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DISCRIMINATION OF COASTAL VEGETATION AND BIOMASS USING AIS DATA

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ABSTRACT

The AIS was flown over a coastal wetlands region near Lewes, Delaware, adjacent to the Delaware Bay on 16 August 1984. Using the AIS data, it was possible to discriminate between four different types of wetland vegetation canopies: (1) trees; (2) broadleaf herbaceous plants (e.g. Acnida cannabina, Hisbiscus moscheutos); (3) the low marsh grass Spartina alterniflora; and (4) the high marsh grasses Distichlis spicata and Spartina patens. The single most useful region of the spectrum was that between 1.40 and 1.90μ, where slopes of portions of the radiance curve and ratios of radiance at particular wavelengths were significantly different for the four canopy types. The ratio between the highest digital number in the 1.40-1.90μ and .84-.94μ regions and a similar ratio between the peaks in radiance in the 1.12-1.40μ and .84-.94μ spectral regions were also very effective at discriminating between vegetation types. Differences in radiance values at various wavelengths between samples of the same vegetation type could potentially be used to estimate biomass. Thus, high spectral resolution spectrometry appears to have great potential value for remote sensing studies of wetland vegetation.

INTRODUCTION

Radiance measurements made using hand-held radiometers have been found to be correlated with, and have been used to predict, biomass of wetland vegetation (Drake 1976, Jensen 1980, Budd and Milton 1982, Hardisky et al. 1984). Landsat imagery has been successfully used to map surface cover types in wetlands (Bartlett and Klemas 1981, Butera 1983). This investigation reports on the potential of AIS data to discriminate between wetland vegetation types and to estimate biomass.

MATERIALS AND METHODS

The AIS was flown over the Old Mill Creek Marsh near Lewes, Delaware, located at 38°45'N and 75°10'W, on 16 August 1984, at approximately 13:30 EST during low tide. The flight line extended from the head of Old Mill Creek to the Delaware Bay. The swath width was about 320m and the flight line was over 5km long. Spatial heterogeneity and vegetation patchiness within the study site are very pronounced and few monospecific areas exist. For the purposes of this study, the vegetation within the flight line has been grouped into four broad categories based upon dominant species: (1) SN, low marsh grass S. alterniflora; (2) PD, high marsh grasses S. patens/Distichlis spicata; (3) AH, A. cannabina, H. moscheutos, and other broadleaf low-salinity marsh species; and (4) TR, trees.

The AIS data were processed and corrected for effects of the solar irradiance curve by JPL. It was unfortunately not possible to correct for the striping due to unequal detector response or for water/atmospheric absorption effects in our AIS imagery. In selecting areas for analysis of spectral features, samples 5x5 pixels (50mx50m) in size were chosen in order to lessen the effects that variability in detector response would have on the spectral radiance curves generated.

RESULTS

Figure 1 displays curves of the reflected radiance of representative AH, TR, SN and PD canopies in the Tree Scan Mode (.84-2.04μ). Four water absorption regions centered at about .94, 1.13, 1.40 and 1.87μ are evident. The spectral curves of the four canopy types exhibit the same basic features. In the first reflected radiance region (.84-.94μ), hereafter referred to as region 1, a peak occurs at .87μ. The radiance peak is at 1.05μ within the second radiance region (.94-1.12μ). The third major radiance region (1.12-1.40μ) is characterized by a peak radiance at about 1.22μ, while a radiance peak at 1.70μ occurs in the fourth radiance region (1.40-1.90μ). Radiance values between 1.90 and 2.34μ (from the Rock Scan Mode) were very low and therefore substantially affected by the variability in detector response, so this spectral region was not extensively analyzed.

The reflected radiance values of SN canopies are lower than those of the other three vegetation types. TR radiance tends to be greater than SN radiance, while the PD and AH canopies exhibit the highest radiance values. The AH curve in region 4 is distinctly different from those of the other three canopy types. A comparison with the PD curve reveals the differences most clearly. The slope of the AH curve between ≃1.56 and 1.70μ is much greater than that of the PD curve. Also, the AH curve peaks slightly beyond 1.70μ, and has a relatively high digital number (DN) value at ≃1.82μ. The unique features of the AH curves are more obvious in Figure 2, where reflected radiance curves between 1.43-1.89μ from representative samples of AH, PD and SN are plotted.

Table 1 lists the mean of several slopes and ratios which were used to successfully discriminate between the four major vegetation types. The first parameter, the ratio between the highest digital number in regions 4 and 1, was significantly different between five out of the six possible vegetation pairs (AH-TR, AH-SN, AH-PD, TR-SN and TR-PD). Only the SN and PD canopies were not distinguishable using this ratio. A similar ratio between the peak DNs in regions 3 and 1 separated all possible pairs but the TR-PD and SN-PD pairs. The other three measures of discrimination between vegetation types shown in Table 1 rely solely upon properties of radiance in the fourth region (1.40-1.90μ). The slope of the straight line drawn between the DN at 1.56μ and at 1.47μ separated all six possible vegetation pairs, the 1.70μ DN/1.82μ DN ratio, all but the TR-PD pair, and the slope of the straight line drawn between the 1.70μ and the 1.56μ DN, all but the TR-PD and AH-PD pairs.

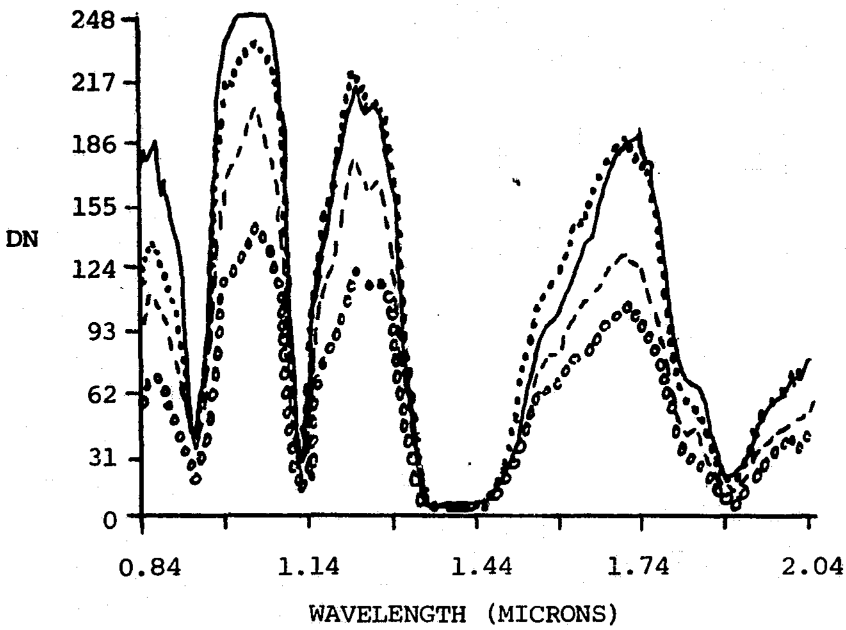

Figure 1. Reflected radiance curves between .84 and 2.04μ for four wetland vegetation types (—— = AH, ••••• = PD, - - - - = TR, ooooo = SN).

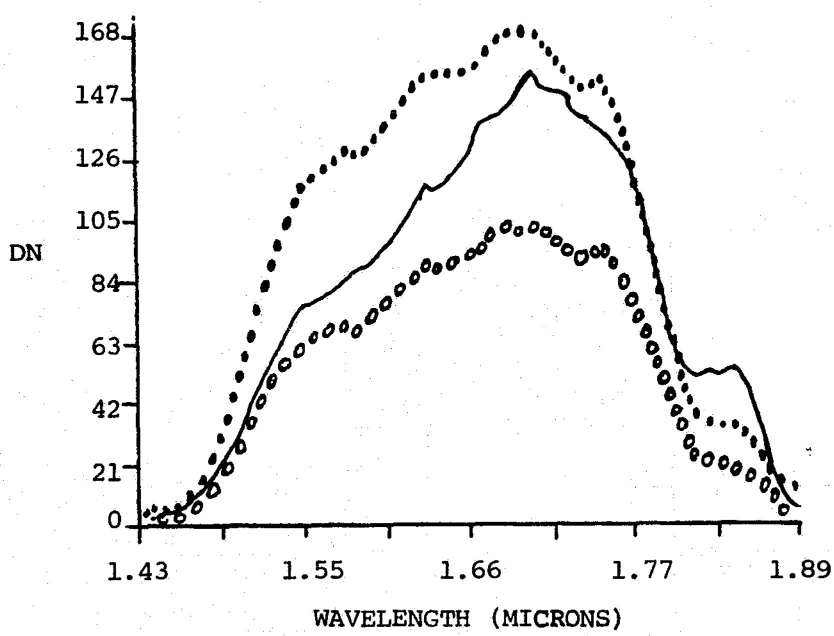

Figure 2. Reflected radiance curves between 1.43 and 1.89μ for three wetland vegetation types (—— = AH, ••••• = PD, ooooo = SN).

Table 1. Parameters successfully used to discriminate between four types of wetland vegetation

Canopy[2] type	Parameter[1]									
	n	I	n	II	n	III	n	IV	n	V
AH	4	1.04(.04)a	7	1.22(.03)a	5	7.67(.23)a	5	3.06(.04)a	5	5.30(.43)a
TR	6	1.30(.04)b	7	1.57(.04)b	5	9.02(.14)b	5	3.95(.12)b	5	3.75(.14)b
SN	4	1.44(.04)c	5	1.73(.04)c	5	6.45(.23)c	5	4.83(.11)c	5	2.71(.05)c
PD	4	1.47(.03)c	8	1.66(.04)bc	5	11.09(.22)d	5	4.17(.09)b	5	4.55(.36)ab

Values are means with one standard error of the mean in parentheses. n = number of replicates. Means followed by a similar letter are not significantly different at the .05 probability level.

[1]Parameters: I = ratio of peak radiance value in region 4 ÷ peak radiance value in region 1; II = ratio of peak radiance value in region 3 ÷ peak radiance value in region 1 (regions: 1 = .84-.94μ; 3 = 1.12-1.40μ; 4 = 1.40-1.90μ); III = slope of straight line between 1.56 and 1.47μ radiance values; IV = highest radiance value at 1.70 or 1.71μ ÷ lowest radiance value in the 1.81 to 1.84μ region; V = slope of straight line between 1.70 and 1.56μ radiance values.

[2]Canopy types: AH = broadleaf brackish marsh; TR = tree; SN = *Spartina alterniflora*; PD = *S. patens/Distichlis spicata*.

DISCUSSION

Although the magnitude of the reflected radiance curves between the four vegetation types (AH, PD, SN, TR) differed substantially, the shape of the curves was generally similar in the five radiance regions bounded by water absorption bands between .84-2.34μ, with the exception of the AH curve in the 1.40-1.90μ region. The reasons for the peculiarities of the AH curve are not obvious and indicate a need for additional field and laboratory studies. Region 4 (1.40-1.90μ) is the single most useful region for discriminating between wetland vegetation types.

Although the data were not shown, the magnitude of reflected radiance varied among samples of the same vegetation type. Hardisky et al. (1984) demonstrated that an Infrared Index [(.76-.90μ radiance − 1.55-1.75μ radiance)/(.76-.90μ radiance + 1.55-1.75μ radiance)] could be used to successfully predict biomass in Delaware wetlands. This suggests that if field data were collected, the AIS radiance data in the near infrared and in the middle infrared could be correlated with biomass and prove very useful in estimating biomass or productivity of wetland vegetation.

Table 1 indicates that, by using a combination of very basic, easy to compute ratios, it should be possible to map wetlands according to vegetation type. This demonstrates the utility of high spectral resolution data for remote sensing studies of vegetation. None of the ratios in Table 1 could be calculated from Landsat MSS or TM or from SPOT data since these instruments only collect data in very broad spectral bands.

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