Maintenance and development of radiative transfer and remote sensing algorithms for the PACE instruments

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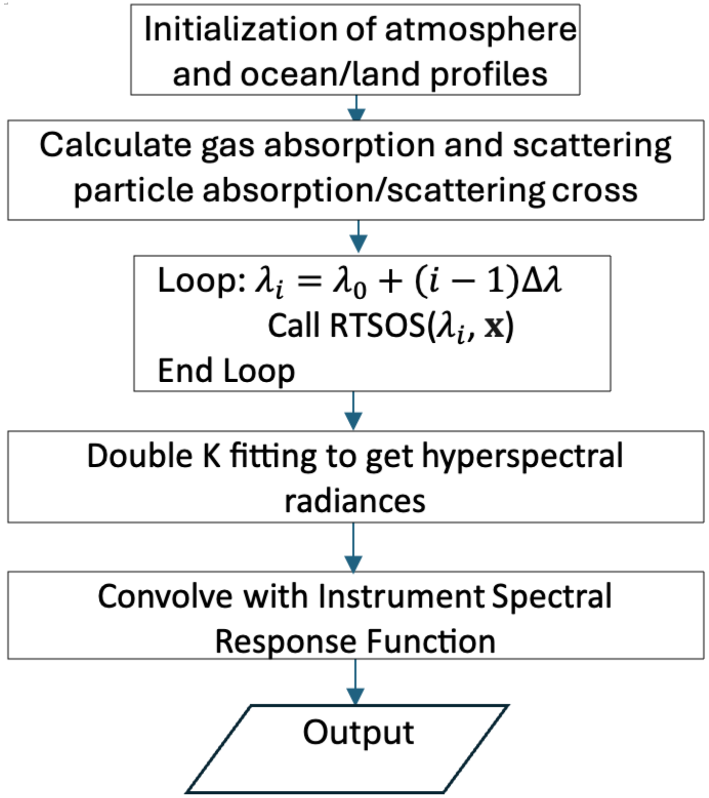
Proposal Objectives

- Maintenance and further development of the radiative transfer packages that we developed for the PACE instruments.
- Improve the aerosol and ocean bio-optical representations in the Fast Multi-Angular Polarimetric Ocean coLor (FastMAPOL) algorithm to include coastal waters.
- Provide an Instantaneous Photosynthetically Available Radiation (IPAR) data product derived from polarimeter measurements.

I. PACE Simulator

Software Structure



Features of the PACE Simulator

- Full spectral range of OCI + HARP2 + SPEXone
- All Stokes parameters (I, Q, U, V)
- Atmosphere-ocean & atmosphere-land systems
- Flexible optical properties for scattering particles
- Gas absorption: O2, H2O, CO2, O3, NO2, CH4
- Spectral response functions: OCI, HARP2, and SPEXone

Applications

- Sensitivity studies
- Aerosol look up tables for atmospheric correction
- Act as a forward model for joint retrievals
- Generate synthetic dataset for training neural networks

Zhai et al., (2022) Front. Remote Sens. 3:840188.

II. FastMAPOL/Multi-Components

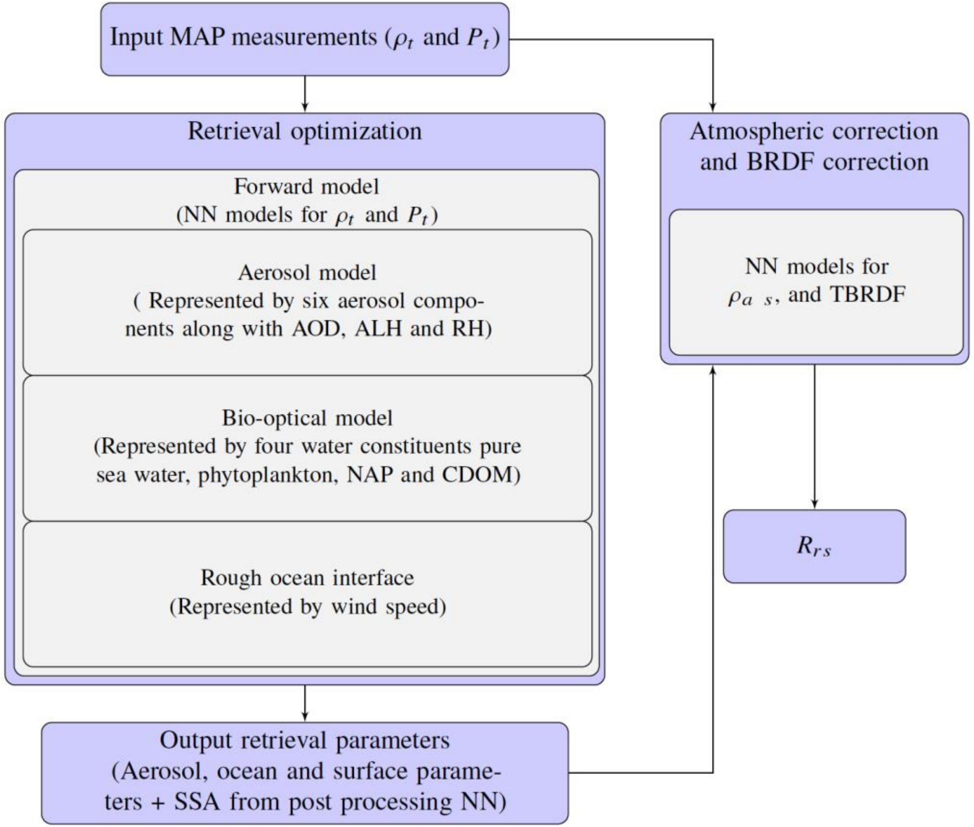


Fig. 2. Flowchart showing different components in the retrieval optimization of FastMAPOL/component.

Bio-Optical Models

$$a_{ph}(\lambda) = A_{ph}(\lambda)[\boldsymbol{Chla}]^{E_{ph}(\lambda)}$$

$$a_{dg}(\lambda) = \boldsymbol{a_{dg}}(\mathbf{440})exp[-0.018(\lambda - 440)]$$

$$b_{bp}(\lambda) = \boldsymbol{b_{bp}}(\mathbf{660})\left[\frac{\lambda}{660}\right]^{-\boldsymbol{S_{bp}}}$$

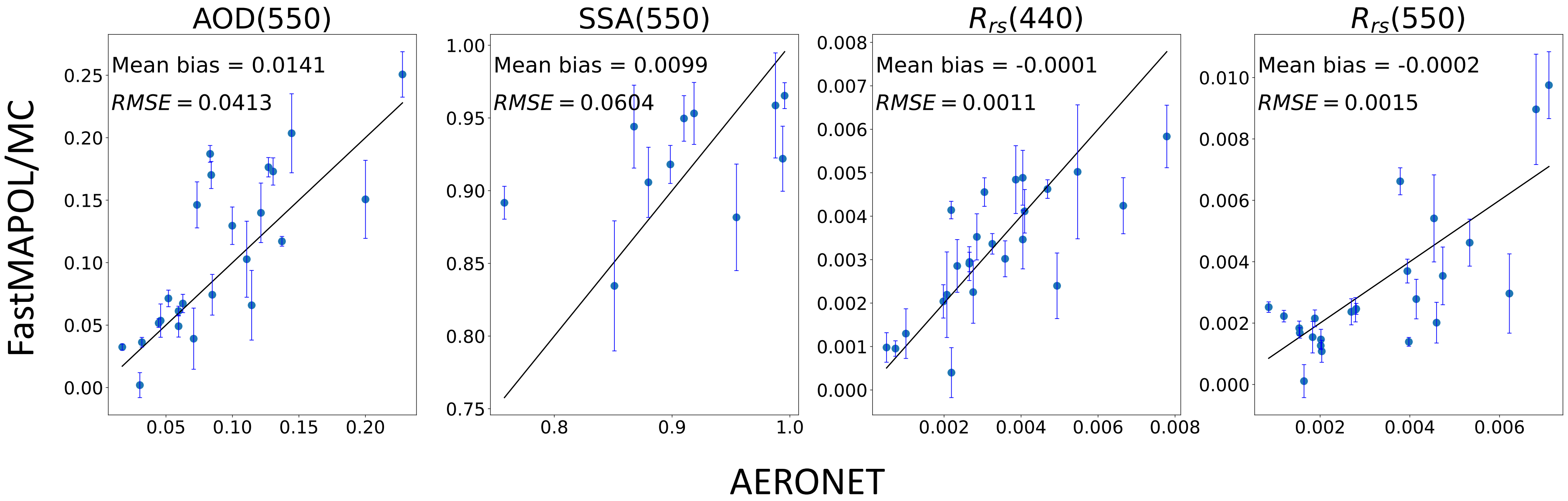
Aerosol Representation

- Mixture of different components with known refractive indices and size.
- Fine mode: BC, BrC, FNAI, FNAS
- Coarse mode: Sea salt, Dust

Aryal et al., Optics Express, 2024

FastMAPOL/MC Validation with AERONET data

Project team: Pengwang Zhai, Kamal Aryal, Meng Gao, Yongxiang Hu



- ➢ Results from SPEXone only configuration (using 10 wavelengths from 410 to 740nm)
- ➢ ~25 collocations up to Jan 2025 (USC_Seaprism, Casabalanca, AAOT, Irbe Lighthouse, Palgrunden

III. IPAR Algorithm

$$\mathrm{IPAR} = \frac{1}{hc}\int_{400}^{700} \lambda\, E_0(\lambda)\, d\lambda.$$

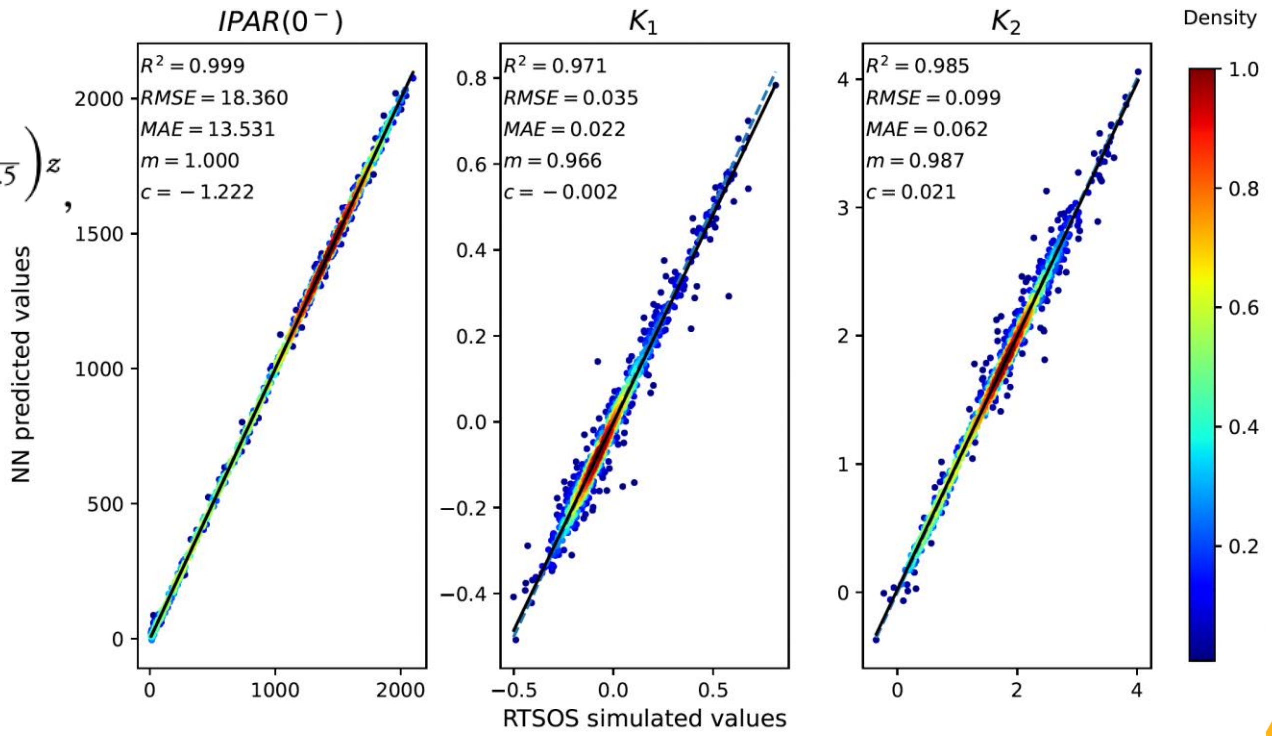
$$\mathrm{IPAR}(z) = \mathrm{IPAR}(0^-)\, e^{-\left(K_1 + \frac{K_2}{(1+z)^{0.5}}\right)z},$$

- NN algorithm inputs:

Wind speed, Chla, solar zenith angle, AOD, SSA, Angstrom Exponent, ozone, Bp, water total absorption coefficient, and bp.

- Outputs:

Vertical distribution of IPAR in ocean waters.



Source: Aryal et al., Applied Optics, 2022.

Preliminary conclusion and plans

- PACE simulator is under continuous development and will keep evolving to serve the PACE science.
- FastMAPOL/component shows promising results with SPEXone data. Comparison with AERONET shows:
  - AOD at 550 is biased high (by ~0.015)
  - Rrs at 550 is biased low (by 0.0003)
  - Rrs shape matches well with AERONET
- Future plan:
  - Further acquisition of validation data for reliable statistics.
  - Use HARP2 measurements along with SPEXone.
  - Adding OCI NIR reflectances.
  - Implement IPAR algorithm once MAP retrieval is reliable.


PLANKTON, AEROSOL, CLOUD, OCEAN ECOSYSTEM
PACE
NASA/GSFC • UMBC • SRON/AIRBUS NL

Thank you!