Update of S-NPP VIIRS On-orbit Calibration and Performance

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Contributions:
- NOAA VIIRS SDR Calibration Team
- NASA VIIRS Characterization Support Team (VCST)
- VIIRS Instrument Vendor (Raytheon)
- S-NPP Mission Operation Team (MOT)
Outline

- S-NPP VIIRS Operation and Calibration
- On-orbit Performance
- SDR Progress and Improvements
- Summary and Future Work

Not Covered: Vicarious Calibration and Validation Activities and Calibration Inter-comparisons
S-NPP VIIRS On-orbit Operation and Calibration

S-NPP VIIRS has successfully operated since October 28, 2011

Spectral bands: 14 RSB, 1 DNB, 7 TEB; 7 dual gain bands
Spatial resolutions: 375/750 m for I/M bands
OBC: SD, SDSM, BB

Solar Diffuser
Solar Diffuser Stability Monitor (SDSM)
Extended SV Port
Rotating Telescope Aft Optics and HAM
Solar Diffuser (SD)
V-groove Blackbody (BB)
S-NPP VIIRS On-orbit Operation and Calibration

• Instrument Operation
  – Same operation configuration (B-side) since launch
  – “Scan Sync Loss” between RTA and HAM: 69 since launch (2-3 min with poor geolocation accuracy each time)
  – Single Board Computer (SBC) lock-up: 10 since launch (most in SAA region)

• On-orbit Calibration
  – SD CAL each orbit and 3 SDSM CAL/week
  – BB warm-up and cool-down (WUCD): quaterly (20 since launch)
  – DNB VROP: monthly
  – Lunar observations: near-monthly (44 since launch)
  – Pitch maneuver for TEB RVS characterization
  – Yaw maneuvers for SD/SDSM screens transmission measurement

Strategies are mostly based on MODIS operation and calibration approaches
On-orbit Performance

- Instrument and On-board Calibrators (OBC)
  - OMM and FPA temperatures
  - BB temperature
  - SD degradation

- Radiometric, Spectral, and Spatial
  - Changes in spectral band responses
  - Detector noise characterization performance
  - Modulated relative spectral response (RSR)
  - Band-to-band registration (BBR)
Overall instrument performance has been very stable (e.g. OMM, VISNIR and cold FPA (SMIR and LWIR), and BB temperatures)

BB long-term stability is within a few mK and short-term stability continues to meet design requirements
Radiometric Performance: Spectral Band Responses (Gains)

- Large changes in NIR and SWIR (due to mirror contamination)
- Small changes in VIS, MWIR, and LWIR
(SNR/SNR_{SPEC} > 1) or (NEdT/NEdT_{SPEC} < 1): better performance

Noticeable SNR decrease in NIR/SWIR is due to degradation of sensor optical throughput
strong wavelength dependent optics degradation

Impact of modulated RSR depends on spectral band location, bandwidth, and OOB response

modulated relative spectral response (RSR)

DNB BW: 500-900 nm
Spatial Performance: Band-to-Band Registration (BBR)

- On-orbit BBR is very stable in both scan and track directions.
- Improved methodology (originally developed for MODIS BBR using lunar observations and validated using on-board SRCA).

![BBR Scan (Corrected)](image1)

![BBR Track (Corrected)](image2)

Centroid of band 1  X Centroid of band 2  X
VIIRS SDR Progress: RSB

- NOAA OC Team calibration parameters are being used for reprocessing the RSB bands;
- This will “meet the needs of the OC community which requires 0.1% accuracy/stability”, while not to expect to introduce negative impacts to other users;
- The OC calibration relies on offline analysis and processing of lunar and solar calibration (Hybrid approach)
- Embarrassingly Parallel Computation with ADL by NOAA STAR VIIRS SDR team leads to fast reprocessing: 8.5 days to reprocess one year of SDR data.

Sample reprocessed granules showing:
1) M2 radiance difference on the order of 2.4% from IDPS
2) High gain and Low gain do not have the same %change (requires further investigation)

Courtesy of Z. Wang
A new algorithm (Ltrace) has been developed at NOAA STAR to correct the longwave infrared channel (primarily M15) biases during WUCD which has been impacting the SST time series;

The root cause of the bias is traced to a flaw in the fundamental assumption of the calibration curve shape change from prelaunch to post launch;

Bias is effectively removed based on sample WUCD data processing, and validation with CrIS, CRTM, and SST (validation support provided by Moeller/Li, L. Wang, X. Liang);

The algorithm is being used for reprocessing.

New correction algorithm effectively removed bias during WUCD (black=before; red=after)

Cao & Wang, 2017, journal paper being submitted
Recent calibration changes:

- Starting from 14:18 UTC on January 12, 2017, the S-NPP VIIRS DNB has begun to use NOAA STAR team delivered calibration coefficients;
- While no major differences are expected for day time observations, there should be a major reduction (~70%) in negative radiances for night observations especially during new moon;
- The new calibration is based on onboard calibration, adjusted with pitch maneuver data, instead of the dark ocean based calibration earlier which were heavily contaminated by air glow.

Major reduction in negative radiances with the new calibration (red=negative radiance pixels)

More details: Uprety & Cao, IGARSS 2017
Improvements for NASA L1B Processing/Re-processing

- SDSM screen transmission ($\tau_{SDSM}$)
- SD screen transmission and $\tau_{SD BRDF_{SD}}$(SDSM_View)
- SD screen transmission and $\tau_{SD BRDF_{SD}}$(RTA_View)
- SD degradation (H)
  - Revised extrapolation of H to the mission very beginning
  - Model H to cover SWIR wavelength
  - Fit H at RTA view to lunar trending
- Correction for the solar vector error
- DNB offsets and stray light correction (forward processing)
  - DNB offsets derived using BB observations during night time orbit
  - Stray light correction LUT (for forward processing) derived from LUTs in previous years (weighted average of the “same” day LUTs from previous years)
Improvements of SDSM screen $\tau_{SDSM\ LUT}$ =>
smooth SD degradation (H-factor) trend

Similar improvements for $\tau_{SD\ BRDF_{SD}(SDSM\ _View)}$ and $\tau_{SD\ BRDF_{SD}(RTA\ _View)}$
8 detectors with wavelengths from 0.41 to 0.93 μm

4 VIIRS SWIR bands: from 1.2 to 2.3 μm

$1 - H(\lambda, t) = \frac{\alpha(t)}{\lambda^{4.07}}$
Summary and Future Work

• S-NPP VIIRS instrument operation continues to be stable and its overall performance has been satisfactory in meeting overall design requirements

• Calibration enhancements have led to production of SDRs and EDRs with improved quality, which benefit both operational and research community

• Dedicated calibration effort remains critical to mission success
  – Support for VIIRS data reprocessing (by NASA and NOAA)
  – Improved use of SD and lunar calibration parameters
  – Tracking potential changes in VIIRS RVS
  – Support for J1 launch (August 2017) and J1 VIIRS intensive calibration and validation (ICV)
  – Calibration consistency (e.g. MODIS, VIIRS, ABI, ...)

• Interagency collaboration and community effort are essential and can continue to provide great benefits (science and cost)