N95- 23854

Comparison of Methods for Calibrating AVIRIS Data to Ground Reflectance

Roger N. Clark[1], Gregg Swayze[1], Kathy Heidebrecht[2], Alexander F. H. Goetz[2], and Robert O. Green[3]

[1]U.S. Geological Survey
MS 964 Box 25046 Federal Ctn., Denver, CO 80225

[2]Center for the Study of Earth from Space (CSES)
Cooperative Institute for Research in Environmental Sciences (CIRES)
University of Colorado, Boulder, CO 80309-0449

[3]Jet Propulsion Laboratory, California Institute of Technology
Pasadena, California 91109-8099

We are comparing three basic methods of calibrating AVIRIS data to ground reflectance:

1) Atmospheric radiative transfer models with the solar flux can be used to calibrate AVIRIS radiance data. Specific methods include the University of Colorado CSES ARP and ATREM algorithms.

2) Robert Green's modified MODTRAN and AVIRIS radiance model. This method is similar to #1 but differs in that the solar radiance is bypassed (so any errors in the solar flux are canceled too).

3) Ground calibration using known sites in the AVIRIS scene.

We are using 1992 AVIRIS data over Cuprite, Nevada, and Blackhawk Island, Wisconsin, as our test scenes. Both these sites have extensive field measurements. The Cuprite site had a very clear atmosphere, thus path radiance was dominated by Rayleigh scattering with little or no flux beyond 1 µm. The Blackhawk site has more aerosols, with significant path radiance flux beyond 2 µm.

We found that models that rely on the solar flux tend to have serious errors. This led to a modification of the CSES ATREM algorithm in 1993 to correct empirically for such problems. To date, the published solar flux spectra have disagreements of greater than ±7% at AVIRIS 1992 resolution and sampling. Unfortunately, these disagreements can impart spectral features greater than 10% in calibrated spectra. Further, it is not clear which, if any, of the published solar flux measurements is correct. It is even possible that some of the spectral features in the solar spectrum are variable.

Green's method uses the AVIRIS radiance along with radiance measured over Roger's Dry Lake for each season, and thus cancels the solar radiance from the calibration. This calibration is dependent on an accurate reflectance of the Roger's Dry Lake surface, a problem limited by the field spectrometer technology available. For the 1993 calibration, we have tried to improve this step with laboratory measurements of Roger's Dry Lake samples measured at the USGS

Denver Spectroscopy Laboratory in conjunction with field measurements (results not yet available).

Ground calibrated AVIRIS data proved to be the best calibration locally. In this method, one or more large uniform calibration sites have their reflectance measured in the field and/or on a laboratory spectrometer, and the corresponding spectra in the AVIRIS scene over the site(s) are used to derive a set of path radiance offsets and multipliers. The disadvantages of this method are that it requires very careful field work to find scenes with large spectrally bland and uniform areas, and it applies to only one elevation level. Our experience is that this calibration requires about one person-month to complete. For elevations in the scene higher than the calibration site, there are residual positive atmospheric features and for elevations lower there are residual atmospheric absorption bands. Outside the main atmospheric bands (0.76-μm oxygen, 0.95-μm water, 1.15-μm water, 1.38-μm water, 1.9-μm water, and 2-μm CO_2 absorptions), the data are calibrated very well.

A remaining problem with the radiative transfer models is with the path radiance correction. Neither algorithm (#1, #2 above) correctly predicted the aerosol path radiance over Blackhawk Island. These models assume Rayleigh scattering with little or no aerosols and thus little or no path radiance flux at wavelengths beyond 1 μm.

It appears that the best possible AVIRIS calibration would be a combination of a radiative transfer correction followed by a ground calibration. This combined method would perform a basic correction of atmospheric absorptions at all elevations, and remove Rayleigh scattering. The ground calibration would correct for fine details, such as errors in solar flux or the AVIRIS radiance calibration, and could better correct for unusual path radiance due to aerosols.