ACROSS (Atmospheric Correction for the Retrieval of Ocean Spectra from Space)

Summary

relevant for PACE instrument design

- ➢ PACE ST polarimeter document

Project	What did we propose	What did we accomplish
ACROSS	➢ Perform sensitivity analyses for proposed PACE instrument options ○ OCI → *NUV-SWIR radiance* ○ OCI/OG → *O2-A band radiance* ○ OCI+ → *1378, 2250 radiance* ○ OCI-3M → *VIS-SWIR polarization*	➢ Proposed PACE instrument sensitivity studies: ○ OCI → *95 channels between 0.35 µm and 2.13 µm* ○ OCI-3M → *5 view angles between +/– 50 degrees* → *5 channels between 0.41 µm and 2.25 µm* → *1% polarization accuracy* ➢ Other satellite instrument sensitivity studies: ○ OCI-2M → *OCI-3M but without polarization* ○ OCI-3M+→ *OCI-3M but more views & better accuracy*
	➢ Write manuscript about sensitivity analyses results	
PACE '15	➢ Compare RT computations for various atmosphere-ocean systems (AOS) ○ 5 AOS models ○ 2 altitudes ○ 4 wavelengths ○ >100 scattering angles	➢ Computations with 3 different RT codes ○ AOS models I, II, III ○ all altitudes, wavelengths, angles ○ 3 Stokes parameters ○ error ~ 1e-6 → $\Delta P < 0.1\%$ ➢ 90+ page draft manuscript *Discuss tomorrow*
	➢ Update hydrosol model ○ Involve input from PACE-IOP group	➢ Investigated 4 multi-parameter models ○ ACROSS-I & -II models, c-model, IOCCG5 ➢ 15+ page draft document
Other	➢ Study aerosol height retrievals from O2-A data	➢ Theoretical and actual aerosol height retrieval studies using blue/UV polarization ➢ manuscript in preperation

relevant for PACE instrument design

ACROSS (Atmospheric Correction for the Retrieval of Ocean Spectra from Space)

1. ACROSS → *Test increase in information in OCI+Polarimeter versus OCI alone*

Retrieval error covariance matrix: expected parameter uncertainty, degrees of freedom

$$\hat{S} = \left[K^T S_\varepsilon^{-1} K + S_a^{-1} \right]^{-1}$$

Measurement error covariance matrix: how we specify instrument characteristics

Prior knowledge matrix: statistical range of our expected results

$$K_{i,j} = \partial F_i(x) / \partial x_j$$

Jacobian matrix: model calculated parameter sensitivity

Ocean Color Imager (OCI)

- 95 channels: 0.35μm to 2.13μm, vicarious calibration radiometric uncertainty 0.3%.

Multi-angle Instrument

- 5 view angles, 5 channels: **[0.41, 0.55, 0.67, 0.865, 2.25μm]**
- Like OCI, radiometric uncertainty is 0.3% .

The Multi-angle Polarimeter A

- Same as Multi-angle Instrument, plus linear polarization
- Polarimetric uncertainty is 1%.

The Multi-angle Polarimeter B

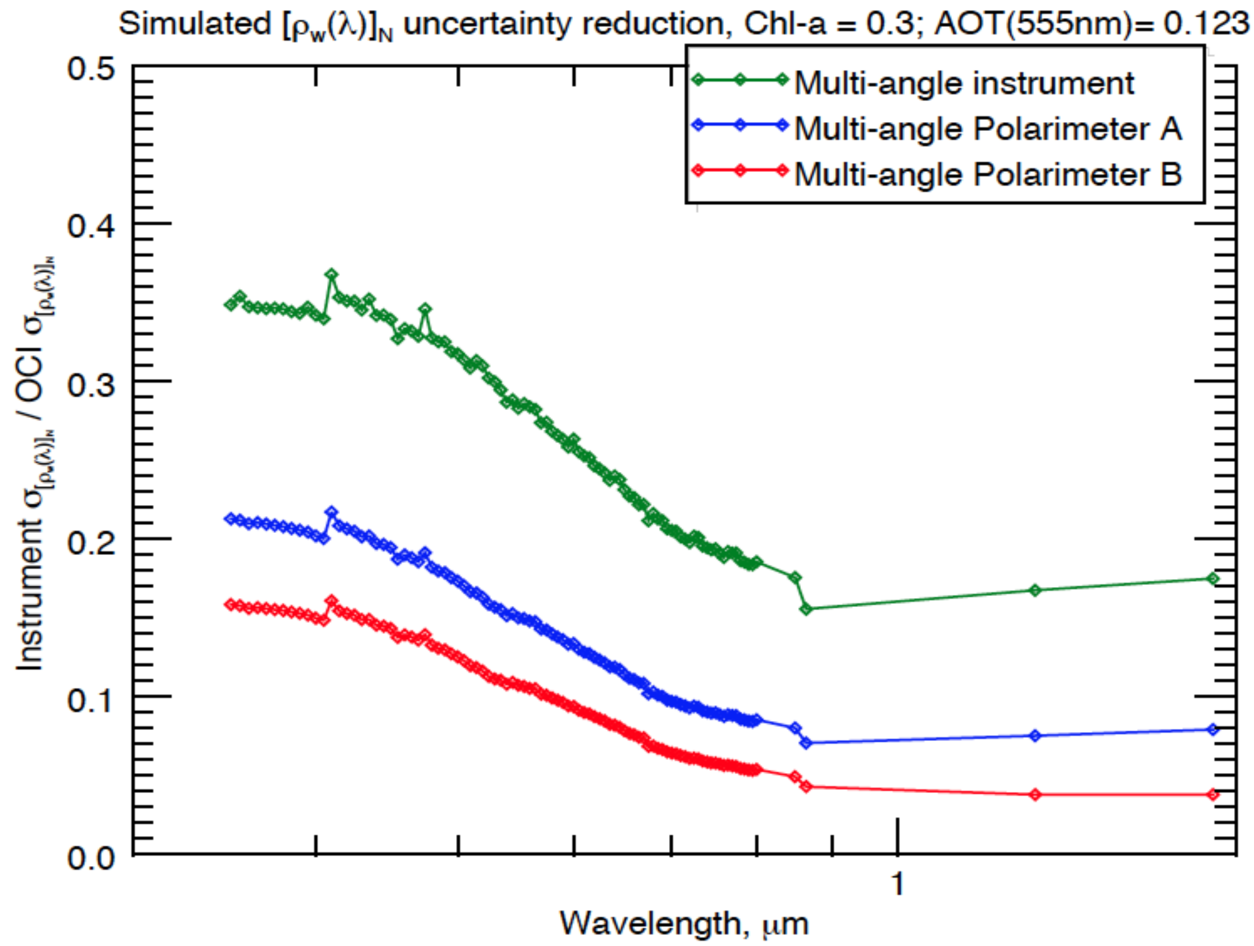
- 10 view angles, same channels as Multi-angle Instrument
- 0.865μm channel now has 50 viewing angles
- Polarimetric accuracy is tightened to 0.5%.

Results on next slide are fraction of polarimetry and/or multi-angle compared to OCI

ACROSS (Atmospheric Correction for the Retrieval of Ocean Spectra from Space)

1. ACROSS → *Test increase in information in OCI+Polarimeter versus OCI alone*

Less improvement in atmospheric correction



More improvement in atmospheric correction

ACROSS (Atmospheric Correction for the Retrieval of Ocean Spectra from Space)

2. PACE '15 → *Update hydrosol model* → couple atmosphere & ocean in atmospheric correction

✓ *"−" below surf*

- Retrieve aerosol model/properties *while accounting for underwater light scattering* → requires an ocean model

(§) $\rho^{-}_{\text{w, model}} = \{I, Q, U\}(\text{view}, \text{IOPs})$

- ○ *NIR total radiance*
- ○ *NIR polarized radiance*
- ○ *VIS total radiance*
- ○ *VIS polarized radiance*
- ○ *UV total radiance*
- ○ *UV polarized radiance*
- ○ *Ocean model assumptions* (§)

aerosol properties

✓ *"+" above surf*

- Retrieve water-leaving radiance in the VIS part of the spectrum

(¶) $\rho_{\text{TOA}} = \rho_{\text{atm-srf}} + t^{\uparrow}_{\text{atm}}\,\rho^{+}_{\text{w,retrieve}}$

- ○ *VIS total radiance* (¶)

Note: $\rho^{-}_{\text{w,model}}$: *approximates* the ocean in aerosol retrieval

↓

spectral residual in fit of ρ_{TOA} cannot be resolved with aerosol

↓

$\rho^{+}_{\text{w,retrieve}}$: *extracted* from ρ_{TOA} using the retrieved aerosol

spectral residual fit

$$\rho^{-}_{\text{w,model}} + \Delta\rho^{-}_{\text{w}} \Longrightarrow \rho^{+}_{\text{w,retrieve}}$$

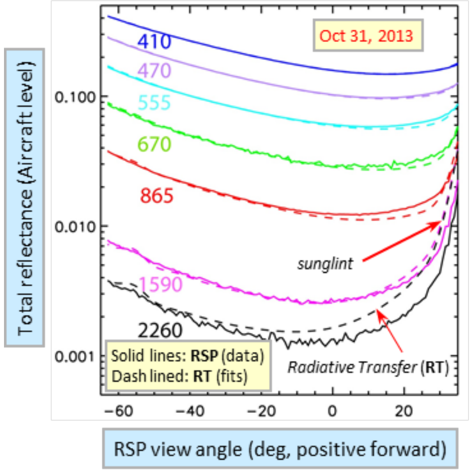
ocean model

retrieval

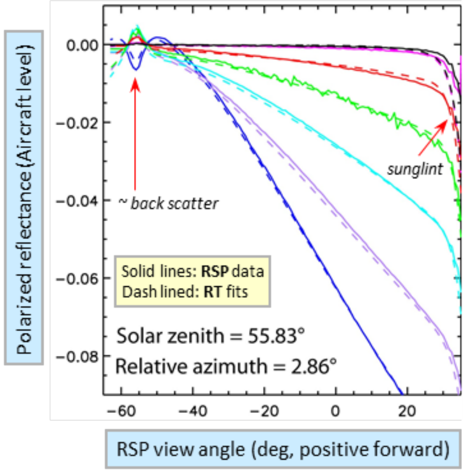
ACROSS (Atmospheric Correction for the Retrieval of Ocean Spectra from Space)

2. PACE '15 → *Update hydrosol model* → couple atmosphere & ocean in atmospheric correction

Note: real W < 1 m/s (minimum RT fit)

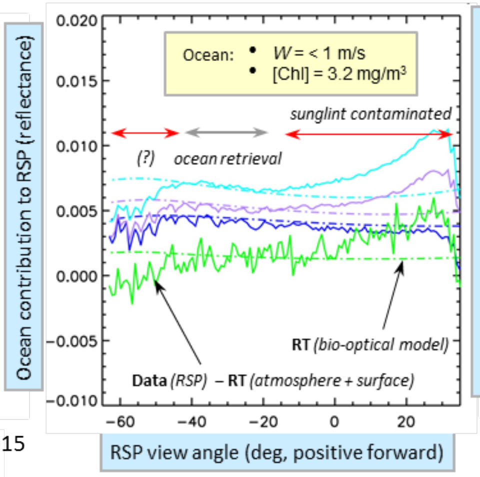


Note: scattering plane reference

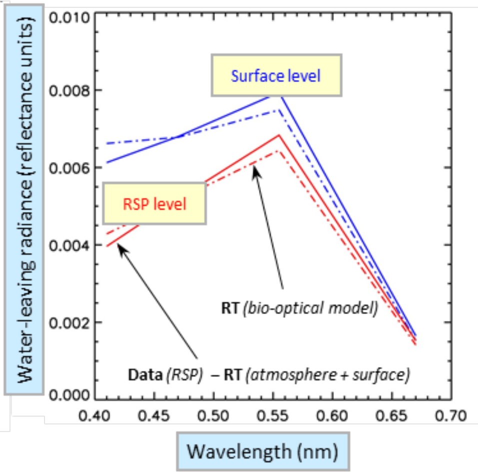


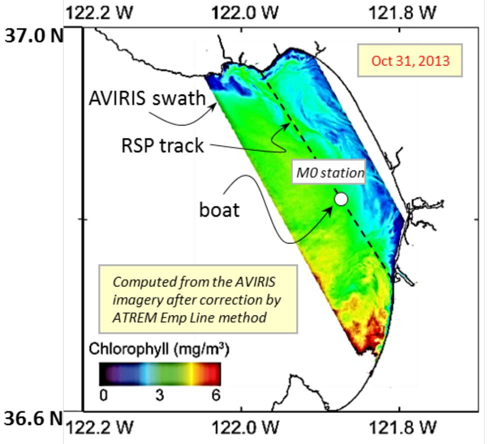
RSP ocean retrieval

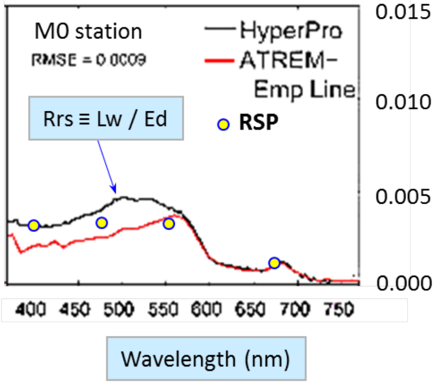
Note: RSP ≈ (π Lw)/($S_0 \cos\theta_0$) × (*atm transmission*)



Note: Surface = RSP / (*atm transmission*)



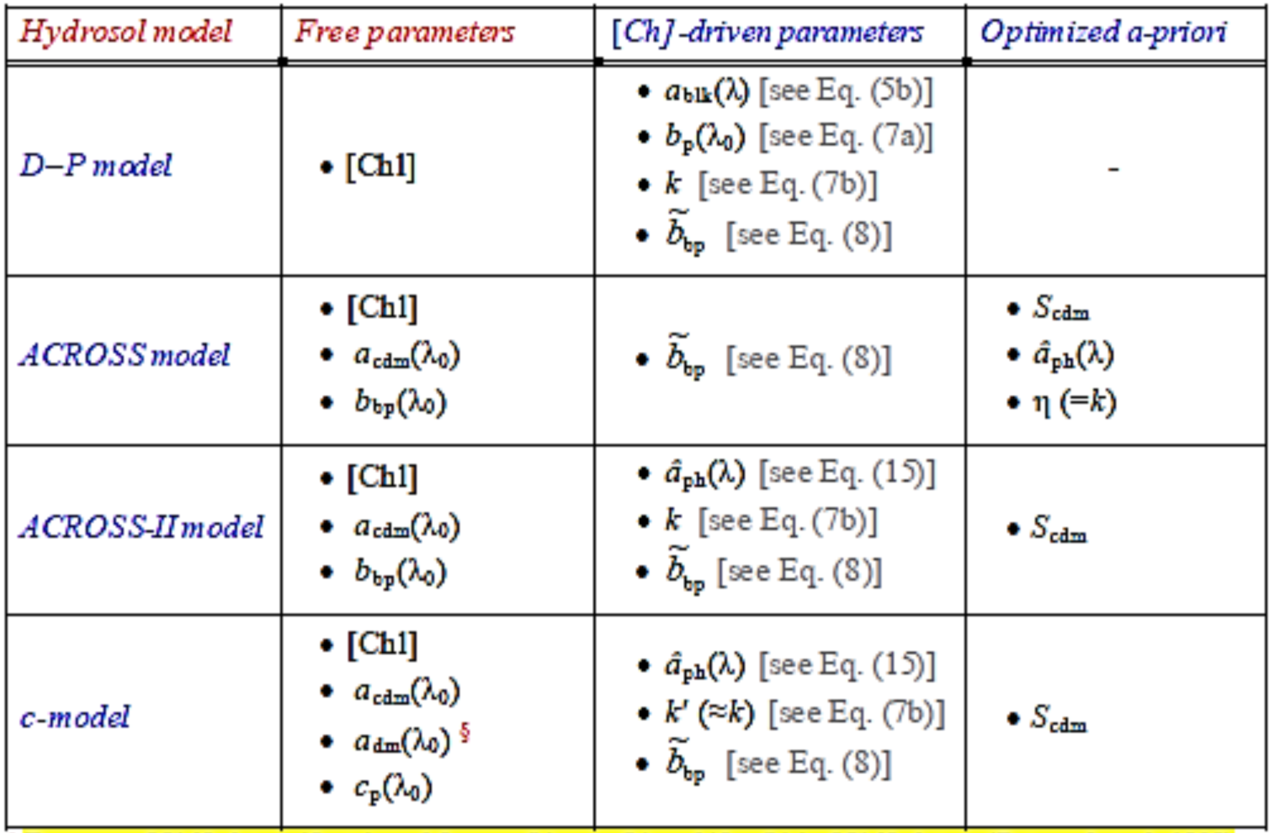




Validation ocean retrieval

ACROSS (Atmospheric Correction for the Retrieval of Ocean Spectra from Space)

2. PACE '15 → *Update hydrosol model* → couple atmosphere & ocean in atmospheric correction

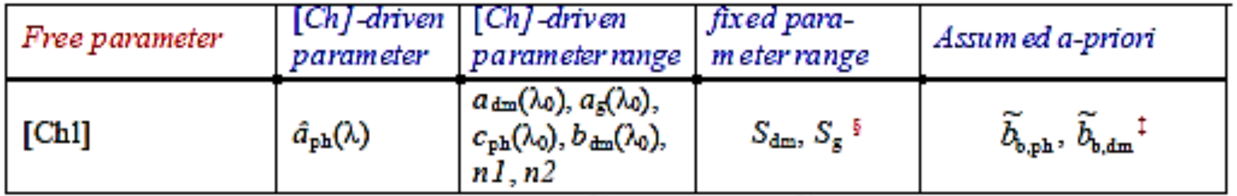


Hydrosol model	*Free parameters*	*[Ch]-driven parameters*	*Optimized a-priori*
D–P model	- [Chl]	- $a_{blk}(\lambda)$ [see Eq. (5b)] - $b_p(\lambda_0)$ [see Eq. (7a)] - k [see Eq. (7b)] - $\tilde{b}_{bp}$ [see Eq. (8)]	-
ACROSS model	- [Chl] - $a_{cdm}(\lambda_0)$ - $b_{bp}(\lambda_0)$	- $\tilde{b}_{bp}$ [see Eq. (8)]	- S_{cdm} - $\hat{a}_{ph}(\lambda)$ - η (=k)
ACROSS-II model	- [Chl] - $a_{cdm}(\lambda_0)$ - $b_{bp}(\lambda_0)$	- $\hat{a}_{ph}(\lambda)$ [see Eq. (15)] - k [see Eq. (7b)] - $\tilde{b}_{bp}$ [see Eq. (8)]	- S_{cdm}
c-model	- [Chl] - $a_{cdm}(\lambda_0)$ - $a_{dm}(\lambda_0)$ § - $c_p(\lambda_0)$	- $\hat{a}_{ph}(\lambda)$ [see Eq. (15)] - k' (≈k) [see Eq. (7b)] - $\tilde{b}_{bp}$ [see Eq. (8)]	- S_{cdm}

§ Becomes *[Chl]-driven* if retrieved from $a_p(\lambda) - a_{ph}(\lambda)$ and if $a_p(\lambda)$ is *[Chl]-driven* (*Bricaud et al.*, 1998)

IOCCG5 model

(back-up slides)



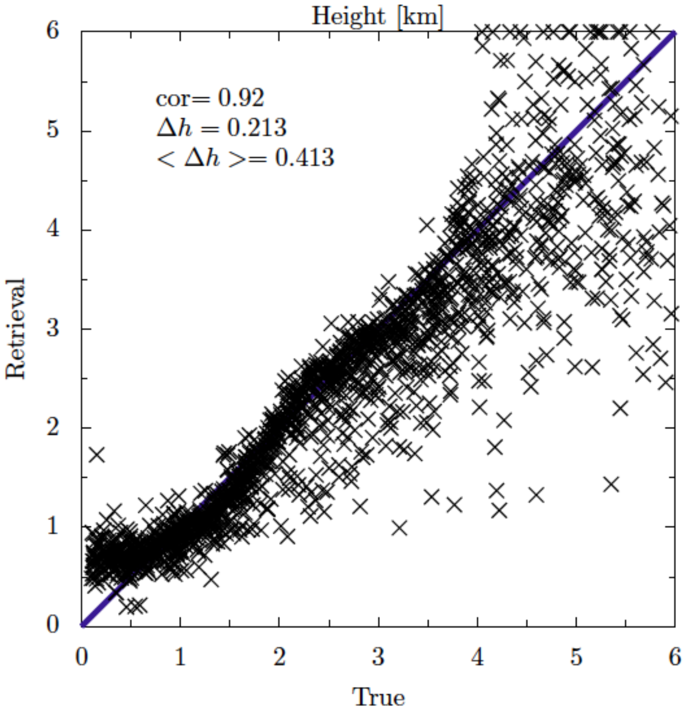
Free parameter	*[Ch]-driven parameter*	*[Ch]-driven parameter range*	*fixed parameter range*	*Assumed a-priori*
[Chl]	$\hat{a}_{ph}(\lambda)$	$a_{dm}(\lambda_0)$, $a_g(\lambda_0)$, $c_{ph}(\lambda_0)$, $b_{dm}(\lambda_0)$, $n1$, $n2$	S_{dm}, S_g §	$\tilde{b}_{b,ph}$, $\tilde{b}_{b,dm}$ ‡

§ $S_{dm} \in [0.007, 0.015]$ and $S_g \in [0.01, 0.02]$; ‡ $\tilde{b}_{b,ph}$=0.01 and $\tilde{b}_{b,dm}$=0.0183

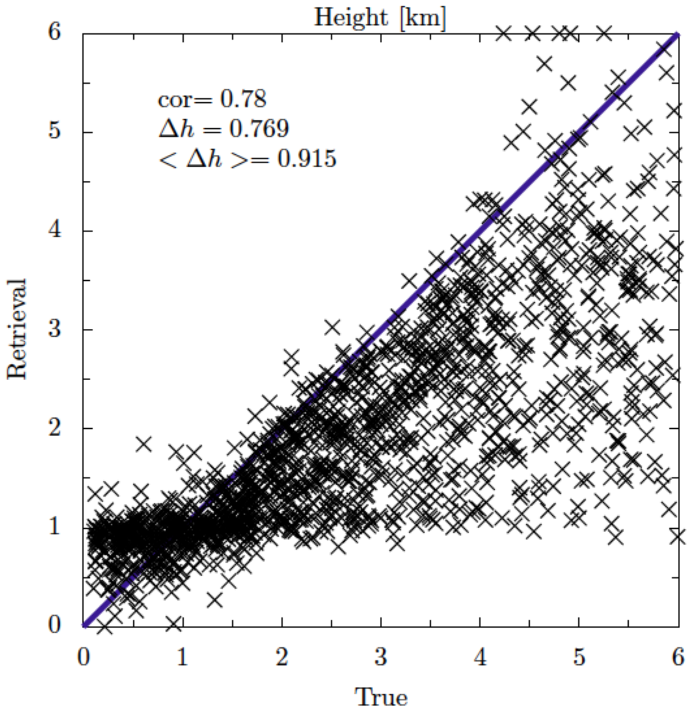
3. Other →

Aerosol Layer Height Retrieval from RSP (synthetic)

radiance + polarization



only radiance



Polarimetry in near UV: elevated aerosol layer 'shields' partly molecular (Rayleigh) scattering → polarization measurements provide aerosol height information.

Polarization measurements in blue / near-UV are needed. (This is for a homogeneous aerosol layer; for plumes MISR has shown that stereo retrievals form multi-angle radiometry work well)

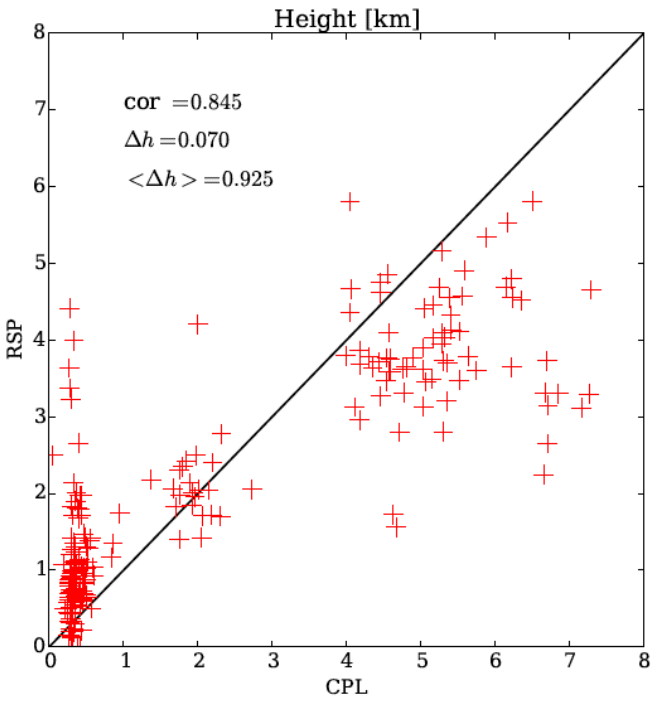
(Wu *et al*, in preparation)

ACROSS (Atmospheric Correction for the Retrieval of Ocean Spectra from Space)

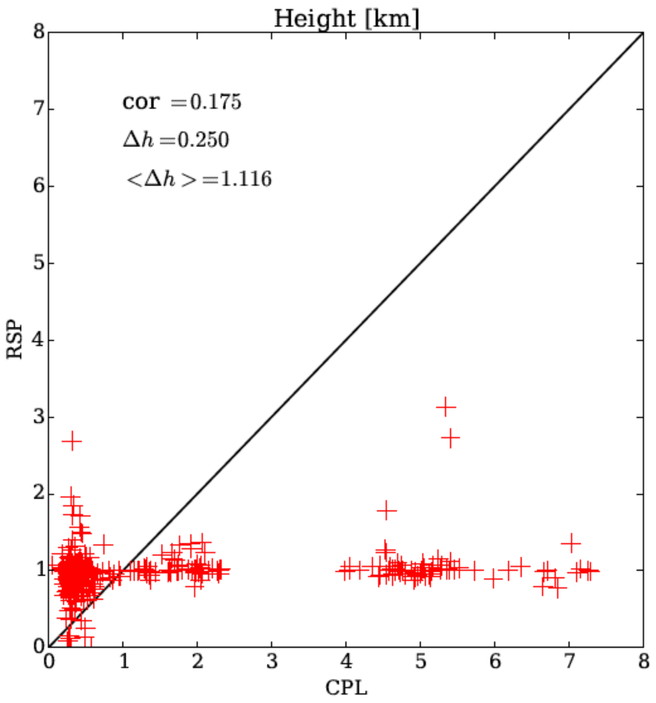
3. Other →

Aerosol Layer Height Retrieval from RSP (real measurements)

radiance + polarization



only radiance



- *Comparison between RSP and the Cloud Physics Lidar from the ER-2.*
- *Given the very different measurement approaches and definition of aerosol layer height, the agreement is very encouraging.*
- *The importance of blue / near-UV polarization measurements is also confirmed for real measurements.*

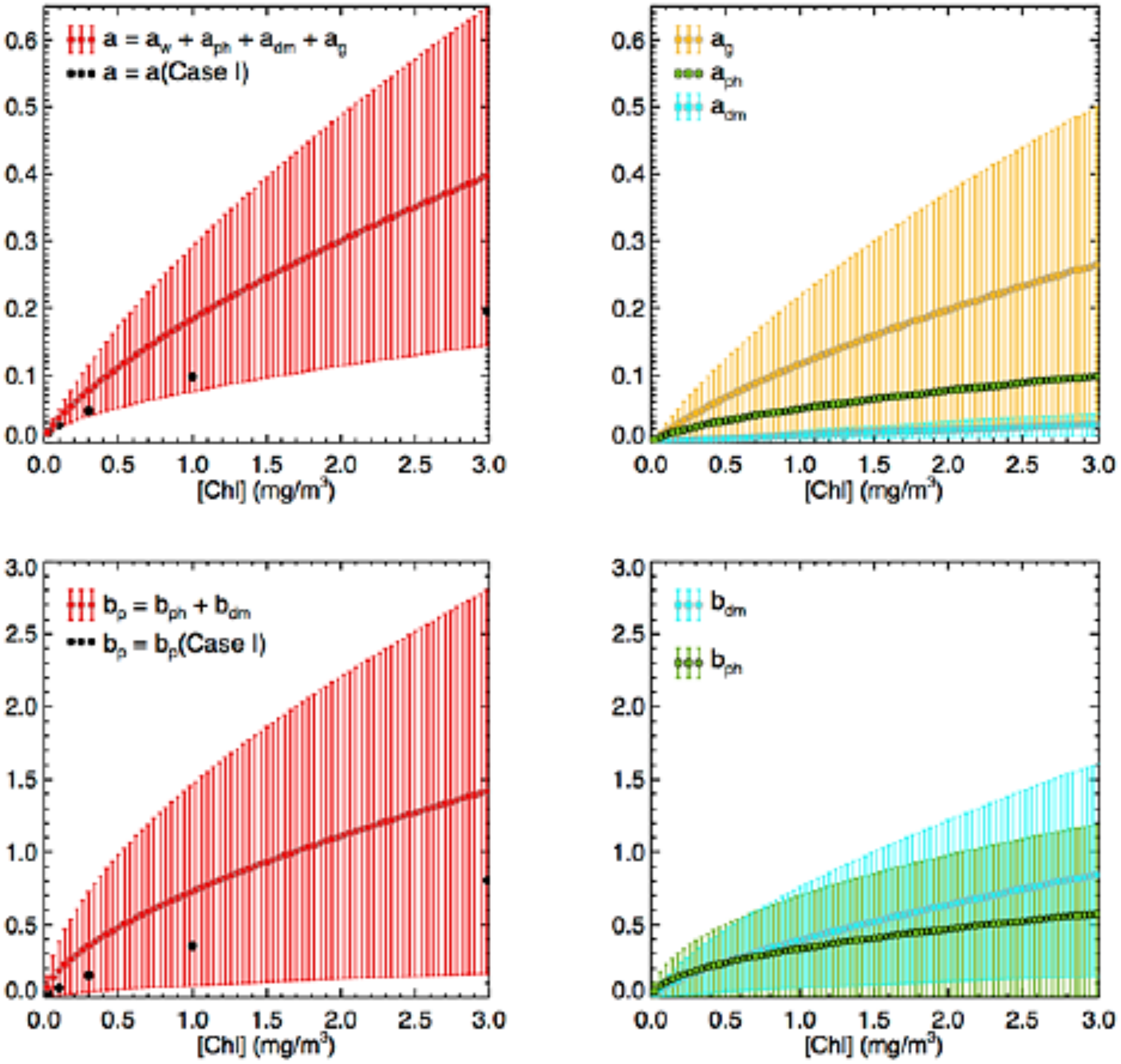
(Wu *et al*, in preparation)

Backup Slides

IOCCG5 model

ACROSS (Atmospheric Correction for the Retrieval of Ocean Spectra from Space)

IOCCG5 model



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IOCCG5 model

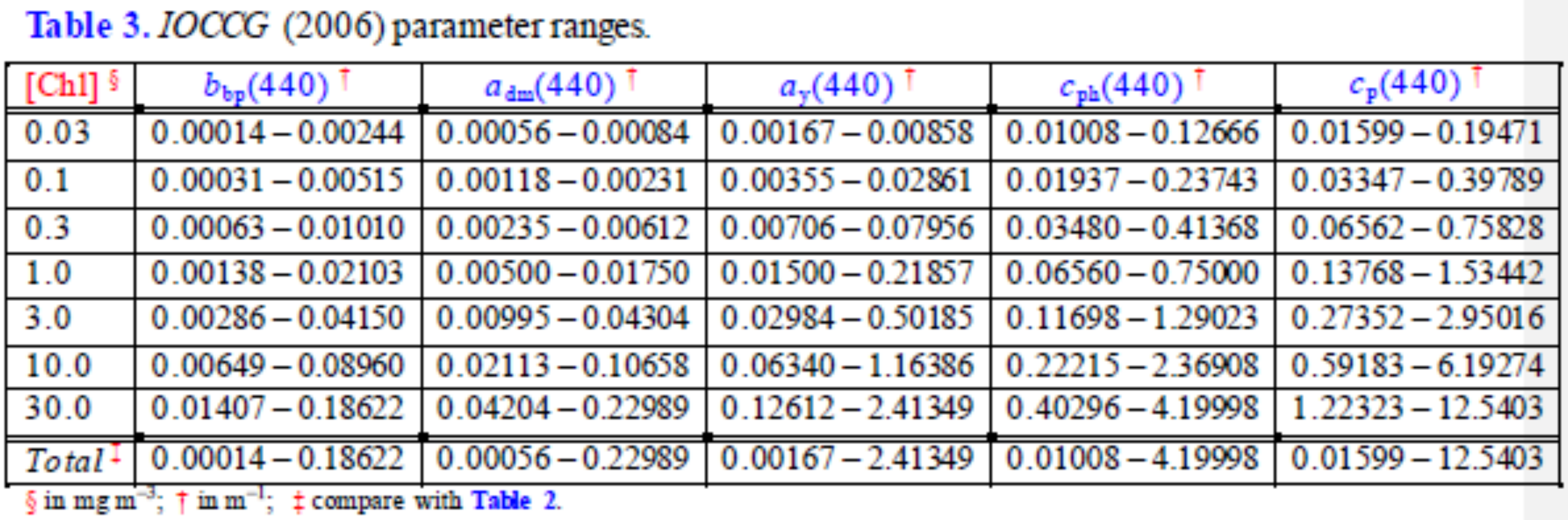

Table 3. *IOCCG* (2006) parameter ranges.

[Chl] §	$b_{bp}(440)$ †	$a_{dm}(440)$ †	$a_y(440)$ †	$c_{ph}(440)$ †	$c_p(440)$ †
0.03	0.00014 – 0.00244	0.00056 – 0.00084	0.00167 – 0.00858	0.01008 – 0.12666	0.01599 – 0.19471
0.1	0.00031 – 0.00515	0.00118 – 0.00231	0.00355 – 0.02861	0.01937 – 0.23743	0.03347 – 0.39789
0.3	0.00063 – 0.01010	0.00235 – 0.00612	0.00706 – 0.07956	0.03480 – 0.41368	0.06562 – 0.75828
1.0	0.00138 – 0.02103	0.00500 – 0.01750	0.01500 – 0.21857	0.06560 – 0.75000	0.13768 – 1.53442
3.0	0.00286 – 0.04150	0.00995 – 0.04304	0.02984 – 0.50185	0.11698 – 1.29023	0.27352 – 2.95016
10.0	0.00649 – 0.08960	0.02113 – 0.10658	0.06340 – 1.16386	0.22215 – 2.36908	0.59183 – 6.19274
30.0	0.01407 – 0.18622	0.04204 – 0.22989	0.12612 – 2.41349	0.40296 – 4.19998	1.22323 – 12.5403
Total ‡	0.00014 – 0.18622	0.00056 – 0.22989	0.00167 – 2.41349	0.01008 – 4.19998	0.01599 – 12.5403

§ in mg m^{-3}; † in m^{-1}; ‡ compare with **Table 2**.

IOCCG5 model