Abstract for submittal to 2005 CALCON Technical Conference on Characterization and Radiometric Calibration for Remote Sensing, August 22–25, 2005, Logan, Utah, USA

Stennis Space Center Verification & Validation Capabilities

Mary Pagnutti, Robert E. Ryan, Kara Holekamp, Duane O'Neal, Kelly Knowlton, Kenton Ross, and Slawomir Blonski

Science Systems and Applications, Inc.

Scientists within NASA's Applied Sciences Directorate have developed a well-characterized remote sensing Verification & Validation (V&V) site at the John C. Stennis Space Center (SSC). This site enables the in-flight characterization of satellite and airborne high spatial and moderate resolution remote sensing systems and their products. The smaller scale of the newer high resolution remote sensing systems allows scientists to characterize geometric, spatial, and radiometric data properties using a single V&V site. The targets and techniques used to characterize data from these newer systems can differ significantly from the techniques used to characterize data from the earlier, coarser spatial resolution systems. Scientists are also using the SSC V&V site to characterize thermal infrared systems and active lidar systems. SSC employs geodetic targets, edge targets, radiometric tarps, atmospheric monitoring equipment, and thermal calibration ponds to characterize remote sensing data products. The SSC Instrument Validation Lab is a key component of the V&V capability and is used to calibrate field instrumentation and to provide National Institute of Standards and Technology traceability. This poster presents a description of the SSC characterization capabilities and examples of calibration data.

This work was directed by the NASA Applied Sciences Directorate at the John C. Stennis Space Center, Mississippi. Participation in this work by Science Systems and Applications, Inc., was supported under NASA Task Order NNS04AB54T.

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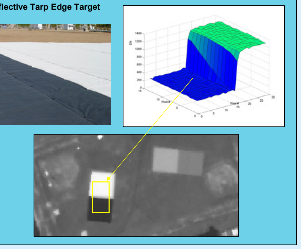
Spatial Response

Edge Response of Tarps

Reflective Tarp Edge Target



Painted Concrete Edge Target

Purpose: Measure spatial response of 1-meter GSD class systems

Reflectance: ~50% and ~4% reflective painted rectangles

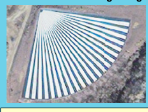
Dimensions: 4 rectangles, 10 m x 20 m each

Total Dimensions: 20 m x 40 m

Orientation: North-South and East-West orientation

Painted Concrete Tri-bar Target Array

Painted Concrete Radial Edge Target



- 130 m radial target > 90° arc angle
- ~4 m thick tapered to < 10 cm

Reflectance Radiometry

ASD Measuring Tarps

Analytical Spectral Devices

Purpose: Analytical Spectral Devices (ASDs) used to calculate accurately target reflectance values used to validate imager radiance values

Spectral Range: 350 - 2500 nm

Sensors: One 512-element photodiode array and two thermoelectrically cooled, extended-range InGaAs photodiodes

Sampling Interval: 1.4 nm from 350 - 1000 nm; 2 nm from 1000 - 2500 nm

Spectral Resolution: 3 nm @ 700 nm; 10 nm @ 1500 nm; 10 nm @ 2100 nm

Number of Channels: 512 channels

Wavelength Accuracy: ±1 nm

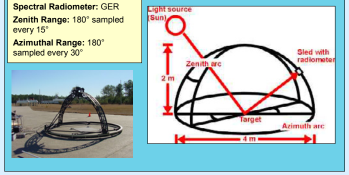
Goniometer

Purpose: Measure BRDF effects of target surface

Spectral Radiometer: GER

Zenith Range: 180° sampled every 15°

Azimuthal Range: 180° sampled every 30°



NIST characterized Spectralon© Panels

Reflective Tarps

Purpose: Tarp panels form two 20-meter edges to measure the edge response of panchromatic and multispectral imaging systems with ground sampling distances of 1 meter or less

Tarps' highly uniform spectral reflectance can be utilized in the characterization of multispectral and hyperspectral sensors

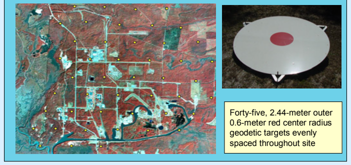
- Tarp Panel 1 - 3.5% Reflectance
- Tarp Panel 2 - 22% Reflectance
- Tarp Panel 3 - 34% Reflectance
- Tarp Panel 4 - 52% Reflectance

Positional Accuracy

QuickBird Observed Geolocational Accuracy

QuickBird Product	Acquisition Date	Empirical CE$_{90}$ (m)	Empirical CE$_{95}$ (m)	Elevation Angle (deg)
Panchromatic *Standard*	8/23/2003	12.67	12.76	76.8
	9/15/2003	17.40	17.62	83.3
	10/21/2003	13.63	13.72	81.3
	1/10/2004	16.27	16.39	89.2
Panchromatic *Orthorectified*	8/23/2003	7.93	8.11	76.8
Multispectral *Standard*	8/23/2003	12.78	12.93	76.8
	9/15/2003	17.34	17.66	83.3
	10/21/2003	13.76	13.77	81.3
Multispectral *Orthorectified*	8/23/2003	7.50	8.43	76.8

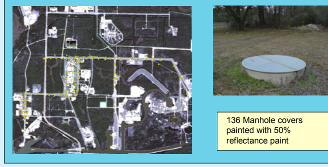
45 GPS-Surveyed Geodetic Targets < 3 cm Accuracy



Forty-five, 2.44-meter outer 0.6-meter red center radius geodetic targets evenly spaced throughout site

17 A-Order monuments On Site

136 Manhole Covers On Site—9 m to 2.44 m

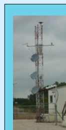


136 Manhole covers painted with 50% reflectance paint

Trimble 5700 GPS

- Centimeter-level accuracy
- Sub-cm accuracies for static survey
- 24-channel receiver

NGS/NOAA-NDBC Operated CORS Site



Continuously Operating Reference Station provides carrier phase and code range measurements for added ease of post-processing GPS survey data

Trimble Pathfinder GPS

Purpose: Field portable real-time GPS survey

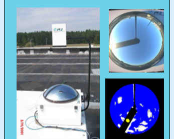
Accuracy: 10 m to submeter

Stationary Atmospheric Monitoring

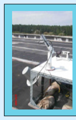
Atmospheric Monitoring Station

- Live Web publishing
- Entirely automated

Total Sky Imager



Cimel Sun Photometer



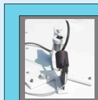
Channels: 440, 670, 870, 936, and 1020 nm

FWHM: 10 nm

FOV: 1.2°

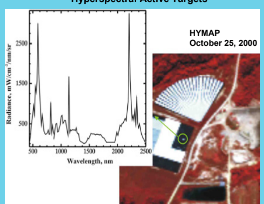
Part of AERONET network

Multi-filter Rotating Shadow-band Radiometer



Hyperspectral Radiometry

Hyperspectral Active Targets

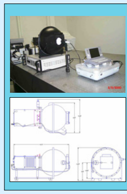


Purpose: Vicariously evaluate wavelength calibrations of airborne hyperspectral sensors

Design: 1500 W metal halide lamps

Laboratory Calibration

NIST-Certified Integrating Spheres



Purpose: Calibration and characterization of spectral radiometers

Controls: Microprocessor-controlled integrating sphere calibration standard

Illumination: 150-W tungsten-halogen, reflectorized lamp with a motorized, computer-controlled, variable aperture

Temperature Range: 2000 to 3000K

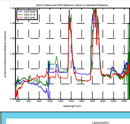
Spectral Range: Calibrated from 300 to 2500 nm

Calibration & Characterization of ASD FieldSpec Spectroradiometers

Purpose: Perform spectral and radiometric calibration of ASD FieldSpec Pro spectroradiometers

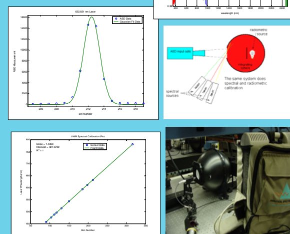
Radiometric Calibration: NIST-calibrated integrating sphere serves as source with known spectral radiance

- Calculate coefficients for conversion of measured DN values to radiance
- Perform periodic checks of ASD radiance calibration using known radiance source
- Check linearity of ASD response by varying integrating sphere radiance level



Spectral Calibration:

- VNIR - laser illumination of integrating sphere produces monochromatic Lambertian source
- SWIR - use gas discharge lamps to illuminate integrating sphere
- Fit Gaussian curve to each spectral peak to estimate bin number corresponding to wavelength at center of peak
- Perform linear regression to assign wavelengths to all spectral bins



Mikron Water Bath Blackbodies

Purpose: Calibration of radiometers

Emitter Area: 12" x 12"

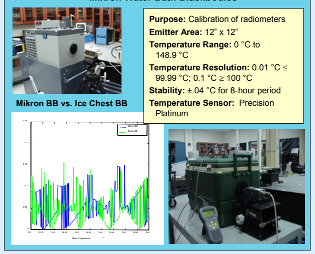
Temperature Range: 0 °C to 148.9 °C

Temperature Resolution: 0.01 °C ≤ 99.99 °C; 0.1 °C ≥ 100 °C

Stability: ±.04 °C for 8-hour period

Temperature Sensor: Precision Platinum

Mikron BB vs. Ice Chest BB



ESPEC Environmental Chamber

Purpose: Simulation of field conditions to validate instrument performance under non-laboratory conditions

Temperature Range: -75 °C to 150 °C

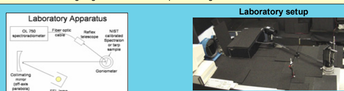
Relative Humidity Range: 10% to 90%

Interior Dimensions: 32 ft^3

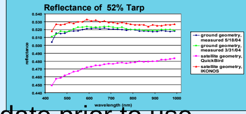
Bidirectional Reflectance

Purpose: Evaluate target bidirectional reflectance to account for the differences between ground measurement viewing angles and satellite acquisition angles

Laboratory Apparatus



Reflectance of 52% Tarp



Test results indicate that bidirectional reflectance effects can change the effective reflectance by as much as 10%

Thermal Radiometry

FLIR Systems SC2000: Thermal Camera

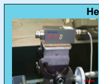
Purpose: Image float's influence on waterbody

Range: Thermal (8-12 μm)

Accuracy: 14-bit digitization with 0.1 °C NED, 240 x 320 pixel array

IFOV: Uncooled, 1.3 milliradian

Heimann Radiometer



Spectral Response: 8-14 μm

Accuracy: ±0.5 °C

Target Spot Size (@ 1 m): 10 cm

Response Time: 0.05-10.0 seconds

FTIR Spectropolarimeter

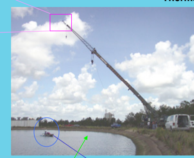
Purpose: Measure hyperspectral thermal data in two polarization

Resolution: ~0.5 (cm^-1) in two polarizations

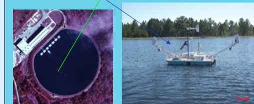
Range: 5000-600 (cm^-1) for KBr

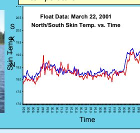
Detector: LN2 cooled MCT

Thermal Float on Stennis Pond



- Float employs 2 Heimann radiometers to measure skin surface temperature
- Additional Heimann measures cold sky temperature
- Two honeycomb black bodies calibrate radiometers during field exercises
- Thermocouple probe measures bulk water temperature



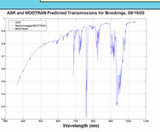


Portable Atmospheric Monitoring

Automated Solar Radiometer

Purpose: Measure direct solar irradiance

Spectral Channels: Nine channels – one total solar and eight 10 nm bandwidth center wavelengths at 382, 400, 440, 521, 610, 671, 781, 870, 940, and 1030 nm



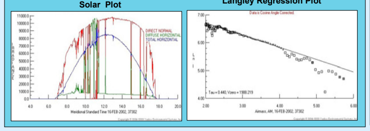
Multi-filter Rotating Shadow-band Radiometer

Purpose: Measure diffuse/direct/horizontal solar irradiance

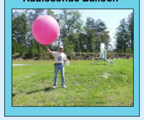
Spectral Channels: Seven channels – one total solar and six 10 nm bandwidth center wavelengths at 415, 500, 615, 673, 870, and 940 nm

Cosine response: <5% for 0-80 degree zenith angle; <1% with correction

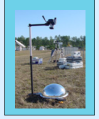
Solar Plot



Radiosonde Balloon



Full Sky Imager



Portable Meteorology Station

Purpose: Record atmospheric measurements during field collects

Atmospheric Measurements: Temperature, humidity, pressure, and wind speed/direction sensors

Solar measurements: Pyrenometer, Pyroheliometer

This work was directed by the NASA Applied Sciences Directorate at the John C. Stennis Space Center, Mississippi.
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14. ABSTRACT
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