# S-NPP VIIRS DNB Calibration Reanalysis

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# Outline

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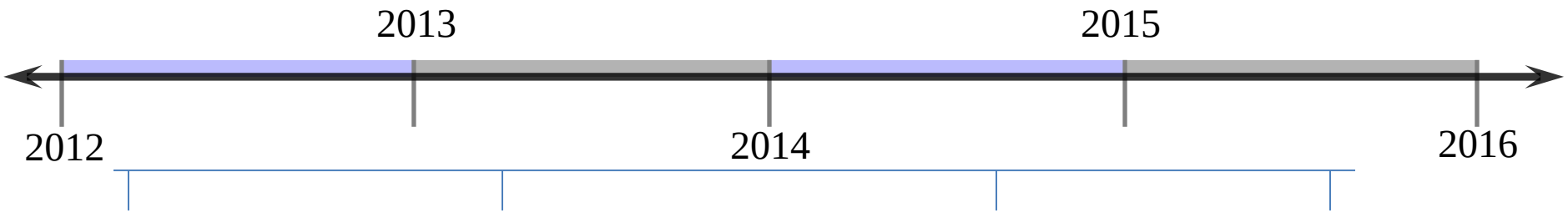
  - Cal. Coeff. Update using VROP
  - Modulated RSRs
  - Straylight correction
  - Terrain Corrected geo
- DNB On-Orbit Calibration
- Compare temporal trends of cal. coeffs.
  - Offset and gain ratio
- Summary

# Background

- S-NPP VIIRS DNB has been providing quality nightime data.
- A number of calibration updates has been performed since early launch
  - aiming to improve the radiometric performance.
  - causes discontinuity in calibration time series.
- DNB calibration parameters (offsets and gain ratio) are determined either using the VROP based data or by using the onboard calibrator data
  - IDPS operational product uses VROP data (offset and gain ratio).
  - RSBAutoCal in IDPS and NASA LandSIPS uses OBC data (gain ratio and slope for offset change).
- This study is focused on reanalyzing the DNB calibration parameters.
- Reanalysing the DNB calibration and reprocessing with improved calibration is a key to generate radiometrically more accurate and consistent data archive.

# DNB major calibration updates




**March 2012**
*1st calibration update using VROP*

- *Updated both onboard and ground offset tables and gain ratio*
- *Improved the radiometric accuracy of esp. for HGS data.*

**April 2013**
*DNB RSR LUT updated with modulated RSRs*

- *Accounts for the RTA degradation impact on RSRs*
- *Improved the radiometric accuracy of all gain stages*

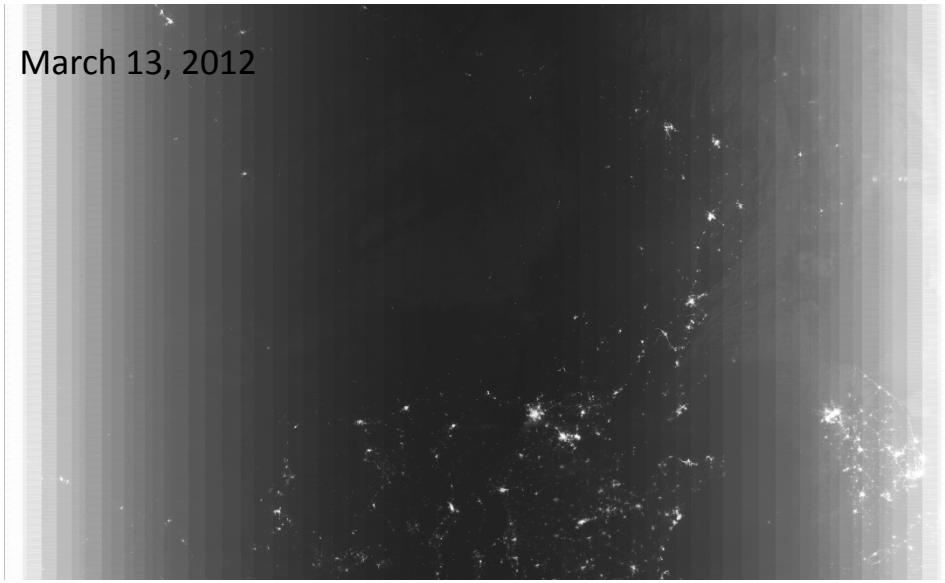
**August 2014**
*Straylight correction implemented*

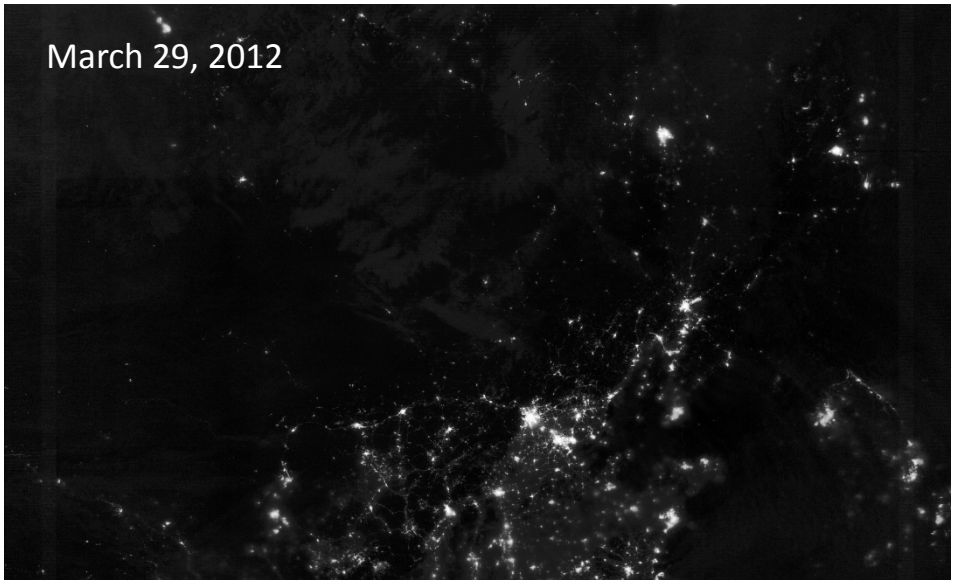
- *Characterize and correct the straylight*
- *improves the data quality*

**May 2015**
*DNB terrain correction implemented*

- *Improves the geolocation accuracy (accuracy from few pixels (over high altitudes such as Tibet) to sub-pixel level)*

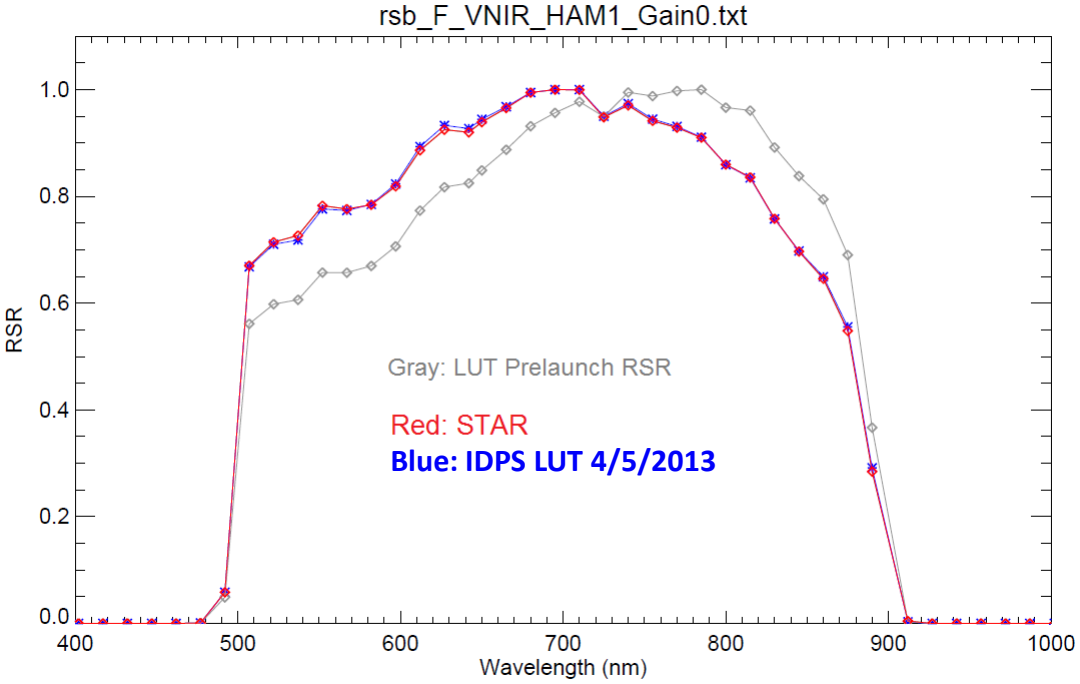
# Cal. Coeff. Update using VROP



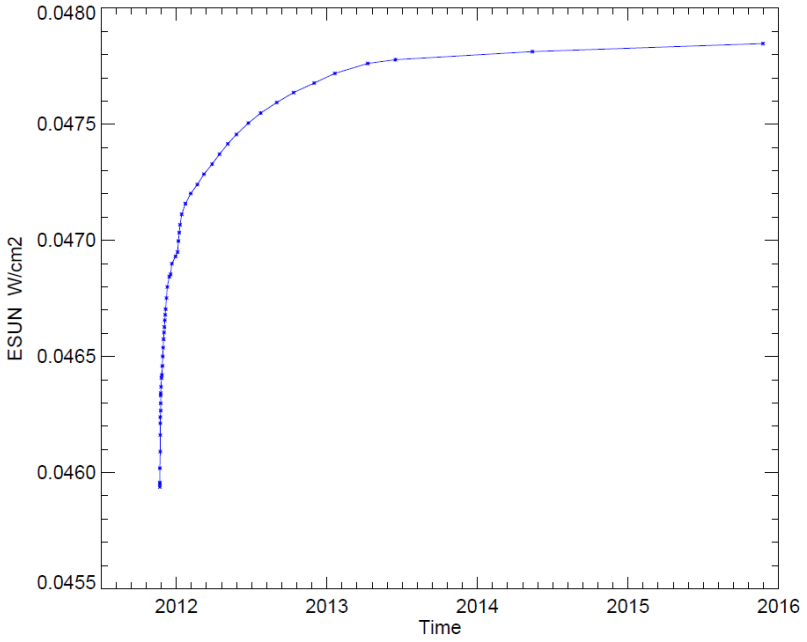

- Show DNB image over same location in earth after 16-day repeat cycle.
- Figure on right shows improvement in DNB calibration after updating offset table (onboard and ground offset ) and gain ratio tables for the first time on March 22, 2012 based on VROP.

# Time-Dependent RSR LUTs

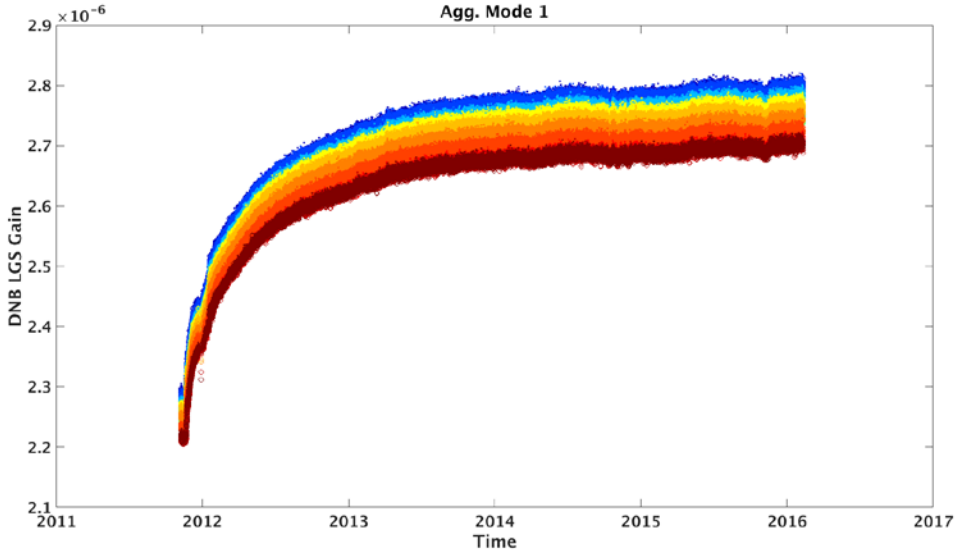



- VIIRS DNB RSRs modified by the telescope degradation
- Derived directly from the F factor changes for bands M4, M5, M6, and M7
- Without using a degradation model
- Agree well with the DNB "modulated" RSR from the IDPS LUT updated on April 5, 2013

- Approx. 50 time-dependent RSRs provide near-continues DNB $E_{sun}$ changes with steps smaller than 0.1%



# DNB LGS Gain Reprocessing for Aggregation Mode 1

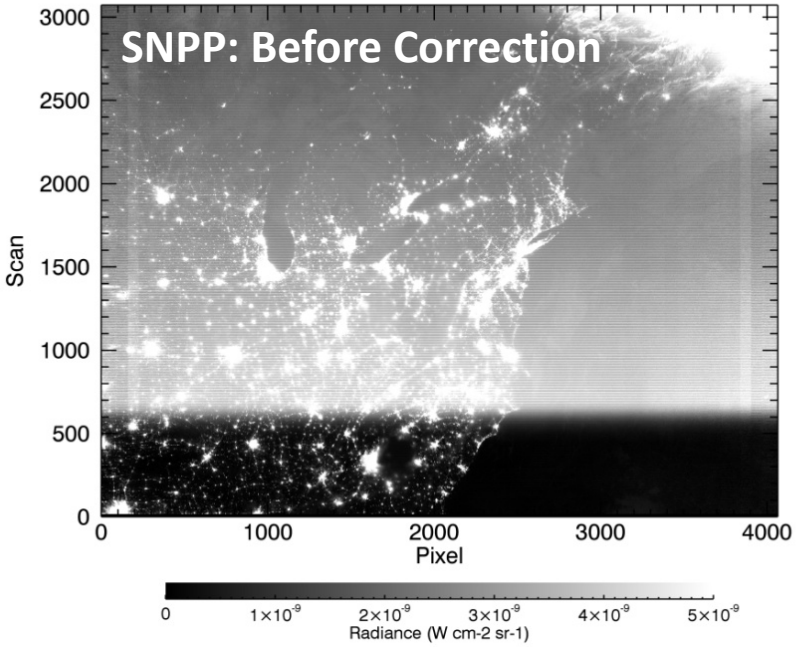

RSBAutoCal w/o RHW filtering:

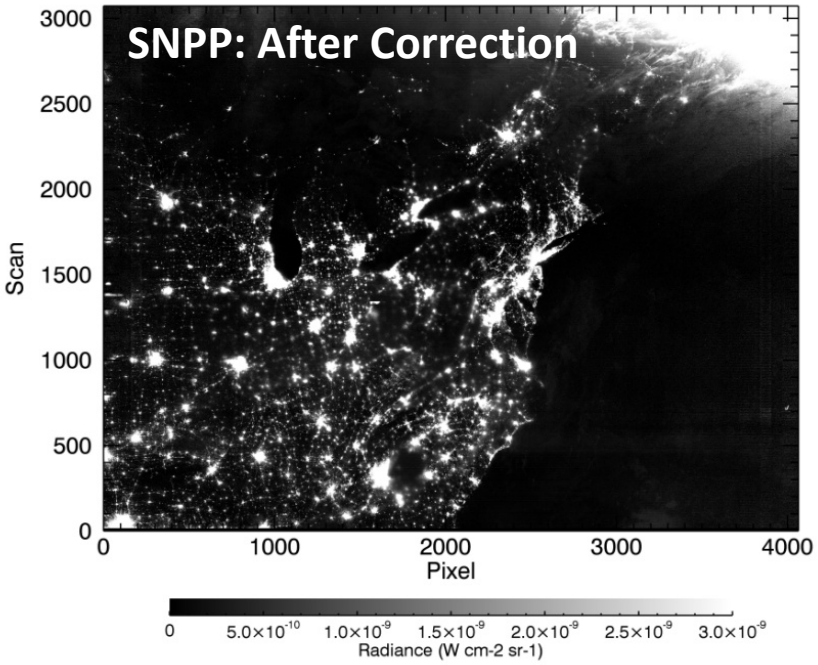
1. Using two RSR LUTs that were used in the operational production of the VIIRS SDRs

2. Using the additional, time-dependent RSR LUTs modified by the telescope throughput degradation

*Similar results for all aggregation modes*

# SNPP DNB Stray Light Correction




- SNPP DNB Stray Light correction transitioned from NG to STAR in 2014
- STAR supported the updates of operational stray light LUT for solar vector error correction.
- All 12 LUTs were updated by the end of 2015

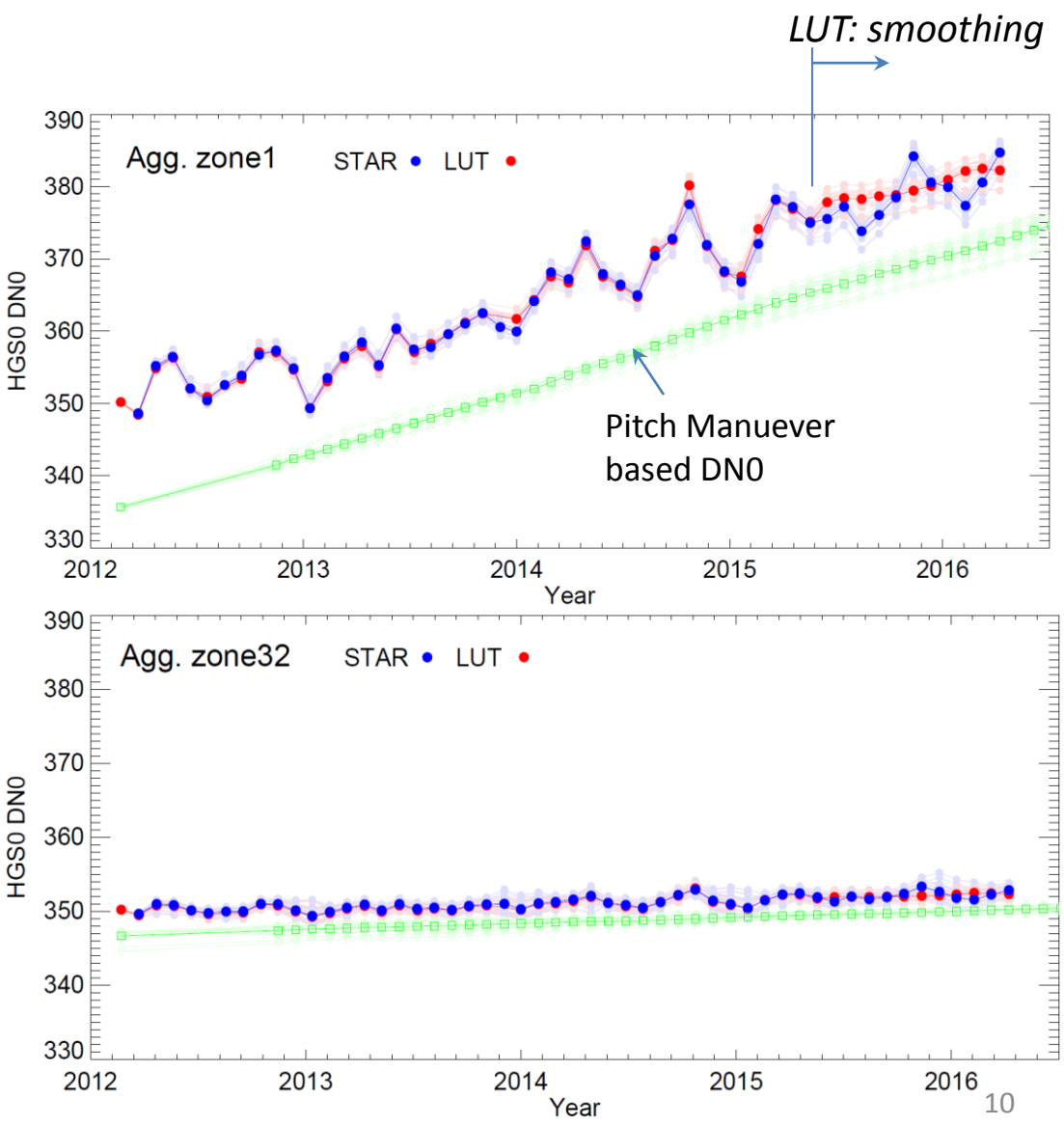
(Courtesy, Wenhui Wang)

# DNB On-Orbit Calibration

- LGS is calibrated using solar diffuser whereas MGS and HGS are calibrated through cross-calibration approach.
- Using VROP 702 and 705
  - performed every month during new moon.
  - Used by NOAA IDPS operational data
  - V702 used to estimate onboard offset table through observations over Pacific Ocean.
  - V705 used to estimate ground offset table (Pacific Ocean) and gain ratio (twilight region)
- Using onboard calibration data
  - NASA VCST *(Ref: Lee et al., 2014)*
    - Estimates gain ratio through cal sector data
    - Estimates ground offset using baseline reference from a) Pitch Maneuver data for HGS and b)VROP for MGS and LGS
    - Offset change over time is characterized through drift in dark measurements from BB
  - RSBAutoCal in IDPS
    - Not operational yet
    - Estimates gain ratio through cal sector data
    - Estimates ground offset using baseline reference from VROP 705
    - Offset change over time is characterized through drift in dark measurements from BB, SV and SD

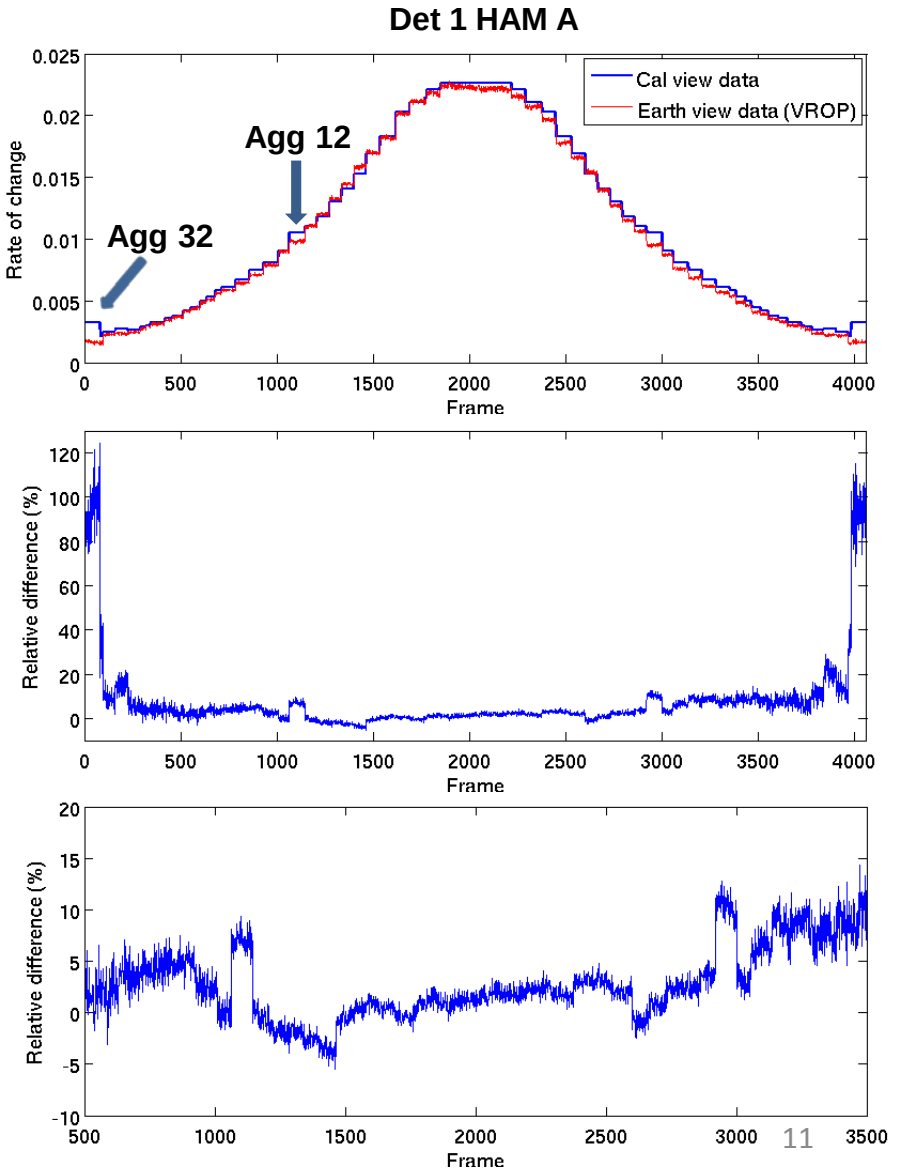
# Ground Offset Table Reanalysis

- Reanalysed VROP data from Feb. 2012 to April 2016 to estimate monthly offset and gain ratio.
- DN0 estimated at STAR using VROP agrees very well with that from LUT. However, starting early 2015, LUT based DN0 is smoothed out.
- Pitch maneuver data as an initial reference and estimated the drift through BB trend.
- Pitch maneuver based DN0 has larger discrepancies with VROP (10-15 DNs) for agg. zone 1. The difference is reduced at higher agg. zones.



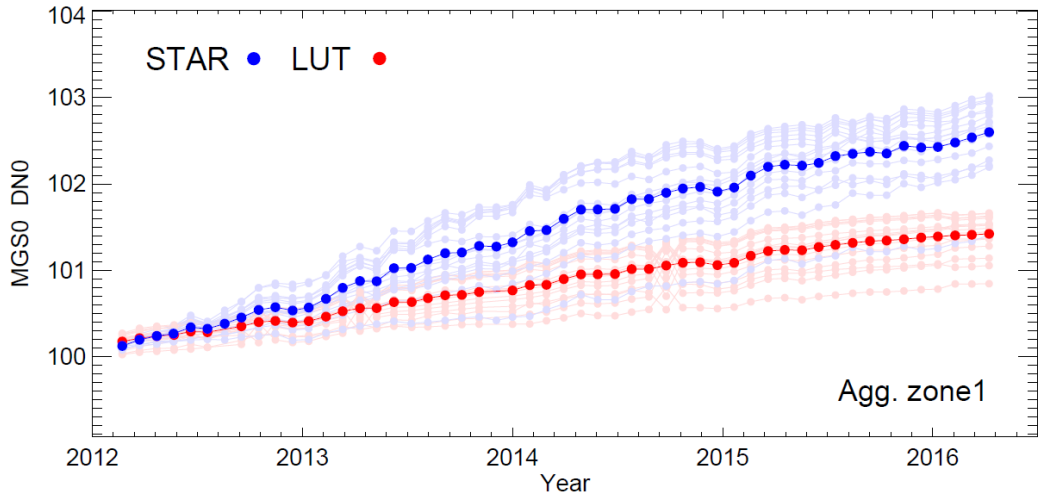
# Compare HGS Drift

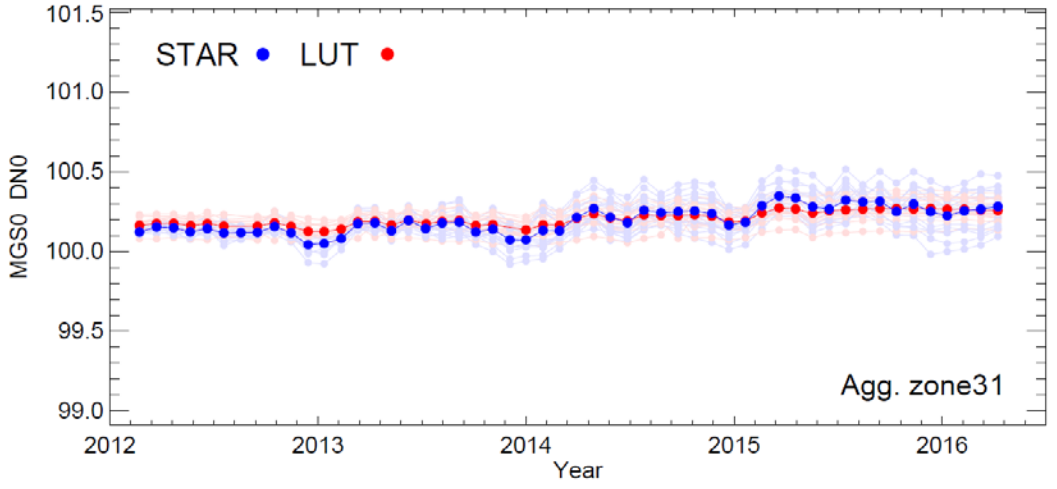
- Top: HGS rate of change fitted from 47 new moon days (02/21/2012 and 46 days between 11/13/2012 and 07/04/2016).
- Cal view data: follow the RSBAutoCal algorithm approach to determine DNB dark signal.
- Earth view data (VROP): DNB DN0 LUT (HGS)
- Middle: relative difference of the fitted change of rate (rate_CalView - rate_EarthView)/rate_EarthView.
- Bottom: zoomed in figure of the middle figure



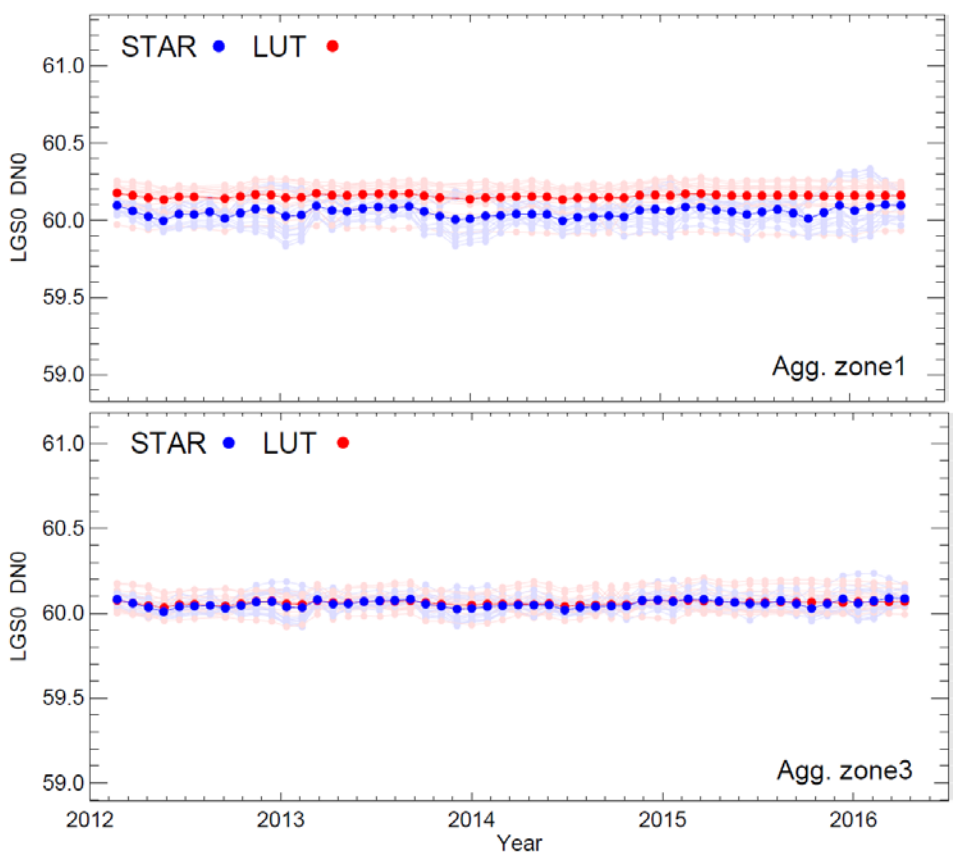
# MGS Ground Offset (DN0)

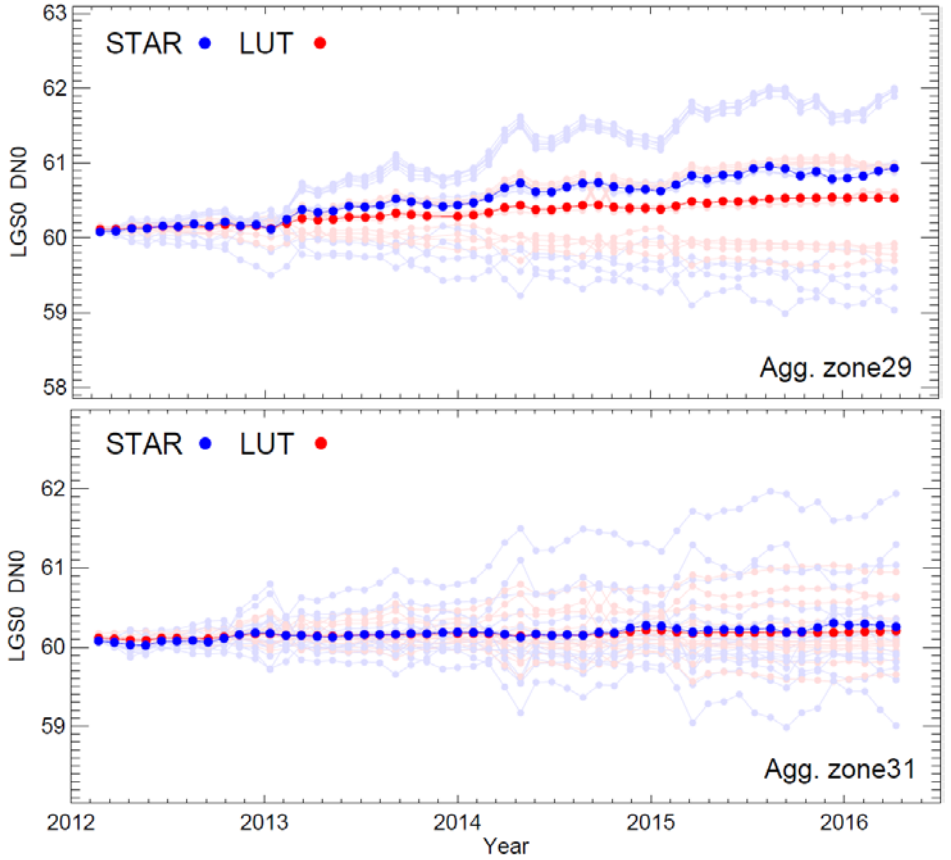
- MGS drift ranges from nearly 2.2 to 3 DNs for 16 dets.
- There exists difference in drift computed by STAR and from LUT. The difference increases over time.
- Difference ~1.2 DNs over four years for agg. Zone 1.
- Drift difference decreases over higher agg. zones such that it is no more noticeable for agg. zone 25 and higher.
- Does it impact on gain ratio?



# LGS DN0







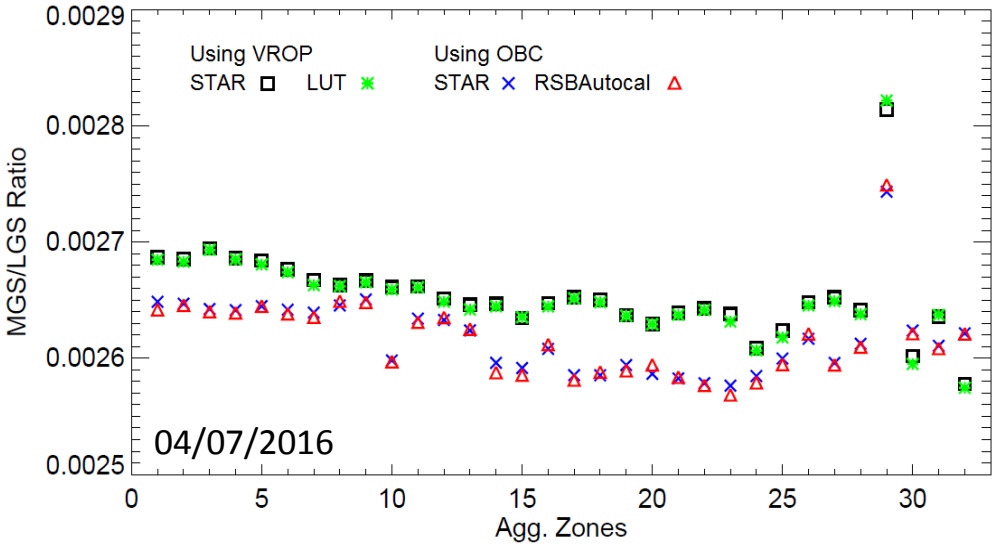


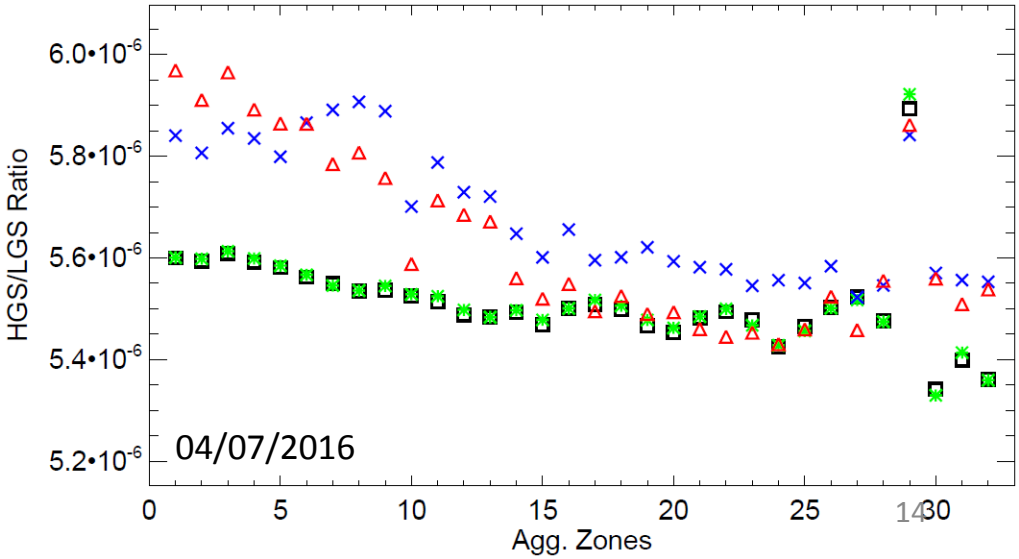

- Few agg. zones suggest ~0.05 to 0.1 DN difference in det. mean that is nearly consistent over time.
- Agg. zone 29-32 suggest large detector spread that is drifting in both upward and downward direction. More noticeable detector dependent spread after October 2012!

# Gain Ratio over 32 Agg. Zones

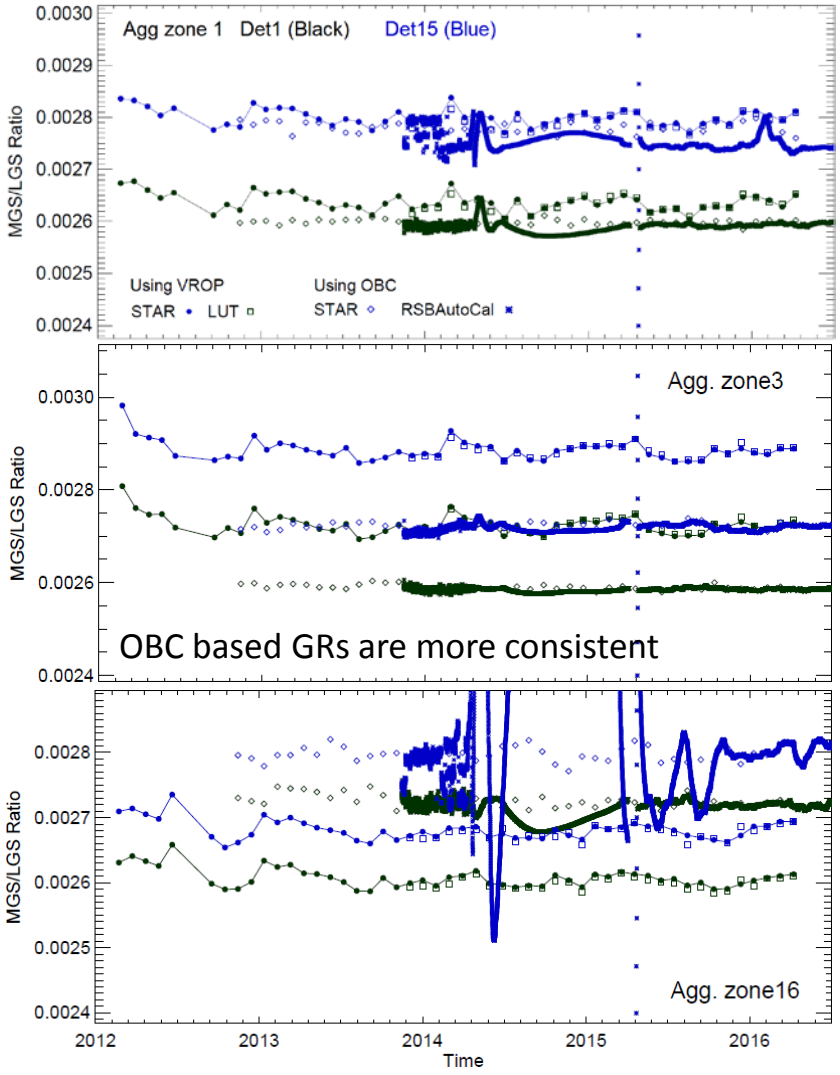
- For LGS and MGS, total offset corresponding to V702 for the same VROP event is used.
- *By using total offset, even if the long term drift in dark offset (DN0) is not accounted properly, there is no impact on gain ratio*.
- For 04/07/2016: HGS/LGS shows upto ~8% difference between VROP and OBC based gain ratio for first few agg. Zones at nadir.
- $(C_{MGS})_{det,\,agg} = (C_{LGS})_{det,\,agg} \times G_{MGS/LGS}$
  $(C_{HGS})_{det,\,agg} = (C_{LGS})_{det,\,agg} \times G_{HGS/LGS}$

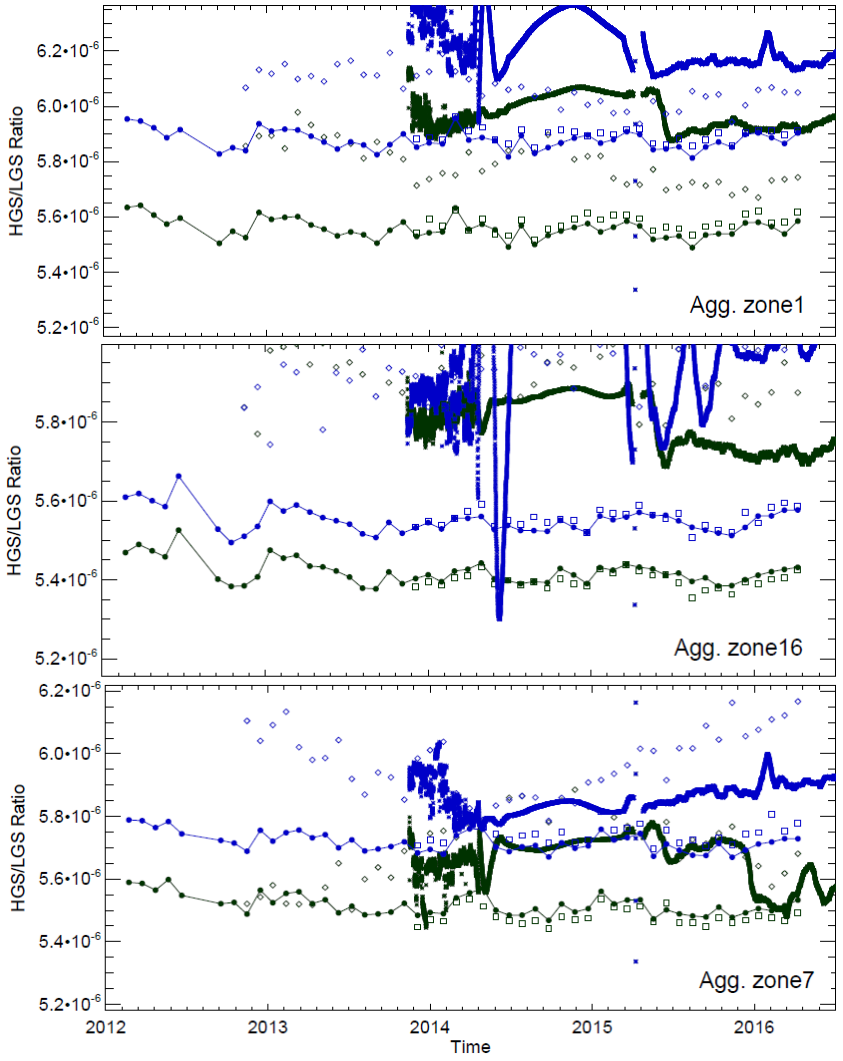
  where, $G_{HGS/LGS} = G_{MGS/LGS} \times G_{HGS/MGS}$



# Compare Gain Ratio Trends




- OBC based gain ratios shows discrepancy among each other and with VROP based values .
- While RSBAutocal based gain ratios suggest to be in better agreement with STAR more recently, some agg. zones indicate much larger discrepancies.

# Summary

- VIIRS DNB has gone through a number of improvements in calibration since launch.
- Temporal trends of ground offset using VROP agrees well with LUT for HGS and LGS. MGS suggests discrepancy of ~1.2 DN for agg. zone 1.
- Pitch Maneuver data based offset indicates difference of ~15-20 DN with VROP for agg. zone 1 which decreases over the higher agg. zones.
- OBC indicate large discrepancy in gain ratio with VROP, ~10% (HGS/LGS) for some agg. zones and needs further investigation.
- OBC suggests much larger spread in time series for HGS/LGS.
- RSBAutocal based gain ratio is more unstable esp. during 2014/2015 and indicates larger discrepancy with STAR computed values and needs further investigation.
- Request LUT from VCST and compare with both offset and gain trends to analyze the differences.