Atmospheric correction in presence of sun glint
Application to MERIS
“POLYMER”

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Outline

Introduction

Algorithm principle

Results
  Level 2
  Level 3

Comparison with MODIS chl products

Conclusion
The difficulty of sun glint correction

- The sun glint can not be predicted accurately from the wind speed
- Standard atmospheric correction techniques fail when $\rho_{gli} > 0.5\%$

Observation at 865 nm

Estimation of the sun glint from the wind speed
First corrections: correct the TOA signal from gaseous absorption and Rayleigh scattering
\[ \rho_{corr}(\lambda) = \frac{\rho_{TOA}(\lambda)}{T_{oz}(\lambda)} - \rho_{mol}(\lambda) \]

Spectral matching of
\[ \rho_{corr}(\lambda) \approx c_0 + c_1 \lambda^{-1} + c_2 \lambda^{-4} + \left( T_{\downarrow\uparrow}(\lambda) \rho_w^+(\lambda) \right) \]

Atmosphere + Sun Glint Model
Ocean Water Reflectance Model

2 methods:
- Neural network method
- Iterative mean square minimization method (preferred)
Models

- We model the atmosphere + sun glint signal by a polynomial:

\[
\begin{align*}
    c_0 & \quad + \quad c_1 \lambda^{-1} \quad + \quad c_2 \lambda^{-4} \\
\text{(sun glint, clouds, foam, aerosols) } & \quad + \quad \text{(aerosols (fine mode))} & \quad + \quad \text{(couplings)}
\end{align*}
\]

- Water reflectance \(\rho_w(\lambda)\): based on Morel and Maritorena (2001). Parameters used:
  - Chlorophyll concentration [chl]
  - Suspended matter backscattering coefficient \(Bb_s\)

- 5 parameters are finally retrieved
Principle of the algorithm: remarks

▶ The choice of bands is flexible. We can use all available bands.

▶ Dealing with smile effect
  ▶ variation of the measured wavelength $\rho_{TOA}(\lambda + \Delta\lambda)$
  ▶ the method makes it possible to perform atmospheric correction at exact wavelength $\lambda + \Delta\lambda$
Example of POLYMER level 2: Mediterranean sea, 2003-07-15

MEGS 7.4
algal_1
(masked with HIGH_GLINT)

Reflectance at 865 nm
Example of POLYMER level 2: Mediterranean sea, 2003-07-15

MEGS 7.4
algal_1
(no mask)

POLYMER
[chl]
Example of POLYMER level 2: Gulf of Mexico, 2003-06-01

MEGS 7.4 algal_1
(masked with HIGH_GLINT)

Reflectance at 865 nm
Example of POLYMER level 2: Gulf of Mexico, 2003-06-01

MEGS 7.4
algal_1
(no mask applied)

POLYMER [chl]
(cloud mask disabled)
Example of POLYMER level 2: Sea of Japan, 2004-03-13

Reflectance at 865 nm

Aerosol optical thickness at 865 nm (about 0.5)
Example of POLYMER level 2: Sea of Japan, 2004-03-13

MEGS 7.4 algal_1 (no mask applied)

POLYMER [chl]
Example of POLYMER level 2: Sea of Japan, 2004-03-13

Polynomial coefficient $c_0$
(corrects spectrally flat components)

Polynomial coefficient $c_1$
(spectral dependency $\lambda^{-1}$, mainly aerosols)
Global coverage increase (Level 3)

MERIS [chl] MEGS 7.4
(masks HIGH_GLINT, ABSOA_DUST, PCD_1_13)

MODIS [chl]
(3 daily level 3 from OC Web)

3 days composite
June 3-5, 2003

Coverage increase with respect to standard product:
about a factor 2

POLYMER [chl]
(with POLYMER cloud mask)
Level 3 parameter: detail

- Sea of Arabia, 3-5 juin 2003, MODIS [chl]
Level 3 parameter: detail

▶ Sea of Arabia, 3-5 juin 2003, MERIS MEGS 7.4 [chl]
Level 3 parameter: detail

- Sea of Arabia, 3-5 juin 2003, POLYMER [chl]
Monitoring dynamic phenomena

Sequences of 3 days composites
June - December, 2006

- Equatorial divergence
- Upwelling offshore Venezuela
Comparison with MODIS level 3 daily [chl] (2003-06-05)

MERIS MEGS 7.4 vs. MODIS

POLYMER [chl] (common with MEGS) vs. MODIS

POLYMER error vs. $\rho_{corr}(865)$

POLYMER [chl] vs. MODIS
### Comparison with respect to MODIS: statistics

<table>
<thead>
<tr>
<th></th>
<th>MERIS MEGS 7.4</th>
<th>POLYMER common with MEGS 7.4</th>
<th>POLYMER</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\Delta \log_{10}(\text{chl})$ bias stderr</td>
<td>21.2% 24.6%</td>
<td>14.9% 29.5%</td>
<td>16.6% 26.4%</td>
</tr>
<tr>
<td>Number of pixels</td>
<td>$9.1 \times 10^5$</td>
<td>$9.0 \times 10^5$</td>
<td>$1.75 \times 10^6$</td>
</tr>
</tbody>
</table>

(Comparison for latitude between $\pm 20^\circ$)

- **Accuracy of the [chl] retrieval:**
  - compares to MEGS 7.4 algal-1 parameter for low [chl]
  - slightly lower for high [chl]
Conclusion

- An original method to make atmospheric and sun glint correction
- Retrieves the [chl] parameter and water reflectances derived from the model
- Robust to the sun glint and semi-transparent clouds
- Very large increase of the global coverage ($\times 2$)
- Used in near real time by CLS since sept. 1st
- Can be easily applied to other sensors

Prospects

- Optimize the choice of bands
- Validation against in-situ data (reflectances spectrum)
- Try to retrieve water reflectances independently of the water reflectance model?