Session 7

2017 STAR JPSS Annual Science Team Meeting,
College Park, Maryland
August 16, 2017

Evaluation of VIIRS Ocean Color products and development of enhanced ocean products and applications

Robert Arnone[1], Sherwin Ladner[2],Bill Gibson[3] , Wes Goode[2],

1- University of Southern MS 2. Naval Research Laboratory 3. La State University

Topics:

1. Cal Val Foster Cruise – 2016 Mathew – Summary
- **Matchups , HyperPro / ASD**
- **Protocols**
- **Flowthrough → also Poster- Ladner, Arnone, Goode, Anderson**

2. Diurnal VIIRS Paper - VIIRS products using difference fields
- **Importance of matchup time for cal –validation -)Seasonal changes in color**

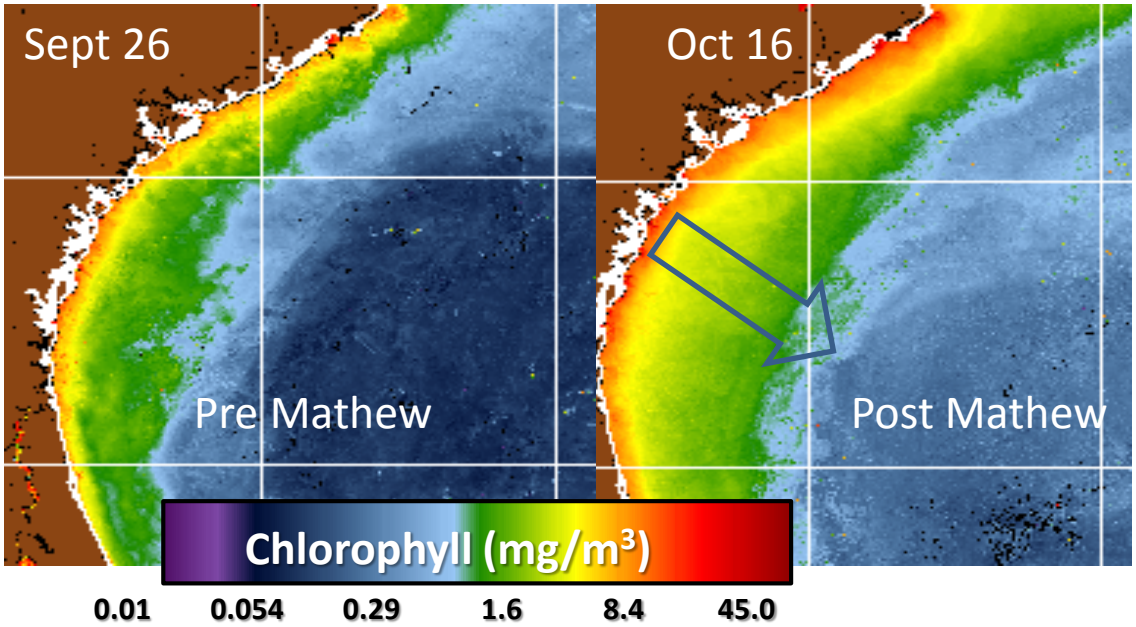
3. Anomaly products (VIIRS and Models) - Events - Hotspots SPIE paper
- **Applied to Blue Fin Tuna Foster → Poster –Arnone, Jones, Soto**

4. WavCIS Aeronet Status

5. Invitation SPIE -Ocean Sensing and Monitoring April 15-19

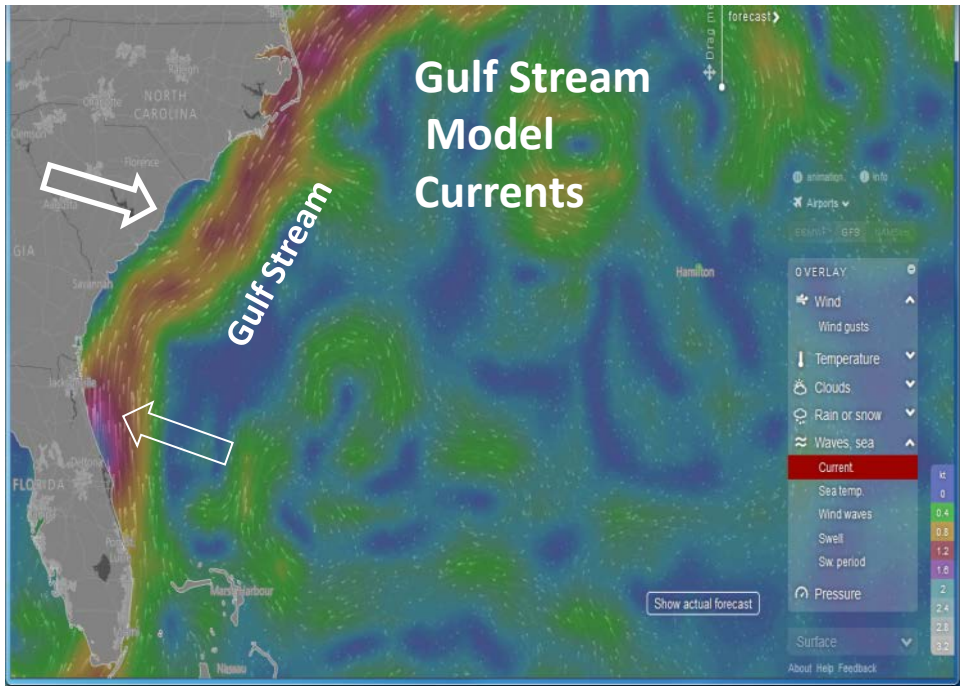
Stennis - Cal val Team Annual Summary

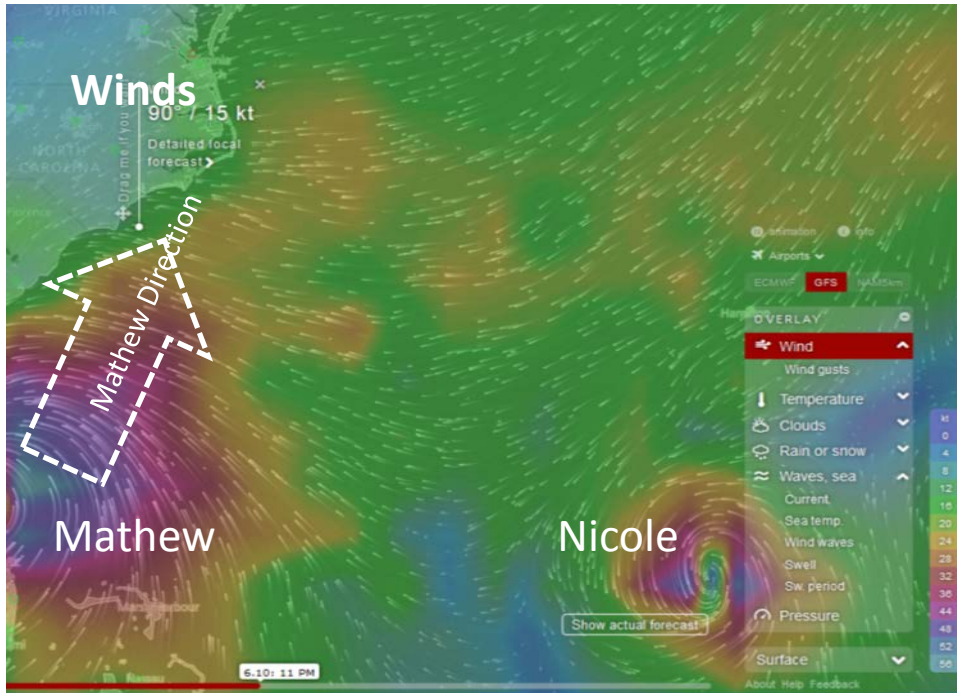
Influence of Hurricane Mathew on the Coastal waters



Foster Oct 2016 Cruise

1. Chl Extended offshore
2. Movement of the Gulf Stream onto the coast areas
   SST didn't detect Stream with uniform Temperature.
3. Exchange of Coast waters offshore Discharge
4. Cruise departed 5 days following Passage of Mathew

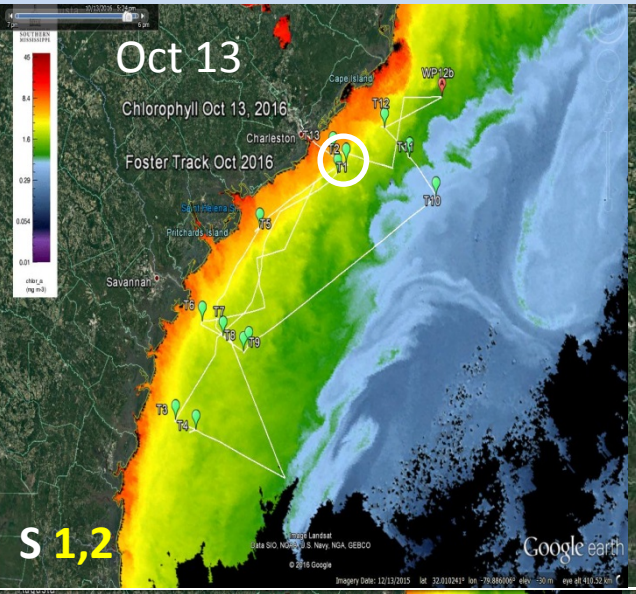


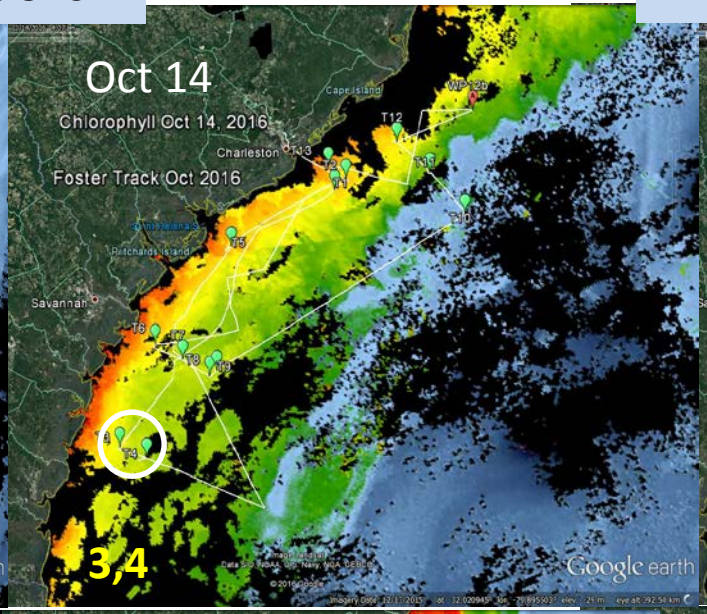


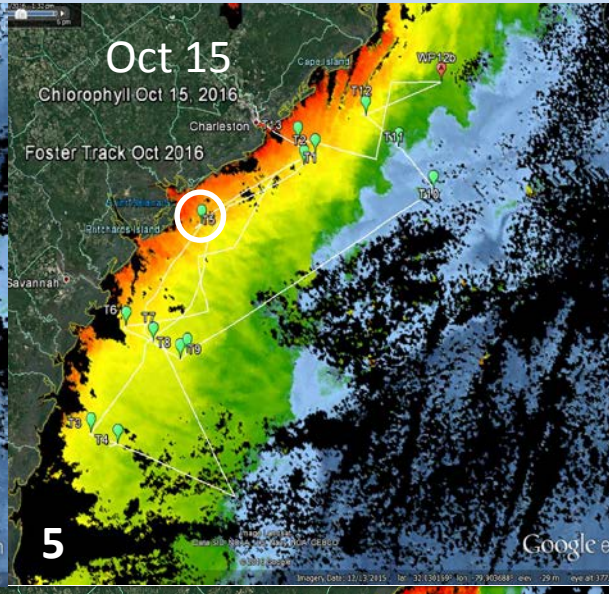
Cal Val cruise 2016 - Foster - Flowthrough – IOP

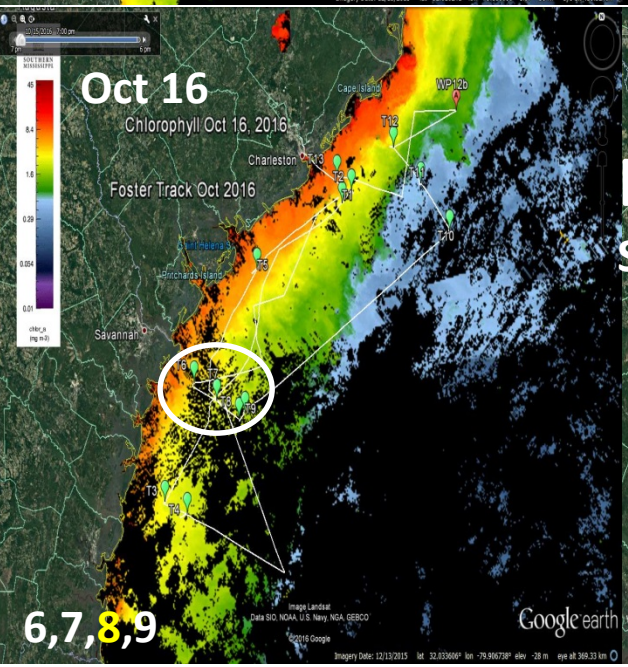
VIIRS Daily Coverage with Stations

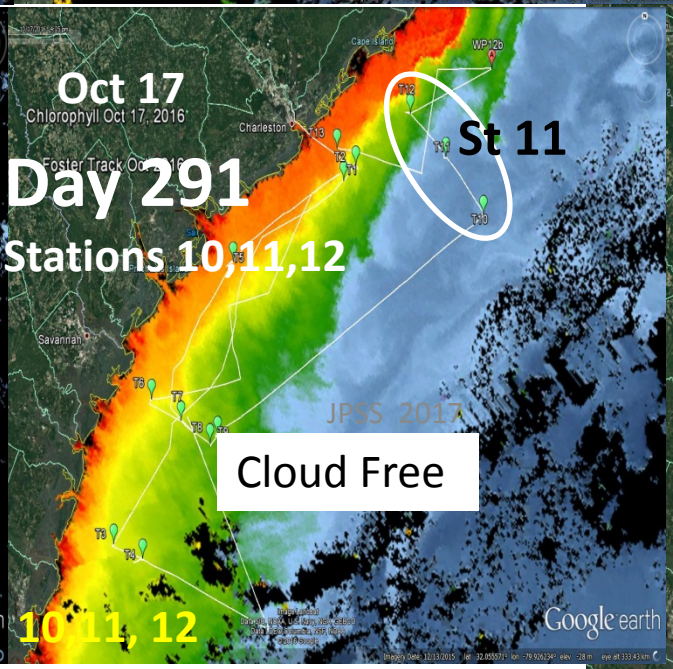
Foster Stations Oct 2016

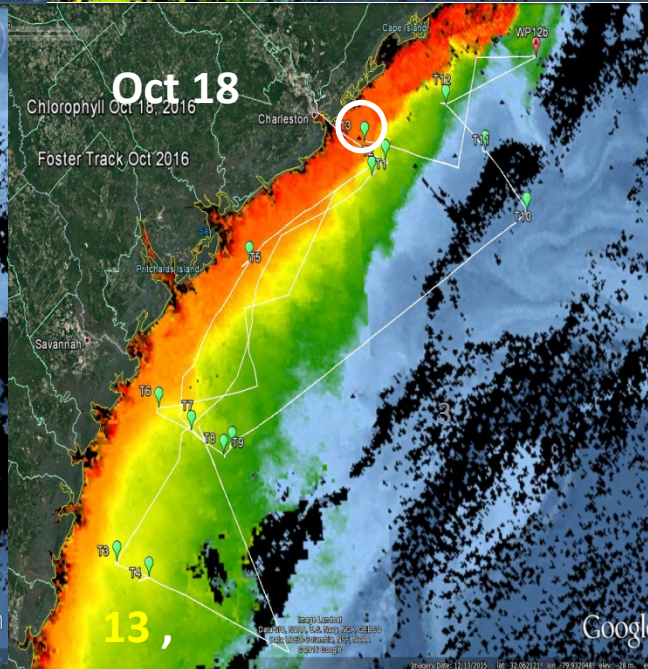












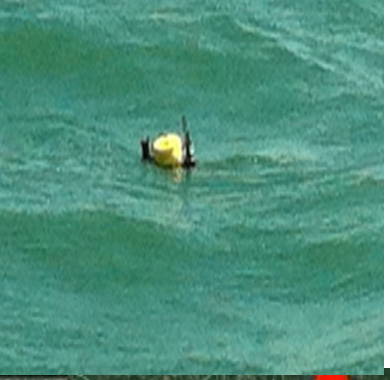
FOSTER 2016 Cal Val cruise

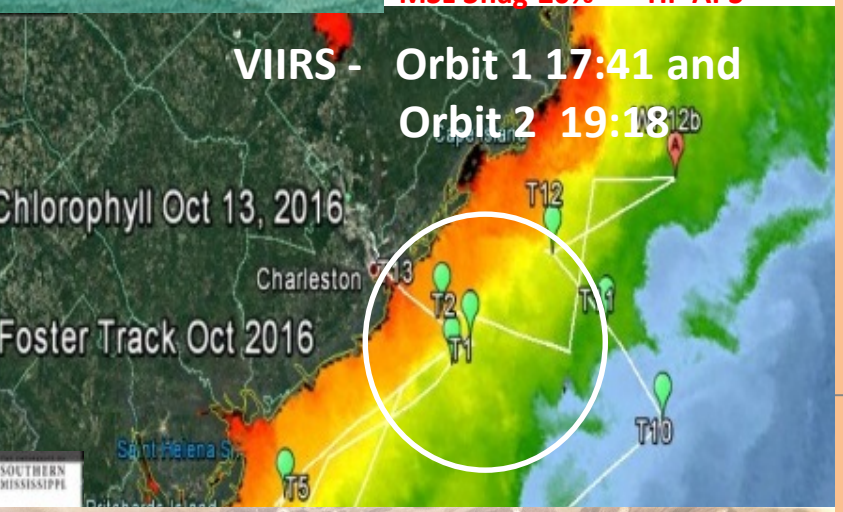
Oct 13, 2016

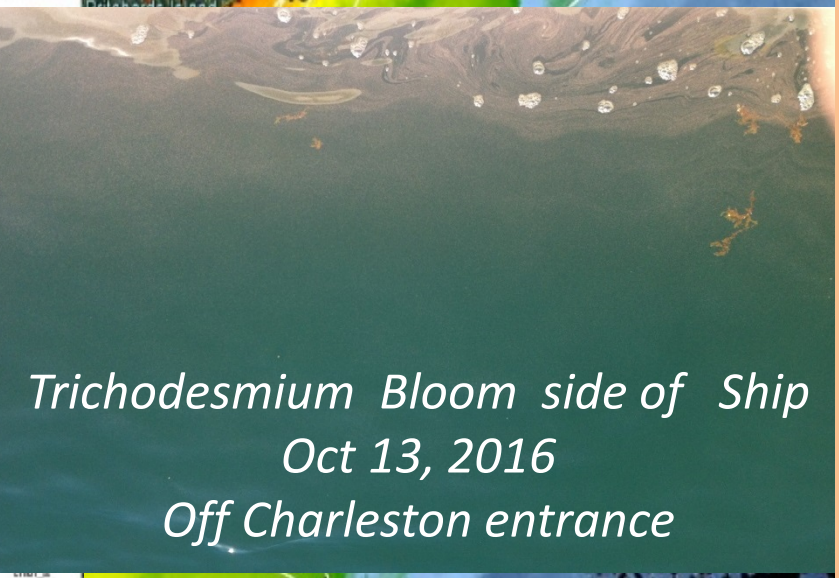
← 2 Floating Hyperpros

- Hyperpro – NOAA
- VIIRS Matchup- revised
- 1x1 APS (5x5)

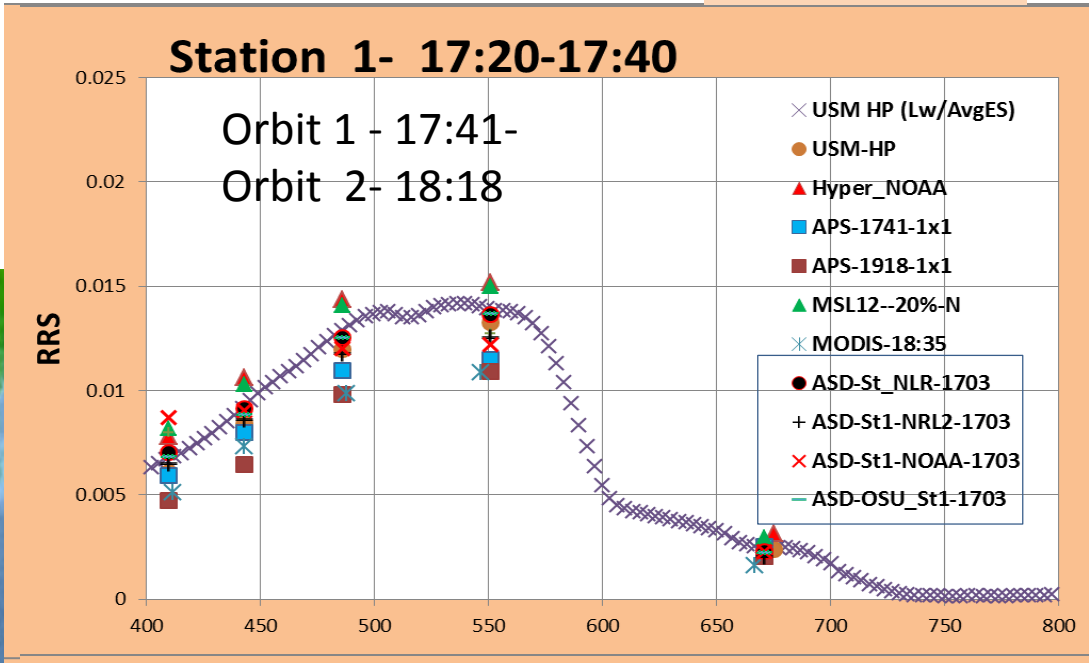
MSL 3flag-20% - HP APS

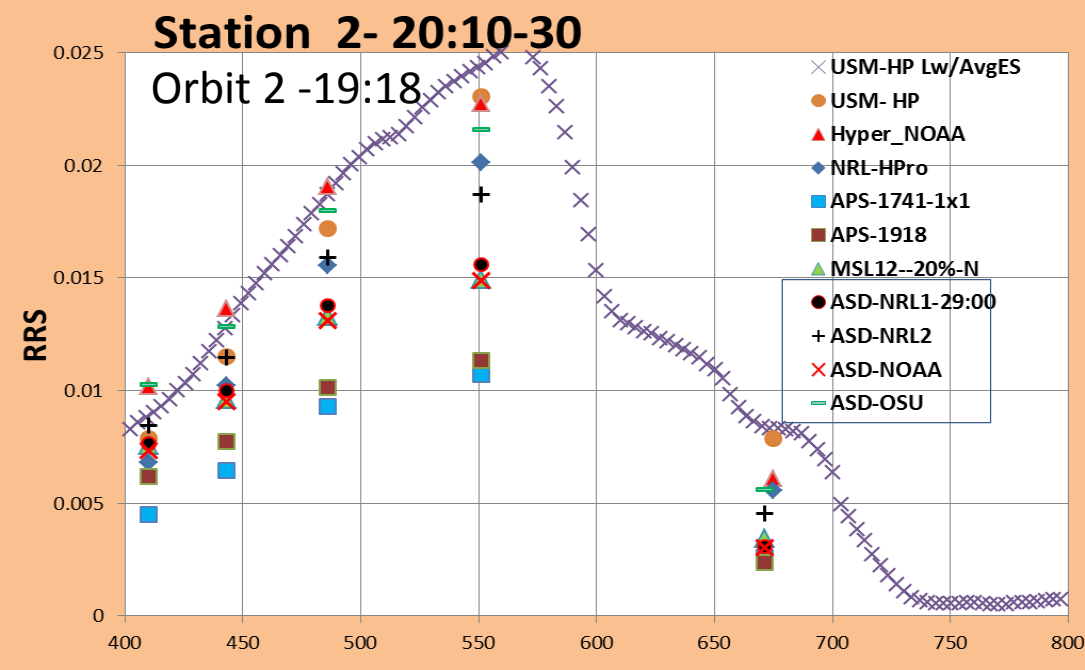






Plus 4 ASD



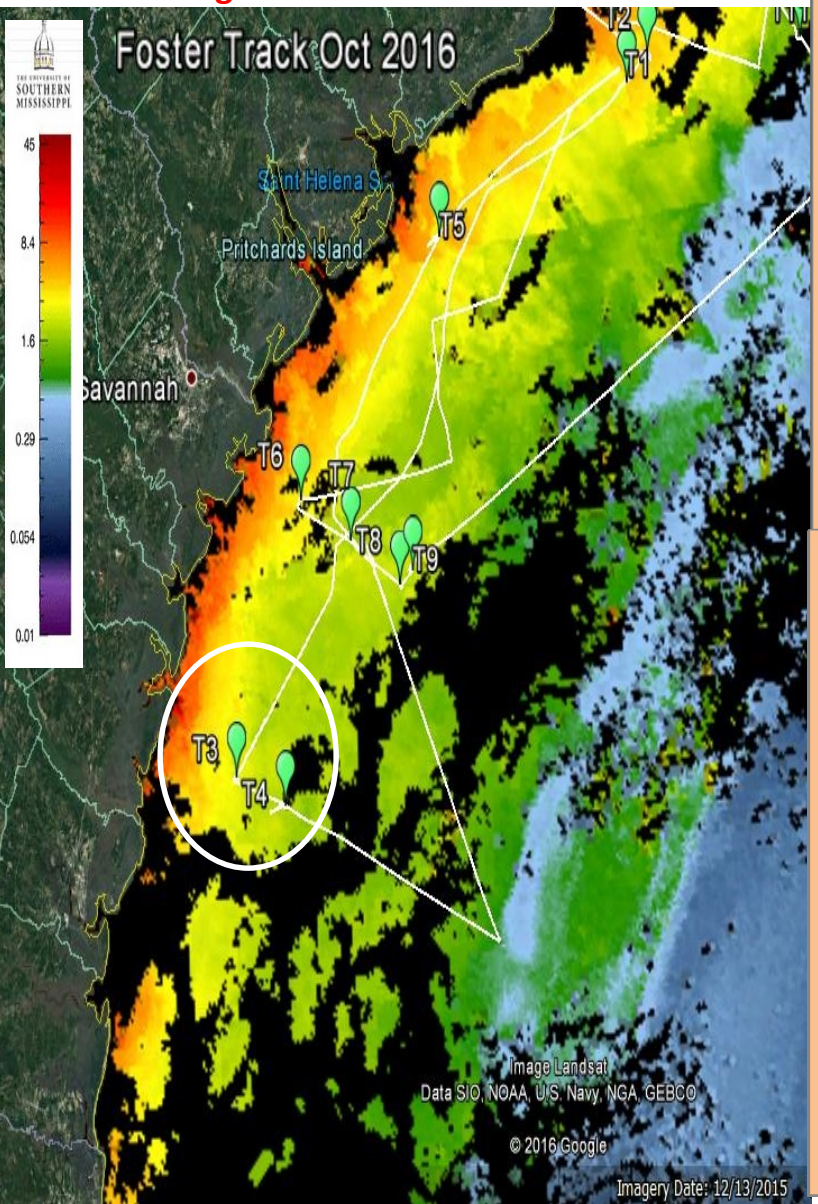


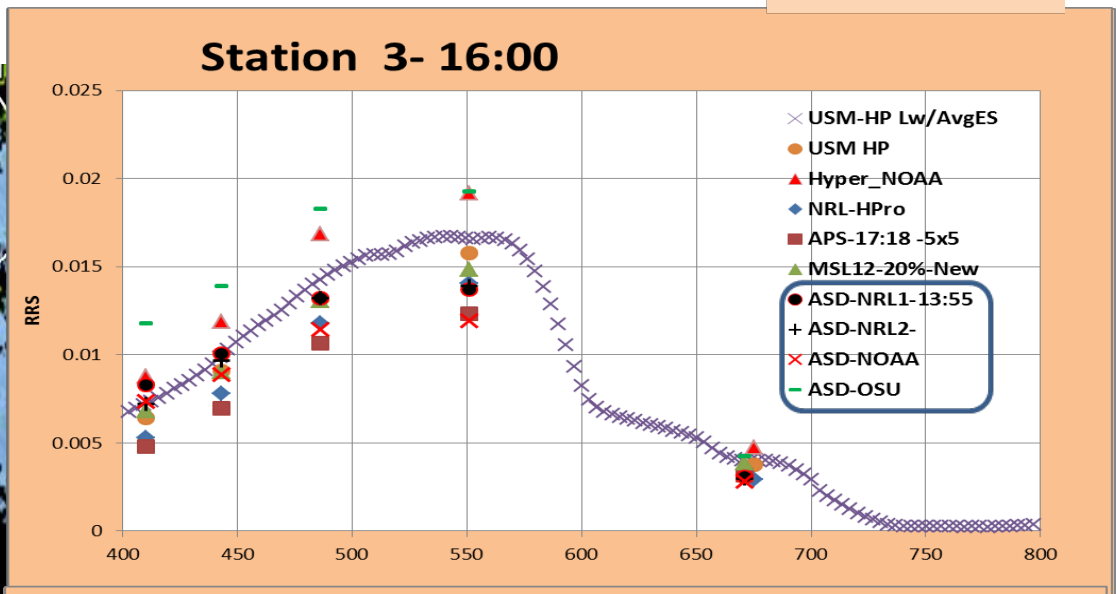
FOSTER 2016 Cal Val cruise Oct 14, 2016

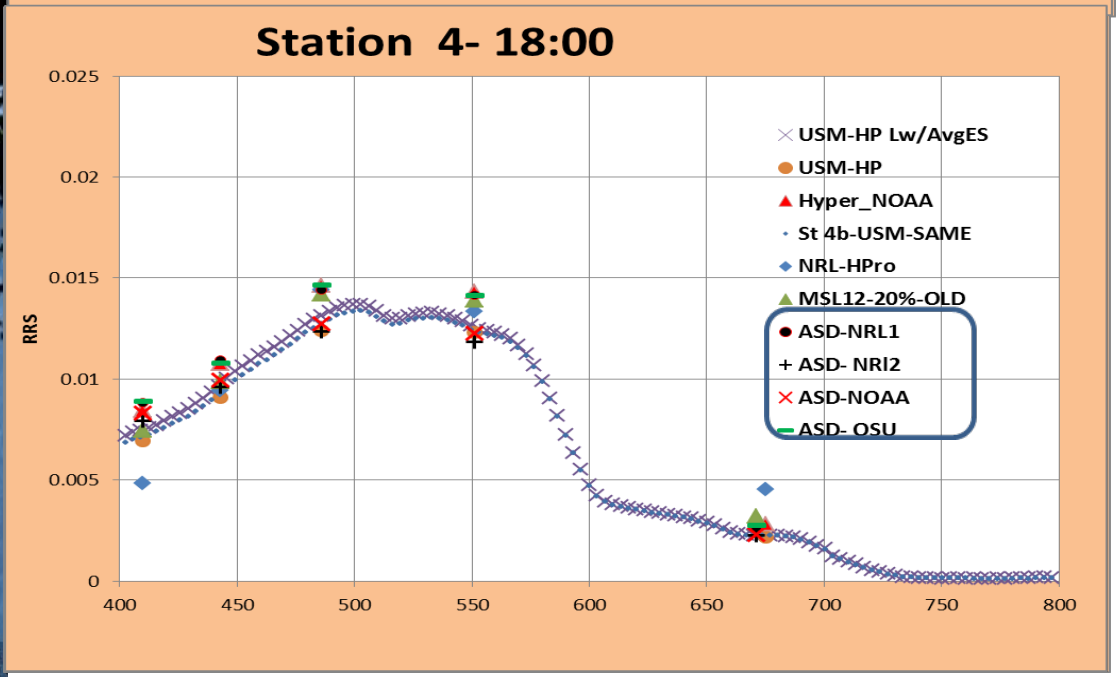
- Floating Hyperpros (USM- NRL)
- Hyperpro – NOAA
- MSL 3flag-20% - HP-APS

VIIRS Overpass – 17:18

Plus 4 ASD





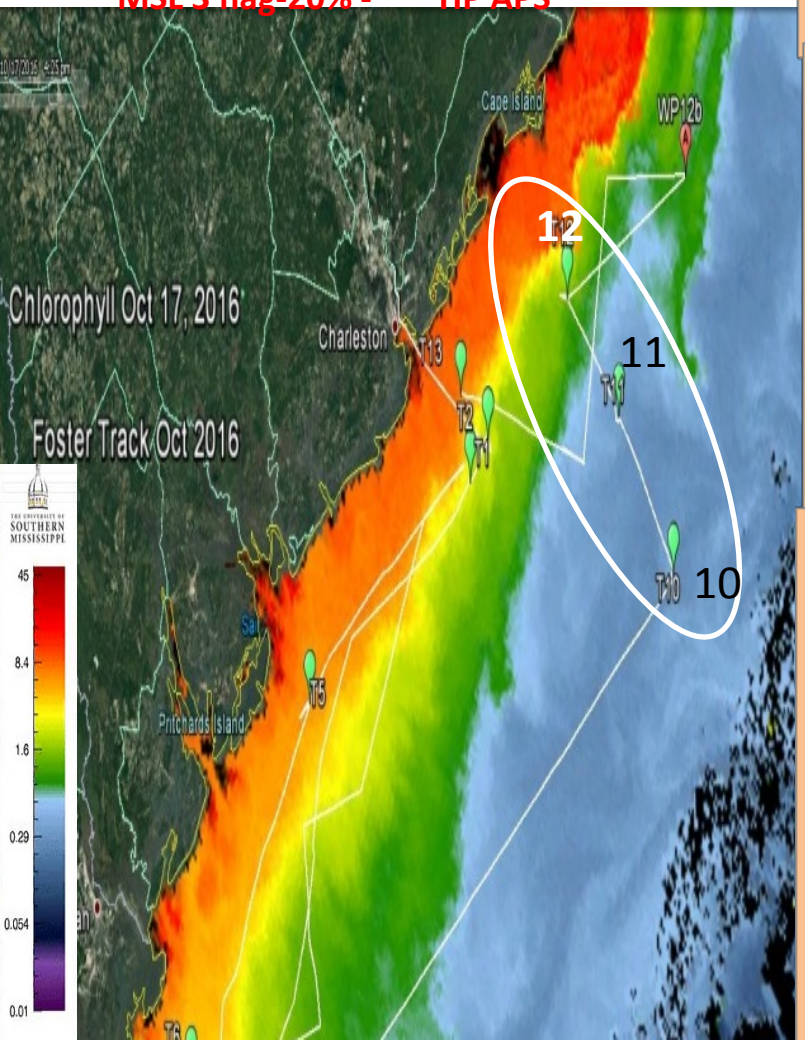


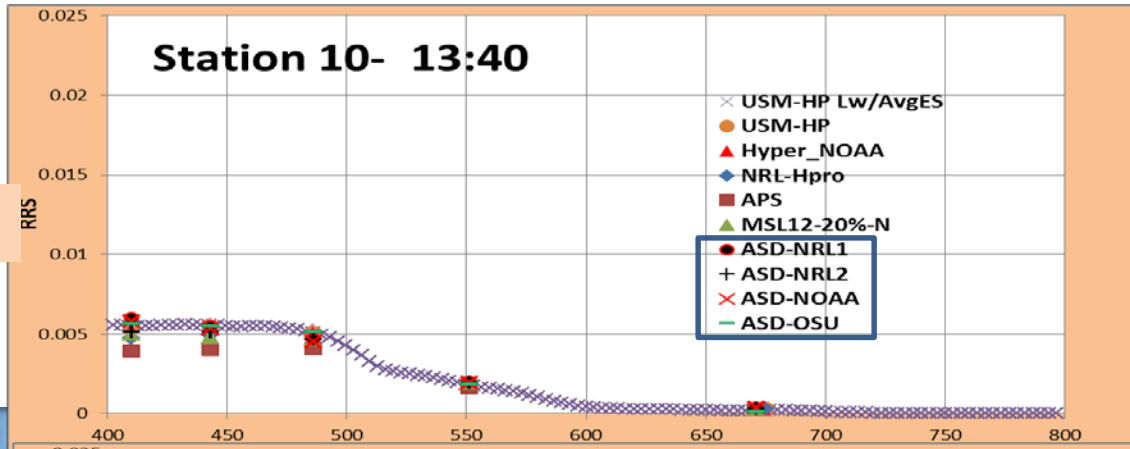
FOSTER 2016 Cal Val cruise Oct 17, 2017

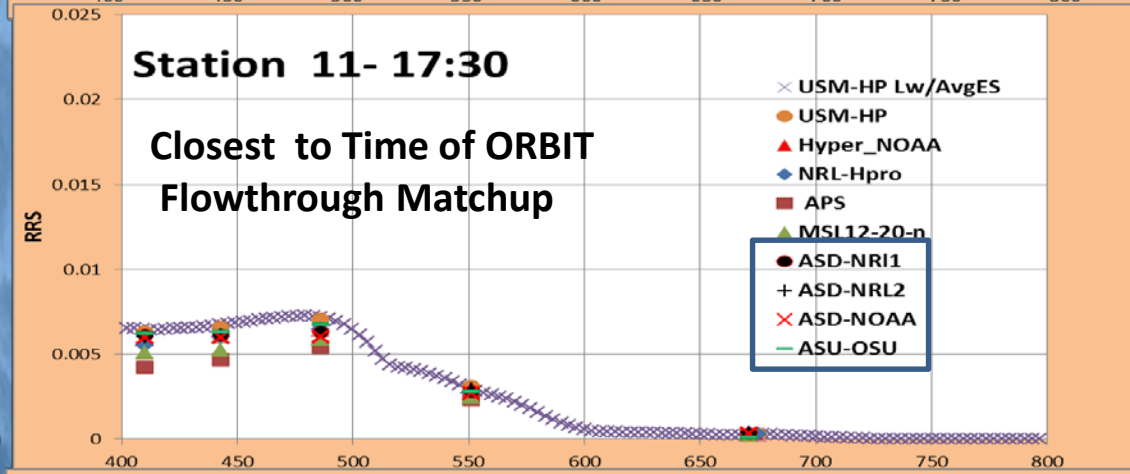
- Floating Hyperpros (USM- NRL
- Hyperpro – NOAA
- St 11 is Closest Matchup at time of Orbit – 18:02

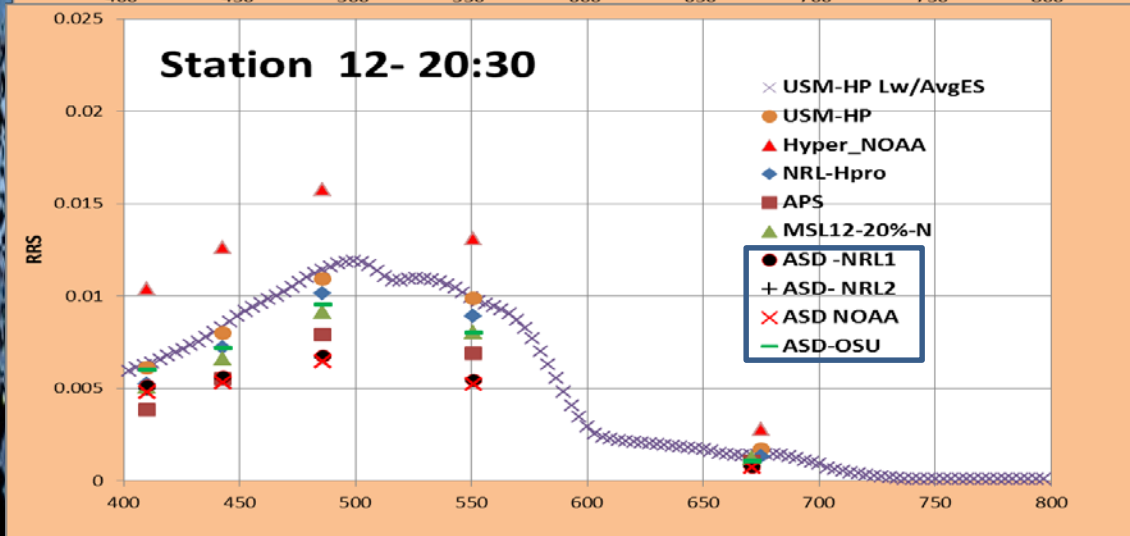
Plus 4 ASD

MSL 3 flag-20% - HP APS



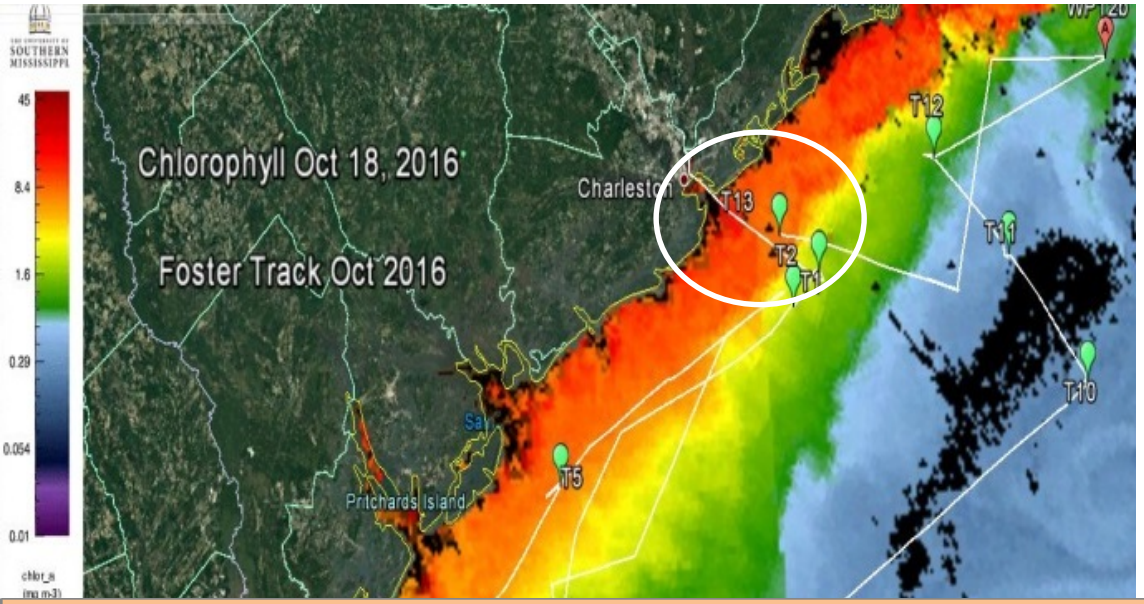




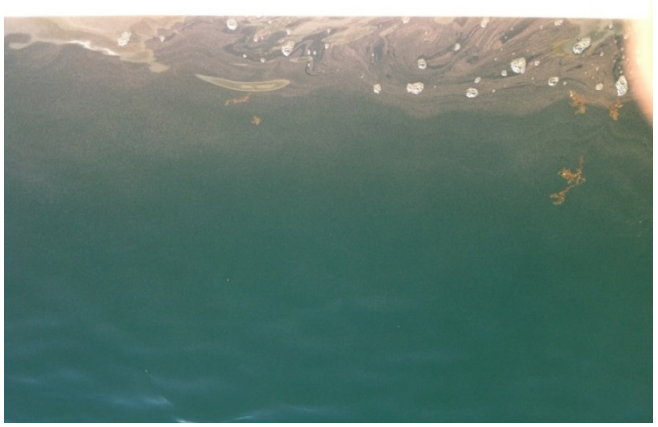


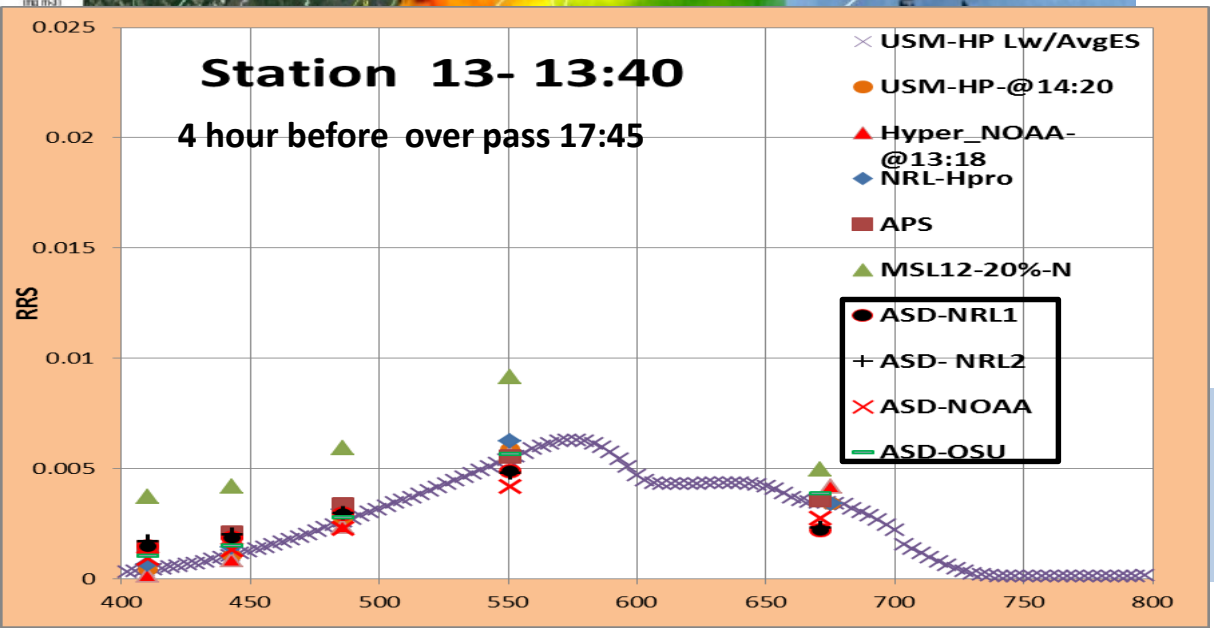
FOSTER 2016 Cal Val cruise

Foster Oct 18-- Orbit at 17:45



The surface Waters were scattered *Trichodesmium Bloom Off side of Ship.*





Plus 4 ASD

3 Hyperpros agreed at Stations

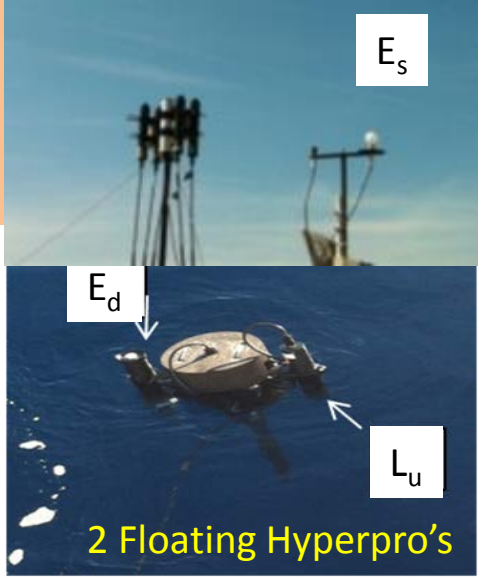
Coastal waters surface Patches

MSL 3 flag-20% - HP APS

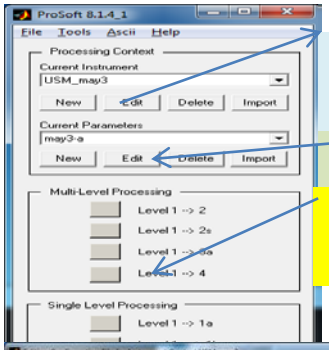
: Established Floating HyperPro Protocols for using Prosoft software for processing.

Floating Hyperpro Protocols

for Post Processing - Prosoft 8.1.4.



1. **Measurements were made over 10 minute time period.**
2. **Processing using Prosoft v8.1.3-4 and data were averaged over the deployment interval and tilts greater than 2 degrees was omitted.**
3. **Use the Es rather that ED (tested both)**
4. **Did a consistency of ALL ES sensors on Foster !**
5. **Fresnel reflectance (*p*) = 0.025 and refractive index of sea water (*n*) = 1.34 (Prosoft Defaults). factor = (1-0.021)/(1.345^2); Rrs = L_u*factor/$E_{d,s}$**



Steps

#1 Edit and load the cal

-

#2 - Edit to set up parameters

#3 process.

level 1→ Level 4

Set ups

```
PROFILER : WET
REFERENCE : OFF
PRO-DARK : OFF
REF-DARK : OFF
PRO-ID : MPR0093
PROCESSING_LEVEL : 4
FILE_CREATION_TIME : 11-Mar-2016 17:27:47
DEGLITCH_PRODAT : OFF
DEGLITCH_REFDAT : OFF
STRAY_LIGHT_CORRECT : OFF
THERMAL_RESPONSIVITY_CORRECT : OFF
DEPTH_RESOLUTION : 0.01 m
BIN_INTERVAL : 0.05 m
BIN_WIDTH : 0.1 m
TIME_INTERVAL : 2 sec
TIME_WIDTH : 1 sec
WAVEL_INTERP : 0 nm
INTEGRATION_POINTS : 5
REFLECTION_ALBEDO : 0.043
REFLECTANCE_INDEX : 0.021
REFRACTIVE_INDEX : 1.345
ET_SOLAR_SPECTRUM : Thuillier
WATER_MEDIUM : sea water
LS_DISTANCE_SURF : 0.2
```

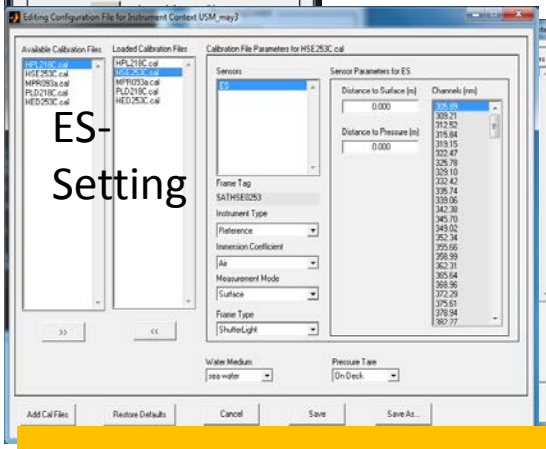
$$L_w(\lambda) = \frac{1-\rho}{n^2} L_u(0^-, \lambda)$$

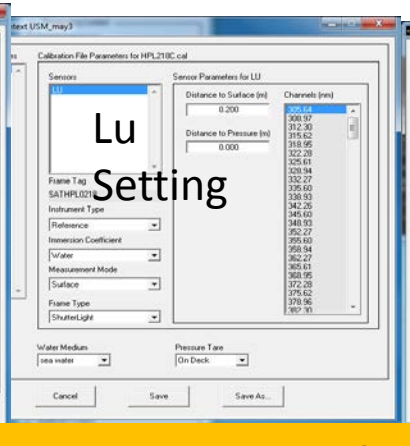
ρ = 0.025 is the Fresnel reflectance of the air sea interface,

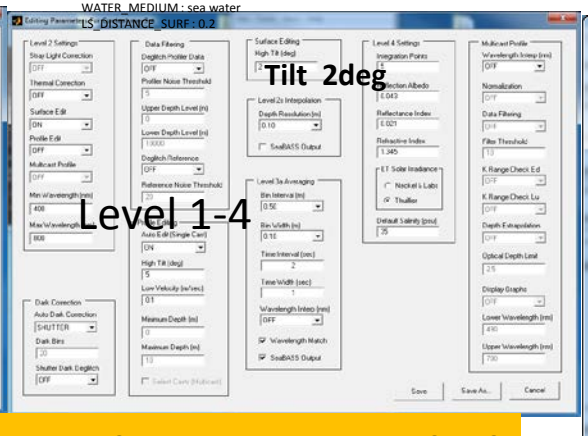
n = 1.34 is the refractive index of seawater.

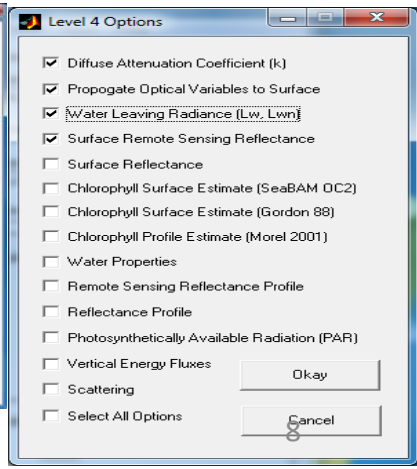
Remote sensing reflectance

$$R_{RS}(\lambda) = \frac{L_w(\lambda)}{E_S(\lambda)}$$







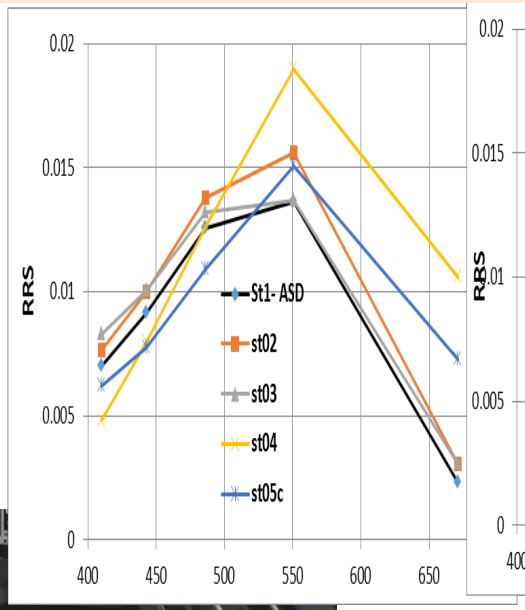


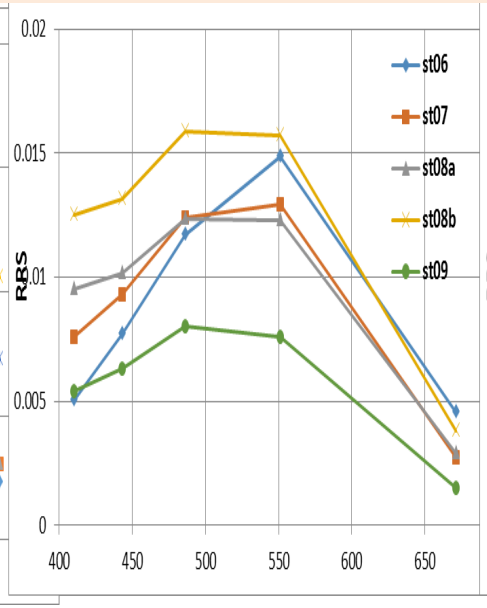
1. Consistent Between Sensors 2. Similar results using ES and Ed

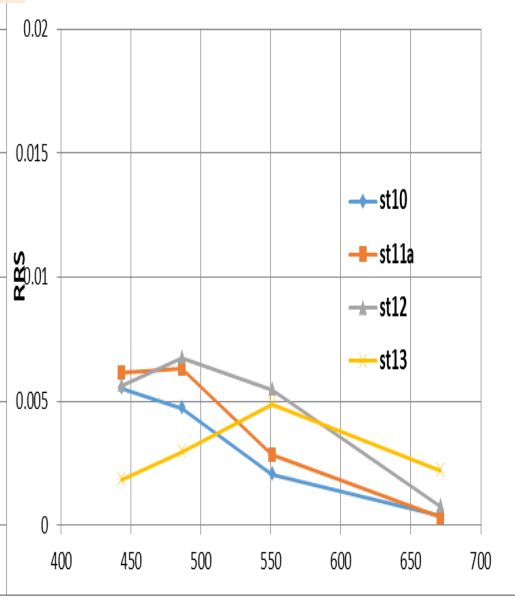
Above water – ASD for Stations and Blue tile

Addressing ASD protocols

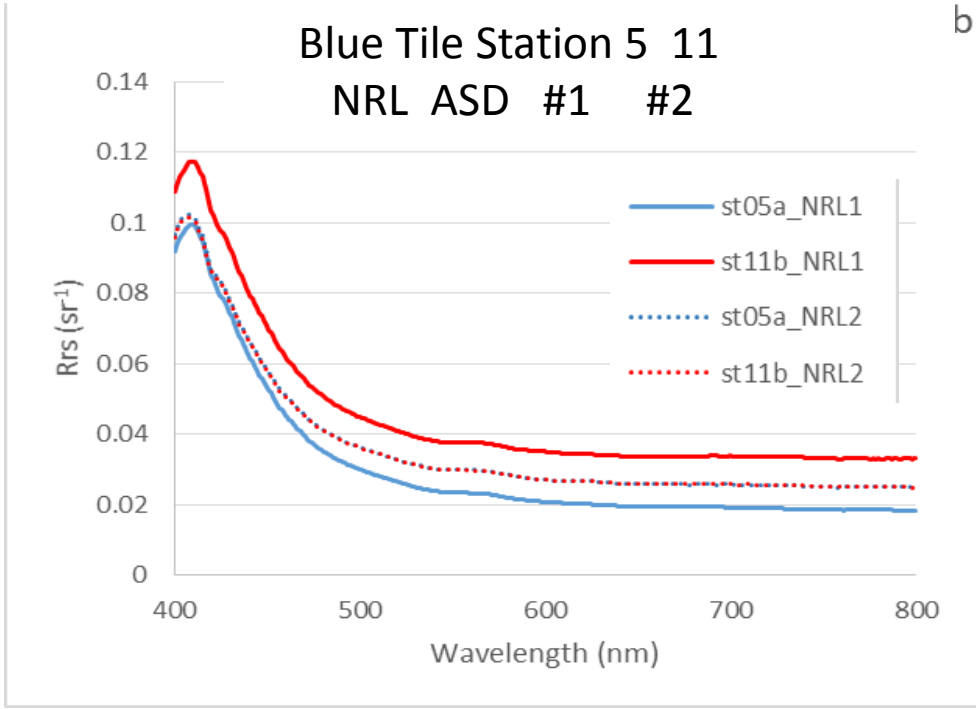
ASD –
St – 1,2,3,4
5,6,7,8a,b,9
10,11,12,13,



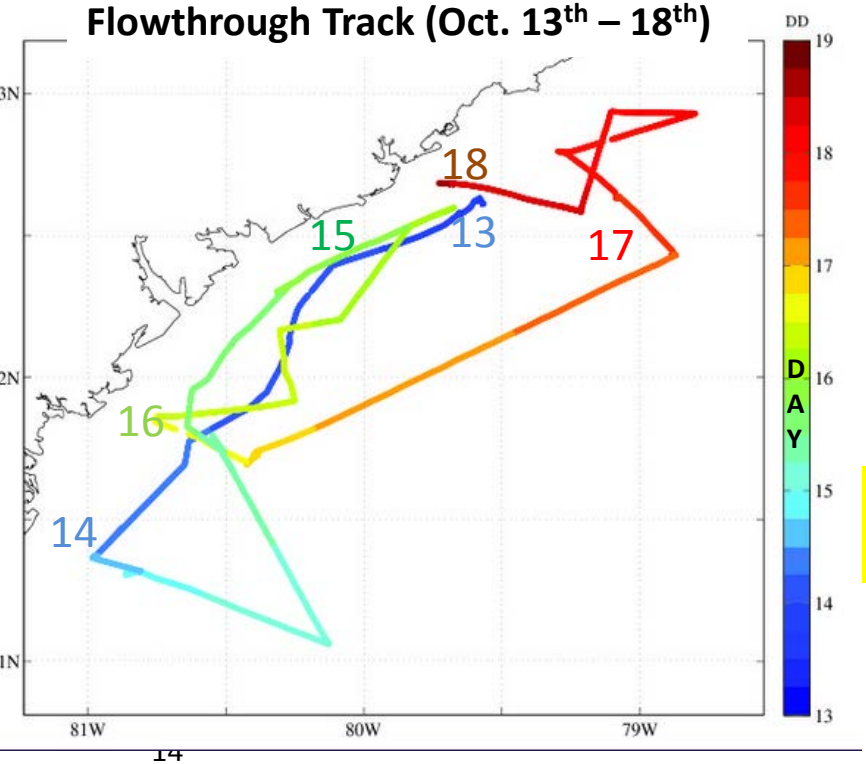




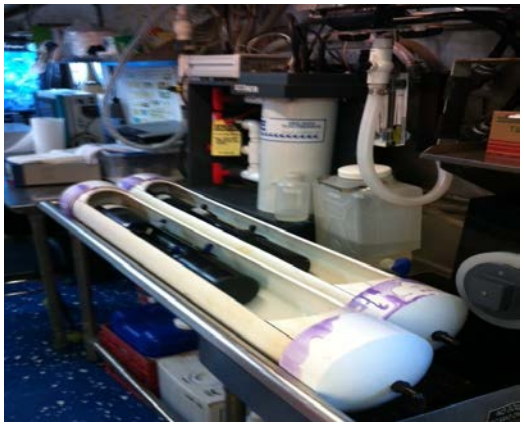
- 2 blue tile stations for 2 NRL ASDs (1,2) for 2 stations (5a,11b).
  - #2 - Consistent at both
  - #1 - Changed



Foster 2016 Flowthrough → absorption (Acs), backscattering bb



Spectral Absorption and Scattering IOP



Acs Filtered and Unfiltered

A. Validate VIIRS Inherent Optical Properties Spectral total absorption → at 410,443, 486, 551,671

B. Continuous underwater measurements from flowthrough defined the spatial optical variability at stations.

C. How did the optics change within a VIIRS Pixel? Needed for pixel calibration !

D. Identified the Spatial variability at the time of Overpass

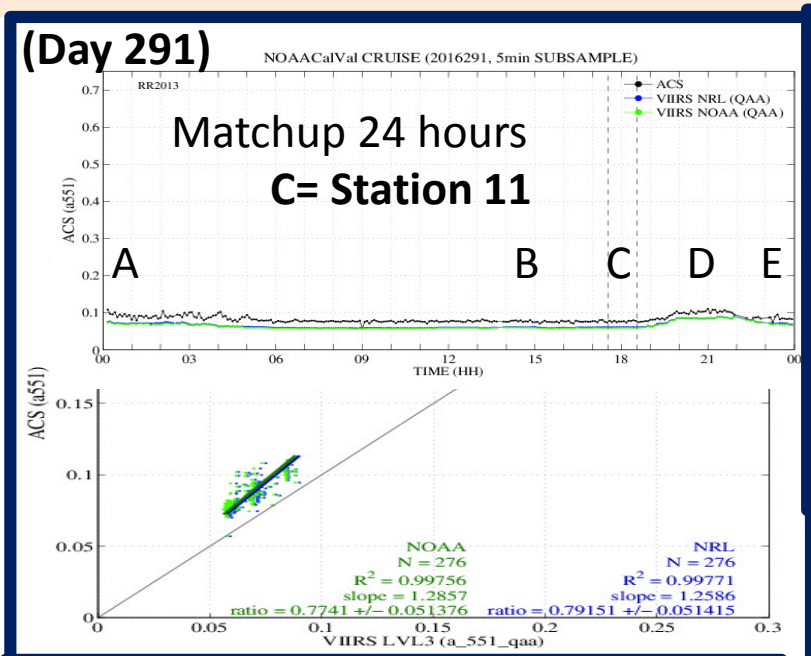
E. Established protocols for acs – Scattering Comparison of Scatter Correction : using Rudiger RR -

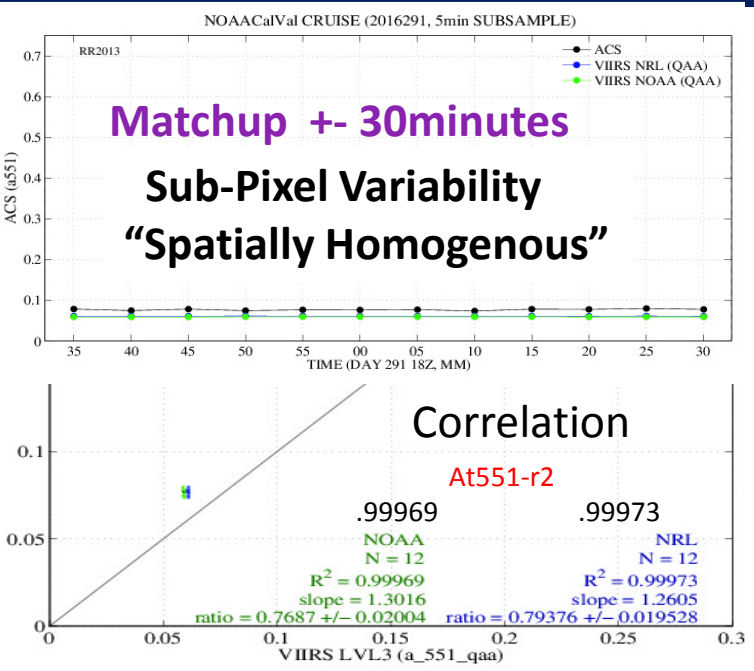
F. VIIRS Validation Matchup done for the 24 hour Day and +- 30 minutes of overpass.

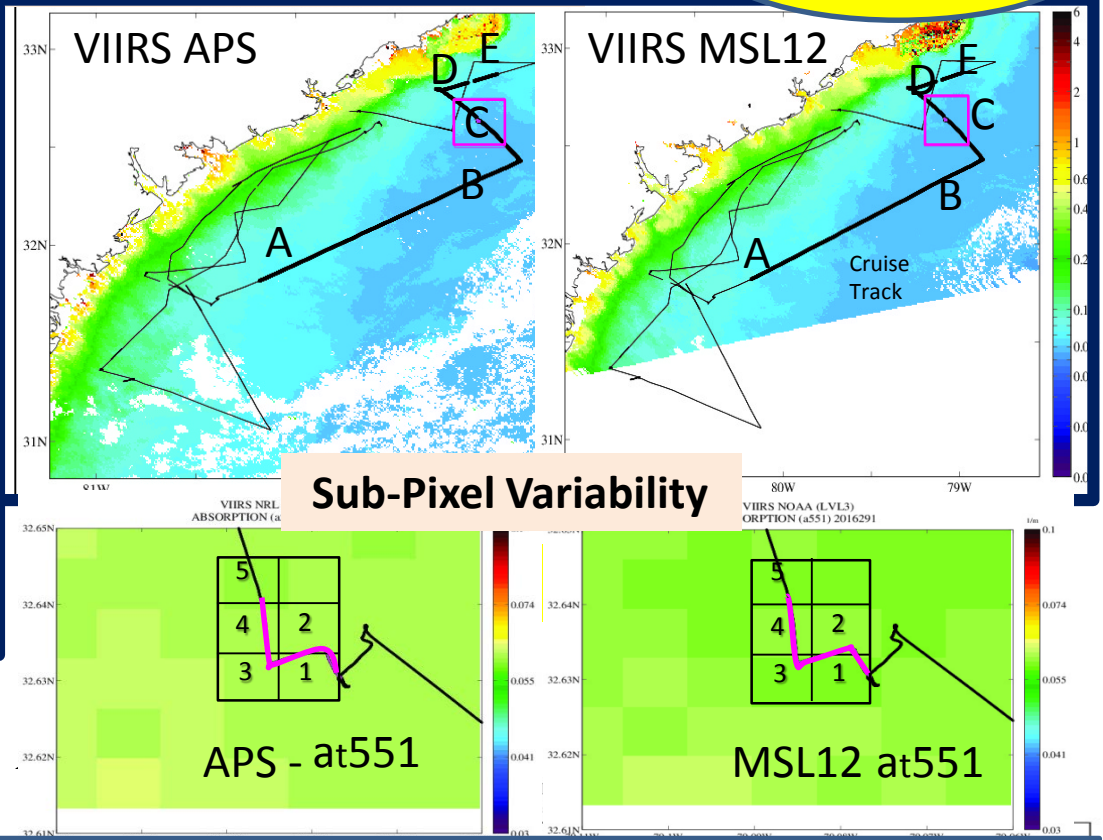
Poster - Evaluation of SNPP VIIRS Inherent Optical Properties during the 2016 NOAA Cal/Val Cruise – Ladner, Arnone, Goode, Anderson

Mar 17,2016 Flowthrough Total Absorption at 551

(Day 291)







Station 11 - Excellent Matchup- Spatially Consistent

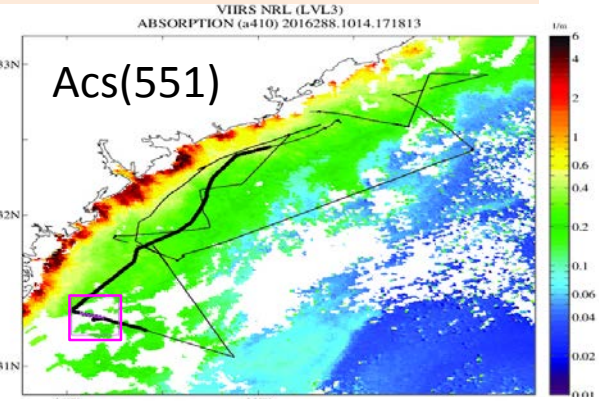
+- 30minutes

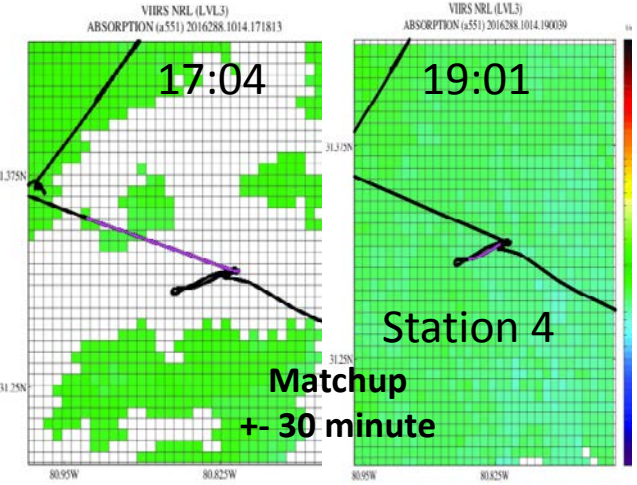
Station 11 VIIRS-Total Absorption R_2

	MSL12	APS
410	.99724	.99744
443	.99768	.99839
486	.99869	.99915
551	.99969	.99973
671	.99992	1.0

Foster 2016 Matchup Flowthrough IOP absorption

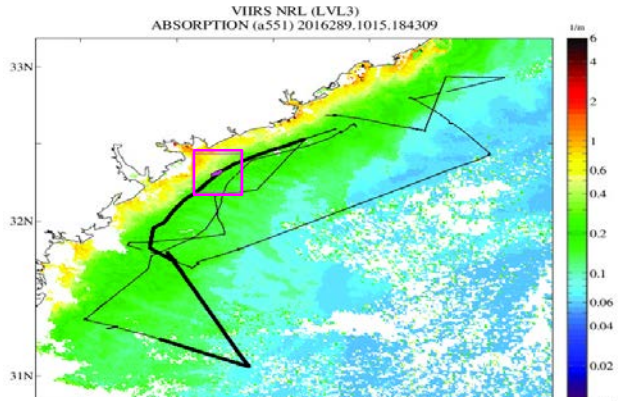
Day 288 - Oct 14 , 2017

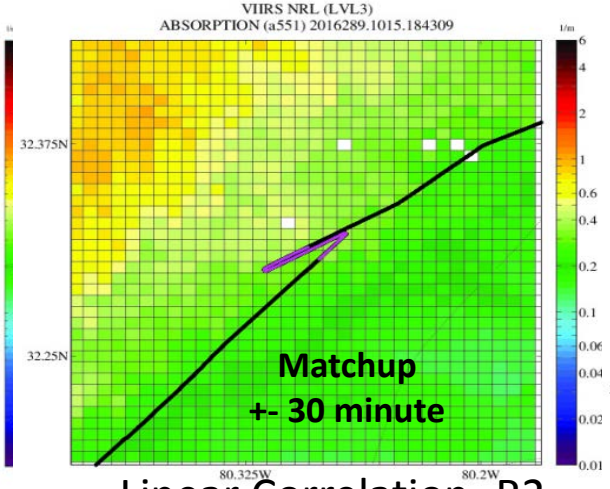




Total Absorption 551 St4		
Day 288 St 4 Oct 14		
	APS R2	
	17:04	19:01
410	.99744	.99829
443	.99883	.999
486	.99987	.9994
551	.99985	.99963
671	.99995	.99997

Day 289- Oct 15, 2017

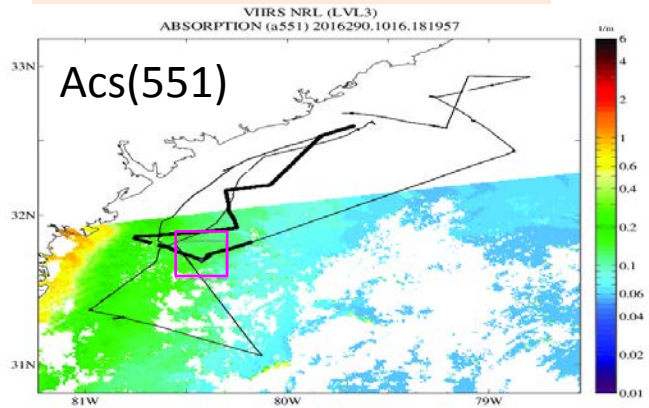


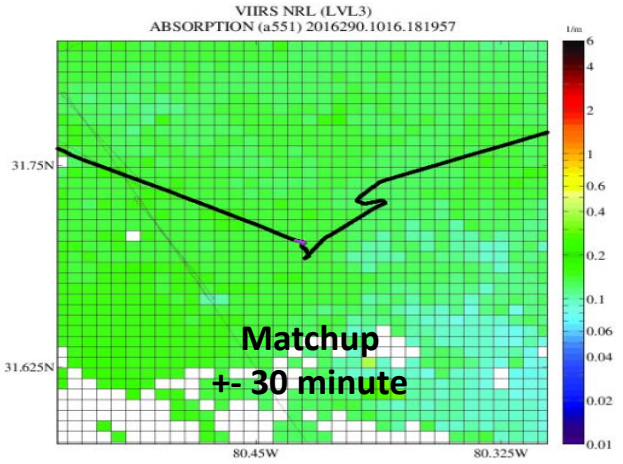


Linear Correlation- R2

Total Absorption 551 – St 5		
Day 289 18:42 Oct 15 R2		
	MSL12	APS 17:06
410	NA	.98689
443	NA	.98587
486	NA	.98526
551	NA	.98458
671	NA	.99497

Day 290- Oct 16, 2017

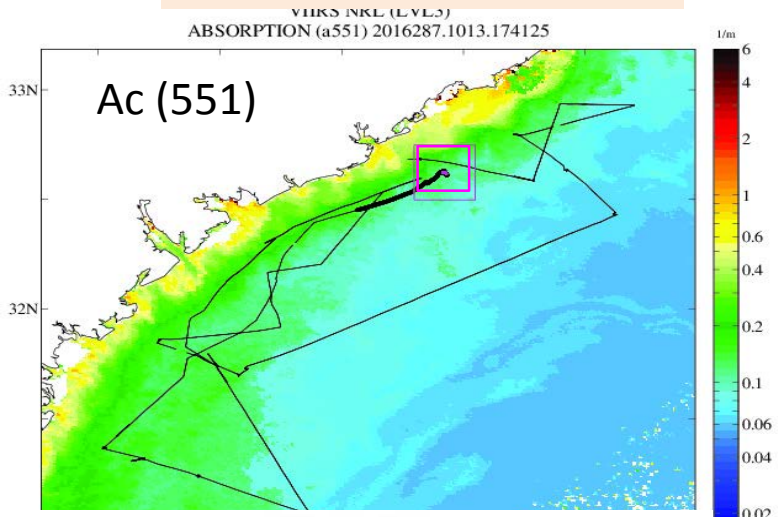


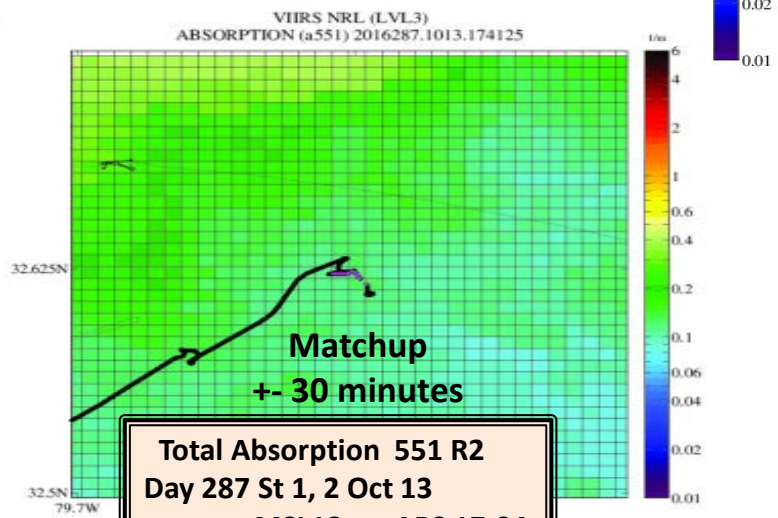


Total Absorption 551 –St 9		
Day 290 - Oct 16 R2		
	APS 19:01	MSL12
410	.99568	clouds
443	.99614	
486	.99602	
551	.99729	
671	.99979	

Foster 2016 Matchup Flowthrough IOP absorption

Oct 13 , Day 287 First

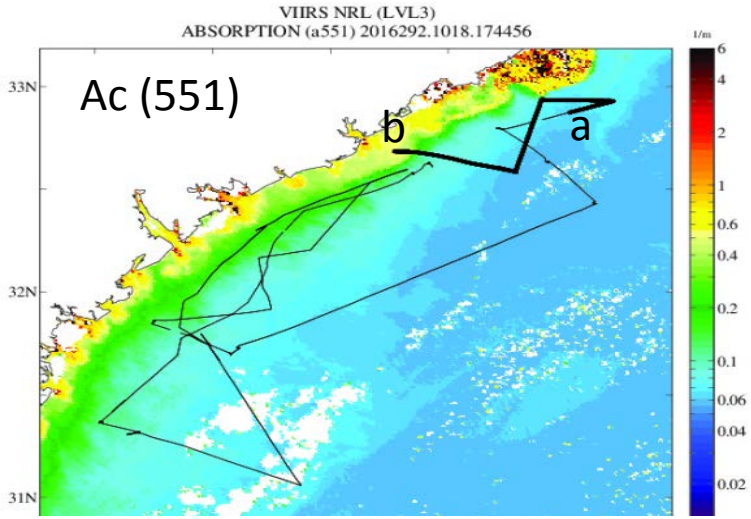




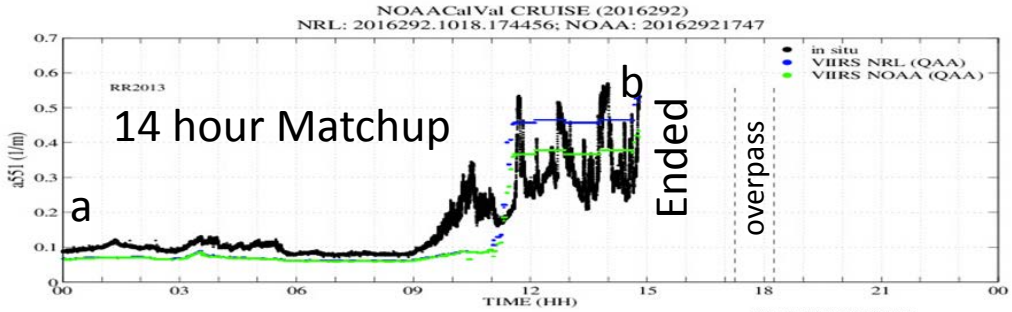
Total Absorption 551 R2
Day 287 St 1, 2 Oct 13

	MSL12	APS 17:04
410	.99994	.99889
443	.99994	.99912
486	.99991	.9916
551	.99991	.99923
671	1.0	.99996

Oct 18 , Day 292 Last

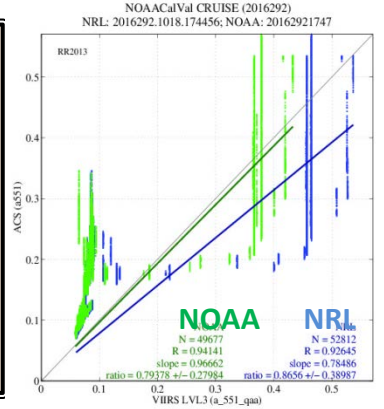


No matchup at Time of Orbit



Total Absorption 551 R2
Day 292 Oct 18 17:47
total 14 hours prior

	MSL12	APS
410	.93352	.93895
443	.94208	.93185
486	.93405	.92439
551	.94141	.92645
671	.94235	.93352



Enhanced Potential VIIRS

New VIIRS – Orbital Overlap
Valid Data
Diurnal Changes in ocean color
~ 100 minutes

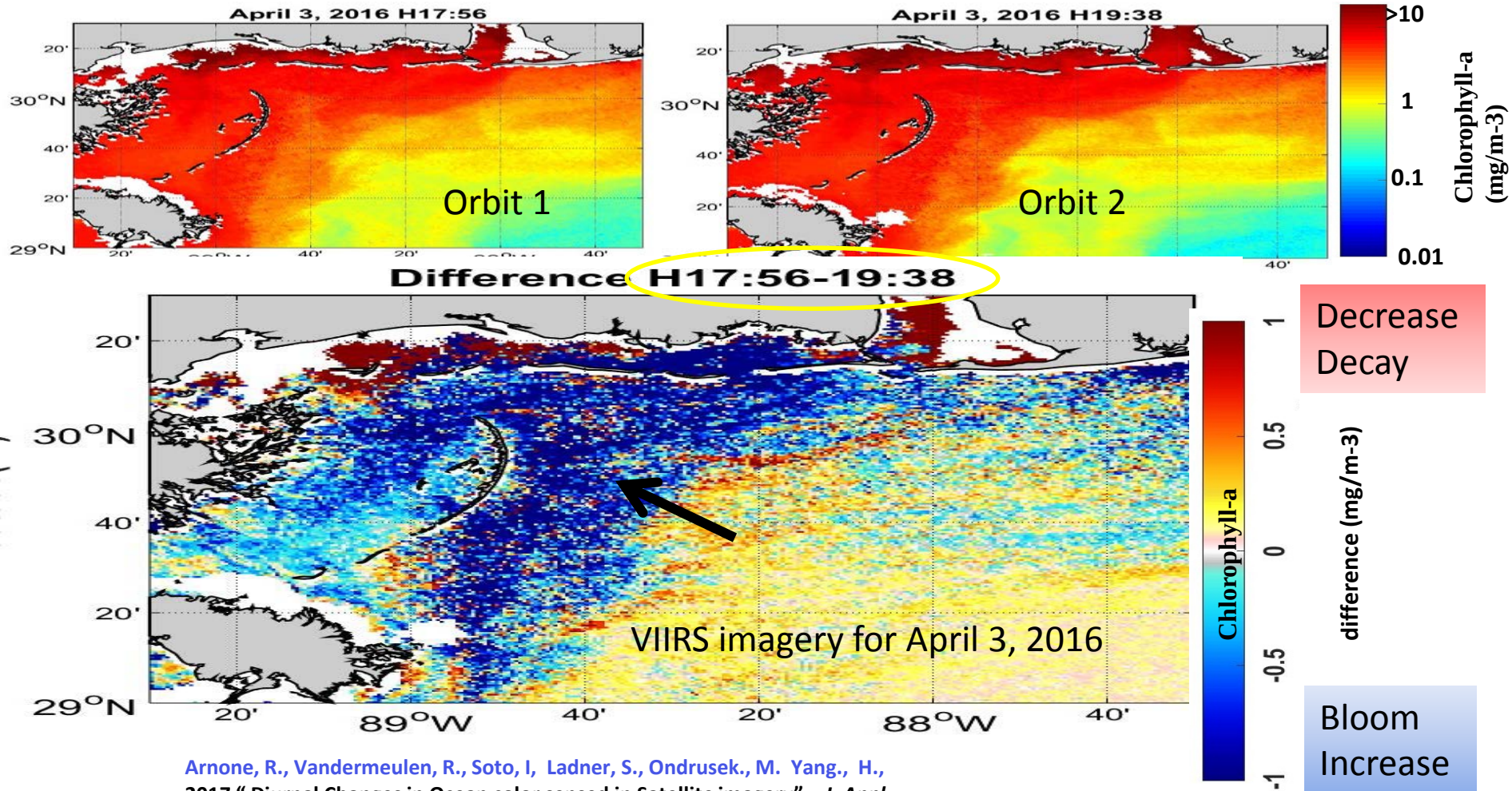
Can affect the Matchup time

Enhanced Products Diurnal Changes from VIIRS Orbital Overlap

What Can Cause Diurnal Color change ?

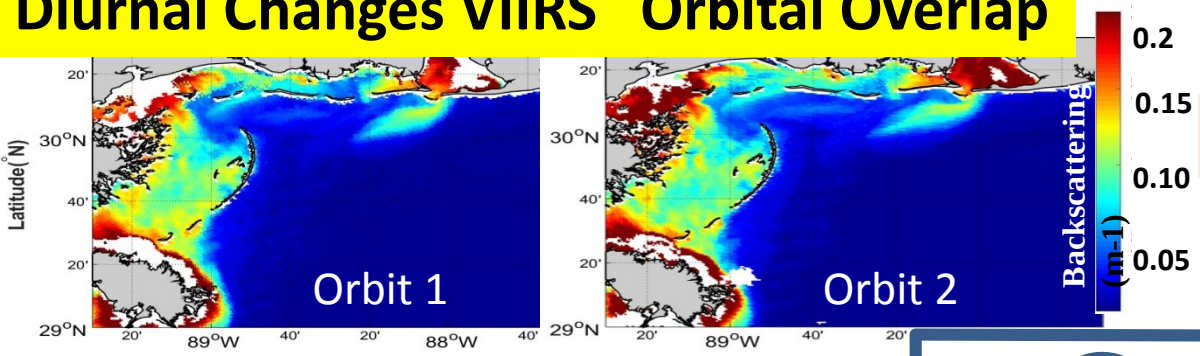
New - VIIRS Difference Products

1- Advection of Water masses - Estimate the surface "currents" →(Max Cross Correlation)
2- Biological Bloom or Decay , Particle Resuspension
3- Vertical Movement of optical layers - Upwelling and Downwelling
- Phytoplankton Migration (HAB detection during the day)



Arnone, R., Vandermeulen, R., Soto, I, Ladner, S., Ondrusek., M. Yang., H., 2017 " Diurnal Changes in Ocean color sensed in Satellite imagery", *J. Appl. Remote Sens*. 11(3), 032406 (May 09, 2017). doi:10.1117/1.JRS.11.032406

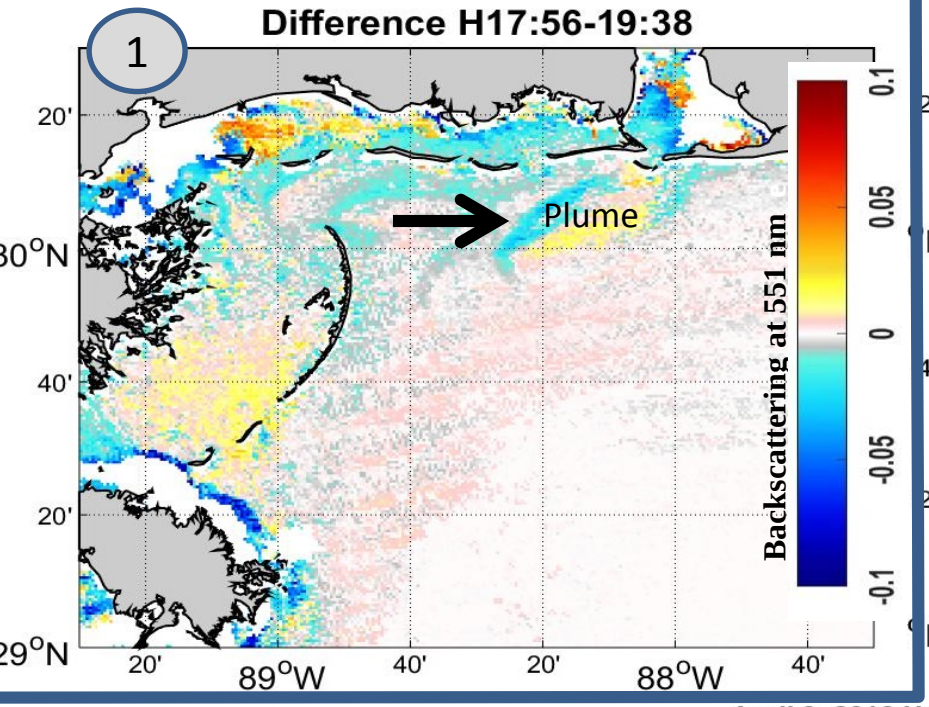
Diurnal Changes VIIRS Orbital Overlap

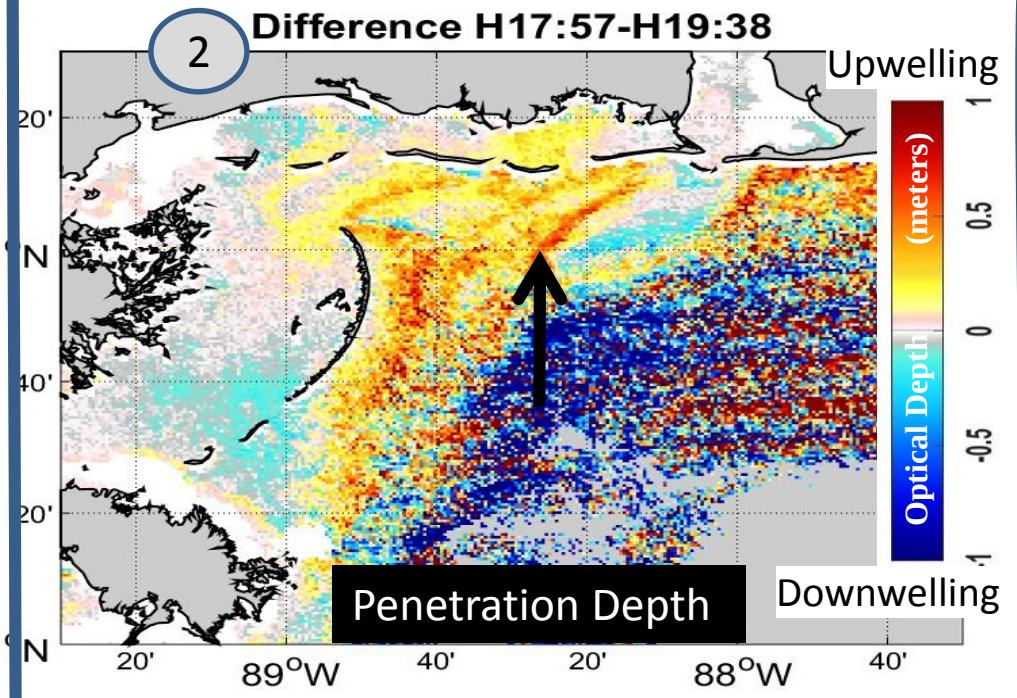


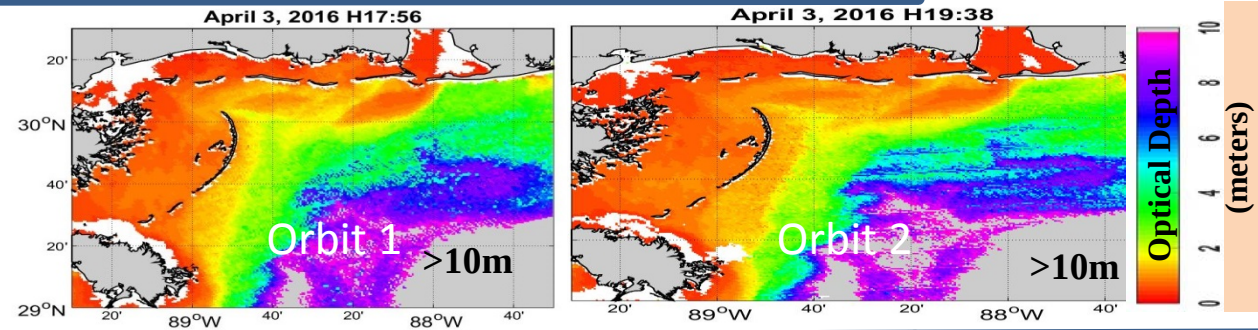
VIIRS Difference Products

1- Backscatter 551 : Particles

2- Satellite Penetration Depth



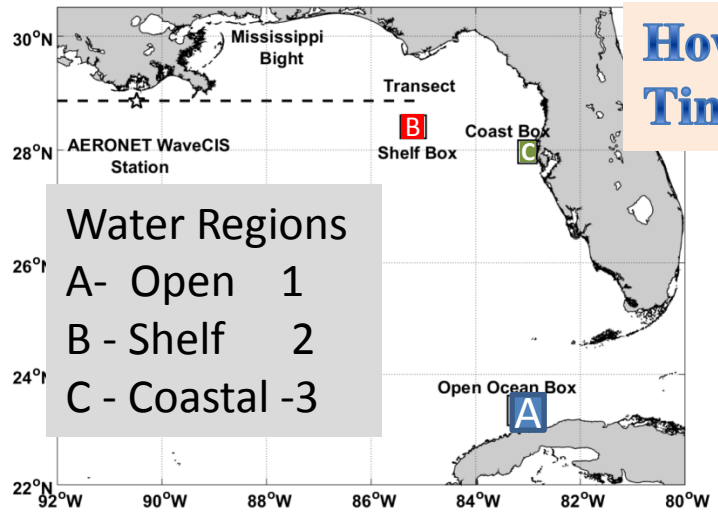




VIIRS Product
Vertical Migration Depth
Within 100 minutes

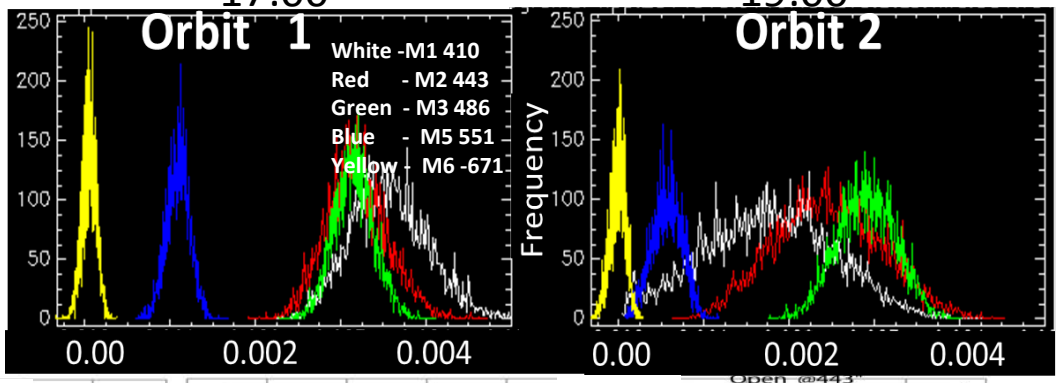
Mobile Plume

How does the Difference Products change Seasonally? Timing of VIIRS Overpass can affect the Ocean Color

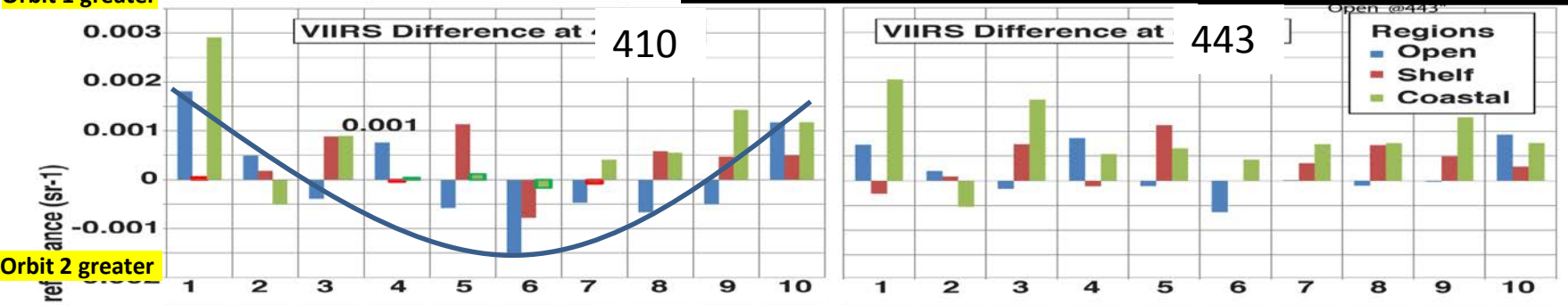


Water Regions
A- Open 1
B - Shelf 2
C - Coastal -3

~17:00 ~19:00

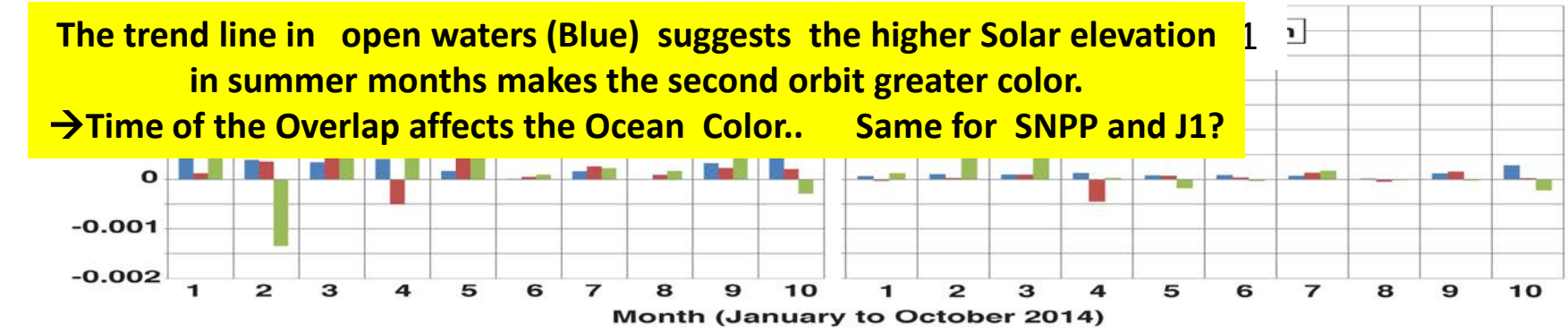


Orbit 1 greater



Orbit 2 greater

The trend line in open waters (Blue) suggests the higher Solar elevation in summer months makes the second orbit greater color.
→Time of the Overlap affects the Ocean Color.. Same for SNPP and J1?



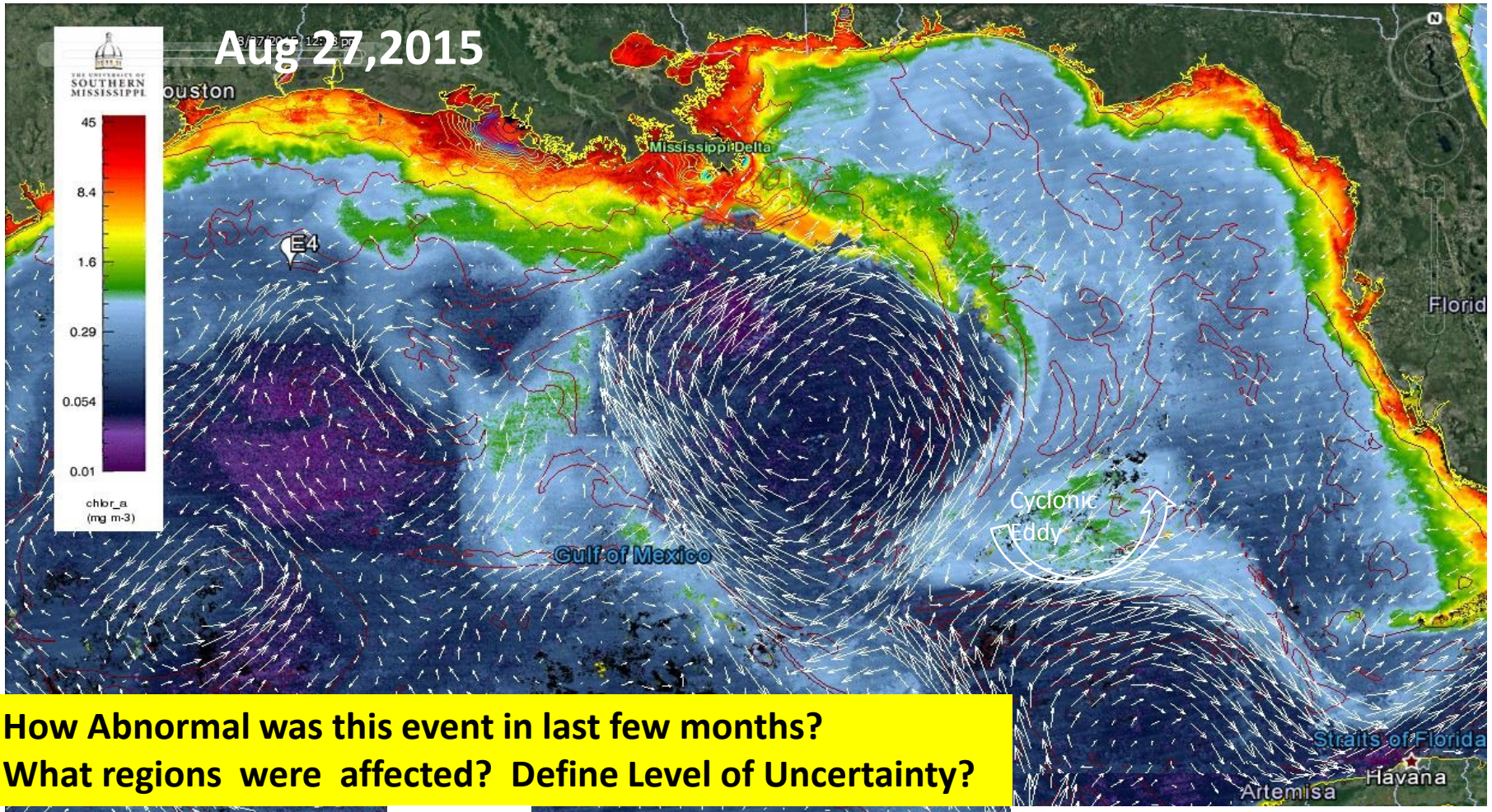
The diurnal difference (orbit 1- orbit2) VIIRS nLW spectral channels (A410, B 443, C551, D671) month 2014

Enhanced VIIRS Products

Identifying Events using VIIRS and Am Seas Model

Events- Mississippi Plume to Key West LOOP Current

Physical and bio-optical Changes to Detect Events and HOTSPOTS



How Abnormal was this event in last few months?
What regions were affected? Define Level of Uncertainty?

Poster

Daily Chlorophyll and Surface Currents and Salinity Contours?

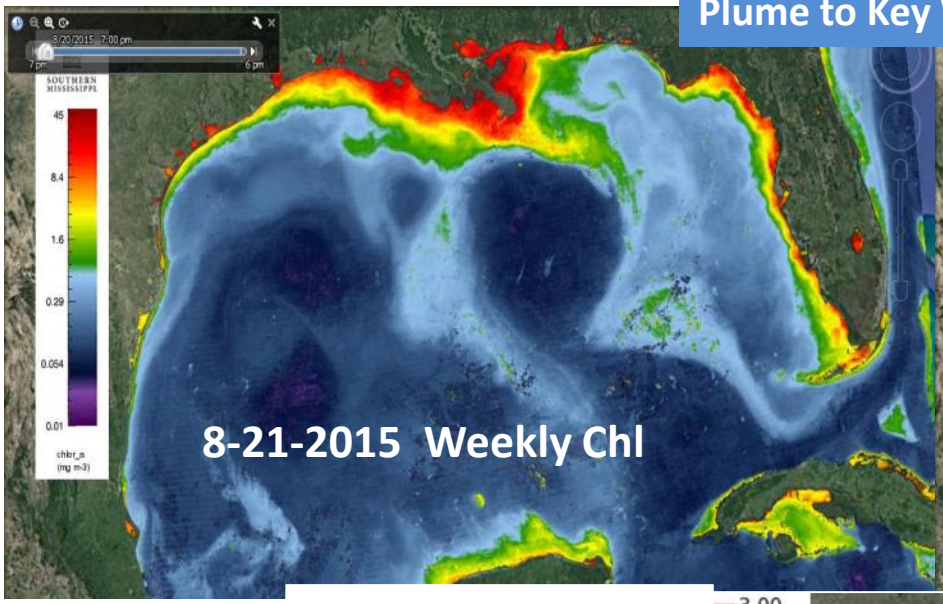
R. Arnone .B. Jones " Monitoring abnormal bio-optical and physical properties in the Gulf of Mexico ", *Proc. SPIE* 10186, Ocean Sensing and Monitoring IX, 101860O (May 22, 2017); doi:10.1117/12.2266789; **http://dx.doi.org/10.1117/12.2266789**

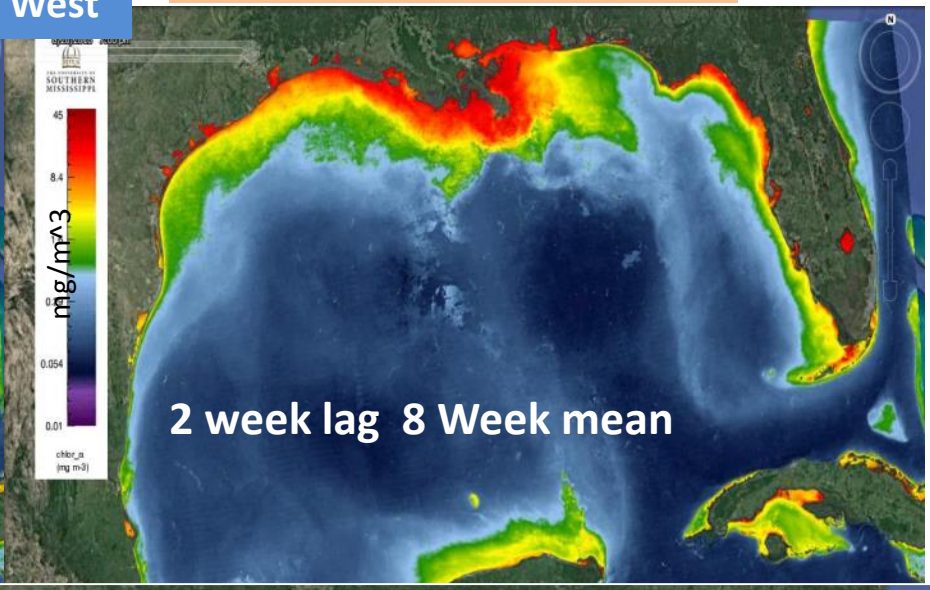
Defining Dynamic Anomalies Properties –DAP

Where are the abnormal Hotspots in 8-21- 2015

Chlorophyll Hotspots

Plume to Key West





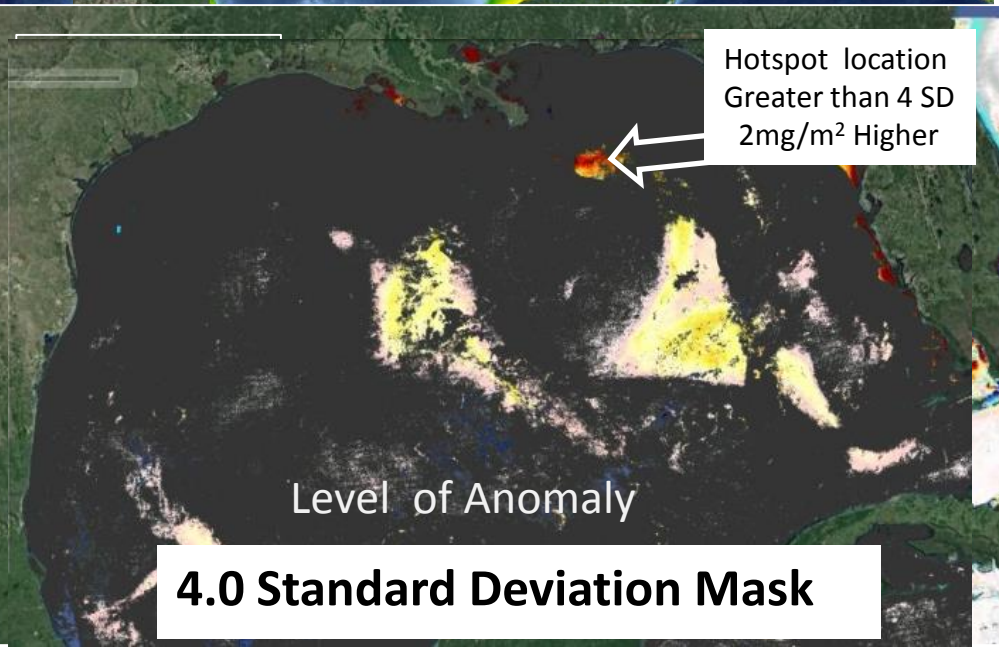
Higher

Normal

Lower

Mg/m²

3.00
1.50
0.00
-1.50
-3.00



Difference

Need to determine the Level of the Anomaly - by a mask of the Standard Deviation

How Abnormal Condition affect the Ecosystem

Coupling Satellite and Ocean Models

VIIRS Products and
America Seas Model

Anomaly Products

Plume to Key West Event Sept 21- 2015

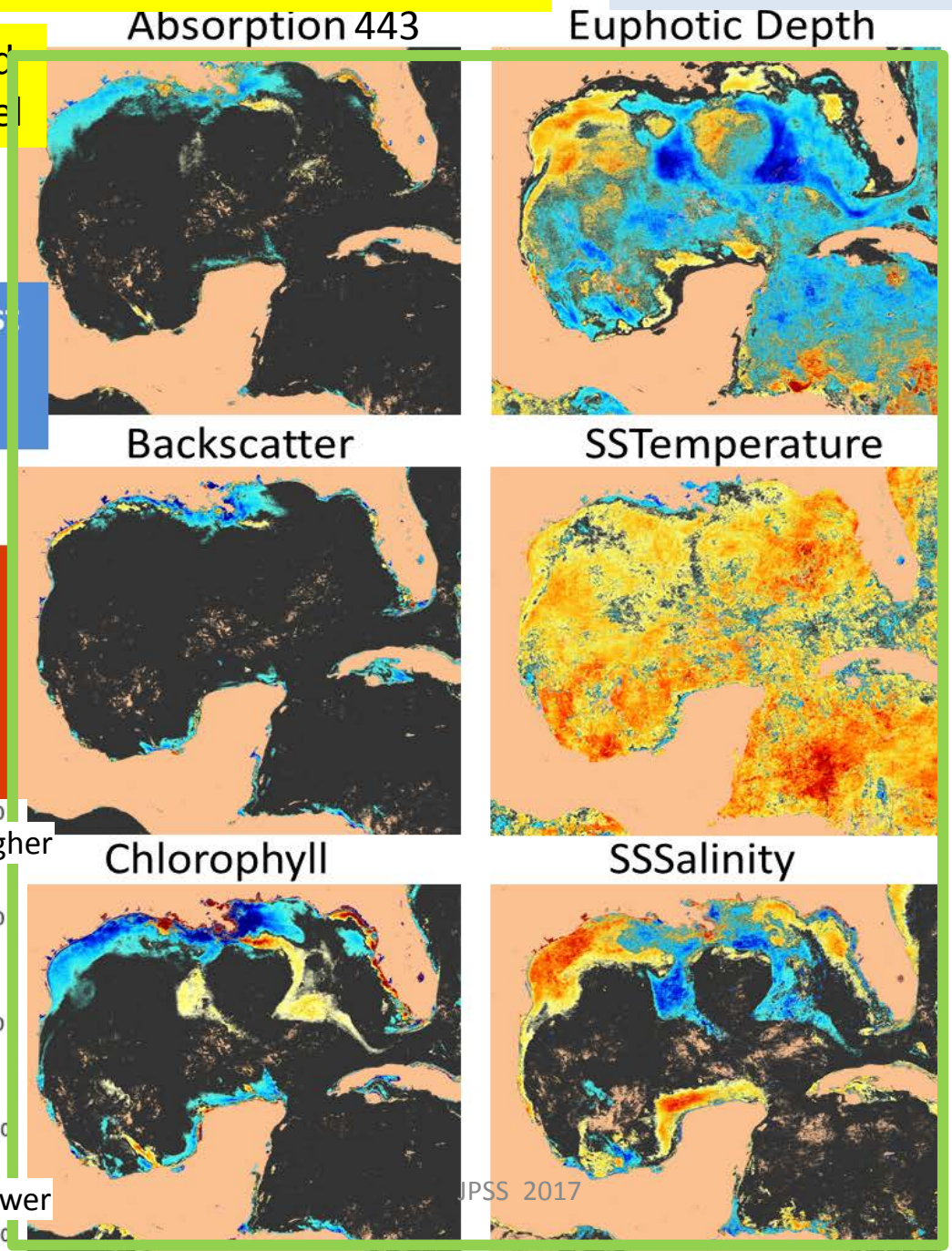
Products

Anomaly

One St-Dev

Weekly
8Week Avg
Anomaly
Stand Deviation

Animation

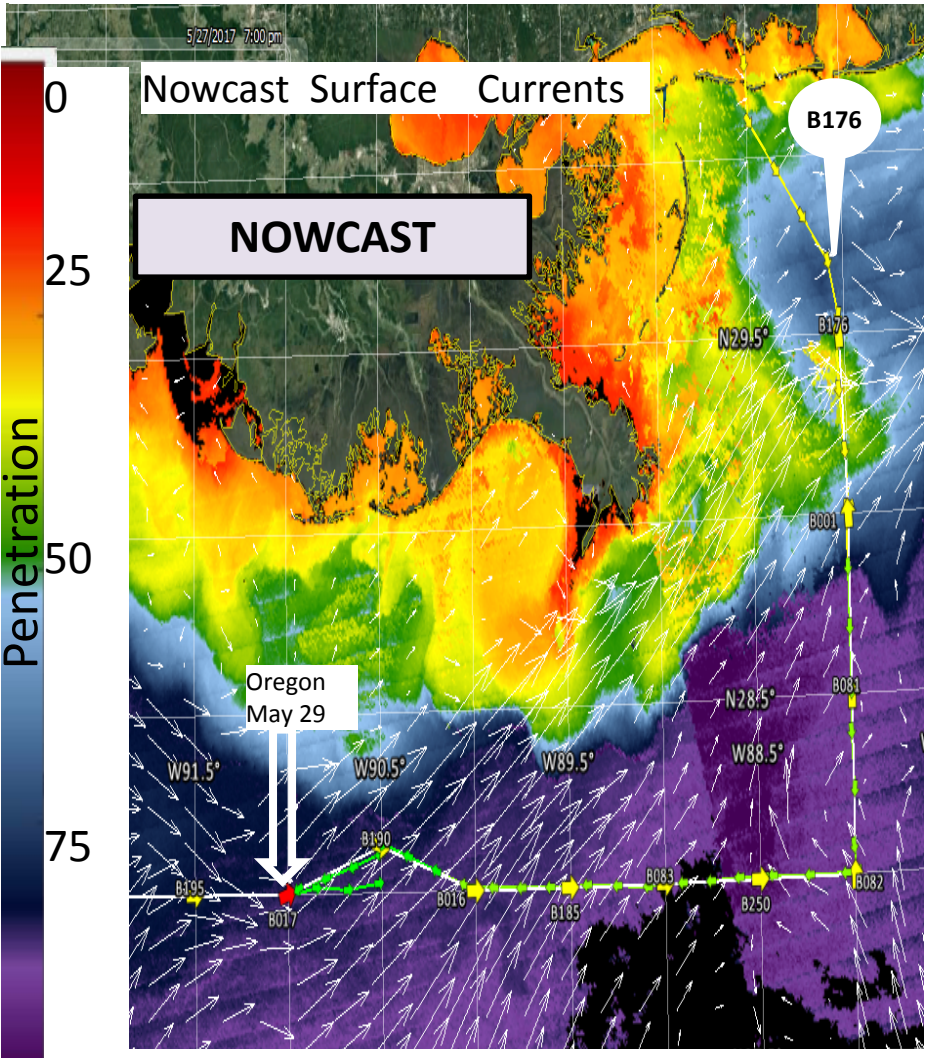


Oregon & Foster Cruise Fishers -- Tuna

Abnormal Patches of more clearer and turbid waters.

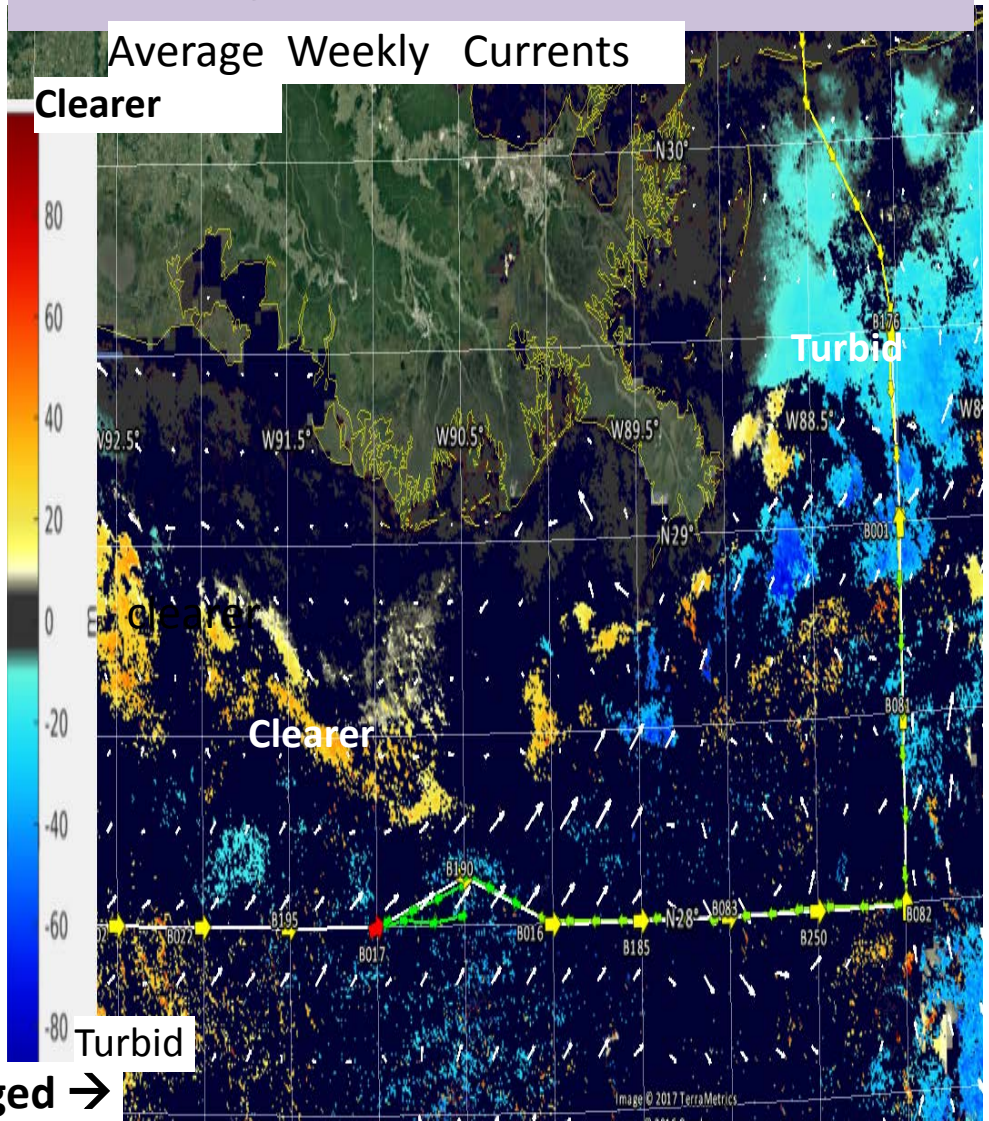
Water Clarity – Euphotic depth

VIIRS Water Clarity May 27



VIIRS Water Clarity Anomaly May 17-24

SD MSK1



Is this typical? What is Different / Changed →

Oregon & Foster Cruise May 2017 Salinity

Nowcast Surface Currents

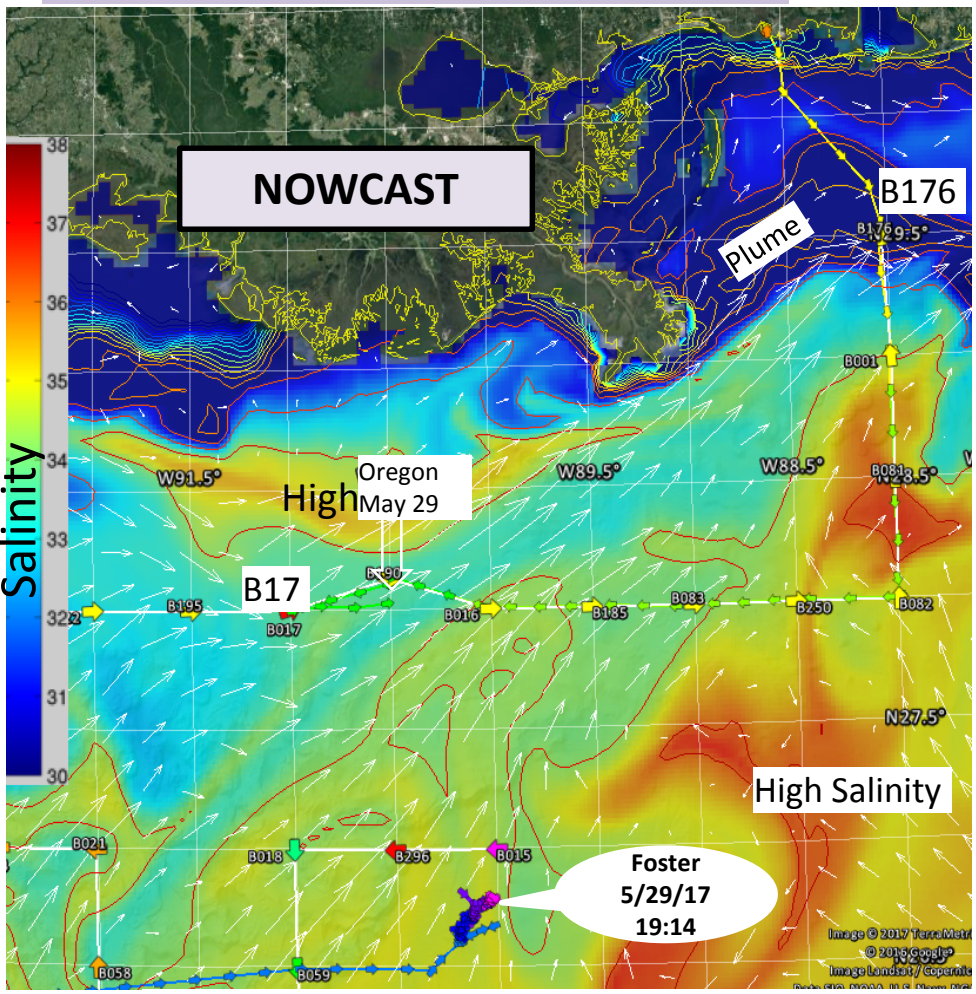
MS plume to EAST

MS- Plume at B176

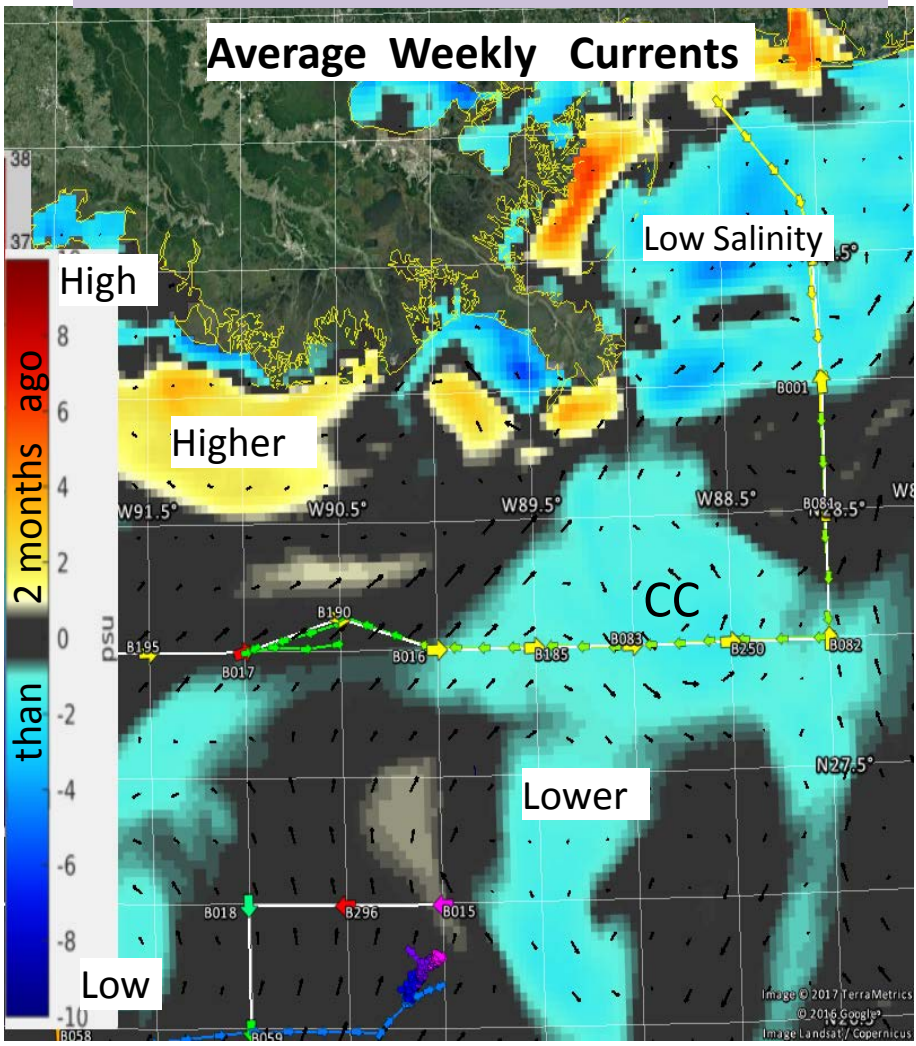
LA- Coast has high Salinity region

Lower Anomaly salinity regions - B176, B185-B082

Surface Salinity May 27



Anomaly May 17-24 SD MSK1

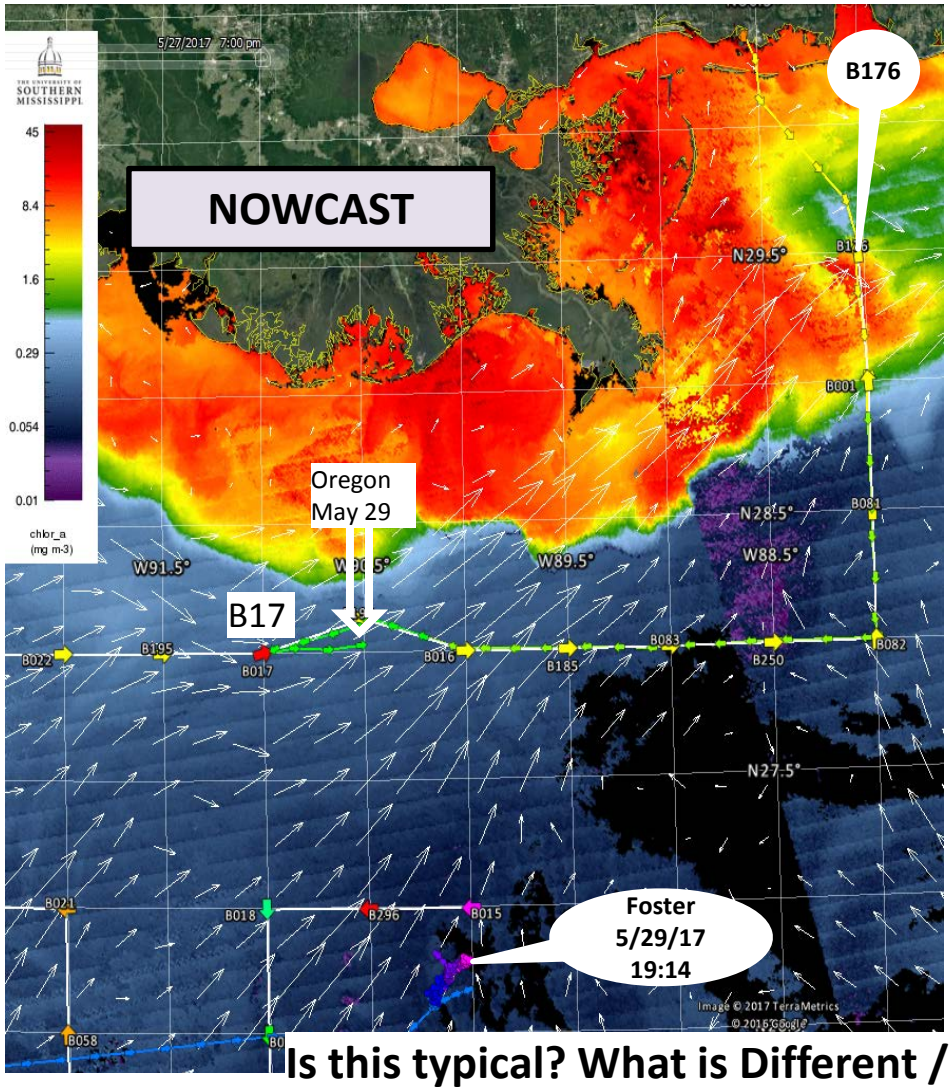


Is this typical? What is Different / Changed

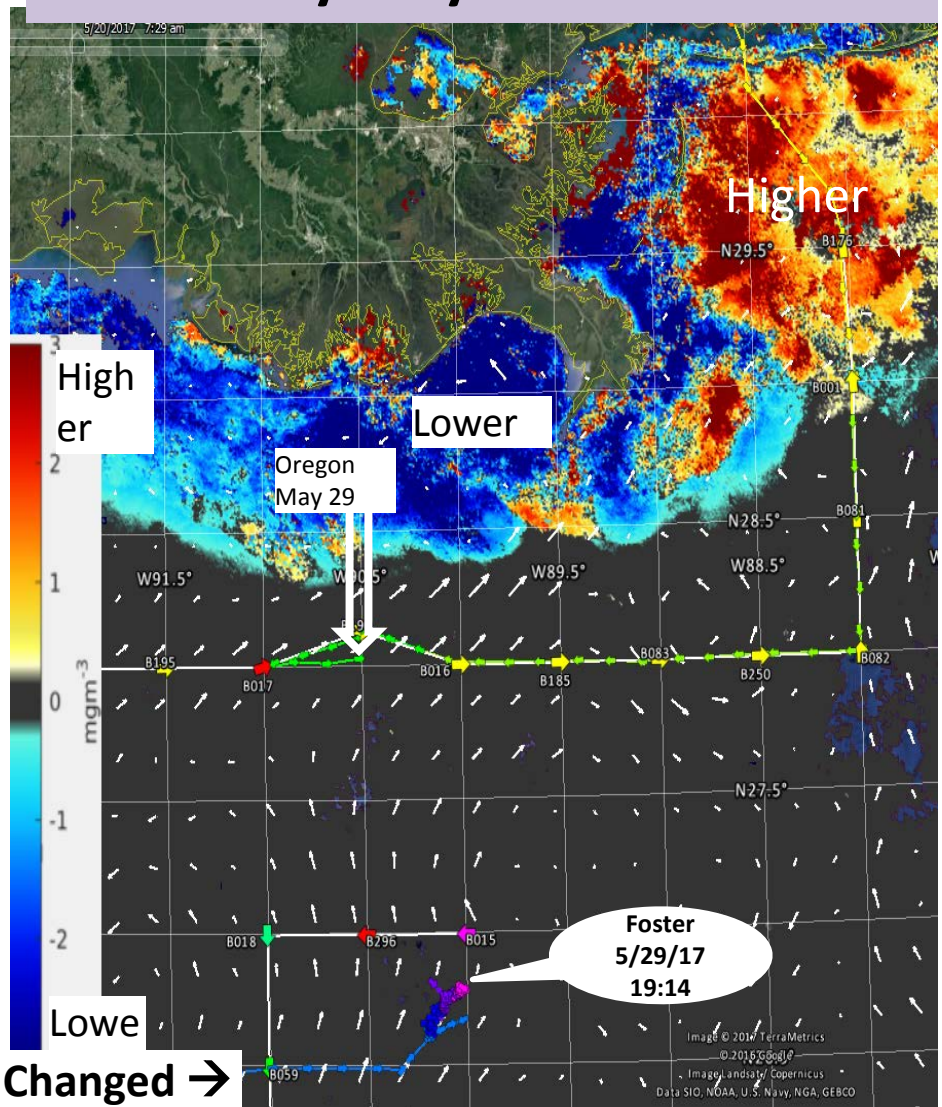
Oregon Foster Cruise
May, 2017 Chlorophyll

Chl- Extending Offshore ! Anomaly Chlorophyll -
Lower along LA coast -
Higher along MS coast

Chlorophyll May 27

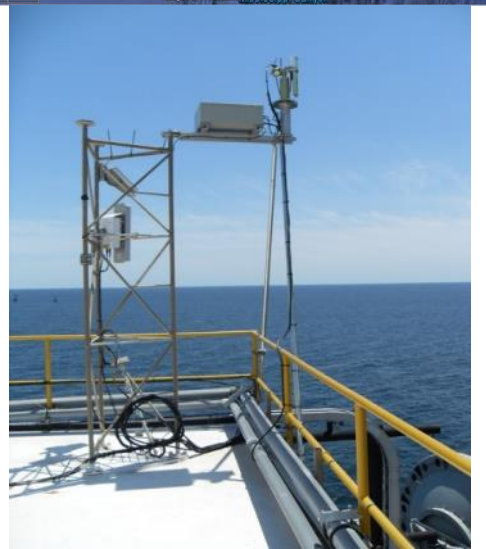


Anomaly May 24- 17 SD MSK1



Is this typical? What is Different / Changed →

Annual Status of WavCis CSI SeaPrism Status Operational -- June 2016- – Aug 2017 SN 610 and SN 638



Instrument Update and Present Status:

A . New Owners of ST52B purchased this platform in November of 2016, new boarding agreement in place by end of March, 2017.

B. SN610 - Operational to Sept 2016 and replaced with SN638 Loaner.

C. SN638 – Operational to May 8, 2017, and replaced with SN610. Returned to NASA recalibrated SN638.

ALL data upgraded to Level 2.

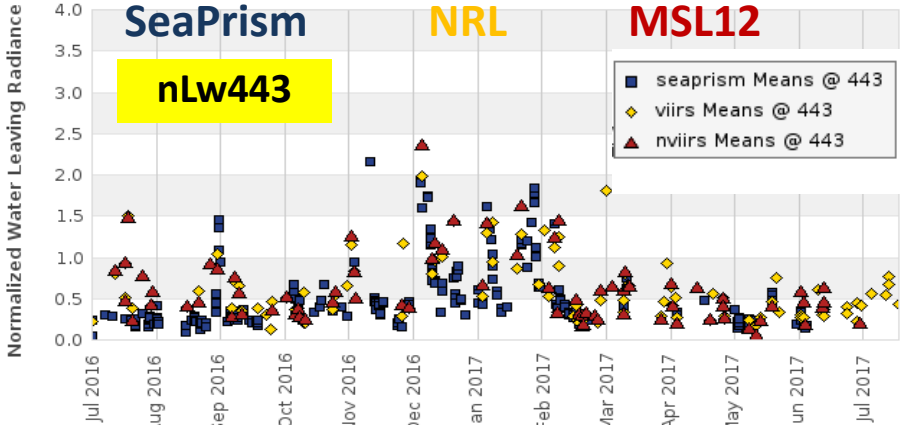
D. ***Problems/ Issues this year 2017.***

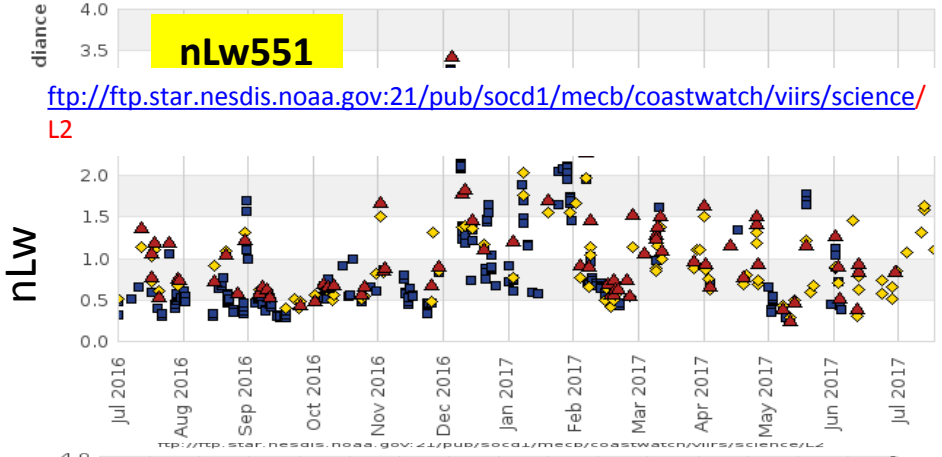
1. April 10th, platform generators down, replaced both battery chargers, main batteries and computer power supply. Site repaired and running.
2. April 30th Platform Lightning strike . Replaced Serial communications on SN 638, PC Serial Data cable and USB RS 232 Port hub. Computer cooling and other subsystems repaired. Back up and verified via the Aeronet Web site.
3. May 26th- SeaPrism time data was not being updated. Corrected problem by installing latest HTTP CIMEL program.
4. SN 638 returned from Goddard in early July, 2017.
5. Presently, main battery might be dead (last replaced in 2013), delays due to bad weather. Sn 638 will be reinstalled ASAP and SN 610 will be returned to NASA. Check Filter Wheel motor.

WaveCIS –CSI "nLw" Operational FULL Time Series

July 2017 – July 2017

lwn_f/Q





CSI Site Matchups this Year

262 points for WaveCIS (4-6 readings/day)

102 for Navy APS VIIRS,

77 for MSL12 VIIRS

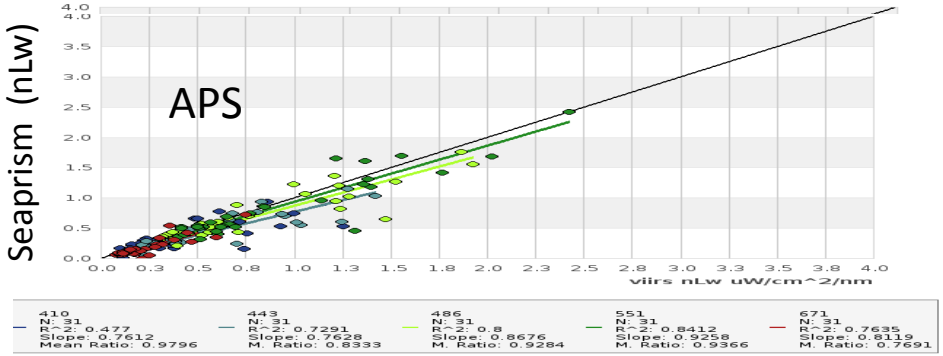
Constraints: Valid

50% of 5x5 box centered around in-situ sensor

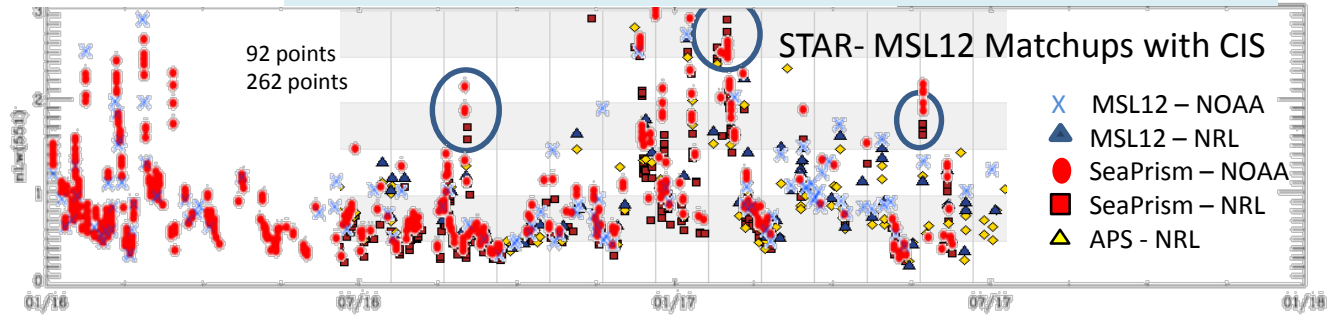
Center pixel valid (WavCis Site Location)

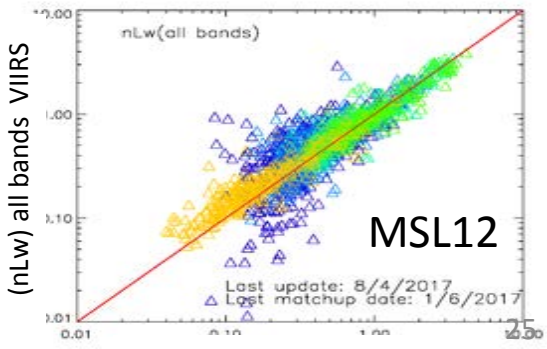
nLw between 0-4

Flagged for CLDICE, HIGLINT, ATMFAIL, PRODFAIL



Note Differences in WavCIS matchup *(MSL12, NRL)*





(nLw) all bands WavCis

Summary

1. Oct 2016 Foster cruise
   Match up with Hyperpros , ASD and Flowthrough
   Coastal waters – *Trichodesmium*
   Protocols for Floating Hyperpro, and IOP-acs

2. Diurnal ocean color using VIIRS Orbital Overlaps - → J1 /NPP Compare
   New VIIRS Difference products. Vertical optical layers , Bloom etc
   VIIRS overlaps support for a Geostationary Sensor !

3. Dynamic Abnormal properties - "Hotspots" using VIIRS and Physical models

4. WavCis – Aeronet Operational and Calibrated at NASA

Thank You

Stennis - Cal val Team
Annual Summary

Invitation: Call for Papers

SPIE – Security and Defense

OCEAN SENSING AND MONITORING X

http://www.spie.org/oceans/
April 15-19, 2018
Gaylord Palms Convention Center
Orlando, Florida, USA

Conference Chairs: **Weilin "Will" Hou**, Naval Research Lab), **Robert A. Arnone**, Univ. Southern Mississippi
Program Committee: **Sam Ahmed**, City College of New York **Linda Mullen**, Naval Air Systems Command **Brandon Cochenour**, Naval Air Systems Command; **Fraser Dalgleish**, Florida Atlantic University); **Chuanmin Hu**, University of South Florida) ; **James Sullivan**, Florida Atlantic University ; **Michael Twardowski**, Florida Atlantic University

Sessions:

A. Ocean Remote Sensing: Lidar, Ocean Color, SST, SAR

active and passive remote sensing of the ocean and atmosphere (visible, IR/SST, microwave/SAR)
inversion techniques for active and passive measurements
calibration and characterization of satellite sensors
cloud screening and effect of ambient/residual cloud on retrievals
Cal/Val, quality control and consistency checks of satellite products, inter-sensor comparisons
uncertainty evaluation
radiative transfer in the ocean and atmosphere

B. In Situ Sensing and Monitoring

C. Extreme Events: Oil Spill & Harmful Algal Bloom (HAB) Sensing and Monitoring

D. Unmanned Systems, Sensors, Measurements

E. Imaging Sensors, Systems and Signal Processing Techniques: Optical & Acoustical

F. Characterization and Forecasting of Oceanic, and Coastal Environments

G. Bioluminescence

Thank You

END