The Use of Simulated Visible/Infrared Imager/Radiometer Suite (VIIRS) and Landsat Data Continuity Mission (LDCM) Imagery for Coral Reef Monitoring

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INTRODUCTION

Coral reefs are some of the most biologically rich and economically important ecosystems on Earth. Coral reefs are Earth's largest biological structures and have taken thousands of years to form. Coral reefs not only provide important habitat for many marine animals and plants, but they also provide humanity with food, jobs, chemicals, protection against storms, and life-saving pharmaceuticals.

Severe bleaching events have occurred that have dramatic long-term ecological impacts to corals, including loss of reef-building corals, changes in benthic habitat, and, in some cases, changes in larval fish populations (Holden and Ledrew, 1998). Some researchers suggest that 10 percent of Earth's coral reefs have already been destroyed and that another 60 percent are in danger. Scientists have proposed that as much as 95 percent of Jamaica's reefs are dying or dead.

This poster reports on a Rapid Prototyping Capability (RPC) experiment done to determine whether future NASA sensors – the Visible/Infrared Imager/Radiometer Suite (VIIRS) and Landsat Data Continuity Mission (LDCM) – could generate key data products for the Integrated Coral Reef Observation Network (ICON)/Coral Reef Early Warning System (CREWS) Decision Support Tool (DST) operated by the National Oceanic and Atmospheric Administration (NOAA).

DATA PROCESSING FOR SELECTED SITES

Sites selected were Looe Key, FL, and Kaneohe Bay, HI. EO-1 Hyperion image data over Looe Key, FL, located at NOAA's National Coastal Data Development Center was collected in autumn (October 26, 2002). The imagery was composed of 242 bands that covered the spectral range from 355 nm to 2577 nm with 10 nm bandwidth. Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) imagery over Kaneohe Bay was obtained from NASA's Jet Propulsion Laboratory archive. AVIRIS provides for 224 channels over a range of 380 nm to 2500 nm. The AVIRIS data over Kaneohe Bay was flown on a Twin Otter on March 1, 2005. This provided ~ 3.7 m pixels and a 1.9 km swath.

Preprocessing the image data included the following:
1) subsetting bands, 2) spatial cropping of image,
3) creating a land mask, 4) assessing striping, 5) removing bad lines, 6) performing an atmospheric correction on the imagery, and 7) deglinting the image.

The atmospheric correction employed a cloud-shadow technique (Reinersman et al., 1998; Lee, 2007). This method was applied to compute the atmospheric radiance contribution using two nearby pixels in which one pixel was cloud-shaded and the neighboring pixel was in direct sunlight.

RAPID PROTOTYPING CAPABILITY

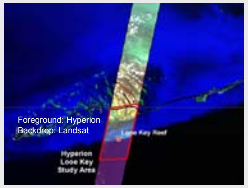
Algorithms for spectral and spatial syntheses were applied to the preprocessed Hyperion and AVIRIS datasets to generate the simulated VIIRS and LDCM data products (Zanoni et al., 2002).

Spectral synthesis yielded useful yet less accurate results for the VIIRS bands than for the LDCM bands because the VIIRS bands are narrower (~15–20 nm) than the LDCM bands and are not much broader than the hyperspectral channels (~10–15 nm) used as input to the simulations. Spatial synthesis was conducted by pixel aggregation that combined low-pass filtering with subsampling. Filter weights were determined from a two-dimensional Gaussian Point Spread Function with full width half maximum that provided expected spatial resolution.

LOOE KEY

Looe Key is located in the Lower Florida Keys approximately 5 nautical miles south of Big Pine Key, FL. Looe Key reef is estimated at 200 yards wide and 800 yards long. The morphology is a horseshoe-shaped region of marginal and patch-reefs. Figure 1 shows a subset of the Hyperion image of the Looe Key area.

Figure 1.



Cannizzaro and Carder (2006) have published ocean color algorithms for optically shallow waters that take into account the use of larger footprint and fewer, broader bands of multispectral sensors and the influence of the sea bottom. Using their approach, a chlorophyll [Chl] concentration image was computed for the Looe Key area. Next, Haltrin (1999) has developed an in-water optical model that parameterizes other water optical properties in terms of [Chl]. The model inputs [Chl] imagery and allows a computation of absorption, *a*, and scattering, *b*, images.

Using a water depth image and optical model, a computation of the water column reflectance was made and subtracted from the total water leaving radiance, *Lw*, to yield bottom return only. This spectral image was used to classify the targeted benthos. A feed-forward, neural net classifier was implemented in the classification work.

KANEOHE BAY

Kaneohe Bay is the largest sheltered body of water in the Hawaiian Islands. The chief physiographic zones of Kaneohe Bay are primarily the inshore-inner bay and outer bay. Numerous patch reefs, rising to less than a meter from the surface, typify the inshore section. The entire shoreline is edged by a fringing reef about 0.5 m deep. The outer bay portion consists of an extensive shallow coral/sand reef of about 0.4 m in depth. Figure 2 exhibits an image of the study area.

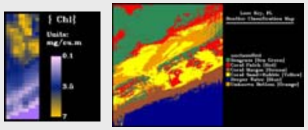
Figure 2.

The processing steps for the AVIRIS data paralleled that of the Hyperion data discussed above. The swath width of the low-altitude AVIRIS dataset (< 5 m pixel size) was not expansive enough for VIIRS simulation (~ 750 m pixel). However, the AVIRIS imagery was important for simulating LDCM and for associated products used in the study.

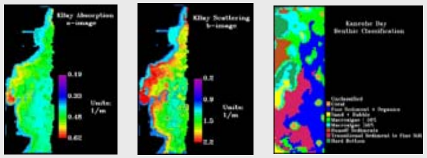
RESULTS

Figure 3a shows a [Chl] image for Looe Key based on simulated VIIRS data. The tan areas near the top of the image are land features. Figure 3b shows the Looe Key benthic classification map based on simulated LDCM data. LDCM RPC imagery was used to compute benthic habitat maps.

Figures 3a and 3b.



Figures 4a, 4b, and 4c show the absorption, scattering, and benthic classification maps for Kaneohe Bay based on LDCM simulated data. Only the central portion of Kaneohe Bay was used to produce Figure 4c.

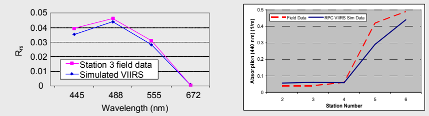


Figures 4a, 4b, and 4c.

DISCUSSION

The validation effort involved locating appropriate ground truth data for Looe Key, FL, and Kaneohe Bay, HI. Six stations of optical data were available from Naval Research Laboratory for the Looe Key site. Of these, only five stations were in the image field. These data consisted of water depth, spectral remote sensing reflectance, and water absorption measurements. Kaneohe Bay ground truth consisted of only a bottom-type map.

Figures 5a and 5b display a comparison between field and processed RPC VIIRS R_{rs} (5a) and absorption data (5b) for Looe Key. For Looe Key, the field R_{rs} and absorption data displayed mean bias values of ~30% and ~27% respectively, compared to image data. Benthic classification map results for Looe Key and Kaneohe sites were both ~75 percent in agreement with field data.



Figures 5a and 5b.

CONCLUSIONS

The results suggest future sensors like VIIRS and LDCM could provide water quality parameters and seabed habitat distributions for ICON/CREWS DST. This assumes that the sensors meet design goals. Recently, there has been concern that VIIRS may not meet required spectral radiometric accuracies due to spectral response issues for particular bands. The present results are limited by availability of information about performance of these sensors. The simulations used in this study are based on nominal or preliminary information available for the VIIRS and LDCM sensors, and they do not attempt to account for the effects that cause current concerns about VIIRS.

RELEVANT REFERENCES

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