Radiometric Stability and Stray Light Performance Monitoring for VIIRS Day/Night Band with Moon Light

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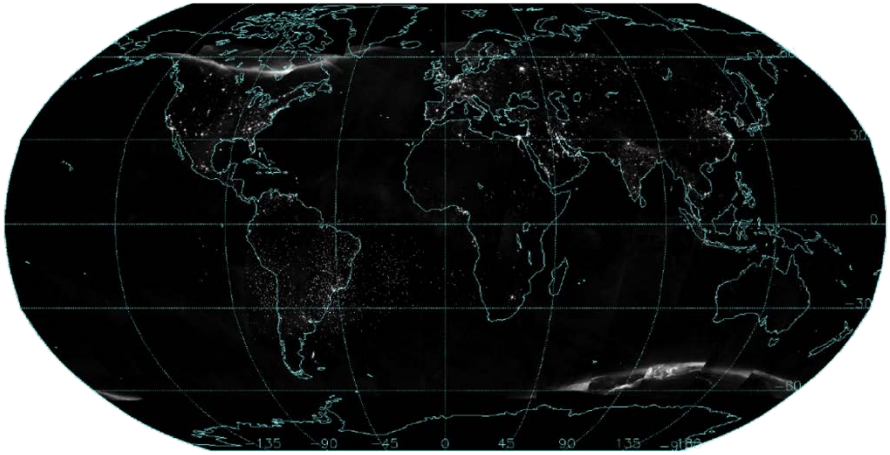
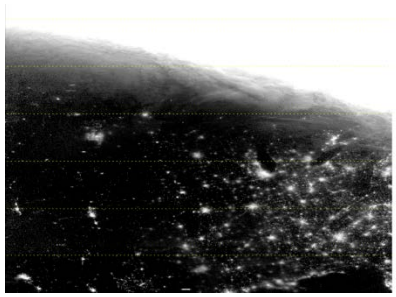
Outline

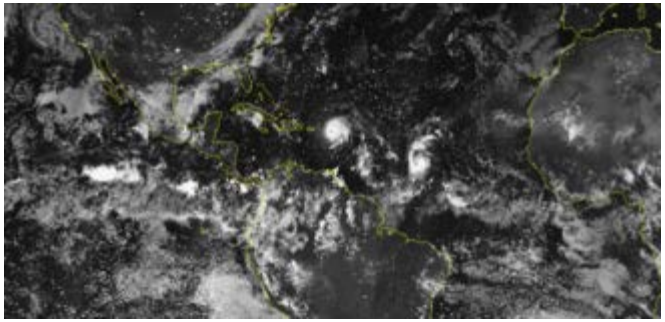
- S-NPP VIIRS Day/Night Band
- Radiometric stability monitoring of DNB with Dome-C under moon light
- Light Contamination Ranking Index (LCRI)-based DNB Stray Light Correction
- Evaluation of stray light correction performance with moon phase-dependent lunar illumination model

VIIRS Day Night Band Calibration

- Three Gain Stage (LGS, MGS, HGS)
  - 7 order of magnitude
  - one panchromatic (0.5-0.9 µm) reflective solar band
- Low gain stage (LGS) gain values are determined by solar diffuser data
- The medium and high gain stage values are determined by multiplying the LGS gains by the MGS/LGS and HGS/MGS gain ratios determined from data collected along solar terminator region
- Offset determined from YAW maneuver data and onboard BB view
- HGS calibration performed monthly



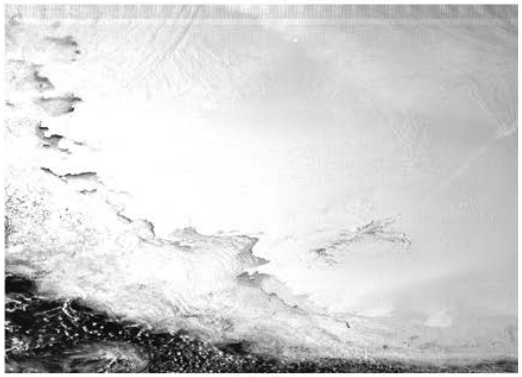




VIIRS Day/Night Band Specifications

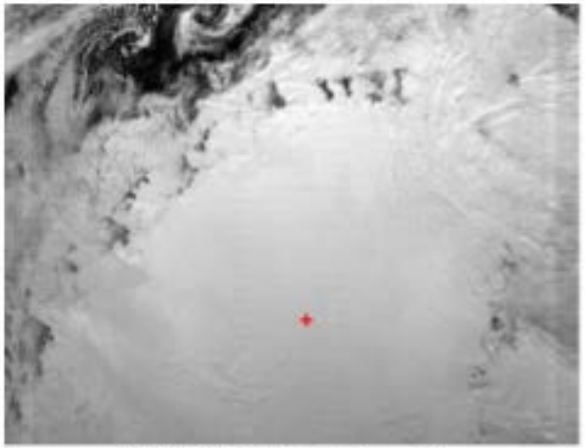
	Suomi-NPP VIIRS DNB
Spectral Band	0.5 – 0.9μm
Number of Bits in A/D:	14 bits (16,384 levels) for HGS; 13 bits (8,192 levels) for MGS and LGS
Saturation	Does not saturate even with full solar illumination
Dynamic Range (W/cm^2-sr)	3×10^{-9} to 0.0209
Additional spectral bands	21 additional bands spanning 0.4 to 12 μm.
Calibration	Solar diffuser is used to calibrate LGS. MGS and HGS are calibrated with gain ratio derived from data collected along solar terminator region.
Calibration Uncertainty (HGS)	15% (1σ) [Liao *et al.*, 2014]
Spatial Resolution:	Nominally 742 m × 742 m
Swath	3040 km
Nighttime overpass	~01:30

DNB observation of Dome C under Moon Light

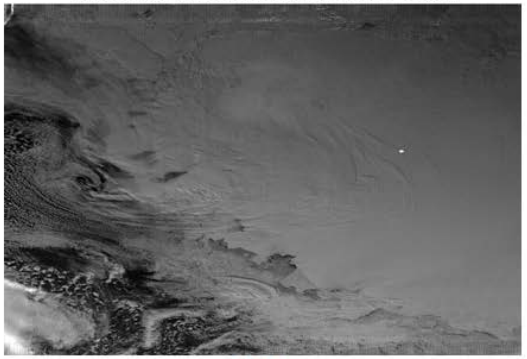


(a)

(b)



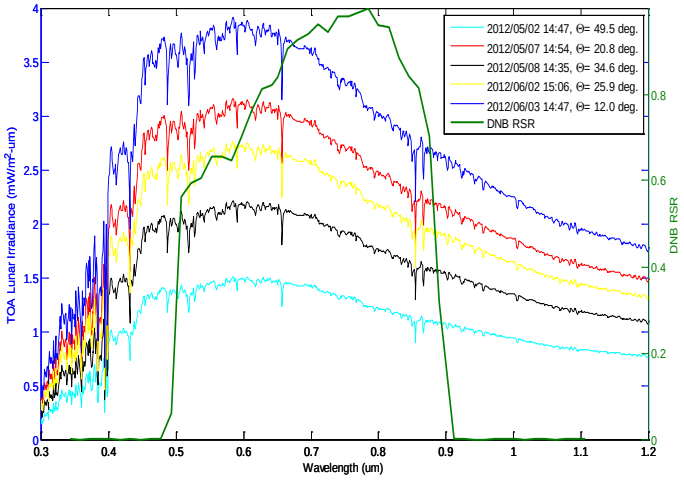
(a) 7/4/2012 15:05 (Dome C)



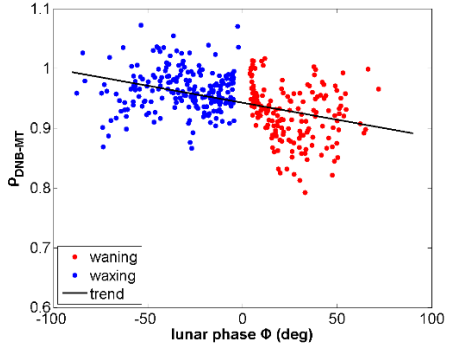
(c)

(d)

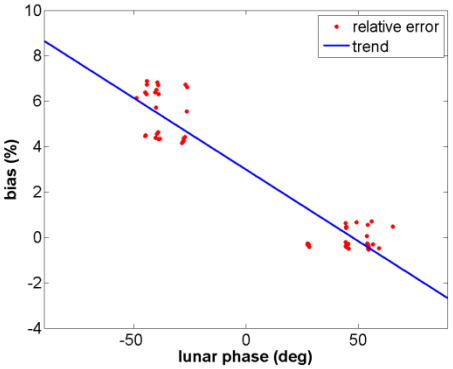
Lunar Irradiance Model and Improvement



Derived Dome-C TOA Reflectance from DNB and MT 2009 Model

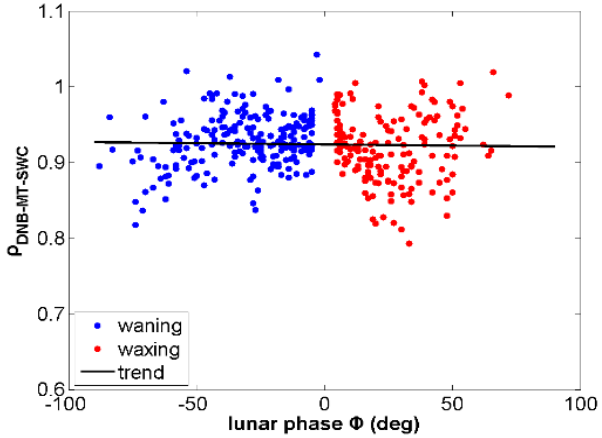


Correction of MT2009 model with SeaWiFS lunar observations

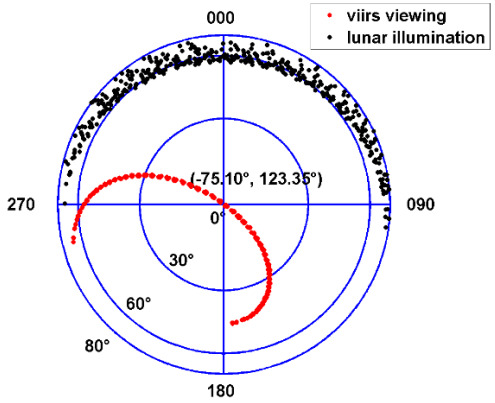


- Miller-Turner (2009) MT2009 lunar irradiance model
- No differentiation of waxing and waning lunar phase
- Derived TOA Dome-C reflectance from DNB shows remnant lunar phase angle dependence
- Used SeaWiFS lunar observations to correct MT2009 model

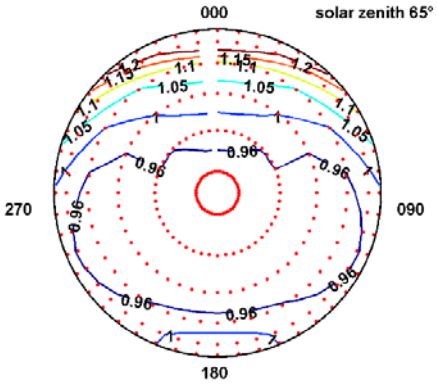
Derived Dome-C TOA Reflectance from DNB and Corrected MT Model



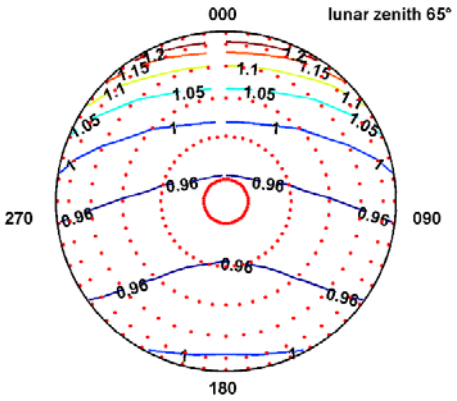
BRDF Correction



Satellite View and Lunar Illumination Geometry Over Dome-C



Hudson-Warren BRDF model of Dome-C (Daytime Solar light-based)

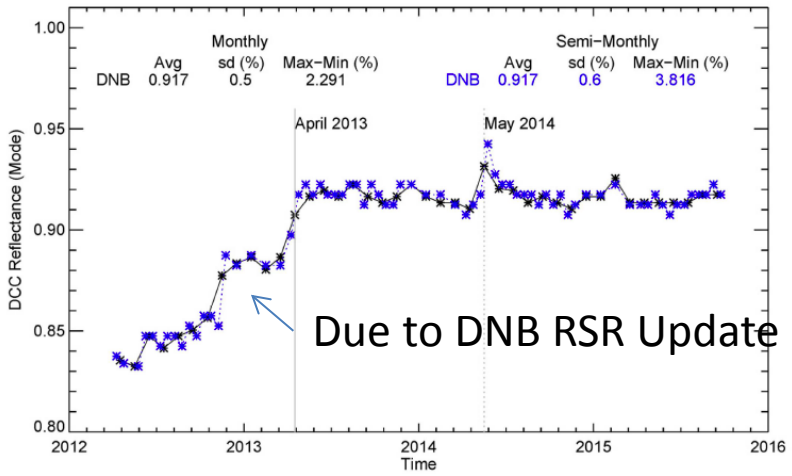


BRDF of Dome C from DNB observation (Nighttime Moon Light-based)

- Consistent BRDF characterization between Hudson-Warren BRDF model and model from DNB-observation under lunar illumination
- Lunar zenith angle-dependent BRDF model of Dome-C has been used to correct DNB-derived TOA reflectance of Dome-C and reduce uncertainty

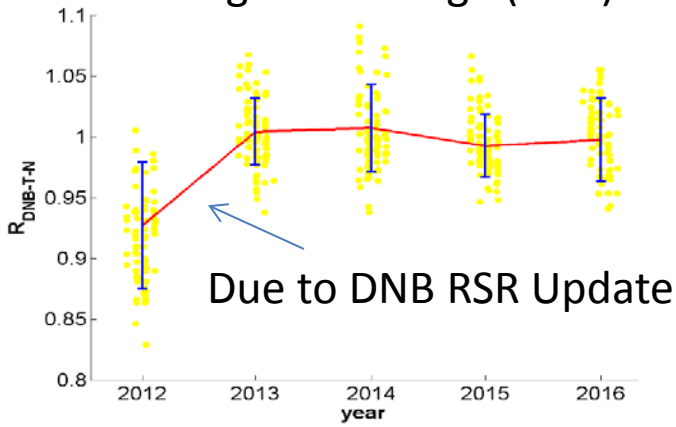
Radiometric Stability Monitoring of IDPS DNB Data

DNB Low Gain Stage (LGS)



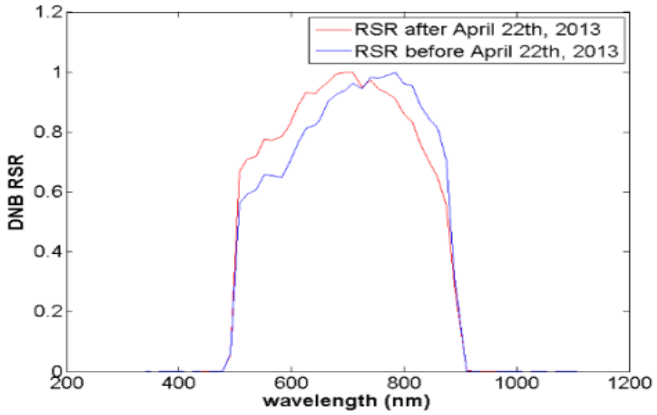
From daytime Deep Convective Cloud (DCC)

DNB High Gain Stage (HGS)



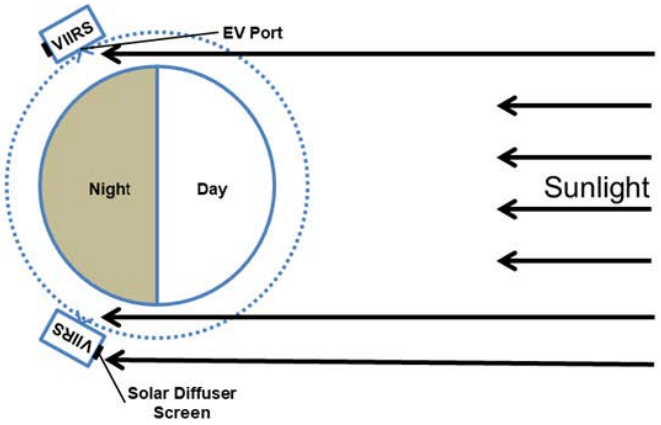
From Night time Dome C under Moon Illumination

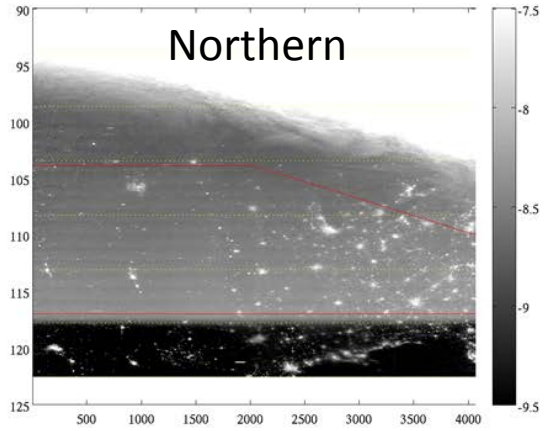
IDPS DNB RSR Update

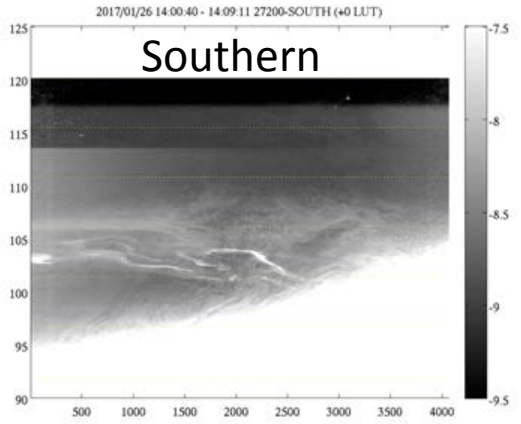


- DNB Daytime DCC is used to monitor stability of DNB low gain stage
- Night time monitoring of Dome C reveals DNB LGS trend has been transferred to DNB high gain stage through gain ratio-based calibration
- DNB HGS is radiometricly stable (<2%) after 2013

DNB Stray Light Correction

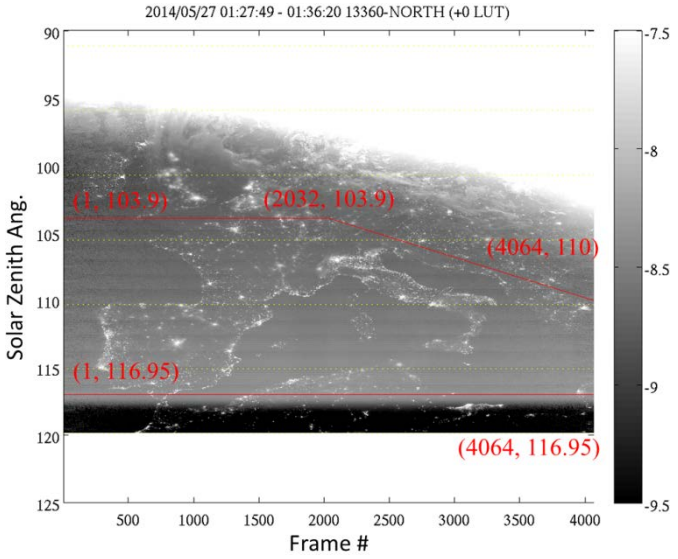






- Northern hemisphere DNB stray light is due to direct sunlight illumination onto Earth view port
- Southern hemisphere DNB stray light is due to illumination of Earth view and solar diffuser ports
- Stray light depends on the relative orientation of the DNB and the incident sunlight
  - Solar zenith angle
  - Solar azimuthal angle
  - Frame number (scan direction)
  - Detector number (track direction)
  - Northern or southern hemisphere
- To minimize the stray light effect, stray light LUTs are generated monthly to remove the offset for pixels that are affected.

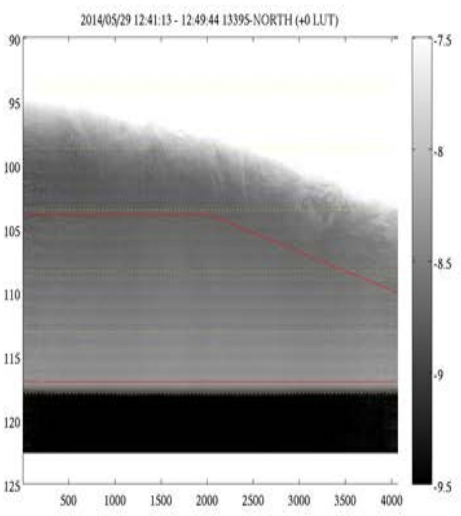
Light Contamination Ranking Index (LCRI)-based Stray Light Correction Method



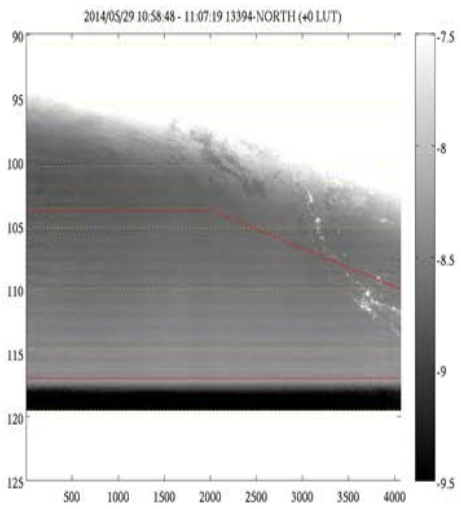
Orbit	50%	100%	150%	200%	250%
13395	99.96749%	67.31832%	0.03537%	0.00008%	0.00000%
13366	99.96804%	62.46468%	0.03698%	0.00011%	0.00000%
13376	99.96275%	57.85372%	0.04428%	0.00597%	0.00389%
13368	99.79812%	74.69313%	0.05384%	0.00409%	0.00290%
13390	99.88809%	62.16261%	0.06400%	0.00510%	0.00351%
13367	99.88875%	77.25621%	0.07236%	0.00146%	0.00007%
13380	99.83539%	77.46734%	0.10551%	0.00047%	0.00001%
13362	99.78120%	61.48673%	0.10904%	0.01224%	0.00668%
13381	99.97120%	89.58044%	0.11449%	0.00353%	0.00215%
13396	99.89003%	76.51415%	0.12741%	0.00182%	0.00041%
13382	99.97035%	87.88314%	0.14386%	0.00946%	0.00557%
13394	99.96447%	59.35575%	0.56302%	0.30148%	0.23344%
13397	99.51645%	86.63664%	0.69430%	0.18186%	0.12770%
13385	99.83027%	81.63833%	0.74870%	0.31382%	0.21388%
13371	99.96798%	74.97915%	0.77368%	0.37278%	0.25381%

- Select and group DNB granules around new moon over northern and southern hemisphere, respectively.
- Define an evaluation region across multiple granules
- Quantitatively score the pixel radiance in the prescribed evaluation region with Light Contamination Index (LCI)
  - Each pixel value within the region is normalized by the corresponding straylight correction value from previous month LUT, i.e. a seeding LUT generated previously .
  - Set a threshold for the normalized pixel value and calculate the percentage of pixels with radiance value above the threshold.
  - Imagery quality score assessed as percentage of bad pixels
  - Rank the LCI of DNB images and select images with LCI below certain threshold which contains minimum artificial lights, aurora, or other light sources.
- Process the selected granules and generate stray light correction LUTs
- The LCRI method removes the visual inspection and selection process and made selection criteria more quantitative and objective.

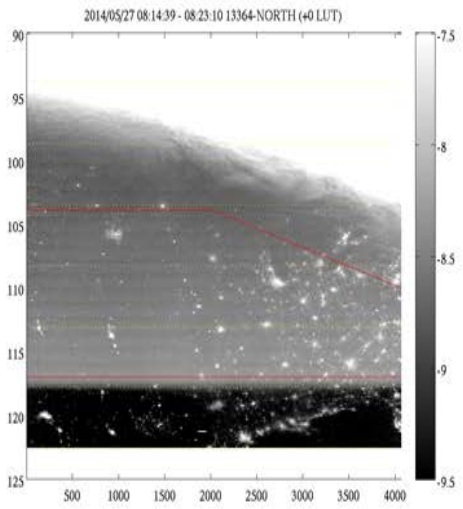
Selection of DNB Images based on LCI for Correction LUT Generation



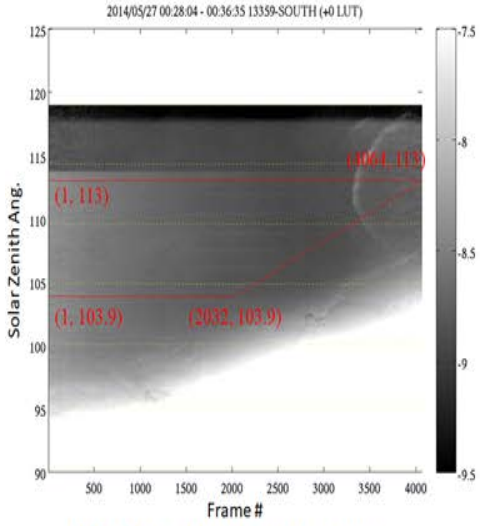
(a) LCI = 0.03537% (Selected)



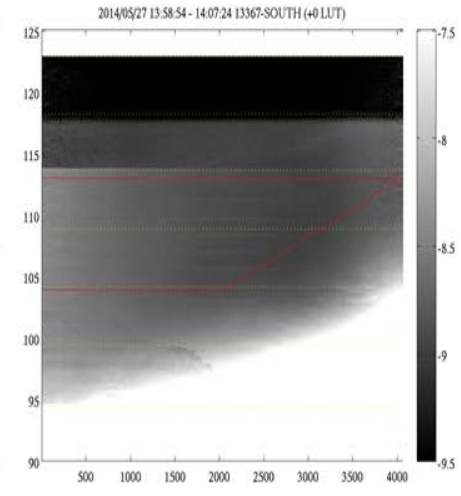
(b) LCI = 0.56302% (Rejected)



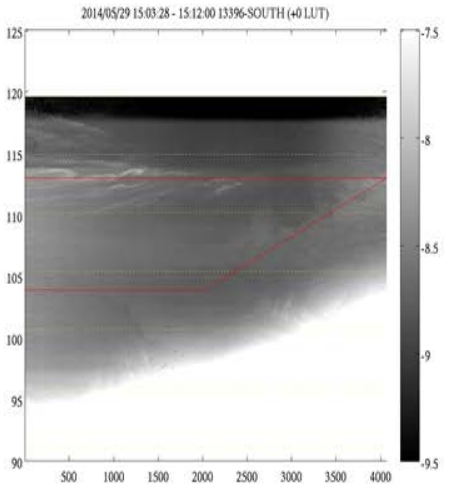
(c) LCI = 9.17762% (Rejected)



(a) LCI evaluation region over southern Hemisphere



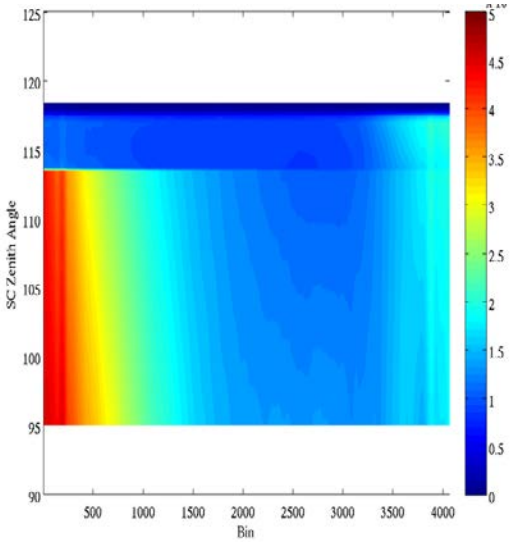
(b) LCI = 0.00129% (Selected)



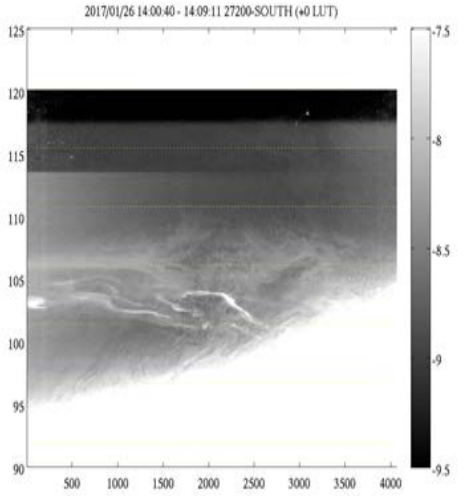
(c) LCI = 35.9107% (Rejected due to aurora contamination)

Example of Stray Light Correction for DNB Data in January, 2017

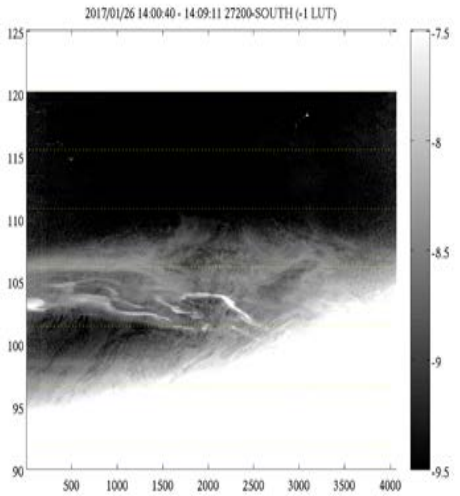
Typical LUT



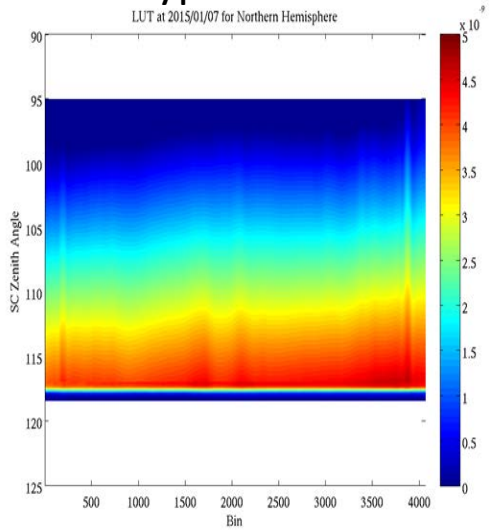
(Southern Hemisphere)



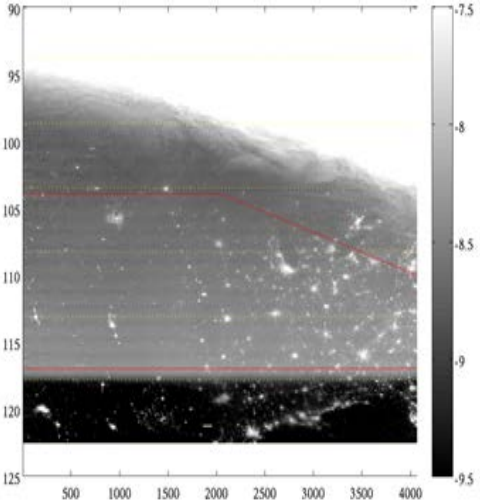
After Correction



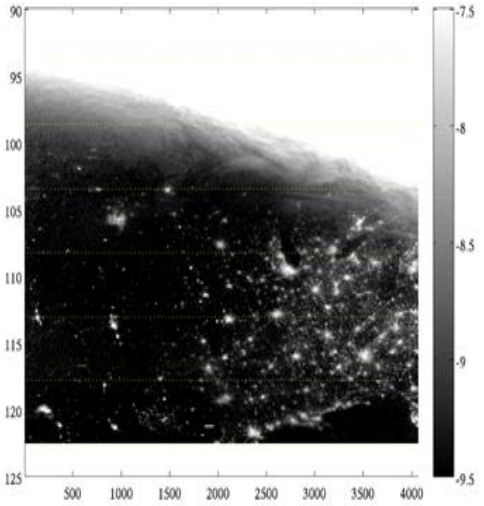
Typical LUT



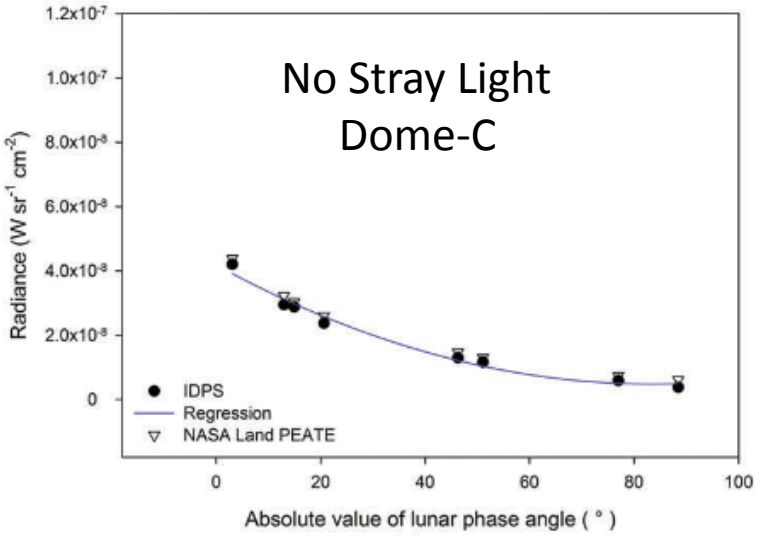
(Northern Hemisphere)

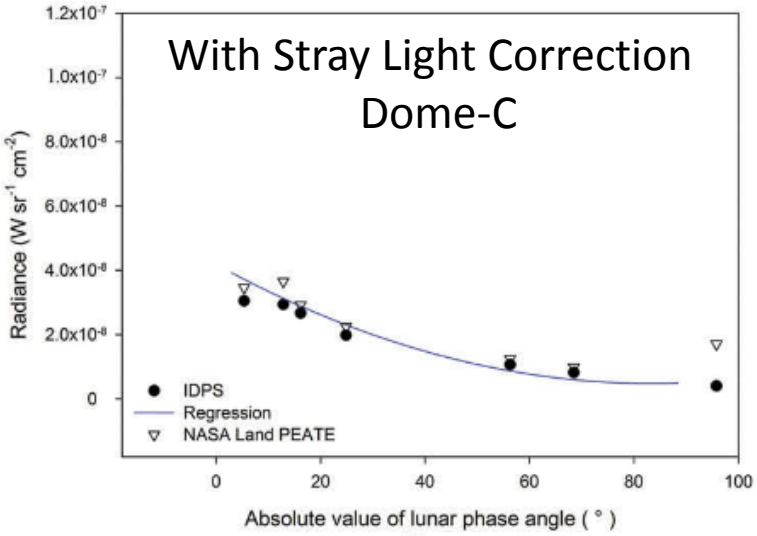


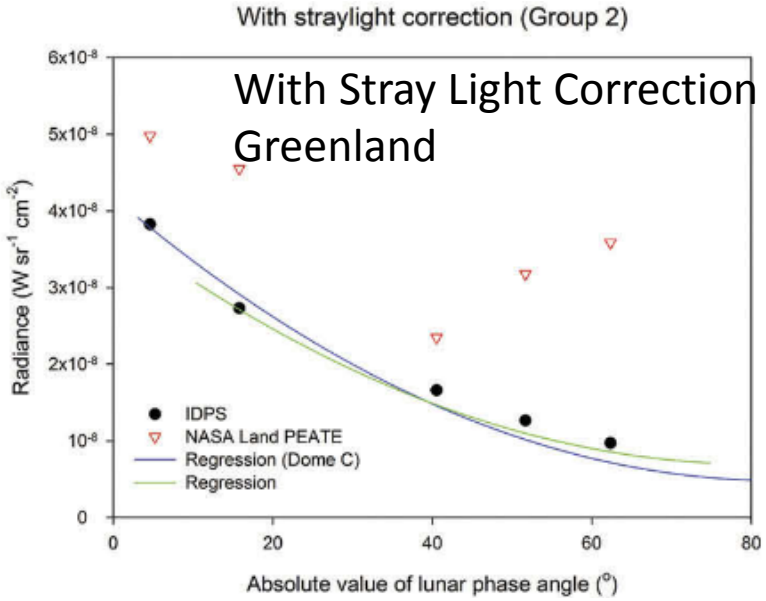
After Correction



Evaluation of Stray Light Correction Performance



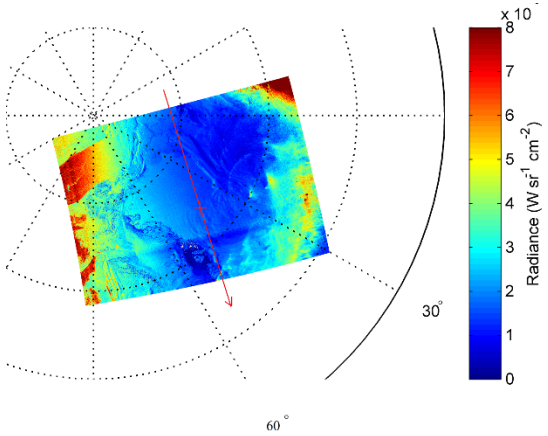




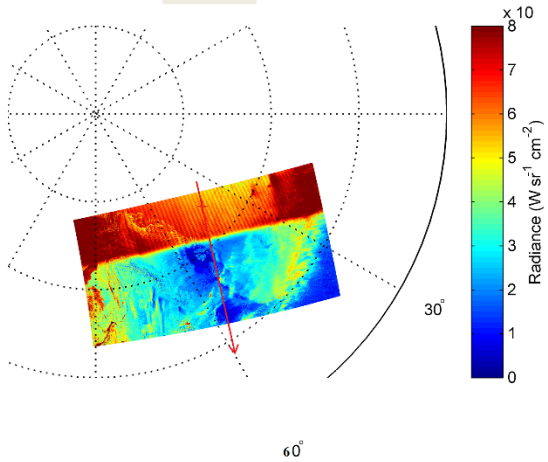
- Dependence of DNB Dome-C radiance vs. lunar phase angle can be used to assess stray light correction performance
- Evaluated two DNB data sources
  - IDPS and NASA LandPEATE
- Consistent DNB stray light correction over Dome-C
- Large discrepancy in stray light correction over Greenland

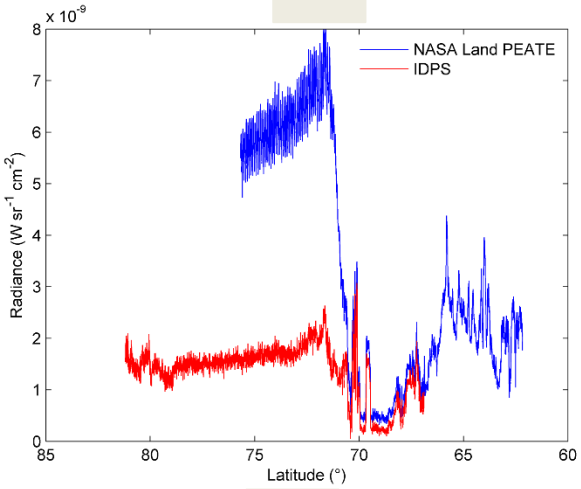
Identifying Causes of Discrepancy in the DNB Products

IDPS



NASA Land PEATE





Greenland(9 Feb. 2014)

Summary

- Performed radiometric stability monitoring for VIIRS Day/Night Band using Dome-C under Moon light
  - Lunar irradiance model with SeaWiFS-based correction
  - BRDF Correction
  - IDPS DNB HGS data is radiometricly stable (<2%) after 2013
- Developed Light Contamination Ranking Index (LCRI)-based DNB stray light correction method for automation
- Evaluated and compared DNB stray light correction performance between IDPS and NASA Land-Peate
- Continue to support DNB radiometric validation and stray light correction for JPSS-1