Validation for Ocean Color satellites (LISCO and Ocean Cruises)

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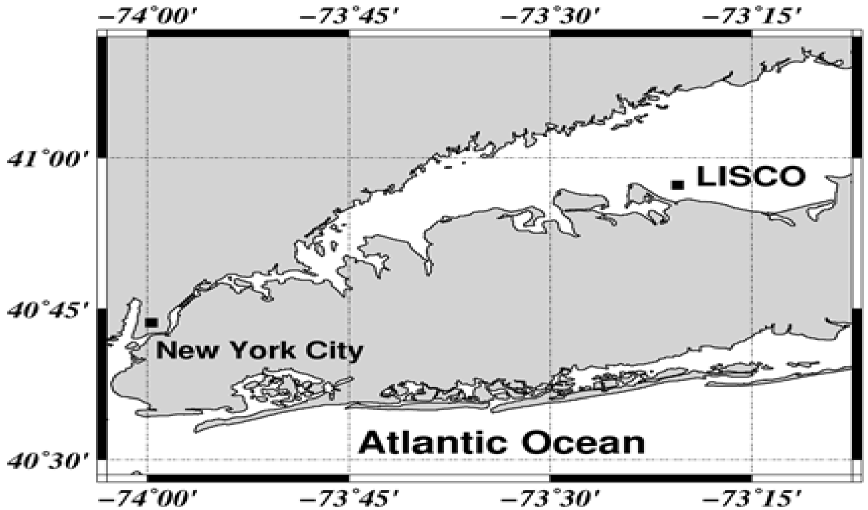
JPSS meeting, August 10, 2016

Long Island Sound Coastal Observatory (LISCO)



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

HyperSAS-POL with polarimetric sensors. Transmitted data to CCNY server every hour. Was on the platform in 2009-2014. Currently used for the shipborne operations.

Comparison of spectral Remote Sensing Reflectance (Rrs) using NASA and NOAA **MSL12** processing and AERONET data

Rrs are obtained from:

- MODIS (412, 443, 488, 547, and 667)
- VIIRS (410, 443, 486, 551, and 671)
- LISCO AERONET-OC, Level 1.5 (413, 442, 491, 551, 668)

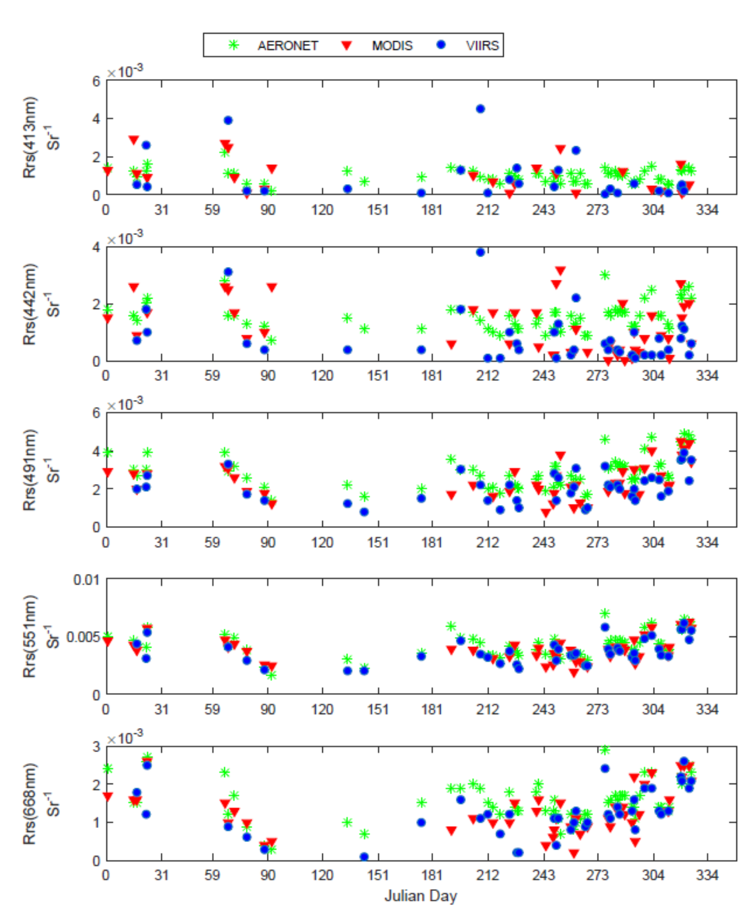
Satellite data are filtered for sunglint and clouds on a 3x3 grid centered at LISCO

Stray-light flag is suspended

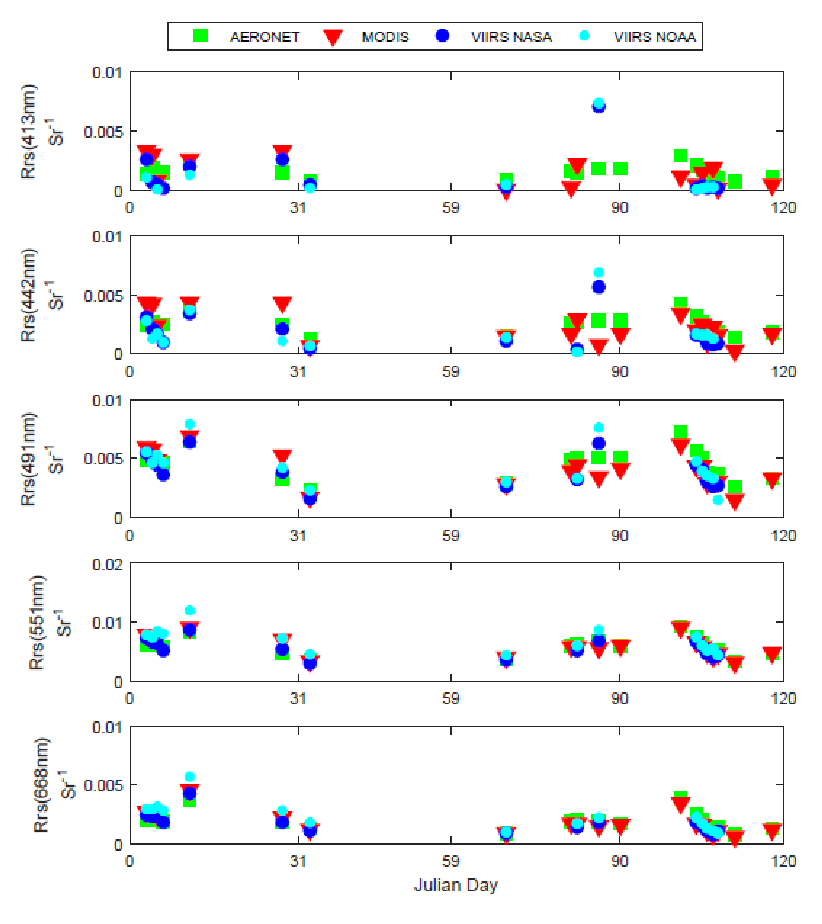
Temporal coincidence is sought with AERONET-OC measurements (±2h)

Time series data for the LISCO site

All 2015



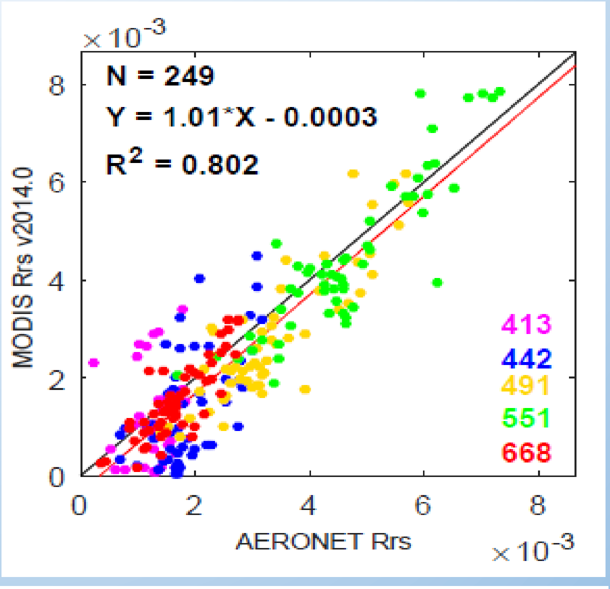
2016



Validation on the LISCO site (all 2015)

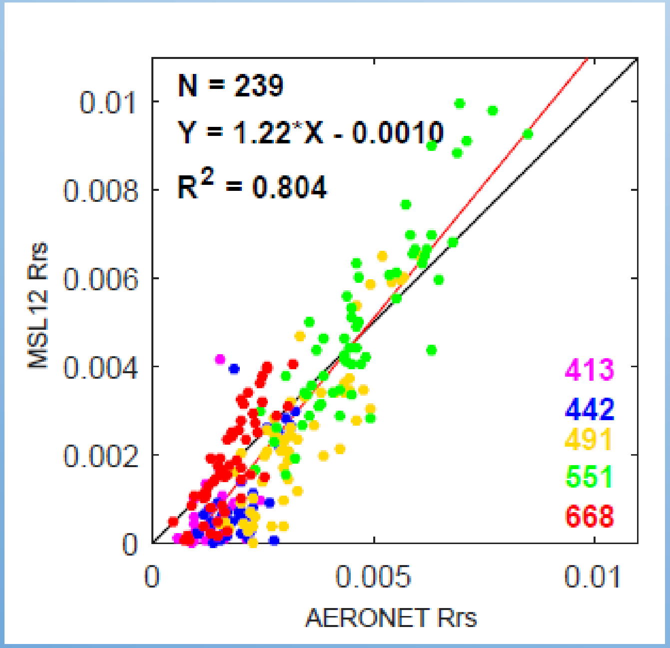
MODIS

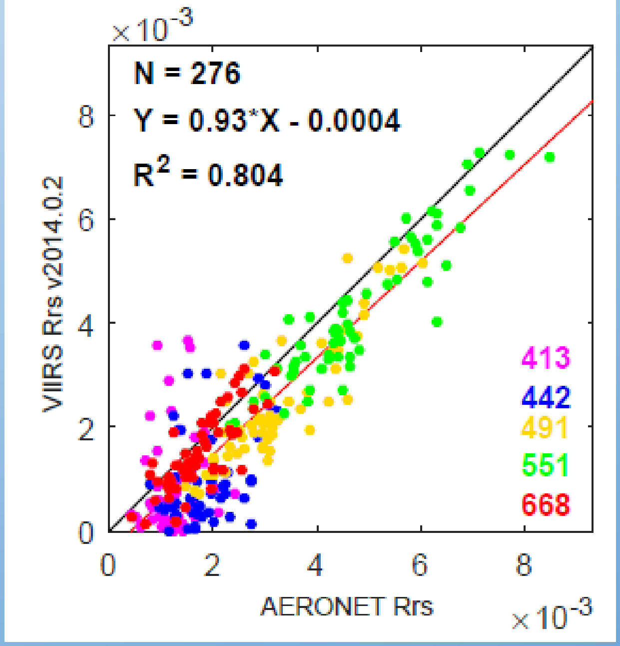
NASA



NOAA
MSL12

VIIRS

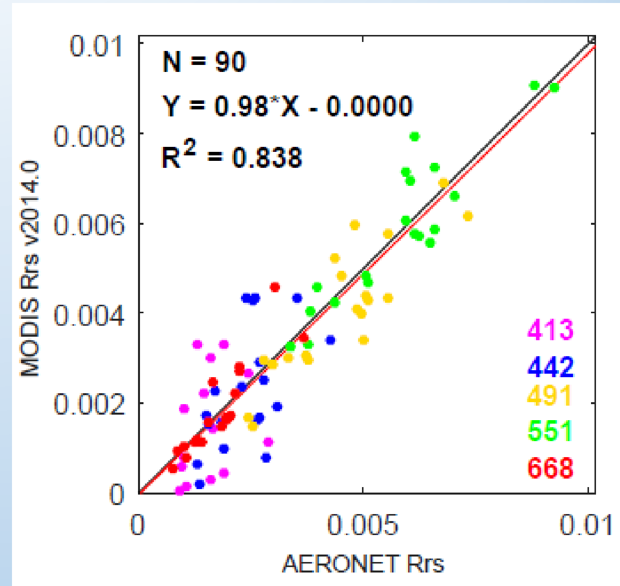




NASA

Validation on the LISCO site (2016)

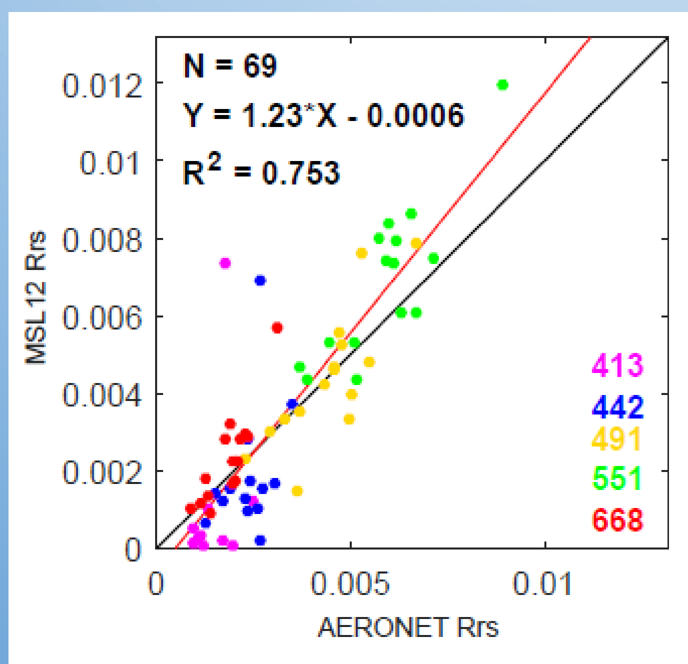
MODIS

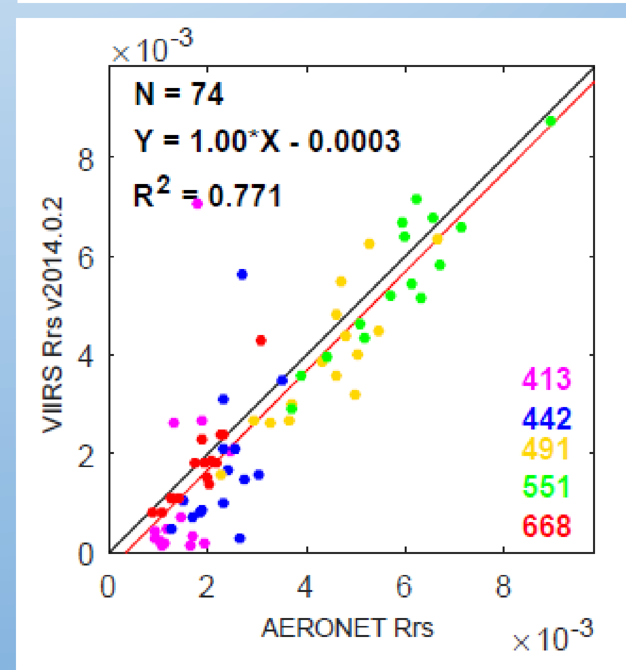


NASA

NOAA
MSL12

VIIRS





NASA

Validation in ocean cruises

CCNY ocean group participated in two VIIRS validation ocean cruises on NOAA R/V Nancy Foster (Nov. 2014, Dec. 2015)

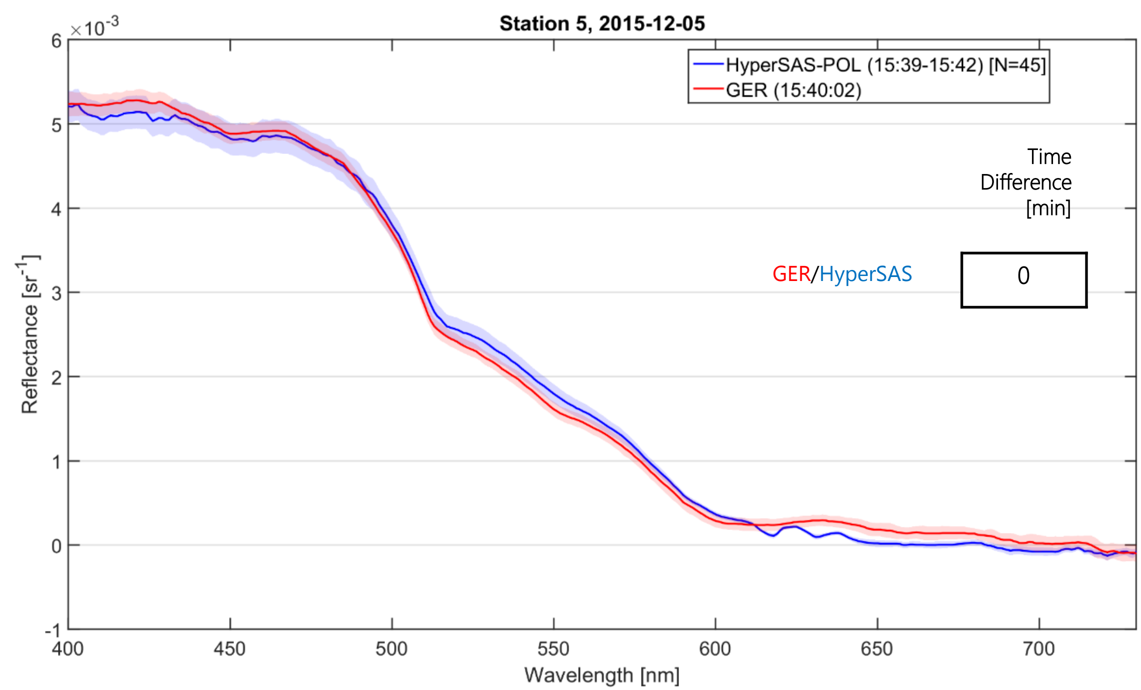
Other teams: NOAA/STAR, NASA, U. of South Florida, OSU, U. of Southern Mississippi, UMAS Boston

CCNY HyperSAS-POL (6 sensors) in front of the ship. Made underway measurements with continuous adjustment of its platform for Sun glint minimization

GER and ASD handheld spectroradiometers for manual operation

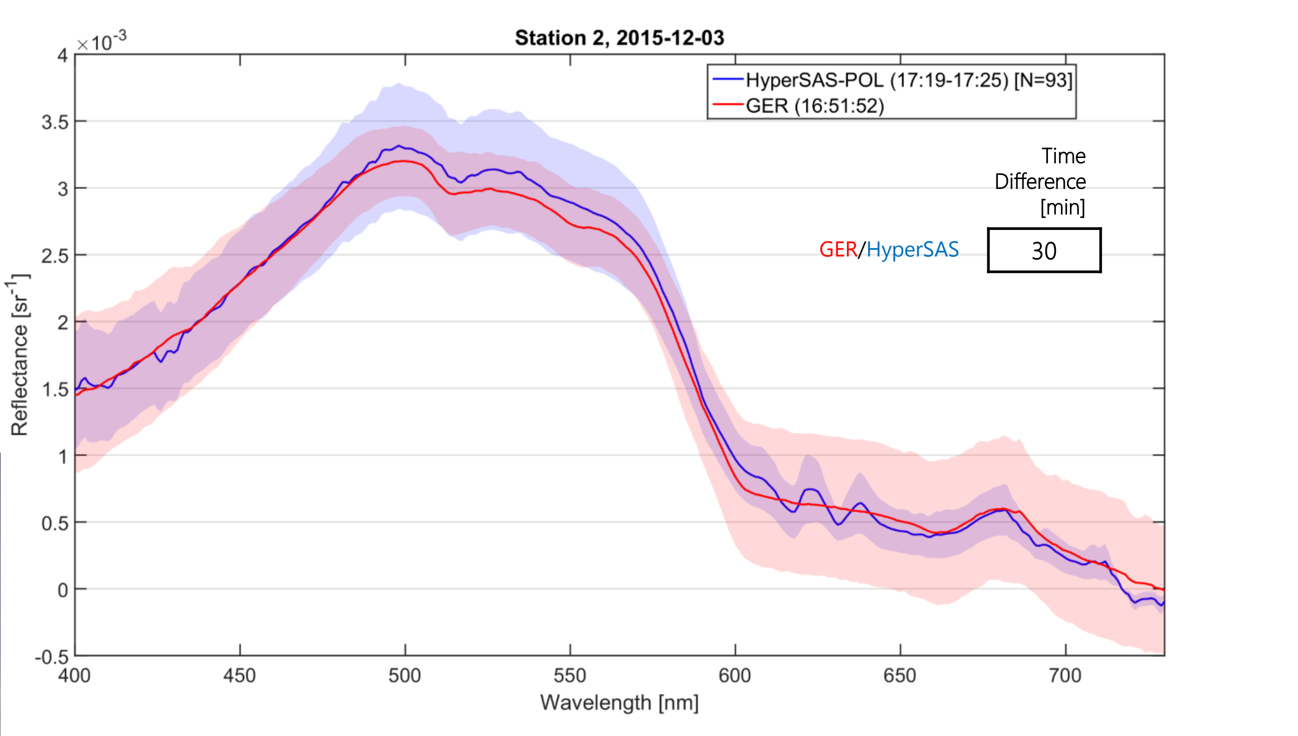
Comparison of HyperSAS and GER (handheld) data (open ocean station)

Station 5

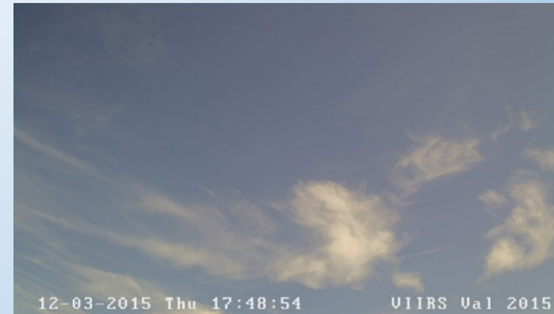


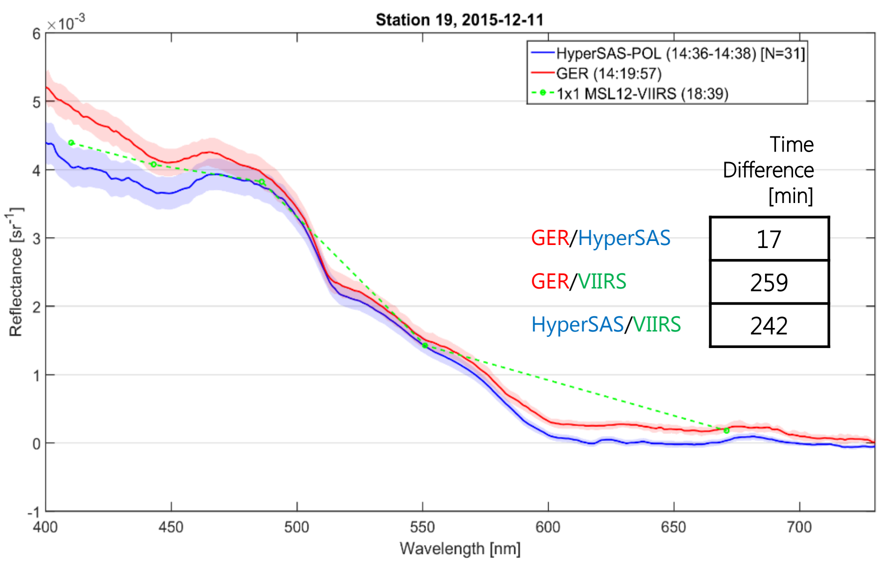
Comparison of HyperSAS and GER (handheld) data (coastal water station)

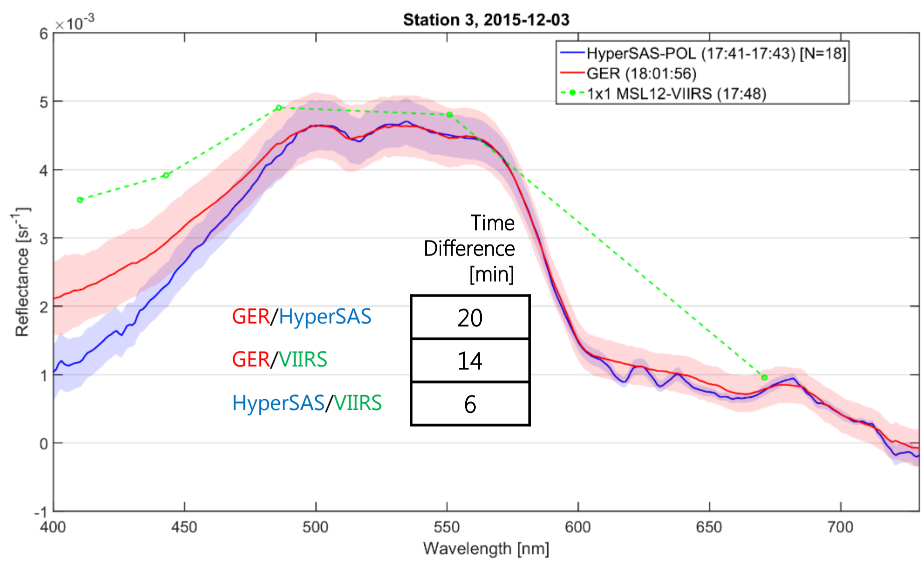
Station 2



Comparison of HyperSAS, GER (handheld) and VIIRS data







Open ocean station

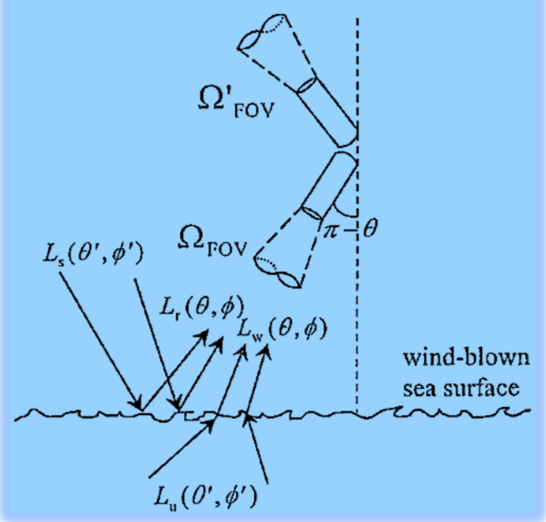
Coastal water station

HyperSAS showed very good performance in comparison with many other instruments on board and can be considered as a stable shipborne instrument for the validation of the satellite data

Glint Correction

How do we estimate polarized Remote Sensing Reflectance?

For scalar reflectance:



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

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

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

For polarized reflectance:

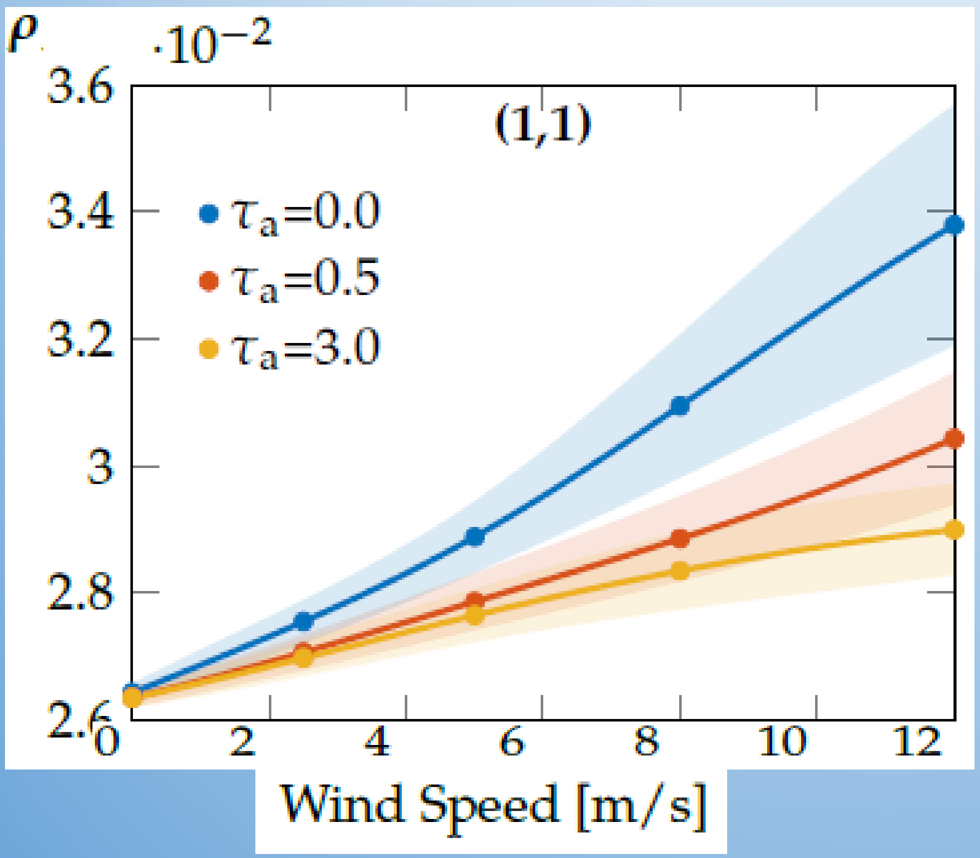
We need to know the full polarization state of the light after interaction with the surface.

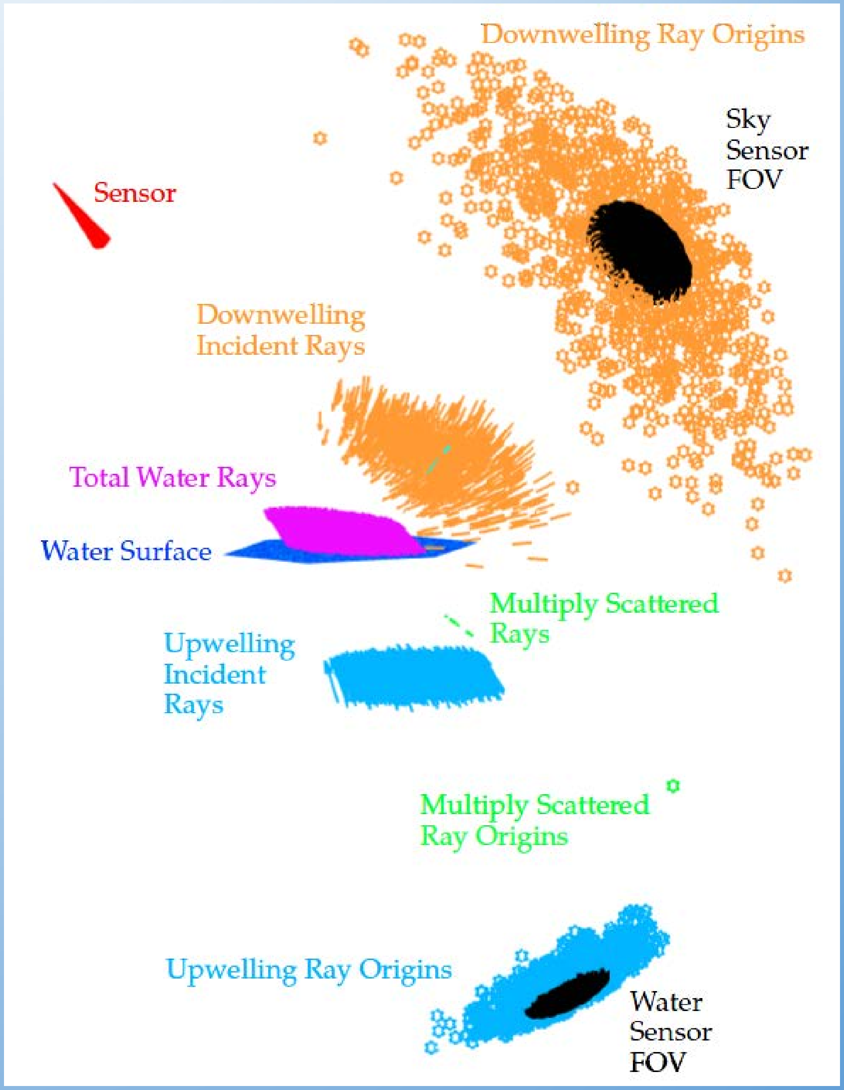
$$\bar{\rho} = \begin{bmatrix} \rho_{11} & \rho_{12} & \rho_{13} & \rho_{14} \\ \rho_{21} & \rho_{22} & \rho_{23} & \rho_{24} \\ \rho_{31} & \rho_{32} & \rho_{33} & \rho_{34} \\ \rho_{41} & \rho_{42} & \rho_{43} & \rho_{44} \end{bmatrix}$$

Goal: Determine $\bar{\rho}$

$$R^p_{rs}(\theta_v, \phi_v, \lambda) = \frac{L^p_t(\theta_v, \phi_v, \lambda) - \bar{\rho} L^p_s(\pi - \theta_v, \phi_v, \lambda)}{E_d(\lambda)} \quad [sr^{-1}]$$

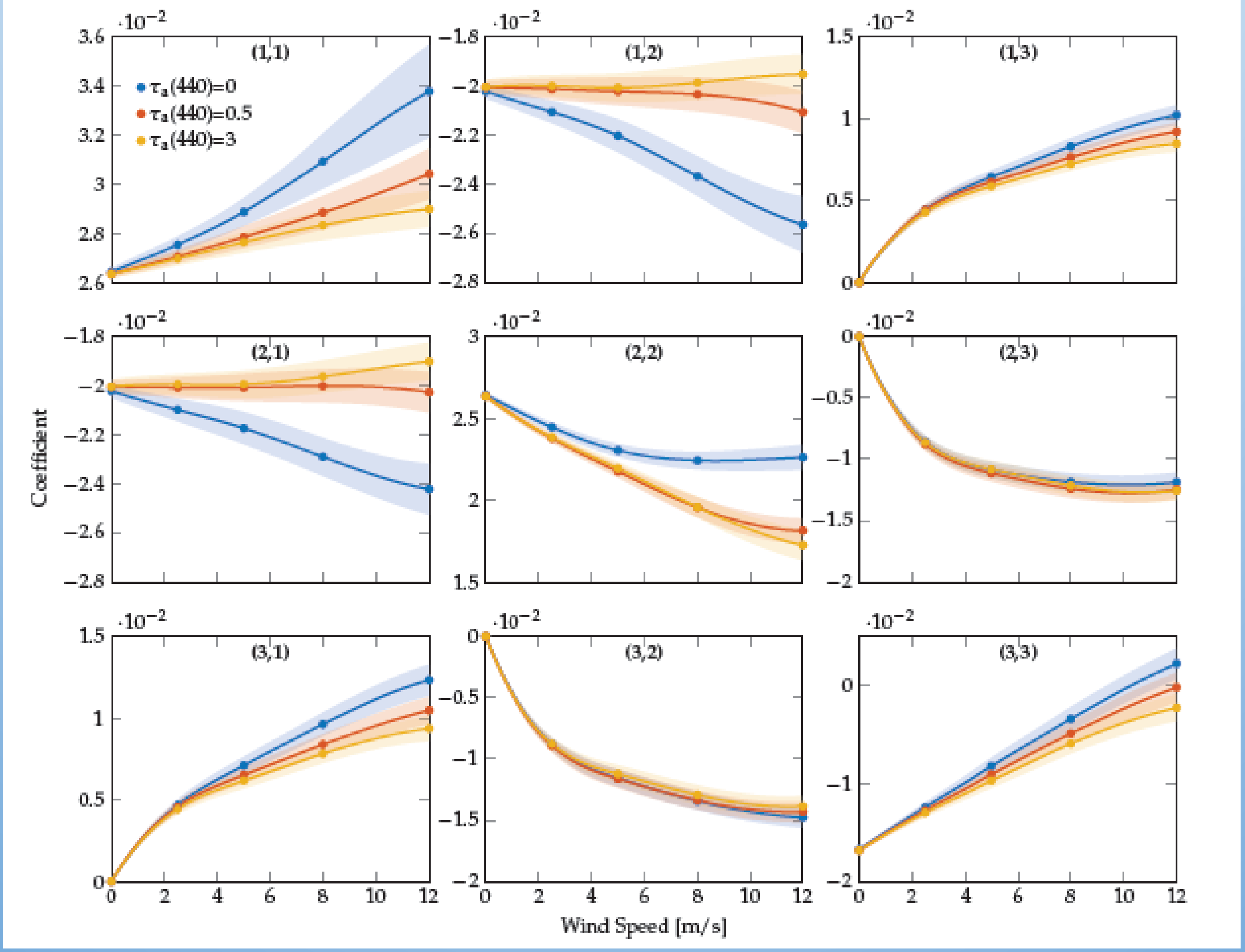
Modeling of light reflection for wind driven ocean surfaces





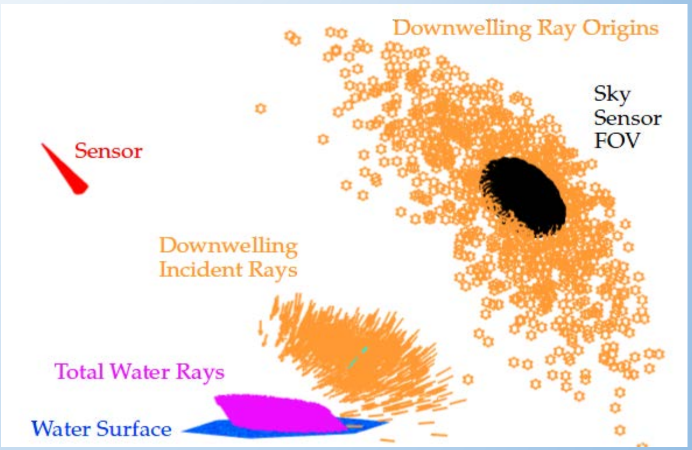
R. Foster et al, Appl. Opt. (in review)

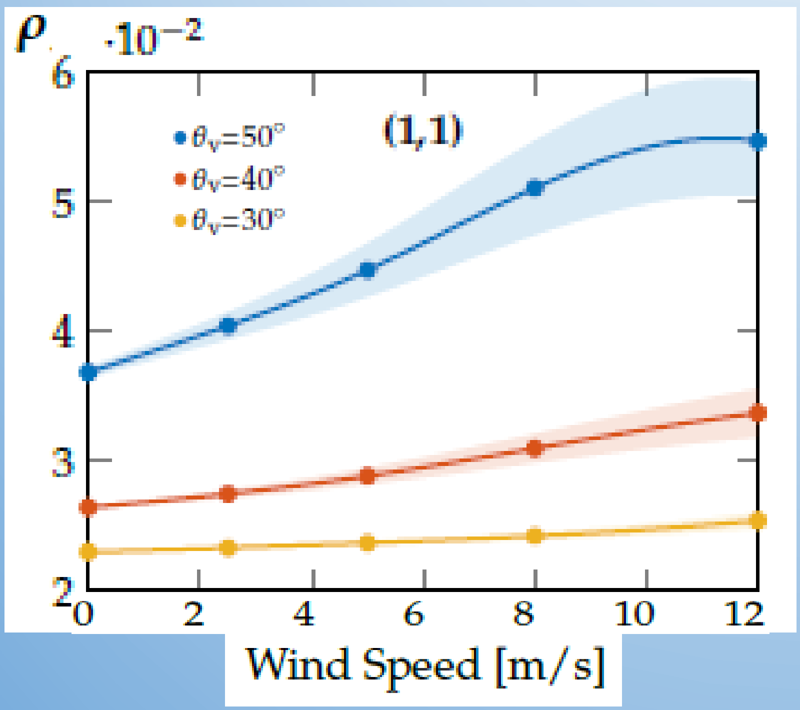
Effective surface reflective matrix

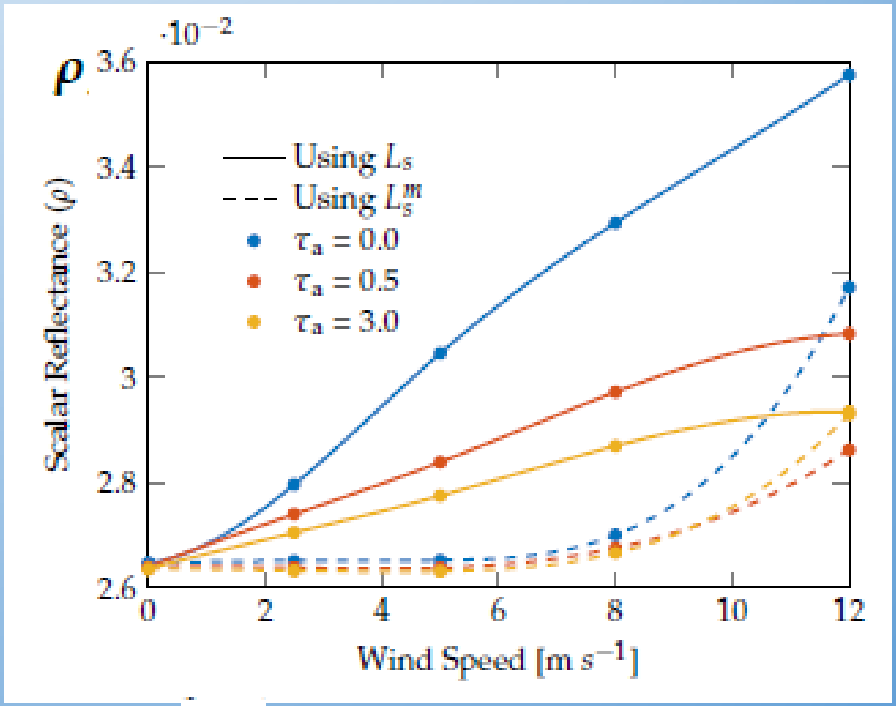


Sun angle 30 deg, viewing angle 40 deg, azimuth angle 90 deg

Dependence of ρ on the viewing angle and a field of view







L_s^m is for the measurement of the radiometer with 5.75 deg half angle

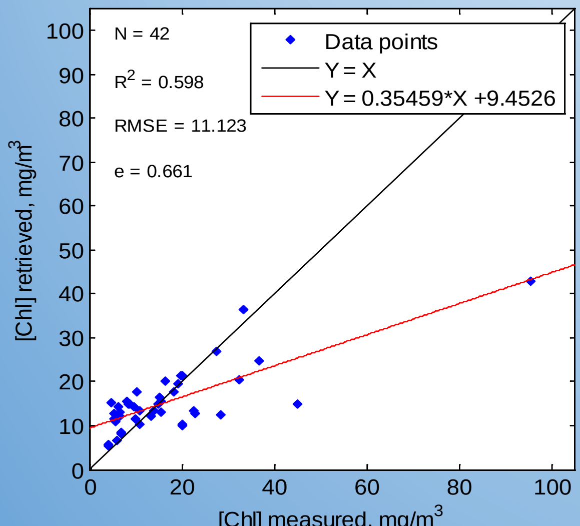
Combination of accurate measurements and correct coefficients improves HyperSAS and other sensors data quality in above water measurements

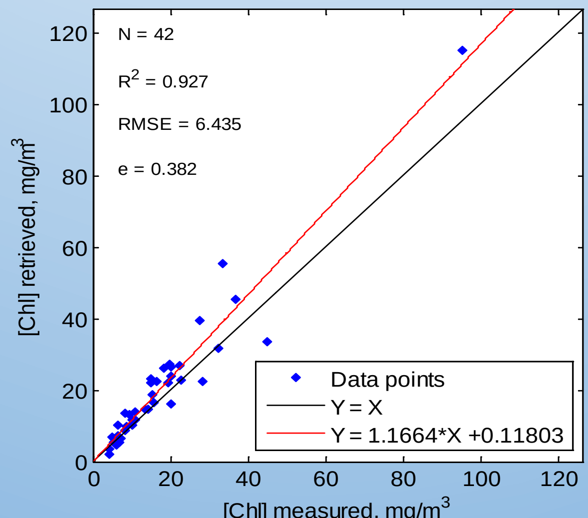
Development of Algorithms for Retrieval of Chlorophyll-a in the Chesapeake Bay and other Coastal Waters Based on JPSS-VIIRS Bands

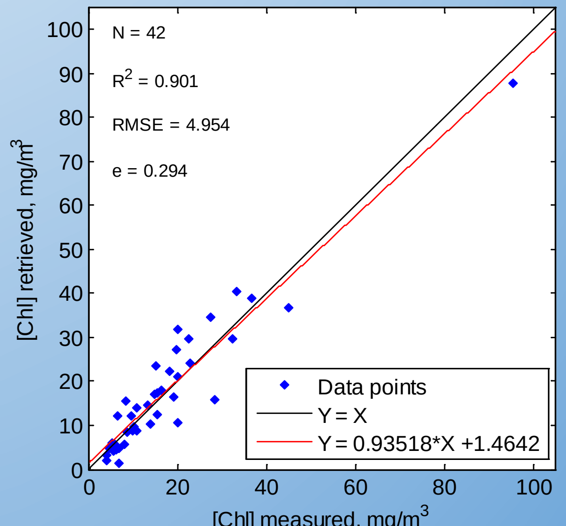
Evaluation on the field data, Chesapeake Bay, 2013

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

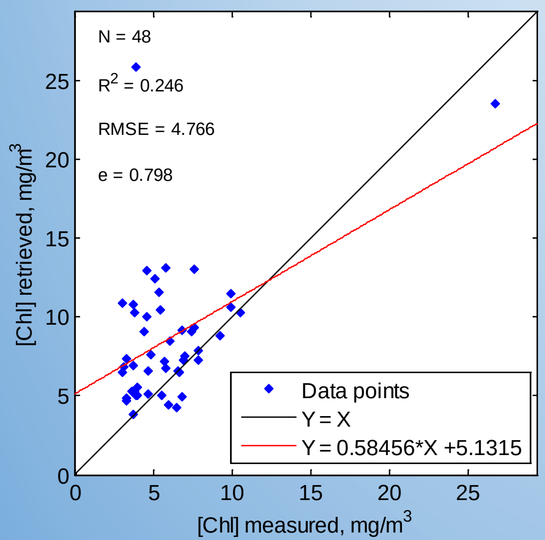
chl1 = 10^(a1 + a2*Rrs488/Rrs550 + a3*Rrs671/Rrs745)

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

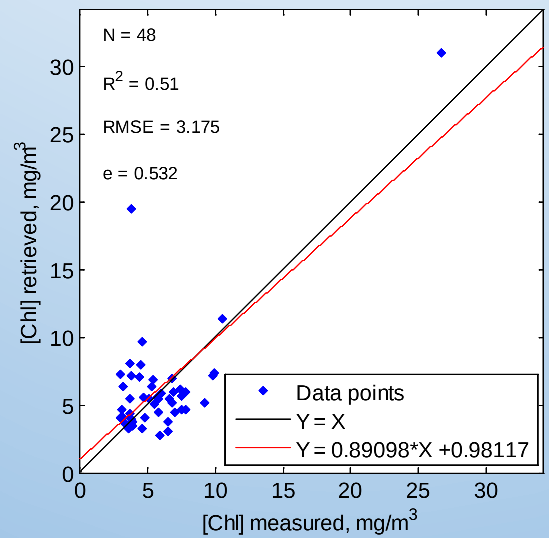
Performance of the algorithms based on the satellite data

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

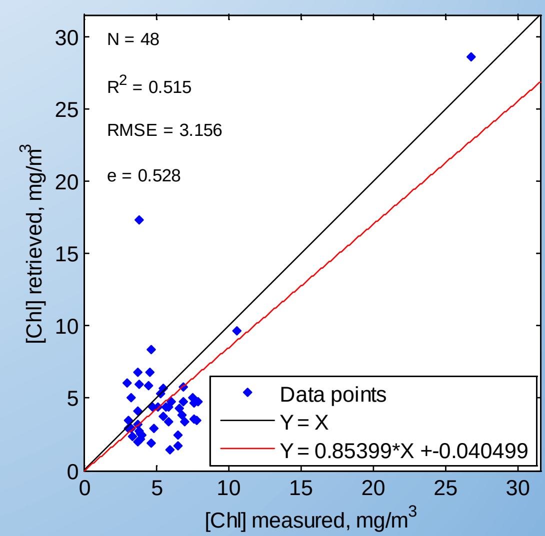
OC3V



$Chl1 = 10^{(a1 + a2*R1 + a3*R2)}$



$Chl2 = c1*(1/R2)^{c2} - c3$



R1=Rrs486/Rrs550; R2= Rrs671/Rrs745)

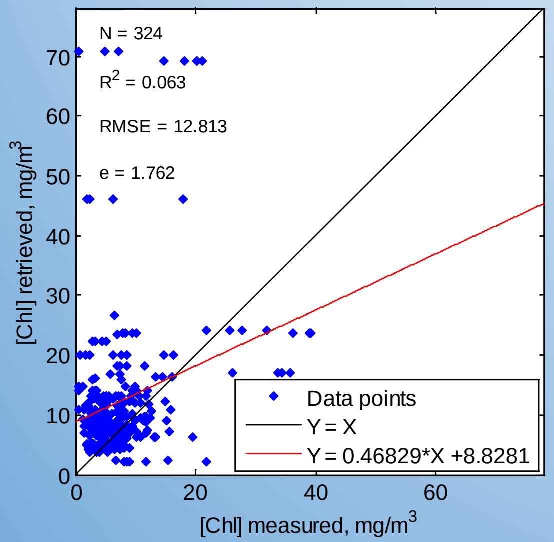
- Good performance of the algorithms which use 745nm band in comparison with OC3V on VIIRS.
- Small amount of data because of the strict filtering

Performance of the algorithms based on the satellite data

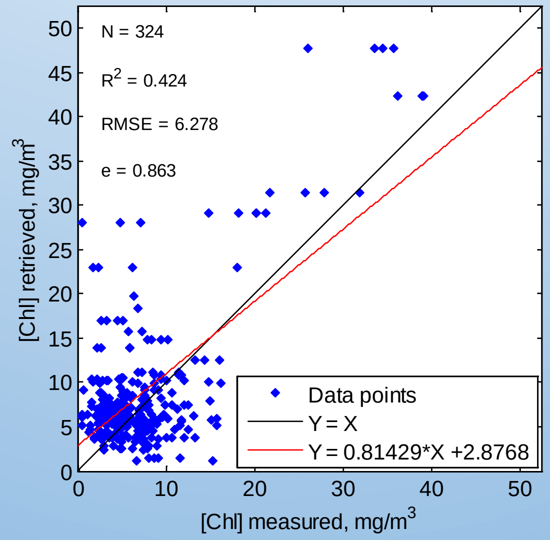
Stray light flag is suspended

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

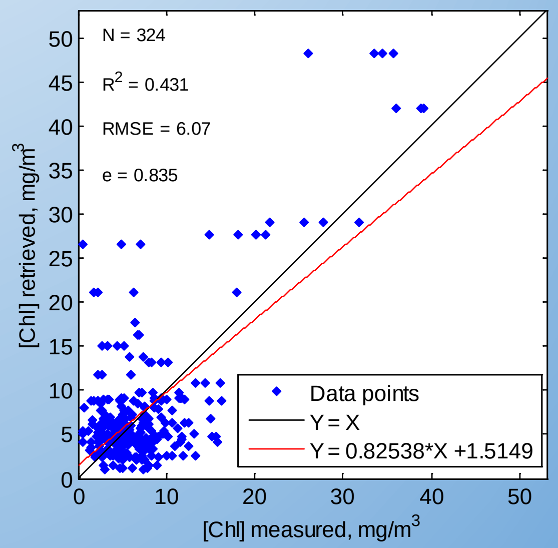
OC3V



Chl1 = 10 $^{(a1 + a2*R1 + a3*R2)}$



Chl2 = c1*(1/R2) ^{c2} - c3



R1=Rrs486/Rrs550; R2= Rrs671/Rrs745)

While few outliers are present, new algorithms significantly outperform OC3V algorithm

Conclusions

- Based on the comparison of the satellite and AERONET-OC data on the LISCO site 412 and 443nm bands for MODIS and VIIRS do not perform well in coastal environment, atmospheric data should be further analyzed.
- HyperSAS instrument performs well in the shipborne mode and can be considered for the validation at the stations and underway.
- Accurate reflection coefficients were simulated for various wind and observation conditions and can be used for the improvement of the sky correction in above water measurements.
- Chlorophyll algorithms for the Chesapeake Bay with VIIRS bands have been developed based on the Rrs671/Rrs745 ratio which significantly outperform standard OC3V algorithms.

- We acknowledge support from the JPSS program and NOAA-CREST.