NOAA Cal/Val Progress Update

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With contributions from NOAA/NESDIS/STAR Scientists

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Outline

• S-NPP/JPSS and GOES-R Programs

• S-NPP VIIRS postlaunch characterization and Cal/Val activities, VIIRS data quality and maturity

• MetOp-B launch and AVHRR cal/val

• GOES-R Cal/Val support:
  – progress in prelaunch test data analysis and post launch capability development
Continuity of NOAA's Polar (Primary) Operational Satellite Programs

Fiscal Year

| 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 |
|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| DoD | DMSP 17 | DMSP 19 | Follow-on (DWSS) |
| DoD/DEUMETSAT | DMSP 16 | DMSP 18 | DMSP 20 | EPS - SG (Follow-on) |
| NOAA | NOAA - 19 | NASA NPP | JPSS - 1 | JPSS - 2 |

Approved: [Signature]  
Assistant Administrator for Satellite and Information Services

Signed on: 10 Oct 2011

Satellite is operational beyond design life  
Post Launch Test Operational

Launched Oct '11
Suomi NPP
(National Polar-orbiting Partnership) satellite

• successfully launched on October 28, 2011

• bridge mission between NASA's EOS (Earth Observing System) and the next-generation NOAA's JPSS (Joint Polar Satellite System)

• 5 instruments:
  ― ATMS (Advanced Technology Microwave Sounder)
  ― CERES (Clouds and the Earth's Radiant Energy System)
  ― CrIS (Cross-track Infrared Sounder)
  ― OMPS (Ozone Mapping and Profiler Suite)
  ― VIIRS (Visible Infrared Imaging Radiometer Suite)
Overview of VIIRS Data Products

- VIIRS data products include SDRs (Sensor Data Records)
  - calibrated and geolocated radiance and reflectance (≈Level 1B)

- 22 types of SDRs:
  - 16 moderate resolution bands (M-bands),
    - 11 Reflective Solar Bands (RSB)
    - 5 Thermal Emissive Bands (TEB)
  - 5 imaging resolution
    - 3 RSB
    - 2 TEB
  - 1 Day Night Band (DNB) broadband

- Input to more than 20 EDRs (Environmental Data Records)
  - “Key Performance Parameters” now become priority 2 products (SST and Ocean Color). Priority 1: radiance product.
VIIRS SDR Calibration/Validation Activities

• Leading the S-NPP VIIRS SDR team, which consists of 40+ members from seven major organizations.
  
  NOAA/NESDIS/STAR, The Aerospace Corp., NASA/VCST, University of Wisconsin, MIT Lincoln Laboratory, Raytheon, NGAS

• Providing life cycle/end-to-end calibration support to S-NPP/JPSS VIIRS (prelaunch, postlaunch, & long-term monitoring).

• Team effort supporting the VIIRS instrument anomaly investigation, mitigation, and impact analysis.

• Working closely with NASA/VCST, resolved many discrepancies existed in the radiometric biases between VIIRS and MODIS (ex: MODIS collection 5 bias issues, Esun issues, and lunar vs. solar calibration).

• Working closely with VIIRS EDR teams to address VIIRS performance issues (OC, fire, aerosol, SST, land...)

• VIIRS is uniquely positioned in earth observations for decades to come, and is gaining popularity internationally owing to it’s superb SDR performance.

• Major publication on VIIRS performance: Cao, C., F. Deluccia, J. Xiong, R. Wolfe, F. Weng, 2013, IEEE TGRS.
VIIRS SDR Product Maturity

• Achieved Beta Status in April 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

• Reached Provisional Status in Jan. 2013
  – 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 Status Expected in 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

SNR performance is exceeding requirements for all Reflective Solar Bands

NEdT performance is exceeding requirements for all Thermal Emissive Bands
VIIRS SDR Provisional Product Highlights

• Stable instrument performance and calibration
• VIIRS radiometric noise is less than specification
• VIIRS F and H tables are routinely updated to take account for VIIRS degradation
• Quality flags were evaluated as normal
• Excellent geolocation ( < 80 meters in track and scan directions )
• Dual gain bands work nominally
• DNB geolocation achieves the same accuracy as the VIIRS M bands
• DNB signal-to-noise ratio is better than specification
• VIIRS and MODIS measurements agree well
• VIIRS EDR teams (e.g. sea surface temperature, ocean color, cloud) are satisfied with the VIIRS SDR quality
VIIRS Mirror Degradation Status

NPP VIIRS SD VisNirBands A Trend F Factor
Updated at Mon Apr 8 17:59:31 2013 UTC

Solar Diffuser Degradation

NPP VIIRS SDSM Sample Trend H Factor
Updated at Mon Apr 8 17:59:31 2013 UTC

NOAA/NESDIS/STAR Satellite Integrated Calibration / Validation System (ICVS)
http://www.star.nesdis.noaa.gov/icvs/NPP/ipm_telemetry_npp_viirs.php
### VIIRS Calibration with SNO and SNOx Extension to Low Latitudes

<table>
<thead>
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<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 difference</td>
</tr>
<tr>
<td>Use for inter-comparisons</td>
<td>Radiometric, Spectral</td>
<td>Radiometric, Geospatial, RVS, spectral</td>
</tr>
</tbody>
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The SNO/SNOx as well as daily SNPP orbital predictions are available at: [https://cs.star.nesdis.noaa.gov/NCC/SNOPredictions](https://cs.star.nesdis.noaa.gov/NCC/SNOPredictions)
Assessing Radiometric Biases between VIIRS and MODIS Collection 5 and 6

- A radiometric bias on the order of 5% between VIIRS band M1 and MODIS band 8 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
- VIIRS datasets agree with MODIS Collection 6 (C6) data, which was recently released by NASA to the public.

VIIRS vs. MODIS
Collection 5

VIIRS vs. MODIS
Collection 6

412 nm Channel
Light Outage Detection during Major Storms with S-NPP VIIRS Day Night Band

- High radiance resolution, large amplitude range. Able to detect light outage and recovery trend.
- Complementing the statistics from power companies
- Cao et al., in press, IEEE GRSL, 2013
Observing Hurricane Isaac with unprecedented 375m resolution in the infrared
• Simply Google “NOAA NCC” to access the Calibration Knowledge Base, which includes user’s guide (updated), relative spectral response, SNO predictions, image gallery, standardized parameters, event database, sample code, conference presentations, publications, etc.

• VIIRS SDR data are now available on an ftp site (last 90 days) at: ftp://ftp-npp.class.ngdc.noaa.gov/, or go to NOAA CLASS at http://www.class.noaa.gov
Challenges and Way Forward

• The dynamics of instrument degradations (mirror reflectivity, solar diffuser, and SDSM detectors) and their mitigation
• Early VIIRS SDR data and reprocessing
• DNB stray light mitigation
• Further investigation of striping
• Instrument and spacecraft maneuvers
• M6 band rollover when saturated
• Other issues:
  – Transition to operations
  – JPSS J1, J2 and beyond
  – Continue relying on the VIIRS SDR team for support
Successful launch of MetOp-B and Post Launch Cal/Val

- Launched in Sept., 2012
- Operational on April, 2013
- Metop-B will be the primary satellite for providing environmental satellite information for both EUMETSAT and NOAA in the mid-morning polar orbit.
- NOAA and EUMETSAT fly satellites with closely-related instruments in different orbits and share the data freely.
- Allowing both organizations to leverage the others’ investment to improve weather forecasts through the use of additional environmental data.
- Cal/Val through SNOs

SNOs between METOP-B and NPP

Routine SNO predictions between MetOp-B and NPP, MODIS, NOAA-19 at [https://cs.star.nesdis.noaa.gov/NCC/SNOPredictions](https://cs.star.nesdis.noaa.gov/NCC/SNOPredictions)
Continuity of NOAA’s Geostationary Operational Satellite Programs

- Decommissioned Dec ’11
- Operational GOES West

Fiscal Year
- GOES-11
- GOES-12 (South America Coverage)
- GOES-13 (GOES East)
- GOES-15
- GOES-14 (On-orbit Storage)
- GOES-R
- GOES-S
- GOES-T
- GOES-U

Approved: Mary E. Haye
Assistant Administrator for Satellite and Information Services

Signed on: 20 Oct 2011

Satellite is operational beyond design life
Post Launch Test / On-orbit storage
Operational
GOES-R ABI Calibration/Validation

- Members of GOES-R Calibration Working Group (CWG) include STAR, NGDC, MIT/LL and NASA/MSFC.
- Participated in prelaunch thermal vacuum testing of Advanced Baseline Imager (ABI) at the vendor facility, and performed analysis on collected data to resolve discrepancies between CWG and vendor results.
- Working with GOES-R Flight and Ground to develop plans for post-launch V&V, calibration parameter updates, and anomaly resolution processes.
- Working with NIST to help validate ABI vendor’s pre-launch instrument testing and ensure on-orbit calibration adheres to accepted international standards.
- Collaborating with MIT/LL, UW and others to determine impacts of potential anomalies on end-user products.
- Developing tools to analyze sensor performance and resolve anomalies both pre- and post-launch.

Predicted radiance biases for ABI & VIIRS over White Sands, NM: biases and uncertainties

Location of underflight imagery (right)
ABI Calibration with Solar Diffuser and Lunar Observation

- SD is critical for evaluating solar band performance, including stability, degradation, signal to noise, and anomaly analysis (as demonstrated in NPP VIIRS).
- ABI SD calibration is more challenging due to partial aperture, and the alternative approach used in prelaunch testing.
- Long-term prediction of lunar imaging window of opportunities with different lunar phase limiter for GOES-EAST and GOES-WEST were performed.

Moon appears within the annular ring between Earth’s limb margin and the outer boundary of the GOES-R ABI’s field of regard (FOR).
Summary

• Great success with NPP postlaunch cal/val
• NOAA scientists are leading postlaunch SDR cal/val for all major NPP instruments
• MetOp-B successfully launched, postlaunch cal/val completed.
• Very good progress with GOES-R prelaunch calibration