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EXAMINATION OF THE SPECTRAL FEATURES OF VEGETATION IN 1987 AVIRIS DATA

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ABSTRACT

Equations for converting AVIRIS digital numbers to percent reflectance were developed using a set of three calibration targets. AVIRIS reflectance spectra from five plant communities exhibit distinct spectral differences.

1. INTRODUCTION

A flight line of AVIRIS data covering Stanford University's 1200 acre Jasper Ridge Biological Preserve plus three calibration targets was acquire on July 24, 1987 at 12:56 PM Pacific Standard Time. Jasper Ridge is located directly west of the main campus, in the foothills of the Santa Cruz Mountains. The preserve contains examples of most of the major plant communities found along the Central California coast. A more detailed report on this study is provided by Elvidge (1988).

2. CALIBRATION OF AVIRIS DATA

The three calibration targets cover a wide range of reflectance values. At the bright end is the roof of the Pulgas Balancing Reservoir belonging to the San Francisco Water Department. This is a highly uniform buff-tan color surface with 35-45 % reflectance. A total of 84 AVIRIS pixels were extracted from the roof. An asphalt parking lot at Canada College was used as a target of intermediate brightness (10-25 % reflectance), providing 35 pixels. Bear Gulch Reservoir is used as the dark calibration target (0-5 % reflectance). A set of 64 lake water pixels were extracted from the reservoir.

Laboratory reflectance spectra were acquired of samples of the roof and asphalt surface using JPL's Beckman UV-5240 spectrophotometer. Due to a lack of access to Bear Gulch Reservoir, PFRS (JPL's Portable Field Reflectance Spectrometer) spectra from nearby Searsville Lake were used as surrogates for the reflectance of Bear Gulch Reservoir. The digital number value for each calibration target pixel has been paired to the average reflectance value for the target in all 209 bands of the radiometrically corrected data. These data sets were plotted and visually examined. Linear regression was used to develop equations of the form: Reflectance = A + B*DN. Highly linear relationships were found between digital numbers and reflectance for all three targets in the first two spectrometers (0.41 to 0.69 um and 0.69 to 1.27 um). Data from the third and fourth spectrometers exhibit in flight changes in the radiometric performance between the roof and the two darker targets plus Jasper Ridge. As a result, only the lake water and asphalt data was used to calibrate data from 1.28 to 2.45 um. There was no relationship between digital numbers and reflectance in the intense atmospheric water absorption bands (e.g. at 1.40 um), signifying that the ground is not being seen with AVIRIS in these bands.

The results of the digital number to reflectance regressions for the 209 bands of radiometrically corrected AVIRIS data are summarized in Figure 1. The regression coefficients (R^2 values) versus wavelength are presented in the lower segment of Figure 1. Equations were formed only for bands yielding R^2 values of 0.7 or better. This excludes bands in three atmospheric water absorption regions (1.3506 to 1.4780 um, 1.7720 to 1.9852 um, and 2.3894 to 2.45 um). The middle segment of Figure 1 shows the slopes determined for the equation: Reflectance = A + B*DN. The upper segement of Figure 1 shows the "additive term" (digital number intercept for zero reflectance) versus wavelength. This curve, which is highest in the blue, depicts the radiance scattered in the atmosphere.

3. REFLECTANCE SPECTRA OF PLANT COMMUNITIES

Figure 2 shows the AVIRIS reflectance spectra derived from five plant communities. The spectra have been adjusted vertically to avoid overlap. The reflectance at 0.8 um is provided for each spectrum. The four plant communities containing green vegetation (golf course, swamp forest, broadleaf evergreen forest, and chaparral) all exhibit red edges, pigment absorptions in the visible, well developed NIR plateaus and leaf water absorption at longer wavelengths. Reflectance difference between plant communities in the pigment absorption region (0.4 to 0.7 um) are clearly visible in the reflectance spectra. The height of the NIR plateau above the pigment absorption and water absorption regions also varies between the plant communities.

The NIR plateau lobe between 1.0 and 1.2 um is normally coequal in height with the NIR lobe between 0.8 and 1.0 um in the reflectance spectra of green leaves. However, the lobe centered at 1.1 um has an abnormal height and shape in the golf course and swamp forest reflectance spectra. This may be due to a shattered blocking filter on the second spectrometer.

The reflectance spectrum of the dry annual grassland shows an absorption wing extending from the visible into the NIR. This is a typical spectral feature for dry yellow grass. Ligno-cellulose absorptions can be observed at 2.09, 2.26, and 2.33 um. A well developed absorption of probable ligno-cellulose origin can also be seen in the golf course spectrum from 2.30 to 2.38 um.

Figure 3 is an AVIRIS image of the Jasper Ridge area depicting the intensity of ligno-cellulose absorption. The image was formed by subtracting reflectance values for two composite bands centered at 2.20 and 2.35 um. Reflectance values in five AVIRIS bands (2.18 to 2.22 um) were averaged to form the first composite band, and eight bands (2.31 to 2.38 um) were averaged to form the second band. The ligno-cellulose vegetation index is of the form: reflectance at 2.20 um minus reflectance at 2.35 um. The strongest ligno-cellulose absorptions occur in dry grasslands, though measureable ligno-cellulose absorptions occurred in the chaparral and broadleaf evergreen forest.

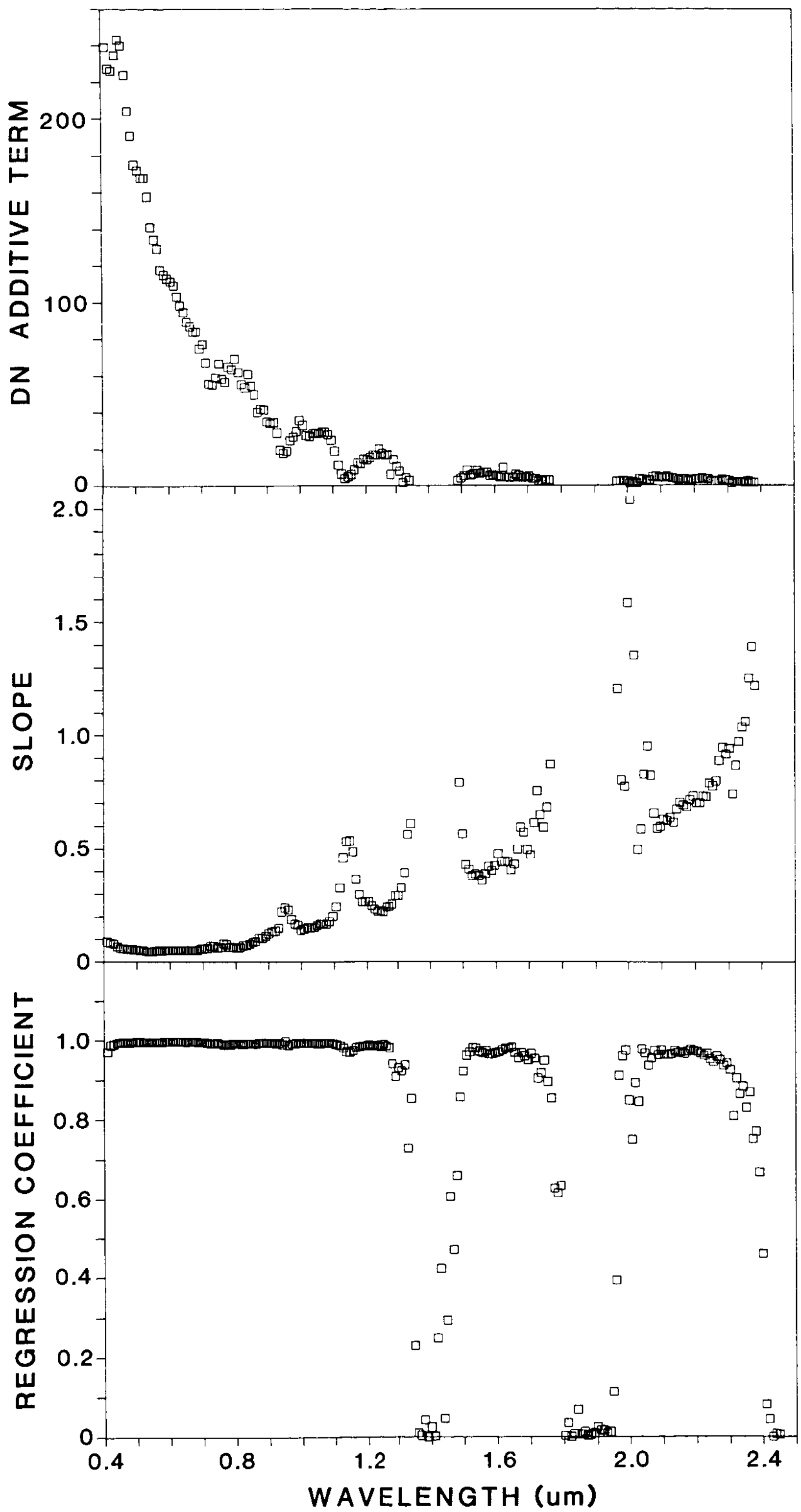

Figure 1. Results from the digital number to reflectance linear regressions.

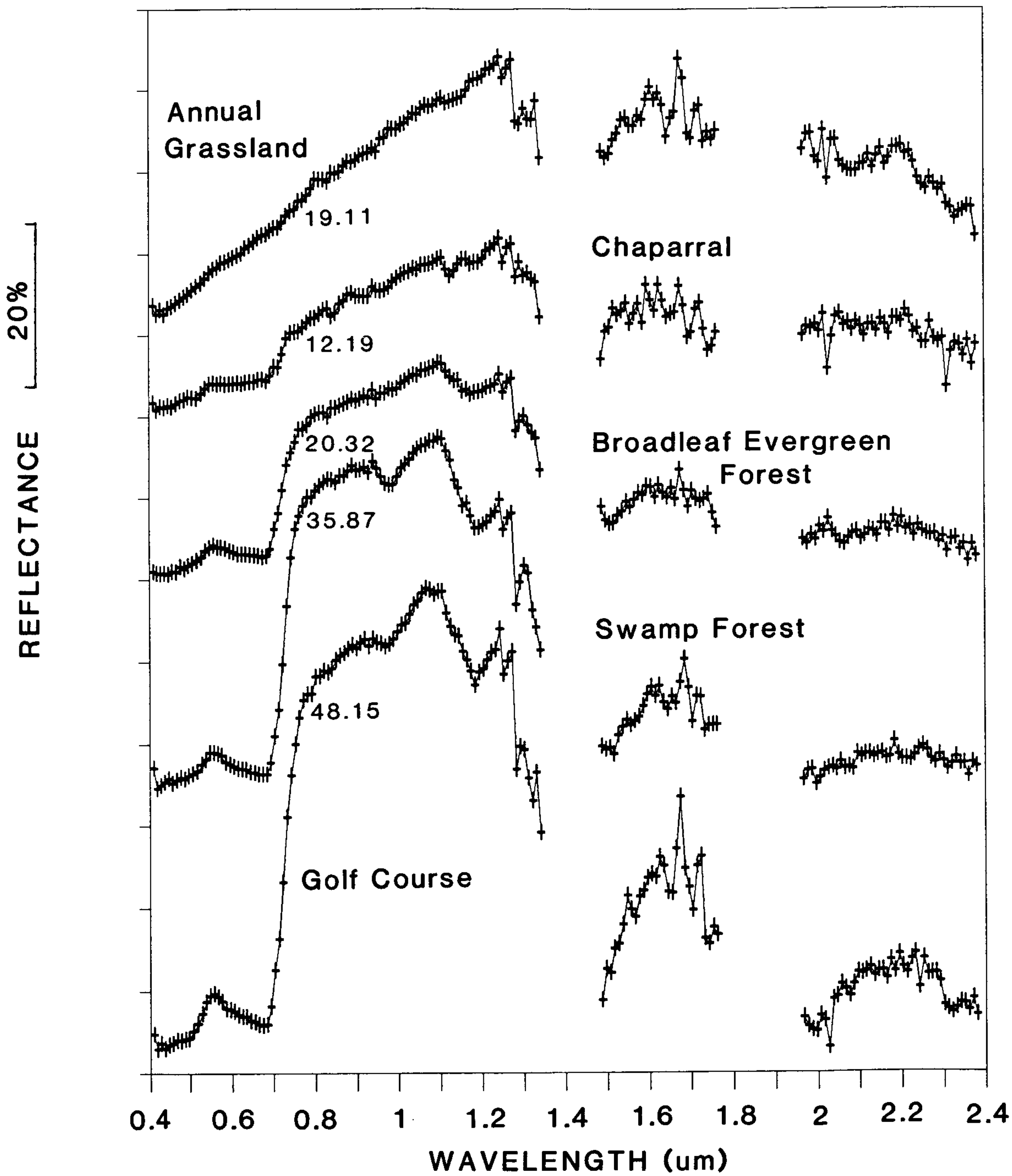

Figure 2. AVIRIS reflectance spectra averages for five plant communities: golf course (16 pixels), swamp forest (42 pixels), broadleaf evergreen forest (120 pixels), chaparral (49 pixels), and a senesced annual grassland (64 pixels).

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4. CONCLUSION

AVIRIS data has been successfully employed to measure reflectance features of vegetation requiring high spectral resolution. Vegetation spectral features that have been observed in AVIRIS data include: details regarding pigment absorption in the visible, the red edge, leaf water absorptions at 0.97 and 1.19 um, and ligno-cellulose absorptions at 2.09, 2.26, and 2.33 um. The detail available in AVIRIS reflectance spectra is comparable to that obtained with laboratory spectrophotometers. Additional work will be required to develop techniques for measuring the spectral features of vegetation in AVIRIS data without the use of calibration targets.

5. REFERENCE

Elvidge, C.D., 1988, Vegetation reflectance features in AVIRIS data. Proceedings of the International Symposium on Remote Sensing of Environment, Sixth Thematic Conference, Remote Sensing for Exploration Geology, ERIM, Houston, TX, May 16-19, 14 p.

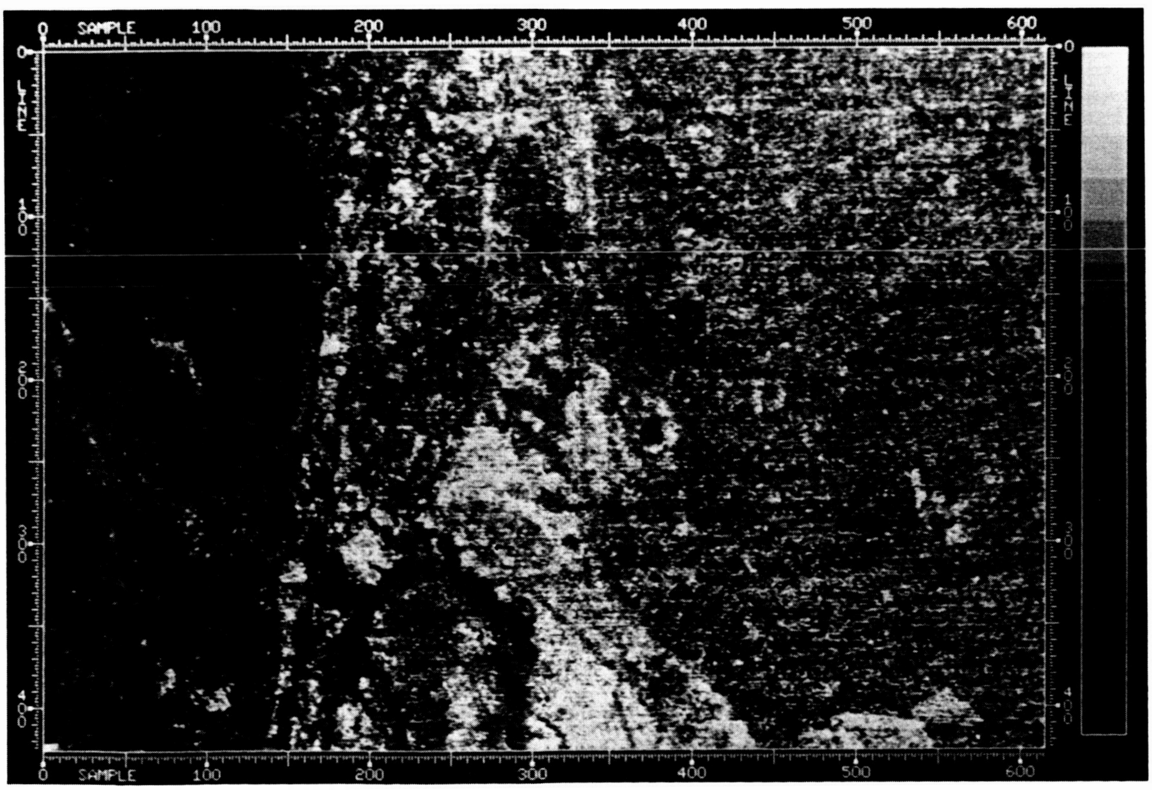

Figure 3. AVIRIS image of the Jasper Ridge area depicting the intensity of ligno-cellulose absorption. The ligno-cellulose vegetation index was formed by subtracting two composite bands of AVIRIS reflectance data: 2.20 um minus 2.35 um. The brightest areas on the image correspond to dry grasslands.