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NOAA Calibration/Validation Update

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NOAA/NESDIS/STAR

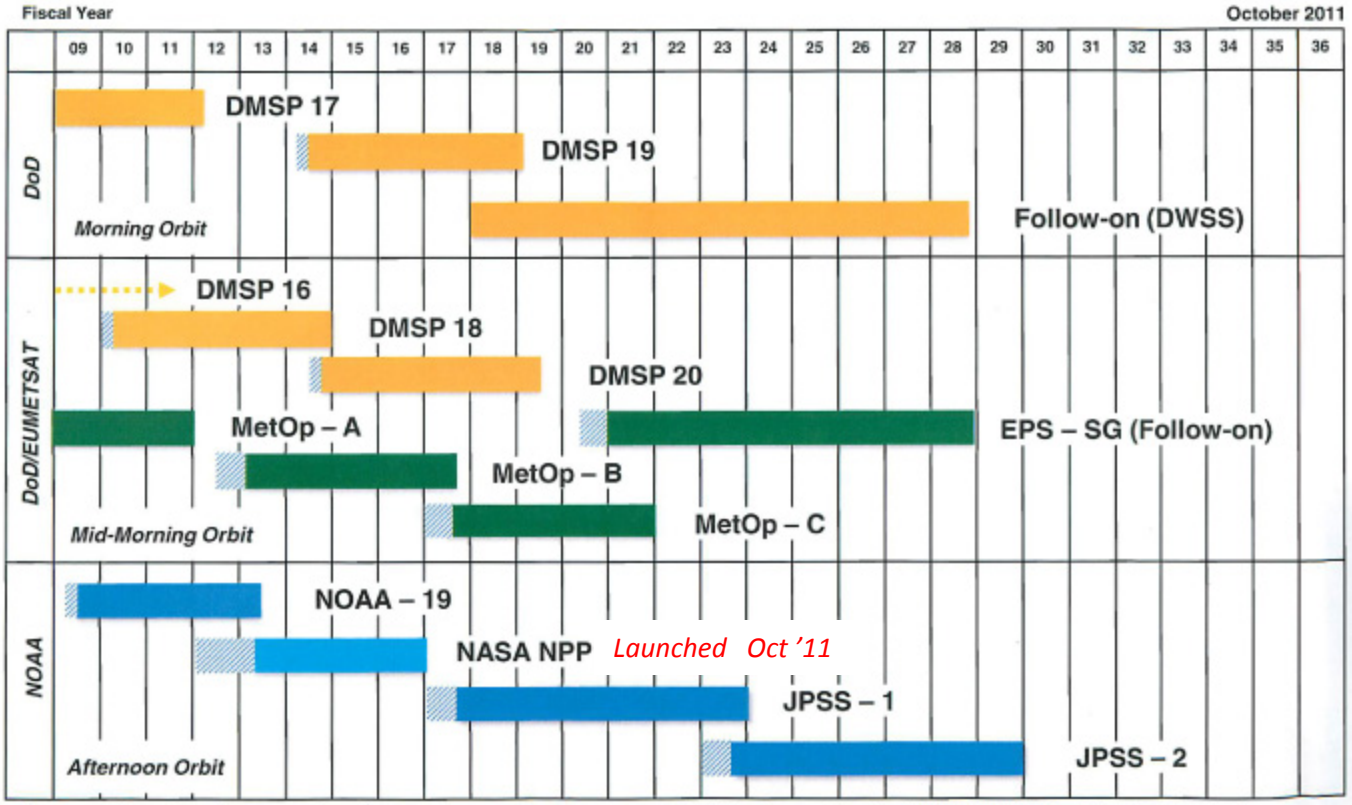
With contributions from NOAA/NESDIS/STAR Scientists

Presented at the WGCV-34, Brisbane, Australia, February 6-10, 2012

Outline

- NOAA polar-orbiting satellite program update:
  - NPP launch and on-orbit verification
- VIIRS post-launch characterization and Cal/Val activities:
  - Antarctic Dome C and simultaneous nadir overpass (SNO) observations
- VIIRS data access, visualization, and analysis tools
- NOAA geostationary satellite program update:
  - GOES 15 transition to operations
- GOES-R program V&V and Cal/Val support:
  - progress in prelaunch test data analysis and post-launch capability development

Continuity of NOAA's Polar (Primary) Operational Satellite Programs



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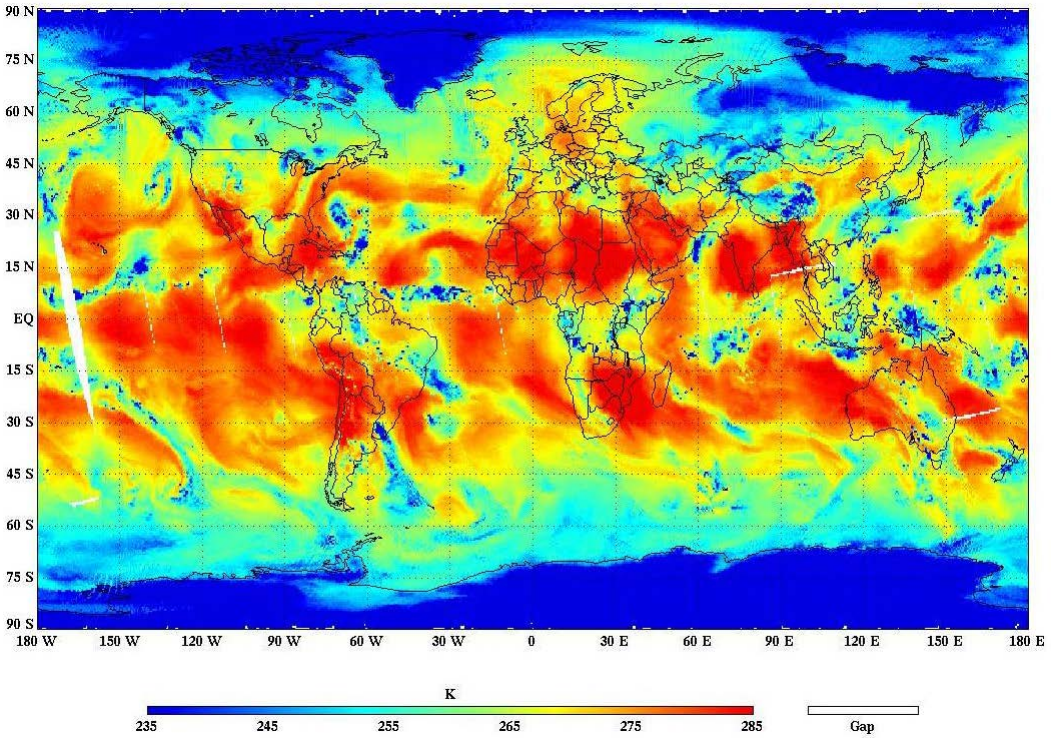
Suomi NPP

(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)
- currently in initial checkout phase before starting regular observations with all instruments
- commissioning activities are expected to be completed in March 2012



First global image of ATMS channel 18 microwave antenna temperature at 183.3 GHz acquired on November 8, 2011

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First Image from NPP VIIRS

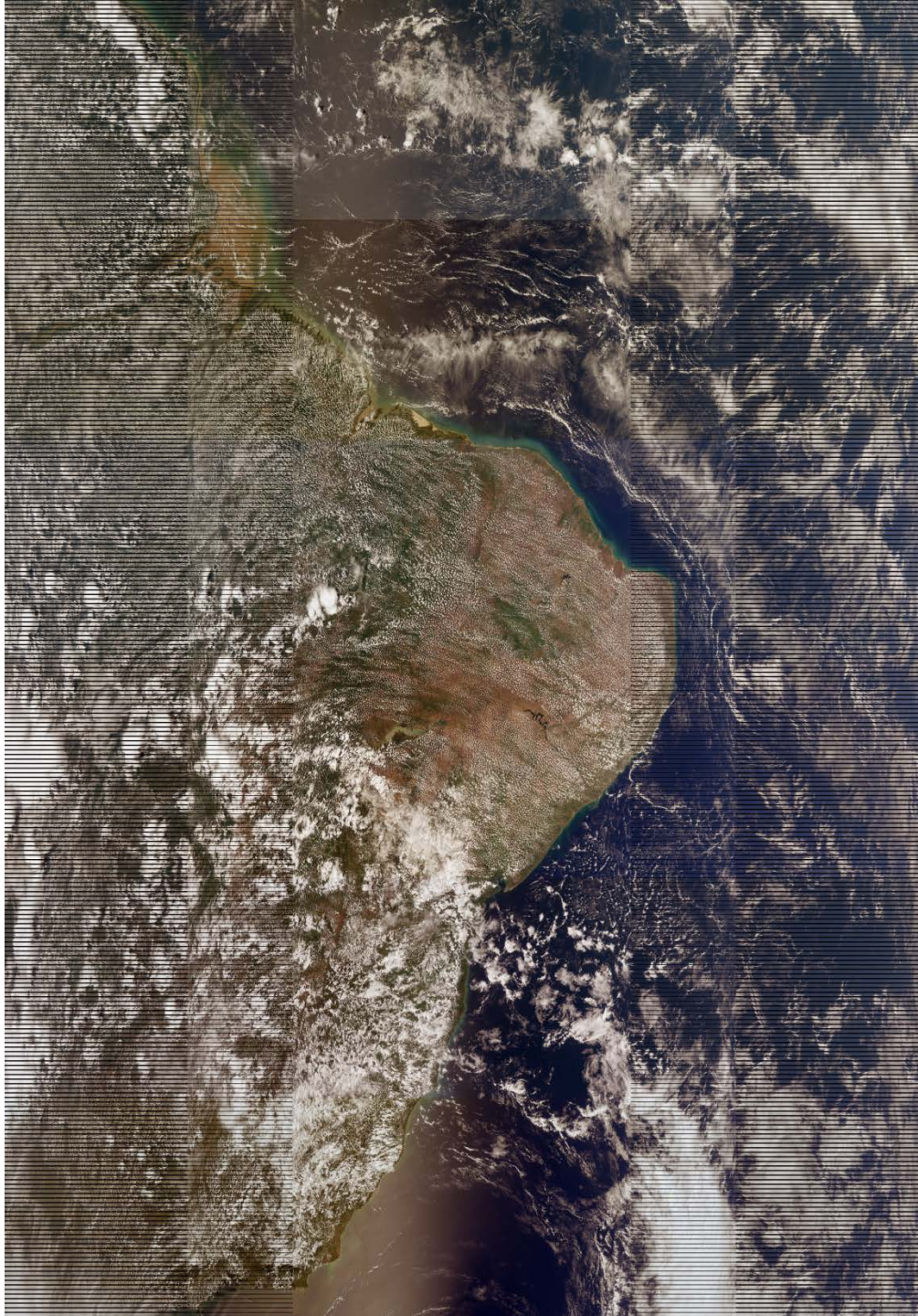
Opening of the VIIRS nadir door on November 21, 2011 ushered in a new generation of operational satellite imaging capability

Purpose: Global observations of land, ocean, and atmosphere with high (~daily) temporal resolution

Heritage: VIIRS builds on a long heritage of operational and research earth observing imaging radiometers with moderate resolution:

- AVHRR (Advanced Very High Resolution Radiometer) on NOAA and MetOp satellites, with 5 (6) bands, since 1979
- MODIS (Moderate-Resolution Imaging Spectroradiometer) on EOS Terra and Aqua, with 36 bands, since 1999
- SeaWiFS (Sea-viewing Wide Field-of-view Sensor), since 1997
- OLS (Operational Linescan System) on DMSP, since 1972

Characteristics: Multispectral scanning radiometer (22 bands between 400 nm and 12 µm: 5 Imaging, 375-m bands, 16 Moderate-resolution, 750-m bands, 1 broadband Day/Night, 750-m band), 12-bit quantization, 3000 km swath width



Bands M5, M4, M2 shown as RGB

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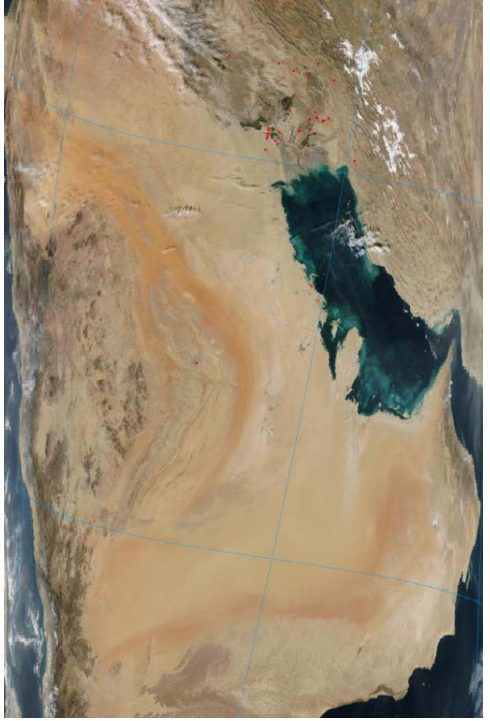
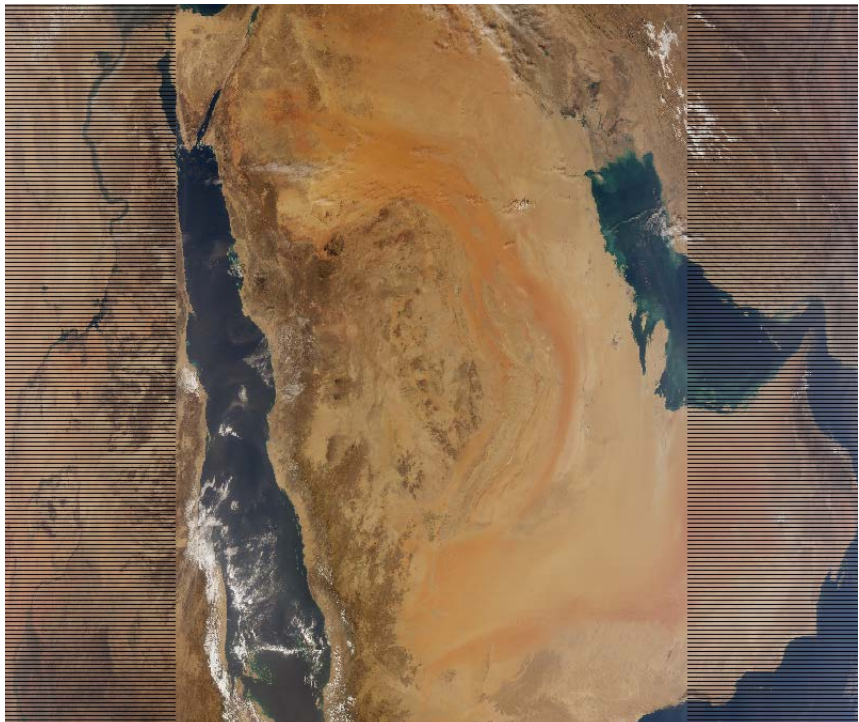
Novel VIIRS Spatial Sampling Characteristics

Three pixel aggregation zones reduce GSD growth as a function of scan angle and allow for extended swath width

MODIS



VIIRS



VIIRS 4-swath mosaic (image courtesy of NASA)

Bands M5, M4, M2 shown as RGB

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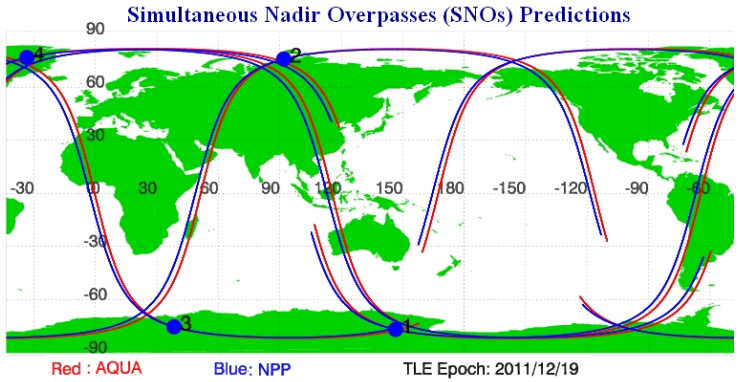
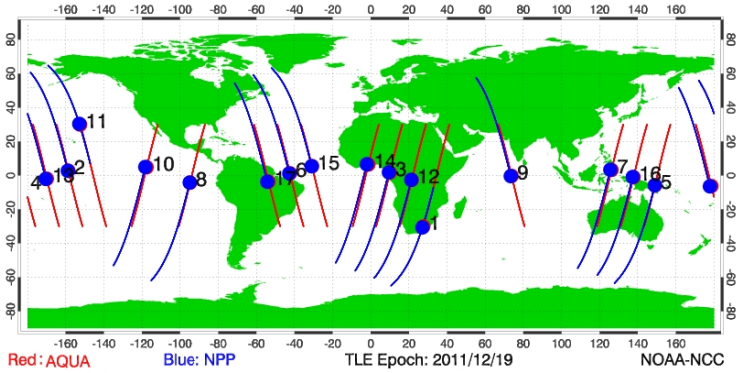
New Progress in SNO Prediction and Routine Use for NPP

- Simultaneous Nadir Overpass (SNO) prediction software has been upgraded with the latest version of the orbital perturbation algorithm and a graphical user interface
- New capabilities were developed to predict both traditional SNOs and SNOx (extended to low latitudes)
- The new system has been predicting routinely since NPP launch, and the predicted SNOs with Aqua/MODIS are being used for VIIRS channel sensitivity monitoring
- The SNOs as well as daily NPP orbital predictions are readily available on the NCC website at:

  https://cs.star.nesdis.noaa.gov/NCC/SNOPredictions



Index	Date	Time (AQUA)	AQUA Lat,Lon	NPP Lat,Lon	Distance(km)	Time Diff (sec)
1	12/21/2011	06:20:44	-76.77, 146.48	-76.77, 146.53	1.13	39
2	12/23/2011	21:47:58	75.93, 91.98	75.93, 91.93	1.46	11
3	12/26/2011	13:15:08	-75.29, 38.37	-75.29, 38.38	0.26	62
4	12/29/2011	06:20:26	76.76, -33.47	76.76, -33.49	0.67	43



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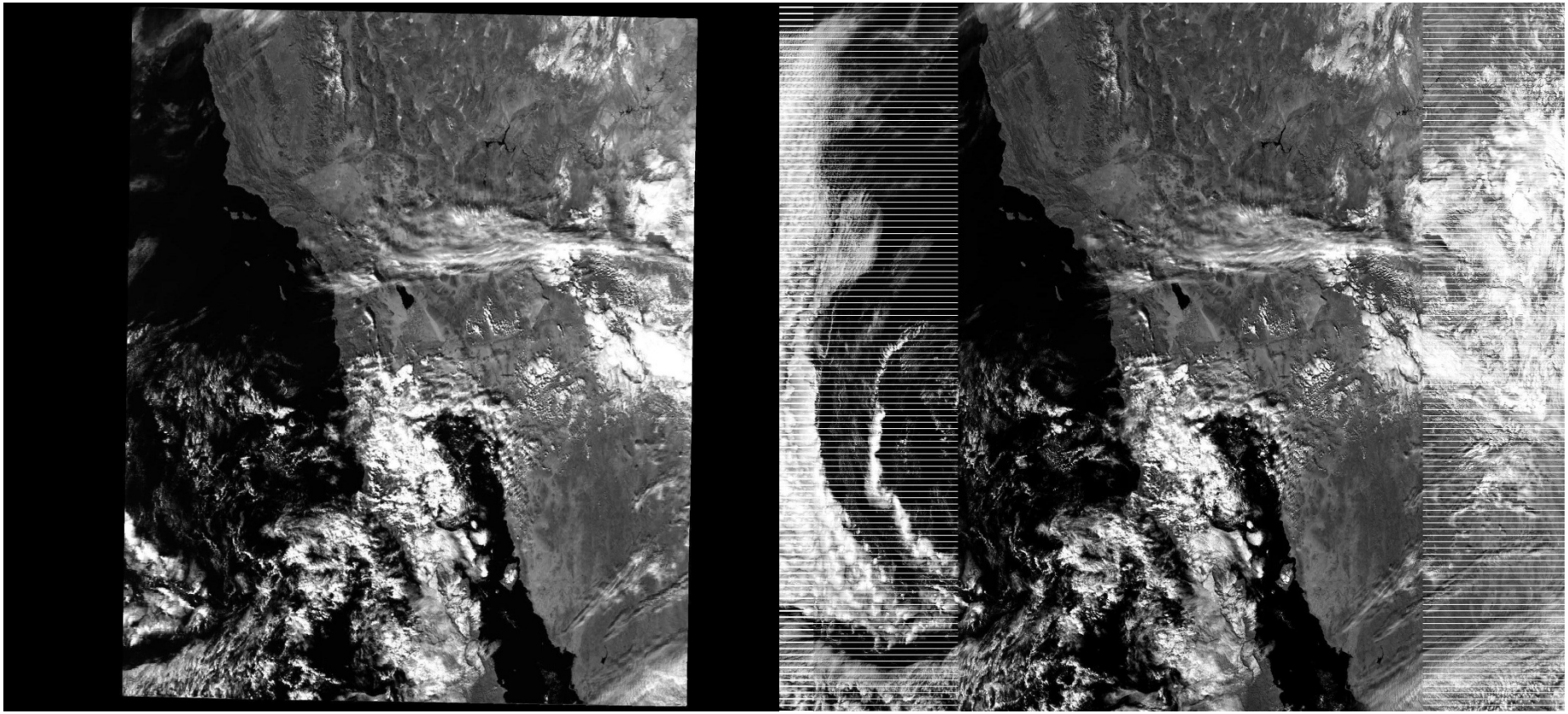
SNOx Example: Remap MODIS to VIIRS using SNO fast GSM

MODIS granule rotated to match VIIRS

VIIRS 4× granule (3200x3000)



- SNOx (extension to the low latitudes) occurs between NPP and Aqua, as well as between NPP and NOAA-19, regularly within ~10 – 3 minutes on the same ground track
- Pixel-by-pixel geospatial matching is computationally expensive: with the fast GSM algorithm, it still takes ~20 min. for a half size image

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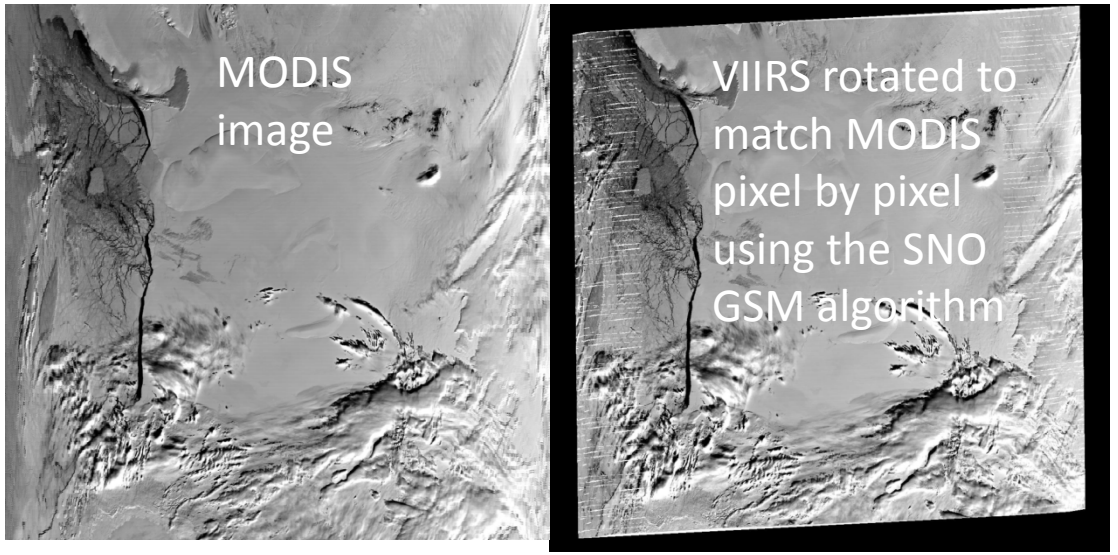
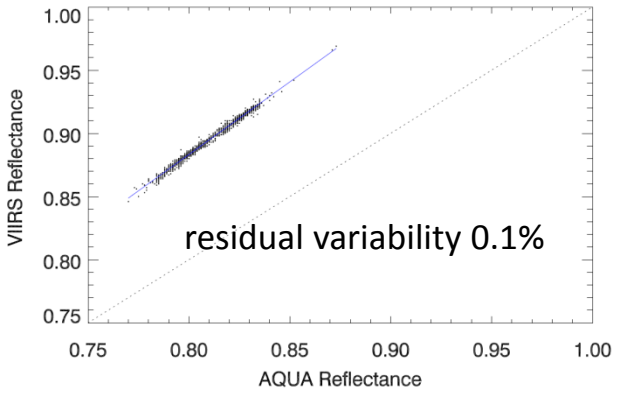
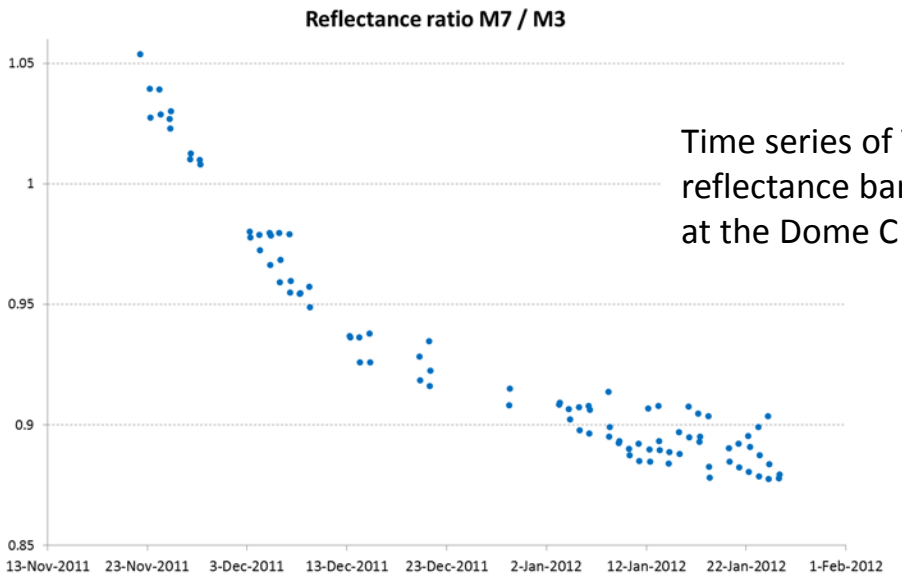
NPP VIIRS Channel Sensitivity Monitoring in the Antarctica

- VIIRS sensitivity changes closely monitored at SNOs between VIIRS and MODIS, as well as at the Dome C site
- A new, fast SNO GeoSpatial Matching (GSM) algorithm applied to remap VIIRS image to MODIS (greatly facilities pixel-by-pixel comparisons for full size images)
- VIIRS monitoring leverages previously published work on the Dome C (Cao et al. 2010, CJRS) and enables developing time series for comparison with established onboard calibrator data



SNO Example





Time series of VIIRS reflectance band ratio at the Dome C site

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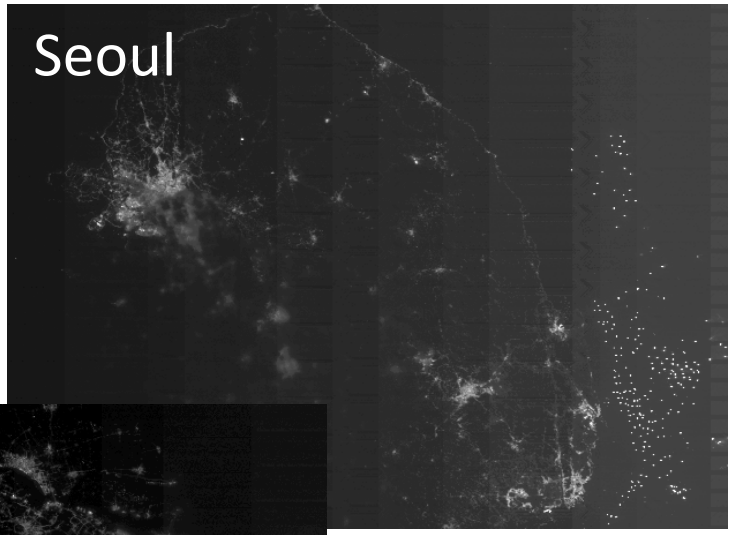
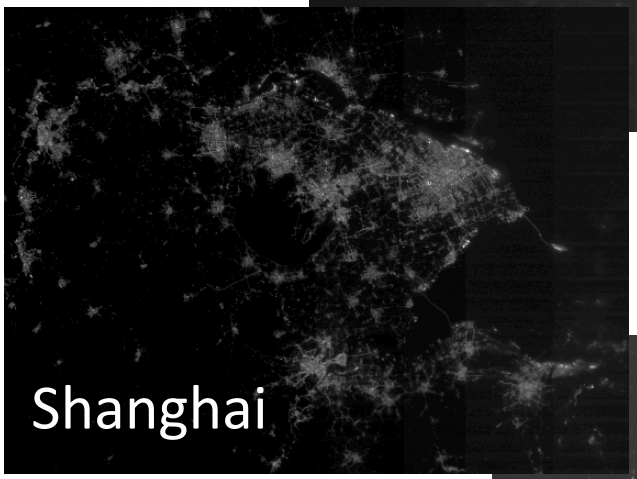
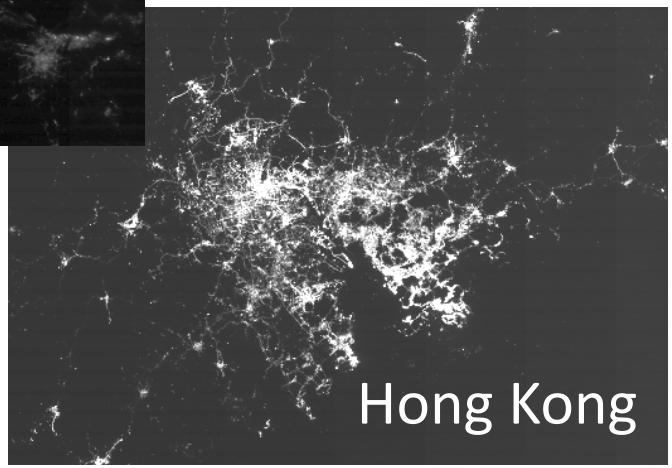
VIIRS Day Night Band (DNB) Images

- The VIIRS Day Night Band (DNB), which outperforms the OLS on DMSP, represents a new capability with NOAA's operational environmental satellites
- Initial check of the DNB band shows that it is functioning well and producing excellent images with high resolution at night (figures on the right show sample night images)
- NOAA has tested the Miller-Turner model for computing the Lunar irradiance for use with the DNB band
- Model results have been compared with those from the USGS ROLO model in preliminary analysis



Squid fishing boat lights





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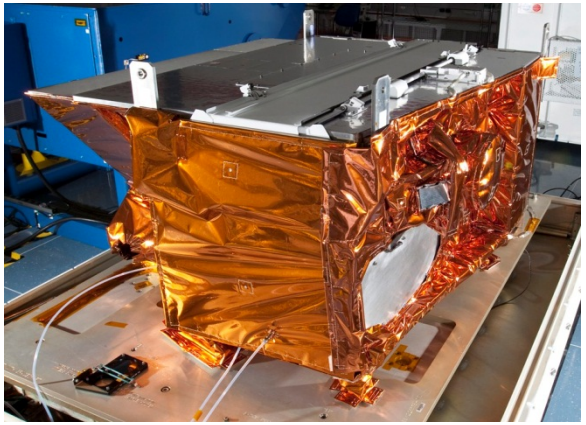
Overview of VIIRS Data Products

- VIIRS data products include SDRs (Sensor Data Records)
  - calibrated and geolocated radiance and reflectance (≈ Level 1B)
- 22 types of SDRs:
  - 16 moderate resolution, narrow spectral bands
    - 11 Reflective Solar Bands (RSB)
    - 5 Thermal Emissive Bands (TEB)
  - 5 imaging resolution, narrow spectral bands
    - 3 RSB
    - 2 TEB
  - 1 Day Night Band (DNB) imaging, broadband



- Input to 21 EDRs (Environmental Data Records)
  - Two “Key Performance Parameters” of NPP mission success:
    - SST
    - Imagery

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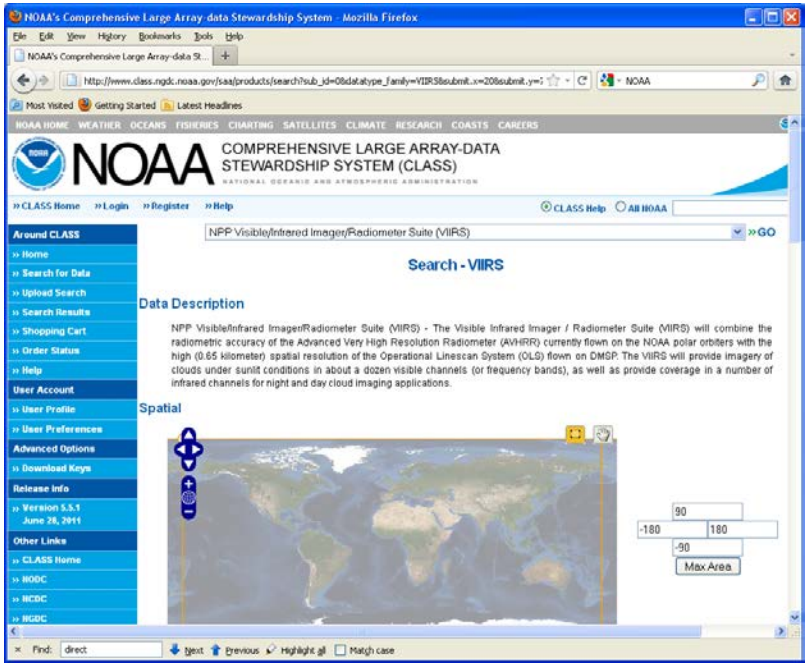
VIIRS Data Distribution and Access

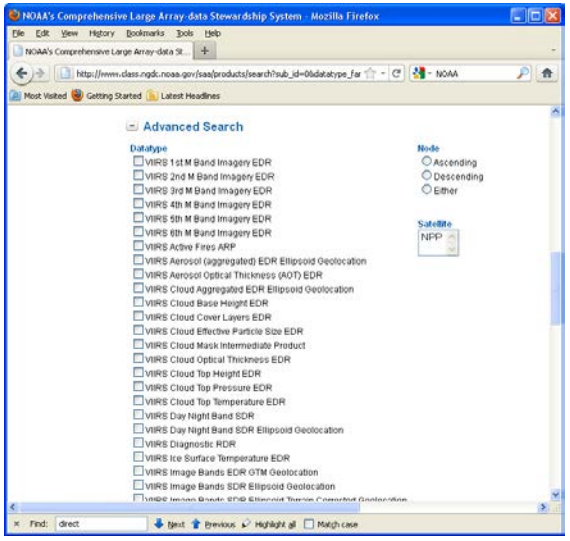
CLASS: www.class.noaa.gov

- Combined granules (4× for M bands)
- Online order and ftp
- Large file size: e.g., an RSB 4× granule with Geo data is 900 MB for M-bands and 1.75 GB for I-bands
- Currently restricted to team members



Centrals:

- NOAA/NESDIS, Suitland, MD
- Air Force Weather Agency (AFWA), Offutt Air Force Base, Omaha, NE



GRAVITE: for team members

NASA PEATE

Direct Readout

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Resources & References

- Software tools:
  - HDF5 file viewer, HDFView 2.7+ (http://www.hdfgroup.org/hdf-java-html/hdfview/)
  - COTS software packages
    - ENVI with HDF5 plugin
    - IDL
    - MATLAB
- VIIRS Info: http://www.star.nesdis.noaa.gov/jpss/VIIRS
  - Algorithm Theoretical Basis Document (ATBD)
  - SDR data format
  - NPP VIIRS Spectral Response Functions
- VIIRS Wiki page: https://cs.star.nesdis.noaa.gov/NCC/VIIRS

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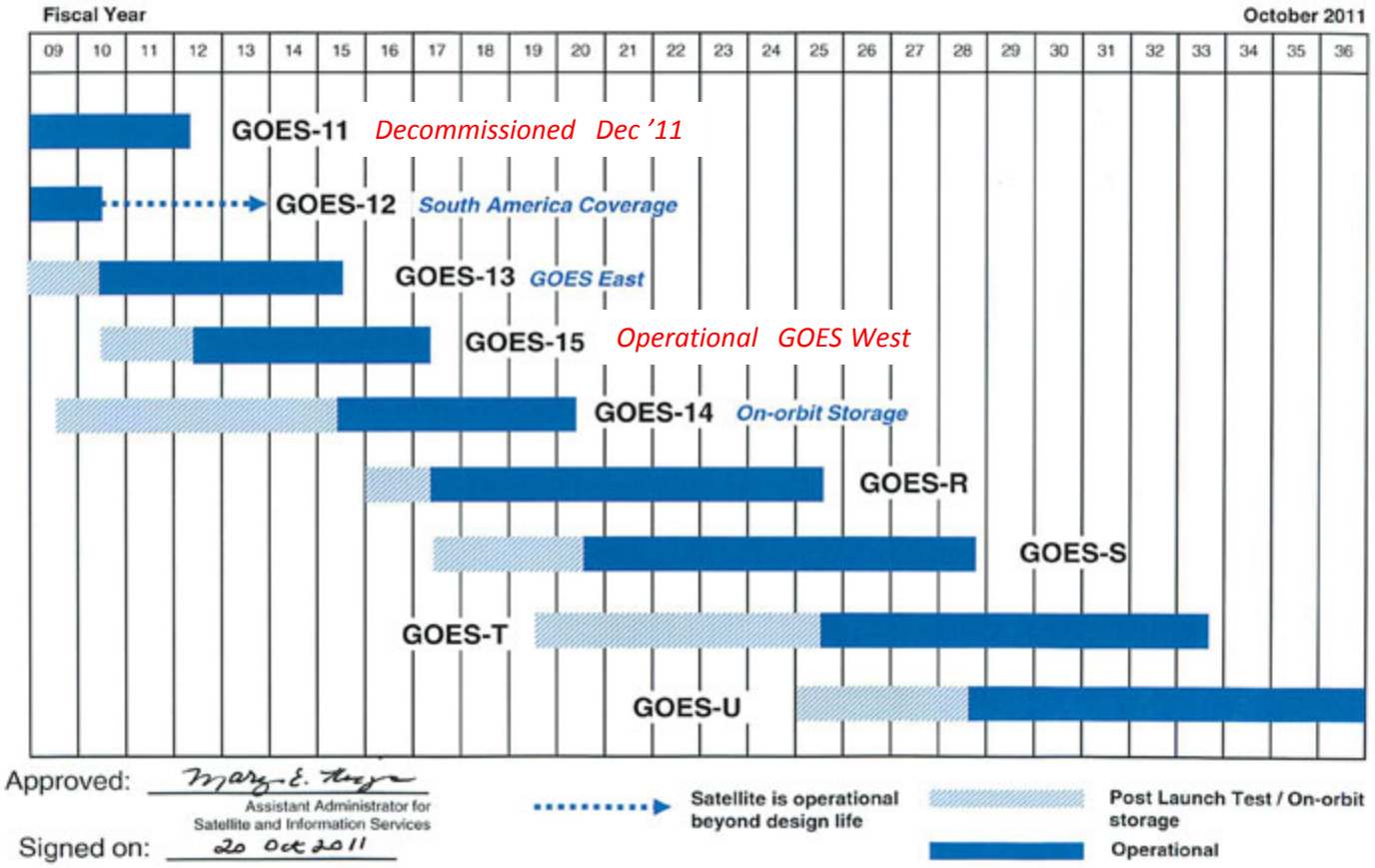
Continuity of NOAA's Geostationary Operational Satellite Programs



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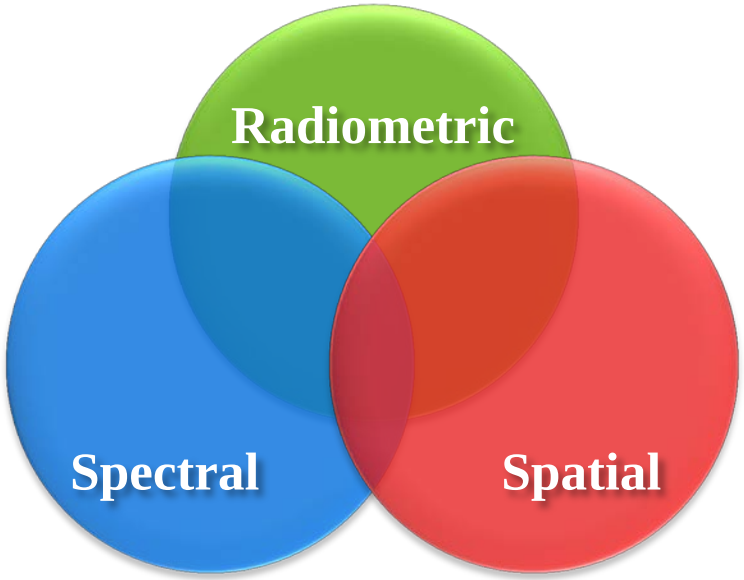
GOES-R Calibration Working Group (CWG)

- Verify and ensure well-calibrated, & well-navigated GOES-R L1B data for the life time of the instruments (ABI, GLM, and Space Weather)
- Ensure Level 1B data quality and science integrity. Provide technical oversight and V&V for:
  - Radiometric calibration
  - Spectral calibration
  - Spatial calibration/navigation
  - Verification of L1B data
  - Instrument performance issues
- Provide technical support to the Flight and Ground through Program System Engineering (PSE)
- Members include scientists and engineers from NOAA, NASA, NIST, MIT/LL, and all segments of GOES-R program



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Prelaunch Test Data Analysis and Verification

Objective

- To ensure that the pre-launch data are evaluated consistently and accurately with respect to requirements and well understood for operational use as well as on-orbit anomaly resolution

Process

- Review test plans and technical reports
- NIST participation in prelaunch testing
- Analyze test data delivered by vendors
- Develop and deliver reports documenting findings

CWG Report Process

Progress

- NIST Prelaunch Tests
  - Completed most tests on PTM (Proto-Type Model), including TXR, VXR, and SIRCUS
- ABI PTM Reports Completed
  - Irradiance Calibration Test for Reflective Bands
  - Emissive Band Calibration Test
- ABI PTM Reports Pending
  - Coherent Noise Test
  - Reflective Band Calibration Test

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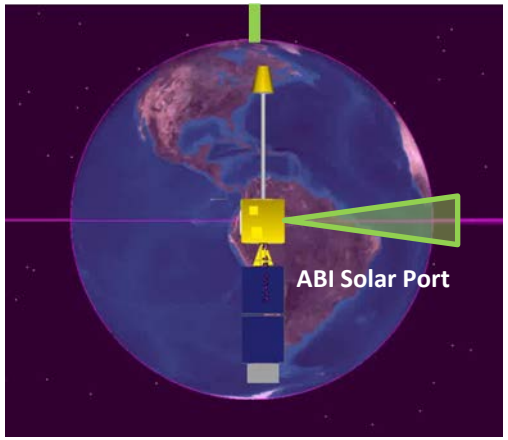
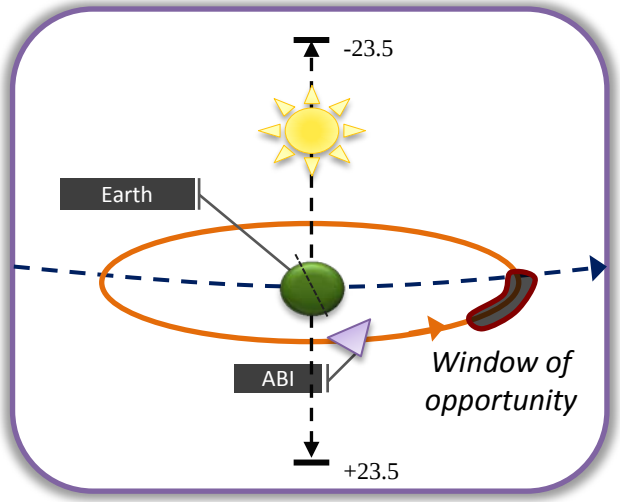
Solar Diffuser (SD) Calibration Support

- 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
- CWG completed analysis of PTM irradiance test results with important findings and provided feedback to the program
- CWG is developing analytical capabilities to support on-orbit solar diffuser calibration, including solar and lunar geometry analysis using orbital perturbation models, leveraging experience with NPP/VIIRS SD calibration





1 Day

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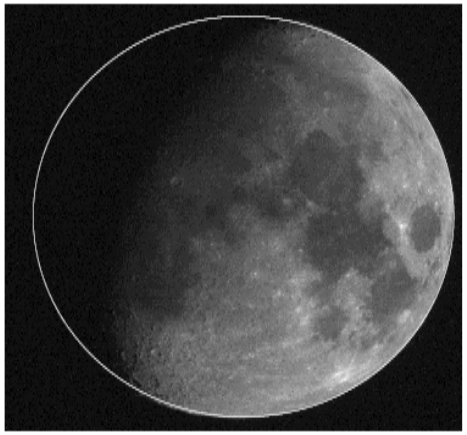
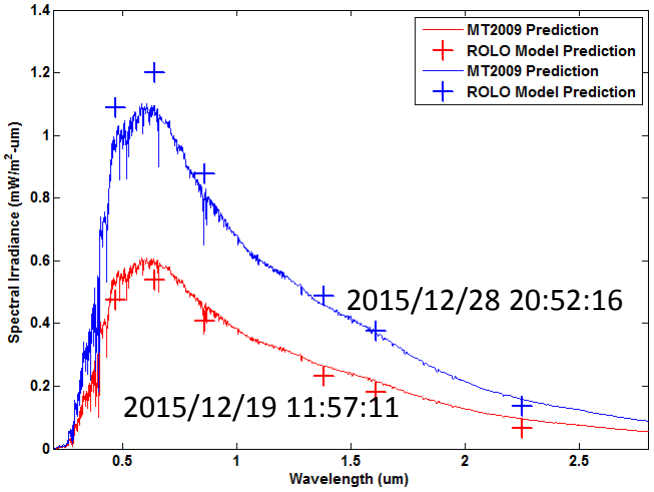
Calibration of GOES-R ABI using Lunar Irradiation Models

- Lunar calibration: Photometric stability of the lunar surface < 10^{-8} /year
- In collaboration with T. Stone from USGS to predict
  - Opportunities to view the Moon from the hypothetical GOES–R positions in geostationary orbit
  - Lunar irradiance with ROLO model in the six ABI solar reflective channels
- Acquired Miller-Turner (MT2009) lunar irradiance prediction model
- Compared moon irradiance predictions between MT2009 model and ROLO model



Sample lunar image (GOES 10)



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Aircraft Campaign to Characterize Vicarious Target BRDF

Background:

- Characterization of WSMR, NM and Sonora Desert, Mexico BRDF with airborne radiometers to support long-term GOES-R V&V efforts

Accomplishments:

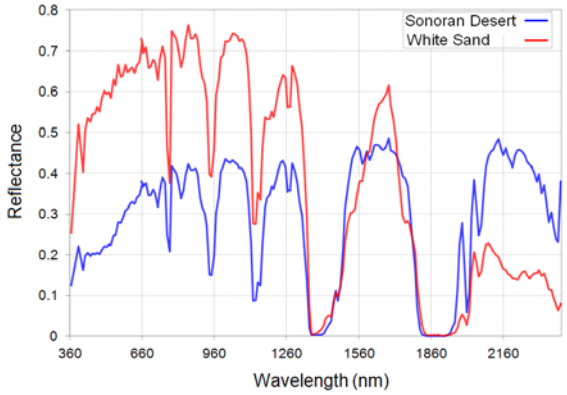
- Completed NASA ER-2 Flights with an AVIRIS (JPL) and MASTER (UC Santa Cruz) payload
- WSMR flight support gained from NASA's AERONET facility at WSMR and forecast and weather data support from El Paso, Texas NWS Line Office
- Sonoran Desert supported by aerosol and water vapor estimated from Microtops sunphotometer measurements taken near the Mexican border south of Yuma, AZ
- WSMR and Sonoran Desert sand is being processed for lab measurement of BRDF

May 24, 2011 post-flight calibration of the AVIRIS performed in Palmdale, CA.

	White Sands Missile Range, NM (32.988,-106.30)	
DATE	EOS Aqua (2020 UTC or 14:20 MDT)	Metop-A (1700 UTC or 11:00 MDT)
5/23/2011	199	139

	Sonora Desert Mexico (32.0,-114.39)			
DATE	EOS Terra (1830 UTC or 11:30 MST)	EOS Aqua (2055 UTC or 13:55 MST)	Metop-A (1735 UTC or 10:35 MST)	N19 (2055 UTC or 13:55 MST)
6/10/2011	275W		60W	92E

Flight day satellite overpasses of WSMR (upper) and Sonoran Desert (lower)



MASTER images at 540 nm (left), 1981 nm (right) for 1030 MDT May 23, 2011. Courtesy of MASTER Instrument Team.

Summary

- Great success with NPP launch and post-launch Cal/Val
- NOAA scientists are leading post-launch SDR Cal/Val for all major NPP instruments
- Very good progress with GOES-R prelaunch calibration
- More up to date information can be found at the NOAA calibration center site at http://ncc.nesdis.noaa.gov