Change detection in Hawaiian coral reefs from 2000-2017 using AVIRIS and simulated HyspIRI Imagery: Initial Results

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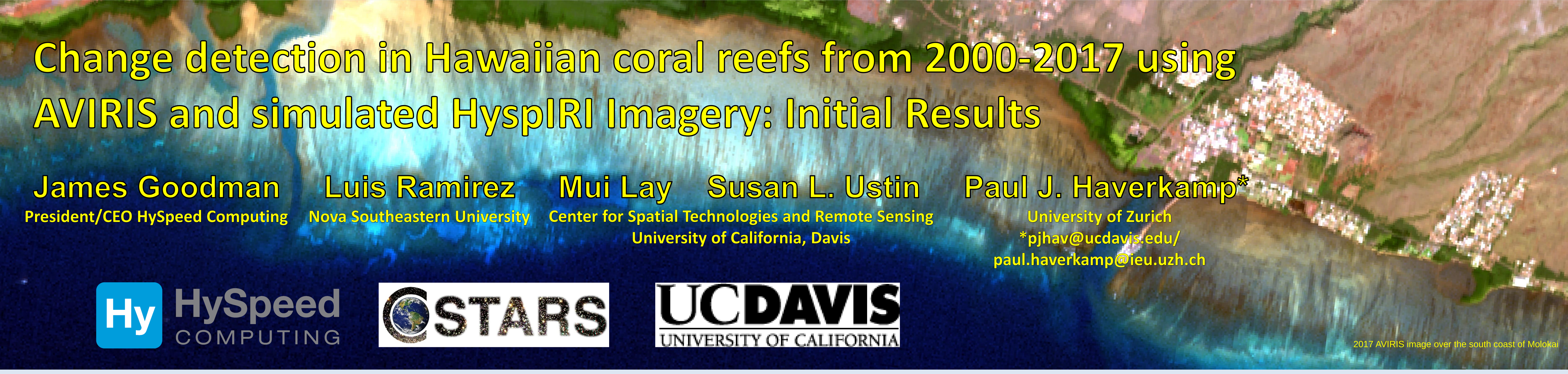

2017 AVIRIS image over the south coast of Molokai

Project Overview

Coral reefs are extremely diverse ecosystems supporting up to 25% of marine fish species. Coral reefs are also highly susceptible to environmental stressors caused by climate change and development, including ocean acidification, near-shore pollution and sedimentation, as well as increasing ocean temperatures. To better understand how this ecosystem is responding to climate change, we will use simulated HyspIRI (AVIRIS) data from 2017 and the early 2000s to identify changes in benthic habitat (coral, algae, and sand) and investigate links to environmental factors (e.g., sea surface temperature, cloud cover, irradiance). We will also investigate how land-use/land-cover change affects the system and develop predictive models to better understand what causes shifts in benthic community structure.

Project Goals

This project will identify changes in coral, sand, and algae in Kaneohe Bay, the south coast of Molokai, and the French Frigate Shoals by comparing benthic classifications from the early 2000s and 2017. To meet this goal, we will:

1. **Develop workflows for processing future HyspIRI and AVIRIS benthic scenes.**
2. **Investigate how different image resolutions impact benthic classification.**
3. **Identify environmental factors that influence benthic habitat change.**

Field Data Collection

In February 2017, we collected field data in Kaneohe Bay, visiting 11 reefs and taking over 145 dive transect photos. We also visited 44 sites and collected over 200 dive transect and drop camera photos off the south coast of Molokai (Figures 1 & 2). All photos were identified to the seafloor habitat and coral type levels (Table 1). These will be used to classify coral, sand, and algae in the AVIRIS images, and identify areas of change between 2000 and 2017.

Figure 1. Dive transects collected nearly 350 images in Kanehoe Bay and off of the south coast of Molokai. Percent cover of coral, sand, and algae were determined for each photo and will be used to train and test benthic habitat classification methods. Bottom panel shows two dive transect images. Photo credits: top – Tom Bell, bottom Luis Ramirez

Table 1. Seafloor habitat and coral type cover percentage for all dive transect photos in Kaneohe Bay and off the southern coast of Molokai.

	Kaneohe Bay	Molokai
Hard Branching Coral	54.33	32.07
Table Coral	1.54	1.16
Soft Coral	0.00	0.01
Encrusting Coral	0.76	10.33
Coralline Algae	0.35	0.00
Green Algae	0.60	1.27
Hardground	0.87	3.13
Rubble	4.96	19.11
Sand	18.08	18.21
Dead Coral	18.07	14.81

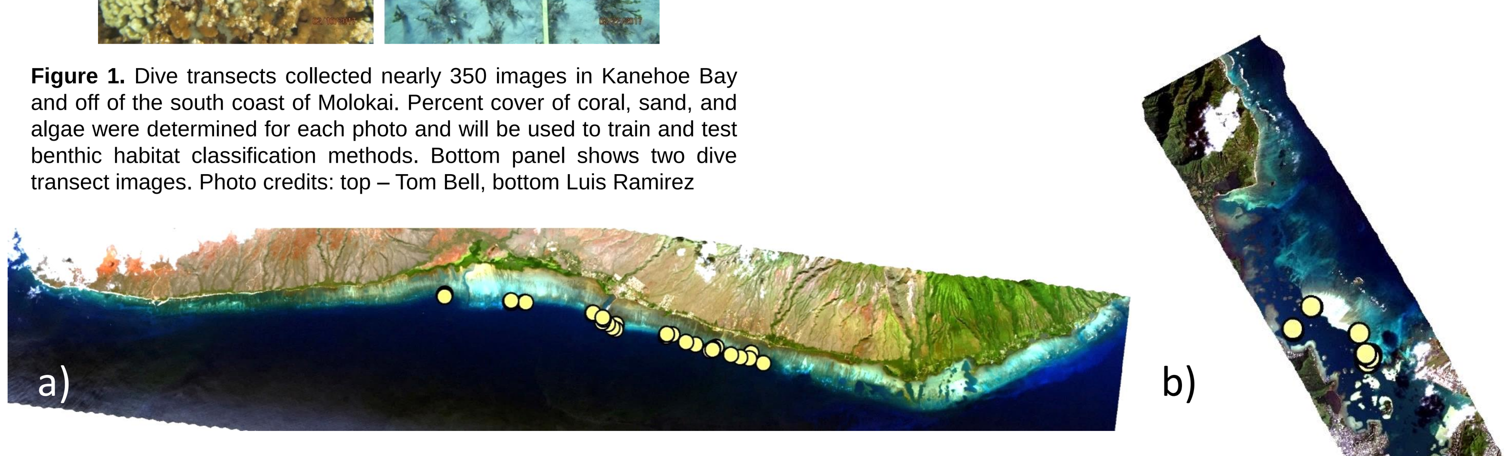

Figure 2. AVIRIS images of the south coast of Molokai (a) and Kaneohe Bay (b) from 2017. Yellow points identify locations of dive transect and drop camera photos at each field site.

Workflow Processing

Our image processing workflow includes: radiometric, geographic, and atmospheric correction from NASA (with alternative atmospheric correction if needed); masking of land, clouds and shadows; sun glint correction; application of an inversion model for water depth and water properties; and multiple options for benthic classification. **Winston Olson-Duvall** and **David Thompson** from JPL worked with our team to generate L2 native resolution products for the older 2000 and 2001 data that is comparable to the 2017 images. This process involved shepherding the older flight lines through the current methods by manually prepping and troubleshooting each step. The main difficulty was in identifying the incompatibilities between the older data and what the current pipeline expected. The final version of the L2 reflectances for the older images were generated by applying the correct gains, generating a compatible wavelengths file, and manually supplying flight parameters using the older flight logs. Spectral reflectances are now comparable between dates (Figure 3).

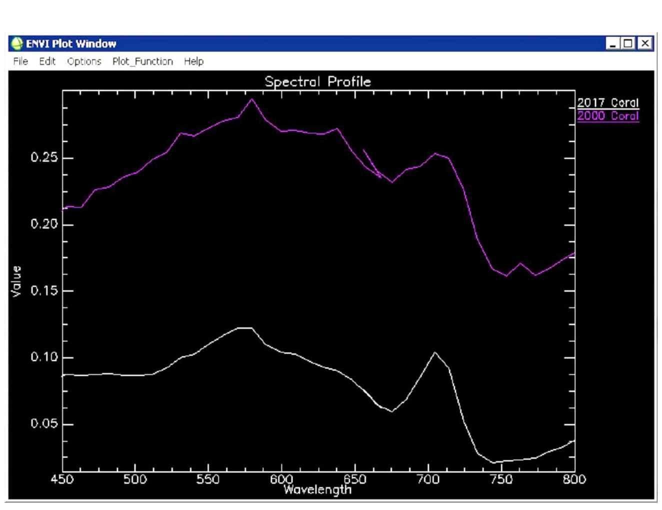

Figure 3. Spectral reflectance of a coral pixel from the 2017 and 2000 Kaneohe Bay images. Further magnitude corrections can be made to help with comparison. This is the same location seen in Figure 5.

Masking and Sunglint Removal

Before inversion, we need to remove the extent of land and clouds in the images to focus the analysis exclusively over the water and coral areas. We are investigating automated methods to identify and mask land, clouds, and shadows in the images to streamline future processing (including for HyspIRI missions). After the land and clouds/shadows are masked, sunglint is removed from the image to reduce noise. The next step will involve a spectral inversion to derive water depth and convert surface reflectance to benthic reflectance. Benthic reflectance will be used for habitat classification to be verified using field collected habitat data, including images and GPS points.

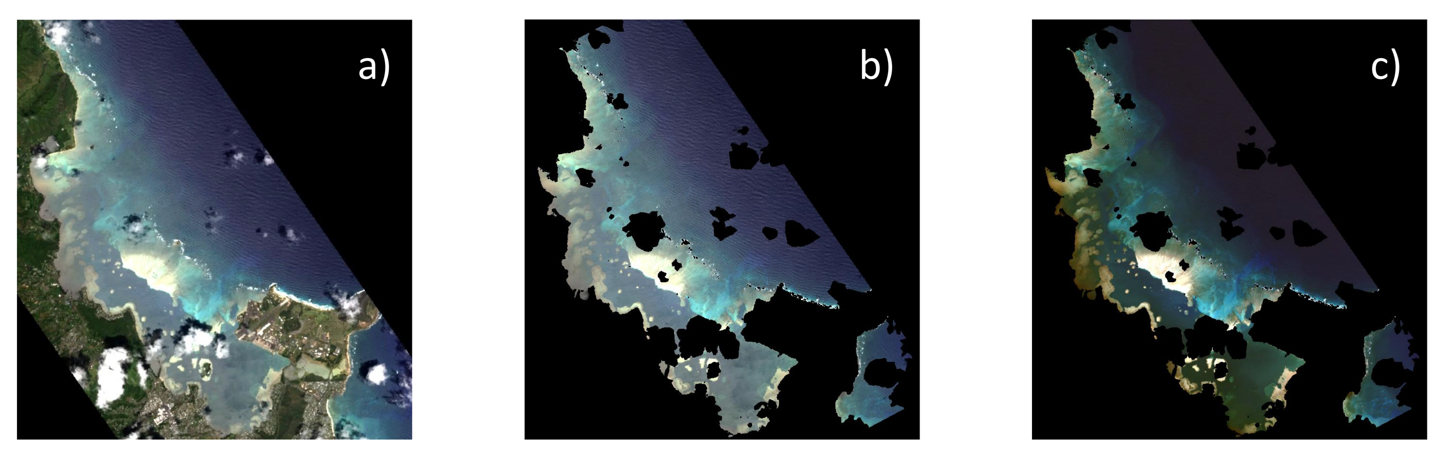

Figure 4. Series of images showing processing steps: (a) Kaneohe Bay raw AVIRIS image from 2000, showing land, clouds, shadows and sunflint. (b) same image with land and cloud/shadow mask applied. (c) image after sunglint removal. The final image (c) will be use in the inversion to derive water depth and benthic reflectance.

Resampling Concerns

As the AVIRIS native resolution images are scaled to HyspIRI resolution (30m/60m), we need to be aware of problems arising from different resampling methods. Figure 5 Illustrates the different GPS locations of a field data point at different image resolutions. Figure 6 shows the spectra at this point (with 100% coral cover) at the different resolutions, while Figure 7 highlights another point with high algae cover at different resolutions.

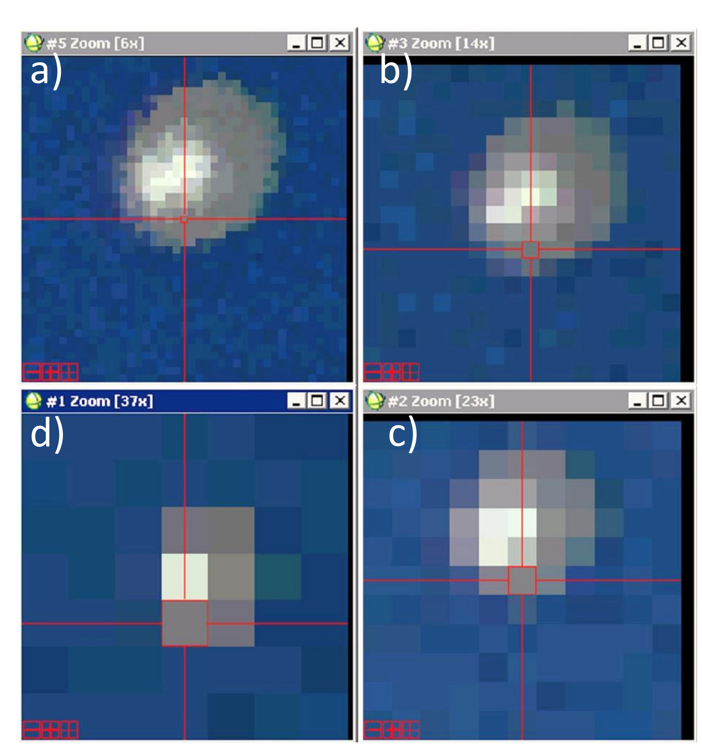

Figure 5. Location of the same GPS location at different image resolutions: (a) native image resolution of 7.3m. (b) image resampled to 18m, comparable to other AVIRIS images. (c) image resampled to 30m, similar to Landsat. (d) image resampled to 60m, proposed HyspIRI resolution.

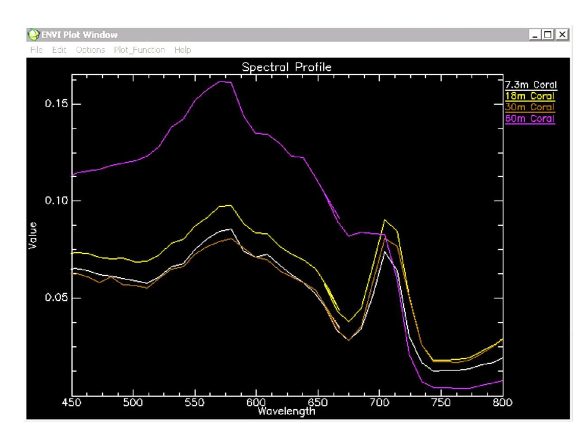

Figure 6. Comparison of reflectances of a pixel with 100% coral cover at the same GPS location, but different image resolutions. Location is same as in Figure 5.

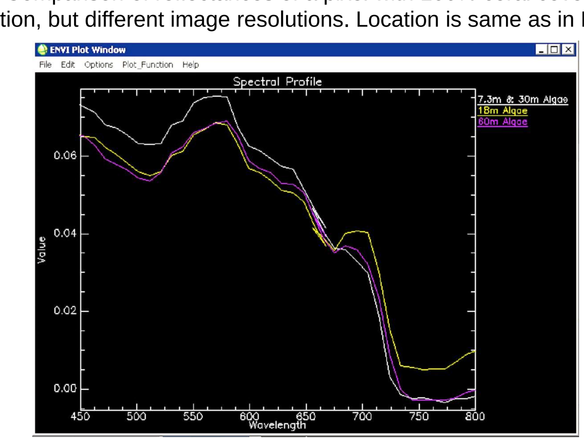

Figure 7. Comparison of reflectances of a pixel with majority algae cover at the same GPS location, but different image resolutions for the 2017 Kaneohe Bay image. Note that the 30m pixel was resampled to have the same reflectance as the 7.3m pixel.

Future Work

We are now working with the masked and sunglint removed images to develop benthic reflection and benthic habitat classification images for the two time periods. We will use these classifications to identify change between years. We are also gathering environmental and land use/land cover change data over the same time periods to examine relationships between environmental change and benthic habitat change. Throughout this research, we plan to streamline the image processing method to allow for a benthic habitat change detection product for the HyspIRI platform, as well as use other AVIRIS images to test this processing method for future and other locations.

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