Bio-optical models suitable for use in forward and inverse coupled atmosphere-ocean RTMs

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One Parameter Bio-optical Model

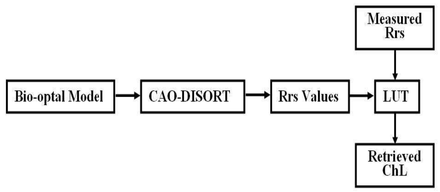
- Absorption Coefficient Morel-Maritorena (2001)

$$a(\lambda) \approx 0.90\ K_d(\lambda)\ [1 + 2.25R(\lambda)]^{-1}\ [1 - R(\lambda)]$$

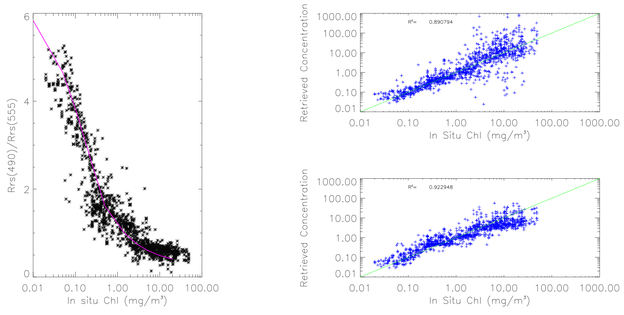
$$R(\lambda) \approx 0.33\ \frac{b_b(\lambda)}{a(\lambda)}$$

- Scattering Coefficient
$b(\lambda) = b_w(\lambda) + b_p(\lambda)$, $b_p(\lambda_i) = \alpha_i C^{\beta_i}$
- Phase Function Petzold (1972) Measurement

Chlorophyll Concentration Retrieval Algorithm: CAO-DISORT/LUT



$\rho_{35} \equiv R_{rs}(490)/R_{rs}(555)$ **2-band algorithm**



In the figures above, left figure shows the comparison of ratio of Rrs(490)/Rrs(555) calculated by LUTs with measured Rrs ratio from SeaBASS data base for a large range of chlorophyll concentrations. Red line: LUT; Stars: Measurements;
right figure shows the Measured versus retrieved chlorophyll concentrations for a SeaBASS data set consisting of 1355 cases. Top panel: results of VIIRS algorithm; Bottom panel: results of our retrieval algorithm.

Two Parameter Bio-optical Model

- Absorption Coefficients

$a(\lambda) = a_w(\lambda) + a_{ph}(\lambda) + a_y(\lambda)$	Total absorption
$a_{ph}(\lambda) = A(\lambda)[C]^{E(\lambda)}$	Phytoplankton absorption Bricaud et al. (1995)
$a_y(\lambda) = a_y(443)\ \exp[-S(\lambda - 443)]$	CDOM absorption

- Scattering Coefficients $b(\lambda) = b_w(\lambda) + b_p(\lambda)$, $b_p(\lambda_i) = \alpha_i C^{\beta_i}$
- Phase Function Petzold's average-particle phase function

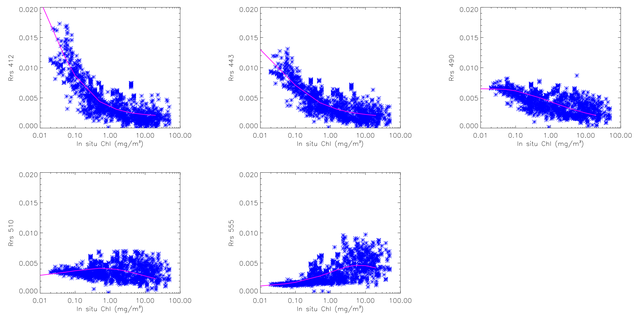
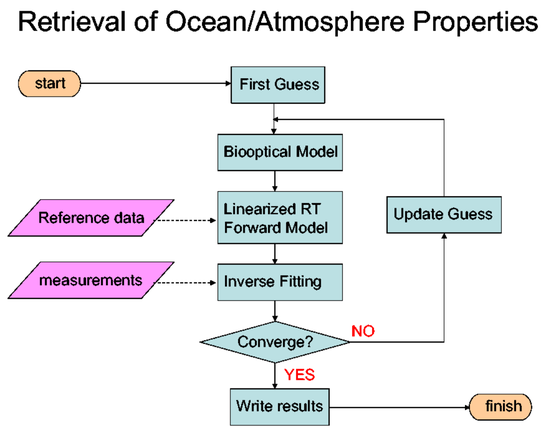


Figure above shows the comparison between calculated and measured R_{rs} values from the SeaBASS data base consisting of 1355 cases. Red line: calculated by our algorithm; Stars: measured R_{rs}.

Ocean Color Retrieval Algorithm (CAO-LDISORT/OE)



Ocean Color Retrieval Inverse Approach

- Iterative chi-square minimization using linearized RT model (CAO-LDISORT)
- Optimal Estimation with loose a priori constraint (aids convergence)
- Simultaneous retrieval of atmospheric and marine parameters combined in one state vector $=\{N_{aer}$, F, C$\}$ or $\{N_{aer}$, F, C, Y$\}$
N_{aer} = total aerosol loading F = aerosol bimodal weighting factor
C = Chlorophyll concentration Y = CDOM absorption
- CAO-LDISORT will deliver weighting functions with respect to All these parameters
- Well-established error budgeting procedures giving clear divisions between sources of uncertainty (Rodgers, 2001)
- Retrieval is stable and fast (3-6 iterations), no matter what the initial state vector guess.

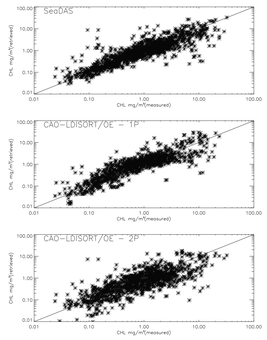


Figure above shows the Retrieved Chl versus measured Chl. Top panel: SeaDAS algorithm; Middle panel: CAO-LDISORT/OE algorithm for 1-parameter bio-optical model; Bottom panel: CAO-LDISORT/OE algorithm for 2-parameter bio-optical model.

Conclusion

- We have constructed a one-parameter bio-optical model as well as an algorithm to retrieve chlorophyll concentration
  - Advantage:
    - Total absorption coefficient is derived from K_d
    - Use ratio of R_{rs} values to retreive Chl
  - Disadvantage: Can only retrieve one parameter Chl
- We have constructed a two-parameter bio-optical model, as input to inverse algorithm to retrieve Chl and $a_y(443)$
  - Advantage:
    - It can retrieve both Chl and $a_y(443)$, or more parameters in the future, such as SPM.
    - Linearized forward model CAO-LDISORT for radiative transfer simulation of satellite radiances and analytic weighting functions
- Advantage for both: We can retrieve aerosol and marine parameters from satellite imagery simultaneously.