

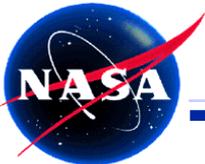
NASA IKONOS Radiometric Characterization

Mary Pagnutti

**Lockheed Martin Space Operations
NASA Stennis Space Center**

March 25-27, 2002

**phone: (228) 688-2135
e-mail: mary.pagnutti@ssc.nasa.gov**



Co-Contributors

Stennis Space Center

Troy Frisbee

NASA, Stennis Space Center

Vicki Zanoni

NASA, Stennis Space Center

Slawek Blonski

LMSO, Stennis Space Center

Erik Daehler

LMSO, Stennis Space Center

Brennan Grant

LMSO, Stennis Space Center

Kara Holekamp

LMSO, Stennis Space Center

Robert Ryan

LMSO, Stennis Space Center

Richard Sellers

LMSO, Stennis Space Center

Charles Smith

LMSO, Stennis Space Center

Steve Tate

LMSO, Stennis Space Center

Bill Smith

DATASTAR, Stennis Space Center

Debbie Fendley

DATASTAR, Stennis Space Center

Braxton Baldrige

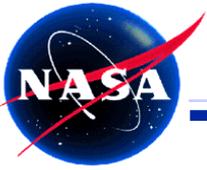
NIMA

Robert Glittone

NIMA

Joe Sirianni

NIMA

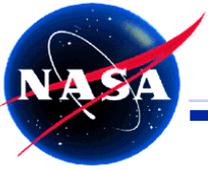


Characterization Overview

Stennis Space Center

- **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
 - U.S. Department of Agriculture SWRC/USWCL
 - Leverage characterization activities with other field measurement programs



Vicarious Calibration Method

Stennis Space Center

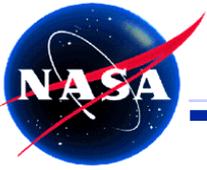
Reflectance-based approach

- 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

Stennis Space Center

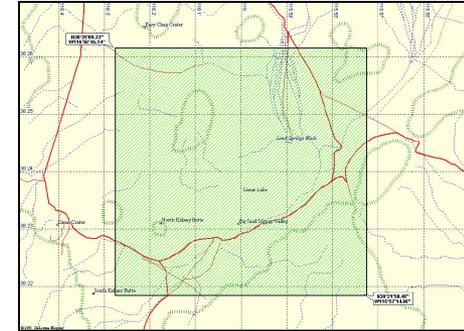
Site: Dry lake bed in central Nevada, predominantly clay surface, no vegetation, surface is hard and nearly impermeable to water.

Elevation approx. 1800 m

Center point 38.4° N, 116.0° W.



General Scene



IKONOS Image Area
8km x 8km

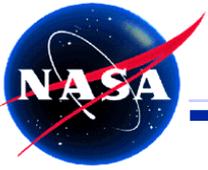
In-Situ Instrumentation: ASD FieldSpec FR spectroradiometers, Yankee MFRSR, Sippican radiosonde, Full sky imager, 99% spectralon panels

Other Coincident Collects: Landsat 7, Terra ASTER/MODIS, ATLAS, EO-1 Hyperion/ALI,



IKONOS Imagery
Blue Band
June 10, 2000

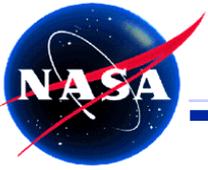
Includes material © Space Imaging LLC



Lunar Lake Ground Truthing

Stennis Space Center



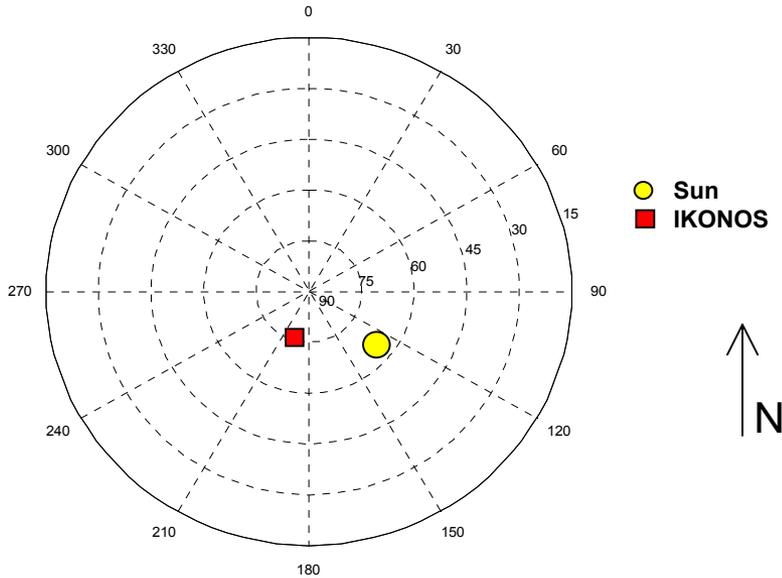


Data Acquisitions

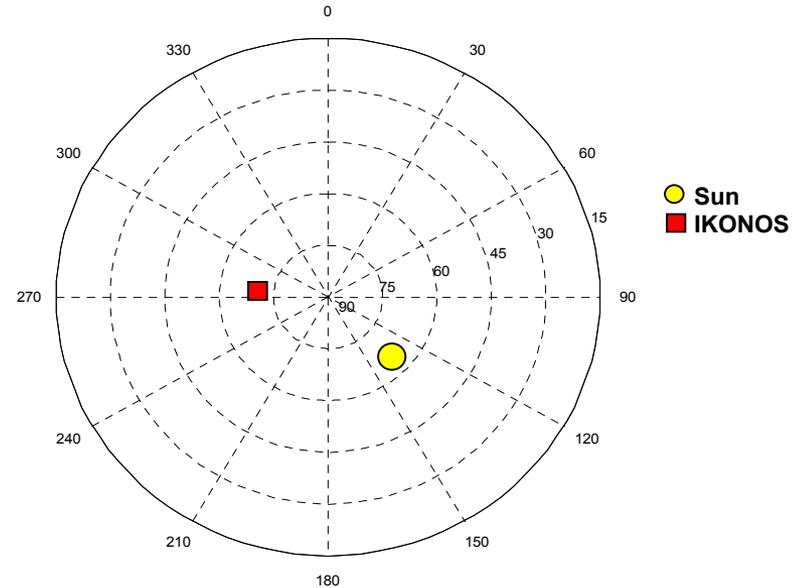
Stennis Space Center

Date	Over Pass Time (UTC)	Satellite Elevation	Satellite Azimuth	Sun Elevation	Sun Azimuth
July 13, 2001	18:39	75.56 deg	207.43 deg	67.60 deg	132.52 deg
July 16, 2001	18:48	69.10 deg	275.94 deg	68.41 deg	137.53 deg

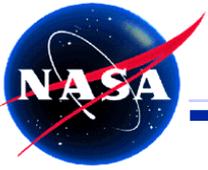
Standard original imagery
MTFC applied
Cubic convolution resampling algorithm



Lunar Lake, NV, 7/13/01



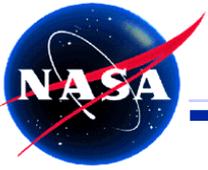
Lunar Lake, NV, 7/16/01



Ground Measurements

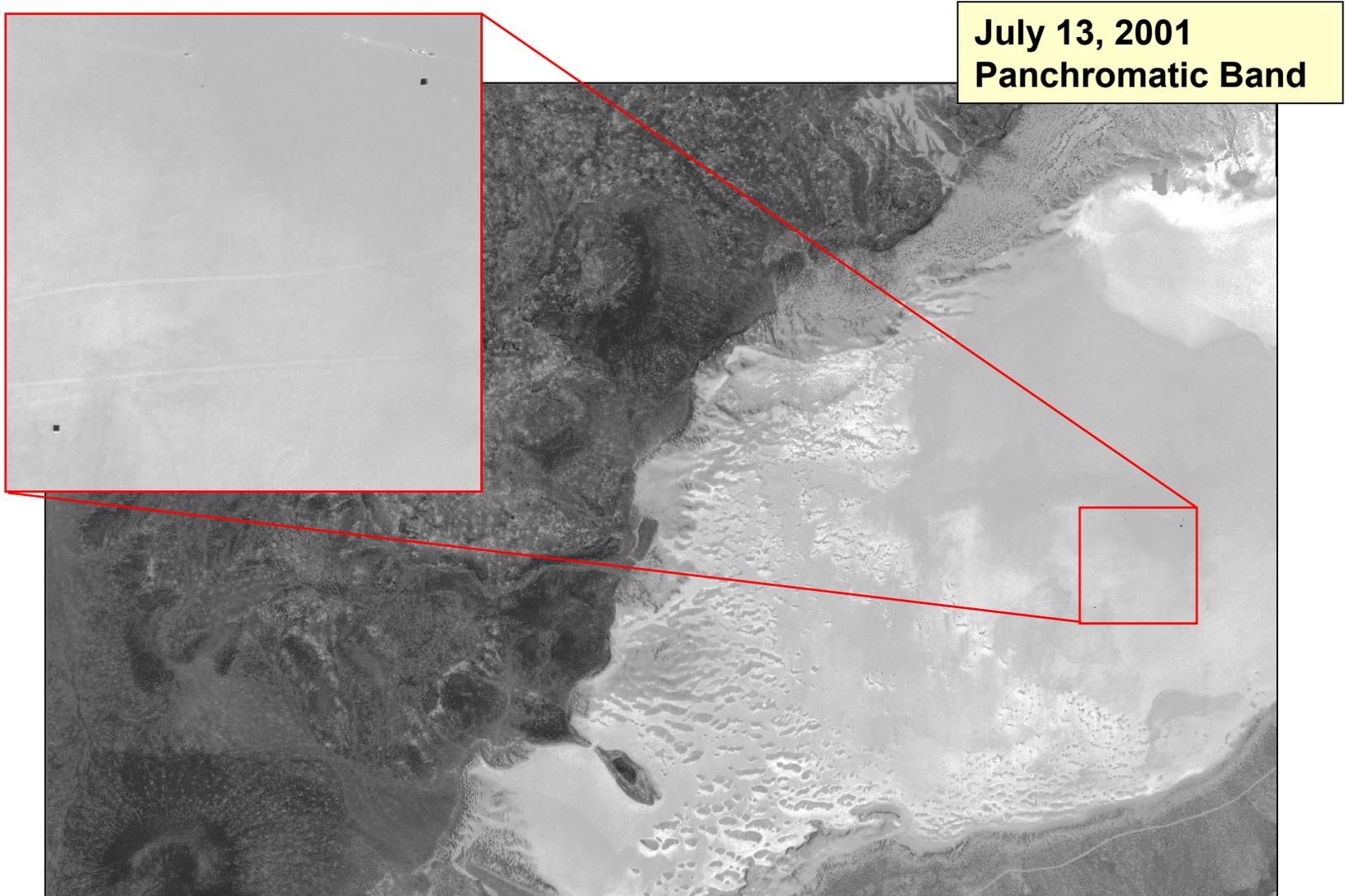
Stennis Space Center

- **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 eight 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 irradiance data from early morning through post-sensor acquisition
 - Radiosonde launch near time of sensor overpass
 - Data acquired July 13 only

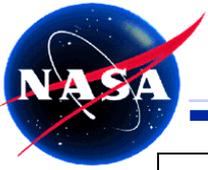


IKONOS Image of Lunar Lake

Stennis Space Center



Includes material © Space Imaging LLC

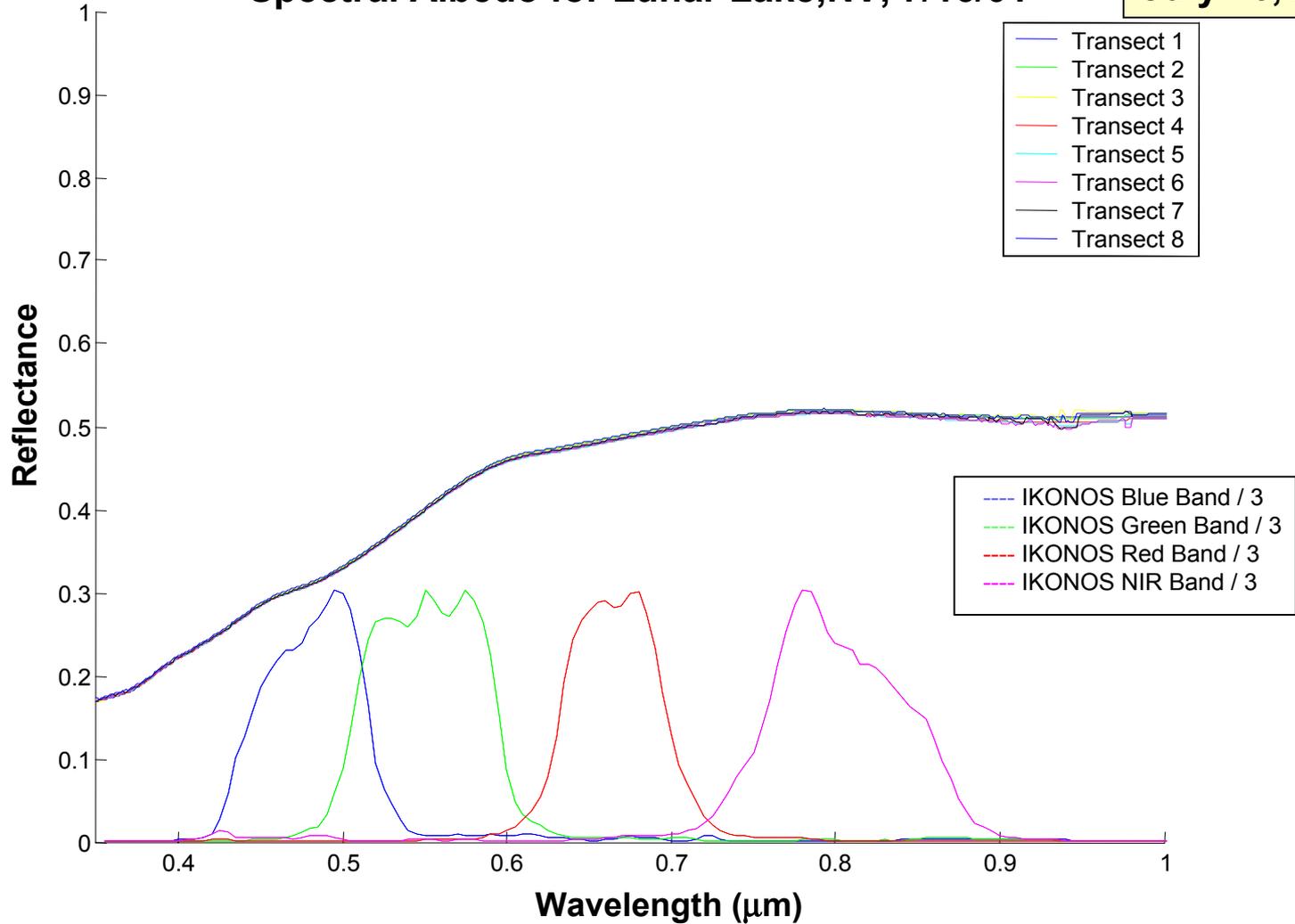


Spectroradiometer Data

Stennis Space Center

**Lunar Lake, NV
July 16, 2001**

Spectral Albedo for Lunar Lake, NV, 7/16/01

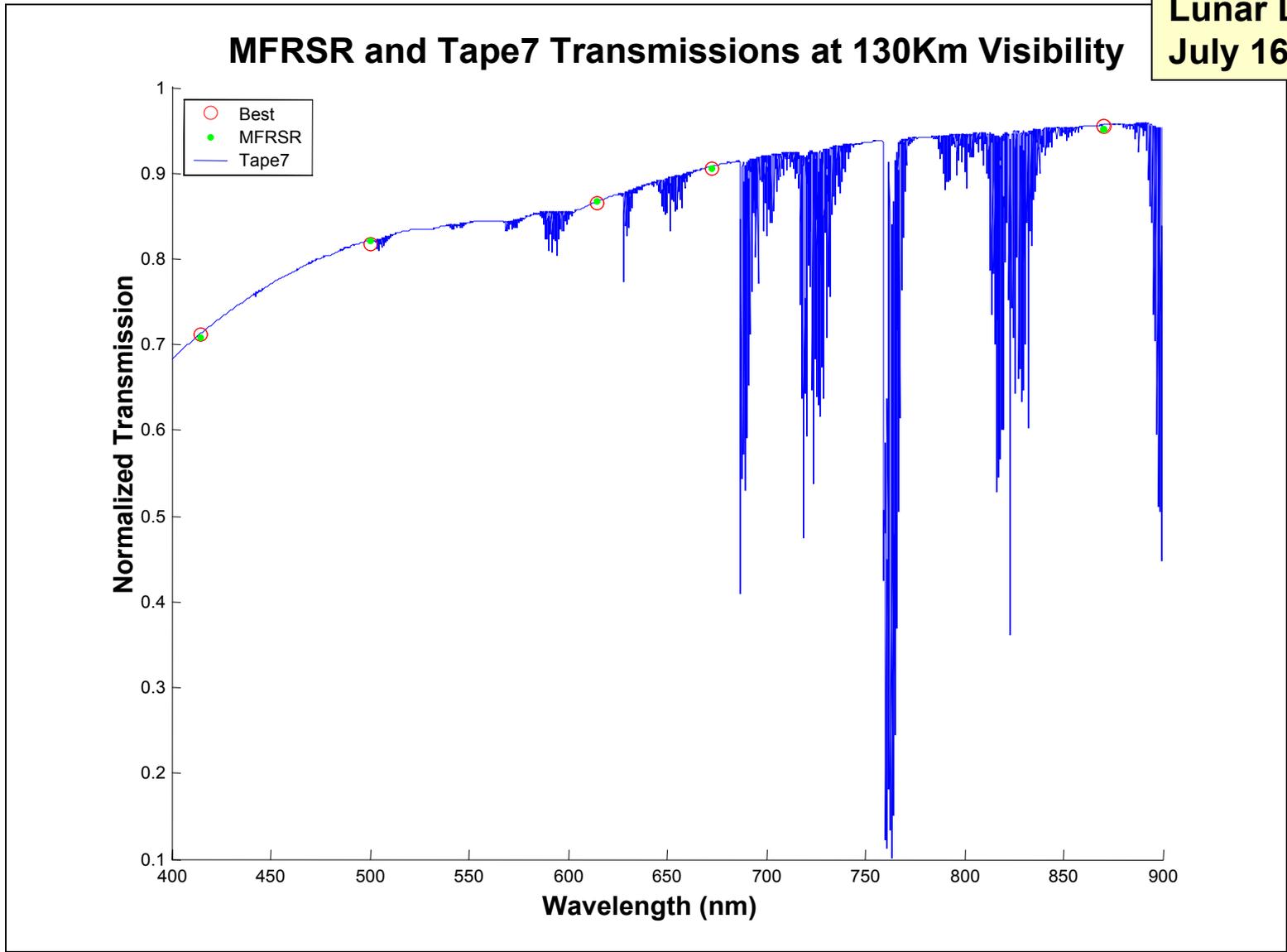


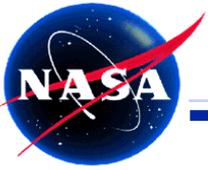


MFRSR/MODTRAN predicted Transmission

Stennis Space Center

Lunar Lake, NV
July 16, 2001



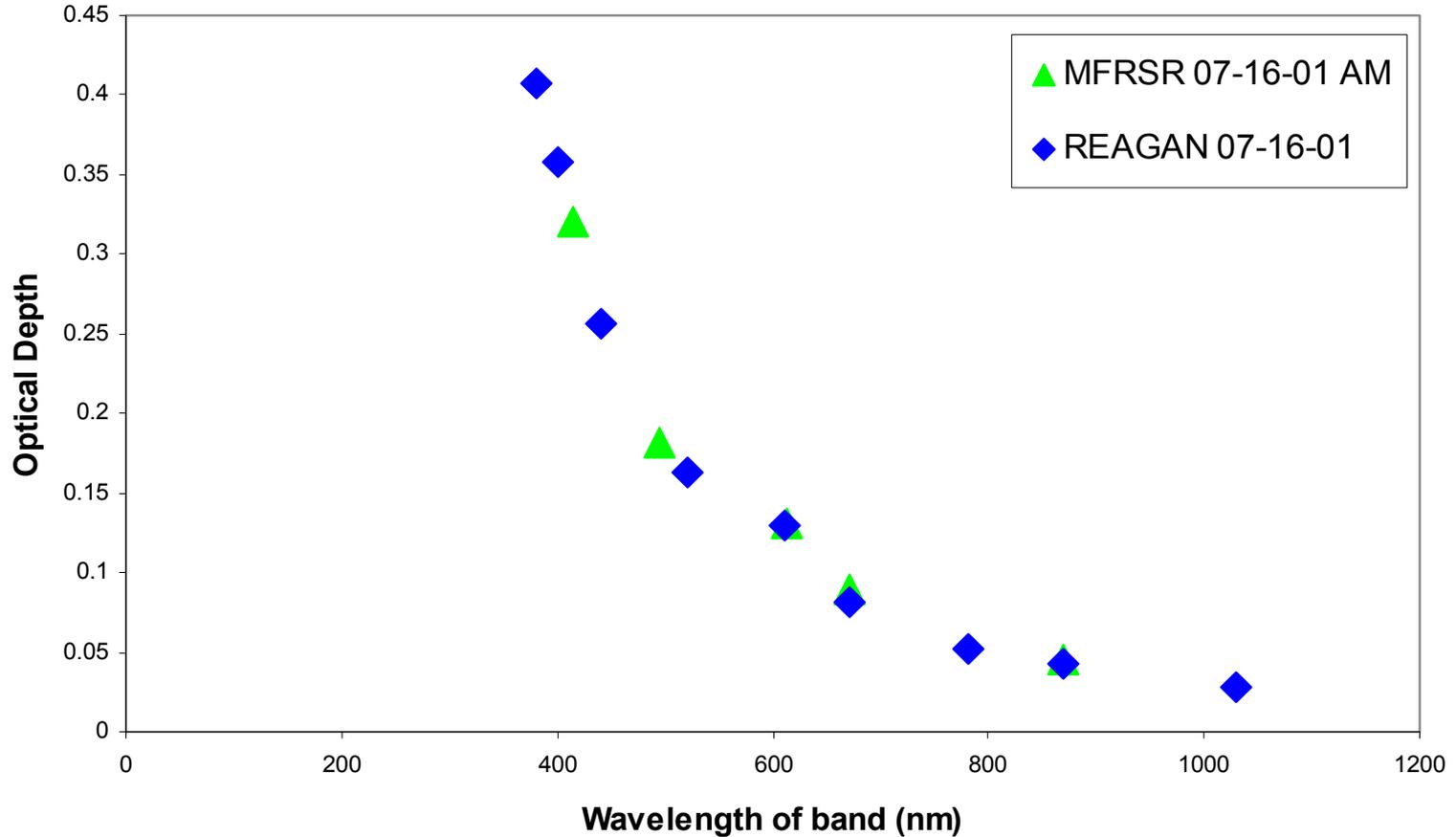


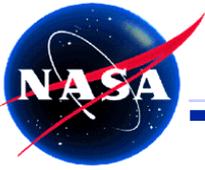
Reagan/MFRSR Optical Depth Values

Stennis Space Center

Lunar Lake, NV
July 16, 2001

MFRSR/Reagan: Optical Depth for Lunar Lake 2001





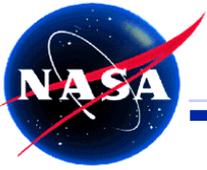
Lunar Lake IKONOS Radiometric Assessment

Stennis Space Center

Lunar Lake, NV
July 13, 2001

	Band (nm)	NASA Estimate (W/m²sr)	IKONOS Measurement (W/m²sr)	% Difference
1	445 - 516	13.574	13.241	2.45%
2	506 - 595	18.311	18.828	2.82%
3	632 - 698	14.284	14.561	1.94%
4	757 - 853	14.892	14.945	0.36%

Percent difference is calculated by: $\text{abs}(1 - \text{IKONOS}/\text{NASA})$



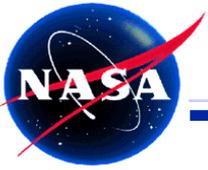
Lunar Lake IKONOS Radiometric Assessment

Stennis Space Center

Lunar Lake, NV
July 16, 2001

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

Percent difference is calculated by: $\text{abs}(1 - \text{IKONOS}/\text{NASA})$



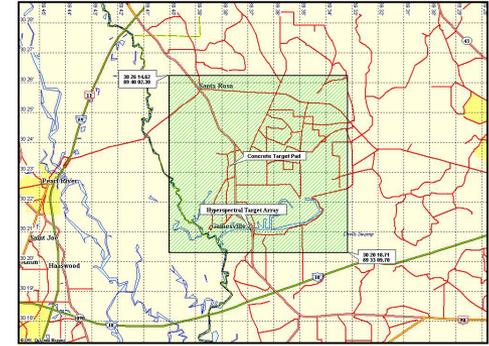
NASA Stennis Space Center, MS

Stennis Space Center

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



General Scene



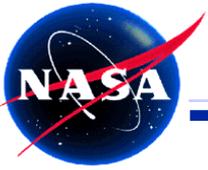
IKONOS Image Area
10.5km x 10.5km

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



IKONOS Imagery
Jan 15, 2002

Includes material © Space Imaging LLC

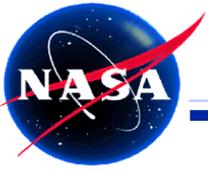


Radiometric Tarps

Stennis Space Center

- 4 20-m x 20-m tarps with reflectance values of
 - less than 3.5%
 - between 22%
 - between 33%
 - between 52%
- 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.

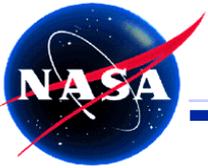




NASA SSC Ground Truthing

Stennis Space Center



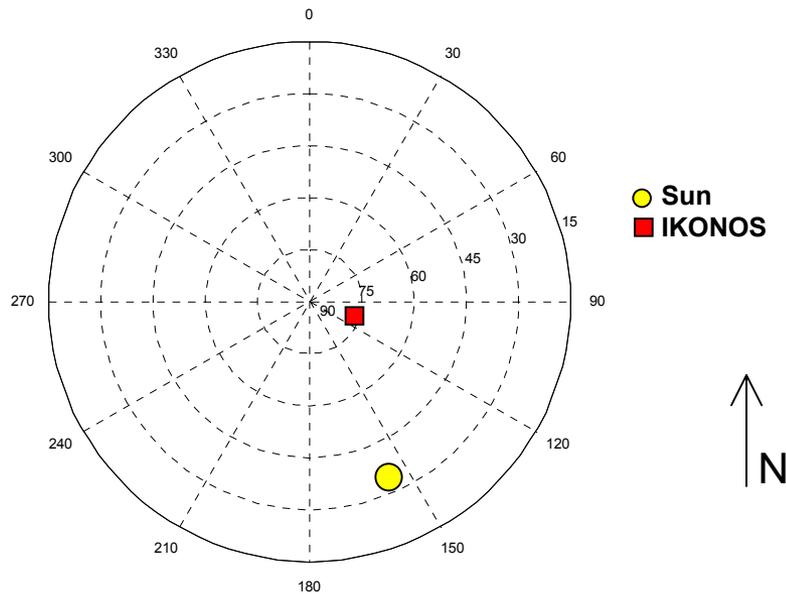


Data Acquisitions

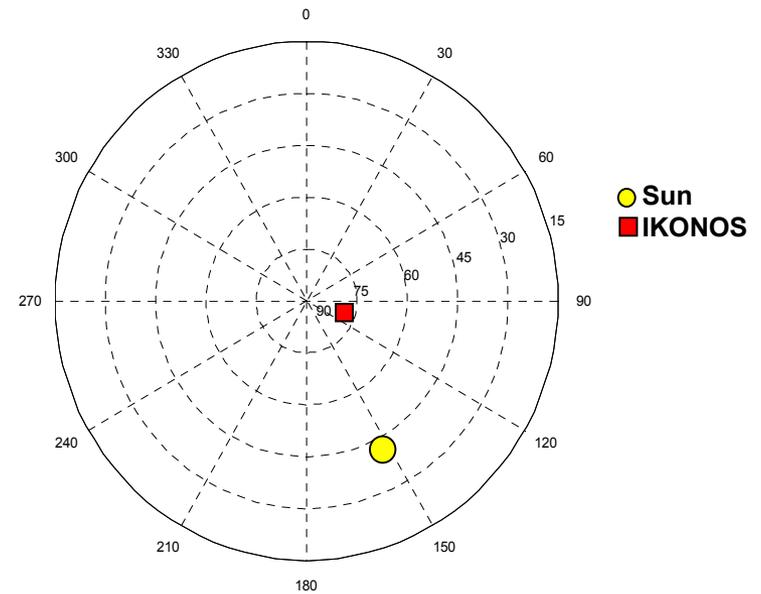
Stennis Space Center

Date	Over Pass Time (UTC)	Satellite Elevation	Satellite Azimuth	Sun Elevation	Sun Azimuth
Jan 15, 2002	16.44	77.19 deg	112.97 deg	34.95 deg	156.10 deg
Feb 17, 2002	16.47	81.88 deg	100.73 deg	43.20 deg	150.82 deg

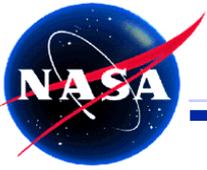
Standard original imagery
MTFC applied
Cubic convolution resampling algorithm



Stennis Space Center, MS, 1/15/02



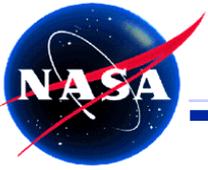
Stennis Space Center, MS, 2/17/02



ASD Measurements

Stennis Space Center

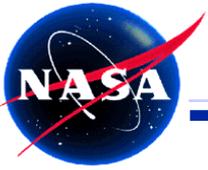
- Measurements of several target areas were taken
 - ~35-m x 15-m area of a dried grassy field
 - ~30-m x 20-m area of a concrete parking lot
 - Three 20-m x 20-m radiometric tarps (3.5%, 52% and 22 % reflectance)
- Measurements were taken along transect lines (grass and concrete) or tarp perimeter
 - 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 minutes of satellite overpass



Atmospheric Measurements

Stennis Space Center

- Solar irradiance 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 approximately 2 miles away
- Radiosonde was launched 30 minutes prior to satellite overpass. Data acquired over a 90-minute period up to 23 km

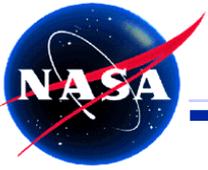


Full Sky Imager

Stennis Space Center

NASA SSC
January 15, 2002

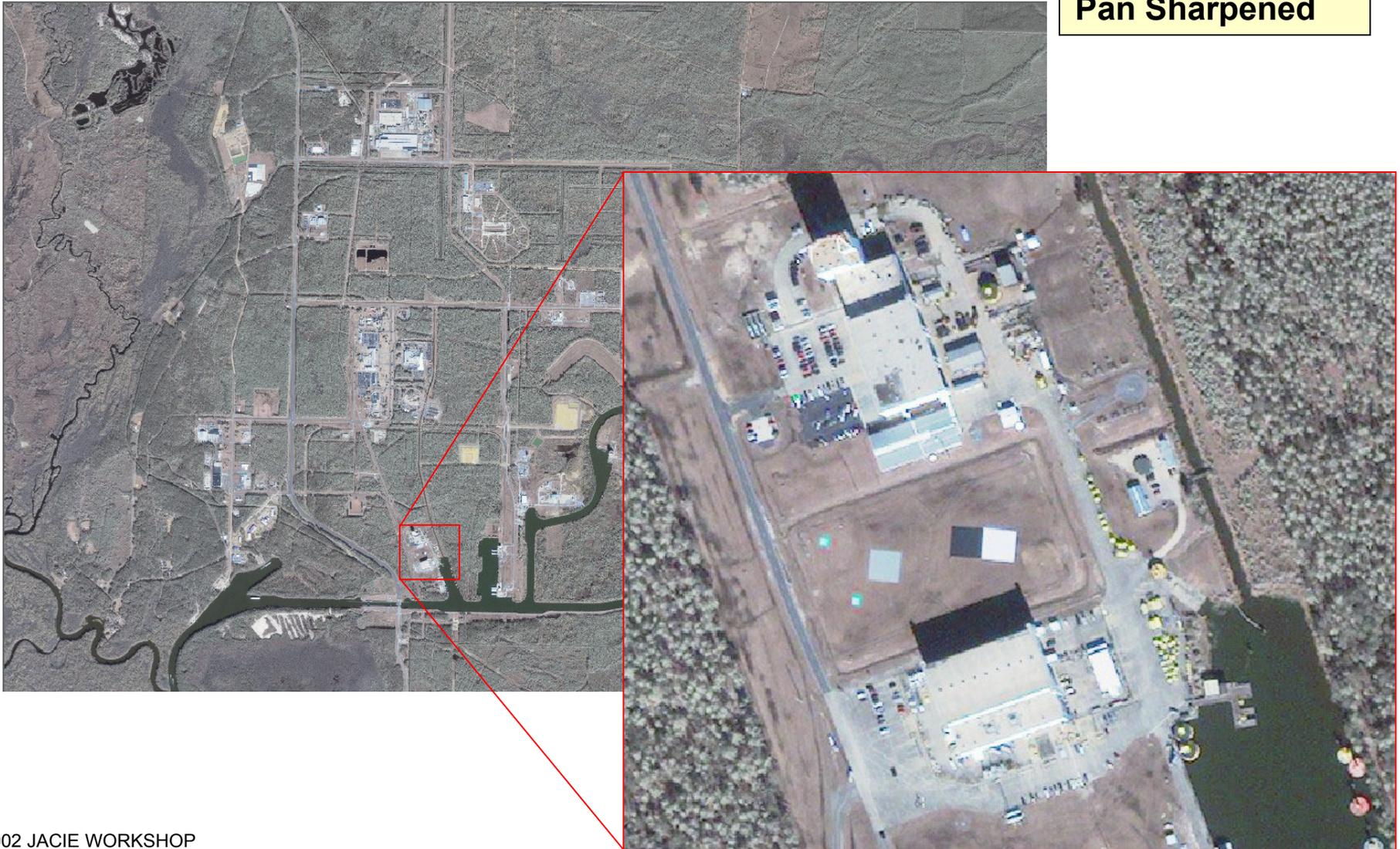


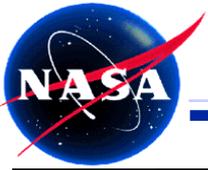


IKONOS Image of NASA SSC

Stennis Space Center

January 15, 2002
Pan Sharpened



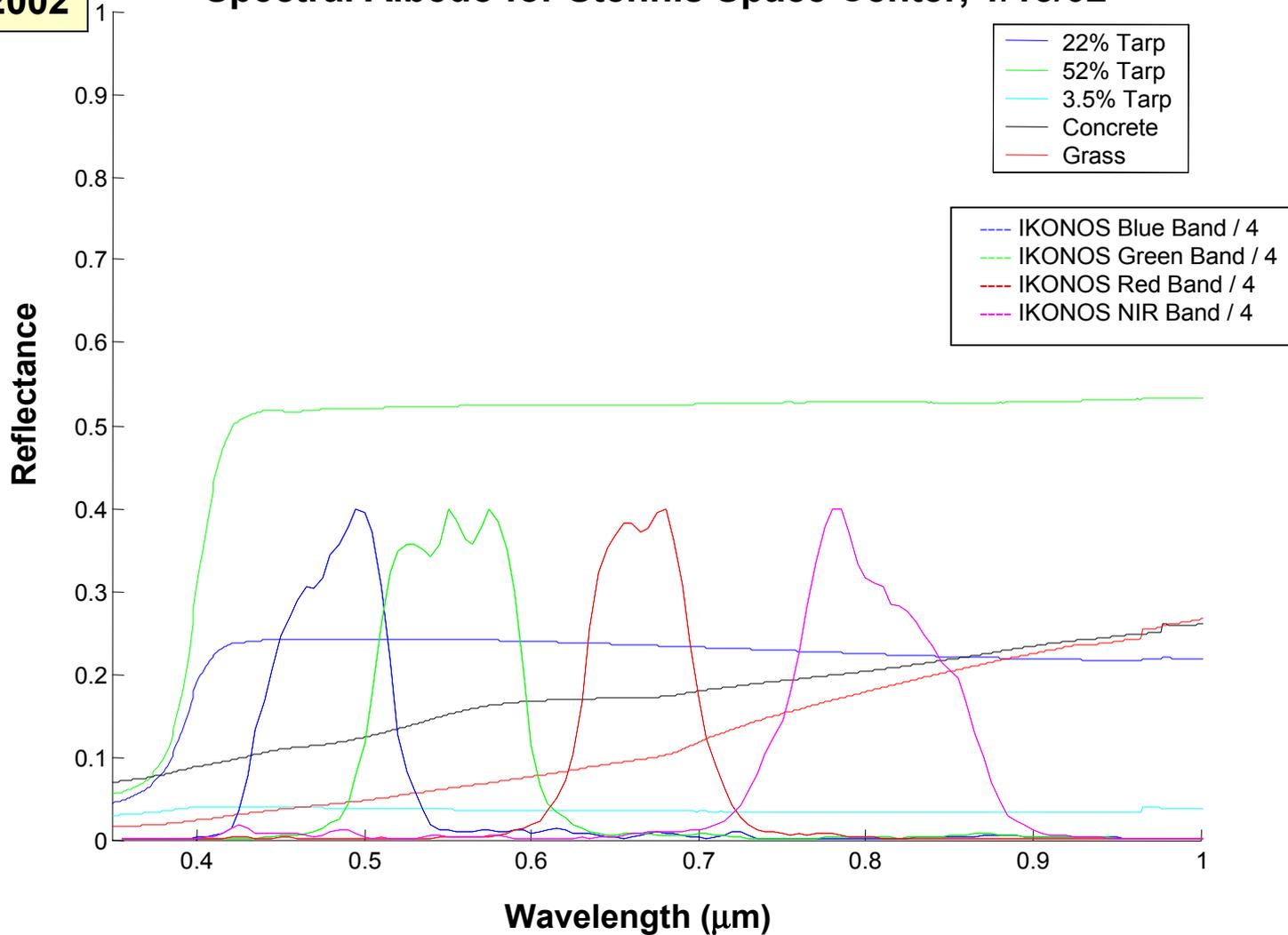


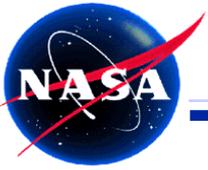
Spectroradiometer Data

Stennis Space Center

NASA SSC
January 15, 2002

Spectral Albedo for Stennis Space Center, 1/15/02



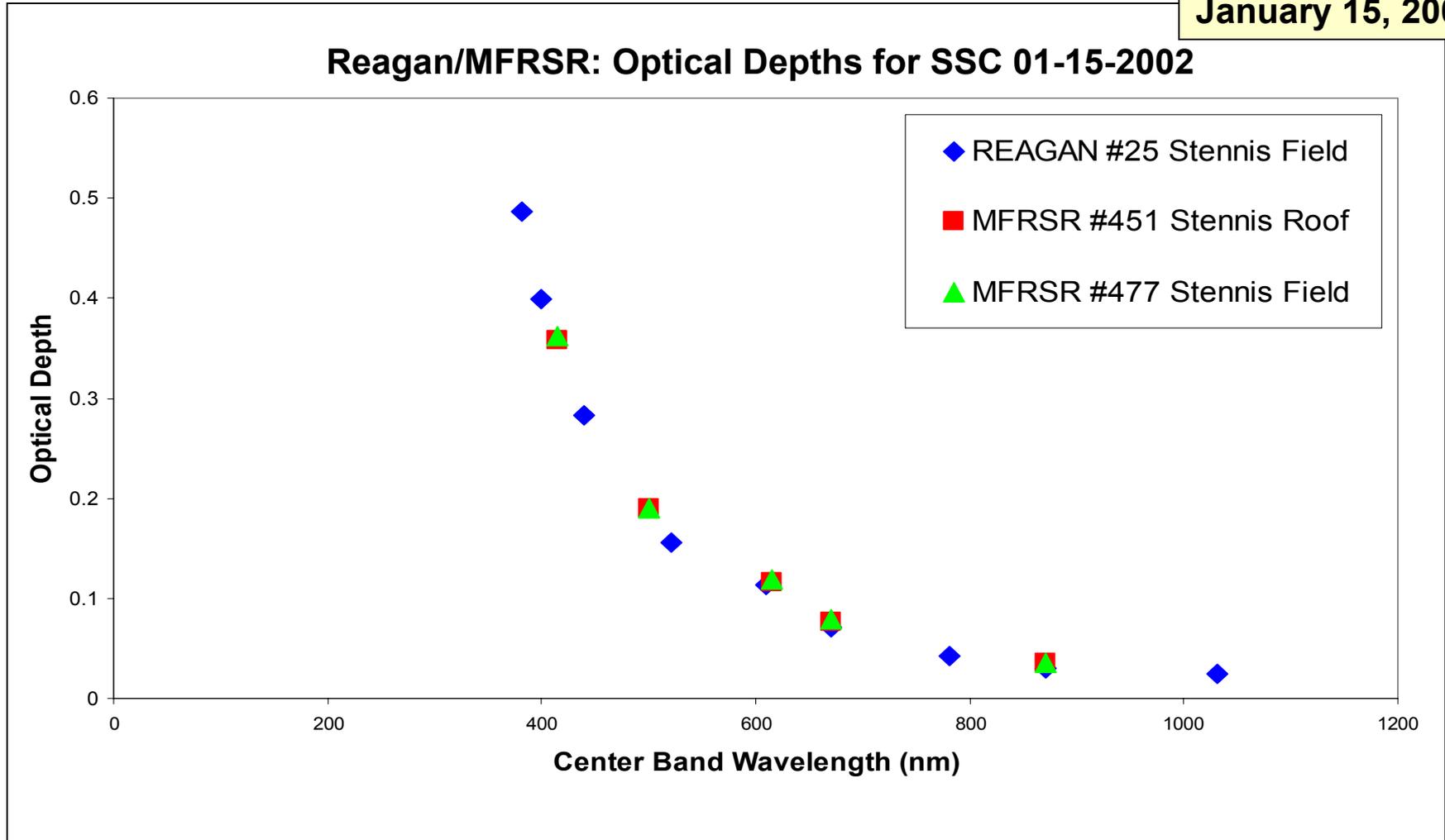


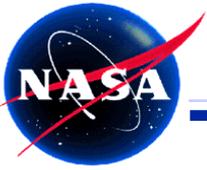
Reagan/MFRSR Optical Depth Values

Stennis Space Center

NASA SSC
January 15, 2002

Reagan/MFRSR: Optical Depths for SSC 01-15-2002

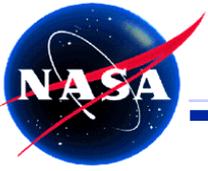




2001-2002 Acquisition Summary

Stennis Space Center

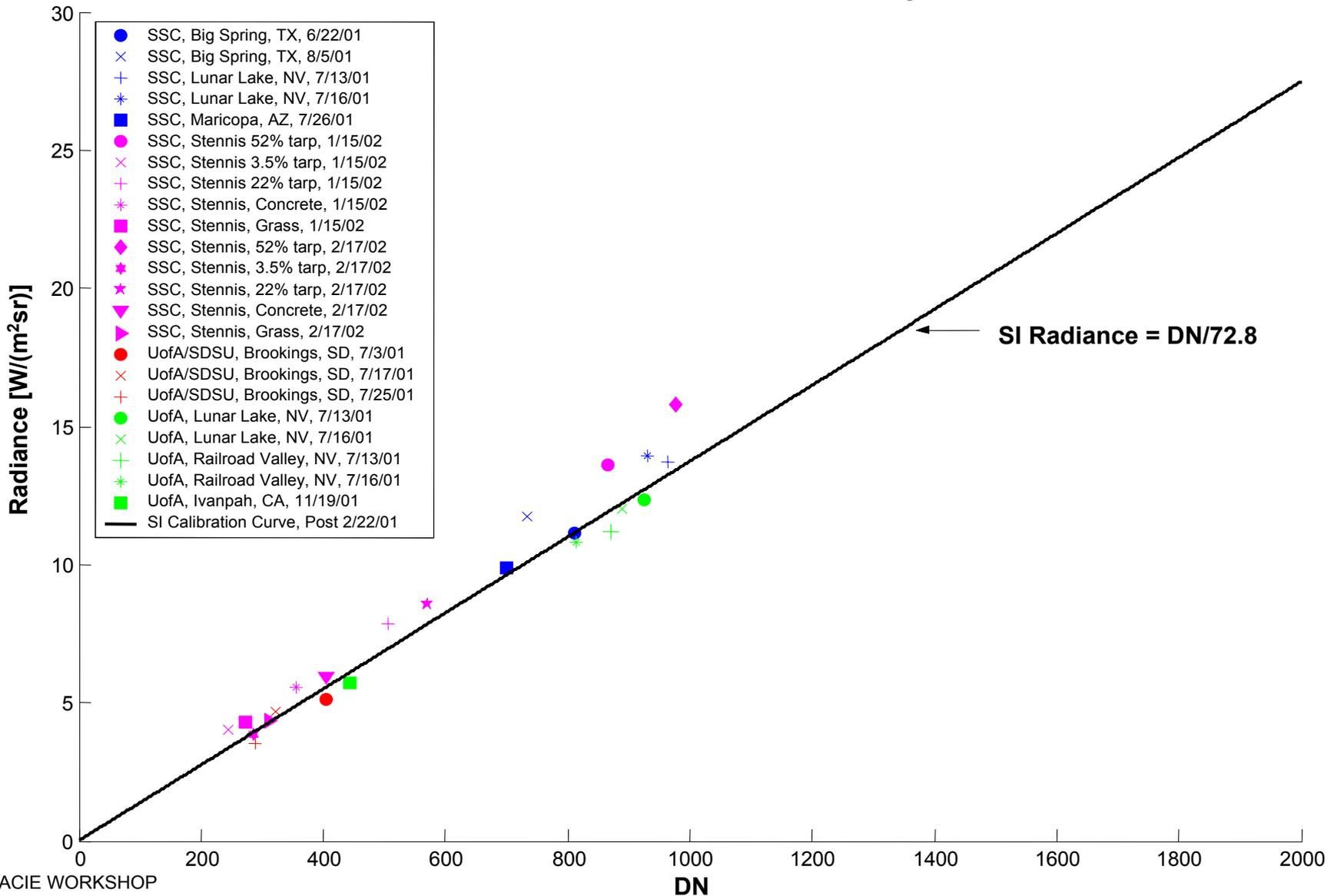
Site Name	Acquisition Date	Time (GMT)	Sensor Elevation (°)	Sensor Azimuth (°)
Big Spring, TX	June 22, 2001	17:36	79.65768	234.2432
Brookings, SD	July 3, 2001	17:34	76.18523	281.8466
Railroad Valley, NV	July 13, 2001	18:39	81.5914	239.8185
Lunar Lake, NV	July 13, 2001	18:39	75.56384	207.4279
Railroad Valley, NV	July 16, 2001	18:48	66.83384	294.4445
Lunar Lake, NV	July 16, 2001	18:48	69.09875	275.9376
Brookings, SD	July 17, 2001	17:44	60.7995	289.9393
Brookings, SD	July 25, 2001	17:36	73.19706	269.4949
Maricopa, AZ	July 26, 2001	18:15	80.15064	170.3587
Big Spring, TX	August 5, 2001	17:40	77.47969	279.8083
Ivanpah Playa, CA	November 19, 2001	18:43	75.90067	279.5004
SSC, MS	January 15, 2002	16:44	77.19418	112.9742
SSC, MS	February 17, 2002	16:47	81.87543	100.7312



IKONOS Blue Band Calibration Summary

Stennis Space Center

Blue Band Calibration Summary

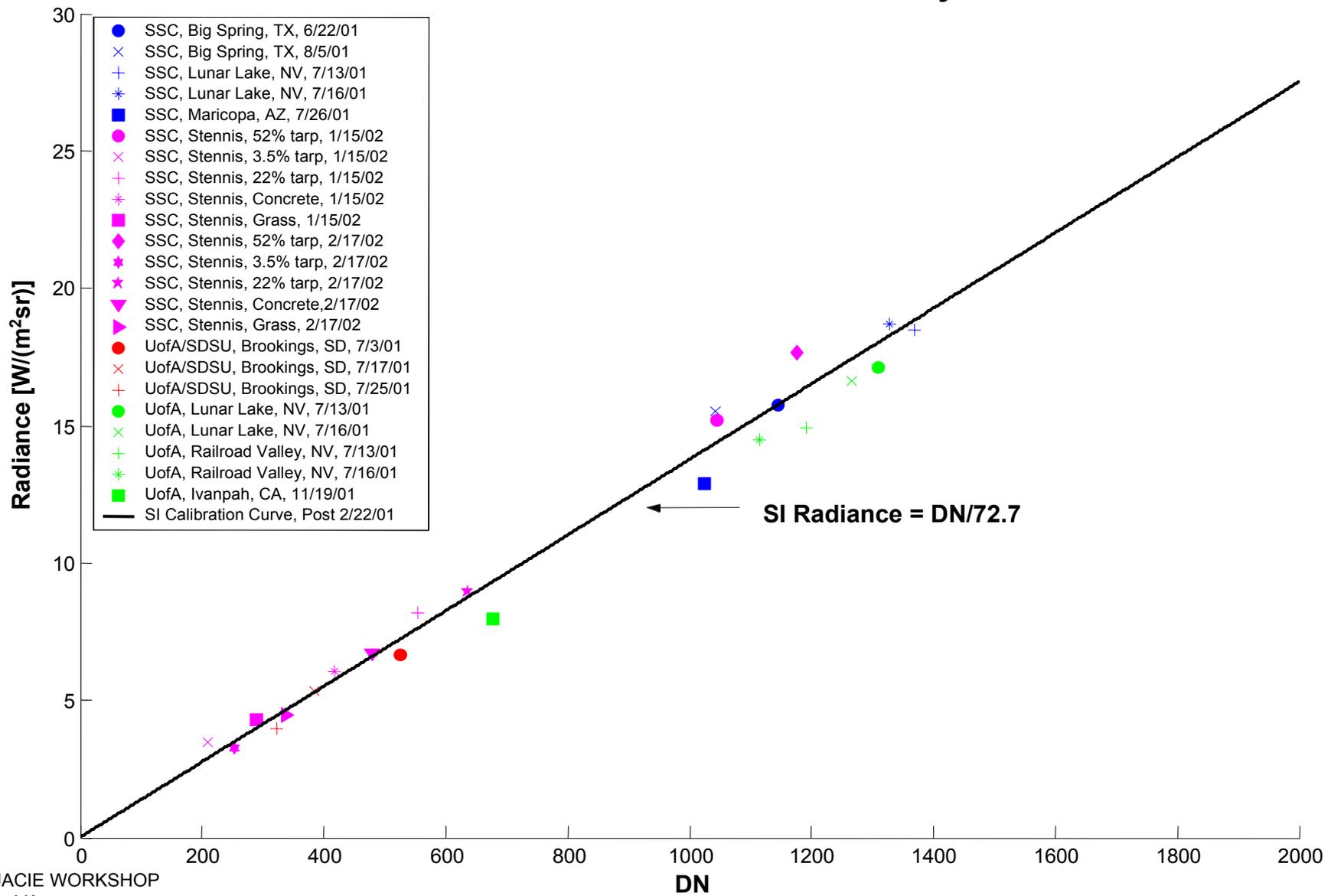


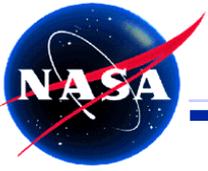


IKONOS Green Band Calibration Summary

Stennis Space Center

Green Band Calibration Summary

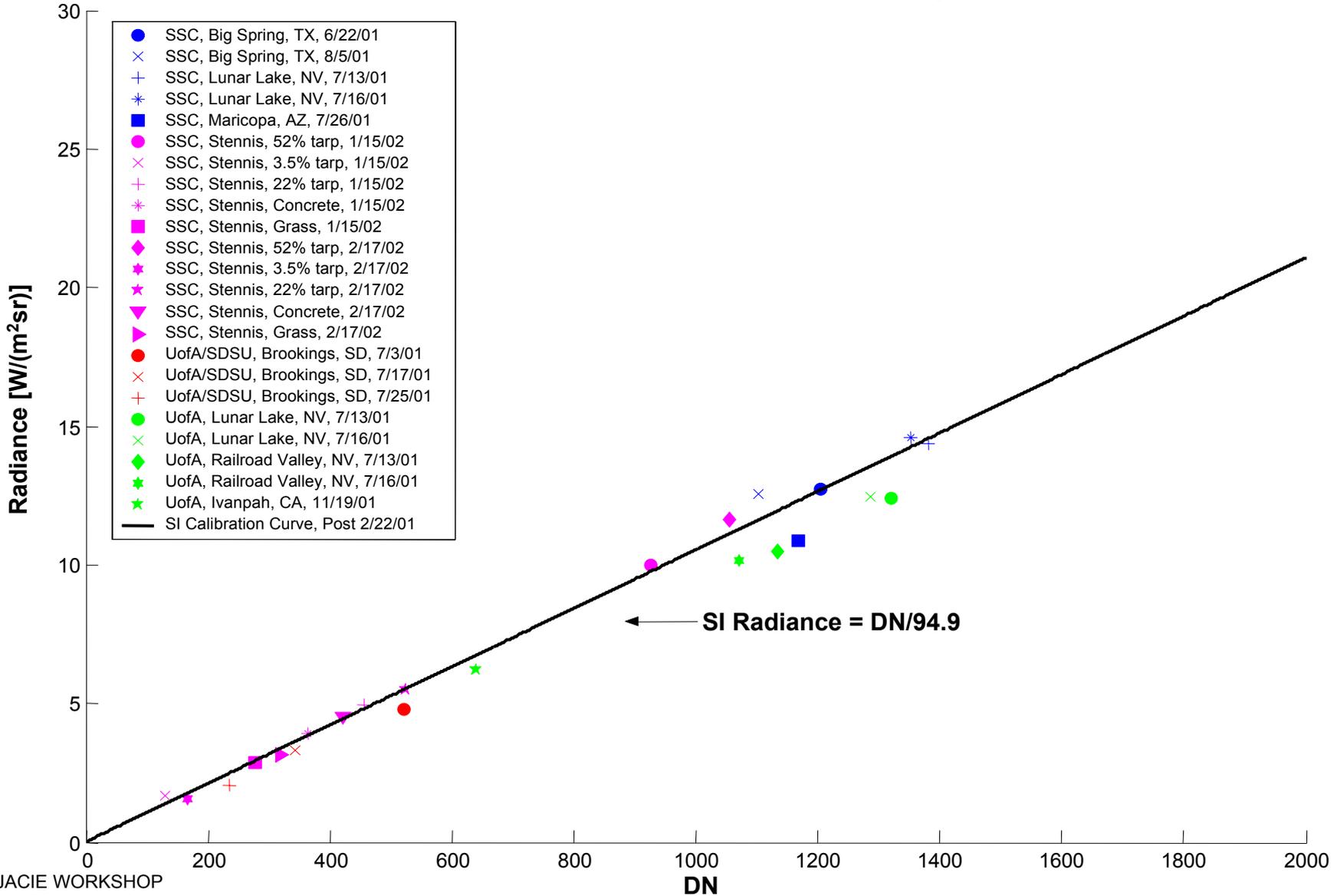


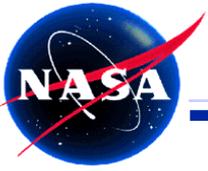


IKONOS Red Band Calibration Summary

Stennis Space Center

Red Band Calibration Summary

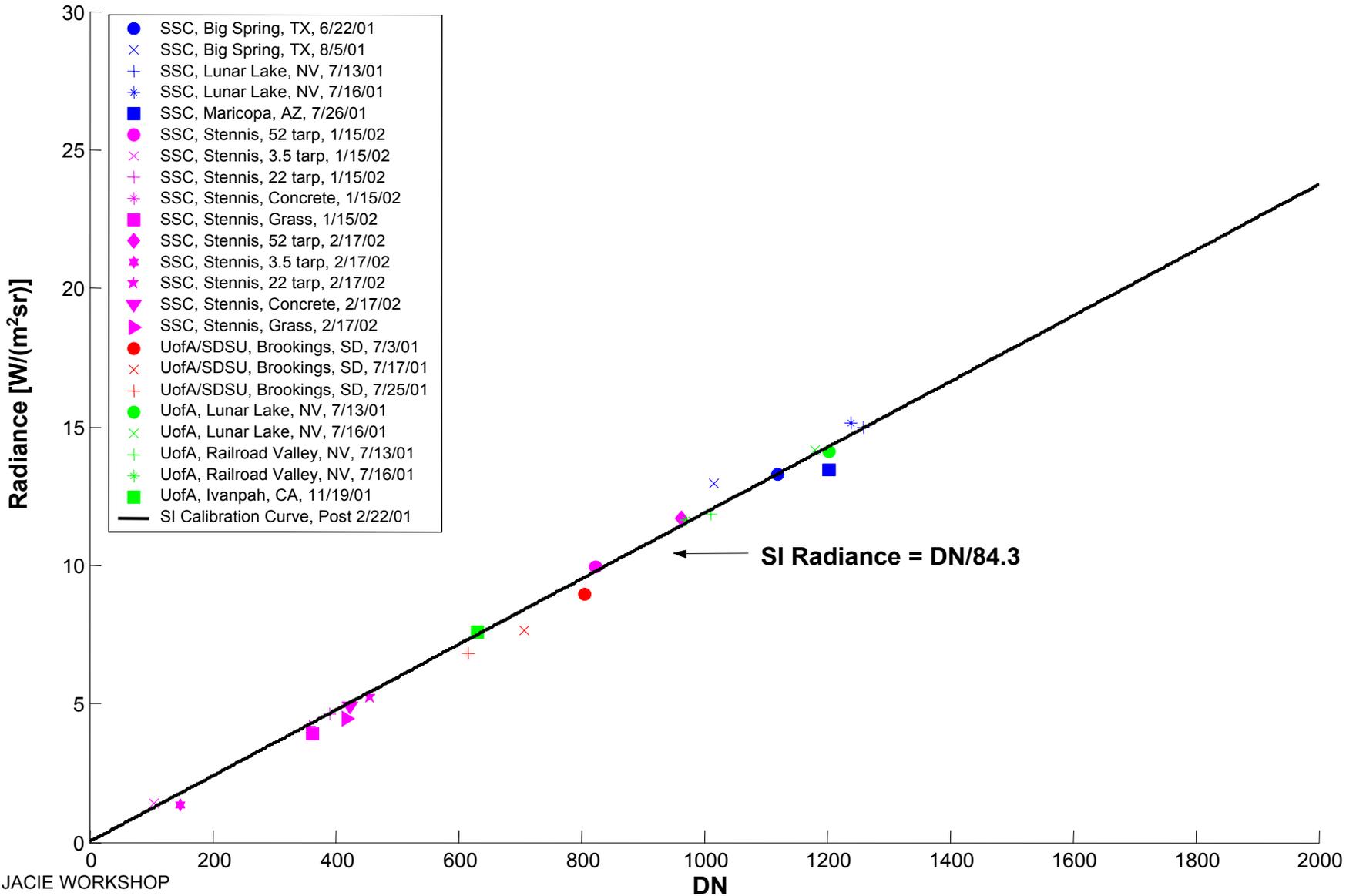




IKONOS NIR Band Calibration Summary

Stennis Space Center

NIR Band Calibration Summary





Summary

Stennis Space Center

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**