Visible Infrared Imaging Radiometer Suite (VIIRS)

Update

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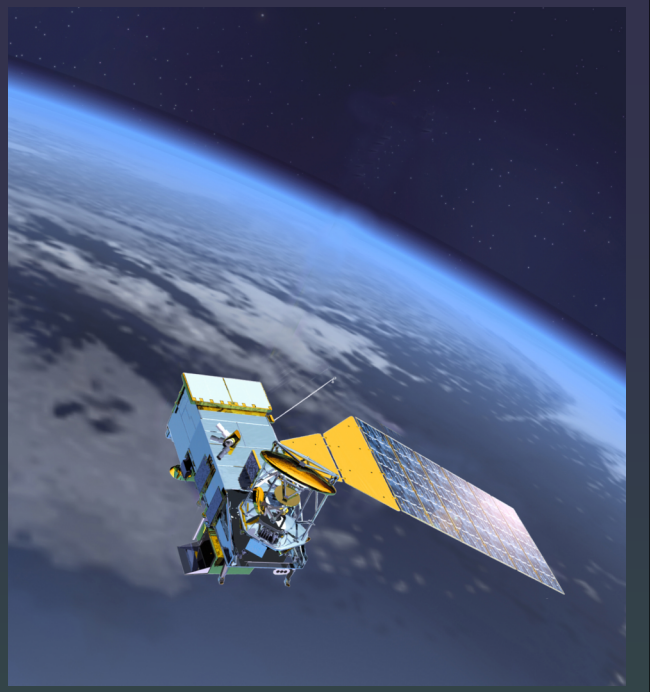
NASA Ocean Color Research Team Meeting
11 May 2010 - New Orleans, LA

VIIRS OVERVIEW

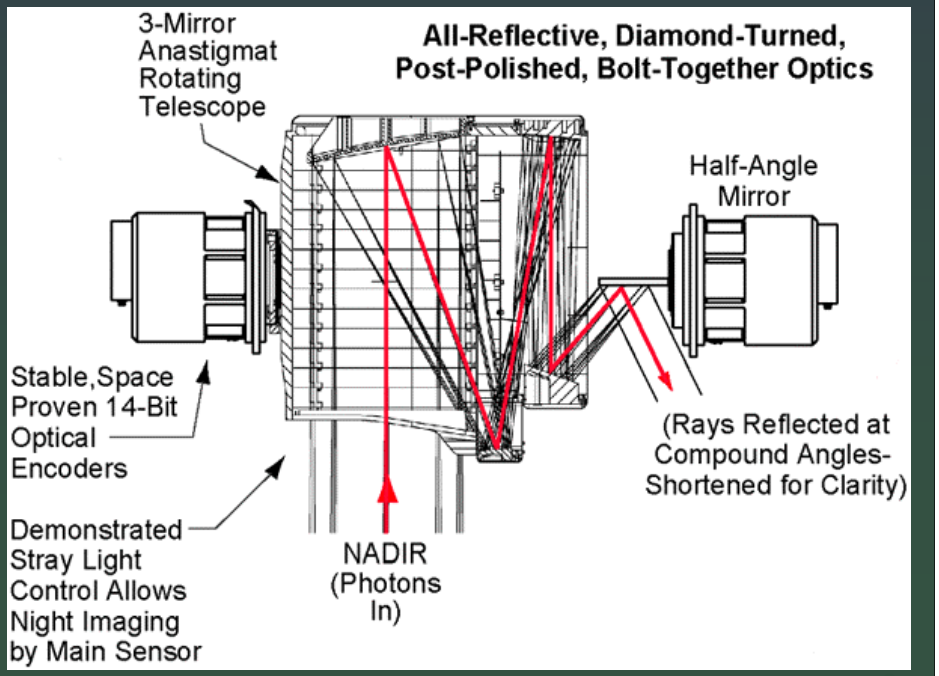


PURPOSE: Global operational observations of land, ocean, & atmosphere parameters.

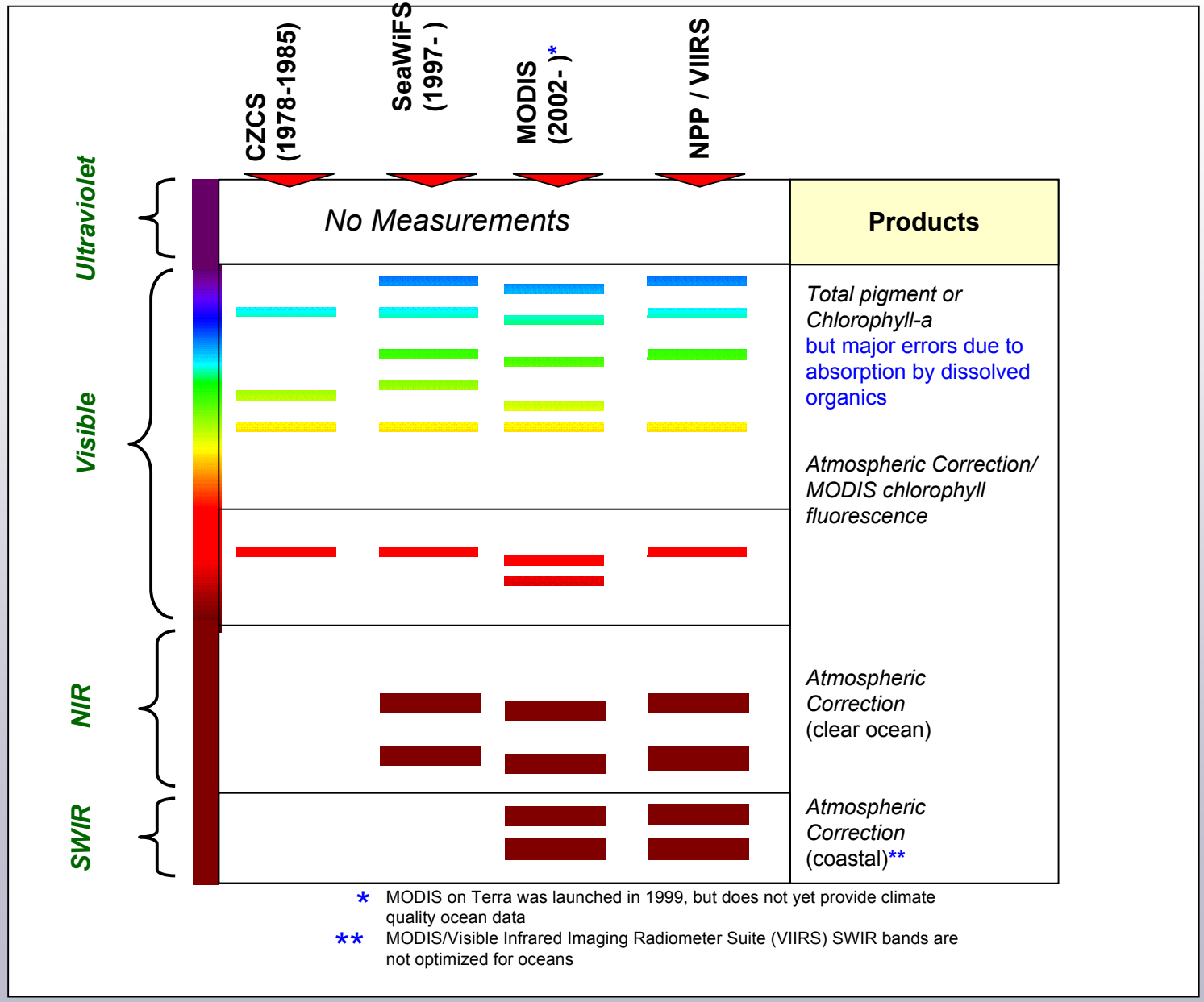
PREDECESSORS: AVHRR, OLS, MODIS, SeaWiFS

FACT SHEET

- **Multi-spectral crosstrack scanning instrument**
- **Flies on every NPOESS satellite, NPP**
- **23 of 55 EDRs – land, ocean, atmosphere**
- **3 of 6 Key Performance Parameters**
  - Imagery, Sea Surface Temperature, Soil Moisture
- **Imagery and radiometry**
  - "Fine" (imaging) 0.4 km resolution (nadir)
  - "Moderate" (radiometry) 0.8 km resolution
  - 12 bit quantization
- **22 spectral bands (0.4 – 12.5 µm)**
  - 15 "reflective" VNIR-SWIR bands 0.4 – 2.3 µm
  - 3 "mixed" MWIR bands 3.5 – 4.1 µm
  - 4 "emissive" LWIR bands 8.4 – 12.5 µm
  - Automatic dual VNIR & triple DNB gains
- **EDR-dependent swath widths**
  - 1700, 2000, and 3000 km



VIIRS BAND SELECTION



* MODIS on Terra was launched in 1999, but does not yet provide climate quality ocean data

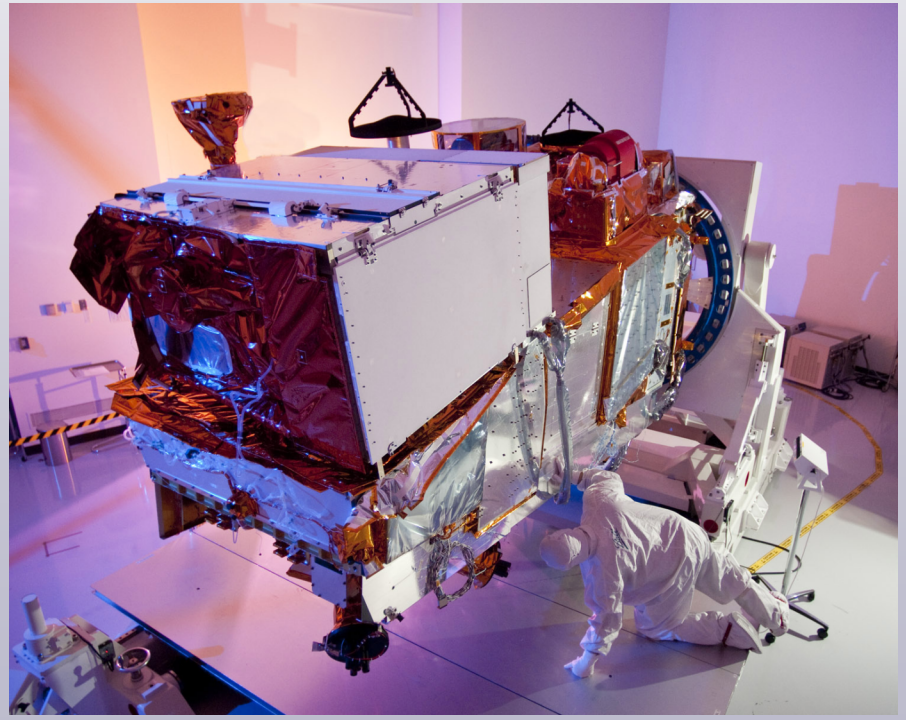
** MODIS/Visible Infrared Imaging Radiometer Suite (VIIRS) SWIR bands are not optimized for oceans

INSTRUMENT STATUS

- VIIRS has been integrated to the spacecraft.
- Flight Unit #1 Completed Ambient, Vibration, EMI/EMC and Thermal/Vacuum characterization, and calibration and on spacecraft with NIST T-SIRCUS.
- Spacecraft-Level Testing included:
  - Gain Characterization
  - Spectral Response
  - End-to-End calibration system test
- Launch dates:

NPP ——— **Oct 2011**
JPSS-1 ——— **Mar 2015***
JPSS-2 ——— **May 2018***

*** - Dates still awaiting formal approval from funding agencies.**



MAJOR CONCERNS

MISSION-LEVEL REPROCESSING

- This is a critical minimum requirement for a quality data record.
- NOAA suggests reprocessing at NCDC or proposed Climate Office.
- However, currently no definitive pathway for reprocessing to occur.

OPERATIONAL ALGORITHMS

- Consistent algorithms required for continuity of historical data record.
- Operational algorithms currently lack most of the last decade of development and validation of the standard NASA algorithms.
- Northrop Grumman suggested limited improvements to atmospheric correction postlaunch; has already inserted OC3M (no well-defined plan yet for how to execute or for tuning to VIIRS bands).
- Pathway to get standard NASA algorithms, new algorithms, or improvements into operational stream has too many decision gateways.

NASA Ocean Color Data Product Development*

1. **NIR correction**
2. **Improved aerosol models**
   - RH-based aerosol selection scheme
   - 80 AeroNET-based aerosol models
3. **Trace gas absorption**
   - NO2 corrections, all sensors
   - updated source spectra for ozone cross-section
4. **Band pass corrections**
   - Lw band-pass correction based on latest Morel bio-optical model
5. **Updated Rayleigh tables, pressure corrections, source spectra**
6. **Revised whitecap algorithm**
7. **BRDF corrections**
   - including upwelling/downwelling reflection/refraction + f/Q.
8. **Tuned Chl-a Algorithm**
   - OC3 or OC4 tuned to NOMAD V2
9. **New K490 algorithm**
   - tuned to NOMAD V2

Calibration Technology

1. Vicarious calibration methodology.
2. Lunar Calibration techniques.
3. Re-characterization.
4. Cross-sensor calibration.

*** - no timely path to inject into NPP/JPSS operational processing.**

MAJOR CONCERNS

CALIBRATION MANUEVERS

Status:

- All maneuvers are still under review by NASA project management.
- VOST is supporting modeling and development for lunar maneuver.

Issue:

- Control of maneuvers decision eventually handed over to operational JPSS management (?); no guarantee that repeated maneuvers will continue at necessary frequency after hand off.

INSTRUMENT PERFORMANCE

- Overall performance is comparable to heritage; but some issues remain.
- Calibrator remains insufficiently tested, and could have problems on orbit.
- Definitive test showed less crosstalk, but more out-of-band (OOB) light leaks.
- OOB likely correctable; crosstalk maybe correctable; characterization uncertainty TBD.

SENSOR PERFORMANCE ASSESSMENT

- Latest characterization data did not reveal clear issues with performance, other than those related to the filter.

- Optical crosstalk seen in system level tests is smaller than seen in component-level tests.

- Out-of-band (OOB) light leaks are larger than seen in EDU.

- OOB spectral response for many bands comparable to worse-case for heritage.

SENSOR PERFORMANCE ASSESSMENT

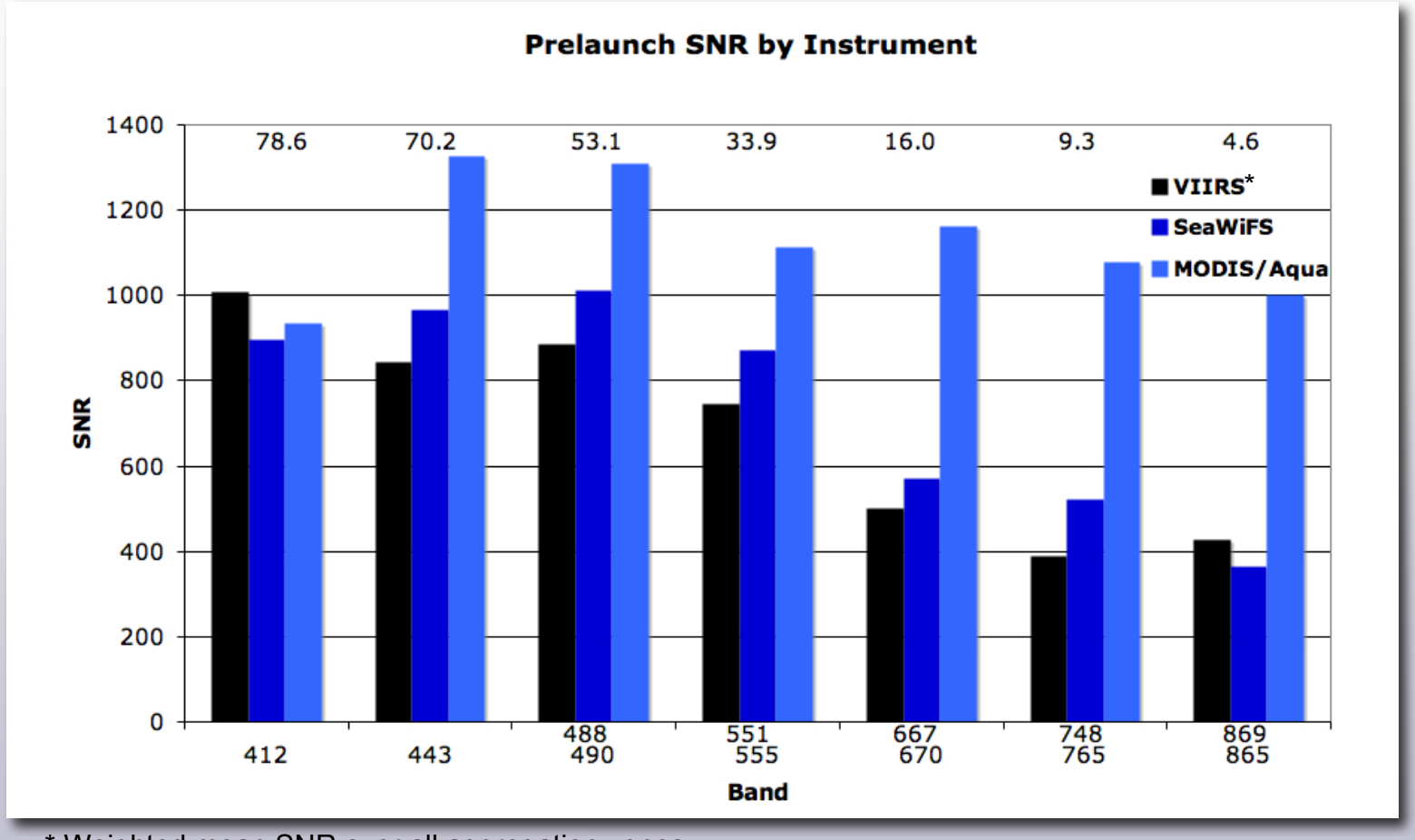
- Crosstalk produces small to moderate effect (TOA radiance biases of 0.3% at 443nm, <0.5% at 869nm, <0.2% in other bands), but…
  - **no legacy correction technique and**
  - **characterization uncertainty still needs to be quantified.**

- Correction of OOB and crosstalk effects may be limited by:
  - **characterization uncertainties (TBD).**
  - **polarization sensitivity.**
  - **electronic crosstalk.**
  - **detector-to-detector differences.**

SENSOR PERFORMANCE ASSESSMENT

Polarization Sensitivity		< MODIS, better characterized
Signal-to-Noise Ratio		< MODIS in visible bands, best in 3:1 agg zone, comparable to SeaWiFS.
Noise		Systematic noise spikes, esp. blue bands (M1-3), ~3:10^{-6} freq.
Resolution		12 bits. (+1 for dual gain bands)
Dynamic Range		M1 (412nm) and M8 (1240nm) thought to switch gain lower than expected, but M1 probably due to red light leak artifact.
Linearity		Linearity < 0.15% for ocean bands. Characterization Uncertainty in spec.
Uniformity		Only the NIR (748 & 865nm) bands pass spec for gain uniformity.
Stability		Within 0.3% over one orbit for bus voltage, temperature.
Response Verses Scan		Meets requirements.
Near-field Response		Comparable to MODIS, better than SeaWiFS. M7 does not pass EOL specification.
Stray Light		Meets spec with large margin (50-100%)

Signal-to-Noise Comparisons



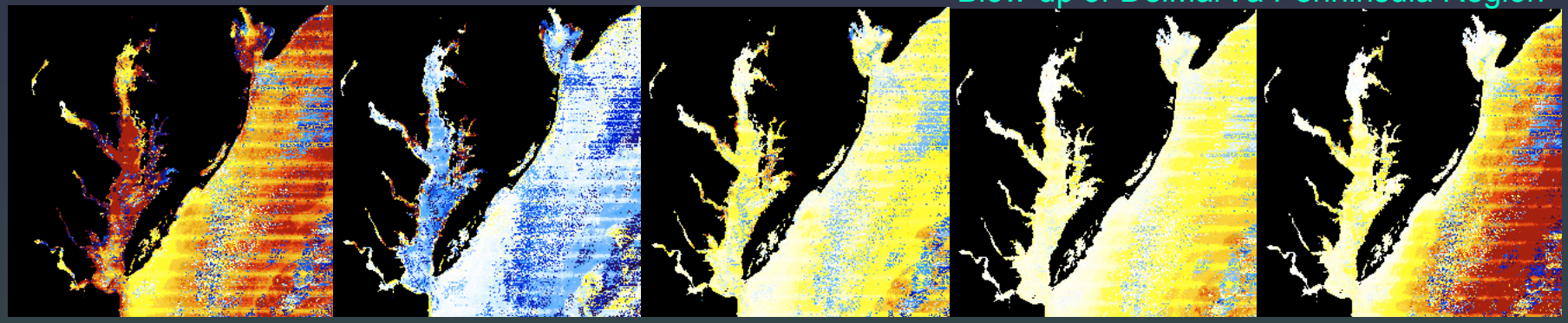
* Weighted mean SNR over all aggregation zones

NOTE: VIIRS Pixel area at nadir is half that of MODIS.
However, the above SNR reflect what are input into the algorithms.

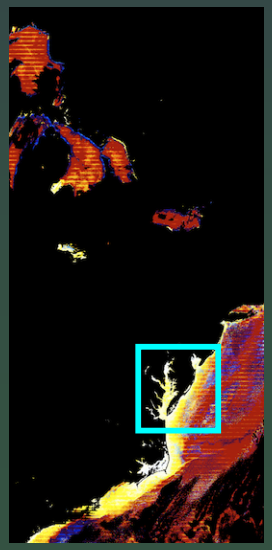
Crosstalk Impact to nLw

nLw Relative Difference

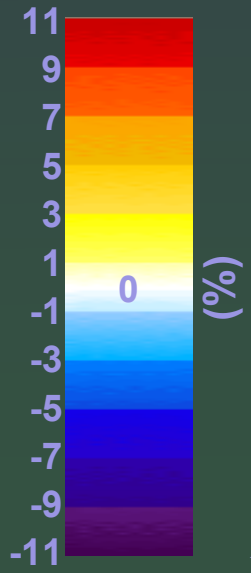
A20051071815 - East USA 17 April 2005
Blow-up of DelMarVa Penninsula Region



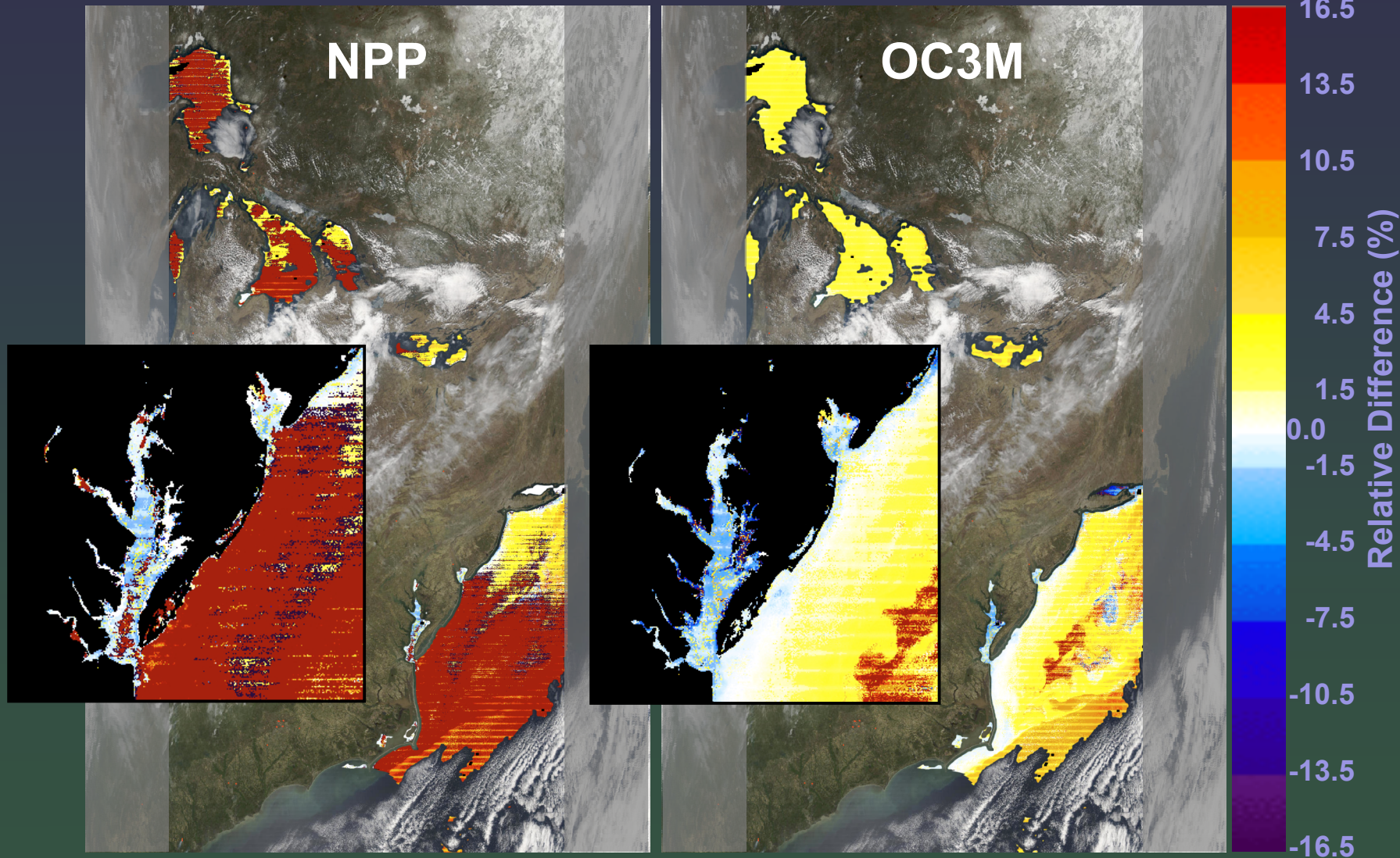
412nm 443nm 488nm 547nm 667nm



The East USA scene was specifically selected to look at particular geographic regions. The above inset shows the neritic Atlantic waters that are fed by the Chesapeake and Delaware bays. Differences in response between turbid and clearer water can be seen.

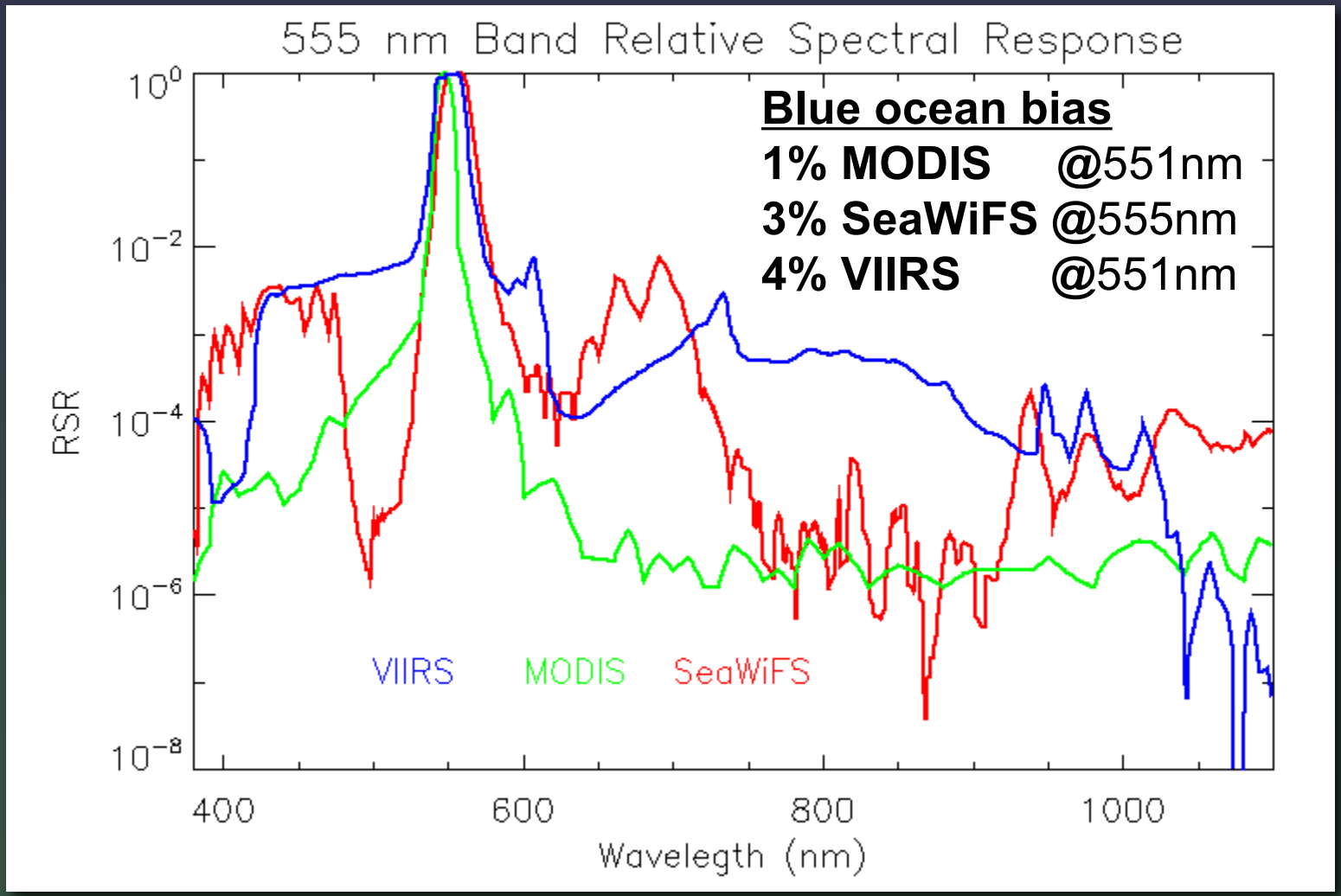


Crosstalk Impact to Chl *a*



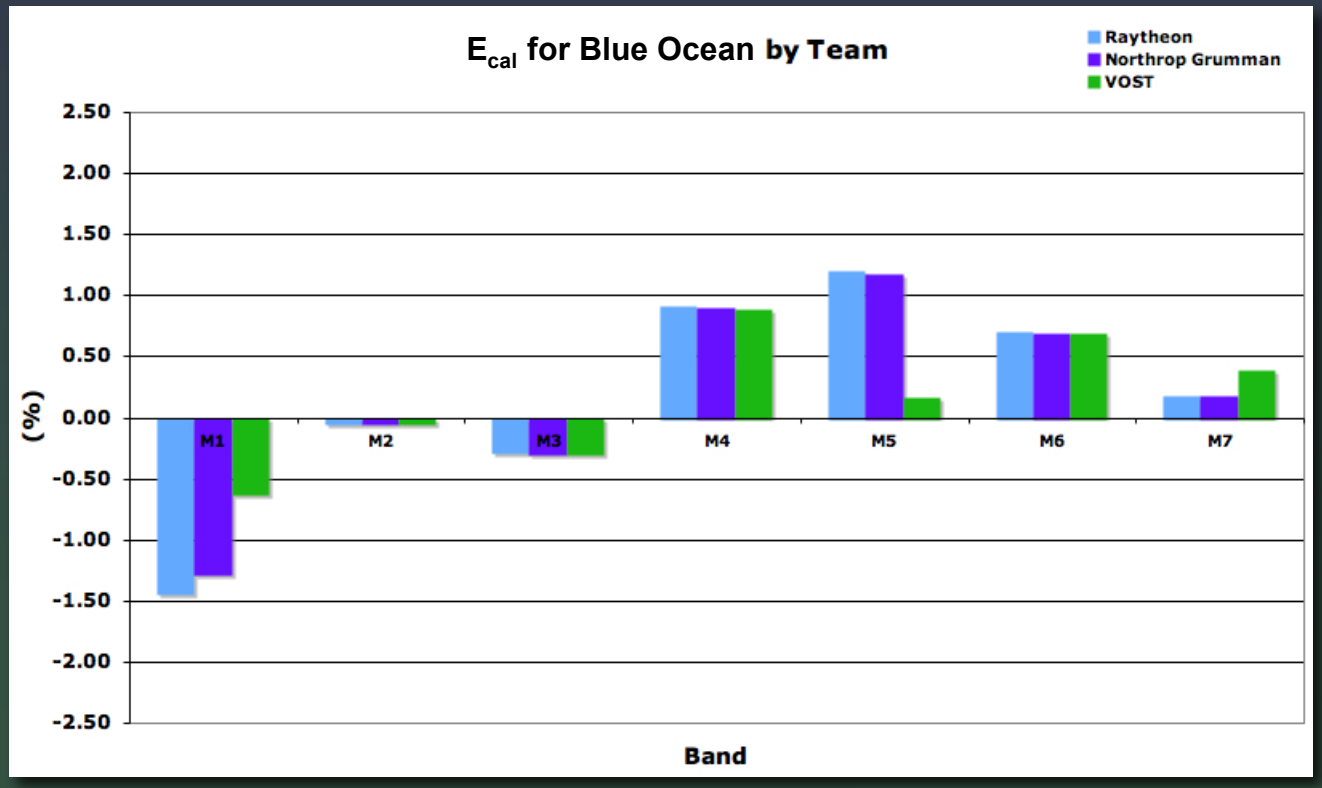
A20051071815 - East USA 17 April 2005

Comparing Sensor Out-of-Band Light Leaks



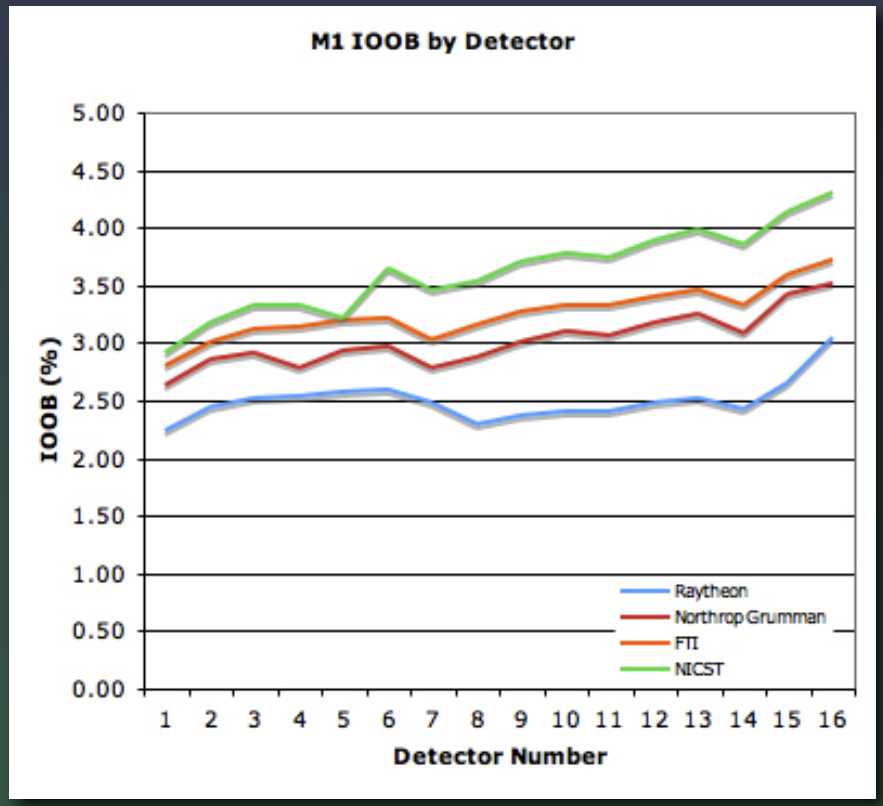
NPP VIIRS Spectral Performance

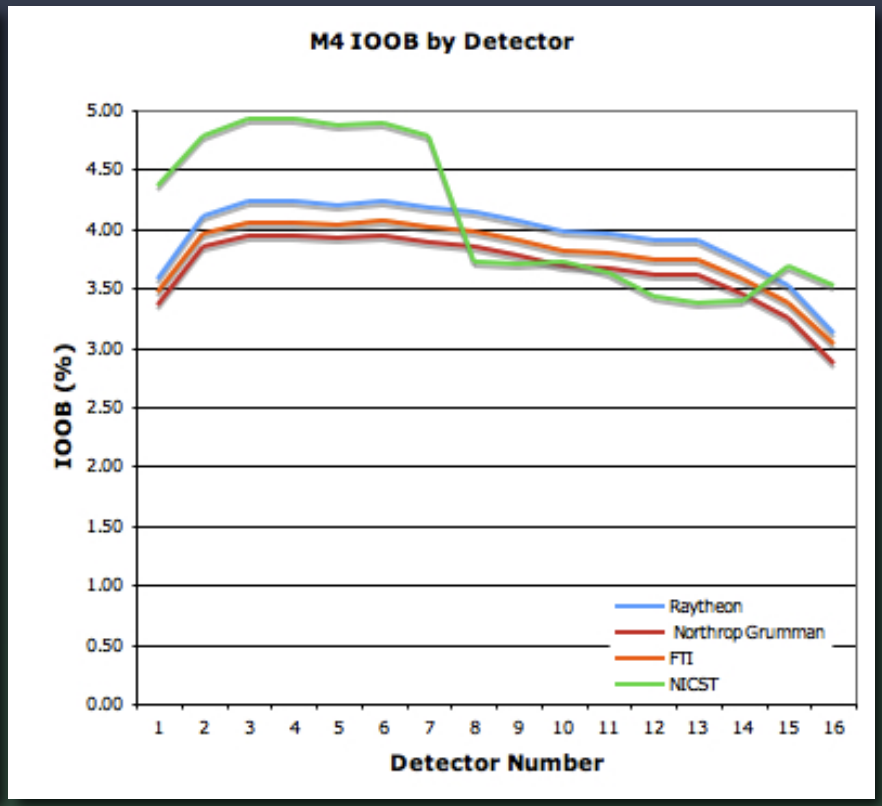
Taking the differences of the radiometric errors from the OOB response when measuring a blue ocean and the solar diffuser provide an estimate of the reflectance error.



NPP VIIRS Spectral Performance

NPP VIIRS FU1 results have yielded significant differences between detectors and between analysis teams.





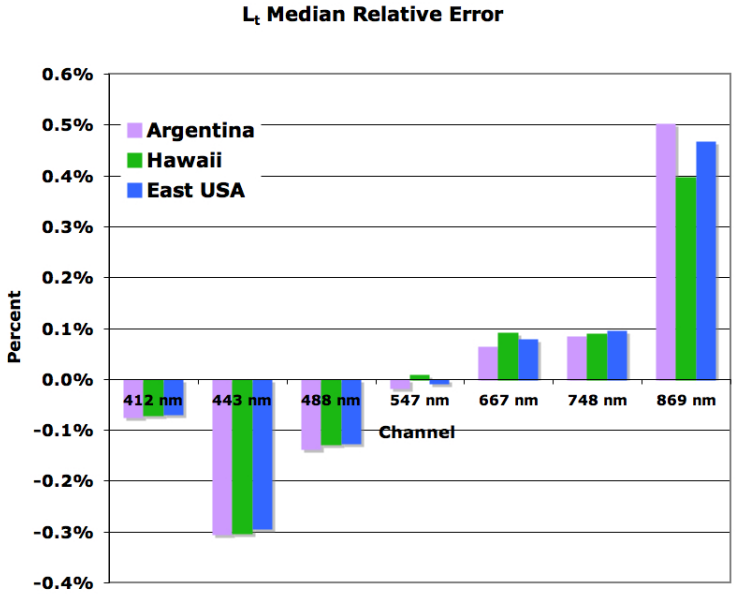
SUMMARY

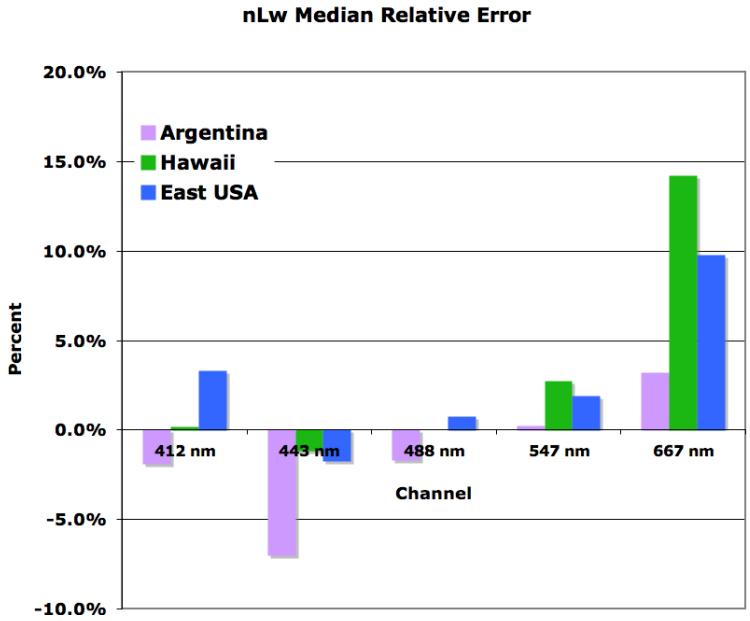
VIIRS simply cannot produce science or climate quality ocean color data without reprocessing, and consistent algorithms will be required to achieve continuity with the historical record.

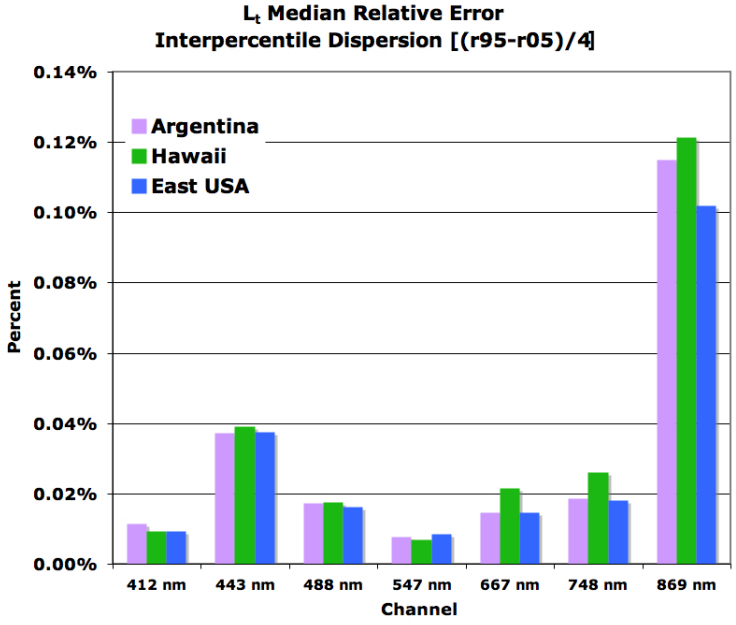
- Mission-level reprocessing is currently not in the scope of JPSS.
- Operational system algorithms remain substandard.
- No viable mechanism apparent for leveraging off current NASA capabilities in NOAA operational system.
- Calibration maneuvers are still being reviewed at NASA; but sustaining maneuvers could fall under operational management.
- Latest characterization data did not reveal clear issues with sensor barring concerns related to the filter and calibration system risks.
- Crosstalk appears smaller in flight unit, but remains a concern.
- VIIRS OOB spectral response is much larger than EDU; 551nm blue leak may impact chlorophyll algorithm.
- Spectral/xtalk characterization uncertainty still being pinned down.

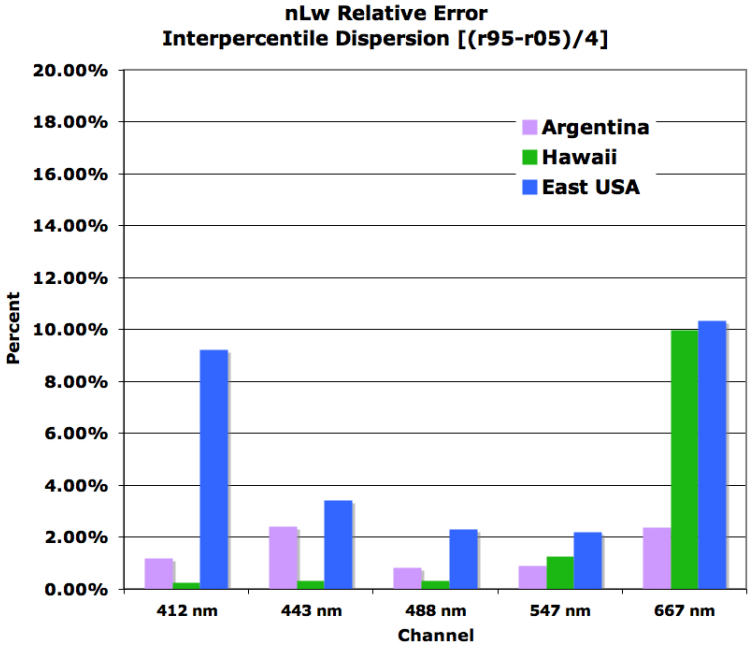
BACKUP SLIDES

Region Bias and Variation Summary Stats

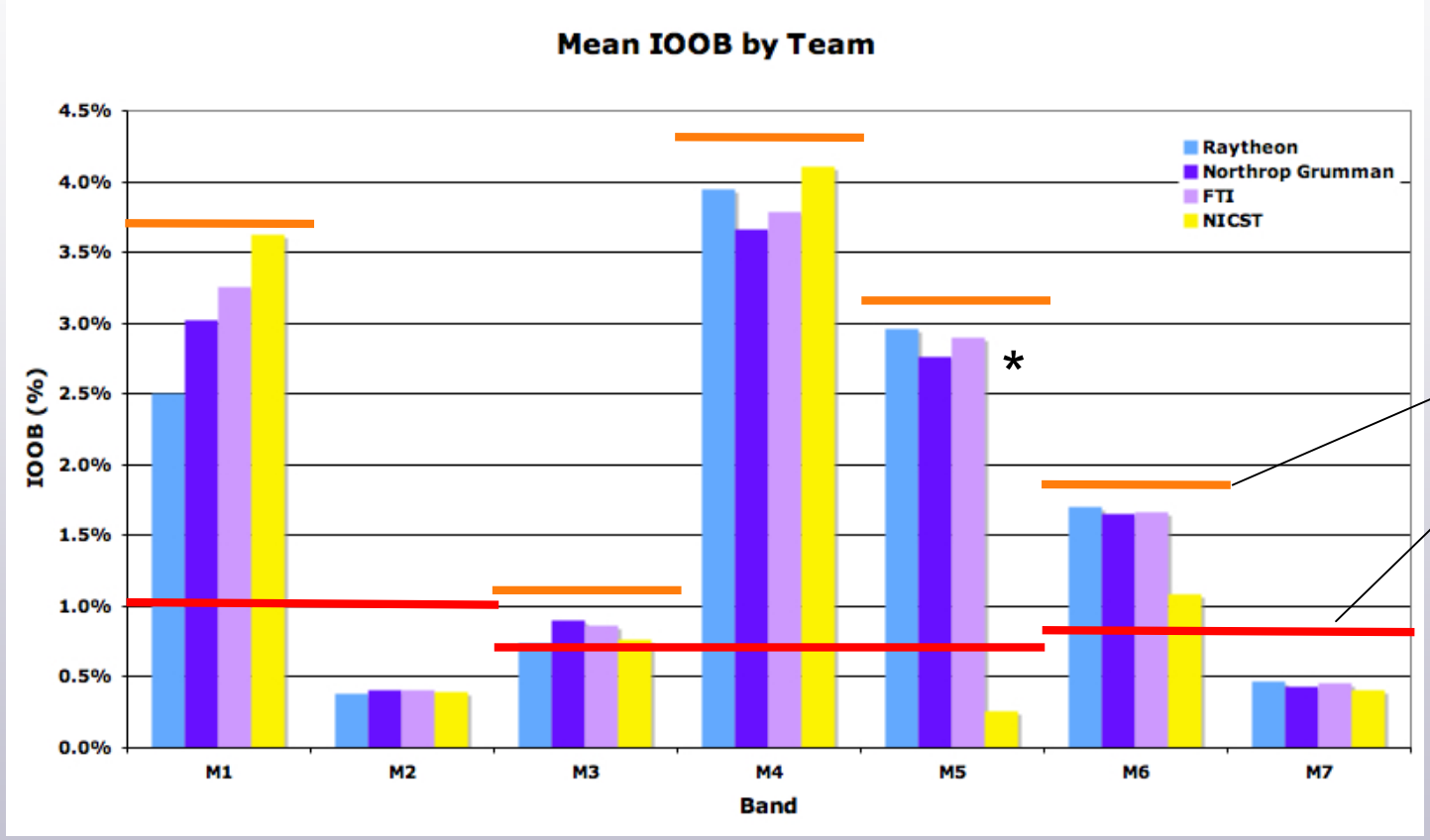






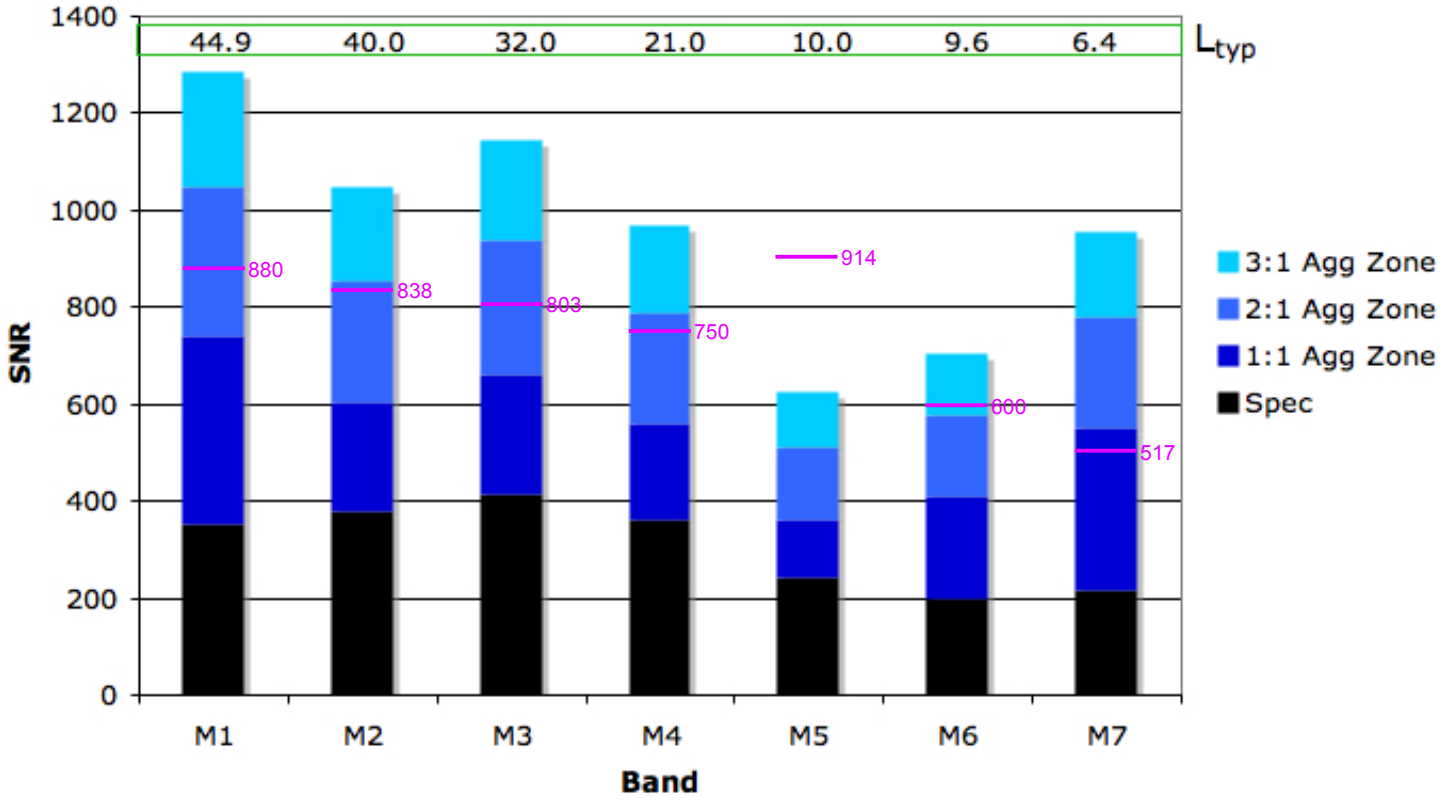


VIIRS Out-of-Band Response

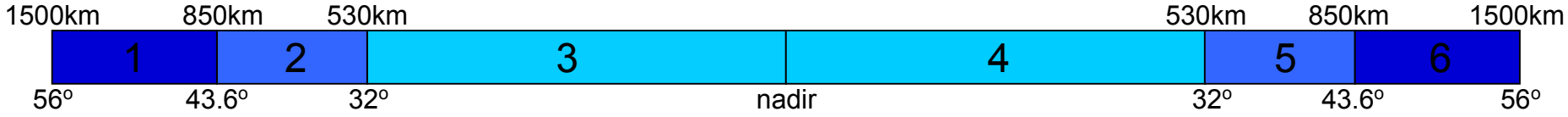


* NICST now predicts a value comparable to the other teams for M5.

SNR@L_{typ} by Aggregation Zone



Scan Aggregation Zones



Dual-gain Bands - samples aggregated on ground.
Singe-gain Bands - samples aggregated on-board (only M6 for ocean bands).

source: MDFCB, 4 Nov 2004