Sun Glint Correction + HyspIRI for Coral Reef Science

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Problem: Glint obscures subsurface features

AVIRIS
f000412t01p03_r08_sc03-04
Kaneohe Bay, Oahu, Hawaii
The deglintoning technique relies on the relationship between NIR and VIS wavebands. It is important to derive glint statistics from an image region of interest (ROI) that is relatively homogenous with respect to subsurface features. Otherwise, the NIR-VIS relationship can be biased by changes in (for example) seafloor albedo. Optically deep water works well.
Hochberg et al. (2003) use the NIR band to find the pixels that have minimum and maximum glint contributions within the ROI. The min/max glint pixels are used to relate relative glint intensity in the NIR to absolute glint intensity in each VIS waveband. Deglinting is accomplished by subtracting scaled glint intensity from the VIS band.

Hedley et al. (2005) recognized that using only the min/max glint pixels (green dots) makes the deglinting process sensitive to outliers. They suggested a linear regression using all pixels in the selected ROI (blue dots), where the slope between NIR and each VIS band represents the best scaling factor:

Deglinted residual = VIS - NIR x slope
The image prior to deglinting exhibits surface clutter that obscures subsurface features. (Image is masked to highlight aquatic areas.)
The deglinting result is an image free of sea surface clutter, significantly enhancing detection of subsurface features. Note that this example was performed without prior atmospheric correction; further processing would be required to derive calibrated water-leaving radiances.
\[
\theta_t = \sin^{-1}\left(\frac{1}{n_w} \sin \theta'\right)
\]

\[
r(\theta') \equiv \frac{1}{2} \left\{ \frac{\sin(\theta' - \theta_t)}{\sin(\theta' + \theta_t)} \right\}^2 + \left\{ \frac{\tan(\theta' - \theta_t)}{\tan(\theta' + \theta_t)} \right\}^2
\]
VIS = 2.70 \times \text{NIR} + 2217.5
f000416t01p03_r03

VIS = 2.69\times\text{NIR} + 2269.2
deglinted using mean slope
- Rough
- High productivity/calcification
- “Healthy”

- Smooth
- Low productivity/calcification
- Not “healthy”
- ~9,000 reefs in the world, covering 500,000 km²
- spread across 200,000,000 km² of ocean
- Quantitative in situ surveys cover only 10s to 100s of km² worldwide
- Only 0.01–0.1% of the world’s reef area
Capabilities of remote sensors to classify coral, algae, and sand as pure and mixed spectra

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Table 1
Classification error matrices for in situ spectral reflectances of three coral reef classes: coral, algae, and carbonate sand

(A) Full-resolution: overall accuracy = 98%

<table>
<thead>
<tr>
<th>Actual class</th>
<th>Algae</th>
<th>Coral</th>
<th>Sand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Predicted class</td>
<td>Algae 2726 (99.2)</td>
<td>75 (3.3)</td>
<td>1 (0.3)</td>
</tr>
<tr>
<td></td>
<td>Coral 23 (0.8)</td>
<td>2168 (96.6)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td></td>
<td>Sand 0 (0.0)</td>
<td>1 (0.0)</td>
<td>320 (99.7)</td>
</tr>
</tbody>
</table>

(C) AVIRIS: overall accuracy = 98%

<table>
<thead>
<tr>
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<th>Coral</th>
<th>Sand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Predicted class</td>
<td>Algae 2725 (99.1)</td>
<td>74 (3.3)</td>
<td>1 (0.3)</td>
</tr>
<tr>
<td></td>
<td>Coral 24 (0.9)</td>
<td>2170 (96.7)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td></td>
<td>Sand 0 (0.0)</td>
<td>0 (0.0)</td>
<td>320 (99.7)</td>
</tr>
</tbody>
</table>
Figure 6. Example of CRESPO processing, based on AVIRIS scene of Kaneohe Bay, Oahu, Hawaii. (A) True-color composite of measured at-sensor radiances, including water column, sea surface and atmospheric radiative transfer effects. (B) The same scene after correction for radiative transfer effects—this is the reef without water. (C) The scene after classification. Reds are varying amounts of coral, greens are varying amounts of algae, pink is pavement, and yellow is sand. The classification map is draped over the depth image product to highlight three-dimensional structure of the reef.
Figure 1.1. Flowcharts showing the logic behind the MOD17 Algorithm in calculating both (a) 8-day average GPP and (b) annual NPP.
GPP = \( E_d \times A \times \varepsilon \)

\( \text{mol C/O}_2 \text{ m}^{-2} \text{ d}^{-1} \) \hspace{1cm} \text{mol photons m}^{-2} \text{ d}^{-1} \hspace{1cm} \text{mol C/O}_2 \text{ mol}^{-1} \text{ photons} \)
Coral reef benthic productivity based on optical absorptance and light-use efficiency

E. J. Hochberg · M. J. Atkinson
rim: 150 km²
rim + lagoon: 1,500 km²