Elimination of Artificial Bright Pixels in VIIRS DNB Nighttime Image over the South Atlantic Anomaly Region

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Outline

1. Background: large amount of scattered bright pixels in DNB nighttime images over the South Atlantic Anomaly (SAA) region.

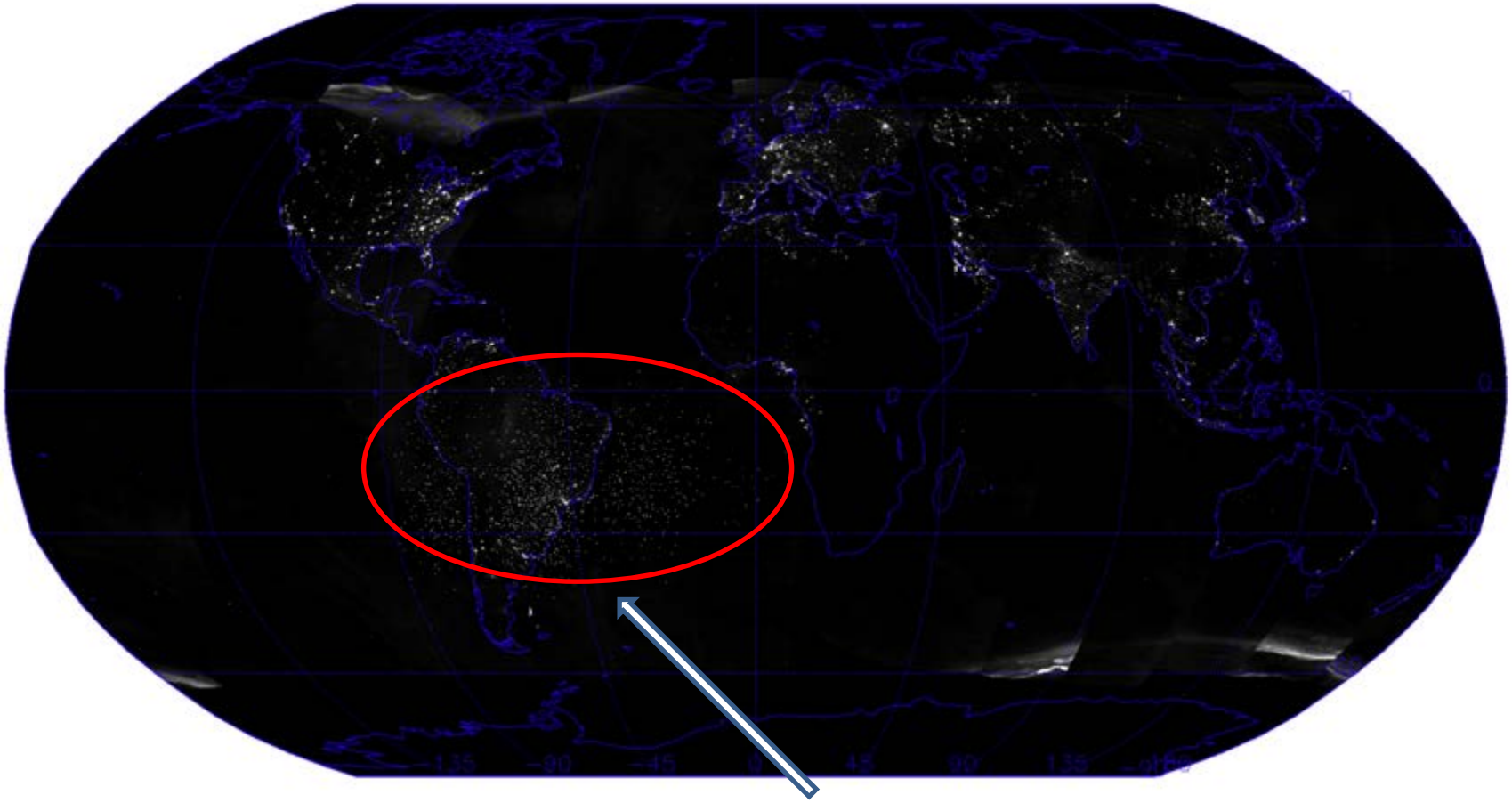
2. Analysis of DNB SDR and RDR for possible cause of isolated high radiance pixels

3. Verification of possible cause by analysis of DNB special acquisition over the SAA region.

4. Potential solution to eliminate artificial bright pixels.

Background: Bright pixels over the SAA Region

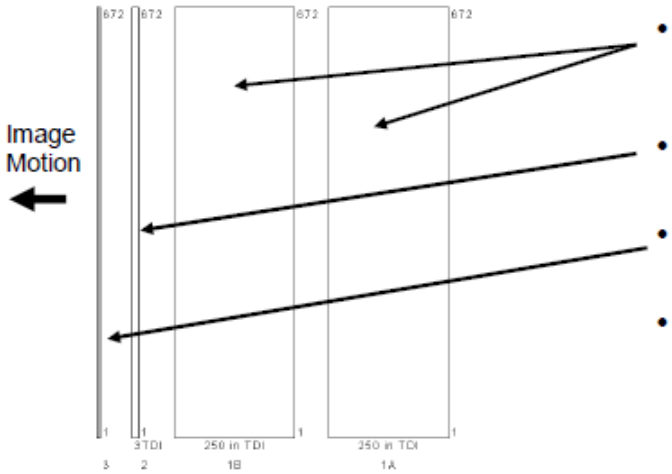
DNB Nighttime global image on 2016-03-09



Large number of isolated high radiance pixels over the SAA region

* DNB nighttime global image is after http://ncc.nesdis.noaa.gov/ (B. Zhang and Y. Bai)

Background: VIIRS DNB CCD Layout



672 sub-pixel detectors in track direction

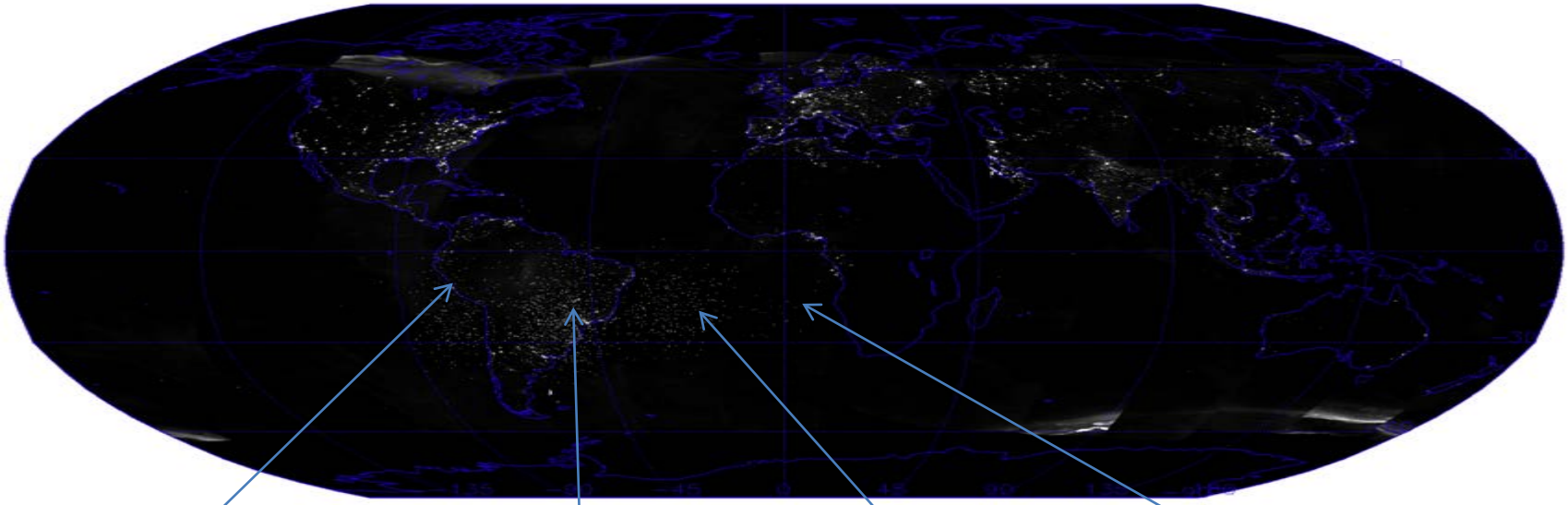
- Two identical high-gain stages allow correction of radiation impacts in data
  - 250 Dets In TDI
- One Intermediate-gain stage
  - 3 Dets in TDI
- One Low-Gain Stage
  - No TDI
  - 35x N.D. Filter
- Operating temp. -20C

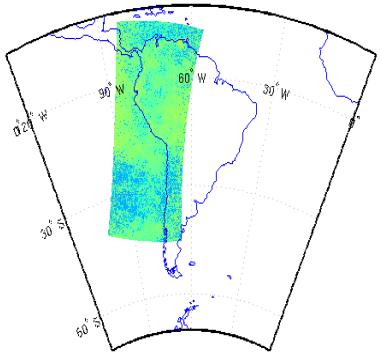
- DNB HGA/B operate in the TDI mode, susceptible of high energy particle (HEP) hitting due to long exposure time.
- HGA/B thresholding algorithm was developed to detect and eliminate the HEP events.
- Are artificial bright pixels observed in the operational DNB radiance images over the SAA region due to failure of HGA/B thresholding algorithm or other unknown issue?

* The DNB CCD layout is after Figure 14 of VIIRS Radiometric Calibration ATBD

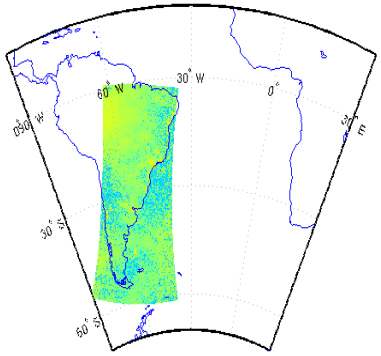
Dataset: 2016-03-09 Nighttime

DNB Nighttime global image on 2016-03-09

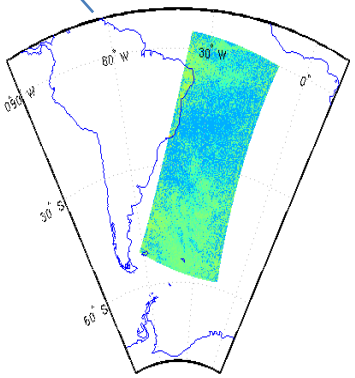




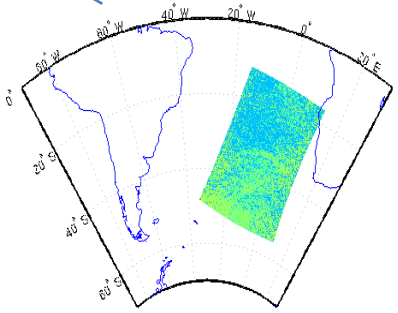
Orbit 22613
12 granules



Orbit 22612
12 granules



Orbit 22611
12 granules

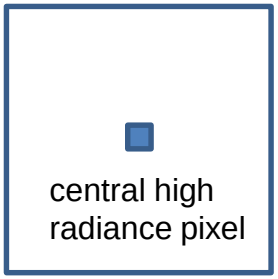


Orbit 22610
8 granules

Statistics of Isolated High Radiance Pixels

Criteria of selecting isolated high radiance pixels*

1. radiance > 300 nW/cm^2-sr
2. radiances of neighboring pixels are less than 0.5% of the central pixel's radiance



window size
2N + 1 pixels
N = 2

Statistics of isolated high radiance pixels (radiance unit: nW/cm^2-sr)

	LGS	MGS	HGS
Orbit 22610	0	**25** (≥3181.76)	0
Orbit 22611	**1** (508.13)	**308** (≥2991.39)	**1** (371.30)
Orbit 22612	0	**765** (≥3006.83)	0
Orbit 22613	0	**262** (≥3072.55)	0

* C. Elvidge, et al, "Automatic boat identification system for VIIRS low light imaging data," Remote Sens. **7**, 3020-3036 (2015).

Isolated High Radiance Pixel Examples: HGS

Line 753, Sample 3926
SVDNB_npp_d20160309_t0301333_e0302574_b22611

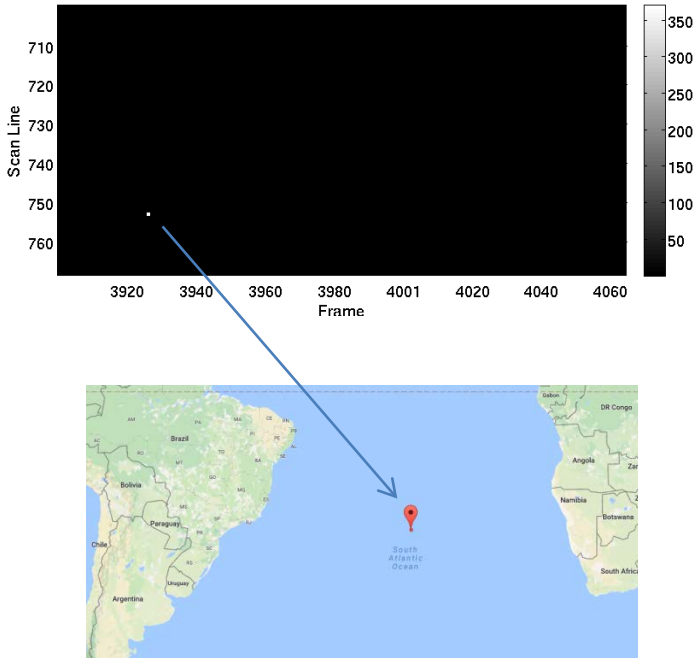
Radiance (nW/cm^2-sr)

0.22	-0.12	0.29	0.25	0.05
-0.19	0.17	0.02	-0.04	-0.12
0.45	-0.06	371.30	1.16	0.62
-0.0003	-0.09	1.18	0.10	0.42
0.42	-0.18	0.19	0.04	0.50

DN

355	352	355	354	353
353	356	355	355	355
357	355	2786	362	359
353	352	361	353	355
357	353	355	354	357

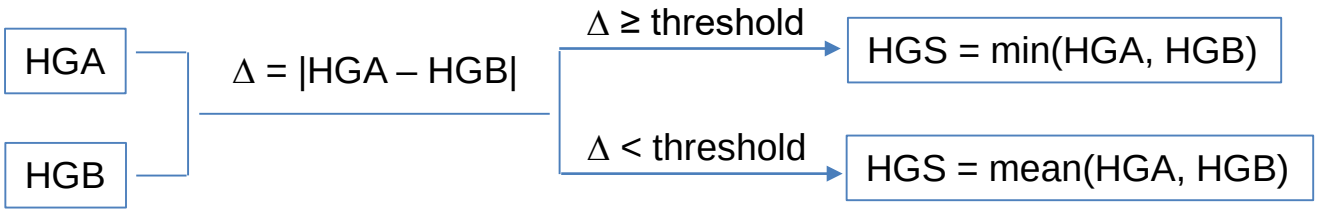
Radiance image



Was this isolated high radiance HGS pixel induced by failure of the HGA/HGB thresholding algorithm?

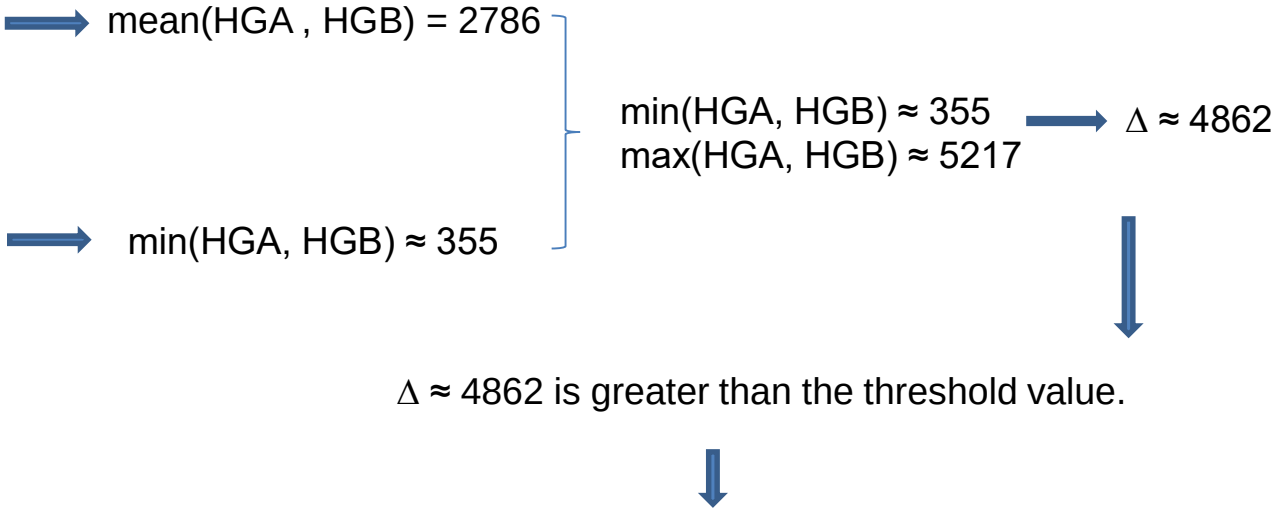
DNB HGA/B Thresholding Algorithm

For each measurement:



Assume high radiance at Line 753 Sample 3926 was induced by failure of the HGA/HGB threshold algorithm.

Because high energy particle (HEP) hit was very short, one of HGA and HGB should be very close to the DNs of the neighboring pixels and can be estimated by their average.



HGA/B thresholding algorithm is working properly by filtering out HEPs.

Isolated High Radiance Pixel Example: MGS

Line 529, Sample 900
SVDNB_npp_d20160309_t0307149_e0308391_b22611

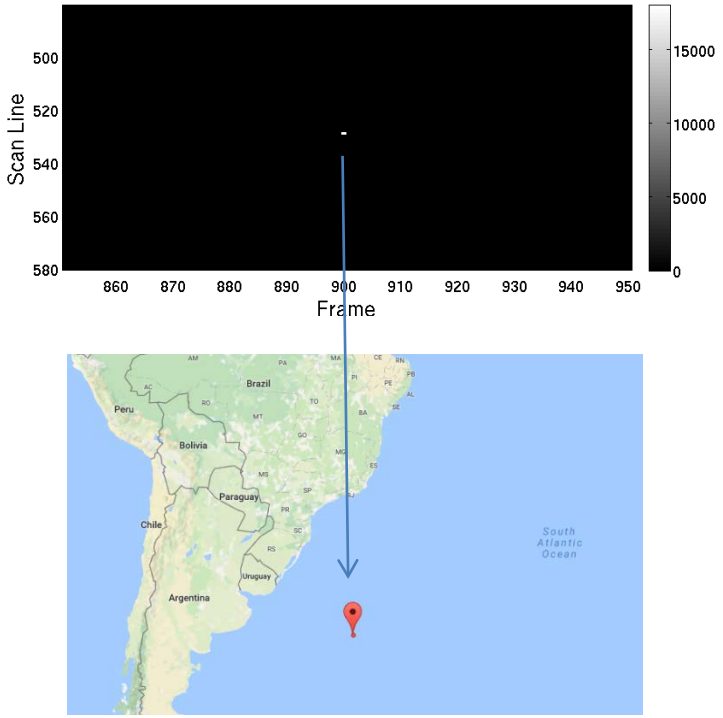
Radiance (nW/cm^2-sr)

0.15	0.22	0.11	0.27	0.16
0.25	0.14	0.09	0.14	0.15
0.12	0.18	18,026.01	0.08	-0.03
0.22	-0.16	0.16	0.15	0.05
0.19	0.14	0.20	0.15	0.09

DN

360	363	360	363	361
363	361	360	361	361
360	361	825	360	357
363	355	362	361	359
362	361	363	361	360

Radiance image

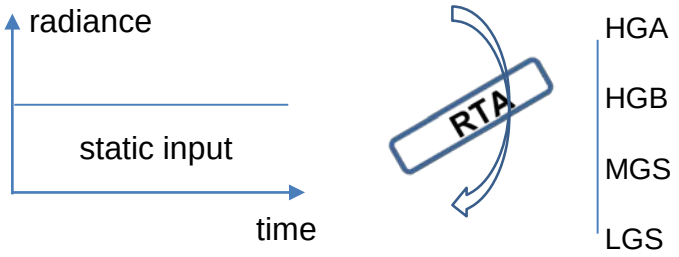


Reason for such a high radiance MGS pixel in DNB nighttime image?

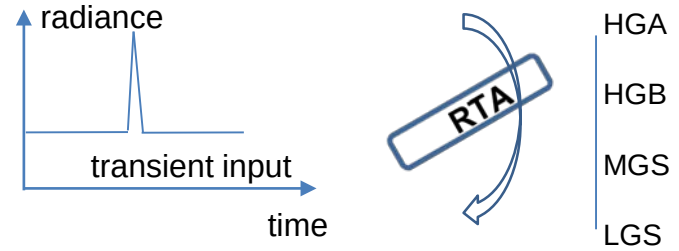
VIIRS Imaging Process and Static/Transient Scene

VIIRS is a ***scanning*** imaging radiometer

- Static scene
  - Input is ***invariant*** when the RTA scans across LGS, MGS, and HGA/B
  - LGS, MGS and HGA/B respond to the same incident radiance



- Transient scene
  - Input is ***varying*** when the RTA scans across LGS, MGS, and HGA/B
  - HEP event is an example of a transient scene
  - Only one of the DNB's gain stages captures incident HEPs



DNs of pixel (529, 900) and the neighboring pixels

360	363	360	363	361
363	361	360	361	361
360	361	825	360	357
363	355	362	361	359
362	361	363	361	360

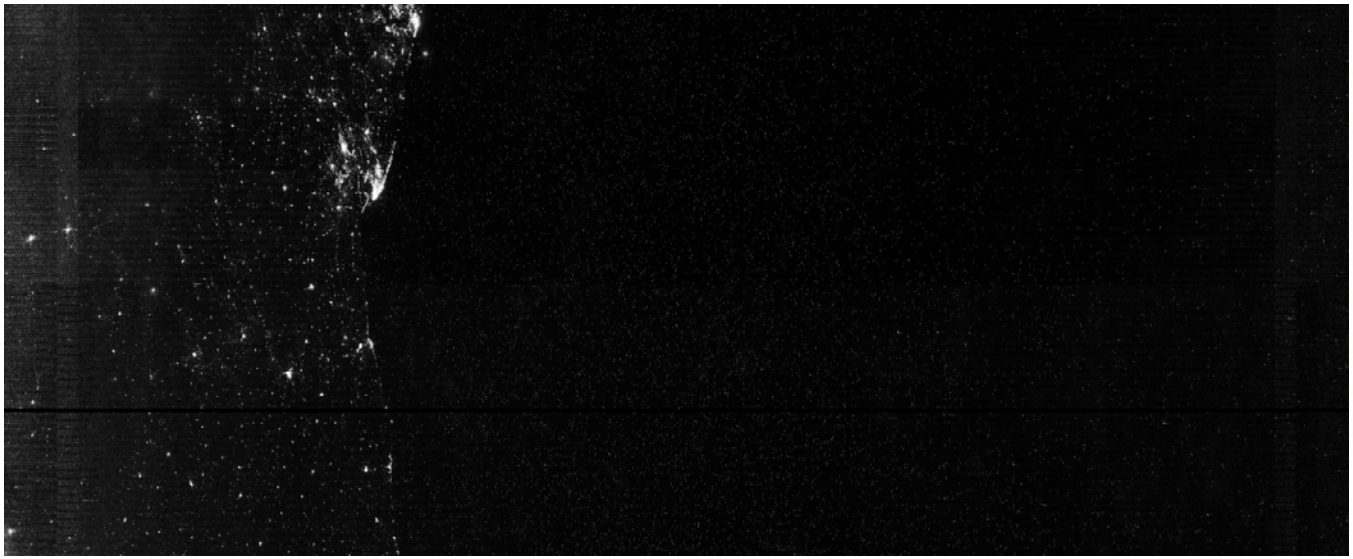
- It is possible that the MGS captured the incident HEPs, and its DN is 825.
- Since the DNs of the neighboring pixels are very uniform, it can be anticipated that the HGS DN of the pixel (529, 900) is on the same level, ~361.

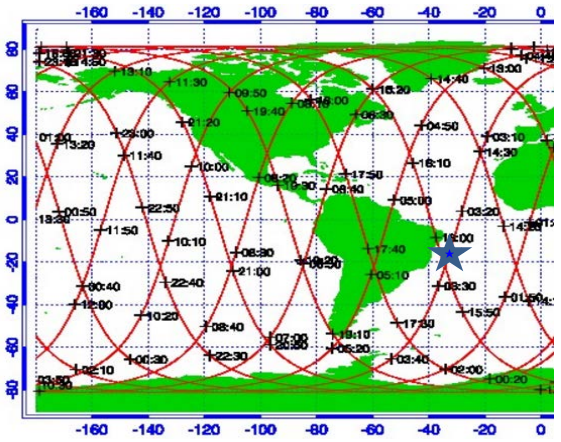
MGS was hit by HEPs and then selected by the DNB gain selection logic.

DNB Special Collection over SAA (2017-01-27)

- VROP 702 on 01/27/2017 starting from 03:24:25 in order to analyze the HEP hits.
- 1 minute for HGB/MGS/LGS and 1 minute for HGA/MGS/LGS.
- No IDPS SDR for VROP 702 data.
- All 3 gain stage RDR data are converted to radiance using appropriate calibration coefficients to analyze the HEP hits.

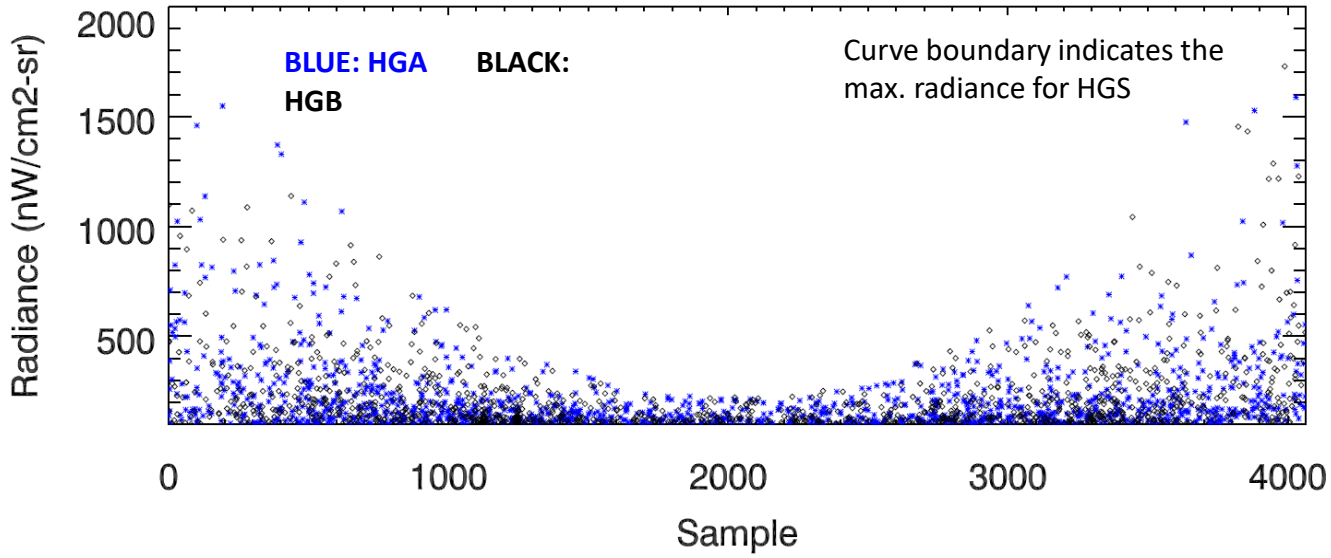
Calibrated DNB Radiance





RNSCA-RVIRS_npp_d20170127_t0324223_e0325477_b27208_c20170127181741132950_noaa_ops.h5
RNSCA-RVIRS_npp_d20170127_t0325477_e0327130_b27208_c20170127181741132950_noaa_ops.h5

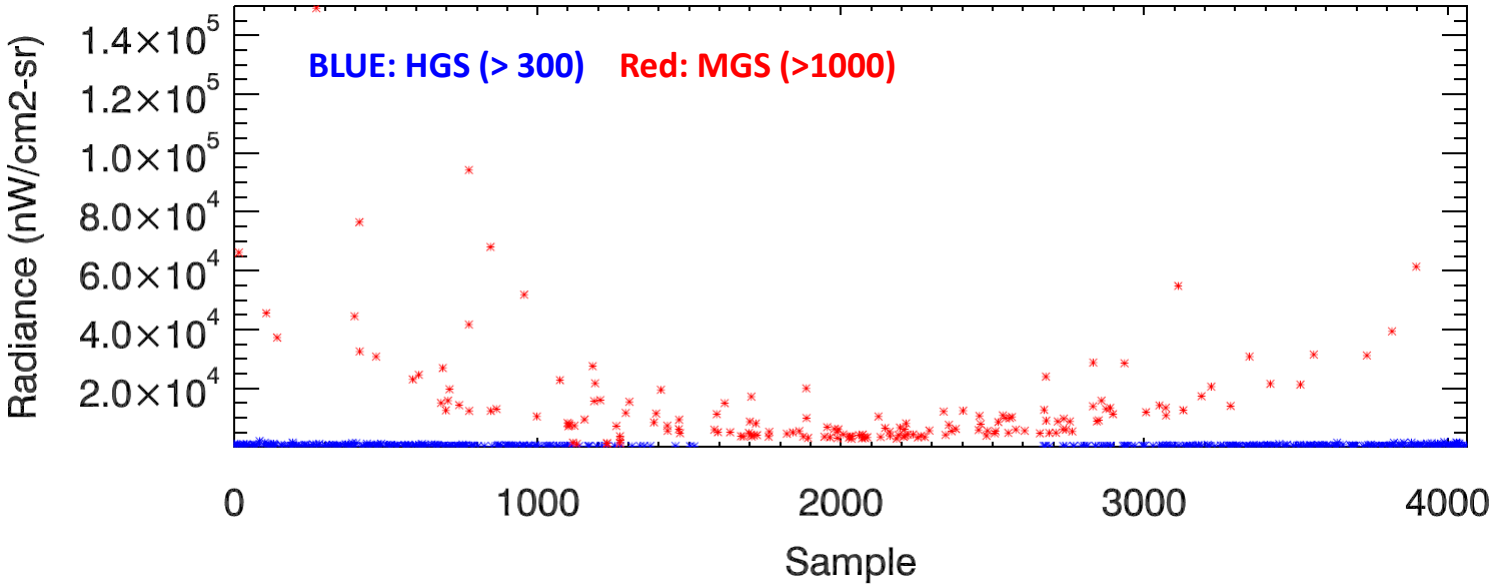
HGS Radiance Analysis



- Many high radiance HGS pixels due to no HGA/B selection
  - 480 pixels with Radiance > 300 nW/cm^2-sr
    - Few of these could be from ships and boats but the majority should be HEP.
  - 29 pixels > 1000 nW/cm^2-sr
    - Should be HEP hits*.

* C. Elvidge, et al, "Automatic boat identification system for VIIRS low light imaging data," Remote Sens. **7**, 3020-3036 (2015).

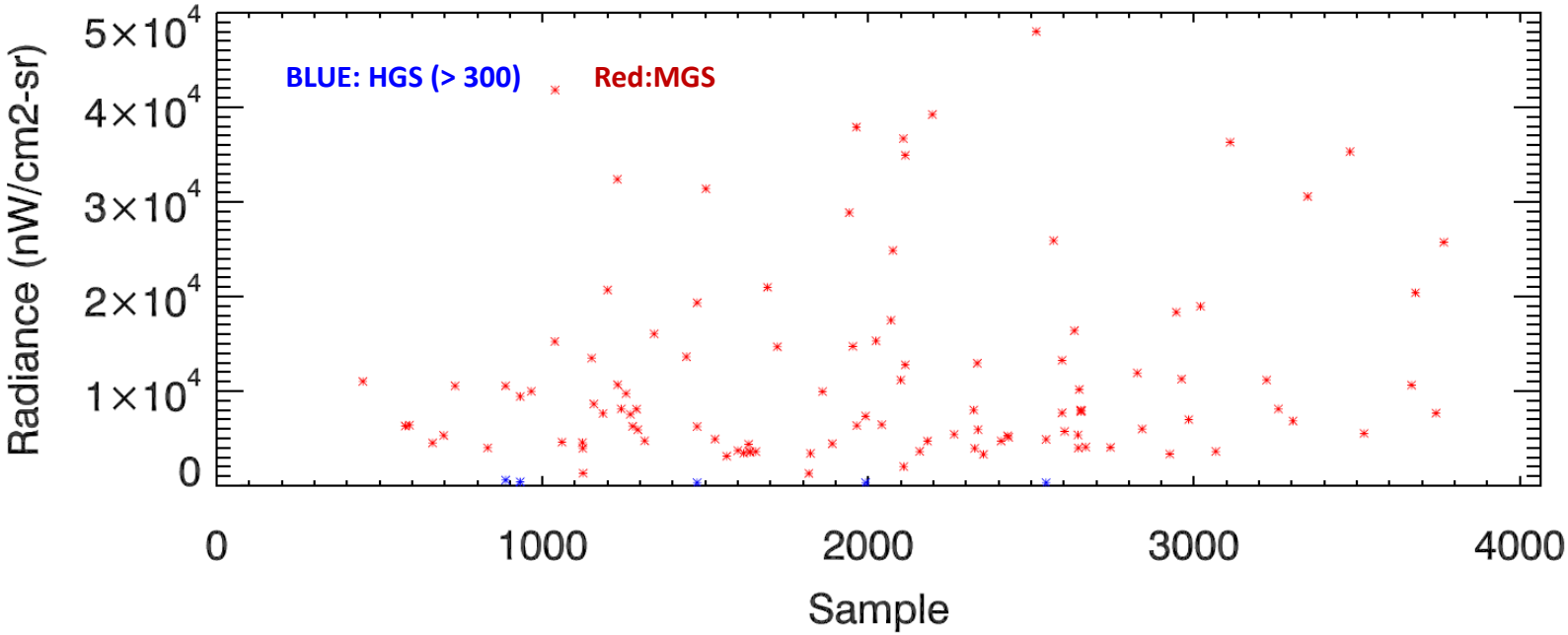
HGS and MGS Radiance



- 171 MGS pixels > 1000 nW/cm^2-sr
  - Should be HEP hits.

HEPs in IDPS SDR Granule

- A SDR granule just after VROP Data Collection was analyzed.
- Largest 5 HGS pixels have radiance range from ~300 to ~586 nW/cm^2-sr.
- 108 MGS pixels have radiance values >1000 nW/cm^2-sr.



- ***HEPs in HGS were filtered out by HGA/B thresholding algorithm.***
- ***HEPs observed in regular IDPS SDRs (SAA region) were from MGS.***

Discussion of Solution

- **Problem**
  - HEP hitting on DNB MGS but no algorithm for detection and elimination
- **Prior knowledge**
  - Independent measurement of DNB HGS, MGS and LGS
  - Rare possibility of simultaneous HEP hitting on DNB HGS, MGS and LGS
- **Potential solution: cross check HGS MGS, and LGS measurement**
  - HGS/MGS/LGS data availability for ground processing
  - Different dynamic range of HGS/MGS/LGS
  - Software change

Conclusions

1. DNB HGA/B thresholding algorithm works properly by filtering out HEPs.

2. Artificial bright pixels observed over the SAA region are from DNB MGS.

3. DNB gain selection logic is the root cause of artificial bright pixels in DNB nighttime images over the SAA region.

4. In principle, artificial bright pixels can be eliminated by a filtering scheme based on the fact that DNB HGS, MGS and LGS are not affected by the same HEP hitting event due to the event's short time period.