Retrieval of the penetration of light, horizontal and vertical visibility in coastal waters from OC remote sensing data

Maéva DORON\textsuperscript{1,2}, Marcel BABIN\textsuperscript{1}, Antoine MANGIN\textsuperscript{2} and Odile FANTON D’ANDON\textsuperscript{2}

\textsuperscript{1}Laboratoire d’Océanographie de Villefranche, France
\textsuperscript{2}ACRI-ST, Sophia-Antipolis, France

29/09/05

MERIS user workshop
Objectives

- Estimation of the light penetration and visibility
- Universal algorithm for Case 1 and Case 2 waters
- Original use of the NIR region of the spectrum
Visibility: some proxies

- **Horizontal visibility** $c$
- **Light penetration** $K_d$
- **Vertical visibility** $Z_{ds}$

*Tyler 1968; Preisendorfer 1986*

- $c(\lambda) \equiv a(\lambda) + b(\lambda)$
- $K_d(z, \lambda) = -\frac{1}{E_d(z, \lambda)} \frac{dE_d(z, \lambda)}{dz}$
- $Z_{SD} = \frac{\alpha}{(K_d + c)}$

\[
\alpha = -\ln \frac{C_{obs}}{C_{SD}} \\
C_{SD} = \frac{R(SD) - R(Z_{SD})}{R(Z_{SD})}
\]
Use of the 490-nm wavelength

Coastlooc data set

$r^2 = 0.98$
Development of the algorithms: assumptions

1\textsuperscript{st} assumption

\[ R(0^-, \lambda) \approx f \frac{b_b(\lambda)}{a(\lambda)} \quad \text{with } f = \text{constant} \]

2\textsuperscript{nd} assumption

\[ a_{\text{tot}}(709 \text{ nm}) = a_w(709 \text{ nm}) \]

3\textsuperscript{rd} assumption

\[ b_{bp}(490 \text{ nm}) = b_{bp}(709 \text{ nm}) \]

Therefore

\[
\hat{b}_b(490) = b_{bw}(490) - b_{bw}(709) + \frac{a_w(709)}{f(709)} R(709) \]

\[
\hat{a}(490) = \frac{f(490)}{f(709)} a_w(709) \frac{R(709)}{R(490)} + \left( b_{bw}(490) - b_{bw}(709) \right) \frac{f(490)}{R(490)} \]

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Final forms

• 4th assumption (from the two-flow equations)

\[ K_d(\lambda) \approx \frac{a(\lambda)}{\mu_d(\lambda)} + b_b(\lambda) \quad \text{with } \mu_d \approx \text{constant} \]

\[ \hat{K}_d(490) = \left( \frac{f(490)}{\mu_d(490)} \right) \frac{1}{R(490)} + 1 \left( b_{bw}(490) - b_{bw}(709) + \frac{a_w(709)}{f(709)} R(709) \right) \]

• 5th assumption

\[ \frac{b_{bp}(490)}{b_p(490)} = \tilde{b}_{bp} = \text{constant} \]

\[ \hat{c}(490) = \left( \frac{f(490)}{R(490)} + \frac{1}{\tilde{b}_{bp}(490)} \right) \left( b_{bw}(490) - b_{bw}(709) + \frac{a_w(709)}{f(709)} R(709) \right) + b_w(490) - b_{bw}(490) \frac{1}{\tilde{b}_{bp}(490)} \]
Robustness on a simulated data set: IOCCG Case 2 waters, $\theta_s = 30^\circ$

$r^2 = 0.99$

$K_d$ estimated (m$^{-1}$)

true $K_d$ (m$^{-1}$)

$r^2 = 0.99$

true $c$ (m$^{-1}$)

$\frac{b_{bP}(490)}{b_P(490)} = \tilde{b}_{bP} = 0.0183$
Intermediate algorithm: $K_d(490)$

$K_d(490)$ estimated (m$^{-1}$)

$K_d(490)$ measured (m$^{-1}$)

+ Adriatic Sea
+ Atlantic Ocean
+ Baltic Sea
+ English Channel
+ Mediterranean Sea Case 1
+ Mediterranean Sea Case 2
+ North Sea

$1:1$

$r^2 = 0.82$
Intermediate algorithms: \( c(490) \)

Algorithm to estimate \( c(490) \)

- Adriatic Sea
- Atlantic Sea
- Baltic Sea
- English Channel
- Mediterranean Sea Case 1
- Mediterranean Sea Case 2
- North Sea

\[ r^2 = 0.74 \]
Match-ups

- No data of $K_d(490)$ or $c(490)$
- Scientific campaigns in various waters and seasons: North Sea, off California…
- Radiance over the atmosphere
- Comparison with MERIS data
- Temporal difference: +/- 2 days
- Use of the 560-nm band, adaptation to take into account the residual absorption
With the backscattering efficiency varying according to the type of water
Sources of error in the comparison between in situ $Z_{SD}$ and MERIS $Z_{SD}$

- Spatial and temporal mismatch between \textit{in situ} and satellite measurements
- Sub-pixel spatial variability in dynamic zones
- Atmospheric corrections of unknown quality
- Error in $Z_{SD}$ measurements
Secchi disk depth maps
Mediterranean Sea –
10th of February 2004
North Sea – 9th of August 2004

Transparency
Secchi depth (m)

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English Channel – 3rd of August 2005
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Transparency
Secchi depth (m)

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Baltic Sea – 5th of August 2005
Conclusion

• Very good results: the inverse model is largely valid for Case 1 and 2 waters
• Need for a better match-up data set
• Need for better atmospheric corrections
• Need for a better sensitivity at 709 nm on ocean color sensors
Acknowledgements

• Study funded by EPSHOM, ESA GSE and ACRI-ST.
• Secchi disk measurements provided by California Cooperative Oceanic Fisheries (CalCOFI), Dyfamed (in the framework of the France-JGOFS program), the Bundesamt für Seeschifffahrt und Hydrographie (BSH), the Norwegian Institute of Marine Research (IMR) and the EPSHOM.
• All MERIS data were provided by the ESA (European Space Agency) and processed at ACRI-ST.
Thank you

Any questions?
Sgagerrak and Kattegat –
11th of April 2004