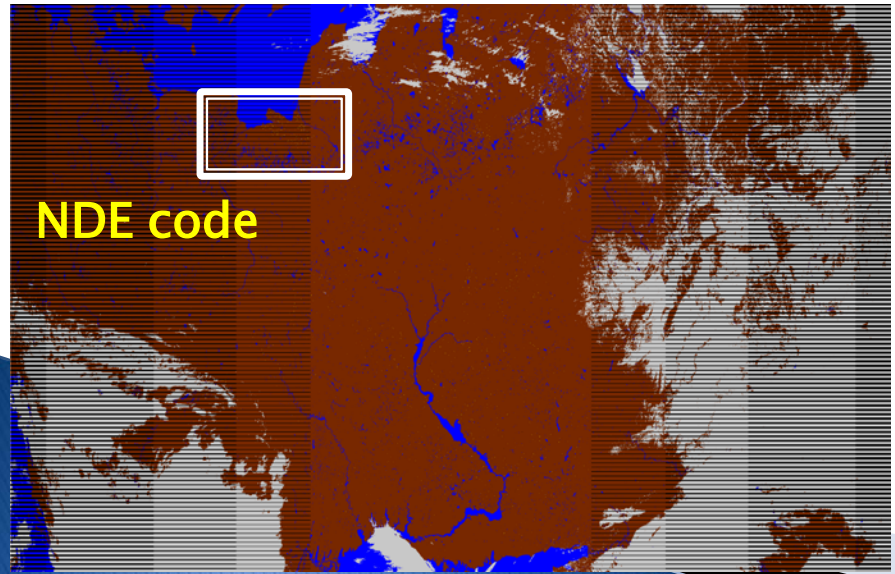
IDPS vs. NDE code

March 10, 2014 10:36-10:40



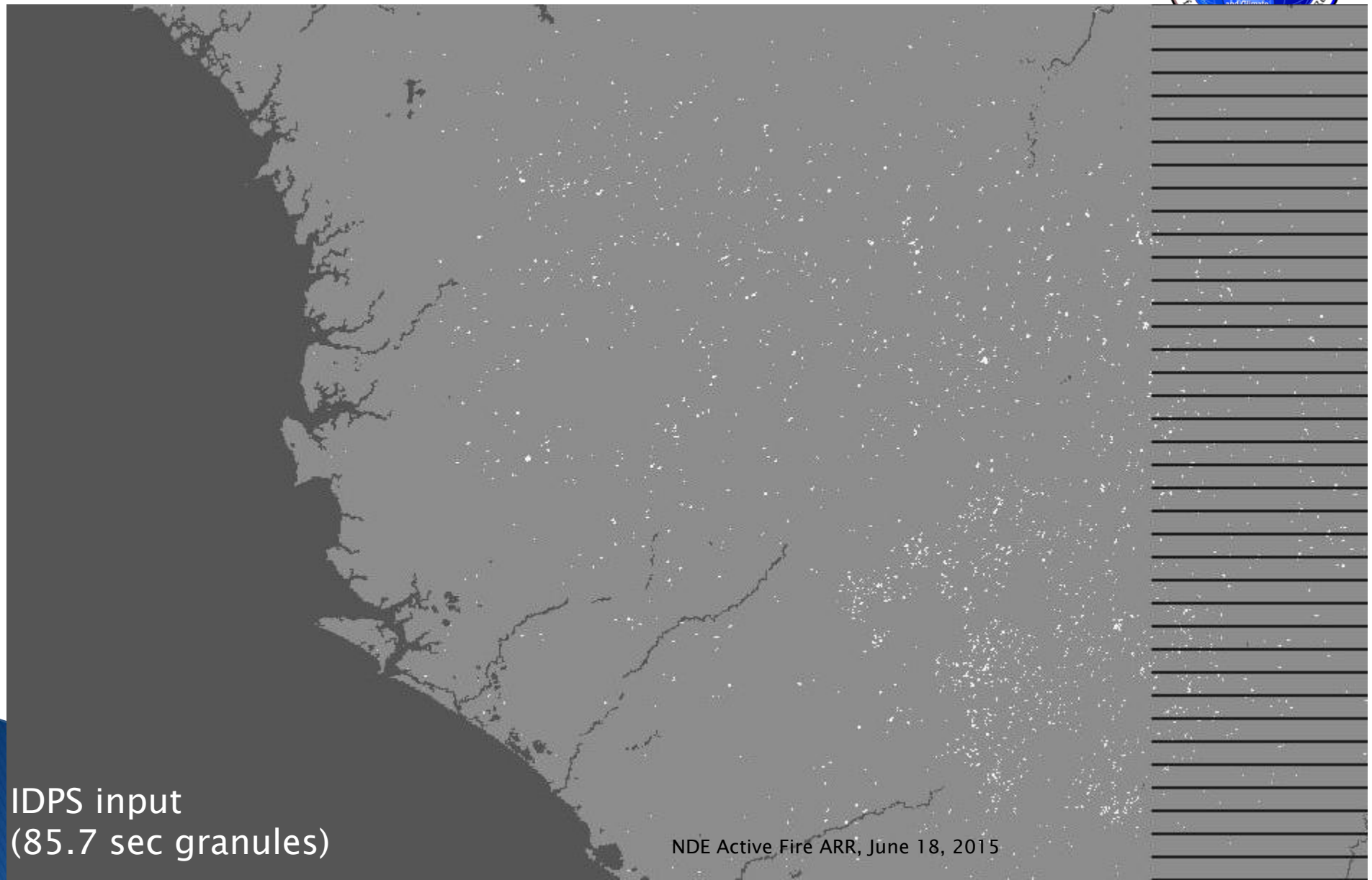






The JPSS 1 "replacement" code has been delivered NOAA STAR Algorithm Implementation Team (AIT) for integration into NOAA operations.

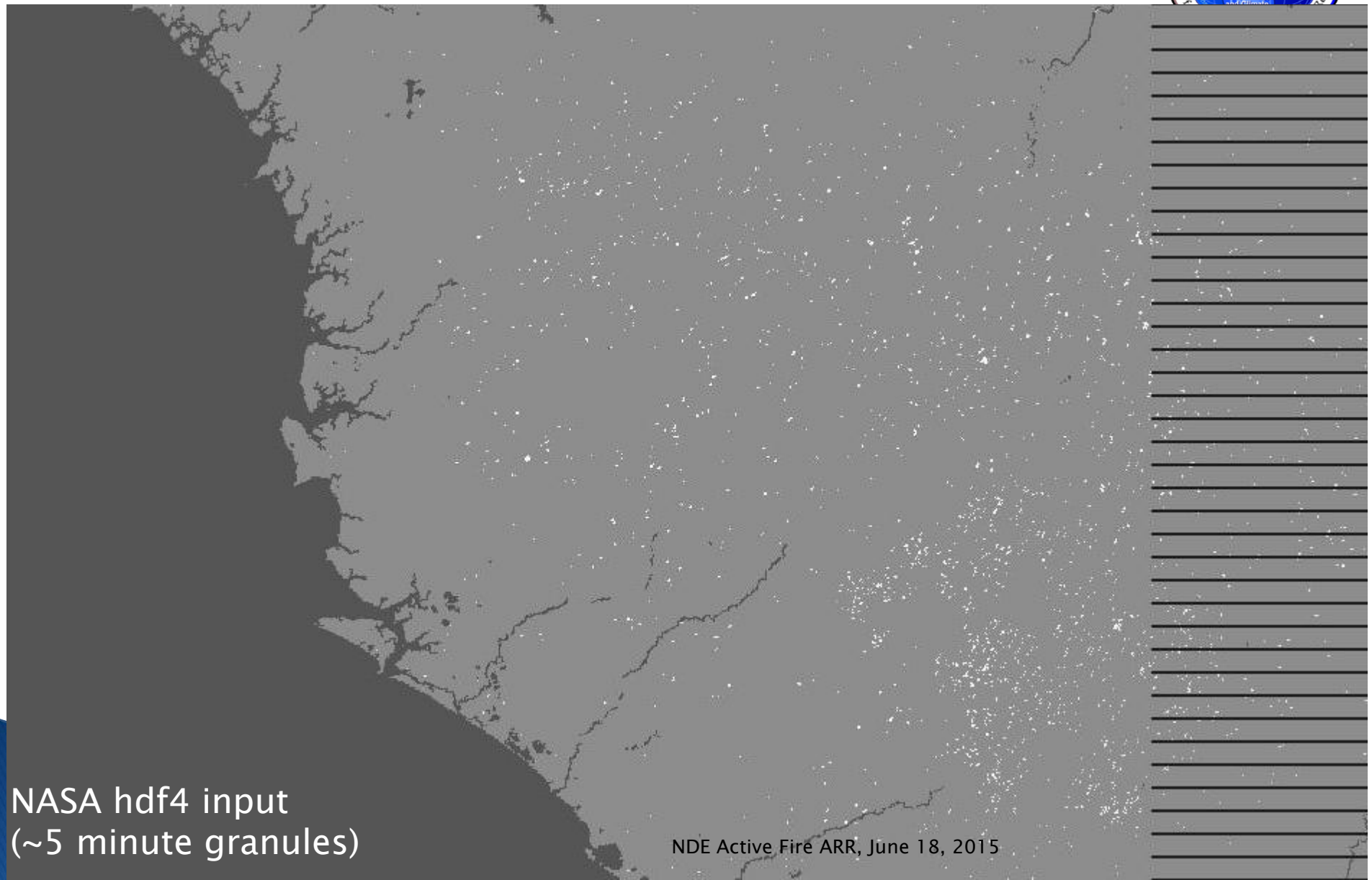
NOAA STAR AIT output



IDPS input
(85.7 sec granules)

NDE Active Fire ARR, June 18, 2015

NASA Science Code output



NASA hdf4 input
(~5 minute granules)

NDE Active Fire ARR, June 18, 2015

STAR vs. NDE (SADIE) output

- A comparison was made for the content of granule AF_20150301_0546405_0548047.nc generated within the STAR testing/development environment and SADIE
- The only differences found were unique ID parameters and creation time
- No differences were found in the science content of the output

Validation / verification summary

- Product accuracy can be traced back to mature and validated MODIS algorithm
- Explicit validation is ongoing
- Available results indicate good detection performance
- Good consistency among FRP estimates from VIIRS, MODIS and TET-1
- Implementation of science code into NOAA environment (STAR; NDE SADIE) is verified using a global sample of cases over one day
- Validation and verification continues

Validated Stage 1 Science Maturity Review for Active Fire

Ivan Csiszar

September 4, 2014

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
- Documentation
- Identification of Processing Environment
- Users & User Feedback
- Conclusion
- Path Forward

Active Fire Cal/Val Team

Algorithm Cal/Val Team Members

Name	Organization	Major Task
Ivan Csiszar	STAR	STAR lead, quality monitoring, LTM, international outreach
Wilfrid Schroeder	UMD	Product monitoring and validation, algorithm development
Louis Giglio	UMD	Algorithm development, quality monitoring
Evan Ellicott	UMD	User readiness
William Walsch	UMD	Code development
Krishna Vadrevu	UMD	International outreach
Chris Justice	UMD	Program coordination, user readiness, MODIS continuity, international outreach
Marina Tsidulko	STAR AIT	Code integration, chain testing

Requirements: L1RD Supplement

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

: Not required for S-NPP

Current IDP product was designed to meet heritage NPOESS requirements., which have been baselined according to L1RDS S-NPP Performance Exclusions (Appendix D). Spatially explicit fire mask and fire characterization are "uppers" in the JPSS L1RD for J1 and beyond.

VIIRS mapping uncertainty

Overall Uncertainty

Residuals	Error (Nadir)	Spec (Nadir)	Error (EOS)	Spec (EOS)
Track mean	-9 m		-20 m	
Scan mean	-7 m		-46 m	
Track RMSE	73 m	133 m	161 m	500 m
Scan RMSE	61 m	133 m	398 m	500 m

- RMSE: Root Mean Square Error (equivalent to unbiased 1 σ)
- Data-days: 632, excluding 18 days right after A/B side switch
- Mean errors are small
- Nadir uncertainties of ~70 m (1 σ) meet spec of 133 m (1 σ) [400 m (3 σ)]
- Edge-of-scan (EOS) uncertainties of ~ 400m (1 σ) meet spec of 500 m (1 σ) [1500 m (3 σ)]

S-NPP requirements explicitly are related to VIIRS SDR mapping accuracy

Considered to be within the VIIRS SDR team's scope; meets requirements

Wolfe et. al., 19 Dec 2013

http://www.star.nesdis.noaa.gov/star/documents/meetings/SNPPSDR2013/dayTwo/Wolfe_NASA_VIIRS.pdf

SNPP Validation and Maturity Stages

Validated Stage 1:

Using a limited set of samples, the algorithm output is shown to meet the threshold performance attributes identified in the JPSS Level 1 Requirements Supplement with the exception of the S-NPP Performance Exclusions

Validated Stage 2:

Using a moderate set of samples, the algorithm output is shown to meet the threshold performance attributes identified in the JPSS Level 1 Requirements Supplement with the exception of the S-NPP Performance Exclusions

Validated Stage 3:

Using a large set of samples representing global conditions over four seasons, the algorithm output is shown to meet the threshold performance attributes identified in the JPSS Level 1 Requirements Supplement with the exception of the S-NPP Performance Exclusions

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

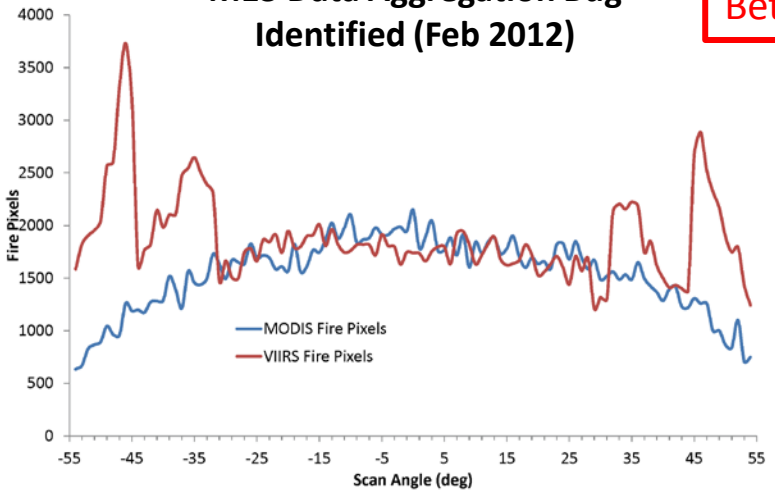
- Findings/Issues from Provisional Review
- Improvements since Provisional
  - Algorithm Improvements
  - LUT / PCT updates
- Cal/Val Activities for evaluating algorithm performance:
  - Test / ground truth data sets
  - Validation strategy / method
  - Validation results

Product Quality metrics

- Estimates of commission / omission errors and **comparison with MODIS**
  - The product performs well in comparison to MODIS and AVHRR
  - Increased resolution and VIIRS mapping geometry improves product quality for off nadir observations and increases spatial coverage
- **VIIRS sensor and SDR performance and quality flagging** (near the high end of the dynamic range) and the **ability to filter bad input data** without compromising detection of valid fire pixels
  - The majority of the work has been analysis of VIIRS SDR quality and work with the SDR team to implement fixes
  - The frequency of the SDR-related detection errors decrease over time as SDR code changes were implemented in IDPS

Comparison with Aqua MODIS

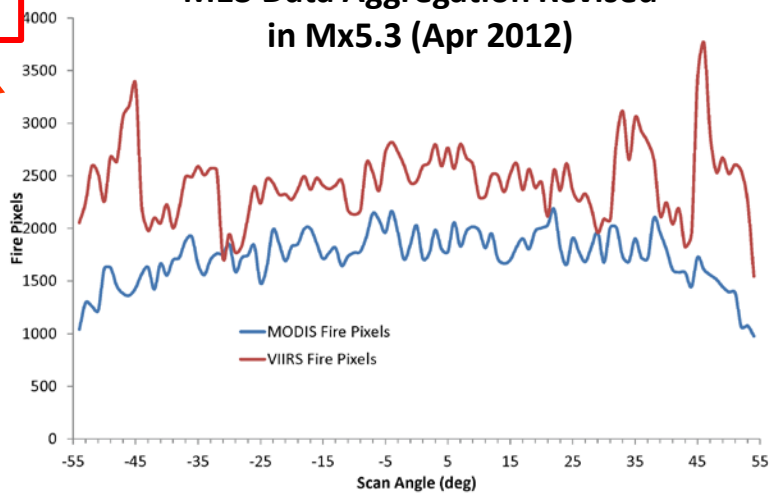
M13 Data Aggregation Bug Identified (Feb 2012)



19 Jan - 13 Feb 2012

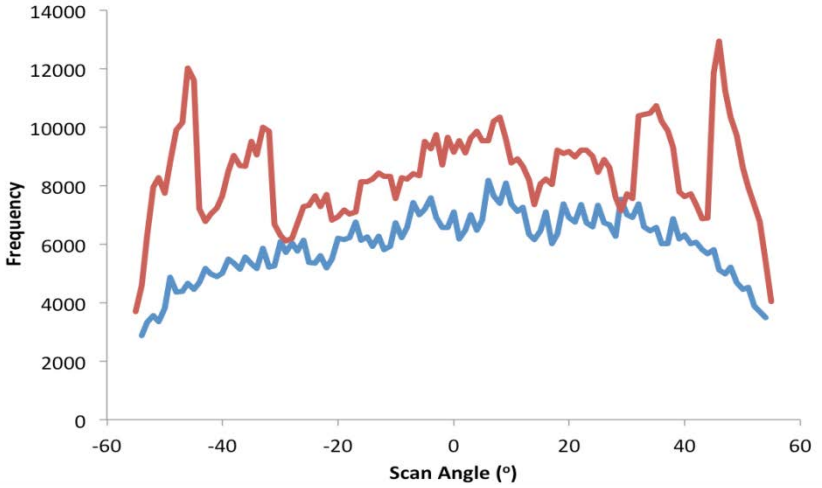
Beta maturity

M13 Data Aggregation Revised in Mx5.3 (Apr 2012)



11 May - 10 Jun 2012

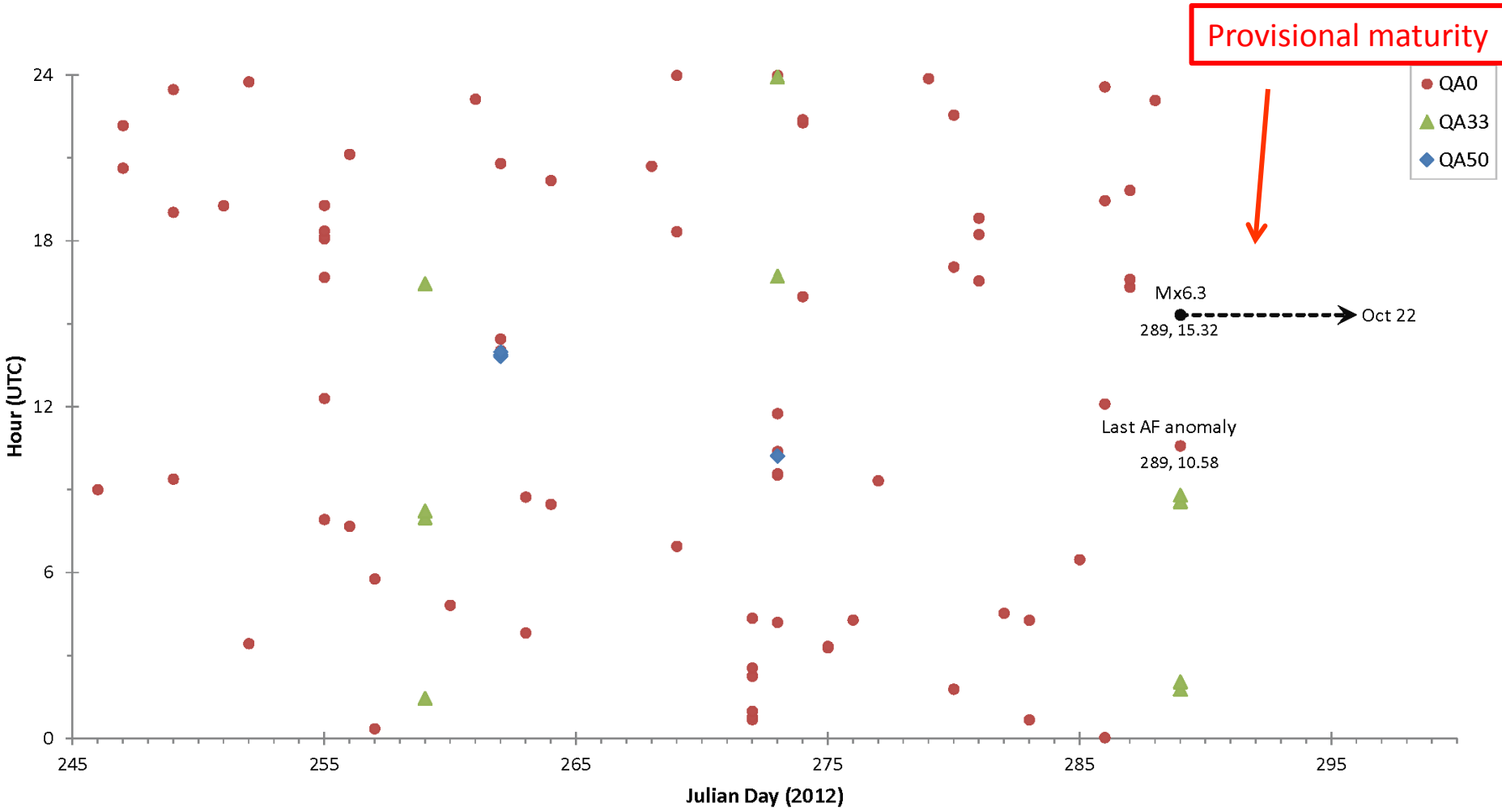
The <u>overall features</u> of the Aqua MODIS and S-NPP functional dependence on scan angle <u>remained the same a year later</u> and over a longer time period



Feb - Jun 2013

(from Provisional Review)

Impact of M13 SDR dual gain fix on active fire product performance



Effectivity date for Provisional Maturity: October 16, 2012
(first full day after the implementation of IDPS Mx6.3 on October 15)

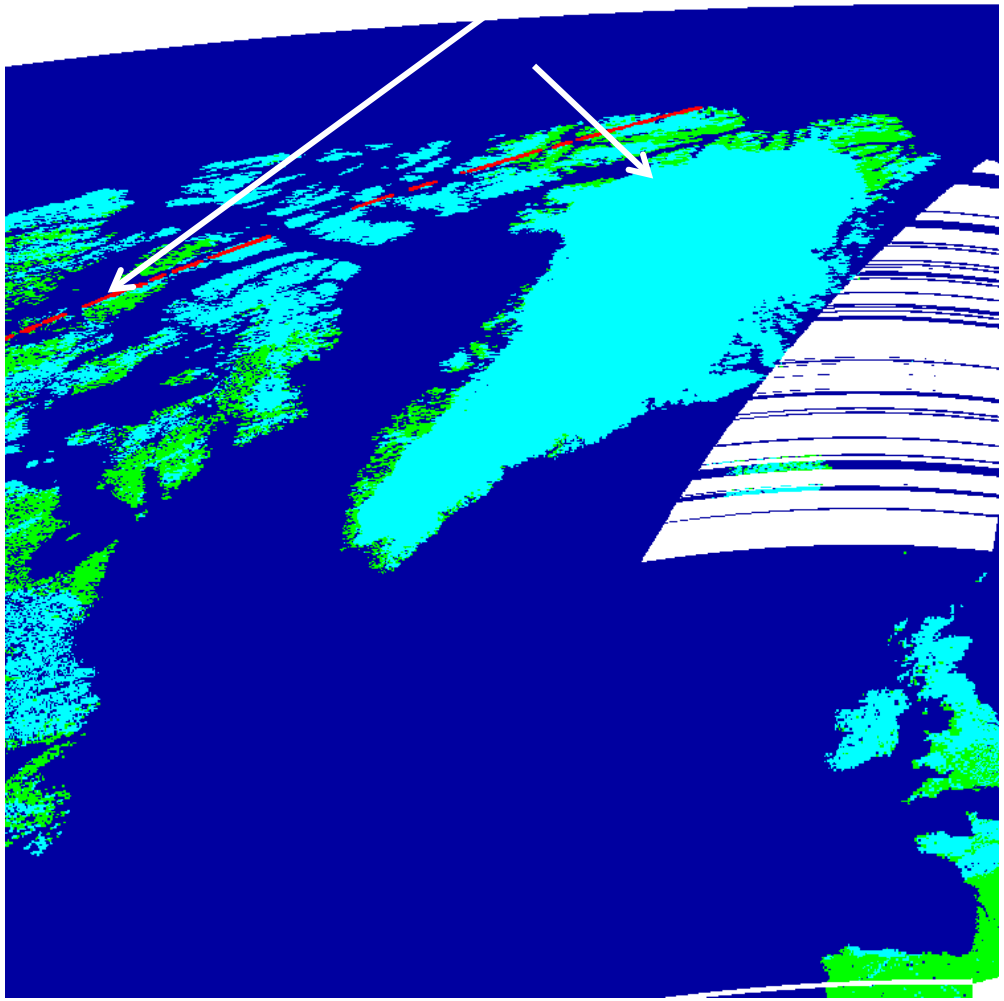
(from Provisional Review)

Current and recent VIIRS SDR issues

- **Non-unique mapping of radiance to brightness temperature** near saturation
  - DR 7294: Radiance and Reflectance/Brightness Temperature Upper Bounds and Quality Flagging Are Inconsistent
    - Work underway: team provided examples
  - Related issue is handling of actual sensor capabilities in SDR software
- **SDR QF1 is set incorrectly and/or cannot be used for unambiguous filtering of bad input data**
  - 474-CCR-14-1667: VIIRS SDR Multiple Issues/Quality Flags & Calibration) (ADRs 7110, 7111, 7112, 7227, 7313, 7448, 7449
  - Implemented in Mx8.5; initial evaluation presented here
- **"Folded" radiance values due to saturation not flagged as invalid; presence of saturation of input pixels prior to on-board aggregation undetected and not flagged**
  - CCR NJO-2014-007: Flagging sub-pixel saturation within nominal aggregated pixels of single-gain VIIRS bands

Primary quality issue: bad scan lines

July 15 2014 14:33:19 UTC



NPP_VAFIP_L2(Active Fire IP) on 2014196, LPEATE (AS3001)

Reference Table for QA bits

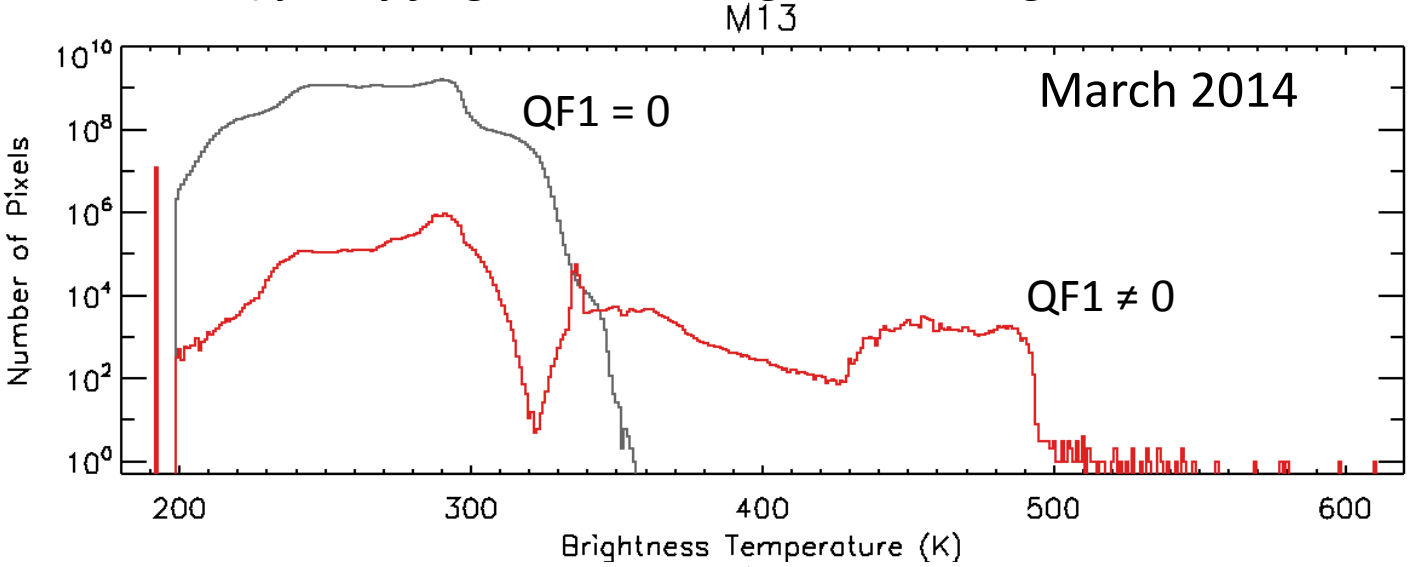
QF1_VIIRSMBANDSDR 1 byte(s) 768 3200	Description	Datum Offset	Data Type	Legend Entries	
	Quality - Indicates calibration quality due to bad space view offsets, OBC view offsets, etc or use of a previous calibration view	0	2 bit(s)	Name	Value
				Good	0
				Poor	1
				No Calibration	2
				Not Used	3
	Saturated Pixel - Indicates the level of pixel saturation	2	2 bit(s)	Name	Value
				None Saturated	0
				Some Saturated	1
				All Saturated	2
				Not Used	3
	Missing Data - Data required for calibration processing is not available for processing	4	2 bit(s)	Name	Value
				All data present	0
				EV RDR data missing	1
				Cal data (SV, CV, SD, etc.) missing	2
				Thermistor data missing	3
	Out of Range - Calibrated pixel value outside of LUT threshold limits	6	2 bit(s)	Name	Value
				All data within range	0
				Radiance out of range	1
				Reflectance or EBBT out of range	2
				Both Radiance and Reflectance/EBBT out of	3

QA	Definition
5	Poor Cal - Some saturated
18	No Calibration - None Saturated - EV RDR Data Missing
33	Poor Cal - None Saturared - Cal Data Missing
34	No Calibration - None Saturated - Cal Data Missing
50	No Calibration - None Saturated - Thermistor Data Missing
129	Poor Cal - None Saturated - All Data Present - Reflectance or EBBT Out of Range
193	Not used – Radiance out of range
65	Poor – Reflectance or EBBT out of range

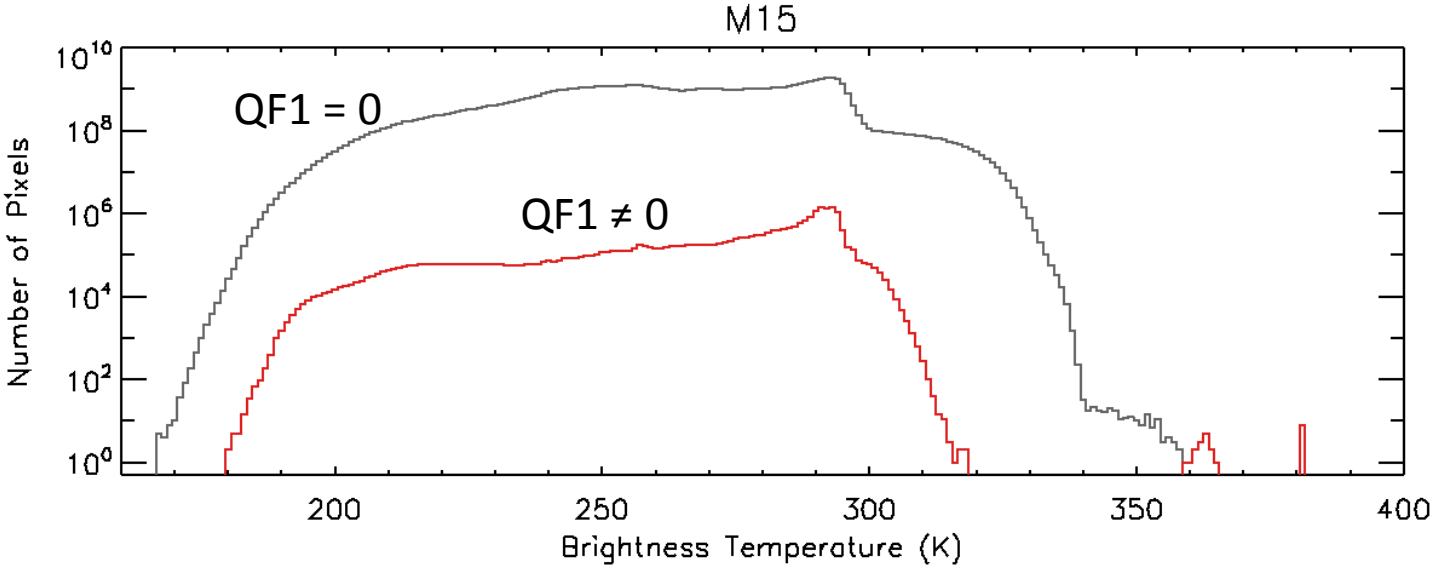
(165 cal data missing)

Issues: input SDR quality flagging

Suomi NPP product quality and maturity has been driven by input VIIRS SDR performance (quality flags, calibration gain switching, saturation handling etc.)

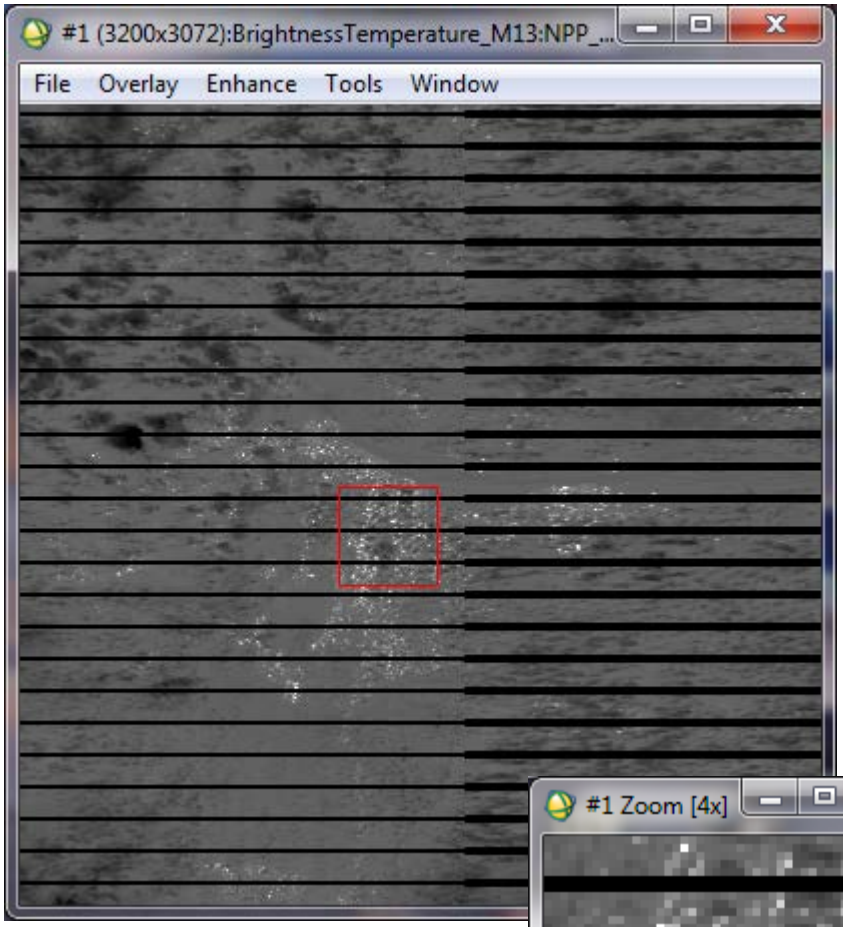


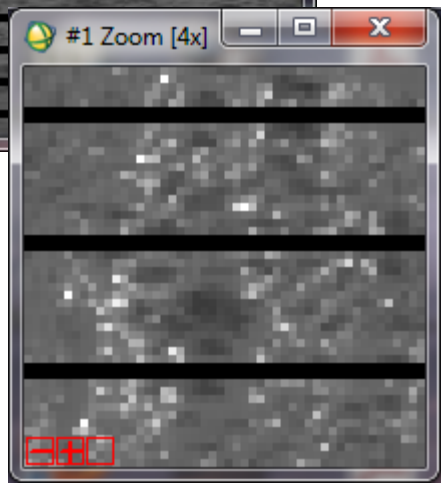
The fire team is preparing for verification by analyzing known granules and cumulative statistics.

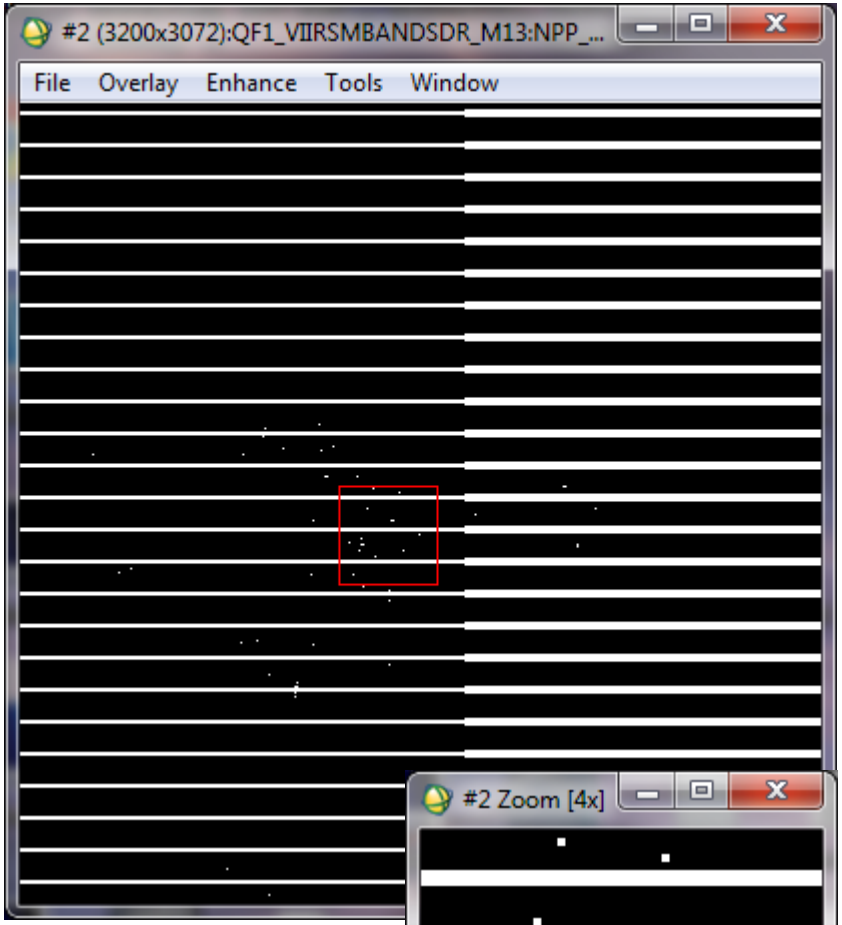


These results are based on Mx7.2 processing within LandPEATE.

Quality flagging of TB>358K



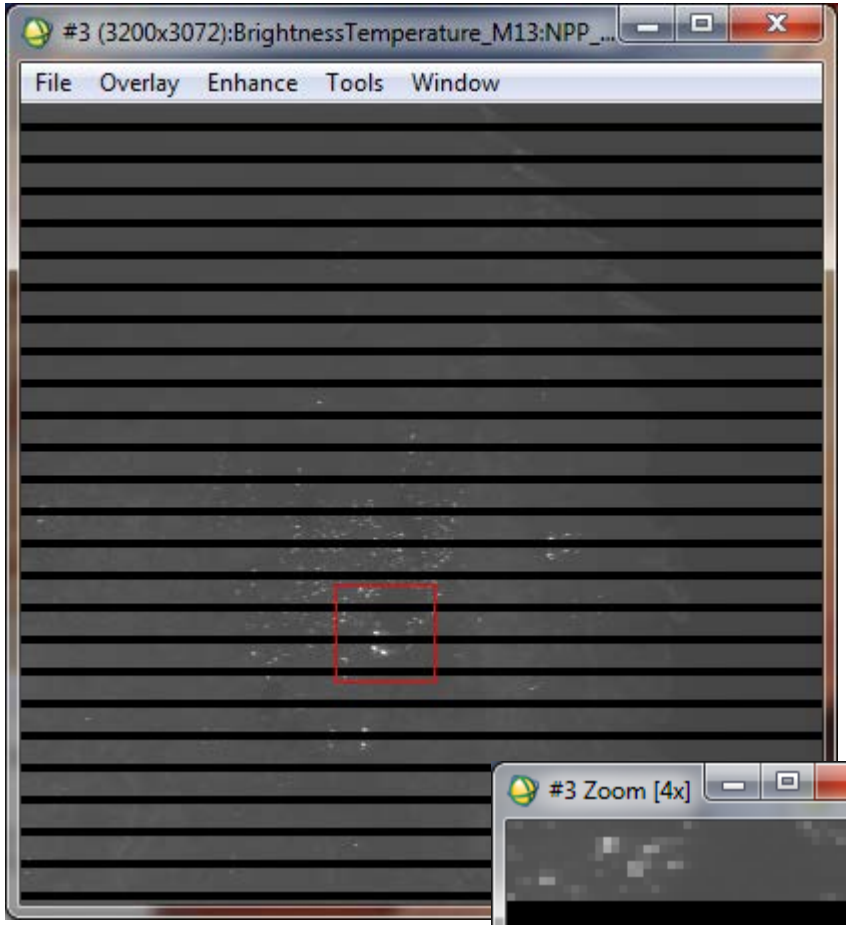


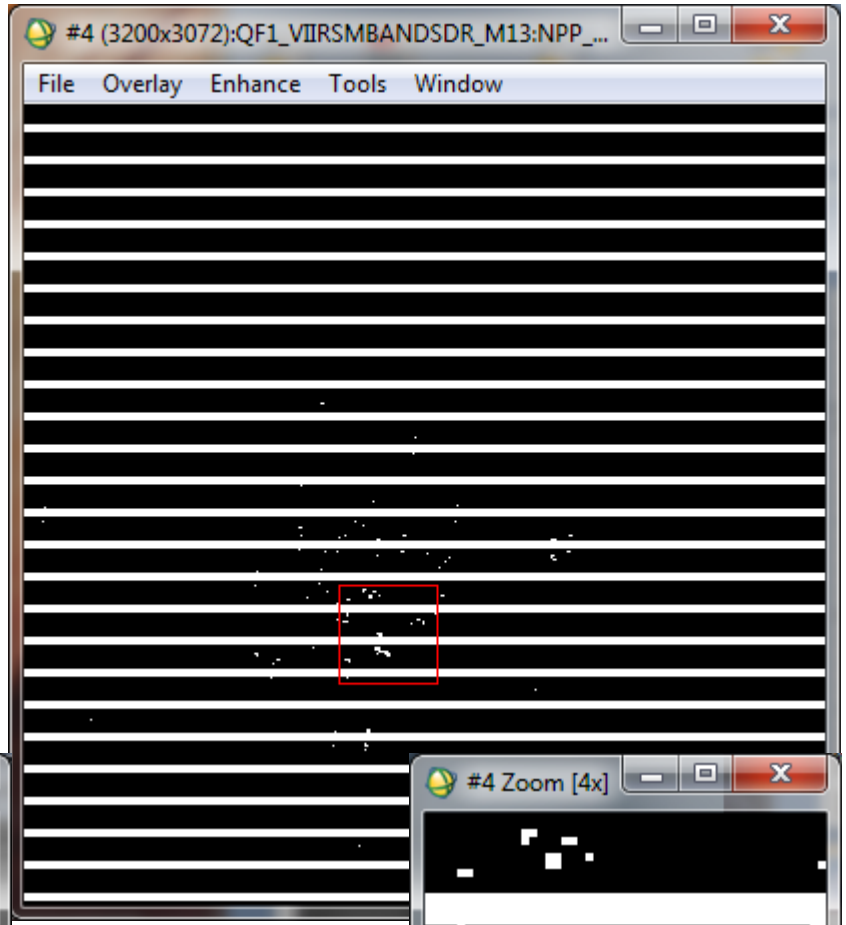


March 12 2014 11:35 UTC
IDPS 7.2 LandPEATE

All pixels with TB>358K have QF>0 (= not "good")

Quality flagging of TB>358K

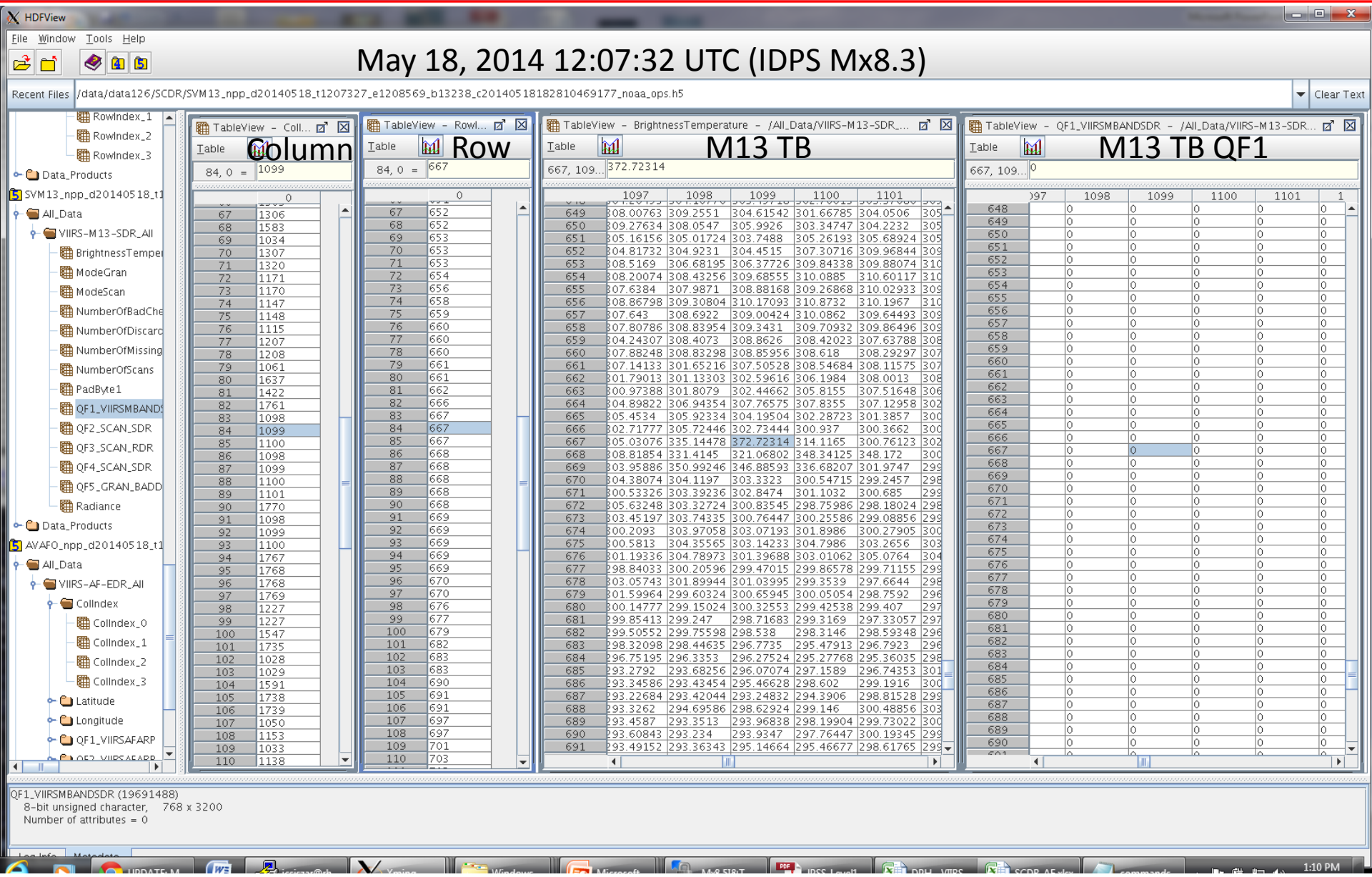




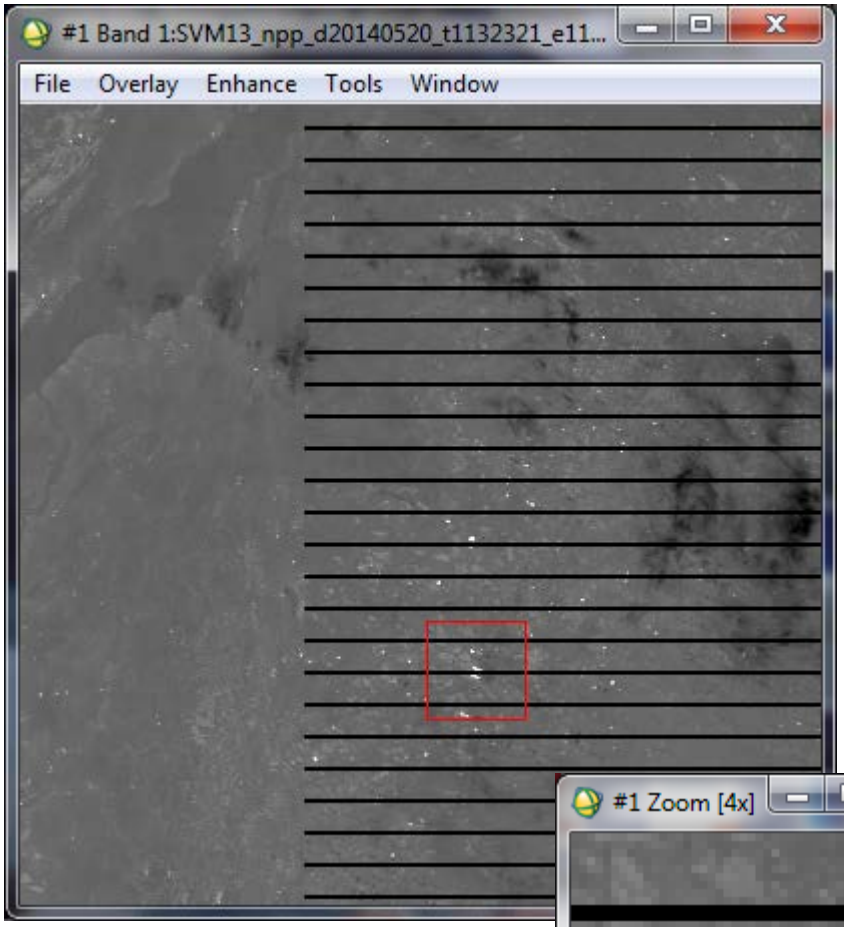
March 22 2014 13:20 UTC
IDPS 7.2 LandPEATE

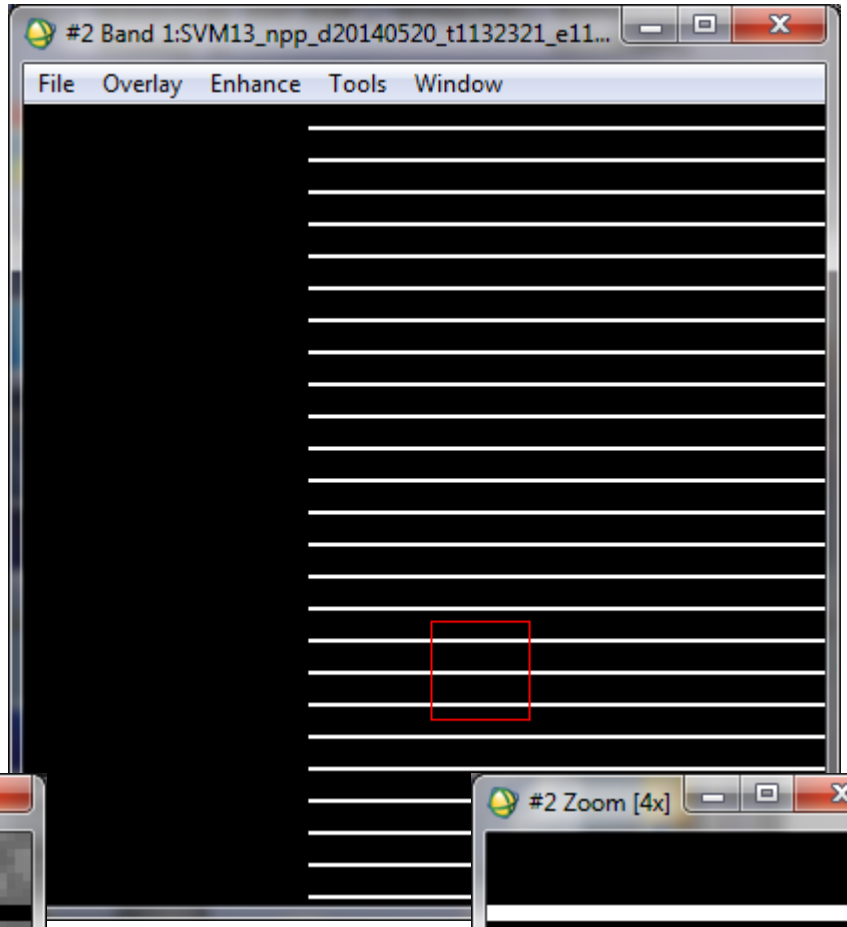
All pixels with TB>358K have QF>0 (= not "good")

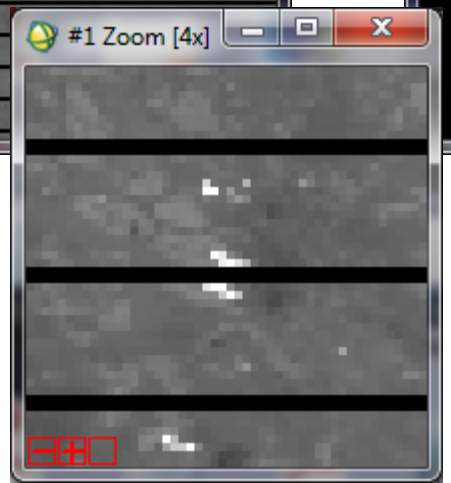
Quality flagging of TB>358K

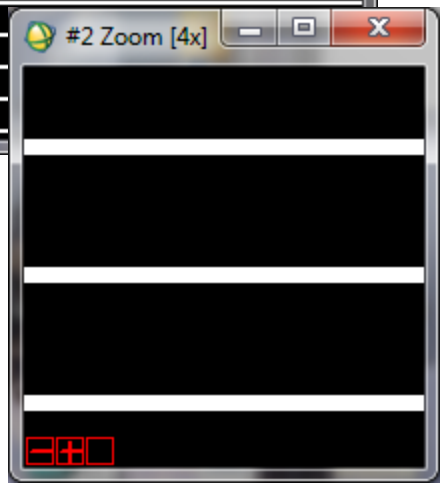


Quality flagging of TB>358K





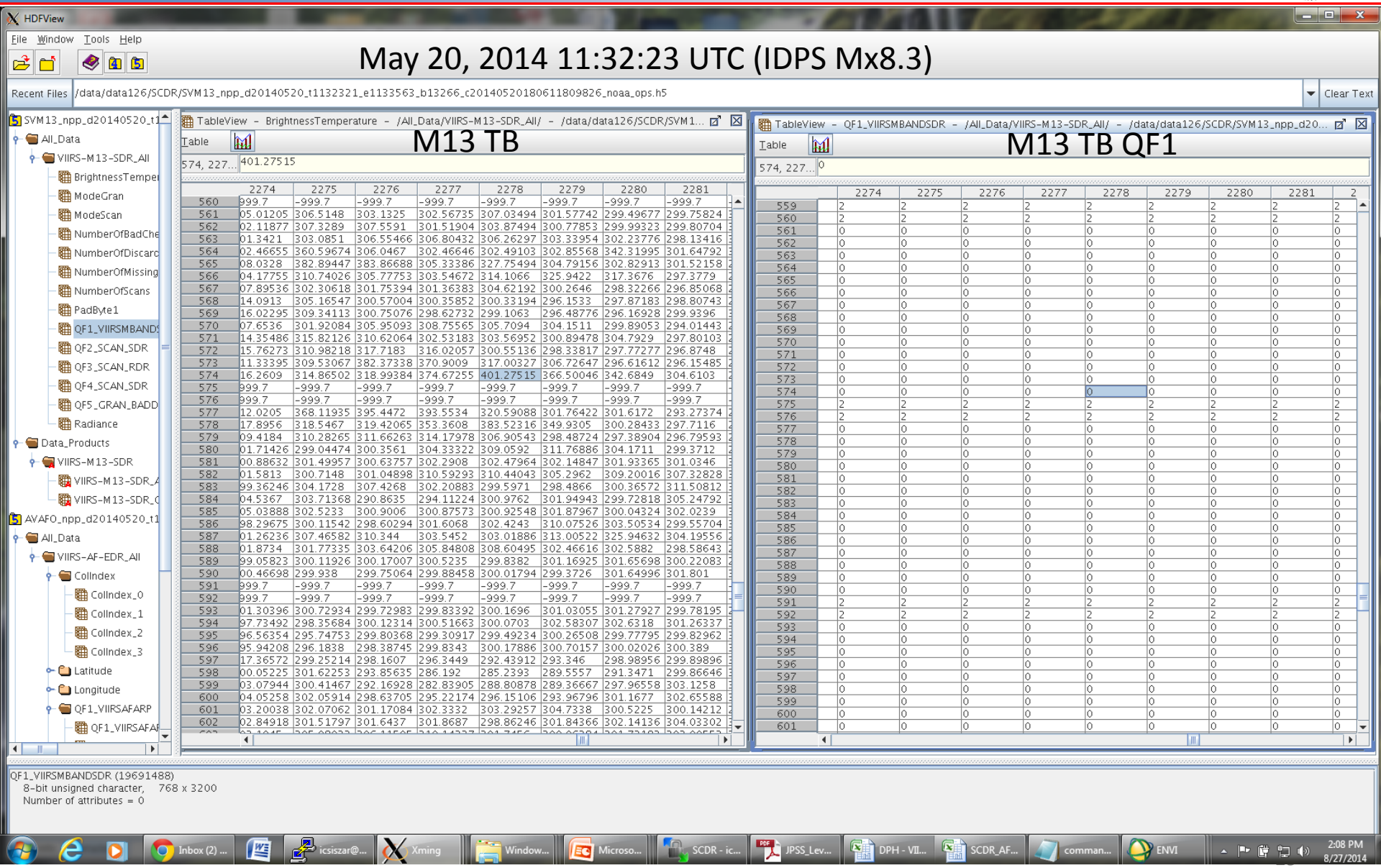




May 20 2014 11:32:32 UTC
IDPS Mx 8.3

All pixels with TB>358K have QF=0

Quality flagging of TB>358K



Datasets for Mx8.5 evaluation

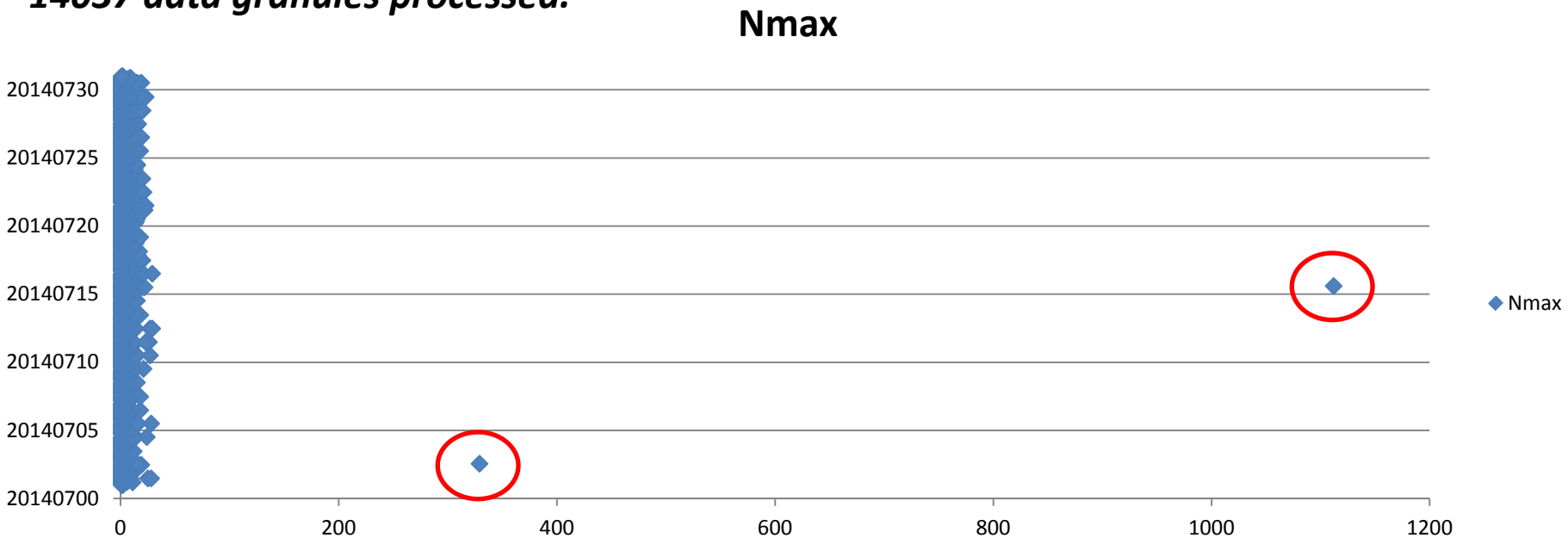
- **IDPS operational data stream**
  - 4/28/14 onward
    - Mx8.4 TTO 5/22/2014 14:40 UTC
    - Mx8.5 TTO 8/13/2014 15:25 UTC
  - STAR SCDR, GRAVITE
- **Mx8.5 Factory Bench Test data from Raytheon**
  - 7/2/2014
  - GRAVITE, recovery of some data from LandPEATE
- **Mx8.5 Integration and Testing data from Raytheon**
  - 7/30/2014 – 8/1/2014; 8/4/2014 – 8/14/2014
  - GRAVITE
- **STAR AIT processing using Mx8.5 for select granules**
  - 7/15/2014

Evaluation method

- Search for **spurious detections** in each Active Fire data granule in operational and test data streams
  - Histogram analysis of fire pixels within scan lines
- **Detailed analysis** of granules with spurious detections
  - VIIRS M13/M15 SDR brightness temperature / radiance output and corresponding quality flags
  - Evaluation of differences between Mx8.4 and Mx8.5
- **Statistical analysis** of VIIRS M13/M15 SDR quality flags

IDPS performance

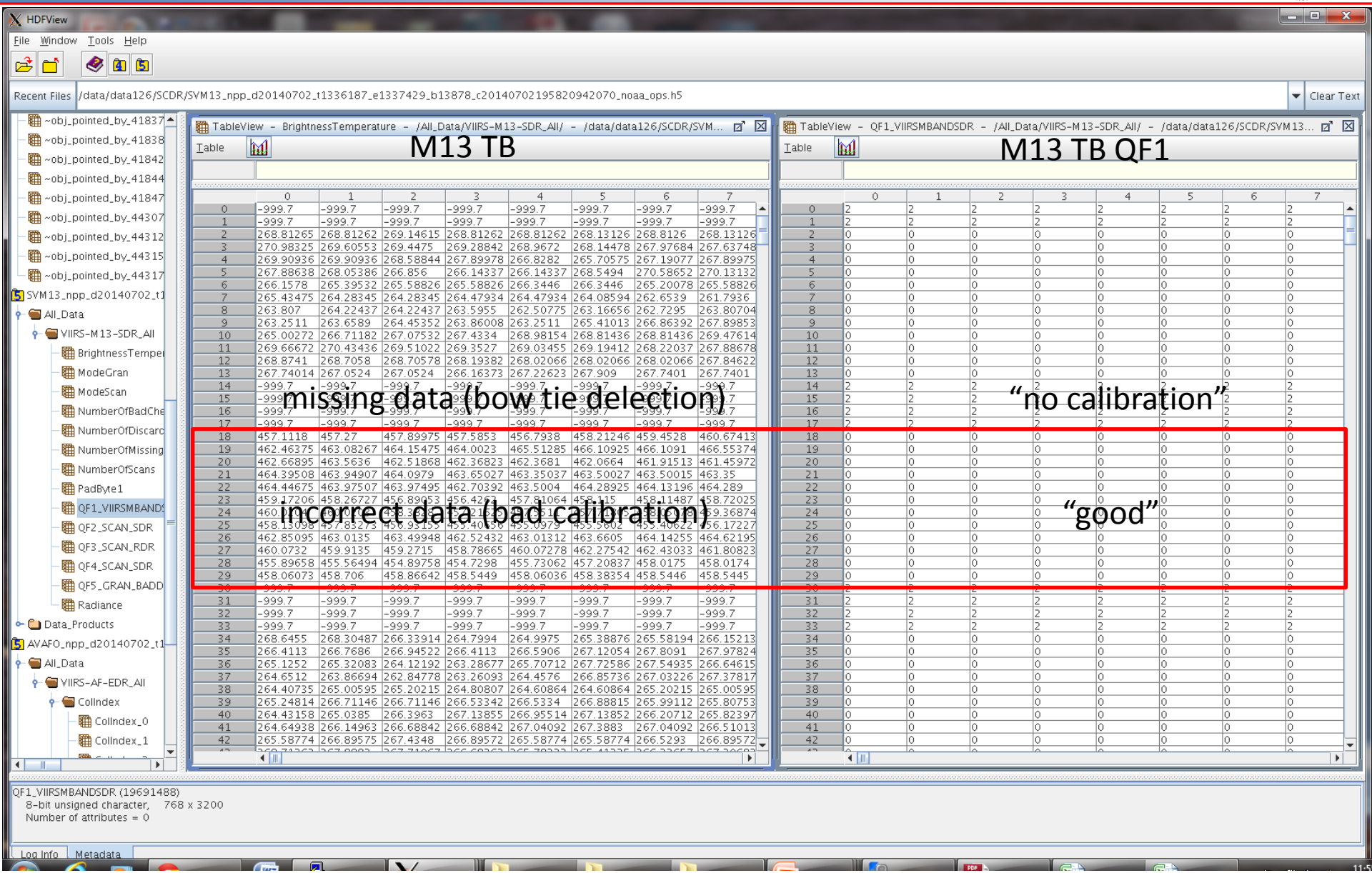
IDPS AVAFO granules from STAR SCDR were processed for April 30 – September 02 2014. Only July 2014 is shown here. No other spurious detections were found out of the total of 14037 data granules processed.



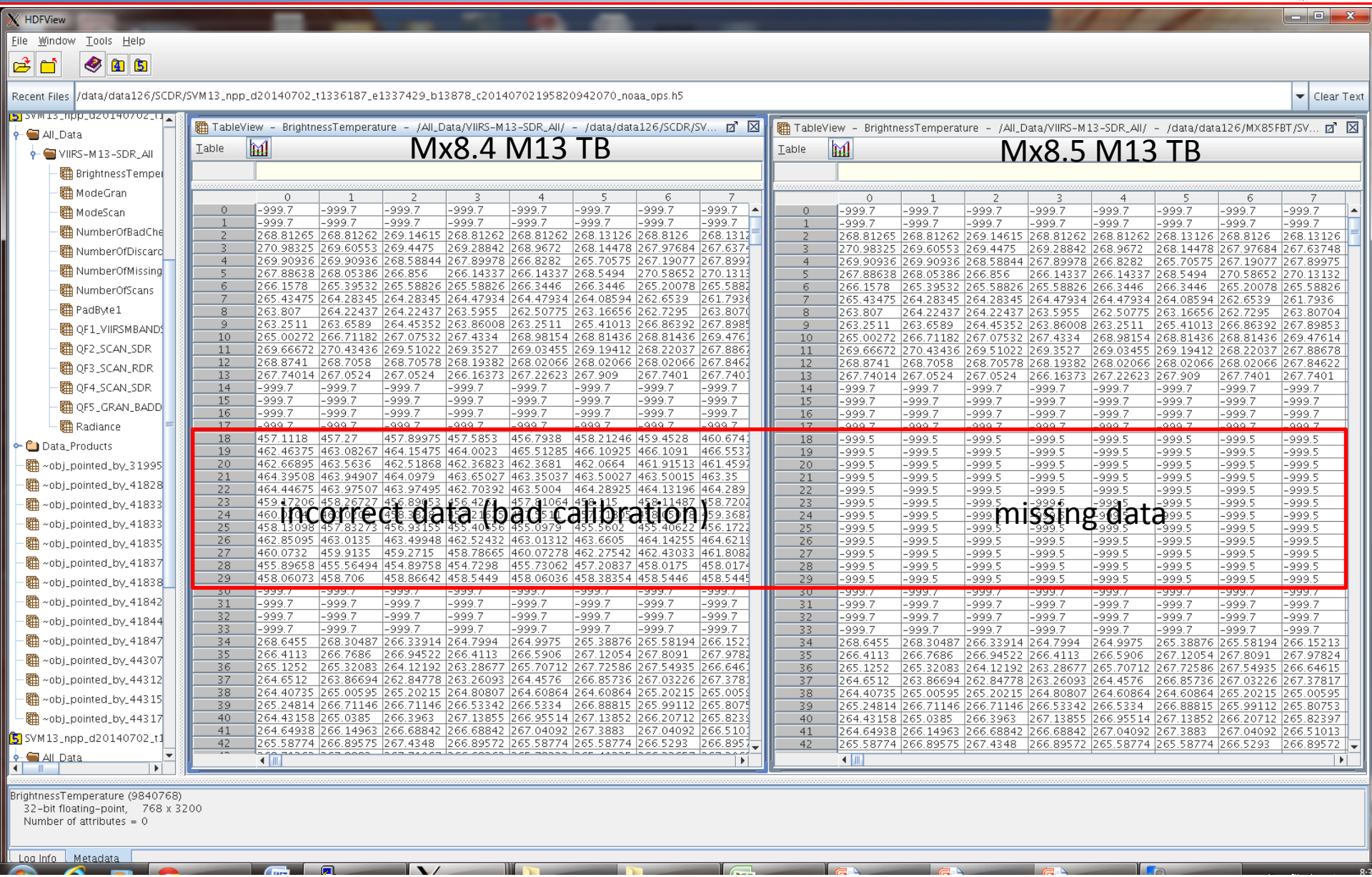
Nmax: maximum number of active fire detections within a single scan line within a granule

Spurious detections: July 02, 2014 13:36:18 – 13:41:59 (Nmax: 329)
July 15, 2014 14:33:19 – 14:34:41 (Nmax: 1112)

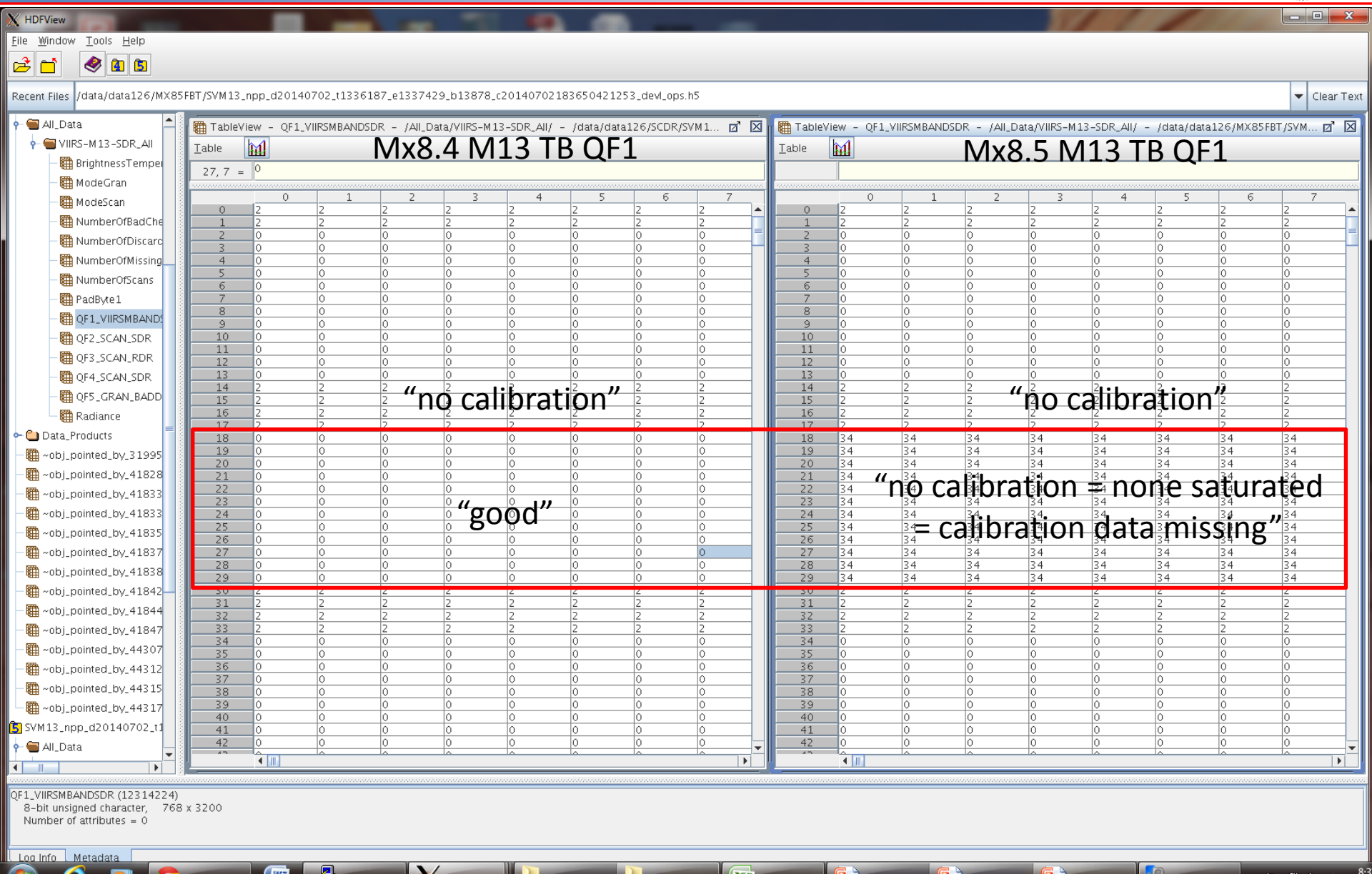
Mx8.4: July 2, 2014 case



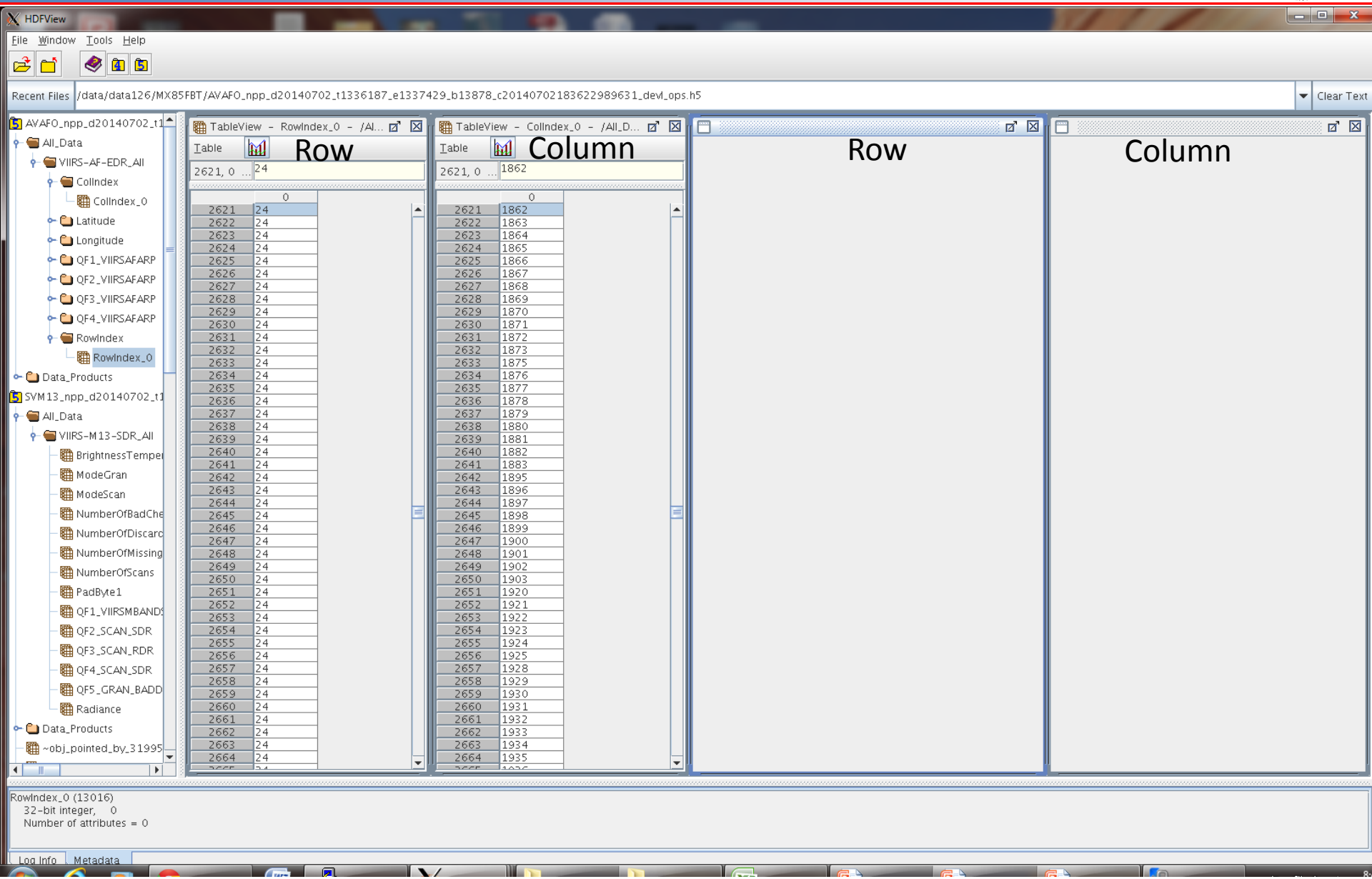
July 2: Mx8.4 vs. Mx8.5 M13 TB



July 2: Mx8.4 vs. Mx8.5 M13 QF1



July 2: Mx8.4 vs. Mx8.5 AVAFO



Issues: input SDR quality flagging

MX8.4 SVM13 QF1

	5	9	18	33	50	129	193 Pixels Sampled
7/2/2014						437971	2484633600
7/31/2014			12704	31904	1638400	509317	2489548800
8/5/2014	1	3				225661	2509209600
8/6/2014						276007	2499379200
8/7/2014				44608	972800	199022	44608 2499379200

MX8.4 SVM15 QF1

	2	9	50	65 Pixels Sampled	
7/2/2014					
7/31/2014	210944	2		3	2489548800
8/5/2014		36		26	2509209600
8/6/2014				2	2499379200
8/7/2014			972800		2499379200

Mx8.5: Bad SDR M13 data properly flagged and no false detections

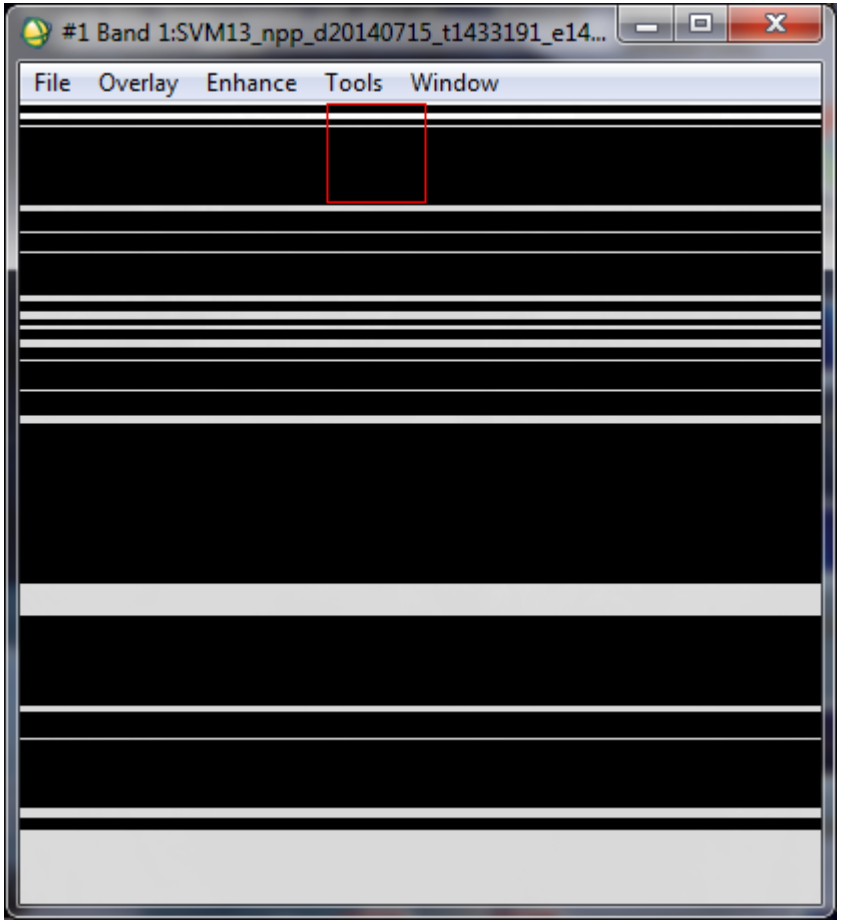
Mx8.5 SVM13 QF1

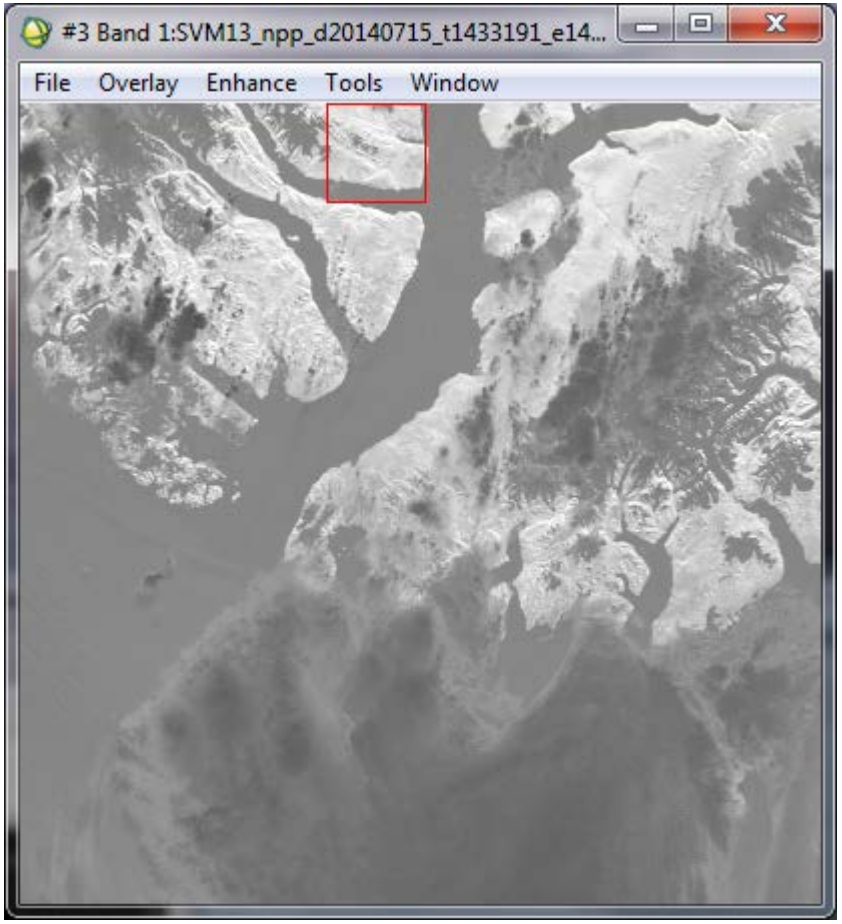
	5	9	33	34	50	129	193 Pixels Sampled
7/2/2014				44608		437971	2487091200
7/31/2014						429358	2484633600
8/5/2014	1	3				237937	3113779200
8/6/2014						276007	2494464000
8/7/2014			44608	44608	972800	205464	44608 2568192000

Mx8.5 SVM15 QF1

	9	18	50	65 Pixels Sampled	
7/2/2014					
7/31/2014	2			3	2484633600
8/5/2014	36			26	3113779200
8/6/2014		6208		2	2494464000
8/7/2014			972800		2568192000

July 15 case: two granules in SCDR

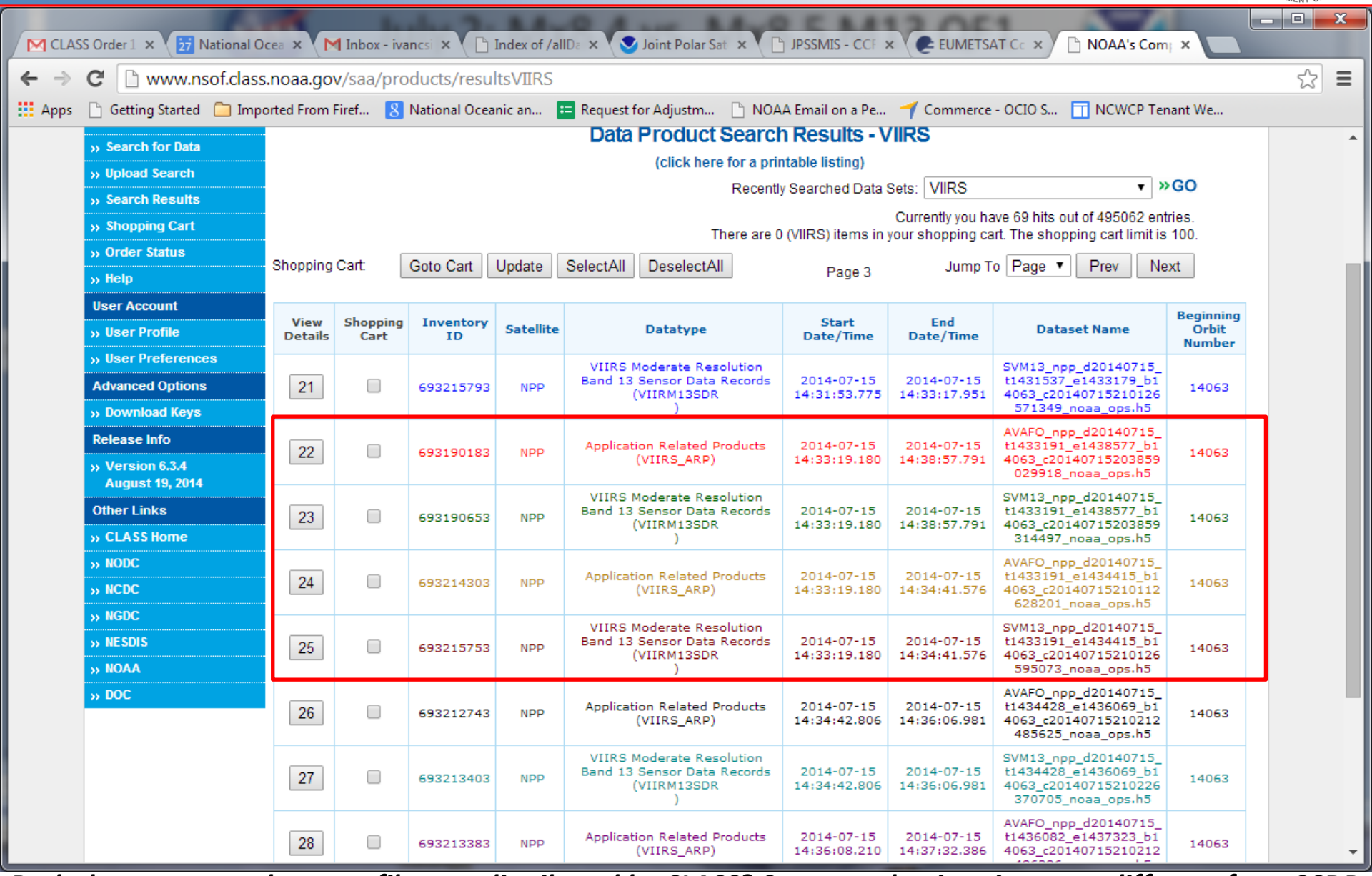




SVM13_npp_d20140715_t1433191_e1434415_b14063_c20140715210319690945_noaa_ops.h5
AVAFO_npp_d20140715_t1433191_e1438577_b14063_c20140715203859029918_noaa_ops.h5

SVM13_npp_d20140715_t1433191_e1434415_b14063_c20140715211948960246_noaa_ops.h5
AVAFO_npp_d20140715_t1433191_e1434415_b14063_c20140715210112628201_noaa_ops.h5

July 15 case: CLASS



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www.nsof.class.noaa.gov/saa/products/resultsVIIRS

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Data Product Search Results - VIIRS

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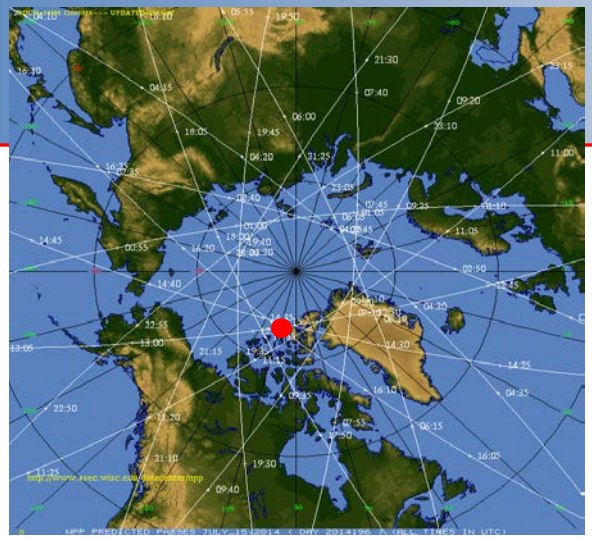
View Details	Shopping Cart	Inventory ID	Satellite	Datatype	Start Date/Time	End Date/Time	Dataset Name	Beginning Orbit Number
21		693215793	NPP	VIIRS Moderate Resolution Band 13 Sensor Data Records (VIIRM13SDR)	2014-07-15 14:31:53.775	2014-07-15 14:33:17.951	SVM13_npp_d20140715_t1431537_e1433179_b14063_c20140715210126571349_noaa_ops.h5	14063
22		693190183	NPP	Application Related Products (VIIRS_ARP)	2014-07-15 14:33:19.180	2014-07-15 14:38:57.791	AVAFO_npp_d20140715_t1433191_e1438577_b14063_c20140715203859029918_noaa_ops.h5	14063
23		693190653	NPP	VIIRS Moderate Resolution Band 13 Sensor Data Records (VIIRM13SDR)	2014-07-15 14:33:19.180	2014-07-15 14:38:57.791	SVM13_npp_d20140715_t1433191_e1438577_b14063_c20140715203859314497_noaa_ops.h5	14063
24		693214303	NPP	Application Related Products (VIIRS_ARP)	2014-07-15 14:33:19.180	2014-07-15 14:34:41.576	AVAFO_npp_d20140715_t1433191_e1434415_b14063_c20140715210112628201_noaa_ops.h5	14063
25		693215753	NPP	VIIRS Moderate Resolution Band 13 Sensor Data Records (VIIRM13SDR)	2014-07-15 14:33:19.180	2014-07-15 14:34:41.576	SVM13_npp_d20140715_t1433191_e1434415_b14063_c20140715210126595073_noaa_ops.h5	14063
26		693212743	NPP	Application Related Products (VIIRS_ARP)	2014-07-15 14:34:42.806	2014-07-15 14:36:06.981	AVAFO_npp_d20140715_t1434428_e1436069_b14063_c20140715210212485625_noaa_ops.h5	14063
27		693213403	NPP	VIIRS Moderate Resolution Band 13 Sensor Data Records (VIIRM13SDR)	2014-07-15 14:34:42.806	2014-07-15 14:36:06.981	SVM13_npp_d20140715_t1434428_e1436069_b14063_c20140715210226370705_noaa_ops.h5	14063
28		693213383	NPP	Application Related Products (VIIRS_ARP)	2014-07-15 14:36:08.210	2014-07-15 14:37:32.386	AVAFO_npp_d20140715_t1436082_e1437323_b14063_c20140715210212	14063

Both the corrupt and correct files are distributed by CLASS? Some production times are different from SCDR.

July 15, 2014 ~14:33-14:34

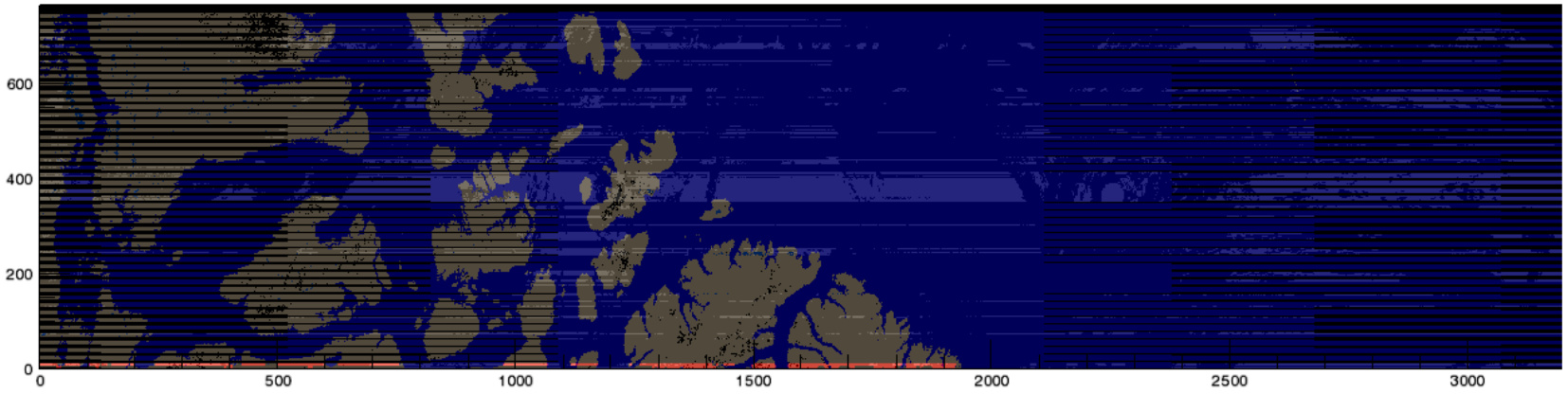
d20140715_t1433174_e1434428_b14063



← Approximate position of Granule's center

Mx8.4 in operational runs

SCDR archive: AF-EDR Granule Version A1M



multiple fires along boundary

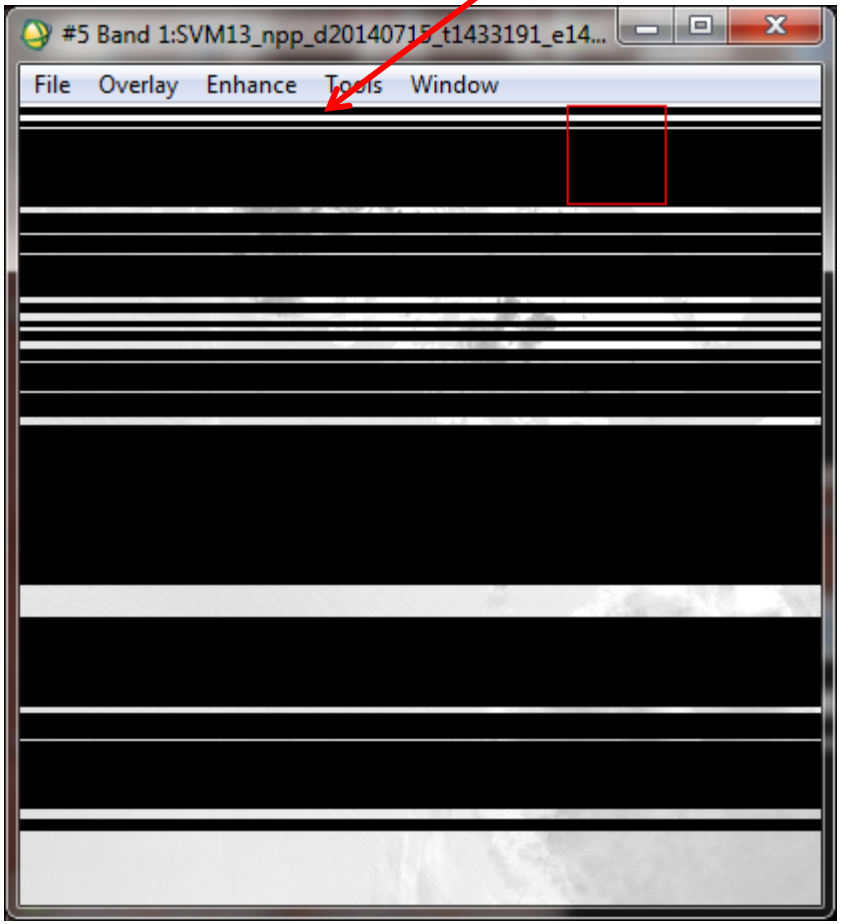
SCDR archive: Granule Version A2
AIT Mx8.5 RDR->SDR->AF EDR run Granule Version A1
AIT Mx8.5 RDR->SDR->AF EDR run Granule Version A2

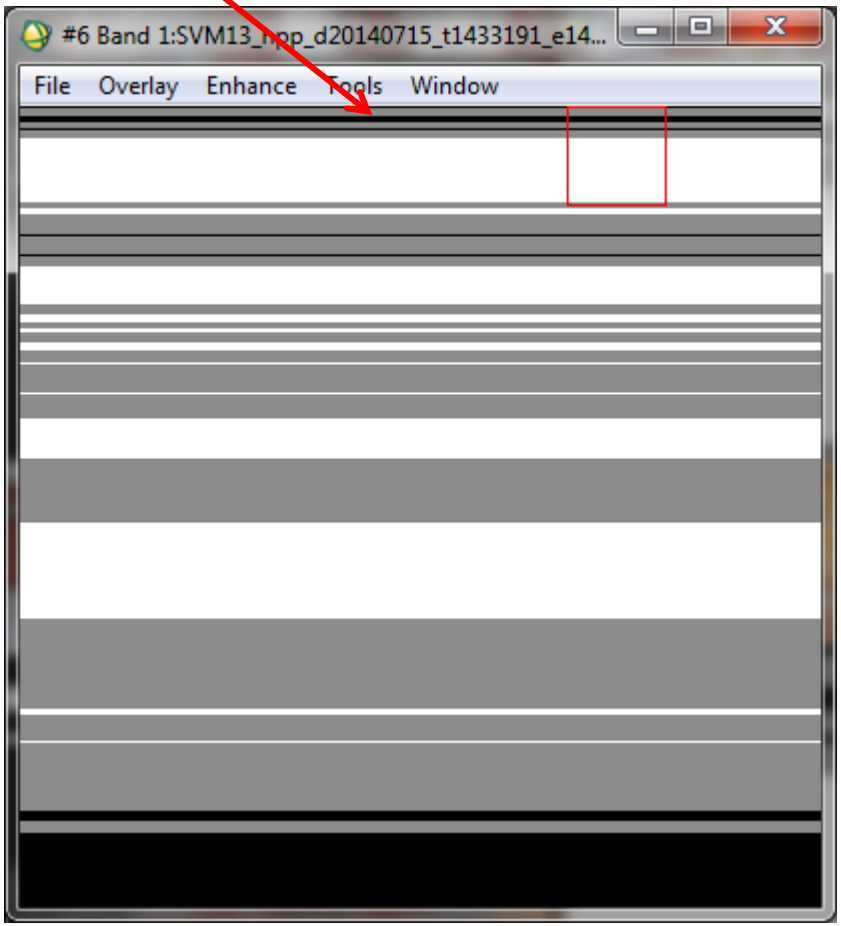
No fires in AF-EDR

July 15 case: Mx8.4 vs. Mx8.5

M13 TB > 400K

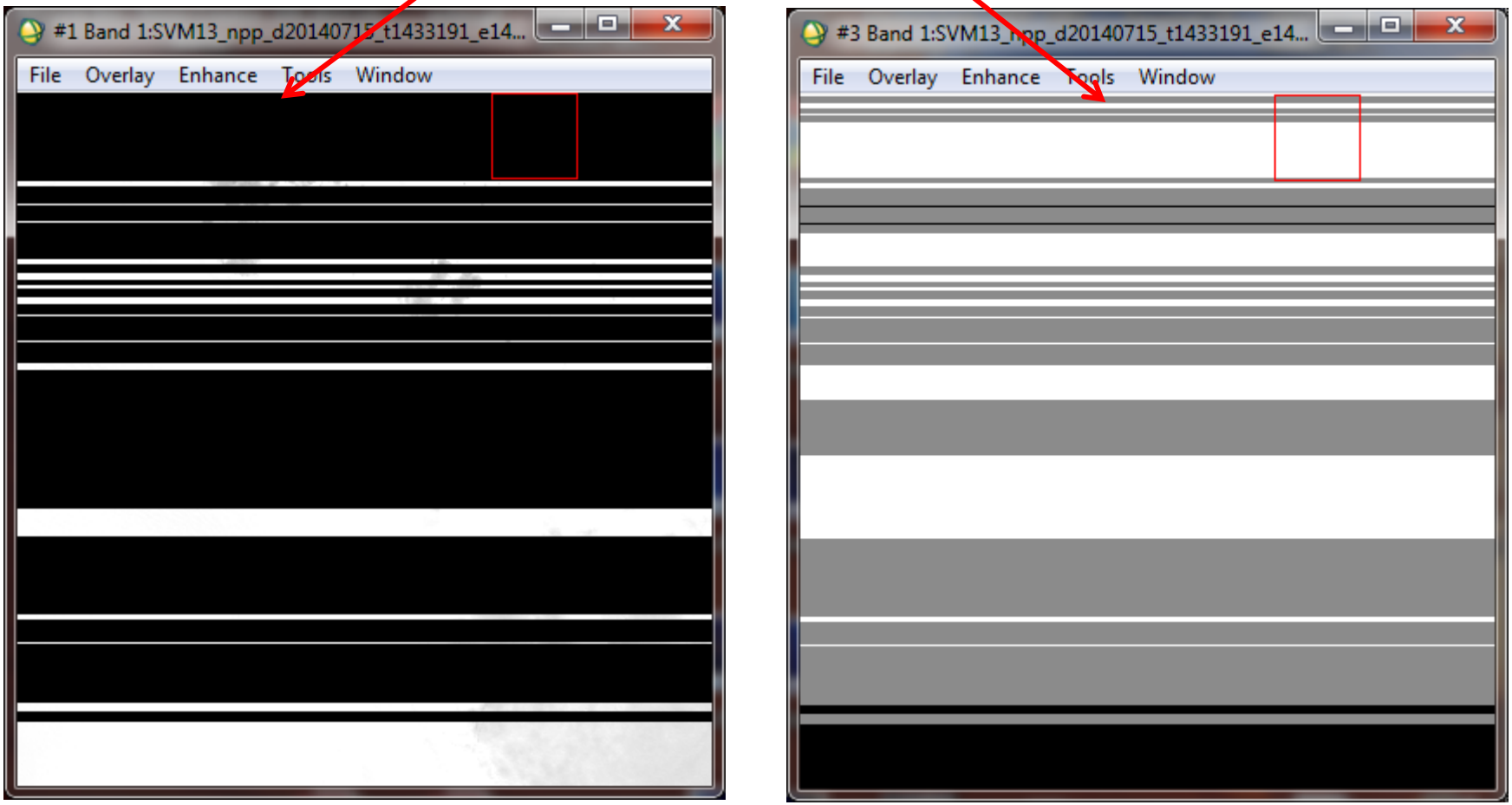
QF=0





IDPS Mx8.4 A1granule version

July 15 case: Mx8.4 vs. Mx8.5



IDPS Mx8.5 code run by STAR AIT

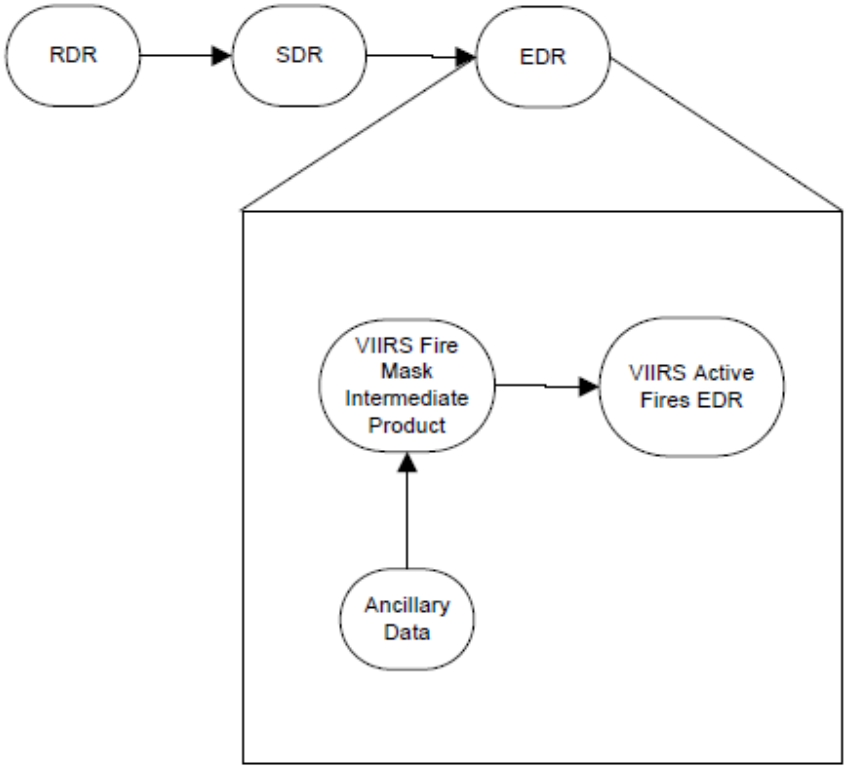
Current SDR input quality summary

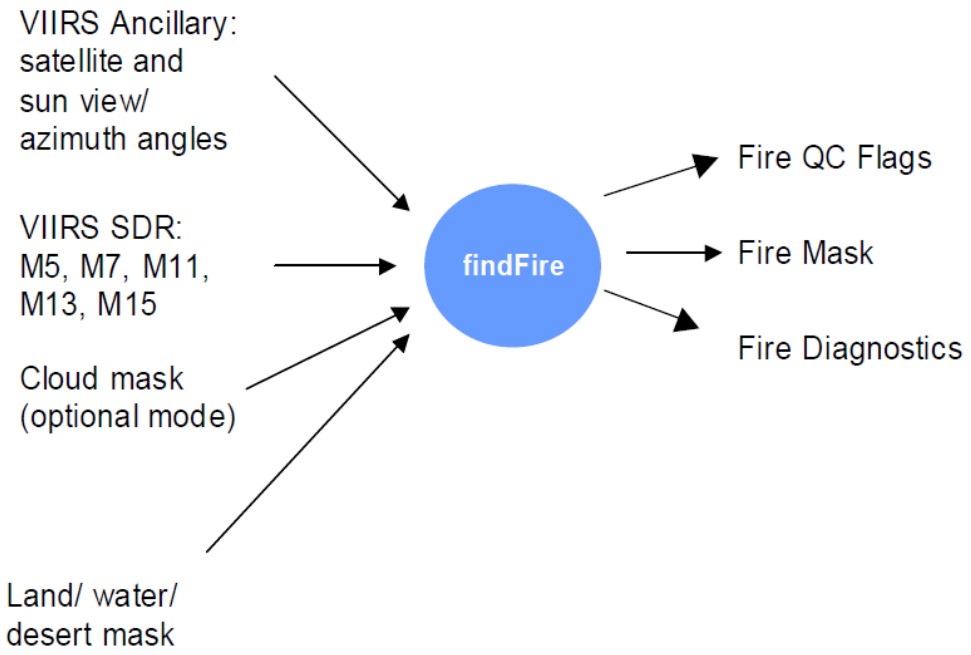
- QF ≠ 0 for high radiances
  - Appears to be fixed in Mx8.3 (TTO 3/18/2014 18:38 UTC)
- Bad data, QF = 0
  - Two cases analyzed suggest that the changes implemented in Mx8.5 worked
  - Conclusion is based on the total ~1 month of data (pre-TTO test datasets, operational IDPS data and STAR AIT test run)
- Radiance – brightness temperature mismatch
  - Not implemented yet, SDR team is working on code change
    - Active Fire EDR team provided examples

Evaluation of the effect of required algorithm inputs

- Required Algorithm Inputs
  - Primary Sensor Data
  - Ancillary Data
  - Upstream algorithms
  - LUTs / PCTs
- Evaluation of the effect of required algorithm inputs
  - Study / test cases
  - Results

Active Fire ARP Dataflow





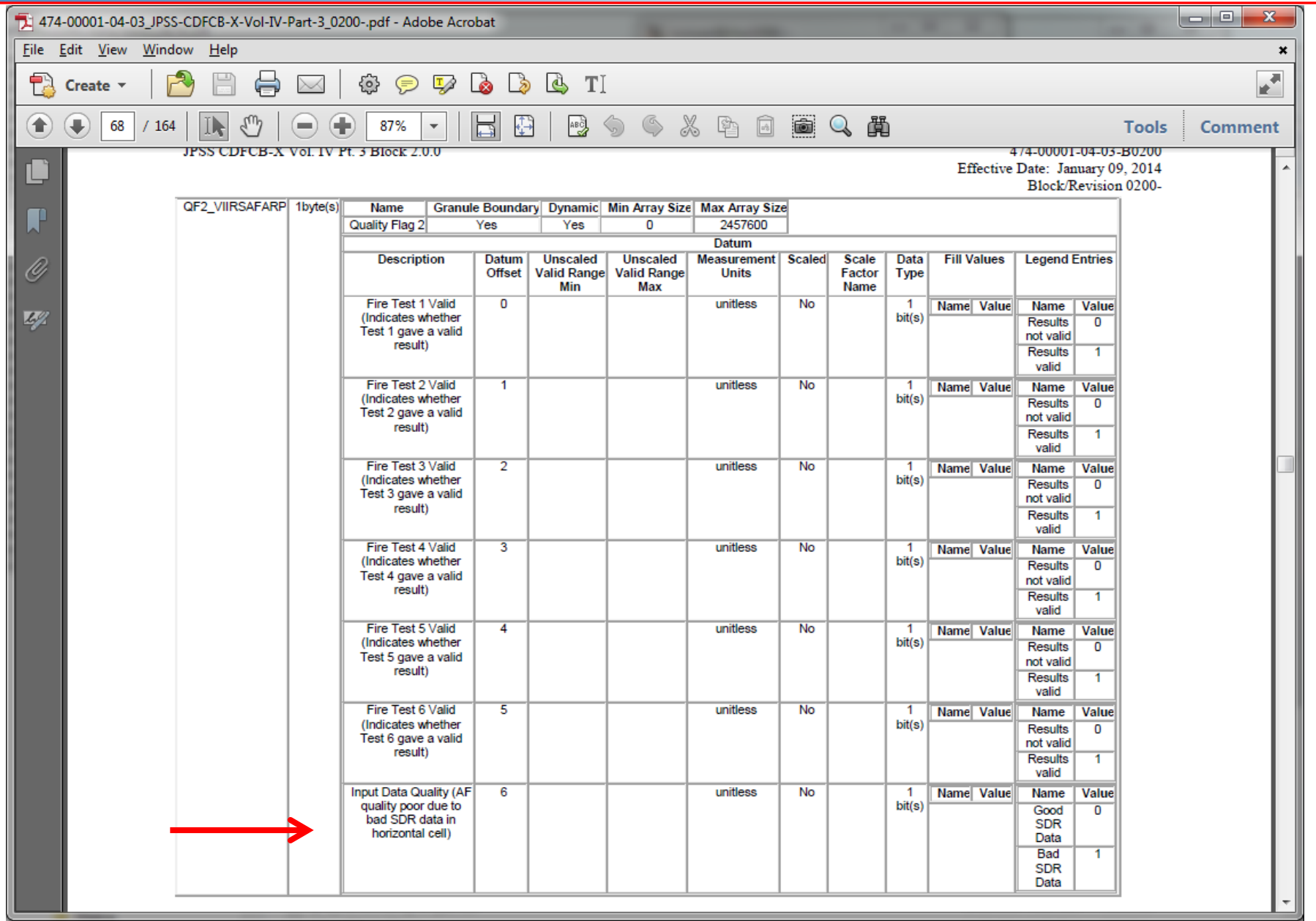
OAD VIIRS Active Fires 474-00064 May 14, 2013; Figure 1 (Processing Chain Associated with VIIRS Active Fires ARP)

ATBD VIIRS Active Fires 474-00030 April 22, 2011; Figure 5 (Algorithm Context Diagram)

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 for next validated stages

Quality flag analysis/validation



474-00001-04-03_JPSS-CDFCB-X-Vol-IV-Part-3_0200-.pdf - Adobe Acrobat

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JPSS CDFCB-X Vol. IV Pt. 3 Block 2.0.0

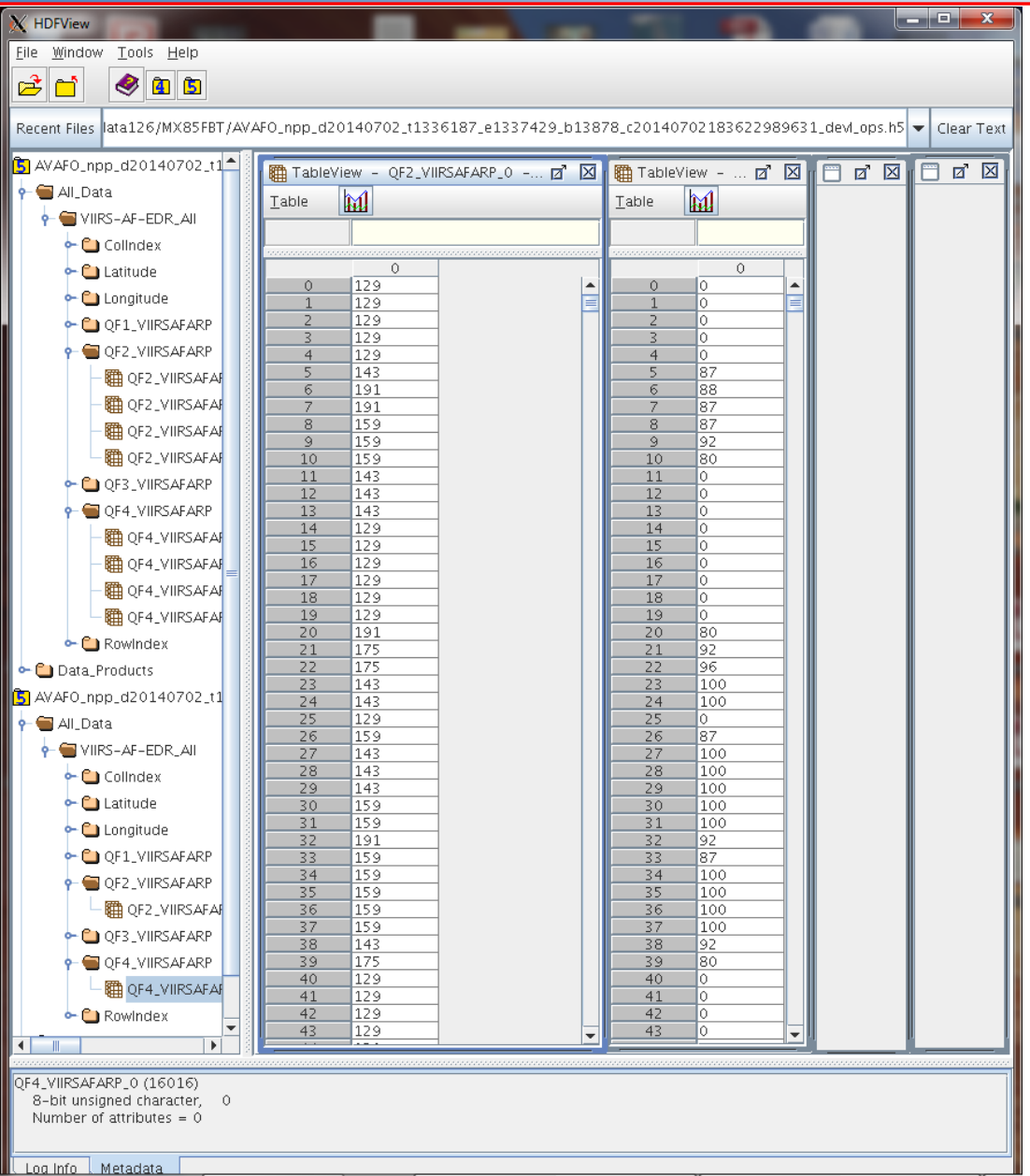
474-00001-04-03-B0200
Effective Date: January 09, 2014
Block/Revision 0200-

QF2_VIIRSAFARP	1byte(s)	Name	Granule Boundary	Dynamic	Min Array Size	Max Array Size
		Quality Flag 2	Yes	Yes	0	2457600

Datum

Description	Datum Offset	Unscaled Valid Range Min	Unscaled Valid Range Max	Measurement Units	Scaled	Scale Factor Name	Data Type	Fill Values Name	Fill Values Value	Legend Entries Name	Legend Entries Value
Fire Test 1 Valid (Indicates whether Test 1 gave a valid result)	0			unitless	No		1 bit(s)			Results not valid	0
										Results valid	1
Fire Test 2 Valid (Indicates whether Test 2 gave a valid result)	1			unitless	No		1 bit(s)			Results not valid	0
										Results valid	1
Fire Test 3 Valid (Indicates whether Test 3 gave a valid result)	2			unitless	No		1 bit(s)			Results not valid	0
										Results valid	1
Fire Test 4 Valid (Indicates whether Test 4 gave a valid result)	3			unitless	No		1 bit(s)			Results not valid	0
										Results valid	1
Fire Test 5 Valid (Indicates whether Test 5 gave a valid result)	4			unitless	No		1 bit(s)			Results not valid	0
										Results valid	1
Fire Test 6 Valid (Indicates whether Test 6 gave a valid result)	5			unitless	No		1 bit(s)			Results not valid	0
										Results valid	1
Input Data Quality (AF quality poor due to bad SDR data in horizontal cell)	6			unitless	No		1 bit(s)			Good SDR Data	0
										Bad SDR Data	1

Quality flags: July 2, 2014 case



129: 10000001
143: 10001111
191: 10111111
159: 10011111
175: 10101111

Mx8.4: (incorrect) SDR quality flags passed through correctly into AF ARP

Mx8.5: no fire detections (correctly), no quality flags

Quality flag analysis/validation

474-00001-04-03_JPSS-CDFCB-X-Vol-IV-Part-3_0200-.pdf - Adobe Acrobat

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		Day/Night (Night = SZA > 85 degrees)	7			unitless	No		1 bit(s)	Name Value	Name Value: Night 0; Day 1	

QF3_VIIRSAFARP	1byte(s)	Name	Granule Boundary	Dynamic	Min Array Size	Max Array Size
		Quality Flag 3	Yes	Yes	0	2457600

Datum

Description	Datum Offset	Unscaled Valid Range Min	Unscaled Valid Range Max	Measurement Units	Scaled	Scale Factor Name	Data Type	Fill Values	Legend Entries
False Alarm Override (likely false alarms due to excessive rejection of legitimate background pixels)	0			unitless	No		1 bit(s)	Name Value	Name Value: No 0; Yes 1
Water Contamination Override (likely false alarms caused by water contaminated background pixels - Flag will not be triggered for sparse array format since only fire pixels are written to output.)	1			unitless	No		1 bit(s)	Name Value	Name Value: No 0; Yes 1
Spare	2			unitless	No		6 bit(s)	Name Value	Name Value

QF4_VIIRSAFARP	1byte(s)	Name	Granule Boundary	Dynamic	Min Array Size	Max Array Size
		Quality Flag 4	Yes	Yes	0	2457600

Datum

Description	Datum Offset	Unscaled Valid Range Min	Unscaled Valid Range Max	Measurement Units	Scaled	Scale Factor Name	Data Type	Fill Values	Legend Entries
Fire Detection Confidence (Pixel level fire confidence in percent for each of the fire pixels)	0	0	100	unitless	No		unsigned 8-bit char	Name Value	Name Value

Downstream impacts: Cloud Mask

474-00001-04-01_JPSS-CDFCB-X-Vol-IV-Part-1_0200-.pdf - Adobe Acrobat

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30 / 477 87.1%

Tools Comment

				Geometry and Wind Based	3
QF2_VIIRSCMIP	1byte(s)	Name	Granule Boundary	Dynamic	Min Array Size	Max Array Size

13

Check the JPSS MIS Server at https://jpssmis.gsfc.nasa.gov/frontmenu_dsp.cfm to verify that this is the correct version prior to use.

JPSS CDFCB-X Vol. IV Pt. 1, Block 2.0.0

474-00001-04-01-B0200
Effective Date: January 09, 2014
Block/Revision 0200-

AlongTrack	Yes	No	768	768
CrossTrack	No	No	3200	3200

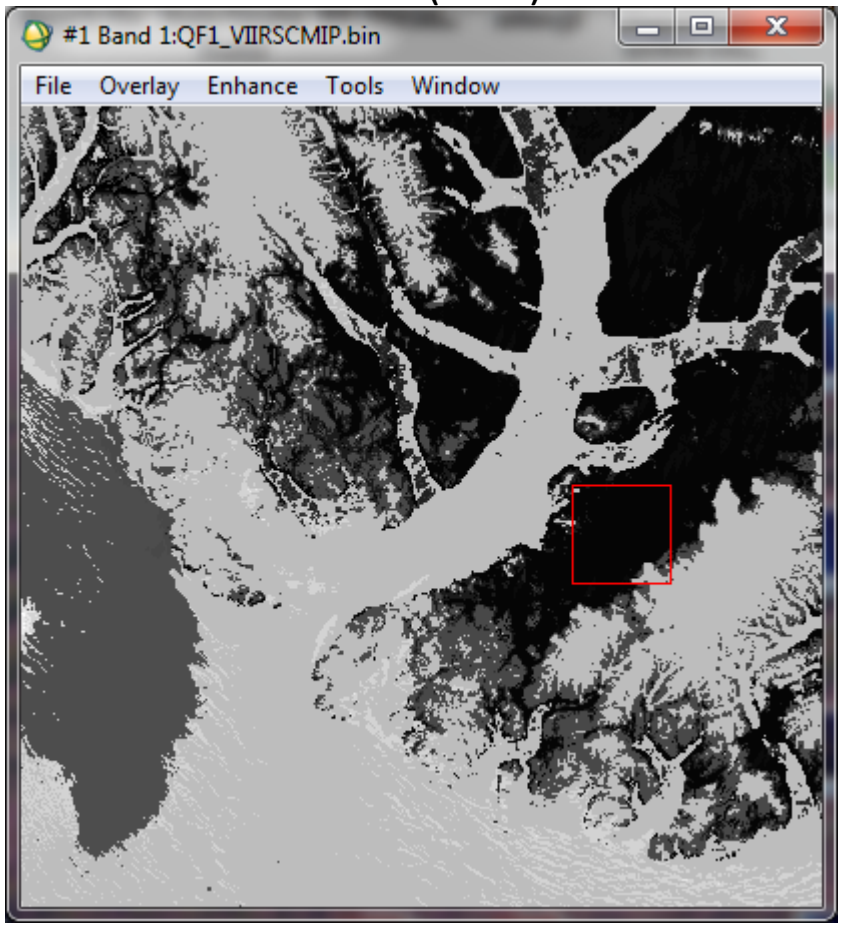
Datum

Description	Datum Offset	Unscaled Valid Range Min	Unscaled Valid Range Max	Measurement Units	Scaled	Scale Factor Name	Data Type	Fill Values	Legend Entries
Land/Water Background Pixel	0			unitless	No		3 bit(s)	Name Value	Name Value; Land and Desert 0; Land No Desert 1; Inland Water 2; Sea Water 3; Coastal 5
Shadow Detected Pixel	3			unitless	No		1 bit(s)	Name Value	Name Value; No 0; Yes 1
Non Cloud Obstruction (Heavy Aerosol)	4			unitless	No		1 bit(s)	Name Value	Name Value; No 0; Yes 1
Fire Detected (Cloud Mask)	5			unitless	No		1 bit(s)	Name Value	Name Value; No 0; Yes 1
Cirrus (Solar RM9)	6			unitless	No		1 bit(s)	Name Value	Name Value; No Cloud 0; Cloud 1
Cirrus IR (BTM15-	7			unitless	No		1 bit(s)	Name Value	Name Value

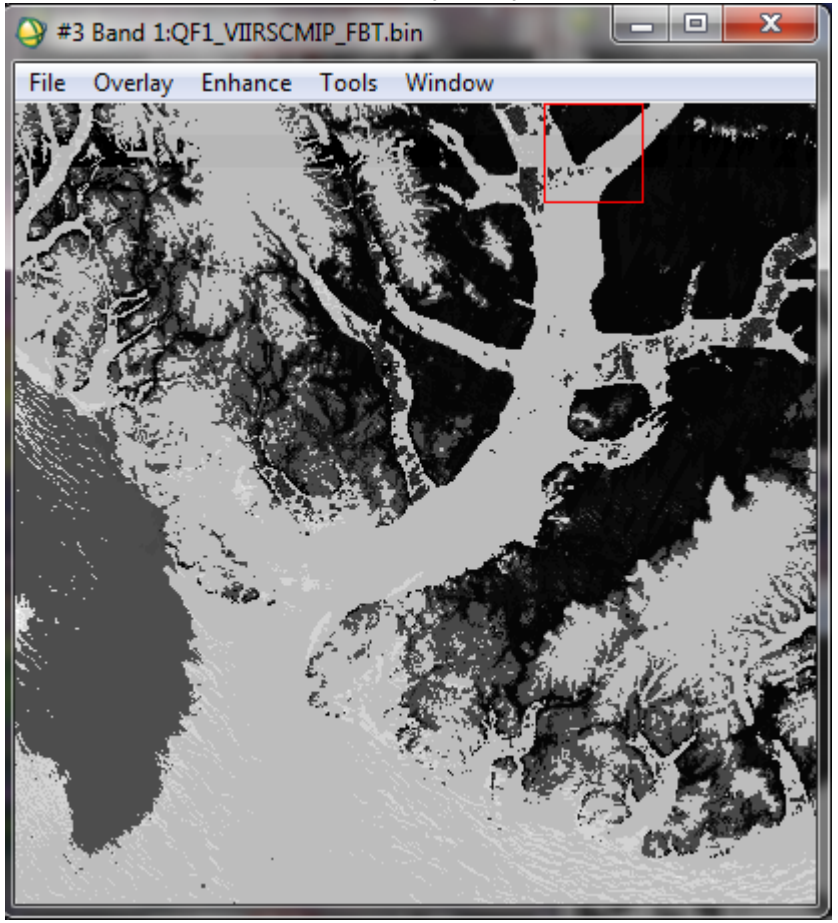
Downstream impacts: Cloud Mask

Cloud Mask Byte 1

Mx8.4 (IDPS)



Mx8.5 (FBT)



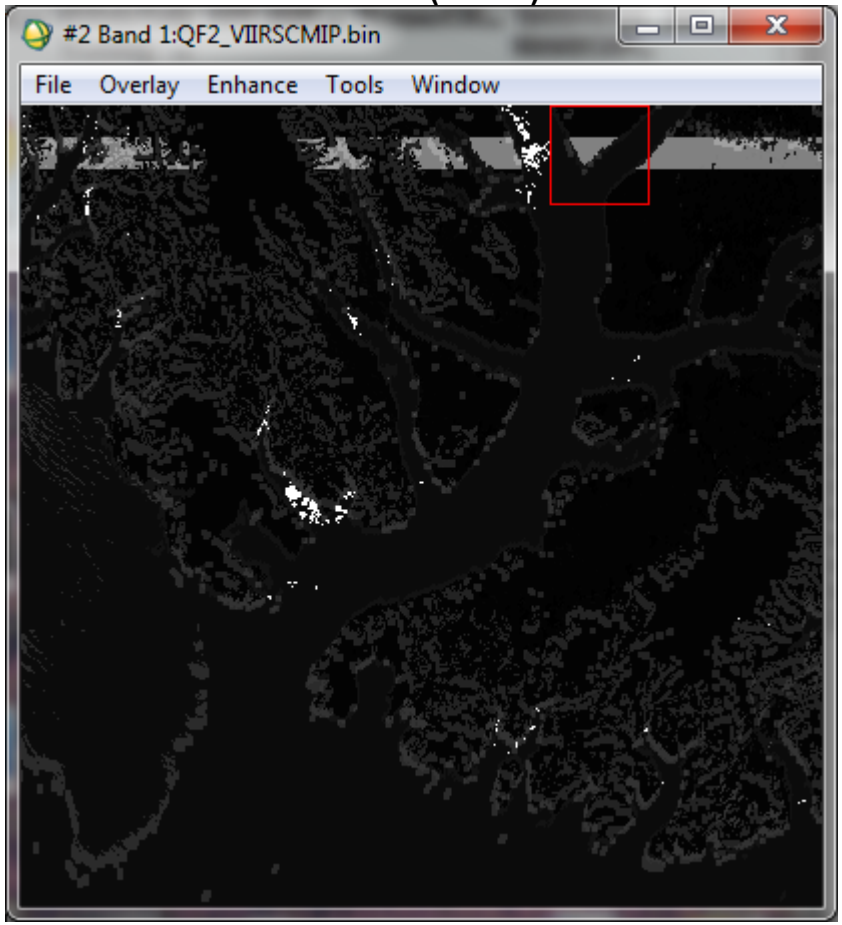
Left: IICMO_npp_d20140702_t1336187_e1337429_b13878_c20140702195750973165_noaa_ops.h5

Right: IICMO_npp_d20140702_t1336187_e1337429_b13878_c20140702183650421253_devl_ops.h5

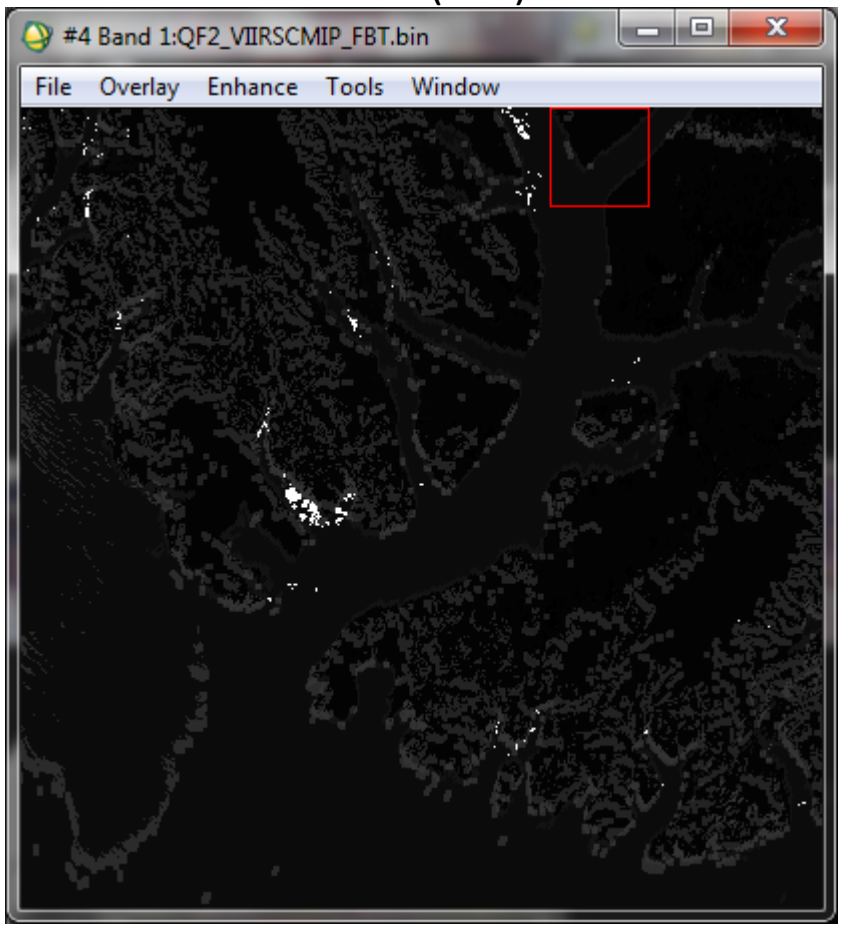
Downstream impacts: Cloud Mask

Cloud Mask Byte 2

Mx8.4 (IDPS)



Mx8.5 (FBT)



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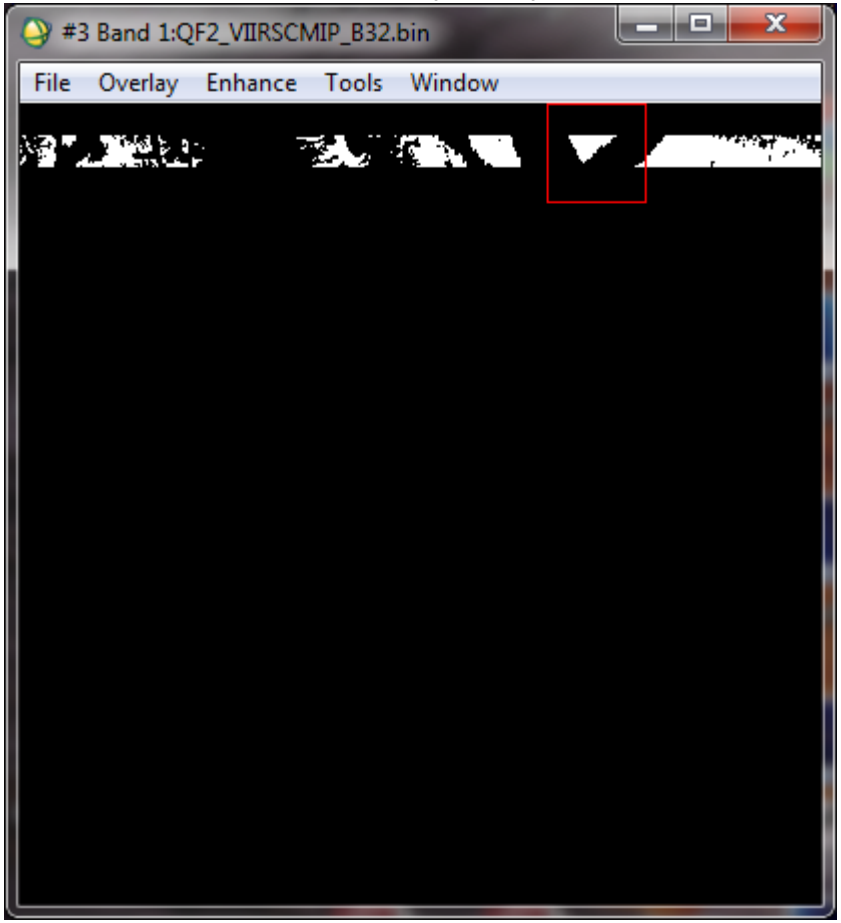
Right: IICMO_npp_d20140702_t1336187_e1337429_b13878_c20140702183650421253_devl_ops.h5

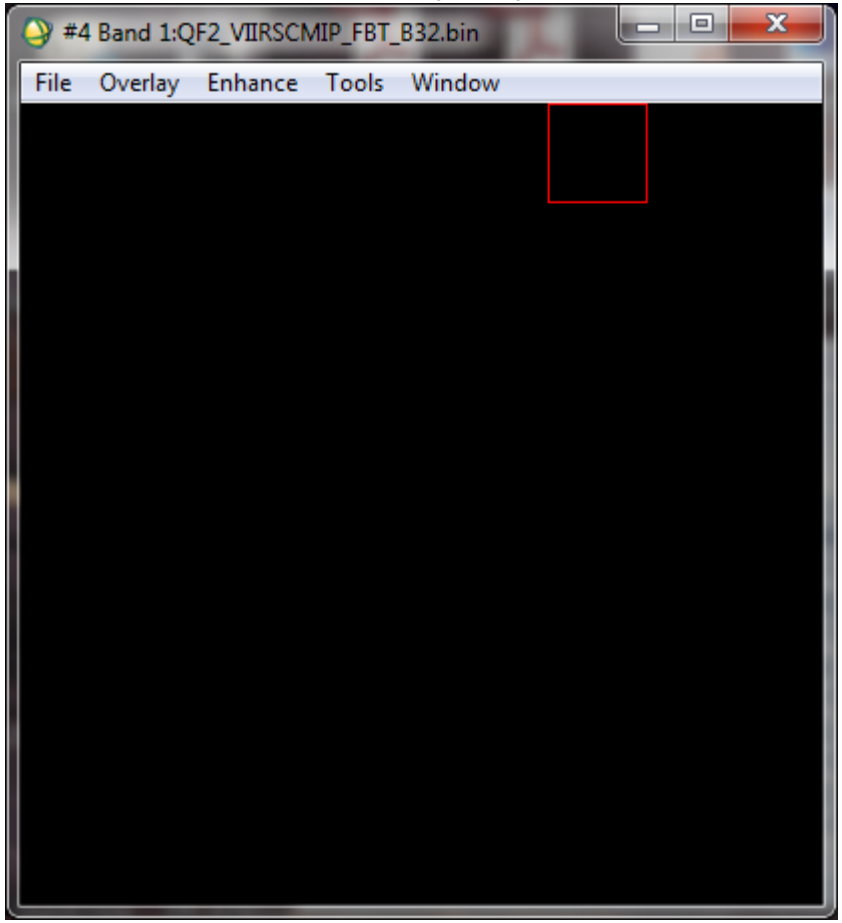
Downstream impacts: Cloud Mask

Cloud Mask Byte 2 Bit 6 (Fire Detected [Cloud Mask])

Mx8.4 (IDPS)



Mx8.5 (FBT)



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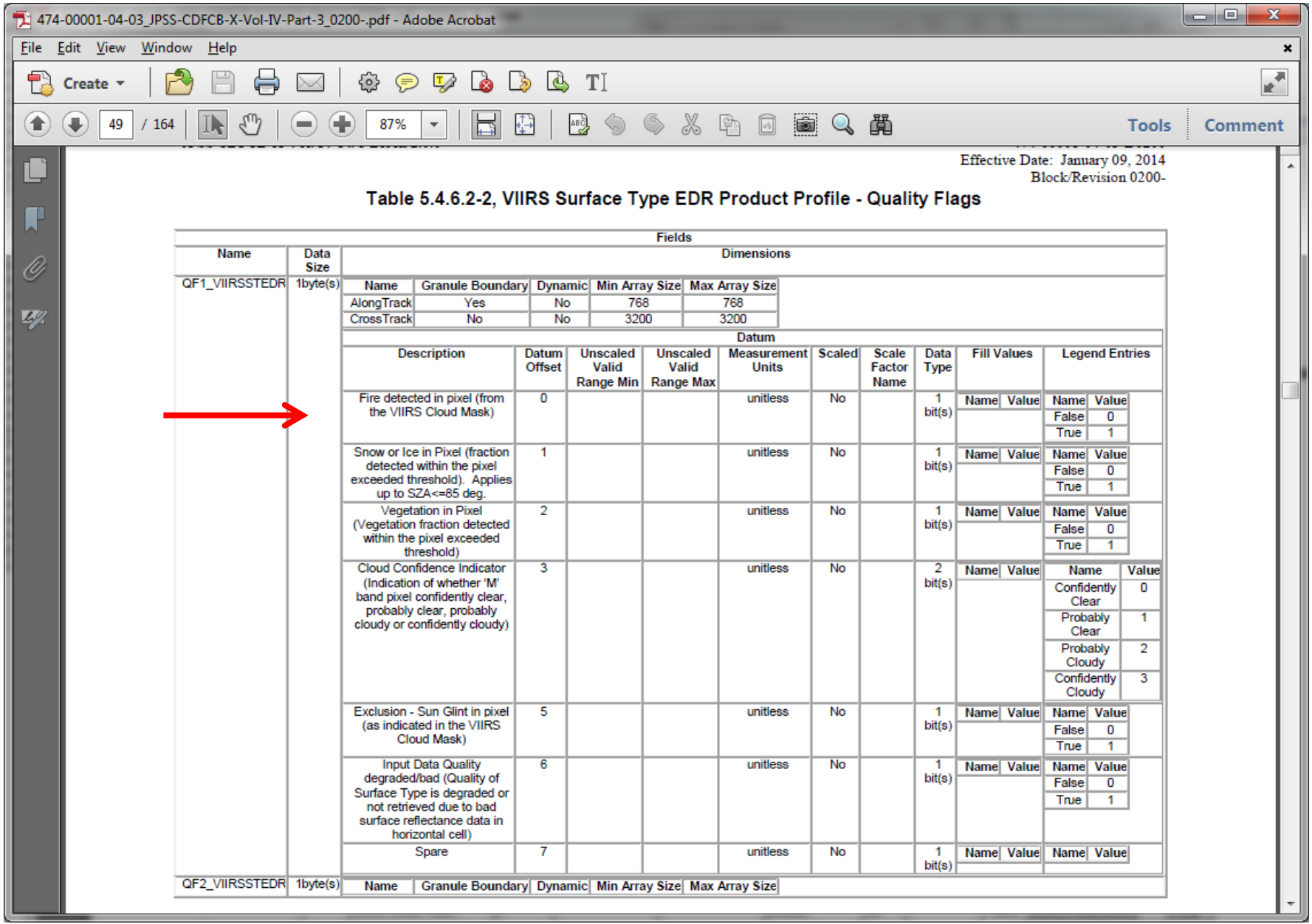
Right: IICMO_npp_d20140702_t1336187_e1337429_b13878_c20140702183650421253_devl_ops.h5

Downstream impacts: Surface Type



474-00001-04-03_JPSS-CDFCB-X-Vol-IV-Part-3_0200-.pdf - Adobe Acrobat

File Edit View Window Help

Create

49 / 164 87% Tools Comment

Effective Date: January 09, 2014
Block/Revision 0200-

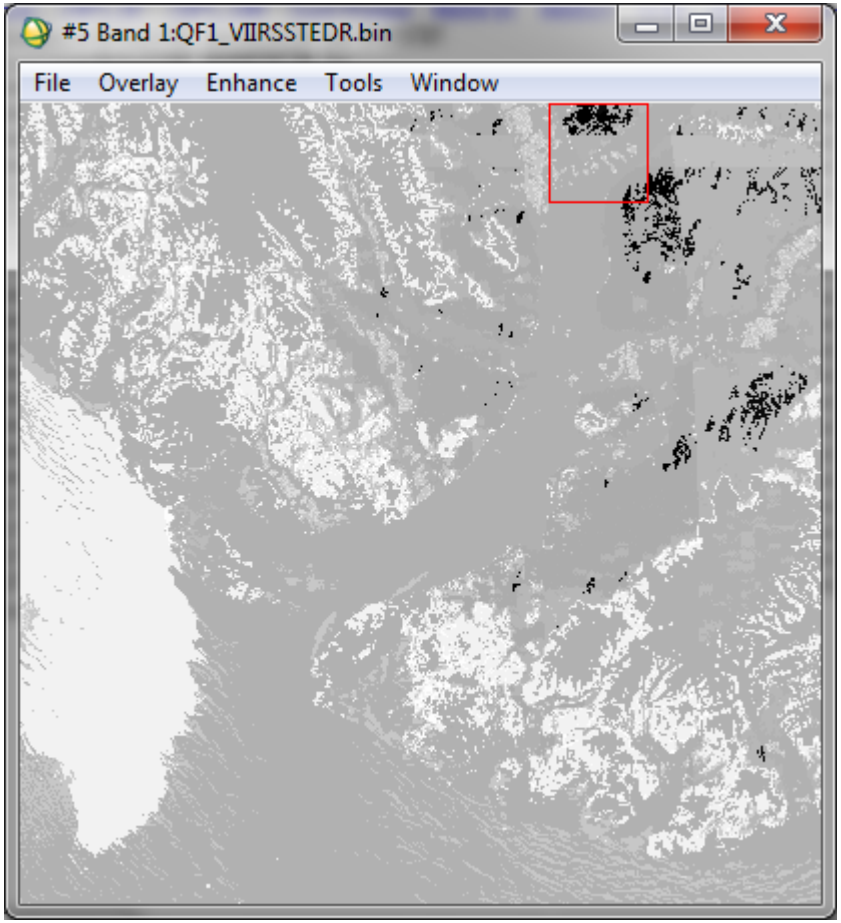
Table 5.4.6.2-2, VIIRS Surface Type EDR Product Profile - Quality Flags

Fields													
Name	Data Size	Dimensions											
QF1_VIIRSSTEDR	1byte(s)	Name	Granule Boundary	Dynamic	Min Array Size	Max Array Size							
		AlongTrack	Yes	No	768	768							
		CrossTrack	No	No	3200	3200							
		Datum											
		Description	Datum Offset	Unscaled Valid Range Min	Unscaled Valid Range Max	Measurement Units	Scaled	Scale Factor Name	Data Type	Fill Values		Legend Entries	
		Fire detected in pixel (from the VIIRS Cloud Mask)	0			unitless	No		1 bit(s)	Name	Value	Name	Value
												False	0
												True	1
		Snow or Ice in Pixel (fraction detected within the pixel exceeded threshold). Applies up to SZA<=85 deg.	1			unitless	No		1 bit(s)	Name	Value	Name	Value
												False	0
												True	1
		Vegetation in Pixel (Vegetation fraction detected within the pixel exceeded threshold)	2			unitless	No		1 bit(s)	Name	Value	Name	Value
												False	0
												True	1
		Cloud Confidence Indicator (Indication of whether 'M' band pixel confidently clear, probably clear, probably cloudy or confidently cloudy)	3			unitless	No		2 bit(s)	Name	Value	Name	Value
												Confidently Clear	0
												Probably Clear	1
												Probably Cloudy	2
												Confidently Cloudy	3
		Exclusion - Sun Glint in pixel (as indicated in the VIIRS Cloud Mask)	5			unitless	No		1 bit(s)	Name	Value	Name	Value
												False	0
												True	1
		Input Data Quality degraded/bad (Quality of Surface Type is degraded or not retrieved due to bad surface reflectance data in horizontal cell)	6			unitless	No		1 bit(s)	Name	Value	Name	Value
												False	0
												True	1
		Spare	7			unitless	No		1 bit(s)	Name	Value	Name	Value
QF2_VIIRSSTEDR	1byte(s)	Name	Granule Boundary	Dynamic	Min Array Size	Max Array Size							

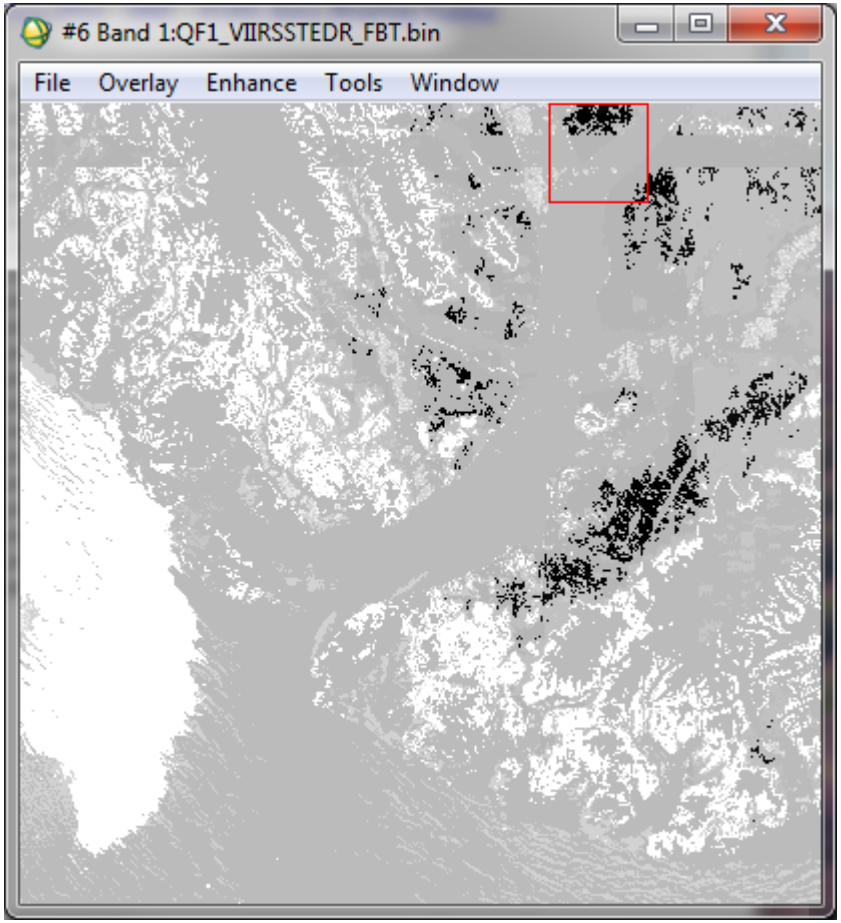
Downstream impacts: Surface Type

Surface Type QF1

Mx8.4 (IDPS)



Mx8.5 (FBT)



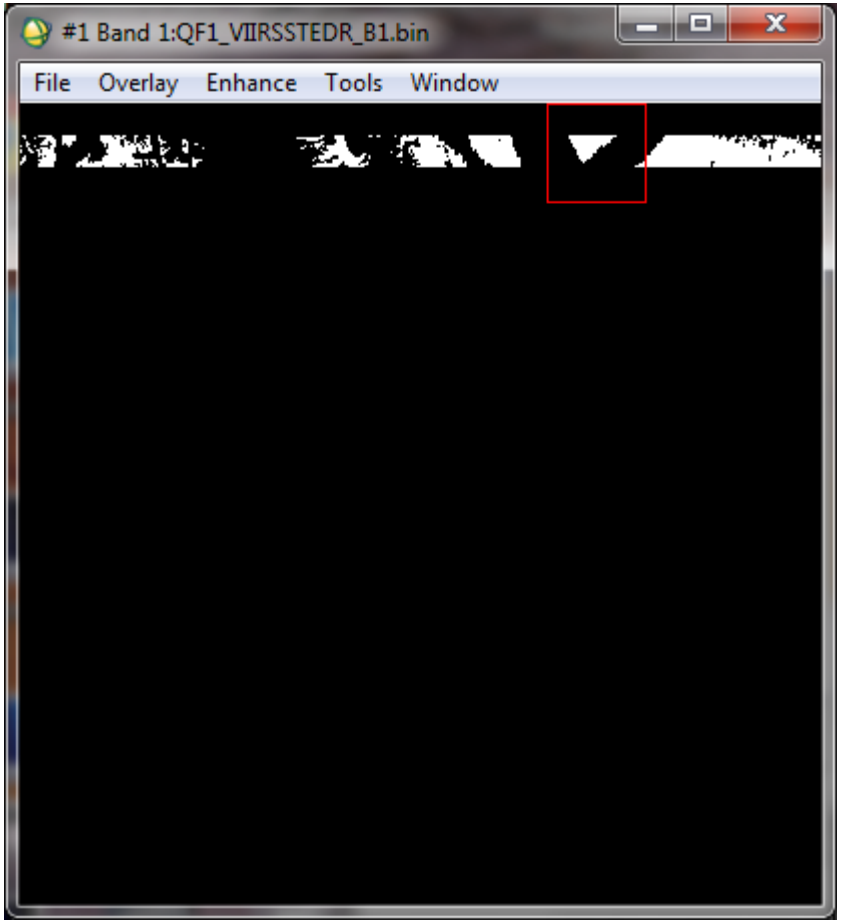
Left: VSTYO_npp_d20140702_t1336187_e1337429_b13878_c20140702195757169854_noaa_ops.h5

Right: VSTYO_npp_d20140702_t1336187_e1337429_b13878_c20140702183653777297_devl_ops.h5

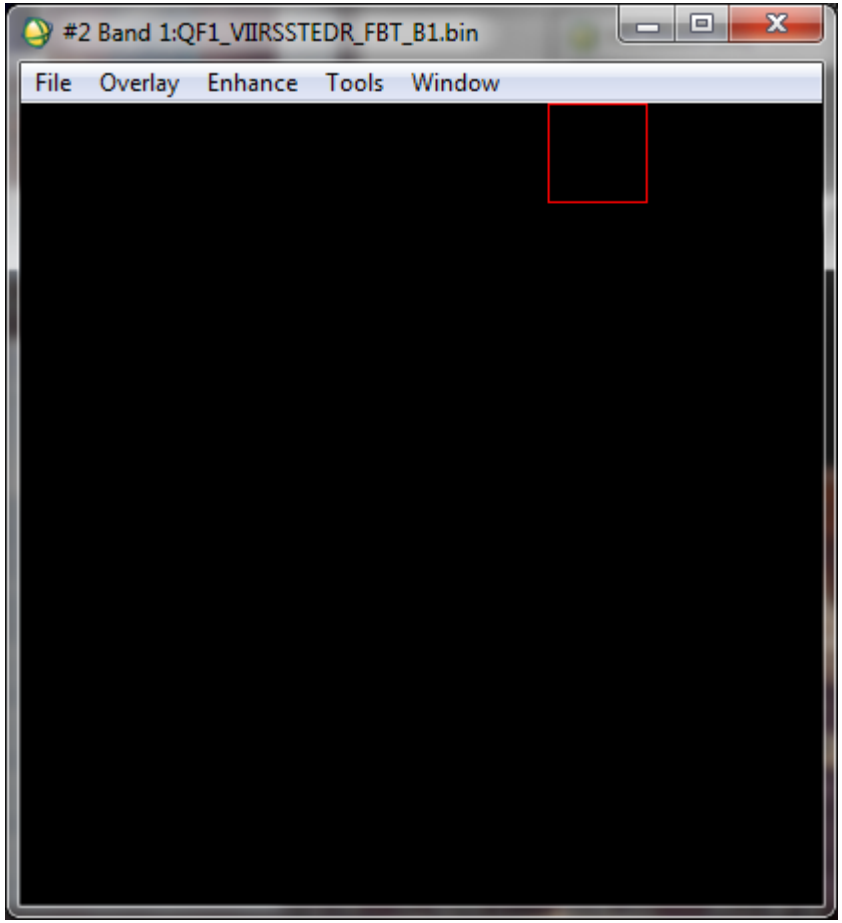
Downstream impacts: Surface Type

Surface Type QF1 Bit 1 ("Fire detected in pixel [from the VIIRS Cloud Mask]")

Mx8.4 (IDPS)



Mx8.5 (FBT)



Left: VSTYO_npp_d20140702_t1336187_e1337429_b13878_c20140702195757169854_noaa_ops.h5

Right: VSTYO_npp_d20140702_t1336187_e1337429_b13878_c20140702183653777297_devl_ops.h5

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	Analysis/Validation Result	Error Summary
Frequency of spurious data due to bad SDR input	Not listed	2 bad granules in Mx8.4 over 4 months No granules found in Mx8.5 over 1 month of data (including the 2 granules that were bad in Mx8.4)	Incremental SDR improvements resulted in overall reduction of errors to virtually none. Statistical sample still limited; continuing systematic monitoring needed.

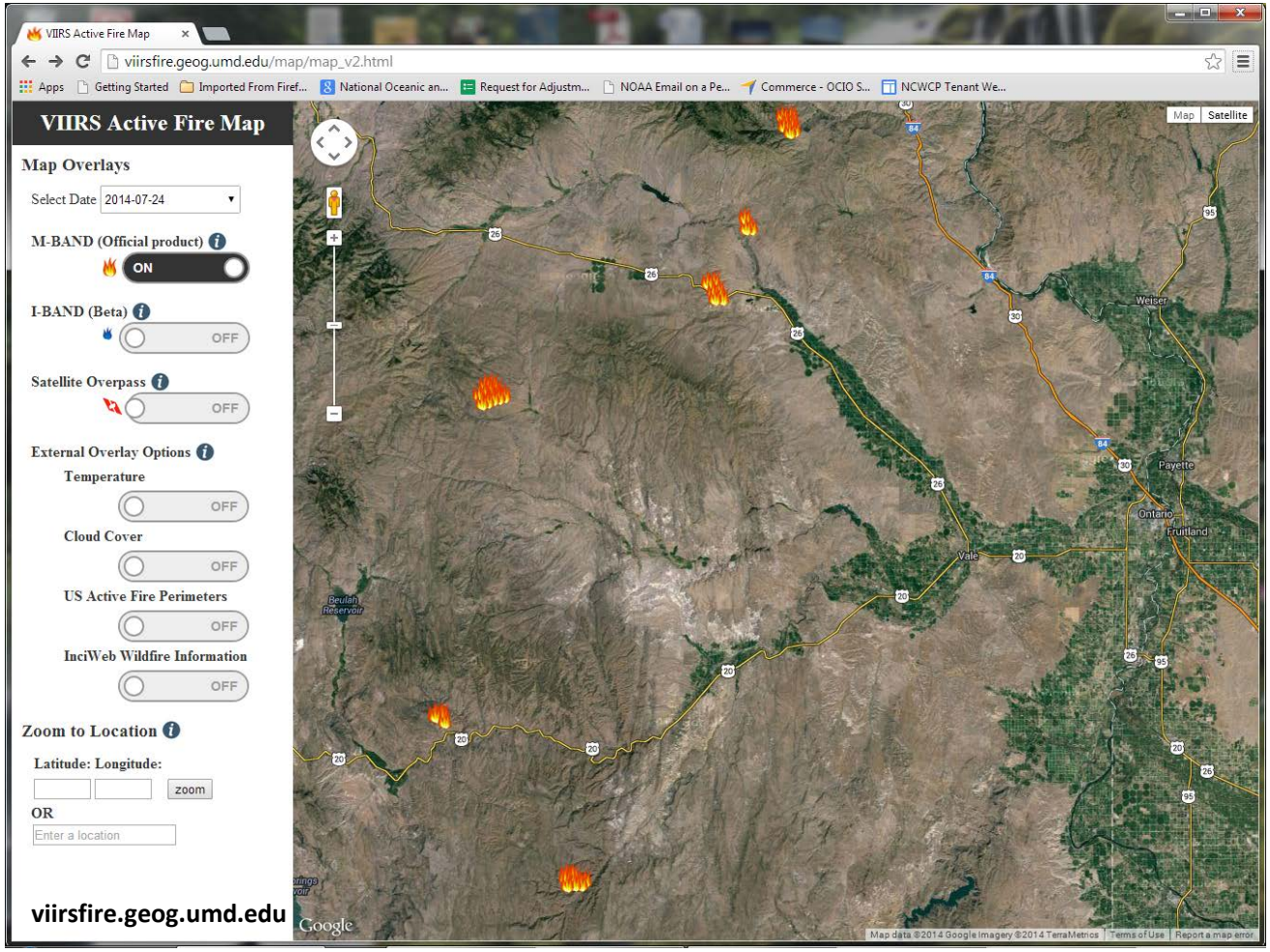
Formal L1RD requirements for VIIRS horizontal cell size and mapping uncertainty are no listed.

Documentation

- The following documents will be updated and provided to the EDR Review Board before AERB approval:
  - Current or updated ATBD
    - Some updates in product format description and detection algorithm are needed
  - Current or updated OAD
    - Deemed to be current
  - README file for CLASS
    - Proposed effectivity date is August 13, 2014
    - Will include discussion on quality flag issues
  - Product User's Guide (Recommended)
    - No users' guide will be prepared by the AERB
    - Documentation and peer-reviewed publications are publicly available

Users and User Feedback

- The operational SNPP VIIRS Active Fire product is a sparse array containing locations of pixels flagged as “fire” by the detection algorithm
- The science team is developing a suite of improved products, including fire radiative power to characterize the fire intensity
- End users are engaged through Proving Ground and User Readiness efforts



Fire detections from the operational Suomi NPP VIIRS Active Fire product in NW US on July 24, 2014. Data in various user-friendly formats are available from the product evaluation portal at viirsfire.geog.umd.edu .

User Readiness: NOAA Hazard Mapping System

- User acceptance of product:

  - Product is being received routinely in SAB and is **ready for full incorporation into the SAB Hazard Mapping System**.

- Preparation:

  - Scripts written to read/write AFP locations from/to files.

  - VIIRS M13 SDR imagery was incorporated into SAB operations in native satellite projection via McIDAS and also remapped to a common Lambert Conic Conformal projection for the HMS. Remapping routine needed to be tailored for use with VIIRS due to higher spatial resolution in order to retain pixel fidelity

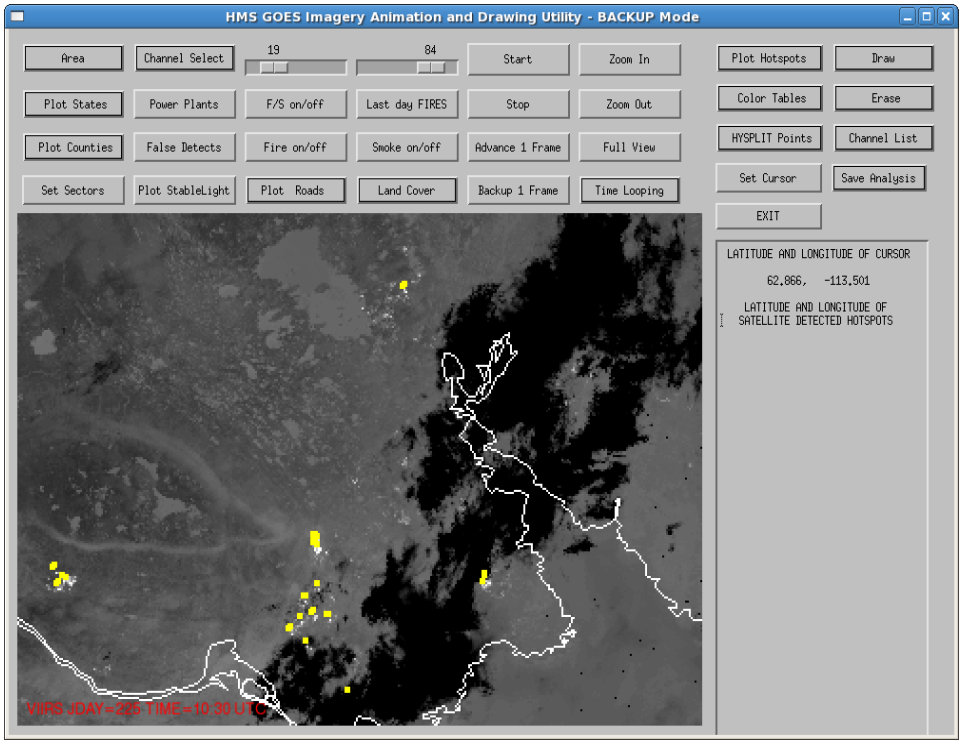
- Usage of products:

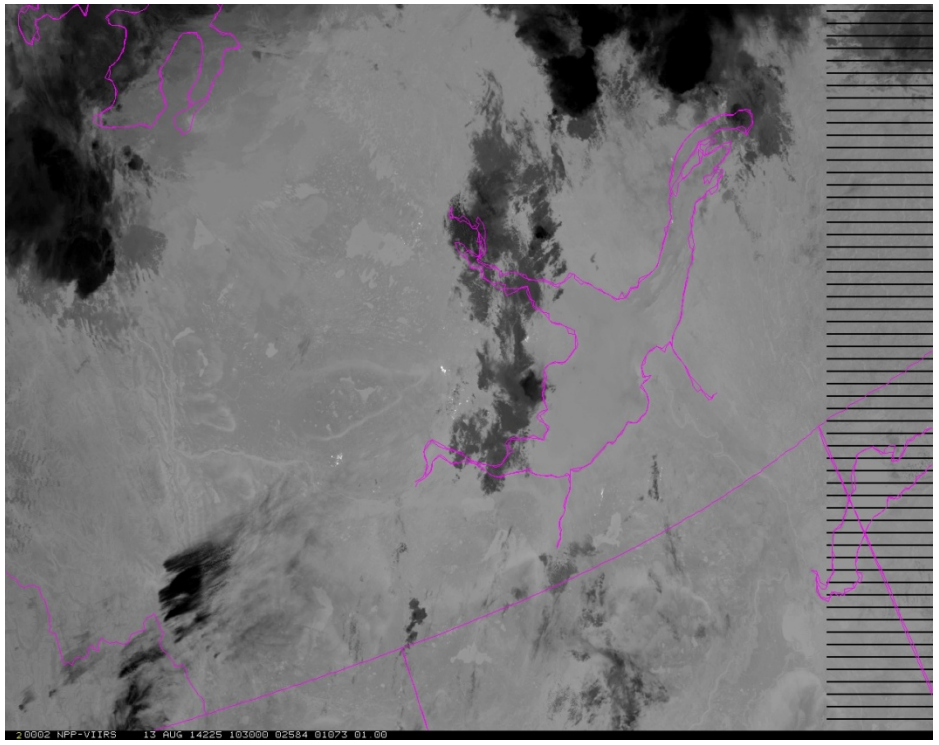
  - Active Fire Product is displayed in Hazard Mapping System for evaluation by SAB analysts. It is incorporated with detected fires from numerous other satellite sources (GOES, POES and MODIS) and undergoes additional manual quality control before being merged into a unified daily fire analysis product for North America. The AFP also provides an additional **data source as input for initializing the daily National Weather Service Air Quality smoke forecast**.

HMS AND McIDAS DISPLAYS

HMS display of VIIRS AFP from 13 August 0850Z and 1030Z images with remapped VIIRS M13 SDR 1030Z image

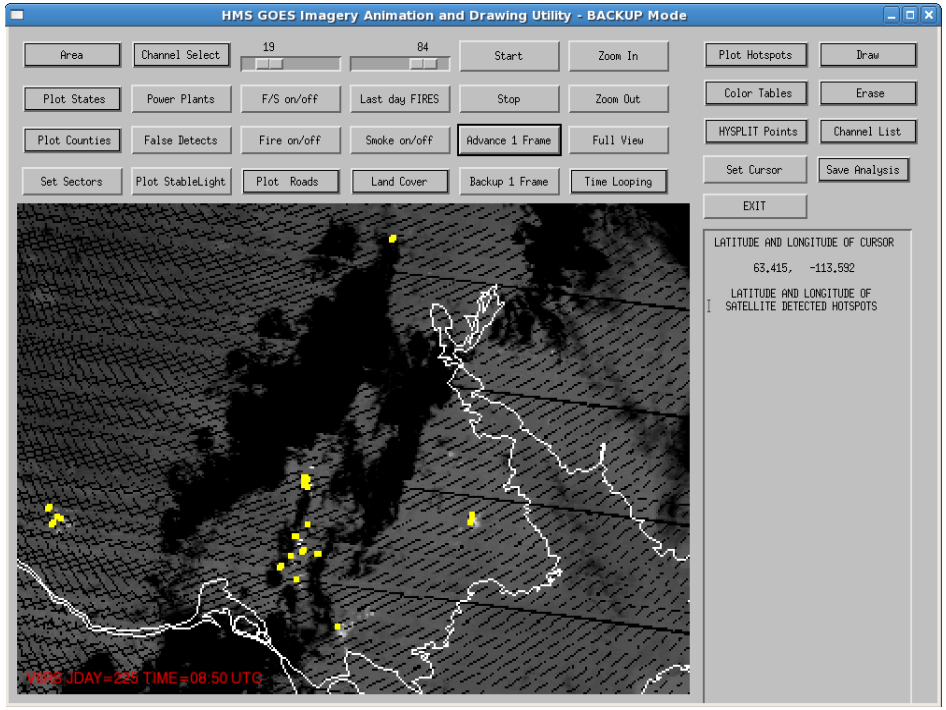
McIDAS display of 13 August 1030Z M13 SDR image in native satellite projection



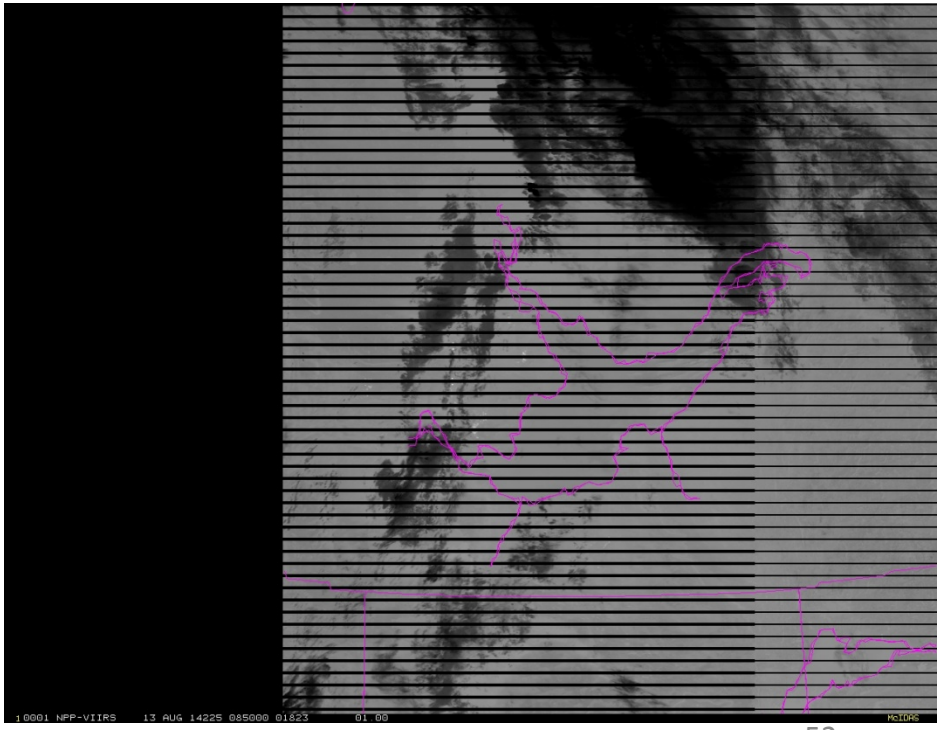


HMS AND McIDAS DISPLAYS

HMS display of VIIRS AFP from 13 August 0850Z and 1030Z images with remapped VIIRS M13 SDR 0850Z image

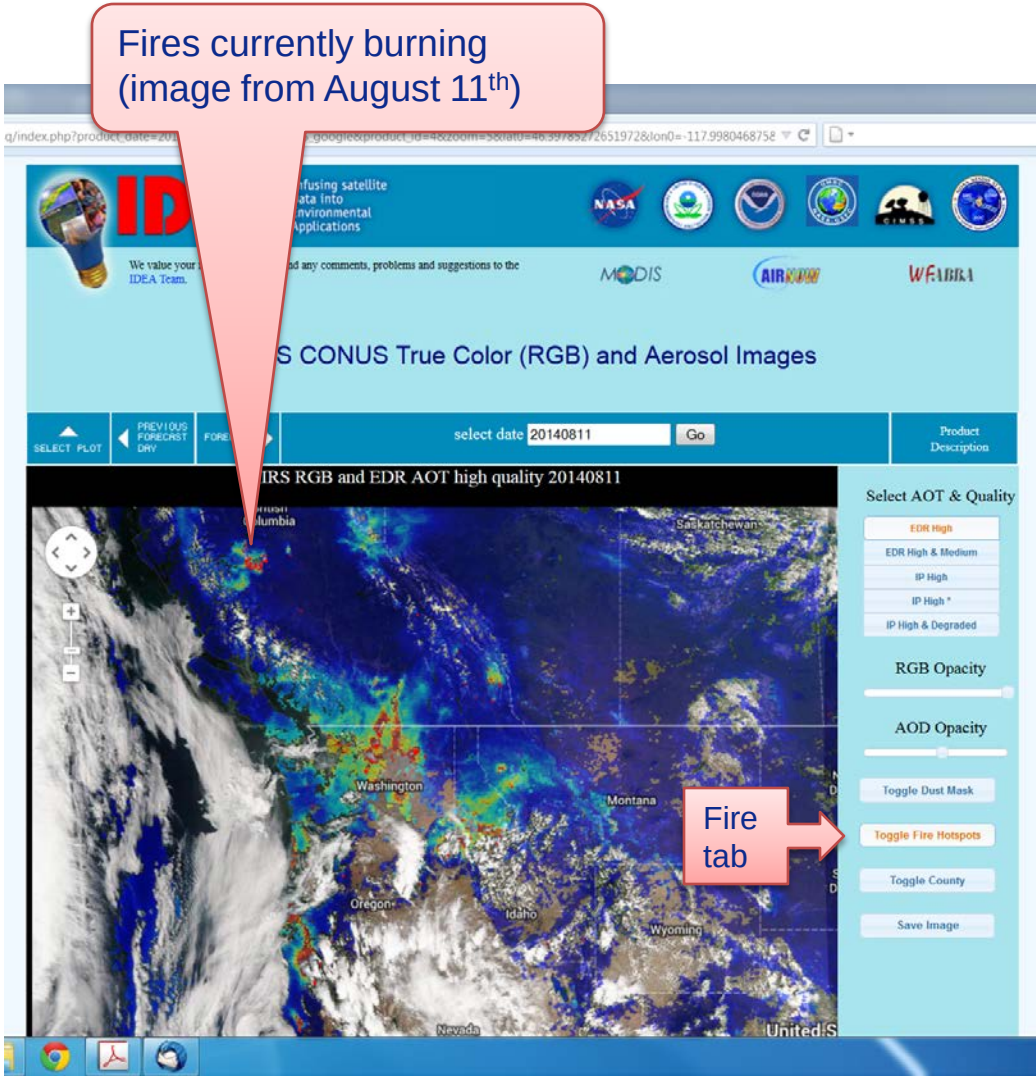


McIDAS display of 13 August 0850Z M13 SDR image in native satellite projection



User Readiness: STAR Smoke Analysis system (IDEA)

- User acceptance of product:
  - IDEA (Infusing satellite Data into Environmental Applications) system and ASDA (Automated Smoke Detection and tracking Algorithm) have been using **VIIRS hot spots** generated from DB data since March 2013. NDE products will also be used when available operationally.
  - GBBEPx (Global Biomass Burning Emissions Product – Extended) will also use the product when **FRP** becomes available along with fire detection
- Preparation:
  - Already in use in real time since March 2013
- Usage of products:
  - Air quality forecasters use the IDEA system in their daily forecasting. *This website gets more than one million hits each year.*
  - NWS Alaska and Western regions will use ASDA smoke plumes for incident monitoring and containment activities. *Through new fire and smoke initiative*
  - GBBEPx using fire detection and FRP will generate emissions that will be used by **NCEP's global aerosol model**



http://www.star.nesdis.noaa.gov/smcd/spb/aq/

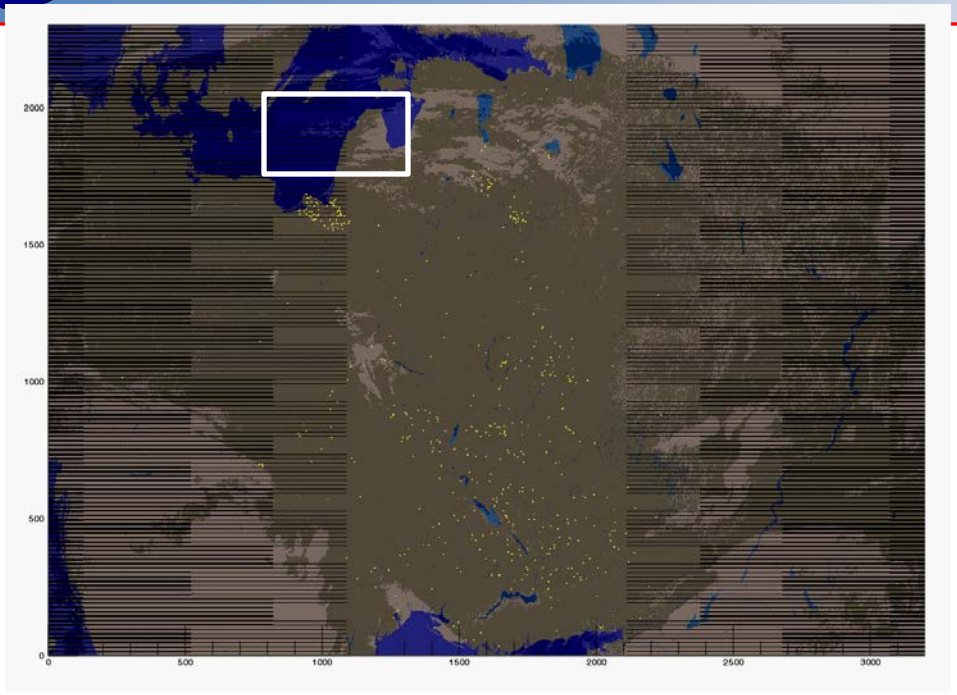
Conclusion

- Based on the available analysis results, the Active Fire team recommends the promotion of the Suomi NPP IDPS Active Fires ARP to Validated 1 maturity status with an effectivity date of **August 13, 2014**.
  - The effectivity date corresponds to the Transition to Operations of IDPS Mx8.5, which includes the implementation of 474-CCR-14-1667: VIIRS SDR Multiple Issues/Quality Flags & Calibration (ADRs 7110, 7111, 7112, 7227, 7313, 7448, 7449)
  - The team will continue systematic monitoring of product quality and will report any issues found immediately.
- The **Suomi NPP Active Fire ARP was declared Operational** by the NESDIS Satellite Products and Services Review Board (SPSRB)

Path Forward

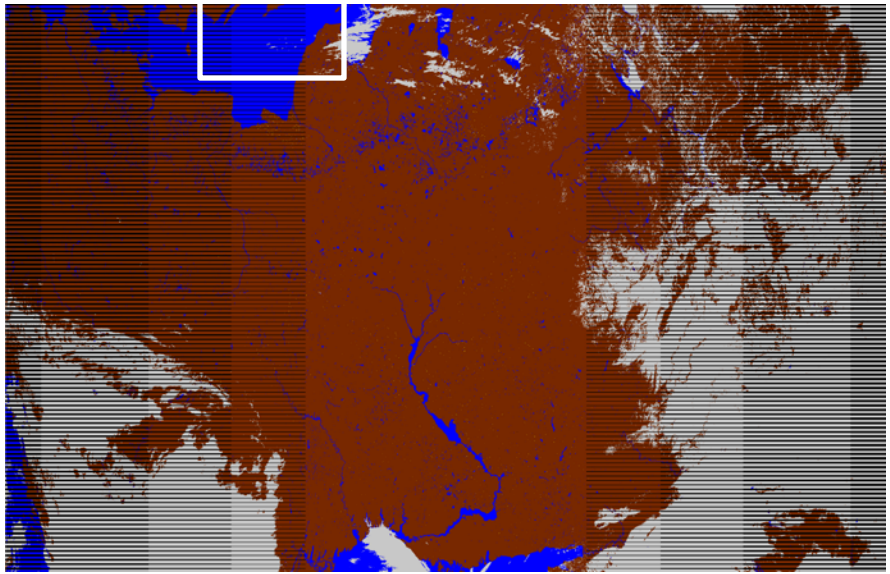
- An automated **long-term monitoring system** is being set up at STAR for quality monitoring and reactive maintenance of the Suomi NPP Active Fire product
- A processing code is available to generate a product that meets the **JPSS 1 requirements** is available
  - Developed as part of a NASA Science Team effort
  - Implemented at STAR
  - NOAA implementation details are being worked on
  - CDR is planned for October 2014
- Continuing efforts towards rigorous **validation** using **independent reference data**

IDPS vs. JPSS “replacement” code



March 10, 2014 10:36-10:40

IDPS operational run
Unpacked from HDF5:
AVAFO* (AF EDR)
IICMO* (CM IP)
Plotted with IDL from binaries:
VIIRS-AF-EDR
VIIRS-CM-IP



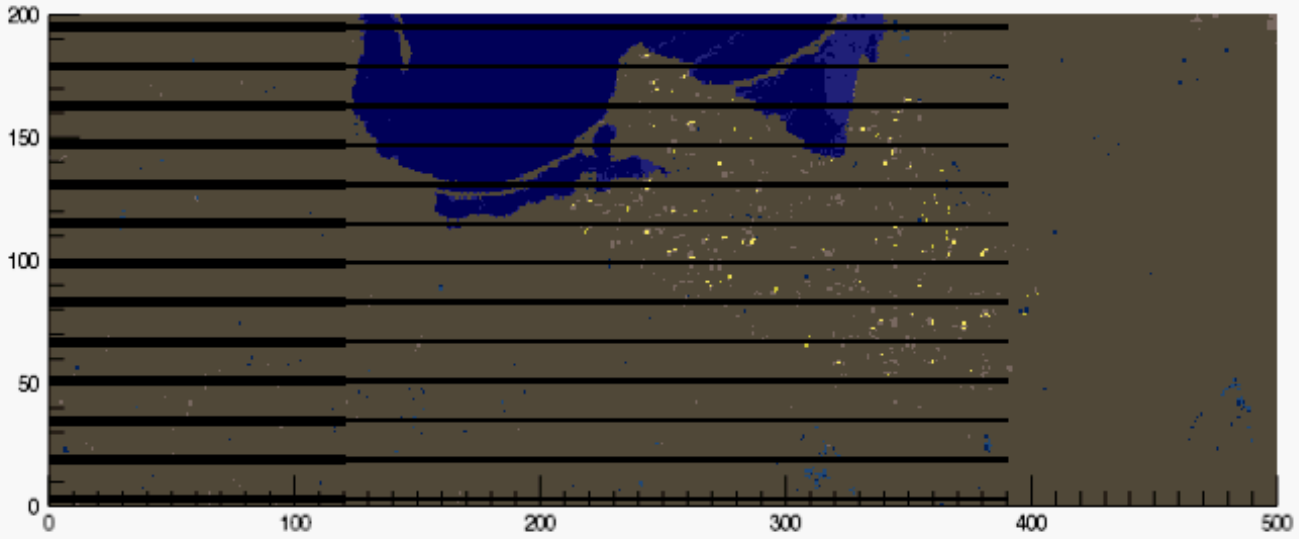
Output from replacement code
Plotted with hdfview from HDF4
“fire mask” field

See next slide for comparison of fire pixels

IDPS vs. JPSS “replacement” code

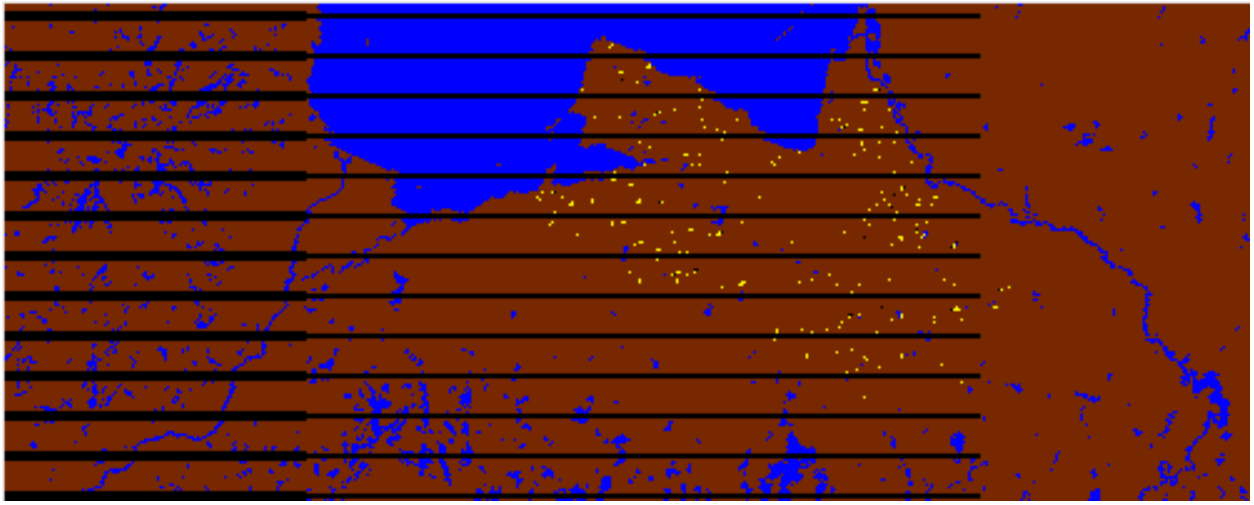
March 10, 2014 10:36-10:40

IDPS



Yellow – fires
Grey - clouds

Replacement code

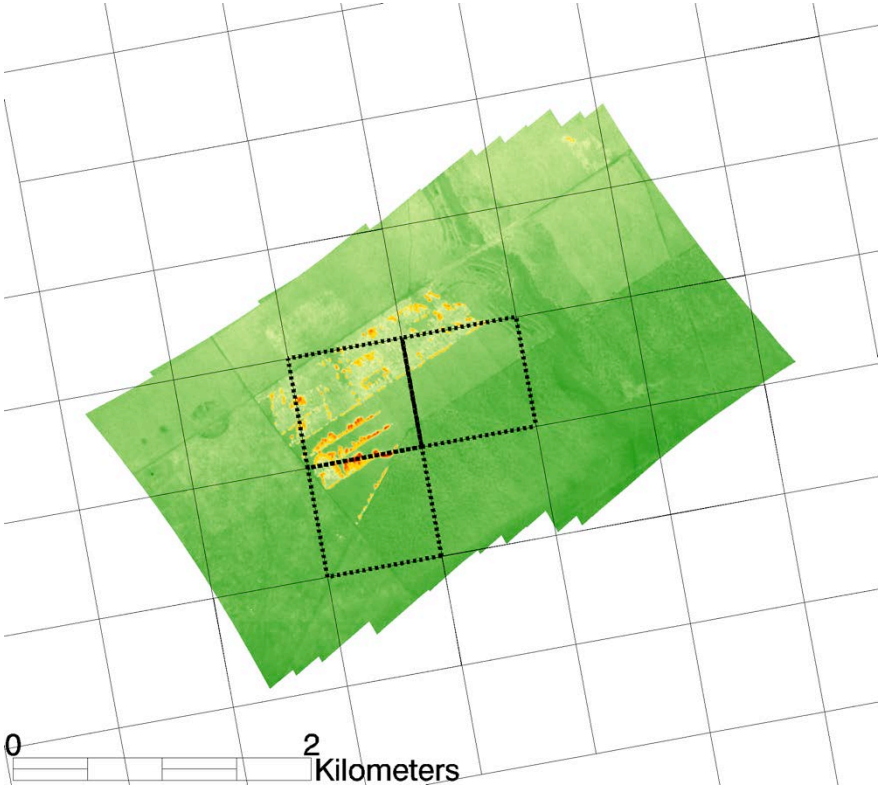


Field Validation Using Coincident Airborne Reference Data

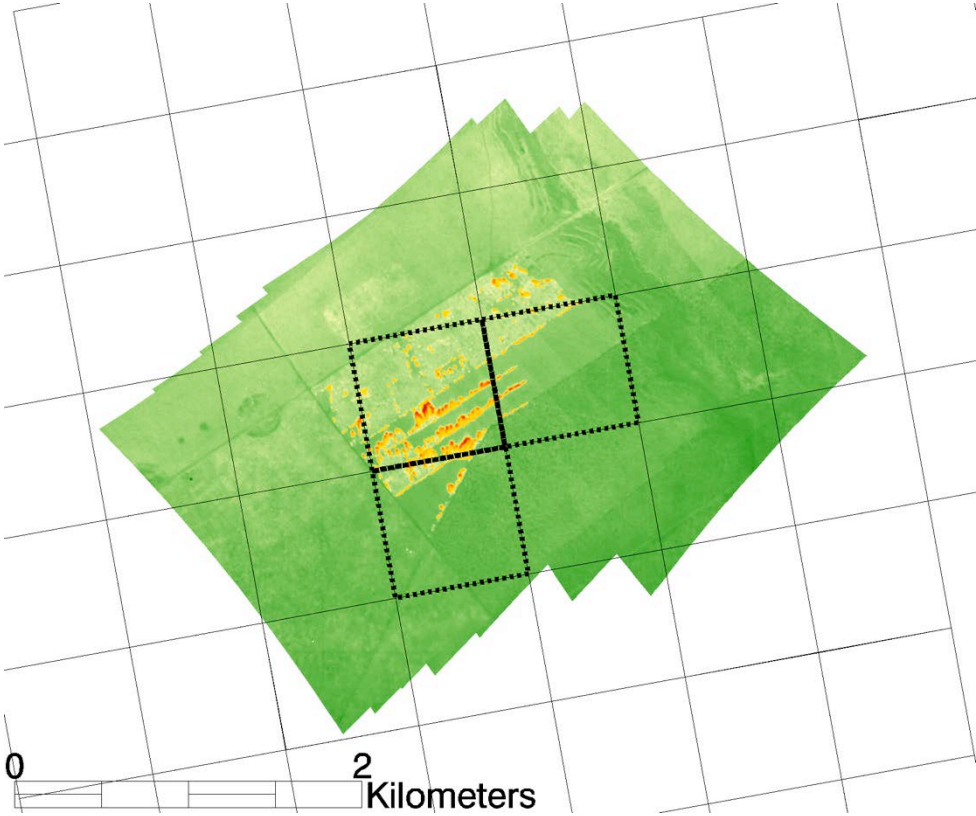
Prescribed Fire Combustion and Atmospheric Dynamics Research (RxCadre) experiment at Eglin Air Force Base/FL
1-15 Nov 2012

VIIRS 750 m Active Fire Algorithm Validation Using Airborne Reference and Auxiliary (fire mask replacement code) Input Data

Grassland fire 10 Nov 2012
(≈16ha flaming/smoldering; 150MW)



VIIRS 18:47:22 UTC
WASP 18:45:28-18:46:04 UTC

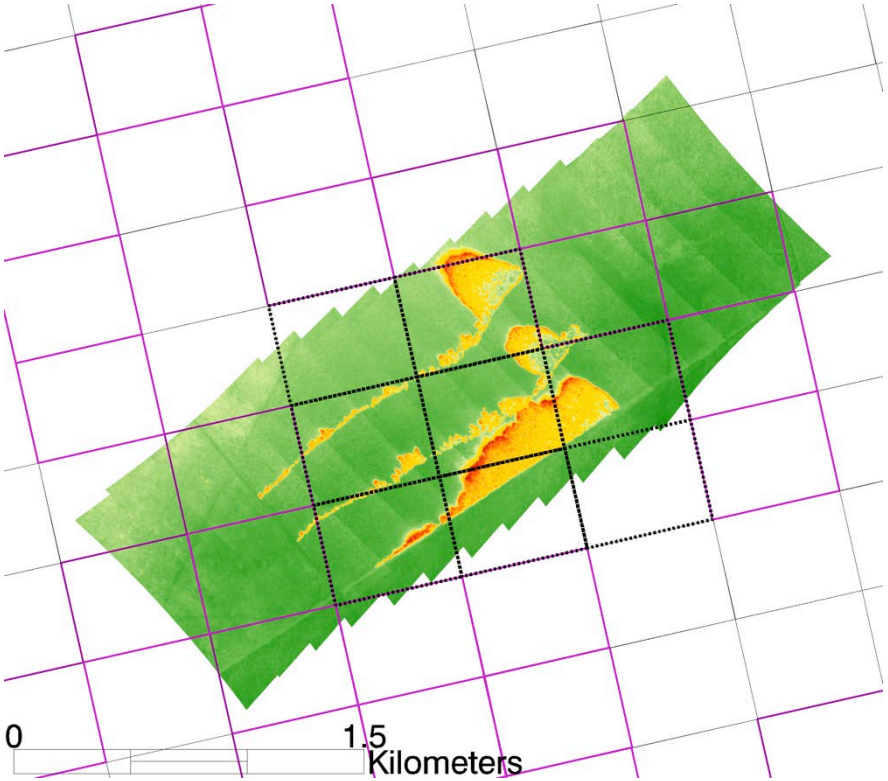


VIIRS 18:47:22 UTC
WASP 18:48:55-18:49:22 UTC

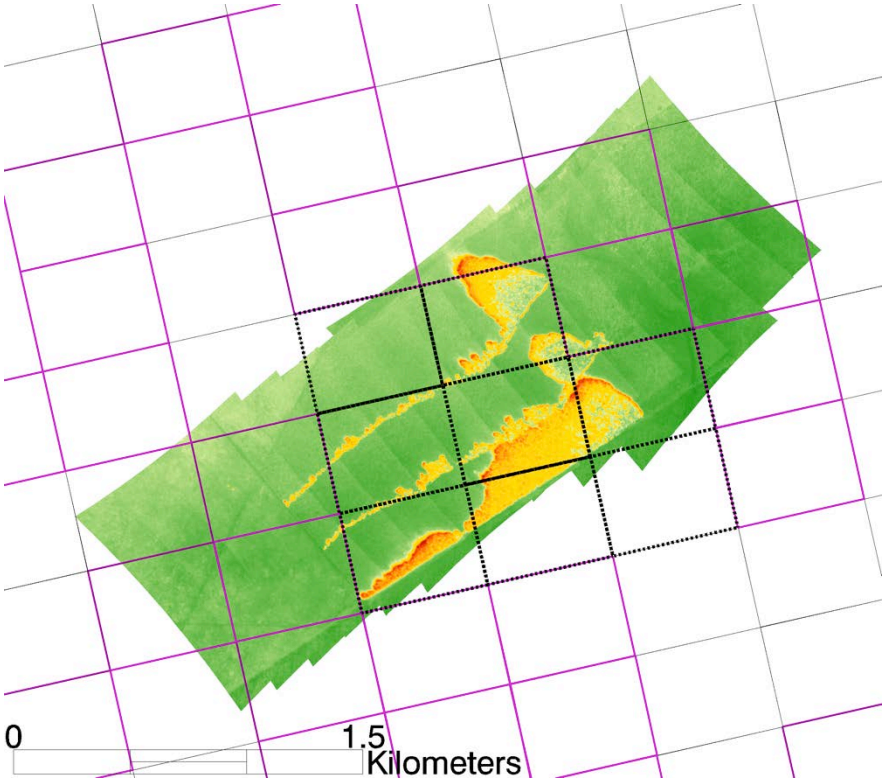
Cloud pixel
Fire pixel
Land pixel

VIIRS 750 m Active Fire Algorithm Validation Using Airborne Reference and Auxiliary (fire mask replacement code) Input Data

Pine forest understory fire 11 Nov 2012
(≈28ha flaming/smoldering; 236MW)



VIIRS 18:28:34 UTC
WASP 18:25:39-18:26:06 UTC

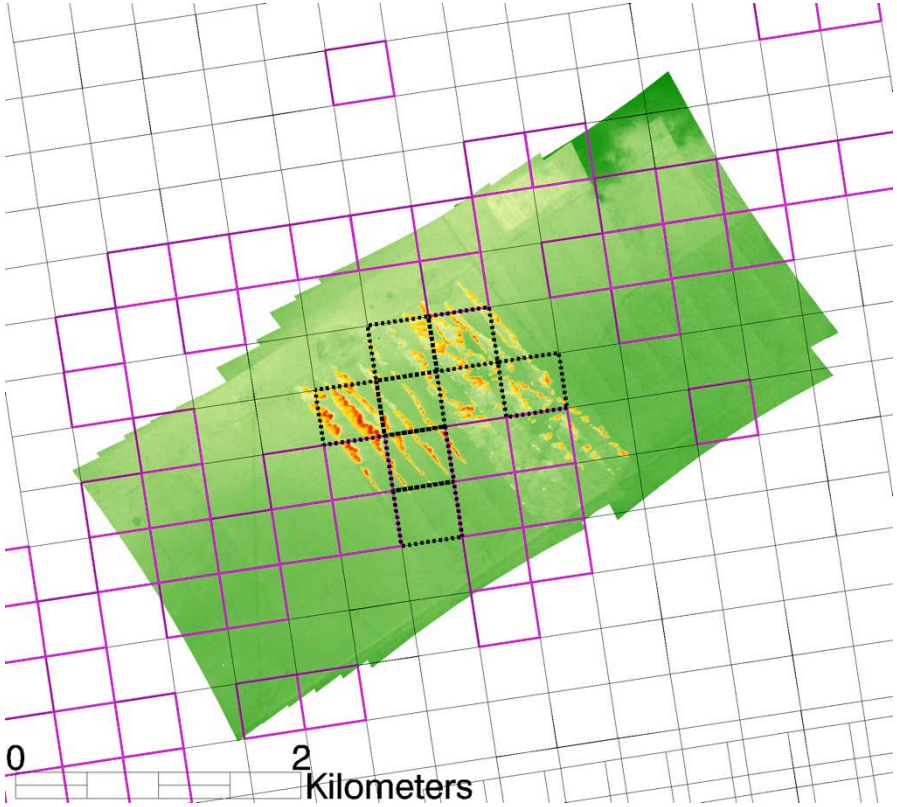


VIIRS 18:28:34 UTC
WASP 18:29:30-18:30:06 UTC

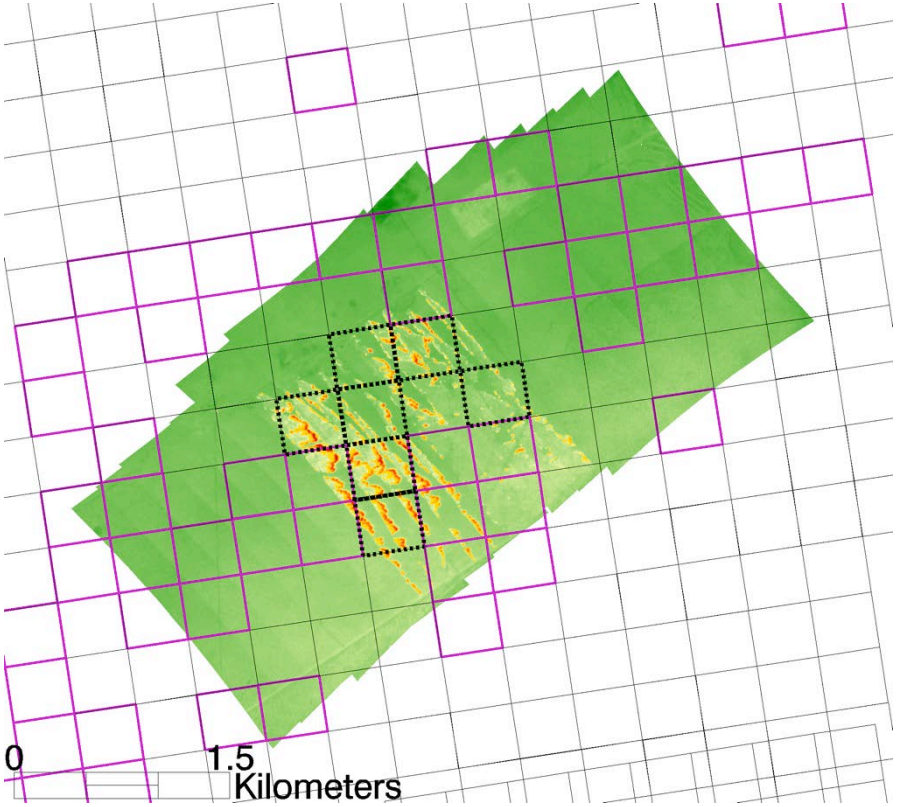
Cloud pixel
Fire pixel
Land pixel

VIIRS 750 m Active Fire Algorithm Validation Using Airborne Reference and Auxiliary (fire mask replacement code) Input Data

Grassland fire 04 Nov 2012
(≈35ha flaming/smoldering; 158MW)



VIIRS 18:59:54 UTC
WASP 18:58:55-18:59:43 UTC



VIIRS 18:59:54 UTC
WASP 19:03:05-19:03:44 UTC

Cloud pixel
Fire pixel
Land pixel