



**NASA
NPOESS Preparatory Project (NPP)
VIIRS Ocean Science Team (VOST)
Activities**

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and other members of the VOST.

**MODIS Science Team Meeting
18-20 May 2011
College Park, Maryland**



CURRENT MANDATE



ROSES10 Appendix A.22 Section 2:

*“... to continue the **evaluation** of NPP/NPOESS (sic) Environmental Data Records (EDRs), to demonstrate the suitability of these data sets for use as ESDRs and/or CDRs, and to **develop and evaluate improvements** to EDR algorithms that could make them more suitable as ESDRs or CDRs;...”*

ROSES10 Appendix A.22 Section 2.1.1.c:

*“...NPP VIIRS was intended to **continue the ocean data record** started in 1978 with CZCS and improved upon by the SeaWiFS and the EOS MODIS instruments. (EDR: Ocean Color / Chlorophyll)”*



VOST OBJECTIVES



- ▼ Evaluate sensor artifacts (e.g, crosstalk) and potential corrections based on
 - ▶ Prelaunch: Characterization data and simulated data.
 - ▶ Postlaunch: Flight data and *in situ* data, if available.
- ▶ Evaluate VIIRS RSB Rad Cal (solar, lunar, & vicarious).
- ▶ Process VIIRS flight data with NASA algorithms to compare against operational products.
- ▶ Sensor-to-sensor and self-consistency checks; will include *in situ* data, if available.
- ▶ Expect to produce a postlaunch quality report after one year.

RSB - Reflective Solar Bands
Rad Cal - Radiometric Calibration



RECENT ACTIVITIES



▼ SCIENCE

- ▶ **NPP VIIRS Ocean Color Data Product Quality Assessment.**
- ▶ **VIIRS Data Simulator.**
- ▶ The “Last” VOAT Meeting?

▼ COMMUNITY

- ▶ NOAA and NAVY participate in weekly NASA NPP VOST meetings.
- ▶ NASA-NOAA Radiometric Calibration Technical Working Group.
- ▶ NRC Committee Assessing Requirements for Sustained Ocean Color Research and Operations.
- ▶ NOAA NPP/JPSS Ocean Cal Team
- ▶ JPSS L1 Reqs Supplement Review.

▼ FLIGHT (Prelaunch)

- ▶ Prelaunch Characterization Archive.
- ▶ VIIRS RSR and ASR analyses.
- ▶ OOB target-specific assesement.
- ▶ Government Spectral Characterization Working Group (Moeller).
- ▶ NICST Memoranda Reviews.
- ▶ Crosstalk Specification Changes.

▼ SENSOR (Postlaunch)

- ▶ **NASA NPP VIIRS RSB Rad Cal WG.**
- ▶ **NASA RSB Radiometric Calibration Plan Outline (VOST, NICSE, USGS).**
- ▶ Reviewed latest version of operational SDR code and gave recommendations.
- ▶ Ocean PEATE Activities (e.g., Ground System Tests).
- ▶ Calibration Maneuvers.
- ▶ ~~NOAA SDR Calibration Working Group.~~



RISK RATING KEY FOR NASA CDR/ESDR CONTINUITY



“Issues are defined as ‘show-stoppers’ requiring immediate action to prevent major technical, cost, or schedule impacts.”



“Concerns are defined as matters requiring special attention and actions to prevent them from becoming Issues.”



“Watch Items are defined as matters requiring attention to prevent them from becoming a Concern or Issue.”

**Source of Definitions: Gordon Fesenger (Northrop Grumman),
“NCF One List Update,” PPT Presentation, 16 Feb, 2010.**



NPP VIIRS OCEAN COLOR DATA PRODUCT QUALITY ASSESSMENT



ASSESSMENT OVERVIEW

!!!

Reprocessing

!!!

Algorithms

!

Instrument Performance and Prelaunch Characterization

On-Orbit Calibration/Validation

!!

▶ **Validation**

!

▶ **Solar Diffuser Calibration**

!!

▶ **Lunar Calibration**

!!

▶ **Vicarious Calibration**

See complete report, available at http://oceancolor.gsfc.nasa.gov/DOCS/NPP_VIIRS_Ocean_Color_Products.pdf



NPP VIIRS OCEAN COLOR DATA PRODUCT QUALITY ASSESSMENT



ASSESSMENT OVERVIEW

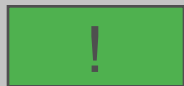


Reprocessing

- ▶ Not supported at a mission level.
- ▶ In our opinion, this is a definite **showstopper** for sustaining a consistent climate data record.

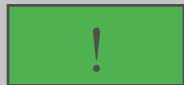
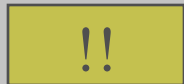


Algorithms

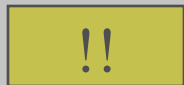
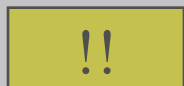


Instrument Performance and Characterization

On-Orbit Calibration/Validation



- ▶ Solar Diffuser Calibration



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NPP VIIRS OCEAN COLOR DATA PRODUCT QUALITY ASSESSMENT



ASSESSMENT OVERVIEW

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Reprocessing

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Algorithms

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Instrument Performance

- ▶ NPP Operational algorithms neither consistent nor up-to-date with algorithms used by NASA.
- ▶ Insertion of updates into operations is problematic.
- ▶ Latency issues could preclude using some science algorithms in the operational stream.

On-Orbit Calibration/Validation

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▶ Validation

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▶ Solar Diffuser Calibration

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▶ Lunar Calibration

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▶ Vicarious Calibration

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NPP VIIRS OCEAN COLOR DATA PRODUCT QUALITY ASSESSMENT



ASSESSMENT OVERVIEW

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Reprocessing

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Instrument Performance and Characterization

On-Orbit Calibration/Validation

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▶ Validation

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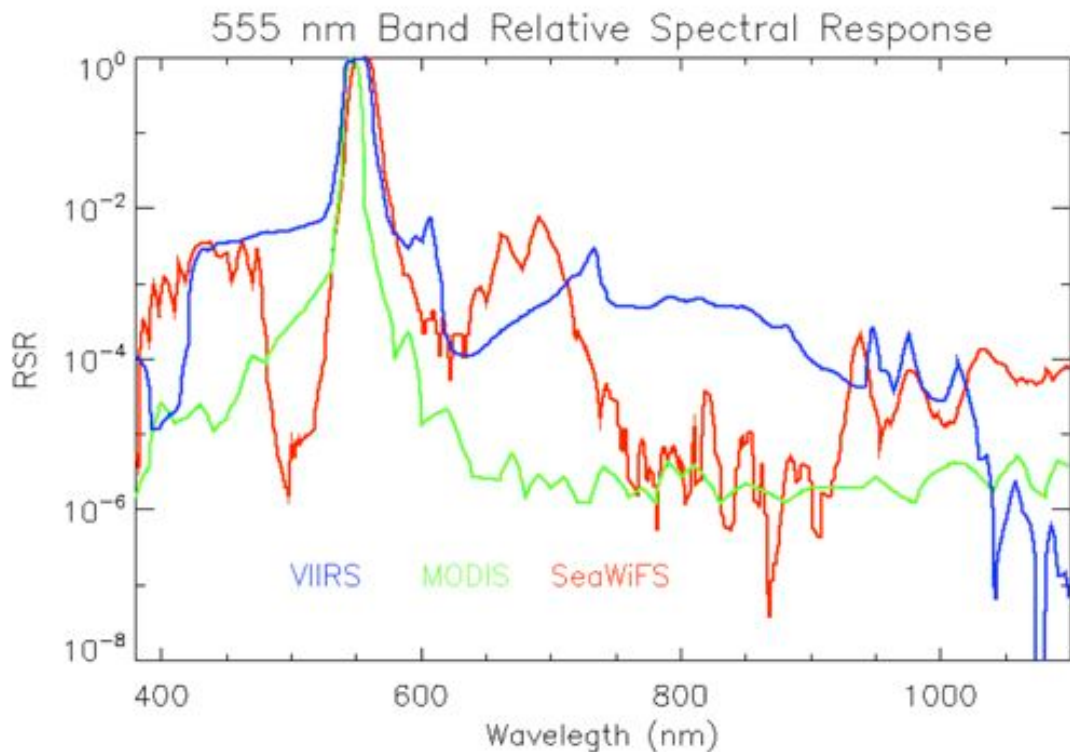
▶ Vicarious Calibration

▶ There is always an inherent risk that on-orbit performance may not match prelaunch expectations.

▶ Given prelaunch expectations, VIIRS is not expected to exceed heritage performance in most areas.

See complete report, available at http://oceancolor.gsfc.nasa.gov/DOCS/NPP_VIIRS_Ocean_Color_Products.pdf

OUT-OF-BAND LIGHT LEAKS



- ▶ Similar to worse cases for SeaWiFS or MODIS.
- ▶ The blue light leak in the green band is the greatest concern, as shown above.

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▶ Lunar Calibration

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▶ Vicarious Calibration

See complete report, available at http://oceancolor.gsfc.nasa.gov/DOCS/NPP_VIIRS_Ocean_Color_Products.pdf

COLOR
ASSESSMENT



VIEW

Characterization

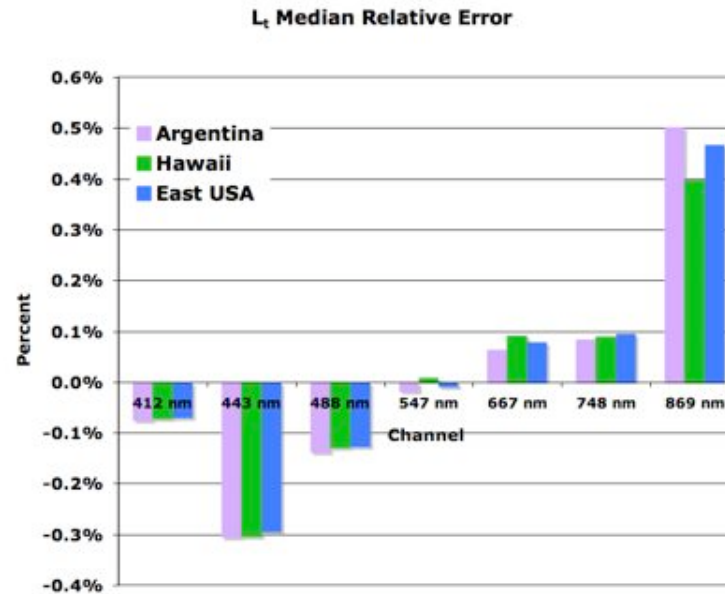
Always an inherent risk that performance may not match expectations.

- ▶ Given prelaunch expectations, VIIRS is not expected to exceed heritage performance in most areas.



OPTICAL CROSSTALK

- ▶ Not seen before for either SeaWiFS or MODIS.
- ▶ For-the-record test showed smaller effect; essentially, a trade-off was made with OOB light leakage, which may be easier to correct.
- ▶ The spatial impact has not been adequately studied, but likely limited to reach no more than a few pixels.
- ▶ Electronic crosstalk effects remain to be studied, but are expected to be minor.



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not expected to exceed heritage performance in most areas.

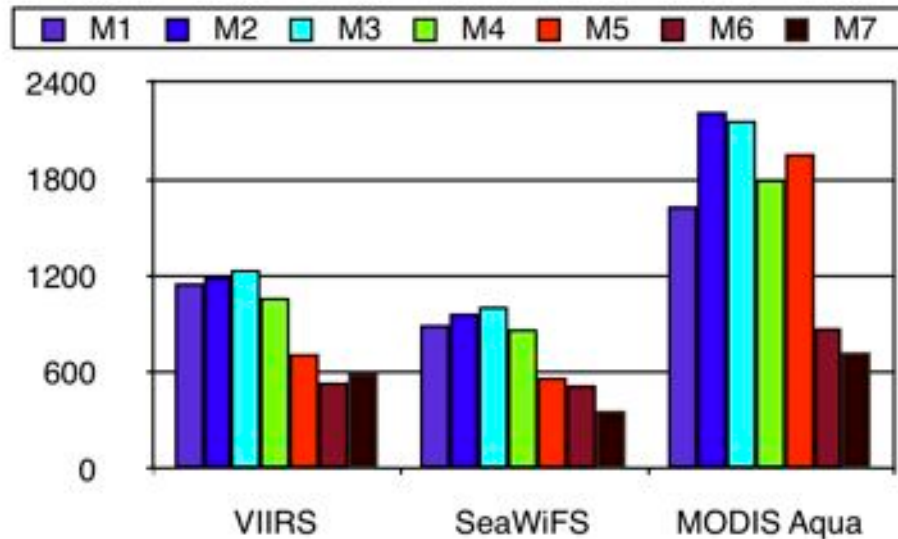
!! ▶ Lunar Calibration

!! ▶ Vicarious Calibration

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SIGNAL-TO-NOISE RATIO



- ▶ VIIRS SNR here is based on typical L_t for ocean.
- ▶ Noise averaged over all six aggregation zones.
- ▶ Overall, noise levels are comparable to SeaWiFS, 3:1 agg zone having better SNR.

Characterization

is always an inherent risk that orbit performance may not match launch expectations.

- ▶ Given prelaunch expectations, VIIRS is not expected to exceed heritage performance in most areas.

▶ Solar Diffuser Calibration

▶ Lunar Calibration

▶ Vicarious Calibration

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NPP VIIRS OCEAN COLOR DATA PRODUCT QUALITY ASSESSMENT



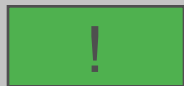
ASSESSMENT OVERVIEW



Reprocessing



Algorithms



Instrument Performance and Characterization

On-Orbit Calibration/Validation



- ▶ Validation effort under Arnone has made good progress.
- ▶ Cal/Val data will be evaluated for storage in SeaBASS.
- ▶ The future of the program is unclear.



▶ **Solar Diffuser Calibration**



- ▶ We have little info regarding Vic/Cal under NOAA or the status of MOBY.
- ▶ Gain correction coeffs are hardcoded to unity in operation code; cannot change sooner than L+60d.

See complete report, available at http://oc2.color.gsfc.nasa.gov/oc2/NPP_VIIRS_Ocean_Color_Products.pdf



NPP VIIRS OCEAN COLOR DATA PRODUCT QUALITY ASSESSMENT



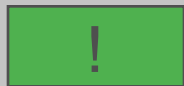
ASSESSMENT OVERVIEW



Reprocessing



Algorithms



Instrument Performance

- ▶ Potential concerns with Cal/Val are mostly programmatic (e.g., planning, funding).
- ▶ NASA NPP VIIRS RSB Rad Cal WG formed to evaluate on-orbit calibration.
- ▶ Developed a RSB Calibration Plan Outline covering Lunar and Solar Cal.

On-Orbit Calibration/Validation



▶ **Solar Diffuser Calibration**



- ▶ NASA has finally approved maneuvers (roll, yaw, & pitch-over).
- ▶ NOAA operations must now approve of continuing lunar roll after NASA hand-off.



See complete report, available at
NPP_VIIRS_Ocean_Color_Products.pdf



NASA NPP RSB RAD CAL WORKING GROUP



A NASA team formed to identify on-orbit reflective solar band (RSB) calibration tasks necessary to meet NASA's climate and science research objectives.

Membership:

Gene Eplee, Kevin Turpie, Gerhard Meister

NASA VIIRS Ocean Science Team (VOST)

Vincent Chiang, Hassan Oudrari, Ning Lei, Jack Xiong

NPP Instrument Characterization Support Element (NICSE)

Tom Stone

USGS ROLO Program

Jim Butler

NPP Deputy Project Scientist for Instruments



NASA NPP RSB RAD CAL WORKING GROUP



▼ Six critical calibration issues identified:

- ▶ Timely generation of calibration LUTs from the solar calibration data analysis, to support operational data processing.
 - ▶ Implementation of the on-orbit lunar calibration data analysis.
 - ▶ Merger of solar-derived and lunar-derived instrument response functions to assure the long-term stability of the on-orbit calibration.
 - ▶ Implementation of a crosstalk mitigation program using lunar data.
 - ▶ Implementation of an RVS monitoring program on an operational basis.
 - ▶ Implementation of a time-dependent calibration in the SDR code and calibration LUTs.
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- ▶ A RSB Rad Cal Plan Outline was developed.
 - ▶ Expected to be submitted to the NASA management shortly.
 - ▶ Recommended Next Step: Use the Outline to develop a full RSB Rad Cal Plan.

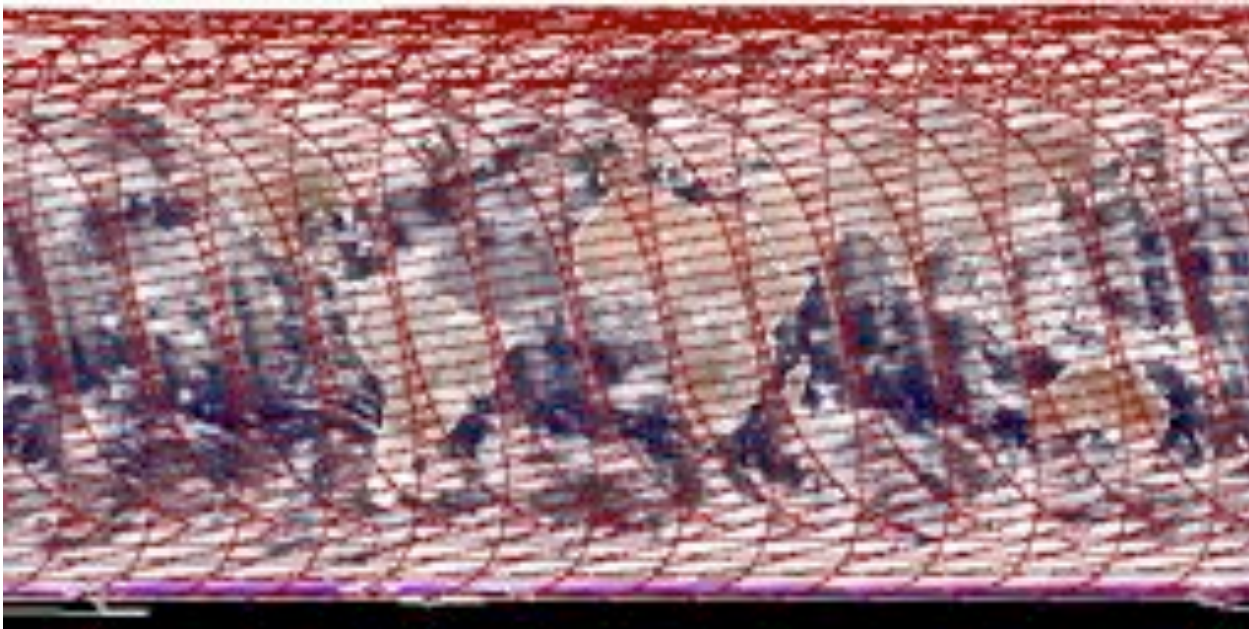


VIIRS DATA SIMULATOR



▶ **The VIIRS Data Simulator was designed to provide the ocean team with a better fidelity product for evaluating instrument effects to EDR quality. Key features:**

- ▶ Can generate global time series.
- ▶ Ability to include sensor response and artifacts.
- ▶ Helps to prepare team and infrastructure for postlaunch evaluation.



**Quasi-true color
browse image showing
global production by
the VIIRS Data Sim-
ulator for one day.**



VIIRS DATA SIMULATOR



► Based on MODIS Aqua L3:

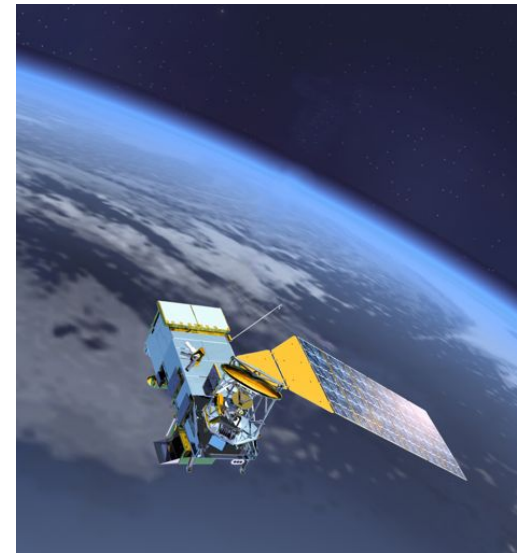
- L3 provides global surface fields.
- VIIRS viewing geometry, w/ aggregation and bow-tie deletion.
- 12gen atmospheric RT modeling provides TOA radiances.
- VIIRS response and artifacts applied (see below).
- Includes clouds and land radiances as well as ocean.
- NASA algorithms used to produce “L2” VIIRS products.

► Sensor artifacts currently included:

- Spectral effects of optical crosstalk.
- Spectral/spatial effects of electronic crosstalk.
- VIIRS RSR, w/ OOB.
- VIIRS polarization response.
- VIIRS RVS.

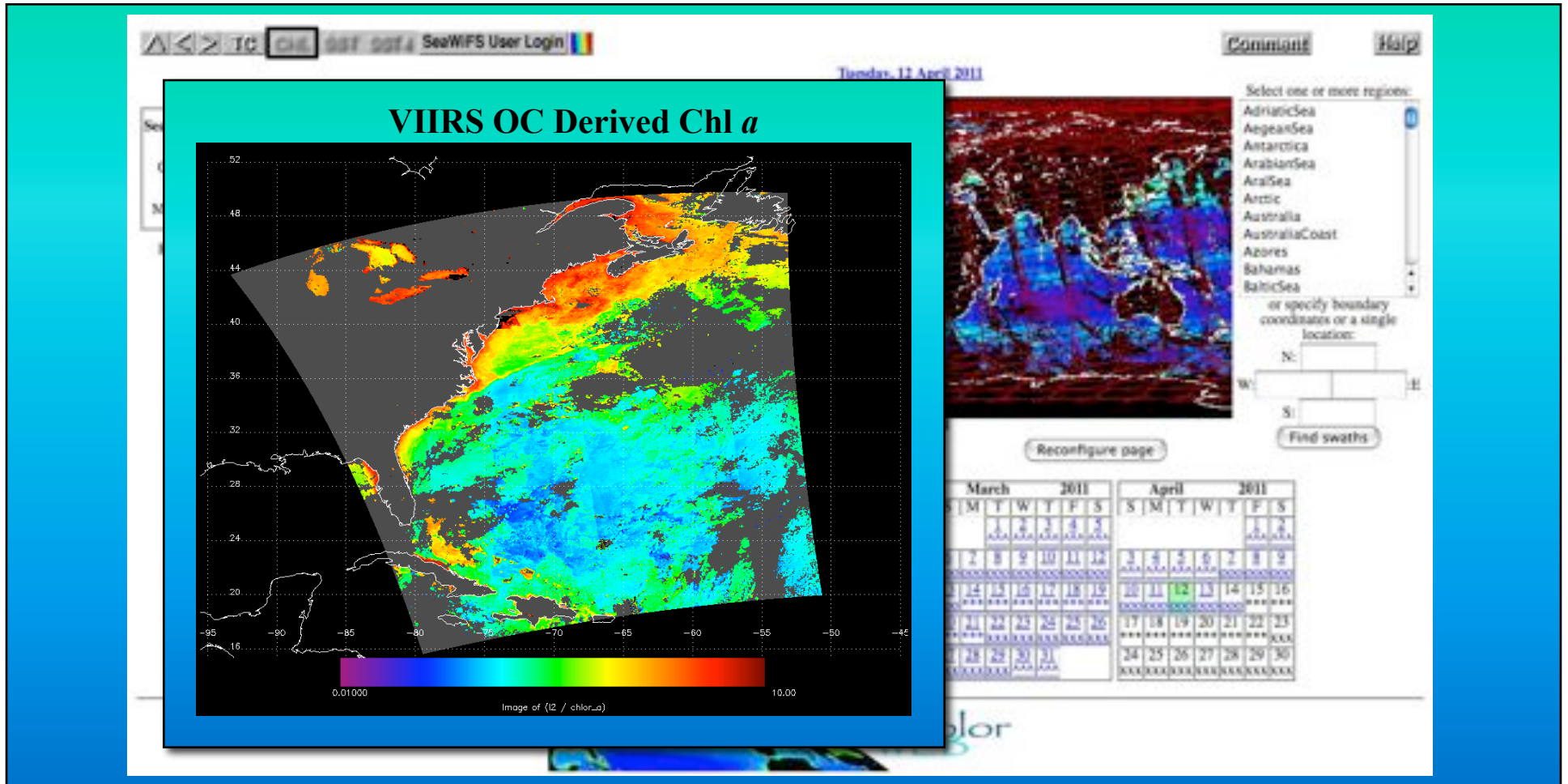
► Artifacts to be included shortly:

- Noise (VIIRS SNR)
- Stray light (NFR)





VIIRS DATA SIMULATOR



- ▶ L1, L2, & L3 simulated data will be available to science team members via restricted access to the oceancolor website. (L3 pending testing)
- ▶ Not operational yet, pending discussion with NPP Science Team members.



CONCLUSION



- ▶ Operational EDR product quality was assessed:
 - ▶ **No reprocessing or inconsistent algorithms imply that: Operational EDR products \neq NASA Climate Record.**
 - ▶ Programmatic issues affecting Cal/Val still exist at L-5mo.
 - ▶ Instrument performance is no longer considered the most significant risk.
 - ▶ Key performance concerns are OOB & XTalk.

- ▶ Operational RSB Calibration and Algorithm was assessed:
 - ▶ Plan is not sufficient to meet NASA science objectives.
 - ▶ An outline for a RSB Rad Cal Plan was drafted.
 - ▶ **Completion and implementation of this plan is strongly recommended.**



CONCLUSION



- ▶ The VIIRS Data Simulator is complete.
 - ▶ Provides the fidelity needed to include instrument effects.
 - ▶ Can produce global time series to observe impact of artifacts on climate research.
 - ▶ Additional sensor artifacts can and will be added (e.g., noise & stray light).

- ▶ VOST assessment continues:
 - ▶ Instrument performance impact assessment based on simulator results and prelaunch characterization data.
 - ▶ Solar and lunar calibration assessment on-orbit.
 - ▶ OC EDR data product evaluation will begin after launch.



THANK YOU!



THE WORK AHEAD- Details



Sensor Characteristics Assessment Deliverables

- ▶ Review crosstalk characterization uncertainty using NIST Data.
- ▼ Reports:
 - ▶ Spectral response determination.
 - ▶ Crosstalk determination.
 - ▶ Crosstalk correction performance based on prelaunch simulation.
- ▶ Crosstalk correction algorithm and code.
- ▶ On-orbit performance assessment report.



THE WORK AHEAD- Details



Cal/Val Assessment Deliverables

- ▶ Complete VIIRS data simulation with module to effect instrument artifacts.*
- ▶ Assessment reports on :
 - ▶ solar calibration. ◆
 - ▶ lunar calibration. ◆
 - ▶ vicarious calibration.
- ▶ Report on simulation study on reprocessing vicarious calibration discontinuity.

* Simulator is complete.

◆ Prelaunch assessment was covered in the NASA NPP VIIRS RSB Calibration Plan Outline and SDR Code Review and Recommendations.



THE WORK AHEAD- Details



Operational Product & Algorithm Assessment Deliverables

- ▶ Standard NASA algorithms to process VIIRS data into:
 - ▶ Operational EDR products (nLw, Chl a, a, b) - requires algorithm tuning.
 - ▶ NASA CDR products not included in operation EDR products (i.e., Rrs).
- ▶ Standard NASA algorithm alternatives to IOP (a & b) and Chl a.
- ▶ One Year Assessment of VIIRS EDR performance including:
 - ▶ Differences between VIIRS products generated with standard NASA algorithms and operational EDR products.
 - ▶ Consistency check with CDR products from other missions.
 - ▶ Self-Consistency check.
 - ▶ Automated match-up with NOMAD to compare performance.