Improving IOP measurement uncertainties for PACE ocean color remote sensing applications

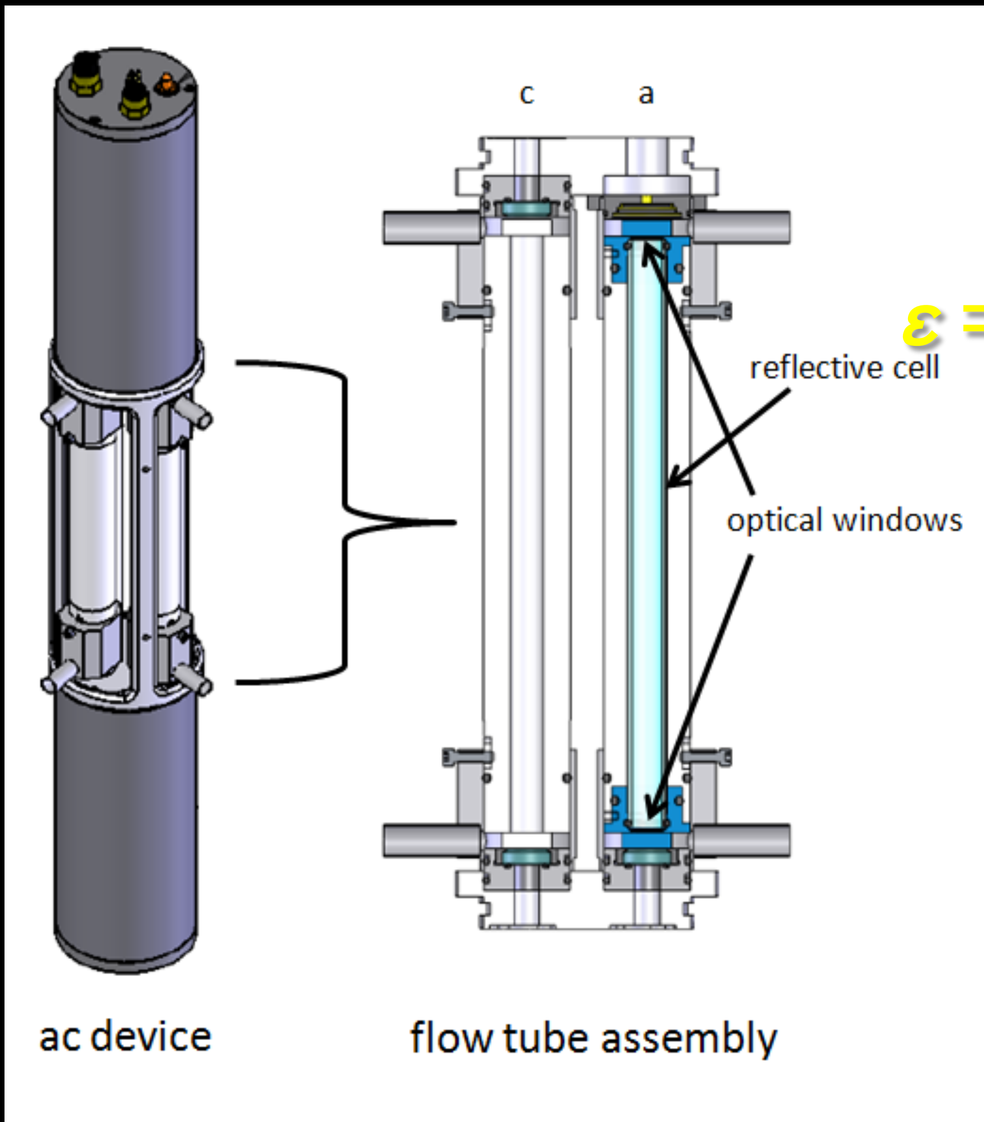
PI: Jim Sullivan
Co-I's: Mike Twardowski & Tim Moore
Collaborators: David McKee & Rudy Röttgers
Technical: Nicole Stockley

HARBOR BRANCH
FLORIDA ATLANTIC UNIVERSITY™
Ocean Science for a Better World™

Project Objectives:

1. Quantify and improve uncertainties (scattering error) in absorption measurements using ac devices.

2. Determine uncertainties associated with different values of the depolarization ratio for pure seawater backscattering (b_{bsw}).



TIR = 41.7°

$$\varepsilon = \int_{\theta_{TIR}\,(41.7°)}^{\pi\ (180°)} 2\pi \sin(\theta)\,\beta(\theta)\,d$$

~ 5 to 6 commonly used correction methods

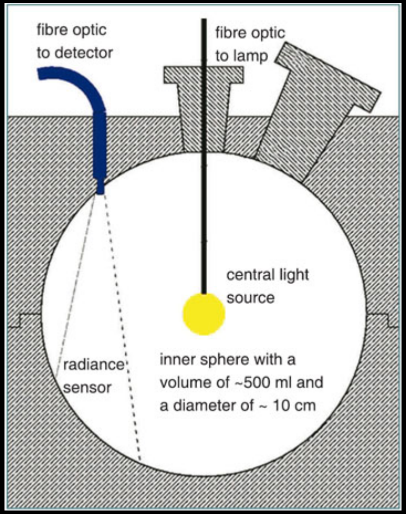
Most assume little to no a_g & a_p at a reference λ

No community consensus

North Sea data comparisons

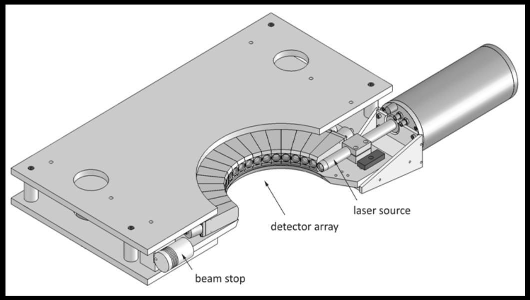
NAME	TYPE	METHOD
RZ1	baseline using ref	Zaneveld 1
RZ1-RR1	baseline w/ ref *a* corr	Zaneveld 1 MOD
RZ2-5	variable percentage	Zaneveld 2
RZ2-10	variable percentage	Zaneveld 2
RZ2-15	variable percentage	Zaneveld 2
RZ2-18	variable percentage	Zaneveld 2
RZ2-20	variable percentage	Zaneveld 2
RZ2-22	variable percentage	Zaneveld 2
RZ3	proportional	Zaneveld 3
RZ3-RR1	proportional w/ ref *a* corr	Zaneveld 3 MOD
VSFWF-100	baseline VSF w/ variable reflectivity	Independent
VSFWF-999	baseline VSF w/ variable reflectivity	Independent
VSFWF-998	baseline VSF w/ variable reflectivity	Independent
VSFWF-995	baseline VSF w/ variable reflectivity	Independent
VSFWF-990	baseline VSF w/ variable reflectivity	Independent
VSFWF-985	baseline VSF w/ variable reflectivity	Independent
VSFWF-980	baseline VSF w/ variable reflectivity	Independent
VSFWF-970	baseline VSF w/ variable reflectivity	Independent
VSFWF-960	baseline VSF w/ variable reflectivity	Independent
VSFWF-950	baseline VSF w/ variable reflectivity	Independent
VSFWF-100P	**proportional VSF w/ variable reflectivity**	**Independent**
VSFWF-999P	**proportional VSF w/ variable reflectivity**	**Independent**
VSFWF-998P	**proportional VSF w/ variable reflectivity**	**Independent**
VSFWF-995P	**proportional VSF w/ variable reflectivity**	**Independent**
VSFWF-990P	**proportional VSF w/ variable reflectivity**	**Independent**
VSFWF-985P	**proportional VSF w/ variable reflectivity**	**Independent**
VSFWF-980P	**proportional VSF w/ variable reflectivity**	**Independent**
VSFWF-970P	**proportional VSF w/ variable reflectivity**	**Independent**
VSFWF-960P	**proportional VSF w/ variable reflectivity**	**Independent**
VSFWF-950P	**proportional VSF w/ variable reflectivity**	**Independent**

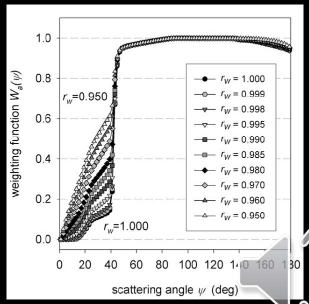
>30 different scattering correction methods compared with <u>independent validation</u> of absorption (56 stations).



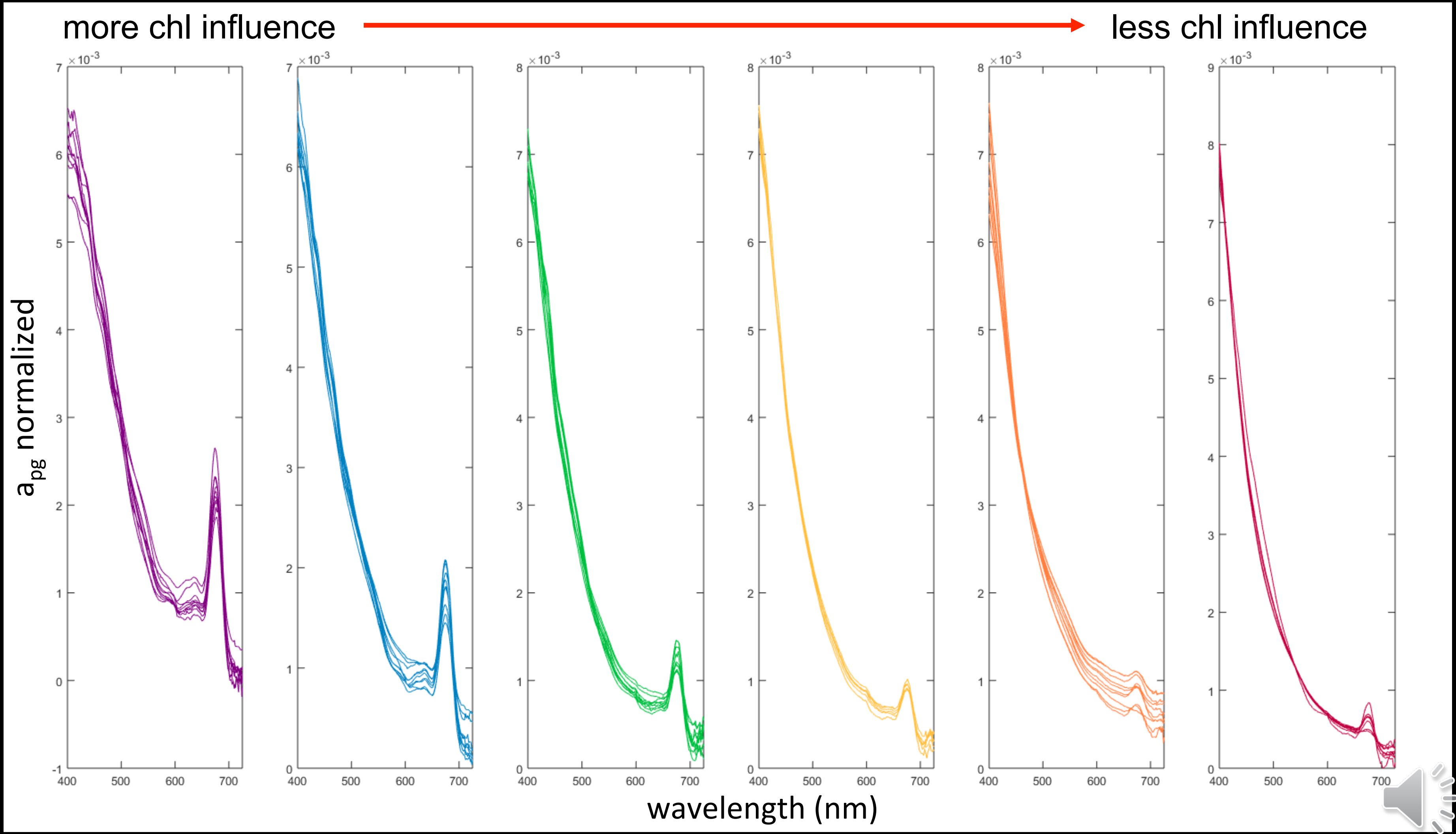
PSICAM (Röttgers) integrating cavity (no scattering error)

Independent correction with concurrent VSF measurements & tube *W(θ)*

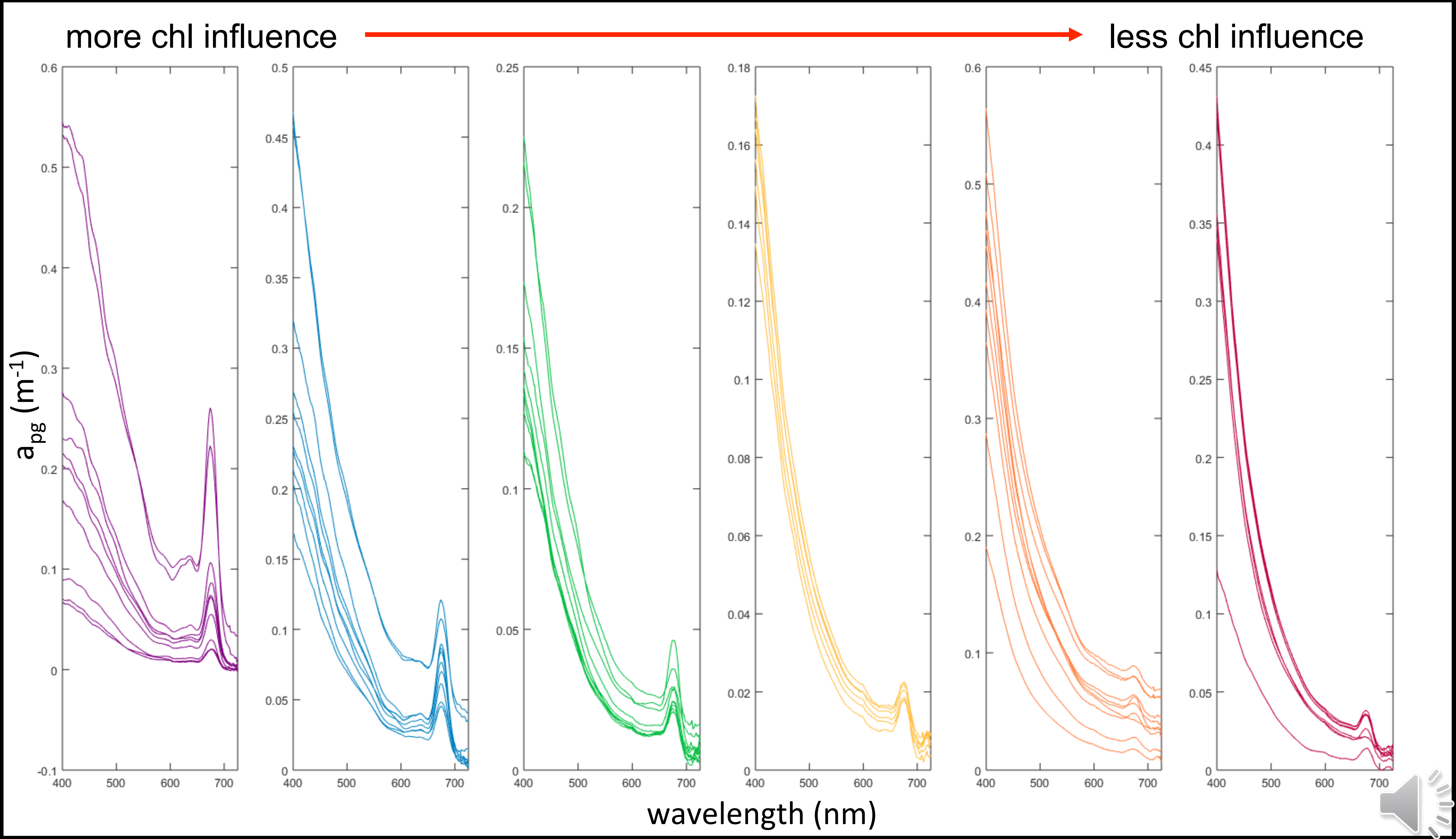




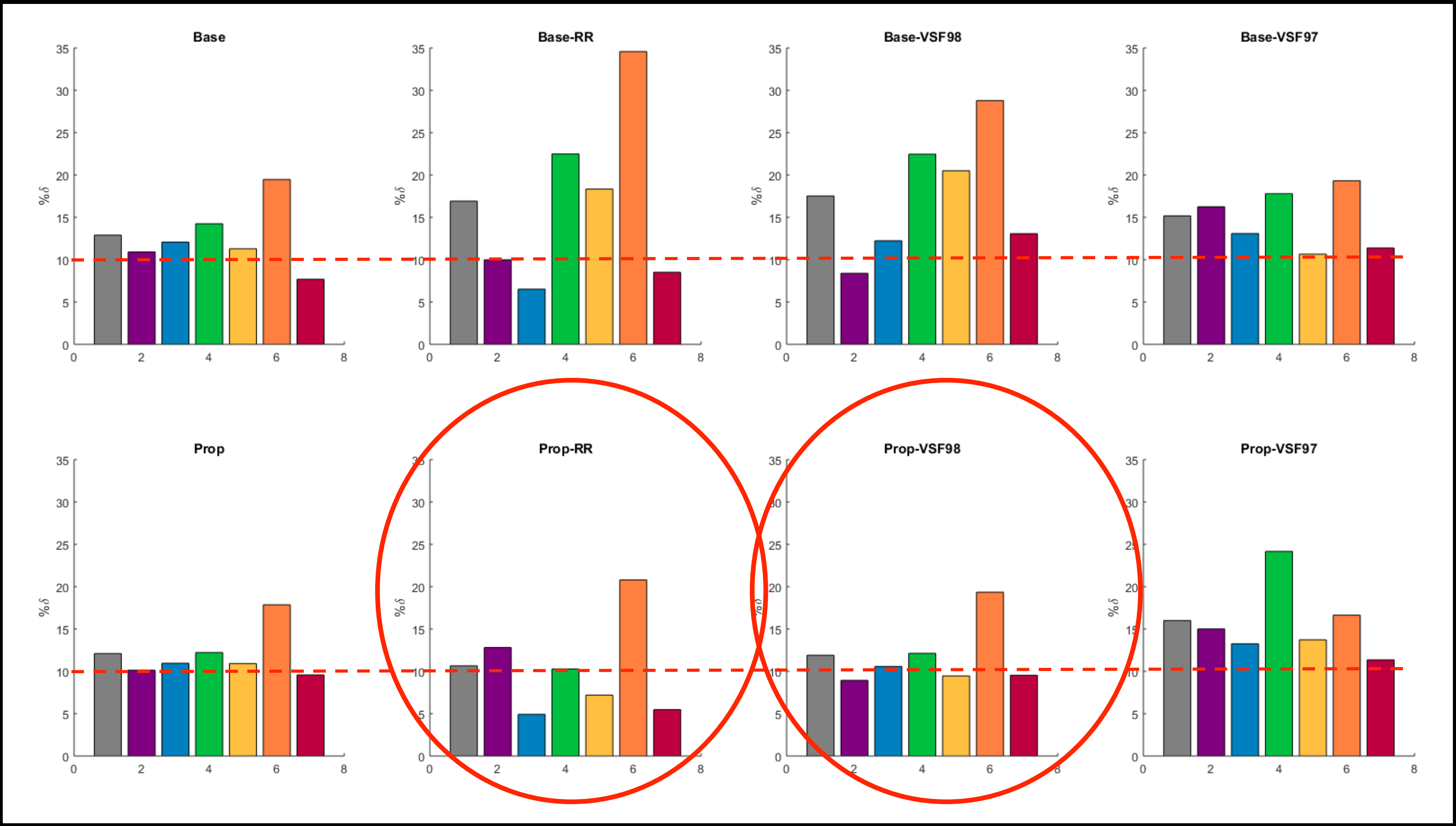
North Sea absorption data sorted into 6 water "types" from algal (chl *a*) dominated to more non-algal absorption dominated (a_{pg} normalized)



North Sea absorption data sorted into 6 water "types" from algal (chl *a*) dominated to more non-algal absorption dominated (a_{pg} magnitude)



Mean absolute error (%δ) between PSICAM and ac spectra using different scattering corrections for the different water types



Stockley et al. (Optics Express)

Absorption closure cruise

When and Where: Jan 8 – 13 2017 off the southeast coast of FL (we are likely on this cruise while you are reading this)

Who: Sullivan, Twardowski, Roesler, Stramski, McKee & Röttgers

What: side by side comparison of current methods to determine the absorption coefficient (ac devices, PSICAM, ICAM, filter pad, AOP inversion) over a large gradient of conditions (turbid coastal to blue water).

Project Objectives:

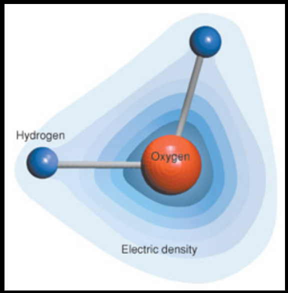
1. Quantify and improve uncertainties (scattering error) in absorption measurements using ac devices.

2. Determine uncertainties associated with different values of the depolarization ratio for pure seawater backscattering (b_{bsw}).

$b_{bsw}(\lambda)$ = F(T, S, pressure, δ)

Where δ is the depolarization ratio

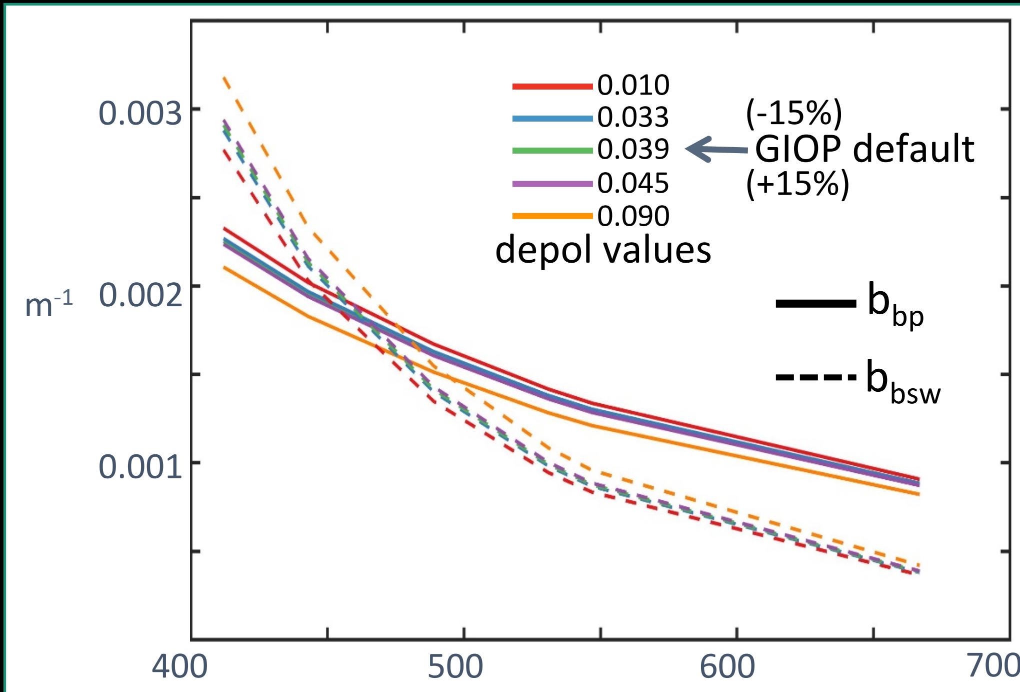
b_{bsw} is ~ 80 - 95% of the water leaving signal in large swaths of the oceans

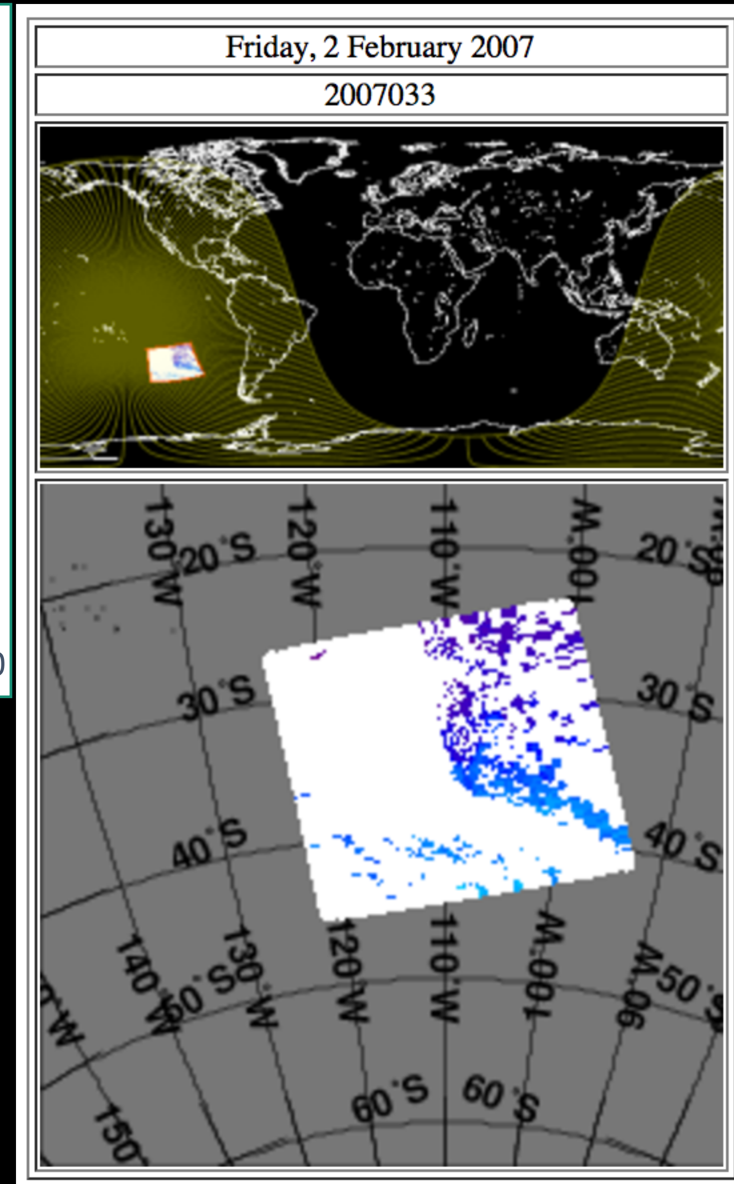


Pure seawater backscattering values (b_{bsw}) as currently parameterized in SeaDAS compared to b_{bsw} values of Zhang et al. (2009) calculated at two different depolarization ratio (δ) values: 0.039 and 0.09 (Farinato & Rowell 1976, Morel 1974 respectively) and at 20°C and 36 PSU.

$b_{bsw}(\lambda)$	412	443	488	547	667
SeaDAS no T/S	0.003327	0.002438	0.001611	0.000989	0.000425
Zhang (δ = 0.09) ~ 3 - 4% lower	0.003192	0.002340	0.001552	0.000960	0.000420
Zhang (δ = 0.039) ~ 10 - 12% lower	0.002920	0.002140	0.001420	0.000878	0.000384

A “typical” pixel from the South Pacific with varying depol ratios run with GIOP





- 10 L2 Aqua images from South Pacific processed with latest GIOP and QAA with varying depol ratios for Zhang bbsw model.
- 8 SeaWiFS L2 daily GAC images also processed.
- Temp and salinity from NODC climatologies
- Depol ratio of 0.039 is default value
- Depol ranges from 0.01 to 0.09 (outer limits)

Relative difference (in %) from default depol = 0.039

b_{bp}

	0.010	0.033	0.045	0.090
Aqua				
GIOP	4.0	0.9	0.9	7.3
QAA	3.9	0.8	0.8	7.5
SeaWiFS				
GIOP	3.9	0.9	0.9	7.3
QAA	3.2	0.7	0.7	6.2
b_{bsw} (for all)	4.8	1.0	1.0	9.3

a_{ph} & a_g (Aqua L2 only)

	0.010	0.033	0.045	0.090
a_{ph} (**)				
GIOP	5.9	2.1	1.5	2.9
QAA	6.0	1.3	1.3	11.7
a_g				
GIOP	7.5	2.5	1.3	4.5
QAA	2.7	0.6	0.6	5.2

** - Not even across wavelength

- All IOP components are affected by the change to b_{bsw} to a similar degree, not just b_{bp}.
- That said, there is only a ~ 1 - 3% difference in b_{bp}, a_{ph} & a_g when using depol ratios within 15% of the current default for all images analyzed, but much higher differences when using the Morel 1974 depol value of 0.09.

Thanks for listening

And see you soon in sunny Florida!