2015 STAR JPSS Annual Science Team Meeting,
College Park, Maryland
August 24-28, 2015

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

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## Stennis - Cal val Team Annual Summary

- Maintain WavCis – Aeronet Site
- Cal Val Cruises



Real-time monitoring

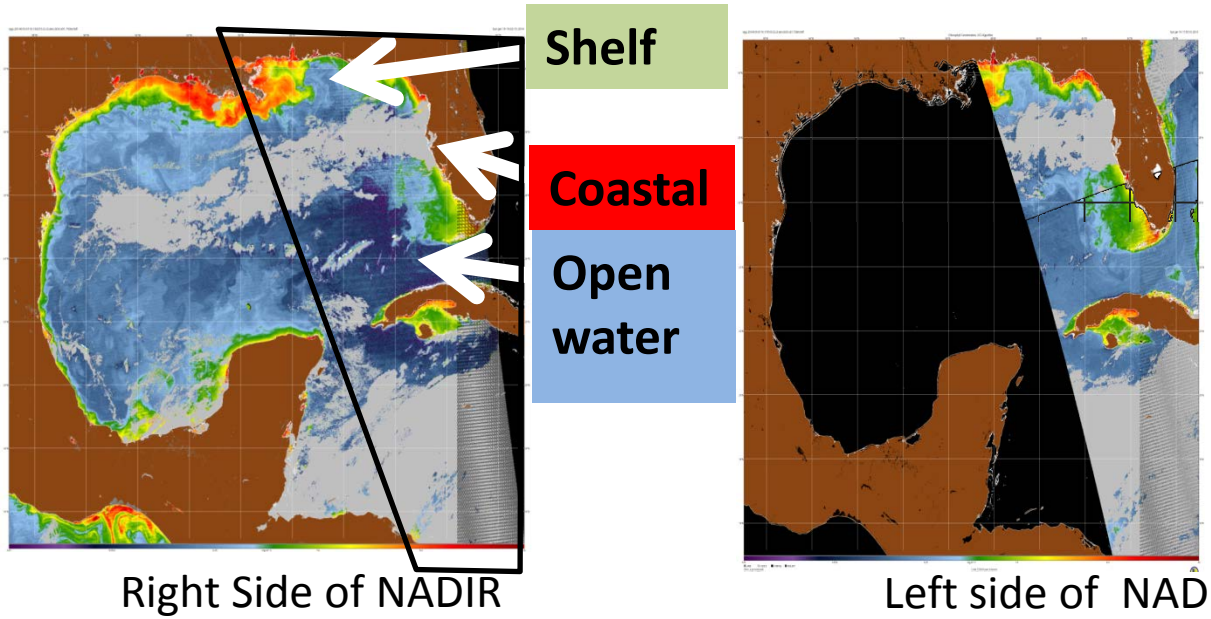
THE UNIVERSITY OF SOUTHERN MISSISSIPPI

# Overview - Annual Highlights – Details in Posters

Stennis
Cal Val Team

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




Right Side of NADIR

Left side of NADIR

## 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"

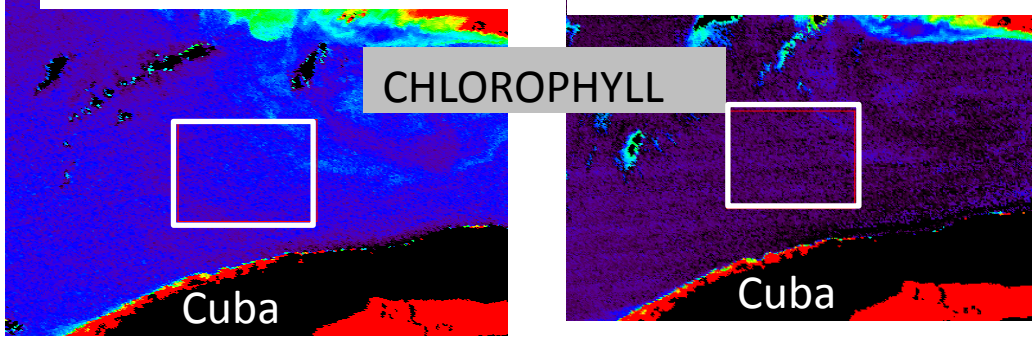
**How do the differences in the color products within 100 minute change with season?**

## Example of Open ocean waters ROI

T175147 GMT

T193215

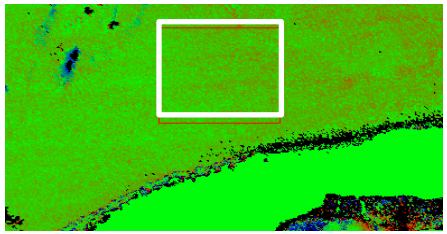
CHLOROPHYLL




Chlor_a mg/ m3

0 .07 1

Chlor_a difference mg/ m

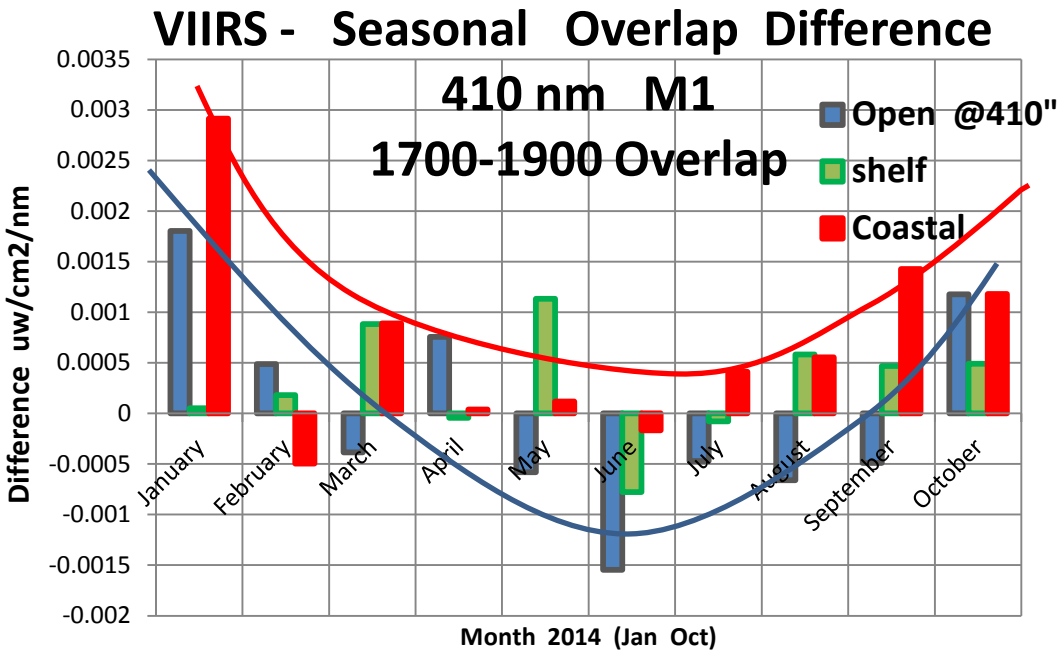


1 0 +1

Chlor_a mg/ m3

VIIRS Product Difference Mean and Variance of the M CHANNELS

# 1) Ocean Color product stability using VIIRS orbital overlaps to track monthly trends



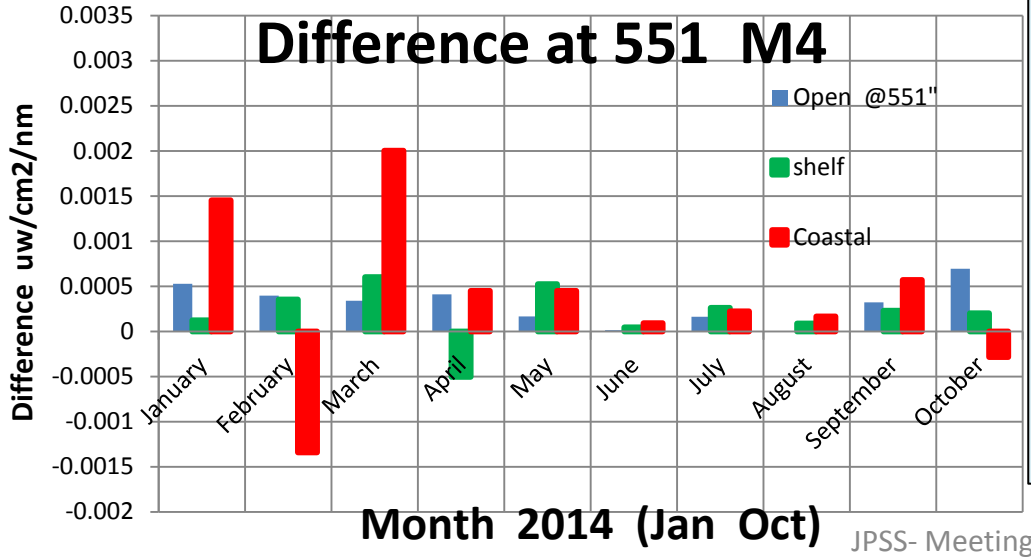

First orbit minus Second orbit .

Which orbit has higher reflectance ?

**Changes in winter to Summer**
**- Solar Angle**

**Largest in M1 Minimal in M5**

**- Strongest in Open ocean water !**
**- Similar trend in Coastal waters**



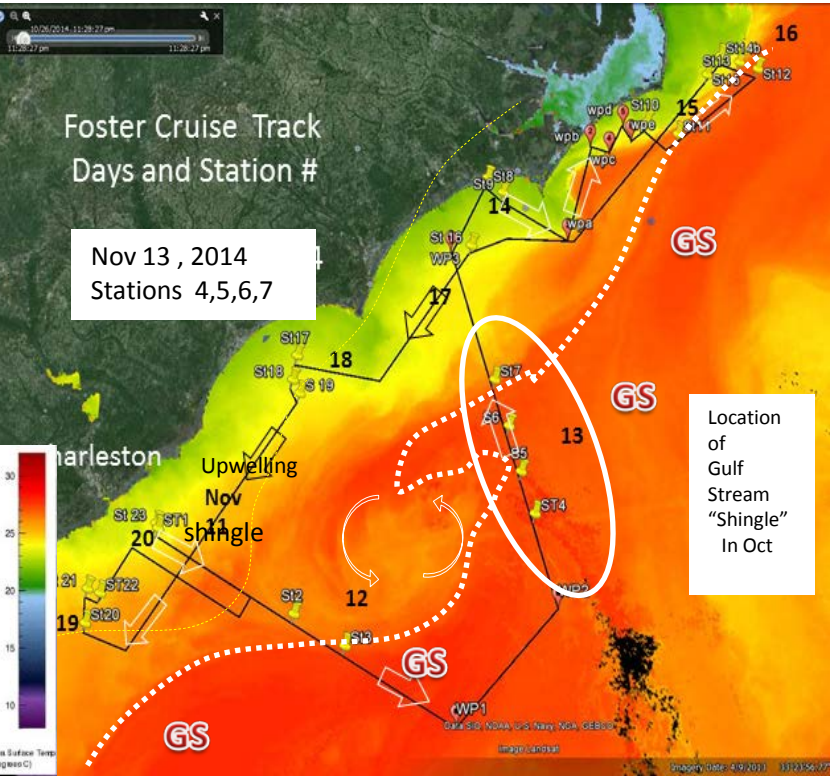

**Summary:**

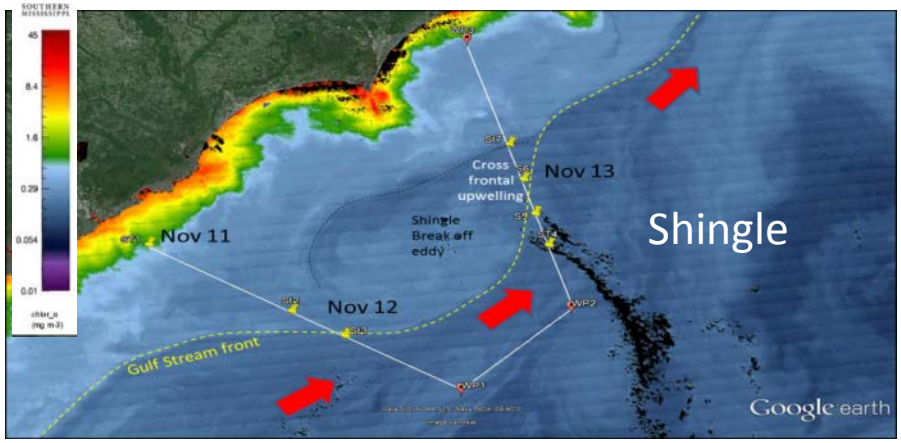
**1. Overlap nLw differences provides very sensitive ability to track the trends in both the Sensor response and processing.**
**- Dependent on diurnal changes ! Next ..**

**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.



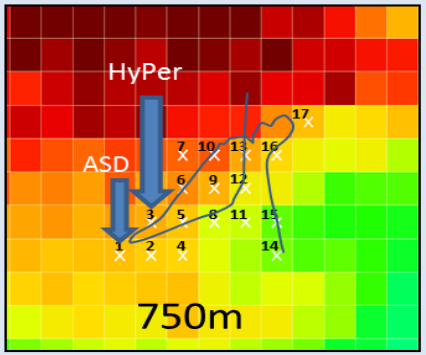



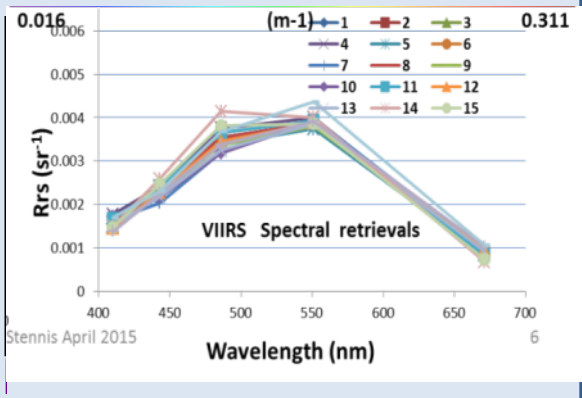

VIIRS – Validation crossing Dynamics Gulf Stream Fronts . -

1) Shingle
2) Cape Hatteras.
3) Charleston

Upwelling - Bio-optical response.

## Characterized the Spatial Variability At each station - Station 18

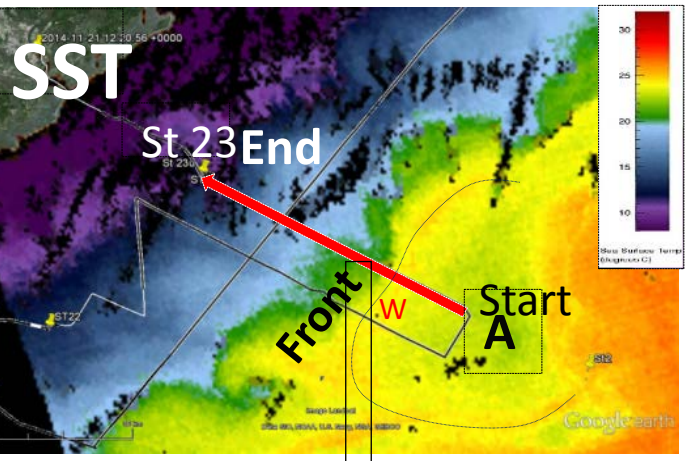


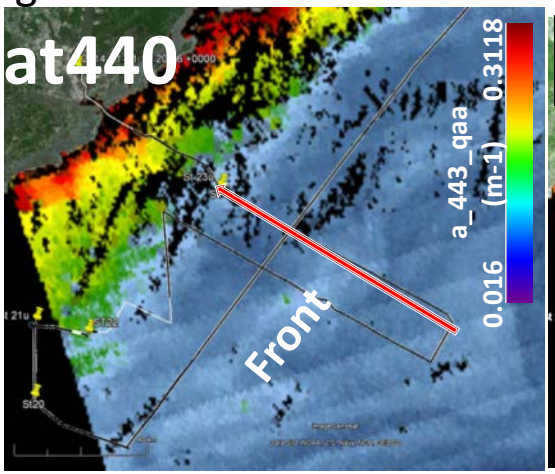



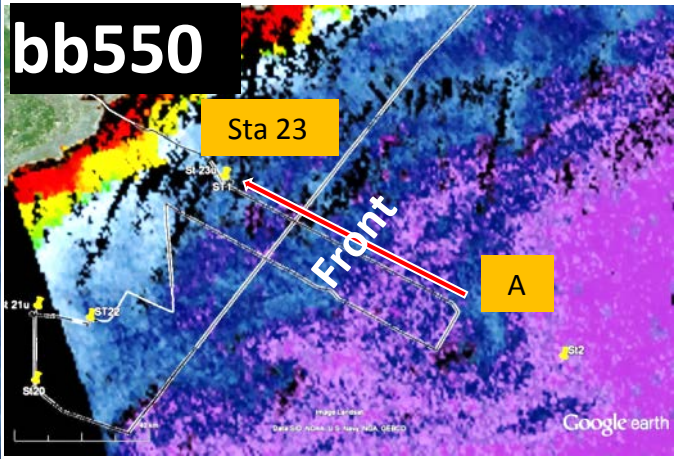

**Calibration - Matchup requires Defining the VIIRS pixel variability**

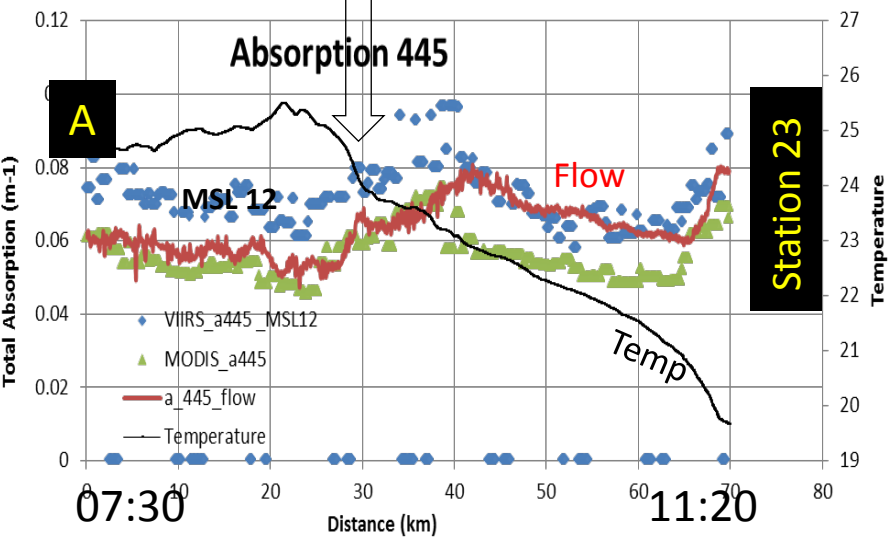
# 2) VIIRS validation of Gulf Stream water masses Foster Cruise

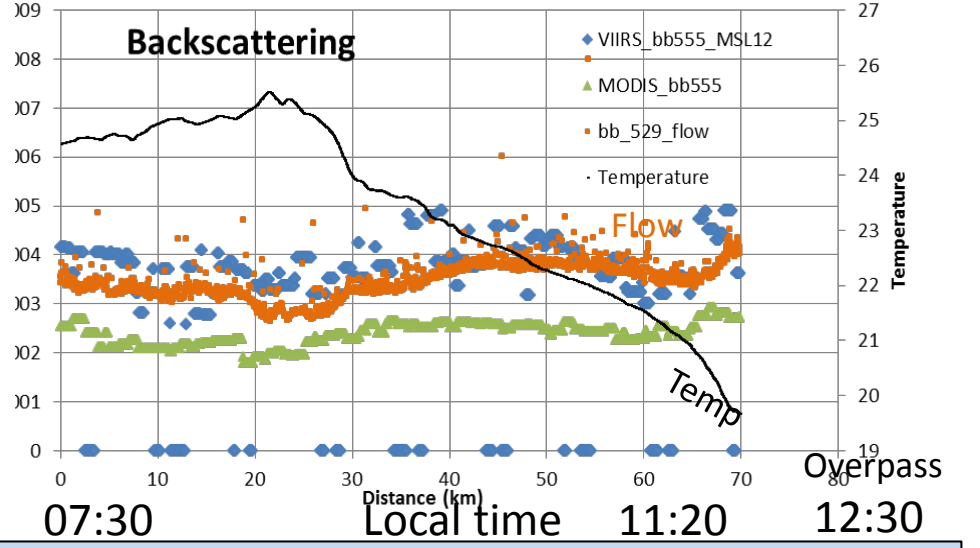
VIIRS Ocean color Validation Along track across front




**Summary -- see poster !!**

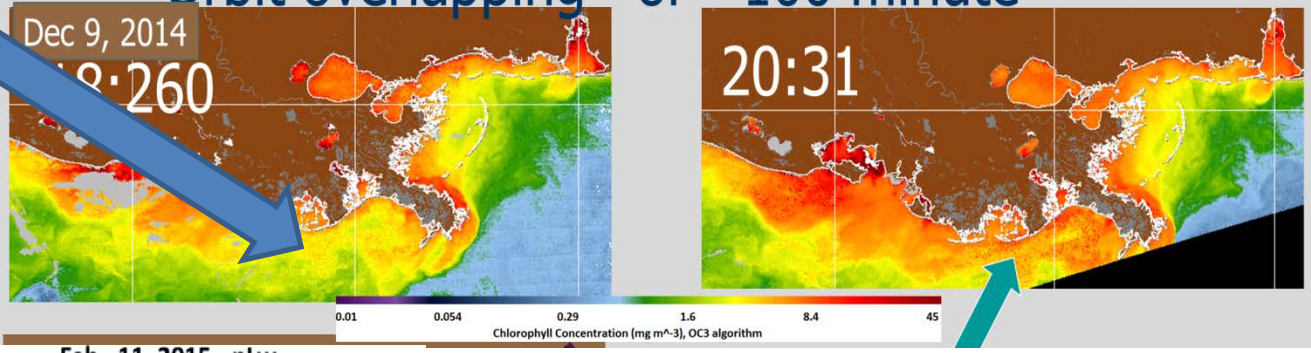
1. **Unique data sets for instrument protocols**
2. **OC Spatial variability on Station**
3. **OC response to ocean processes !**
4. **Agreement of VIIRS and Flowthrough optics**
5. **New Questions to address → accuracy of instruments vs temporal and spatial variability.**
6. **Bio-optical Water Mass classification -**

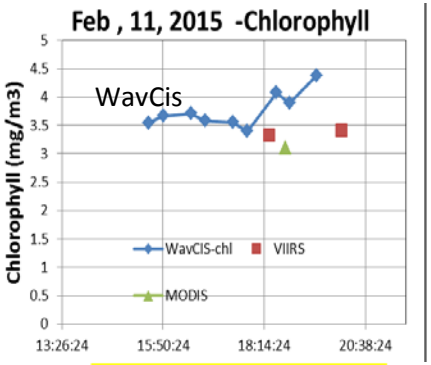
# 3) Characterizing the diurnal changes in bio-optical properties in coastal waters

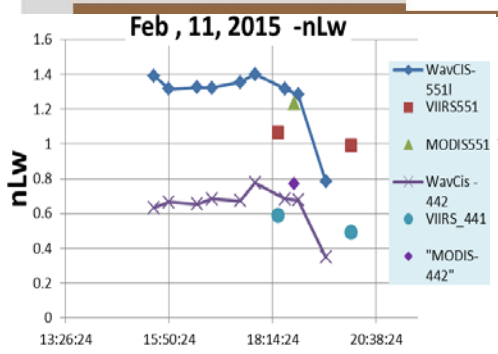

How fast can Ocean Color change in ~ 100 minutes?

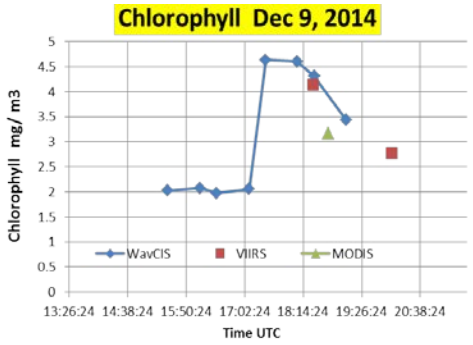
VIIRS nLw validated
The diurnal changes !
Poster includes MOBY

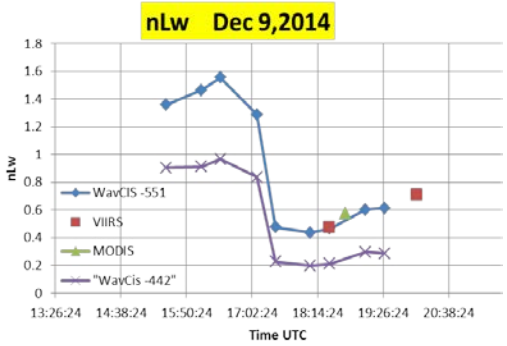
## Diurnal Variability of Chlorophyll and nLw at WavCis
## Orbit overlapping of ~100 minute

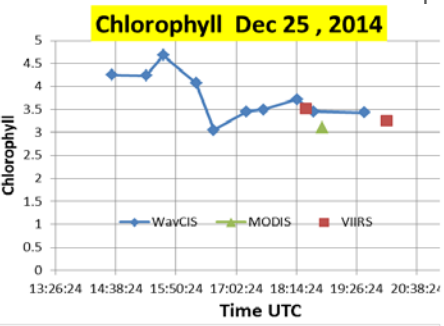


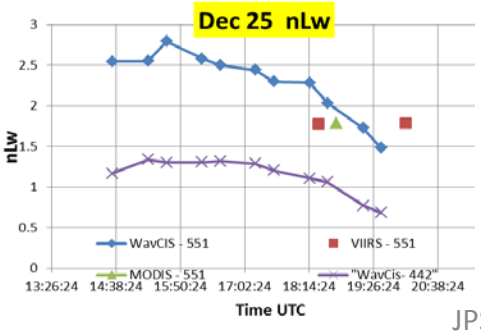



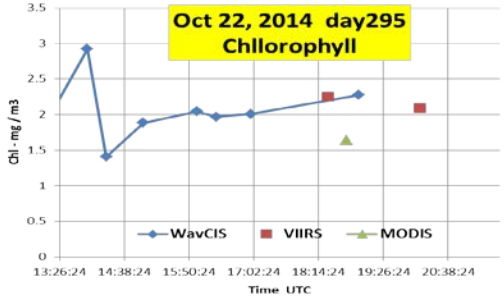



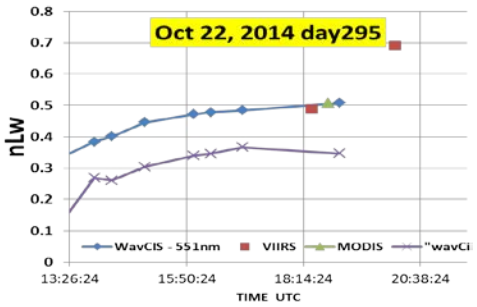



# 3) Characterizing the diurnal changes in bio-optical properties in coastal waters

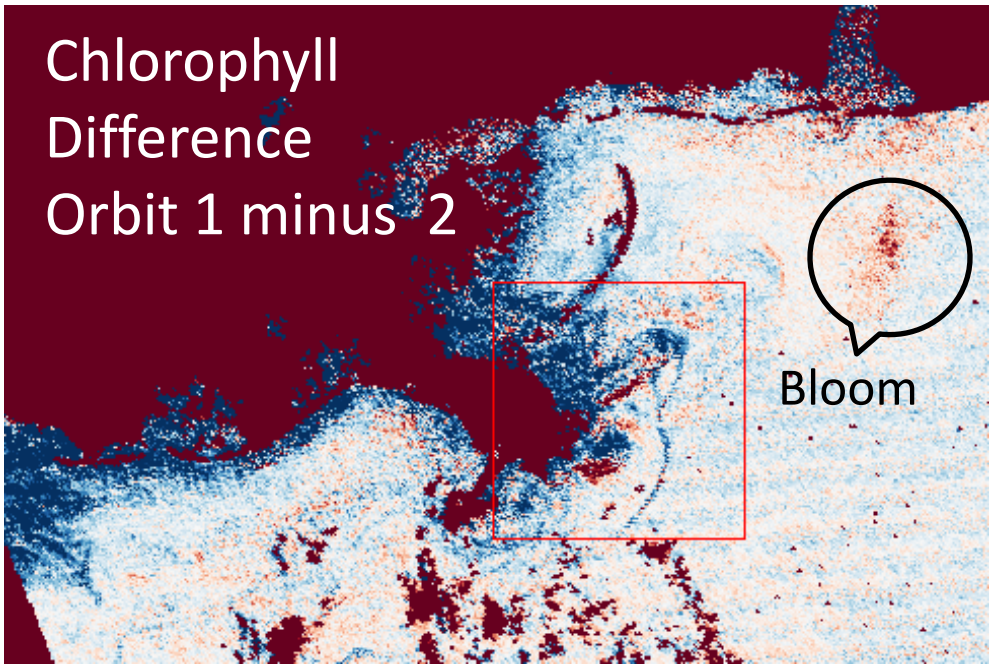
**Summary;**

**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 !**

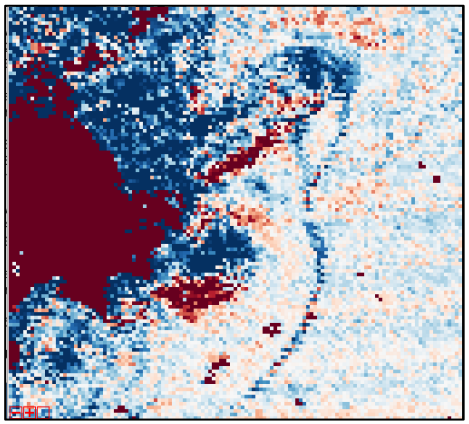
**Diurnal Changes identifies new ocean processes product . Bloom occurring!**



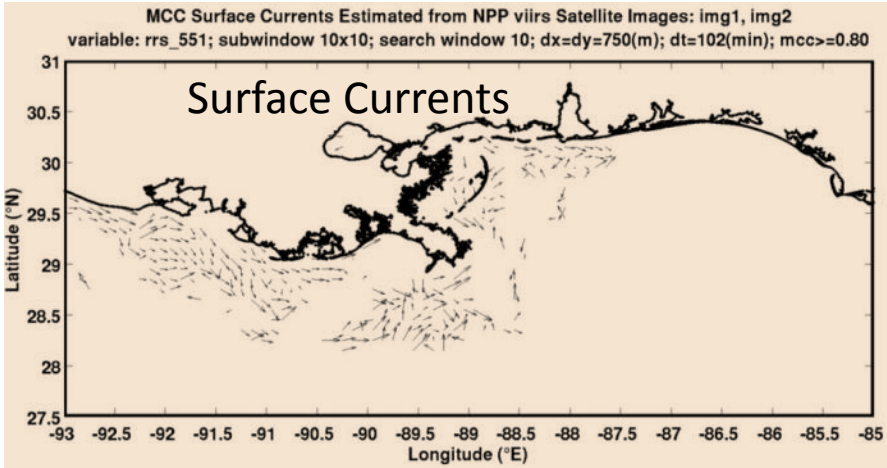

Second Pass Greater

-1 (mg/m3) +1

Bloom Decay



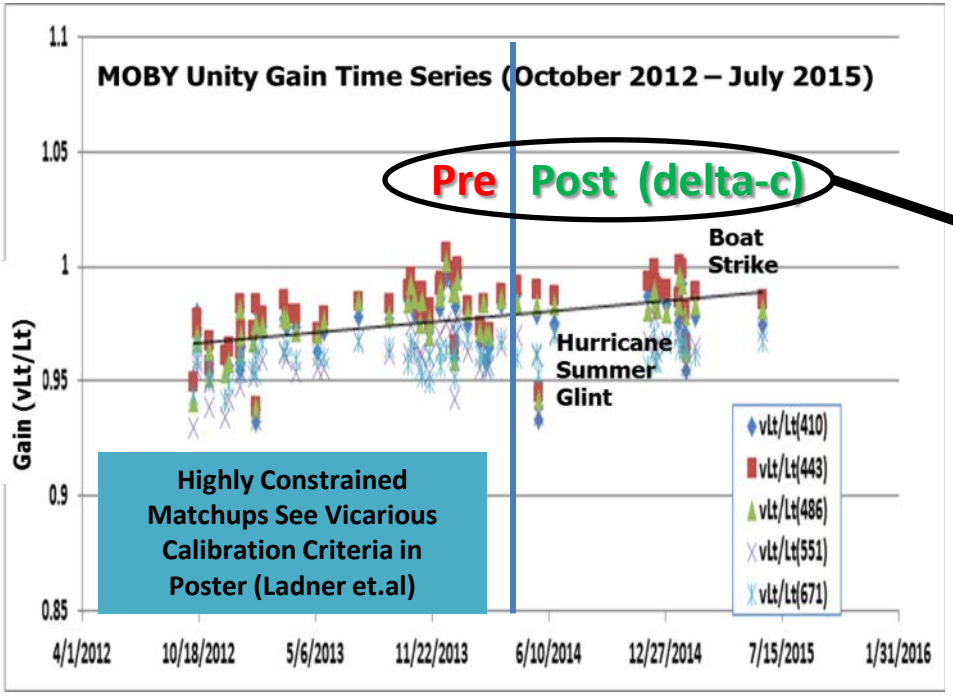
Frontal Movement



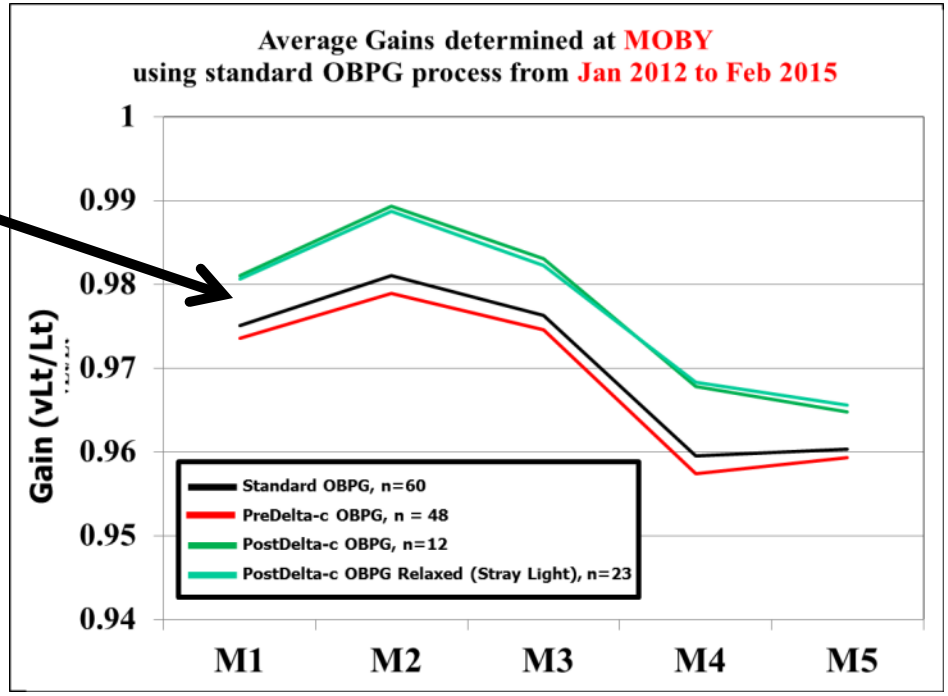

Yang, H.; Arnone, R.; Jolliff, J.; Estimating Advective near – surface currents from ocean color satellite images. Remote Sensing of Environment Volume 158, 1 March 2015, Pages 1–14

# 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






*Trend (unity gains) shows:*

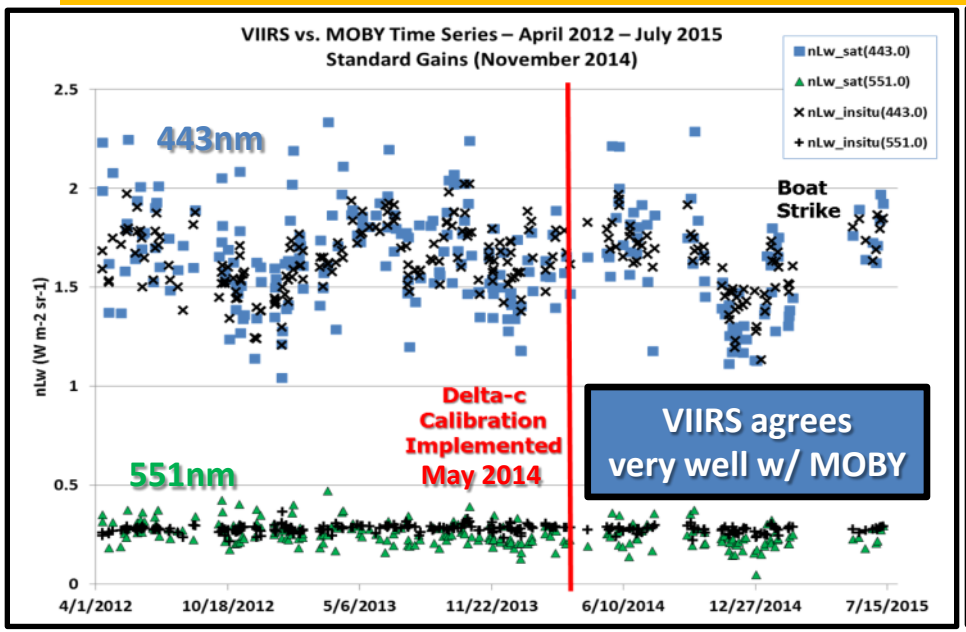
- NOAA real-time SDR improvement over time (not stabilized).
- Need continuous vicarious calibration for operations.

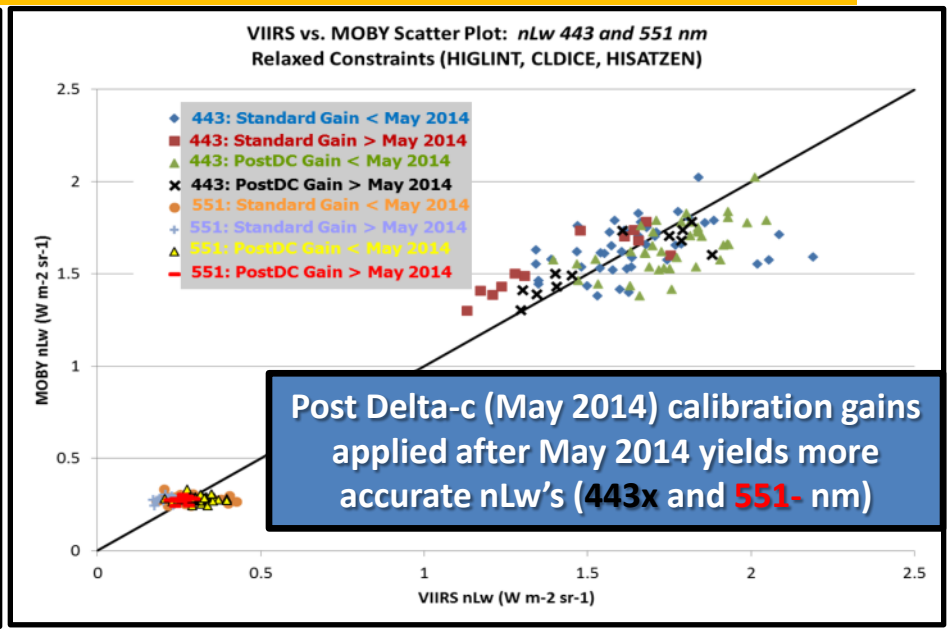
- A pre and post delta-c (May 2014) calibration change exist.
- Needs further evaluation w/ more matchups highly constrained matchups.
- Evaluation at green water AERONET site (WavCIS) underway.

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

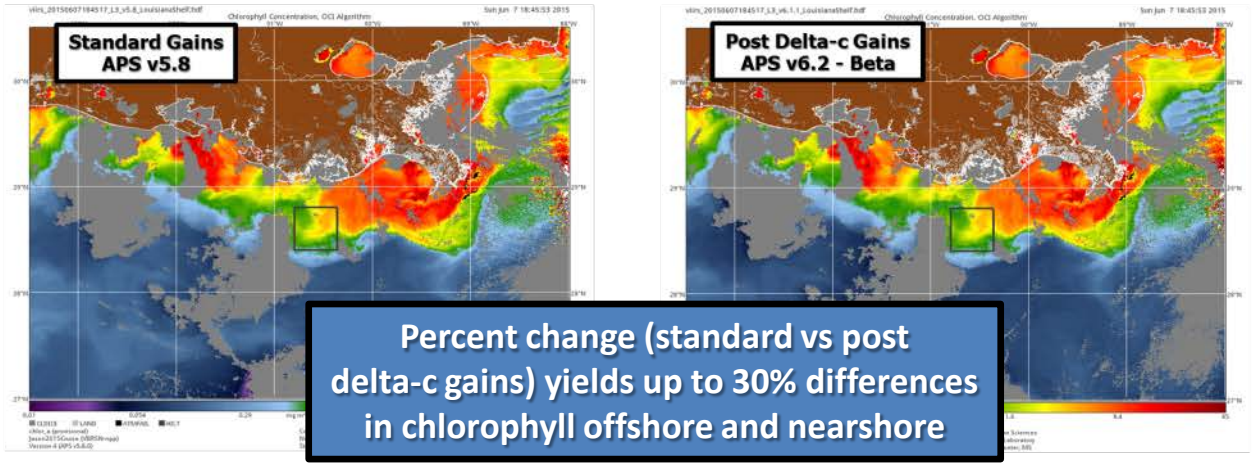
## MOBY and WavCIS Time Series Analysis and SDR Calibration Effect (Delta-c May 2014)

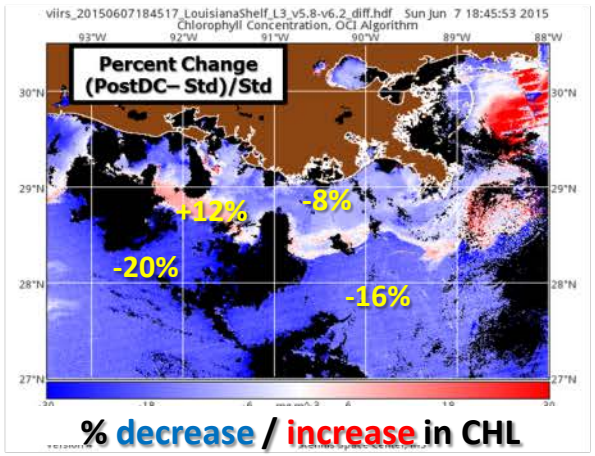
*(See poster for more results including post delta-c green water analysis at WavCIS, cruise matchups, etc.)*




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

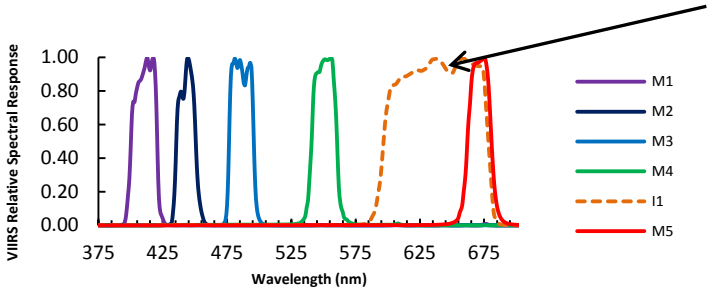


# 5) Using the VIIRS I 1-band to enhance bio-optical monitoring of coastal waters

## New VIIRs Ocean Color Product for Coastal Applications - See Poster

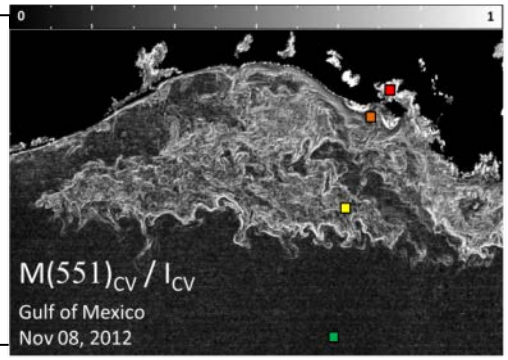
**Spatially improved ocean color products are obtained by combining the 750-m M(λ) bands with the 375-m I1-band**

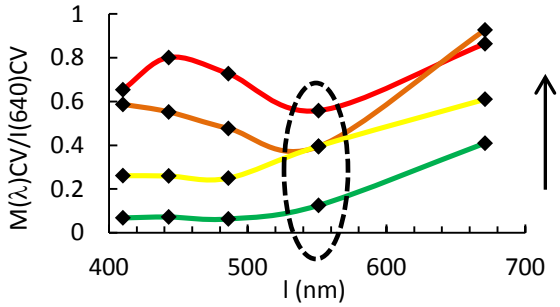



**Algorithm based on covariance of each M(λ) band with I1-band**

Less covariance — More covariance

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

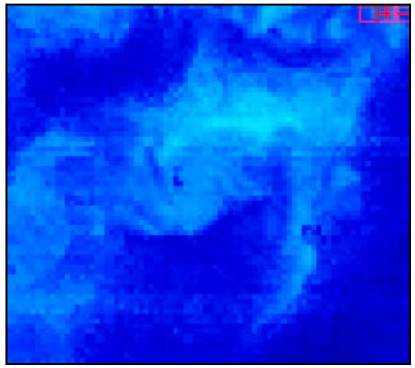


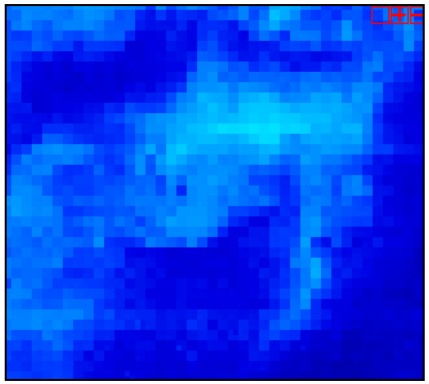

**MORE COVARIANCE = MORE SHARPENING**

## *Sharpened* Normalized Water Leaving Radiance Spectrum

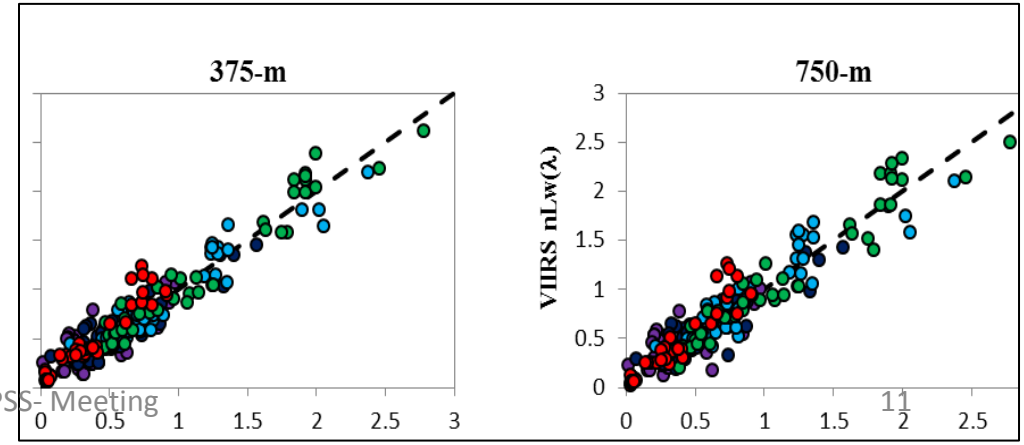
**nLw_410 : 375-m**



**nLw_410 : 750-m**

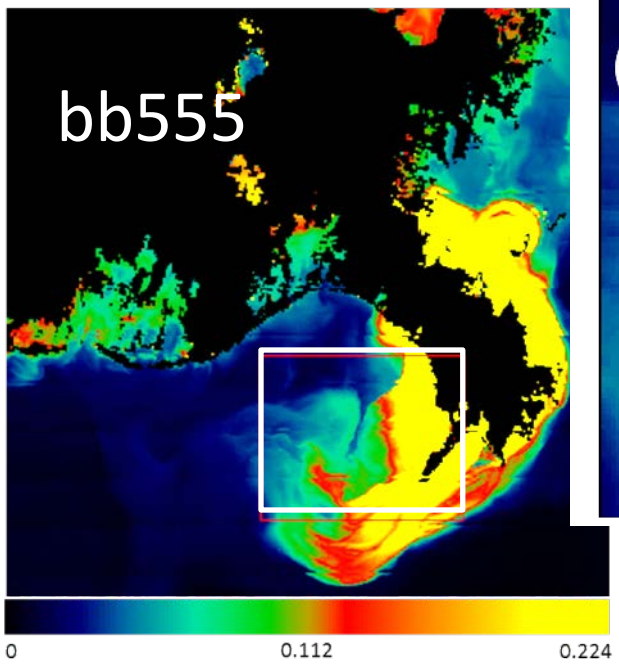


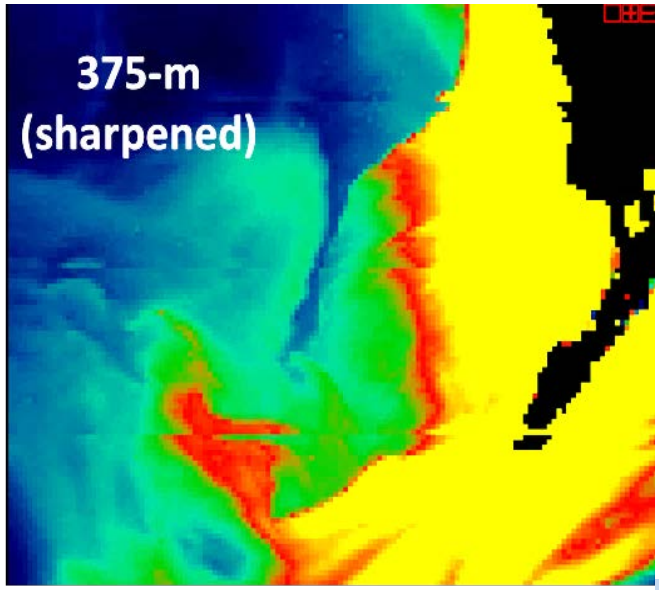
44 coastal matchups show that sharpened nLw have improved R-values, RMSE, and NMB!

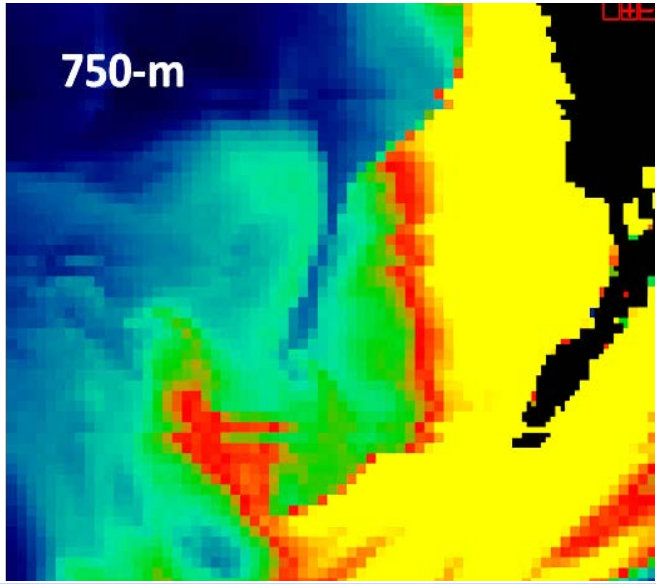


# 5) Using the VIIRS I 1-band to enhance bio-optical monitoring of coastal waters

Gulf of Mexico, 05/14/13

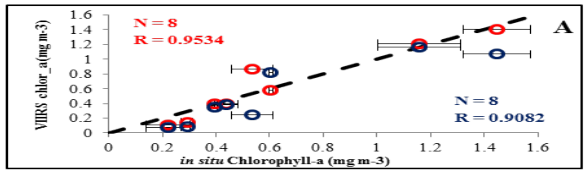


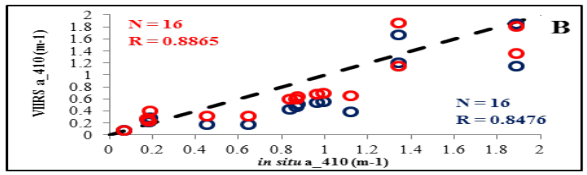



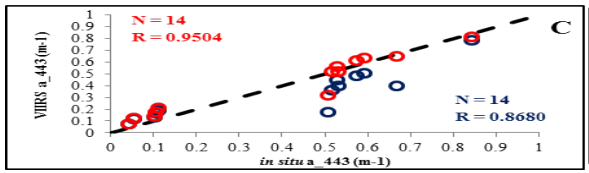




***375-m products (QAA, chlorophyll) match up better with in situ than 750-m***


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




## 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.

Validation

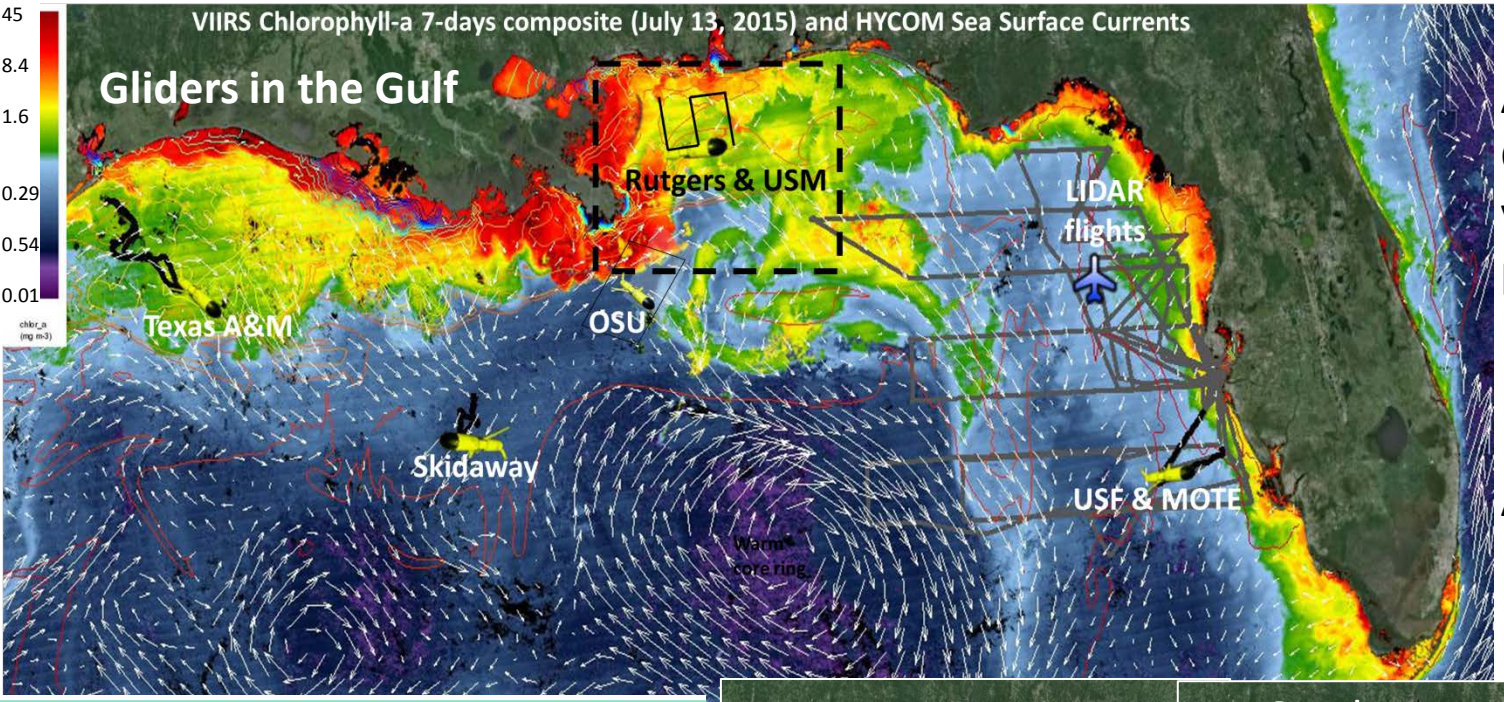
New VIIRS use of I BANDS


Vandermeulen, R. A., Arnone, R., Ladner, S., & Martinolich, P. (2015). Enhanced satellite remote sensing of coastal waters using spatially improved bio-optical products from SNPP–VIIRS. *Remote Sensing of Environment*, *165*, 53-63.

# 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

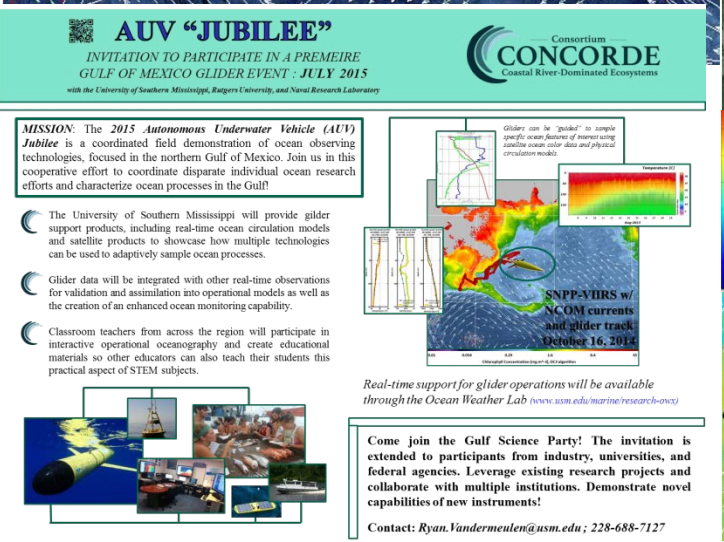
--See Poster

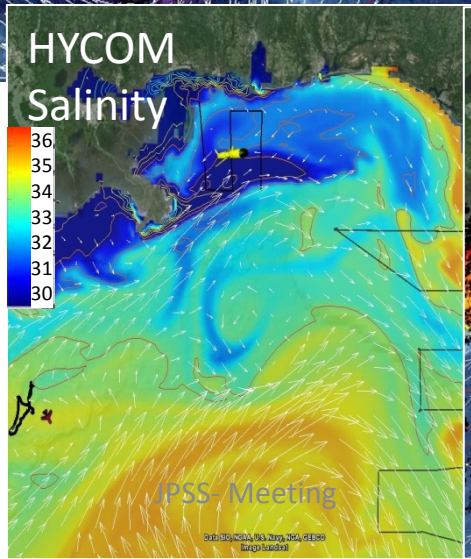


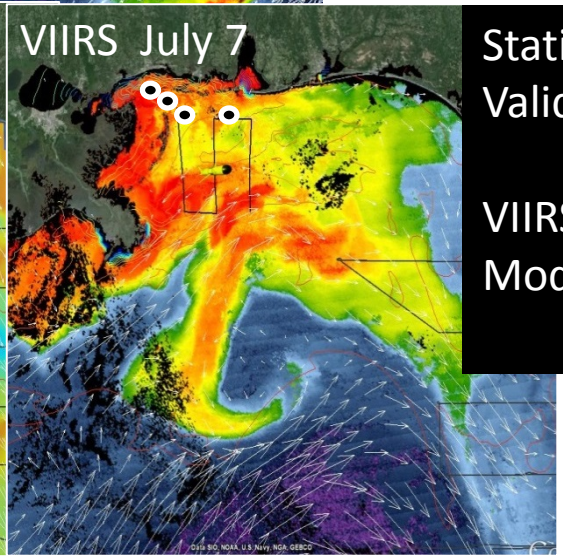

Real time Animated VIIRS Color and models to validate coastal plumes.

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*

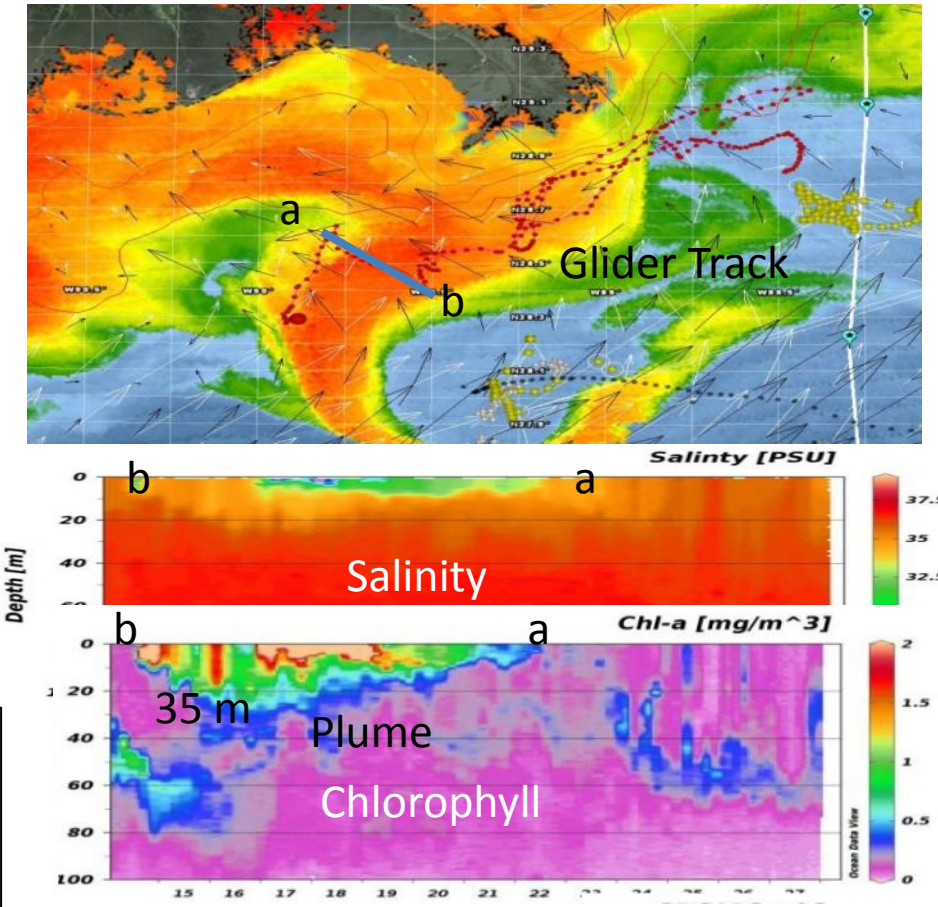
**Ancillary data**
*Real-time data from buoys or moorings, weather data, meteorological models (wind data)*

**Poster details 4 Steps on how VIIRS is used In steps for adaptive sampling!**

**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**

How to optimally apply VIIRS data for sampling !
"Plume"




**VIIRS ocean color provides a critical component in defining River Plumes ecosystems!**
**AUV Jubilee activities in Gulf**

# Summary:

**See 6 Posters for details .**

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**