Five-year Survey of the U.S. Natural Gas Flaring Observed from Space with VIIRS

Mikhail ZHIZHIN
CIRES / NOAA
Mikhail.Zhizhin@noaa.gov
Gas flares are readily detected in the VIIRS M10 spectral band.
VIIRS Nightfire (VNF):
A global fire product created from nighttime multispectral satellite data

VIIRS data is available from March 2012 – present.
Nine channels of data are collected at night.
VIIRS M-band spatial resolution is 742m at nadir.
Nighttime collection of channel 11 is expected to start in 2017
Flare Array in Basra

2017-05-23  22:14 UTC
T = 1572K, S = 115 m²
Time Series Analysis of VNF Detections

• Run VIIRS Nightfire Algorithm for and save in a PostgreSQL database (130 GB for global coverage 3/2012 – 12/2016)
• Accumulate detections with $T > 1300K$ into a 15 arc-second grid
• Remove noise and fires, mask out grid cells < 3 detections
• Use “watershed” algorithm to separate flare sites
• Manually label flare types based on the Google Earth images
• Accumulate annual detection statistics within each flare site
• For each site, estimate average lat-lon location, temperature $T$, surface area $S$, shape and radiant heat $RH$
Gridded VNF Detections in North Dakota
Temperature > 1300K, Ndetect > 3
Syria, site #271
Lat=34.911244 Lon=43.432322 deg.

M10 Radiance

Temp. K

DNB Radiance

DNB Spike Index
Flare Shapes: Heat vs View Angle

Flare in Northern Iraq

Flare Array in Basra

Door to Hell in Tadzhikistan

Radiant Heat

Satellite view angle
Calibration

Sum of flare “radiant heat “ RH’ = $T^4 \times S^D$ (no clouds) in proportion to the percent of detections (PCT). Here D is nonlinear correction factor, S is surface area.

Flared volume is given by the Regression Through the Origin (RTO) relating the CEDIGAZ reported country level BCM and RH’

$$\text{Flared Volume} = \text{Slope} \times \text{RH’}.$$

The 95 % confidence interval for the RTO slope are

$$\text{Slope} = 0.0294 \pm 0.0017$$

For RTO the prediction interval varies in a narrow range 3 - 3.5 BCM for the full range of the observed RH’ from 0 to 700.

CEDIGAZ, http://www.cedigaz.org/
OLS, Year=2012.2015, D=0.7, slope=0.029353

- **Regression slope**
- **Confidence intervals**
- **Prediction intervals**

- Correlation $\hat{R}_H' / BCM$
- Power $S^D$ in $R_H'$

- **RTO**
- **WLS**

- Reported BCM
- Estimated $R_H'$

- Correlation $R_H' / BCM$
- Power $S^D$ in $R_H'$
Flared Volume for Top 20 Countries, Upstream

Year | World BCM, upstream
--- | ---
2012 | 140
2013 | 137
2014 | 141
2015 | 144
2016 | 147

Total flares: 17043
Q & A

• Where to find the Nightfire data?
  https://www.ngdc.noaa.gov/eog/viirs/download_viirs_fire.html
  https://www.ngdc.noaa.gov/eog/viirs/download_global_flare.html

• Where is it published?