Evaluation of VIIRS performance in coastal waters and in its capacity to detect dark water and harmful algal blooms

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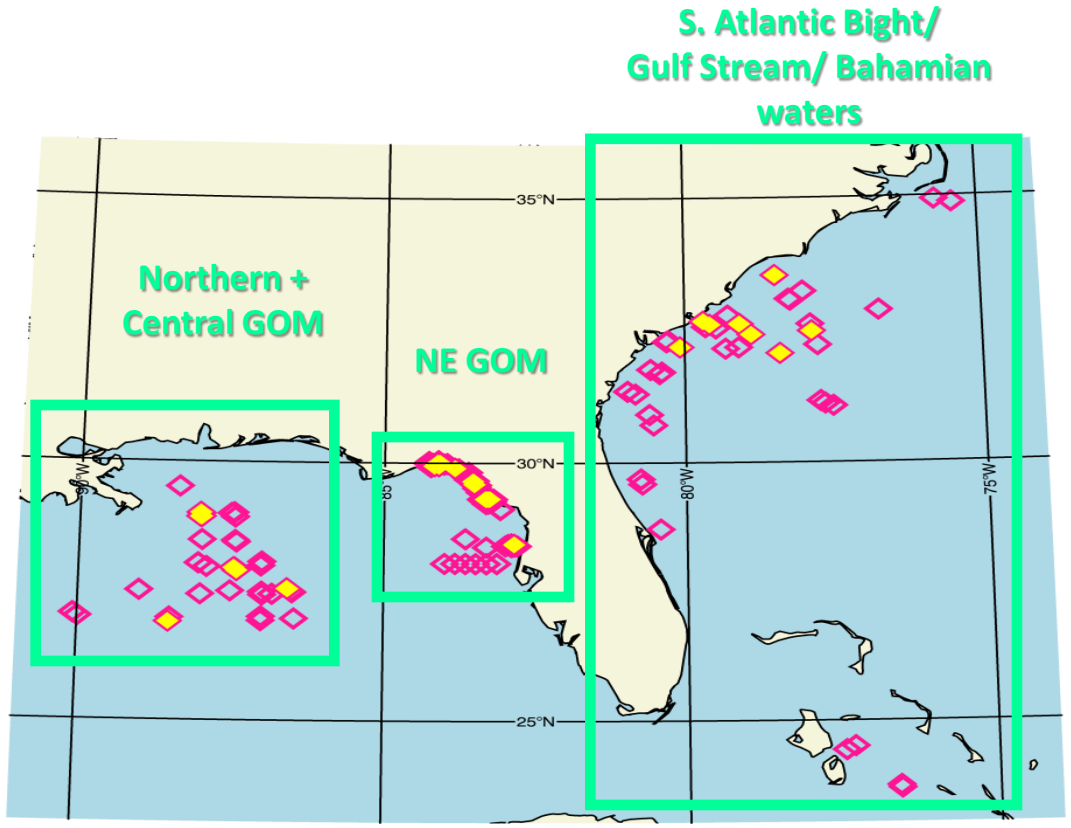
1. Performance for open-ocean and coastal waters
2. Performance for estuaries
3. Application for harmful algal blooms
4. Application for floating macroalgae blooms

1. Performance for open-ocean and coastal waters

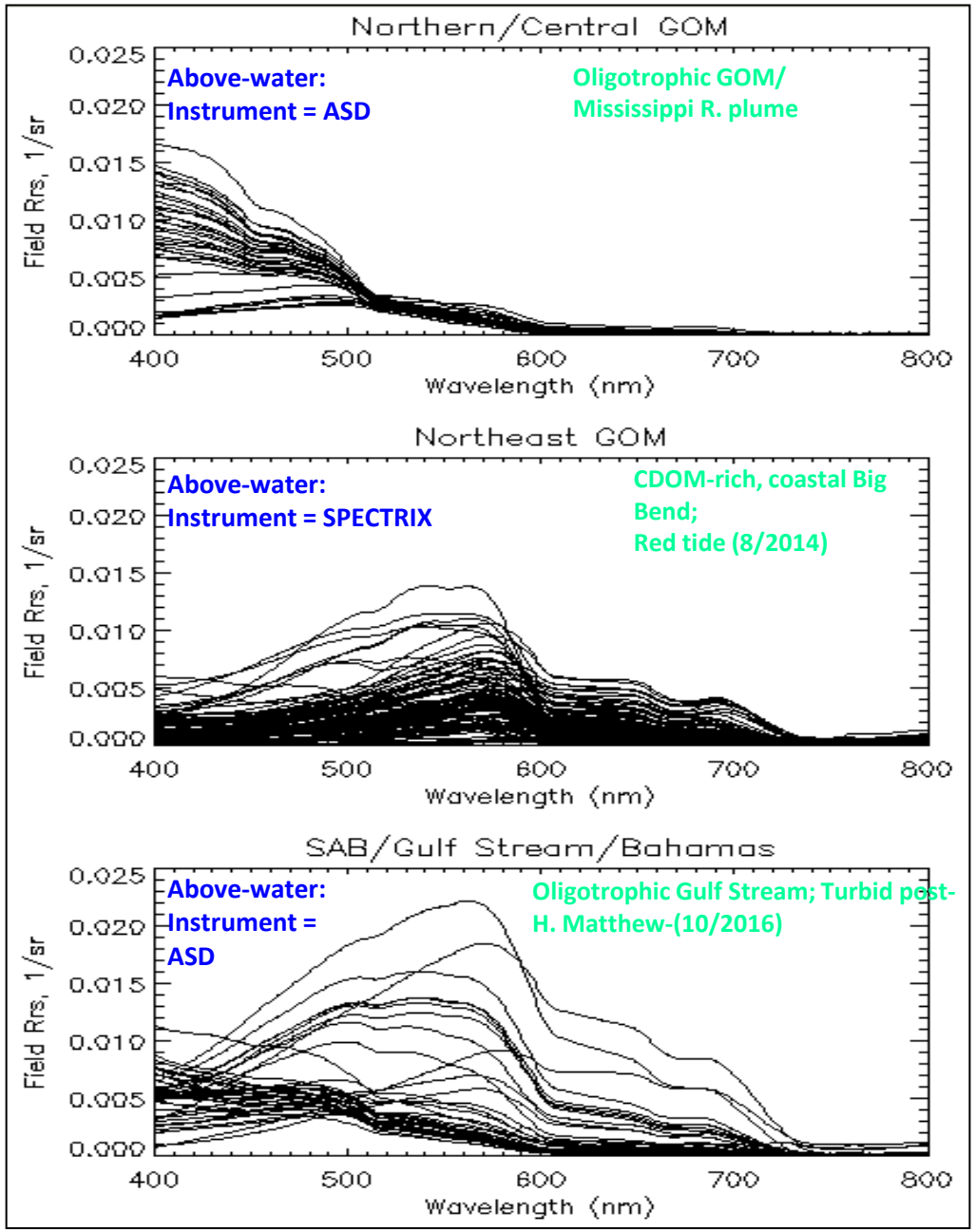
Summary of USF Field Experiments in oceanic/coastal waters (2012-2016)

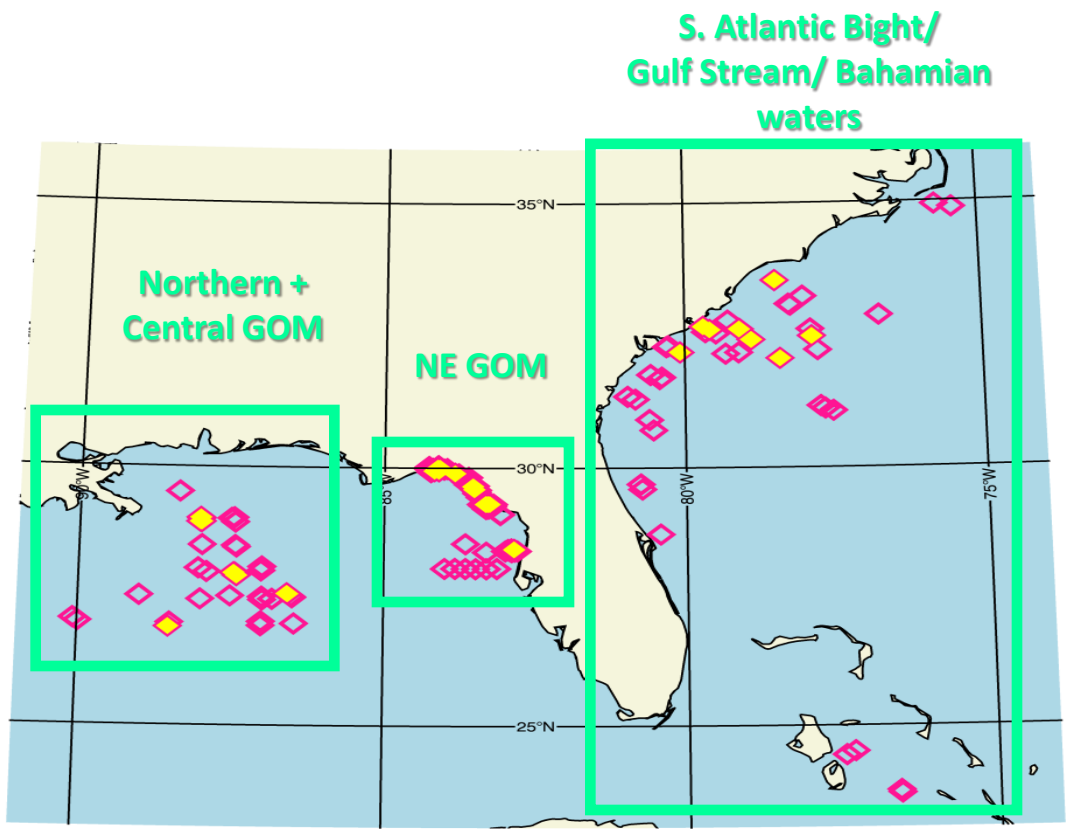
Region	Project	Cruise	Start Date	End Date	Field $R_{rs}(\lambda)$	
Northern and Central Gulf of Mexico	GoMRI DEEPEND	DP01	05/01/15	05/08/15	7	n=35
		DP02	08/08/15	08/22/15	13	
		DP03	05/01/16	05/16/16	8	
		DP04	08/05/16	08/20/16	7	
Northeastern Gulf of Mexico	HAB event response	BE1408	08/04/14	08/05/14	8	n=104
	NASA Big Bend	SC1209	09/28/12	09/28/12	8	
		CK1211	11/15/12	11/15/12	5	
		HICO	10/26/13	10/26/13	9	
			11/17/13	11/17/13	14	
			11/21/13	11/21/13	13	
			04/11/14	04/11/14	10	
		bb1606	06/08/16	06/08/16	4	
			06/10/16	06/10/16	2	
			06/13/16	06/13/16	2	
			06/14/16	06/14/16	3	
			06/20/16	06/20/16	4	
			06/21/16	06/21/16	3	
			06/22/16	06/22/16	1	
			06/23/16	06/23/16	3	
		bb1607	07/20/16	07/20/16	5	
		bb1610	10/03/16	10/03/16	10	
South Atlantic Bight, Gulf Stream, and Bahamian waters	NOAA VIIRS Cal/Val	NF-14-09	11/11/14	11/20/14	7	n=45
		NF-15-13	12/02/15	12/13/15	26	
		NF-16-08	10/13/16	10/18/16	12	



Total # of field $R_{rs}(\lambda)$ = 184

Summary of USF Field Experiments in oceanic/coastal waters (2012-2016)

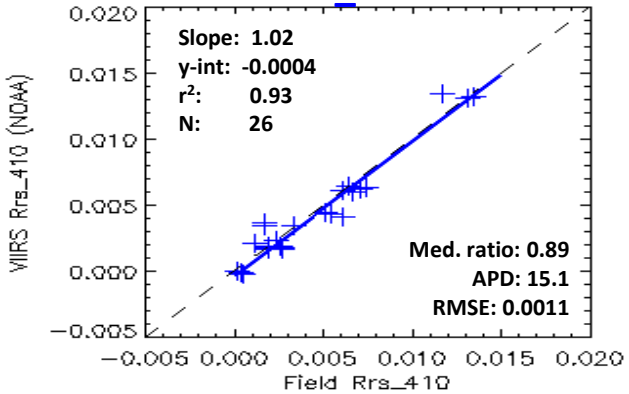




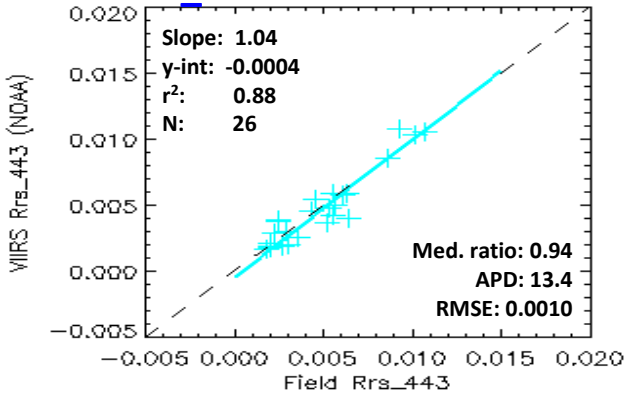
Field $R_{rs}(\lambda)$
Valid VIIRS same day match-ups

‘Old’ VIIRS MSL12

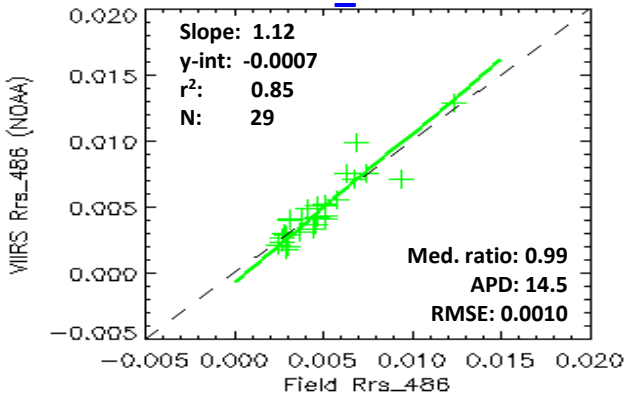
Rrs_410



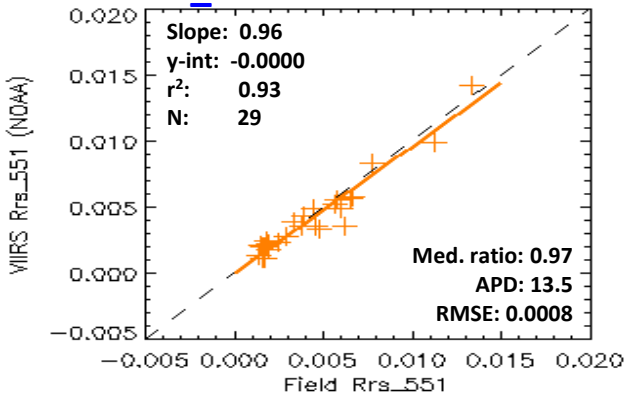
Rrs_443



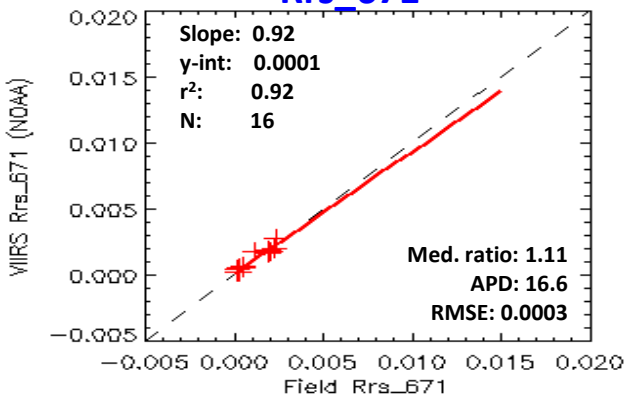
Rrs_486



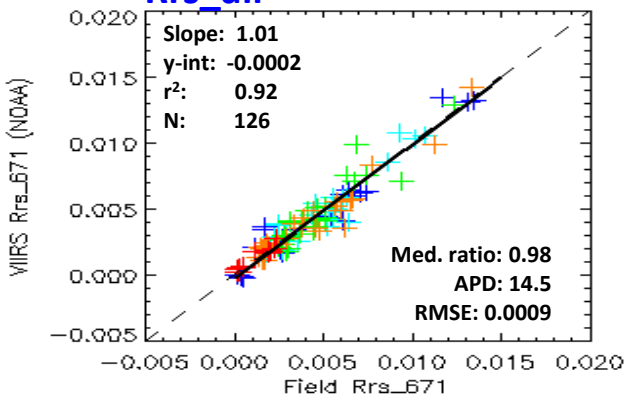
Rrs_551



Rrs_671

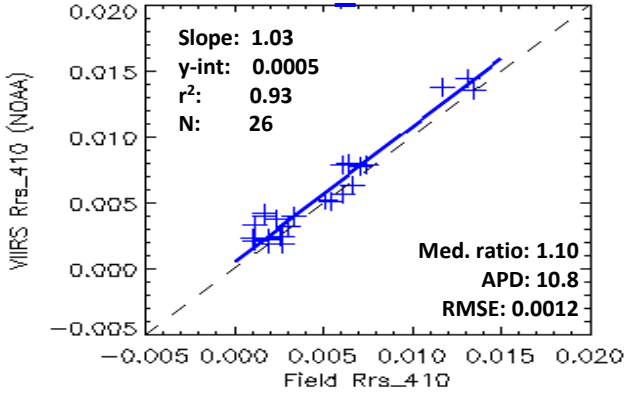


Rrs_all



‘New’ VIIRS MSL12

Rrs_410



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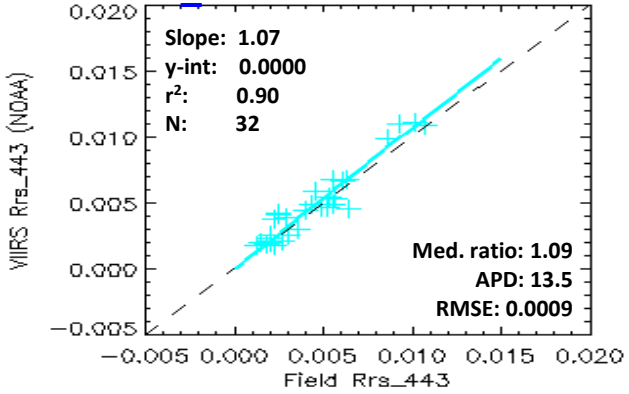
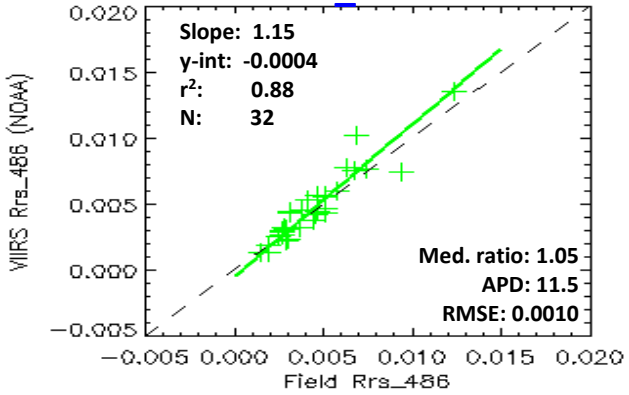
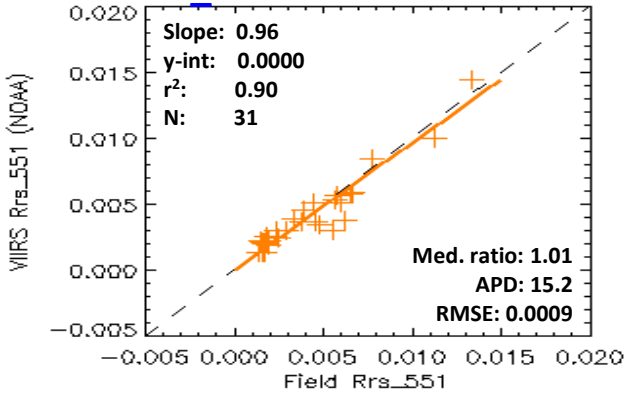


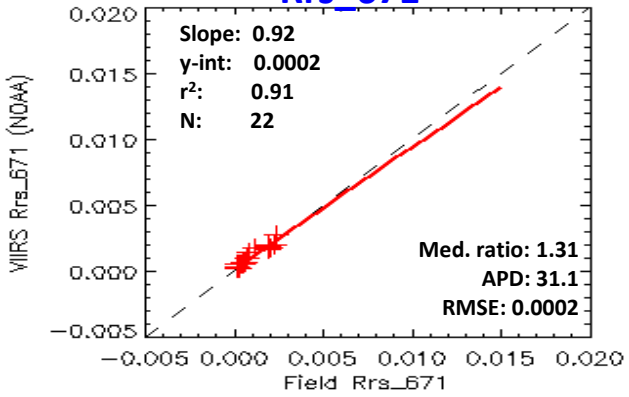
Rrs_486



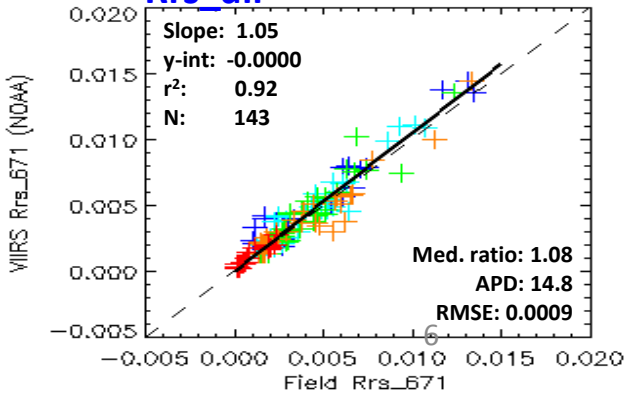
Rrs_551



Rrs_671



Rrs_all



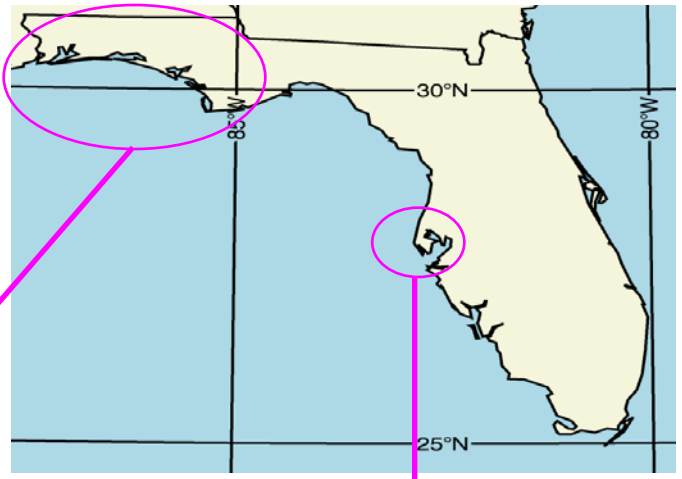
2. Performance for estuaries

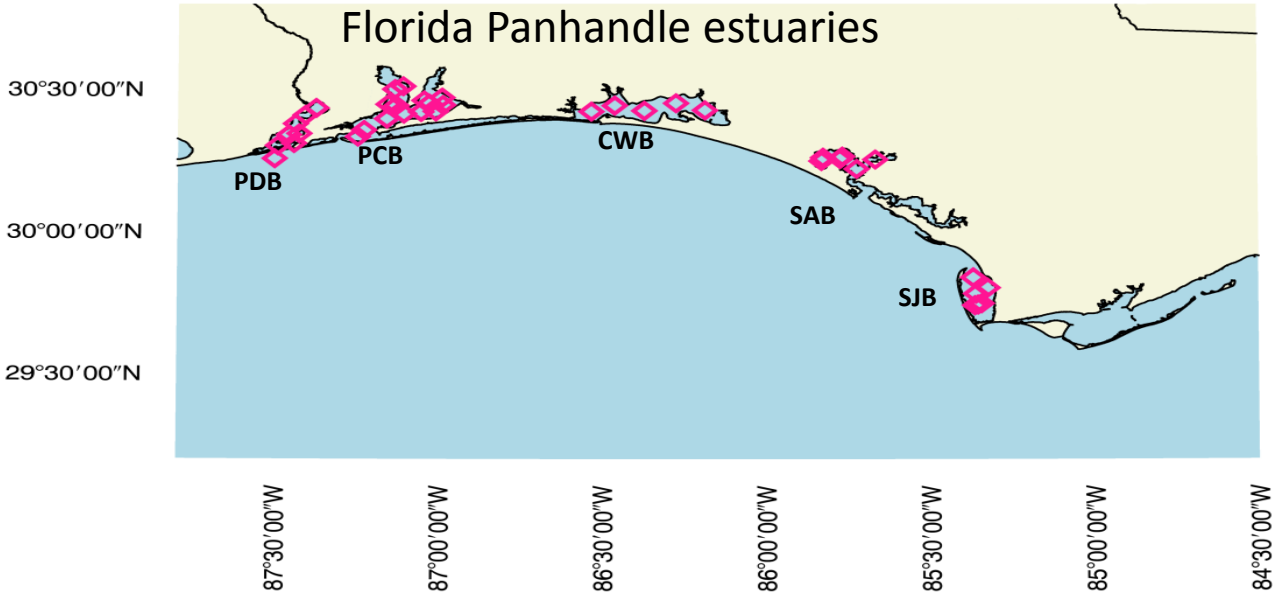
Summary of USF Field Experiments in estuarine waters (2012-2016)

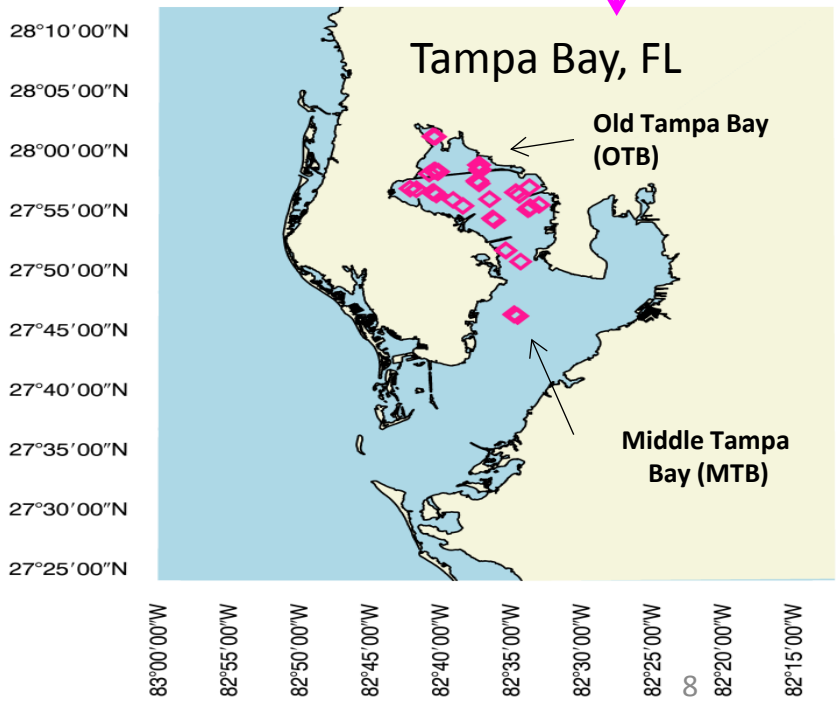
Start Date	End Date	Project	Cruise_ID	Region	[Chl *a*]	$a_p(\lambda)$, $a_d(\lambda)$	$a_{CDOM}(\lambda)$	$b_b(\lambda)$	$R_{rs}(\lambda)$
01/20/12	12/18/13	HAB Event Response	-	Old Tampa Bay/ Middle Tampa Bay	347	348	348	200	44
05/07/12	-	NASA-Tampa Bay	t1205		7	7	7	0	7
08/24/12	-	NASA-Tampa Bay	t1208		6	6	6	0	6
12/15/15	-	Florida FWC Panhandle estuaries NOAA VIIRS Cal/Val	pan1512	PCB	9	0	9	0	10
12/16/15	-		pan1512	CWB	5	0	5	0	0
12/01/15	-		pan1512	SAB	4	0	4	0	4
03/14/16	-		pan1603	PDB	1	0	1	0	1
03/16/16	-		pan1603	CWB	4	0	4	0	4
05/18/16	-		pan1605	SJB	3	0	3	0	3
05/19/16	-		pan1605	SAB	2	0	2	0	2
05/21/16	-		pan1605	CWB	5	0	5	0	5
05/22/16	-		pan1605	PCB	11	0	11	0	11
05/23/16	-		pan1605	PDB	7	0	7	0	7
07/22/16	-		pan1607	SJB/SAB	8	0	7	0	8
07/24/16	-		pan1607	PCB	3	0	3	0	3
07/25/16	-		pan1607	PCB	1	0	1	0	1
				TOTAL:	423	361	423	200	116

n=57

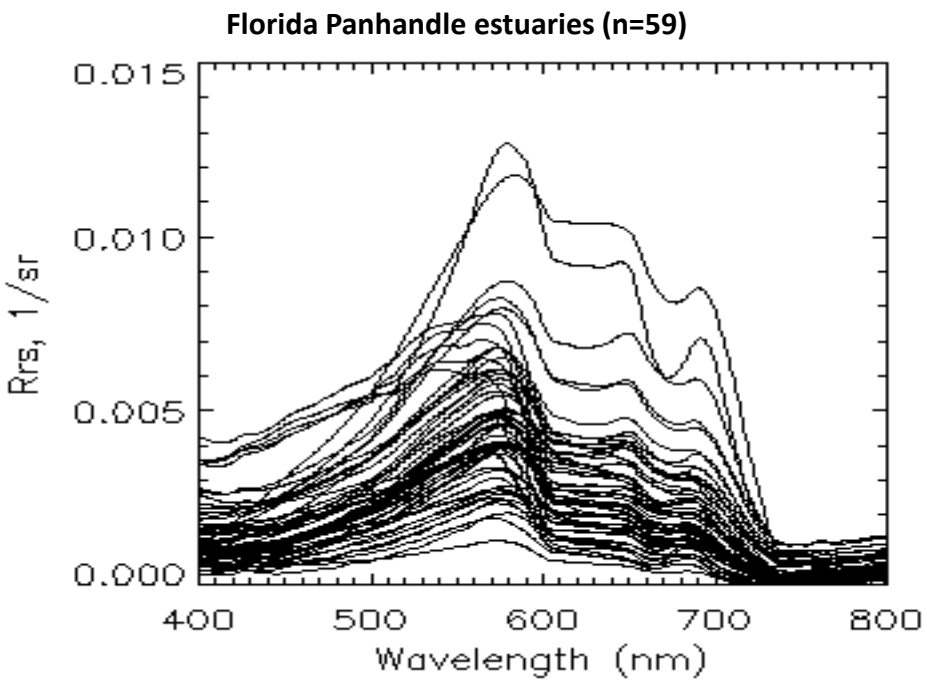
n=59

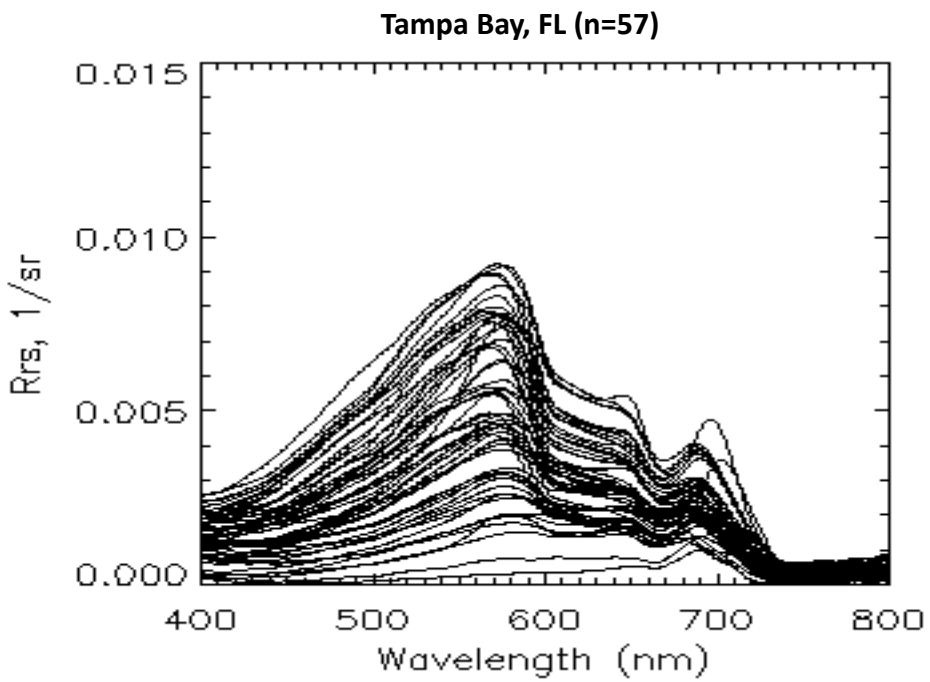






Field $R_{rs}(\lambda)$:





Chl-a: 0.91 – 11.9 mg m $^{-3}$
4.9 ± 2.8 mg m $^{-3}$

$a_{CDOM}(443)$: 0.05-1.7 m^{-1}
0.91 ± 0.40 m^{-1}

Chl-a: 3.0 – 53.6 mg m $^{-3}$
12.6 ± 10.2 mg m $^{-3}$

$a_{CDOM}(443)$: 0.36 – 11.0 m^{-1}
1.4 ± 1.7 m^{-1}

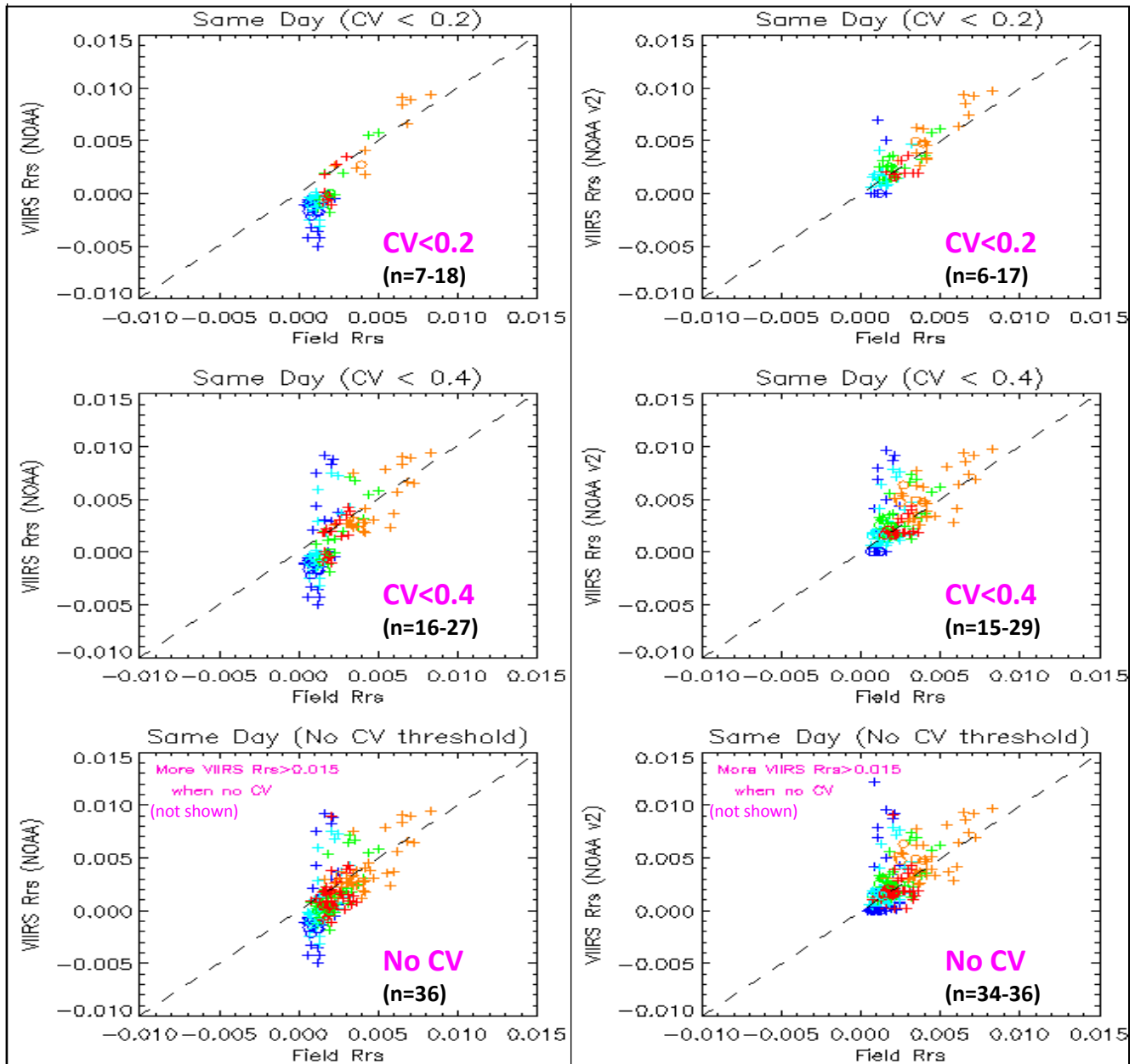
VIIRS $R_{rs}(\lambda)$ match-up results: *variable processing schemes/spatial homogeneity filters; standard I2 flags applied*

NOAA (v1 – aka "old") NOAA (v2 – "new") ←*processing*

(most recent processing)

Observations:

- Important: *cannot directly compare processing schemes using data shown here!* Why? Because the dates and locations of match-up pairs differed greatly amongst processing schemes. For example: only 4 match-up pairs were available when field and VIIRS Rrs(551) using all three processing schemes were valid.
- Relaxation of spatial homogeneity filter led to increased # of match-up pairs, but poorer match-up quality.
- Agreement between field and VIIRS Rrs(λ) weakest at 410nm.



410nm
443nm
486nm
551nm
671nm

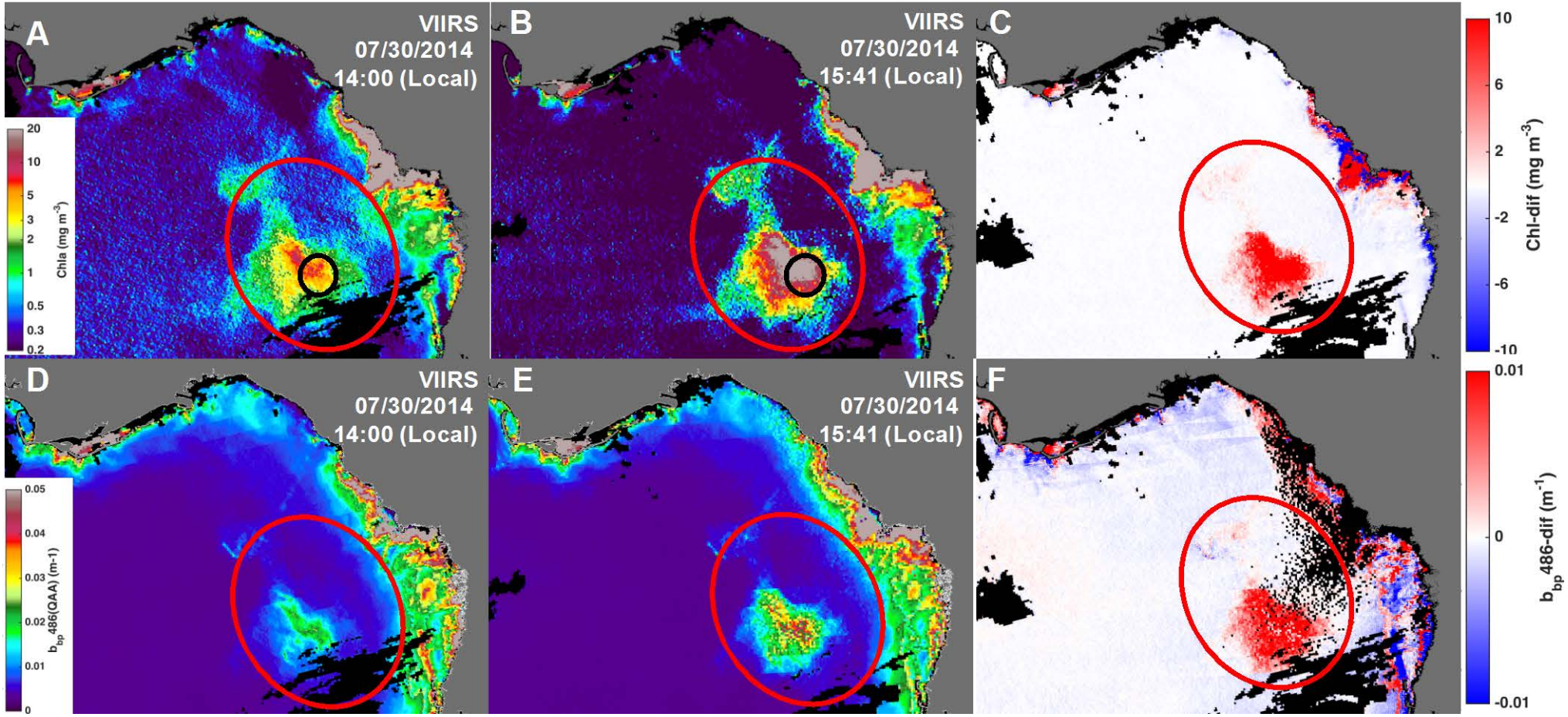
3. Application for harmful algal blooms

VIIRS captures phytoplankton vertical migration in the NE Gulf of Mexico

14:00 hour | 15:41 hour | Difference

Chl =>

b_{bp} =>



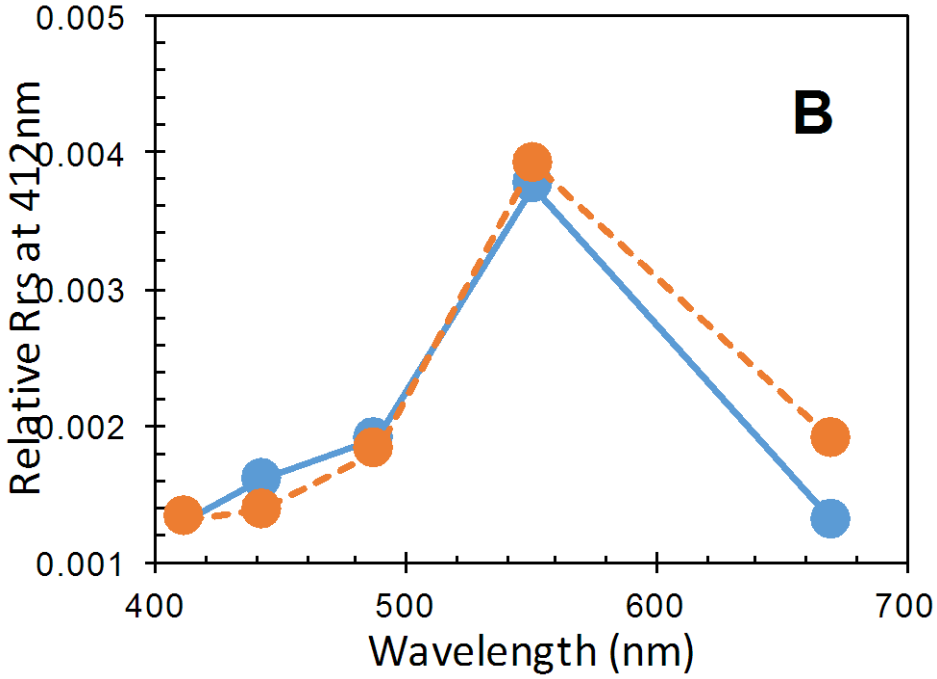
Karenia brevis bloom (red tide), from Qi et al. (2017, Harmful Algae)

VIIRS captures phytoplankton vertical migration in the NE Gulf of Mexico

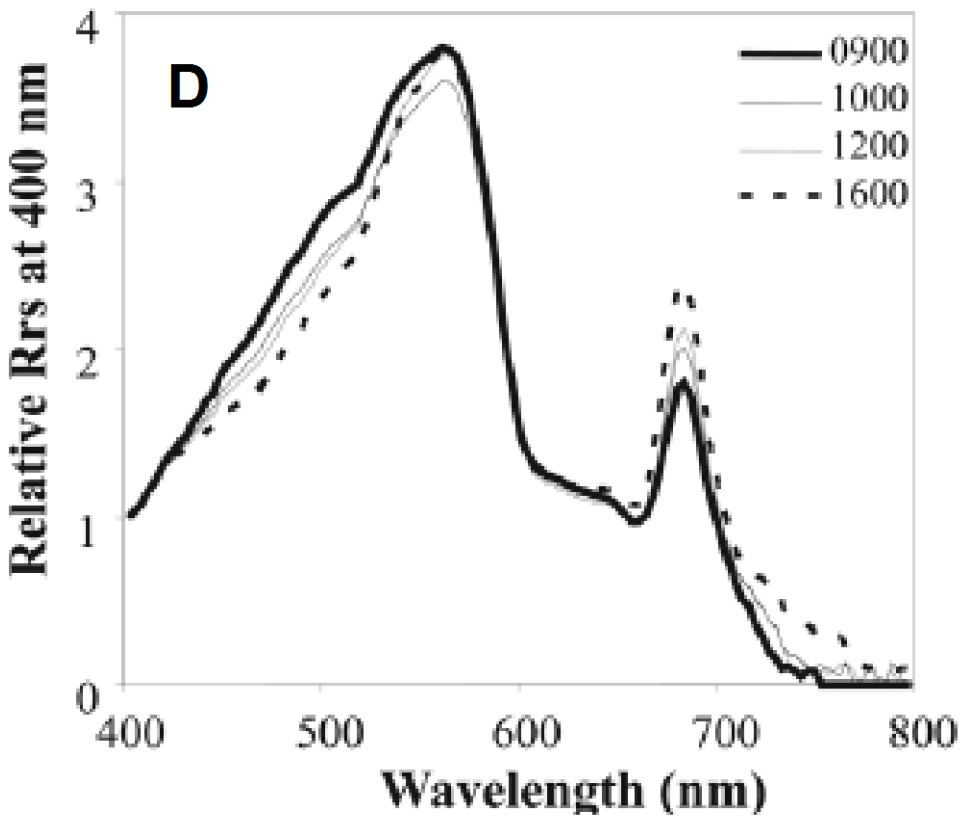
Rrs spectral changes in 100 minutes (left) agree with previous field measurement (right)

From VIIRS measurements, July 30, 2014

Blue: 14:00; Brown: 15:41



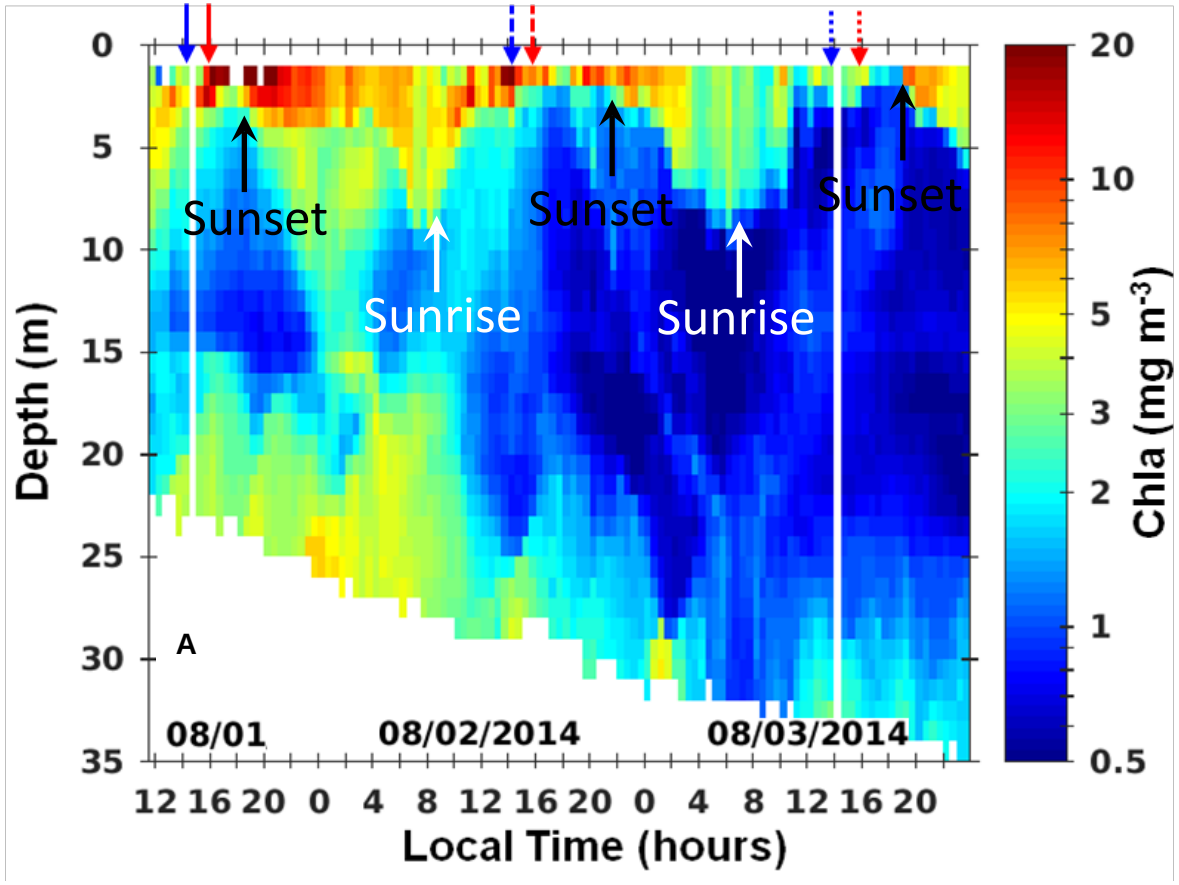
From Schofield et al. (2006, JGR)



VIIRS captures phytoplankton vertical migration in the NE Gulf of Mexico

Glider measurement from the same bloom shows thinner surface layer at 15:41 than at 14:00 within a diel cycle of *K. brevis* vertical migration (Hu et al., 2016)

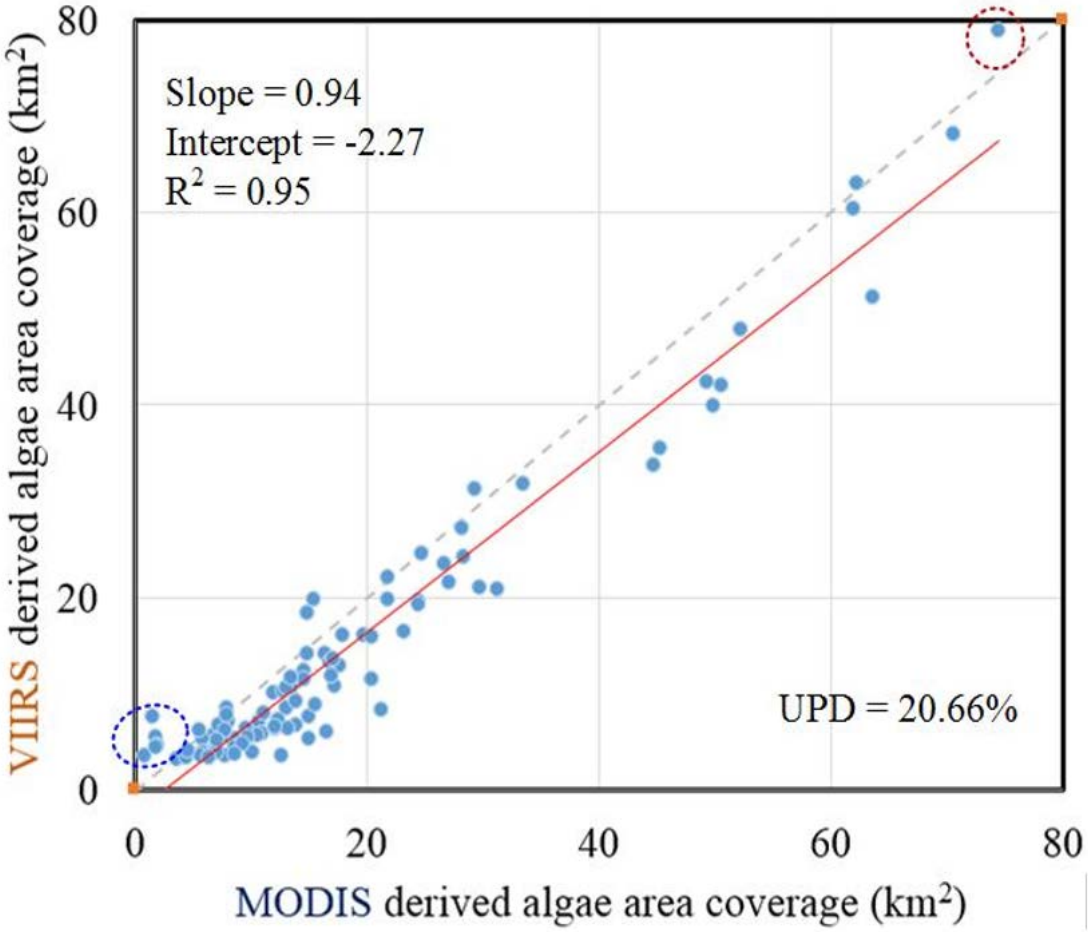
Blue: 14:00; red: 15:41



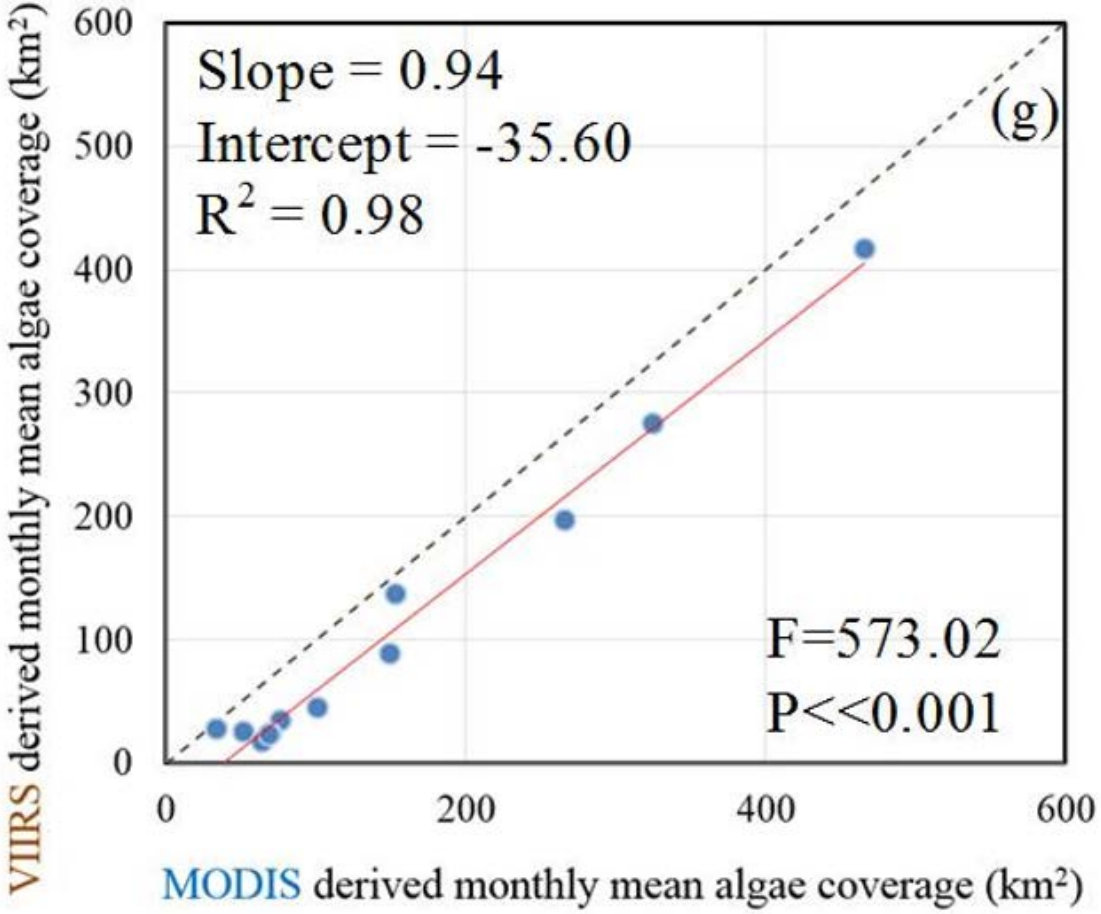
4. Application for floating macroalgae blooms

VIIRS continuity in monitoring floating macroalgae in the Atlantic

Algae coverage from simultaneous image pairs



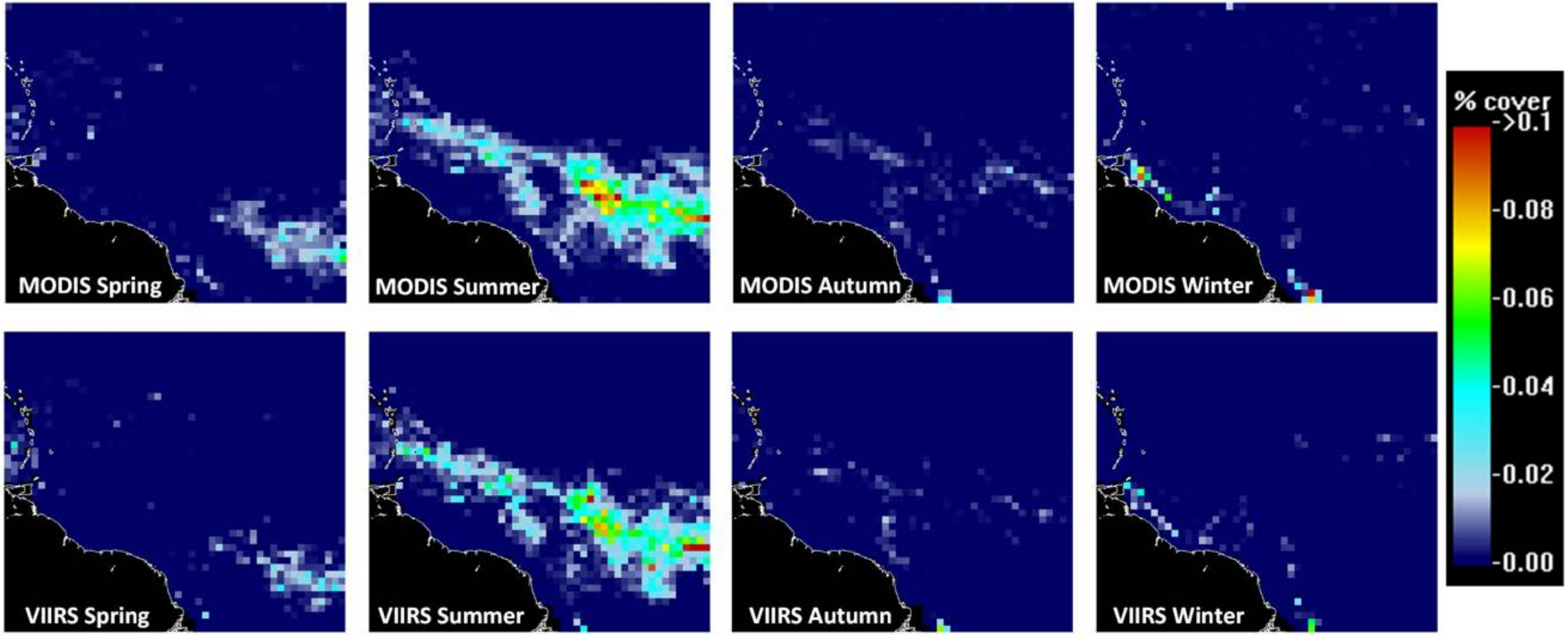
Algae coverage from monthly composites



From Wang and Hu (submitted)

VIIRS continuity in monitoring floating macroalgae in the Atlantic

Color represent mean surface density during 2016 for 0 – 22N, 63 – 38W



From Wang and Hu (submitted). 0.1 on the color scale means 0.1% instead of 10%

CONCLUSIONS

- Considering that ~40% of the open ocean and coastal match-ups pairs for the Gulf of Mexico were collected in shallow (z=3-8m), optically complex coastal waters with variable bottom types, the overall agreement between field and satellite $R_{rs}(\lambda)$ was impressive!
- For the Panhandle and Old Tampa Bay estuaries, performance degraded, but was still reasonable except for the 410-nm band.
- VIIRS observations of macroalgae slicks in global oceans were consistent with the MODIS data product
- VIIRS also showed unique capability to study short-term changes in surface harmful algal blooms
- The Rrs validation work is being summarized in a manuscript (Cannizzaro et al.), while other works have been published (Hu et al., 2016; Qi et al., 2017) or submitted (Wang and Hu).