Ensuring Continuity of Coastal Ocean Optical Products in Support of Navy Operations

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Ensuring Continuity of Coastal Ocean Optical Products in Support of Navy Operations – ***Team Stennis***

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  - Vencore, Inc.
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  - University of Southern Mississippi

Ensuring Continuity of Coastal Ocean Optical Products In Support of Navy Operations: *Outline*

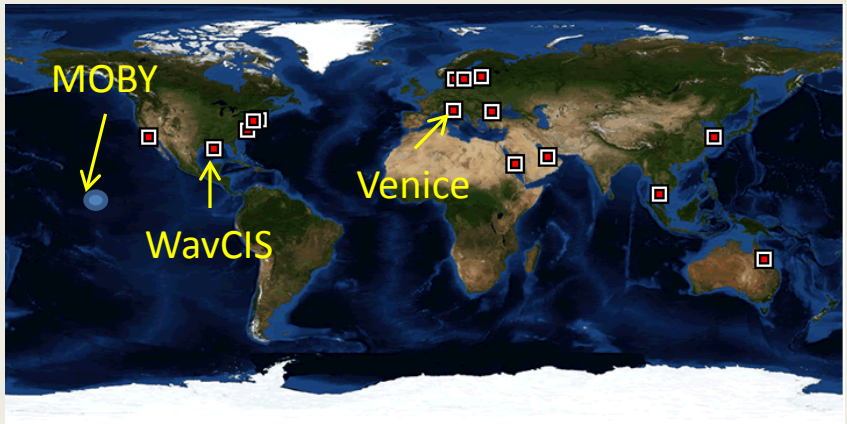
- Continuity and Consistency
- Satellite Processing and Cal/Val Components
  - Automated Processing System (APS)
  - Aerosol Robotic Network – Ocean Color (AeRoNet-OC)
  - Satellite Validation Navy Tool (SAVANT)
- Examples
- Conclusions
- Future Plans

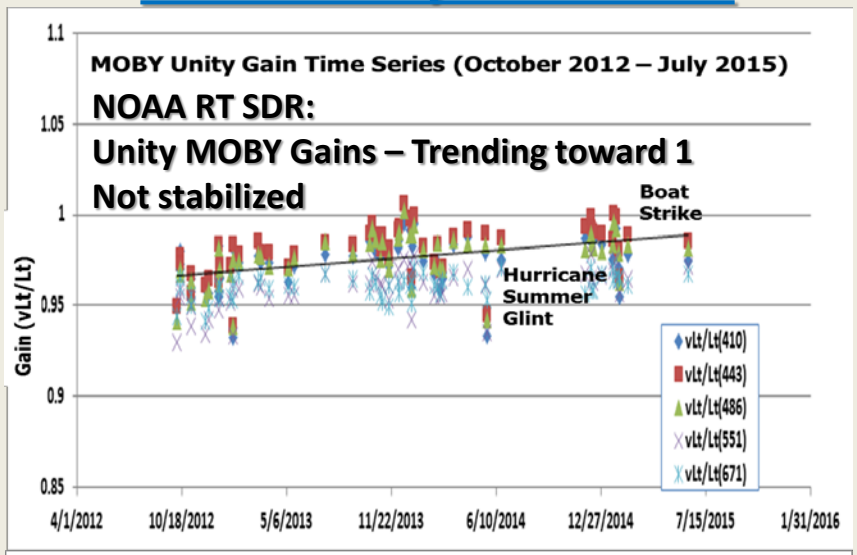
Ensuring Continuity of Coastal Ocean Optical Products In Support of Navy Operations: *Continuity and Consistency*

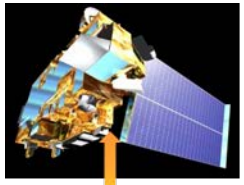
- Continuity refers to maintaining an ocean color asset in space
  - Ocean Color Sensors
    - CZCS -> SeaWiFS -> MODIS -> VIIRS
    - MERIS -> OLCI
  - Channels are similar on each, but not exactly the same
- Consistency refers to calibrating sensors on different platforms, so that the values are identical or nearly so.
  - A product generated from one sensor must agree with a product generated from another sensor
  - On-orbit calibrations do not provide this consistency

Ensuring Continuity of Coastal Ocean Optical Products In Support of Navy Operations: *Calibration/Validation*

15 AeRoNet-OC (ocean color) sites + MOBY





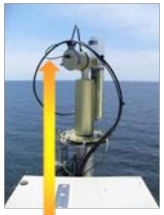


$$\text{Gain} = Lt_{satellite} / Lt_{\text{in situ}}$$

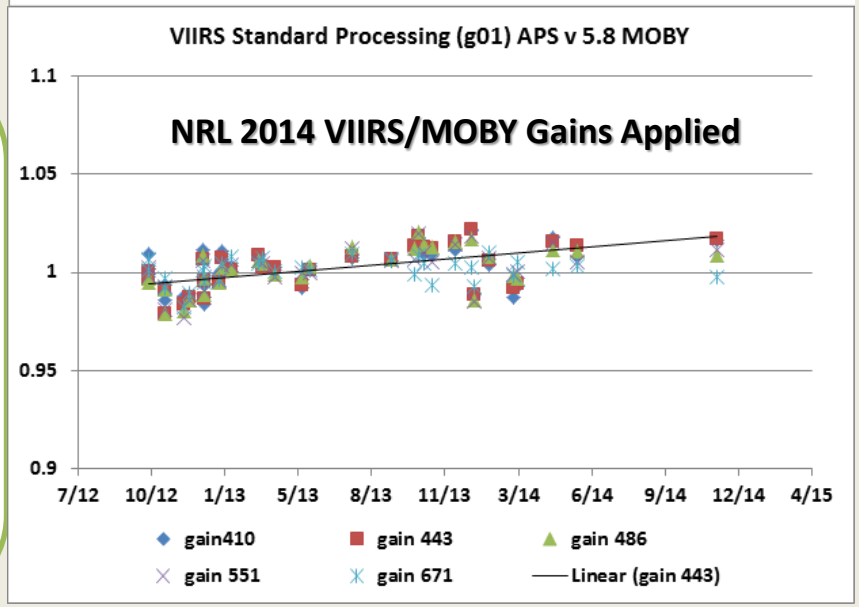
$Lt_{satellite}$
800 km

Atmospheric Correction

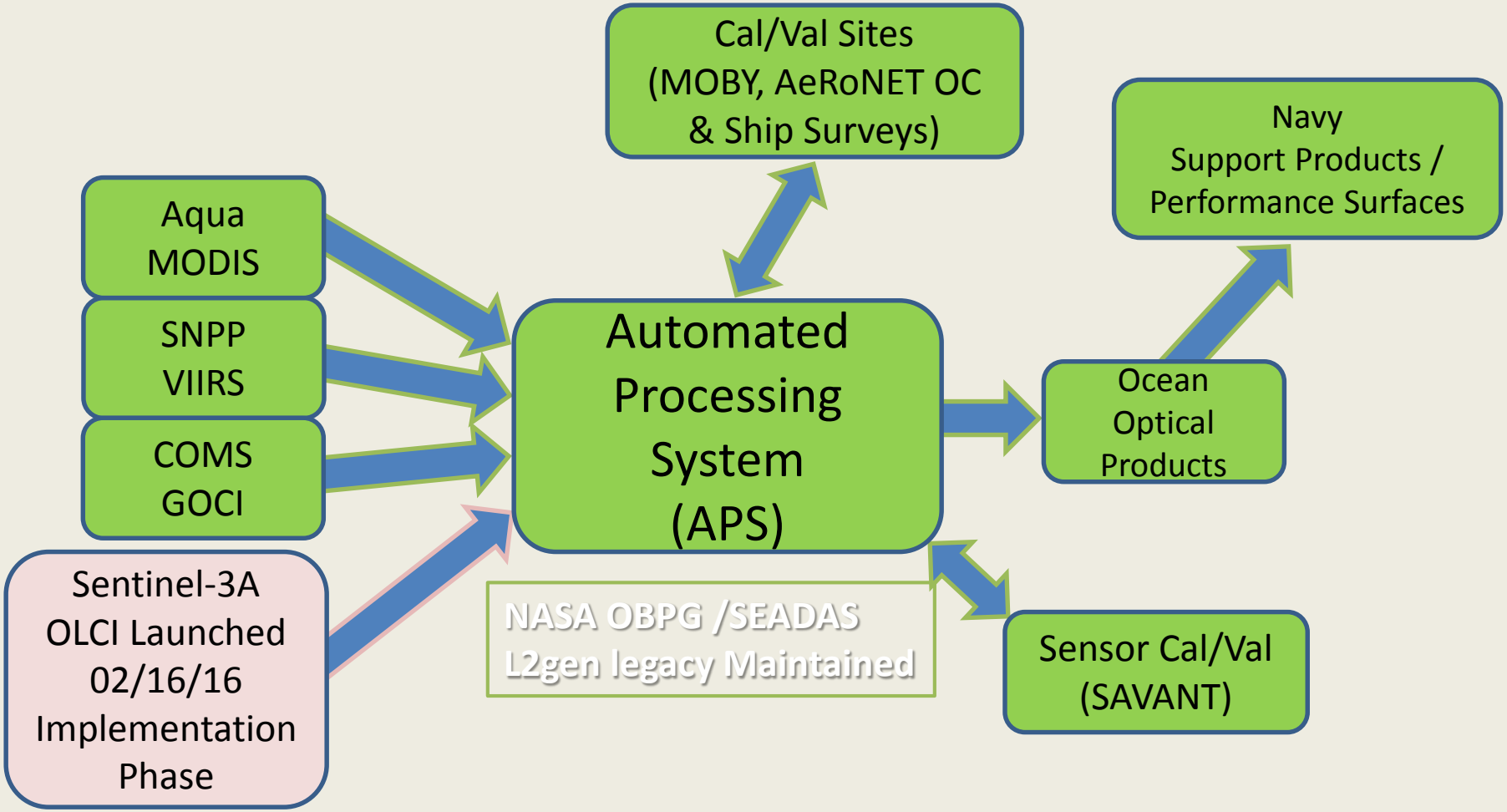
$Lt_{\text{in situ}}$
30 m



Sea Level



Ensuring Continuity of Coastal Ocean Optical Products In Support of Navy Operations: *Processing System*



Operational | **Beta** | **Future**

Ensuring Continuity of Coastal Ocean Optical Products In Support of Navy Products: *Standard Navy Ocean Optical Products*

- Radiances/Reflectances (Rrs)
- Chlorophyll (Chl-a)
- Absorption Coefficients
  - Detrital (Adg)
  - Sediment
  - CDOM
  - Phytoplankton (Aph)
- Backscattering Coefficient (Bb) – Sediment Characterization and Processes
- Diffuse (Kd) and Beam (c) Attenuation Coefficients – Lidar and *Diver Performance Surfaces*
- Suspended Particulate Concentrations
  - Total (TSS)
  - Organic (POM)
  - Inorganic (PIM)
- Euphotic Depth
- Visibility
  - Horizontal
  - Vertical

- IOP's -> Lee's Quasi-Analytical Algorithm (QAA), Hoge and Lyon's Linear Matrix Inversion (LMI).

Ensuring Continuity of Coastal Ocean Optical Products In Support of Navy Operations: *Satellite Validation Navy Tool (SAVANT)*

SAVANT

MOBY, AeRoNet and Satellite nL_ws

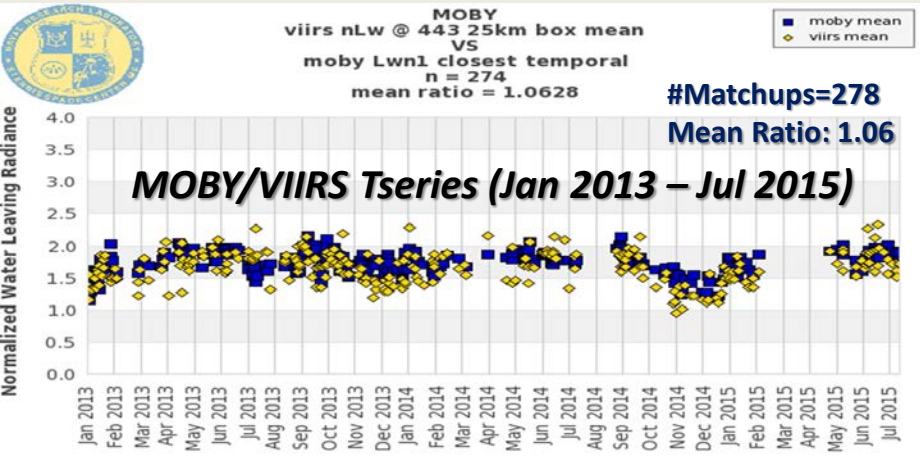
Match-up analysis

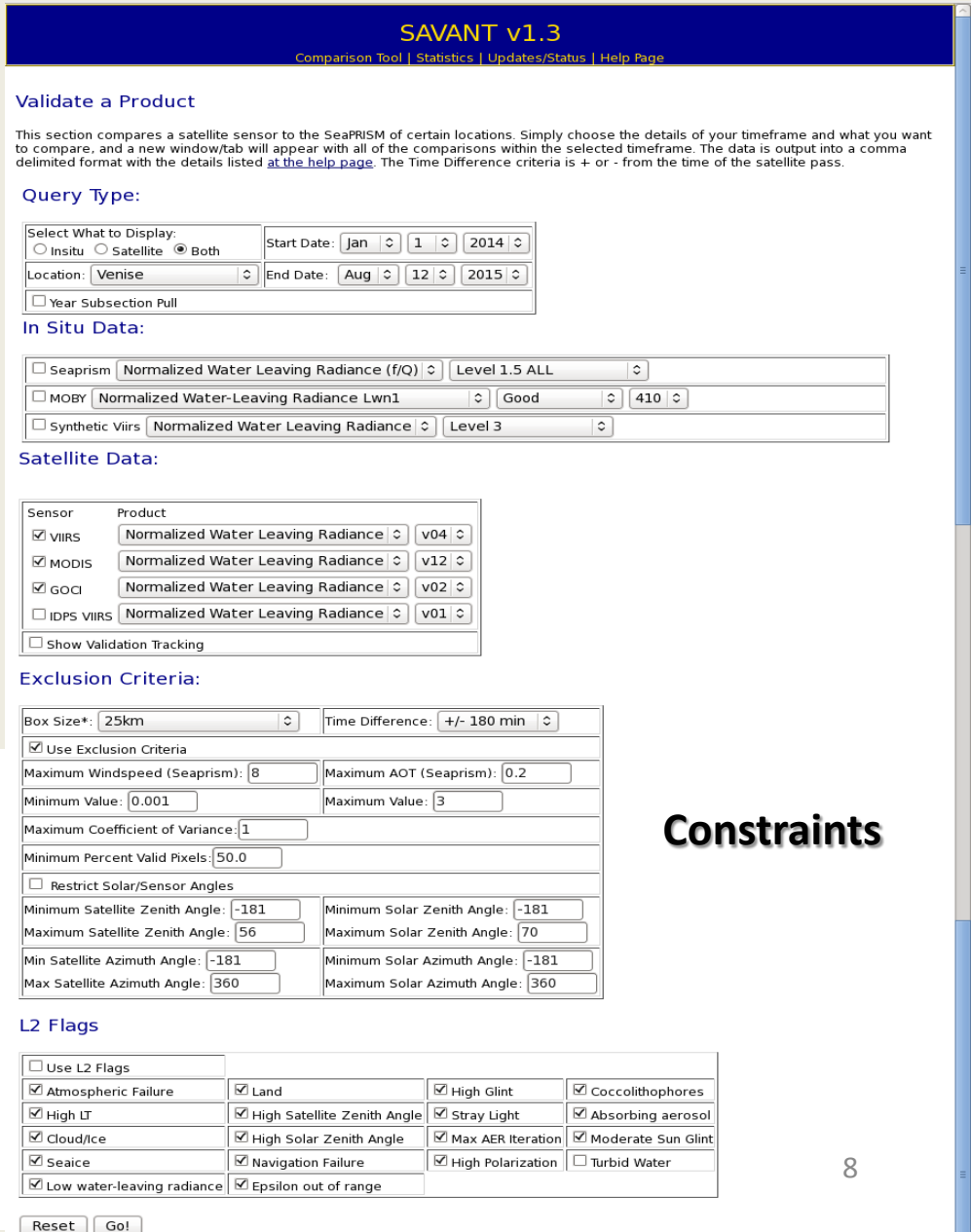
- Flag Selection / Combinations
- Sensor and Solar Angles
- Glint
- Clouds
- Coastal, etc.

NASA's Ocean Biology Processing/Procedures

Semi-automated

Daily updates

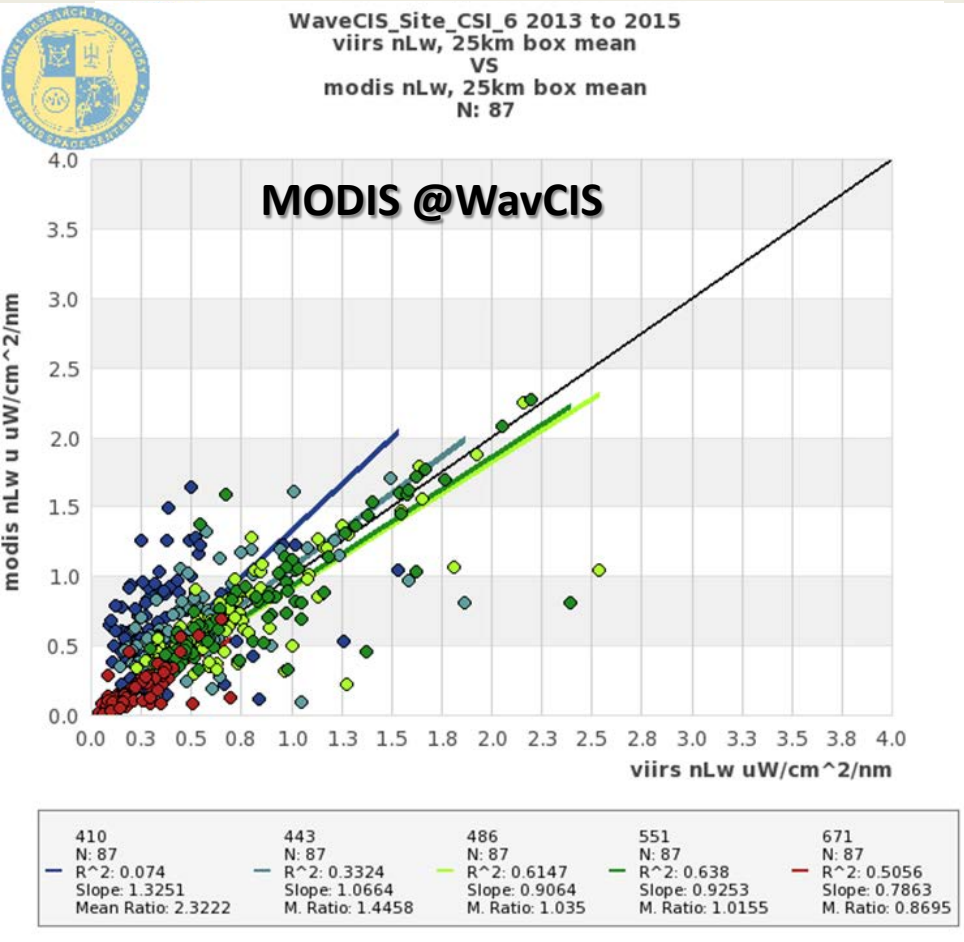


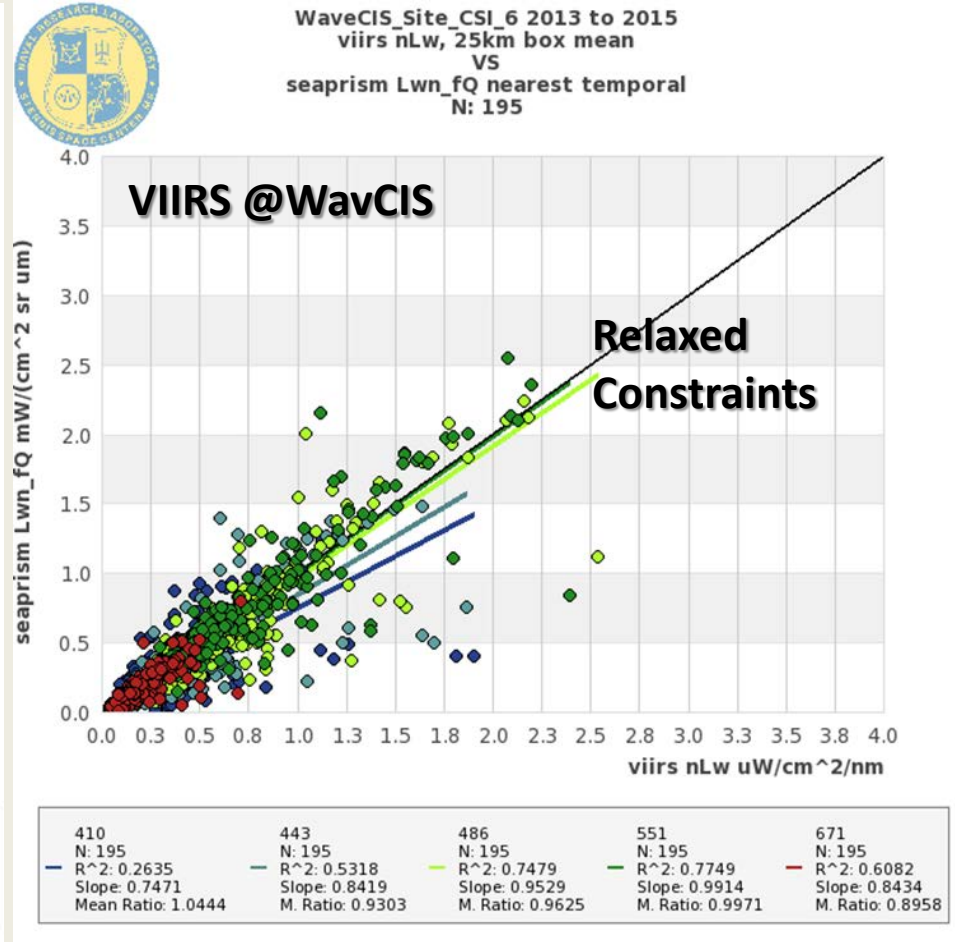


Constraints

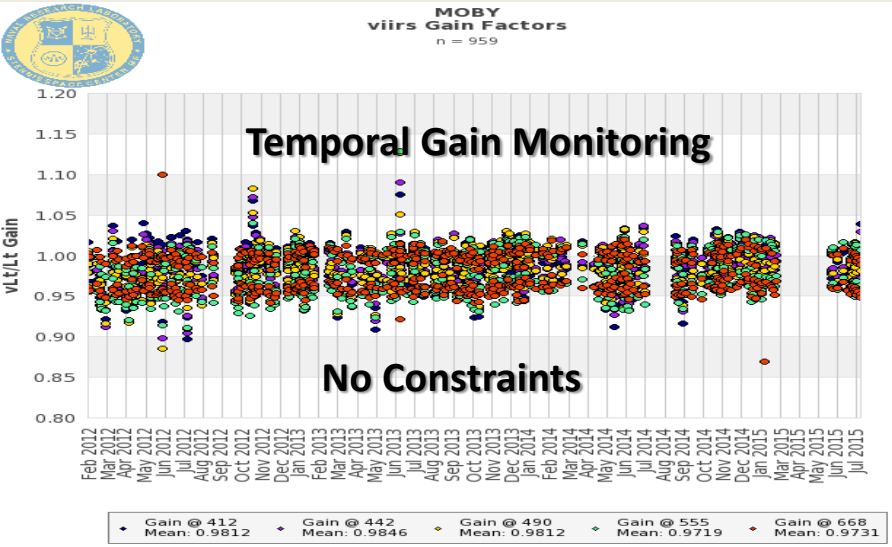
Ensuring Continuity of Coastal Ocean Optical Products In Support of Navy Operations: ***MODIS and VIIRS Comparisons @ WavCIS AOC (Coastal Water)***

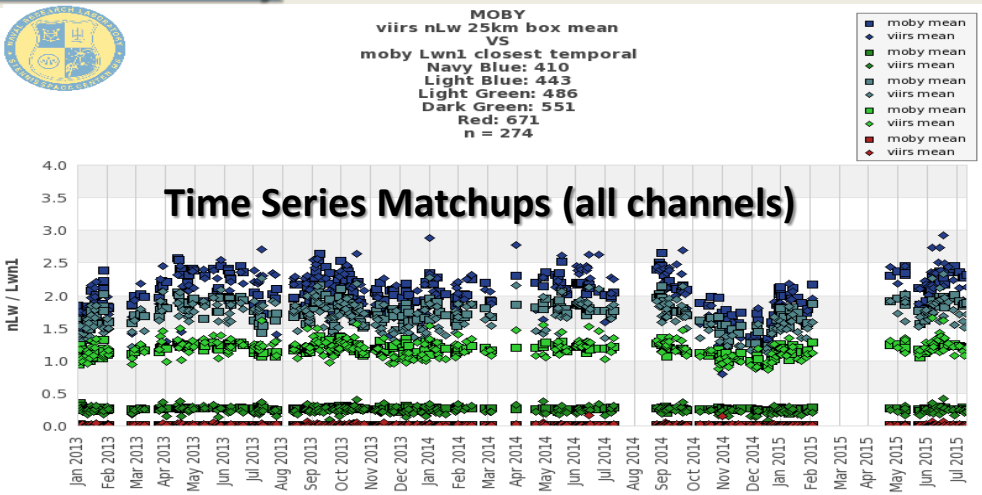
SAVANT

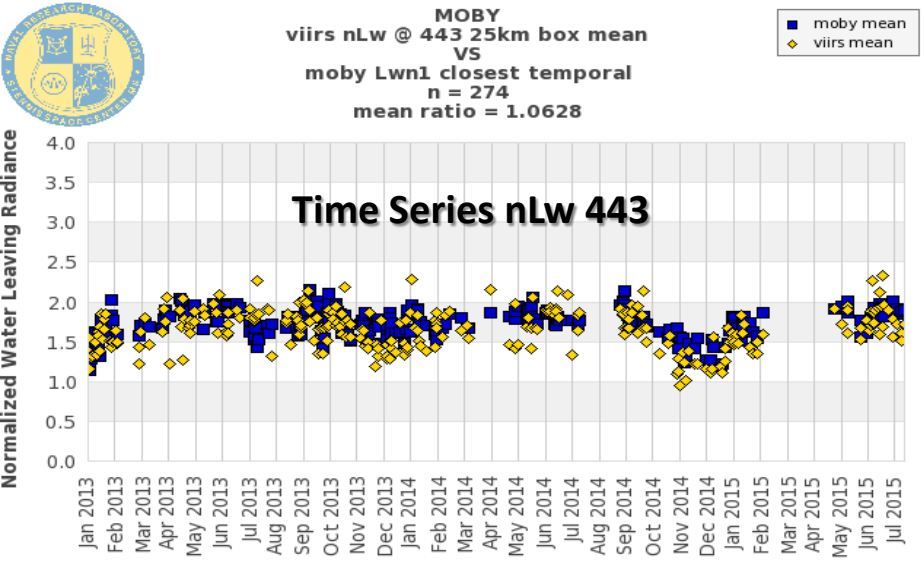


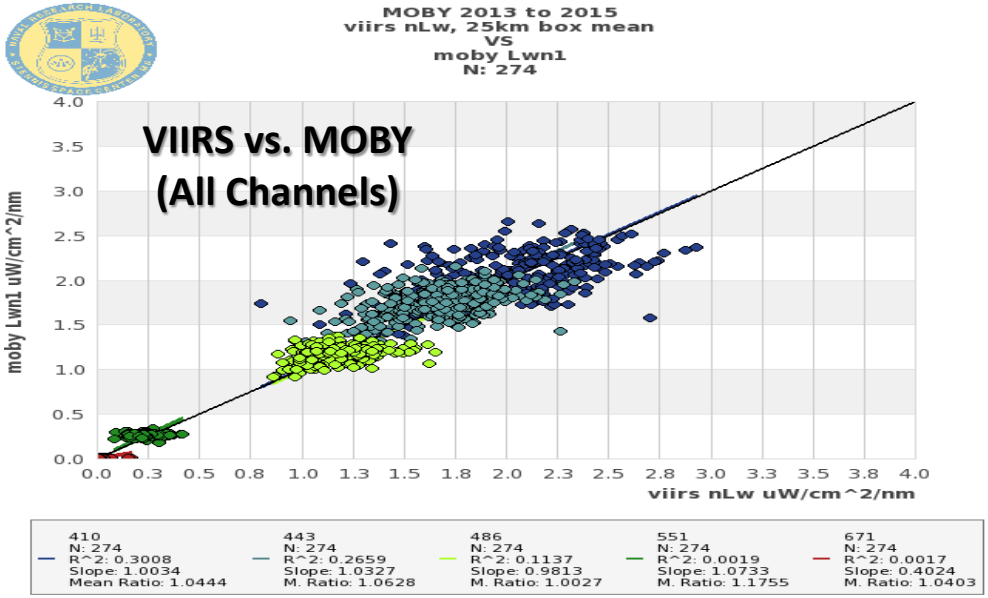


Ensuring Continuity of Coastal Ocean Optical Products In Support of Navy Operations: *VIIRS comparisons @ MOBY (Standard Cal/Val Site - Blue Water)*

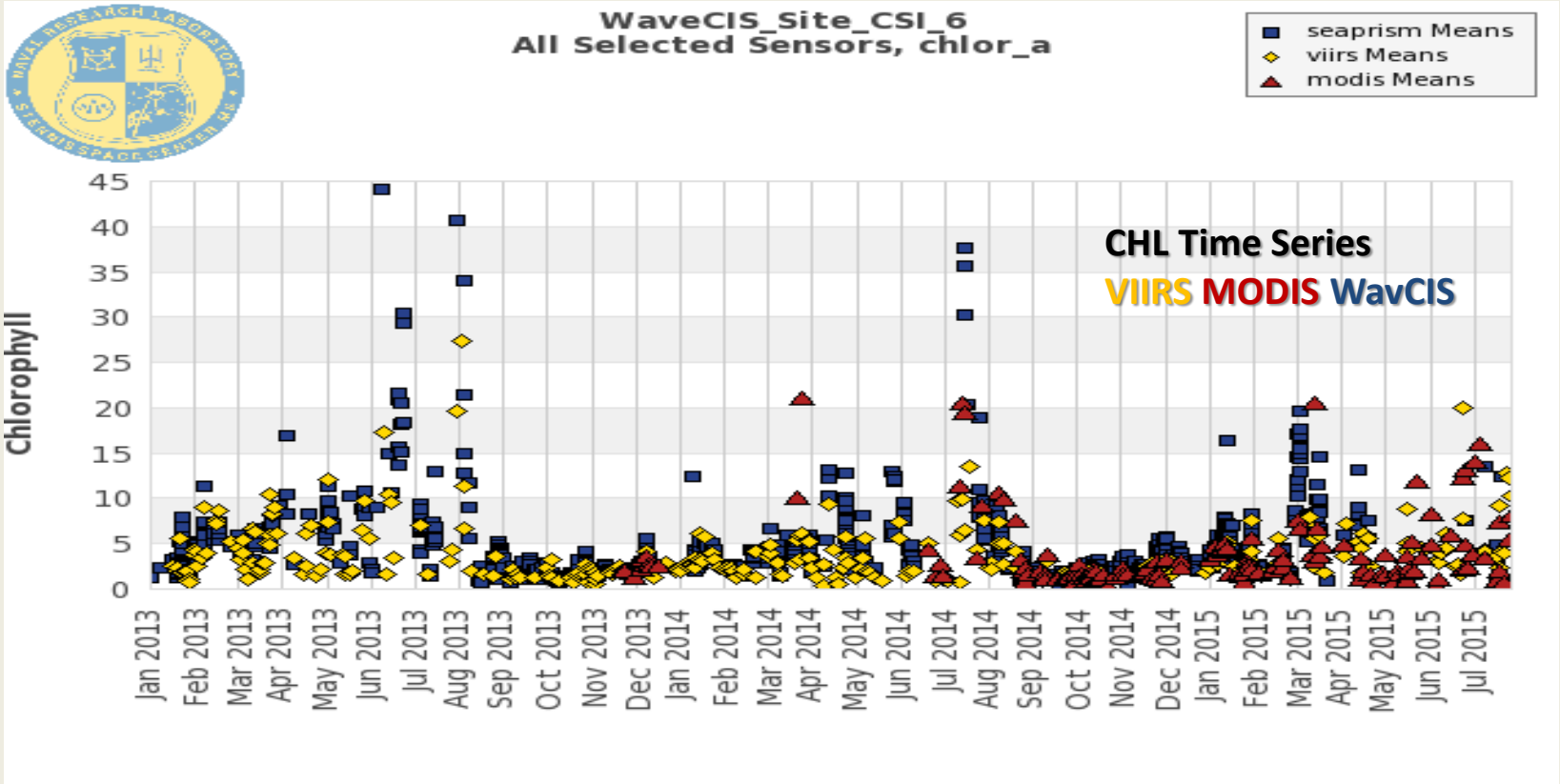






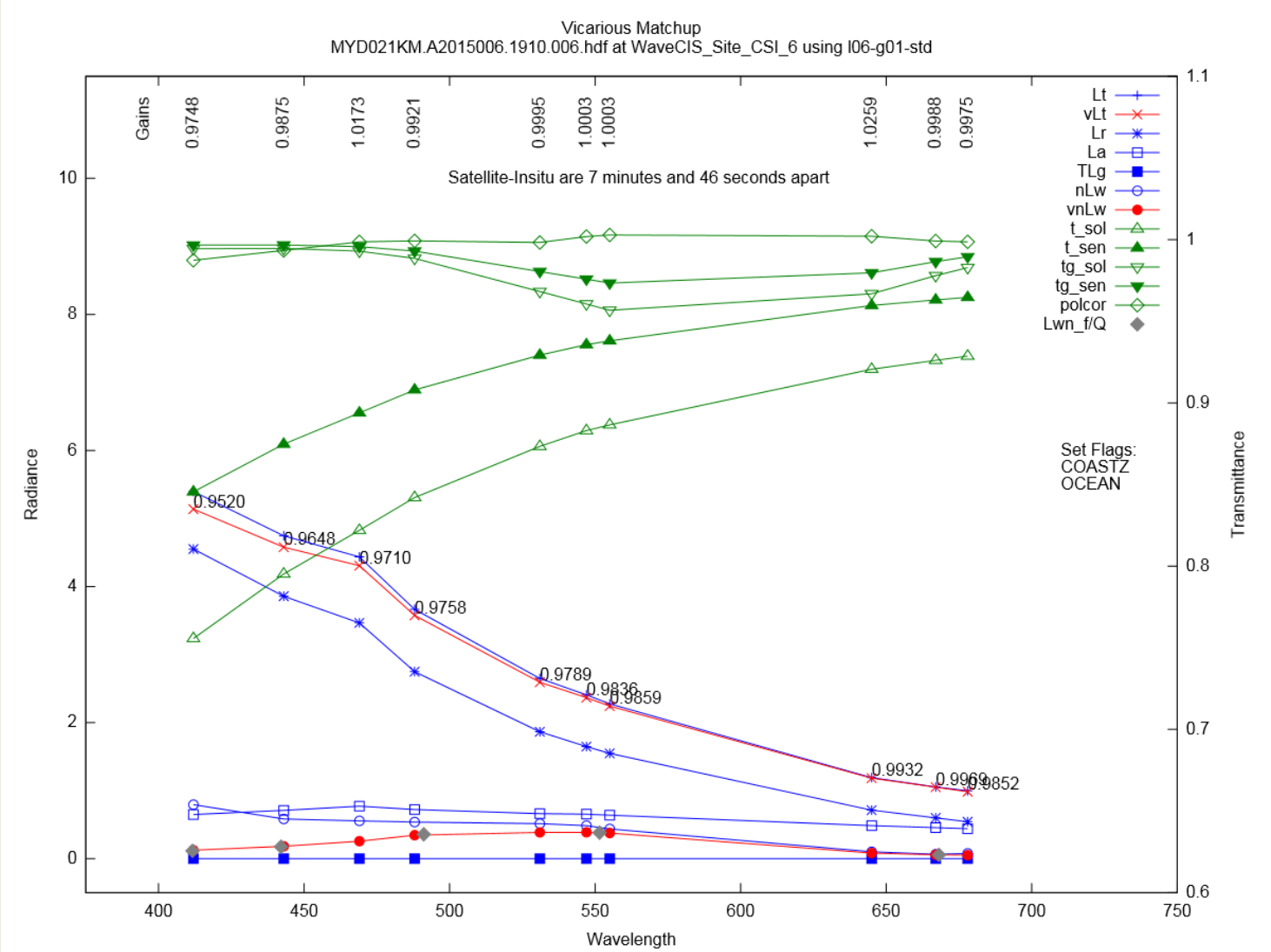


Ensuring Continuity of Coastal Ocean Optical Products In Support of Navy Operations: *Spatial Consistency at AeRoNet-OC Site (WavCIS) 2014 - 2015*



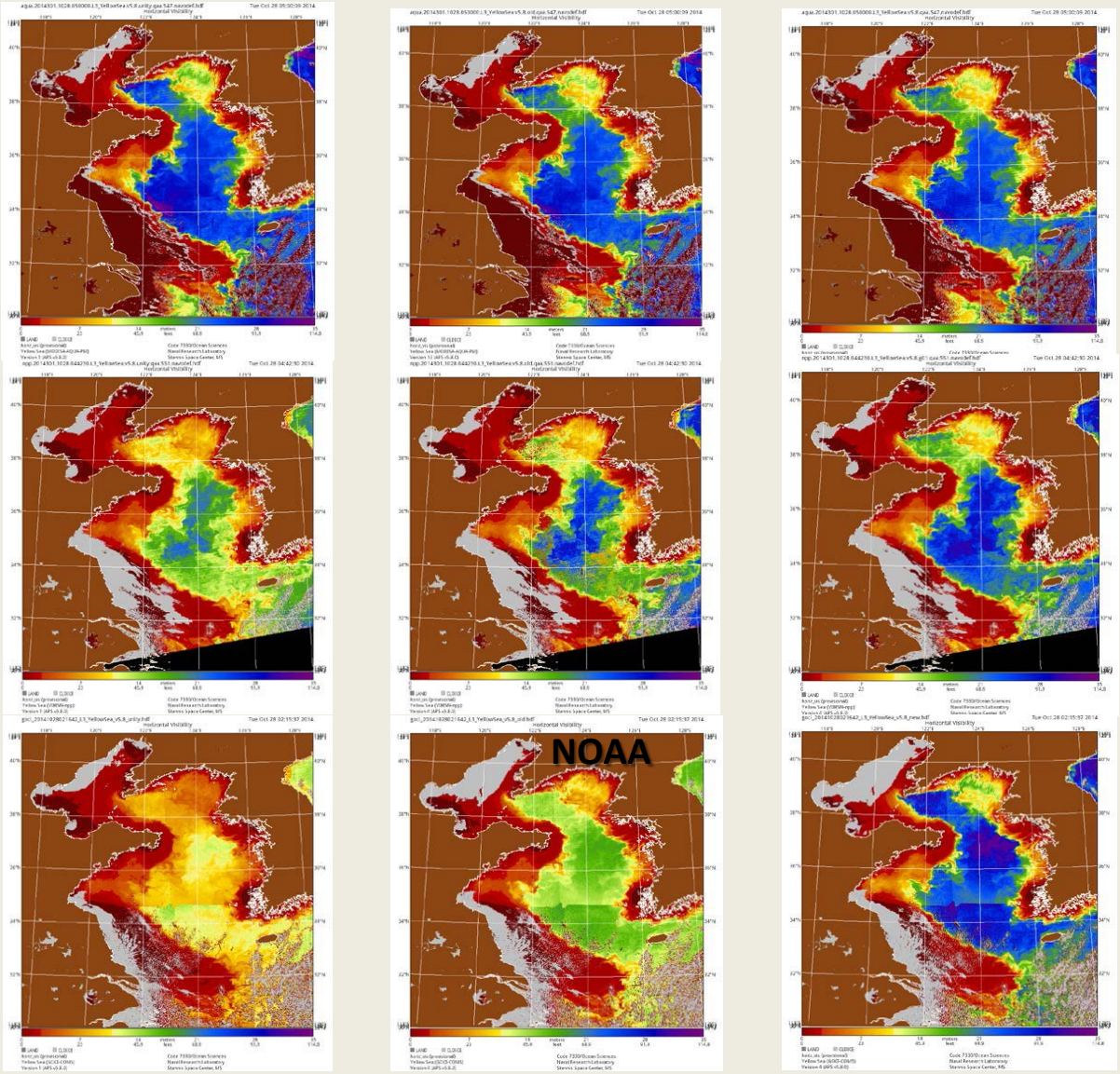
- VIIRS and WavCIS in situ Chlorophyll comparisons
- Satellite – Chlorophyll derived using NRL's APS (n2gen/l2gen)
- WavCIS – Chlorophyll derived using AeRoNet band ratios.
- VIIRS CHL compares very well to insitu CHL (WavCIS)

Ensuring Continuity of Coastal Ocean Optical Products In Support of Navy Operations: *Daily Vicarious Matchup – VIIRS and WavCIS AeRoNet-OC site*



Ensuring Continuity of Coastal Ocean Optical Products In Support of Navy Operations: *Vicarious Calibration Results*

Oct. 28, 2014 Horizontal Visibility



Aqua MODIS

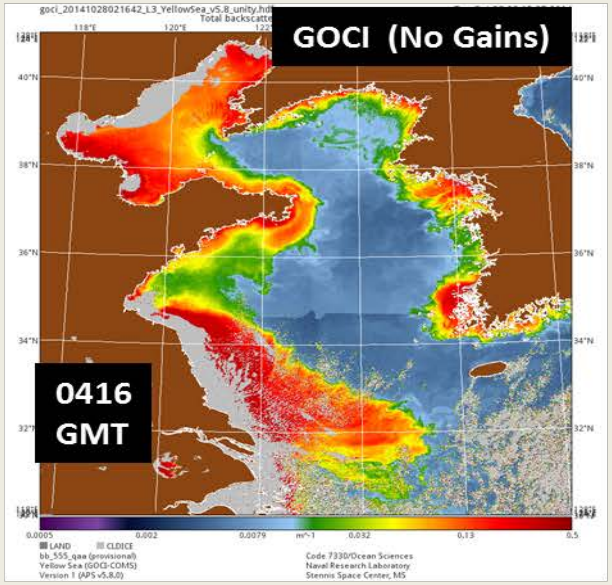
SNPP VIIRS

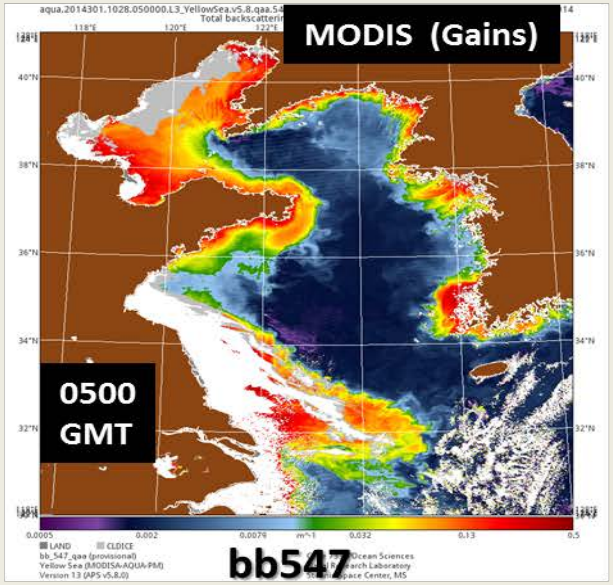
COMS GOCI

Sensor Calibrated | APS 5.10 | APS 5.12

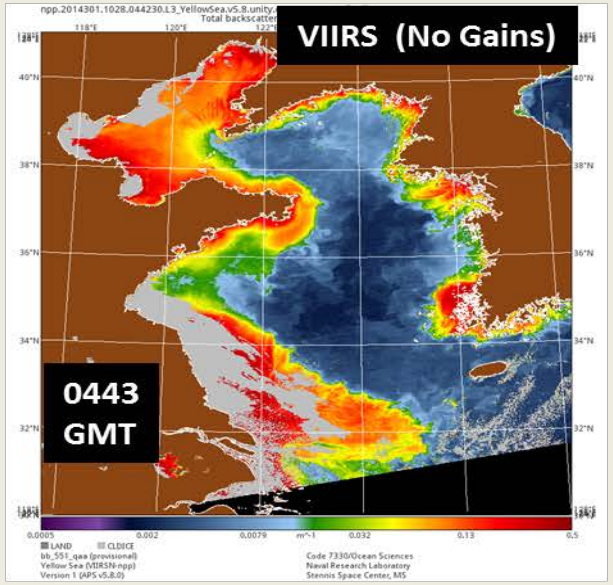
Ensuring Continuity of Coastal Ocean Optical Products In Support of Navy Operations: *Vicarious Calibration Results*

Vicarious Calibrations Applied - Yellow Sea – October 28, 2014 – Backscattering 555/547/551nm





bb547



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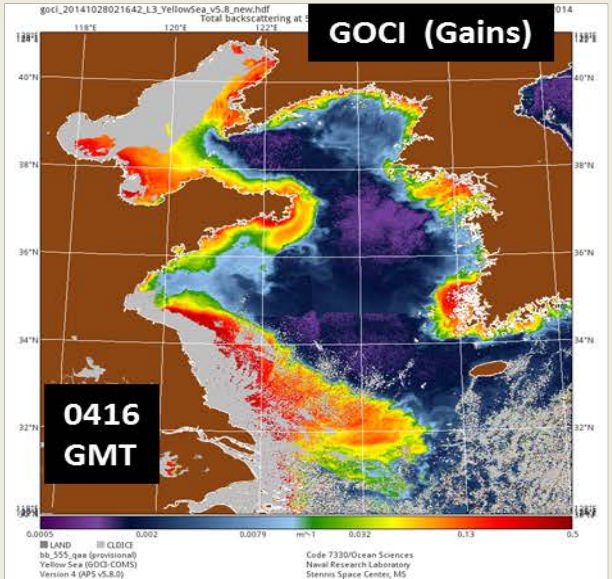
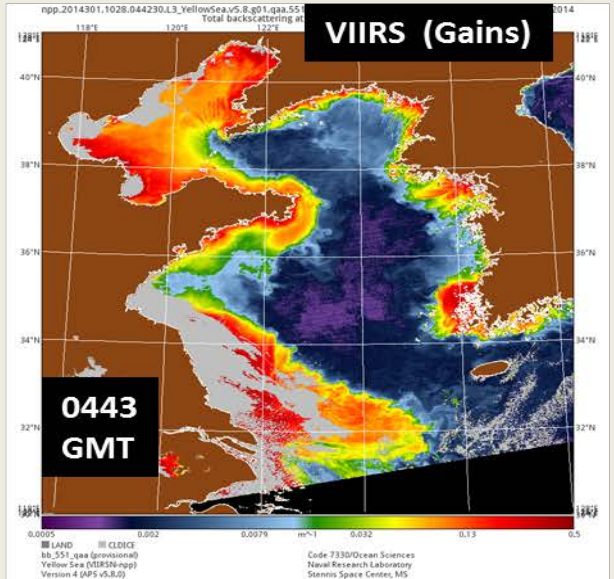
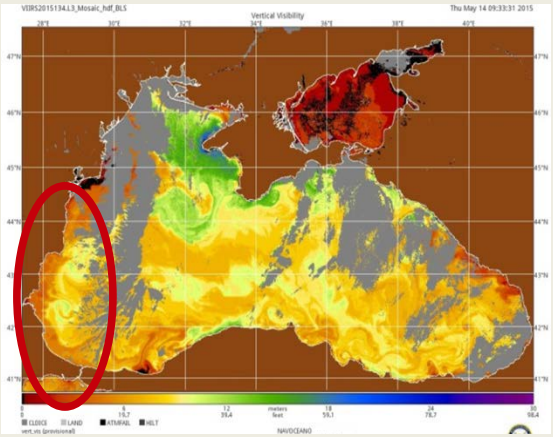




bb551

Ensuring Continuity of Coastal Ocean Optical Products In Support of Navy Operations: *Merging Capability*

- Merging averages “good” pixels and fills those contaminated due to clouds, glint, atmospheric and algorithm failures, stray light and saturation in one image.
- Inter-sensor consistency / calibration and validation important.
- Temporal differences in acquisition time yield atmospheric and geometric challenges.
- Merging allows compositing for daily, weekly, 8-day running, and monthly ocean optical properties and reduces number of products to fleet.
- Sentinel OLCI will provide a morning alternative to evaluate diurnal/natural variability. In Korea, GOCI adds significant information to sensor merging.



NPP VIIRS 1107 GMT

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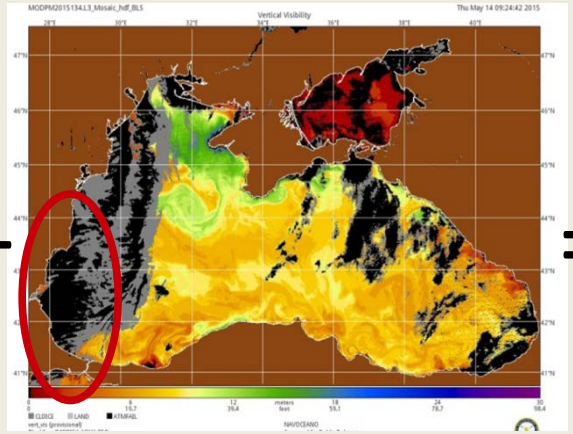

Aqua MODIS 1220 GMT

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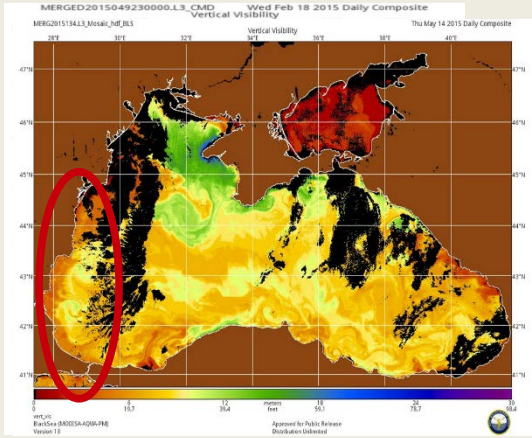
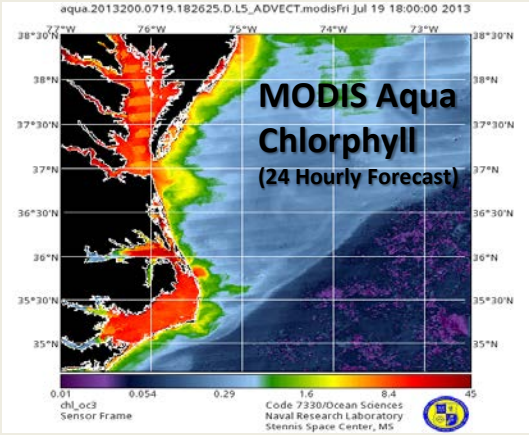


Merged Image

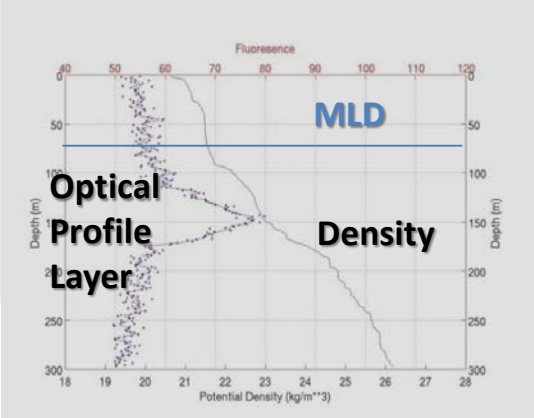
Ensuring Continuity of Coastal Ocean Optical Products In Support of Navy Operations: *Optical Forecasting by Fusing Satellite, Numerical Model and In Situ Data*

BioCast / Satellite Optics

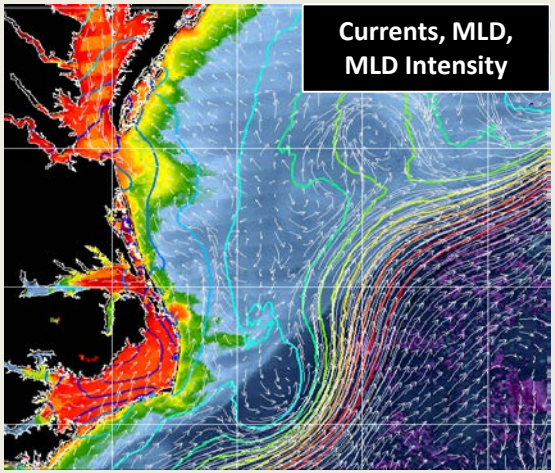


In situ Observations (Optics, Physics)

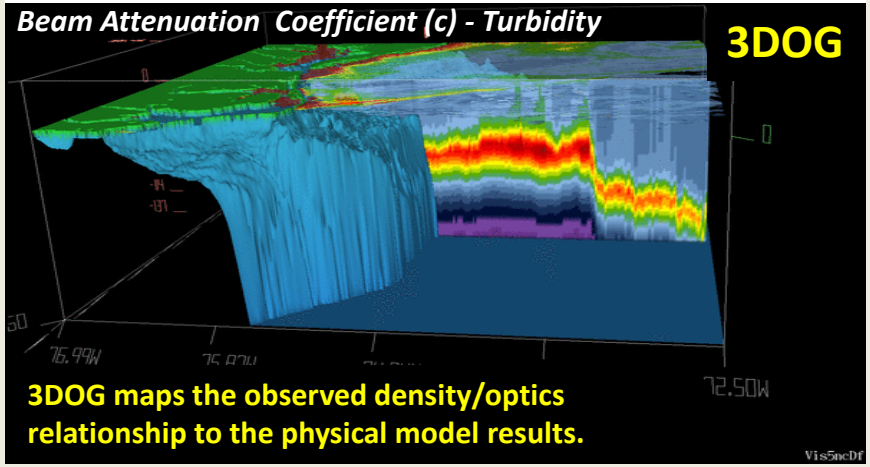
Vertical Profiles



Circulation Models



3D Optical Volume/Profiles & Visibility



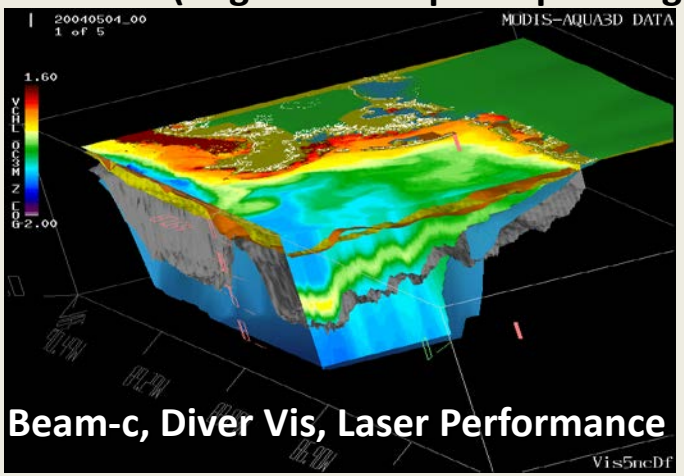
Diver Visibility, Laser Imaging and Bathy System Performance Surfaces

Ensuring Continuity of Coastal Ocean Optical Products In Support of Navy Operations:

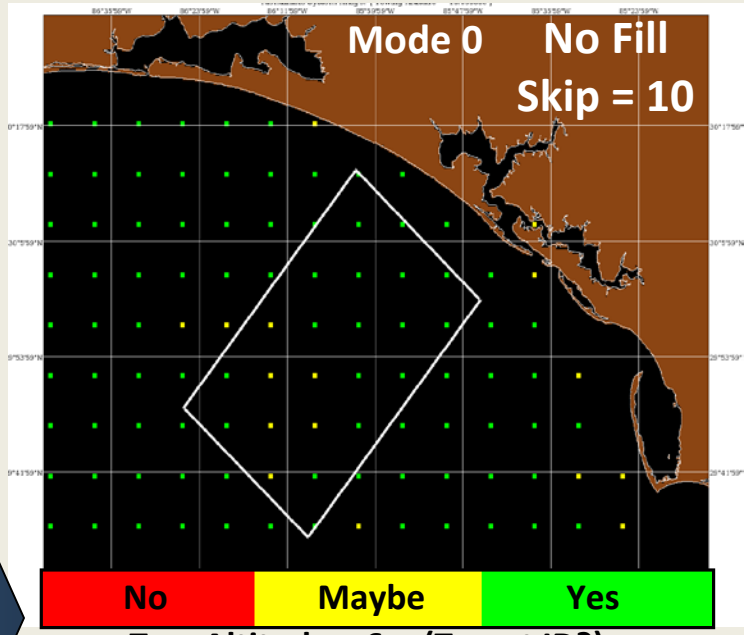
Performance Surfaces Supporting Laser Imaging

3DOG/BioCast - Enhanced Regional Optical Forecasting of the Operational Environment

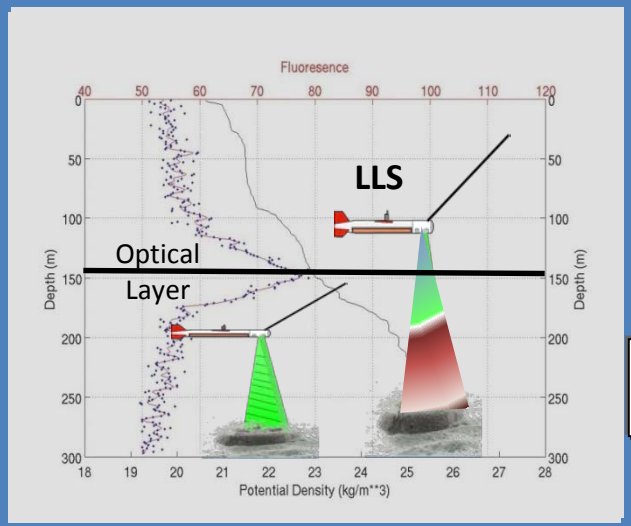
(Regional 3D optical profile grid)



Regional Performance Surfaces



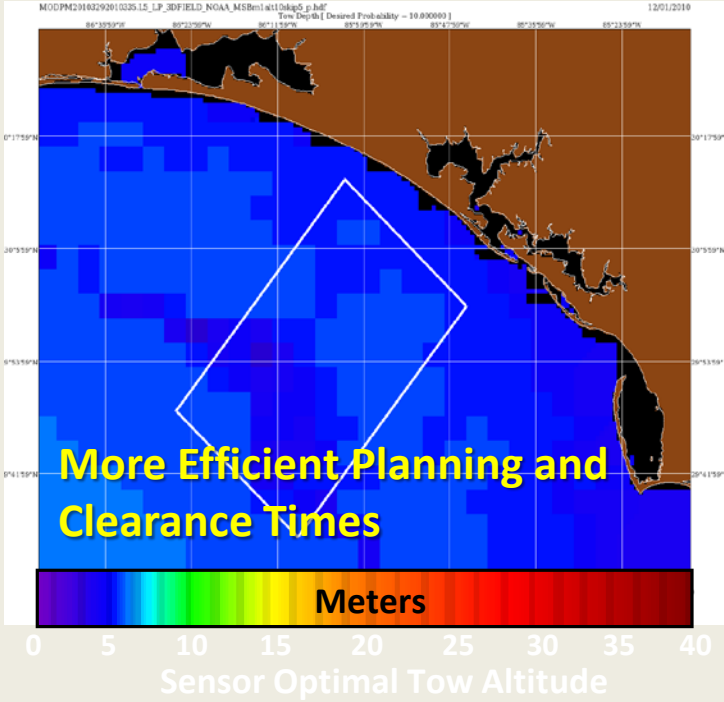
Tow Altitude = 6m (Target ID?)



Point Performance (BSP)

Tow Above/Below Optical Layer

Target ID?



Ensuring Continuity of Coastal Ocean Optical Products In Support of Navy Operations: *Conclusions*

- Vicarious calibration using cal/val sites (MOBY and AeRoNet-OC) allows for tracking sensor calibration and stability and yields good results for both coastal and offshore water types for multiple ocean color satellites.
- SAVANT provides a semi-automated and daily near-realtime method for monitoring sensor performance
- MODIS, VIIRS, and GOCI inter-comparisons match very well and provide continuity.
- Products from different ocean color sensors are consistent and agree very well.
- Merging technique shows promise for cloud and glint clearing and mosaicking images and the addition of Sentinel-3A will improve daily merging.

Ensuring Continuity of Coastal Ocean Optical Products

Future Plans

- Continue cal/val MODIS, VIIRS, and GOCI sensors when necessary (Calibration changes, major software upgrades, etc.). NASA OBPG plans for future upgrades?
- Work with NASA OBPG on integration of Sentinel-3A OLCI into APS. NASA OBPG Plans for initial I/O and Aerosol/Rayleigh Tables?
- Monitor Sentinel-3A OLCI when launched and data available

  Info on Level 1B data stream?
- Inter-calibrate MODIS, VIIRS, GOCI, and OLCI for consistency
- Investigate am/pm differences in imagery
- Add OLCI to merging capability / optical forecasting for Navy performance surfaces (divers, bathy and imaging lidar performance, etc.)

Insuring Continuity of Coastal Ocean Optical Products In Support of Navy Operations: ***Questions***

- Thank you