CCNY VIIRS validations at the Long Island Sound Coastal Observatory (LISCO) and on Cruises

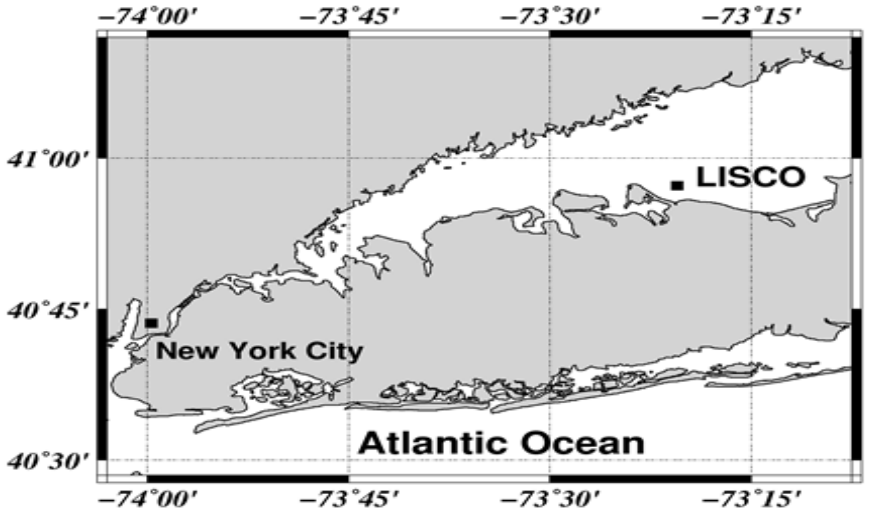
Alex Gilerson, Robert Foster, Eder Herrera, Matteo Ottaviani, Ahmed El-Habashi, Carlos Carrizo, Andrei Golovin, Samir Ahmed

Optical Remote Sensing Laboratory,
The City College of the City University of New York





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 NOAA **MSL12** and NASA and 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)

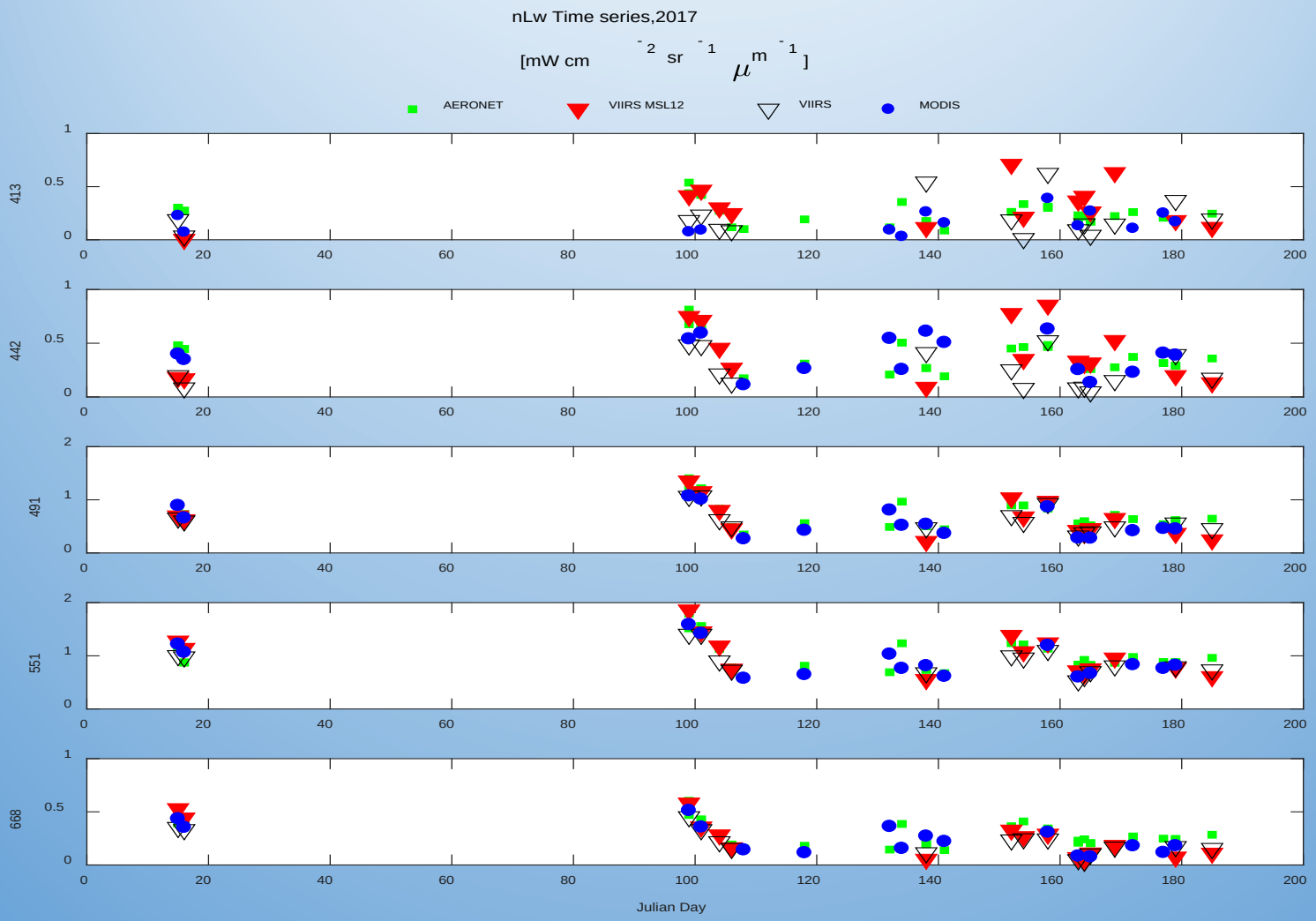
Satellite data are filtered for sunglint and clouds on a 3x3 grid centered at LISCO

Stray-light flag is suspended

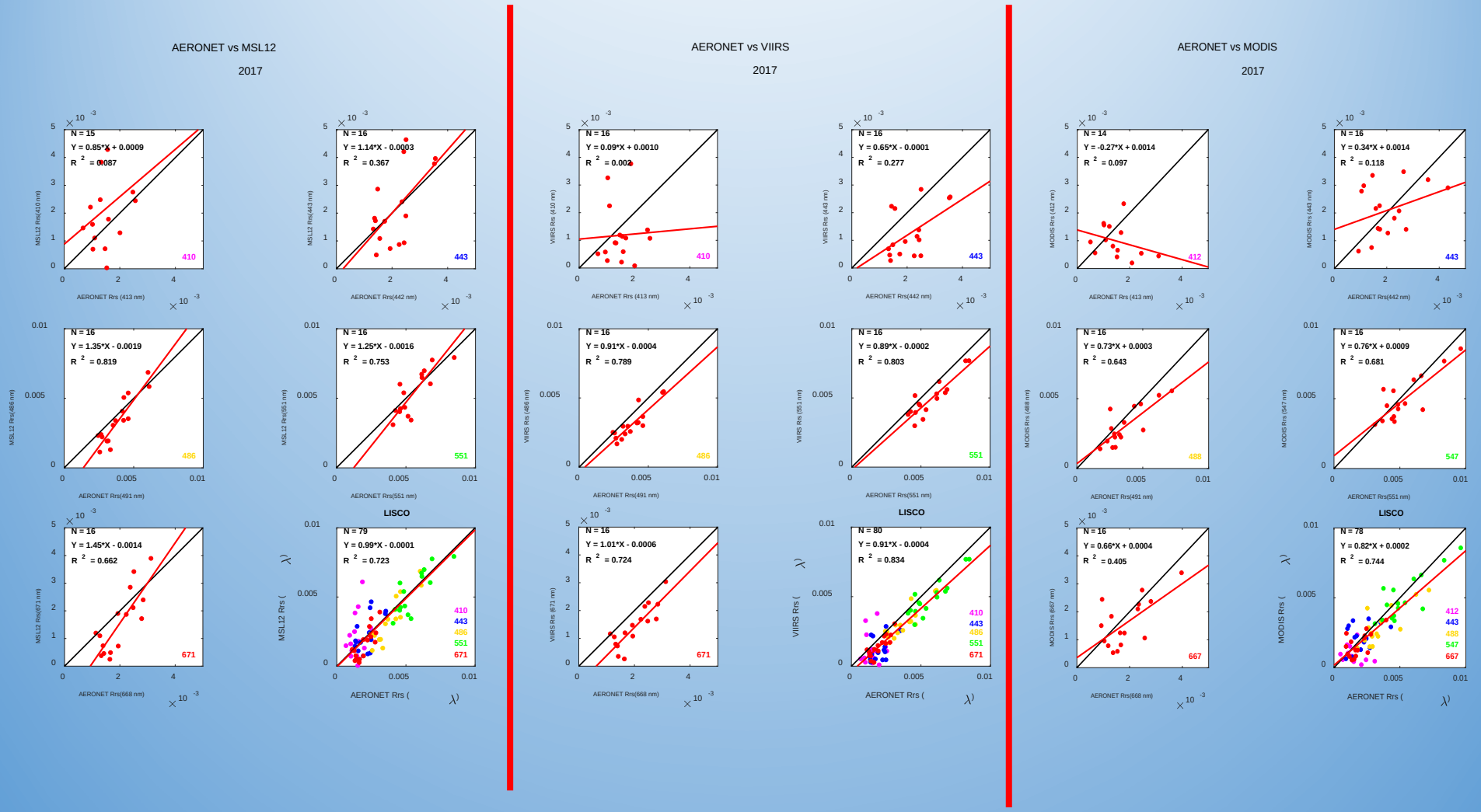
Temporal coincidence is sought with AERONET-OC measurements (±2h)

Time series data for the LISCO site

2017



Matchups with satellites at the LISCO site



Validation in ocean cruises

CCNY ocean group participated in three VIIRS validation ocean cruises on NOAA R/V Nancy Foster (Nov. 2014, Dec. 2015, Oct. 2016)

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



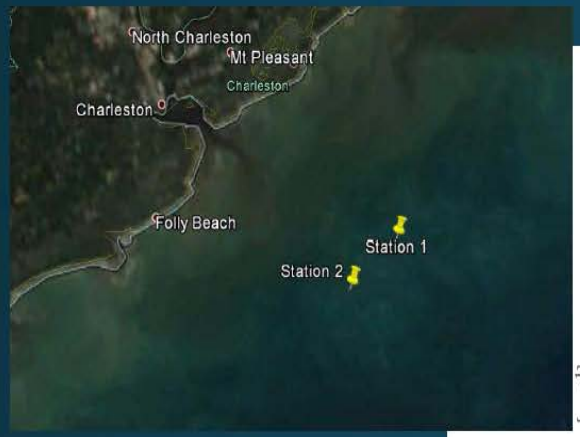


CCNY HyperSAS-POL (6 sensors) in front of the ship. Made at the stations and underway measurements with continuous adjustment of its platform for Sun glint minimization. Shown together with full Stokes green band camera.

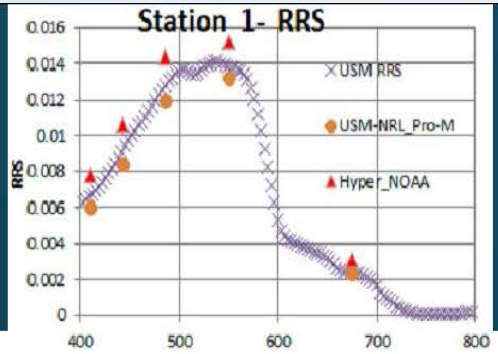
GER handheld spectroradiometer for manual operation

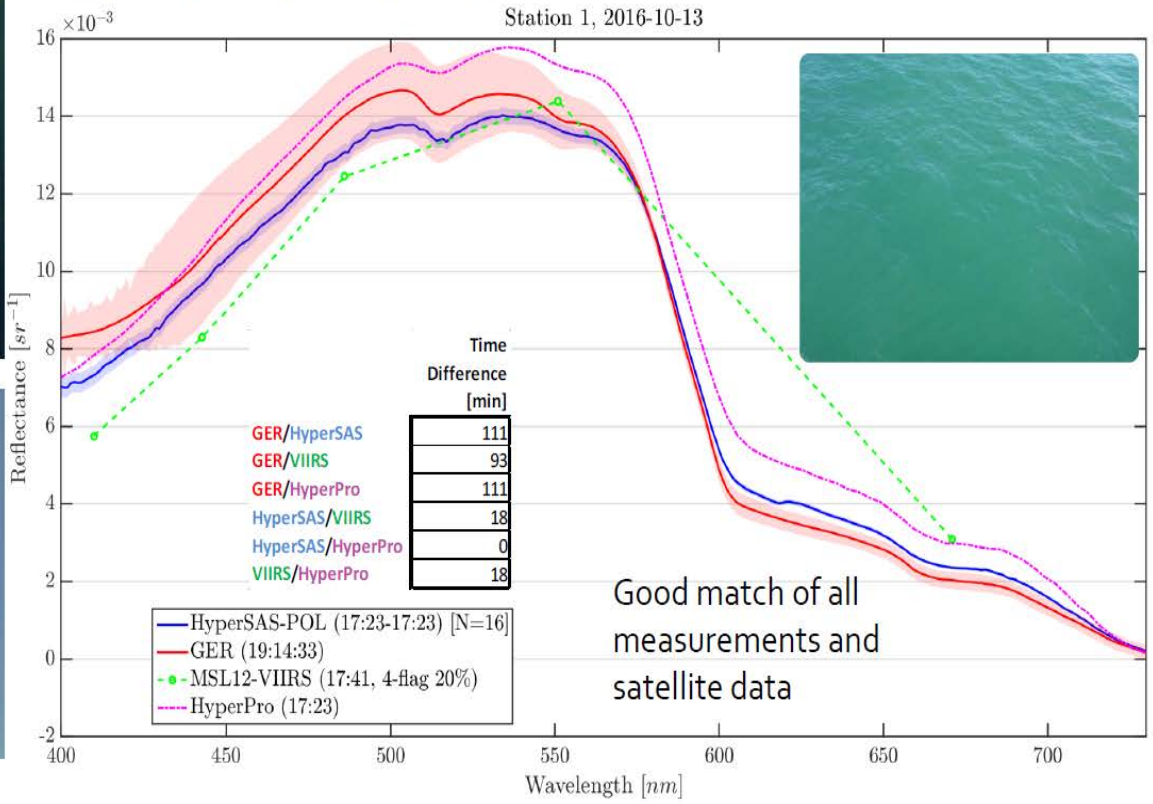
Comparison of HyperSAS and GER data with other measurements (coastal station)

Station 1







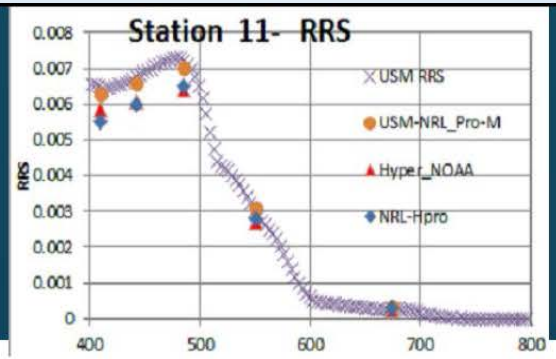


Comparison of HyperSAS and GER data with other measurements (open ocean water station)

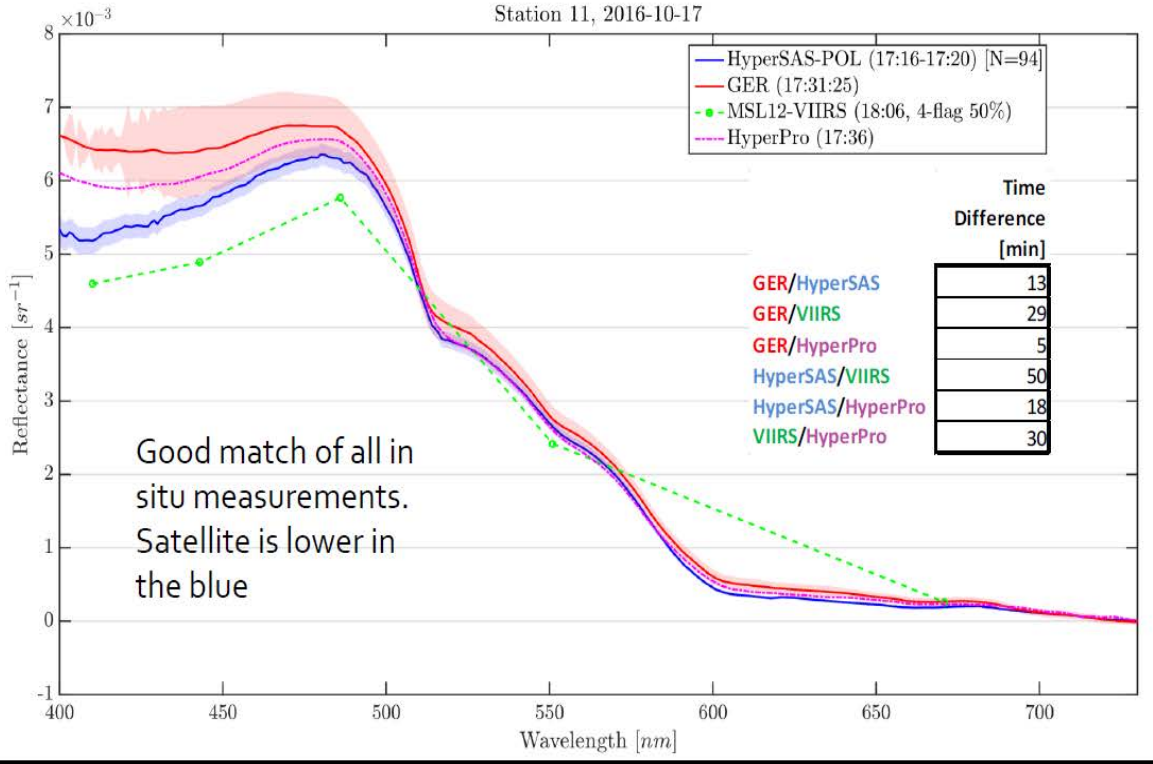
Station 11



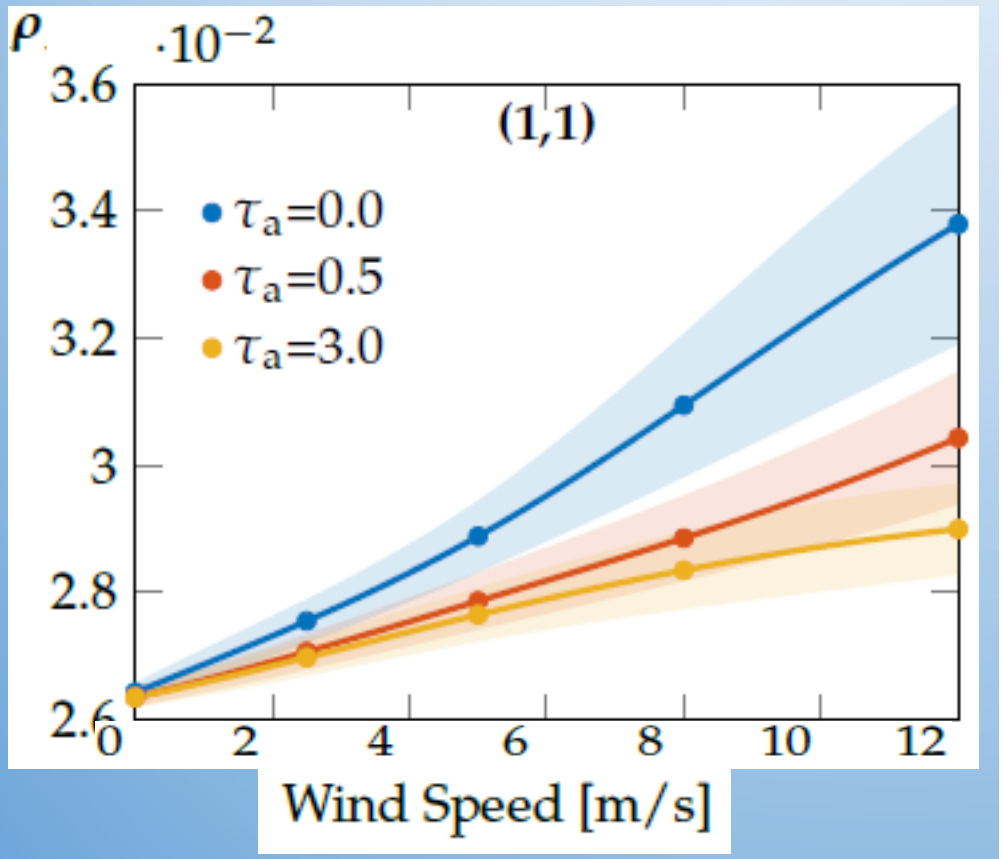


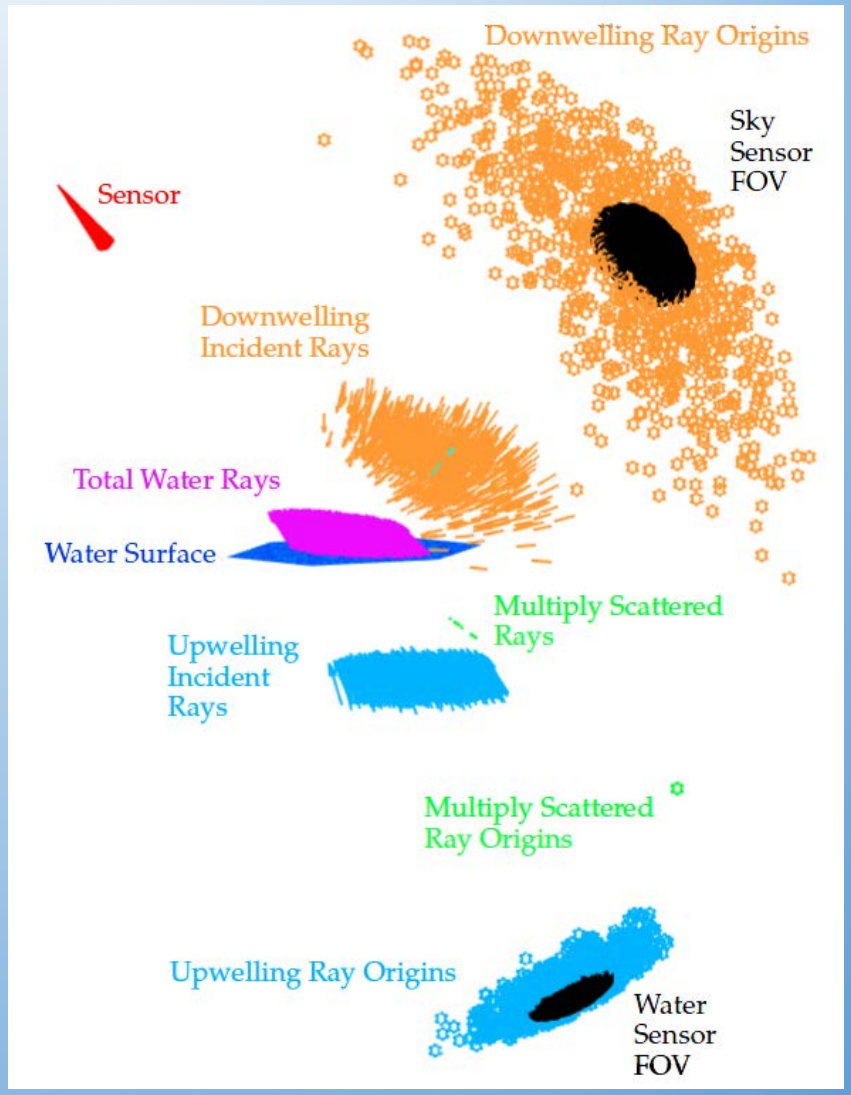






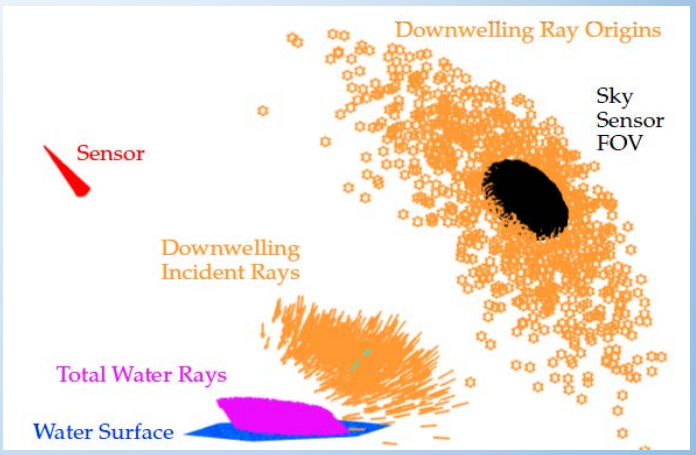
Modeling of light reflection for wind driven ocean surfaces

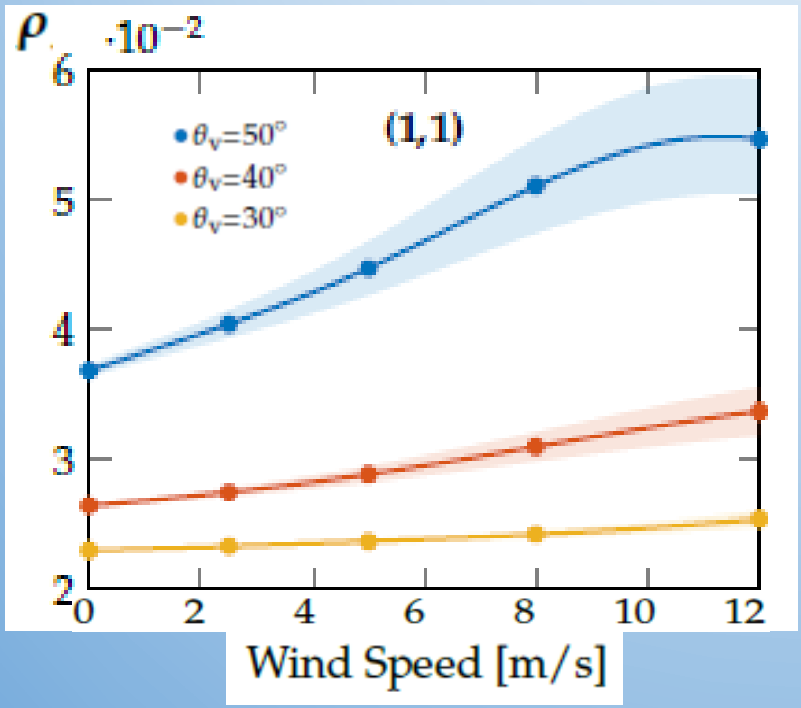


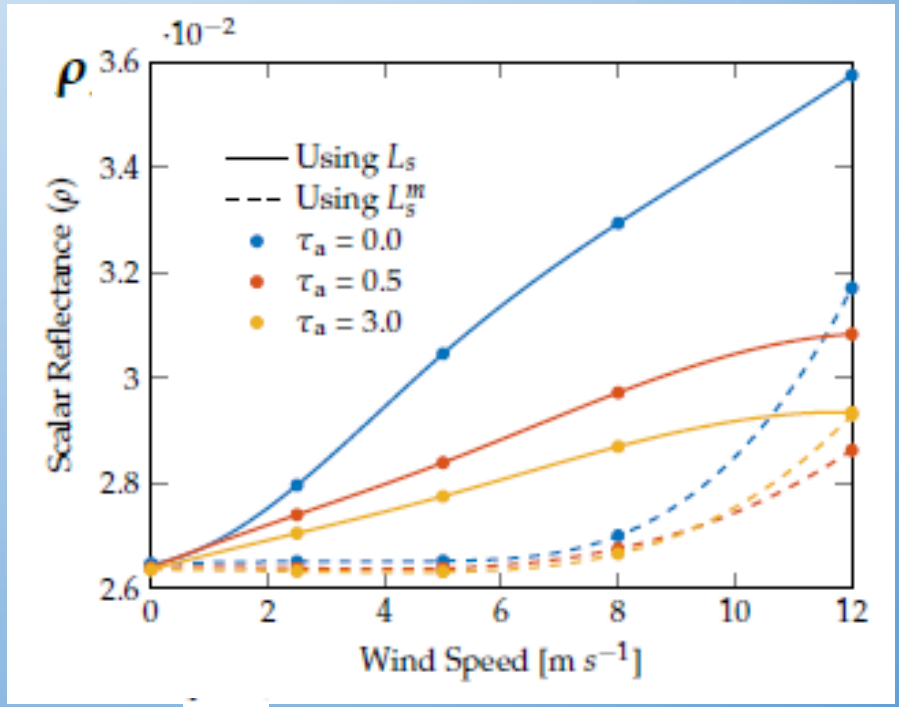


R. Foster et al, Appl. Opt. 2016

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







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

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

Snapshot hyperspectral Imager

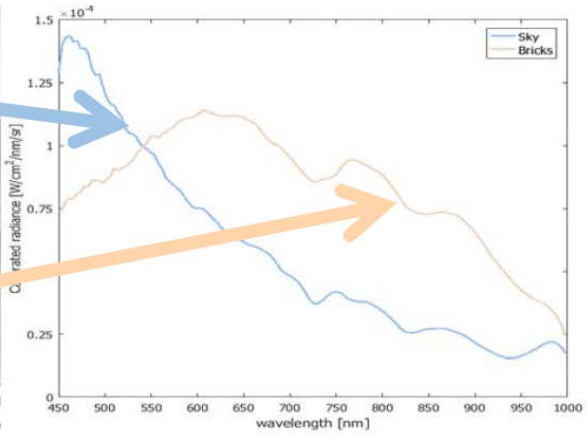




450-1000nm, 138 bands
Field of view: 40 deg
1000x1000 pixels in grey scale
50x50 pixels hyperspectral

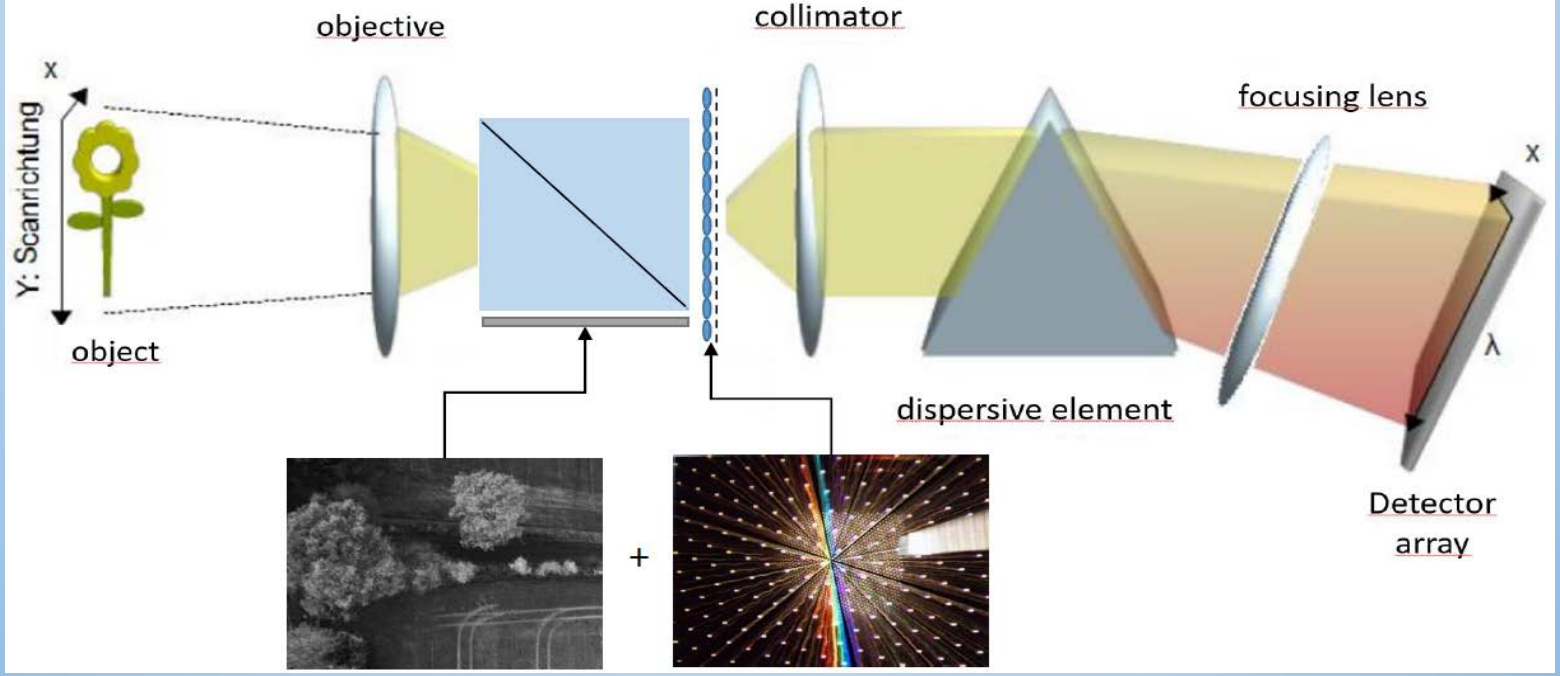


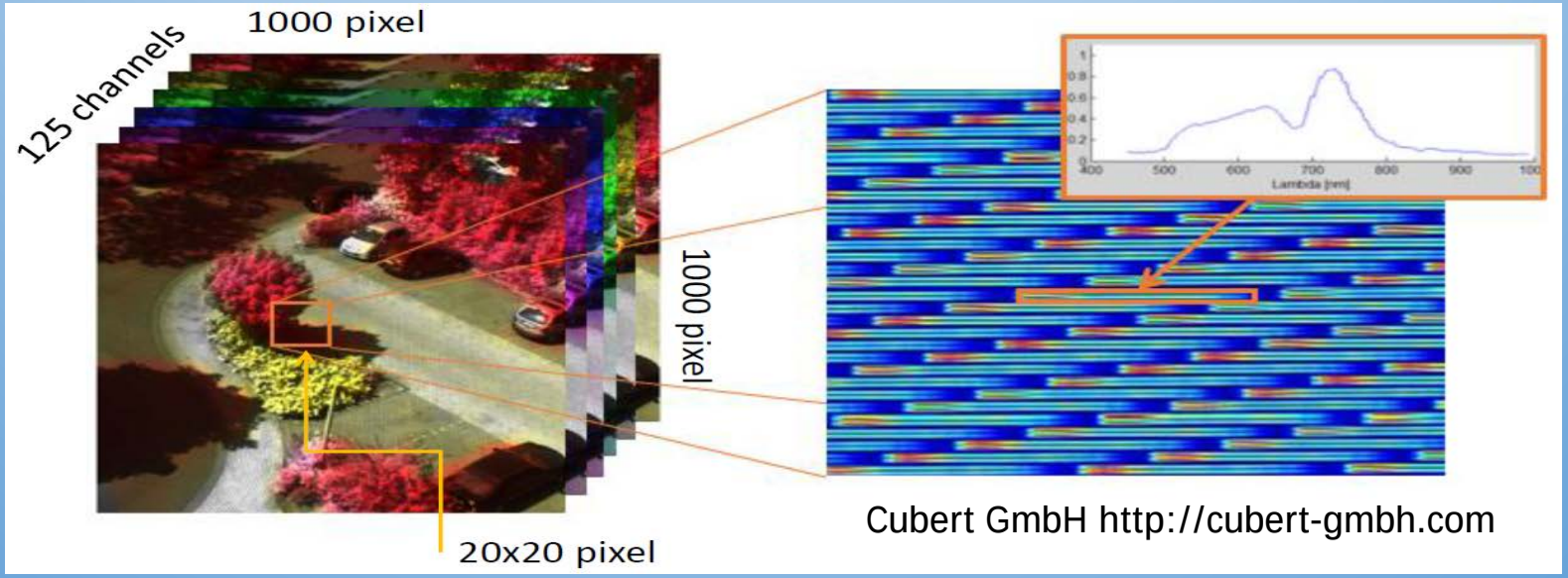
Black & White image



Spectra for signal inside circular ROI (Region of Interest)

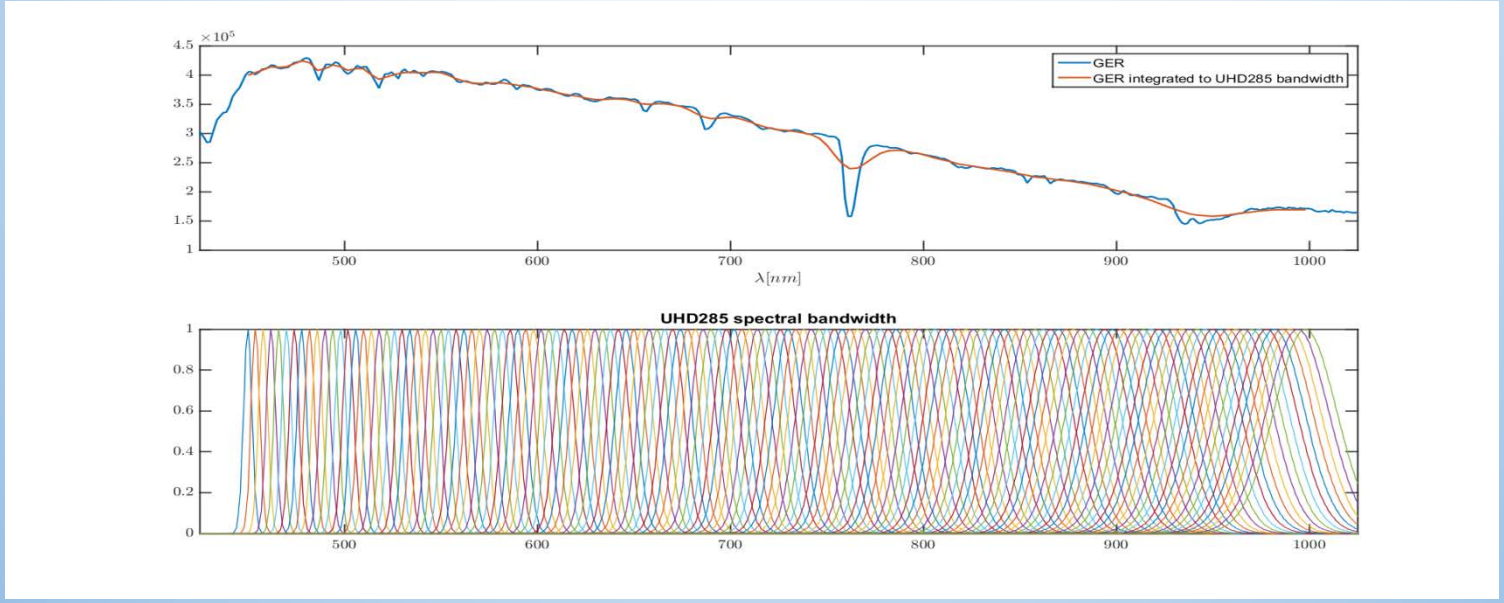
Hyperspectral Imager



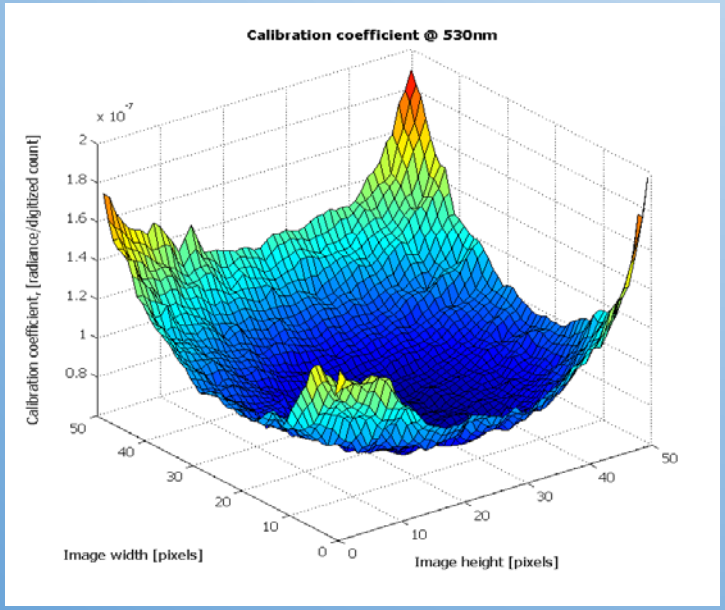


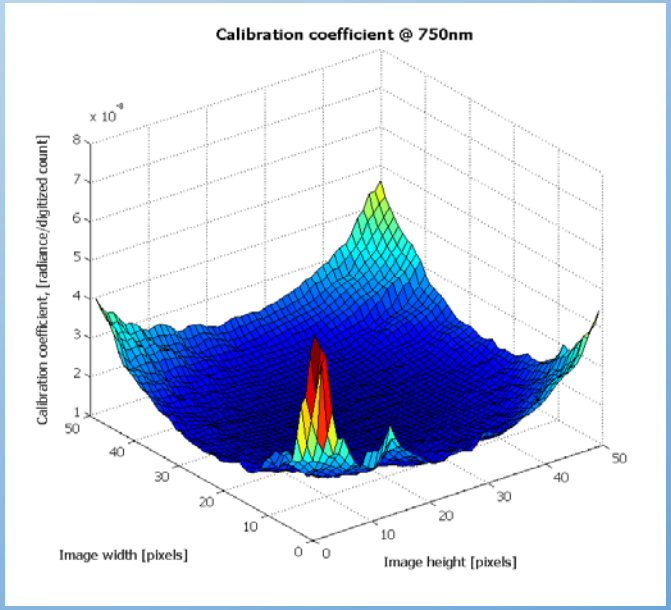
Cubert GmbH http://cubert-gmbh.com

Calibration



Band integration





Examples of calibration coefficients for 50x50pixels. Done for all 138 bands



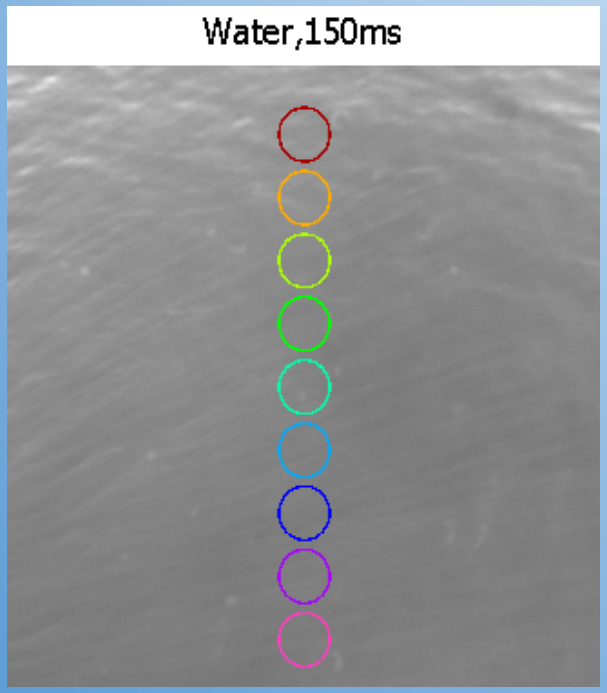
Images of water surface

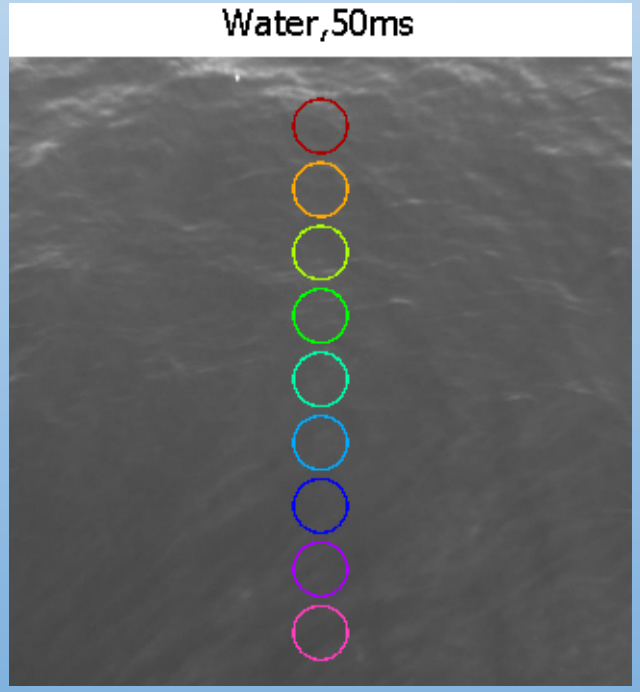


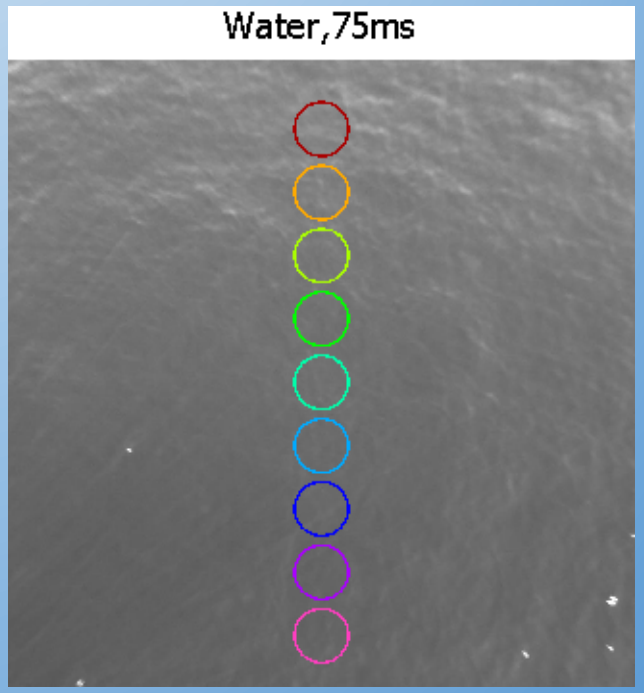
About 100m from the shore a(400) =1.2m^{-1}, c(400)=6.4m^{-1}

Pier is ~6m above water
Depth 5m

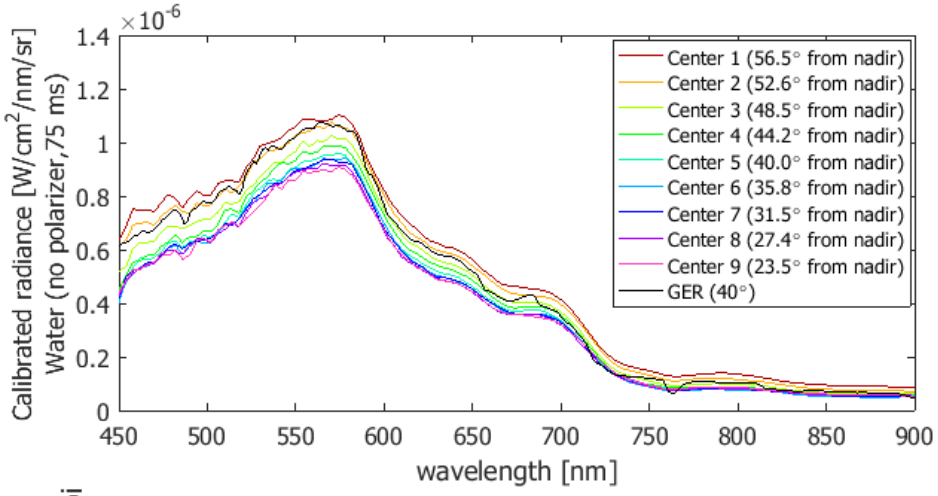
Sun zenith angle	62 deg (8:30 am)	39 deg (10:30 am)	24 deg (12:30 pm)
Wind speed	2m/s	2m/s	3m/s

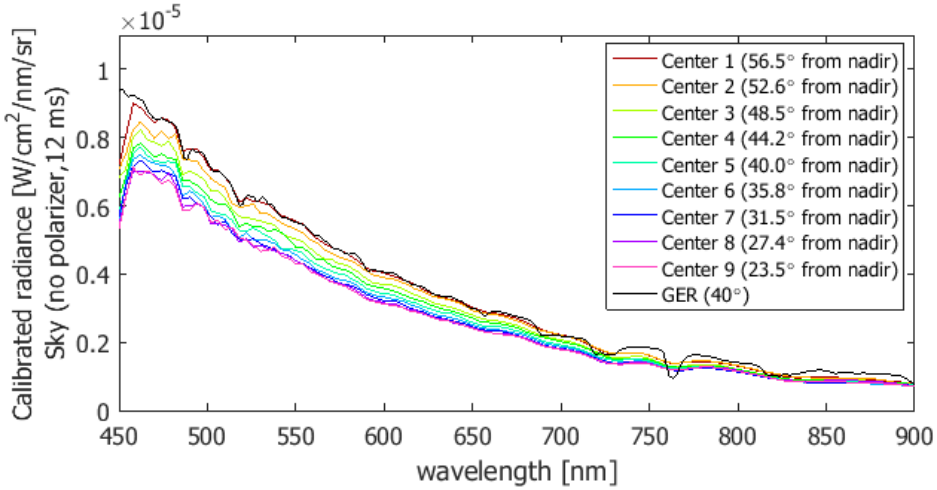


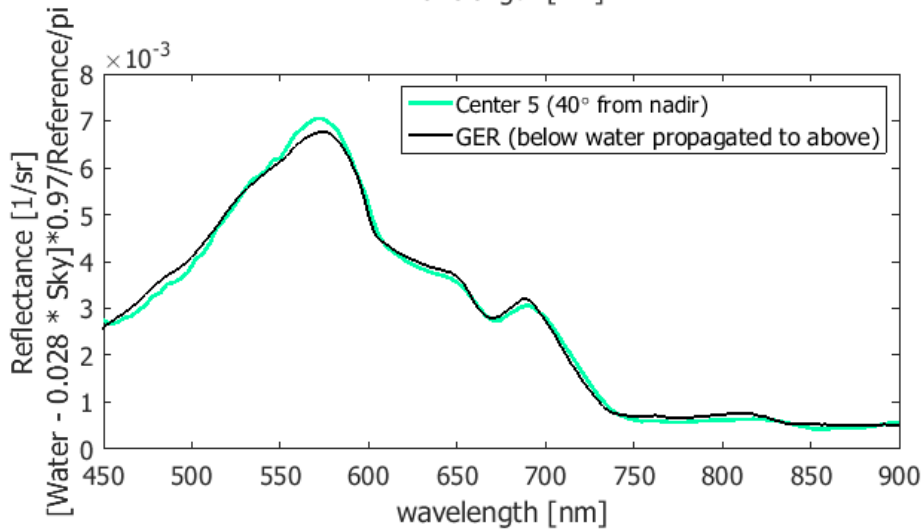


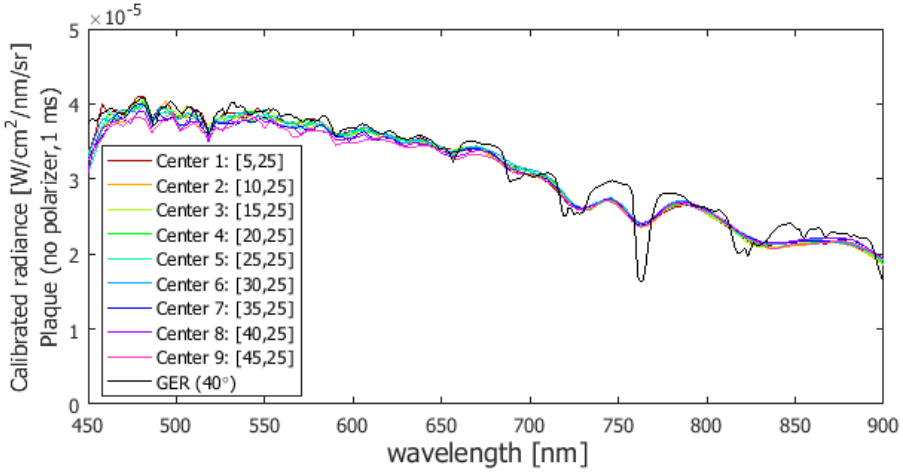


Measured spectra









Reflectance coefficient

$$L_w = L_t^{40} - 0.265 L_s^{40}$$

$$r^i = (L_t^i - L_w) / L_s^i$$

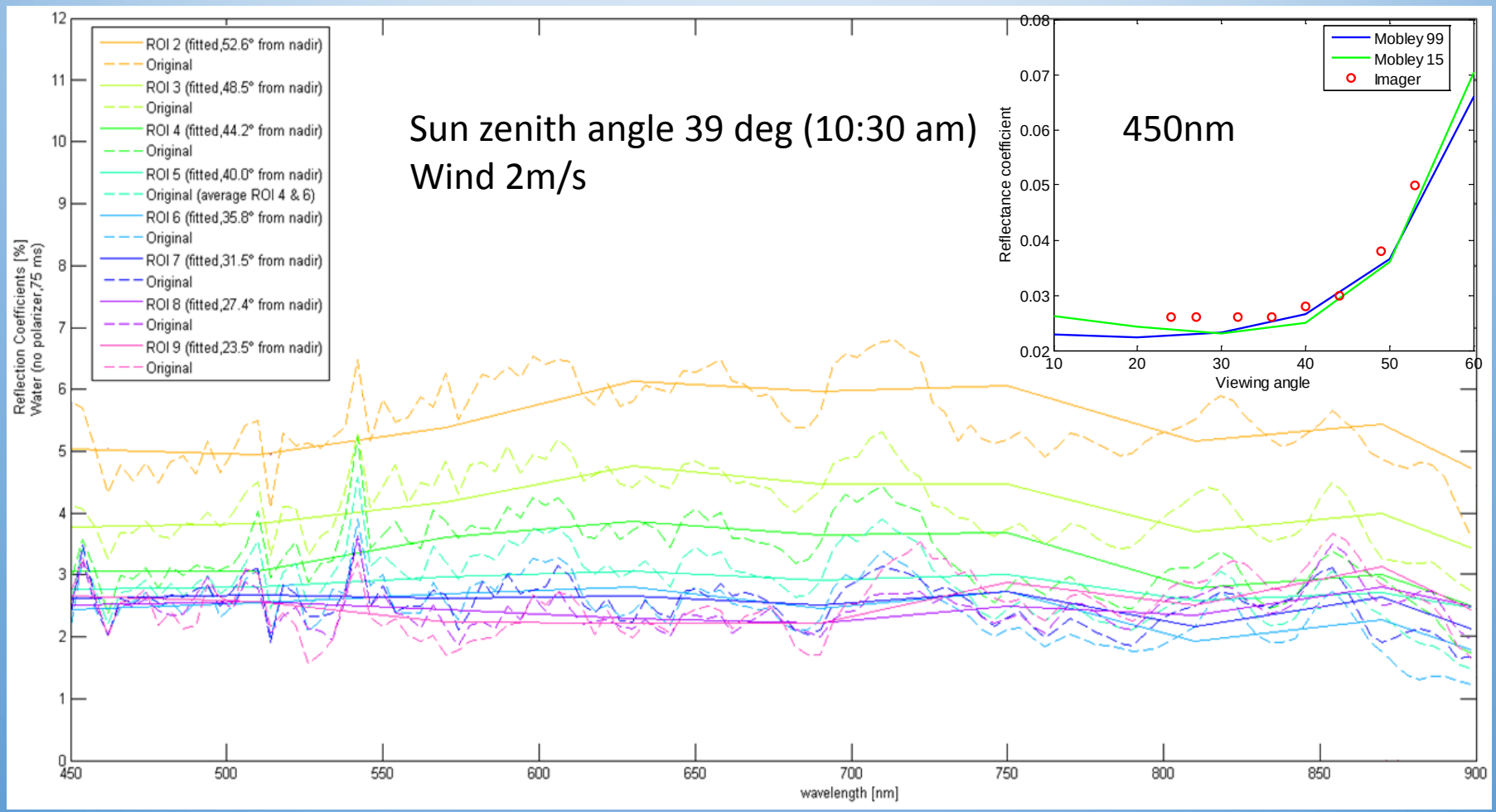
Same but L_w with BRDF correction (Park, et al., 2005)

$$L_w = L_t^{40} - 0.265 L_s^{40}$$

$$r^i = (L_t^i - L_w) / L_s^i$$

L_w measured by GER with the fiber + depth and BRDF correction (Park, et al., 2005)

$$r^i = (L_t^i - L_w) / L_s^i$$



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, overall MSL12 processing works well for the site.
- HyperSAS and GER matched well HyperPro and other instrument at several stations, discrepancies are higher at other stations due to partial shadowing or time difference.
- Reflectance coefficients from ocean surface measured with a new snapshot hyperspectral imager. At 450nm coefficients matched well ones from Mobley, 99.
- No spectral dependence of the reflectance coefficient was found in the spectral range 450-900nm and viewing angles 23 -53 degrees.

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