Use of the Airborne Visible/Infrared Imaging Spectrometer to Calibrate the Optical Sensor on board the Japanese Earth Resources Satellite-1

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ABSTRACT

In this paper, we describe an experiment to calibrate the Optical Sensor on board the Japanese Earth Resources Satellite-1 with data acquired by the Airborne Visible/Infrared Imaging Spectrometer (AVIRIS).

On the 27th of August 1992 both the OPS and AVIRIS acquired data concurrently over a calibration target on the surface of Rogers Dry Lake, California. The high spectral resolution measurements of AVIRIS have been convolved to the spectral response curves of the OPS. These data in conjunction with the corresponding OPS digitized numbers have been used to generate the radiometric calibration coefficients for the eight OPS bands. This experiment establishes the suitability of AVIRIS for the calibration of spaceborne sensors in the 400 to 2500 nm spectral region.

1.0 INTRODUCTION

Calibration of remote sensing instruments is required: 1) to derive quantitative parameters of the Earth's surface, 2) to measure changes from region to region and from time to time, 3) to compare data between different sensors, and 4) to analyze measured data with computer model predictions.

The Japanese Earth Resources Satellite-1 (JERS-1) was launched in early 1992 with an Optical Sensor (OPS). OPS has eight bands in spectral region from 400 to 2500 nm. These bands range in width from 60 to 130 nm and are described in Table 1. OPS has approximately 20 m spatial resolution with a 75 km cross-track swath.

AVIRIS operates on a platform at 20 km altitude and measures the total upwelling spectral radiance from 400 to 2500 nm in the spectrum at 10 nm spectral intervals. Data are acquired as 11 km by up to 100 km images with 20 m spatial resolution. AVIRIS is calibrated in the laboratory before and after each flight season (Chrien et al., 1990). The laboratory calibration is validated inflight at the beginning, middle and end of each flight season (Conel et al., 1988, Green et al., 1990, and Green et al., 1992). This work has shown AVIRIS to have a radiometric calibration of better than 7 percent inflight.

The high spectral resolution and validated calibration of AVIRIS provide the basis for this experiment to calibrate OPS on-orbit (Green et al., 1993). Figure 1 shows a plot of the AVIRIS spectral coverage with the JERS-1 OPS spectral response curves and a transmission spectrum of the atmosphere.

2.0 JERS1/AVIRIS CALIBRATION EXPERIMENT

On August 27th a calibration experiment was carried out under clear sky conditions at Rogers Dry Lake. This site is located approximately 100 km north of Los Angeles in the State of California. Both JERS-1 OPS and AVIRIS imaged a calibration target on the dry lake bed on the 27th of August (see Slide 9). The calibration target was a homogeneous 40 by 200 meter area of the lake bed with blue tarps placed at each end. The spectral signature of these tarps allows unambiguous location of the lake bed calibration target in the AVIRIS imagery. Once located in the AVIRIS imagery, data from the corresponding region in the OPS imagery are extracted. For this experiment, the flight path of AVIRIS was oriented orthogonal to the JERS-1 ground track and extended to cover the entire OPS swath. To limit the effects from time-variable atmospheric transmittance, the AVIRIS overpass was synchronized with that of the JERS-1 OPS data acquisition.

3.0 AVIRIS DATA ANALYSIS

Total upwelling radiance spectra of the calibration target were extracted from the AVIRIS data. These data were calibrated based on the AVIRIS calibration files and calibration algorithms

(Green et al., 1991). The average AVIRIS spectrum of the 40 m by 200 m calibration target at Rogers Dry Lake is shown in Figure 2. To estimate the upwelling radiance at the top of the atmosphere, a transmittance spectrum from 20 km to 100 km calculated by the MODTRAN2a radiative transfer code (Berk et al., 1989) was used. Less than 2 percent absorption due to stratospheric ozone was calculated for the visible portion of the spectrum. At 760 nm absorption due to oxygen and at 2050 nm absorption due to carbon dioxide were also calculated. This transmittance spectrum was multiplied by the AVIRIS radiance spectra to correct the AVIRIS spectrum to the top of the atmosphere.

4.0 CALIBRATION OF JERS-1 OPS

Spectral response curves of the OPS bands were measured prior to launch of the JERS-1 satellite. These measured OPS curves were spline fit to the AVIRIS spectral channel positions. The resulting spline fit spectral response curves are shown in Figure 3. The high spectral resolution of AVIRIS allows accurate modeling of the eight OPS bands. Spectral weighting functions were developed from these spectral response curves to convolve the AVIRIS upwelling radiance to the eight bands of the JERS-1 OPS. AVIRIS derived upwelling radiance's for OPS bands are shown in Figure 4 in conjunction with the top of the atmospheric corrected AVIRIS spectrum.

From the uncalibrated JERS-1 OPS image of Rogers Dry Lake the digitized numbers (DN) of the calibration target were extracted. The dark signal of each OPS band was estimated based on a scene acquired at night and found to be 0.0 except for band 6 which had a value of 0.4 DN. OPS radiometric calibration coefficients (RCCs) are calculated from the OPS DN and the AVIRIS measured radiance convolved to OPS channels. For the 27th of August 1992 the RCCs for OPS are given in Table 2 in units of microwatts per square-centimeter nanometer steradian digitized-number ($\mu W/cm^2$ nm sr DN). The nominal prelaunch RCCs are given in Table 2 as well.

5.0 FUTURE WORK

Work is planned to use the 100 km AVIRIS flight line to evaluate the variation in the calibration across the OPS swath derived from the 4096 different cross-track detectors for each OPS band.

During October 1992 and June 1993, JERS-1 OPS and AVIRIS acquired additional calibration data sets. These data will be analyzed to determine changes in the calibration of OPS through time.

Analysis of JERS-1 OPS onboard calibrator data and concurrent AVIRIS data will be used to establish the calibration for the OPS onboard radiometric source.

Finally, we will investigate the possibility of solving for the spectral band shape of JERS-1 OPS using concurrently acquired AVIRIS and OPS data over spectrally diverse targets.

6.0 CONCLUSION

JERS-1 OPS has been calibrated on orbit with the high altitude radiance spectra measured by the AVIRIS sensor. This experiment establishes the use of AVIRIS as a calibrated spectroradiometer at 20 km altitude for the calibration of current and future spaceborne sensors in this spectral region.

7.0 ACKNOWLEDGMENTS

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9.0 Tables

Table 1. JERS-1 OPS data characteristics

SPECTRAL

Band	Center nm	Width nm
1	560	80
2	660	60
3	810	100
4	810	100*
5	1655	110
6	2065	110
7	2190	120
8	2335	130

GEOMETRIC

Field of view	75 km
Instantaneous field of view	18.3*24.2 m
*Stereo angle (881 nm)	15.3 degrees

Table 2. OPS Radiometric Calibration Coefficients from the JERS-1/AVIRIS Calibration Experiment

Band	Radiance	DN	Dark	AVIRIS RCC*	Prelaunch RCC*
1	16.26	25.58	0.00	0.6356	0.5400
2	16.49	33.78	0.00	0.4882	0.4098
3	12.36	26.93	0.00	0.4589	0.4133
4	12.30	27.06	0.00	0.4545	0.3983
5	02.83	40.23	0.00	0.0704	0.0653
6	00.91	23.59	0.40	0.0393	0.0336
7	00.97	29.84	0.00	0.0325	0.0269
8	00.57	23.21	0.00	0.0245	0.0200

*($\mu W / cm^2$ nm sr DN)

10.0 Slide

Slide 9, which shows the AVIRIS image of Rogers Dry Lake calibration site, is located in the back pocket of the book. In this slide the vertical panels portray the 224 spectral measurements underlying each 20 m spatial element. A portion of the homogeneous playa surface was used as the calibration target for the AVIRIS/OPS calibration experiment.

11.0 Figures

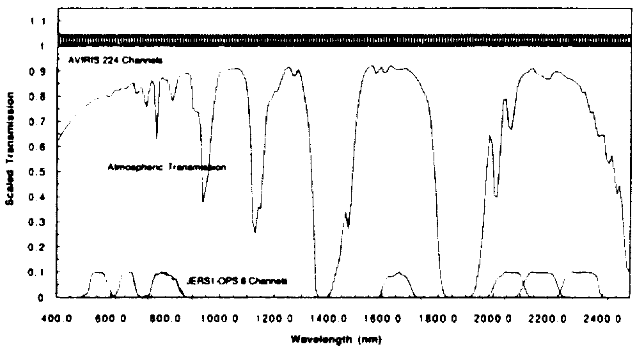

Figure 1. Depiction of the 8 JERS-1 OPS bands, typical atmospheric transmission and the 224 AVIRIS spectral channels.

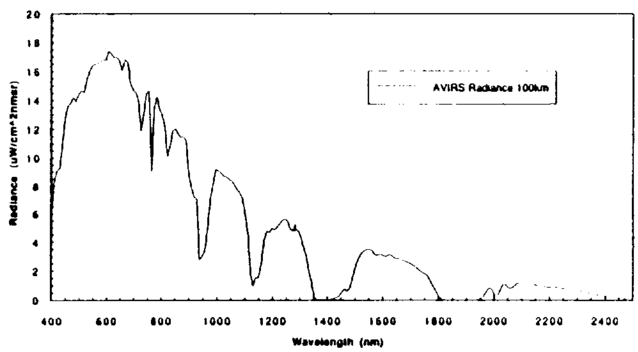

Figure 2. AVIRIS spectrum of upwelling radiance from calibration target.

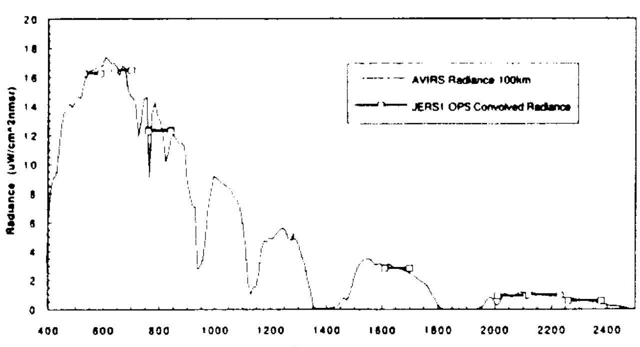

Figure 3. JERS-1 OPS spectral response curves spline fit to AVIRIS spectral channel positions.

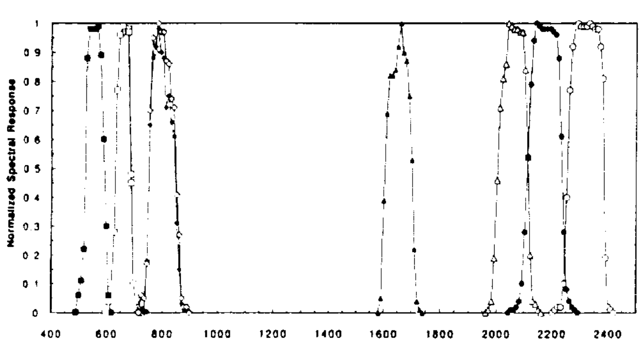

Figure 4. AVIRIS measured radiance in JERS-1 OPS spectral bands and AVIRIS spectrum corrected to top of the atmosphere.