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(1)

TEMPORAL CHANGES IN ENDMEMBER ABUNDANCES, LIQUID WATER ANI) WATER VAPOR OVER VEGETATION AT JASPER RIDGE

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1. INTRODUCTION

Imaging spectrometry offers a new way of deriving ecological information about vegetation communities from remote sensing. Applications include derivation of canopy chemistry (e.g., Wessman et al., 1989), measurement of column atmospheric waler vapor and liquid water (Green et al., 1991), improved detectability of materials (Sabol et al., 19X?), more accurate estimation of green vegetation cover and discri imi nation of spectrally distinct green leaf, non-photosynthetic vegetation (NPV: litter, wood, bark etc.) and shade spectra associated with different vegetation communities (Roberts et al., 1993).

Much of our emphasis has been on interpreting Airborne Visible and Infrared imaging Spectrometry (AVIRIS) data as spectral mixtures. Two approaches have. been used, simple models, where the data arc. treated as a mixture of 3 to 4 laboratory/field measured spectra, known as reference endmembers (EMs), applied uni formly to the whole image, to more complex models where both the number of EMs and the types of EMs vary on a per-pixel basis (Roberts et al. , 1992), Where simple mode.ls are applied, materials, such as NPV, which arc spectrally similar to soils, can be discriminated on the basis of resid ual spectra (Roberts c1 al., 1993). One key aspect is that the data are calibrated to reflectance and modeled as mixtures of reference J :Ms, permitting temporal comparison of EM fractions, independent of seem location or data type. in previous studies the calibration was performed using a modified-empirical line calibration (Roberts et al., 1 993), assuming a uniform atmosphere across the scene.

In this study, a Modtran-based calibration approach was used to map liquid water and atmospheric water vapor and retrieve surface reflectance from three AVIRIS scenes acquired in 1992 over the Jasper Ridge Biological Preserve (see Green et al., 1993). The data were acquired on June, 2nd, September 4th and October 6th. Reflectance images were analyzed as spectral mixtures of reference EMs using a simple 4 EM model. Atmospheric water vapor derive.cl from Modtran was compared to elevation, and community type. Liquid watt.r was compared to the abundance of NPV, Shade and Green Vegetation (GV) for select silts to determine whether a relationship existed, and under what conditions the relationship broke down. Temporal trends in endmember fractions, liquid water and atmospheric wale.r vapor were investigated also. The combination of spectral m ixtu re analysis and the Modtran based atmospheric/liquid water models was used to develop a unique vegetation community description.

2.. RESULTS

Atmospheric waler vapor, liquid water and the abundance of soil, NPV, GV and photometric shade, were determined for 14 sites of known elevation from the 3 dates (Fig. 1). A comparison of atmospheric water vapor 10 elevation demonstrated a good Ii near relationship for all 3 dales, with September having the highest water vapor

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concentrations, June intermediate and October the lowest (Fig. 2). Atmospheric watt.r vapor was negatively correlated to increased elevation. The steepest gradient occured at intermediate water vapor concentrations in Jane., producing the highest contrast between elevations. The relationship between elevation and atmospheric water vapor showed a marked departure from predicted water vapor over heavily vegetated areas in June and September. In all of the.sc regions, except the Stanford Golf Course (C in Fig. 1), the atmospheric water vapor was higher over the vegetated regions. These departures may represent evapotranspired water vapor, trapped water vapor in canyons or an incomplete separation of liquid water from atmospheric water vapor. The latter, however, is unlikely, because liquid water and atmospheric wale.r vapor, although positively correlated, were not directly correlated in all areas. Liquid water was mapped as showing very sharp gradients between vegetated and non-vegetated areas. Atmospheric water vapor, on the other hand, had gradational bounderies. Heavily vegetated sites did not show above normal wale.r vapor concentrations on the dryest date, in October, potentially attributable to low transpiration rates at that lime.

Figure 1

Figure 1. Index mrsp showing the location of 10 of [he. study silts, These include a Horse Ranch (A), Webb Ranch (B), Stanford Golf Course (C), Evergreen Broadleaf Forest (D), Serpentine Grassland (E), Chaparral (F), Annual Grassland (G), Forested Wetland (11) and 3 high elevation grasslands (I, J and K). Four forested areas in the Santa Cruz Mountains, one at Alambique Creek (317 m), and three along an elevational transect in Martin Creek, at 183, 2[,2 and 390 m, respectively, were off the map.

The EM fractions changed among the three dates, primarily due to a decrease in the solar elevation and senescence, producing an increase in the shade and NPV fractions and a decrease in the GV fraction (Fig. 3, Site locations, Fig. 1). For a more detailed discussion of the relationship between endmember abundances, vegetation communities, and temporal trends see Sabol et al. (1993).

Fractions of NPV, GV and shade were compared to liquid water absorptions for the three dates (Fig. 4a-c). The best relationships occurred in Jane, where shade and GV were positively correlated to liquid water rind NPV was negatively correlated. The best fit was for NPV and liquid water. The only major departure was in the Serpentine site (E on

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Fig. 1), where the soil fraction was high. GV showed departures at two sites, the Stanford Golf Course, where the GV fraction was high, but the liquid watt.r concentration low, and in the Santa Cruz Mountains (Martin and Alambique Creeks), where the highest liquid waler absorptions occured but GV was low due to a high shade fraction (>0.60). In these areas, shade showed a high correlation with liquid wale.r. The di fference between GV and liquid wale.r absorption is due, most likely, to the low leaf area of the golf course grasses. The relationship between the EM fractions was similar for the other two date.s, although the fit was poorer. Liquid water absorption showed a systematic change, between the three dam; values for September were higher than J uric. by 20, whereas the October value.s were lower for the lowest sites (by approximately 1()) and slightly higher for the, sites with the highest absorption. Whether these differences arc real (due to rainfall in September), or due to modeling errors (e.g., slight wavelength miscalibrations) requires further investigation.

Figure 2. Comparison between atmospheric water vapor and elevation for the 14 study silts over the three dates. Water vapor was negatively correlated with elevation (June: Y = -1 .236*X+1820, R^2=0.966: Sept: Y= -0.759*X+ 2225, R^2= 0.875: Oct.: Y = -0.576*X + 1117, R^2= 0.896).

Figure 3. Changes in endmember fractions at 7 silts on three dates. The first, second and third columns are for June, next three for September and last three for October. Negative and super-positive (>1 .0) fractions are due to limitations in the simple. model (see Sabol et al., 1993).

3. SUMMARY

AVIRIS provides information about vegetation that cannot be obtained using other sensors. In this paper we mapped temporal and spatial patterns in liquid watt.r,

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atmospheric water vapor, shade, GV, NPV and soil, relating these parameters to vegetation types. Examples included atmospheric waler vapor which was mode.lc(l as higher, for a given elevation, over vegetated sites than non-vegetated sites for June and September, but not for October, on a dryer day, Liquid water was correlated with GV on all three dates except for highly shaded areas, where shade showed a better relationship, and areas withlow leaf area but a high GV fraction, such as the Stanford Golf Course.. Under these instances, liquid water estimates and mixture models provide complementary, but different information about vegetation. Through this analysis, we offer a new way to characterize vegetation communities through their physical attributes (EM fractions and liquid water) and associated atmospheric properties (water vapor).

Figure 4. Scatterplot between scaled liquid water absorption aod NPV, GV and Shade fractions. For all three dates, NPV was negatively correlated and shade and GV were positively correlated

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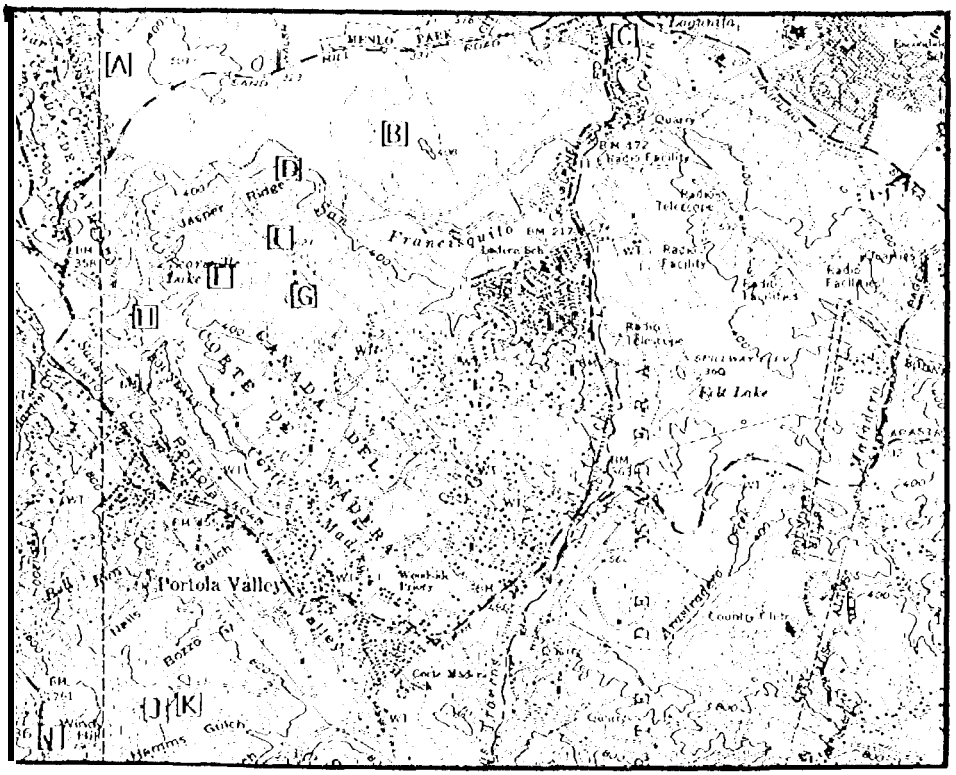

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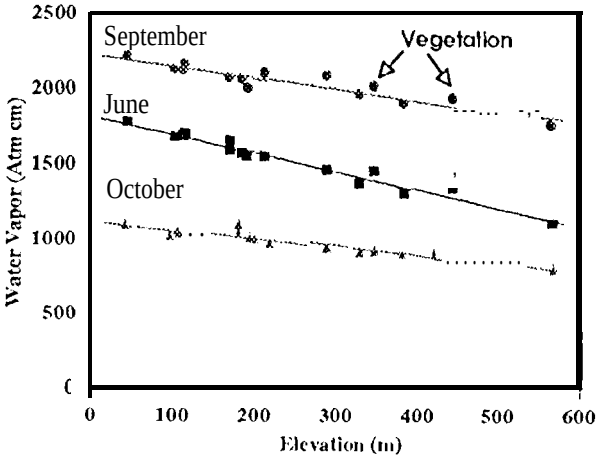

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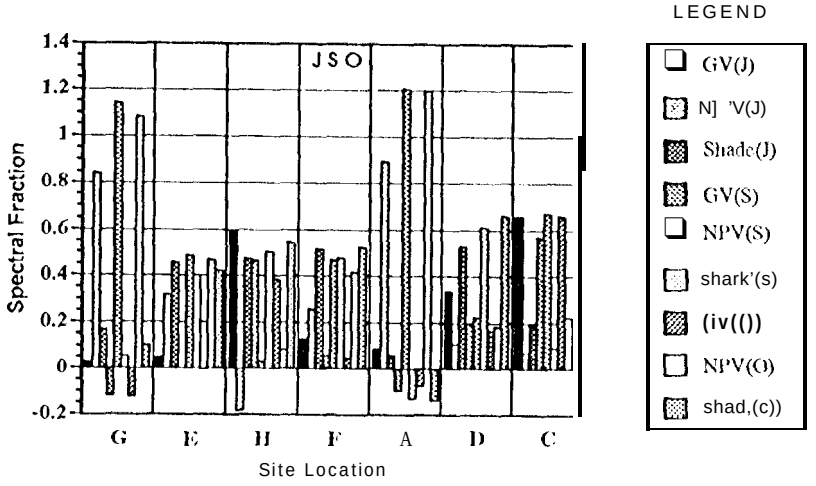

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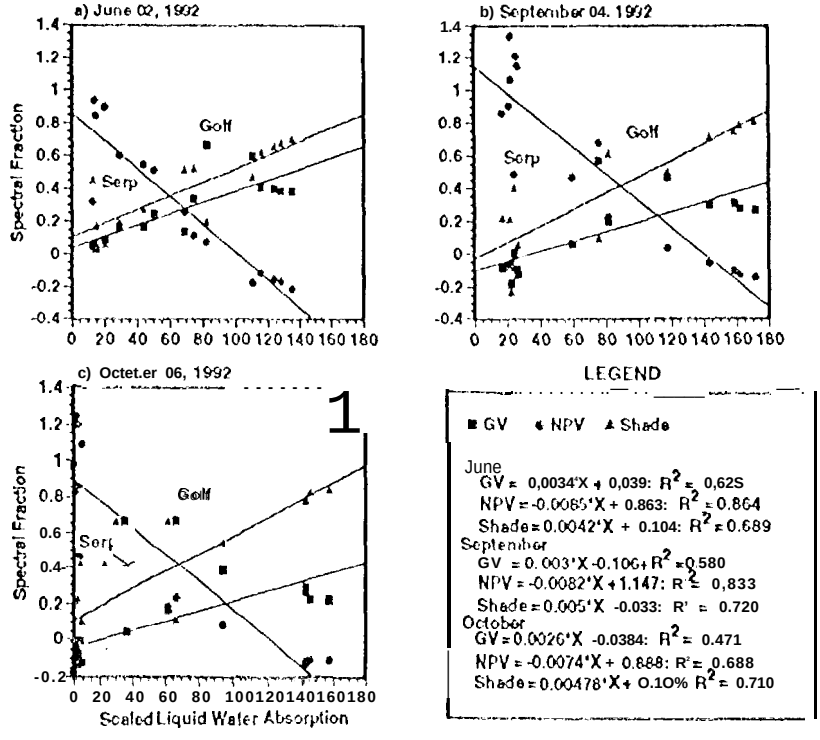

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