Suomi NPP Reprocessing Status

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NOAA Ocean Color,
NASA VCST,
& Aerospace Corp.

- Introduction
- Algorithm Updates and Issues
  - Reflective Solar Bands (RSB)
  - Thermal Emissive Bands (TEB)
  - Day Night Band (DNB)
- Provisional Schedule
  - Processing capability
- Summary

Introduction

- S-NPP VIIRS SDR product needs to be reprocessed
  - To improve early lifetime SDR data in all RSB, TEB and DNB.
- Anomalies in RSB
  - Sudden H-factor updates in 2014
  - Long-term differences between SD and lunar F-factors
  - Possible degradation in SWIR bands
  - Applying lunar F-factor into SD F-factors
- TEB Warm-Up-Cool-Down (WUCD) issues with SST
  - Option 1 : Aerospace solutions
  - Option 2: NOAA VIIRS SDR team's current progress
- DNB improvements
  - Initial calibration changes
  - DNB Relative Spectral Response (RSR) changes
  - Updated VROP for DN0 (bias)
  - Stray light LUT update

- Significant F-factor discontinues were found in bands M1~M4 (up to 1.5% differences in band M1) cause by sudden H-factor (Solar Diffuser degradation).

- Initial VIIRS SDR products in early 2012 need to be updated with new RSB F-factors.
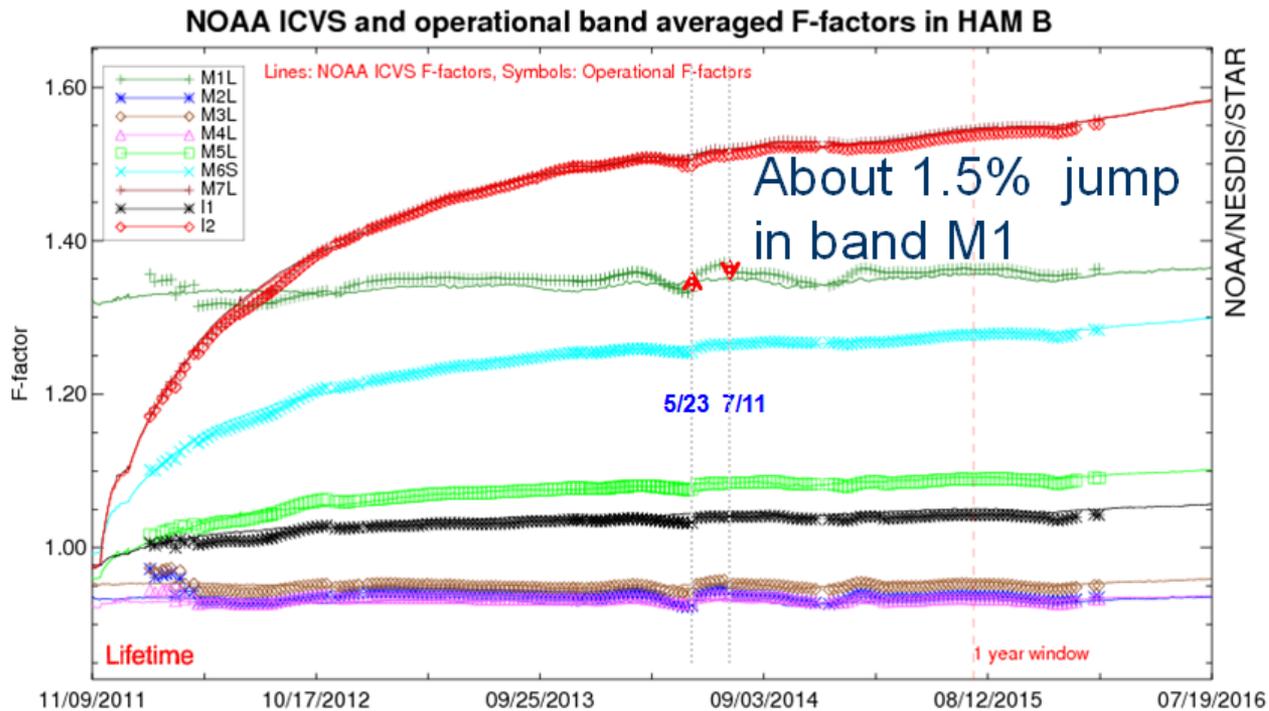

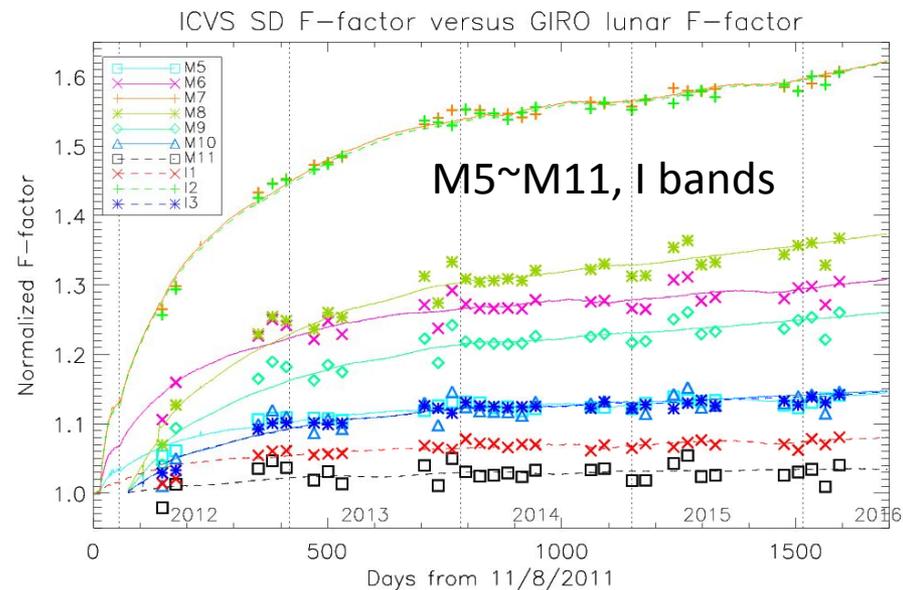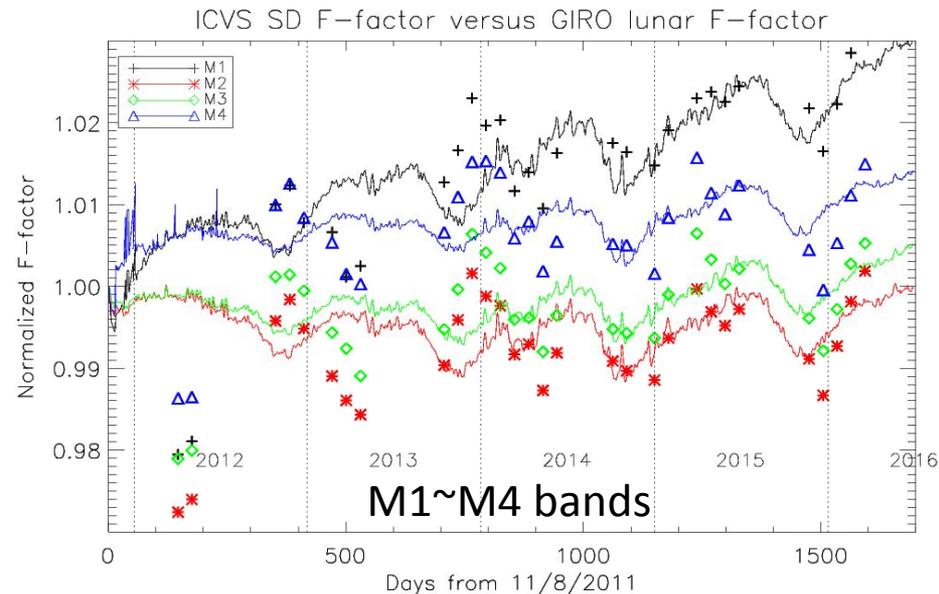**Figure 1**. S-NPP VIIRS RSB Operational (Symbols) and ICVS F-factors (lines)

- ## F-factor ratio (NASA VCST/ NOAA RSBAutoCal)
  - ### VIS/NIR bands
    - There are initial offsets and long-term drifts.
    - The differences are larger in short wavelength bands and getting smaller in longer wavelengths.
    - Because of NASA's lunar corrections into the SD F-factors.
  - ### SWIR bands
    - H-factor (SD degradation) free bands show long-term drifts.
    - Because of NASA's update SD degradation into the SD H-factors.
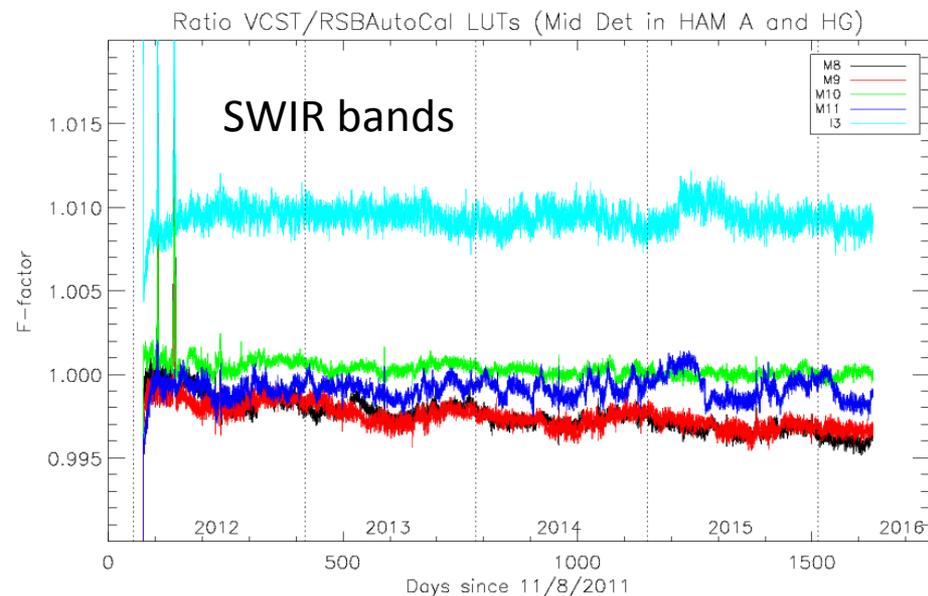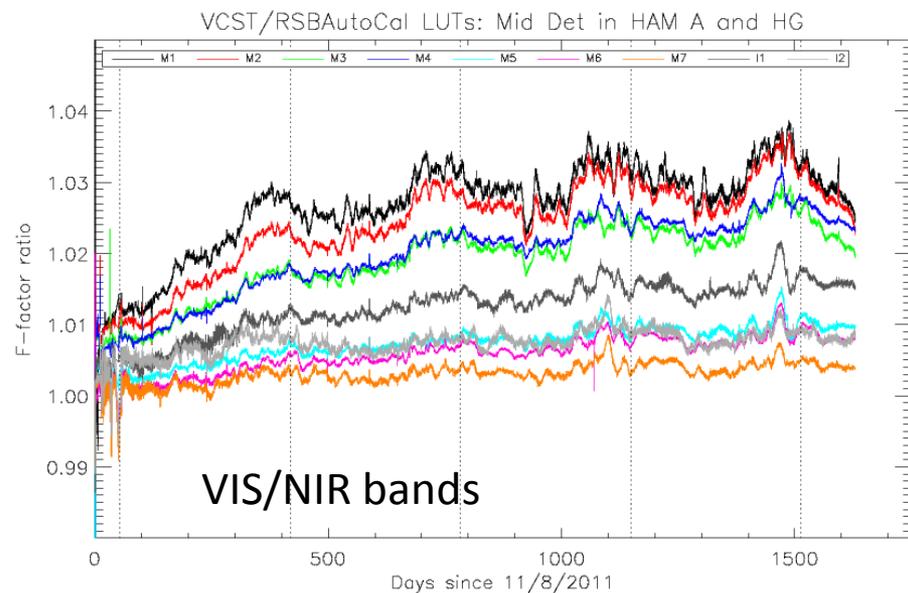
- The two F-factors need to be normalized (or scaled) properly because of the different solar irradiance models.

- The SD F-factors (solid lines) are normalized for better comparison and visualization in the figures.

- The best fitting scaling factors are calculated and applied for lunar F-factors (symbols).

- Lunar and SD F-factors are showing similar annual trends in starting from end of 2014 to current time.

- The first two lunar points are below the SD F-factors.

  – Potential errors in SD F-factors.

ICVS SD F-factor versus GIRO lunar F-factor
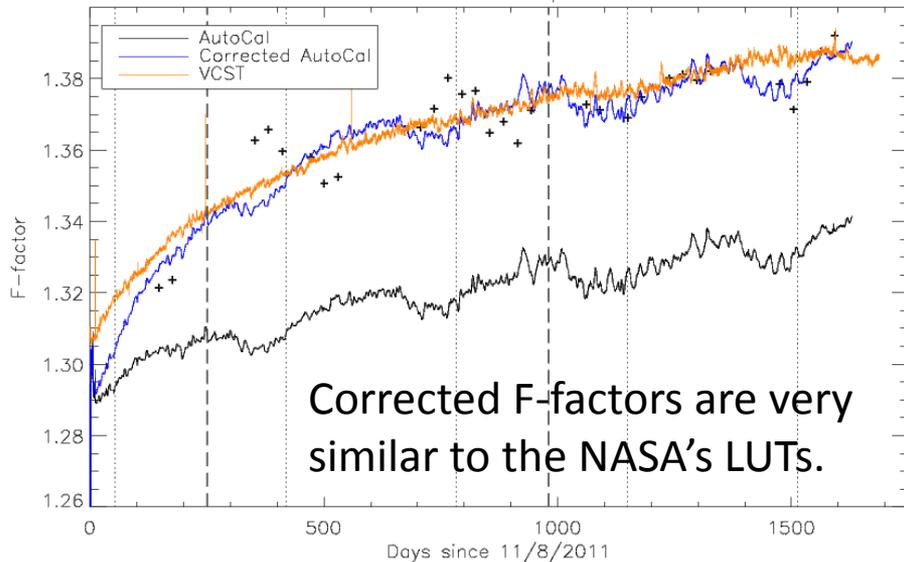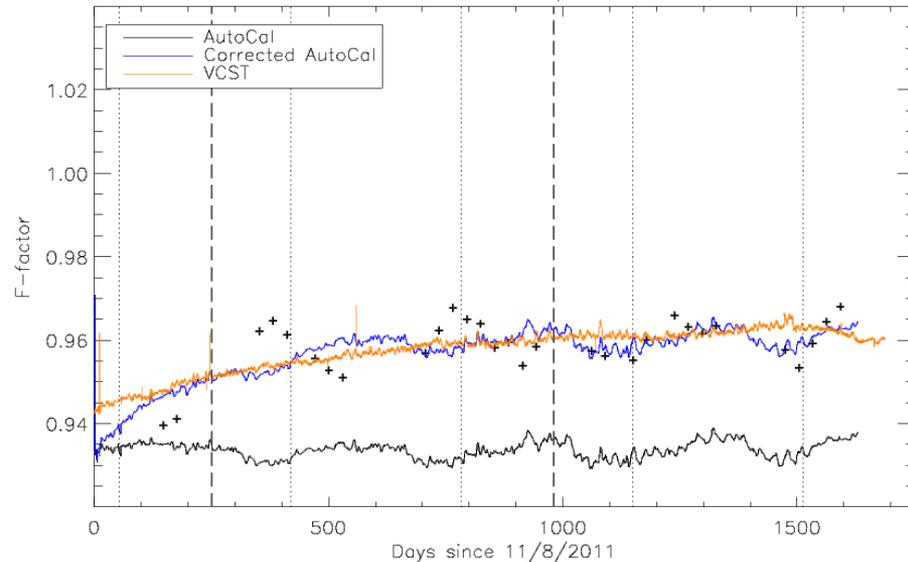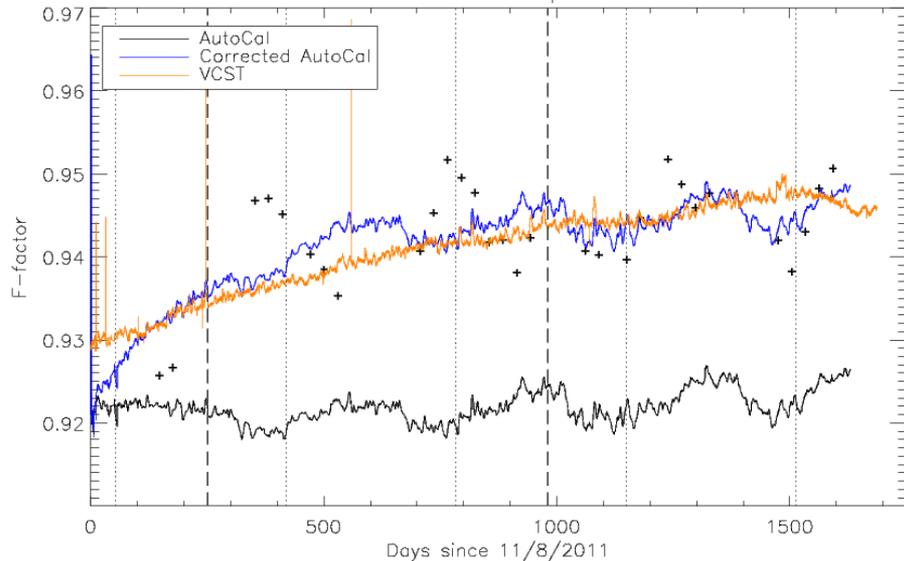
M1~M4 bands

ICVS SD F-factor versus GIRO lunar F-factor

M5~M11, I bands

Corrected F-factors are very similar to the NASA's LUTs.

Our version of the corrected F-factors have more curvature than NASA LUTs in early lifetime.

Ocean Color Group **Hybrid Approach**
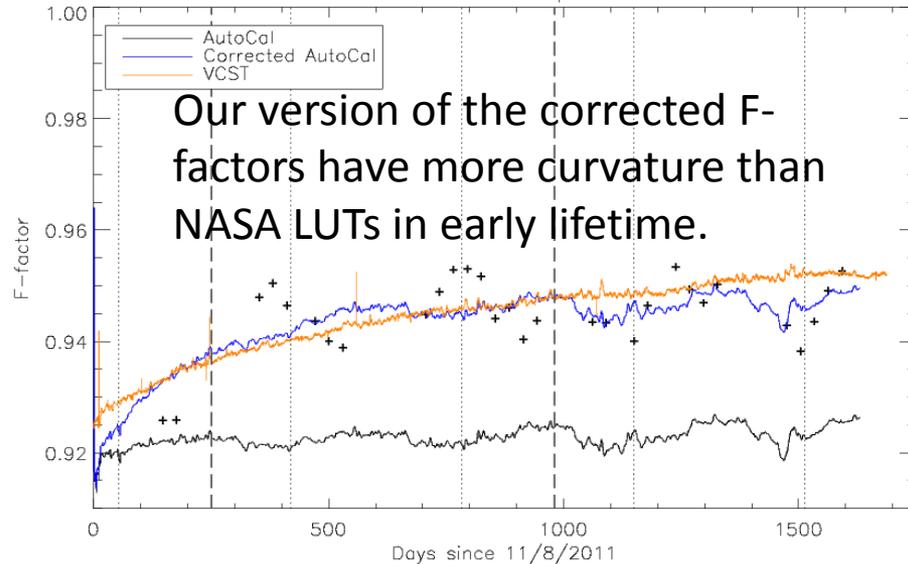
- SD Calibration

  – SD degrades non-uniformly, resulting long-term drifts

  – Results are stable and smooth

  – Observation in every orbit

- Lunar Calibration

  – No degradation issue

  – Infrequent and no observation in three months every year

- **Hybrid Approach**

  F-Factors Ratios are fitted to quadratic polynomials of time

$$\mathcal{F}(B,D,M,G) = R(B,t) \cdot F(B,D,M,G)$$

$$R(B,t) = \left\langle f(B,M,t) \right\rangle_M / \left\langle F(B,D,M,0,t) \right\rangle_{D,t-15<t_i<t+15,M}$$

  – **Lunar calibration provides long-term baseline**

  – **SD calibration provides smoothness and frequency**

- *J. Sun and M. Wang, "Radiometric Calibration of the VIIRS Reflective Solar Bands with Robust Characterizations and Hybrid Calibration Coefficients," Appl. Opt., 54, 9331-9342 (2015).*
- *J. Sun and M. Wang, "VIIRS Reflective Solar Bands Calibration Progress and Its Impact on Ocean Color Products," Remote Sensing, 8, 194 (2016).*

Calibration coefficients Ratios
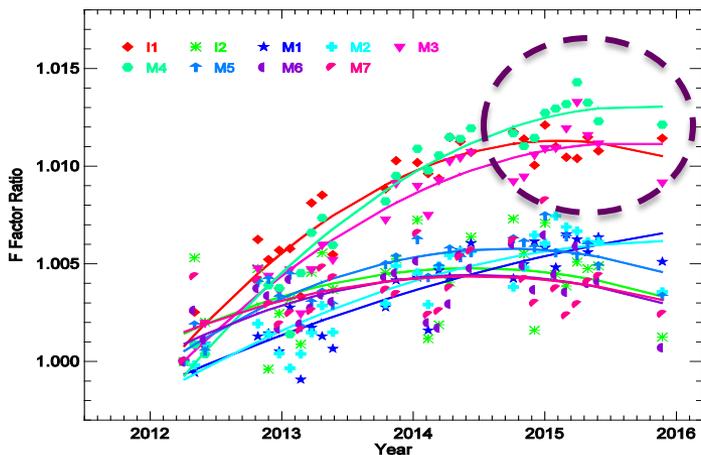
Calibration Coefficients (M4)
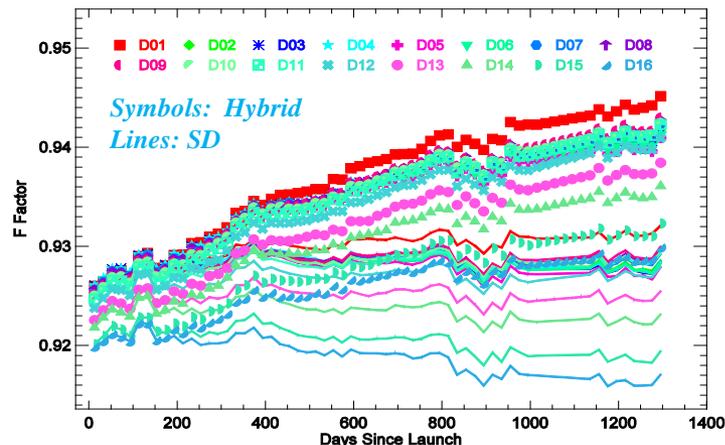
Calibration Coefficients
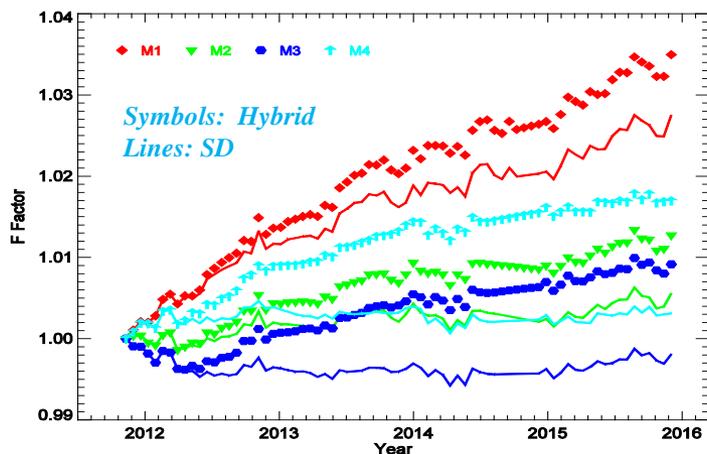
Earth-based SDR studies show that Hybrid-mitigated SDRs give correct time series

VIIRS M4 vs MODIS B4(555 nm)
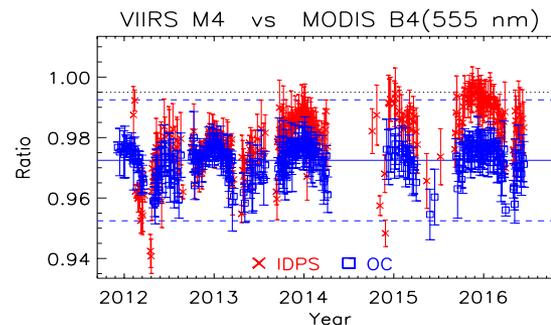
Poster: "Radiometric Comparison of the RSBs of the SNPP VIIRS and Aqua MODIS through SNO analysis" by M. Chu, J. Sun and M. Wang.

Slide is taken from *VIIRS RSB Calibration for Ocean Color applications by* Junqiang Sun and Menghua Wang

- A tentative decision was made recently for VIIRS RSB calibration.

- NOAA Ocean Color group will provide
  - Ocean Color RSB calibration coefficients to STAR VIIRS SDR team for testing.

- The OC group's RSB F-factors will be scrutinized before making the further decision.
  - From inputs from other working groups such as Land/Fire and Atmosphere.

Courtesy of Dr. Ignatov, 2015 JPSS Annual Science Team Meeting

- VIIRS SST product is generally consistent with drifter measurements, except
- Issue 3: "Global warming of ~0.3K" occurs in VIIRS SST every 3 months, due to warm up cool down (WUCD) calibration anomaly.

This slide is taken from VIIRS TEB calibration potential improvements by Wenhui Wang et. al.

- Aerospace proposed a method to reduce F-factor anomalies and scene temperature biases during WUCD (October 7, 2015, Option 1):
- The initial proposed method was further updated to flatten F-factors during WUCD by implementing (August 3, 2016, Option 2) :

M15, HAM-A, D1
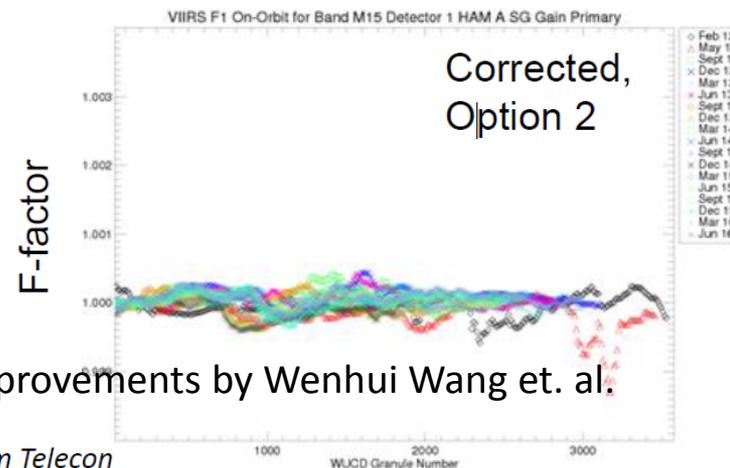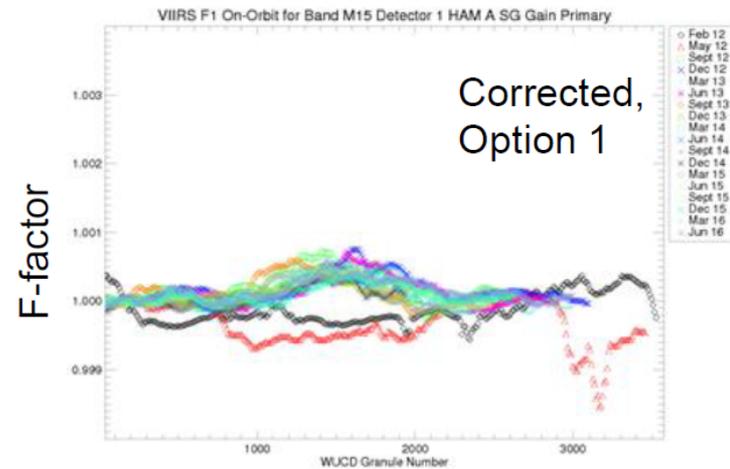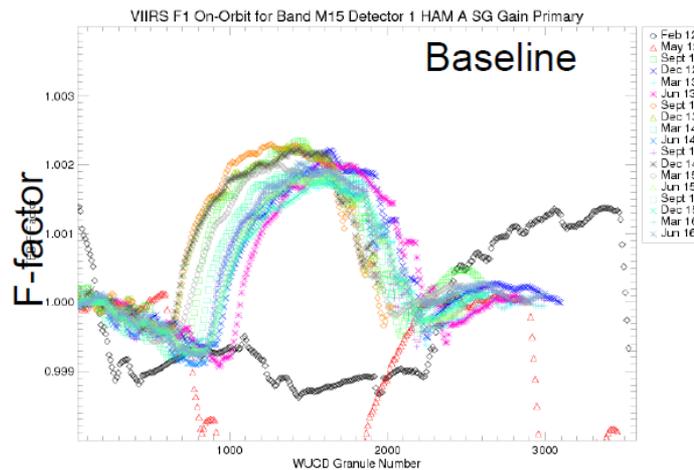
Other detectors/bands show similar patterns
F Factors Smoothed Over Orbits

This slide is taken from VIIRS TEB calibration potential improvements by Wenhui Wang et. al.

Courtesy of David Moyer, Aerospace, Aug 3, 2016 VIIRS SDR Team Telecon

- NOAA SDR Team's Recent Progress
- As a part of reconciling the pre/post calibration differences activities, a new C0 coefficient update method was tested.
  - Only change one LUT, no other change is needed;
  - Effectively reducing 3 types of M15 scene BT biases:
  - 1)Cold scene bias; 2)Constant bias; 3) WUCD bias.
- Further analyzing the sensitivity of different terms, including C coefficients, on WUCD F-factor anomaly and scene temperature biases;
- Currently we have 2 options.
  - Continue to investigate for a better solution.
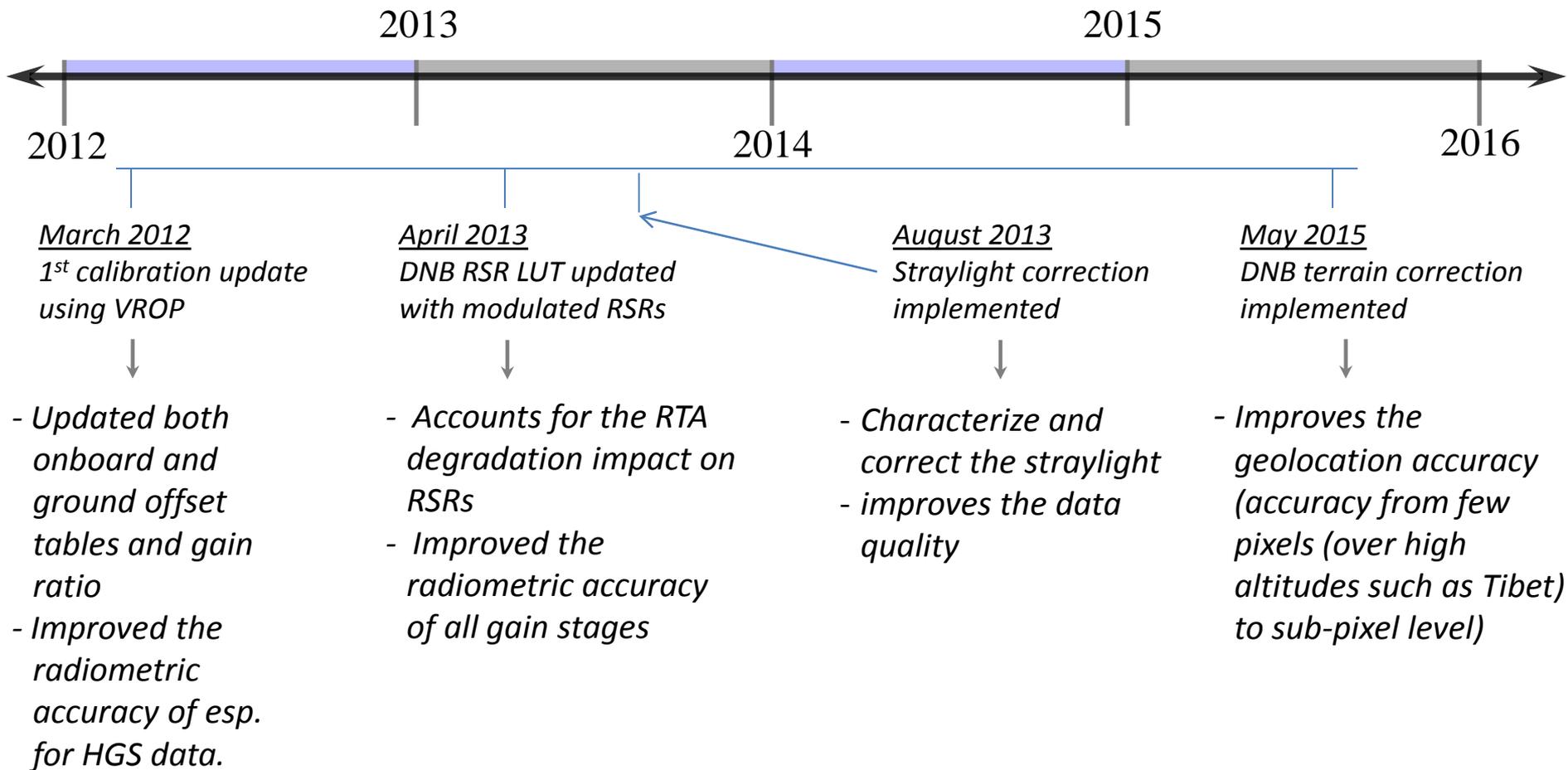

This slide is taken from VIIRS TEB calibration potential improvements by Wenhui Wang et. al.
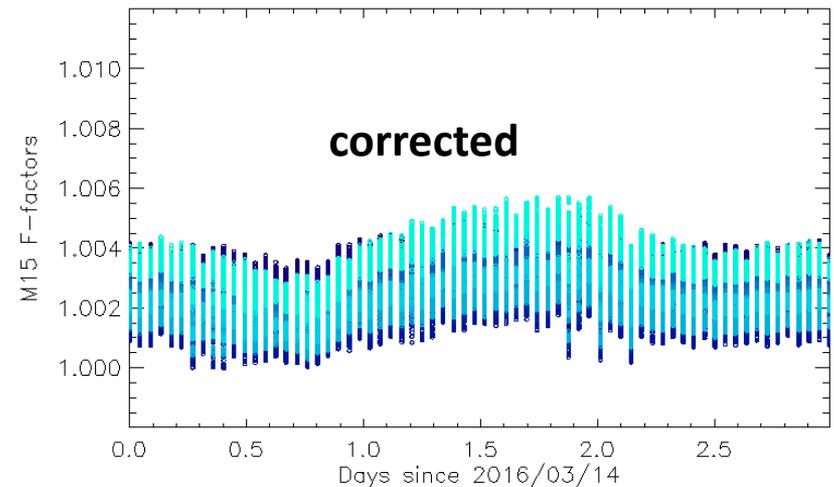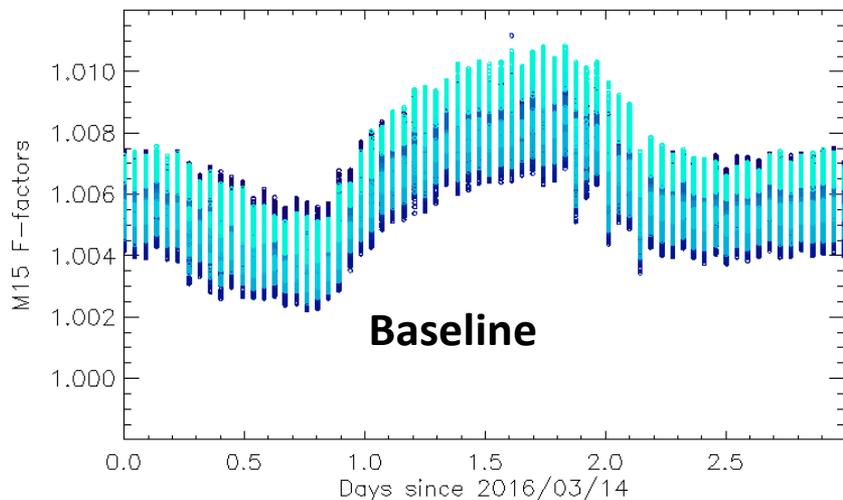
Algorithm Updates & Issues in DNB

2013

2015

2012

2014

2016

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 2013
*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)*

This slide is taken from Preparation for DNB recalibration by Sirish Uprety and Yalong Gu

- The DNB gain LUTs only applied one time Relative Spectral Response (RSR) update in 2013
  - causing approximately 5% jump in DNB calibration.
- ICVS DNG gain uses a continuous RTA Degradation Model.
  - Correcting the initial calibration changes, RSR update in 2013 , and lunar eclipse anomaly in 2014.

Operational & ICVS Normalized DNB LGS Detector Averaged Gain
07/20/2016-00:16:43 UTC

March 13, 2012

March 29, 2012
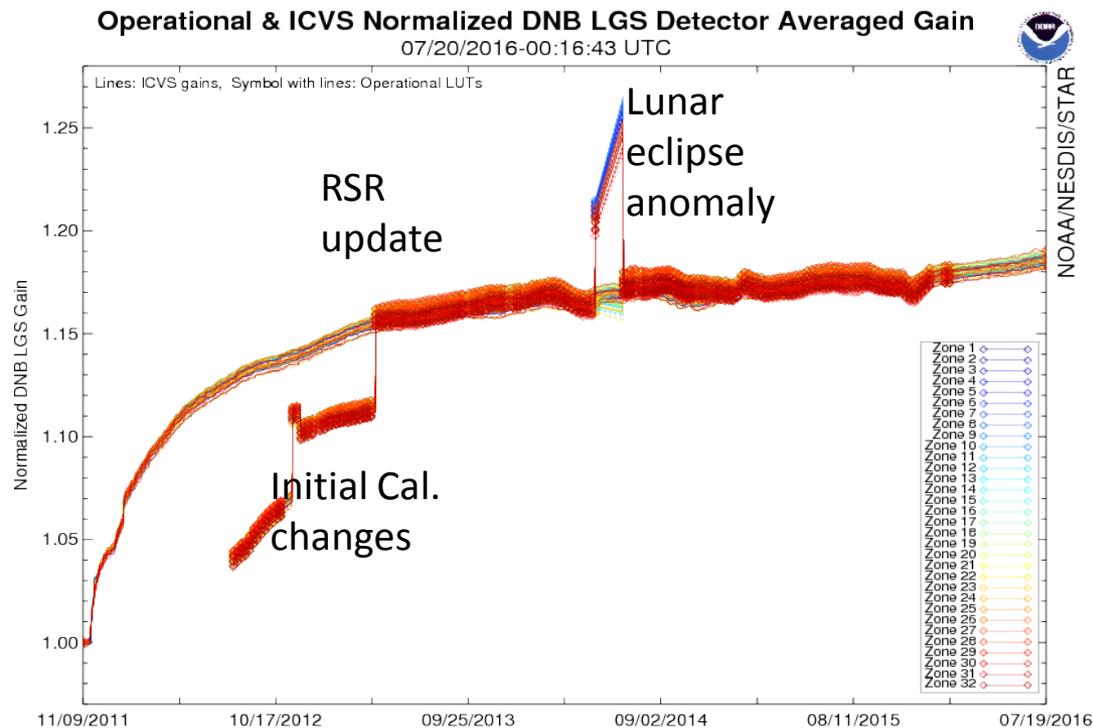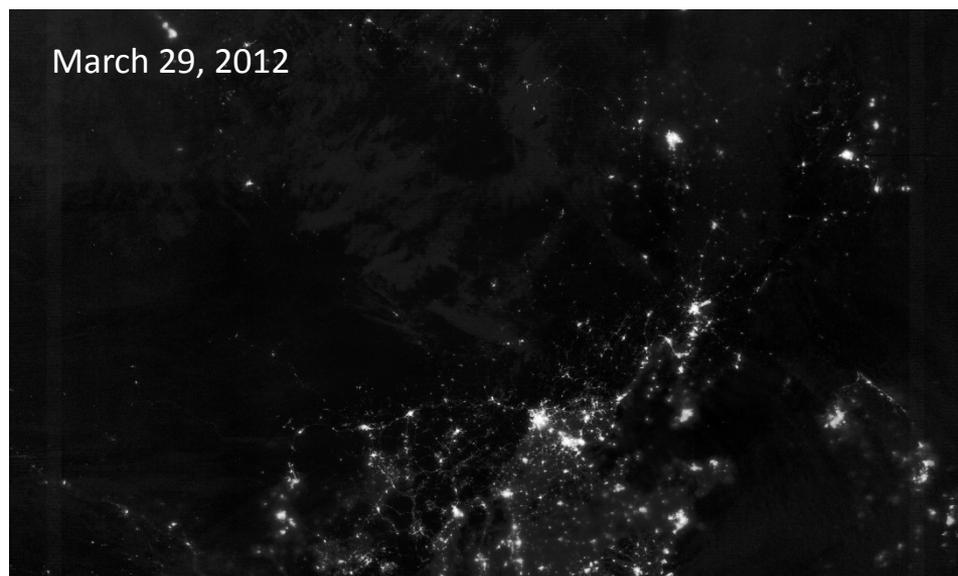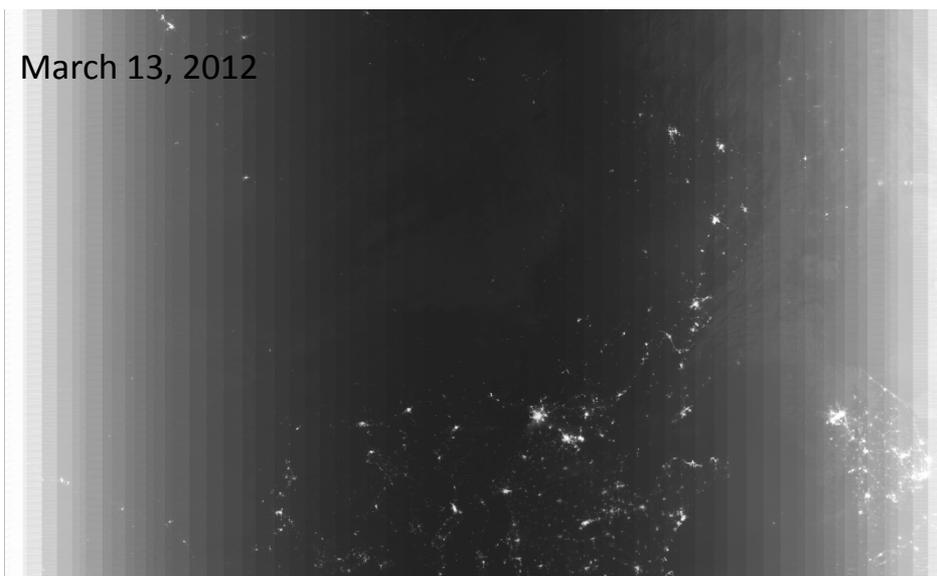
- Show DNB image over same location in earth after 16-day repeat cycle.
- Figure on right shows improvement in DNB calibration after updating offset table (onboard and ground offset) and gain ratio tables for the first time on March 22, 2012 based on VROP.

This slide is taken from Preparation for DNB recalibration by Sirish Uprety and Yalong Gu

SNPP: Before Correction

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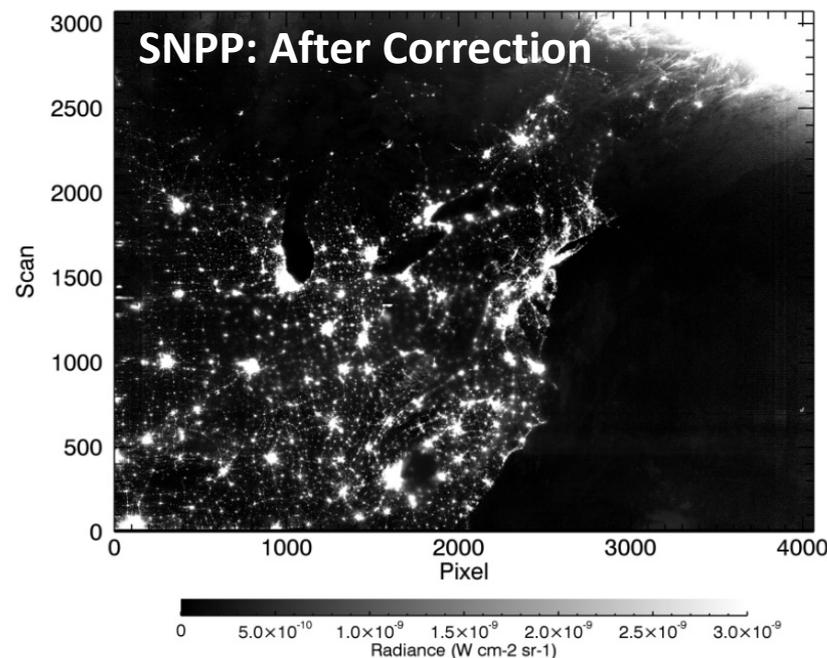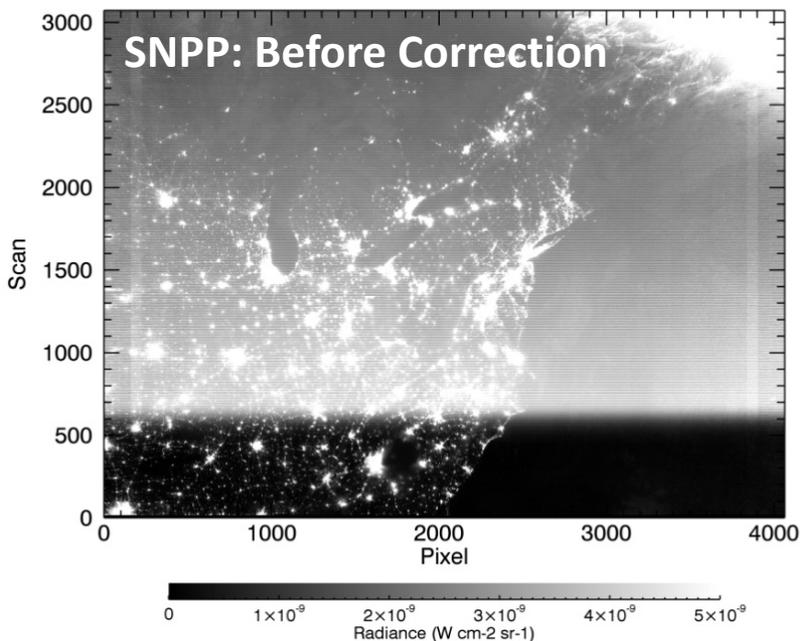
- SNPP DNB Stray Light correction transitioned from NG to STAR in 2014
- STAR supported the updates of operational stray light LUT for solar vector error correction.
- All 12 LUTs were updated by the end of 2015

This slide is taken from Preparation for DNB recalibration by Sirish Uprety and Yalong Gu (Courtesy, Wenhui Wang)

- RSB (Not ready yet)
  - NOAA Ocean Color group will provide RSB LUTs by September 15th, 2016.
  - One year of VIIRS data will be ready by the end of November, 2016.
  - RSB LUTs for reprocessing will be ready by December 15th, 2016.
- TEB (Conditionally ready)
  - The option 1 solution from Aerospace is ready as a baseline.
  - Currently working on better solution.
- DNB (Ready)
  - LGS gain LUTs are ready.
  - DN0 LUTs are ready.
  - Stray light correction LUTs are ready.
  - Currently working on better gain ratio LUTs.
    - With baseline operational gain ratio LUTs.

Provisional Reprocessing Schedule

One day processing scenario

**RDRs IN
(55GB/1013
Granules)**

→

Determine total granule numbers
& total CPU numbers used
Assign evenly all granules to
each CPU/node — 3 S

↓

Distribute ADLs
Link Terrain files (~55GB)
Create multiple ADL_HOME
(5/node, Limited by RAM size) — 40 S

↓

Unpacking RDRs at each local drive
(Directly read from storage) — 21 S

↓

Link TLE,PolarWanders,LUTs
Run ADL controller on 18 nodes,
No-cross talk

↓

Directly output to storage — 1849S

↓

**SDR OUT
(540GB)**

**UMD
CICS/Bamboo
ADL 4.2 Mx 8.11**

One Year
Reprocessing time
cost: 8.5 days
(If RAM upgrade to
128G, this time cost
can be further
reduced)

Total: 33.4 Min

Total CPU hours:
229 (19/24 idle)

NOTE: Assuming that hardware works normally and
resources are available (such as no power outage, no disk
failure etc)
Assuming all input data (RDR, TLE, Polar Wander and LUTs)
are ready.

Summary

- RSB band improvements
  - The reprocessing LUTs will correct up to 1.5% sudden changes caused by sudden H-factor updates, C0=0 update, and F-fast track to RSBAutoCal LUT transition.
  - The unstable initial calibration LUTs will be updated.
  - A new OC group's RSB F-factor LUTs with Lunar correction will be tested for their 0.1~0.3% radiometric uncertainty requirements.

- TEB band improvements.
  - TEB F-factor changes during the blackbody Warm-Up Cool-Down (WUCD) needs to be resolved before reprocessing (currently under study).

- DNB band improvements
  - The reprocessing LUTs will correct radiometric calibration up to 5%.
    - Caused by the initial calibration changes, RSR update, and lunar eclipse anomaly.
  - The new bias (DN0) LUTs will improve bias errors.
    - Using the VIIRS Recommended Operation Procedure (VROP) 702.
  - The new stray light correction LUTs will correct the contaminated scenes before August 2013.