A Proposed Update to the Solar Irradiance Spectrum Used in LOWTRAN and MODTRAN

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ABSTRACT

The calibrated upwelling radiance spectra measured by AVIRIS are increasingly being analyzed with radiative transfer codes. Analysis of AVIRIS data with the LOWTRAN and MODTRAN radiative transfer codes has led to indications of an error in the solar irradiance spectra used by these codes. This paper presents evidence for the error and a proposed update to the solar irradiance spectra used by LOWTRAN&MODTRAN.

1.0 INTRODUCTION

AVIRIS measures the total upwelling radiance at 20 km altitude through 224 spectral channels from 400 to 2500 nm. The upwelling radiance measured results from solar energy being transmitted, scattered and reflected from the atmosphere and surface. Quantitative analysis of calibrated AVIRIS radiance with radiative transfer codes requires accurate knowledge of the solar irradiance spectrum from 400 to 2500 nm at AVIRIS spectral resolution. The LOWTRAN (Kneizys et al., 1987) and MODTRAN (Berk et al., 1989) radiative transfer codes are increasingly used in the analysis of AVIRIS measured radiance. In this paper we describe the evidence for spectrally distinct errors in the solar irradiance spectrum shared by the codes. We present a proposed update to the LOWTRAN&MODTRAN solar irradiance.

2.0 LOWTRAN&MODTRAN SOLAR IRRADIANCE ERROR

A common radiative transfer based analysis of AVIRIS data is the inversion of AVIRIS measured radiance to apparent surface reflectance (Green et al., 1990; Green et al., 1993; Gao et al., 1992). When the MODTRAN radiative transfer code is used for this calculation, systematic and spectrally distinct discrepancies have been encountered (Green et al., 1992). This problem has been mitigated by using a MODTRAN based inflight calibration as the radiometric calibration for AVIRIS in the calculation of apparent reflectance. This approach effectively cancels any errors in the MODTRAN solar irradiance spectrum. An example of this discrepancy caused by using the LOWTRAN&MODTRAN solar irradiance is shown in Figure 1. In this figure the MODTRAN calculated reflectance and concurrently field measured field reflectance for the Rogers Dry Lake calibration target is given for the 2000 to 2500 nm spectral region. Also in this figure, the percent difference between the LOWTRAN&MODTRAN solar irradiance and proposed solar irradiance update is given. The erroneous features in the reflectance and irradiance difference correspond closely.

3.0 PROPOSED UPDATE SOLAR IRRADIANCE

The proposed update solar irradiance is based on the Neckels and Labs continuum spectrum (Neckels et al., 1984). The spectrum has been modified to include transmission of the solar atmosphere as measured by the ATMOS sensor on board the Space Shuttle. A plot of the LOWTRAN&MODTRAN solar irradiance spectrum and proposed update is given in Figure 2. In addition to the disagreement in the 2000 nm region a significant departure is evident near the 940 nm region. This is a region of strong water vapor absorption in the Earth's atmosphere and is consistent with the aircraft sensor platform source of the LOWTRAN&MODTRAN irradiance spectra.

A percent difference plot between the LOWTRAN&MODTRAN solar irradiance spectrum and proposed update is given in Figure 3. The spectrally distinct differences in the 2000 nm region approach 20 percent in magnitude. Discrepancies of 5 percent are seen between 900 and 2500 nm.

As a validation of the proposed update to the solar irradiance, the surface reflectance of the calibration target at Rogers Dry Lake was recalculated. A comparison of the calculated reflectance and field measured reflectance using the update irradiance is given in Figure 4. This improvement in agreement between the measured and calculated reflectance shows the importance of the solar irradiance in calculating parameters from measured upwelling spectral radiance.

It is planned to provide this update to the solar irradiance spectrum to the developers of LOWTRAN&MODTRAN (Anderson, pers. comm.)

4.0 CONCLUSION

In the region from 900 to 2500 nm spectrally distinct errors in the solar irradiance spectrum are shown. These discrepancies are largely compensated for with use of the proposed update to the solar irradiance. Continued improvement of knowledge of the solar irradiance spectrum is required as quantitative algorithms are applied to measurement of radiance in this spectral region.

5.0 ACKNOWLEDGMENTS

This research was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.

6.0 REFERENCES

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7.0 FIGURES

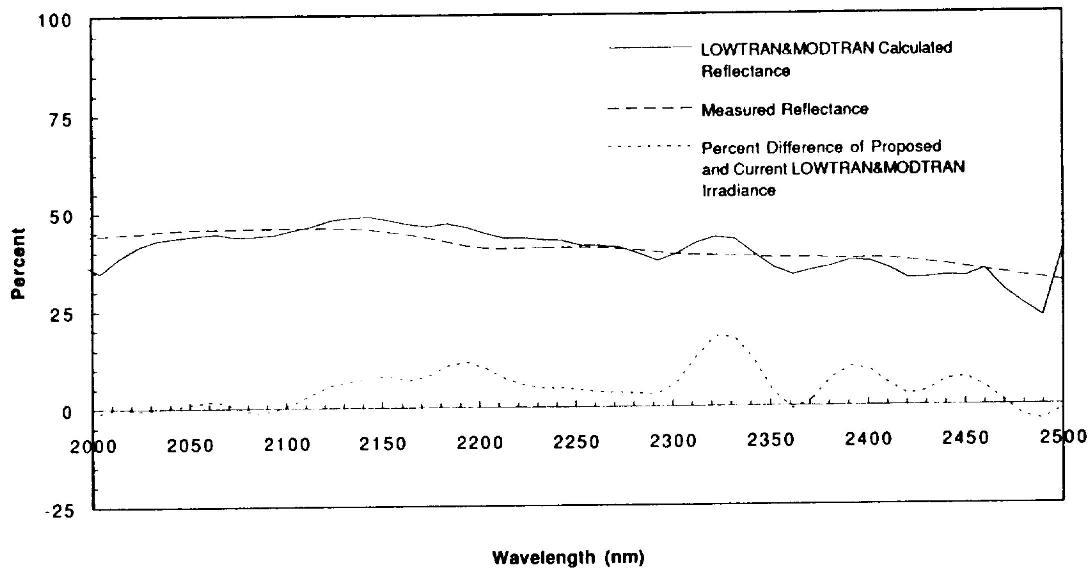

Figure 1. Comparison of LOWTRAN&MODTRAN calculated reflectance and field measured reflectance with the percent difference between the LOWTRAN&MODTRAN and the proposed update to the solar irradiance.

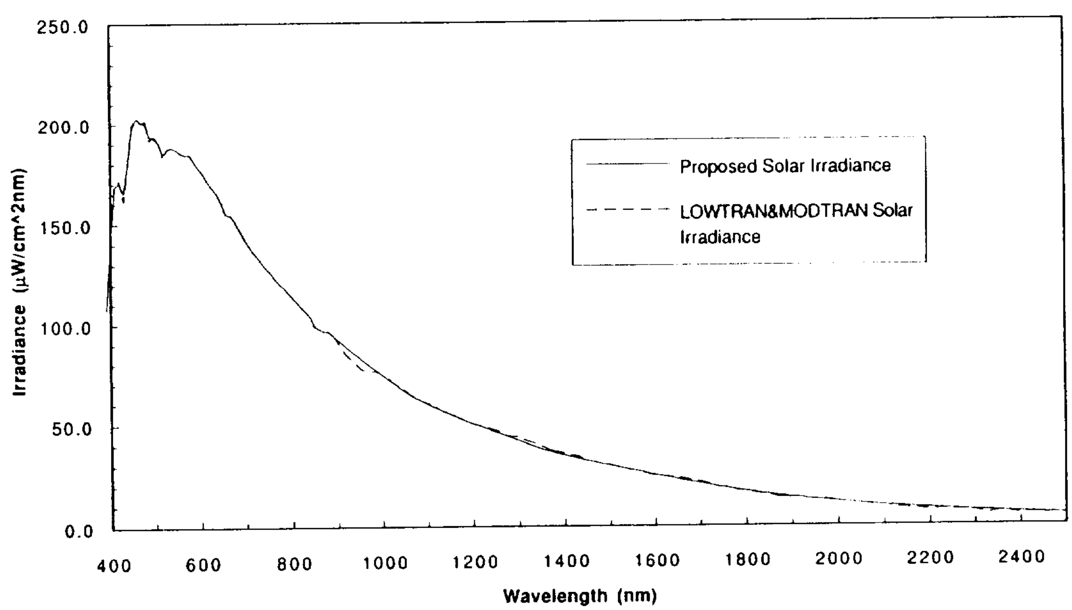

Figure 2. LOWTRAN&MODTRAN solar irradiance spectrum and proposed update.

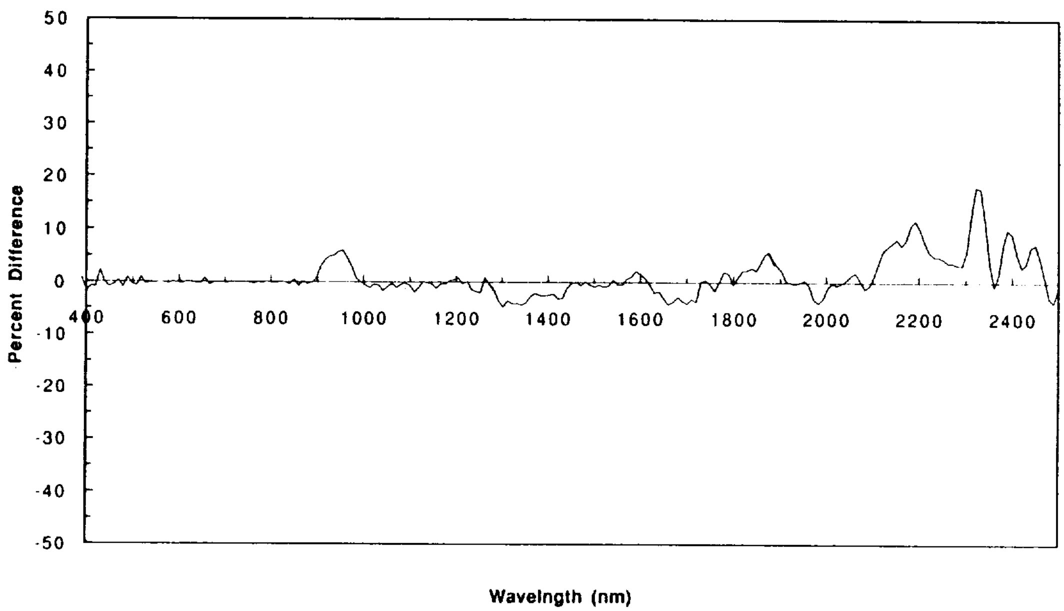

Figure 3. Percent difference between LOWTRAN&MODTRAN and the proposed update to the solar irradiance.

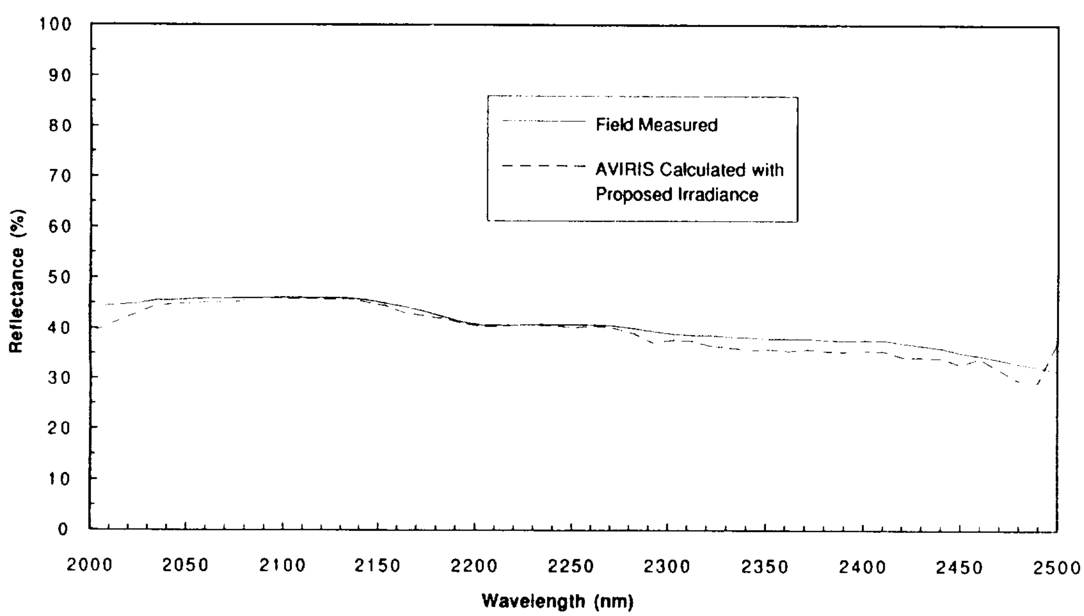

Figure 4. Comparison of radiative transfer calculated reflectance using proposed solar irradiance with field measured reflectance.