NASA IKONOS Radiometric Characterization

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## Co-Contributors

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<thead>
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<td>NIMA</td>
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Characterization Overview

• Objective
  – Perform radiometric vicarious calibrations of IKONOS imagery and compare with Space Imaging calibration coefficients

• Approach
  – Utilize multiple well-characterized sites
    Widely used by the NASA science community for radiometric characterization of airborne and spaceborne sensors
  – Perform independent characterizations with independent teams. Each team has slightly different measurement techniques and data processing methods
    • NASA Stennis Space Center
    • University of Arizona Remote Sensing Group
    • South Dakota State University
    • USDA Department of Agriculture SWRC/USWCL
  – Leverage characterization activities with other field measurement programs
Reflectance-based Approach

- Characterize target reflectance at time of satellite overpass
  - Measurements taken of target area and a 99% reflectance
    spectralon panel (Jackson BRDF model)

- Characterize atmosphere at time of satellite overpass
  - Radiosonde data used to determine Rayleigh scattering and water
    molecule extinction
  - Least squares fit of sun photometer data to determine model
    atmosphere parameters

- Use MODTRAN radiative transport code to predict at-sensor
  radiance

- Compare predicted at-sensor radiance to actual radiance acquired
  by sensor
Lunar Lake Playa, Nevada

**Site:** Dry lake bed in central Nevada, predominantly clay surface, no vegetation, surface is hard and nearly impermeable to water. Elevation approx. 1800 m Center point 38.4° N, 116.0° W.

**In-Situ Instrumentation:** ASD FieldSpec FR spectroradiometers, Yankee MFRSR, Airsonde radiosonde, Full sky imager, 99% spectralon panels

**Other Coincident Collects:** Landsat 7, Terra ASTER/MODIS, ATLAS

Includes material © Space Imaging L.P.
Lunar Lake Ground Truthing

Sfennis Space Center

2002 JACIE WORKSHOP
Reston, VA
# Data Acquisitions

<table>
<thead>
<tr>
<th>Date</th>
<th>Over Pass Time (UTC)</th>
<th>Satellite Elevation</th>
<th>Satellite Azimuth</th>
</tr>
</thead>
<tbody>
<tr>
<td>July 13, 2001</td>
<td>18:39</td>
<td>75.56 deg</td>
<td>207.43 deg</td>
</tr>
<tr>
<td>July 16, 2001</td>
<td>18:48</td>
<td>69.10 deg</td>
<td>275.94 deg</td>
</tr>
</tbody>
</table>

Standard Original imagery
MTFC applied
Cubic convolution resampling algorithm
Ground Measurements

- **ASD measurements**
  - An area on the playa ~ 100 m x 100 m, visually uniform, was identified
  - All measurements were taken twice, with two different ASDs to check repeatability
  - Measurements were taken along 8 transect lines evenly dividing the target area
    - All measurements were taken while walking to increase spatial averaging
    - 8000 spectra in total were averaged to obtain the playa reflectance values
    - Spectralon panel measurements were taken between transects
    - Before any measurements were taken, the instrument was optimized and dark current measurements were made
  - All data taken within 20 minutes of satellite overpass

- **Atmospheric measurements**
  - Collect solar radiance data from early morning through post-sensor acquisition
  - Radiosonde launch near time of sensor overpass
    - Data acquired July 13 only
Lunar Lake, NV
July 16, 2001
MFRSR and Tape7 Transmissions at 130Km Visibility

Lunar Lake, NV
July 16, 2001
IKONOS Spectral Response

IKONOS Relative Spectral Response

Relative Spectral Responsivity

Wavelength (nm)

Pan
Blue
Green
Red
NIR
<table>
<thead>
<tr>
<th>Band (nm)</th>
<th>NASA Estimate (W/m²sr)</th>
<th>IKONOS Measurement (W/m²sr)</th>
<th>% Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>445 - 516</td>
<td>13.574</td>
<td>13.241</td>
</tr>
<tr>
<td>2</td>
<td>506 - 595</td>
<td>18.311</td>
<td>18.828</td>
</tr>
<tr>
<td>3</td>
<td>632 - 698</td>
<td>14.284</td>
<td>14.561</td>
</tr>
<tr>
<td>4</td>
<td>757 - 853</td>
<td>14.892</td>
<td>14.945</td>
</tr>
</tbody>
</table>

Percent difference is calculated by: abs(1 - IKONOS/NASA)
## Lunar Lake IKONOS Radiometric Assessment

Lunar Lake, NV  
July 16, 2001

<table>
<thead>
<tr>
<th>Band (nm)</th>
<th>NASA Estimate (W/m²sr)</th>
<th>IKONOS Measurement (W/m²sr)</th>
<th>% Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 445 - 516</td>
<td>13.534</td>
<td>12.783</td>
<td>5.55%</td>
</tr>
<tr>
<td>2 506 - 595</td>
<td>18.380</td>
<td>18.275</td>
<td>0.57%</td>
</tr>
<tr>
<td>3 632 - 698</td>
<td>14.418</td>
<td>14.232</td>
<td>1.29%</td>
</tr>
<tr>
<td>4 757 - 853</td>
<td>15.033</td>
<td>14.683</td>
<td>2.33%</td>
</tr>
</tbody>
</table>

Percent difference is calculated by: abs(1 - IKONOS/NASA)
Site: Scattered buildings within a heavily wooded area, man-made reservoirs and canals.
Elevation 5.5m - 10m
30.388 degrees N, 89.61 degrees W

In-Situ Instrumentation:
ASD FieldSpec FR spectroradiometers, Yankee MFRSRs, Reagan sunphotometer, Airsonde radiosonde,
(Full sky imager, 20m x 20m radiometric tarps,
99% spectralon panels

Includes material © Space Imaging L.P.
Radiometric Tarps

- 4 20m x 20m tarps with reflectance values of
  - less than 5%
  - between 20% and 25%
  - between 30% and 40%
  - between 50% and 55%
- Spectral measurement range of 400 to 1050 nm
- Standard deviation about average reflectance less than 1% spatially
- Peak to peak variation in reflectance less than 10% within any 100 nm spectral band
- Less than 10% variation in reflectance values when measuring tarps from 10 deg to 60 deg off axis
- Each side is straight to within ±6.0 centimeters over the 20 meter length
- Each tarp panel has 60 square witness samples measuring 30.5 centimeters by 30.5 centimeters.
## Data Acquisitions

<table>
<thead>
<tr>
<th>Date</th>
<th>Over Pass Time (UTC)</th>
<th>Satellite Elevation</th>
<th>Satellite Azimuth</th>
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<tbody>
<tr>
<td>Jan 15, 2002</td>
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<td>77.19 deg</td>
<td>112.97 deg</td>
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<tr>
<td>Feb 17, 2002</td>
<td>16.47</td>
<td>81.88 deg</td>
<td>100.73 deg</td>
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</table>

Standard Original imagery
MTFC applied
Cubic convolution resampling algorithm
ASD Measurements

- Measurements of several target areas were taken
  - ~35-m x 15-m area of a dried grassy field
  - ~30-m x 20-m area of a concrete parking lot
  - Three 20-m x 20-m radiometric tarps (3.5%, 52% and 22% reflectance)
- Measurements were taken along transect lines (grass and concrete) or tarp perimeter
  - All measurements were taken while walking to increase spatial averaging
  - Between 2500 and 7500 points were taken of each target
  - ASD optimization and dark current measurements were taken prior to target measurements. Periodic spectralon panel measurements were taken
- Stationary ASD measurements taken of a spectralon panel to record sun position effect on radiometry
- ASD measurements taken of a spectralon panel across measurement field to record building presence effect on radiometry
- All data taken within 20 min of satellite overpass
Atmospheric Measurements

- Solar radiance data taken from early morning through post-sensor acquisition
  - (1) MFRSR and (1) Reagan sunphotometer acquired data from the measurement field
  - (1) MFRSR acquired data from a building rooftop approx. 2 miles away
- Radiosonde was launched 30 minutes prior to satellite overpass. Data acquired over a 90-min period up to 23 km
Full Sky Imager

NASA SSC
January 15, 2002
Spectral Albedo for Stennis Space Center, 1/15/07

22% Tarp
52% Tarp
3.5% Tarp
Concrete
Grass

Reflectance vs. Wavelength (μm)
IKONOS Blue Band Calibration Summary

Stennis Space Center

Blue Band Calibration Summary

- SSC, Lunar Lake, 7/13/01
- SSC, Lunar Lake, 7/16/01
- SSC, Maricopa, 7/26/01
- SSC, Big Spring, 8/5/01
- UofA, Brookings, 7/3/01
- UofA, Railroad Valley, 7/13/01
- UofA, Lunar Lake, 7/13/01
- UofA, Railroad Valley, 7/16/01
- UofA, Lunar Lake, 7/16/01
- UofA, Brookings, 7/17/01
- UofA, Brookings, 7/25/01
- UofA, Ivanpah Playa, 11/19/01

Space Imaging Calibration Curve, Post 2/22/01

SI Radiance = DN/72.8

Image DN

Predicted Radiance [W/(m²sr)]
IKONOS Green Band Calibration Summary

Sample Sites:
- SSC, Lunar Lake, 7/13/01
- SSC, Lunar Lake, 7/16/01
- SSC, Maricopa, 7/26/01
- SSC, Big Spring, 8/5/01
- UofA, Brookings, 7/3/01
- UofA, Railroad Valley, 7/13/01
- UofA, Lunar Lake, 7/13/01
- UofA, Railroad Valley, 7/16/01
- UofA, Lunar Lake, 7/16/01
- UofA, Brookings, 7/17/01
- UofA, Brookings, 7/25/01
- UofA, Ivanpah Playa, 11/19/01

Graph:
- Predicted Radiance [W/(m²sr)] vs. Image DN
- SI Radiance = DN/72.7

2002 JACIE W
Reston, VA
Red Band Calibration Summary

- SSC, Lunar Lake, 7/13/01
- SSC, Lunar Lake, 7/16/01
- SSC, Maricopa, 7/26/01
- SSC, Big Spring, 8/5/01
- UofA, Brookings, 7/3/01
- UofA, Railroad Valley, 7/13/01
- UofA, Lunar Lake, 7/13/01
- UofA, Railroad Valley, 7/16/01
- UofA, Lunar Lake, 7/16/01
- UofA, Brookings, 7/17/01
- UofA, Brookings, 7/25/01
- UofA, Ivanpah Playa, 11/19/01

- Space Imaging Calibration Curve, Post 2/22/01

SI Radiance = DN/94.9
IKONOS NIR Band Calibration Summary

NIR Band Calibration Summary

- SSC, Lunar Lake, 7/13/01
- SSC, Lunar Lake, 7/16/01
- SSC, Maricopa, 7/26/01
- SSC, Big Spring, 8/5/01
- UofA, Brookings, 7/3/01
- UofA, Railroad Valley, 7/13/01
- UofA, Lunar Lake, 7/13/01
- UofA, Railroad Valley, 7/16/01
- UofA, Lunar Lake, 7/16/01
- UofA, Brookings, 7/17/01
- UofA, Brookings, 7/25/01
- UofA, Ivanpah Playa, 11/19/01

Space Imaging Calibration Curve, Post 2/22/01

SI Radiance = DN/84.3
### NASA Radiometric Characterization Summary

#### Stennis Space Center

**Units of Gain = 
\[\text{W} / (\text{m}^2 \text{ sr})] / \text{DN}\**

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<tr>
<th>Band</th>
<th>NASA Gain</th>
<th>Space Imaging Gain</th>
<th>NASA Gain SI Initial Gain</th>
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<tr>
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<td>63.7</td>
<td>0.99</td>
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<tr>
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<td>3</td>
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<tr>
<td>4</td>
<td>74.6</td>
<td>50.3</td>
<td>1.48</td>
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The current "Post 2/22/01" calibration coefficients provided by Space Imaging agree well with the NASA team vicarious calibration

- IKONOS sensor has been radiometrically stable over the past year
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<td>Mary Pagnutti</td>
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<td>Conference - High Spatial Resolution Commercial Imagery Workshop IKONOS Reston Virginia</td>
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