Fires, flares, boats and lights: product lines from nighttime VIIRS data

Christopher D. Elvidge, Ph.D.
NOAA-NESDIS-NCEI Earth Observation Group
Boulder, Colorado USA
chris.elvidge@noaa.gov
Kimberly Baugh, Mikhail Zhizhin, Feng-Chi Hsu, Tilottama Ghosh
University of Colorado
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Lights At Night!



Cities and human settlements



Boats



Industrial Sites



Gas Flares



Fires

How many VIIRS spectral band collect low light imaging data? Five!

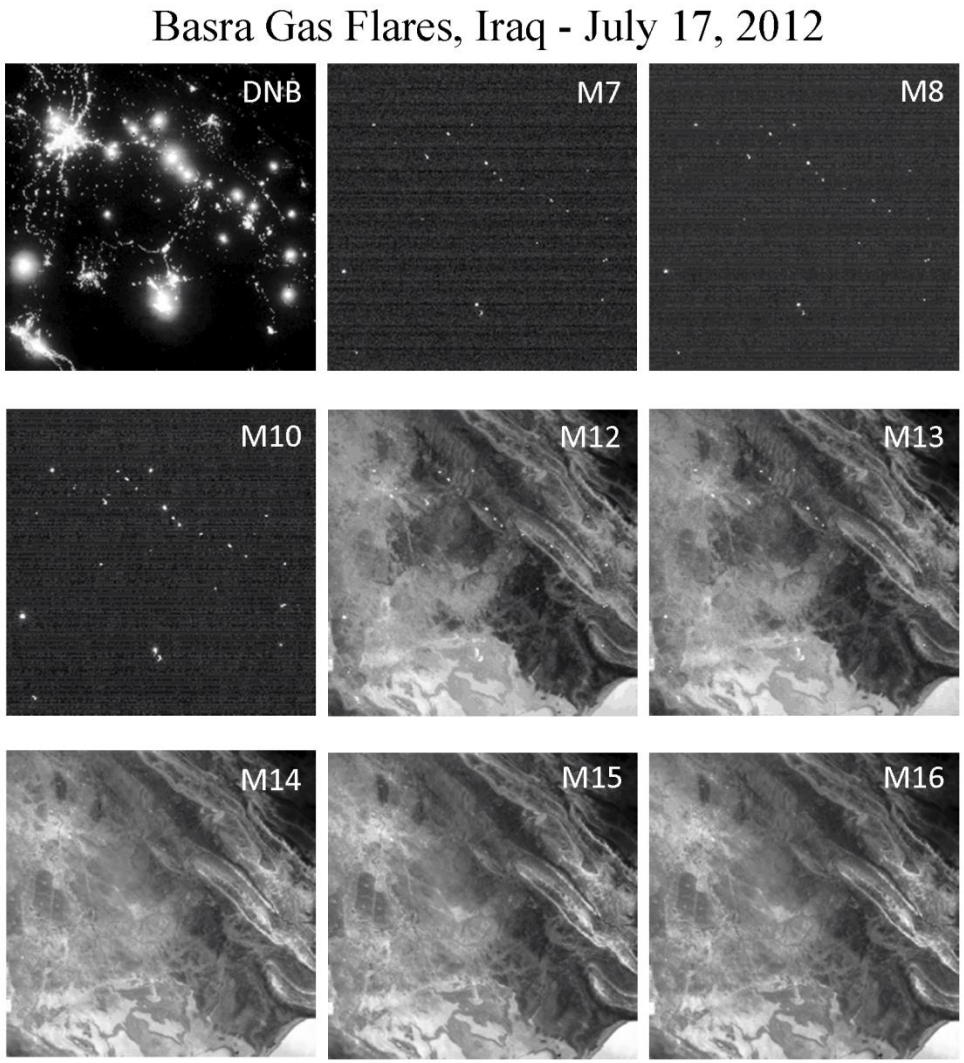
1. Day/night band (DNB) signal intensification detects faint radiant emissions in the visible and near infrared.
2. Daytime channels at night – enabling the detection of radiant emissions that are obscured by reflected sunlight.

   M7 at 0.865 um

   M8 at 1.24 um

   M10 at 1.61 um

   M11 at 2.25 um

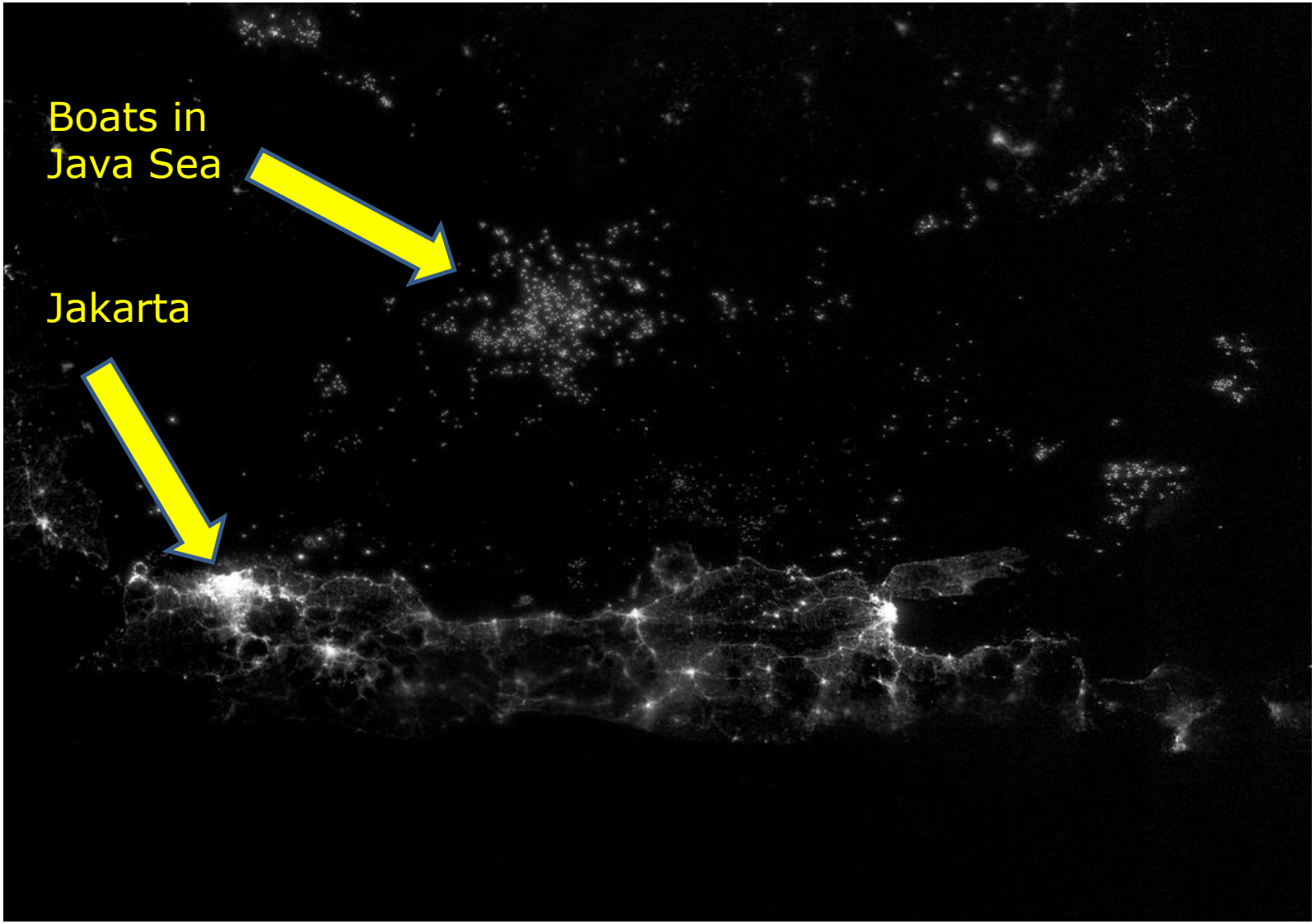


VIIRS low light imaging at night: DNB detects electric lighting, fires and flares. M7,8 & 10 detect combustion sources.

Three global product lines
https://ngdc.noaa.gov/eog/viirs/index.html

- **VIIRS boat detections (VBD):** Offshore detections of lights used by fishery agencies. Expanded to global in May, 2017. JPSS proving ground project (FY15-17). Four hour temporal latency. https://ngdc.noaa.gov/eog/viirs/download_boat.html
- **VIIRS nightfire (VNF):** Multispectral detections of fires, flares and other IR emitters. Used for annual surveys of gas flare locations and flared gas volumes. JPSS proving ground project (FY12-14). NASA carbon monitoring system (FY16-18). Four hour temporal latency. https://ngdc.noaa.gov/eog/viirs/download_viirs_fire.html
- **VIIRS nighttime lights (VNL):** Global annual average radiances filtered to remove sunlit, moonlit, and cloudy observations. Additional filtering to remove lightning, fires, aurora, and background noise. NASA VIIRS Science Team (FY15-17). Widely used in the sciences, social sciences, and development tracking communities. https://ngdc.noaa.gov/eog/viirs/download_dnb_composites.html

VIIRS boat detection (VBD)

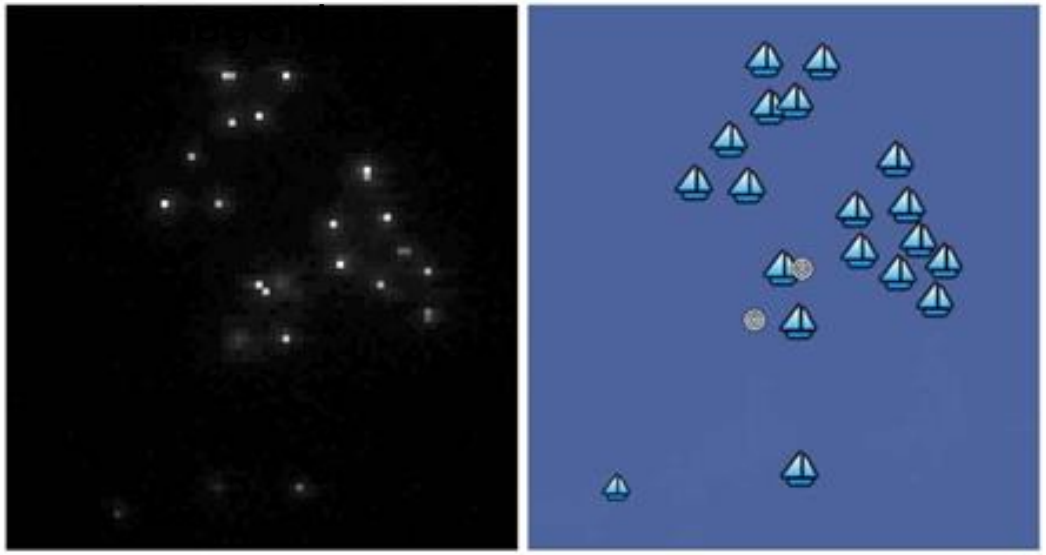


Algorithms run on images, output points, vast data volume reduction



VIIRS day/night band (DNB) nighttime

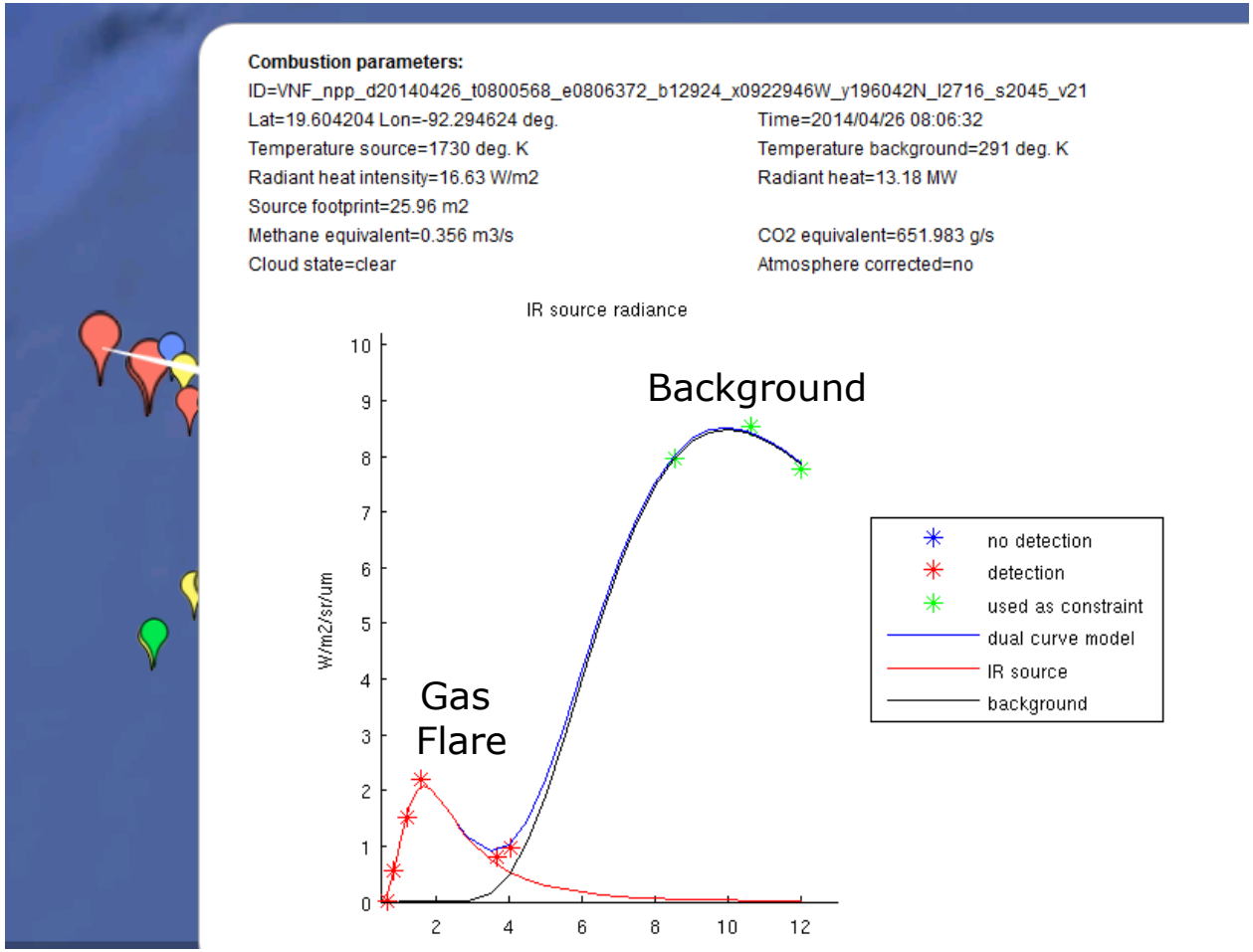
Boat detection data (points)



VIIRS Nightfire (VNF)

- A multispectral global fire product
- Makes use of near-infrared and shortwave infrared data.
- What is different from other global fire products?
  - Five independent IR source detection algorithms:
    - M7,8,10 & 11 mean plus x std. devs.
    - M12-M13 in the midwave infrared
  - Dual Planck curve fitting (background and hot source) followed by calculations using physical laws
  - Temperature calculation based on Wien's Displacement Law
  - Source area estimation based on Planck's Law
  - Radiant heat (W/m2) calculated using the Stefan-Boltzmann Law
- Nightly global data are available at: http://ngdc.noaa.gov/eog/viirs/download_viirs_fire.html
- Global gas flaring data are available at: http://www.ngdc.noaa.gov/eog/viirs/download_global_flare.html

Why Multispectral?

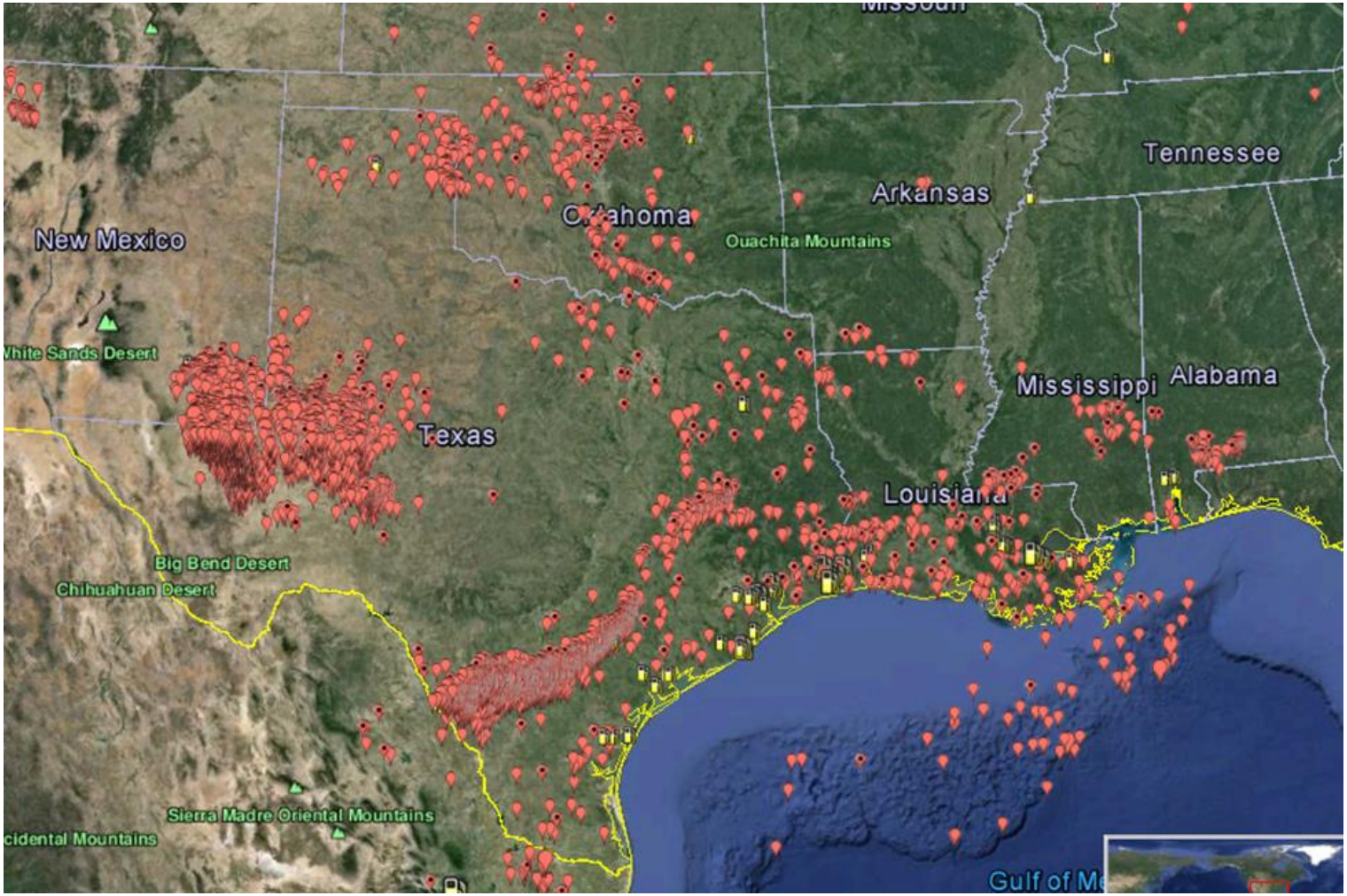


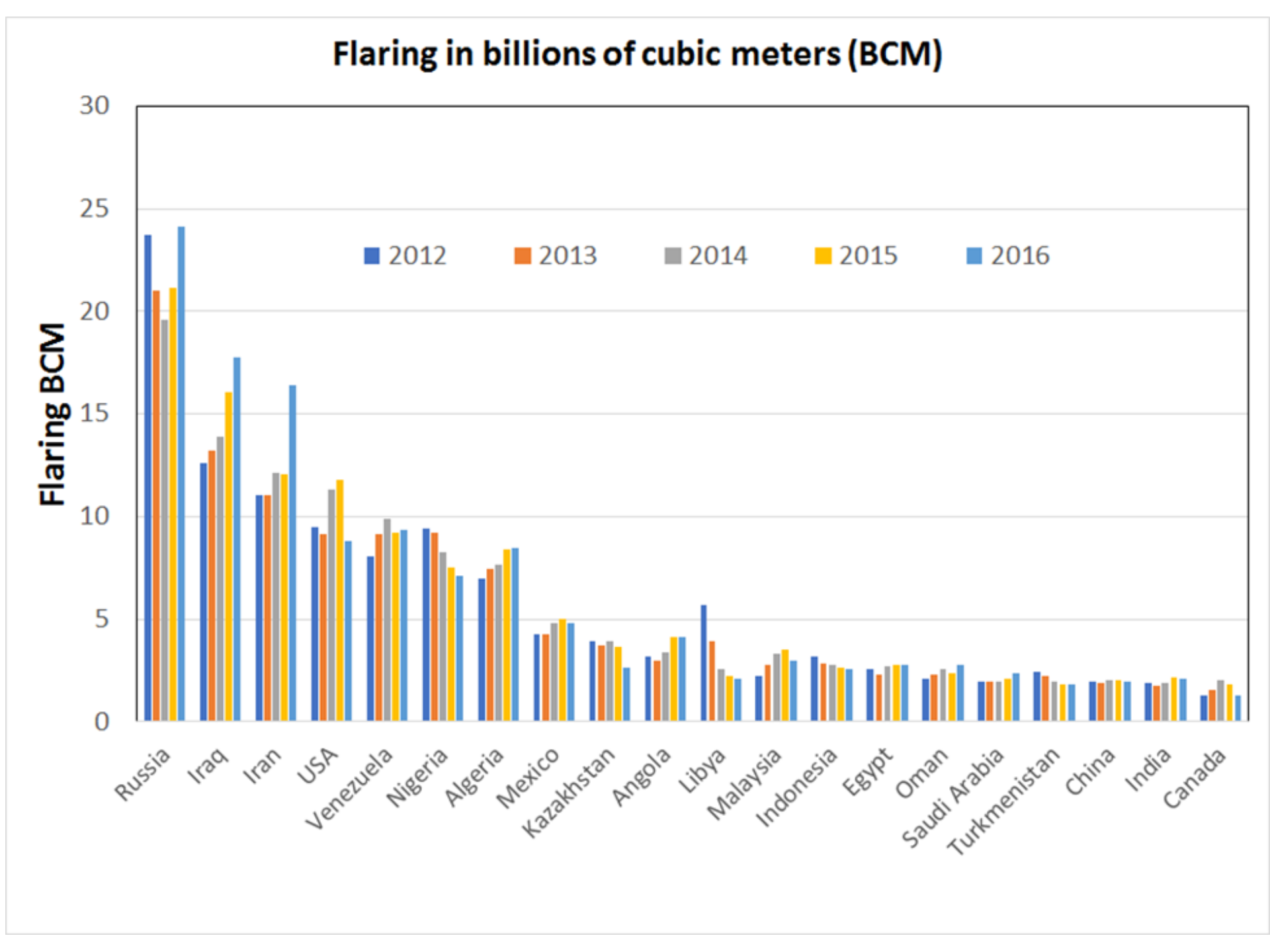
To get at the Planck curves!

Daily files are in csv and kmz formats

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

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




Flaring in billions of cubic meters (BCM)
Flaring BCM
30
25
20
15
10
5
0
2012
2013
2014
2015
2016
Russia
Iraq
Iran
USA
Venezuela
Nigeria
Algeria
Mexico
Kazakhstan
Angola
Libya
Malaysia
Indonesia
Egypt
Oman
Saudi Arabia
Turkmenistan
China
India
Canada

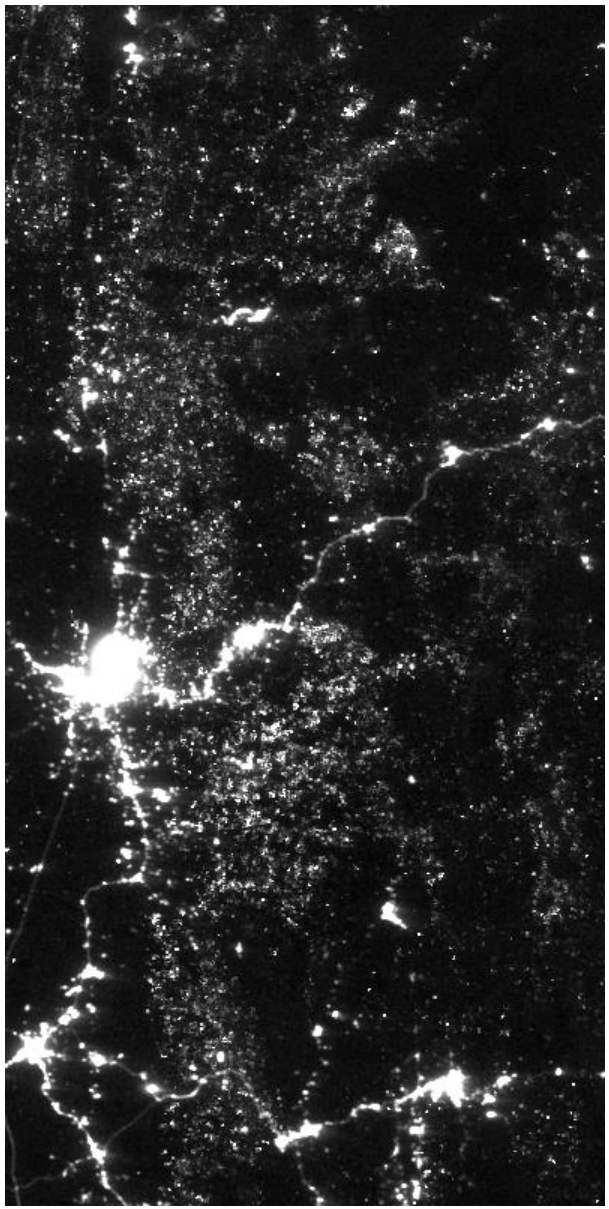
VIIRS Nighttime Lights (VNL)



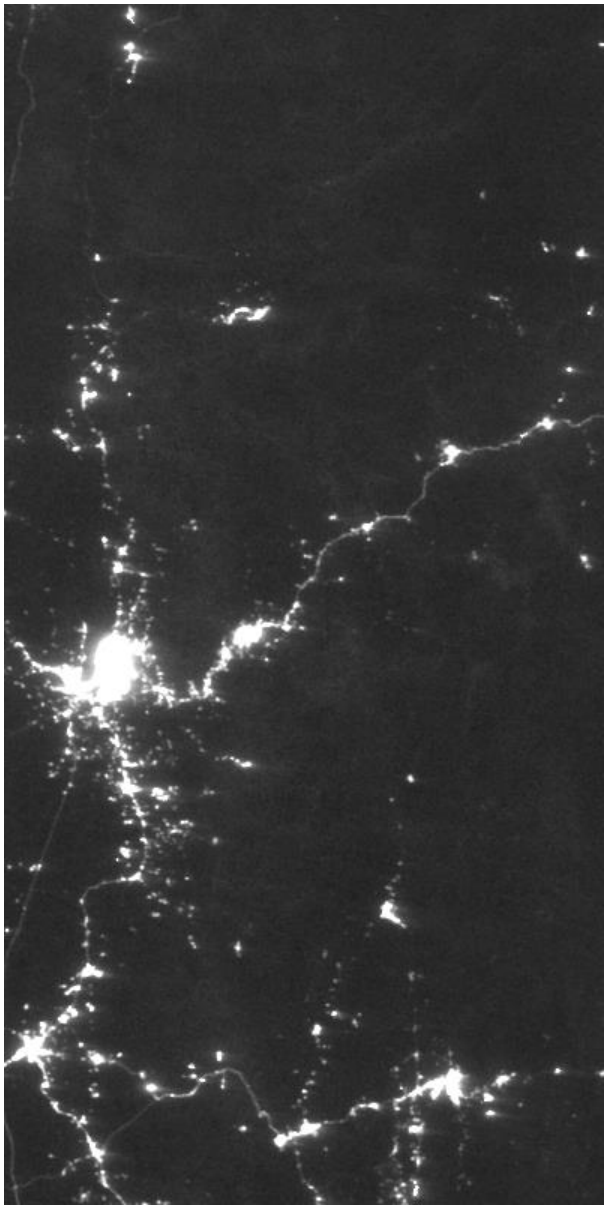
- Raw cloud-free composite: Average DNB radiance filtered to remove sunlit, moonlit, cloudy, and lightning.
- Outlier removal to filter out the biomass burning and most of the aurora contamination.
- VIIRS nighttime lights: Filtered to remove background noise and manual editing to removed remaining aurora features.

VIIRS Nighttime Lights (VNL)

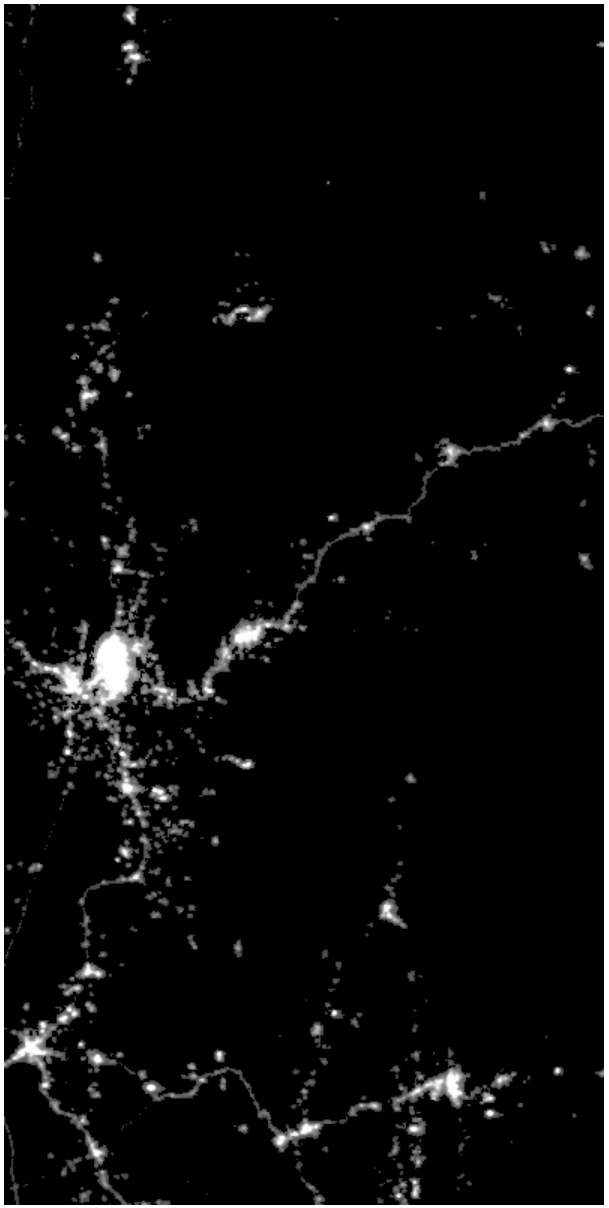
Raw cloud-free composite



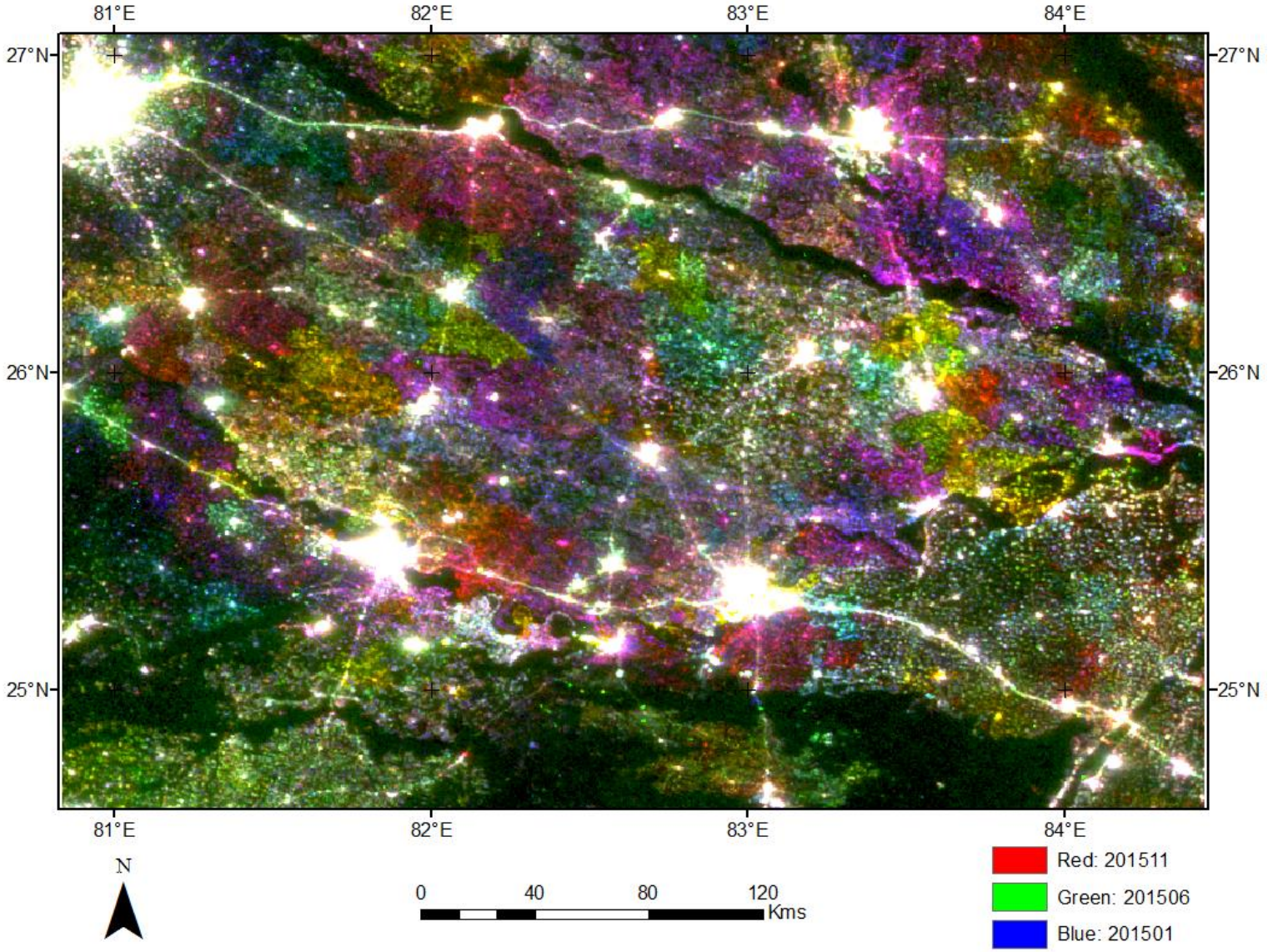
Outlier removed

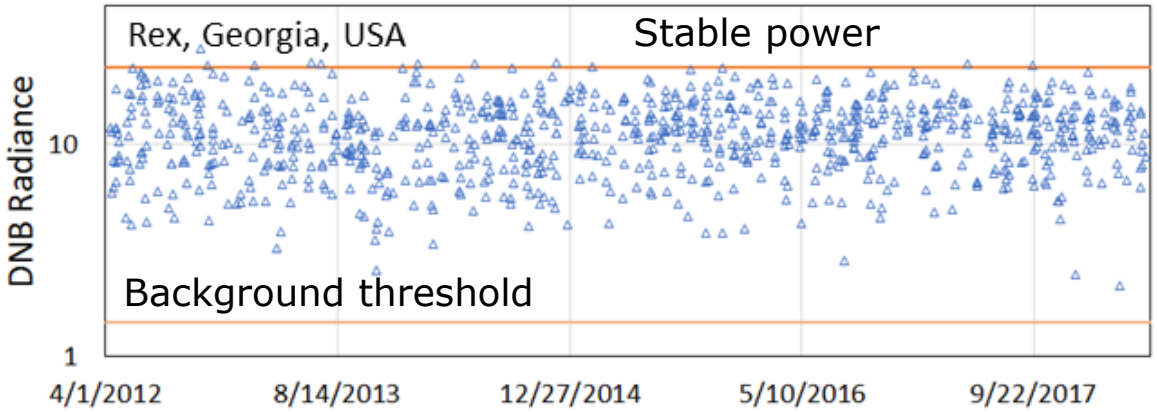


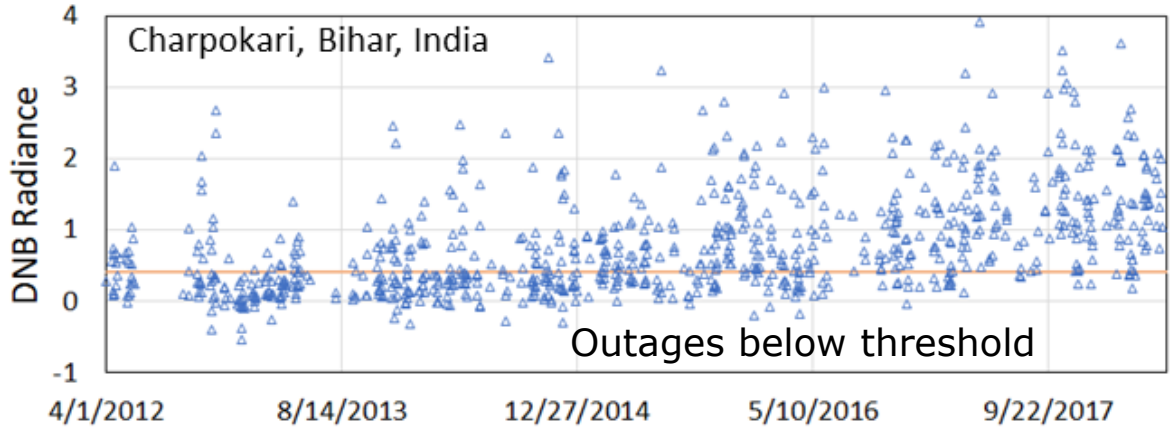
Nighttime lights

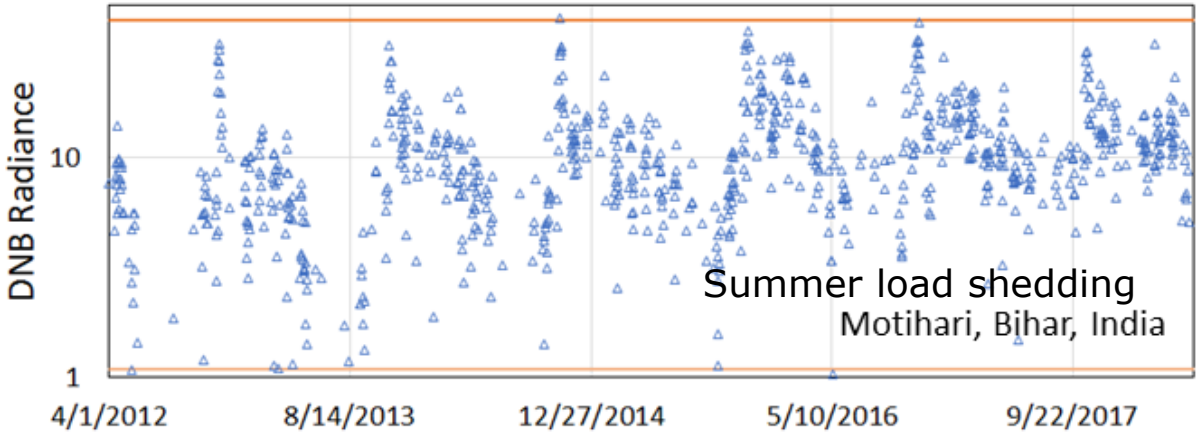


Power instability in India



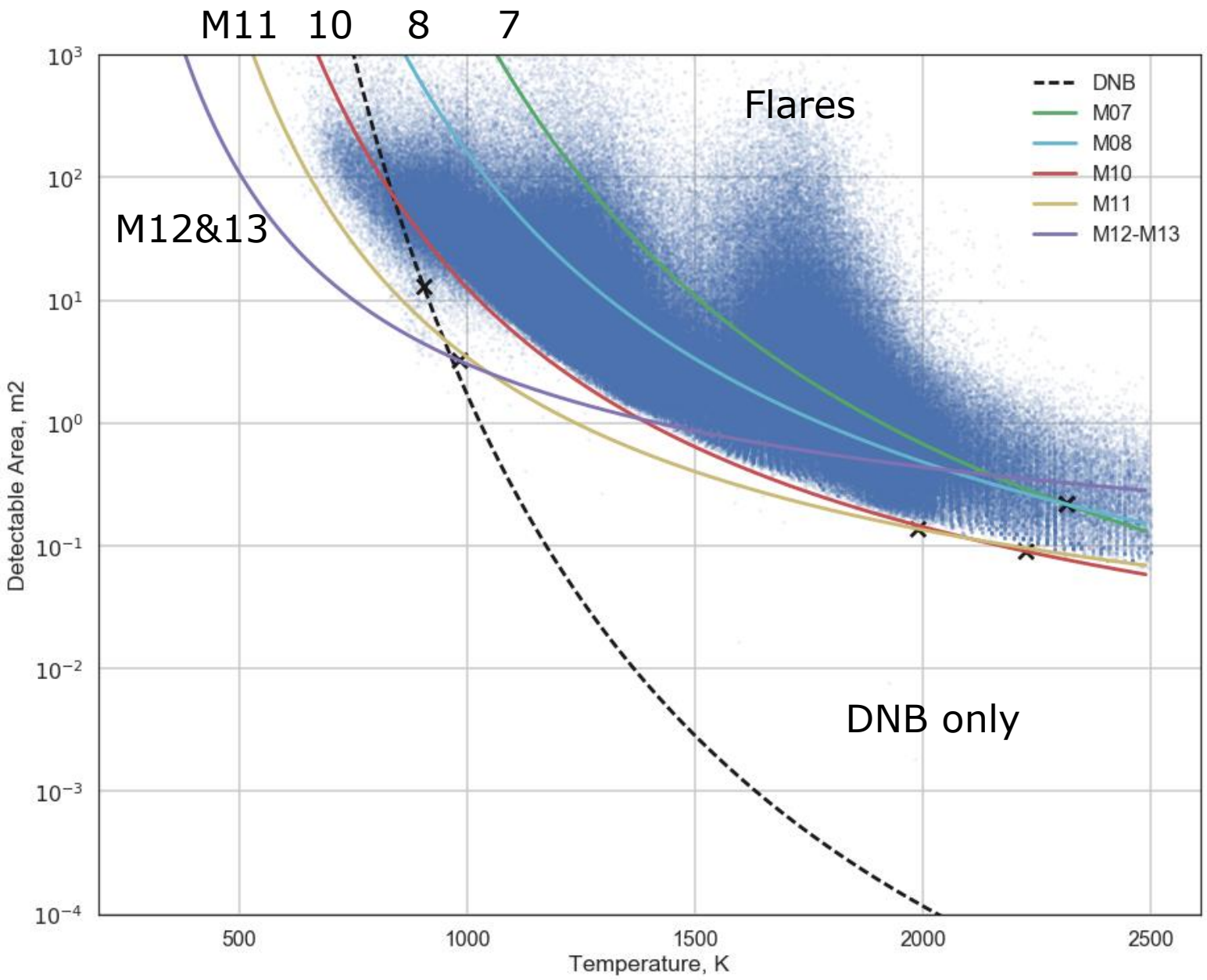






Temporal profiles reveal electric power instabilities

Does DNB detect IR sources unseen by M bands? Yes!



Future Plans

- Continue global product generation for VNL, VNF and VBD.
- R&D on separating flaming from smoldering in VNF (JPSS proving ground project).
- Develop a DNB fire product to augment VNF.
- Develop a DNB road product for use in rating infrastructure connectivity between urban centers.
- Develop an annual power stability index with monthly near real time updates.
- Develop alert system for power outages.

Recent Publications

- Elvidge, C. D., Bazilian, M. D., Zhizhin, M., Ghosh, T., Baugh, K., & Hsu, F. C. (2018). The potential role of natural gas flaring in meeting greenhouse gas mitigation targets. *Energy Strategy Reviews*, 20, 156-162.
- Elvidge, C.D., Ghosh, T., Baugh, K., Zhizhin, M., Hsu, F.C., Katada, N.S., Penalosa, W., Hung B.Q. (2018) Rating the effectiveness of fishery closures with Visible Infrared Imaging Radiometer Suite boat detection data. *Frontiers in Marine Science, section Marine Conservation and Sustainability*, 5, 132.
- Do, Q-T, Shapiro, J.N., Elvidge, C.D., Abdel-Jelild, M., Ahne, D.P., Baugh, K., Hansen-Lewis, J., Zhizhin, M., Bazilian, M. (2018). Terrorism, geopolitics, and oil security: Using remote sensing to estimate oil production of the Islamic State. Energy Research & Social Science, (*in press*).
- Small, C., Sousa, D., Yetman, G., Elvidge, C., & MacManus, K. (2018). Decades of urban growth and development on the Asian megadeltas. *Global and Planetary Change* 165, 62-89.
- Kyba, C.C., Kuester, T., de Miguel, A.S., Baugh, K., Jechow, A., Hölker, F., Bennie, J., Elvidge, C.D., Gaston, K.J. and Guanter, L., (2017). Artificially lit surface of Earth at night increasing in radiance and extent. *Science advances*, 3(11), p.e1701528.
- Coscieme, L., Sutton, P. C., Anderson, S., Liu, Q., & Elvidge, C. D. (2017). Dark Times: nighttime satellite imagery as a detector of regional disparity and the geography of conflict. *GIScience & Remote Sensing*, 54(1), 118-139.
- 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.