Suomi NPP VIIRS SDR postlaunch cal/val
- Overview of progress and challenges

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¹NOAA, ²NASA
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Sample VIIRS images from yesterday

- Logan
- Salt lake city

DNB w/ 750m resolution

I-5 w/ 375 m resolution

New Orleans

Hurricane Issac
The VIIRS SDR Team Members

- NOAA/NESDIS/STAR
- The Aerospace Corp.
- NASA/VCST
- University of Wisconsin
- MIT Lincoln Laboratory
- Raytheon
- NGAS

Thank Dr. Frank De Luccia of the Aerospace Corporation, and the VIIRS SDR team members for their dedication and support to VIIRS.

Great Team
The VIIRS Instrument

### VIIRS Onboard Calibration Comparisons

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<th>VIIRS</th>
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<th>AVHRR</th>
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<td>45 deg mirror (image pixel rotation at high scan angles)</td>
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<td>V-Grooved Blackbody</td>
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<td>Space view</td>
<td>Space view</td>
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<td>Solar diffuser + screen (VISNIR+DNB)</td>
<td>Solar diffuser +screen+<strong>door</strong> (VISNIR)</td>
<td>Vicarious (desert)</td>
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<tr>
<td>Solar diffuser stability monitor</td>
<td>Solar diffuser stability monitor</td>
<td>-</td>
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<tr>
<td>Lunar cal</td>
<td>Lunar cal</td>
<td>-</td>
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<tr>
<td>None</td>
<td>SRCA</td>
<td>None</td>
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</tbody>
</table>

Source: VIIRS SDR User’s Guide (v1.01)
https://cs.star.nesdis.noaa.gov/NCC/VIIRS
VIIRS Sensor Data Records (SDRs)

- SDRs = L1b = calibrated, geolocated radiance, reflectance and brightness temperature
- 22 types of SDRs
  - 16 moderate resolution (MOD),
    - 11 Reflective Solar Bands (RSB)
    - 5 Thermal Emissive Bands (TEB)
  - 5 imaging resolution (IMG),
    - 3 RSB; 2 TEB
  - 1 Day Night Band (DNB) imaging, broadband
- 6 non-gridded geolocation products
  - DNB, IMG, IMG terrain corrected, MOD, MOD terrain corrected, MOD unaggregated
- 2 gridded geolocation products
  - MOD, IMG
## Environmental Data Products (EDRs) Derived from VIIRS SDRs

<table>
<thead>
<tr>
<th>Category</th>
<th>Products</th>
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<tbody>
<tr>
<td><strong>Land</strong></td>
<td>Active Fire (Application Related Product)</td>
</tr>
<tr>
<td></td>
<td>Land Surface Albedo</td>
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<tr>
<td></td>
<td>Land Surface Temperature</td>
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<tr>
<td></td>
<td>Ice Surface Temperature</td>
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<tr>
<td></td>
<td>Snow/Ice Characterization</td>
</tr>
<tr>
<td></td>
<td>Snow Cover/Depth</td>
</tr>
<tr>
<td></td>
<td>Vegetation Index</td>
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<tr>
<td></td>
<td>Surface Type</td>
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<td></td>
<td>Soil Moisture</td>
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<tr>
<td></td>
<td>Net Heat Flux</td>
</tr>
<tr>
<td><strong>Ocean</strong></td>
<td>Sea Surface Temperature (KPP)</td>
</tr>
<tr>
<td></td>
<td>Ocean Color/Chlorophyll</td>
</tr>
<tr>
<td><strong>Imagery</strong></td>
<td>Imagery (KPP)</td>
</tr>
<tr>
<td></td>
<td>Cloud Mask (Intermediate Product)</td>
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<tr>
<td></td>
<td>Cloud Optical Thickness</td>
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<tr>
<td></td>
<td>Cloud Effective Particle Size</td>
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<tr>
<td></td>
<td>Cloud Top Pressure</td>
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<td></td>
<td>Cloud Top Temperature</td>
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<tr>
<td></td>
<td>Cloud Base Height</td>
</tr>
<tr>
<td></td>
<td>Cloud Cover/Layers</td>
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<tr>
<td></td>
<td>Probable Water</td>
</tr>
<tr>
<td><strong>Aerosols</strong></td>
<td>Aerosol Optical Thickness</td>
</tr>
<tr>
<td></td>
<td>Aerosol Particle Size</td>
</tr>
<tr>
<td></td>
<td>Suspended Matter</td>
</tr>
<tr>
<td><strong>Low Light Imaging</strong></td>
<td>Near Constant Contrast (NCC) Imagery</td>
</tr>
</tbody>
</table>

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* JPSS Logos are placed at the top left and top right corners of the page.
Cal/Val to Ensure Product Maturity

- **Beta (L+150)**
  - 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)**
  - 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+20mo)**
  - 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

**VIIRS 58 Cal/Val tasks**

- Functional Performance & Format Evaluation (7)
- Calibration System Evaluation (7)
- Image Quality Evaluation (4)
- Radiometric Evaluation (24)
- Geometric Evaluation (9)
- Performance and Telemetry Trending (7)

**VIIRS SDR team Weekly telecons, reports, technical tagup, SDR/EDR interactions, blogs, and wiki.**
VIIRS SDR Data Access and Calibration Knowledge Base

- The VIIRS SDR team developed the Calibration Knowledge base and made available on the website at https://cs.star.nesdis.noaa.gov/NCC/VIIRS with a wealth of information including user’s guide, relative spectral response, SNO predictions, image gallery, standardized parameters, conference presentations, etc.

- The VIIRS SDR User’s Guide is being actively maintained and updated.

- VIIRS SDR data is now open to the public on the NOAA CLASS archive at http://www.class.noaa.gov
RSB Radiometric Performance

SNR performance is exceeding requirements for all bands

Pre-launch Value
Post-launch Value
May 2012
TEB Radiometric Performance

NEdT performance is exceeding requirements for all bands
VIIRS Mirror Degradation - Recent Trend
Solar Diffuser Degradation
A series of (15) yaws performed (February 15 and 16, 2012), covering solar azimuthal angles from 13.7 to 30.6 degrees. Verified SD BRF and screen transmission; improved SDSM screen transmission.
Roll Maneuvers - Lunar Calibration

VIIRS lunar observations have been made via SC roll maneuvers; different roll angles used to keep lunar phase angles to within a small range.

Examples of band I1 lunar images from 6 consecutive scans (Jan 4, 2012)

- Corrections for lunar view geometry differences applied using the ROLO model (USGS)
- Lunar observations are used track VIS/NIR calibration stability
SNO and SNO extension to the Low Latitudes (SNOx) - Aqua/MODIS vs. SNPP/VIIRS

<table>
<thead>
<tr>
<th></th>
<th>SNO</th>
<th>SNOx</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time diff</td>
<td>30 sec</td>
<td>~10 mins</td>
</tr>
<tr>
<td>Nadir distance</td>
<td>&lt; 10 km</td>
<td>~100 km</td>
</tr>
<tr>
<td>Location</td>
<td>Polar regions</td>
<td>Low latitudes</td>
</tr>
<tr>
<td>Surface</td>
<td>Snow/ice/ tundra</td>
<td>Ocean, desert, forest, etc.</td>
</tr>
<tr>
<td>Uncertainty factors</td>
<td>High solar zenith angle (sza), ozone, ground truth</td>
<td>Sun glint, clouds, atmosphere, sza diff</td>
</tr>
<tr>
<td>Use for inter-</td>
<td>Radiometric, Spectral</td>
<td>Radiometric, Geospatial, RVS, spectral</td>
</tr>
<tr>
<td>comparisons</td>
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</tr>
</tbody>
</table>

The SNO/SNOx as well as daily SNPP orbital predictions are available at: https://cs.star.nesdis.noaa.gov/NCC/SNOPredictions
VIIRS, AVHRR, and MODIS
Spectral Response Comparisons

[Graphs showing spectral response comparisons for different wavelengths and sensor types.]
NOAA/STAR and NASA/VCST work together to assess radiometric biases between VIIRS and MODIS

• A radiometric bias on the order of 5% between VIIRS M1 vs. MODIS B8 was found since February 2012.
• After a thorough investigation by the VIIRS SDR team, the bias was found to be due to MODIS calibration drift in the Collection 5 (C5) data set.
• The bias disappears when compared with MODIS Collection 6 (C6) data, which will be released publicly soon.
• It is expected that VIIRS M1 and MODIS B8 will match well once their C6 data are released.
VIIRS vs. Aqua/MODIS at SNOx
VIIRS M1 and MODIS B8 (Collection 6)

See Calcon poster by Uprety et al for more details
Radiometric Biases between VIIRS and MODIS bands

Comparisons between VIIRS and MODIS matching bands at the SNO/SNOx show that radiometrically:

- Bands match relatively well such as M3, M4, M7

- TEB bands performing well in general (M13-M16) but there are issues, such as temperature dependent bias for M15 (per CrIS Team)

- Blue bands M1-M2 (for ocean color) show biases up to 5% with MODIS C5, while bias much reduced with MODIS C6

- Bands have large biases due to relative spectral response differences (RSR) such as M5, and M12 (day time reflected solar)

- Bands require further investigation: M4, M6, M8, M9, M10

- Bands do not have matching spectral response: M11
Suomi NPP VIIRS DNB band

- Despite the straylight effect, the Day/Night Band has been used to detect a major power outages in the Washington, DC on the night of June 29, 2012.
- An analysis of the data after the storm showed that most areas had power restored within 3 days.

![Image](image_url)

**VIIRS DNB of the Washington/Baltimore area on June 26th (top) and June 30th.**

The suburbs west of DC and Baltimore, in particular show dark areas.

**VIIRS DNB radiance time series before and after the power outage (6/29)**
shows that most of the power was restored in three days.
Challenges and Way Forward

- The dynamics of instrument degradations (mirror responsivity, solar diffuser, and SDSM detectors) and mitigation
- A-side vs. B-side
- M6 band rollover when saturated
- Early VIIRS SDR data and reprocessing
- DNB straylight mitigation
- Further investigation on striping
- Instrument and spacecraft maneuver
- Other issues

- Transition to operations
- J1, J2 and beyond
- Continue relying on the VIIRS SDR team for the heavy lifting
Summary

• VIIRS radiometric performance is very good
  – Extensive pre-launch test program provided highly accurate calibration on orbit
  – SNR performance is consistent with pre-launch measurements and complies with requirements
  – Data quality appears to be comparable to that of MODIS (if not better)
  – RSB throughput degradation is being mitigated
  – DNB images are excellent except in regions affected by stray light
  – Additional tuning of SDR LUTs expected to improve radiometric quality

• VIIRS geometric performance is excellent (~80m or ~1/4 pixel)

• The VIIRS SDR team provided mission critical support, and will continue to work together to address challenges going forward, and transition to operations
Backup
Bias due to Spectral Response Differences

The bias in M5 vs. MODIS B1 (on the order of 9%) is primarily due to spectral response differences, according to radiative transfer calculations.

This bias amount remains the same between MODIS C5 and C6, as expected.

EDR users should keep in mind of this issue in product comparisons.
VIIRS M1 vs. MODIS B8 (collection 5)

–Ocean Example (at SNOx)

\[ Y = 0.92534 \times X + 0.0212 \]

- Res. Std: 0.13%
- R Sq: 95.8%

- Suggests small changes. Need longer SNO time series to validate.
- Variability in the bias scatter plot increases with longer time period.