Vector Radiative Transfer in CAO systems and applications

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Motivation

Polarimeter is indispensable for satellite missions (PARASOL, GLORY, ACE, GEOCAPE, etc.)

A combination of active and passive remote sensing will serve a unique role for ACE-like missions.

The interpretation of many field measurements needs to simulate polarized light multiply scattered in atmosphere and ocean.

A fast vector radiative transfer package with flexibility and accuracy.
Vector Radiative Transfer (VRT) Model

Atmosphere

\[ S_1^m = \omega \frac{P^m(\mu,\mu_0)}{4\pi} e^{-\tau/|\mu_0|} E_0 \]

Ocean

\[ L_1^m = e^{-(\tau-\tau^*)/|\mu_0|} |\mu_0| B_t^m(\mu,\mu_0) \frac{e^{-\tau^*/|\mu_0|}}{\pi} E_0 \]

\[ L_n^m(\tau, \mu > 0) = \int_0^{\tau} \exp\left\{ -(\tau' - \tau)/|\mu| \right\} S_n^m(\tau', \mu) d\tau/|\mu| \]

\[ L_n^m(\tau, \mu < 0) = \int_0^{\tau} \exp\left\{ -(\tau' - \tau)/|\mu| \right\} S_n^m(\tau', \mu) d\tau/|\mu| \]


Model Comparison
Experimental Data Provided by Optical Remote Sensing Laboratory, CCNY
Ocean Color Study: Viewing Angle

Sensitive to viewing geometries

\[ \theta_v = 0 \degree \]

\[ \theta_v = 45 \degree \]

\[ \theta_v = 60 \degree \]

Water Leaving Reflectance vs. \( \frac{b_b}{a+b_b} \)
The decoupling radiance error at the TOA. $\theta_s=60^\circ$ (a) chlorophyll a concentration $[\text{Chl}] = 0.3 \text{mg m}^{-3}$ the wavelength 412 nm. (b) chlorophyll a concentration $[\text{Chl}] = 3 \text{mg m}^{-3}$ wavelength 412 nm. (c) chlorophyll a concentration $[\text{Chl}] = 0.3 \text{mg m}^{-3}$ and wavelength 555 nm. (d) chlorophyll a concentration $[\text{Chl}] = 3 \text{mg m}^{-3}$ and wavelength 555 nm.
Aerosol Application: Multilayer Aerosol Sensitivity

**Single layer aerosol test**

- Slope = 0.99997
- Bias = -5.7405e-05
- Corr Coeff = 0.99797

**Two layer aerosol test**

- Slope = 0.9748
- Bias = -9.4816e-05
- Corr Coeff = 0.94904

\[
\frac{\tau_{865,1} + \tau_{865,2}}{\tau_{865,1} + \tau_{865,2}} = \text{Retrieved } m_r,1 + \text{Retrieved } m_r,2
\]
A vector radiative transfer model has been built for coupled atmosphere and ocean system based on the successive order of scattering method.

The code is accurate, efficient and easy to use. A few examples of the usage of the SOS code are:

- Aerosol retrieval algorithm using Least squares fitting of the RSP instrument data.
- Ocean water leaving simulation to study the ocean water back scatter and viewing angle sensitivity.
- Ocean color decoupling error study.