DETERMINATION OF THE IN-FLIGHT SPECTRAL CALIBRATION OF AVIRIS USING ATMOSPHERIC ABSORPTION FEATURES

Robert O. Green

Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109
and
University of California, Santa Barbara, CA 93106

1. IN-FLIGHT SPECTRAL CALIBRATION

Spectral calibration of the Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) as data are acquired in flight is essential to quantitative analysis of the measured upwelling spectral radiance (Green, 1995). In each spectrum measured by AVIRIS in flight, there are numerous atmospheric gas absorption bands that drive this requirement for accurate spectral calibration. If the surface and atmospheric properties are measured independently, these atmospheric absorption bands may be used to deduce the in-flight spectral calibration of an imaging spectrometer (Conel et al., 1988, Green et al., 1988, 1993).

Both the surface and atmospheric characteristics were measured for a calibration target during an in-flight calibration experiment held at Lunar Lake, Nevada on April 5, 1994 (Green et al., 1995). This paper uses upwelling spectral radiance predicted for the calibration target with the MODTRAN radiative transfer code (Berk et al., 1989) to validate the spectral calibration of AVIRIS in flight.

Surface reflectance, atmospheric optical depths, and water vapor measurements were used to constrain the MODTRAN and predict at high spectral resolution the upwelling radiance at AVIRIS over the in-flight calibration target (Figure 1). To compare this MODTRAN radiance with AVIRIS radiance, MODTRAN must be convoluted to the AVIRIS spectral channels (Figure 2). The radiance reported by the AVIRIS channels in the vicinity of each atmospheric absorption is strongly dependent on the laboratory-calibrated (Chrien et al., 1990) spectral wavelength position of each AVIRIS channel. An algorithm was developed in 1988 to derive the in-flight spectral calibration of AVIRIS using these atmospheric absorption bands (Green et al., 1988). This algorithm optimizes the agreement between the AVIRIS-measured spectrum and the MODTRAN-predicted spectrum across a single absorption band by varying the AVIRIS channel spectral calibration characteristics (Figures 3 through 6). Results for this algorithm, when applied to the April 1994 calibration experiment data, are given in Table 1. The spectral locations of the atmospheric band, the band source, the AVIRIS spectrometer affected, the AVIRIS channel spectral shift from laboratory calibration, and the confidence level are given.

Table 1. AVIRIS In-Flight Spectral Calibration

Wave Length, nm	Source	Spectro-meter	Shift from Lab, nm	Confidence, nm
430	Solar	A	-0.3	±2.0
520	Solar	A	+0.4	±2.0
620	H_2O	A	-0.4	±2.0
650	H_2O	A	+1.2	±2.0
690	H_2O	B	-0.6	±2.0
730	H_2O	B	+0.4	±2.0
760	O_2	B	-0.7	±1.0
820	H_2O	B	+0.3	±2.0
940	H_2O	B	-0.5	±1.0
1140	H_2O	B	+0.0	±1.0
1260	O_2	C	+0.0	±2.0
1470	H_2O	C	-0.2	±2.0
1580	CO_2	C	+1.2	±2.0
1610	CO_2	C	-0.9	±2.0
2020	CO_2	D	-0.3	±1.0
2060	CO_2	D	-0.8	±1.0
2350	CH_4	D	+0.2	±2.0
2380	CH_4	D	-0.8	±2.0
2420	CH_4	D	+0.0	±2.0
2460	CH_4	D	-0.1	±2.0

In this analysis, none of the derived in-flight spectral channel calibrations exceeded the uncertainty of the algorithm. The uncertainty, or confidence level, is based on the spectral contrast of the absorption band. Contrasts of the absorption band *minima to continua* of greater than 25 percent are given a confidence of ±1.0 nm. Bands with less than 25 percent contrast are given a ± 2.0 nm confidence. Levels of 1.0 and 2.0 nm are estimated based on confidence in the MODTRAN model, AVIRIS radiometric stability, and in situ measurement. These confidence levels are supported in the algorithm results by the discrepancy for pairs of absorption bands in the same spectrometer. For example, the strong CO_2 bands at 2020 and 2060 nm give differing results of 0.5 nm and the results for the week CO_2 bands at 1580 and 1610 differ by 2.1 nm. In overview, this analysis shows that the in-flight spectral calibration had not changed with respect to the laboratory spectral calibration at the level of confidence in the algorithm.

2. ACKNOWLEDGMENTS

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3. REFERENCES

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

Chrien, T.G., R.O. Green, and M. Eastwood, Laboratory spectral and radiometric calibration of the Airborne Visible/Infrared Imaging Spectrometer (AVIRIS), SPIE Vol. 1298, Imaging spectroscopy of the terrestrial environment, 1990.

Conel, J.E., R.O. Green, R.E. Alley, C.J. Bruegge, V. Carrere, J.S. Margolis, G. Vane, T.G. Chrien, P.N. Slater, S.F. Biggar, P.M. Teillet, R.D. Jackson and M.S. Moran, In-flight radiometric calibration of the Airborne Visible/Infrared Imaging Spectrometer (AVIRIS), SPIE Vol. 924, Recent advances in sensors, radiometry and data processing for remote sensing, 1988.

Green, R.O., G. Vane, and J.E. Conel, "Determination of in-flight AVIRIS spectral, radiometric, spatial and signal-to-noise characteristics using atmospheric and surface measurements from the vicinity of the rare-earth-bearing carbonatite at Mountain Pass, California," Proc. Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) Performance Evaluation Workshop, JPL Pub. 88-38, Jet Propulsion Laboratory, Pasadena, CA, 162-184, 1988.

Green, R.O., J.E. Conel, M. Helmlinger, J. van den Bosch, C. Chovit and T. Chrien, "Inflight Calibration of AVIRIS in 1992 and 1993," Summaries of the Fourth Annual JPL Airborne Geoscience Workshop, Vol. 1, AVIRIS Workshop, JPL Pub. 93-26, Jet Propulsion Laboratory, Pasadena, CA, 69-72, 1993.

Green, R. O., "An Improved Spectral Calibration Requirement for AVIRIS," Summaries of the Fifth Annual JPL Airborne Earth Science Workshop, JPL 95-1, Vol. 1, AVIRIS Workshop, Jet Propulsion Laboratory, Pasadena, CA, January 23, 1995 (this volume).

Green, R. O., J. E. Conel, M. Helmlinger, and J. van den Bosch, "Inflight Radiometric Calibration of AVIRIS in 1994," Summaries of the Fifth Annual JPL Airborne Earth Science Workshop, JPL 95-1, Vol. 1, AVIRIS Workshop, Jet Propulsion Laboratory, Pasadena, CA, January 23, 1995 (this volume).

4. FIGURES

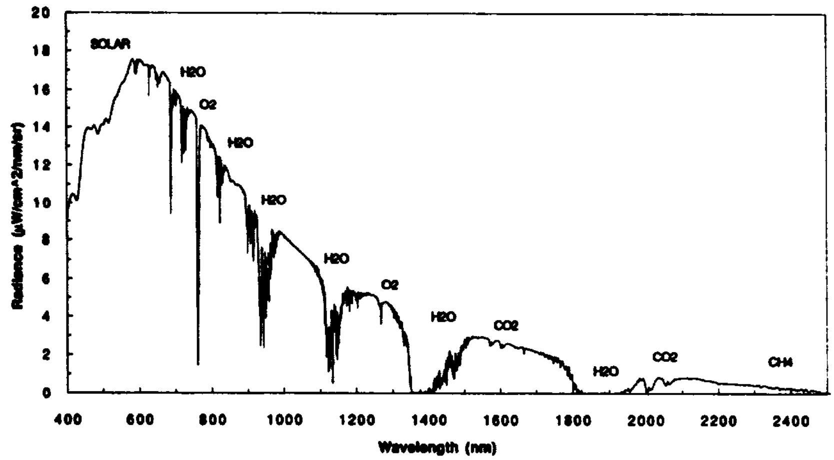

Figure 1. Upwelling spectral radiance predicted by MODTRAN for the AVIRIS over flight of Lunar Lake, NV on April 5, 1994.

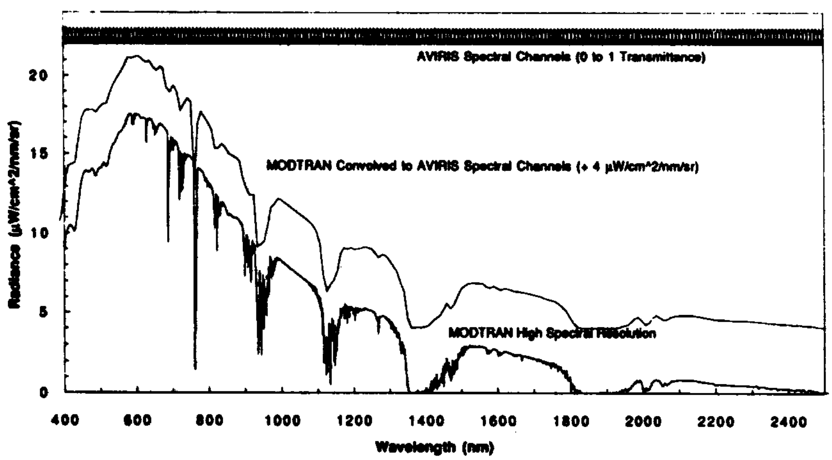

Figure 2. Convolution of MODTRAN to AVIRIS spectral channel characteristics.

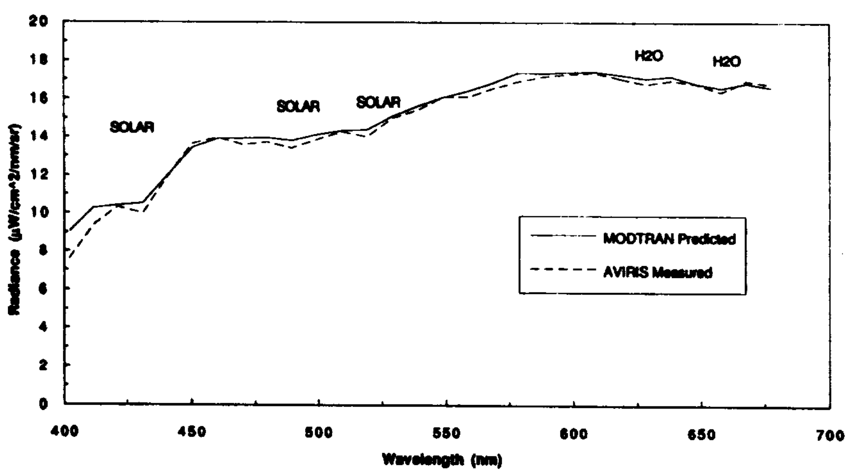

Figure 3. AVIRIS-measured and MODTRAN-predicted radiance for the A spectrometer, based on the laboratory spectral calibration.

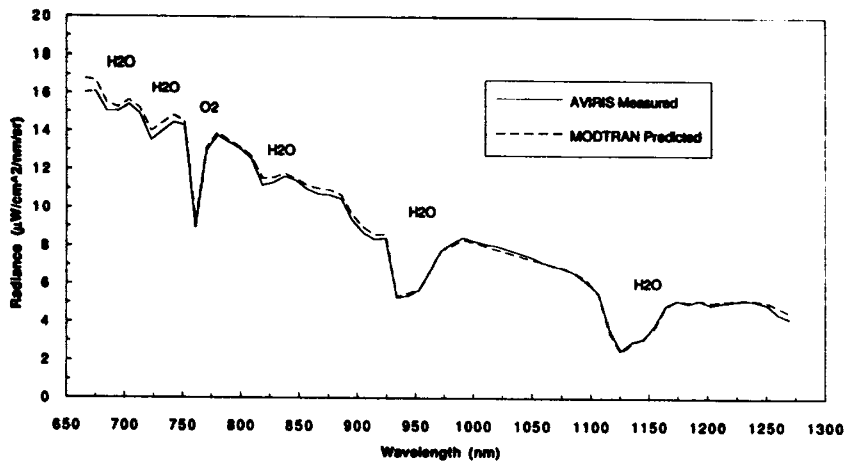

Figure 4. AVIRIS-measured and MODTRAN-predicted radiance for the B spectrometer, based on the laboratory spectral calibration.

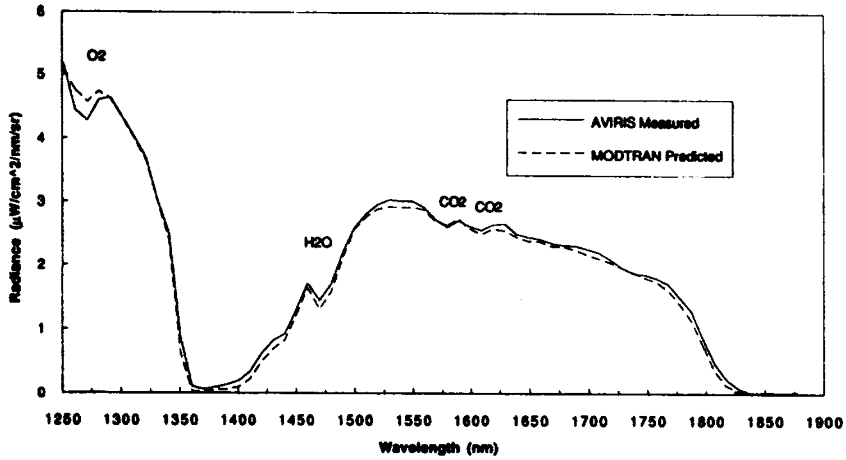

Figure 5. AVIRIS-measured and MODTRAN-predicted radiance for the C spectrometer, based on the laboratory spectral calibration.

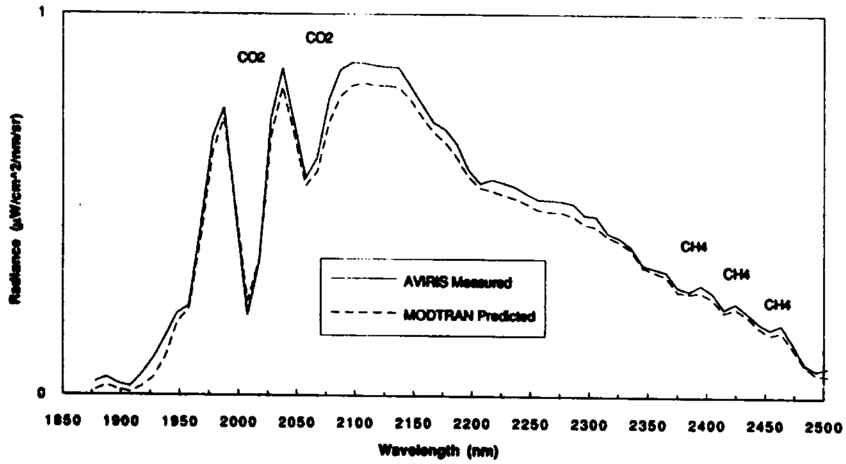

Figure 6. AVIRIS-measured and MODTRAN-predicted radiance for the D spectrometer, based on the laboratory spectral calibration.