CCNY VIIRS validations at the Long Island Sound Coastal Observatory (LISCO) and on cruises, algorithm development

Sam Ahmed, Alex Gilerson

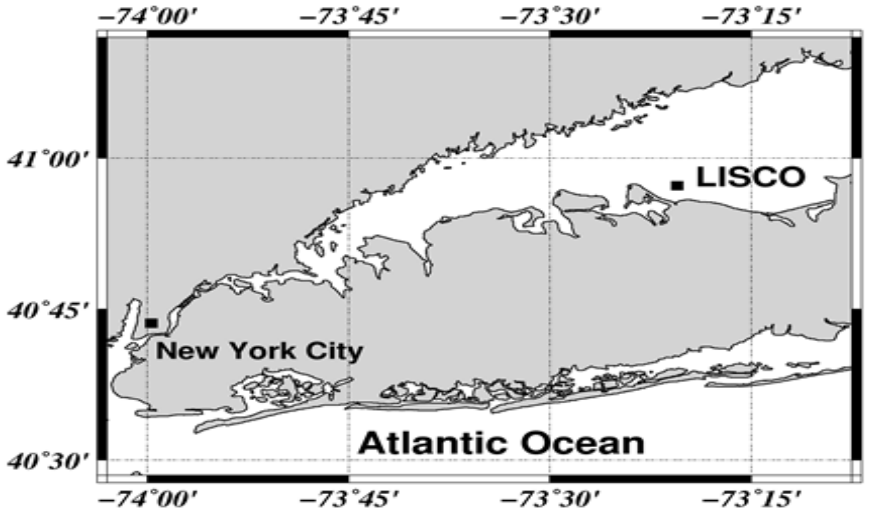
The City College of New York

Scientists: Matteo Ottaviani, Amir Ibrahim (now at GSFC)
Students: Robert Foster, Ahmed El-Habashi, Carlos Carrizo, Eder Herrera, Anna McGilloway

Outline

- Validation on the LISCO site
- Validation on SABOR and VIIRS cruises
- VIIRS algorithms development
- Radiative transfer vicarious calibration/validation
- Sky glint correction in polarization mode

Validation from Long Island Sound Coastal Observatory (LISCO)







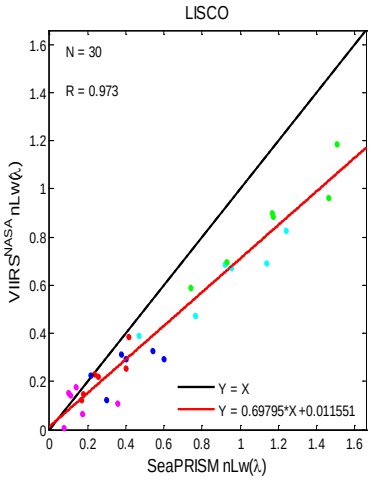


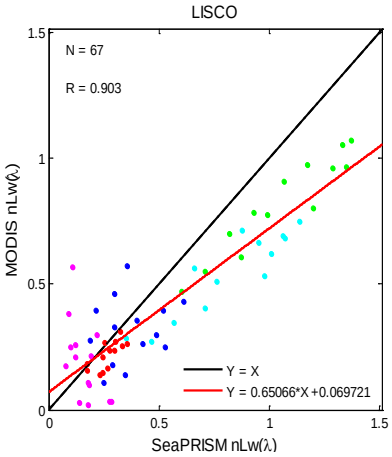
Mult-spectral SeaPRISM instrument. Transmits data to NASA AERONET every hour.

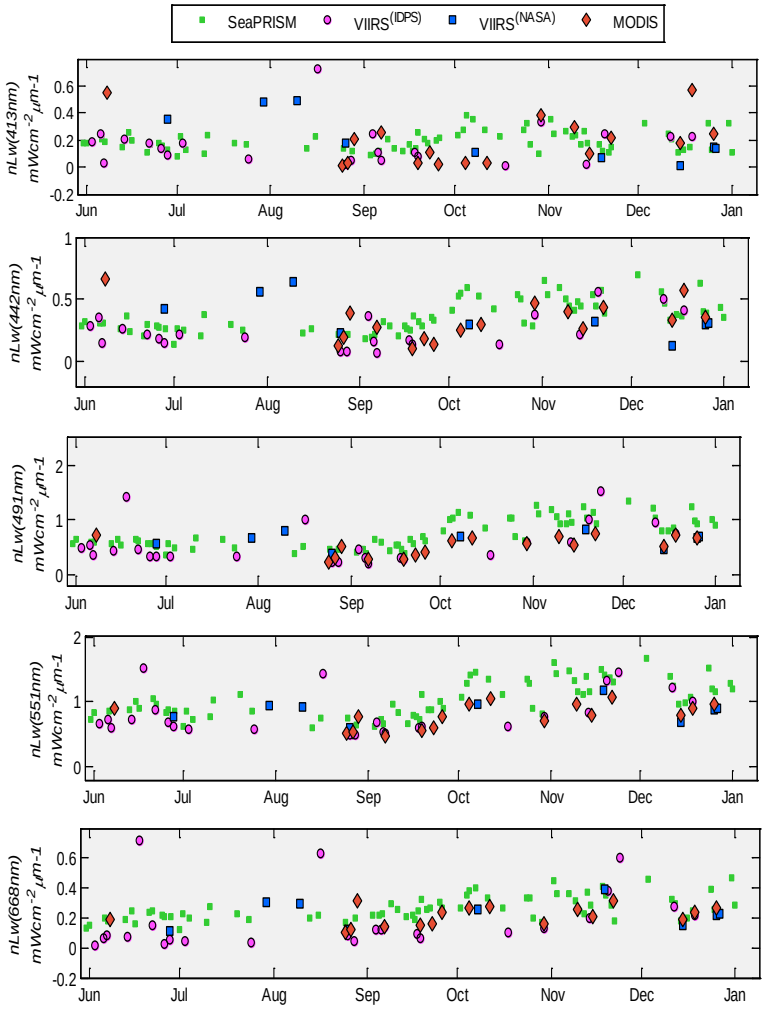
HyperSAS-POL with polarimetric sensors. Transmits data to CCNY server every hour.

Time series and Match-up Comparison

(June 14 2014- January 15 2015)

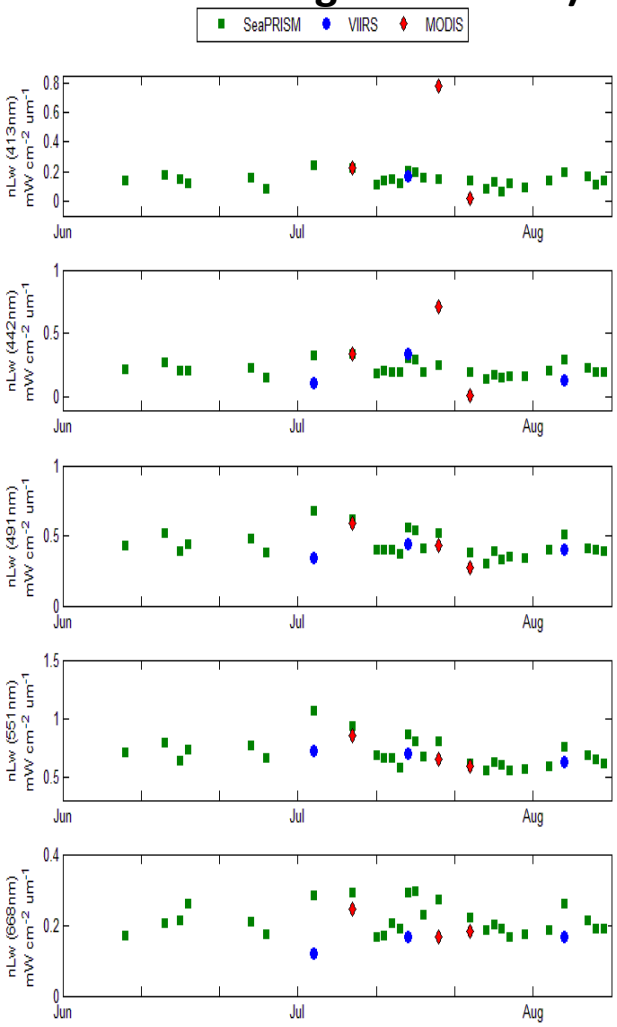






No Stray light flag

(June 10 2015- August 21 2015)



No Stray light and modglint flags

Match-up plots show fairly high correlation for 491, 551, and 668nm for all sensors. Much lower correlation is observed for violet (413nm) and blue (442nm), which is independent of the processing scheme or the sensor.

Ship-Airborne Bio-Optical Research (SABOR)
NASA Cruise July 17- August 7, 2014

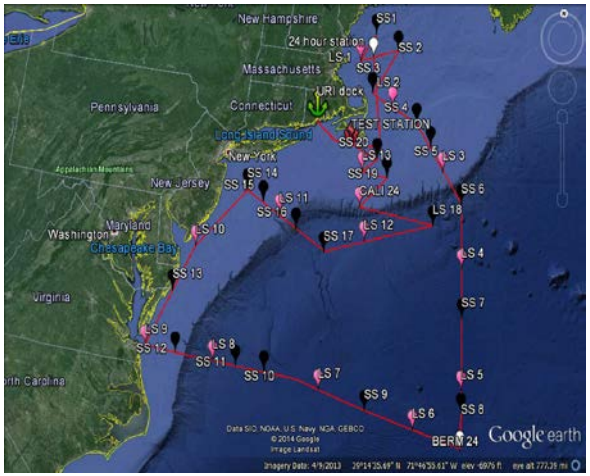




R/V Endeavor owned by NSF operated by University of Rhode Island, 185 feet, crew -12, scientists -15

NASA GISS, NASA Langley CCNY, U. of Maine, Oregon State University, Sequoia Scientific, WET Labs

CCNY team: A. Gilerson, PhD students R. Foster, C. Carrizo



Rhode Island – Bermuda – Norfolk, VA - Rhode Island

Research Scanning Polarimeter (RSP) and lidar were installed on the aircraft

Included satellite validation component

NOAA VIIRS Cal/Val Cruise, November 2014



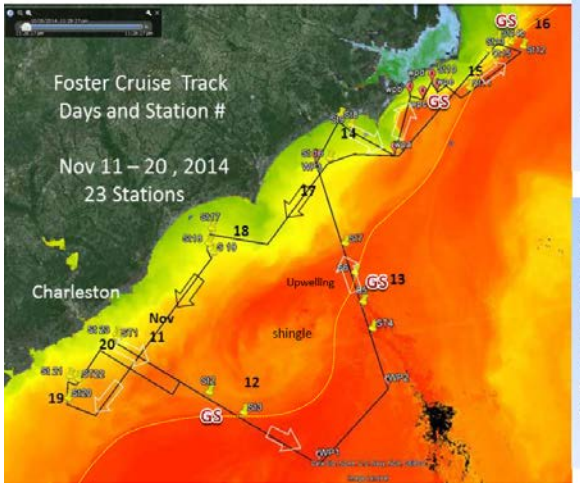
R/V Nancy Foster

CCNY team: PhD students A. Ibrahim, A. El-Habashi



Update on cruise report

Objectives:
Uncertainty of products
Insitu protocols assessments
Characterizing the spatial uncertainty of VIIRS Products



From R. Arnone, 02/12/15

Overall Goals

Gulf Stream Station Transects
A. Nov 12 – Stations 2 and 3
B. Nov 13 – Stations 4,5,6,7
C. Nov 15 – Stations 10, 11
D. Nov 16 - Stations 12,13, 14 !!

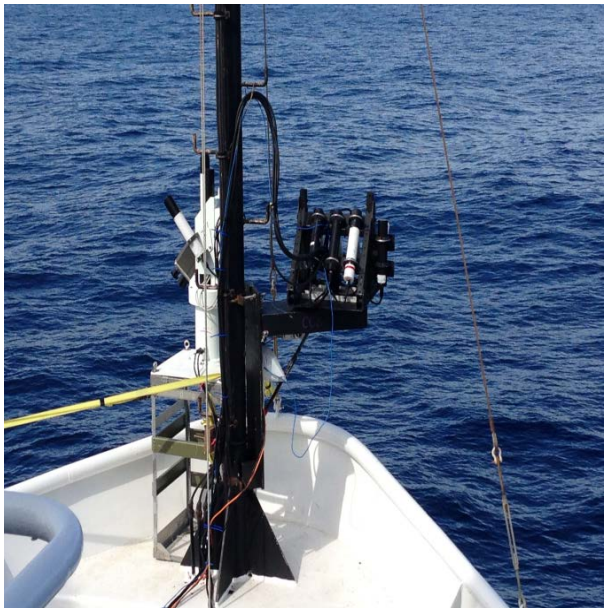
Night time transect flowthrough
A. Nov 11- 12 – West front of GS
B. Nov 12 – 13 - East front and Offshore waters
C. Nov 19- 20 - 2 parallel crossing

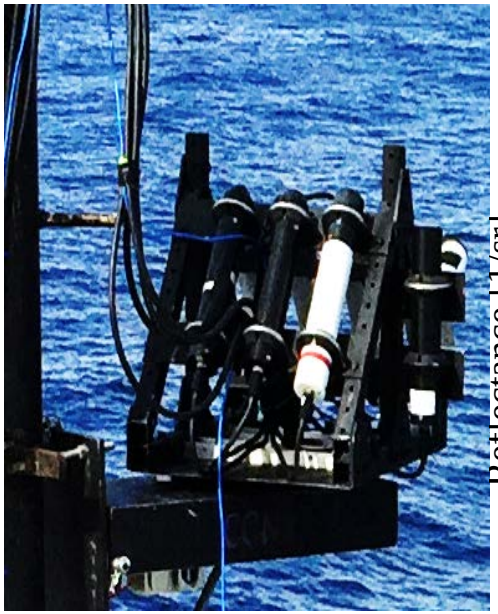
Shelf and Coastal waters sampling
Nov 14 – Station 8,9
Nov 15 - 10, 11
Nov 18 – Station 17,18,19
Nov 19 Station 20, 21,22
Nov 20 Station 23

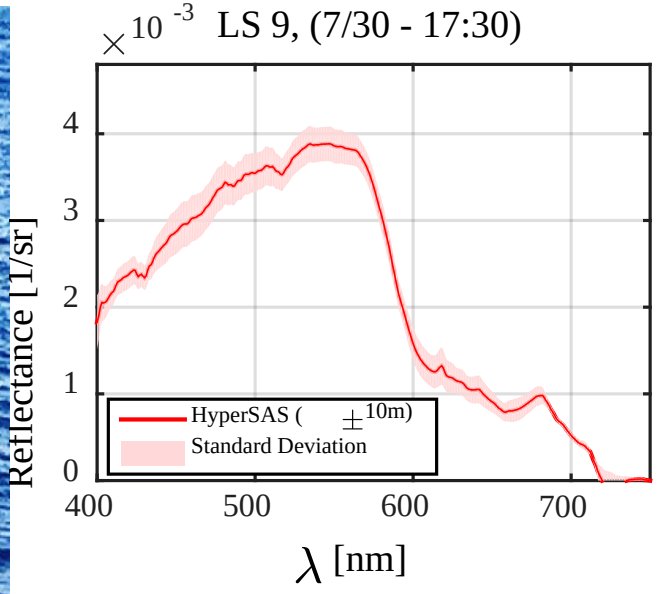
Night time transects
Nov 14 – 15 – Zig zag pattern
Nov 18 – 19 - southern transects water fronts

Participants: NOAA/NESDIS, NASA – Goddard, NRL, U. Southern Mississippi, U. of Massachusetts, U. of South Florida, CCNY, Columbia U., JRC (Italy)

HyperSAS-POL, Handheld spectroradiometers







HyperSAS had 2 radiometers in unpolarized mode and 4 with polarization sensitivity



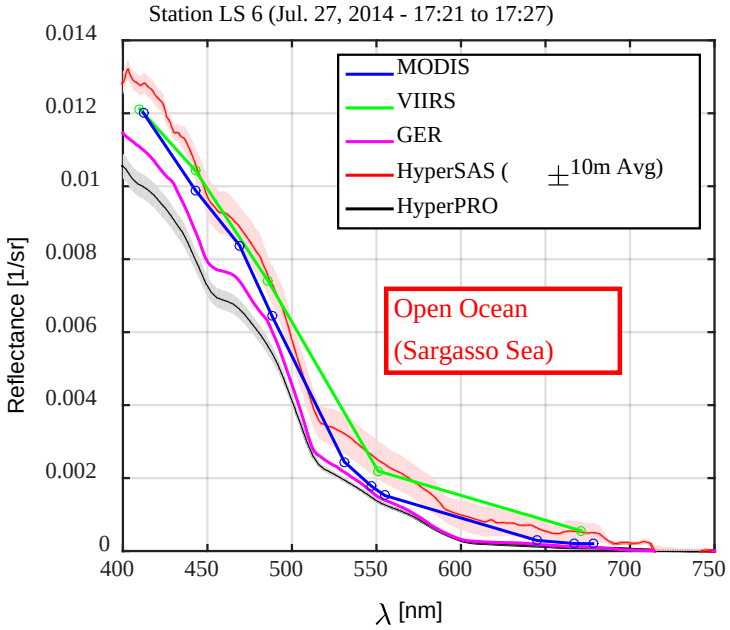
GER-1500

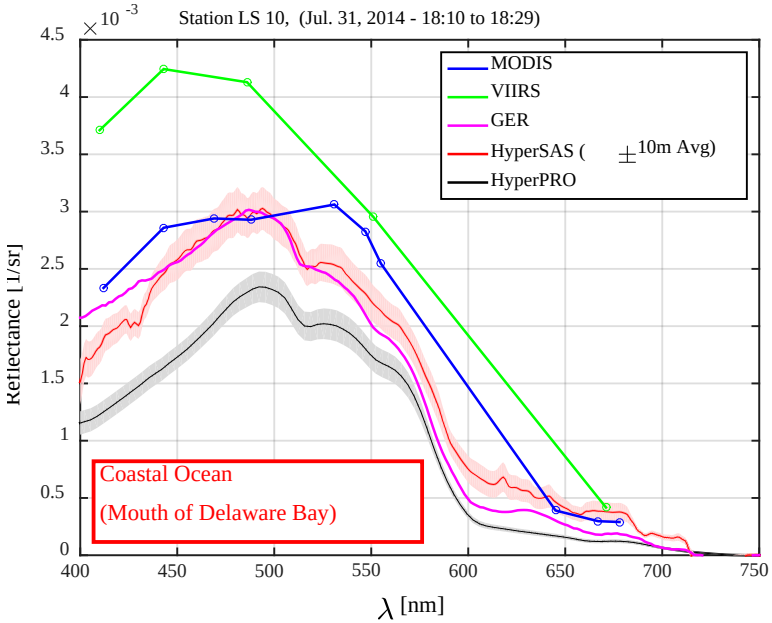


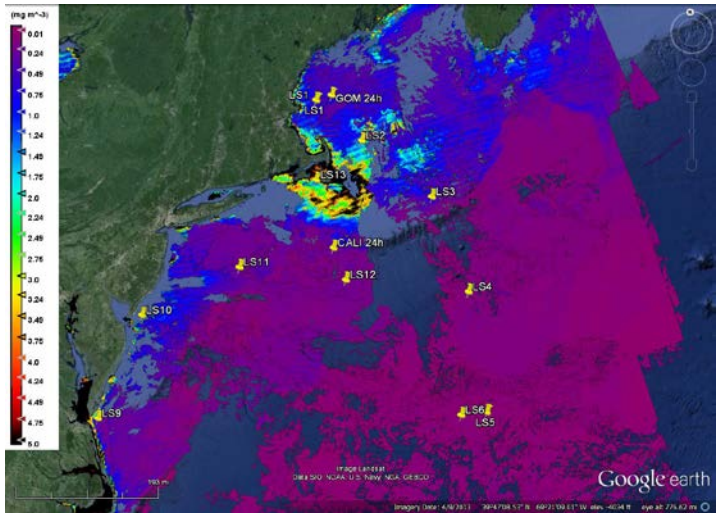
ASD Handheld2

HyperSAS integration time was 2000ms for water and 128-250 ms for sky measurements, 6-4000ms for ASD and 160 ms for GER

Remote Sensing Reflectance comparison between GER, HyperSAS, HyperPRO, MODIS and VIIRS on July 26th and on July 31st (SABOR cruise)







VIIRS and MODIS

- Grid size: 3x3
- Pixels flagged: 0%
- Flags not checked: high and moderate sun glint contamination and stray light contamination.

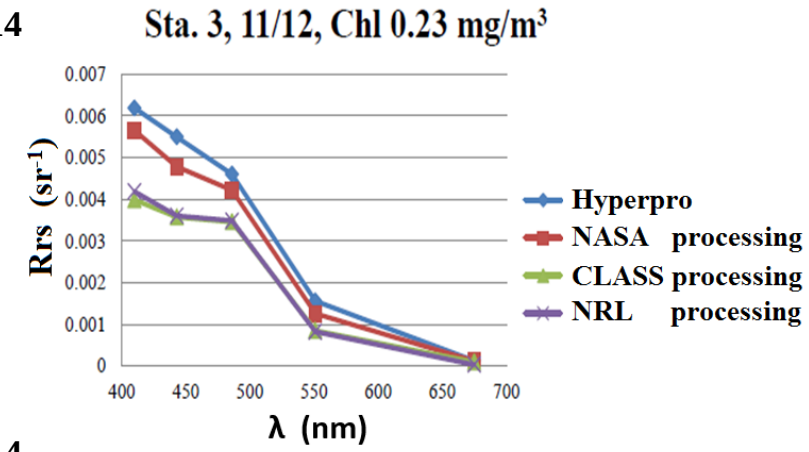
Several other instruments from other groups (above and below water) were deployed, comparison is in progress

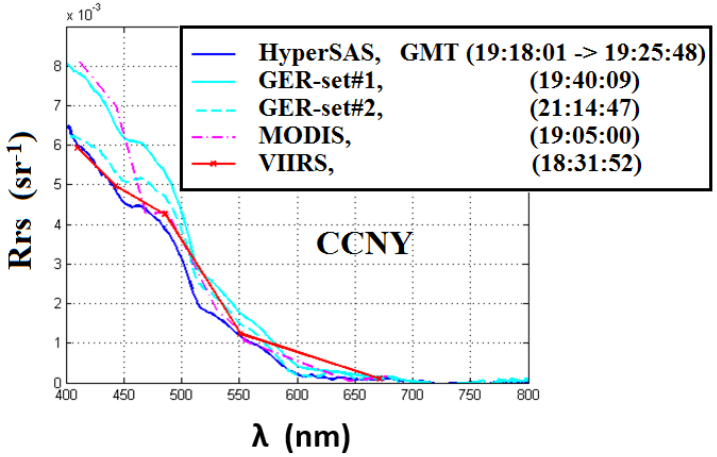
Spectral Remote Sensing Reflectance comparison between GER, HyperSAS, HyperPRO, MODIS and VIIRS (VIIRS cruise)

November 12, 2014

Blue water

Station 03

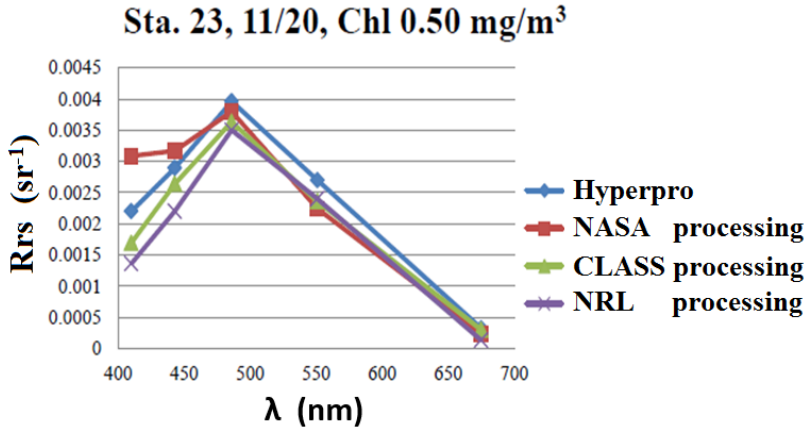


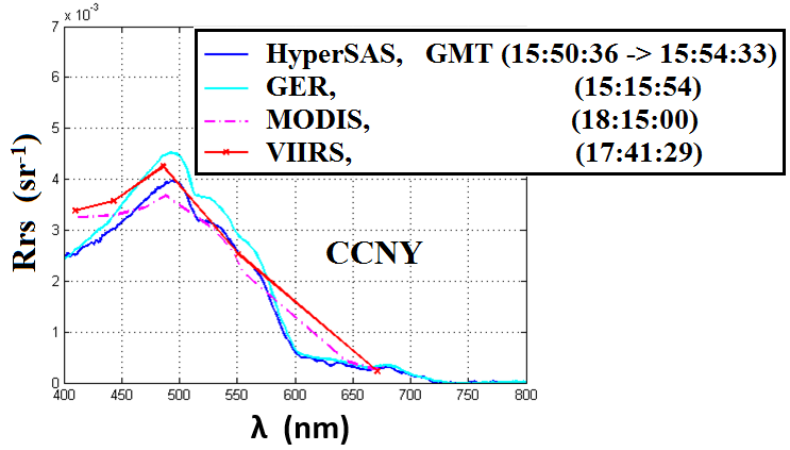


November 20, 2014

Blue water
Turbid water on the way into port

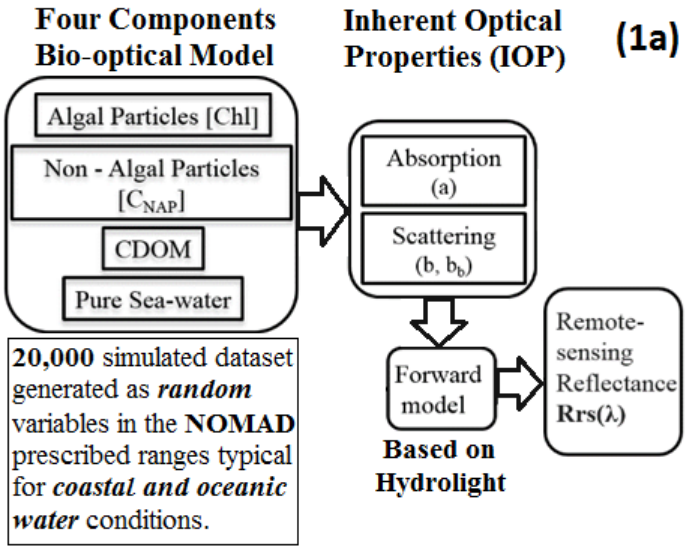
Station 23





From M. Ondrusek Dec 18, 2014

Algorithm Developments-Neural Network (NN) algorithm for VIIRS KB Harmful Algal Bloom (HABS) retrievals in WFS



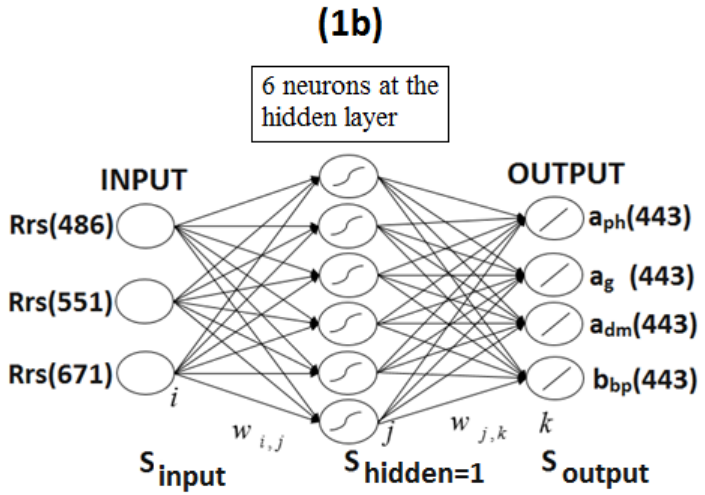
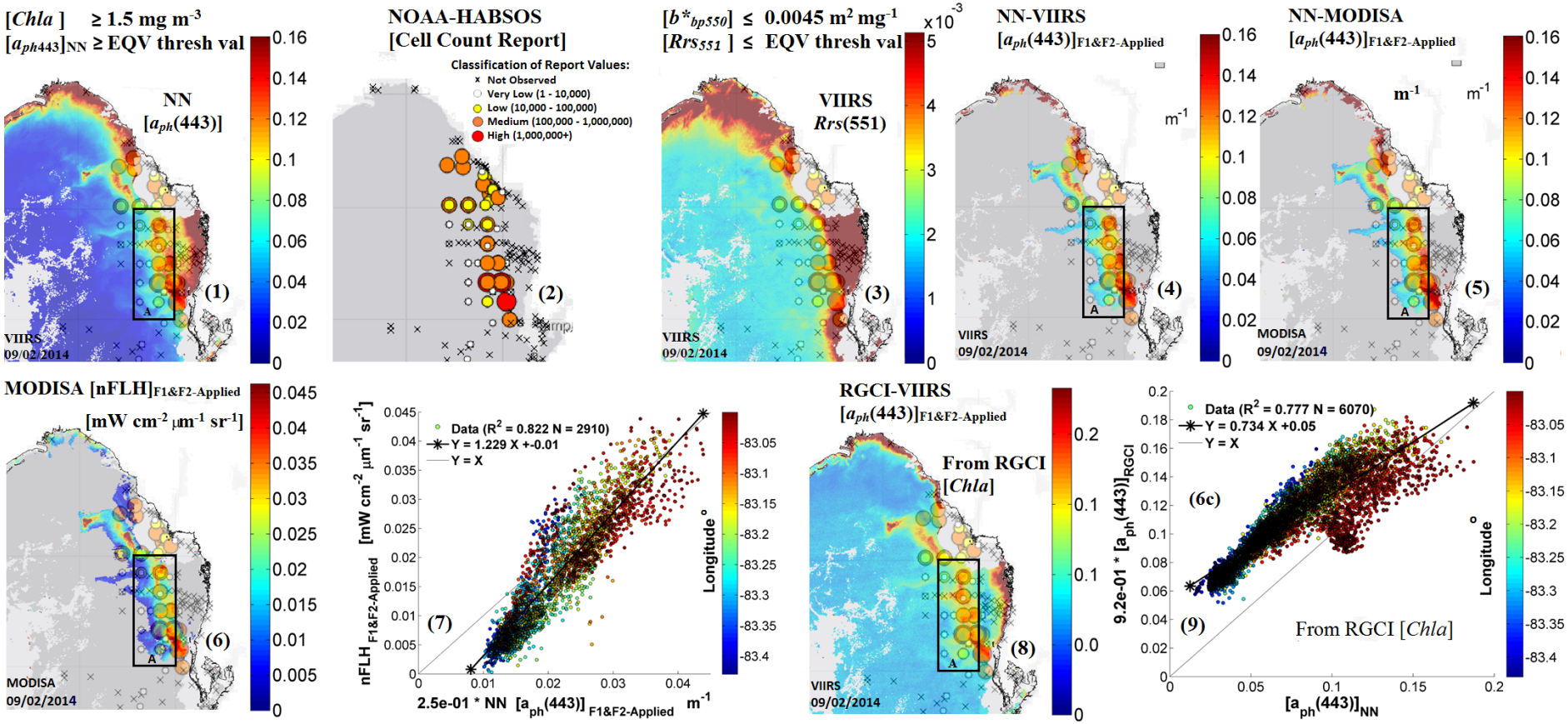


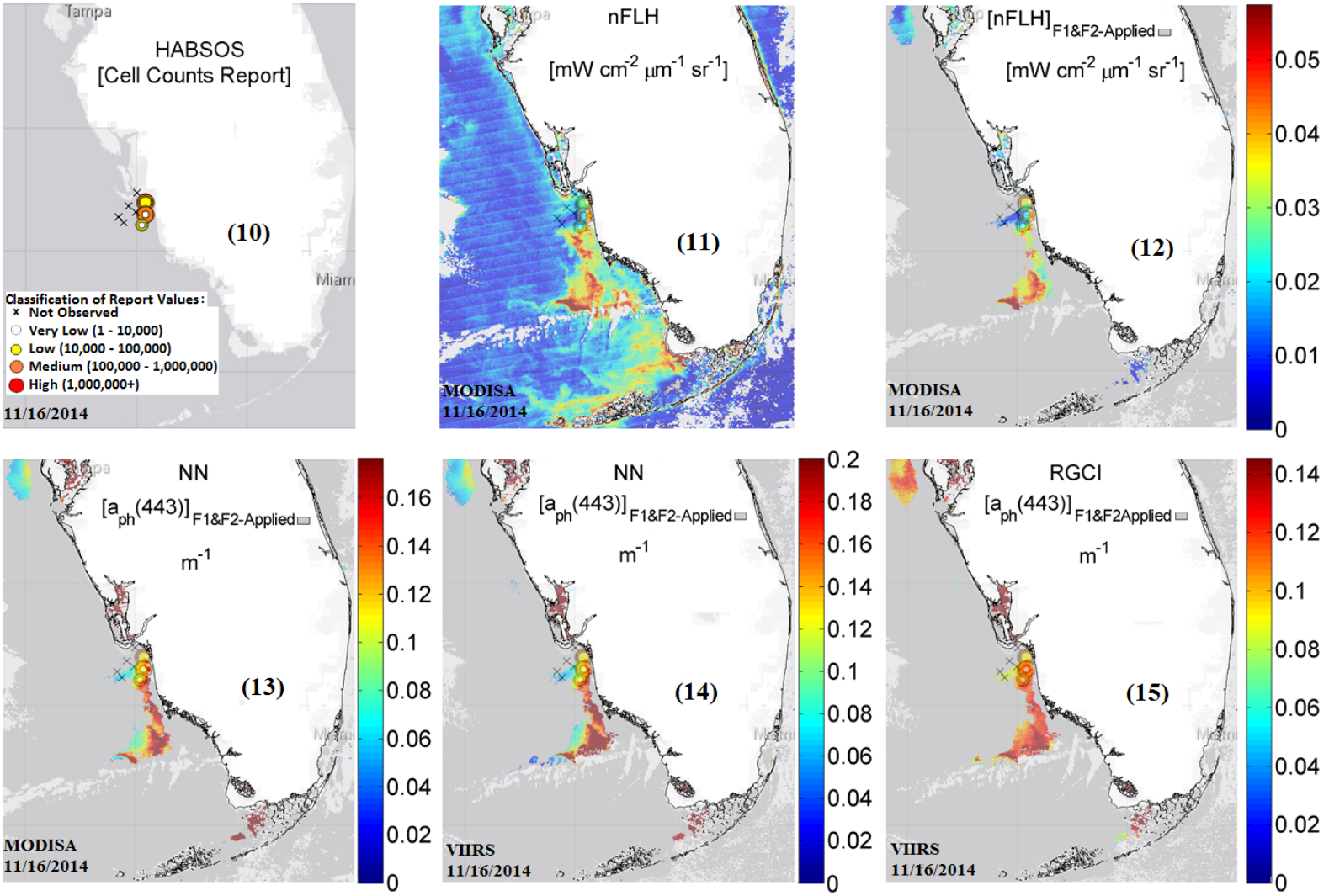
Fig. 1a Shows the Bio-Optical model and the Radiative Transfer simulations. of 20000 random IOP data sets within NOMAD **prescribed ranges and resulting related Rrs values generated by Hydrologht**

Fig. 1b Architecture of NNVIIRS, one-hidden layer multilayer perceptron (MLP) with 6 neurons at the hidden layer, trained with 10,000 set of Rrs and related IOPs **NN trained on 10,000 data sets to model relationship of Rrs values to IOPs at 443 nm**

NN KB HABS retrieval comparisons site 1 on 9/2/2014-major HAB occurence



NN KB HABS retrieval comparisons site 2 on 9/16/2014 much nearer coast

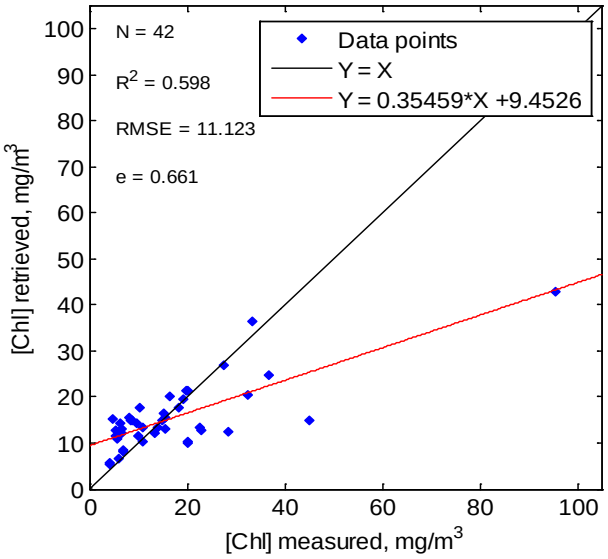


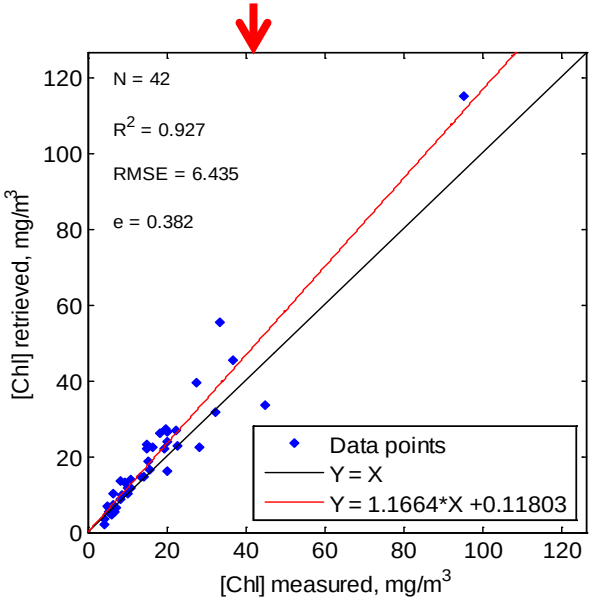
Development of Algorithms for Retrieval of Chlorophyll-a in the Chesapeake Bay and other Coastal Waters Based on JPSS-VIIRS Bands

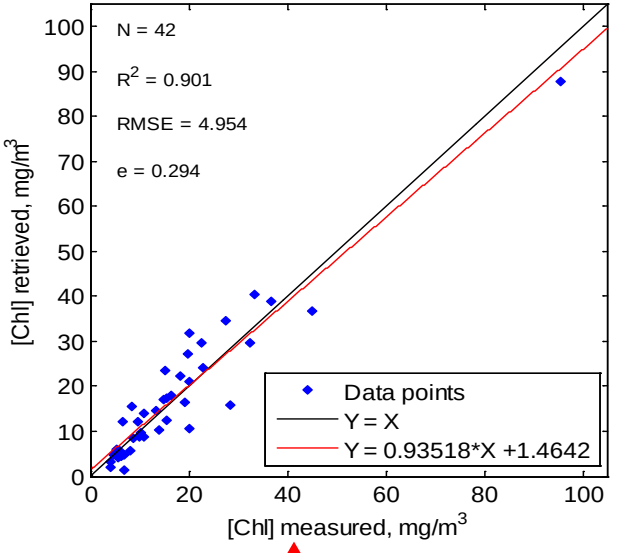
Evaluation on the field data, Chesapeake Bay, 2013

OC3V

[Chl] =(35.75*(Rrs708/Rrs665) - 19.30).^1.124
Gilerson et al 2010 very high data consistency;
no 708nm band on VIIRS







Algorithms which include 745nm band

chl1 = 10^(a1 + a2*Rrs488/Rrs550 + a3*Rrs671/Rrs745)

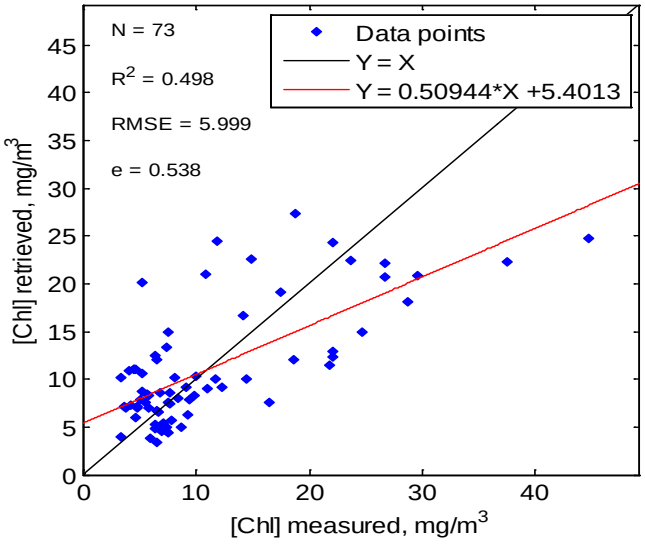
Similar results chl2 = ((2.459*(t1*Rrs745/Rrs671) - 0.439 + t2)/(0.022))^1.124

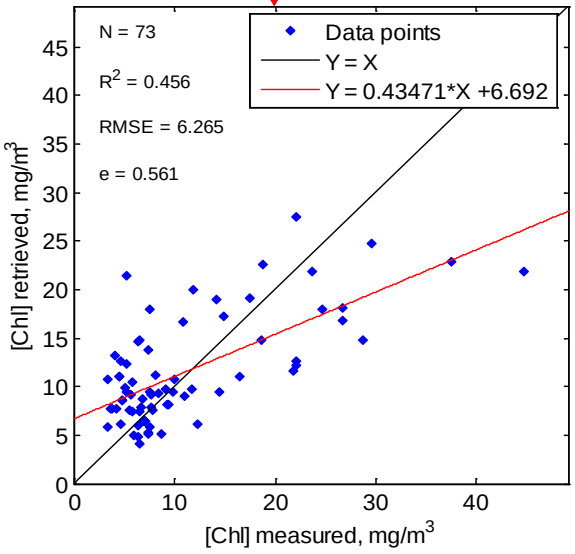
Performance of the algorithms based on the satellite data

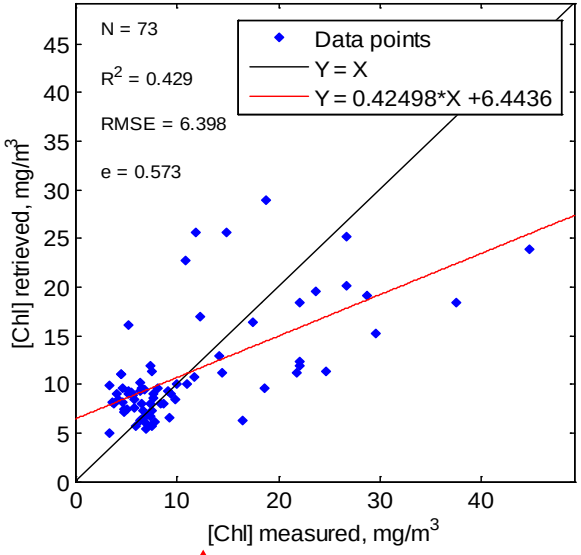
Evaluation on the satellite data VIIRS 2012-15, strict filtering, matchups with the in situ data of the Chesapeake Bay Program

OC3V

chl1 = 10^(a1 + a2*Rrs488/Rrs550 + a3*Rrs671/Rrs745)







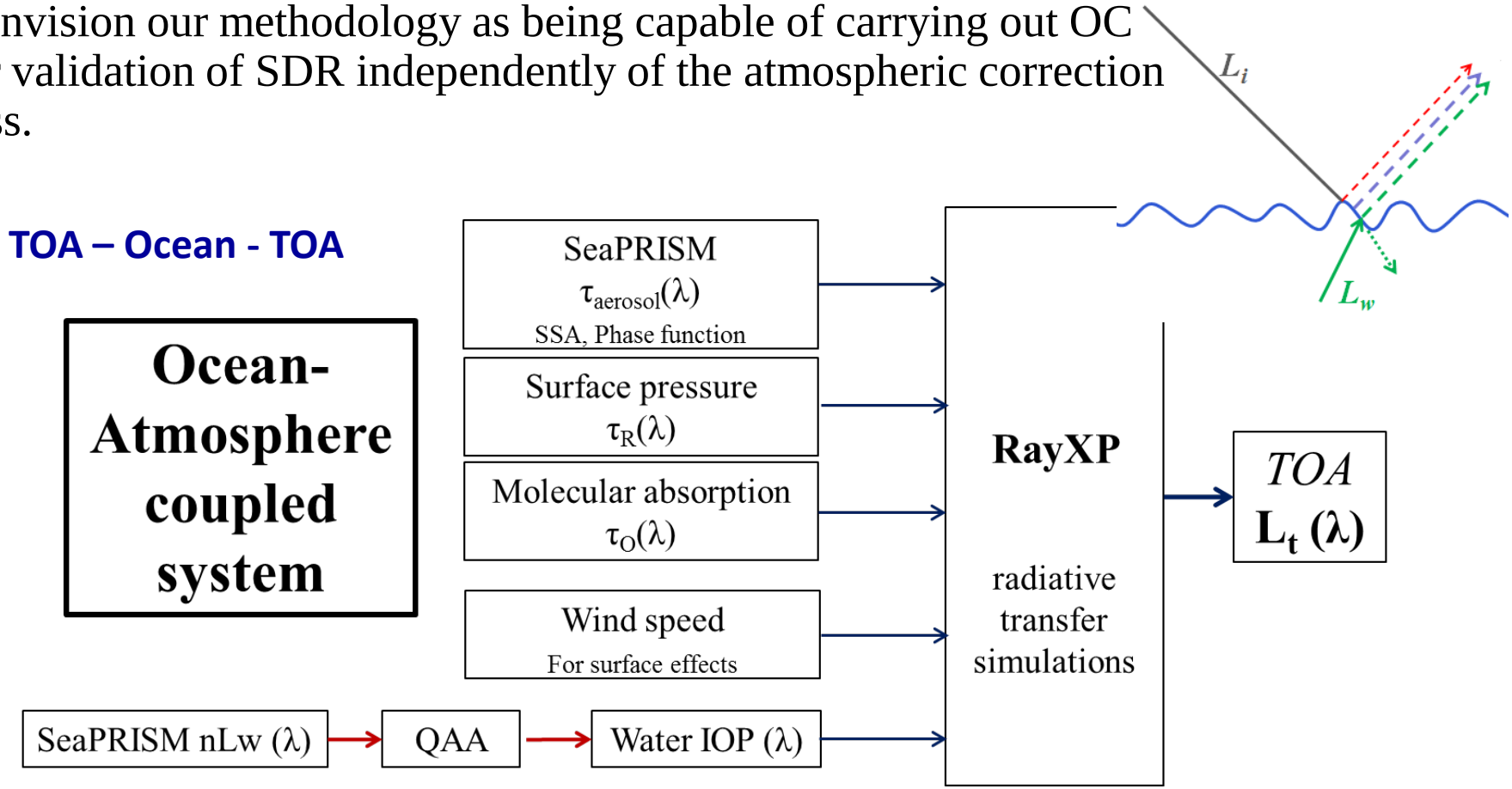
chl2 = ((2.459*(t1*Rrs745/Rrs671) - 0.439 + t2)/(0.022))^1.124

- Relatively good performance of OC3V on VIIRS in comparison with MODIS probably due to the better VIIRS spatial resolution.
- Algorithms based on 745nm band show performance similar to OC3V. That means that statistics of retrieval is determined by the spatial and temporal characteristics of matchups

A Radiometric Approach for Calibration of Current and Future Ocean Color Satellite Sensors using AERONET-OC data

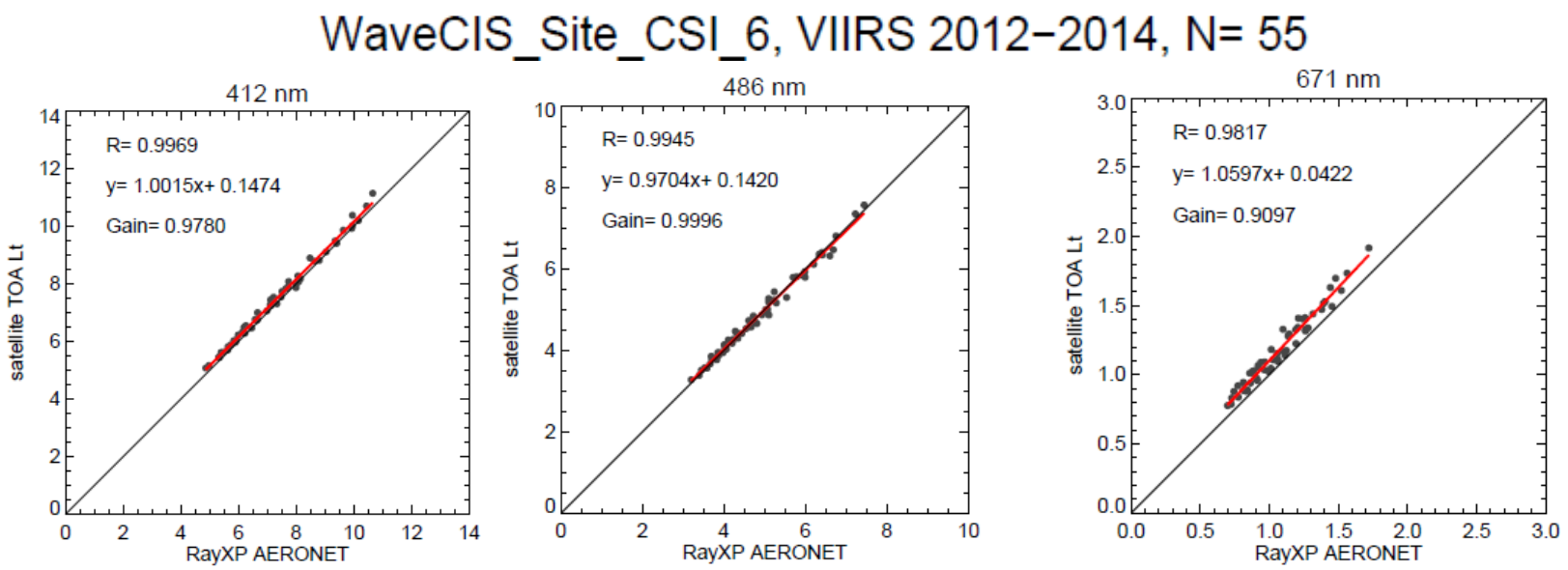
- To demonstrate a Radiative Transfer (RT) based radiometric vicarious calibration methodology for current and future satellite OC sensors.

- We envision our methodology as being capable of carrying out OC sensor validation of SDR independently of the atmospheric correction process.

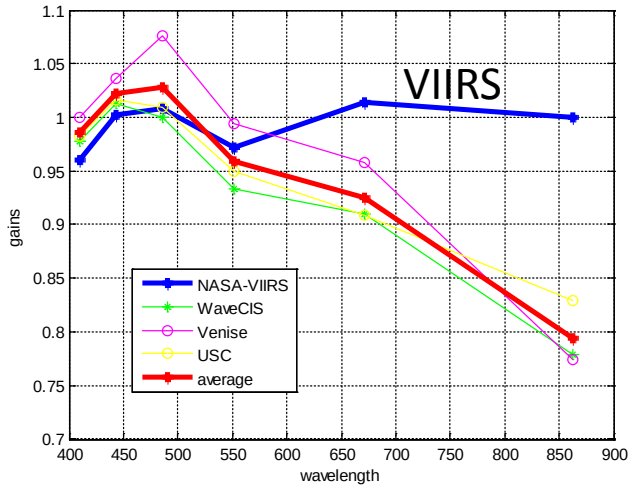


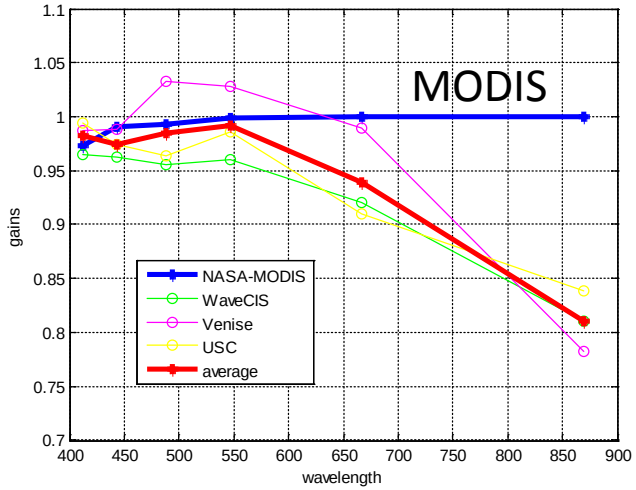
Optics Express, 2014

RT-satellite matchups and estimated gain factors



Estimated gain factors based on WaveCIS, Venise and USC





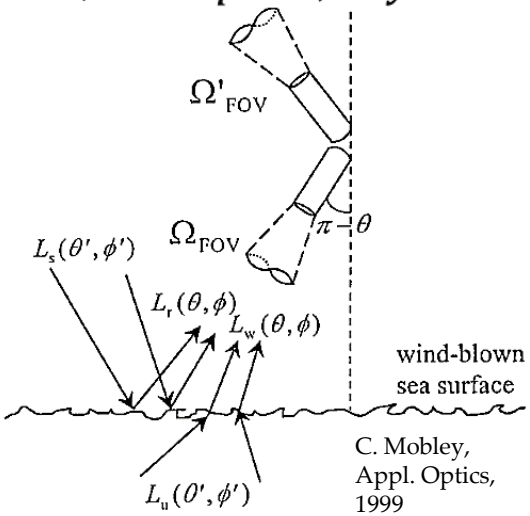
Scalar Sky Glint Correction Methods

$$\overline{Rrs} = (\bar{L}_t - \rho \cdot \bar{L}_s)/\bar{E}_d$$

For scalar reflectance:

ρ estimates how much incident light is reflected from the surface.

$$\rho = f\begin{pmatrix}\theta_s, \phi_s, \theta_v, \phi_v, n(\lambda), \Omega \\ windspeed, sky\ illumi\end{pmatrix}$$



C. Mobley, Appl. Optics, 1999



How do we estimate polarized Remote Sensing Reflectance?

How much polarized light is reflected from a sea surface?

D

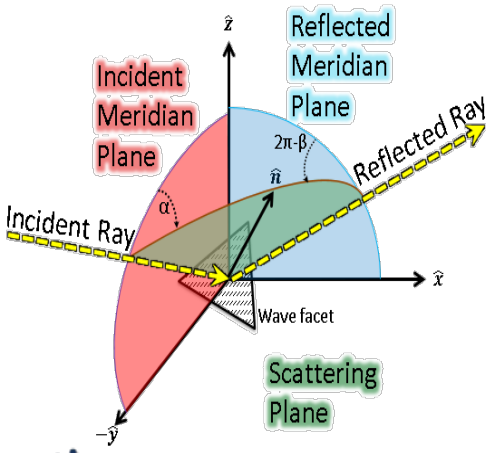
Stokes Vector Rotation

$$\bar{R}_s(\theta) = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos(2\theta) & -\sin(2\theta) & 0 \\ 0 & \sin(2\theta) & \cos(2\theta) & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

polarized ρ

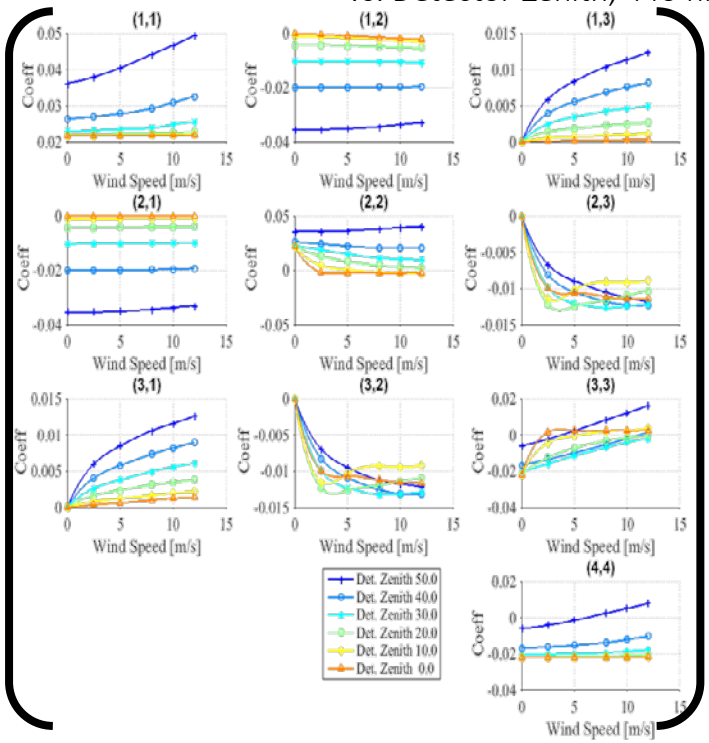
$$\bar{S}_{Refl} = [\bar{R}_s(\beta) \cdot \bar{F} \cdot \bar{R}_s(\alpha)] \cdot \bar{S}_{sky}$$

Fresnel matrix for facet.

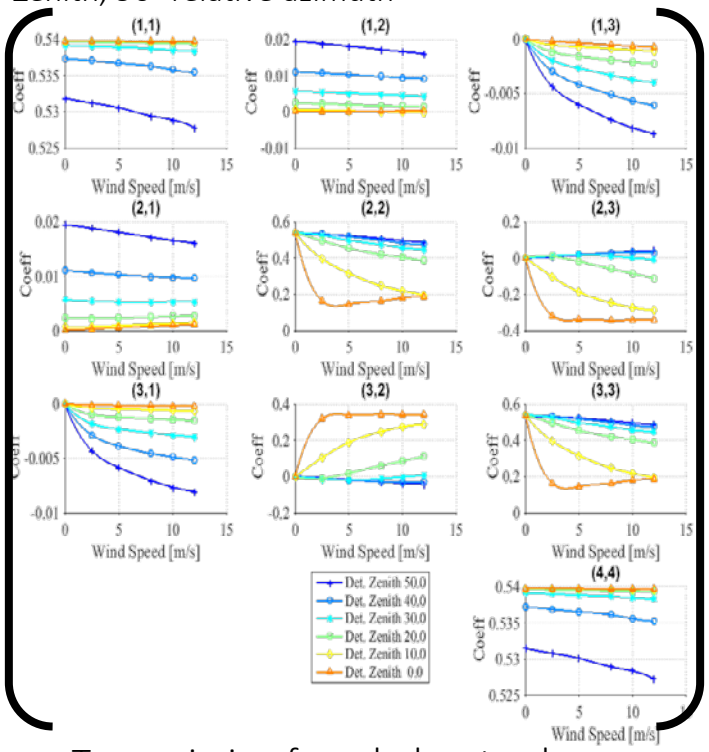


Effective Fresnel Matrices (ρ) For Glint Correction

vs. Detector Zenith, 440 nm, 40° Solar Zenith, 90° relative azimuth



Reflection of light from surface



Transmission from below to above

Comparison with Underwater Polarimeter

16:37 UTC, July 30th, 2014.
80 *km* South-East of Norfolk, VA.

