“Ocean EDR Product Calibration and Validation Plan
For the VIIRS Sensor for Ocean products”

Developed by the Government Ocean Team representing
(NOAA, NAVY. NASA, University )

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1) Develop an integrated cross-agency Cal/Val plan for the ocean “EDR” products that is based on present infrastructure and architectures used for heritage satellite sensors. (operational at NASA, NOAA, NAVY)

2) Ensure consistency of Ocean EDR products with heritage satellite products (from e.g. SeaWiFS, MODIS, MERIS and AVHRR) through extensive cross-evaluation and inter-comparison.

3) Construct a readiness program beginning with MODIS and MetOp-AVHRR FRAC (1km global) as a pathfinder to ocean calibration and validation for Ocean EDRs for NPP VIIRS and extending to VIIRS on NPOESS C1 and C2.

Environmental Data Records (EDRs) – Rrs, SST, Chl, IOPs…
EDRs are calculated from Sensor Data Records (SDRs) which are the calibrated and geolocated at sensor radiances. Navy, NOAA, NASA and NGST will all produce EDRs which need to be compared and evaluated.
Time schedules in preparation for NPP:

I. Prelaunch period emphasis on heritage instruments AVHRR, SeaWiFS and MODIS.
   - review, unify, evolve and document the methods and resources required for operational calibration and validation;
   - set up procedures and protocols to effectively communicate the Cal/Val results within the Team, and between the Team, IPO, NGST and the user Community;
   - set up methodology and tools to Quality Control in-situ data used in validation, satellite-derived products and associated clear-sky radiances over oceans;
   - set up a near-real time data stream to generate proxy VIIRS SDRs (by reformatting MODIS data into NPOESS HDF5 format and simulating VIIRS performance characteristics);
   - investigate the potential for at least two targeted prototype campaigns to evaluate the credibility of operational NPOESS validation strategies.
II. Intensive Cal/Val program immediately post launch

- acquire VIIRS SDRs, generate Navy, NASA and NOAA heritage ocean products and process them through the heritage Calibration and Validation algorithms.
- conduct targeted validation campaigns and demonstrate methods and use of operational field data sets.
- conduct a rigorous inter-comparison and cross-evaluation of the SDR-derived government products, and the NGST standard products (SST, Rrs and chl.)
  - Evaluate Government VIIRS ocean products (NASA, NOAA, NAVY) against NGST products.
  - Evaluate Government, University and NGST products against heritage products.
  - Evaluate products against in-situ observations.
III. Define a long term Cal/Val monitoring system

- add new data streams (SDRs and government derived products, and associated clear-sky radiances over oceans) to the existing long-term monitoring data bases.
- increasingly rely on operational in situ monitoring sites such as, buoys for SST comparisons, MOBY or follow-on for ocean color radiances, coastal sites and AERONET Ocean Sites with SeaPRISM and others with reliable validated in-situ ocean data.
- analyze long-term performance of NPOESS products relative to the heritage products.
Ocean product “Calibration – Validation”

“The Plan” and “The Execution”

• 6 investment areas

1. Define a VIIRS Proxy Data Stream
2. Define the required in situ data stream for Cal/Val
3. Tuning of algorithms and LUTS (Vicarious calibration and SDR feedback)
4. Ocean Algorithm, stability evaluation and uncertainty
5. Product validation and product long-term stability
6. Satellite inter-comparisons, robustness, seasonal and product stability

Not in order or priority
## Table 1: Tasking linked to the Major Ocean Cal Val Components

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<tbody>
<tr>
<td><strong>Proxy VIIRS Data Stream</strong></td>
<td>Software versions - MODIS to VIIRS Proxy</td>
<td><strong>&quot;Insitu&quot; data collection</strong></td>
<td>Vicarious Calibration and LUT tuning</td>
<td>Algorithm Performance</td>
<td>Product Validation</td>
<td>Inter-satellite calibration</td>
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<td>6.</td>
<td>11. Instrument upgrades and NIST traceability</td>
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<td>Thrust Areas</td>
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Current Efforts

- Cross thread the agency contributions with the investments
- Identify the Gaps and responsibilities.
- Coordinate across disciplines
- Identify international efforts
1. **VIIRS Proxy Data Stream**

1. Establish a proxy data stream using MODIS (RTPE) data. Address the sensor issues and data format issues to prepare the govn’t and community for VIIRS data.

2. Include realistic estimates of errors and sensor uncertainties based on laboratory calibrations data to determine SDR uncertainty prior to launch.

3. Establish spiral development of software updates to the Proxy data stream
   1. Coordinated with the IPOs GRAVITE for software distribution

4. Provide proxy software and data stream in real time for operational and research evaluation.

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**Diagram:**

- Define a VIIRS Proxy Data Stream
- Define the required in situ data stream for Cal/Val
- Ocean Algorithm, stability evaluation and uncertainty
- Product validation and product long-term stability
- Satellite inter-comparisons, robustness, seasonal and product stability
- Not in order or priority
What being executed..

1) (cont.) Proxy Data Stream  FY09-10

1) V 1.0 In place -- Role of GRAVITE data Format → NRPE NRTPE (NASA) (Global) → Data stream → -- Joe Zajic,
2) VIIRS – Ocean color
   - HDF5 format into Navy APS → Lyon, Martinolich
   - Hyperspectral Convolution with VIIRS / MODIS
     - P. Lee, P. Lyon, M. Wang, C. Davis
3) VIIRS – SST
   - D. May, Cayolga, B. Evan, P. Minnett,
   - Ignatov, B. Emery
4) Integration with Updates from VIIRS sensor specs –
   - Cross – Talk, Spectral, Polarization etc.
   - Continued development of Proxy data stream as we gain more information about the specific characteristics of VIIRS data.

A Real-time Data Stream being developed ---
To Prepare for VIIRS – Data Stream – Assess the Algorithms
**Ocean Color – Proxy Data Stream**

**Level 1- MODIS**
- Top of Atm Radiance
- MODIS channels

**Level 2- MODIS**
- Derive Water Properties (IOP)
  - At 6 \( \lambda \) s

Expand IOP at MODIS \( \lambda, \rho_w \)
To Continuous Spectrum

**Top of Atm Radiance VIIRS**
\( \text{Lt}(v) \)

\[ \text{Lt}(v) = \text{Lw}(v) + \text{La}(v) + \text{Lr}(v) \]

Expand Continuous Spectrum
To Top of Atmosphere

Convolve the VIIRS spectral response with 3 HSI components.

- Expand MODIS to Hyperspectral Rayleigh Spectrum
- Expand MODIS to Hyperspectral Aerosol Spectrum
- MODIS – hyperspectral Continuous Water Spectrum

**Note:** \( \rho = \) reflectance

White Paper in draft
Looking for Contributions
Team forming
2. *In-situ* data stream for cal val

Addresses “2 types” of insitu data - one for vicarious calibration (e.g. MOBY) and a second for product validation.

1. Define where and what in-situ data is required and how it is integrated into the “end-to-end” product cycle.
2. Define the critical validation site locations and ocean extremes required for validation.
3. Define the spatial and temporal uncertainty of the observations and the measurement protocols for both calibration and validation.
4. Determine protocols and the NIST traceability which are required for each insitu data set.
5. Identify the data base manager for these insitu data.

Insitu Cruise measurements
SST Buoy and Skin
Ocean Color – Radiance, IOP, Chl.
2. (cont.) Insitu Data Collection

1) SST match up using data from Buoys – 10000/ 2 weeks (May)
2) Moby – Ondrusek et al. (Real time Web access)
3) A-MERI (surface skin temperature) Cruises – Minnett/ Evans –
   1) Must correct for Skin vs. Bulk relationships
   2) International – UK, Web sites (Minnett, May, Robinson)
4) AUV- SST – Emery
5) Aeronet/ SeaPRISM Goal → Real-time Web Availability)
   1) CUNY – New York (Ahmed)
   2) Gulf of Mexico (Lyon, Vaughn, Scarborough, Ladner, Martinolich)
   3) West Coast (Davis, Jones)
   4) East Coast – MVCO, Ch. Bay (Hou, Hooker)
   5) International (Zibordi et al.,) (Paper on the Software and protocols)
   6) Australia (Decker)
6) Ship Cruises –
   1) Insitu match up data sets
      1) West Coast – Time Series Davis, Letelier
      2) Navy / NURC Cruises Lyon, Gould, Trees.
      3) NOAA Cruises (Chesapeake Bay) Ondrusek, Stumpf
6) Data management tools (Fargron / NASA -- SeaBASS)
7) International IOCCG (Davis, Lee DiGiacomo, Fargron, Trees)
8) Sampling Strategy / Uncertainty (Trees/ Alvarez)
3) Tuning of algorithms and LUTS (Vicarious Calibration and SDR feedback)

1. Integrate the tuning of the Look up Tables that are introduced at the SDR level with ocean observations for both ocean color and SST.
2. Define the timeliness and update cycle by defining the temporal uncertainty and stability of the sensor and the algorithms.
3. Develop capability to perform rapid matchups of satellite and ocean parameters to optimize the ocean products.
4. Automate the vicarious calibration procedures and integrate within the SDR-EDR levels.
5. Define vicarious calibration strategy for initialization (address immediate post-launch) and for long term.
6. Address multiple approaches for initial vicarious calibration. Address the needs for short-time scales. (Climatology, satellite matchup and in situ.)
3. (cont.) Vicarious Calibration / Tuning LUT
FY09 – FY 10

1) Automate – Ocean Color Vicarious methods
   on Different data sets (Aeronet, Ship, MOBY)
   1) Lyon, Vaughn, Navy → NAVO (transition) Inversion of L2Gen
   2) Wang / Ondrusek - NOAA - “New Methods”
   3) NASA (Werdell, Bailey, Franz)
2) Rayleigh Look up Tables (Wang)
3) SST --- Skin/bulk relationships -- Tuning Minnett/ Evans
4) Radiative transfer simulations - Ignatov → Web sites → NOAA
5) GRIST – Minnett ., May International - Web sites)
6) Integration of Vicarious Calibration within GRAVITE and IDPS … Zijac, Guenther
4) Ocean Algorithm, stability evaluation and uncertainty

1. Evaluate aspects of algorithm performance with VIIRS proxy data and follow-on sensor data. (e.g. the atmospheric correction in ocean color products)

2. Examine algorithms over the full range of expected conditions and define the limitations and uncertainties associated with seasonal variations, latitudinal variations, coastal vs. open ocean, cloud / land boundary affects, varying atmospheric types (aerosols and Total Perceptible Water).

3. Examine algorithms uncertainty from variety of default inputs to the algorithms - (Determine the ensemble spread or the algorithm’s uncertainty maps.)

4) Algorithm Evaluation - FY 09 – 10

1) VIIRS proxy data / MODIS / MERIS data - “Proxy Data Stream”
   1) NRL – Stennis (Lyon, Vaughn, Arnone, Gould, Ladner)
   2) West Coast (Davis, Letelier)
   3) Coastal Areas – Stumpf

2) NIR/VIIRS Atmospheric Correction
   1) Wang – NIR/ SWIR – VIIRS / MODIS algorithms
   2) Gao - MODIS/VIIRS

3) SST
   1) SST – regional studies – VIIRS / MODIS/ AVHRR
      1) May, NAVY
   2) Radiative Transfer Simulations / Studies Ignotov – Web sites
   3) Regional studies – MODIS / to AVHRR to VIIRS (Evans, Minnett)
   4) Others - -
5) Product validation and product long-term stability
(initially based on VIIRS Proxy data, MODIS, METOP etc)

1. Comparisons of ocean waters observations (SST and Rrs - Color) with derived satellite products including their uncertainty.
   1. Develop procedures and protocols on match up methods for insitu and satellite products.
   2. Define the spatial and temporal uncertainty of the match-up of insitu data to the satellite retrieved geophysical parameter.
2. Determine how to evaluate ocean products in a range of environmental conditions which are defined through required data sets.
   1. Ocean product evaluation should include the atmospheric uncertainty (aerosols and TPW) and the ocean product.
   2. Define the error estimates of the products in different conditions, to include (sensor configurations, solar cycles, coastal vs. open ocean, etc.)
5. Determine how the ocean product validation is influenced by the sensor stability?
6. Time series Buoy SST monitoring and SeaPRISM RRS tracking
   1. Define Protocols for tracking validation procedures.
   2. Leverage off on MODIS/ SeaWIFS, AVHRR/ METOP
5) (cont.) Product Validation for FY 09 – 10

1) Ocean Color Validation → Match-up and uncertainty
   1) Automated match up – Ship (Trees, Davis, Lyon, Stumpf, Ondrusek)
   2) Automated matchup – Aeronet / SeaPRISM
      1) (Lyon, Ahmed, Davis, Jones, Zibordi)
      2) Web site - for near real-time Spatial / Temporal / Measurements and uncertainty analysis
   3) Coordinate with IOCCG – International efforts (DiGiacomo, Davis, Lee)

2) SST match up
   1) Buoy Bulk temperature Match up – May, Minnett
   2) Spatial uncertainty - AUV Emery
   3) Ship transects skin/bulk uncertainty – Minnett/ Evans
   4) International GHRIST (May, Minnett, Evans, Robinson)

3) Uncertainty of insitu data (SST / Color) – Almeriz/ Trees
6) Satellite Continuity –
Inter-comparisons, robustness, seasonal and product stability
“Baseline approach”
(Define the methods which VIIRS will be evaluated based on existing ocean products.)

1. Define the protocols to compare ocean satellite products from different satellites
   1. Use as a pathfinder MODIS, SeaWIFS, MERIS, METOP, …
2. Determine the spatial and temporal uncertainty of match-up differences between satellite products.
   1. Spatial variability of sensors regional differences
   2. Examine the seasonal differences

3. Demonstrate the ability for satellite ocean product continuity in near real time.
   1. Time series analyses of regional products (e.g. SST variability)
   2. Determine how to define methods to track product stability

4. Demonstrate the methods which NPP will evaluated against heritage ocean products
   1. Spatial and temporal statistical analyses
      (binning, histograms etc.)

5. Define a VIIRS Proxy Data Stream

6. Satellite inter-comparisons, robustness, seasonal and product stability
6. (cont.) Satellite Data Continuity

1) Ocean Color Continuity
   1) Protocols for SeaWiFS / MODIS / MERIS / OCM / Sentinel 2 / HICO
      1) Coastal and Regional Studies (Stumpf)
      2) VIIRS proxy / MODIS/ MERIS color products –
         1) West Coast - (Davis, Letelier, Jones)
         2) East Coast - (Wang, Ondrusek, Ahmed)
         3) Gulf of Mexico & International Areas (Arnone, Lyon, Gould)
      3) Continue using MOBY for vicarious calibration (Ondrusek)
   2) MODIS/ MERIS - Global Studies - Bailey, NASA
   3) IOCCG – GlobColour – International Coordination (Fargion)

2) SST – AVHRR / METOP / MODIS /
   1) Integrate MODIS cal val procedures into Operations – May / Minnett
   2) MODIS / AVHRR – Protocols – May / Minnett / Evans
   3) VIIRS/ MODIS – comparison / regional studies , May
   4) NOAA – Operation SST – Ignatov.
Summary

• We have begun to identify roles and responsibilities
  – “Beginning execution”
• Interagency and Integrated Program Office (IPO)/NGST efforts are being coordinated.
• Preparing in situ capability.
• Preparing way Forward through heritage Sensors.
• Looking forward to soonest possible launch of NPP.