Aerosol Optical Thickness Retrieval from Landsat TM Image over SGP Site of the ARM Program

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Introduction

It is recognized that the uncertainty in the magnitude of the effect of aerosols on climate is seriously hindering our ability to assess the effect of greenhouse on climate (IPCC 1996). Accurately retrieving aerosol optical thickness (AOT) from space is necessary to reduce the uncertainty due to the effects of anthropogenic aerosols in global climate system. However, the retrieval of AOT over land is very difficult due to the inhomogeneity surface characteristics. In this paper, we apply the path radiance technique to retrieve AOT from a Landsat Thematic Mapper (TM) image over Southern Great Plains (SGP) site of the Atmospheric Radiation Measurement (ARM) Program and compare the retrieved AOT to the ground-based sunphotometer measurements.

Data Sets

A TM image was acquired on September 27, 1997, during the first Landsat Intensive Observation Period (IOP) (part of the Integrated IOP). The images cover an area of about 196 km x 185 km with a resolution of 28.5 m over the SGP site. The solar zenith angle was about 43.7° and the azimuth angle was 143.2° at the time the image was acquired. We use the blue band (band 1 at 0.49 μm), red band (band 3 at 0.66 μm), and the mid-infrared (IR) band (band 7 at 2.2 μm) in the AOT retrieval. Ground-based sunphotometer of AERONET (Holben et al. 1998) and several other sun-tracking radiometers were continuously making AOT measurements (Schmit et al. 1999). Because the ground-based AOT measurements agree very well with each other, we choose the measurements from the CIMEL sunphotometer of AERONET in this study.

Path Radiance AOT Retrieval

The path radiance technique for AOT retrieval over land is based on the fact that in some geographic regions (e.g., vegetation, wet soil) the surface reflectance between visible (blue and red) and mid-IR at 2.2 μm are correlated (Kaufman et al. 1997). When surface reflectances between visible and mid-IR are linear correlated, the apparent reflectances at the two spectra are also correlated provided horizontally uniform aerosols over vegetation or wet soil surfaces. Since aerosols are generally in sub micron sizes,

the aerosol effect on apparent reflectance at 2.2-μm band is negligible. Thus, the path radiance in band 7 is approximately zero. Instead of using the fixed visible and mid-IR relations at the surface, we use the information from the apparent reflectance as described below.

In path radiance approach, we use homogeneous clusters to extract the linear relation between visible and mid-IR top-of-atmosphere (TOA) reflectance, as shown in Figure 1. Homogenous clusters are defined as N x N pixels (N~10) with small standard deviation in mid-IR reflectance (e.g., less than 0.02). A linear line is fitted to the bottom envelope of visible and mid-IR relations. The intercept, where the path radiance in band 7 is zero, gives the path radiance in the visible, and from it AOT may be easily retrieved. In the retrieval process, the AOT is retrieved for each sub-scene of 512 x 512 pixels. The histogram of the AOT is presented in Figure 2. The retrieved mean AOTs are 0.088 and 0.071 with standard deviation of 0.044 and 0.051 for blue and red bands, respectively. The sunphotometer-measured AOTs at the two bands are 0.07 and 0.05, respectively (Schmit et al. 1999).

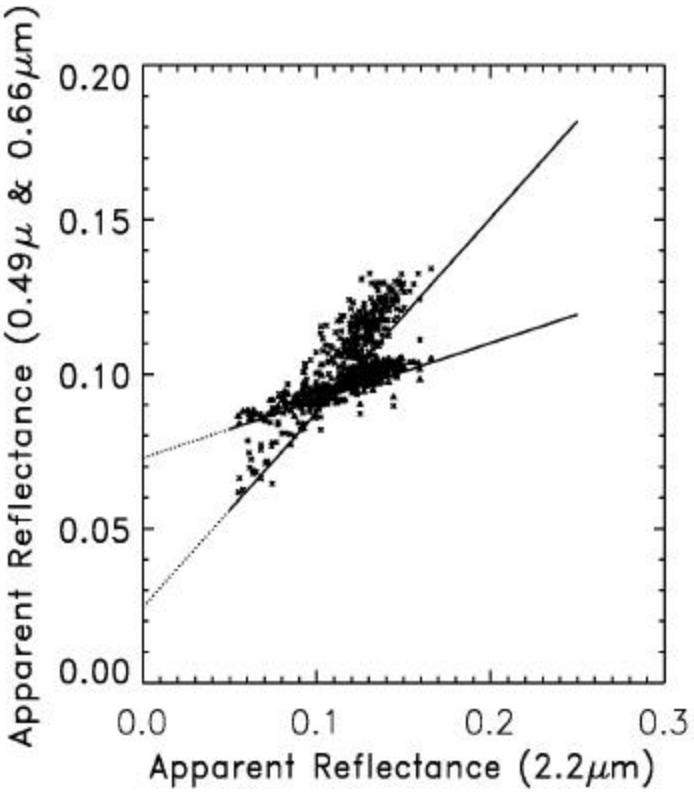

Figure 1. The scatter plots show the visible and mid-IR relations for homogeneous clusters size of 10 x 10 pixels from a sub-scene of 512 x 512 pixels (triangles: blue and mid-IR relations; crosses: red and mid-IR relations). A straight line is fitted to the lower 20% of scattered points.

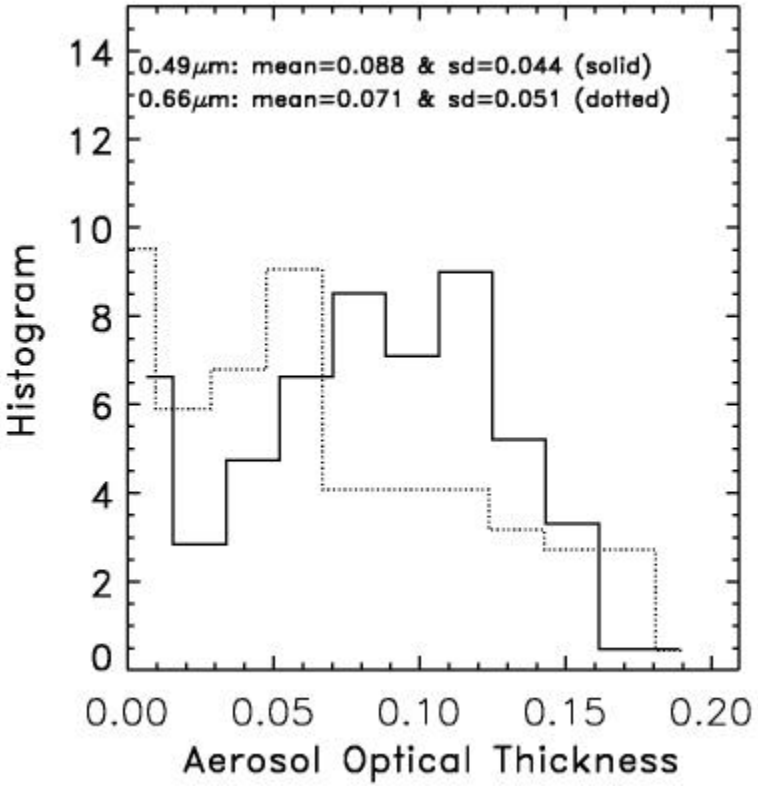

Figure 2. The distribution of path radiance-retrieved AOT for blue band at 0.49 μm (solid) and red band at 0.66 μm (dotted). The means of AOTs are 0.088 and 0.071 with standard deviation of 0.044 and 0.051 for blue and red bands, respectively.

Summary and Discussion

The Landsat IOP together with the Integrated IOP in the fall of 1997 provided us with a unique opportunity to apply the path radiance technique to the TM image, and to compare the retrieved AOT with ground-based measurements at the ARM Program's SGP site. The path radiance-retrieved AOTs of both blue and red bands agree very well with the ground-based sunphotometer measurements. The ability to retrieve small AOT makes this technique promising. However, we have applied the technique to only one TM scene at present. With the launch of Landsat 7, we expect to have better Enhanced Thematic Mapper Plus (ETM+) images. We plan to use ARM data to further test our ability to retrieve aerosol optical properties over land from space.

References

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