Evaluation of VIIRS ocean color products and development of enhanced ocean products and applications

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Annual Summary

- Maintain WavCis – Aeronet Site
- Cal Val Cruises
1) Ocean Color product stability using VIIRS orbital overlaps to track monthly trends

2) VIIRS validation of Gulf Stream water masses Foster Cruise

3) Characterizing the diurnal changes in coastal bio-optical properties in coastal waters

4) Temporal Assessment of the Calibration and Accuracy of VIIRS Radiometric (SDR) and Ocean Color Products (EDR) at MOBY and WavCIS

5) Using the VIIRS I 1-band to enhance bio-optical monitoring of coastal waters

6) Applications of VIIRS ocean color for real time adaptive sampling
1) Ocean Color product stability using VIIRS orbital overlaps to track monthly trends

How do the differences in the color products within 100 minute change with season?

**Example of Open ocean waters ROI**

**Chlor_a difference mg/ m**

**VIIRS 100 minute Overlap**

Track the differences in products to test VIIRS Stability

Approach evaluates complete VIIRS sensor cal val process. “SDR cal, atm corr, Product”
1) Ocean Color product stability using VIIRS orbital overlaps to track monthly trends

VIIRS - Seasonal Overlap Difference

410 nm M1 1700-1900 Overlap

Open @410"
shelf Coastal

Changes in winter to Summer
- Solar Angle
Largest in M1 Minimal in M5
- Strongest in Open ocean water!
- Similar trend in Coastal waters

First orbit minus Second orbit.
Which orbit has higher reflectance?

Difference uw/cm²/nm Difference uw/cm²/nm

Summary:
1. Overlap nLw differences provides very sensitive ability to track the trends in both the Sensor response and processing.
   - Dependent on diurnal changes! Next ..
2. Enables internal consistency within the sensor across the orbital swath.
3. Can be applied on a global basis.
2) VIIRS validation of Gulf Stream water masses Foster Cruise

Characterized multiple instruments for Spectral radiance .. Above and in water etc.

VIIRS – Validation crossing
Dynamics Gulf Stream Fronts -
1) Shingle
2) Cape Hatteras.
3) Charleston

Upwelling - Bio-optical response.

Characterized the Spatial Variability
At each station - Station 18

Calibration - Matchup requires
Defining the VIIRS pixel variability
2) VIIRS validation of Gulf Stream water masses Foster Cruise

VIIRS Ocean color Validation Along track across front

Summary -- see poster!!

1. Unique data sets for instrument protocols
2. OC Spatial variability on Station
3. OC response to ocean processes!
4. Agreement of VIIRS and Flowthrough optics
5. New Questions to address \( \rightarrow \) accuracy of instruments vs temporal and spatial variability.
6. Bio-optical Water Mass classification -
3) Characterizing the diurnal changes in bio-optical properties in coastal waters

How fast can Ocean Color change in ~ 100 minutes?

Diurnal Variability of Chlorophyll and nLw at WavCis

VIIRS nLw validated
The diurnal changes!
Poster includes MOBY

Feb 11, 2015 - Chlorophyll
Feb 11, 2015 - nLw
Chlorophyll Dec 9, 2014
nLw Dec 9, 2014
Chlorophyll Dec 25, 2014
Dec 25 nLw
Oct 22, 2014 day 295
Chlorophyll
Oct 22, 2014 day 295
nLw
3) Characterizing the diurnal changes in bio-optical properties in coastal waters

Summary;
1. VIIRS – Overlap products was able to capture hourly changes in ocean color!!
2. Calibration and validation in coastal areas requires short time for matchup!
3. New product capability from VIIRS! See poster!

Diurnal Changes identifies new ocean processes product. Bloom occurring!

Chlorophyll Difference
Orbit 1 minus 2

Second Pass Greater
-1 (mg/m3) +1

Bloom Decay

4) Temporal Assessment of the Calibration and Accuracy of VIIRS Radiometric (SDR) and Ocean Color Products (EDR) at MOBY and WavCIS (Aeronet-OC)

**SDR (Real time) Gains Trend @ MOBY**

**Effect of SDR Calibration Change May 2014 (Delta-c) on Vicarious Calibration Gain Sets**

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**Trend (unity gains) shows:**
- NOAA real-time SDR improvement over time (not stabilized).
- Need continuous vicarious calibration for operations.

**- A pre and post delta-c (May 2014) calibration change exist.**
**- Needs further evaluation w/ more matchups highly constrained matchups.**
**- Evaluation at green water AERONET site (WavCIS) underway.**
4) Temporal Assessment of the Calibration and Accuracy of VIIRS Radiometric (SDR) and Ocean Color Products (EDR) at MOBY and WavCIS (Aeronet-OC)

MOBY and WavCIS Time Series Analysis and SDR Calibration Effect (Delta-c May 2014)

(See poster for more results including post delta-c green water analysis at WavCIS, cruise matchups, etc.)

VIIRS vs. MOBY Time Series – April 2012 – July 2015
Standard Gains (November 2014)

VIIRS agrees very well w/ MOBY

Post Delta-c (May 2014) calibration gains applied after May 2014 yields more accurate nLw’s (443x and 551- nm)

Percent change (standard vs post delta-c gains) yields up to 30% differences in chlorophyll offshore and nearshore

VIIRS Chlorophyll June 7, 2015 – Post Delta-c Calibration Effect

Standard Gains APS v5.8

Post Delta-c Gains APS v6.2 - Beta

Percent Change (PostDC– Std)/Std

-20% -12% -8% +16%

% decrease / increase in CHL
5) Using the VIIRS I 1-band to enhance bio-optical monitoring of coastal waters

New VIIRs Ocean Color Product for Coastal Applications - See Poster

Spatially improved ocean color products are obtained by combining the 750-m M(\(\lambda\)) bands with the 375-m I1-band

**Sharpened Normalized Water Leaving Radiance Spectrum**

For each pixel and \(\lambda\), the sharpening is weighted as a direct function of M(\(\lambda\)) covariance with the high resolution (I-1) band in a 5x5 subarray. Maps of “sharpening confidence” are created.

44 coastal matchups show that sharpened nLw have improved R-values, RMSE, and NMB!
5) Using the VIIRS I 1-band to enhance bio-optical monitoring of coastal waters

Gulf of Mexico, 05/14/13

**Summary**

1. New product and coastal applications for VIIRS sensor in ocean color.
2. Enhance resolutions for VIIRS ocean color can be achieved by combining the I bands with the M bands.
3. New VIIRS Coastal ocean product derived at 375m for coastal waters.
4. Spatial Covariance used to spectrally weight Band sharpening.
5. Results are confirmed in coastal waters and demonstrate improved VIIRS validation.

**Sharpened (375) nLw M bands** are linked into processing to produce high resolution Ocean Color Products.

**Validation**

New VIIRS use of I BANDS

6) Applications of VIIRS ocean color for real time adaptive sampling

Using Circulation Models and VIIRS Ocean Color to direct sampling locations in Fronts, River Plumes, and validating Ocean Models

---See Poster---

Real time Animated VIIRS Color and models to validate coastal plumes.

Enabled Glider Deployments Adaptive Sampling.

Define Model Uncertainty

Stations for Validation of VIIRS Models
6) Applications of VIIRS ocean color for real time adaptive sampling

**Management Decisions** for Near Real-time Adaptive Sampling

**STEP1:** Gather data into google Earth

- **VIIRS Ocean Data**
  - Chlorophyll-a,
  - backscattering,
  - absorption, euphotic
  - depth, sea surface temperature

- **Physical circulation models**
  - SST, currents, salinity,
  - mixed layer depth, sea
  - surface height

- **Ancillary data**
  - Real-time data from
    - buoys or moorings,
  - weather data,
  - meteorological models
    - (wind data)

**How to optimally apply VIIRS data for sampling! “Plume”**

**Plume**
- 35 m
- JPSS - Meeting

**Glider Track**

**Summary:**
1. Fusing Satellite color and SST with circulation models defines uncertainty.
2. VIIRS Color data used for Model Validation
3. Glider deployment is dependent on density Requires accurate location of Plumes!
4. Adaptive sampling used to optimize samples for VIIRS validation

**VIIRS ocean color provides a critical component in defining River Plumes ecosystems!**

**AUV Jubilee activities in Gulf**
1. VIIRS Orbital Overlaps – tracks the trends are stable
   - Validated the diurnal response – 100 minutes of VIIRS color
   - Spatial and temporal response of ocean color is required for cal/val procedures.
2. Foster Cruises validated VIIRS ocean color transects
3. VIIRS cal/val:
   - VIIRS real-time SDR improving over time @ MOBY
   - VIIRS/insitu matchups indicate high quality operational OC products.
   - Cal/val @ MOBY indicates a pre and post delta-c (May 2014) calibration change.
4. VIIRS new products:
   - Enhanced spatial resolution - I and M band Sharpening
   - Diurnal changes in Color -- Blooms and Currents
   - Tested the cal/val protocols.
5. VIIRS color Applications for Adaptive sampling and models validation
6. WavCIS Platform – maintained and updated with calibrated Seaprism Aug. 2015!

Plans:
Cruises - a) Cal Val Foster Gulf Stream, b) Gulf of Mexico Cruise – Plumes
Monitor Diurnal Changes.
Maintain - Operational WavCIS – Aeronet