P3.13 RETRIEVAL OF SURFACE BRDF PARAMETERS AND ALBEDO FROM THE AVHRR PATHFINDER ATMOSPHERE DATASET

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1. INTRODUCTION

Solar radiation reflected by land is often non-Lambertian; reflectances are described better by a bidirectional reflectance distribution function (BRDF). The BRDF is required to fully understand the reflected radiation, for instance to estimate albedo. Herein, a BRDF retrieval method is described for the AVHRR Pathfinder Atmosphere (PATMOS) dataset (Jacobowitz et al., 2002). It is the precursor toward retrieving aerosol optical depth over land from AVHRR (see paper 5.2).

2. PATMOS DATA

The Advanced Very High Resolution Radiometer (AVHRR) has flown nearly continuously on numerous NOAA satellites since 1981. This vast amount of data is condensed into a useable format in the PATMOS data set (Jacobowitz et al., 2002). The volume of the Global Area Coverage (GAC) AVHRR data has been significantly reduced from terabytes to gigabytes by statistically decreasing the spatial resolution. The GAC data are binned into 110×110 km^2 quasi-equal area grid cells where statistics are calculated for each AVHRR channel for each grid cell.

The PATMOS daily-radiance data set (PATMOS-1) includes 71 parameters for each grid cell. 54 parameters are direct variables of AVHRR measurements. Four statistical categories are used for each channel: All pixels, clear sky, aerosol burden and cloudy. Statistics for each category (generally, the mean and standard deviation) are recorded for each channel. The parameter used in this study is the channel 1 (0.63µm) reflectance (R_{sat}) deemed cloud-free by the Clouds from AVHRR (CLAVR-1) algorithm.

3. RADIATIVE TRANSFER

The DISORT radiative transfer model version 2 (Stamnes and Swanson, 1981) is used to produce theoretical TOA reflectances. TOA reflectances (R_{LUT}) were simulated at 13 solar zenith angles, θ_1: 10°-70°, 15 satellite zenith angles, θ_2: 0°-70° and 19 azimuth angles, ϕ_1-ϕ_2: 0°-180°. Atmospheric effects were held constant during the calculations, with ozone absorption and Rayleigh scattering characteristic of a tropical atmosphere.

(Privette et al., 1997) compare different BRDF models and conclude that the model described by (Rahman et al., 1993) describes a multitude of surfaces with higher accuracy than other models. Therefore, it was used in this research to model the surface; it uses three terms to describe the surface: the magnitude of the surface reflectance, ρ; the Henyey-Greenstein function parameter, Θ; and the level of anisotropy, k. For each viewing geometry in the LUT, calculations were performed at 1100 BRDF combinations, with ρ: 0.001 to 0.09, Θ: -1 to 1, and k: 0.0 to 1. Each BRDF was used in a DISORT run to calculate the R_{sat} due to the surface BRDF and Rayleigh scattering for each of the 3705 possible geometries.

Lastly, aerosol scattering and absorption are included in these calculations via the continental aerosol described by Kaufman et al (1997). One look-up table is computed with $\tau = 0.05$. This is the assumed to be the minimum τ observed during the composite time period.

4. Surface BRDF Retrieval

The surface BRDF is estimated by compositing PATMOS reflectances. The satellite repeat cycle of the NOAA series of satellites is eight days. Thus, over the course of 24 days it is possible to composite 3 observations from each look angle (given plenty of cloud-free observations). However at some sites, cloudy skies limit the number of observations, so the time period is allowed to vary from 24 to 48 days. Circles in figure 1 show an example of 24 days of cloud-free channel 1 reflectances from the Patmos-1 data. It is clear that a significant trend as a function of view zenith angle is present and that there is noise in this trend. Assuming that the presence of aerosol increases the reflectance (i.e., that the aerosol absorption is low), then the darkest of these points in the composite is likely to have the lowest τ.

The LUT is used to determine the surface BRDF. First, the LUT is interpolated for the viewing geometry of each of the points. This narrows the possible solutions to the 3705 combinations of

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BRDF parameters. A cost function is then used to retrieve the best-fit BRDF parameters.

An example BRDF retrieval is also shown in figure 1. The circles represent PATMOS observations over Cuiaba, Brazil. The squares represent the TOA reflectances given the retrieved BRDF. In general, the squares compare well with the darkest observed reflectances.

5. ESTIMATING ALBEDO AND NDVI

The calculation of the NDVI is straightforward after the BRDF has been determined. The standard NDVI equation is used, however the reflectances come from the Rahman BRDF equation rather than satellite observations. Since these parameters were retrieved using atmospheric correction, the NDVI is more representative of the surface.

Similarly, the broadband albedo calculation is an estimate of what actually exists at the surface, however the calculations is less direct. First, the BRDF – using the retrieved parameters – is integrated over the hemisphere. Then, the narrow-band hemispheric albedos are converted to broadband albedos via a linear equation from (Liang, 2001). Again, since this estimate uses some amount of atmospheric correction for a more accurate estimate of the surface albedo.

6. RESULTS

The primary result of this research is the resulting BRDF of the land surfaces of the globe from 1981-2000. The BRDF values are available for each season from Fall 1981 through Winter 2000. The NDVI and broadband albedo are also available. These retrieval maps area available at:

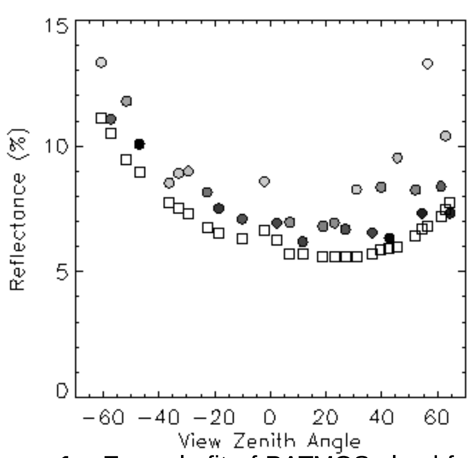

Figure 1 – Example fit of PATMOS cloud-free observations (circles) to a BRDF (squares) at Cuiaba, Brazil. The retrieved parameters BRDF are $\rho = 0.03$, $k = 0.1$, and $\Theta = 0.1$. Negative viewing angle corresponds to viewing away from the Sun.

http://orbit-net.nesdis.noaa.gov/crad/sat/atm/aerosol/kknapp/
(Due to the number, color and size of these images, they are not included here).

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