# VNL, VBD & VNF:
# VIIRS data gems from the night

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# Lights At Night!

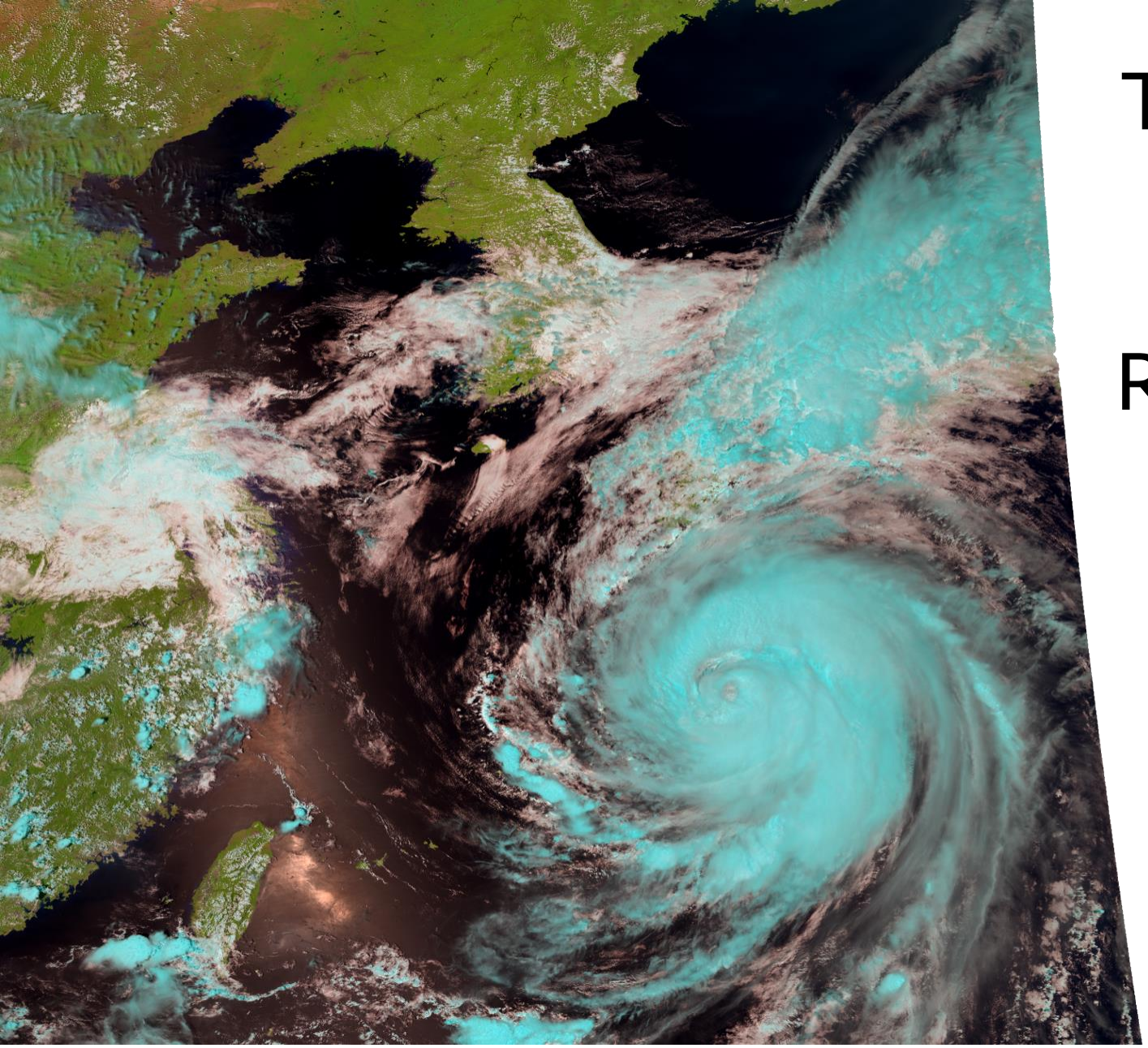
Cities and human settlements

Boats

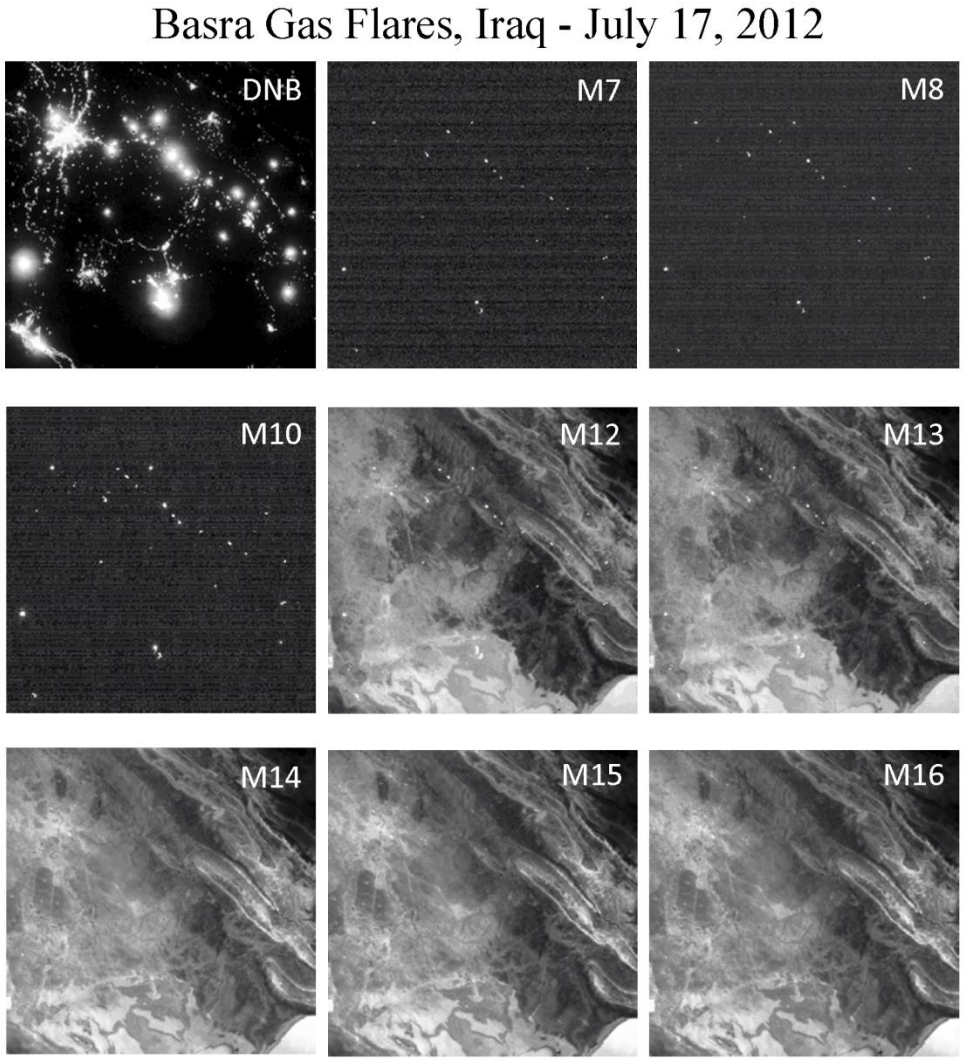
Industrial Sites

Gas Flares

Fires

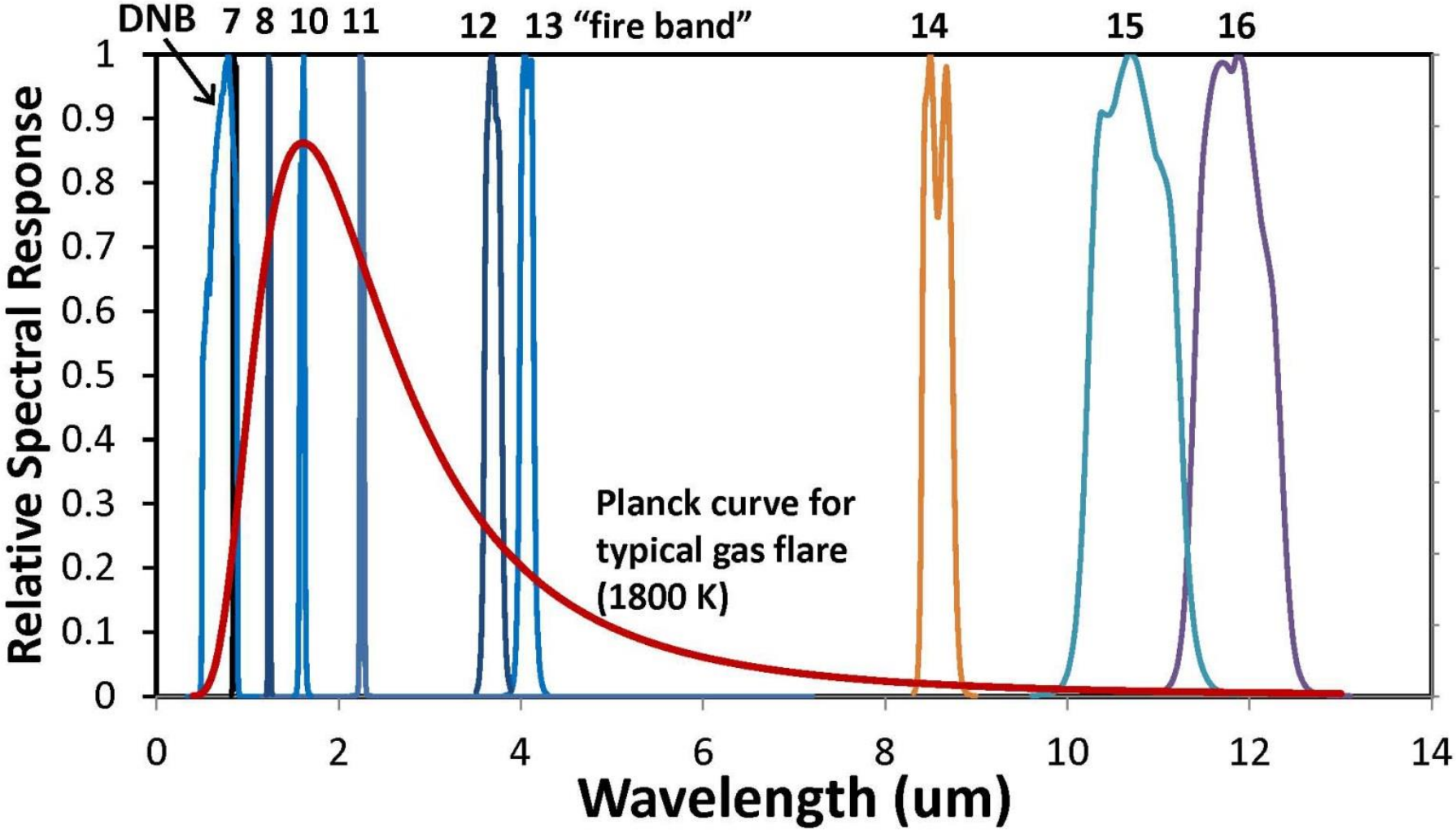


The Visible Infrared Imaging Radiometer Suite (VIIRS) primary mission is weather.




VIIRS low light imaging at night: DNB detects electric lighting, fires and flares. M7-11 detect combustion sources.

# VIIRS Nightfire (VNF): A global multispectral fire product
## Nine channels of data collected at night



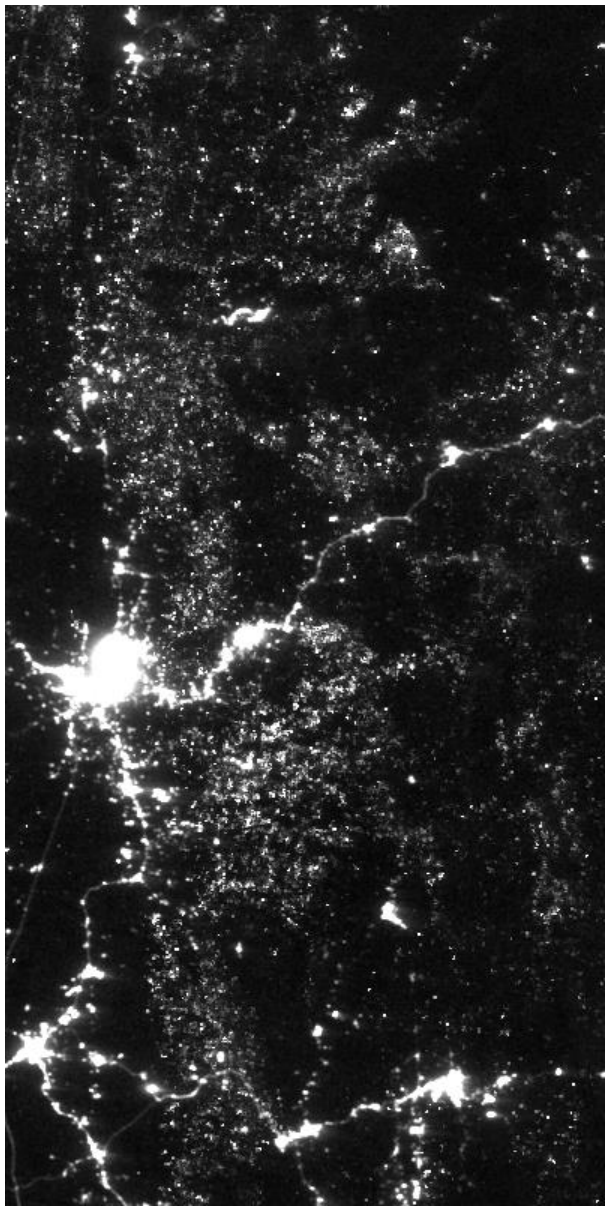
# Three global product lines

https://payneinstitute.mines.edu/eog/

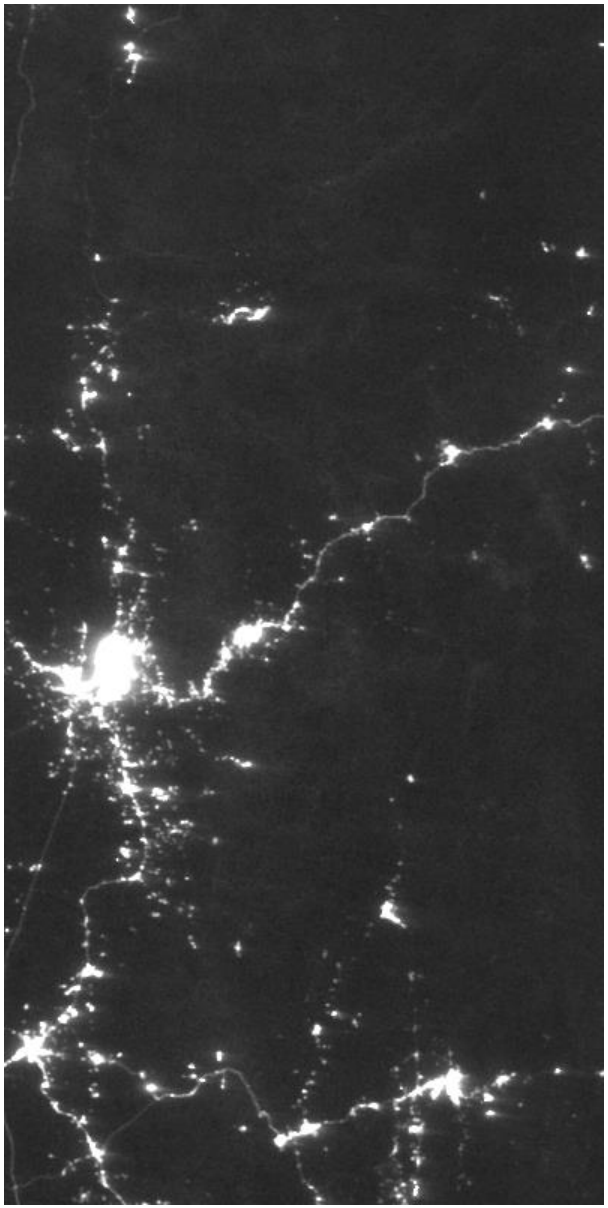
- **VIIRS nighttime lights (VNL):** 1) Monthly cloud-free average DNB radiances, filtered to remove sunlit, moonlit and cloudy pixels. 2) Annual product further filtered to remove fires, aurora, and background.
- **VIIRS boat detections (VBD):** Offshore detections of lights used by fishery agencies. Primarily fishing boats using lights. Four hour temporal latency target. https://ngdc.noaa.gov/eog/viirs/download_boat.html
- **VIIRS nightfire (VNF):** Multispectral detections of fires, flares and other IR emitters. Calculates temperature, source size and radiant heat using physical laws. Current R&D on subpixel analysis of flaming vs smoldering. Four hour temporal latency target.

# VIIRS Nighttime Lights (VNL) 2015 Myanmar

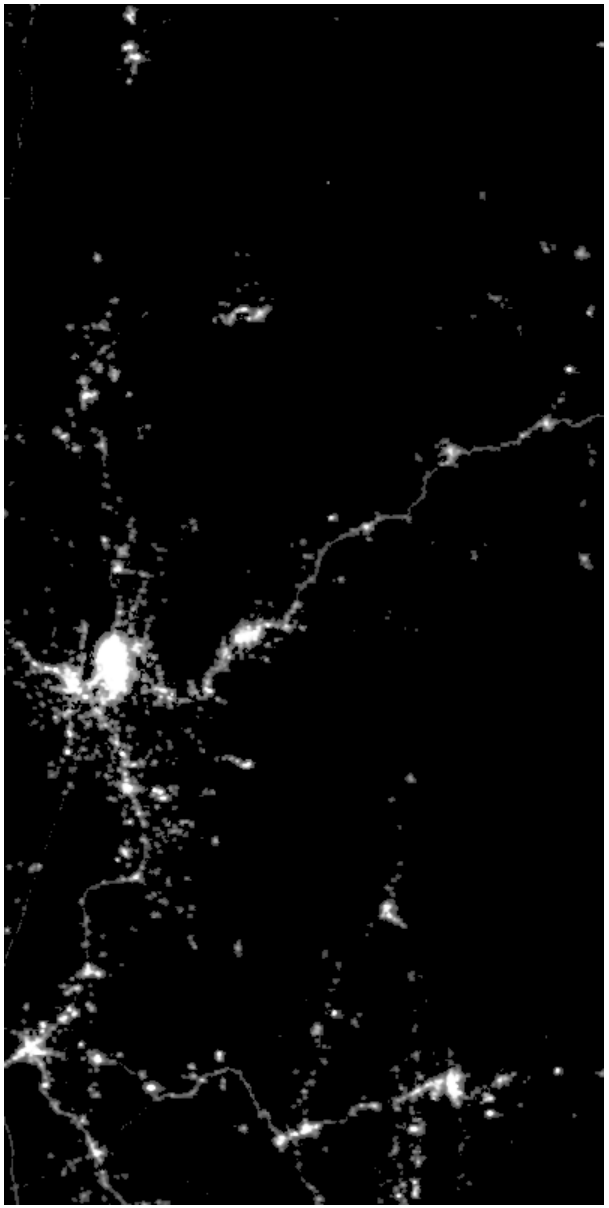
Raw cloud-free composite

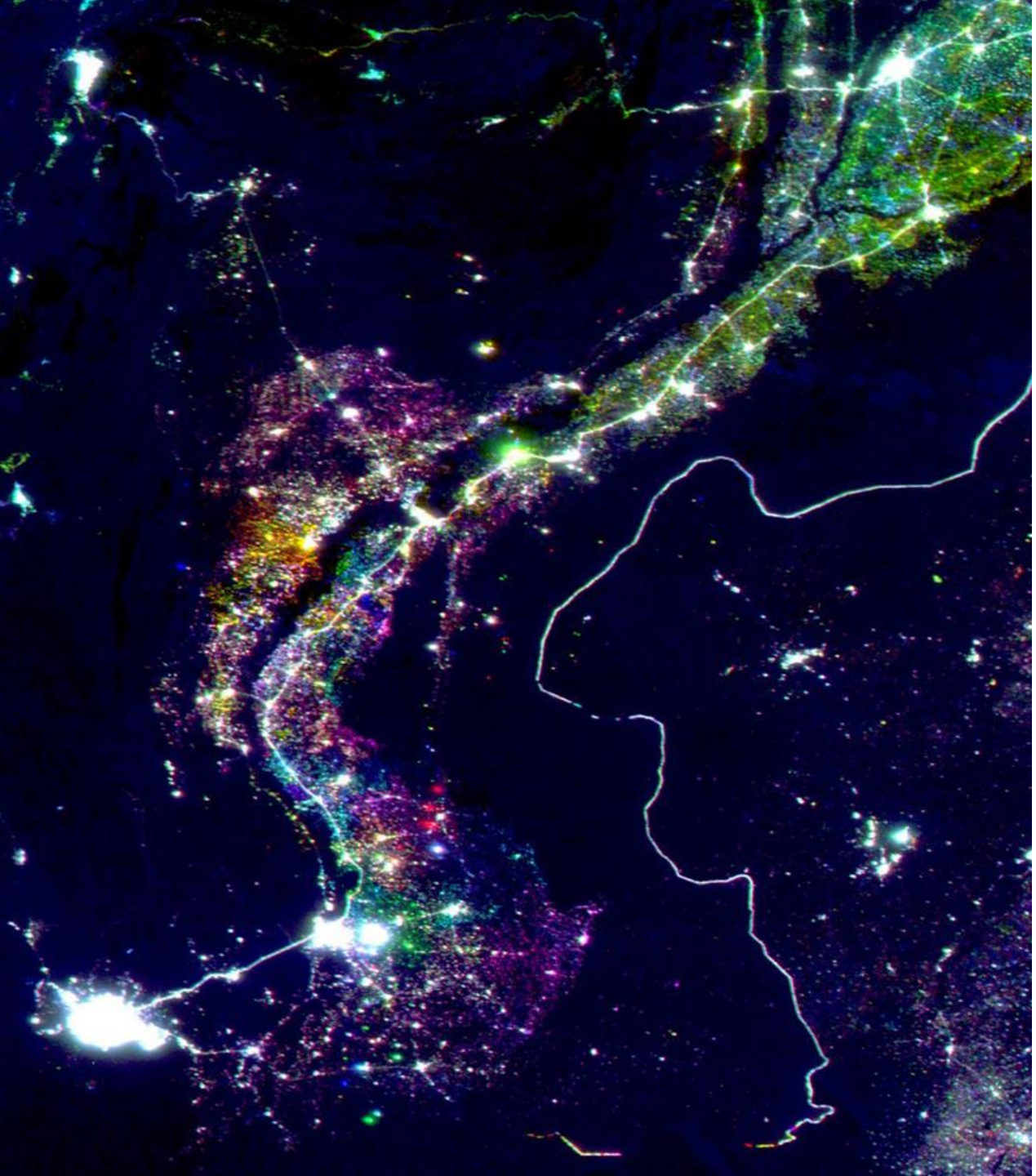


Outlier removed



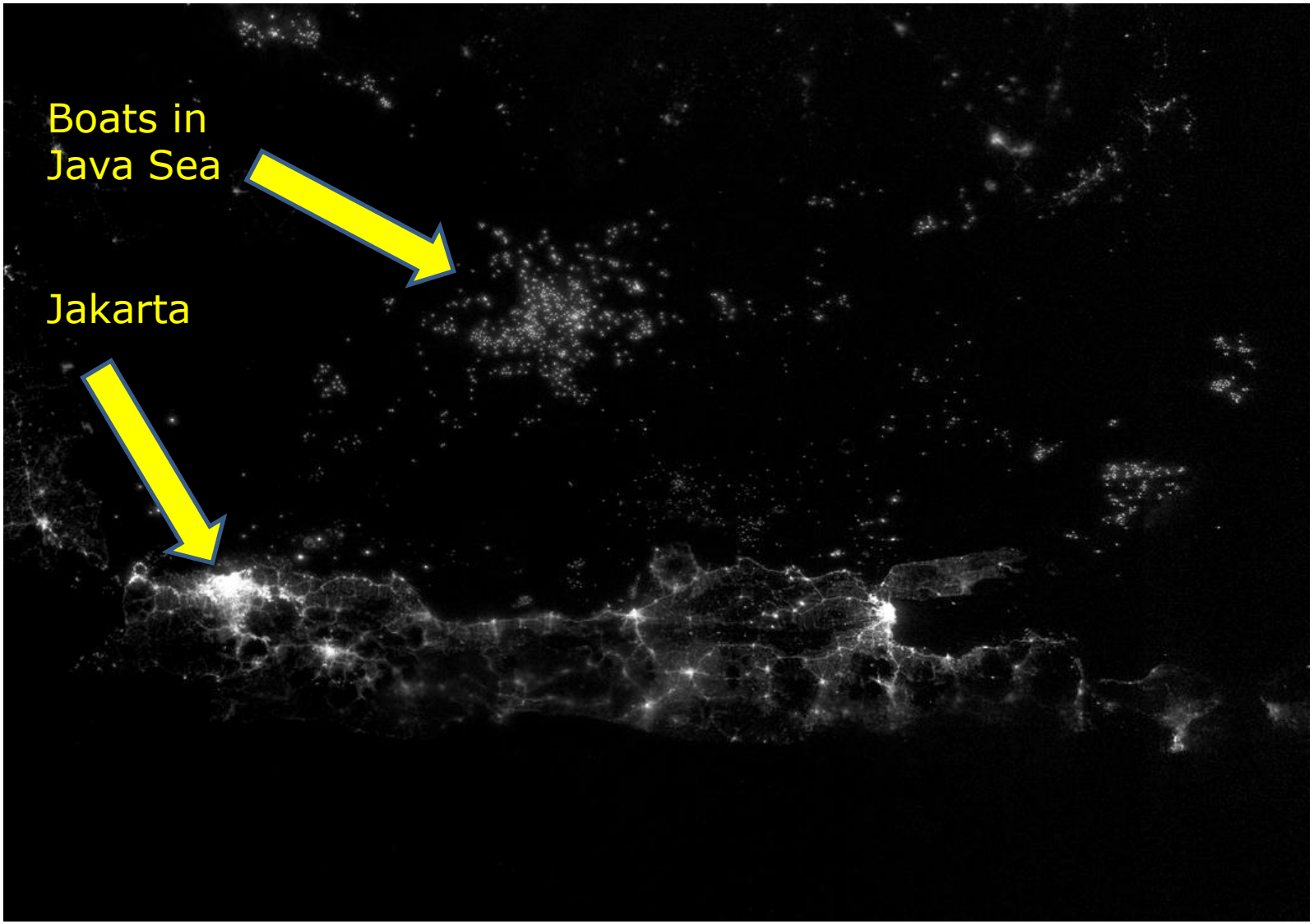
Nighttime lights





Power grid behaviors uncovered by VIIRS in Pakistan. Three months as RGB (Jan. 2013 red, Oct. 2012 green, April 2012 blue).

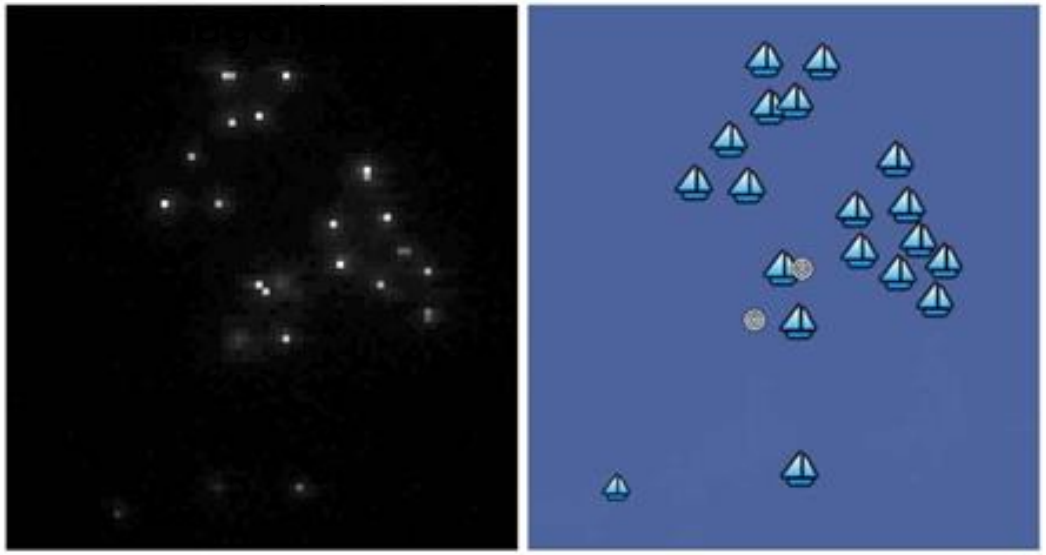
# VIIRS boat detection (VBD)



# Algorithms run on images, output points, vast data volume reduction

VIIRS day/night band (DNB) nighttime

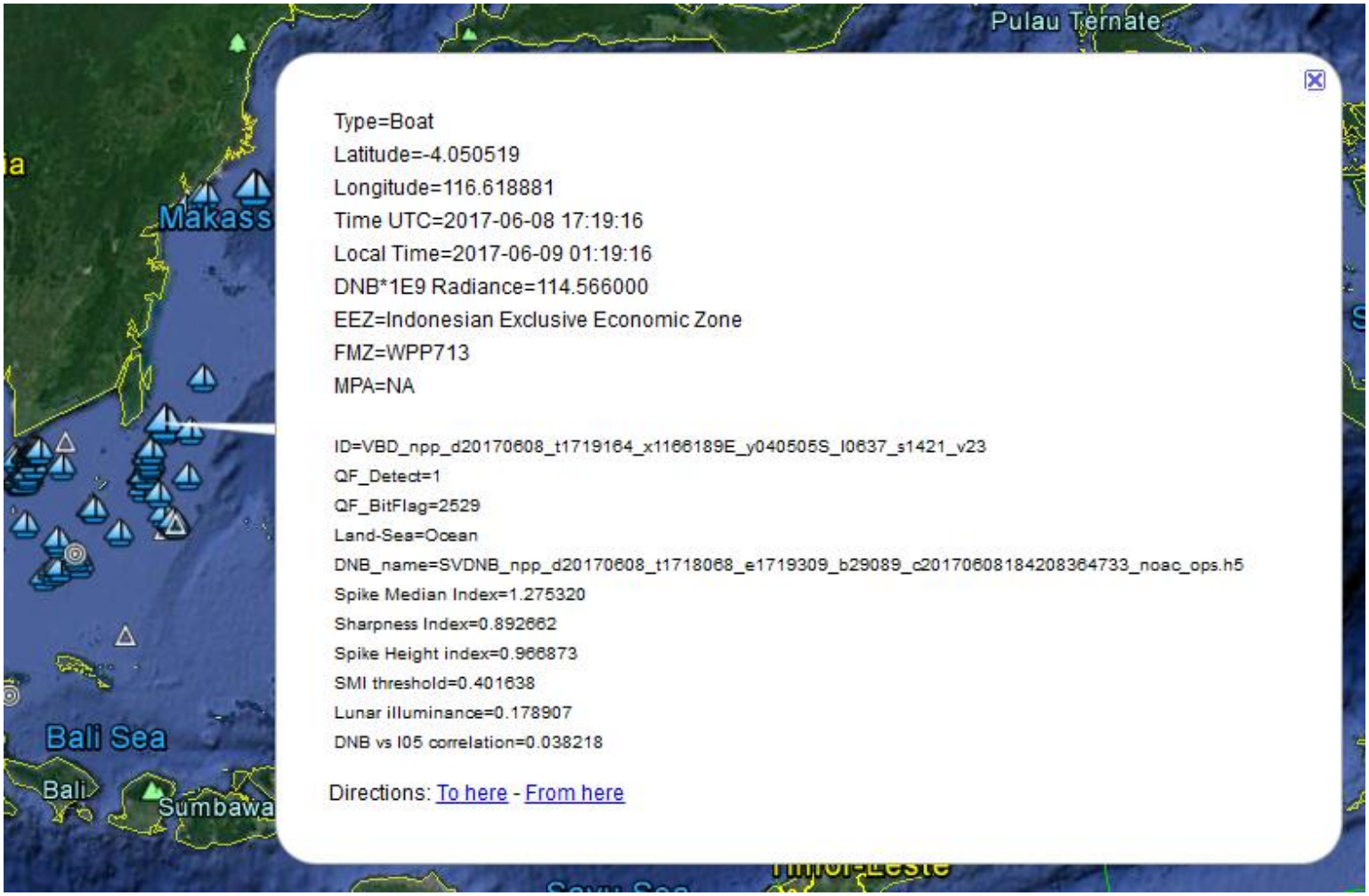
Boat detection data (points)



# Single Night of Detections (June 9, 2017)

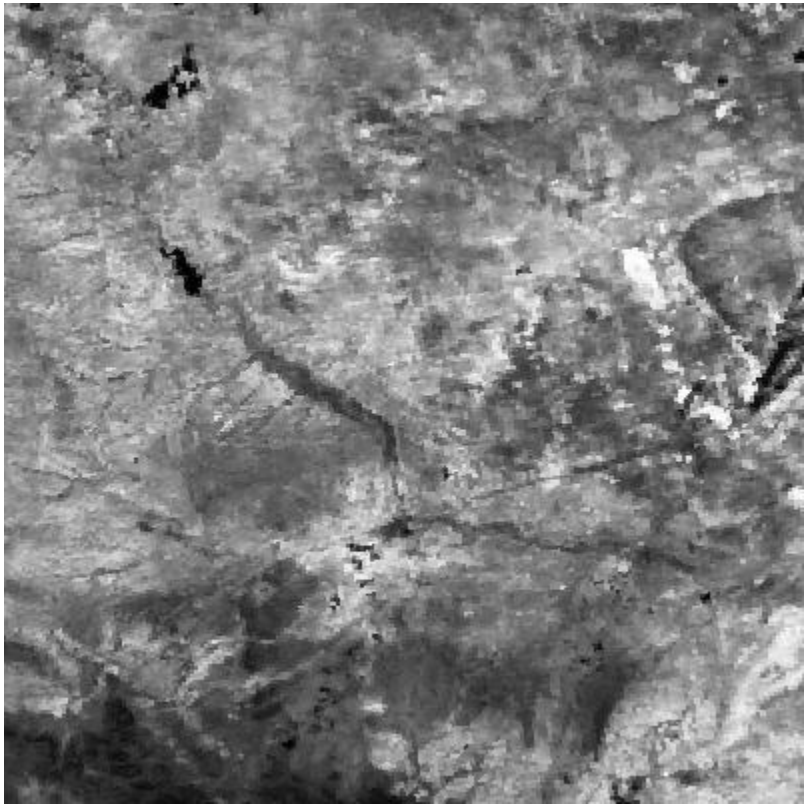
Standard is four hour temporal latency,
with files available at 06:00 local time

# Placemarks sized based on radiance and have information panels

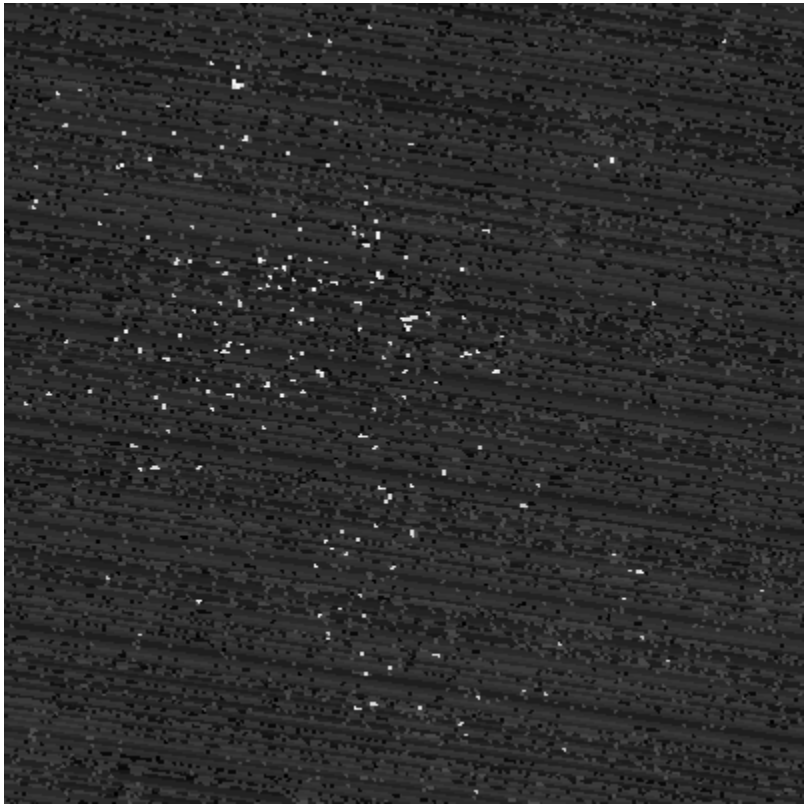


# For gas flares – the nighttime is the right time!
# Bakken Oil Field, North Dakota

Shortwave infrared (1.63 um) day

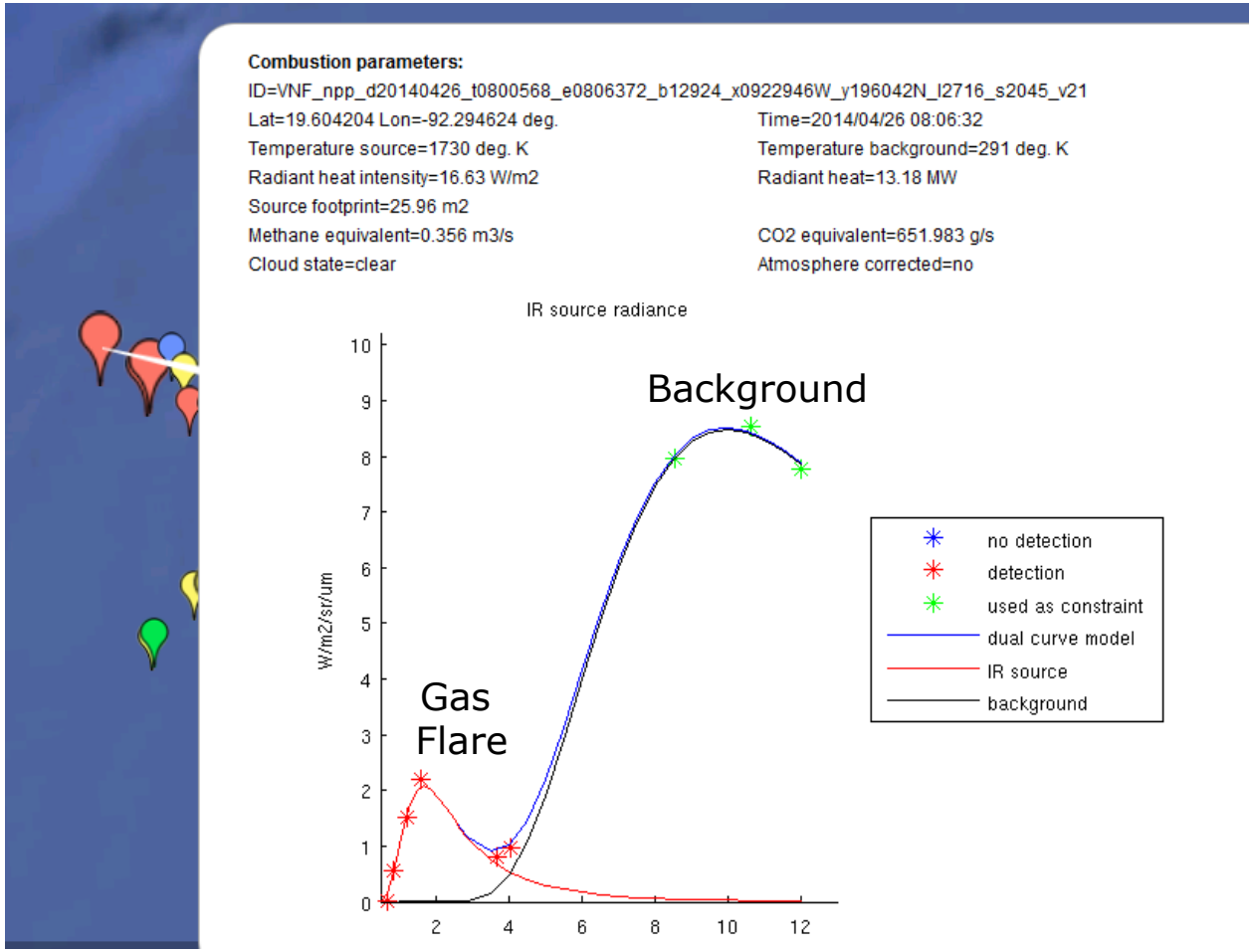


Same band, same area, next night



Gas flare peak radiant emissions are near 1.63 micrometers.
The flare radiance is lost during the day due to sunlight.

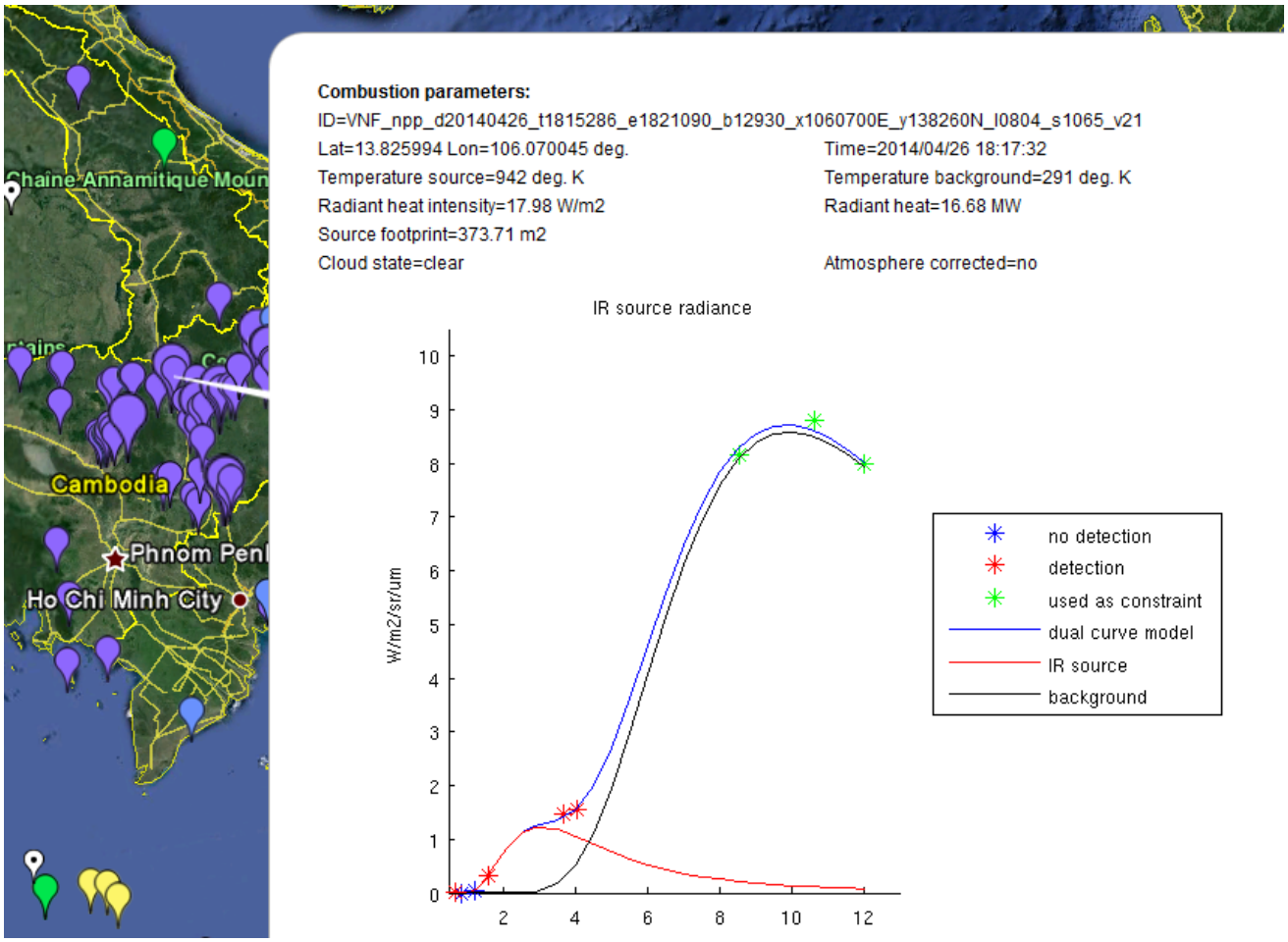
# Why Multispectral?




To get at the Planck curves!

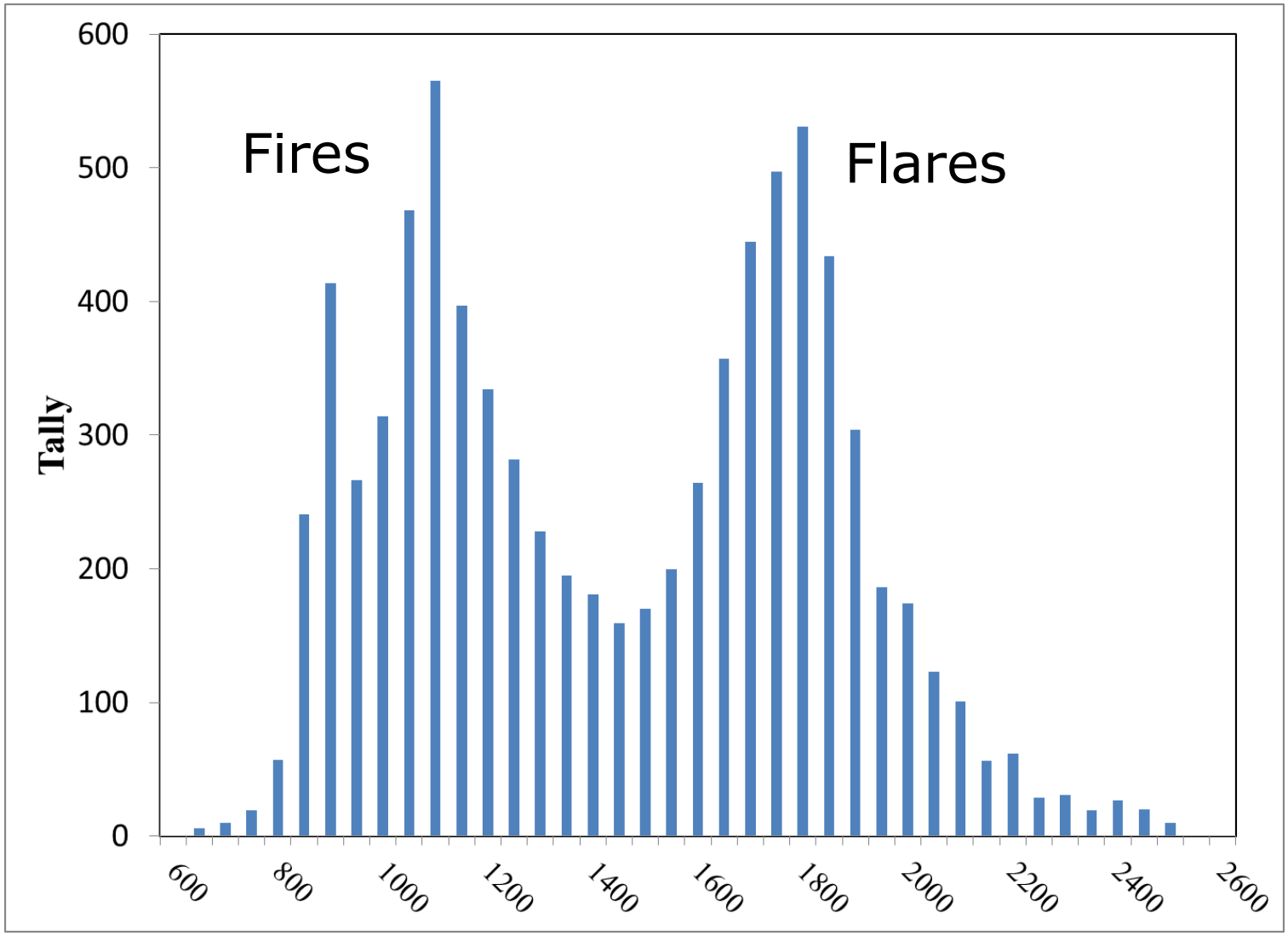
Daily files are in csv and kmz formats

# Typical Biomass Burning Detection



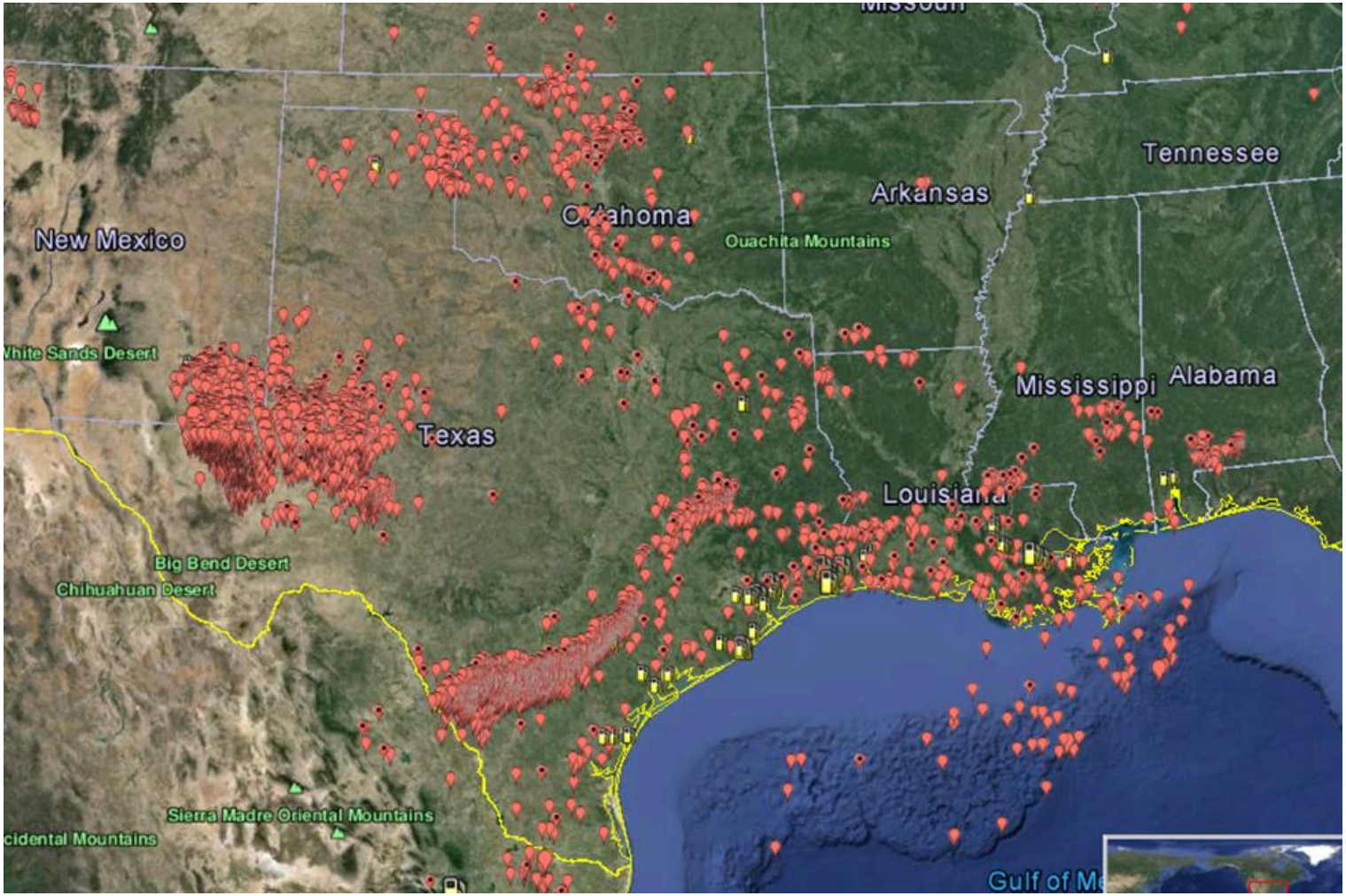

Lower temperature than gas flaring. Often these have larger source size than gas flares.

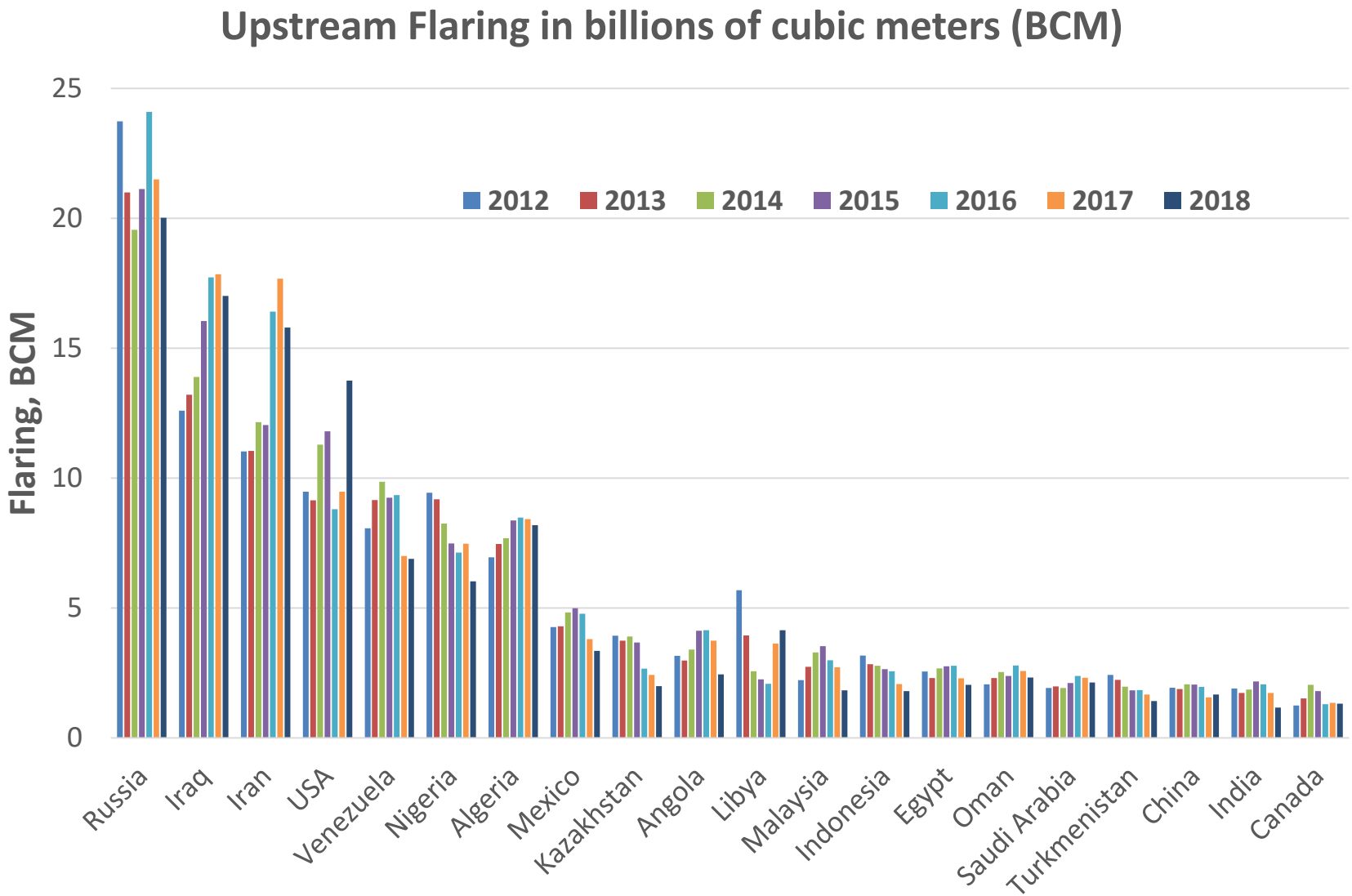
# Temperatures are bimodal

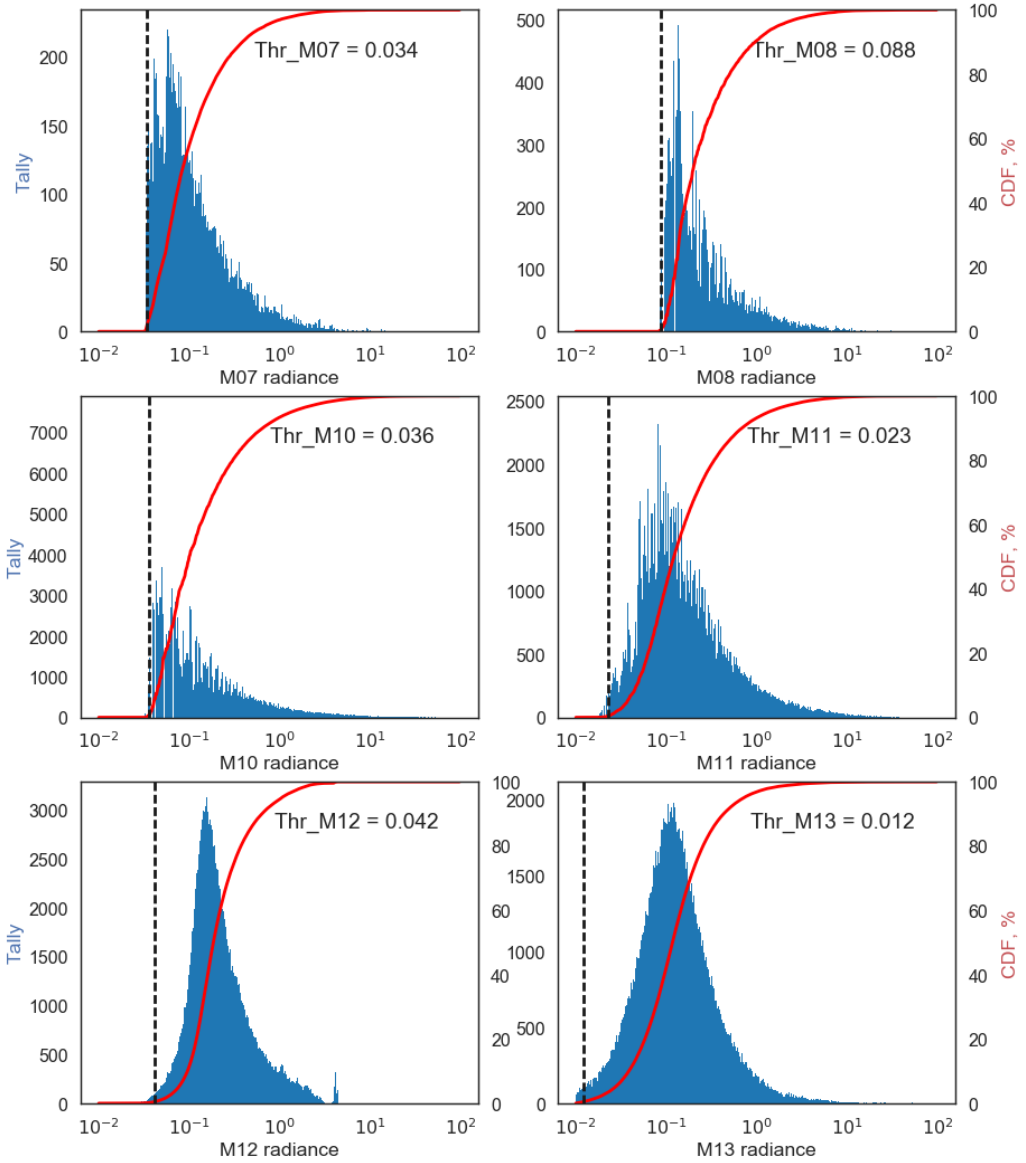


# Annual summaries of gas flare locations and gas flare volume estimates are available at:

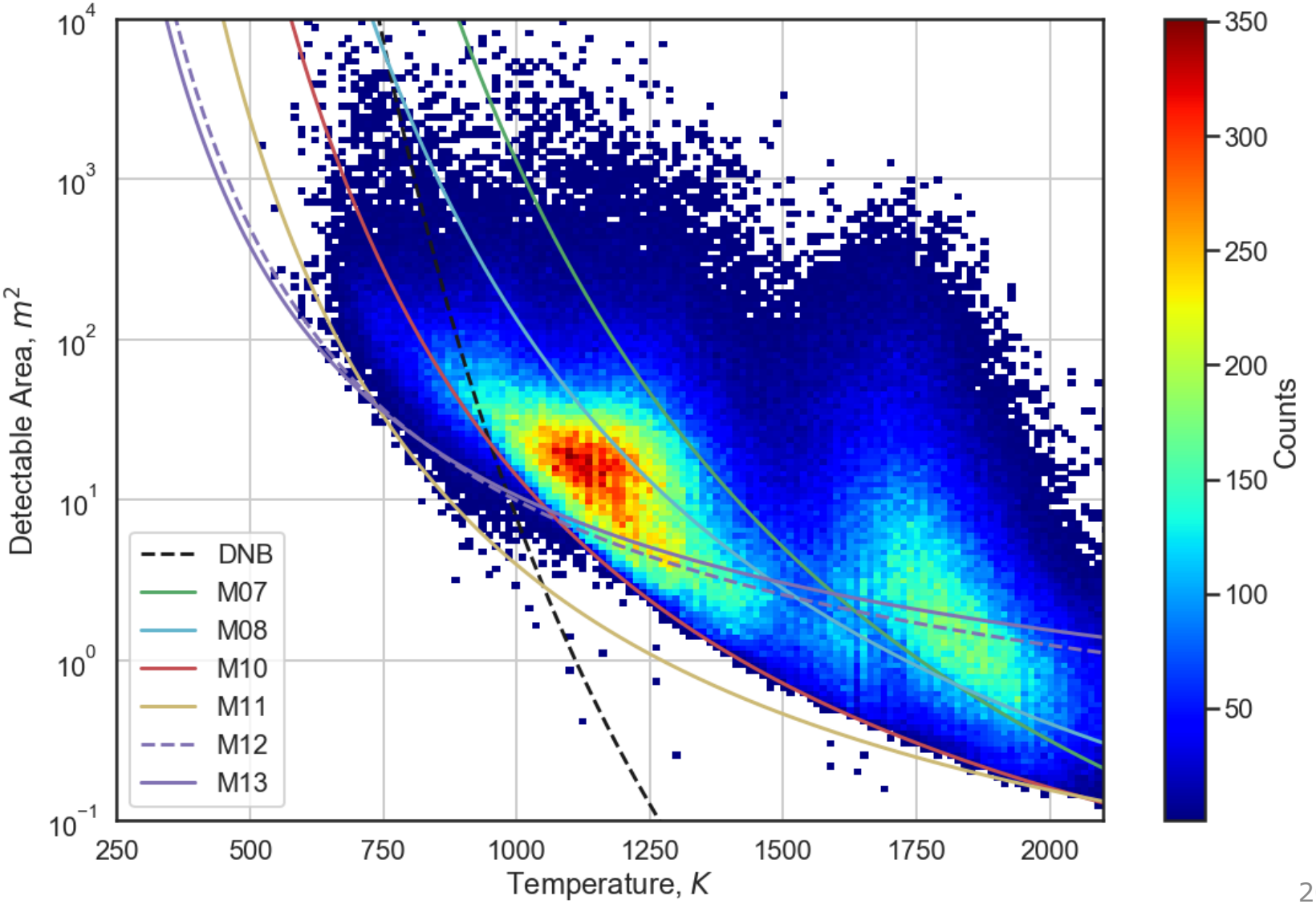
https://ngdc.noaa.gov/eog/viirs/download_global_flare.html




Upstream Flaring in billions of cubic meters (BCM)
Flaring, BCM
25
20
15
10
5
0
2012
2013
2014
2015
2016
2017
2018
Russia
Iraq
Iran
USA
Venezuela
Nigeria
Algeria
Mexico
Kazakhstan
Angola
Libya
Malaysia
Indonesia
Egypt
Oman
Saudi Arabia
Turkmenistan
China
India
Canada


Thr_M07 = 0.034
Thr_M08 = 0.088
Thr_M10 = 0.036
Thr_M11 = 0.023
Thr_M12 = 0.042
Thr_M13 = 0.012
Tally
CDF, %
M07 radiance
M08 radiance
M10 radiance
M11 radiance
M12 radiance
M13 radiance

# VNF Detection Limits



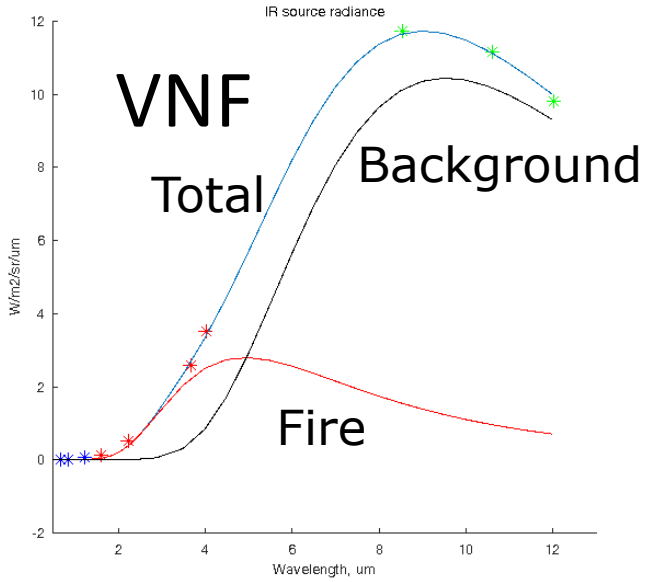
# VNF+ Pixel Types

## Type 4 is amenable to flaming vs smoldering analysis

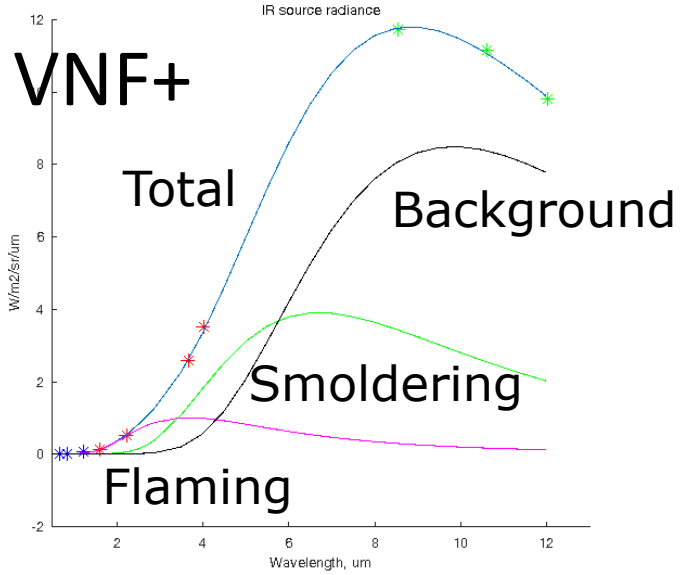
| Type | Spectral bands | Fitting | Notes |
|---|---|---|---|
| 0 | M11 | None | Filter out solitary pixels |
| 1 | M7, 8, 10, 11 | Single Planck curve fitting | Flaming phase combustion – primarily natural gas flares. |
| 2 | M11,12,13 | Dual Planck curve fitting for IR emitter and background | Flameless glowing embers? |
| 3 | M12,13 | Dual Planck curve fitting for IR emitter and background | Rare occurrences. |
| 4 | M7,8,10,11,12,13 | Triple phase fitting for two IR emitters and background | Solve for temperature and source area for a flaming and a cooler combustion phases plus background. |
| 5 | M7,8,10,11,12,13 | Dual Planck curve fitting for IR emitter and background | Assembled from Type 4 detections that yielded spurious results in triple phase analysis. |

# VNF vs VNF+ Peat Fire, Sumatra

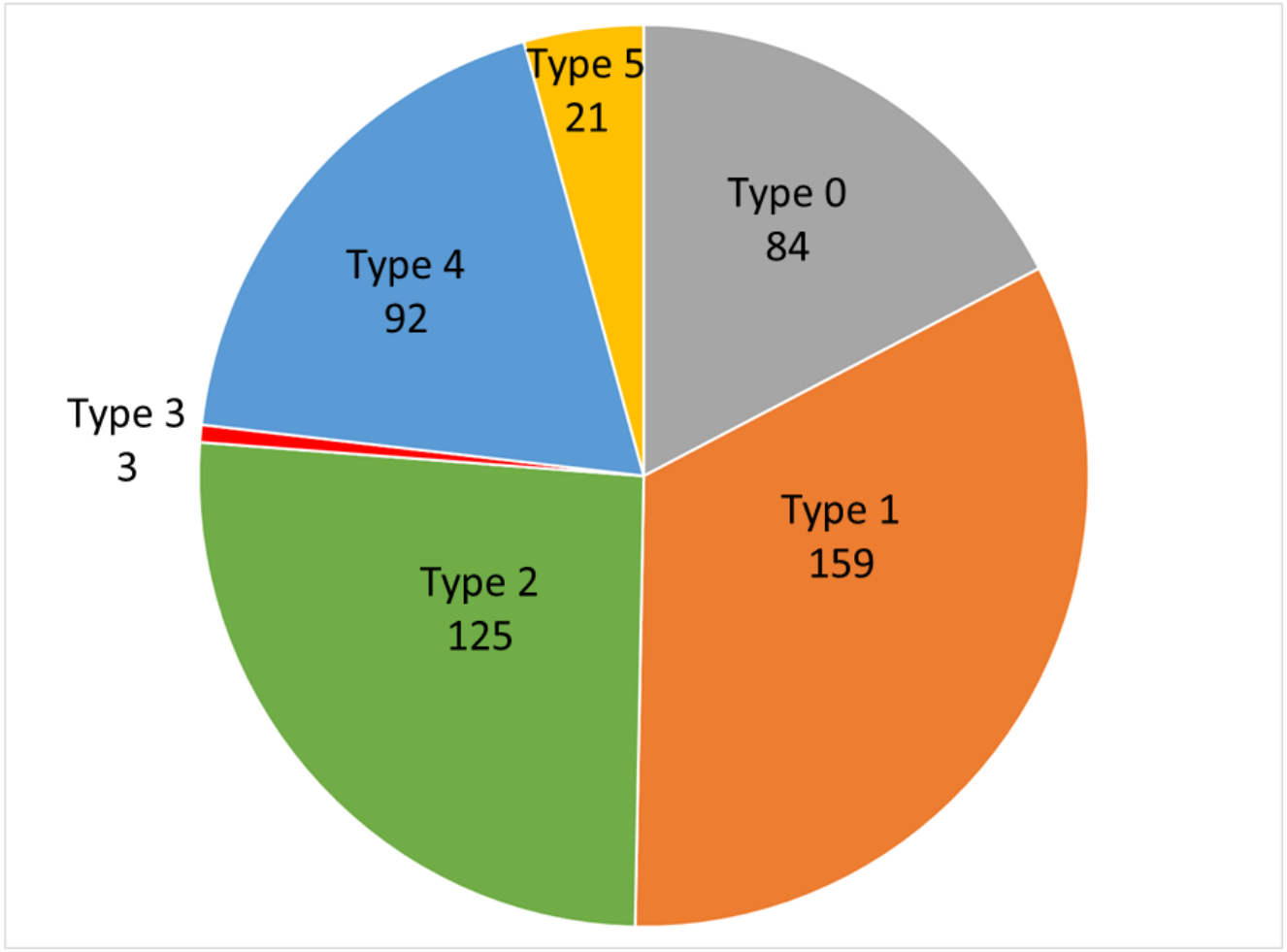
**Combustion parameters:**
ID=VNF_npp_d20140926_t1852060_e1857464_b15101_x1054459E_y031839S_l2212_s2419_v30
Lat=-3.183881 Lon=105.445885 deg. Time=2014/09/26 18:56:00
Radiant heat intensity=65.55 W/m2 Radiant heat=67.99 MW
Source temperature=588 K Source footprint=10034.13 m2
Background temperature=303 K Local time=2014/09/27 01:56:00
Cloud state=clear Atmosphere corrected=yes
File=SVM10_npp_d20140926_t1852060_e1857464_b15101_c20140927005747875402_noaa_ops.h5

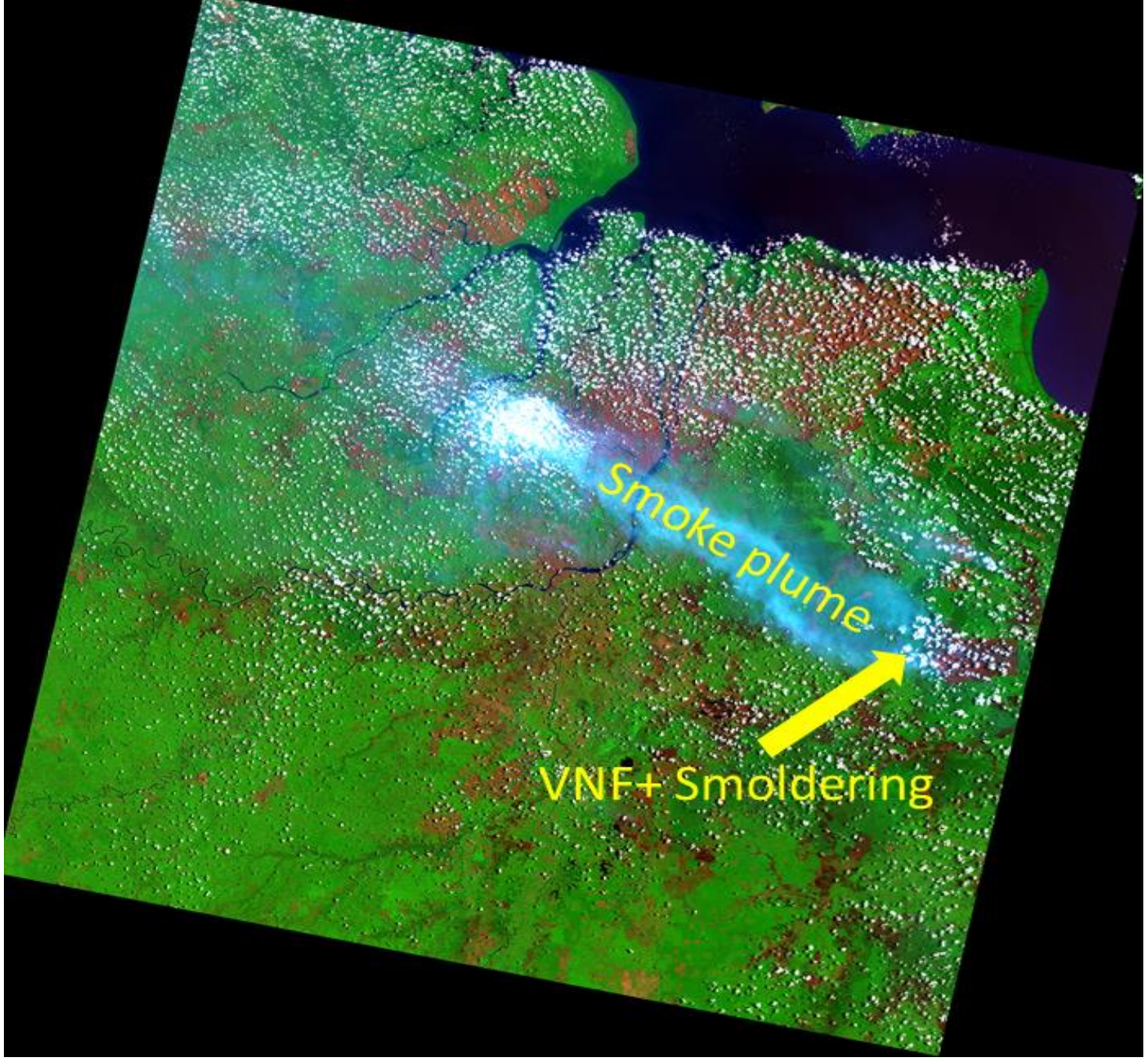



**Combustion parameters:**
ID=VNF_npp_d20140926_t1852060_e1857464_b15101_x1054459E_y031839S_l2212_s2419_v30
Lat=-3.183881 Lon=105.445885 deg. Time=2014/09/26 18:56:00
Radiant heat intensity=142.35 W/m2 Radiant heat=26.38 MW
Flaming temperature=788 K Flaming footprint=831.46 m2
Smoldering temperature=432 K Smoldering footprint=65437.34 m2
Background temperature background=294 K Local time=2014/09/27 01:56:00
Cloud state=clear Atmosphere corrected=yes
File=SVM10_npp_d20140926_t1852060_e1857464_b15101_c20140927005747875402_noaa_ops.h5



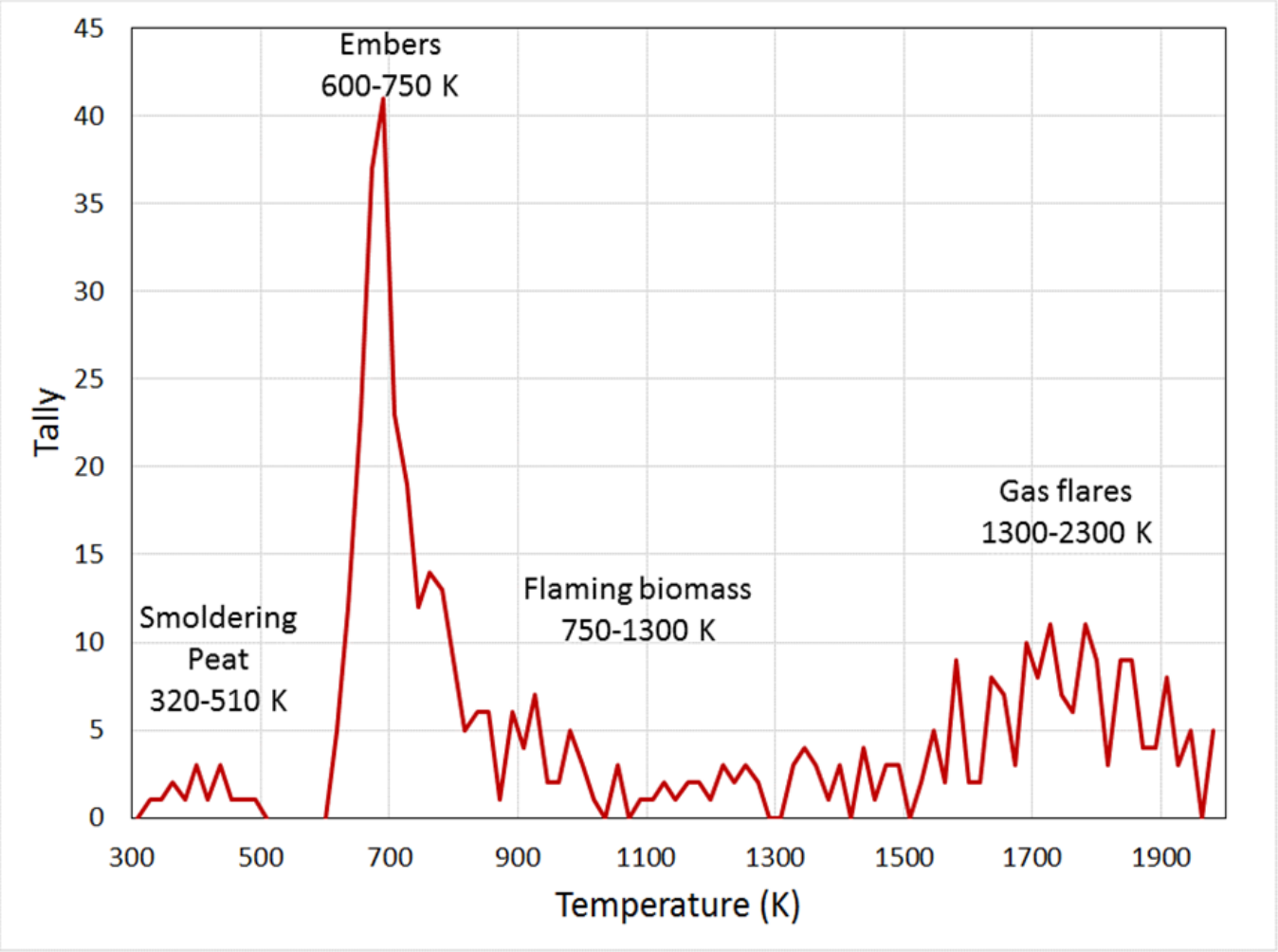

Type 4 pixels are analyzed with triple Planck curve fitting. Flaming, smoldering and background.


Type 5
21
Type 0
84
Type 4
92
Type 3
3
Type 1
159
Type 2
125




VNF+ smoldering pixelsare the source area for a smoke plume visible in Landsat 8 later the same day.

# VNF+ temperature histogram 20190926 Sumatra



# Summary: Three global products

- VBD: Nightly VIIRS boat detection (VBD) data is primarily detecting fishing boats using lights to attract catch. This is a common practice in Asia and several other areas. EOG also generates monthly and annual summary grids.
- VNF: VIIRS nightfire is a multispectral fire product reporting temperatures, source sizes and radiant heat. Used for annual global surveys of gas flaring sites and flared gas volumes. Current R&D on flaming versus smoldering subpixel spectral unmixing.
- VIIRS nighttime lights – monthly and annual cloud-free composites of DNB radiances.

# Key EOG publications

Elvidge, Christopher D., Mikhail Zhizhin, Kimberly Baugh, Feng Chi Hsu, and Tilottama Ghosh. "Extending Nighttime Combustion Source Detection Limits with Short Wavelength VIIRS Data." Remote Sensing 11, no. 4 (2019): 395.

Elvidge, C. D., Baugh, K. E., Zhizhin, M., Hsu, F -C., & Ghosh, T. (2017). VIIRS night-time lights. International Journal of Remote Sensing, 38(21), 5860-5879.

Elvidge, C. D., Zhizhin, M., Baugh, K. E, Hsu, F -C., & Ghosh, T. (2015). Methods for global survey of natural gas flaring from Visible Infrared Imaging Radiometer Suite Data. Energies, 9(1), 1-15.

Elvidge, C. D., Zhizhin, M., Hsu, F -C., Baugh, K. E., Khomarudin, R., Vetrita, Y., Sofan, P., Suwarsano, S., & Hilman, D. (2015). Long-wave infrared identification of smoldering peat fires in Indonesia with nighttime Landsat data. Environmental Research Letters, 10(6), 1-12.

Elvidge, C. D., Zhizhin, M., Baugh, K. E., & Hsu, F -C (2015). Automatic boat identification system for VIIRS Low Light Imaging Data. Remote Sensing, 7(3), 3020-3036.

Elvidge, C. D., Zhizhin, M., Hsu, F -C., & Baugh, K. (2013).VIIRS nightfire: Satellite pyrometry at night. Remote Sensing 5(9), 4423-4449.