Physics

Plans and Progress

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Physics

Decomposition of TOA Reflectance

$$\rho_t(\lambda) = \rho_r(\lambda) + \rho_A(\lambda) + t_v(\lambda) t_s(\lambda)[\rho_w(\lambda)]$$

,

Physics

STUDIES

- Sub-surface Bidirectional Reflectance distribution Function (BRDF)
- Morel's Gothic R Factor
- Diffuse Transmittance (Corrected for BRDF)
- MODIS Instrument Polarization
- Coupled Ocean-Atmosphere Bio-optical Retrievals

Physics

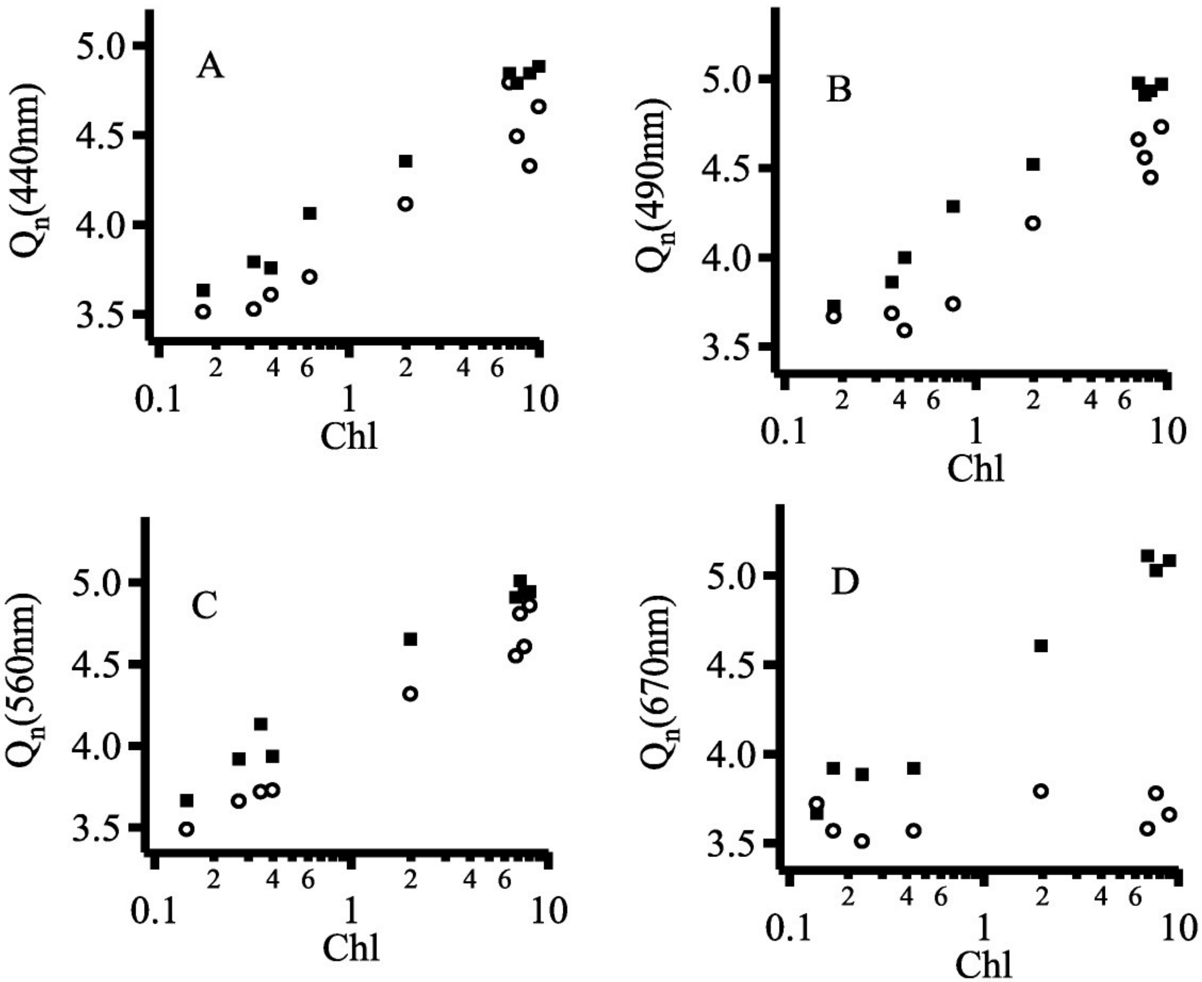
Bidirectional Reflectance distribution Function (BRDF)

Physics

- Compared, favorably, the most recent Morel-Gentilli BRDF model with experimental measurements of the BRDF taken with the radiance distribution camera system (RADS-II).
- Plan to analyze data collected with the NuRADS camera system during the last several years to make an empirically based BRDF correction for clear water — specifically for the MOBY site.

Physics

$$[L_w(\hat{\xi}_v)]_N = \overline{F}_0 \Re(\hat{\xi}'_v, \hat{\xi}_s) \frac{R(\hat{\xi}_s)}{Q(\hat{\xi}'_v, \hat{\xi}_s)}$$



Voss: open circles   Morel: filled squares

Physics

- Plan to analyze data collected with the NuRADS camera system to develop a turbid water BRDF — specifically data from the Chesapeake Bay.
- Plan to collect BRDF data on the upcoming Bouselle-AOPEX cruise with Andre Morel in the Mediterranean.

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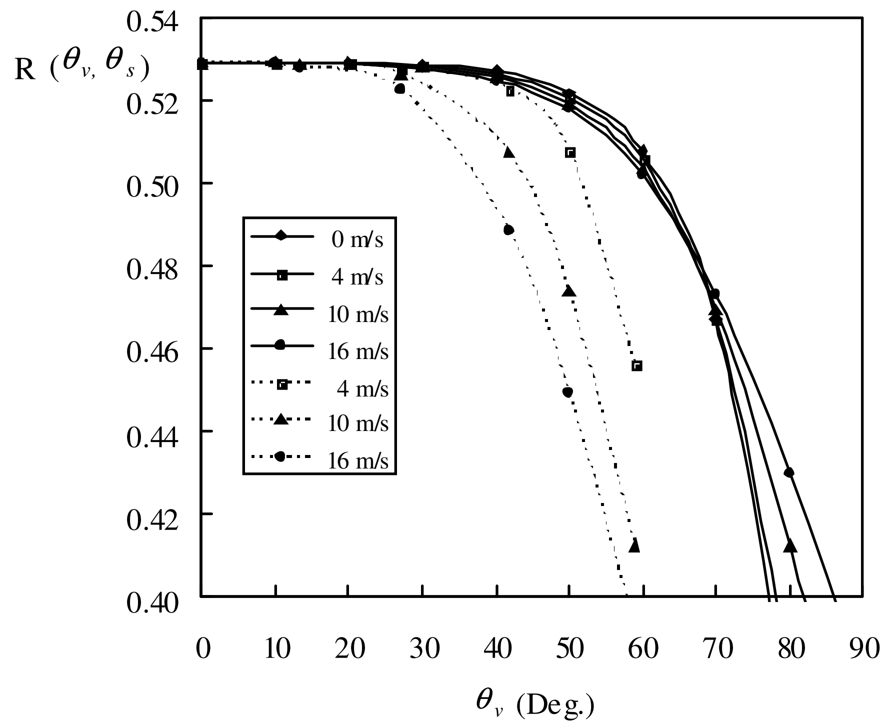
- If there are sufficient funds available, plan to collect BRDF data on a South Pacific Cruise with Andre Morel (Easter Island to Chile), covering the most oligotrophic waters known.
- We are expanding our measurements of the upwelling radiance distribution to look at the polarization of the upwelling radiance.

We Revisited Morel's Gothic-R Factor

Physics

$$[L_w(\hat{\xi}_v)]_N = \overline{F}_0 \Re(\hat{\xi}'_v, \hat{\xi}_s) \frac{R(\hat{\xi}_s)}{Q(\hat{\xi}'_v, \hat{\xi}_s)}$$

$$\Re(\hat{\xi}'_v, \hat{\xi}_s) = \left[\frac{(1-\rho_f(\hat{\xi}'_v))(1-\overline{\rho}_f(\hat{\xi}_s))}{m^2(1-\overline{r}R(\hat{\xi}_s))} \right]$$



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Diffuse Transmittance (Corrected for BRDF)

$$t_v(\hat{\xi}_v) = \frac{1}{F_0 \left|\hat{\xi}_v \bullet \hat{n}\right| T_f(\hat{\xi}_v)} \int \left|\hat{\xi} \bullet \hat{n}\right| L_1(-\hat{\xi}) \frac{L_u(\hat{\xi})}{L_u(\hat{\xi}'_v)} d\Omega(\hat{\xi})$$

If L_u is uniform,

$$t_v^*(\hat{\xi}_v) = \frac{E_{1d}(-\hat{\xi}_v)}{F_0 \left|\hat{\xi}_v \bullet \hat{n}\right| T_f(\hat{\xi}_v)}$$

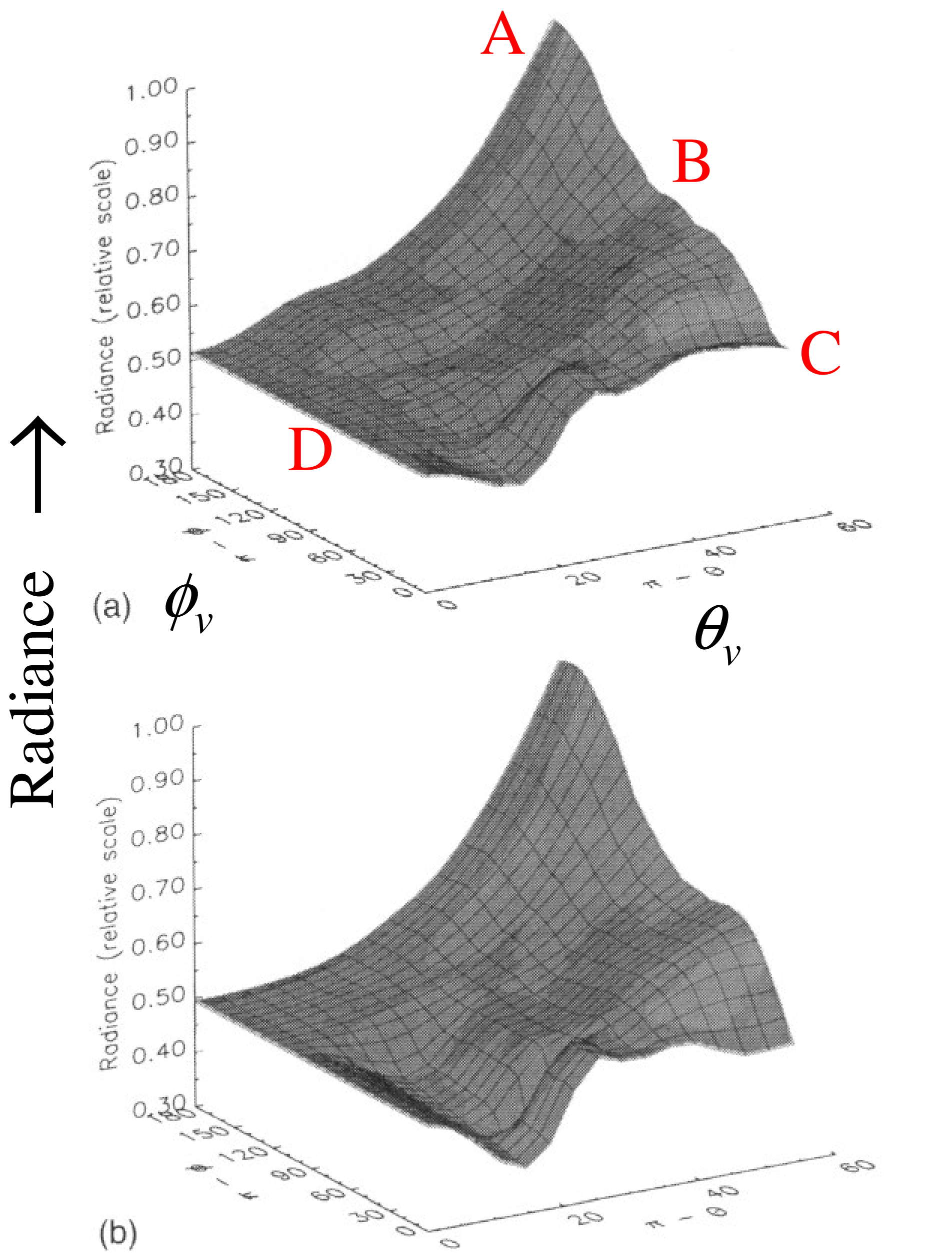

Fig. 6. Subsurface upwelling radiance distributions measured Voss with the radiance distribution system (RADS)[13,29]: (a) λ = 450 nm, $\theta_0 = 58.2°$; (b) λ = 500 nm, $\theta_0 = 59.7°$.

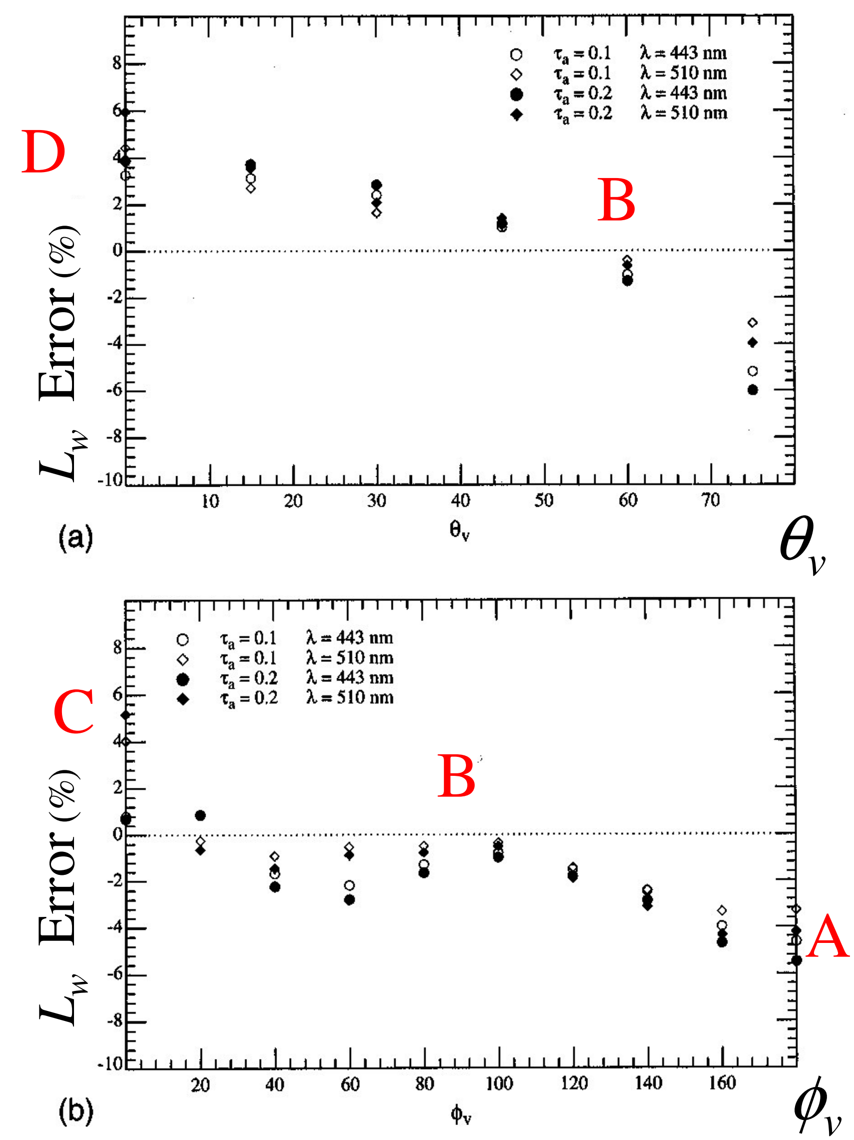

Fig. 7. Error in t, induced by the assumption that L_u is uniform, as a function of wavelength and aerosol optical thickness, with the Voss subsurface upwelling radiance distribution: (a) $\theta_0 = 60°$ viewing in the perpendicular plane to the Sun, (b) $\theta_v = \theta_0 = 60°$ with viewing azimuth ϕ_v. The M90 aerosol model is used in all computations.

C ~ 0.3 mg/m^3

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The error in L_w using t^* instead of t is $\sim \pm 4\%$.

Improving this requires knowing the angular distribution of L_u, i.e., a solid BRDF model.

Physics

MODIS Instrument Polarization Sensitivity

- Have been working on modeling the MODIS instrument polarization with others at Goddard. Implementing the MODIS optics and thin film designs into an optical design ray tracing program (ZEMAX) and doing the polarization modeling in this program. Hope to reproduce the pre-launch polarization data then investigate possible deteriorations in the MODIS instrument and its effect on the polarization sensitivity
- Developing technique for incorporating aerosol polarization in the polarization sensitivity correction section of the MODIS code.

Physics

Coupled Ocean-Atmosphere Bio-optical Retrievals

- Atmospheric correction in dust.
- Atmospheric correction for Case 2 waters.
- Will be collecting Lidar data on aerosol vertical distribution during the upcoming Bouselle-AOPEX cruise with Andre Morel in the Mediterranean.

Atmospheric Correction

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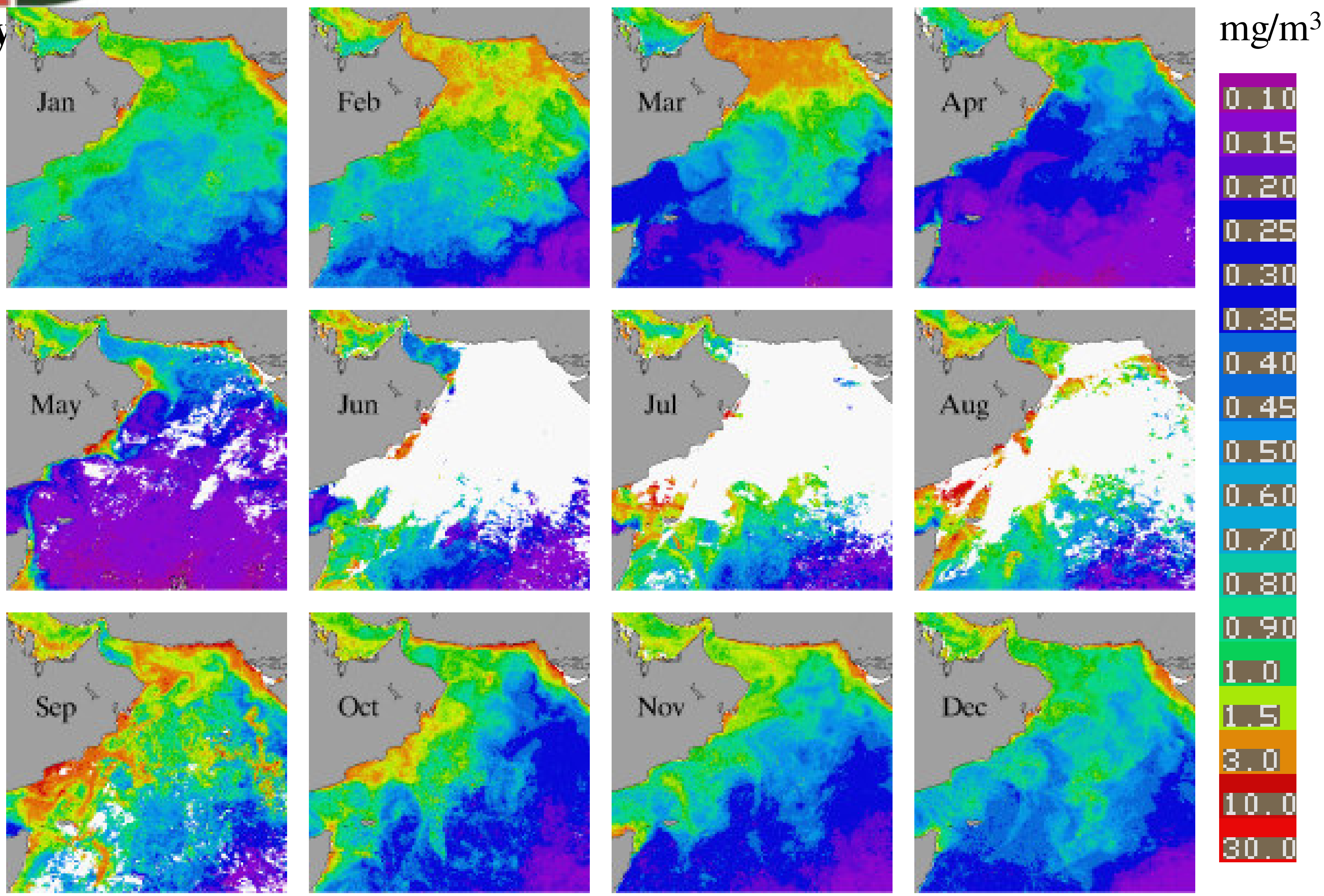
Combine dust models with "Spectral Matching Algorithm" (*Gordon et al*., 1997).

- Given $\rho_A(\lambda)+t_v(\lambda)t_s(\lambda)[\rho_w(\lambda)]_N$ and $\rho_A(865)$.
- Use ocean model to provide $[\rho_w(\lambda)]_N$ as function of pigments and backscattering.
- Use dust models (including vertical dist.) to provide $\rho_A(\lambda)$ and $t_v(\lambda)t_s(\lambda)$ from $\rho_A(865)$.
- Find combination of parameters that best reproduce $\rho_A(\lambda)+t_v(\lambda)t_s(\lambda)[\rho_w(\lambda)]_N$ in an RMS sense
- Use retrieved atmospheric properties along with OC4V4 to find Chl *a*.

Year 2000: SeaWiFS Monthly Chl *a*

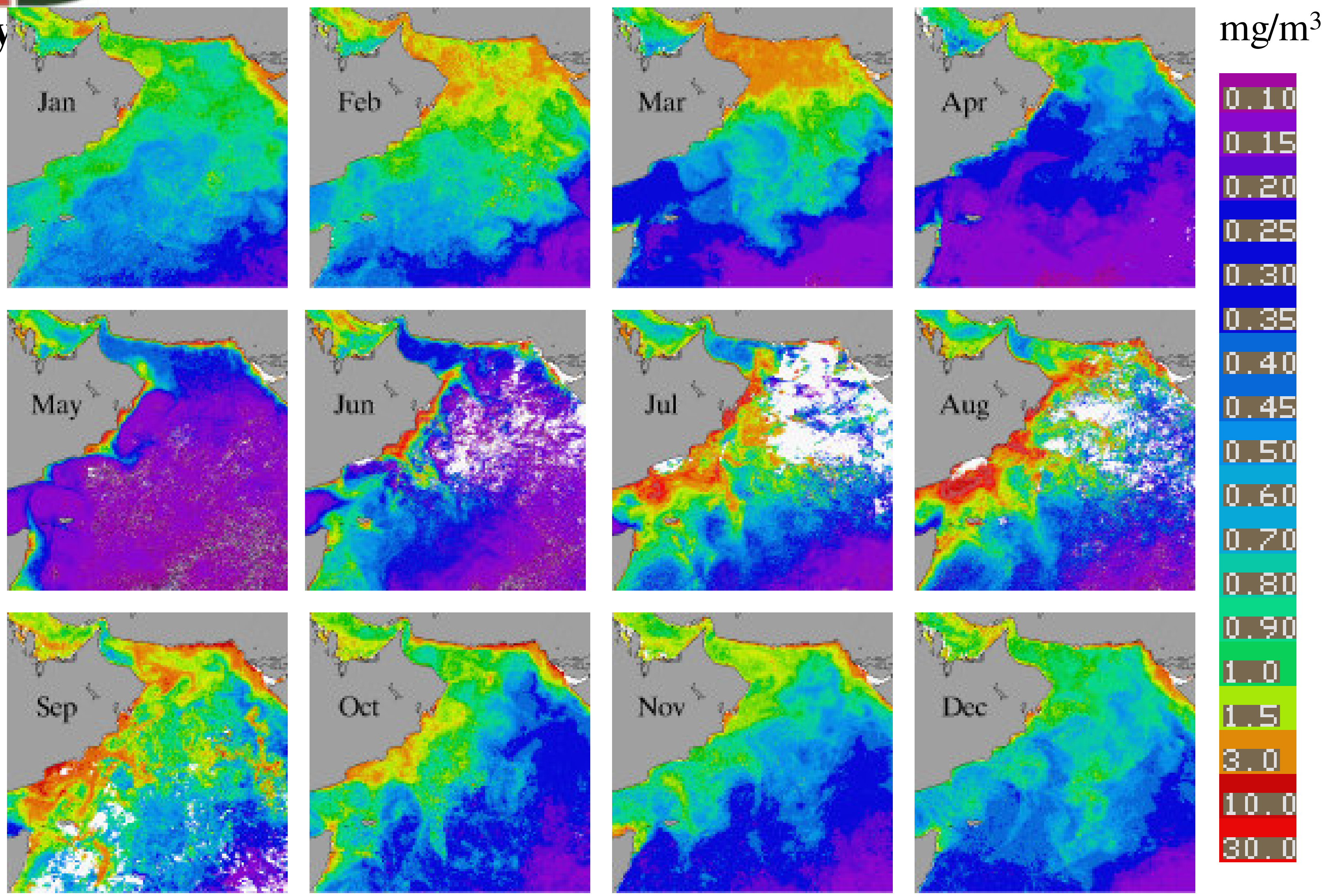
Standard Processing => Data Gaps due to Cloud/Dust Masking

Phy



Year 2000: SMA Monthly Chl *a*

Phy



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Spectral Optimization

$$\rho_t(\lambda) = \rho_r(\lambda) + \rho_A(\lambda) + t_v(\lambda) t_s(\lambda) [\rho_w(\lambda)]_N ,$$

$$\rho_{Aw}(G, \lambda, measured) \equiv \rho_A(G, \lambda) + t_v(G, \lambda) t_s(G, \lambda) [\rho_w(\lambda)]_N .$$

The modeled counterpart of ρ_{Aw}:

$$\begin{aligned} \hat{\rho}_{Aw}(G, \lambda, m_r, m_i, \nu, \tau_a, C, a_{cdm}(443), (b_b)_{p0}) \equiv {} & \hat{\rho}_A(G, \lambda, m_r, m_i, \nu, \tau_a) \\ & + \hat{t}_v(G, \lambda, m_r, m_i, \nu, \tau_a) \hat{t}_s(G, \lambda, m_r, m_i, \nu, \tau_a) \\ & \times [\hat{\rho}_w(\lambda, C, a_{cdm}(443), b_{bp}(443))]_N . \end{aligned}$$

Assuming $\rho_w(765)$ and $\rho_w(865) = 0$ gives estimation of the parameters ν and τ_a for each aerosol model, i.e., $\nu(m_r, m_i)$ and $\tau_a(m_r, m_i)$.

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Given the $\nu(m_r,m_i)$ and $\tau_a(m_r,m_i)$ relationships as constraints, we minimize the quantity.

$$\sum_{\lambda_i}\left\{\begin{matrix}\hat{\rho}_{Aw}(G,\lambda_i,m_r,m_i,\nu,\tau_a,C,a_{cdm}(443),b_{bp}(443)) \\ - \\ \rho_{Aw}(G,\lambda_i,measured)\end{matrix}\right\}^2$$

In effect, we have optimized for 7 parameters:

C, $a_{cdm}(443)$, $b_{bp}(443)$, ν, τ_a, m_r, and m_i

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Case 2 Waters

To extend to Case 2 waters

- Use the retrieved water parameters to estimate ρ_w in the NIR.
- Subtract the water contribution from $\rho_t - \rho_r$ in the NIR, and process the pixel again.
- Do this until stable values of ρ_w in the NIR are obtained.

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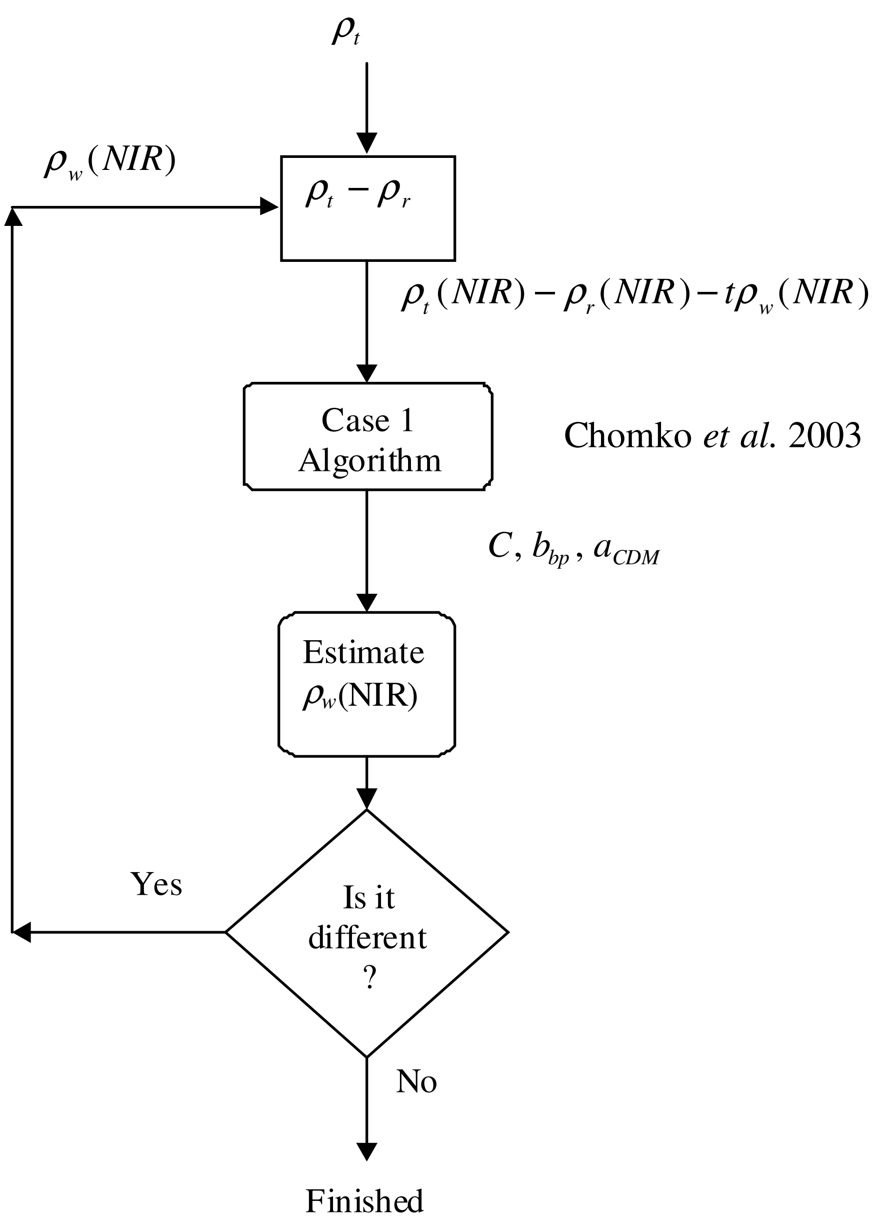
ρ_t
$\rho_w(NIR)$
$\rho_t - \rho_r$
$\rho_t(NIR) - \rho_r(NIR) - t\rho_w(NIR)$
Case 1 Algorithm
Chomko *et al.* 2003
C, b_{bp}, a_{CDM}
Estimate ρ_w(NIR)
Yes
Is it different ?
No
Finished