STAR Algorithm and Data Products (ADP) Beta Review

Suomi NPP Active Fires ARP Product

Ivan Csiszar

Active Fires ARP Lead

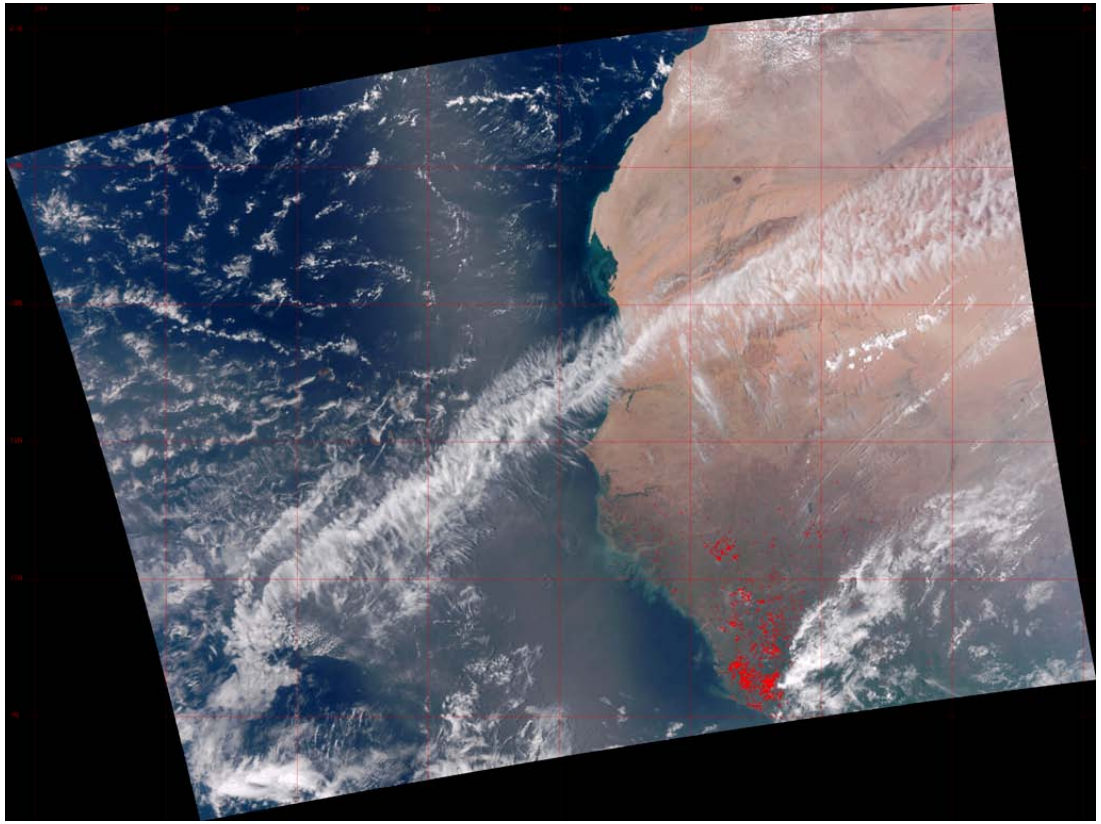
9/14/2012

STAR ADP Active Fires
ARP Team Member Goals

- Ivan Csiszar (NOAA/NESDIS/STAR)
  - STAR ARP lead, international outreach
- Wilfrid Schroeder (UMD/ESSIC)
  - product monitoring and validation; algorithm development
- Louis Giglio (UMD/Geography)
  - algorithm development
- Evan Ellicott (UMD/Geography)
  - user readiness
- Brad Wind (UMD/Geography)
  - ADL
- Chris Justice (UMD/Geography)
  - program coordination, user readiness, MODIS continuity

Background of Active Fires ARP Product

- 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
- Product is expected to be used by **real-time resource and disaster management; air quality monitoring; ecosystem monitoring; climate studies** etc.



Western Africa
03 April 2012
14:21:39-14:27:20 UTC

L1RD Requirements

Active Fires		
ATTRIBUTE	**THRESHOLD**	**OBJECTIVE**
a. Horizontal Cell Size		
1. Nadir	0.75 km	0.25 km
2. Worst case	1.6 km	
b. Horizontal Reporting Interval	HCS	
c. Horizontal Coverage	Land Regions	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	4.0 $(10)^2$ K to 1.2 $(10)^3$ K
3. Sub-pixel Area of Active Fire	N/A	From 100 m^2 to 50m times the Ground Sample Distance in Scan Direction
f. Measurement Uncertainty		
1. Fire Radiative Rower (FRP)	50%	20%
2. Sub-pixel Average Temperature of Active Fire	N/A	25K
3. Sub-pixel Area of Active Fire	N/A	30%
g. Refresh	At least 90% coverage of the globe every 12 hours (monthly average)	N/A
h. Latency	See L1S00015	15 min

Current IDP product was designed to meet heritage NPOESS requirements. Beta evaluation is done against those heritage requirements. Spatially explicit fire mask and fire characterization are additional requirements in the JPSS L1RD.

Major Users of Active Fire Products (Point Of Contact)

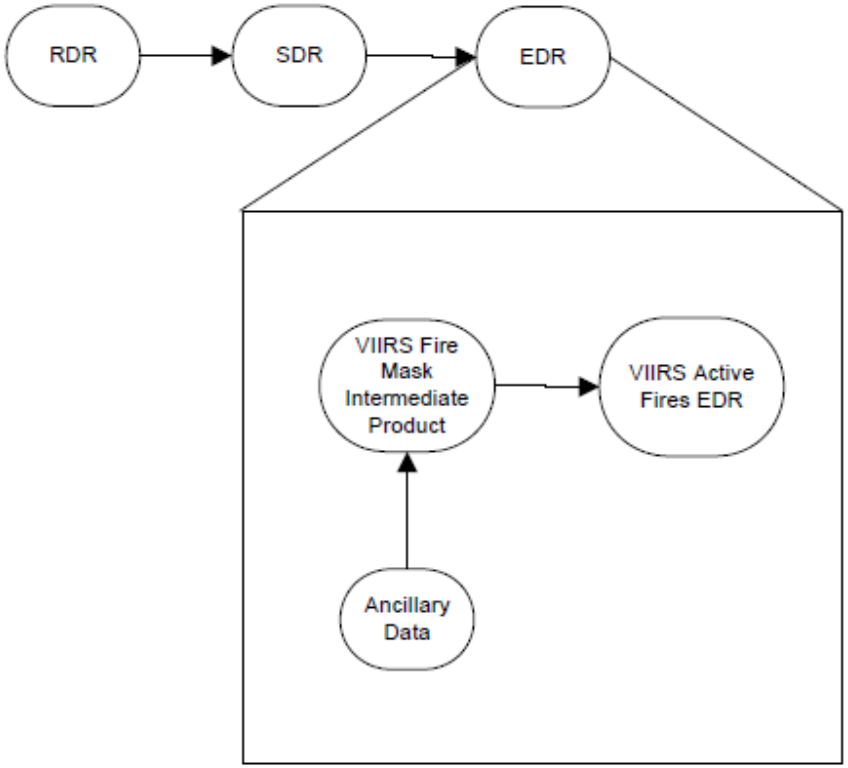
- **U. S. Users:**
  - US Forest Service (Brad Quayle)
  - STAR – Center for Satellite Applications and Research (Shobha Kondragunta)
  - NOAA National Weather Service (Peter Roohr, Larry Van Bussum)
  - NASA Ames (Amber Soja)
  - NRL (Edward Hyer)

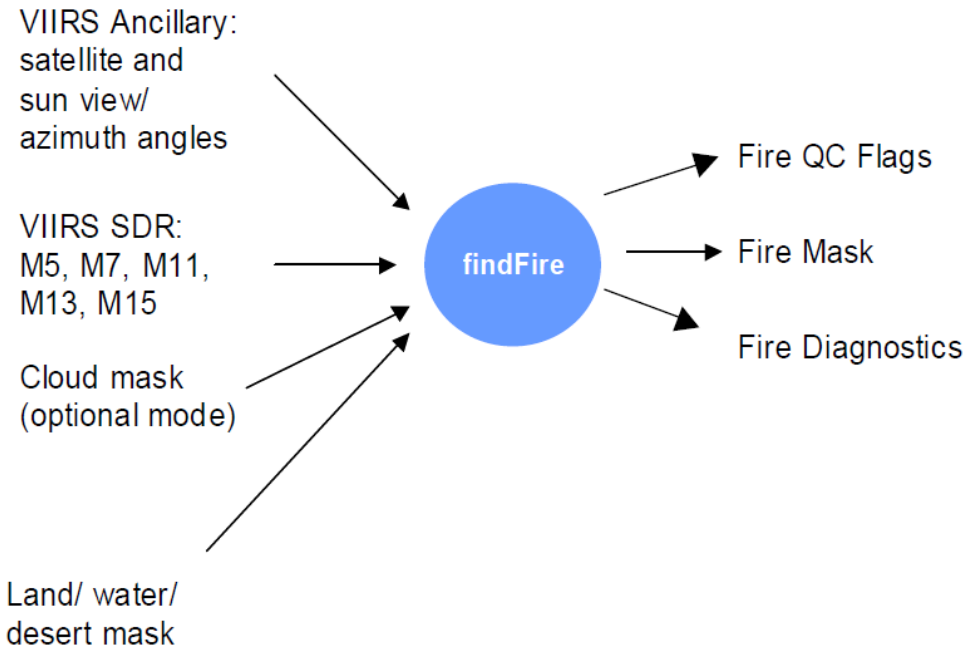
- **Foreign Users (coordinated by GOFC-GOLD – Global Observation of Forest and Landcover Dynamics):**
  - CONABIO, Mexico (Isabel Cruz)
  - INPE/CPTEC, Brazil (Alberto Setzer)
  - INTA, Argentina (Carlos di Bella, Nicolas Mari)
  - University of Alcala, Spain (Emilio Chuvieco)
  - Space Research Institute, Moscow, Russia (Evgeny Lyupian)
  - National University of Mongolia (Renchin Tsolmon)
  - King's College, London, UK (Martin Wooster)

Overview of Active Fires ARP

- Geolocation of pixels for which fires are detected (no spatially explicit fire/clear land/cloud/water mask)
  - The algorithm is a hybrid **thresholding and contextual** algorithm
  - Uses radiometric signals from M13 and M15, and tests spatial heterogeneity to identify candidate pixels.
  - Uses additional bands and a suite of tests for **internal cloud mask** and the rejection of **false alarms**.
  - Current IDPS product is based on the **MODIS Collection 4** algorithm
- Assumption for ARP validation is that the **VIIRS SDR is calibrated**.
  - Pre-beta and beta versions of SDR have been used to help **algorithm and instrument assessments** during EOC and the early stages of ICV
  - Team provided **feedback to SDR team** that helped identify SDR issues
    - Lower than expected VIIRS detection rates – traced back **to incorrect M13 aggregation**; fixed in Mx 5.3
    - Spurious detections along scanlines 1-2 times a day – partly traced back to **VIIRS Dual Gain Switching Sequence Anomaly**; to be fixed in Mx 6.3

Active Fire ARP Dataflow





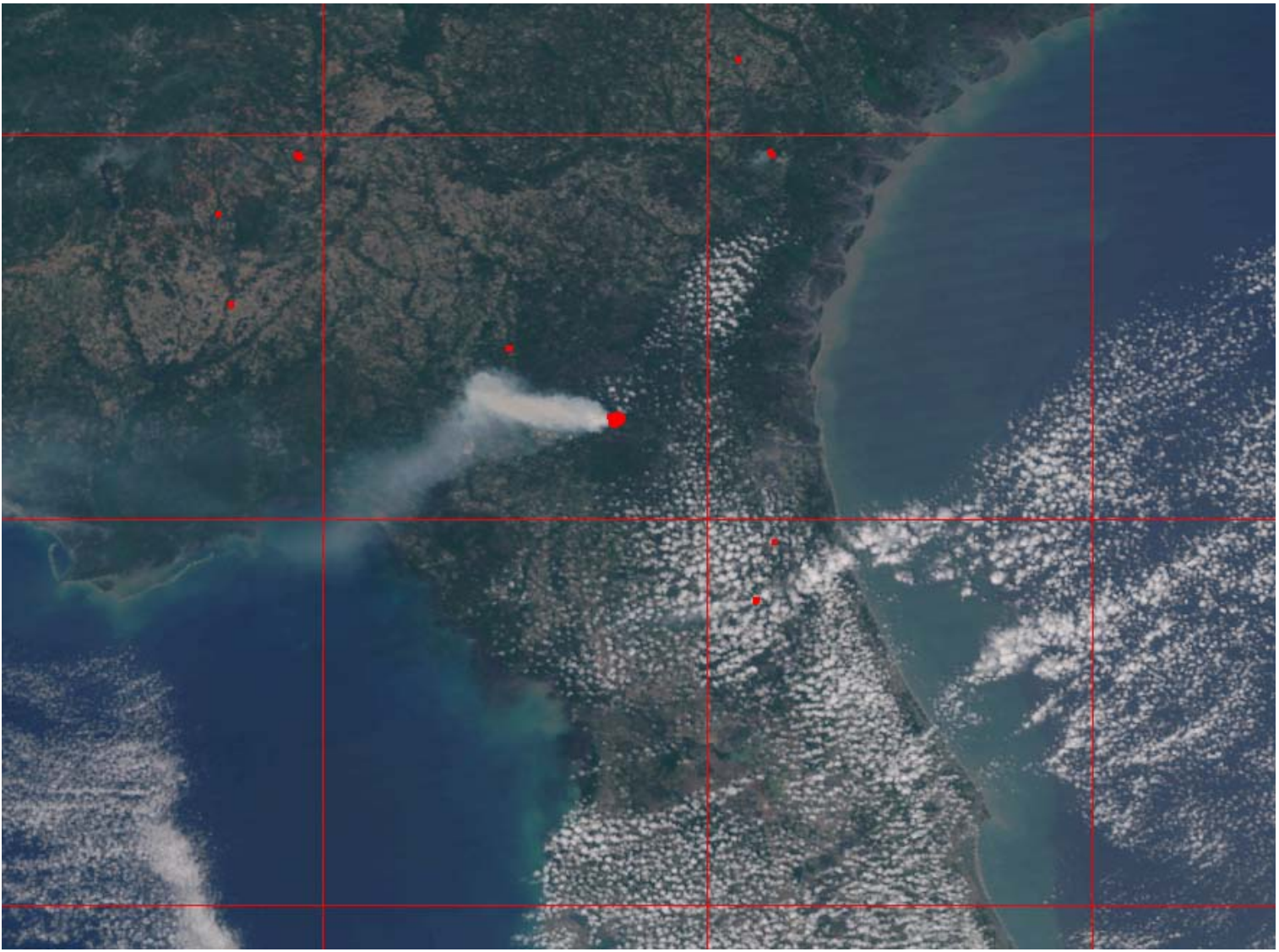
OAD VIIRS Active Fires 474-00064 January 18, 2012; Figure 1 (Processing Chain Associated with VIIRS Active Fires ARP)

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

History of Algorithm changes/updates

Date	Update/DR#	Reason	Status
2-2-2012	DR 4547	Spurious Fire Pixels	3-8-2012; worked through VIIRS SDR DR 4620
3-6-2012	DR 4620	Dual Gain Calibration OBC States Mismatch	POC Assigned and CCR in Work; Priority fix for block 1.5
1-31-2012	DR 4543	M13 Low Gain SDR Calibration Mismatch with High Gain SV	Implemented in Mx5.3
2-9-2012	DR 4568	M13 LG Calibration Coefficients Incorrect	Closed; implementation included in DR 4591
2-19-2012	DR 4591	Update delta C LUT and G coefficients	Implemented 2/29/12
2-7-2012	DR 4563	VIIRS M13 SDR Aggregation in Temperature Domain	Implemented in Mx5.3

Suomi NPP Active Fire Detections



SE US

M5-M4-M3 RGB
+
IDPS Active Fire ARP

VIIRS 04 April
2012
18:43UTC

Error Budget

- **No sufficient reference data are available** to determine commission and omission errors

- Current quantitative evaluation is based on **correlative analysis with Aqua MODIS**

- **MODIS performance is well characterized** using moderate resolution (Landsat-class) reference data

Aqua MODIS vs. Suomi NPP VIIRS

- Aqua and NPP have **similar overpass times (1:30pm)**
  - sampling of the diurnal fire cycle is similar
- Saturation levels of the primary bands allow **unsaturated radiance measurements** for most fires
  - Bands 21/22 for MODIS and M13 for VIIRS
- Some differences in **spectral placement**
- Processing **algorithms are compatible**
  - Current VIIRS algorithm is based on MODIS, albeit an earlier version
  - Differences can be resolved and the impact can be minimized
- **Primary driver** of differences is **spatial sampling**
  - Pixel size
  - Variations along scanline (aggregation schemes)
  - Variations within pixels (line-spread function, aggregation)
  - Differences in swath width (VIIRS has no gaps at low latitudes)

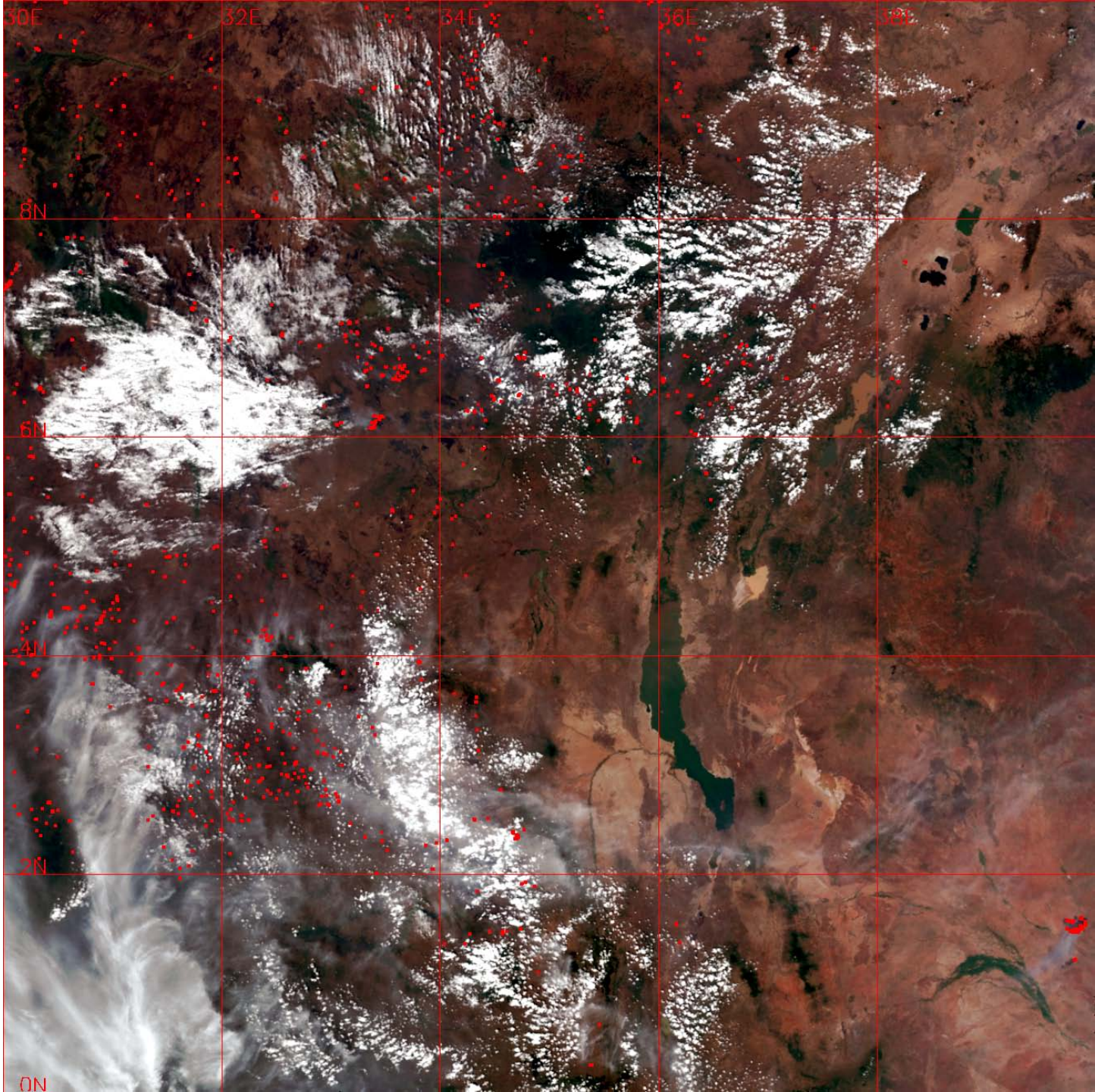
Suomi NPP Active Fire Detections

- The following slides will provide examples of product performance over **four distinct ecosystems**:
  - Central Africa: tropical agricultural maintenance fires
    - first light imagery **before the M13 aggregation fix**
  - SE Australia: bushfires
  - Central Asia: mid-latitude grassland and agricultural fires
  - Siberia: boreal forest
    - these three examples are from data acquired **after the M13 aggregation fix**
- **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

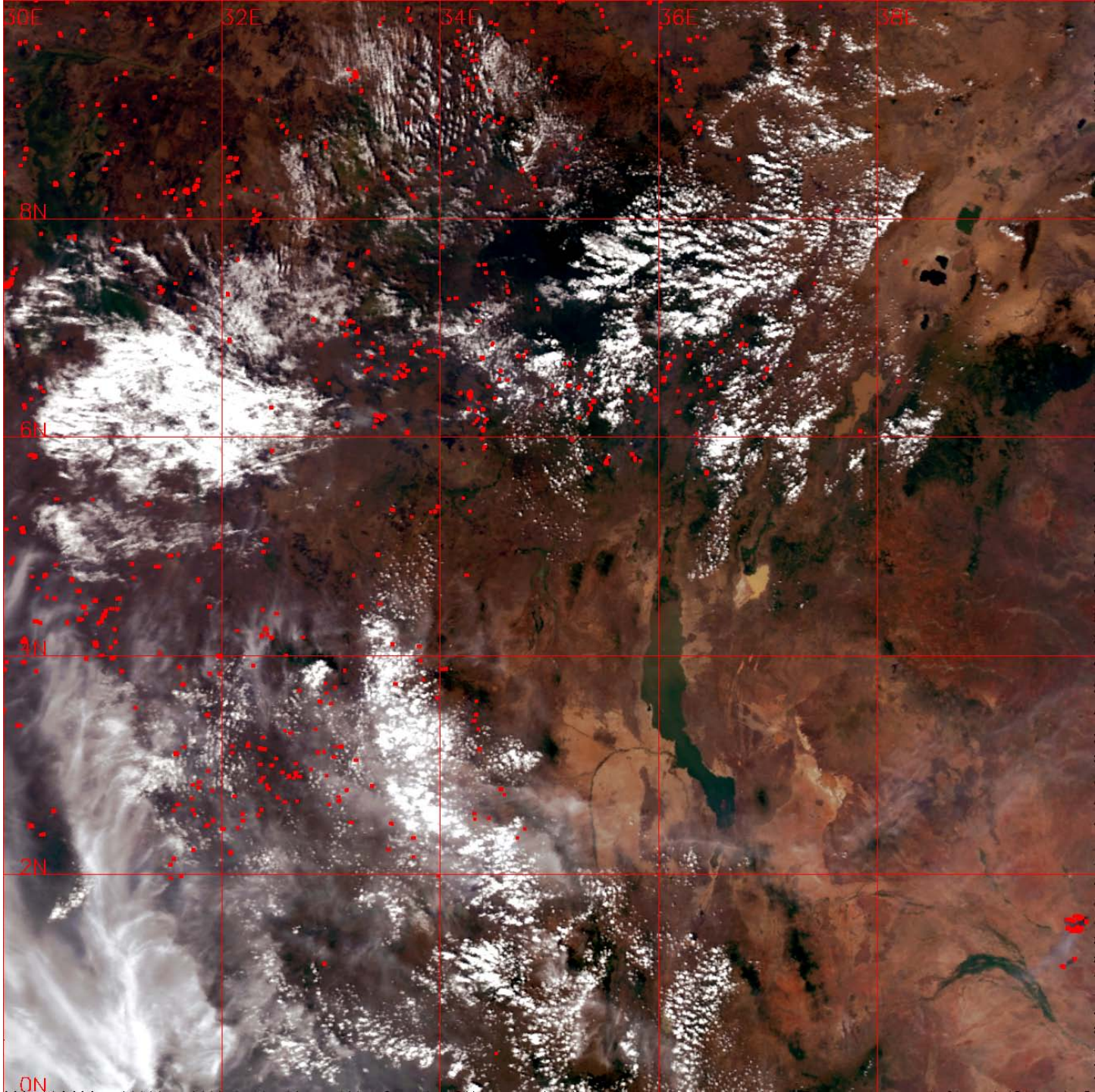


January 19, 2012
~11:05 UTC

…followed by Aqua MODIS five minutes later

Band 1-4-3 RGB
+
MYD14

January 19, 2012
~11:05 UTC

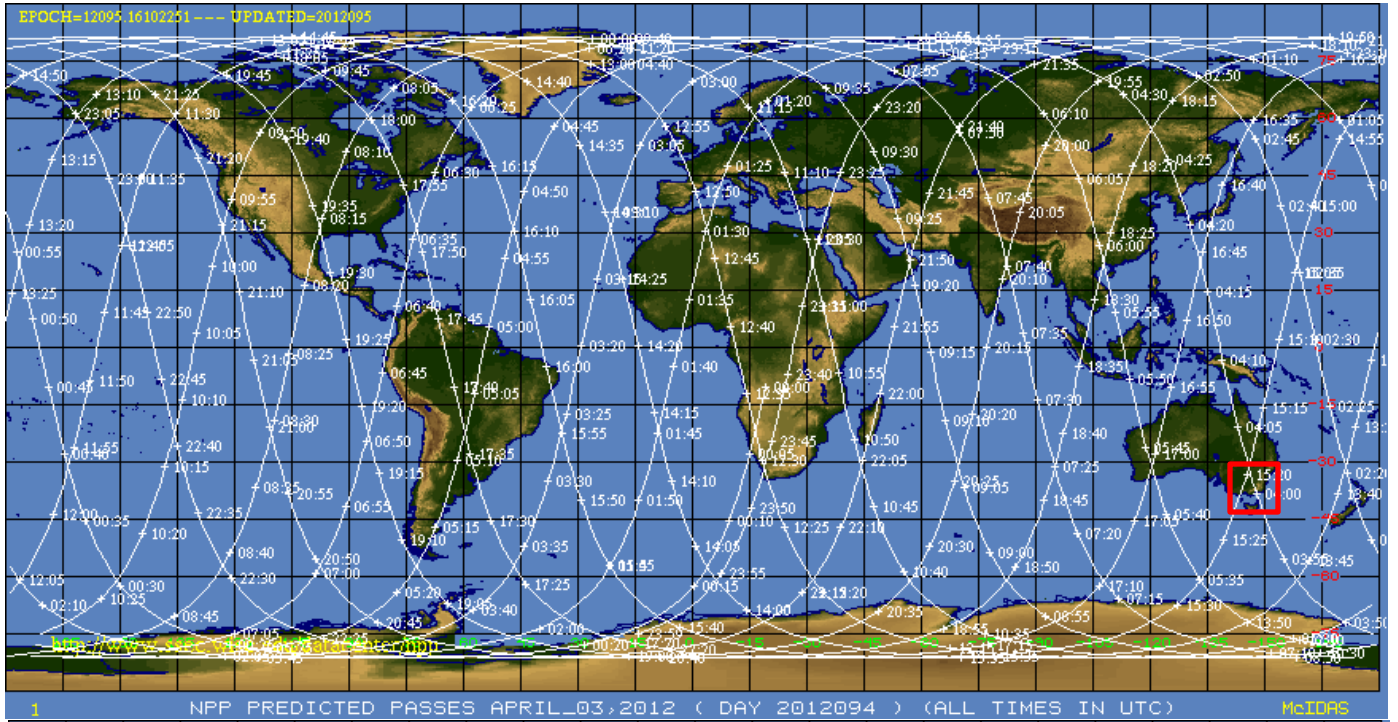


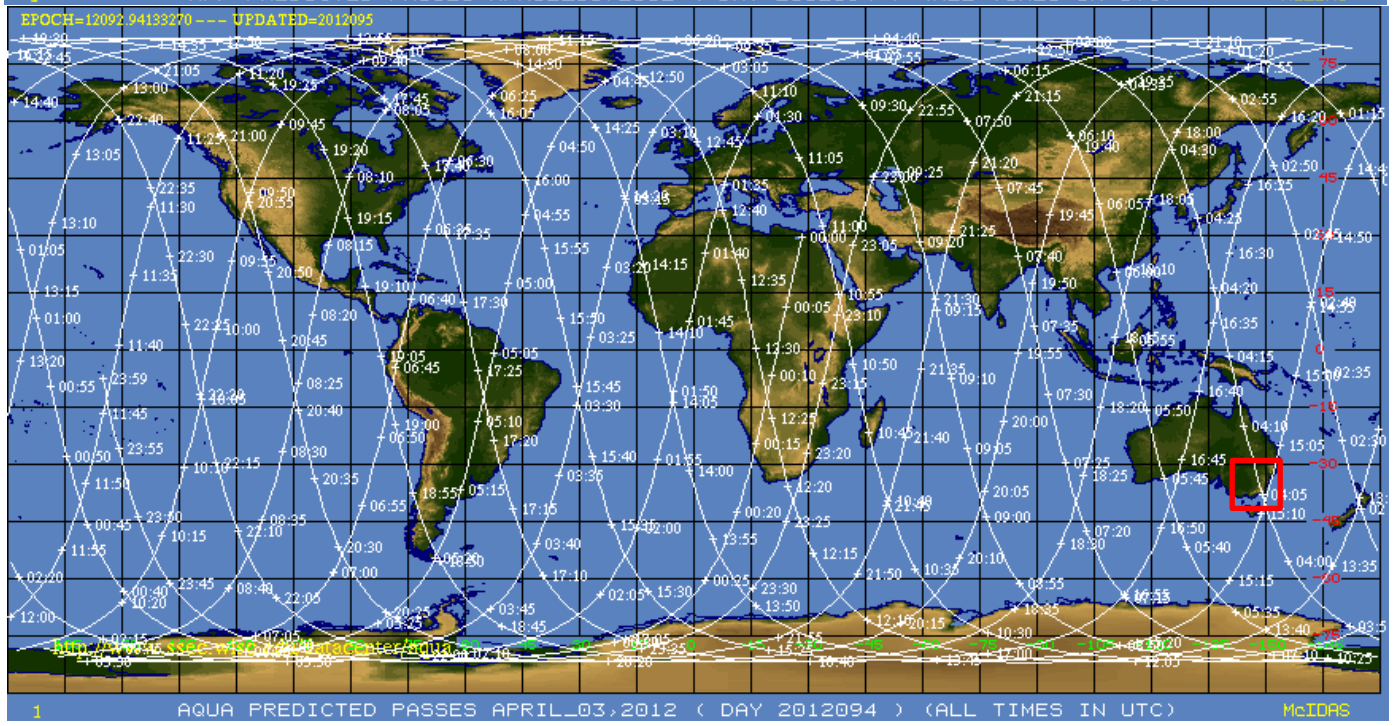
NPP

Satellite orbit tracks

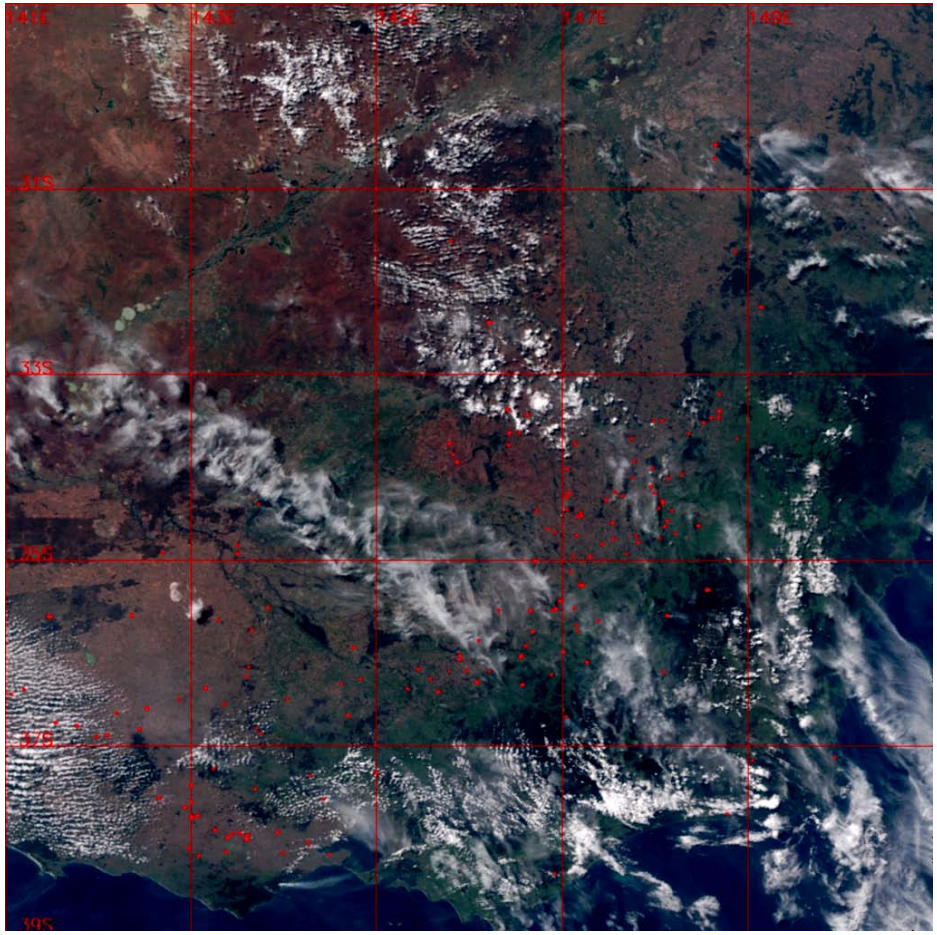
April 3, 2012

Aqua

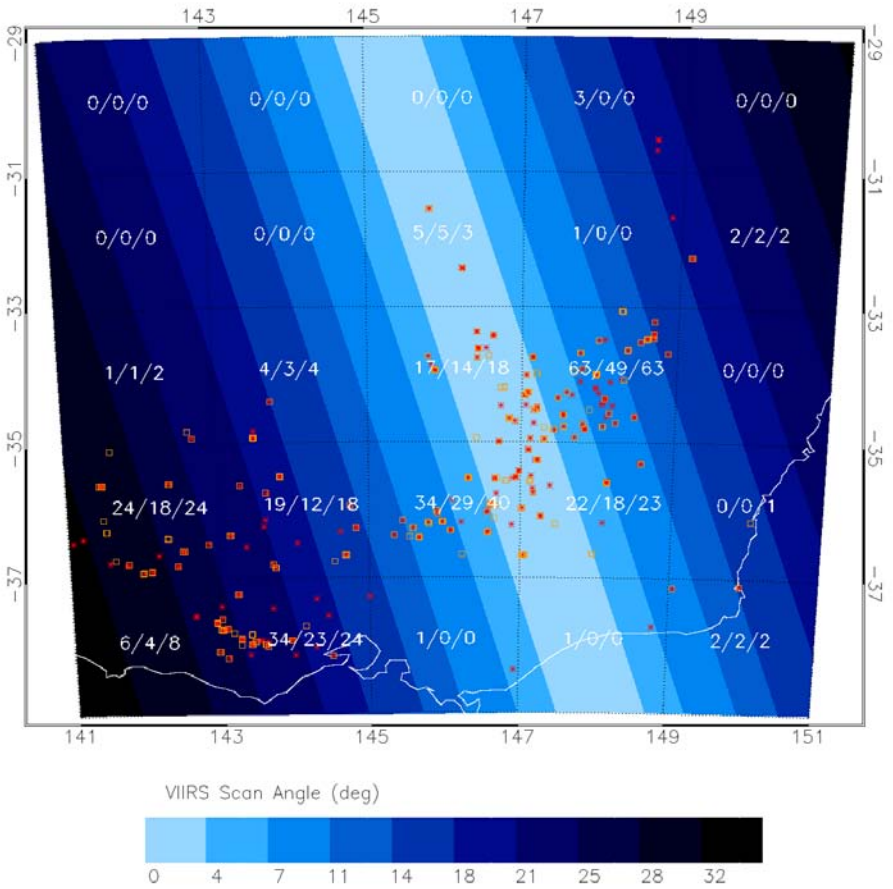




MODIS and VIIRS fire detections at nadir: post-launch on-orbit data

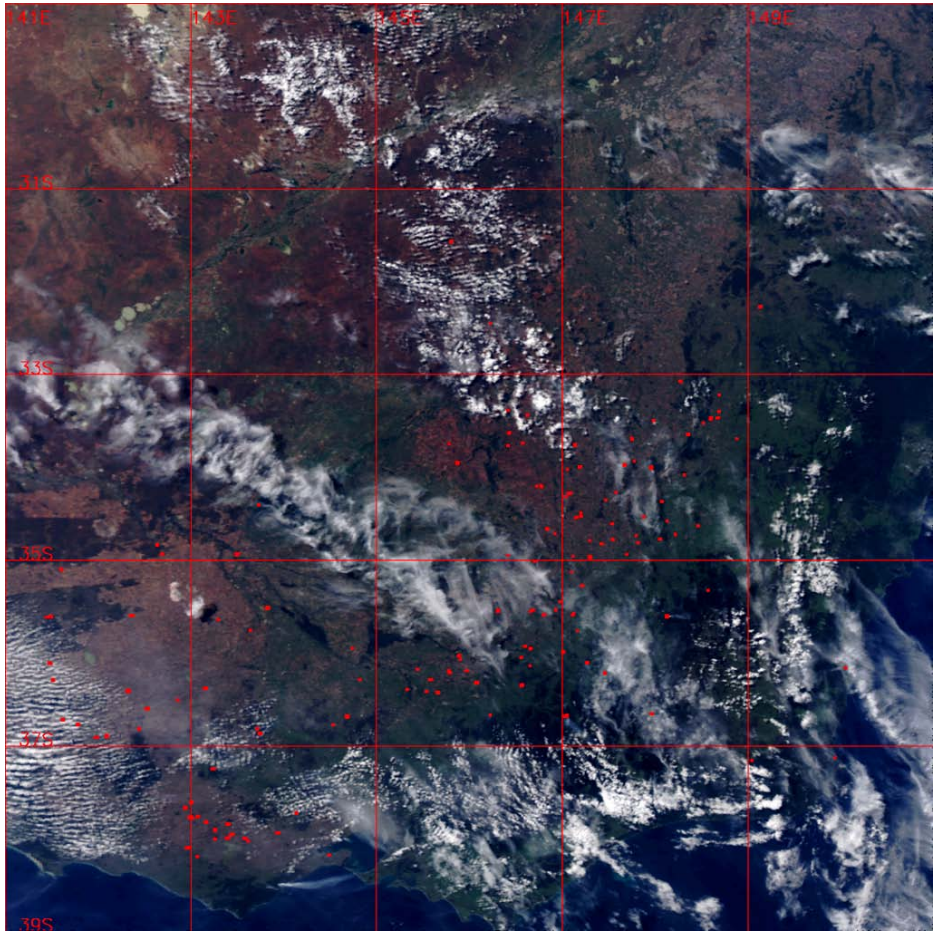


VIIRS 03 April 2012 03:55UTC
(SE Australia)

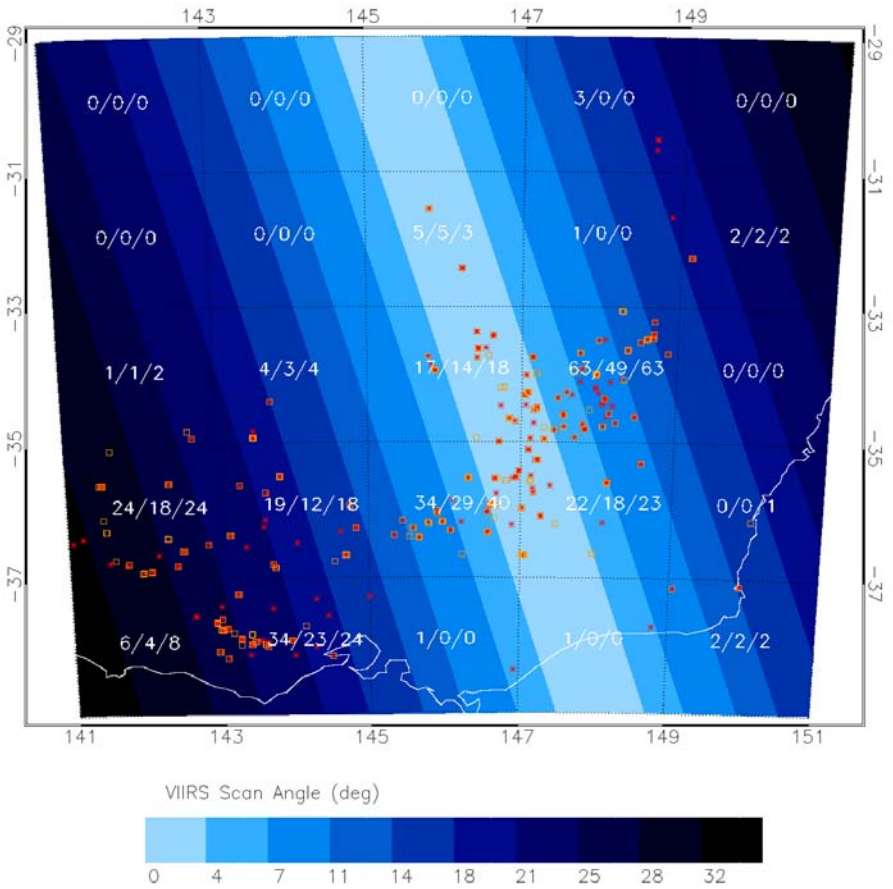


Gridded statistics: AA/BB/CC
AA – number of VIIRS fire pixels (red symbols)
BB – number of VIIRS fire pixels with overlapping Aqua/MODIS fire pixels
CC – number of Aqua/MODIS fire pixels (orange symbols)

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



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



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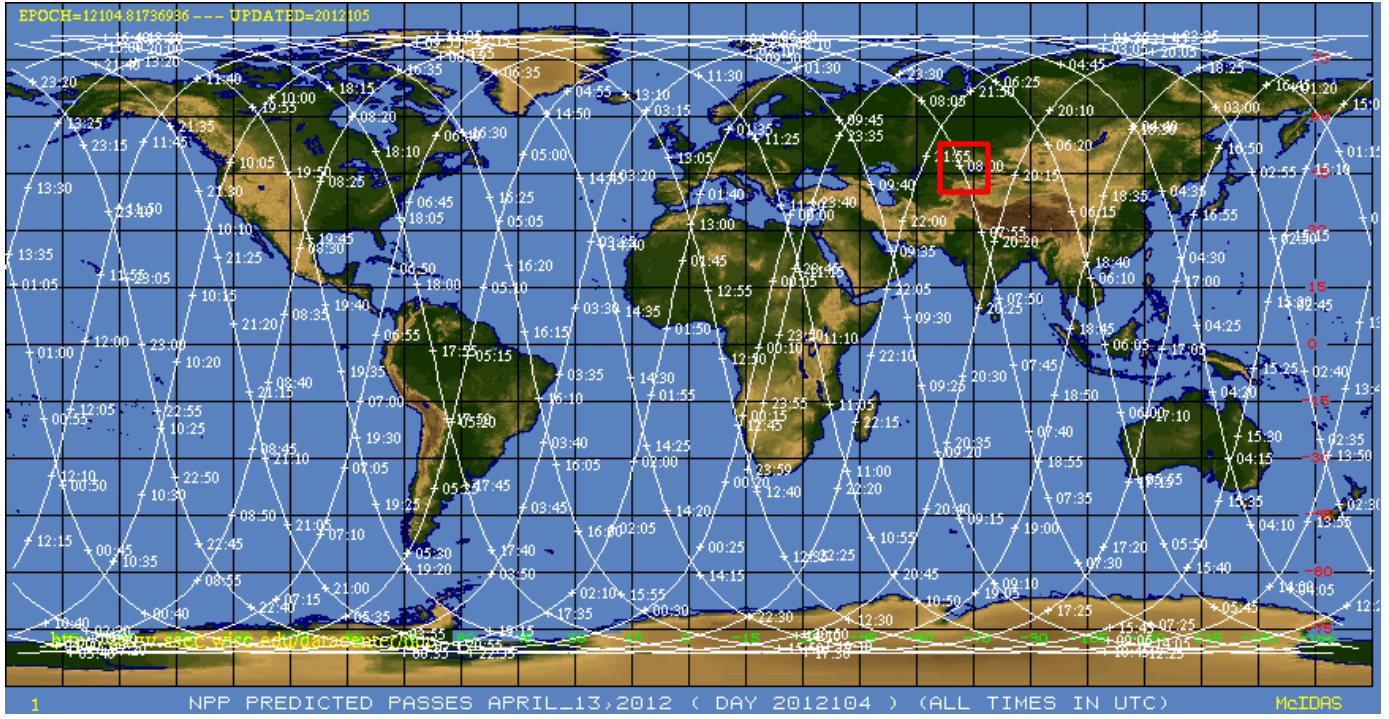
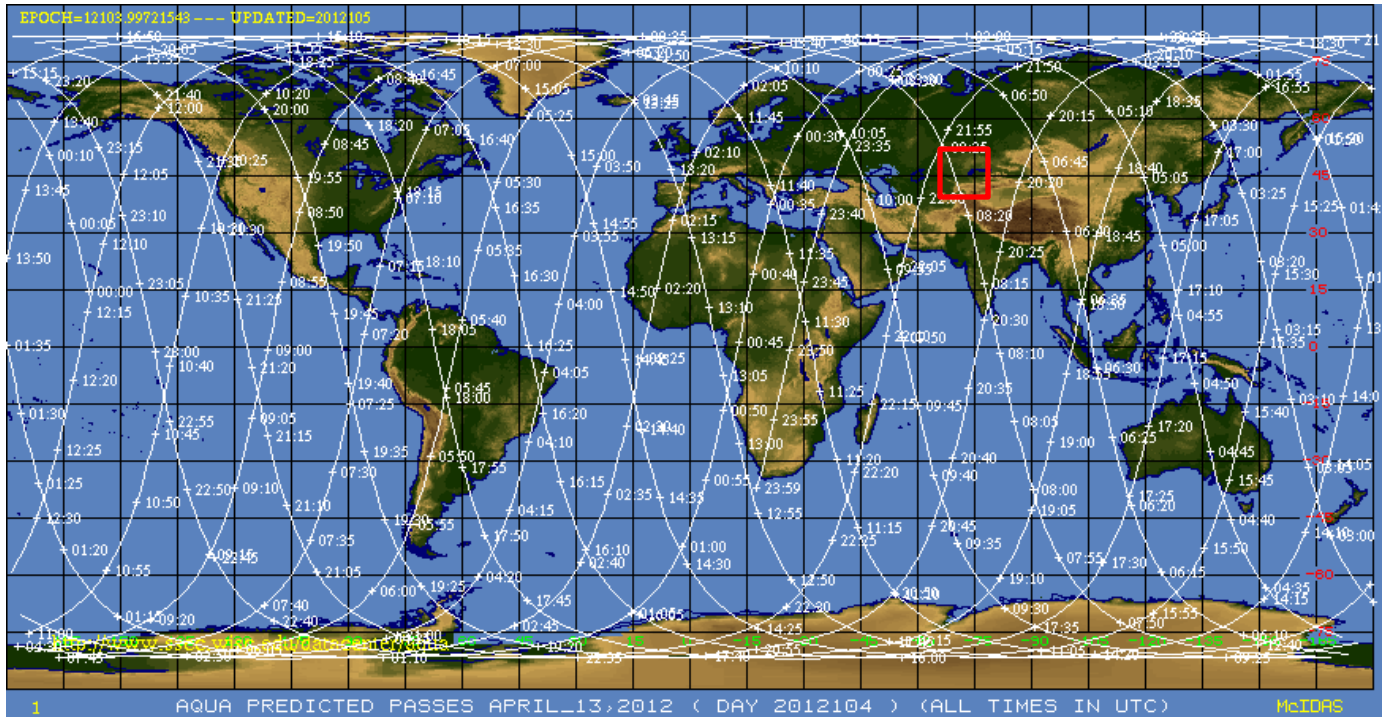
NPP

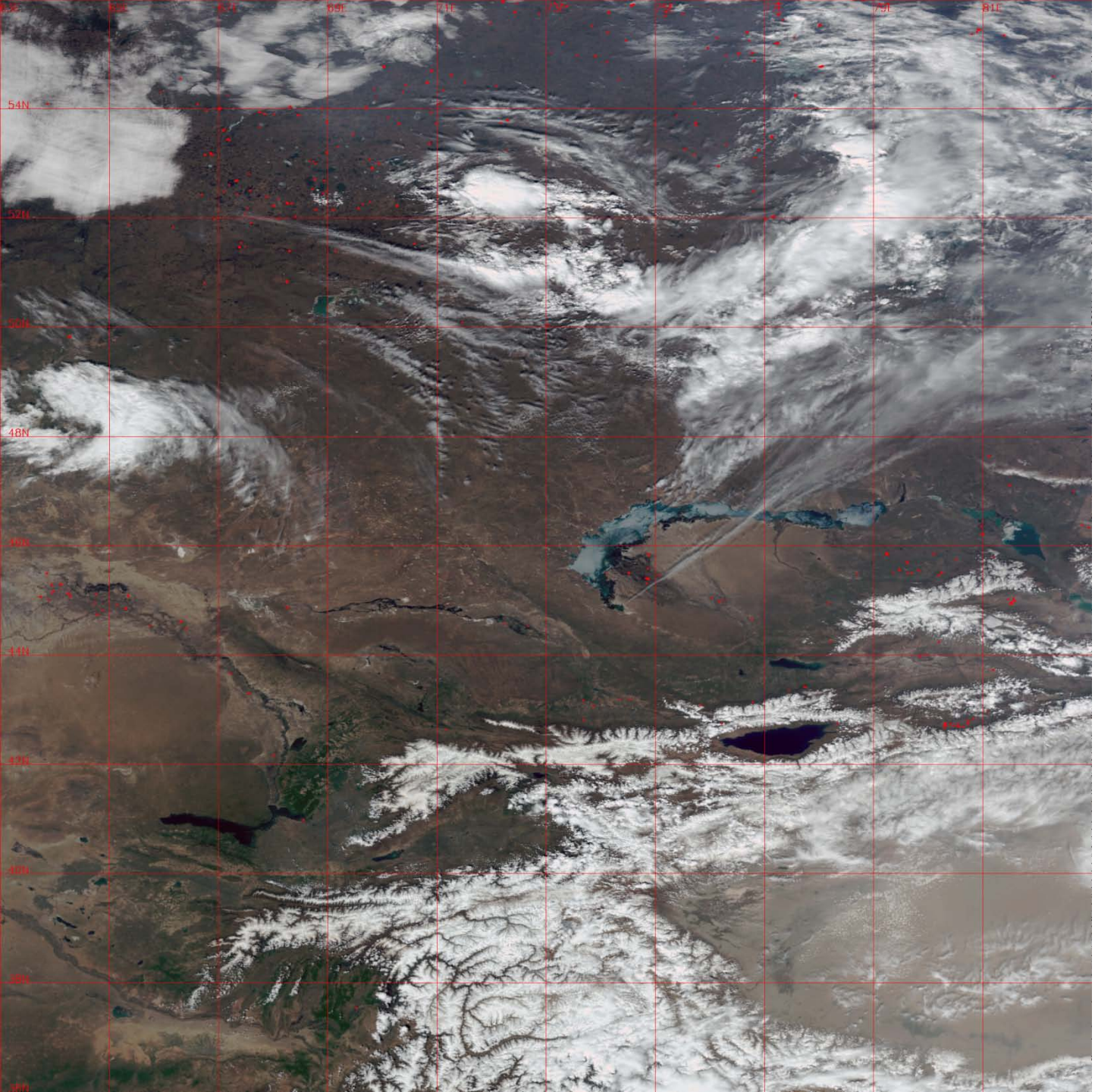
Satellite orbit tracks

April 13, 2012



Aqua





NPP VIIRS

Central Asia

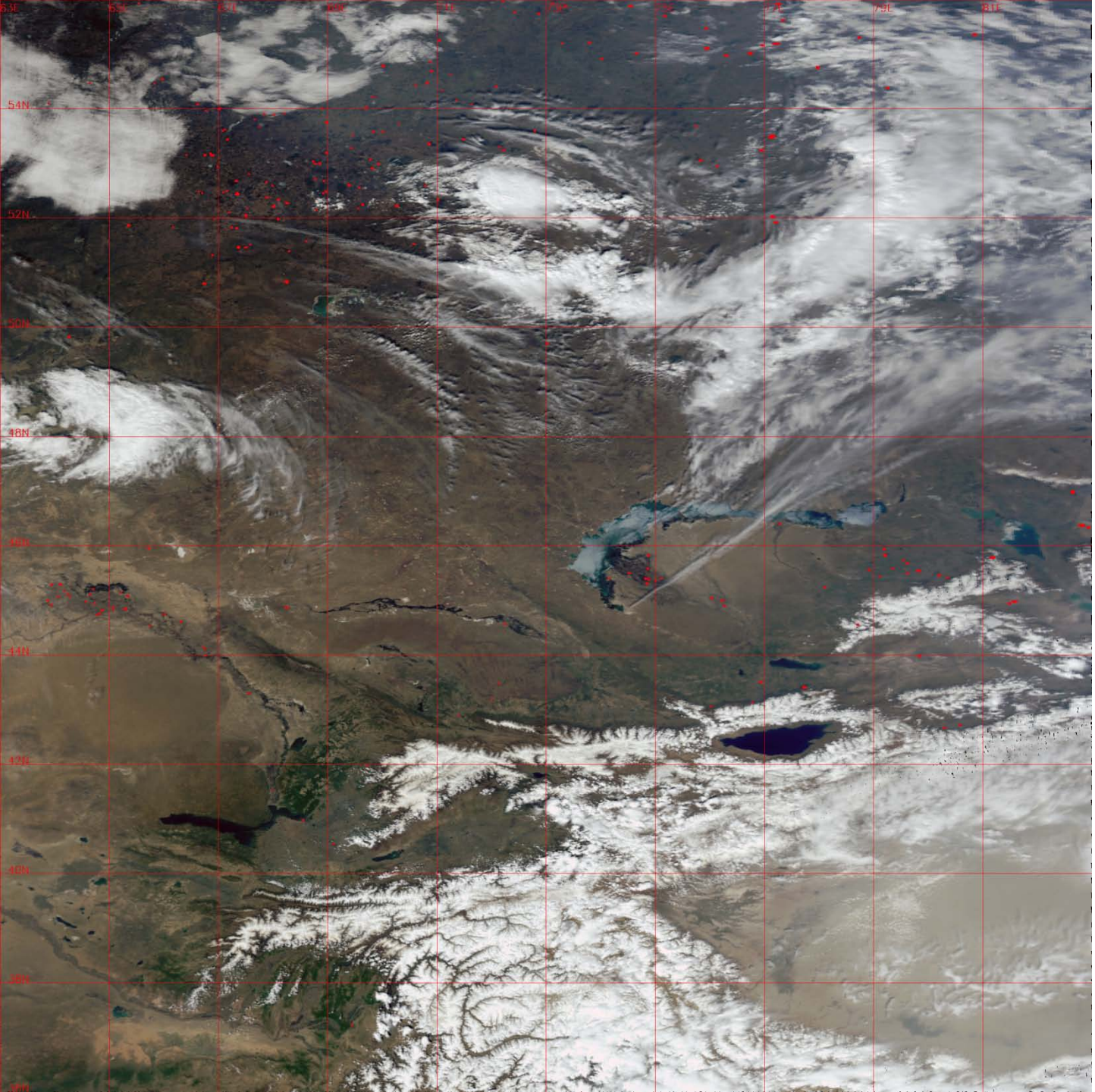
April 13 2012

7:53 UTC

M5-M4-M3 RGB

+

IDPS Active Fire ARP



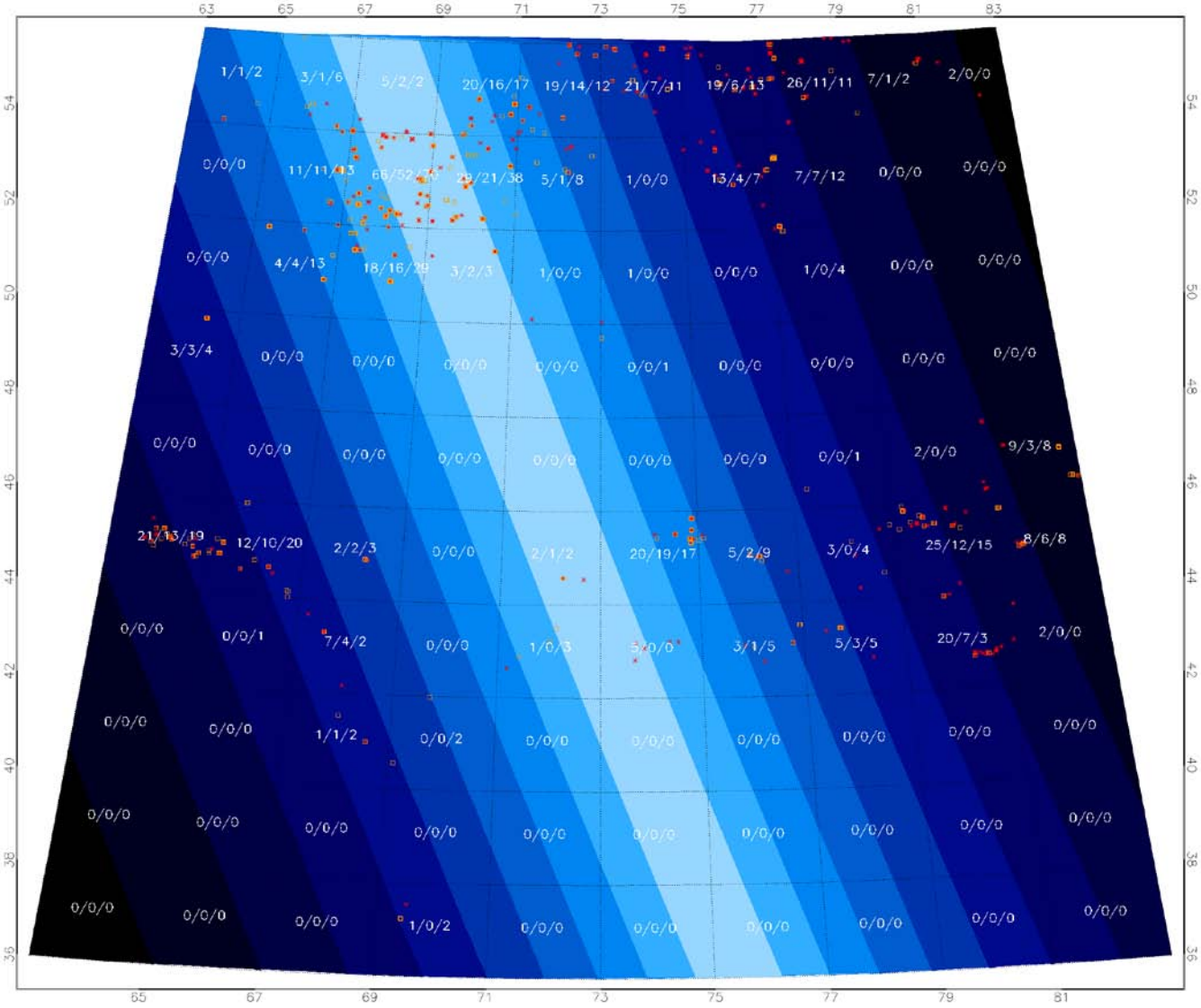
Aqua MODIS

Central Asia

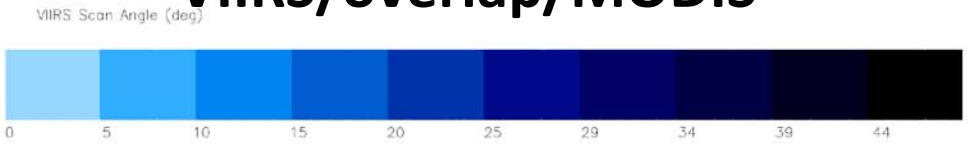
April 13 2012

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
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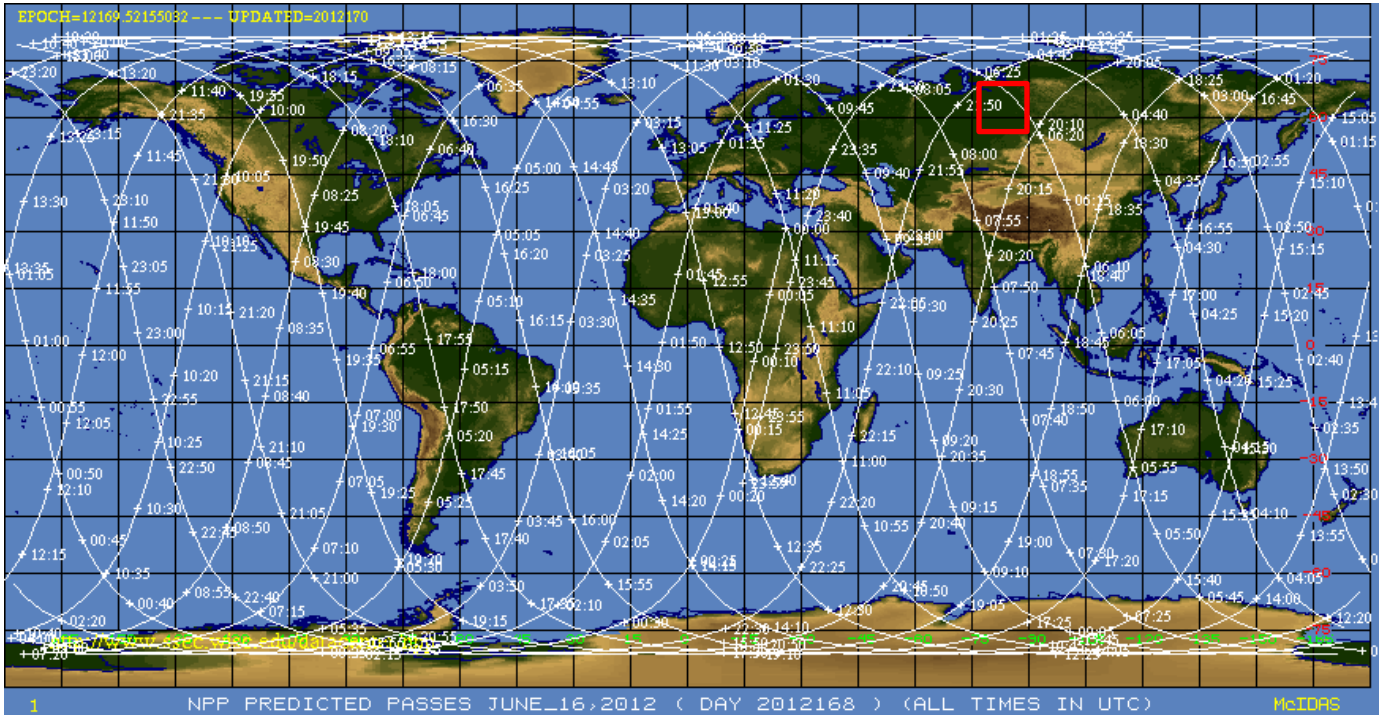
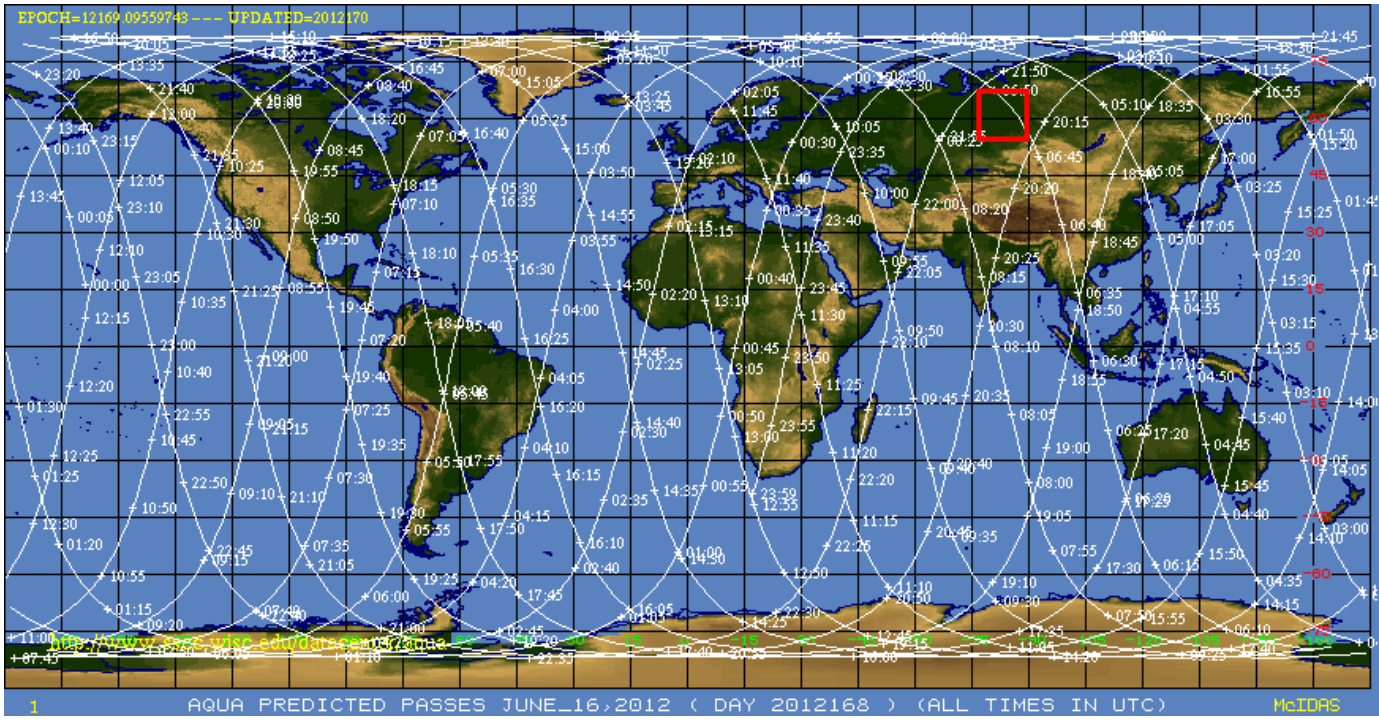
NPP

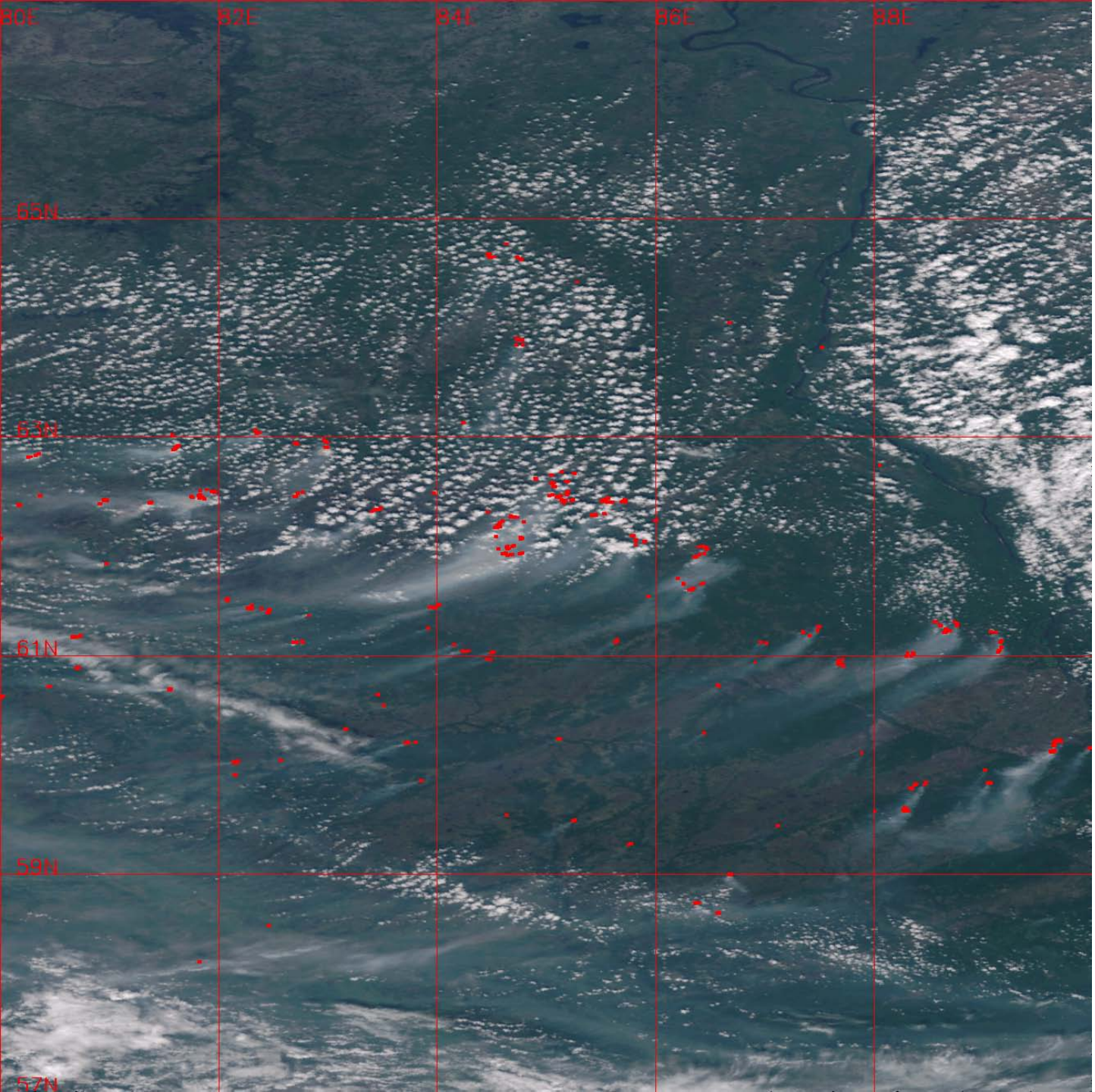
Satellite orbit tracks

June 16, 2012

Aqua







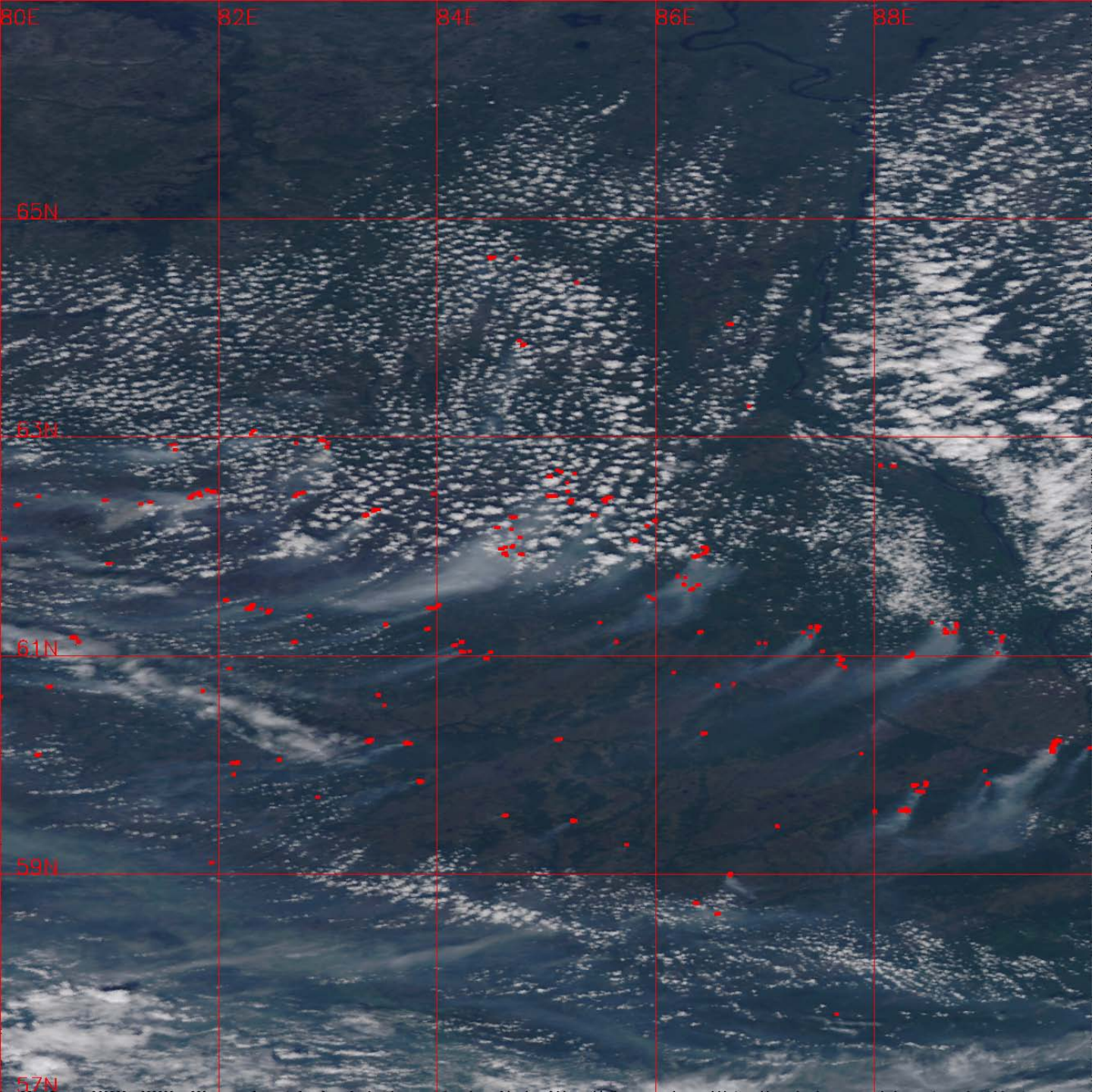
NPP VIIRS

Western Siberia

June 16 2012

6:15 UTC

M5-M4-M3 RGB
+
IDPS Active Fire ARP



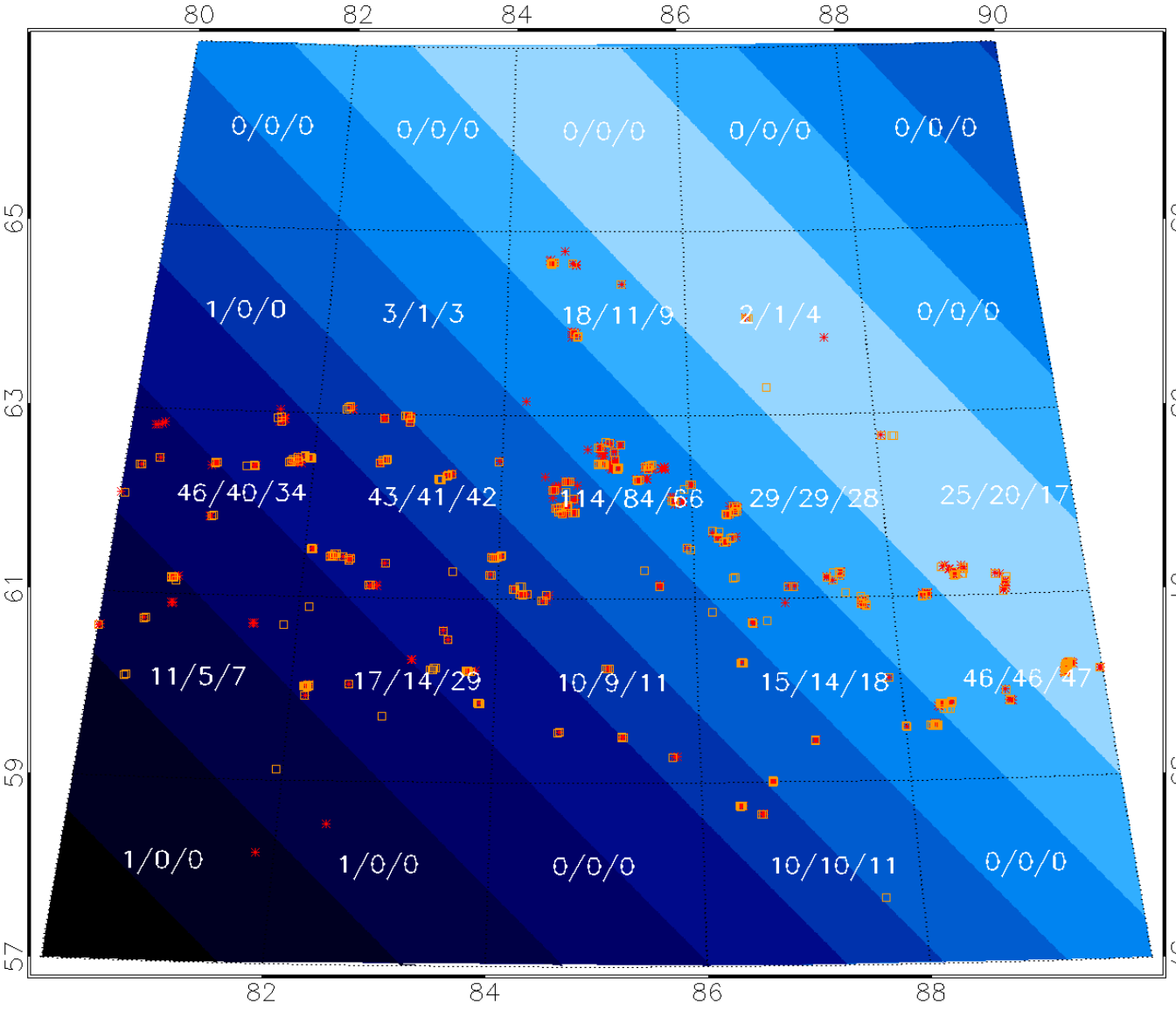
Aqua MODIS

Western Siberia

June 16 2012

6:42 UTC

Band 1-4-3 RGB
+
MYD14



VIIRS

vs.

MODIS

Western Siberia

April 13 2012

VIIRS/overlap/MODIS

Gridded statistics: AA/BB/CC
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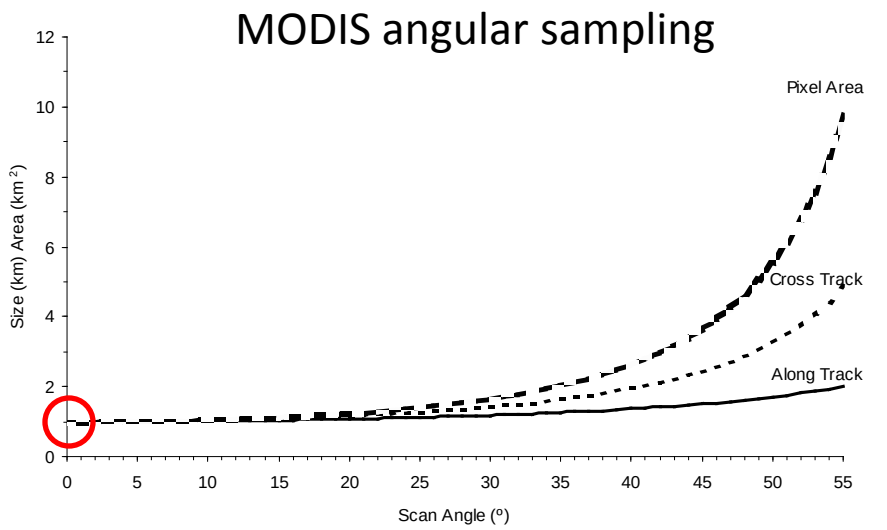
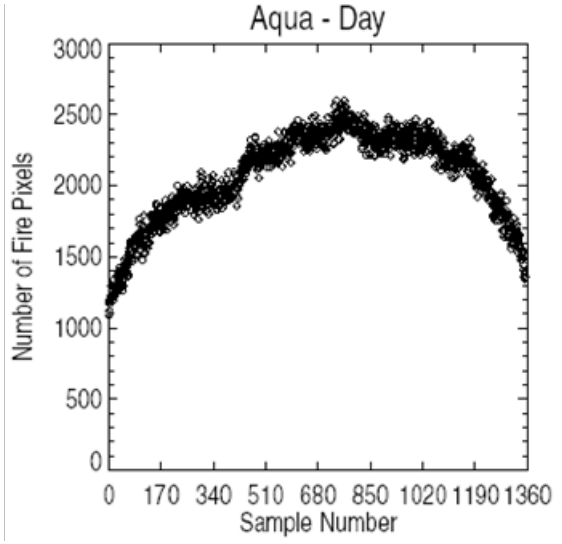
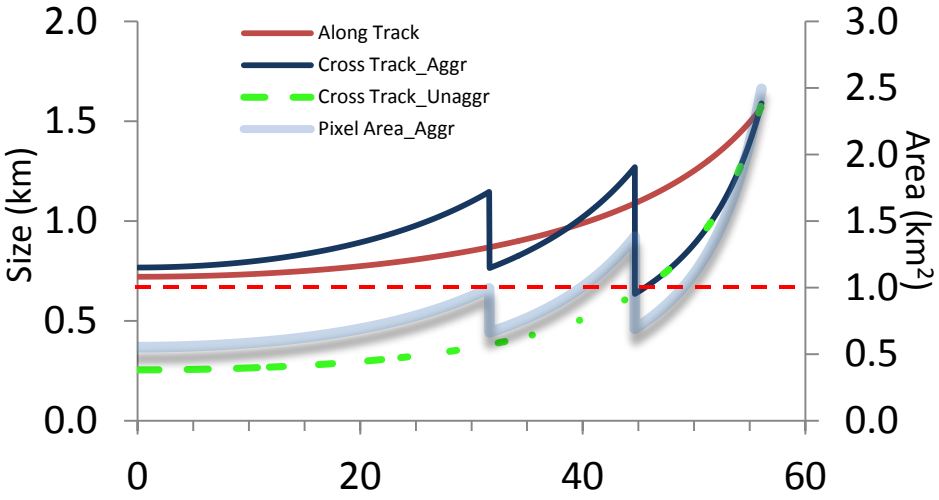
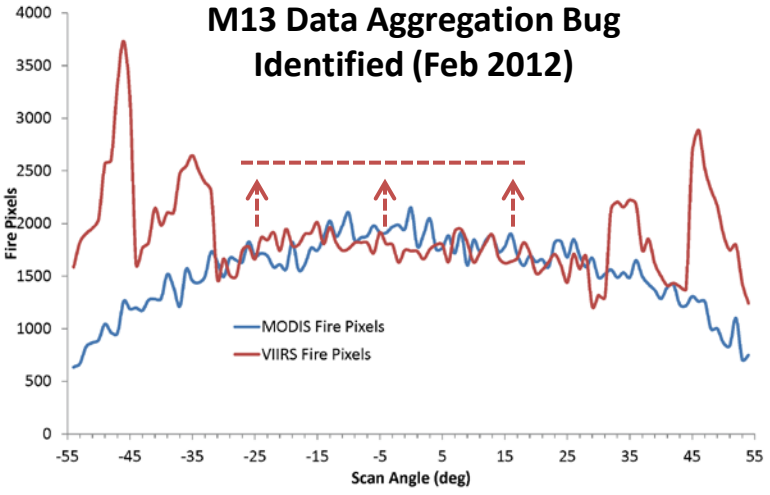
Aqua MODIS vs. Suomi NPP VIIRS





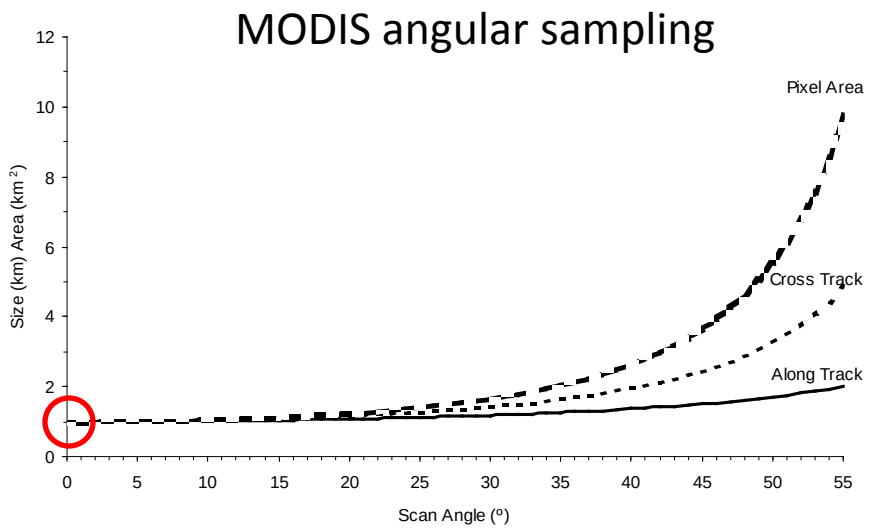


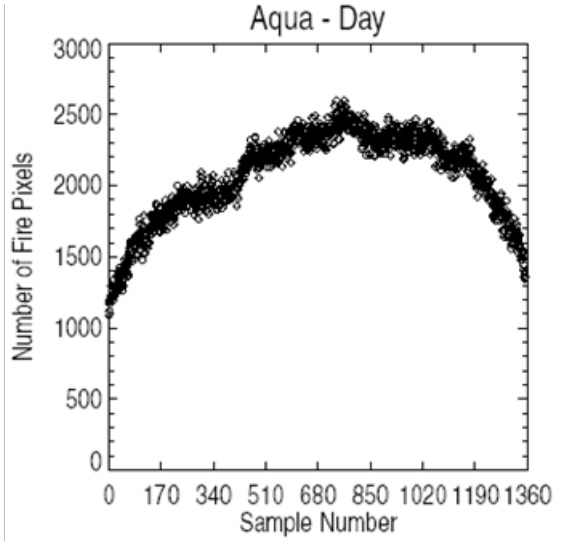


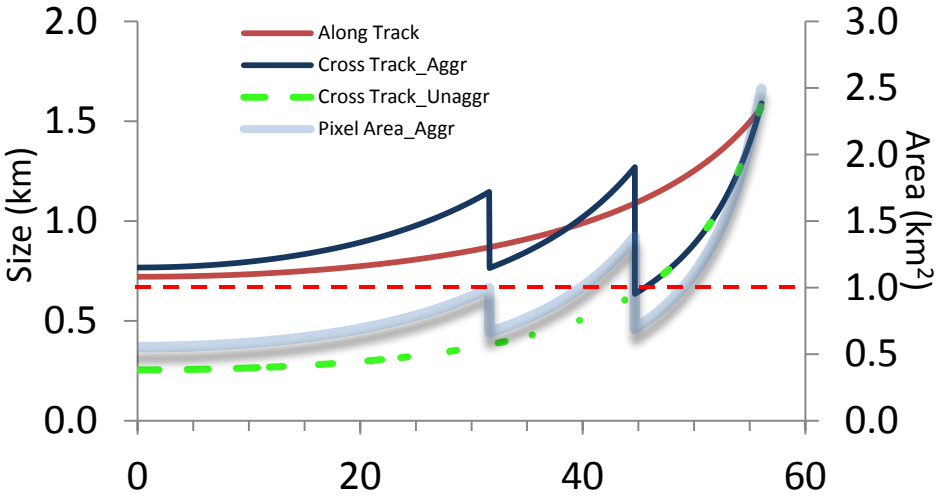
Compatible orbital segments are determined by pixel sizes

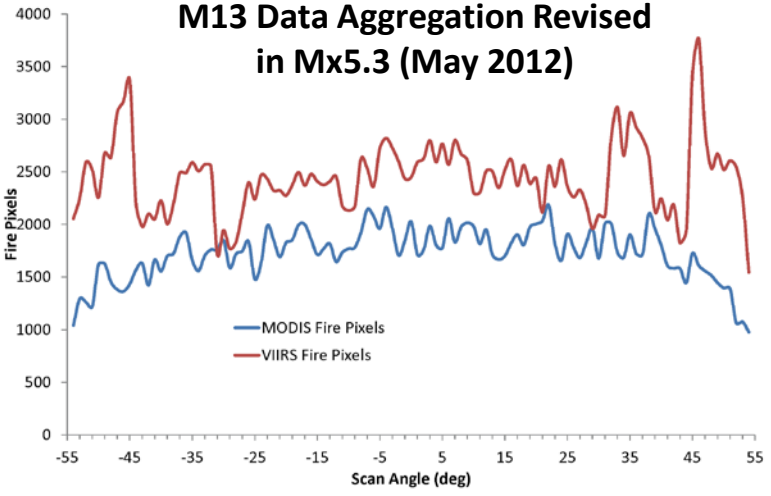
VIIRSxMYD14 Fire Detection Frequency (**19 Jan <> 13 Feb**)

Aqua MODIS vs. Suomi NPP VIIRS





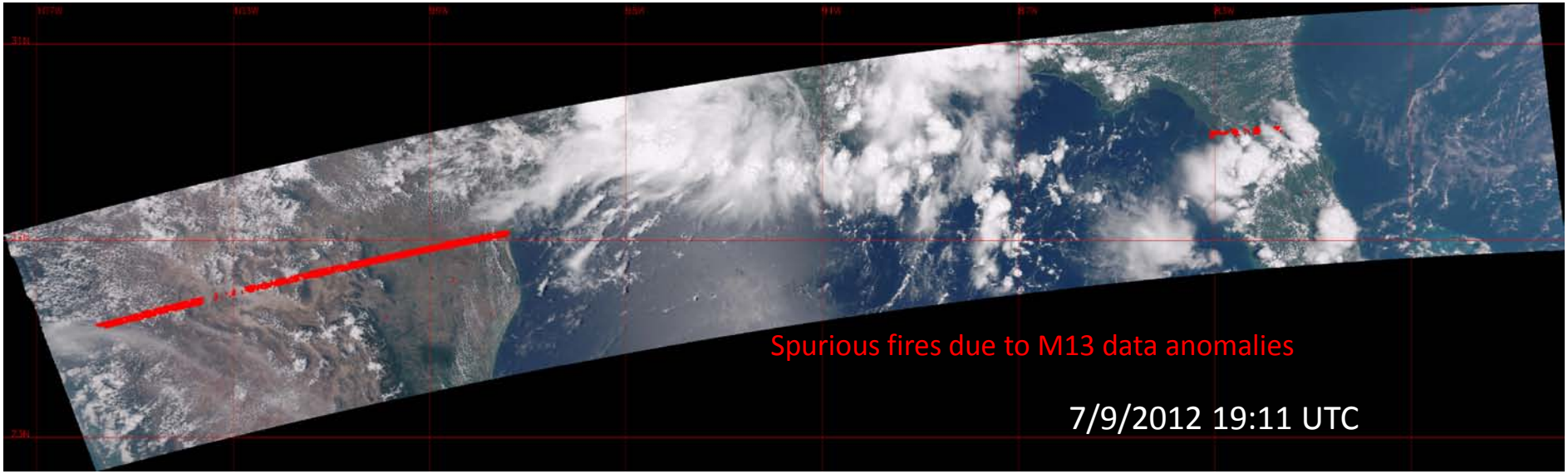


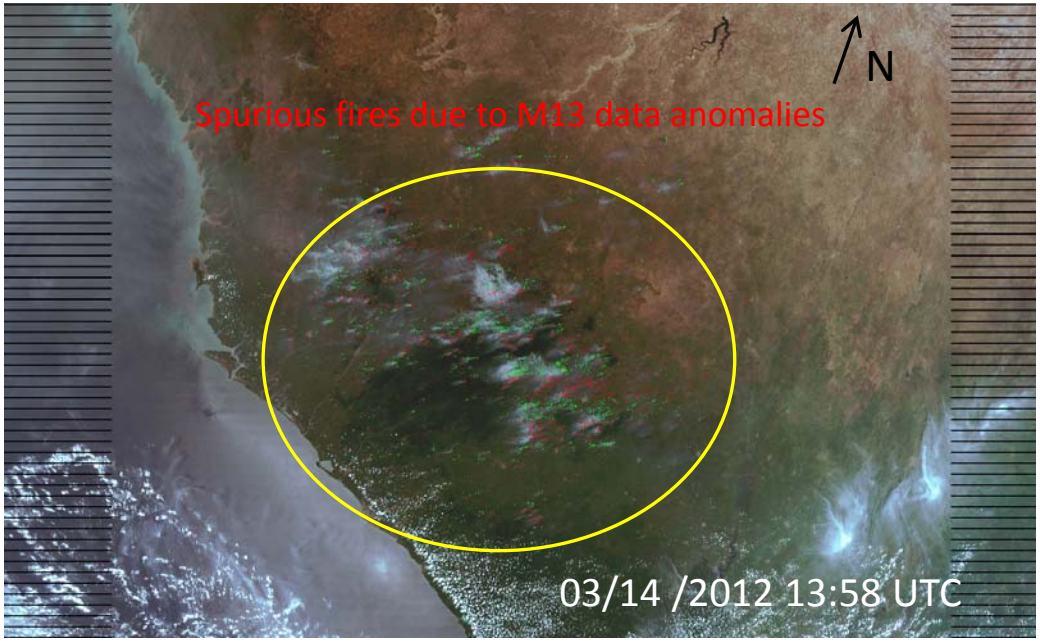


Compatible orbital segments are determined by pixel sizes

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

Known Issues Leading to Spurious Fire Detections





Known Issues Leading to Spurious Fire Detections

Main anomalies identified:

- Block of corrupted M13 brightness temperature values (>450K) along a single scan
  - SDR QA flags do not show the anomaly – spurious fire pixels produced
  - SDR QA flags correctly identify anomaly – fire algorithm still generates false detections
- Alternating omission of fire pixels between successive scans
  - SDR data and QA flags for omitted fire pixels look normal
  - QA flags for adjacent scans indicating calibration errors
- Block of spurious fire pixels coinciding with terminator
  - No anomalies were found in the associated SDR data and QA flags

Identification of root cause of fire data anomalies is often compromised by the data archive management

- Single data repository can have multiple versions of the same data granule
- Data granules obtained form different archives (CLASS, GRAVITE, NESDIS-SCDR, LandPEATE) show unique processing times

Imperative to be able to trace the generation of the L2 AVAFO (Active Fire) data back to the input SDR&RDR files used during processing

- Data archives must contain those files and reduce/eliminate ambiguities

Validation Without Traceability is Impossible

Example of only available information, L2 AVAFO (Active Fire) metadata, for establishing input data (SDR, geolocation, land water mask, coefficients) to Active Fire EDR algorithm :

N_Input_Prod = 4ff60879-8fc3f-0a180213-5a16a27b,4ff60879-953e7-0a180213-5a16fa23,4ff609d0-35412-0a180213-5a10fba5,4ff609d0-39f65-0a180213-5a1146f8,4ff609d0-42bdb-0a180213-5a11d36e,4ff609d0-47889-0a180213-5a12201c,4ff609d0-4aa3f-0a180213-5a1251d2,4ff609d0-4ca8f-0a180213-5a127222,4ff6148a-58bd2-0a180212-5a133e1e,4ff6148a-5c884-0a180212-5a137ad0,4ff614a4-c604a-0a180212-5a1a12b0,4ff614a4-e5acc-0a180212-5a1c0d32,4ff61578-d16c5-0a180212-5a1ac9ff,4ff61578-d636c-0a180212-5a1b16a6,4ff61578-ed66a-0a180212-5a1c89a4,4ff61579-00e6f-0a180212-5a0dc1aa,4ff61579-0417a-0a180212-5a0df4b5,4ff61579-0e847-0a180212-5a0e9b82,4ff6157d-90c0a-0a180212-5a16bf49,4ff6157d-a6765-0a180212-5a181aa4,4ff6157d-b8897-0a180212-5a193bd6,4ff6157d-bca9a-0a180212-5a197dd9,4ff6157d-bf7e7-0a180212-5a19ab26,4ff6157d-c1740-0a180212-5a19ca7f

- Internal URID information such as shown above is not convertible back to file names for accurate independent scene replication and validation/investigation
- **Active Fires algorithm run in ADL produced different results than same data granule in IDPS**
  - Aggregated version of the same data granule contained spurious fires
  - Constituent 84 second granules of same aggregate data product file did not contain spurious fires
  - Corrupted M13 brightness temperature issues, aggregation, and/or other cause(s) suspected

Root cause(s) impossible to trace without knowledge of inputs utilized during generation of AVAFO data

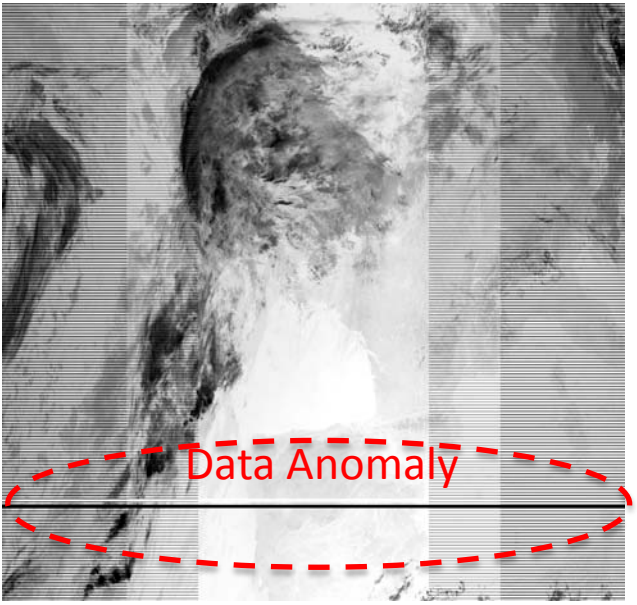
Imperative to be able to trace the generation of the L2 AVAFO (Active Fire) data back to the input SDR&RDR and all other input files used during processing

- AVAFO data files must contain filename references to those input files used to generate them and eliminate ambiguities

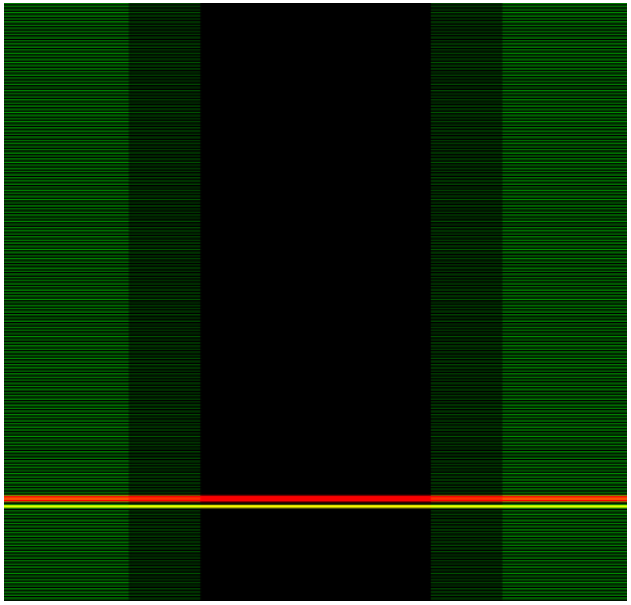
M13 - QA33 Issue

VIIRS_20120817_t0211442_e021724

5min Swath – Nighttime Data

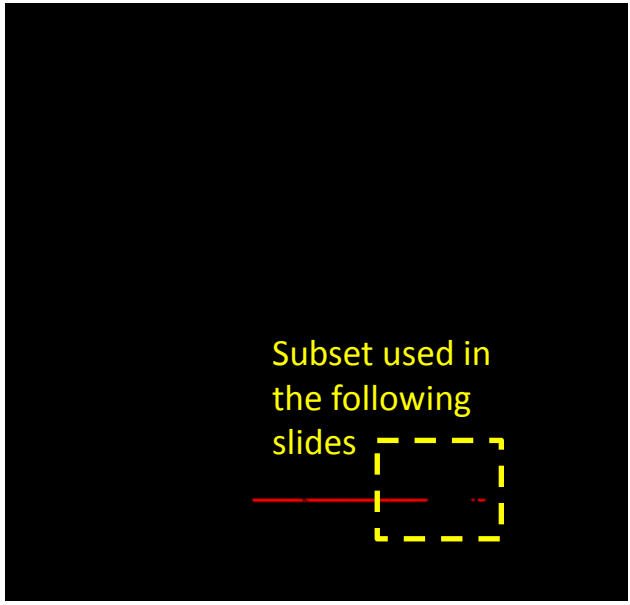


M13 brightness temperature data



M13 QA layer

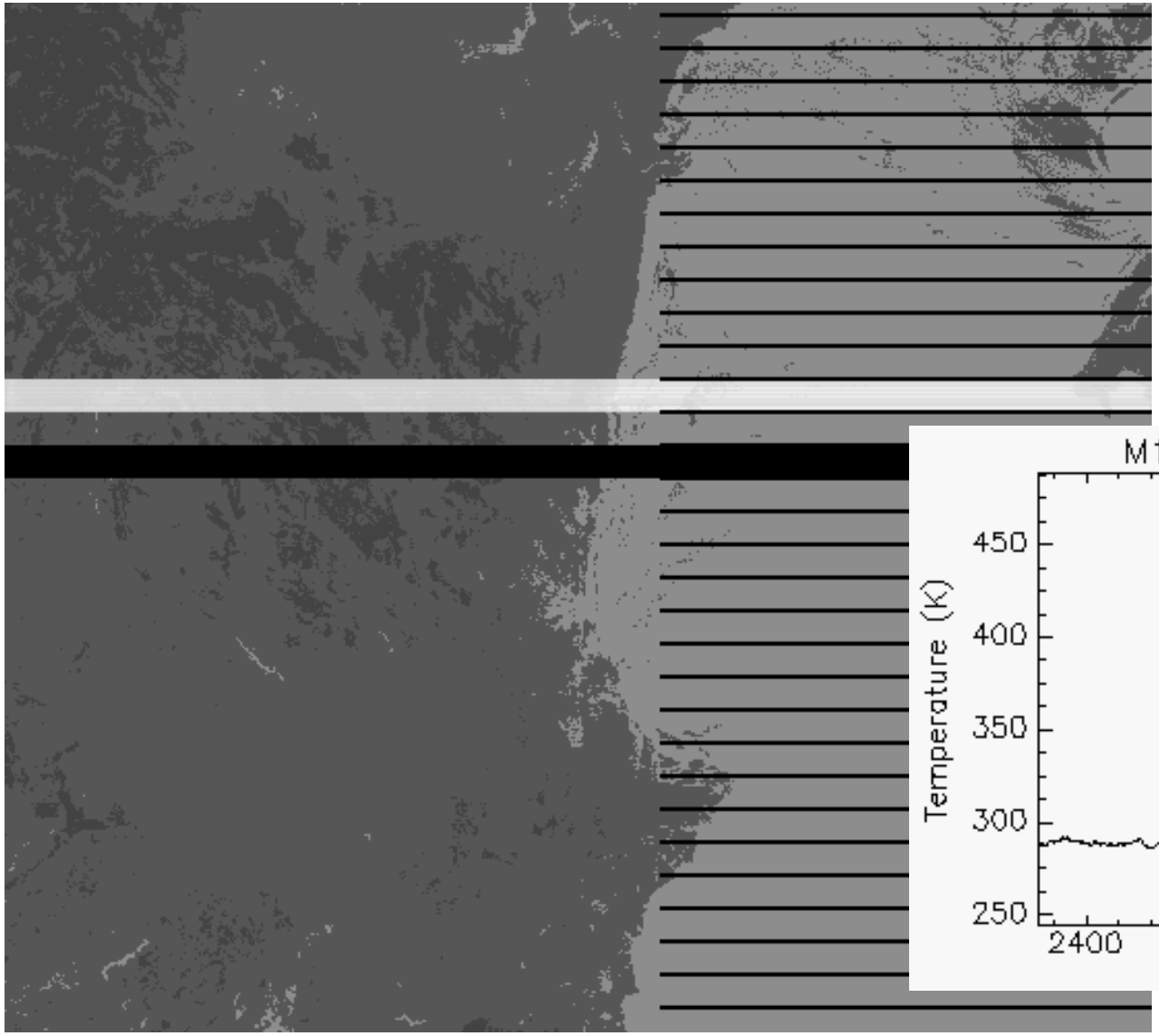
Black = 0
Green = 2
Red = 33 (*Poor Calibration - Cal data missing*)
Yellow = 34 (*No Calibration - Cal data missing*)



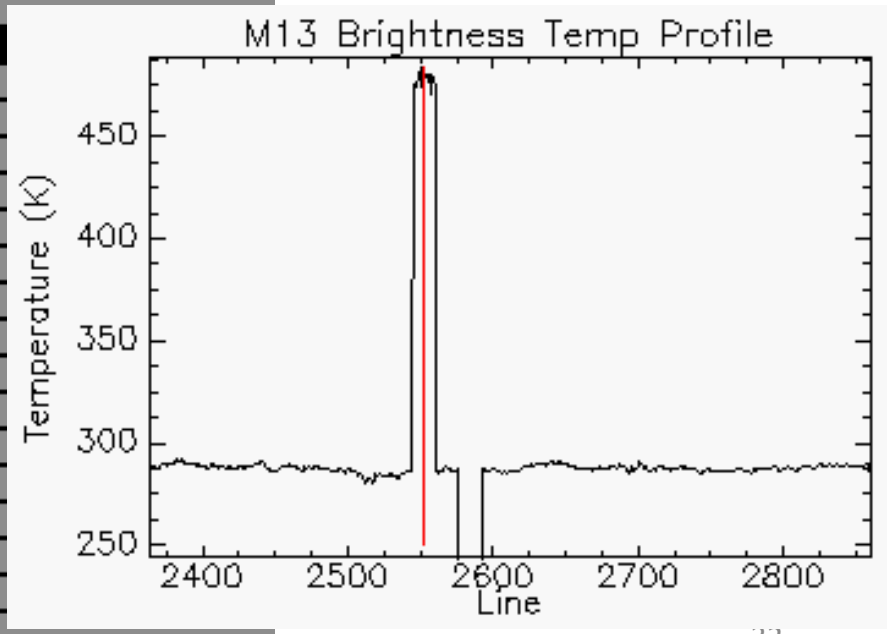
Active Fire Product

Black = no fire
Red = fire

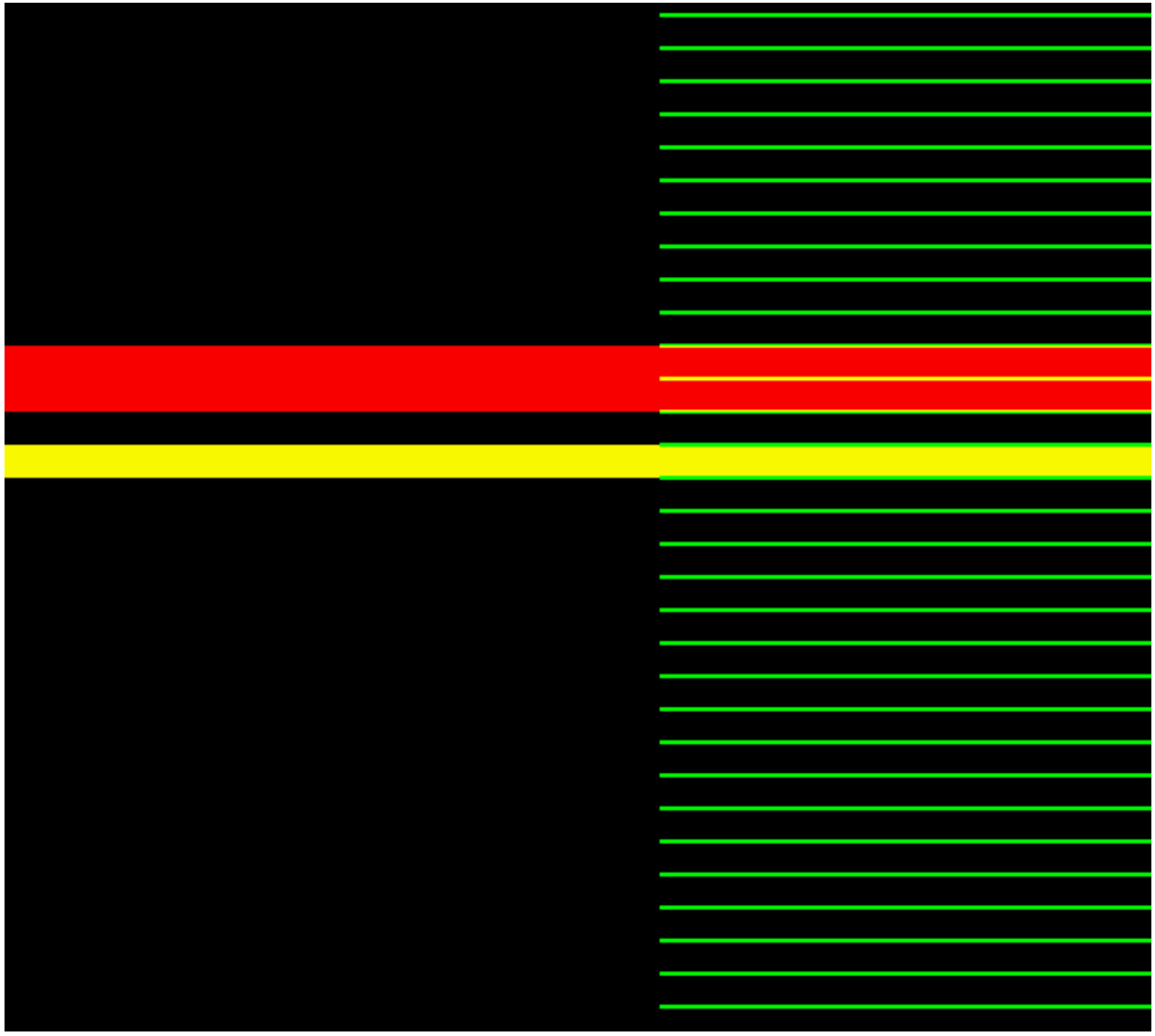
M13 - QA33 Issue



M13 Brightness Temp
Color-enhanced to
show features



M13 - QA33 Issue



QA M13

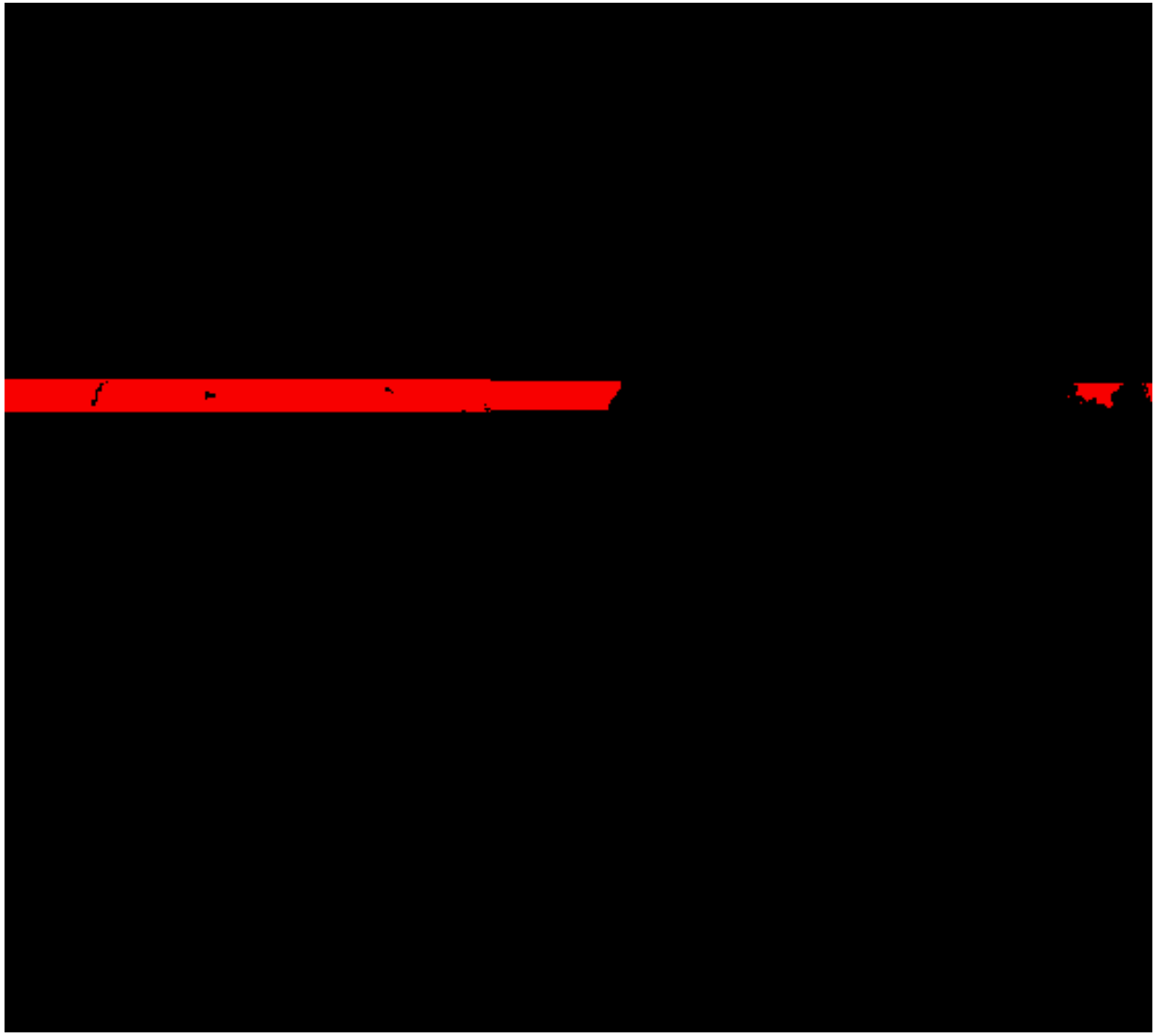
Black = 0

Green = 2

Red = 33 (Cal data missing)

Yellow = 34 (EVR data missing)

M13 - QA33 Issue



Active Fire
Black = no fire
Red = fire

Discontinuities
caused by clouds

Beta Evaluation

Beta Definition	Artifacts (Deliverables)	Delivered Artifacts
Early release product:	N/A	N/A
Minimally validated:	Data Record Algorithm output from a minimum of 3 distinct examples of the product with corresponding validation data or comparative analysis.	Examples of VIIRS-MODIS correlative analysis over Central Africa, SE Australia, Central Asia and Siberia included in this briefing
May still contain significant errors:	Narrative, listing and discussing known errors.	VIIRS Dual Gain Switching Sequence Anomaly results in spurious fire detections. Illustration and narrative are provided.
Versioning not established until Beta establishes the baseline for this product:	Description of the development environment and algorithm used to generate the product validation materials.	Product validation materials are based on IDPS Mx5.3
Available to allow users to gain familiarity:	ADP STAR will request feedback from appropriate users for the product. The notification letter will include a Beta Maturity disclaimer.	NOAA National Weather Service and US Forest have been involved in product evaluation. International users have been briefed on product basics through GOFC-GOLD communication and science presentations.
Product is not appropriate as the basis for quantitative scientific publications studies and applications:	Warning of potential non-reproducibility of results due to continuing calibration and code changes.	Disclaimer is included in separate CLASS “Readme” document.

Beta Considerations/Remaining Issues

- **Overall performance** of the Suomi NPP VIIRS fire product is **good**
- **Problems involving primary (M13) band used in fire algorithm appear to persist after implementatin of Mx5.3**
  - Dual gain switching causing (random) data anomalies resulting in abnormally high brightness temperatures
    - Associated SDR quality flags may leave corrupted pixels unmarked (QA=0)
  - Fire team will continue to provide feedback to SDR team
  - Fire team currently working on ADL → fire code bypassing M13 QA
    - Pixels with QA flag 33 incorrectly classified as active fire
- More work is needed to implementation of **new MODIS algorithm components** (implemented in Version 6) and **sensor-specific tuning** in the VIIRS product
- Explicit **validation** remains crucial

Future Plans

- Near-term
  - September 2012
    - Start evaluation of VIIRS **Dual Gain Switching Sequence Anomaly fix** in Mx 6.3-compatible **ADL drop**
    - Initial end user evaluation and feedback
  - October 2012
    - Start evaluation of **VIIRS Dual Gain Switching Sequence Anomaly fix** in **IDP**S Mx 6.3
    - Initial algorithm adjustments and **science code** testing
      - MODIS collection 6 tests, full fire mask, sensor-specific adjustments, Fire Radiative Power
- Mid- to long-term
  - Full evaluation of **updated science algorithm and code**
  - **Provisional status** by May 2013

Summary of Findings

- Preliminary results show that the **VIIRS Active Fire product is working well**.
  - Results are preliminary
  - VIIRS Dual Gain Switching Sequence Anomaly is present at this time
- We are deriving global and regional statistics from **VIIRS-MODIS correlative analysis**
  - Current results indicate that the **M13 aggregation fix in Mx 5.3 worked**
  - Results reflect **expected VIIRS performance** and differences between MODIS and VIIRS fire counts
    - Angular distribution consistent with VIIRS aggregation scheme
    - Higher VIIRS fire counts consistent with higher VIIRS spatial resolution