NOAA Satellite Cal/Val Progress Update

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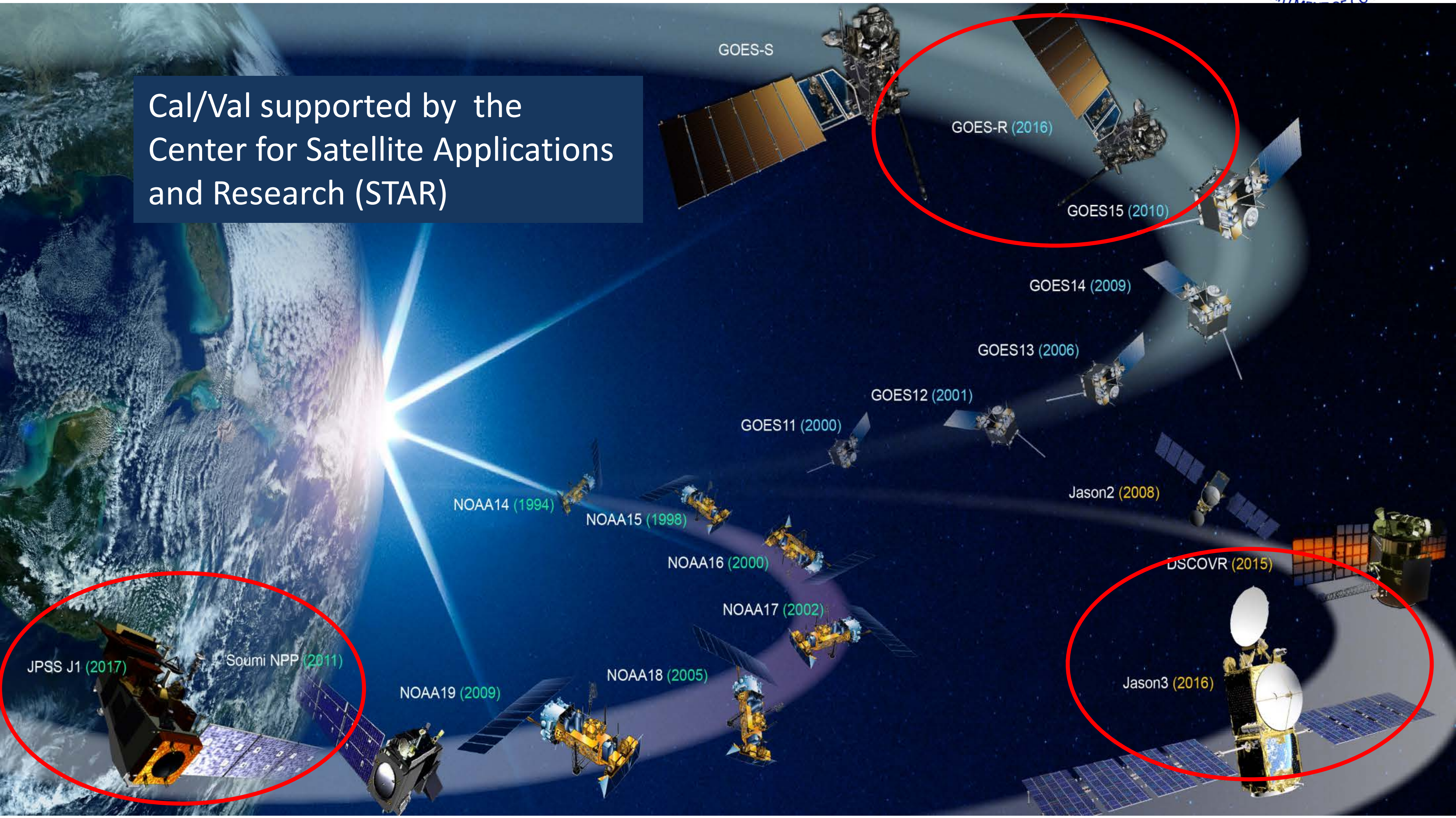
NOAA/NESDIS/STAR

40th CEOS Working Group on Calibration and Validation Plenary
(WGCV-40)
Canberra, Australia, March 14-18, 2016

Outline

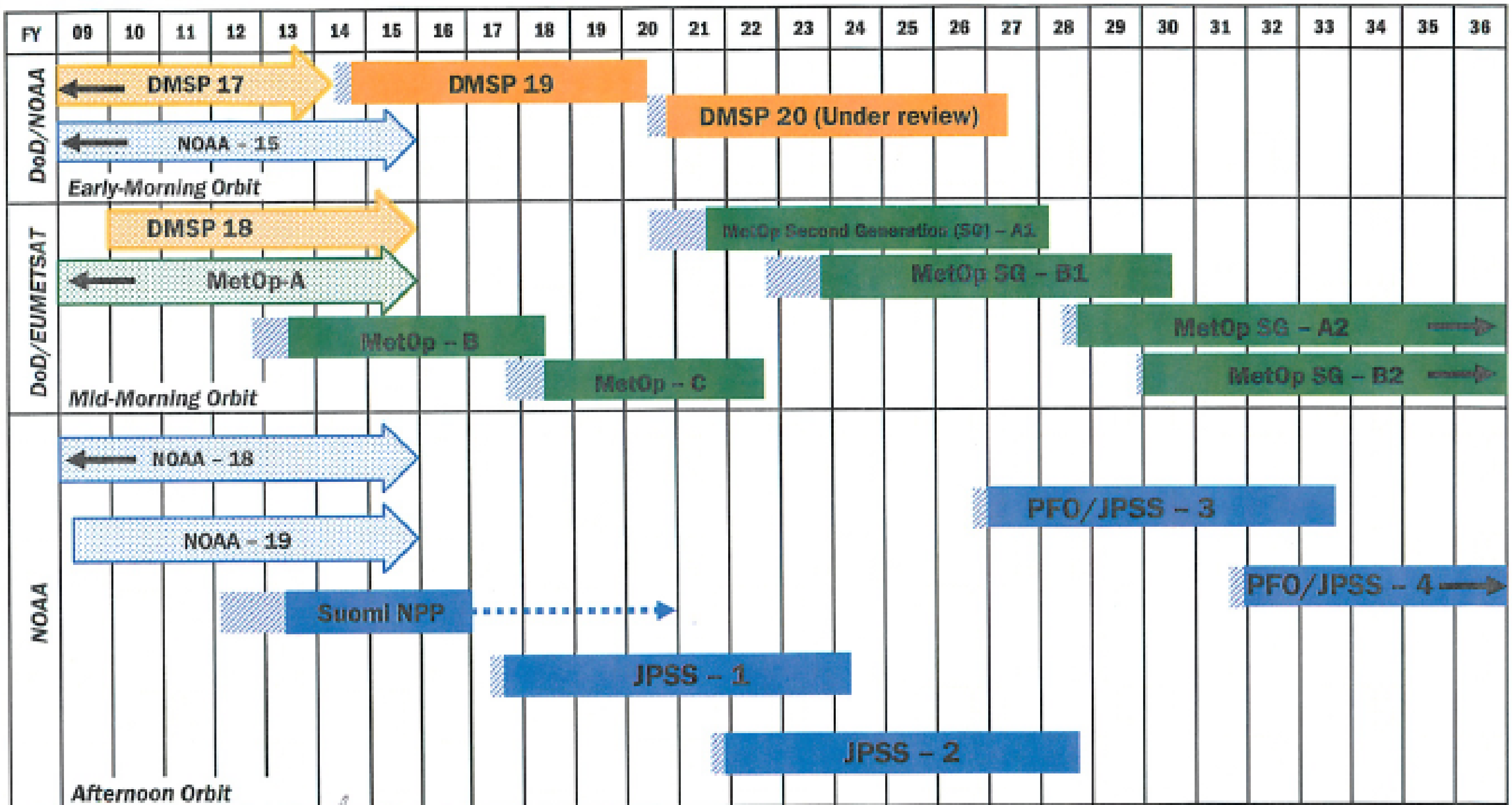
- Suomi-NPP/JPSS Program Update
  - » Suomi-NPP VIIRS post-launch characterization and Cal/Val activities
  - » J1 VIIRS Prelaunch Calibration and Launch Preparation
- GOES-R Program Update
  - Himawari/AHI vs. CrIS intercomparisons
  - Field Campaign Preparation
- Jason 3 (Launched Jan. 17, 2016) radiometer stability monitoring
- GSICS collaboration

NOAA Satellite Missions



NOAA & Partner Polar Weather Satellite Programs
Continuity of Weather Observations

As of April 2015



Approved: Mark S. Paese

Assistant Administrator for Satellite and Information Services

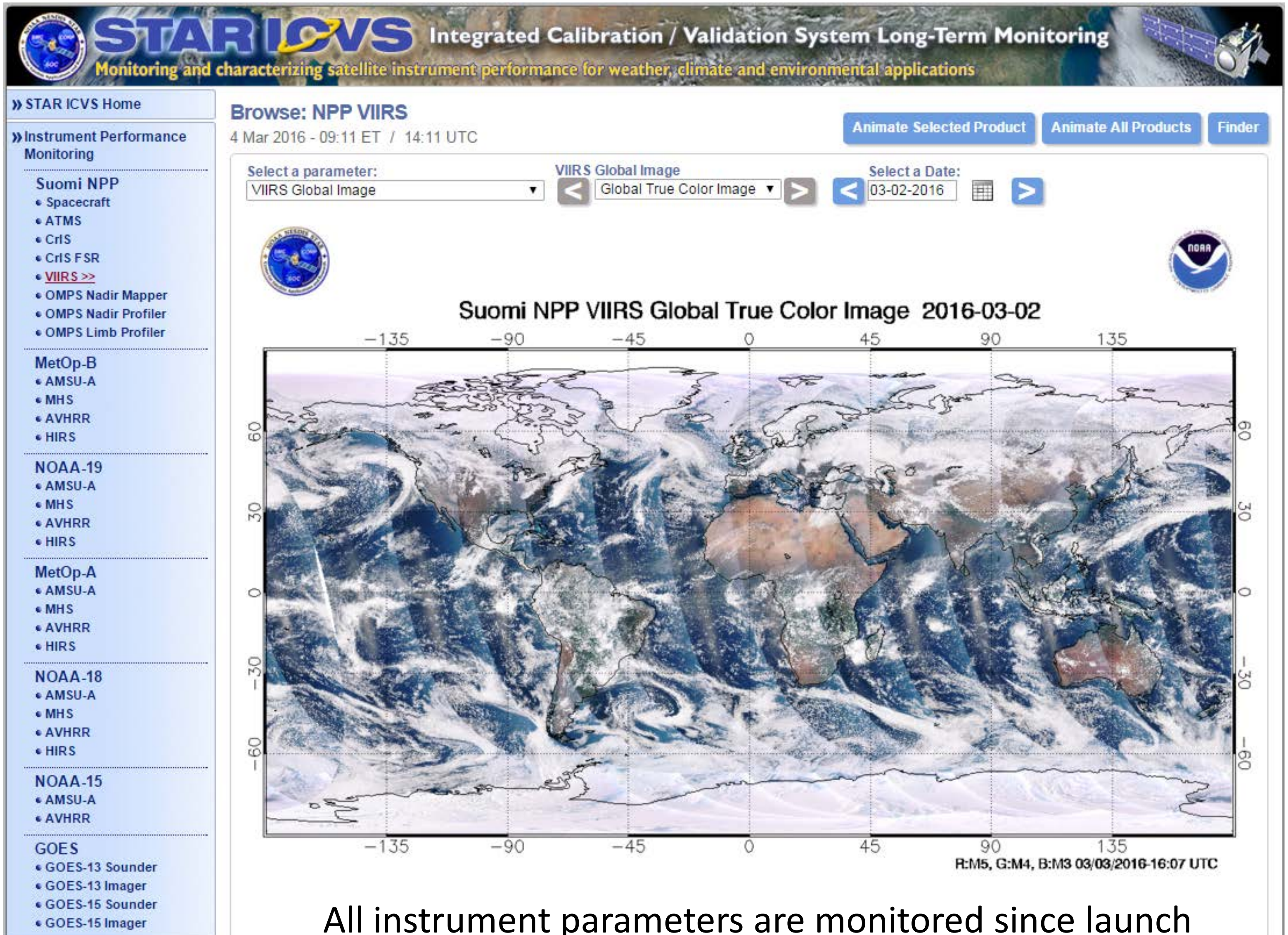
Note: Extended operations are reflected through the current FY, based on current operating health.

DMSP: Defense Meteorological Satellite Program
JPSS: Joint Polar Satellite System Program
Suomi NPP: Suomi National Polar-orbiting Partnership

Note: DoD and EUMETSAT data provided for reference only

- Post Launch Test
- Operational based on design life
- Secondary
- Operational beyond FY 2036
- Extended mission life
- Launched before Oct 2008

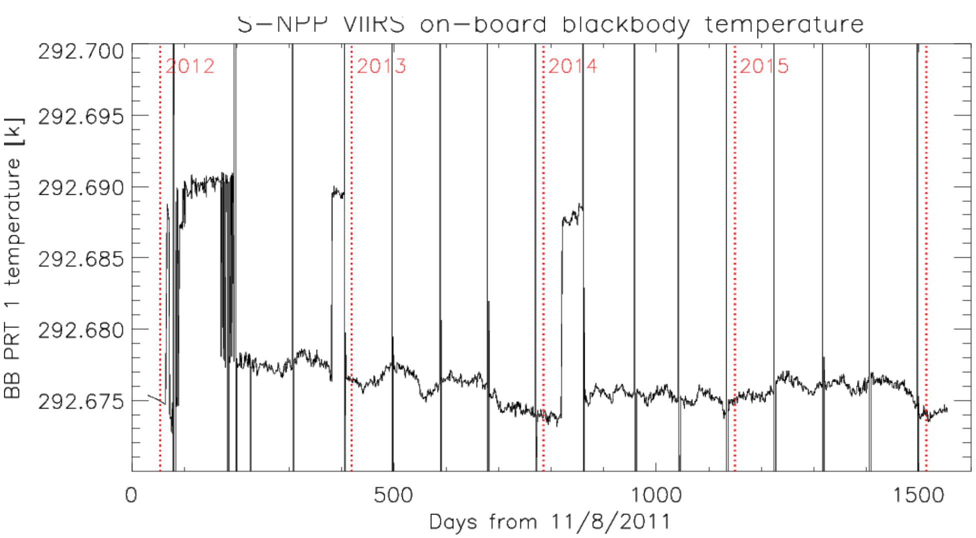
Integrated cal/val longterm monitoring

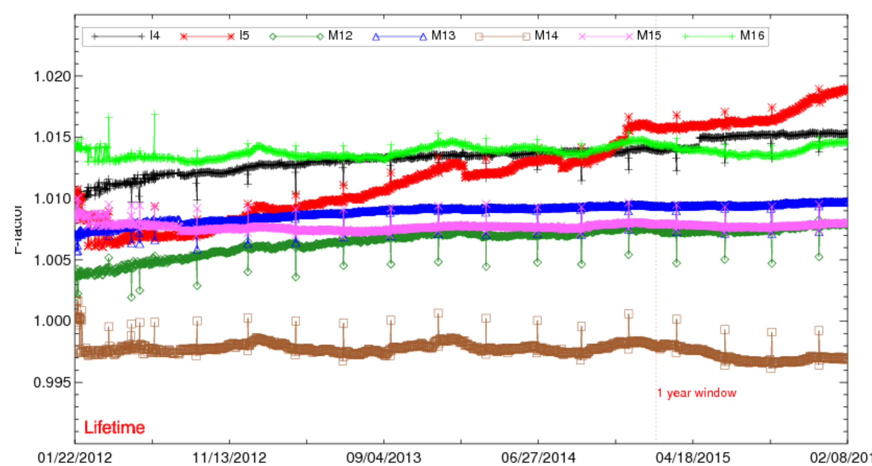


All instrument parameters are monitored since launch

S-NPP VIIRS Thermal Emissive Bands (TEB)

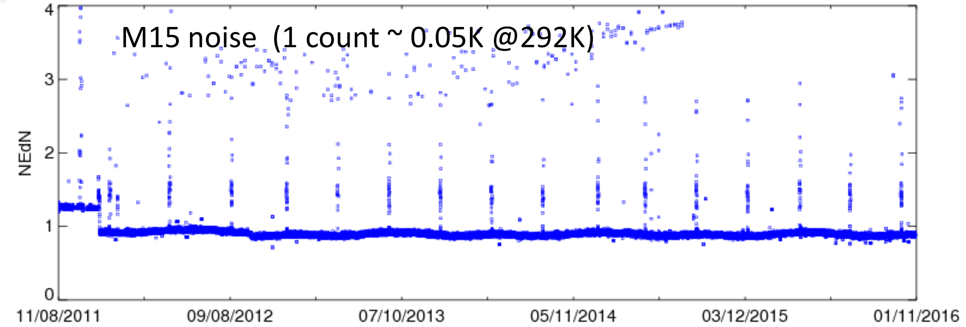
- TEB Calibration has been performing well.
- The source of TEB calibration is on-board blackbody (BB), which showed an excellent thermal stability within 4 mK since launch (excluding configuration changes).
- Corresponding F-factors are also very stable over 4+ years.
  - » Mostly with in 0.5%

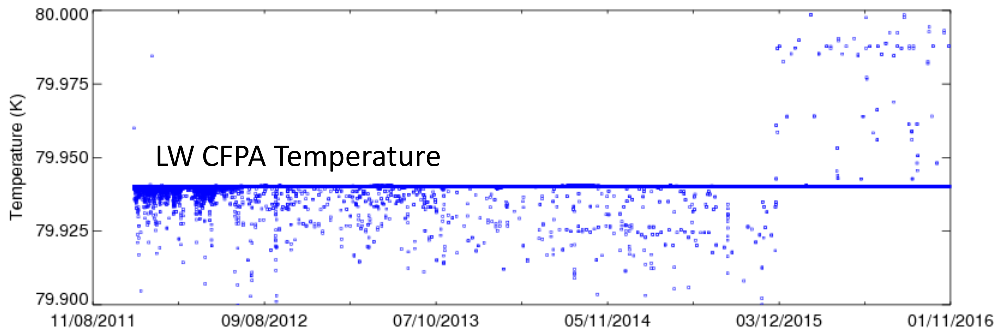


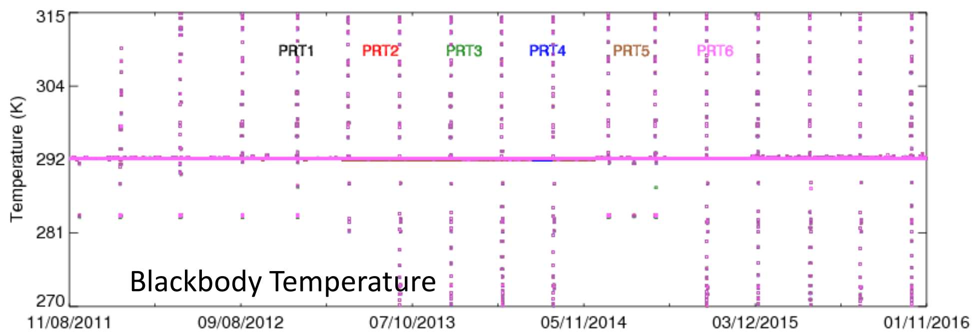


S-NPP VIIRS Thermal Emissive Band (TEB) (continued)

- TEB band noise remains low, has not changed significantly since launch, according to ICVS monitoring;
- Cold focal plane array temperature is very stable;
- Blackbody temperature is maintained as ~292.6K, with a max ~0.04k orbital variation for two thermistors;
- Quarterly warm up cool down (WUCD) of the blackbody to characterize nonlinearity changes;
- WUCD has a small impact on SST during such events.



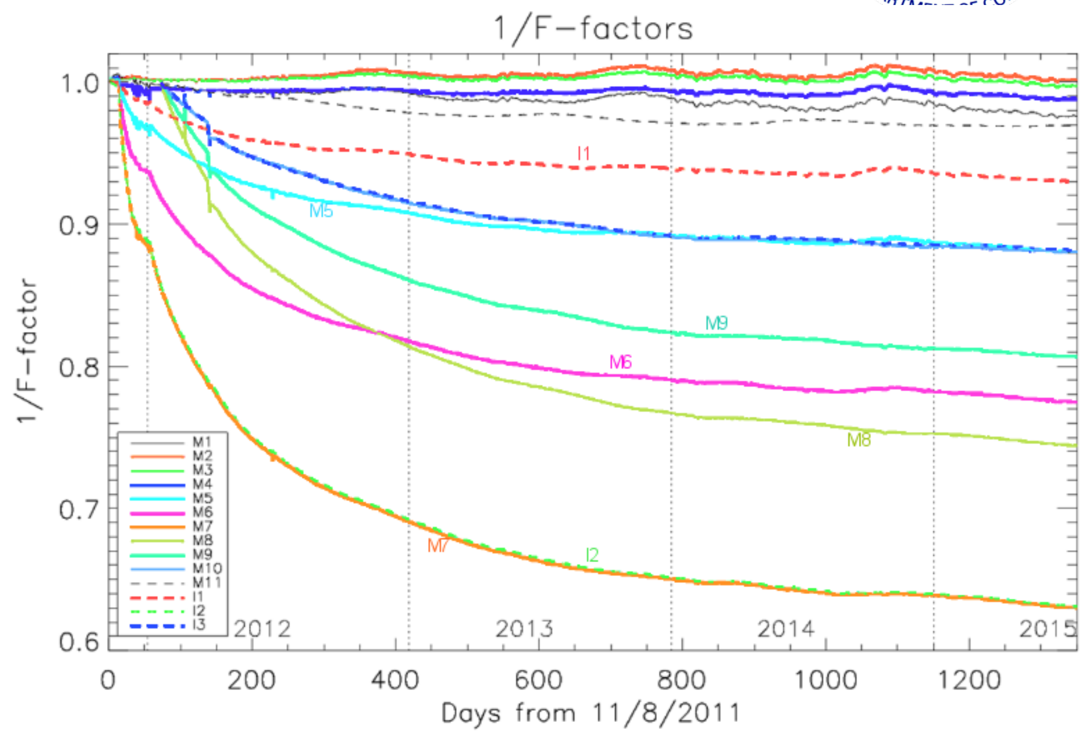




S-NPP VIIRS Reflective Solar Band (RSB) performance

-Rotating Telescope Assembly (RTA) mirror degradation

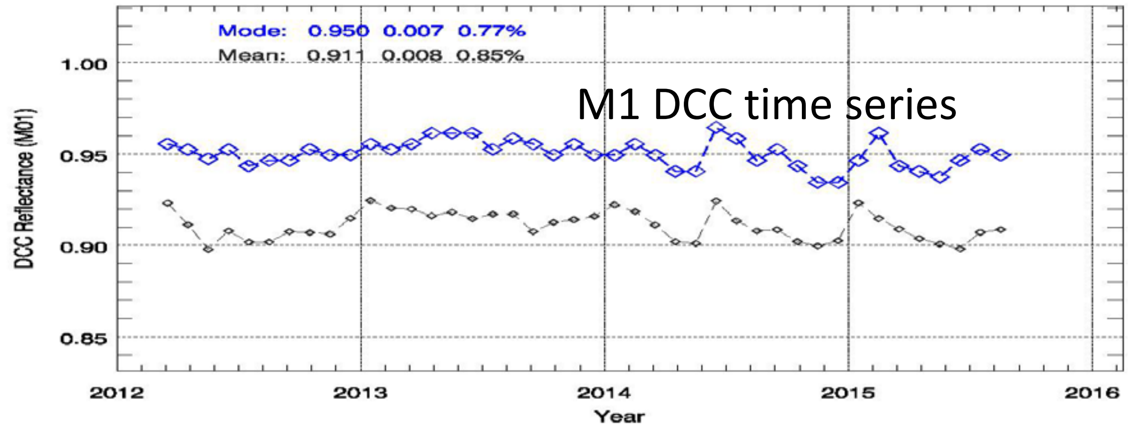
- Rotating Telescope Assembly (RTA) mirror degradation was a major postlaunch anomaly, due to prelaunch contamination;
- Band M7 has the largest degradation (~35%) since launch; while degradation at shorter wavelength is much smaller;
- The degradation has leveled off since mid 2013;
- The VIIRS SDR team actively maintains the calibration to compensate for the degradation;
- Impact on users are only limited to early orbits during beta maturity which would require reprocessing.

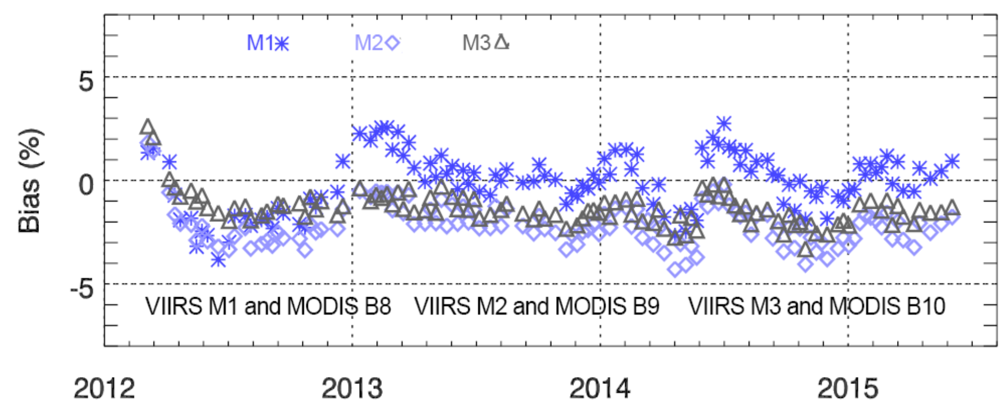


1/F factor is indicative of the instrument gain which shows the degradation due to RTA mirror reflectivity change

S-NPP VIIRS Calibration Stability and Accuracy

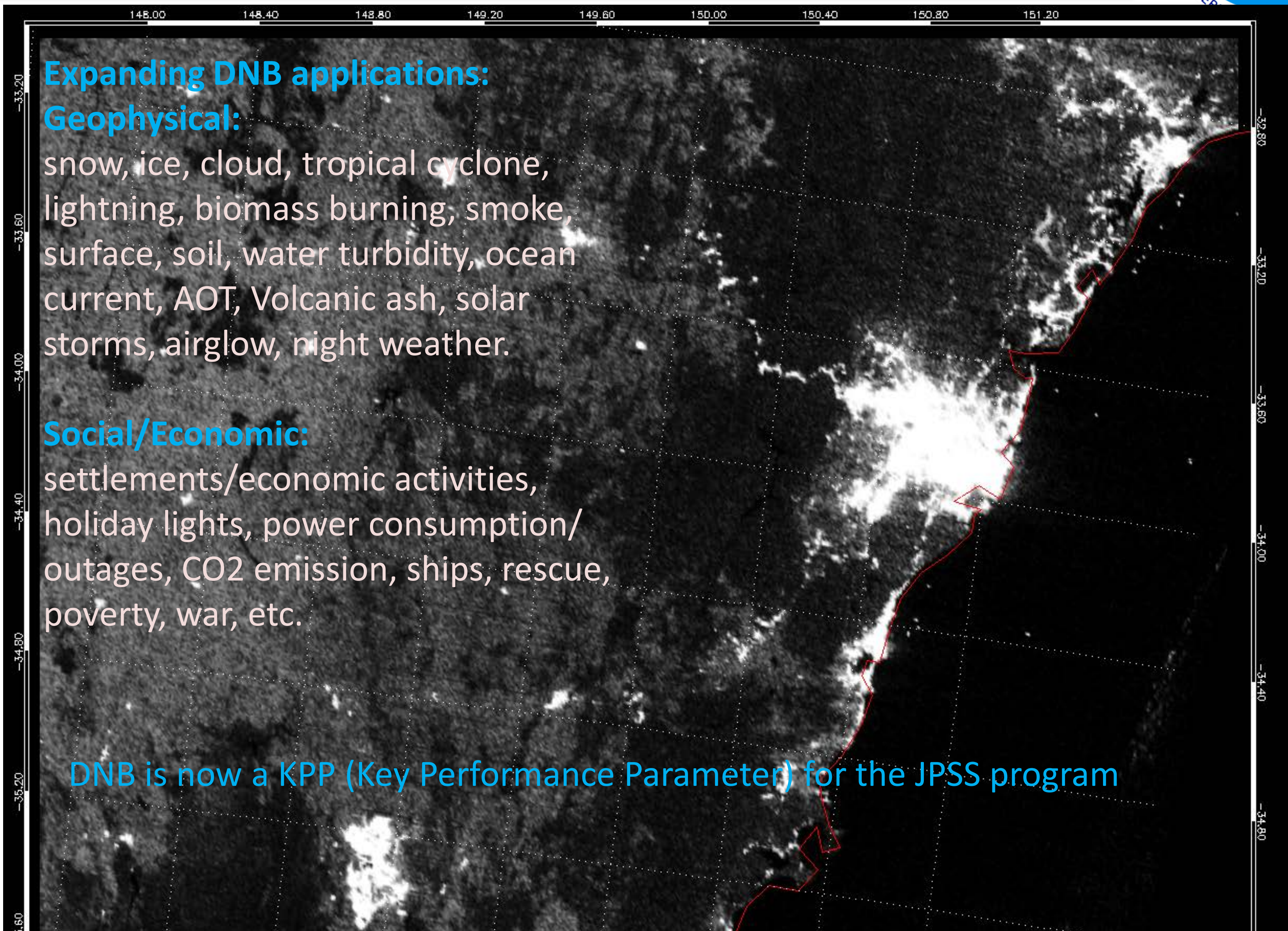
- VIIRS calibration is closely monitored at 30+ cal/val sites worldwide;
- Time series shows the calibration is very stable, and accurate
  (better than the +/-2% spec)
- Comprehensive calibration & monitoring include monthly maneuvers such as lunar cal, as well as DNB offset and gain transfer (VROP702)





VIIRS accurate compared to MODIS

Excellent SNPP VIIRS DNB performance leads to expanding applications



Expanding DNB applications:

Geophysical:

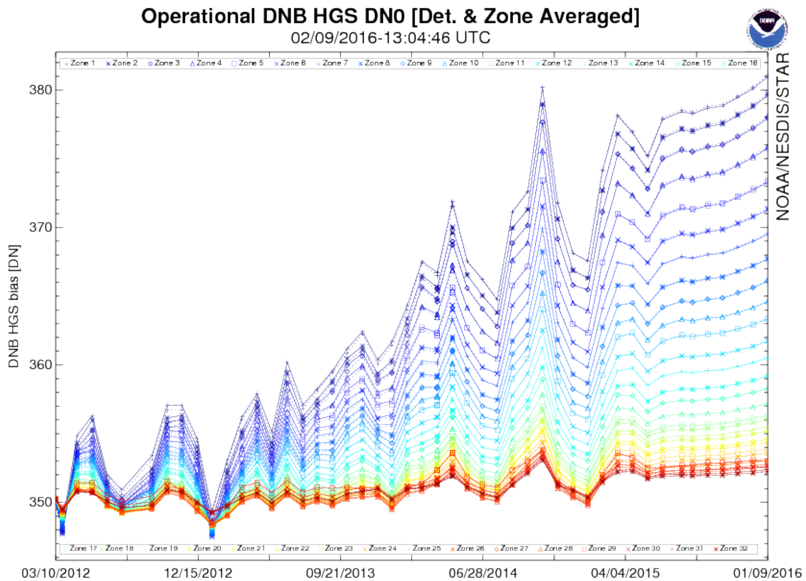
snow, ice, cloud, tropical cyclone, lightning, biomass burning, smoke, surface, soil, water turbidity, ocean current, AOT, Volcanic ash, solar storms, airglow, night weather.

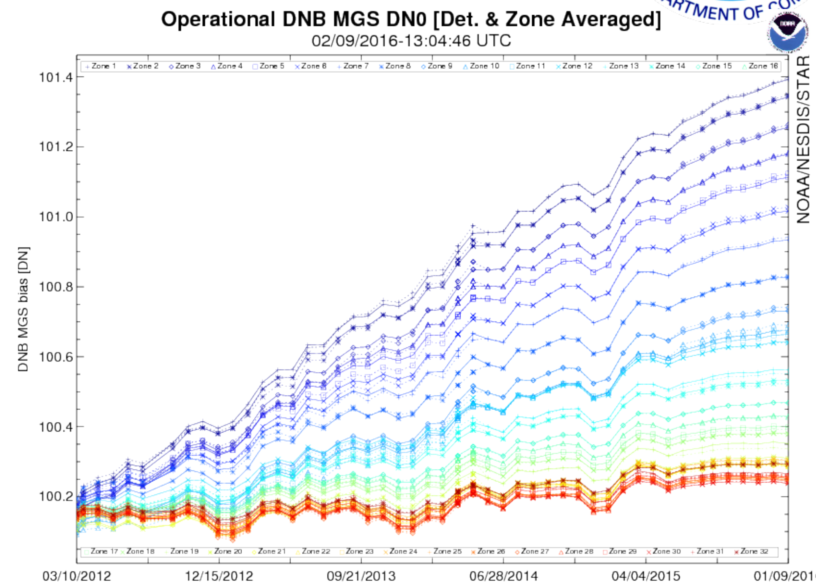
Social/Economic:

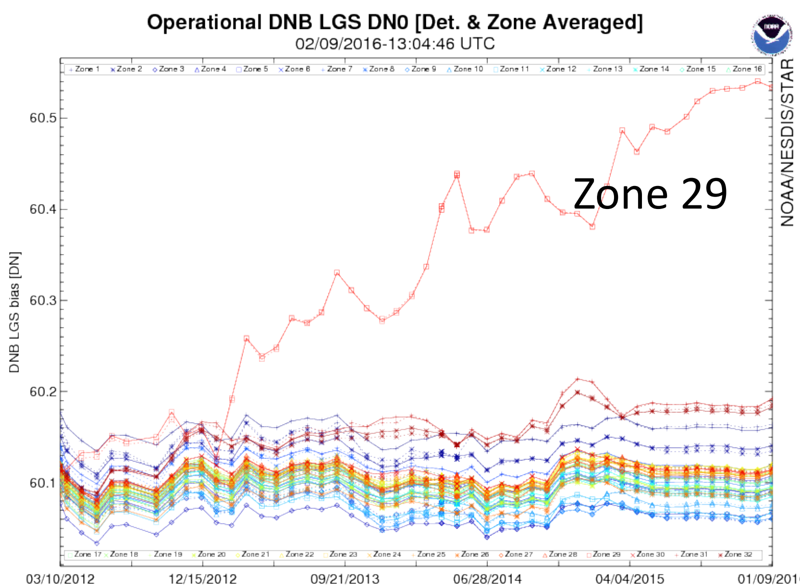
settlements/economic activities, holiday lights, power consumption/ outages, CO_2 emission, ships, rescue, poverty, war, etc.

DNB is now a KPP (Key Performance Parameter) for the JPSS program

S-NPP VIIRS DNB Offset changes



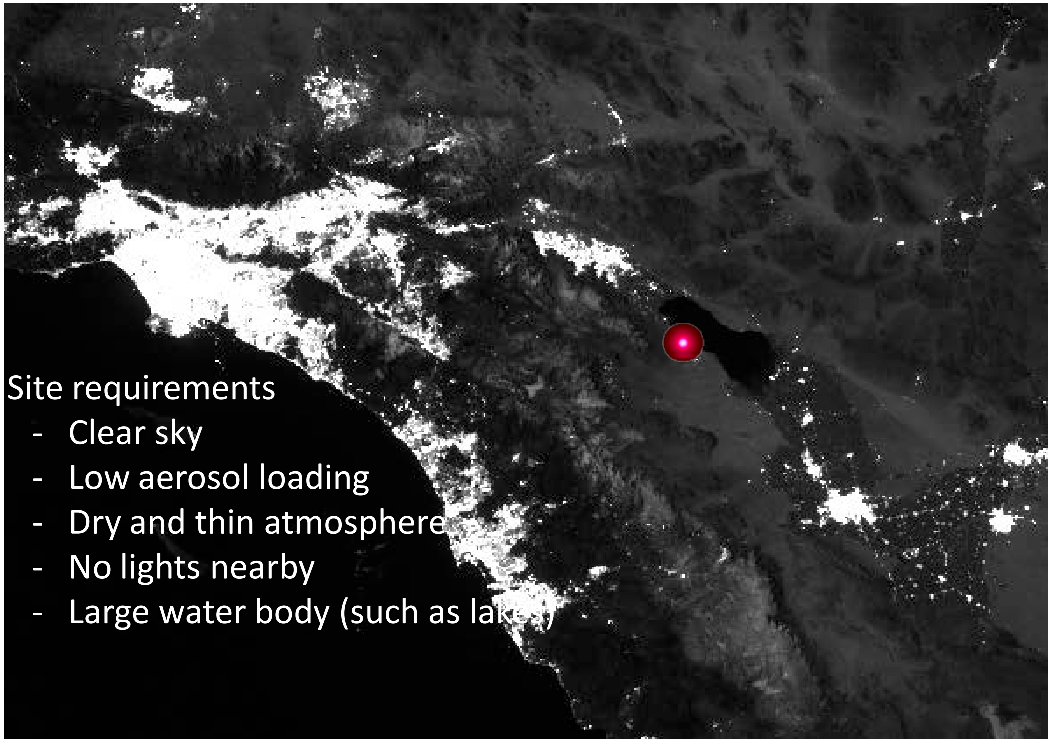




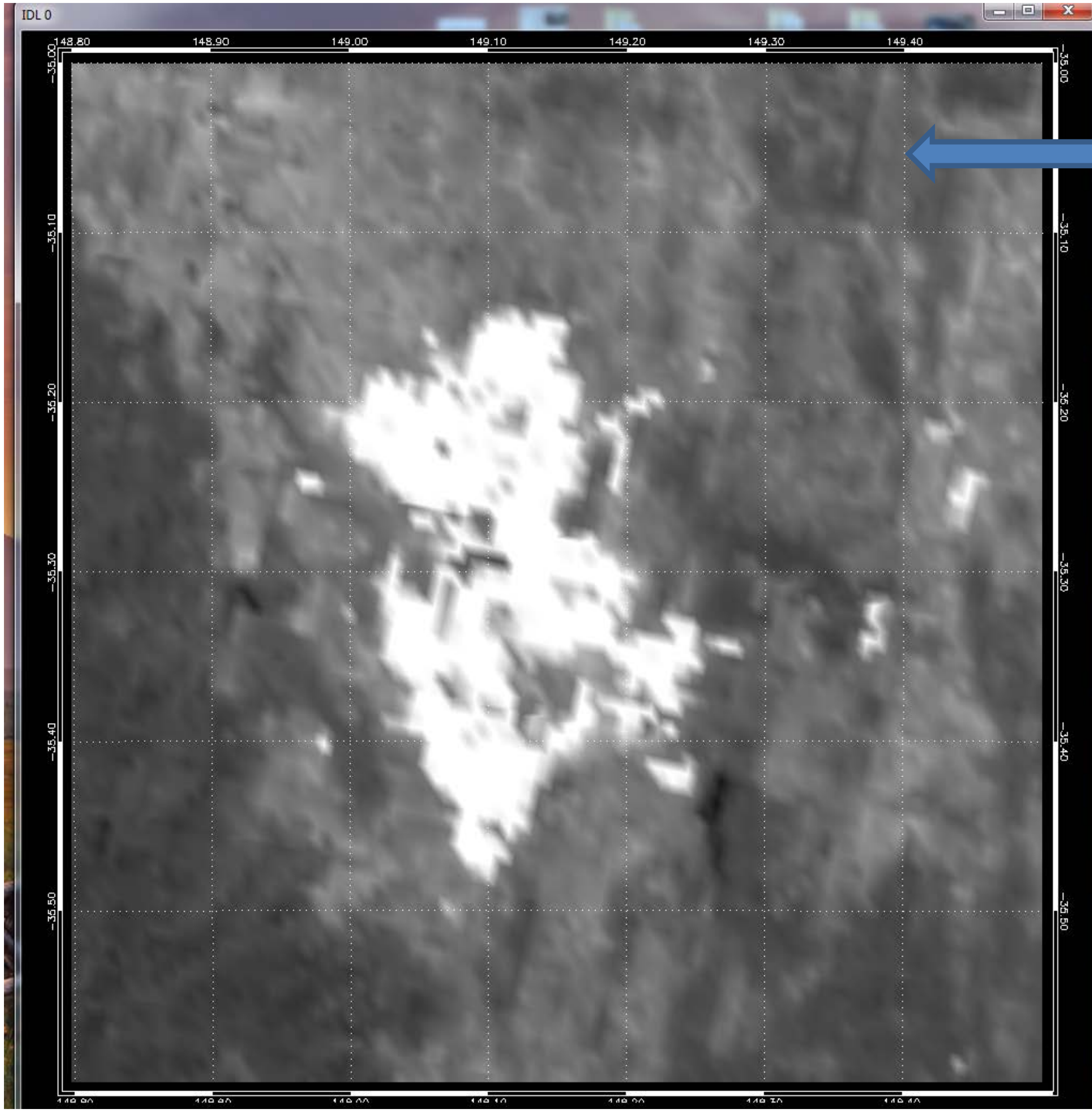
Offset (DN0) increase greatest towards Agg. zone 1, due to dark current increases

Active Night Light Sources for DNB Calibration

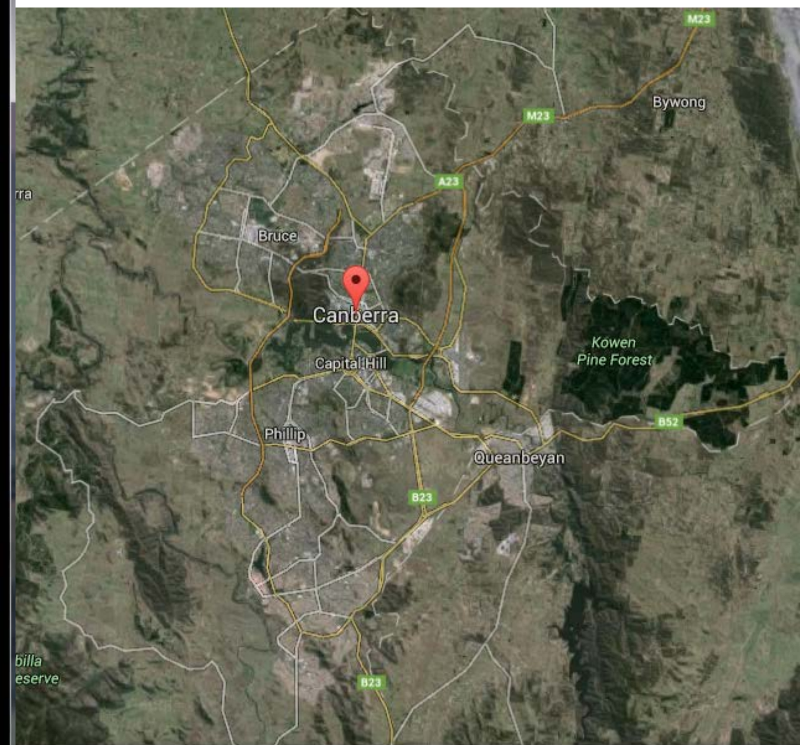
- Investigating vicarious validation sites suitable for DNB (at low radiances):
  - » Analysis of nightlight point sources (from bridges, fishing vessels, cities) showed the potential to validate DNB calibration (Cao & Bai, *Remote Sens* 2014)
  - » Emphasizes the need and feasibility of developing active light source references
- SBIR project in progress to develop active nightlight for VIIRS DNB validation, working closely with NIST and NASA scientists
- Potential collaboration with RADCALNET



VIIRS DNB Nighttime Observation of Canberra

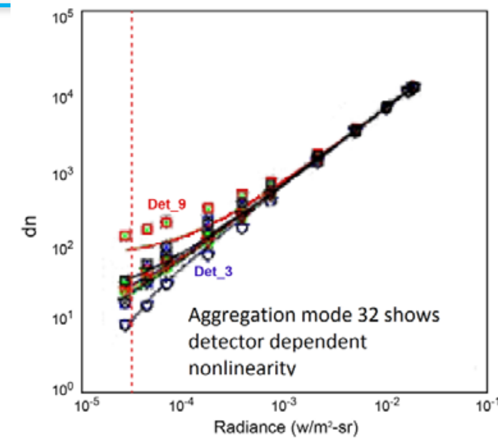


February 22, 2016, Full Moon



J1 VIIRS DNB non-linearity Mitigation

- 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

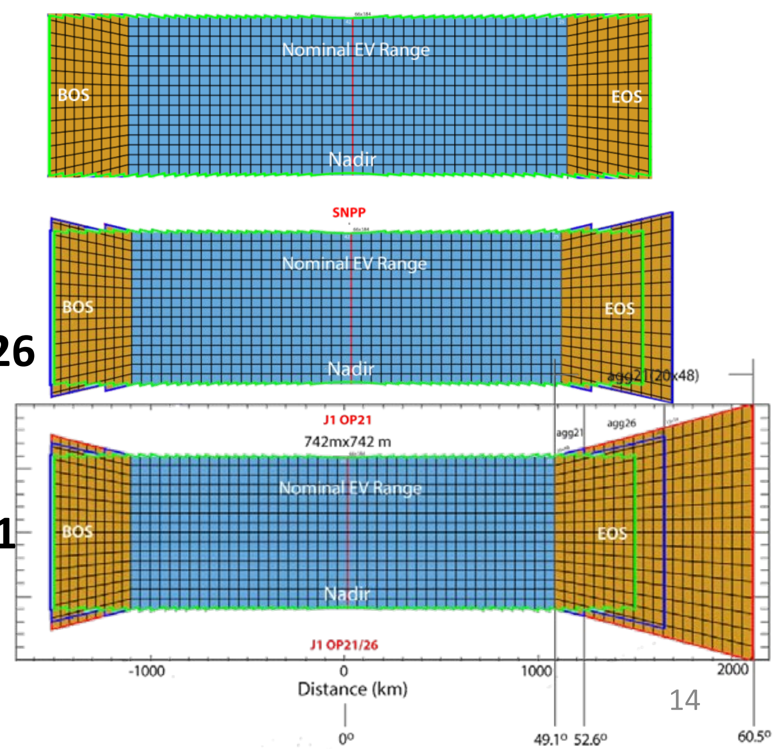


- Two options have been proposed by the J1 data working group:
  - » **Op21 (Baseline)**
    Extend AggMode 21 up to 32
  - » **Op21/26**
    Extend AggMode 21 up to 25
    Extend AggMode 26 up to 32

SNPP

J1 Op21/26

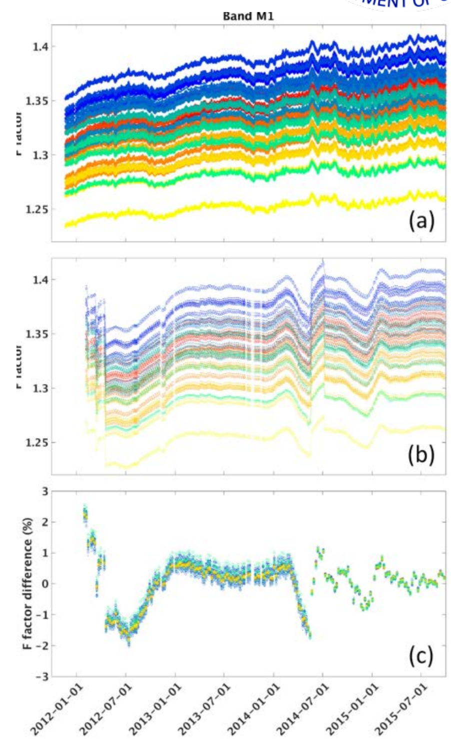
J1 Op21



Reprocessing of SNPP SDR data

- **SNPP VIIRS SDRs will be reprocessed at NOAA using:**
  - » Latest RSB radiometric calibration coefficients generated by RSBAutoCal
  - » Improved DNB LUTs
    - Stray light LUTs with solar vector error corr.
    - New RSR and LGS LUTs between launch and mid-2013
  - » Improved TEB LUTs
  - » Latest geolocation LUTs
  - » Latest SDR algorithms
  - » Reprocessing is planned to start in 2017
  - » Reprocessing validation capabilities are being developed at NOAA STAR

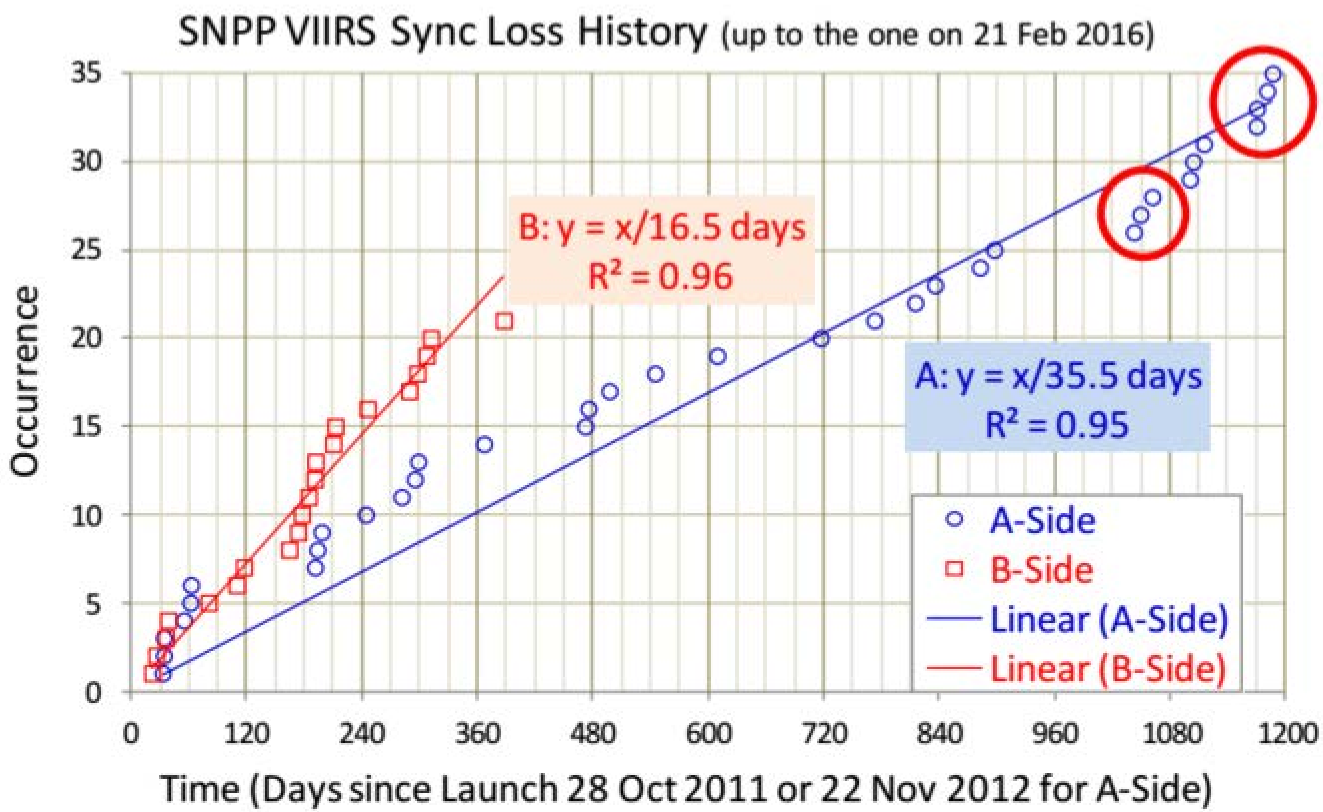
(http://ncc.nesdis.noaa.gov/VIIRS/ReprocessingLUTs.php)



M1 F-factors: (1) generated by RSBAutoCal; (2) NOAA operational; (3) differences

Blanski and Cao, RS, 2015

S-NPP VIIRS Issue: SNPP VIIRS RTA/HAM Sync Loss



Courtesy of G. Lin, VCST

Special issue of *Remote Sensing* (Guest Editor: Dr. Changyong Cao) "VIIRS Cal/Val and Applications" 27 papers already published online (http://www.mdpi.com/journal/remotesensing/special_issues/VIIRS?view=default)

Article: Preliminary Inter-Comparison between AHI, VIIRS and MODIS Clear-Sky Ocean Radiances for Accurate SST Retrievals
Remote Sens. 2016, 8(3), 203; doi:10.3390/rs8030203

Review: VIIRS Reflective Solar Bands Calibration Progress and Its Impact on Ocean Color Products
Remote Sens. 2016, 8(3), 194; doi:10.3390/rs8030194

Article: Radiometric Inter-Calibration between Himawari-8 AHI and S-NPP VIIRS for the Solar Reflective Bands
Remote Sens. 2016, 8(3), 165; doi:10.3390/rs8030165

Article: Evaluation of VIIRS and MODIS Thermal Emissive Band Calibration Stability Using Ground Target
Remote Sens. 2016, 8(2), 158; doi:10.3390/rs8020158

Article: The Potential of Autonomous Ship-Borne Hyperspectral Radiometers for the Validation of Ocean Color Radiometry Data
Remote Sens. 2016, 8(2), 150; doi:10.3390/rs8020150

Article: Assessing the Effects of Suomi NPP VIIRS M15/M16 Detector Radiometric Stability and Relative Spectral Response Variation on Striping
Remote Sens. 2016, 8(2), 145; doi:10.3390/rs8020145

Article: JPSS-1 VIIRS Pre-Launch Response Versus Scan Angle Testing and Performance
Remote Sens. 2016, 8(2), 141; doi:10.3390/rs8020141

Article: An Overview of the Joint Polar Satellite System (JPSS) Science Data Product Calibration and Validation
Remote Sens. 2016, 8(2), 139; doi:10.3390/rs8020139

Article: Soumi NPP VIIRS Day/Night Band Stray Light Characterization and Correction Using Calibration View Data
Remote Sens. 2016, 8(2), 138; doi:10.3390/rs8020138

Review: Comparison of the Calibration Algorithms and SI Traceability of MODIS, VIIRS, GOES, and GOES-R ABI Sensors
Remote Sens. 2016, 8(2), 126; doi:10.3390/rs8020126

Article: Assessment of S-NPP VIIRS On-Orbit Radiometric Calibration and Performance
Remote Sens. 2016, 8(2), 84; doi:10.3390/rs8020084

Letter: An Investigation of a Novel Cross-Calibration Method of FY-3C/VIRR against NPP/VIIRS in the Dunhuang Test Site
Remote Sens. 2016, 8(1), 77; doi:10.3390/rs8010077

Article: Fast and Accurate Collocation of the Visible Infrared Imaging Radiometer Suite Measurements with Cross-Track Infrared Sounder
Remote Sens. 2016, 8(1), 76; doi:10.3390/rs8010076

Article: Improved VIIRS and MODIS SST Imagery
Remote Sens. 2016, 8(1), 79; doi:10.3390/rs8010079

Article: Inter-Comparison of S-NPP VIIRS and Aqua MODIS Thermal Emissive Bands Using Hyperspectral Infrared Sounder Measurements as a Transfer Reference
Remote Sens. 2016, 8(1), 72; doi:10.3390/rs8010072

Article: Pre-Launch Radiometric Characterization of JPSS-1 VIIRS Thermal Emissive Bands
Remote Sens. 2016, 8(1), 47; doi:10.3390/rs8010047

Article: JPSS-1 VIIRS Radiometric Characterization and Calibration Based on Pre-Launch Testing
Remote Sens. 2016, 8(1), 41; doi:10.3390/rs8010041

Article: Spectral Cross-Calibration of VIIRS Enhanced Vegetation Index with MODIS: A Case Study Using Year-Long Global Data
Remote Sens. 2016, 8(1), 34; doi:10.3390/rs8010034

Article: Monitoring the NOAA Operational VIIRS RSB and DNB Calibration Stability Using Monthly and Semi-Monthly Deep Convective Clouds Time Series
Remote Sens. 2016, 8(1), 32; doi:10.3390/rs8010032

Article: Improved Band-to-Band Registration Characterization for VIIRS Reflective Solar Bands Based on Lunar Observations
Remote Sens. 2016, 8(1), 27; doi:10.3390/rs8010027

Article: Radiometric Stability Monitoring of the Suomi NPP Visible Infrared Imaging Radiometer Suite (VIIRS) Reflective Solar Bands Using the Moon
Remote Sens. 2016, 8(1), 15; doi:10.3390/rs8010015

Article: Comparison between the Suomi-NPP Day-Night Band and DMSP-OLS for Correlating Socio-Economic Variables at the Provincial Level in China
Remote Sens. 2016, 8(1), 17; doi:10.3390/rs8010017

Article: User Validation of VIIRS Satellite Imagery
Remote Sens. 2016, 8(1), 11; doi:10.3390/rs8010011

Article: Validation of S-NPP VIIRS Sea Surface Temperature Retrieved from NAVO
Remote Sens. 2015, 7(12), 17234-17245; doi:10.3390/rs71215881

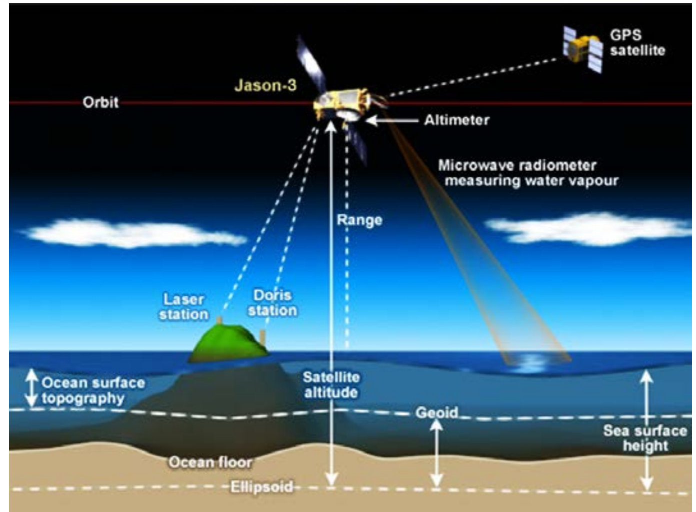
Article: Validation of the Suomi NPP VIIRS Ice Surface Temperature Environmental Data Record
Remote Sens. 2015, 7(12), 17258-17271; doi:10.3390/rs71215880

Article: Suomi NPP VIIRS Reflective Solar Bands Operational Calibration Reprocessing
Remote Sens. 2015, 7(12), 16131-16149; doi:10.3390/rs71215823

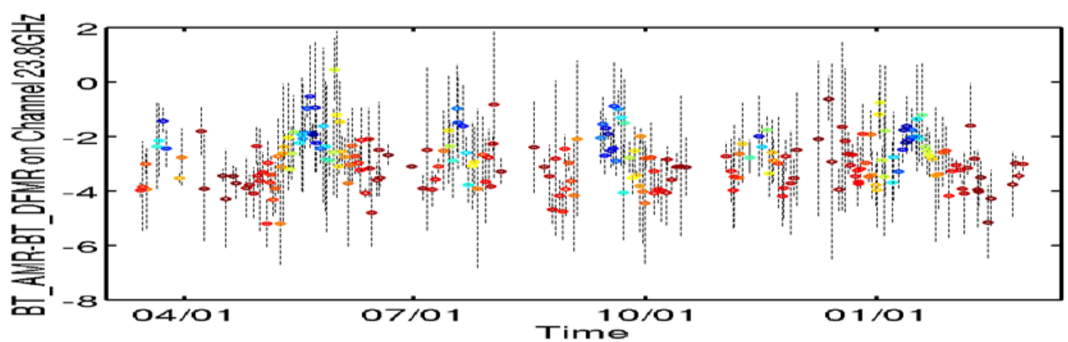
Article: Quality Assessment of S-NPP VIIRS Land Surface Temperature Product
Remote Sens. 2015, 7(9), 12215-12241; doi:10.3390/rs70912215

Jason 3 Radiometer Calibration Support

- Jason 3 AMR radiometer will be intercompared with Jason 2 and other instruments to ensure stability;
- Pitch maneuver will also be performed to improve the calibration on the cold end;
- Cal/Val methodologies have been developed based on Jason 2, SARAL, and other missions;
- We will support the Radiometer calibration, working closely with the altimetry team.



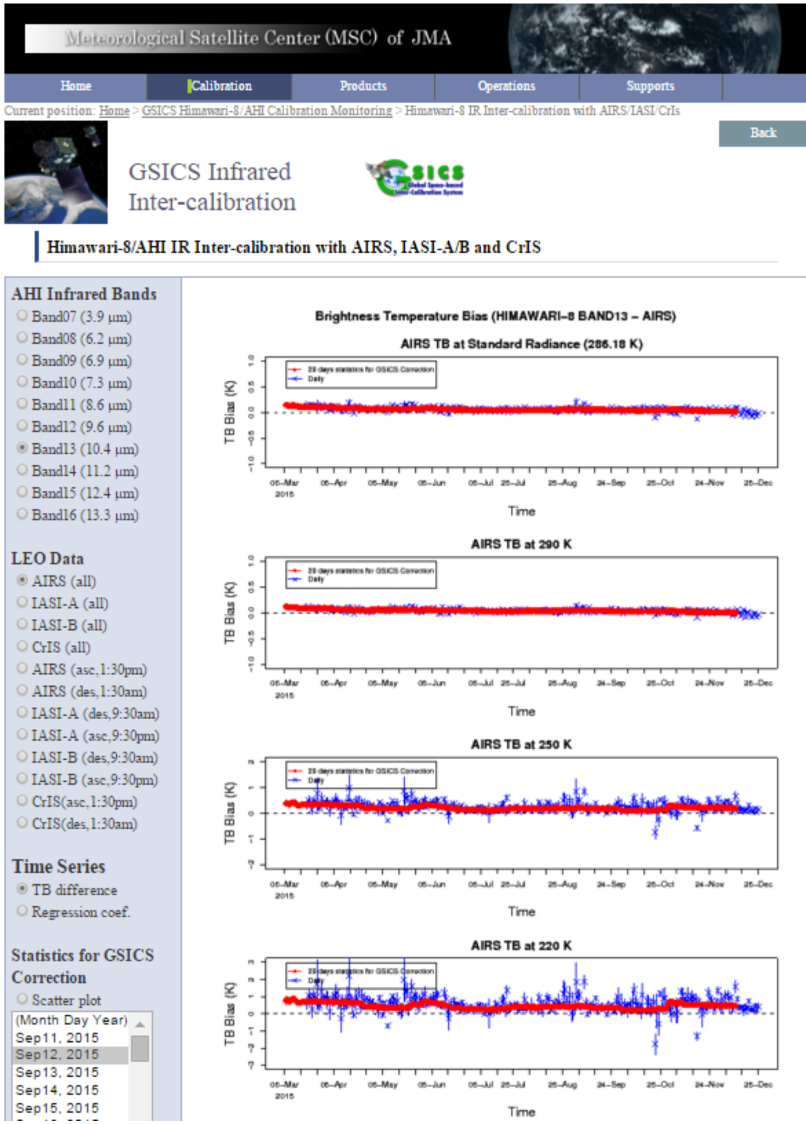
Courtesy of Laury Miller, Satellite Altimetry Laboratory, STAR/SOCD

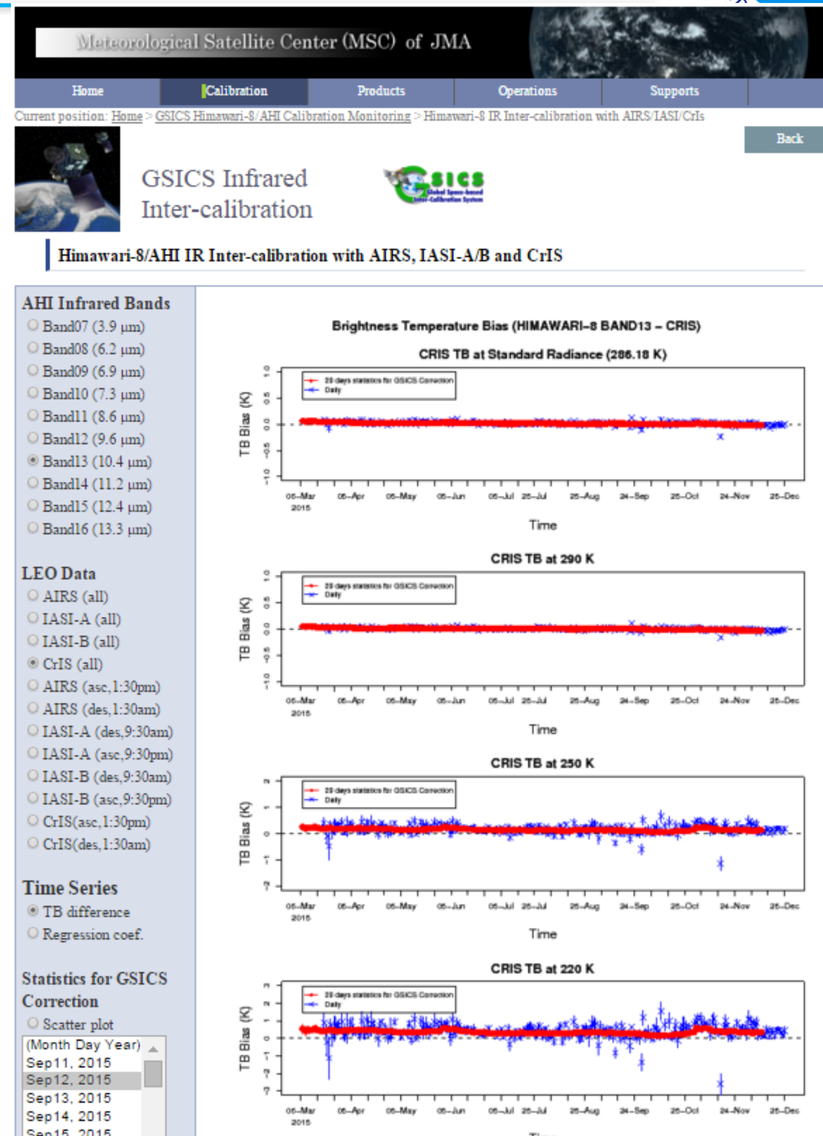


Brightness temperature difference between Jason2/AMR and SARAL/Altika/DFMR for the 23.8G Hz common channel. Color represents meridian distance from equator (or latitude without sign). No clear trend in both difference and ratio time series is observed.

Zhang et al., Marine Geodesy Special Issue: The SARAL/AltiKa Satellite Altimetry Mission, Volume 38, 2015

GOES-R/ABI: Himawari/AHI and IASI/CrIS/AIRS Intercomparison





Courtesy of JMA

GOES-R Field Campaign Overview

The purpose of the GOES-R field campaign is to support post-launch validation of L1b & L2+ products:

Advanced Baseline Imager (ABI) & Geostationary Lighting Mapper (GLM):

- Planning ~6 week field campaign (~100 flight hours) with the high-altitude NASA ER-2 platform coordinated with ground based and near surface observations over several Earth targets
  - » April – June 2017

Small UAS

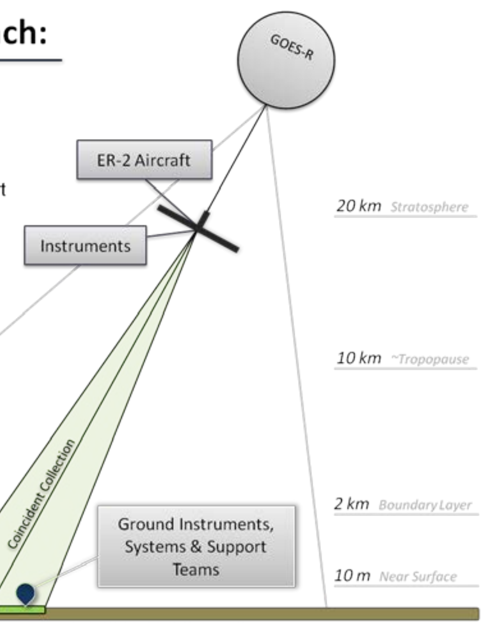
ABI Field Campaign Approach:

Primary Objective: provide validation of ABI L1b spectral radiance observations to validate SI traceability

Secondary objective: provide surface and atmospheric geo-physical measurements to support L1b & L2+ product validation

Targets of Interest:

- Desert
- Open Ocean
- Land/Vegetation
- Clouds



GLM Field Campaign Approach:

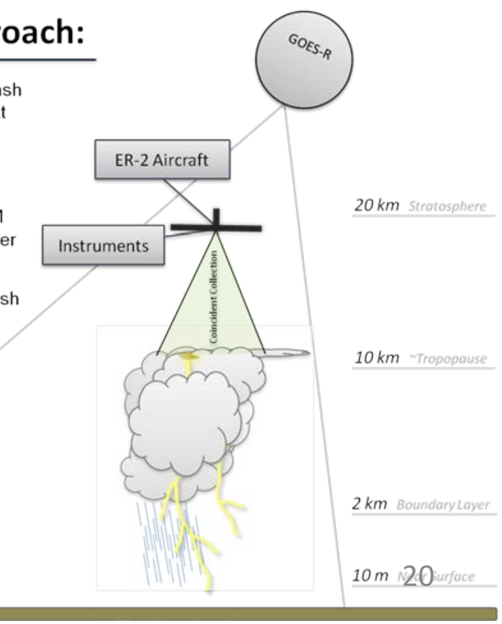
Primary Objective: provide validation of GLM flash detection efficiency day through night over land at well characterized total lightning super sites: Northern AL, Lubbock TX, Norman OK, KSC FL, and Wallops/DC area

Secondary Objective: provide validation of GLM flash detection efficiency day through night at other land locations and over ocean

Tertiary Objective: provide validation of GLM flash location & time stamp accuracy, and GLM image navigation and registration (INR) accuracy

Targets of Interest:

- Storms



GSICS - CEOS Interaction

Background

- The initial concept of GSICS was brought forward by people involved in calibration activities with some links with CEOS WGCV.
- Important interaction on the QA4EO in (2009-2010). Resulted in GPPA (inherited from QA4EO).
- *WGCV Chair in the GSICS Executive Panel, and the GSICS EP Chair in WGCV. Lots of overlap among group members*.

Interaction in 2014

- In Feb 17-21, 2014 , 37th **CEOS** WGCV-36 held in **Frascati**, Italy. GSICS members Jerome Lafeuille (GSICS EP Member) and Tim Hewison invited to the meeting.
- In Sept – Oct 2014 NOAA hosted, 38 th **CEOS** , Mitch Goldberg (GSICS EP Member) , Lawrence E Flynn (Director GCC) and Manik Bali (Deputy Director GCC) presented GSICS , GSICS Coordination Center activities and GSICS Procedure for Product Acceptance (GPPA).

Outcome of 38th CEOS Meeting at NOAA

Meeting resulted in following action items on GSICS

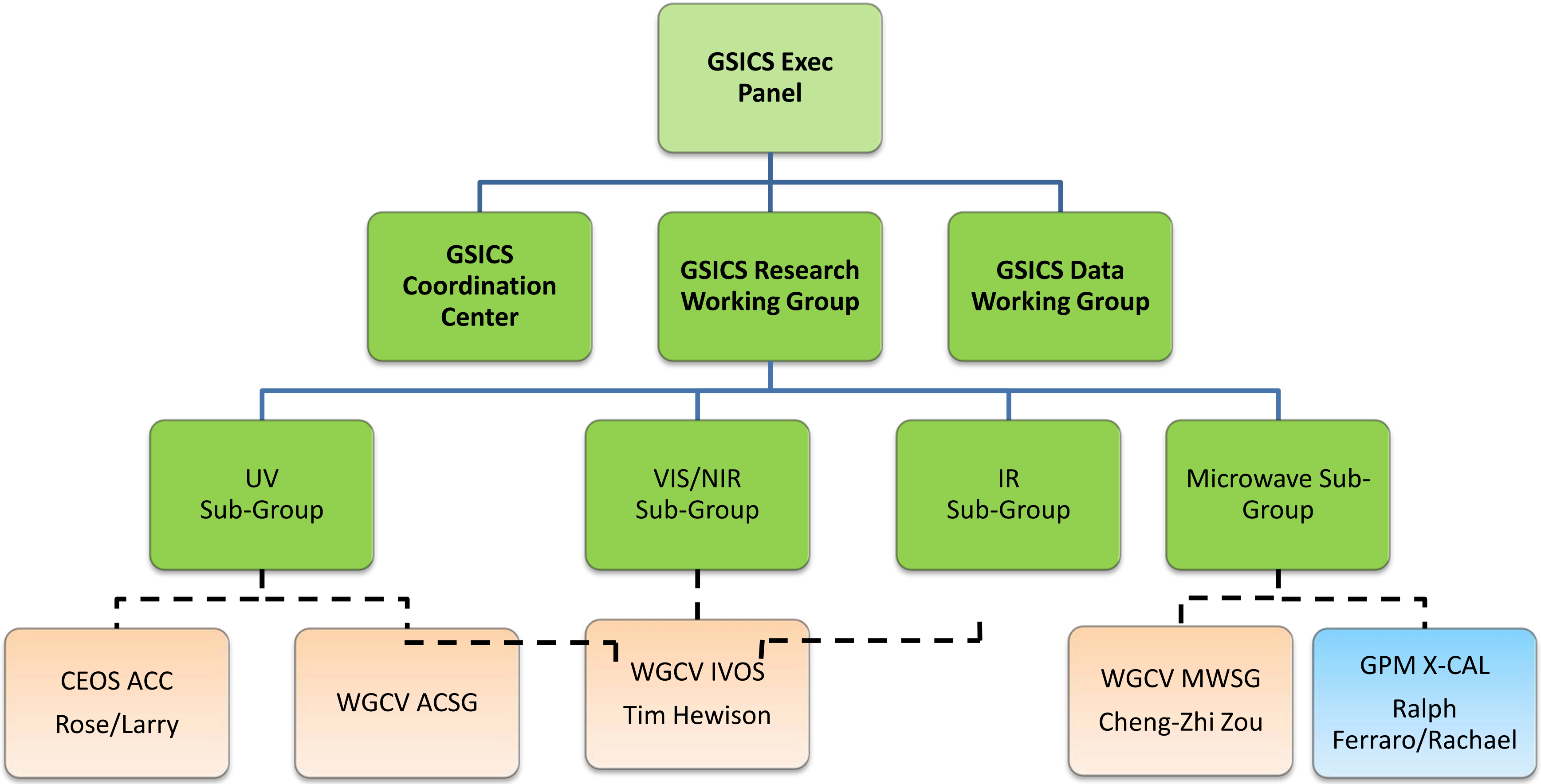
- MWSG Chair to have a communication with GSICS on how WGCV can offer support on best practices.
- WGCV Secretariat to send out the list of potential GSICS-WGCV Cooperation items outlined by GSICS to each subgroup chair
- WGCV (Completed) Subgroup Chairs to identify and prioritize specific activity areas for interaction with GSICS.
- Mitch Goldberg suggested to WGCV to establish surface reference sites, and help with procedures for best practices.

Challenges in GSICS

- Multiple GSICS References
  - » Merging or Single
  - » Handling Transitions
  - » Traceability
  - » CLARREO/TRUTHS
  - » The Moon
  - » The Sun
- New Instruments in GSICS
  - – New Channels (GEO NIR UV MW)
  - – Sounders
  - – Hyperspectral
  - – High-Resolution
- New Sub-Groups

Curtsey Tim Hewison

GRWG CEOS Collaboration

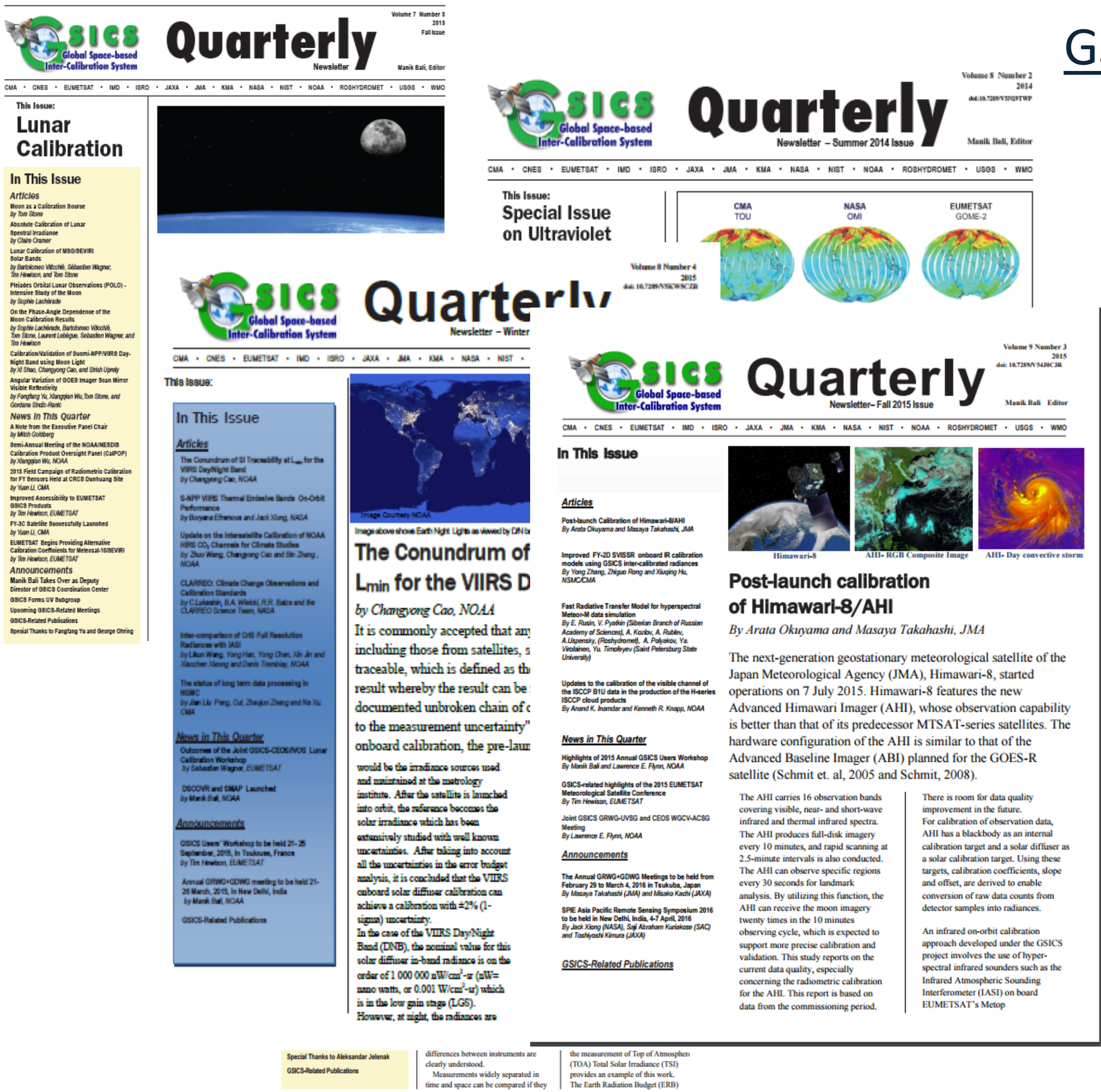


Close interaction with CEOS needed at subgroup level to meet challenges.

Areas include : SAR calibration, Solar spectrum for calibration, lunar inter-calibration etc.

Curtsey Tim Hewison

GCC – GSICS Quarterly Newsletter



GSICS Quarterly Newsletter Features

- New format since Fall 2013.
- Since Winter 2014, the Newsletter has a doi.
- Accepts articles on topics related to calibration (Pre and Post launch).
- New Landing page on the GCC website.
- Rate and Comment section: readers and authors can interact.
- Articles are reviewed by subject matter experts

Summary

- VIIRS on Suomi NPP has been performing well;
  - » The RTA mirror degradation has leveled off
- Scientists continue to explore the new capabilities of the DNB;
- J1 VIIRS is not identical to Suomi NPP VIIRS
  - » Several issues on SNPP are resolved for J1
    RTA mirror degradation, SEU, and Sync loss
  - » Several waivers are being mitigated
    DNB &SWIR nonlinearity, polarization sensitivity, etc
  - » Additional validation capabilities are being developed, especially for DNB
- Other initiatives:

  reprocessing, J1 launch preparation, VIIRS special issue …
- S-NPP VIIRS RSB, TEB, and DNB performance factors are monitored in near real-time.
  - » NOAA National Calibration Center (NCC) site at http://ncc.nesdis.noaa.gov/VIIRS/index.php
  - » NOAA Integrated Cal/Val System (ICVS) site at http://www.star.nesdis.noaa.gov/icvs/status_NPP_VIIRS.php