Status of S-NPP VIIRS On-orbit Calibration

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VIIRS Characterization Support Team (VCST), NASA GSFC

and

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Outline

• VIIRS Instrument
• On-orbit Calibration and Characterization
• Performance Summary
• Status of VIIRS SDR and LUTs
• Future Improvements
Visible Infrared Imaging Radiometer Suite (VIIRS)

- Key Instrument on S-NPP and Future JPSS Satellites
  - S-NPP launched on October 28, 2011
    - Instrument turn-on: 11/8/11
    - Nadir door open: 11/21/11 (first image from VIS/NIR)
    - Cryo-cooler door open: 1/18/12 (observations from all bands)
  - JPSS-1 launch in 2016
    - Sensor ambient phase 1&2 completed
    - Sensor TVAC testing in July, 2014
    - S/C level testing in 2015
  - JPSS-2 launch in 2020
    - Most components available
      (modifications and improvements)
- Strong MODIS Heritage
  - Sensor Design and On-board Calibrators
  - Operation and Calibration
On-orbit Calibration and Characterization

22 Spectral Bands:
15 RSB (0.4-2.3 mm), including 1 DNB
7 TEB (3.7-12 mm)
Calibration Activities

- **SD and SDSM**
  - SD calibration performed every orbit (no SD door and no scheduling required)
  - SDSM operated most on a daily basis and now at a reduced frequency (time duration), starting from May 16, 2014

- **Lunar Calibration (20)**
  - Regularly scheduled via S/C roll maneuvers (8-9 times/year)

- **BB Calibration (9 WUCD)**
  - Nominally controlled at 292 K (no scheduling is needed)
  - Periodic warm-up and cool-down (scheduled on a quarterly basis)

- **Calibration Maneuvers**
  - Executed during Intensive Cal/Val (ICV) phase at the mission beginning
Performance Summary

• **Instrument and On-board Calibrators**
  – Instrument Temperatures: extremely stable
  – SD Degradation: wavelength dependent
  – BB Stability: excellent

• **Changes in Spectral Band Response**
  – Reflective Solar Bands (RSB): wavelength dependent
    ➢ **Modulated RSR and impact**
  – Thermal Emissive Bands (TEB): changes are small ( < 0.7% for all bands over 2.5 years)

• **Detector SNR and NErdT**
  – Continue to meet the design requirements
SD Degradation

VIIRS SD Degradation
(As of April 2014)

Shorter wavelength: larger degradation

Comparison of MODIS & VIIRS SD Degradation

VIIRS has no SD door
A-MODIS SD door is closed when no calibration is scheduled
T-MODIS SD door fixed at open since July 2003
BB Stability

Long-term trend of daily-averaged $T_{BB}$
- Stable to within a few mK.
- ~15mK offsets were due to the use of different $T_{BB}$ settings.

Short-term stability (scan-by-scan $T_{BB}$)
- Orbital variations of individual thermistors up to 40mK
- Variations in average temperature ~ 20mK
- Temperature difference between individual thermistors up to 60mK
- BB uniformity meets the requirement with standard deviation less than 30mK
Changes in Spectral Band Response (RSB)

SD and lunar calibration made at the same angle of incidence (AOI)

Large changes in NIR/SWIR response

Noticeable SD and Lunar calibration seasonal difference in VIS (M1-M3)
Changes in Spectral Band Response (TEB)

The discontinuities in the F-factor are coincident with SC maneuvers and anomalies during which the cold FPA temperatures changed.

<table>
<thead>
<tr>
<th>Band</th>
<th>I4</th>
<th>I5</th>
<th>M12</th>
<th>M13</th>
<th>M14</th>
<th>M15</th>
<th>M16</th>
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</thead>
<tbody>
<tr>
<td>Average F-factor: 03 26 2012</td>
<td>1.0105</td>
<td>1.0040</td>
<td>1.0035</td>
<td>1.0070</td>
<td>0.9946</td>
<td>1.0056</td>
<td>1.0102</td>
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<tr>
<td>Average F-factor: 03 16 2014</td>
<td>1.0135</td>
<td>1.0106</td>
<td>1.0068</td>
<td>1.0092</td>
<td>0.9960</td>
<td>1.0065</td>
<td>1.0119</td>
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<tr>
<td>Trend [%]</td>
<td>0.30</td>
<td>0.65</td>
<td>0.33</td>
<td>0.21</td>
<td>0.14</td>
<td>0.09</td>
<td>0.18</td>
</tr>
</tbody>
</table>
Detector SNR (RSB) and NEdT (TEB)

RSB SNR* > 1: performance better than specified requirements
TEB NEdT* < 1: performance better than specified requirements

SNR* and NEdT*: normalized to specified values
Impact of $\lambda$-dependent Changes in Detector Response

Mirror Degradation Impact on Sensor Relative Spectral Response

$\lambda$ dependent optics degradation

Modulate RSR has been applied to VIIRS calibration and data production

Large impact on DNB
Impact of $\lambda$-dependent Changes in Detector Response

Modulated RSR should be applied to both solar and lunar calibration

Remaining issues:
(1) lunar model uncertainty (to be investigated)
(2) solar vector calculation error (in IDPS common geolocation library)
Status of VIIRS SDR and LUTs

- **IDPS VIIRS SDR Code/LUTs (radiometric)**
  - 19 major code versions (post launch); numerous LUT updates.
  - LUT update strategy: on demand ➔ weekly ➔ automated.

- **VCST Support Land PEATE SDR Code/LUTs and data reprocess (C1.0 & C1.1)**
  - 15 sets of LUTs for VISNIR/SWIR and DNB delivered to Land PEATE for data reprocess and SDR/EDR assessments.
    - Jan 31, 2013: LUTs from Jan 2012 to Jan 2013 generated using IDPS algorithm Mx6.3 but with smoothed functions to remove outliers.
    - Nov 13, 2013: LUTs from Jan 2012 to Oct 2013 generated with calibration improvements based on Mx6.4, including SD/SDSM screen transmission, SD BRDF, RTA mirrors degradation model, modulated RSRs, and smoothed fitting functions.
    - Mar 12, 2014: LUTs from Jan 2012 to Nov 2013 generated with “best” sensor characterization improvements based on Mx7.2 algorithm for Land PEATE reprocess Collection 1.1, including DNB Stray Light Correction algorithm and smoothed fitting functions.
    - Latest LUTs updates: May 14 for Mar/Apr 2014 Cal coefficients; Apr 1 for Dec/Jan/Feb.
  - Future work includes solar vector error correction, update of SD/SDSM screen transmission and SD BRDF LUTs, and update of SD degradation and Cal F-LUT.
Product Maturity Definition

• Beta (L+150) – April 05, 2012
  – Early release product, initial calibration applied, minimally validated and may still contain significant errors
  – 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 (Beta+2mo) – October 24, 2012
  – Product quality may not be optimal
  – Incremental product improvements are still occurring as calibration parameters are adjusted with sensor on-orbit characterization
  – 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 NPP Cal/Val Team representatives prior to use of the data in publications

• Validated/Calibrated (L+1 yr) – December 19, 2013
  – 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
Future Improvements

• **Implementation of solar vector error correction algorithm**
  – Derive and apply new screen transmission functions
    ▪ Remove impact due to solar vector error
    ▪ Fill angular gaps in the yaw maneuver data sets with “daily” SD calibration data sets
  – Update SD degradation and RSB calibration coefficients

• **Improvement of SD and lunar calibration**
  – Resolve and reduce the difference between SD and lunar calibration with improved lunar model reference

• **Improvement of SWIR bands calibration**
  – Examine and eliminate SD degradation impact
  – Validate performance via vicarious calibration

• **Consistent calibration LUTs in support of SDR/EDR quality assessment**