VIIRS Nighttime Lights Development Update

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Nighttime Lights Composites
What are they?

A nighttime lights composite is made to serve as a baseline of persistent light sources.

Composites are made as an average of the highest quality nighttime lights imagery over desired time period – usually monthly or annually.

"Stable Lights" composites have ephemeral light sources and non-light (background) areas are removed from a composite.

EOG group is producing current monthly cloud-free/no-moon DNB nighttime lights composites and is doing algorithm development to turn these in to Stable Lights composites.

Nighttime Lights Composites
Processing Steps

Flag input DNB data so only the "highest quality" nighttime data gets averaged into a composite. Currently defined as:

- Cloud-free (using the VIIRS cloud-mask (VCM) product)
- Nighttime with solar zenith angles greater than 101
- Not affected by moonlight (lunar illuminance < 0.0005 lux)
- Middle of swath (DNB has increased noise at edge of scan)
- Free of lights from lightning
- Free of "lights" from South Atlantic Anomaly

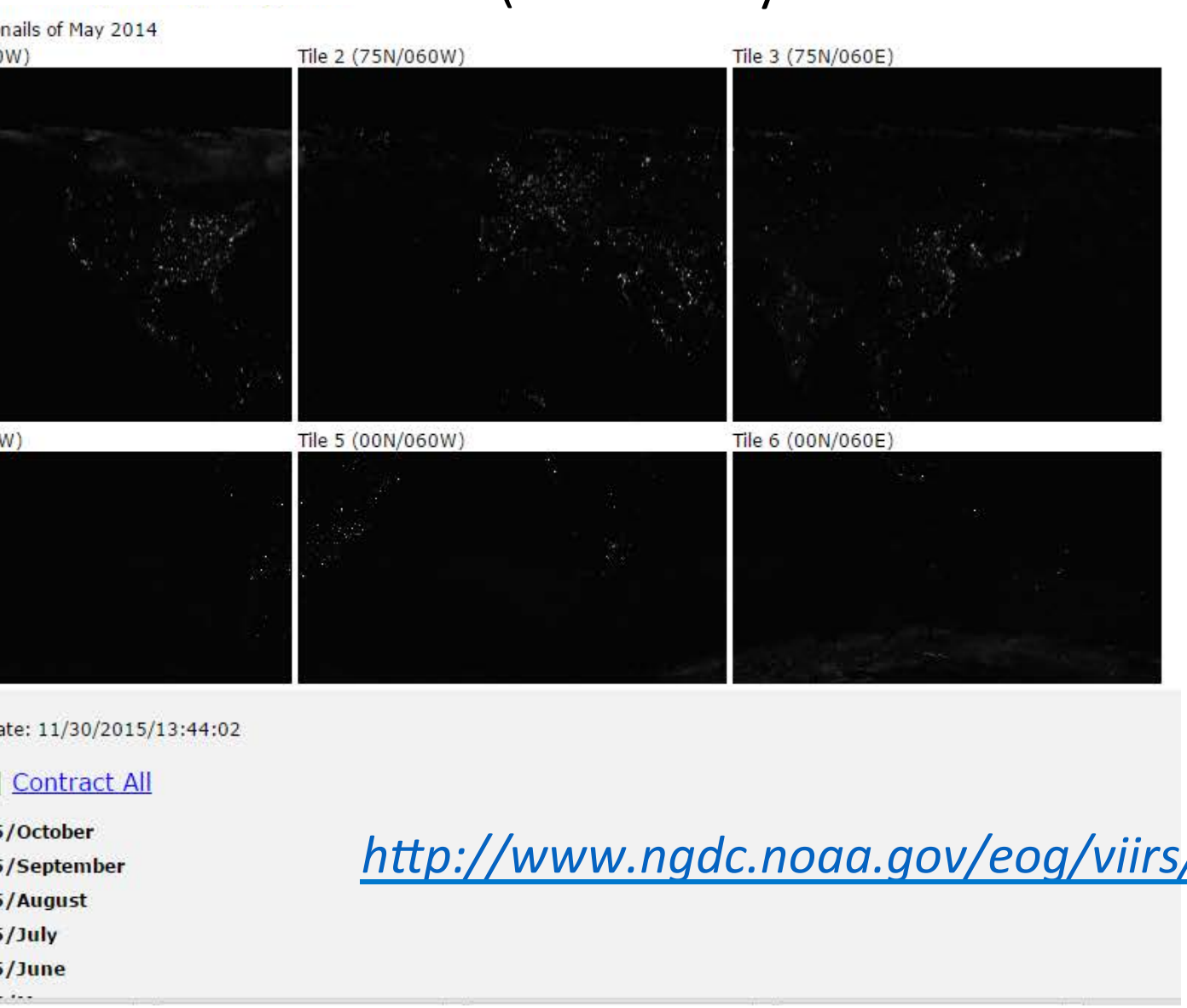
Create annual average DNB composite products and histograms of individual observations

Use annual histograms to remove DNB outliers (ephemeral lights and other sensor noise

Identify and remove background (non-light) areas

Create TOA and atmospherically-corrected DNB composites

Nighttime Lights Composites
(Monthly DNB Products)



- Monthly DNB nighttime li composites are available online
- Globe is cut into 6 tiles to reduce individual file size
- These products still conta ephemeral lights and non lights (background).

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

DNB Stray Light

rthrup Grumman algorithm was implemented the IDPS in August 2013.

es a good job of mitigating stray light effects for ual interpretation.

me issues for algorithm development within the ay light corrected region:

- Can under/over-correct, especially at transition into stray light and in Southern hemisphere
- Variance of data across scan is altered
- Correction quality is dependent on time from correction lookup table generation

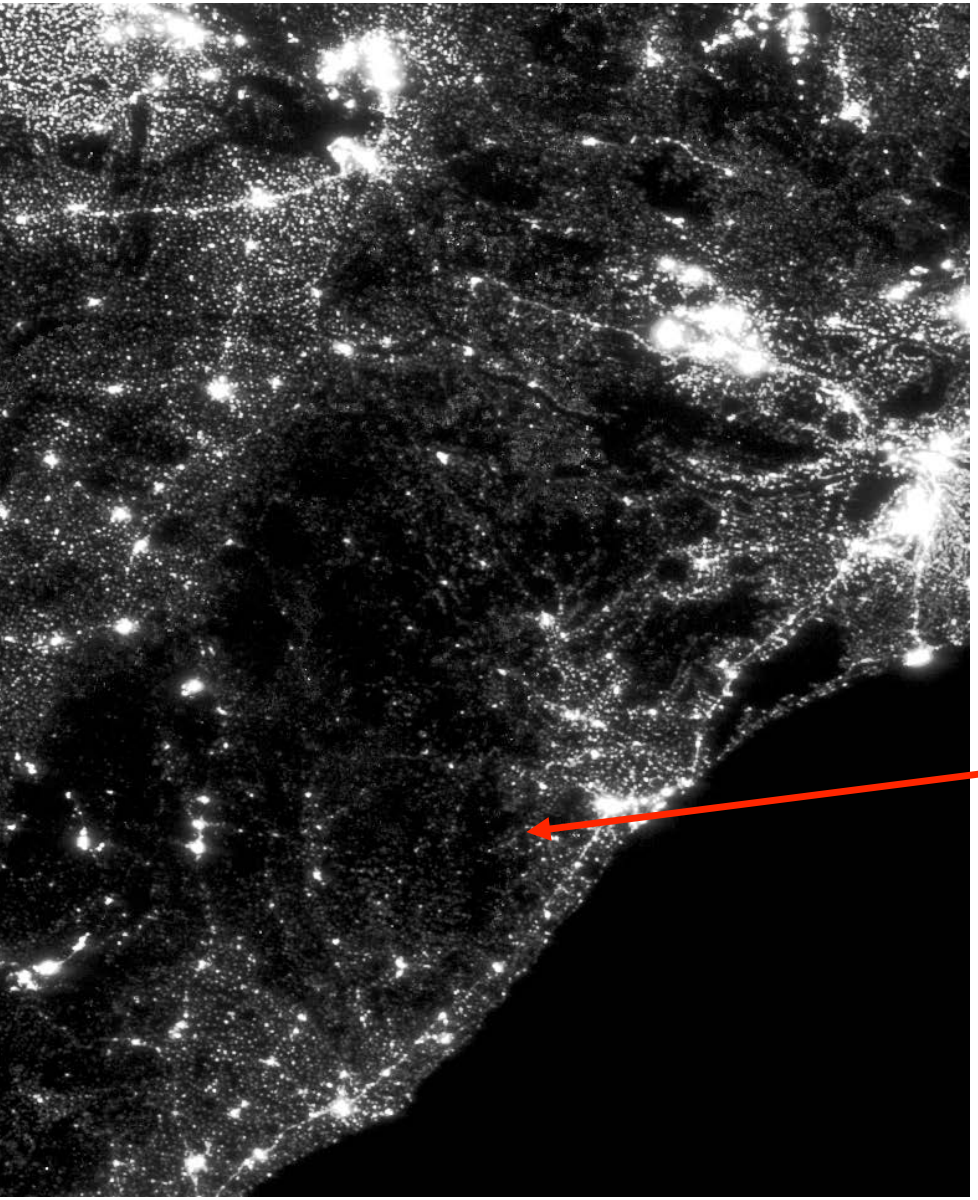
ray light corrected regions are identified and rocessed separately

DNB Ephemeral Light Removal

pproach:

- Create histograms of DNB radiances using an extended time series (annual)
- Use histograms to identify and remove outliers
- Similar to algorithm developed for DMSP-OLS Stable Lights
- Advantages: This algorithm removes ANY outliers, including fires, boa unfiltered-SAA, crosstalk, …
- Disadvantages: Persistent flares and volcanic activity can remain. Method requires long time-series of data.

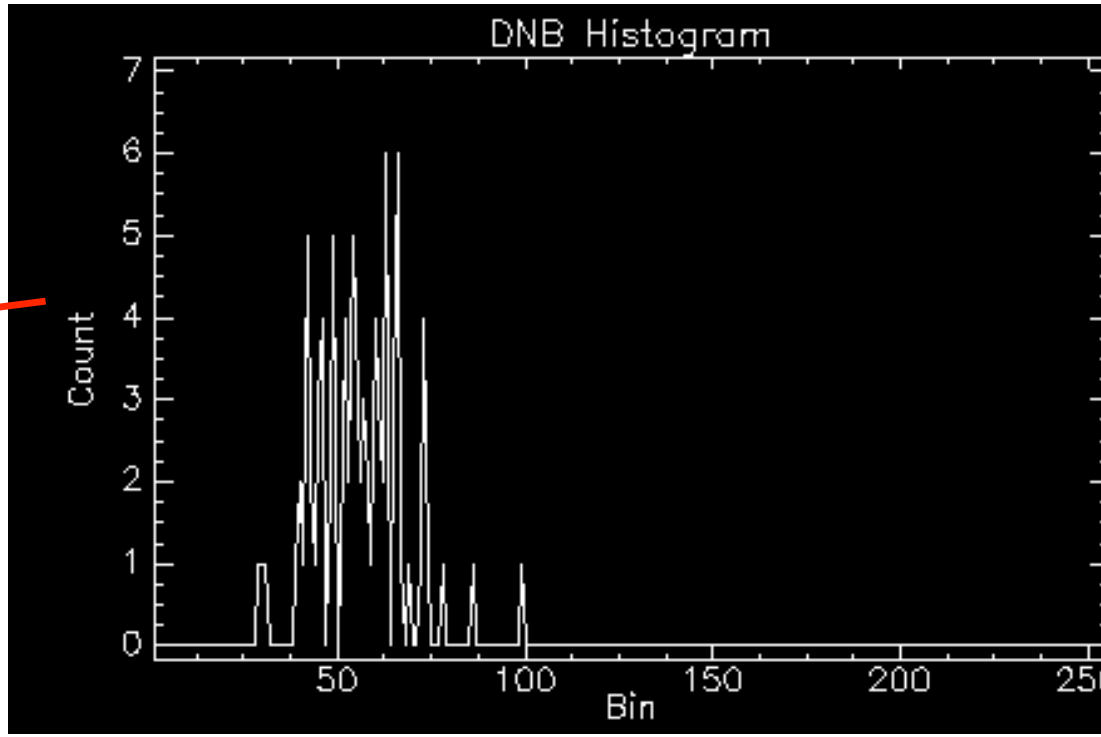
DNB Ephemeral Lights: Outlier Removal



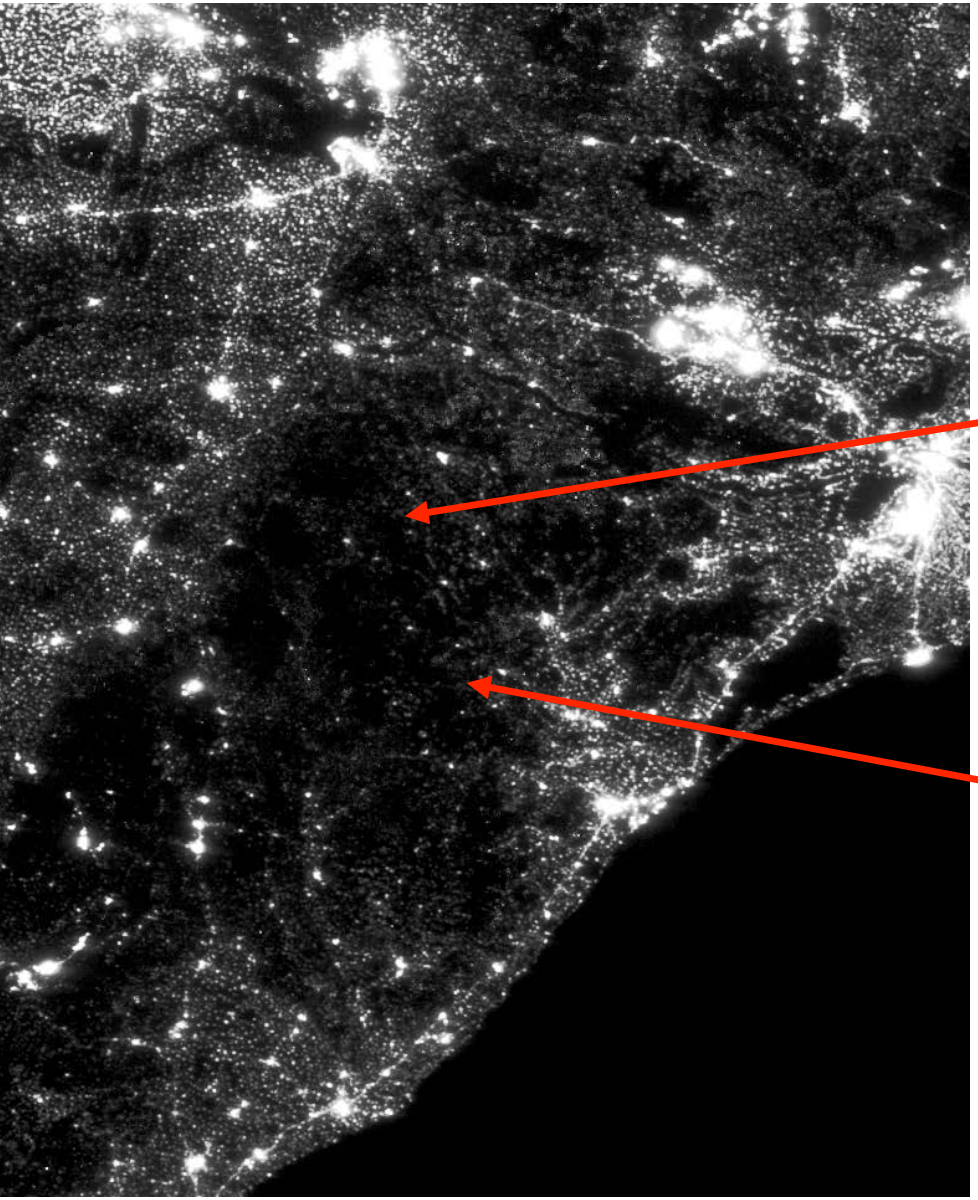
Odisha, India 2014 DNB Composite

- Histograms are made for each grid cell in compo
- DNB radiance values are placed in discrete bins on log transform. Bin=floor(100*(log(1E9*Rad+

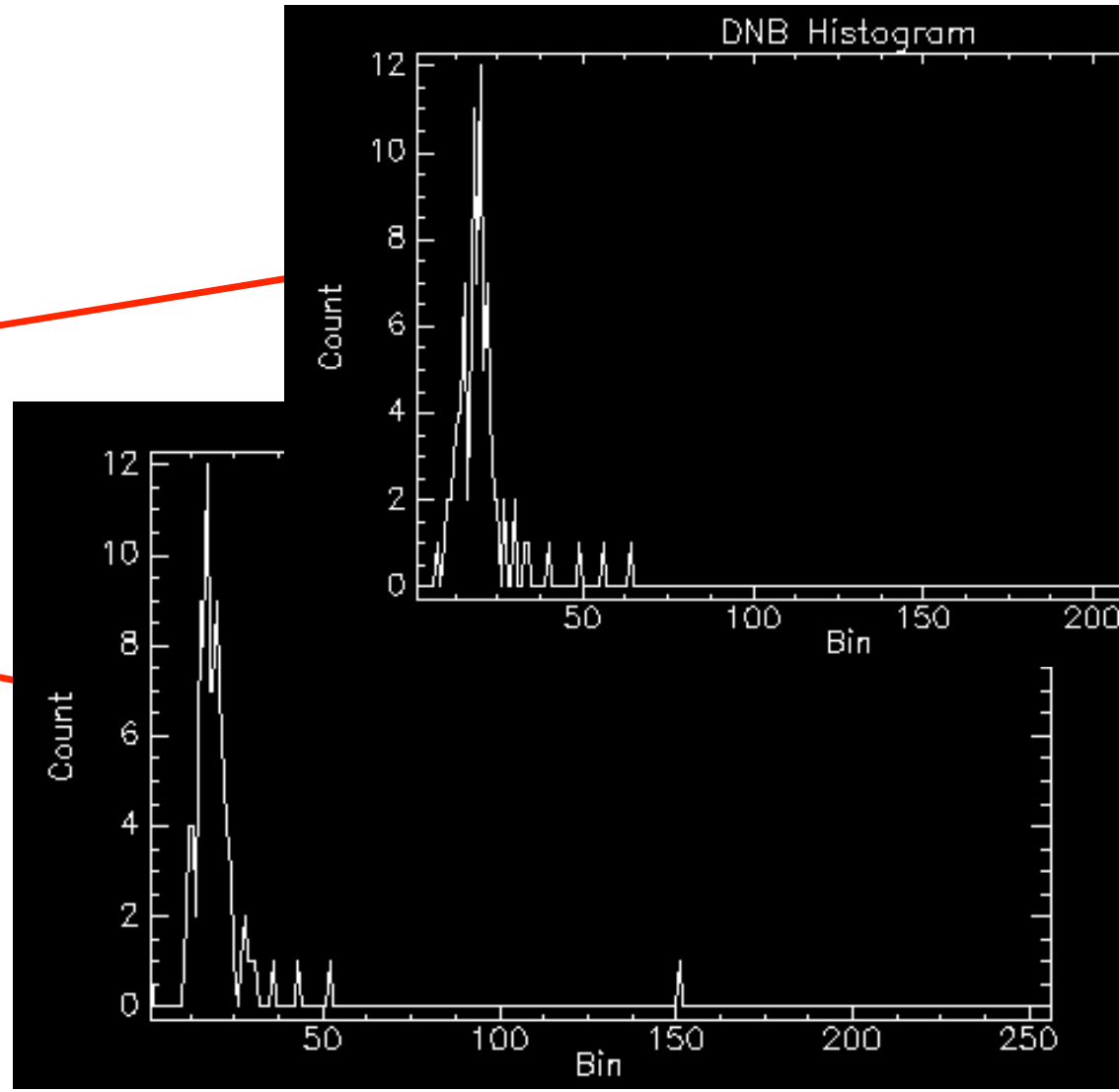
Example histogram of small village



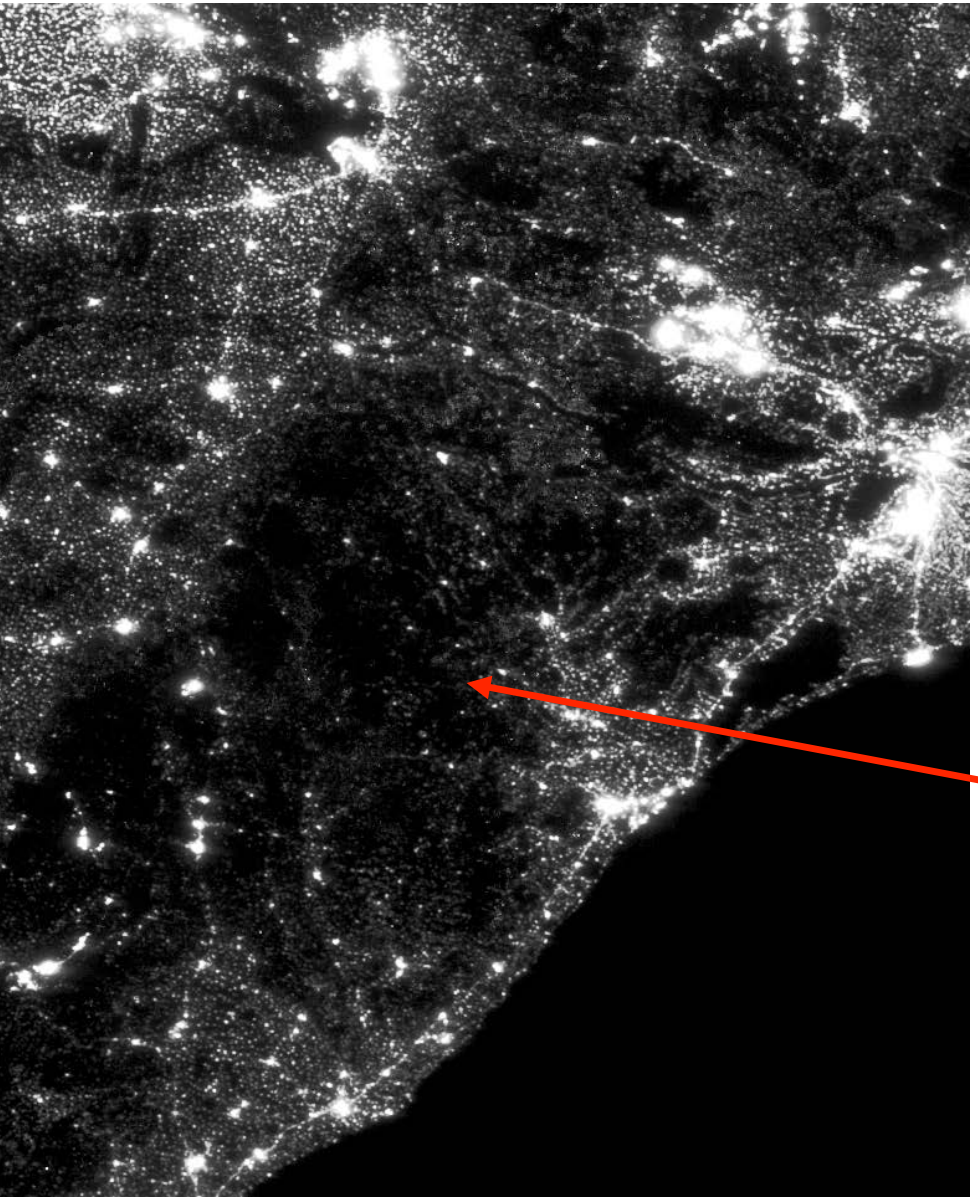
DNB Ephemeral Lights: Outlier Removal



Example histograms of grid cells containing fires

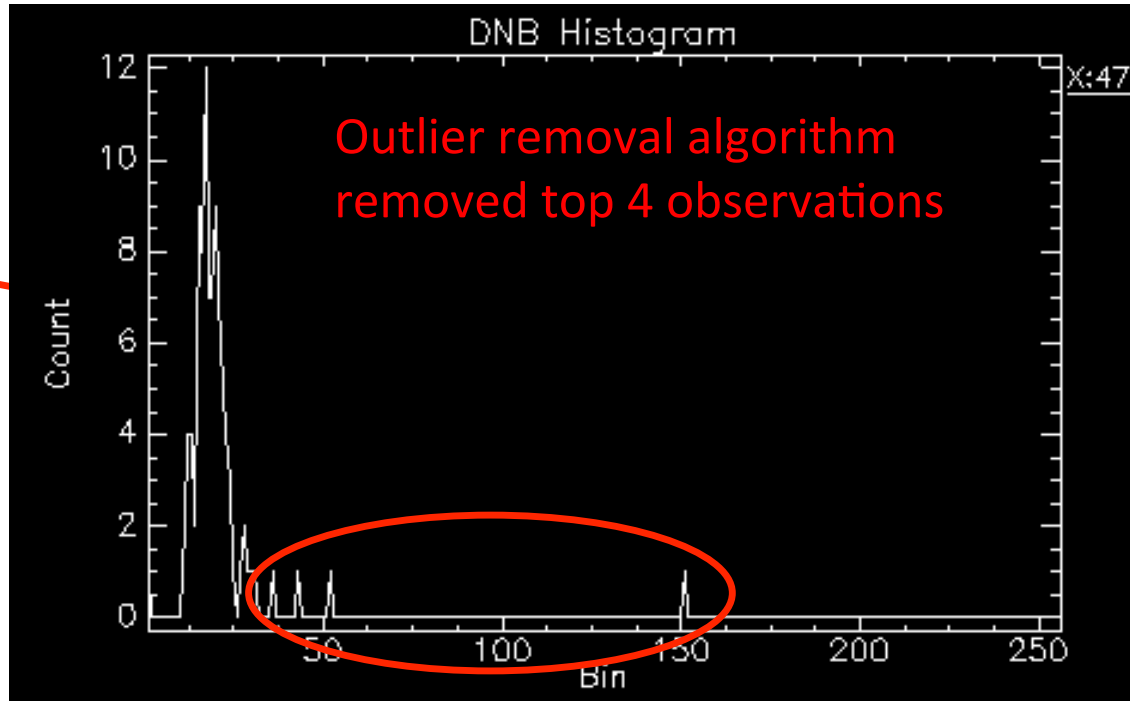


DNB Ephemeral Lights: Outlier Removal



Algorithm:

1) Compute standard deviation of observations
2) Remove highest observation
3) Re-compute standard devation
4) Repeat steps 2-3 if difference in standard devia threshold
5) Re-compute average of remaining observation



DNB Ephemeral Lights: Before Outlier Remova

with next slide

now regions with
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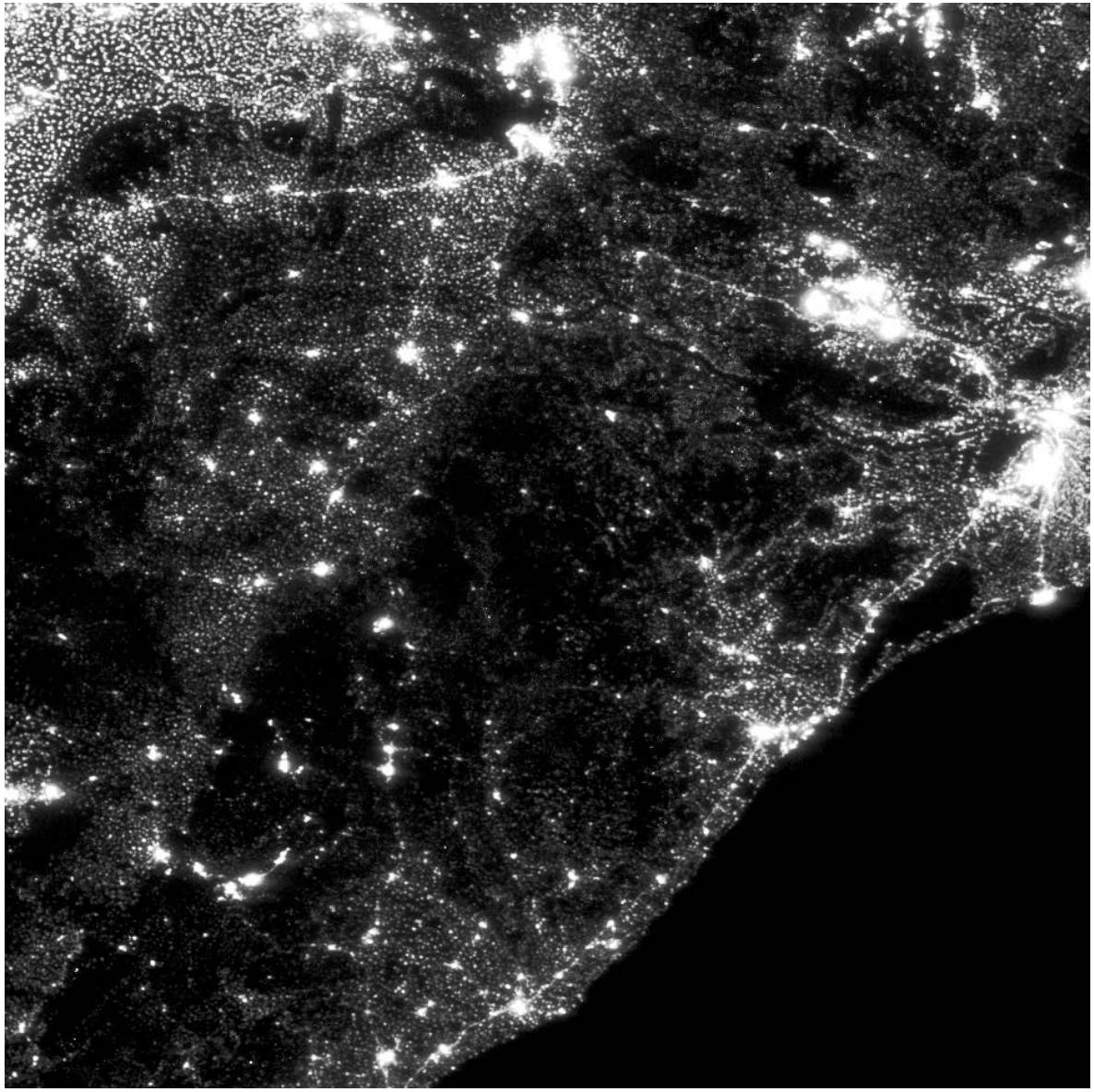

DNB Ephemeral Lights: After Outlier Removal

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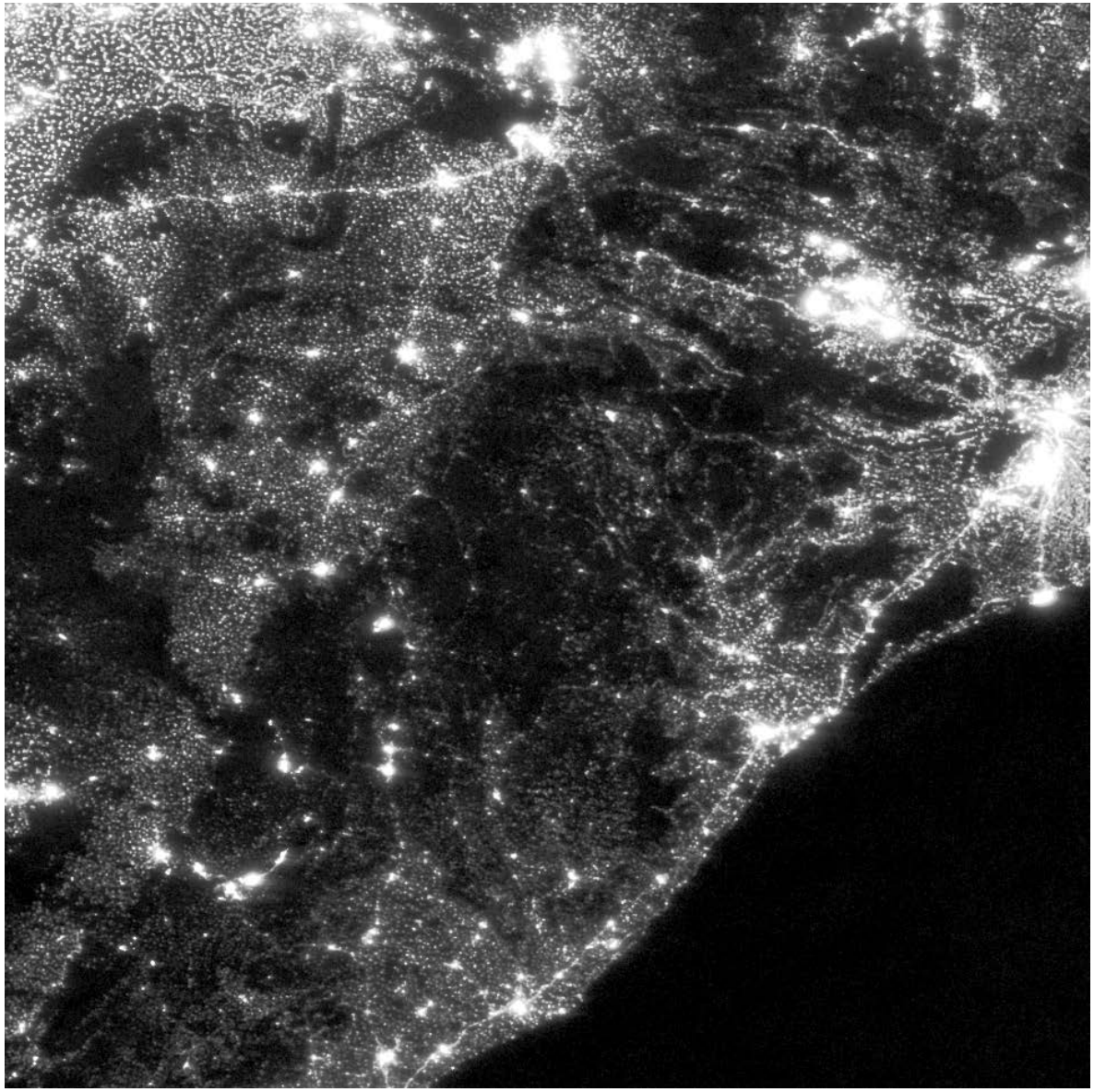
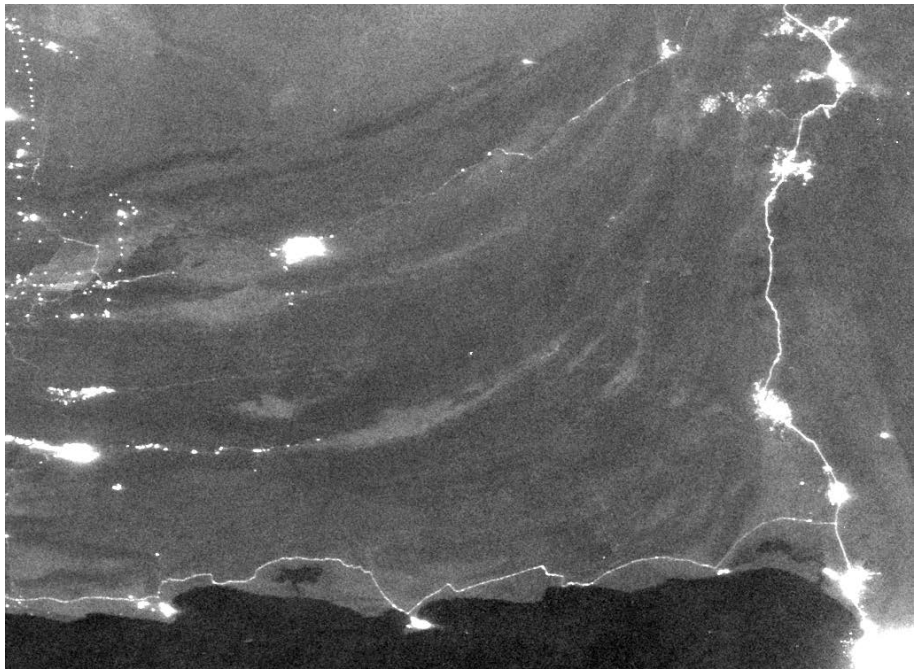


DNB Background Removal

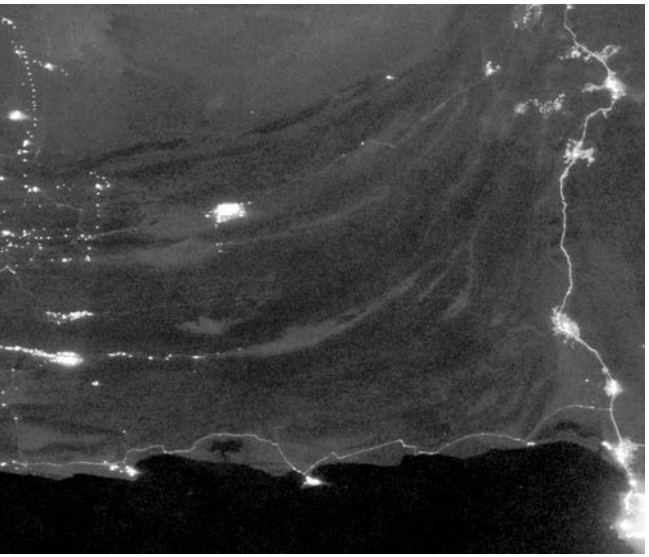
- The DNB's detection limits are low enough, that even without moonlight presen nocturnal airglow can light up terrain and high albedo surfaces, making it challenging to separate dim lights from high albedo surfaces.



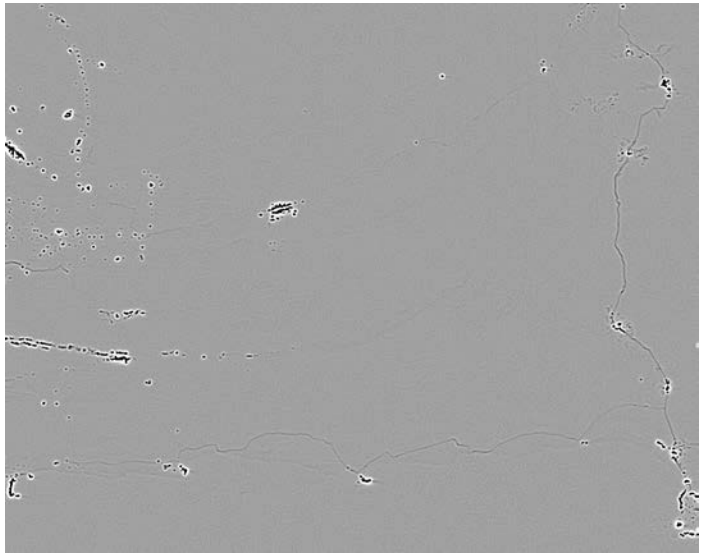
2014 DNB Composite over Southern Pakistan – some road features have lower average radiance values than no-light areas with high albedo

2014 DNB Composite over Himalayas – snow-covered peaks have higher average radiances than some of the villages

DNB Background Removal



014 DNB Composite with
utliers removed



First derivative – areas close to zero are background (gray)

2014 DNB Composite with background masked using deriv image

Radiance values of terrain surfaces can equal radiances of dim lights, but the value
vary more slowly spatially than dim lights

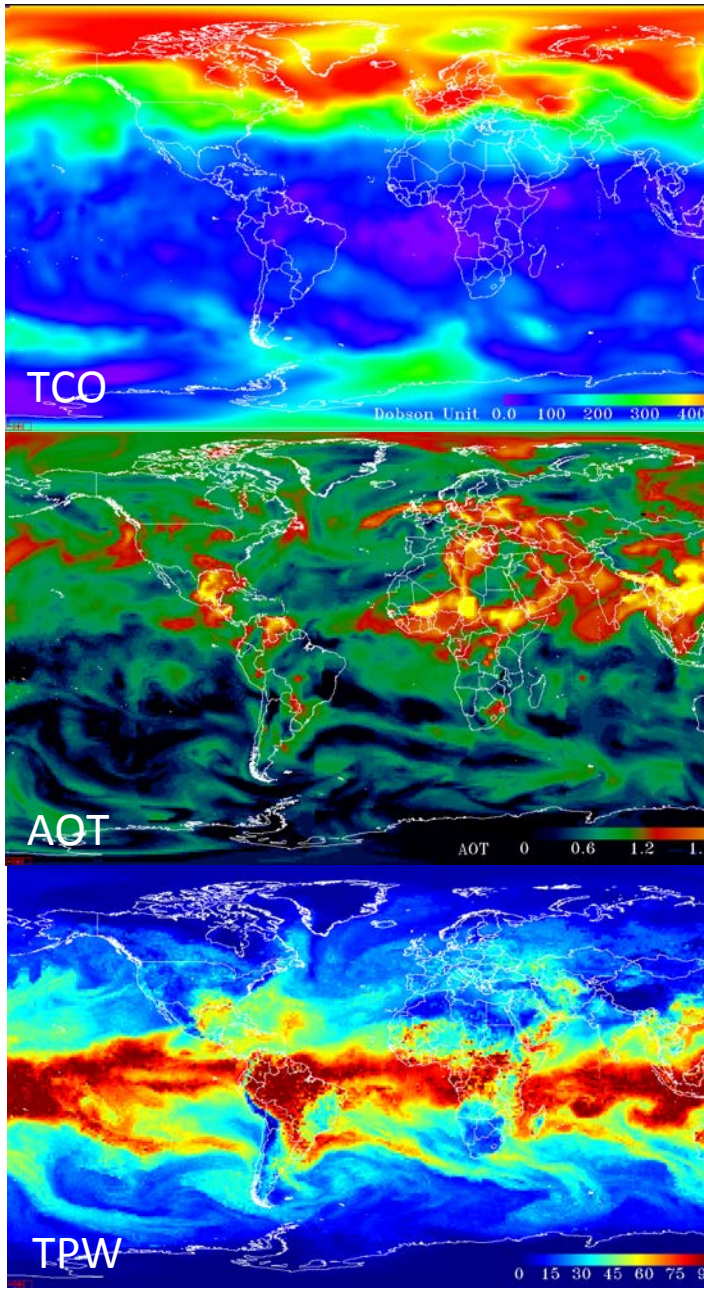
First derivative, or gradient images of DNB composites lend well to thresholding to
bring out nighttime lights

Initial testing shows most nighttime lights from cities/villages are retained, dim roa
can get fragmented.

tmospheric Correction for nttime DNB: Working with 6S

puts

- TCO
  - NOAA/OSPO TOAST
- AOT
  - NAAPS model (NPP VIIRS IVAOT)
- TPW
  - NPP ATMS -> NOAA MIRS
- Geometry
  - SatZ, SatA, SolZ, SolA
  - DEM: SRTM + GTOPO 30
- Unified grid
  - 1 degree Lat/Lon grid
  - Confined by TOAST resolution / Save computation



Date represented: 2016/4/13

Radiative Transfer Model

$$\rho\uparrow* = \rho\downarrow a + \rho\downarrow t / 1 - \rho\downarrow t\, S\, T(\theta\downarrow s)T(\theta\downarrow v)$$

For nocturnal self-emitting source under zero lunar illumination

- $\rho\downarrow a$ =0 (radiance in atmosphere)
- $\rho\downarrow t$ =1 ($reflectance\ of\ target$)
- $T(\theta\downarrow s)$=1 (downwelling transmissivity)

Thus apparent radiance becomes

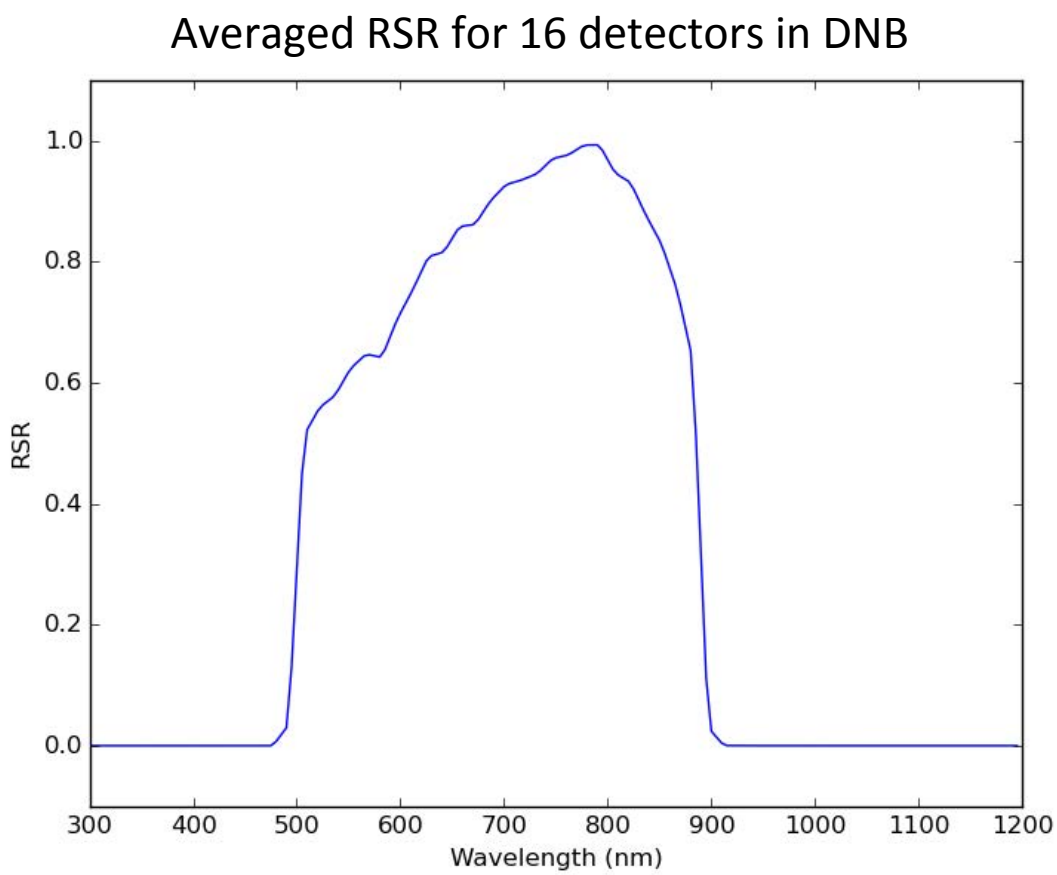
$$\mathrm{I}\uparrow* = \mathrm{I}\rho\uparrow* = \mathrm{I}/1 - \mathrm{S}\ \mathrm{T}(\theta\downarrow \mathrm{v})$$

Rewritten to isolate correction factor C

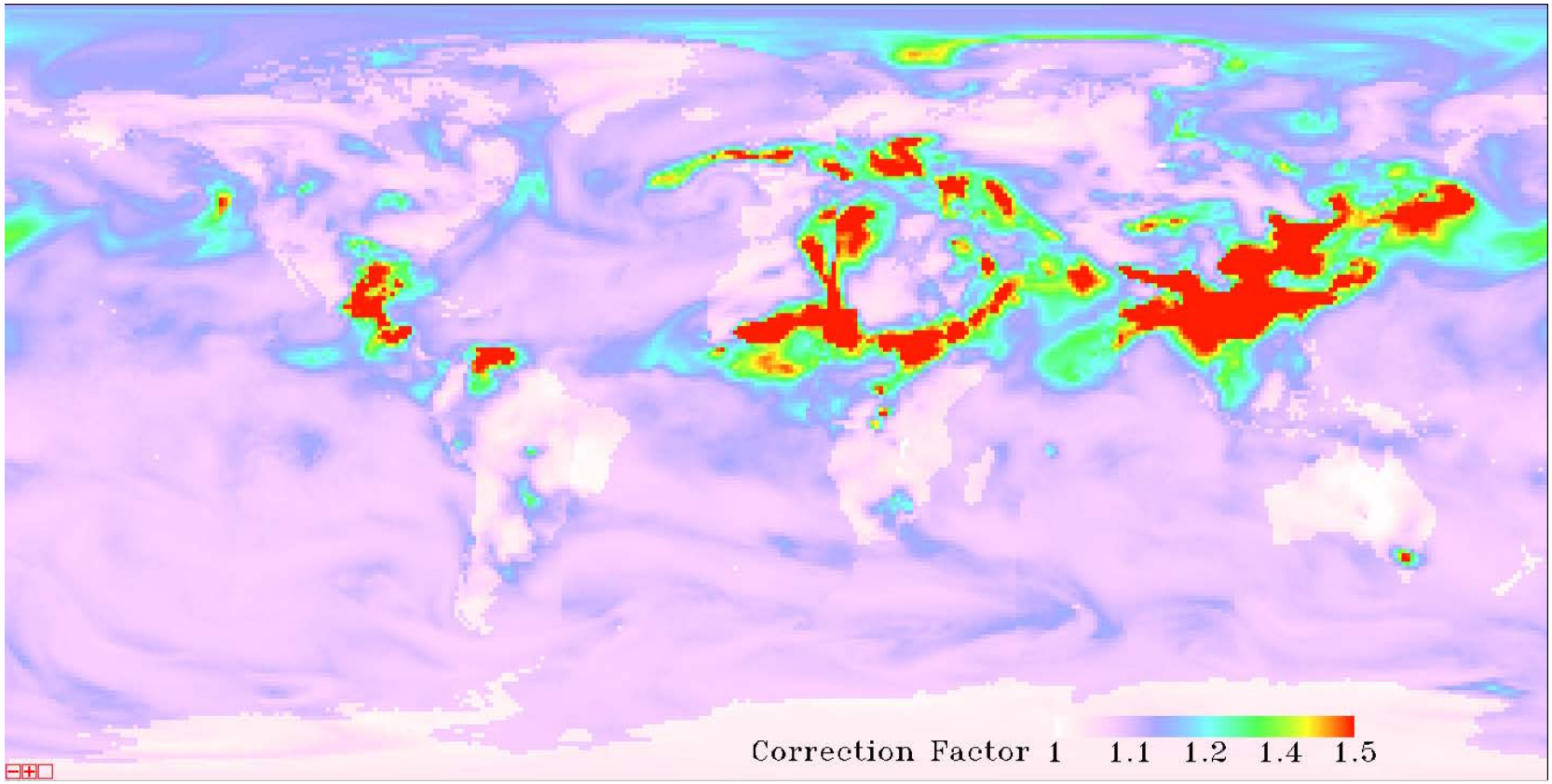
$$\mathrm{I} = I\uparrow*\ (1 - \mathrm{S})/\mathrm{T}(\theta\downarrow \mathrm{v}) = I\uparrow*\ C$$

Band Averaging

- Consider the spectral sensitivity of DNB



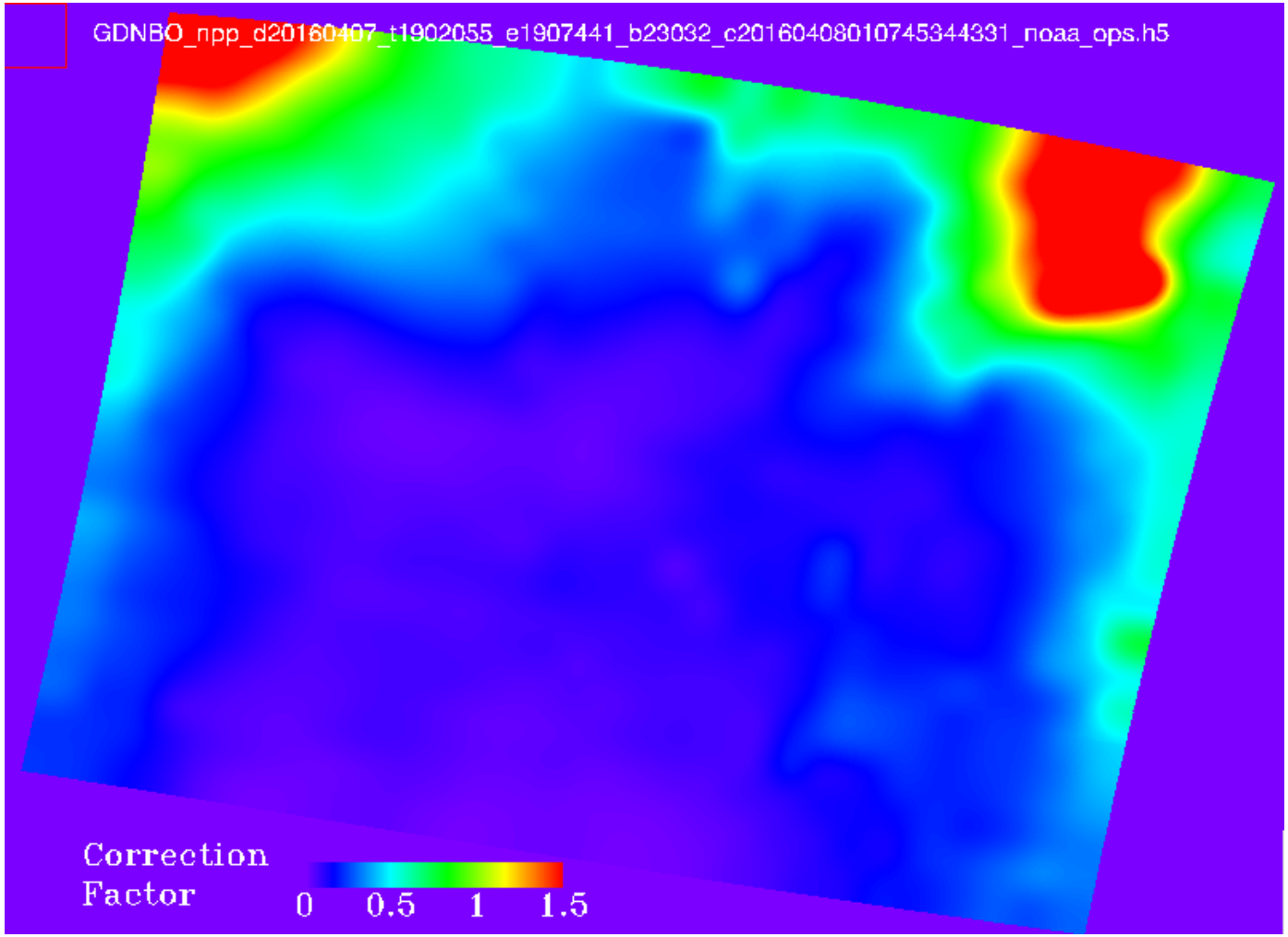
Global Correction Factor Grid



Date represented: 2016/4/13

This sample global grid is generated with fixed geometry properties
SATZ=0, SATA=0, SOLZ=150,SOLA=0

Aggregate Level Correction



Nighttime Lights Composites: Next Steps

- Finalize atmospheric correction algorithm
- Test outlier removal/background removal algorithms on aurora
- Add in Nightfire detections to identify locations of persistent flares and volcanos