

CALIBRATION AND VEGETATION FIELD SPECTRA COLLECTION FOR THE 2000 AVIRIS HAWAII DEPLOYMENT

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Introduction

As part of the April 2000 AVIRIS Hawaii deployment, two researchers from the University of California, Santa Barbara, were sent to Hawaii to collect supporting field data. The primary goal of the fieldwork was to obtain spectra of bright targets to be used for retrieving surface reflectance from AVIRIS imagery. Secondary goals included recording the spectra of dominant vegetation, marking the position of homogeneous land cover for use as potential image endmembers (PIEs), and recording firsthand impressions of cover types. Primary and secondary goals were met. Spectra were recorded for 12 calibration targets on 5 islands and spectra were obtained for 61 vegetation species. Twenty PIEs were located, and video was used to document cover at 56 locations.

Background

An analytical spectral devices full range (FR) spectrometer was used to measure surface radiance. The FR spectrometer samples at an interval of 1.4 nm between 350 and 1000 nm and at an interval of 2.0 nm between 1000 and 2500 nm (Analytical Spectral Devices, Boulder, Colorado). A spectralon panel was used as a reference standard. Raw digital numbers (DNs) were recorded for both the material being measured and the standard. A differential global positioning system (GPS) was used to record the location of spectra, PIEs, and video recordings. The United States Coast Guard (USCG) differential signal was used to enhance positional accuracy. Coverage by the USCG signal was spotty and in many locations differential correction was not available. Estimated positional error, supplied by the GPS unit, was recorded for most locations.

Calibration Targets

Possible calibration targets were evaluated on the basis of their brightness, size, and probable Lambertian behavior. High reflectance, approximate Lambertian targets at least 40 meters by 40 meters in size were sought. Past experience from Southern California AVIRIS reflectance retrieval (Roberts et al., 1998) has shown that beaches provide excellent calibration spectra. Nine of the 12 documented targets are beaches (Table 1). One gravel and 2 bare soil targets were also acquired. Clouds restricted our ability to measure several of the calibration targets. Spectra were recorded in transects along each of the targets, except where noted.

Spectra of 5 calibration targets were recorded on Oahu. The highest-quality calibration site on Oahu was Waimea Bay Beach. Makaha Beach, on the west side of the island, was slightly smaller but was plagued by cloud cover. Waimea Bay Beach and Makaha Beach were the only beaches on Oahu to fit the target size criterion. A bright, flat field, recently cleared and graded for an industrial park, was found north of Kapolei. There was no activity at the site during two site visits on April 5th and April 7th, but the site likely saw activity soon afterward. Reflectance at this site appeared to be less homogeneous than at Waimea Bay or Makaha beaches. Spectra were also taken at Ala Moana Beach and at Kahe Point Beach; however, these beaches may not be wide enough to ensure a pure pixel within an AVIRIS image.

The Big Island (Hawaii) has few wide coral beaches. The best beach target on the island was Hapuna Beach, south of Kawaihae. The pier at Kawaihae, constructed of crushed rock, is also an adequate calibration target. The pier is a larger target but is probably less Lambertian than Hapuna beach. Cloud cover and a lack of wide, bright beaches prohibited obtaining a calibration target for the east side of the Big Island. Calibration targets were also difficult to find at high elevation. Spectra were taken along a transect of a sparsely vegetated hillslope at an elevation of 3000 meters on Mauna Kea. The slope of the target was measured at 14 deg, so it may be difficult to use for calibration.

Majors Bay Beach was the only calibration target on Kauai that fit the target criteria. The transect of Majors Bay Beach was interrupted by clouds, so the quality of the spectra is unknown. Cloud cover also interfered with obtaining spectra on Maui and Molokai. Sand samples from Oneloa Beach (Maui), the Kalaupapa Peninsula (Molokai), and Papohaku Beach (Molokai) were removed and sealed in plastic bags. The spectra of these samples were measured in Santa Barbara. A high-quality, cloudless transect of Papohaku Beach was done after the sample

was taken. Papohaku Beach was the widest beach encountered in the islands, and is considered the better of the two calibration targets for Molokai. Comparison of spectra from Kalaupapa and Papohaku Beach reveal differences in sand composition (Figure 1). The Papohaku beach spectrum indicates a deeper broad absorption feature between 800 and 1100 nm, possibly due to higher iron content. Carbonate absorption is evident in both beach spectra.

Vegetation species

Meetings with U.S. Fish and Wildlife, National Park Service, and National Tropical Botanical Garden scientists produced a list of important native and non-native vegetation species in the Hawaiian Islands. Dominance, prevalence, vegetation height, and likelihood of cloud cover were all considered in creating the list. Agricultural crops were given lowest priority, since their spectra can be collected from other sources or using PIEs. The variety of spectra is less than desirable for a few of the species. For example, *Metrosideros polymorpha*, although abundant, was only measured in a few locations within Volcanoes National Park, where stature is shorter and cloud cover was not a problem. Spectra were obtained for native rainforest dominants, including *Acacia koa* and *Metrosideros polymorpha*, lowland dominants including *Aleurites moluccana*, *Grevillea robusta*, *Hibiscus tiliaceus*, and *Syzygium cumini*, and dry montane dominants, including *Sophora chrysophylla* and *Styphelia tameiameia*. Important invasive species sampled include *Lantana camera*, *Pennisetum setaceum*, *Schinus terebinthifolius*, and *Ulex europaeus*.

PIEs and Video Documentation

Large areas with homogeneous cover can be extracted from an AVIRIS image to obtain a relatively pure image endmember. Sites at least 40 meters by 40 meters, approximately four times the size of an AVIRIS pixel, can be selected as potential image endmember (PIE) sites. PIEs were also used when cloud cover or high canopies prevented direct spectral measurement. PIE locations were recorded and will be used to extract image endmembers from registered AVIRIS images. PIEs included agricultural crops (ex: coconut, sugar cane, pineapple, taro), homogeneous vegetation cover (ex: *Prosopis pallida*, *Bambusa vulgaris*) and non-vegetated areas (ex: basalt flows).

Video was used to document calibration targets and PIEs. Video was also recorded in locations that offered commanding views of surrounding terrain. This video footage will be used to assist image interpretation.

Results

Spectra were averaged and processed to reflectance. A total of 182 calibration reflectance spectra and 884 vegetation reflectance spectra were produced. Sixty species are represented in vegetation library. Calibration spectra are freely available for reflectance processing of AVIRIS data; contact the authors to receive a copy of the calibration library. The vegetation library and PIEs will be used to build regionally specific spectral libraries for the Hawaiian Islands. These libraries will be used to map vegetation cover in leeward areas of the islands. Vegetation maps will in turn be used to estimate fire hazard in these areas.

The utility of the calibration spectra and PIEs was demonstrated by mapping the extent of three introduced species on the Kalaupapa Peninsula and "topside" Molokai. The AVIRIS f000425t01p03_r02, scene 5 contains a calibration target on the tip of the Kalaupapa Peninsula and PIEs for *Lantana camera*, *Schinus terebinthifolius*, and *Casuarina spp.* *Lantana camera* dominates the north side of the peninsula, while *Schinus terebinthifolius* grows in the central portion of the peninsula. *Casuarina* has been planted as a timber tree on the cliffs above the peninsula. The AVIRIS scene was processed to reflectance, using the methods described in Green et al., 1993. Averaged reflectance from several calibration spectra was used to adjust the modeled reflectance.

PIEs were plotted on a map of the peninsula and image endmembers were extracted from single pixels in the AVIRIS scene. ENVI's matched filter routine was used to match image spectra to the three extracted image endmembers (Better Solutions Consulting, Lafayette, Colorado and Research Systems Inc., Boulder, Colorado). Matched filter sigmas greater than 0.4 are plotted in Figure 2. The matched filter results closely agree with field observations of extent for all three species.

Conclusions

Calibration spectra, vegetation spectra, and PIEs were acquired on five Hawaiian islands as part of the 2000 AVIRIS Hawaii deployment. Freely available calibration reflectance spectra can aid retrieving reflectance from AVIRIS imagery collected during the deployment. Vegetation reflectance spectra and image endmembers extracted from PIE sites will be used for mapping dominant vegetation cover. Matched filter mapping of three vegetation species on the Kalaupapa Peninsula and topside Molokai demonstrates the use of calibration spectra and PIEs for vegetation mapping.

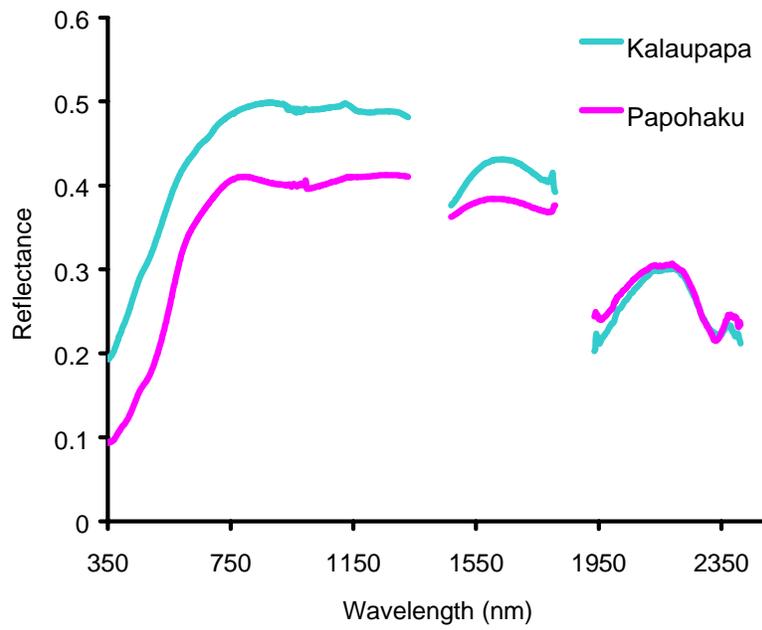


Figure 1. Spectra from Kalaupapa and Papohaku beaches.

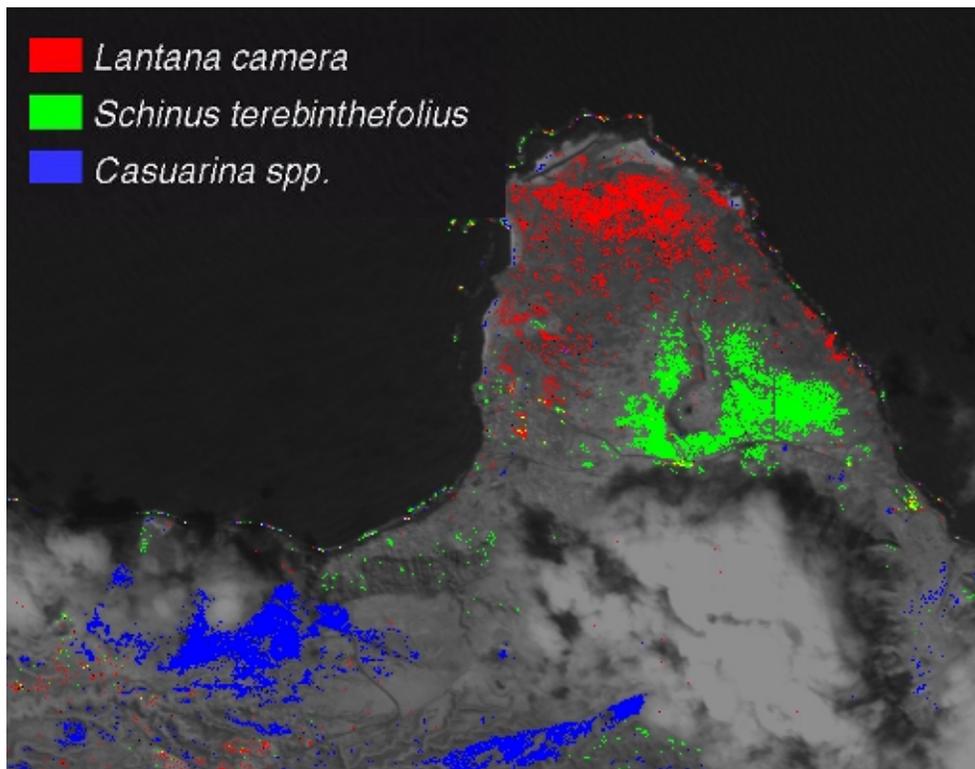


Figure 2. Matched filter results for three species found on the Kalaupapa Peninsula and topside Molokai.

Table 1. Calibration Targets

Date	Location	Island	#spectra	Latitude	Longitude	Elev. (m)	Surface	Comments
4/6/00	Ala Moana Beach	Oahu	7	21.288	-157.846	0	sand	clouds
4/7/00	Kapolei	Oahu	27	21.329	-158.088	0	compacted soil	clouds
4/7/00	Kahe Pt. Beach	Oahu	10	21.360	-158.132	0	sand	beach < 20 m wide
4/7/00	Waimea Bay Beach	Oahu	24	21.639	-158.064	0	sand	excellent
4/9/00	Makaha Beach	Oahu	4	21.476	-158.22	0	sand	clouds
4/11/00	Kawaihae	Hawaii	25	20.030	-155.83	0	gravel	excellent
4/11/00	Hapuna Beach	Hawaii	22	19.991	-155.826	0	sand	excellent
4/14/00	Mauna Kea	Hawaii	17	19.763	-155.619	3000	soil, rock and grass	east facing slope
4/18/00	Majors Bay Beach	Kauai	3	21.995	-159.767	0	sand	clouds
4/29/00	Papohaku Beach	Molokai	16	21.174	-157.254	0	sand	clouds
5/2/00	Oneloa Beach	Maui	10	20.633	-156.449	0	sand	measured in Santa Barbara
5/2/00	Kalaupapa	Molokai	8	21.209	-156.965	0	sand	measured in Santa Barbara
5/2/00	Papohaku Beach	Molokai	9	21.174	-157.254	0	sand	measured in Santa Barbara

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