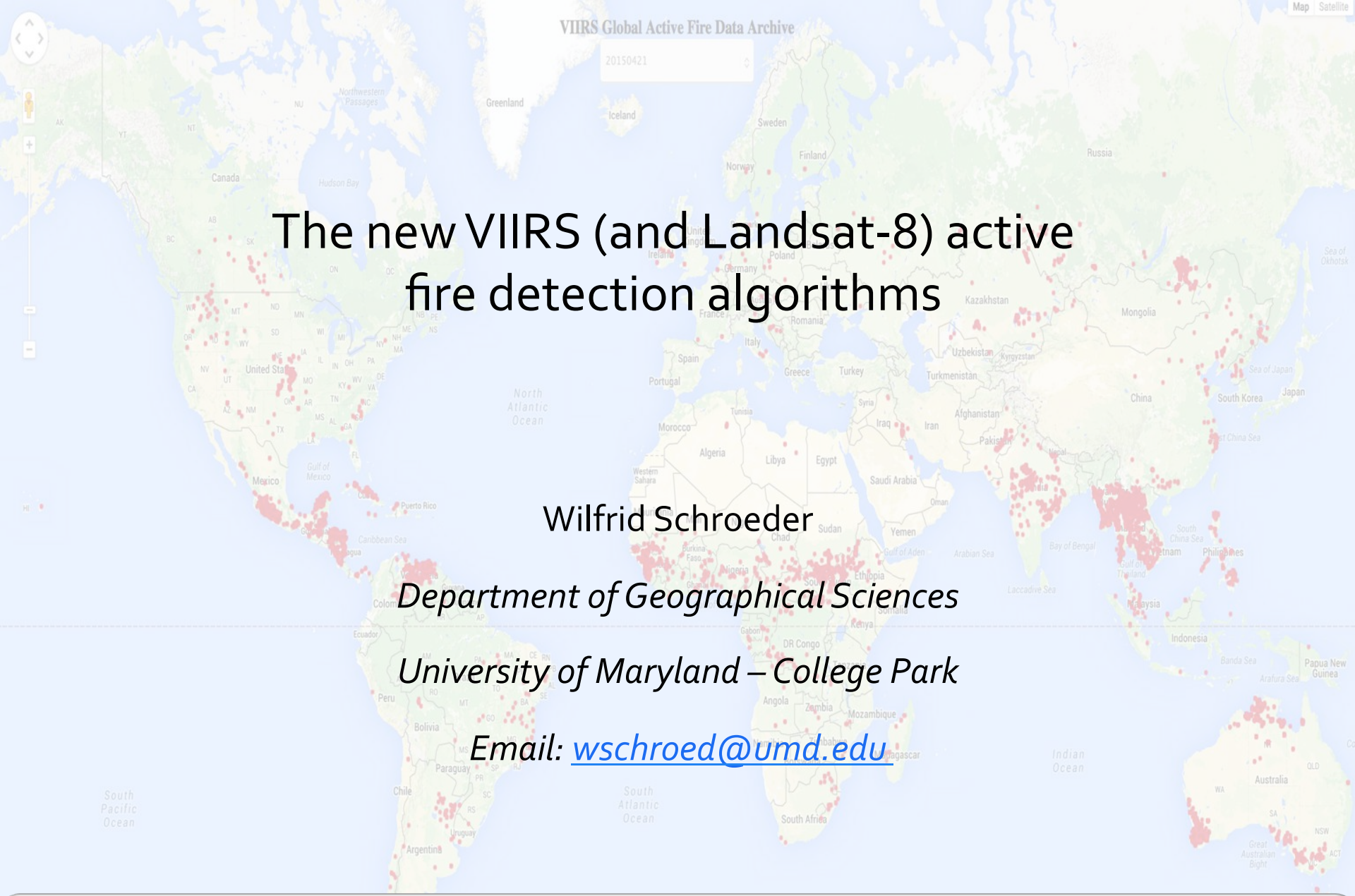


# The new VIIRS (and Landsat-8) active fire detection algorithms

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*University of Maryland – College Park*

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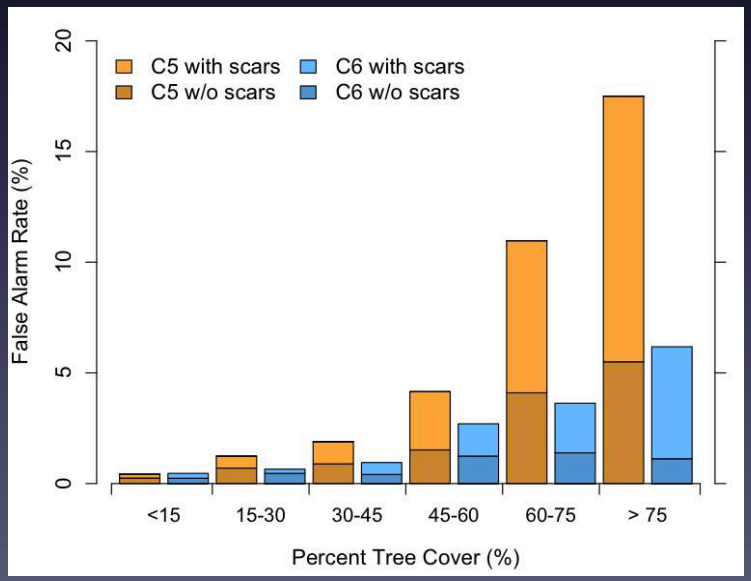
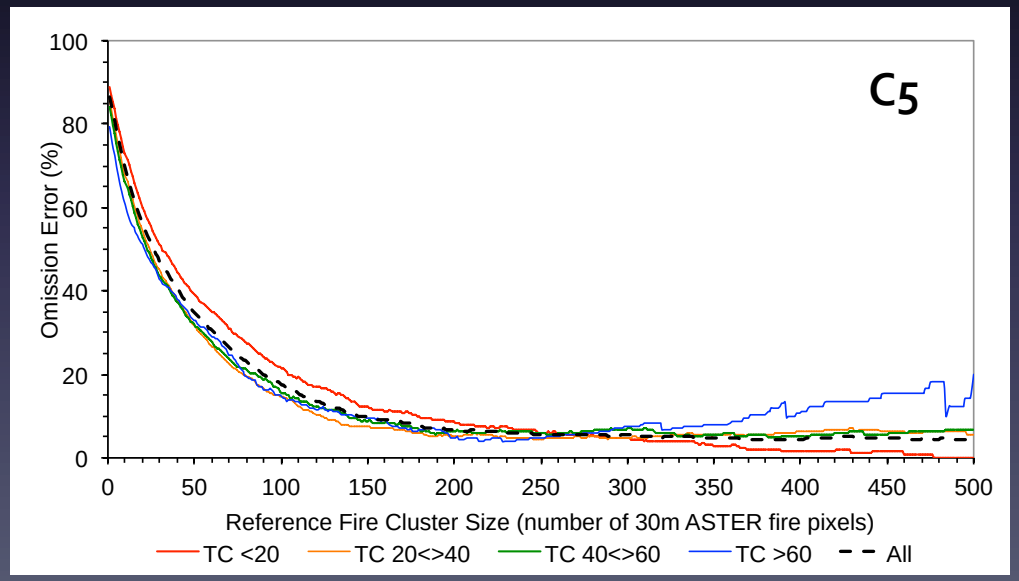
UNIVERSITY OF MARYLAND
DEPARTMENT OF GEOGRAPHICAL SCIENCES
FOREST SERVICE U.S. DEPARTMENT OF AGRICULTURE
USDA
NCAR NATIONAL CENTER FOR ATMOSPHERIC RESEARCH
DLR
NASA
NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION U.S. DEPARTMENT OF COMMERCE
NATIONAL WEATHER SERVICE

# Quick Update on MODIS C6

- Targeted improvements achieved with new algorithm
  - Fewer false alarms associated with tropical deforestation
  - Lower omission errors associated with large fires
- Re-processing under way
  - To be completed in a few months
  - C5 and C6 will co-exist until re-processing is complete, then C5 will phase out



# Quick Update on MODIS C6

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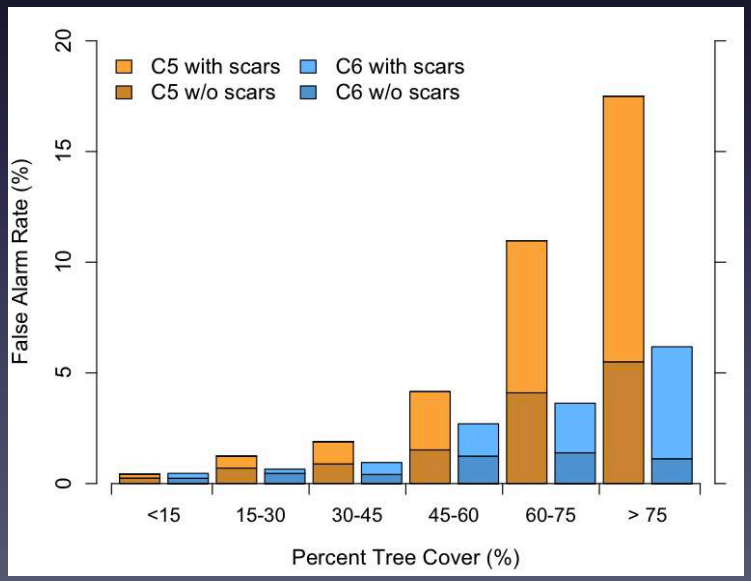
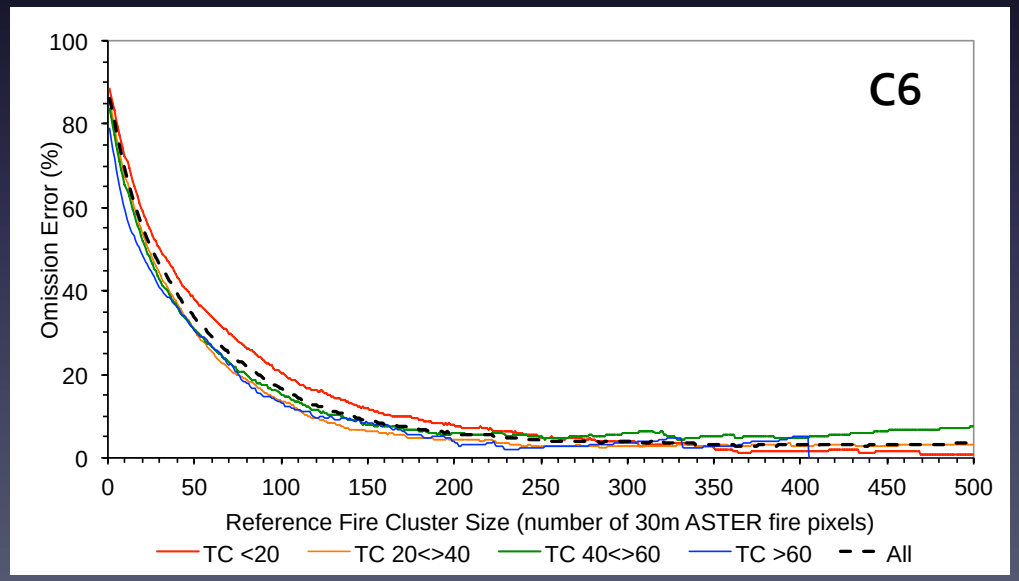


# The Visible Infrared Imaging Radiometer Suite (VIIRS)

- On board Suomi-NPP (launched Oct/2011)
  - 1:30am & 1:30pm local overpass

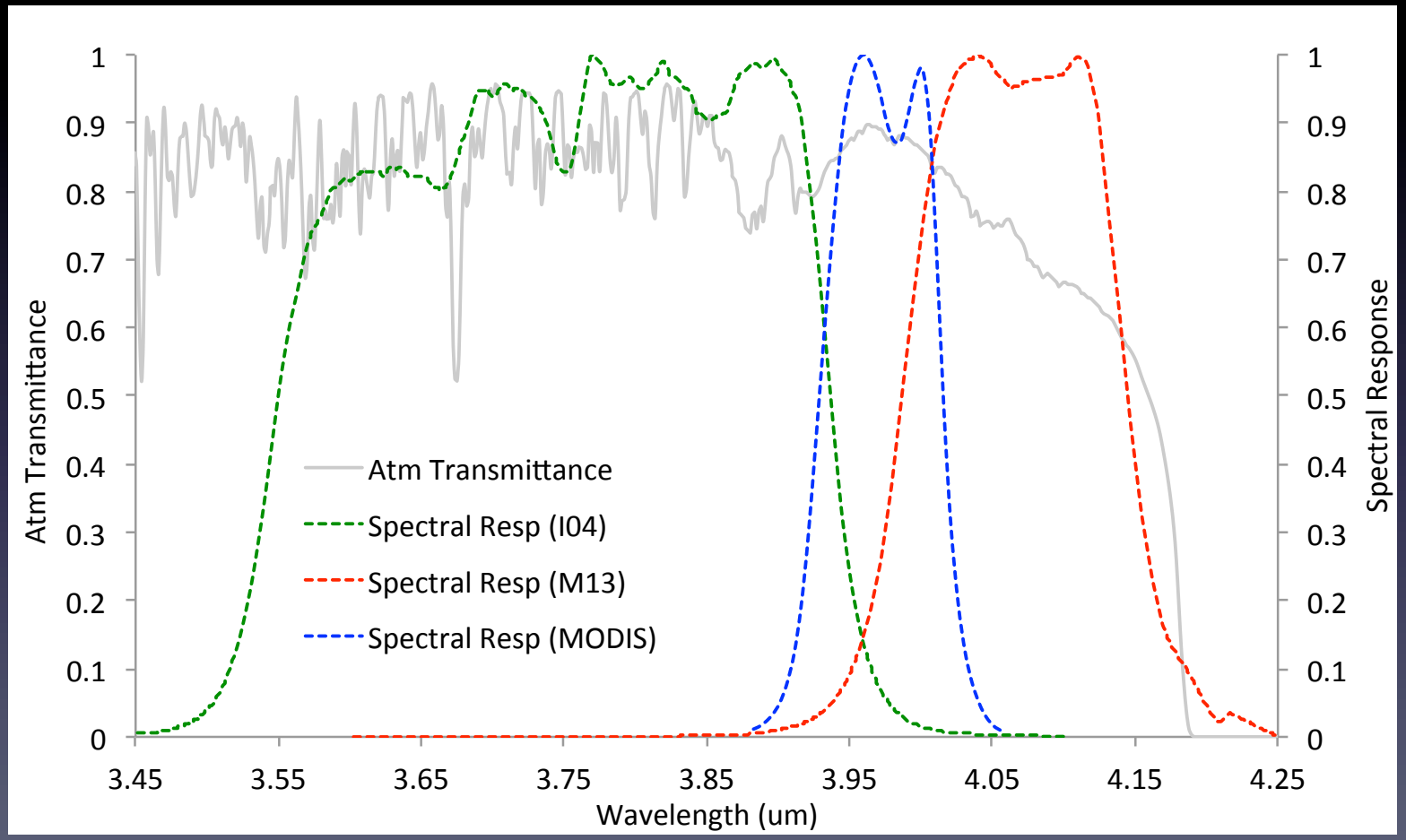
- 16 bands @ 750 m resolution (including dual-gain MIR with saturation temperature +600K)
- 5 bands @ 375 m resolution (including MIR though with frequent saturation)

- Second VIIRS to be launched onboard JPSS-1 in 2017
  - Expected to fly on same orbit as NPP trailing by 20-50min

# VIIRS Heritage: MODIS and AVHRR

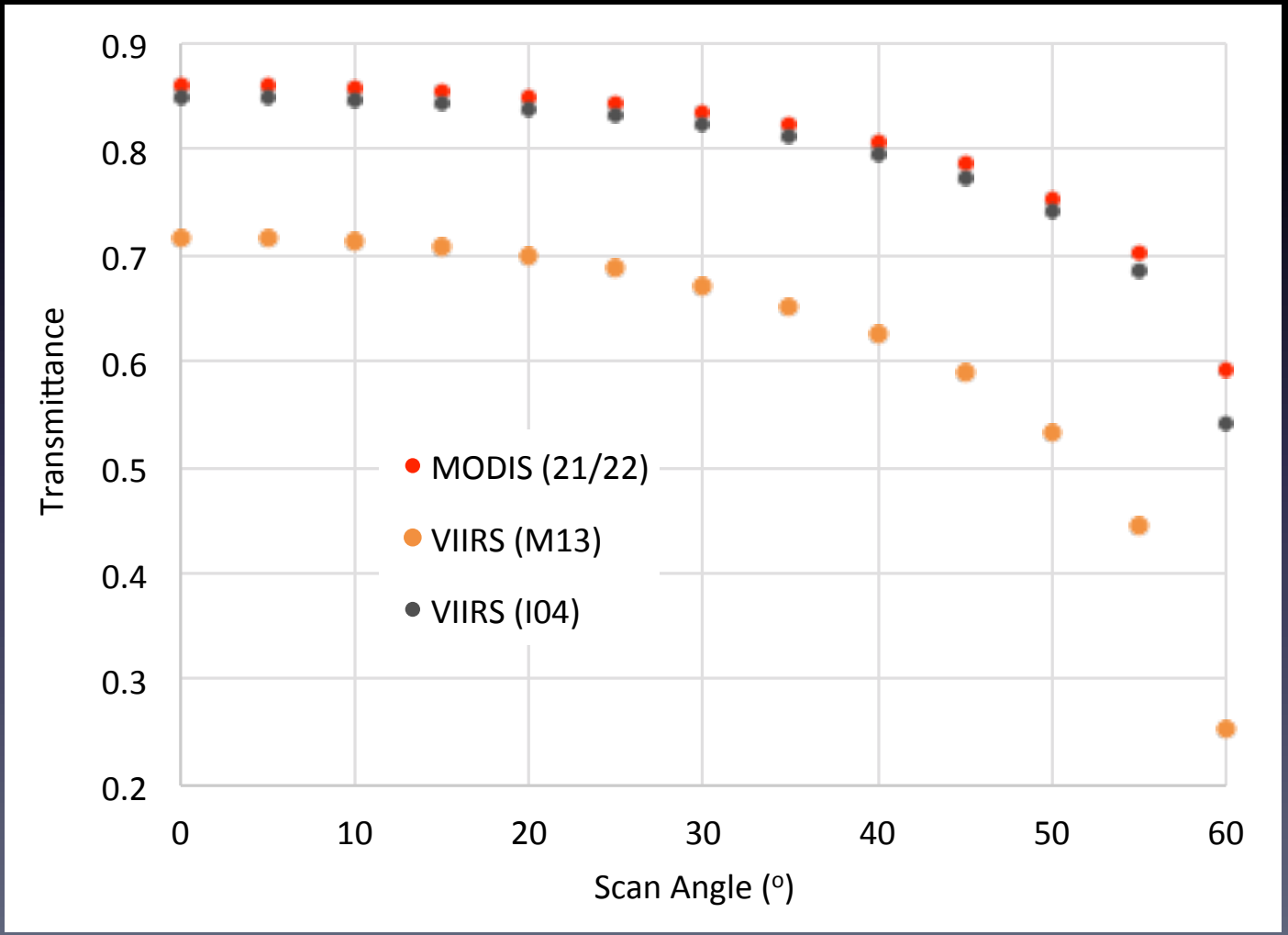
| VIIRS | | | MODIS Equivalent | | | AVHRR-3 Equivalent | | | OLS Equivalent | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Band | Range (um) | HSR (m) | Band | Range | HSR | Band | Range | HSR | Band | Range | HSR |
| DNB | 0.500 - 0.900 | | | | | | | | HRD<br>PMT | 0.580 - 0.910<br>0.510 - 0.860 | 550<br>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<br>10 | 0.459 - 0.479<br>0.483 - 0.493 | 500<br>1000 | | | | | | |
| M4 | 0.545 - 0.565 | 750 | 4<br>12 | 0.545 - 0.565<br>0.546 - 0.556 | 500<br>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<br>14 | 0.662 - 0.672<br>0.673 - 0.683 | 1000<br>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<br>22<br>23 | 3.929 - 3.989<br>3.929 - 3.989<br>4.020 - 4.080 | 1000<br>1000<br>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<br>32 | 10.780 - 11.280<br>11.770 - 12.270 | 1000<br>1000 | 4<br>5 | 10.300 - 11.300<br>11.500 - 12.500 | 1100<br>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 | | | |

# Primary 750m MIR Channel Overlapping $CO_2$ Absorption Band



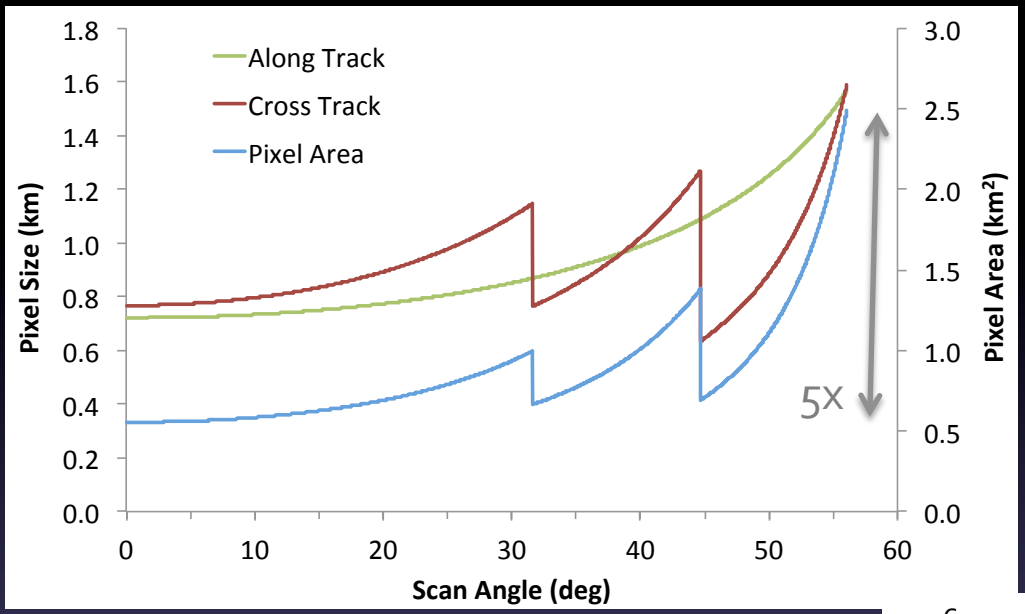
# Primary 750m MIR Channel Overlapping $CO_2$ Absorption Band

MODTRAN Simulation Using Standard Atmospheric Profile



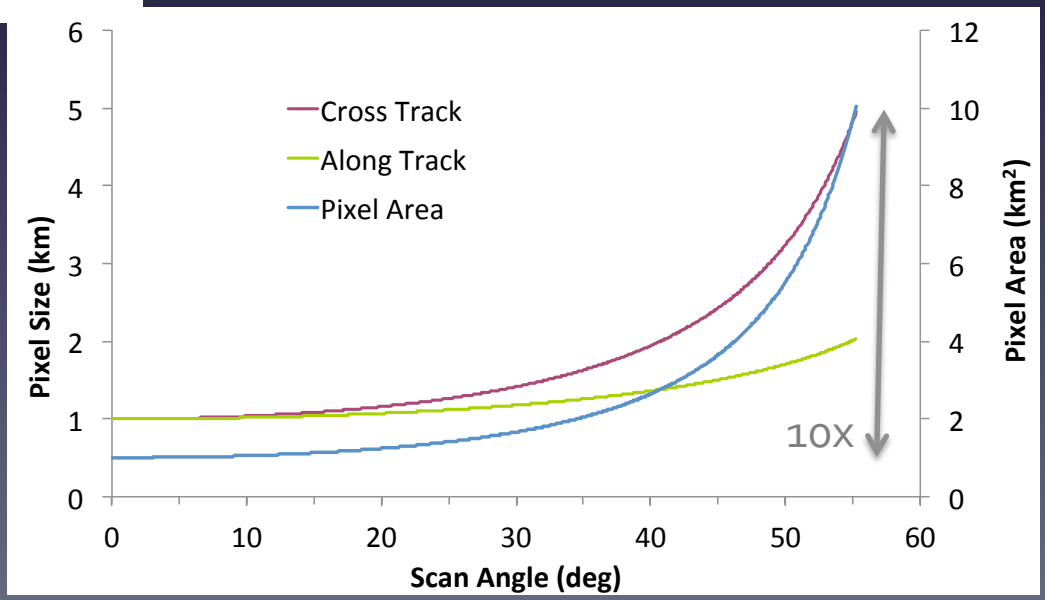
# VIIRS × MODIS

## Spatial Resolution

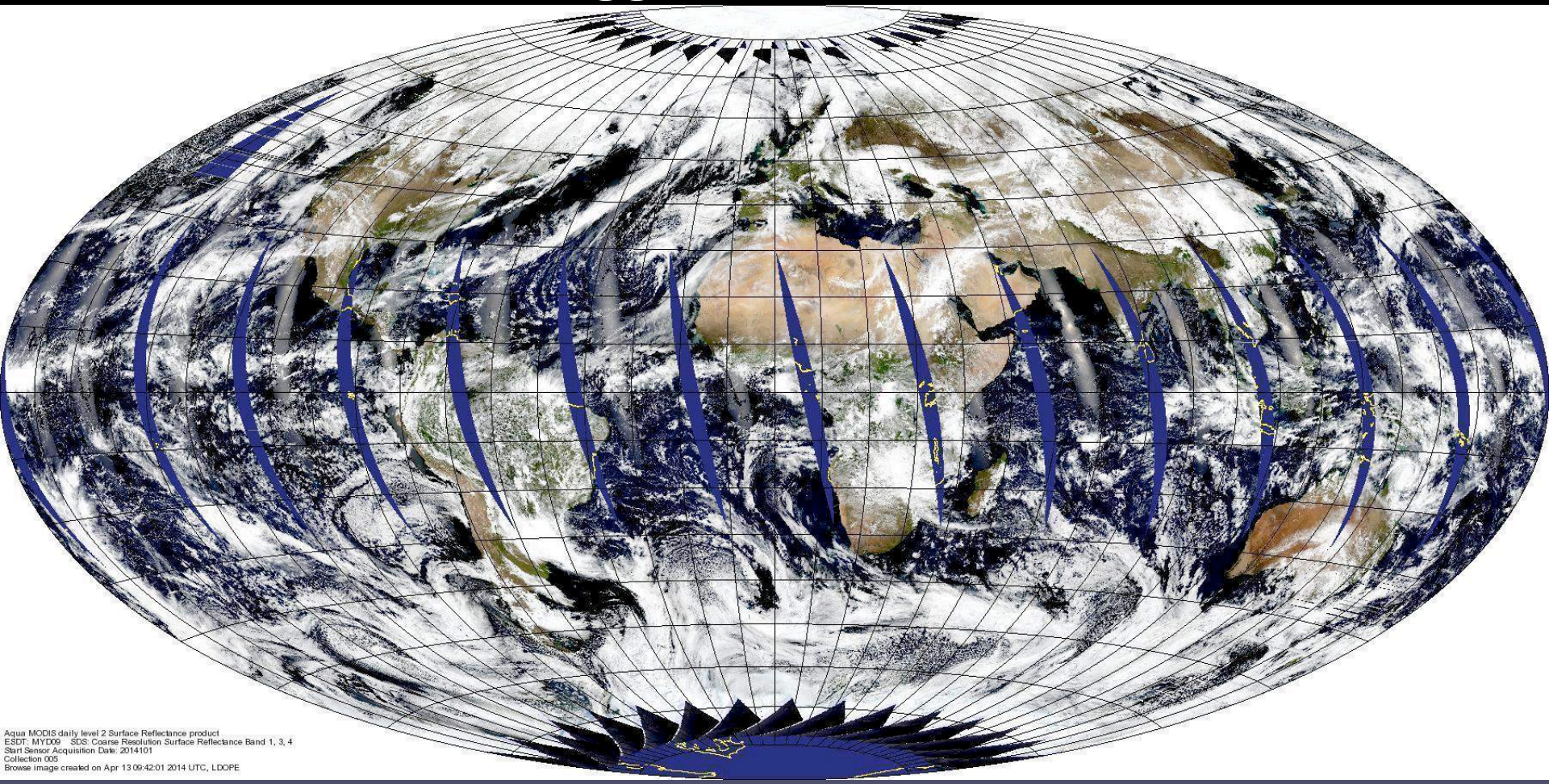



MODIS 1km

Data aggregation performed for all VIIRS 750 m (and 375 m) channels (dual-gain data processed on the ground)

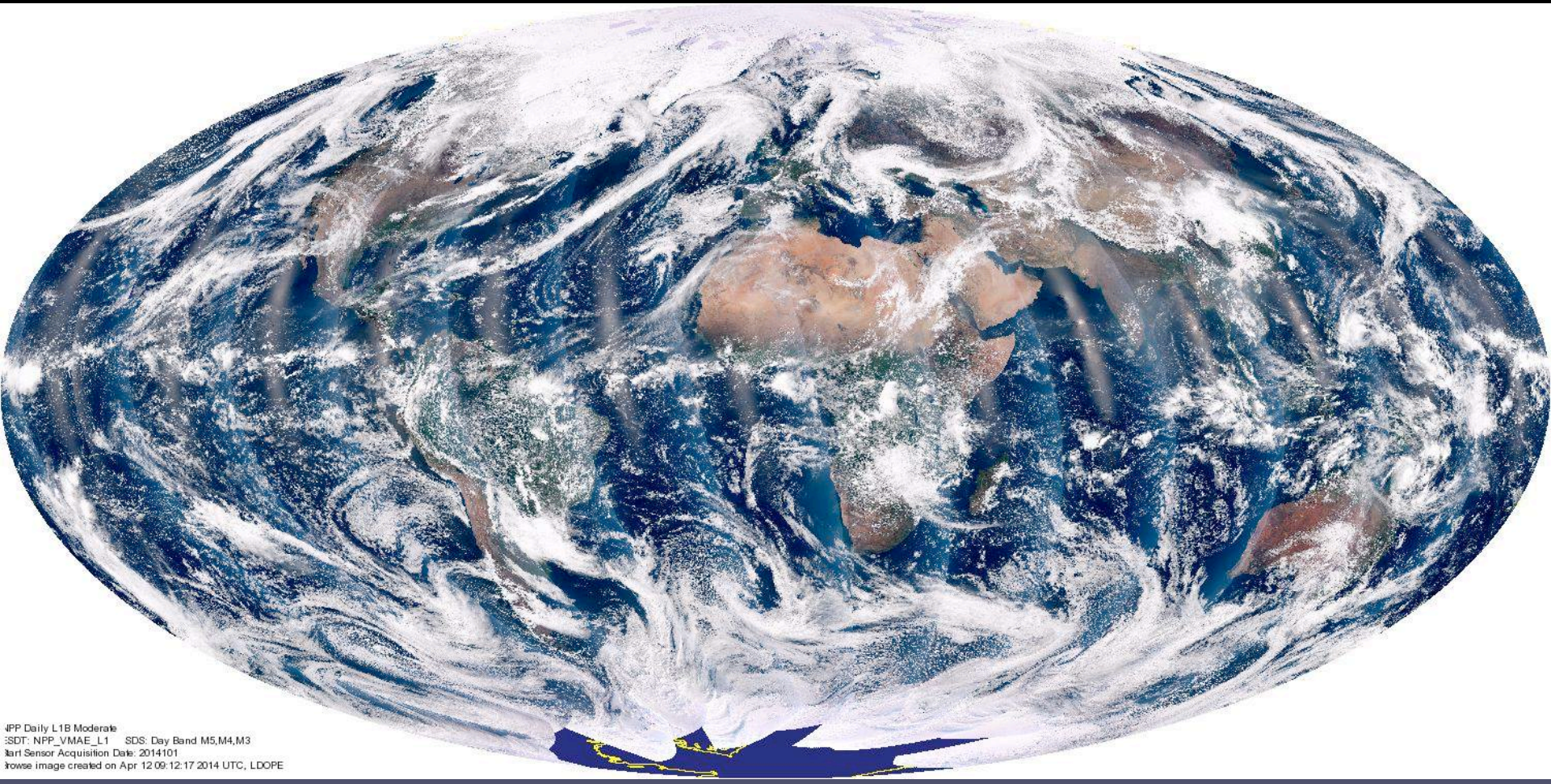


# MODIS 1 km Global Coverage
# 2330 km Swath



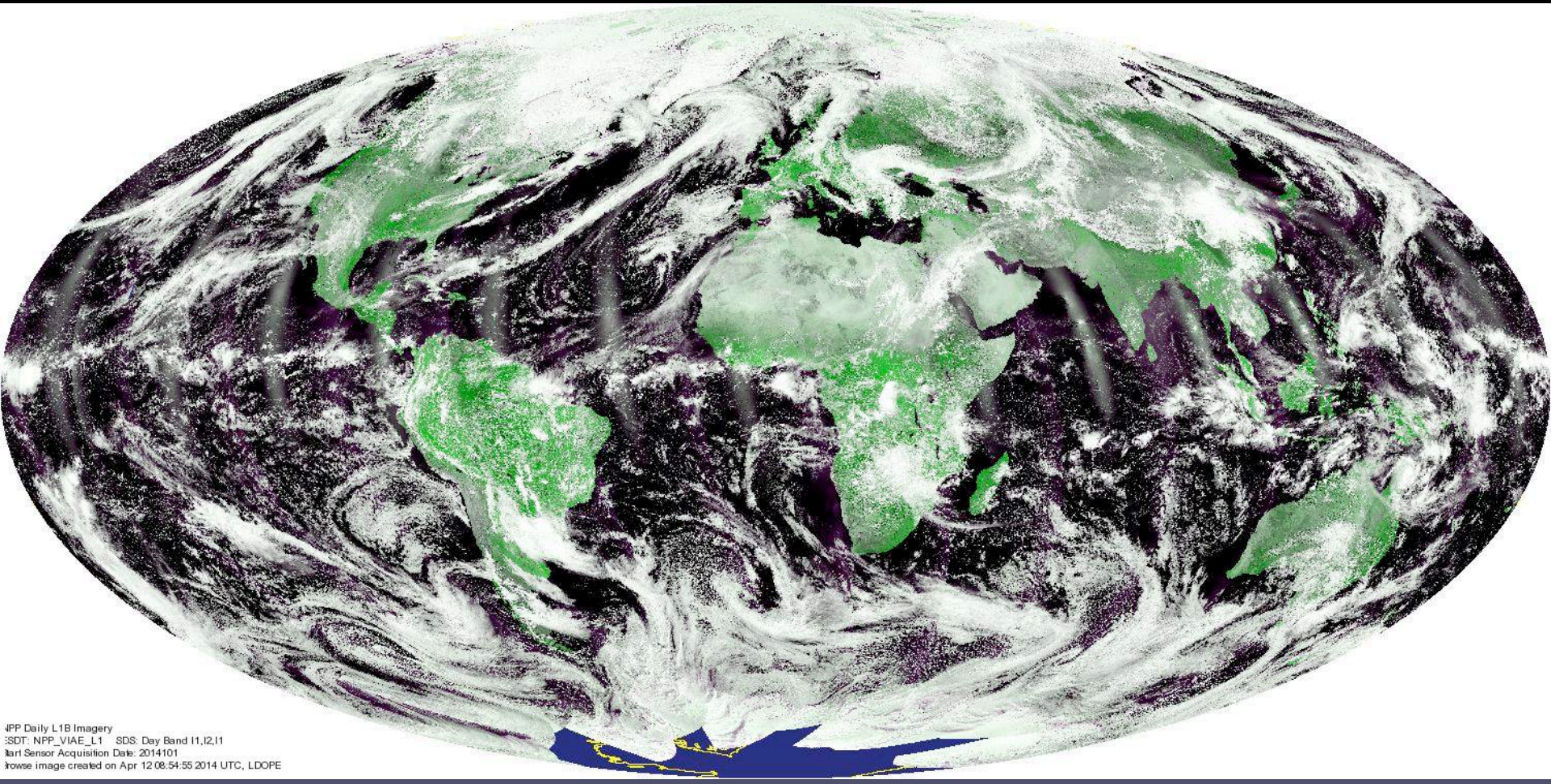

Launched: Dec/1999 (Terra) and May/2002 (Aqua)
Observation times (local): 10:30am/pm (Terra) 1:30pm/am (Aqua)
Fire product features: detection and characterization (Fire Radiative Power)

# VIIRS 750 m Global Coverage
# 3000 km Swath



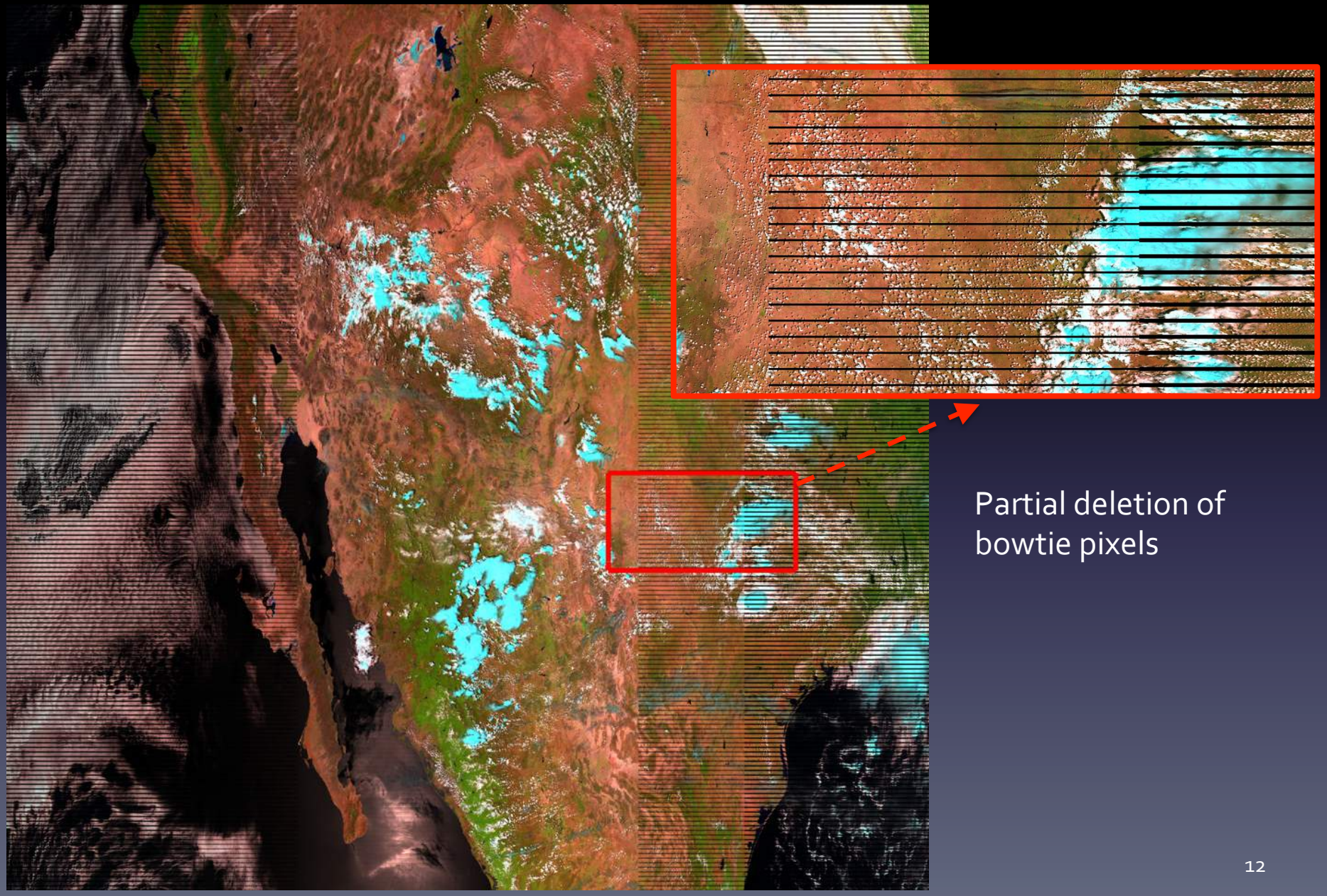

Launched: Oct/2012
Observation times (local): 1:30pm/am
Fire product features: detection and characterization (Fire Radiative Power)

# VIIRS 375 m Global Coverage
# 3000 km Swath



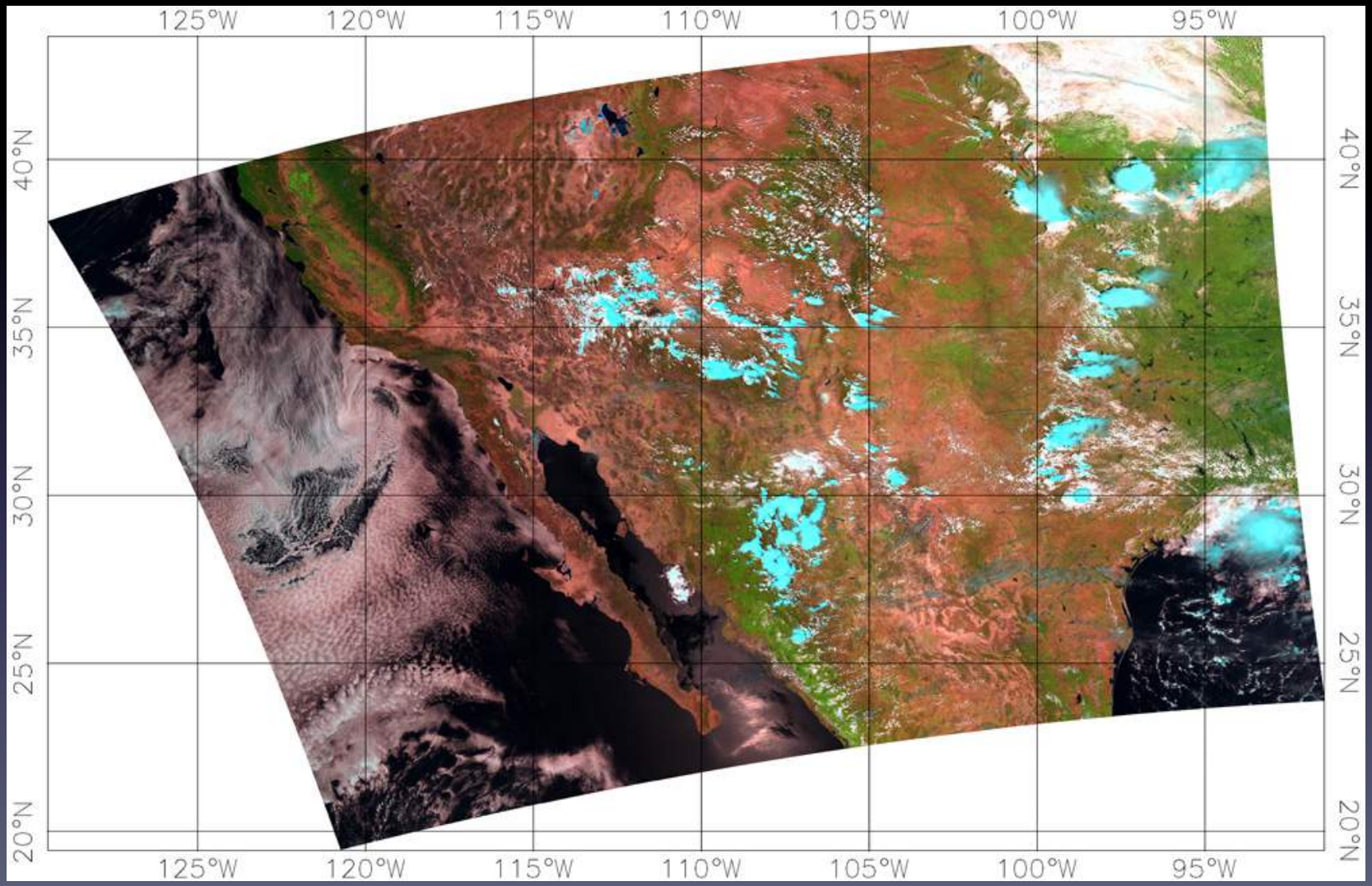

Launched: Oct/2012
Observation times (local): 1:30pm/am
Fire product features: detection

# VIIRS Level 1 Data (swath)



Partial deletion of bowtie pixels

# VIIRS Resampled Data



# The Visible Infrared Imaging Radiometer Suite (VIIRS)

**NOAA (750m product)**

- Operational data
- No re-processing capabilities (being considered)
- Based on MODIS C4
  - List of lat/lon coordinates
  - No fire mask
  - No FRP
- NOAA CLASS archive
- HDF5 ~5min segments
- MODIS C6 code being implemented in parallel processing system (NDE)

**NASA (750m product)**

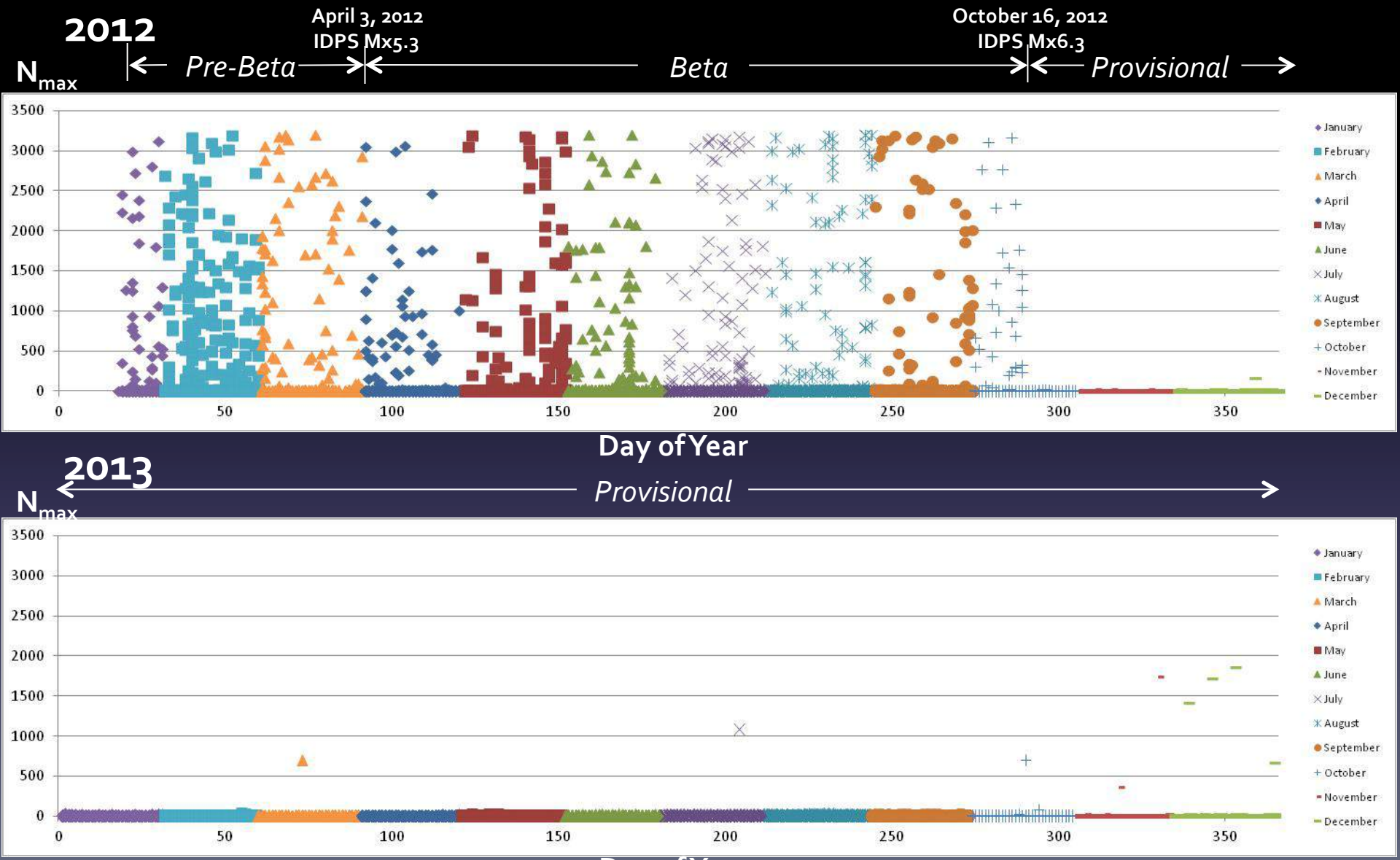
- Science data
- Pre-processing capability in place
- Based on MODIS C6
  - Fire mask
  - FRP
- Land SIPS archive
- HDF4 ~5min segments
  - Transitioning to NetCDF

**NASA (375m product)**

- Science/experimental data
- Builds on MODIS methodology
  - Fire mask
  - No FRP due to frequent saturation
- Being implemented at Land SIPS

Slowly progressing towards hybrid algorithm

# NOAA (IDPS) NPP Active Fire Product history: data anomalies and product maturity (2/1)



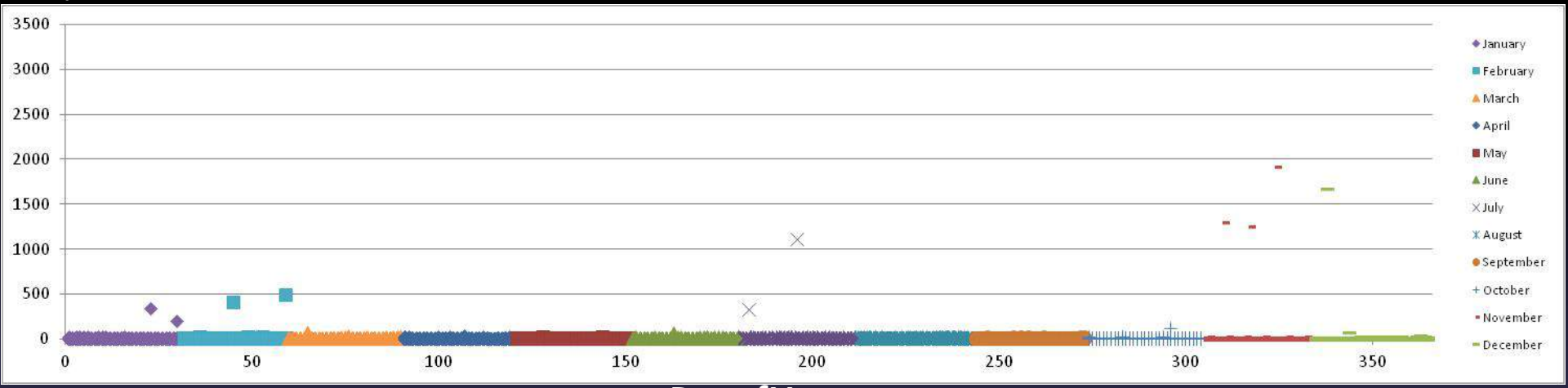

*$N_{max}$: maximum number of detections within a scanline*

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

**2014**

August 13, 2014
IDPS Mx8.5

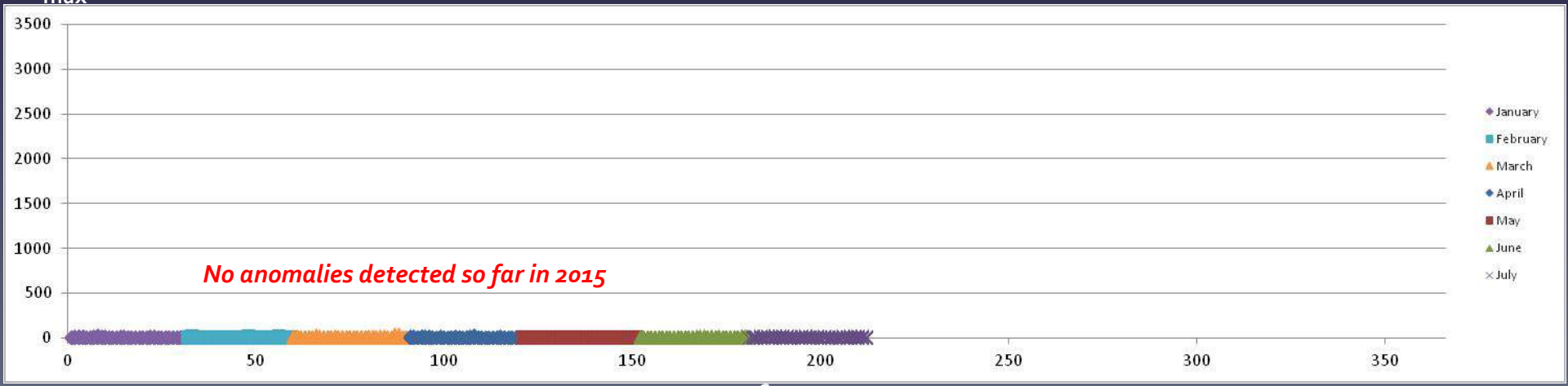
$N_{max}$ ← *Provisional* → | ← *Validated stage 1* →




Day of Year

**2015**

$N_{max}$ ← *Validated stage 1* ---------→

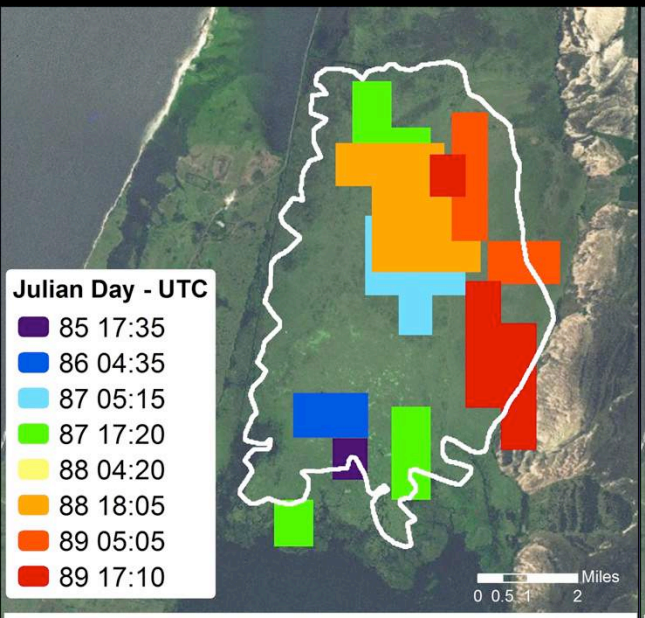



Day of Year

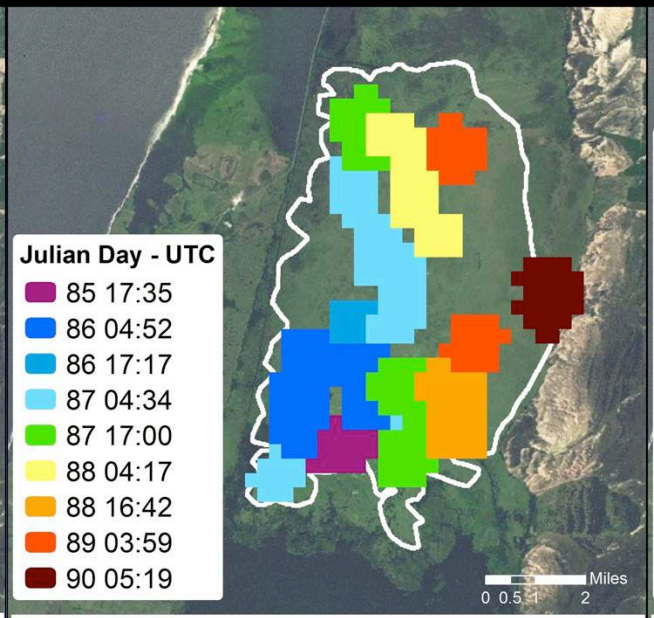
*$N_{max}$: maximum number of detections within a scanline*

# MODIS 1 km × VIIRS 750 m × VIIRS 375 m Fire Data Intercomparison

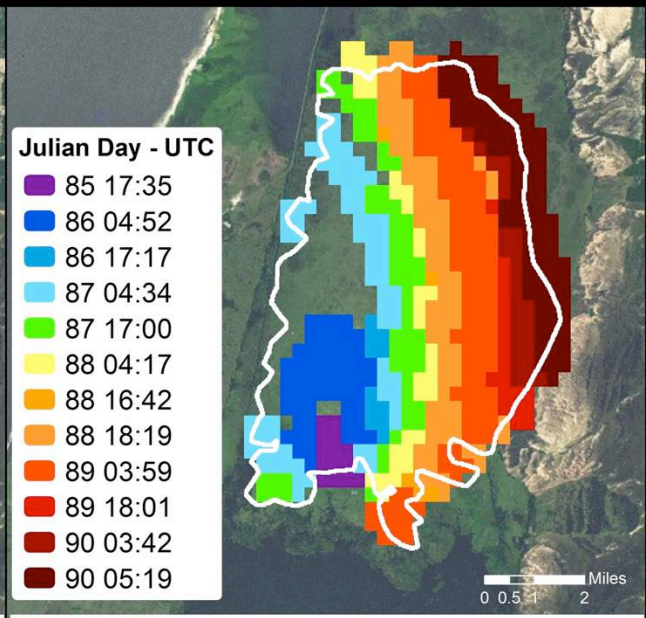
Taim Ecological Reserve, Southern Brazil (March 2013)




Aqua/MODIS 1 km




NPP/VIIRS 750 m




NPP/VIIRS 375 m

Pixel Area
1<>10 km²

Image Swath
2330 km

Pixel Area
0.56<>2.5 km²

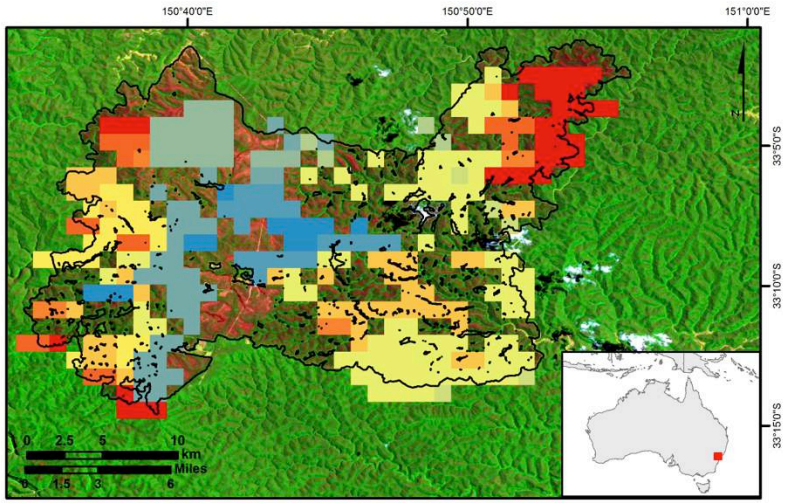
Image Swath
3000 km

Pixel Area
0.14<>0.625 km²

Image Swath
3000 km

# *Improved Satellite Mapping of Active Fires Using VIIRS 375m Data*

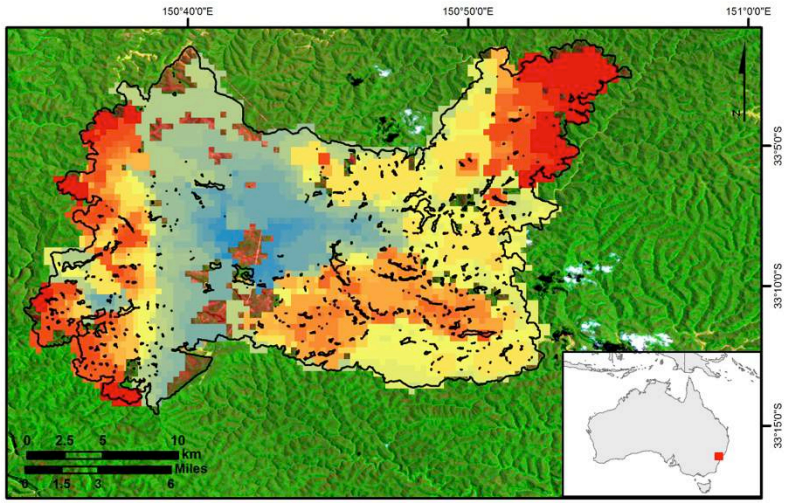
**Aqua/MODIS 1km**




**MODIS-Aqua 1km**

| Date_Time (UTC) | | | |
|---|---|---|---|
| 20131024 04:00 | 20131027 04:30 | 20131103 04:35 | 20131107 04:10 |
| 20131025 04:40 | 20131028 03:35 | 20131104 03:40 | 20131108 04:55 |
| 20131026 03:55 | 20131028 04:05 | 20131105 04:25 | 20131109 04:00 |
| | 20131102 03:55 | 20131106 03:30 | |

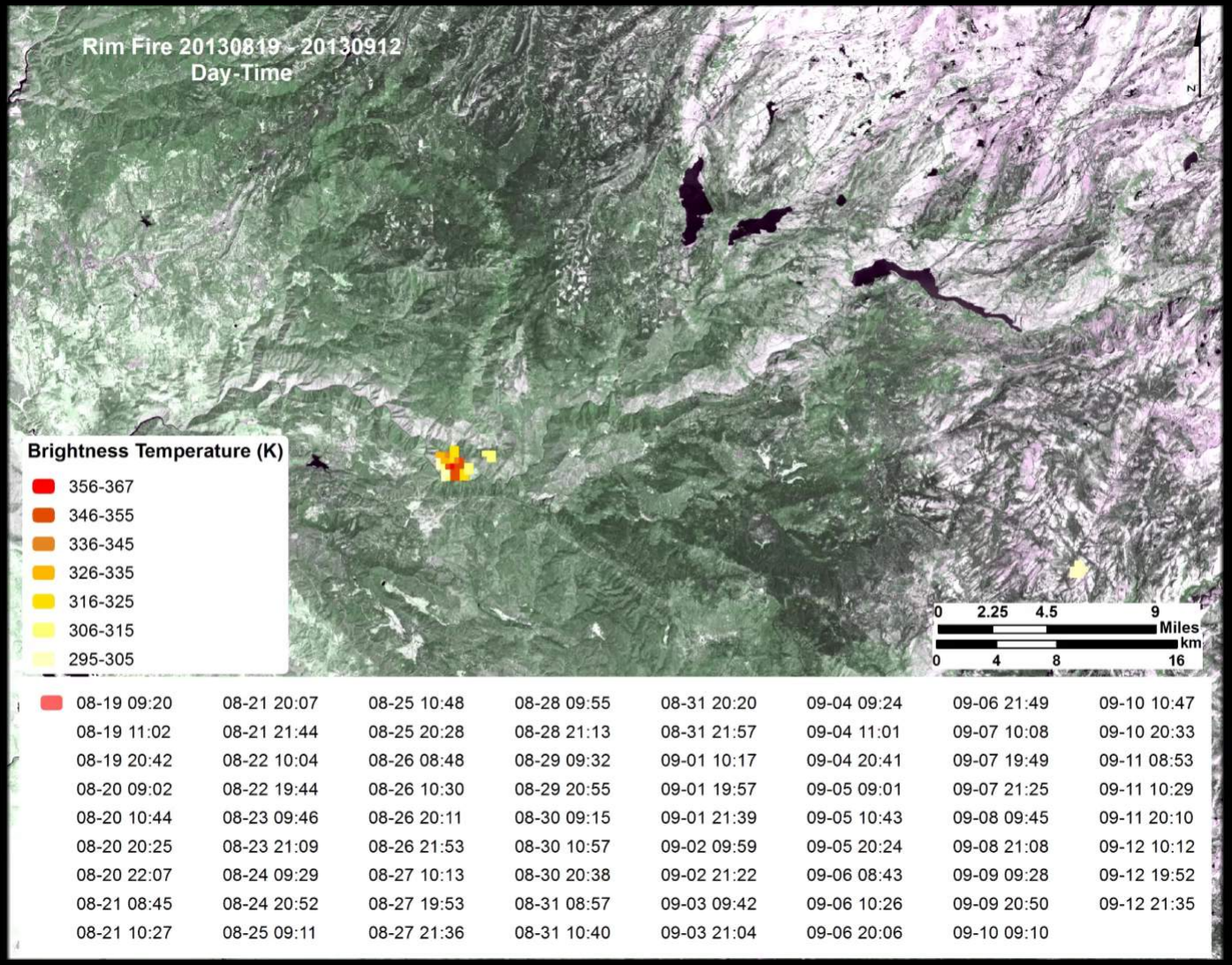
**S-NPP/VIIRS 375m**

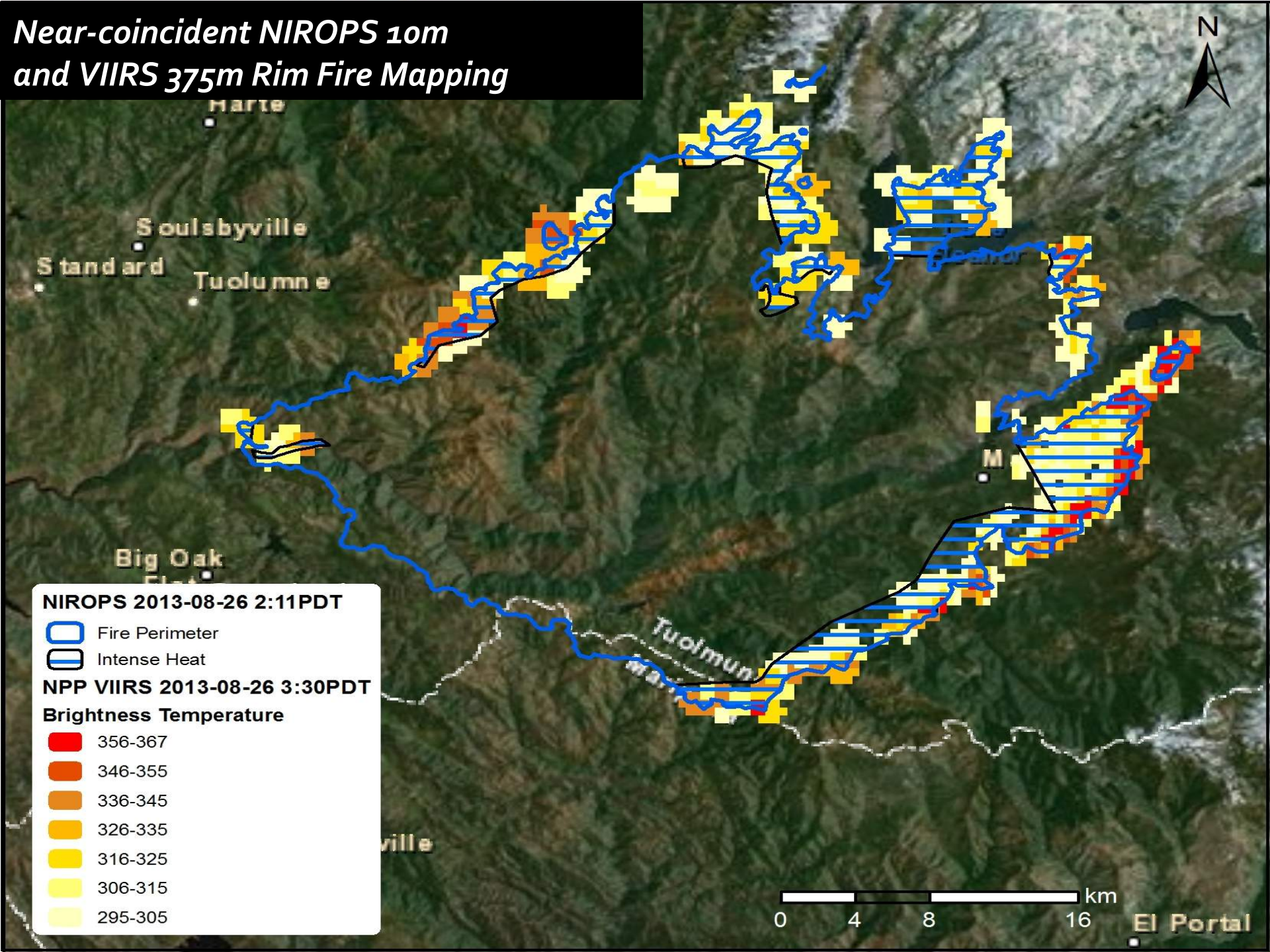



**VIIRS 375m**

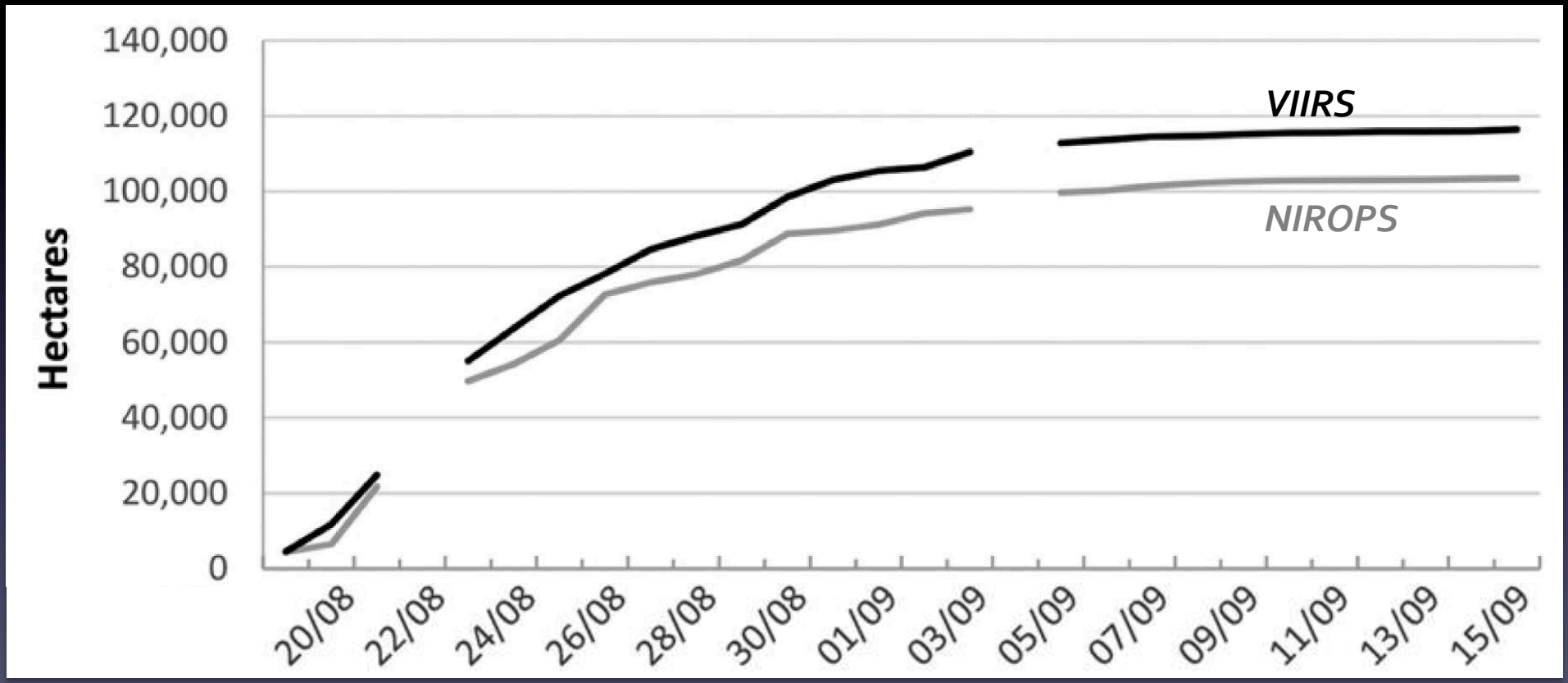
| Date_Time (UTC) | | | |
|---|---|---|---|
| 20131023 14:27 | 20131026 15:12 | 20131103 03:05 | 20131106 03:50 |
| 20131024 04:29 | 20131027 03:37 | 20131103 04:42 | 20131106 15:07 |
| 20131024 14:10 | 20131027 14:54 | 20131103 14:23 | 20131107 03:26 |
| 20131024 15:52 | 20131028 14:36 | 20131103 16:05 | 20131107 14:49 |
| 20131025 04:12 | 20131031 03:58 | 20131104 04:25 | 20131108 04:51 |
| 20131025 15:29 | 20131101 14:58 | 20131104 15:42 | 20131108 14:26 |
| 20131026 03:54 | 20131102 03:23 | 20131105 04:07 | 20131109 04:34 |
| | 20131102 14:40 | 20131105 15:24 | |

# GIS Mapping of 2013 Rim Fire/ CA Using New VIIRS 375 m ≈12h Data

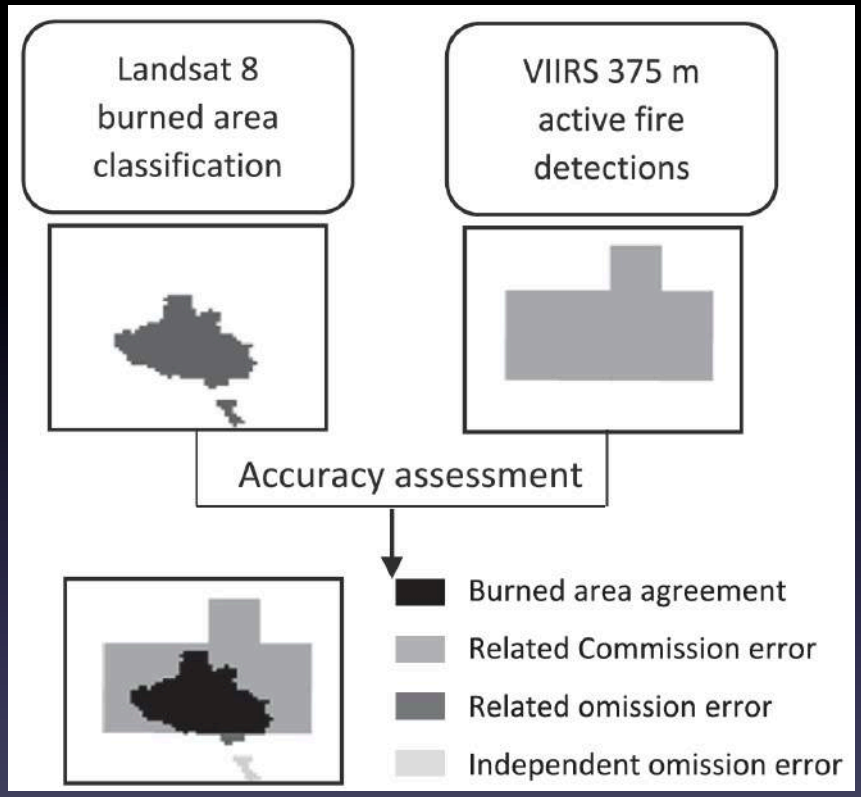


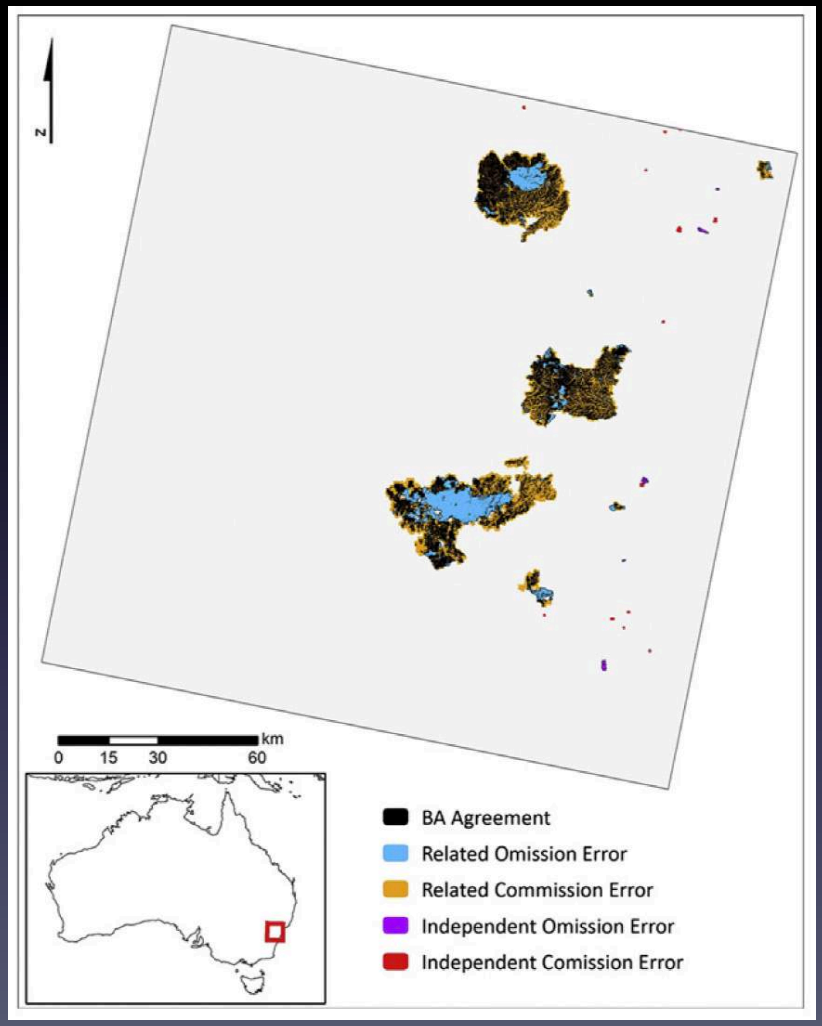

Near-coincident NIROPS 10m
and VIIRS 375m Rim Fire Mapping
N
Harte
Soulsbyville
Standard
Tuolumne
Big Oak
Tuolumn
ville
M
El Portal
NIROPS 2013-08-26 2:11PDT
Fire Perimeter
Intense Heat
NPP VIIRS 2013-08-26 3:30PDT
Brightness Temperature
356-367
346-355
336-345
326-335
316-325
306-315
295-305
km
0
4
8
16

# *Daily Fire Growth Mapping of 2013 Rim Fire/ CA Using New VIIRS 375 m and NIROPS (10 m airborne) Data*



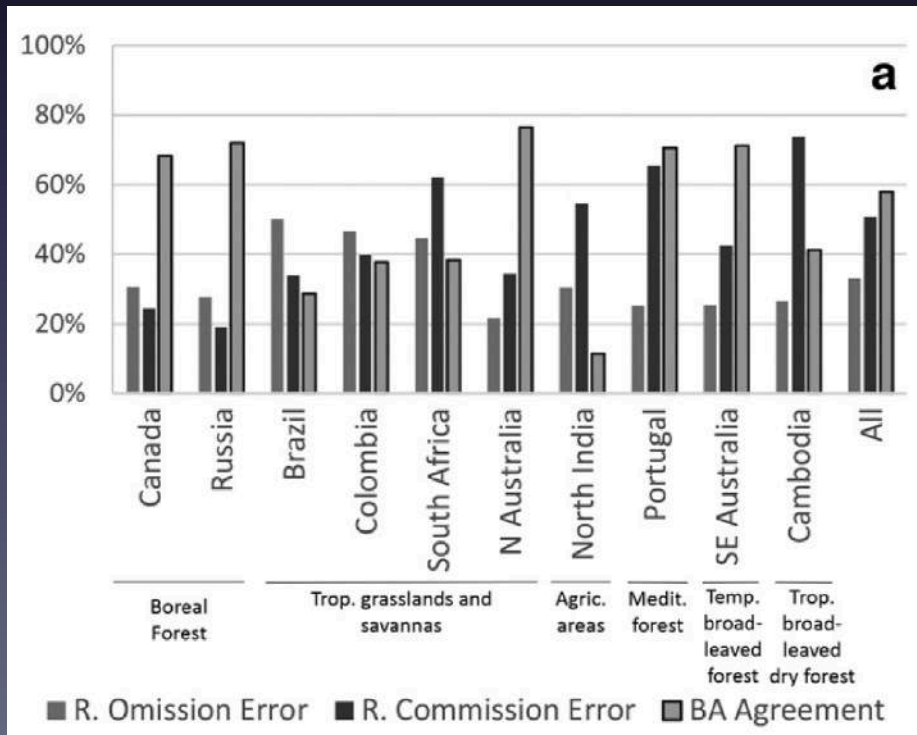
# *Assessment of VIIRS 375mactive fire detection product for direct burned area mapping*

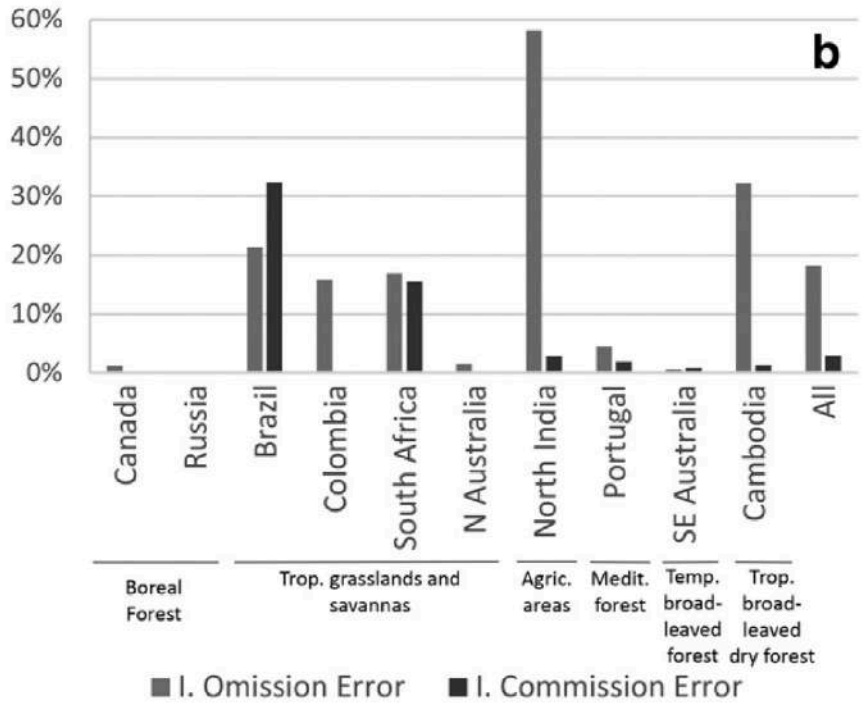


# *Assessment of VIIRS 375mactive fire detection product for direct burned area mapping*

| Biome | Study area | Fires >0.9 ha | | | Fires >10 ha | | | |
|---|---|---|---|---|---|---|---|---|
| | | N. of fires detected | | Fire detection rate (%) | N. of fires detected | | Fire detection rate (%) | Reference BA (%) |
| | | Reference dataset | VIIRS | | Reference dataset | VIIRS | | |
| Boreal forest | Canada | 5 | 4 | 80.00 | 5 | 4 | 80.00 | 100 |
| | Russia | 7 | 6 | 85.71 | 7 | 6 | 85.71 | 100 |
| Tropical grasslands and savannas | Brazil | 129 | 25 | 19.38 | 56 | 14 | 25.00 | 99.41 |
| | Colombia | 3094 | 596 | 19.26 | 892 | 389 | 43.60 | 98.13 |
| | South Africa | 8239 | 1479 | 17.95 | 794 | 382 | 48.11 | 92.52 |
| | North Australia | 505 | 242 | 47.92 | 136 | 109 | 80.15 | 99.25 |
| Agric. area | North India | 70,648 | 5478 | 7.75 | 2637 | 760 | 28.82 | 67.00 |
| Mediterranean forest | Portugal | 1568 | 766 | 48.85 | 298 | 241 | 80.87 | 97.06 |
| Temp. BL forest | SE Australia | 13 | 8 | 61.54 | 13 | 8 | 61.54 | 100 |
| Trop. BL dry forest | Cambodia | 41,681 | 10,757 | 25.81 | 1974 | 1285 | 65.09 | 71.46 |



# *The New Landsat-8 30 m Active Fire Detection Data*

***Pros***:

>150x more information per unit area than VIIRS 375 m

>1000x more information per unit area than MODIS 1km

***Cons***:

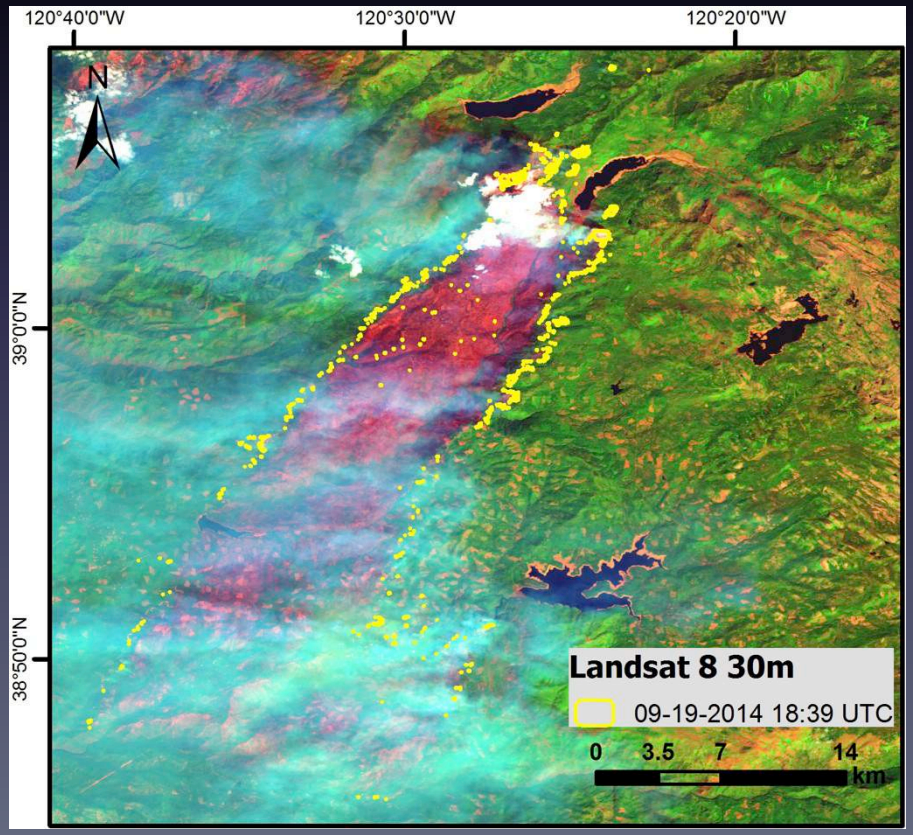
Limited coverage (16 day-interval)

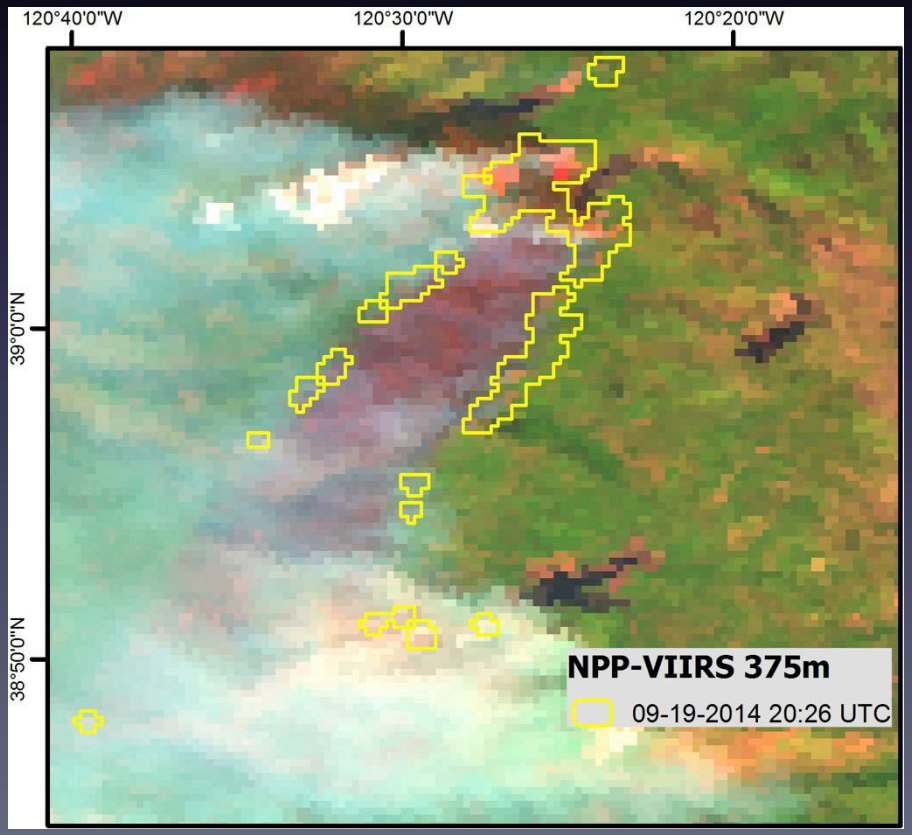
***Potential***:

Launch of other similar sensors could greatly increase data availability in the future (2-3 years)

Near real-time data processing/distribution being explored

Community can/will have a major role defining the future of Landsat-class data applications



# Data Validation

- *Use of Landsat-class data to validate VIIRS is not an option due to prohibitively large time separation between same-day acquisitions*
- *Use of prescribed fires (easy/accessible)*
- *Coincident ground, airborne, spaceborne data acquisitions*
- *Community-organized (reduce spending, maximize output)*

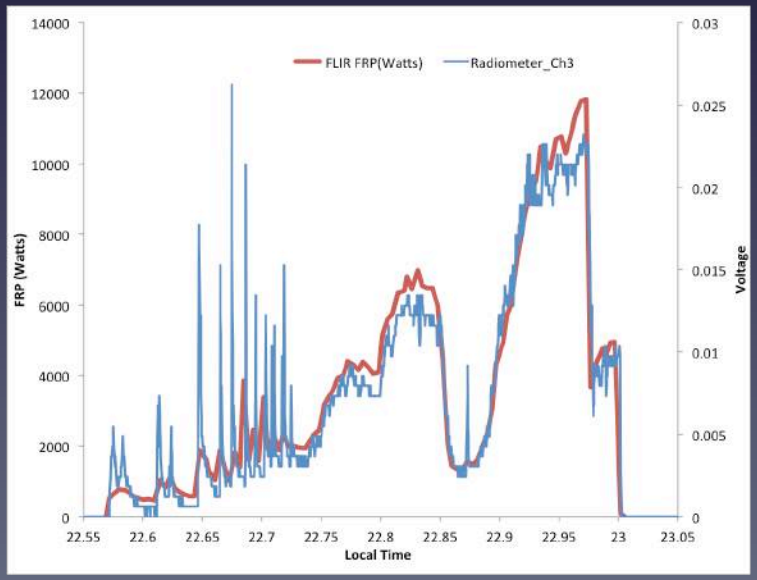
# Data Validation

Experimenting new/inexpensive ways of collecting reference data in support of algorithm validation

- Use of relatively low-cost drones
- Use of relatively low-cost instrumentation

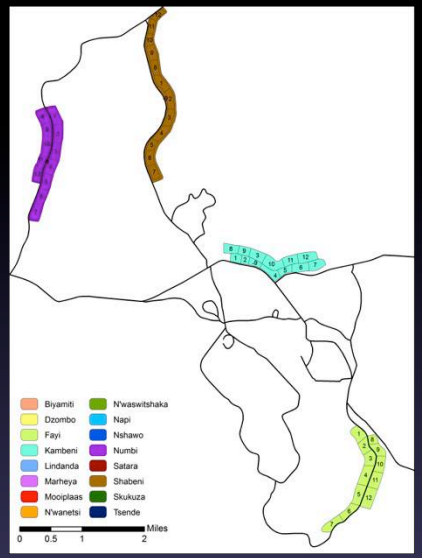
Dual-band radiometer ($)

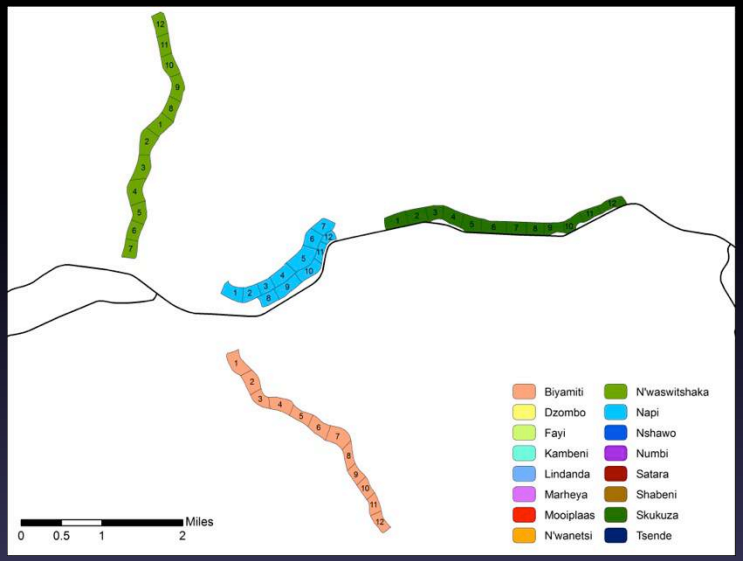

Hexacopter + FLIR camera ($$)

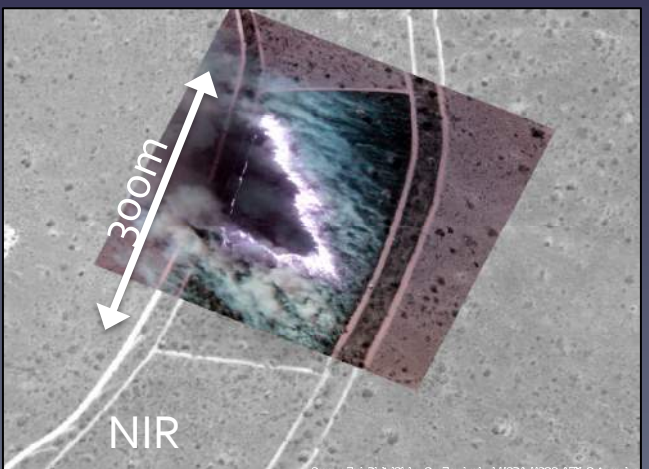


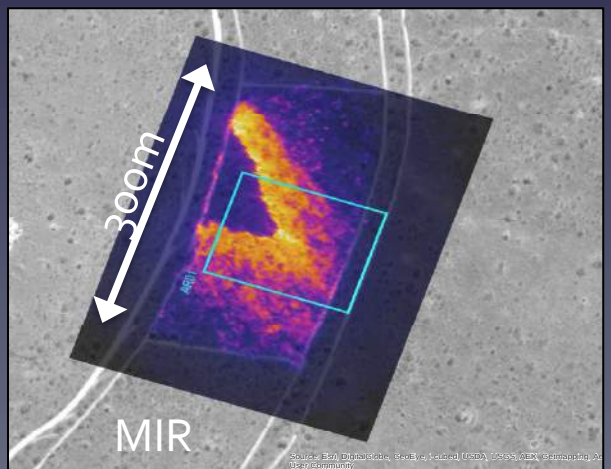
# Experimental Fires in Kruger National Park/South Africa August 2014

Several plots averaging **7 ha** in area



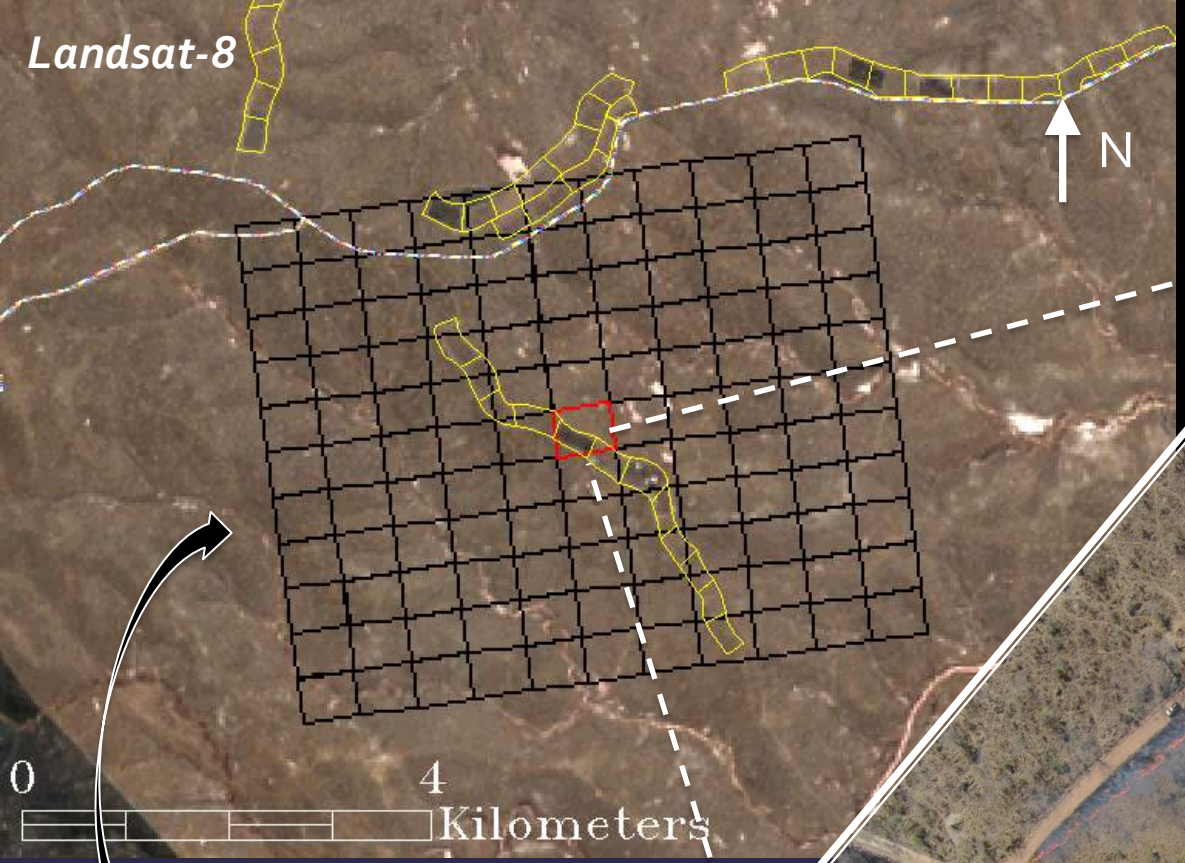



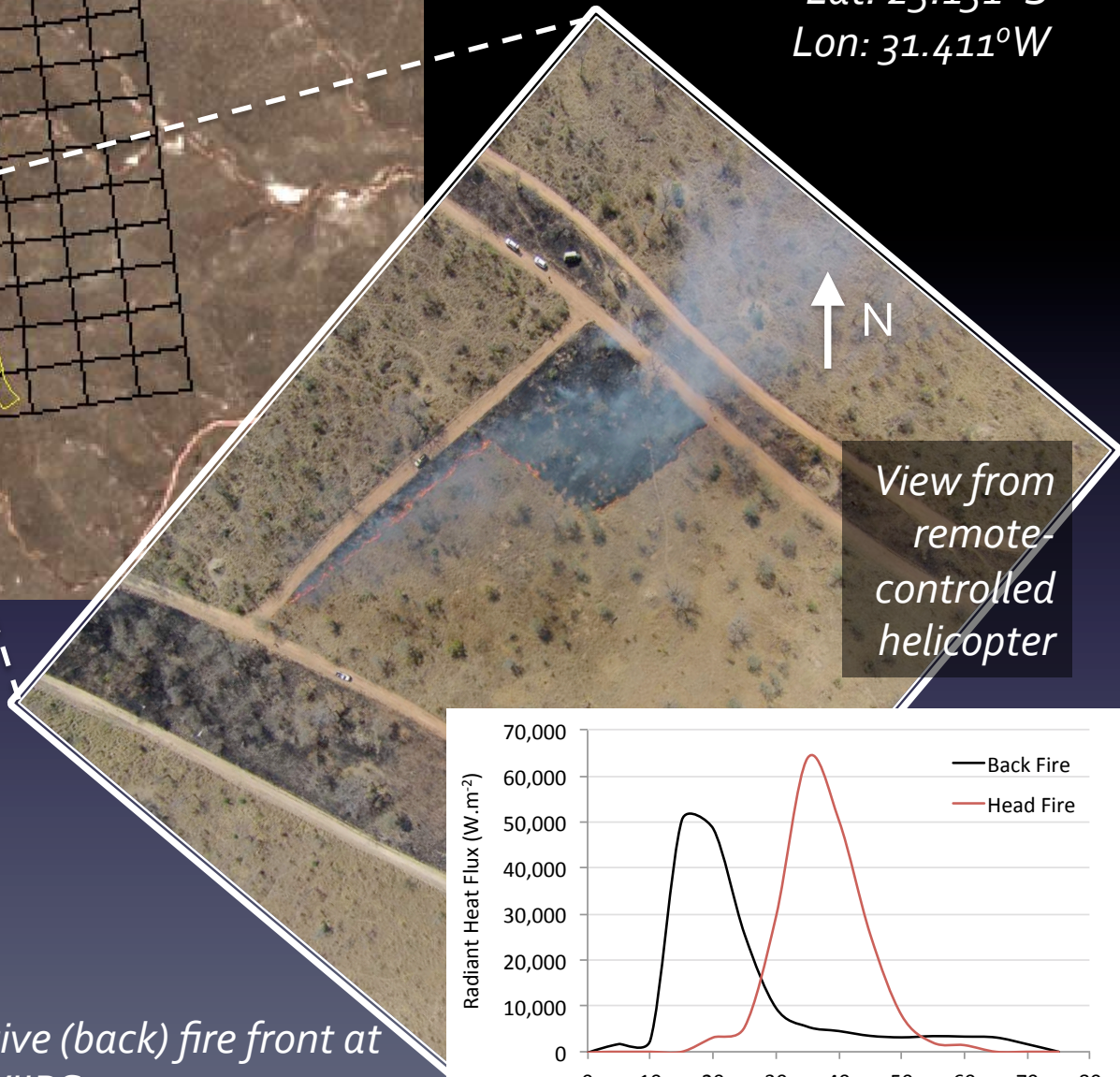





Kruger National Park,
26 Aug 2014
Lon: 31.442° E
Lat: 25.099° S
4ha plot
5min duration




Kruger National Park
19 August 2014
Lat: 25.131° S
Lon: 31.411°W




View from remote-controlled helicopter

Subset of VIIRS 375 m pixel grid (fire detection in red)

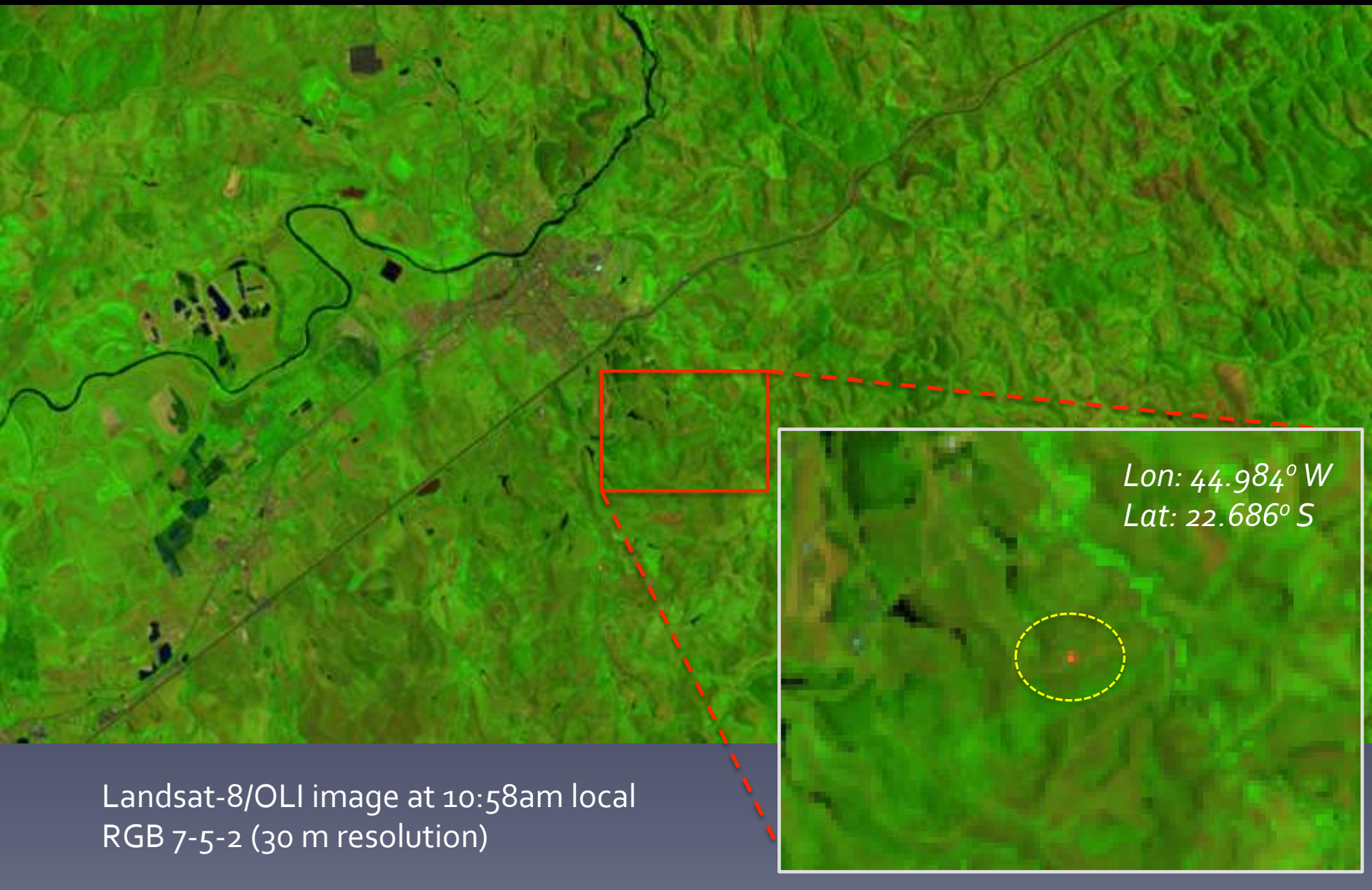
Surface-leaving FRP (VIIRS):
4.4±0.2MW
@ 13:24:26 h local time




Length of active (back) fire front at time of VIIRS overpass: 200 m

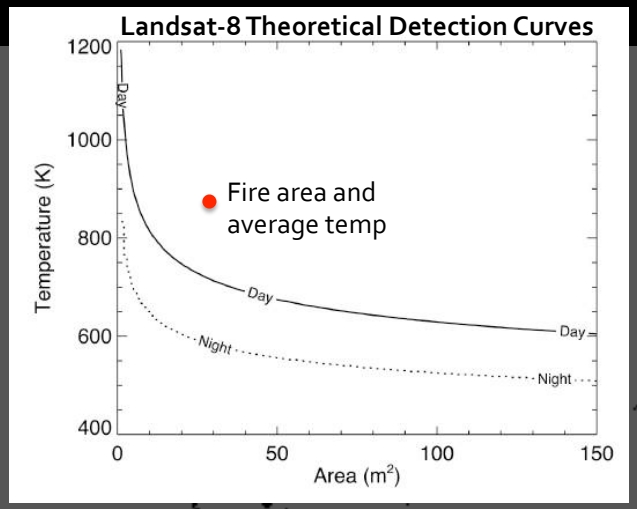
# Small Fire Validation
# Landsat-8 and VIIRS 375 m example in Cachoeira Paulista/Brazil

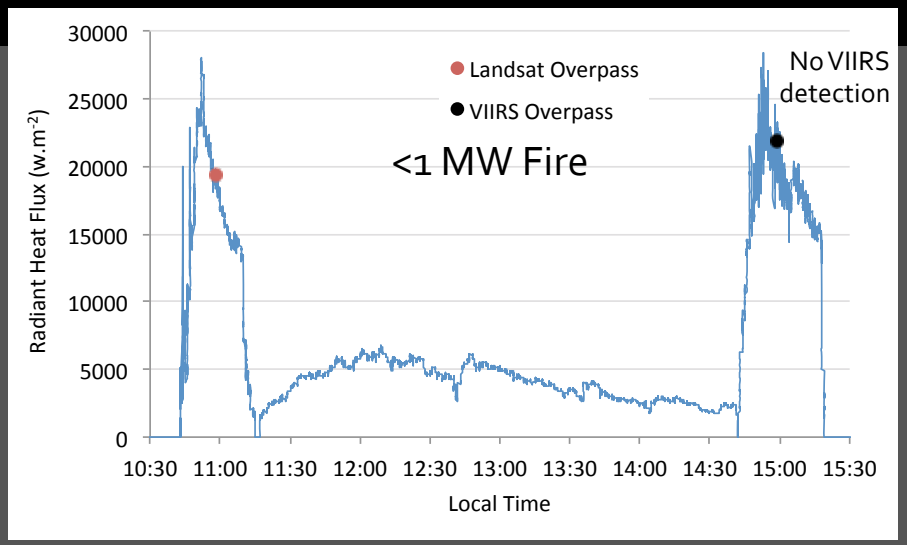
# Small Fire Validation
# Landsat-8 and VIIRS 375 m example in Cachoeira Paulista/Brazil

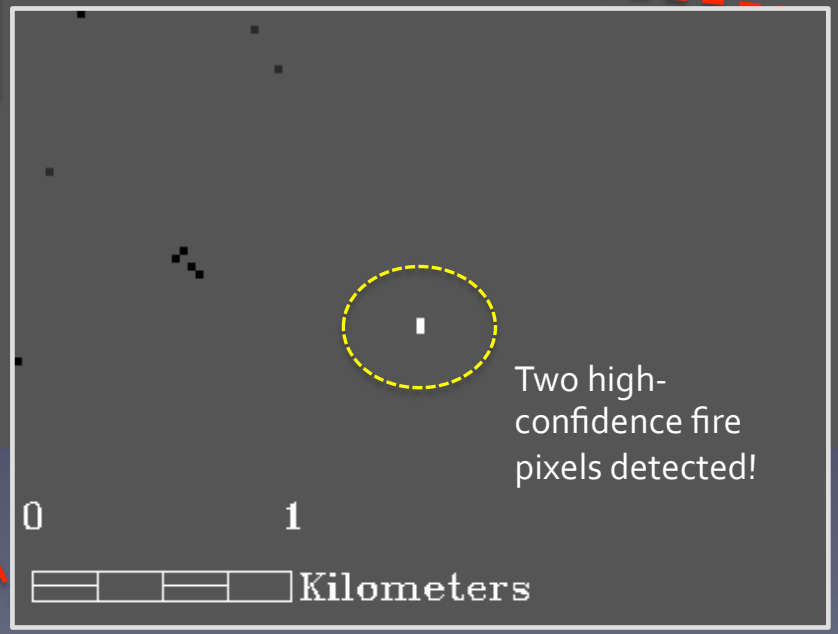



Landsat-8/OLI image at 10:58am local
RGB 7-5-2 (30 m resolution)

# Small Fire Validation
# Landsat-8 and VIIRS 375 m example in Cachoeira Paulista/Brazil



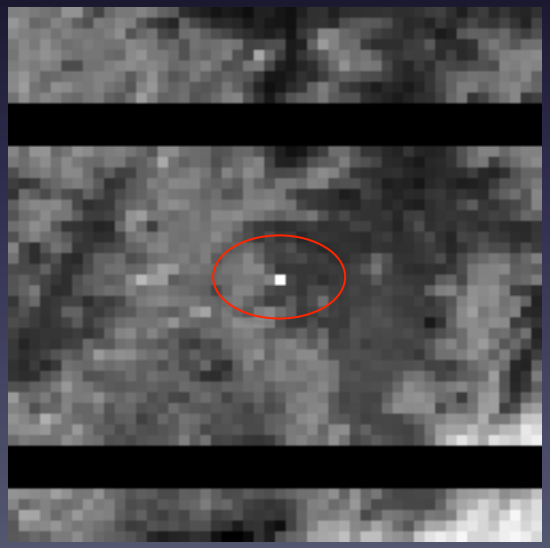




0 5 Kilometers

Fire mask (30 m resolution)

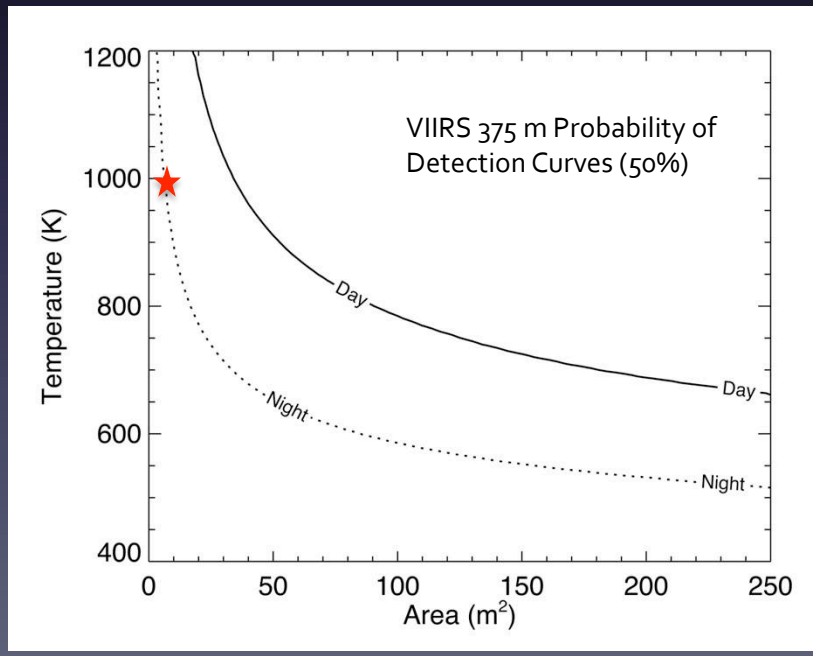
# Small Fire Validation
# VIIRS 375 m nighttime example in Rio de Janeiro/Brazil



Subset of VIIRS L1B data
08 July 2013 4:23 UTC (1:23am local)
Coinciding with bonfire

2.5 m diameter
experimental bonfire

Single pixel detection
Pixel fraction containing
active fire: 0.004%



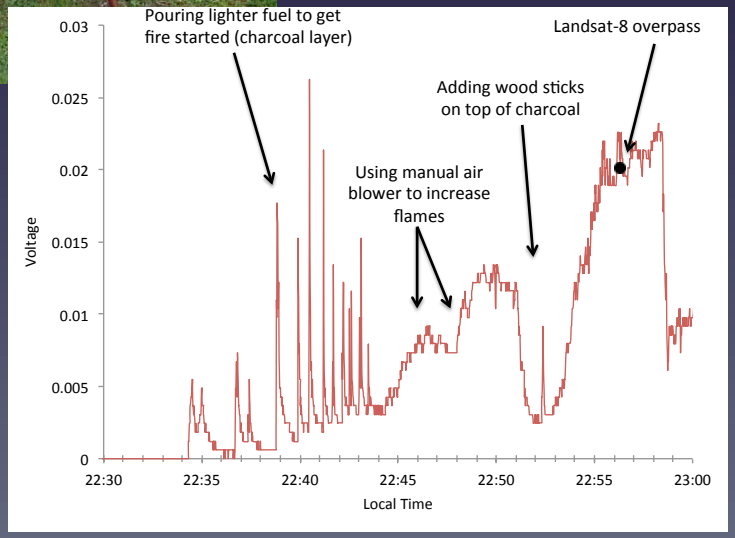
# Very Small Fire Validation
# Landsat-8 nighttime example in Greenbelt/USA

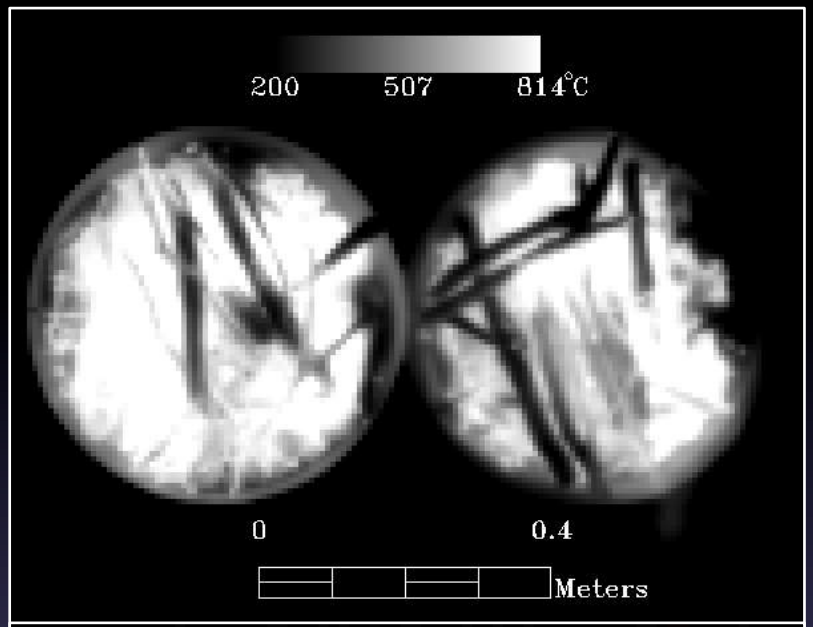
04 April 2015
10:56pm local

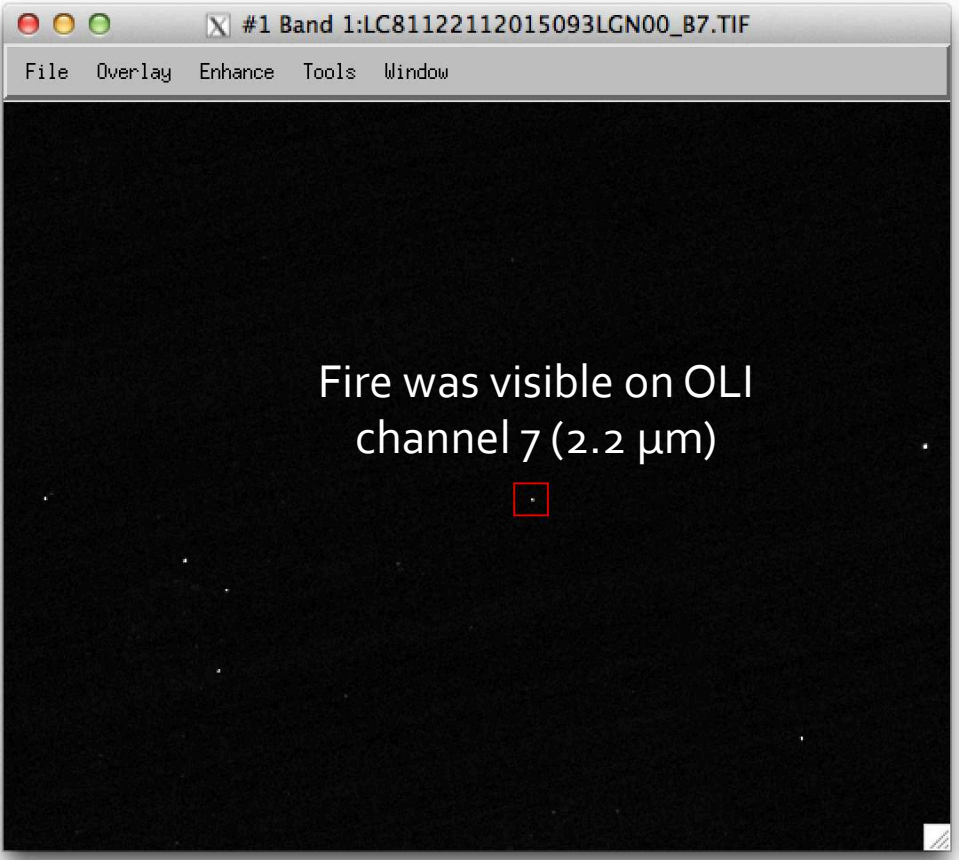
FLIR camera and dual-band radiometer mounted to 5 m telescoping tower overlooking grill fire

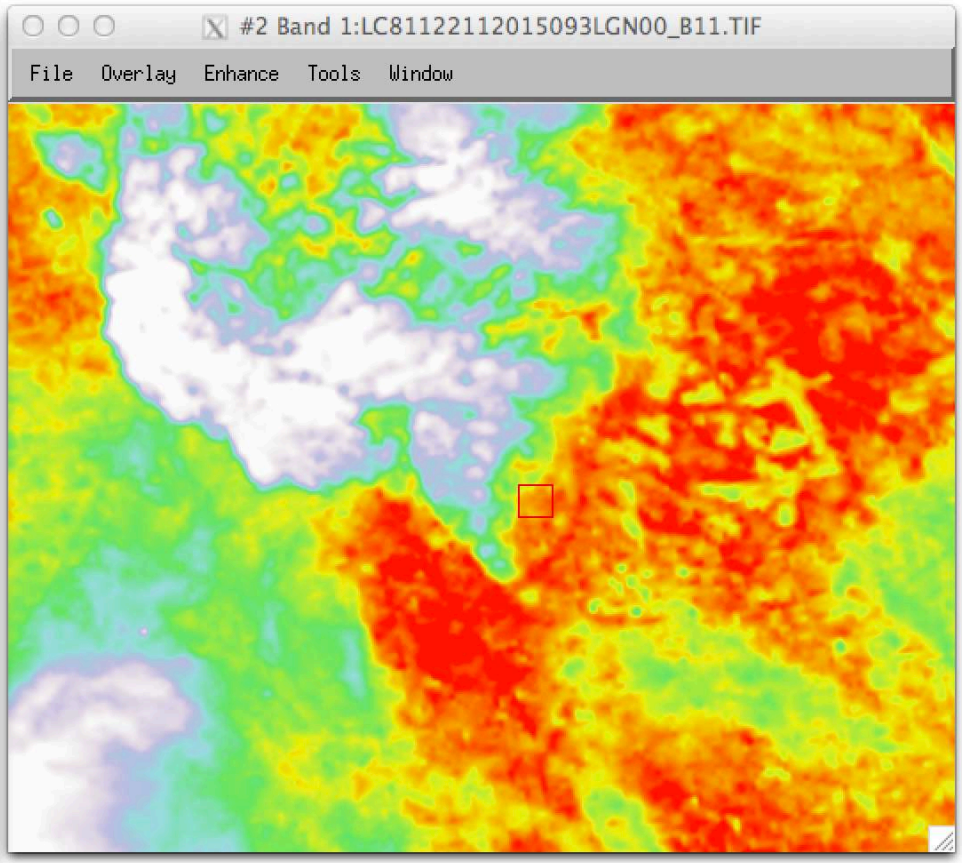
Effective area (combined): 0.5 $m^2$

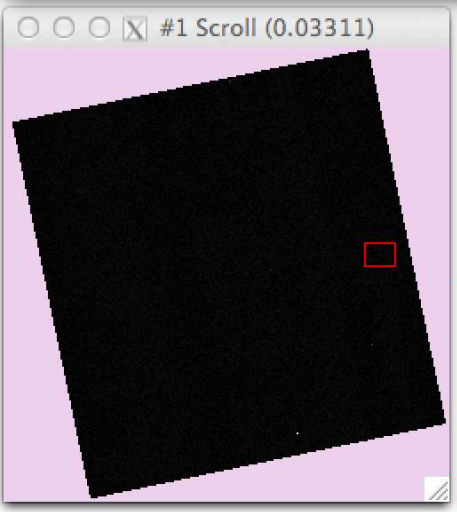
Lon: 76.870° W
Lat: 39.009° N

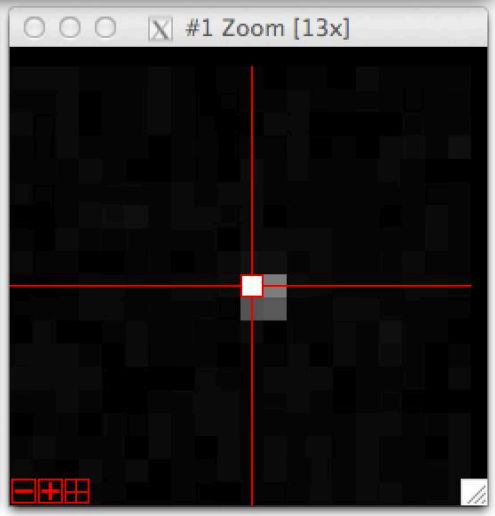


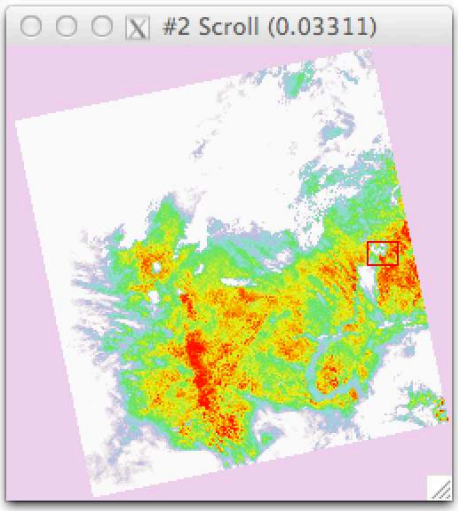



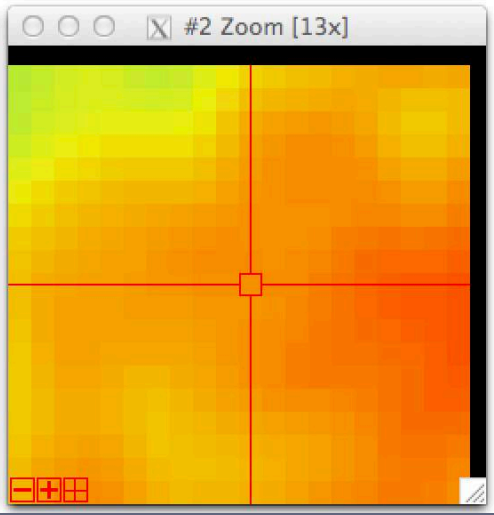


#1 Band 1:LC81122112015093LGN00_B7.TIF
File Overlay Enhance Tools Window
Fire was visible on OLI
channel 7 (2.2 µm)


#2 Band 1:LC81122112015093LGN00_B11.TIF
File Overlay Enhance Tools Window


#1 Scroll (0.03311)


#1 Zoom [13x]


#2 Scroll (0.03311)


#2 Zoom [13x]

# Very Small Fire Validation
# Landsat-8 nighttime example in Greenbelt/USA

- Fire radiative power output at overpass time (using IR camera data):

  0.01 MW

- Simulated channel 7 fire radiance (using IR camera data):

  0.453 W/m².sr.µm

  - Surface-equivalent (no atmosphere)

  - Assuming rectangular spatial response function

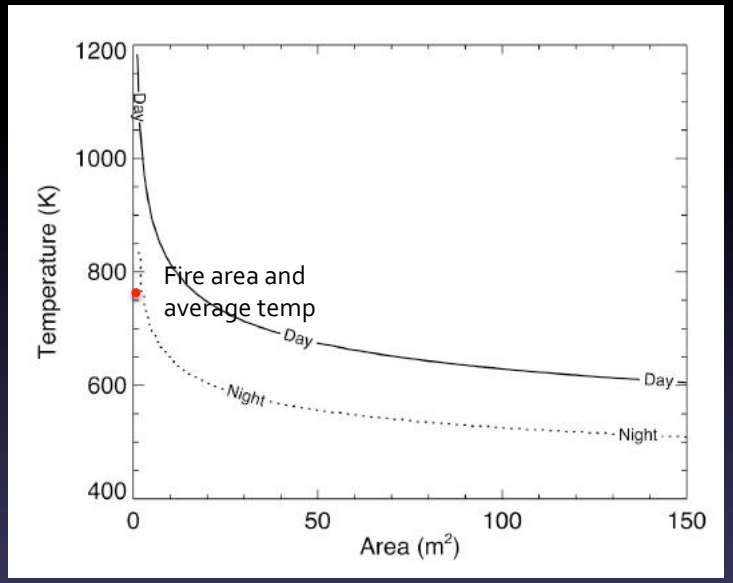
- Actual channel 7 top-of-atmosphere pixel radiance:

  0.229 W/m².sr.µm

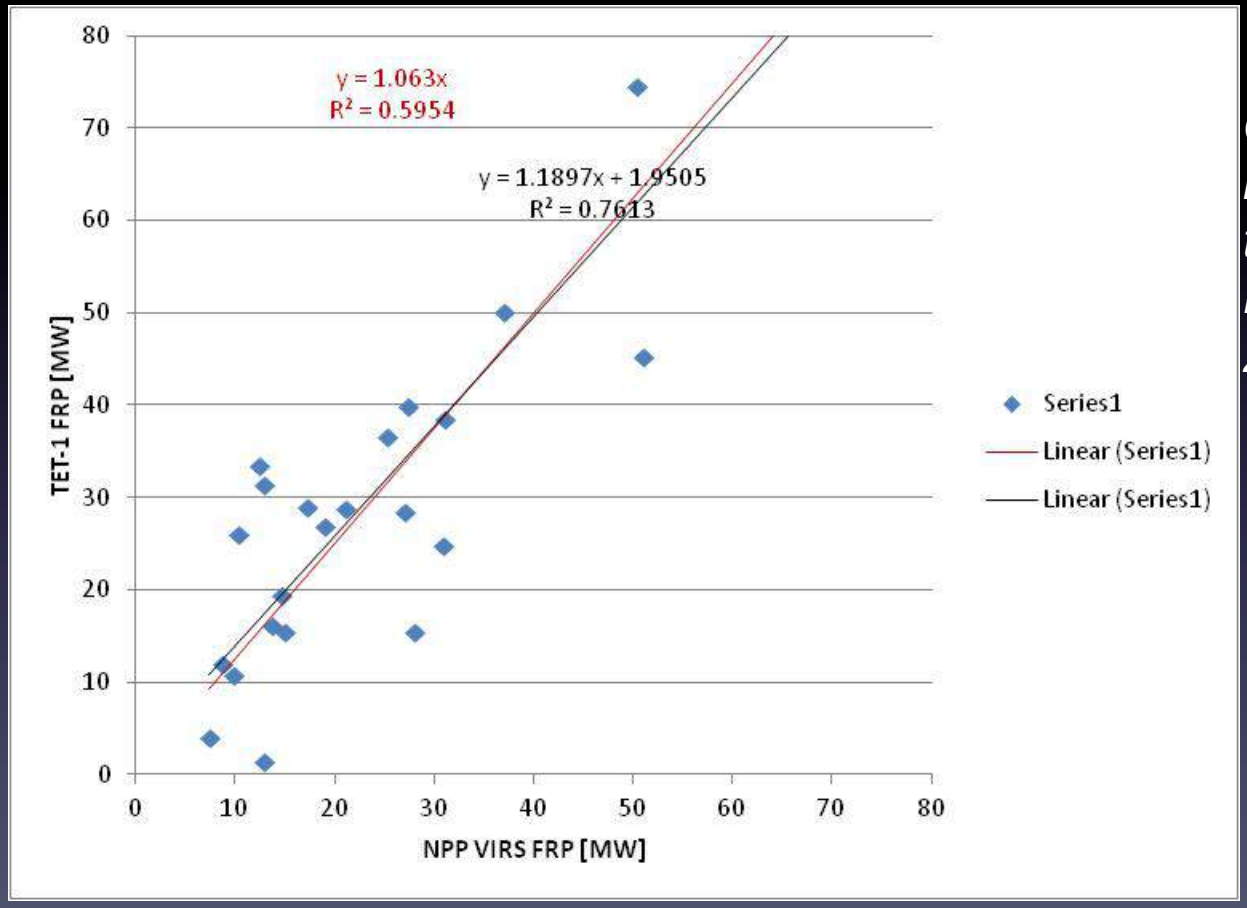
- Single fixed threshold proposed for nighttime fire algorithm:

  1 W/m².sr.µm

Algorithm failed to detect fire!



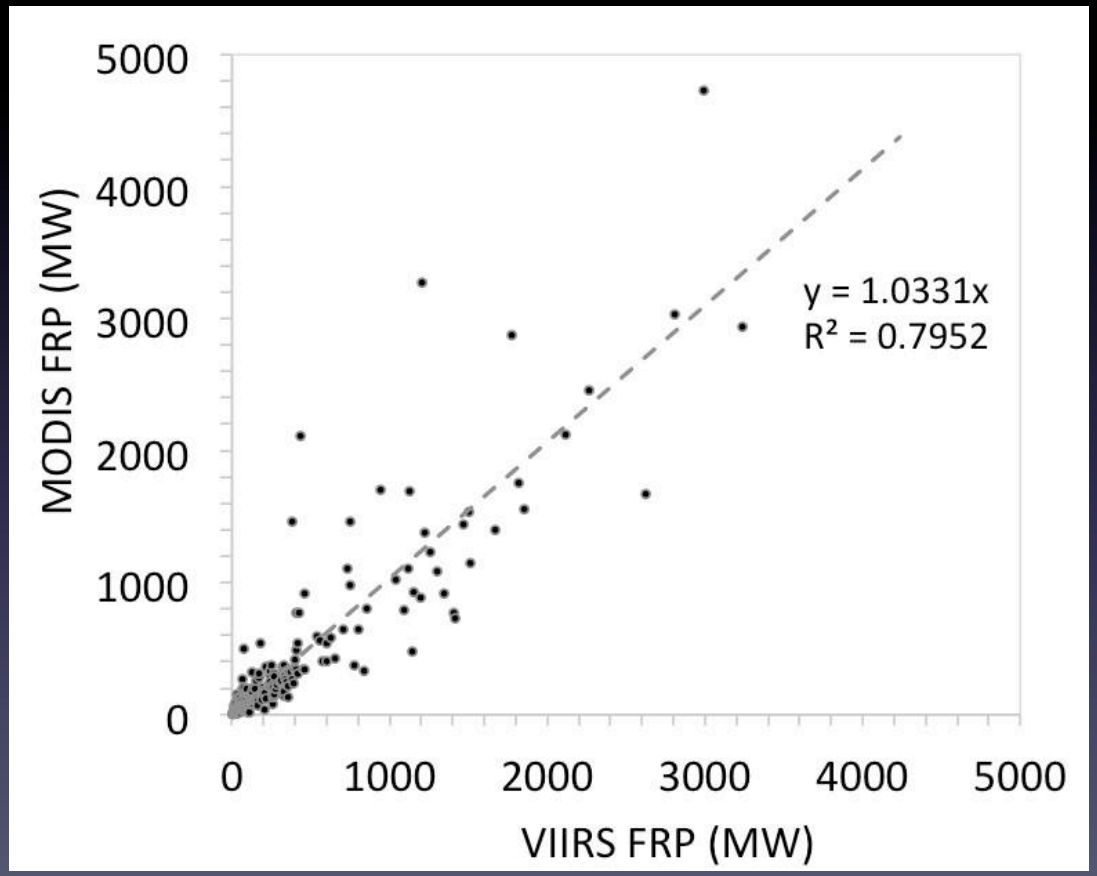
# VIIRS 750 m FRP evaluation using Coincident DRL TET-1




*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 356m unsaturated measurements for hotspot characterization***

# VIIRS 750 m FRP evaluation using Coincident Aqua/MODIS data




*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.*

# *Conclusions*

- New satellite active fire products enabling improved detection of small fires, refined mapping of large fires
- Evolving from fire pixels to fire events (fire pixel clusters)
- Improved fire line delineation supporting landscape analyses
- VIIRS 375m shows potential for first-order assessment of fire-affected area during large events
- Use of spatially refined data could support tactical fire management
- Algorithms being transitioned into operations
- Seeding of burned area products being pursued (new VIIRS burned area product)
- Algorithm refinement/improvement underway

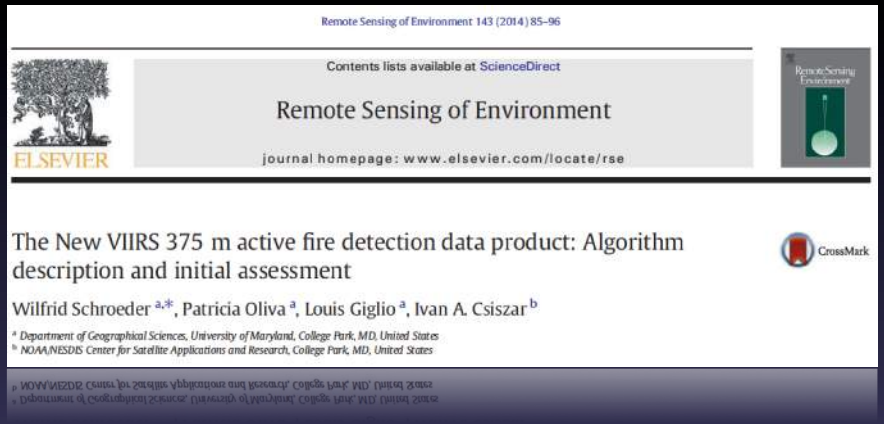
# *Supplementary Information:*

Wilfrid Schroeder @ UMD: http://geog.umd.edu/facultyprofile/Schroeder/Wilfrid

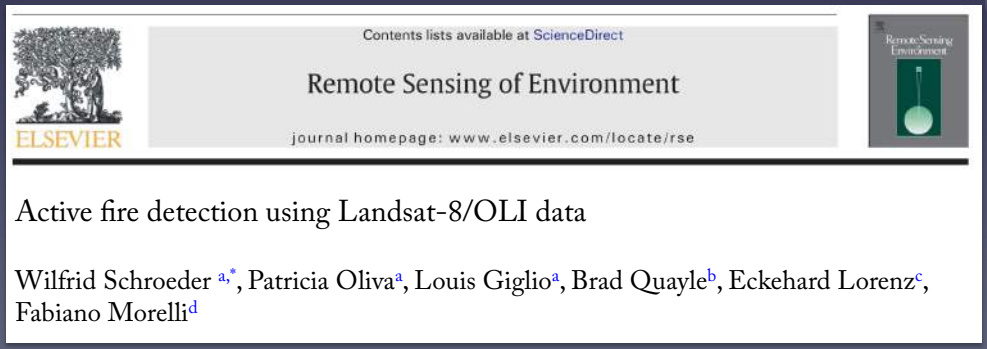
S-NPP/VIIRS active fire data: http://viirsfire.geog.umd.edu/map/index.html

Near real-time global VIIRS 375 m fire detection data: ftp://blaze.umd.edu/VIIRS375/NRT/

USDA Forest Service satellite fire mapping: http://activefiremaps.fs.fed.us/



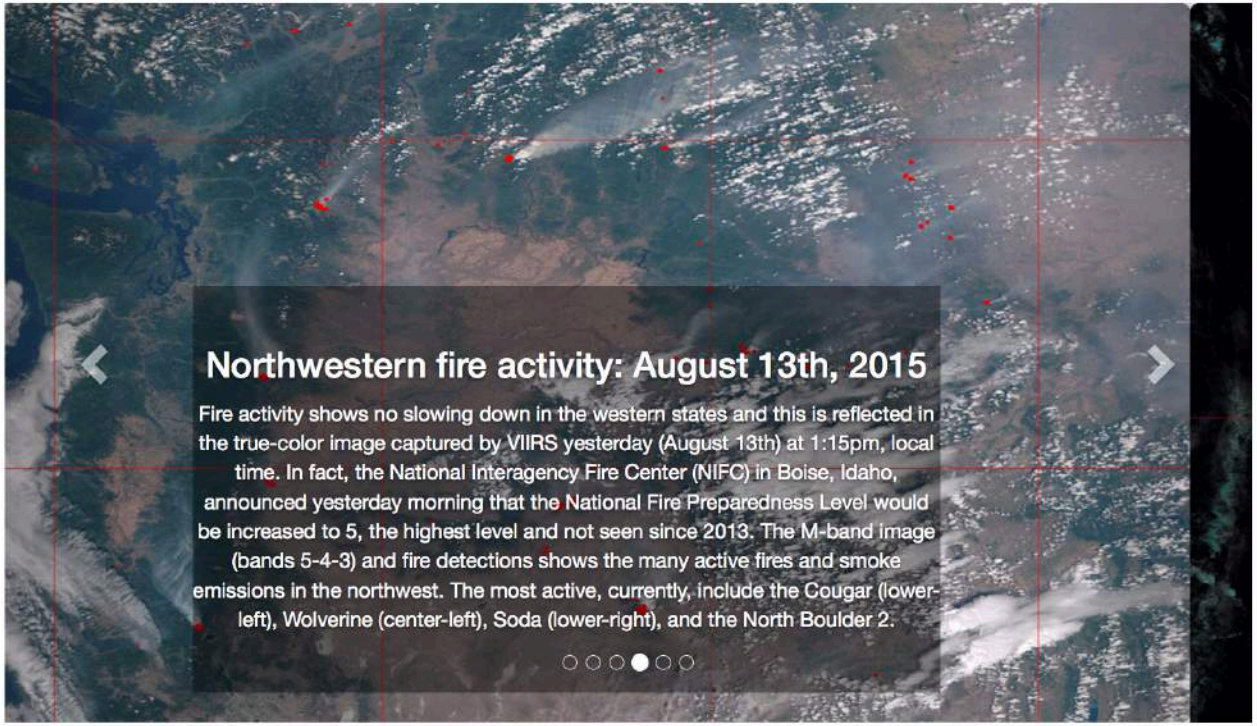





Accepted for publication
RSE Landsat-8 special edition

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

VIIRS Active Fire | Home | About | FAQ | VIIRS AF Products | VIIRS vs MODIS | Maps & Data




## About

The Visible Infrared Imaging Radiometer Suite (VIIRS) sensor was launched aboard the Suomi National Polar-orbiting Partnership (NPP) satellite on October 28th, 2011 and on January 18th, 2012 cooler doors for the thermal sensor were opened. Within hours data were being retrieved and fire detections produced. The 5 minute swath quicklooks presented here highlight recent fire detections superimposed on RGB images (bands 5-4-3).

Read more

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### Links

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NOAA

NOAA-STAR

USFS RSAC

GOFC Fire