VIIRS (and Landsat-class) Active Fire Data Products

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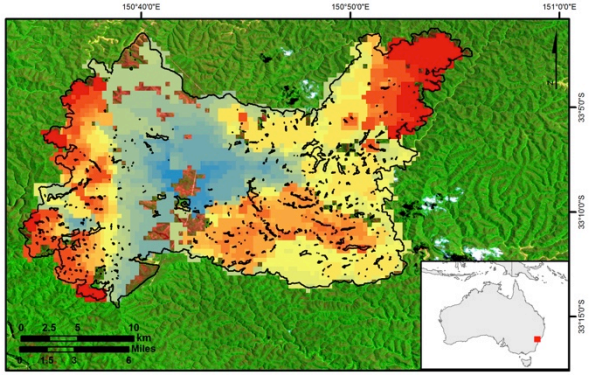
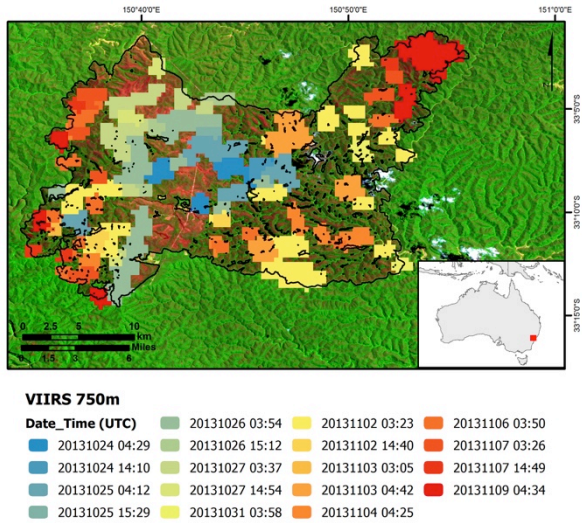
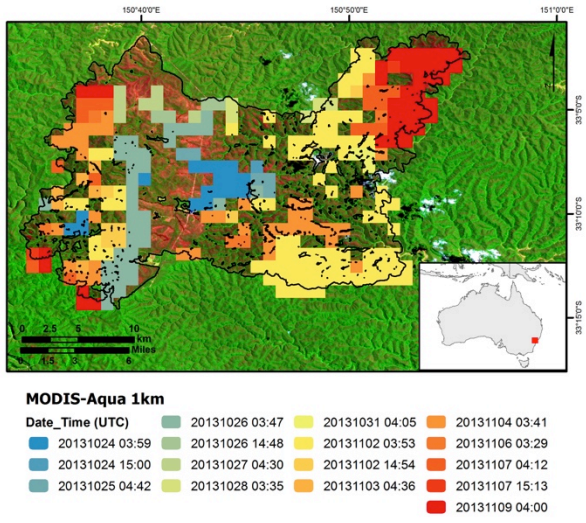
VIIRS Active Fire Data Status

- NOAA 750m product (**AVAFO ->AF_v1r0_npp**)
  - Original active fire data set (**AVAFO**) based on C4 MODIS fire algorithm
    - List of fire pixel lat/lon
    - Available through NOAA-CLASS online archive system (inconsistent record due to changes in input data)
    - Also available through IPOPP, CSPP direct readout data processing packages
    - To be discontinued soon
  - Revised product based on C6 MODIS fire algorithm (**AF_v1r0_npp - similar to VNP14**)
    - Mimics MOD/MYD14 data format/content
    - Running at NDE (≈3h latency), feeding NOAA-CLASS archive
- NASA 750m product (**VNP14**)
  - Based on C6 MODIS fire algorithm
    - Running at Land SIPS (≈12h latency), incomplete/inconsistent record due to changes in input data and data retention
    - Also available through IPOPP direct readout data processing package
- NASA 375m product (**VNP14IMG**)
  - Builds on MODIS fire product, customized for VIIRS 375m data characteristics
    - Running at Land SIPS (≈12h latency), incomplete/inconsistent archive due to changes in input data and data retention
    - Running at LANCE, feeding FIRMS/Worldview since Dec 2015
    - Also available through through IPOPP direct readout data processing packages
- Data reprocessing tasks being implemented at NASA and NOAA

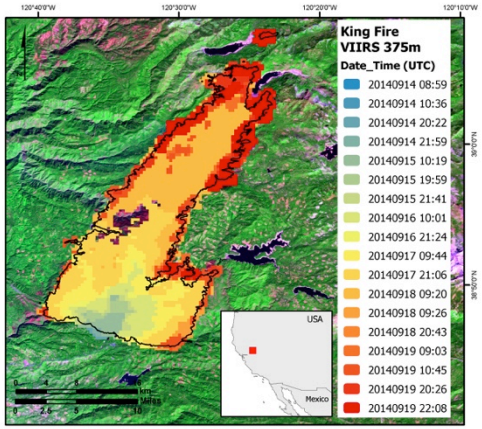
S-NPP/VIIRS 375 x 750m x Aqua/MODIS 1km Fire Data Quick Comparison



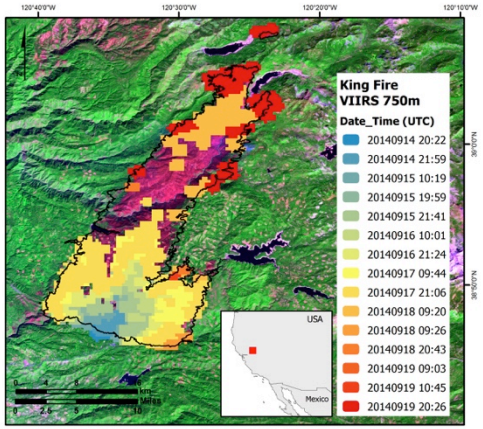




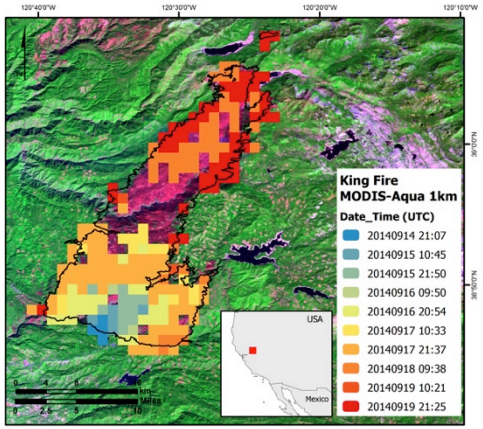
S-NPP/VIIRS 375 m



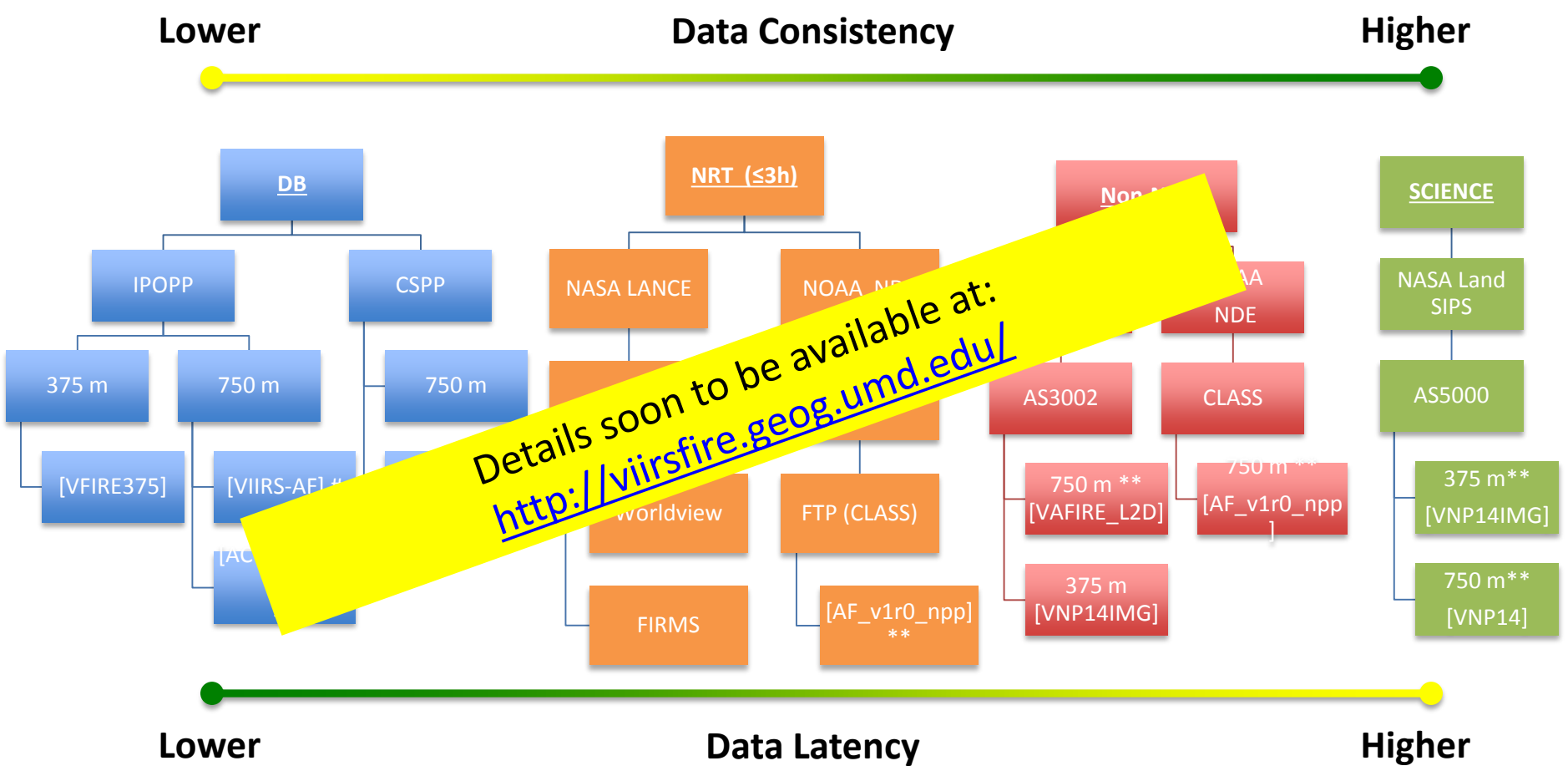
S-NPP/VIIRS 750 m



Aqua/MODIS 1 km

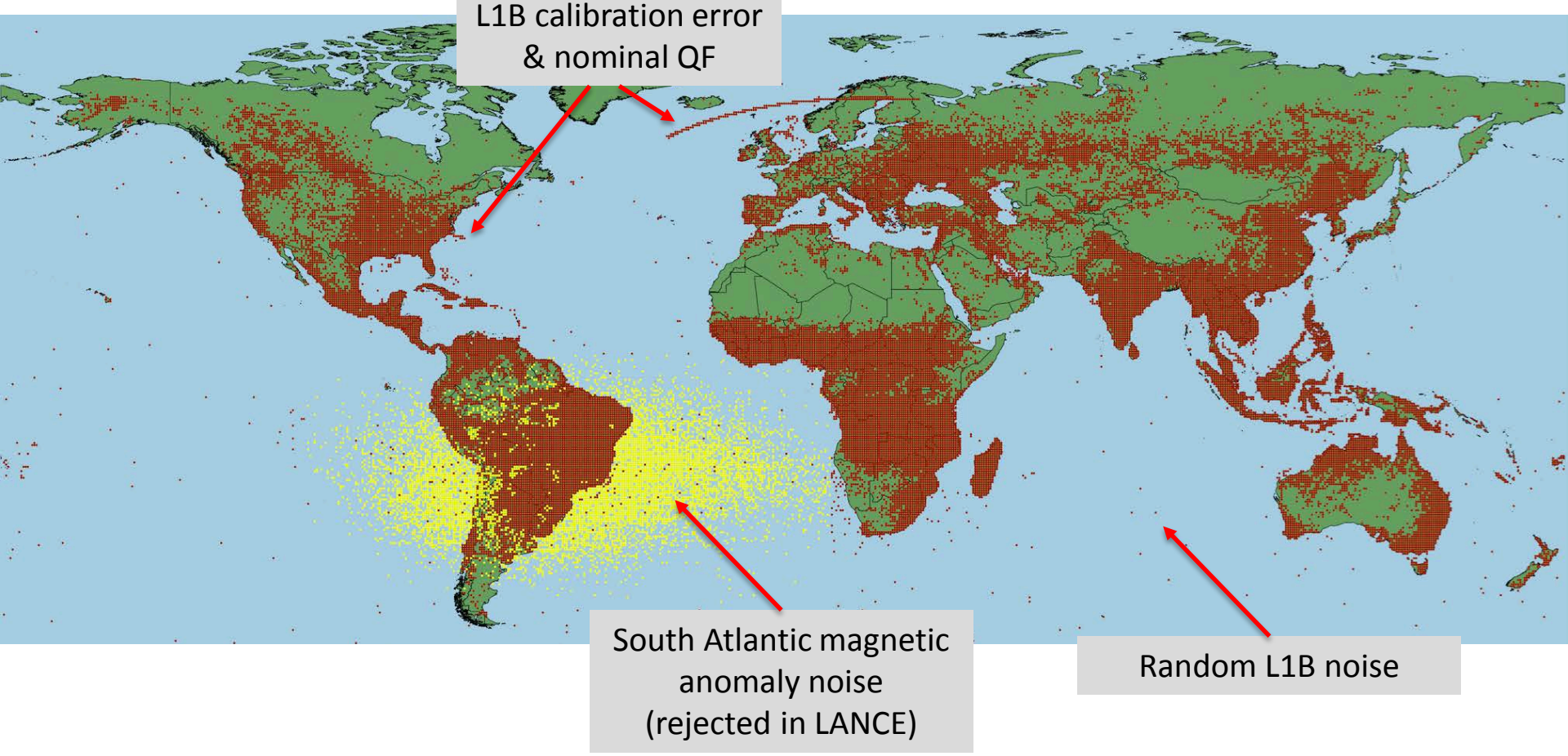


VIIRS Active Fire Product Lineage

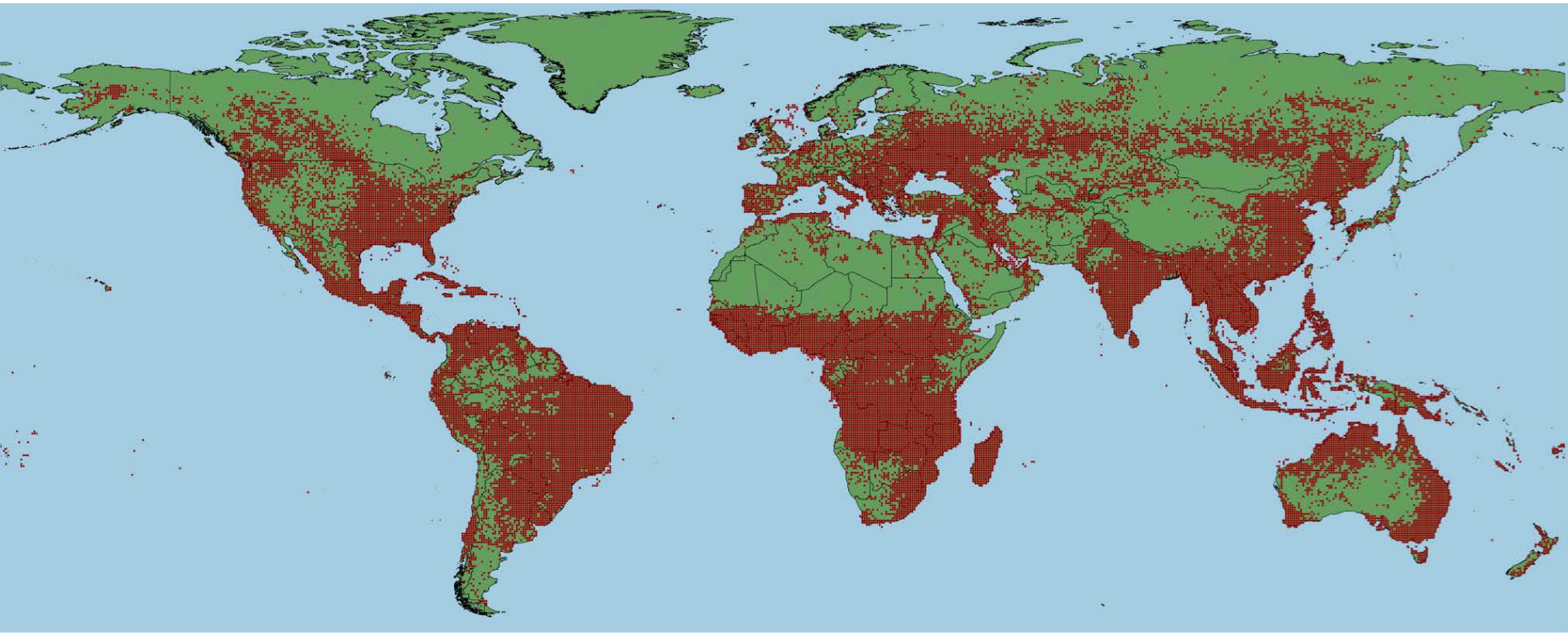


** marked products include FRP retrieval
# marked products describe discontinued algorithm
[ ] indicate official product name

VIIRS 375 m Active Fire Data
Version 1 (currently at NASA Land SIPS, LANCE/FIRMS/Worldview, IPOPP)
Using NOAA/NASA L1B (SDR) input data
Jan-Dec 2015 (Julian days 1,10,20,…,360)

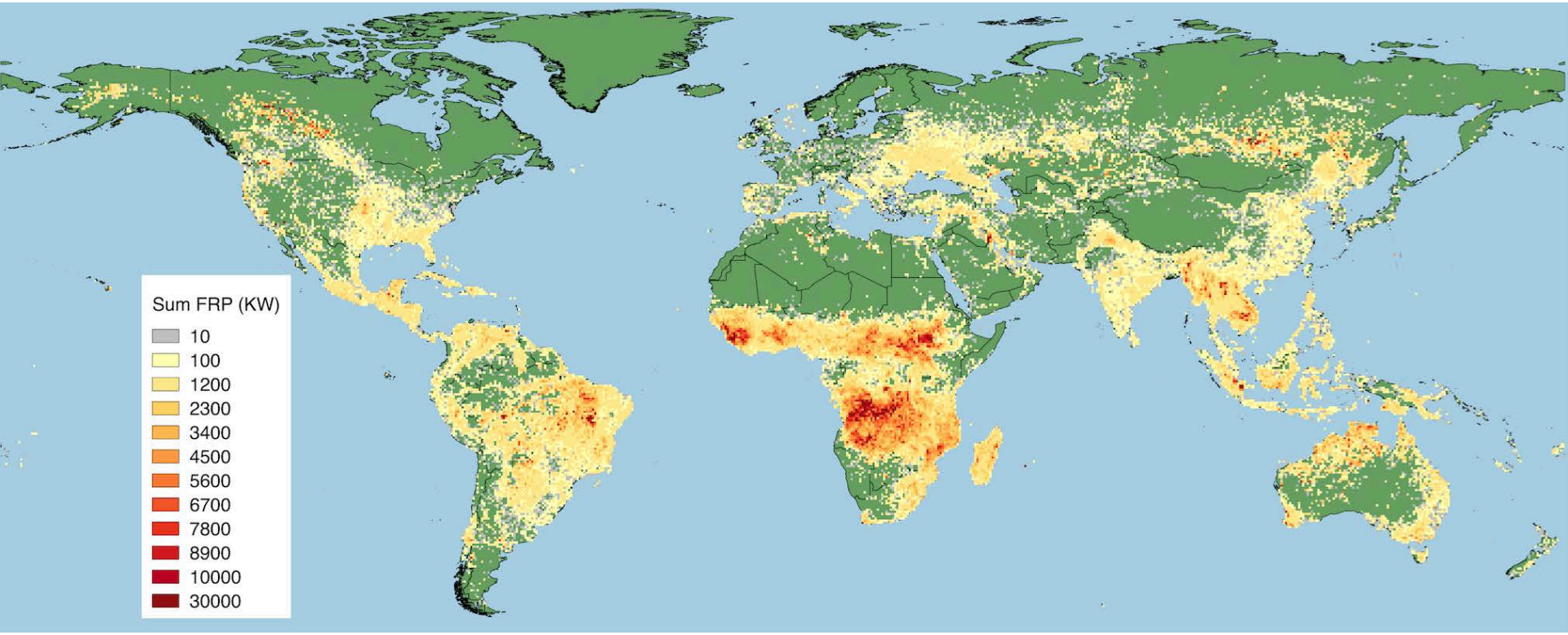


VIIRS 375 m Active Fire Data
Hybrid Version 2 (being ported to NASA Land SIPS, LANCE, IPOPP)
Using new NASA L1B (netcdf/hdf5) input data
Jan-Dec 2015 (Julian days 1,10,20,…,360)



L1B noise addressed with additional data filters in fire algorithm
South Atlantic magnetic anomaly flagged in fire product QF

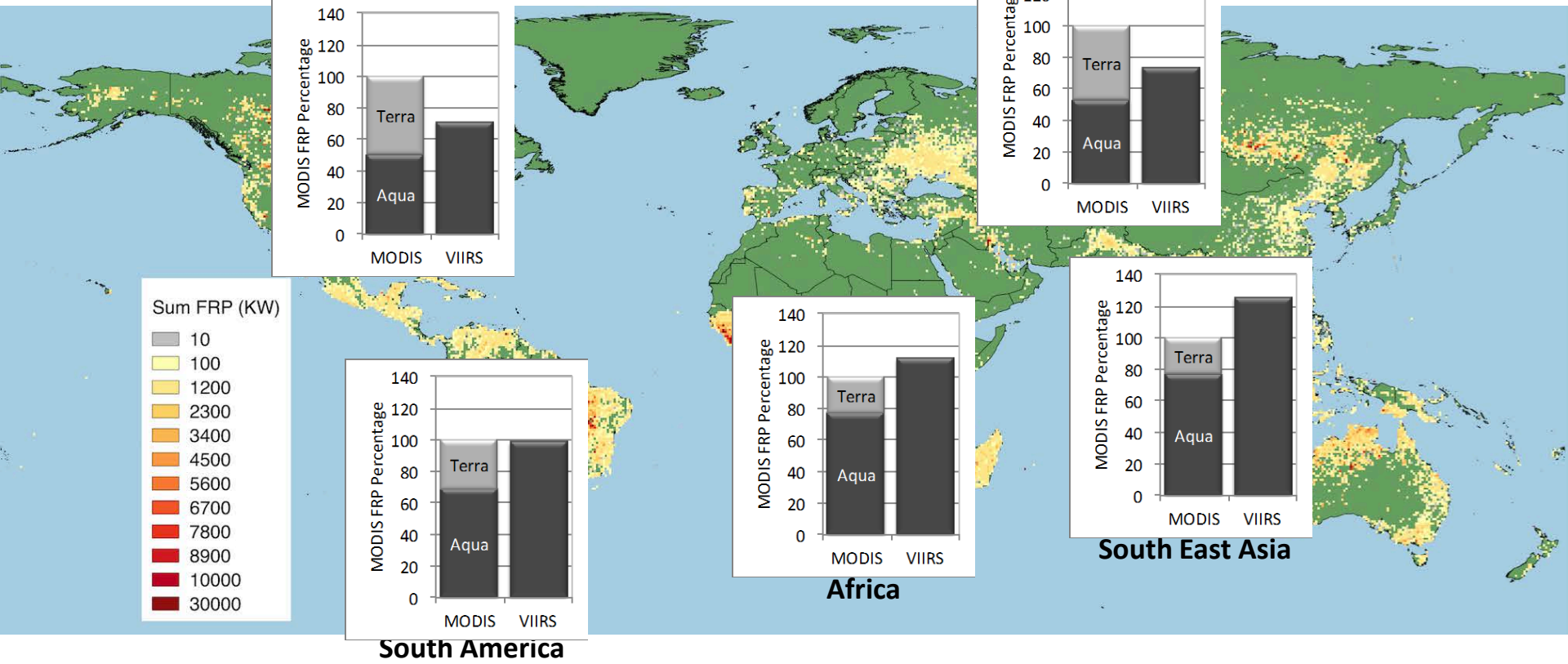
VIIRS 375 m Active Fire Data
Hybrid Version 2 (being ported to Land SIPS, LANCE, IPOPP)
Using new NASA L1B (netcdf/hdf5) input data
Jan-Dec 2015 (Julian days 1,10,20,…,360)



Sum of FRP over sampling period using 0.5^{o} grid

MYD14 1km Collection 6 Fire Radiative Power

Jan-Dec 2015 (Julian days 1,10,20,…,360)



North America

Russia

South America

Africa

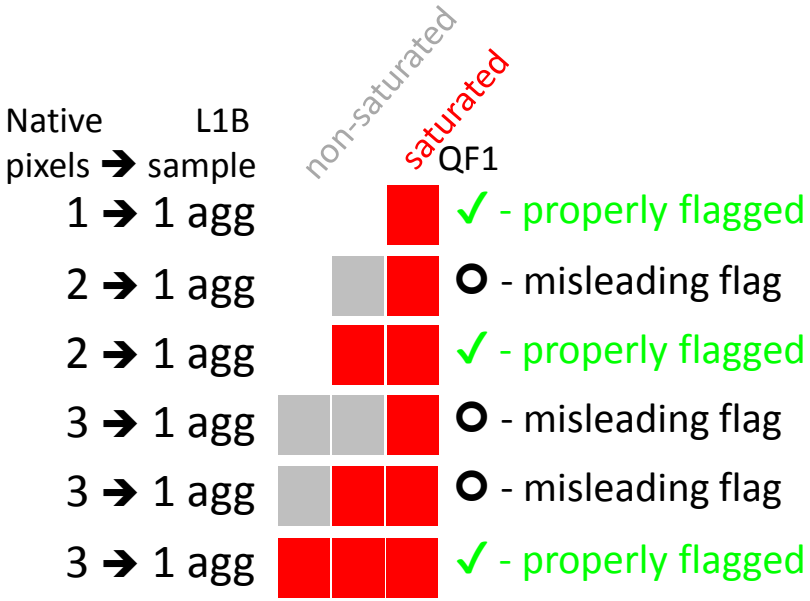
South East Asia

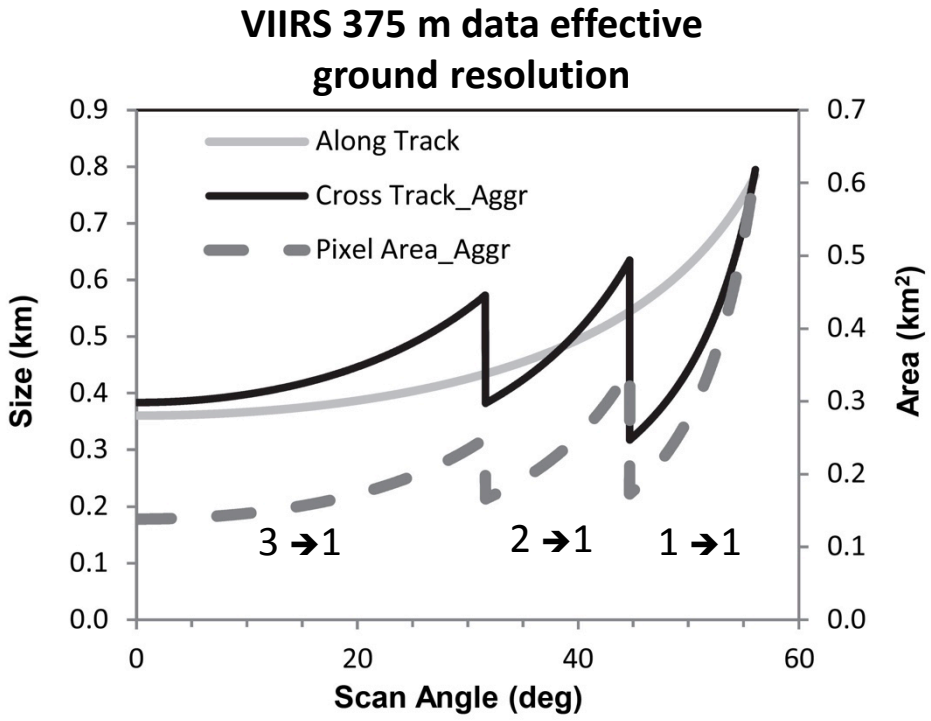
Global TOA FRP totals:
Terra/MODIS: 6.1×10^6 MW
Aqua/MODIS: 13.4×10^6 MW
S-NPP/VIIRS: 19.6×10^6 MW

FRP Retrievals in 375m Product

Why can't we use 375 m mid-IR (I4) radiance data in VIIRS FRP retrieval?

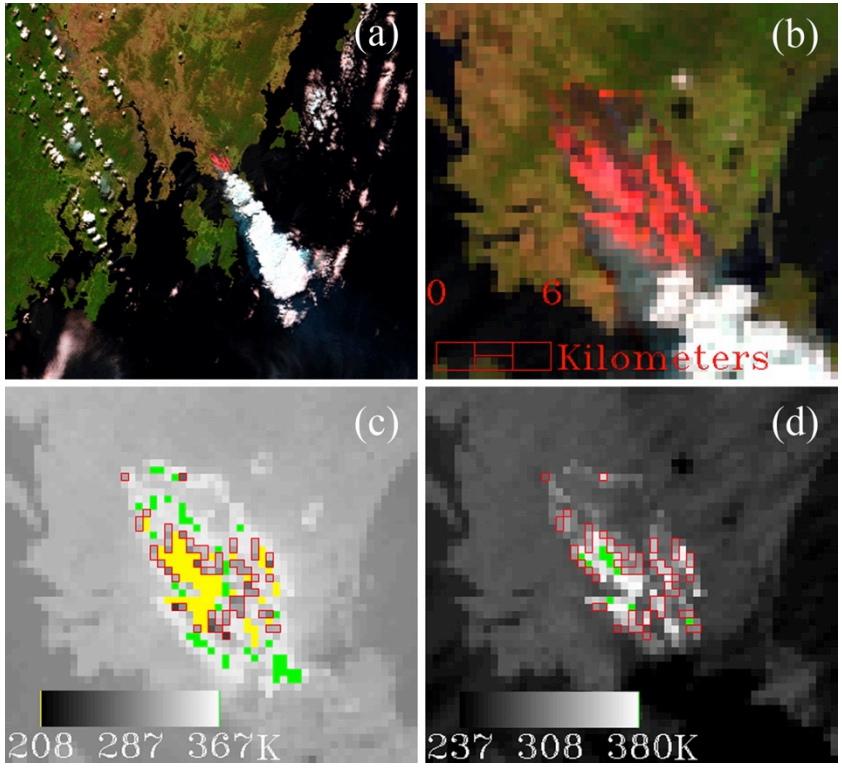
- Frequent data saturation/folding
- Quality flags (QF1) assigned during L1B onboard data aggregation won't indicate partial saturation





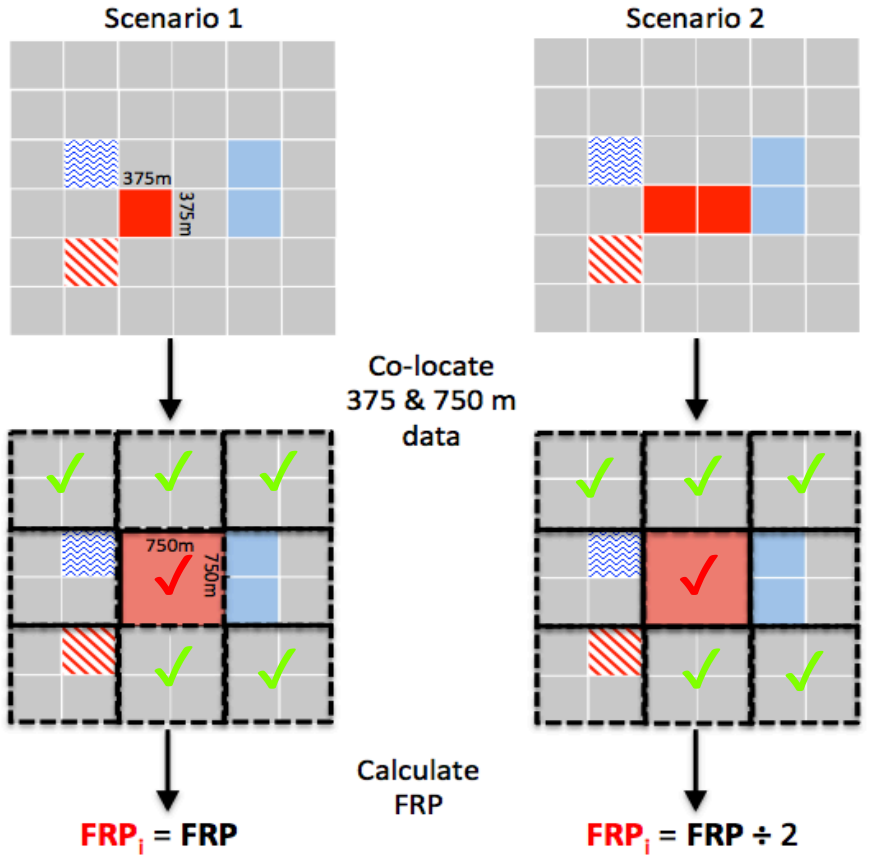
FRP Retrievals in 375m Product

- ≈10% nominal fire pixel saturation rate in mid-IR I4 channel
- Additional saturation affecting aggregated pixels (not flagged in L1B)

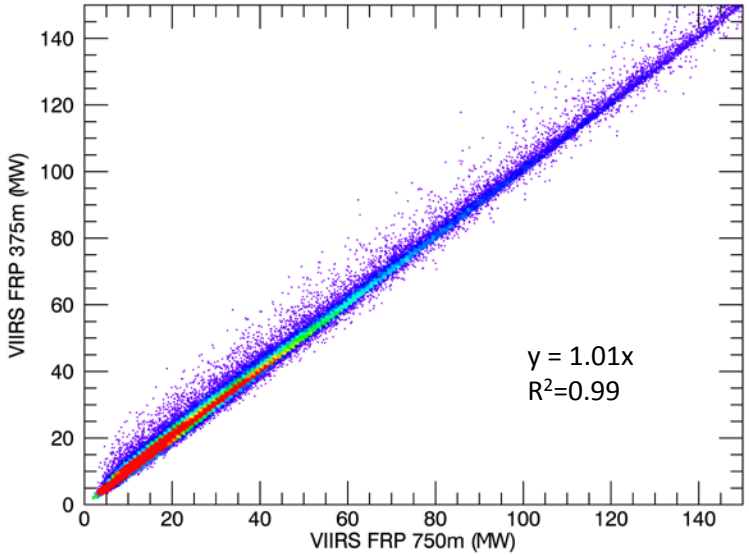


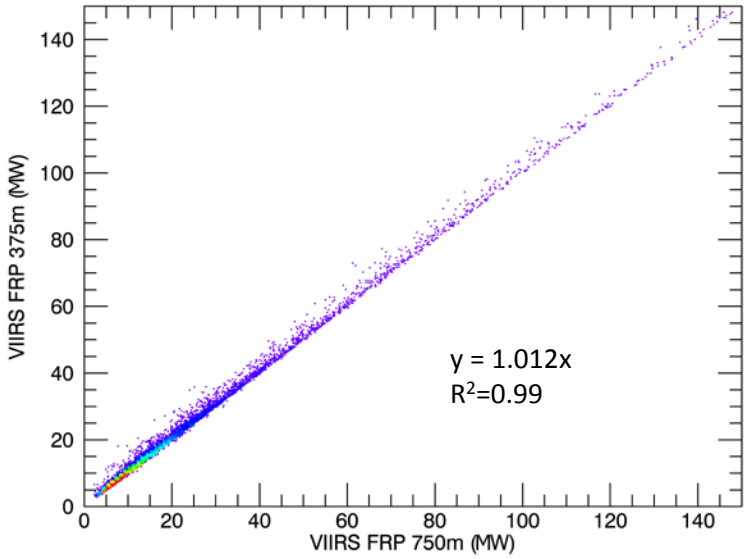
Yellow: folding of pixel radiance (208K)
Green: nominal saturation (367K)
Red outline: partial saturation (nominal quality flag in L1B)

FRP retrievals using co-located dual-gain mid-IR M13 channel (750m) as a surrogate for **ALL** fire pixels detected using 375 m data

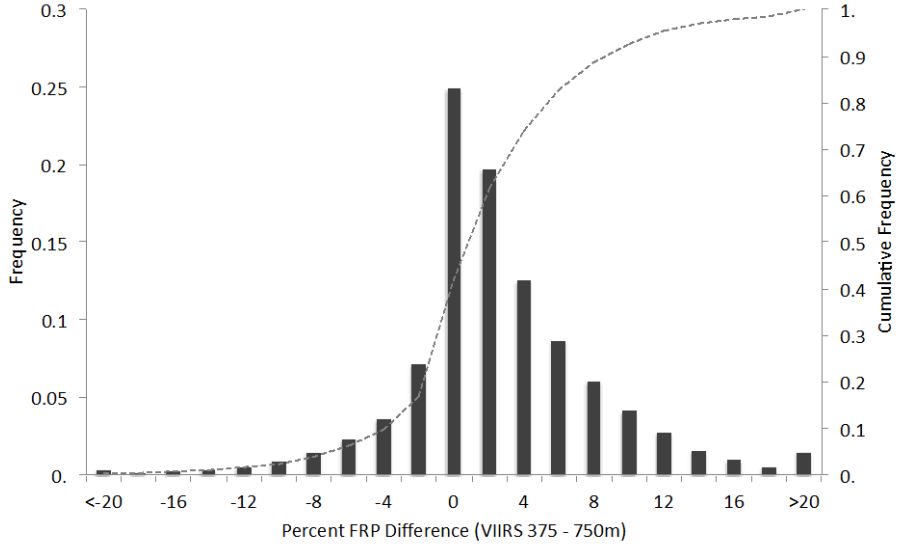


VIIRS 375 m x 750 m FRP Comparison

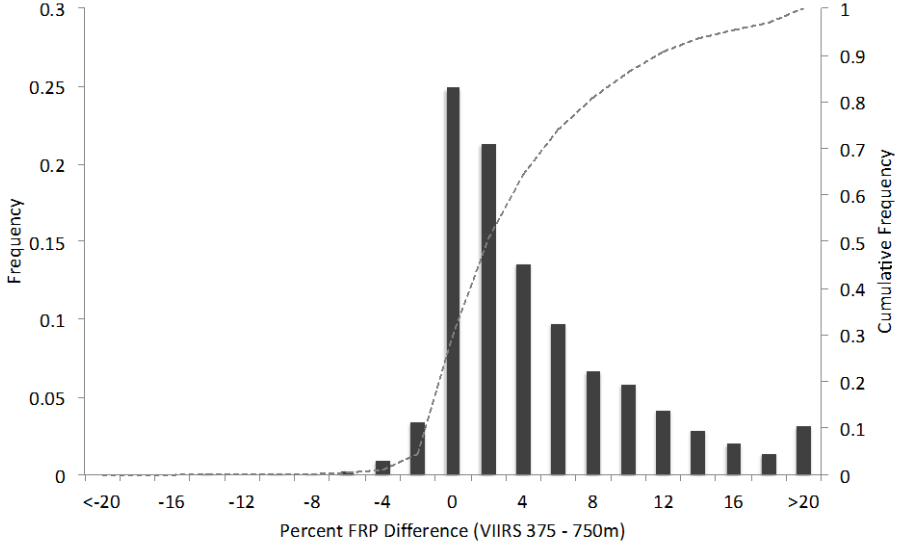




Daytime

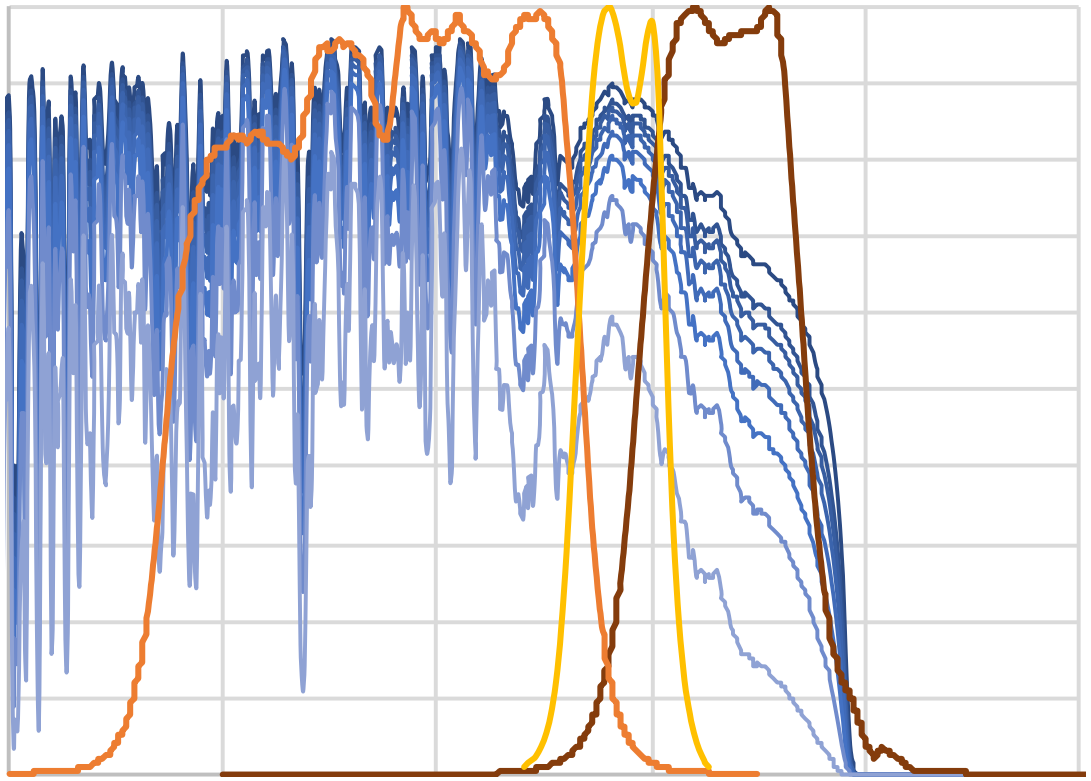


Nighttime



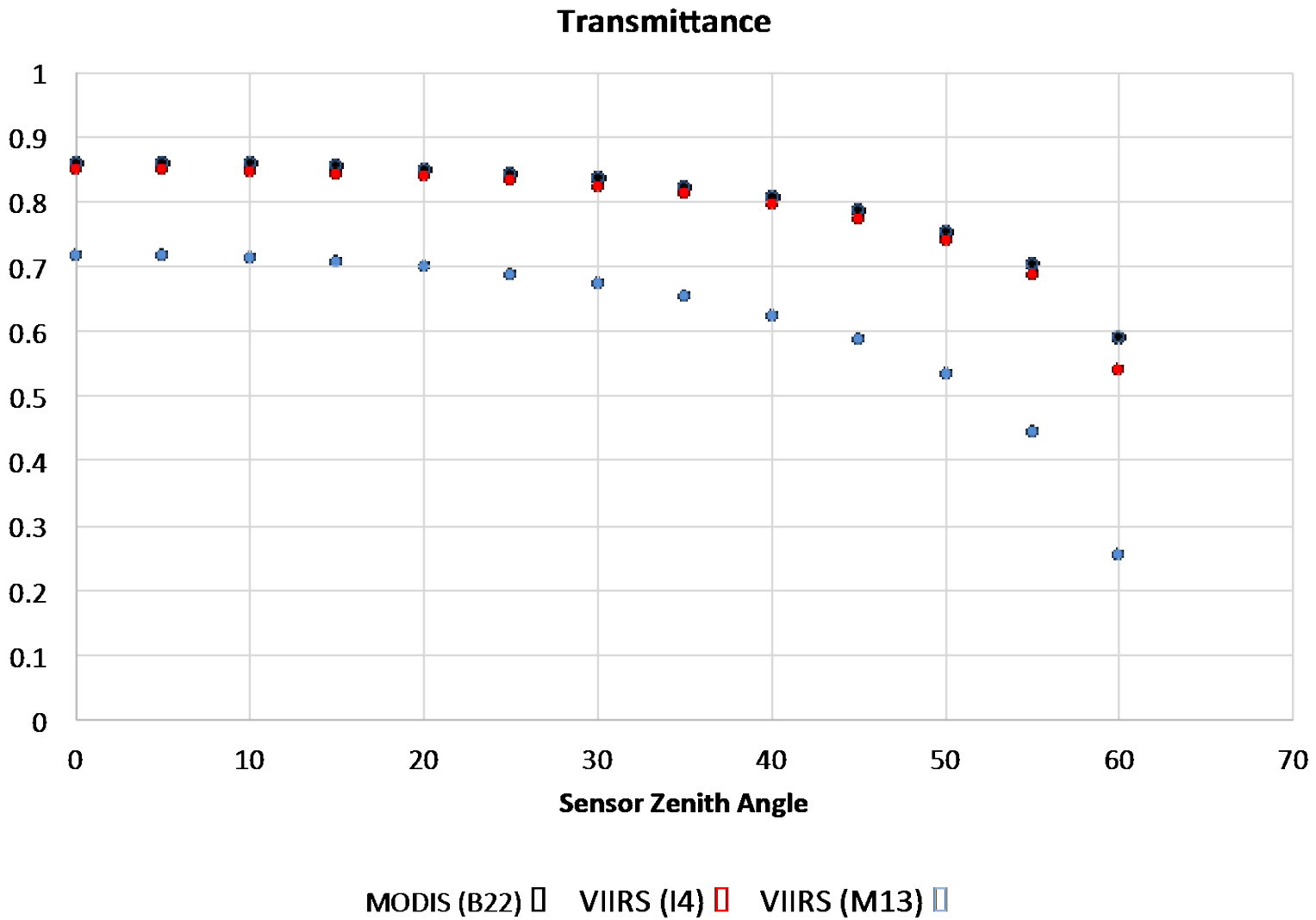
Data from co-located 375 and 750m FRP retrievals

MODIS x VIIRS Mid-IR
Spectral Responses & Atmospheric Transmittance



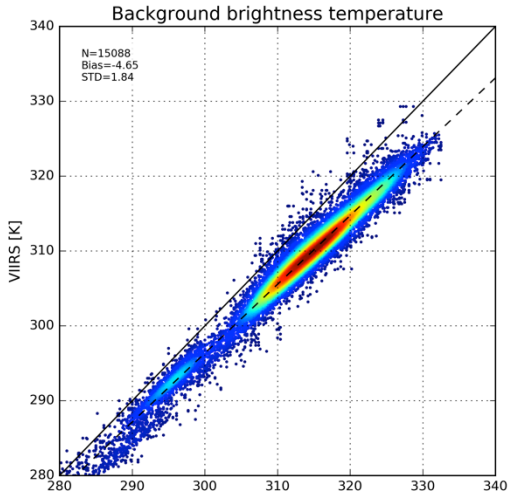
B-22 SRF

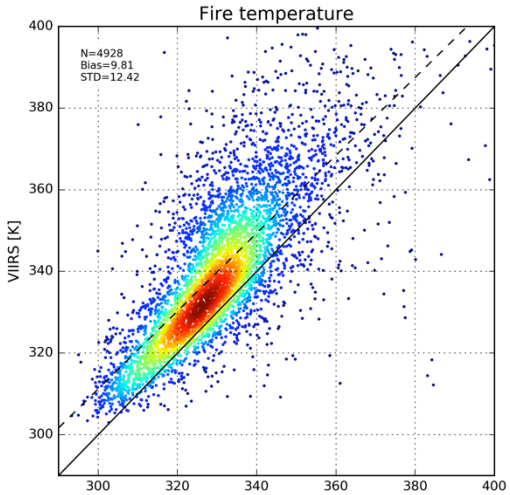
MODIS x VIIRS Mid-IR
Atmospheric Attenuation x Sensor Zenith Angle
(Standard US atmosphere)

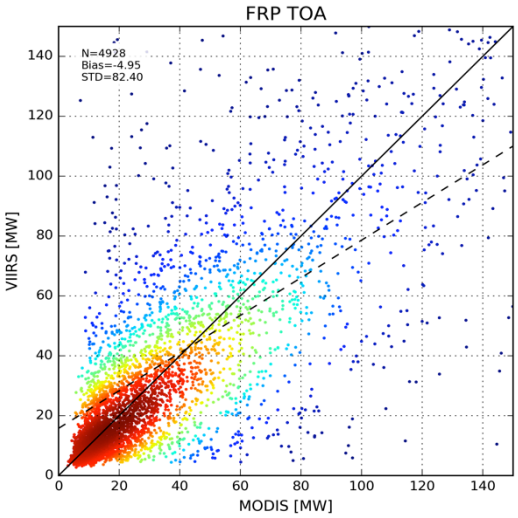


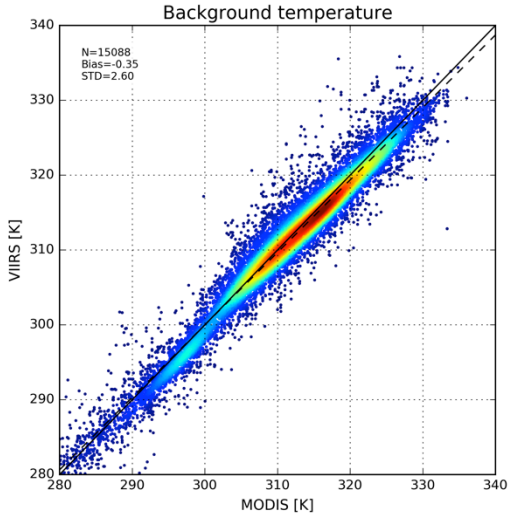
Atmospheric Correction of MODIS and VIIRS Fire Radiative Power Retrievals

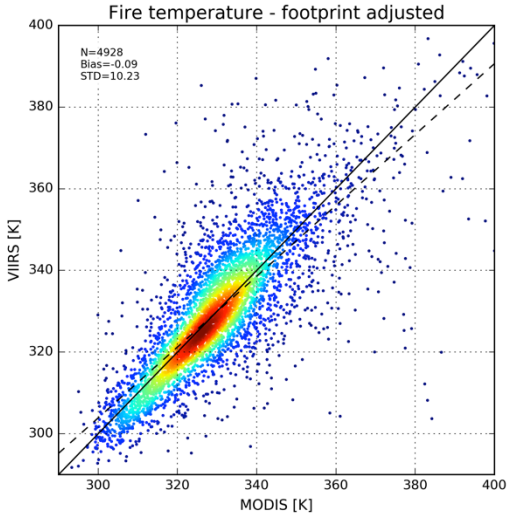
Implementing fast/efficient approach to correct Level 2 (NRT) and Level 3/4 products in support of data continuity

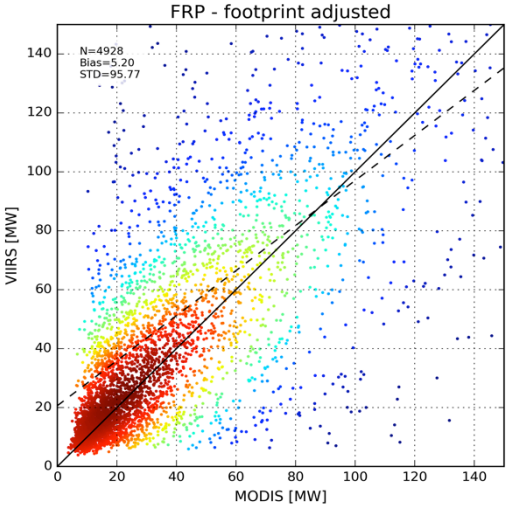




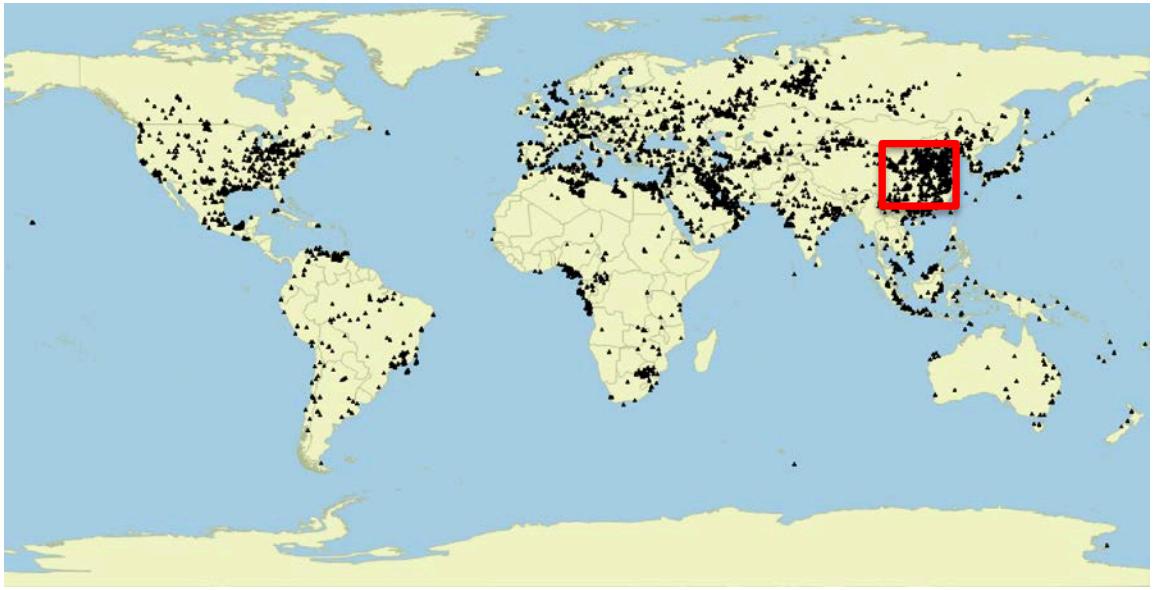




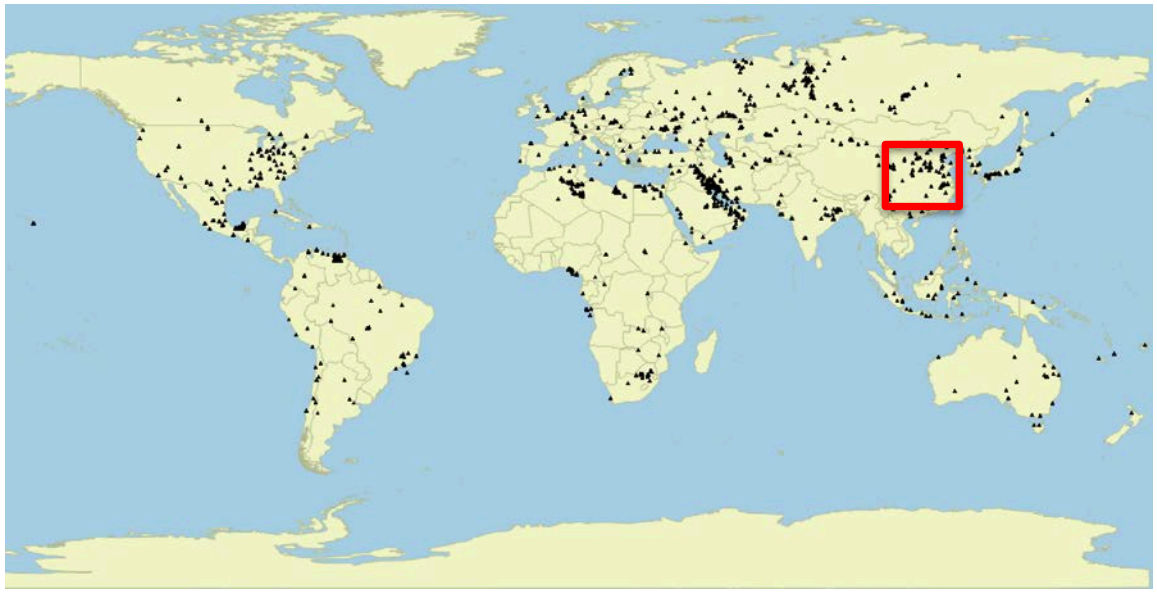




VIIRS 375 m Persistent Detections

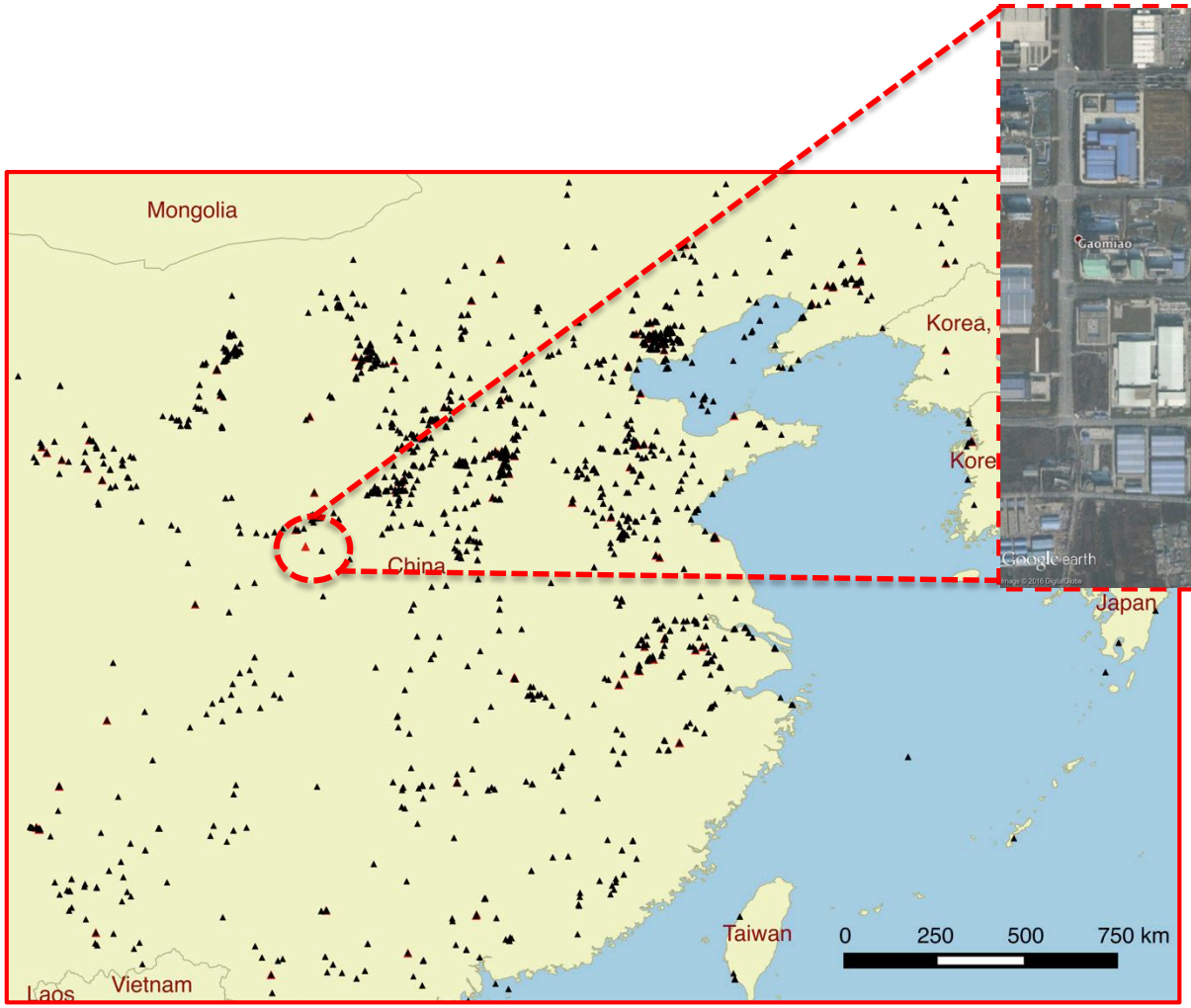


Nighttime data
Regular 0.004° grid
+4,900 Locations
≥ 10 hits in 200 days
(max 210 hits in Persian Gulf)



Daytime data
Regular 0.004° grid
+**1,100** Locations
≥ 10 hits in +200 days

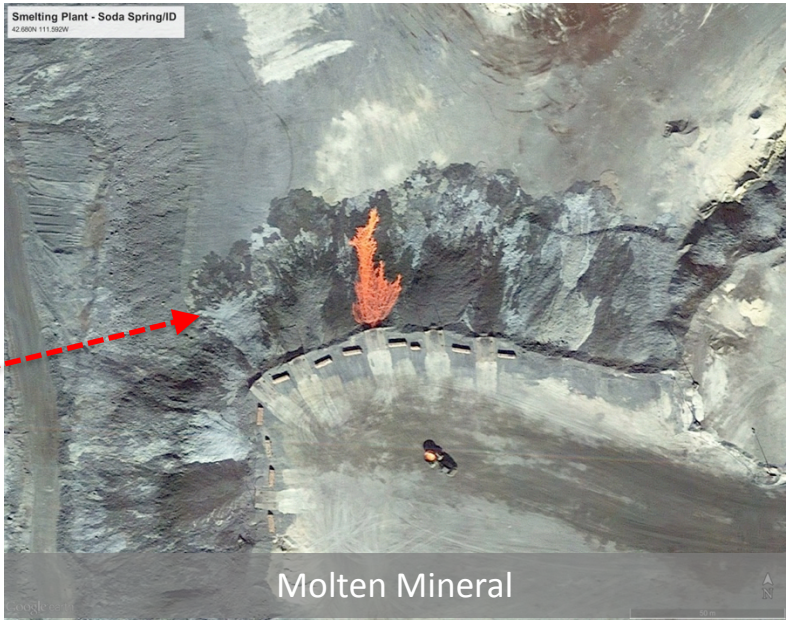
Night × Daytime Detection Persistence - China

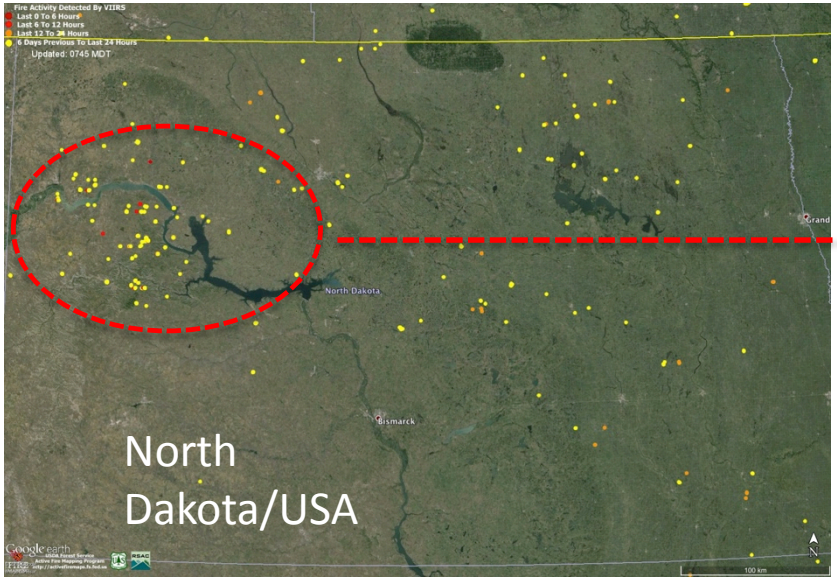


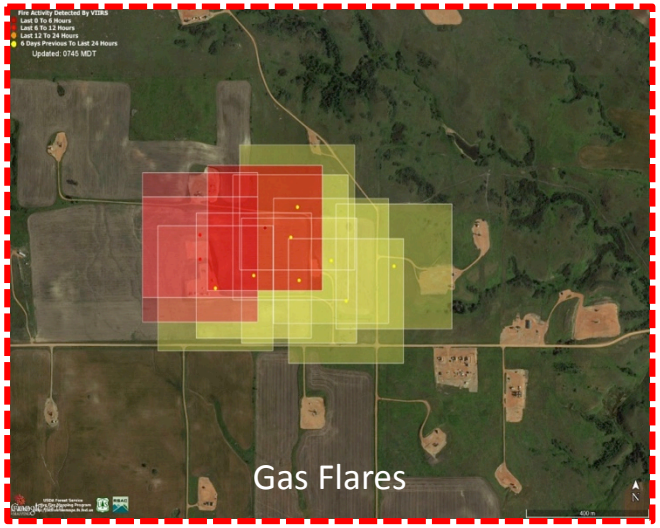
1 unique daytime location among
+1,200 nighttime persistent heat sources

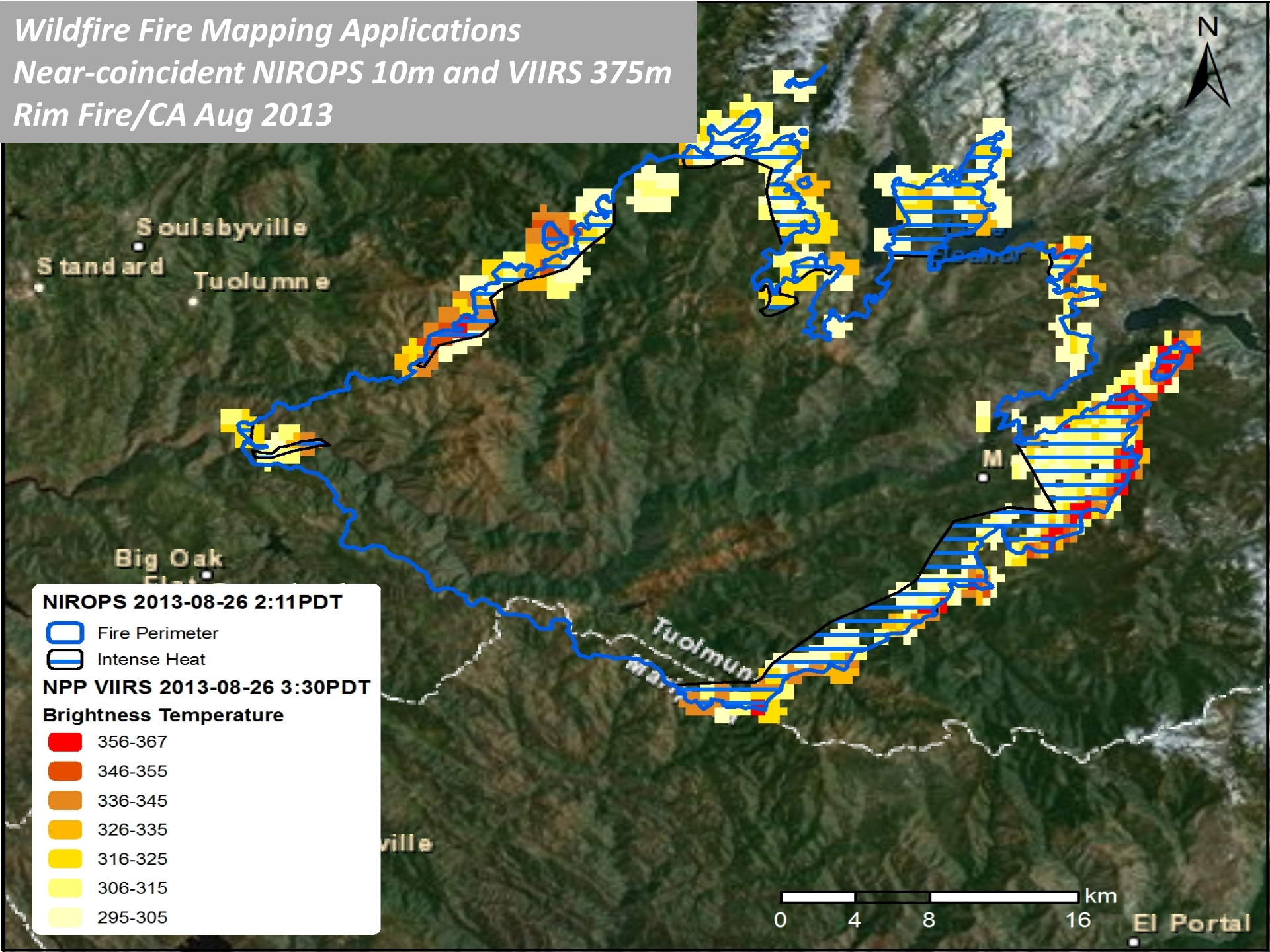
Large industrial park

Typical Sources of Persistent Thermal Anomalies

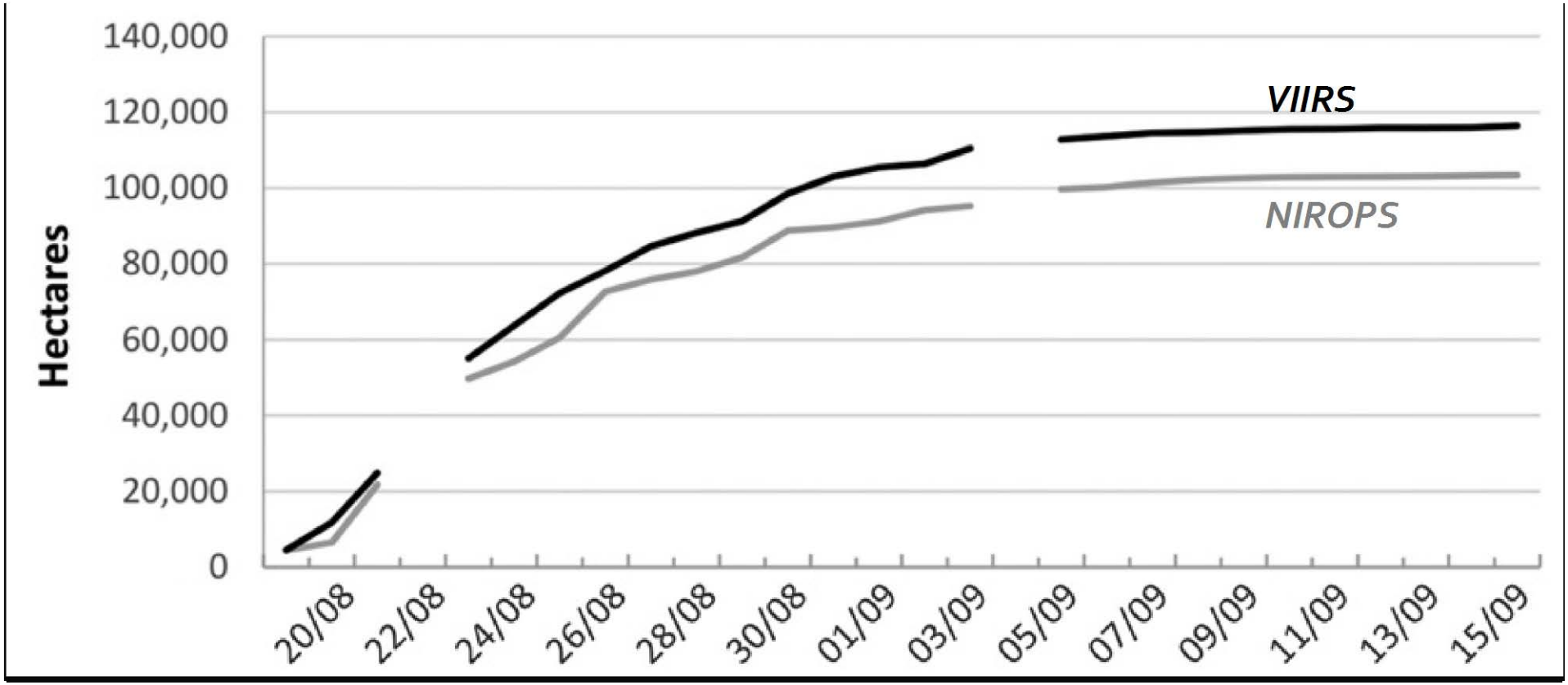




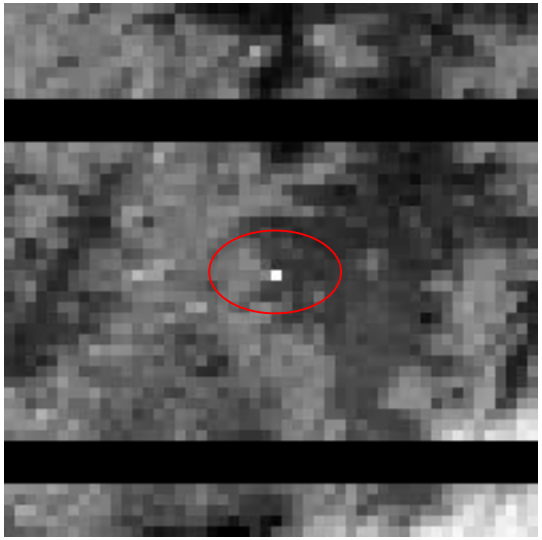



Wildfire Fire Mapping Applications
Near-coincident NIROPS 10m and VIIRS 375m
Rim Fire/CA Aug 2013
N
Soulsbyville
Standard
Tuolumne
Big Oak
Tuolumn
NIROPS 2013-08-26 2:11PDT
Fire Perimeter
Intense Heat
NPP VIIRS 2013-08-26 3:30PDT
Brightness Temperature
356-367
346-355
336-345
326-335
316-325
306-315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

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



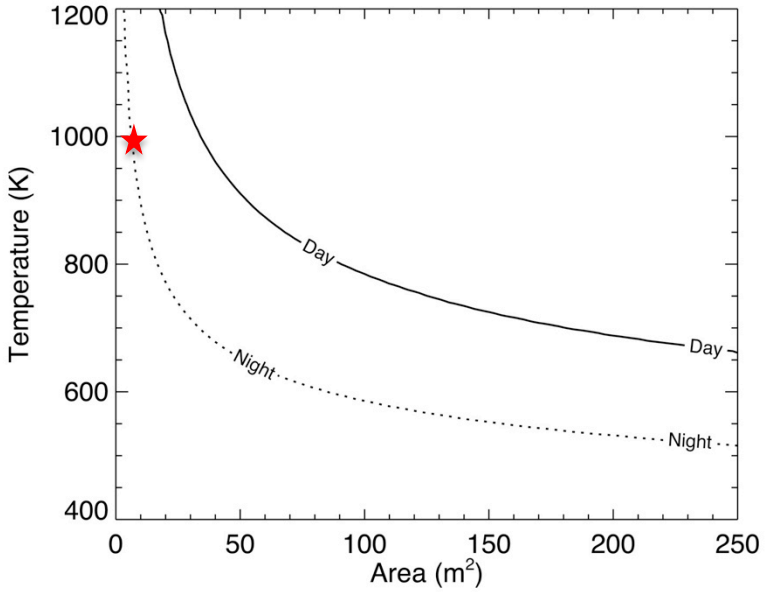
Small Fire Validation
VIIRS 375 m example in Rio de Janeiro/Brazil



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%**



Landsat-class Active Fire Detection Data

Approach:
No fire-science mid-IR data available
NIR+SWIR ratio/differencing approach (saturation/folding artifacts)

Pros:
>150x more information per unit area than VIIRS 375 m
>1000x more information per unit area than MODIS 1km

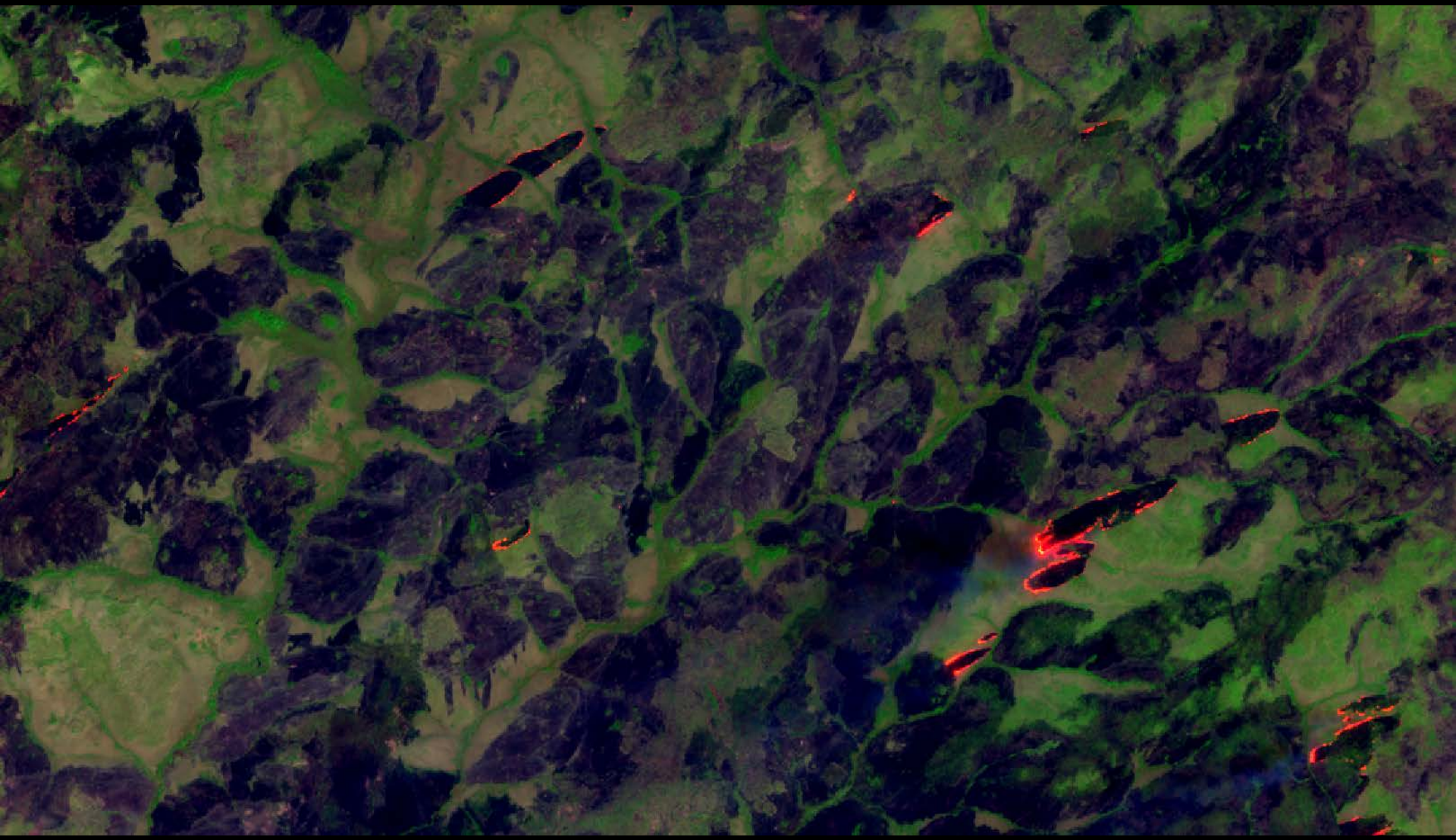
Cons:
Limited coverage/infrequent data

Potential:
Launch of similar sensors increasing data availability

- Landsat-8, Sentinel-2a/2b, Landsat-9

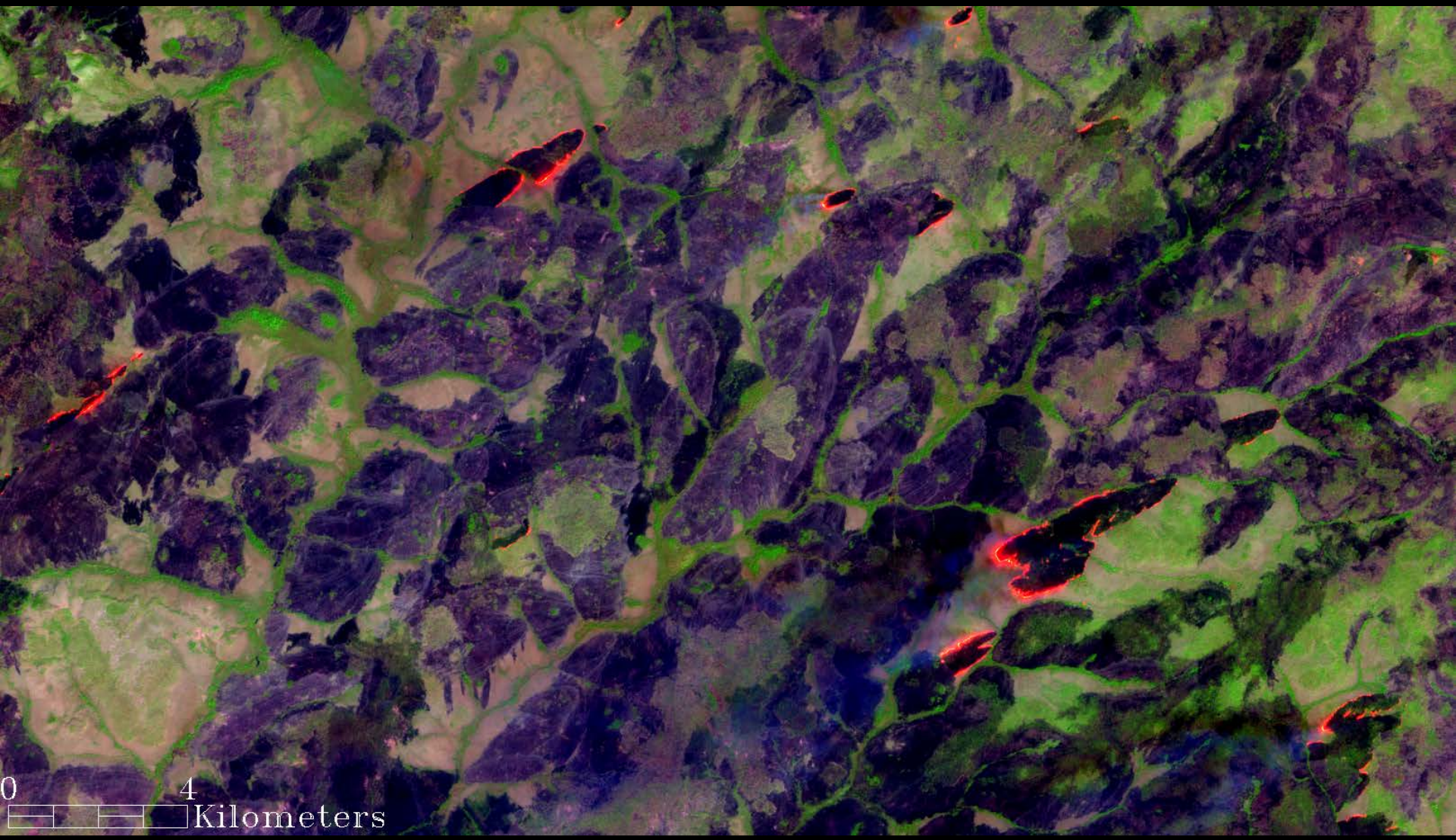
Near real-time data processing/distribution being explored
Community can/will have a major role defining the future of Landsat-class data applications

Landsat-8 + Sentinel-2a



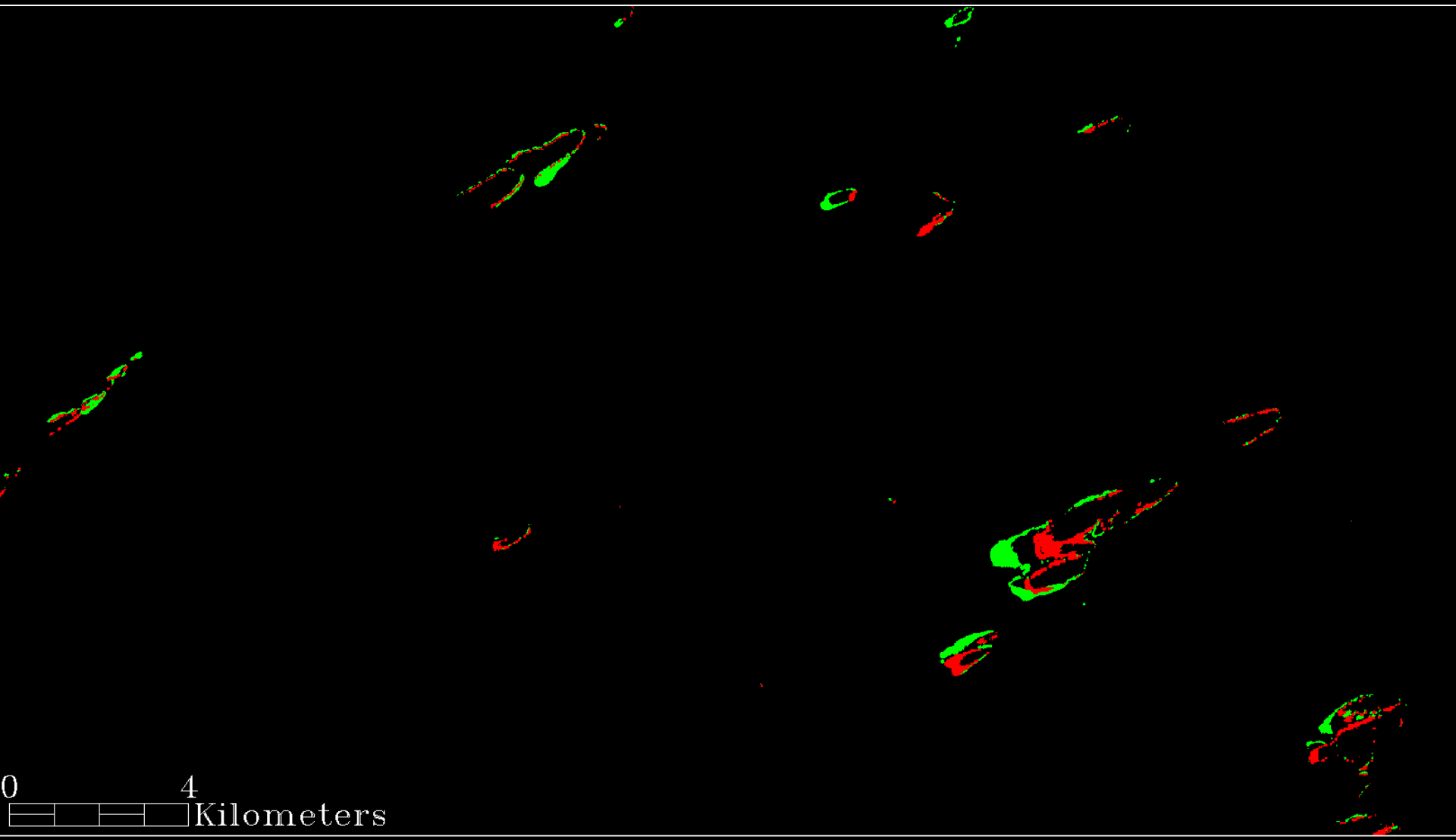
Landsat-8 (30 m)

Landsat-8 + Sentinel-2a



ESA/Sentinel-2a (20 m)
16 min later

Landsat-8 + Sentinel-2a

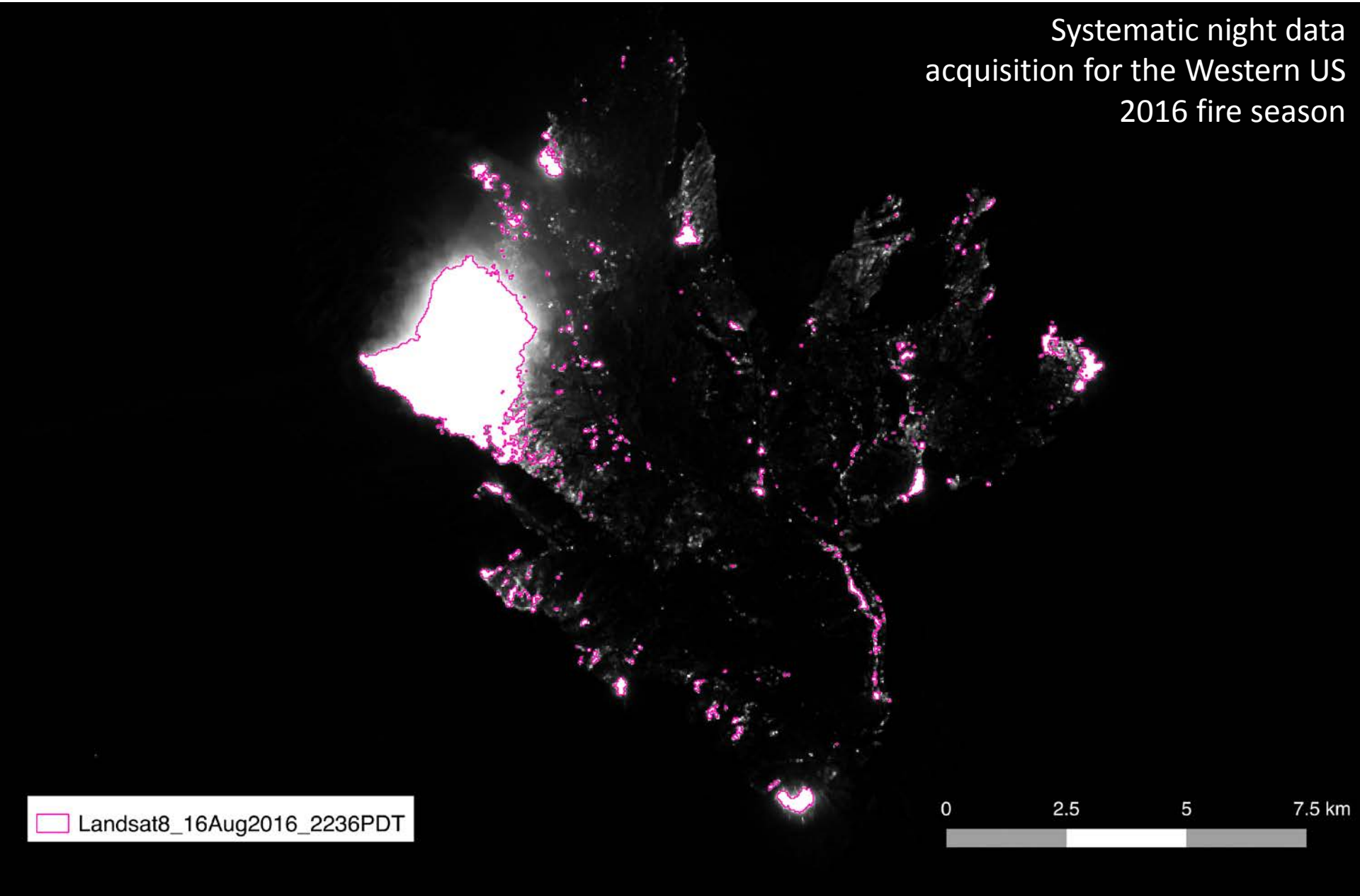


Landsat-8 fire mask: red

Sentinel-2a fire mask: green

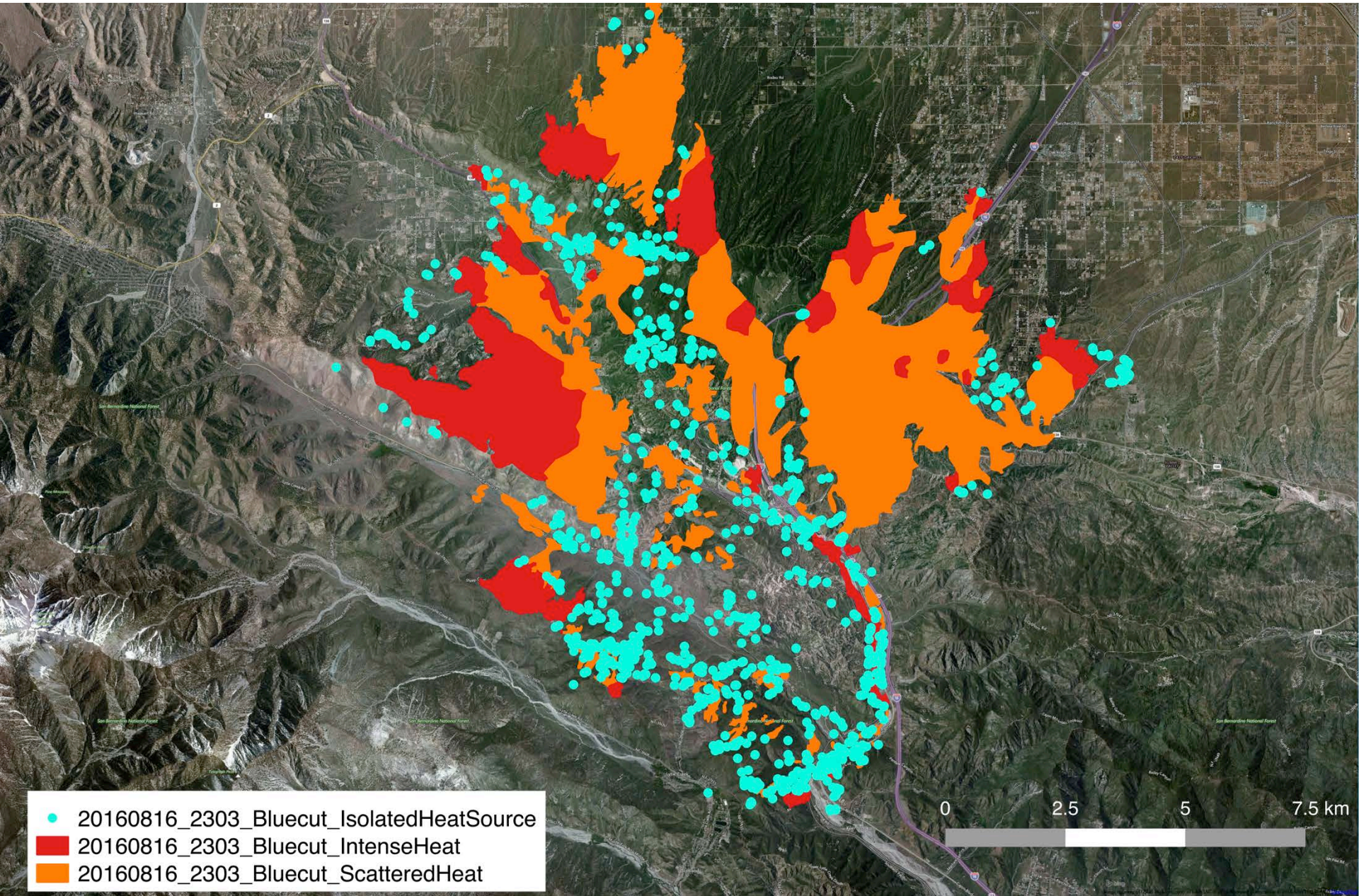
On-demand nighttime Landsat-8 acquisition

Blue Cut Fire 16 Aug 22:36 PDT



On-demand nighttime NIROPs acquisition

Blue Cut Fire 16 Aug 23:03 PDT



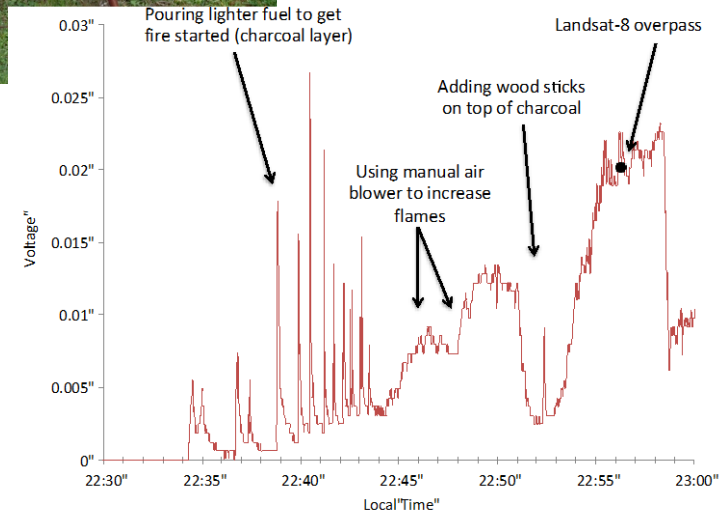
Very Small Fire Validation
Landsat-8 nighttime example in Greenbelt/USA

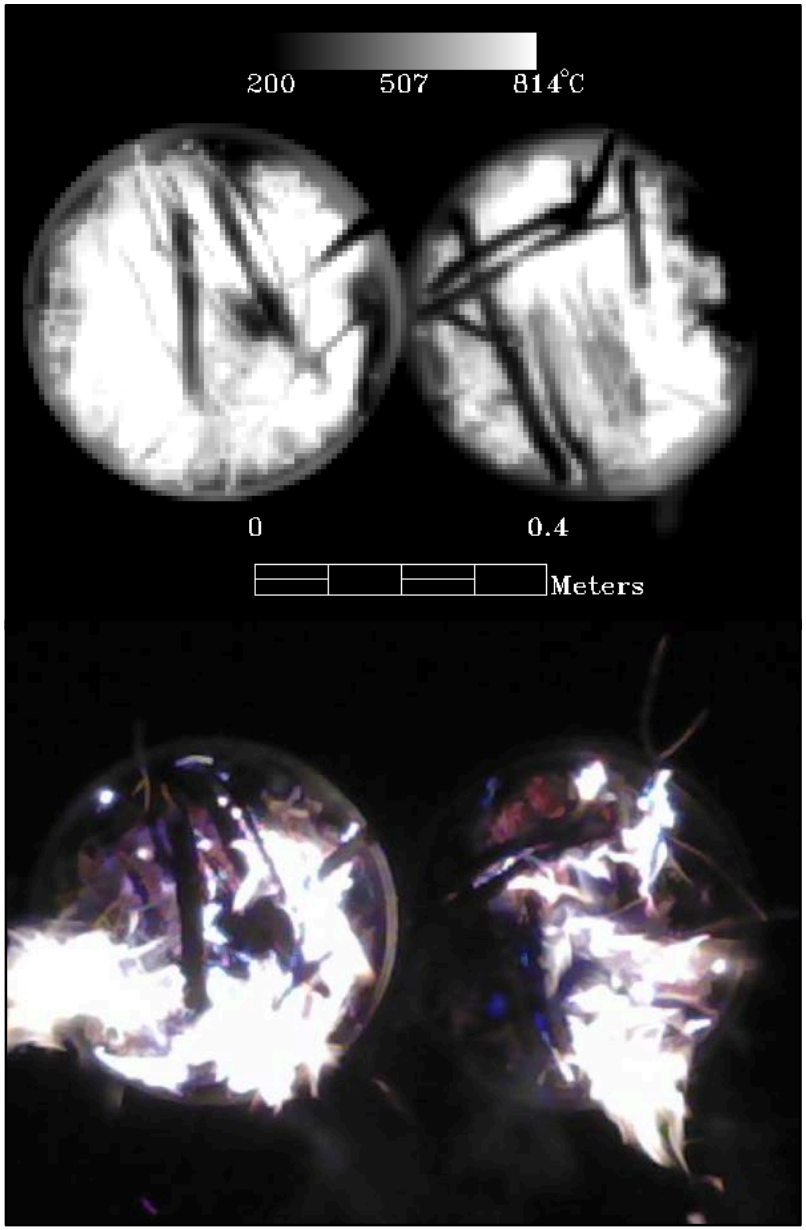
04 April 2015
10:56pm local

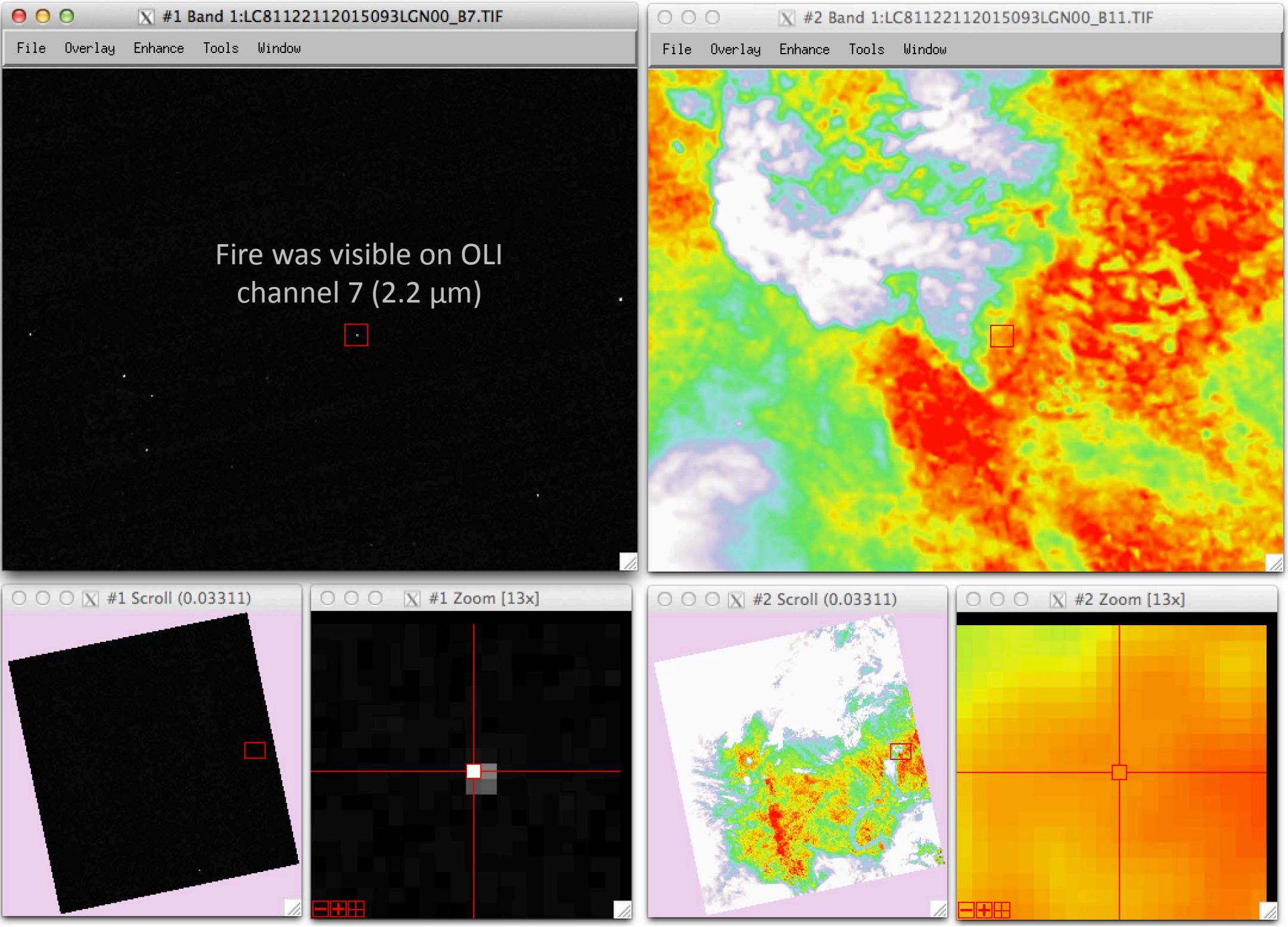
FLIR camera and dual-band radiometer mounted to 5 m telescoping tower overlooking grill fire

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):

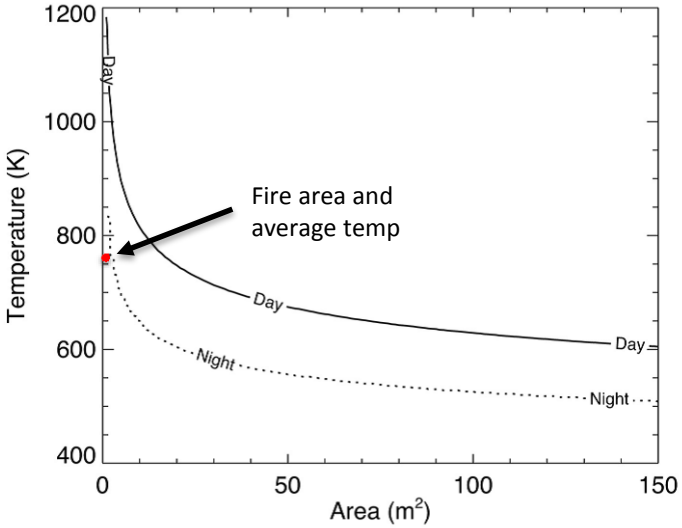
  0.453 W/m^2.sr.µm

  - Surface-equivalent (no atmosphere)

  - Assuming rectangular spatial response function and no data smearing
- Actual channel 7 top-of-atmosphere pixel radiance:

  0.229 W/m^2.sr.µm
- Single fixed threshold proposed for nighttime fire algorithm:

  1 W/m^2.sr.µm

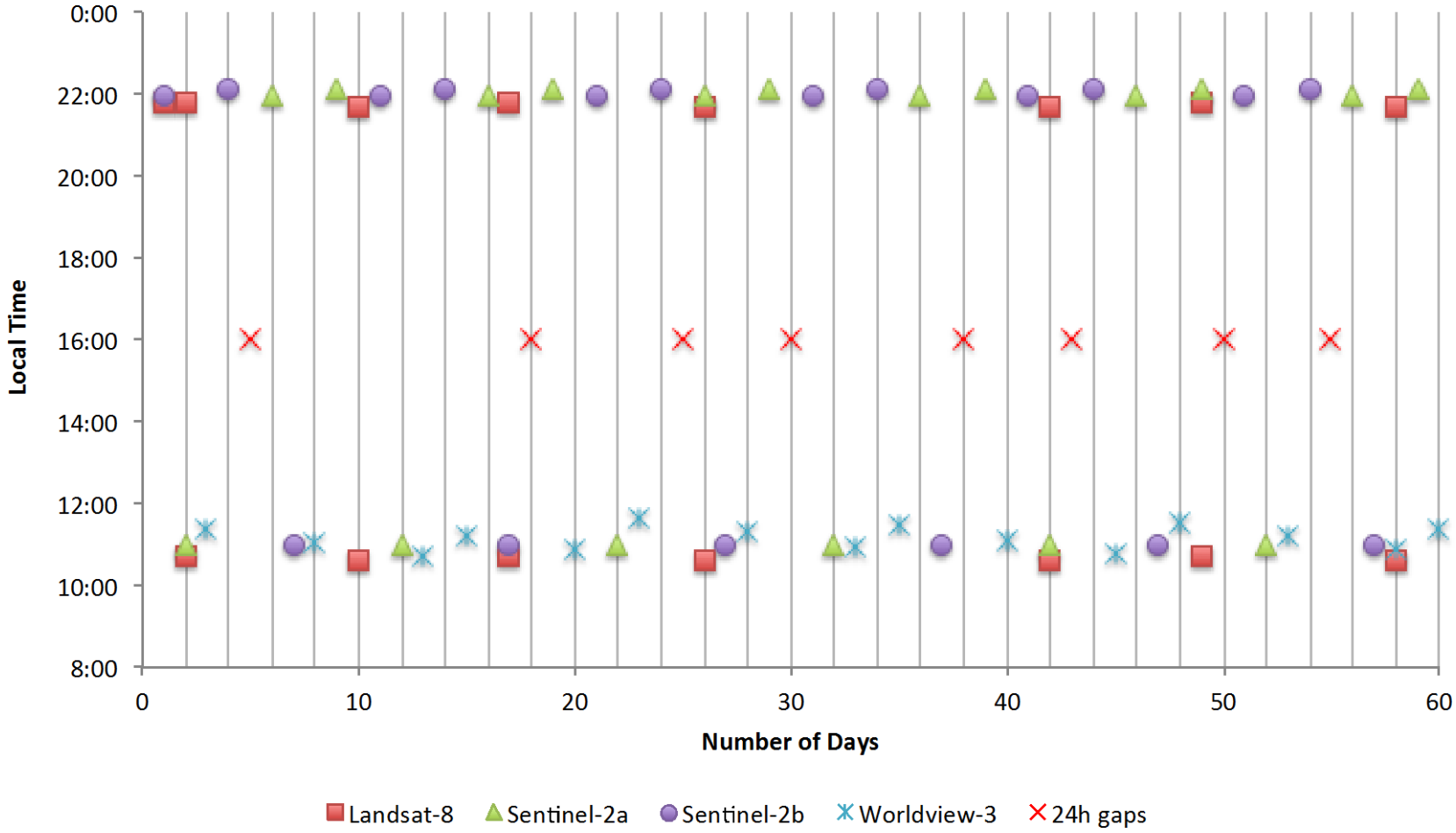


Current nighttime algorithm settings are made <u>intentionally conservative</u> in order to avoid large number of urban-related thermal anomalies!

Data Coverage Outlook

Expansion of sensor network and data acquisition capabilities resulting in gradual increase in observation frequency

Hypothetical coverage scenario @ 40°N including nighttime acquisitions



Conclusions I

- Most of VIIRS data calibration & quality issues have been addressed
  - South Atlantic magnetic anomaly noise still present
  - Random data noise still present (<<%)
  - L1B data reprocessing task started at NASA's Land SIPS (currently at Julian day 260/2012 @ ≈10x)
  - VNP14 and VNP14IMG reprocessing to start soon
    - Data & documentation (ATBD, Users Guide) will be made publicly available
  - Hybrid product (375m v2) soon to be available through LANCE/FIRMS & IPOPP including FRP retrievals
  - Hybrid version will be ported to NOAA/NDE operational system in 2017

- Landsat-8 active fire algorithm transitioned into operations at USDA Forest Service, serving incident teams
  - USGS supporting nighttime acquisition over priority areas

- Sentinel-2 active fire data being tested
  - Building on Landsat-8 fire algorithm with similar/encouraging results

Conclusions II

- New VIIRS and Landsat-class fire data enabling new applications
  - Improved mapping of smaller/low intensity fires
  - Active fire data being assimilated into cutting-edge coupled weather-fire models
  - Data supporting tactical fire applications, decision making, landscape-scale analyses

- Disasters applications currently limited by higher latency of Landsat-8/Sentinel-2 data
  - Community should consider lobbying for NRT Landsat-class data access

- Improved spatial resolution also raising new challenges
  - Approaching point of diminishing return (mapping biomass burning × recreational fires**)**
  - Detecting larger number of urban heat sources and potential false alarms
  - Increasing need for high quality/resolution urban mask and/or alternative solutions

Conclusions III

- NASA Applied Sciences – Wildfires subcomponent approaching the end of 1+3year funding cycle
  - Nine projects funded including pre-, active-, post-fire applications
  - NASA required buy-in from partnering agencies (e.g., USDA Forest Service, state agencies), plus operational implementation of project deliverables
  - Most projects reaching anniversary around Fall/2017, NASA provided small funding supplement to allow groups to perform a socio-economic impact assessment of new tools/methodologies
  - This funding cycle is likely to be followed by similar/longer period of reduced funding opportunities for new fire applications. New administration could make it worse
  - USDA Forest Service R&D budget tends to be redirected towards wildfire management half-way through the fiscal year as fire season ramps up

- Expecting NASA call for proposals extending EOS/MODIS & JPSS/VIIRS fire product development + validation, data continuity