Retrieving Optical Parameters of Coastal Waters Using Hyperion Data
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Satellite remote sensing of the bio-optical parameters of coastal waters can be an important way of monitoring the coastal environment. The currently operating ocean color instruments such as MODIS and SeaWiFS meet the needs of global ocean monitoring, but their spatial resolution is too coarse for coastal applications. High-resolution Landsat-type satellite sensors often do not have the spectral specificity for quantitative study of the coastal waters. These instruments have a limited number of spectral bands. Their broad bandwidths have a high signal-to-noise ratio (SNR) but lack spectral specificity. High-resolution hyperspectral instruments are required to perform quantitative analysis of coastal systems.

The Hyperion instrument on-board the EO-1 satellite is designed primarily for land applications, and its SNR is often thought to be sub-optimal for ocean applications. Nevertheless, Case II waters, such as coastal waters with high sediment load, usually have a higher reflectance in the visible wavelength region than the clear Case I waters in open oceans. Hence, the SNR of Hyperion data over coastal waters may be sufficiently high so that meaningful measurements of the optical properties of the coastal seawaters are possible. The objective of this study was to investigate how well the Hyperion data could be used to retrieve the optical properties of coastal waters.

The study approach involved spectral fitting of the hyperspectral reflectance spectra to a model that included both the atmospheric effects and the scattering and absorption of light by seawater constituents (Figure 1). The optical parameters retrieved were the absorption coefficients of chlorophyll and dissolved organic matter, and the backscattering coefficient of suspended sediments, all evaluated at a reference wavelength of 400 nm. The results were compared with the MODIS Level 2 ocean products for an almost-simultaneous MODIS scene acquired on the same day as the Hyperion data acquisition. Figure 2 shows a Hyperion image and a MODIS image of the same area of the South China Sea. Both images are similarly stretched. The color and intensity features of both images are practically identical.

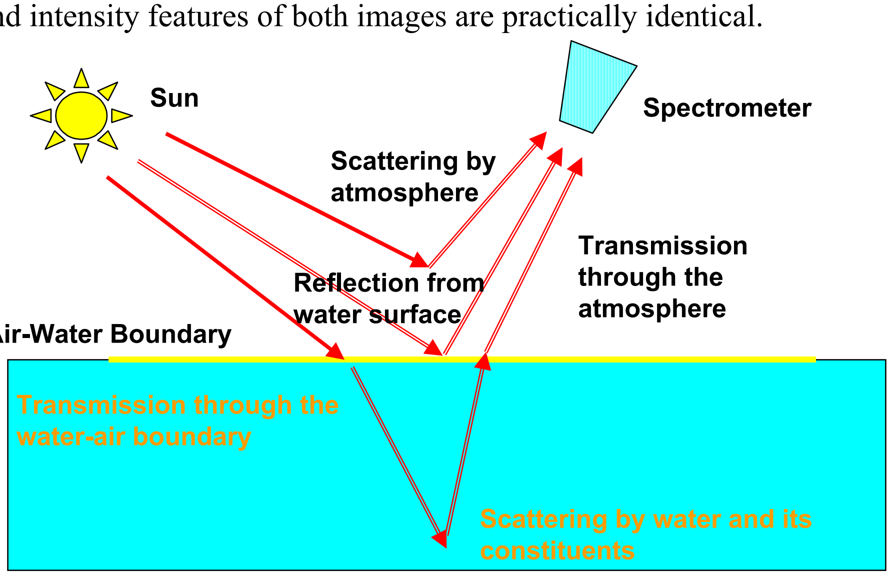

Figure 1. Reflectance measurement.

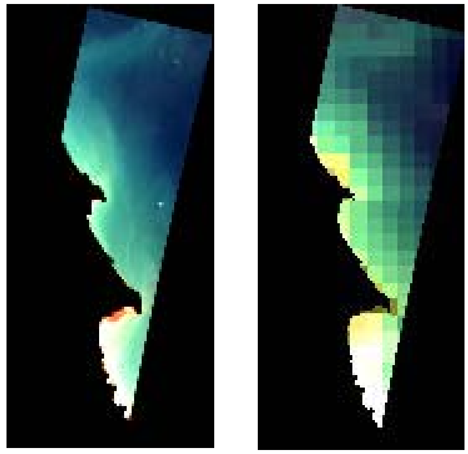

Figure 2. Left: Hyperion image (Day 137, 2001) of the South China Sea off the southeastern coast of Peninsular Malaysia, about 100 km north of Singapore. (Red: 671nm, Green: 550 nm, Blue: 489 nm). Right: MODIS image of the same area. (R: 667 nm, G: 551 nm, B: 490 nm)

The study indicated that the water leaving radiance derived from Hyperion data had a good correlation with the corresponding MODIS Level 2 parameters (Figure 3). The scattering coefficient of suspended solids and absorption coefficient of colored dissolved organic matter (CDOM) retrieved from Hyperion correlated strongly with the band ratio of reflectances at 489 nm and 550 nm. The retrieved chlorophyll absorption at 440 nm had a weaker correlation with the band ratio (Figure 4). The MODIS-derived chlorophyll absorption and CDOM absorption (Figure 5) seem to correlate well with the Hyperion-derived CDOM absorption. The conventional band ratio-based algorithms for chlorophyll retrieval were known to have problems when applied to coastal waters where scattering from sediments and absorption of dissolved organic matter complicate the retrieval of chlorophyll. Using hyperspectral data and a suitable model of the water-atmosphere system, the backscattering and absorption coefficients of the three constituents of coastal water could be retrieved.

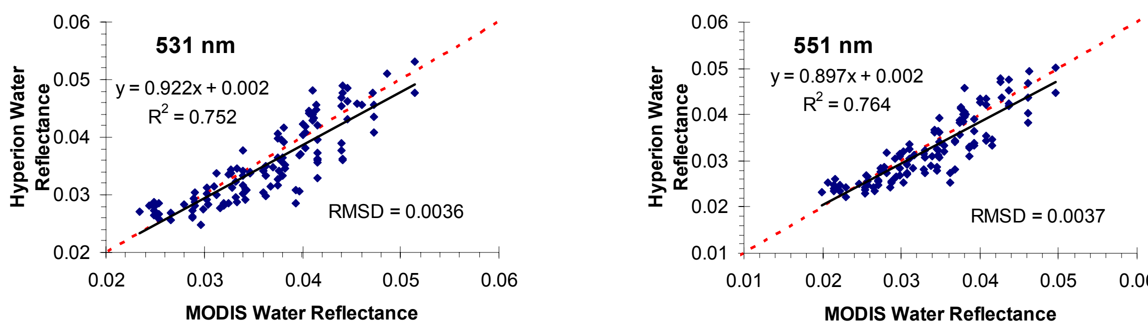

Figure 3. Scatter plots of Hyperion and MODIS Level 2 water leaving reflectance.

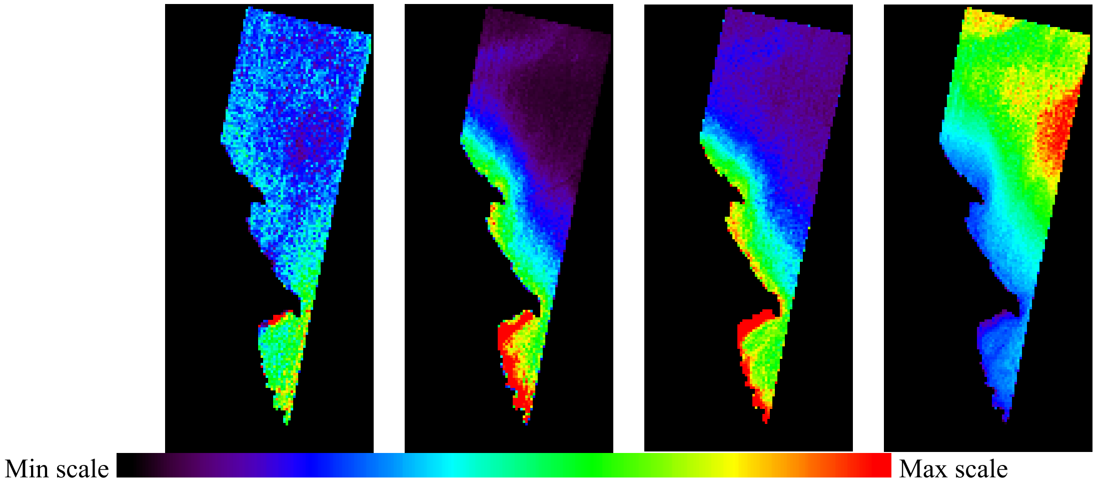

Figure 4. Maps of seawater optical parameters derived from Hyperion data. From left to right: Chlorophyll absorption coefficient at 440 nm. (Min. scale = 0, max. scale = 0.048 m^{-1}); suspended sediments backscattering coefficients at 440 nm. (Min. scale = 0, max. scale = 0.24 m^{-1}); CDOM absorption coefficient at 440 nm (Min. scale = 0, max. scale = 0.80 m^{-1}); reflectance band ratio R489 nm/R550 nm (Min. scale = 0.6, max. scale = 1.4).

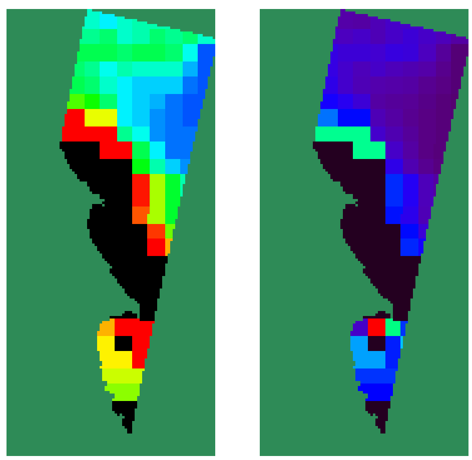

Figure 5. Left: MODIS OCL2B chlorophyll absorption coefficient at 670 nm (Max scale = 0.043 m^{-1}). Right: MODIS OCL2B CDOM absorption coefficient at 400 nm (Max scale = 0.78 m^{-1}).

Conclusions: Investigators concluded that Hyperion data could be used to derive coastal water optical parameters; they have developed a technique to derive these parameters from Hyperion-measured reflectance spectra by using a coupled atmosphere-seawater reflectance model. The problem of low SNR could be overcome by averaging over a larger area (10 x 10 pixels), an acceptable approach for seawater. Investigators found good agreement between Hyperion TOA (top-of-atmosphere) reflectance and MODIS Level 1 TOA reflectance and also good agreement between Hyperion-derived water leaving reflectance and MODIS Level 2 water leaving reflectance. Chlorophyll absorption coefficient at 440 nm retrieved from Hyperion had a low correlation with MODIS chlorophyll concentration. However, MODIS chlorophyll concentration seemed to correlate well with the Hyperion-derived CDOM absorption coefficient.