MEASUREMENT OF ATMOSPHERIC WATER VAPOR, LEAF LIQUID WATER AND REFLECTANCE WITH AVIRIS IN THE BOREAL ECOSYSTEM-ATMOSPHERE STUDY: INITIAL RESULTS

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1. INTRODUCTION

The Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) acquired data as part of the Boreal Ecosystem-Atmosphere Study (BOREAS) in 1994. Flights occurred over the Northern Study Area (NSA) in the region of 56 degrees north latitude and 98.5 degrees west longitude and over the Southern Study Area (SSA) at 54 degrees north latitude and 105 degrees west longitude (Table 1).

Table 1. Acquisition of AVIRIS data for BOREAS in 1994.

Southern Study Area	19 April 1994
Northern Study Area	20 April 1994
Northern Study Area	28 April 1994
Northern Study Area	8 June 1994
Southern Study Area	21 July 1994
Northern Study Area	4 August 1994
Northern Study Area	8 August 1994
Southern Study Area	16 September 1994

These data will be used to directly derive spectral properties of the surface and atmosphere and to provide supporting data for other instruments, models, and experiments in support of the BOREAS objectives. In this paper we present a preliminary evaluation of the AVIRIS data collected in BOREAS in terms of the AVIRIS-derived parameters: water vapor, leaf water, and apparent spectral reflectance.

2. WATER VAPOR, LEAF WATER, AND REFLECTANCE

AVIRIS data were acquired over the Old Jack Pine (OJP) site at 53.88 degrees north latitude and 104.92 degrees west longitude on July 21, 1994, at 16:55 UTC (Figure 1). These data, including the data over the SSA OJP site, were calibrated from the AVIRIS-measured signal to upwelling spectral radiance (Figure 2). From the upwelling radiance the atmospheric water vapor was derived with a nonlinear least squares spectral fitting algorithm (Green et al., 1991, 1993) employing the MODTRAN radiative transfer code (Berk et al., 1989). For the SSA OJP site an abundance of 23.8 ±0.5 precipitable mm of water vapor was determined (Figure 3). The algorithm was applied to the entire SSA OJP AVIRIS scene (Figure 4). A range of water vapor from 22.5 to 25.5 precipitable mm was mapped. Absorption of leaf liquid water was simultaneously derived from the water vapor with the water vapor algorithm. At the SSA OJP a value of 2.6 ±0.1 mm equivalent path transmittance leaf liquid water was required (Figure 5). Values from 0.0 to 4.5 mm of equivalent path transmittance leaf liquid water were derived for the entire AVIRIS data set (Figure 6). Over areas of open water the derived water vapor is high and leaf water is low due to the dominance of multiple scattering of light and minimal surface reflectance at 940 nm in the AVIRIS spectrum. Using the derived water vapor in conjunction with AVIRIS-based estimates of the aerosol scattering, the upwelling spectral radiance for the SSA OJP site measured by AVIRIS was inverted to apparent spectral reflectance (Green, 1990; Green et al., 1993) (Figure 7). Examination of the inverted spectrum shows good agreement with that expected for a coniferous vegetation spectrum.

3. CONCLUSION

In 1994, AVIRIS measured images of upwelling spectral radiance for BOREAS during 8 different flights, including both southern and northern areas. Spectral fitting and inversion algorithms were applied to spectra measured over the SSA OJP region on July 21, 1994 to evaluate the calibration and quality of the AVIRIS data. Water vapor, leaf liquid water, and apparent surface reflectance were directly derived from the measured spectra, indicating good calibration. Based on this AVIRIS calibration, research may proceed with the derived atmospheric and surface parameters to address the objectives of BOREAS.

4. FUTURE WORK

AVIRIS-derived atmospheric and surface parameters will be compared to equivalent parameters measured by in situ instrumentation. Data acquisitions spanning the eight AVIRIS flights and two regions will be further evaluated with respect to calibration and inter-comparability.

5. ACKNOWLEDGMENTS

The research described in this paper was carried out in part at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.

6. REFERENCES

Berk, A., L. S. Bernstein, and D. C. Robertson, 1989, *MODTRAN: A moderate resolution model for LOWTRAN 7, Final Report, GL-TR-0122*, AFGL, Hanscom AFB, MA, 42 pp.

Green, R. O., 1990, "Radiative-transfer-based retrieval of reflectance from calibrated radiance imagery measured by an imaging spectrometer for lithological mapping of the Clark Mountains, California," *SPIE, Vol. 1298, Imaging Spectroscopy of the Terrestrial Environment*, pp. 213-221.

Green, R. O., J. E. Conel, J. S. Margolis, C. J. Bruegge, and G. L. Hoover, 1991, "An Inversion Algorithm for Retrieval of Atmospheric and Leaf Water Absorption From AVIRIS Radiance With Compensation for Atmospheric Scattering," *Proc. Third Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) Workshop, JPL Publication 91-28*, Jet Propulsion Laboratory, Pasadena, CA, pp. 51-61.

Green, R. O., J. E. Conel, and D. A. Roberts, 1993, "Estimation of aerosol optical depth, pressure elevation, water vapor and calculation of apparent surface reflectance from radiance measured by the Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) using a radiative transfer code," *SPIE, Vol. 1937, Imaging Spectrometry of the Terrestrial Environment*, pp. 2-11.

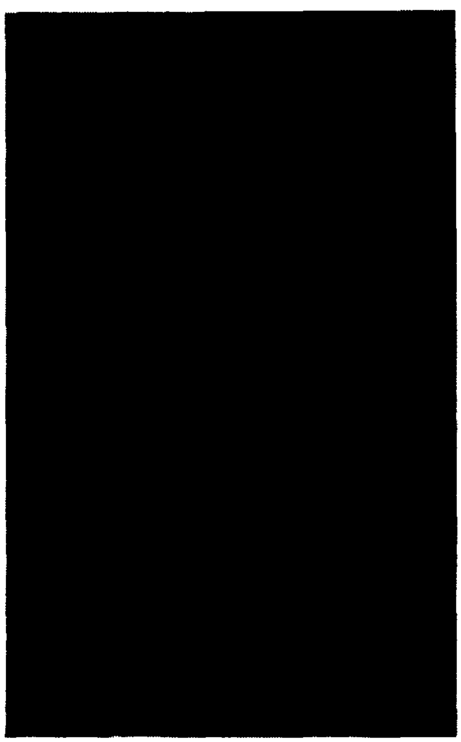

Figure 1. AVIRIS image of SSA Old Jack Pine region (see AVIRIS Workshop Slide 3).

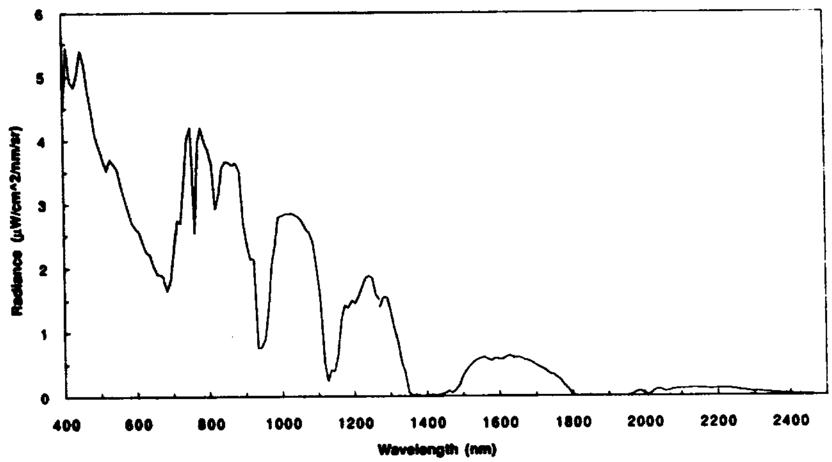

Figure 2. Upwelling spectral radiance measured by AVIRIS for the Old Jack Pine site on 21 July 1994.

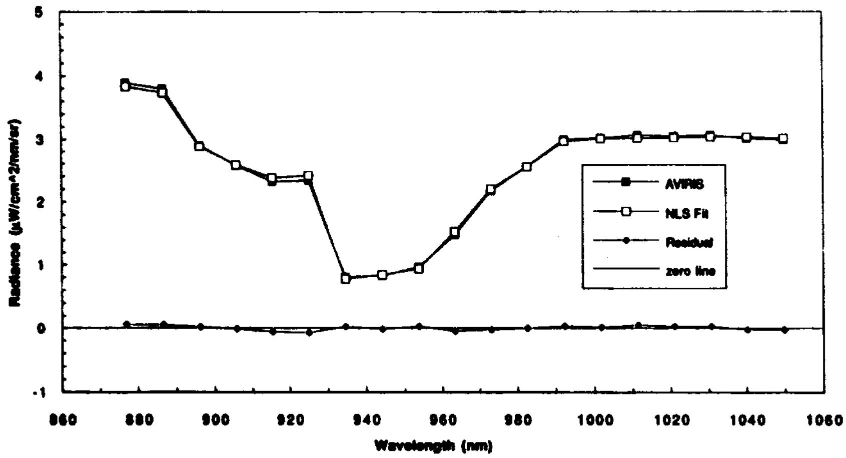

Figure 3. Nonlinear least squares spectral fit for determination of water vapor.

Figure 4. Image of water vapor over the SSA Old Jack Pine site (see AVIRIS Workshop Slide 3).

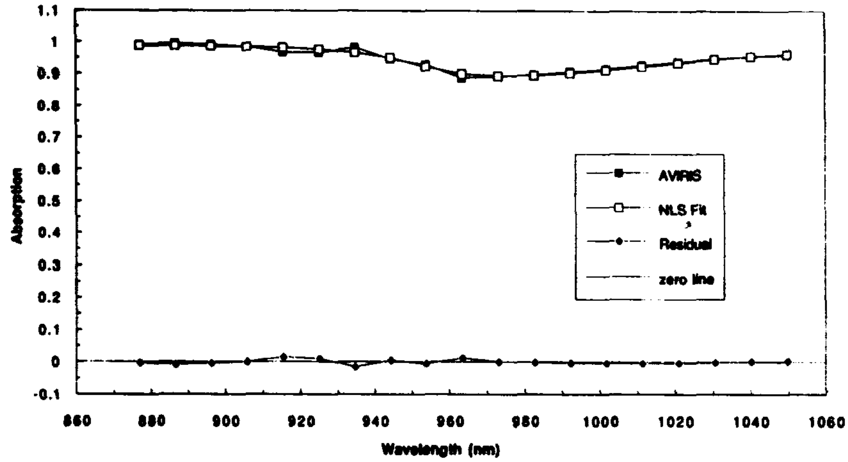

Figure 5. Nonlinear least squares spectral fit for determination of absorption due to leaf liquid water.

Figure 6. Image of leaf liquid water absorption, derived from AVIRIS spectral data (see AVIRIS Workshop Slide 3).

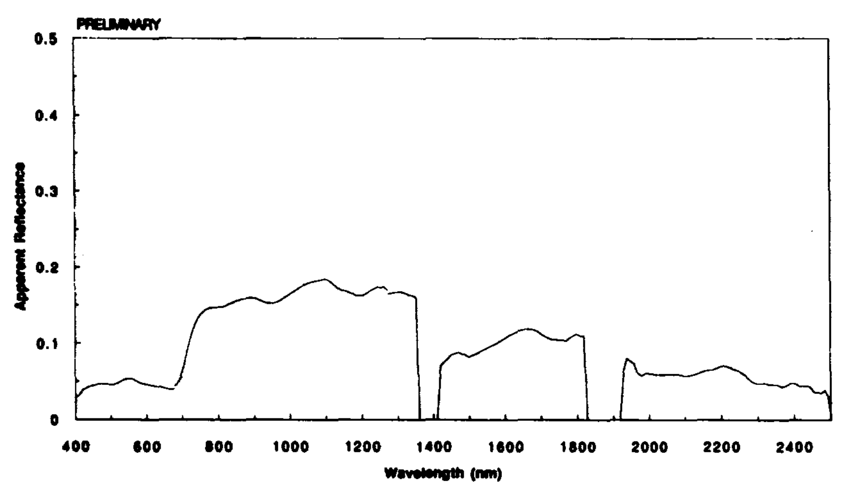

Figure 7. RTC-derived surface reflectance for SSA Old Jack Pine site, from AVIRIS on 21 July 1994.