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

PACE → 5+ instrument options

Table 1: P, S, *and* T = *primary, secondary, and tertiary sensitivity to carry out ACT*

Instrument	Data (sub-)set	Scattering (aerosol)	Absorption (aerosol)	Height (aerosol)	Spectrum (ocean)
OCI	○ *radiance* ○ *[NUV–SWIR]*	○ **P** → (r_e, v_e, N) ○ [NIR, SWIR]	○ **P** → (m_i) ○ [NUV]†	○ **S** → (z) ○ [NIR]‡	○ **P** → (x_{ocn}) ○ [NUV, VIS]§
OCI/OG	○ *radiance* ○ *[O_2 A band]*	○ **T** → (r_e, v_e, N) ○ [O_2 A]	○ **S** → (m_i) ○ [O_2 A]	○ **P** → (z) ○ [O_2 A]	–
OCI+	○ *radiance* ○ *[1378, 2250]*	○ **P** → (cirrus) [1378] ○ **P** → (r_e, v_e, N)¶ [2250]	–	–	–
OCI-3M, OCI/A-3M	○ *polarization* ○ *[VIS–SWIR]*	○ **P** → (m_r, $f_{spheroid}$, cirrus) ○ [VIS, NIR, SWIR]	○ **S** → (m_i) ○ [VIS]	○ **T** → (z) ○ [VIS]	○ **T** → (x_{ocn}) ○ [NUV, VIS]§

Table 2: *Retrievable parameters and state vector for the atmosphere and ocean.*

Vector	Layer		Effective size distribution†	Spectral refractive index	Amount	Shape§
x_{atm}	○ z_{top} (○ z_{bot})	*Fine*	○ radius: $r_{e\,(fine)}$ ○ variance: $v_{e\,(fine)}$	○ real: $m_{r\,(fine)}(\lambda)$ ○ imaginary: $m_{i\,(fine)}(\lambda)$	○ $N_{(fine)}$	– ($f_{spheroid} = 0$)
		Large	○ radius: $r_{e\,(large)}$ ○ variance: $v_{e\,(large)}$	○ real: $m_{r\,(large)}(\lambda)$ ○ imaginary: $m_{i\,(large)}(\lambda)$	○ $N_{(large)}$	○ $f_{spheroid} \geq 0$

† as defined by Hansen and Travis (1974), with $r_{e\,(fine)} < 1\ \mu m$ § $f_{spheroid}$ ≡ fraction of particles that are spheroids

Vector	Particulate matter	Plankton	Dissolved and detrital matter	*Optional* Surface wind ¶
x_{ocn}	○ b_{bp} (λ_0 = 443 nm)†	○ [Chl]‡	○ a_{cdm} (λ_0 = 443 nm)§	○ speed ○ direction

† see Eq. (1) ‡ see Eq. (2) § see Eq. (3) ¶ for pixels contaminated by sun glint

Motivation for *ACROSS:*

*The most critical factor for the success of **PACE** is the capacity to account for atmospheric scattering. However, none of the proposed **PACE** instrument options have been evaluated for their ability to carry out the atmospheric correction task (ACT) for the retrieval of ocean spectra from space.*

Objectives for *ACROSS:*

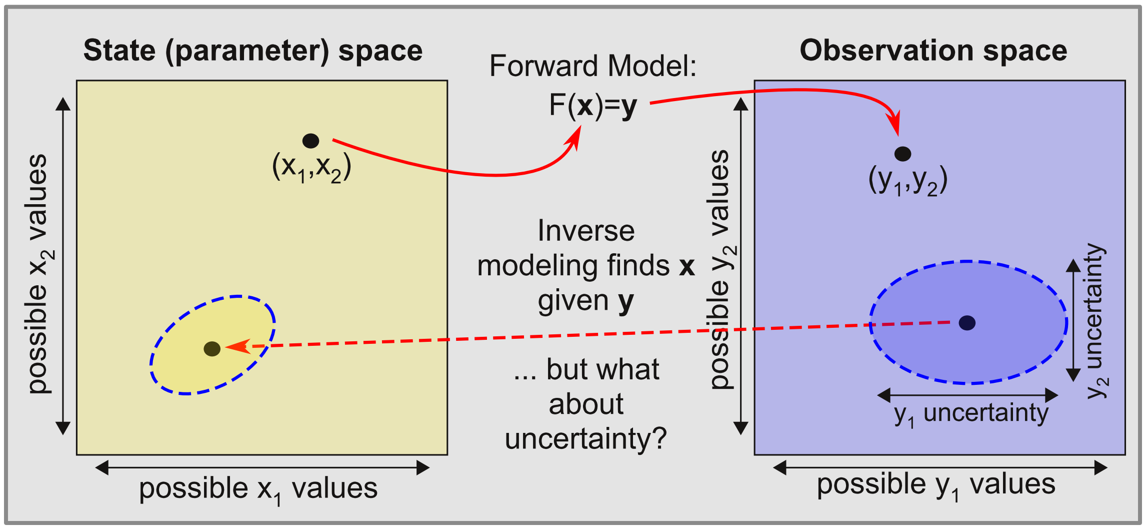
*To evaluate the ACT capability of **PACE** instrument options, we will*

1. **assess data information** *for various instrument options,*
2. **invert synthetic measurements** *and optimize ACT*
3. **validate performance** *using **PACE**-like field observations for a range of instrument options.*

ACROSS (J. Chowdhary, B. Cairns, K. Knobelspiesse, B. van Diedenhoven, O. Hasekamp, M. Alexandrov)

1. Information content analyses

- Relates measurement characteristics to expected (best case) retrieval uncertainty
- Bayesian statistical basis (C.D. Rodgers: Inverse Methods for Atmospheric Sounding, 2000)
- Possible collaborations: R. Frouin (Bayesian approach), O. Kalashnikova



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

Measurement error covariance matrix: how we specify instrument characteristics

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

Jacobian matrix: model calculated parameter sensitivity

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

Prior knowledge matrix: uncertainty range of our expected results

"Essentially, all models are wrong, but some are useful"
– George Box

a) Quick instrument prototyping
Radiative transfer calculations only needed to make Jacobians

b) Shows best possible retrieval uncertainty
Does not account for model limitations, convergence, "unknown unknowns".

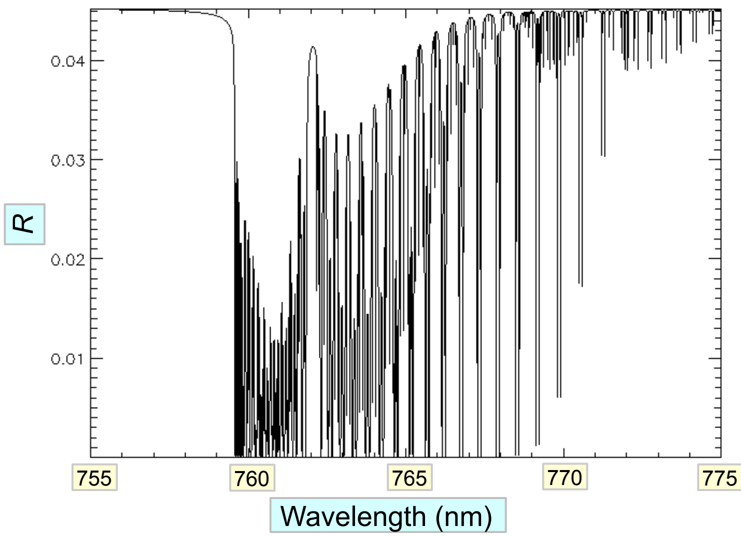
c) Cannot do better than this without additional information
Shows capability upper limit

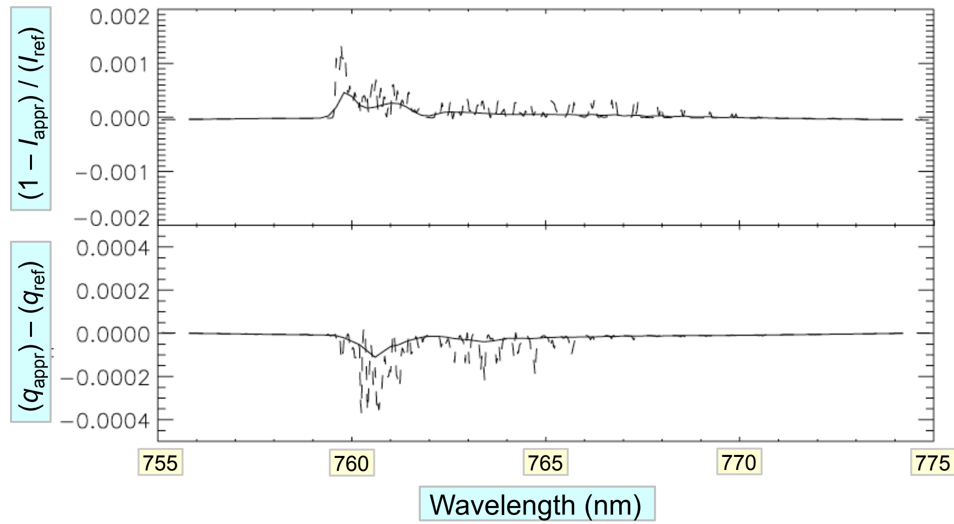
d) Well established technique
Used in variety of disciplines

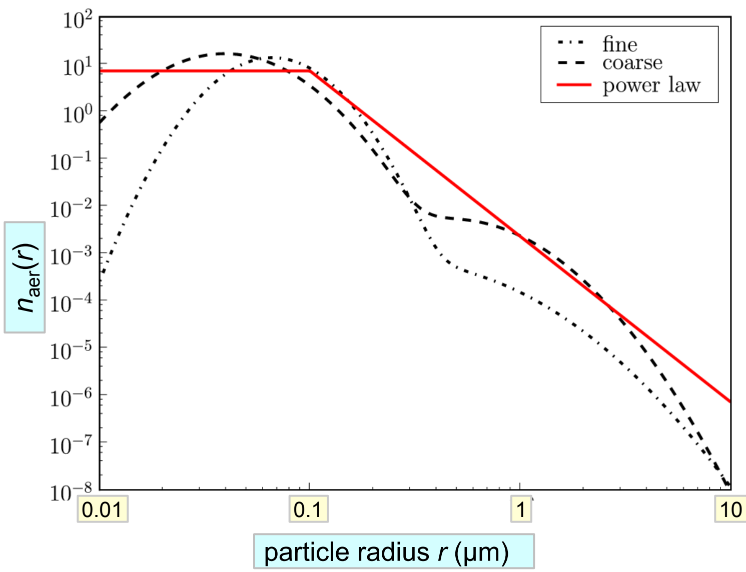
ACROSS (J. Chowdhary, B. Cairns, K. Knobelspiesse, B. van Diedenhoven, O. Hasekamp, M. Alexandrov)

1. Information content analyses

- O_2 A-band aerosol retrievals: RemoTec
- Possible collaborations: R. Frouin, S. Platnick (O_2 A-band)







a) Well-established model
Used for aerosol correction in GHG retrievals (GOSAT, TROPOMI, OCO-2)

b) Fast results
Efficient modeling of O_2 A-band using modified k-binning approach

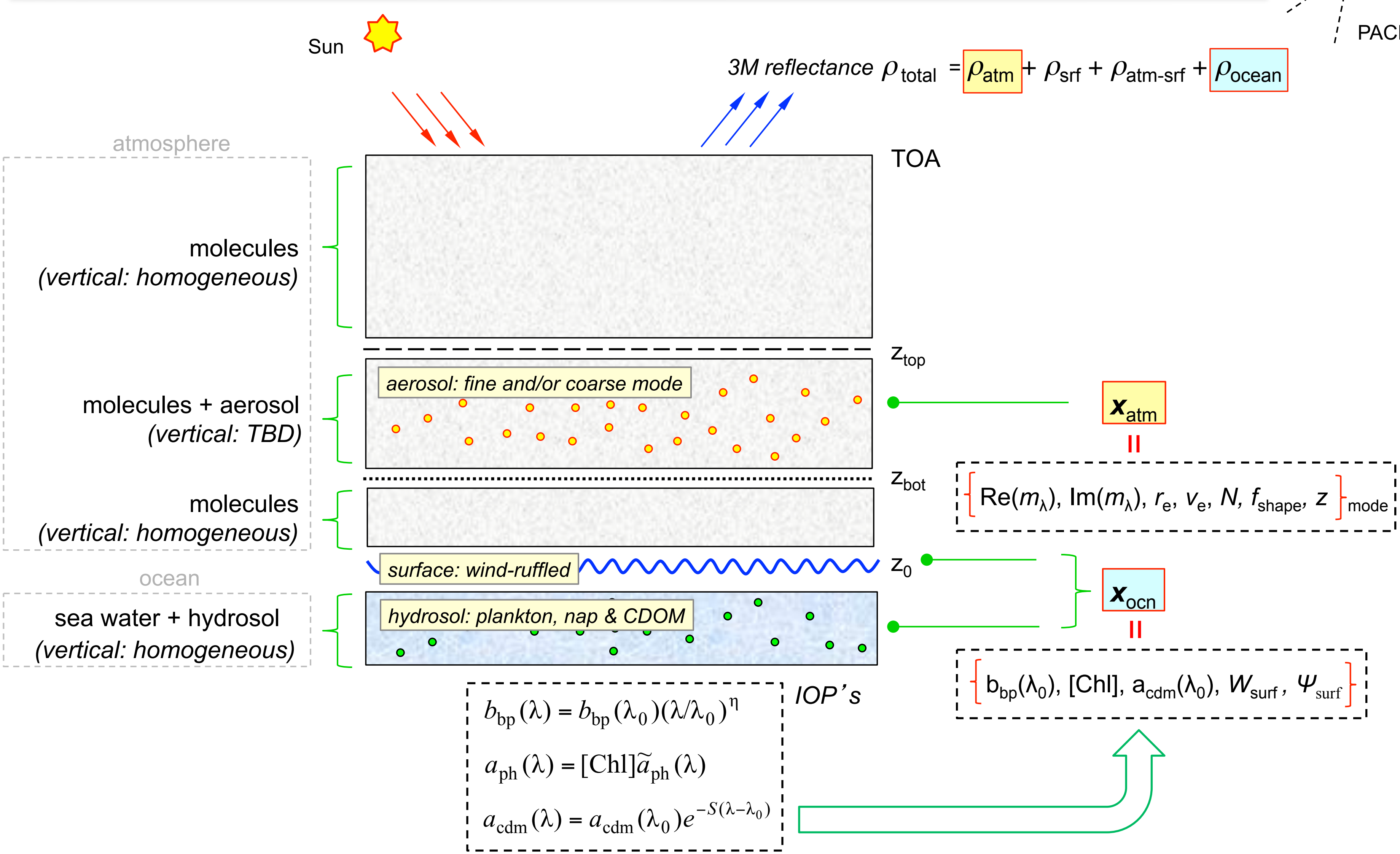
c) Flexible set-up
Aerosol distribution, height distribution, spectral resolution, etc.

ACROSS

(J. Chowdhary, B. Cairns, K. Knobelspiesse, B. van Diedenhoven, O. Hasekamp, M. Alexandrov)

2. Synthetic measurements

- Possible collaborations: S. Ackleson, E. Boss, S. Maritorena, B. Mitchel, Z. Lee (IOPs); X. Zhang, J. Sullivan, M. Twardowski (VSF)



3. Validation studies

- Possible collaborations: O. Kalashnikova, B.-C. Gao, Z. Lee (data analyses)

Campaign	Data sets	(PACE-like)		ACT products
ACOCO	➢ AVIRIS (high-altitude airborne, radiance) ○ *Hyperspectral imaging: {370–2500 nm}* †	➢ *OCI, OCI+ (NUV–SWIR)*	*retrieve*	➢ Atmosphere: ○ $\boldsymbol{x}_{atm} \rightarrow \rho_{atm}(\lambda)$
	➢ RSP (high-altitude airborne, radiance) ‡ ○ *3M: 152 views along ground track, total radiance, linear polarized radiance,* ¶ *412, 470, 555, 670, 865, 1590, 2250 nm}*	➢ *OCI-3M (3M)*	*retrieve*	➢ Ocean: ○ $\boldsymbol{x}_{ocn} \rightarrow \rho_{w}(\lambda)$
OCEANIA	➢ C-AIR (airborne, radiance) ○ *Up- & downwelling: {320, 340, 380, 395, 412, 443, 465, 490, 510, 532, 555, 589, 625, 670, 683, 710, 780 nm}* ○ *Downwelling irradiance*		*validate*	➢ Atmosphere: ○ $\rho_{atm}(\lambda)$
	➢ Aerosol measurements(airborne, *in-situ*) ○ *Particle size distribution* ($\rightarrow r_e, v_e$) ○ *Particle concentration (N)* ○ *Particle scattering coefficient* ($\rightarrow m_r$) *{450, 550, 700 nm}* ○ *Particle absorption coefficient* ($\rightarrow m_i$) *{462, 523, 648 nm}*		*validate*	➢ Atmosphere: ○ $\boldsymbol{x}_{atm}$
	➢ Microtops II sunphotometer (shipborne, sky radiance) ○ *8 bands: {340, 380, 440, 500, 675, 870, 936, 1020 nm}* ($\rightarrow$ *AOD*, r_e, v_e)		*validate*	
	➢ C-OPS (shipborne, underwater radiance) ○ *Upwelling: {320, 340, 380, 395, 412, 443, 465, 490, 510, 532, 555, 589, 625, 670, 683, 710, 780 nm}* ○ *Downwelling irradiance*		*validate*	➢ Ocean: ○ $\rho_{w}(\lambda)$
	➢ IOPs and pigment measurements (shipborne, *in-situ*) ○ *Absorption coefficients* (a_{blk}, a_{ph}, a_{cdm}): *{350–750 nm}* § ○ *Particle backscattering coefficient* (b_{bp}): *{420, 442, 470, 510, 590, 700 nm}* ○ *Chlorophyll a concentration ([Chl])*		*validate*	➢ Ocean: ○ $\boldsymbol{x}_{ocn}$

† *10 nm spectral resolution* § *1–2 nm spectral resolution* ¶ *Stokes parameters I, Q, U* ‡ *pixel size limit: 280 m*