VIIRS SDR Breakout Session
Opening remarks: accomplishments and path forward

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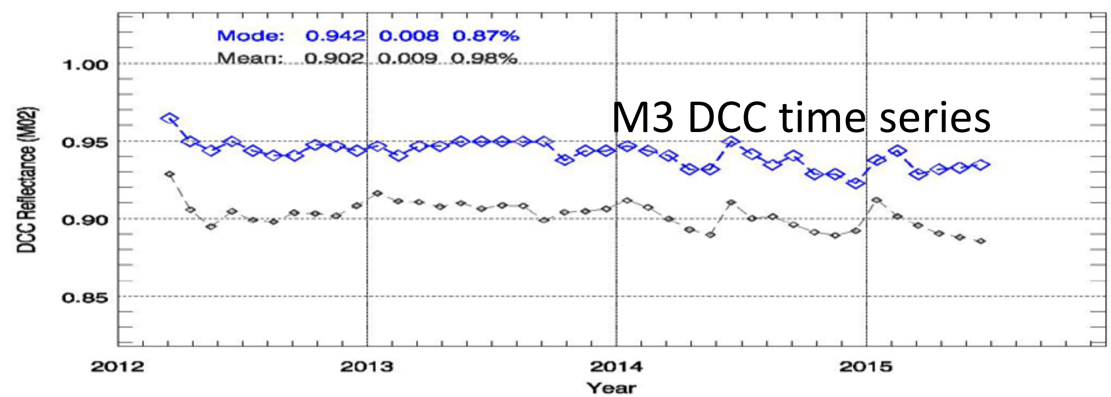
NOAA/NESDIS/STAR

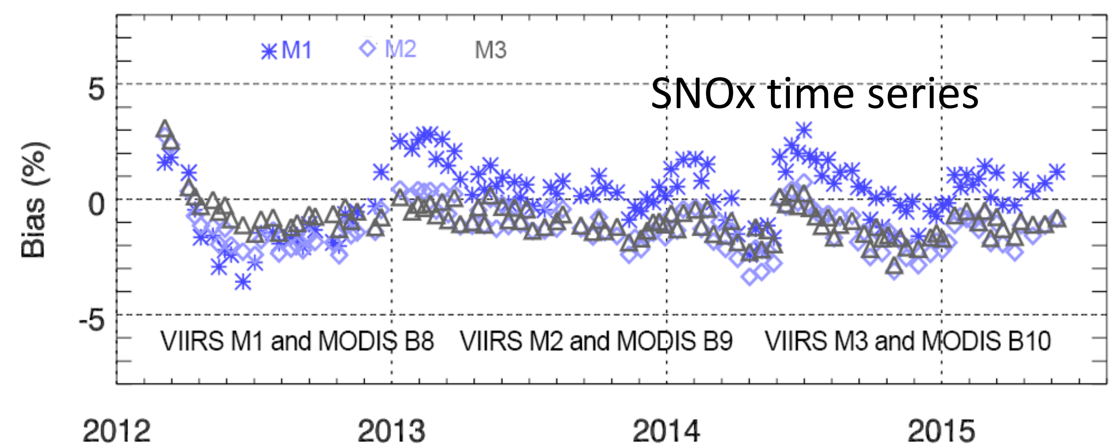
August 26, 2015

VIIRS Calibration: Very Stable and Accurate

- VIIRS calibration is closely monitored at 30+ cal/val sites worldwide;
- Time series shows the calibration is very stable, and accurate (better than the +/-2% spec);
- Comprehensive calibration & monitoring include monthly maneuvers such as lunar cal, as well as DNB offset and gain transfer (VROP702)



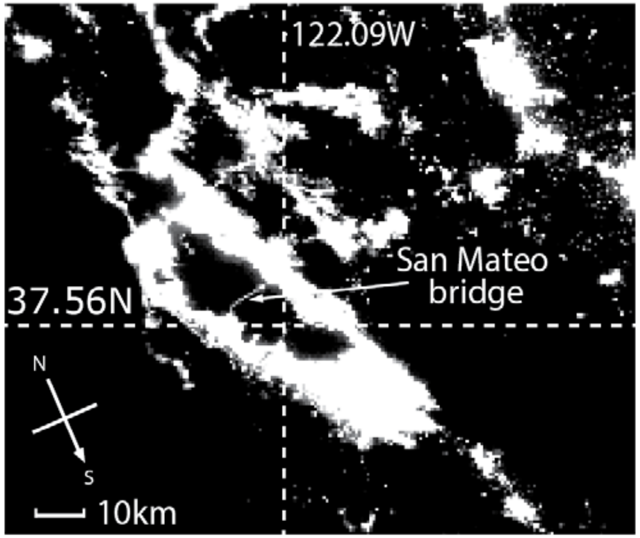
VIIRS very stable according to DCC trending

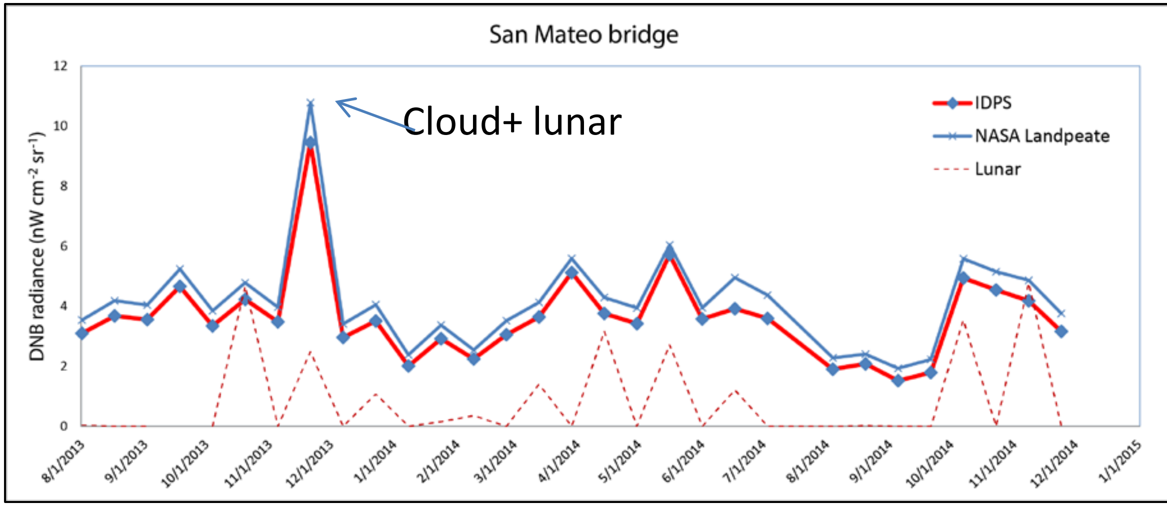


VIIRS very accurate when compared to MODIS

VIIRS DNB Stability Monitoring using Night Bridge Lights

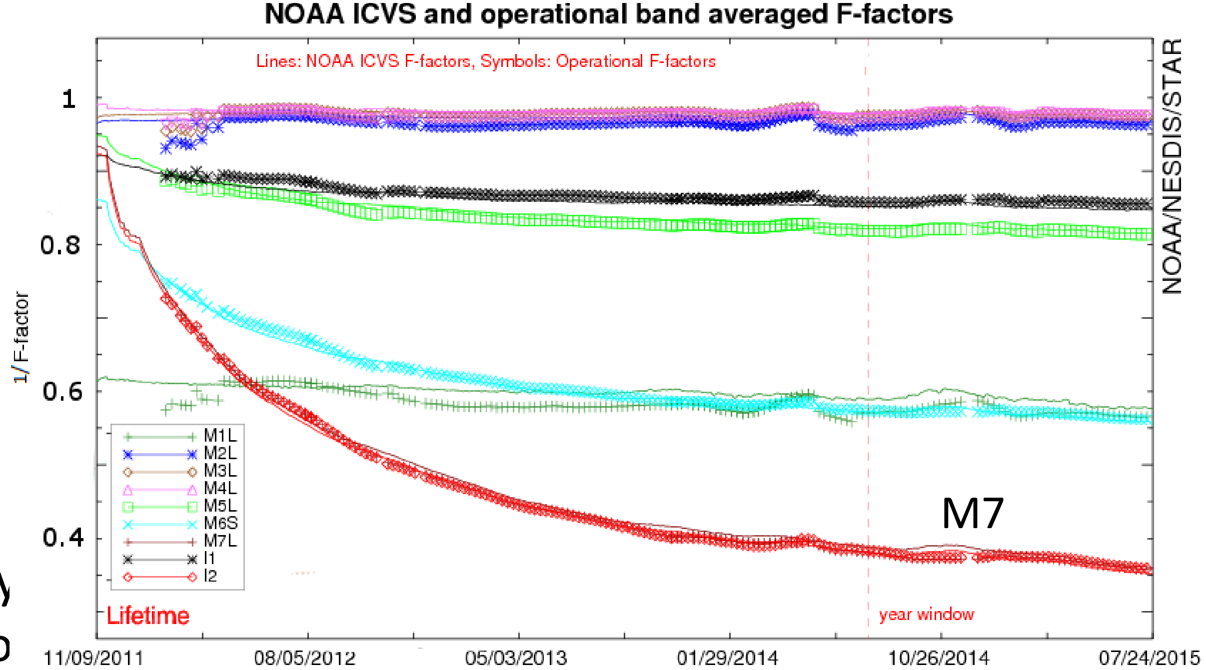
- Validation using San Mateo bridge lights (faint light near Lmin)
- Time series shows NASA LandPeate is consistent with IDPS radiances
- Lunar has minimal impact in clear sky due to narrow bridge width, except in cloudy cases
- Further work expanded to oil platforms





VIIRS RTA Degradation Rate Becomes negligible

- Rotating Telescope Assembly (RTA) mirror degradation was a major anomaly, due to prelaunch contamination;
- Band M7 has the largest degradation (~70%) since launch;
- The degradation rate has become negligible since a year ago;
- The VIIRS SDR team actively maintains the calibration to compensate for the degradation;
- Impact on users are only limited to early orbits during beta maturity.



VIIRS SDR Team 2015 Top Ten Accomplishments

- Developed J1 VIIRS DNB waiver mitigation and delivered pre-operational software to the program on-time, which greatly reduced program schedule and cost risks (Wang & Lee), in addition to operational straylight correction.

- Prepared all 47 J1 VIIRS LUTs (ver1.0) based on analysis of prelaunch test data, tested using ADL and simulated J1 data, and delivered to the program(Aerospace/VCST/STAR);

- Developed and demonstrated VIIRS DNB radiometric and geolocation monitoring/characterization capabilities using nightlight point sources (Cao & Bai, 2014,RS.), which is critically needed for J1 postlaunch validation of the waivers;

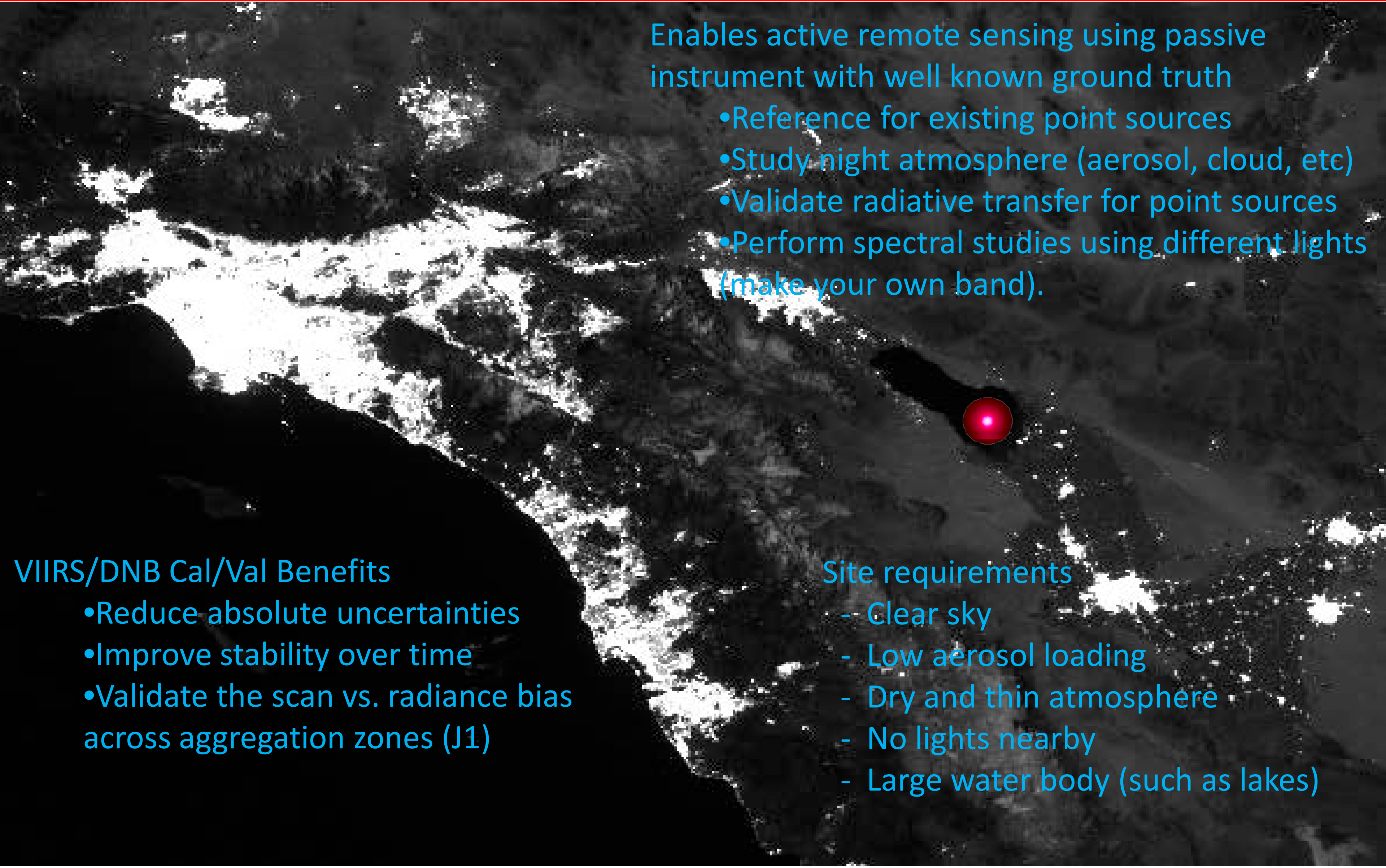
- Expanded validation time series with the 30+ validation sites worldwide, with added capabilities in the SWIR bands, as well as comparing with GOSAT FTS hyperspectral observations (Uprety & Cao, 2015, RSE);

- Generated recalibration coefficients since launch with the latest corrections and RSB Autocal (Blonski)

VIIRS SDR Team 2015 Top Ten Accomplishments

- Completed J1 VIIRS prelaunch test data analysis (VCST/Aerospace/STAR)
- Improved RSB autocal maturity;
- Geolocation thermal chip development for the infrared bands;
- Modeled VIIRS solar diffuser degradation using surface roughness and metrology;
- Active nightlight SBIR project feasibility study in support of VIIRS DNB cal/val.

Active Light Sources for DNB



Enables active remote sensing using passive instrument with well known ground truth

- Reference for existing point sources
- Study night atmosphere (aerosol, cloud, etc)
- Validate radiative transfer for point sources
- Perform spectral studies using different lights (make your own band).

VIIRS/DNB Cal/Val Benefits

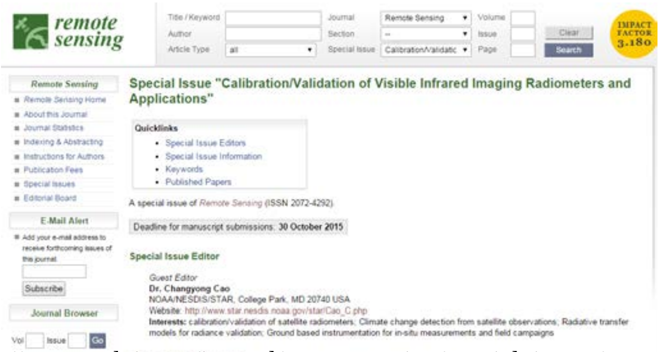
- Reduce absolute uncertainties
- Improve stability over time
- Validate the scan vs. radiance bias across aggregation zones (J1)

Site requirements

- Clear sky
- Low aerosol loading
- Dry and thin atmosphere
- No lights nearby
- Large water body (such as lakes)

What's Ahead?

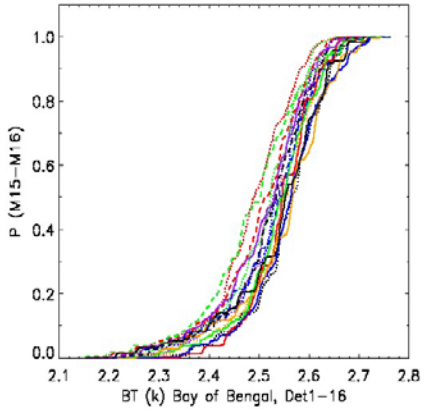
- VIIRS Cal/Val Special Issue (due Oct 30, 2015)



http://www.mdpi.com/journal/remotesensing/special_issues/VIIRS

- Additional waiver mitigation
  - SWIR nonlinearity
  - Saturation
  - Bad detector
  - Improve LUTs

- VIIRS SDR L1.5 product development (in collaboration with SST team)
  - Bow-tie refill
  - Feature contiguity in bow-tie deletion zone
  - Striping reduction



- VIIRS SDR reprocessing

- RSB autocal operational

- Field campaign preparation augmenting J1 cal/val in conjunction with GOES-R ABI, including near surface measurements with polarimeter, goniometer, and UAS based systems;

- Finalize Cal/val plan and ATBD

Status Overview of JPSS VIIRS Testing

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Acknowledgements:
VIIRS Characterization Support Team (VCST)
NASA VIIRS On-site Instrument Team

August 25-28, 2015

Talk overview

Provide the context for the detailed talks to follow

- Follow-up to the previous talk from the government perspective
- What you should get from this talk
  - J1 VIIRS is not identical to NPP VIIRS
  - Government/Raytheon partnership has provided a J1 VIIRS that will prove to be a worthy follow-on sensor
- Outline
  - J1 VIIRS testing overview
  - Overall Sensor Performance Assessment
  - Waivers – why and what
  - What next

Pre-launch testing objectives

Characterize overall performance and identify potential noncompliance issues

- Testing includes radiometric, geometric, and spectral performance
- Ensure sensor performance meets its design requirements
- Check that sensor data quality is adequate to achieve overall science objectives
- Allows key sensor performance parameters to be derived for on-orbit operation and calibration
- Support implementation of potential mitigation strategies designed to address noncompliance issues

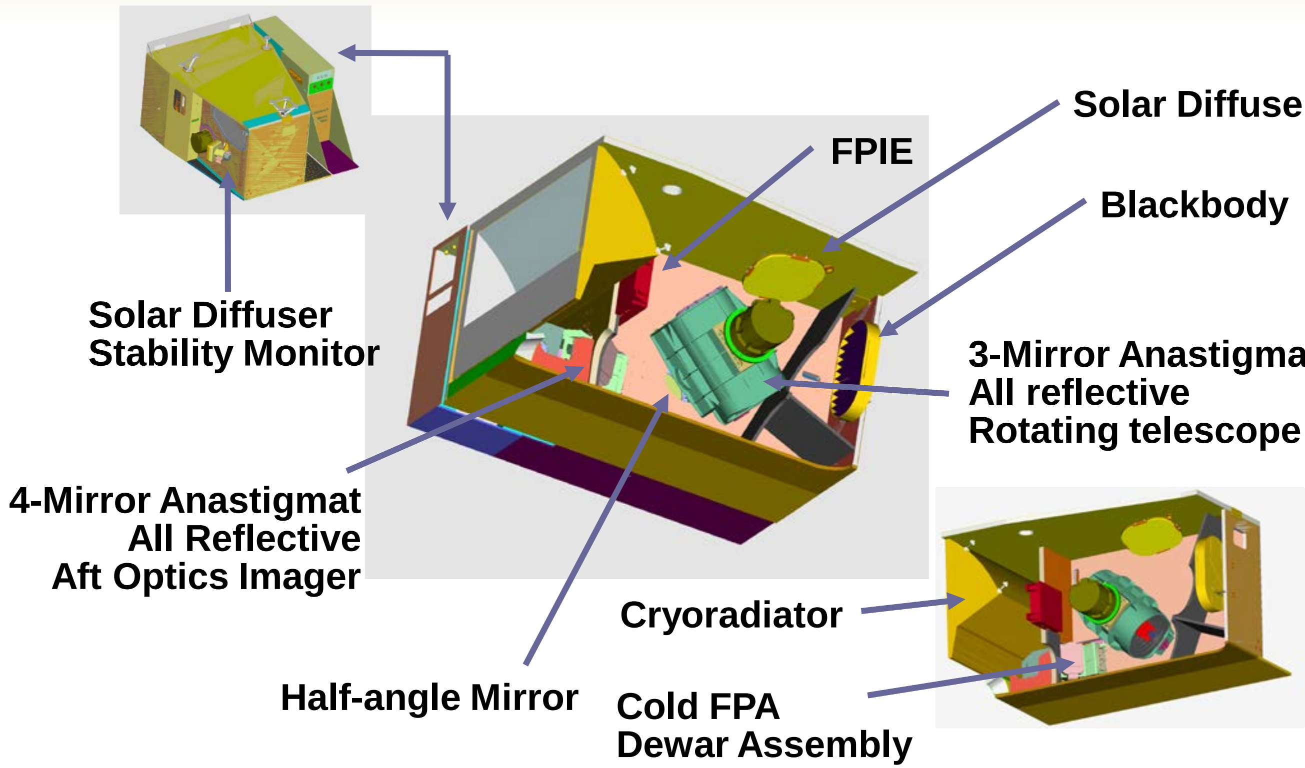
Pre-launch testing phases

Three major phases in pre-launch

- Component and Sub-system Level Testing
- Sensor Level Testing
  - Ambient
  - Pre-TVAC
  - TVAC
  - Post-TVAC
- Observatory Level Testing

Pre-launch testing overview

Complicated sensor such as VIIRS leads to a long list of tests

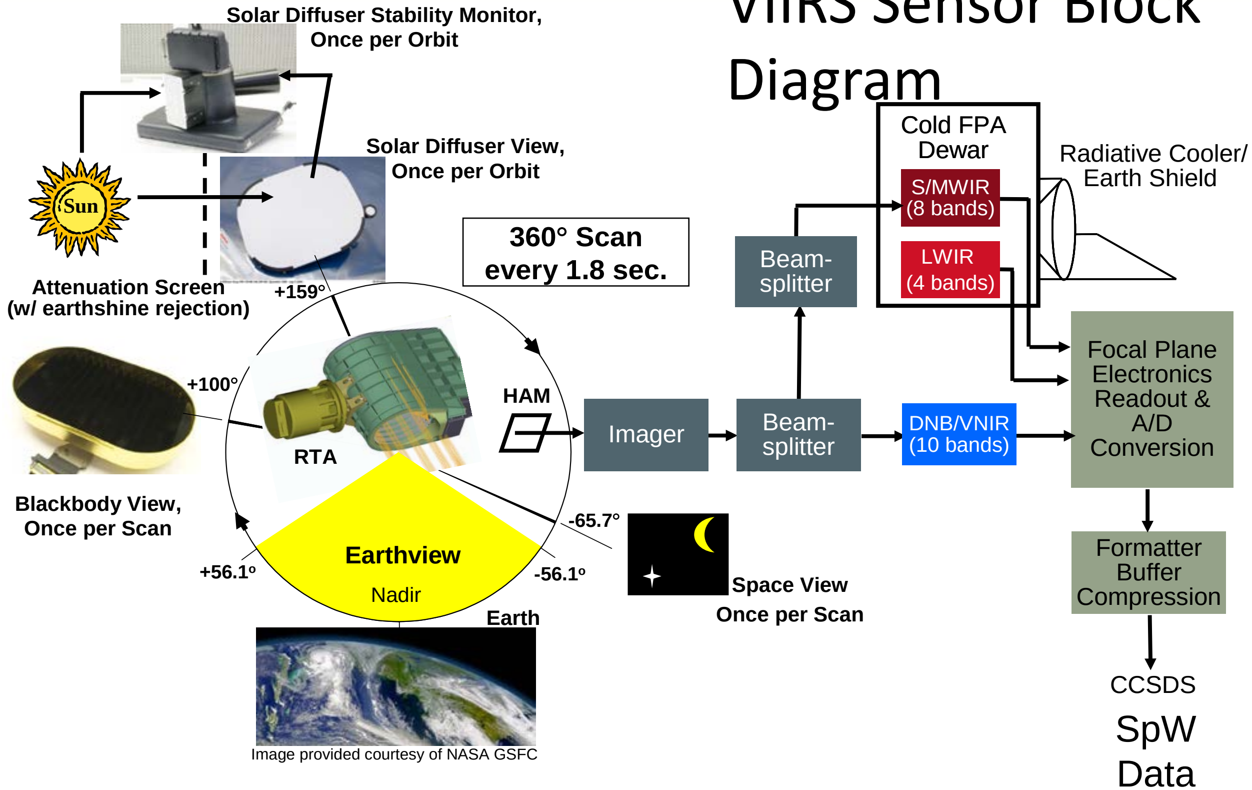


- Radiometric
  - SNR/NEdT, detector gains and dynamic range
- Spectral
  - In-band and out-of-band relative response
- Spatial and geometric
  - Band-to-band registration, modulation transfer function, and pointing

Prelaunch testing overview

Tests also included evaluation of the full system including onboard calibrators

VIIRS Sensor Block Diagram



- Thermal testing
- Electromagnetic interference
- Response versus scan-angle
- Solar diffuser and diffuser monitor screen transmission function
- Vibration testing
- Polarization sensitivity
- Blackbody emissivity
- Solar diffuser BRDF
- Stray light

Assessing sensor performance

Test data evaluated by sensor vendor (Raytheon SAS) and government teams

- Independent assessments as well as collaborative
- Government Team
  - Aerospace Corp.
  - U. of Wisconsin
  - NASA
  - NOAA

- Periodic reviews
  - Data Review Boards to evaluate results presented by sensor team
  - Data Analysis Working Group to evaluate results primarily from government team
  - Special technical interchange meetings
  - Regular briefing at NOAA VIIRS SDR meetings

Data Analysis Working Group

DAWG's sharing of J1 test finding with science community deserves a bit more attention

- Analysts from a range of government-funded organizations
- Provided independent examination of the J1 instrument test data
- Shared performance results and issues
  - NOAA and NASA subject matter experts (SMEs) for SDRs and EDRs
  - JPSS Project Science Office
  - Instrument vendor, Raytheon
- Gave early information on areas of J1 performance noncompliances

Overall results summary

Component, subsystem, and sensor level test results indicate J1 VIIRS data can meet our science objectives

- J1 and NPP VIIRS are not identical – good and not so good
- 15 waivers were approved prior to J1 shipment to the spacecraft vendor
- Items identified as key drivers for science:
    - SWIR nonlinearity at low light levels
    - Emissive band striping (noisy detectors, which do not require a waiver, impact this as well as detector to detector variability in RSR)
    - Dynamic Range (and rollover)
    - Near Field Response
- Issues found with J1 VIIRS are correctable with mitigation plans or will lead to acceptable impact

NPP versus J1

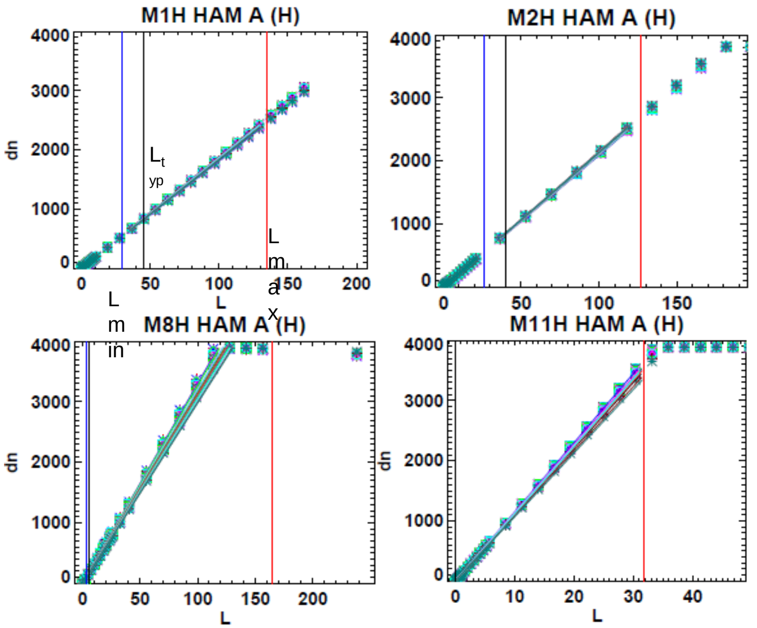
No two identical sensors behave identically as we learned from Landsat TM and MODIS

- Design changes between NPP and J1 VIIRS and build-to-build variations led to performance differences
- Optical changes made to coatings of RTA mirrors and dichroic give J1 better spatial stability
- Exposure of mirrors to tungsten was eliminated which should improve J1 SNR over sensor lifetime
- VisNIR Integrated Filter Coating changes were made
  - Reduced crosstalk and out-of-band light giving better defined relative spectral response
  - *Increased polarization sensitivity in Bands M1-M4*
- DNB and SWIR non-linearities are seen at low radiance for J1

RSB Radiometric Performance

Meeting nearly all requirements for SNR, dynamic range, and gain transition

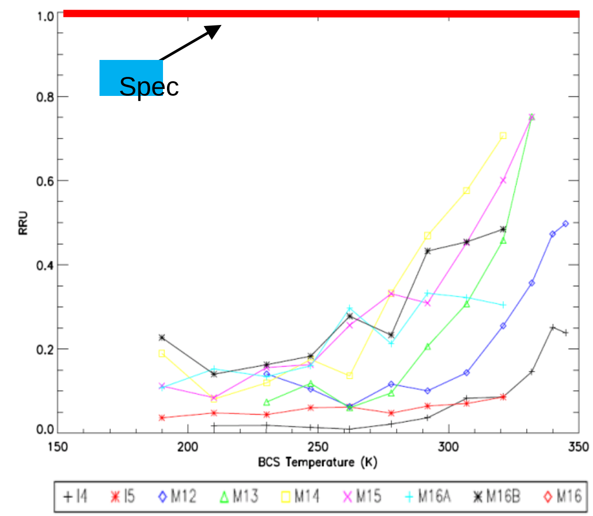
- **As good as S-NPP**
- Minor non-compliances for dynamic range
  - M8 (72%) and I3 (91%)
  - I3 Det4 is a bad detector (very noisy and lower responsivity)
- Shortwave bands non-linearity
  - High residuals at low radiance
  - Issue can be mitigated using higher order calibration equation
- DNB HGS/MGS non-linearity
  - Shown only at higher aggregation modes (22-32)
  - Altering aggregation approach can mitigate this



TEB Radiometric Performance

Meeting all requirements for NEdT, Dynamic Range, and non-linearity

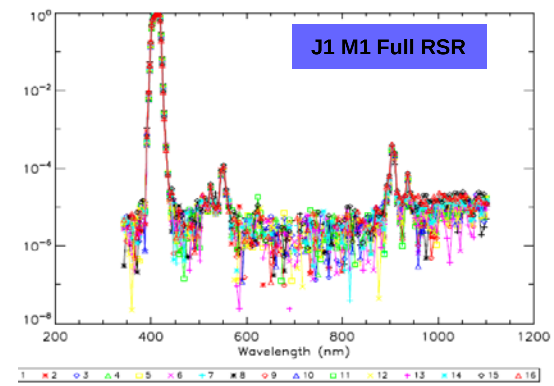
- Minor noncompliance issues include M12 not meeting the absolute radiometric calibration (ARD) at low temperature
  - Similar to SNPP
  - J1 also did not meet the characterization uncertainty for many bands
- Out of family detectors (higher noise) were identified
  - M16B D5 and M15 D4, are considered as low risk
  - Could result into striping in products such as SST

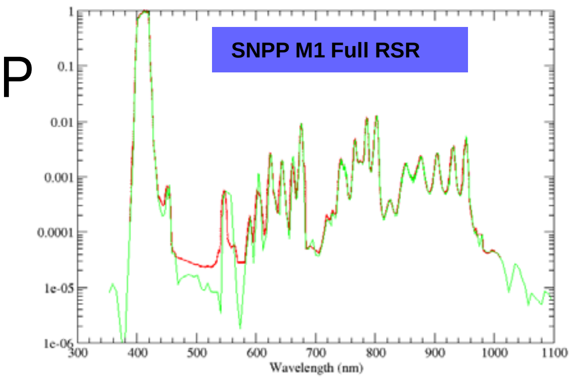


Sensor Spectral and Spatial Performance

J1 spectral performance is generally better than SNPP

- J1 RSRs Version 0 (V0) was released on 02/26/2015 by DAWG team with Version 1 (V1) in June 2015
- Future releases with TSIRCUS are also planned
- Electrical and optical crosstalk generated from spectral testing is comparable to SNPP performance
- No significant crosstalk effect has been seen to this point with S-NPP on-orbit data
- Spatial performance is overperforming on J1
- Band-to-band registration differences are now larger in track as opposed to cross-track





Waivers – why and what

Analysis of results showed several noncompliances that required waivers

- Ideally, sensor would meet all requirements
- Complexity of VIIRS sensor makes it difficult to achieve full compliance for all requirements at the same time
- The following options were essentially available to correct a non-compliance on J1
  - **Option 1:** Accept a waiver for use of J1 as is
  - **Option 2:** Change the requirement to encompass the existing performance for J1 and likely J2
  - **Option 3:** Hardware changes

J1 waivers handled through group effort

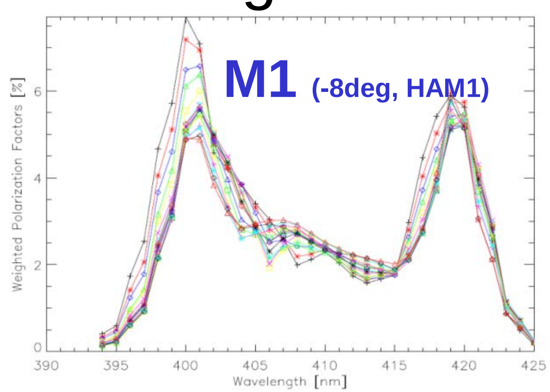
J1 waivers could be viewed as a success, at least from an analysis standpoint

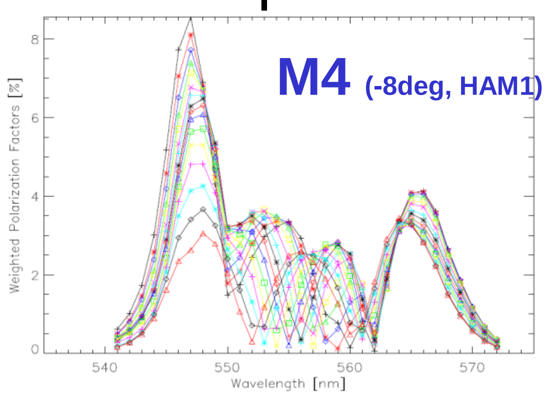
- Waiver Working Group was formed to evaluate the options for each waiver
- Formal process because requirements are contractual
  - Some are more important than others
  - Process attempts to ensure government spends its dollars on the non-trivial waivers
- Schedule was not favorable
  - Pre-ship review originally scheduled for mid-January 2015
  - Formal discussions of the Waiver Working Group began mid-November
- J1 Science community evaluated the waivers and proposed recommended options for each prior to the end of 2014

Waivers were not just accepted - no, really

Additional testing was recommended in several cases

- Added polarization testing provided data needed to implement an on-orbit polarization correction
  - Extension of original Raytheon tests
  - Inclusion of NIST's traveling laser-based source (TSIRCUS)
- Added tests to evaluate alternate approaches for operating the DNB to mitigate non-linearity
- TSIRCUS testing of ocean color spectral response





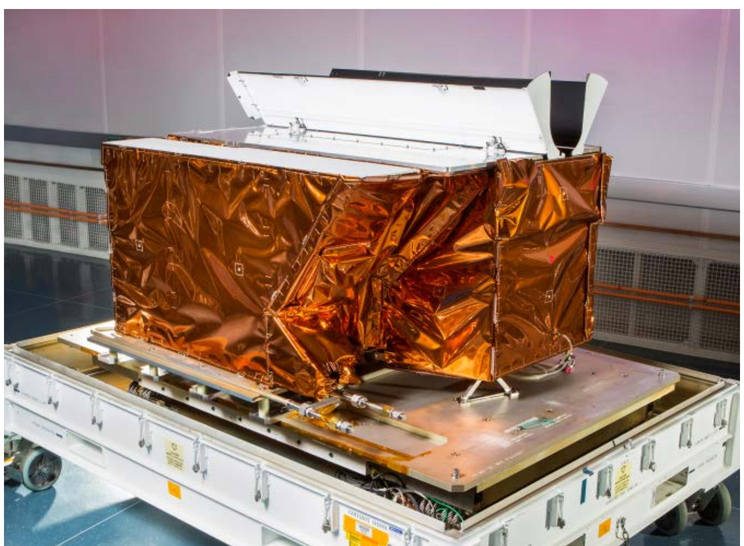
Waiver summary

- **Polarization sensitivity** – TSIRCUS and broadband results consistent and point to an on-orbit mitigation
- **RSR** - consistent with S-NPP and no major impacts to EDRs expected
- **Emissive bands** – similar behavior to S-NPP
- **BBR** – noncompliance from in-track direction, not scan
- **RSB - SWIR non-linearity -**Cubic equation to enhance radiometric performance
- **Spatial resolution** – waivered on the "better" side
- **Crosstalk -**J1 is better than S-NPP
- **DNB straylight** – additional testing was performed
- **DNB non-linearity** – additional testing was performed
- **Near-field response –** primarily due to conservative assessments regarding causes of optical scatter
- **Lmax -** Similar behavior as S-NPP but a bit worse from better optical performance of J1

Way forward

J1 Sensor (Shipped Feb 5th, 2015)

- Another round of testing early in 2016
- Another round of telecons and reviews as well
- Present the results at next year's meeting



Raytheon/NASA Team – Sensor Shipping from RTN

VIIRS J1 installation on the Spacecraft

J1 VIIRS Waiver Mitigations

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ERT Inc & NOAA/NESDIS/STAR

August 26, 2015

Outline

- Overview of J1 VIIRS waivers
- Objectives
- J1 VIIRS waiver mitigations
  - VIIRS GEO code change to accommodate J1 DNB AggMode change
  - DNB stray light correction
  - Assessing impact of J1 polarization sensitivity on SDR
  - Other J1 waiver mitigation efforts
- Summary & future work

J1 VIIRS Waivers Overview

- The Joint Polar Satellite System (JPSS-1, J1) satellite is scheduled to be launched in early 2017.
- J1 VIIRS sensor performance exceeds/meets requirements in most cases.
- Non compliances are addressed in performance waivers and their impact assessments

J1 VIIRS Waivers Overview

J1 Waivers	Description	Impacts
DNB Non-linearity	High nonlinearity in radiometric response especially at edge of scan	Major Require aggregation mode change (Op21, Op21/26) → Require GEO code change
DNB Stray Light	When VIIRS itself is sunlit and DNB is viewing night side of the earth	Major; same methodology used for S-NPP can be adapted to make corrections
Polarization Sensitivity	Linear polarization sensitivity (M1-M4)	Moderate Degraded OC/aerosols products Striping
SWIR non-linearity and uncertainty	SWIR M-bands at low radiance	Minor for AOT; Major for OC, esp. in coastal zones; SDR Science code change required to improve calibration accuracy
Emissive band radiometric calibration	RRU: M12, M13(HG), & M14 RRCU: M12 & I5	Minor Cloud, cryosphere products Striping ; low temperature bias

J1 VIIRS Waivers Overview

J1 Waivers	Description	Impacts
Spatial Resolution-DFOV	J1 smaller DFOV due to normal sensor-to sensor build variability	Minor; AF detection & consistency btw satellites
Spatial Resolution -MTF	M1-M7/M13	Major; AF, coastal OC may be impacted
Crosstalk	Dominated by static electrical crosstalk	Moderate on OC
Near Field Response (NFR)	M7, M13, M16A; I3	Moderate for AF Minor for OC
Dynamic Range	M5LG, **M8**, M9, M10, M11, I1, **I3**, and I4 saturation; DNB	Minor for Nightfire; moderate for AF, COP, cloud mask and down-stream products
Relative Spectral Response (RSR)	Mainly in several SWIR&LWIR bandpass/center wavelength	Small; Potential inconsistency in time series compared to S-NPP
Band-to-Band Registration (BBR)	Dominated by in-track registration; I-bands	Minor; potential impact on cloud mask & AF product

J1 VIIRS Waivers Overview

- J1 waivers has been discussed extensively and their impacts have been studied by VIIRS SDR & EDR teams:
  - Most waivers have small to negligible impacts on EDR performance;
  - Certain waivers need to be mitigated at the SDR level and require science code change;
  - The remaining waivers are mitigated at the EDR level.

Objectives

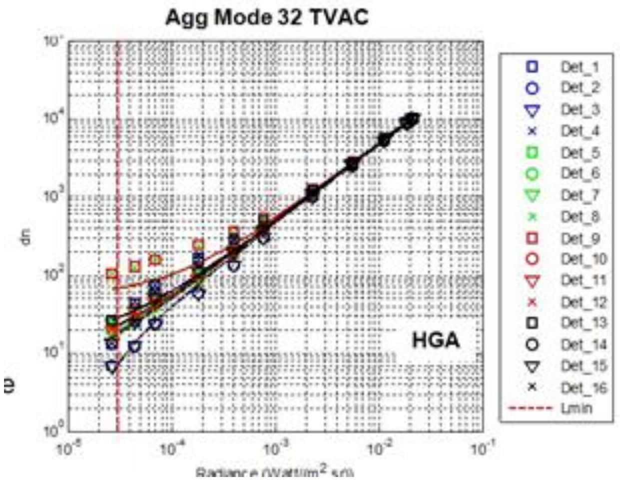
STAR VIIRS SDR Team's efforts to mitigate J1 waivers

- VIIRS GEO code change to accommodate DNB AggMode change
- DNB stray light correction
- Assessing impact of J1 polarization sensitivity on SDR products
- Other waiver mitigation efforts

VIIRS GEO Code Change
-DNB non-linearity waiver

- J1 VIIRS DNB has high nonlinearity in radiometric response especially at edge of scan based on prelaunch tests, which is different from the behavior of the SNPP VIIRS

- Two options have been proposed by the J1 data working group:
  - **Op21 (Baseline)**
    Extend AggMode 21 up to 32
  - **Op21/26**
    Extend AggMode 21 up to 25
    Extend AggMode 26 up to 32



VIIRS GEO Code Change

- SNPP SDR science code analysis indicates that VIIRS radiometric calibration code does not require a modification for J1

- However, current geolocation code cannot deal with the new J1 aggregation schemes properly
  - J1 DNB aggregation zones are **asymmetric**, different from SNPP
  - **Hard-coded** DNB EV nadir frame # & aggregation zones

- Without code change, J1 DNB geolocation products will not be generated correctly

J1 VIIRS GEO Code Change Scheme

- Using Block 2 ADL as baseline
- The dimensions of GEO-DNB-PARAM-LUT are unchanged
  - Contents are updated for J1
- Modify code to accommodate J1 DNB aggregation mode change
  - Does not change the core of VIIRS geolocation algorithm
  - Derives correct agg. zone & nadir frame # solely from geoParams LUTs
- The modified code is designed to be backward compatible with SNPP and supports both Op21 and Op21/26 for J1

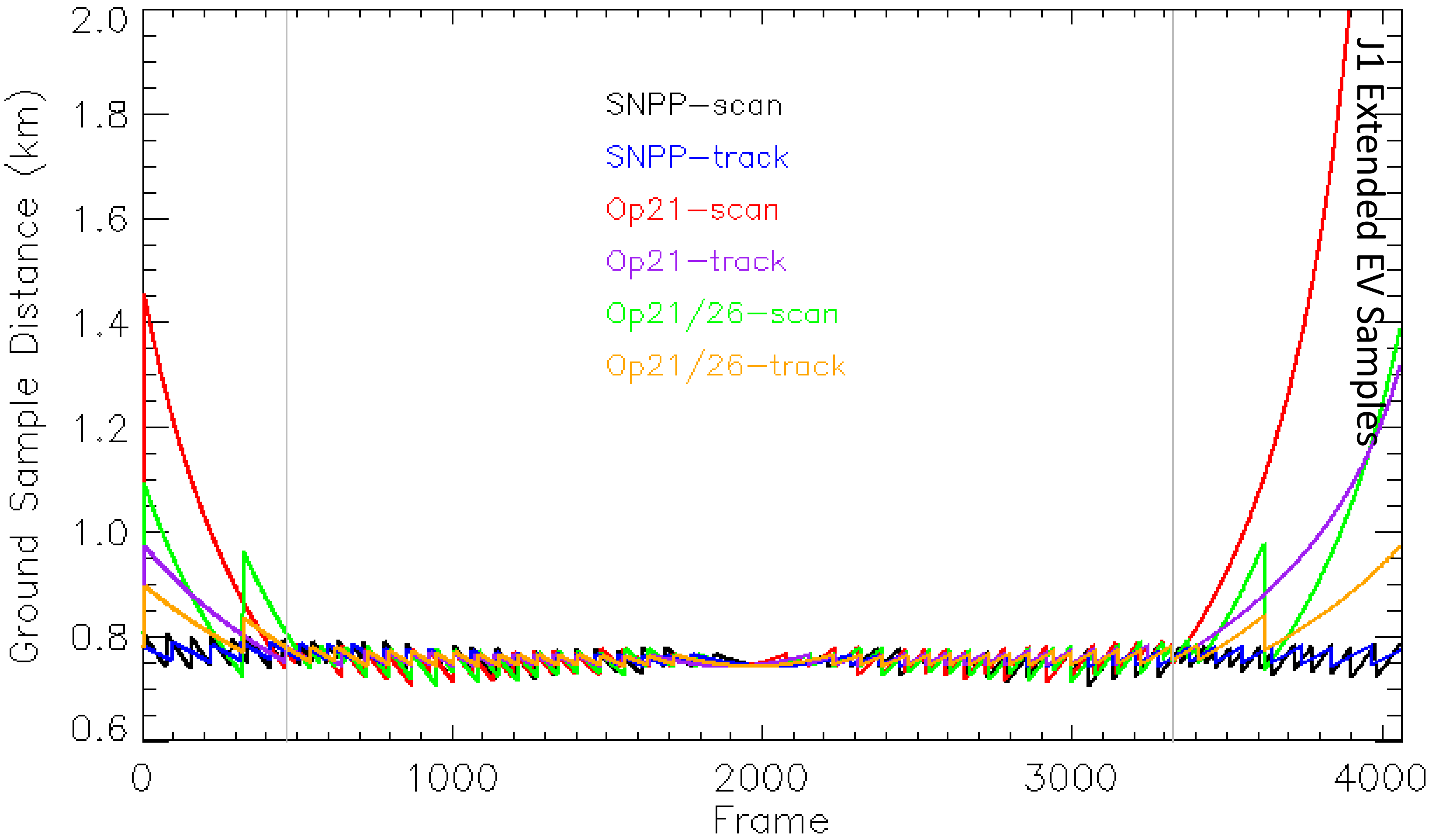
Scope of VIIRS GEO Code

Files	Changes
GEO_determine_DNB_sample_time_offsets.cpp	1. Determine DNB sample time offsets
GEO_interpolate_mirror_encoder.cpp ***GEO_interpolate_telescope_encoder.cpp***	2. Extrapolating of encoder data
ProSdrViirsGeoDataStructs.h ***GEO_process_parameters.cpp*** *fixSatAngles.cpp* *ProSdrViirsGeo.cpp* *geolocateDecim.cpp* *geolocateAllRecPix.cpp*	3. Hard-coded nadir frame #
GEO_parameters.h *ProViirsGeoRectangle.h* *ProGeoloc_createInterpRectangles.cpp* *calcModFromImg.cpp* *geolocateGranule.cpp*	4. Interpolation rectangles

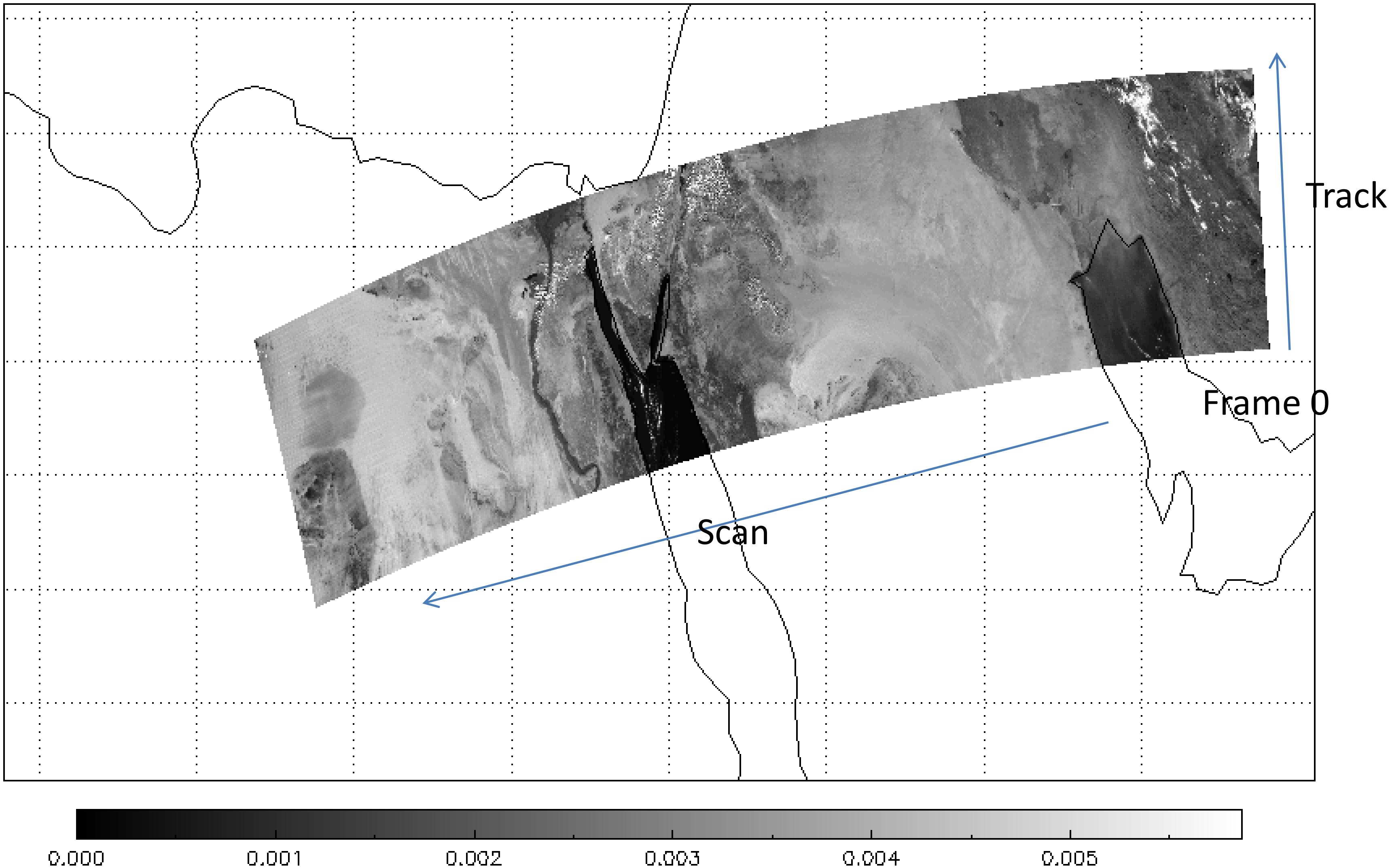
Files with red color have relatively more changes.

- Totally 14 files were modified (~165 lines)

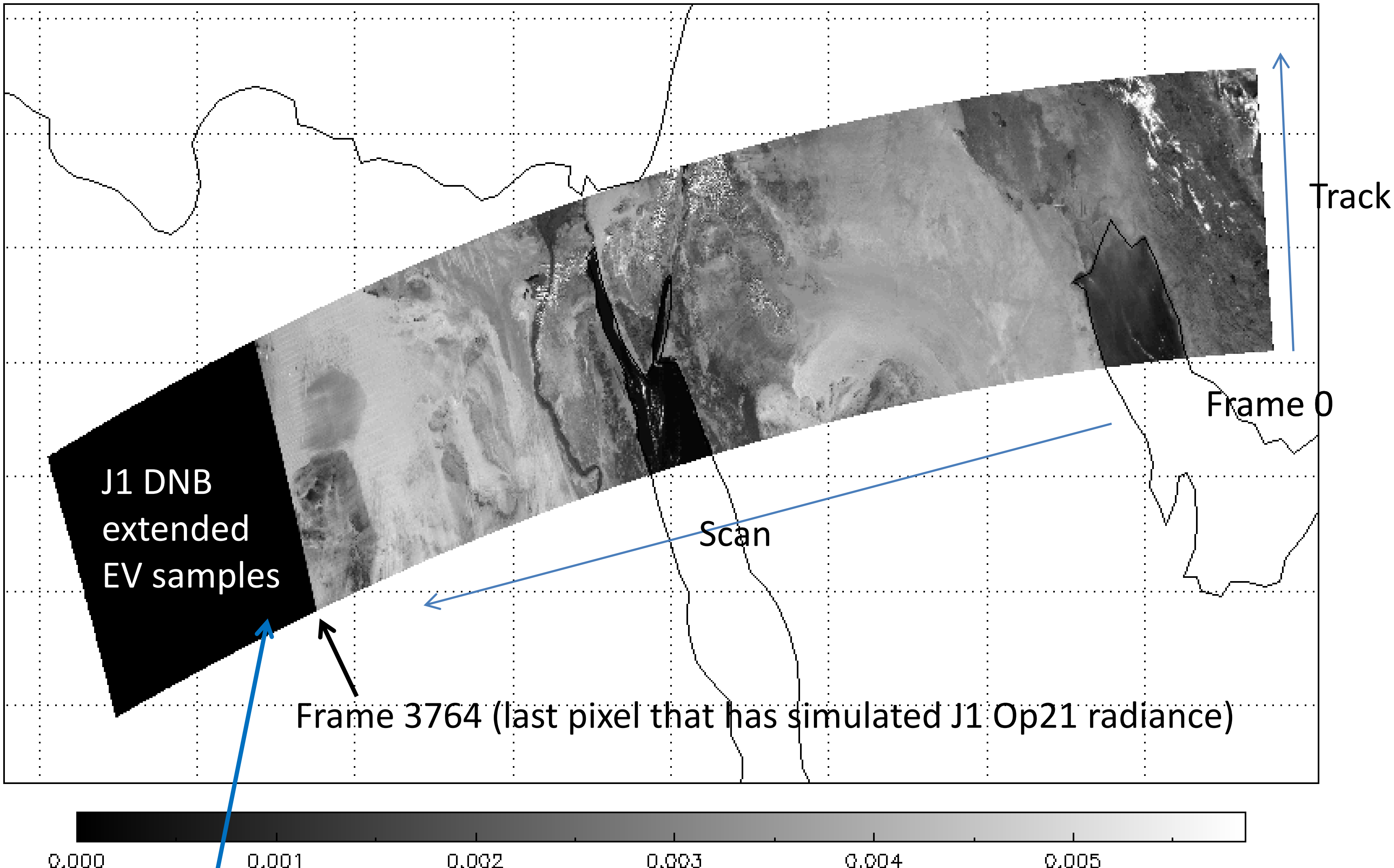
SNPP , Op21, Op21/26



Original SNPP Radiance

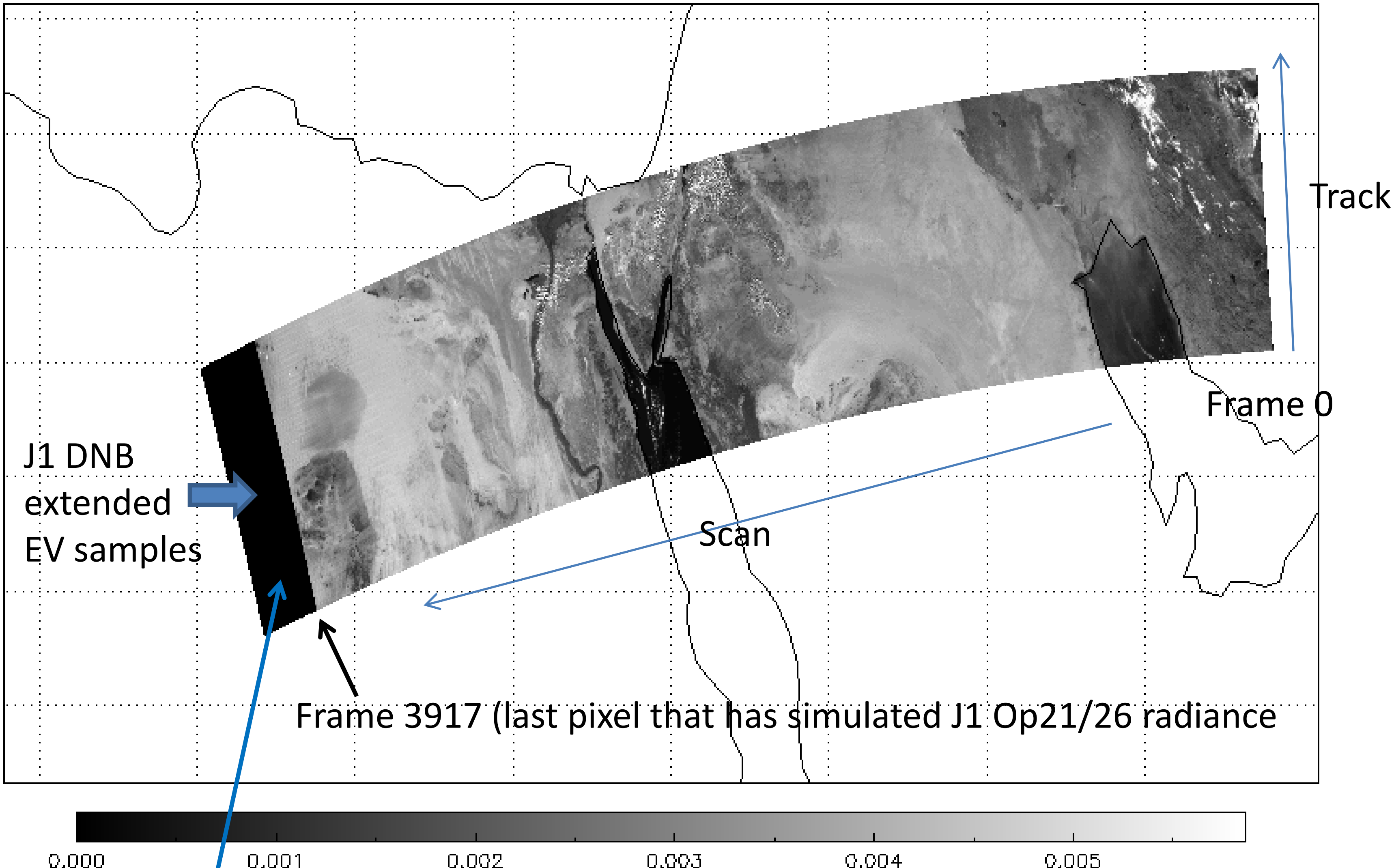


J1 Code Change (J1 Op21)



After frame 3805, lat/lon are calculated using extrapolated encoder data

J1 Code Change (J1 Op21/26)

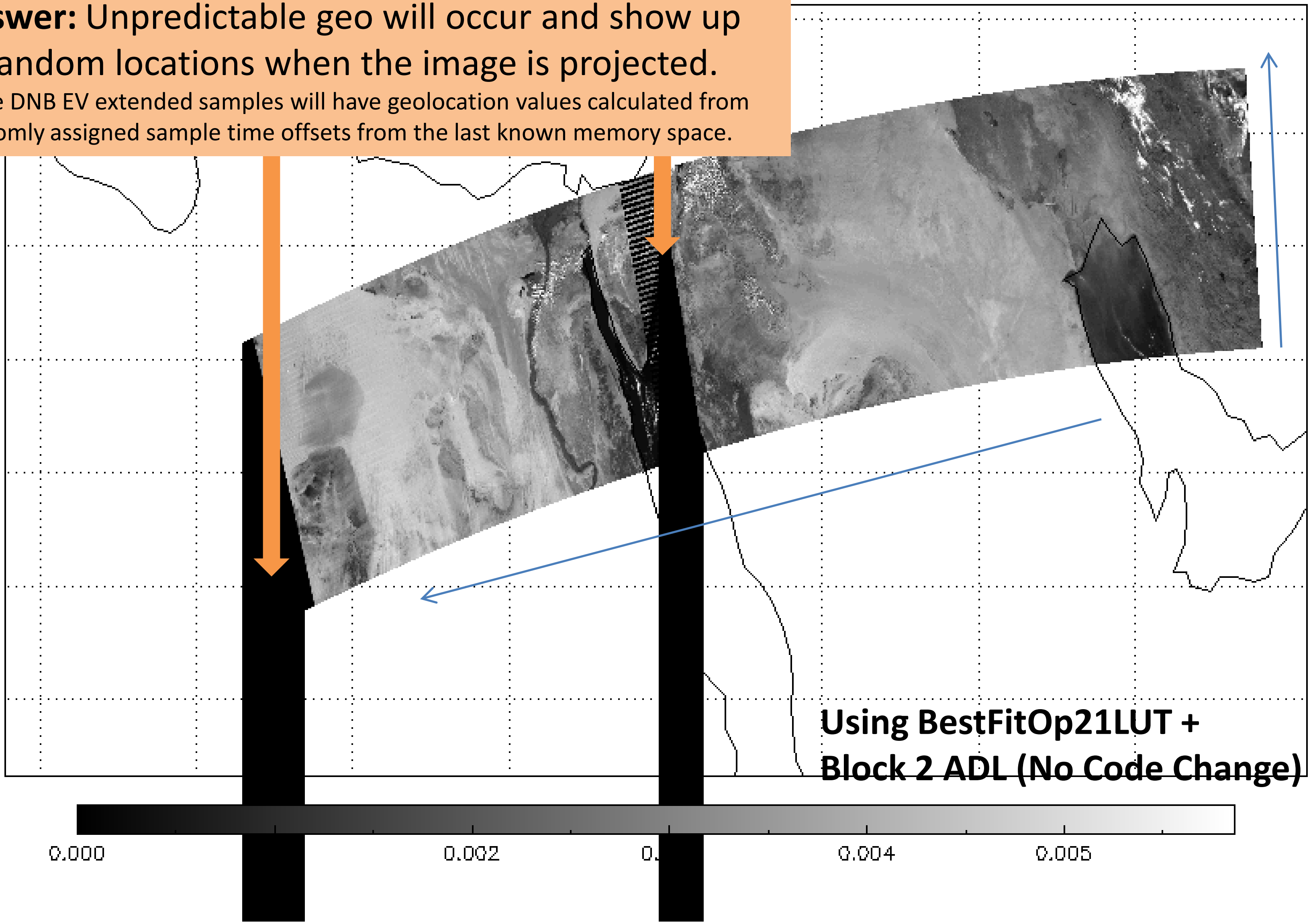


After frame 3972, lat/lon are calculated using extrapolated encoder data

What if the GEO code is not changed?

Answer: Unpredictable geo will occur and show up in random locations when the image is projected.

Some DNB EV extended samples will have geolocation values calculated from randomly assigned sample time offsets from the last known memory space.



Status of VIIRS GEO Code Change

- **STAR VIIRS SDR team has successfully completed the GEO code change package.**
  - Tested using Block 2 ADL and simulated J1 RDRs & SDRs.

- **The package was peer-reviewed by NASA VCST, Aerospace, Raytheon, and the STAR VIIRS SDR team**

- **It has been tested by STAR AIT and delivered to DPE on schedule (Aug 7, 2015) for further test and integration.**

DNB Stray Light Correction

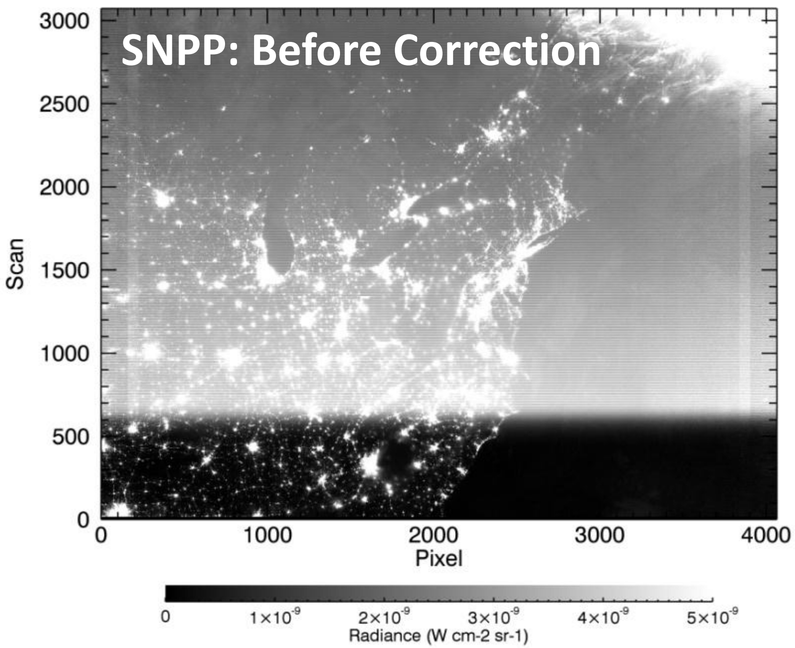
- **SNPP DNB observations are affected by stray light.**
  - Especially at high latitude
  - Can affect regions as south as 33º latitude in the NH during summer.

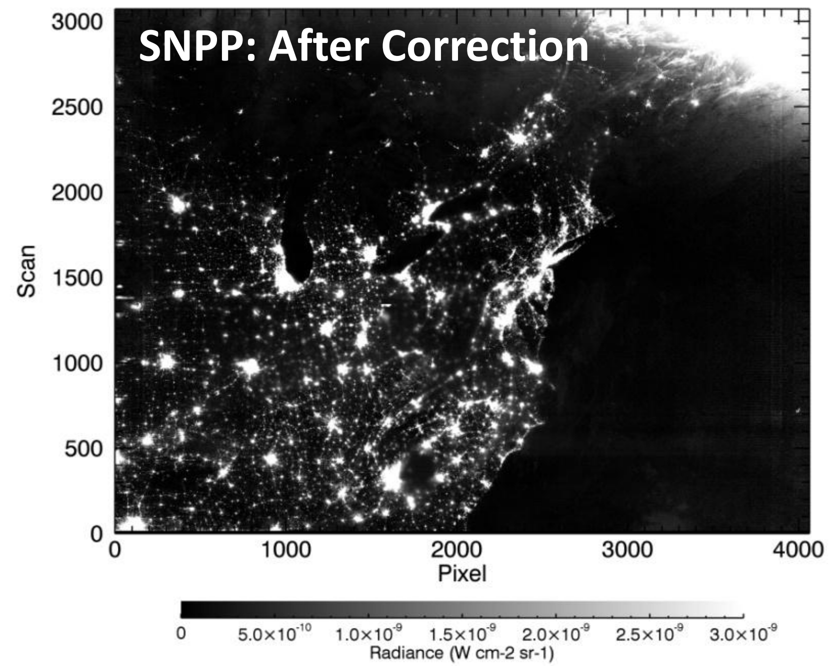
- **NG developed methodology for SNPP DNB stray light correction (adopted by IDPS for operational processing)**

- **STAR successfully transitioned the SNPP DNB Stray Light correction from NG to STAR in 2014**

- **STAR has been supporting operational stray light LUT updates with solar vector error correction since January 2015.**

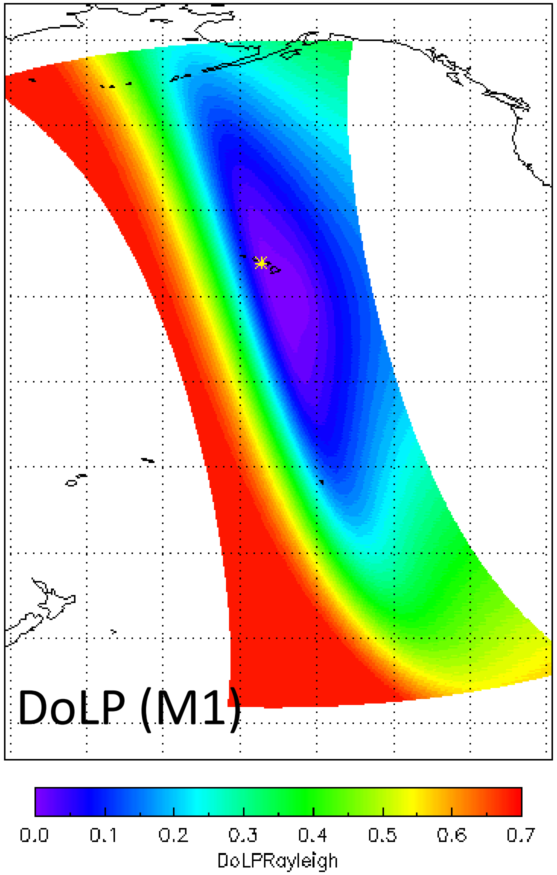
DNB Stray Light Correction





- J1 VIIRS DNB is expected to have similar stray light issue as SNPP.
- SNPP stray light correction tool may need to be modified due to J1 DNB aggregation mode change. STAR will further investigate the issue after J1 is launched.

Impacts of J1 VIIRS Polarization Sensitivity on SDR



- The impacts of J1 VIIRS polarization sensitivity were analyzed using:
  - prelaunch polarization characterization data by NASA VCST
  - 6SV simulated clear-sky DoLP for a NPP VIIRS orbit over the Pacific Ocean
  - Polarization correction algorithm ([Meister et al. 2005](#))

Impacts of J1 VIIRS Polarization Sensitivity on SDR

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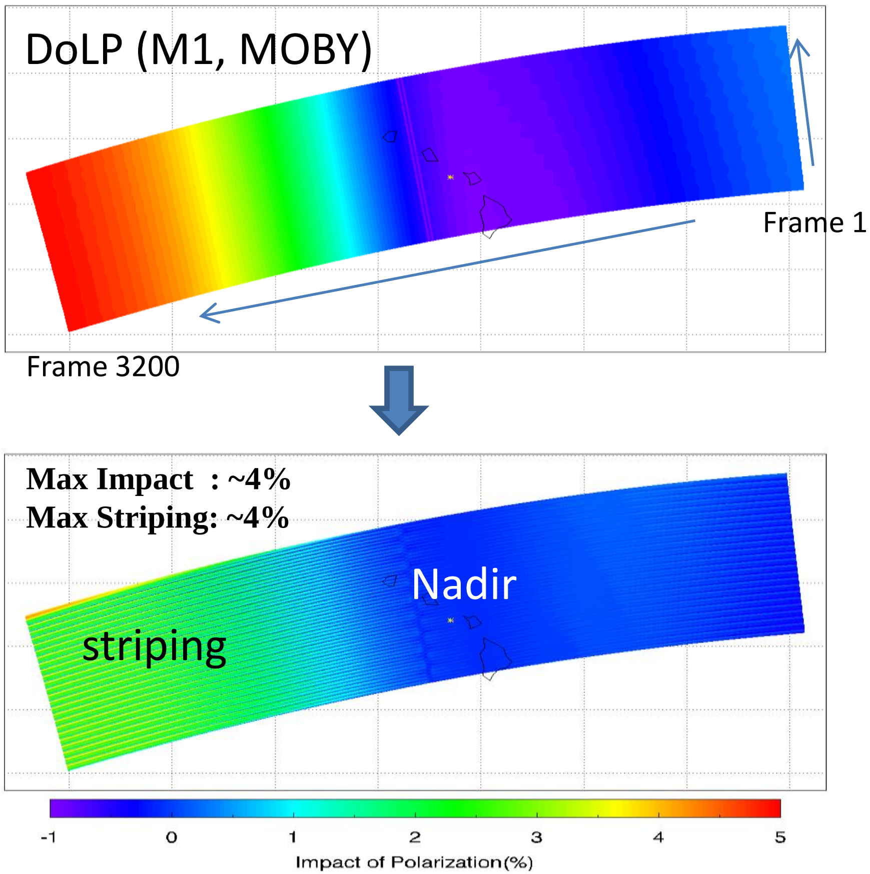


- **The impact on band M1 TOA reflectance may be as large as ~4%.**
- **Band M1 Stripping due to HAM-side/detector level polarization sensitivity differences may also be ~4%.**

Other J1 Waiver Mitigation Efforts

- Dual calibration for SWIR
  - Completed radiometric calibration code analysis
  - Proposed dual calibration methodology to mitigate SWIR non-linearity waiver

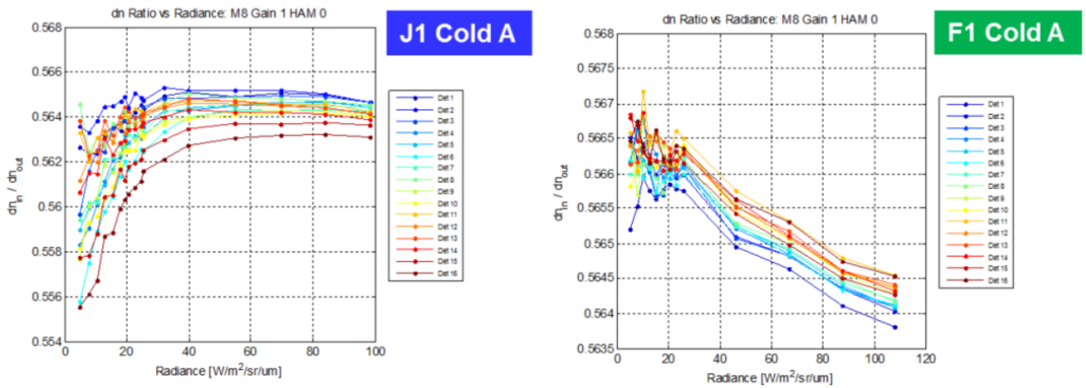


Figure 1, Ratio of sensor response value (dn) for attenuator in to attenuator out for J1 (left) and NPP (right).

Courtesy of Raytheon

Other J1 Waiver Mitigation Efforts

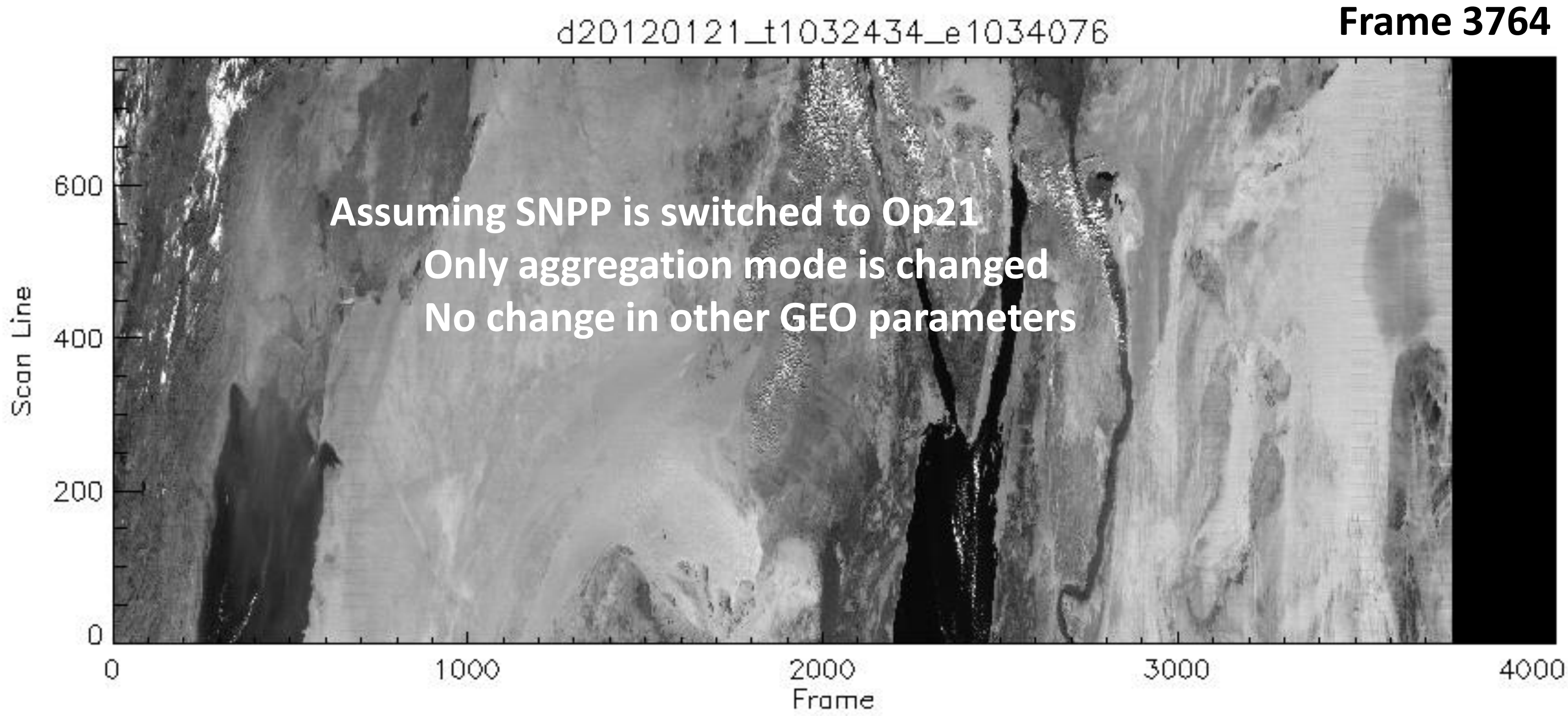
- Block 2 ADL testing
  - Successfully supported J1 GEO code change testing
  - Successfully supported J1 pre-launch DNB calibration/geolocation LUTs (Op21 & Op21/26) testing;

- Cooperated closely with the Raytheon Test Data Working Group (TDWG)
  - MDR_28: simulated J1 RDRs using SNPP radiance
  - MDR_39: J1 RDRs based on FP-X test data (DNB Op21, Op21/26)

- STAR simulated J1 DNB radiances using in-house tools
  - Simulated J1 DNB aggregation (along scan direction) using SNPP radiance
  - Used in GEO code change science test
  - May also useful for DNB NCC imagery EDR (DNB nonlinearity waiver mitigation)

Simulated J1 Op21 DNB Radiance

Using NPP Radiance + Agg zone data from NPP and J1 Op21



Note: this method can simulate Op21 effect in the scan direction,
But cannot simulate the Op21 effect in the track direction, also cannot simulate J1 DNB non-linearity effect.

No simulated J1 Op21 radiances after frame 3764, set to 0.

Summary and Future Works

- **STAR VIIRS SDR Team has provided strong supports for J1 VIIRS waiver mitigations.**
  - Successfully completed VIIRS GEO code change package and delivered on schedule;
  - Successfully completed the transition of DNB stray light correction from NG to STAR;
  - Assessed the impacts of J1 polarization sensitivity on SDR;
  - Obtained strong Block 2 ADL testing capabilities

- **Next Step: continue to support J1 VIIRS waiver mitigations**
  - Dual calibration for SWIR nonlinearity mitigation research;
  - Adapt SNPP DNB stray light correction methodology to J1;
  - Support other waiver mitigations, such as M8/M9/I3 saturation;
  - Assess the impact of noisy detector (I3, D4).

J1 VIIRS DNB Unique Features

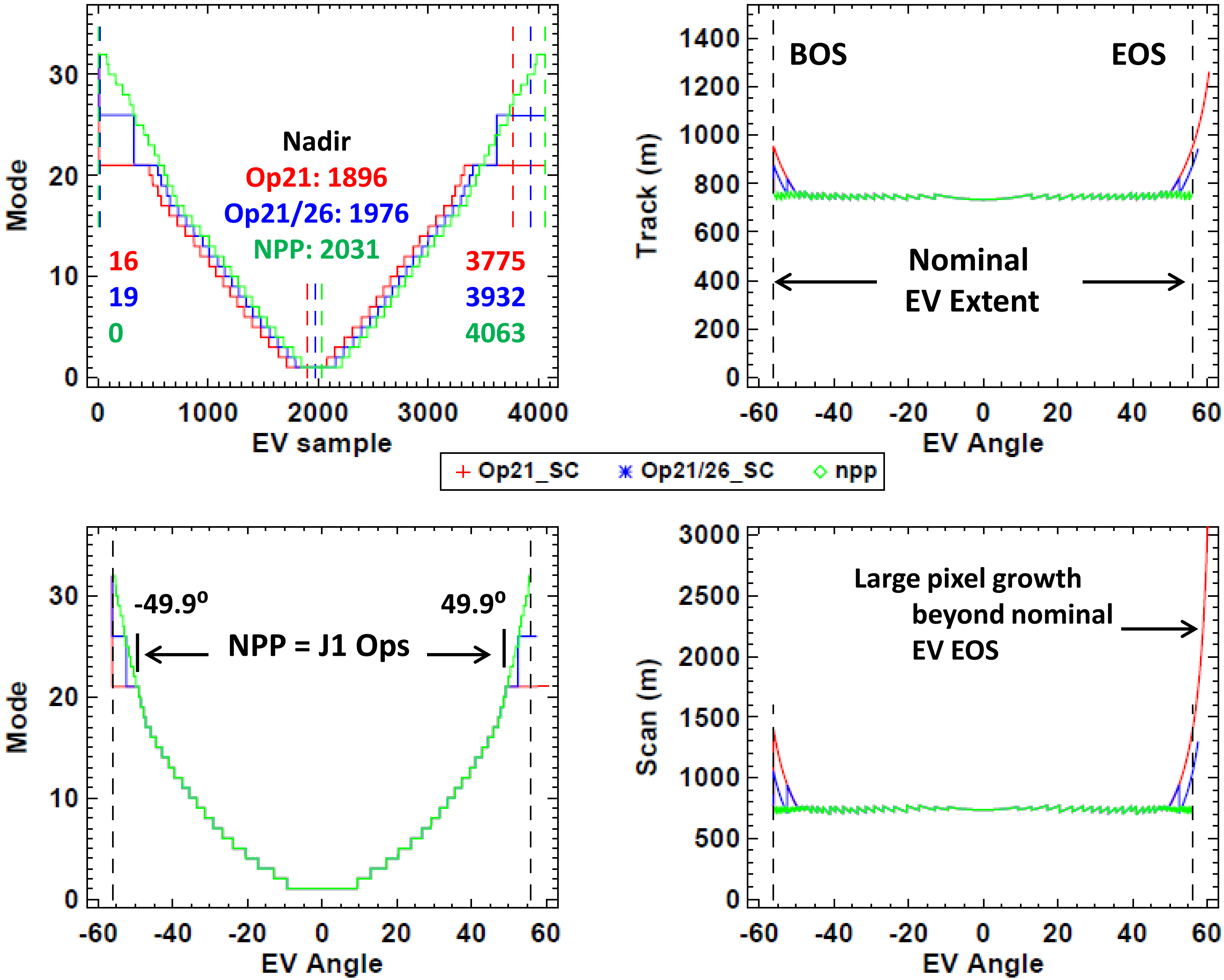
Shihyan Lee
SSAI/JPSS

Aug 26, 2015

Outline

- Cause: J1 DNB radiometric nonlinearity
- Mitigation: remove DNB agg mode with severe nonlinear behavior
  - J1 Op21: J1 DNB Aggregation Option 21
  - J1 Op21/26: J1 DNB Aggregation Option 21/26
  - NPP vs. J1 options
- Impact:
  - Imagery
  - Calibration

J1 DNB Aggregation Options

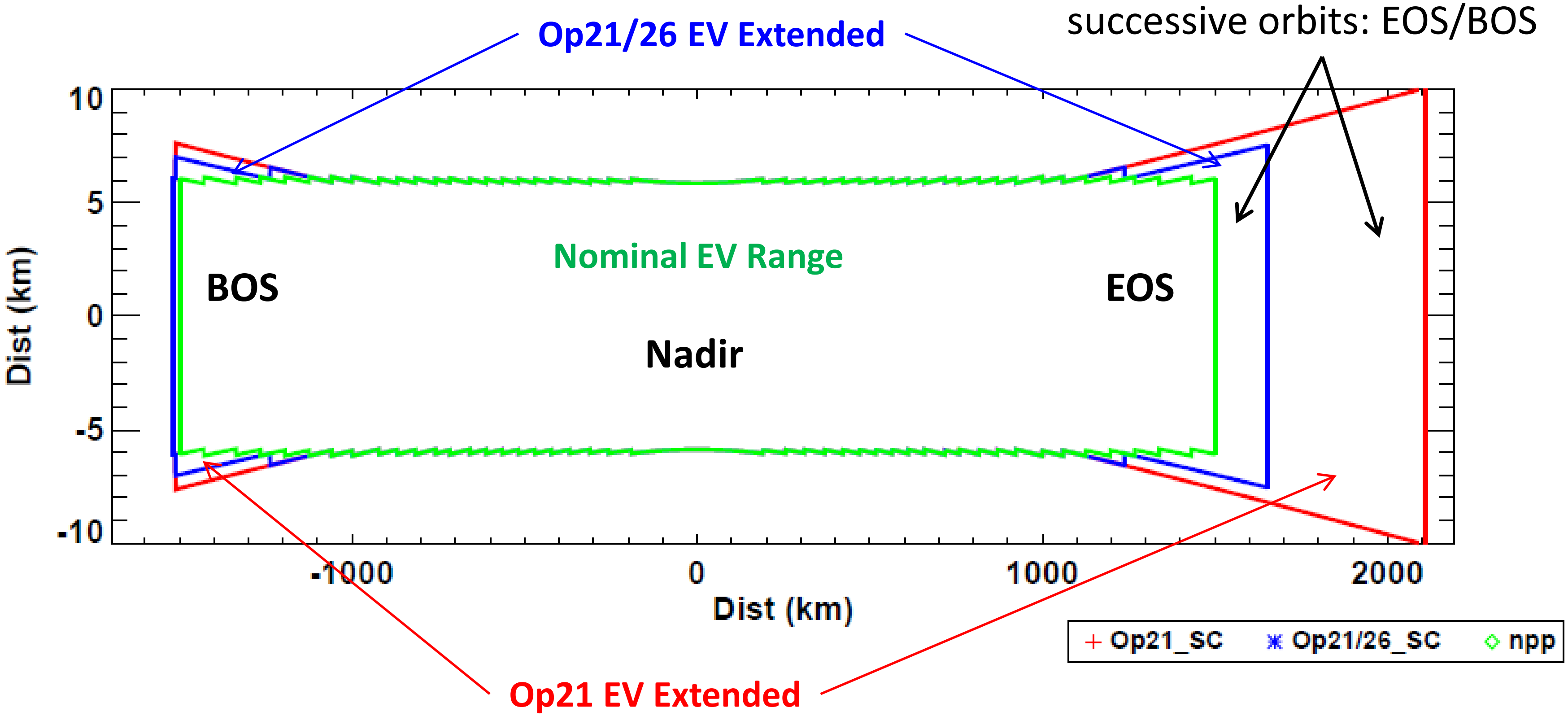


Simulated DNB EV pixel growth based on nominal parameters

J1 DNB Options EV Extent

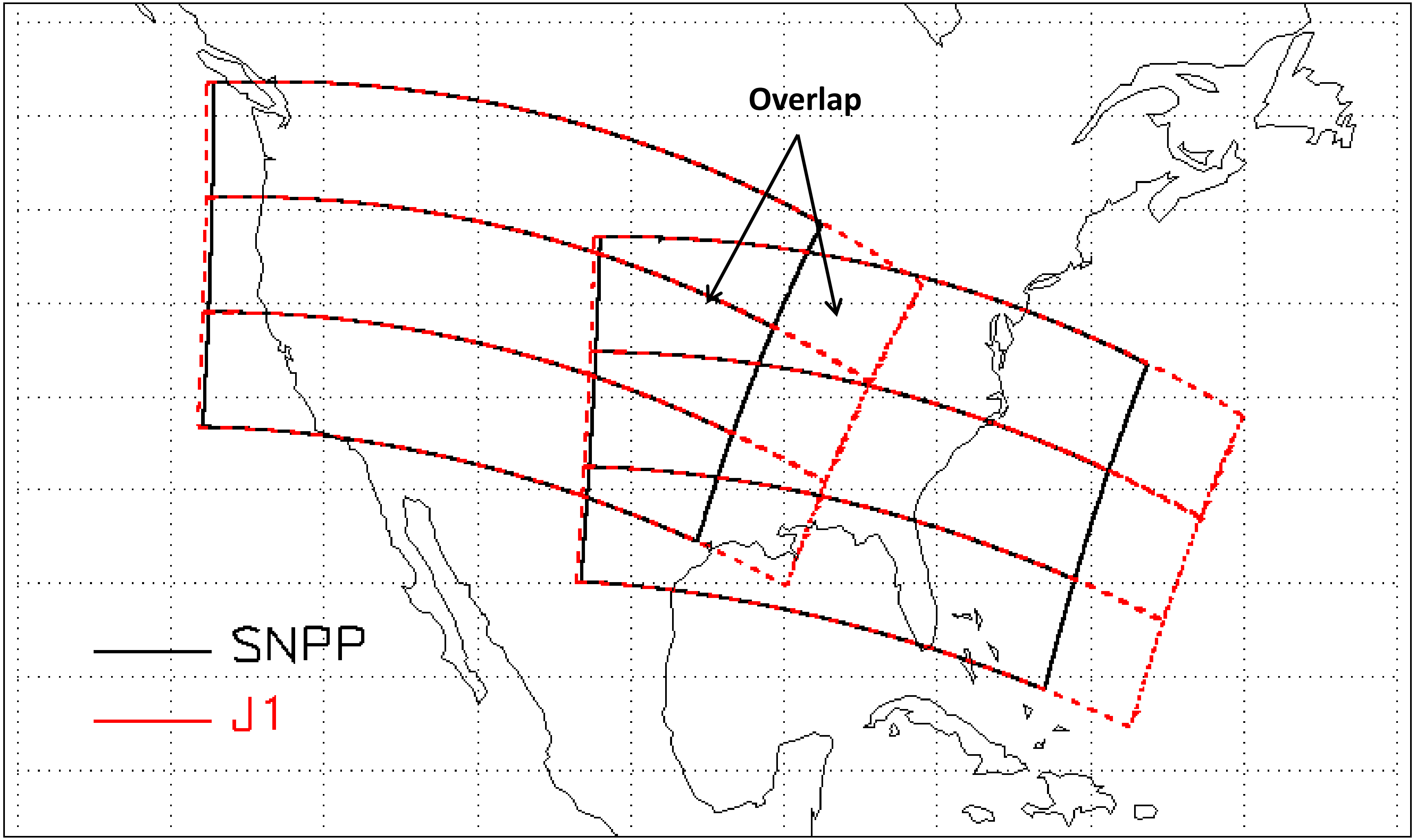
Simulated DNB EV data extents

Reduced resolution at high scan angles
Increase coverage overlaps:
successive scans: Bowtie
successive orbits: EOS/BOS

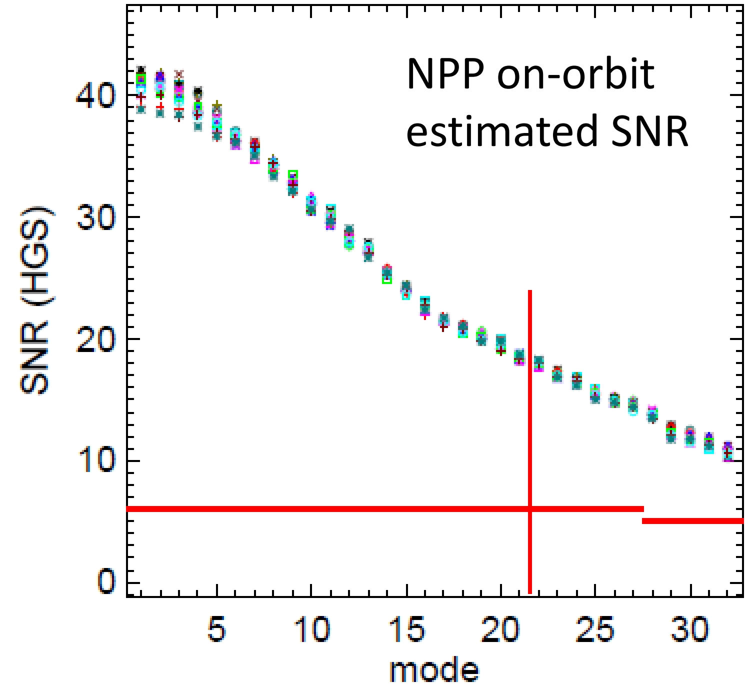


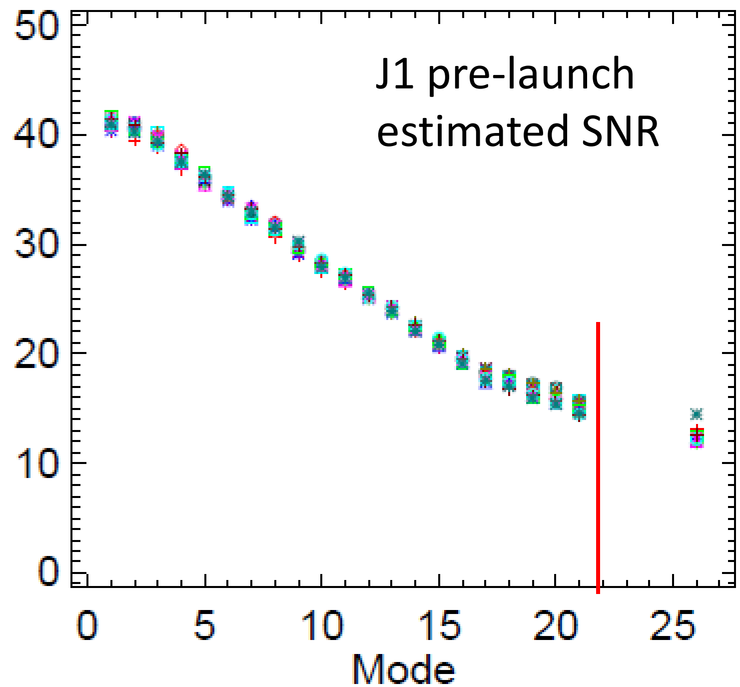
J1 DNB EV Extended pixels can be turn on/off by LUT updates

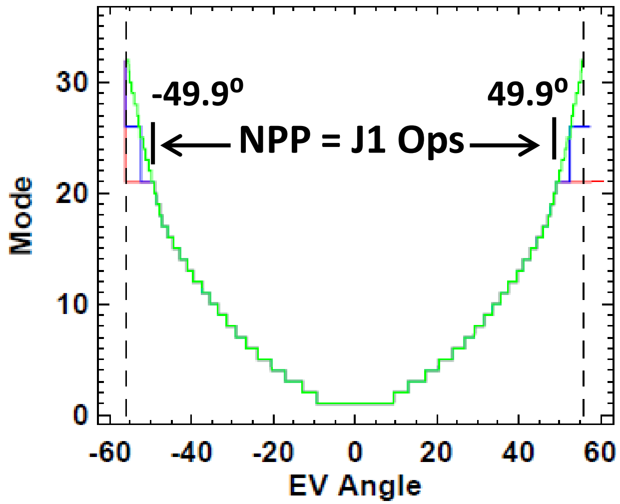
J1 DNB Options EV Extent



DNB SNR: NPP vs. J1







- J1 DNB Options vs NPP at high scan angles:
  - lower spatial resolution
  - higher SNR

SDR Calibration: J1 Options

DNB_Frame_to_zone*

DNB_LGS_Gain
DNB_Gain_Ratios

$$L = (DN - DN0) * DNB\_Coef * DNB\_RVF$$

DNB-RVF*

DNB_DN0*
DNB_DN0_sat*
VIIRS-SDR-CAL-AUTOMATE
-DNB_Dark_signal_ref
-DNB_Moon_illumination

DNB_Frame_to_zone
- Define EV pixel DNB aggregation mode

DNB_DN0
- EV pixel based offset

DNB_DN0_sat
- (Uploaded) on-board EV pixel based offset

DNB_RVF
- EV pixel based RVS

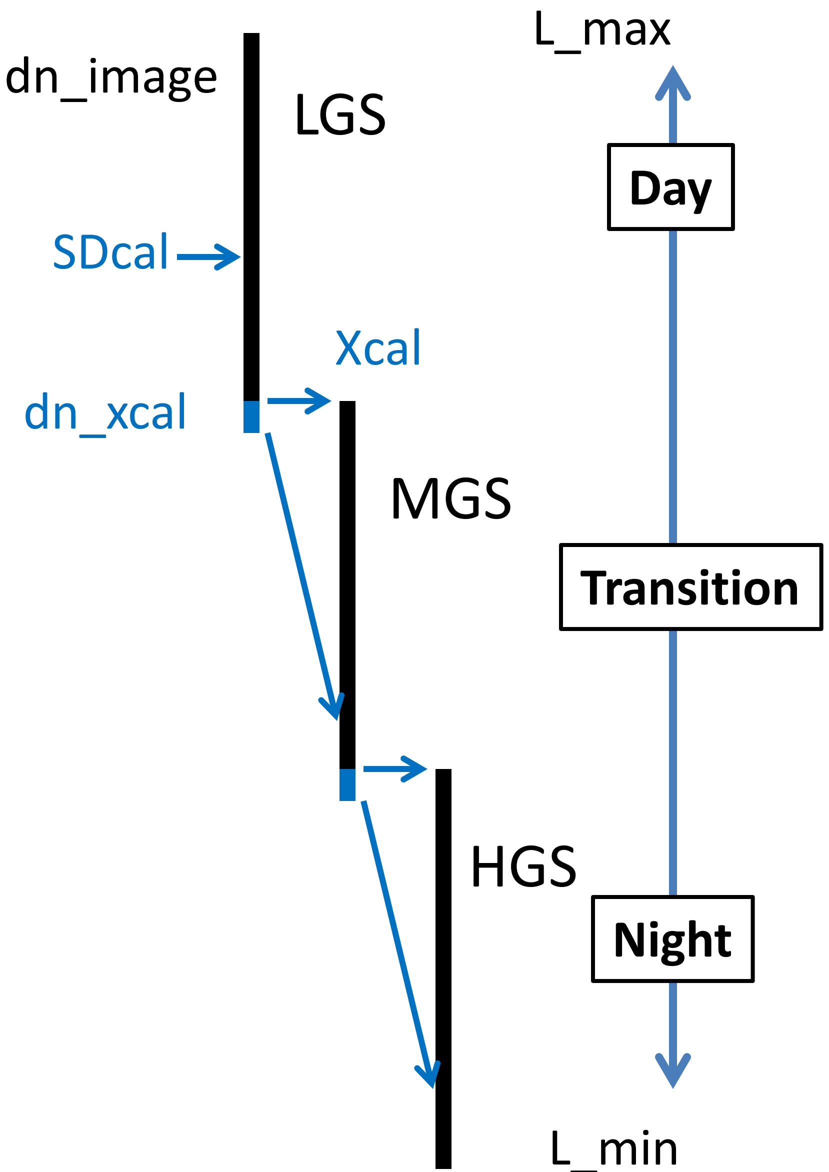
DNB_Dark_signal_ref
- OBC mode based offset

DNB_Moon_illumination
- Moon illumination used to select OBC dark data

DNB_LGS_Gain, DNB_Gain_Ratios

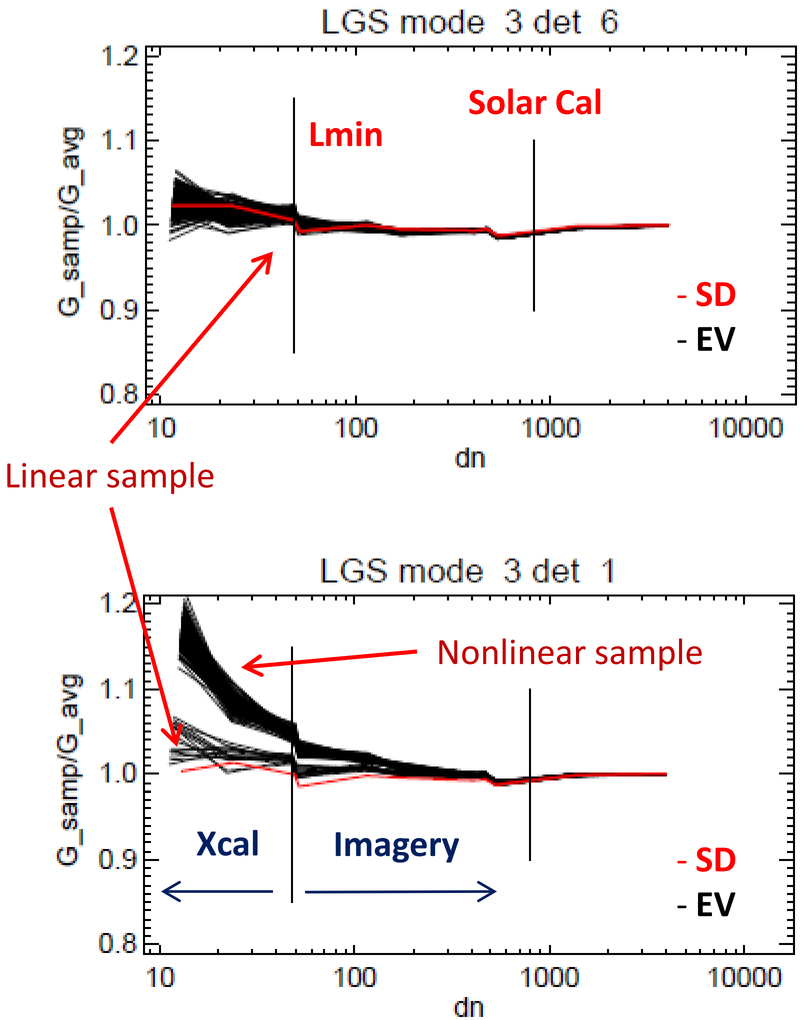
*** DNB Option specific LUT needed**

DNB On-Orbit Cal & SDR



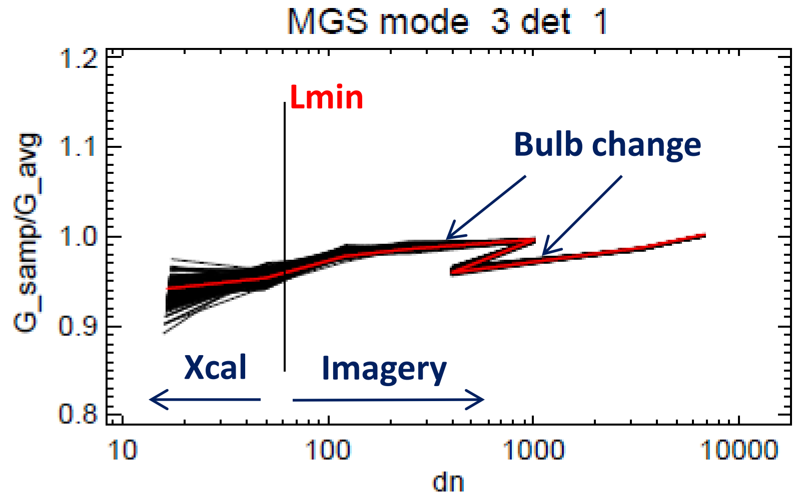
- Three gain stages
- LGS gain:
  - SD during Solar Calibration
  - SD vs. EV gain at SD cal?
  - EV gain linearity?
- MGS and HGS gain:
  - Gain transfer using transitional signal (Xcal)
  - MGS = LGS * MGS/LGS
  - gain ratios determined by EV vs. SD?
- Nonlinearity
  - dn_xcal: Xcal
  - dn_image: SDR & Xcal
- Current Cal: linear gain
- What is the impact of nonlinearity on SDR calibration?

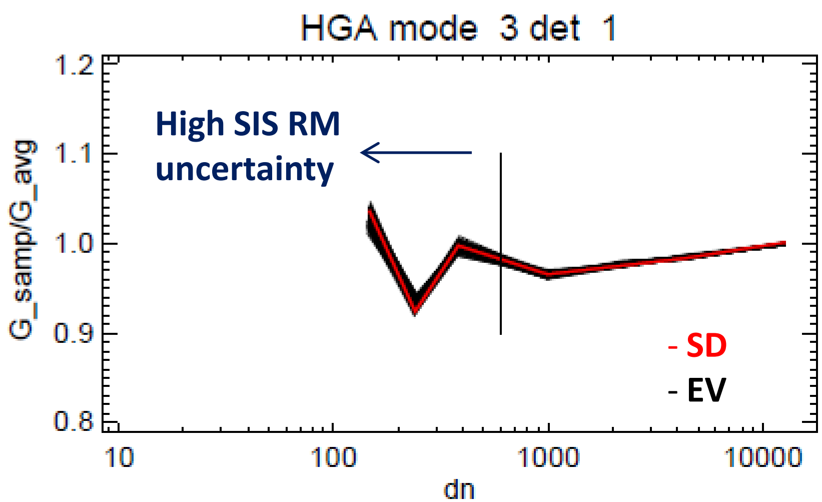
DNB LGS Characteristics



- Normalized EV (pixel) and SD (mode) gain
- Some LGS detectors show different response behavior among pixels within the same agg mode
- Nonlinear: sample dependent, worse at lower dn
- The gain is more linear in SD than EV
- SD ~ EV gain at Solar Calibration
- Nonlinearity above Lmin (small): imagery
- **Nonlinearity below Lmin (large): Xcal**
- Mode based calibration can not resolve nonlinearity at sample space?

DNB MGS/HGS



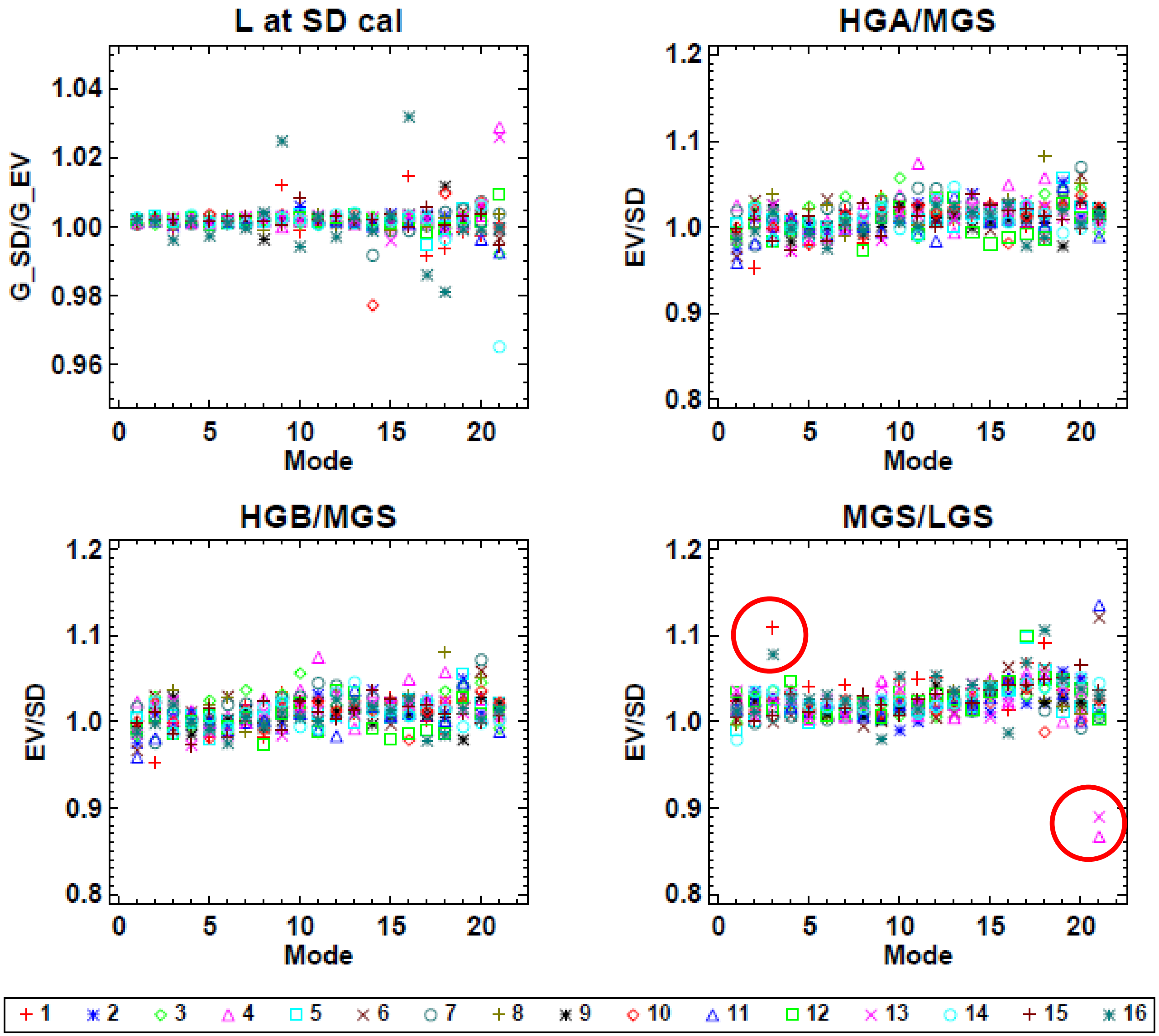


- Normalized EV (pixel) and SD (mode) gain
- SD ~ EV gain
- No EV sample dependency as observed in LGS
- SIS radiance uncertainty: discontinuity in MGS due to bulb change

  Uncertainty in determine HGA low dn radiance

Difficult to conclude the severity of MGS and HGS nonlinearity

EV vs. SD



- EV vs. SD for each DNB mode/det

Solar Cal (LGS)

- EV gain ~ SD gain, few detectors/mode has up to 3% differences

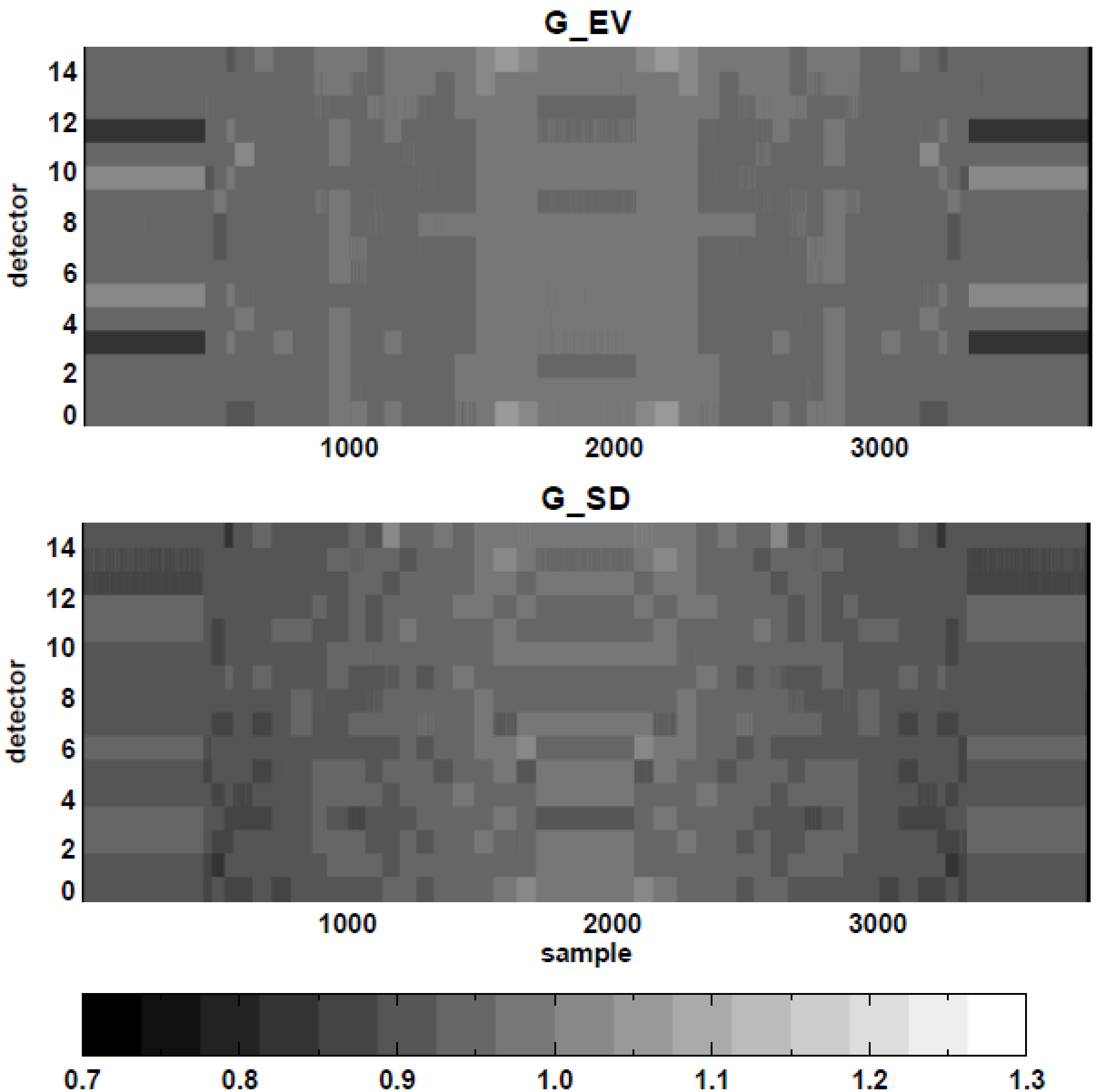
Xcal

- LGS/MGS: some mode/det has large SD/EV difference

Uncertainty:

- Few calibration view samples
- limited dn levels in Xcal

SDR Impact



Calibrated/measured Gain

Top: Xcal by EV data

Bot: Xcal by SD data

Horizontal striping

- Cross detector variation

Vertical striping

- Cross mode variation

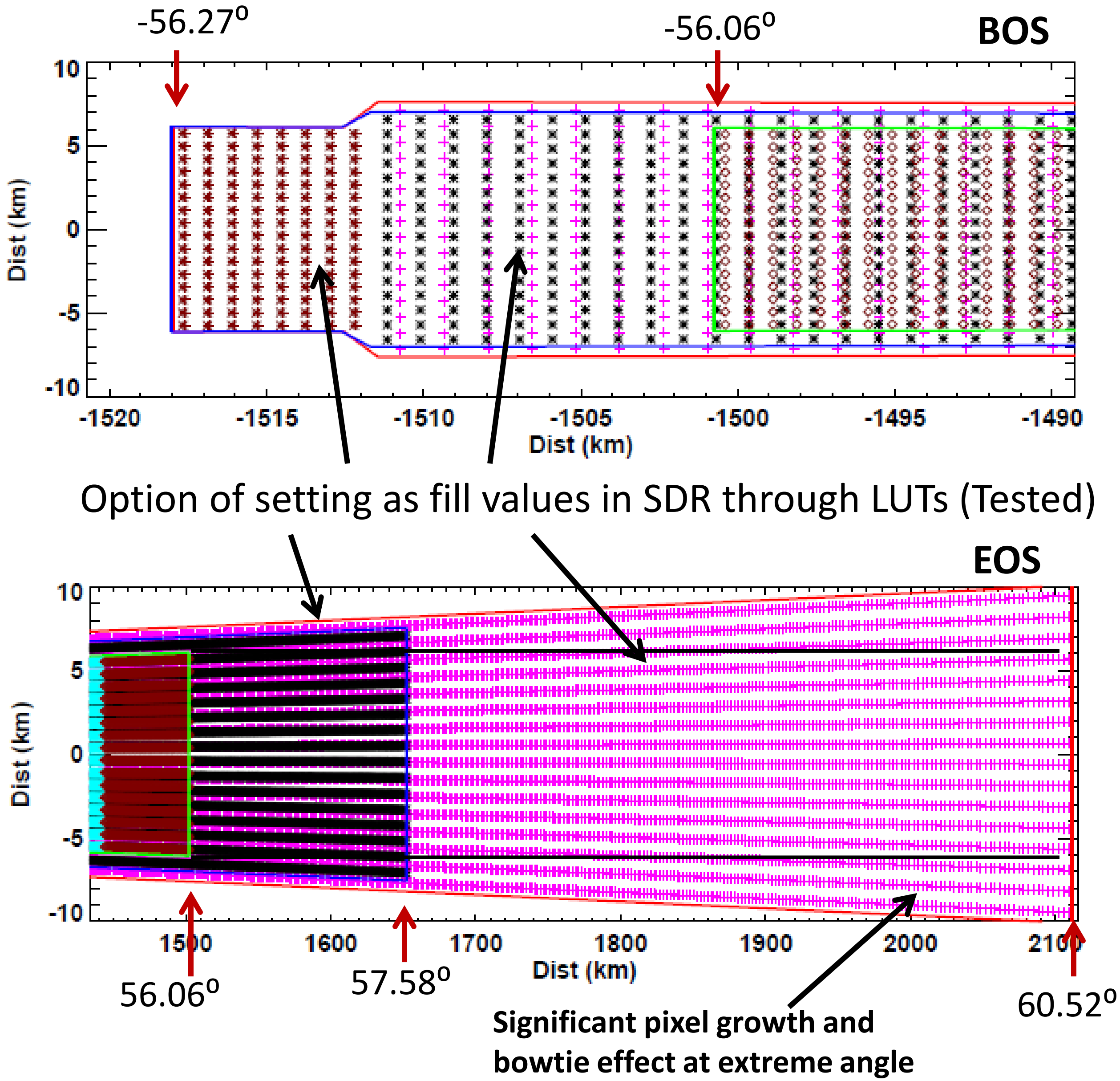
Additional uncertainty from HGS nonlinearity

Summary

- J1 DNB aggregation options
  - No change for scan angle within ~50 degree of nadir
  - Use mode 21 (Op21) or mode 21/26 (Op26) from ~50 to EOS.
- Impact on Imagery
  - Pixels at high scan angle will have reduced spatial resolution, higher SNR
  - Larger EV extent, increase overlaps
- Impact on Calibration
  - Some LUTs will need to be J1 Option specific
  - The nonlinearity could have significant impact on nighttime SDR due to gain ratio biases
  - The calibration bias could cause horizontal/vertical striping in DNB nighttime images due to detector/sample gain dependency
- Needs further investigation after J1 launch
  - Gain ratios computed using EV vs. SD data
  - EV sample dependency
  - Algorithm change: Sample base cal, quadratic fit.

backup

J1 DNB Extended EV



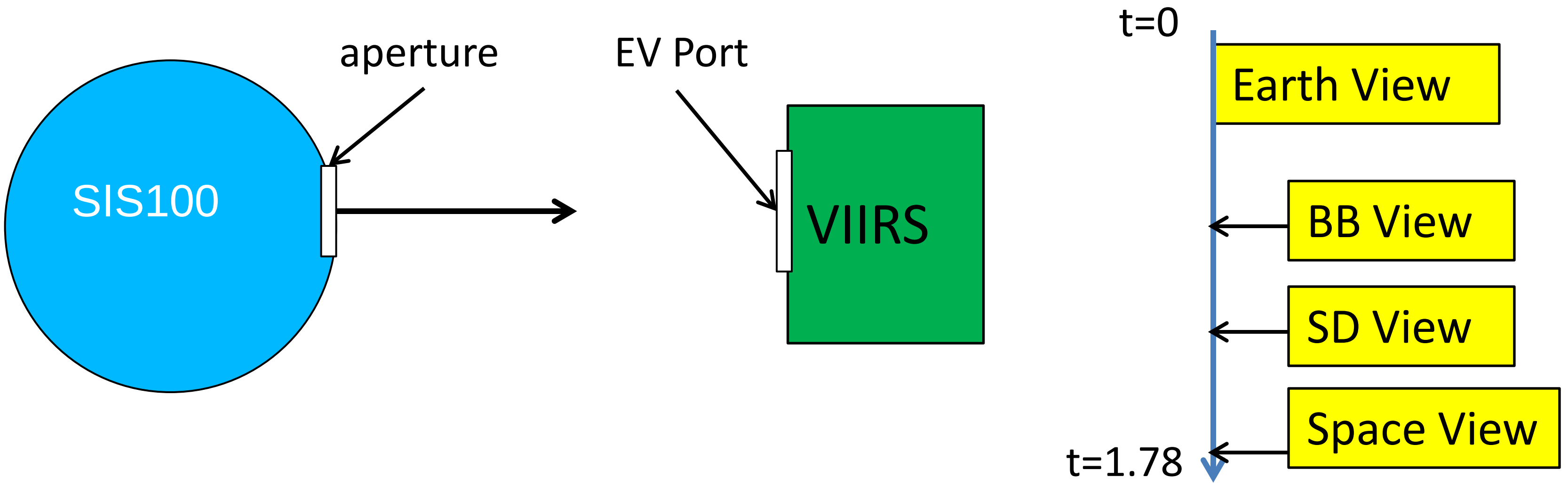
BOS:

- NPP: -56. 06°
- J1 Ops: -56.27°
- Op21 Extended EV samp: 8 (mode 32) + 8 (mode 21)
- Op21/26 Extended EV: 8 (32) + 10 (26)

EOS:

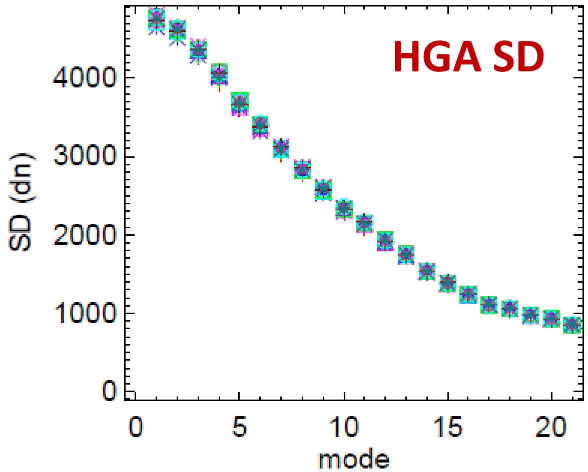
- NPP: -56. 06°
- Op21: 60.52°
- EV Extended samp: 288 (21)
- Op21/26: 57.58°
- EV Extended samp: 131 (26)

Test: RC2 Part4

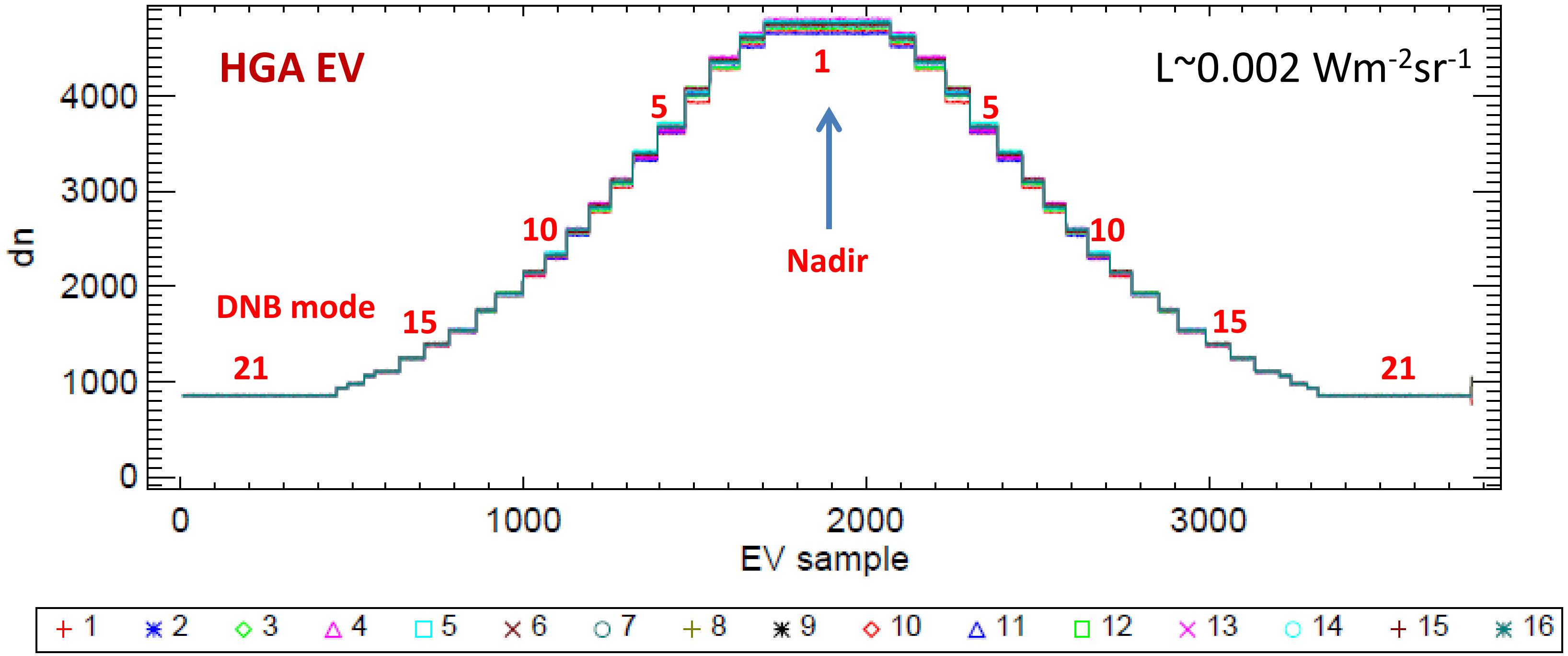


- RTA fixed, staring at SIS100
- 27 source levels to cover from the DNB dynamic range
  - 3 collects at each level: Attenuator (in/out), dark
- Staring at the same source output
  - All DNB EV samples (aggregation modes) are recorded
  - All calibration views (SV/BB/SD) are recorded, DNB modes cycled from 1-36
  - All DNB gain stages are recorded
- Enable single source comparison for all DNB modes/stages/detectors

Test Data: TV Hot Op21



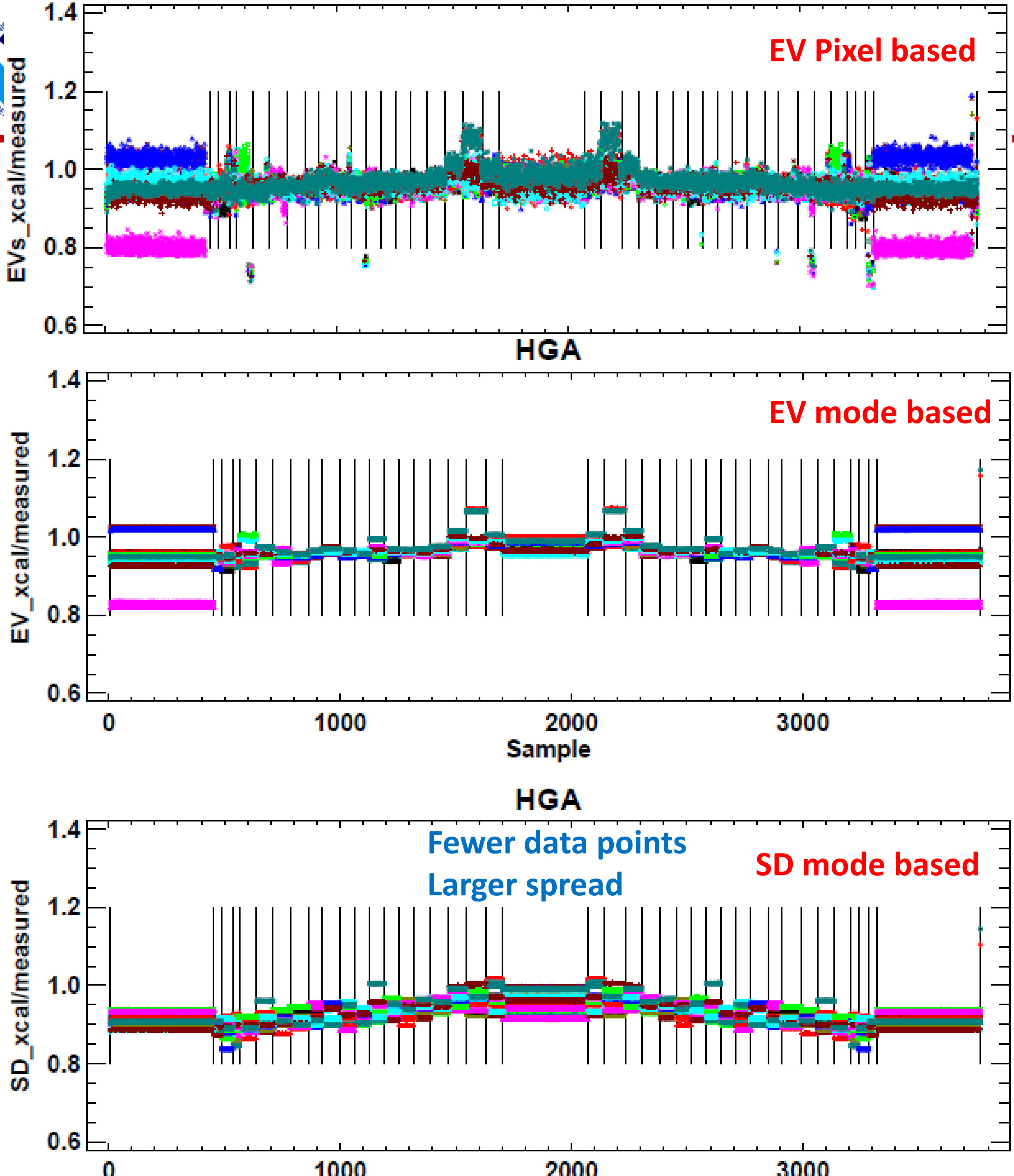
- TV_Hot_Op21: HGA example
- Characterize EV per DNB sample
- Characterize EV/Cal View per DNB mode
- Cross examination of EV/Cal View behavior
- Cross-stage calibration (Xcal)
- Assess operational calibration strategies



SDR Impact Analysis

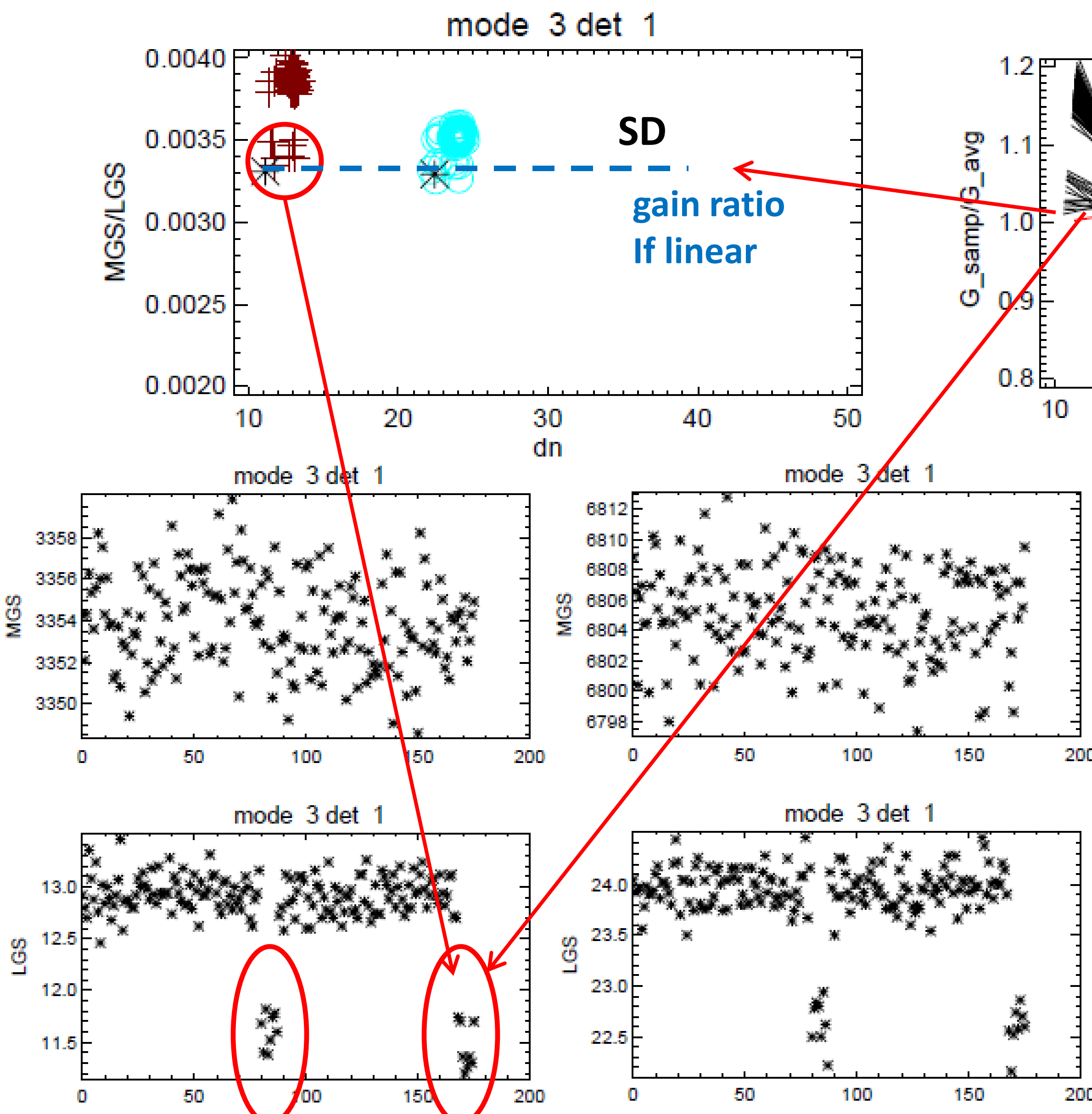
- Compute EV gain: per sample/mode
- Compute SD gain: per mode
  - Gain = dn/L_{SIS} (linear)
- Compute the calibrated DNB gain using the measured LGS gain and gain ratios
  - EV vs. SD at SD calibration
  - EV vs. SD gain ratios
- Compared calibrated vs. measured HGS gain
  - Calibration impact on nighttime SDR

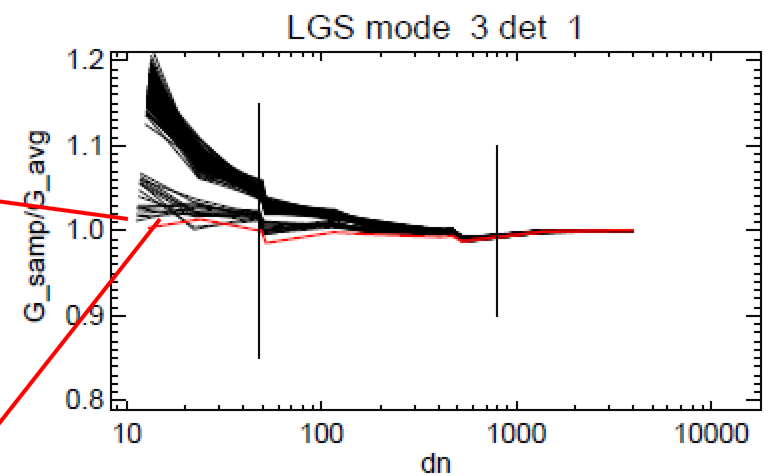
SDR Impact



- Calibrated vs. measured HGA gain
- EV_xcal: LGS*EV_xcal
- SD_xcal: LGS*SD_xcal
- EV_xcal: some mode/detector show large biases due to LGS nonlinearity
- EV pixel based Xcal can't solve the issue
- SD_xcal: more spread (fewer data points), fewer outliers

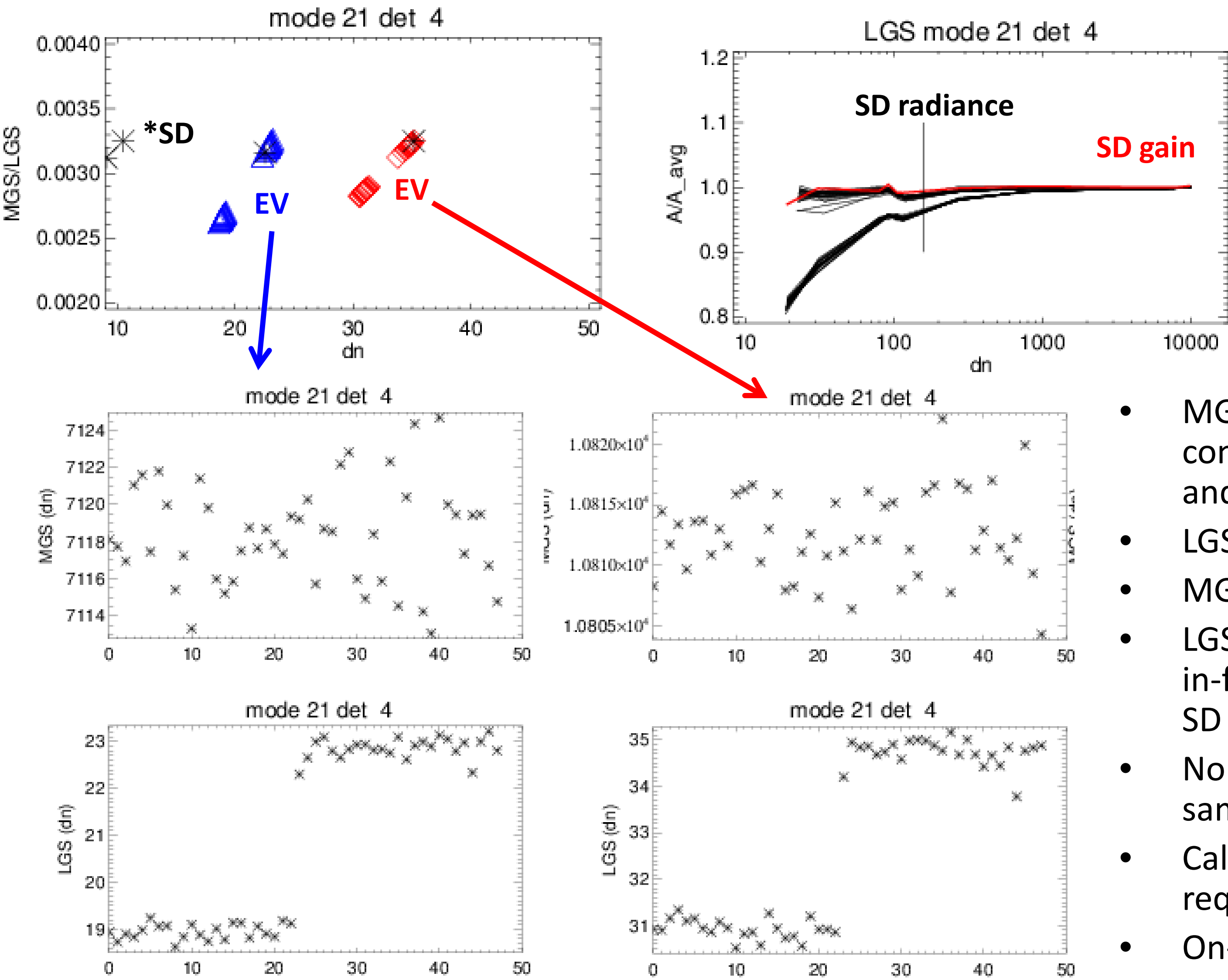
DNB Mode 3, Detector 1





- MGS/LGS gain ratio spread
- LGS responses have a dip in the last 8 samples
- MGS dn consistent
- The last 8 EV samples and SD are more linear and better for Xcal

Non-linearity: R & D



TV-Cold
Mode 21, Detector 4

- MGS/LGS gain ratio not consistent over EV sample and radiance level
- LGS: higher last 25 samples
- MGS: consistent
- LGS gain: last 25 samples are in-family with the mean and SD gain
- Non-linearity only in certain samples
- Cal method (Code) change required to address this
- On-orbit update?

J1 VIIRS DNB Waiver Validation Readiness

Xi Shao[1], Yan Bai[1], Changyong Cao[2]

1. University of Maryland, College Park
2. NOAA/NESDIS/STAR
Date: August 26, 2015

Outline

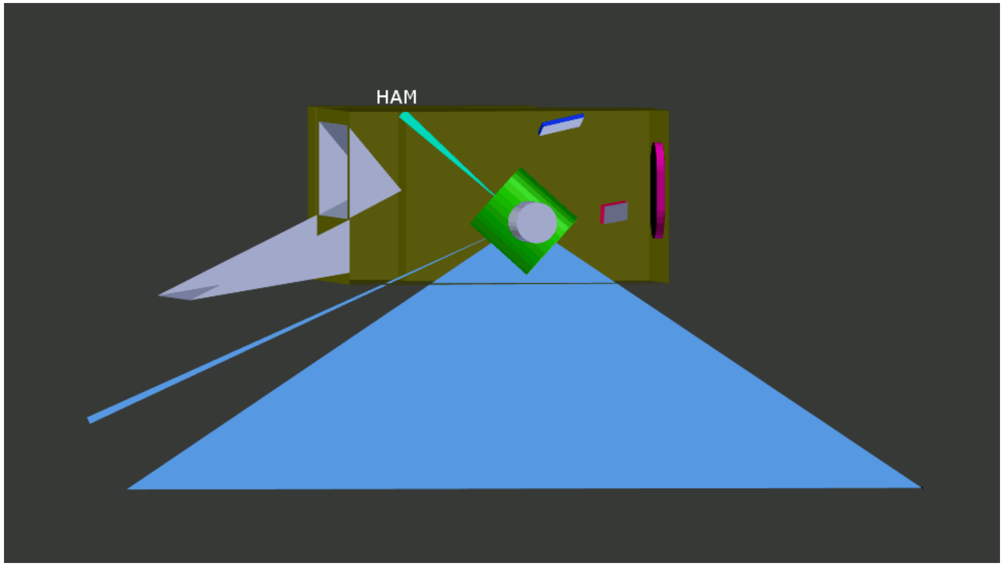
- **J1 VIIRS DNB Calibration/Validation**
- **Challenges from J1 DNB waiver**
- **Mitigations**
  - Stability trending with stable point light source (Bridge/Oil platforms/Power Plant)
  - Monitoring radiometric response versus scan angle
  - VIIRS DNB geolocation validation site time series
  - Active Nightlight Source (SBIR Project)

The VIIRS DNB Calibration

a complex calibration system

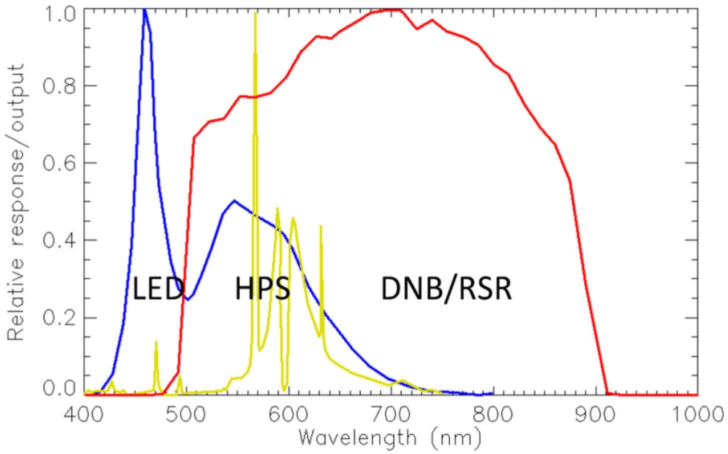
•Only the low gain stage(LGS) of DNB is calibrated using the solar diffuser; then transferred to the medium and high gains based on gain ratio

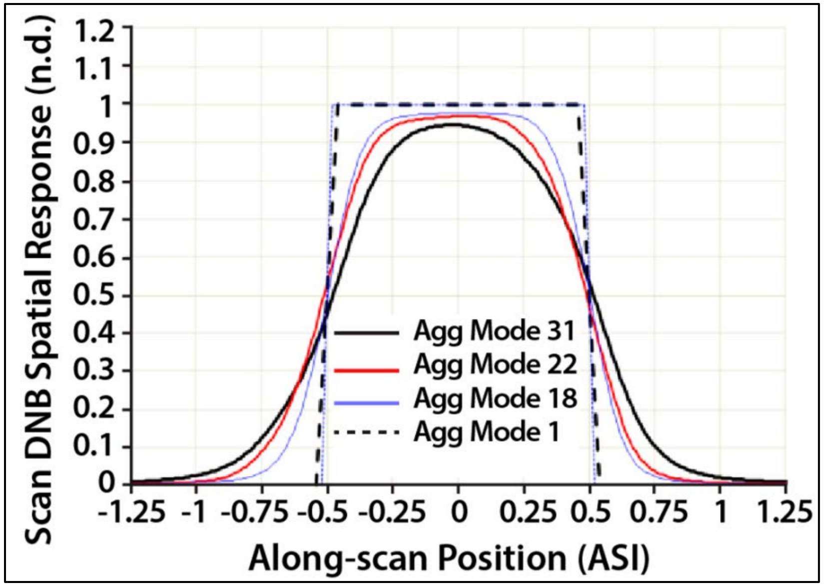
•DNB onboard calibration is performed per scan, per half angle mirror side (HAM), and per detector



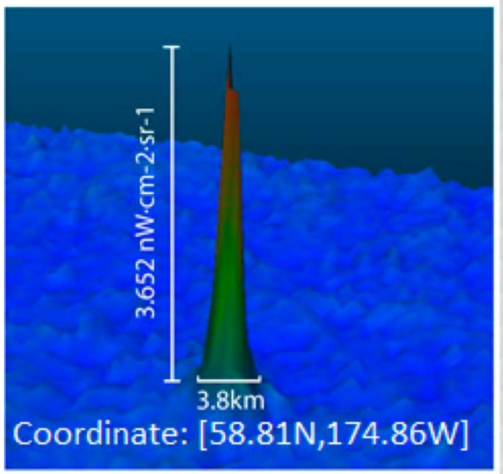
- DNB space view cannot be used as offset because it's "too bright". Blackbody and solar diffuser night views are better but also have issues
- Operationally the offset is determined using earth view during new moon in the darkest part of the pacific ocean (with airglow removed)
- Each DNB scan (LGS) only calibrates one of the 32 aggregation zones. As a result, a complete calibration involves at least 36x2 scans

Spectral, Spatial, and Radiometric Response of the VIIRS DNB





Courtesy of G. Lin

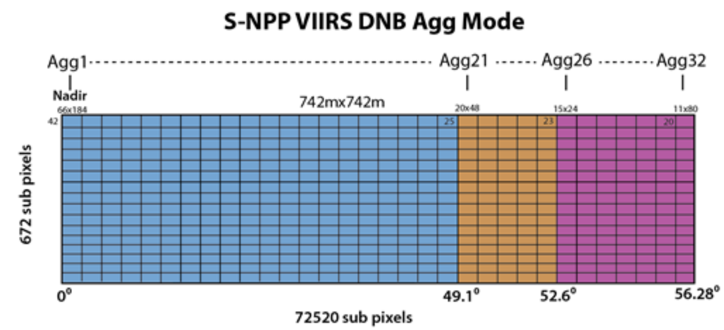


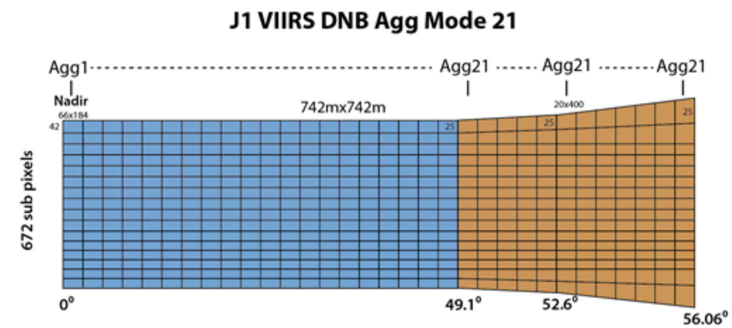
DNB view of fishing boat
(Cao & Bai, 2014, Remote Sens.)

- DNB has 32 aggregation zones from nadir to edge of scan, each with its own calibration
- The response across the 32 zones are not the same and may not be linear at high scan angles
- Point spread function is also aggregation zone dependent, with a near square response at nadir

J1 VIIRS SDR Algorithms (Waiver Mitigation)
Challenge: added complexity due to J1 Waivers (scan angle dependency)

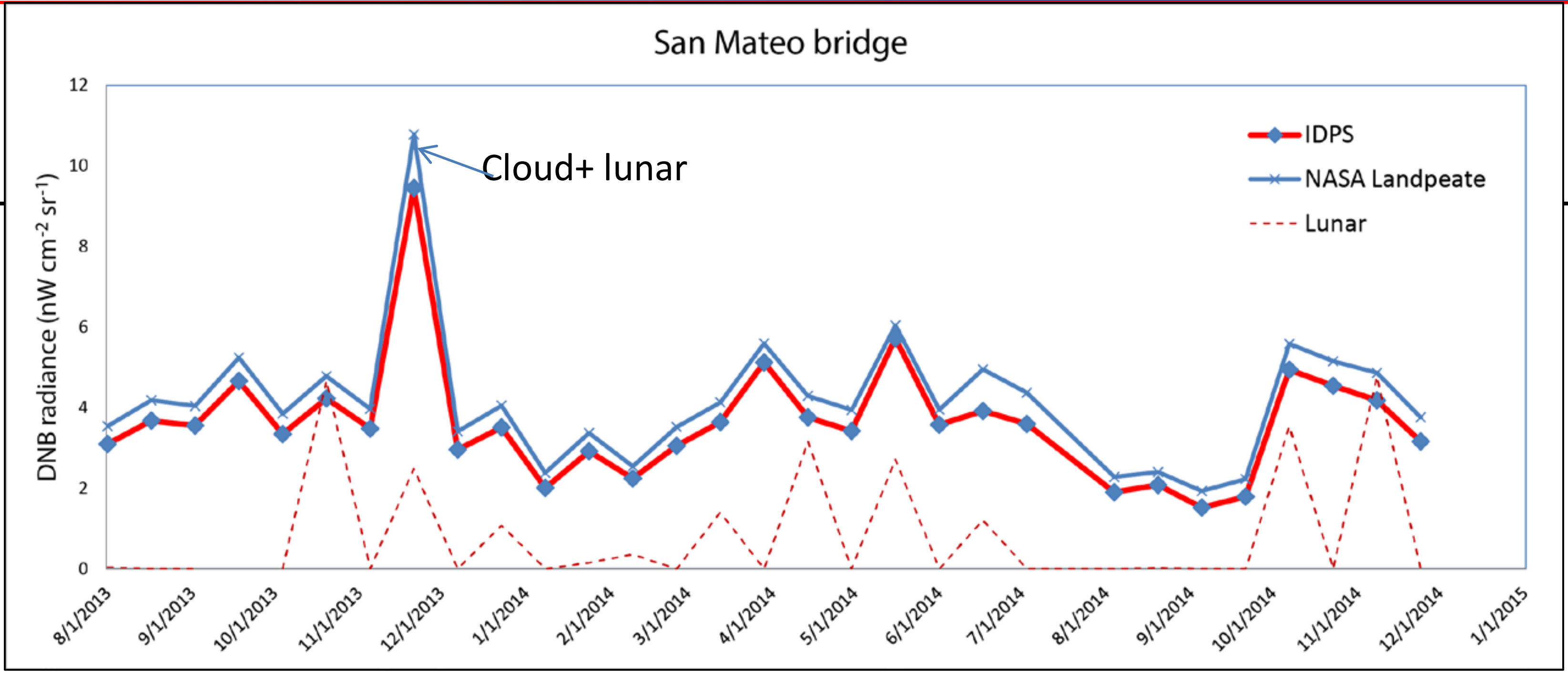
- **DNB nonlinearity at high scan angles (Requires change in Aggregation Mode)**
  - Baseline is Agg Mode 21
    - ➢ Radiometric calibration:
      - » Develop LUTs;
      - » Do not expect code change
    - ➢ Geolocation (require code change)
      - » Change LUT
      - » Code Change
  - DNB other Agg mode (Agg21/26)



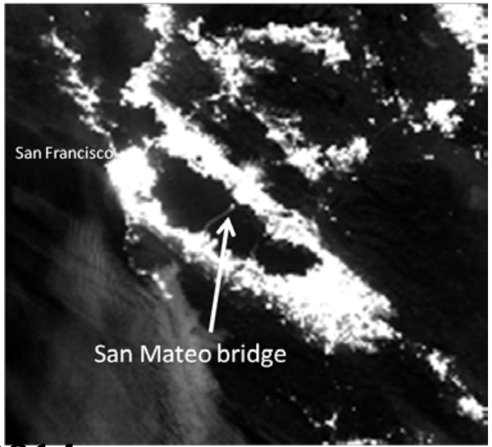


Notional drawing, not to scale; all values subject to change

Mitigation 1: VIIRS DNB Stability Monitoring using Night Bridge Lights

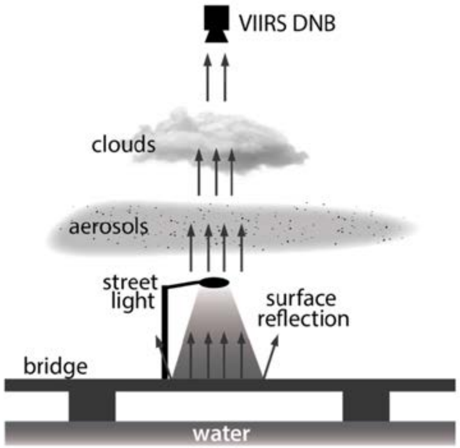


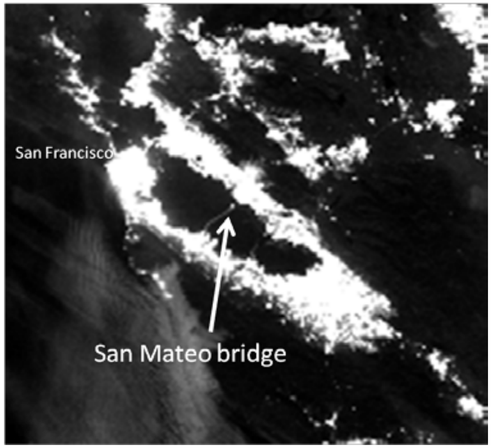
- Enable J1-DNB radiometric stability monitoring using nadir observation of San Mateo bridge lights near Lmin
- LEDs have replaced traditional light bulbs according to California Dept. of Transportation
- LandPeate ~15% higher than IDPS radiances
- Lunar has minimal impact in clear sky due to narrow bridge width
- Lunar has large impact in cloudy cases

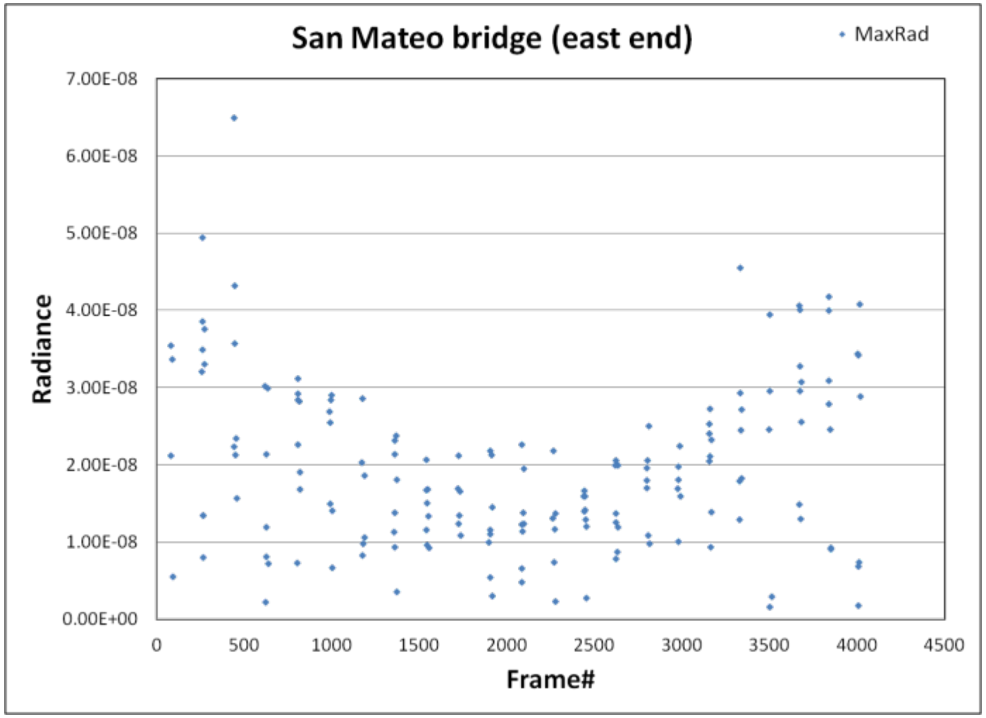


After Cao and Bai, RS, 2014

Mitigation 2: Monitoring Radiometric Response versus Scan Angle



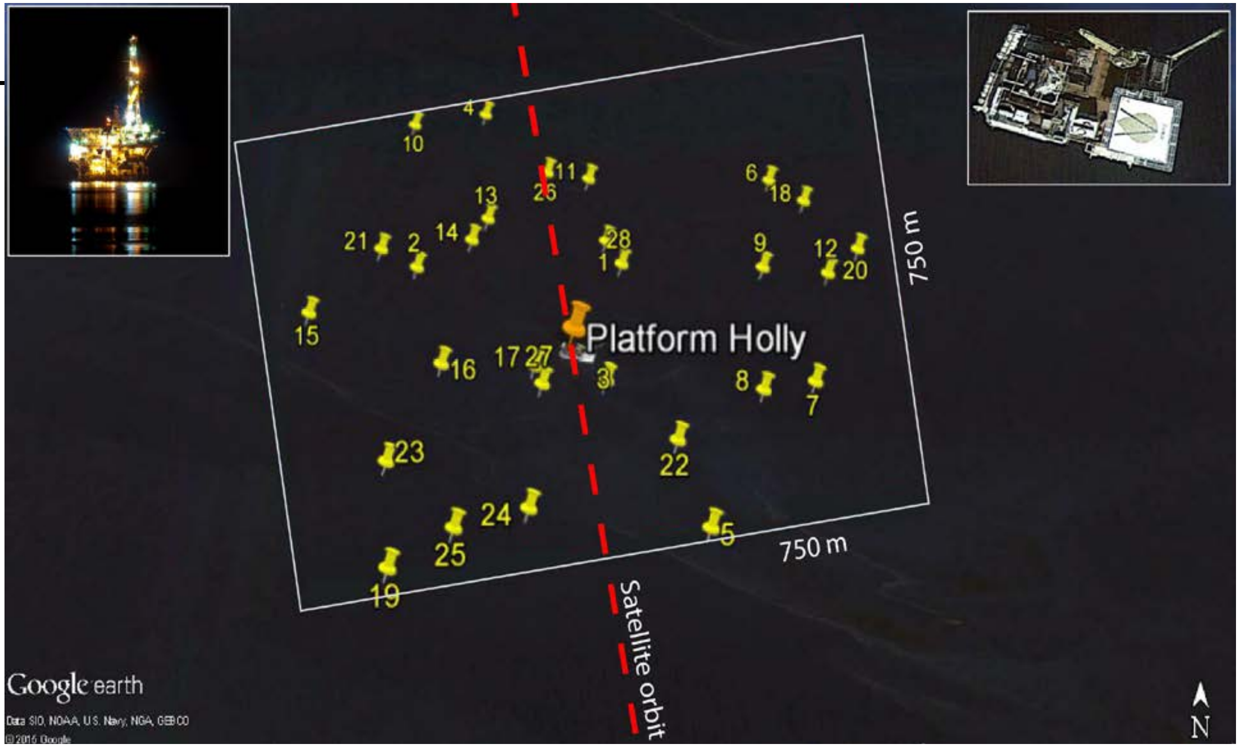




- Baseline of scan-angle dependence from SNPP DNB
- Useful for diagnosing the J1 aggregation mode

Mitigation 3: Oil Platform Holly Geolocation Validation (Spatial distribution)

- 28 samples from March-April, 2015
- All within 750x750m pixel
- Centered around the Oil Platform Holly
- Statistics:
  - Mean bias: 29m (or <4% of a pixel)
  - N Samples: 28
  - Single point uncertainty: ½ pixel
  - Larger errors when cloudy

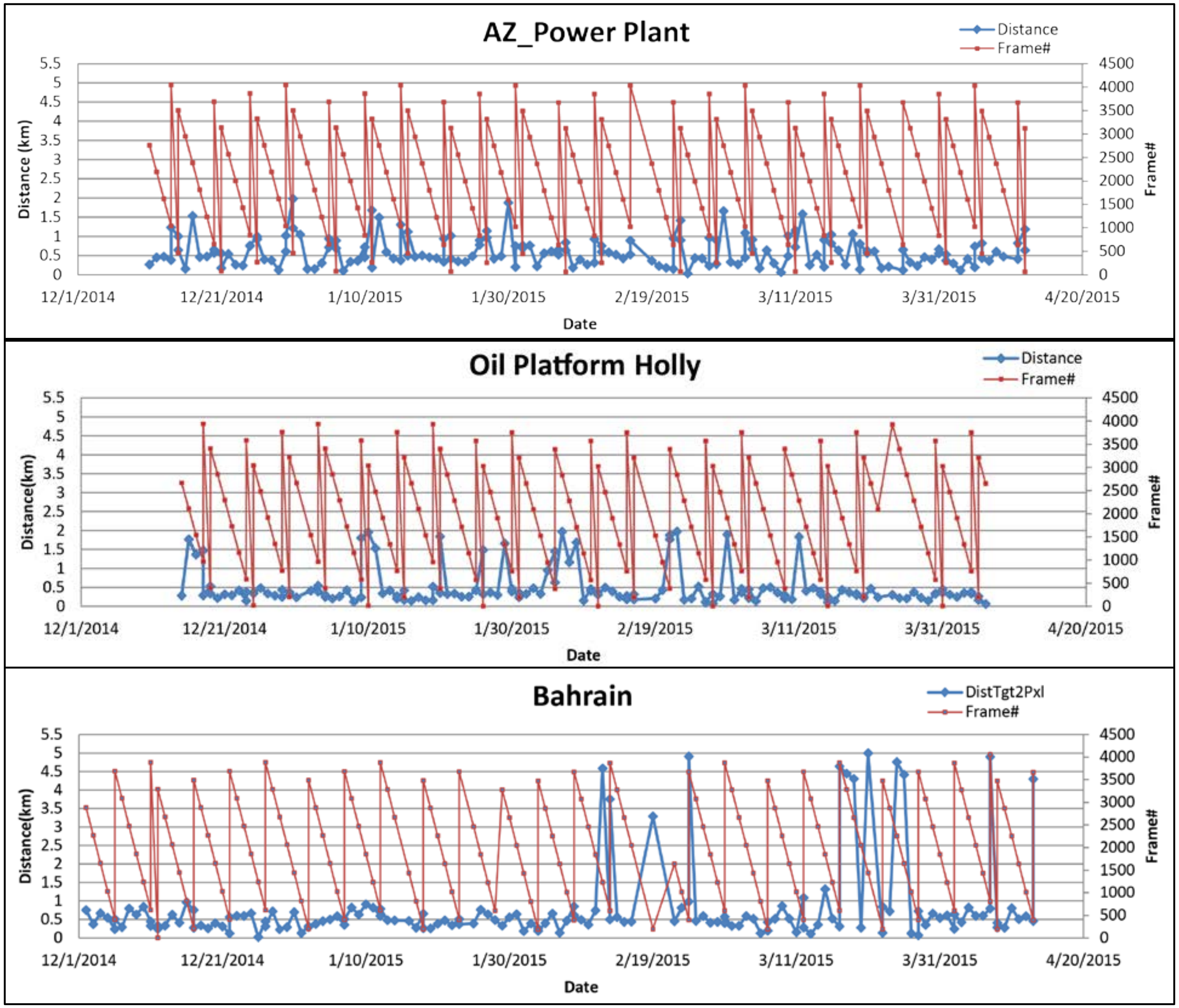


28 Samples from March-April 2015, all within one pixel

Fill gap of DNB geolocation validation with point light source tracking

Mitigation 3: Suomi NPP VIIRS DNB Geolocation Validation Site Time Series

- Sites include power plants, oil platforms, gas flares, volcanoes, and bridges
- Single pixel geolocation uncertainty about ½ pixel
- Mean bias: 29m (or <4% of a pixel) for Oil Platform Holly
- Distance error not correlated with scan angle or frame number
- Support J1-DNB geolocation validation at different scan angles using point sources



Mitigation 4: Active Nightlight Source SBIR Project

NOAA Small Business Innovation Research FY2015

Agency:	Department of Commerce
Program/Year:	SBIR / 2015
Solicitation Number:	NOAA-2015-1

Release Date:	October 15, 2014
Open Date:	October 15, 2014
Close Date:	January 14, 2015

+ 8.1: Resilient Coastal Communities and Economies

+ 8.2: Healthy Oceans

+ 8.3: Climate Adaptation and Mitigation

− 8.4: Weather-Ready Nation

  + 8.4.1W: Monitoring Active Region Development on the Far-Side of the Sun

  + 8.4.2R: Ultrasonic Anemometers/Thermometers with Increased Spatial Resolution

  + 8.4.3D: Accurate Nightlight for Satellite Calibration for Weather and Climate Applications

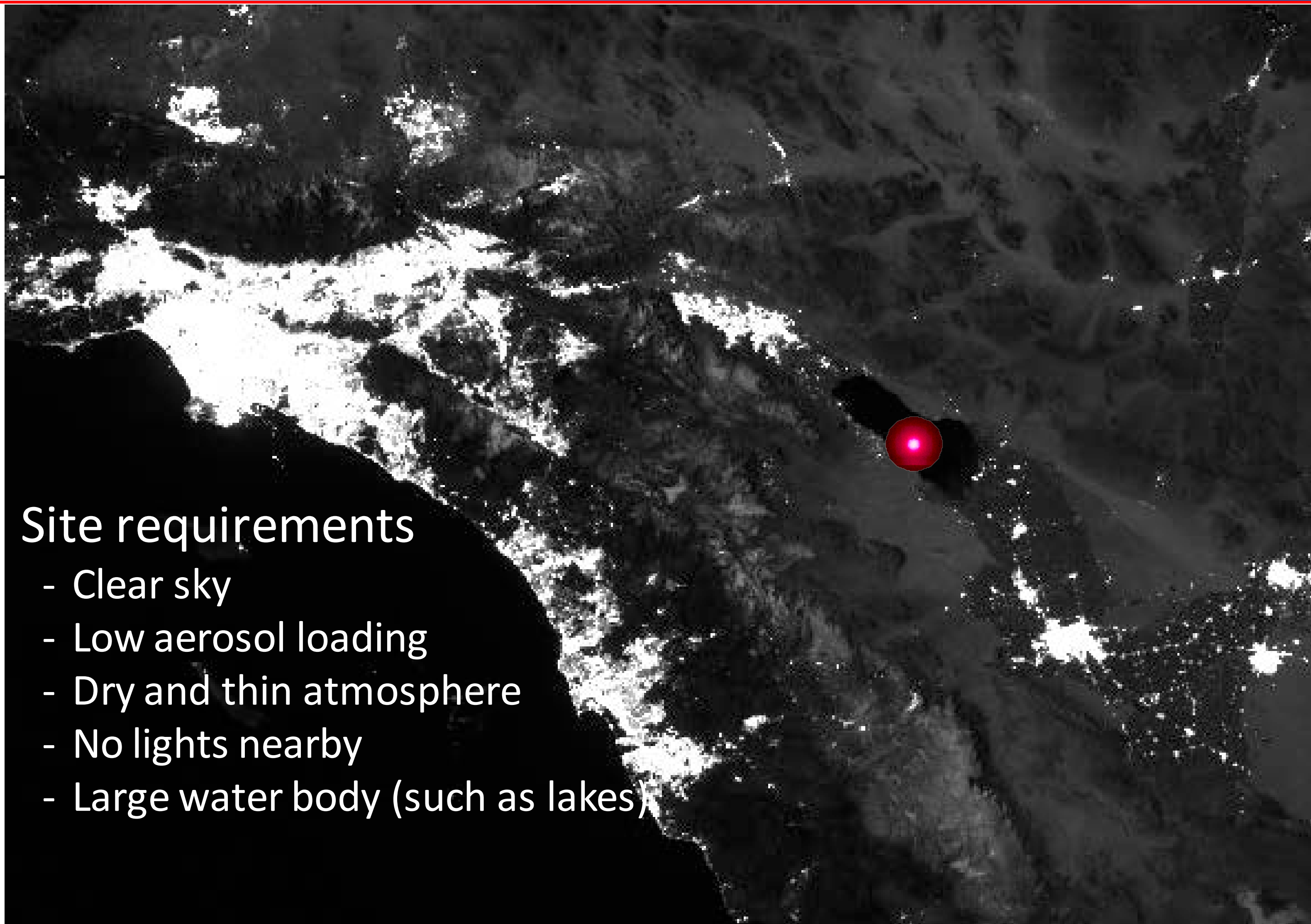
New SBIR initiative to develop active nightlight for VIIRS DNB validation, working closely with NIST and NASA scientists

Potential use of the Active Night Light Source

- VIIRS/DNB Cal/Val
  - Reduce absolute radiometric uncertainties
  - Improve calibration stability over time
  - Validate the scan vs. radiance bias across aggregation zones (especially useful for J1 VIIRS due to nonlinearity at high scan angles)
  - Geolocation/geometric validation at different scan angles
- Enables active remote sensing using passive instrument with well known ground truth
  - Use as a reference for existing point sources (boat light, etc)
  - Study night atmosphere (aerosol, cloud, etc)
  - Validate radiative transfer for point sources
  - Perform spectral studies using different color LEDs, Tungsten-Halogen, Incandescent, etc. as source
- Collaborate with UAS programs to support cal/val, and nightlight remote sensing

Cao et al, SPIE/EOS 2015

Ideal Sites



Site requirements

- Clear sky
- Low aerosol loading
- Dry and thin atmosphere
- No lights nearby
- Large water body (such as lakes)

Cao et al, SPIE/EOS 2015

Summary

- STAR VIIRS SDR team has made great progress developing DNB radiometric and geolocation trending capabilities for J1 waiver mitigations
    - o Radiometric trending using bridge lights and oil platforms;
    - o Radiometric response versus scan angle
    - o VIIRS DNB geolocation validation using point sources at different scan angles
- Capabilities will be extremely useful for J1 VIIRS DNB waiver mitigation and aggregation mode validation
- Studies of existing night light source is encouraging that a ground based source can be developed for improved accuracy

J1 VIIRS LUT Readiness

Frank De Luccia, Evan Haas, Gabriel Moy

The Aerospace Corporation

August 26, 2015

Overview

- Tasked by NOAA STAR to create an at-launch quality set of Look Up Tables (LUTs) for JPSS-1 (J1) VIIRS
  - *Total of 47 LUTs, some with multiple versions*
  - *Initial versions of all LUTs were delivered on July 24, 2015*
    - 21 LUTs are at-launch quality
    - 14 LUTs might be at-launch quality
    - 12 LUTs are not at-launch quality
- Effort was led by Frank De Luccia
- Contributing teams:
  - *NOAA STAR*
  - *VCST*
  - *The Aerospace Corporation*
  - *University of Wisconsin*
- LUTs and peer review presentations are available on eRooms

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LUT Details (1 of 8)

LUT Name	At Launch Quality?	Comments
VIIRS_SDR_CAL_AUTOMATE_LUT	Yes	Auto and manual, Side A and B
VIIRS_SDR_RVF_LUT	No	Working on TEB & RSB comparisons
VIIRS_SDR_RELATIVE_SPECTRAL_ RESPONSE	No	Incorporating T-Sircus test
VIIRS_SDR_QA_LUT	Maybe	Lunar and SAA values taken from SNPP LUT
VIIRS_SDR_DELTA_C_LUT	No	Under review and comparison
VIIRS_SDR_F_PREDICTED	Yes	F set to 1, F_trend set to 0

LUT Details (2 of 8)

LUT Name	At Launch Quality?	Comments
VIIRS_SDR_DG_ANOMALY_DN_LIMITS_LUT	No	
VIIRS_SDR_OBSERVATIONS_TO_PIXELS_LUT	Yes	Same as NPP
VIIRS_SDR_REFLECTIVE_LUT	Maybe	
VIIRS_SDR_SOLAR_IRAD_LUT	Yes	Thullier spectrum, high resolution
VIIRS_SDR_TELE_COEFF_LUT	Yes	Electronic A & B sides separate
VIIRS_SDR_RADIOMETRIC_PARAM_V3_LUT	Yes	
VIIRS_SDR_DNB_FRAME_TO_ZONE_LUT	Yes	Two versions: Op21 and Op21/26

LUT Details (3 of 8)

LUT Name	At Launch Quality?	Comments
VIIRS_SDR_DNB_RVF_LUT	No	Edge detector issue
VIIRS_SDR_DNB_DN0_LUT	Maybe	In work
VIIRS_SDR_DNB_GAIN_RATIOS_LUT	Maybe	In work
VIIRS_SDR_DNB_LGS_GAINS_LUT	Maybe	In work
VIIRS_SDR_DNB_STRAY_LIGHT_CORRECTION_LUT	Yes	All zeros
VIIRS_SDR_EBBT_LUT	Yes	
VIIRS_SDR_EMISSIVE_LUT	Yes	

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LUT Details (4 of 8)

LUT Name	At Launch Quality?	Comments
VIIRS_SDR_BB_TEMP_COEFFS_LUT	Yes	Unused values set to zero
VIIRS_SDR_HAM_ER_LUT	Maybe	Spectral averaging?
VIIRS_SDR_OBC_ER_LUT	Maybe	Spectral averaging?
VIIRS_SDR_OBC_RR_LUT	Maybe	Spectral averaging?
VIIRS_SDR_RTA_ER_LUT	Maybe	Spectral averaging?

LUT Details (5 of 8)

LUT Name	At Launch Quality?	Comments
VIIRS_RSBAUTOCAL_BRDF_SCREEN_ TRANSMISSION_PRODUCT_RTA_VIEW_LUT	No	Data being collected
VIIRS_RSBAUTOCAL_BRDF_SCREEN_ TRANSMISSION_PRODUCT_SDSM_VIEW_LUT	Yes	
VIIRS_RSBAUTOCAL_DNB_DARK_SIGNAL_ AUTOMATE_LUT	Maybe	
VIIRS_RSBAUTOCAL_DNB_GAIN_RATIOS_ AUTOMATE_LUT	Maybe	Same as SNPP
VIIRS_RSBAUTOCAL_DNB_LGS_GAIN_ AUTOMATE_LUT	Maybe	Same as SNPP
VIIRS_RSBAUTOCAL_DNB_MOON_ ILLUMINATION_LUT	Yes	

LUT Details (6 of 8)

LUT Name	At Launch Quality?	Comments
VIIRS_RSBAUTOCAL_H_AUTOMATE_LUT	Yes	SNPP with refinements
VIIRS_RSBAUTOCAL_H_LUT	No	SNPP with refinements
VIIRS_RSBAUTOCAL_ROT_MATRIX_LUT	Yes	
VIIRS_RSBAUTOCAL_RSB_F_AUTOMATE_LUT	Yes	Same as SNPP
VIIRS_RSBAUTOCAL_RVF_LUT	Maybe	Data being collected
VIIRS_RSBAUTOCAL_SDSM_SOLAR_ SCREEN_TRANS_LUT	No	Data being collected

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LUT Details (7 of 8)

LUT Name	At Launch Quality?	Comments
VIIRS_RSBAUTOCAL_SDSM_TIME_LUT	No	SNPP is incorrect and will be revised. J1 version TBD.
VIIRS_RSBAUTOCAL_VOLT_LUT	Maybe	Same as SNPP, values cancel out in code
VIIRS_RSBAUTOCAL_HISTORY_AUX	Yes	
VIIRS-SDR-GAIN-LUT	Yes	All zeros
VIIRS-SDR-COEFF-A-LUT	Yes	SNPP values changed to unity
VIIRS-SDR-COEFF-B-LUT	Yes	SNPP values changed to unity

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LUT Details (8 of 8)

LUT Name	At Launch Quality?	Comments
VIIRS_SDR_GEO_DNB_PARAM_LUT	No	Further basis for "earth view delay" value needed. "T_inst2SC" requires update based on SC test data. Versions for other DNB timing options needed prior to launch.
VIIRS_SDR_GEO_IMG_PARAM_LUT	No	In work
VIIRS_SDR_GEO_MOD_PARAM_LUT	No	In work
CMNGEO-PARAM-LUT	Yes	

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Lessons Learned

- Define requirements early on
  - *Delivery of big endian vs. little endian vs. both*
  - *Naming convention*

- Use of a repository
  - *Manual tracking of 47 LUTs with multiple versions is labor intensive*

- Define testing protocol
  - *What are the best ways to test new LUTs?*
  - *How to test multiple versions of the same LUT?*
    - Op 21 vs. Op 21/26
    - Side A vs. Side B
    - Automated (RSBAutoCal) vs. predicted (manual F LUT deliveries)

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Path Forward

- Bring all LUTs to at-launch quality
  - *Identify LUTs and justifications if not possible*
- Convert LUTs to little endian for ADL 5.x
  - *Who is responsible?*
  - *Are LUT deliveries going to be little endian in the future?*
- Test LUTs with both ADL 4.2 and ADL 5.x
  - *Test both DNB Op21 and Op21/26 options*
  - *Test automated and manual RSBAutoCal modes*
- Get a set of LUTs on the Delegated Authority List (previously known as fast track)

Acknowledgements

- VCST
  - *Jack Ji, Jeff McIntire, Jinan Zeng, Tom Schwarting, Ning Lei, Gary Lin, Bin Tan*
- NOAA STAR
  - *Slowak Blonski, Shihyan Lee, Julie Wang, Jason Choi, Wenhui Wang, Sirish Uprety, Seah Shao, Mitch Schull*
- The Aerospace Corporation
  - *David Moyer, Frank De Luccia, Evan Haas, Gabe Moy, Frank Sun, Peter Isaacson*
- University of Wisconsin
  - *Chris Moeller*

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Integrated Cal/Val System (ICVS) Readiness for J1 VIIRS

Taeyoung (Jason) Choi[1], Ninghai Sun[1] , Lori Brwon[2], Fuzhong Weng[3], Changyong Cao[3]

[1]ERT, [2]NOAA StormCenter (IMSG), [3]NOAA STAR

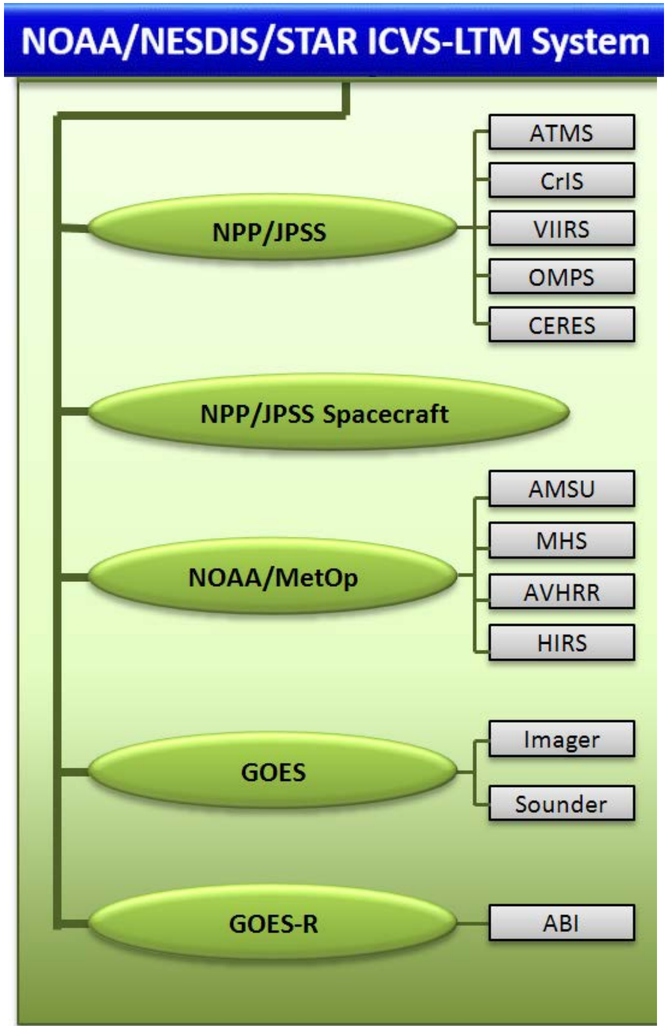
Date: August 26, 2015

Outline

- Introduction to STAR Integrated Cal/Val System (ICVS)
- J1 Readiness Status
  - ICVS Code Structure
  - J1 Proxy Data
  - Imagery Process Functionality Check
  - Calibration Process Functionality Check
- Major Accomplishments
- Future Improvements
  - Reflective Solar Band (RSB)
  - Thermal Emissive Band (TEB)
  - Day Night Band (DNB)
- Summary

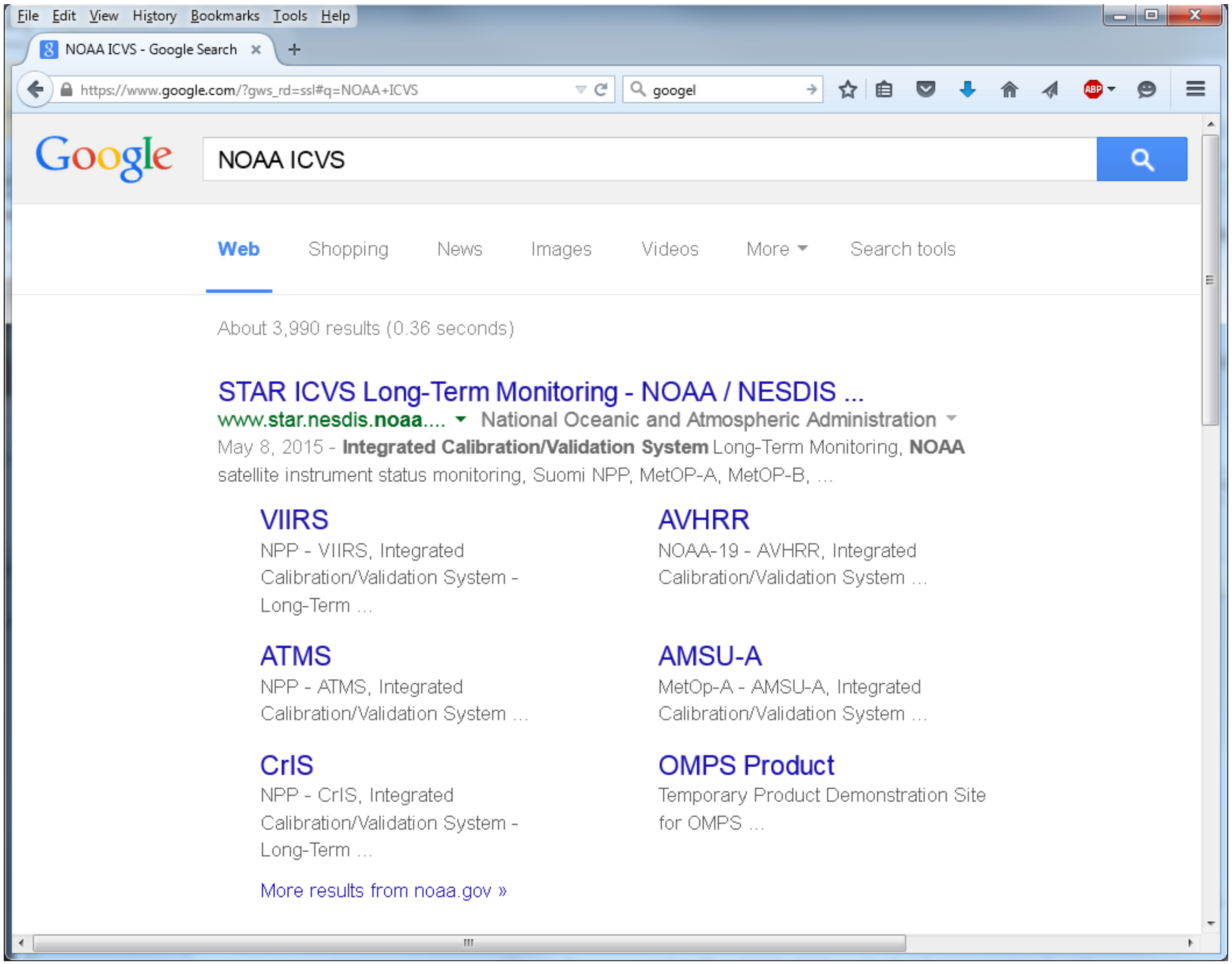
Introduction

- STAR Integrated Cal/Val System (ICVS) Long Term Monitoring (LTM) system goals
  - Provide near real time and long term instrument status and performance monitoring
  - Provide near real time and long term SDR/EDR level 1 data product quality monitoring
  - Provide real time support for sensor calibration activities
  - Provide quick and preliminary estimate of satellite data impact in NWP applications
  - Ensure the integrity of the climate data records from broader satellite instruments

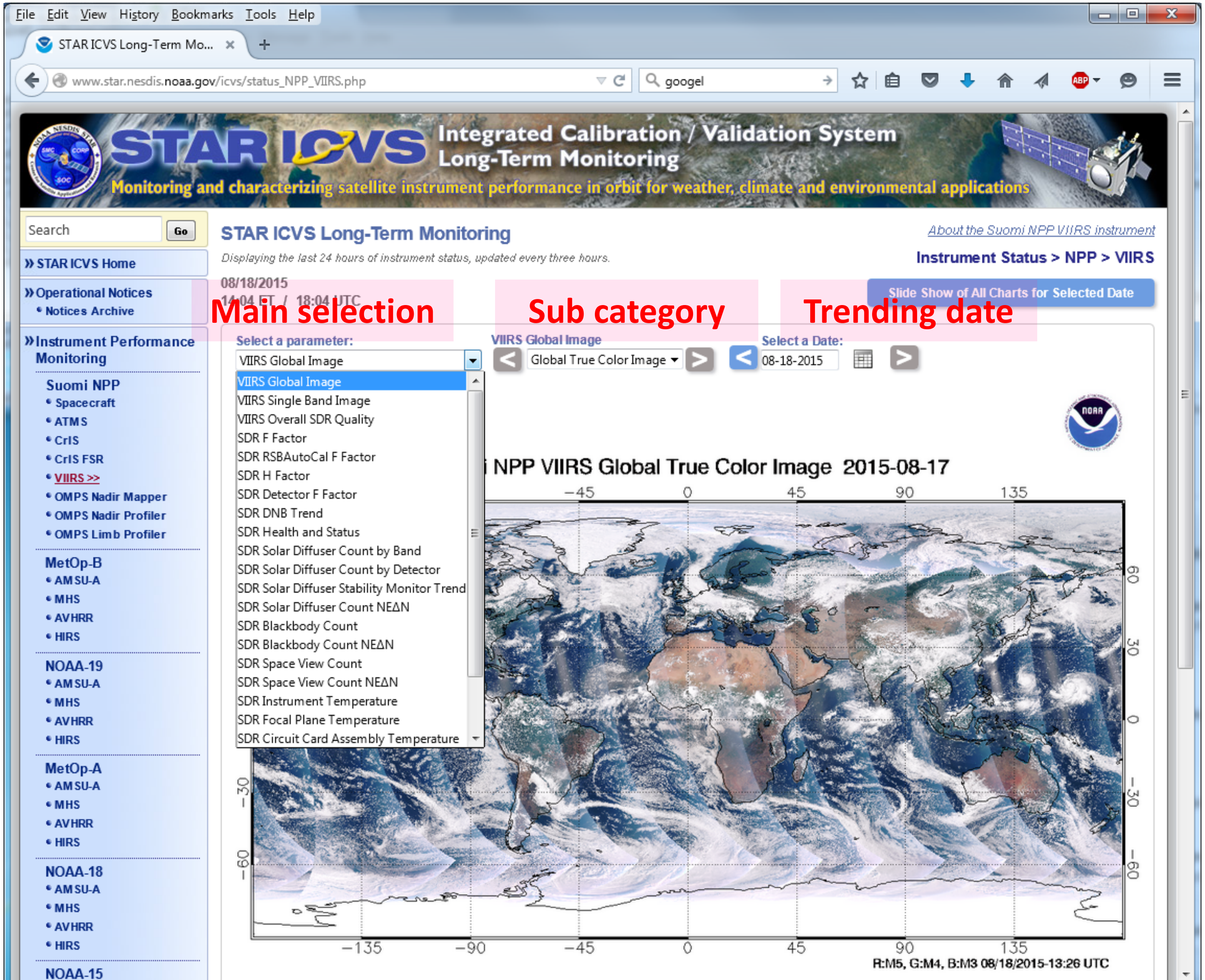


Introduction

- Website is at http://www.star.nesdis.noaa.gov/icvs/index.php
- Or search Google by ‘NOAA ICVS’



Introduction



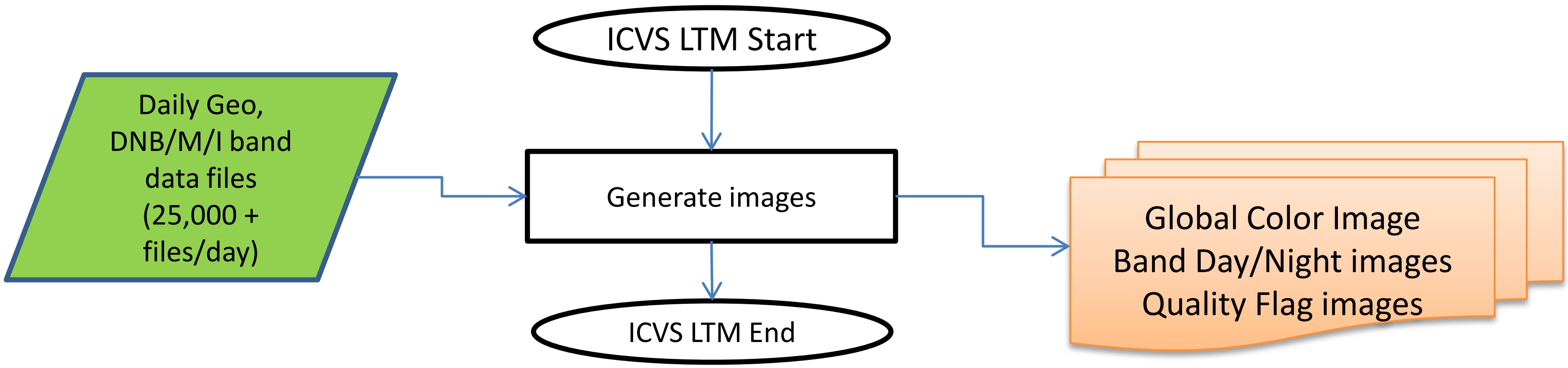
Introduction

Parameters	Descriptions	Dimensions	Usage
Global Image	Global true color image and single band image	38	VIIRS Imagery/Products
SDR Quality Flag	SDR data product quality flags	22	Check SDR data quality
F/H factor tending	H-factor, RSB F-factors, Operational vs. ICVS F-factor comparisons, Operational vs. RSBAutoCal F-factors, TEB Linear Gain, DNB LUTs	58	Degradation trending
Telemetry/Temperature	BB, RTA, cavity, HAM, FPA, cooler, Mainframe, Circuit Card Assembly, instrument current/voltage	41	Instrument Healthy status
SD Counts	VIIRS observation DN of Solar diffuser for band I1~I3, M1~M11, DNB over band average	28	Degradation trending
SD NEΔN	Noise NEΔN for SD signal of solar bands	14	NEDT Trending
SDSM Counts	SD, Sun, Ratio trending for all the 8 detectors	8	degradation for Detector uniform
BB Counts	VIIRS observation Blackbody DN for 22 bands	22	IR gain derivation
BB NEΔN	Noise NEΔN for black body signal	22	IR NEDT derivation
SV Counts	VIIRS observation Space view DN for 22 bands	22	Background signal trending
SV NEΔN	Dark Noise NEΔN for Space view signal	22	Dark noise signal
HAM/RTA No Sync	Indicates No Synchronization between RTA and HAM	1	Notification generated
Alaska Images	Alaska EDR Images	12	Animated Images

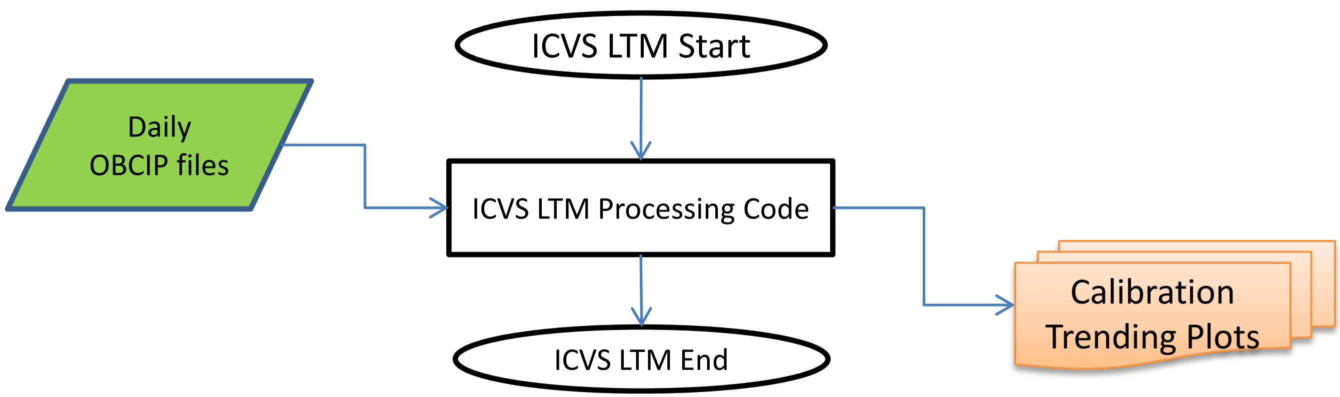
*** 323 trending plots are generated in near real time**

J1 Readiness Status

- ICVS LTM Code Structure
  - ICVS LTM Imagery Process (C++ / FORTRAN / IDL)



  - ICVS LTM Calibration/Telemetry Process (IDL)

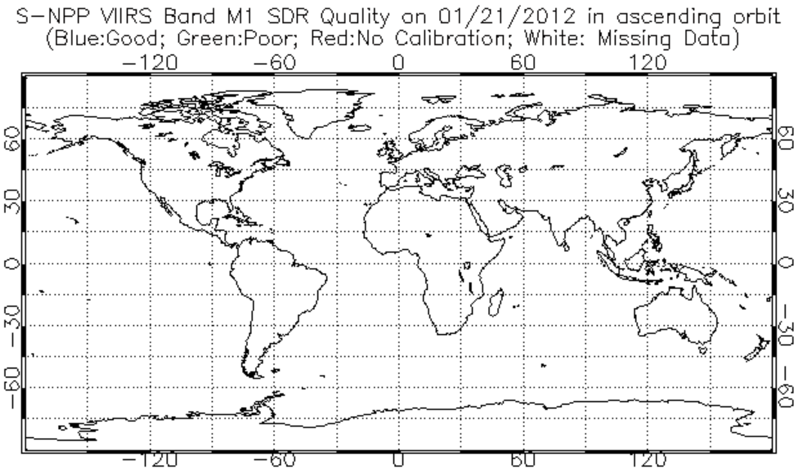


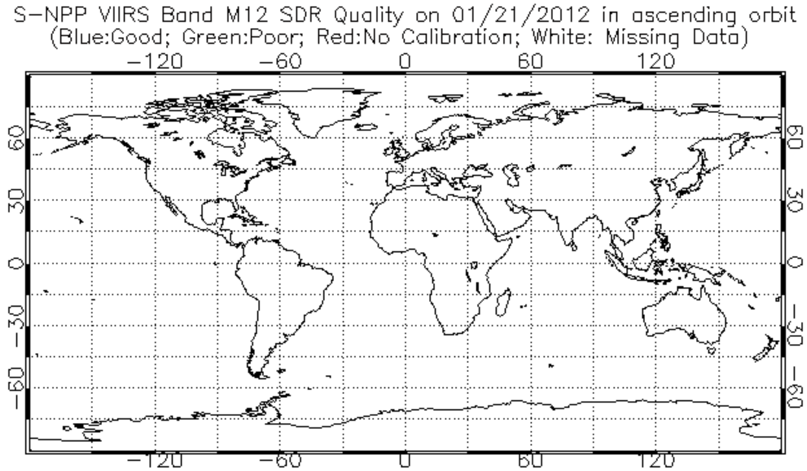
J1 Readiness Status

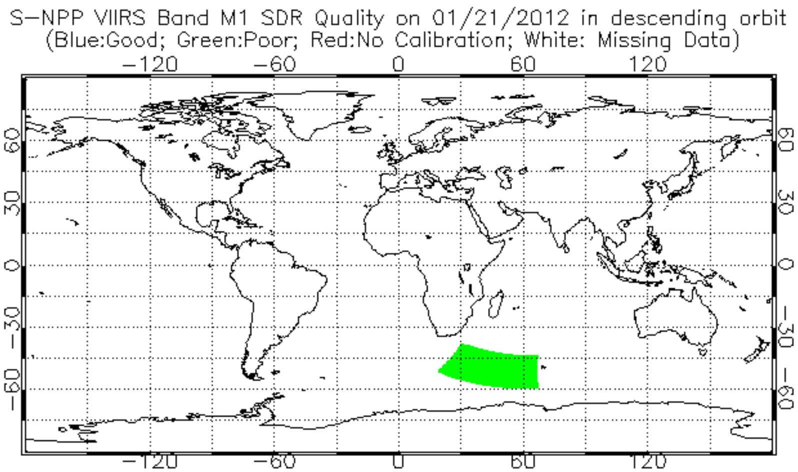
- ICVS Code Functionality Check
  - J1 proxy data is generated using 14 orbits of S-NPP data set on Jan. 21, 2012 (MDR 28).
  - Including S/C Diary RDR.
  - Processed to generate SDR using Block 2.0 ADL.
    - Only 3 granules are available from 21:37~21:41 (nighttime)
      - IVOBC_j01_d20120121_t2137026_e2138268_b01213_c20150813172512004324_NULu_int.h5
      - SVM01_j01_d20120121_t2137026_e2138268_b01213_c20150813172511144379_NULu_int.h5
  - The J1 proxy data formats are exactly the same as S-NPP format in OBCIP, Geo, and band image data files.

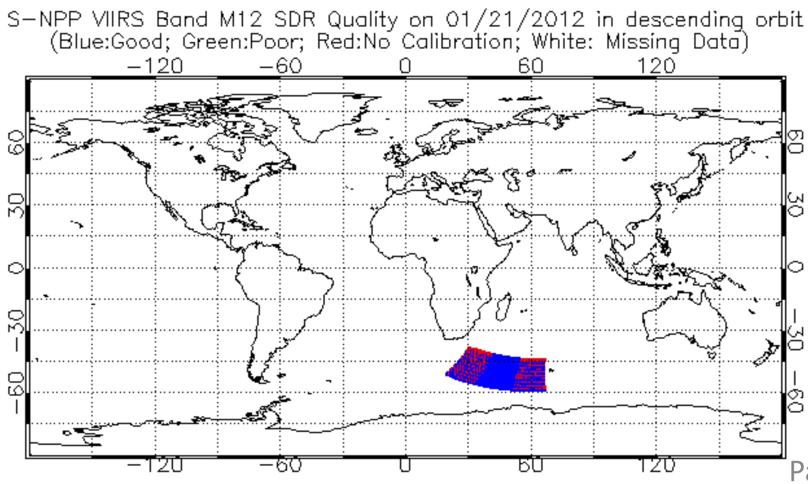
J1 Readiness Status

- ICVS Code Functionality Check
  - QF images are successfully generated.



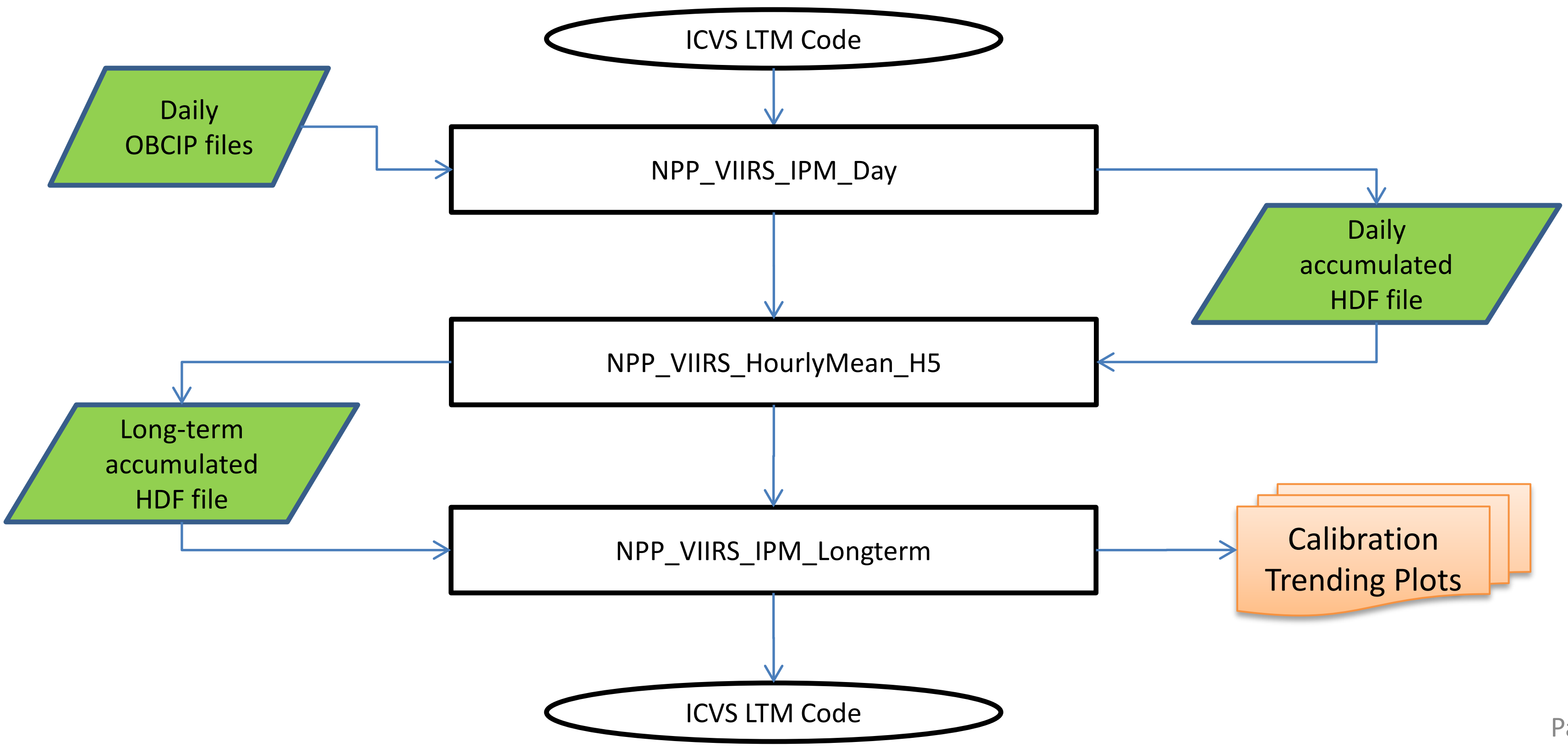




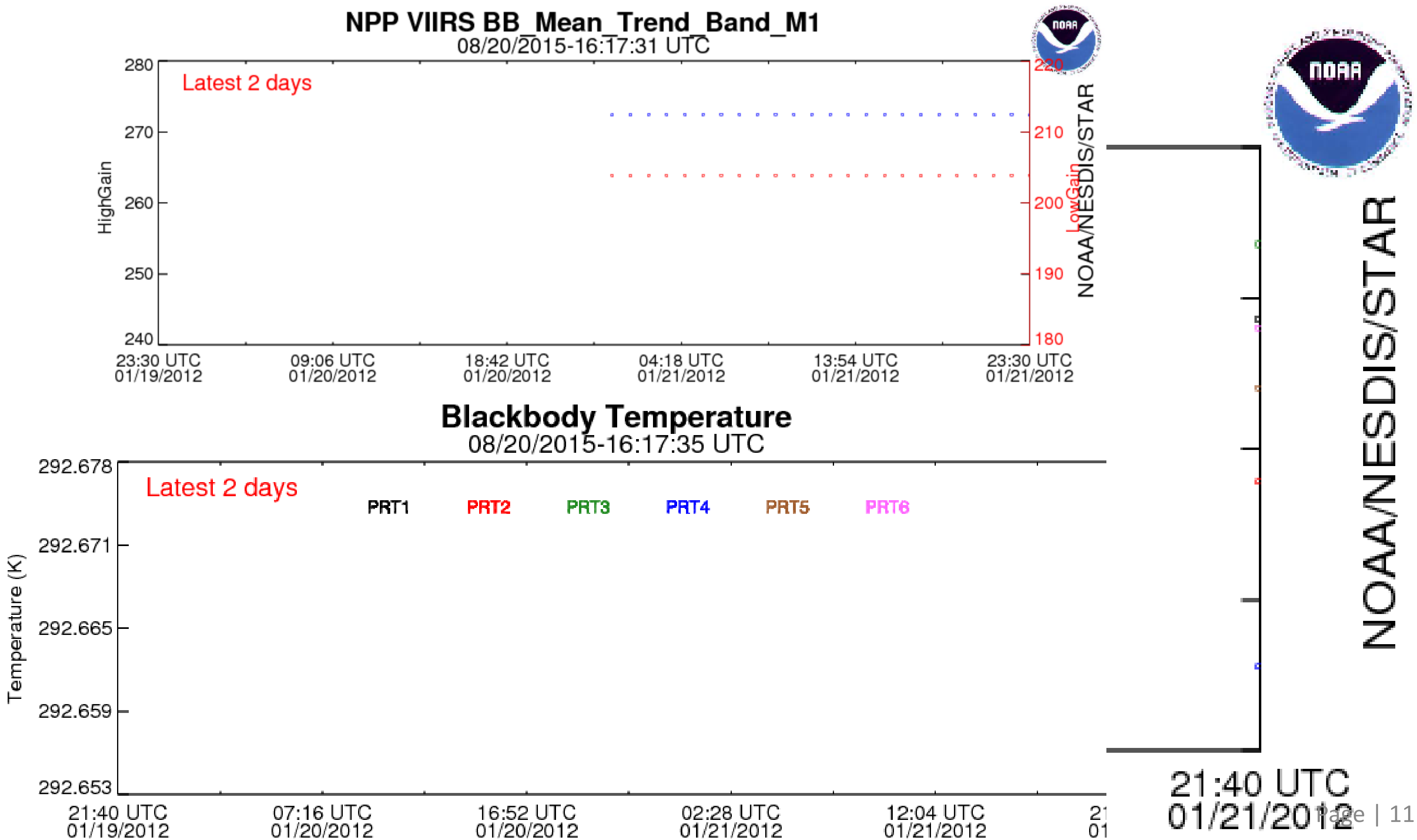


J1 Readiness Status

- ICVS Code Functionality Check
  - ICVS LTM Code Structure
    - ICVS LTM Calibration/Telemetry Process (IDL)
      - J1 proxy data does not include SD or SDSM data → code was modified.
      - Successfully generated intermediate HDF files and trending plots.

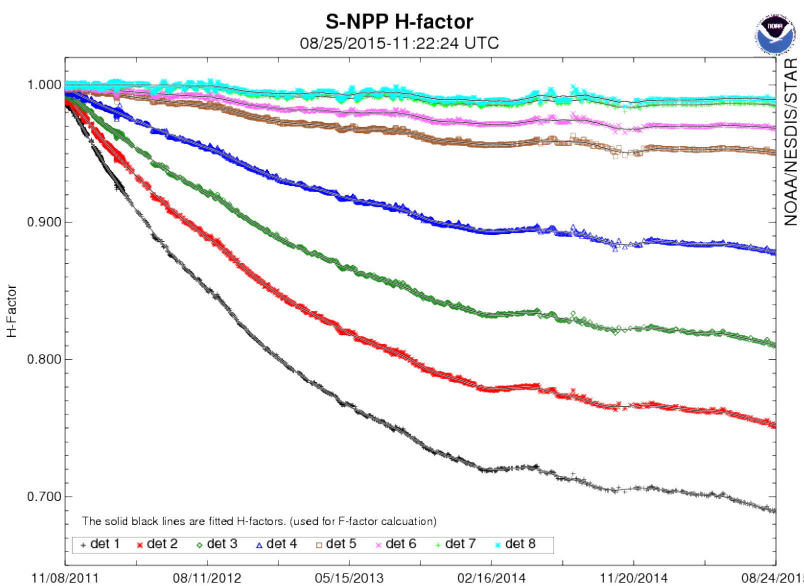


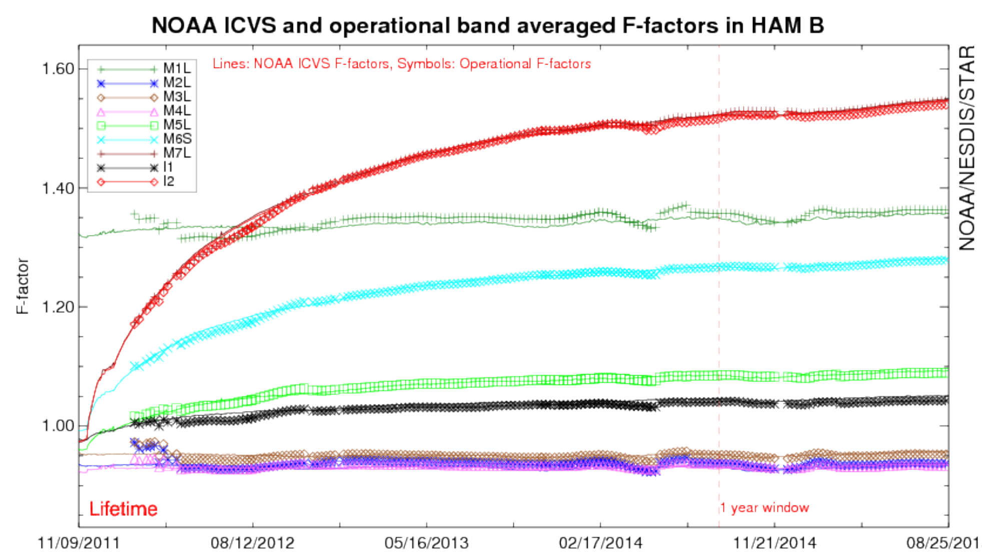
- ICVS Code Functionality Check
  - Calibration trending & telemetry plots are successfully generated.



Major Accomplishments

- Developed ICVS H / F-factors
  - Independently developed to validate operational F-factor LUTs.
  - H/F-factors
  - Detector dependent F-factors
  - Operational F-LUTs vs. ICVS F-factors
  - Operational F-LUTs vs. RSBAutoCal F-factors (GRAVITE)





Future Improvements for J1

- RSB Calibration
  - Intermediate trending plots will be included from F-factor calculation
    - C coefficient trending plots
      - Detector and electronics temperature trending plots
    - $L_{\text{sun model}}$ and $L_{\text{sun observation}}$ trending plots
    - τ_{sds} and SD SNR trending plots

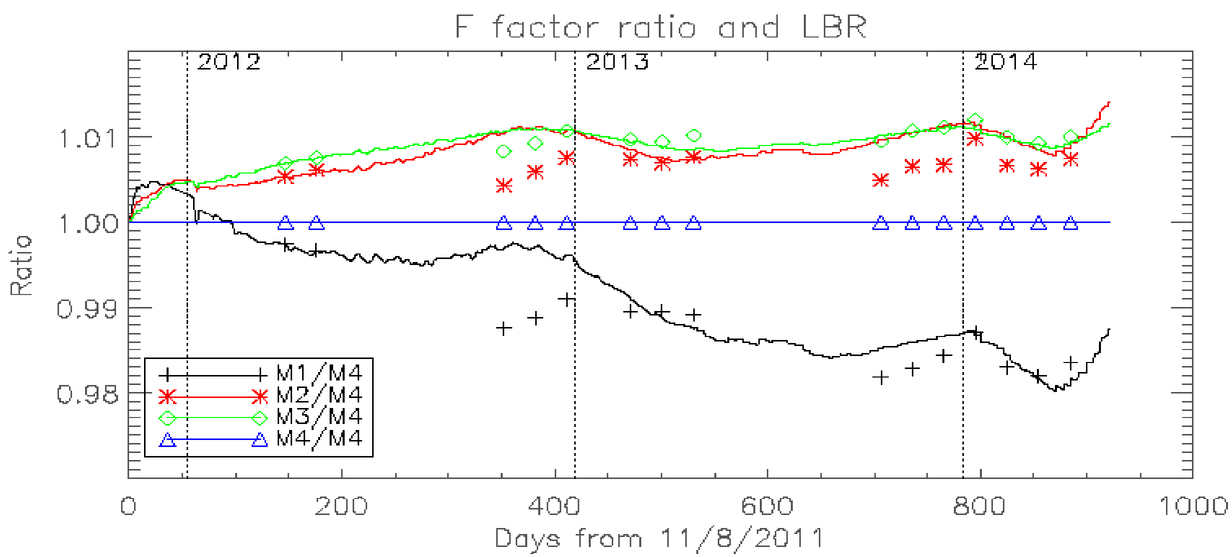
$$F = \frac{L_{Sun\_Model}}{L_{Sun\_Observation}} = \frac{Computed\_L_{Sun}}{Observed\_L_{Sun}}$$

$$F = \frac{\cos(\theta_{inc}) \cdot \left[E_{sun} \cdot \tau_{sds} \cdot BRDF(t)\right] \cdot RVS_{SD}}{c_0 + c_1 \cdot dn_{SD} + c_2 \cdot dn_{SD}^2}$$

Future Improvements for J1

- RSB Calibration and Validation
  - Lunar Band Ratio (LBR)
  - Lunar F-factor using Miller or ROLO model

$$\mathrm{LBR(B)} = \frac{\sum L_{Pixel}(B)}{\sum L_{Pixel}(Band\ M4)}$$



Future Improvements for J1

- TEB Calibration
  - Current TEB calibration in ICVS webpage is ‘linear slope’.

$$Linear\ \ Slope = \frac{L_{BB}}{DN_{BB} - DN_{SV}}$$

  - The official TEB F-factors and related trending plots will be added.
    - C Coffs., BB Temp., L_{ap}, L_{Bkgr}, εL_{BB}, etc.

$$F = \frac{L_{BB\_Model}}{L_{BB\_Observation}} = \frac{Computed\_L_{BB}}{Observed\_L_{BB}} = \frac{RVS_{BB} \cdot L_{ap} + L_{Bkgr}}{c_0 + c_1 \cdot dn_{BB} + c_2 \cdot dn_{BB}^2}$$

$$L_{ap} = \varepsilon L_{BB} + (1-\varepsilon)(F_{RTA}L_{RTA} + F_{BB\_SH}L_{BB\_SH} + F_{CAV}L_{CAV})$$

$$L_{Bkgr} = (RVS_{BB} - RVS_{SV}) \cdot \left[\frac{(1-\rho_{RTA})L_{RTA} - L_{HAM}}{\rho_{RTA}} \right]$$

Future Improvements for J1

- DNB Calibration
  - Gain, gain ratio, and intermediate values will be added to ICVS web.
  - Values will be compared to the delivered operational LUTs.

$$A(\det, N_{agg}, LGS) = \frac{RVS_{SD} \cdot \cos(\theta_{inc}) \cdot E_{sun} \cdot \tau_{sds} \cdot BRDF(t)}{dn_{SD}(\det, N_{agg}, LGS)}$$

$$dn_{SD}(\det, N_{agg}, LGS) = DN_{SD}(\det, N_{agg}, LGS) - DN_{SV}(\det, N_{agg}, LGS)$$

$$BRDF(t) = H_{Norm}(t) \cdot BRDF(t_0), \quad H_{Norm}(t) = H(t) / H(t_0)$$

$$H(t) = \frac{dc_{SD} \cdot \tau_{SDSM}}{dc_{SUN} \cdot BRDF(t_0) \cdot \tau_{SDS} \cdot \cos(\theta_{inc}) \cdot \Omega_{SDSM}}$$

Gain transfer by ratios

$$A(\det, N_{agg}, MGS) = \overline{R}_{M:L}(\det, N_{agg}) \cdot A(\det, N_{agg}, LGS)$$

$$A(\det, N_{agg}, HGS) = \overline{R}_{H:M}(\det, N_{agg}) \cdot A(\det, N_{agg}, MGS)$$

Summary

- STAR Integrated Cal/Val System (ICVS) Long Term Monitoring (LTM) system provides comprehensive near real time and long term instrument status and performance monitoring.
  – From imagery global coverage to detailed radiometric calibration status.
- STAR ICVS LTM code is ready for J1.
  – Functionality has been validated using J1 proxy data
  – Generated quality flag images
  – Generated intermediate daily/long-term calibration HDF files.
  – Generated telemetry plots successfully.
- STAR ICVS LTM capabilities will be improved.
  – By adding intermediate RSB F-factor trending plots.
  – Lunar Band Ratio (LBR) and lunar F-factor validation
  – Improving TEB calibration related plots
  – DNB calibration detailed trending plots.

THE AIT PROCESS SUPPORTING VIIRS

BIGYANI DAS

Bigyani Das[1], Marina Tsidulko[1], Weizhong Chen[1], Qiang Zhao[1], Valerie Mikles[1], Walter Wolf[2]

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[2]NOAA/NESDIS/STAR, College Park, MD 20740, USA

STAR JPSS 2015 Annual Science Team Meeting
NCWCP, College Park, MD, USA
August 26, 2015

I.M. Systems Group, Inc.

Overview

1. AIT and POCs for VIIRS Algorithms
2. ADL Framework
3. Testing and Troubleshooting
4. Communication
5. Quality Check & Reviews

Algorithm Integration Team (AIT)

AIT: JPSS STAR Algorithm Integration Team (From 2012)

Government Lead: Walter Wolf

Team Members: Bigyani Das, Valerie Mikles, Marina Tsidulko, Weizhong Chen, Qiang Zhao, Vipuli Dharmawardane, Kristina Sprietzer, Yunhui Zhao, Mike Wilson

Primary Responsibilities: Support JPSS Mission in Science Transition to Operations

Strengths:

- Degrees in Physical Sciences, Mathematics, Engineering
- Years of Experience in Programming in Fortran, C, C++
- Better Understanding of Science
- Years of Experience in Documentation, Communication, Programming, Presentation Skills, Manuscript Preparation, Results Analysis

Role of STAR AIT

- Code Testing in Algorithm Development Library (ADL)
- Troubleshooting
- Code Integration
- Algorithm Package Preparation and Delivery
- Communication with Science Teams, DPES and Raytheon
- Attending Science Team Meetings
- Reviewing ATBD and OAD and Other Documents
- Consultancy to Science Teams
- Emulation of Various Operational Scenarios
- Code Research and Analysis and Result Analysis
- Lead Algorithm Lifecycle Reviews

AIT POCs for VIIRS Algorithms

Algorithm	POC	Backup POC
VIIRS SDR	Weizhong Chen	Qiang Zhao, Bigyani Das
VIIRS EDR - Cryosphere	Marina Tsidulko	Bigyani Das
VIIRS EDR - Imagery	Marina Tsidulko	Bigyani Das
VIIRS EDR – Active Fire (AF)	Marina Tsidulko	Qiang Zhao, Bigyani Das
VIIRS EDR – NDVI	Qiang Zhao	Bigyani Das, Marina Tsidulko
VIIRS EDR – Surface Reflectance	Qiang Zhao	Marina Tsidulko, Bigyani Das
VIIRS EDR – Cloud Mask	Weizhong Chen	Bigyani Das
VIIRS EDR – Cloud Products	Weizhong Chen	Bigyani Das
VIIRS EDR - Aerosol	Bigyani Das	Weizhong Chen
VIIRS EDR - LAND	Qiang Zhao	Marina Tsidulko
Requirements, Reviews, Quality Checks, Documents	Valerie Mikles	Algorithm POCs
Software Installation/Maintenance	Weizhong Chen	Algorithm POCs
ADL Chain Run	Weizhong Chen	Algorithm POCs

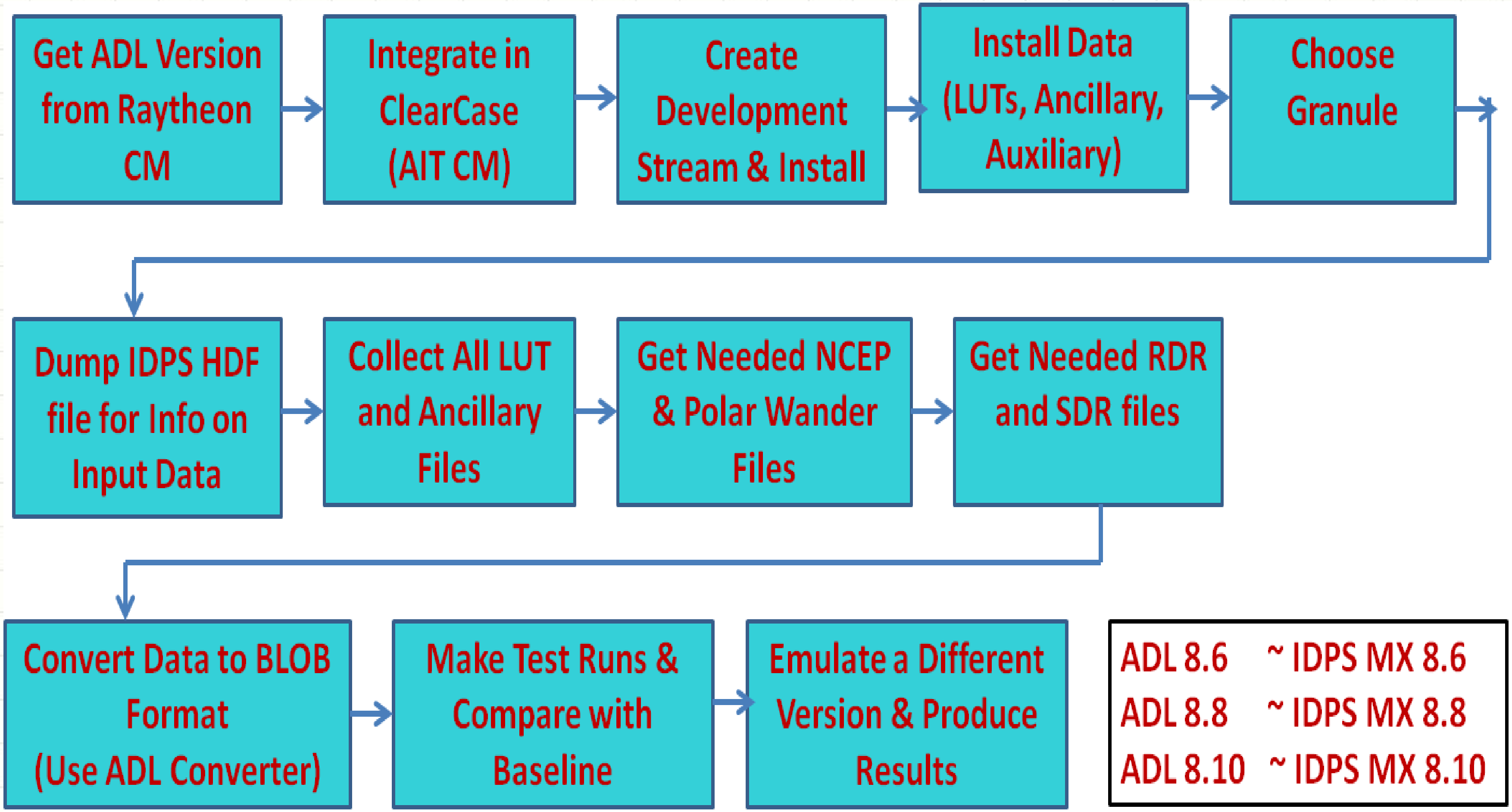
ADL Framework

- ADL is the Test System - Developed by Raytheon
- ADL mimics Operational IDPS system
- ADL provides a Diagnostic Framework
- ADL is recommended by Data Products Engineering and Services (DPES)
- I-P-O Model (Input-Processing-Output)
- ADL Versions evolve with IDPS Versions (Example: IDPS MX8.10~ADL4.2_MX8.10)

Testing & Troubleshooting in ADL

- **Step 1:** Get ADL Version from Raytheon CM system
- **Step 2:** Put these versions in STAR AIT Common CM system giving this a distinct name to differentiate from other baselines
- **Step3:** Create a Test Stream out of the above Main Integration Streams
- **Step 4:** Work with the Test Stream creating Future Emulation Scenarios
- **Step 5:** Commit changes so that others can use these changes with their algorithm updates to create a new emulation scenario
- **Step 6:** Use the Golden Day (special days for specific events) of interest recommended by the science teams
- **Step 7:** Organize all the needed input files for this test date
- **Step 8:** Build ADL and Run the Executables to generate Product Data

Testing & Troubleshooting in ADL



Testing & Troubleshooting in ADL

- **Step 1**: **Get ADL Version from Raytheon CM system at https://199.46.132.15/cqweb/**

ADL Source Tar Packages:

- ADL4.2.2 + Mx8.5 Code and Data Packages
- ADL4.2.2 + Mx8.6 Code and Data Packages
- ADL4.2.2 + Mx8.8 Code and Data Packages
- ADL4.2.2 + Mx8.10 Code and Data Packages

- **Step 2: Put these versions in STAR AIT Common CM system giving this a distinct name to differentiate from other baselines**

Examples:

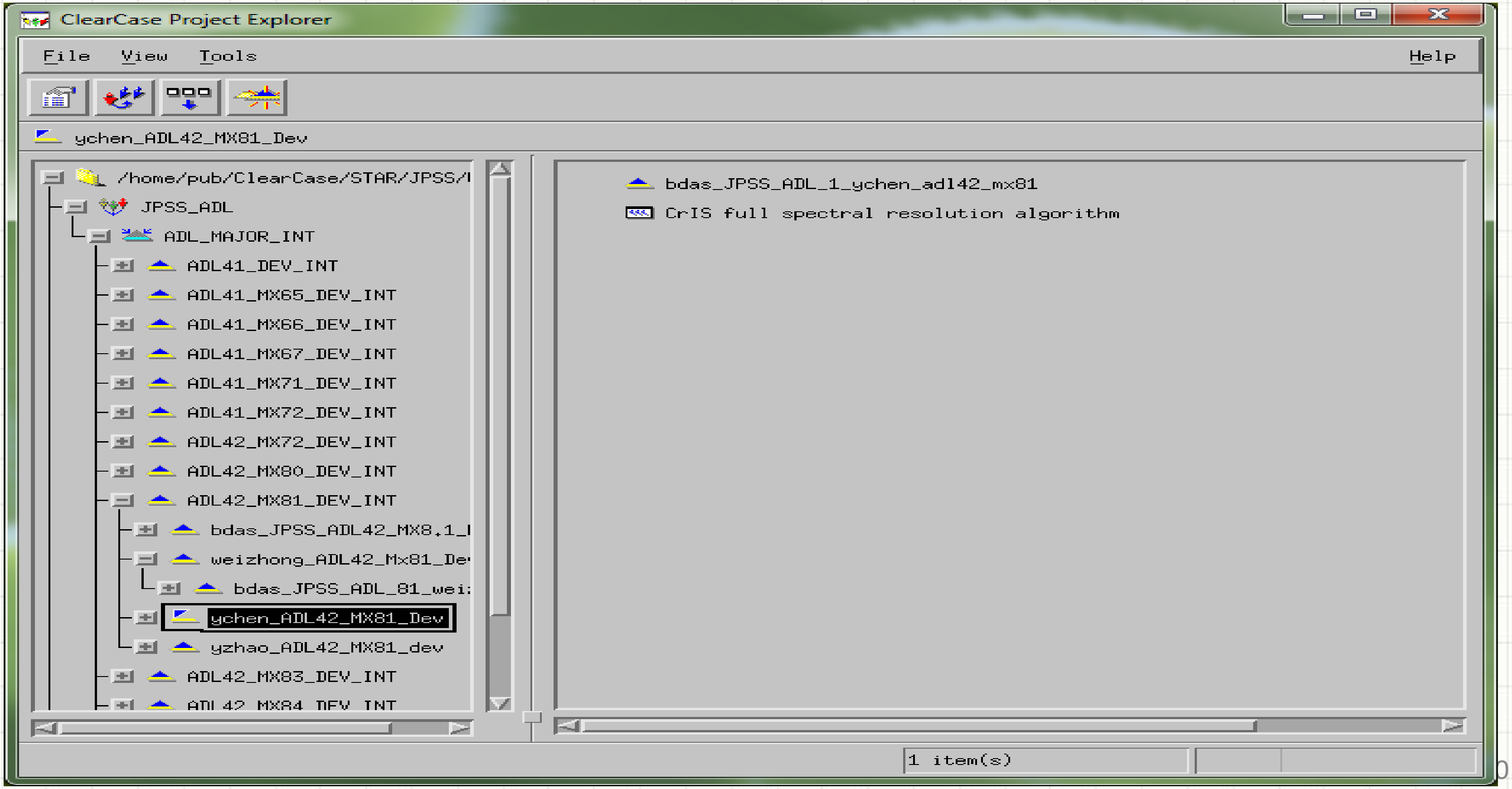
- ADL42_MX87_DEV_INT
- ADL42_MX88_DEV_INT

Note: We have installed COTS from University of Wisconsin site at at https://jpss-adl-wiki.ssec.wisc.edu/mediawiki/index.php/ADL_Installation. We obtained previous versions of ADL from this site

Testing & Troubleshooting in ADL

- **Step3:** Create a Test Stream out of the above Main Integration Streams

Examples: bdas_JPSS_ADL_ADL4.2_MX8.8_Dev
weizhong_JPSS_ADL_ADL4.2_MX8.10_Dev



Testing & Troubleshooting in ADL

- **Step 4:** Work with the Test Stream creating Future Emulation Scenarios

Examples:

- Use changes for VIIRS SDR to a Baseline Version, Say MX8.10
- Use changes for Aerosol EDR to the Baseline Version, Say MX8.10

- **Step 5:** Commit these changes so that others can use their changes over your changes and create a new emulation scenario

Examples:

Use both the above changes to test a Future Emulation Scenario for Aerosol EDR

Testing & Troubleshooting in ADL

- **Step 6: Find out the Golden Day (special days for specific events) of interest from the science team member**

  Get this information from the scientists. The special granules may be chosen according to the product of their interest.

- **Step 7: Organize all the needed input files for this test date**

Some files for VIIRS SDR are first track: VIIRS-SDR-GEO-DNB-PARAM-LUT, VIIRS-SDR-DNB-C-COEFFS-LUT, VIIRS-SDR-DG-ANOMALY-DN-LIMITS-LUT etc. The data that come with a particular version of ADL might have all of these recent files.

Updated LUTs, compatible first track files and compatible ancillary files such as Polar Wander, NCEP, NAAPS files etc. should be compatible for the date we choose for the test

- **Step 8: Build ADL and Run the Executables to generate Product Data**

Communication

- Science Teams, Raytheon and DPES
- Attend Science Team Meetings
- Attend Meetings with Raytheon for Discussions on ADL
- Verify code updates, results with science team
- Resolve discrepancy in ADL version and results with DPES
- Verify input tables, LUTs, ancillary data etc.
- Verify change request package, functional test results, regression test results
- Provide support for the AERB review process

Quality Control

ADL Version Check

Run sample SDR and EDR cases for each new ADL version and compare the results with IDPS results

Science Check

Communicate with the Science Team for Result Verification

Document Check

- ATBD documents
- OAD documents
- Other presentations, publications, review documents, and requirement documents required by the science teams

Quality Control (Continued)

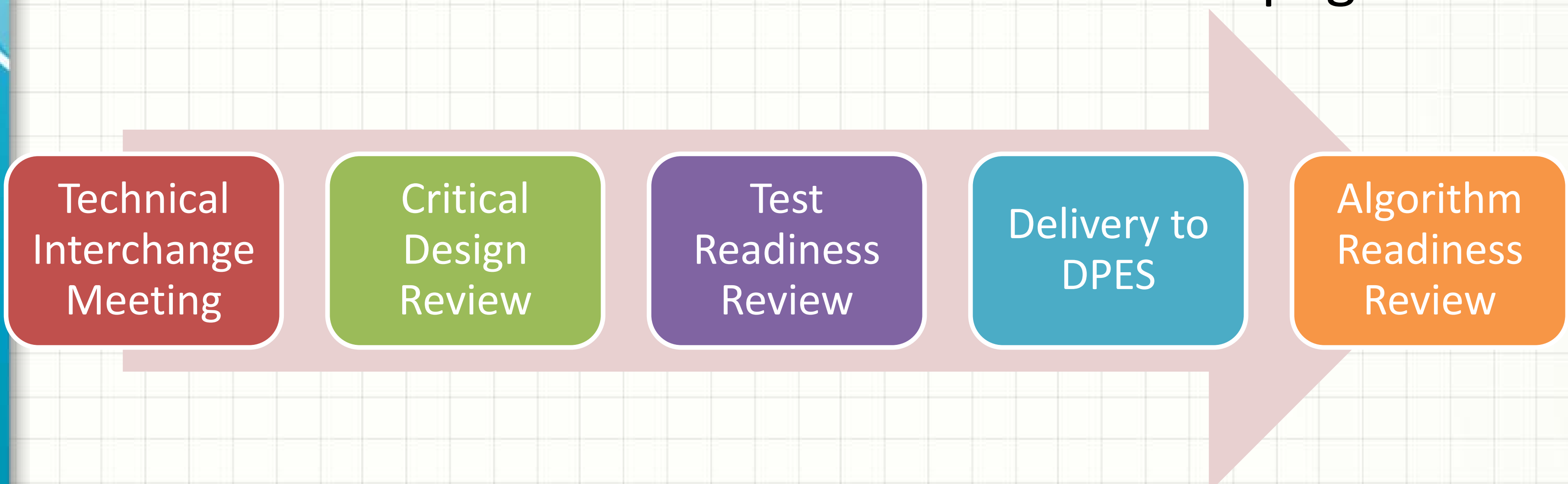
Algorithm Package Check

- ATBD Documents
- OAD Documents
- Test Data Sets
- Updated Software
- Baseline and Updated Results
- DPE Processing Request Form
- Algorithm LUT PCT or Algorithm Delivery Checklist
- Update Delivery Report
- Any Other Supporting Documents

Life Cycle Reviews for J1 Algorithms

STAR AIT Review Process for J1 is based upon the Capability Maturity Model Integration Level 3 Process.

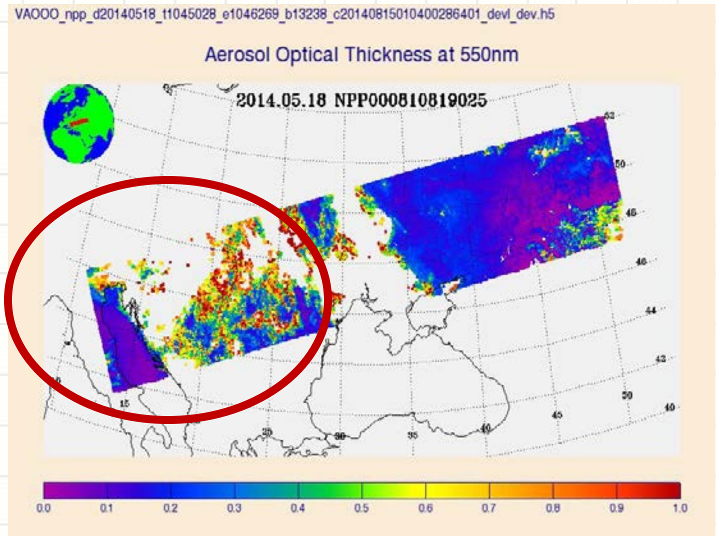
- Shows understanding of the requirements
- Shows the algorithm development to meet the requirements
- Ensures all stakeholders are on the same page

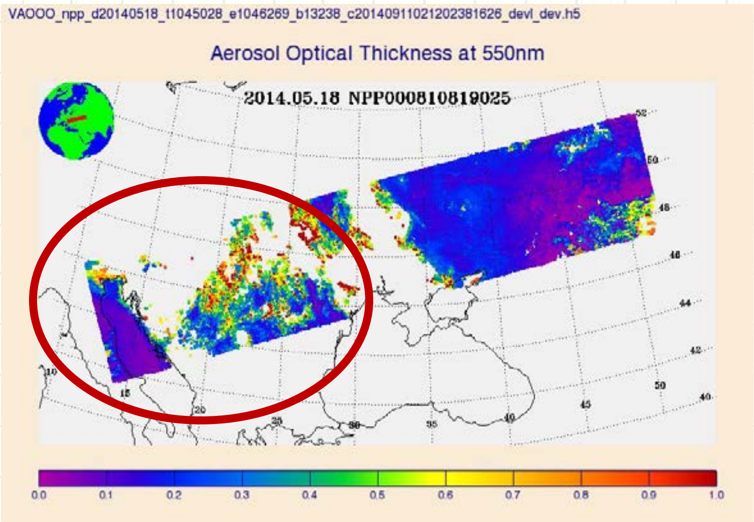


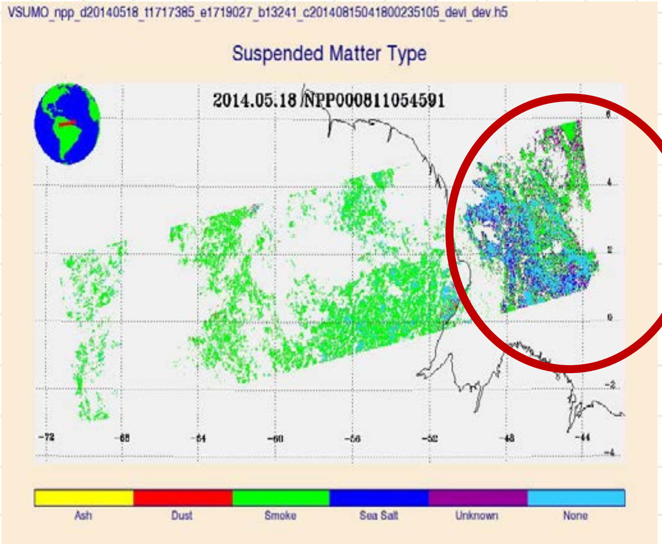
AIT Work Examples (VIIRS)

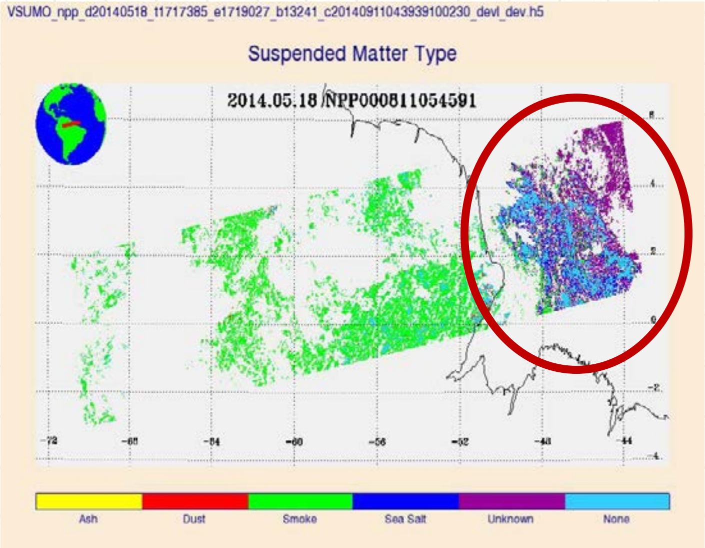
- VIIRS GEO Code Updates and LUT Update for J1
- VIIRS SDR Testing with Updated LUTs for J1
- Add Quality Check for Active Fire (AF)
- Complete Testing and Prepare AF Algorithm Package for NDE
- Land Surface Albedo LUT updating
- Equation Modification for Sea Surface Temperature and Evaluating Downstream Impact
- Roll Back LST LUT from Provisional to Beta Version
- Conducting sensitivity tests for Ice Age algorithm
- Implementing NOAA Global Multisensor Automated Snow/Ice Map (GMASI) Tile

AIT Work Examples (VIIRS)









MX8.4 Baseline

MX8.4 Baseline with new internal snow test

AIT Work Flow Sequence

- Science teams find a discrepancy
- Science teams file an algorithm discrepancy report (ADR) (at times AIT POC also helps filing the ADR)
- AIT POC is notified about this ADR
- ADR is discussed in DRAT and AIT POC participates
- Science Teams formulate hypothesis, try solution ideas, engage AIT POC in testing, integration and verification process
- AIT POC participates in Technical Interchange Meeting (if held)
- Once AIT testing and integration results are verified by the science team, AIT POC prepares change request package and submits to DPES.
- DPES verifies AIT testing in GADA (AIX system)
- Algorithm JAM files a CCR
- AERB review is held and changes accepted

Summary

Accuracy of Algorithms -> Product Accuracy

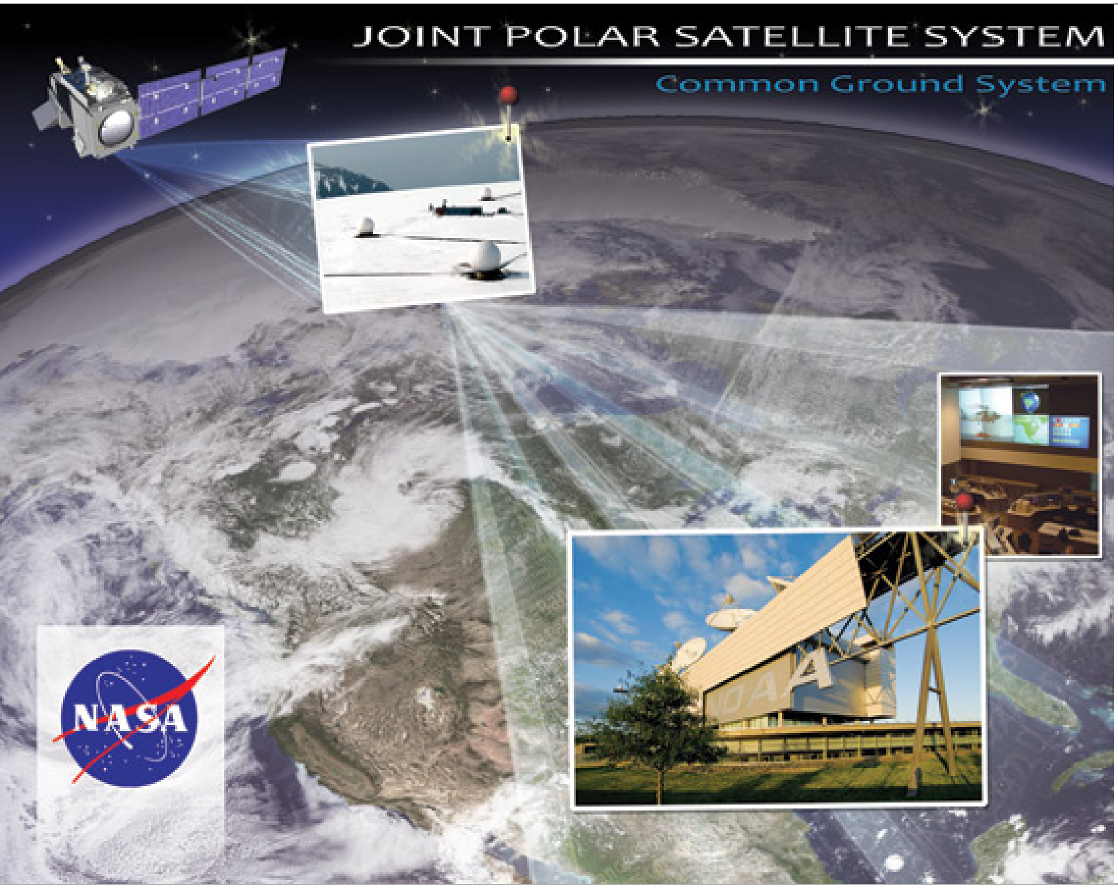
STAR AIT ROLES:

- ❖ **Testing and Troubleshooting**
  - ➢ Facilitates Structured Tests
  - ➢ Performs Emulation Experiments with Chain Run Tests
  - ➢ Performs Code Updates, Tests and Delivery
  - ➢ Facilitates Review Process
  - ➢ Produces Product Test Data
- ❖ **Communication Facilitation**
- ❖ **Quality Control: Algorithm Check, Science Check & Documentation Check**

QUESTIONS?

JPSS Common Ground System

Raytheon
Intelligence, Information and Services



IDPS Readiness for VIIRS

Wael Ibrahim
Michelle Hoover
Garrett Pachl

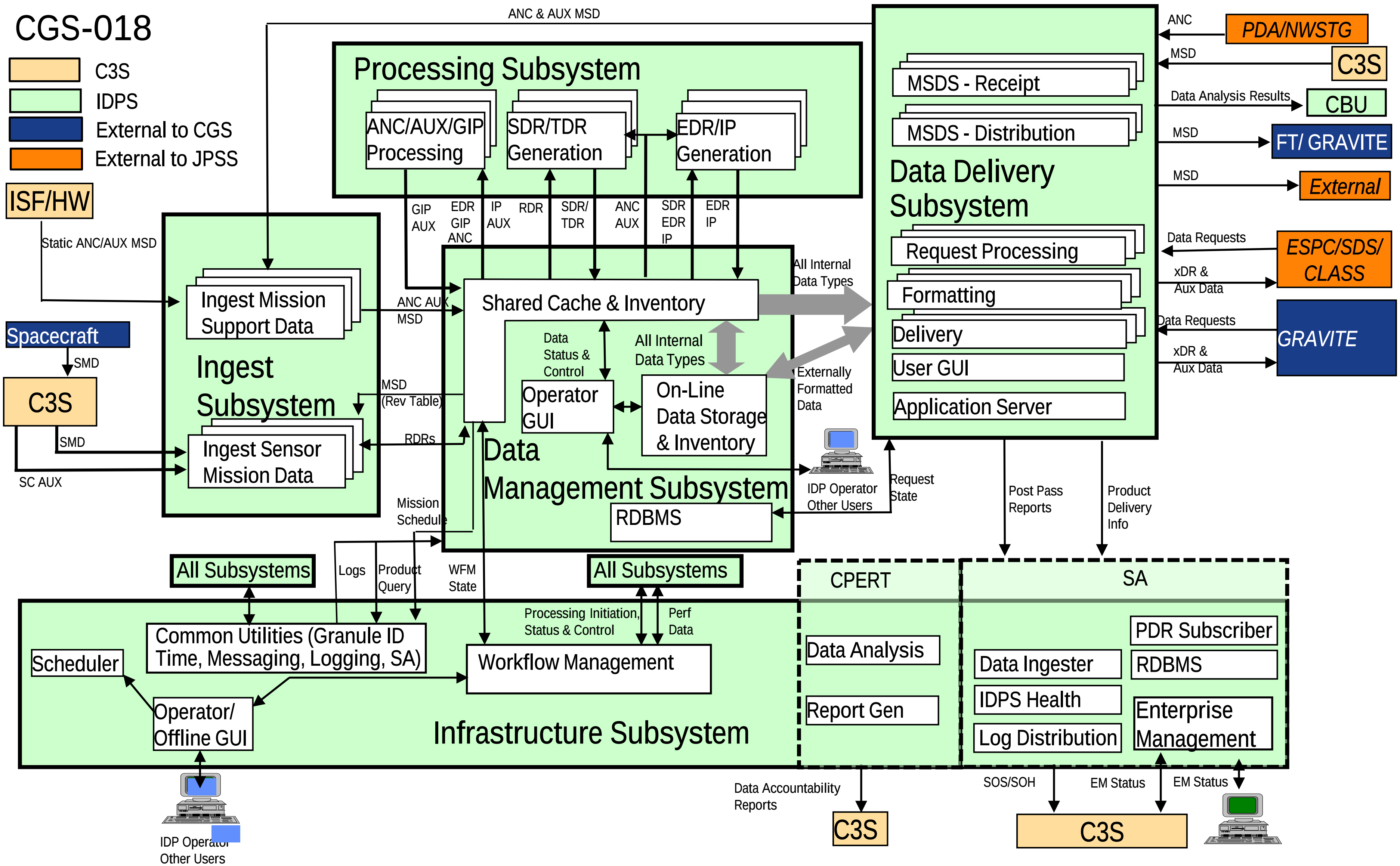
STAR JPSS Annual Science Team Meeting
NCWCP, College Park, MD
August 26, 2015

RAYTHEON COMPANY
INTELLIGENCE, INFORMATION AND SERVICES (IIS)
JPSS CGS PROGRAM
AURORA, COLORADO

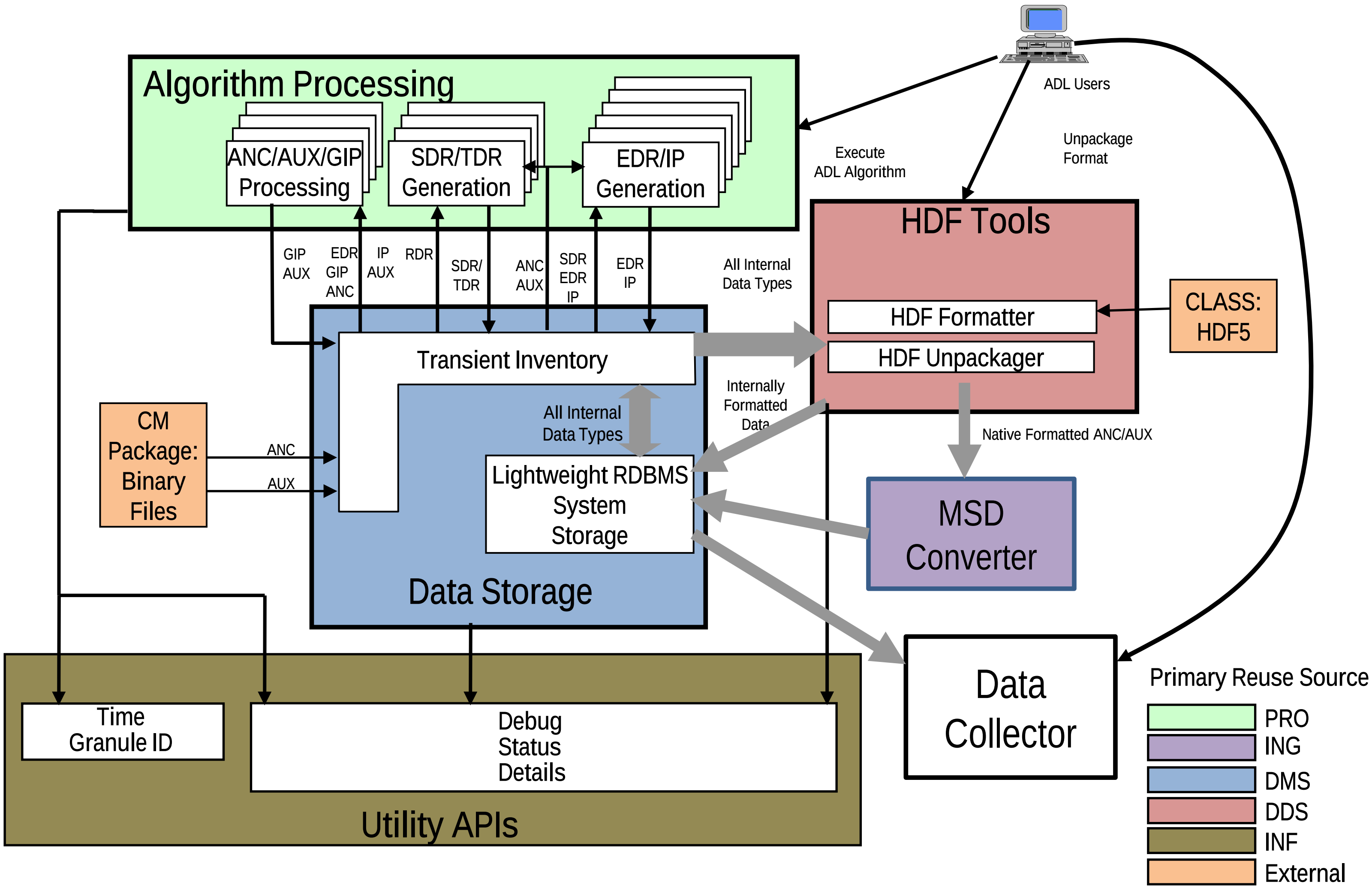
Outline

- IDPS Architecture Diagram – Block 2
- ADL Architecture Diagram – Block 2
- VIIRS Product Change Summary
- Data Request and Delivery
- Algorithm Documentation
- Data Endianness
- VIIRS Extended Granule
- NOVAS Library Update
- Upcoming VIIRS Algorithm Updates
- ADR/PCR Status

IDPS Architecture Diagram – Block 2



ADL Architecture Diagram – Block 2



VIIRS Product Change Summary (1/4)

- The following changes have been made to VIIRS product types in Block 2:
  - VIIRS Cloud Mask update from IP to EDR
  - VIIRS Active Fire update from ARP to EDR
- VIIRS Net Heat Flux (NHF) and corresponding GEO product are no longer produced/delivered in Block 2.
- The term "Retained IP, RIP" is retired for Block 2 and thus corresponding IPs are now deliverable IPs in Block 2
- Next slide shows a list of those deliverable IPs in Block 2

VIIRS Product Change Summary (2/4)

Product	DPID	CSN	Documentation (SRS Vol 2 document number)
VIIRS Aerosol Model Information IP	IVAMI	VIIRS-Aeros-Modl-Info-IP	474-00448-01-12; Aerosol
VIIRS Aerosol Optical Thickness IP	IVAOT	VIIRS Aerosol Optical Thickness IP	474-00448-01-12; Aerosol
VIIRS Bright Pixel IP	IVPBX	VIIRS-Bright-Pixel-Mod-IP	474-00448-01-06; VIIRS RDR SDR
VIIRS Calibrated Dual-gain Band IP	IVCDB	VIIRS Calibrated Dual-Gain Band IP	474-00448-01-06; VIIRS RDR SDR
VIIRS Cloud Base Height IP	IVCBH	VIIRS-CB-Ht-IP	474-00448-01-16; Cloud Physical Properties
VIIRS Cloud Cover-Type IP	IVCLT	VIIRS-Cd-Cov-Type-IP	474-00448-01-16; Cloud Physical Properties
VIIRS Cloud Layer-Type IP	IVICC	VIIRS-Cd-Layer-Type-IP	474-00448-01-16; Cloud Physical Properties
VIIRS Cloud Optical Properties IP	IVCOP	VIIRS-Cd-Opt-Prop-IP	474-00448-01-14; Cloud Optical Properties
VIIRS Cloud Top Parameters IP	IVCTP	VIIRS-Cd-Top-Parm-IP	474-00448-01-16; Cloud Physical Properties
VIIRS Global/Rolling 5-km NBAR NDVI Gridded IP	IVGNN	GridIP-VIIRS-Nbar-Ndvi-Rolling-Tile	474-00448-01-07; AncAuxGridGran
VIIRS Ice & Night Water Cloud Top Temperature IP	IVIWT	VIIRS-INWCTT-IP	474-00448-01-14; Cloud Optical Properties
VIIRS Ice Concentration IP	IVIIC	VIIRS-I-Conc-IP	474-00448-01-17; Cryosphere
VIIRS Ice Quality Flags IP	IVIQF	VIIRS-I-Qual-Flags-IP	474-00448-01-17; Cryosphere
VIIRS Ice Reflectance/Temperature IP	IVIRT	VIIRS-I-Refl-Temp-IP	474-00448-01-17; Cryosphere
VIIRS Ice Weights IP	IVIIW	VIIRS-I-Wts-IP	474-00448-01-17; Cryosphere
VIIRS Land Surface Albedo Gridded IP	IVGLA	GridIP-VIIRS-Land-Surf-Albedo-17Day-Tile	474-00448-01-07; AncAuxGridGran
VIIRS Monthly Brightness Temperatures, Surface Reflectance & Vegetation Index Gridded IP	IVTRF	GridIP-VIIRS-Mth-SR-BT-VI-Monthly-Final-Tile	474-00448-01-07; AncAuxGridGran
VIIRS On-board Calibrator IP	IVOBC	VIIRS-OBC-IP	474-00448-01-06; VIIRS RDR SDR
VIIRS Parallax Corrected Cloud Mask IP	IVPCM	VIIRS-Parx-Corr-CM-IP	474-00448-01-16; Cloud Physical Properties
VIIRS Parallax Corrected Cloud Optical Properties IP	IVPCP	VIIRS-Parx-Corr-Cd-Opt-Prop-IP	474-00448-01-16; Cloud Physical Properties
VIIRS Parallax Corrected Cloud Top Parameters IP	IVPTS	VIIRS-Parx-Corr-Cd-Top-Parm-IP	474-00448-01-16; Cloud Physical Properties
VIIRS Snow Ice Cover IP	IVSIC	VIIRS-GridIP-VIIRS-Snow-Ice-Cover-Mod-Gran	474-00448-01-07; AncAuxGridGran
VIIRS Snow/Ice Cover Gridded IP	IVGSC	GridIP-VIIRS-Snow-Ice-Cover-Rolling-Tile	474-00448-01-07; AncAuxGridGran
VIIRS RSB Autocal History AUX		VIIRS-RSB-AUTOCAL-HISTORY-AUX	474-00448-01-06; VIIRS RDR SDR
VIIRS Surface Reflectance IP	IVISR	VIIRS-Surf-Refl-IP	474-00448-01-15; Surface Reflectance
VIIRS Surface Temperature IP	IVSTS	VIIRS-Surf-Temp-IP	474-00448-01-17; Cryosphere
VIIRS Un-aggregated 750m Dual-Gain Band Geo IP	IVCDB	VIIRS-DualGain-Cal-IP	474-00448-01-06; VIIRS RDR SDR

VIIRS Product Change Summary (3/4)

- New metadata items:
  - N_IDPS_Mode
    - Defines the mode that the system was in at the time the data was produced. Value depends on domain, observation time, and transition that are defined in the Infrastructure.
    - Values are defined in CDFCB Vol 1: ops, int, dev, ada, etc.
    - Applies to RDR, SDR/TDR, EDR/IP, GEO, DQN
  - N_Primary_Label
    - Defines the labeling of JPSS Data Products as primary or non-primary. All products delivered are labeled xDR, GEO, DQN, AUX (produced by CGS), and tile products.
    - Values are 'Primary' or 'Non-Primary'

VIIRS Product Change Summary (4/4)

- The following table highlights changes to existing metadata for Block 2:

Metadata	Block 1	Block 2	Details
Document Ref	N_NPOESS_Document_Ref	N_JPSS_Document_Ref	Metadata name change for Block 2
N_Reference_ID and N_Input_Prod	N_Input_Prod values are an array of strings containing N_Reference_ID (URID) Example: ZZZ05567890ABCD01020304VNCD25678)	N_Input_Prod values are an array of strings containing N_Reference_ID Example: VIIRS-MOD-RGEO:NPP001212022917:A1	Block 2 values updated to include CSN, N_Granule_ID, N_Granule_Version

Data Request and Delivery

- Data Packaging
  - In Block 2, GEO products can be requested and delivered in separate HDF5 files, i.e., no need to request, for example, VIIRS SDR M-Band to get the MOD-Res Ellipsoid GEO (VIIRS-SDR-GEO) product.

- Data Compression
  - In Block 2, delivery of compressed HDF5 product is per DDS request.
  - Compression does not apply to RDRs, ANC, nor native format deliveries (Mission Notice nor Data Production Report).
  - The following data types may be compressed (based on request):
    - SDR/TDR
    - IP
    - GEO
    - EDR
    - AUX

Algorithm Documentation (1/2)

- In Block 2, some of the DFCB (external and internal) volumes are replaced with corresponding Software Requirement Specification (SRS) volumes. Algorithm information is documented in the SRS Volumes 1 - 4. A set of SRS Volumes is in place for each algorithm category:
  - SRS Volume 1: Requirements and Input/Output processing info
  - SRS Volume 2: Data Dictionary, product format information
  - SRS Volume 3: Reference to the applicable OAD(s)
  - SRS Volume 4: Parameter File, contains quality flag, fill value, notification logic
- CDFCB Volume 1 applies to Block 2 and includes a list of all applicable CSNs/DPIDs
- Next slide provides a more comprehensive list

Algorithm Documentation (2/2)

Product Information	Block 1 Document Reference	Block 2 Document Reference
Algorithm Input/output	EDR IR	SRS Volume 1's – Table 3-1 Part 2 - 30
Product Format Info (RDR, SDR, EDR, IP, LUTs)	CDFCB Vol 2 – 4, 8	SRS Volume 2: Data Dictionaries Part 2-30
Product Format Info (IP)	IDFCB Vol 3 (Retained IP)	SRS Volume 2's (Delivered IP) Part 2 -30
Algorithm Science/Processing Descriptions	ATBDs and OADs	ATBDs SRS Volume 3 (References OADs)
Quality Flag, Data Quality Notification, and Fill information	EDR PR	SRS Volume 4's (Parameter File) SRS Volume 2 Data Dictionaries
Metadata Information	CDFCB Vol 5 IDFCB Vol 3	SRS Volume 2 for Common Algorithms (CAS Data Dictionary)
General product info, product CSN and DPIDs	CDFCB Vol 1	CDFCB Vol 1
Ancillary, Auxiliary Data, Messages, Reports	CDFCB Vol 6	CDFCB Vol 6

Data Endianness (1/3)

- In Block 1, Auxiliary binary files (e.g. Lookup Tables (LUTs), Processing Coefficient Files (PCTs) and Data Quality Threshold Tables (DQTTs)) provided to IDPS are in Big Endian (BE) file format type. In Block 2, they will come to IDPS as Little Endian (LE).
- Endianness is not currently marked on the binaries. In Block 2, binaries will be posted externally and endianness needs to be communicated to the user.
- JPSS Ground Project has requested dual LUTs (BE and LE versions) be delivered starting with OB-SAT in September 2015. STAR has determined AIT will be responsible for providing binaries in correct format.
- On-going discussions (NASA DPES, NASA SEIT, NASA IDPS, AMP, Raytheon) seem converging on agreement to place the “LE” as the first 2 digits of the 50 total allowed in the Version Field contained between PS and PE, of the binary file name.

Data Endianness (2/3)

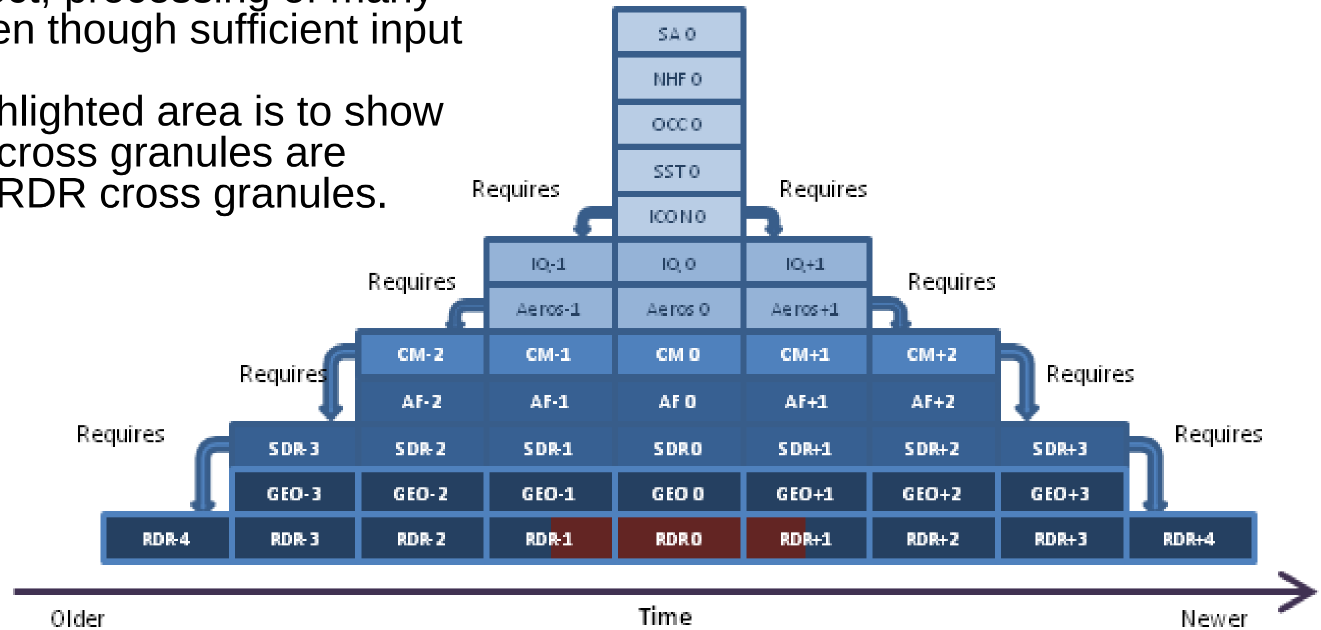
- IDPS PRO SW outputs AUX products, e.g., VIIRS-RSBAUTOCAL-HISTORY-AUX as BE. The internal-only ByteOrder metadata is set to 'BE'. PRO SW will convert it to LE before using it as an input.
- IDPS DDS SW does not perform any Endianness conversion, thus, DDS wraps the PRO output binary in the same Endianness PRO has produced it.
- Since VIIRS-RSBAUTOCAL-HISTORY-AUX is produced as BE and is HDF5-wrapped for delivery, then, no change is required in the filename.
- Next slide provides a more comprehensive list

Data Endianness (3/3)

Product Family	File Format Type
RDR	Big Endian Binary (structure stored within HDF5)
Deliverable Indirect Indexed GridIP Tiles (LSA 17Day, Monthly SR/BT/VI Final, NBAR NDVI)	Big Endian Binary (structure stored within HDF5)
GMASI Snow/Ice Cover Gridded IP, VIIRS Quarterly Surface Type Gridded IP Quarterly Tile, VIIRS Annual Maximum/Minimum Normalized Difference Vegetation Index (NDVI) Gridded IP Quarterly Tile	Little Endian Binary
Official Dynamic Ancillary Data (NOAA Global Multisensor Automated Snow/Ice Map - Northern Hemisphere/Southern Hemisphere)	Big Endian Binary (structure stored within HDF5)
Official Static Ancillary Data (ex. Aerosol Optical Thickness Climatology Files, NASA Code 916 Cloud Top Pressure Files, Nitrate Depletion Temperature Files, Ozone Profile: Fortuin and Kelder Climatology, Surface Pressure (TUG87) Climatology Files	Little Endian Binary IEEE 754
IPDS Terrain Database	Little Endian Binary
LUTs, PCs (Automated and Manual Processing Coefficients)	Little Endian Binary
VIIRS-RSBAUTOCAL-HISTORY-AUX	Big Endian Blob (stored within HDF5)
DQTT	Little Endian Binary

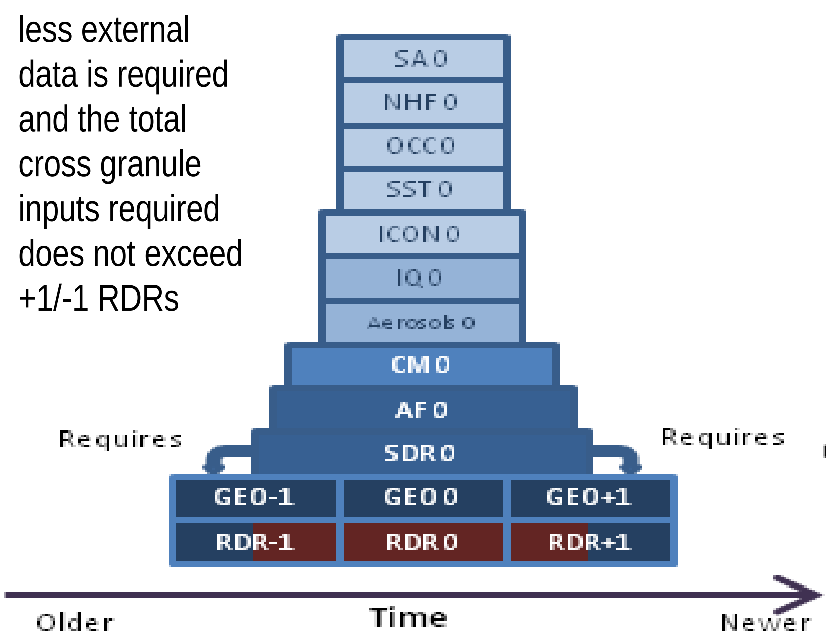
VIIRS Extended Granule (1/5)

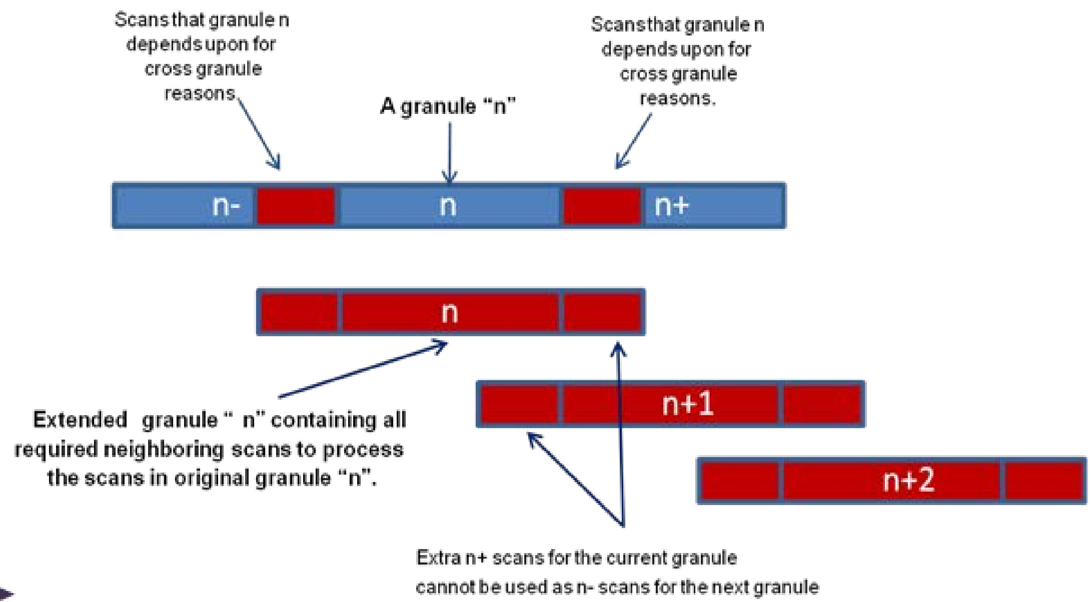
- The following illustration displays the cross-granule requirement concept for the VIIRS processing chain, i.e.,
  - Ice Concentration (ICON) requires +1/-1 Ice Quality (IQ) cross granules
  - IQ requires +1/-1 Aerosols cross granules
  - Aerosols requires +1/-1 Cloud Mask (CM) cross granules
  - CM requires +1/-1 SDR cross granules
  - SDR requires +1/-1 RDR cross granules
- Thus, a cascading dependency is created where +4/-4 RDRs are needed for ICON to get processed .
- As an undesirable side effect, processing of many products would have to even though sufficient input data is available.
- The purpose of the red-highlighted area is to show that only parts of the RDR cross granules are needed and not the whole RDR cross granules.



VIIRS Extended Granule (2/5)

- Extended Granule Characteristics
  - Allows for greater availability of products.
  - Extends the contents of a granule to include the needed data, e.g., scans, from the input cross granules.
  - The core granule and the extended scans "slivers" are created as separate products to allow for use of the core granule in the event that the extended scans are not needed as input to a product.





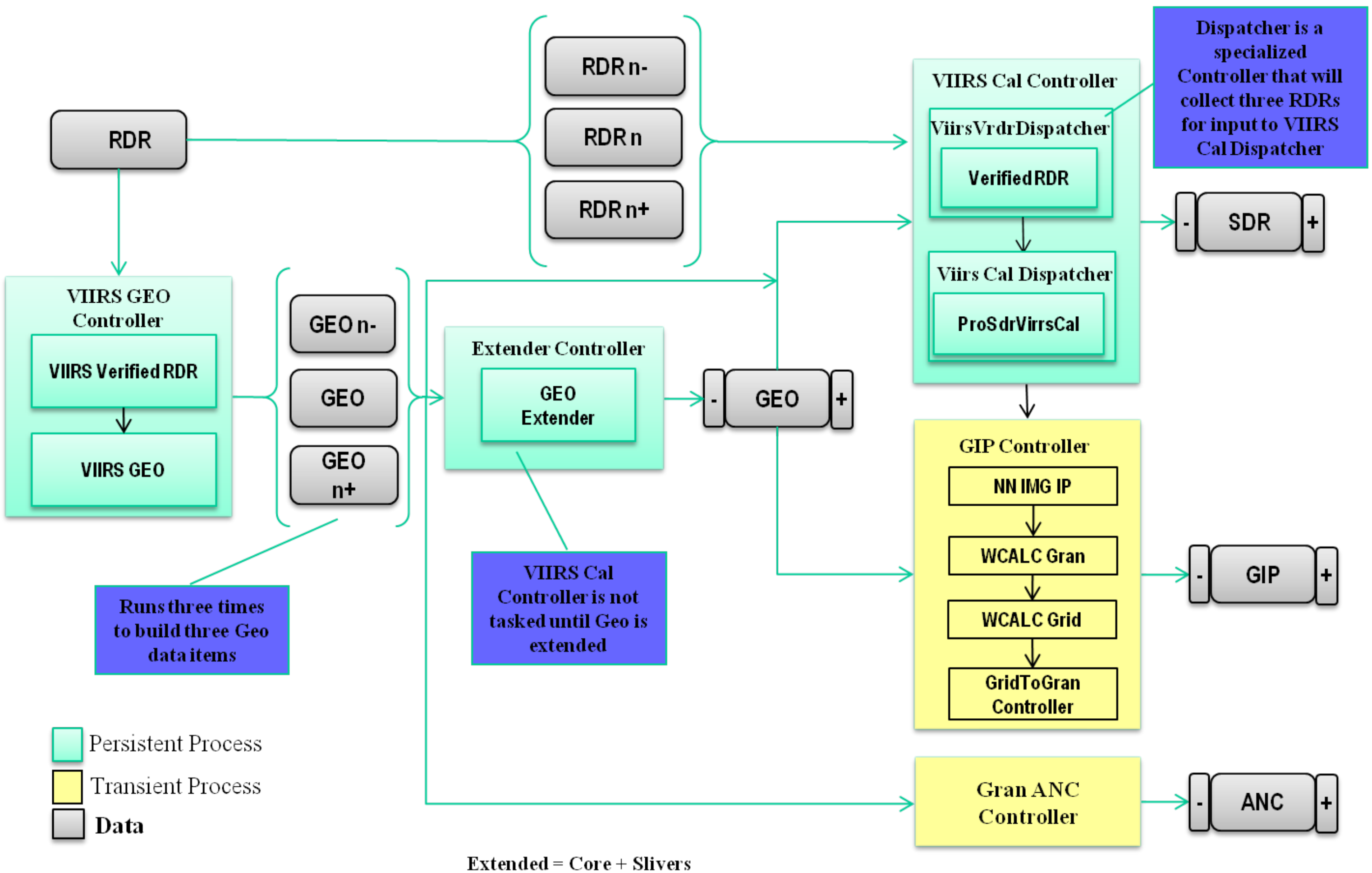
VIIRS Extended Granule (3/5)

- The sliver binary files are not included in the HDF5 packages generated when running the VIIRS chain.
- Per implementation of the "Extended Granule," the VIIRS SDR Controller, in Block 2, is split into multiple executables.
  - Algorithms requiring only geolocation do not need to wait for other algorithms that were formerly in the VIIRS SDR Controller.
  - Next slide illustrates the splitting for the SDR Controller.

VIIRS Extended Granule (4/5)

Data Item Diagram

Splitting of the VIIRS SDR Controller



VIIRS Extended Granule (5/5)

- Block 2 ADL provides a tool, i.e., Gran Extender, that creates an extended granule from a core granule and its cross granule data items "slivers."
  - If the granule has already been extended, the tool will not re-extend it.
- The Extender Tool provides a simple command-line-based user interface. There are several ways to run the tool.
  - Accepts a single granule ID (or list of granule IDs) and produces the extended granule for the single granule (or each of the listed IDs).
  - Accepts a time range and extends all available granules within that time range.

NOVAS Library Update (1/6)

- The following is an excerpt from the weekly Cal/Val Lead meeting notes provided by the meeting chair, Janna Feeley:

  *" **N**aval **O**bservatory **V**ector **A**stronomy **S**oftware (NOVAS):*

    - Current IDPS version is NOVAS-C 2.0.1 (outdated and unsupported by U.S. Naval Observatory).
    - IDPS will upgrade to the current available version, NOVAS-C 3.1, with Block 2.0. Raytheon OAA Team will generate test data products to compare the same set of granules produced with the current version, NOVAS-C 2.0.1, and the updated version, NOVAS-C 3.1. These data will be provided to the Cal/Val teams for analysis of impacts to data products in September 2015 (exact date TBD)."

NOVAS Library Update (2/6)

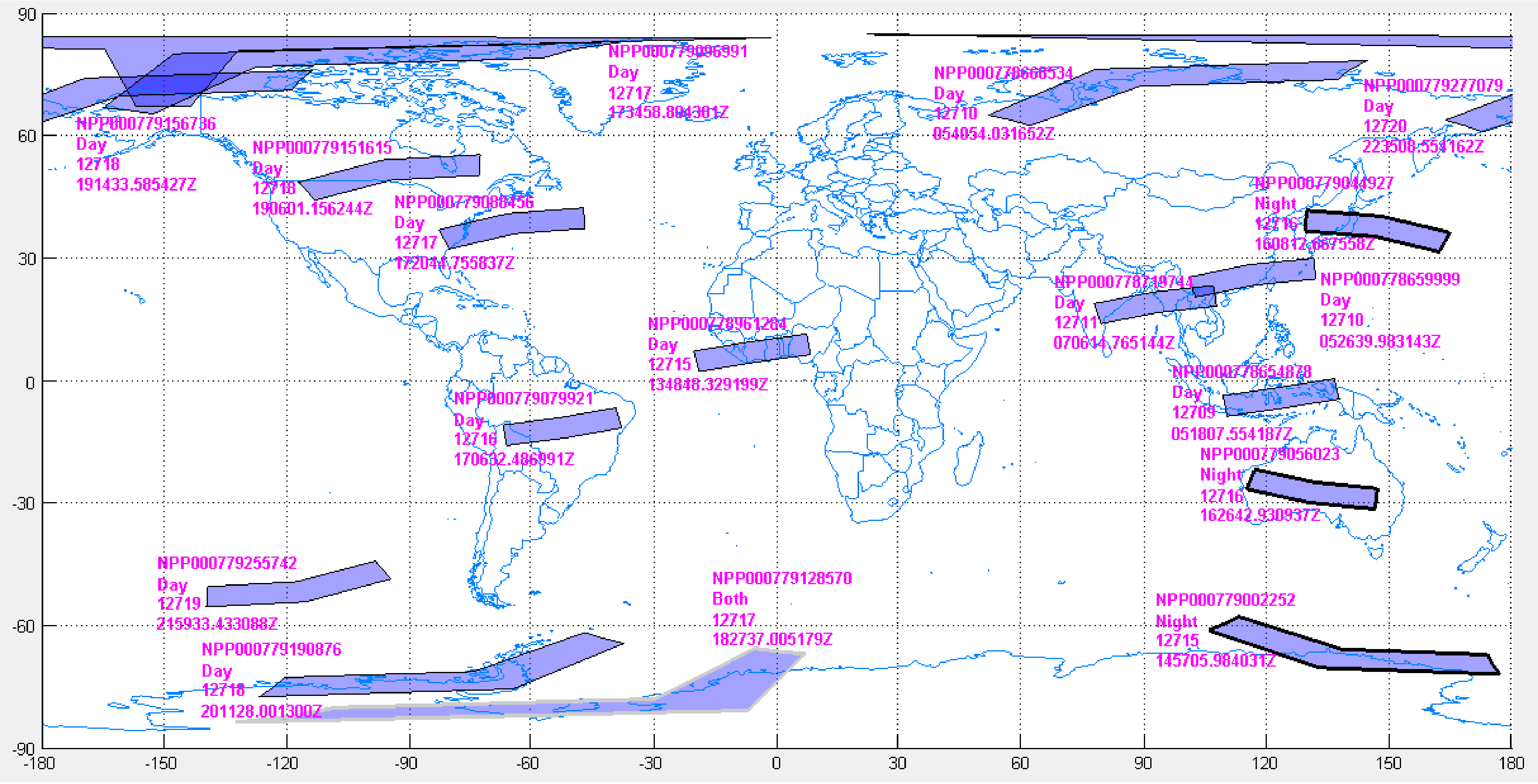
- Raytheon OAA performed analyses related to the impact of the NOVAS-C library upgrade in IDPS Block 2.

- OAA utilized the VIIRS Science and S/C Diary RDRs from the April 11th, 2014 Focus Day dataset. This FD dataset is used by OAA for various Block 1.0 / Block 2.0 Build-to-Build "B2B" verification and regression analysis.

- The VIIRS test dataset consists of 17 granules that cover a wide variety of scene conditions & geographical locations.

- Next slide illustrates the locations of the selected 17 granules

NOVAS Library Update (3/6)



NOVAS Library Update (4/6)

- Two IDPS Block 2.0 builds are used for analysis:
  1. SAT07 (Base) build with the original (outdated) NOVAS-C 2.0.1 library suite is used as the baseline for the analysis*
  2. SAT07 (NOVAS) build which is a SAT07 (Base) build with the NOVAS-C library suite being upgraded to the NOVAS-C 3.1 version, i.e., the NOVAS upgrade is the only change that could affect the IDPS algorithms/products.

  *Notes:
  - The Block 2 SAT07 (Base) build is equivalent to the operational Mx8.10 build
  - A parallel activity is in progress to ensure both build contents (PCRs, LUTs, PCTs, etc.) are fully synched together.

- The IDPS Block 2 Factory Segment Integration Linux-based (Little Endian) hardware is used to generate the VIIRS chain runs for both SAT07 (Base) and SAT07 (NOVAS) builds, e.g., various SDR and GEO products.

- The OAA Linux-based hardware is used to execute the OAA analysis MATLAB-based tool suite (QCV/VOID), perform the comparison analysis and generate the B2B analysis artifacts.

NOVAS Library Update (5/6)

- The comparison results between SAT07 (Base) vs. SAT07 (NOVAS) builds revealed the following:
  - GEO Products:
    - The 5 Geo products (VIIRS-MOD-GEO, VIIRS-MOD-GEO-TC, VIIRS-IMG-GEO, VIIRS-IMG-GEO-TC, and VIIRS-DNB-GEO) showed no differences in QFs. The differences were observed in the following GEO fields:
      - S/C Attitude (RPY)
      - S/C Solar Zenith Angle
      - S/C Solar Azimuth Angle
      - Latitude
      - Longitude
      - Height
      - Satellite Zenith Angle
      - Satellite Azimuth Angle
      - Satellite Range
      - Solar Zenith Angle
      - Solar Azimuth Angle
      - Lunar Zenith Angle (DNB)
      - Lunar Azimuth Angle (DNB)

- The maximum absolute difference in S/C attitude RPY components was on the order of ~ e-02 arcsec.
- The differences observed in the remaining Geo fields were, in general, several orders of magnitude less than the retrieved values.
- Complete analysis spreadsheet is sent out to the SDR team for their review.

NOVAS Library Update (6/6)

- VIIRS-OBC-IP Product:
  - This product showed differences in the following fields:
    - Solar and Lunar Vectors
    - Sun Zenith
    - Earth-Sun Distance
  - The magnitudes of the differences observed were several orders of magnitude less than retrieved physical values
- SDR Products:
  - For the SDR (M-bands, I-Bands, and DNB) products, differences were only observed in the reflectance fields in RSB bands M1-M11 and I1-I3. The differences observed were relatively small in magnitude and on the order of ~ e-05. No differences were observed in QFs.

Complete analysis spreadsheet is sent out to the SDR team for their review.

Upcoming VIIRS Algorithm Updates

Change	Description	Delivery Da	Receiver U	Mission	Block	Build(s)	NASA V	Reference Information
New DNB APIDs	Adds new APIDs to RDR in support of Cal/Val	NA	NA	J1	2	SAT_09	OB-SAT	Ground 474-CCR-15-2427 - IDPS process two new APIDs for VIIRS DNB for JPSS-1 PCR49336: Allocated to SAT and is Path C.
VIIRS M11 at Night	Collect M11 at night and associated data processing updates	ATP TBD	NA	NPP/J1	2	PSAT_11 (TBD)	JCT-3A Dry Run	Ground CCR pending for MDFCB updates AERB 474-CCR-15-2510 - SRS Parameter File Updates for VIIRS M11 at Night Ground 474-CCR-15-2434 - IDPS Updates for VIIRS M11 at Night AERB 474-CCR-14-2020 - VIIRS SDR to Include Band M11 in Nighttime Operations - DR 7755 OPS ERB ECR-OPS-0319 S-NPP VIIRS FSW Load V.0x4017
VIIRS Sensor/Table updates	Updates based on sensor characterization	9/23/15 9/23/15	SEI:21218 SEI:21219	J1	2	PSAT_14	JCT-3B Dry Run	Need B2.0 G-ADA ready for use, for DPES testing
VIIRS Sensor Mounting Coefficients	Updates based on sensor mounting	5/23/2016	SEI:21216	J1	2	MxI2.0.X (TBD)	JCT-3B Dry Run	May get pre-environmental in time for JCT-3B (Launch - 11 months delivery to science teams). Final updates during LEO&A.

ADR/PCR Status

- There are currently no Block 1 DR/PCRs planned for VIIRS SDR
  - With exception of FastTrack tables
- Block 2 Sat 09 build will contain DR 7032
  - This will be the first Block divergence introduced

PCR049986	Subsystem >> **PRO**	Severity >> **3-Moderate**	State >> **Fixed**	AssignedTo >> **sjoo**
Title1	**DR7032-VIIRS SDR DNB GEO Percent Out of Bounds QF is not calculated properly**			
ProblemDescription	In VIIRS Maneuver PROXY Dataset 4, Granule NPP001212117655 (Short Granule with DNE fill), the "Percent Out of Bounds" quality flag is not calculated properly. When determining the value for percent out of bounds, the denominator should be the total number of pixels that are not DNE fill. The code for this is in ProSdrViirsGeo.cpp geolocate(). *Note in the code how the variables imgSize and modSize have the number of DNE subtracted from the total number of pixels where as the variable dnbSize does not.			
FixDescription	Added code that will stop counting the values that are Vdne for dnb logic. Reference the htmldiff folder for differences in code.			

And The Thank Yous Goto..

- JPSS IDPS PRO SE – Cristi Owen
- CGS Block Leadership Team – Paula Smit
- OAA – Khalil Ahmad

RSBAutoCal Status and Path Forward

Evan Haas
The Aerospace Corporation

August 26, 2015

Outline

- Introduction
- Background
  - *5 Calibration Quantities*
  - *Robust Holt Winters (RHW) Filtering*
- Current SNPP RSBAutoCal Status
  - *IDPS Data Stream*
  - *Path to Automate*
- J1 RSBAutoCal Preparation
  - *Proposed Turn On Strategy*
  - *Studies*
- Auxiliary Tool Development
- Conclusion

Evan.M.Haas@aero.org
The Aerospace Corporation

Introduction (1 of 2)

- Since the launch of the Suomi National Polar-orbiting Partnership (SNPP) satellite the VIIRS reflective bands have been calibrated via updates to look-up tables (LUTs) ingested by the Joint Polar Satellite System (JPSS) Interface Data Processing Segment (IDPS) operational ground processing software
- The calibration parameters in these LUTs are calculated from instrument science and telemetry data captured in On-Board Calibrator Intermediate Products (OBC IPs) generated by IDPS
- Currently, VIIRS Reflective Solar Band (RSB) calibration quantities are calculated manually, delivered on a weekly basis, and put into operations one week after delivery
  - *This process is undesirable due to 1-2 week predict ahead errors*
  - *This process is incapable of maintaining SDR calibration quality even at the required 2% level when unexpected changes in H trend have occurred*
    - Too much time required to recognize trend change and take remedial actions
  - *This process is also manually intensive*

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Introduction (2 of 2)

- VIIRS Day Night Band (DNB) has 3 calibration quantities that are calculated on either a weekly or monthly basis
  - *This process is undesirable due to predict ahead errors and infrequency of updates (particularly for monthly updates)*
  - *DNB offsets degraded by airglow effects that are difficult to mitigate entirely*
  - *This process is also manually intensive*
- RSBAutoCal is the most extensive VIIRS SDR code change to date and provides automatic per orbit calibration quantities
  - *Eliminates predict ahead errors*
  - *Changes engineer's role from LUT production to data review and reduces manually time intensive processes*
  - *Automatically and accurately tracks unexpected trend changes due to per-orbit calibration cadence*
- Integrated into ground processing code and operational in manual mode in December 2013
  - *Re-initialization, parameter tuning, and fixes applied since integration*
  - *Weekly calibration factors are ready to switch to automated mode, while monthly calibration factors require more time for study*

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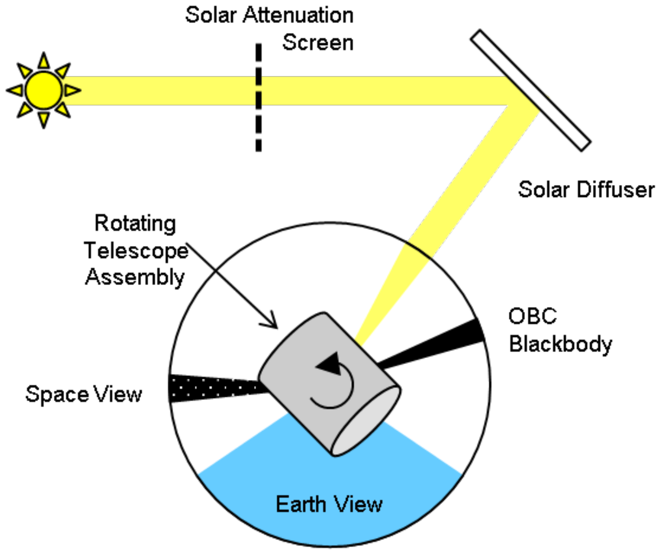
Background: 5 Calibration Quantities (1 of 2)

- H factor: Compensates for the degradation in SD reflectance over the lifetime of the mission
  - *Calculated from LUTs and OBC IP data from the Solar Diffuser Stability Monitor (SDSM), a ratioing radiometer incorporated in VIIRS that alternately views the SD, the sun and an internal dark reference*
  - *RSBAutoCal provides per orbit smoothed values that get updated whenever the SDSM is used, rather than once per week in the current operational methodology*
- F factor: Compensates for the RSB's change in response while on orbit
  - *RSBAutoCal provides per orbit smoothed values that are updated each orbit, rather than once per week as in the current operational methodology*



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Background: 5 Calibration Quantities (2 of 2)

- DNB Low Gain Stage (LGS) Gain: Compensates for the DNB's change in response for the LGS
  - *DNB has three gain stages: LGS, Mid Gain Stage (MGS) and High Gain Stage (HGS), which allow the DNB to image in a wide range of illumination conditions*
  - *The LGS is not saturated while viewing the SD, so it can be calibrated similarly to the RSBs*
  - *RSBAutoCal provides per orbit smoothed values that are updated each orbit, rather than once per week as in the current operational methodology*
- DNB Dark Signals: Used to generate offset change over time and in calculation of DNB Gain Ratios described below
  - *DNB dark signals are collected from all gain stages in all calibration sectors, the space view, the OBC BB view and the SD view, when the satellite is fully eclipsed by the earth, so that no sunlight can reach the DNB focal plane when viewing any of these sources*
- DNB Gain Ratios: Used to determine MGS and HGS gains, since they cannot be calculated directly with the LGS gain methodology above
- DNB Dark Signals and Gain Ratios are updated by RSBAutoCal whenever illumination conditions are suitable, rather than once per month with the current operational methodology, providing more responsive and accurate calibration

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Background: Robust Holt Winter Filtering

- All calculated calibration quantities are smoothed with a Robust Holt Winters Filter
  - *The filter only requires the last state (stored in a LUT) and current measurements to calculate the current state*
  - *If there are no updated measurements (e.g. infrequent SDSM usage for new H factors), the current state is linearly propagated from the previous state using the current trend*
  - *Provides automatic outlier rejection*
- Filter parameters were extensively studied and tuned for each calibration quantity based on SNPP mission history
  - *For H and F factors, parameters were optimally tuned to match a 2-day running mean – requested by NOAA/STAR*

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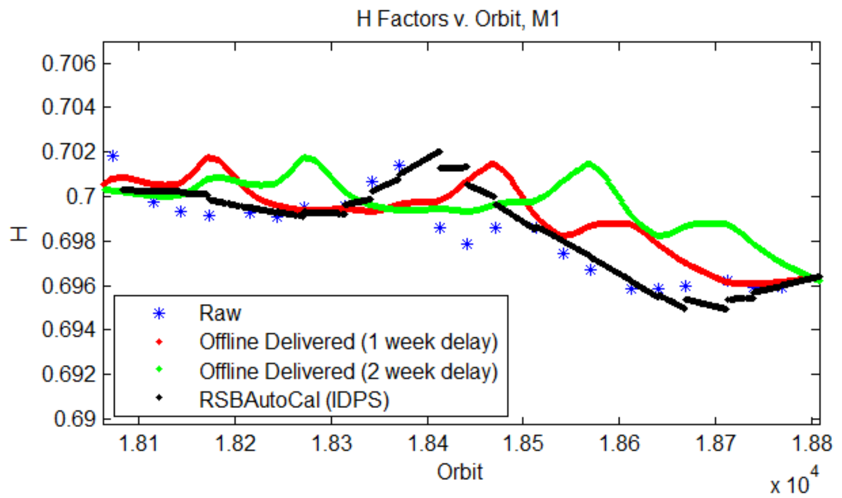
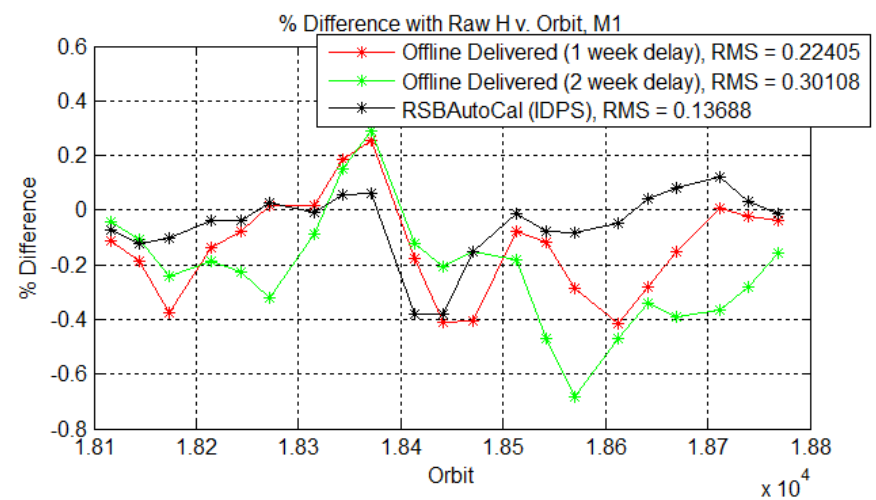
Current SNPP RSBAutoCal Status: H factor

- RSBAutoCal H factors perform better than offline delivered H factors because offline delivered values have 1-2 week predict ahead error
  - *RSBAutoCal H factors track data better*
  - *Actual offline % differences will lie somewhere between the 1 and 2 week lines plotted to the right*
- Differences in current RSBAutoCal H factors with Raw values are the same order as noise in H factors
- Additional smoothing is performed after H factors are applied to F factors





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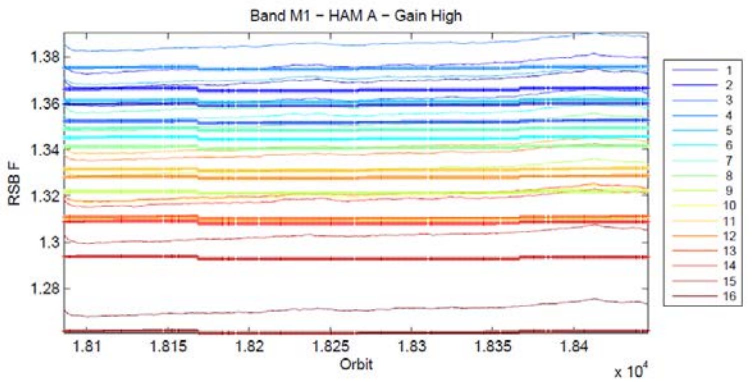
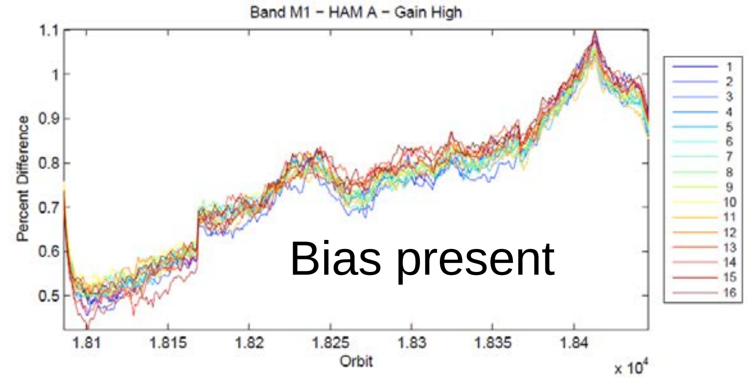
Current SNPP RSBAutoCal Status: F Factor (1 of 2)

- Careful comparison of F factors between RSBAutoCal and offline delivered LUTs revealed biases in some bands
- Careful debugging eventually led to the cause – VIIRS-RSBAUTOCAL-BRDF-SCREEN-TRANSMISSION-PRODUCT-RTA-VIEW-LUT wavelengths are not monotonic, but the RSBAutoCal interpolation code expected them to be
  - *Current offline code using Matlab did not have a problem because Matlab automatically sorts vectors prior to interpolation*
  - *LUT documentation did not specify wavelength ordering and RSBAutoCal code assumed ordering was monotonic*
  - *Simplest fix is to create a new LUT with monotonic wavelengths rather than a code change*

Thin lines = RSBAutoCal
Thick points = Operational LUT Deliveries





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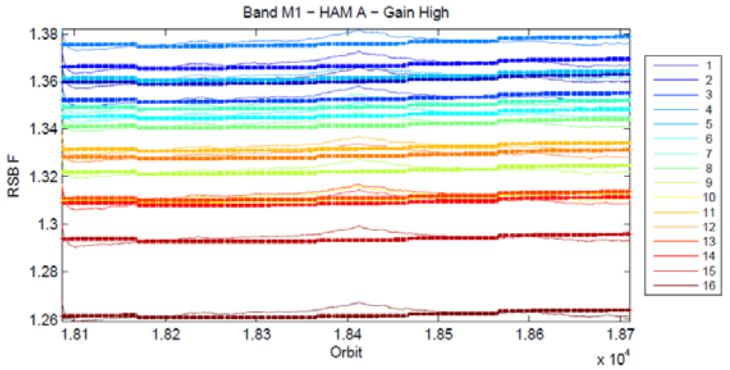
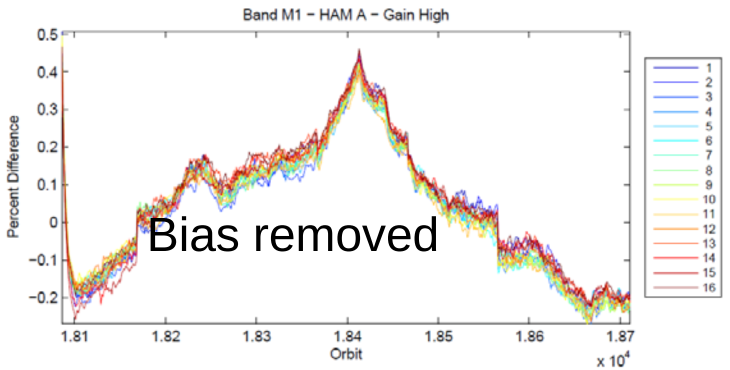
Current SNPP RSBAutoCal Status: F Factor (2 of 2)

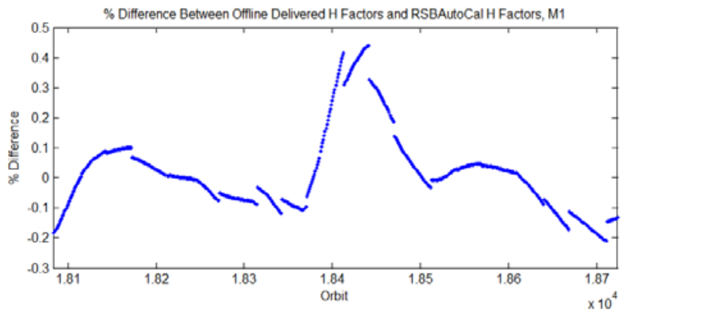
- With new LUT, bias in F factors is gone
  - *Remaining differences are primarily due to two things:*
    - H factors differences (slide 4)
    - Predict ahead error in F LUTs



- Offline Matlab code is not affected by this change



- DR 8008 for LUT change being processed
  - *Estimated LUT implementation is August 28*



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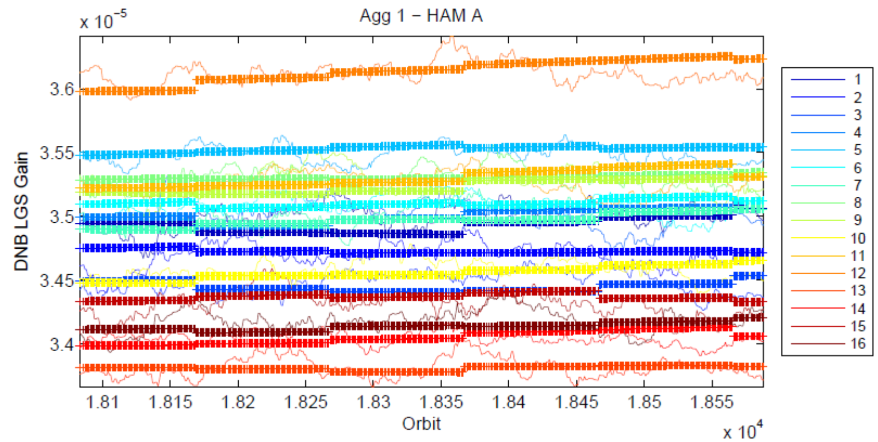
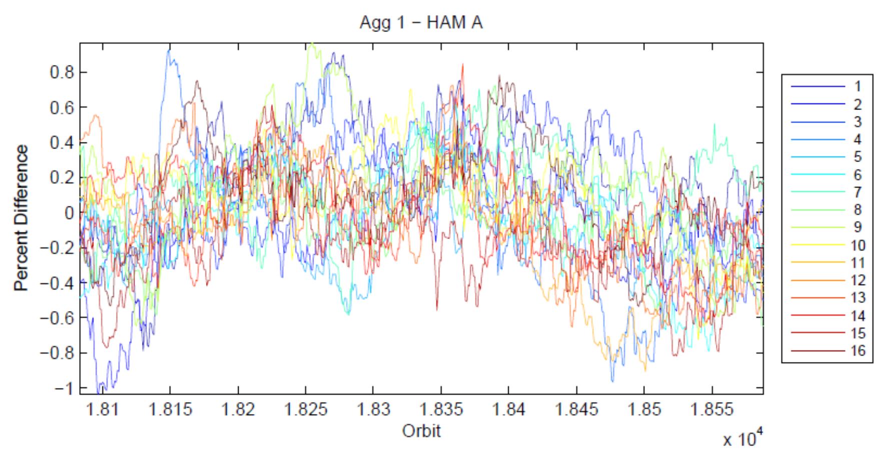
Current SNPP RSBAutoCal Status: DNB LGS Gain

- Good agreement between offline LUT deliveries and RSBAutoCal
- Differences appear strictly due to the dynamics that the RHW filter allows through versus weekly updates





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Current SNPP RSBAutoCal Status: DNB Gain Ratio and Dark Signals

- More time is needed to study the DNB gain ratio and dark signals from RSBAutocal
  - *There appear to be differences between current DNB gain ratios and RSBAutoCal signals*
    - An objective study is underway to look at DNB SDR radiance continuity at gain transitions as a potential discriminator
    - Collection and analysis of data is fairly time consuming
  - *Dark signal behavior indicates gain drift correction will perform well*

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Path to Place RSBAutoCal in Automated Mode

- Pending implementation of new Transmission*BRDF LUT, H factors, F factors, and DNB LGS gains are ready to enter automated mode
  - *DR8008 LUT is expected to go into operations on August 28*
  - *RSBAutoCal will improve the quality of these factors compared to weekly LUT deliveries*
- DR 8012 for new CAL-AUTOMATE-LUT to switch H, F, and LGS gains to automated mode
- DNB gain ratios and dark signals need further evaluation before they are placed in automated mode

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J1 RSBAutoCal Preparation

- J1 Prelaunch RSBAutoCal filter parameter tables will match those of SNPP
  - *After sufficient J1 mission history is established, new optimal filter parameters should be calculated*
- RSBAutoCal code will be running when J1 launches, but it is advised that RSBAutoCal be in manual mode for launch
  - *RSBAutoCal filter values can be sensitive to initial conditions and tuning parameters*
  - *Initial post-launch data can be inconsistent and require additional engineering judgement for evaluation and proper calibration*
  - *Manual mode requires analysts to provide calibration LUTs*
- RSBAutoCal should be placed in automated mode once initial checkouts and algorithm initializations are complete

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Auxiliary Tool Development

- Aerospace has developed a tool to apply scale factors and offsets to the RSBAUTOCAL-HISTORY-AUX-LUT
  – *This method should be much easier to use to change/reset the state of RSBAutoCal quantities as compared to the current method*
    - The current method requires careful timing to make sure the new history file is actually used rather than skipped over by the code
    - The new method will allow scale factors and offsets to be applied to current quantities without such careful regard for timing
- Raytheon has checked out and approved the code
- We are waiting for final IDPS approval and implementation
- Having this tool will be valuable to support SNPP as well as J1 VIIRS

Conclusion

- RSBAutoCal is on the cusp of being placed in automated mode for weekly calibration quantities
- Greater calibration accuracy and therefore SDR quality will be realized when RSBAutoCal is in automated mode
- We recommend that J1 not be placed in automated mode at launch, but rather start in manual mode to allow checkouts to be completed

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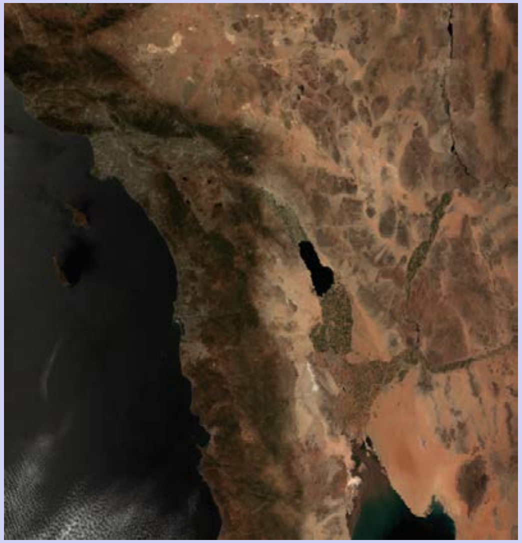
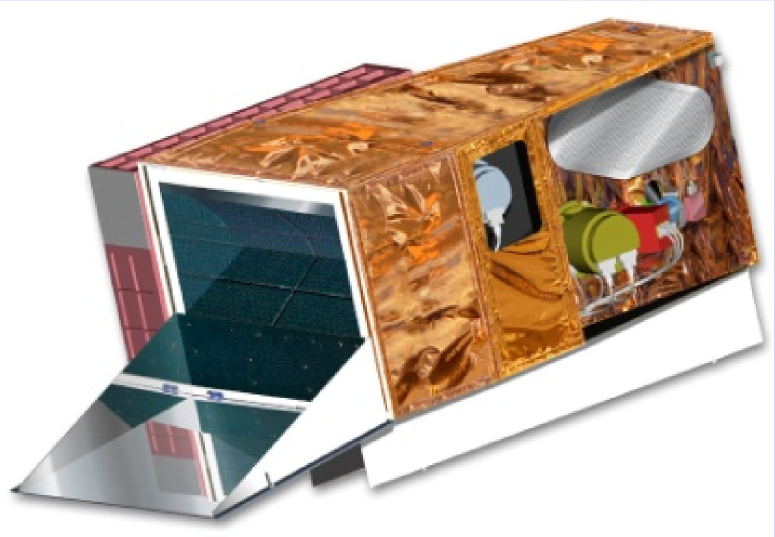
JPSS-1 VIIRS Radiometric Performance Summary
– Pre Launch Performance –

Hassan Oudrari, NASA/VCST
Jeff McIntire, NASA/VCST
With Contributions from all VCST team members

Acknowledgements:

DAWG, Raytheon, NASA VIIRS On-site Instrument Team





Courtesy of NASA NPP LPEATE

NOAA/STAR Annual Meeting, College Park, (MD), Aug. 26, 2015

Content

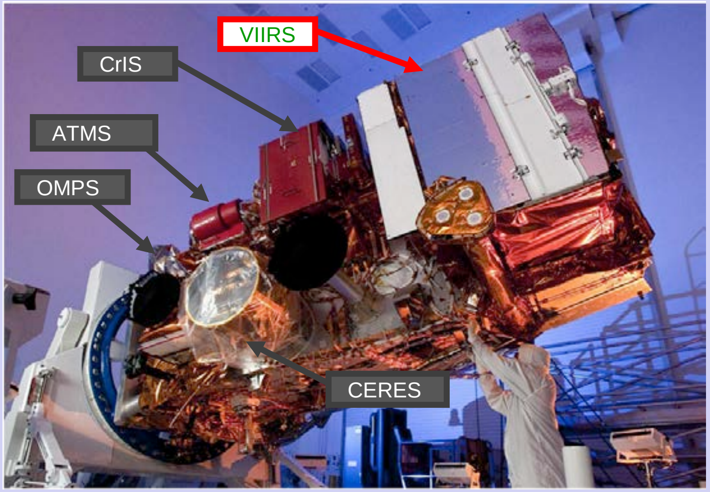
- J1 VIIRS Instrument Status
- J1 VIIRS Testing Program
- J1 VIIRS Performance Summary
  - ❑ RSB/TEB Radiometric Sensitivity
  - ❑ Polarization
  - ❑ Near Field Response (NFR)
  - ❑ Stray Light Response (SLR)
  - ❑ Response Versus Scan (RVS)
  - ❑ Relative Spectral Response (RSR)
- Summary/Conclusion

Latest J1 Instrument Status

Raytheon/NASA Team – Sensor Shipping from RTN

VIIRS J1 Leaving Raytheon in Route to Ball

VIIRS J1 installation on the Spacecraft



- J1 VIIRS is the follow on sensor after SNPP VIIRS
- J1 VIIRS completed successfully its sensor level testing program
- Sensor Shipped from Raytheon to Ball (spacecraft) on 2/6/15
- Sensor installed on spacecraft on 2/20/15
- J1 VIIRS completed its initial ambient testing on 03/17/2015.
- J1 VIIRS TV testing (as-you-fly), expected spring 2016.
- J1 VIIRS Launch December 2016

J1 VIIRS Sensor Integration to Spacecraft and Initial Performance Trending were Completed Successfully

VIIRS Bands and Products

VIIRS 22 Bands:
16 M-Band, 5 I-Band and 1 DNB

	Band	λc(nm)	Δλ(nm)	Spatial Resolution (m)	MODIS Equivalent Band
VisNIR	DNB	700	400	750	
	M1	**412**	**20**	**750**	B8
	M2	**445**	**18**	**750**	B9
	M3	**488**	**20**	**750**	B3-B10
	M4	**555**	**20**	**750**	B4-B12
	M5	**672**	**20**	**750**	B1
	I1	640	80	375	B1
	M6	746	15	750	B15
	M7	**865**	**39**	**750**	B2
	I2	865	39	375	B2
SMWIR	M8	1240	20	750	B5
	M9	1378	15	750	B26
	M10	1610	60	750	B6
	I3	1610	60	375	B6
	M11	2250	50	750	B7
	I4	3740	380	375	B20
	M12	3700	180	750	B20
	M13	**4050**	**155**	**750**	B21-B22-B23
LWIR	M14	8550	300	750	B29
	M15	10763	1000	750	B31
	I5	11450	1900	375	B31-B32
	M16	12013	950	750	B32

Dual Gains

VIIRS 22 EDRs
Land, Ocean, Clouds, Aerosol

Land

1- Active Fires
2- Snow Cover
3- Land Surface Albedo
4- Vegetation Index
5- Land Surface Temperature
6- Surface Type
7- Ice Surface Temperature
8- Net Heat Flux
9- Snow Ice Characterization

Ocean

1- Sea Surface Temperature
2- Ocean Color/Chlorophyll

Imagery and Clouds

1- Imagery and low light imaging
2- Cloud Top Height
3- Cloud Optical Thickness
4- Cloud Top Temperature
5- Cloud Effective Particle Size
6- Cloud Base Height
7- Cloud Top Pressure
8- Cloud Cover/Layers

Aerosol

1- Aerosol Optical Thickness
2- Aerosol Particle Size
3- Suspended Matter

Data Analysis Working Group (DAWG) Activities

- **The Data Analysis Working Group (DAWG) team derived an independent verification of J1 instrument**
  - Successful DAWG activities due to collaborative and efficient effort between GVT teams and sensor vendor:
    - NASA, NOAA-STAR, Aerospace, U. of Wisconsin
  - Shared performance results and issues with Raytheon, NOAA-STAR and NASA science subject matter experts (SMEs)
  - Delivered a large set of J1 technical reports and memos, al available on JPSS eRoom
  - Derived a list of J1 performance and testing issues (~44), reviewed by science members and Raytheon.
    - Led to additional testing to complete investigation and to get better instrument characterization before breaking configuration
  - DAWG approval of J1 testing completion & success

RSB Radiometric Performance

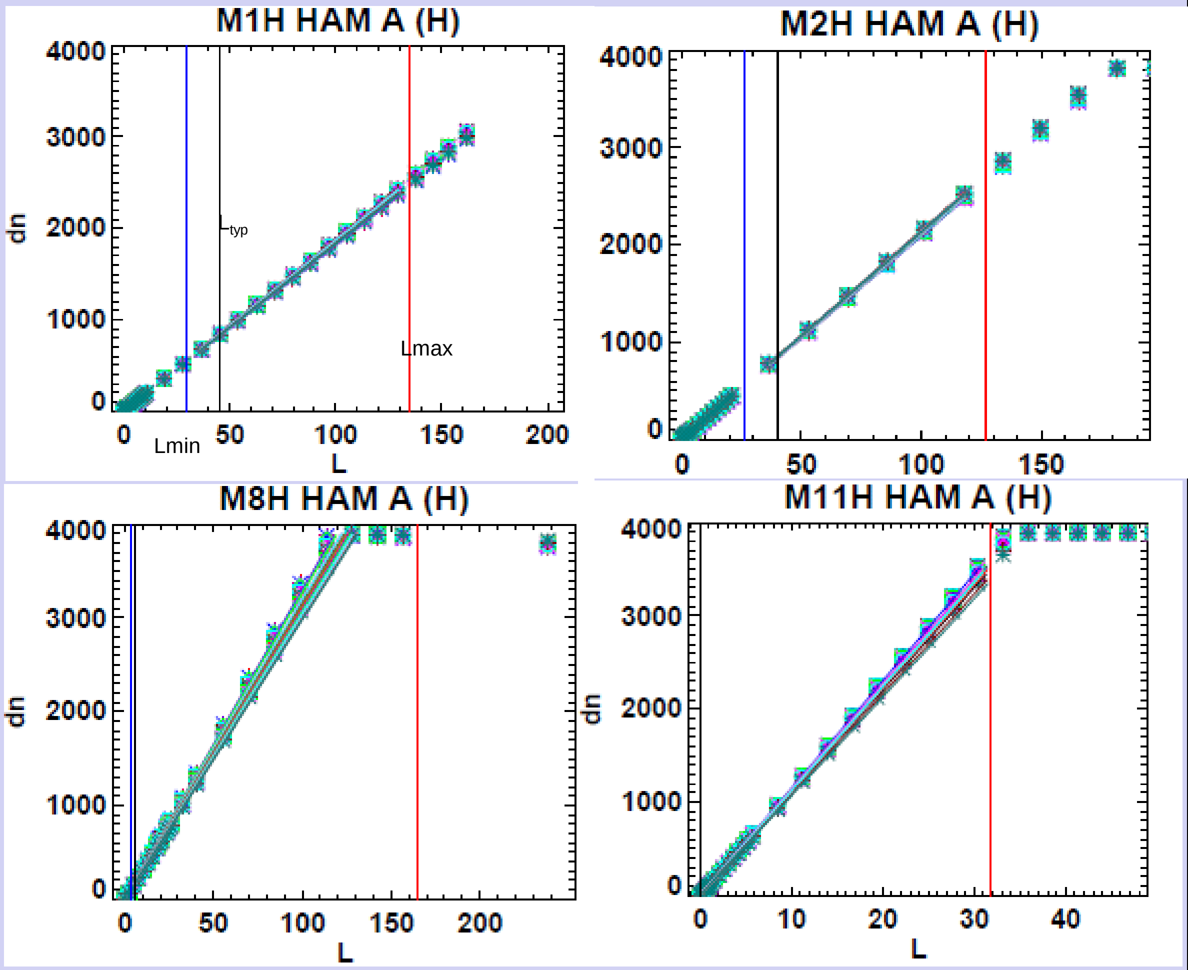
Dual-Gain bands Transition

Band	L_{MAX}	L_{MAX} + 50%	L_trans
M1	135	202.5	**154.4**
M2	127	190.5	**136.8**
M3	107	160.5	**113.3**
M4	78	117	**87.3**
M5	59	87.5	**61.3**
M7	29	43.5	**30.7**

Full Compliance of Gain Transition

- **Attenuator method used to generate Calibration Coefficients (c0, c1, c2)**
- **J1 Radiometric performance is quite similar to SNPP**
- **Higher than expected non-linearity seen in SWIR bands and DNB**

RSB Calibration



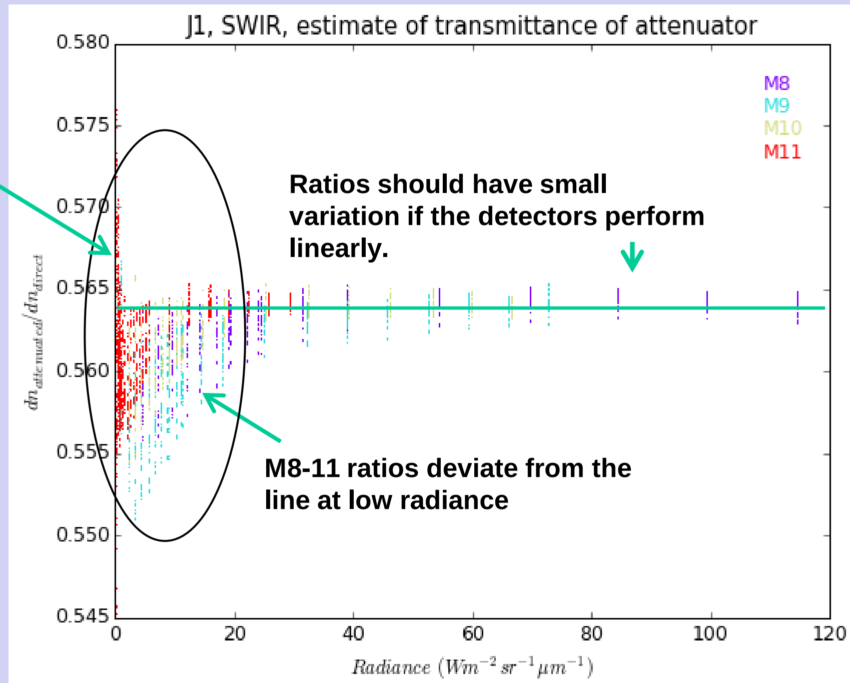
$$L = c_0 + c_1 dn + c_2 dn^2 + O(dn^3)$$

$$\tau \cdot L = c_0 + c_1 dn_a + c_2 dn_a^2 + O(dn_a^3)$$

SWIR Radiometric Performance

SWIR Non-Linearity Issue (Low Radiance)

Quantized data



$$L = c_0 + c_1 dn + c_2 dn^2 + O(dn^3)$$

$$\tau \cdot L = c_0 + c_1 dn_a + c_2 dn_a{}^2 + O(dn_a{}^3)$$

$$L = c_0 + c_1 dn + c_2 dn^2 + c_3 dn^3 + O(dn^4)$$

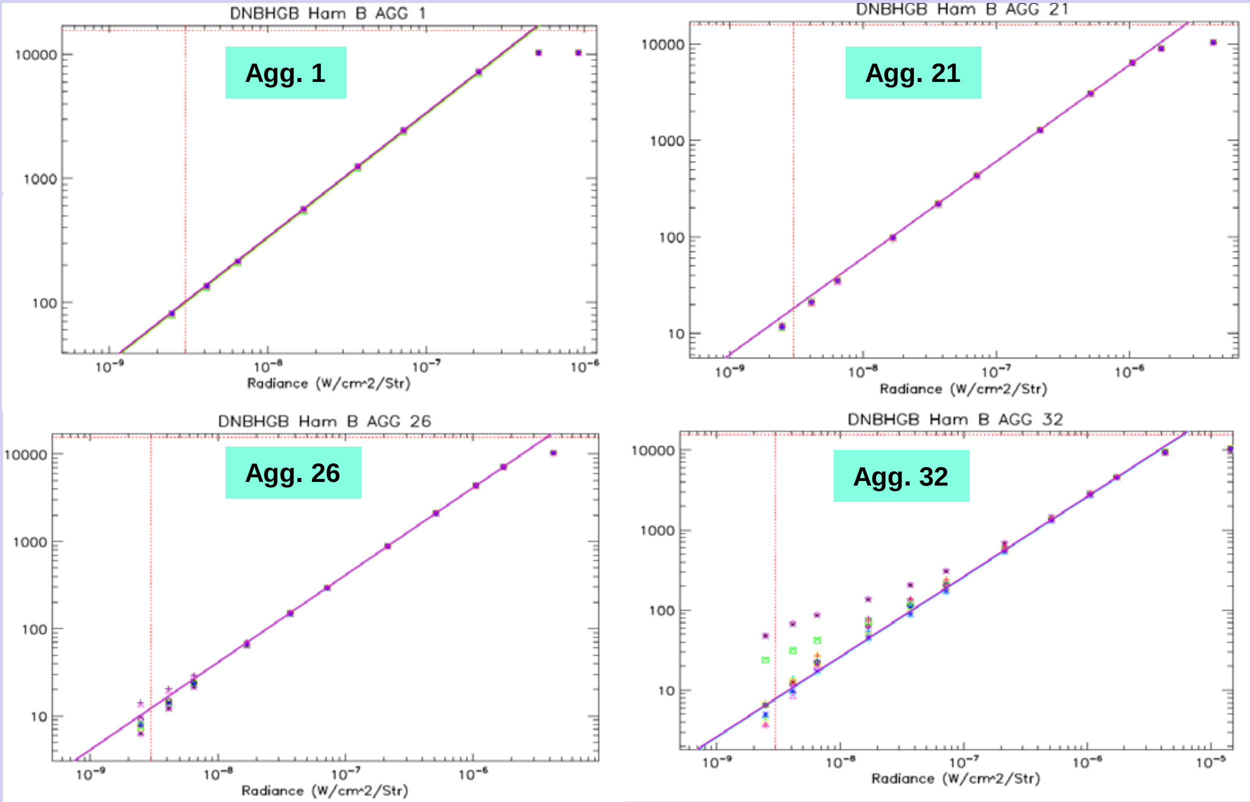
$$L = c_0 + c_1 dn + c_2 dn^2 + c_3 dn^3 + c_4 dn^4 + O(dn^5)$$

Increased enhancement

- SWIR Non-Linearity issue was observed at low radiances
- Issue characterized and root cause identified (ASP electronics bias, VR_Clamp)
- Quantized data are contribution to the non-linear behavior
- Mitigation plan is ready (if needed) for SDR software (3rd or 4th degree equation, two-piece calibration)

DNB Radiometric Performance

DNB HGS Non-Linearity Issue (Low Radiance)



- **Issue characterized and root cause identified (timing card setting)**
- **Limited to agg. modes at the end of scan (21-32)**
- **Mitigation plan was developed (Option agg. Mode 21), and is being tested**
  - ❑ **Better radiometric performance (e.g. uniformity, SNR, on-orbit cal.)**
  - ❑ **Loss of spatial resolution at the edge of scan (low risk)**

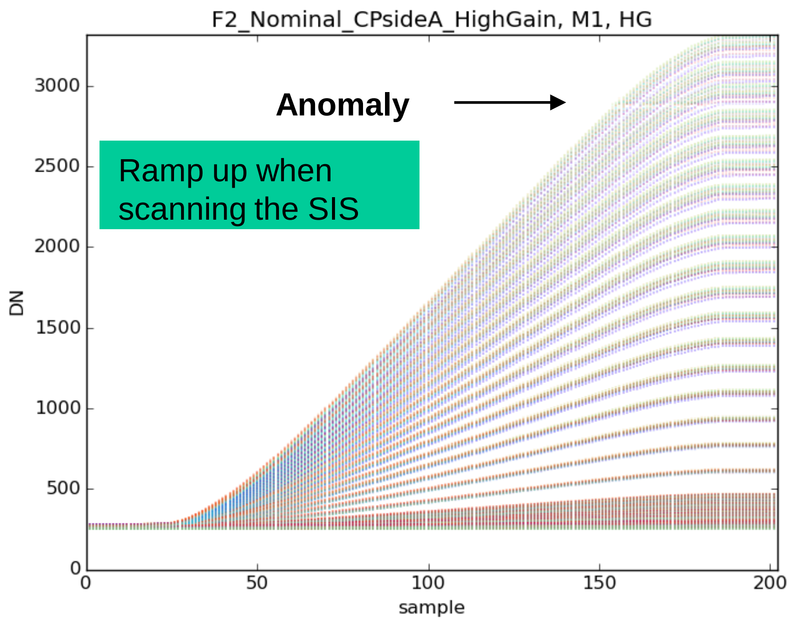
J1 RSB SNR and Lsat

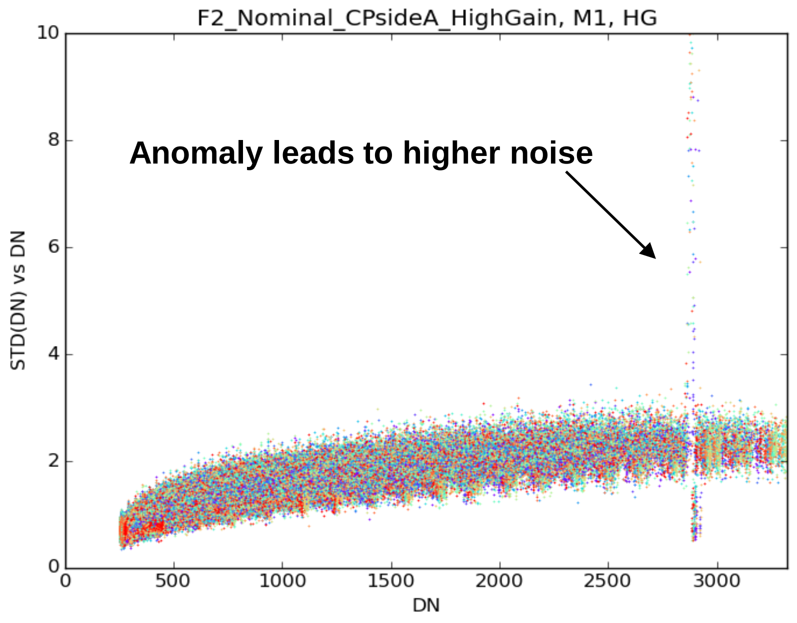
Band	Gain Stage	SNR (Spec)	Lmax (Spec)	SNPP SNR	J1 SNR	SNPP SNR/Spec	J1 SNR/Spec	SNPP L_sat/Lmax	J1 L_sat/Lmax
M1	High	352	135	613	636	1.74	1.81	1.16	1.21
M1	Low	316	615	1042	1066	3.30	3.37	1.13	1.10
M2	High	380	127	554	573	1.46	1.51	1.41	1.40
M2	Low	409	687	963	986	2.35	2.41	1.20	1.30
M3	High	416	107	683	706	1.64	1.70	1.29	1.31
M3	Low	414	702	1008	1063	2.44	2.57	1.20	1.20
M4	High	362	78	526	559	1.45	1.54	1.42	1.39
M4	Low	315	667	864	844	2.74	2.68	1.31	1.28
M5	High	242	59	373	380	1.54	1.57	1.24	1.25
M5	Low	360	651	776	751	2.16	2.09	1.12	1.11
M6	High	199	41	409	428	2.06	2.15	1.16	1.16
M7	High	215	29	524	549	2.44	2.55	1.28	1.26
M7	Low	340	349	721	760	2.12	2.23	1.19	1.17
M8	High	74	164.9	358	335	4.84	4.53	0.77	0.72
M9	High	83	77.1	290	325	3.49	3.91	1.09	1.04
M10	High	342	71.2	691	765	2.02	2.24	1.14	1.09
M11	High	10	31.8	105	216	10.49	21.57	1.09	1.10
I1	High	119	718	261	227	2.19	1.91	1.07	1.08
I2	High	150	349	273	287	1.82	1.91	1.18	1.17
I3	High	6	72.5	176	190	29.36	31.72	0.97	0.91

- **J1 SNR met requirement with significant margin.**
- **Dynamic range is not met for M8 and I3, M9 (D1-3)**
- **In general, very good linearity performance (<<1%)**

- **Similar to SNPP, non-compliances seen for characterization uncertainty and uniformity.**
- **Waivers released by Raytheon show low risk**

RSB Radiometric Performance





Dual Gain Anomaly (DGA)

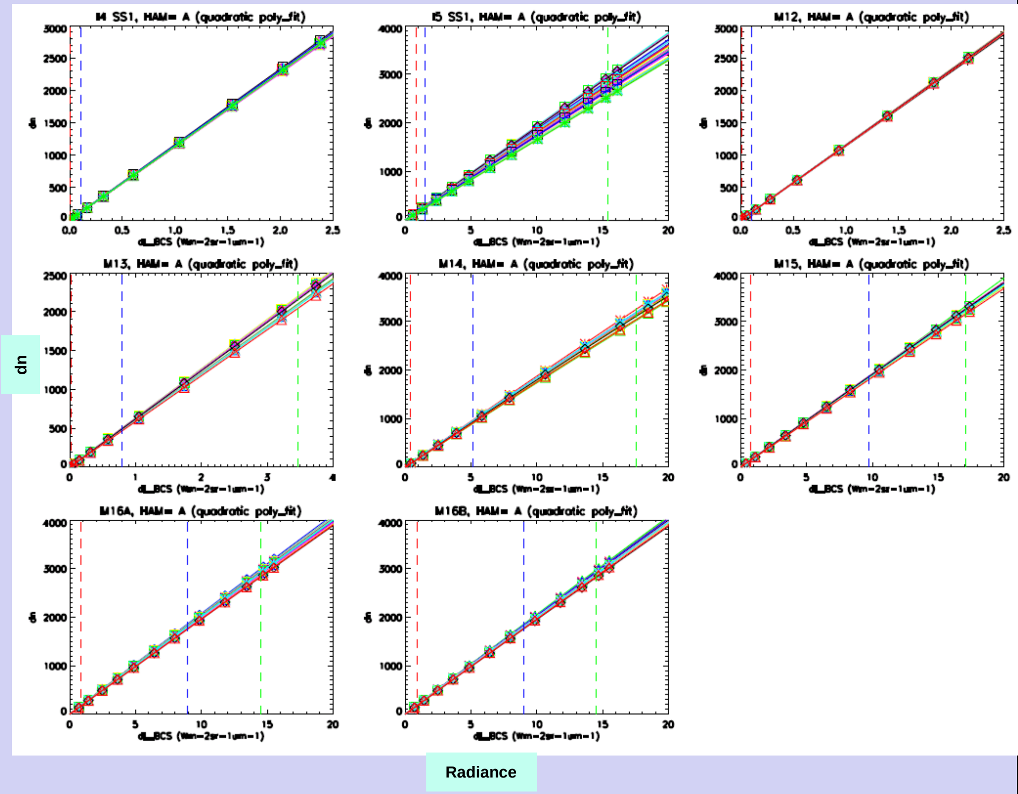
ramp up	M1		M2		M3		M4		M5		M7	
Detector	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
16	2846	2882	3186	3222	2984	3016	3195	3269	2987	3017	3117	3139
15	2849	2887	3182	3224	2979	3010	3172	3252	3034	3094	3101	3123
14	2849	2891	3207	3240	2975	3014	3157	3204	3017	3070	3100	3126
13	2862	2902	3227	3256	3022	3054	3201	3277	3006	3096	3123	3151
12	2884	2923	3215	3250	2989	3028	3206	3243	2986	3087	3053	3122
11	2849	2893	3194	3232	2977	3019	3187	3223	2972	3012	3055	3124
10	2855	2897	3216	3250	3016	3033	3191	3267	2959	3047	3111	3188
9	2842	2885	3212	3244	3004	3038	3183	3205	2988	3018	3120	3184
8	2851	2894	3196	3233	3004	3023	3156	3237	3028	3052	3125	3154
7	2851	2890	3202	3248	2995	3028	3162	3217	3008	3088	3106	3138
6	2851	2894	3192	3229	2989	3018	3160	3266	3015	3049	3100	3123
5	2853	2895	3196	3229	2977	3003	3174	3212	2995	3029	3095	3128
4	2855	2893	3192	3216	2972	3013	3190	3224	3060	3097	3085	3118
3	2856	2893	3206	3244	2981	3023	3165	3274	2993	3026	3069	3143
2	2884	2920	3202	3242	2988	3026	3195	3259	2957	3029	3108	3141
1	2867	2902	3218	3241	3015	3033	3181	3262	3012	3099	3085	3124

- **J1 DGA was expected and similar to SNPP**
- **Root-cause well understood based on SNPP testing**
- **Noise increase up to 4 times in DGA region**
- **J1 testing allowed DGA characterization for SDR flagging**
- **Low risk for on-orbit data products**

J1 TEB Performance: NEdT & Lsat

Band	NEdT at Ttyp				Lsat			
	Spec	SNPP	J1	J1/Spec	Spec	SNPP	J1	J1/spec
I4	2.5	0.41	0.42	0.17	353	357	357	1.01
I5	1.5	0.42	0.41	0.27	340	373	370	1.09
M12	0.396	0.13	0.12	0.30	353	357	358	1.01
M13 HG	0.107	0.044	0.043	0.40	343	364	363	1.06
M13 LG	0.423	0.34	0.304	0.72	634	--	--	--
M14	0.091	0.061	0.05	0.55	336	347	348	1.04
M15	0.07	0.03	0.026	0.37	343	365	359	1.05
M16	0.072	0.038	0.043	0.60	340	368	369	1.09

J1 VIIRS meets all NEdT and Lsat requirements with margins



- **J1 TEB calibration shows very good overall performance.**
- **Minor non-compliances observed: T_{MIN} for I4 and M14; M13 gain transition radiance, out of family detector noise for M15 (D4) and M16B (D5)**
  - **Impact to science is expected to be small.**

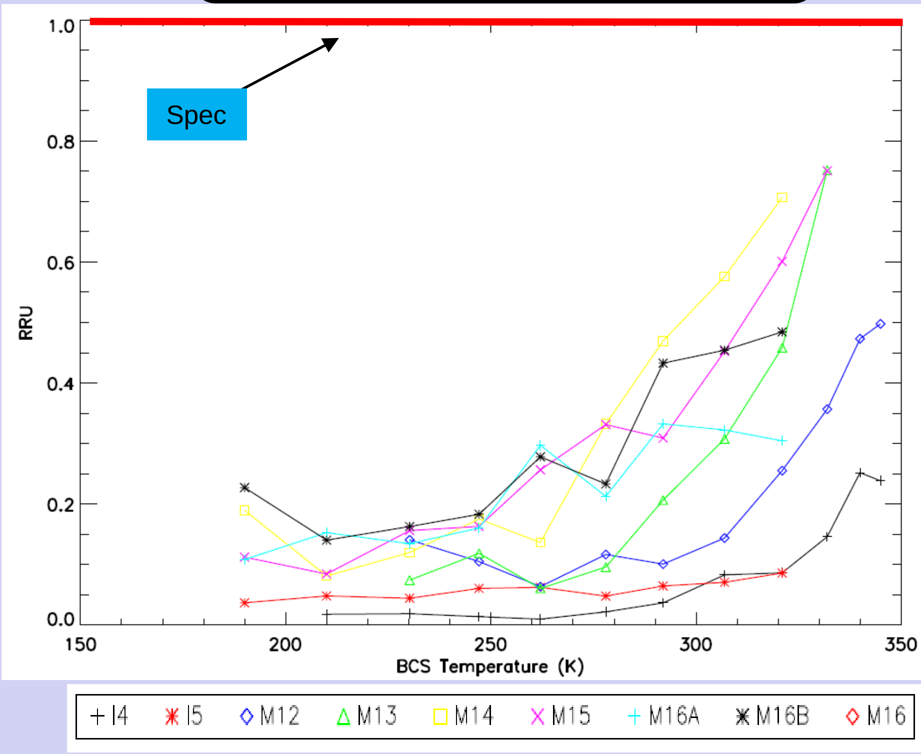
J1 TEB Radiometric Performance

Absolute Radiometric Uncertainty (ARD): Nominal

ARD Performance (%)								
Temp (K)	**I4**	**I5**	**M12**	**M13**	**M14**	**M15**	**M16A**	**M16B**
190	~	~	~	~	0.68	0.29	0.17	0.25
230	~	~	7.60	2.95	0.11	0.07	0.08	0.04
267	0.48	0.10	~	~	~	~	~	~
270	~	~	0.24	0.15	0.08	0.05	0.04	0.04
310	~	~	0.25	0.17	0.11	0.06	0.03	0.04
340	~	~	0.27	0.18	0.09	0.05	0.03	0.03
ARD Specification (%)								
Temp (K)	**I4**	**I5**	**M12**	**M13**	**M14**	**M15**	**M16A**	**M16B**
190	~	~	~	~	12.30	2.10	1.60	1.60
230	~	~	7.00	5.70	2.40	0.60	0.60	0.60
267	5.00	2.50	~	~	~	~	~	~
270	~	~	0.70	0.70	0.60	0.40	0.40	0.40
310	~	~	0.70	0.70	0.40	0.40	0.40	0.40
340	~	~	0.70	0.70	0.50	0.40	0.40	0.40

J1 ARD requirements met with margins

Uniformity – Det. Striping Nominal



- **J1 TEB calibration shows very good performance for ARD and uniformity (striping).**
  - **ARD is below ~0.3 % except at low temperatures for the MWIR (as expected).**
  - **Detector-to-detector uniformity shows some small potential for striping at high temperatures in bands M12 – M14 (similar to SNPP).**

J1 VisNIR Polarization Sensitivity

- **DAWG data analysis showed that bands M1 – M4 were non-compliant with the polarization sensitivity requirements**
  - First reported on December 28, 2013 (Ambient phase)
  - Root-cause is the band spectral filters (Bandpass edges)

- **A series of telecons were held with NASA and NOAA SMEs**
  - NASA/NOAA-STAR identified SMEs for each discipline (01/29/2014)
  - Impact assessments were performed for Ocean, Land , Atmosphere
  - Correction methodologies were shown to enhance the EDR products

- **Additional testing was requested after TVAC**
  - Additional scan angles were measured using a broadband source
  - Limited narrowband measurements were performed with a laser source for model validation

Successful and comprehensive J1 polarization testing was completed

J1 Polarization Factor (%)

HAM A

Band	Sensor	Scan Angle												
		-55	-45	-37	-30	-22	-15	-8	4	20	45	55	Max Pol.	Spec
I1	SNPP	1.5	1.24	~	~	0.93	~	0.85	~	0.7	0.64	0.62	**1.24**	2.5
	J1	0.81	0.74	0.75	0.73	0.73	0.79	0.76	0.8	0.82	0.85	0.85	**0.85**	2.5
I2	SNPP	0.29	0.27	~	~	0.34	~	0.37	~	0.47	0.51	0.51	**0.51**	3
	J1	0.73	0.62	0.54	0.47	0.36	0.37	0.37	0.43	0.5	0.61	0.66	**0.62**	3
M1	SNPP	2.99	2.63	~	~	1.95	~	1.79	~	1.42	1.21	1.4	**2.63**	3
	J1	5.13	5.26	5.35	5.52	5.54	5.56	5.65	5.7	5.66	5.51	5.37	**5.7**	3
M2	SNPP	2.11	1.97	~	~	1.63	~	1.53	~	1.28	1.17	1.29	**1.97**	2.5
	J1	3.72	3.79	3.85	3.95	3.9	3.89	3.94	3.95	3.9	3.99	4.04	**3.99**	2.5
M3	SNPP	1.2	1.14	~	~	0.9	~	0.82	~	0.61	0.7	0.8	**1.14**	2.5
	J1	2.89	2.85	2.83	2.85	2.73	2.69	2.68	2.63	2.62	2.8	2.84	**2.85**	2.5
M4	SNPP	1.05	1.1	~	~	1.19	~	1.16	~	1	0.88	0.84	**1.19**	2.5
	J1	3.61	3.9	4.08	4.16	4.17	4.22	4.18	4.18	4.04	3.89	3.8	**4.22**	2.5
M5	SNPP	1.19	1.02	~	~	0.85	~	0.84	~	0.76	0.73	0.69	**1.02**	2.5
	J1	1.9	1.86	1.9	1.86	1.82	1.85	1.79	1.83	1.81	1.8	1.8	**1.9**	2.5
M6	SNPP	0.99	0.96	~	~	0.94	~	0.94	~	0.88	0.82	0.76	**0.96**	2.5
	J1	1.62	1.32	1.13	0.99	0.86	0.85	0.79	0.75	0.73	0.75	0.76	**1.32**	2.5
M7	SNPP	0.17	0.19	~	~	0.25	~	0.28	~	0.38	0.42	0.41	**0.42**	3
	J1	0.73	0.62	0.54	0.46	0.36	0.36	0.32	0.39	0.45	0.55	0.6	**0.62**	3

J1 Polarization test data have very good quality for all bands

- **Broadband data analyzed and DoLP / phase determined for all VisNIR bands**
- **Uncertainty requirements met for all bands (max ~0.4 %)**
- **Very good testing repeatability (DoLP to within ~0.11 %)**
- **T-SIRCUS showed DoLP agreement to within ~0.5 %**

T-SIRCUS Polarization Measurements

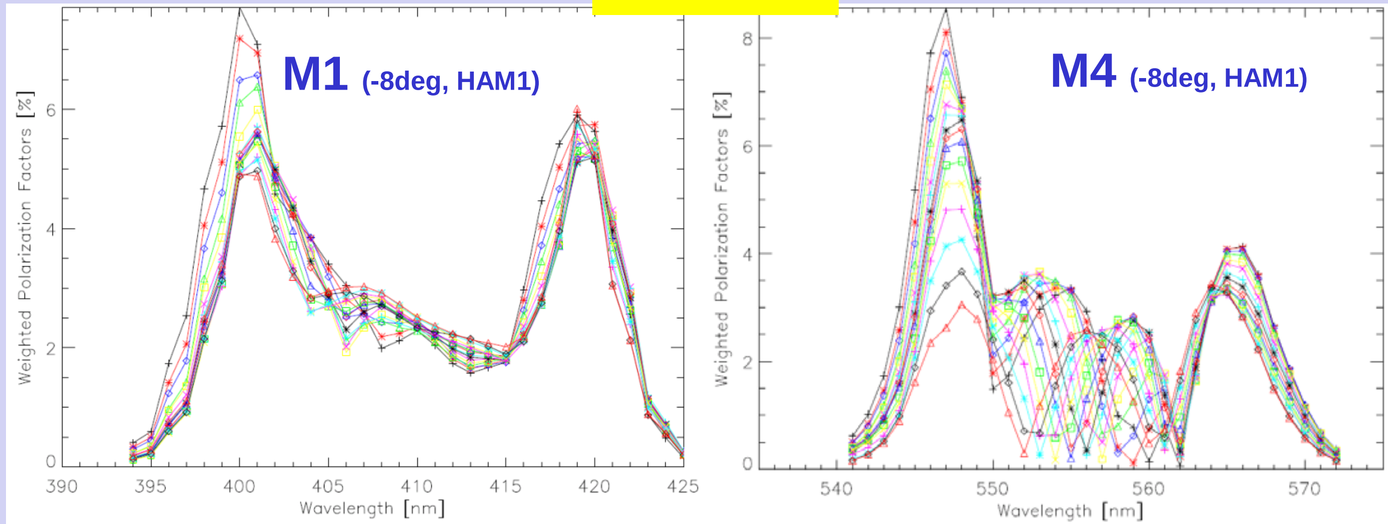
T-SIRCUS polarization measurements were performed in December 2014 (M1 and M4).

Limited number of measurements made in terms of scan angle, HAM side, and wavelength.

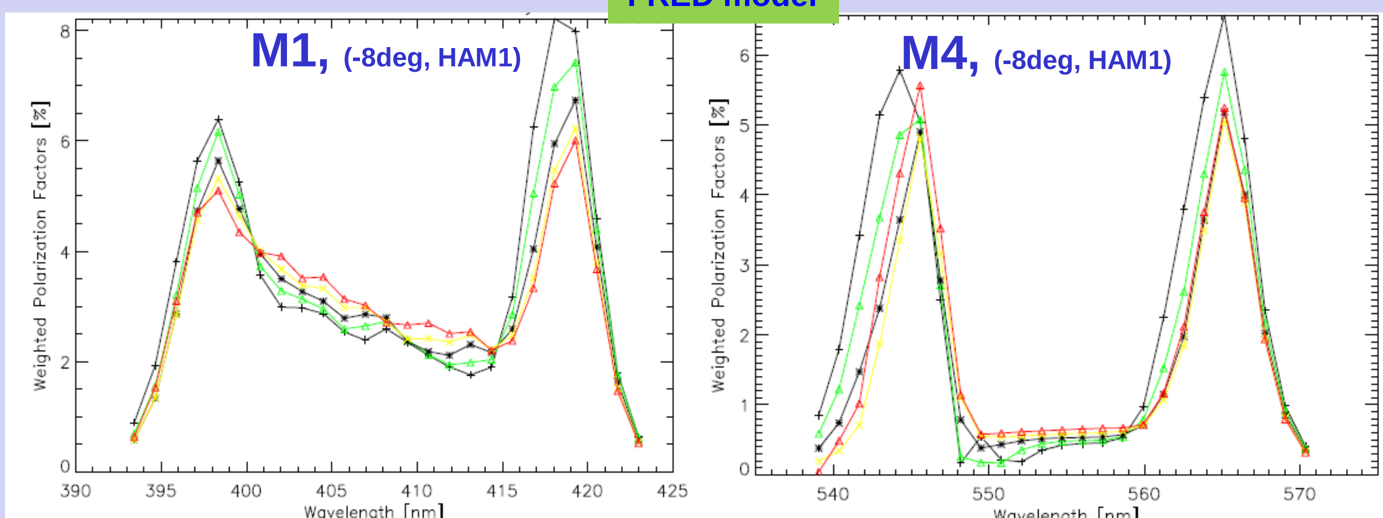
FRED model data compared to measurement results:

1) **Good agreement on general shape of wavelength dependence**
2) **Largest contribution comes from the edges of the filter bandpass**
3) **Phase shifts in the center of M4 bandpass not represented by model**

Measurement



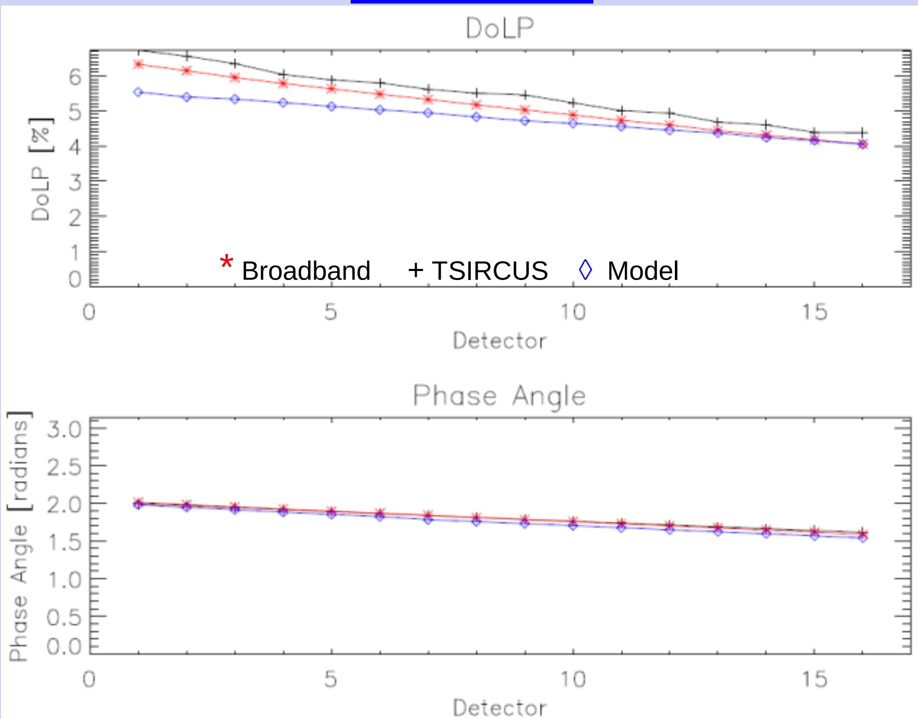
FRED model



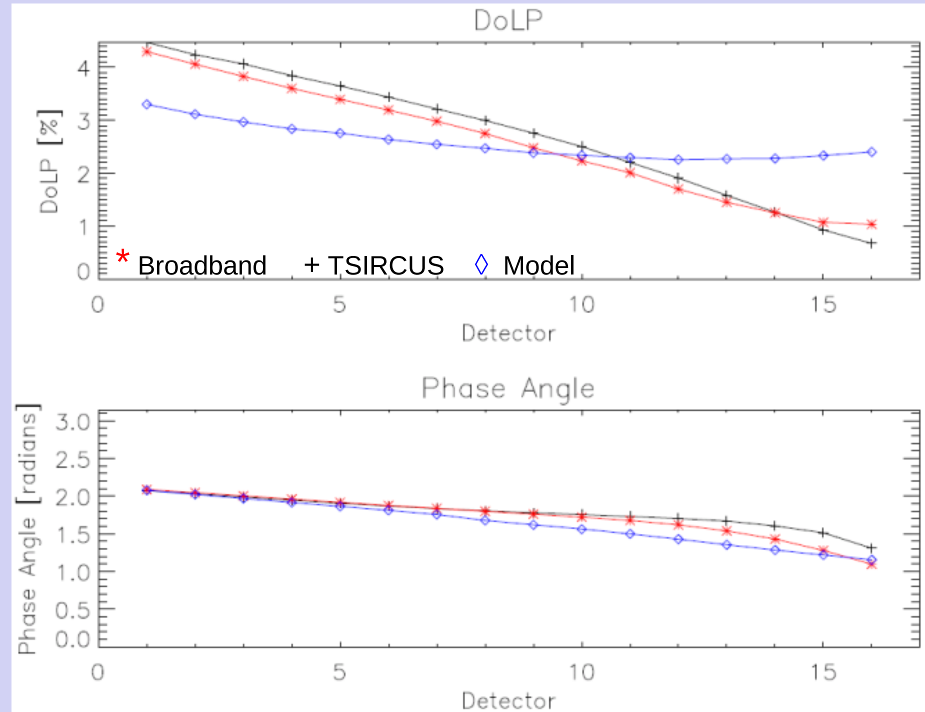
Polarization Sensitivity Comparison:

Broadband vs T-SIRCUS vs. Model

M1 (-8, HAM 1)



M4 (-8, HAM 1)



DAWG team concluded that J1 Polarization test data have good quality

- Uncertainty requirements met for all bands (max ~0.4 %)
- Broadband test data were consistent (DoLP to within ~0.11 %; phase to within ~4^0)

T-SIRCUS data analyzed and DoLP / phase determined for M1 and M4

- Agreement between SIRCUS and FP-11 / FP-11' to within ~0.5 %
- FRED model needs enhancement to be consistent with J1 instrument

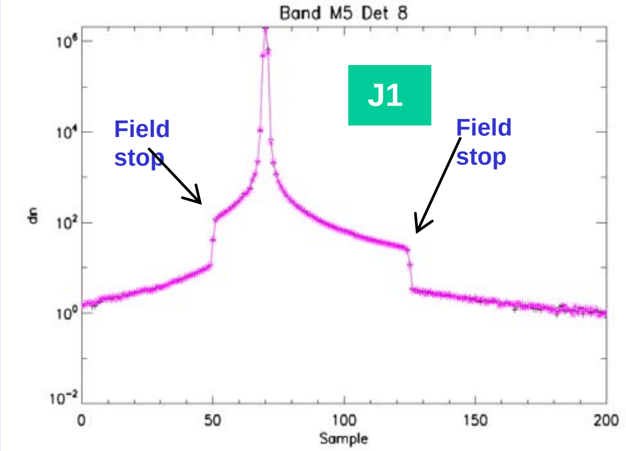
Near-Field Response (NFR) Performance

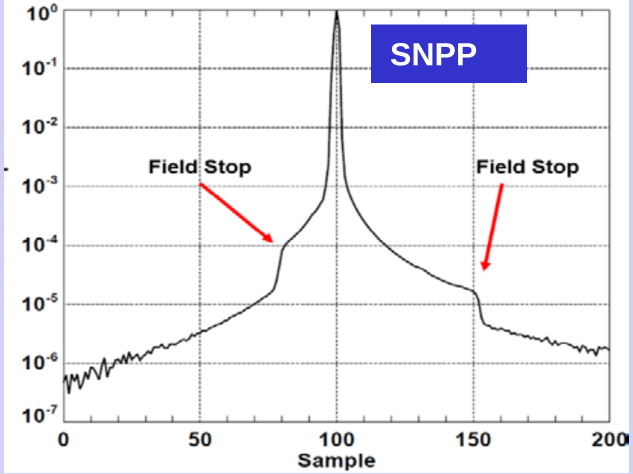
J1 NFR Performance at Beginning of Life (BOL)

Band	Center Wavelength (nm)	Angular Separation (mrad)	L_{bright}	L_{scat}	SNPP L_{scat} / L_{spec}	JPSS-1 L_{scat} / L_{spec}
M1	412	6	162	2.77E-03	0.39	0.37
M2	445	6	180	2.22E-03	0.45	0.42
M3	488	6	160	2.00E-03	0.5	0.36
M4	555	6	160	1.31E-03	0.47	0.48
M5	672	6	115	8.70E-04	0.63	0.60
M6	746	12	147	1.31E-03	0.12	0.13
M7	865	6	124	5.16E-04	0.90	0.83
M8	1240	6	57	9.47E-04	0.62	0.60
M9	1378	NA	NA	NA	NA	NA
M10	1610	6	86.1	8.48E-04	0.76	0.30
M11	2250	6	1.2	1.00E-03	0.42	0.63
M12	3700	3	0.3	1.67E-03	0.64	0.40
M13	4050	3	1.7	1.86E-03	0.63	0.32
M14	8550	NA	NA	NA	NA	NA
M15	10763	3	12.5	7.75E-04	1.25	0.01
M16	12013	3	11.3	7.92E-04	1.26	0.88
DNB	12013	3	NA	2.00E-03	NA	0.41

J1 NFR requirements are met for all bands at BOL

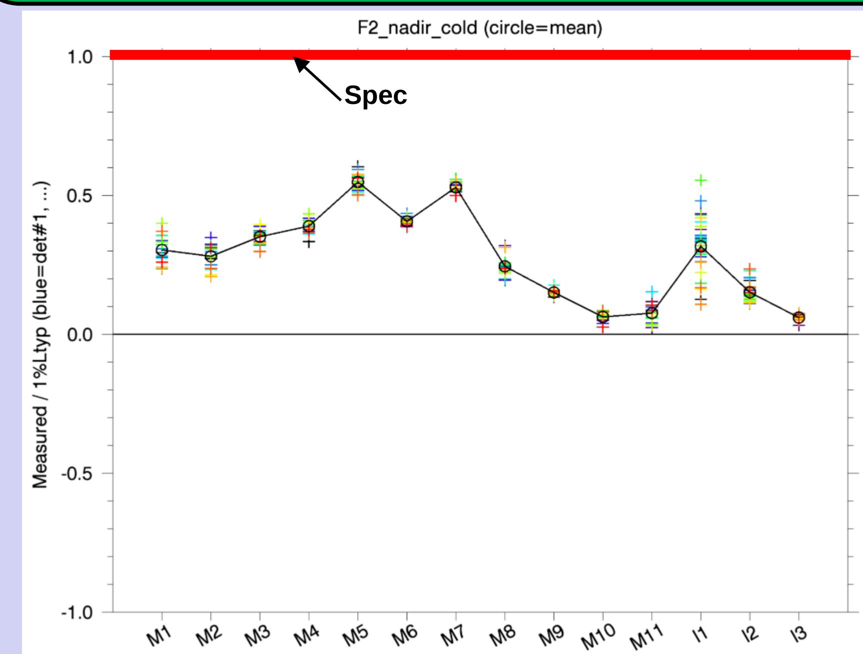
Measured near-field response for band M5 (672 nm) detector 8, as a function of samples. The figure also shows the location of the field stops



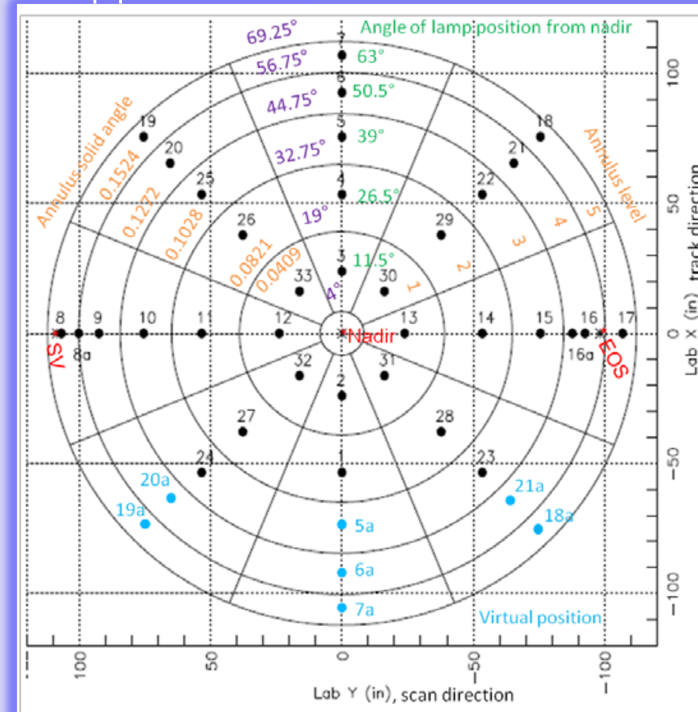


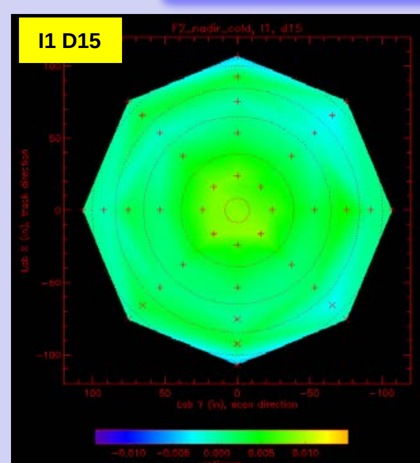
Stray-Light Response (SLR) Performance

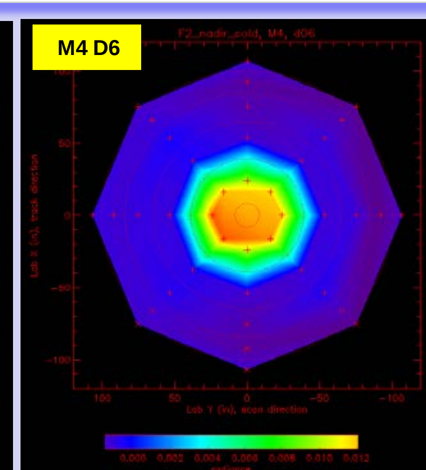
- J1 SLR performance is comparable to SNPP. The right hand side shows a couple of examples (out of 336) of simulated views from detectors.
- **All RSB detectors meet SLR specification at Beginning of Life (BOL) (plot below).**
- Bands M5 and M7 are predicted to fail Spec at the End of Life (EOL), while M6 will become marginal.



Lamp position chart

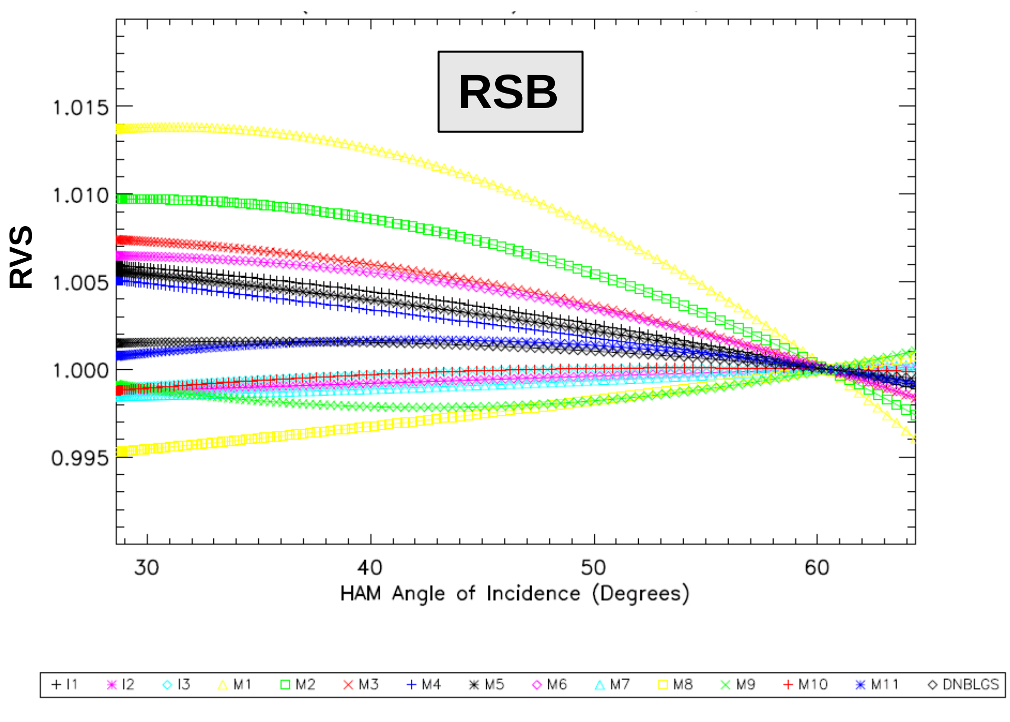


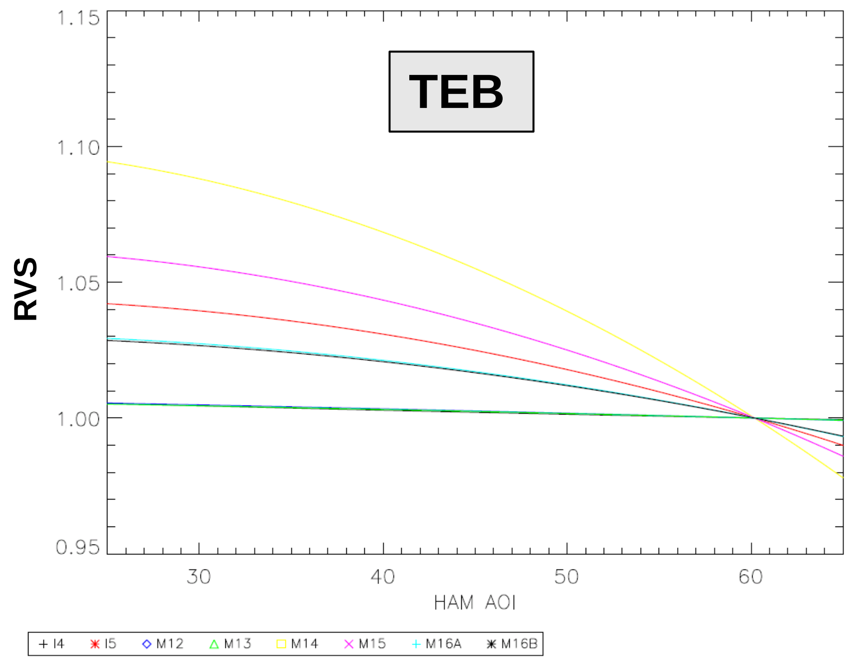




Response vs. Scan (RVS) Performance

RVS is the HAM reflectance as a function of HAM Angle of incidence (AOI)

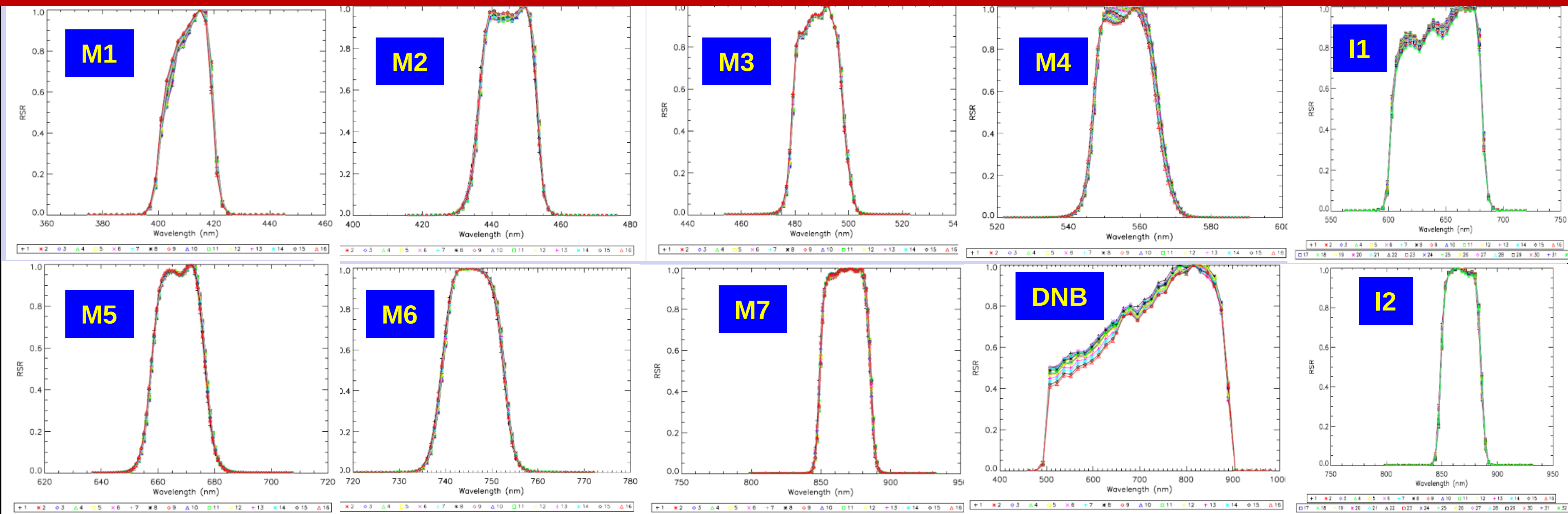


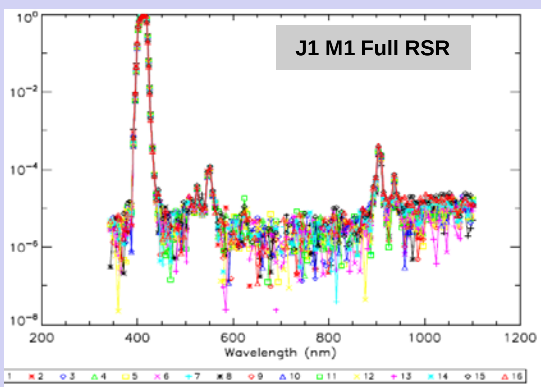


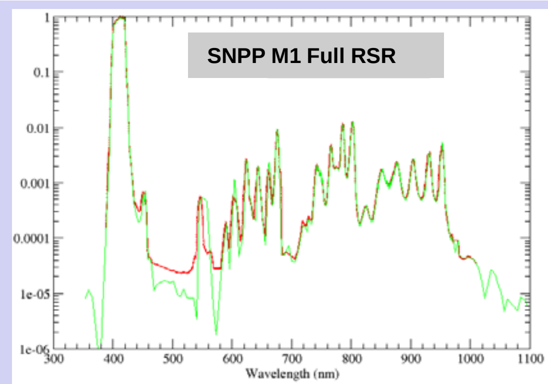
- **Uncertainty under 0.06% for all bands except I3 det4 and M9 (water vapor).**
- **Short wavelength bands M1 and M2 have the largest RVS.**

- **Uncertainty under 0.15 % for all bands.**
- **Largest RVS observed in LWIR (with M14 up to ~10 %) and the smallest in the MWIR (less than 1%).**

J1 Spectral Performance:
VisNIR bands

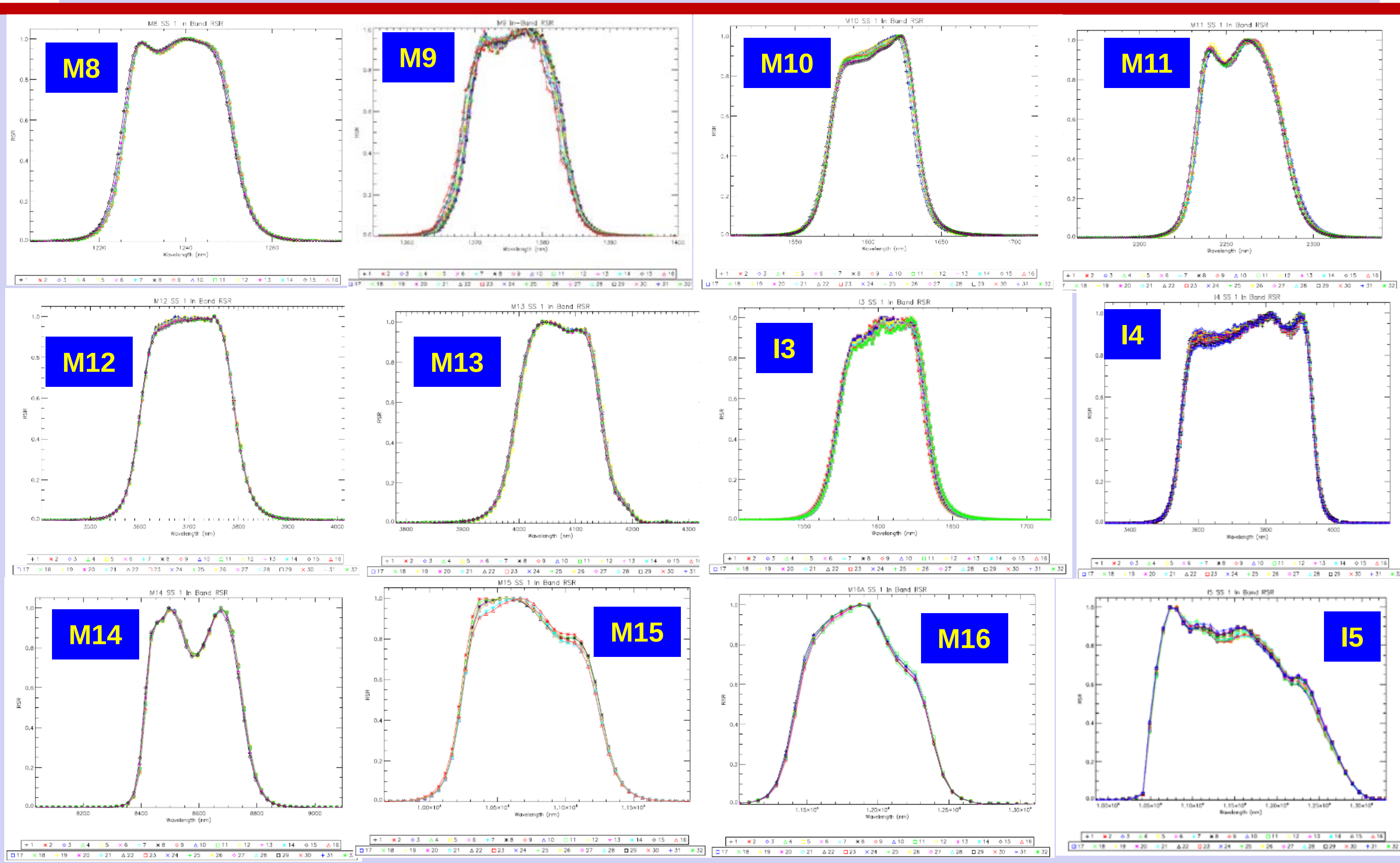






- VisNIR Relative Spectral Response (RSR) was completed successfully for all bands
- Good performance of J1 Crosstalk (optical/electric), as good as SNPP or better
- Laser test data (TSIRCUS) are being merged with the SpMA to refine J1 RSRs

J1 Spectral Performance:
SMWIR/LWIR



- SWMIR/LWIR Relative Spectral Response (RSR) was completed successfully for all bands
- M9 RSR was corrected for water vapor leading to smoother RSR profile

J1 Spectral Performance

SNPP

Band	Band center	Bandpass (FWHM)	Lower 1% point	Upper 1% point	MIOOB
'M1'	pass	pass	pass	pass	FAIL
'M2'	pass	FAIL	pass	pass	pass
'M3'	pass	pass	pass	pass	FAIL
'M4'	FAIL	pass	pass	pass	FAIL
'I1'	pass	pass	pass	pass	pass
'M5'	pass	pass	pass	pass	FAIL
'M6'	pass	pass	pass	pass	FAIL
'I2'	pass	pass	pass	pass	FAIL
'M7'	pass	pass	pass	pass	pass
'M8'	pass	FAIL	pass	pass	pass
'M9'	pass	pass	pass	pass	pass
'I3'	pass	pass	pass	pass	pass
'M10'	pass	pass	pass	pass	pass
'M11'	pass	pass	pass	pass	pass
'I4'	pass	pass	pass	pass	pass
'M12'	pass	pass	pass	pass	pass
'M13'	pass	pass	pass	pass	pass
'M14'	pass	FAIL	pass	pass	FAIL*
'M15'	pass	pass	pass	pass	FAIL*
'I5'	pass	pass	pass	FAIL	FAIL*
'M16A'	FAIL	pass	pass	pass	FAIL*
'M16B'	FAIL	pass	pass	pass	FAIL*
DNBLGS	pass	pass	pass	pass	pass

J1

Band	Band center	Bandpass (FWHM)	Lower 1% point	Upper 1% point	MIOOB
'M1'	pass	FAIL	pass	pass	pass
'M2'	pass	pass	pass	pass	pass
'M3'	pass	pass	pass	pass	pass
'M4'	pass	pass	pass	pass	pass
'I1'	pass	pass	Pass	pass	pass
'M5'	pass	pass	pass	pass	pass
'M6'	pass	pass	pass	pass	pass
'I2'	pass	pass	pass	pass	pass
'M7'	pass	pass	pass	pass	pass
'M8'	pass	FAIL	pass	pass	pass
'M9'	pass	pass	pass	pass	pass
'I3'	pass	pass	pass	pass	pass
'M10'	pass	pass	pass	pass	pass
'M11'	pass	pass	pass	pass	pass
'I4'	pass	pass	pass	pass	pass
'M12'	pass	pass	pass	pass	pass
'M13'	pass	pass	pass	pass	pass
'M14'	pass	FAIL	pass	pass	pass
'M15'	pass	pass	pass	pass	pass
'I5'	pass	pass	pass	FAIL	pass
'M16A'	FAIL	pass	pass	pass	pass
'M16B'	FAIL	pass	pass	pass	pass
DNBLGS	pass	pass	pass	pass	pass

- J1 RSR showing good performance as expected. Minor non-compliances are small risk
- J1 RSR version 1 (V1) was released to the science community in June, 2015
- J1 RSR data set (V1) is available from a secure web site.

*High noise floor in LWIR out-of-band response test

J1 Lesson Learned & Implementation into J2

- **A series of lessons learned discussions led to a list of 97 items.**
- **Most of these items will lead to no additional testing time, but expect the total testing time to be reduced**
  - 35 identified as “will do”
  - 26 identified as “task order” candidates
  - 3 identified as “already implemented”
  - 3 identified as “AOA risk reduction”
  - 6 identified as “open”
  - 24 rejected – acceptable risk not to implement

Summary & Conclusion

- **J1 VIIRS test program at the instrument level was completed successfully**

  - VIIRS testing provided an extensive amount of high quality data to enable the assessment of sensor performance
  - VIIRS performance exceeds requirements with few non-compliances
  - Non-compliances have been reviewed, impacts have been assessed, and mitigation plans are being prepared for on-orbit processing

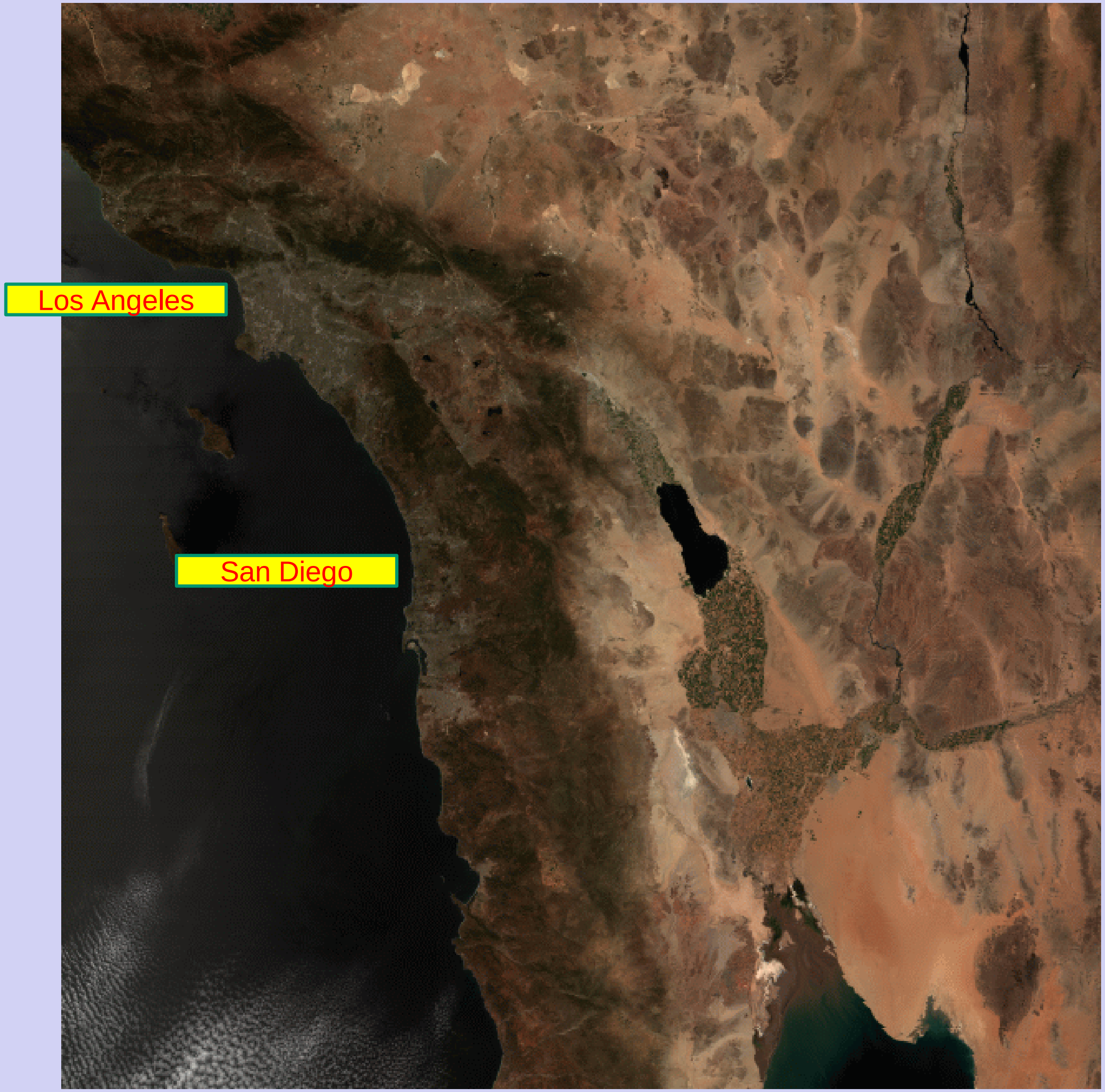
- **J1 VIIRS spacecraft testing is ongoing**

  - VIIRS instrument was integrated successfully onto the spacecraft, awaiting TV testing (April 2016)
  - Key TV testing includes the DNB testing and verification of the configurations planned to reduce non-linearity issue on orbit.

- **J1 LUTs development for SDR processing**

  - J1 SDR LUTs effort is ongoing based on pre-launch testing. Initial version released in July 2015
  - **J1 SDR effort is ongoing to mitigate performance issues (e.g. DNB and SWIR non linearity, polarization).**

SNPP VIIRS Imagery



Courtesy of NASA NPP LPEATE

RGB using M5, M4 and M3 SDR bands

J1 VIIRS is also expected to deliver high quality radiance and environmental data products

Thank You!

J1 VIIRS Performance Waivers

Raytheon Waiver #	Title	Status
RDW_148	J1 Relief against reflective band absolute radiometric calibration uncertainty requirements for bands M1-M3	Approved
RDW_149	J1 Relief against reflective band absolute radiometric calibration uncertainty requirements for band M11	Approved
RDW_150A	J1 Relief for DNB stray light in certain viewing geometries and related impacts on sensitivity and radiometric calibration	Approved
RDW_151	J1 relief against maximum radiance requirement for bands M8, I1 and possibly M1LG and I3.	Approved
RDW_166	J1 relief agains maximum polarization sensitivity requirement for bands M1 to M4.	Approved
RDW_153	J1 relief against electrical and optical crosstalk. Stringent requirements and testing artefacts are leading to non-compliances	Approved
RDW_150A	J1 relief against the sensor modulated transfer function (MTF)	Approved
RDW_161	J1 relief against the relative spectral response (RSR) requirements. Band center (M5, M16), Band width (M1,M8,M14,DNB), 1% limit (I5,DNB), IOOB (M16)	Approved
RDW_168	J1 relief against near field response (NFR). Non-compliance for (M7, M13, M16A and I3)	Approved
RDW_171	J1 relief from emissive relative radiometric reponse calibration uniformity (M12-M14 at high temp) and characterization uncertainty (I5 and M12).	Approved
RDW_172	J1 relief from reflective band characterization uncertainty (all bands non-compliant except M4HG and M5HG, and M7HG), and uniformity characterization (all bands non-compliant except M1-M7 high gain and M6)	Approved
RDW_173	J1 relief from band-to-band registration for I bands (non-compliance for I1-I3, I2-I3, I1-I4, I2-I4, I1-I5, I2-I5, I3-I5, I4-I5)	Approved
RDW_174	J1 relief from DNB SNR, uniformity and RCU.	Approved
RDW_175	J1 relief from spatial dynamic field of view (DFOV). All M bands and I5 not compliant	Approved
RDW_177	J1 DNB relief from dynamic range (LGS)	Approved

- **All 15 waivers were approved by NASA/NOAA review board**
- Completed a series of telecons (half-dozen) with NASA and NOAA SMEs to review each waiver
- Compliance is against end-of-life (EOL) performance
- All of non-compliances have mitigation plans, or will lead to acceptable impact.

J1 VIIRS Performance Based on Sensor Level Testing

- **RSB Radiometric Performance:**
  - **J1 VIIRS meets all requirements for Signal to Noise Ratio, Dynamic Range, Gain Transition,**
    - Successful J1 RSB radiometric calibration. Overall, as good as SNPP
    - Minor non-compliances for dynamic range: M8 (72%) and I3 (91%), while I3 Det4 is a bad detector (very noisy and lower responsivity).
    - Shortwave bands non-linearity: High residuals at low radiance. Issue can be mitigated using higher order calibration equation.
    - DNB HGS/MGS non-linearity: shown only at higher agg modes (22-32). Identified resolution plan (agg mode 21, agg mode 21-26).

J1 VIIRS Performance Based on Sensor Level Testing

- **TEB Radiometric Performance**
  - **J1 VIIRS meets all requirements for Noise (NEdT), Dynamic Range, and non-linearity**
    - TEB showed excellent calibration performance based on the TV testing; comparable to SNPP performance.
    - Minor non-compliances include M12 not meeting the absolute radiometric calibration (ARD) at low temperature, and similar to SNPP, J1 did not meet the characterization uncertainty for many bands.
    - Out of family detectors (higher noise) were identified, **M16B D5** and **M15 D4**, are considered as low risk, but could result into striping in products such as SST.
- **J1 VIIRS Bands Spectral Performance**
    - Successful spectral testing with minor non-compliance. J1 performance is in general better than SNPP.
    - J1 RSRs Version 0 (V0) was released on 02/26/2015 by DAWG team.
    - Work is ongoing to released enhanced J1 RSRs Version 1 (V1) by June 2015. Further releases (TSIRCUS) are planned.
    - Electrical and optical crosstalk generated from spectral testing is comparable to SNPP performance. SNPP did not show crosstalk on-orbit.

JPSS NASA Program Science Staff

JPSS Program Scientist: **Mitch Goldberg**
JPSS Project Scientist: **Jim Gleason**
Deputy JPSS Senior Project Scientist (Flight): **Jim Butler**

JPSS VIIRS Instrument Scientists:
Kurt Thome (NASA)

NASA VCST Lead:
Jack Xiong (NASA)

STAR VIIRS SDR Leads:
Changyong Cao (NOAA/STAR)

DAWG Lead:
Hassan Oudrari (NASA/SSAI)

- Each Instrument Scientist has the support and staffing they need to provide an independent verification of critical instrument performance requirements.
- **Coordinates with NOAA-STAR SDR Team to ensure test results get into data production system.**

VIIRS Sensor Block Diagram

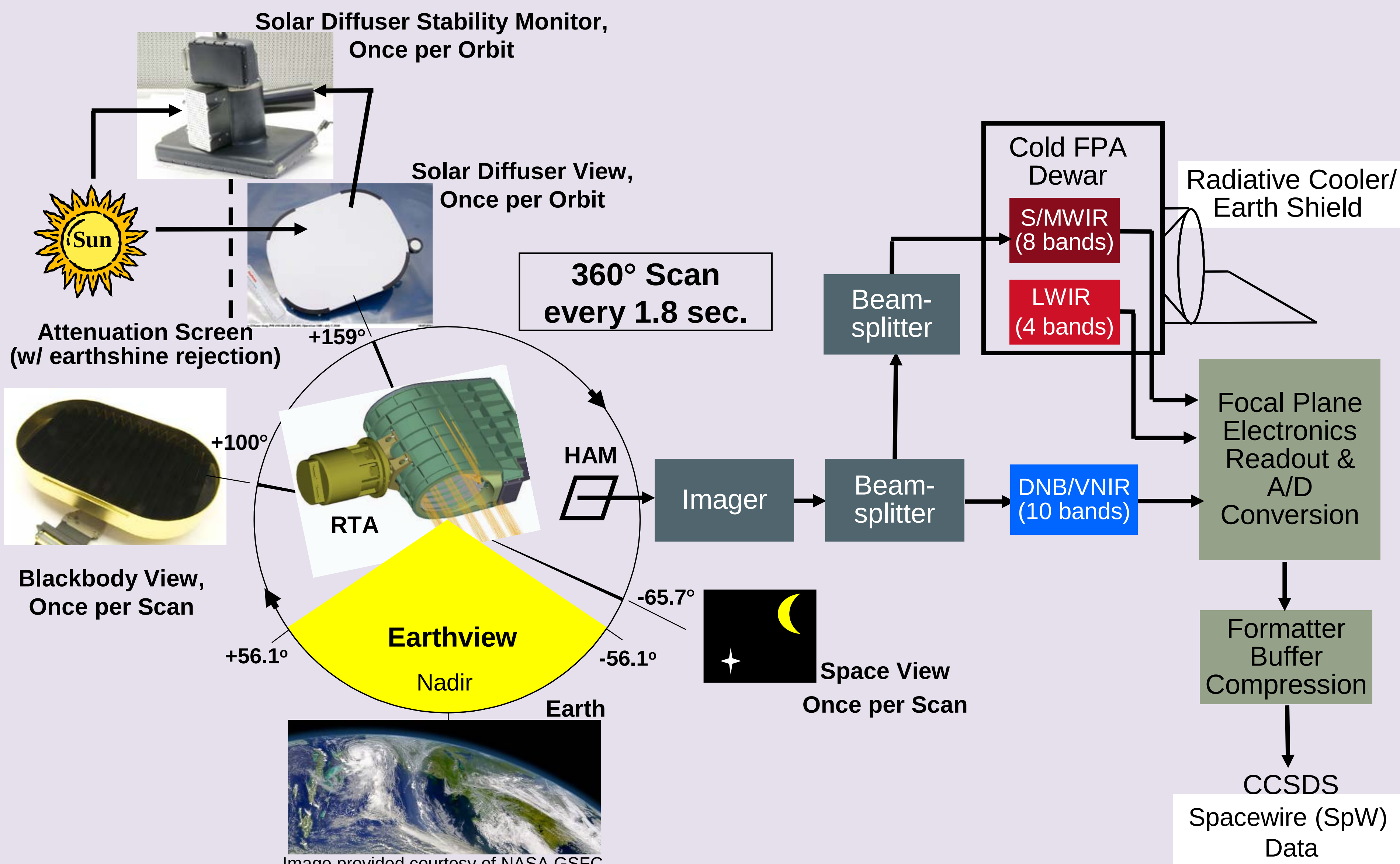


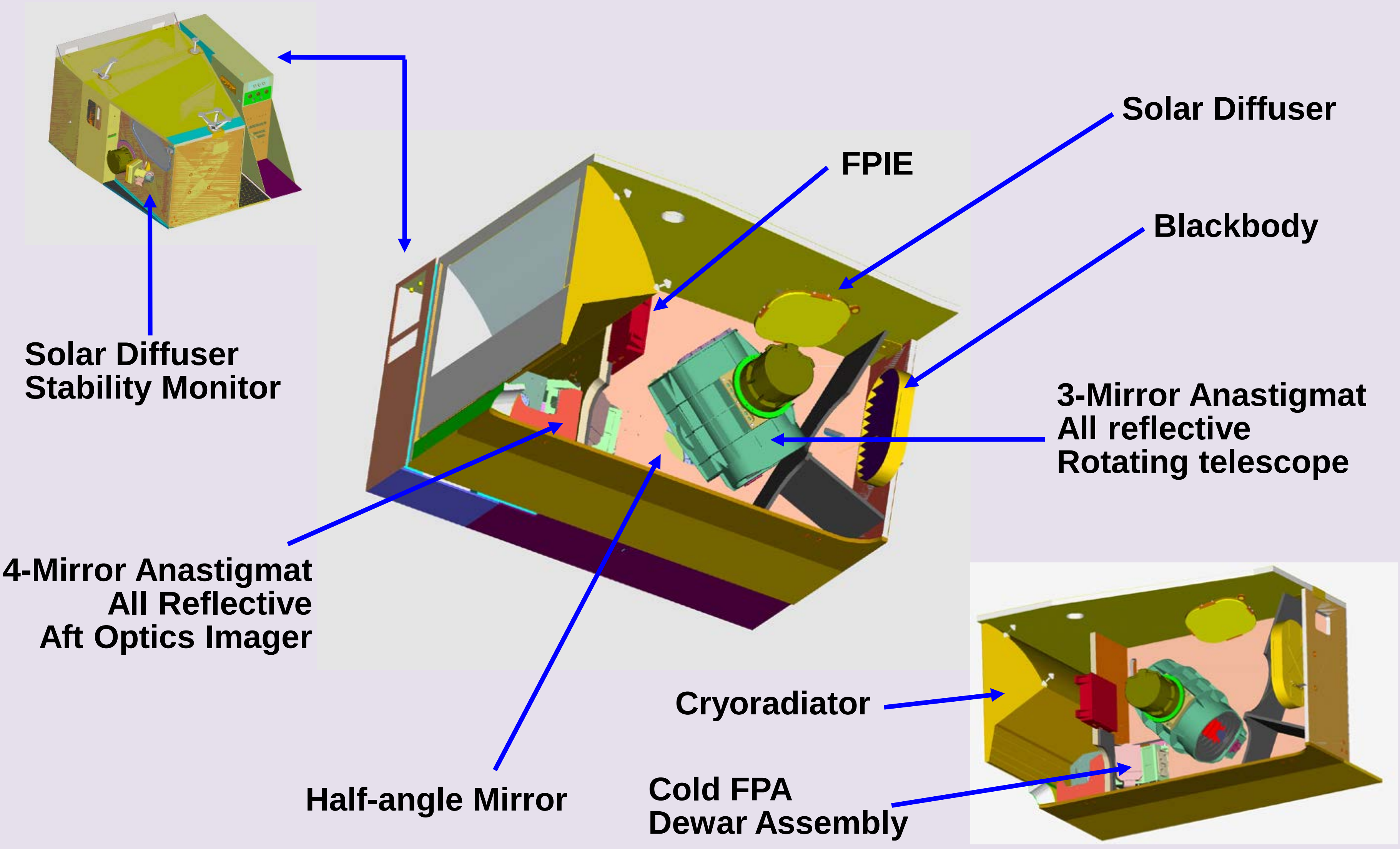
Image provided courtesy of NASA GSFC

DAWG List of J1 Testing/Performance Issues:

- **Sample of J1 VIIRS list of issues identified, understood, and resolved/accepted.**
  - 34 items from Ambient, and 42 from thermal vacuum.

Priority (L,M,H)	Issue #	Date	Authors	Test	Title	EFR #	Description	Status	DAWG Comments	DAWG Review (10-01-2014)	Tests requested
Closed	1	7/2/2014	Oudrari	FP15/FP16	SpMA bulb A failure		Raytheon reported lamp failure after testing M6 on Wednesday July 2nd. Testing was stopped, and resumed on Monday July 7th using Lamp B.	Closed	Lamp life expectancy was about 150 hrs based on F1 testing. Lamp failure occurred at less than 80 hrs. Lamb B was installed in the SpMA on July 7th. Lamp B also showed signs of impending failure after about 80 hrs. Lamp D was burned in for use on remaining VisNIR and DNB bands. Lamp C was planned to be burned in over the weekend (July 4-6th), but due to script error was burned in for 80 hrs instead of 11 hrs.	DAWG team agreed to close this issue. This list of issues contains other items addresing the RSO issue. This is expected to be included in the lessons learnd for J2+ testing.	None
Low	2	7/8/2014	McIntire	FP15	Noise due to dual gain anomaly		Some of the RSR data falls within the dual gain anomaly region, at or near peak response. The standard deviation of the spectral data has shown out of family values (high and low), and this standard deviation variability resembles the behavior in the dual gain anomaly region.	Open	VCST presented these findings on July 8, 2014 (report #14-036). Impact on the RSR still to be assessed.	DAWG team expects a small impact on the spectral performance assessment. Post-launch SIRCUS testing will provide validation of the SpMA derived RSRs. A note should be shared with NIST to avoide the Dual gain anomlay (DGA) region in their radiance settings.	Post-TV TSIRCUS: Avoid DGA in the radiance setting
Closed	3	7/8/2014	Schwarting	FP16/FP15	Wrong DNB band substitution table		VCST got unexpected results when analyzing DNB crosstalk data (FP16). This issue was reported on 7/9/2014 at the DAWG telecon.	Closed	(7/9/2014) VCST thinks that this issue affects DNB when all of the bands were illuminated, and might need to repeat FP16 crosstalk for many bands. The DNB table was updated only for two bands: M7 and DNB (the last 2 bands tested for FP15/FP16). RTN does not believe in cross-FPAs optical crosstalk, so RTN does not believe for the need to repeat FP15/FP16. DAWG will continue looking at the test data available to identify any concern for the DNB optical xtalk (e.g. FP13, etc.).	DAWG team agree to close this issue. FP13 and FP14 testing did not show obvious crosstalk between VisNIR and DNB focal planes. Team will continue to mitor DNB optical crosstalk.	None
Medium	4	7/9/2014	McIntire	FP16/FP15	Spectral non-compliance of bands M1, M5, and DNB		M1 bandpass was short for some detectors, M5 center wavelength was short (by a very small margin for one detector) and the DNB LGS bandwidth and center wavelength were short and long respectively.	Open	Issues with RSO collection may impact some these non-compliances. Spectral to be refined after all spectral testing is complete at the end of Nominal plateau.	DAWG team assigned medium priority level to this issue because it still needs re-analysis based on the final RSOs. Team also determined that post-launch SIRCUS testing will provide valuable validation data.	Post-TV TSIRCUS: Avoid DGA in the radiance setting
Medium	5	7/14/2014	McIntire/Moyer	FP15/FP16	Lamp D RSO issue - Spectral shift		Based on Moyer's presentation at the DAWG, RSR derived for DNB MGS showed a spike around 670nm, and higher RSR in the blue region when compared to RSR LGS. Using Lamp B RSO provides more consistent RSRs for the DNB.	Open	Investigation done by David Moyer has shown that a shift in the RSO could be the reason (7/15), and this was confirmed few days later by Raytheon. The lock-in amplifier used for the SiPD reference detector had a firmware issue, resulting in incorrect wavelength values being reported (wavelength shift). EFR3565 was created on July 16, 2014. FRB was held on 7/22, and path forward was defined. SpMA Merlin lock-in amplifier issue was fixed (8/9). Additional testing is planned (ETP 392, FP15 M4 and I1). Fix was implemented (fix details are not known). TSIRCUS. will help for M5 the highest impact. Need of RSO-c and RSO-a Post TV.	DAWG team assigned medium priority level to this issue because it still needs re-analysis based on the final RSOs. Team also determined that post-launch SIRCUS testing will provide valuable validation data, especially to validate most affected band (M5). Team also requested to perform RSOa and RSO-c in the post TV phase.	Post-TV TSIRCUS: Avoid DGA in the radiance setting. Team also requested to perform RSOa and RSO-c in the post TV phase.

Opto-Mechanical Module



Performance Differences between J1 and SNPP

- **RTA mirrors changed from Ni coated to VQ**
  - Performance Area Positively Impacted: Better Spatial Stability with Temperature
    - Eliminated the focus change issues over temperature
- **Dichroic 2 coatings redesigned**
  - Performance Area Positively Impacted: Spatial
    - Coating redesign improved focus between the SMWIR & LWIR
- **Throughput degradation due to Tungsten exposure eliminated**
  - Performance Area Positively Impacted: Radiometric Sensitivity
    - J1 performance will not be impacted by the silver coating tungsten exposure issue seen on SNPP
- **VisNIR Integrated Filter Coating change from SNPP**
  - Performance Areas Positively Impacted: Crosstalk, IOOB, and RSR
    - J1 crosstalk performance for the VisNIR bands is greatly improved with this redesign effort
  - Performance Area Negatively Impacted: Polarization, Bands M1 – M4
- **Changes to voltage (Vclamp) and DNB timing card**
  - Performance Area Negatively Impacted: non-linearity issue at low radiance for SWIR and DNB (Agg Modes 21 – 32)
    - DNB: Plan to modify aggregation tables as a mitigation to this issue
    - SWIR: Plan to use cubic equation to enhance radiometric performance.

J1 VIIRS Performance Based on Sensor Level Testing

- **Key decisions during J1 VIIRS Testing**
  - SpaceWire replaced the 1394 communication bus, and a new Single Board Computer was installed
  - A-side electronics was designated as the primary electronics (B-side is the redundant one)
  - The CFPA operation temperature was set to 80.5 K

JPSS-1 VIIRS DNB, Prelaunch Tests & Performance

Steve Mills
Stellar Solutions
August 26, 2015

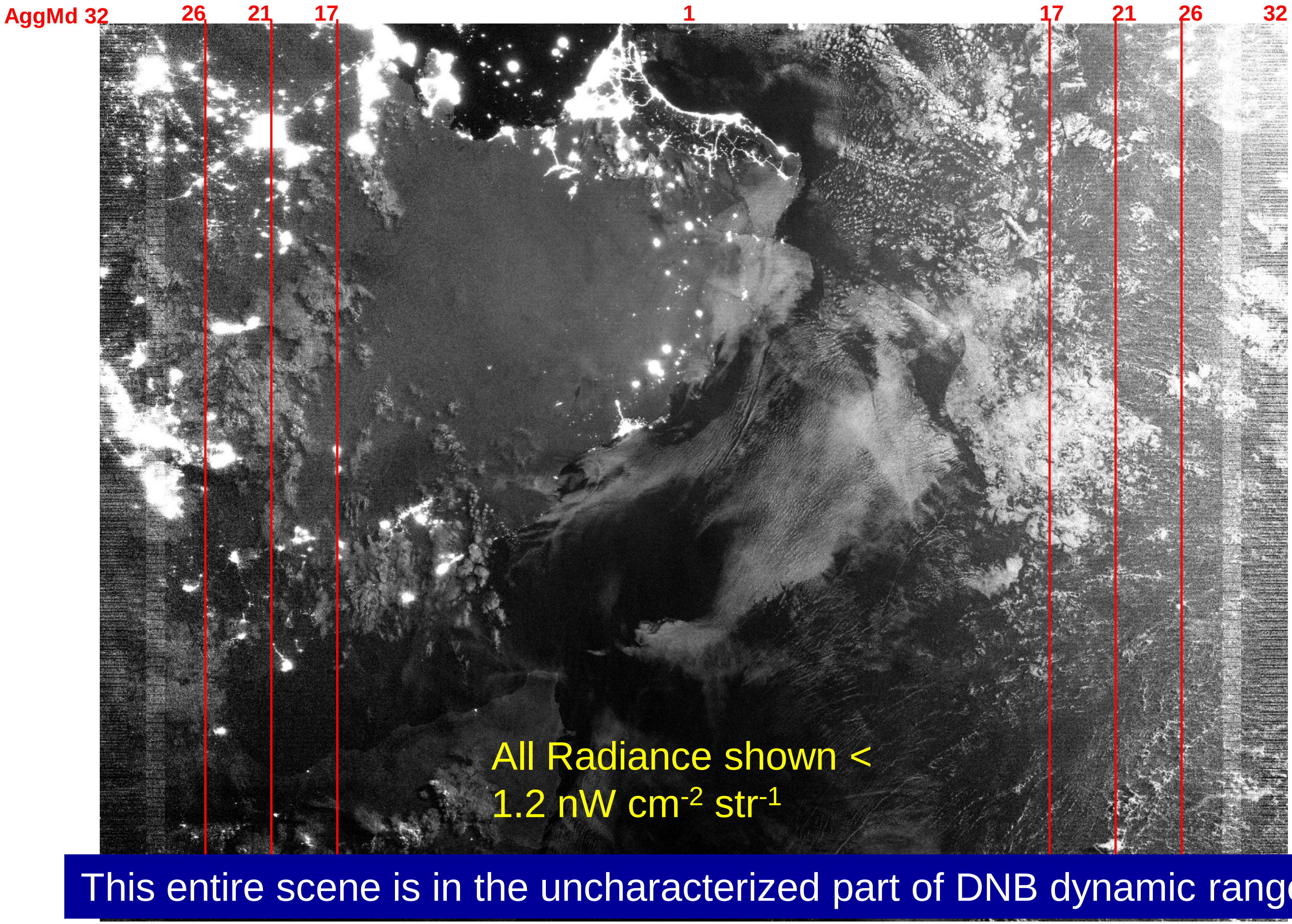
Part 1 -DNB Nonlinearity for Very Low Radiance High-Gain Stage(HGS)

Background for High-Gain Nonlinearity

- DNB Radiometric tests at Raytheon
  - Radiometric response was measured for DNB in RC2-Part4 test for radiances from 1.4 nW $cm^{-2}str^{-1}$ to 56 mW $cm^{-2}str^{-1}$
  - Severe nonlinearities were observed in high gain stage (HGS) for Aggregation Modes(AggMd) 27 to 32 near edges of swath
  - Correctable nonlinearity observed in 4 detectors for AggMd 22 to 26
  - Two options to eliminate or correct nonlinearities were proposed & tested
    - Option 21 would extend AggMd21 to the edge of swath reducing resolution by 56% at edge
    - Option 26 would extend AggMd21 to replace AggMds 22-25, and AggMd26 to edge of swath reducing area resolution by 26% at edge of swath
- Response not measured for low radiance < 1.4 nW $cm^{-2}str^{-1}$
  - VIIRS requirements define performance only down to 3 nW $cm^{-2}str^{-1}$ (L_{min})
  - Quarter moon illuminated scenes typically < 1.4 nW $cm^{-2}str^{-1}$
  - Astronomical twilight, airglow & auroras scenes typically < 1.4 nW $cm^{-2}str^{-1}$

We lack knowledge of an important part of DNB dynamic range

Quarter Moon Scene—16 Sep 2014

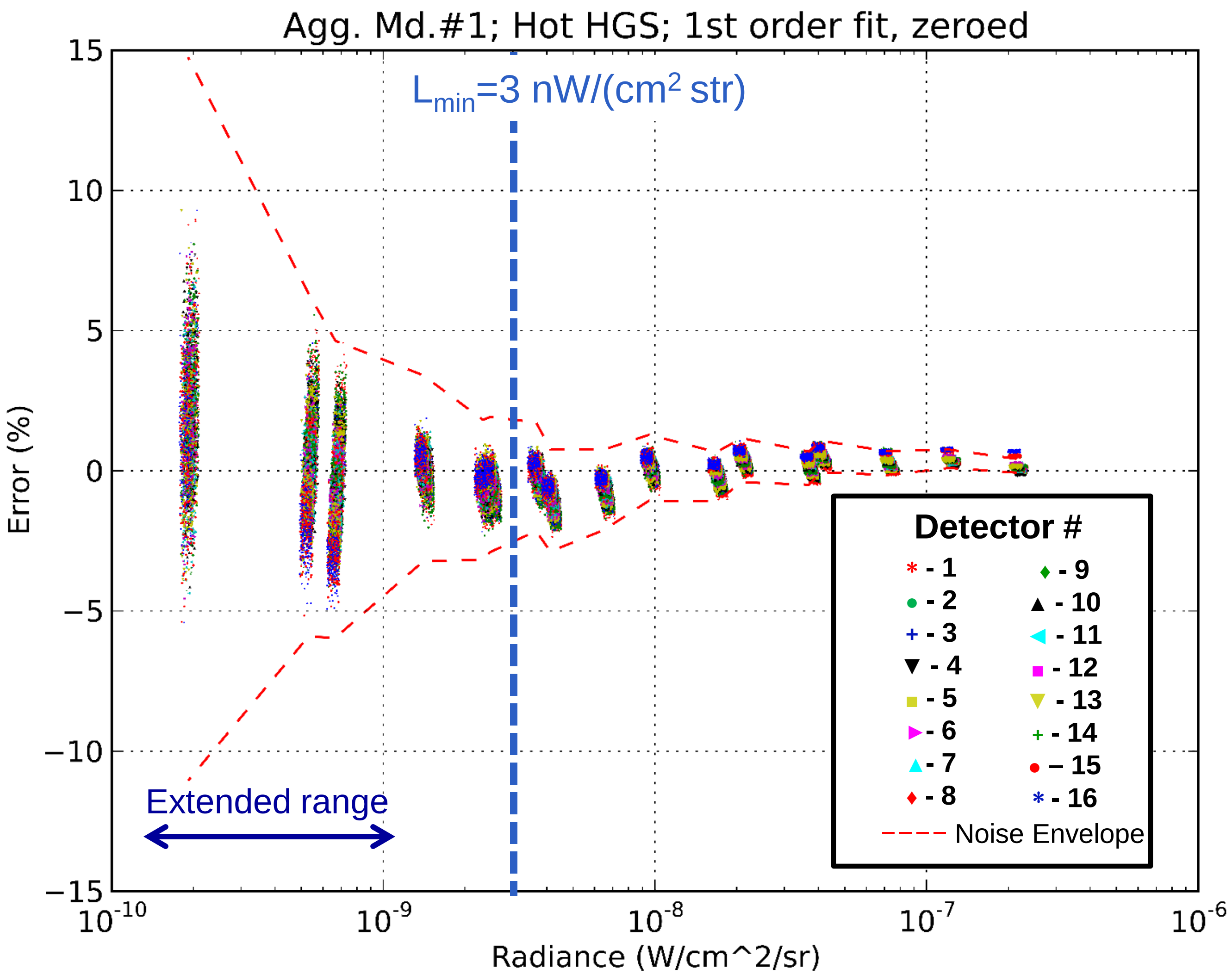


This entire scene is in the uncharacterized part of DNB dynamic range

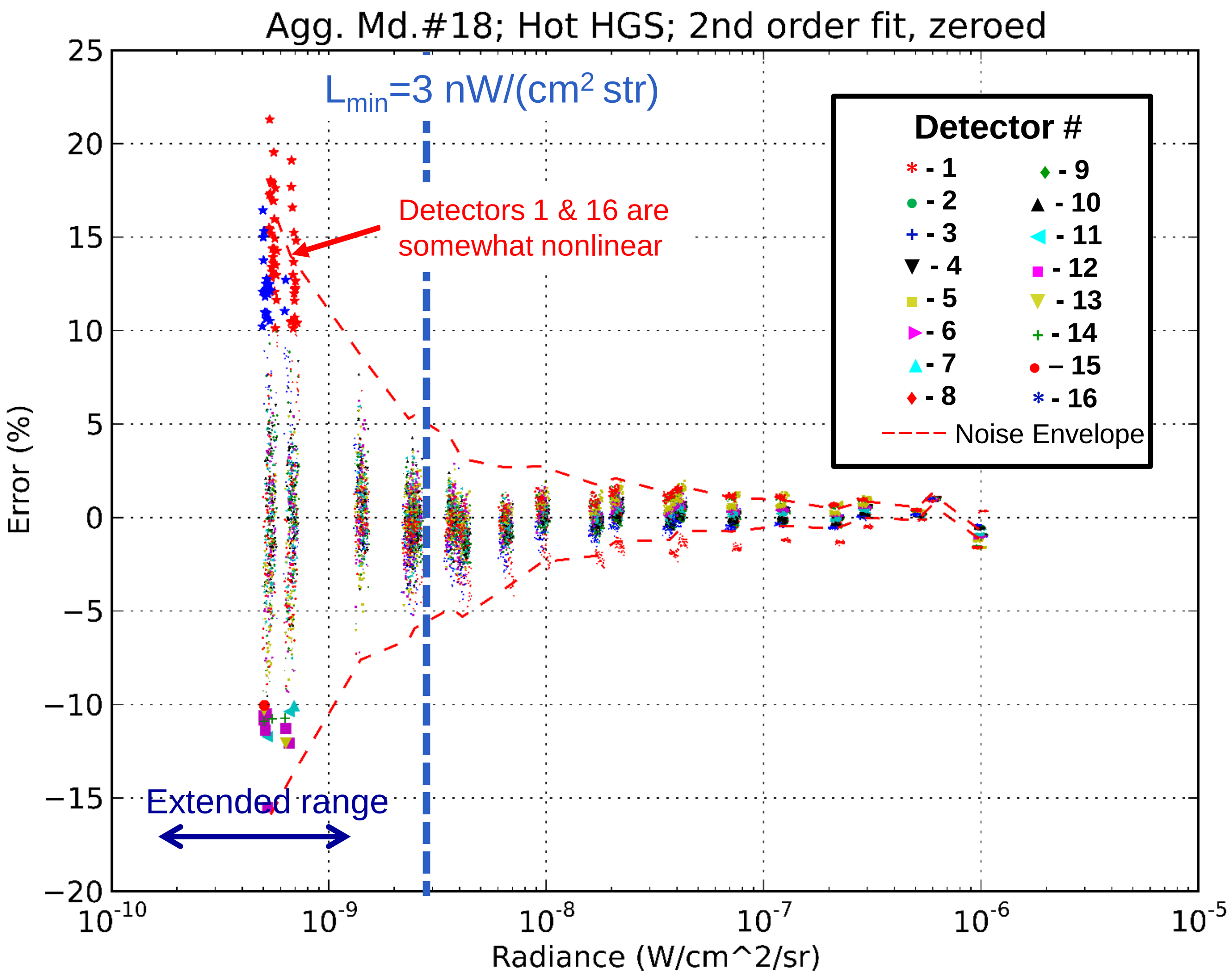
How to determine radiometric response at these very low radiances?

- The "space view" reference signal at the highest LGS illumination levels has laboratory stray light in the HGS range
  - The "space view" calibrator is black, but has a small reflectance
  - This stray light signal for highest level LGS was about at the same counts in HGS as the lowest radiance level of 1.4 nW $cm^{-2}str^{-1}$
- The stray light signal can be estimated as a fraction of the total SIS illuminator signal
  - The factor was determined to be a <u>constant</u> 9.75×10^{-7} (a good stray-light suppression factor)
  - With this it is possible to characterize the dynamic range down an additional order of magnitude to 0.1 nW $cm^{-2}str^{-1}$
- This extended range does not appear in Raytheon's official performance results

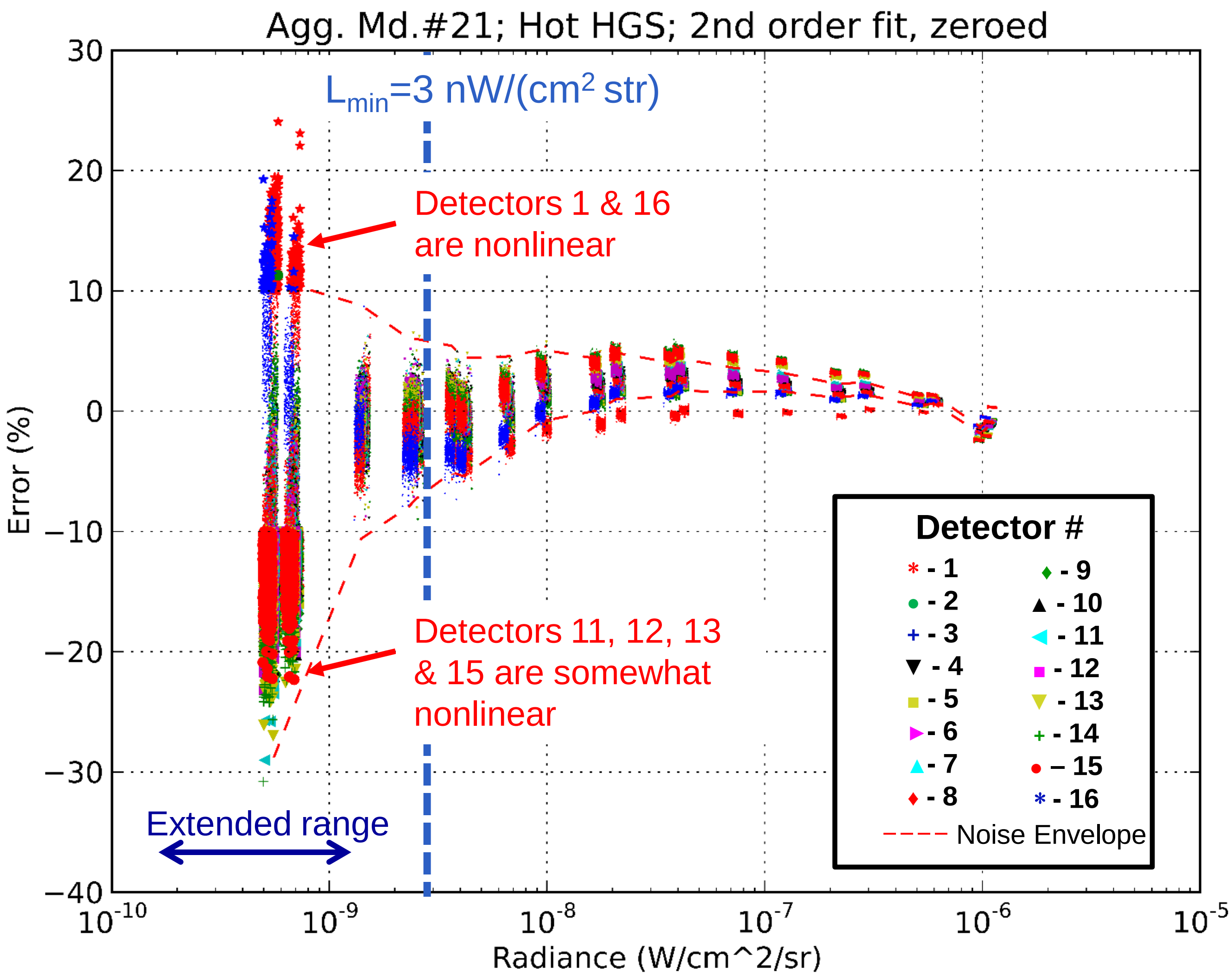
AggMd 1 (near nadir) is very linear



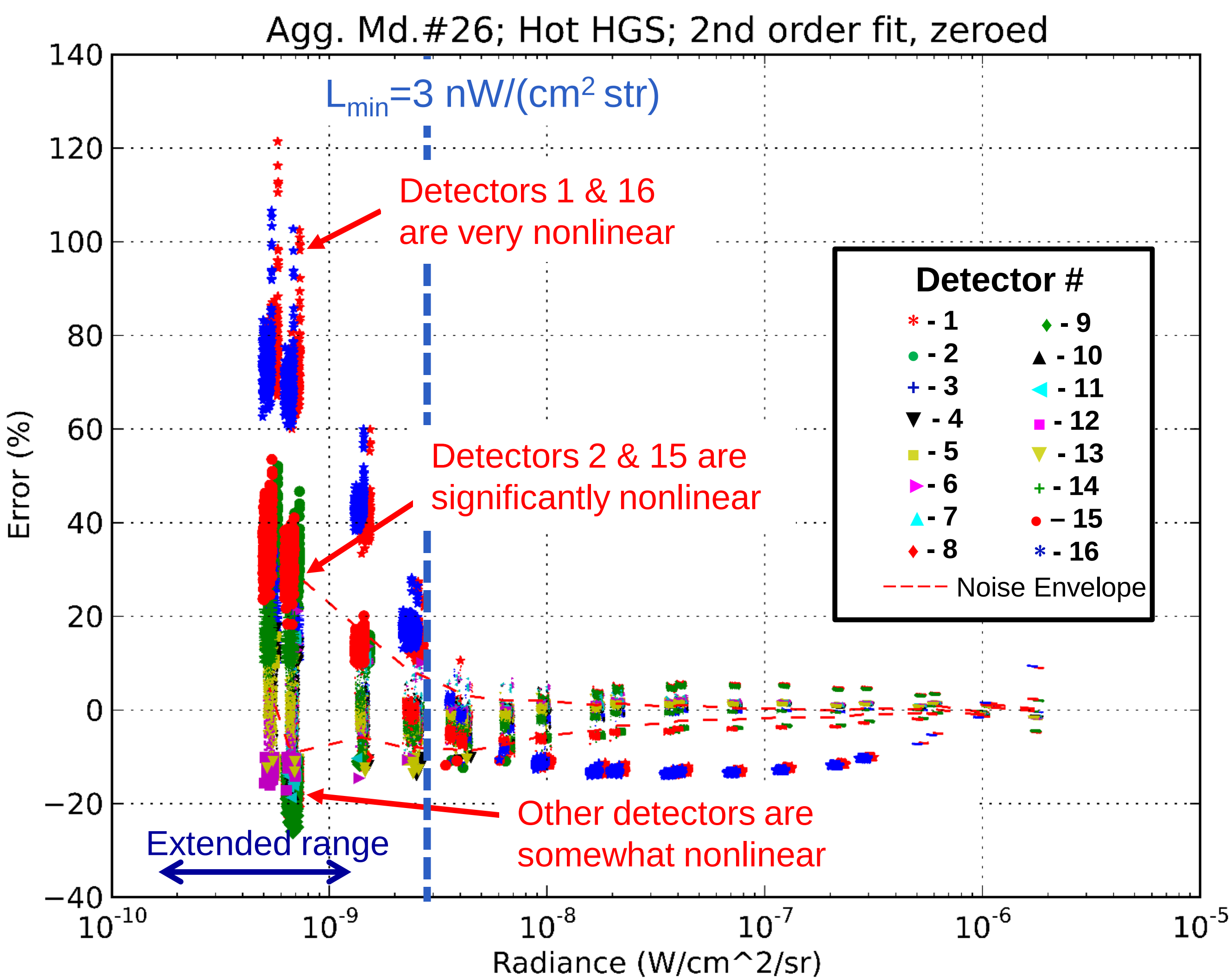
AggMd 18 has some nonlinearity



AggMd 21 (from Option 21) has significant nonlinearity



AggMd 26 (in Option 26) has strong nonlinearity



Conclusions

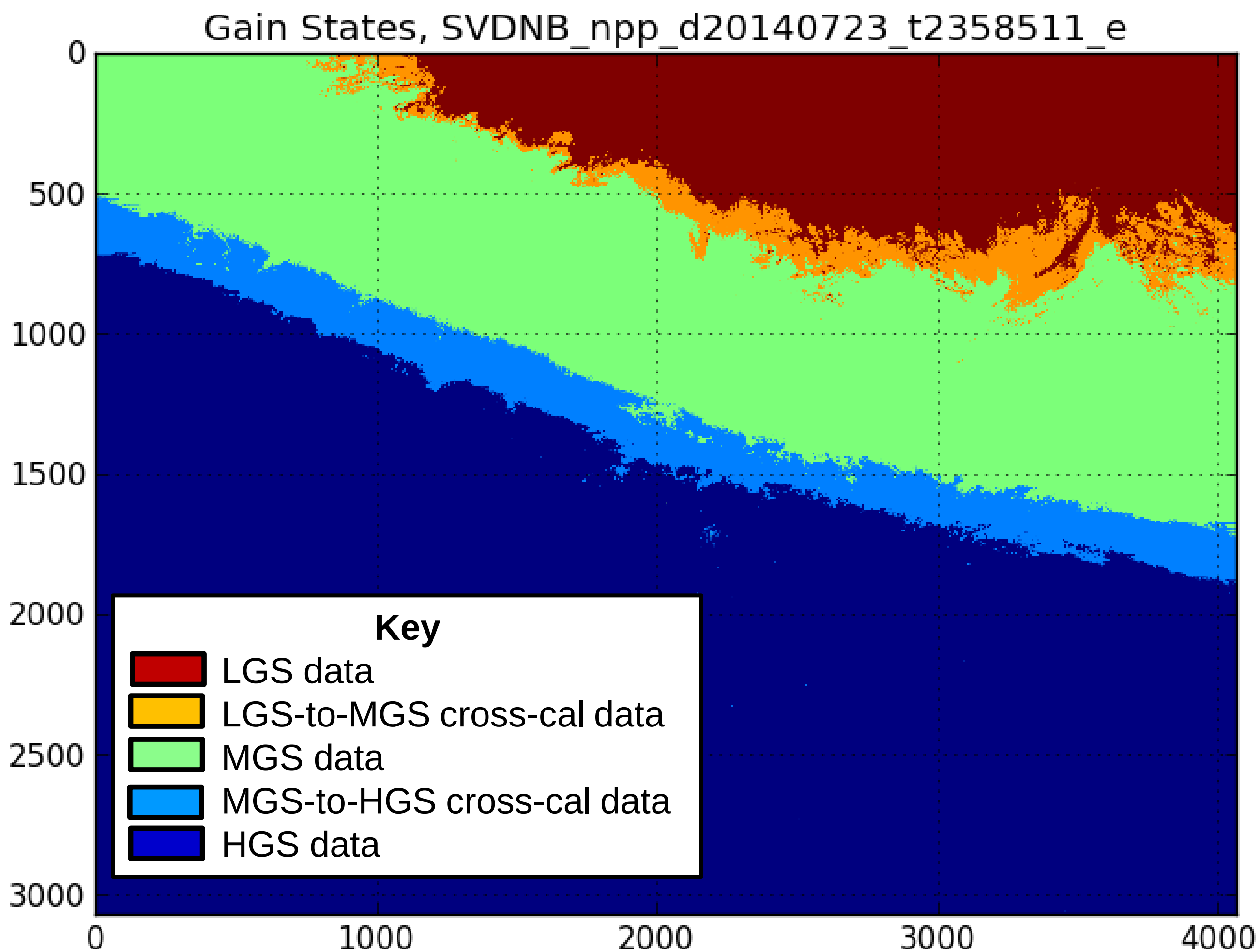
- DNB radiometric response characterized for radiance as low as 0.2 nW cm^{-2} str^{-1}
  - Source was extended with the stray laboratory light reflecting off the “black” space view
- In HGS Aggregation Modes 1 to 16 are linear for all 16 detectors
- For Aggregation Modes 17 to 21 several detectors are somewhat nonlinear
- Agg Mode 26 has 4 very nonlinear detectors 1,2, 15 & 16
- These nonlinearities will result in striping for Quarter Moon scenes affecting 39% of swath
  - Even some of full moon scenes, in twilight scenes and air glow illuminated scenes

Part 2—Computation of DNB Gain-Ratio Calibration Errors

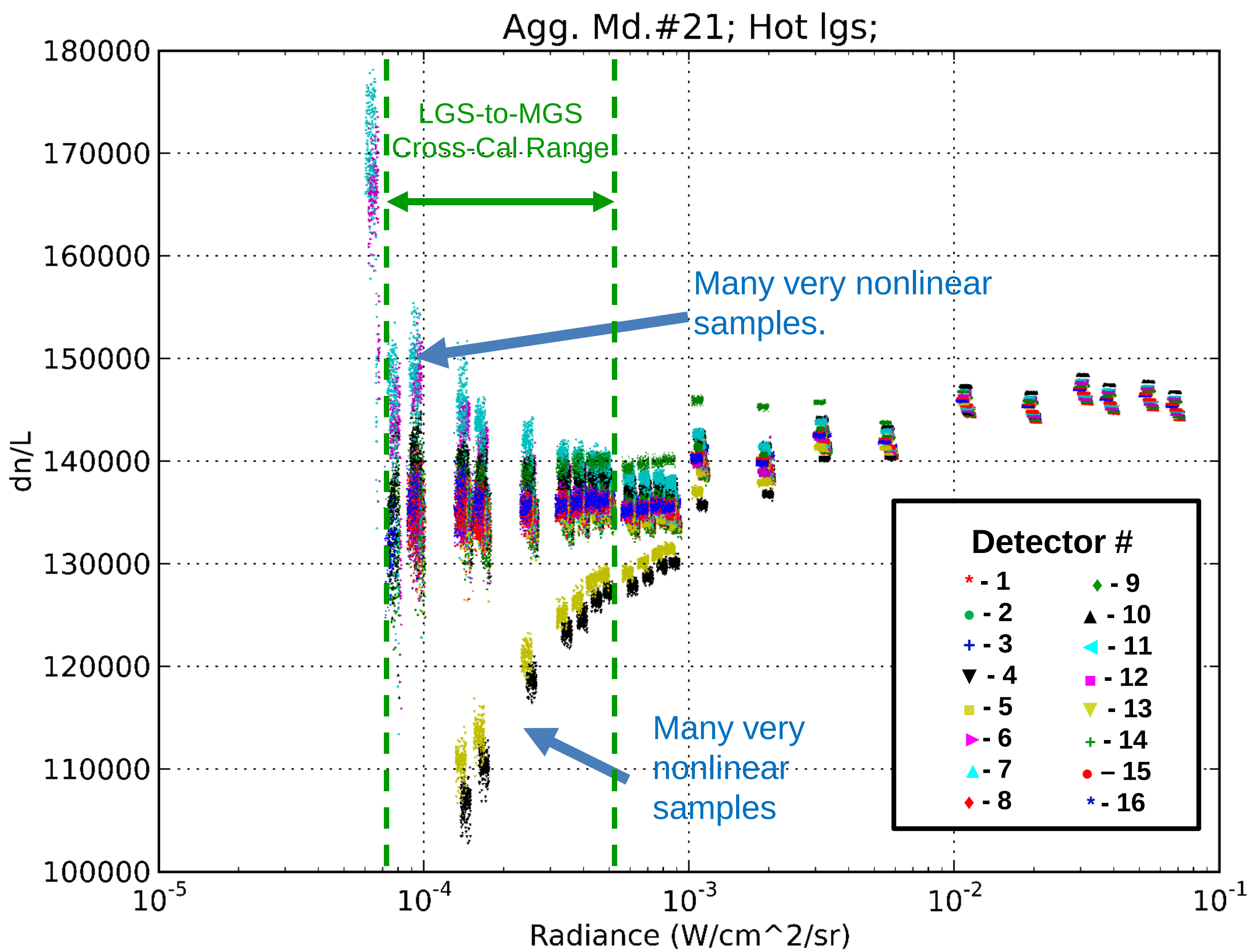
Gain-Stage Cross Calibration

- Only the low gain (LGS) is calibrated using the solar diffuser (SD)
  - Process is similar to the other VIIRS reflective solar bands (RSB)
  - Mid gain and high gain saturate when the sun is illuminating the SD so cannot be directly calibrated from SD
- Gain transfer to MGS & HGS uses special process, VROP 705, viewing twilight region around day-to-night terminator crossing
  - Day-to-night mode transition is started earlier while VIIRS still viewing daylight,
  - Process is currently performed once per lunar month
  - Additional data is transmitted so that all gain stages are available
  - Unfortunately, due to this process gain and uniformity errors from lower stages transfer to higher stages
- This presentation uses the RC2-Part 4 data to estimate calibration errors due to Gain-Stage cross-calibration

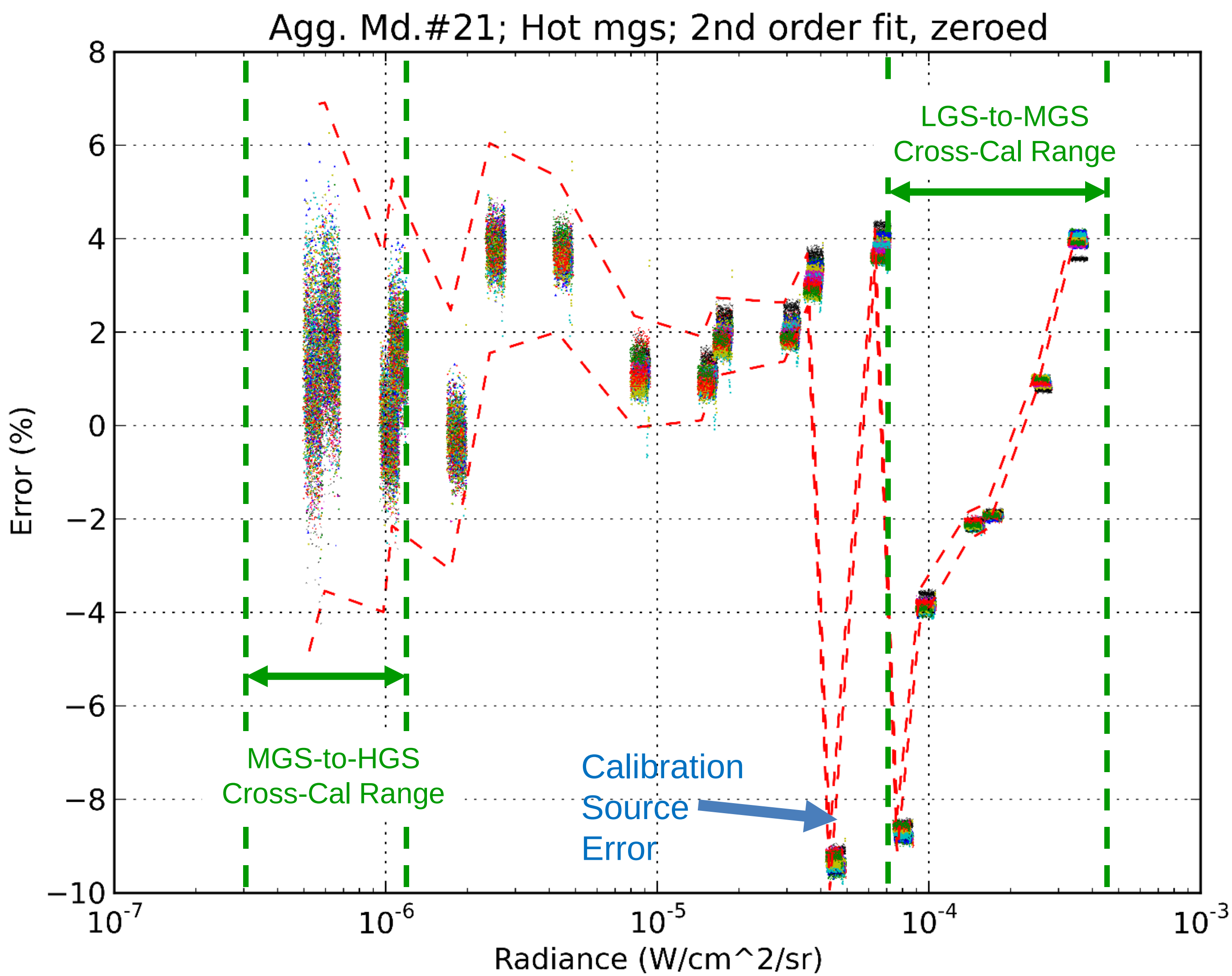
Typical VROP 705 Data—23 Jul 2014



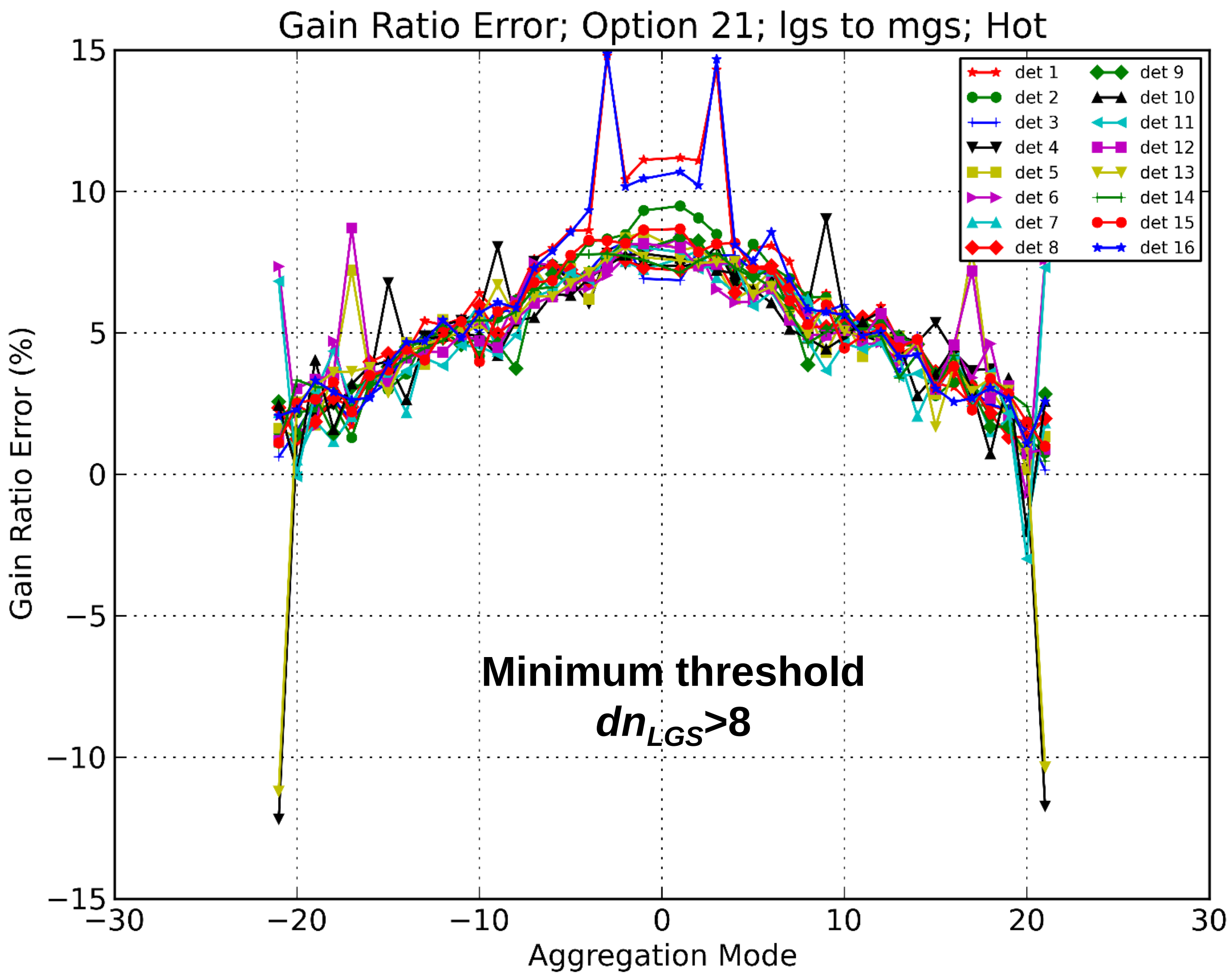
Example of LGS Nonlinearity



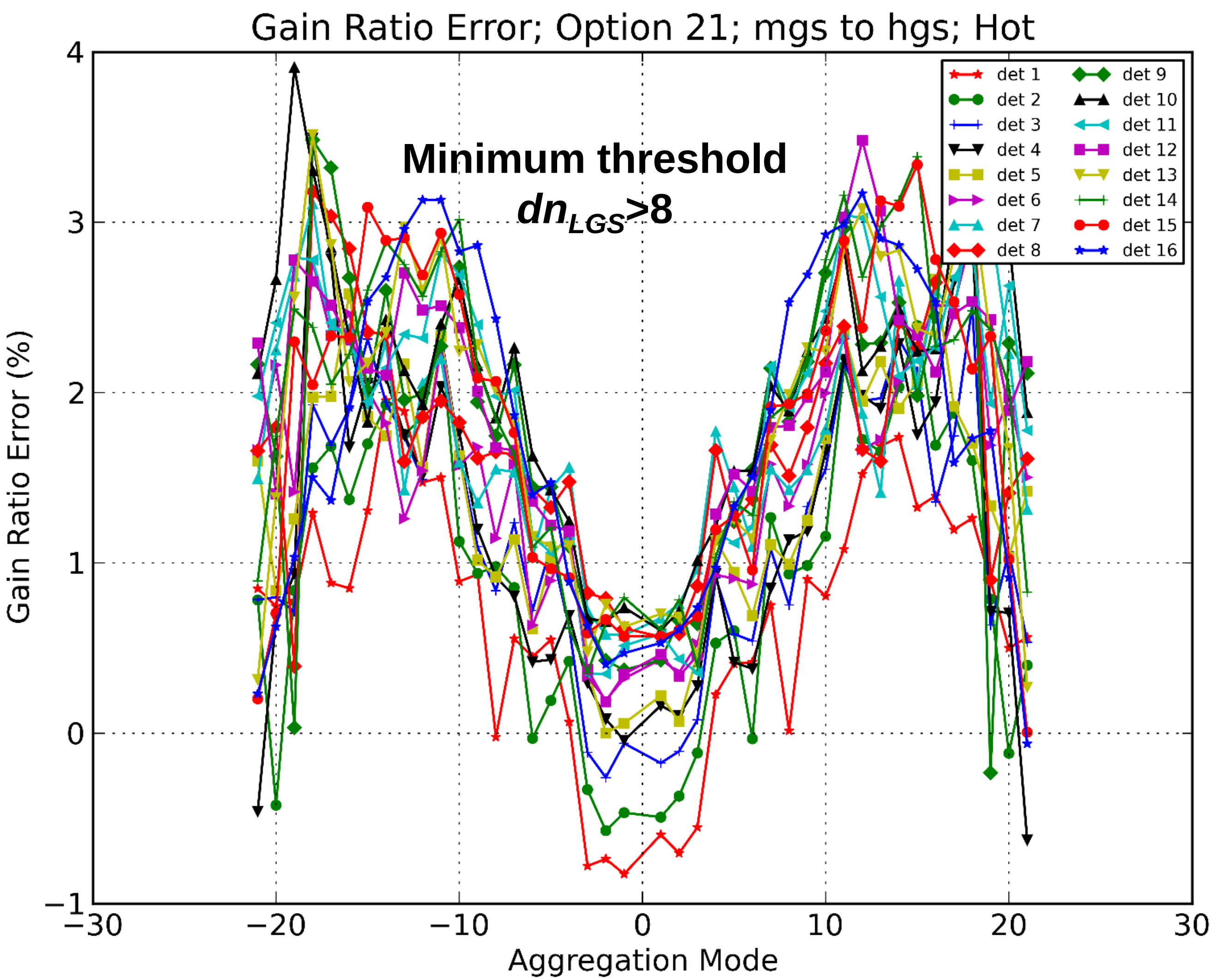
Example of MGS Nonlinearity



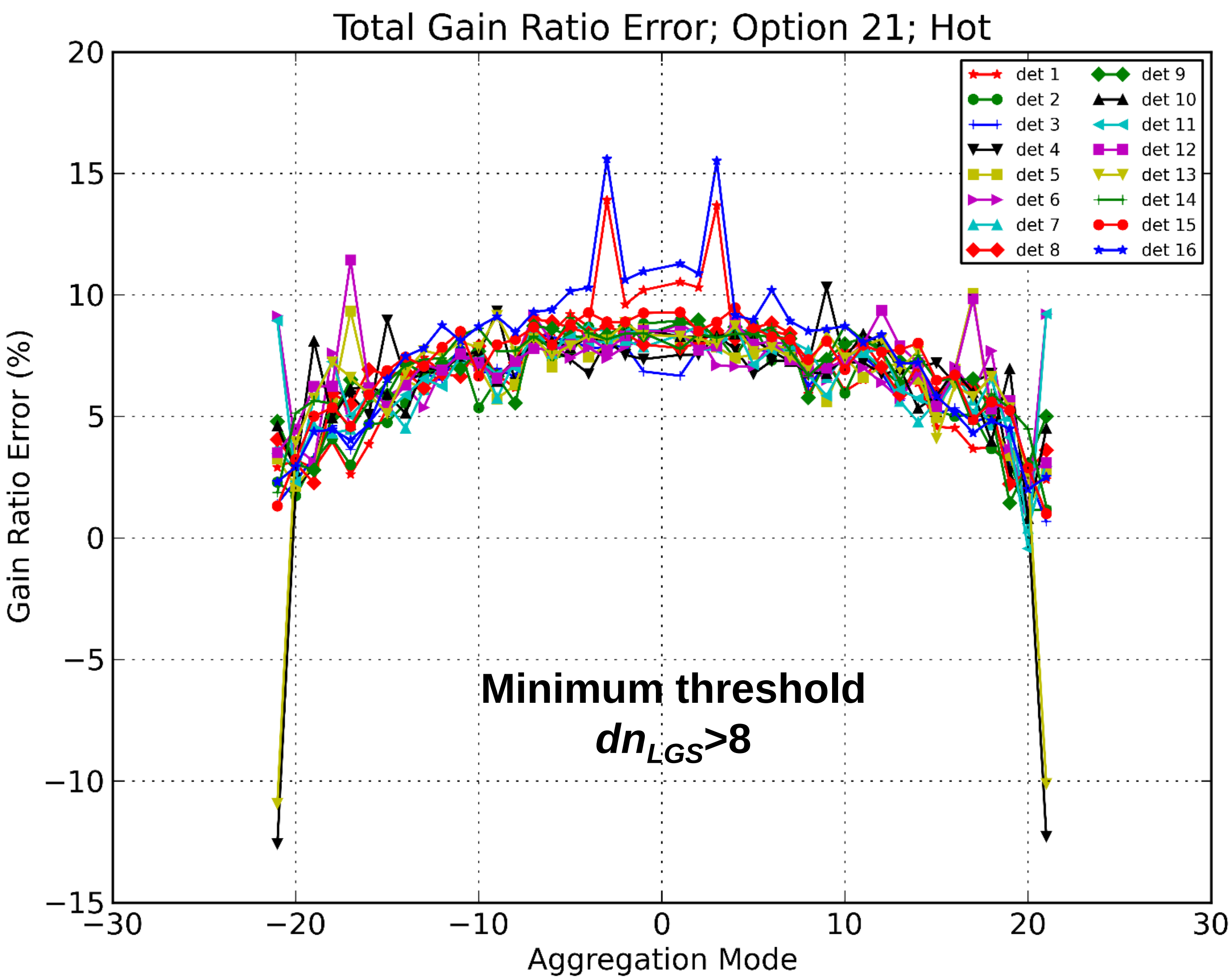
LGS-to-MGS Gain Ratio Errors



MGS-to-HGS Gain Ratio Errors



LGS-to-HGS Total Gain Ratio Errors



Observations

- Most gain errors are positive, which will cause a negative bias in radiances of MGS and HGS
  - Bias is averages about 8% at nadir
  - Bias decreases to about 2% near edge of scan
  - This is due to higher detector gain in LGS for radiance < 1×10^{-4} W cm^{-2} str^{-1}
- For AggMds 1 to 20
  - AggMd 3 is a bad actor with det. 1 & 16 having gain errors 8% to 10% higher than other detectors
  - AggMds 9, 15 & 17 have one detector with about 5% out-of-family gain error
- AggMd 21 has 4 detectors that are bad actors in the LGS-to-MGS gain ratio
  - Det. 5 & 13 have gain errors that are 20% less than most of the others
  - Det. 11 & 12 have gain errors that are 5% > than most of the others

Conclusions & Recommendations

- With the current linear cross-calibration process, **all twilight and nighttime scenes** will have serious striping **regardless of the option chosen**, and impacts 34% of the swath in Option 21
- Striping magnitude exceeds the uniformity requirement in:
  - AggMd 21 for MGS & HGS over entire dynamic range with a total spread of 26%
  - AggMd 3 for MGS & HGS over entire dynamic range with a total spread of 8%
- For HGS & MGS there is a bias of up to 8% that peaks at nadir
- These errors are not related to and will **not be mitigated** with a dual range calibration change
- **Recommendation:** Change the current the cross-calibration process to use characterization of DNB nonlinearities from RC2-Part 4.

Part 3—Simulations of Nighttime Imagery with Calibration Errors

Simulation Methodology

- 7 S-NPP night time scenes are used from 3 dates
- Destriping algorithm is applied to produce a pristine reference scene
  - Destriping algorithm is described in S. Mills & S. Miller, "VIIRS Day-Night Band (DNB) calibration methods for improved uniformity," SPIE 9218-7, 2014
  - Very low-level uncorrected striping remains in these "pristine scenes"
- Residual errors (shown in part 1)are computed for each radiance level and saved as a table
  - Calibration coefficients are derived from radiometric Tvac test data
  - 2^{nd} order fit for calibration coefficients, per detector, per Agg. Mode
  - Fit constrained to zero at zero *dn*
  - Radiances from SDR are used to linearly interpolate residual error
  - Residuals errors are added to radiance
- LGS-to-HGS total gain ratio error are computed as described in Part 2 of this presentation
  - RC2-Part4 test data from the hot plateau is used
  - Errors are saved in a table by detector and aggregation mode
  - Each pixel's radiance is multiplied by a gain ratio error factor

7 Test Scenes

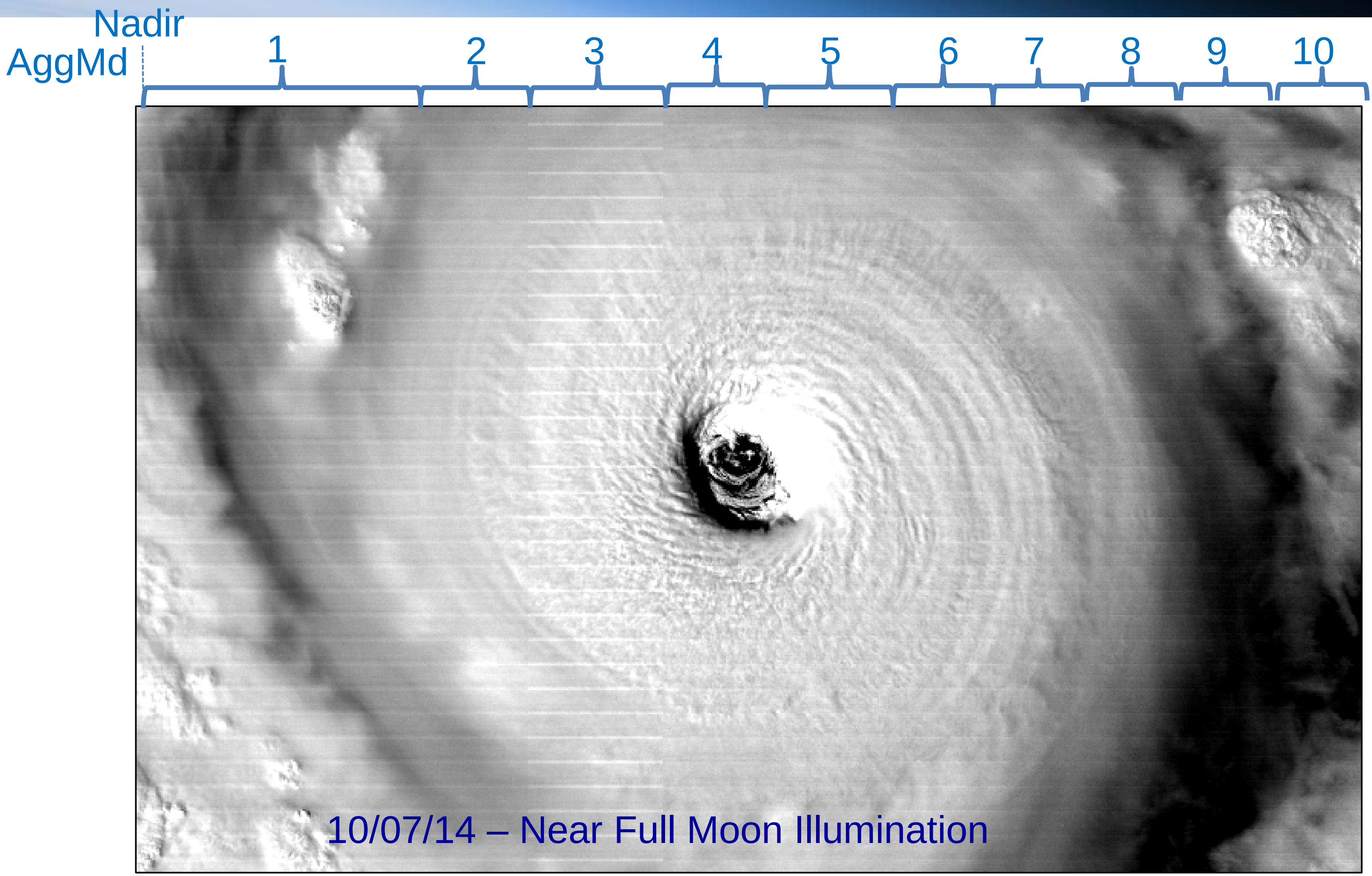
All scenes shown are 375 km in-track by 600 km in-scan:

1. 10/07/14 (Lunar phase nearly full), Typhoon Vongfong
2. 09/09/14 (Lunar phase nearly full), Parts of Sudan & Red Sea
3. 09/09/14, (Lunar phase nearly full), Parts of Alaska, Yukon & Arctic Ocean
4. 09/16/14, (Lunar phase—last quarter), Clouds over Seward Peninsula, Alaska
5. 09/16/14, (Lunar phase—last quarter), Northern Libya and Mediterranean Sea
6. 09/16/14, (Lunar phase—last quarter), Southern Egypt
7. 09/09/14 (Lunar phase nearly full), Parts of Arabian Peninsula & Persian Gulf

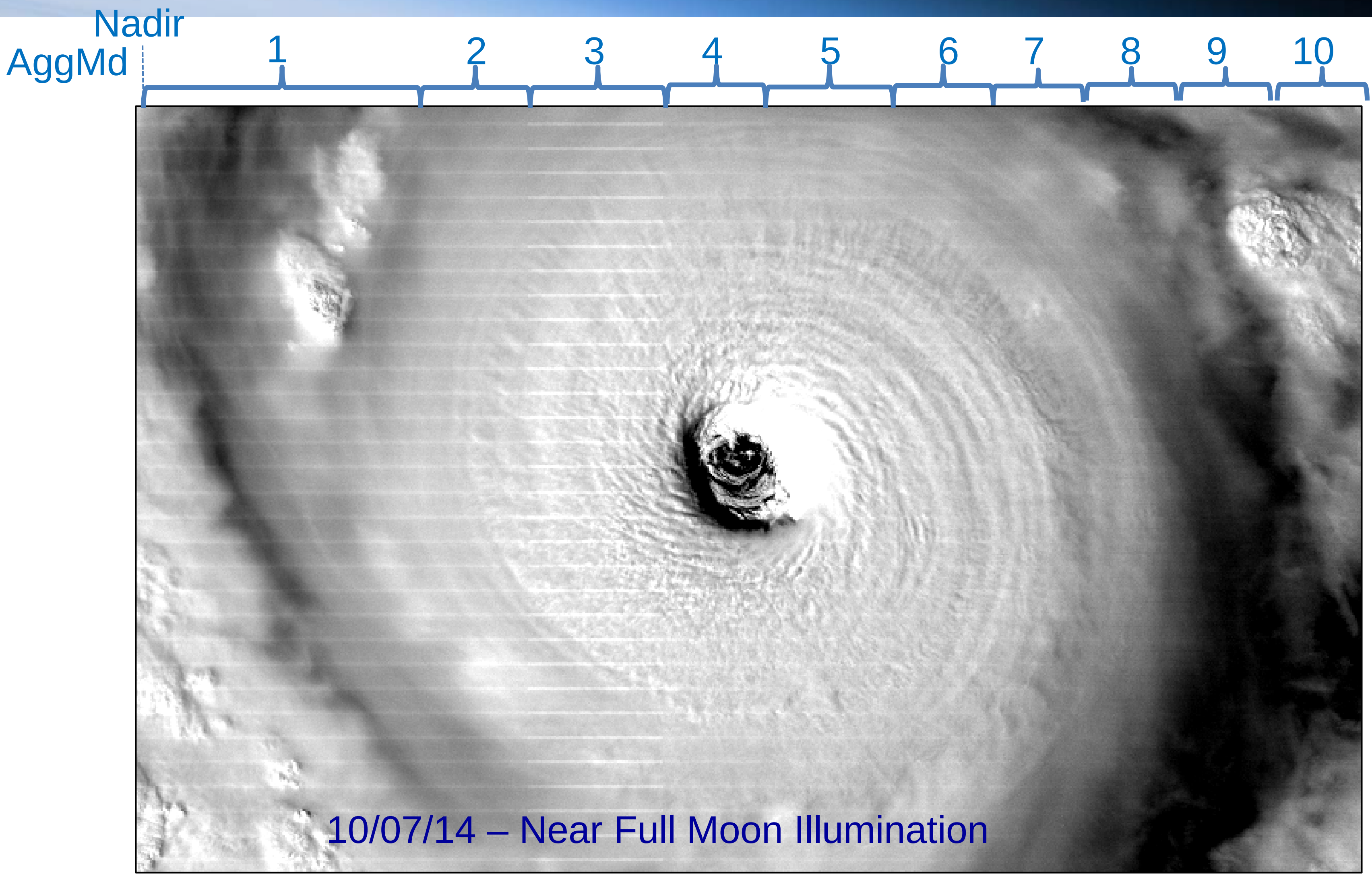
Vongfong, Pristine (destriped) Image

Radiance range grayscale: black=12; white=30 nW cm^{-2} str^{-1}

Vongfong, Simulated JPSS-1

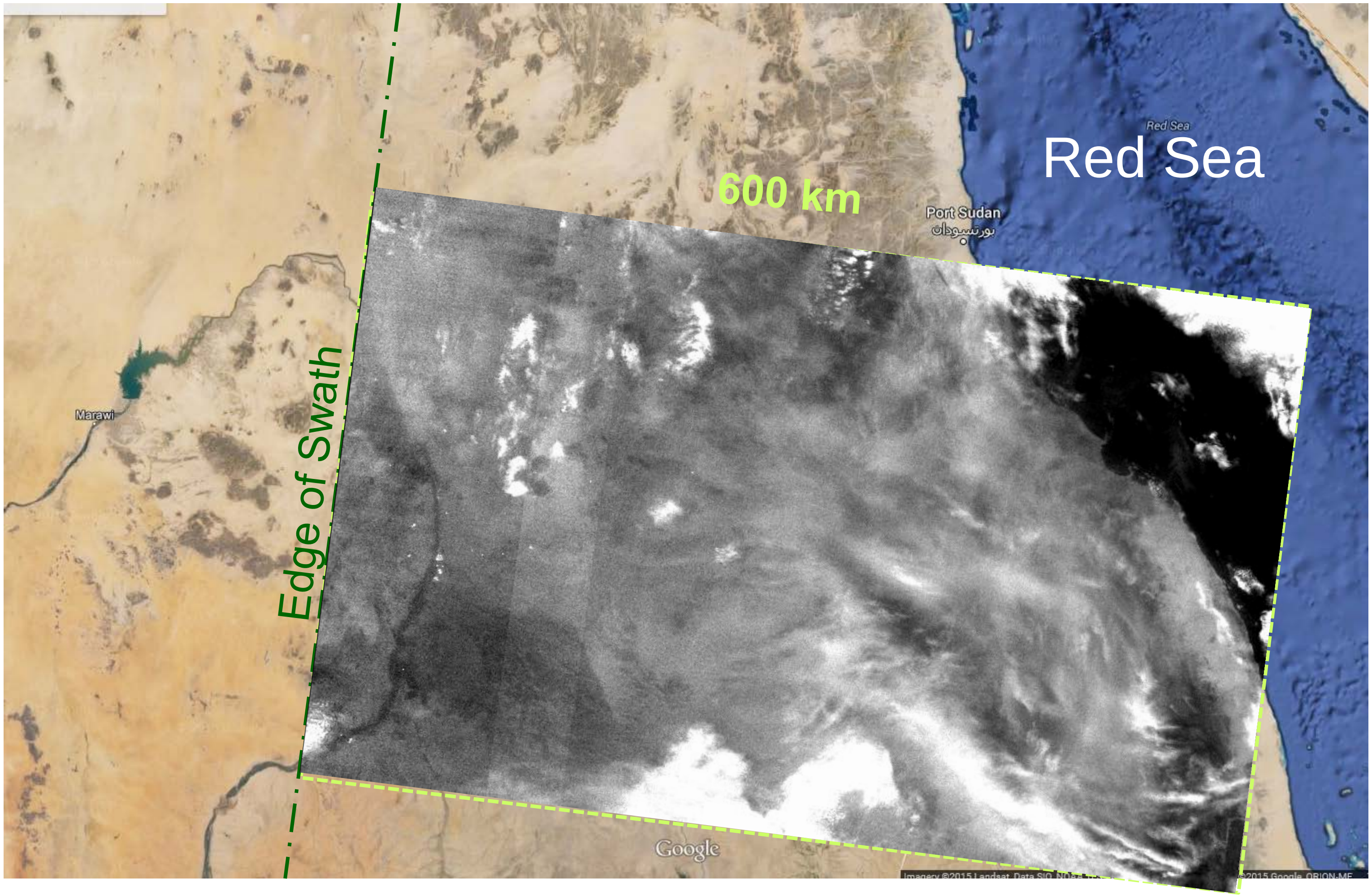


Vongfong, Actual S-NPP Image

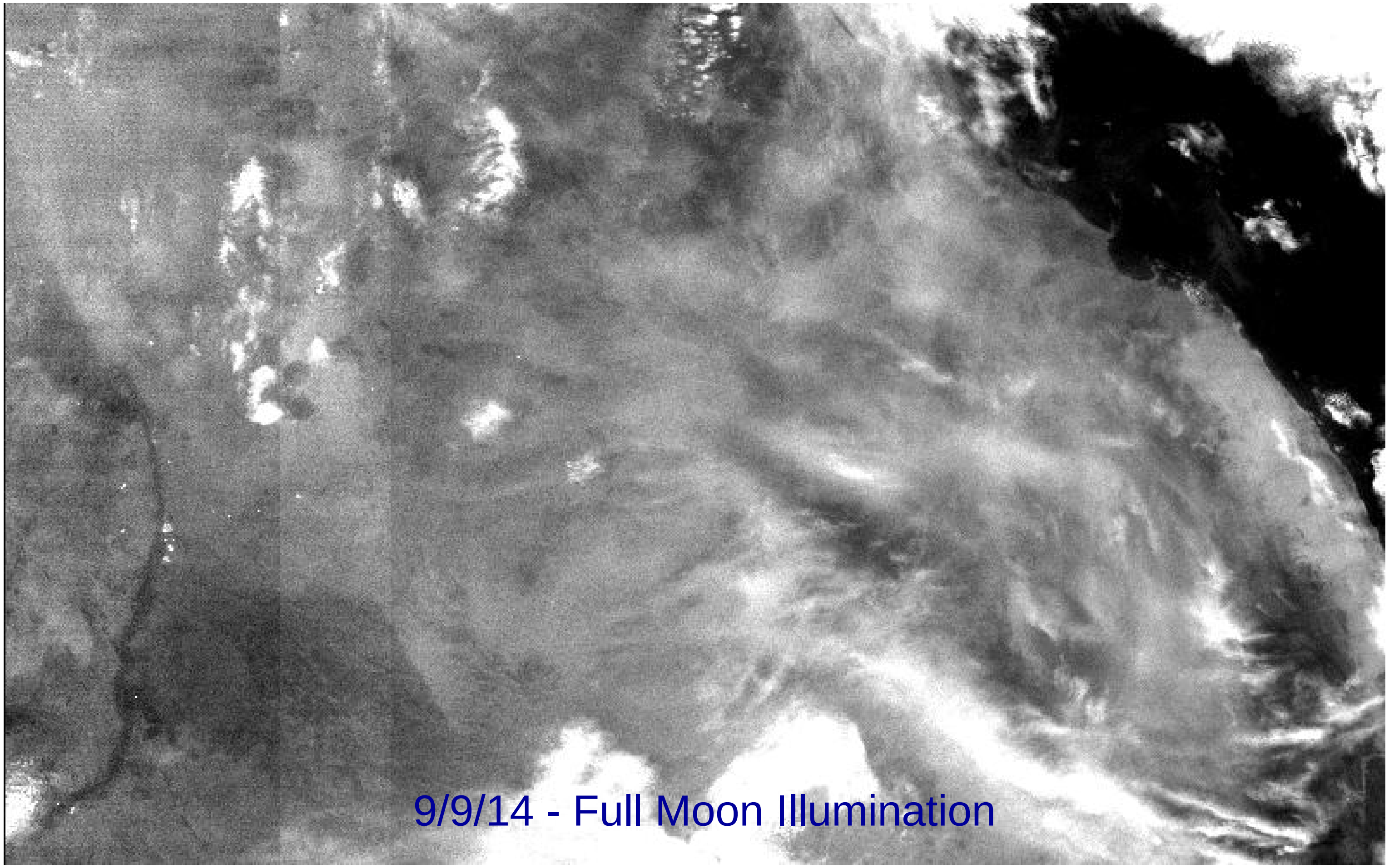


Scene 2, Sudan & Red Sea

Scene 2, Sudan & Red Sea

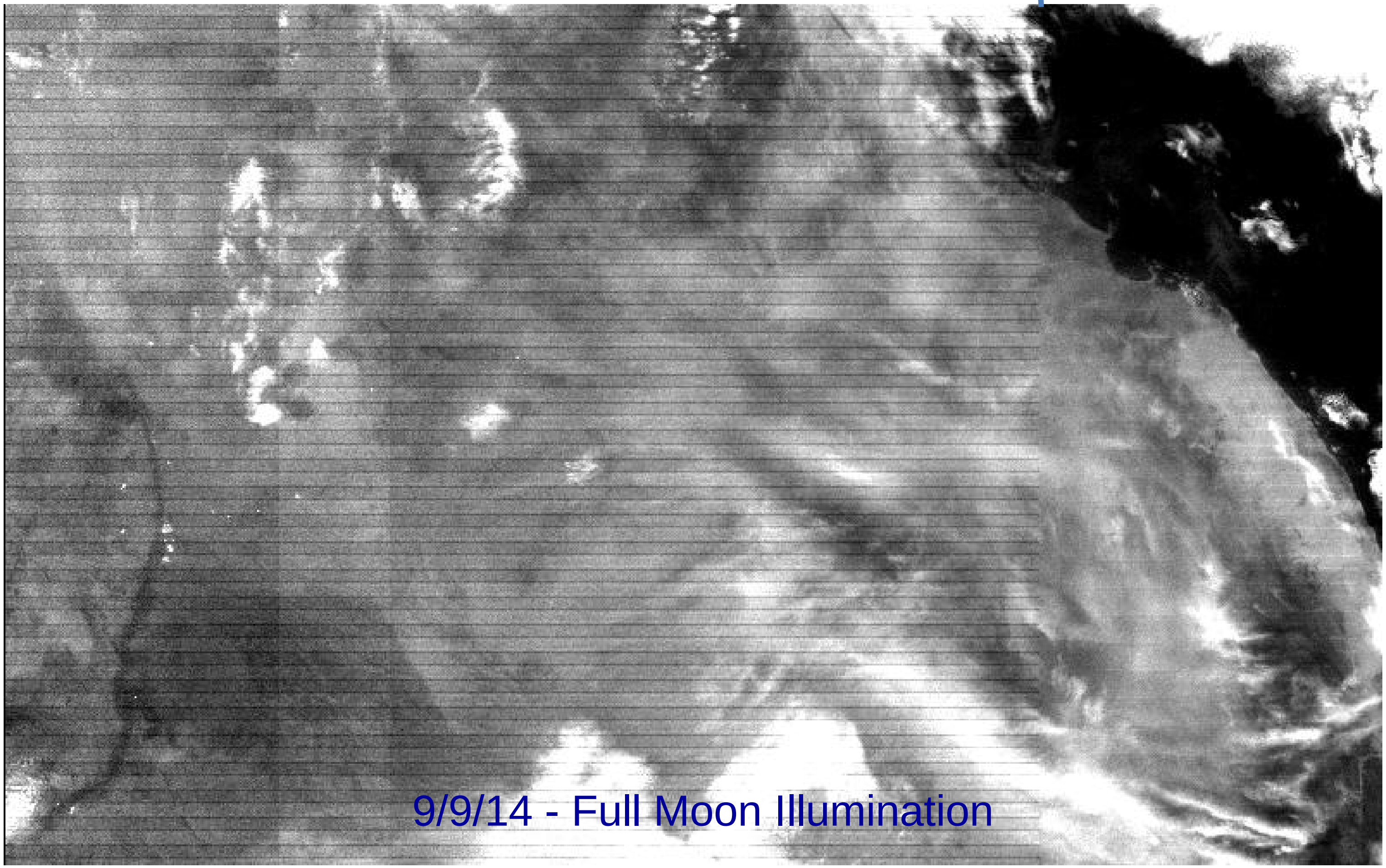


Pristine (destriped) Image

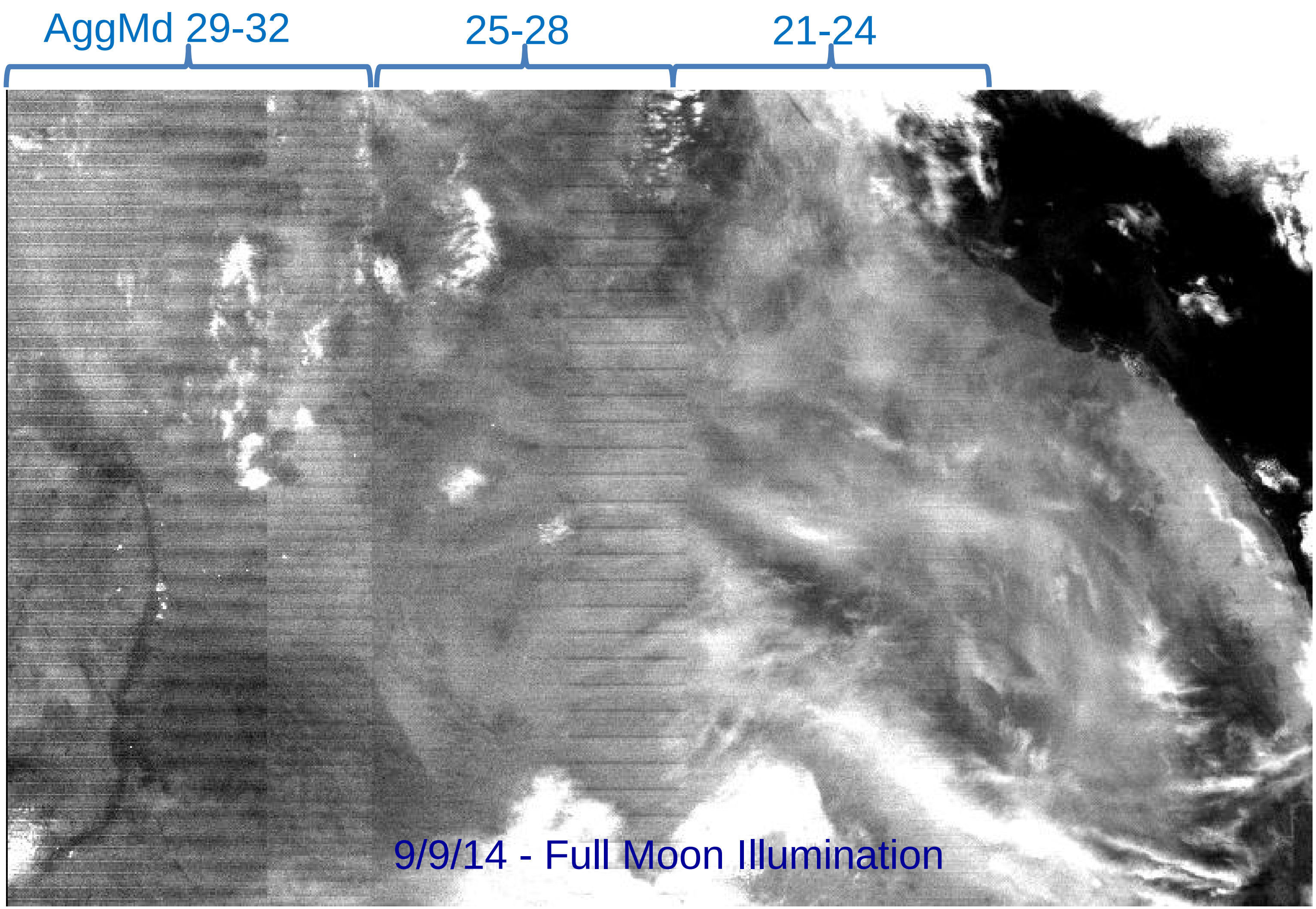


Simulated JPSS-1, Option 21

AggMd 21

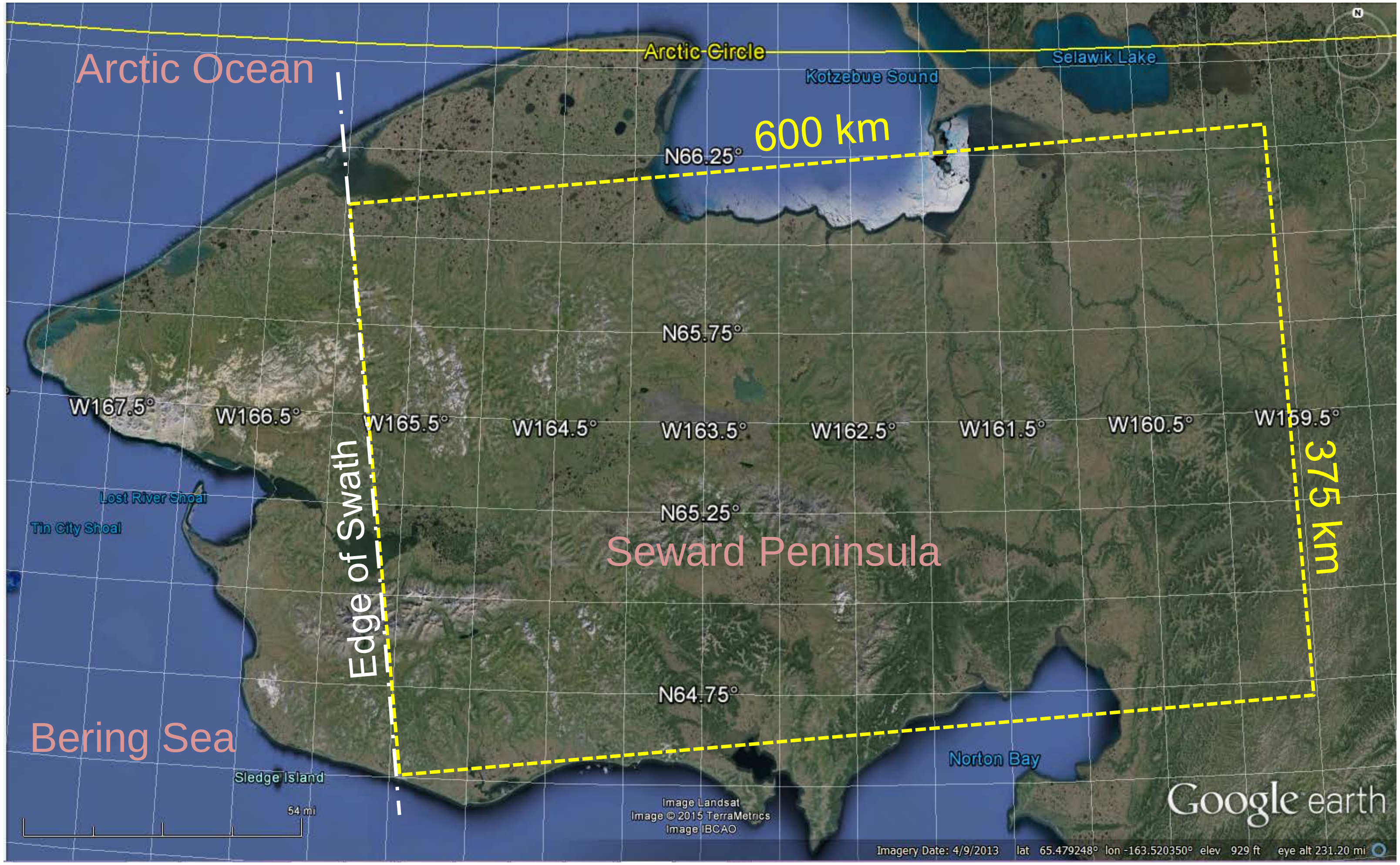


S-NPP Image with Striping

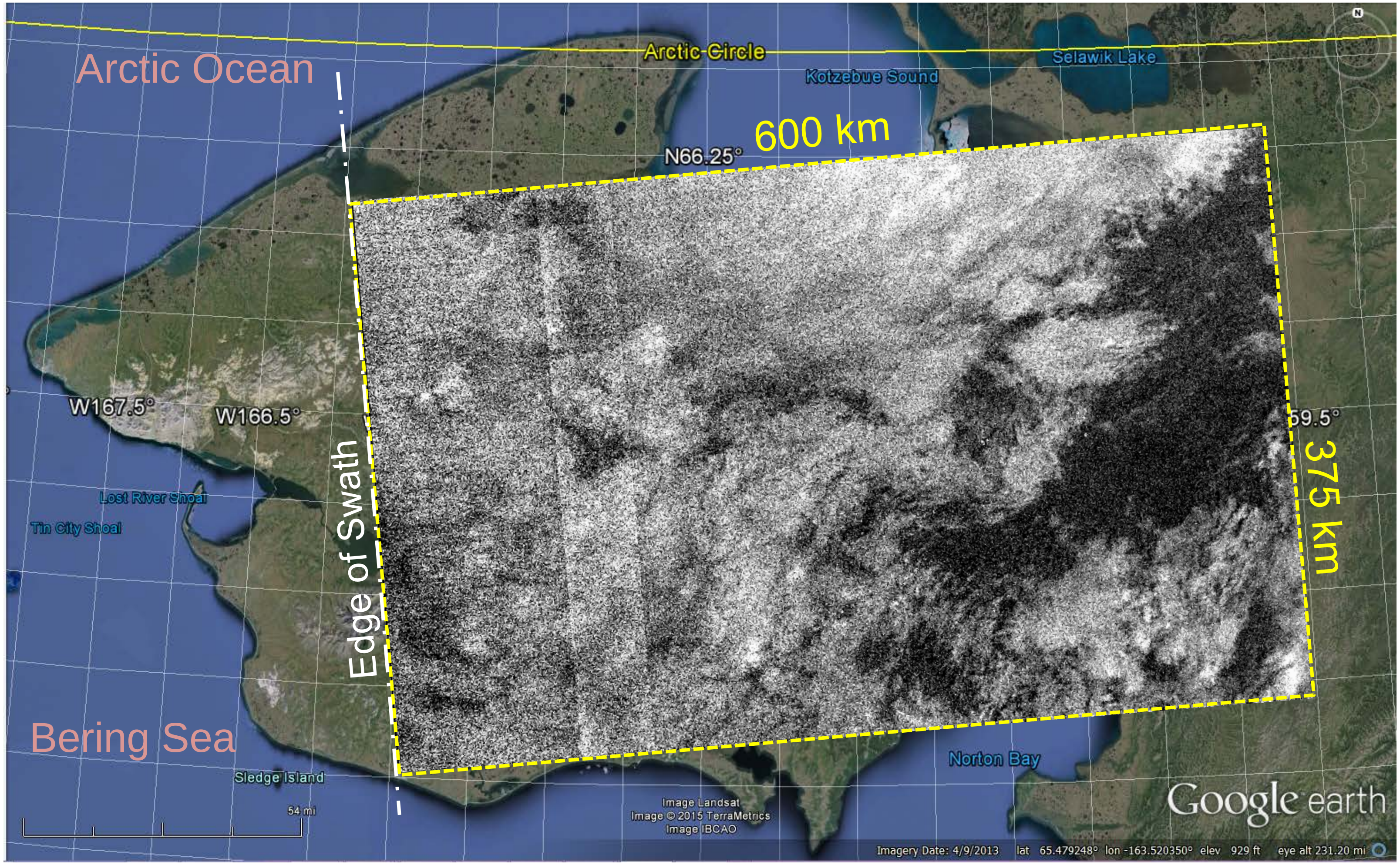


S-NPP has less striping near edge of scan than JPSS-1

Scene 4-Last Quarter, 9/16/14 Clouds over Seward Peninsula, Alaska

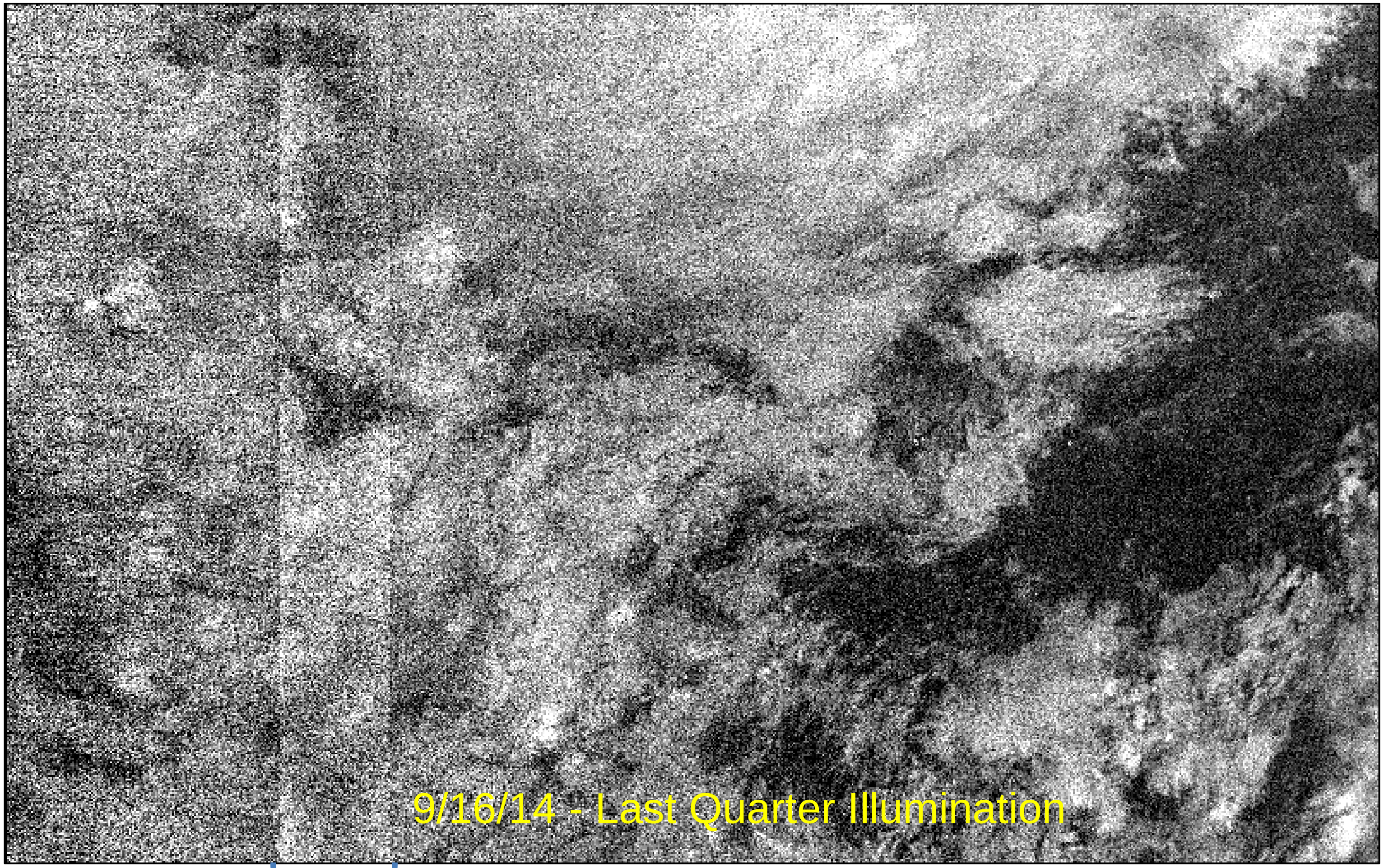


Scene 4-Last Quarter, 9/16/14
Clouds over Seward Peninsula, Alaska



Pristine (Destripped) Image

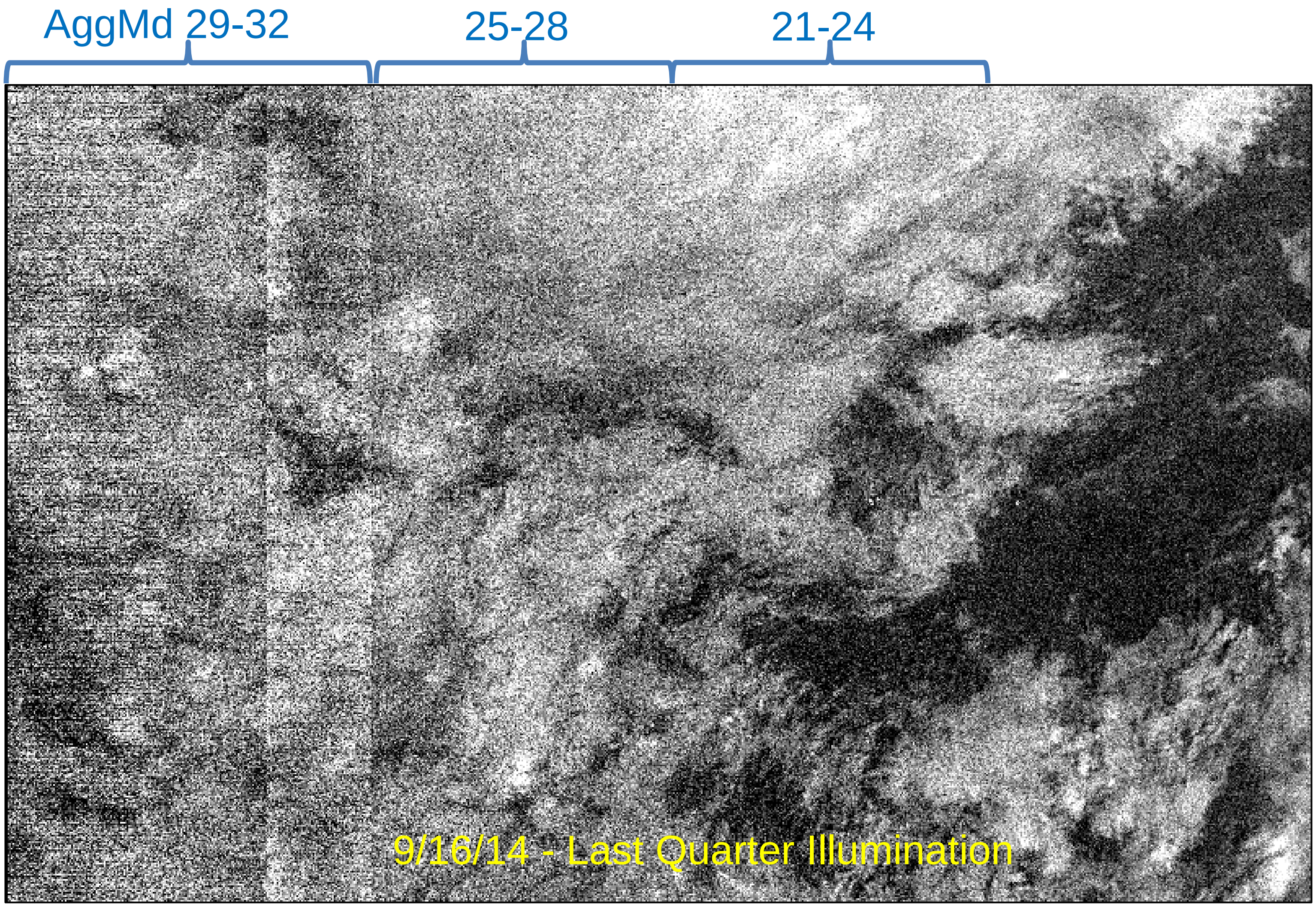
Radiance range grayscale: black=0.0; white=1.2 nW cm^{-2} str^{-1}



Simulated JPSS-1, Option 21

AggMd 21

S-NPP Image with Striping



S-NPP has less striping near edge of scan than either JPSS-1 Option

Conclusions

- JPSS-1, even with Option 21, will have strong striping near edge-of-scan
  - It affects **30% of swath area**
  - This striping is much stronger than is seen in the same region for S-NPP
  - If this striping is not corrected it would represent a degradation of the imagery product relative to S-NPP expectations
- For JPSS-1 VIIRS the striping near nadir is very visible
  - Affects another **17% of swath area**
  - The magnitude of the near-nadir striping is similar to S-NPP
  - The S-NPP striping may be caused by these same nonlinearity errors in the cross-calibration
- In total, gain-ratio error causes striping in **47% of swath area**

Nonlinearity affects all 3 gain stages and for best results the cross-calibration should take this into account

Recommendations

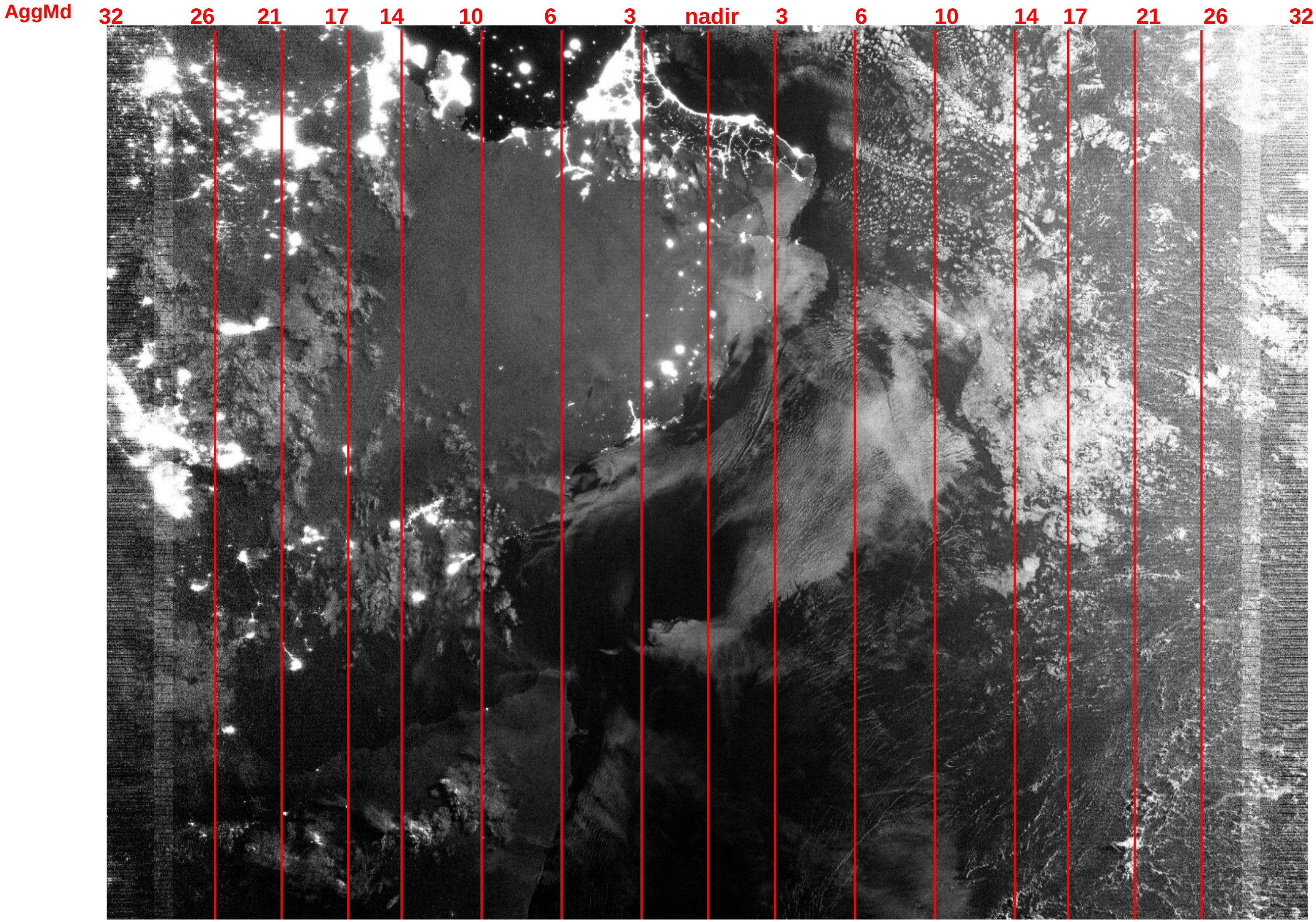
Almost all this striping could be eliminated with these calibration algorithm modifications:

1. Highest Priority - Modify gain-stage cross-calibration process (VROP 705) to include nonlinearity characterization
   - Will eliminate striping in nadir region for all options for 17% of swath
   - For Option 21 will eliminate almost all striping for 30% of swath at the edge
   - For Option 26 will eliminate almost all striping for 13% of swath at the edge
2. Modify the IDPS DNB SDR calibration algorithm to allow using a two-part quadratic fit for response correction
   - Combined with gain-stage cross calibration will eliminate almost all remaining striping
   - LGS twilight scenes: Will eliminate almost all striping for both Options 21 & 21/26
   - Nighttime scenes: For Option 26 will eliminate almost all remaining striping for 17% of swath at the edges
   - Would require changes to IDPS DNB calibration algorithm
3. Use Option 21 unless or until Recommendation #2 can be implemented
   - Striping would not, however, be fixed in LGS twilight scenes

If nothing is done JPSS-1 imagery will be **worse** than S-NPP

Back-up charts

Aggregation Mode Locations

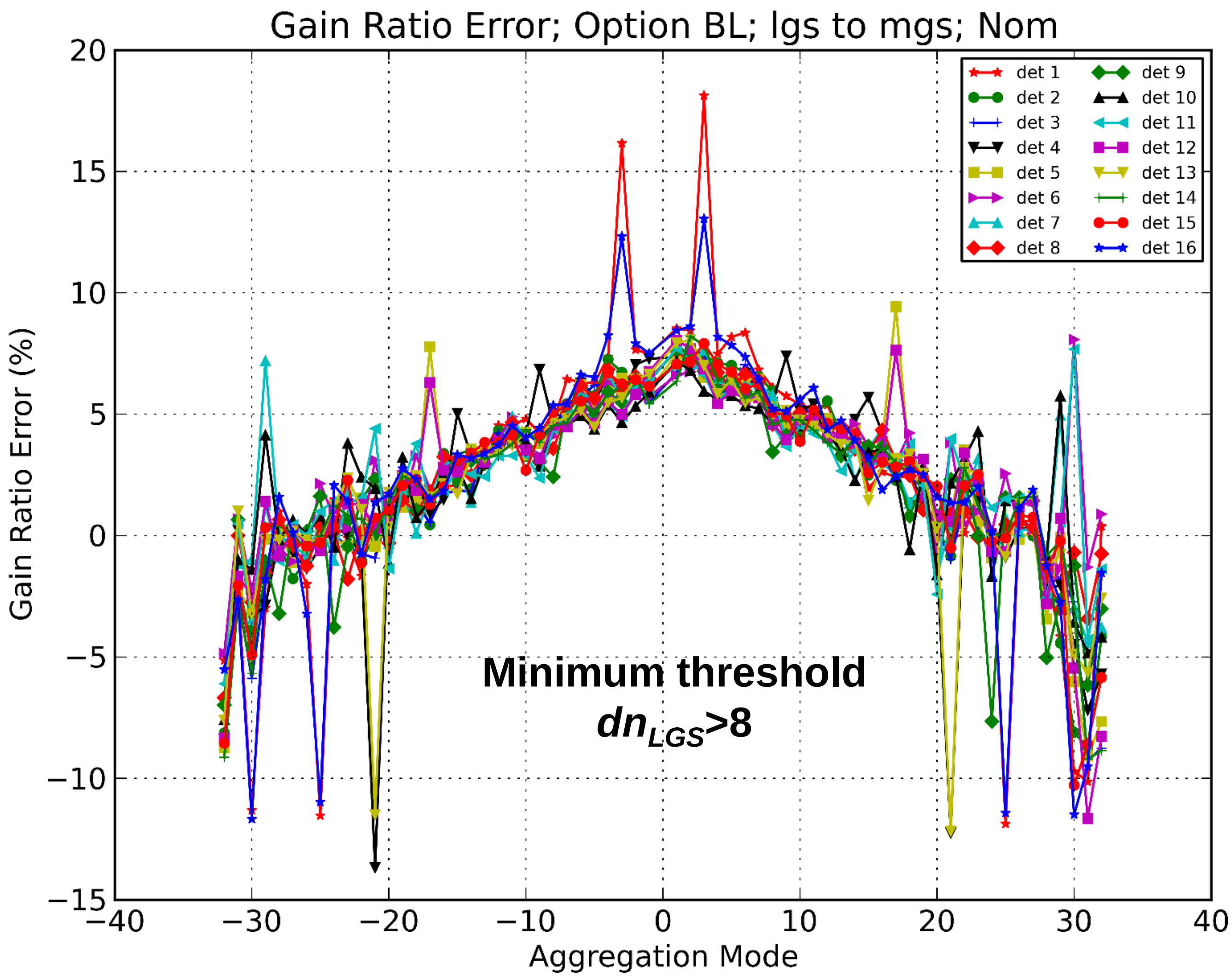


Computing cross-calibration Error

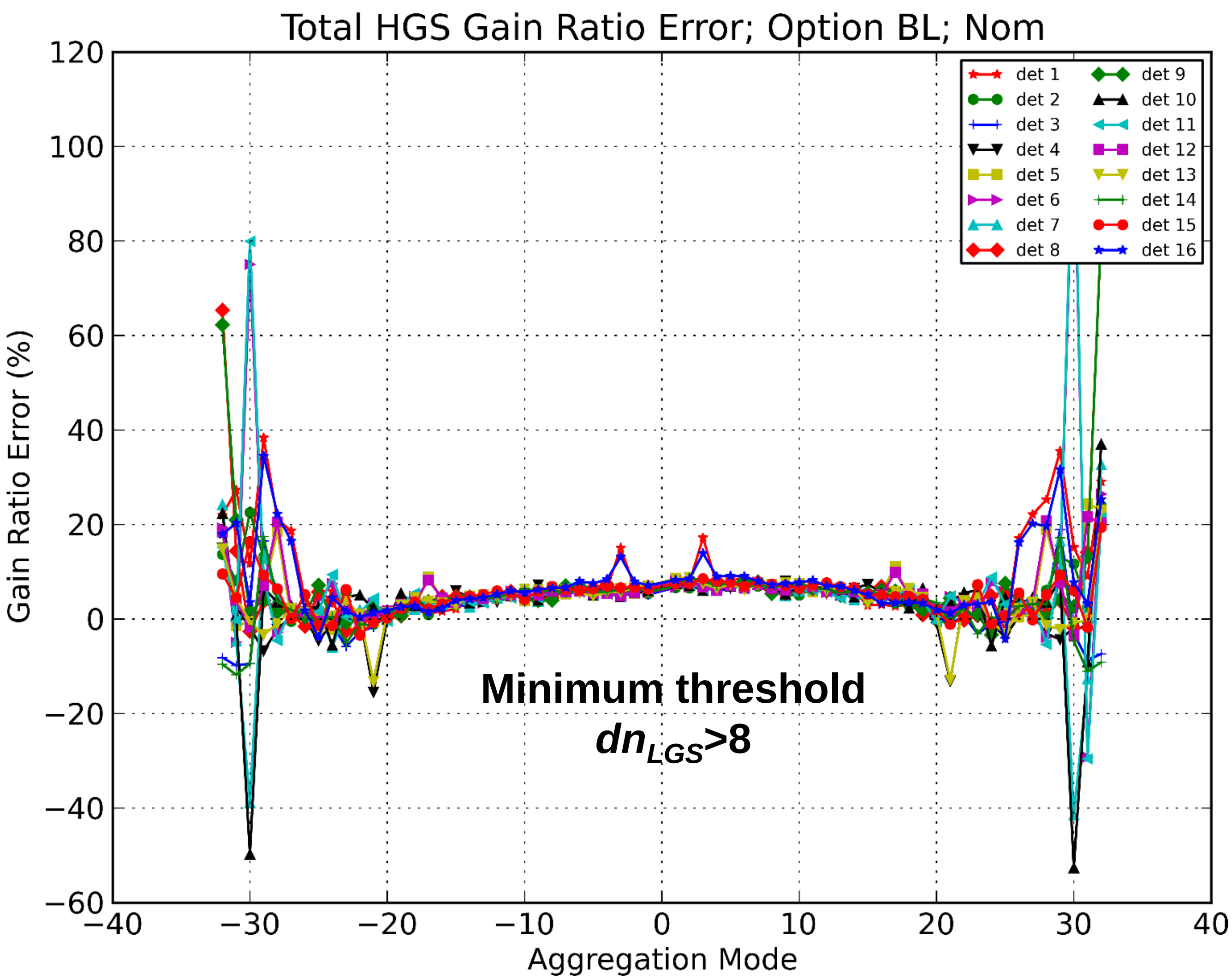
1. Determine response counts by subtracting the space view counts, so dn_{sig} = (DN_{sig}–DN_{SV})
   A. Compute for all lamp levels, detectors and samples in swath
   B. Do this for data for HGS, MGS and LGS
   C. Flag and filter out saturated data, and data close to zero counts
2. Separate samples into Aggregation Modes (aggMd)
3. Perform a zero-constrained linear fit
   A. Do for each aggMd, detector and gain stage
   B. Slope of fit is the gain, $L/dn=G_{agg,det,stg}$
4. Determine gain ratio from *dn* for for radiance cross-over range.
   A. Cross-over range is where higher gain stage is not saturated and lower gain stage is above a minimum threshold *dn.*
   B. Take the average for all radiance levels in the cross-over range, $R_{agg,det,stg1,stg2}$=mean($dn_{agg,det,stg1,lev}/dn_{agg,det,stg2,lev}$)
5. Determine the gain ratio error:

$$E_{agg,det,stg1,stg2}=R_{agg,det,stg1,stg2}\cdot G_{agg,det,stg1}/G_{agg,det,stg2} - 1$$

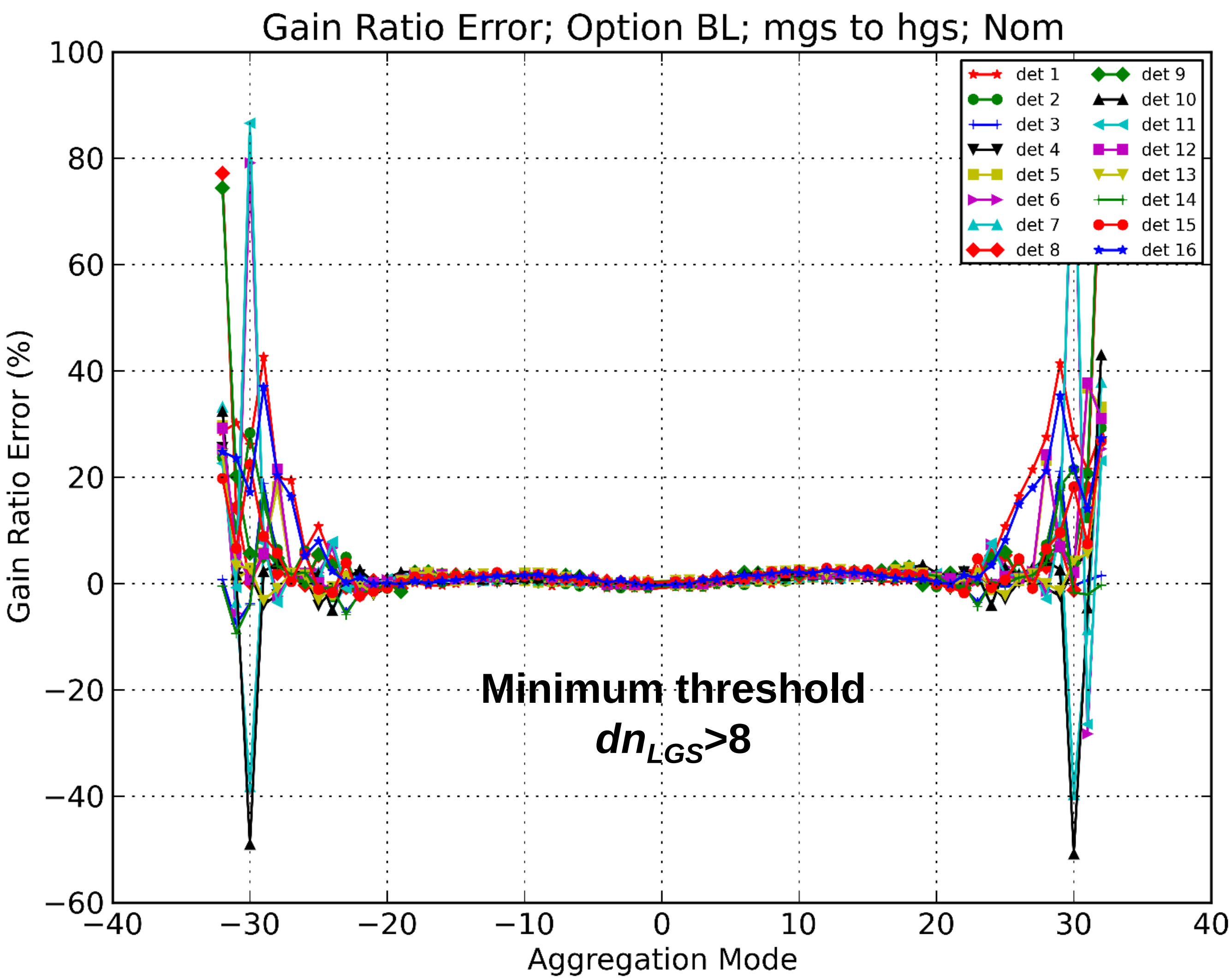
LGS-to-MGS Gain Ratio Errors for Baseline



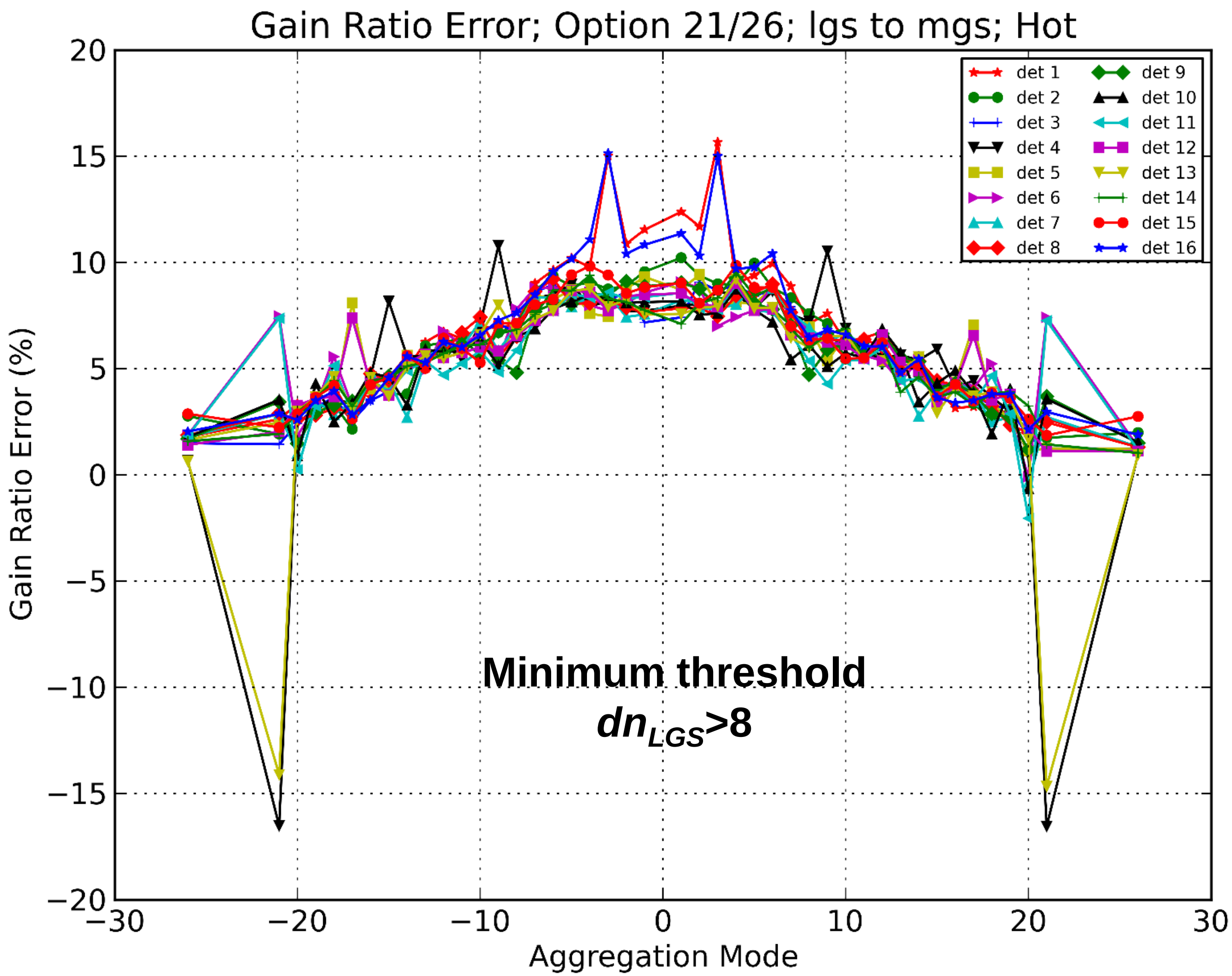
MGS-to-HGS Gain Ratio Errors for Baseline



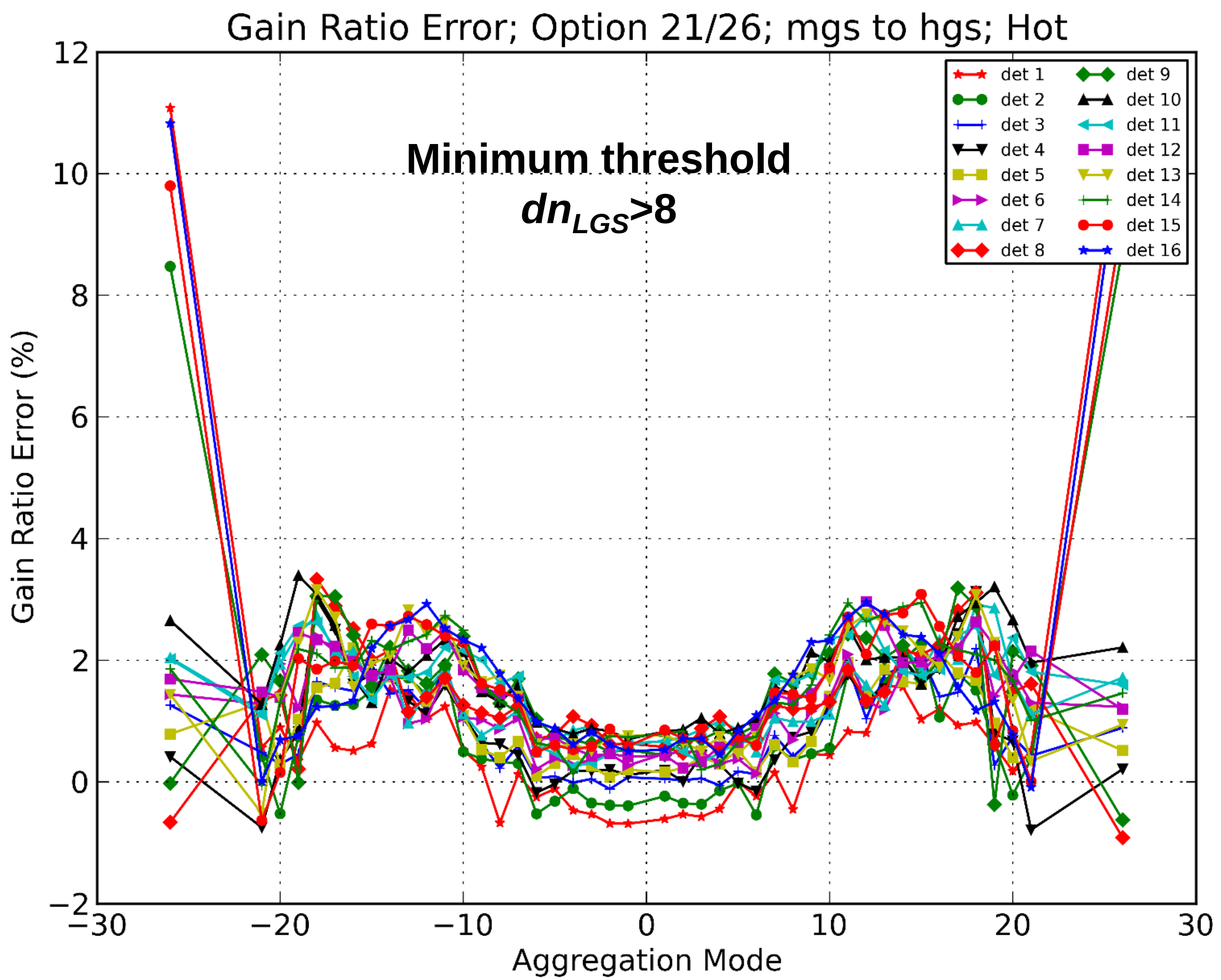
LGS-to-HGS Total Gain Ratio Errors for Baseline



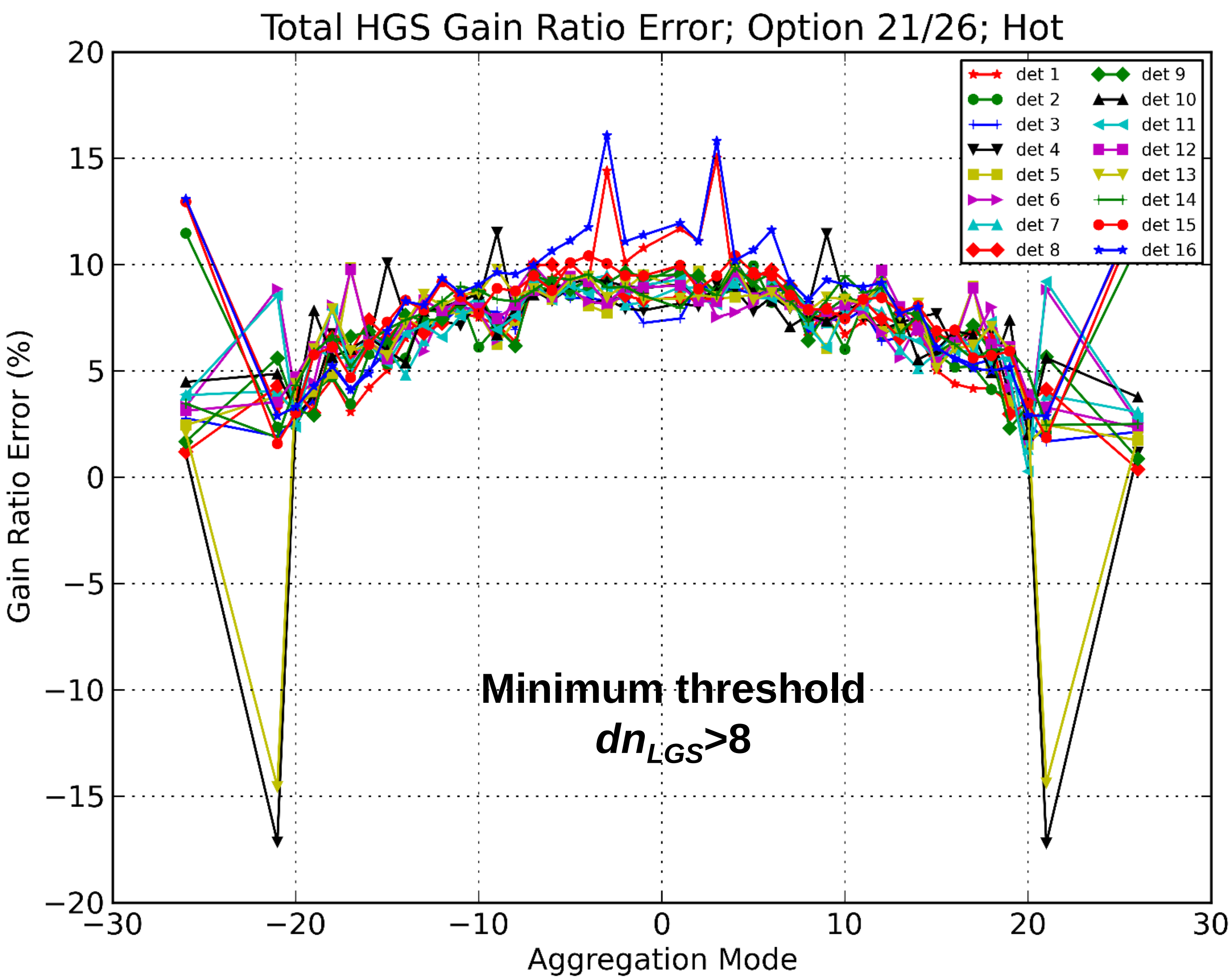
LGS-to-MGS Gain Ratio Errors for Option 26



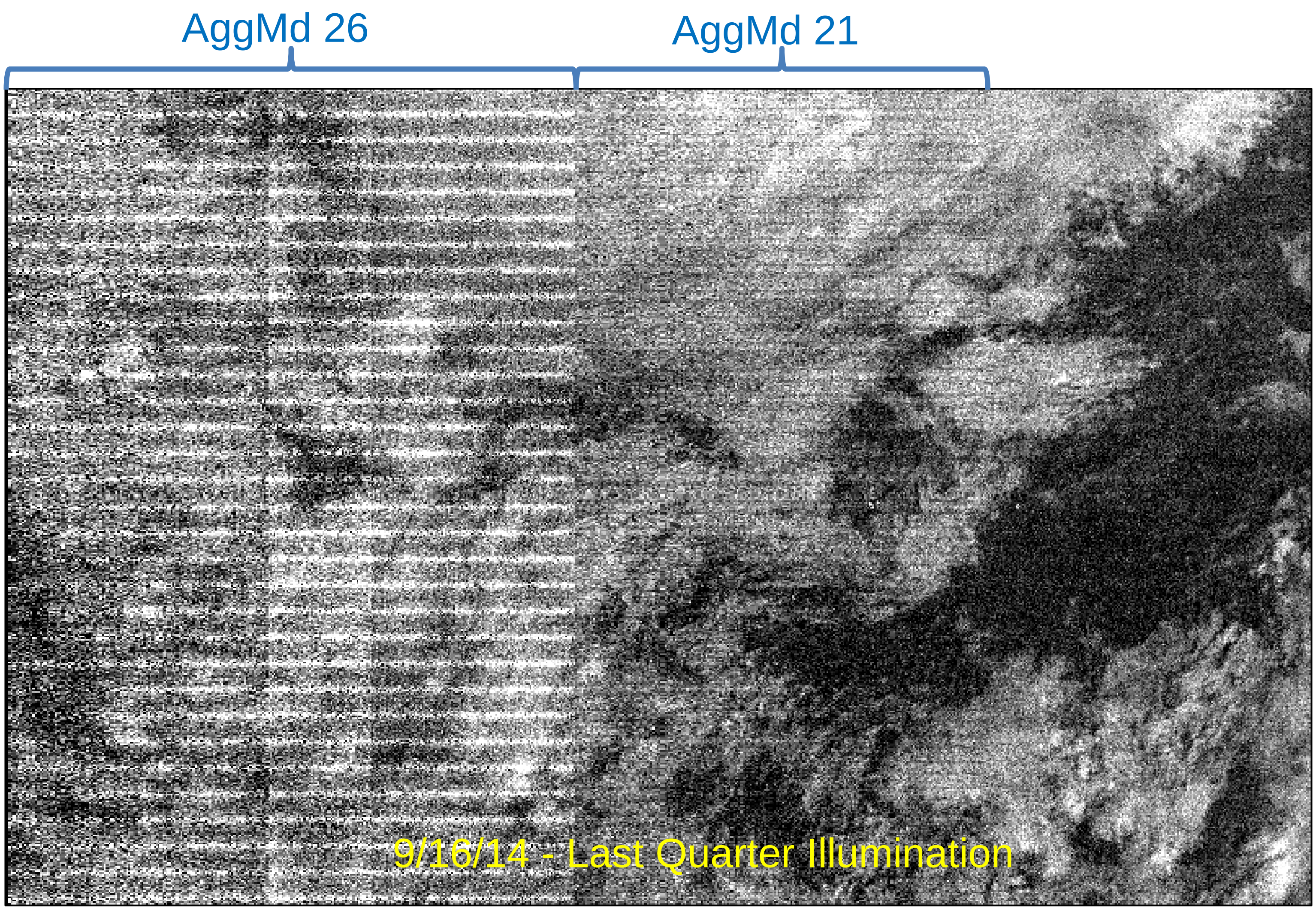
MGS-to-HGS Gain Ratio Errors for Option 26



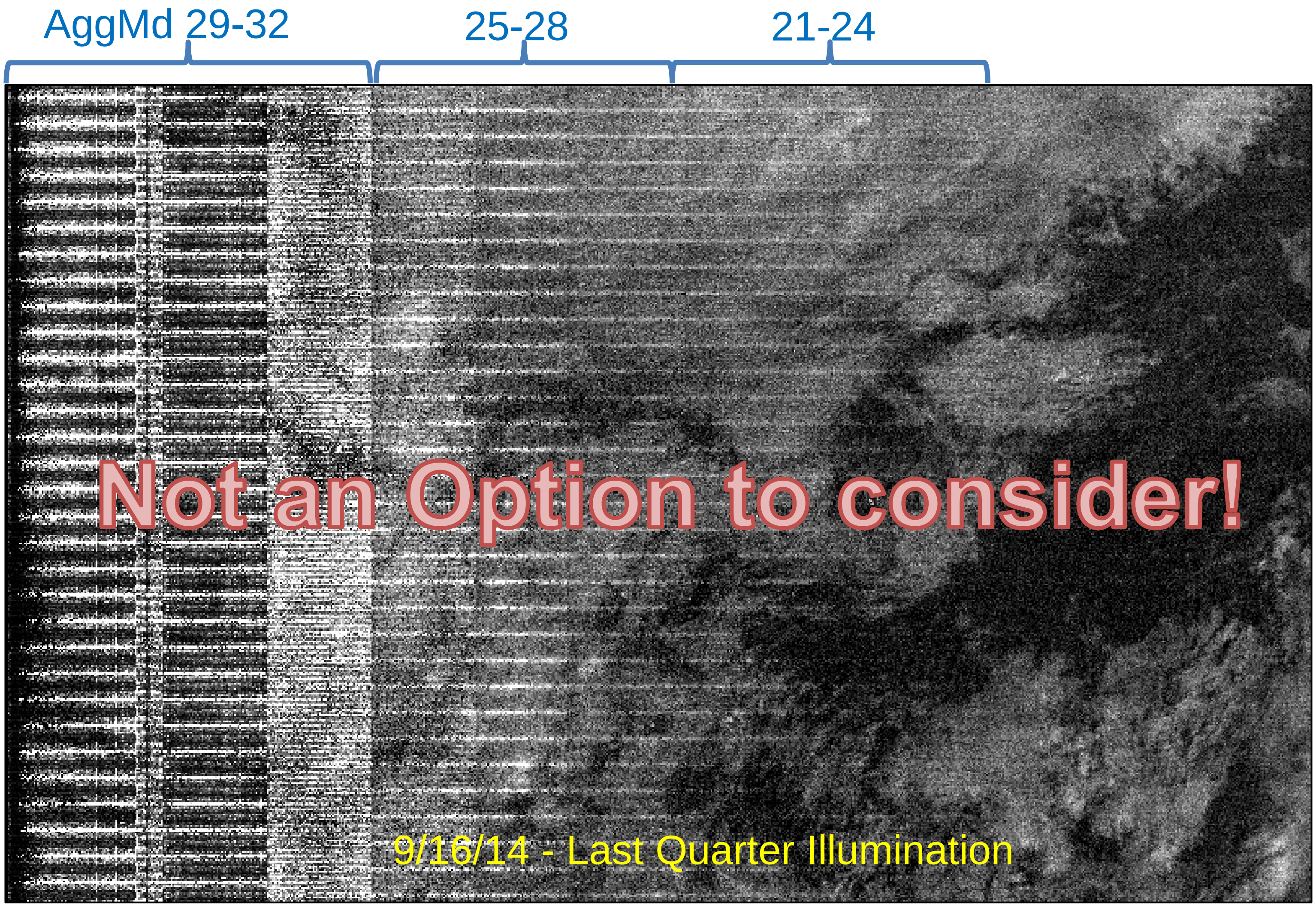
Total LGS-to-HGS Gain Ratio Errors for Option 26



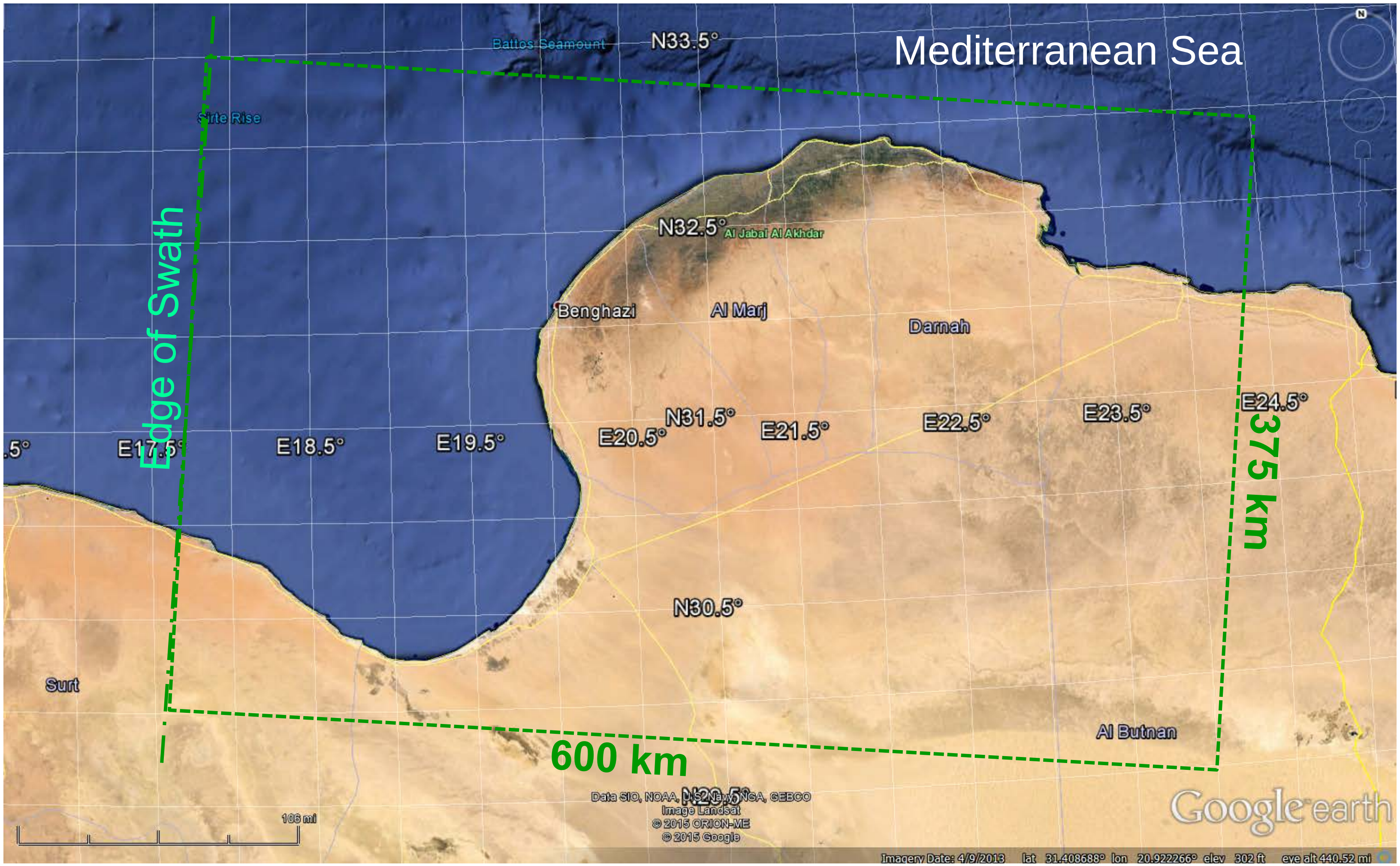
Simulated Option 26



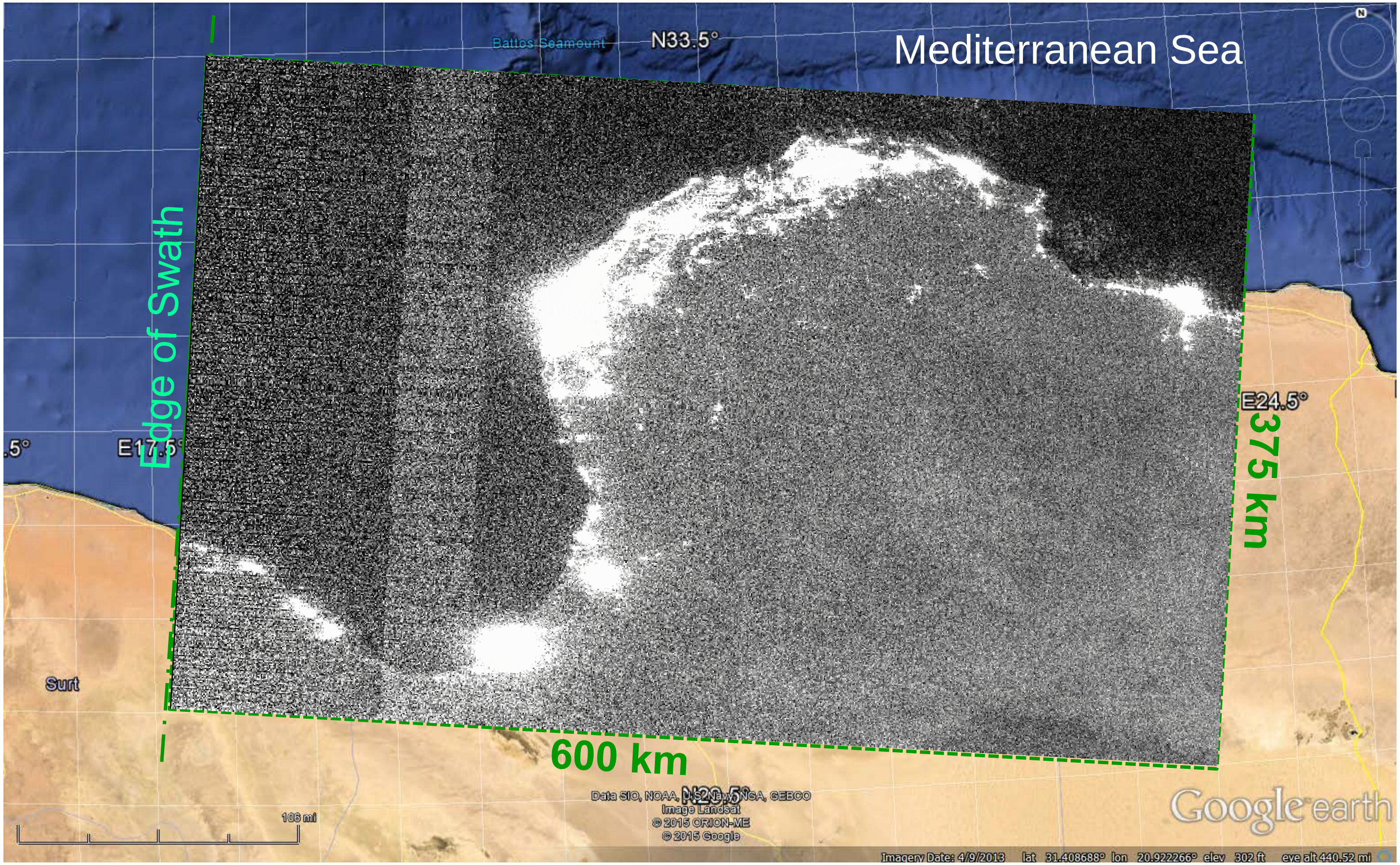
Simulated JPSS-1 Old Baseline



Scene 5-Last Quarter, 9/16/14
Libya & Mediterranean

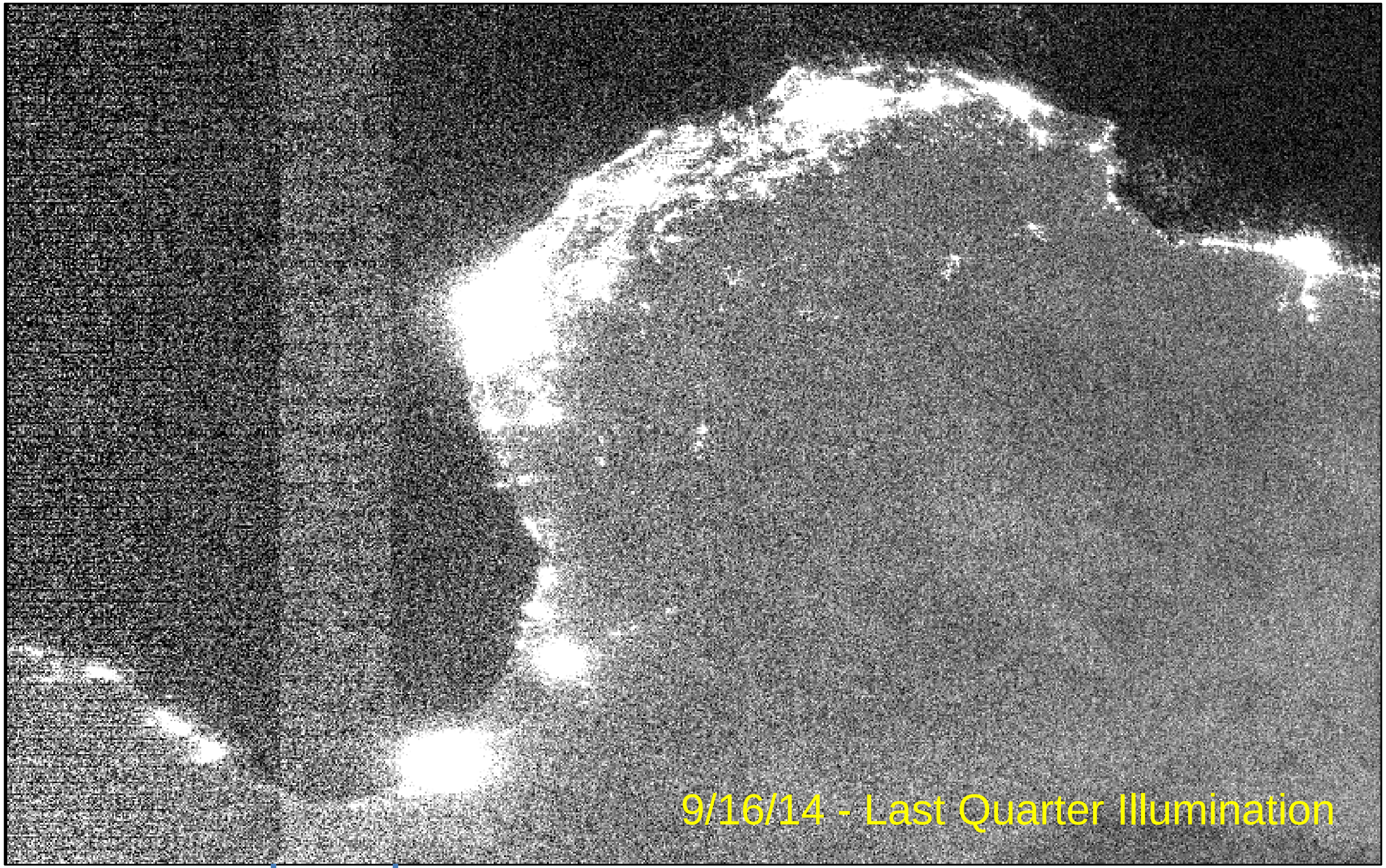


Scene 5-Last Quarter, 9/16/14
Libya & Mediterranean



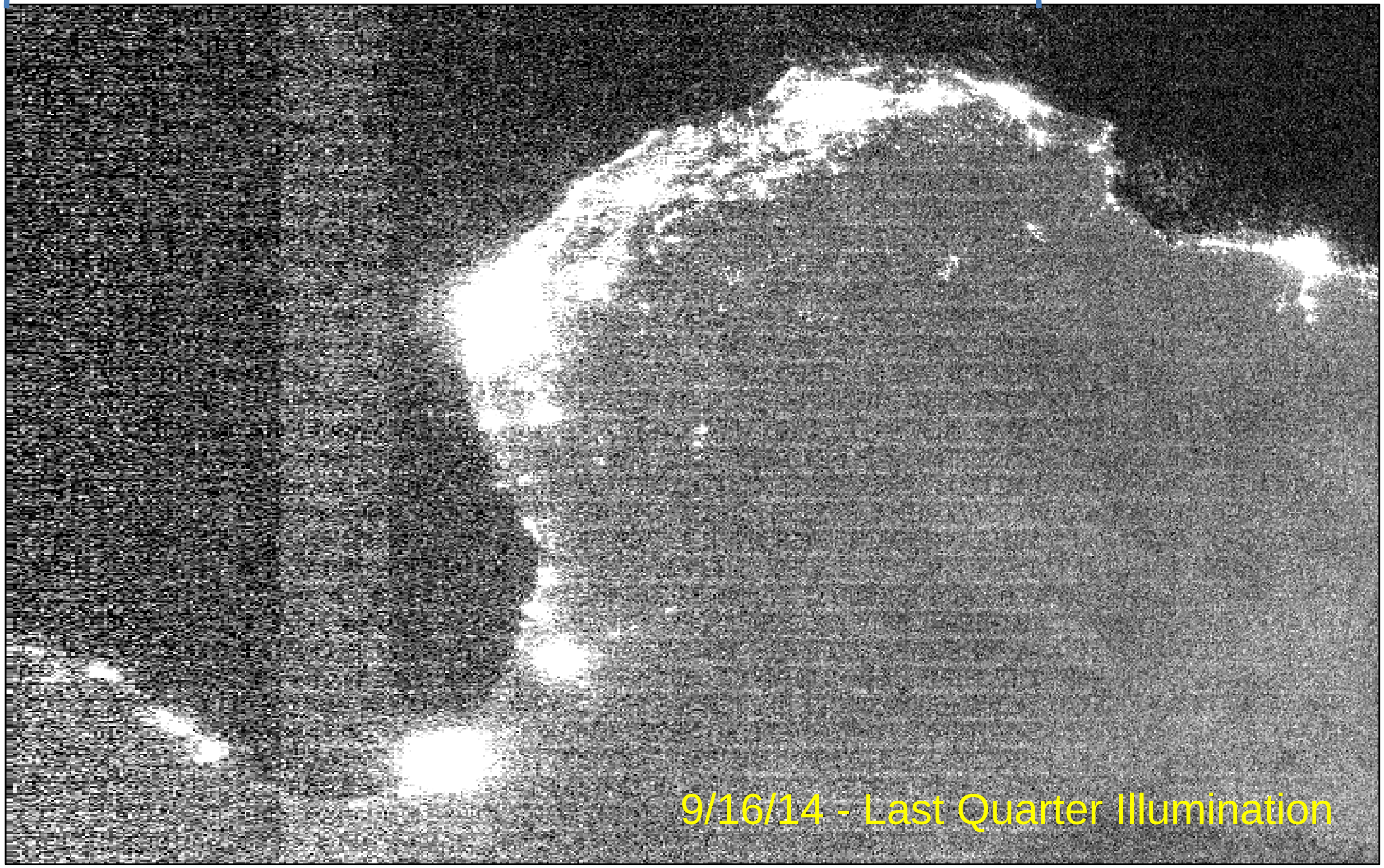
Pristine Edge-of-Swath Image

Radiance range grayscale: black=0.0; white=0.8 nW cm^{-2} str^{-1}

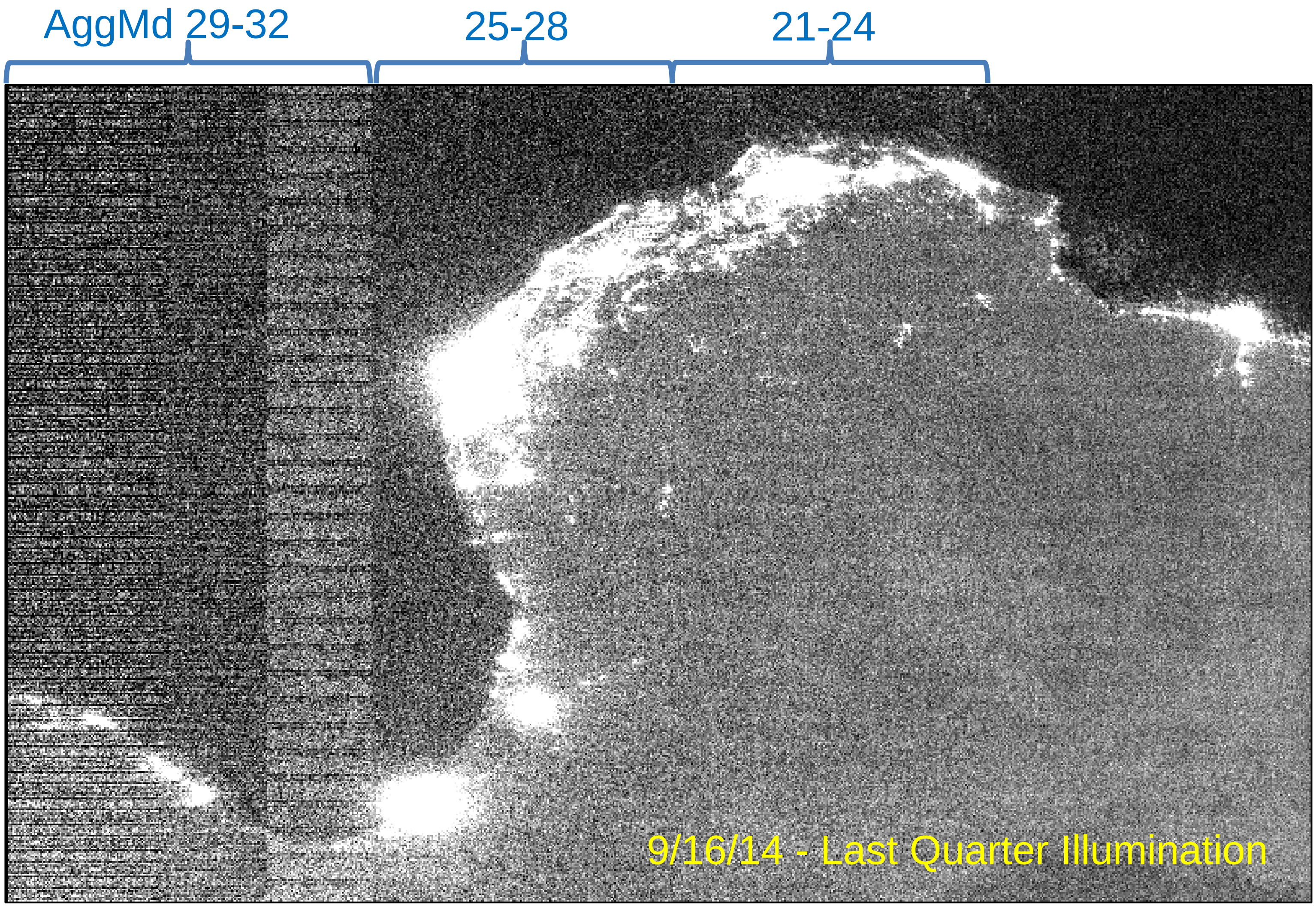


Simulated JPSS-1, Option 21

AggMd 21

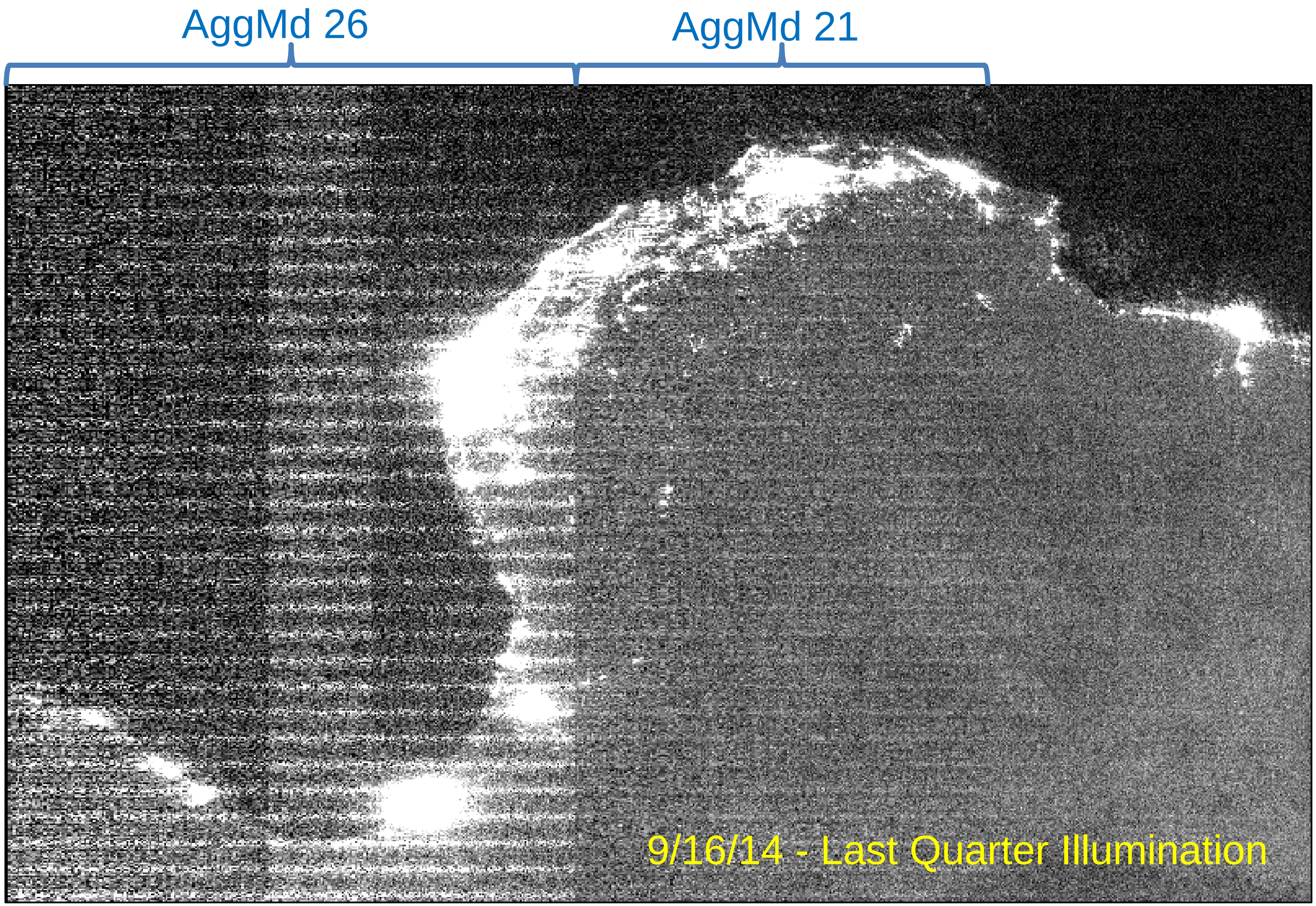


NPP Image with Striping



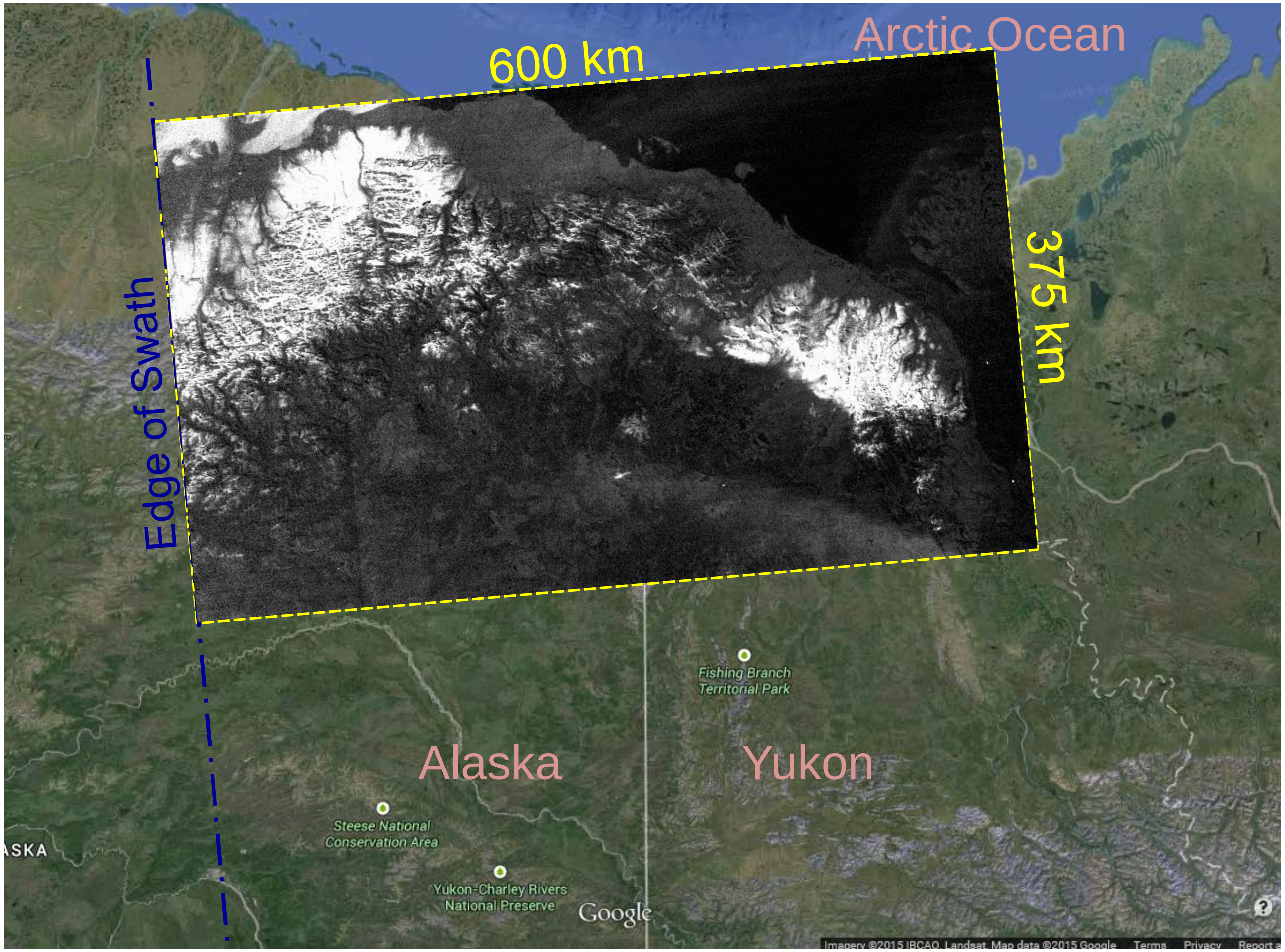
S-NPP has less striping near edge of scan than either JPSS-1 Option

Simulated Option 26

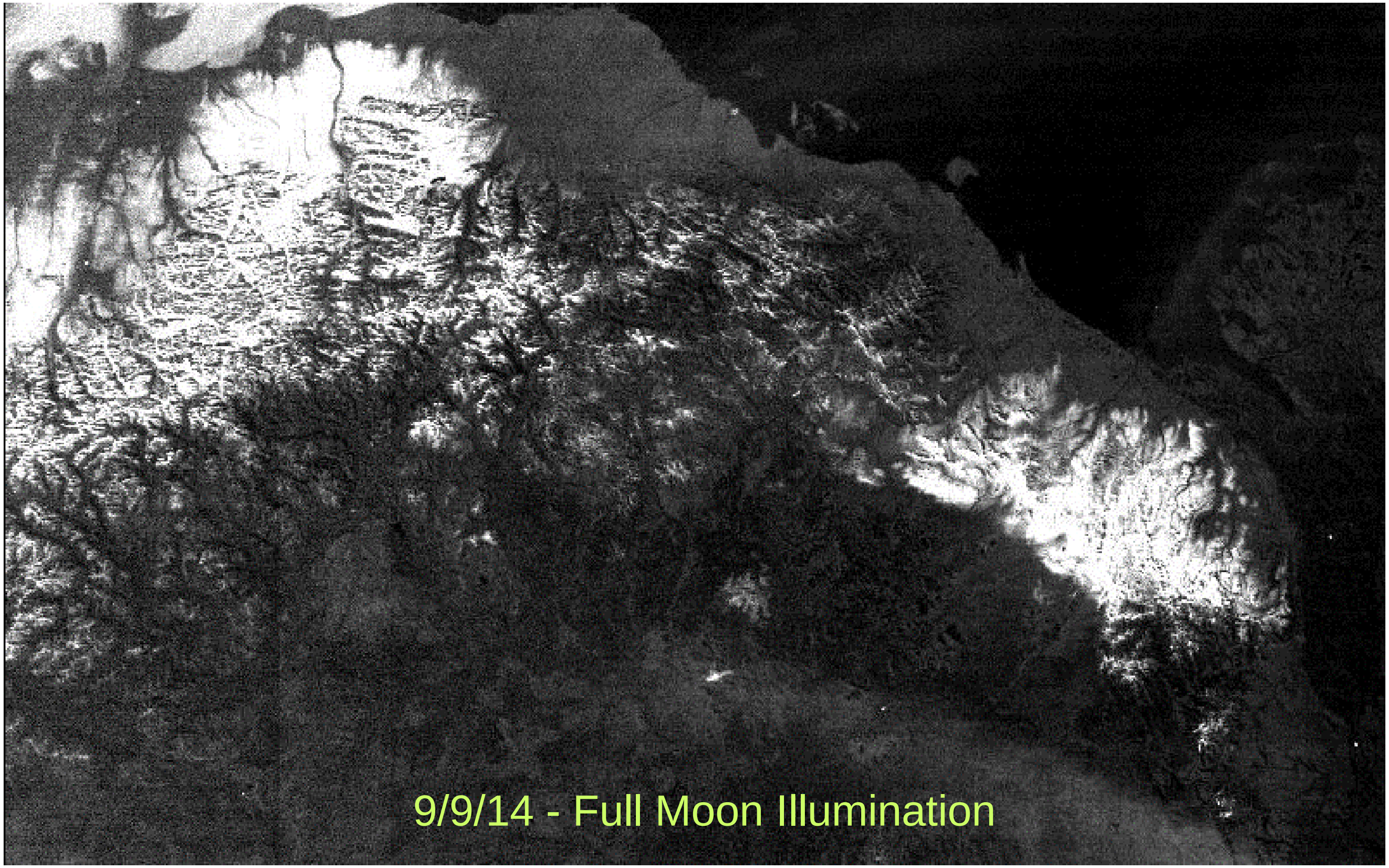


Scene 1, Northern Alaska & Yukon

Scene 1, Northern Alaska & Yukon

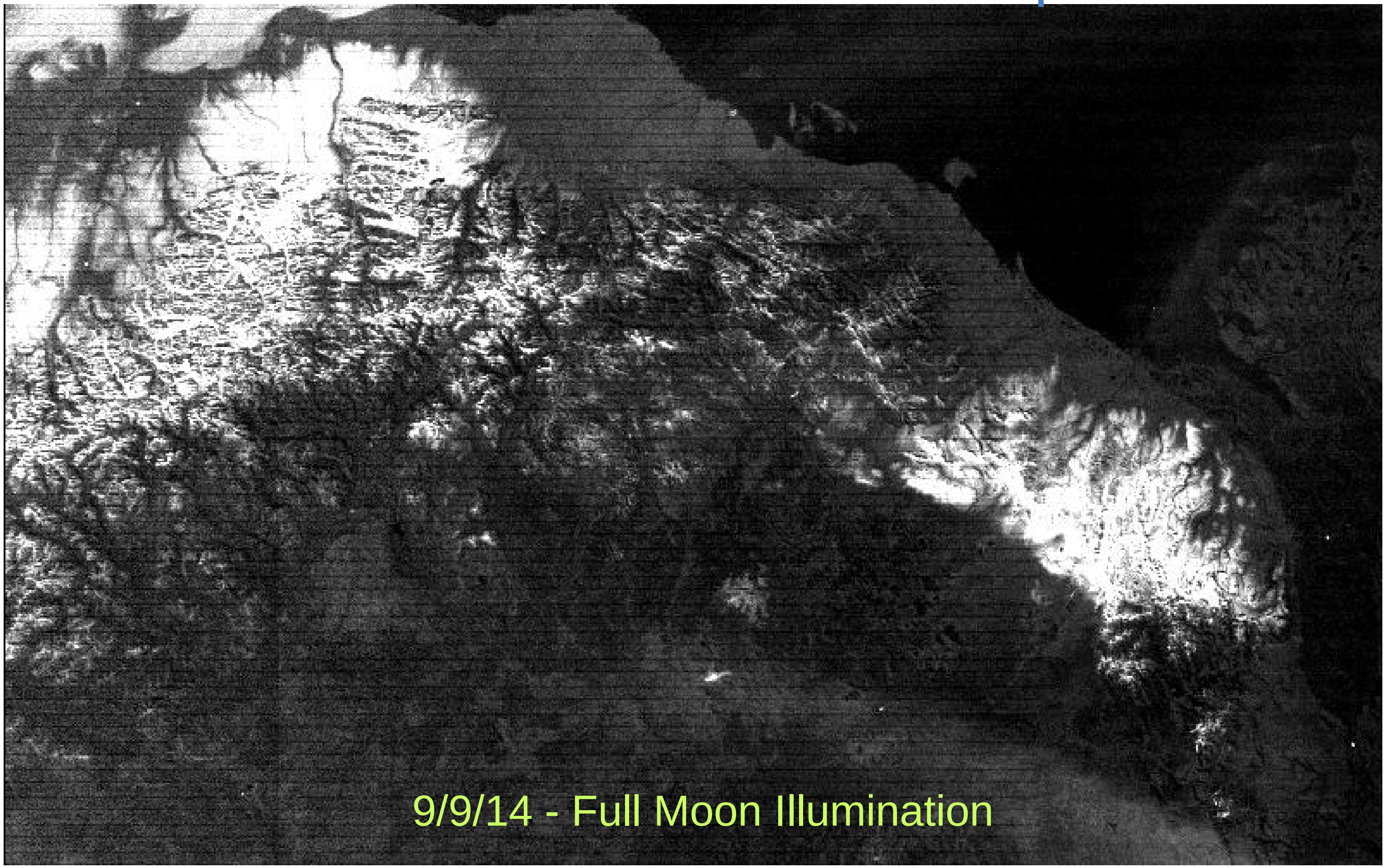


Pristine Edge-of-Swath Image

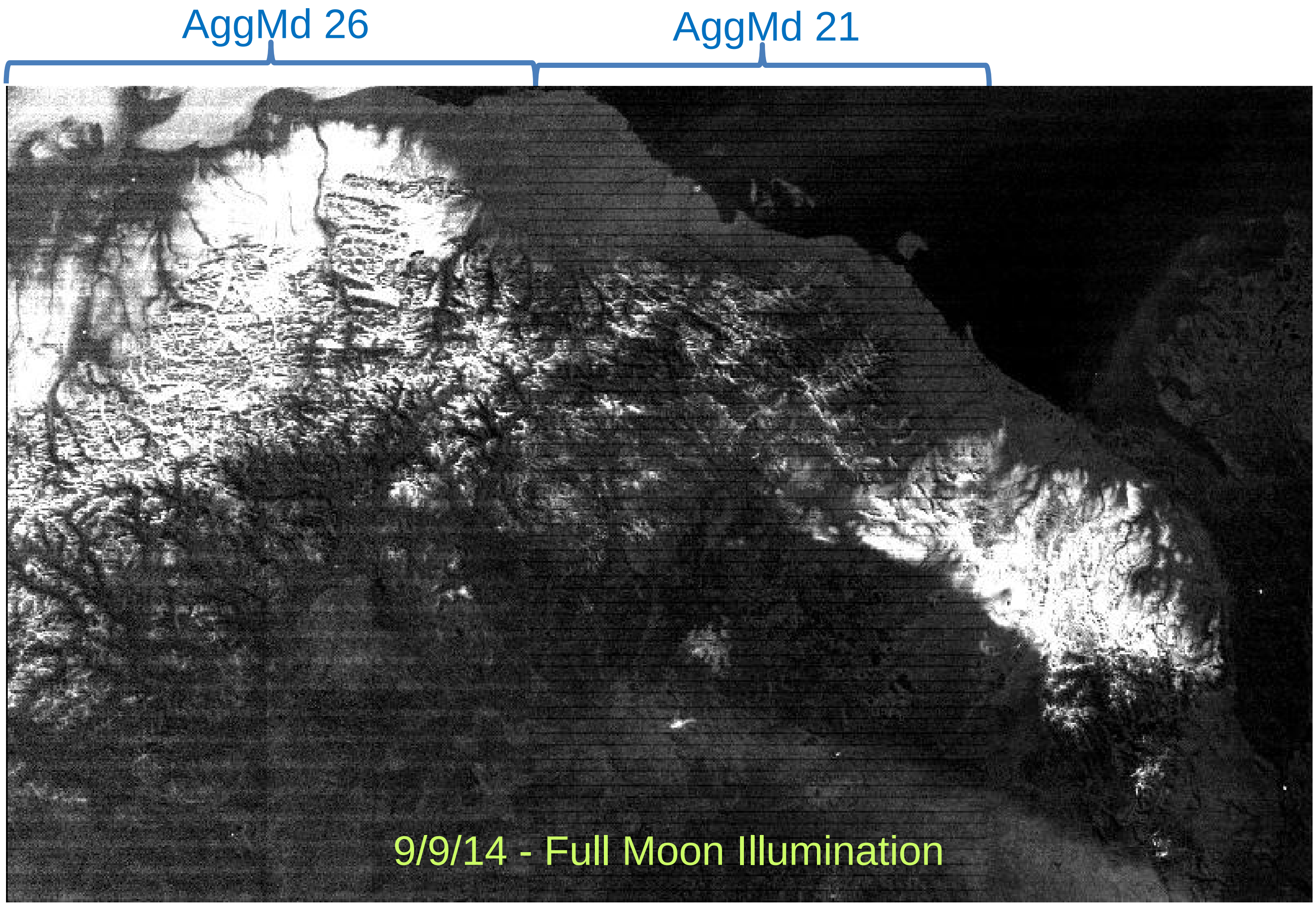


Simulated Option 21

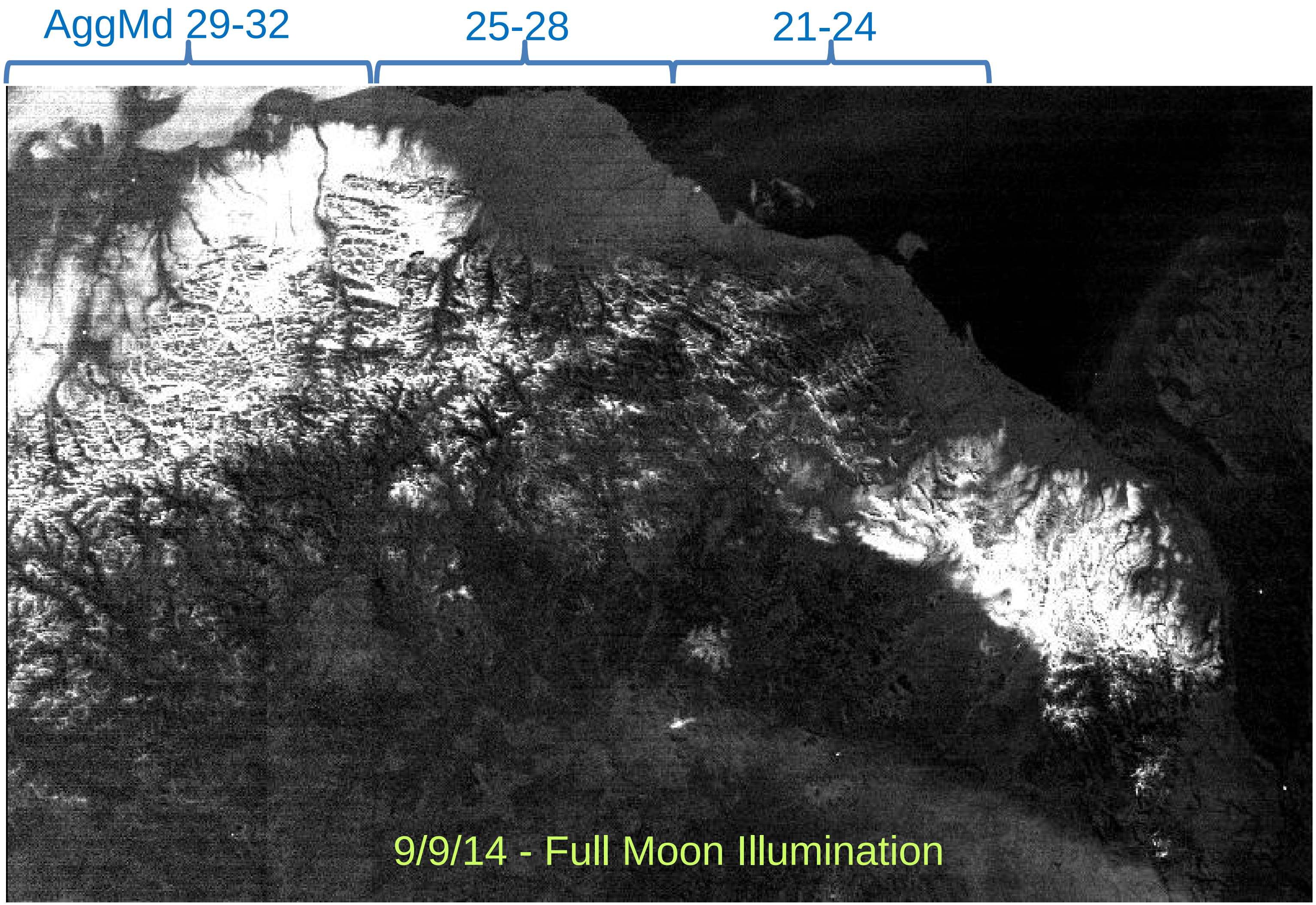
AggMd 21



Simulated Option 26

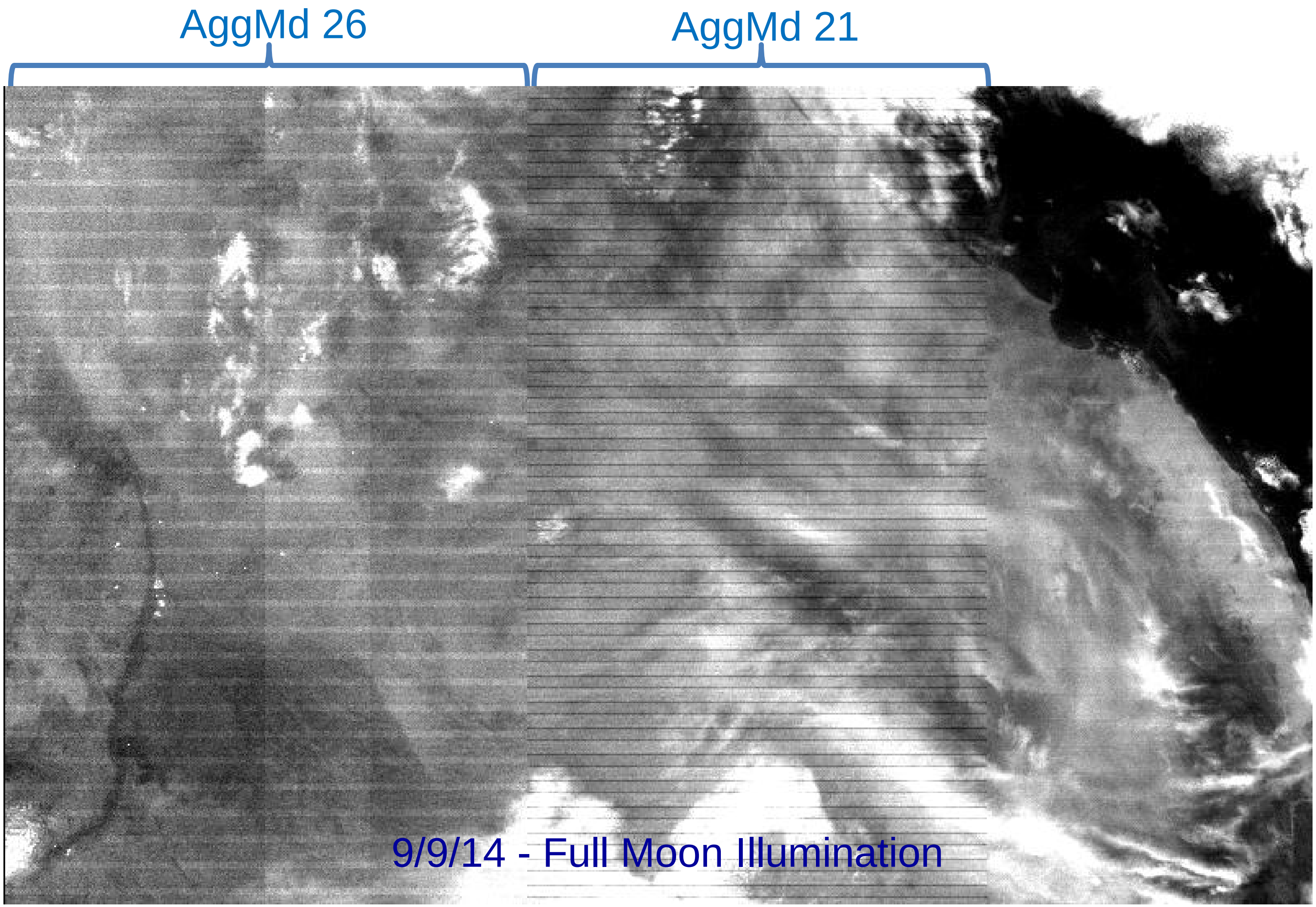


S-NPP Image with Striping

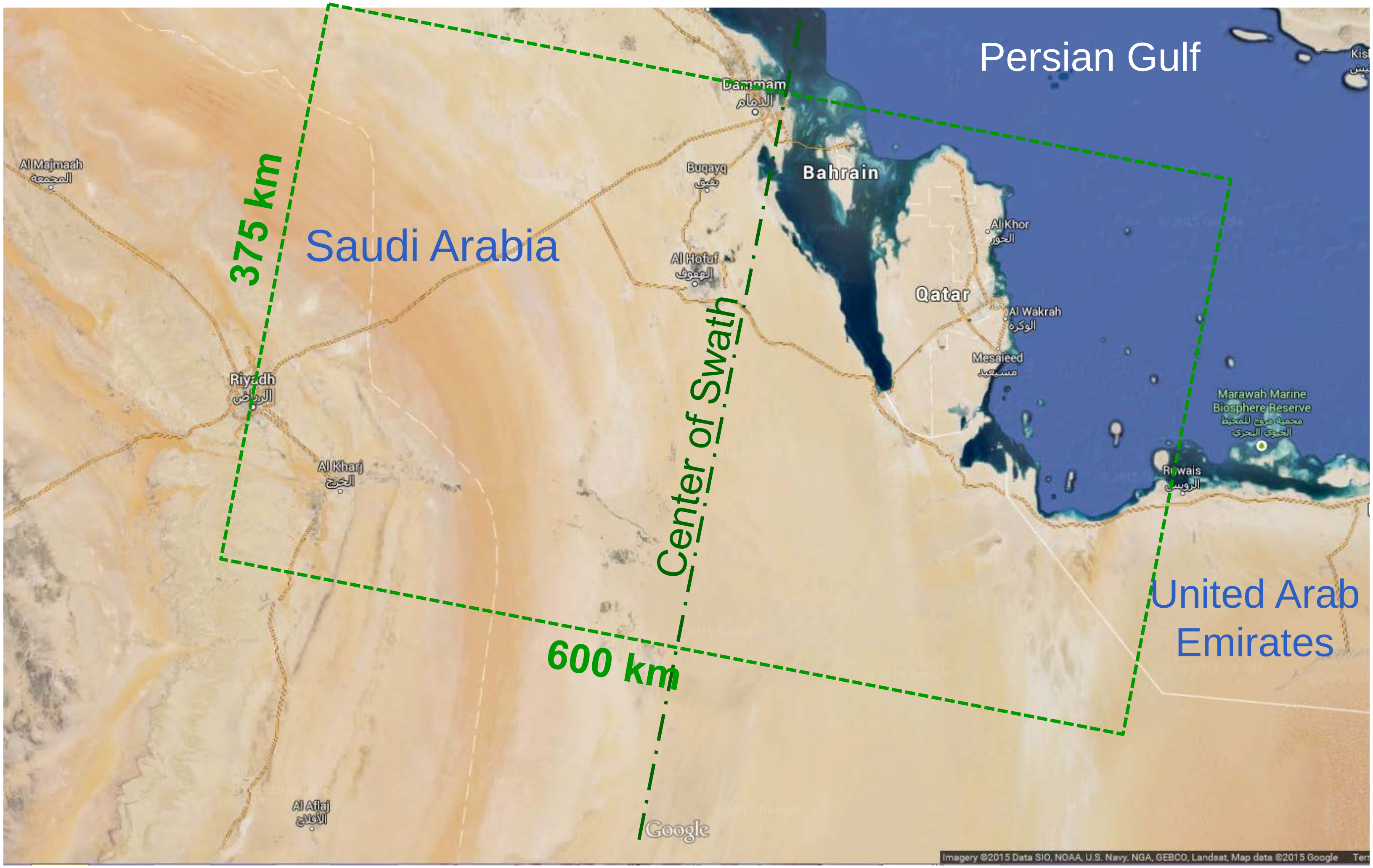


S-NPP has less striping near edge of scan than JPSS-1

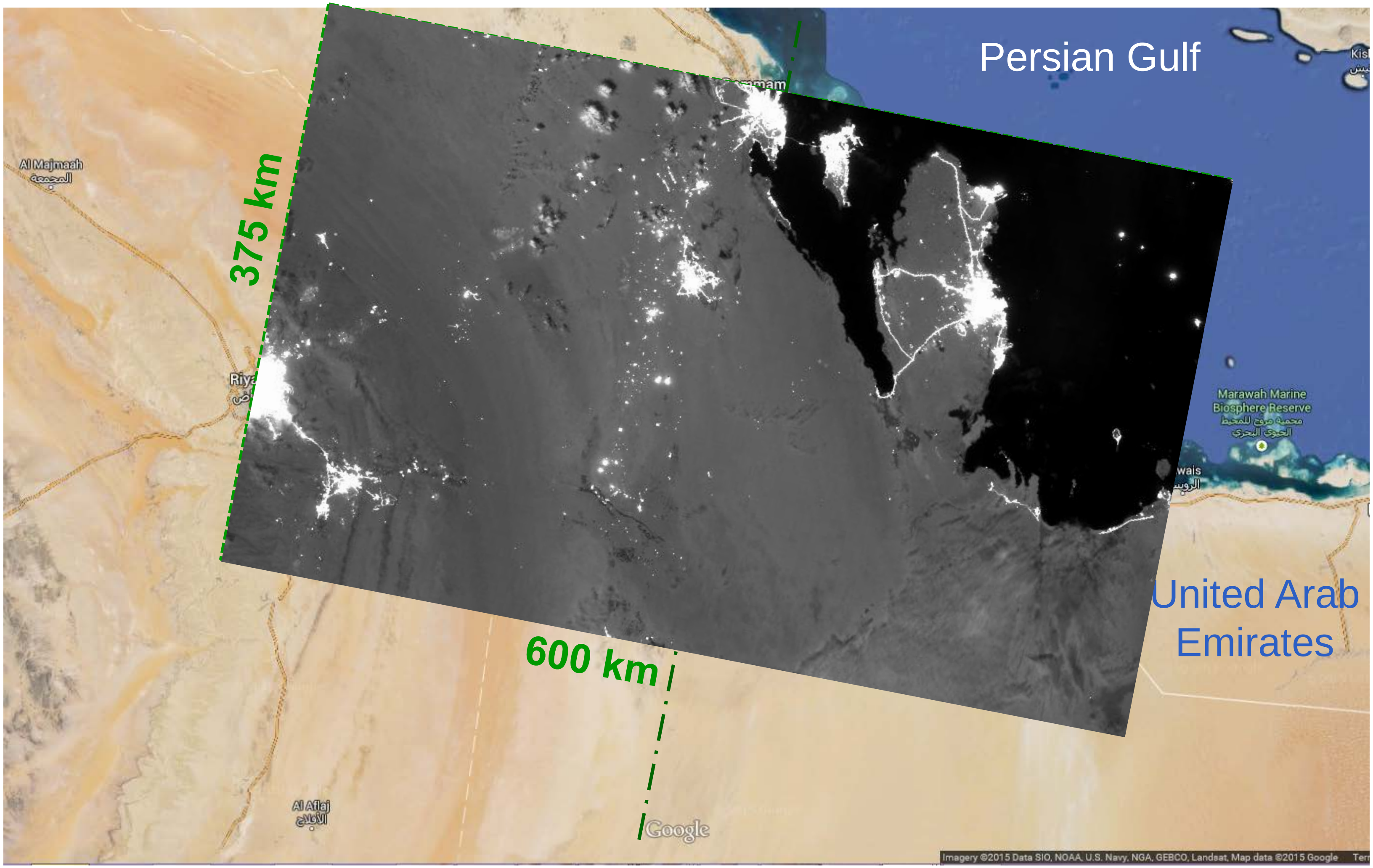
Simulated Option 26



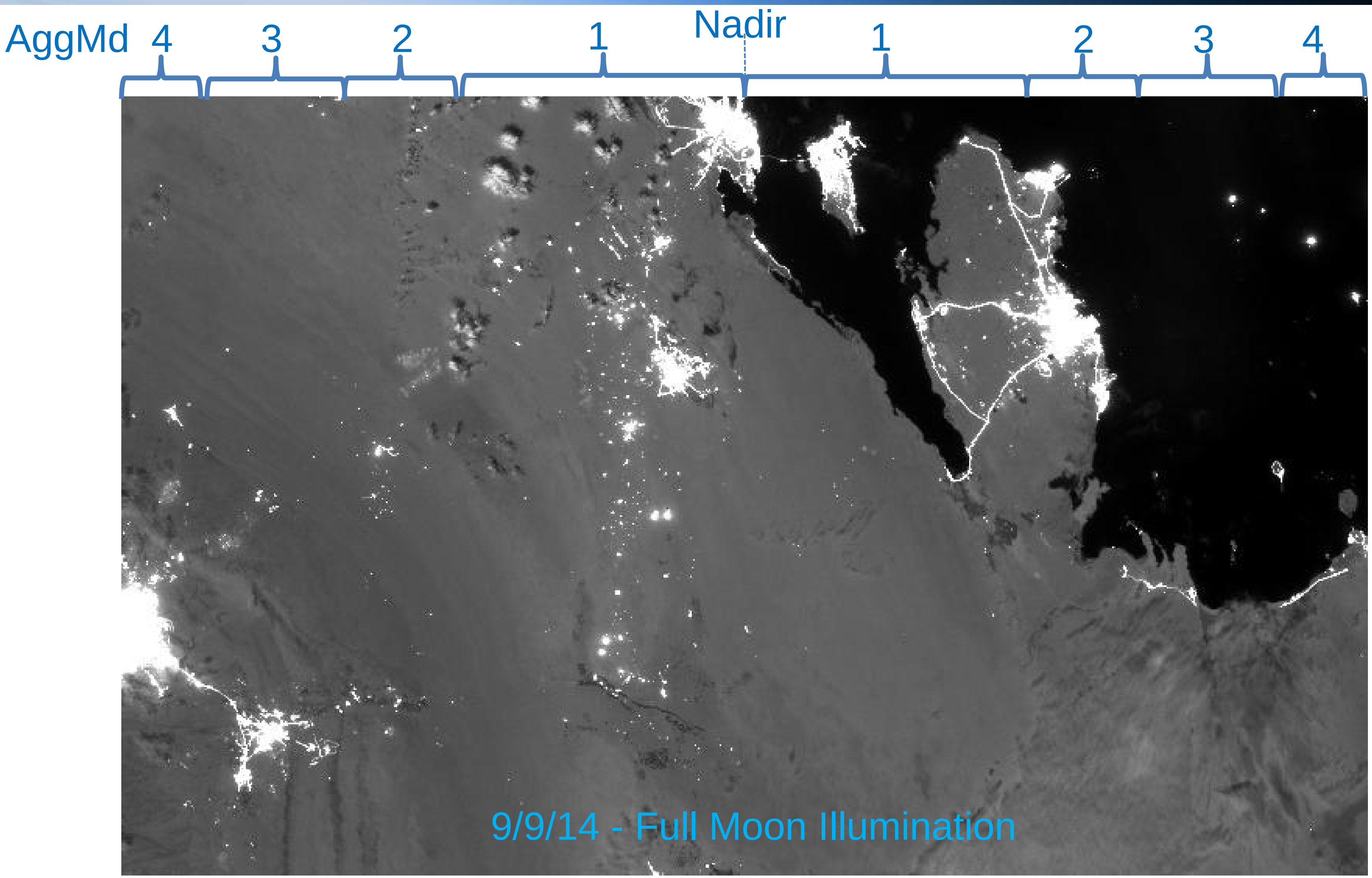
Scene 3, Arabia & Persian Gulf



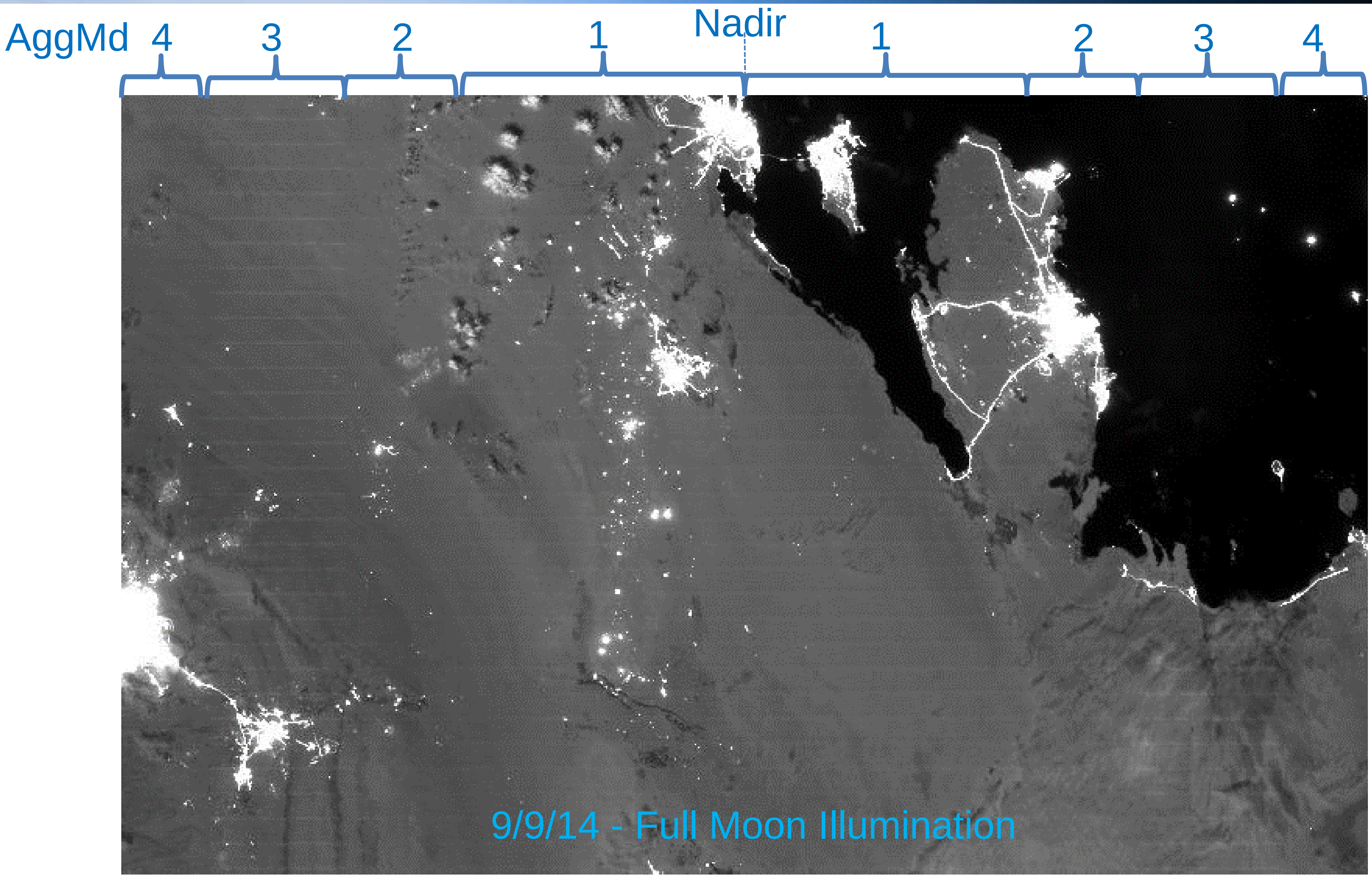
Scene 3, Arabia & Persian Gulf



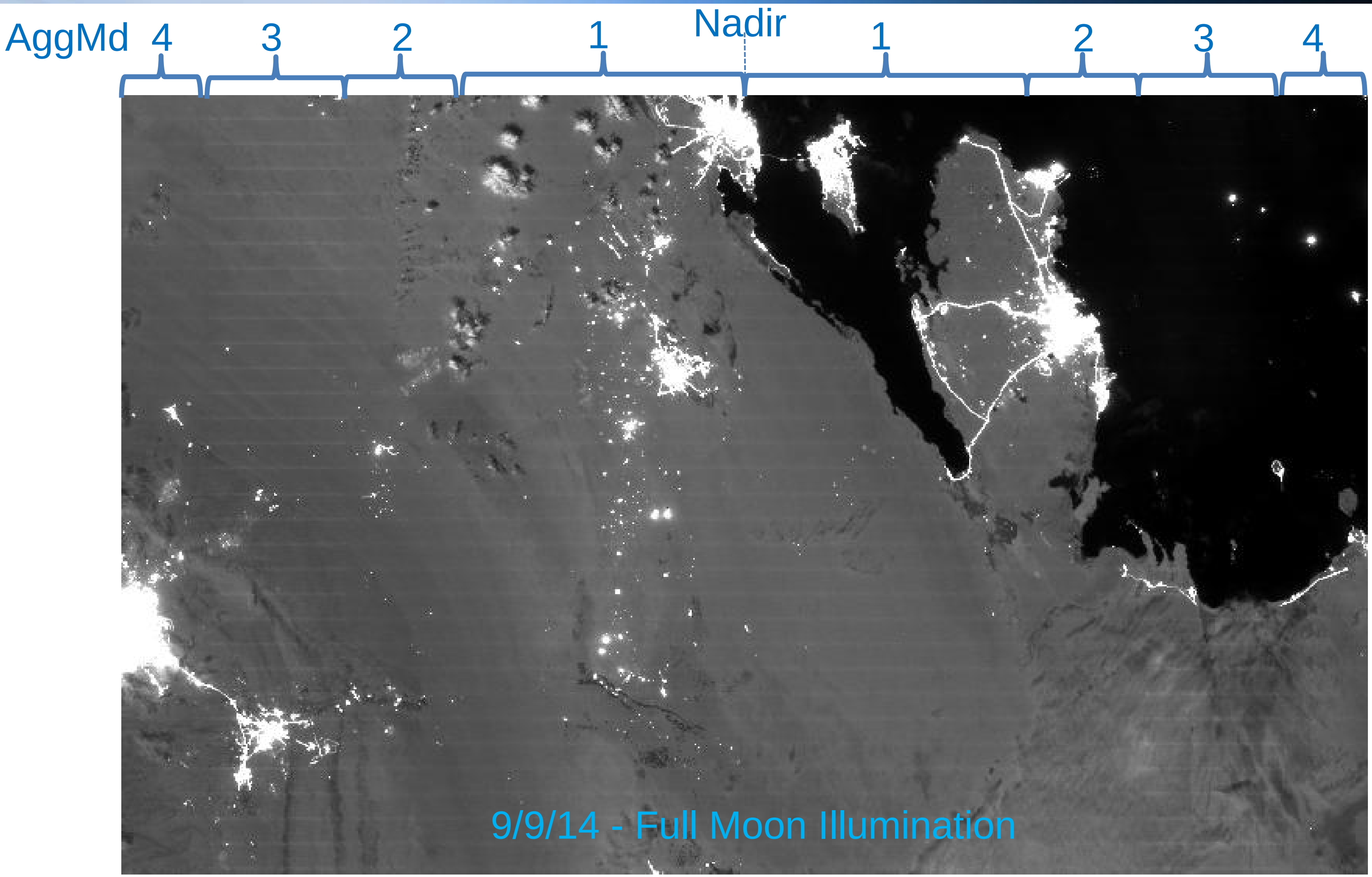
Pristine Nadir Image



Simulated Option 21 or 21/26



S-NPP Image with Striping



S-NPP has similar striping near nadir as JPSS-1

Additional Gain Ratio Error Observations

- Most gain errors are positive, which will cause a negative bias in radiances of MGS and HGS
  - Bias is averages about 8% at nadir
  - Bias decreases to about 2% near edge of scan
  - This is due to higher detector gain in LGS for radiance < 1×10^{-4} W cm^{-2} str^{-1}
- AggMd 26 has 4 detectors that are bad actors in the LGS-to-MGS gain ratio
  - Det. 1, 2, 15 & 16 have gain errors that are about 10% > than most of the others
- AggMds 27 to 32 have large errors in both LGS-to-MGS and MGS-to-HGS gain ratios
  - Errors range from -50% to +85% for AggMd 30
  - These large errors are another reason that the baseline is not a viable option

Simulation Caveats & Assumptions

- Model the reduced pixel resolution in Options 21 or Option 26 only in the scan direction
- Assumes that the same process currently used for the gain ratio computation for S-NPP is **unmodified for JPSS-1**.
  - Assumption based on NOAA STAR presentation 4/9/14
  - NOAA STAR is considering more research and possible update to gain-ratio cross-calibration process after launch
- Does not consider uncertainties in the offset determination.
  - This has been a cause of striping for S-NPP.
- Does not consider the long-term stability of the nonlinearities.
- Because of these assumptions, actual images will likely be worse

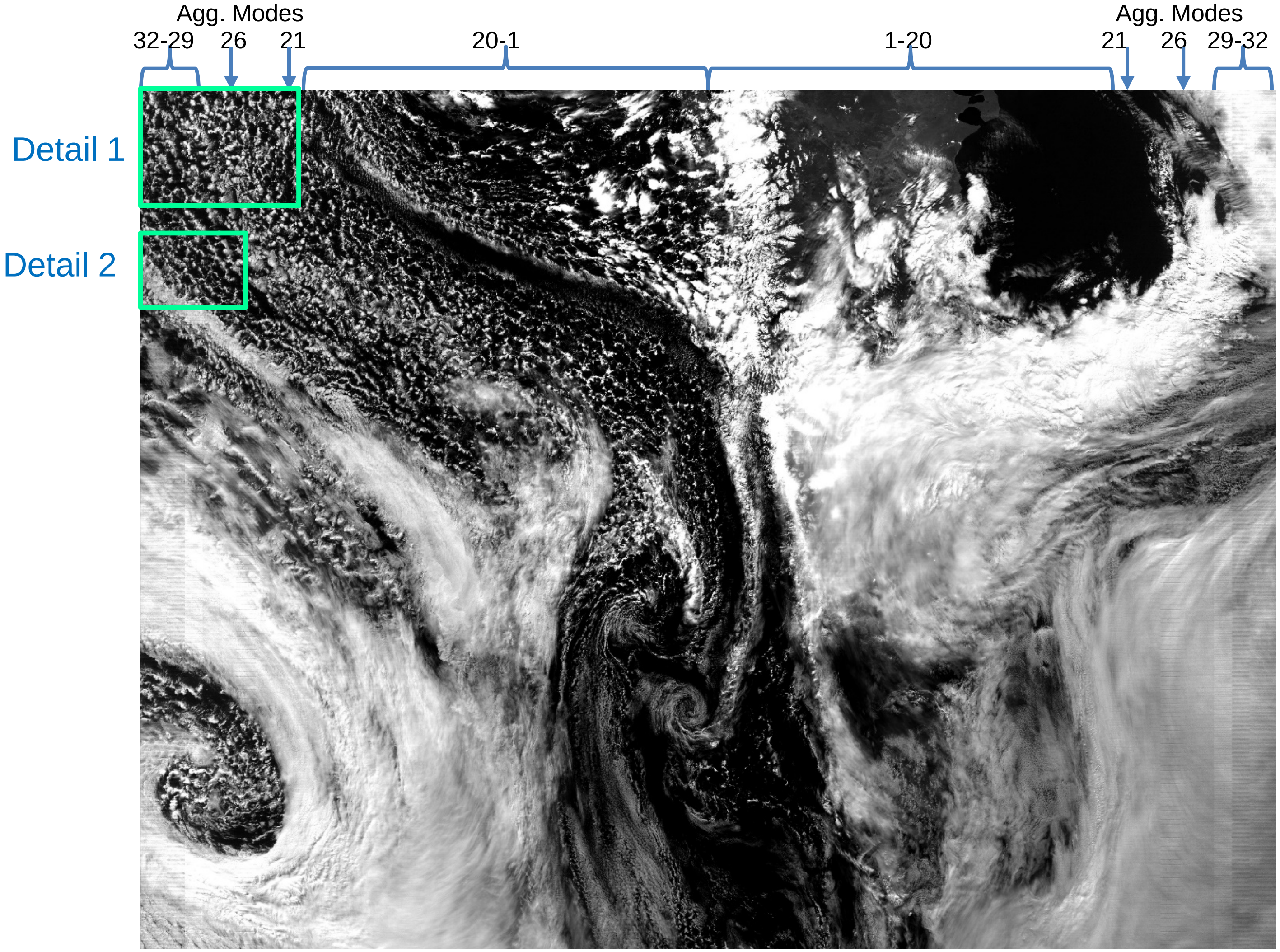
Actual on-orbit striping will almost certainly be worse than shown

Simulated Resolution Affects from reduced Aggregation Modes

Simulation of spatial resolution

- NPP Scene was chosen to have many small clouds
- NPP striping was removed using destriping algorithm
- Convolutions were performed on each aggregation zone using the size of the cell after aggregation as the kernel
- Scenes are shown for the baseline 750 m cells across the entire swath
- Simulated reduced resolution images are shown for the first 450 km at edge of swath that includes Agg. modes 32- 21
  - Option 21 & Option 26 are simulated
- Images with baseline resolution are compared with the two reduced resolution aggregation options
- Images should be viewed in full screen mode to understand loss of resolution

Resolution Test Scene



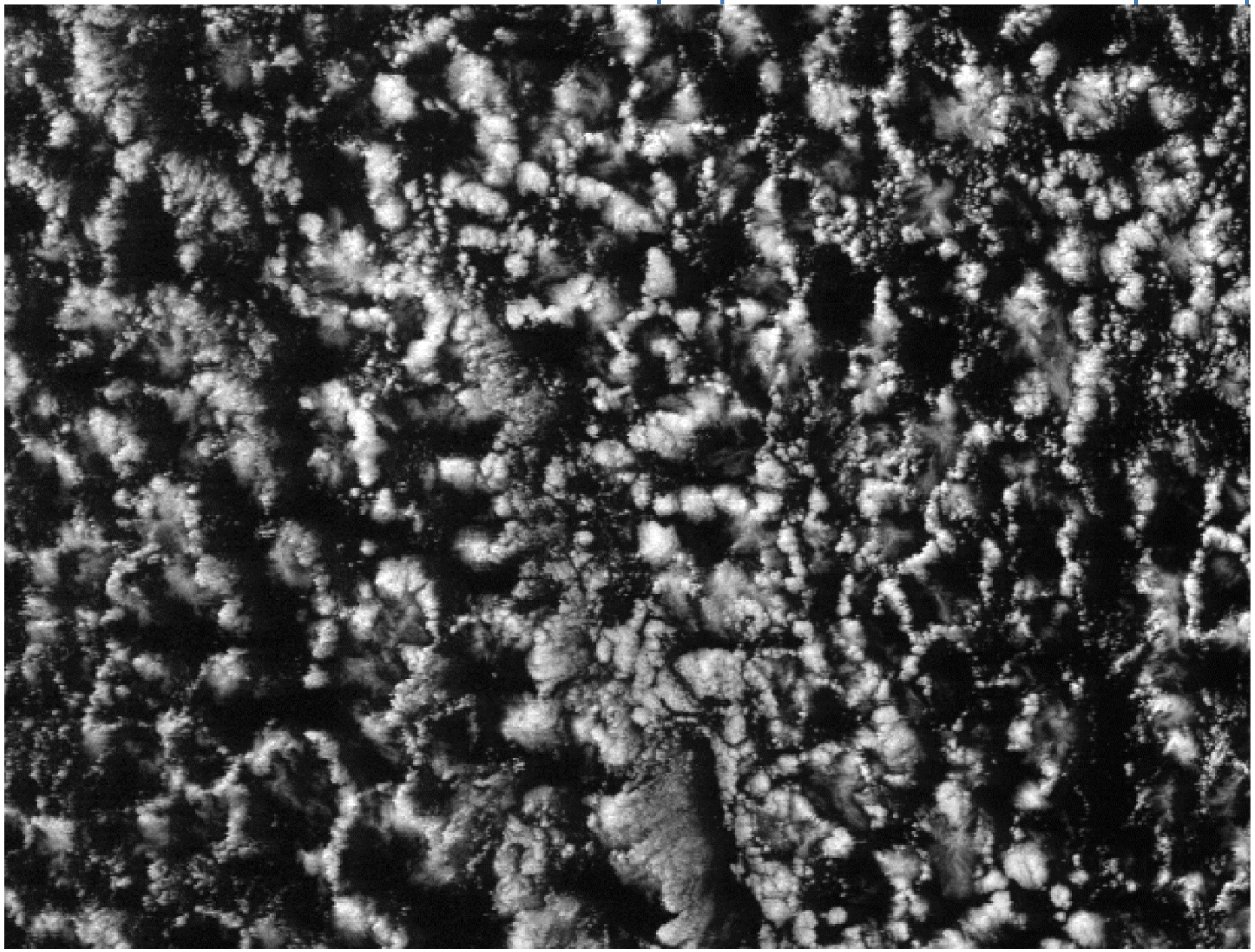
Detail 1, full 750 m resolution

Edge of Scan

Agg. Mode 26

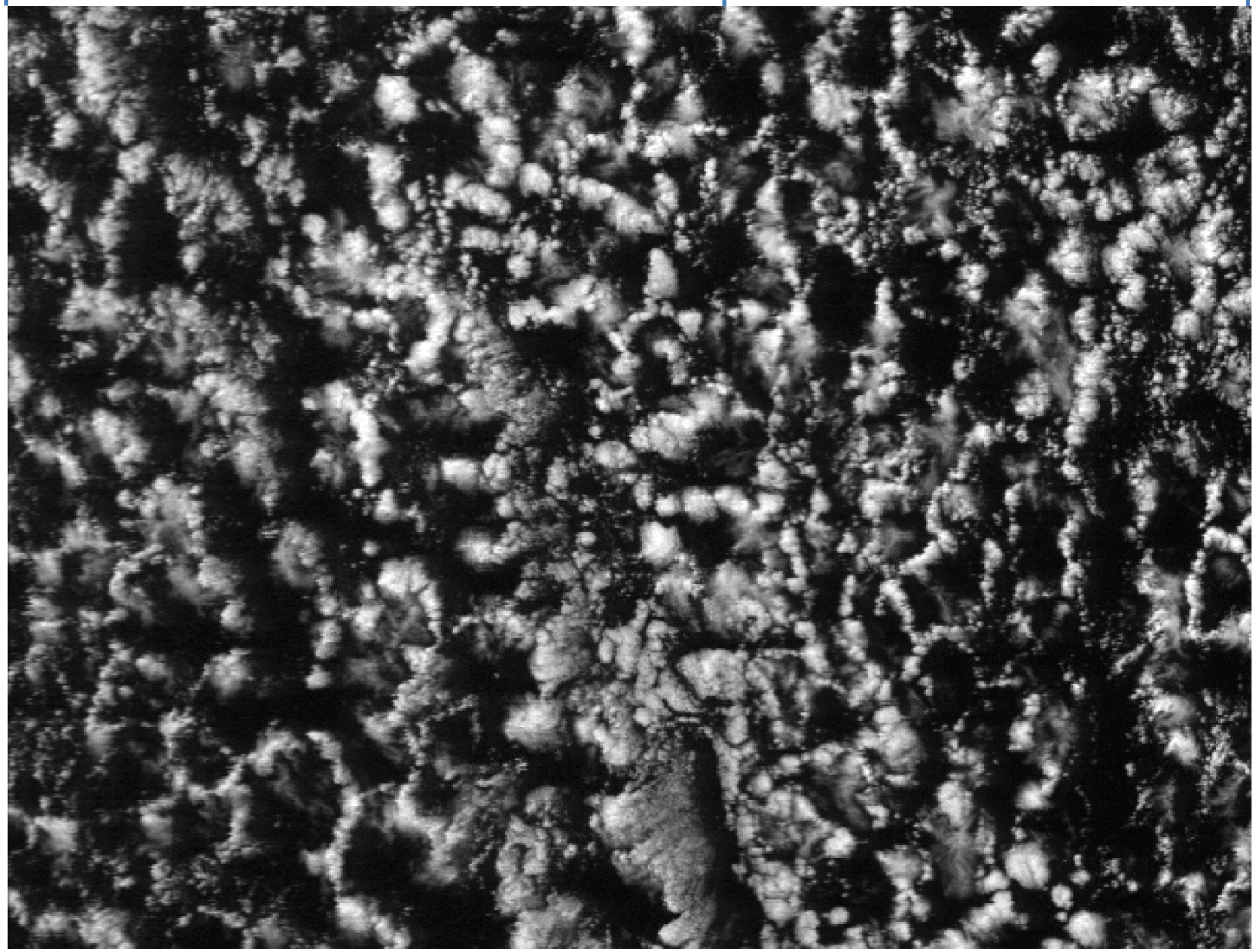
Agg. Mode 21

340 km

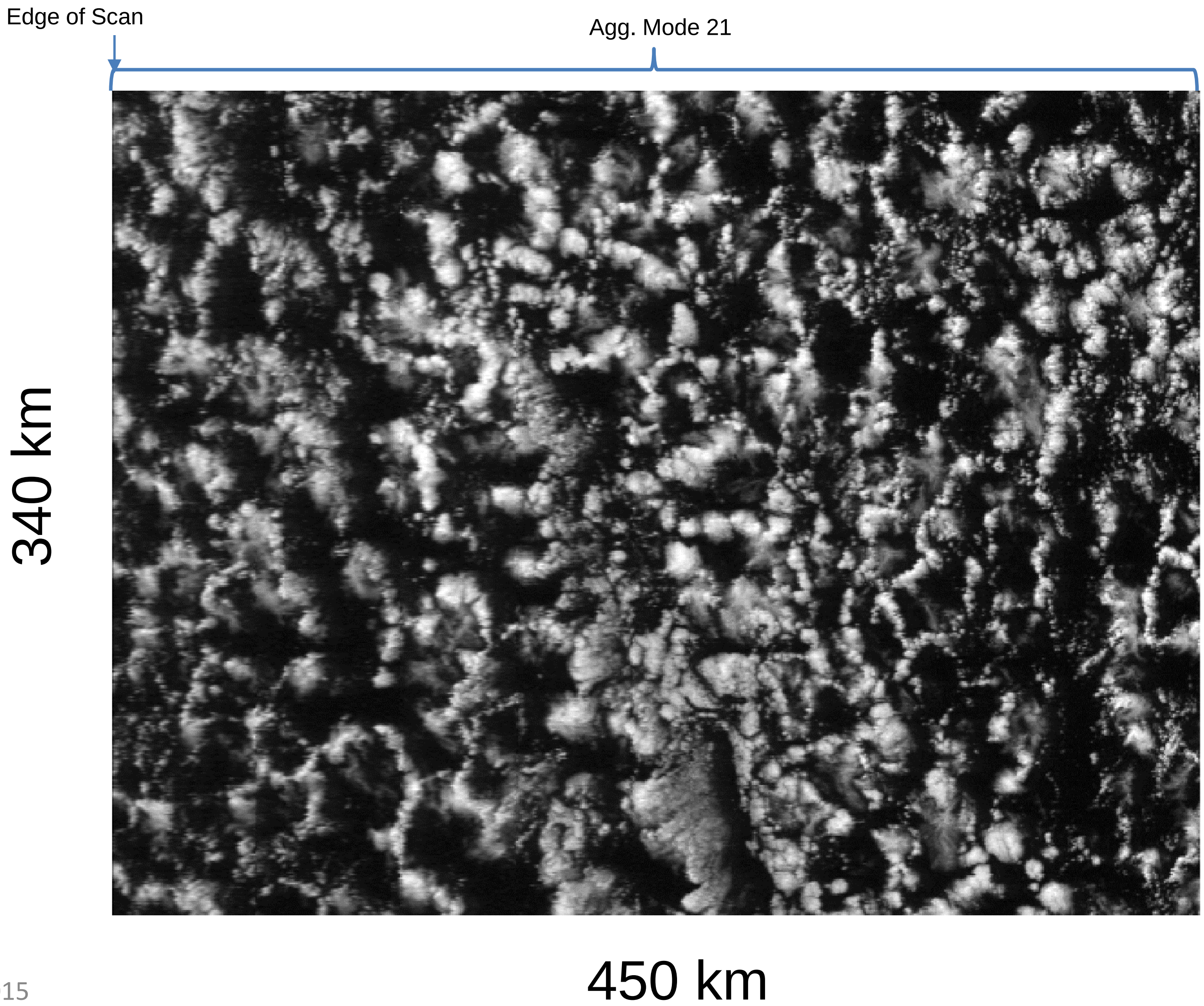


450 km

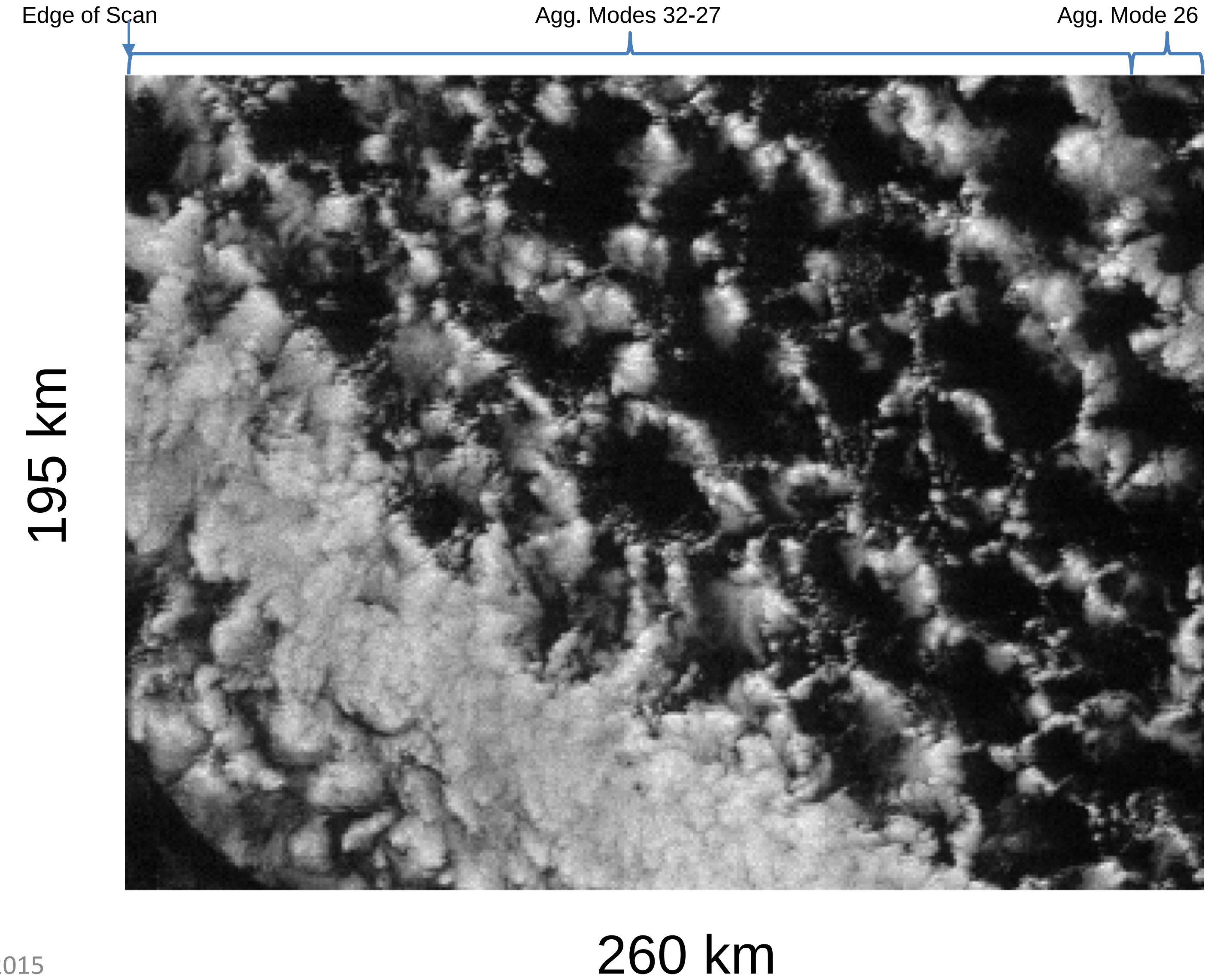
Detail 1, Option 26 resolution



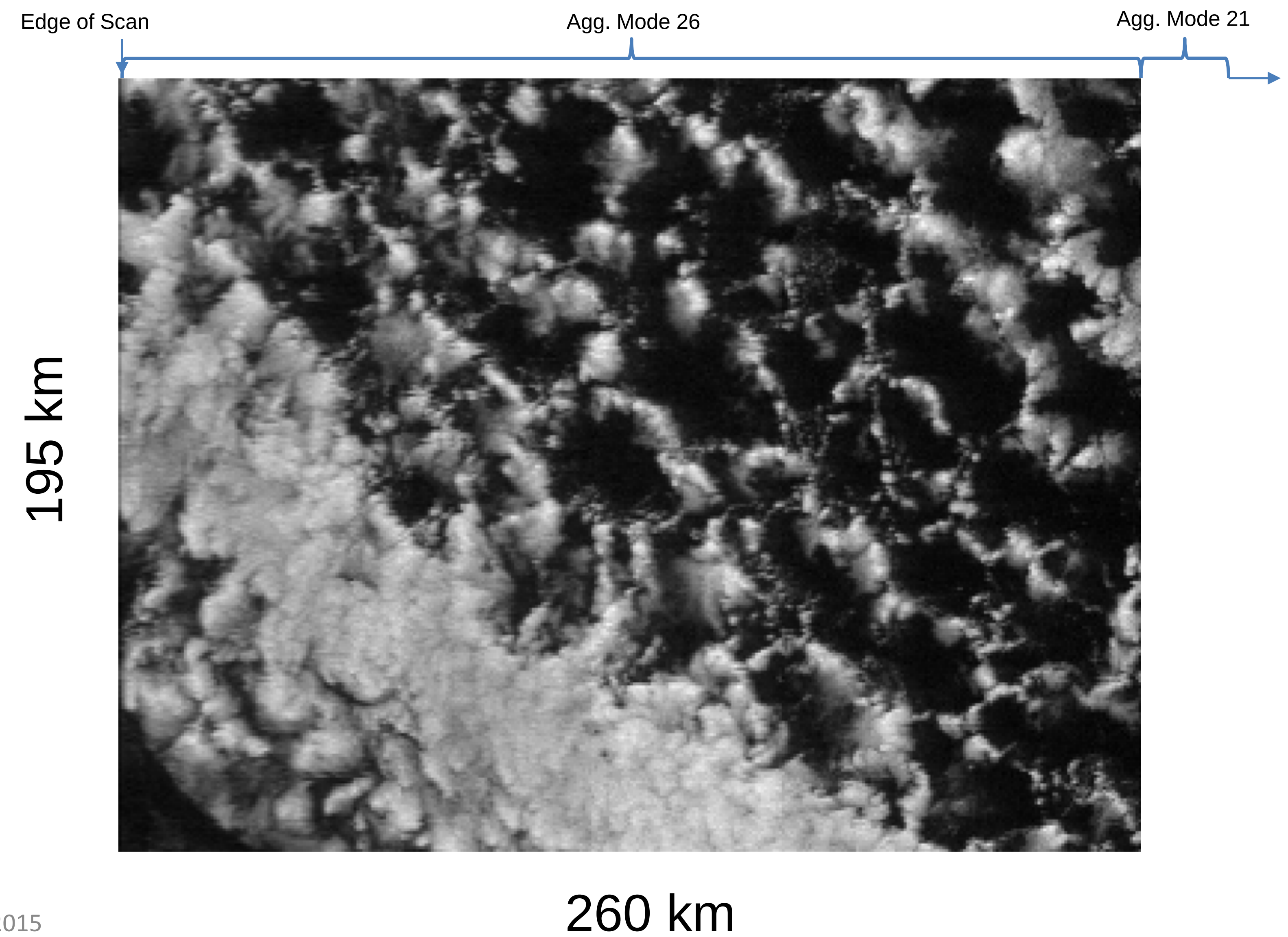
Detail 1, Option 21 resolution



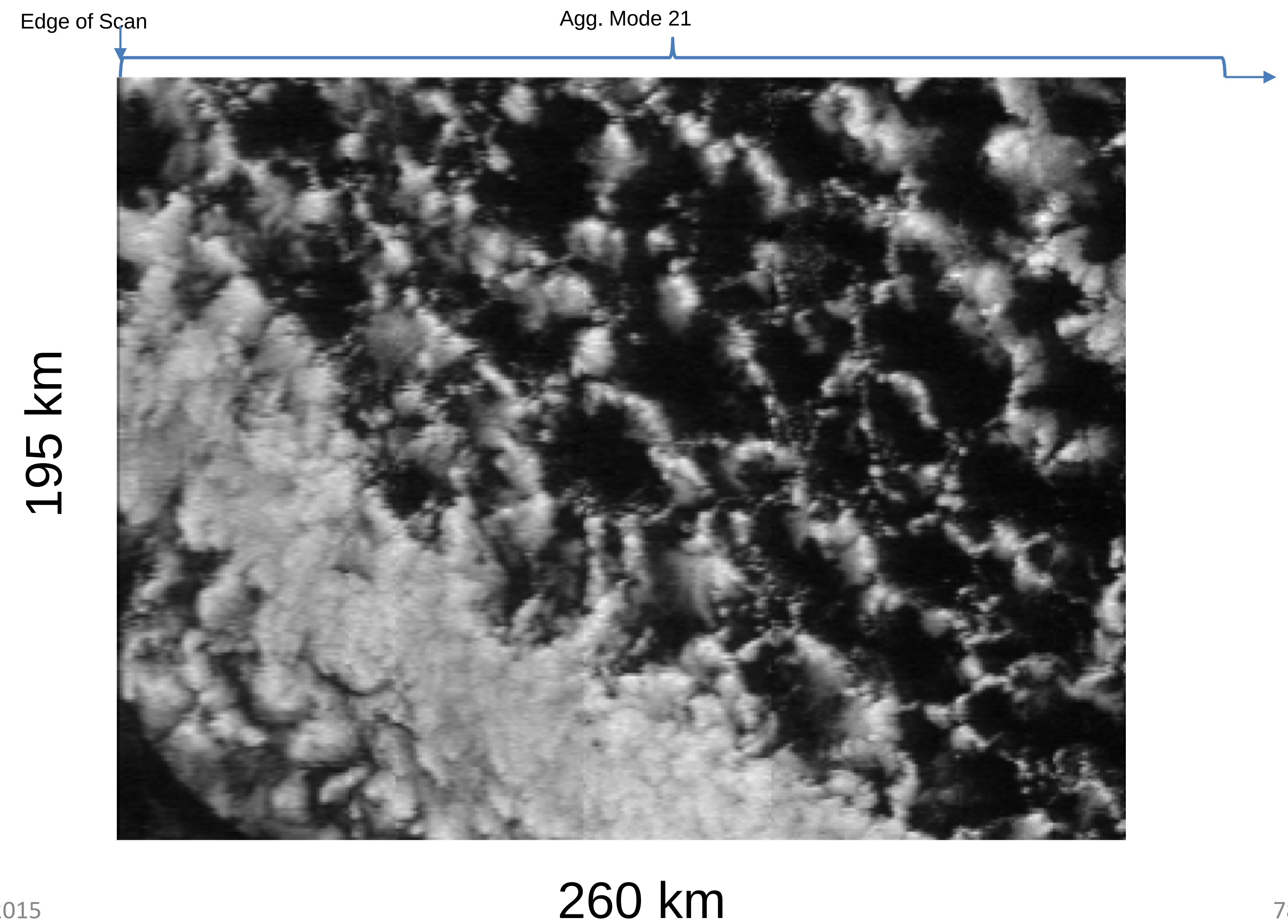
Detail 2, full 750 m resolution



Detail 2, Option 26 resolution



Detail 2, Option 21 resolution



JPSS-1 VIIRS Spectral Calibration and performance

Chris Moeller[a], Tom Schwarting[b], Jeff McIntire[b], Dave Moyer[c]

[a]*Univ. Wisconsin - Madison*

[b]*VCST*

[c]*Aerospace Corporation*

Acknowledgement to the Raytheon instrument measurement and spectral analysis teams

2015 STAR JPSS Science Teams Anuual Mtg

August 24-28, 2015

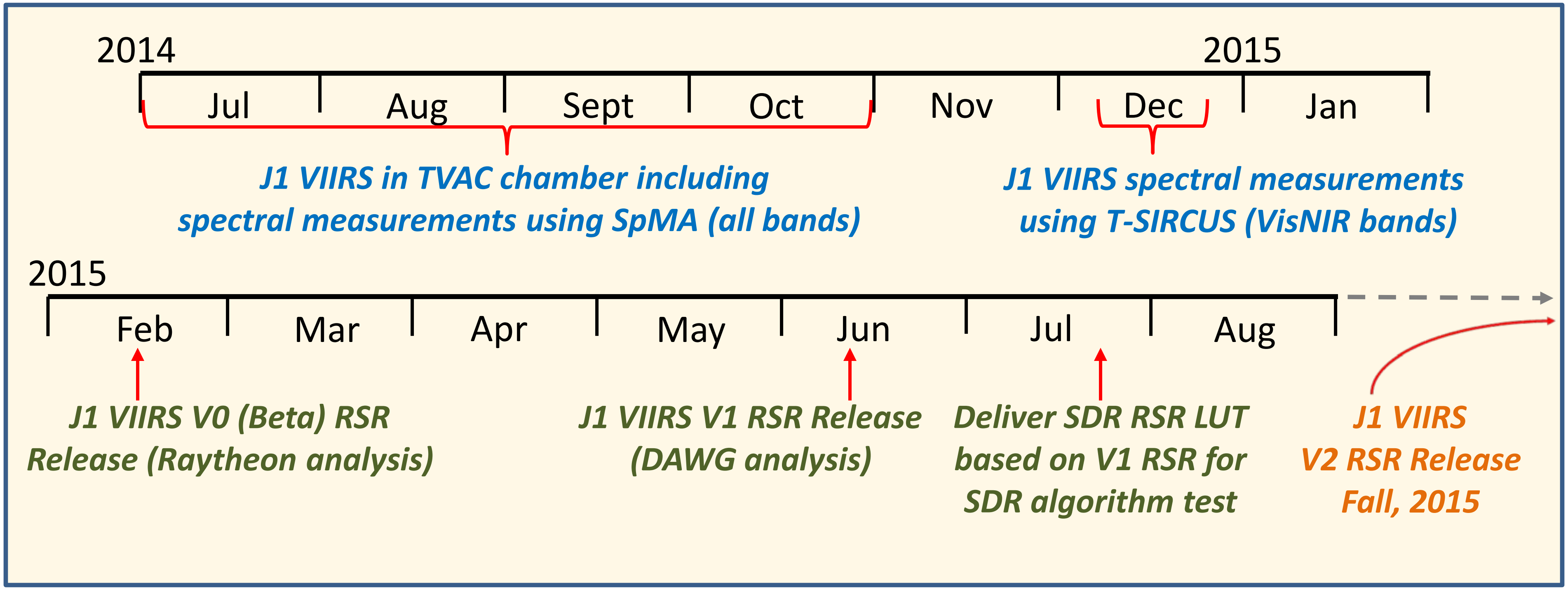
College Park , MD

Outline

- Overview of spectral test program and RSR releases
- DAWG Version 1 (V1) Release
- S-NPP/JPSS-1 RSR comparisons
- S-NPP/JPSS-1 spectral metrics
- Spectral impact on SDR (compared to S-NPP)
- Summary
- JPSS-1 RSR will not be modulated by WO2 contamination experienced on S-NPP

Overview and Timeline of VIIRS Spectral Measurements/Releases

- All bands, all detectors (DNBHGS surrogate: DNBMGS) measured using single band illumination (all bands) plus VisNIR full focal plane illumination
- Measurements predominantly contiguous at FWHM in spectral space
- First release (V0) within 4 months of completing spectral measurements
- V1 release replaced V0 release



Pedigree of the DAWG J1 VIIRS V1 Relative Spectral Response (RSR)

- Independent RSR analysis by the govt-sponsored VIIRS Data Analysis Working Group (DAWG).
  - DAWG chose which measurement collects to use
  - DAWG generated its own Relative Spectral Output correction.
  - DAWG performed its own in-band to out-of-band stitching
  - DAWG set its own SNR-based data quality filtering
  - DAWG created its own band average (over all detectors) RSR
- Analysis uses FP-15,-16 measurements collected at Raytheon El Segundo facility during the July-October 2014 sensor test program.
- T-SIRCUS based measurements of VisNIR band RSR in December 2014 are not included; however, preliminary T-SIRCUS based RSR were allowed to indirectly influence the DAWG RSR analysis for some bands.

The DAWG J1 VIIRS RSR V1 Release

- Consists of: RSR files (tar file), PDF showing RSR plots, README
- Stitched IB+OOB RSR with all RSR normalized at the peak to 1.0.
- Detector and band average RSR provided at the native spectral sampling of the test data. M9 RSR is water vapor corrected. M16A and M16B band average RSRs are averaged into an "M16" RSR.
- Detector numbering convention is "sensor order", i.e. leading detector in along track direction is detector 1.
- Band average SNR metric used to separate high quality (i.e. light-driven) response from low quality (i.e. noise-driven). A quality flag (0=High; 1 = Low) is provided at each wavelength in the detector RSR, and supports data quality filtering for the band average RSR.
- Low quality response including negative response is retained in the detector RSR but is set to 1E-10 in the band average RSR.
- RSR are not corrected for a minor SpMA spectral smile influence.

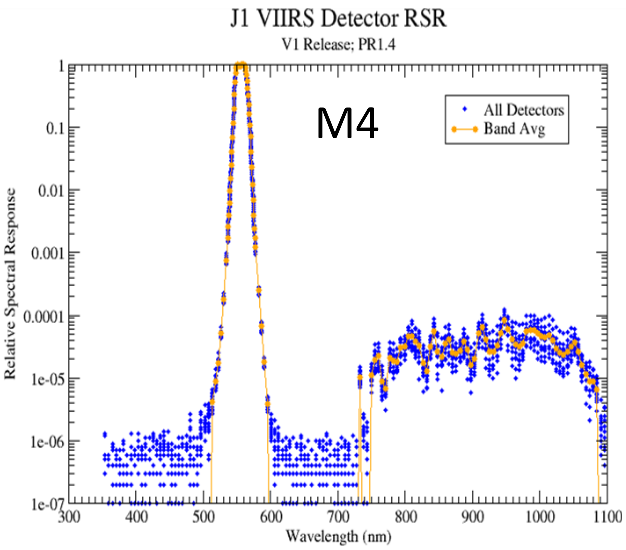
The V1 Release* is available on the limited access NASA eRoom:

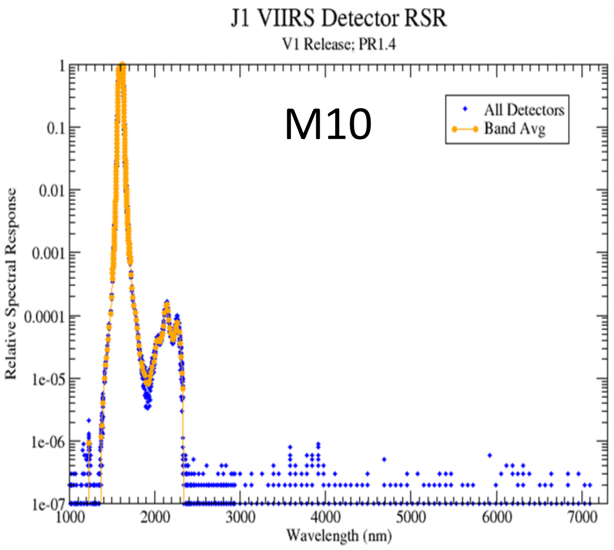
https://jpss-erooms.ndc.nasa.gov/eRoom/JPSSInstruments/VIIRSF2_JPSS1/0_fa80

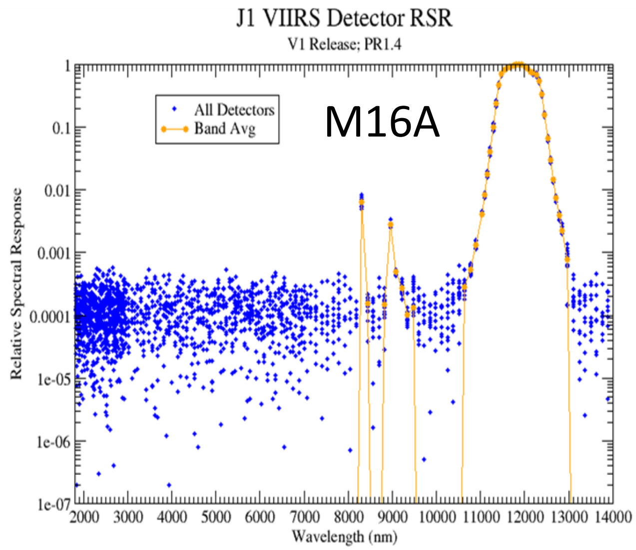
*under EAR99 protection

Version 1 RSR Data Quality

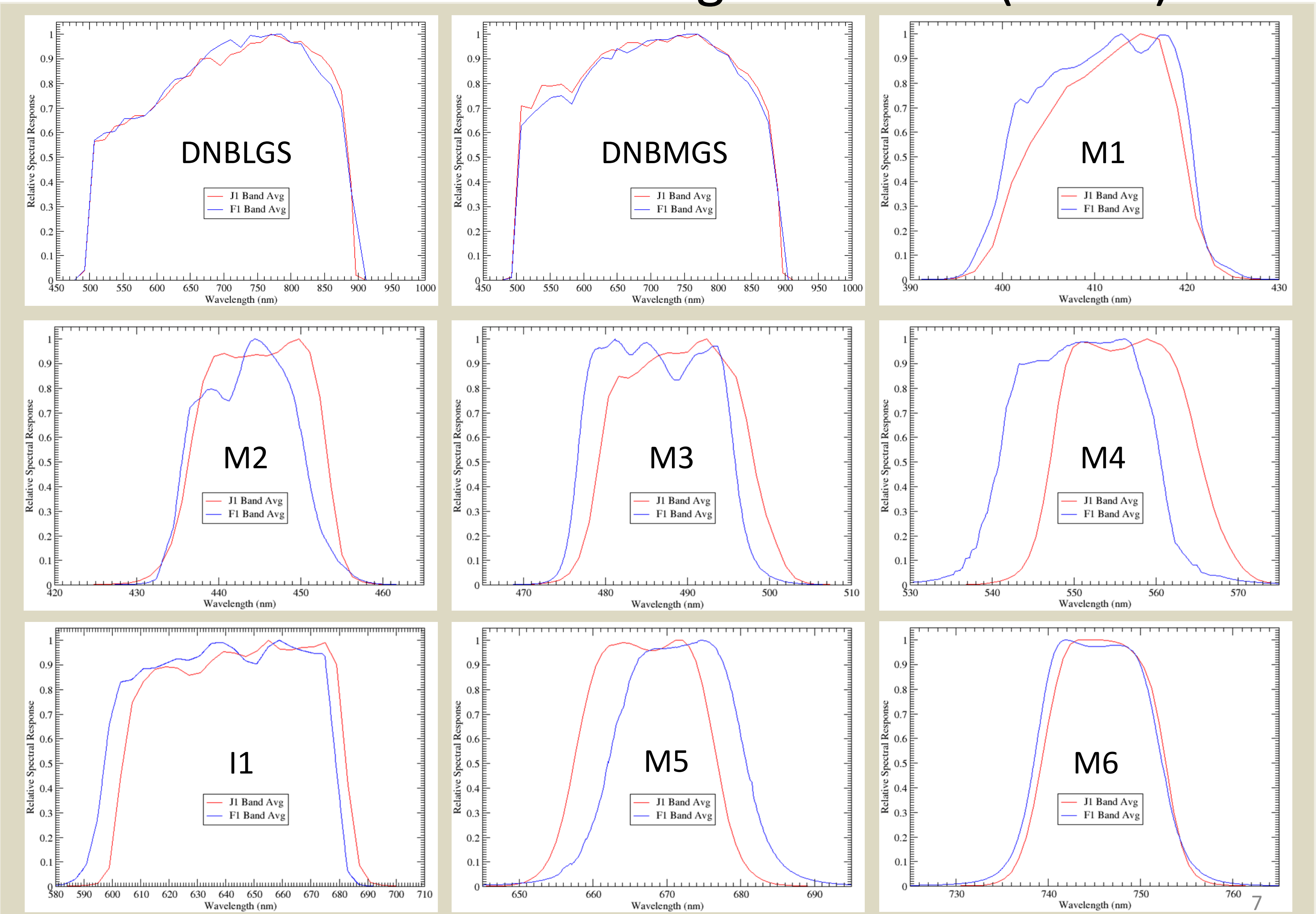
- Set data quality filter thresholds to distinguish high quality response (i.e. light-driven) from low quality response (i.e. noise-driven).
- Average the detector RSR into a band average RSR for each band, applying the data quality filter to screen out low quality response from the averaging process.



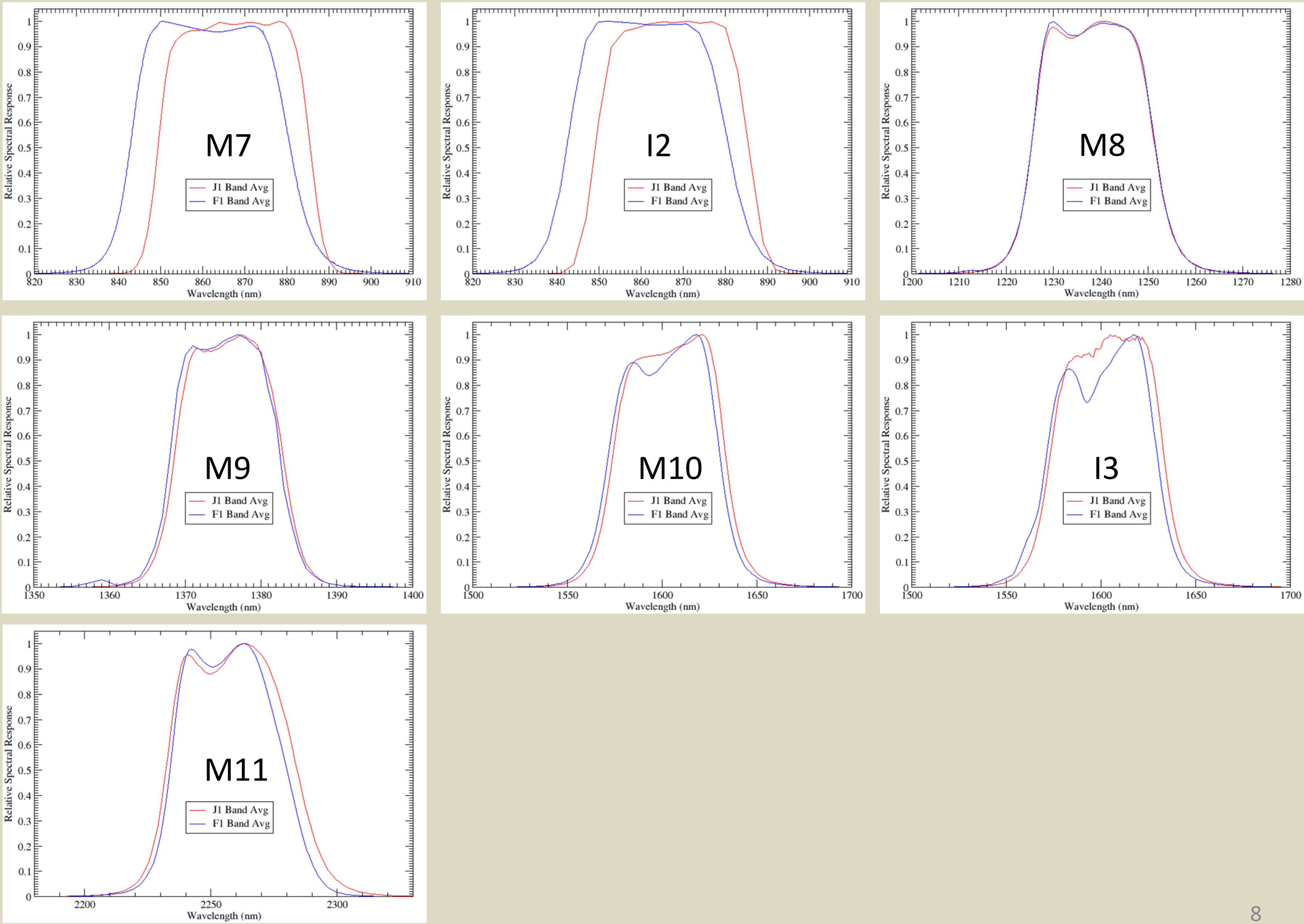




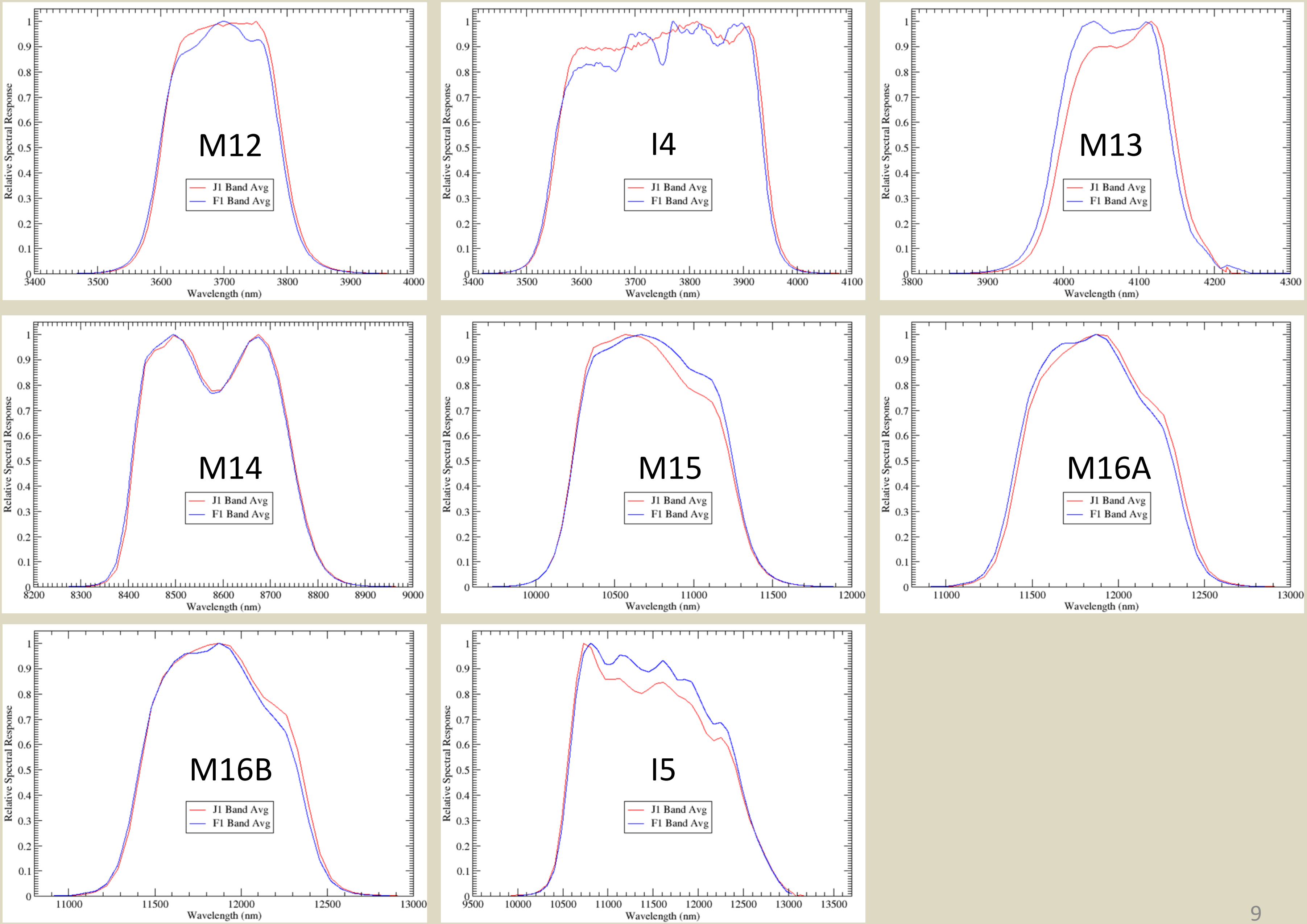
J1 VIIRS V1 Band Average RSR: RSB (1 of 2)



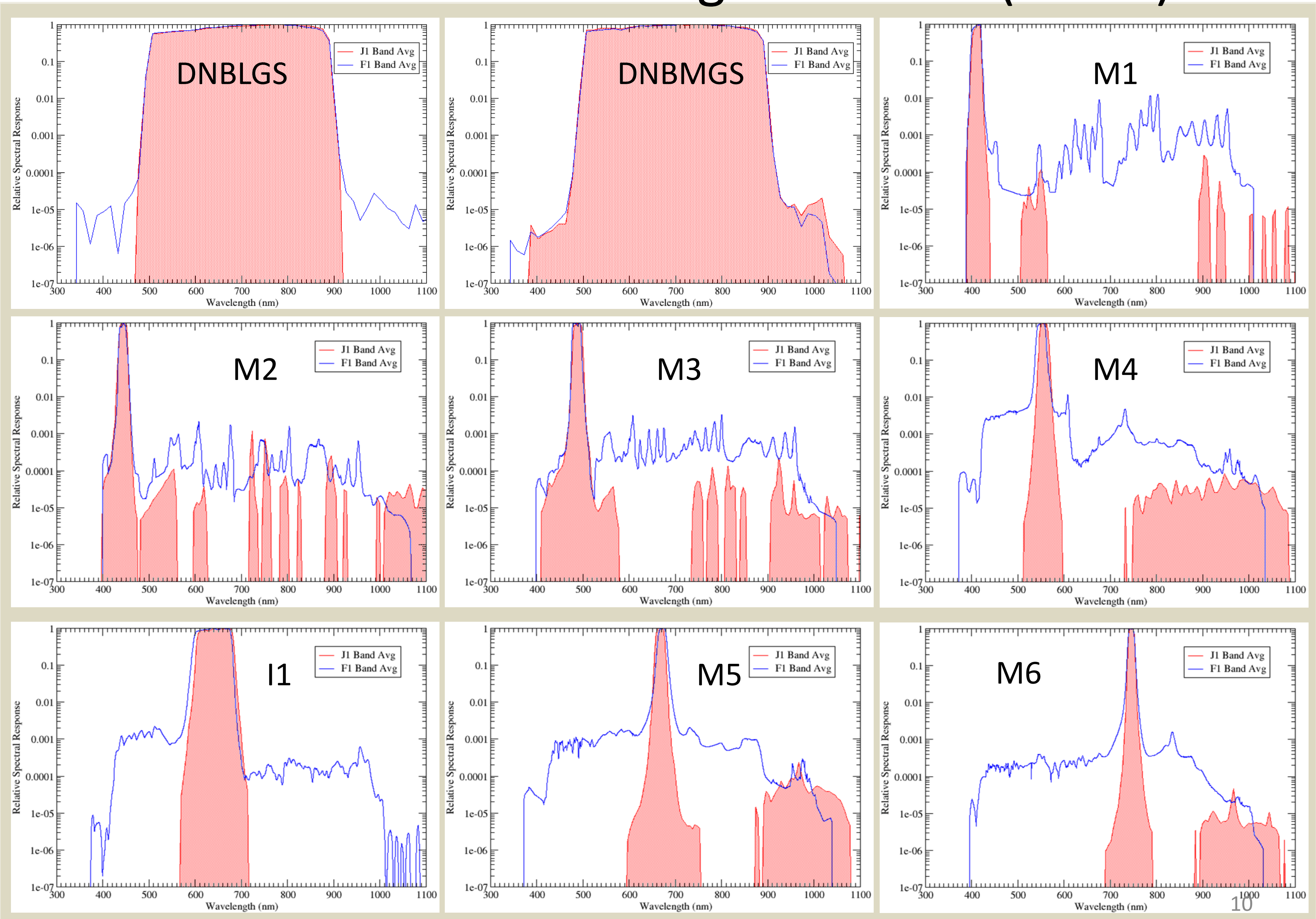
J1 VIIRS V1 Band Average RSR: RSB (2 of 2)



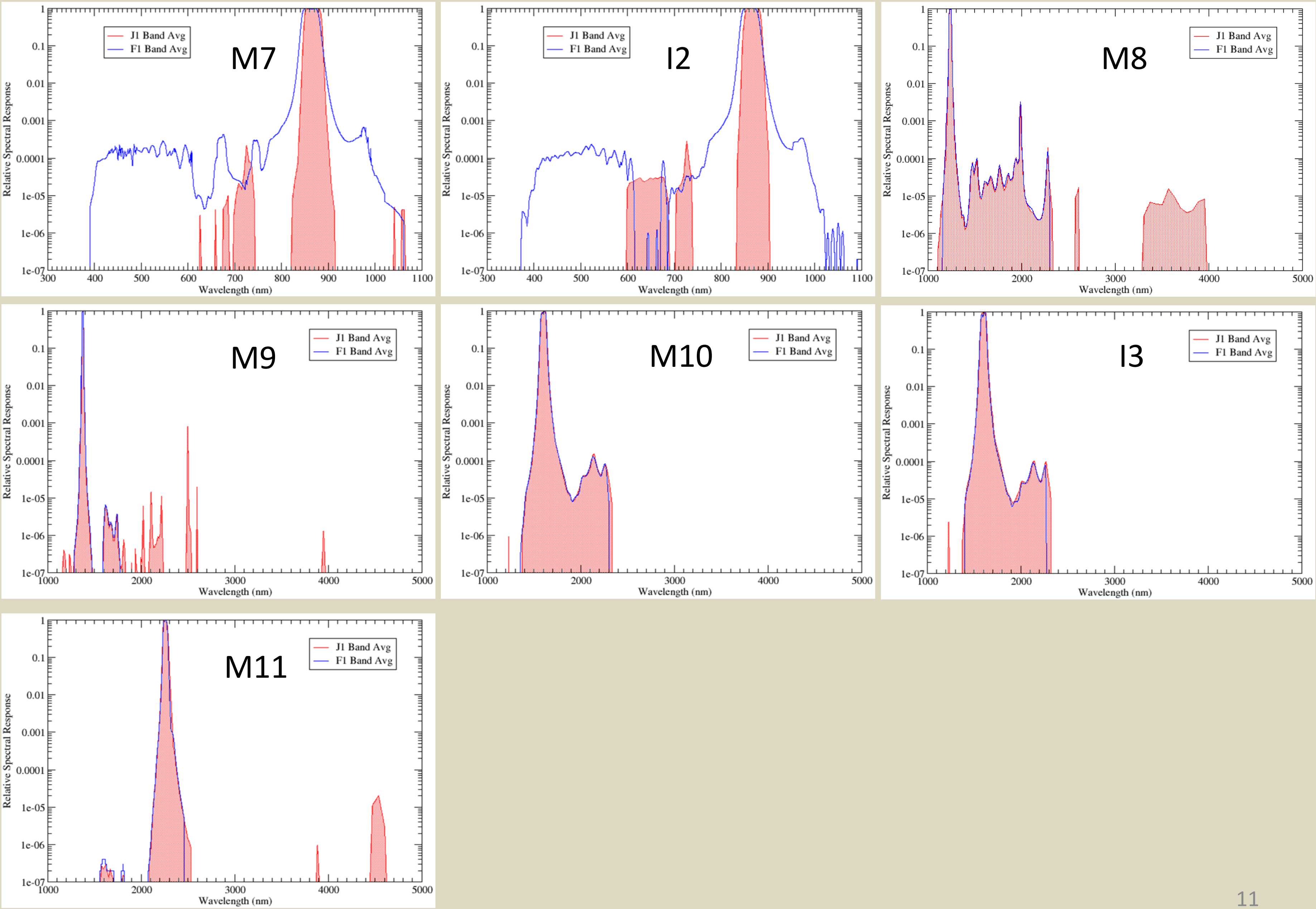
J1 VIIRS V1 Band Average RSR: TEB



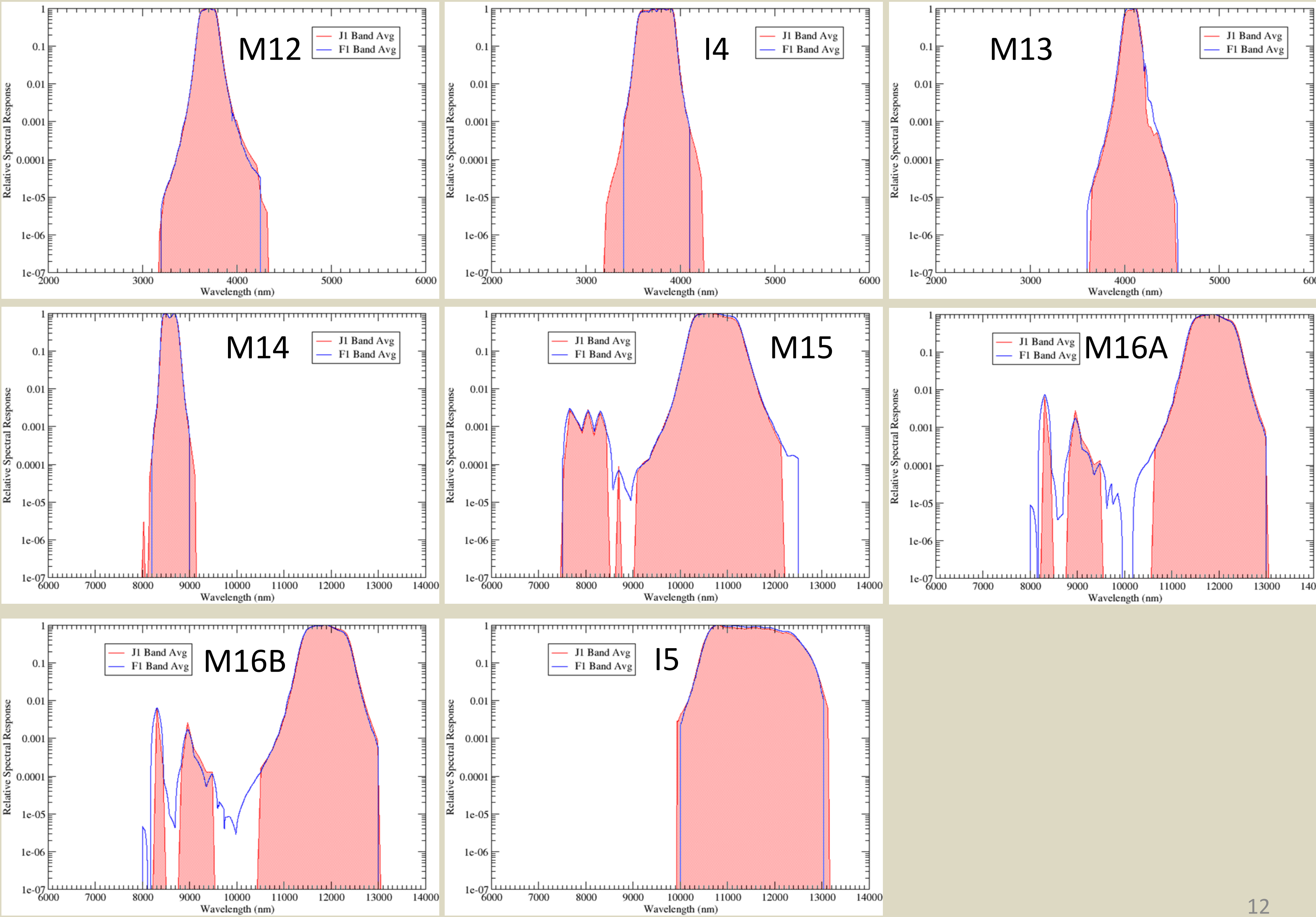
J1 VIIRS V1 Band Average RSR: RSB (1 of 2)



J1 VIIRS V1 Band Average RSR: RSB (2 of 2)



J1 VIIRS V1 Band Average RSR: TEB

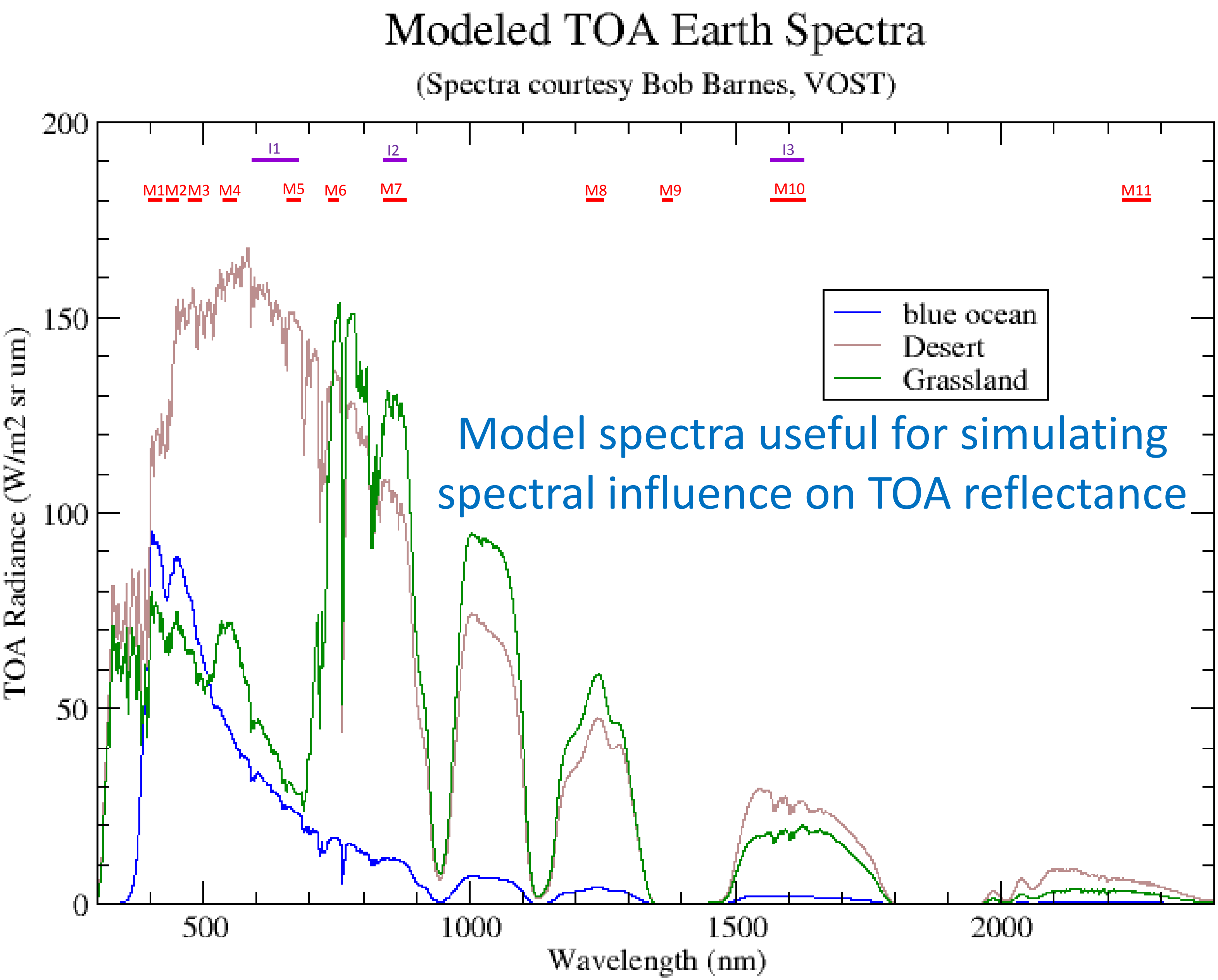


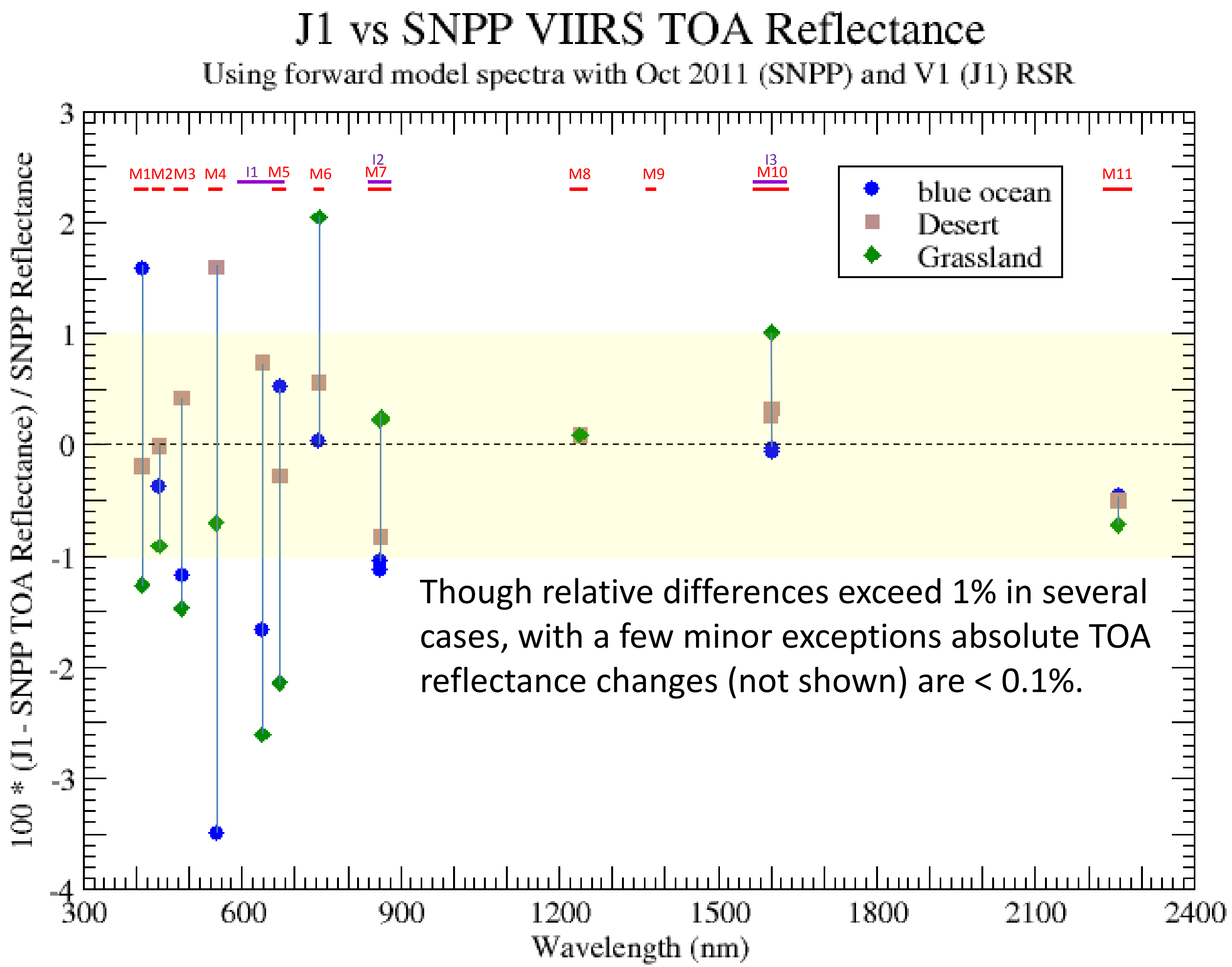
J1 VIIRS V1 Spectral Compliance (Band Avg RSR)

Non-compliant with specification (red cells)

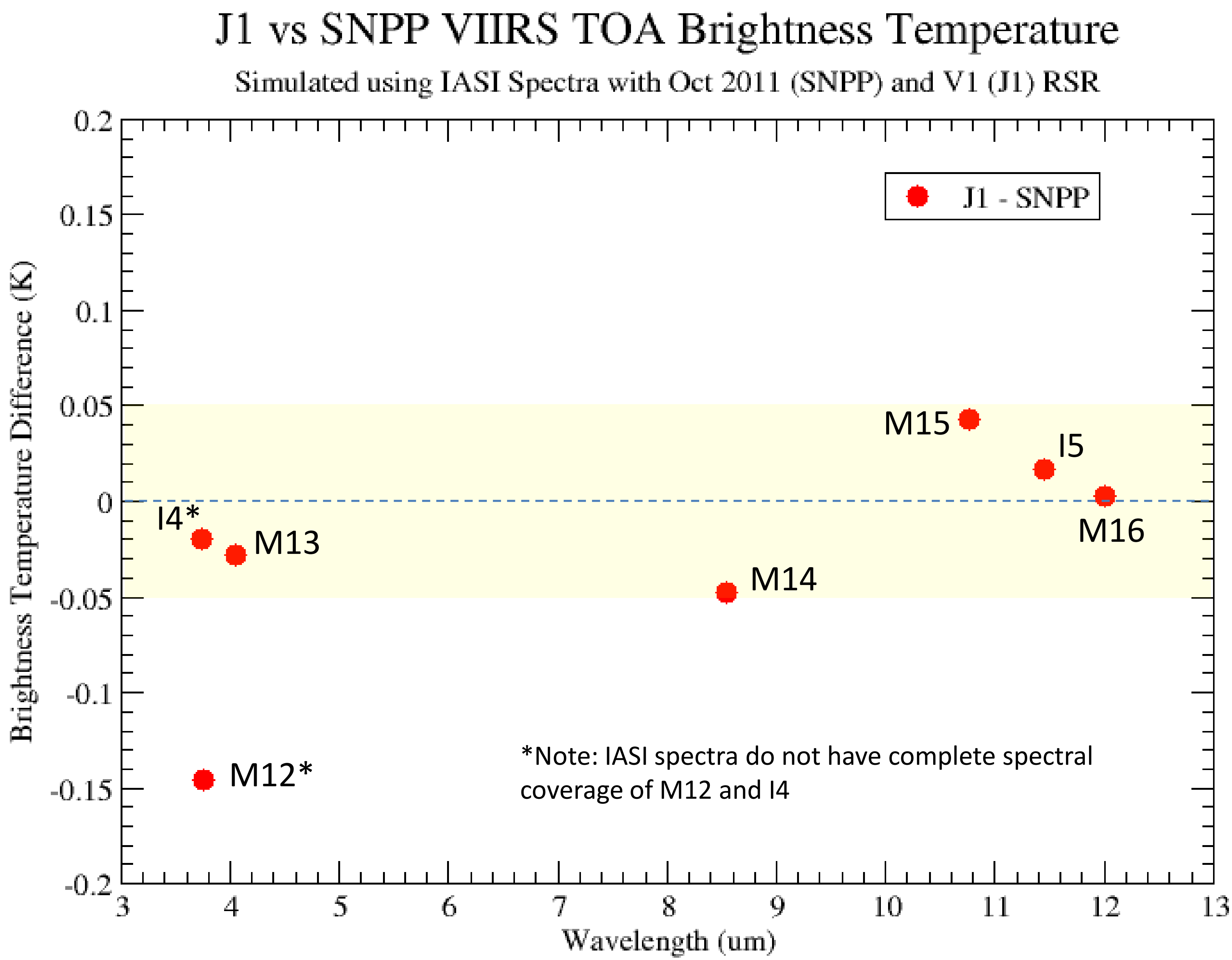
Focal Plane Legend: (yellow) - VisNIR; (green) - S/MWIR; (blue) - LWIR

Band	S-NPP Measured Center (nm)	JPSS-1 Measured Center (nm)	S-NPP Specified Bandwidth (nm)	JPSS-1 Measured Bandwidth (nm)	S-NPP Specified Lower 1% Limit (nm)	JPSS-1 Measured Lower 1% Limit (nm)	S-NPP Specified Upper 1% Limit (nm)	JPSS-1 Measured Upper 1% Limit (nm)	J1 Measured IOOB (%)	S-NPP Measured IOOB (%)
I1	637.8	643.0	81.6	78.6	583.2	593.9	686.6	693.6	0.07	0.33
I2	861.6	867.3	38.3	36.4	828.7	841.5	897.9	893.6	0.09	0.48
I3	1601.2	1603.2	58.9	60.7	1543.1	1544.3	1664.1	1667.7	0.44	0.51
I4	3743.5	3747.6	385.6	387.5	3473.0	3474.1	4009.0	4015.2	0.16	0.24
I5	11507.9	11483.1	1881.7	1875.1	10191.0	10170.8	13081.3	13090.6	0.08	0.65
M1	410.5	411.1	20.2	17.6	394.6	395.3	426.8	425.4	0.17	2.40
M2	443.0	444.8	15.1	17.0	431.1	429.3	458.6	457.9	0.30	0.39
M3	486.0	488.6	19.4	19.0	472.1	473.0	502.8	504.4	0.27	0.76
M4	550.6	556.3	19.6	18.5	529.4	540.0	572.3	573.7	0.24	3.92
M5	671.4	667.1	18.8	19.5	649.5	649.6	693.9	684.9	0.25	2.99
M6	745.3	746.0	14.1	13.5	730.5	733.9	760.4	758.0	0.23	1.70
M7	861.8	867.5	38.0	36.3	829.6	842.8	897.8	892.5	0.10	0.46
M8	1238.4	1238.4	26.1	26.1	1213.5	1214.0	1265.2	1264.9	0.48	0.59
M9	1375.3	1375.8	13.9	14.5	1362.1	1362.0	1390.0	1390.0	0.41	0.42
M10	1601.2	1603.8	59.4	60.2	1542.6	1545.7	1664.8	1667.6	0.43	0.48
M11	2257.1	2258.2	46.4	52.0	2211.6	2209.4	2303.0	2314.4	0.35	0.42
M12	3694.6	3697.9	192.4	194.8	3516.2	3519.1	3890.0	3893.8	0.33	0.38
M13	4065.8	4074.0	158.0	155.0	3900.5	3911.7	4213.7	4214.1	0.35	0.88
M14	8577.8	8580.3	340.8	340.1	8333.5	8336.3	8875.9	8879.3	0.19	0.30
M15	10743.6	10730.9	1014.4	1001.7	9918.7	9916.9	11649.9	11638.7	0.35	0.42
M16A	11861.4	11882.8	919.1	914.6	11095.1	11104.1	12670.0	12692.5	0.39	0.56
M16B	11869.1	11883.0	922.8	934.5	11098.3	11101.5	12678.7	12698.5	0.38	0.54


Modeled TOA Earth Spectra
(Spectra courtesy Bob Barnes, VOST)
TOA Radiance (W/m2 sr um)
Wavelength (nm)
200
150
100
50
0
500
1000
1500
2000
I1
I2
I3
M1
M2
M3
M4
M5
M6
M7
M8
M9
M10
M11
blue ocean
Desert
Grassland
Model spectra useful for simulating spectral influence on TOA reflectance



J1 vs SNPP VIIRS TOA Reflectance
Using forward model spectra with Oct 2011 (SNPP) and V1 (J1) RSR
M1
M2
M3
M4
I1
M5
M6
I2
M7
M8
M9
I3
M10
M11
blue ocean
Desert
Grassland
100 * (J1 - SNPP TOA Reflectance) / SNPP Reflectance
Wavelength (nm)
Though relative differences exceed 1% in several cases, with a few minor exceptions absolute TOA reflectance changes (not shown) are < 0.1%.


J1 vs SNPP VIIRS TOA Brightness Temperature
Simulated using IASI Spectra with Oct 2011 (SNPP) and V1 (J1) RSR
J1 - SNPP
M15
I5
I4*
M13
M14
M16
M12*
*Note: IASI spectra do not have complete spectral coverage of M12 and I4
Brightness Temperature Difference (K)
Wavelength (um)
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
3
4
5
6
7
8
9
10
11
12
13

Summary

- Govt-sponsored DAWG has performed an independent analysis of spectral test data leading to the V1 Release of J1 VIIRS RSR (under EAR99 protection). V1 replaces V0 Beta Release.
- Thanks to IFA redesign, J1 out-of-band response in VisNIR bands is compliant, a great improvement over F1. Performance similar to F1 performance on other spectral metrics.
- Spectral position and/or shape have changed noticeably for many bands compared to F1, but all are well characterized. Minor impact on SDR reflectances/brightness temperatures.
- V1 RSR are not an "at-launch" RSR product. A V2 Release is planned for later in 2015, adding NIST T-SIRCUS VisNIR measurements plus addressing CO_2 influence in M13.

J1 VIIRS
Geometric Calibration and Performance & On-Orbit Expectations

NASA VIIRS Characterization Support Team (VCST)
Geometric Calibration Group

Guoqing (Gary) Lin, SSAI/GSFC
Robert E. Wolfe, NASA/GSFC Code 619
Masahiro (Mash) Nishihama (retired)

NOAA STAR JPSS STM
College Park, Maryland
Wednesday, 26 August 2015

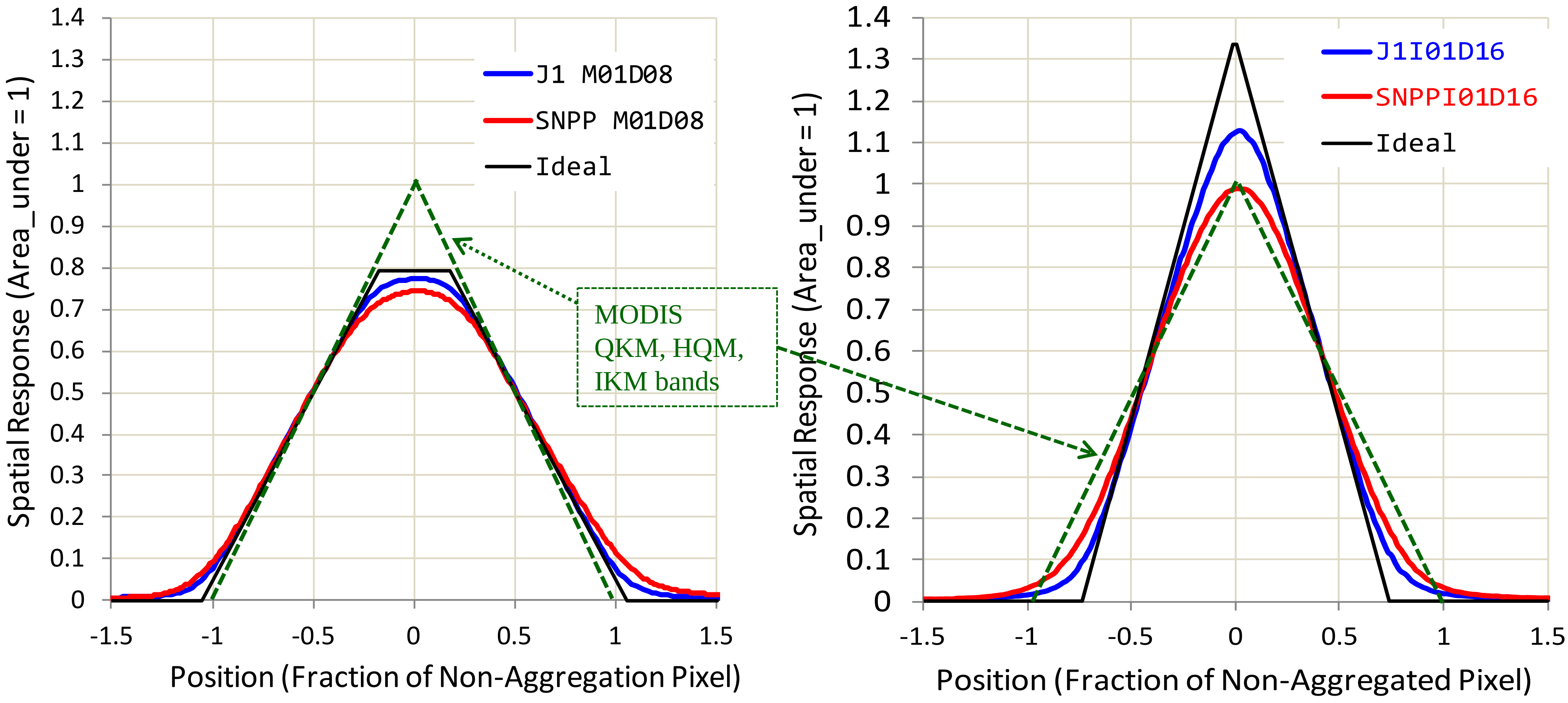
Acknowledgements

- Thanks the NASA instrument team led by Phil Driggers for the efforts in improving the J1 VIIRS optical system.
- Thanks the Raytheon VIIRS instrument test team for the efforts in addressing many concerns, including BBR related ones.
- Thanks the NOAA STAR team, NASA JPSS Project Science Office, NASA VCST Radiometric Calibration Team, UW spectral calibration team, Aerospace team, instrument on-site team & SC I&T on-site team for cooperation and assistance.
- Thanks Bin Tan, Zhangshi Yin and John Dellomo of the VCST Geo Group for data handling and processing.

Outline

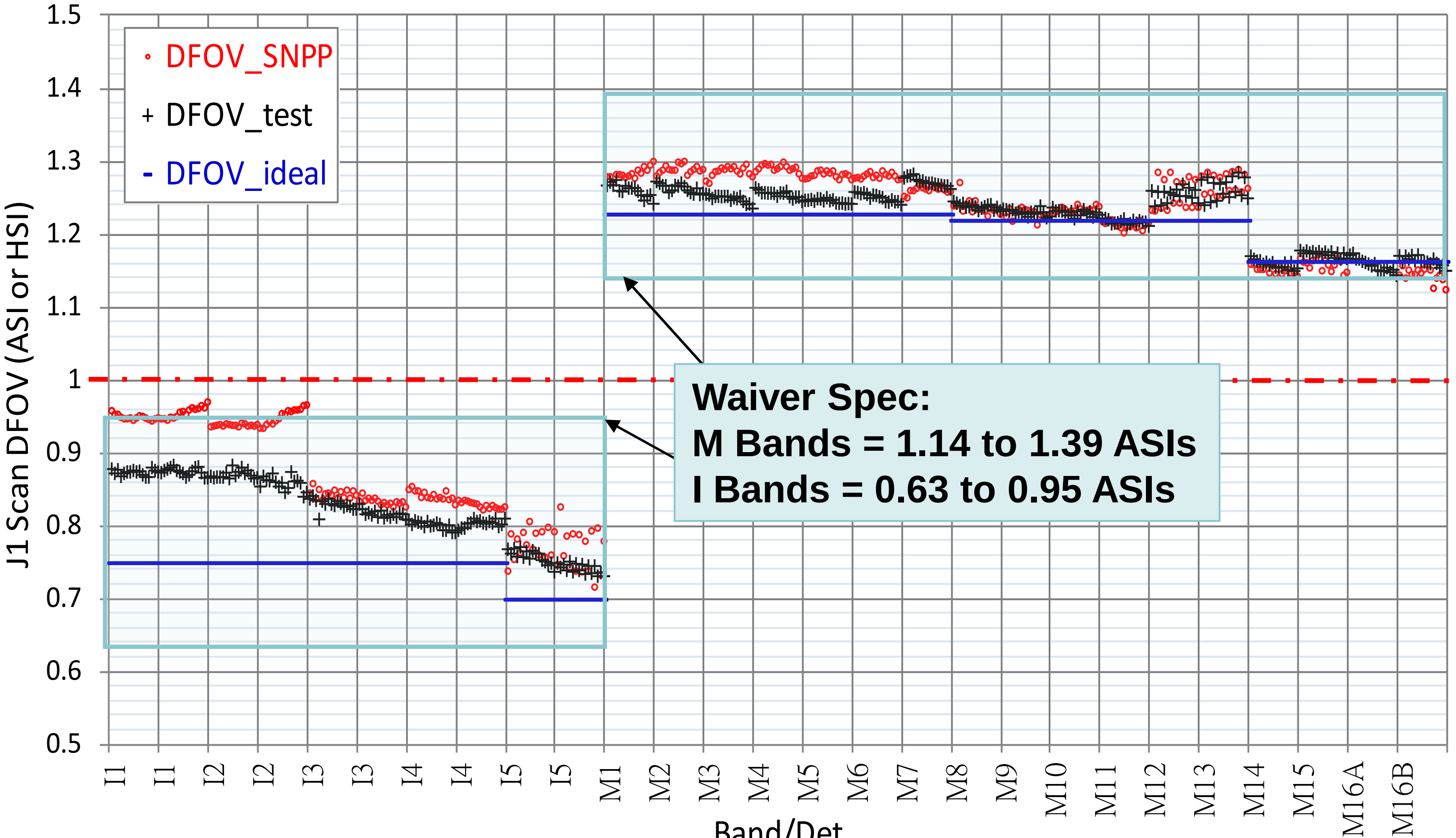
- Spatial Responses, LSF, DFOV, MTF
- Band-to-Band Co-registration (BBR)
- Pointing (for on-orbit geolocation)
- DNB Geometric Performance
- Concluding Remarks

Improved optical system



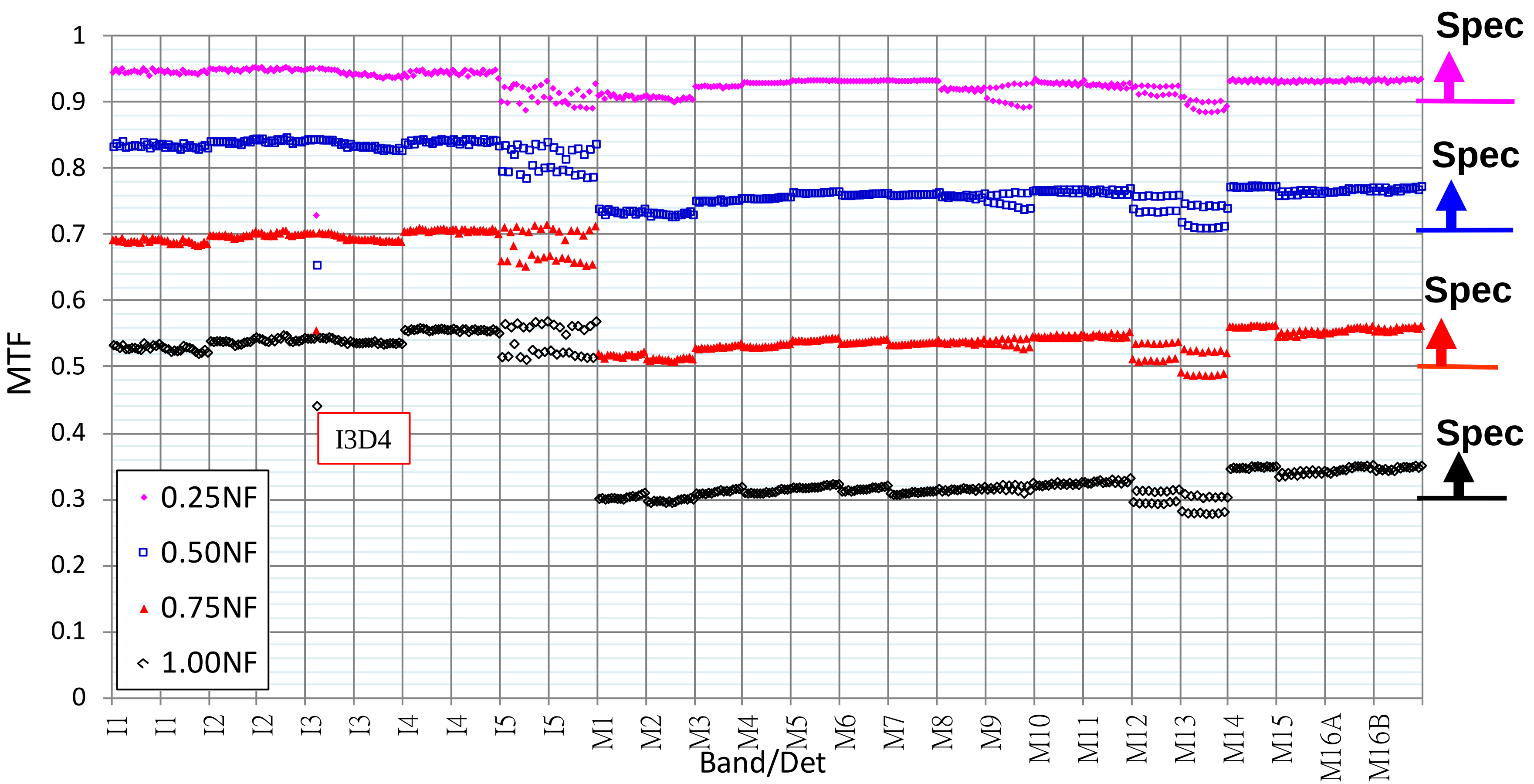
- J1 VIIRS scan direction line spread function is closer to ideal (non-defocus, non-optical scattering, non-test artifacts, etc) system spatial response than the SNPP VIIRS.
- Scan LSF side-lobes for M1&M2 are reduced, and for M11 have disappeared, as compared to those in SNPP VIIRS.

Scan LSF → DFOV



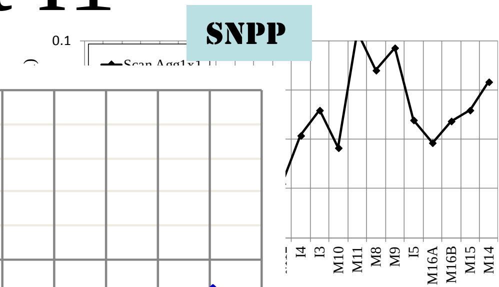
- J1 F2 optical performance is good (better than SNPP F1).
- M-Bands over-sample the earth, in the un-aggregated zones.
- I-bands under-sample the earth (TOA), mostly in the un-aggregated zones.
- Track direction LSFs are nearly square, IFOV ~= 1.0 ASI (or HSI on the ground).

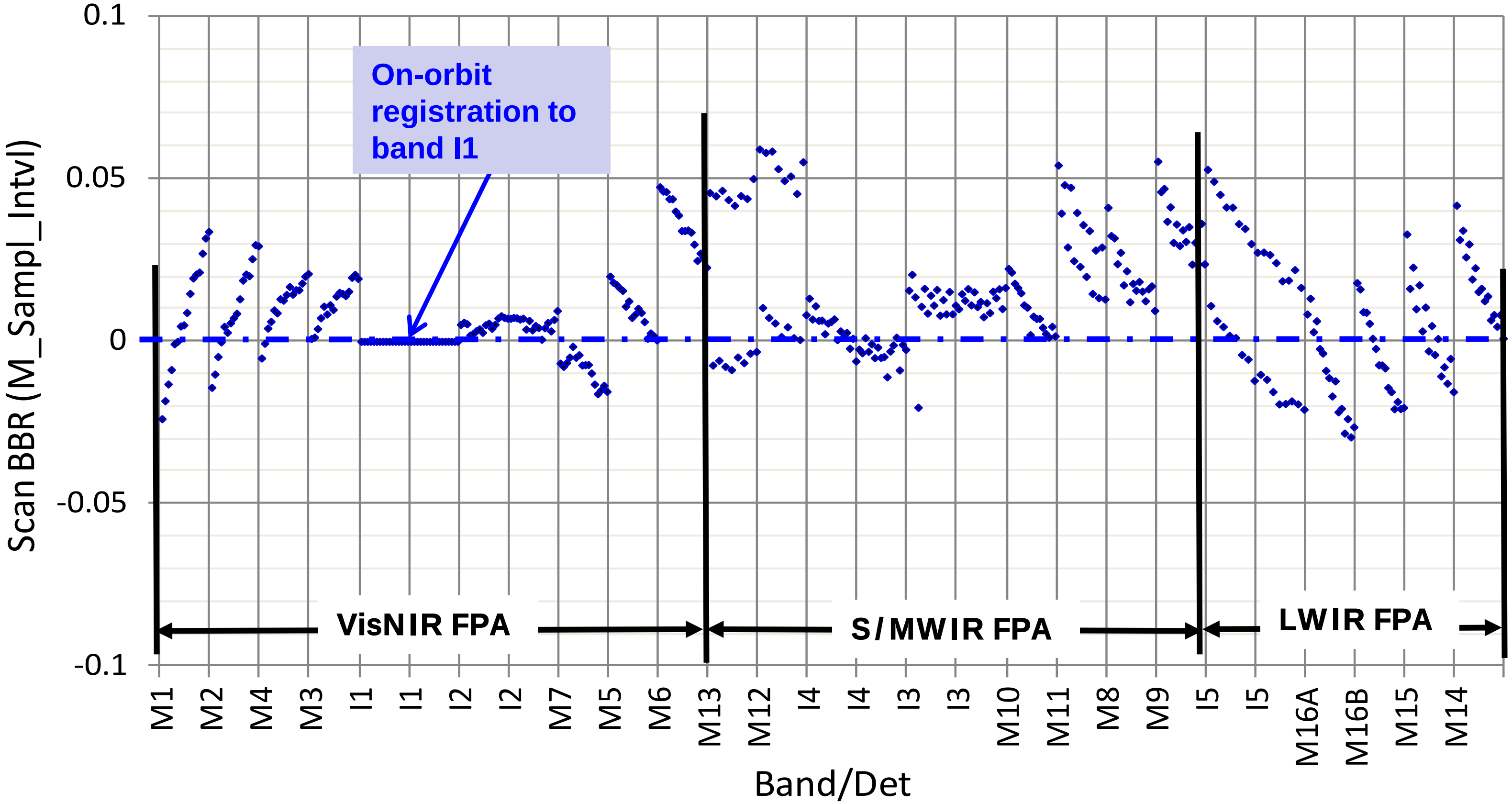
Scan LSF → MTF



- MTF for M-bands mostly meets specification.
- I-bands images are very sharp, at least at TOA (I3D4 under-performs but is still good in MTF).
- Track direction LSFs are nearly square, MTF ~= 0.63 at 1.00NF (Nyquist Frequency).

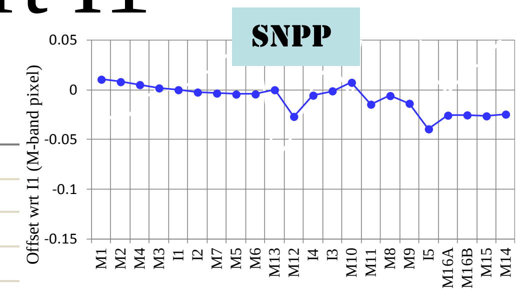
Scan (mis-)Registration wrt I1

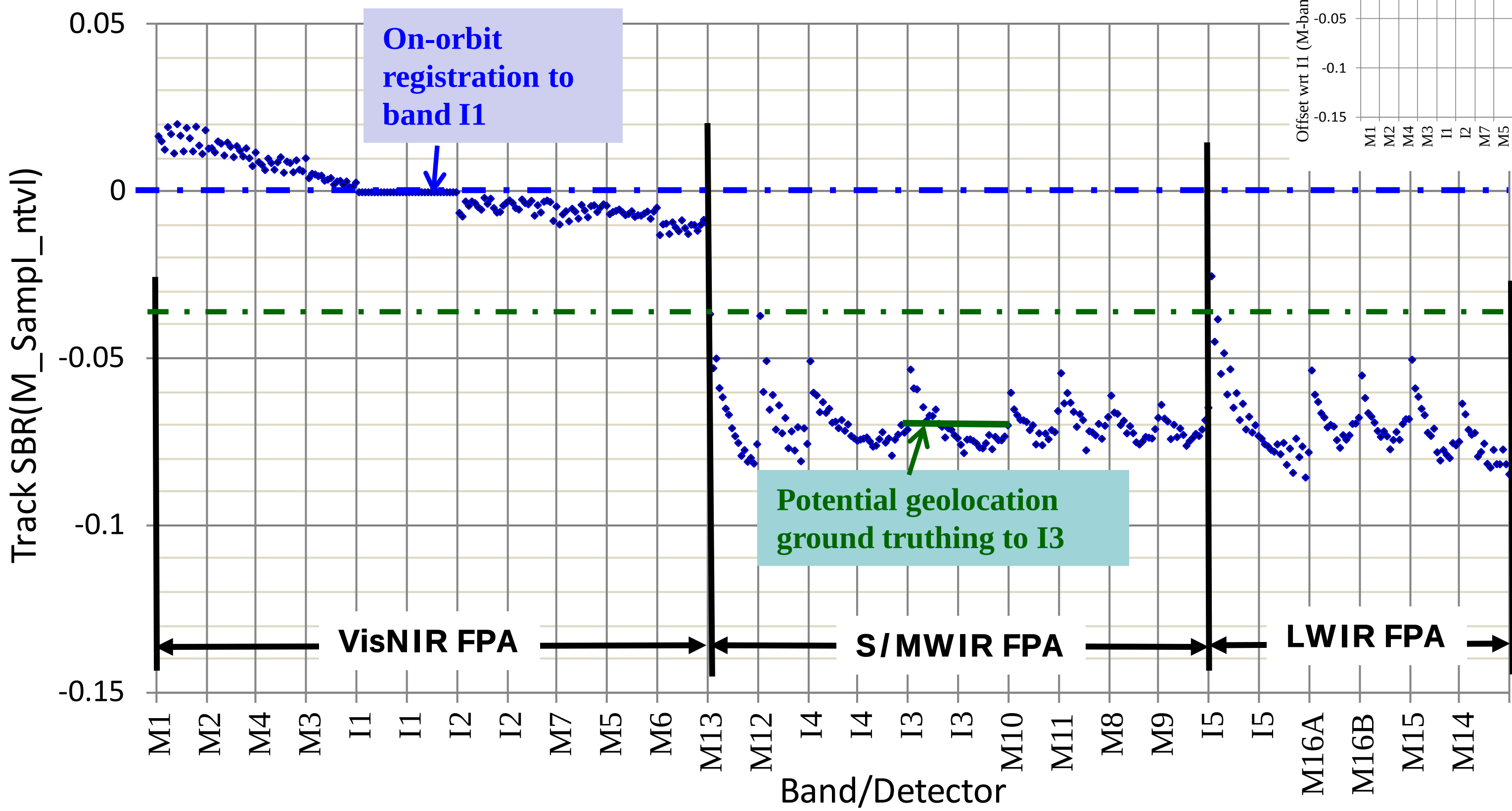




- The scan rate is nominal @1.786 sec/scan or 3.517 rad/sec (0.4% slower than SNPP).
- Mis-reg is < ~5% for M-band and < ~10% for I-bands in the un-agg zones.
- Data shows for un-agg zones. Mis-reg in Agg2x1 and 3x1 zones is 1/2 and 1/3 of those in the un-agg zones.

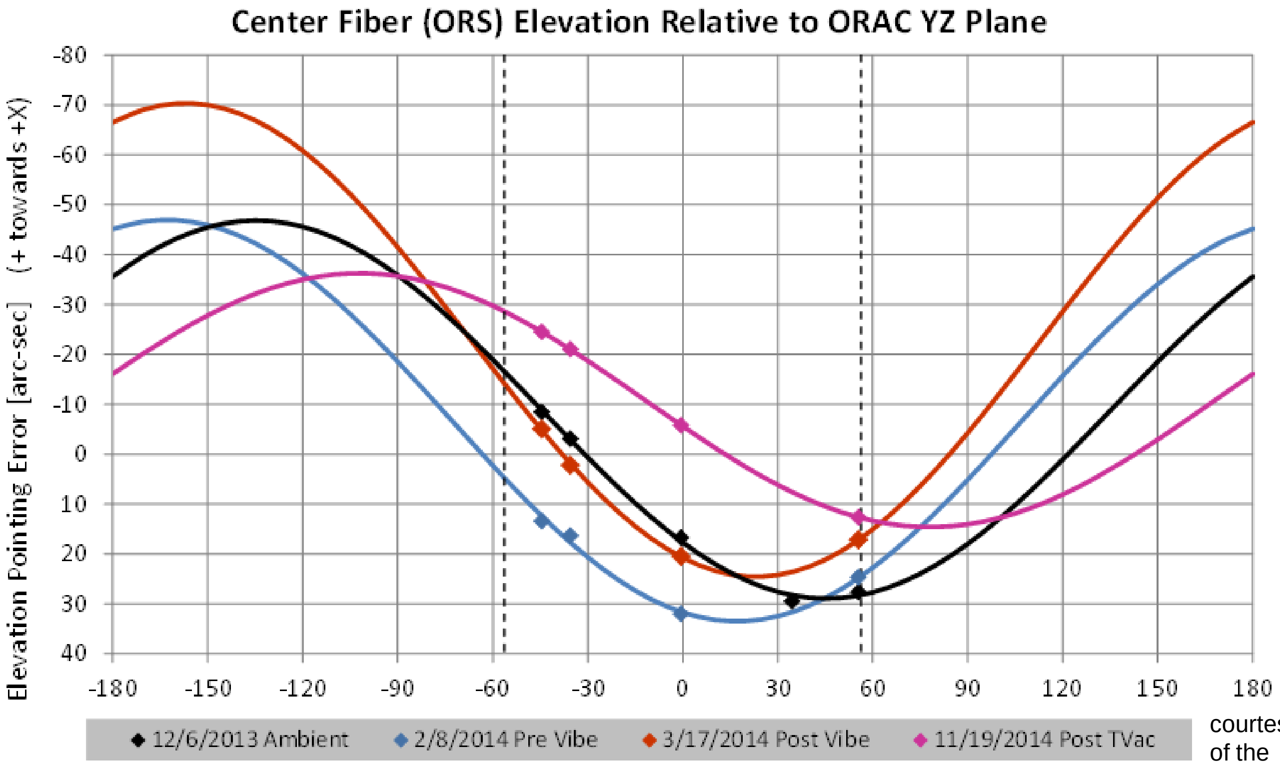
Track (mis-)Registration wrt I1





- Track direction bands co-register well within each FPA.
- Bands on SWMWIR and LWIR FPAs shifted from bands on VisNIR FPA, ~ 7% for M-bands and ~ 14% for I-bands. Mapping uncertainties are also affected, $RMSE = \sqrt{\sigma^2 + \mu^2}$.
- On-orbit ground truthing for geolocation is to I1. Thermal bands offsets are temperature dependent and a monitoring method is under development.

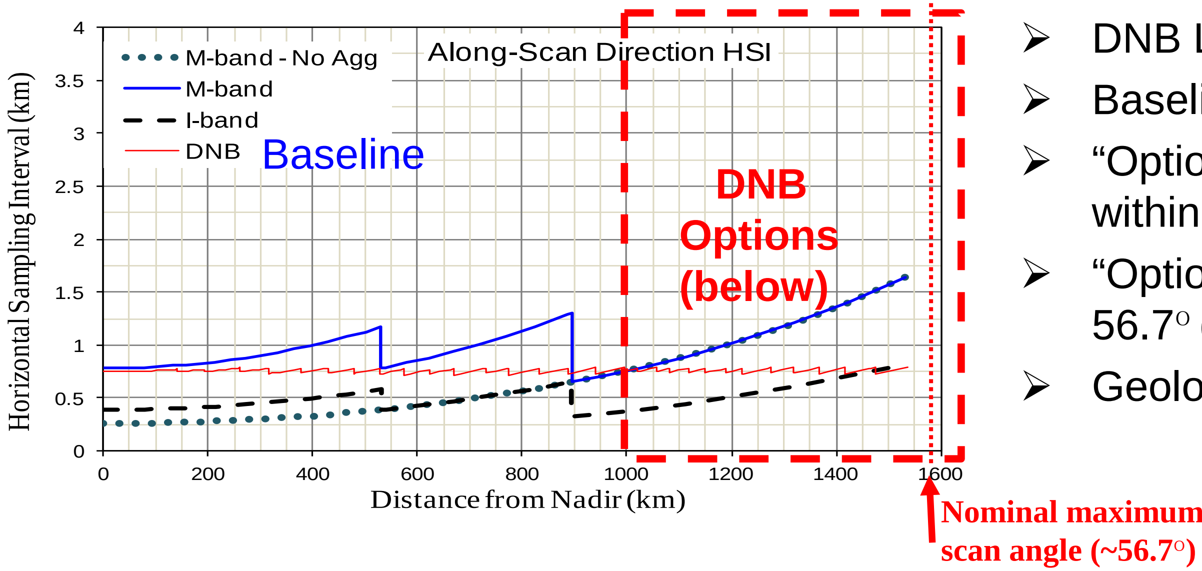
Pointing (for geolocation)



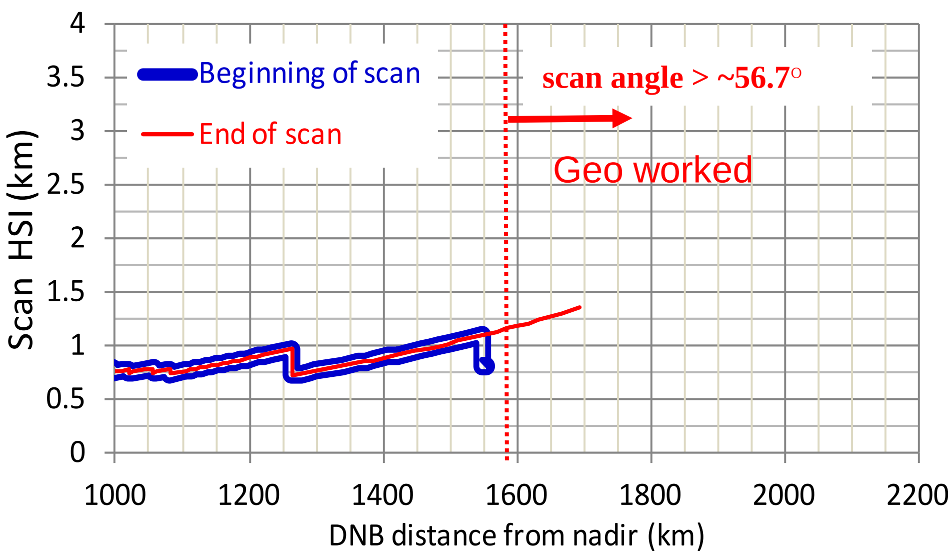
courtesy of the instrument vendor

- Scan plane was measured to within 1 arcmin.
- Instrument mounting, launch will add to the variation.
- On-orbit geolocation CalVal will remove biases and sub-pixel accuracy is expected for M- & I-bands.

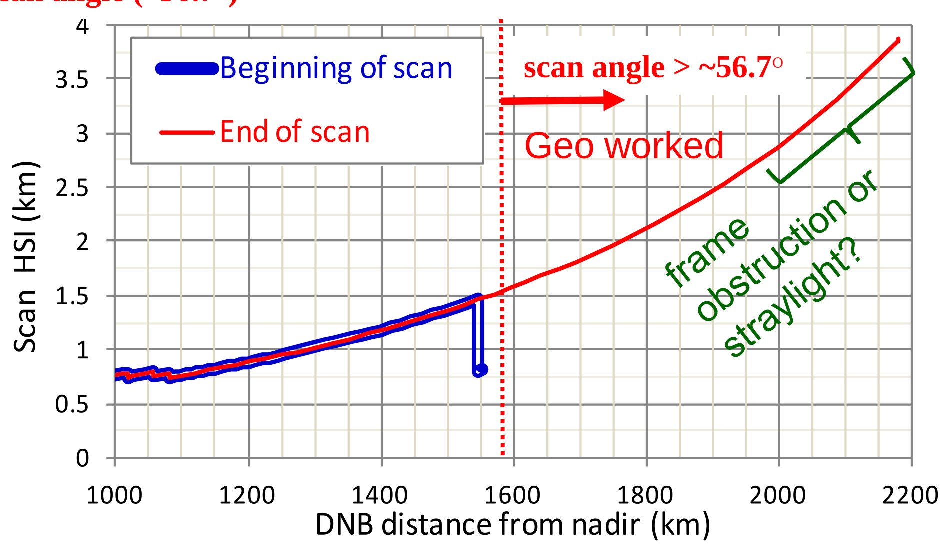
DNB Geometric Performance



- DNB LSFs are nearly square.
- Baseline HSI is ~ 750 m.
- “Option21-26” has HSI max of 1.1 km within 56.7° (up to 1.4 km @57.6°).
- “Option21” has HSI max of 1.6 km within 56.7° (up to 3.9 km @60.5°).
- Geolocation worked beyond 56.7°.

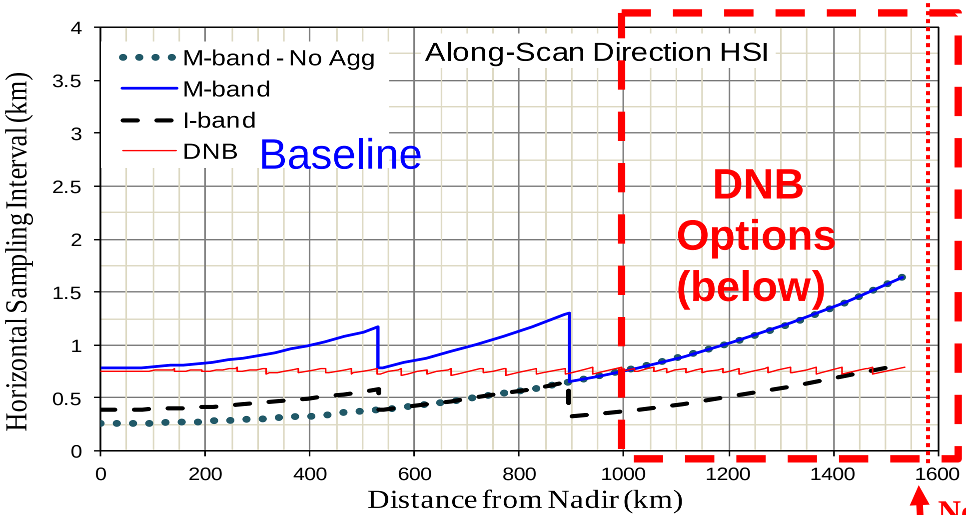


“Option21-26”



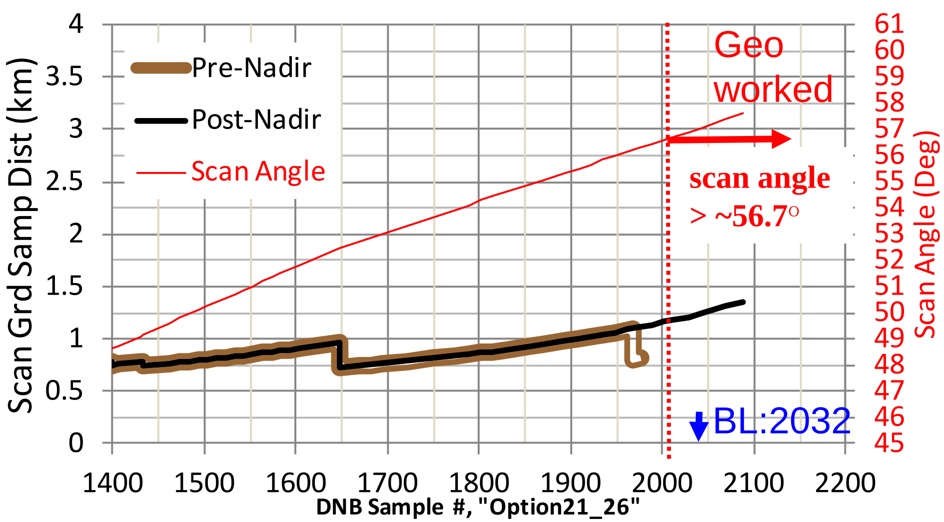
“Option21”

DNB Geometric Performance

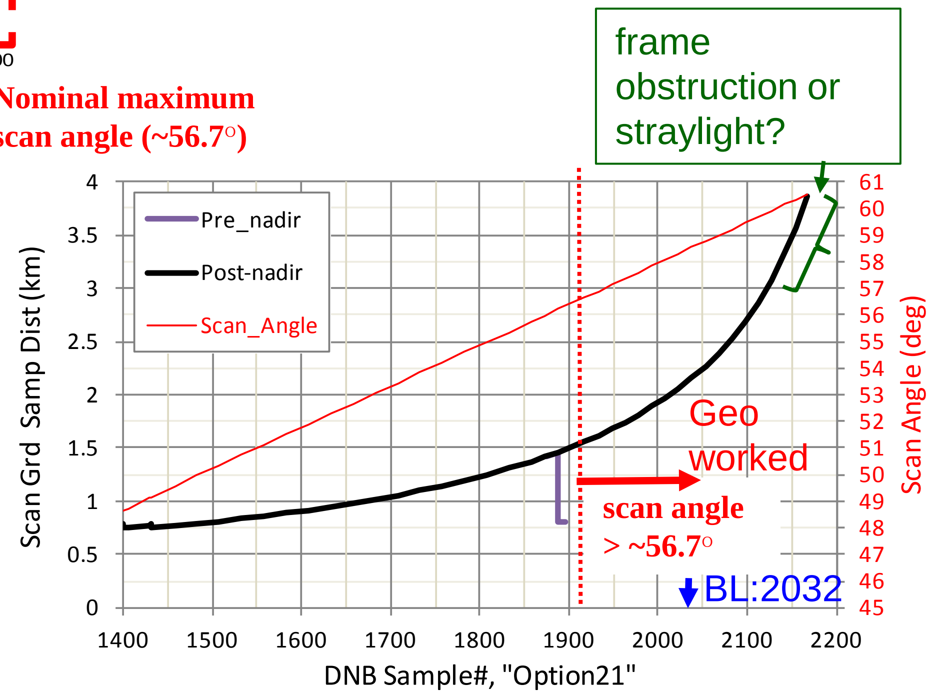


- DNB LSFs are nearly square
- Baseline HSI is ~ 750 m
- "Option21-26" has HSI max of 1.1 km within 56.7° (up to 1.4 km @57.6°)
- "Option21" has HSI max of 1.6 km within 56.7° (up to 3.9 km @60.5°)
- Geolocation worked beyond 56.7°.

Nominal maximum scan angle (~56.7°)



"Option21-26"



"Option21"

Concluding Remarks

- J1 VIIRS has good optical performance (better than SNPP).
- J1 VIIRS scan rate is nominal @1.786 sec/scan or 3.517 rad/sec (SNPP VIIRS is @ 1.779 sec/scan or 3.531 rad/sec).
- J1 VIIRS BBR aligns well in scan direction.
  - However, in the track direction, bands (**I3-5, M8-16**) on the CFPAs are shifted from bands (**I1-2, M1-7**) on VisNIR FPA, ~ 7% for M-bands and ~ 14% for I-bands. Mapping uncertainties will be affected.
- Pointing was measured. On-orbit geolocation CalVal will remove biases and sub-pixel accuracy is expected for M- & I-bands.
- J1 DNB geometry is TBD (1 baseline, 2 options).
  - NOAA STAR will assess J1 DNB on-orbit geolocation accuracy.

Backup

1. Summary of geometric calibration and performance
2. Image Resolution Specifications – FOVs

Summary

- J1 VIIRS optical system was re-worked and has better optical performance than SNPP → satisfactory DFOV and MTF.
- J1 VIIRS scan rate is nominal @1.786 sec/scan or 3.517 rad/sec (SNPP VIIRS is @ 1.779 sec/scan or 3.531 rad/sec).
- J1 VIIRS BBR aligns well in scan direction.
  - However, in the track direction, bands (**I3-5, M8-16**) on the CFPAs are shifted from bands (**I1-2, M1-7**) on VisNIR FPA, ~ 7% for M-bands and ~ 14% for I-bands. Mapping uncertainties will be affected.
- Pointing was measured. On-orbit geolocation CalVal will remove biases and sub-pixel accuracy is expected for M- & I-bands.
- J1 DNB geometry is TBD (1 baseline, 2 options).
  - NOAA STAR will assess J1 DNB on-orbit geolocation accuracy.

Image Resolution Specifications – FOVs

- Scan Dynamic Field of View (DFOV), including integration drag
  - = Full Width Half Maximum (FWHM) of Line Spread Function (LSF)
  - I-bands, original Spec (actual dominated by integration_drag & EFL)
    - I1, I2: 114 (116) µrad
    - I3: 108 (116) µrad
    - I4: 109 (116) µrad
    - I5: 102 (109) µrad

    ±10% for spec
  - M-bands: original Spec (actual dominated by detector_size & EFL)
    - M1 to M11: 382 (381) µrad
    - M12, M13: 379 (378) µrad
    - M14, M15: 362 (361) µrad
    - M16: 364 (361) µrad

    ±5% for spec
- Track IFOV, without integration drag
  - Given by FWHM of LSF curve, nearly square
  - I-bands: IFOV = 445.5 µrad ±5%
  - M-bands: IFOV = 891 µrad ±5%

- Note: angular sampling interval (ASI) (and horizontal sampInterval (HSI)) at nadir w/ avg Alt=838.8 km
  - I-bands scan ASI = 155.21 µrad (130 m @ nadir) ->3 ASIs = 465.6 µrad (391 m @ nadir)
  - I-bands track ASI = 445.5 µrad (381 m @ nadir)
  - M-bands scan ASI = 310.42 µrad (260 m @ nadir) ->3 ASIs = 931.3 µrad (790 m @ nadir)
  - M-bands track ASI = 891 µrad (762 m @ nadir)

Expanding validation capabilities for J1 VIIRS

Sirish Uprety[a], Changyong Cao[b], Wenhui Wang[c] Xi Shao[d],
CIRA, Colorado State University[a],
NOAA/NESDIS/STAR[b], ERT[c], UMD[d]

Date: August 26, 2015

Outline

- Introduction
- Sensor on-orbit calibration/validation
  - Characterize radiometric stability and accuracy
- S-NPP VIIRS validation techniques
  - Sensor intercomparison using SNO/SNO-x
    - Reference standards: Instruments such as MODIS, OLI, further expanded to GOSAT TANSO-FTS.
  - Pseudo-invariant calibration sites
  - Deep Convective Clouds (DCC)
  - Comparing SDR products
- Summary

Introduction

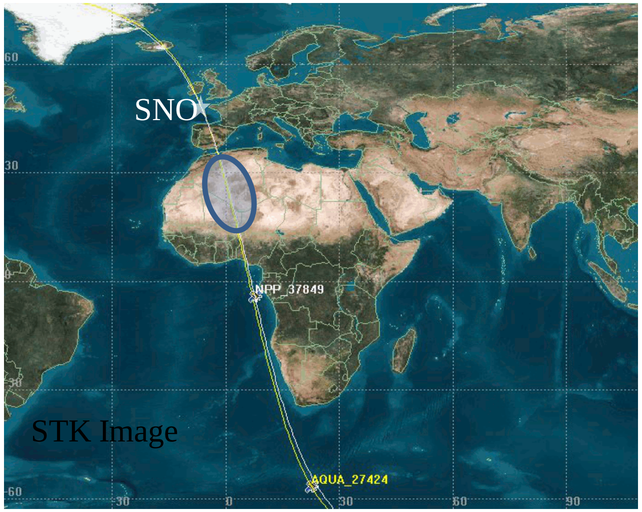
- Satellite instrument degradation is a common phenomena.
- If characterized well, data can easily meet high standard radiometric accuracy.
- Radiometric validation
  - assess the stability and accuracy: independently verifying the instrument performance
  - tracks how well the onboard calibration system is.
  - results can be used as feedbacks to further improve the calibration.
- VIIRS calibration stability and accuracy are continuously monitored using independent methods since early launch.
- Similar to S-NPP VIIRS, postlaunch radiometric validation is critical for J1 VIIRS
  - Primary motive is to ensure that the data quality is well within the specification.
  - Monitoring calibration stability through independent techniques.
    - trending the instrument over vicarious calibration sites, Lunar and DCC.
  - Characterizing radiometric accuracy
    - comparing with other well calibrated instruments.
    - vicarious calibration using underflights during satellite overpass.

S-NPP VIIRS Radiometric Validation

- Every radiometric validation technique has its own limitations so multiple techniques are used.
- Instrument comparison to evaluate radiometric accuracy and consistency
- Reference instruments used in comparison are AQUA MODIS, Landsat-8 OLI, and GOSAT TANSO-FTS (mainly for CO2 absorption M10 band).
- Hyperspectral measurements from EO-1 Hyperion, AVIRIS along with radiative transfer models such as MODTRAN, 6S are used:
  - characterize the spectral characteristics of calibration sites
  - quantify the spectral differences between the instruments during intercomparison.
- Radiometric validation techniques used are:
  - SNO
  - SNO-x
  - Vicarious Calibration Sites
  - Deep Convective Clouds
  - Lunar Trending
  - SDR product comparison from different agencies

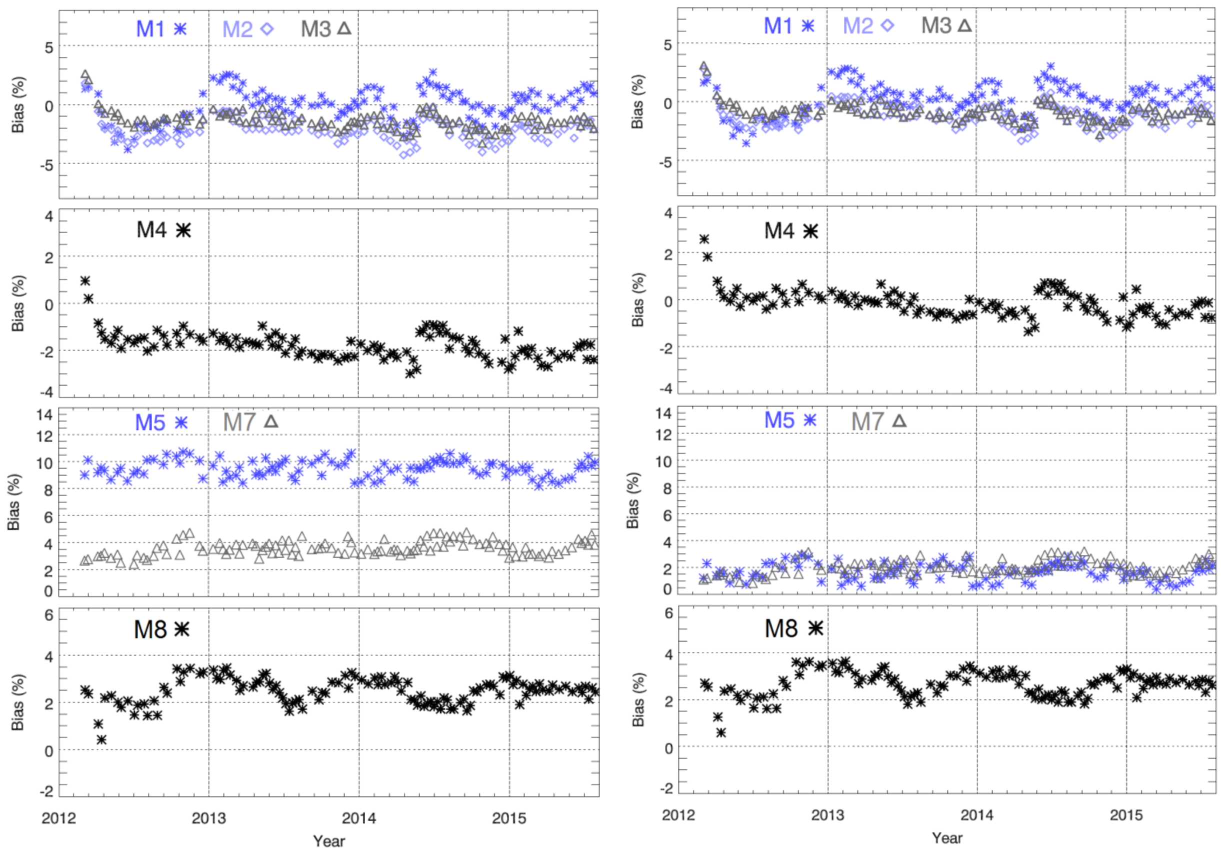
Simultaneous Nadir Overpass (SNO)

- **SNO**: Comparison of simultaneous measurements from two or more instruments at their orbital intersection with almost identical viewing conditions
- Orbital intersection usually occurs at high-latitude polar region for polar orbiting satellites
- Extended SNO (**SNO-x**) in low latitudes is an approach inherited from SNO approach that extends orbits to low latitudes for inter-comparing sensors over a wide dynamic range such as over ocean surface, desert targets, green vegetation etc.
- VIIRS and MODIS sensors are compared at overlapping regions of extended SNO orbits at North African deserts and over ocean to assess radiometric bias.
- This approach will be adopted for J1 to evaluate its radiometric performance.



VIIRS Comparison with MODIS (SNO-x)

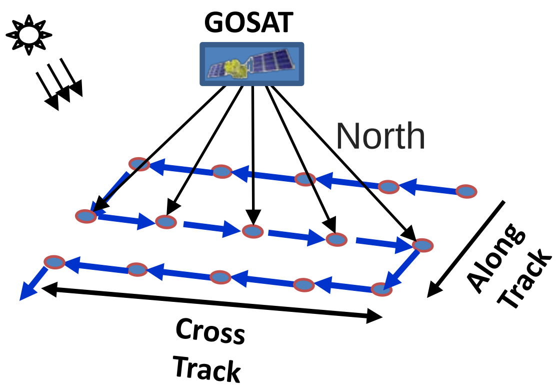
Before Spectral correction   **After** Spectral correction

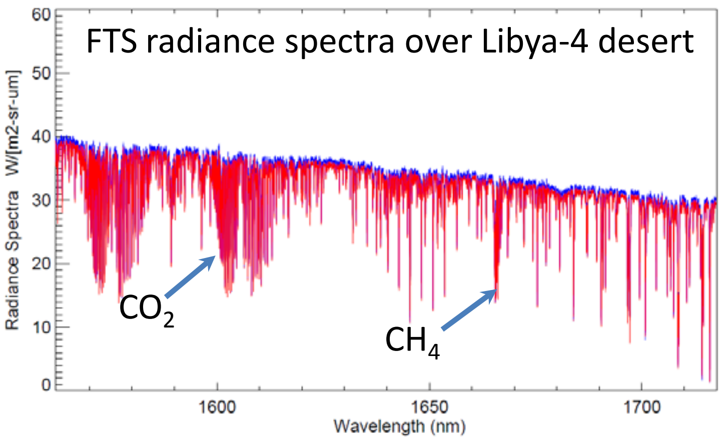


- VIIRS bias estimated through SNO-x by comparing with AQUA MODIS *(Uprety et al. 2013, JTech)*
- The bias suggested that VIIRS radiometric performance mostly meet requirements (± 2%)
- Bias trends are very important to characterize the instrument stability and radiometric accuracy
- Similar intercomparison will be done for J1 VIIRS to evaluate its bias (short/long term)

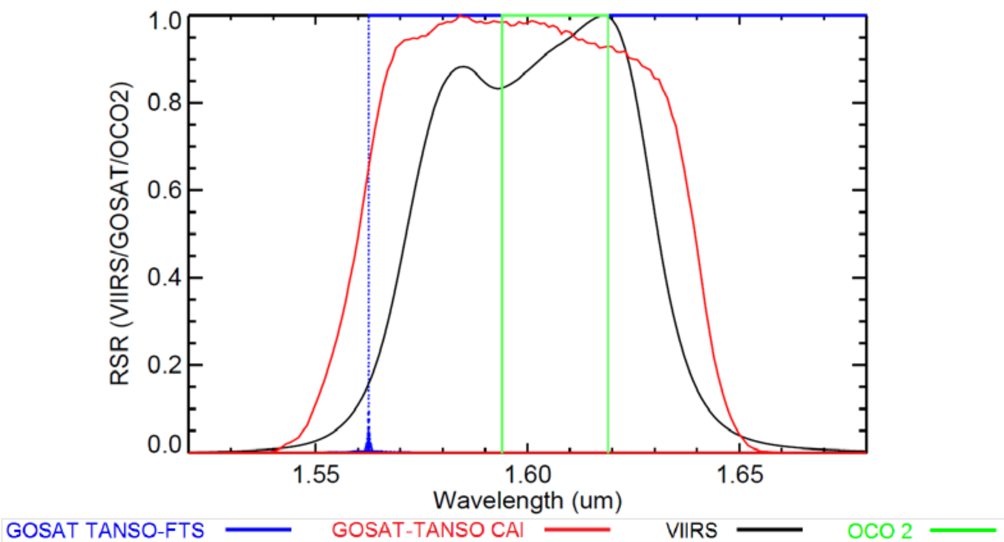
GOSAT TANSO-FTS for VIIRS M10 Validation

- GOSAT is a cooperative project among JAXA, NIES and the MOE.
- Launched on January 23, 2009 with payloads: Thermal and Near Infrared Sensor for Carbon Observation - Fourier Transform Spectrometer (TANSO-FTS) and a Cloud and Aerosol Imager (TANSO-CAI)
- TANSO-FTS:
  - RSB bands: 0.76, 1.64, and 2.00 um
  - Spectral resolution: 0.2 wavenumbers (about 0.05 nm at 1.6 μm)
  - Spatial Resolution: ~10.5 km
- There are not very good references to validate M10. MODIS has a number of inoperable detectors for matching band.





GOSAT FTS and VIIRS



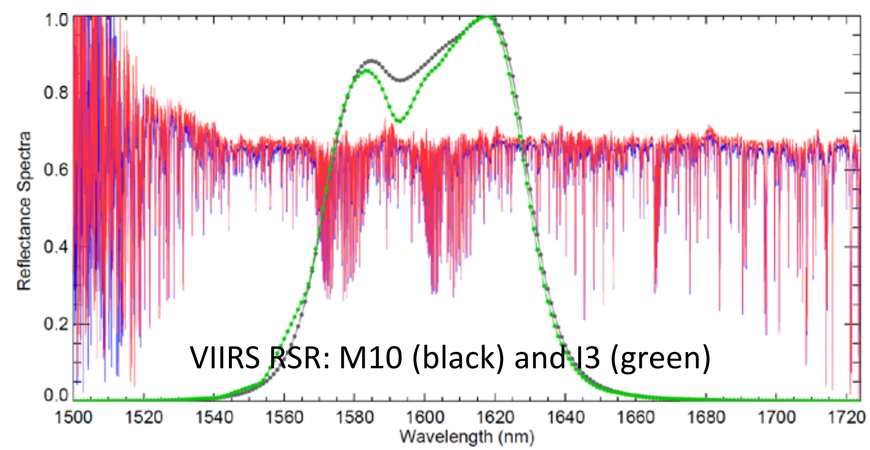
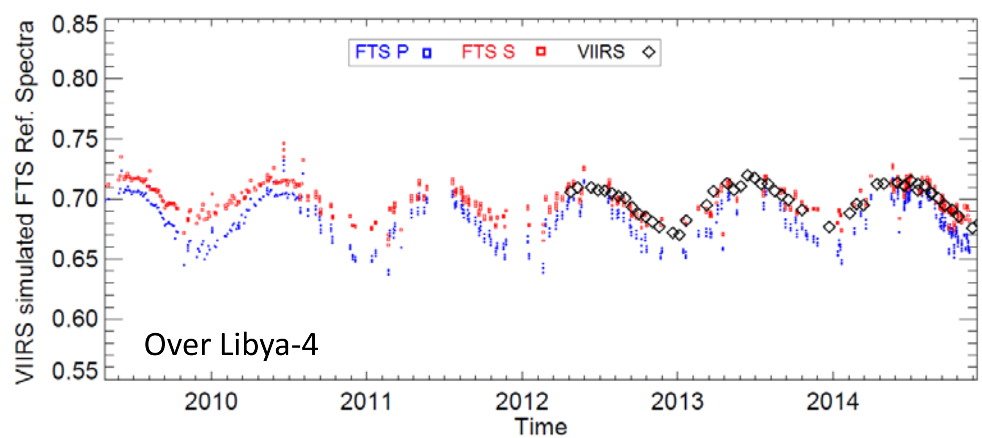


Figure. GOSAT FTS reflectance spectra for P and S polarized reflectance over Libyan Desert.

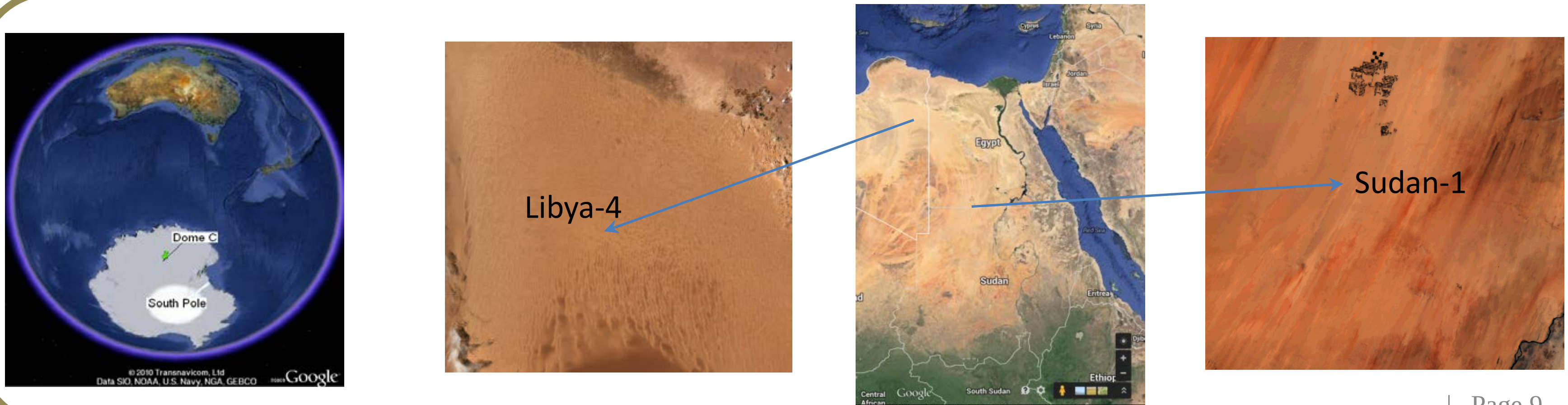
- FTS hyperspectral measurements over Libya-4 convolved with VIIRS RSR and compared.
- VIIRS M10 and FTS S polarized light agree very well to within 0.5% ± 0.9%.
- In future, planning to use OCO-2 as well.



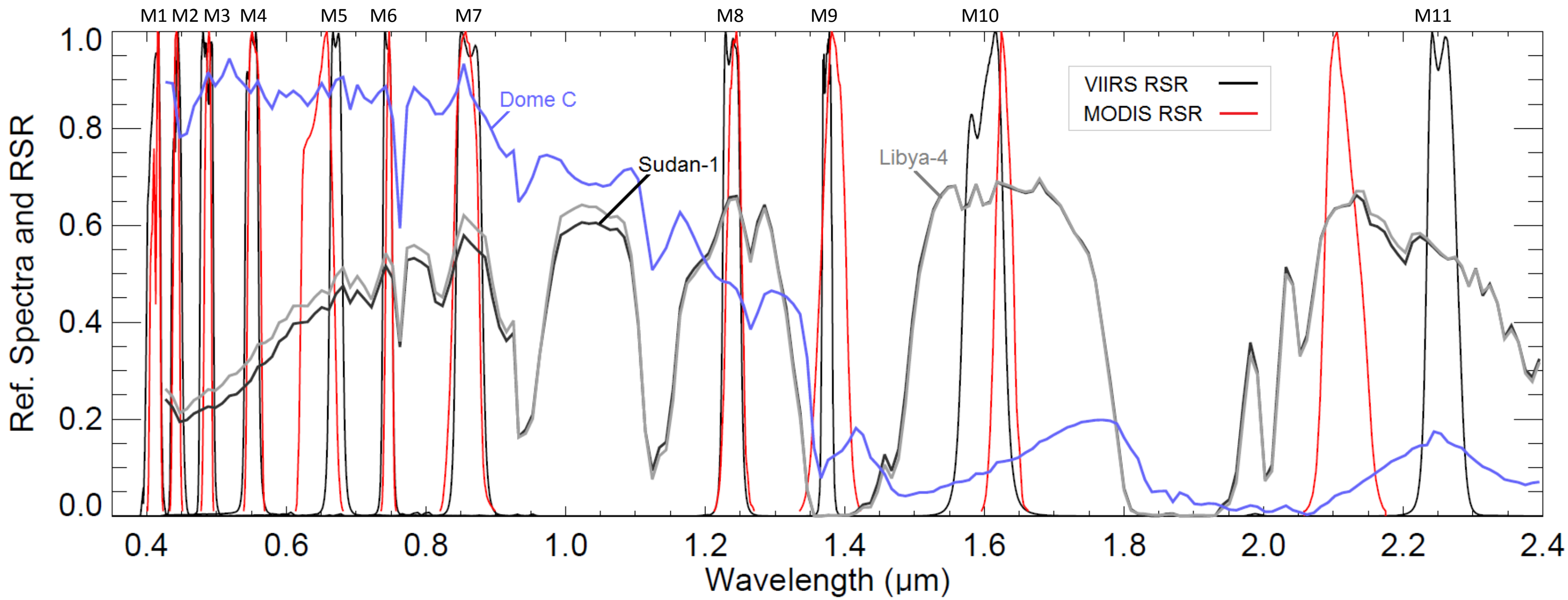
Ref: Uprety et al. 2015 (submitted to Jtech)

Vicarious Calibration Sites

- Vicarious Calibration Sites such as deserts, snow sites, etc are used as independent sources of radiometric cal/val for satellite instruments either with or without onboard calibration devices
- These sites can be used to characterize the sensor degradation, validate the radiometric performance, perform the inter-comparison between sensors etc.
- VIIRS calibration performance has been continuously monitored and characterized using a number of Saharan desert calibration sites such as Libya-4 and Sudan-1 deserts, ocean sites such as near Moby in Hawaii, Antarctica Dome C snow flat.

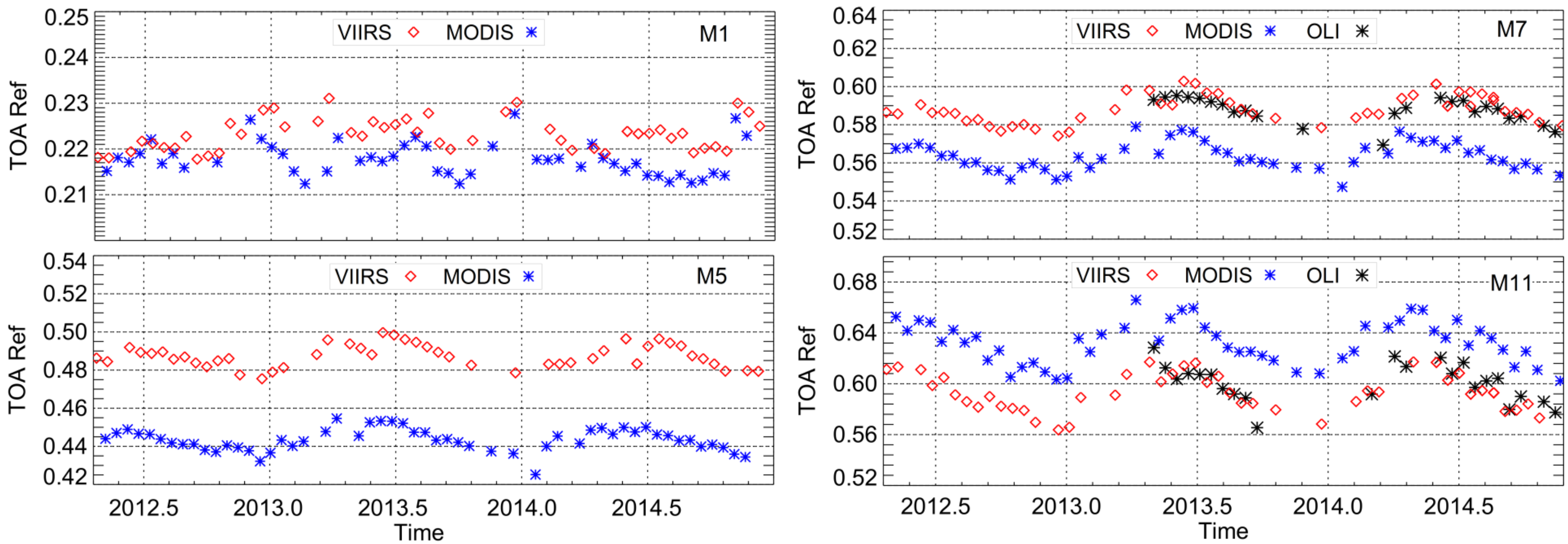


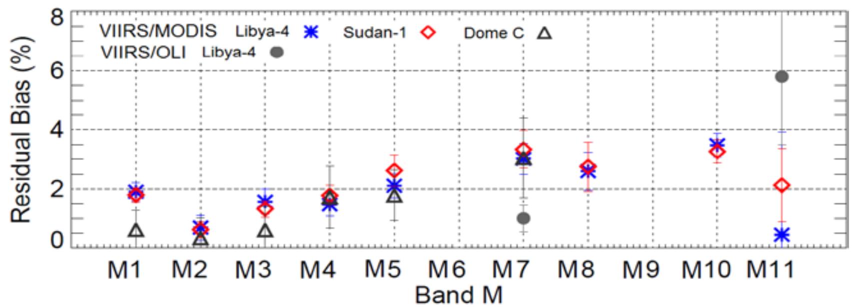
Why choose Multiple Targets?

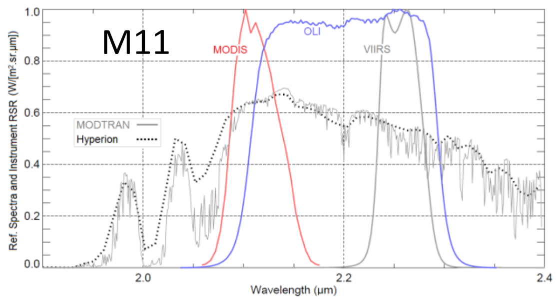


- Desert: Better for longer wavelength RSB.
- Ocean: Uses high gain for most of the dual gain RSB bands.
- Dome C: Spectrally nearly flat over VNIR
- DCC: High reflected radiance for VNIR with low atmospheric absorption variability.
- Moon: Reflectance is nearly constant at a given phase angle.

Estimating VIIRS Radiometric Bias

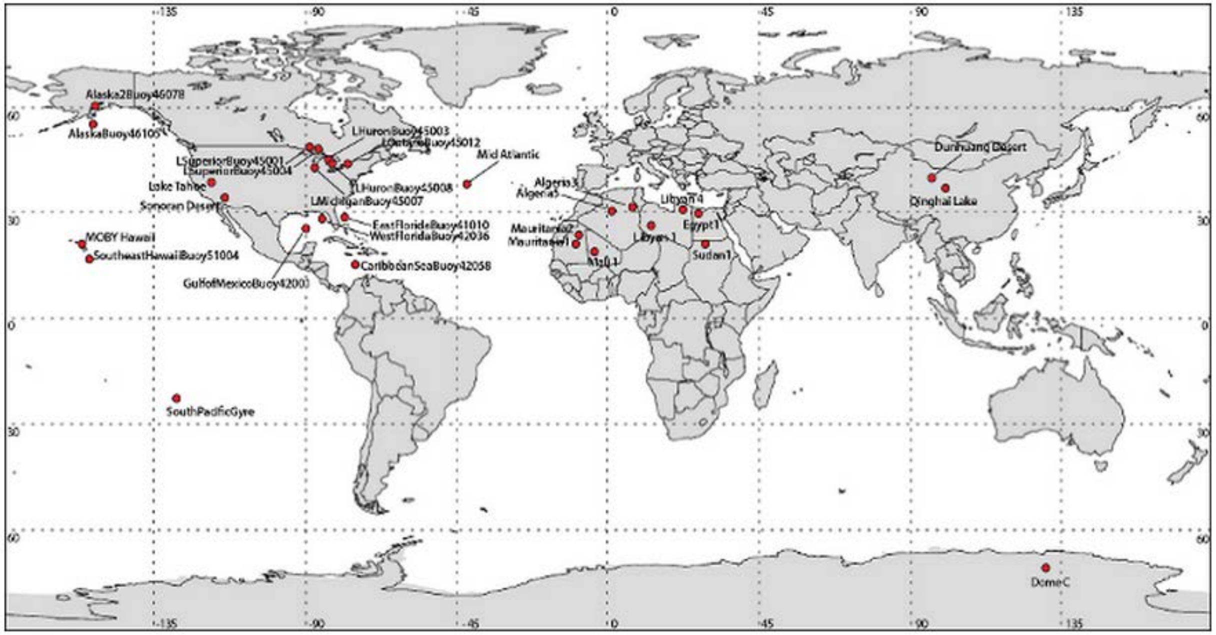






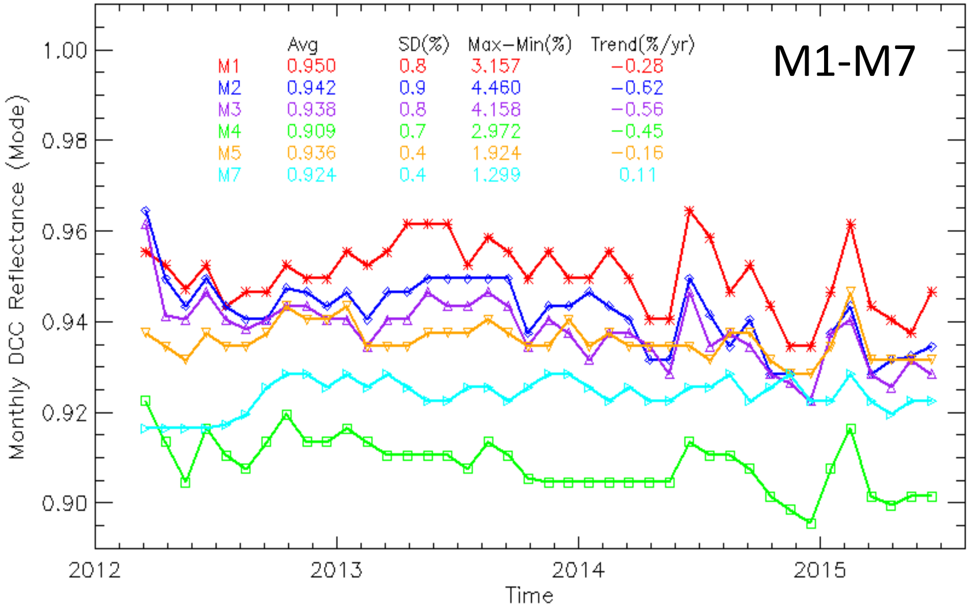
- Track radiometric stability (trending over the desert sites) and accuracy (compare with MODIS and OLI) of VIIRS *(Uprety and Cao, 2015, RSE).*
- Bias trends provide critical feedbacks about VIIRS radiometric performance in absolute scale.
- System analysis will be expanded to J1 VIIRS to monitor its radiometric performance.

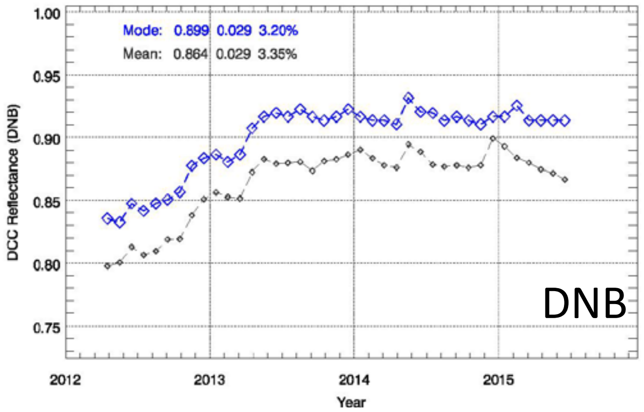
Validation Time Series

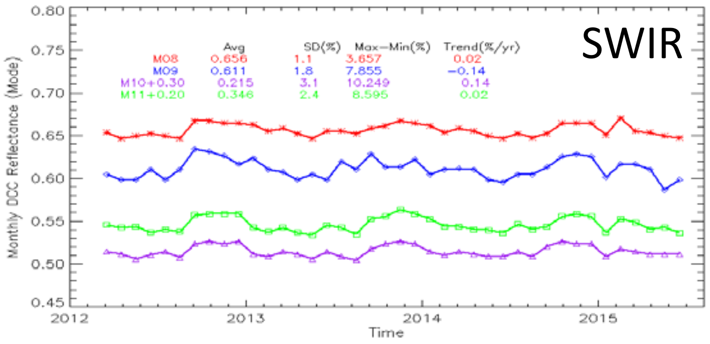


- Monitor calibration stability of VIIRS using a large number of world-wide calibration sites.
- Construct the radiometric time series over about 30 vicarious sites to monitor the stability of the VIIRS calibration.
- Tracking the calibration stability by trending the nadir observations as the satellite overpass through these sites
- Service is available from NCC website for VIIRS (*http://ncc.nesdis.noaa.gov/VIIRS/VSTS.php*)
- System can be modified to suit for the study of J1 VIIRS calibration stability over time

Deep Convective Clouds (DCC)



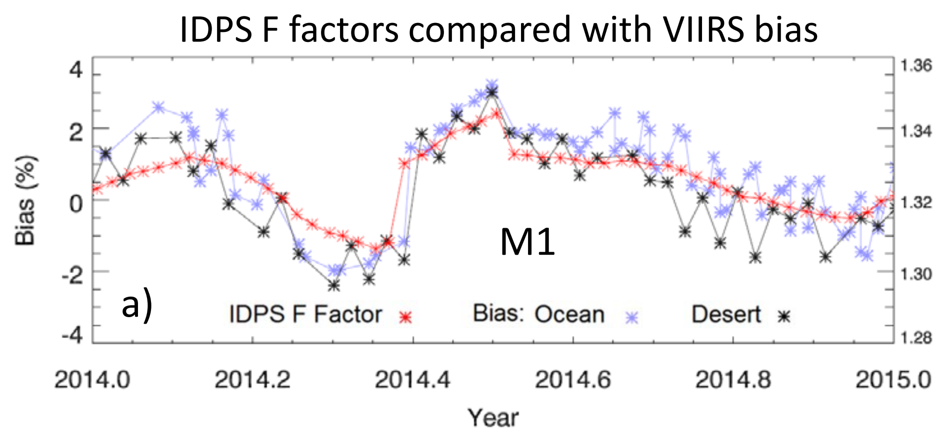


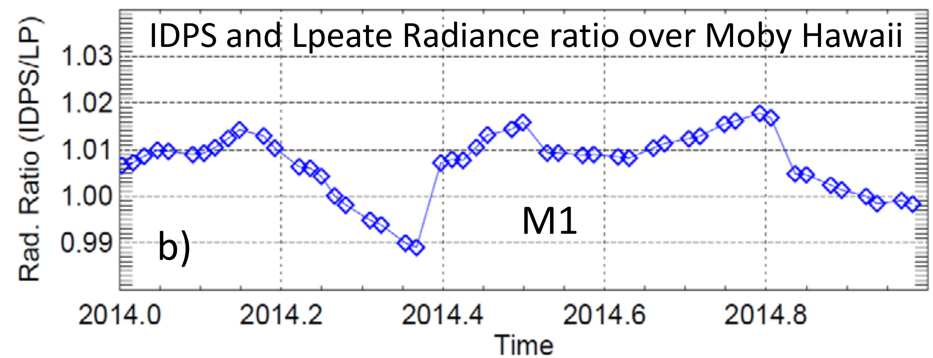


- DCC time series for VIIRS RSB and DNB operational calibration stability monitoring.
- The time series are updated monthly and available online at:
  https://cs.star.nesdis.noaa.gov/NCC/VSTS.
- J1 VIIRS will also be adopted with this technique to assess the calibration stability.

SDR Product Comparison

- IDPS F factors compared with VIIRS bias (using SNO-x) over ocean and desert (Figure a.)
- Bias trends track the operational F factors very well.
  - SNO-x validation provides significant feedbacks on onboard calibration performance
- Radiance ratio of VIIRS SDR from IDPS and Lpeate/SIPS.
  - Ratio trend (Figure b.) matches well with trends in top figure.
  - Suggests mainly the calibration differences.
  - Indicates that reprocessing IDPS products can improve the radiometric quality and consistency.

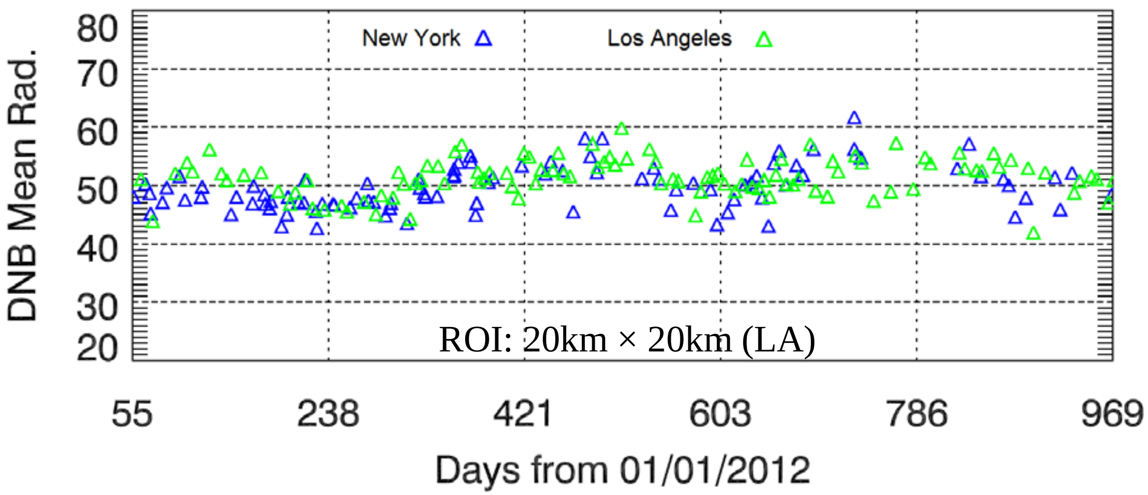


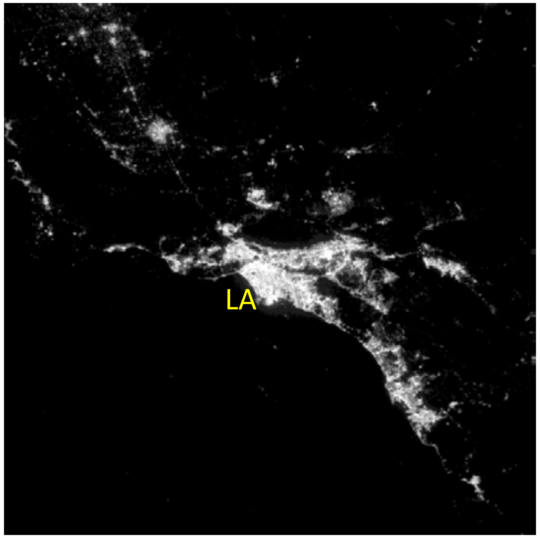


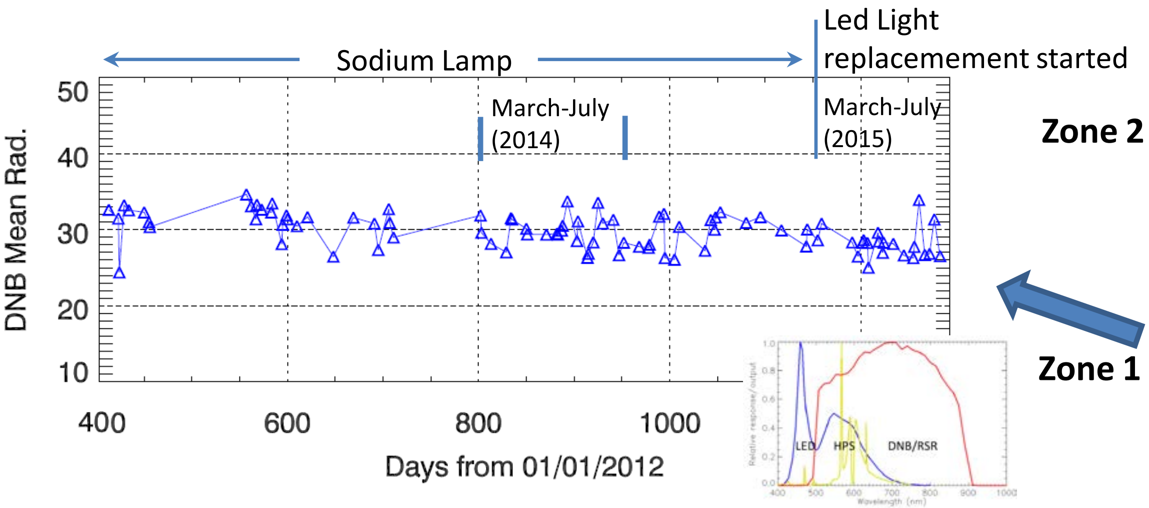
VIIRS DNB Validation

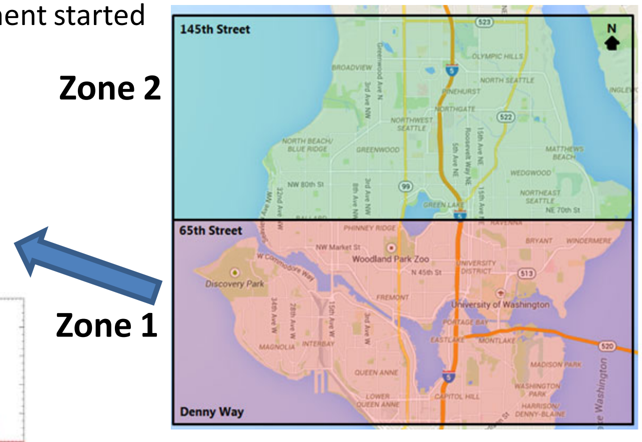
- New SBIR initiative to develop active nightlight for VIIRS DNB calibration/validation, working closely with NIST and NASA scientists (explained in earlier presentation)
  - Develop and deploy accurate active light sources (AALS) to selected calibration sites for the cal/val of the VIIRS DNB low light performance.
- DNB radiometric stability and accuracy:
  - Deep Convective clouds
  - City light time series
  - Bridge light time series (demonstrated in earlier presentation)
  - Comparison with other instruments using lunar illuminated targets such as Dome C site.

DNB Stability using City Lights









The conversion work will cover Seattle's arterial roadways between **Denny Way and 65th Street** (highlighted in **red**).

Depending on progress, this phase of work may extend north to **145th Street** (highlighted in **green**).

It is expected that all City of Seattle arterial roadways will be completed within two to three years.

- DNB unit: W/cm^2sr

Summary

- Radiometric validation techniques that has been developed and under continuous use for S-NPP VIIRS will be modified for analyzing the post-launch radiometric performance of J1 VIIRS.
- RSB validation techniques will be further expanded to include new instruments such as OCO-2 to evaluate the radiometric consistency with VIIRS M10.
- Apart from MODIS, OLI, FTS and OCO-2, we will have the opportunity to validate J1 VIIRS data with current S-NPP VIIRS.
- In addition, DNB validation will incorporate accurate active light source that will be developed through SBIR project.
- J1 validation will also leverage from GOES-R underflight project:
  - Ground truth measurement and absolute radiometric validation of J1 performance.

Cal/Val Plan and Field Campaign Preparation

Xi Shao[1], Changyong Cao[2], Mitch Schull[3], Wenhui Wang[3]

1. University of Maryland, College Park

2. NOAA/NESDIS/STAR

3. ERT Inc.

Date: August 26, 2015

Outline

- J1-VIIRS Cal/Val Plan
- J1-VIIRS Field Campaign Preparation

J1 VIIRS Cal/Val Plan Status

- **Cal/Val plan (Version 1.0) prepared by STAR**
- **Under review by external members**

Joint Polar Satellite System (JPSS)
VIIRS Calibration/Validation Plan

Version 1.0

Prepared by
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Section 3 of VIIRS Cal/Val Plan

- ***3.1. J1 VIIRS Pre-launch Characterization***
  - Summarize major test results and their analysis from Performance Verification Reports (PVRs)
  - *Band-to-Band Registration (BBR)*
  - *Crosstalk*
  - *Emissive Band Calibration*
  - *Near Field Response (NFR)*
  - *Pointing*
  - *Polarization Sensitivity*
  - *Radiometric Sensitivity Dynamic Range*
  - *Reflective Band Radiometric Calibration*
  - *Day/Night Band (DNB) Radiometric Calibration*
  - *Relative Spectral Response*
  - *Spatial*
  - *Straylight*

3.2. Post-launch Tests (PLT) (Being filled)

Test	Test Description	Objective
VIIRS Activation	Includes initial power on, possible memory loads/patches/dumps including DNB Table Loads. When Operational Power is applied by the S/C, Section A of the VIIRS internal power supply becomes active, which results in power being applied to the SBC with associated telemetry and communications electronics becoming active. Upon receipt of power, the FSW automatically performs the BIT routines and reports their successful completion via the housekeeping telemetry packet and VIIRS is then placed in ACT mode	To activate/turn-on VIIRS for satellite operations and perform memory loads to adjust DNB Science Data output. DNB Tables loads may include test tables (for calibration or diagnostics), modifications to adjust Science Data output, command sequence updates (SCT) and contingency fixes (tables can be uploaded in Safe mode)
VIIRS Trending	Monitor Power, Instrument Temperatures, SC Temperatures for VIIRS, BB, Cryo-Performance, Motor Current, Motor temperatures, Scan Rate/Control, Time Sync	To trend telemetry mnemonics for the performance of the instrument and quality of science data.
VIIRS Dynamic Range and Linearity Verification	A "Fast Find," to restore the FPA offsets, must be performed each time the user changes the integration times. Collect up to one orbit of data with each of the integration times. Repeat for all integration times desired then change the integration times back to the nominal on-orbit values	To characterize the Imaging Frame Sync (ISF) or Radiometric Frame Sync (RSF).
DNB Offset Determination	DNB Offsets are comprised of Detector Dark Current and Electronic/Clock Offsets	"Provide data necessary to periodically update the DNB Offsets Correction tables applied to the Earthview data as part of the VIIRS on-board processing, and should be run frequently during LEO&A to better understand the frequency of the DNB Offset Variability. Eventually, the frequency will be reduced to once every few months when confidence and understanding in the Offset Stability is established. NOTE: "Composite" Dark Current and Clock Offset data will be available no more than once a month as it should be collected over the ocean and with no moon."
Solar Diffuser Calibration	Initial measurements of the Solar Diffuser (SD) reflectance to be made with the Solar Diffuser Stability Monitor (SDSM) as soon as possible on orbit	"Provide a relative SDSM measurement of reflectance and the first on-orbit measurements. The SDSM measures three items during each calibration sequence: the radiance of the Sun as attenuated by the SD Attenuation Screen and as reflected by the SD, a direct measurement of the Sun's radiance as measured through the SDSM Solar Attenuation Screen, and a no irradiance dark view. These measurements are made sequentially as the SDSM's optical input is directed to each of these three sources by a steering mirror, but simultaneously in eight separate spectral channels."

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In collaboration with NASA Flight Project

3.3 VIIRS Cal/Val Post-launch Tasks

- *Update from 56 tasks for SNPP-VIIRS to form 72 tasks for J1-VIIRS*
- *Functional Performance and Format (FPF) Evaluation*
- *Calibration System Evaluation (CSE)*
- *Image Quality Evaluation (IMG)*
- *Radiometric Evaluation (RAD)*
- *Geolocation/Geometric Evaluation (GEO)*
- *Performance and Telemetry Trending (PTT)*
- Waiver verification/validation (WAV) (added for J1)

65	WAV1	J1 DNB aggregation mode verification	To verify that aggregation option 21is implemented and processed correctly.
66	WAV2	J1 DNB geolocation vs. aggregation zone	To verify that the geolocation is processed correctly by aggregation zone to ensure the modified geo code software is functioning properly
67	WAV3	J1 DNB aggregation mode change test	Change the J1 DNB aggregation mode from Op21 to Op21/26 to collect data and perform analysis for optimizing the aggregation
68	WAV4	J1 DNB straylight assessment and correction LUT development	To assess the straylight and temporal variability to develop correction LUTs.
69	WAV5	J1 DNB radiometric/geolocation monitoring using point sources	To evaluate the radiometric and geolocation stability, as well as band to band coregistration of DNB using point sources such as bridge lights, oil platforms, flares.
70	WAV6	J1 VIIRS saturation monitoring	To characterize the saturation in several bands including M8, M7, and others. Develop a solution if possible.
71	WAV7	J1 VIIRS SWIR nonlinearity characterization	To characterize SWIR nonlinearity and develop a solution if possible.
72	WAV8	J1 VIIRS polarization characterization	To characterize polarization of the VIS bands by comparing observations with data from other sources (other satellites, ground/aircraft measurements, models)

3.4 Calibration Tools

- **NOAA-STAR (STAR), NASA, Raytheon (RTN), The Aerospace Corp. and others**
- **Currently have 38 tools and being added**
  - *J1-VIIRS Data Extraction Tools*
  - *Integrated Cal/Val System (ICVS)*
  - *J1-VIIRS Orbital Prediction Toolkit*
  - *Tool kits for Radiometric Calibration Analysis and Testing of J1-VIIRS*
  - *Offline F/H Factor Analysis, Prediction and Validation Tool*
  - *SNO Based Inter-satellite Calibration Tool*
  - *J1-VIIRS SWIR Band (1.61 μm) Inter-calibration Tool*
  - *Validation Site Time Series Monitoring Tool*
  - *Radiative Transfer Modeling tool for Post-launch Cal/Val of J1-VIIRS*
  - *Dual Gain Anomaly (DGA) Analysis Tool*
  - *Offline DNB Calibration/Validation Tools*
  - *DNB On-board Offset LUTs Verification Tool*
  - *DNB Stray Light Correction LUT Generation and Validation Tool*
  - *Tool for Inter-comparison of CrIS-VIIRS Geolocation*
  - *VIIRS DNB Geolocation Validation Tool*
  - *DNB Aggregation Mode Change Analysis Tool*
  - *…….*

4. METHODOLOGY OF CAL/VAL TASKS

- **Methodology for 72 tasks**

Example

4.9 Onboard Calibrator Black Body (OBCBB) Temperature Uniformity

Task Objectives: To verify that telemetered values of the six thermistors in the OBCBB are within specified bounds.

Prerequisites and Conditions: SC Mode: Nominal, VIIRS Mode: Operational

Methodology: This recurrent task requires that the thermistors be monitored over the life of the instrument. The thermistors values are obtained from either the engineering packet or the SDR Calibration Intermediate Product (IP). Time series of the values of each thermistors, the mean of the six thermistors, and the standard deviation of the six thermistors are generated to monitor changes in thermistor behavior. The SDR algorithm must be updated to compensate for changes if any of the thermistors should exhibit "out-of-family" behavior.

Necessary Tools: Telemetry Probes-Encoder, Temperatures, SDSM

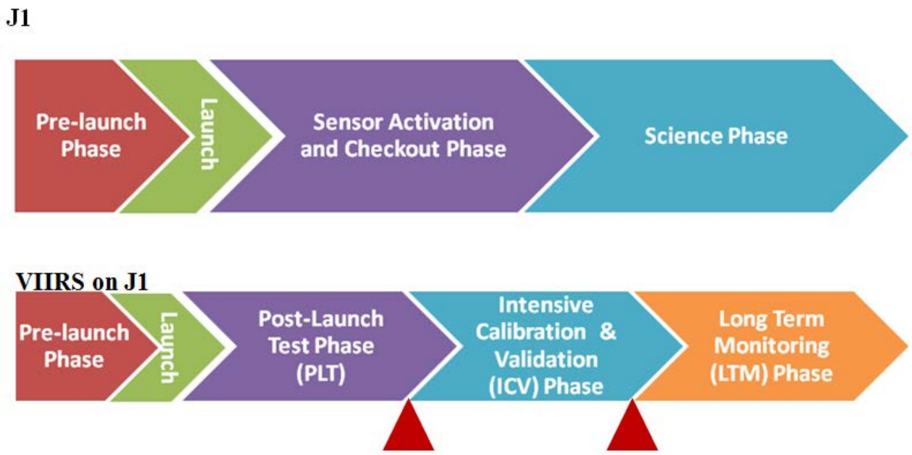
Products: Time series of values, mean and standard deviation of 6 OBCBB thermistors.

5. CAL/VAL CHALLENGES AND AREAS OF CONCERN

- DNB non-linearity
- SWIR and MWIR non-linearity
- DNB image artifacts
- DNB Straylight
- Stronger polarization sensitivity effects in bands M1-M4
- Multiple uncertainties in the solar diffuser stability monitoring
- Saturation and roll-over in radiometric response in several bands
- Non-operational or noisy detectors
- Band-to-band thermal dependence

6. SCHEDULES AND MILESTONES

6.1 Cal/Val Maturity Timeline



JPSS SDR Product Maturity Levels

Beta

- Early release product.
- Initial calibration applied.
- Minimally validated and may still contain significant errors (rapid changes can be expected. Version changes will not be identified as errors are corrected as on-orbit baseline is not established)
- Available to allow users to gain familiarity with data formats and parameters
- Product is not appropriate as the basis for quantitative scientific publications studies and applications

Provisional

- Product quality are nominal but may not be optimal
- Incremental product improvements are still occurring as calibration parameters are adjusted with sensor on-orbit characterization (versions will be tracked)
- General research community is encouraged to participate in the QA and validation of the product, but need to be aware that product validation and QA are ongoing
- Users are urged to contact JPSS Cal/Val Team representatives prior to use of the data

Validated/Calibrated

- On-orbit sensor performance characterized and calibration parameters adjusted accordingly
- Ready for use by the Centrals and in scientific publications
- There may be later improved versions
- There will be strong versioning with documentation

Pre & Post-Launch Activities/Milestones

Pre-Launch Activities/Milestones

Table 4: Pre-launch Cal/Val schedule: tasks/activities, deliverables, and timeline

Year	Tasks/Activities	Deliverables
2015	• Address the Waiver Tasks described in Sections 3.1, 3.2 and 4. • Ground test data analysis and software development.	• Initial Pre-launch LUTs • Software code changes • Cal/Val documentation
2016	• Further analysis on pre-launch test data and refinement of LUTs	• Improved version of Pre-launch LUTs • Revised Cal/Val documentation • Ground and field campaign preparation

Post-Launch Activities/Milestones

Table 5: Post-lauch Cal/Val schedule: tasks/activities, deliverables, and timeline

Year, Phase	Tasks/Activities	Deliverables
2017, PLT to ICV	• Execute the Cal/Val tasks (> 60) described in Sections 3.2 and 4. • Checkout of the VIIRS instrument during normal operation mode • Adjust instrument settings • Update appropriate SDR LUTs and coefficients that optimize the sensor's performance. • Make the instrument and software properly staged for Intensive Cal/Val (ICV) activities.	Provisional SDR products
2018, ICV to LTM	• Continue with cal/val, perform intercomparisons with other instruments and in situ measurements; • Improve the calibration; establish longterm monitoring. • Validate the VIIRS products through verification and cross-comparison with external independent measurements and models. • Make refinement of the VIIRS algorithms • Provide radiances that are stable and accurate to support EDR retrievals.	Validated VIIRS SDR products

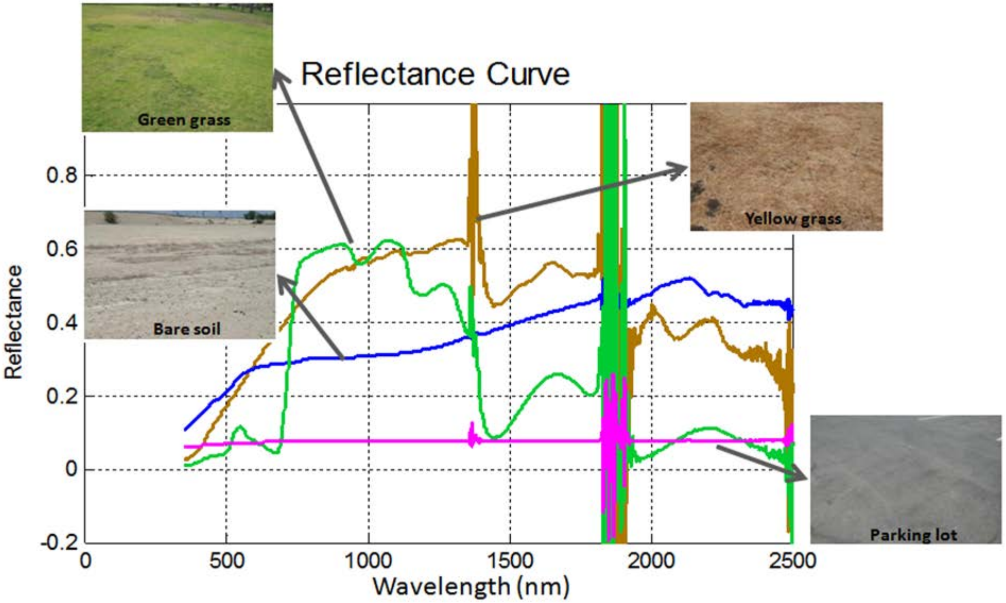
Being Developed

Field Campaign Preparation

- Ongoing preparation
- Ground and near surface measurement to support J1-VIIRS overflight field campaign
- Collaborative efforts to enhance J1 VIIRS field campaign capabilities with Unmanned Aircraft System (UAS)
  - Collaborate with GOES-R CWG, NOAA UAS program and University of Maryland
  - Enable large area goniometric surface measurements
- Address J1 VIIRS polarization sensitivity impacts with ground-based polarimeter
- Collaborate with NIST to characterize solar diffuser degradation through NIST-NOAA NCC collaboration

Ground and Near-surface measurements in support of J1-VIIRS Cal/Val

- Leverage past experience of ground and near surface field measurements to support J1-VIIRS Cal/Val
  - Portable ASD spectrometer
  - Sun photometer
  - Kinetic Temperature Measurement
  - Surface Atmospheric State
  - Handheld Context Devices
- Sonoran desert, Salton Sea



Collaborative Efforts to Enhance J1 VIIRS Field Campaign Capabilities with Unmanned Aircraft System (UAS)

- Collaborate with the **NOAA UAS Program**
- Leverage support from **GOES-R CWG** through "Near Surface UAS Feasibility Demonstration Study" project - NOAA Cooperative Institute Partnership with the University of Maryland (UMD)
- Small UASs combined with compact sensors provide an unmatched surface observation capability:
    - o Collect high quality goniometric observations of surface targets
    - o Large geospatial coverage comparable to satellite observations

Rotary Systems


Objective:

Collect high quality goniometric observations of the Earth's surface (launched & recovered from an ocean vessel):
» L1b, Radiation Budget, Aerosol, LST, SST

Fixed-Wing Systems

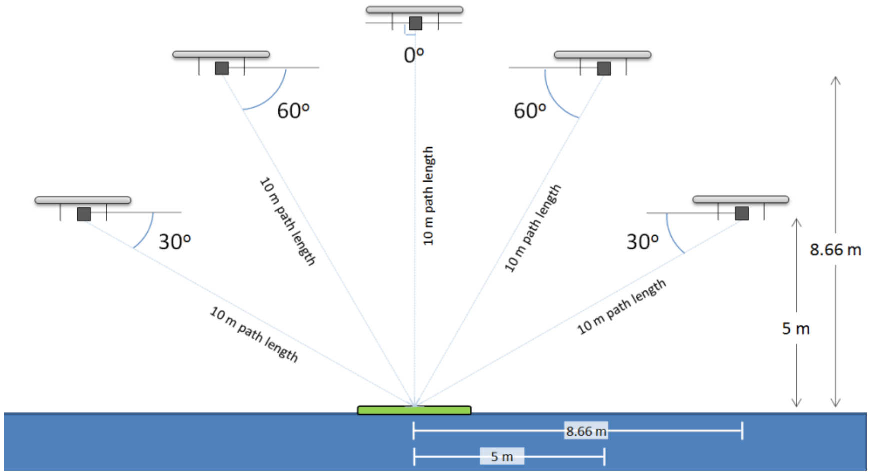

Objective:

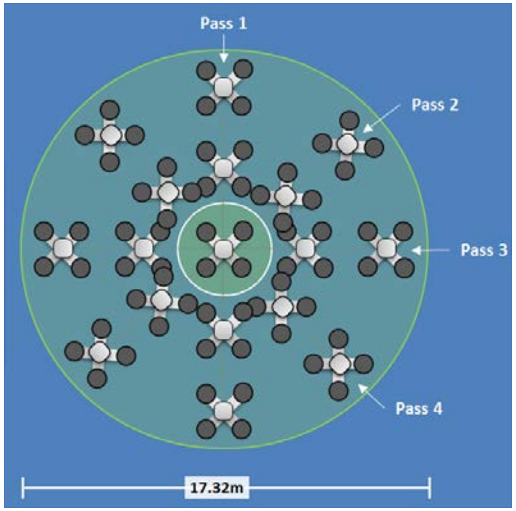
Collect high quality large area observations of the Earth's surface:
» L1b, LST, SST

hyperspectral observations (0.4 – 2.5 µm) and **(broadband IR – 8-14 µm/potentially filtered to match the VIIRS channels)**

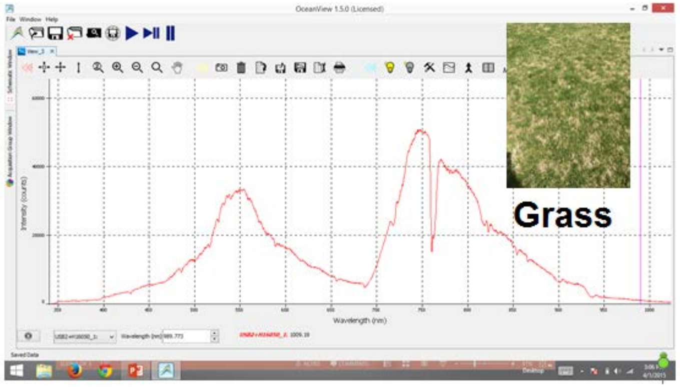
Acknowledgement: Frank Padula of GOES-R

Initial Efforts of UAS Field Campaign Design and Development



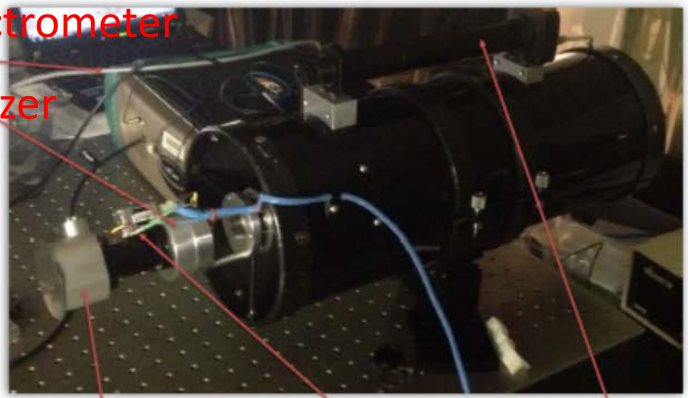


On going integration of modular spectrometer at University of Maryland



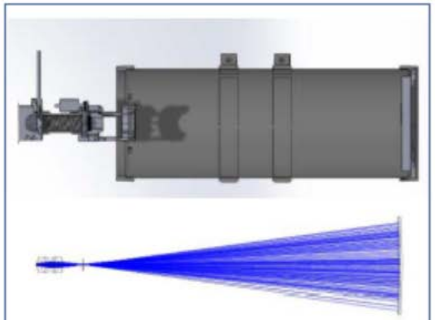
Address J1 VIIRS Polarization Sensitivity Impacts

- Prelaunch polarization characterization indicates that the polarization sensitivity in bands M1-M4 of the J1 VIIRS is higher than the performance specifications.
- This sensitivity influences retrievals of aerosol and ocean color products.
- Develop a ground-based spectroradiometer for polarization measurements by combining an off-the-shelf spectroradiometer with an enhanced front-end design to measure varying linear polarization states



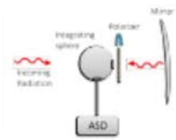
manufacturer	Gigahertz-Optik
model	UPK-30-L
aperture diameter (mm)	5
interior diameter (mm)	30
material	OD M98

clear aperture (mm)	21
focal length (mm)	200
field of view (10^{-3} radians)	25x35
sensor size (pixels)	1536x2048



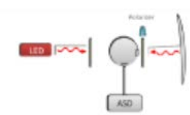
Polarimeter	
collection area (m^2)	0.015
primary focal length (mm)	500
field of view (10^{-3} radians)	25

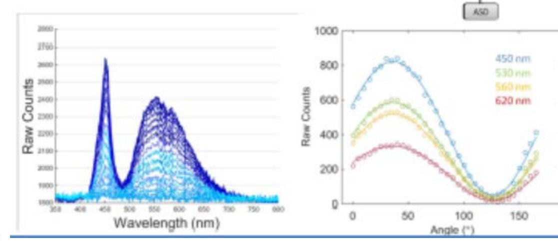
Incident radiation reflects off the mirror and propagates through the polarizer, integrating sphere, and collected by the ASD's fiber bundle.



Lab Characterization

Shows that the polarization state of incoming light is detected across the LED spectrum

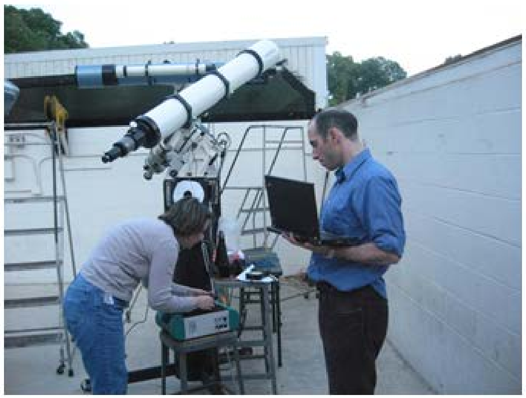


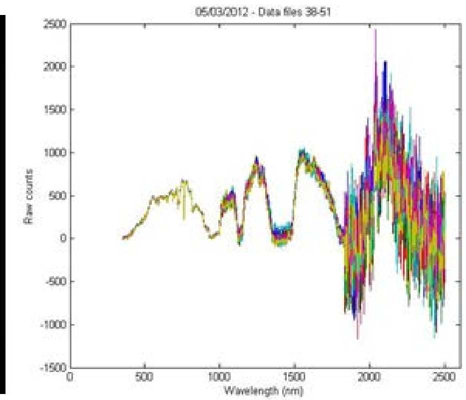


Courtesy: Aaron Pearlman, Steven Lorentz

Spectral and Polarization Measurement with Moon

- Collaborate with UMD Astronomical Observatory
- Performed initial spectral and polarization measurement with Moon





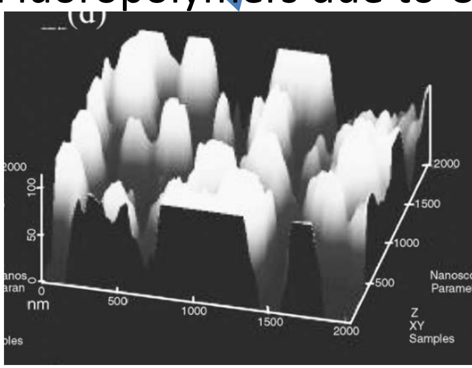
Spectral Polarimeter:
Initial Lunar Measurements

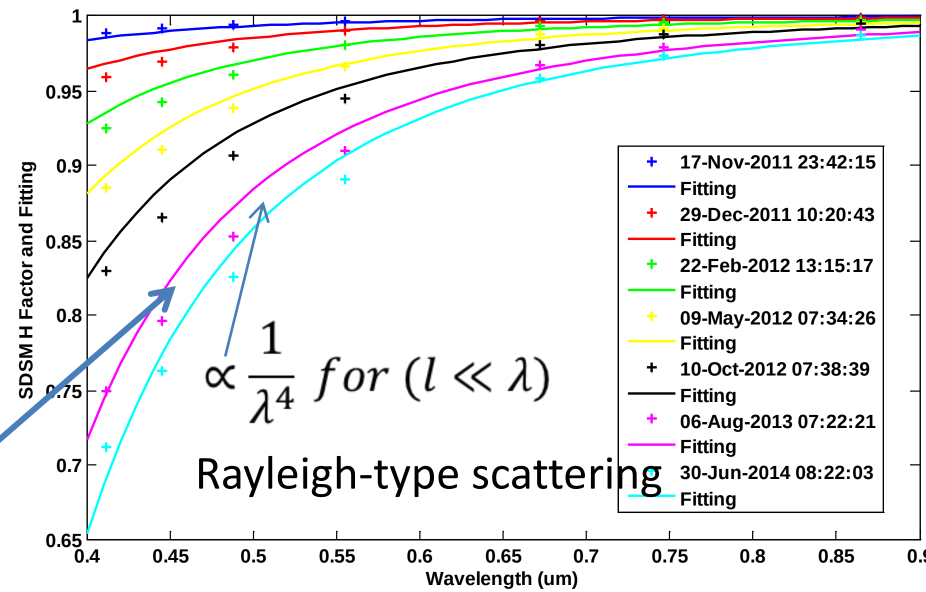
Characterization of Solar Diffuser Spectral Degradation

UV
Protons
O^+

Solar Diffuser

Surface roughness on Fluoropolymers due to UV





$$\propto \frac{1}{\lambda^4}\ for\ (l \ll \lambda)$$

Rayleigh-type scattering

NPP VIIRS SDSM Measurement of Solar Diffuser Spectral Degradation

- Radiometric calibration for RSB of J1 VIIRS relies on onboard solar diffuser
- Laboratory experiment to investigate spectral degradation of SD
  - Characterize UV exposure impacts on surface roughness change and spectral performance
- NIST-NOAA NCC Workshop held in July, 2015 to facilitate collaboration

Summary

- **J1 VIIRS Cal/Val Plan**
  - Cal/Val plan (Version 1.0) prepared by STAR
  - Under review by external members
- **Field Campaign Preparation**
  - Ground and near surface measurement
  - Collaborative efforts to enhance J1 VIIRS Field Campaign Capabilities with Unmanned Aircraft System (UAS)
  - Address J1 VIIRS polarization sensitivity impacts
  - Collaborate with NIST to characterize solar diffuser degradation through NIST-NOAA NCC collaboration