S43-43
189089
N94-16709

MULTITEMPORAL DIURNAL AVIRIS IMAGES OF A FORESTED ECOSYSTEM

BY

SUSAN L. USTIN
DEPARTMENT OF LAND, AIR, AND WATER RESOURCES
UNIVERSITY OF CALIFORNIA, DAVIS, CA 95616

AND

MILTON O. SMITH, AND JOHN B. ADAMS
DEPARTMENT OF GEOLOGICAL SCIENCES
UNIVERSITY OF WASHINGTON, SEATTLE, WA 98195

INTRODUCTION

Both physiological and ecosystem structural information may be derived from diurnal images. Structural information may be inferred from changes in canopy shadows between images and from changes in spectral composition due to changes in proportions of subpixel mixing resulting from the differences in sun/view angles. Physiological processes having diurnal scales also may be measurable if a stable basis for spectral comparison can be established. Six diurnal images of an area east of Mt. Shasta, CA were acquired on September 22, 1989. This unique diurnal data set provided an opportunity to test the consistency of endmember fractions and residuals. We expected that shade endmember abundances would show the greatest change as lighting geometry changed and less change in the normalized fractional proportion of other endmembers. Diurnal changes in spectral features related to physiological characteristics may be identifiable as changes in wavelength specific residuals.

METHODS

Multitemporal images of AVIRIS data were acquired at 9.97, 10.36, 10.96, 12.97, 13.36, and 13.96 hr local solar time. This resulted in three pairs of images (flight 17; runs 2, 3, 5, 11, 23, 14; segment 1) roughly matched in time before and after local solar noon (Δ 4.2min, Δ16.8 min, and Δ4.2min). The flight schedule was chosen to maximize the diurnal separation between the first and last flightlines (3.99hr) but to minimize the changes in canopy shading due to the diurnal trajectory of the solar zenith angle. The study area included discontinuous ponderosa pine forests, recent clear cuts, Great Basin sagebrush communities, meadows, and narrow riparian zones along drainages. The terrain is relatively flat over most of the area. Sky conditions measured with a Regan Radiometer were clear with optical depth at the theoretical maximum (389km), with low aersols (876.7mbar, 255.8matm O_3). Overflights were acquired at the end of the dry Mediterranean summer about one week after a relatively heavy precipitation event. Leaf area index was determined from three sites within the flightline from fisheye photographs. Tree height, DBH, and stand density was measured in several stands and biomass estimated from allometric relationships.

Spectral mixture analysis was performed on each of the six AVIRIS images. The iterative mixture analysis resulted in the selection of the same set of library endmembers for each image and converged upon similar gains and offsets for each calibration.

RESULTS

We found that most of the region could be modeled by four endmembers, a green vegetation type characteristic of ponderosa pine foliage in the library, shade, and two nonphotosynthetic endmembers: one having the characteristics of "stems," i.e., resembling bark or having a redish-brown cast, and the other having spectral characteristics consistent with weathered litter. In all cases, dry plant material rather than soils or mineral samples was selected from the spectral library as the best fit to the image endmembers. This is the first example that we are aware of in which more than one nonphotosynthetic canopy component has been identified in AVIRIS images. The nonphotosynthetic fractions are generally negatively correlated, although different community types (dry meadows to mature forests) characteristically fall within restricted regions of the data volume. The two nonphotosynthetic fractions exhibit independent relationships with the green vegetation fraction. Thus, the fraction patterns of these endmembers are independent and appear to be community specific. This suggests that endmember fractions can provide a good method for differentiating communties.

As expected, the shade endmember showed the largest magnitude of diurnal change, although patterns were not symmetric about solar noon and appeared to relate more consistently to community types and structure differences. Normalized green and nonpyhotosynthetic vegetation fractions (rescaled without the shade fraction) exhibited a smaller range of diurnal variation. Figure 1 shows the diurnal pattern in the green vegetation endmember abundances we observed for ten community types. The magnitudes of diurnal patterns were community specific and consistent for given types. They did not exhibit diurnal symmetry expected from sun angle changes. Least evidence of diurnal changes was found in dry meadows and greatest in mature forests. Forests exhibited a trend for decreasing green vegetation fraction during the four hour period. The magnitude of the fraction change appears to be greater than can be explained by calibration errors, although the basis is not understood. These patterns may possibly result from different canopy components being illuminated as sun angles change.

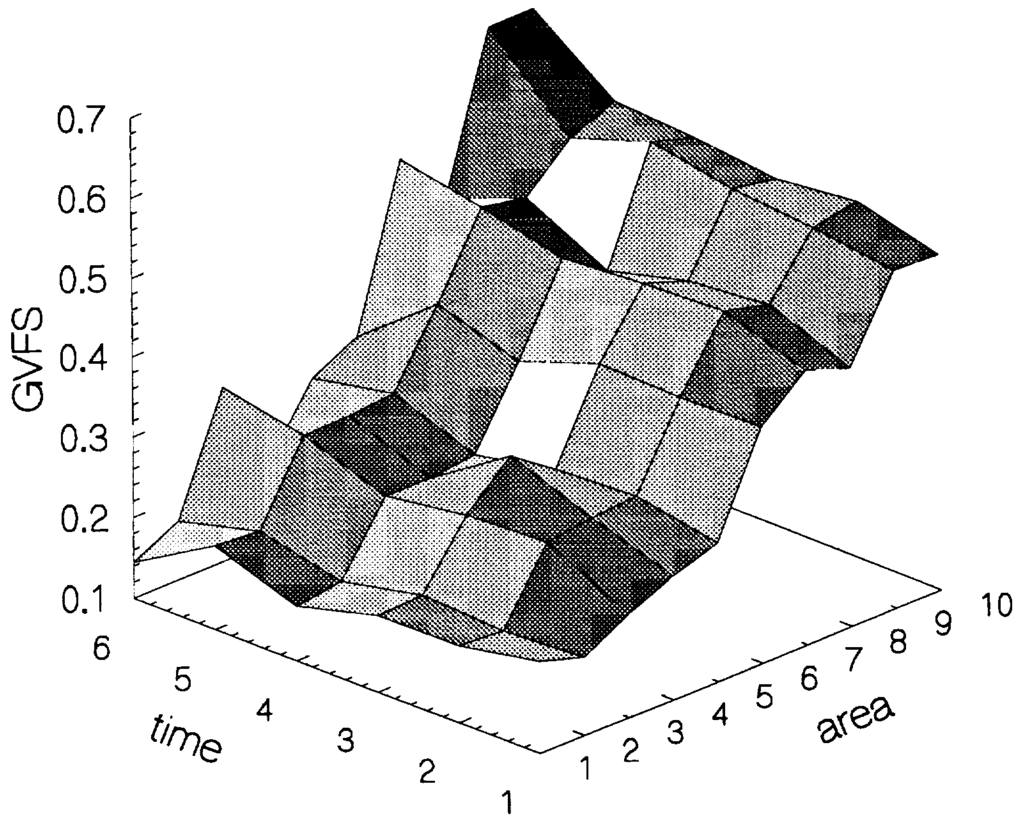

Figure 1. Changes in GVFS in six AVIRIS images of ten areas near Shasta, California. The numbered times correspond to 1) 9.97, 2) 10.36, 3) 10.96, 4) 12.97, 5)13.36, and 6) 13.96 local solar time. The numbered areas correspond to 1) 1st recent clear cut 2) 2nd recent clear cut, 3) 1st older clear cut, 4) 2nd older clear cut, 5) 1st mature second growth ponderosa pine forest, 6) 2nd mature ponderosa pine forest, 7) ponderosa pine plantation, 8) 1st young ponderosa pine forest, 9) 2nd young ponderosa pine forest, and 10) meadow.