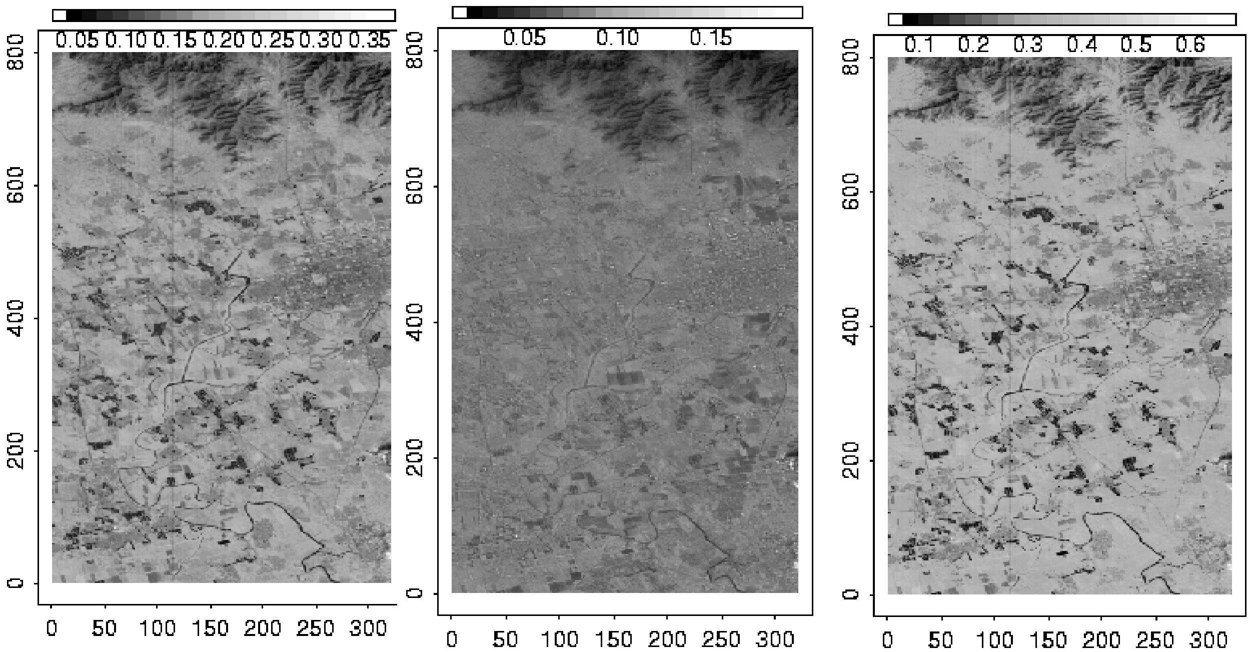
Using ALI Observations to Estimate Land Surface Biophysical Variables

Shunlin Liang

This study examined whether observations from the EO-1 Advanced Land Imager (ALI) can be used to estimate land surface biophysical variables accurately. The investigators developed and tested a series of new algorithms and validated the derived products using correlative ground measurements through field campaigns. Validation through field campaigns was carried out at the U.S. Department of Agriculture Beltsville Agricultural Research Center in Beltsville, Maryland, and at the Coleambally Irrigation Area in Australia.

The investigation focused primarily on two biophysical variables: broadband albedos and leaf area index (LAI). Albedo is important when determining the Earth's climate and for computing the surface energy balance. Land surface albedo can be acquired only through remote sensing. LAI is also an important factor in land surface models.

Two important pre-processing steps must occur before albedo and LAI can be quantitatively estimated. First, sensor radiometric calibration that converts the digital numbers to top-of-atmosphere (TOA) radiance must take place. Second, TOA radiance must be converted to surface reflectance. This is done through atmospheric correction. An atmospheric correction algorithm designed for use with the Landsat Enhanced Thematic Mapper (ETM+) imagery was enhanced for this purpose. The method used to develop this enhanced algorithm built on a series of steps. First, atmospheric correction that converts TOA radiance to surface directional reflectance was carried out. ALI's one extra blue band proved very useful in this atmospheric correction algorithm. Then, BRDF (Bidirectional Reflectance Distribution Function) modeling that converts directional reflectance to narrowband albedos, and also narrowband to broadband conversions were done. A set of formulae were developed for converting ALI narrowband albedos to three broadband albedos. Figure 1 shows broadband albedo maps over Beijing City, China.



Shortwave **Visible** **Near IR**

Figure 1. ALI broadband albedo maps over Beijing, China.

To estimate canopy LAI, two types of algorithms can be used: (1) statistical, which relies primarily on vegetation indices that are linked with measured LAI data; and (2) physical models. The second type, physical models, is based on inverting canopy reflectance models and is very time-consuming and difficult at the regional level. In this study, investigators developed a "hybrid," or "inversion," algorithm that combined both statistical and physical algorithms. The statistical part of this model used a nonparametric regression algorithm to link LAI and band reflectance. The physical component used the canopy radiative transfer model for extensive simulations. Figure 2 shows LAI maps made using the hybrid inversion algorithm at three different times of crop growth. The maps show logical LAI for the crops and months being mapped. Validation resulted in an error of less than 0.5.

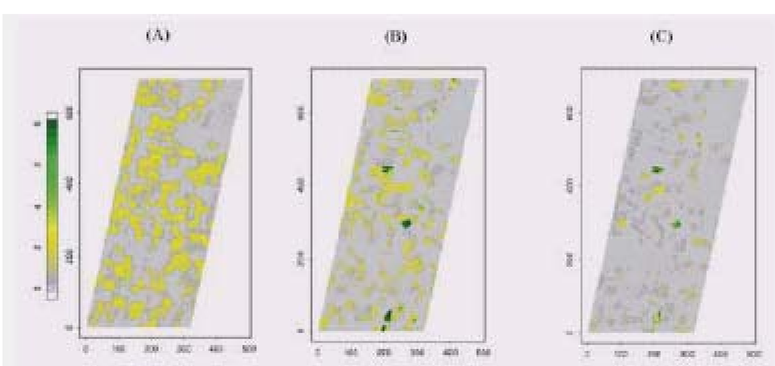


Figure 2. Retrieved LAI maps over Coleambally Irrigation Area from ALI imagery in January (left), February (center), and March (right).

Results and Conclusions:

Comparisons of ALI corrected imagery that used the newly developed algorithm with simultaneous measurements of surface reflectance indicated that the algorithm was highly accurate. Use of the algorithm enabled accurate retrieval of surface reflectance with residual errors of about 0.01 in the shortwave bands and about 0.03 in the near-IR bands. Figure 3 shows a composite image before and after atmospheric correction. Results also demonstrated that the algorithm could remove heterogeneous aerosol scattering effects effectively. It was also seen that the additional spectral bands present on ALI but not on the ETM+ were helpful for atmospheric correction and retrieval of land surface variables. In particular, the additional blue band helped identify hazy regions in the algorithm. Further, the two near-IR bands (4' and 5') were valuable in converting narrowband to broadband albedos and determining LAI. The advantages these additional bands provide may be algorithm-dependent, but the algorithms developed in this investigation were able to take full advantage of the additional bands.

Figure 3. False-color composite imagery near Beijing City, China, before (left) and after atmospheric correction.