Simultaneous Retrieval of Aerosol and Coastal Ocean Properties by Optimal Estimation

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Summary

We analyze Sea Viewing Wide Field-Of-View Sensor (SeaWiFS) images over the Santa Barbana Channel (SBC).

- Pixel-by-pixel measurements of radiances at eight SeaWiFS channels and analytic Jacobians are simulated using a coupled atmosphere-ocean radiative transfer model; the inverse algorithm is based on optimal estimation with loosely constrained a priori data.
- The 5-element state vector has two aerosol (optical depth at 865 nm, bimodel fraction of particles) and three marine (chlorophyll concentration, detrital/dissolved-matter absorption at 443 nm, and backscttering coefficient at 443 nm) parameters.
- The retrieval is stable and well posed; the results are smoother and show less spread than those derived from the standard SeaDAS v4.8 algorithm.
- For an 28 February 2003 SeaWiFS image, the average radiance residual is less than 1% for seven SeaWiFS channels, and less than 2% for the 765 nm channel.
- For a series of SBC SeaWiFS match-up cases over a 4-year period, estimated water-leaving radiances agree well with field measurements.

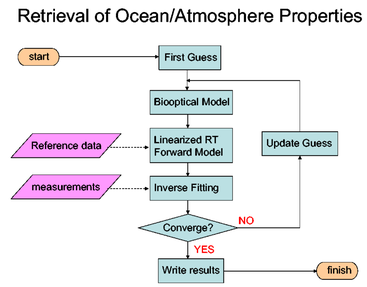
Aerosol and Ocean Color Retrieval Algorithm

3 Parameter Bio-optical Model:

$$\begin{aligned} a_{ph}(\lambda) &= \alpha_1(\lambda)\mathbf{CHL}^{\alpha_2(\lambda)} && \text{Phytoplankton abs.} \\ a_{cdm}(\lambda) &= \mathbf{CDM}\ e^{-S(\lambda-443)} && \text{CDOM and detritus abs.} \\ b_{bp}(\lambda) &= \mathbf{BBP}\ (\lambda/443)^{-\eta} && \text{Backscattering coeff.} \end{aligned} \quad (1)$$

Ocean Color Retrieval Inverse Approach (see Spurr et al.,2006, Li et al.,2008)

- Iterative χ-square minimization using a 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 vetor = $(\tau_{aer}, F, CHL, CDM, BBP)$
  τ_{aer} = total aerosol loading F = aerosol bimodal weighting factor
  CHL = chlorophyll concentration CDM = CDOM absorption at 443 nm
  BBP = Backscattering coefficient at 443 nm
- CAO-LDISORT will deliver weighting functions with respect to all these parameters
- Well-established error budgeting procedures giving clear divisions between sources of uncertainty
- Retrieval is stable, no matter what the initial state vector guess.



SeaWiFS SBC Image Retrieval

Results for SeaWiFS 28 February 2003 scene

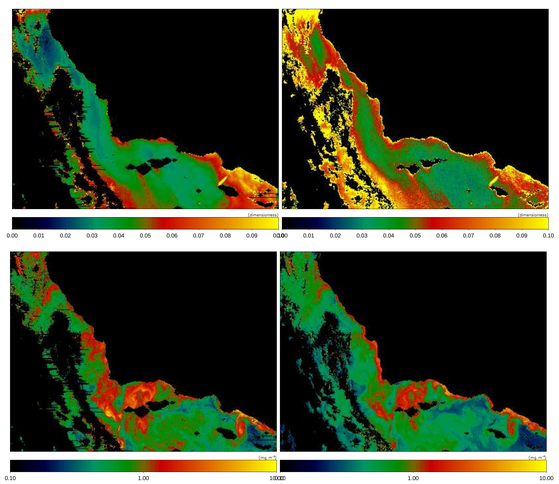


FIGURE 1: SeaWiFS SBC image 2/28/2003: comparisons of retrieved aerosol optical depth (top panels) and chlorophyll concentrations (bottom panels). (a) and (c): our new algorithm; (b) and (d): SeaDAS standard algorithm.

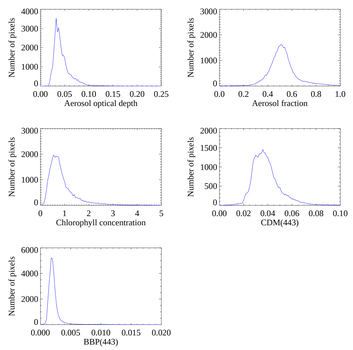


FIGURE 2: SeaWiFS SBC image 2/28/2003: distributions of the other retrieved parameters. (a) aerosol optical depth; (b) aerosol model fraction; (c) chlorophyll concentration; (d) CDM443; (e) BBP443.

Table 1. Radiance Residuals at all SeaWiFS channels.

Wavelength	Average relative error	Pixels with ¡ 1% relative error
412 nm	-0.26%	99.70%
443 nm	+0.27%	99.47%
490 nm	-0.47%	99.08%
510 nm	+0.66%	94.95%
555 nm	-0.08%	99.49%
670 nm	-0.94%	63.62%
765 nm	+1.89%	17.17%
865 nm	-0.78%	77.29%

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SBC Match-up Cases

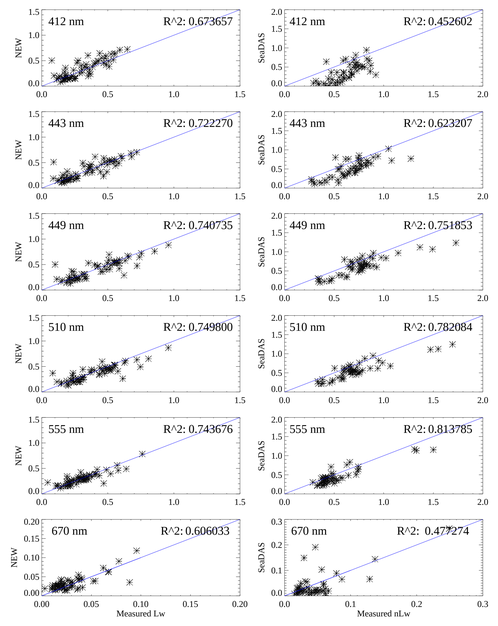

FIGURE 3: SBC Match-up cases: Water-leaving radiance comparisons between field measurements and retrievals from the new algorithm (left panels) and from SeaDAS (right panels).

Match-up case were assighed using ±3hour time windows and 3*3 pixel averaging in the SeaWiFS scene. For the period 2000-2003, 74 possible SBC match-ups from the PnB experiment were identifed.

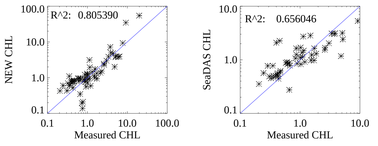

FIGURE 4: SBC Match-ups: CHL comparisons between field measurements and retrievals from the new algorithm (left panels) and from SeaDAS (right panels).

Discussion and Future Work

- A key to the successful retrievals appears to be the availability of high quality field data for the construction of a consistent bio-optical model appropriate to the oceanic region.
- The method can easily be applied to SeaWiFS images from other firld-measured coastal waters.
- To establish the limitations and accuracy of the new ocean color algorithm, and error analysis will be carried out.
- Speed up is possible by creating look-up tables of simulated radiances and Jacobians by means of a neural network.

Reference:

1. Li, W., K. Stamnes, R., Spurr, and J. Stamnes, Simultaneous retrieval of aerosol and ocean properities by optimal estimation: SeaWiFS case studies for the Santa Barbara Channel, IJRS, in press, (2008).
2. Spurr, R., K. Stamnes, H. Eide, W. Li, K. Zhang, and J. Stamnes, Simultaneous retrieval of aerosol and ocean color: A classic inverse modeling approach: I. Analytic Jacobians from the linearized CAO-DISORT model, J. Quant. Spectrosc. Radiative Transfer, doi: 10.1016/j/jqsrt.2006.09.009 (2006)