Initial Radiometric Calibration of the AWiFS using Vicarious Calibration Techniques

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Four selected targets of opportunity near Stennis Space Center are hundreds of meters across:

- Two gravel pit sand sites
- Large monoculture fields
- Cut grass amateur golf course
A target of opportunity was found near an Aerosol Robotic Network (AERONET) site near Park Falls
  – Large grass field

AWiFS imagery (4,3,2)  
August 5, 2005

Landsat 7 imagery (7,4,2)  
August 5, 2005

Target field
Ground Reflectance Measurements

- ASD FieldSpec® FR spectroradiometer measurements of Spectralon® panels and several target areas were taken
  - ~50 m x 50 m area of a grassy field/golf course
  - ~100 m x 200 m area of a rye grass field
  - ~100 m x 100 m area of two sand sites
- Measurements were taken along transects aligned with the sensor azimuth
  - Measurements were taken at nadir and satellite elevation angles to account for BRDF effects
  - All measurements were taken while walking to increase spatial averaging
  - Periodic Spectralon panel measurements were taken
- All data were acquired within 40 minutes of satellite overpass
SSC Calibration and Characterization of ASD FieldSpec Spectroradiometers

• NASA SSC maintains four ASD FieldSpec FR spectroradiometers
  – Laboratory transfer radiometers
  – Ground surface reflectance for V&V field collection activities
• Radiometric Calibration
  – NIST-calibrated integrating sphere serves as source with known spectral radiance
• Spectral Calibration
  – Laser and pen lamp illumination of integrating sphere
• Environmental Testing
  – Temperature stability tests performed in environmental chamber
• Novel hyperspectral sun photometer is capable of acquiring measurements comparable to both ASRs and MFRSRs by making use of the laboratory radiometric calibration of the FieldSpec FR spectroradiometers
  – Optical Depth/Transmission
  – Diffuse-to-Global Ratio
• Sun photometer developed with fewer limitations than current sun photometers, utilizing equipment already used in the field
  – Radiometrically calibrated FieldSpec FR spectroradiometers
  – 99% reflectance Spectralon panels
• Measurements are made only at the time of overpass, thus reducing the impact of a changing atmosphere on the calculation of optical depth

### Sample Results

<table>
<thead>
<tr>
<th>Band</th>
<th>ASR 27</th>
<th>ASD</th>
<th>Difference</th>
<th>Percent Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>380 nm</td>
<td>0.588</td>
<td>0.5982</td>
<td>-0.010</td>
<td>-1.74%</td>
</tr>
<tr>
<td>400 nm</td>
<td>0.495</td>
<td>0.4852</td>
<td>0.010</td>
<td>1.99%</td>
</tr>
<tr>
<td>440 nm</td>
<td>0.366</td>
<td>0.3216</td>
<td>0.044</td>
<td>12.14%</td>
</tr>
<tr>
<td>520 nm</td>
<td>0.224</td>
<td>0.1988</td>
<td>0.025</td>
<td>11.25%</td>
</tr>
<tr>
<td>610 nm</td>
<td>0.161</td>
<td>0.1563</td>
<td>0.005</td>
<td>2.91%</td>
</tr>
<tr>
<td>670 nm</td>
<td>0.108</td>
<td>0.1002</td>
<td>0.008</td>
<td>7.26%</td>
</tr>
<tr>
<td>780 nm</td>
<td>0.07</td>
<td>0.0691</td>
<td>0.001</td>
<td>1.33%</td>
</tr>
<tr>
<td>870 nm</td>
<td>0.049</td>
<td>0.0508</td>
<td>-0.002</td>
<td>-3.58%</td>
</tr>
<tr>
<td>RMS 1:8</td>
<td></td>
<td>0.019</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Data Acquisitions – Wiggins, MS

<table>
<thead>
<tr>
<th>Date</th>
<th>Camera</th>
<th>Overpass Time (UTC)</th>
<th>Satellite Elevation</th>
<th>Satellite Azimuth</th>
<th>Sun Elevation</th>
<th>Sun Azimuth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mar 24, 2005</td>
<td>B</td>
<td>16:59</td>
<td>71.1 deg</td>
<td>285 deg</td>
<td>57.2 deg</td>
<td>149.8 deg</td>
</tr>
<tr>
<td>Apr 27, 2005</td>
<td>B</td>
<td>16:50</td>
<td>84.5 deg</td>
<td>285 deg</td>
<td>67.7 deg</td>
<td>135.4 deg</td>
</tr>
</tbody>
</table>

Wiggins, MS, 3/24/05

Wiggins, MS, 4/27/05
### Data Acquisitions – Park Falls, WI

<table>
<thead>
<tr>
<th>Date</th>
<th>Camera</th>
<th>Overpass Time (UTC)</th>
<th>Satellite Elevation</th>
<th>Satellite Azimuth</th>
<th>Sun Elevation</th>
<th>Sun Azimuth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aug 5, 2005</td>
<td>A</td>
<td>17:02</td>
<td>83.9 deg</td>
<td>103 deg</td>
<td>57.8 deg</td>
<td>149.7 deg</td>
</tr>
</tbody>
</table>

[Diagram of Sun and AWiFS positions]
Green Band Calibration Summary

NASA Radiance = DN \times (0.60 \pm 0.02) + (-5.49 \pm 5.36)

AW Radiance = DN \times 0.51

- AW Cal Curve
- SSC Cal Curve
- SSC Cal Curve \pm 1\sigma
Red Band Calibration Summary

NASA Radiance = DN \cdot (0.46 \pm 0.01) + (2.60 \pm 3.89)

AW Radiance = DN \cdot 0.40

March 16, 2006
NIR Band Calibration Summary

NASA Radiance = DN \times (0.31 \pm 0.02) + (-3.11 \pm 6.69)

AW Radiance = DN \times 0.28

AW Cal Curve

SSC Cal Curve

SSC Cal Curve ± 1σ
<table>
<thead>
<tr>
<th></th>
<th>Green</th>
<th>Red</th>
<th>NIR</th>
<th>SWIR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NASA Estimate</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cal Coeff (W/m² sr μm DN)</td>
<td>0.60 ± 0.02</td>
<td>0.46 ± 0.01</td>
<td>0.31 ± 0.02</td>
<td>0.056 ± 0.004</td>
</tr>
<tr>
<td>Offset</td>
<td>-5.49 ± 5.36</td>
<td>2.60 ± 3.89</td>
<td>-3.11 ± 6.69</td>
<td>-2.82 ± 2.15</td>
</tr>
<tr>
<td><strong>AWiFS Provided</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cal Coeff (W/m² sr μm DN)</td>
<td>0.51</td>
<td>0.40</td>
<td>0.28</td>
<td>0.045</td>
</tr>
<tr>
<td>Offset</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Green Band Calibration Summary

(Zero-Offset)

NASA Radiance = DN ^ 0.58 ± 0.06

AW Radiance = DN ^ 0.51

Graph showing the calibration summary with data points and lines representing different radiance values.
Red Band Calibration Summary

(Zero-Offset)

NASA Radiance = DN \times 0.47 \pm 0.05

AW Radiance = DN \times 0.40
NIR Band Calibration Summary

(Zero-Offset)

NASA Radiance = DN × 0.30 ± 0.02

AW Radiance = DN × 0.28
SWIR Band Calibration Summary

(Zero-Offset)

NASA Radiance = DN * 0.052 ± 0.005
AW Radiance = DN * 0.045

Radiance [W/(m²·sr·µm)]

SWIR Band Calibration Summary

- Wiggins, grass, 3/24/05
- Wiggins, ryegrass, 3/24/05
- Wiggins, gravel(p), 3/24/05
- Wiggins, gravel(d), 4/27/05
- Wiggins, ryegrass, 4/27/05
- Wiggins, gravel(p), 4/27/05
- Park Falls, Field A, 8/5/05
- UofA, Ivanpah, 6/18/05
- UofA, RRV, 6/18/05
- UofA, Ivanpah, 6/23/05
- UofA, RRV, 8/10/05
- SDSU, mowed grass, 6/22/05
- SDSU, unmowed grass, 6/22/05

AW Cal Curve
SSC Cal Curve
SSC Cal Curve ± 1σ

March 16, 2006
## Initial Radiometric Calibration Coefficients (Zero-Offset)

<table>
<thead>
<tr>
<th>Band</th>
<th>NASA Team Estimate [W/m² sr μm DN]</th>
<th>AWiFS Provided [W/m² sr μm DN]</th>
<th>% Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green</td>
<td>0.58 ± 0.06</td>
<td>0.51</td>
<td>12.1%</td>
</tr>
<tr>
<td>Red</td>
<td>0.47 ± 0.05</td>
<td>0.40</td>
<td>14.9%</td>
</tr>
<tr>
<td>NIR</td>
<td>0.30 ± 0.02</td>
<td>0.28</td>
<td>6.7%</td>
</tr>
<tr>
<td>SWIR</td>
<td>0.052 ± 0.005</td>
<td>0.045</td>
<td>13.5%</td>
</tr>
</tbody>
</table>

Percent difference is calculated by \(1 - \frac{\text{AWiFS}}{\text{NASA Mean}}\)
AWiFS Results Summary

• The NASA team of University of Arizona, South Dakota State University, and NASA SSC produce consistent results

• The AWiFS calibration coefficients agree reasonably well with the NASA team estimate

• The NASA team will continue to assess AWiFS radiometric accuracy
Contributors

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