Development of datasets and algorithms for hyperspectral IOP products from the PACE ocean color measurements

Principal Investigator: ZhongPing Lee

Co-Investigators: Michael Ondrusek
NOAA/NESDIS/STAR

Collaborator: Nicholas Tufillaro
Oregon State University

This ppt is quite self-explanatory, email me is you have questions …

Objectives:

a. **Development of a hyperspectral dataset**. Compile a hyperspectral (350 - 700 nm, 5 nm resolution) R_{rs}-IOPs dataset for the community to use. In particular, this dataset will ensure a closure between the measured R_{rs} and the modeled R_{rs} using *in situ* IOPs -- a hyperspectral R_{rs}-IOPs dataset with closure (HyRIDc). √

(Lin et al. 2017)

b. **Algorithm revision**. This will include
i) improve the determination of SS_{IOP} from remote sensing for different water bodies,
ii) extend the QAA and HOPE algorithms to include measurements in the UV (350-400 nm) and expanding IOP products to absorption coefficients of specific pigments (e.g., chlorophyll-a, -b, -c, and phycocyanin). √

(Wei et al. 2015, Wang et al. 2016, 2017)

c. **Test and evaluation of the revised algorithms with HICO measurements.** √

(Wang et al. 2016)

Results from these efforts will provide desired tools and knowledge, and contribute to "*consensus and community-endorsed paths forward for the PACE sensor(s)*".

Accomplishments in 2017:

1. Impact of spectral bands on the inversion of a_{pig} from Rrs

2. IOPs derived from in situ AOPs

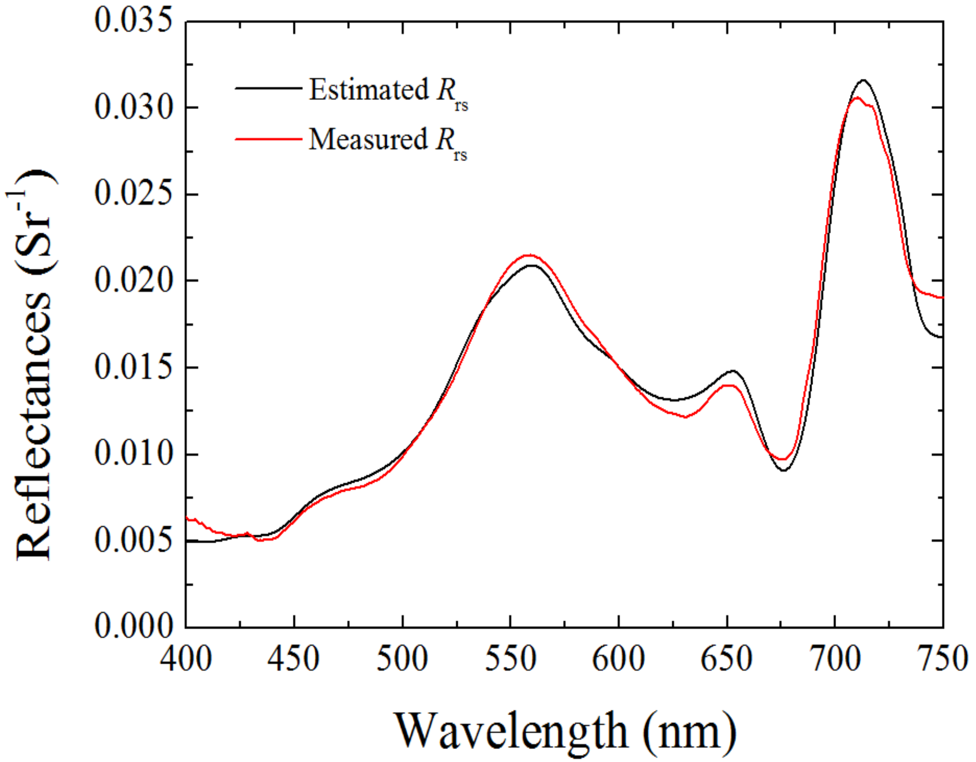
3. Application of IOPs for vertical profiles of solar radiation

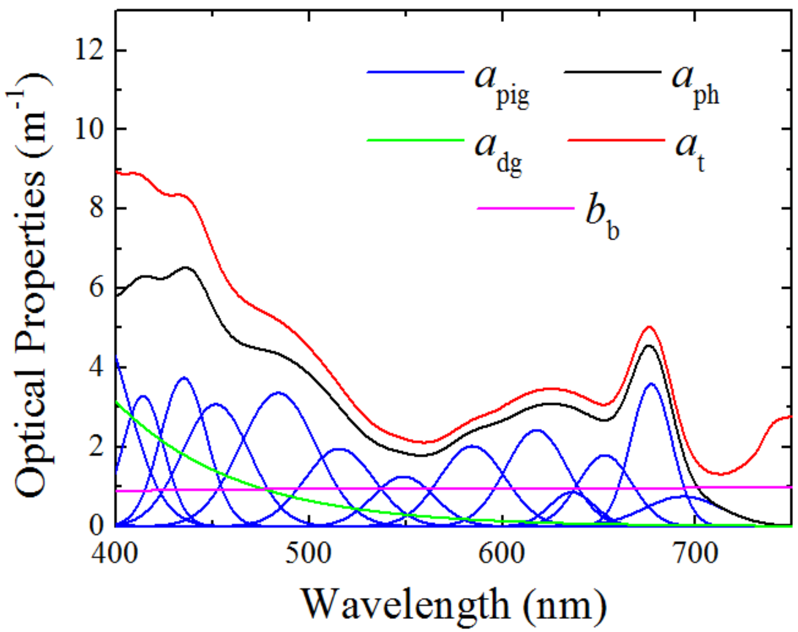
1. Impact of spectral bands on the inversion of a_{pig} from Rrs

Multiple Pigment Inversion (MuPI) algorithm (Wang et al. 2016):

$$a_{ph}(\lambda) = \sum_{1}^{13} a_{pig}(\lambda_i)\, Gau(i)$$

(Hoepffner and Sathyendranath, 1991)

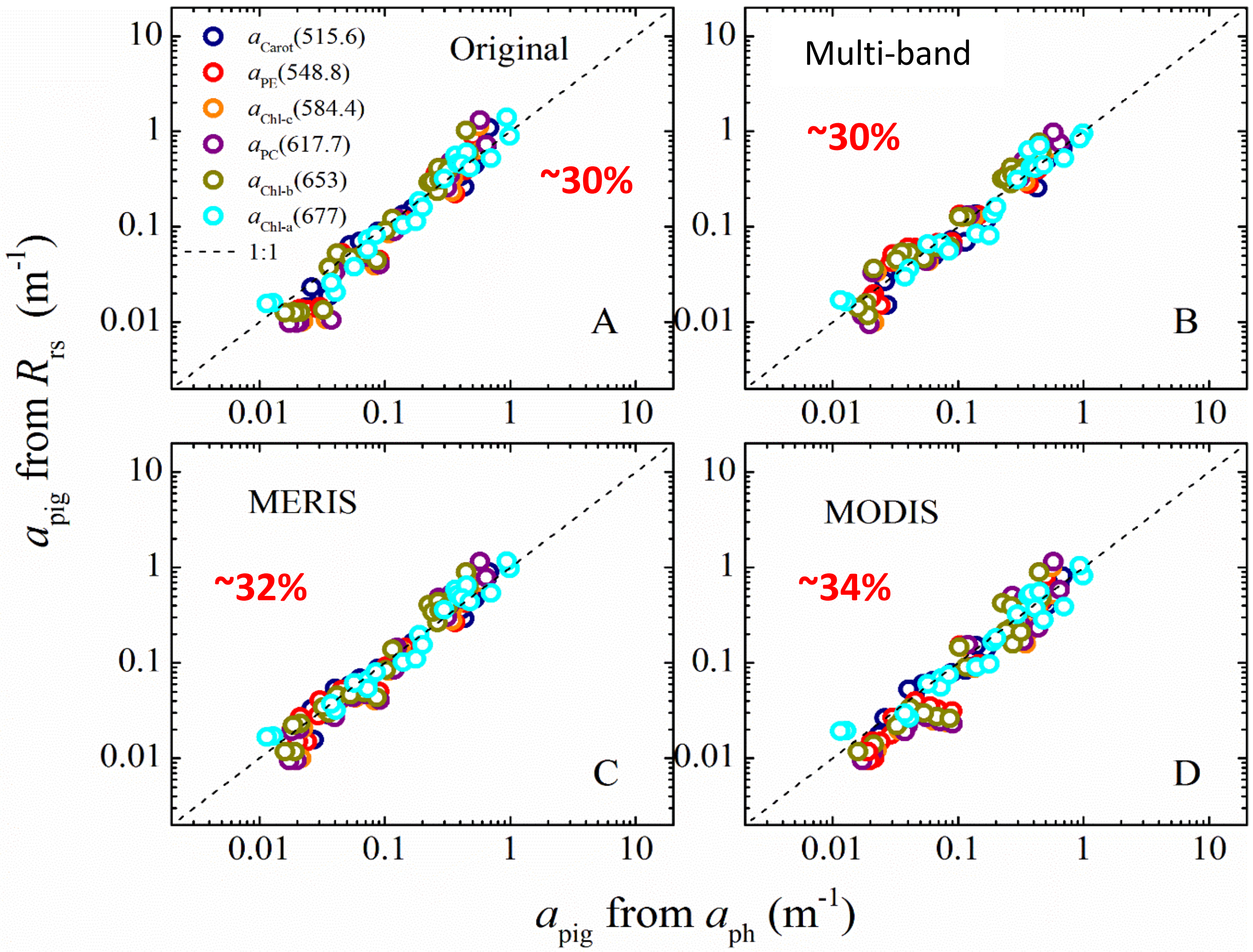




(Wang et al 2016)

The multi-spectral band sensors: Future multi-band, OLCI, MERIS, MODIS, and VIIRS.

Index	Future multi-band	OLCI	MERIS	MODIS	VIIRS
1	400	400			
2	412	413	413	412	410
3	443	443	443	443	443
4	490	490	490	488	486
5	510	510	510		
6	530			531	
7	555	560	560	547	551
8	620	620	620		
9	645			645	
10	655				
11	665	665	665	667	
12	675	674		678	671
13	681	681	681		
14	709	709	709		
15	745	754	754	748	745



(Wang et al 2017)

Conclusion 1:

A. **With hyperspectral remote sensing reflectance, absorption coefficients of multiple pigments can be reasonably retrieved using a refined/updated Gaussian decomposition model.**

B. **When the number of spectral bands is reduced, more uncertainties will be introduced. But the results are nearly the same between hyperspectral and 15 bands.**

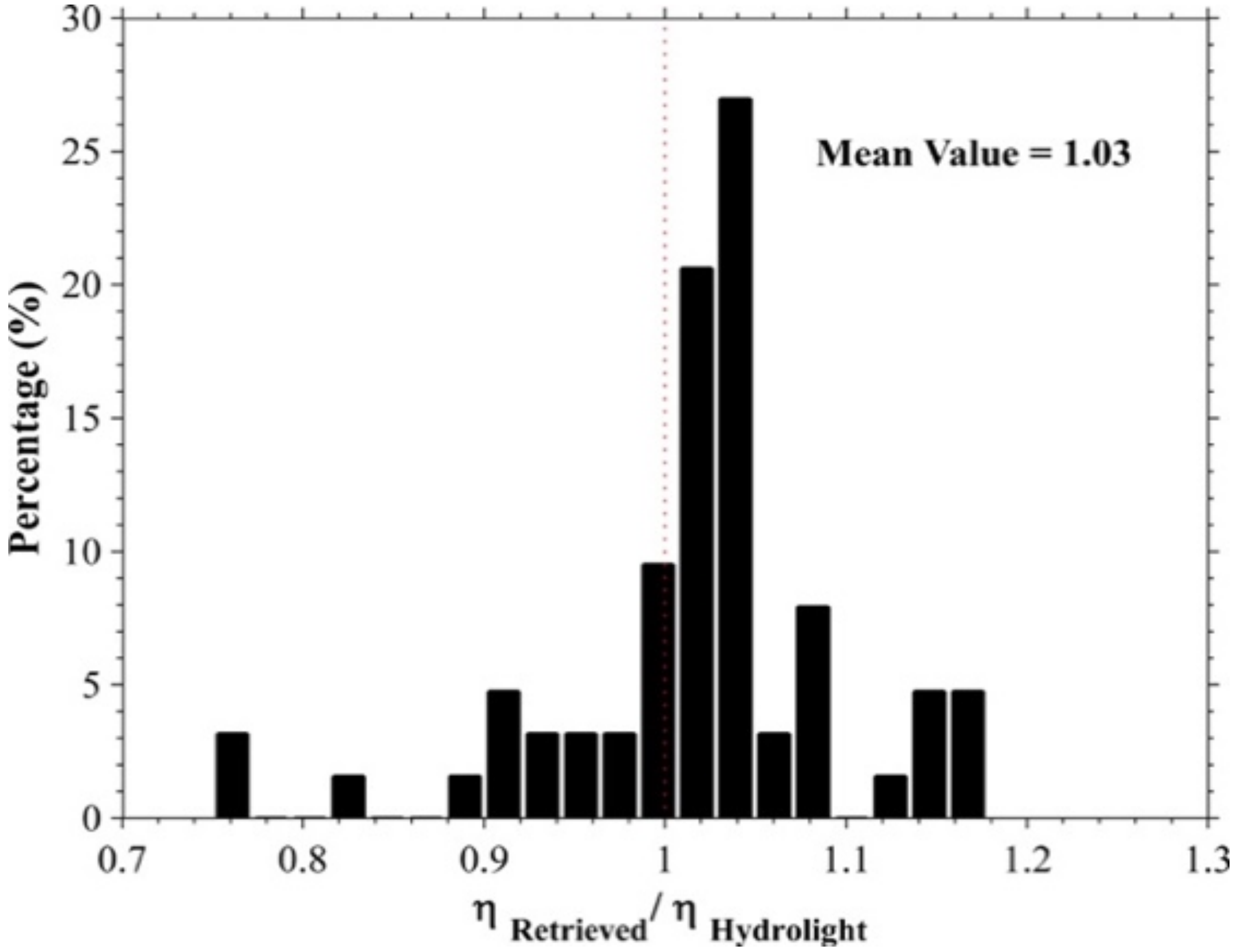
2. IOPs derived from in situ AOPs

In situ measurements → R_{rs} and K_d

$$\begin{cases} R_{rs} = F_1\{a, b_b\} \\ K_d = F_2\{a, b_b\} \end{cases} \Rightarrow \{\text{spectra of } a, b_b\}$$

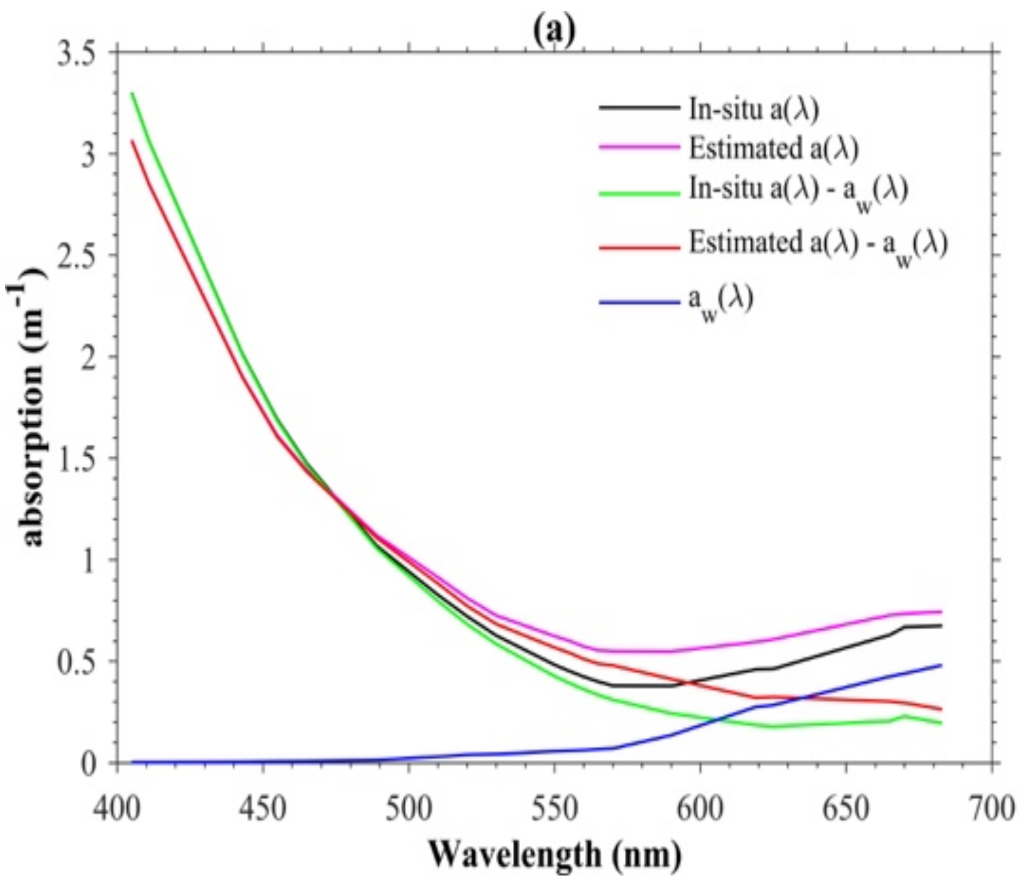
Application to *Hydrolight* dataset

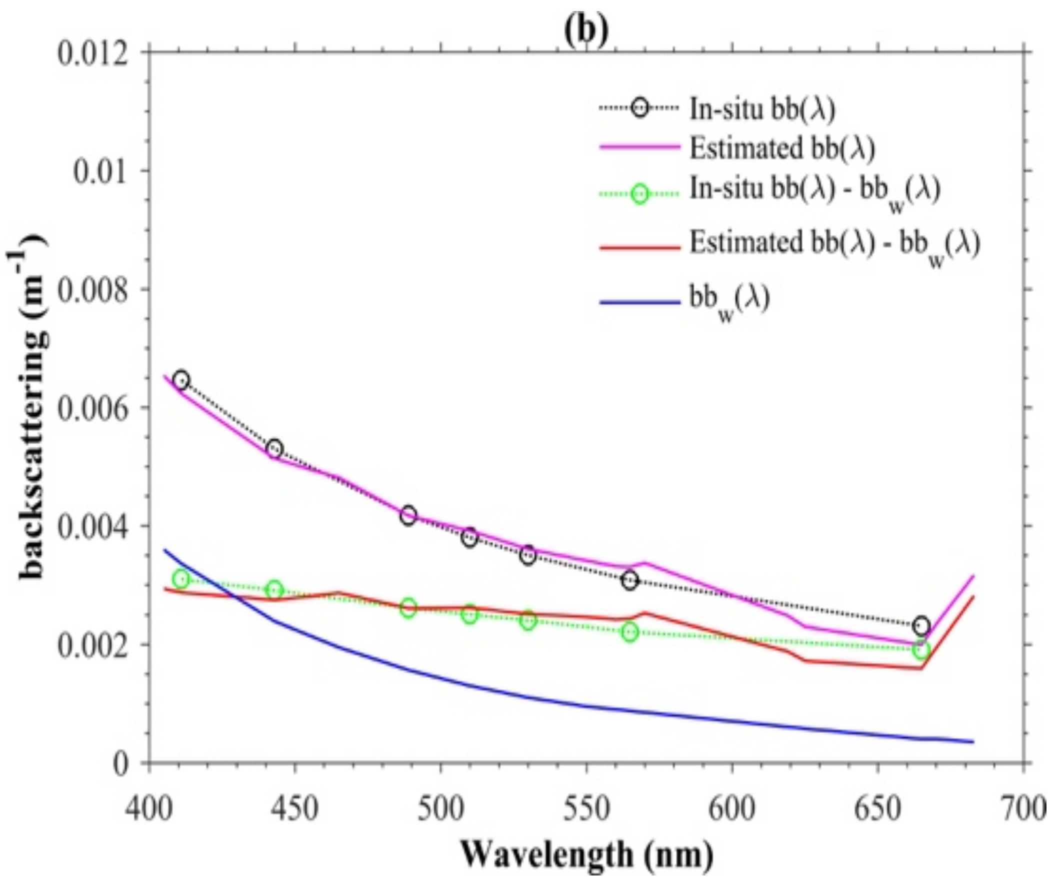
$$b_{bp}(\lambda) = b_{bp}(\lambda_0)\left(\frac{\lambda_0}{\lambda}\right)^{\eta}$$



(Lin et al. 2017)

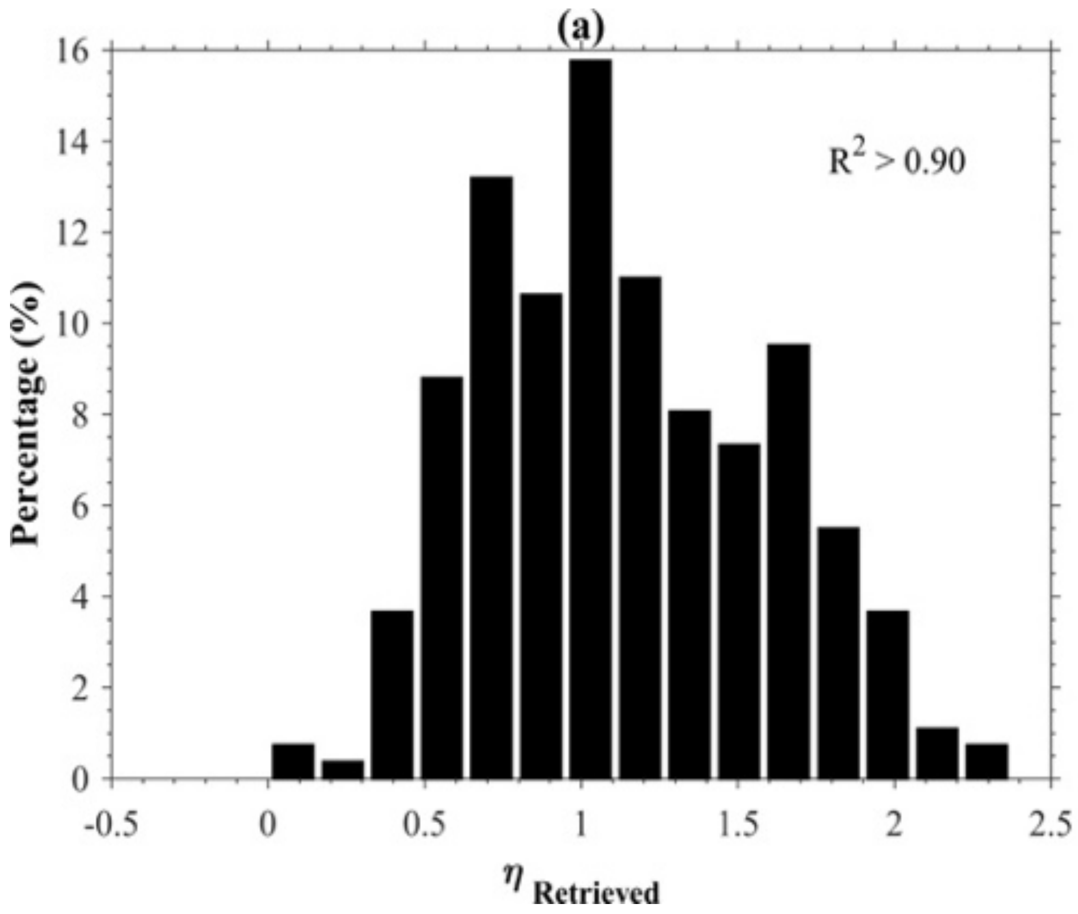
Application to *NOMAD* dataset.



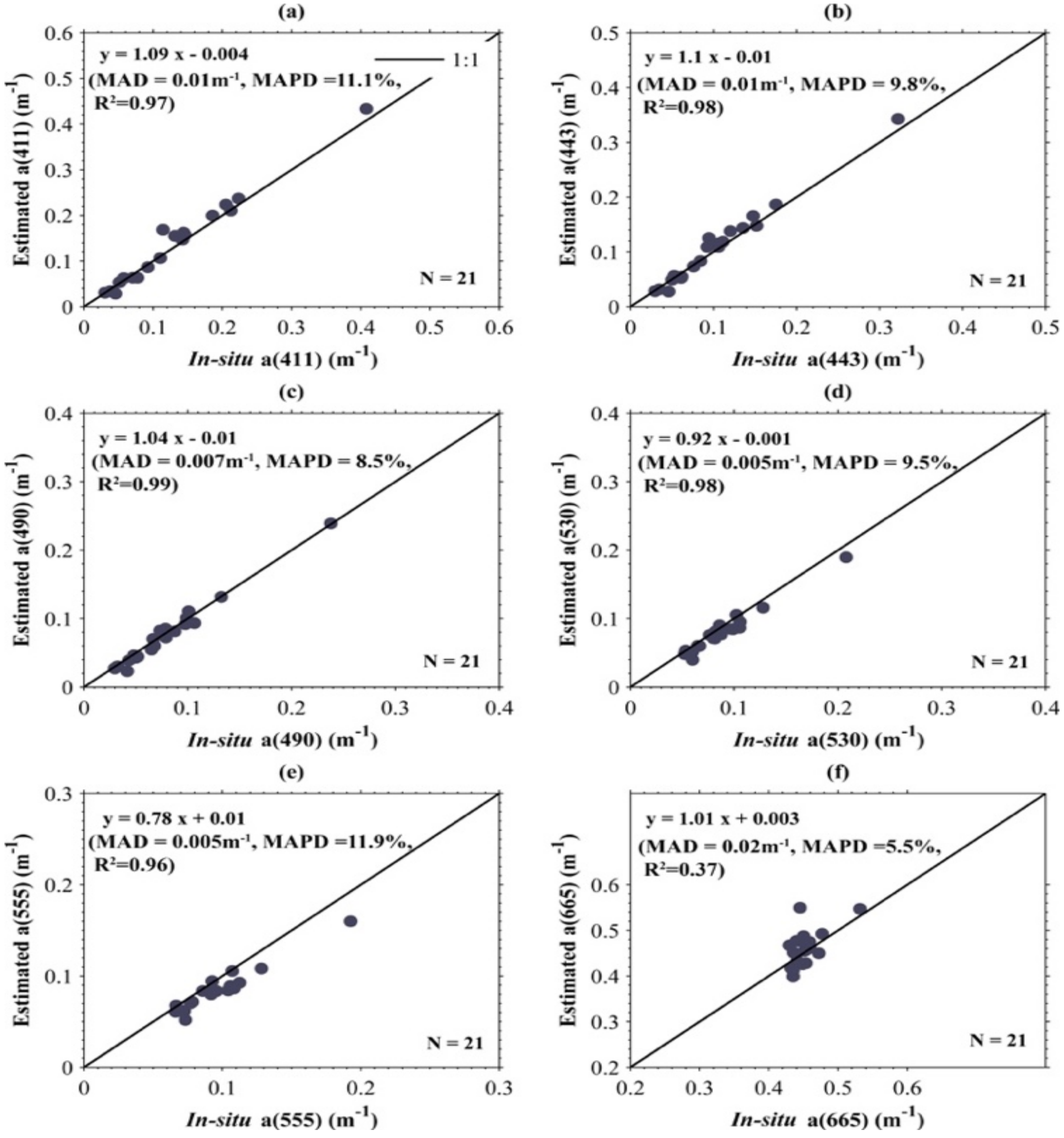


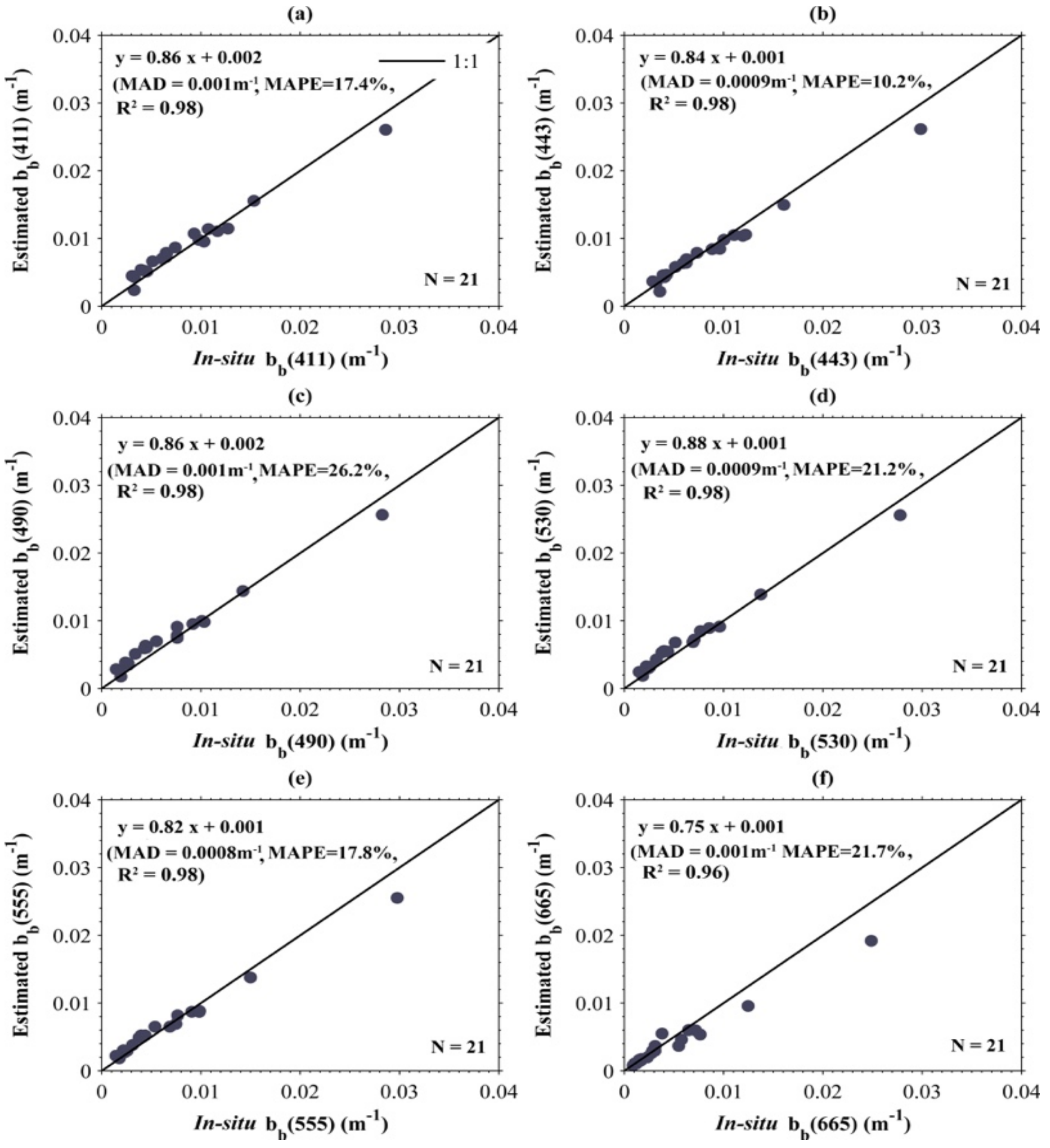
(Lin et al. 2017)

Distribution of the retrieved η of NOMAD dataset.

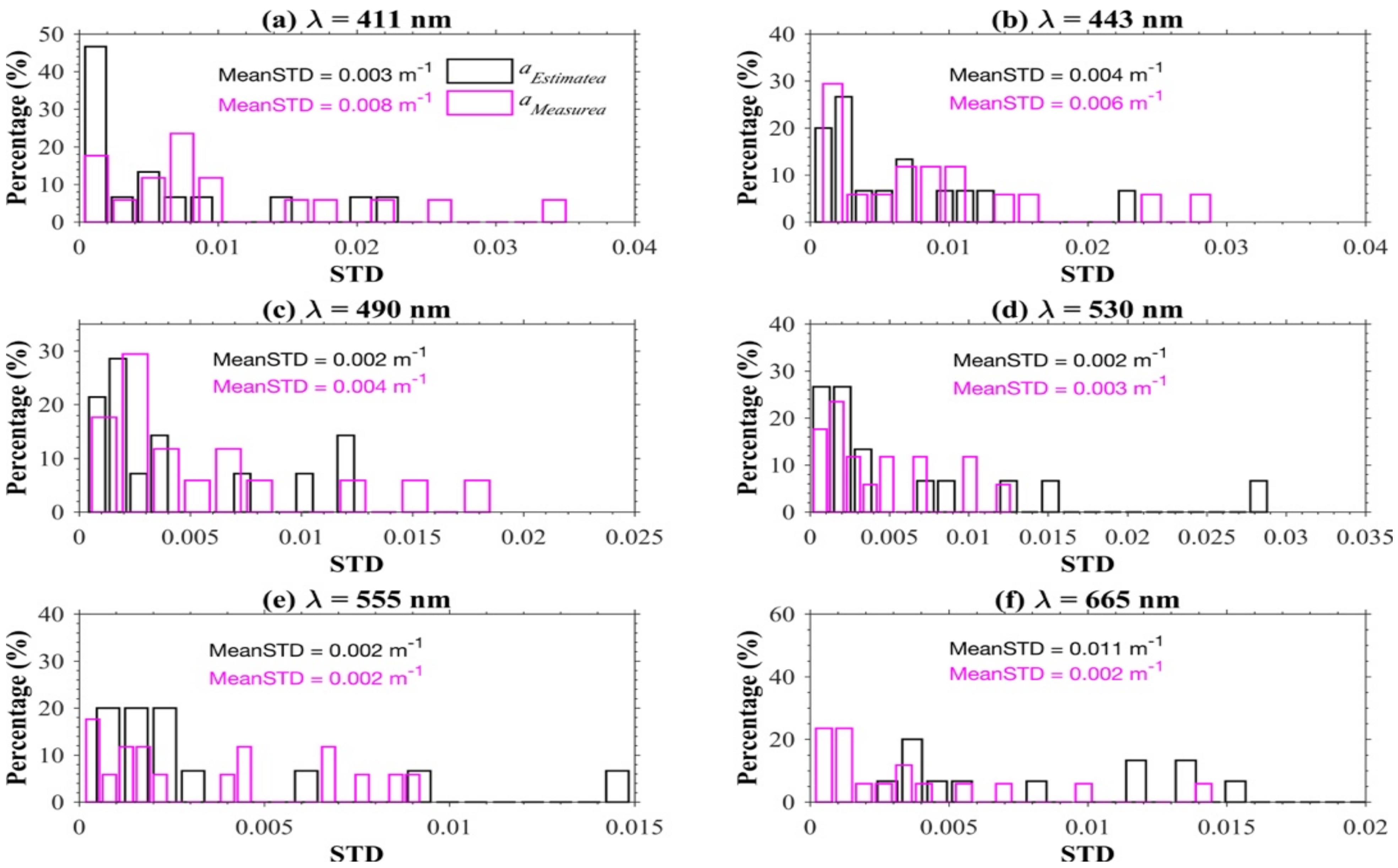


VIIRS2014 dataset





Comparison of uncertainty



Conclusion 2:

A. Hyperspectral absorption (*a*) and backscattering (b_{bp}) coefficients were well retrieved from concurrent hyperspectral Rrs and Kd, with uncertainties equivalent to that of present ACs system.

Data are available to share with the team and the community.

A. Hyperspectral b_{bp} fill a gap of no instrument to obtain this property in situ.

B. For most waters, the power-law function is found still an effective model for $b_{bp}(\lambda)$, with η found in a range of ~0 – 2.5, consistent with historical observations.

3. Application of IOPs for vertical profiles of solar radiation

$$\mathrm{TR_{VIS}(z) = PAR(z)/PAR(0) = x} \cdot e^{-\mathrm{y \cdot z}}$$

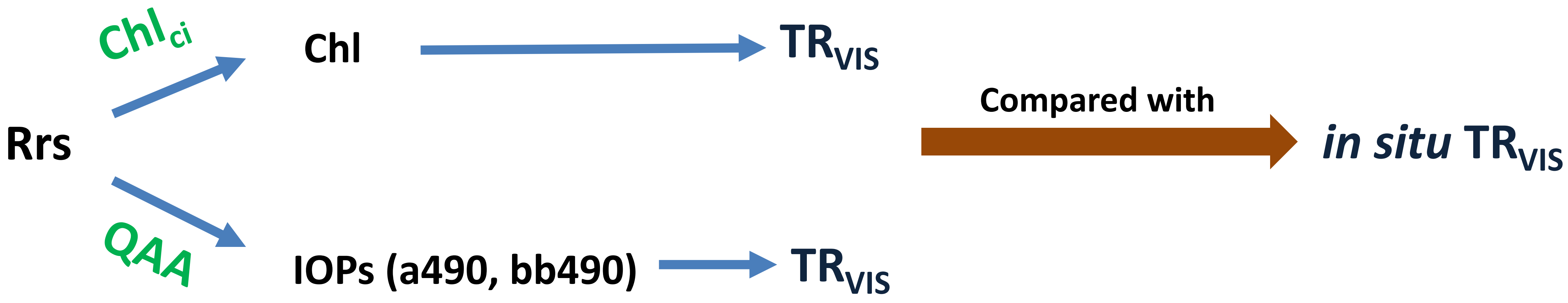
Chl-based models for TR_{VIS}:

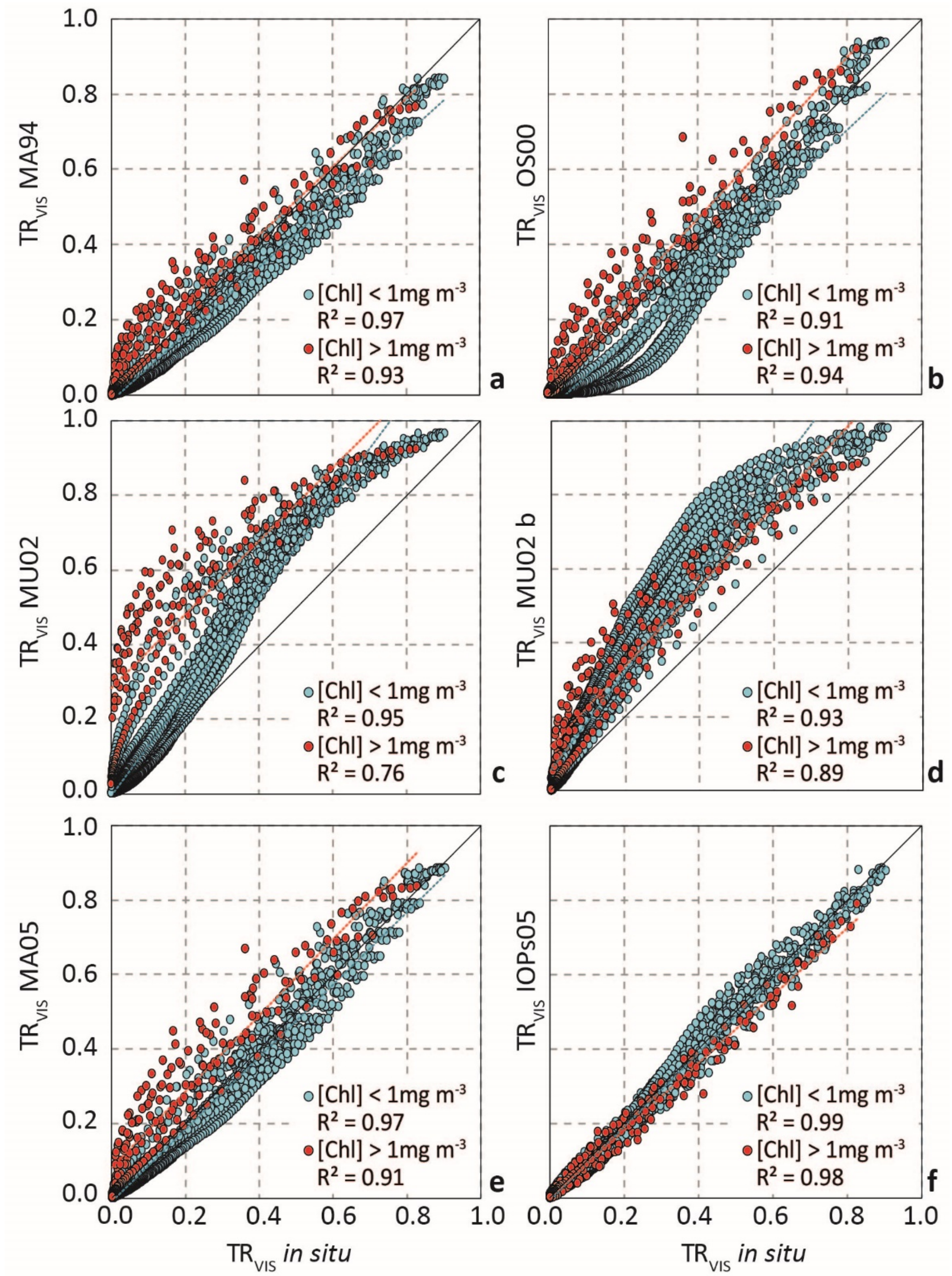
Morel and Antonie (1994), Muturgude et al (2002), Ohlmann and Siegel (2000), Manizza et al. (2005)

IOP-based models for TR_{VIS}:

Lee et al. (2005)

How these models behave when the only known input data are Rrs?


Chlci
Chl
TRVIS
Compared with
Rrs
in situ TRVIS
QAA
IOPs (a490, bb490)
TRVIS



Conclusion 3:

A. Chl-based models do not show improvement compared to the one developed in the 1990’s.

B. More errors are introduced using Chl-based model and treating K_{PAR} as a constant vertically.

C. IOPs-based model show much more robust performance, for both oceanic and coastal waters. This is in part due to a depth-dependent model for K_{PAR}.

(Zoffoli et al. 2017)

Thank you!