Laboratory Measurement of Bidirectional Reflectance of Radiometric Tarps

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Objective
- To determine the magnitude of radiometric tarp BRDF
- To determine whether an ASD FieldSpec Pro spectroradiometer can be used to perform the experiment

Background
- Radiometric tarps with nominal reflectance values of 52%, 35%, 22%, and 3.5%, deployed for IKONOS, QuickBird, and OrbView-3 overpasses
- Ground-based spectroradiometric measurements of tarp and Spectralon® panel taken during overpasses using ASD FieldSpec Pro spectroradiometer, and tarp reflectance calculated
- Reflectance data used in atmospheric radiative transfer model (MODTRAN) to predict satellite at-sensor radiance for radiometric calibration
- Reflectance data also used to validate atmospheric correction of high-spatial-resolution multispectral image products

Apparatus
- 1000-watt FEL lamp source
- Gonimeter allows incidence and viewing angles to be varied separately
- Optronic OL 750 double monochromator/spectroradiometer

Procedure
1) Measure signal of NIST-calibrated Spectralon panel irradiated by collimated light at incidence angle of calibrated reflectance, viewing normal to panel surface \( L(\theta_{\text{NIST}}) \).
2) Measure signal of Spectralon panel irradiated at incidence angle equal to solar zenith angle at time of overpass \( L(\theta_{\text{NIST}}) \).
3) Calculate reflectance of Spectralon panel irradiated at solar zenith angle, viewing normal to panel surface (ground geometry):
\[
R(\theta_{\text{Lambert}}) = \frac{L(\theta_{\text{NIST}})}{L(\theta_{\text{NIST}})} \times \frac{L(\theta_{\text{Lambert}})}{L(\theta_{\text{Lambert}})}
\]
(R = reflectance, L = signal)

Results
- Minimum and Maximum Values for Tarp Reflectance Correction Factor \( C_{\text{tarps}} \) for the 52% Tarp, Averaged over Approximate Spectral Bandwidths for the Satellites

<table>
<thead>
<tr>
<th>Band</th>
<th>Maximum</th>
<th>Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blue (450-510 nm)</td>
<td>1.075</td>
<td>0.914</td>
</tr>
<tr>
<td>Green (510-690 nm)</td>
<td>1.094</td>
<td>0.924</td>
</tr>
<tr>
<td>Red (630-690 nm)</td>
<td>1.062</td>
<td>0.931</td>
</tr>
<tr>
<td>Infrared (750-780 nm)</td>
<td>1.058</td>
<td>0.936</td>
</tr>
</tbody>
</table>

- The above results indicate that non-nadir viewing correction can change the effective reflectance of tarps by as much as 10%.
- A 10% error in tarp reflectance caused by BRDF effects could cause a corresponding error in satellite radiometric calibration coefficients.
- The tarp reflectance correction factor, \( C_{\text{tarps}} \), was found to be 0.005 (1%). Because \( C_{\text{tarps}} \) consists of a quotient of two signal measurements, precision of \( C_{\text{tarps}} \) is estimated at 2%.
- This procedure has allowed us to detect the presence of non-Lambertian behavior of the tarps, to determine the magnitude, and to correct for the effects of the non-Lambertian behavior.

Is the ASD FieldSpec Pro sensitive enough to measure differences in radiance caused by bidirectional reflectance properties of Spectralon?

- Measuring tarp signal with ASD FieldSpec Pro during overpass
- Comparing lab radiance measurements \( L(\theta) \) to NIST reflectance measurements \( L(\theta) \) is not a viable option.

Laboratory Apparatus

1. Reflectance Measurement
2. Spectralon Panel
3. FEL Lamp
4. Optronics OL 750 Double Monochromator/Spectroradiometer

Laboratory Setup

1. Calibrating lamps (off-axis parallel)
2. Fiber optic cable
3. ASD FieldSpec Pro
4. Reflectance
5. Reflectance Measurement

Examples of Tarp Reflectance Values Calculated at Ground and Satellite Geometry Corresponding to QuickBird and IKONOS Overpasses on 2/17/02

For the 52% tarp, the highest values for \( C_{\text{tarps}} \) occurred when satellite viewing direction was closest to the direction of incident solar irradiation. This behavior appears to be caused by tiny shadows cast by the weave of the tarp fabric; these shadows are least visible when the tarp is viewed along the direction of incidence. This behavior is less noticeable for the 35% and 22% tarps and is absent for the 3.5% tarp because the shadows are invisible against the dark tarp surface. For the 3.5% tarp, the tarp reflectance correction factor \( C_{\text{tarps}} \) was observed to increase by up to 5% as the viewing direction approached the direction of specular reflection.

The reflectance was measured for tarp samples that had bidirectional reflectance by Georgiev Georgiev and James J. Butler at the NASA/GSFC Diffuser Calibration Facility (DCaF). The DCaF reflectance measurement results are discussed in Georgiev, G., and J. Butler (2003), The effect of weave orientation on the BRDF of tarp samples, "Proc. SPIE," 5189:145–152.

Reference