Surface BRDF-based albedo from multiple view angle airborne imagery spectrometry

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Summary

In this study, the ability and limitation of the airborne CASI images to obtain surface albedo were explored and some suggestions about future flight missions regarding to BRDF/Albdeo studies were made. The results then are being used to validate the albedo Product of MODIS.

1- Introduction

Surface albedo is an important parameter in surface energy balance and climate change studies and is described as the ratio between the hemispherical upwelling and downwelling fluxes at a point. Since surface albedo highly varies in space and time, extensive ground measurements are needed that is extremely difficult and expensive esp. in large heterogeneous areas. Satellite data with wide spatial coverage and having continuous information for the whole coverage seems an appropriate means to obtain this physical variable.

2- Data

CASI 2 (Compact Airborne Spectrographic Imager) data provided by the NERC Airborne Research & Survey Facility (ARSF) has the advantage of being programmable before or during the flight (ARSF_Website).

The data employed in this study was collected on the 17th of JUN 2006 as a part of NCAVEO field campaign in spatial mode, 512 pixels across swath with 15 spectral bands. The data comprises 8 closely-spaced flight lines and one orthogonal flight line that provide multi-view observations for overlapped areas.

The collected CASI images covers an area about 6 by 10 km located in Chilbolton, Hampshire, Southern England. A subset of 170 by 750 pixels with 5 different observations was chosen to obtain albedo map.

The ancillary data were also employed such as Digital Surface Model (DSM) data with 5 m resolution and the point data representing the land cover of the area collected during NCAVEO Field Campaign 2006.

3-Geometric correction

Airborne images are difficult to be geocorrected due to high variations in aircraft altitude, attitude and velocity. AZGCOOR uses the information about position and attitude (roll, shift and heading) of the aircraft in level 1B data to do a precise geometric correction without the need to any ground control (AZGCORR 2005).

4- Atmospheric correction

To obtain surface reflectance, atmospheric effects should be removed. ATCOR-4 software uses the database created by MODTRAN-4 to do atmospheric correction for airborne imagery (Richter 2007).

Using geo-corrected image as an input to ATCOR that doesn't correspond to the information in the sensor file, a scan angle file, consisting of view zenith and azimuth angles and elevation data, is required. Using scan angle, ATCOR applies an off-nadir atmospheric correction to obtain more accurate results.

5-View and illumination geometry:

To be able to determine the BRDF and also correcting the atmosphere effects, knowing the view and illumination geometry for each pixel is necessary.

To produce view geometry, the geometry and attitude of aircraft over each scan line and geometry and topography of each pixel in the scan line were considered.

The sun geometry was estimated knowing the timing and the position of the image.

6- BRDF model

To obtain the surface anisotropy behaviour, a simple empirical BRDF model was employed (walthall, 1985).

$$r = a\theta_v^2 + b\theta_v \cos(\phi_v - \phi_i) + c$$

Where r is the surface reflectance, θ_v and ϕ_v view zenith and azimuth angles, θ_i and ϕ_i illumination zenith and azimuth angles and a, b and c are the coefficients.

Also, a modified Walthall model were employed (Nilson and Kuusk ,1989).

$$r = a\theta_i\theta_v \cos(\phi_v - \phi_i) + b\theta_i^2\theta_v^2 + c\left(\theta_i^2 + \theta_v^2\right) + d$$

Where θ_s is solar zenith angle.

Two approaches were employed one using view geometry in different flight lines that gives BRDF per pixel and the other using view geometry in each land cover in each flight line image the produces BRDF per land cover.

7- Surface albedo

Surface albedo is mathematically defined as (Wanner, Strahler et al. 1997):

$$\alpha(\lambda) = \frac{\int_0^{2\pi}\int_0^{\pi/2} L_{\uparrow}(\theta_\upsilon, \phi_\upsilon, \lambda)\sin\theta_\upsilon \cos\theta_\upsilon d\theta_\upsilon d\phi_\upsilon}{\int_0^{2\pi}\int_0^{\pi/2} L_{\downarrow}(\theta_i, \phi_i, \lambda)\sin\theta_i \cos\theta_i d\theta_i d\phi_i}$$

Where $L\uparrow$ is reflected radiance and $L\downarrow$ is incoming radiance.

To produce spectral albedo, surface reflectance was integrated in the whole view and azimuth angles in each spectral band. The spectral albedo then were integrated in the whole spectral bands and a broadband albedo were created.

Based on two approaches in producing BRDF, two different albedo one per pixel and another per land cover were produced.

9- References

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