Cal/Val Plan and Field Campaign Preparation

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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
The VIIRS SDR Science Team
(POC: Mitchell A. Schull)
NOAA/Center for Satellite Applications and Research

Date: June 19, 2015
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)

- 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 BIF routines and reports their successful completion via the housekeeping telemetry packet and VIIRS is then placed in ACT mode.
  - DNB Table loads may include test tables (for calibration or diagnostics), modifications to adjust Science Data output, command sequence updates (SCU) and contingency fixes (tables can be uploaded via Safe mode).

- VIIRS Trending
  - Monitor Power, Instrument Temperatures, SC Temperatures for VIIRS, BB, Csys, Performance, Motor Current, Motor temperatures, Scan Rate Control, Time Sync
  - To monitor telemetry parameters for the performance of the instrument and quality of science data.

- VIIRS Dynamic Range and Linearity Verification
  - A “Fast Fix,” 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 (IFS) or Radiometric Frame Sync (RFS).

- DNB Offset Determination
  - DNB Offsets are compiled of Detector Dark Current and Electronic Clock Offsets
  - “Provide data necessary to periodically update the DNB Offset Correction tables applied to the Earthview data as a part of the VIIRS on board processing, and should be run frequently during LEOSA 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 within 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
  - 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-radiance 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.

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)

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

<table>
<thead>
<tr>
<th>Phase</th>
<th>Status</th>
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</thead>
<tbody>
<tr>
<td>Pre-launch Phase</td>
<td>Beta</td>
</tr>
<tr>
<td>Launch</td>
<td>Early release product.</td>
</tr>
<tr>
<td>Sensor Activation and Checkout Phase</td>
<td>Initial calibration applied.</td>
</tr>
<tr>
<td>Science Phase</td>
<td>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)</td>
</tr>
<tr>
<td>VIIRS on J1</td>
<td>Available to allow users to gain familiarity with data formats and parameters</td>
</tr>
<tr>
<td>Post-Launch Test Phase (PLT)</td>
<td>Product is not appropriate as the basis for quantitative scientific publications, studies, and applications</td>
</tr>
<tr>
<td>Intensive Calibration &amp; Validation (ICV) Phase</td>
<td></td>
</tr>
<tr>
<td>Long Term Monitoring (LTM) Phase</td>
<td></td>
</tr>
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</table>

**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-Launch Activities/Milestones

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

<table>
<thead>
<tr>
<th>Year</th>
<th>Tasks/Activities</th>
<th>Deliverables</th>
</tr>
</thead>
</table>
| 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-launch Cal/Val schedule: tasks/activities, deliverables, and timeline

<table>
<thead>
<tr>
<th>Year, Phase</th>
<th>Tasks/Activities</th>
<th>Deliverables</th>
</tr>
</thead>
</table>
| 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 |

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Being Developed
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:
  - Collect high quality goniometric observations of surface targets
  - Large geospatial coverage comparable to satellite observations

**Rotary Systems**
- 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**
- Collect high quality large area observations of the Earth’s surface:
  - L1b, LST, SST

Objective: 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

On-going integration of modular spectrometer with drone at UMD
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.

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

- 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

\[ \frac{1}{\lambda^4} \text{ for } (l \ll \lambda) \]
Rayleigh-type scattering

Surface roughness on Fluoropolymers due to UV

NPP VIIRS SDSM Measurement of Solar Diffuser Spectral Degradation
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