VIIRS FIRE PRODUCTS UPDATE

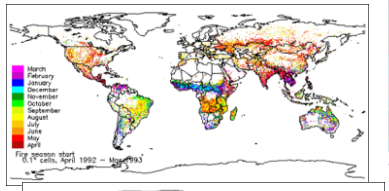
Ivan Csiszar[1], Wilfrid Schroeder[2], Louis Giglio[2], Brad Wind[2], Evan Ellicott[2], Christopher O. Justice[2]

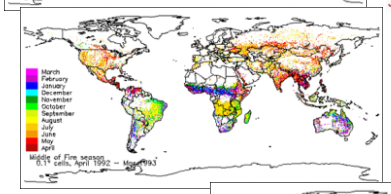
[1]NOAA/NESDIS Center for Satellite Applications and Research, Camp Springs, MD

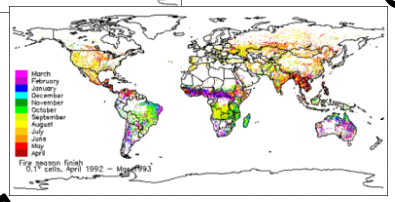
[2]University of Maryland, College Park, MD

This work was supported by the NOAA JPSS and NASA Suomi NPP programs

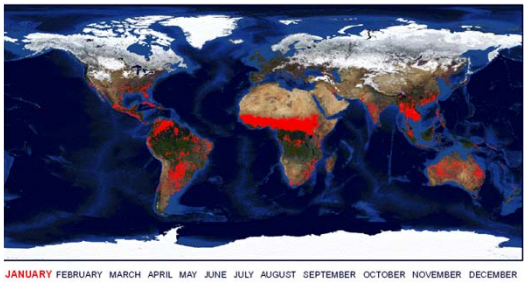
THE GLOBAL FIRE PRODUCT (1992-93)







bioval.jrc.ec.europa.eu/



1980s

1990s

2000s

2010s

AVHRR production

AVHRR global analyses

GOES production

GOFC-GOLD Fire

GCOS Fire ECV

MODIS production

MODIS validation

MODIS CMG

GOES reprocessing

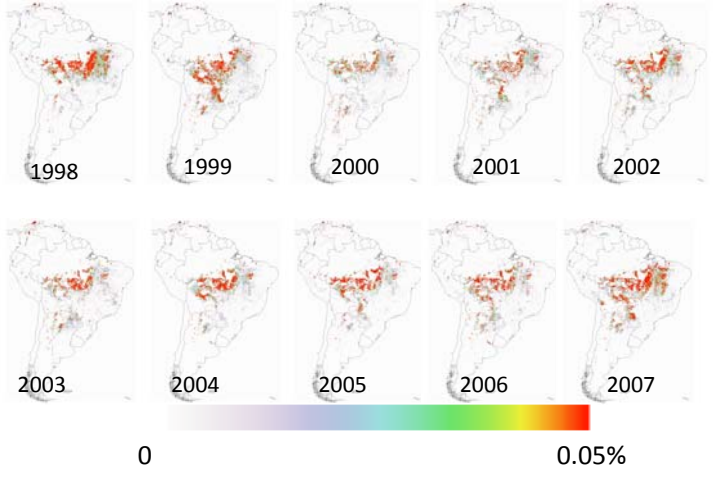
SNPP VIIRS

JPSS VIIRS

GOES-R ABI

PRESENT

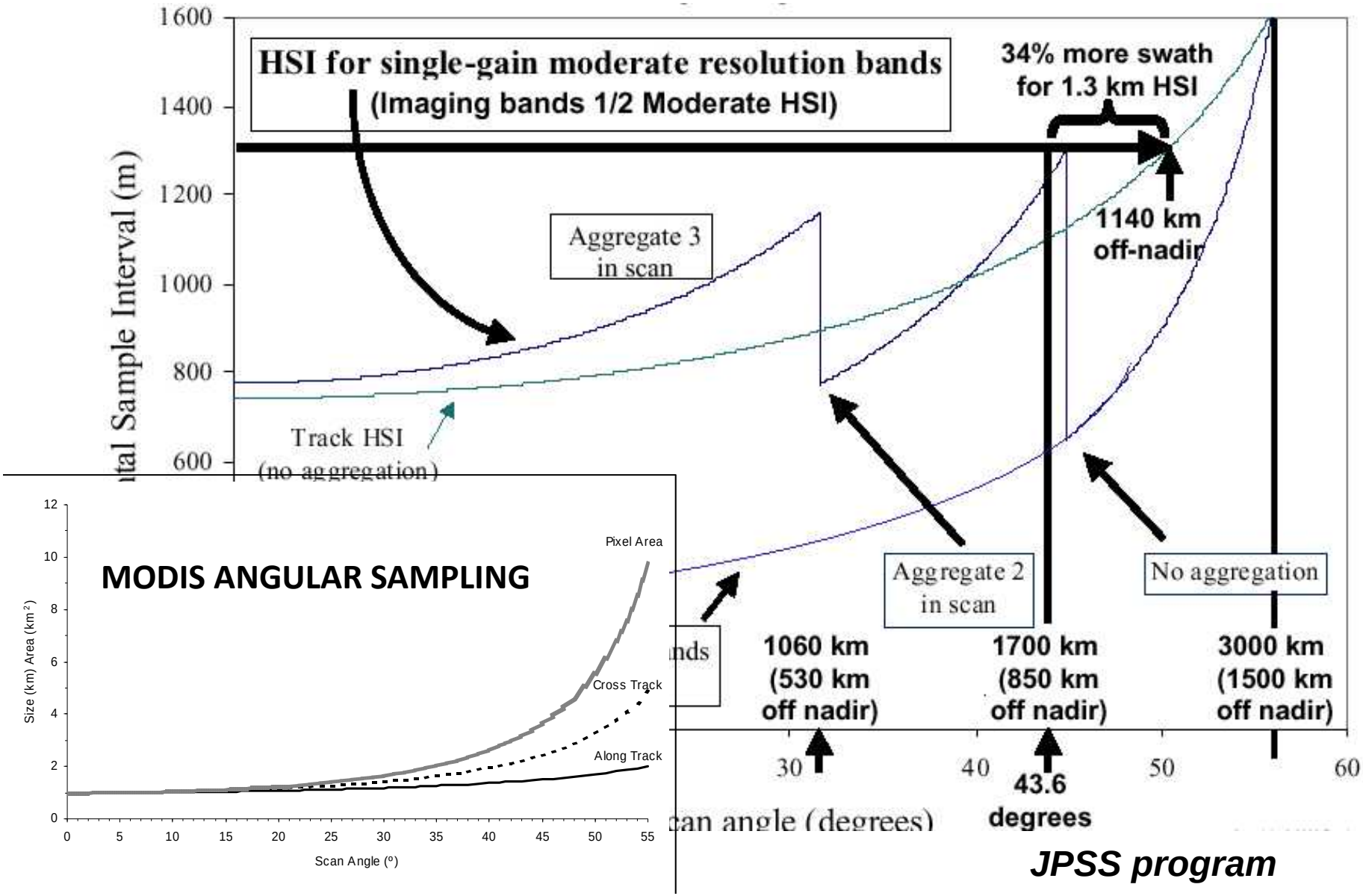
Fraction of GOES clear-sky observations with fire



VIIRS Heritage: MODIS and AVHRR

VIIRS			MODIS Equivalent			AVHRR-3 Equivalent			OLS Equivalent		
Band	Range (um)	HSR (m)	Band	Range	HSR	Band	Range	HSR	Band	Range	HSR
DNB	0.500 - 0.900								HRD PMT	0.580 - 0.910 0.510 - 0.860	550 2700
M1	0.402 - 0.422	750	8	0.405 - 0.420	1000						
M2	0.436 - 0.454	750	9	0.438 - 0.448	1000						
M3	0.478 - 0.498	750	3 10	0.459 - 0.479 0.483 - 0.493	500 1000						
M4	0.545 - 0.565	750	4 12	0.545 - 0.565 0.546 - 0.556	500 1000						
I1	0.600 - 0.680	375	1	0.620 - 0.670	250	1	0.572 - 0.703	1100			
M5	0.662 - 0.682	750	13 14	0.662 - 0.672 0.673 - 0.683	1000 1000	1	0.572 - 0.703	1100			
M6	0.739 - 0.754	750	15	0.743 - 0.753	1000						
I2	0.846 - 0.885	375	2	0.841 - 0.876	250	2	0.720 - 1.000	1100			
M7	0.846 - 0.885	750	16	0.862 - 0.877	1000	2	0.720 - 1.000	1100			
M8	1.230 - 1.250	750	5	SAME	500						
M9	1.371 - 1.386	750	26	1.360 - 1.390	1000						
I3	1.580 - 1.640	375	6	1.628 - 1.652	500						
M10	1.580 - 1.640	750	6	1.628 - 1.652	500	3a	SAME	1100			
M11	2.225 - 2.275	750	7	2.105 - 2.155	500						
I4	3.550 - 3.930	375	20	3.660 - 3.840	1000	3b	SAME	1100			
M12	3.660 - 3.840	750	20	SAME	1000	3b	3.550 - 3.930	1100			
M13	3.973 - 4.128	750	21 22 23	3.929 - 3.989 3.929 - 3.989 4.020 - 4.080	1000 1000 1000						
M14	8.400 - 8.700	750	29	SAME	1000						
M15	10.263 - 11.263	750	31	10.780 - 11.280	1000	4	10.300 - 11.300	1100			
I5	10.500 - 12.400	375	31 32	10.780 - 11.280 11.770 - 12.270	1000 1000	4 5	10.300 - 11.300 11.500 - 12.500	1100 1100	HRD	10.300 - 12.900	550
M16	11.538 - 12.488	750	32	11.770 - 12.270	1000	5	11.500 - 12.500	1100			

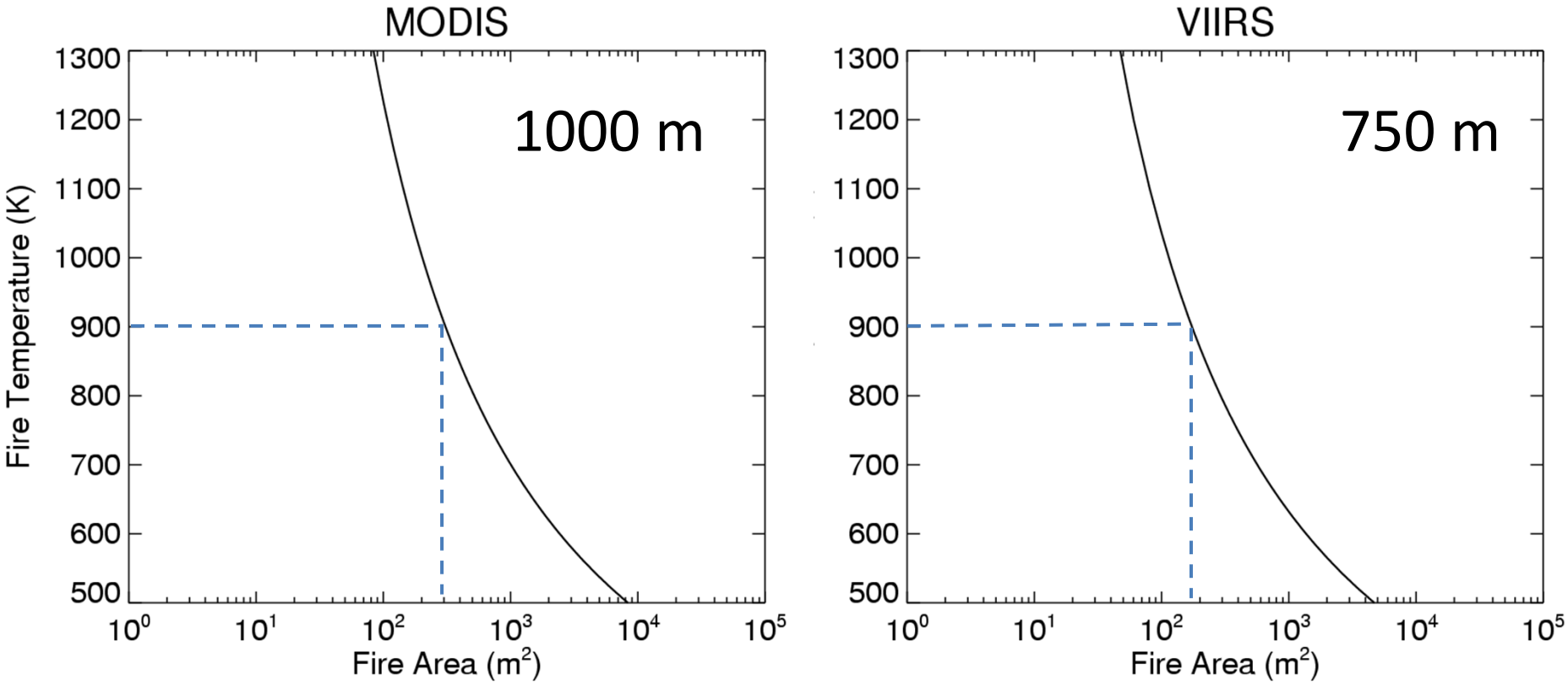
VIIRS Detector Aggregation Scheme



JPSS program

MODIS and VIIRS fire detections at nadir: modeling

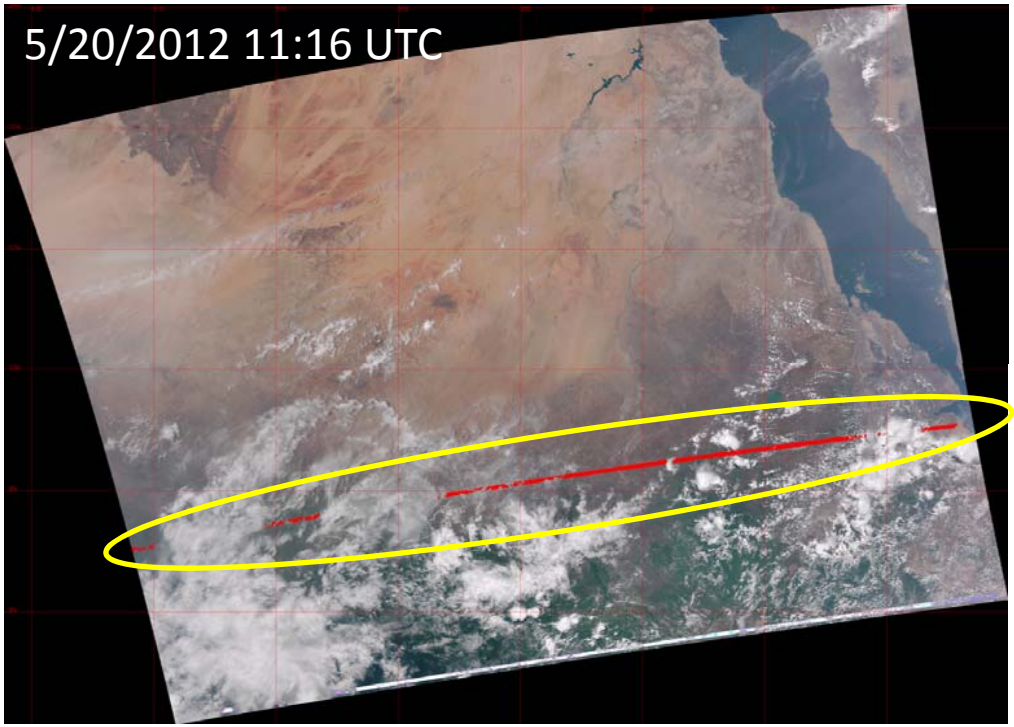
VIIRS spatial resolution is higher that of MODIS; in general,
VIIRS is expected to detect smaller fires at nadir



90% probability of detection; boreal forest; nadir view

Post-launch product evaluation

- **24/7 script for data visualization**
  - ***Designed for qualitative assessment of fire data***
  - ***Used to identify major anomalies in data***
- **VIIRS x Aqua/MODIS intercomparison**
  - ***Designed for qualitative assessment of VIIRS fire detection using near-coincident Aqua/MODIS data***
  - ***Verify active fire product consistency on a per-pixel and/or grid basis***
- **Detailed data inspection tool**
  - ***Used to assess quality of individual bands and the corresponding quality flags***
- **Collection and analysis of in-situ and airborne data**
  - ***Explicit validation***
- **M13 SDR feedback**
  - ***Aggregation, low/high gain***
- **Product improvements**
  - ***Spatially explicit fire mask***
  - ***FRP***
  - ***VIIRS-specific algorithm changes***



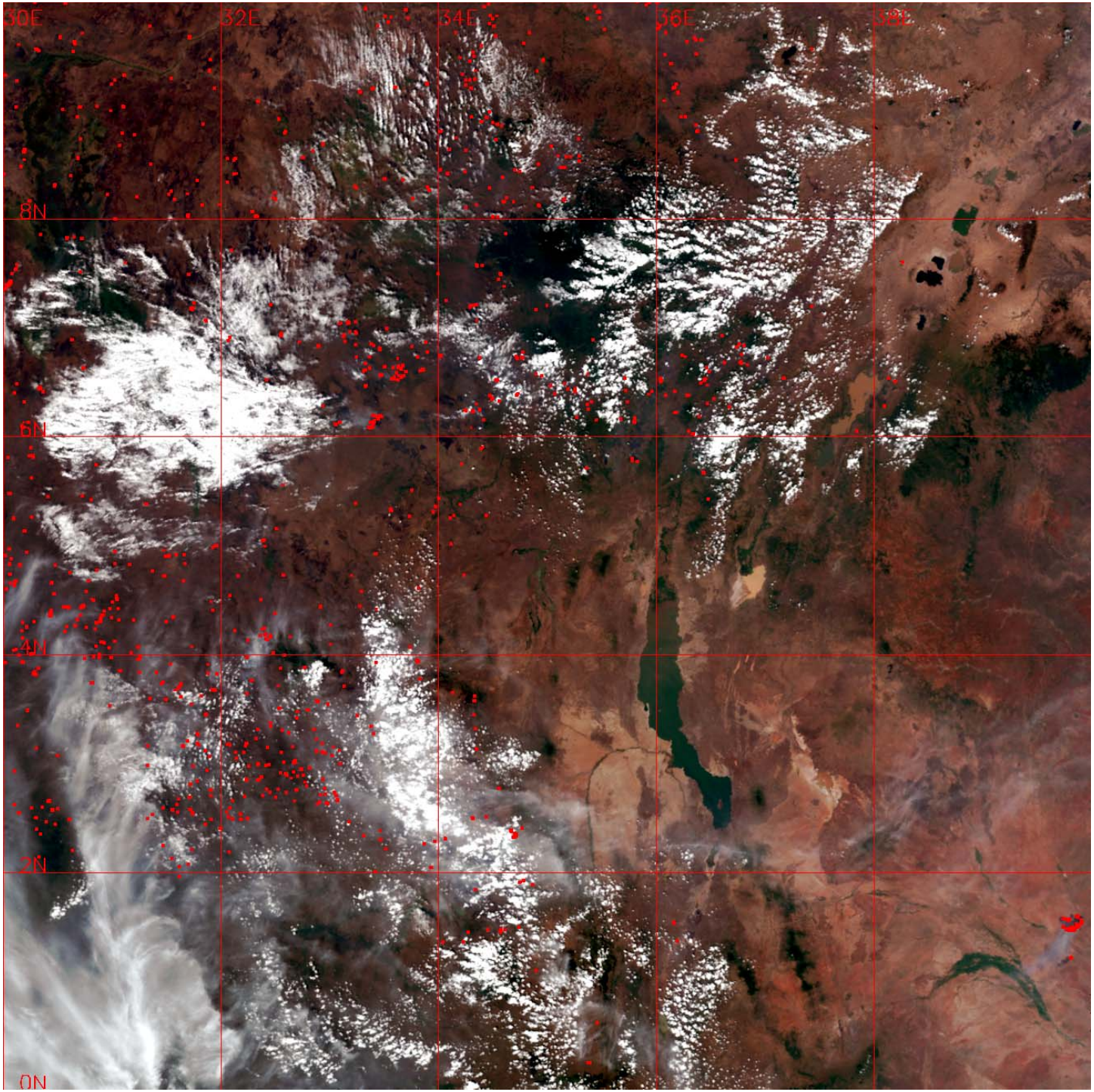
VIIRS-MODIS Comparisons

- The following slides will provide examples of product performance over **four distinct ecosystems**:
  - Central Africa: tropical agricultural maintenance fires
  - SE Australia: bushfires
  - Central Asia: mid-latitude grassland and agricultural fires
  - Siberia: boreal forest
- **Visual expert analysis**, based on MODIS experience, has been used to identify performance shortcomings
- **Quantitative analysis** of near-simultaneous VIIRS and MODIS fire counts over a spatial is performed
- Further examples are available at the **JPSS VIIRS Active Fire Product website**:

http://viirsfire.geog.umd.edu/

First light NPP VIIRS fire data

M5-M4-M3 RGB
+
IDPS Active Fire ARP

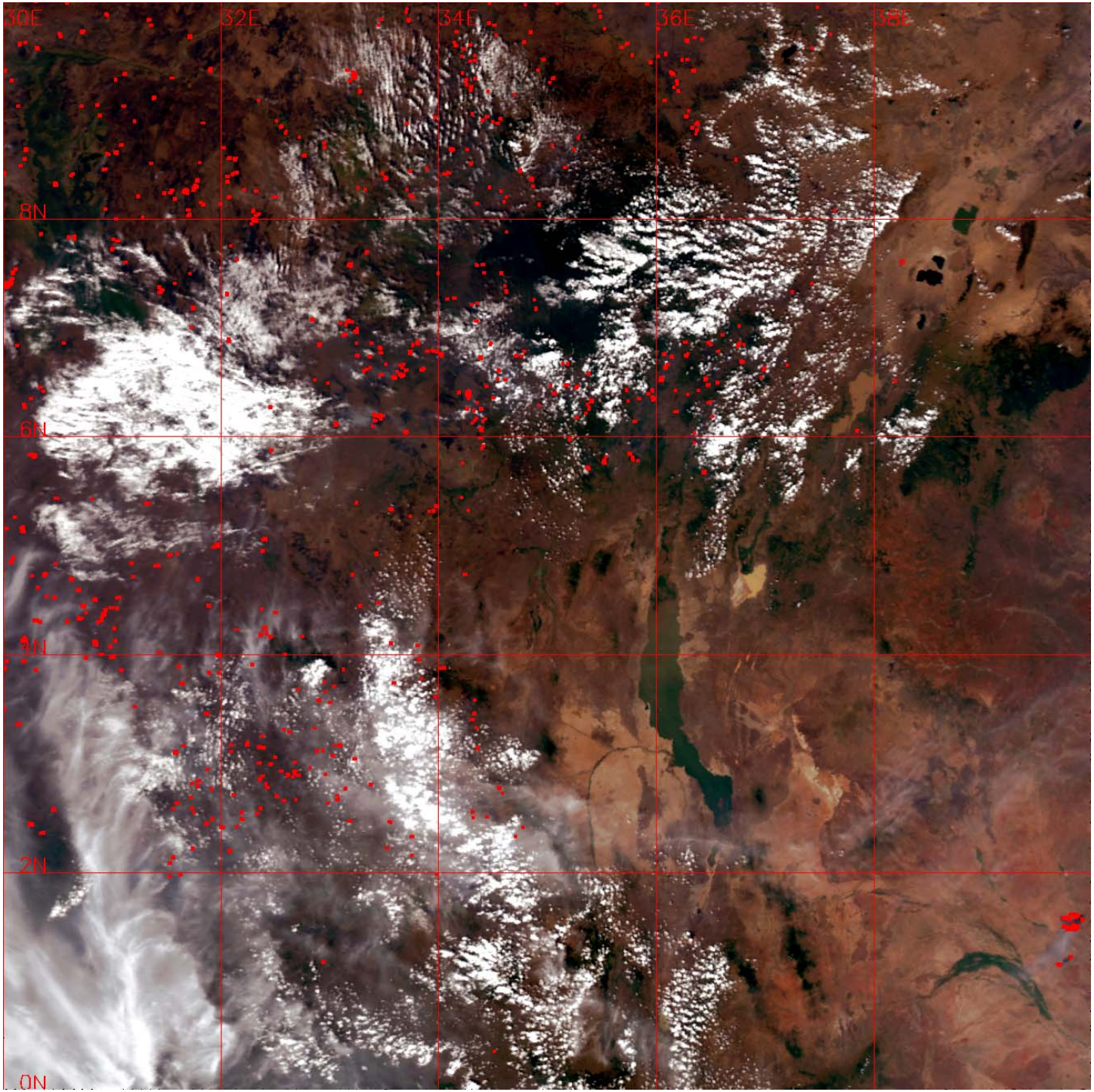


January 19, 2012
~11:05 UTC

…followed by Aqua MODIS five minutes later

Band 1-4-3 RGB
+
MYD14

January 19, 2012
~11:05 UTC

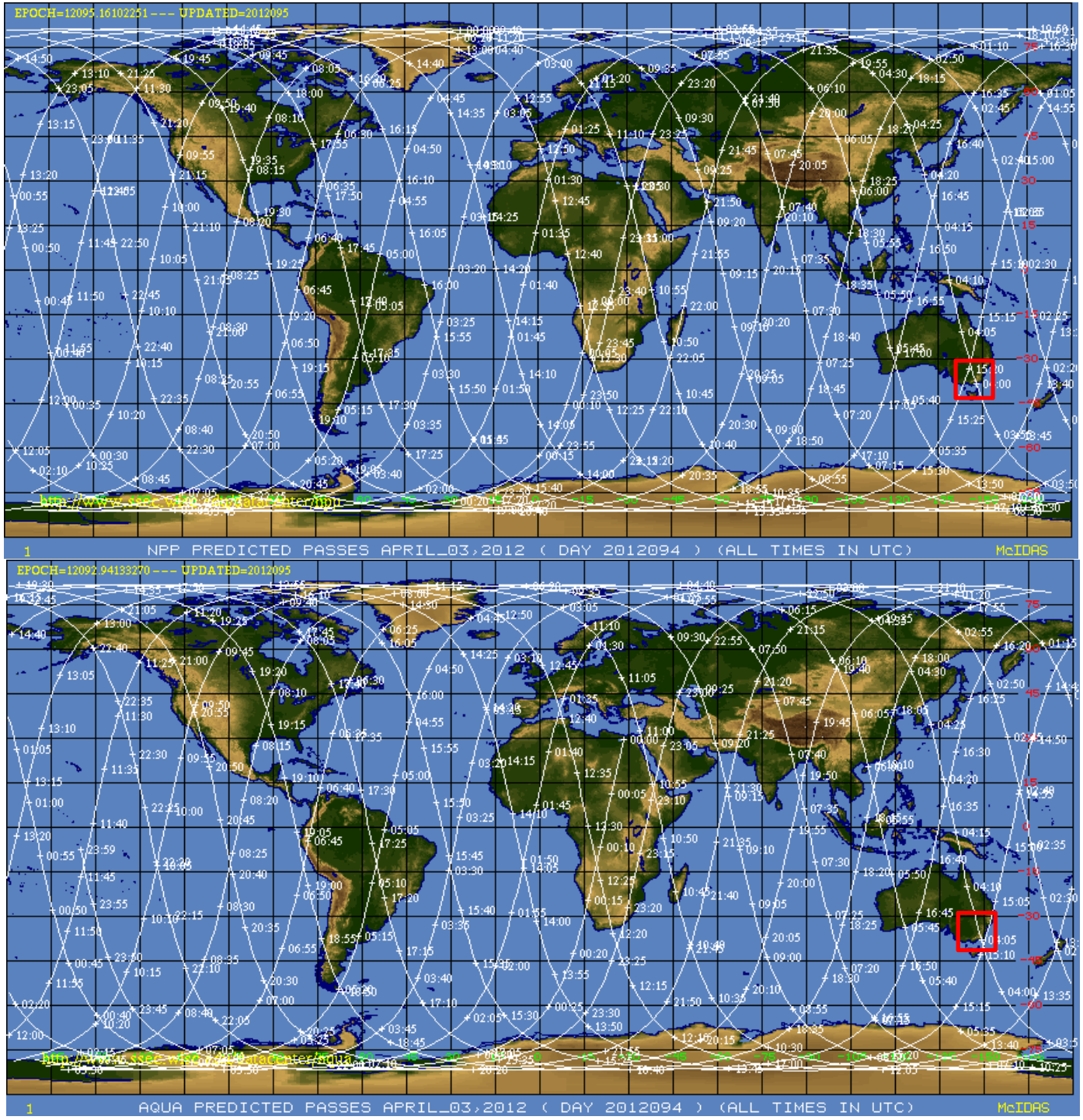


NPP

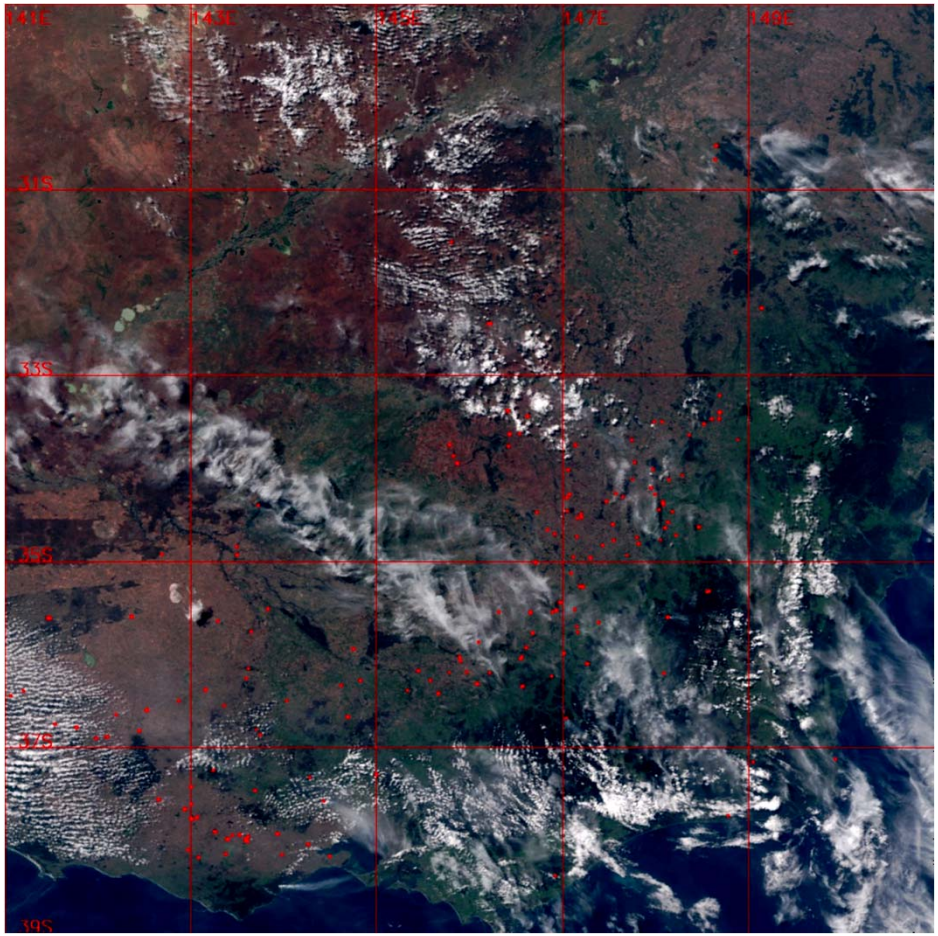
Satellite orbit tracks

April 3, 2012

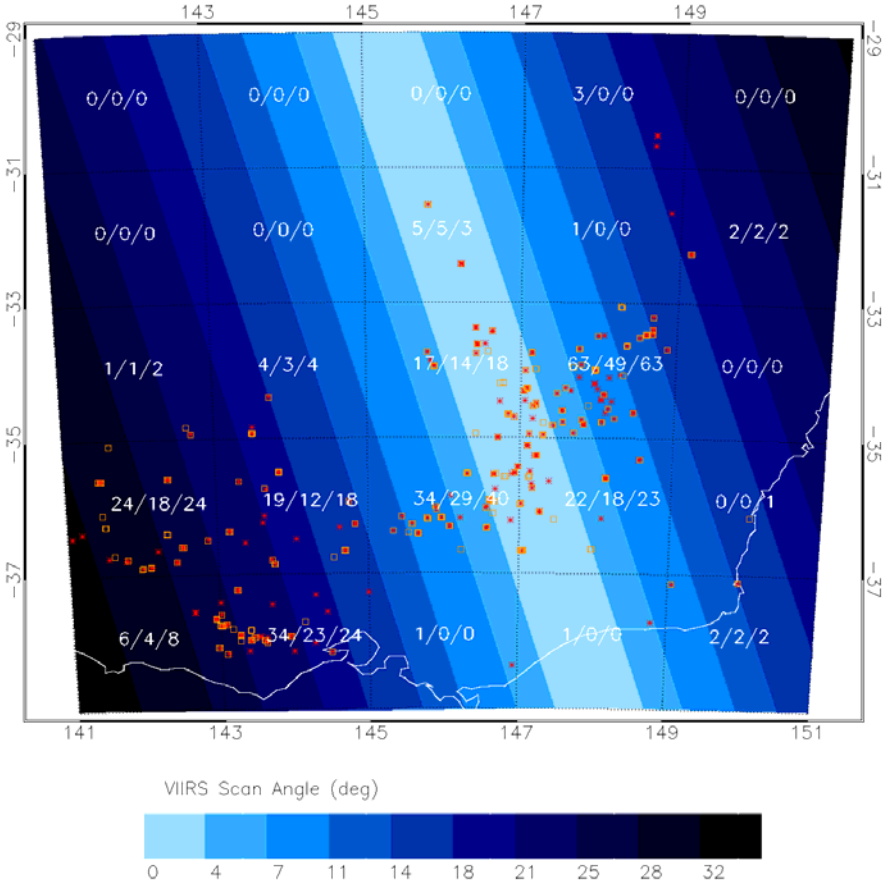
Aqua



MODIS and VIIRS fire detections at nadir: post-launch on-orbit data

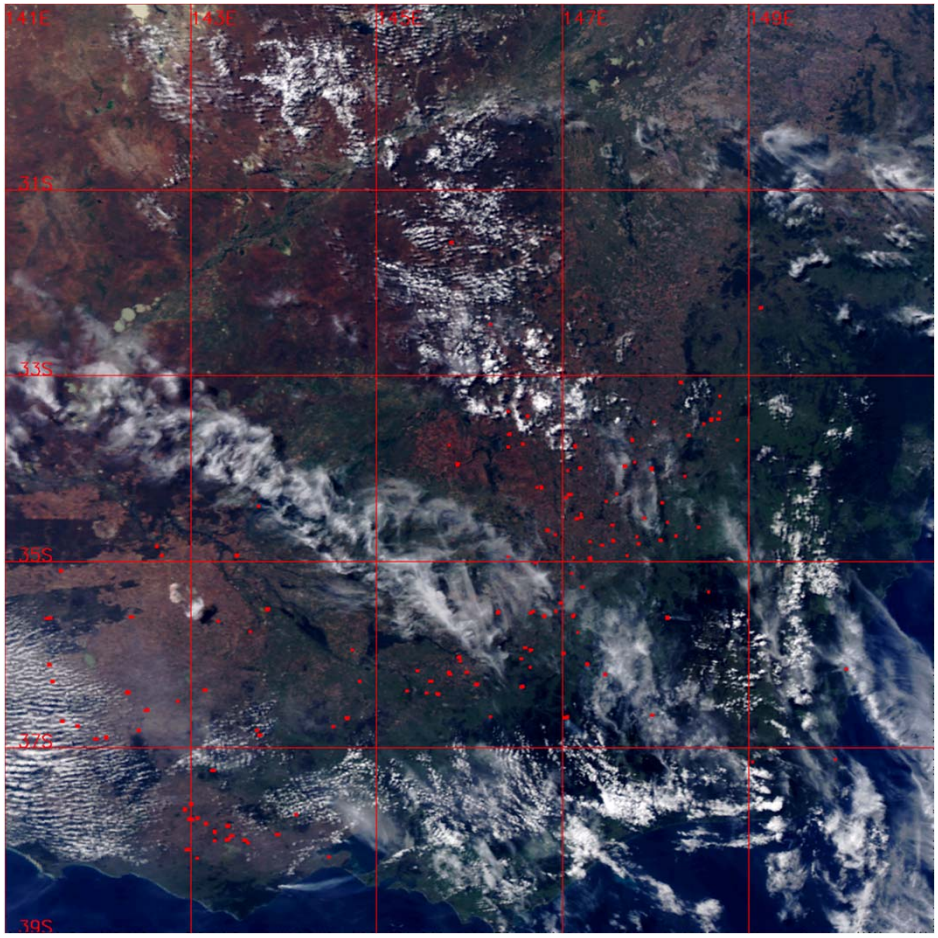


VIIRS 03 April 2012 03:55UTC
(SE Australia)

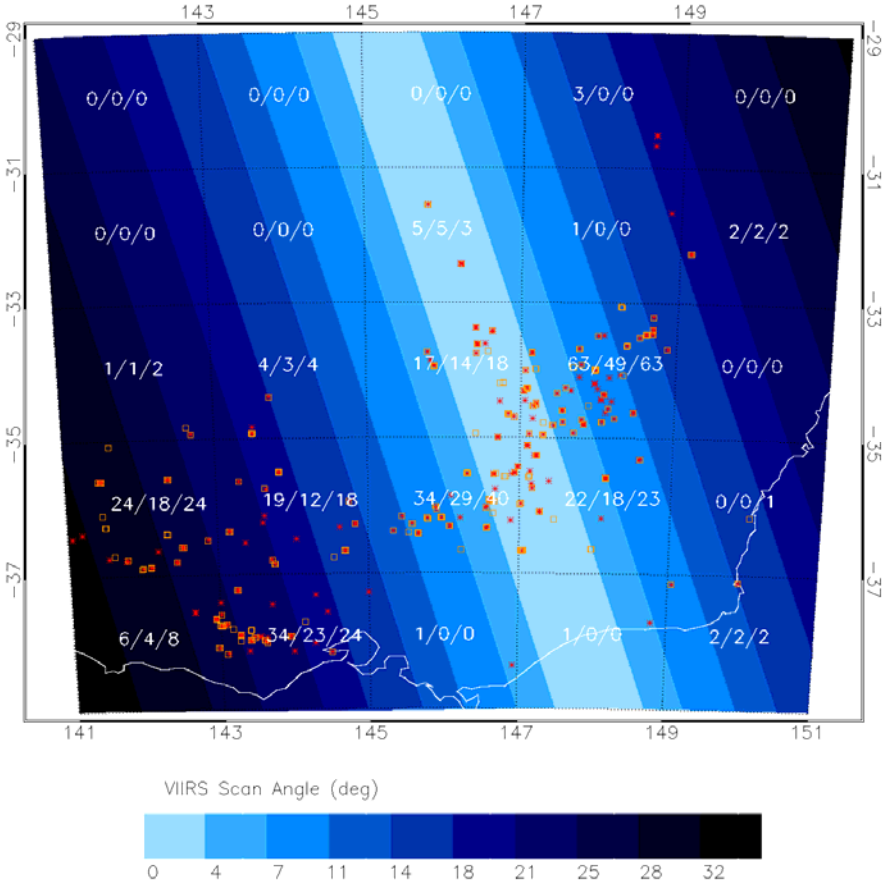


Gridded statistics: AA/BB/CC
AA – number of VIIRS fire pixels (red symbols)
BB – number of VIIRS fire pixels with overlapping Aqua/MODIS fire pixels
CC – number of Aqua/MODIS fire pixels (orange symbols)

MODIS and VIIRS fire detections at nadir: post-launch on-orbit data



MODIS 03 April 2012 04:05UTC
(SE Australia)



Gridded statistics: AA/BB/CC
AA – number of VIIRS fire pixels (red symbols)
BB – number of VIIRS fire pixels with overlapping Aqua/MODIS fire pixels
CC – number of Aqua/MODIS fire pixels (orange symbols)

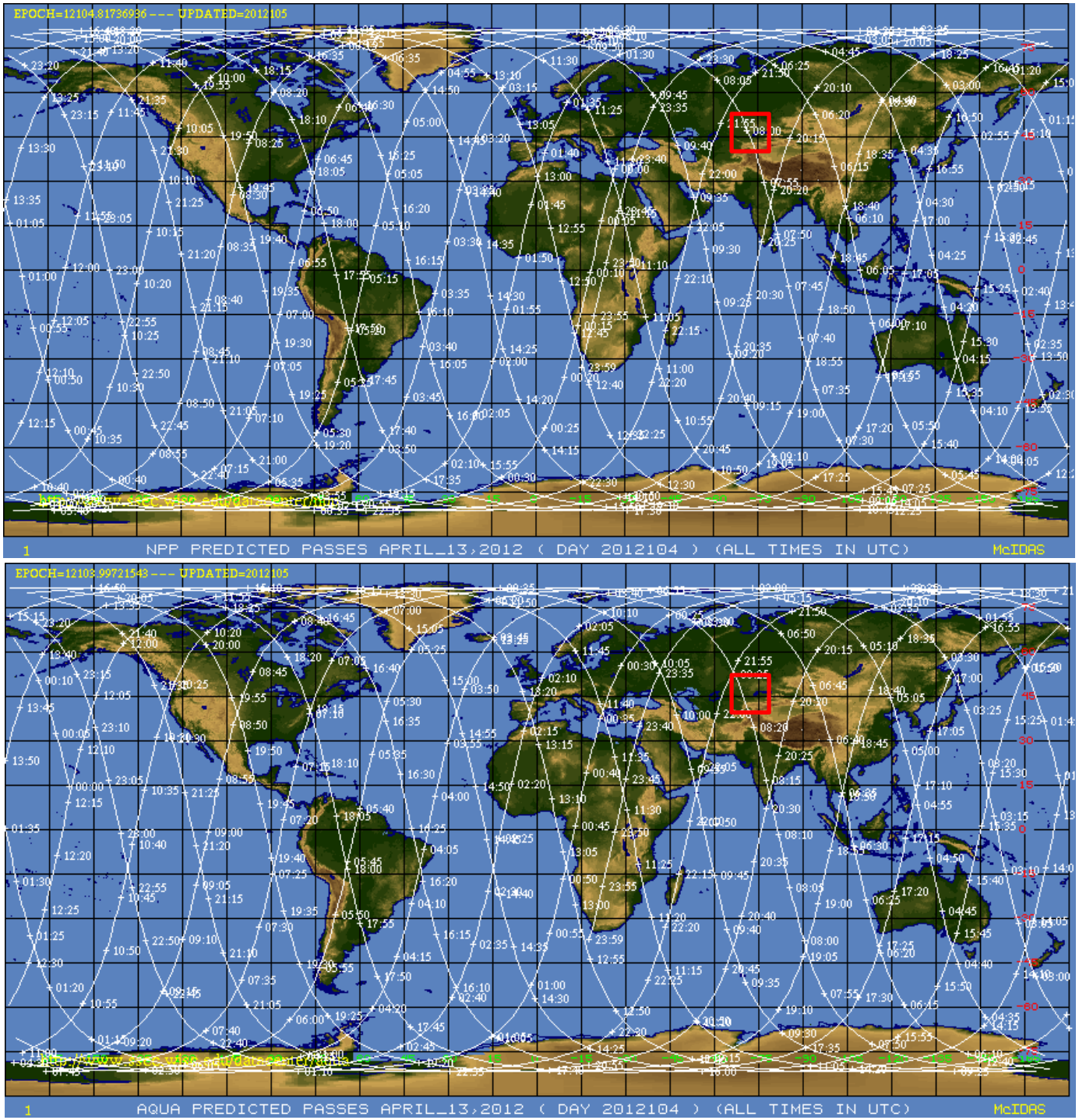
NPP

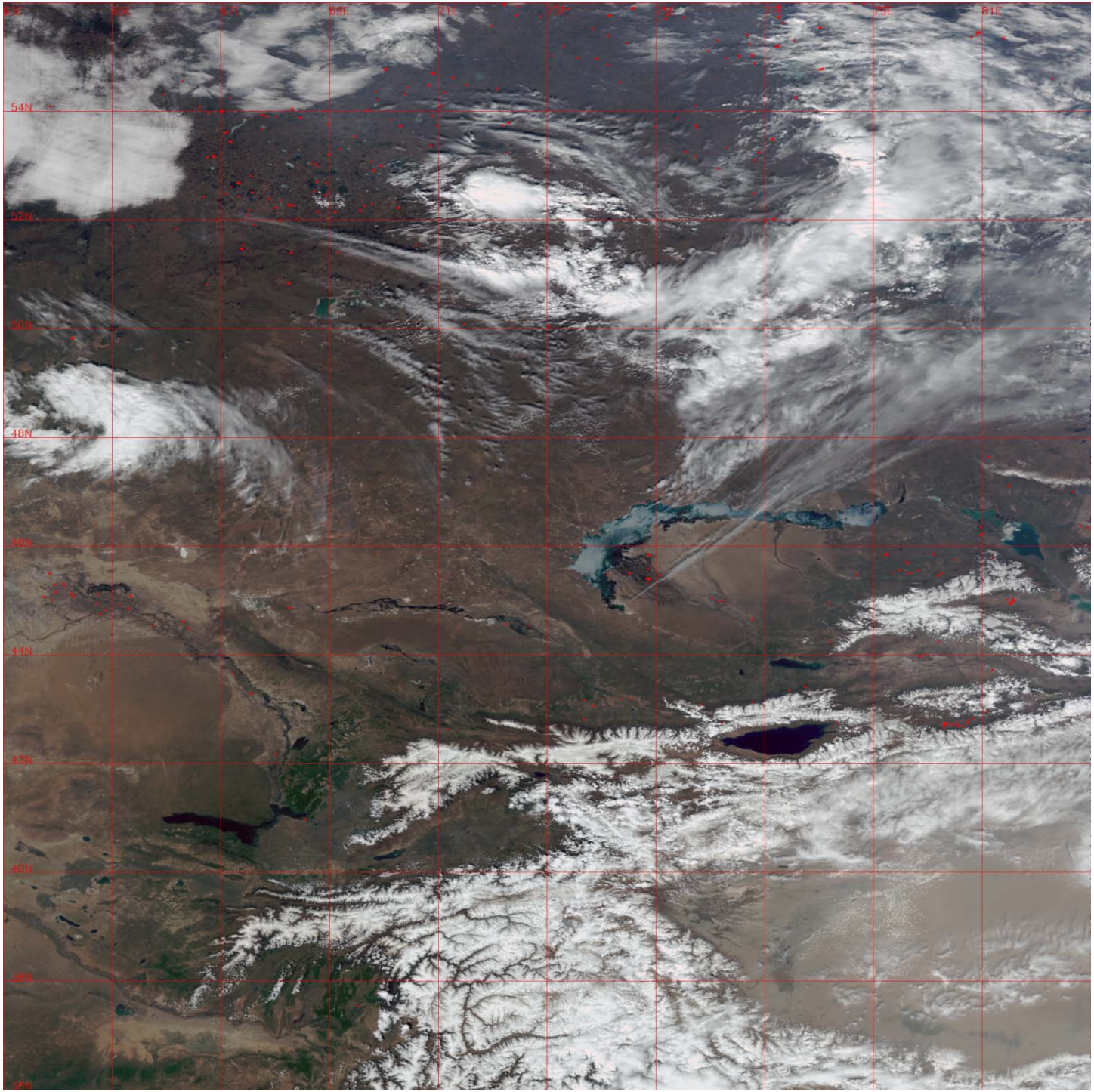
Satellite orbit tracks

April 13, 2012

Aqua

http://www.ssec.wisc.edu/datacenter/orbit_tracks.html





NPP VIIRS

Central Asia

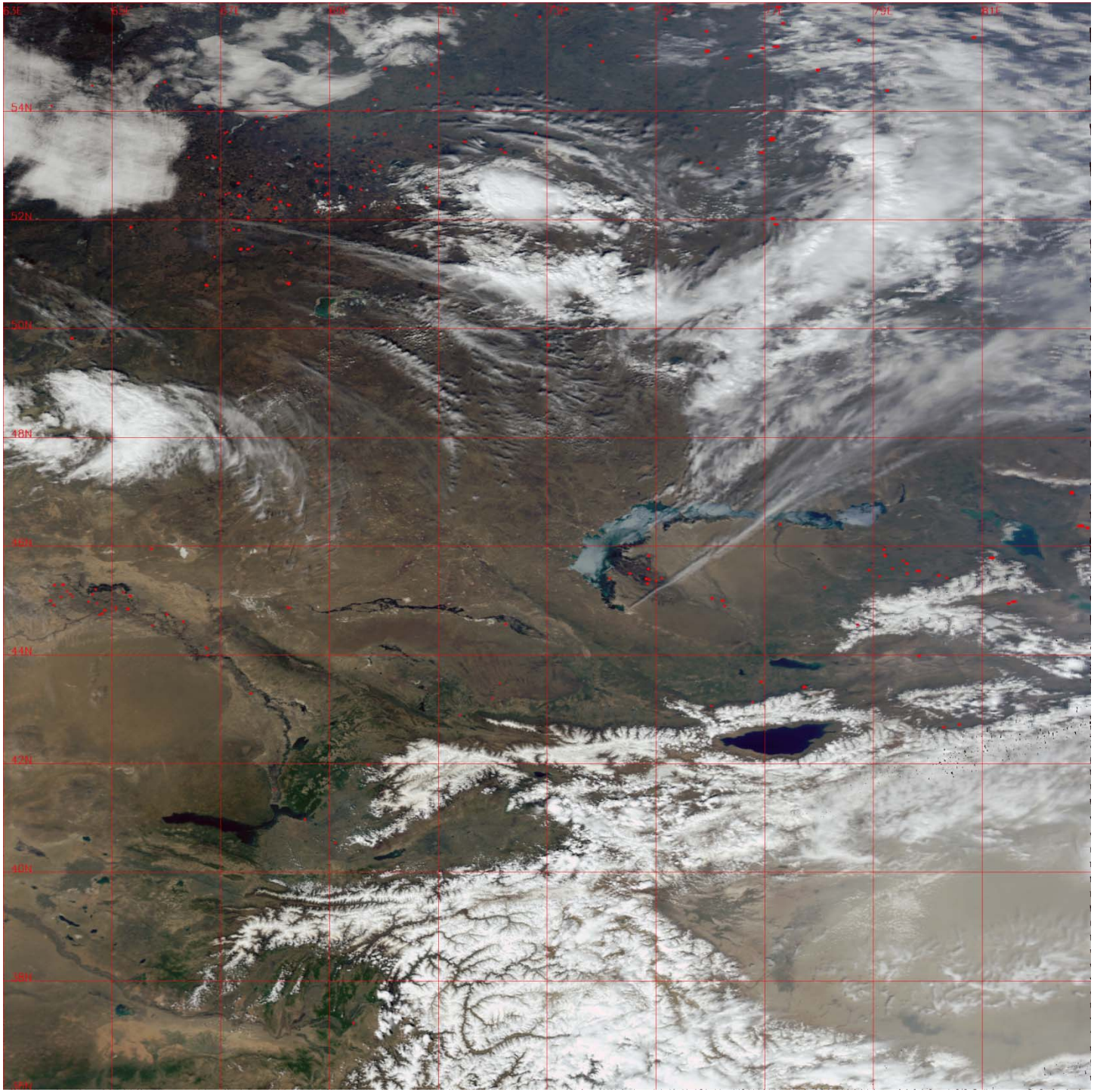
April 13 2012

7:53 UTC

M5-M4-M3 RGB

+

IDPS Active Fire ARP



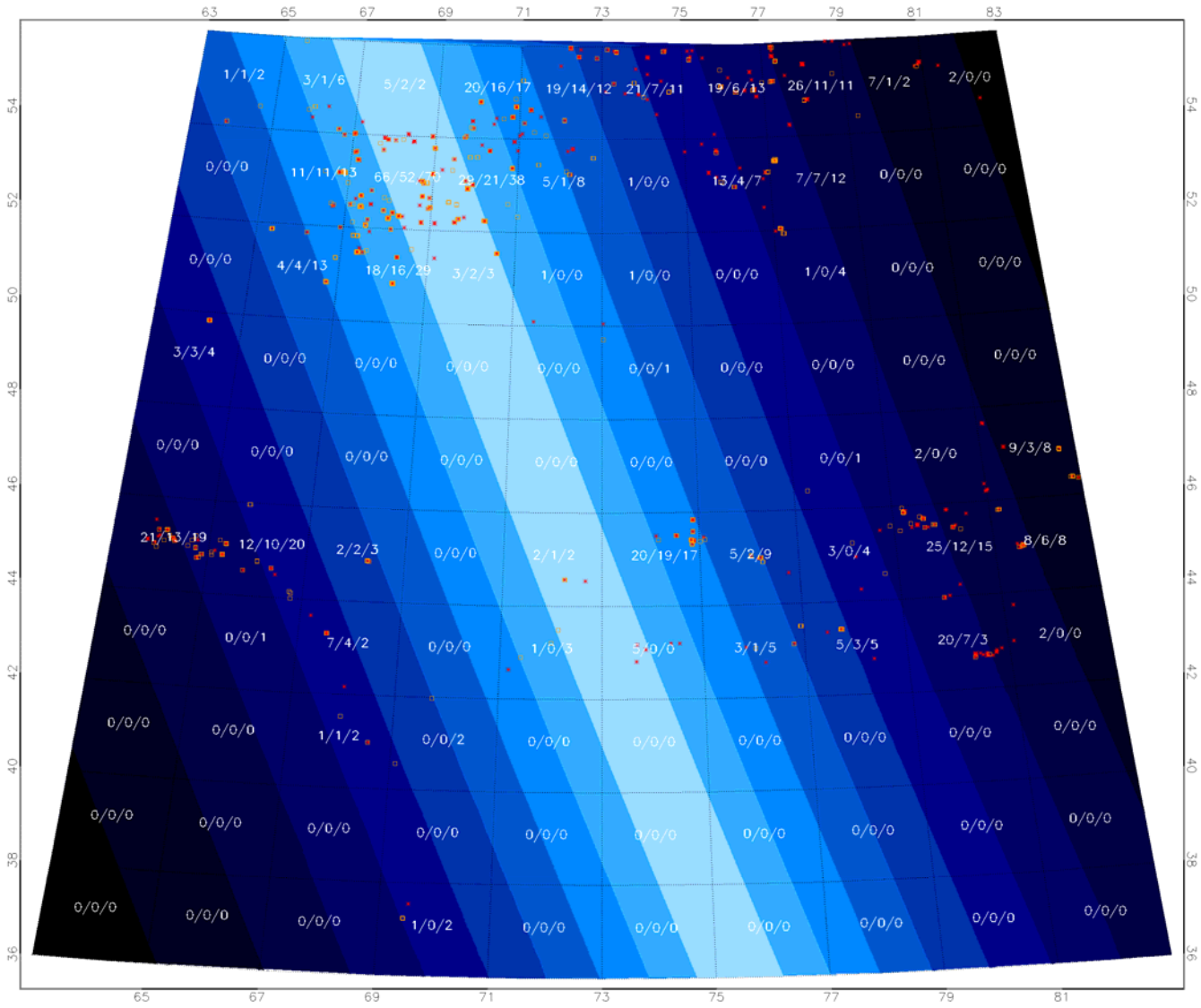
Aqua MODIS

Central Asia

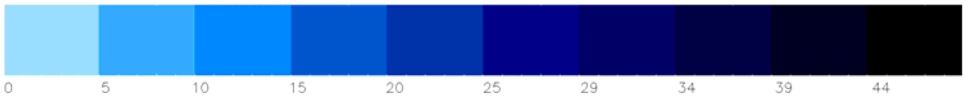
April 13 2012

8:18 UTC

Band 1-4-3 RGB
+
MYD14



VIIRS/overlap/MODIS



VIIRS

vs.

MODIS

Central Asia

April 13 2012

Gridded statistics: AA/BB/CC
AA – number of VIIRS fire pixels (red symbols)
BB – number of VIIRS fire pixels with overlapping Aqua/MODIS fire pixels
CC – number of Aqua/MODIS fire pixels (orange symbols)

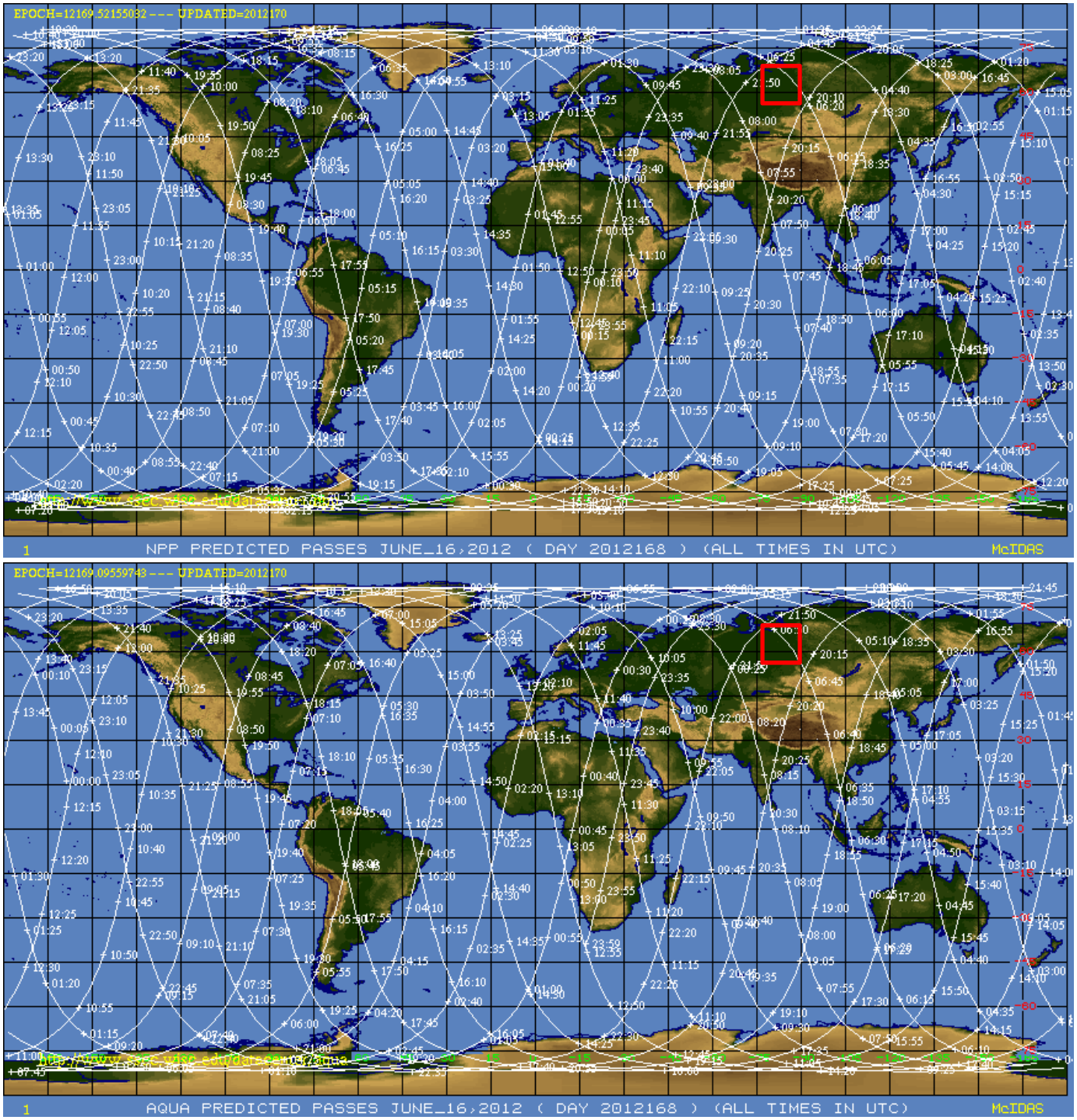
NPP

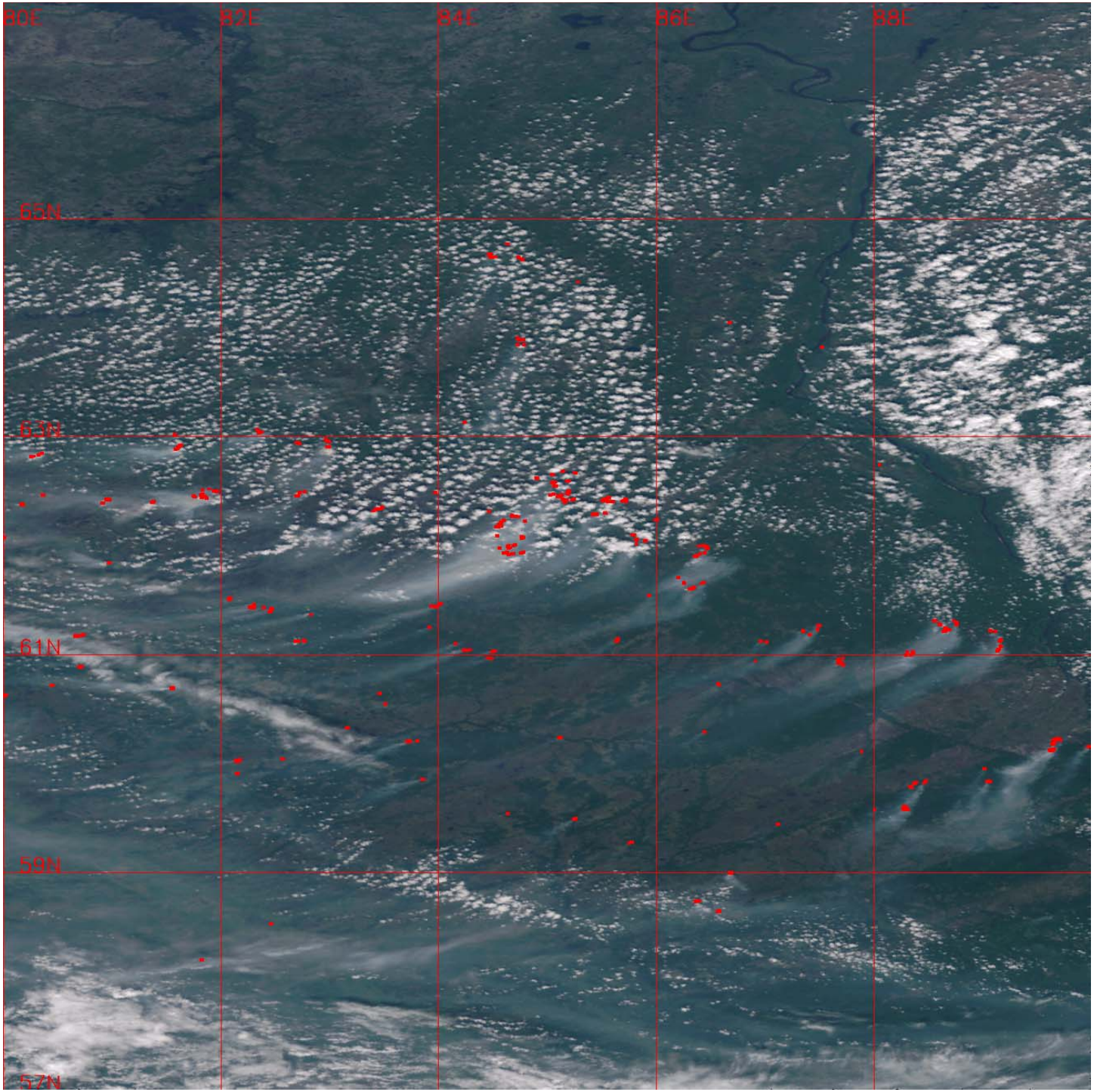
Satellite orbit tracks

June 16, 2012

Aqua

http://www.ssec.wisc.edu/datacenter/orbit_tracks.html





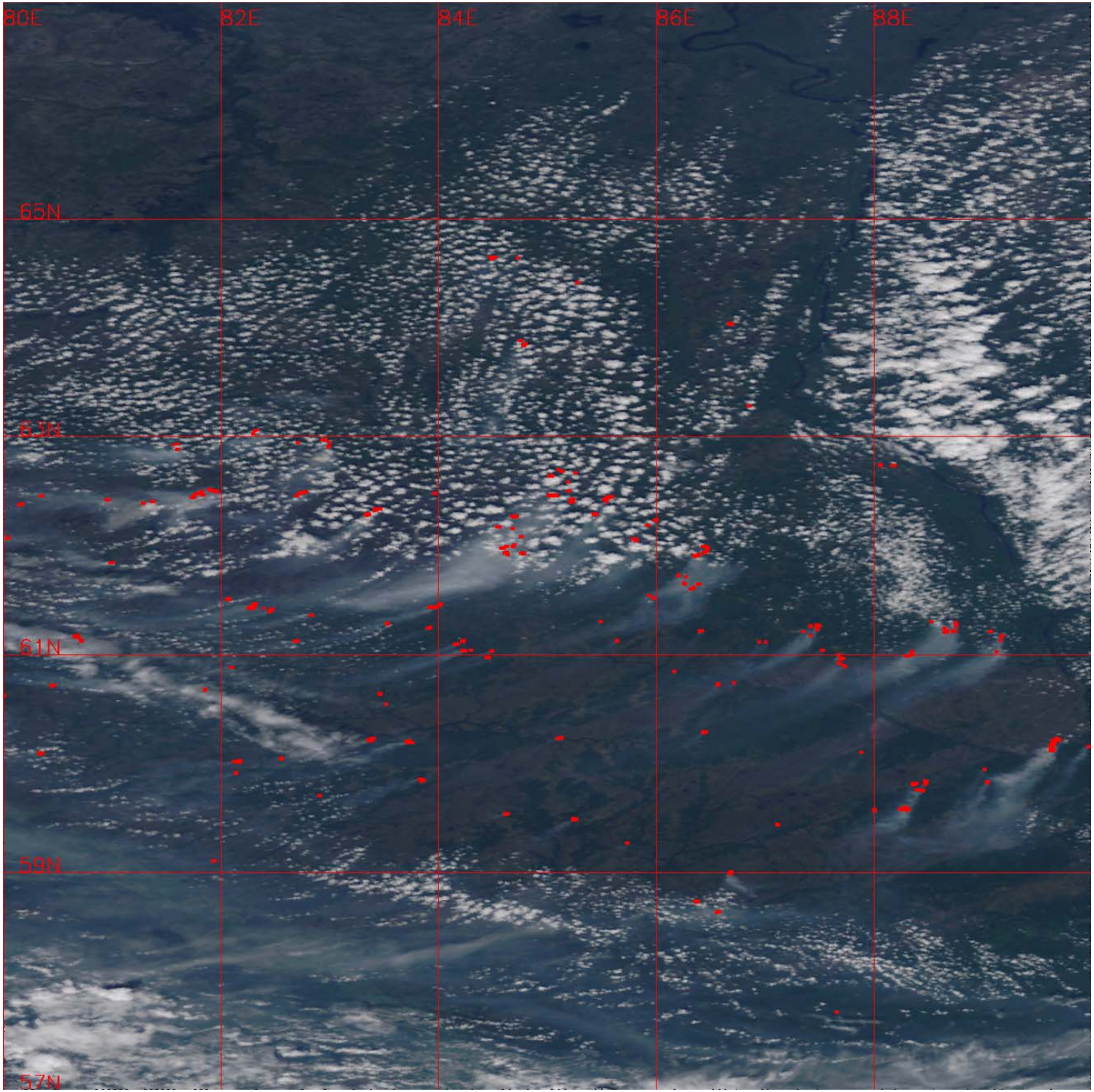
NPP VIIRS

Western Siberia

June 16 2012

6:15 UTC

M5-M4-M3 RGB
+
IDPS Active Fire ARP



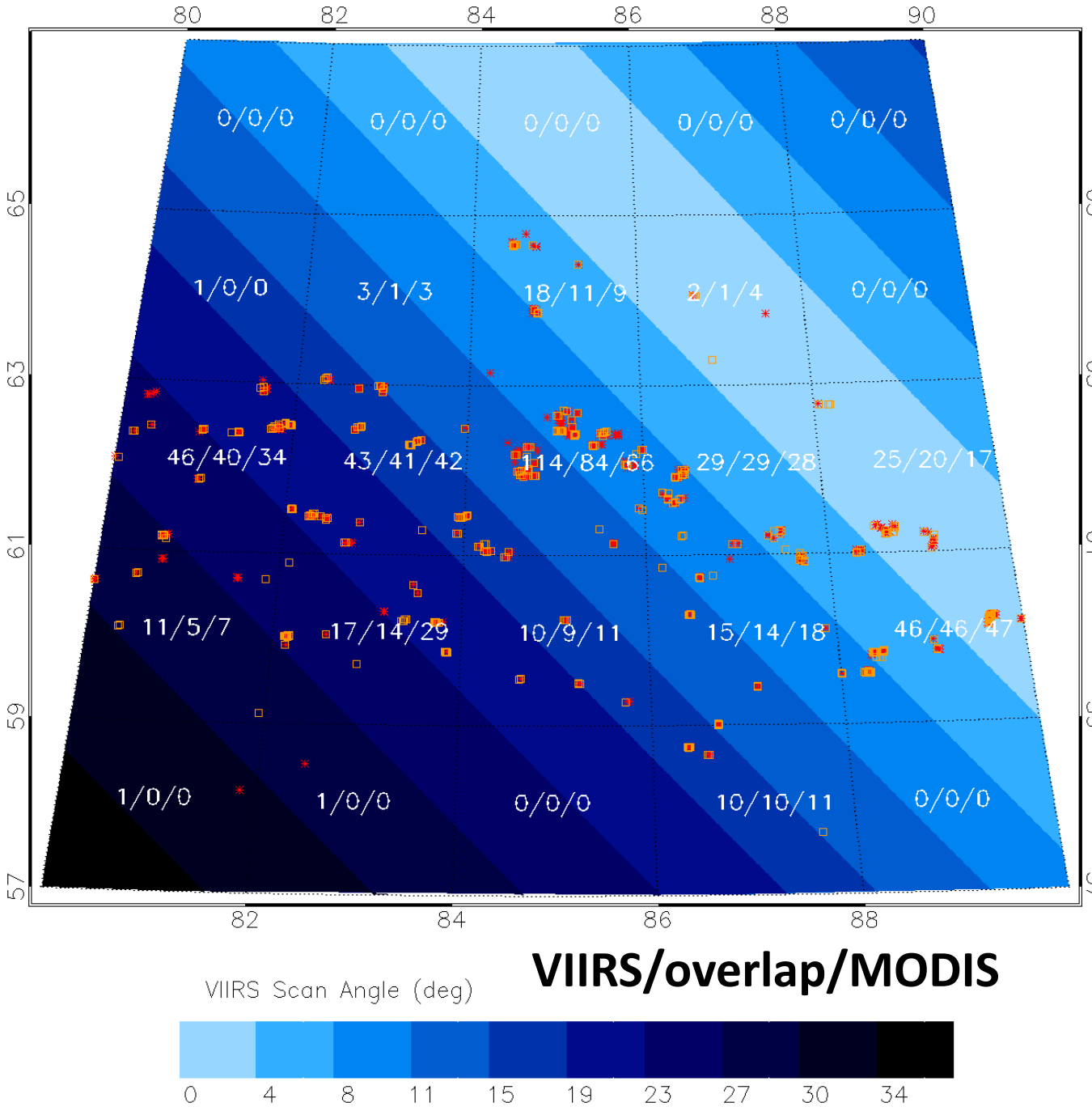
Aqua MODIS

Western Siberia

June 16 2012

6:42 UTC

Band 1-4-3 RGB
+
MYD14



VIIRS/overlap/MODIS

VIIRS Scan Angle (deg)

0 4 8 11 15 19 23 27 30 34

VIIRS

vs.

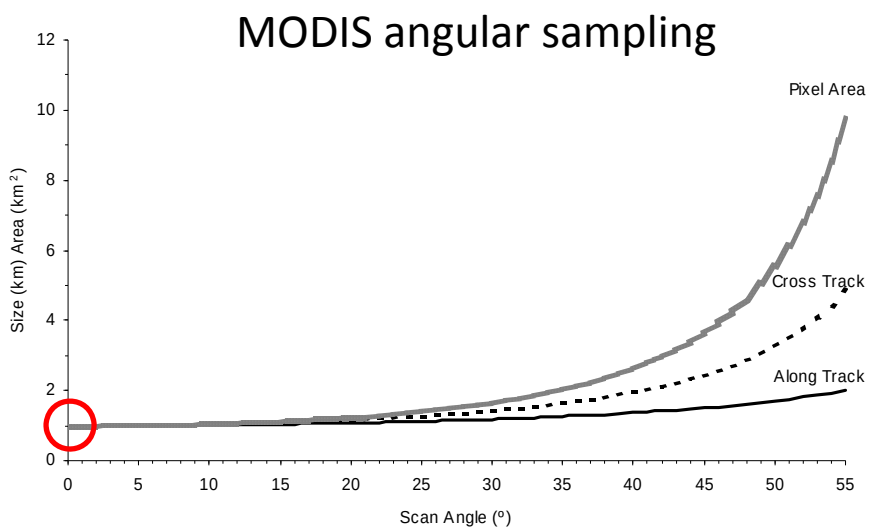
MODIS

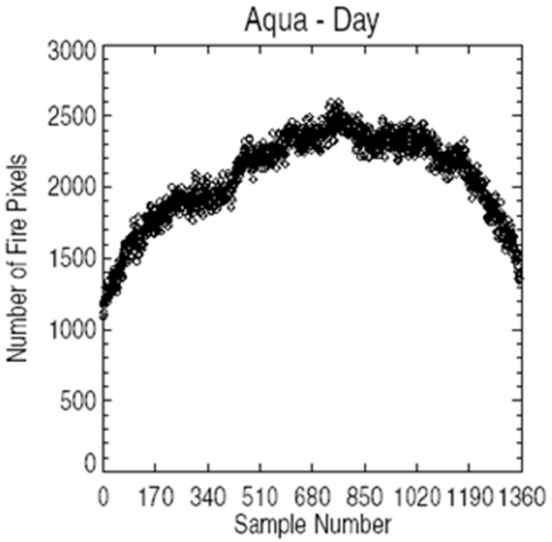
Western Siberia

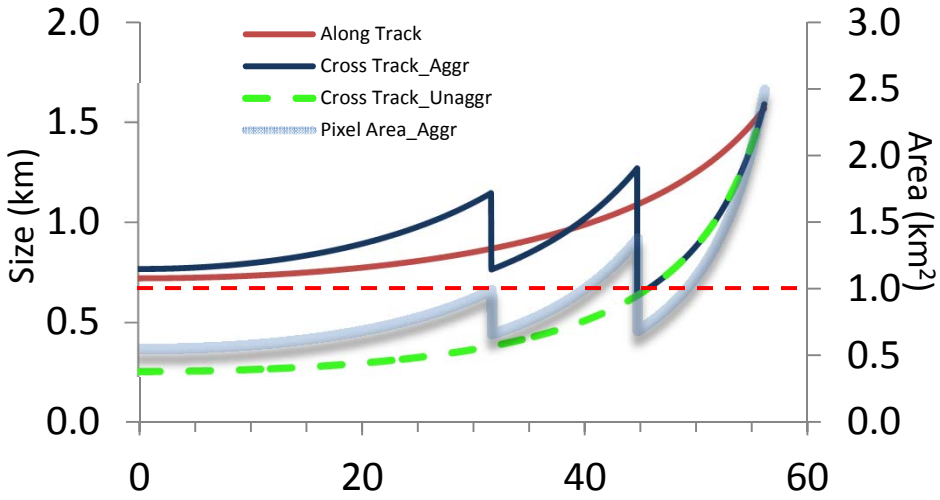
April 13 2012

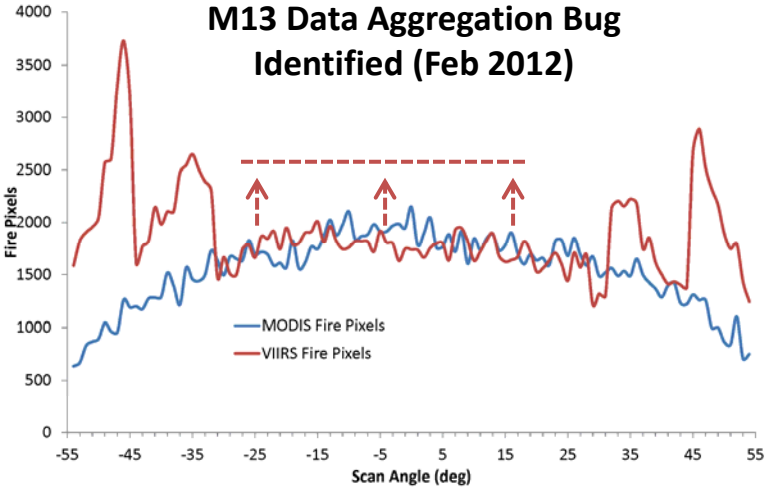
Gridded statistics: AA/BB/CC
AA – number of VIIRS fire pixels (red symbols)
BB – number of VIIRS fire pixels with overlapping Aqua/MODIS fire pixels
CC – number of Aqua/MODIS fire pixels (orange symbols)

Aqua MODIS vs. Suomi NPP VIIRS





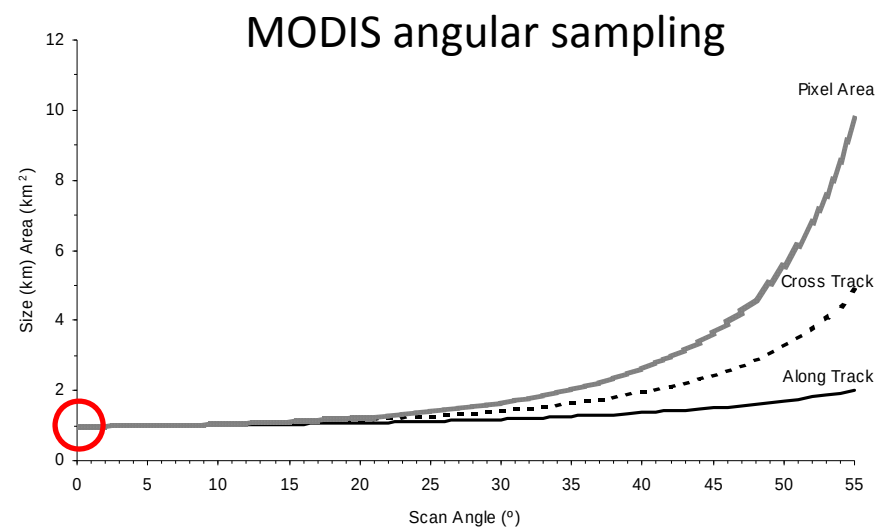


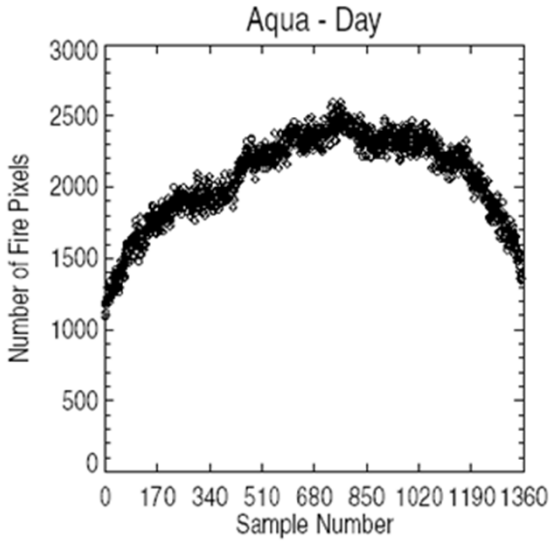


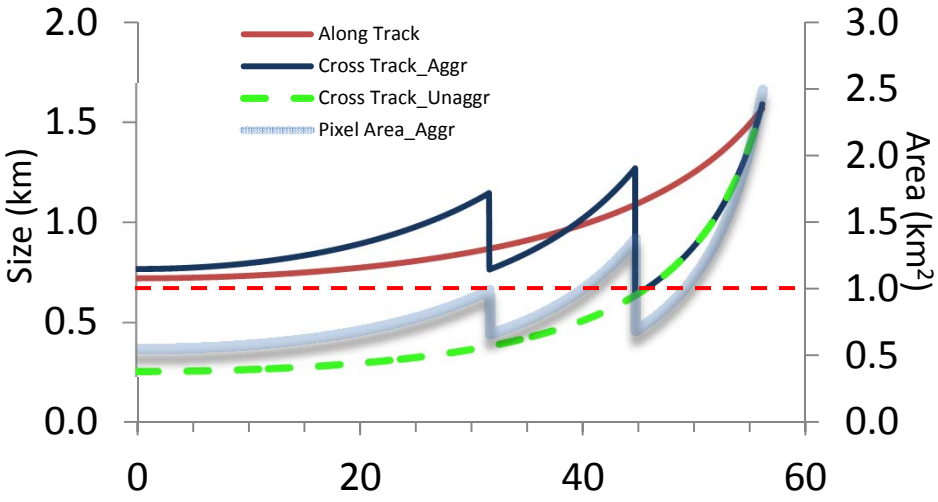
Compatible orbital segments are determined by pixel sizes

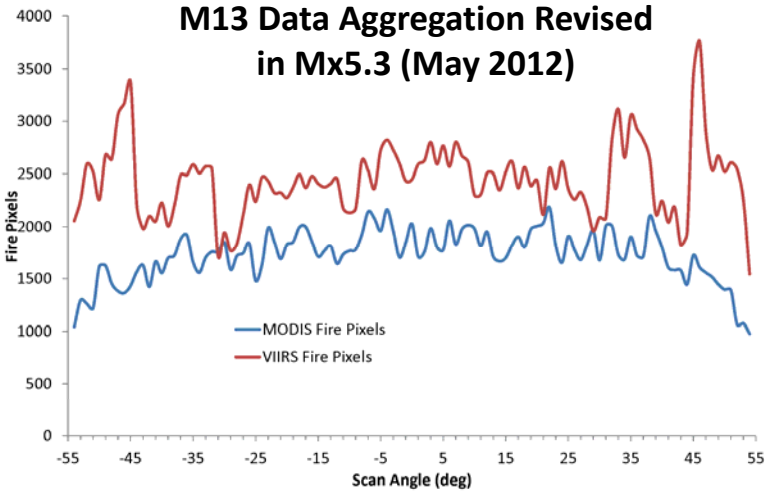
VIIRSxMYD14 Fire Detection Frequency (**19 Jan <> 13 Feb**)

Aqua MODIS vs. Suomi NPP VIIRS





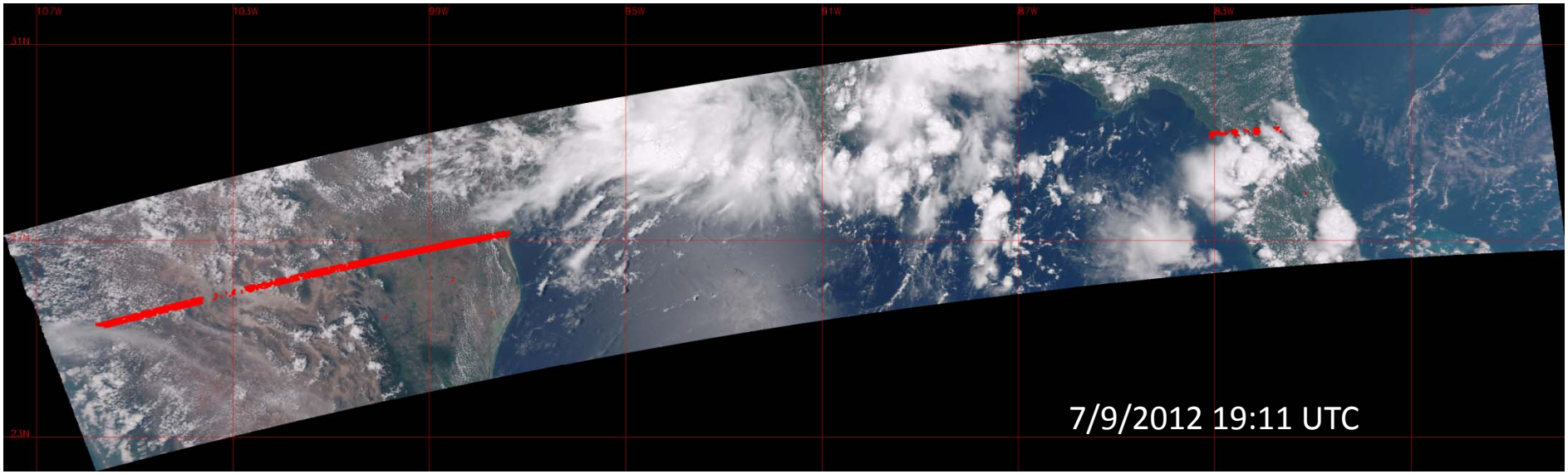


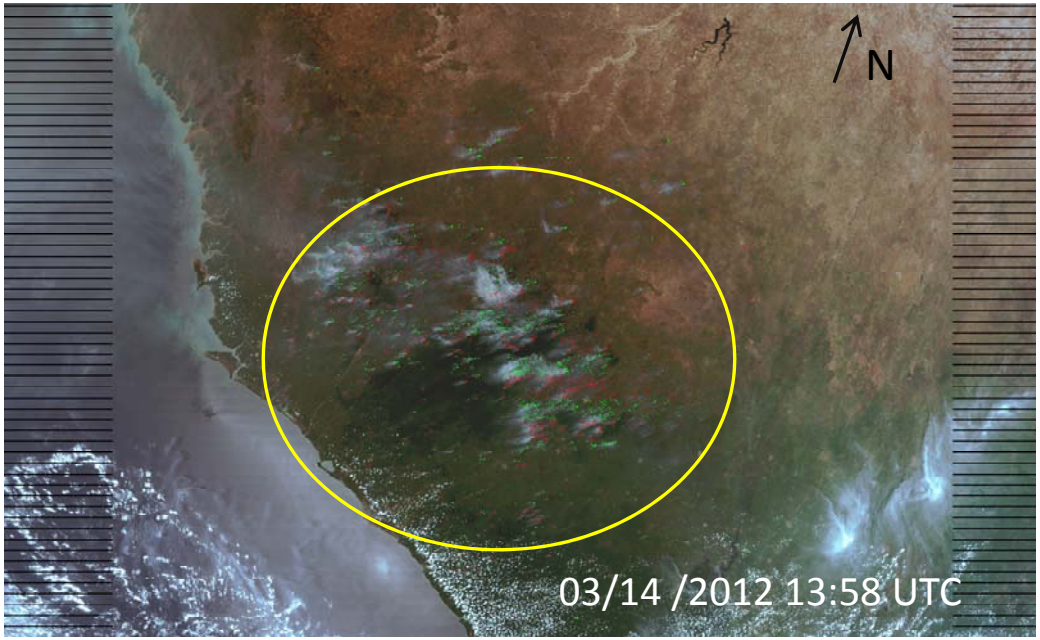


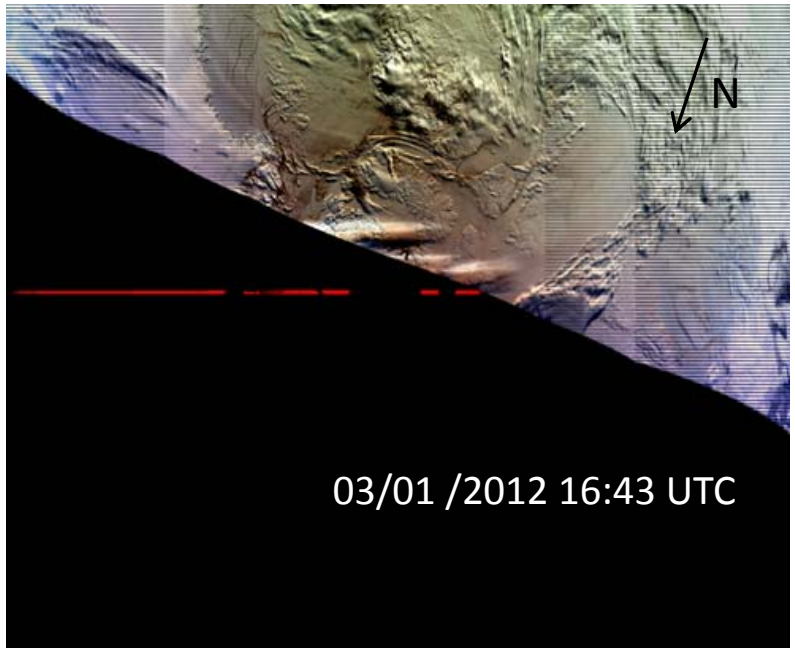
Compatible orbital segments are determined by pixel sizes

VIIRSxMYD14 Fire Detection Frequency (**11 May <> 10 Jun**)

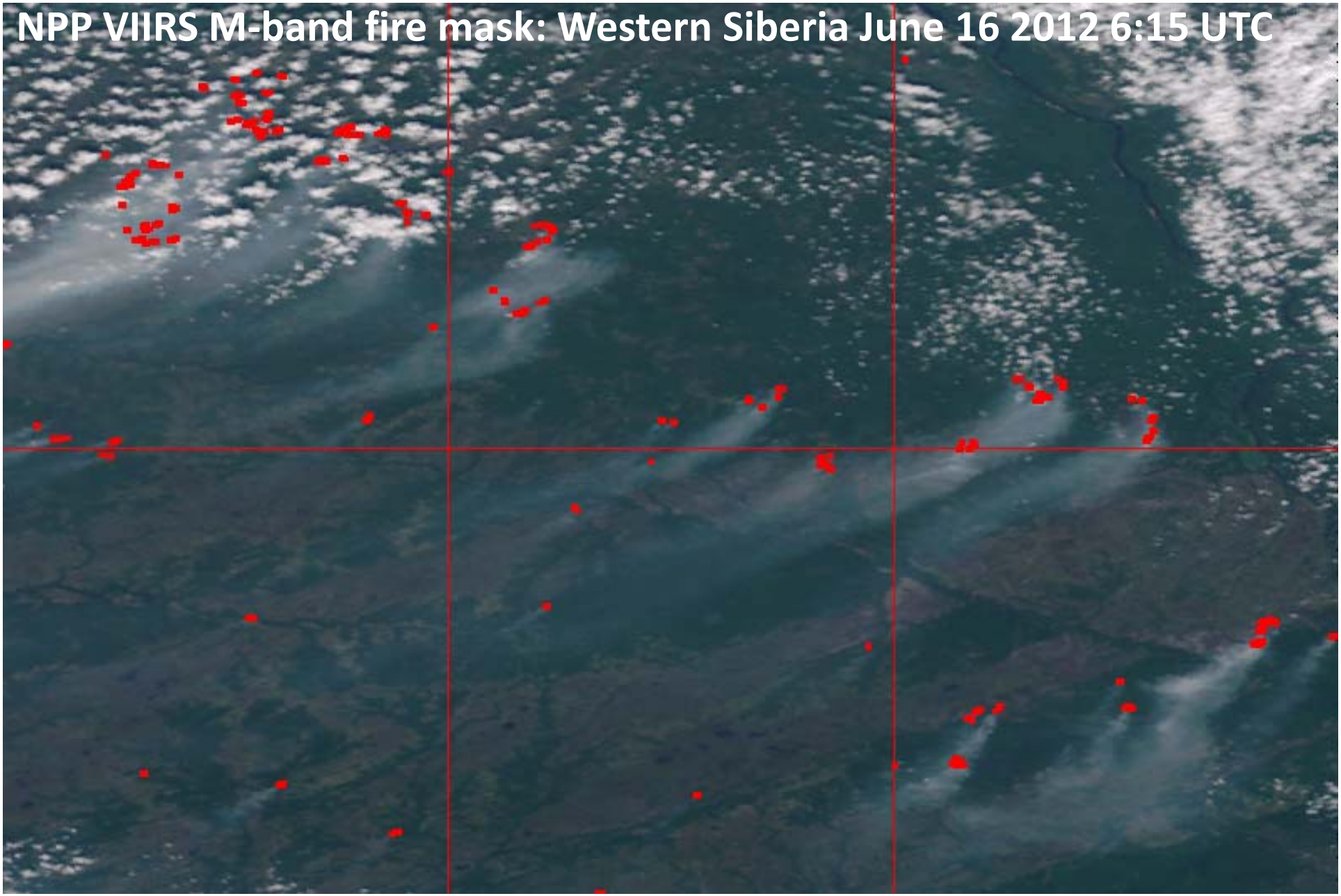
Spurious fire detections



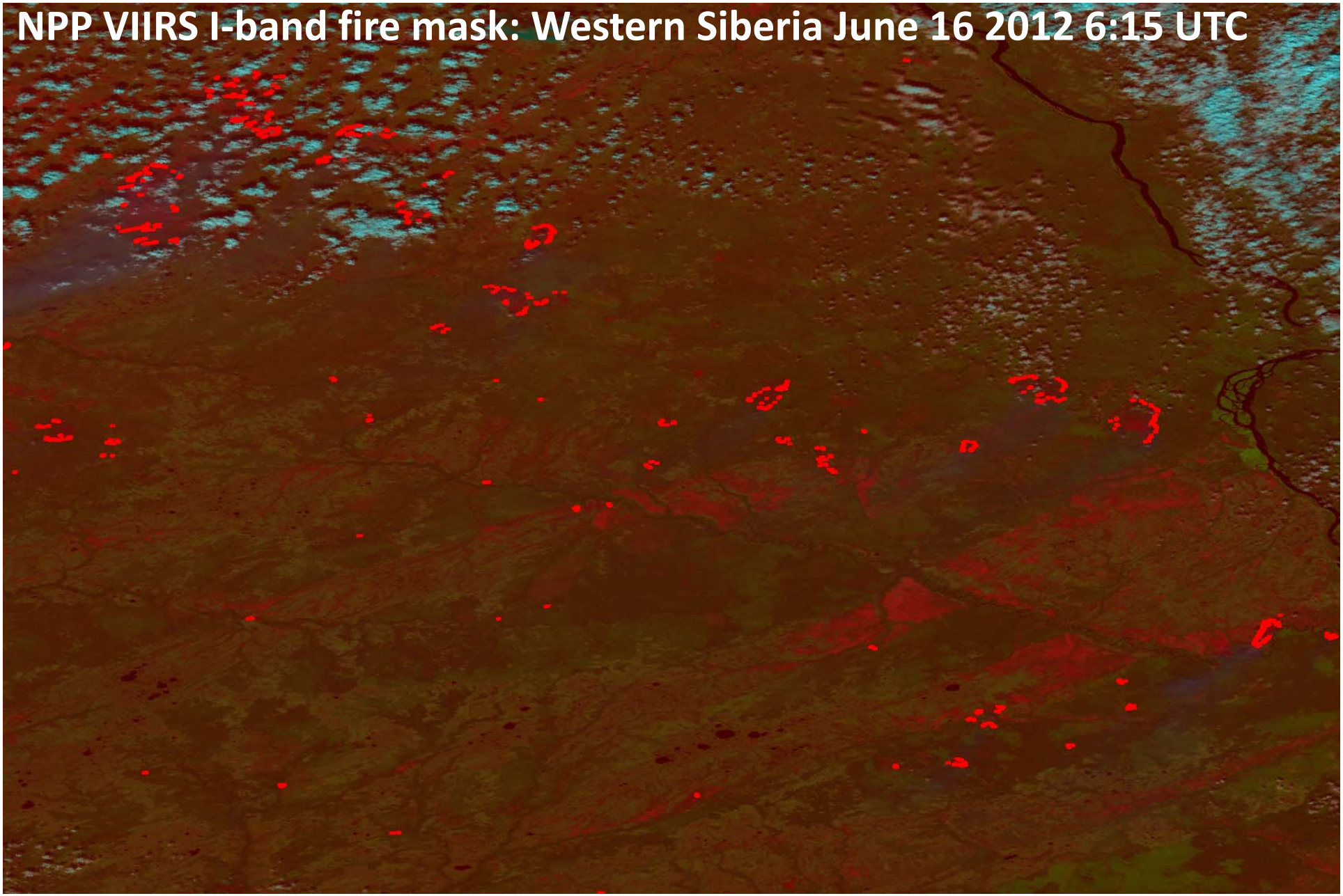




One step further: use of VIIRS “I” bands



One step further: use of VIIRS “I” bands



Fire characterization from S-NPP VIIRS

- **M13 saturation temperature: 634K**
  - very small percentage of fires to trigger saturation
  - Fire Radiative Power retrieval is possible
- **M15 saturation temperature: 363K**
  - small, but non-negligible percentage of fires triggers saturation of native resolution pixels
  - more complex characterization (i.e. smoldering ratio) be compromised
- **Fire Radiative Power to be included in VIIRS active fire product**
  - now a requirement for J1 and beyond

VIIRS active fire product development

NOAA: "real-time NOAA operational applications"

- Operational product generated by IDPS (Interface Data Processing Segment)
- Part of integrated processing chain
- Low latency
- Detections only
- Locations only (no fire mask)

VIIRS Fire Team

Algorithm updates

Upstream processing updates

NASA: "science, long-term continuity + added value NRT"

- Experimental MODIS continuity product a at the Land PEATE (Product Evaluation and Test Element)
- Detections, Fire Mask and Fire Radiative Power, CMG
- Spatially explicit fire mask
- Spatial and temporal aggregates – heritage deliver systems (RR, FIRMS)

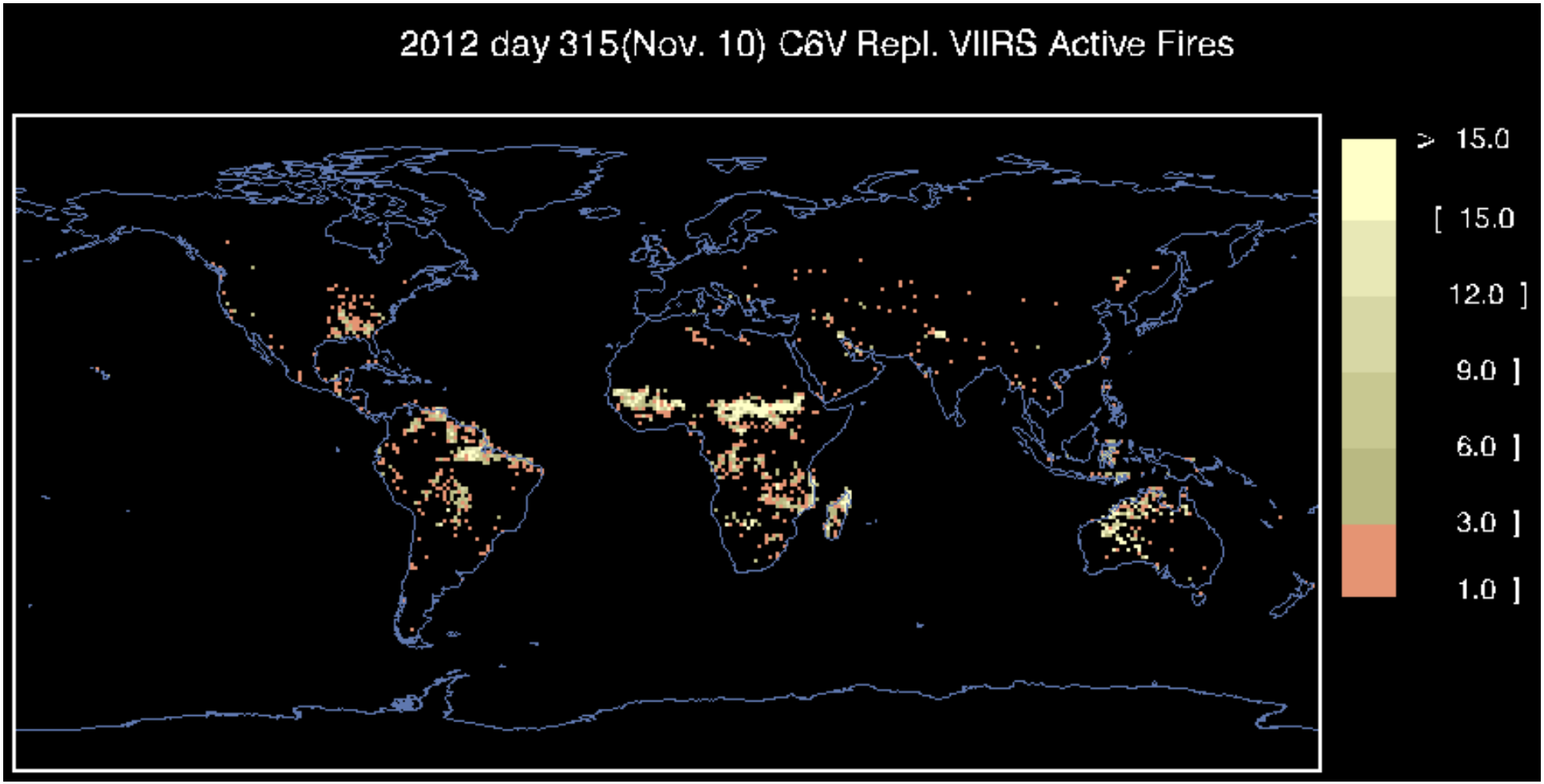
algorithm synchronization, end user feedback

DIRECT READOUT

- **Can run IDPS, NASA or locally developed code**
- **Stand-alone**

Replacement algorithm (MODIS C6)

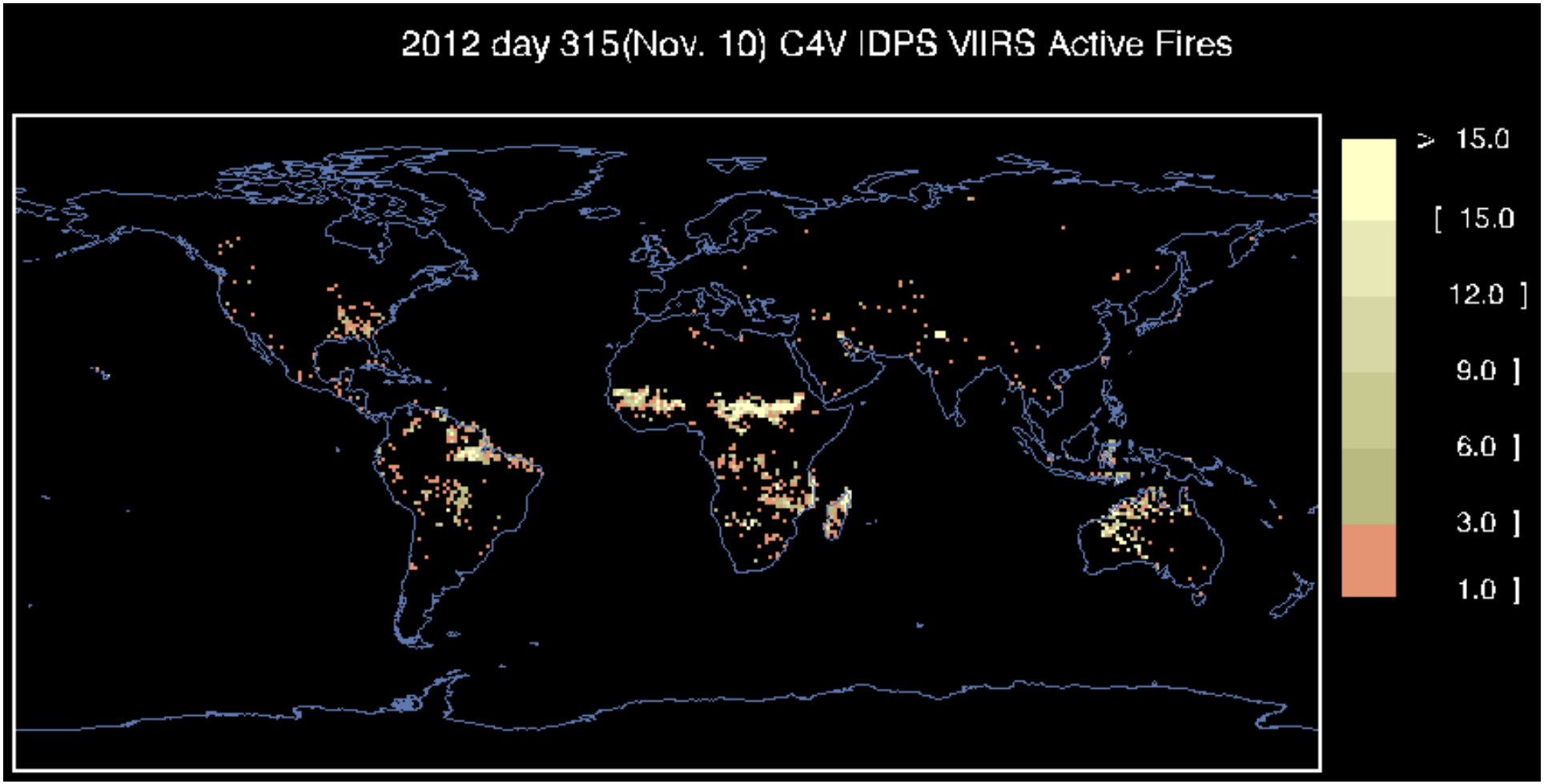
MODIS V6 code running on VIIRS data at LCF and in LandPEATE



- ***Spatially explicit fire mask and FRP - > new JPSS L1 Requirements Supplement***
- ***Additional data layers for CMG***
- ***Ocean processing for gas flares, a new false-alarm rejection test over tropical regions, and dynamic potential fire thresholds***

IDPS algorithm (MODIS C4)

MODIS Version 4 algorithm running on VIIRS data

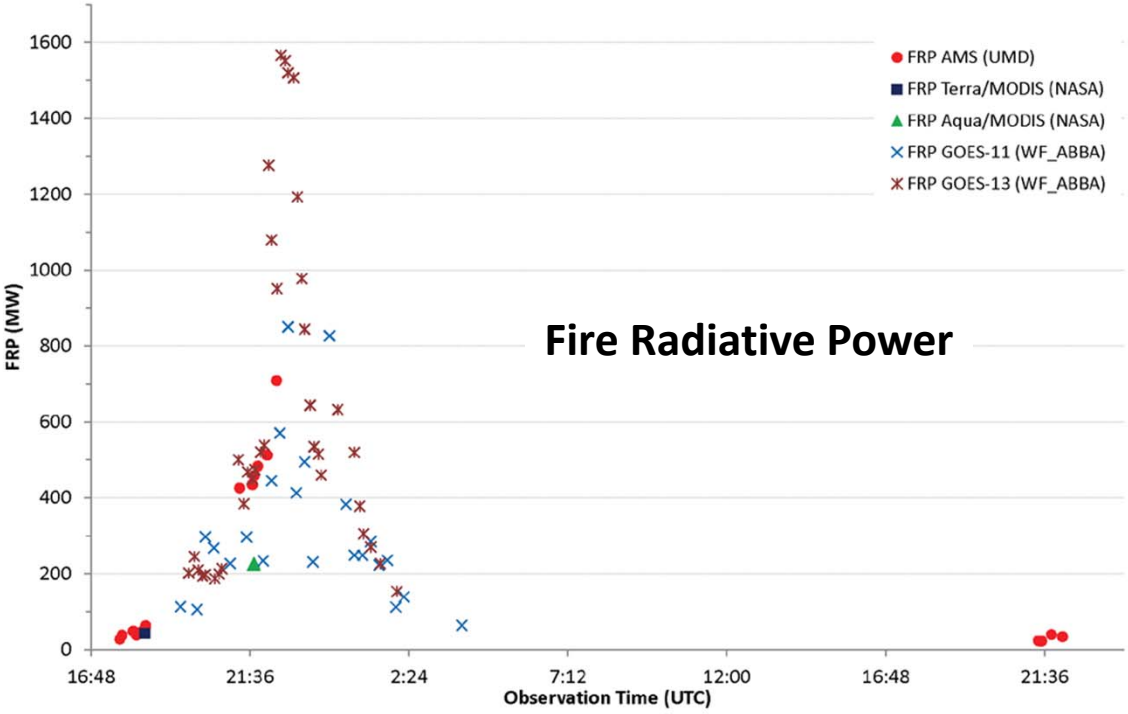


- ***Sparse array of fire pixels – no spatially explicit fire mask***
- ***No FRP***
- ***Land-only processing***

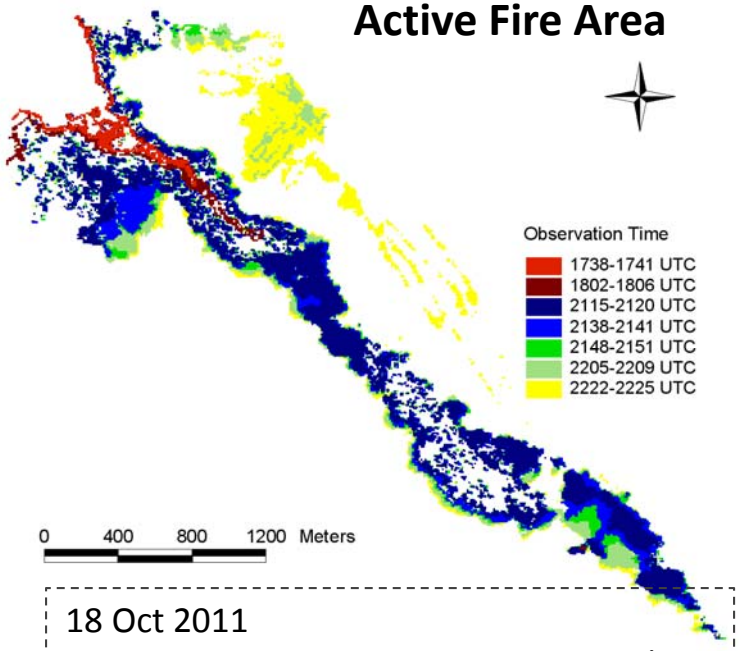
Validation: remote sensing data

Airborne

•USDA Forest Service, NASA



Fire Radiative Power



Active Fire Area

18 Oct 2011
450 ha Rx fire at Henry Coe State Park/CA

Aerial coverage provided by NASA/Ames AMS airborne sensor @10 m resolution

Coincident acquisition from MODIS (Terra and Aqua) and GOES East/West

Spaceborne

•DLR: Technology Experimental Probe (TET-1) and Berlin Infrared Optical System (BIROS)

•Use I-band to validate M-band

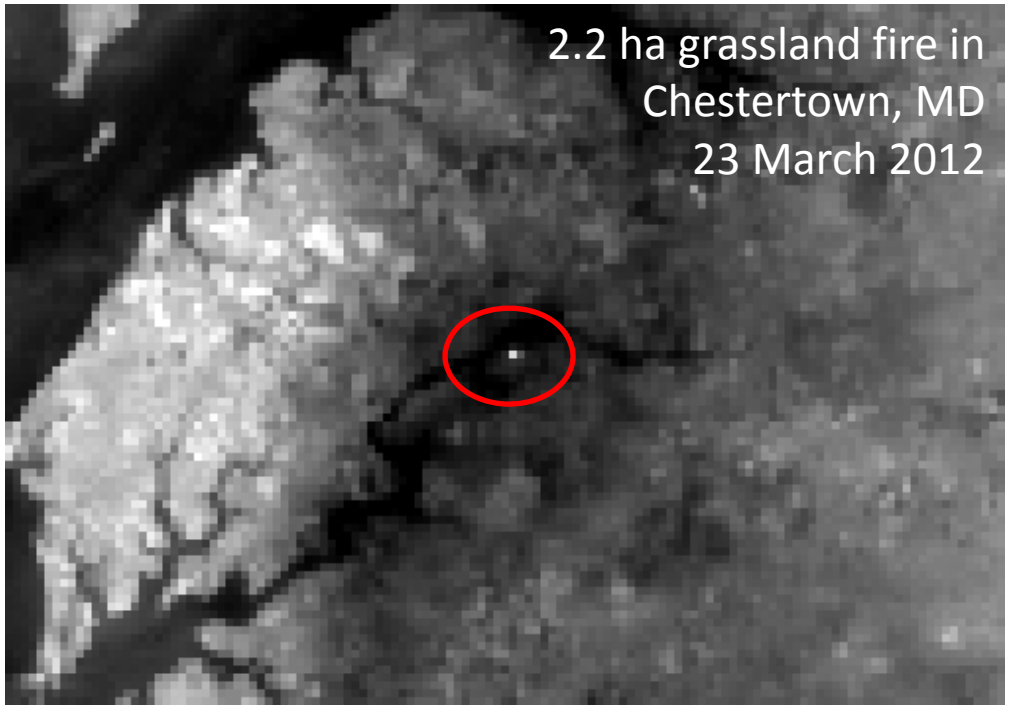
Validation: in-situ data

Ground Verification – qualitative assessment

Use of coincident prescribed burns to verify active fire detection data using both I and M bands

Engaging:

- Individuals (private land owners)
- State agencies (fire/forestry departments)
- Federal agencies (USDA Forest Service)
- International community



Validation Activities: in-situ data

Ground Verification – qualitative assessment

Use of coincident prescribed burns to verify active fire detection data using both I and M bands

Fire information provided by USDA personnel

- Date and location of burn
- Area burned
- Fuel load & fuel consumption

National Forests in Alabama

2012 Rx Fire Smoke Monitoring

Notification to NOAA NESDIS Satellite Analysis Branch

The following information should be forwarded to the NOAA NESDIS team on each burn the morning of the burn:

Date of Burn: 3/27/2012

Name of Burn: Rattlesnake

Coordinates: 33°30'59" Lat -85°43'07" Lon (decimal degrees)

Burn Acres: 500

Hours of Active Burning: Start Time - 1000 (CST)

End Time: 1800 (CST)

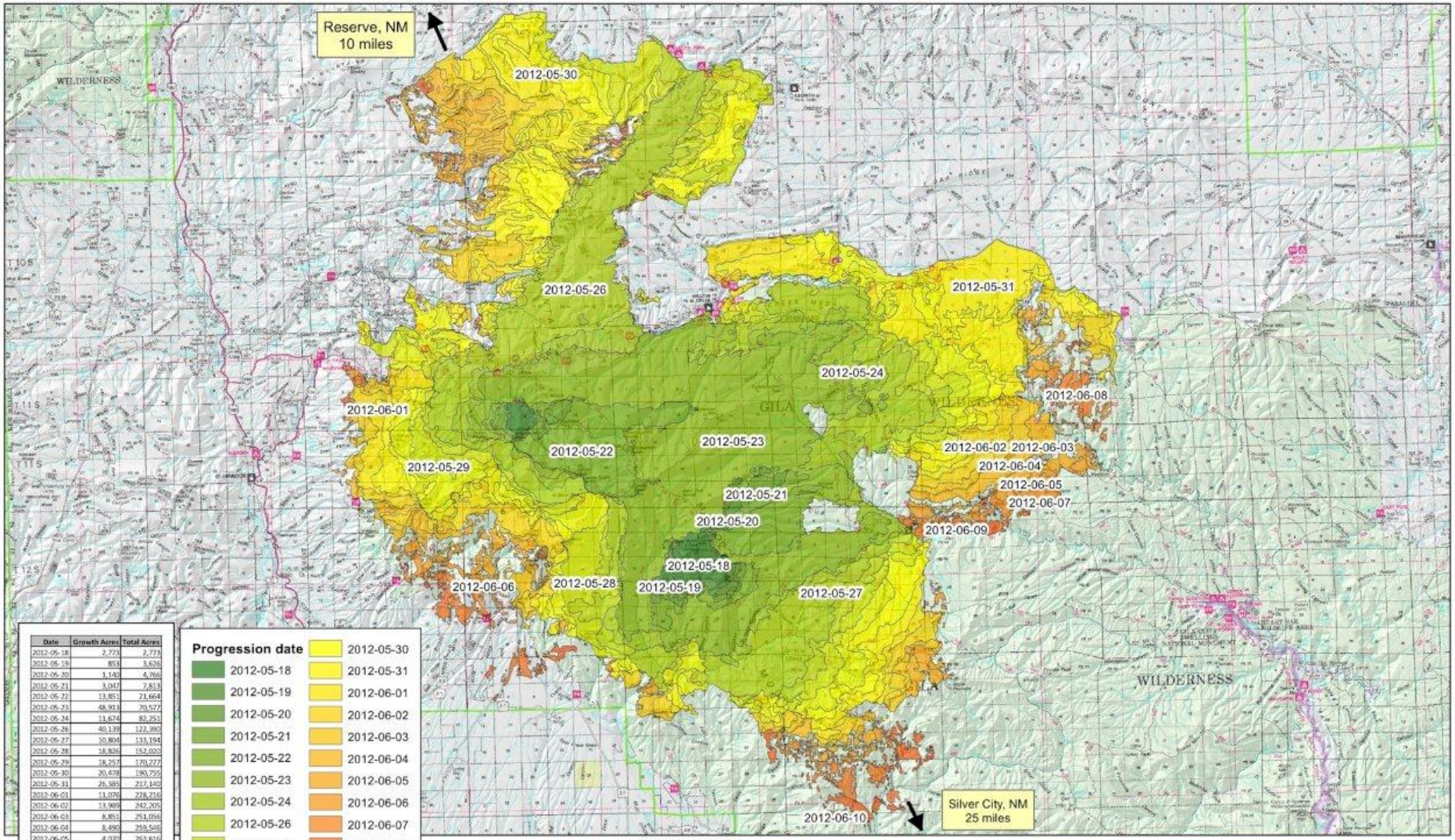
Fuel Loading: 7.0 (tons per acre)

Estimated Fuel Consumption: 5.0 (tons per acre)

VIIRS Active Fire Product Website

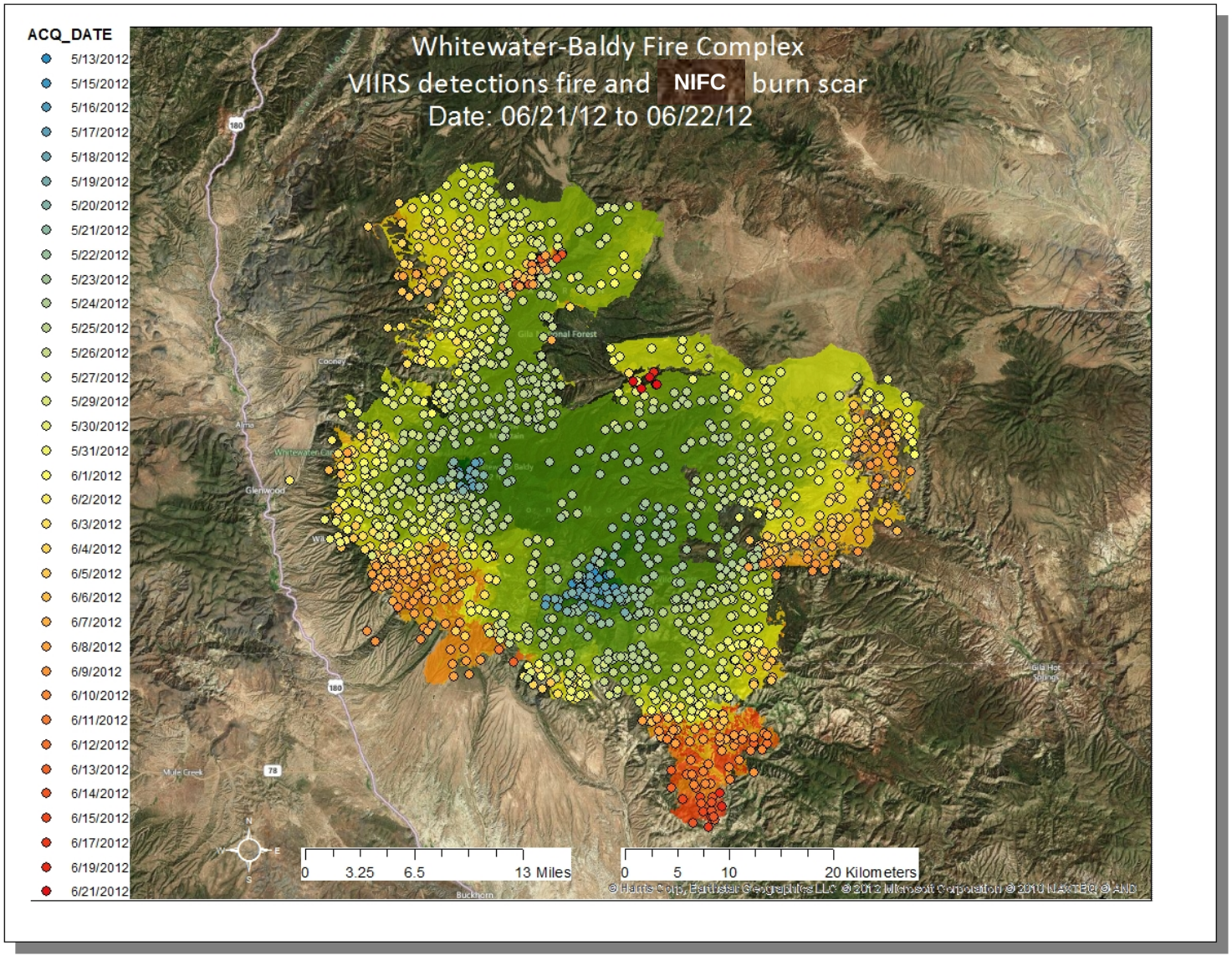
viirsfire.geog.umd.edu

Whitewater-Baldy Fire Progression



Date	Growth Acres	Total Acres
2012-05-18	2,773	2,773
2012-05-19	853	3,626
2012-05-20	3,140	6,766
2012-05-21	3,047	7,813
2012-05-22	13,851	21,664
2012-05-23	48,913	70,577
2012-05-24	11,674	82,251
2012-05-26	40,139	122,390
2012-05-27	10,804	133,194
2012-05-28	18,826	152,020
2012-05-29	18,257	170,277
2012-05-30	20,478	190,755
2012-05-31	26,385	217,140
2012-06-01	11,076	228,216
2012-06-02	13,989	242,205
2012-06-03	8,851	251,056
2012-06-04	8,490	259,546
2012-06-05	4,070	263,616
2012-06-06	3,892	267,508
2012-06-07	3,270	270,778
2012-06-08	4,105	274,883
2012-06-09	3,201	278,084
2012-06-10	683	278,767

courtesy Rob Balfour

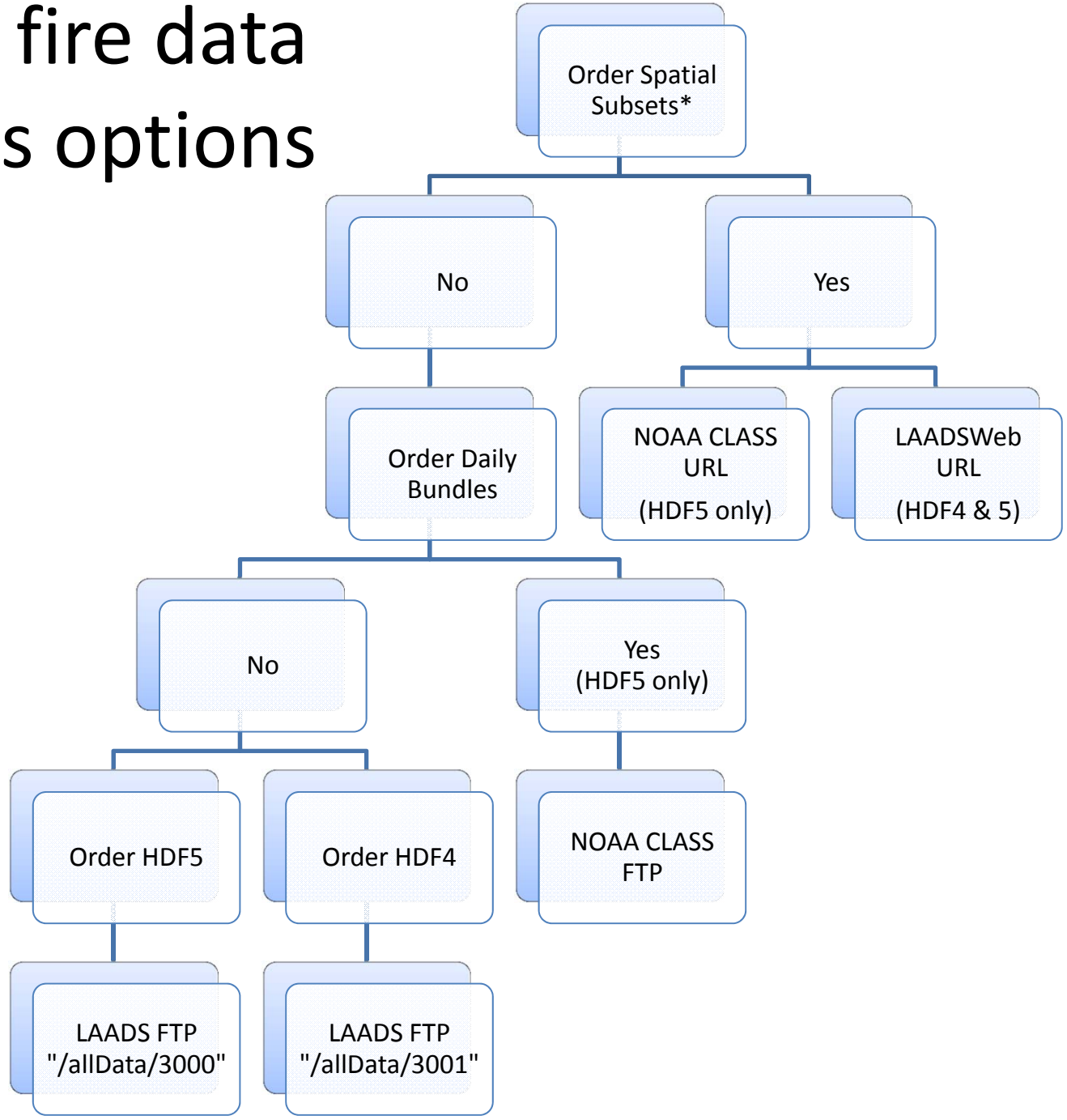

ACQ_DATE
5/13/2012
5/15/2012
5/16/2012
5/17/2012
5/18/2012
5/19/2012
5/20/2012
5/21/2012
5/22/2012
5/23/2012
5/24/2012
5/25/2012
5/26/2012
5/27/2012
5/29/2012
5/30/2012
5/31/2012
6/1/2012
6/2/2012
6/3/2012
6/4/2012
6/5/2012
6/6/2012
6/7/2012
6/8/2012
6/9/2012
6/10/2012
6/11/2012
6/12/2012
6/13/2012
6/14/2012
6/15/2012
6/17/2012
6/19/2012
6/21/2012
Whitewater-Baldy Fire Complex
VIIRS detections fire and NIFC burn scar
Date: 06/21/12 to 06/22/12
Cooney
Alma
Glenwood
Mule Creek
Buckhorn
180
78
0 3.25 6.5 13 Miles
0 5 10 20 Kilometers

VIIRS fire data access

- Options:
  - NOAA CLASS Web
    - www.class.noaa.gov
  - NASA LAADSWeb
    - ladsweb.nascom.nasa.gov/data/search.html
  - NOAA CLASS ftp (anonymous)
    - ftp-npp.class.ngcd.noaa.gov
  - NASA LAADS ftp (anonymous)
    - ladsweb.nascom.nasa.gov
- Detailed instructions:

  viirsfire.geog.umd.edu/Documents/VIIRS_data_tutorial.pdf

VIIRS fire data access options



NPP EDR Product Maturity Levels	
1. Beta • Early release product • Minimally validated • May still contain significant errors. • Versioning not established until a baseline is determined. • Available to allow users to gain familiarity with data formats and parameters • Product is not appropriate as the basis for quantitative scientific publications studies and applications	
2. Provisional • Product quality may not be optimal • Incremental product improvements are still occurring. • Version control is in affect • General research community is encouraged to participate in the QA and validation of the product, but need to be aware that product validation and QA are ongoing • Users are urged to consult the EDR product status document prior to use of the data in publications • May be replaced in the archive when the validated product becomes available • Ready for operational evaluation	
3. Validated • Product performance is well defined over a range of representative conditions • Ready for use by the Centrals and in scientific publications • There may be later improved versions • There are three validation stages (see next column)	**Stage 1 Validation:** Product performance has been demonstrated to comply with the specification using a small number of independent measurements obtained from selected locations, periods, and associated ground-truth/field program efforts.
	Stage 2 Validation: Product performance has been demonstrated to comply with the specification over a widely distributed set of locations and periods via several ground-truth and validation efforts.
	Stage 3 Validation: Product performance has been demonstrated to comply with the specification and the uncertainties in the product well established via independent measurements in a systematic and statistically robust way representing global conditions.

SNPP EDR PRODUCT MATURITY DEFINITIONS

CLASS WILL START DISTRIBUTION OF PRODUCTS WHEN THEY REACH "BETA" MATURITY LEVEL

http://www.jpss.noaa.gov/science-maturity-level.html

JPSS program

NOAA SUOMI NPP DATA ACCESS: CLASS

http://www.class.ncdc.noaa.gov

"NPP products will be released to the user community over a time frame of several months. As products become available please go to the Suomi NPP FAQ to determine which products can be ordered. All newly released products will be 'beta'. Please see Product Maturity Level page to determine level of quality for each product."

- ***Frequently asked questions (FAQ)***
- ***Product Maturity Levels***
- ***Tutorial on Data Access***

http://www.class.ngdc.noaa.gov/notification/pdfs/VIIRS_Active%20Fire%20ARP_Release_Readme_final.pdf

Online articles

- **First Fire Images from VIIRS (January 26, 2012)**

http://earthobservatory.nasa.gov/IOTD/view.php?id=77025

- **NASA/NOAA Satellite Sees Western U.S. High Mountain Blazes (July 13, 2012)**

http://www.nasa.gov/mission_pages/NPP/news/west-blazes.html

- **NASA Finalizes Contracts for NOAA's JPSS-1 Mission (August 10, 2012)**

http://www.nasa.gov/centers/goddard/news/releases/2012/12-066.html

- **Complex Interactions between Wildfires and Lightning during Summer 2012 (December 12, 2012 by Scott Rudloski)**

http://essic.umd.edu/joom2/index.php/outreach-main/its-severe-blog/1229-complex-interactions-between-wildfires-and-lightning-during-summer-2012

Challenges

- **Product Latency for some users**
  - Early fire detection is critical
  - CLASS latency is insufficient for NRT applications – default latency is 6 hours
  - DB processing is one possible solution at local scales
  - need also direct access to IDPS output for non-DB users and for development / demonstration purposes (2 hour latency)
- **Algorithm Improvements**
  - Algorithm validation and development are still ongoing
  - IDPS algorithm prior to Mx6.3 produced spurious scan-lines
- **Provision > Validation (L1, L2, L3)**
  - MODIS as references serves as initial evaluation source for consistency (i.e. expected relative performance due to sensor differences)
  - Collection of “truth” reference data is costly and logistically difficult
    - Airborne high resolution radiometers
    - In-situ data (mainly from field campaigns)
    - Reference satellite data (e.g. DLR German Space Agency TET / BIROS missions)
- **Science and applications**
  - Algorithm and product suitability, continuity, long-term monitoring, reprocessing

Summary and Conclusions

- **Early assessment** of the SNPP VIIRS fire product is **encouraging**
  - Suomi NPP fire product is currently in the Intensive Calibration and Validation phase
- Active Fires product has been declared **Beta maturity** and is publicly available
  - Ready for user evaluation
- User Readiness and Proving Ground activities are reaching out various **domestic and international end users - goal is the continuity and enhancement of the MODIS product suite – LANCE, RR, FIRMS**
- Implementation of **DB processing systems** is underway domestically and internationally
  - Continuing coordination regarding product evaluation and algorithm versioning is critical
- More work is needed to implement **new MODIS algorithm components** (C6) and **sensor-specific tuning** in the VIIRS product, product content and product suite
  - Use of **I band - DNB data** (detection, validation, fused products)
- **Validation** of global product remains crucial and will be challenging