Landsat IOPs: Dissemination of TM and ETM+ Data, and Atmospheric Correction

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Introduction

License restrictions, which had limited the use of Landsat data in the 1980s and early 1990s, have now been lifted, allowing free dissemination of this high-resolution data through such public means as the Atmospheric Radiation Measurement (ARM) archive. Five images are so far in the archive, and more are being provided from both clear and cloudy scenes. More intensive observation periods (IOPs) are planned at all three ARM sites. Future launch of the Enhanced Thematic Mapper Plus (ETM+) instrument with on-board calibration and improved resolution on Landsat-7 will provide new opportunities for strengthening the mutual benefit between the ARM and Landsat programs. (See *http://climate.gsfc.nasa.gov/Landsat* for details)

Atmospheric correction is coupled with atmospheric parameter retrieval. Among those parameters, aerosol optical thickness (AOT) and column water vapor amount are the most important. ARM IOPs provide valuable information to improve and validate Landsat clear-sky atmospheric correction, and at the same time, the 30-m spatial resolution Landsat images provide the ARM Program more detailed information on both surface and atmospheric parameters.

A "dark target" approach (Liang et al. 1997) is used to perform atmospheric correction of Landsat imagery. This technique assumes 1) that there is negligible atmospheric impact in band 7, at 2.2 µm; 2) that the surface reflectance of solar spectrum in blue at 0.49 µm and red at 0.66 µm bands are well correlated with that of mid-infrared (IR) band at 2.2 µm for dense vegetation and forest; and 3) that AOT has a power relation with wavelength.

In the fall 1997 Landsat IOP, a Landsat-5 image was acquired on September 27, 1997—a very clear day (Figure 1). Atmospheric AOT, columnar water vapor, and total ozone amounts were continuously observed from a variety of instruments including radiosonde, ground-based microwave radiometers and sunphotometers. One Analytical Spectral Devices FieldSpec spectroradiometer, owned by Dr. Stephen Schiller's group at South Dakota State

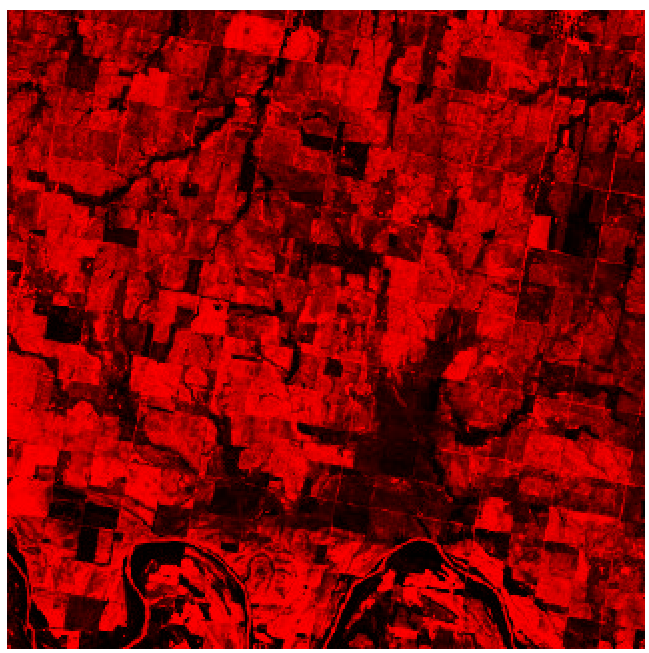

Figure 1. The sub image of 512 x 512 pixels of a Landsat-5 image acquired on September 27, 1997, shows the area over the central facility site. (For a color version of this figure, please see *http://www.arm.gov/docs/documents/technical/conf_9803/wen-98.pdf*.)

University, collected spectral reflectance over vegetation in a open field near the Cloud and Radiation Testbed (CART) site before and after the Landsat satellite overpass.

AOT is less than 0.1 for all sunphotometer channels on September 27, 1997, over the central facility site. In order to minimize the difference between retrieved AOT with that from sunphotometer measurements, we need to use the empirical relation

$$\alpha_1 = 0.21\alpha_7, \quad \alpha_3 = 0.73\alpha_7$$

where α_1, α_3, and α_7 are surface reflectance of band1 (0.49 µm), band3 (0.66 µm), and band7 (2.2 µm). Frequency distribution of retrieved AOT for band1 and band3 are presented in Figure 2 with sunphotometer observed ones indicated by arrows.

Using the observed AOT, water vapor profile, and averaged surface reflectance, we also compared Landsat apparent reflectance with those computed by radiative transfer model calculations. Figure 3 shows the averaged surface spectral reflectance, and apparent reflectance from Landsat observation and that from radiative transfer model. We

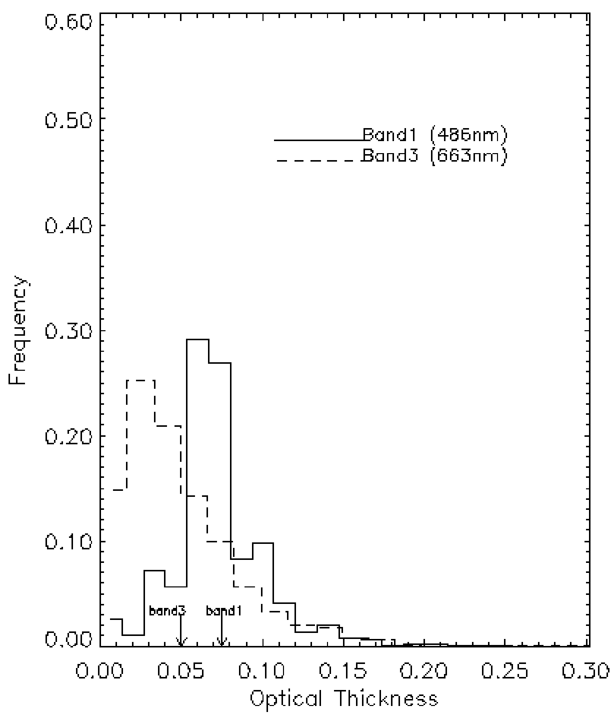

Figure 2. By using the dark object approach, AOT for band1 and band3 are retrieved. The frequency distributions are compared with sunphotometer measurements (about 0.07 for band 1 and 0.05 for band 3) indicated by arrows.

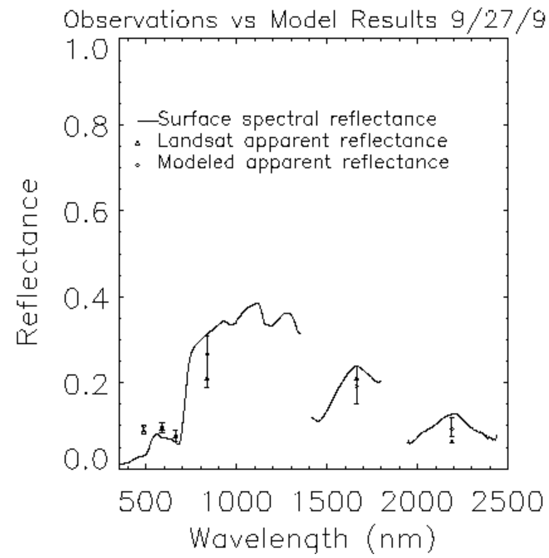

Figure 3. Radiative transfer modeled apparent reflectances (triangles) at Landsat 6 solar bands are compared with observed ones (diamonds). The error bars for modeled reflectance are related to the variability of surface reflectance. The averaged surface spectral reflectance (solid line) is plotted to demonstrate the atmospheric effects.

found that the model overestimates the apparent reflectance for all solar bands. The largest discrepancy occurs at band 4 (0.84 µm), where Landsat apparent reflectance is 0.22 while the modeled result is 0.27. However, this discrepancy is within the variability of observed surface reflectance.

The ARM IOP has provided valuable information to improve Landsat clear-sky atmospheric corrections. Landsat-7 is scheduled to be launched in December 1998. The ETM+ instrument, with onboard calibration, is expected to provide significantly improved images compared to those of the Landsat-5 TM. A new ground receiving station in Alaska will allow ETM+ acquisitions at the North Slope of Alaska (NSA) site. Images will also be acquired at the Tropical Western Pacific (TWP) site in future IOPs. Our current Goddard archive includes 10 TM images over the Southern Great Plains (SGP) site and 2 at the NSA site, and 5 of these 15 are now in the ARM archive. More images will be sent to the ARM archive with both clear and cloudy scenes.

Reference

Liang, S., H. Fallah-Adl, S. Kalluri, J. Jaja, Y. J. Kaufman, and J. R. G. Townshend, 1997: An operational atmospheric correction algorithm for Landsat Thematic Mapper imagery over the land. *J. Geophy. Res.*, **102**, 17,173-17,186.