IOP inversion from shallow waters

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\[ R_{rs} = f(a, b_b) \]

\[ \frac{L_u(0^-)}{E_d(0^+)} \]

\( L_u(0^-) \): upwelling radiance
\( E_d(0^+ \): downwelling irradiance
PBR approach:

- Basis vectors
- absorption
- \( a_\phi(\lambda) = a_\phi(\lambda_0) \left[ S_f a_{\text{micro}}(\lambda_0) + (1-S_f) a_{\text{pico}}(\lambda_0) \right] \)
- \( a_{dg}(\lambda) = a_{dg}(\lambda_0) \exp(-S(\lambda-\lambda_0)) \)
- backscattering
- \( b_{bp}(\lambda) = b_{bp}(\lambda_0) (\lambda/\lambda_0)^{-Y} \)
- Radiance Reflectance equation [400:10:650]
- \( R_{rs} = 0.0949( b_b/(b_b+a)) + 0.0794 (b_b/(b_b+a))^2 \)
- Linear regression method
- Data set: simulated by hydrolight (Rrs, a and b_b)
Some results:
IOP comparison ($a$ and $b_b$)

Total Absorption Comparison

average of relative difference: 11.9%
total backscattering comparison

average of relative difference: 14.2%
Now story changed......
Rrs from shallow waters:

Strange rrs
Matlab complain
No solutions !!!
$R_{rs} = L_u/E_d = (L_u^{dp} + L_u^B)/E_d$

$$= L_u^{dp}/E_d + L_u^B/E_d = R_{rs}^{dp} + R_{rs}^B$$

downwelling irradiance, upwelling radiance from water column and bottom
simple idea, hard application; fortunately……


basically:

\[ r_{rs} \approx r_{rs}^{dp}[1-\exp(-2KH)] + r_{rs}^B \exp(-2KH) \approx \]

\[ r_{rs}^{dp}(1-A_0 \exp\{-[(1/\cos \theta_w)+D_0(1+D_1u)^{0.5}]\alpha H\}) + \]

\[ A_1 \rho \exp\{-[(1/\cos \theta_w)+D’_0(1+D’_1u)^{0.5}]\alpha H\}. \]

\( r_{rs} \): subsurface remote-sensing reflectance, sr\(^{-1}\)
\( r_{rs}^{dp} \): subsurface remote-sensing reflectance for deep waters, sr\(^{-1}\)
\( r_{rs}^B \): subsurface remote-sensing reflectance for the bottom, sr\(^{-1}\)
\( K \): diffuse attenuation, m\(^{-1}\)
\( H \): bottom depth, m
\( \theta_w \): subsurface solar zenith angle, rad
\( u \): \( b_b/(a + b_b) \)
\( \alpha \): attenuation coefficient (=\( a + b_b \)), m\(^{-1}\)
\( \rho \): bottom albedo
\( A_{0,1} D_{0,1} D’_{0,1} \): from Lee et al, 1998
After subtracting the bottom influence, we get…

Now matlab smiled and we got solutions !!!
Coefficient of Variance:
(express sample variability relative to the mean of the sample)

Total absorption:

Total Backscattering:
IOP inversion results from shallow waters:

Total Absorption:

Total Backscattering:
Conclusions:

• Bottom reflectance has a huge impact on the remote sensing reflectance;
• Current semi-analytic algorithm can be successfully applied to invert IOPs after bottom correction;
• PBR approach can find strange $r_{rs}$ which is caused by the environment or bad measurements?
Acknowledgements