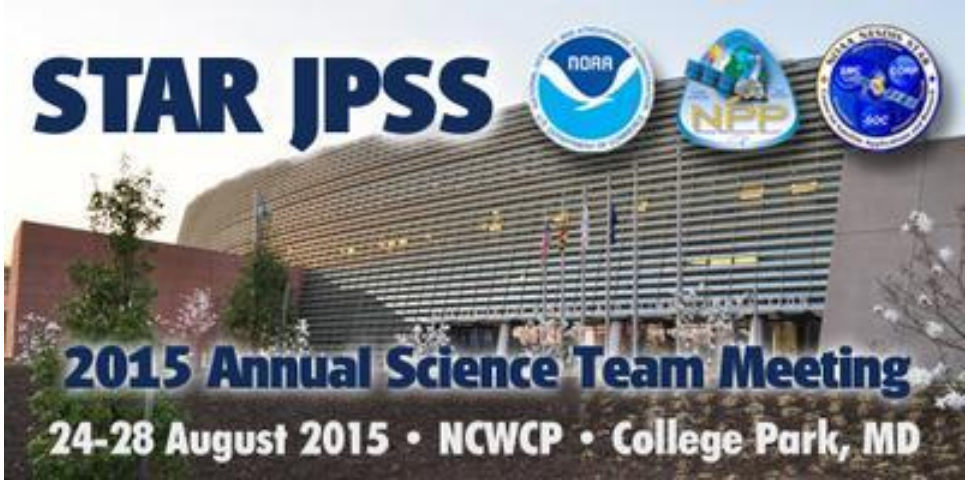


VIIRS Ocean Color Breakout
Thursday, 27 August 2015

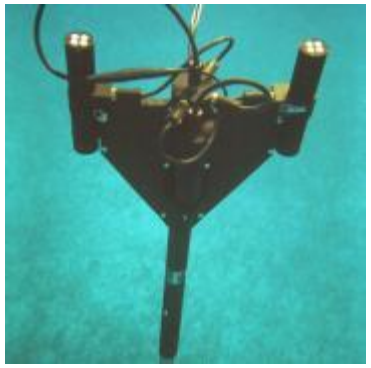
Comparisons of Optical Validation Measurements from the November 2014 VIIRS Cal/Val Cruise

Michael Ondrusek, Bob Arnone, Zhongping Lee, Giuseppe Zibordi, Eric Stengel, Ryan Vandermeulen, Sherwin Ladner, Scott Freeman, Wesley Goode, Chuanmin Hu, David English, Charles Kovach, Jianwei Wei, Junfang Lin, Marco Talone, Alex Gilerson, Sam Ahmed, Amir Ibrahim, Ahmed El-Habashi, Robert Foster

Instruments used to measure Remote Sensing Reflectance

Profilers





HyperPro (Satlantic) – free-falling hyperspectral optical profiler. 10 nm bands sampled every 3 nm. Radiance FOV 8.5 degrees. Calibrated from 350 to 800 nm.

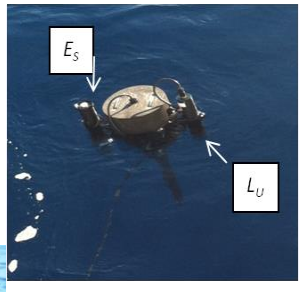


MicroPro (Satlantic) - free-falling multispectral optical profiler. Seven spectral bands with 10 nm bandwidth centered at nominal wavelengths of 412 nm, 443 nm, 490 nm, 510 nm, 555 nm, 665 nm, and 683 nm. 18 degree FOV.



C-OPS (Biospherical Instruments, Inc.) – compact multispectral optical profiling system. a spectral range from 300 nm to 900 nm, with 19 wavebands wavelengths each: 305 nm, 320 nm, 340 nm, 380 nm, 395 nm, 412 nm, 443 nm, 465 nm, 490 nm, 510 nm, 532 nm, 555 nm, 565 nm, 625 nm, 665 nm, 683 nm, 710 nm, 780 nm, and 875 nm.

Instruments used to measure Remote Sensing Reflectance



Surface

HyperTSRB (Satlantic) – Same instrument as hyperpro but collared to float at surface.



SBA (Satlantic) – Sky- Blocking Apparatus (SBA) radiometer package composed of one HyperOCR radiance sensor and one irradiance sensor. directly measures the water-leaving radiance Lw while blocking out sky-light (Lee et al., 2013).

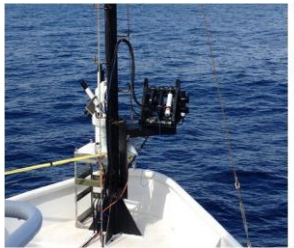
Above-water



ASD Analytical Spectral Device (PANalytical) – Handheld 2 above-water spectrometer. Spectral range of 325 to 1075 nm. Spectral Resolution <3.0 nm, FOV 10 degrees. 2nd asd has 7 degrees FOV.



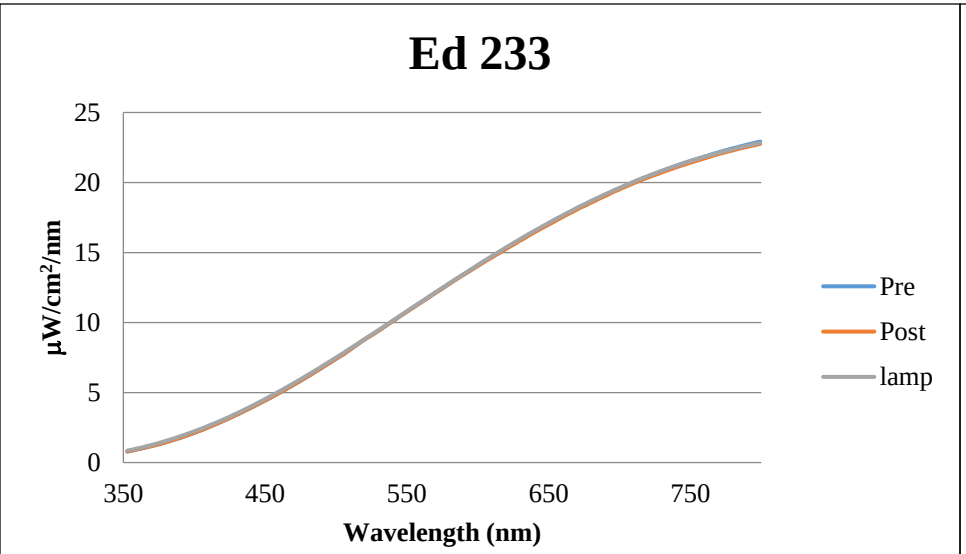
GER (Spectra Vista Corporation) – The GER 1500, Field Portable hand-held Spectroradiometer. Wavelengths from 350 nm to 1050 nm at 3 nm resolution with 4° nominal field of view (FOV).

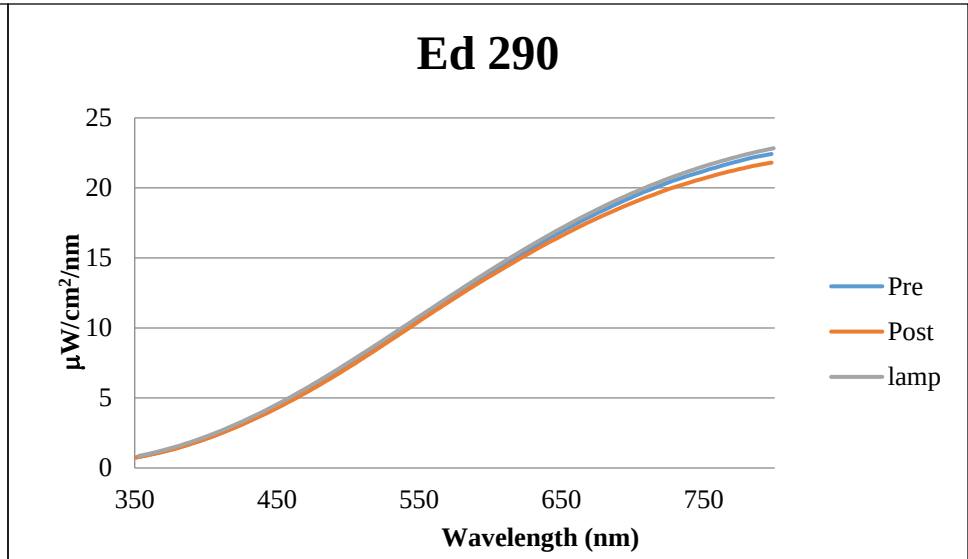


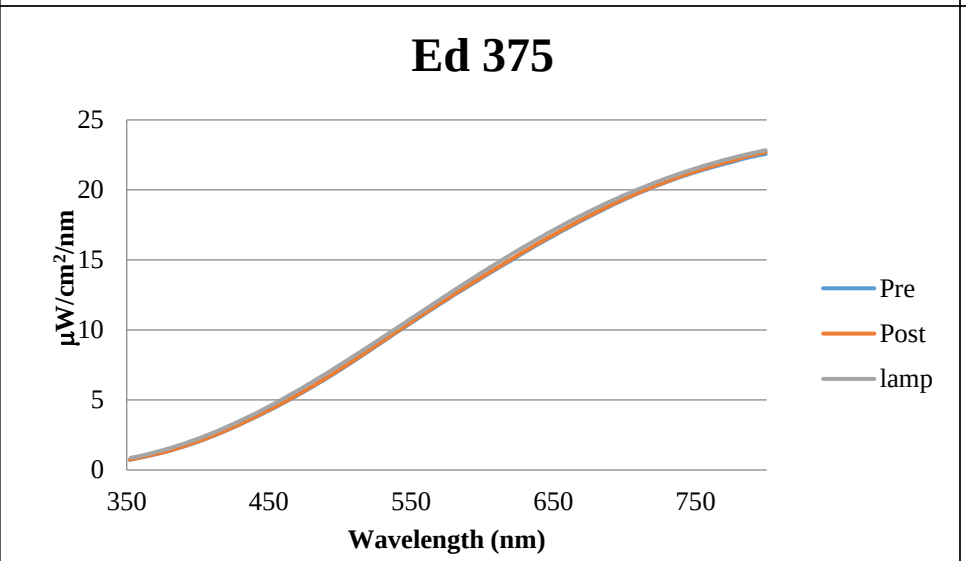


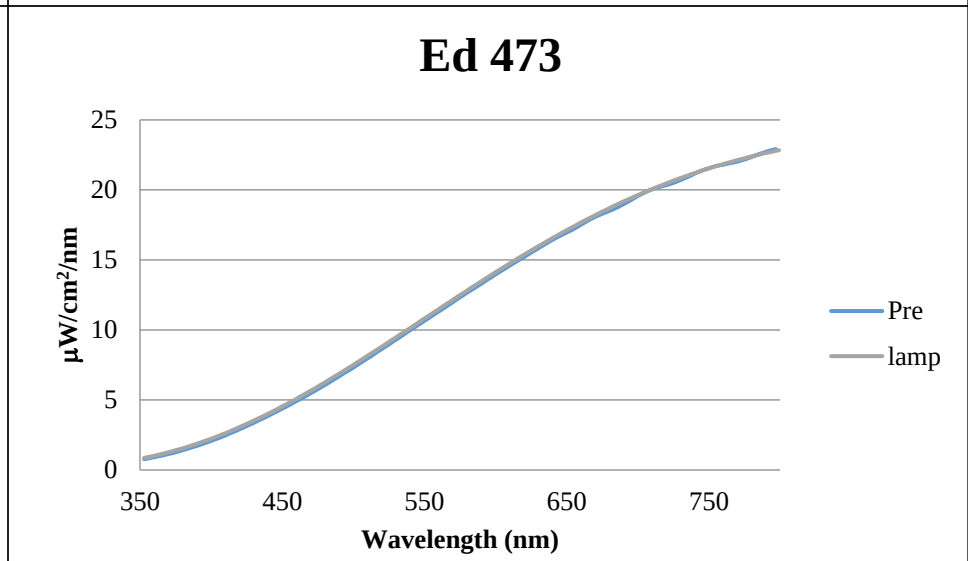
HyperSAS (Satlantic) – Autonomous above-water OCR's with narrow FOV of 3 degrees. Also set up to measure polarization

Pre- and Post-cruise inter-calibration of Satlantic irradiance Ed sensors used in Nov. 2014 Cal/Val cruise

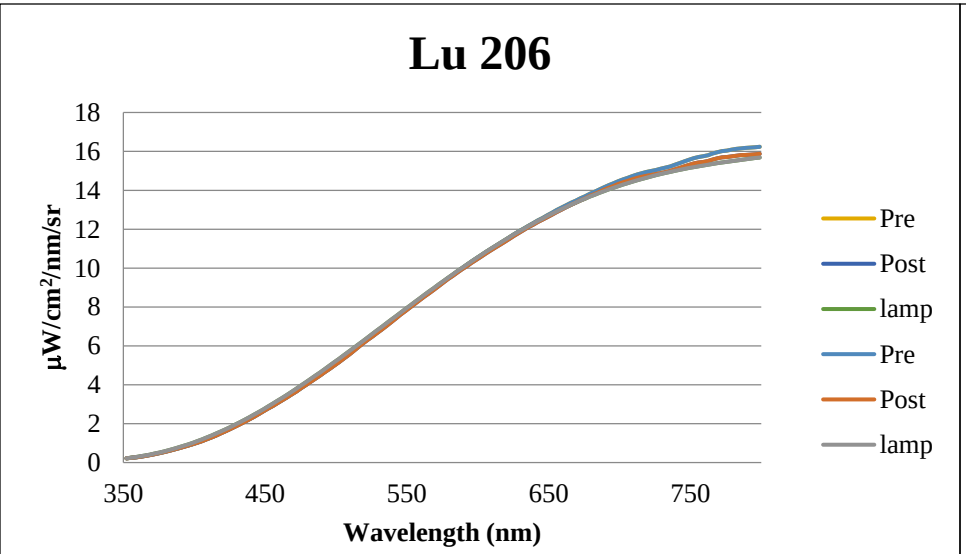


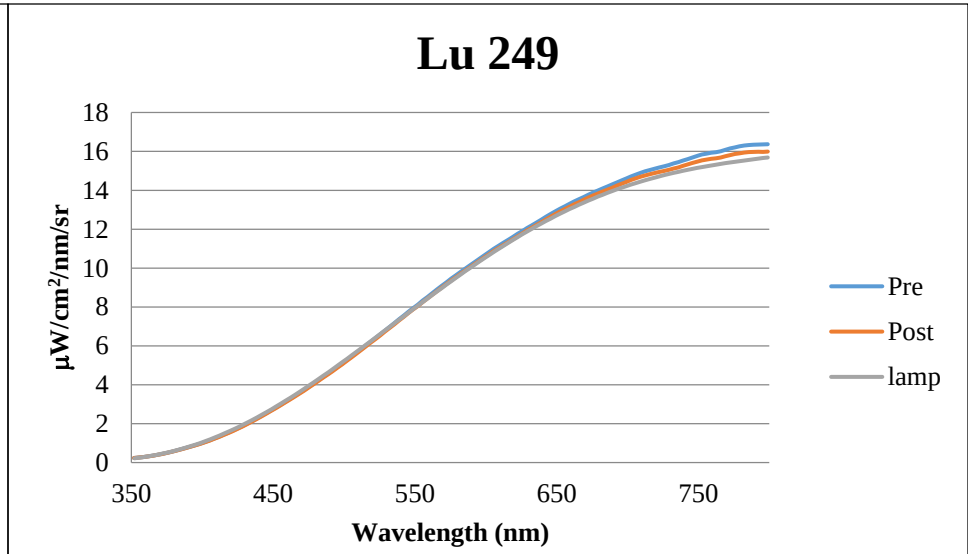


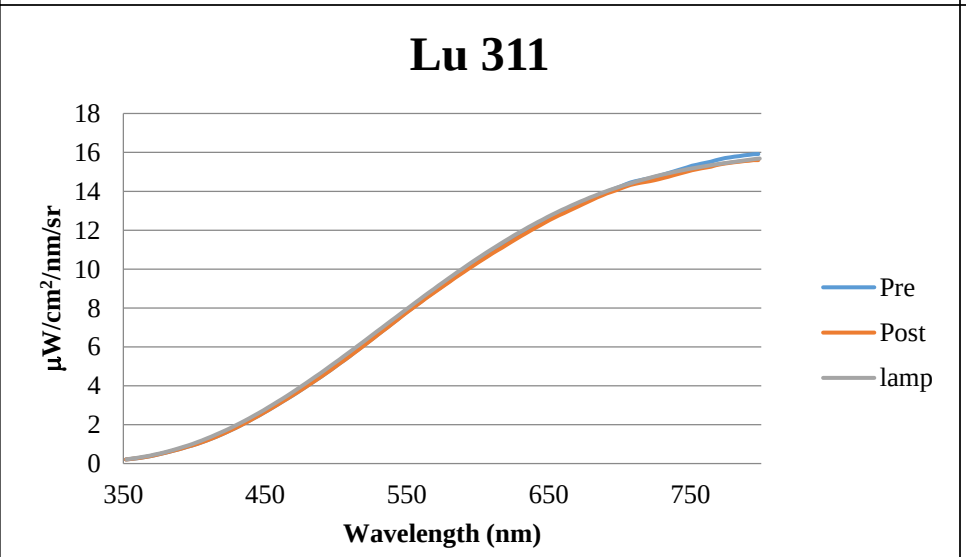


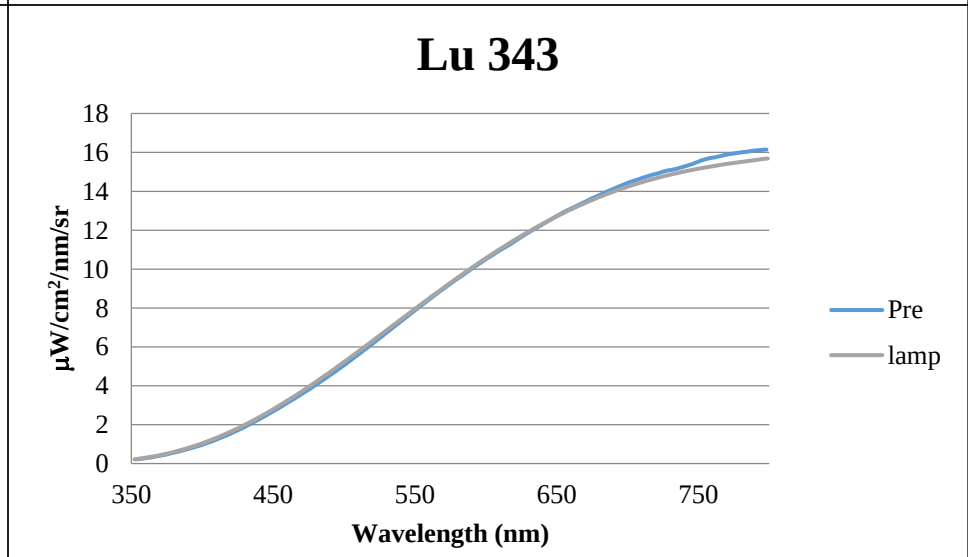


Pre- and Post-cruise inter-calibration of Satlantic radiance Lu sensors used in Nov. 2014 Cal/Val cruise

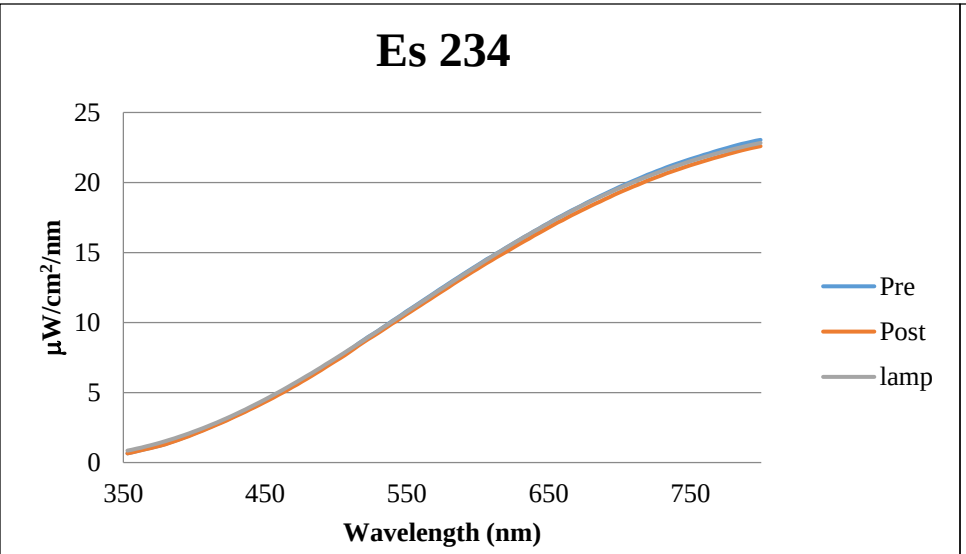


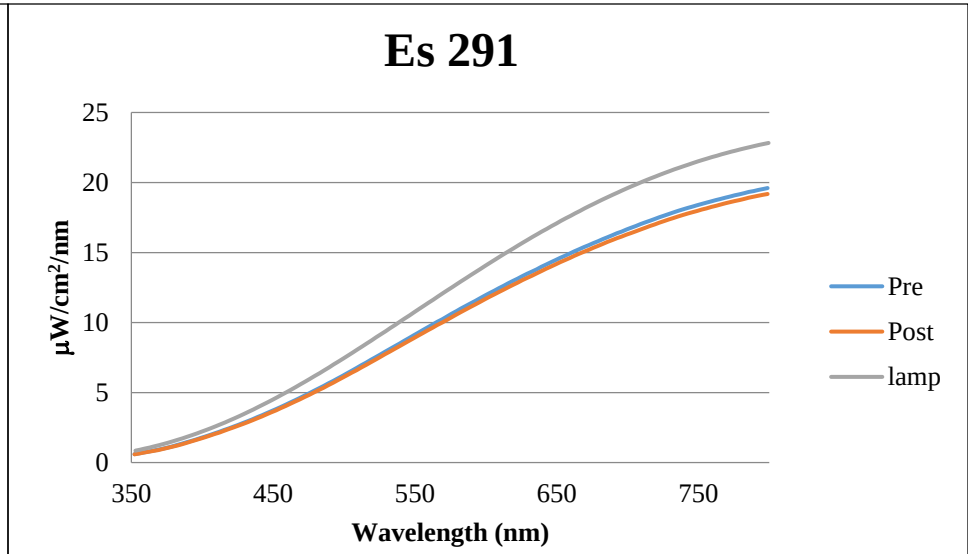


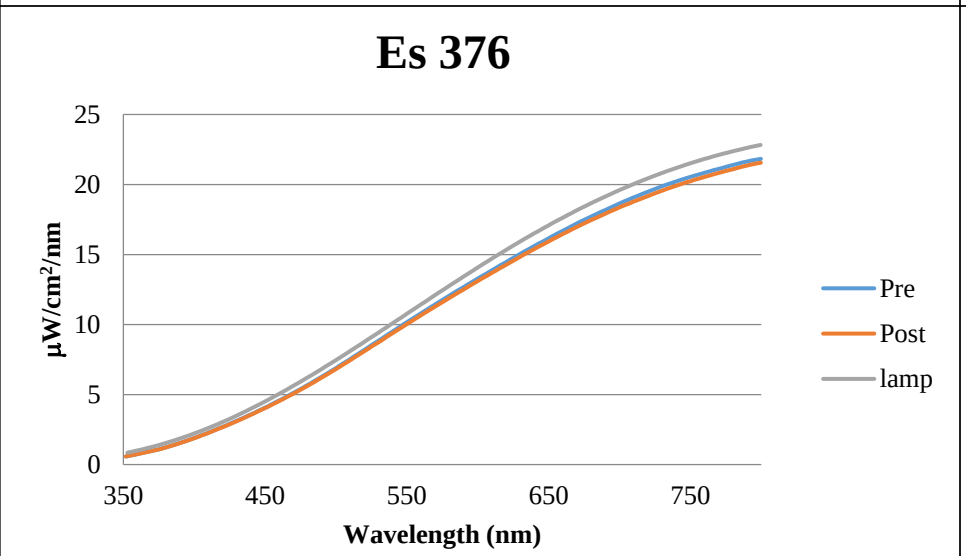


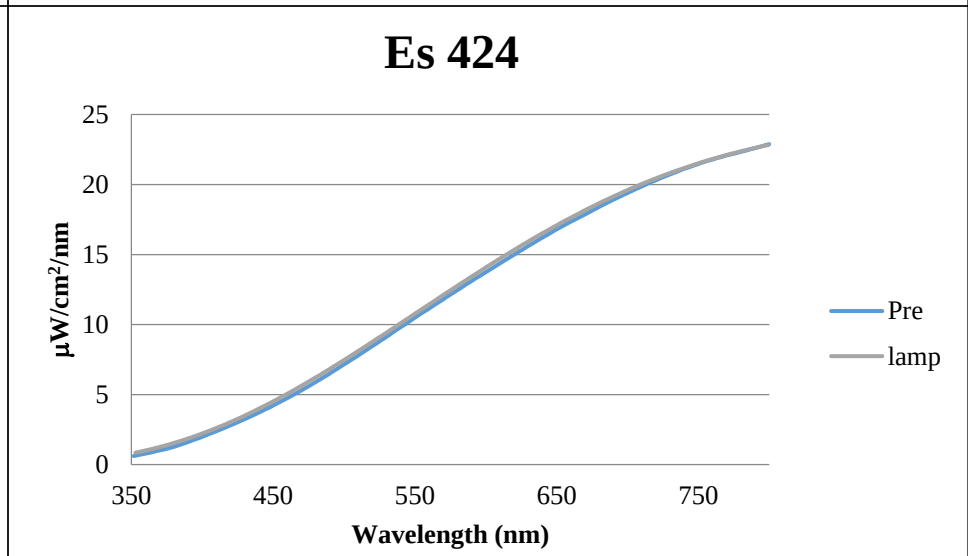


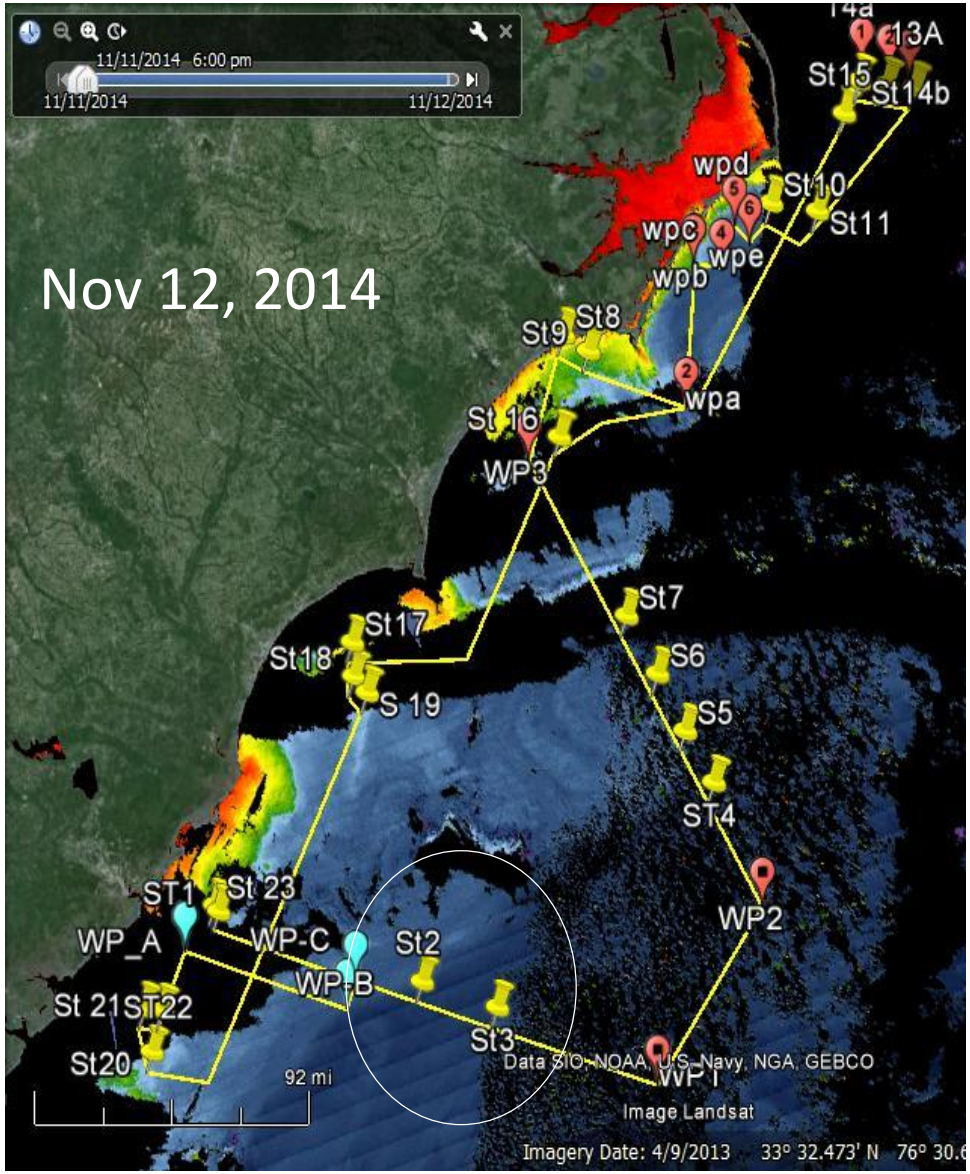
Pre- and Post-cruise inter-calibration of Satlantic irradiance Es sensors used in Nov. 2014 Cal/Val cruise



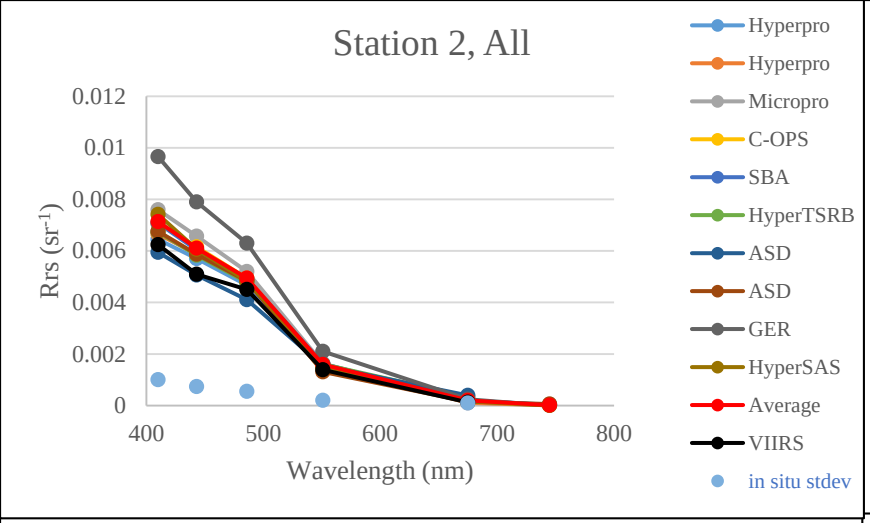


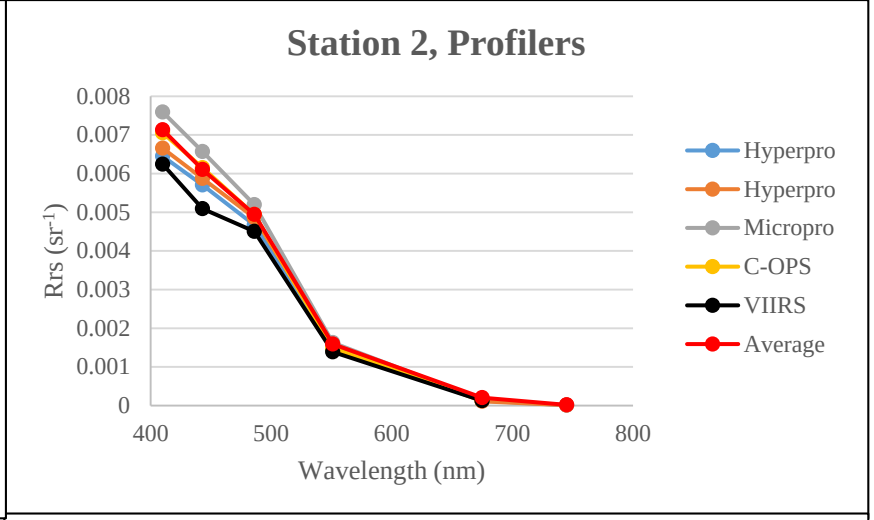


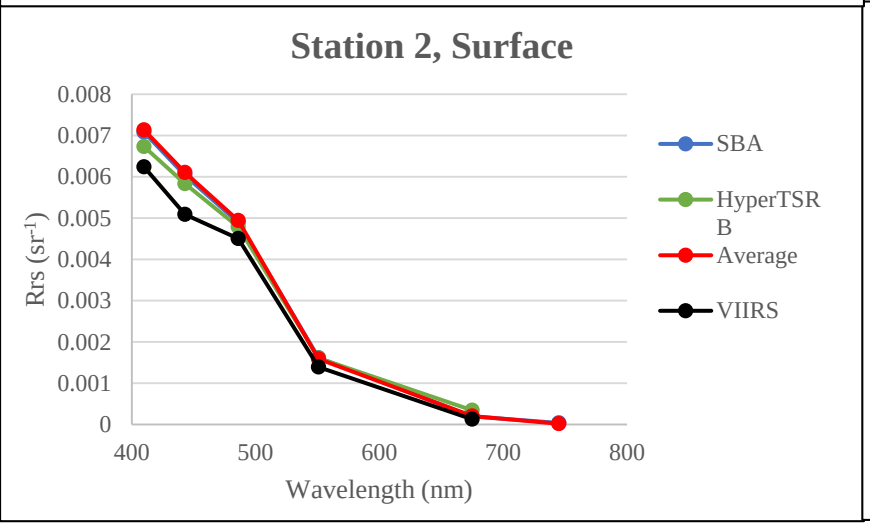


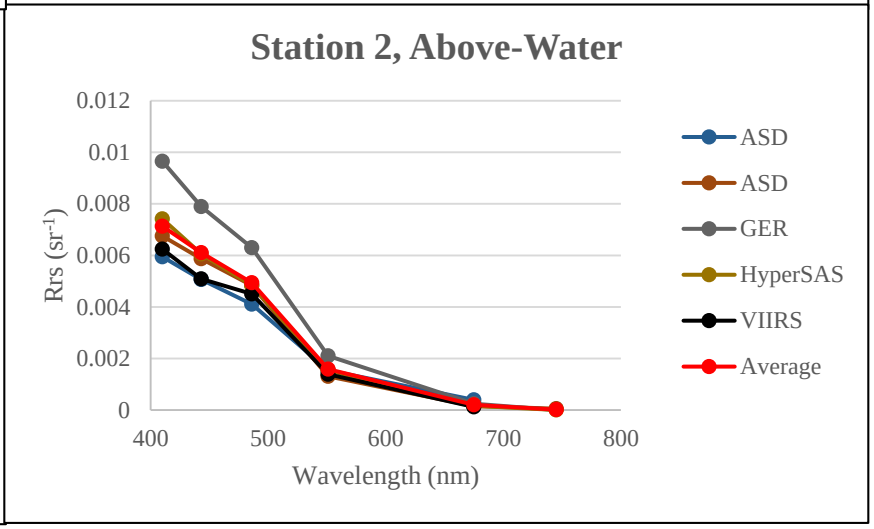


November 12, 2014 Blue water validations



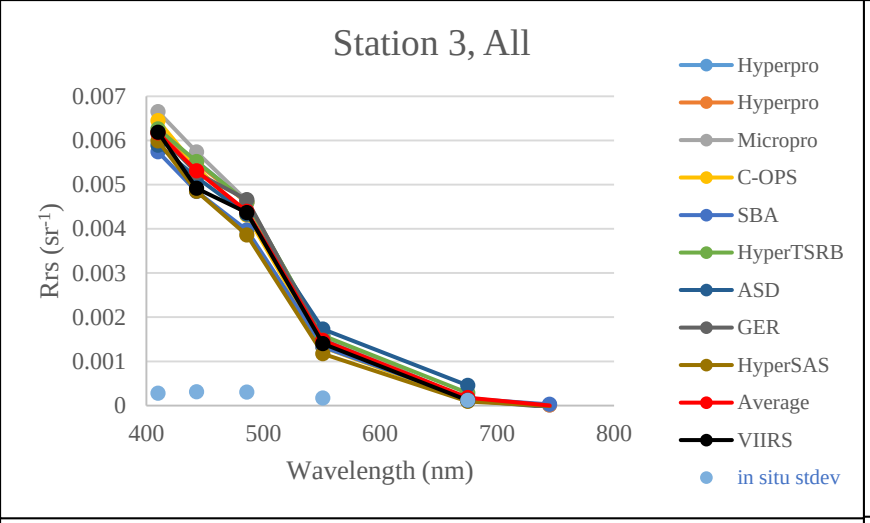


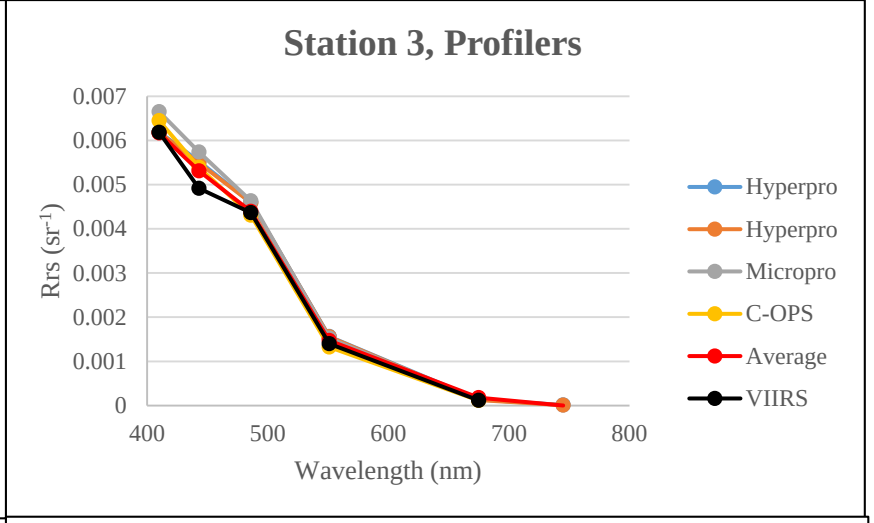


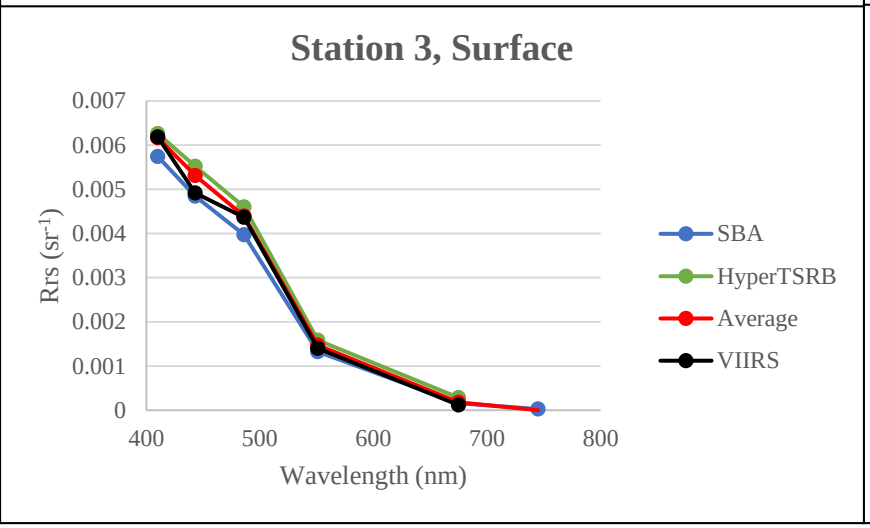


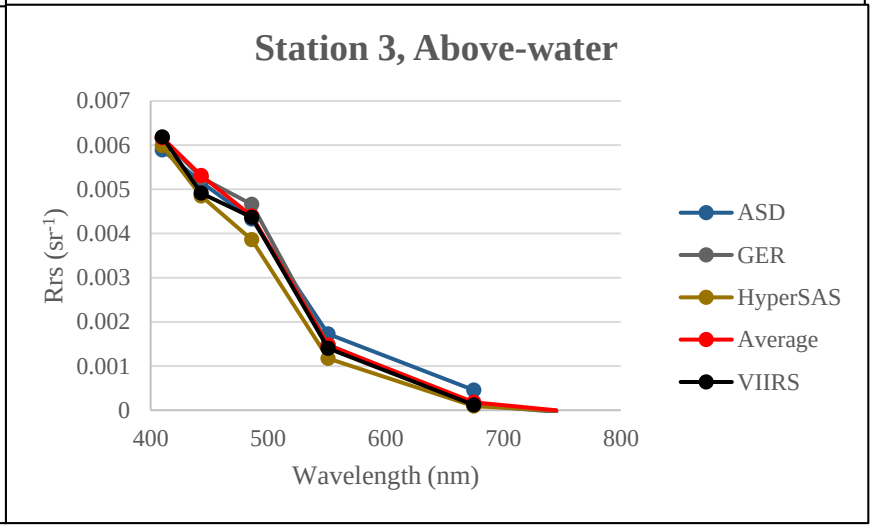
Date (Nov): **18th**
Description: **offshore shelf, Just west of Stream**
Above-Water time: **1000**
Surface time: **1030**
Profile time: **1200**
Depth (m): **103**
Cloud cover (%): **15**
Wind speed (kts): **10**
Seas (ft.): **2-4**
Chl (mg/m3) **0.24**

Percent difference relative to Average										
Band	Hyperpro	Hyperpro	Micropro	C-OPS	SBA	HyperTSRB	ASD	ASD	GER	HyperSAS
410	-9.61	-6.69	6.44	-1.10	-0.75	-5.62	-16.68	-5.30	35.33	3.97
443	-6.59	-3.81	7.61	0.79	-1.17	-4.45	-17.09	-3.84	29.34	-0.77
486	-5.51	-1.63	5.16	-0.06	-0.94	-3.20	-16.89	-2.25	27.39	-2.07
551	-5.49	-0.98	2.40	-6.91	1.65	1.02	-2.82	-17.83	32.30	-3.34
675	-38.69	-45.58	-25.35	-32.09	-2.83	69.76	94.66	-24.12	21.40	-17.18





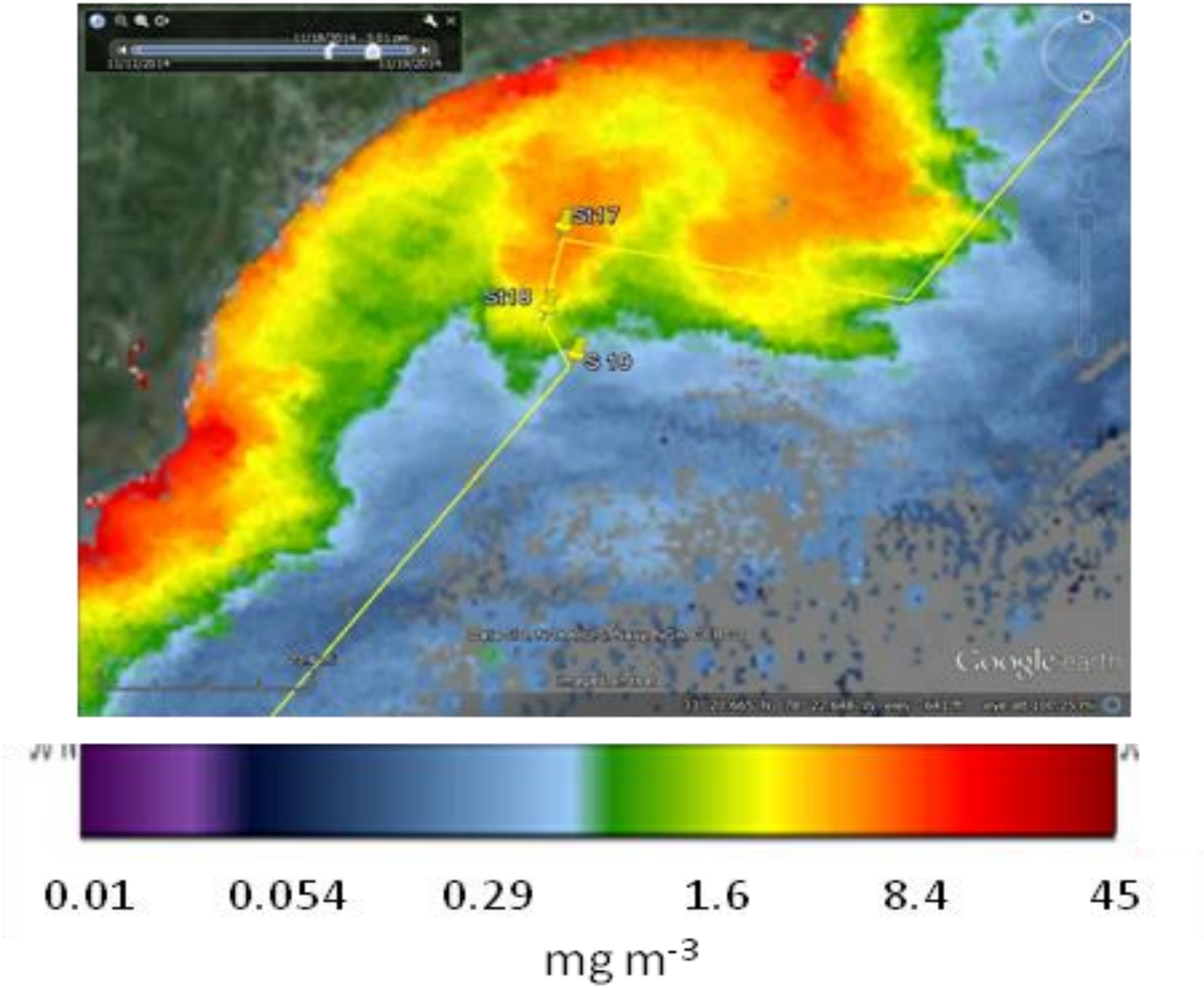




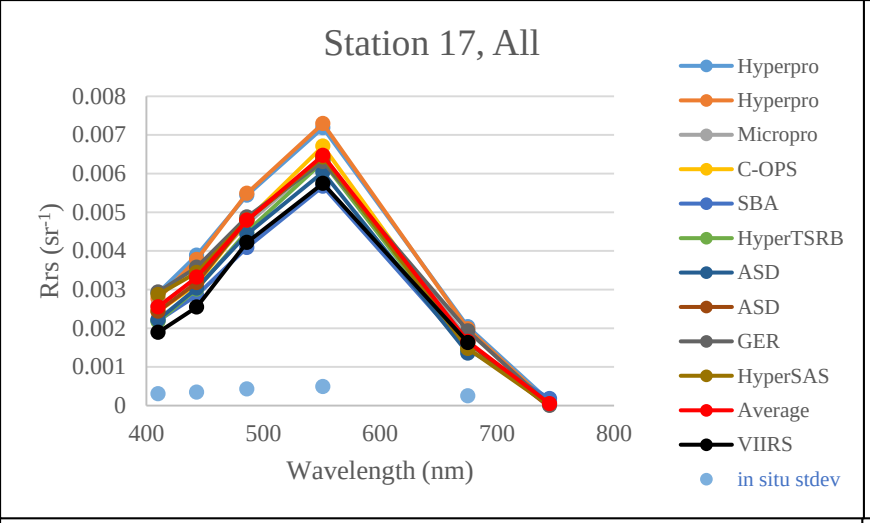
Date: 12
Description: Offshore,East of stream front
Above-Water time: 1435
Surface time: 1530
Profile time: 1445
Depth: 120
Cloud cover: 10
Wind speed: 10
Seas (ft.): 1-3
Chl (mg/m3) 0.23

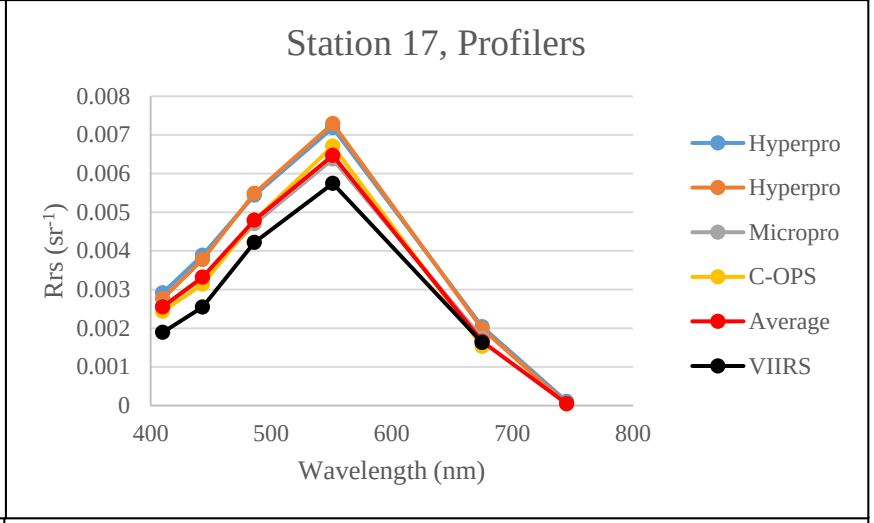
Percent difference relative to Average

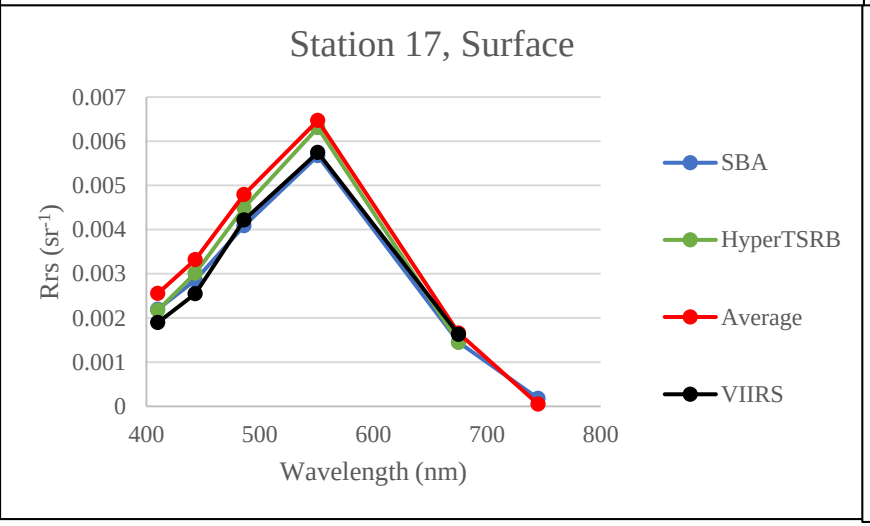
Band	Hyperpro	Hyperpro	Micropro	C-OPS	SBA	HyperTSRB	ASD	ASD	GER	HyperSAS
410	0.40	0.26	7.82	4.56	-6.92	1.52	-4.51		-0.21	-2.92
443	4.09	3.37	8.08	1.52	-8.77	3.99	-2.76		-0.82	-8.70
486	4.53	4.57	5.44	-1.96	-9.64	4.70	-1.49		6.05	-12.20
551	6.12	5.54	3.47	-10.07	-10.05	7.51	17.27		0.69	-20.47
675	-23.07	-30.03	-24.94	-36.06	-13.55	57.23	152.43		-33.31	-48.69

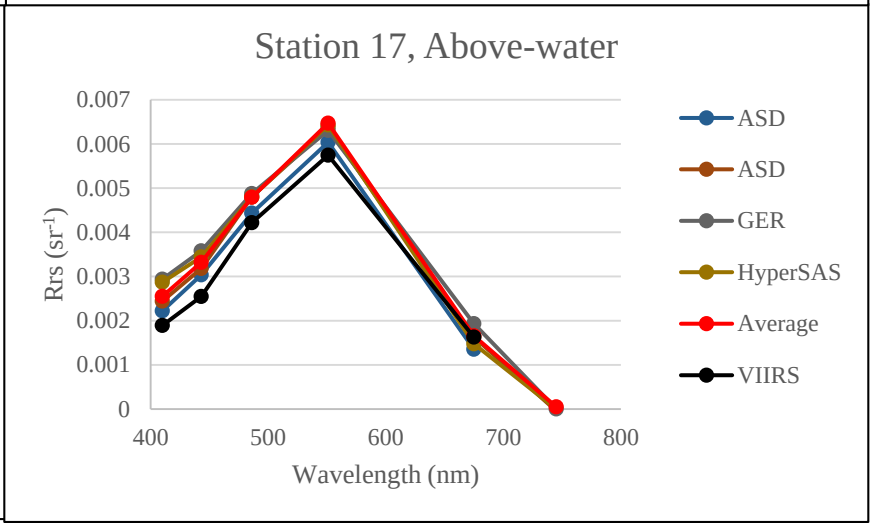


Locations of stations and track from 18 November with the VIIRS-NRL chlorophyll imagery



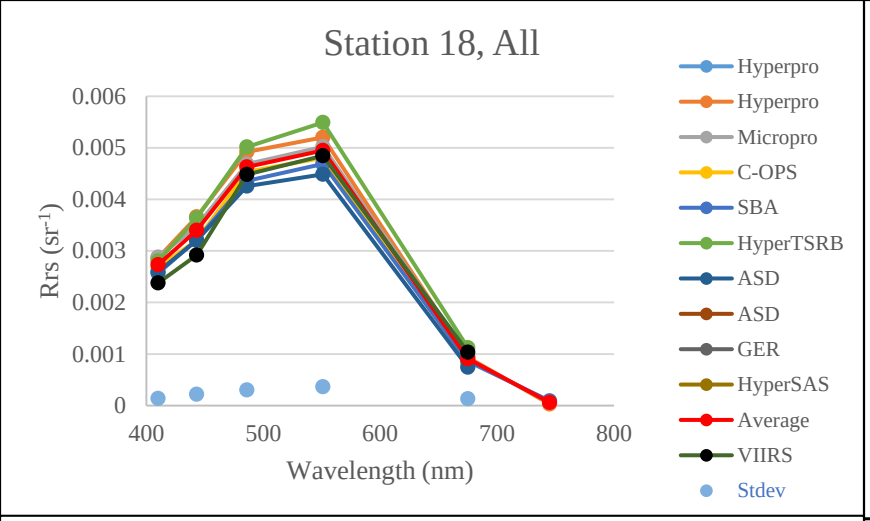


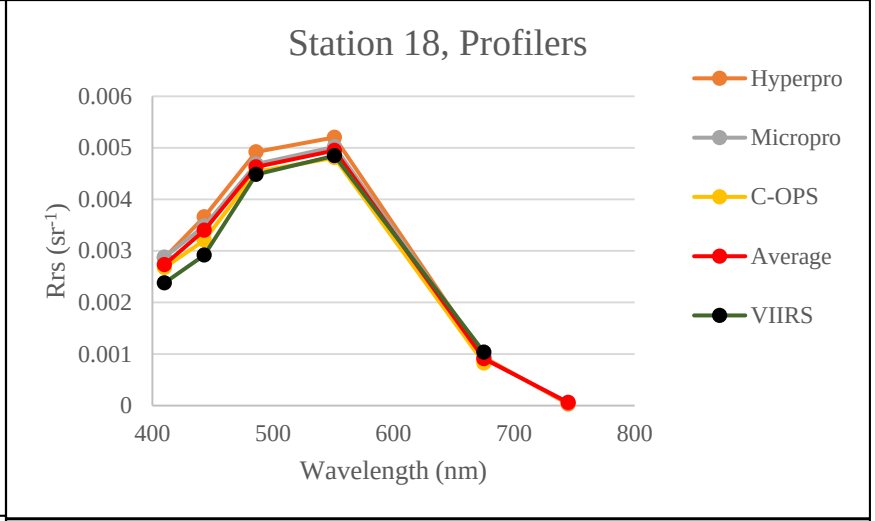


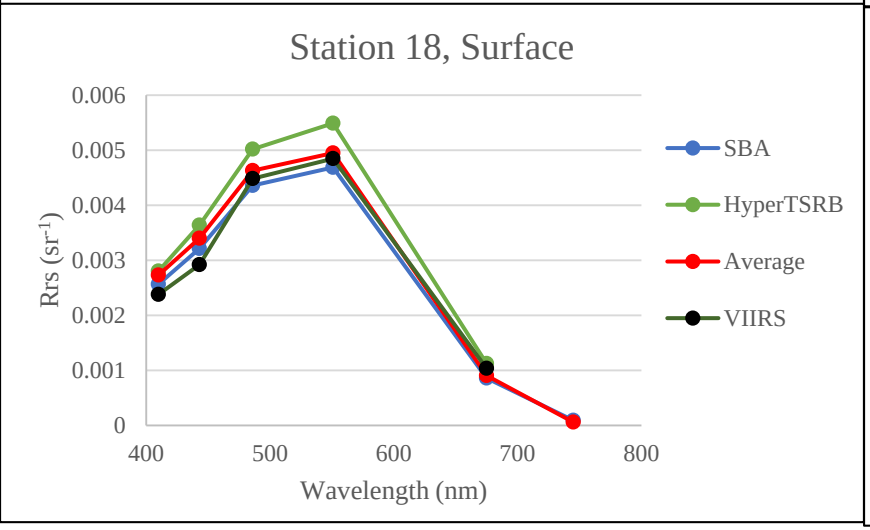


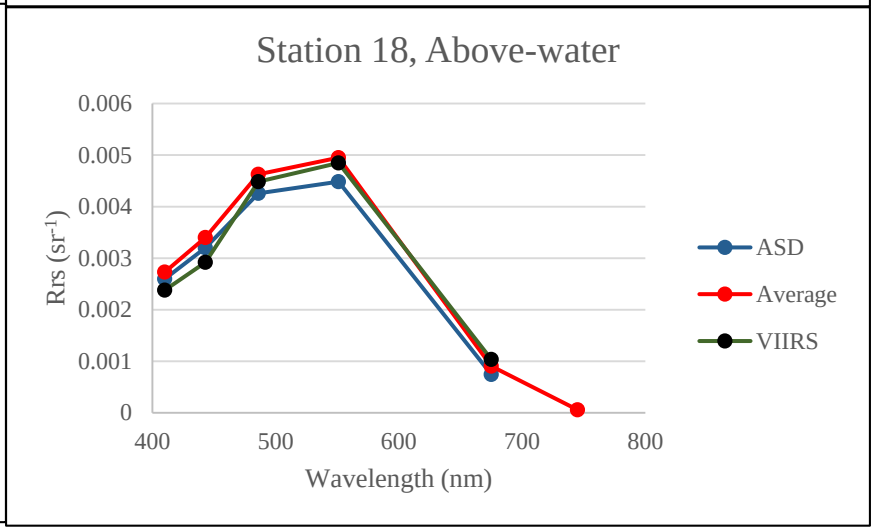
Date: 18
Description: Coastal, in bloom
Above-Water time: 1047
Surface time: 920
Profile time: 1005
Depth: 18
Cloud cover: 5
Wind speed: 18.5
Seas (ft.): 2-4
Chl (mg/m3) 6-8

Percent difference relative to Average										
Band	Hyperpro	Hyperpro	Micropro	C-OPS	SBA	HyperTSRB	ASD	ASD	GER	HyperSAS
410	14.13	8.40	0.78	-4.57	-14.01	-14.85	-12.99	-4.38	15.07	12.41
443	17.17	13.77	-1.02	-5.42	-14.02	-9.26	-8.56	-4.15	7.79	3.70
486	13.49	14.58	-1.84	-0.04	-14.76	-6.10	-7.47	0.22	1.77	0.15
551	11.08	12.78	-1.47	3.71	-12.34	-2.52	-6.67	-1.46	-2.49	-0.63
675	23.04	19.76	4.70	-7.82	-12.48	-12.74	-18.37	-1.55	16.48	-11.03





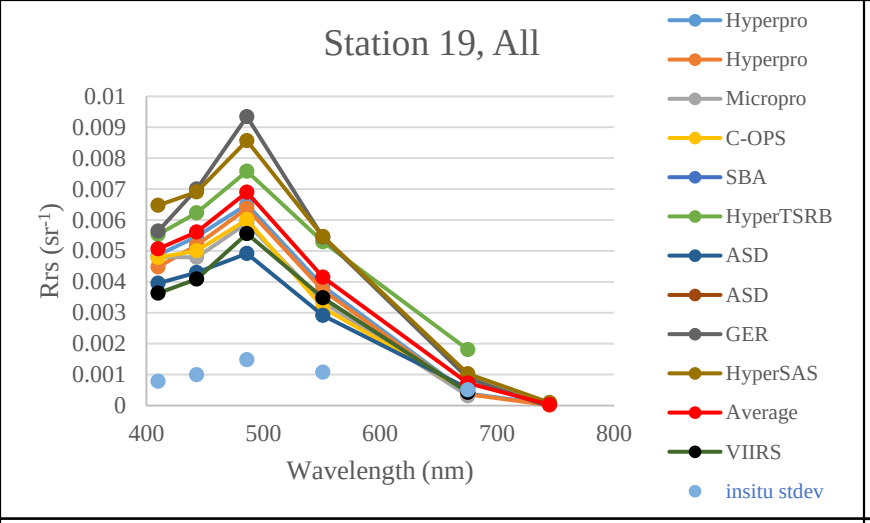


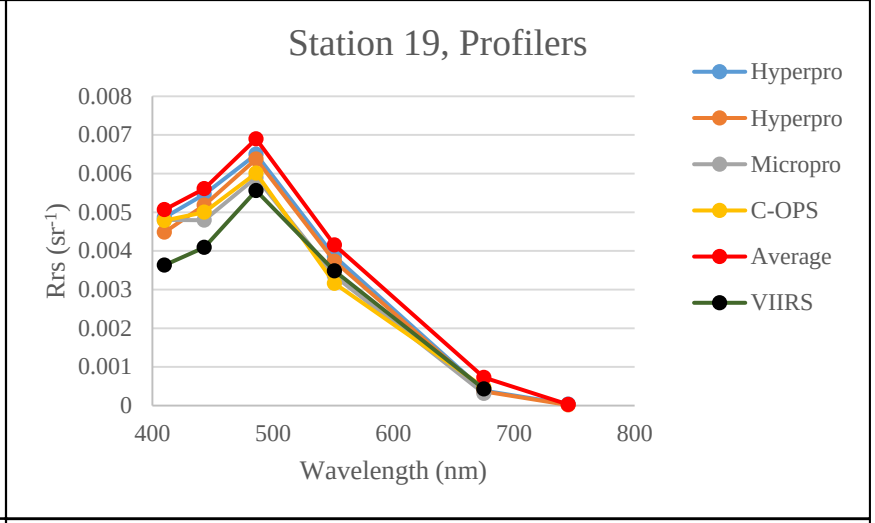


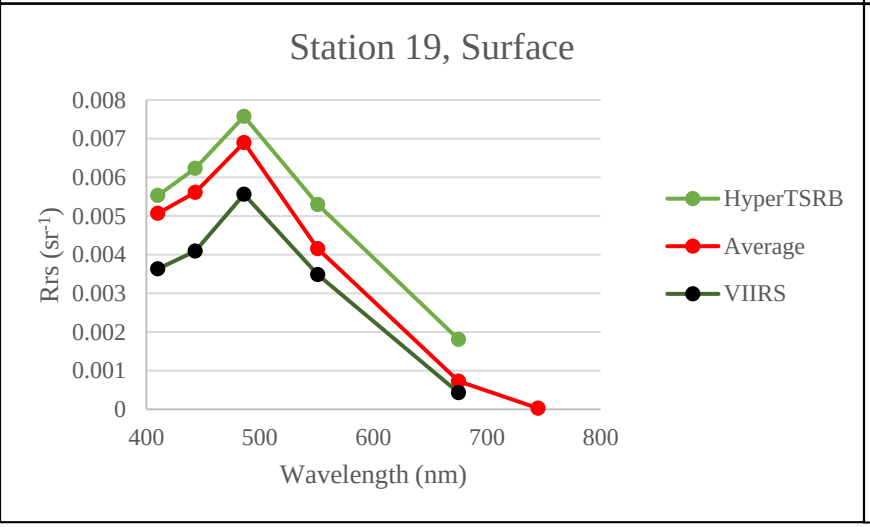
Date: 18
Description: Coastal, in bloom near front
Above-Water time: 1315
Surface time: 1240
Profile time: 1328
Depth: 22
Cloud cover: 5
Wind speed: 15
Seas (ft.): 2-4
Chl (mg/m3) 2.2

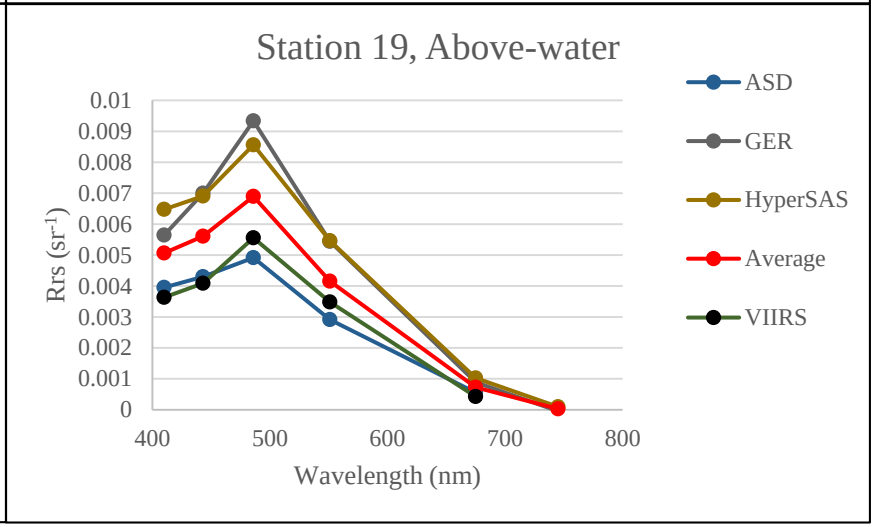
Percent difference relative to Average

Band	Hyperpro	Hyperpro	Micropro	C-OPS	SBA	HyperTSRB	ASD	ASD	GER	HyperSAS
410		4.96	5.37	-2.01	-6.03	2.61	-4.91			
443		7.62	2.38	-5.68	-5.49	6.97	-5.80			
486		6.30	1.23	-2.09	-5.83	8.42	-8.02			
551		5.12	1.41	-2.85	-5.27	10.96	-9.37			
675		3.27	5.11	-9.01	-5.24	23.80	-17.92			





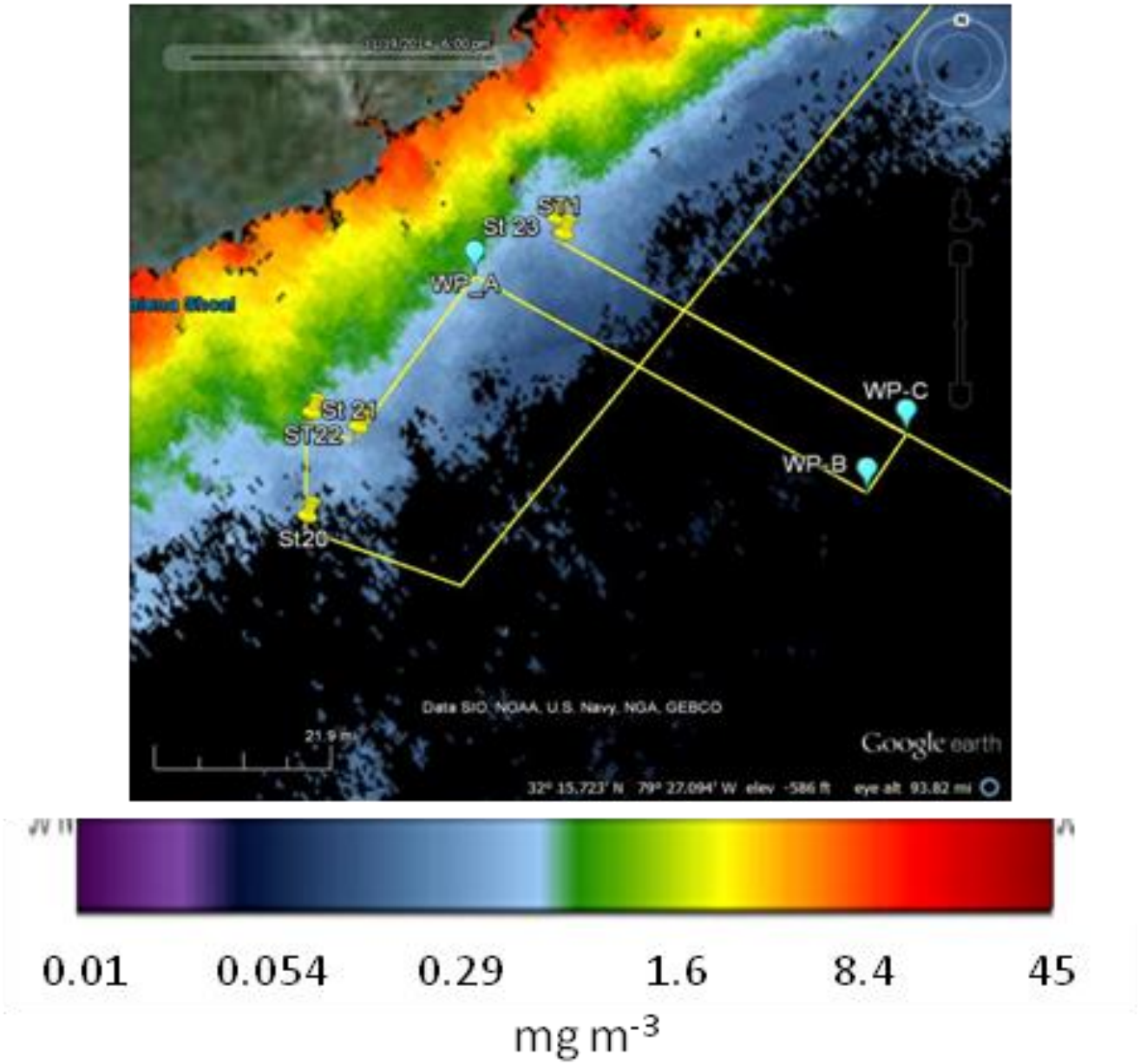




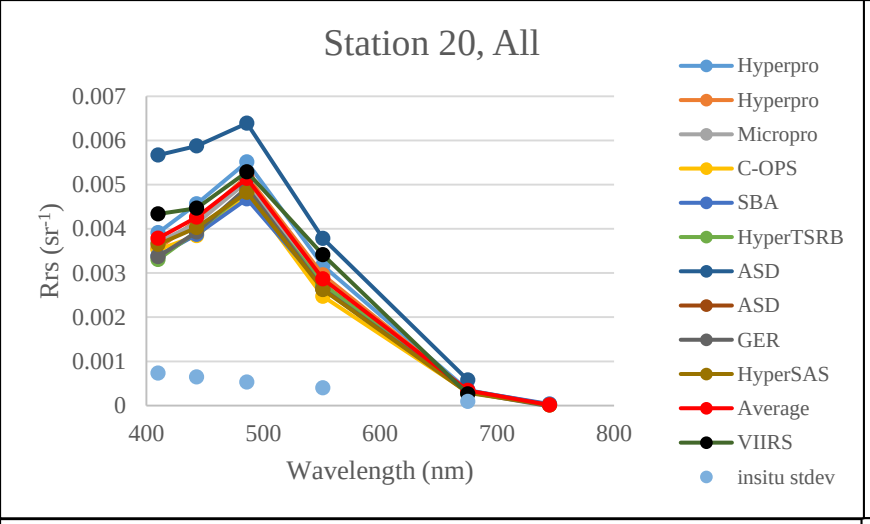
Date: 18
Description: Coastal, Clear side of front
Above-Water time: 1610
Surface time: 1645
Profile time: 1600
Depth: 26
Cloud cover: 35
Wind speed: 10
Seas (ft.): 2-3
Chl (mg/m3) 0.59

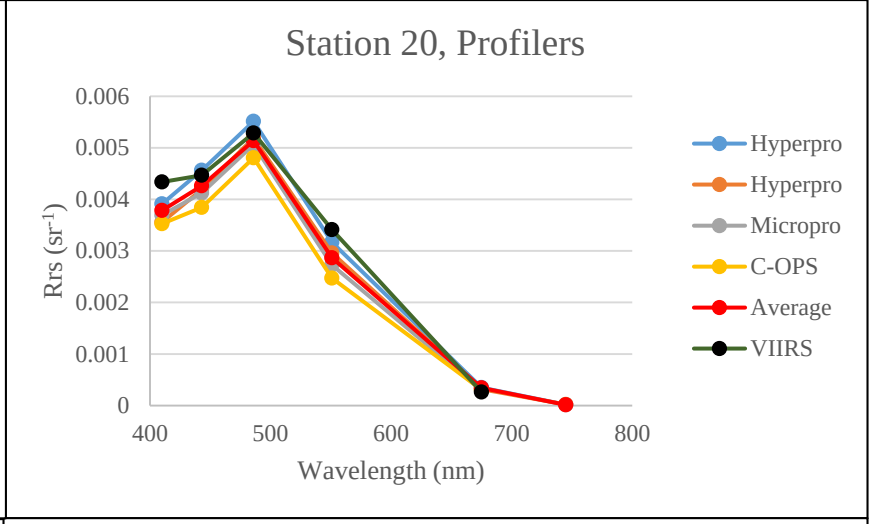
Percent difference relative to Average

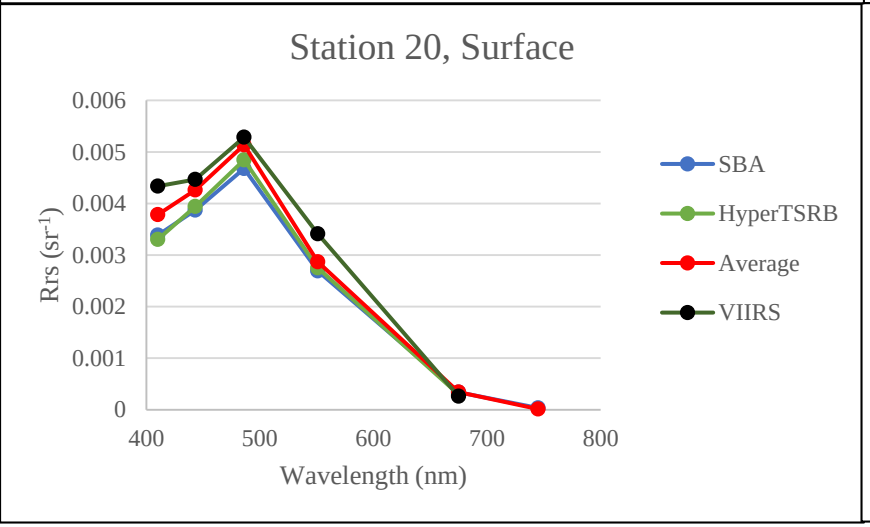
Band	Hyperpro	Hyperpro	Micropro	C-OPS	SBA	HyperTSRB	ASD	ASD	GER	HyperSAS
410	-3.99	-11.54	-5.21	-5.55		9.11	-21.97		11.35	27.78
443	-2.60	-7.59	-14.54	-10.85		11.02	-23.35		24.76	23.14
486	-5.77	-7.58	-14.49	-12.85		9.82	-28.70		35.40	24.17
551	-7.03	-10.21	-19.23	-23.88		27.48	-29.82		31.05	31.63
675	-46.65	-49.78	-57.18	-35.52		148.52	-23.56		22.70	41.48

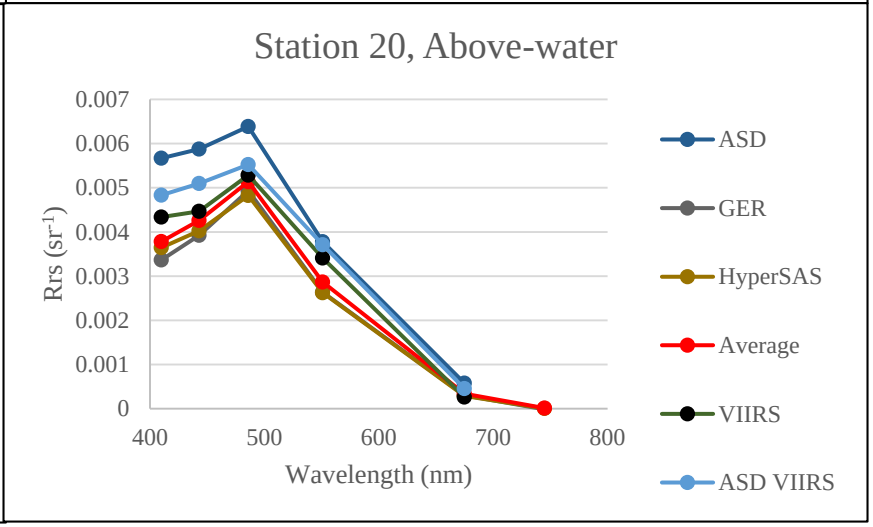


Locations of Stations 20, 21 and 22 on 19 November showing the transect of the shelf fronts with respect to chlorophyll image.





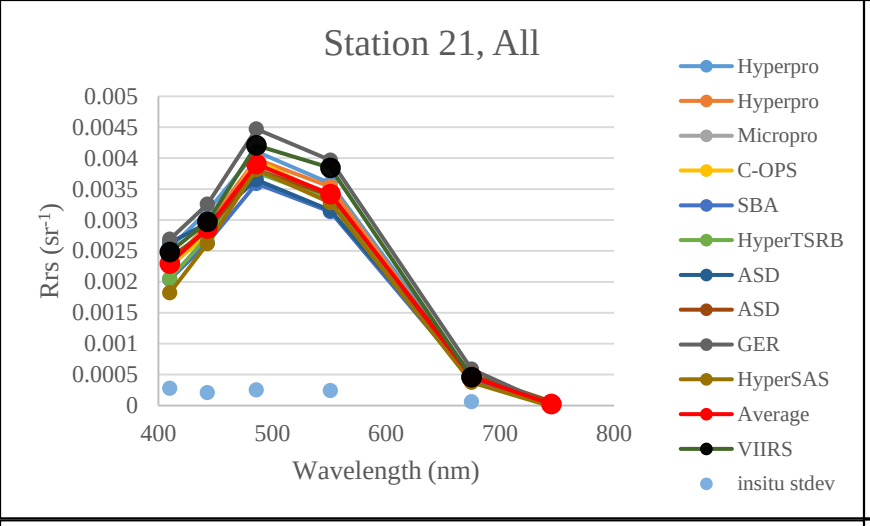


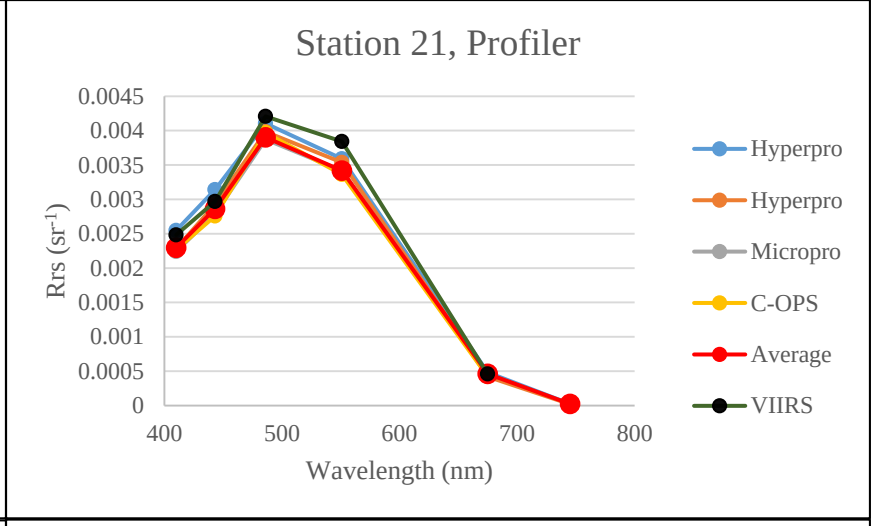


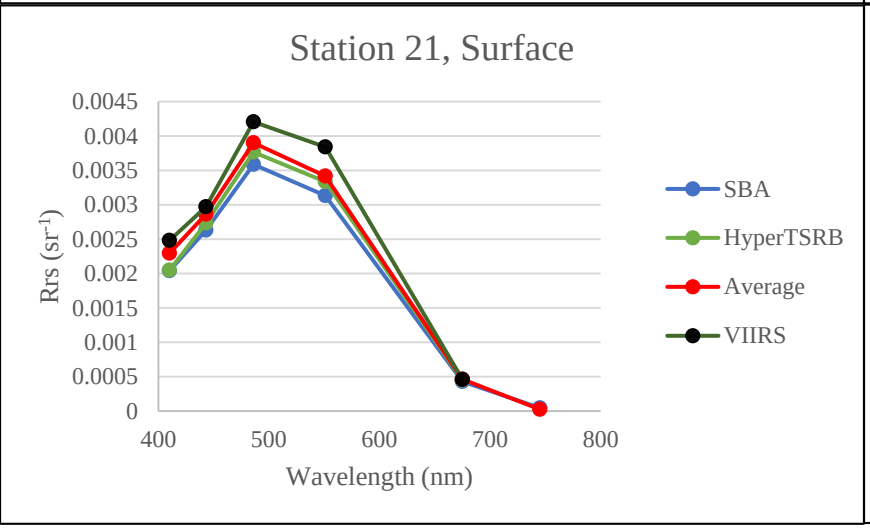
Date: 19
Description: South of Charleston, shelf
Above-Water time: 1026
Surface time: 930
Profile time: 1008
Depth: 24
Cloud cover: 40
Wind speed: 10.5
Seas (ft.): 1-2
Chl (mg/m3) 0.54

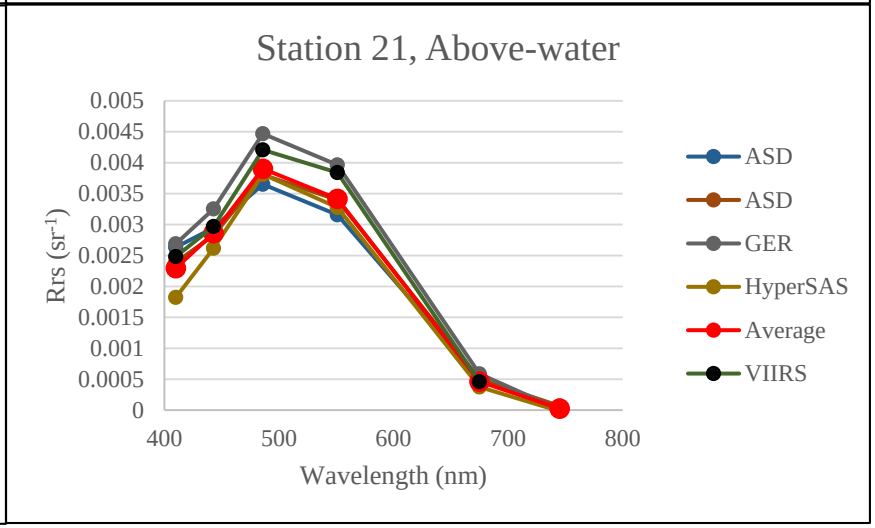
Percent difference relative to Average

Band	Hyperpro	Hyperpro	Micropro	C-OPS	SBA	HyperTSRB	ASD	ASD	GER	HyperSAS
410	3.38	-6.01	-2.38	-6.83	-10.49	-12.74	49.75		-11.04	-3.65
443	7.09	-1.70	-3.25	-9.83	-9.16	-7.53	37.85		-7.92	-5.55
486	7.29	1.02	-1.44	-6.47	-8.97	-5.70	24.32		-3.98	-6.07
551	10.46	3.15	-4.95	-13.83	-6.08	-4.04	31.84		-8.03	-8.51
675	2.41	-7.16	-12.94	-10.93	-0.91	-13.52	69.38		-10.70	-15.63



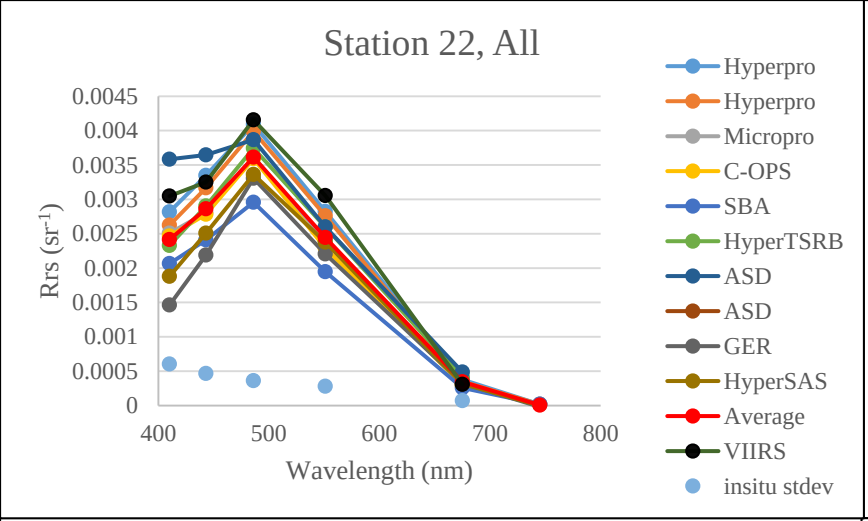


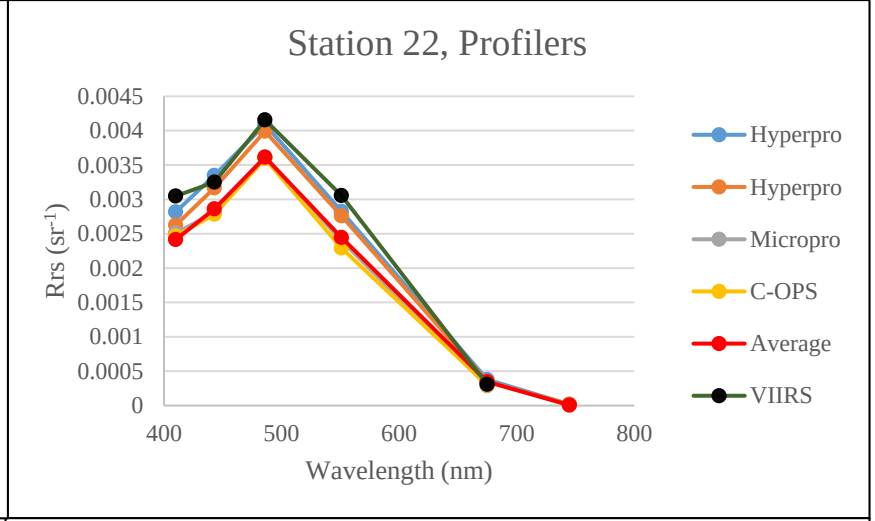


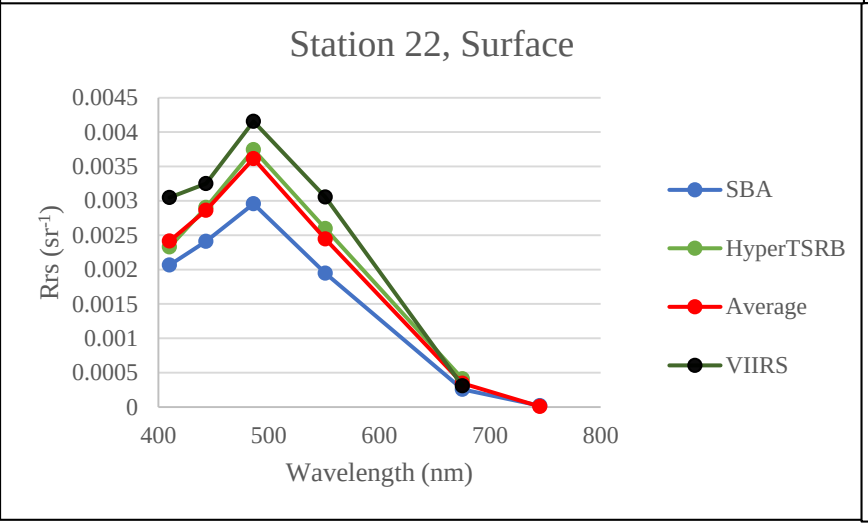


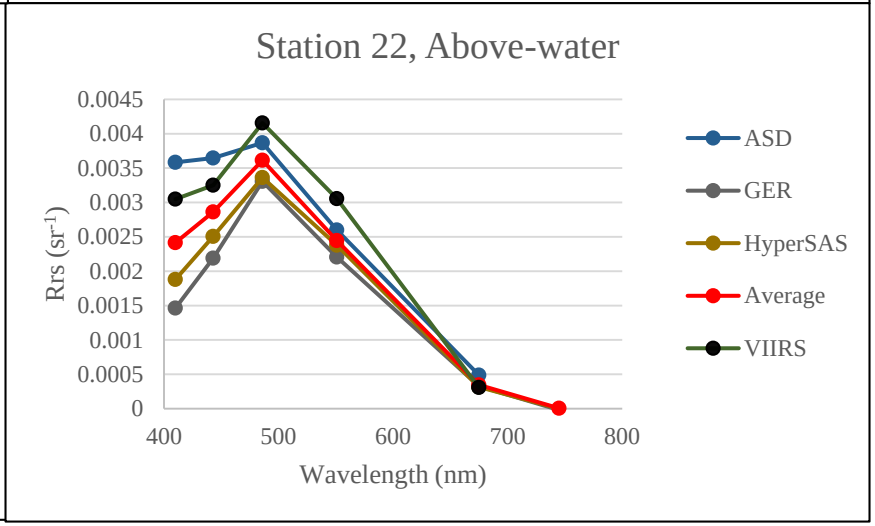
Date: 19
Description: South of Charleston, shelf
Above-Water time: 1301
Surface time: 1255
Profile time: 1305
Depth: 18
Cloud cover: 0
Wind speed: 9
Seas (ft.): 1
Chl (mg/m3) 0.95

Percent difference relative to Average										
Band	Hyperpro	Hyperpro	Micropro	C-OPS	SBA	HyperTSRB	ASD	ASD	GER	HyperSAS
410	10.91	-0.61	-2.46	-1.17	-11.17	-10.75	14.65	4.11	17.13	-20.65
443	9.77	2.22	-2.57	-3.66	-8.10	-4.51	3.03	-1.28	13.68	-8.59
486	5.18	2.06	-0.78	1.72	-8.08	-3.50	-6.45	-2.44	14.54	-2.25
551	5.07	3.49	-0.02	-1.59	-8.33	-2.39	-7.61	-0.57	16.03	-4.08
675	4.44	-9.16	-3.87	-7.84	-7.19	-2.63	10.07	7.90	27.23	-18.93





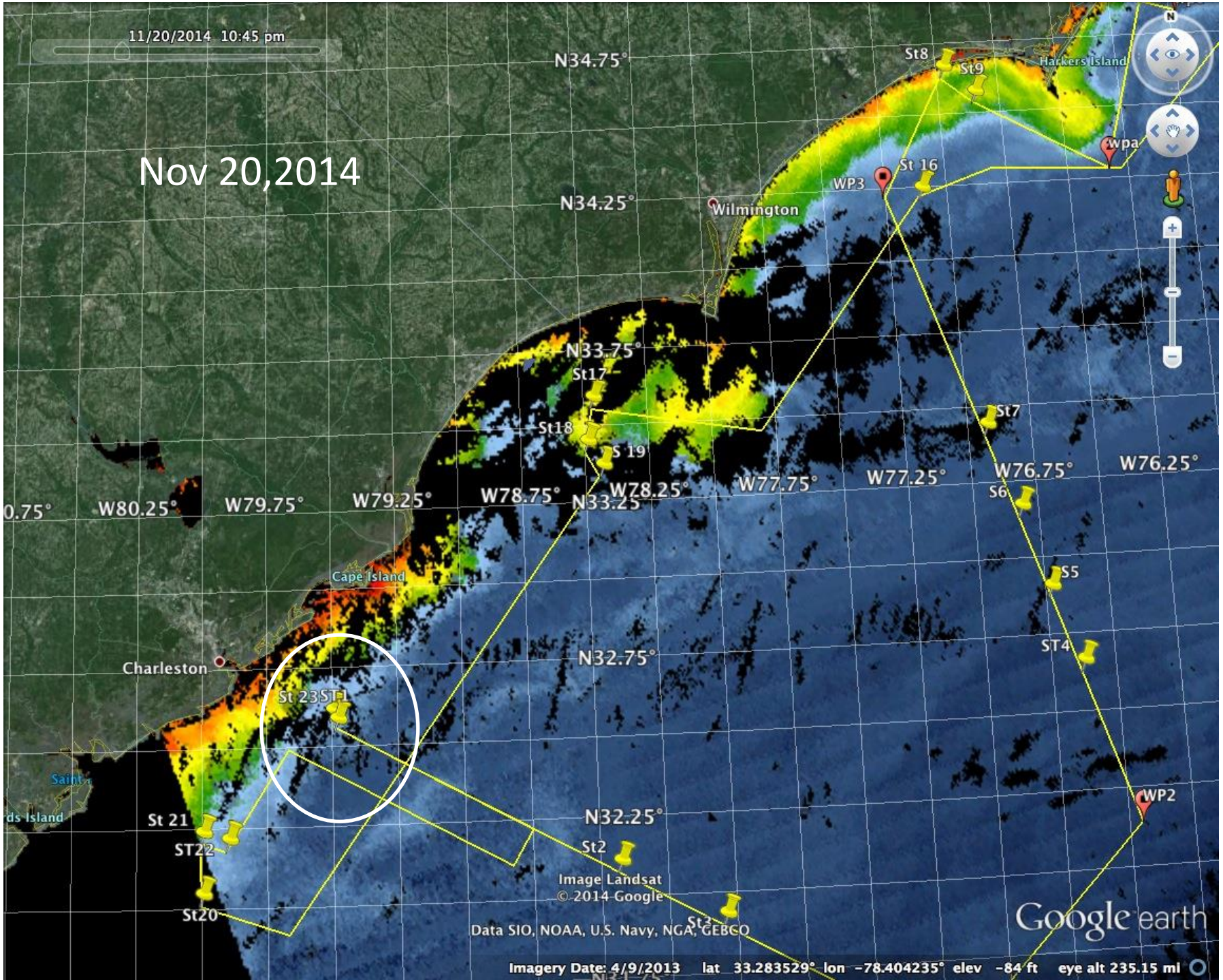


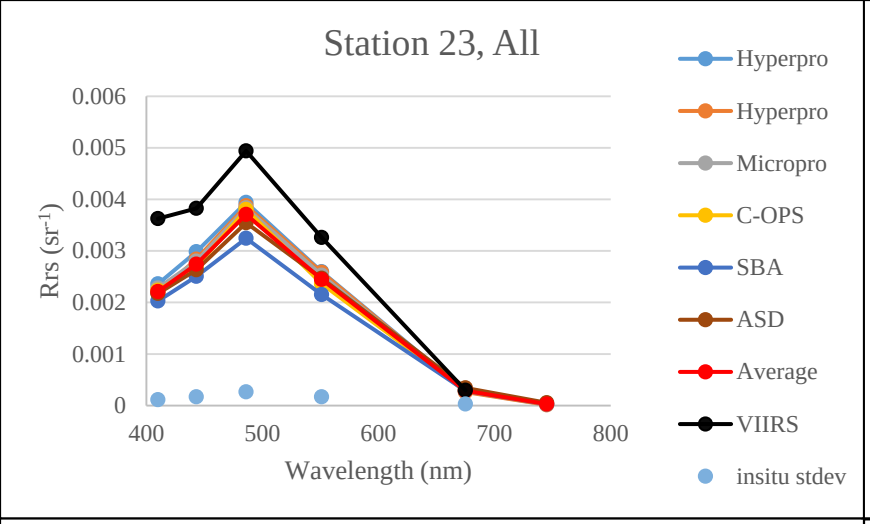


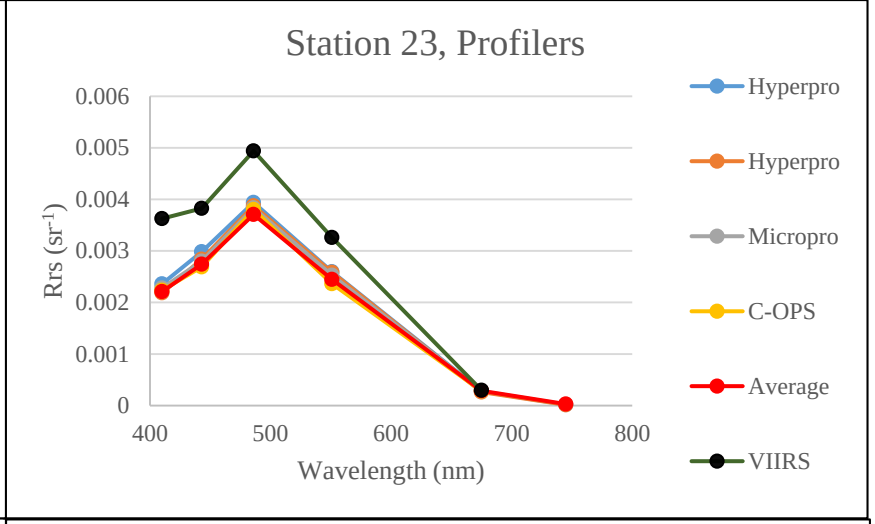
Date: 19
Description: South of Charleston, shelf
Above-Water time: 1520
Surface time: 1555
Profile time: 1520
Depth: 26
Cloud cover: 0
Wind speed: 4
Seas (ft.): 1
Chl (mg/m3) 0.62

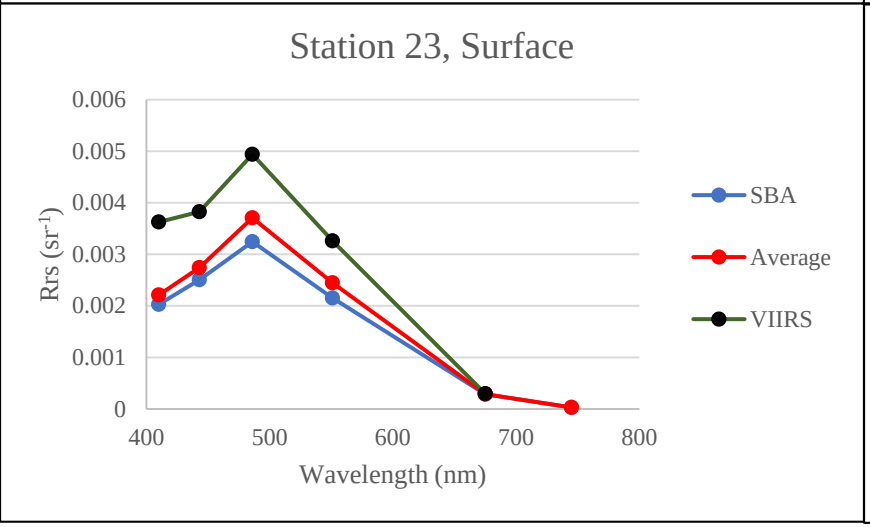
Percent difference relative to Average

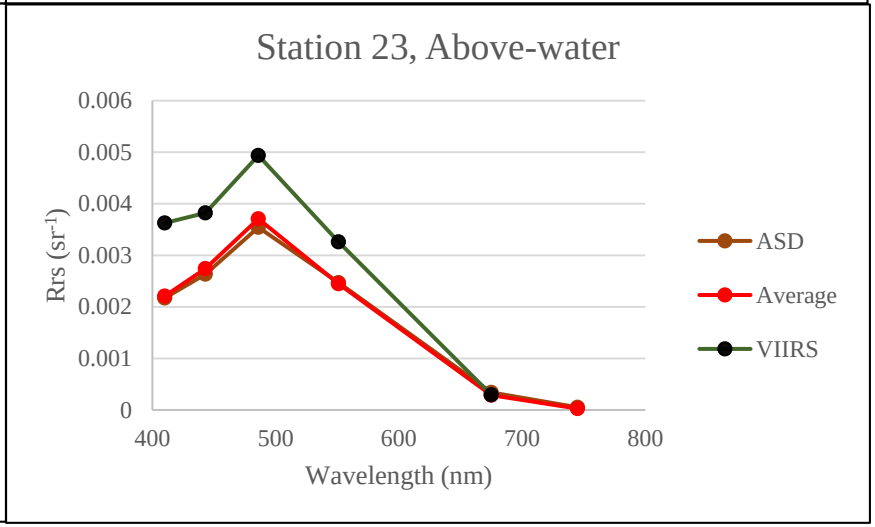
Band	Hyperpro	Hyperpro	Micropro	C-OPS	SBA	HyperTSRB	ASD	ASD	GER	HyperSAS
410	16.63	8.63	3.86	2.14	-14.47	-3.60	48.41		-39.39	-22.21
443	17.01	10.65	-1.96	-2.82	-15.82	1.48	27.39		-23.51	-12.41
486	13.18	10.43	-0.02	-0.58	-18.20	3.63	7.04		-8.50	-6.98
551	15.55	12.83	-1.66	-6.25	-20.38	6.17	6.28		-9.81	-2.73
675	9.16	1.46	-16.96	-13.56	-25.67	18.79	41.11		-5.57	-8.75


11/20/2014 10:45 pm
Nov 20,2014
N34.75°
N34.25°
N33.75°
N33.25°
N32.75°
N32.25°
W80.25°
W79.75°
W79.25°
W78.75°
W78.25°
W77.75°
W77.25°
W76.75°
W76.25°
St8
St9
Harkers Island
wpa
St 16
WP3
Wilmington
St17
St18
S 19
St7
S6
S5
ST4
WP2
Cape Island
Charleston
St 23 ST1
St 21
ST22
St20
St2
St3
Image Landsat
© 2014 Google
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Google earth
Imagery Date: 4/9/2013 lat 33.283529° lon -78.404235° elev -84 ft eye alt 235.15 mi









Date: 20
Description: Charleston Sea Buoy
Above-Water time: 950
Surface time: 825
Profile time: 900
Depth: 19
Cloud cover: 0
Wind speed: 16
Seas (ft.): 1-2
Chl (mg/m3) 0.5

Percent difference relative to Average

Band	Hyperpro	Hyperpro	Micropro	C-OPS	SBA	HyperTSRB	ASD	ASD	GER	HyperSAS
410	6.76	-1.13	3.17	1.14	-8.24			-1.70		
443	8.81	3.53	2.16	-1.90	-8.66			-3.94		
486	6.25	4.50	3.43	2.64	-12.45			-4.37		
551	6.02	5.56	3.27	-3.54	-12.16			0.84		
675	-4.10	-8.97	-2.75	-2.20	-0.70			18.72		

Instrument Percent difference relative to average of all instruments

Band	Hyperpro	Hyperpro	Micropro	C-OPS	SBA	HyperTSRB	ASD	ASD	GER	HyperSAS
410	4.83	-0.41	1.93	-1.49	-9.01	-4.29	6.47	-1.82	4.04	-0.75
443	6.84	3.12	-0.35	-4.21	-8.90	-0.28	1.34	-3.30	6.19	-1.31
486	4.83	3.81	-0.37	-2.19	-9.86	1.01	-4.71	-2.21	10.38	-0.75
551	5.22	4.14	-1.86	-7.24	-9.12	5.52	-0.11	-4.75	8.53	-1.16
675	-9.18	-14.02	-14.91	-17.22	-8.57	36.15	38.47	0.24	5.46	-11.25
All	2.51	-0.67	-3.11	-6.47	-9.09	7.62	8.29	-2.37	6.92	-3.04

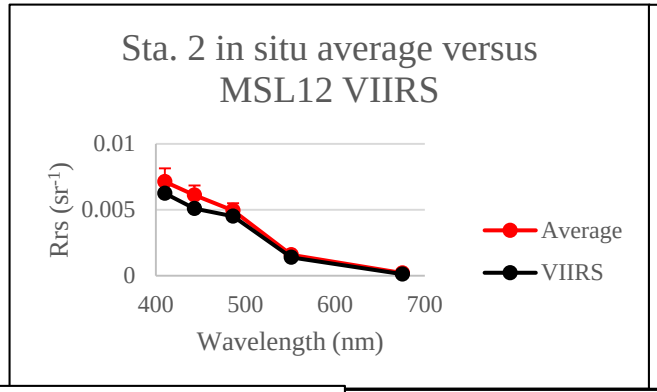
MSL12 VIIRS Percent difference relative to in situ (with Sta 23)

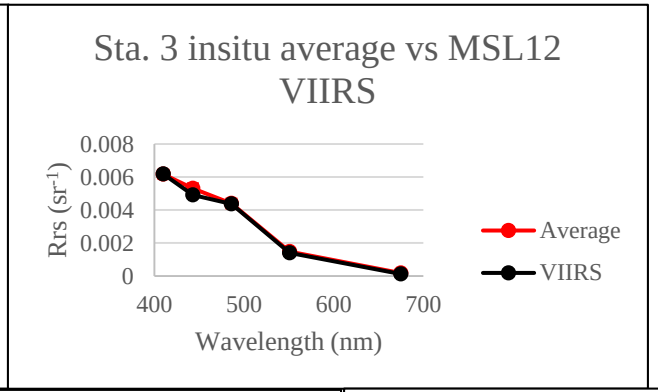
Band	Hyperpro	Hyperpro	Micropro	C-OPS	SBA	HyperTSRB	ASD	ASD	GER	HyperSAS	Average
410	0.82	4.34	1.76	5.01	18.87	1.57	-8.17	10.18	3.33	3.85	**3.75**
443	-7.99	-5.81	-2.57	1.19	10.21	-7.42	-8.53	4.25	-8.44	-3.90	**-3.01**
486	-2.51	-2.01	1.93	3.71	16.39	-2.84	3.67	7.71	-8.83	0.35	**1.65**
551	0.07	0.49	6.81	13.31	19.27	-2.89	2.89	10.40	-2.82	5.52	**4.72**
675	-8.22	1.01	1.54	2.05	-2.53	-28.45	-25.91	-10.19	-22.89	-4.94	**-14.87**
All	-3.57	-0.40	1.89	5.05	12.44	-8.01	-7.21	4.47	-7.93	0.18	**-1.55**

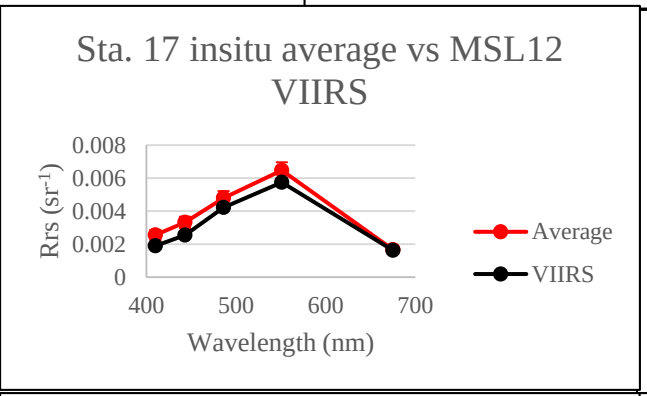
MSL12 VIIRS Percent difference relative to in situ without (Sta. 23)

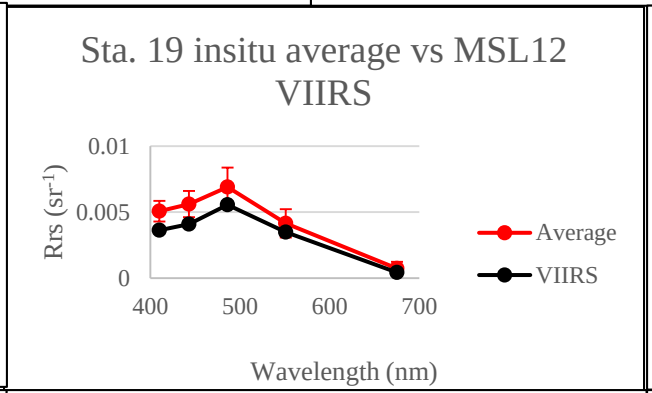
Band	Hyperpro	Hyperpro	Micropro	C-OPS	SBA	HyperTSRB	ASD	ASD	GER	HyperSAS	Average
410	-6.73	-3.36	-5.39	-2.15	10.31	1.57	-8.17	-8.73	3.33	3.85	**-3.79**
443	-13.15	-10.87	-7.45	-3.93	4.15	-7.42	-8.53	-9.38	-8.44	-3.90	**-8.31**
486	-6.49	-5.70	-1.44	0.45	11.28	-2.84	3.67	-2.83	-8.83	0.35	**-2.30**
551	-3.58	-2.71	4.05	10.21	14.65	-2.89	2.89	3.18	-2.82	5.52	**1.17**
675	-10.37	-0.44	1.06	1.70	-3.34	-28.45	-25.91	-9.02	-22.89	-4.94	**-17.04**
All	-8.07	-4.62	-1.83	1.26	7.41	-8.01	-7.21	-5.36	-7.93	0.18	**-6.05**

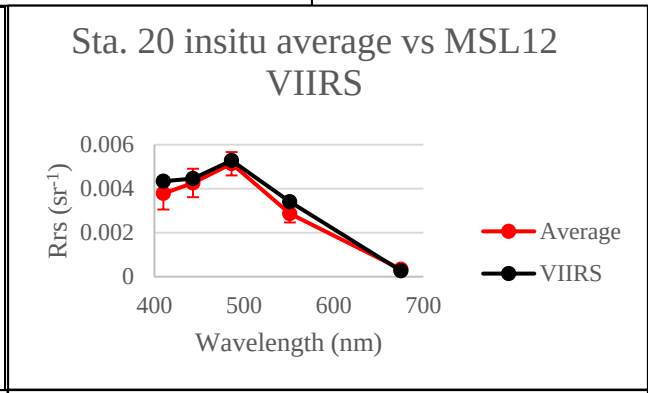
MSL12 VIIRS 5x5 avg vs avg of all Rrs measurements

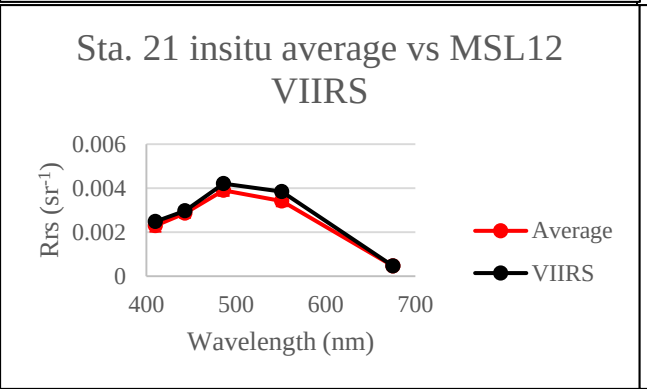


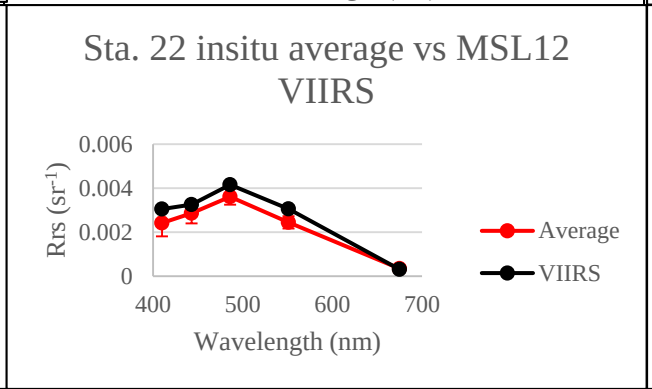


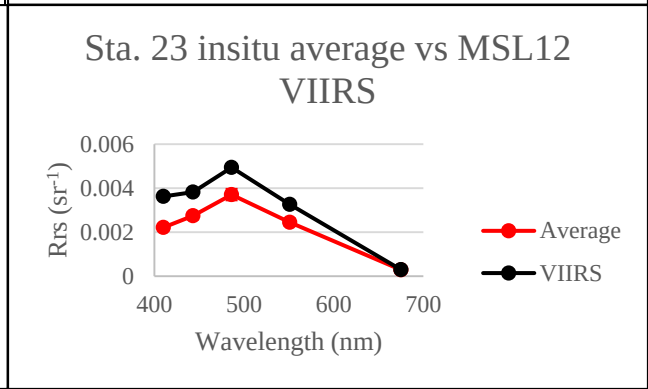


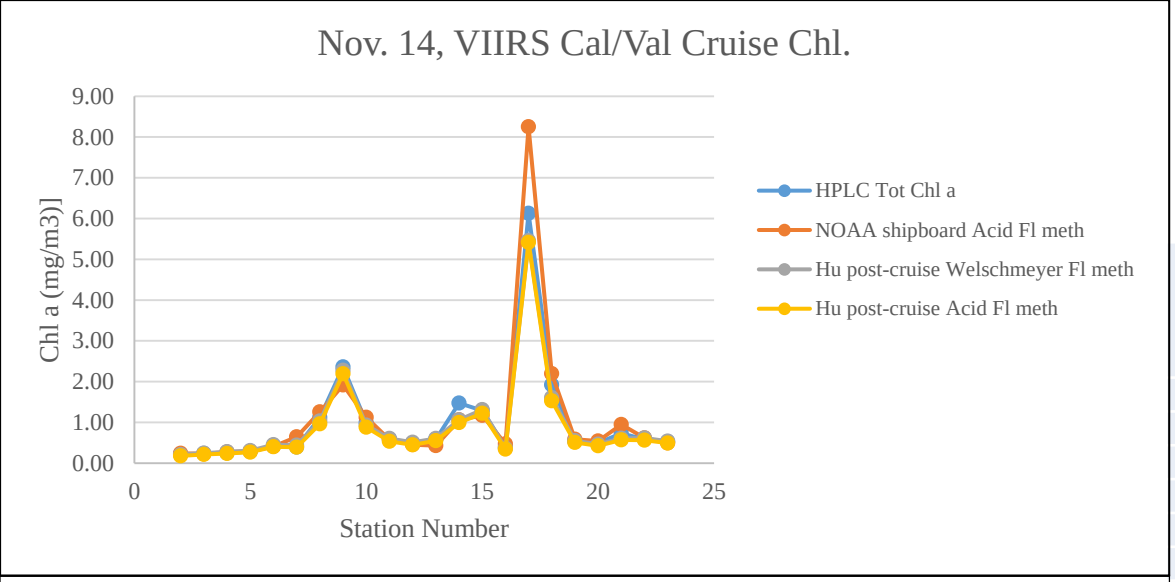


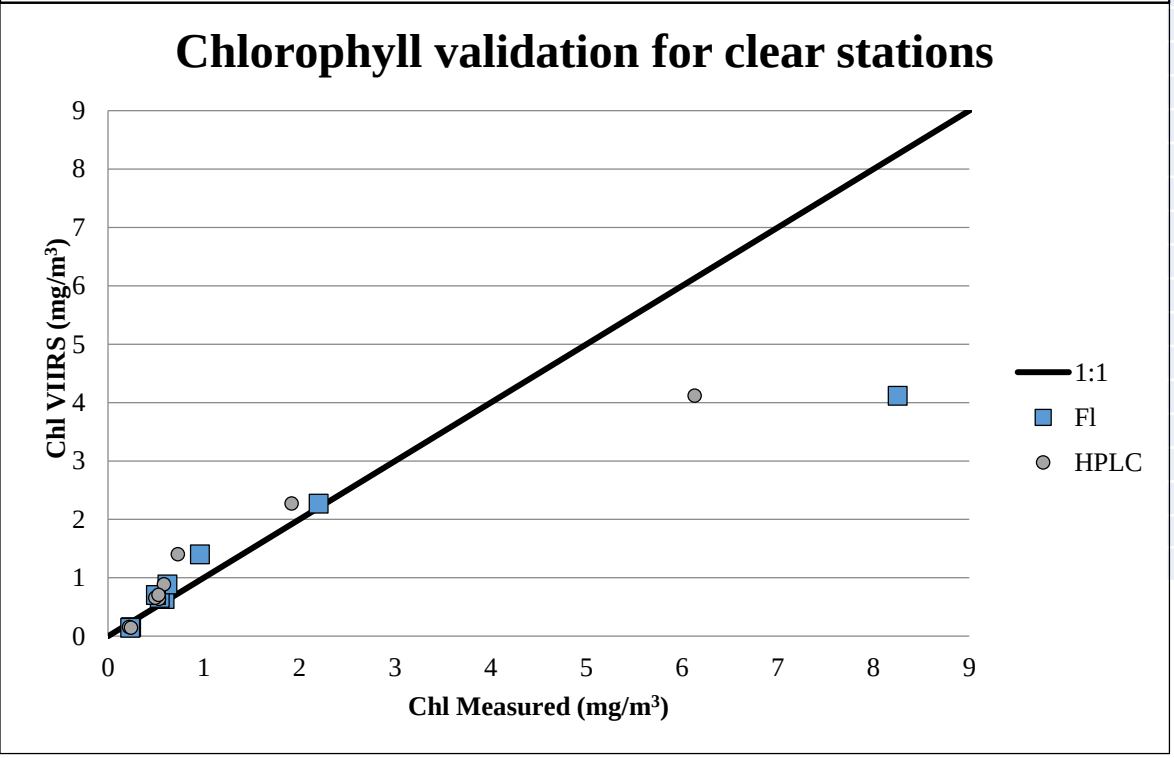












Station	HPLC Tot Chl a	NOAA shipboard Acid Fl meth	Hu post-cruise Welschmeyer Fl meth	Hu post-cruise Acid Fl meth
1	0.77	0.77	0.82	0.78
2	0.22	0.24	0.21	0.18
3	0.24	0.23	0.25	0.22
4	0.25	0.27	0.28	0.24
5	0.28	0.29	0.31	0.27
6	0.41	0.41	0.45	0.40
7	0.39	0.65	0.44	0.39
8	1.12	1.26	1.03	0.96
9	2.36	1.92	2.28	2.19
10	0.99	1.12	0.93	0.88
11	0.59	0.57	0.60	0.54
12	0.48	0.45	0.51	0.45
13	0.59	0.43	0.61	0.55
14	1.47	1.06	1.06	0.99
15	1.29	1.17	1.31	1.22
16	0.39	0.47	0.37	0.34
17	6.13	8.25	5.46	5.42
18	1.92	2.20	1.61	1.53
19	0.53	0.59	0.55	0.51
20	0.50	0.54	0.47	0.43
21	0.73	0.95	0.61	0.57
22	0.59	0.62	0.62	0.56
23	0.53	0.50	0.54	0.49

Conclusions:

Consistency between 10 independent measurements of water leaving radiance is within 10%.

Differences between in situ measurements is most likely dominated by variability in water masses

VIIRS matchups to in-water validation measurements are promising.