

Nighttime VIIRS products: Fires, Flares, Lights, and Boats

Christopher D. Elvidge, Ph.D.
Earth Observation Group
NOAA National Geophysical Data Center
Boulder, Colorado USA
chris.elvidge@noaa.gov

Kimberly Baugh, Feng-Chi Hsu, Mikhail Zhizhin, Tilottama Ghosh
Cooperative Institute for Research in the Environmental Sciences
University of Colorado

August 25, 2015

Lights At Night!



Cities and human
settlements
Industrial Sites



Boats



Gas Flares



Fires

UN Initiative to end routine flaring by 2030

Zero Routine Flaring by 2030



FEATURED

< 2 / 2 >



The Zero Routine Flaring Initiative

May 22, 2015 — The initiative was launched by UNSG Ban Ki-moon and WBG President Jim Yong Kim with governments, oil [Read More »](#)

[Initiative](#)

[Q&A](#)

[Quick Facts](#)

[Endorsers](#)

[Get Involved](#)

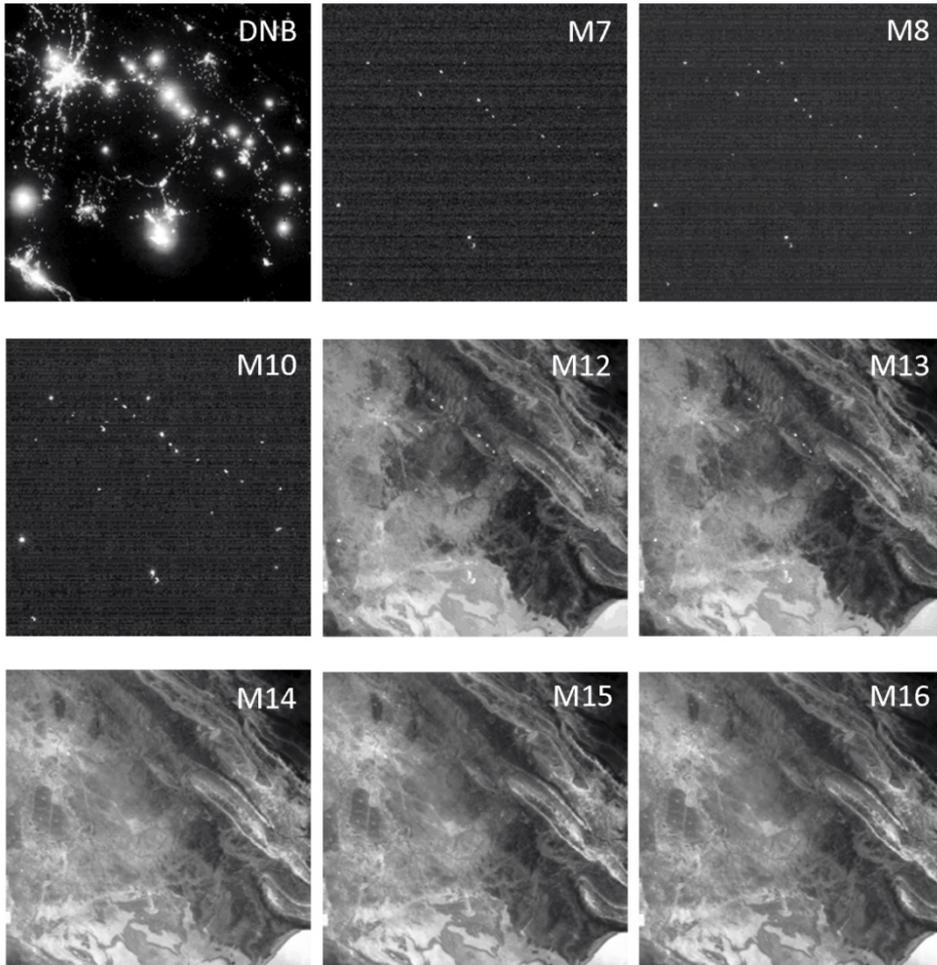
[Related Information](#)

[Flaring in the News](#)

How will progress be tracked? VIIRS!

During oil production, associated gas is produced from the reservoir together with the oil.

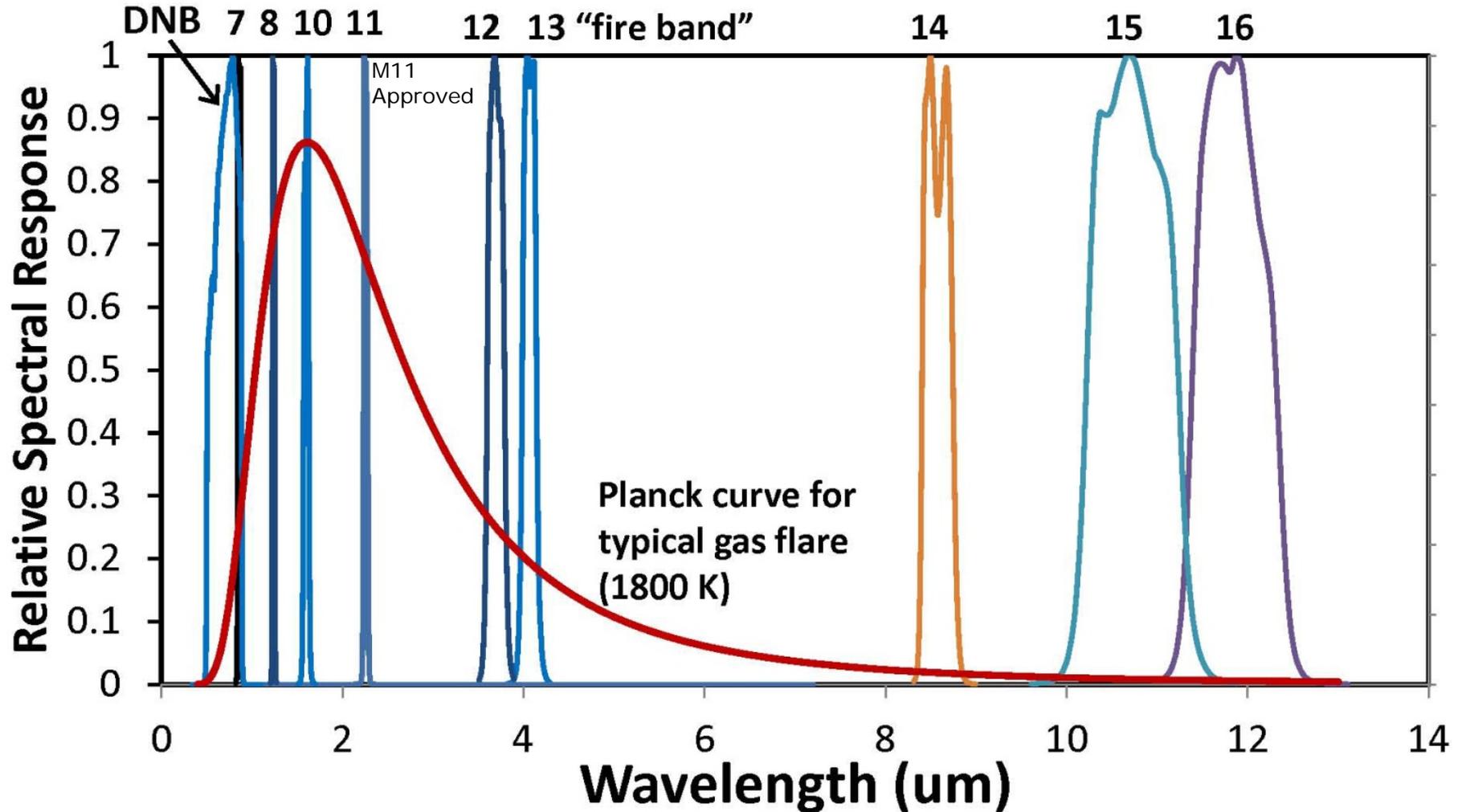
Basra Gas Flares, Iraq - July 17, 2012



Gas flares are readily detected in the VIIRS M10 spectral band

VIIRS Nightfire (VNF): A global multispectral fire product

Nine channels of data are collected at night



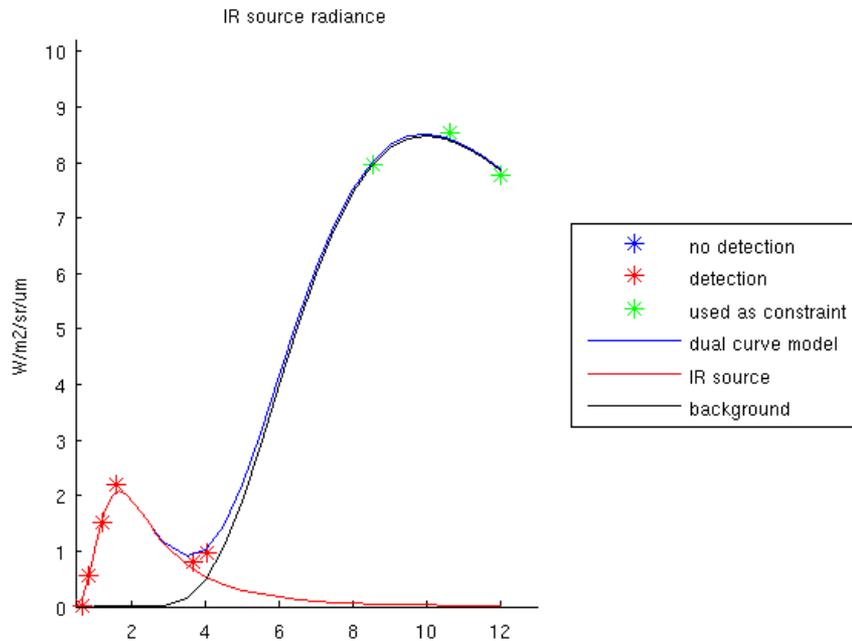
Nighttime collection of channel 11 is expected to start in 2015

Why Multispectral?

To get
at the
Planck
curves!

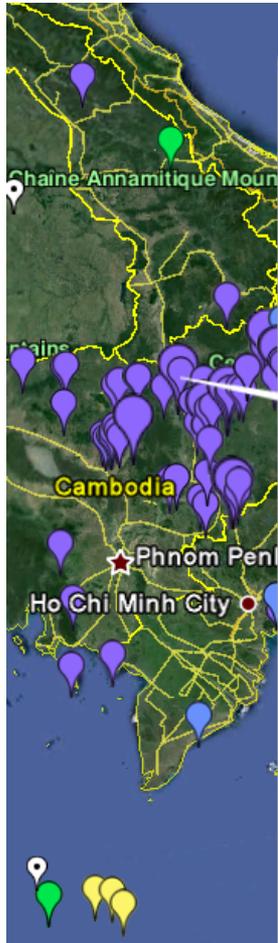
Combustion parameters:

ID=VNF_npp_d20140426_t0800568_e0806372_b12924_x0922946W_y196042N_l2716_s2045_v21
Lat=19.604204 Lon=-92.294624 deg. Time=2014/04/26 08:06:32
Temperature source=1730 deg. K Temperature background=291 deg. K
Radiant heat intensity=16.63 W/m² Radiant heat=13.18 MW
Source footprint=25.96 m²
Methane equivalent=0.356 m³/s CO₂ equivalent=651.983 g/s
Cloud state=clear Atmosphere corrected=no



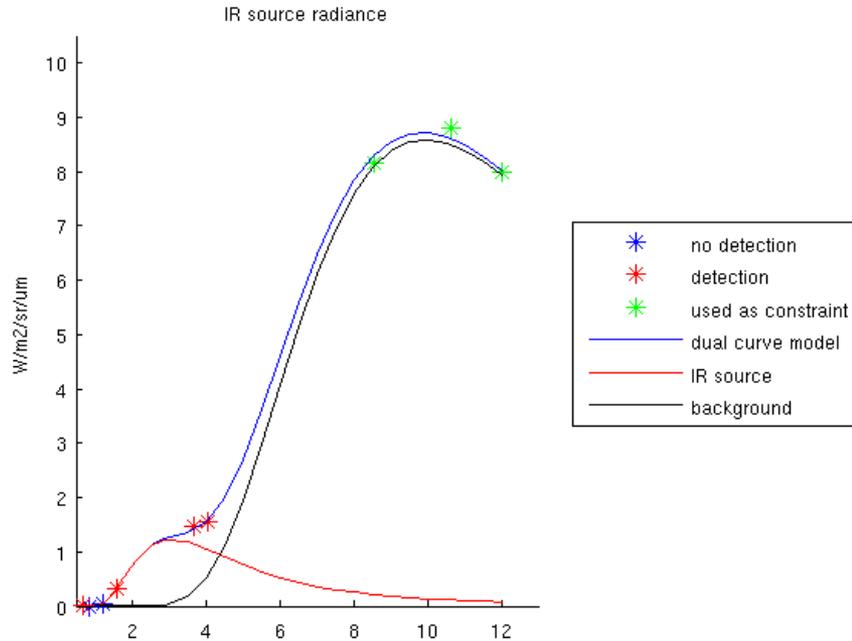
Daily files are in csv and kmz formats

Typical Biomass Burning Detection



Combustion parameters:

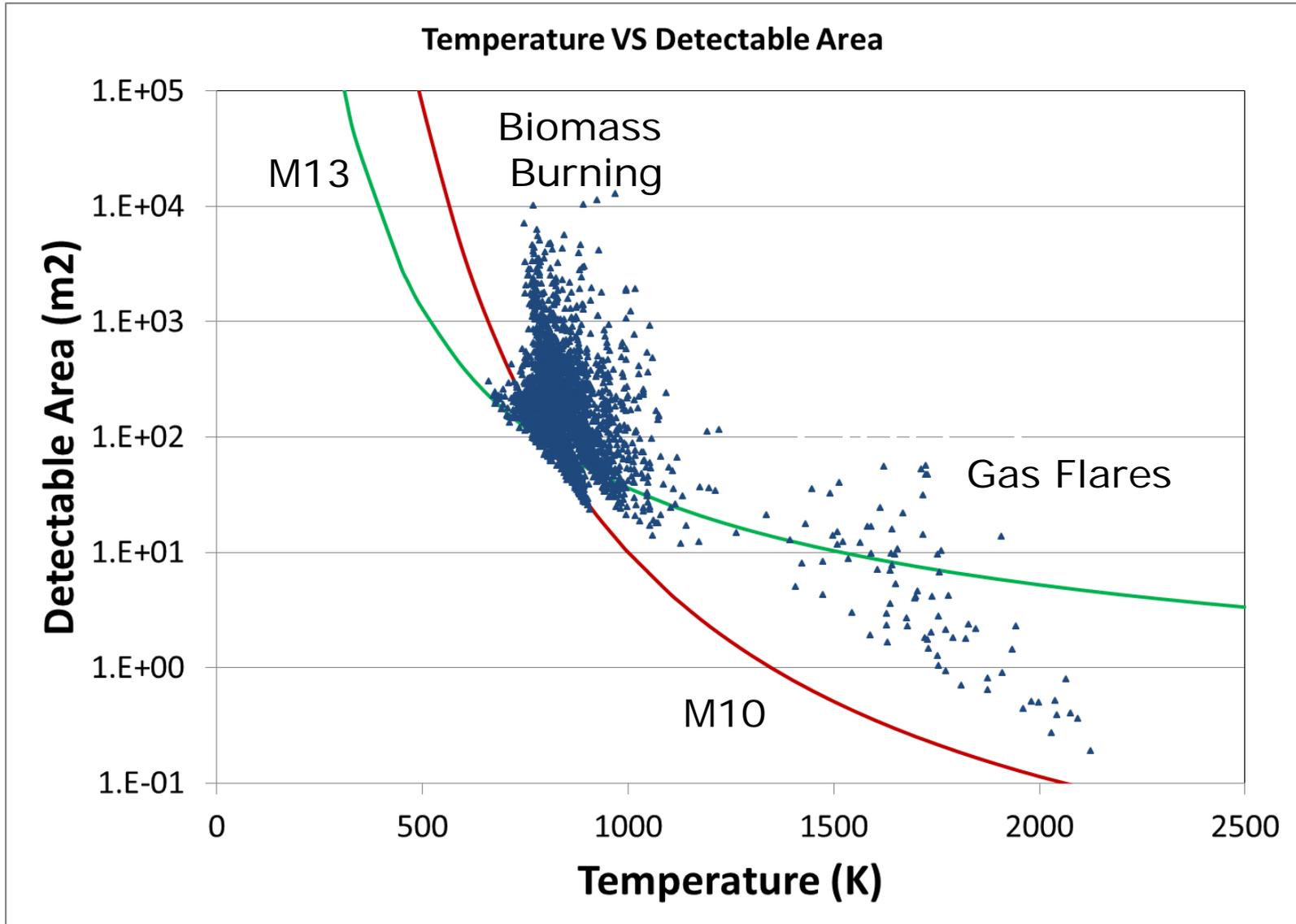
ID=VNF_npp_d20140426_t1815286_e1821090_b12930_x1060700E_y138260N_l0804_s1065_v21
Lat=13.825994 Lon=106.070045 deg. Time=2014/04/26 18:17:32
Temperature source=942 deg. K Temperature background=291 deg. K
Radiant heat intensity=17.98 W/m2 Radiant heat=16.68 MW
Source footprint=373.71 m2
Cloud state=clear Atmosphere corrected=no



Lower temperature than gas flaring. Often these have larger source size than gas flares.

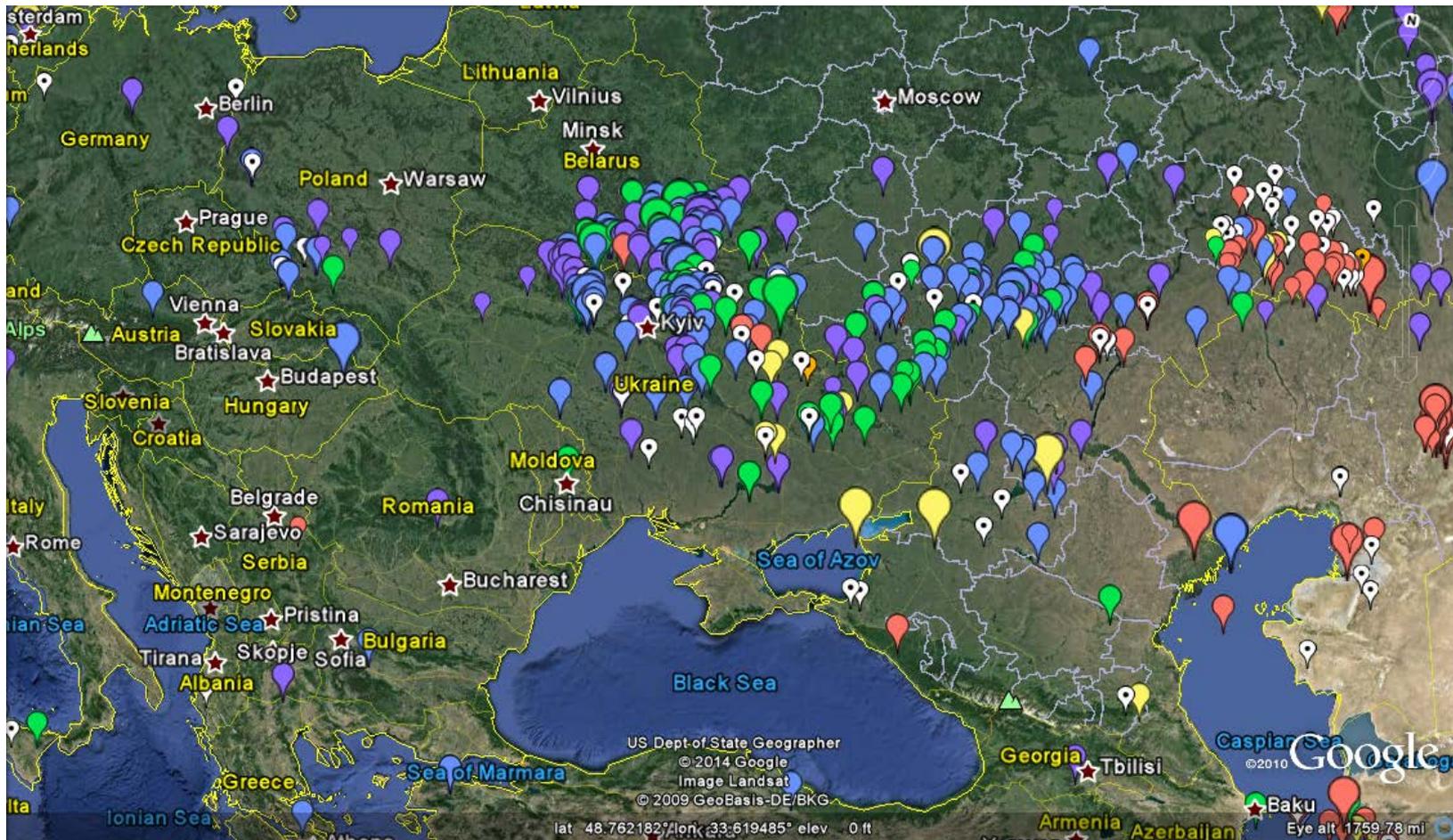
Detection Limits

At 1800 K flares as small as 0.25 m² are detectable



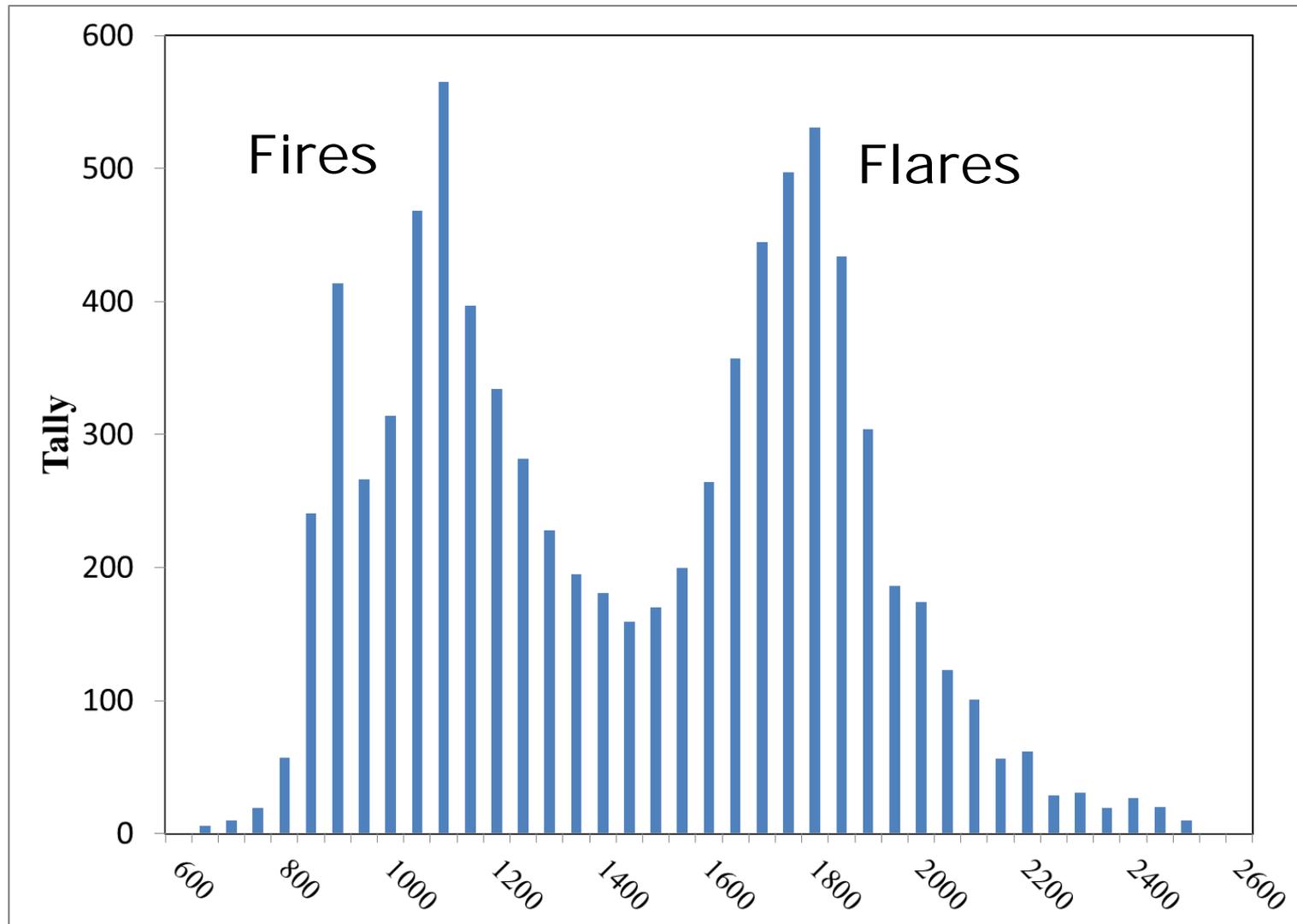
Daily VNF data are available at:

http://ngdc.noaa.gov/eog/viirs/download_viirs_fire.html

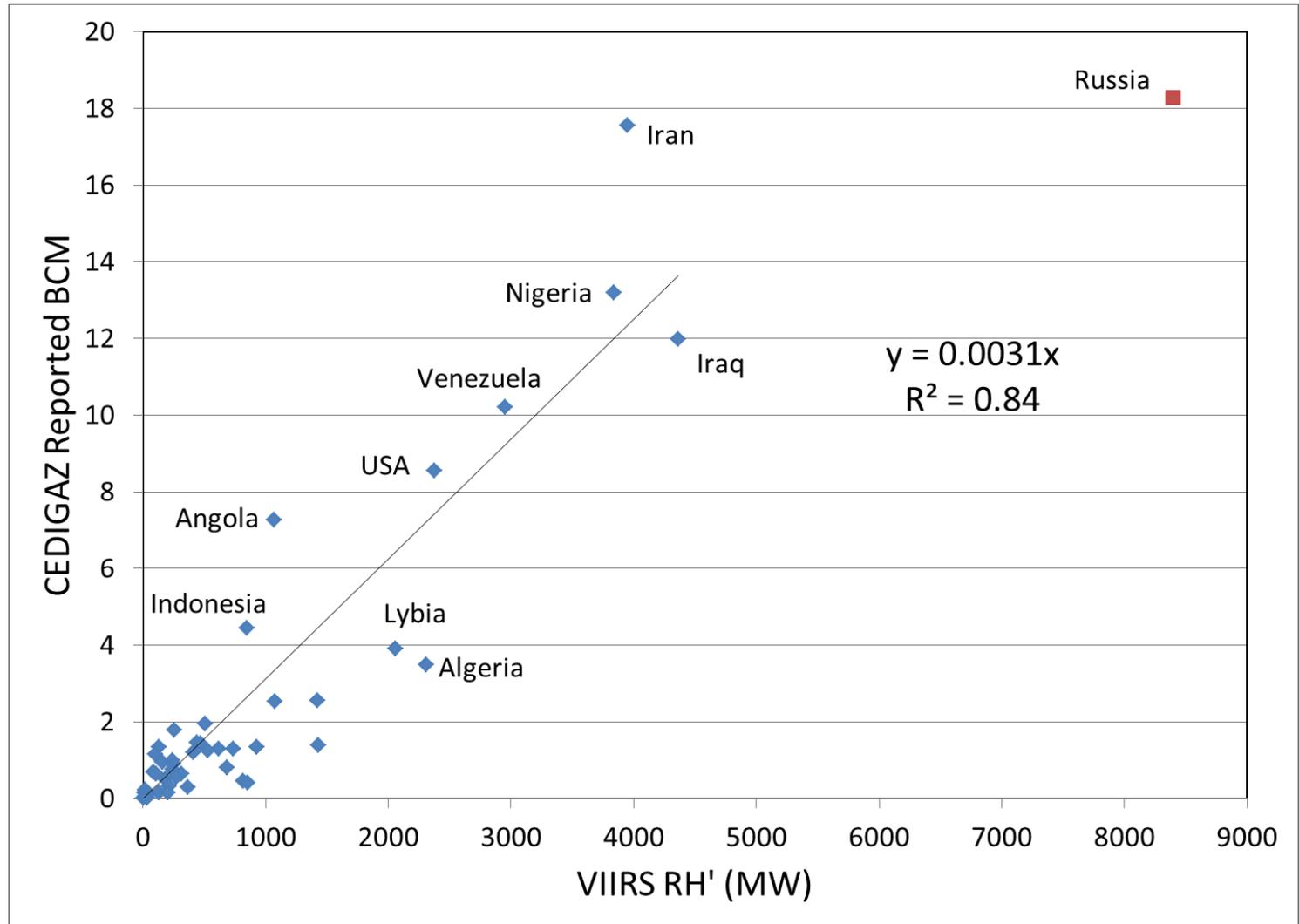


Current processing typically runs with a four hour delay

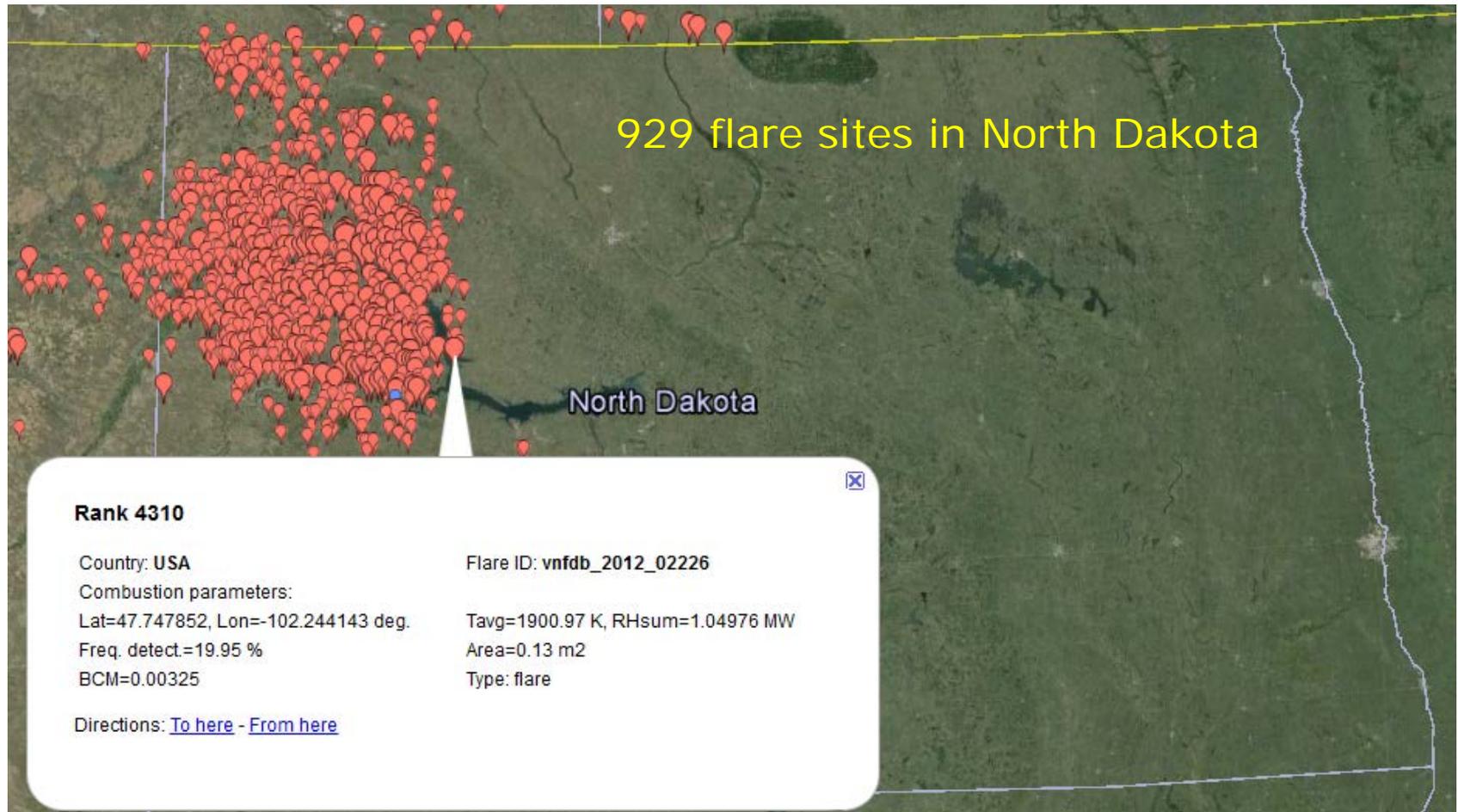
Temperatures are bimodal



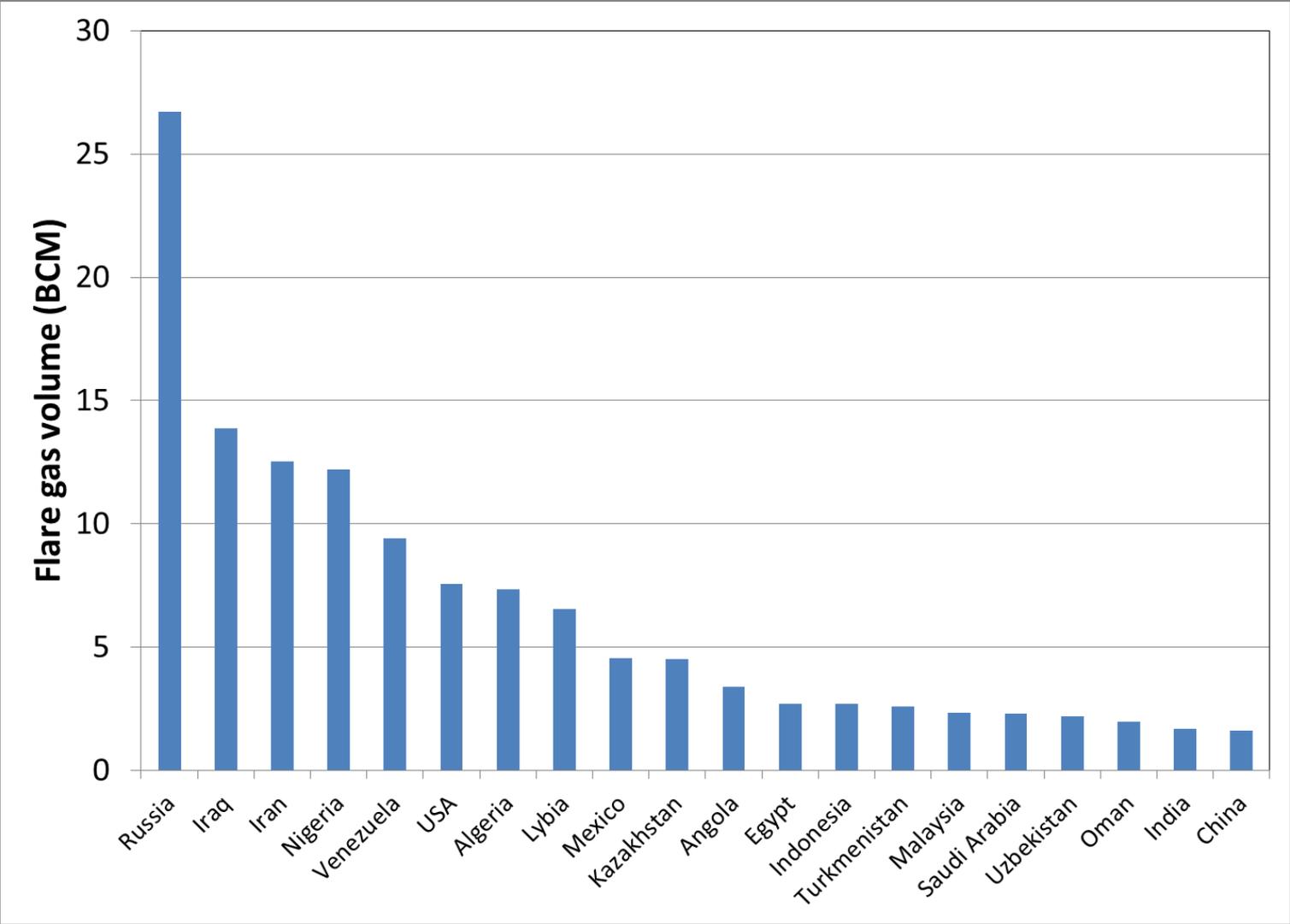
Calibration for estimating BCM from radiant heat



Gas flaring volumes estimated at 7438 sites worldwide

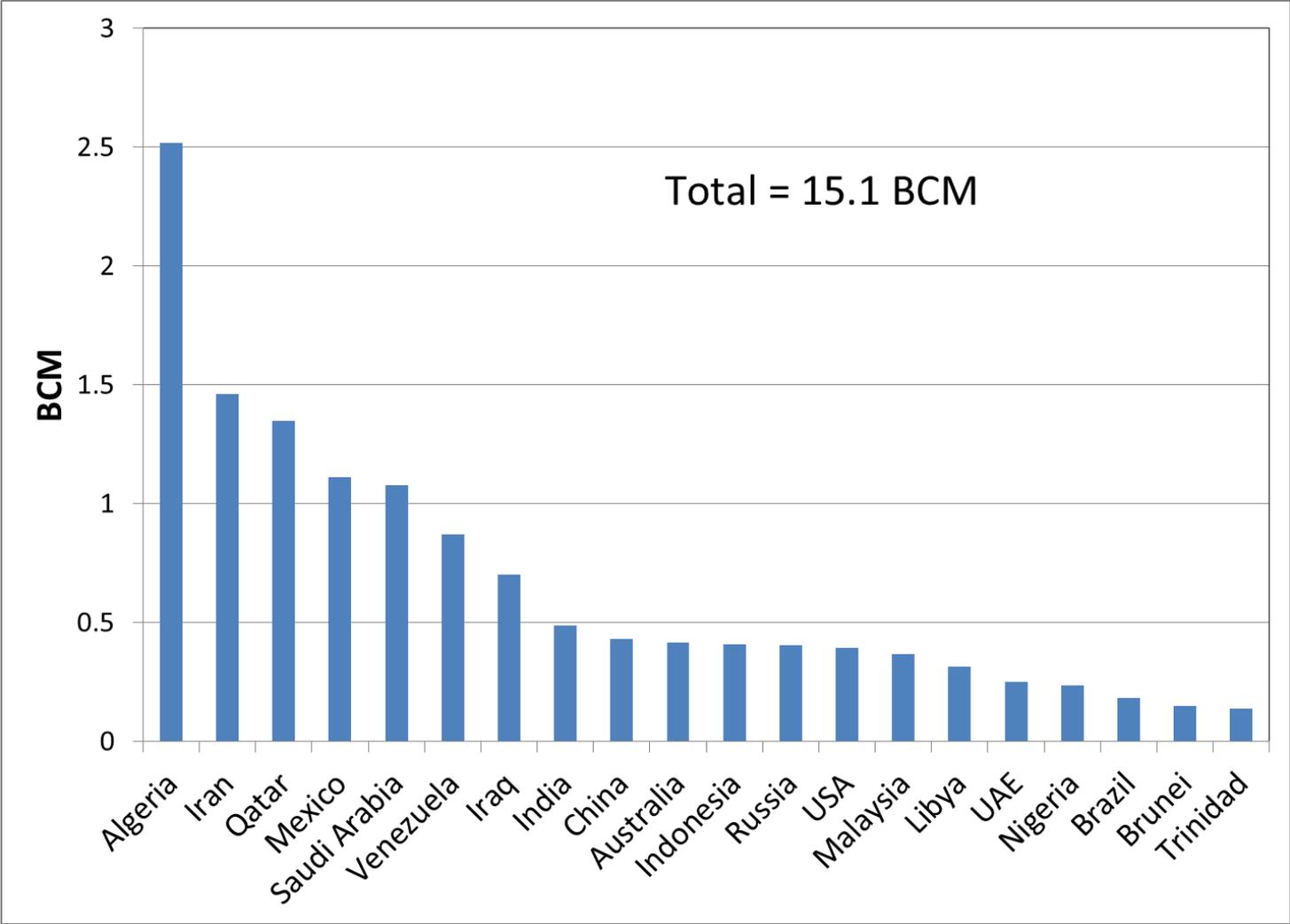


Upstream gas flaring by country in billions of cubic meters (BCM)



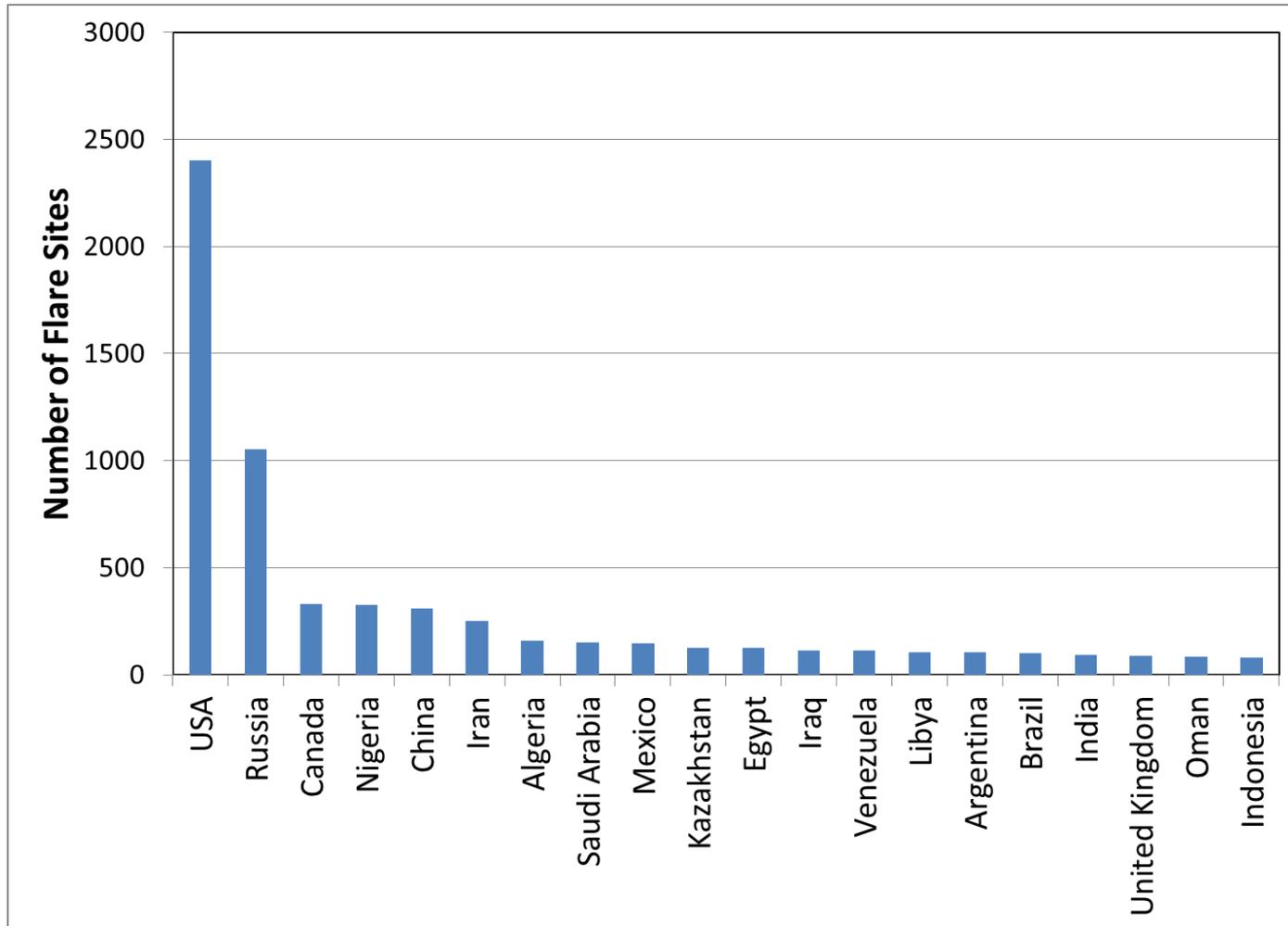
Global
total
145 BCM

Downstream flaring by country in billions of cubic meters (BCM)

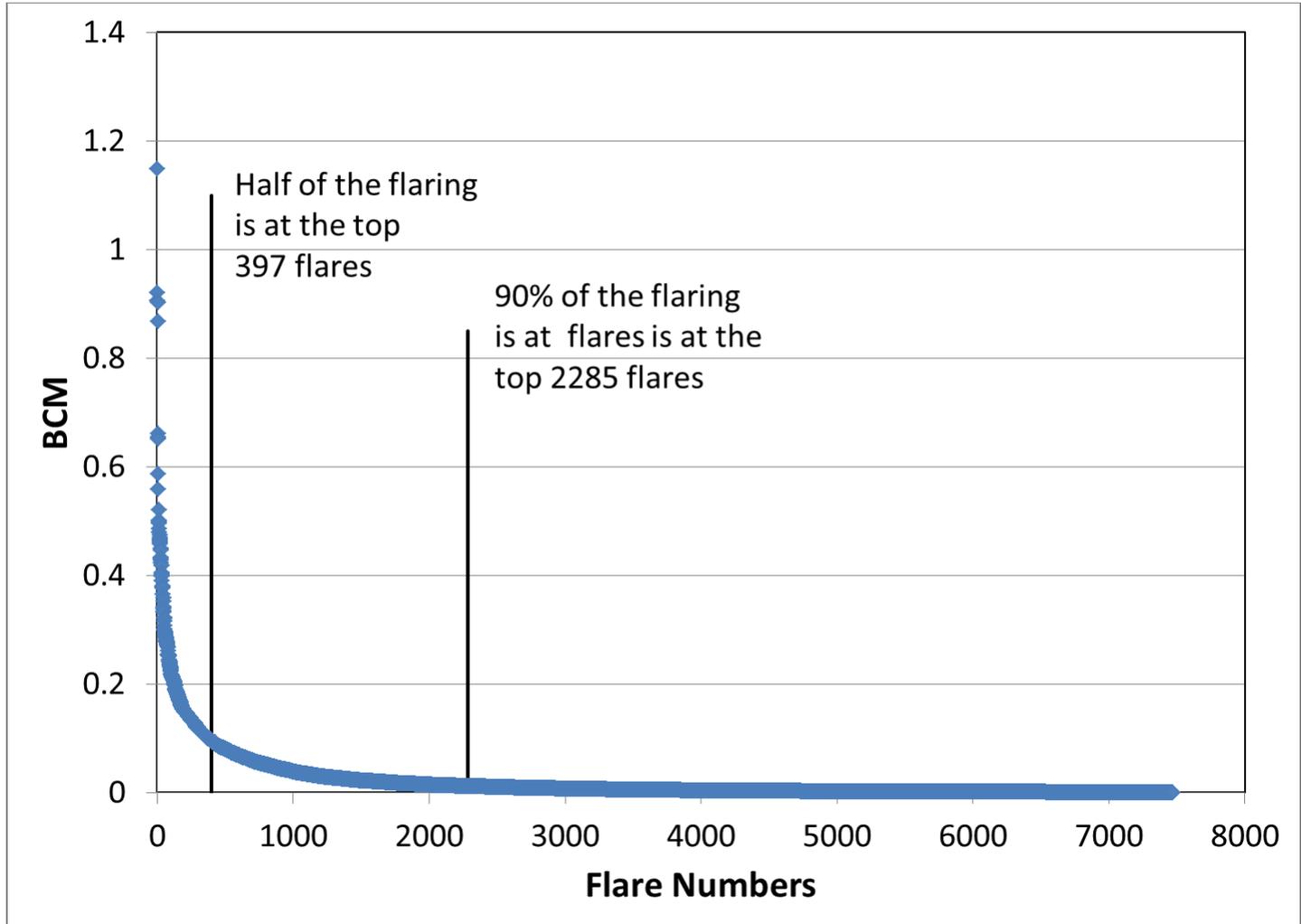


Flare site numbers by country

30% of flare sites are in the USA



Gas flaring site numbers by country.



Discrimination of flaming and smoldering combustion

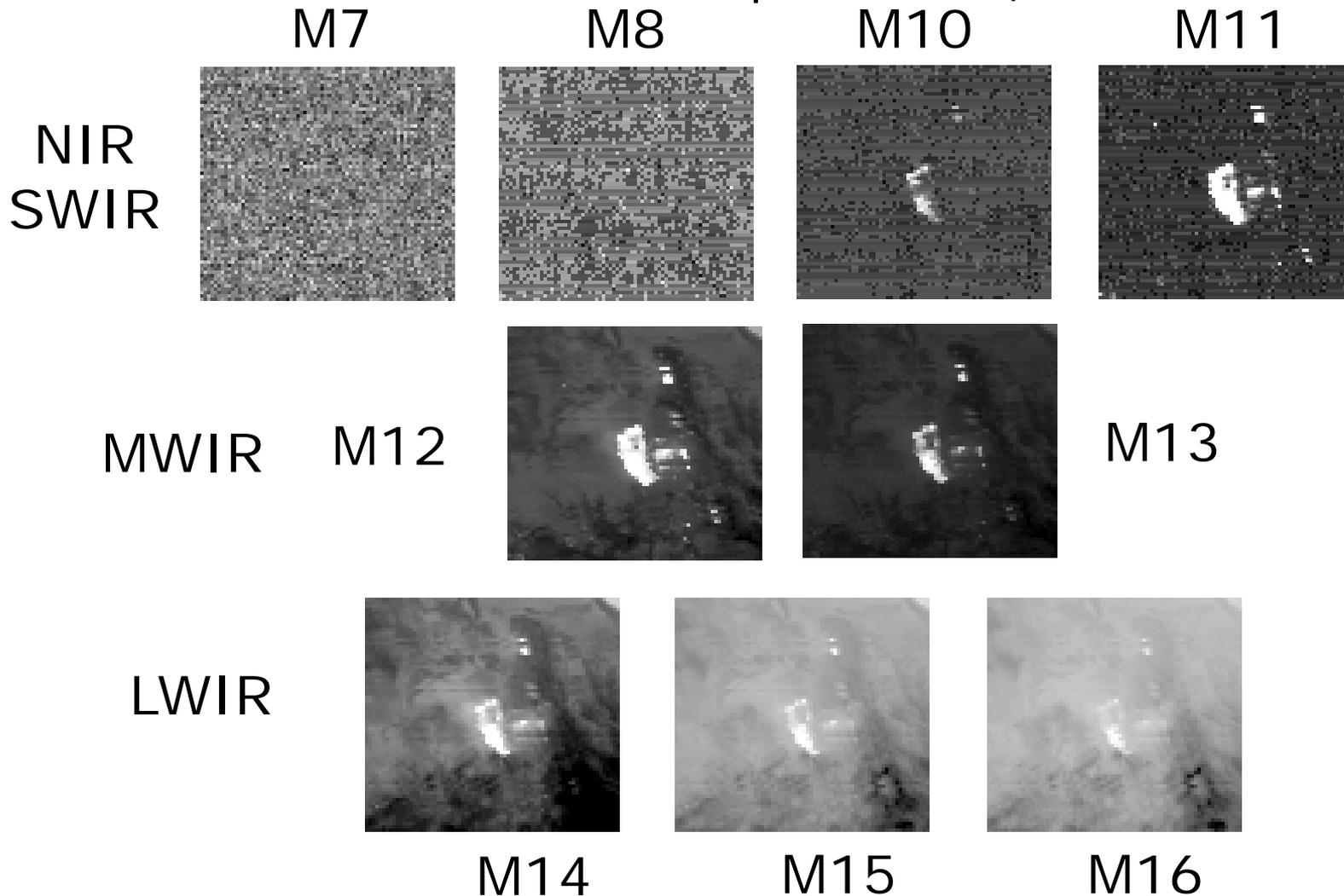
- There are two distinct combustion phases
- Flaming: higher temperature 700-1200 K, good oxidation, low smoke
- Smoldering about half as hot as flaming 350-450 K, poor oxidation, high smoke production
- Discriminating between flaming and smoldering could improve emission modeling
- There is a 400-500 K temperature differential
- Is the temperature differential sufficient to discriminate flaming and smoldering with VIIRS data?

Approach

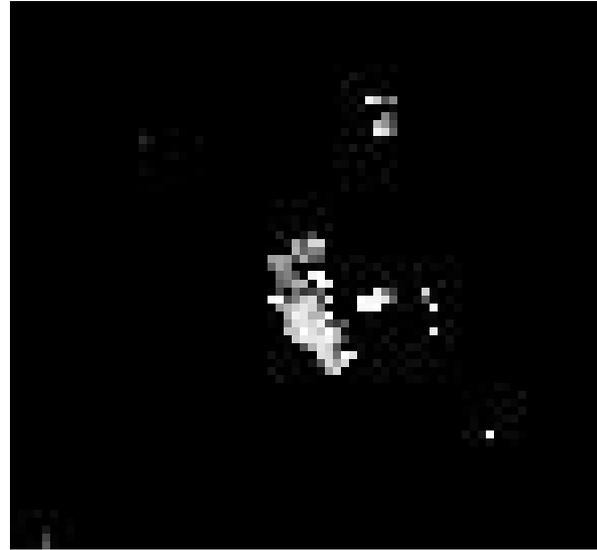
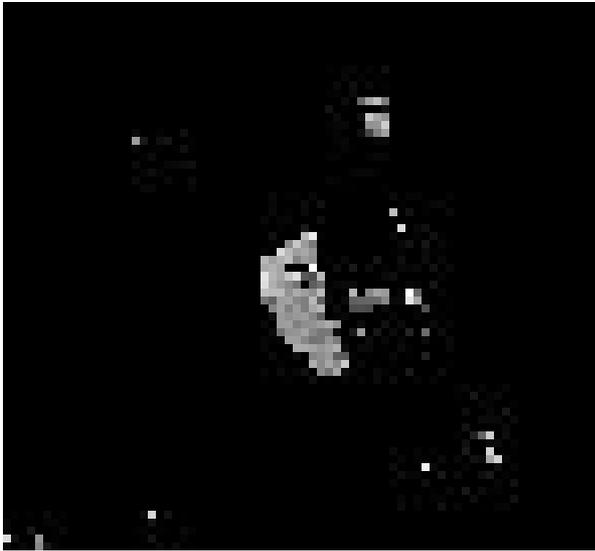
- Prototype method developed with nighttime Landsat 8 data
- Model the flaming phase by Planck curve fitting the M10 & M11 radiances, producing flaming phase radiance estimates in long wave bands
- Subtract the flaming phase radiance and background radiance in bands M12,13,14,15,16
- Residual thermal anomalies suggest smoldering

Sumatra Peat Fire Study

With M11 – September 26, 2014



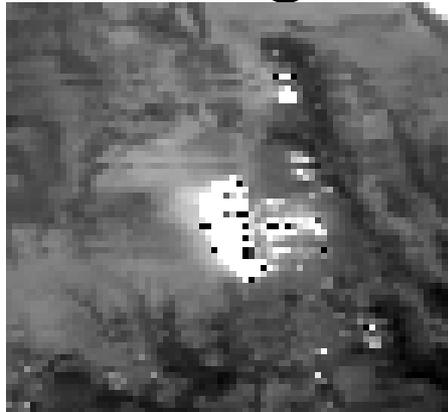
Temperature and source area from M10 & M11 Planck curve fitting



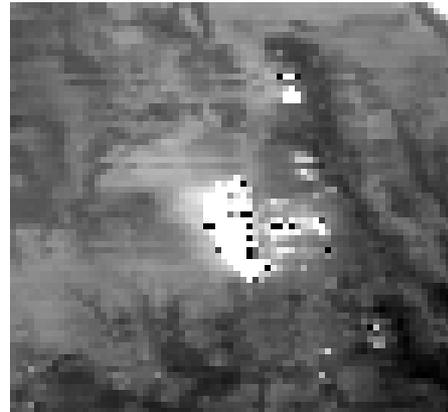
Residuals

After subtracting flaming phase and average background radiances

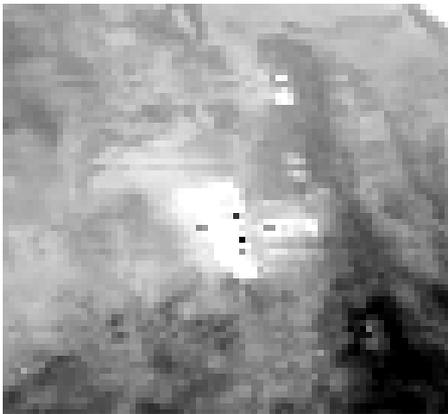
M12



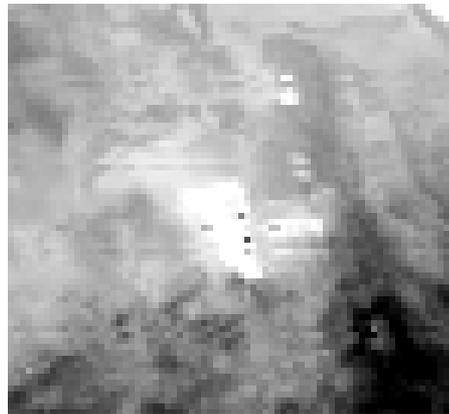
M13



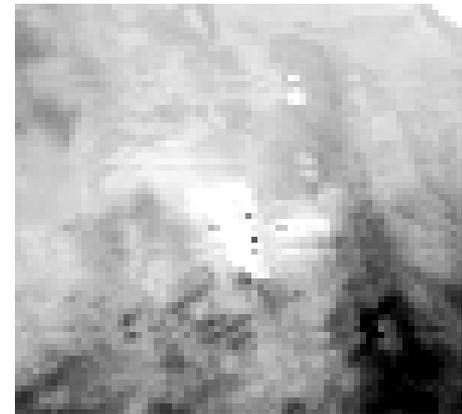
M14



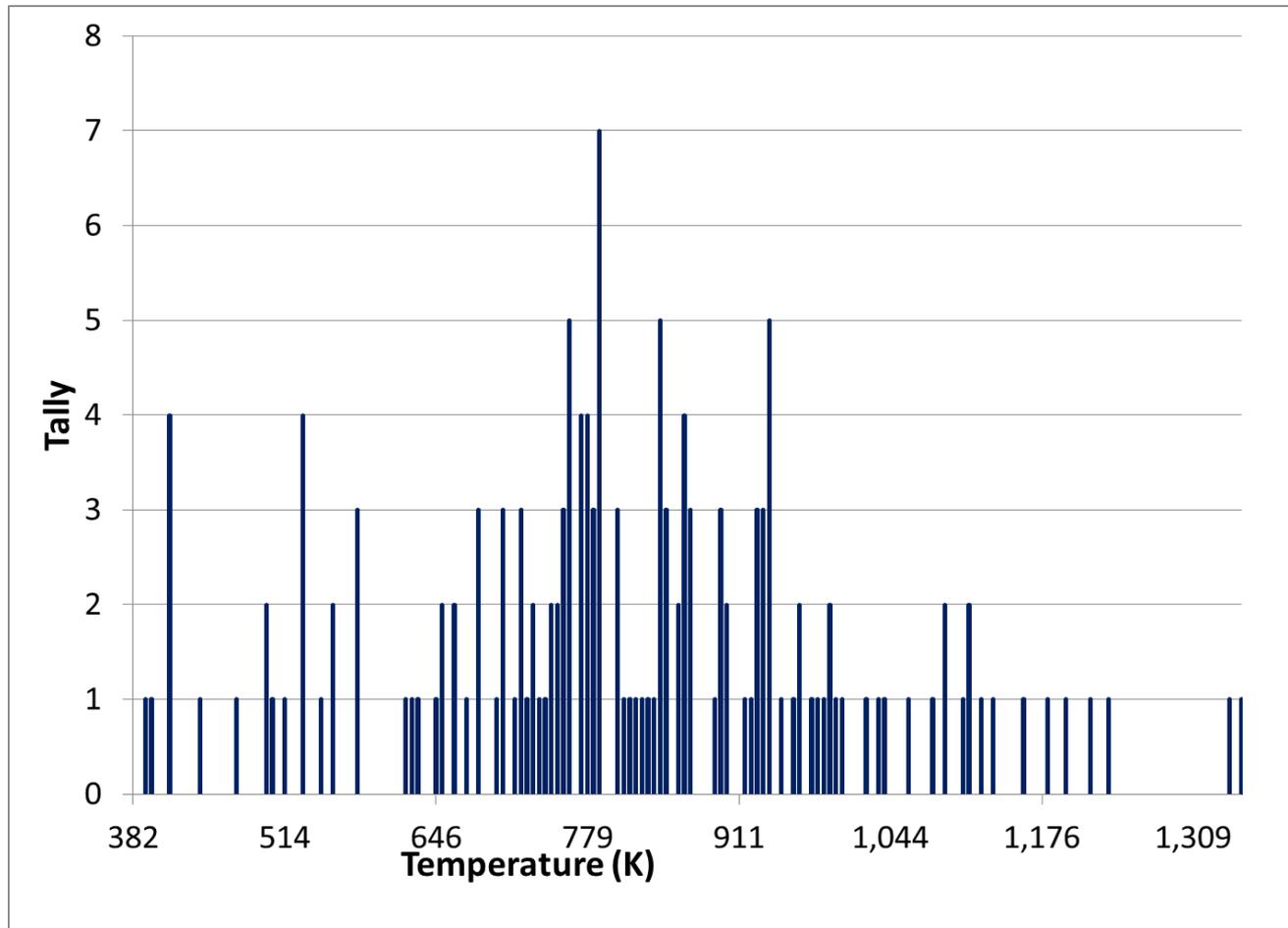
M15



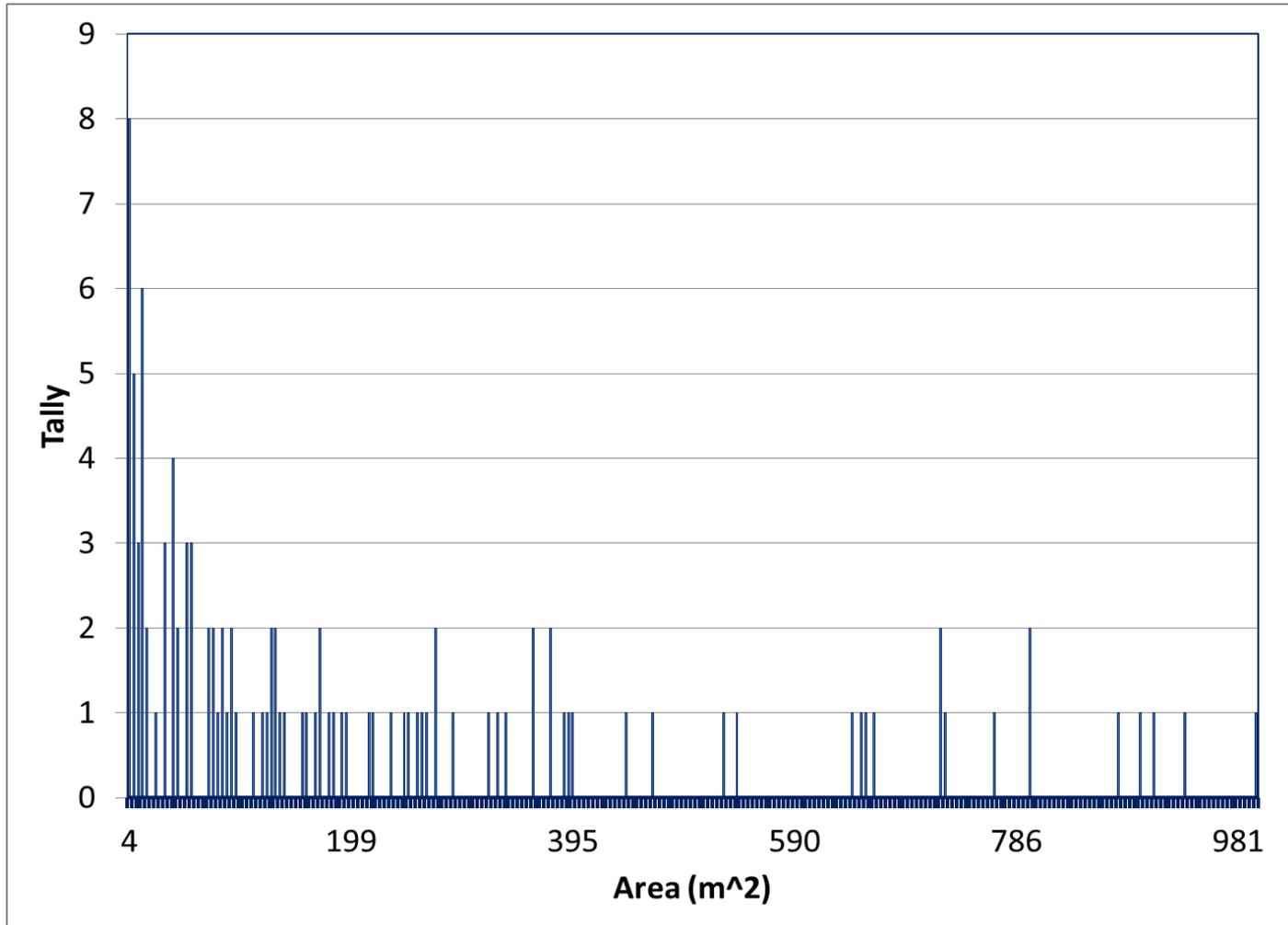
M16



Temperatures from M10 & M11 Planck curve fit – Sumatra September 26, 2014



Source areas from M10 & M11 Planck curve fit – Sumatra September 26, 2014



Summary on Flaming vs Smoldering with VIIRS

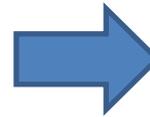
- M10 & M11 radiances can be used to extract flaming phase temperatures and source areas
- The presence of residual hotspot radiances in mid-long wave infrared channels after subtracting flaming phase and background radiances suggests the presence of smoldering in Sumatra peat fires.
- Can smoldering phase temperatures and source areas be estimated?
- The method needs to be tested more widely.

VIIRS detects lights from boats at night

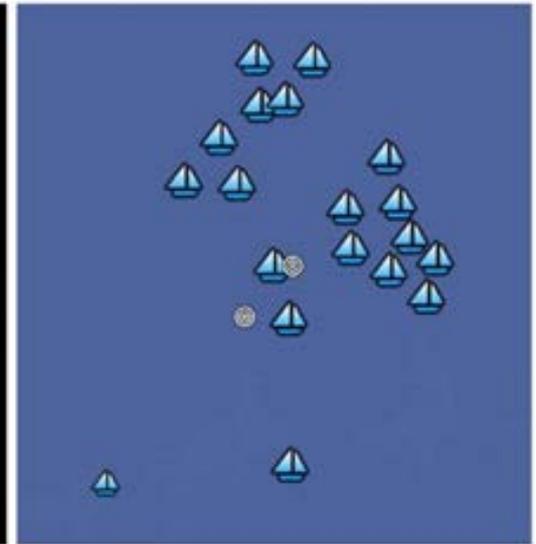
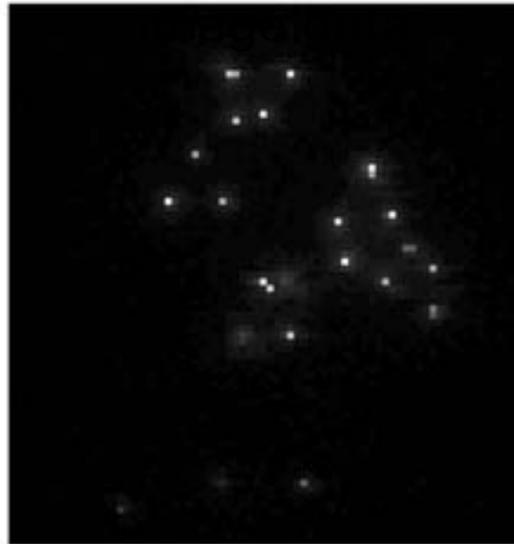
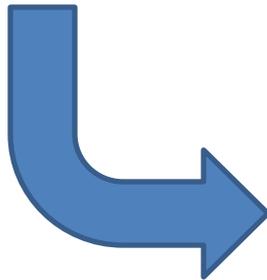
Near real time service running for Indonesia.
Expansion to other regions begins later this year.



VIIRS
day/night
band (DNB)
nighttime



Boat detection
data (points)



http://www.ngdc.noaa.gov/eog/viirs/download_indo_boat.html

Applications for VIIRS boat detections

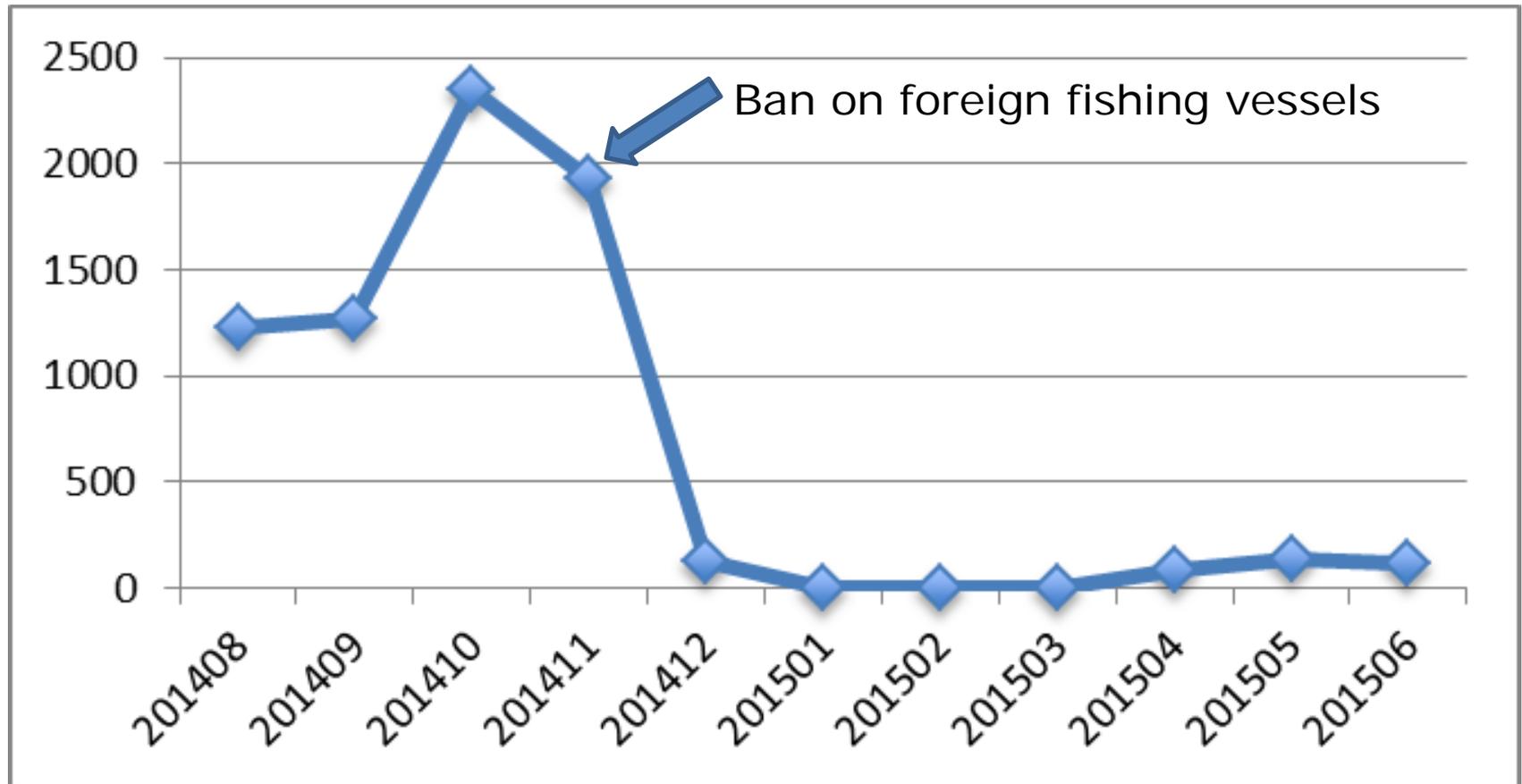
- Supply alerts for boats detected in “no-take” and Marine Protected Areas
- Cross correlate with GPS beacon data to ID potentially illegal fishing
- Monitor for transboundary foreign vessels
- Assess the impacts of new regulations and enforcement regimes

Boat Detections Running for Indonesia



Documenting effectiveness of regulations

Aru Island, Arafura Sea



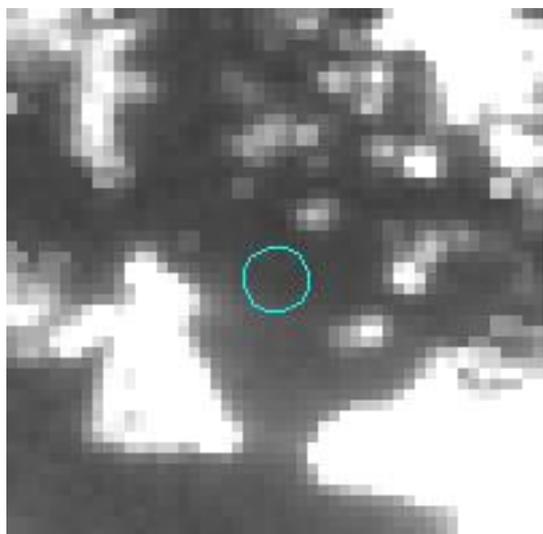
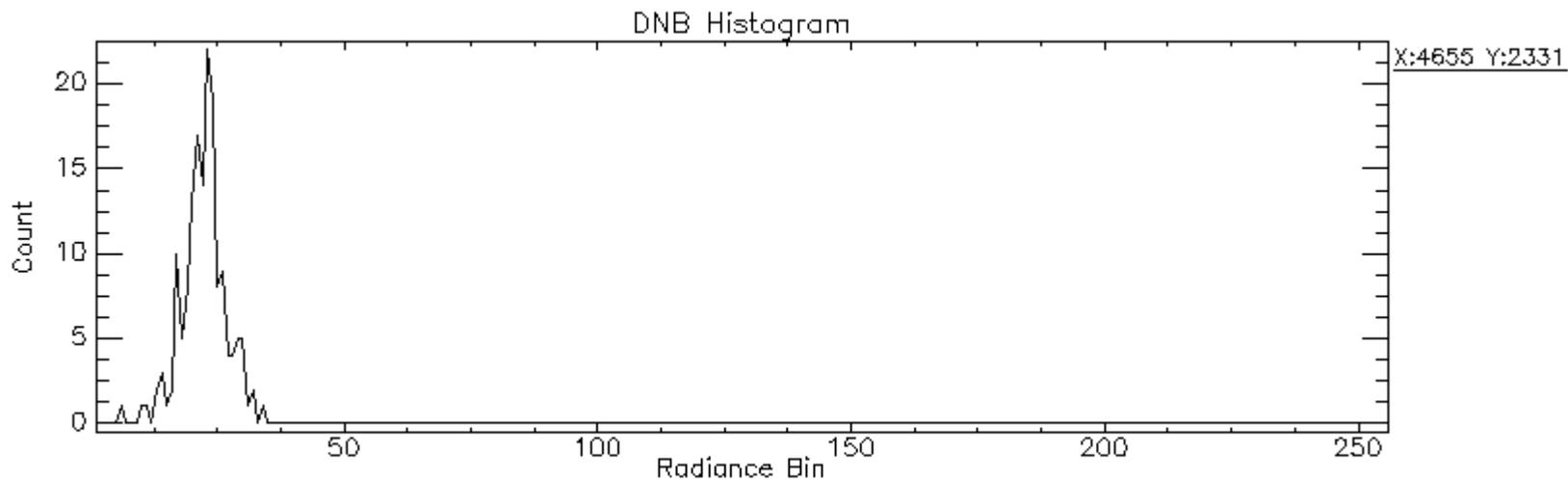
VIIRS Nighttime Lights Algorithm Development

- Algorithms developed to remove lighting and fires.
- The DNB based fire removal algorithm should work well for removing South Atlantic Anomaly (SAA) detector hits and may also remove aurora.
- Last major hurdle is removal of background.

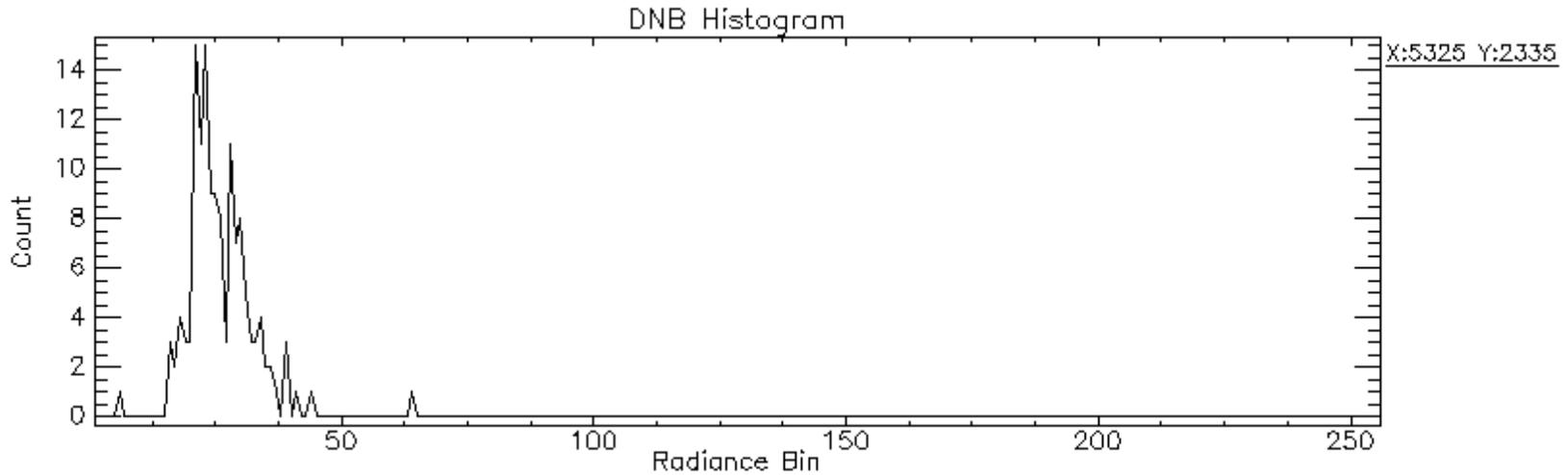


South Asia
DNB
cloud-free
composite

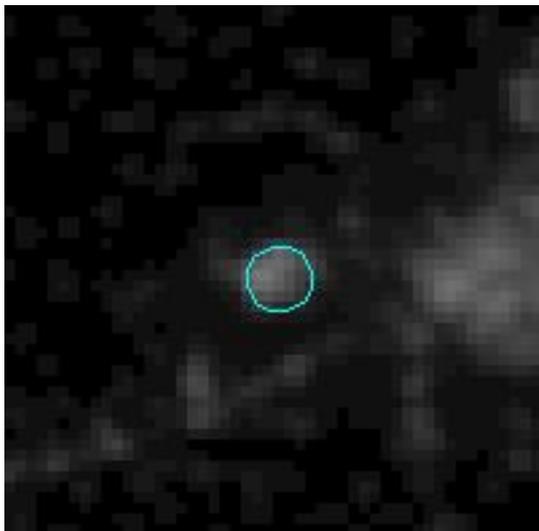
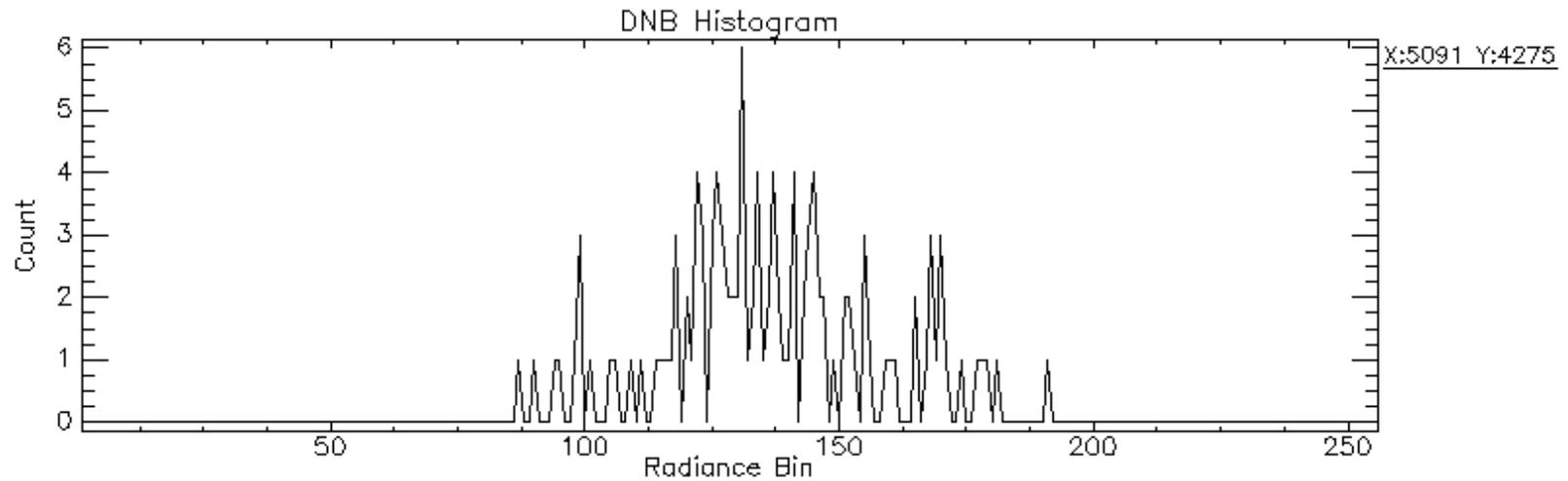
Background



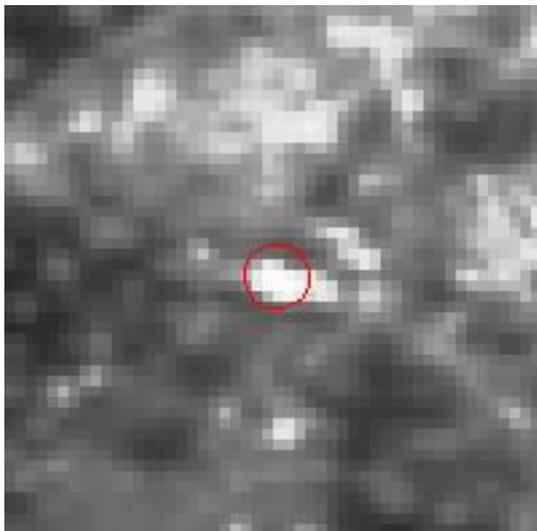
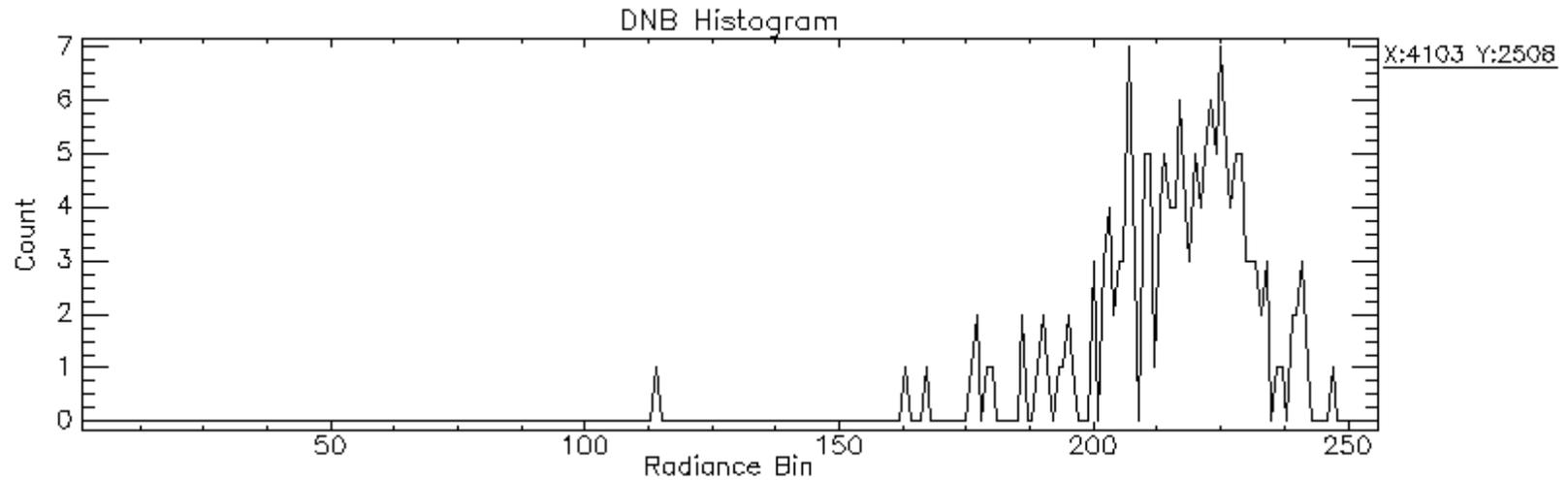
Background with infrequent light



Minor urban area

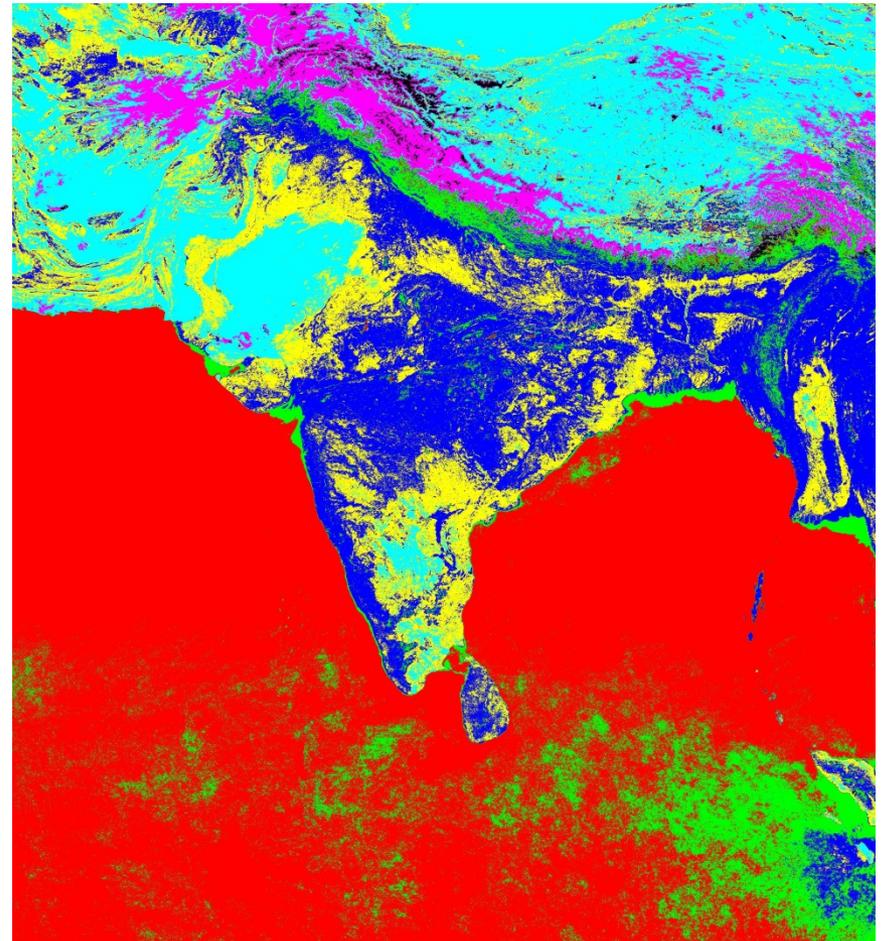
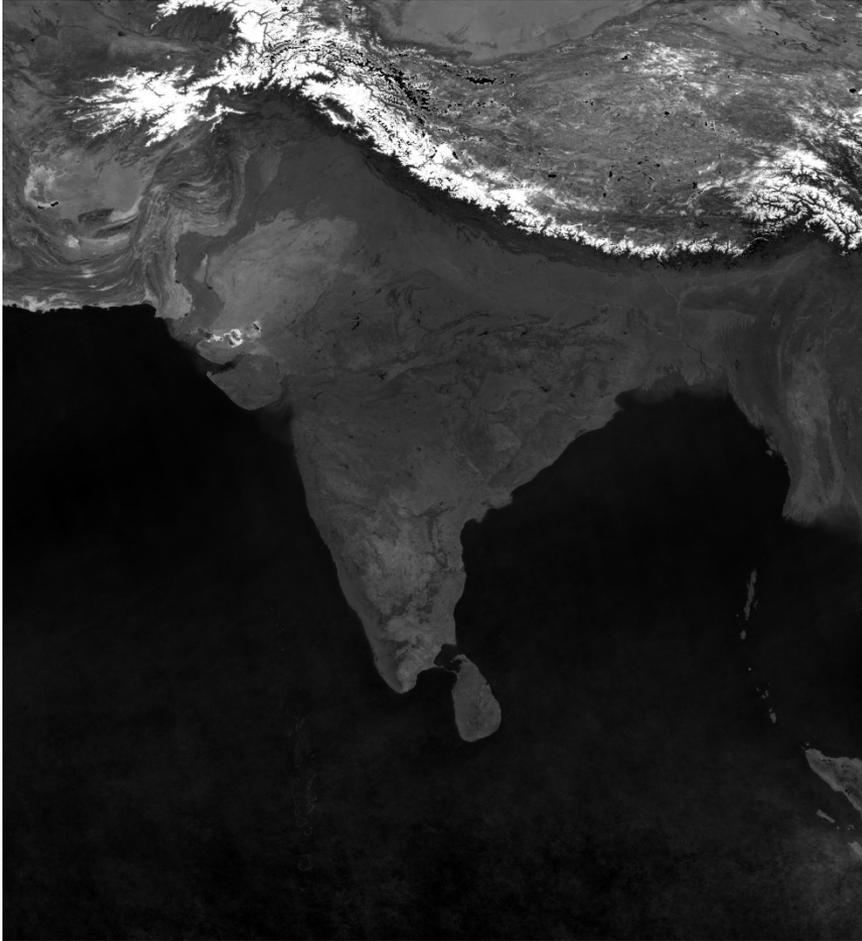


Brighter urban area



Daytime DNB Cloud-free Composite

Ten brightness classes



Summary

- There are four unique types of nighttime VIIRS products:
- VIIRS Nightfire (VNF) produced globally on 24 hour increments. Gas flaring observations used to estimate flared gas volumes worldwide. Research is ongoing on discrimination of subpixel flaming and smoldering.
- VIIRS boat detections (VBD) currently running for Indonesia. Will begin the expand to other areas this year.
- VIIRS nighttime lights (VNL) last hurdle is the background removal algorithm.

EOG Publications

- Long-wave infrared identification of smoldering peat fires in Indonesia with nighttime Landsat data <http://iopscience.iop.org/1748-9326/10/6/065002/>
- Automatic Boat Identification System for VIIRS Low Light Imaging Data <http://www.mdpi.com/2072-4292/7/3/3020>
- VIIRS Nightfire: Satellite pyrometry at night <http://www.mdpi.com/2072-4292/5/9/4423>
- What is so great about nighttime VIIRS data for the detection and characterization of combustion sources? <http://dx.doi.org/10.7125/APAN.35.5>
- Using the short-wave infrared for nocturnal detection of combustion sources in VIIRS data <http://dx.doi.org/10.7125/APAN.35.6>
- Why VIIRS data are superior to DMSP for mapping nighttime lights <http://dx.doi.org/10.7125/APAN.35.7>
- Nighttime lights compositing using the VIIRS day-night band: Preliminary results <http://dx.doi.org/10.7125/APAN.35.8>