Nighttime VIIRS LCLUC Applications

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VIIRS

- The Visible Infrared Imaging Radiometer Suite (VIIRS) is the primary imaging sensor flown on the NASA/NOAA Suomi National Polar Partnership satellite.
- Launched on October 28, 2011, VIIRS began to collect usable data in late-February 2012.
- 22 spectral channels, most with 750 meter pixels at nadir.
- 3000 km swath. Overpasses at ~01:30 and 13:30 daily.
- VIIRS is unique for collecting near and short-wave infrared data at night.

Lights At Night!

Cities and human settlements

Boats

Industrial Sites

Gas Flares

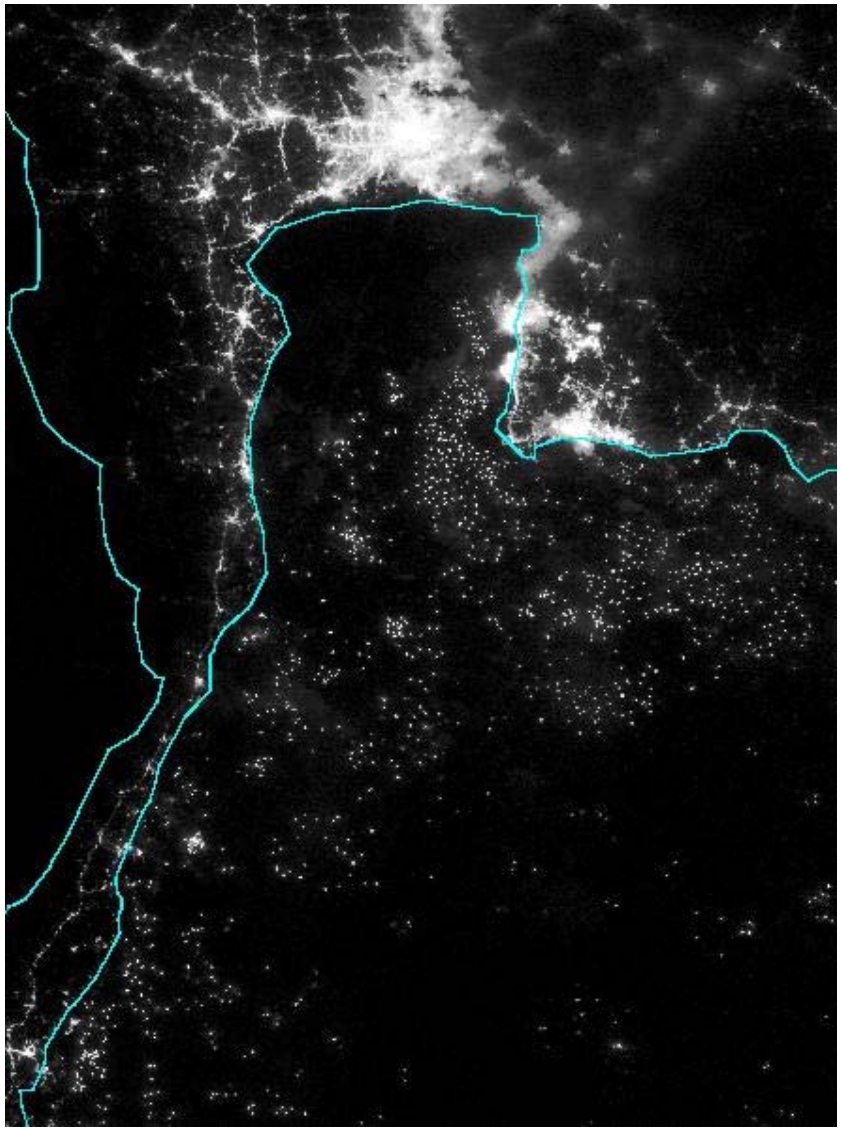
Fires

VIIRS Low Light Imaging

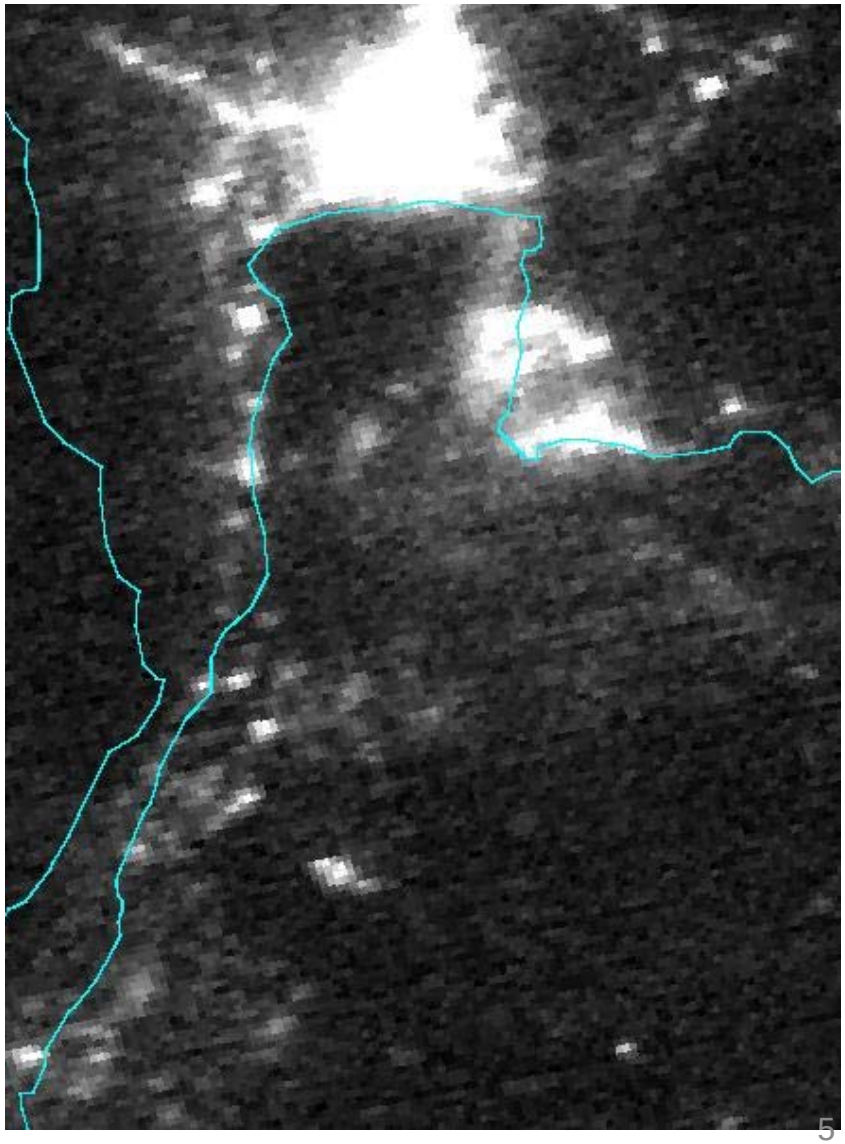
- Use of light intensification to detect faint radiant emissions. For example, the VIIRS Day/Night Band (DNB) high gain detector uses Time Delay and Integration to aggregate signal across detectors on the CCD. This enbles the mapping of lights sources present at the Earth's surface.
- Use of daytime channels at night to detect and measure radiant emissions that are obscured by reflected sunlight. This is used for multispectral fire detection and analysis.

VIIRS Provides Improved Spatial Resolution Fishing Boat Detections

VIIRS October 15, 2012 01:30



DMSP-OLS October 14, 2012 19:30



What Makes VIIRS Better Than DMSP?

- The VIIRS DNB footprint is 45 times smaller than the DMSP pixel footprint!

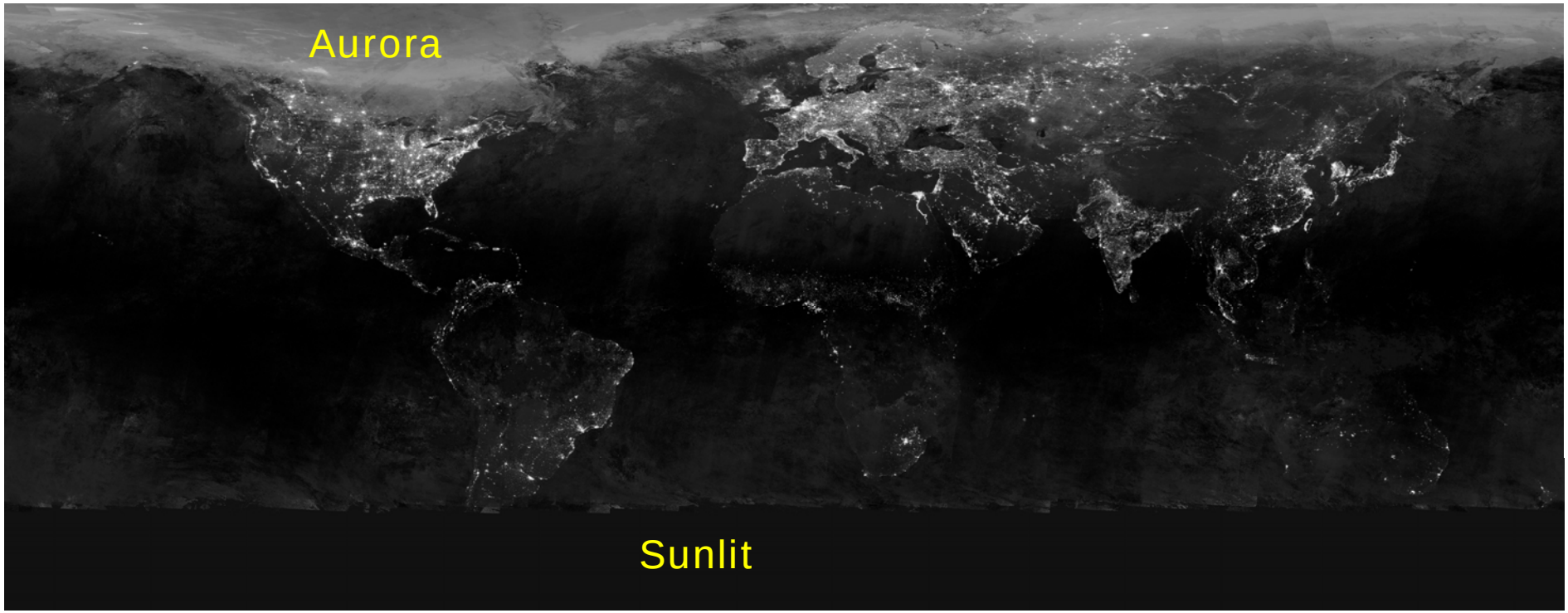
What Else Makes VIIRS Better Than DMSP?

- ***Quantization:*** VIIRS 14 bit versus 6 bit for DMSP.
- ***Dynamic Range:*** Due to limited dynamic range, DMSP data saturate on bright lights in operational data collections.
- **Lower Detection Limits:** VIIRS can detect dimmer lighting than DMSP.
- ***Quantitative:*** VIIRS is well calibrated, the DMSP visible band has no in-flight calibration.
- ***Multispectral:*** VIIRS has additional spectral bands to discriminate combustion sources from lights and to characterize the optical thickness of clouds.

Current Status of NGDC DNB Products

- Nightly mosaics in png and Google Earth Super-overlay formats http://ngdc.noaa.gov/eog/viirs/download_ut_mos.html
- Rough monthly averages. Four preliminary products are available at: http://ngdc.noaa.gov/eog/viirs/download_monthly.html
- Monthly and annual cleaned nighttime lights still in development
  - Free of solar, lunar, aurora, South Atlantic Anomaly detector hits
  - Filtered to remove lightning
  - Combustion sources removed
  - Background noise removed

Average VIIRS DNB Composite - January 2013 Contrast Enhanced to Show the Flaws

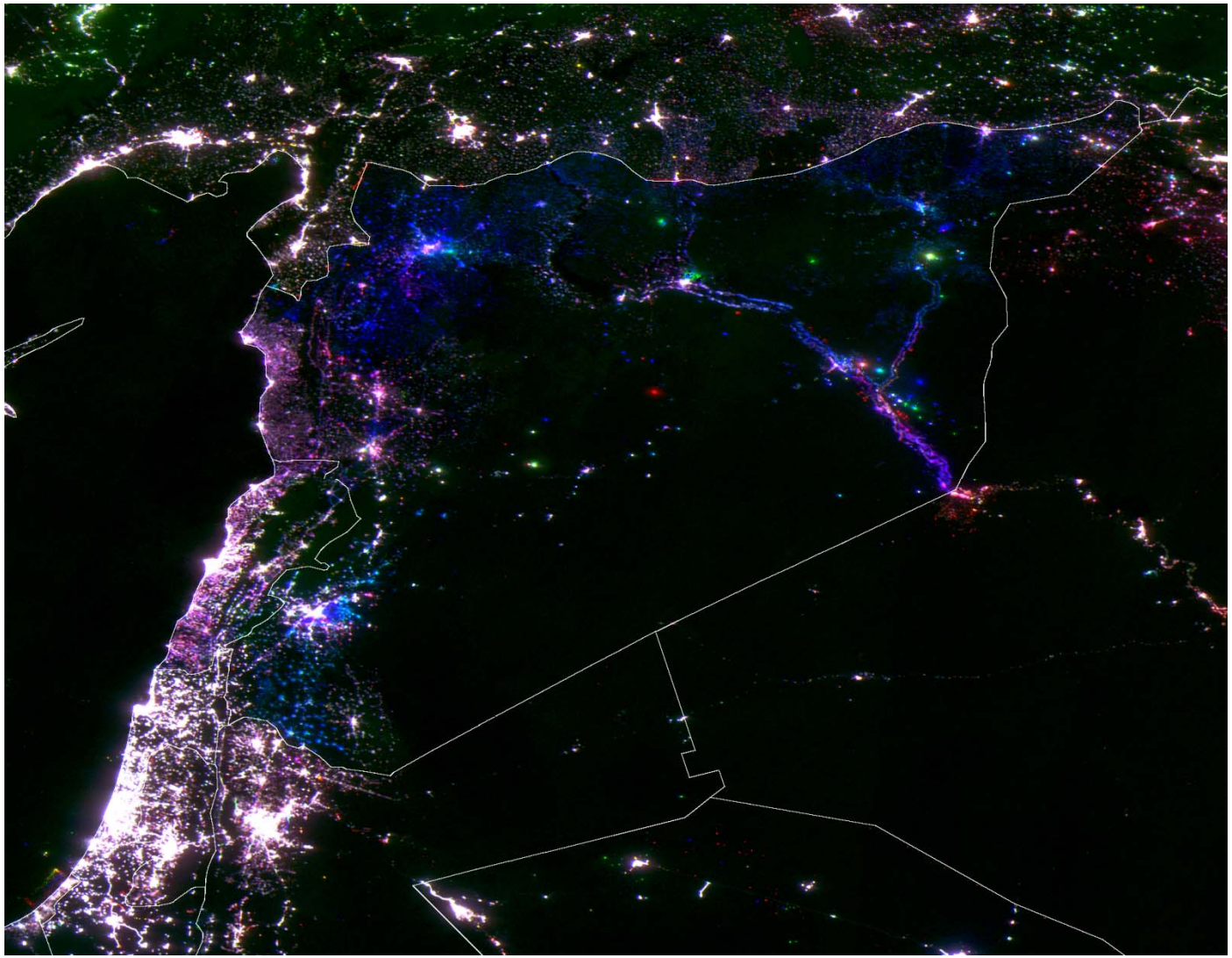


- Dimensions 86400 x 33601. Too large to output as GEOTIFF!
- Original units multiplied by a billion (E9) to yield nanoWatts/(cm^2·sr)
- Issues in the production of nighttime lights: removal of background noise, aurora, fires, fuzzy lights.

LCLUCC Applications for VIIRS Nighttime Lights

- Spatial definition of human settlements and areas with built infrastructure
- Measuring growth rates in built infrastructure.
- Estimation of the density of constructed surfaces
- Modeling habitat fragmentation
- Light pollution studies
- Spatial modeling of human development indices
  - Access to electricity
  - Gridded GDP
  - Poverty mapping
- Urban metabolism analyses
  - Spatial modeling of water consumption, waste water production,

Nighttime lights should be used cautiously in LCLUC analyses due to their plasticity



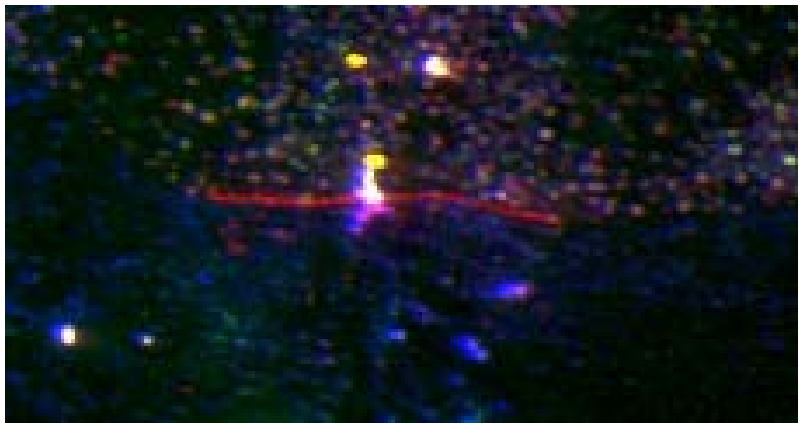
Color composite of three monthly average DNB products.
201204 = blue
201301 = green
201405 = red

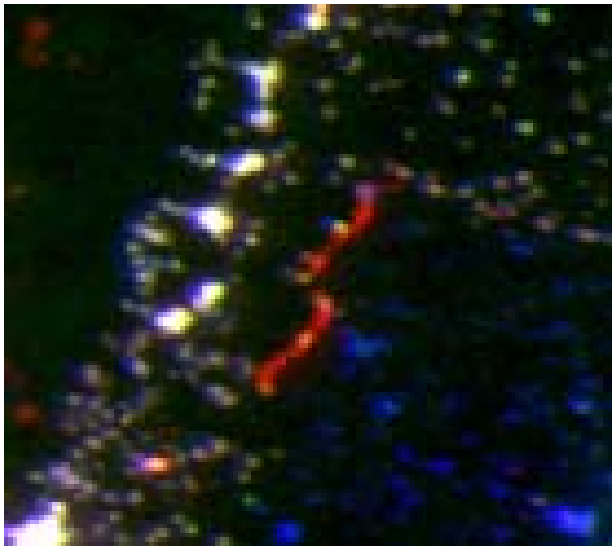
Blue indicates power outages in 2013 and 2014. Purple indicates power outage in 2013.

Syria

Syria

Color composite of three monthly average DNB products.
201204 = blue, 201301 = green, 201405 = red

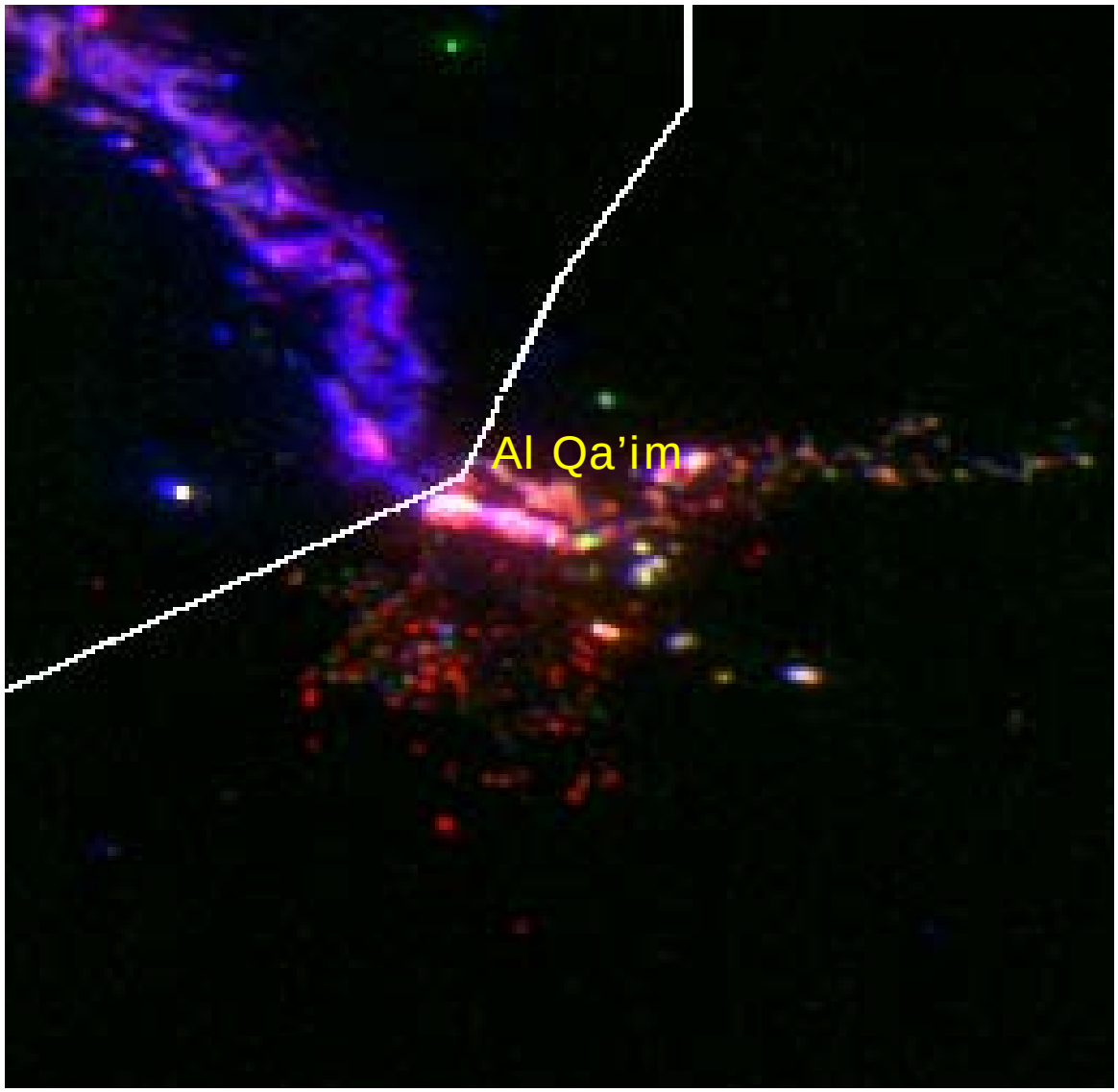




Red lines on Turkish side of border.
Refugee camps?
24 hour border control operation?

Iraq

Color composite of three monthly average DNB products.
201204 = blue, 201301 = green, 201405 = red



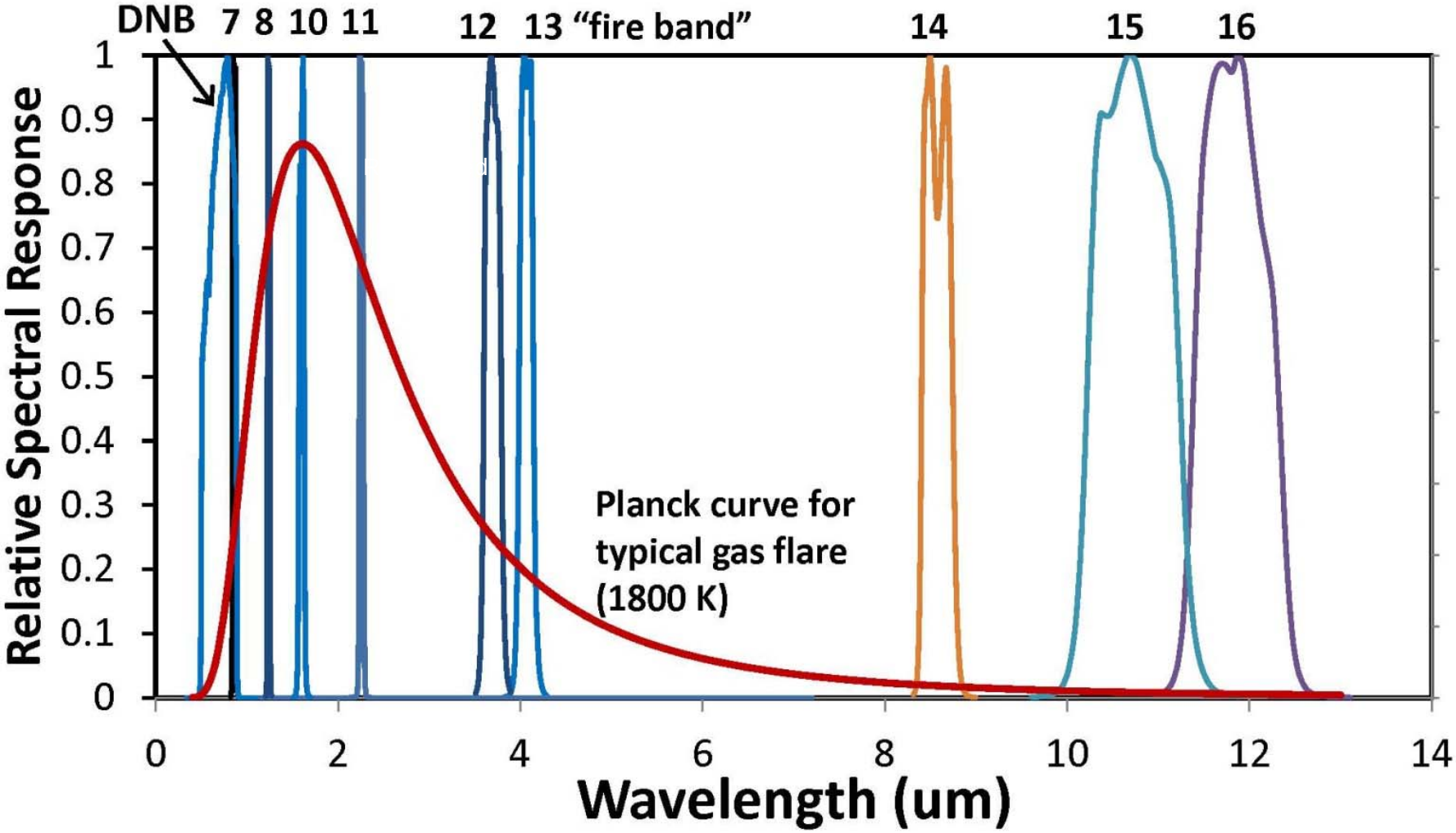
Disorganized set of lights south of Al Qa'im, Iraq. ISIS controlled territory. Refugee camps? Military camps?

Available Monthly DNB Composites

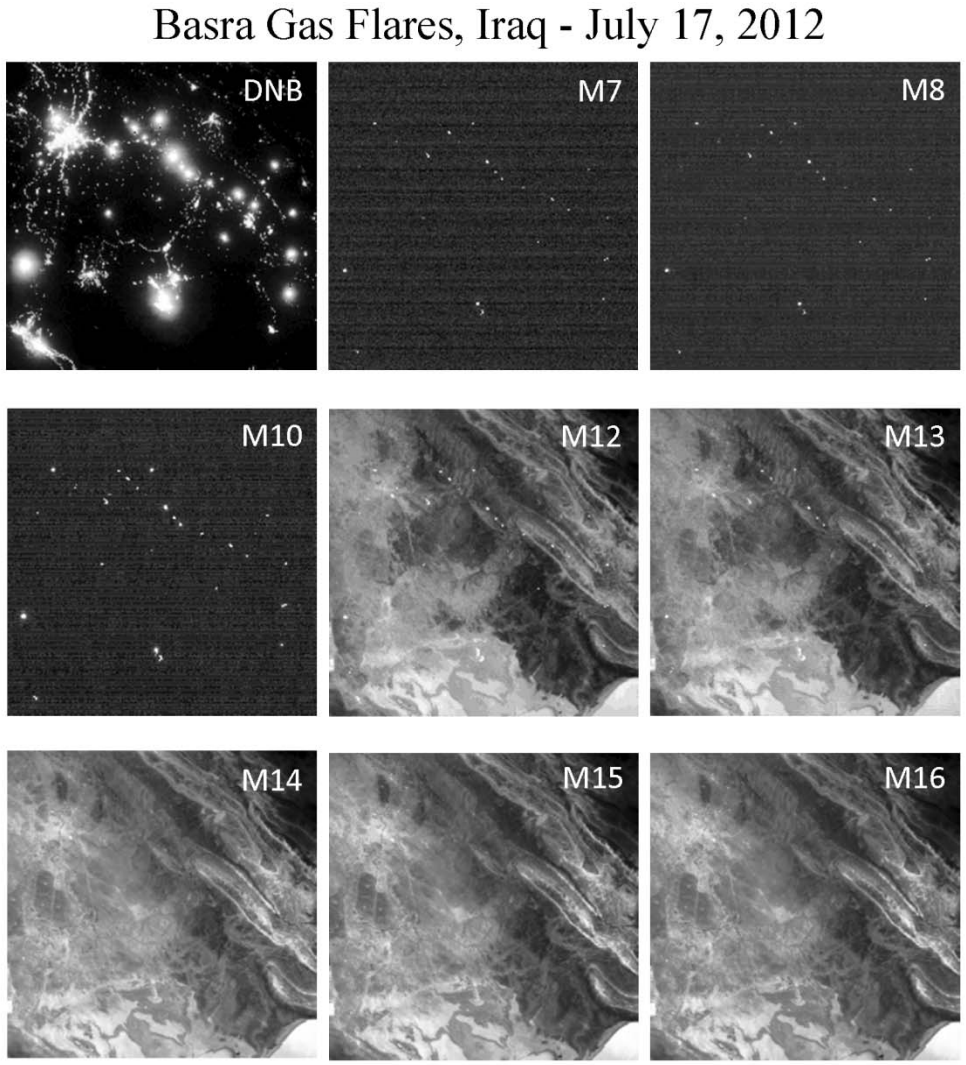
- March 2012
- April 2012
- October 2012 (has minor pointing error that will be corrected in reprocessing)
- January 2013
- May 2014
- June 2014

Eventually all the available months will be processed

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

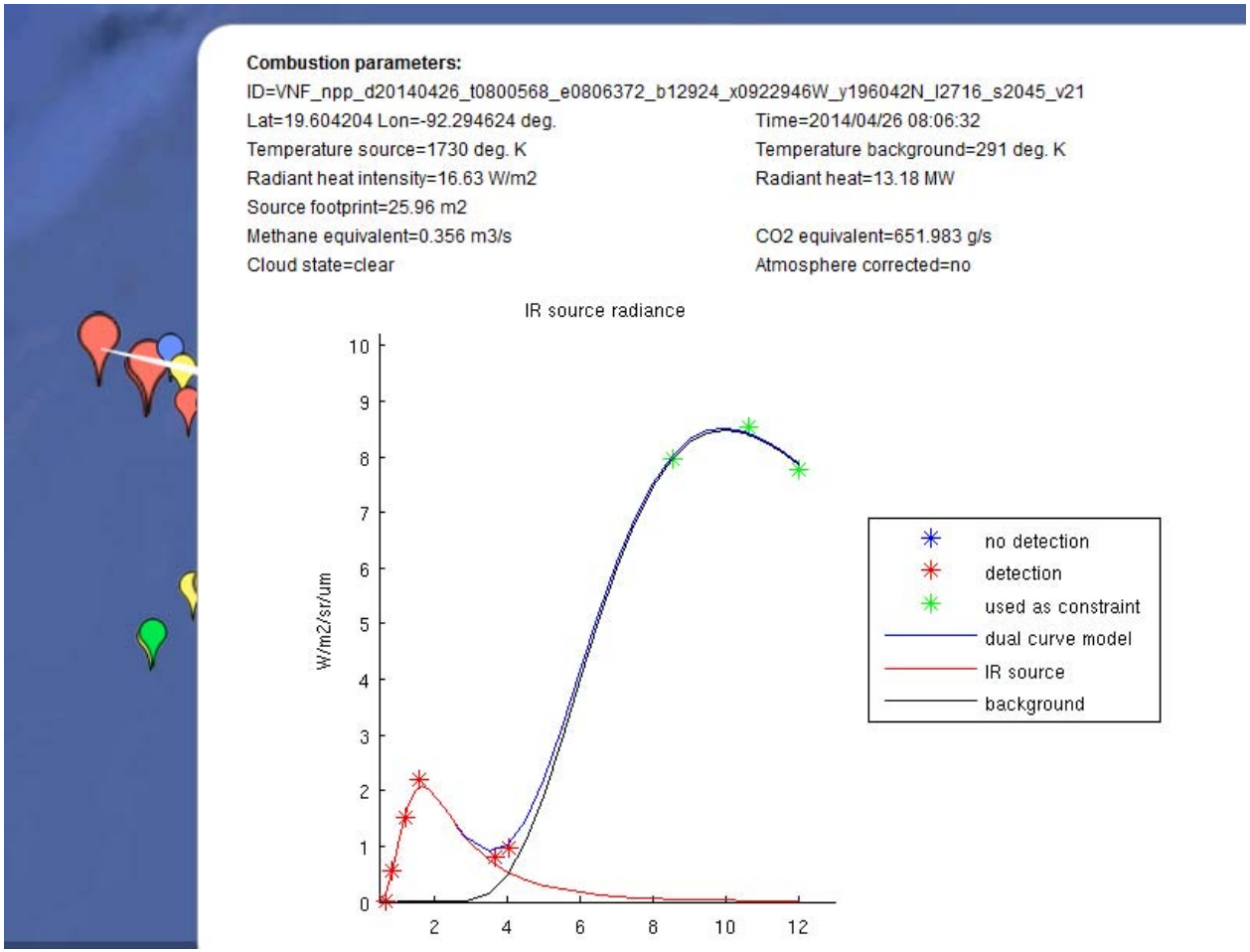


Nighttime collection of channel 11 is expected to start in 2015



Gas flares are readily detected in the VIIRS M10 spectral band

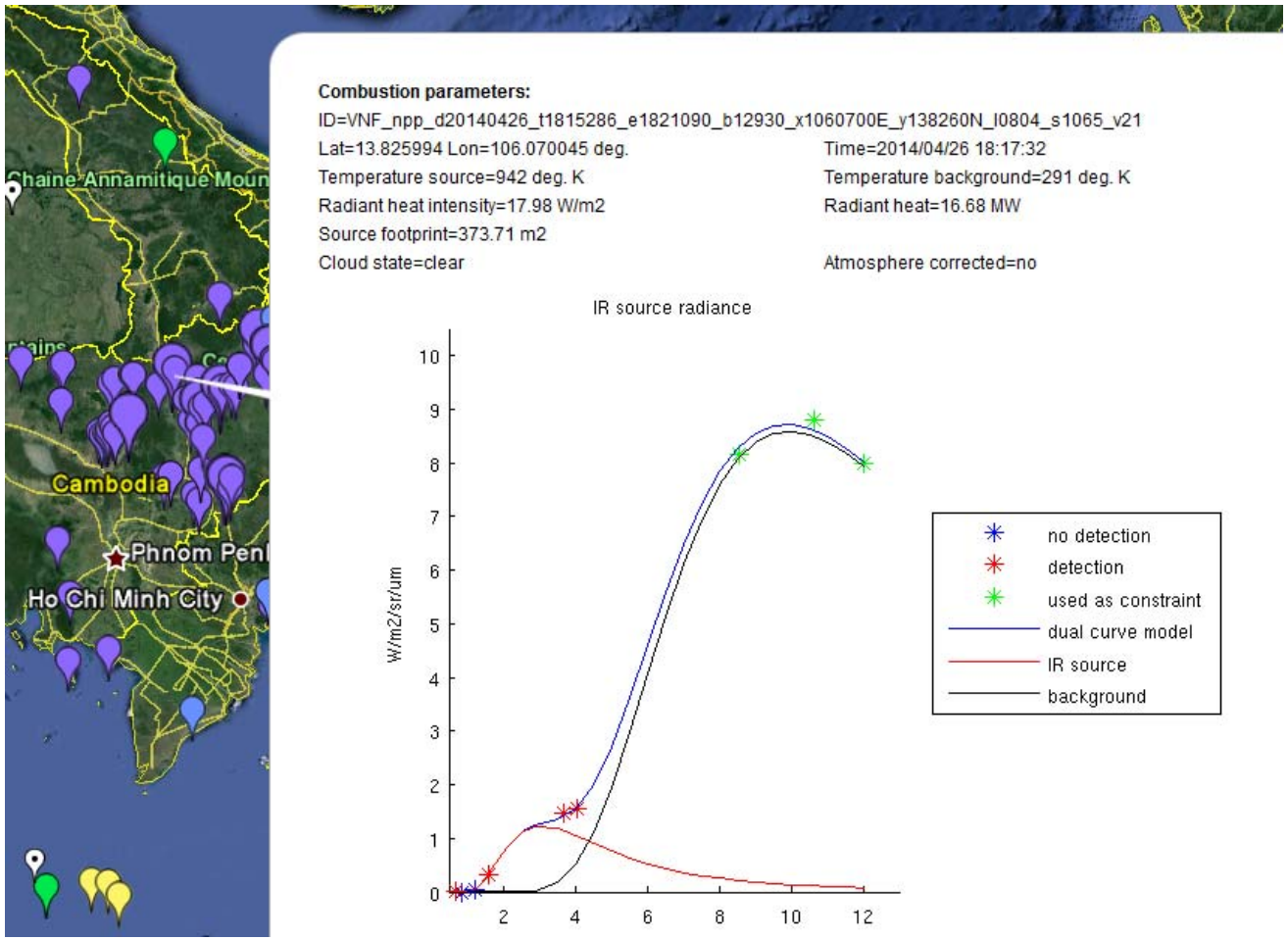
Why Multispectral?



To get at the Planck curves!

Daily files are in csv and kmz formats

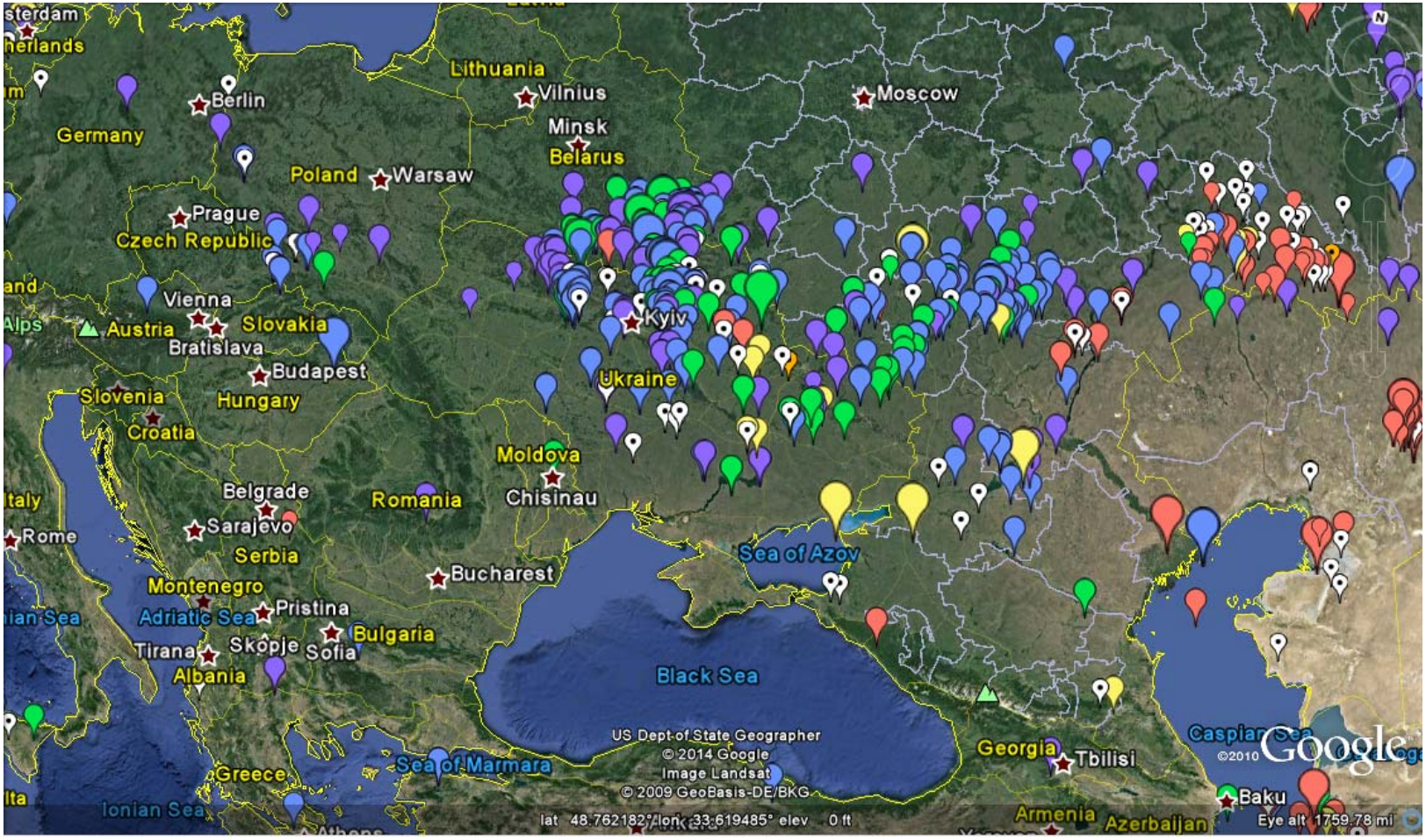
Typical Biomass Burning Detection



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

Daily VNF data are available at:

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



Current processing typically runs with a 3.5 hour delay

LCLUC Applications for VNF data

- VNF temperatures and source sizes may be useful in modeling fire induced land cover change.
- As an indicator of oil and gas development activity levels.
- As an indicator of encroachment into protected and high biodiversity value areas.

EOG Publications

- 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
- Illuminating the capabilities of the Suomi NPP VIIRS Day/Night Band. http://dx.doi.org/10.3390/rs5126717