Outline

• Actions from last WGCV 38th meeting
  » Altimeter radiometer inter-comparison (NOAA/ESA)
    - Jason-2 AMR Envisat RA-2 Inter-comparison
• Suomi-NPP/JPSS Program Update
  » Suomi-NPP VIIRS post-launch characterization and Cal/Val activities
    - GOSAT inter-comparison (supports “CEOS Strategy for Carbon Observations from Space” WGCV actions)
    - Active light sources for DNB cal/val - new capability
• GOES-R Program Update
  » GOES-R pre-launch and post-launch Cal/Val readiness activities
    - Pre-launch Support
    - Post-launch tests & long-term monitoring
    - JMA collaboration
    - Field Campaign Preparations
      ▪ Near Surface Measurements - new capability
Action from CEOS/WGCV38

• Collaboration project on Altimeter Microwave Radiometer inter-comparisons (Action from a side meeting with Albrecht von Bargen, Bojan Bojkov, Xiaolong Dong, and Changyong Cao)

• Since WGCV38, NOAA scientists have performed inter-comparisons between Jason 2 Advanced Microwave Radiometer and Envisat RA-2 for the 23.8 GHz channel.

• Preliminary results are now available (see next slide)

• Future work will further collaborate with Bojkov and Dong.
Inter-Comparison between Jason-2 AMR and Envisat RA-2 (23.8 GHz channel)

Mean Ratio = 0.986

Mean Bias = -2.22 K

Bias = -2.31 K

Courtesy of Bin Zhang, Changyong Cao and Laury Miller
NOAA & Partner Polar Weather Satellite Programs
Continuity of Weather Observations

As of April 2015

<p>| FY | 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/NOAA |
| Early-Morning Orbit |</p>
<table>
<thead>
<tr>
<th>DMSP 17</th>
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<tr>
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<tr>
<td>DMSP 18</td>
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<td>MetOp-A</td>
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<td>Mid-Morning Orbit</td>
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<td>DoD/EUMETSAT</td>
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<td>NOAA - 19</td>
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<td>Afternoon Orbit</td>
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<td>NOAA</td>
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<tr>
<td>PFO/JPSS - 3</td>
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<td>PFO/JPSS - 4</td>
</tr>
<tr>
<td>DMSP: Defense Meteorological Satellite Program</td>
</tr>
<tr>
<td>JPSS: Joint Polar Satellite System Program</td>
</tr>
<tr>
<td>Suomi NPP: Suomi National Polar-orbiting Partnership</td>
</tr>
</tbody>
</table>

Note: Extended operations are reflected through the current FY, based on current operating health.

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

Post Launch Test
Operational based on design life
Secondary
Operational beyond FY 2036
Extended mission life
Launched before Oct 2008
S-NPP VIIRS and GOSAT TANSO-FTS Inter-calibration

• Supports CEOS work plan and Strategy on Carbon Observations from Space actions:
  - Cross-calibration of carbon (CO2- and CH4) measuring sensor to evaluate and improve radiometric accuracy
  - Ensure consistent, well-calibrated, bias free satellite time series carbon products

• The Greenhouse gases Observing SATellite (GOSAT):
  » Joint effort of JAXA, NIES, & MOE
  » launched on January 23, 2009
  » Payloads: Thermal and Near Infrared Sensor for Carbon Observation - Fourier Transform Spectrometer (TANSO-FTS) and a Cloud and Aerosol Imager (TANSO-CAI)
  » TANSO-FTS measures P and S polarized light

• VIIRS M10 (1.61 µm) inter-calibration with TANSO-FTS band 2 at Libya-4 region.
• TANSO-FTS S polarized observations agree very well to within 0.3% with uncertainty less than 1%.
• Larger radiometric inconsistency between VIIRS and P polarized measurements: 1.2% @16° solar zenith angle to nearly 3% @55° solar zenith angle.
Active Night Light Sources for DNB Calibration

• Investigated vicarious validation sites suitable for DNB (at low radiances):
  » Analysis of nighttime point sources (from bridges, fishing vessels, cities) showed the potential to validate DNB calibration (Cao & Bai, Remote Sens 2014)
  » Emphasizes the need and feasibility of developing active light source references

• New SBIR initiative to develop active nightlight for VIIRS DNB validation, working closely with NIST and NASA scientists

• Potential collaboration with RADCALNET

Source properties to consider
• Spectral distribution
• Flux (radiant exitance)
• Stability
• Calibration uncertainty
Candidate types
• Power LEDs
• Tungsten lamps
Other considerations
• Atmospheric impacts
  » Modeling for active sources
  » Cloud impacts
  » Source altitude
• Stray light contamination
  » Lunar light
  » Air glow, starlight, zodiacal light
  » Anthropogenic light

Long-Term Monitoring of DNB Radiance of a Bridge Light Site

(Cao & Bai, Remote Sens 2014)
Continuity of GOES Mission

Calendar 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

As of April 2015

GOES-13
GOES East

GOES-14
On-orbit spare

GOES-15
GOES West

GOES-R

GOES-S

GOES-T

GOES-U

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

GOES: Geostationary Operational Environmental Satellite

- On-orbit Storage
- Test & Checkout
- Operational
- Fuel-Limited Lifetime

Approved: [Signature] 4/21/2015
Assistant Administrator for Satellite and Information Services
GOES-R Advanced Baseline Imager (ABI)
Pre-launch Cal/Val Support

Instrument Status:

» Calibration Working Group (CWG) pre-launch assessment of GOES-R and GOES-S ABI complete:
  - ABI FM1 is undergoing spacecraft-level testing

» CWG is continuing pre-launch support for GOES-S & GOES-T ABI
  » Detector-level SRF impacts (to be presented at IGARSS 2015, SPIE Remote Sen. 2015)
  » Polarization sensitivity impacts (to be presented at SPIE Optical Engineering + Applications 2015)
Developing capabilities and tools for post launch instrument performance characterization and monitoring:

**PLT**: focus on instrument functionality and meeting specification

**Science Tests (PLPTs)**: focus on instrument performance and meeting user/science needs

Monitoring through NOAA/NESDIS/STAR Integrated Calibration/Validation System (ICVS)

- Supports Suomi NPP, MetOP-A, MetOP-B, NOAA-18, NOAA-19, DMSP, & GOES instruments
- Extending ICVS for GOES-R

Leveraged VIIRS 57 tasks, heritage GOES PLT, similar programs, and international partners [Cao et al. 2013 *JGR*]
Preparations for Post-launch: NOAA-JMA Collaboration

• Collaborating with Japan Meteorological Agency (JMA) to enhance GOES-R Readiness
  » Himawari-8 Advanced Himawari Image (AHI), was launched in the Fall of 2014, a sister instrument to the future GOES-R ABI
  » JMA hosted NOAA experts:
    - Exchanged data, analyses, and expertise
    - Supports ABI risk reduction
  » NOAA received and analyzed early on-orbit calibration instrument performance
  » NOAA analyzing AHI data to evaluate ABI L1b & L2+ products
The purpose of the GOES-R field campaign is to support post-launch validation of L1b & L2+ products:

- Advanced Baseline Imager (ABI) & Geostationary Lighting Mapper (GLM):
  - An integrated approach is planned that includes both high-altitude manned & near surface unmanned systems coordinated with ground-based observations over several Earth targets (desert, ocean, land and lightning producing storms)
  - These activities will be coordinated with WMO GSICS partners and low Earth orbit environmental satellites which include S-NPP, Terra/Aqua, METOP, Landsat and ISS
  - ER-2 Campaign Timeframes: October – November 2016 & April – June 2017

Completed GOES-R Field Campaign Workshop (April 8-9, 2015):
- Achieved a baseline consensus of the initial GOES-R Field Campaign plan
  http://www.goes-r.gov/users/2015-Campaign-Workshop.html

ABI Field Campaign Approach:
Primary Objective: provide high-altitude validation of ABI L1b spectral radiance observations to validate SI traceability
Secondary objective: provide surface and atmospheric geo-physical measurements to support L1b & L2+ product validation

Targets of Interest:
- Desert
- Open Ocean
- Land/Vegetation
- Clouds

GLM Field Campaign Approach:
Primary Objective: provide validation of GLM flash detection efficiency day through night over land at well characterized total lightning super sites: Northern AL, Lubbock TX, Norman OK, KSC FL, and Wallops/DC area
Secondary Objective: provide validation of GLM flash detection efficiency day through night at other land locations and over ocean
Tertiary Objective: provide validation of GLM flash location & time stamp accuracy, and GLM image navigation and registration (INR) accuracy

Targets of Interest:
- Storms
High Altitude Aircraft (ER-2) Based Sensors – Direct Radiance comparison (L1b validation)

Ground and Near Surface – End-to-End Image Chain Analysis (L1b & L2+ validation)

Matching View Geometry – Broad coordination & collaboration between NOAA and NASA science teams

Ground & Near Surface Collection of Representative Geophysical Reference Data – Developing new post-launch validation measurement capabilities using small low cost Unmanned Aircraft Vehicles (UAVs)
Objective is to transition a commercially available off-the-shelf technology into operations in support of GOES-R post-launch validation efforts:

Small UAVs provide an unmatched surface observation capability:

- Large geospatial coverage (especially if swarmed)
- Collection does not disturb the surface collection environment
- Ability to collect goniometric measurements

- Deployment of UAV(s) at several different locations within a satellite footprint can characterize the degree of uniformity within the footprint:
  - Ideally, this could be done for all reference Cal/Val sites in different seasons
- Enduring capability for Cal/Val scientist
  - Near surface UAV campaigns can be replicated numerous times throughout the year at significantly reduced costs in comparison to heritage approaches
- BRDF surface measurements can be used to check components of model values used in retrieval algorithms
- Unprecedented capability to collect measurements that are representative of satellite observations
Developing and Maturing Ground-Based Measurements Capabilities

» NOAA ground instruments for deployment to support validation efforts:
  - Sun photometer — Deployed for NASA HYSPIRI mission collaboration
  - Spectroradiometer — Deployed for NASA HYSPIRI mission collaboration & around NOAA NCWCP
  - Thermal IR camera — Context imager
  - Spectral Polarimeter — Deployed at NCWCP & UMD
    ▪ Recent upgrade provides lower uncertainty measurements and measurement automation capability

ASD Field Measurements

Spectral Polarimeter Testing

Courtesy of L-1 Standards & Technology, Inc.
GSICS-CEOS Interaction

Background

- The initial concept of GSICS was brought forward by people involved in calibration activities with some links with CEOS WGCV.
- Important interaction on the QA4EO in (2009-2010). Resulted in GPPA (inherited from QA4EO).
- WGCV Chair in the GSICS Executive Panel, and the GSICS EP Chair in WGCV. **Lots of overlap among group members.**

Interaction in 2014

- In Feb 17-21, 2014, 37th CEOS WGCV-36 held in Frascati, Italy. GSICS members Jerome Lafeuille (GSICS EP Member) and Tim Hewison invited to the meeting.
- In Sept – Oct 2014 NOAA hosted, 38th CEOS, Mitch Goldberg (GSICS EP Member), Lawrence E Flynn (Director GCC) and Manik Bali (Deputy Director GCC) presented GSICS, GSICS Coordination Center activities and GSICS Procedure for Product Acceptance (GPPA).

Outcome of 38th CEOS Meeting at NOAA

**Meeting resulted in following action items on GSICS**

- MWSG Chair to have a communication with GSICS on how WGCV can offer support on best practices.
  - Cheng-Zhi Zou (GSICS MW subgroup Ex Chair) is exploring possibility to have a joint GSICS-CEOS Microwave subgroup meeting to exchange ideas and calibration/inter-calibration methodologies.
- WGCV Secretariat to send out the list of potential GSICS-WGCV Cooperation items outlined by GSICS to each subgroup chair
- WGCV (Completed) Subgroup Chairs to identify and prioritize specific activity areas for interaction with GSICS.
- Mitch Goldberg suggested to WGCV to establish surface reference sites, and help with procedures for best practices.
- CEOS members invited to publish their work in GSICS Newsletter.
- More interaction required in formalizing GSICS SNO Coding standards (for eg Unit Testing)
Summary

• NOAA continuing to ensure data quality through inter-comparisons:
  » Jason-2 AMR and Envisat RA-2
  » Suomi-NPP VIIRS and GOSAT

• We continue to prepare for GOES-R launch by supporting pre-launch testing, developing post-launch test plans and analysis tools, & extending our long-term monitoring capabilities (ICVS)

• NOAA is developing new validation capabilities for VIIRS & GOES-R validation:
  » Active Light Sources for VIIRS DNB
  » Near Surface Measurement Validation
BACKUP
GOES-R Advanced Baseline Imager (ABI)

ABI is the next generation GOES Imager
GOES-R is scheduled to launch in 2015

<table>
<thead>
<tr>
<th></th>
<th>Current</th>
<th>ABI</th>
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<tbody>
<tr>
<td>Spectral Coverage</td>
<td>5 Bands</td>
<td>16 Bands</td>
</tr>
<tr>
<td>Spatial Resolution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.64 µm visible</td>
<td>1.0 km</td>
<td>0.5 km</td>
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<tr>
<td>Other visible/near-IR</td>
<td>N/A</td>
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<tr>
<td>1.38 µm</td>
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<tr>
<td>Bands &gt; 2µm</td>
<td>4 km</td>
<td>2.0 km</td>
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<tr>
<td>Spatial Coverage</td>
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<td></td>
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<tr>
<td>Full disk</td>
<td>Scheduled (3 hrs)</td>
<td>4 per hour</td>
</tr>
<tr>
<td>Visible (Reflective)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>On-orbit calibration</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

- Increase in spectral coverage facilitates more quantitative products
- Increased emphasis on calibration

http://cimss.ssec.wisc.edu/goes/abi/
Overview of VIIRS Data Products

National Polar-orbiting Partnership satellite

- Bridge mission between NASA's EOS (Earth Observing System) & the next-generation NOAA’s JPSS (Joint Polar Satellite System)

- **SDRs (Sensor Data Records) = Level 1b**
  - Calibrated and geo-located: radiance, reflectance, and brightness temperature

- **VIIRS SDR team** consists of experts from NOAA, NASA, The Aerospace Corp., University of Wisconsin, MIT/Lincoln Lab, NGAS & Raytheon

- Providing life cycle/end-to-end calibration support to S-NPP/JPSS VIIRS (pre-launch, post-launch, & long-term monitoring)

- VIIRS SDR product is used to produce 20+ Environmental Data Records (EDRs)

Suomi NPP VIIRS
Launched: October 28, 2011

22 SDRs Types

- **16 Moderate resolution bands**
  - M-Bands (0.75 km):
    - 11 Reflective Solar Bands (RSB)
    - 5 Thermal Emissive Bands (TEB)

- **5 Imaging resolution bands**
  - I-Bands (0.375 km):
    - 3 RSB
    - 2 TEB

- **1 Day Night Band (DNB) broadband**
  - DNB (0.75 km)
Visible Infrared Imaging Radiometer Suite (VIIRS)

The Visible Infrared Imaging Radiometer Suite (VIIRS) is one of the key instruments on the Suomi NPP and the JPSS satellites. It is an advanced instrument designed to monitor various aspects of the Earth's atmosphere, oceans, and land surfaces. VIIRS provides continuous observations of the Earth from space, enabling researchers and policymakers to make informed decisions on environmental issues.

**News and Documents**
- VIIRS Longterm Monitoring
- VIIRS On-orbit Performance Table
- Standardized Calibration Parameters
- VIIRS Spectral Response Functions
- VIIRS Event Log Database (experimental)
- NPP/AQUA SNO Predictions
- Radiometric Intercomparison with MODIS
- VIIRS at Cal/Val Sites
- Lunar Calendar for DNB
- VIIRS Line Spread Function along scan
- VIIRS Software Tools
- Planck Calculator for Infrared Remote Sensing
- VIIRS Data on GLASS
- VIIRS Data on ftp site (90 days)
- VIIRS Image Gallery
- Data on GRAVITE
- VIIRS FAQ
- Standard Radiometric Test Scenes
- VIIRS SDI Data Format
- About VIIRS
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**VIIRS Paper**
Backup slide

**VIIRS and MODIS matching bands used in the inter-comparison**

<table>
<thead>
<tr>
<th>VIIRS</th>
<th>MODIS</th>
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<tr>
<td>Band</td>
<td>Wavelength (μm)</td>
</tr>
<tr>
<td>M1</td>
<td>0.402 - 0.422</td>
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<tr>
<td>M2</td>
<td>0.436 - 0.454</td>
</tr>
<tr>
<td>M3</td>
<td>0.478 - 0.498</td>
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<tr>
<td>M4</td>
<td>0.545 - 0.565</td>
</tr>
<tr>
<td>M5</td>
<td>0.662 - 0.682</td>
</tr>
<tr>
<td>M6</td>
<td>0.739 - 0.754</td>
</tr>
<tr>
<td>M7</td>
<td>0.846 - 0.885</td>
</tr>
<tr>
<td>M8</td>
<td>1.230 - 1.250</td>
</tr>
</tbody>
</table>
S-NPP Field Validation Campaigns: NASA ER-2 Underflights

- VIIRS SDR accuracy evaluation
- SHIS (NIST-traceable blackbody source, 0.1 K)
- MASTER (50 m spatial resolution mapping)
- 3 underflights for S-NPP

**RSS Total Uncertainty Estimate**

\~0.12 K (I4, I5, M12, M13, M15, M16)

0.21 K (M14)

**Complete Spectral Coverage**
GOES/GOES-R ICVS Development

- To provide instrument scientists with calibration healthy status and users with the information regarding the satellite data quality for product generation
- As part of NOAA STAR ICVS, the GOES ICVS continues to evolve for the instrument performance and radiance quality monitoring
- While still under development, it already played a key role in detecting the calibration anomaly, diagnosing the root cause and assessing the impacts of anomalous events.

An example of GOES-13 Sounder IR noise expressed as NEdT@300K from Jan. 1, 2012 to Sept. 23, 2012 before the GOES-13 shutdown event on Sept. 23, 2012. The jumped and elevated noise at LW channels were apparent since July 2012.

Current GOES/GOES-R ICVS Development.
SDR Team Support To EDR Teams

- Working closely with VIIRS EDR teams to address VIIRS performance issues
- SDR Team has demonstrated strong positive action in response to user inputs:
  » Support spans from addressing:
    - Clear errors impacting data quality to questions that challenge the state-of-the-art of space-based imaging system performance
  » Sea Surface Temperature EDR Team
    - Small yet apparent striping pattern (at noise level)
  » Ocean Color EDR Team
    - Discrepancies between VIIRS and MODIS-Aqua chlorophyll-a since early 2013
  » Fire EDR Team
    - Data quality and saturation limits


Images Courtesy: https://cs.star.nesdis.noaa.gov/NCC/GalleryPage04