National Environmental Satellite, Data, and Information Service

NOAA Cal/Val Progress Update

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With contributions from NOAA/NESDIS/STAR Scientists

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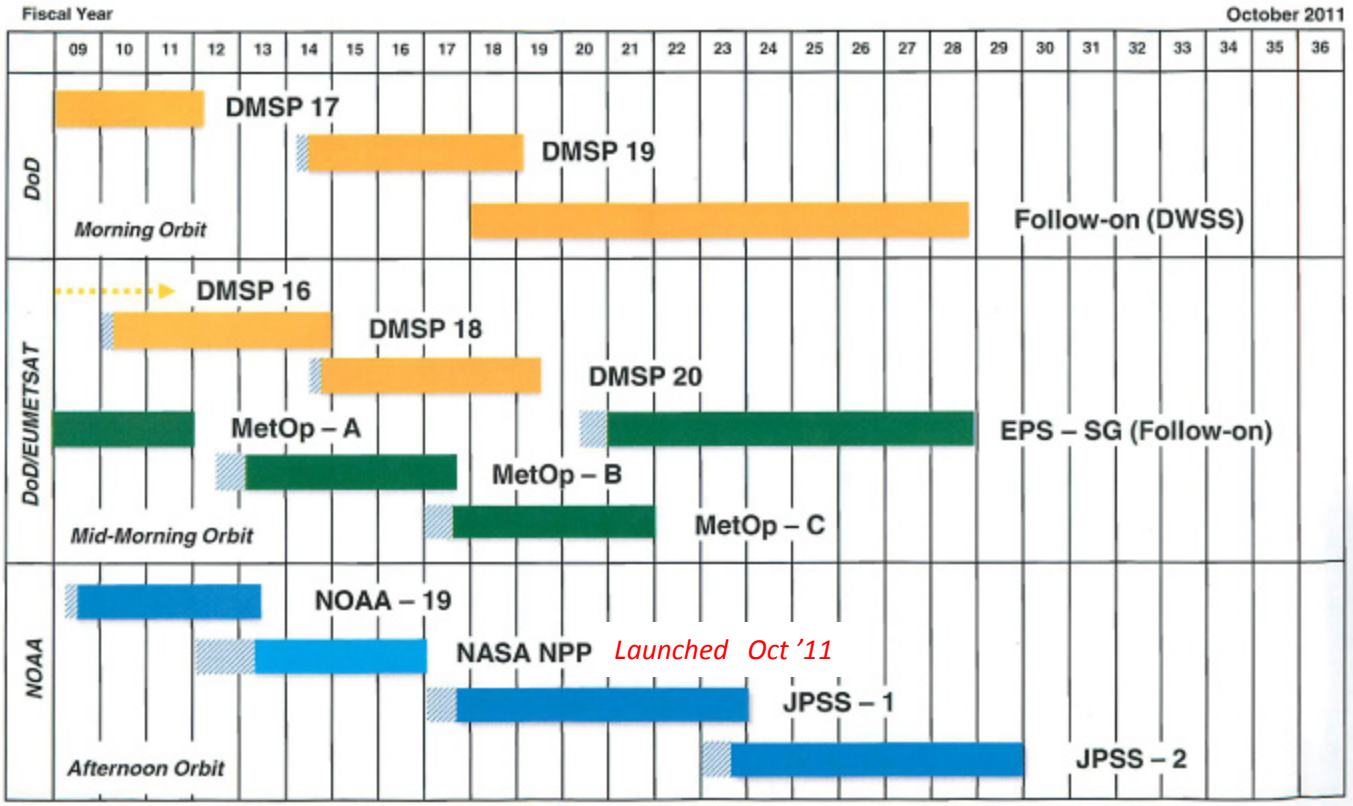
Outline

- 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



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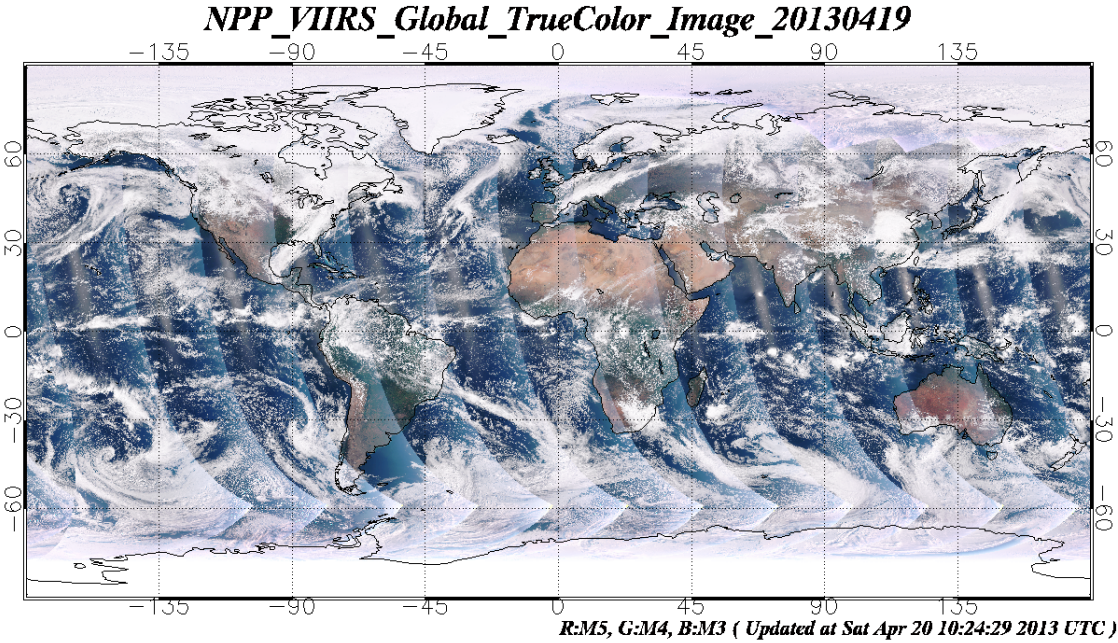
Suomi NPP

(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)



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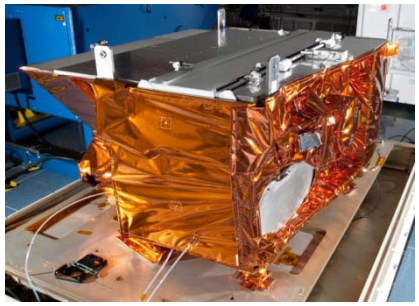
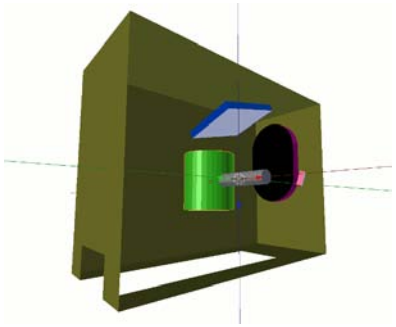
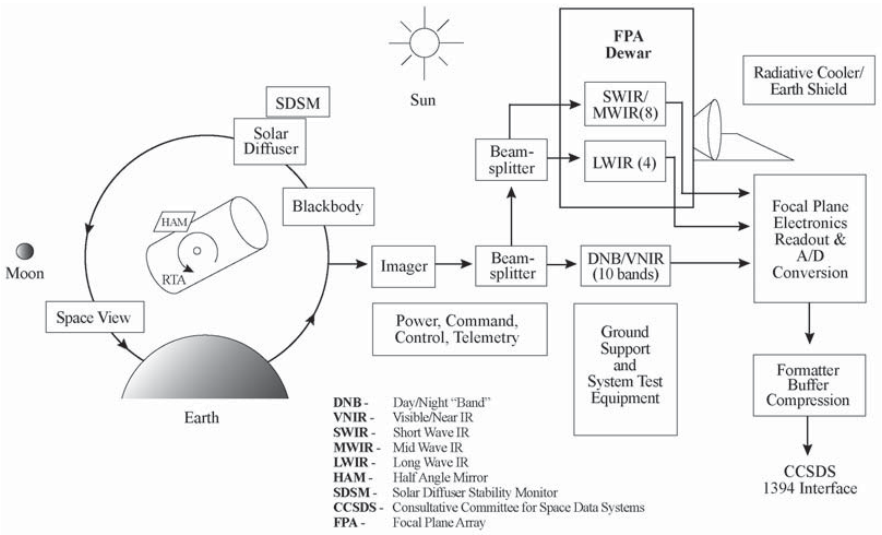
Overview of VIIRS Data Products

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

- 22 types of SDRs:
  - 16 moderate resolution 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.







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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.*

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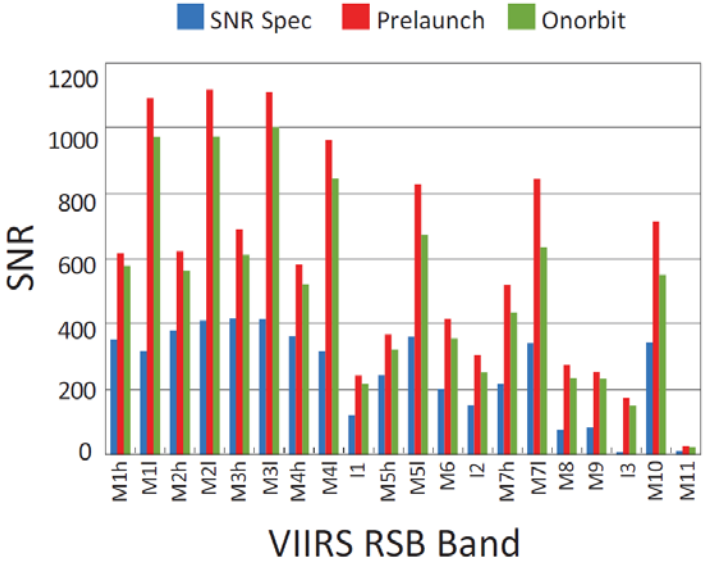
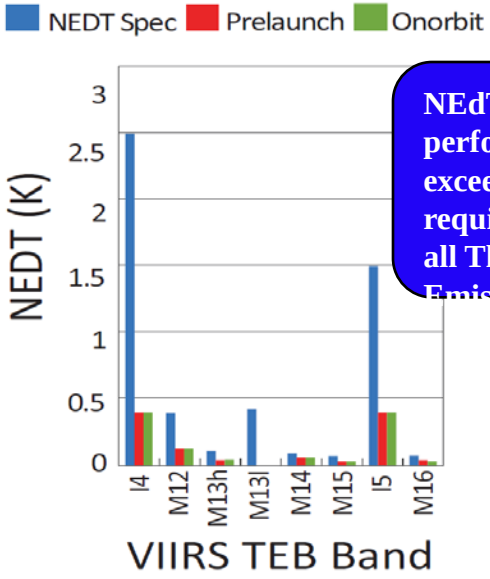
VIIRS SDR Product Maturity

- 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





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

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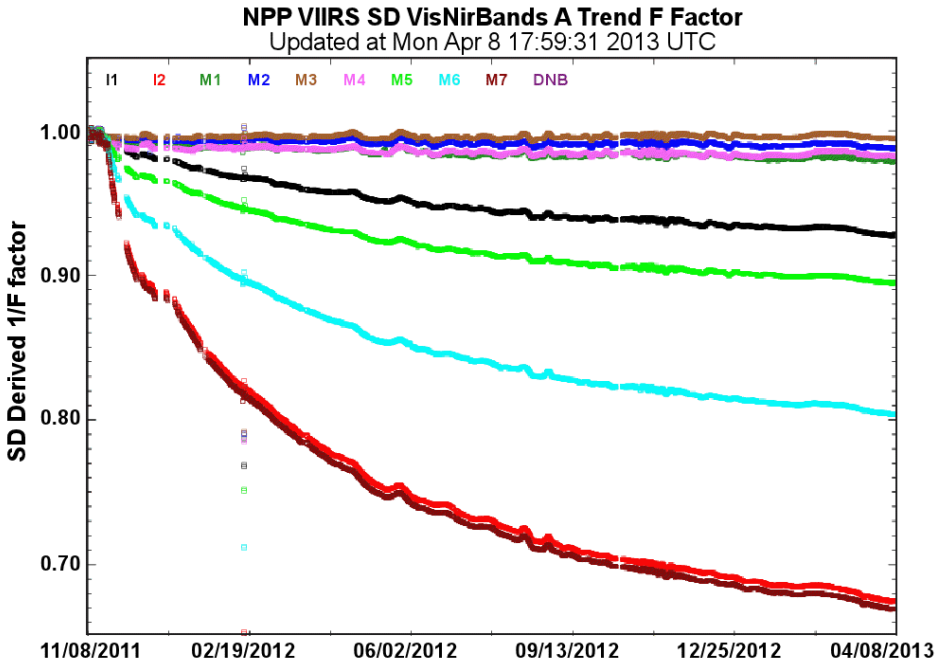
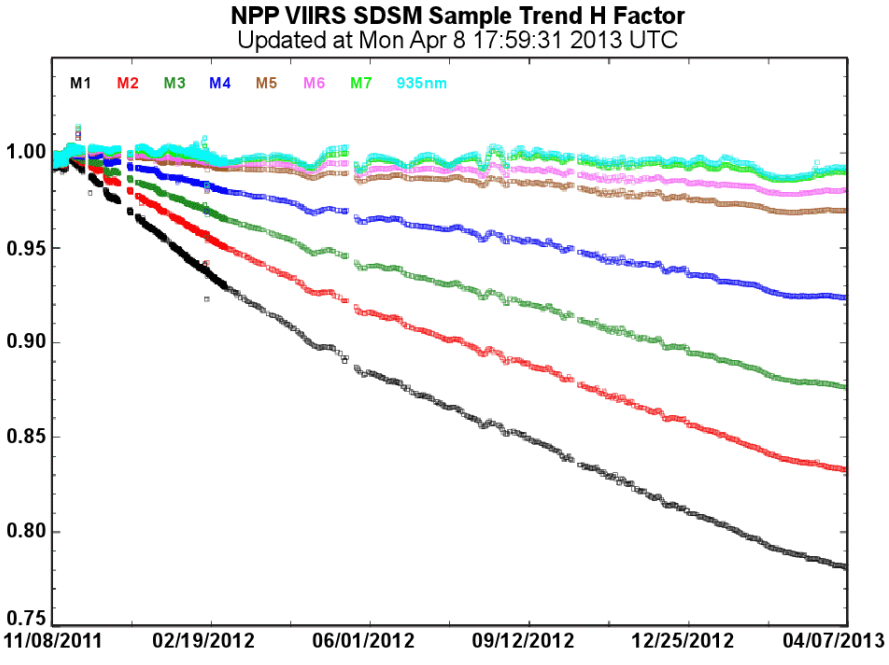
VIIRS Mirror Degradation Status



Solar Diffuser Degradation



NOAA/NESDIS/STAR **Satellite Integrated Calibration / Validation System (ICVS)**
http://www.star.nesdis.noaa.gov/icvs/NPP/ipm_telemetry_npp_viirs.php

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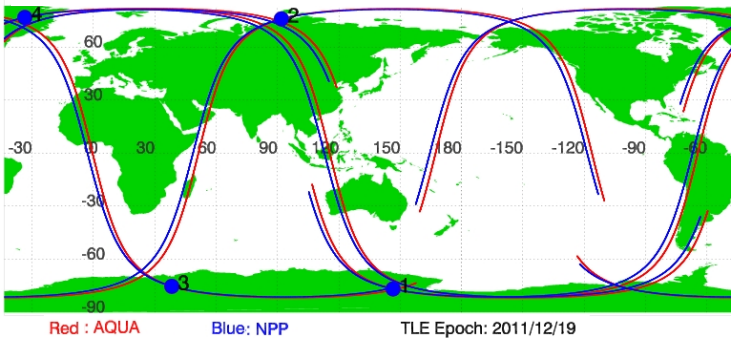
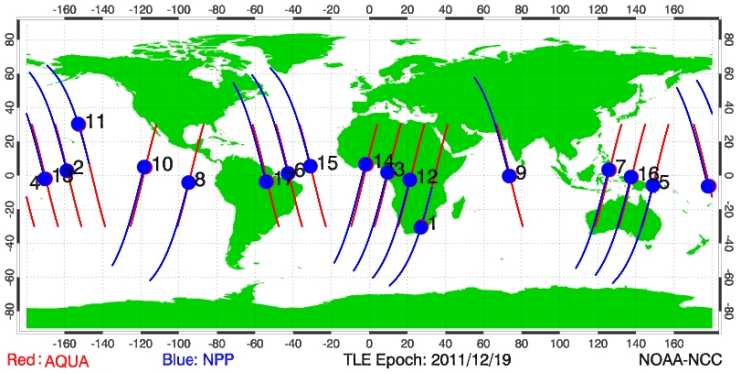
VIIRS Calibration with SNO and SNO Extension to Low Latitudes

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

SNO (Simultaneous Nadir Overpass)



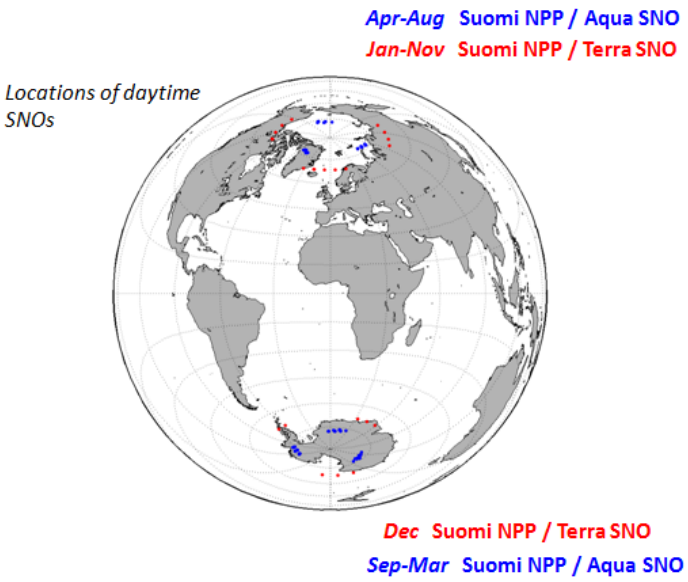
SNOx (SNO extension to low latitudes)



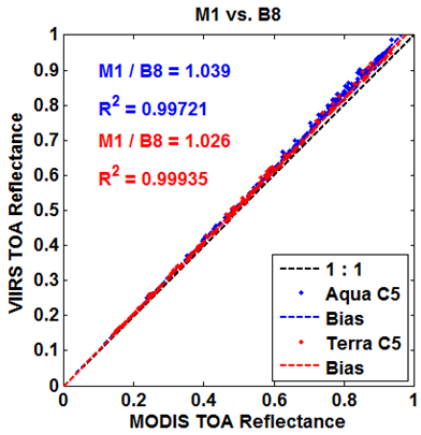
The SNO/SNOx as well as daily SNPP orbital predictions are available at:
https://cs.star.nesdis.noaa.gov/NCC/SNOPredictions

Assessing Radiometric Biases between VIIRS and MODIS Collection 5 and 6

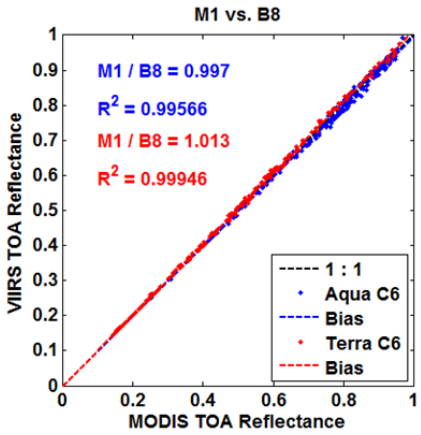
- A radiometric bias on the order of 5% between VIIRS band M1 and MODIS band 8 was found since February 2012
- After a thorough investigation by the VIIRS SDR team, the bias was found to be due to MODIS calibration drift in the Collection 5 (C5) data
- VIIRS datasets agree with MODIS Collection 6 (C6) data, which was recently released by NASA to the public.



VIIRS vs. MODIS Collection 5



VIIRS vs. MODIS Collection 6



412 nm Channel

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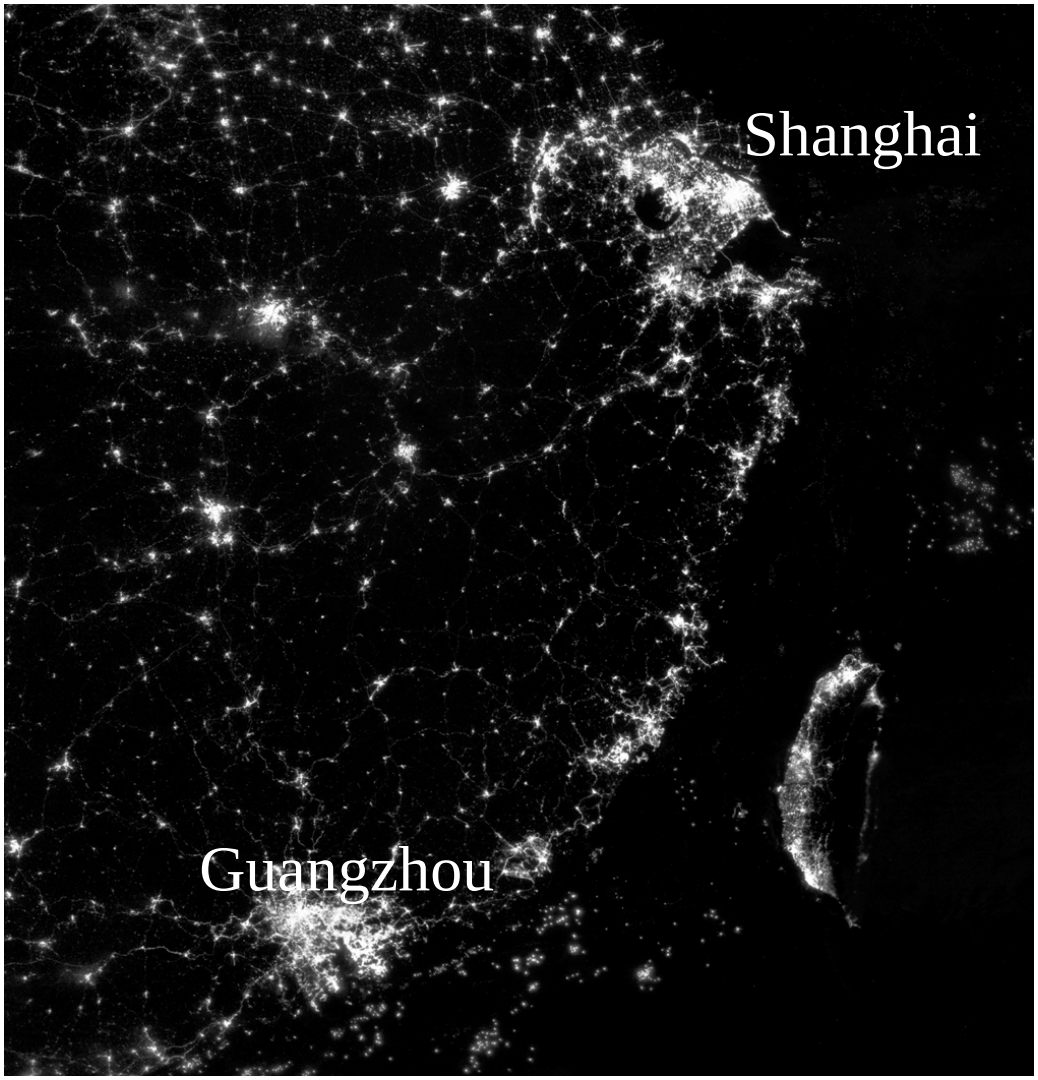
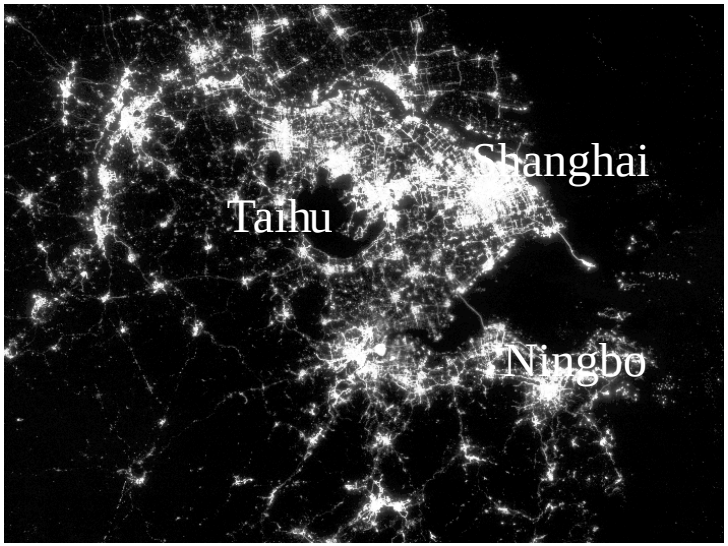
S-NPP VIIRS Day Night Band





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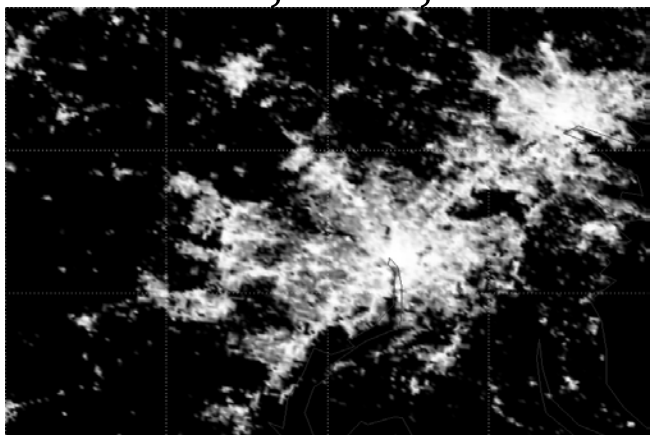
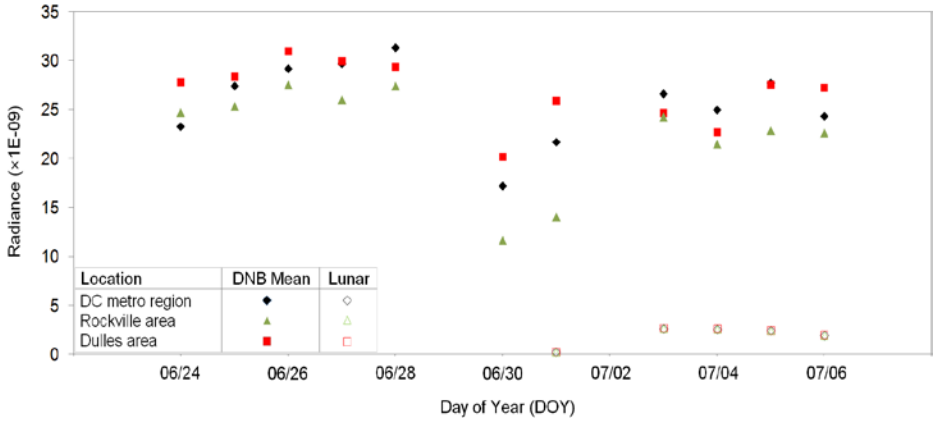
Light Outage Detection during Major Storms with S-NPP VIIRS Day Night Band

Derecho Storm, June, 2012

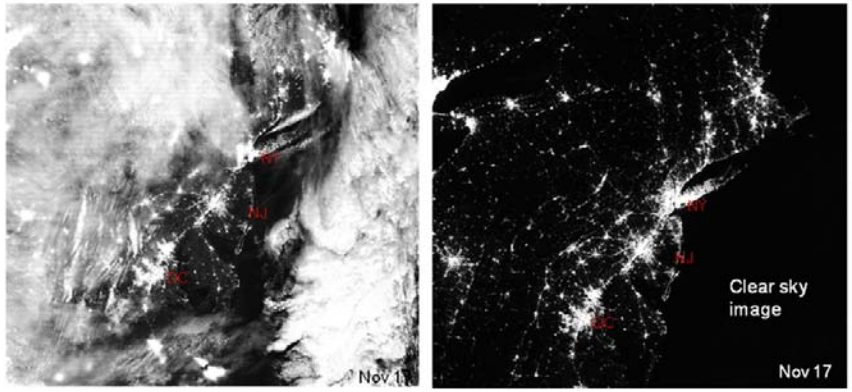


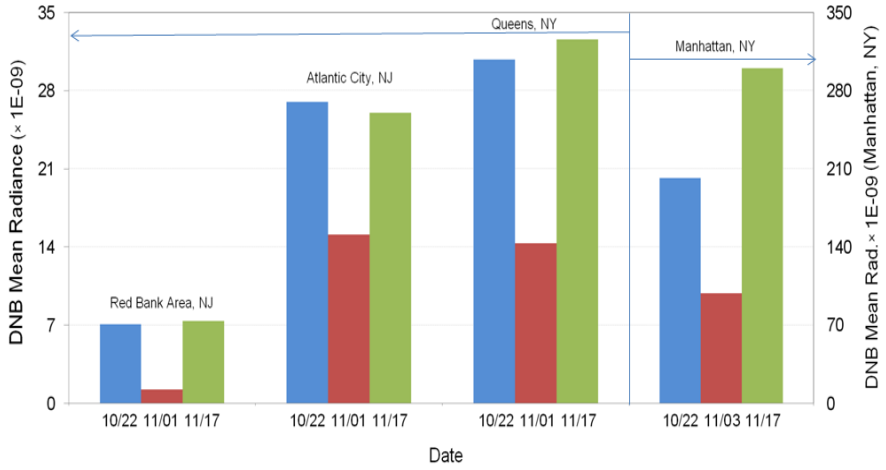
VIIRS DNB of the Washington/Baltimore area



VIIRS DNB radiance time series before and after the power outage

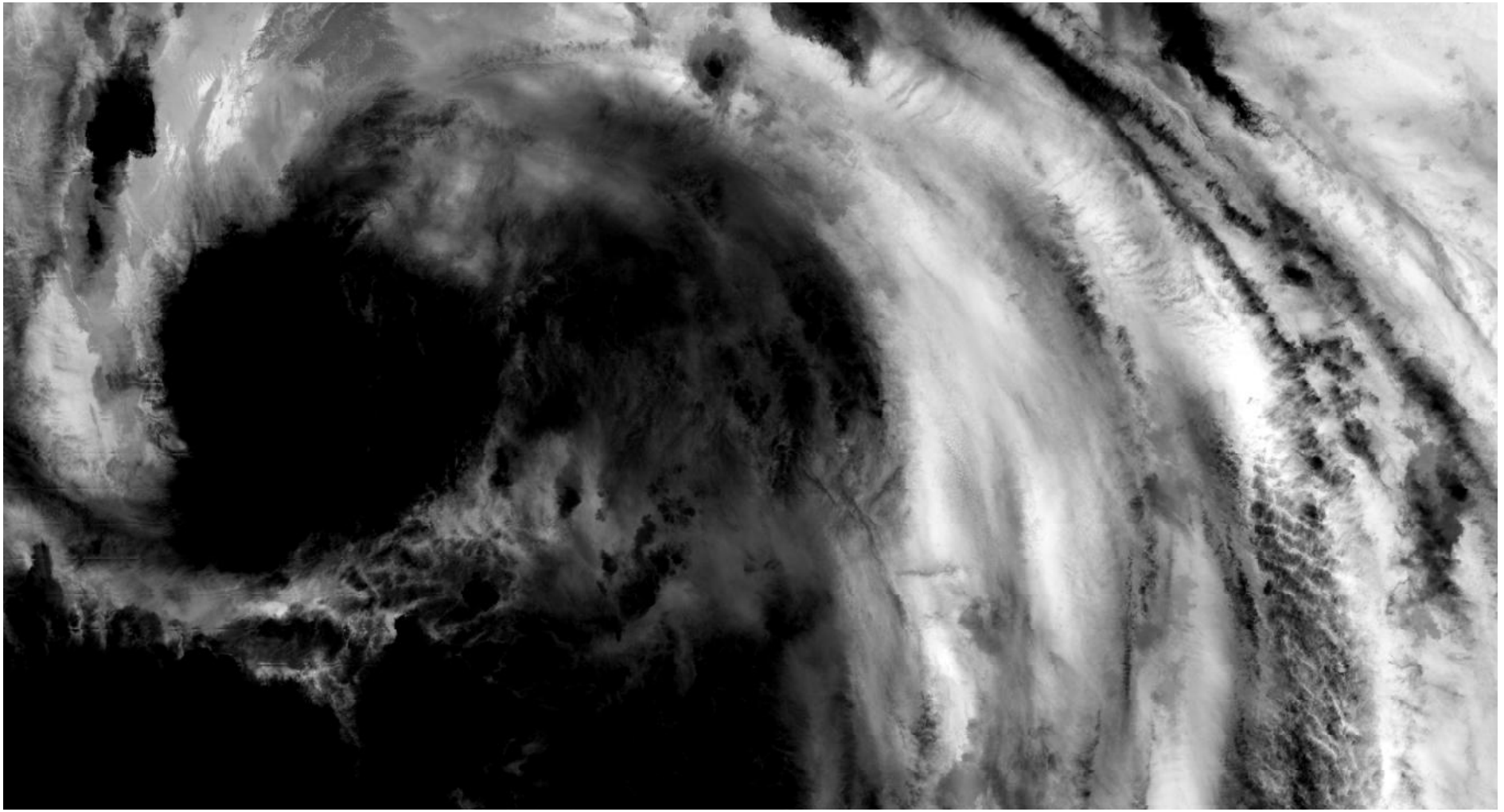
Hurricane Sandy, Oct. 2012





- 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



Aug. 28, 2012

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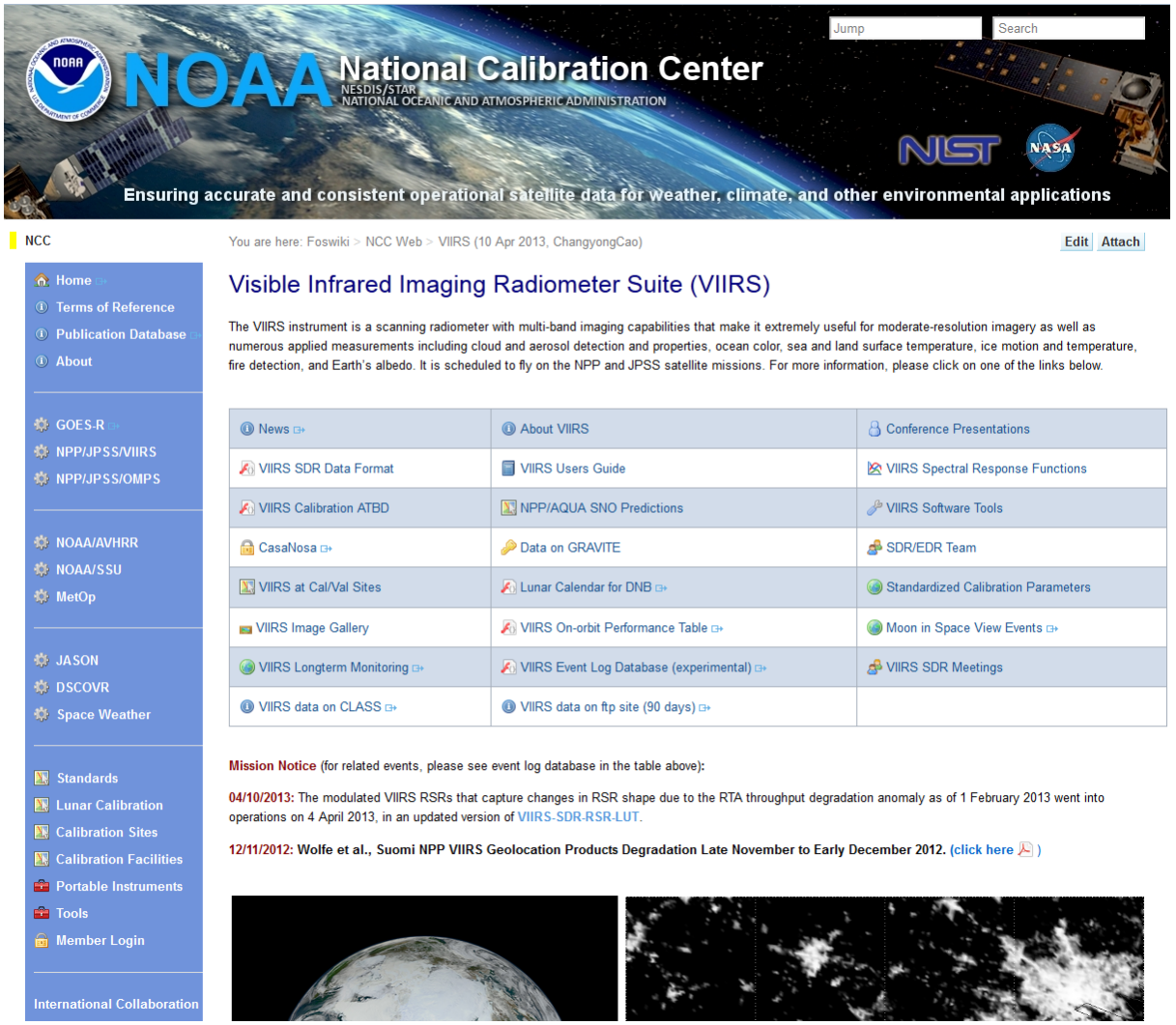
VIIRS Calibration Knowledge Base and Data Access

- 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

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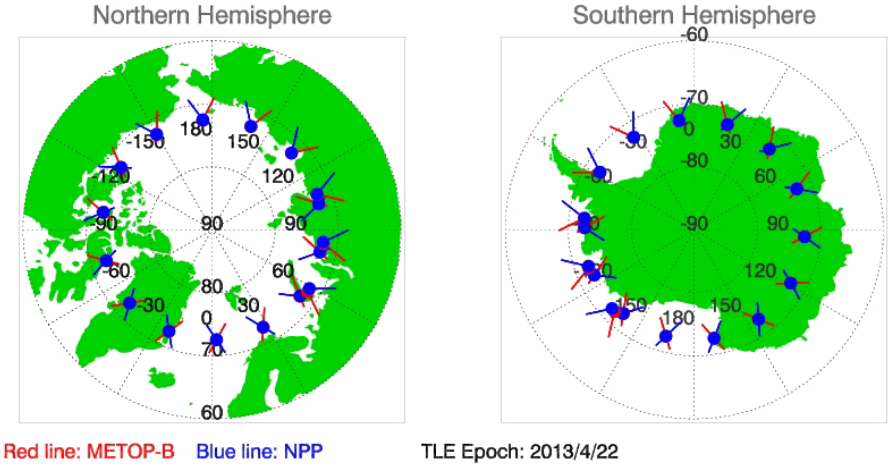
Successful launch of MetOp-B and Post Launch Cal/Val

- 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

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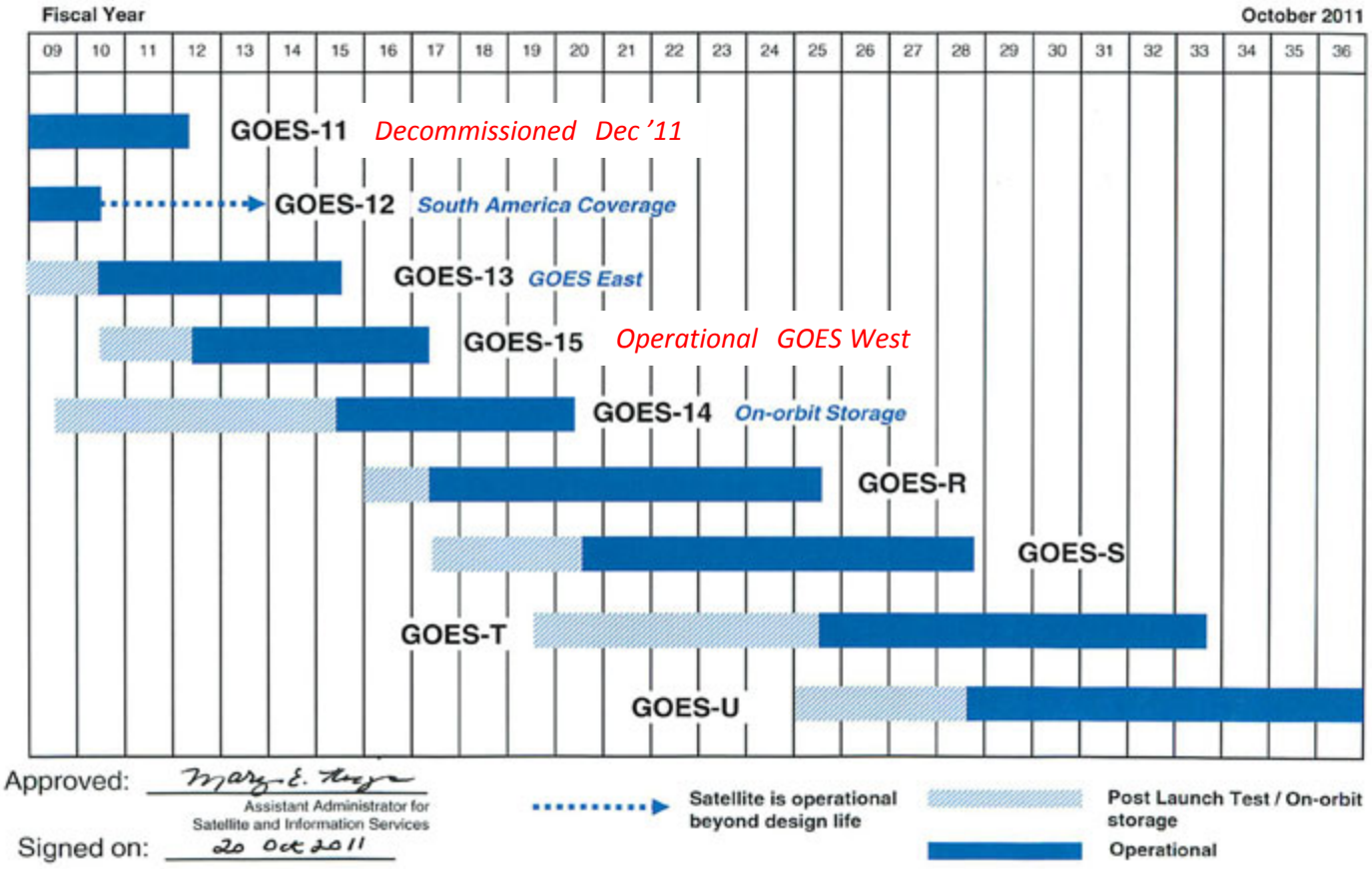
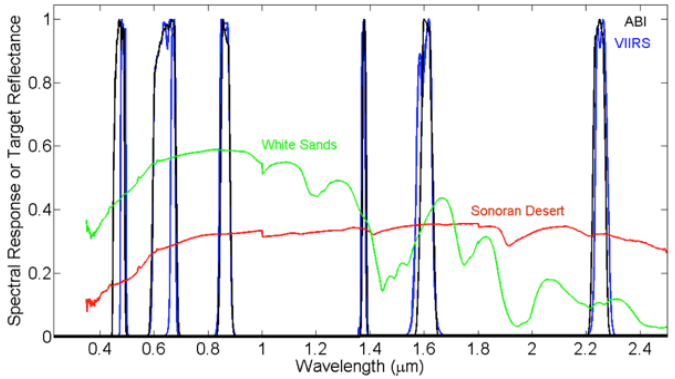
Continuity of NOAA's Geostationary Operational Satellite Programs

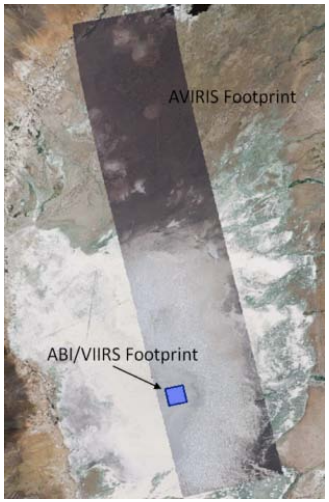


GOES-R ABI Calibration/Validation

- 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.



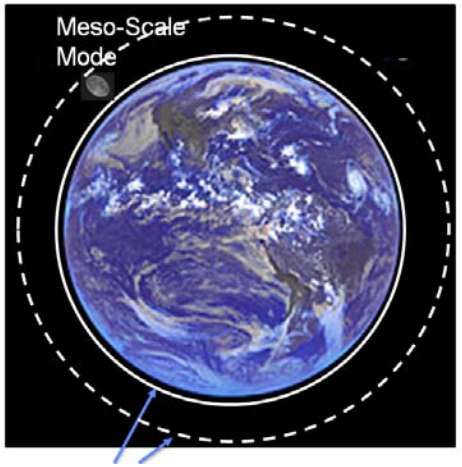
Predicted radiance biases for ABI & VIIRS over White Sands, NM: biases and uncertainties



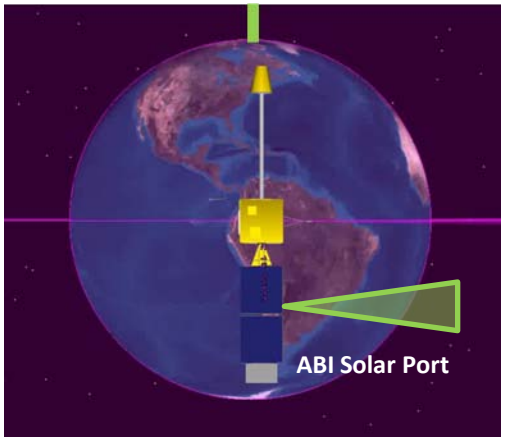
Location of underflight imagery (right)

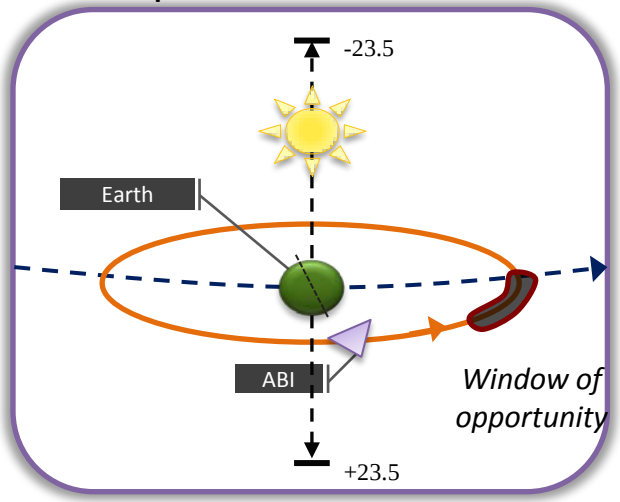
ABI Calibration with Solar Diffuser and Lunar Observation

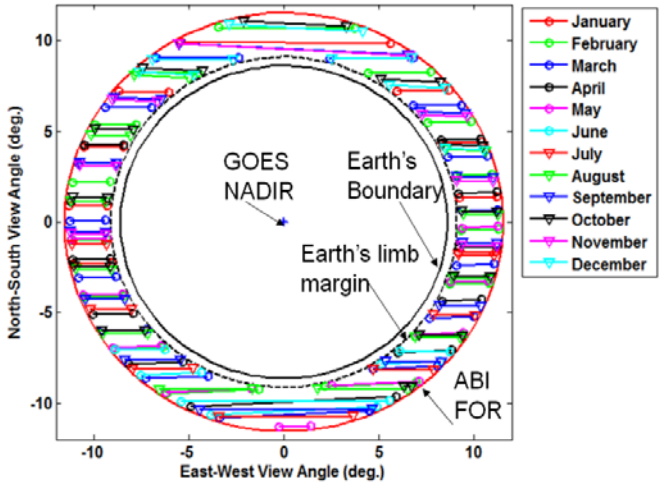
- SD is critical for evaluating solar band performance, including stability, degradation, signal to noise, and anomaly analysis (as demonstrated in NPP VIIRS)
- ABI SD calibration is more challenging due to partial aperture, and the alternative approach used in prelaunch testing
- Long-term prediction 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).







1 Day

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