



Stennis Space Center

NASA IKONOS Radiometric Characterization

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Characterization Overview

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- **Objective**

- Perform radiometric vicarious calibrations of IKONOS imagery and compare with Space Imaging calibration coefficients

- **Approach**

- Utilize multiple well-characterized sites

no bold **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

- no bold*
 - **NASA Stennis Space Center**
 - **University of Arizona Remote Sensing Group**
 - **South Dakota State University**
 - **US Department of Agriculture SWRC / USWCL**

- Leverage characterization activities with other field measurement programs



Vicarious Calibration Method

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Reflectance-based Approach

- Characterize target reflectance at time of satellite overpass

no bold

Measurements taken of target area and a 99% reflectance spectralon panel (Jackson BRDF model)

- Characterize atmosphere at time of satellite overpass

no bold

- **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



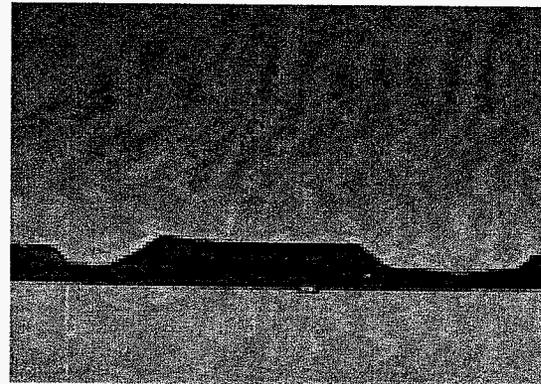
Lunar Lake Playa, Nevada

Stennis Space Center

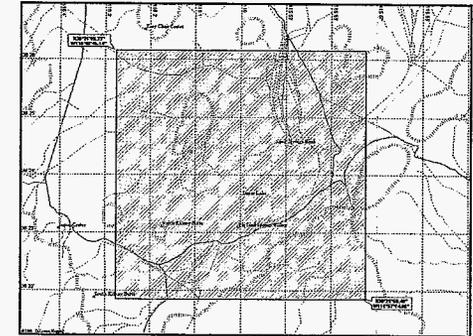
Site: Dry lake bed in central Nevada, predominantly clay surface, no vegetation, surface is hard and nearly impermeable to water.

Elevation approx. 1800 m

Center point 38.4° N, 116.0° W.



General Scene

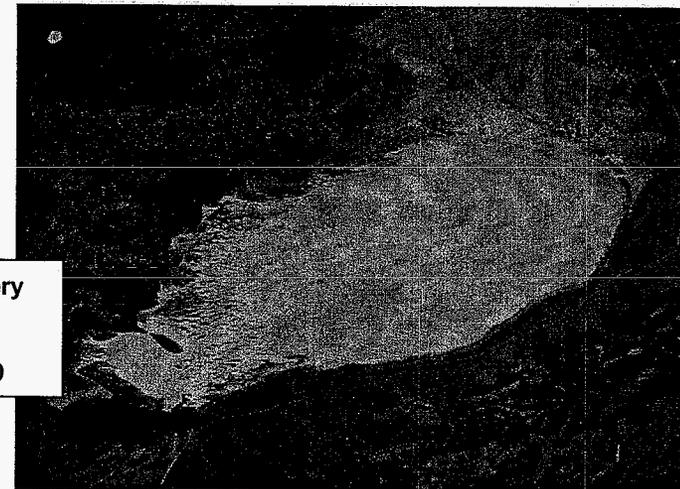


IKONOS Image Area
8km x 8km

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

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

IKONOS Imagery
Blue Band
June 10, 2000



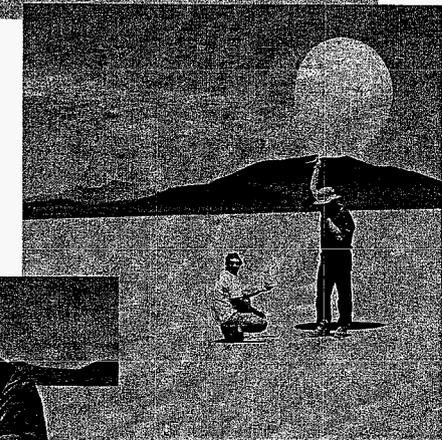
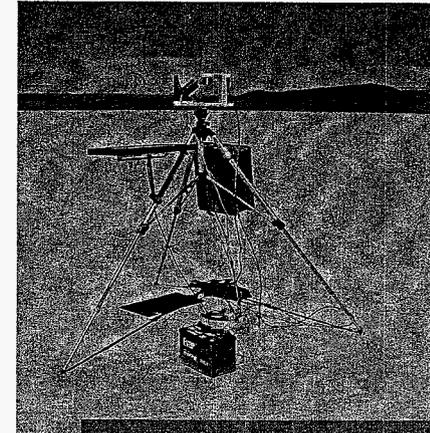
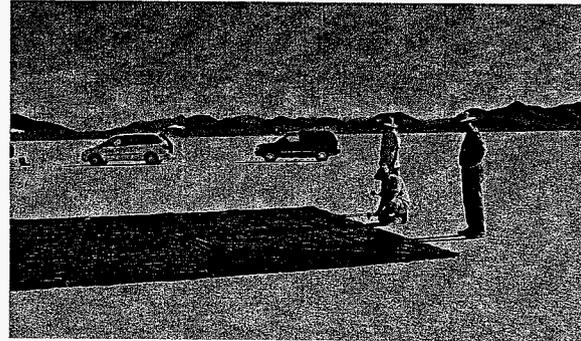
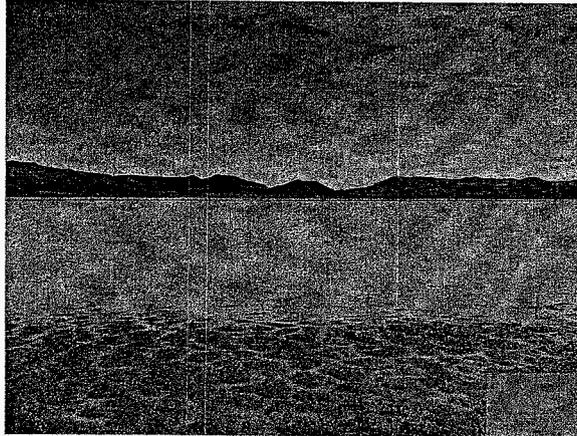
Includes material © Space Imaging L.P.





Lunar Lake Ground Truthing

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Data Acquisitions

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

Standard ~~Original~~ imagery
MTFC applied
Cubic convolution resampling algorithm



Ground Measurements

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- **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

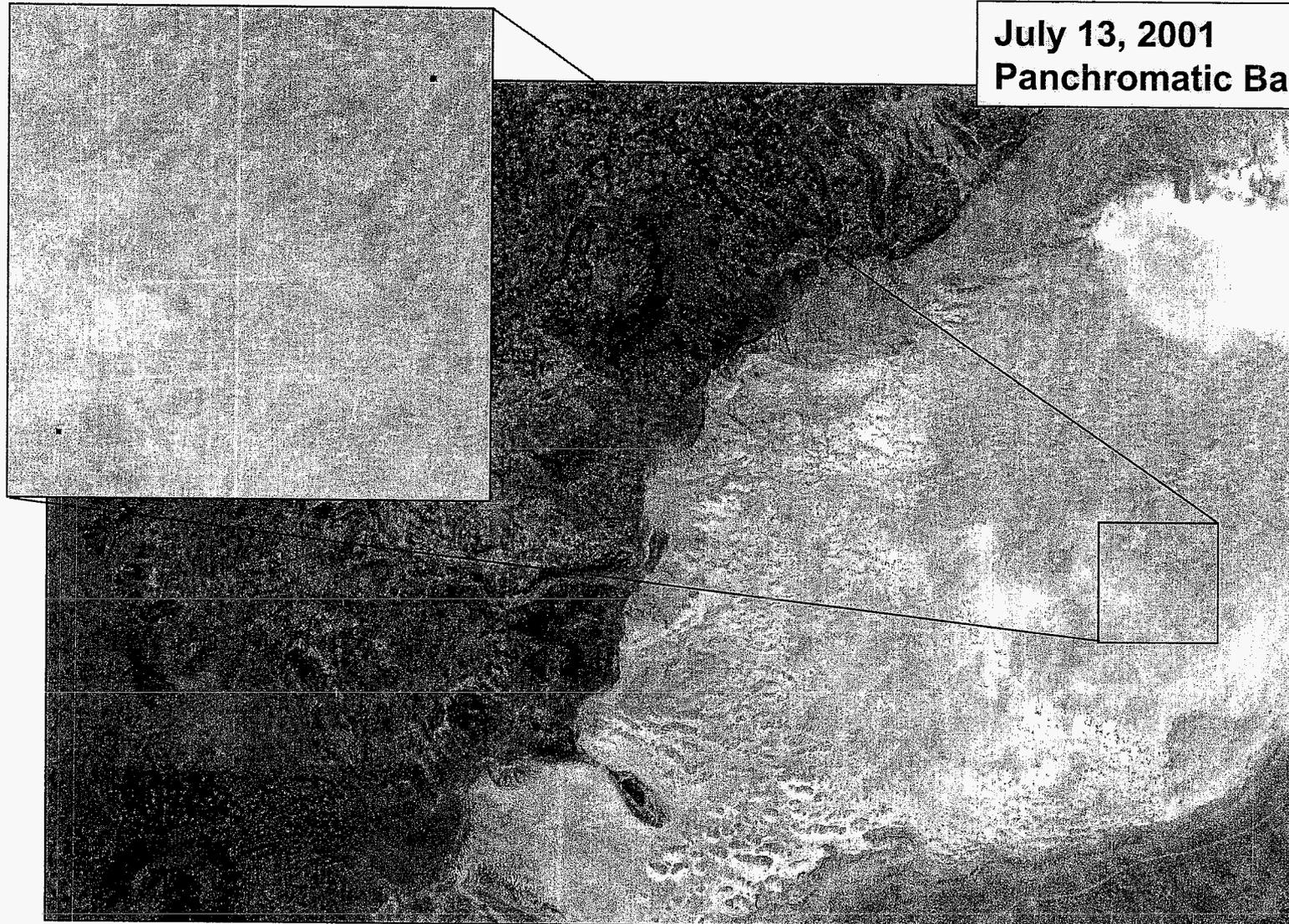
- **Atmospheric measurements**

- Collect solar radiance data from early morning through post-sensor acquisition
- Radiosonde launch near time of sensor overpass
- Data acquired July 13 only



IKONOS Image of Lunar Lake

Stennis Space Center

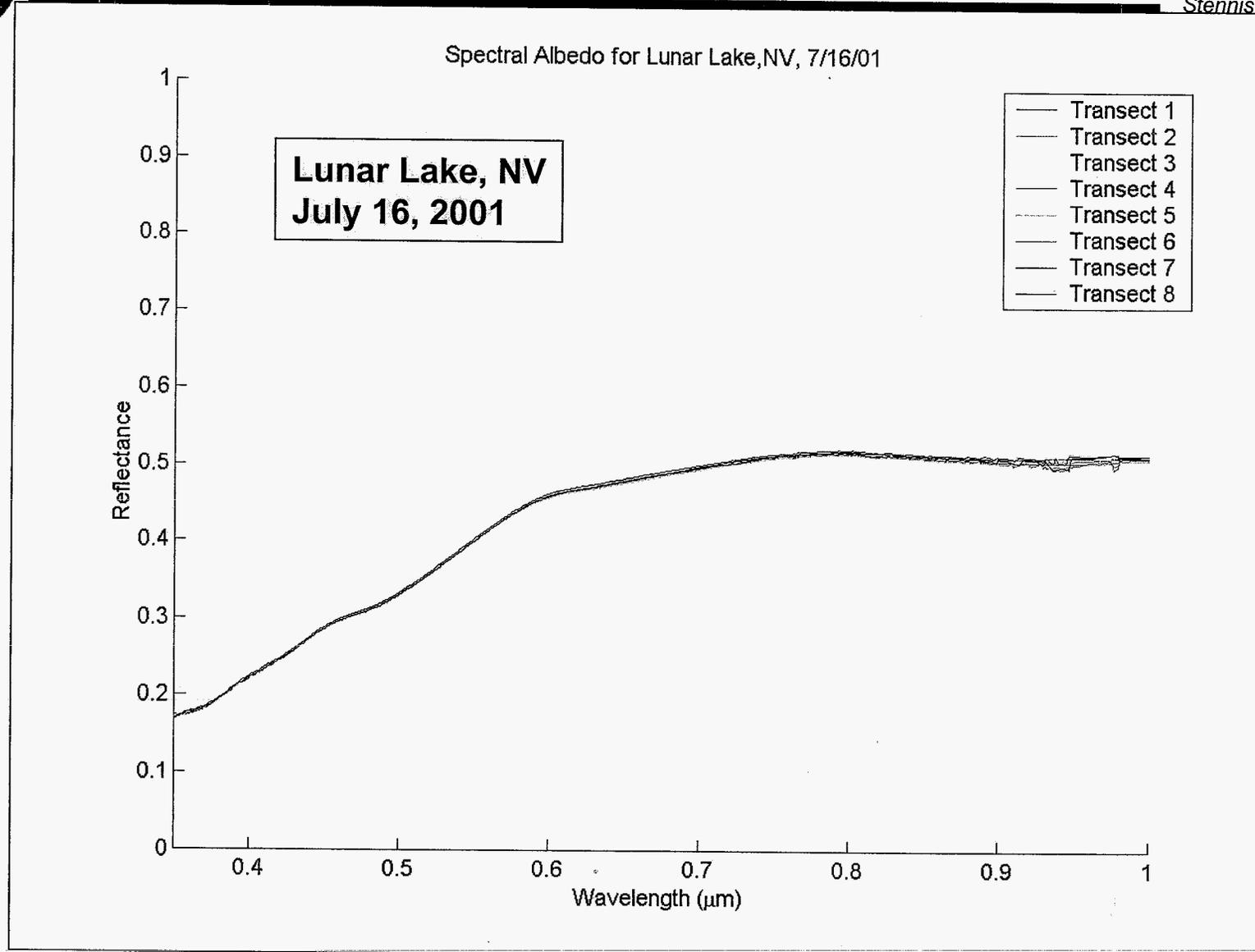


July 13, 2001
Panchromatic Band



Spectroradiometer Data

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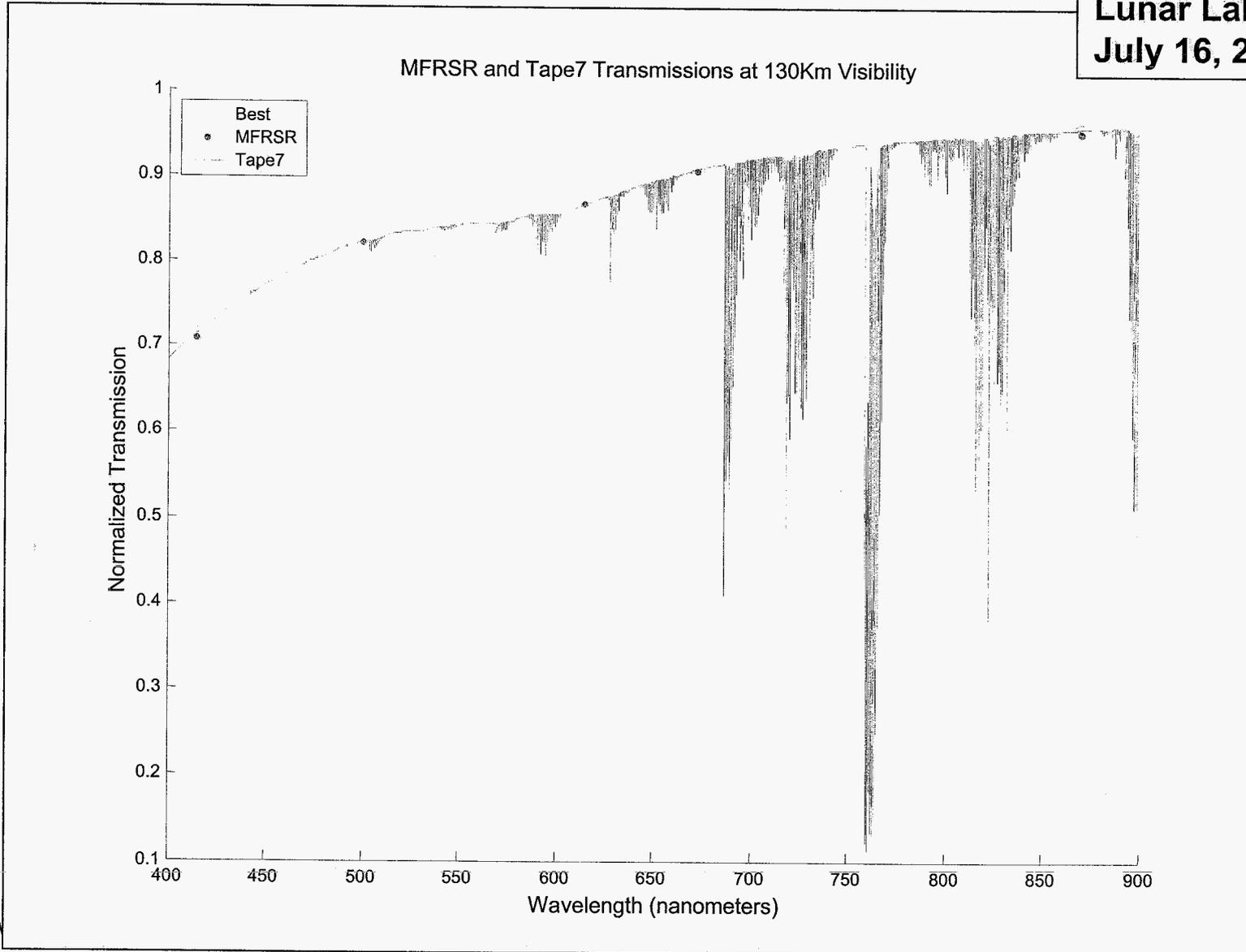




MFRSR/MODTRAN predicted Transmission

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Lunar Lake, NV
July 16, 2001

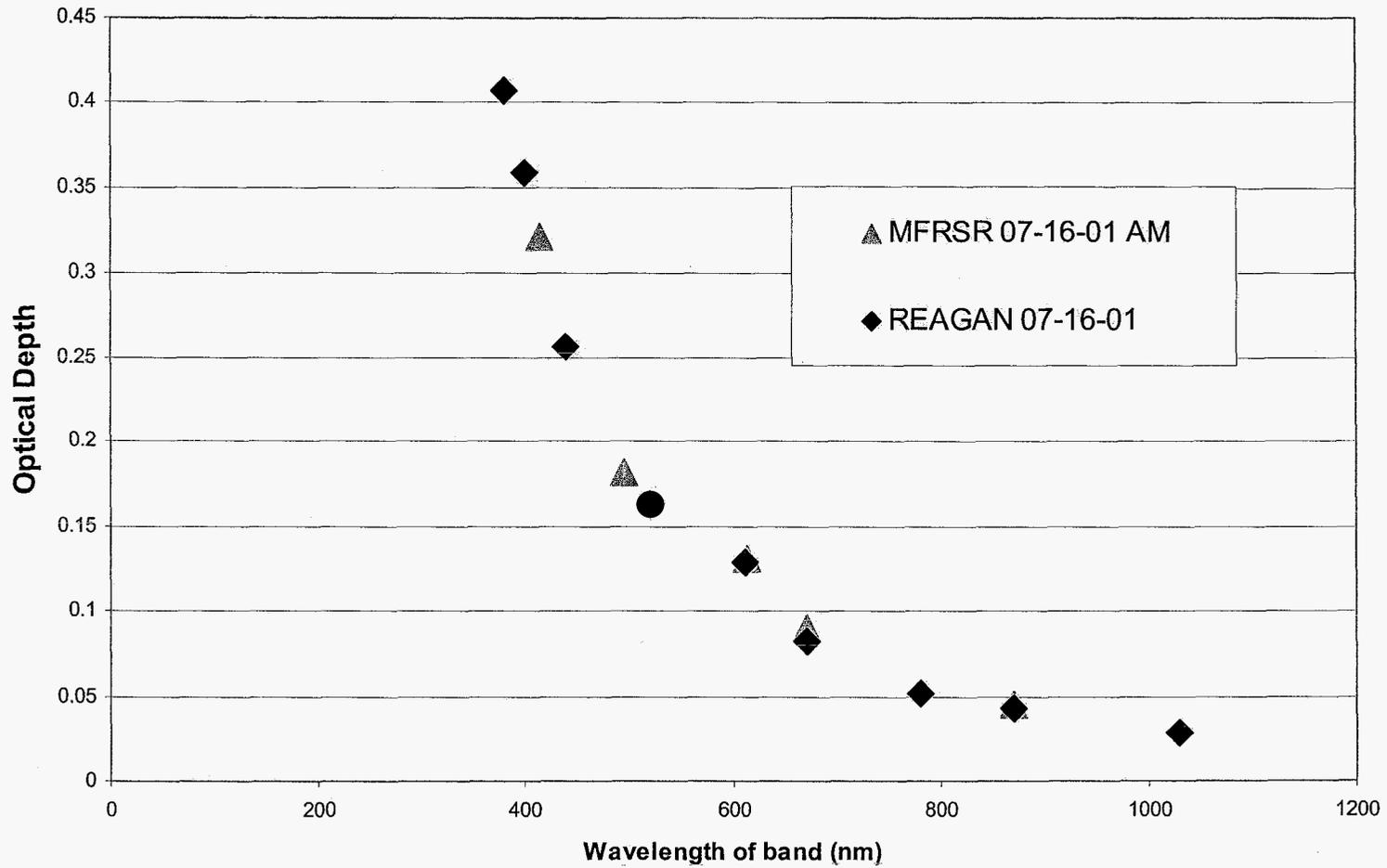




Reagan/MFRSR Optical Depth Values

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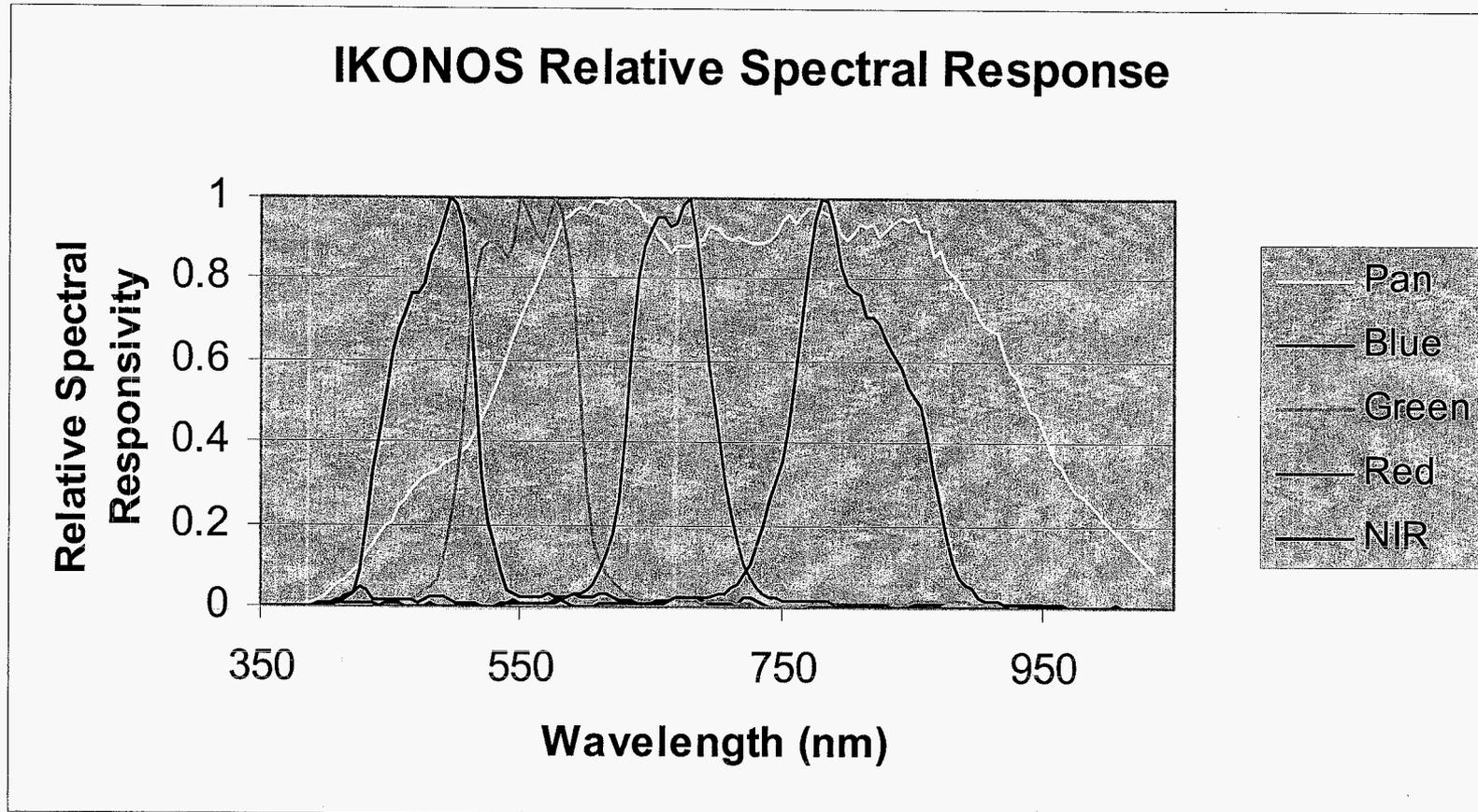
MFRSR/Reagan: Optical Depth for Lunar Lake 2001





IKONOS Spectral Response

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Lunar Lake IKONOS Radiometric Assessment

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Lunar Lake, NV
July 13, 2001

	Band (nm)	NASA Estimate (W/m ² sr)	IKONOS Measurement (W/m ² sr)	% 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/m ² sr)	IKONOS Measurement (W/m ² sr)	% 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%

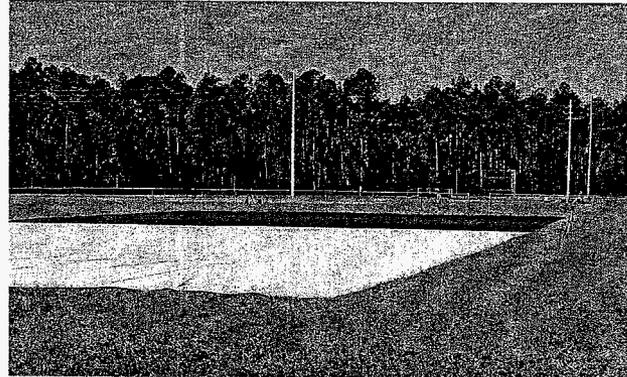
Percent difference is calculated by: $\text{abs}(1 - \text{IKONOS}/\text{NASA})$



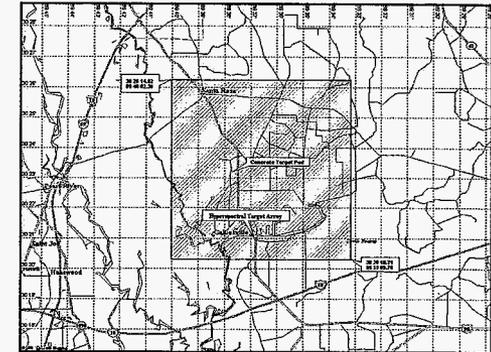
NASA Stennis Space Center, MS

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Site: Scattered buildings within a heavily wooded area, man-made reservoirs and canal
Elevation 5.5m - 10m
30.388 degrees N, 89.61 degrees W



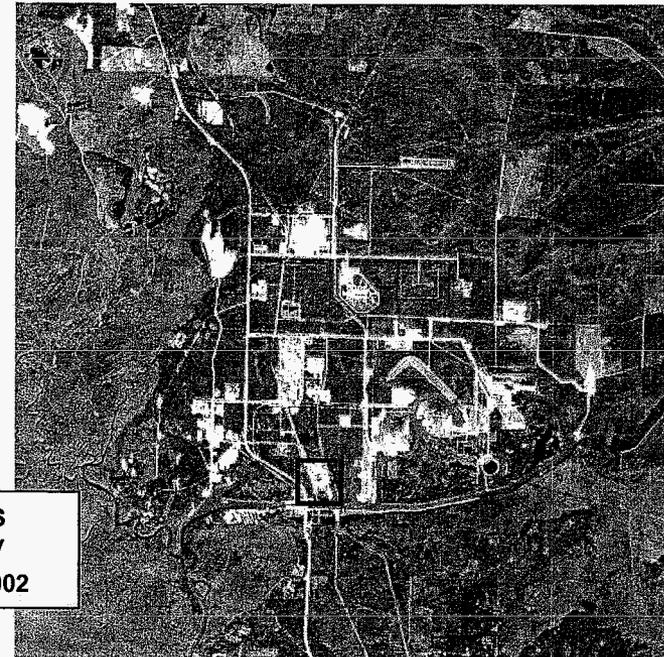
General Scene



IKONOS Image Area
10.5km x 10.5km

In-Situ Instrumentation:

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



IKONOS
Imagery
Jan 15, 2002

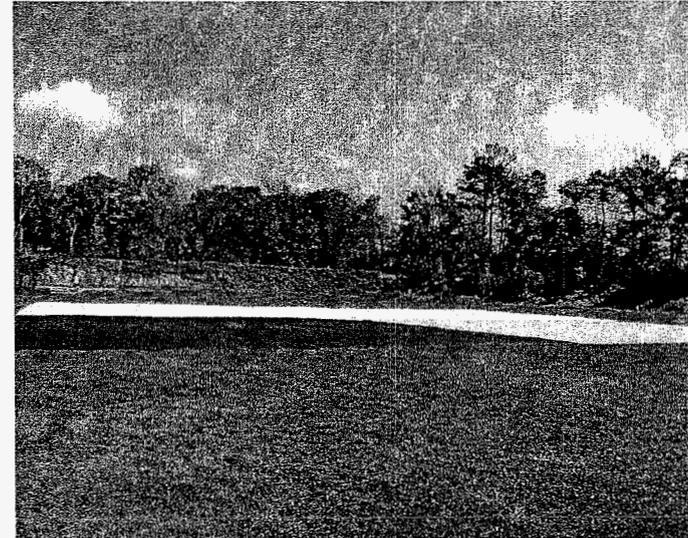




Radiometric Tarps

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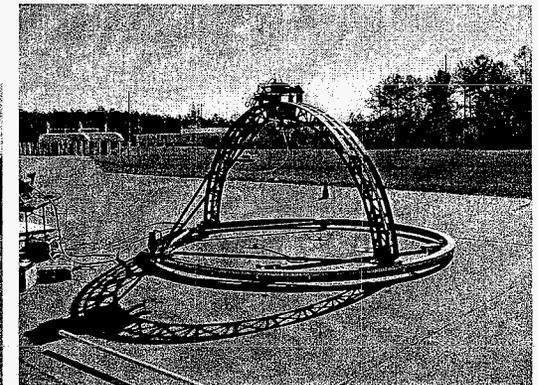
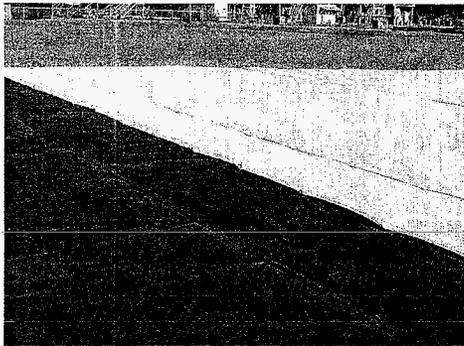
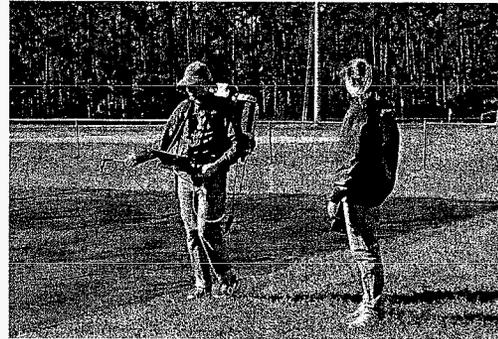
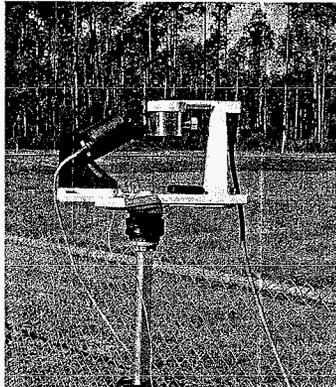
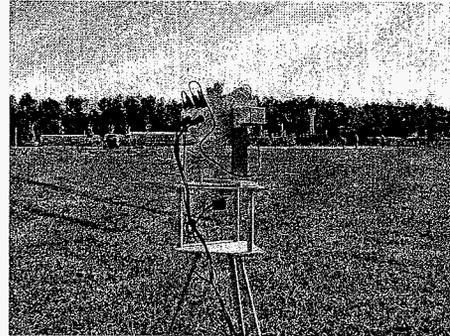
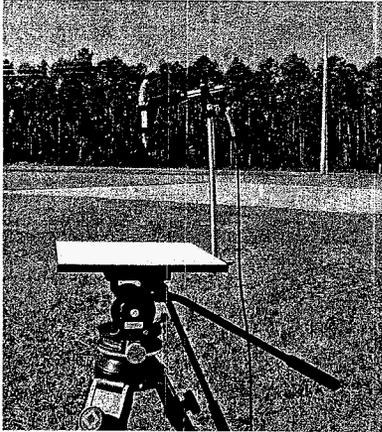
- 4 20m x 20m tarps with reflectance values of
 - less than 5%
 - between 20% and 25%
 - between 30% and 40%
 - between 50% and 55%
- Spectral measurement range of 400 to 1050 nm
- Standard deviation about average reflectance less than 1% spatially
- Peak to peak variation in reflectance less than 10% within any 100nm 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

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

Standard ~~Original~~ imagery
MTFC applied
Cubic convolution resampling algorithm



ASD Measurements

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- 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^{utes} of satellite overpass



Atmospheric Measurements

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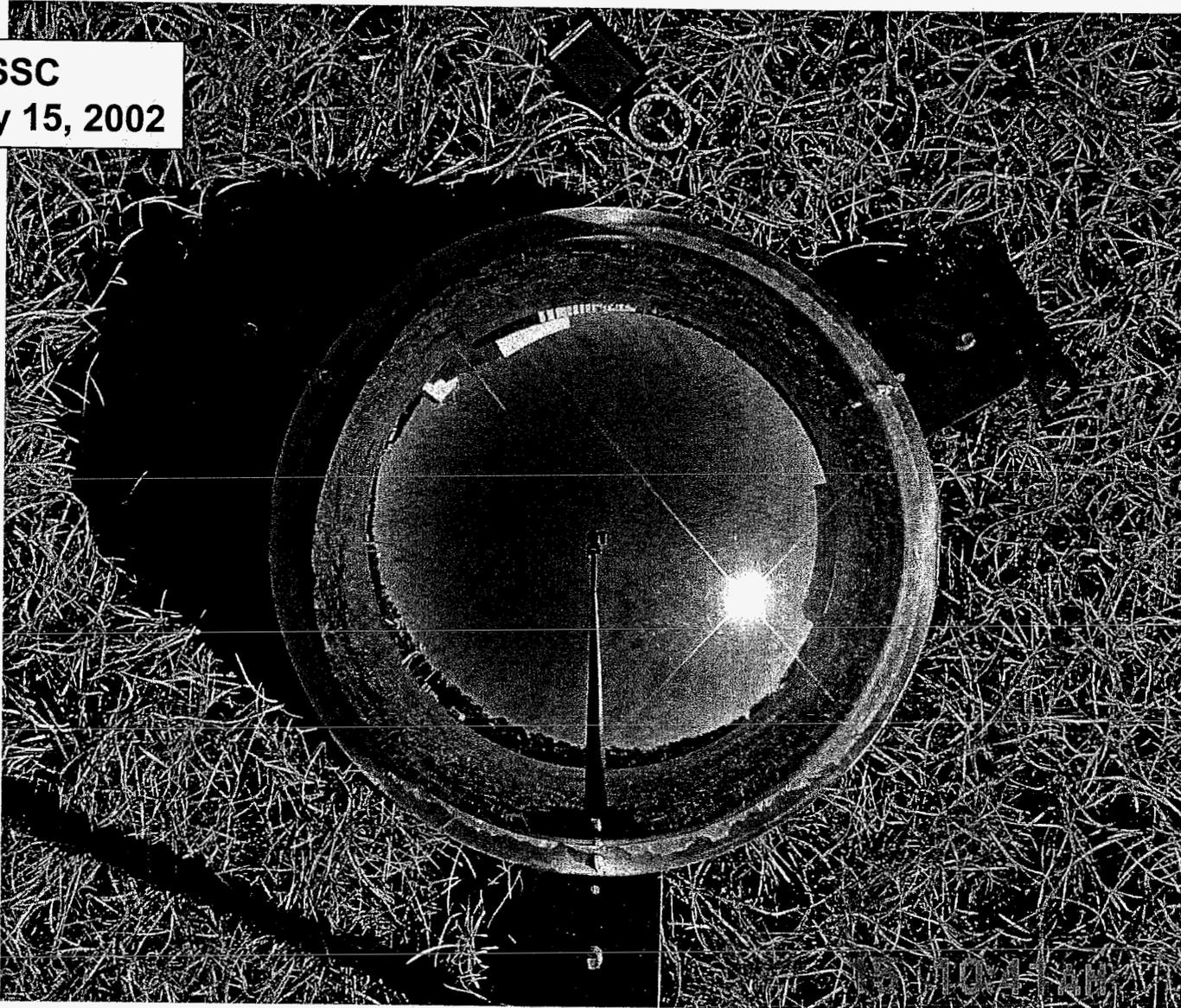
- Solar radiance data taken from early morning through post-sensor acquisition
 - (1) MFRSR and (1) Reagan sunphotometer acquired data from the measurement field
 - (1) MFRSR acquired data from a building rooftop approx. 2 miles away
- Radiosonde was launched 30 minutes prior to satellite overpass. Data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



Full Sky Imager

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NASA SSC
January 15, 2002

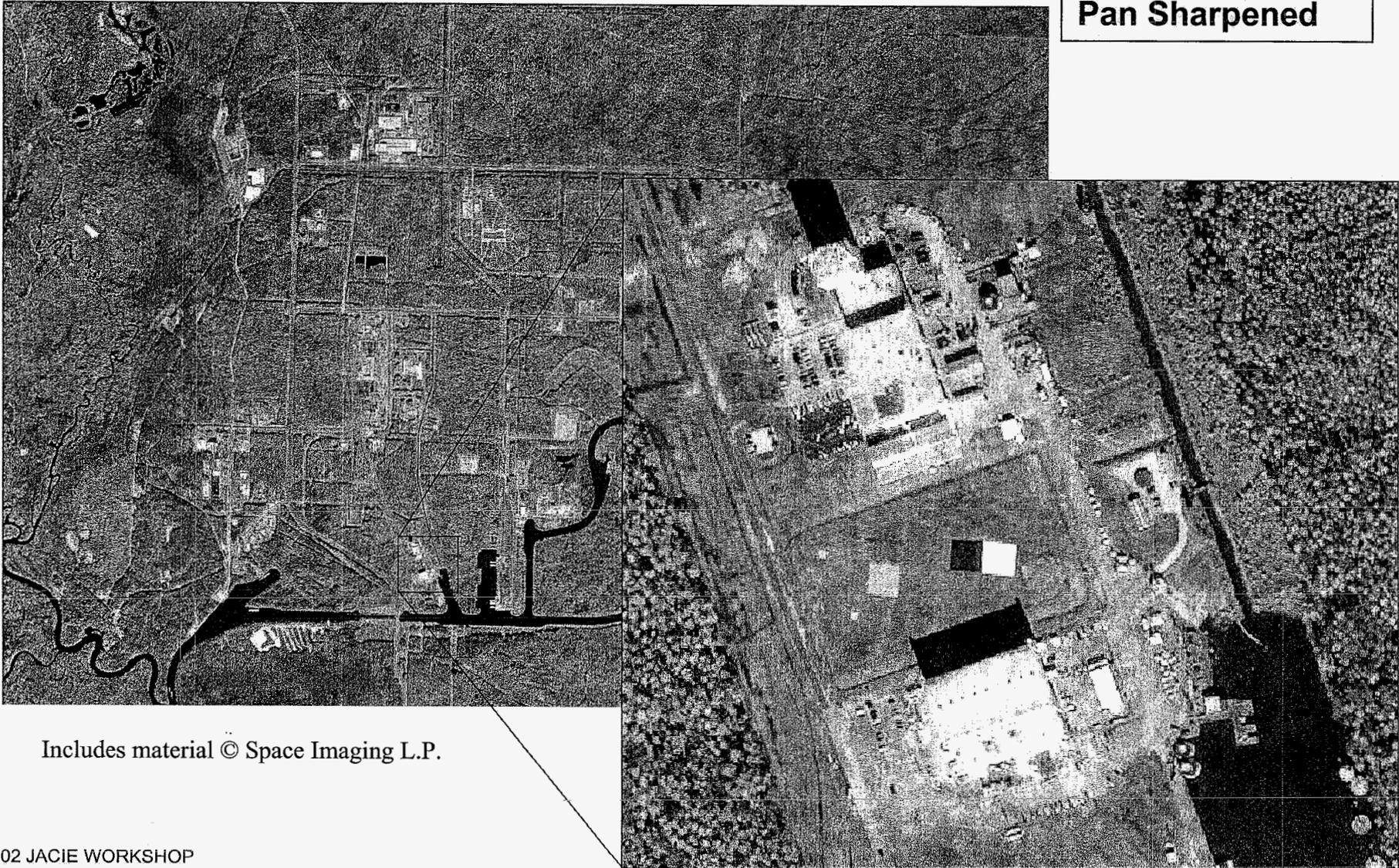




IKONOS Image of NASA SSC

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January 15, 2002
Pan Sharpened

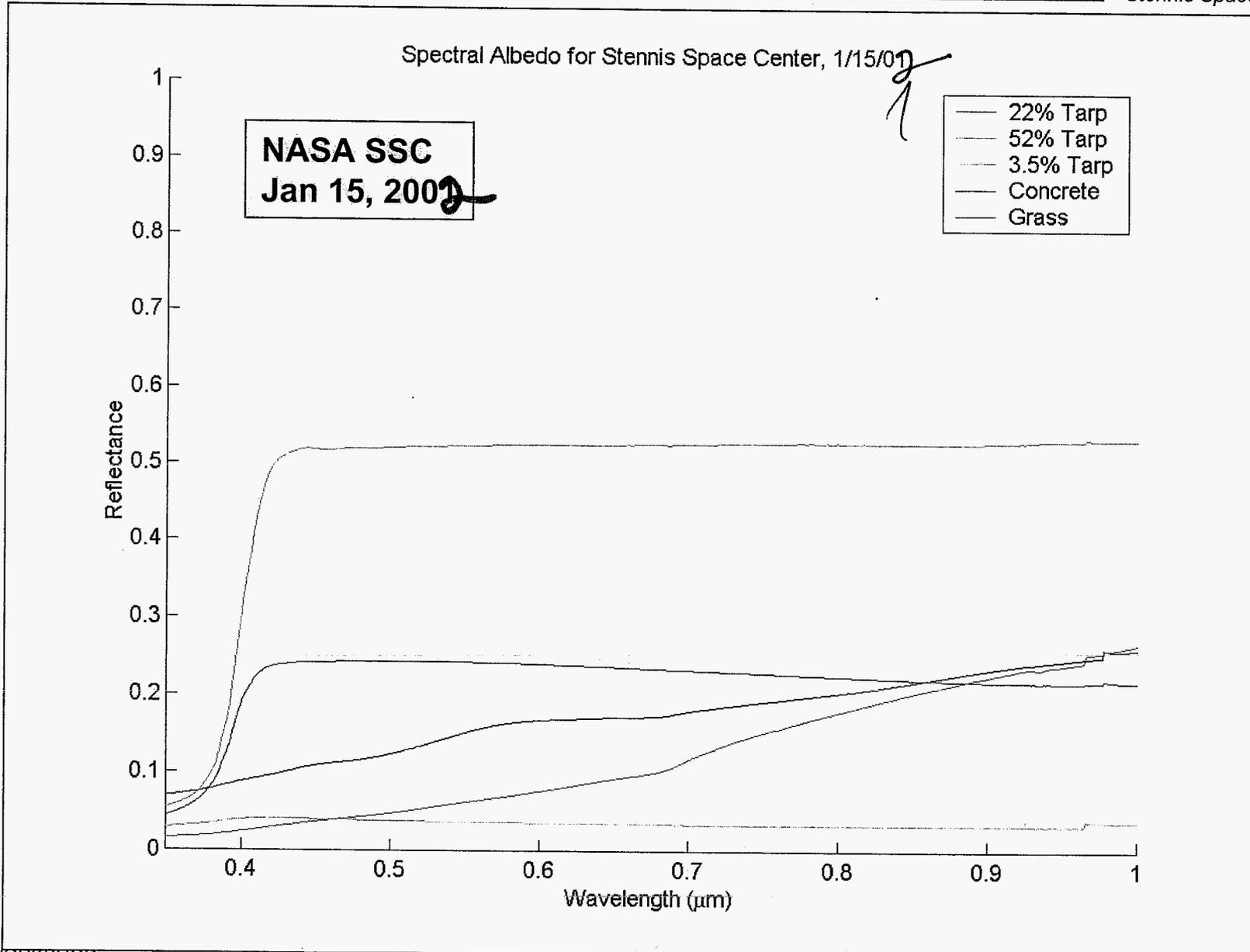


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Spectroradiometer Data

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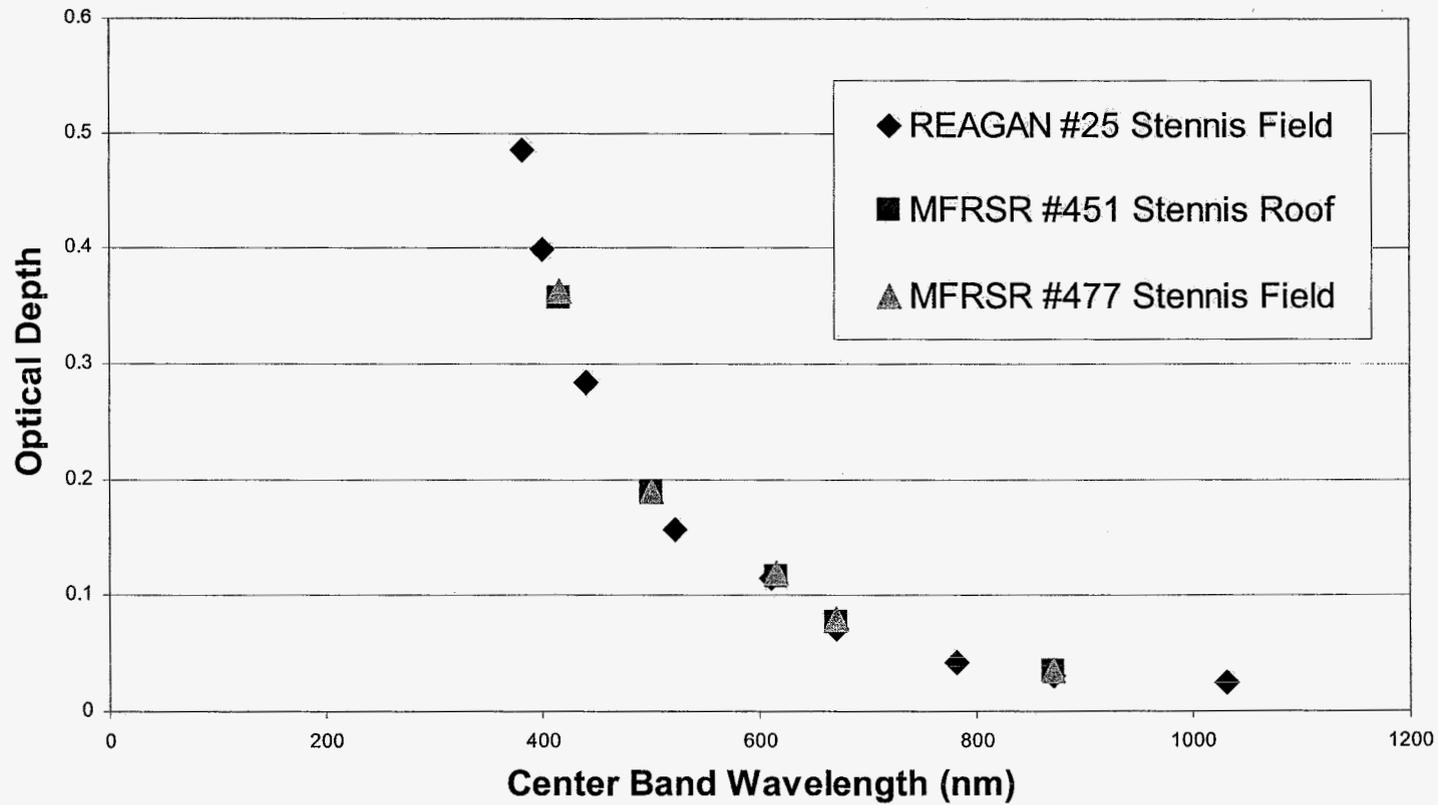




Reagan/MFRSR Optical Depth Values

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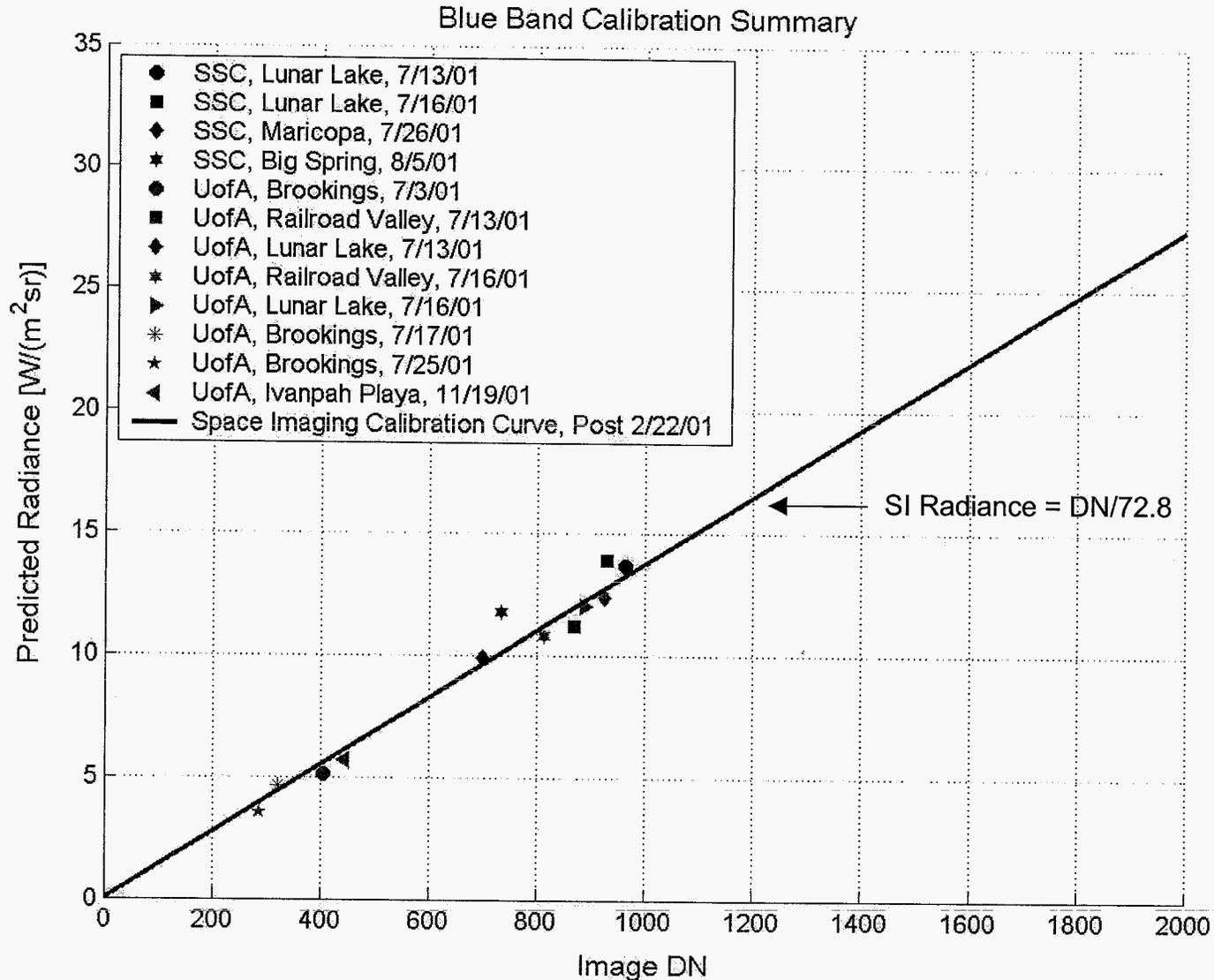
SSC, MS
Jan 15, 2002





IKONOS Blue Band Calibration Summary

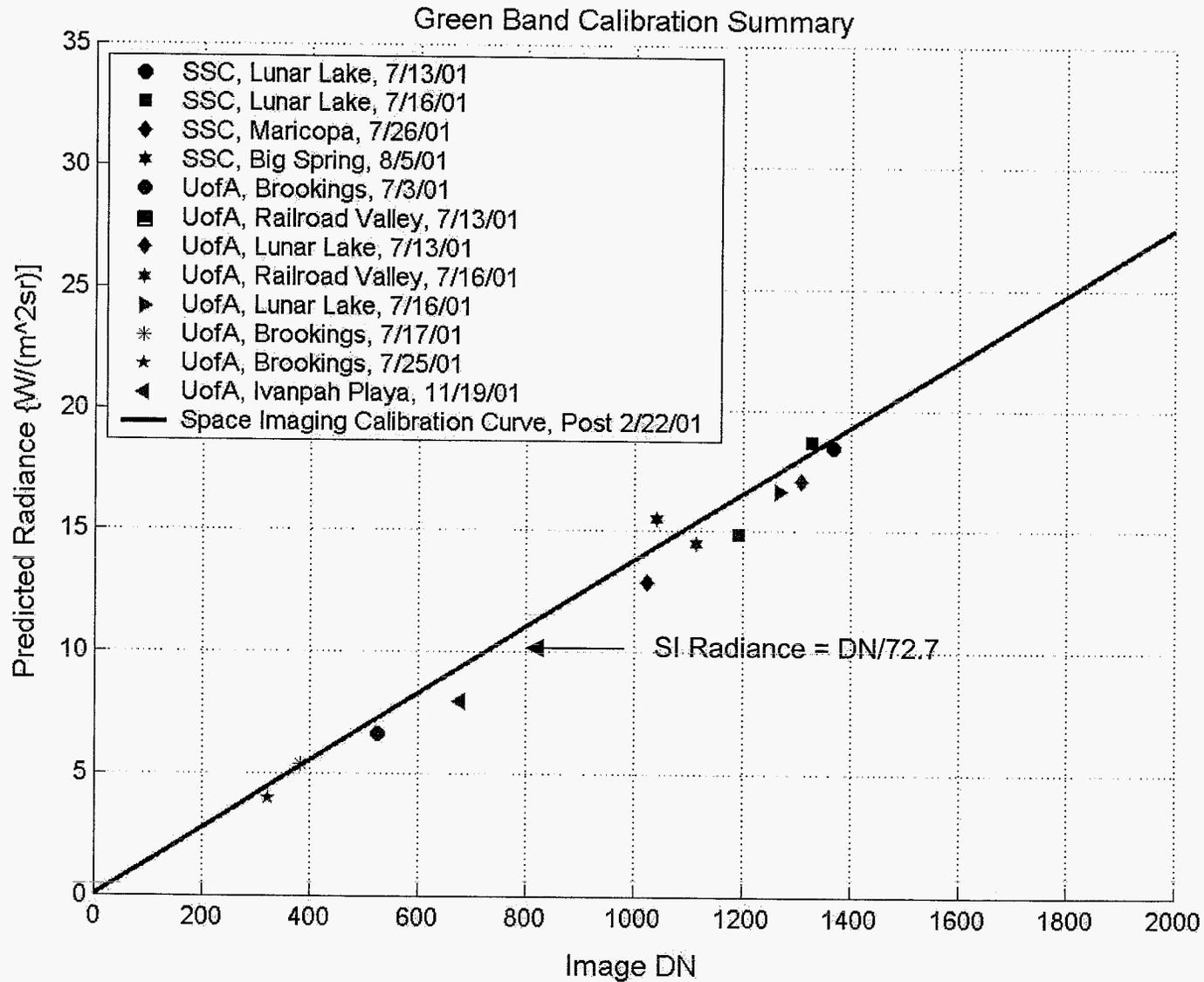
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IKONOS Green Band Calibration Summary

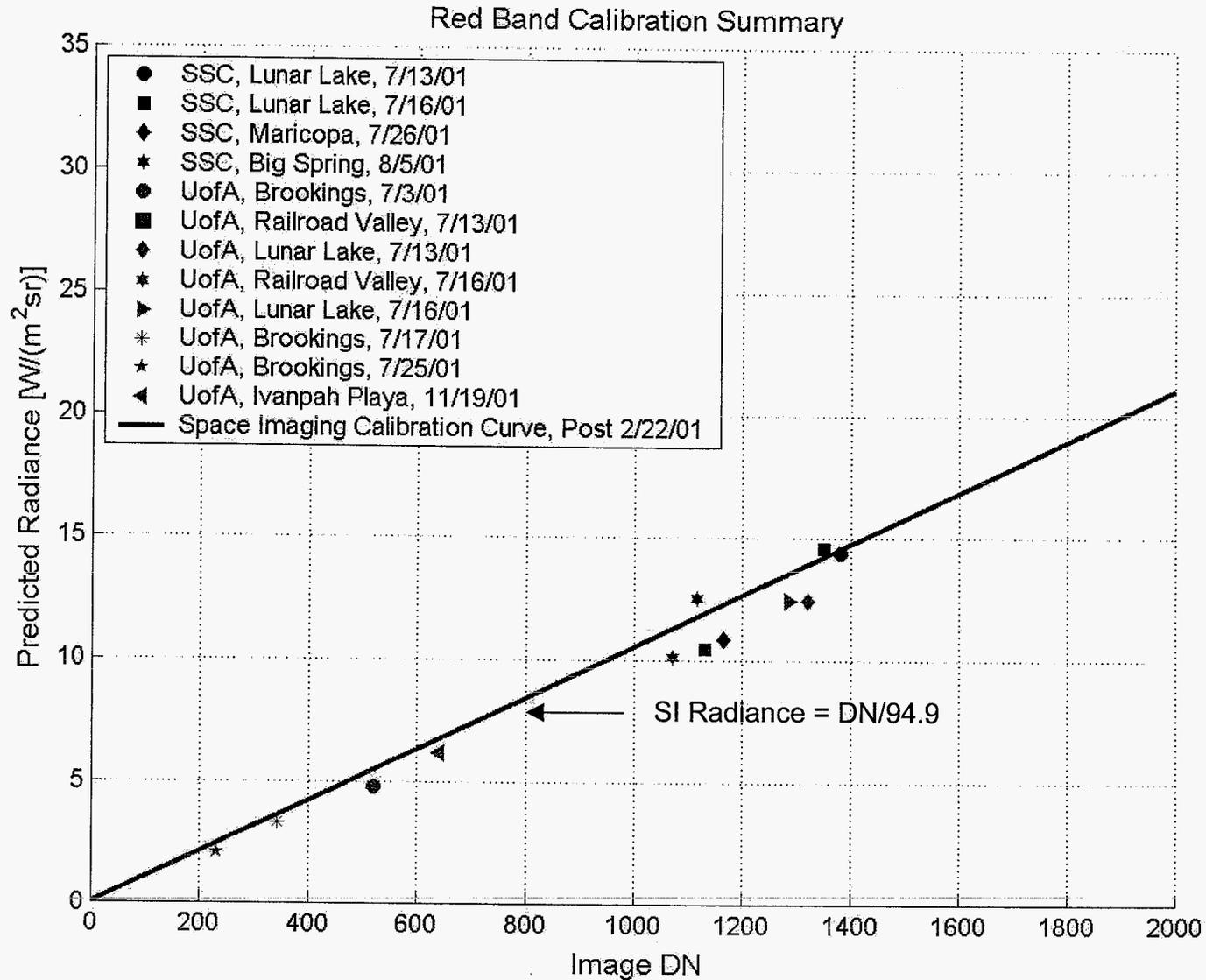
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IKONOS Red Band Calibration Summary

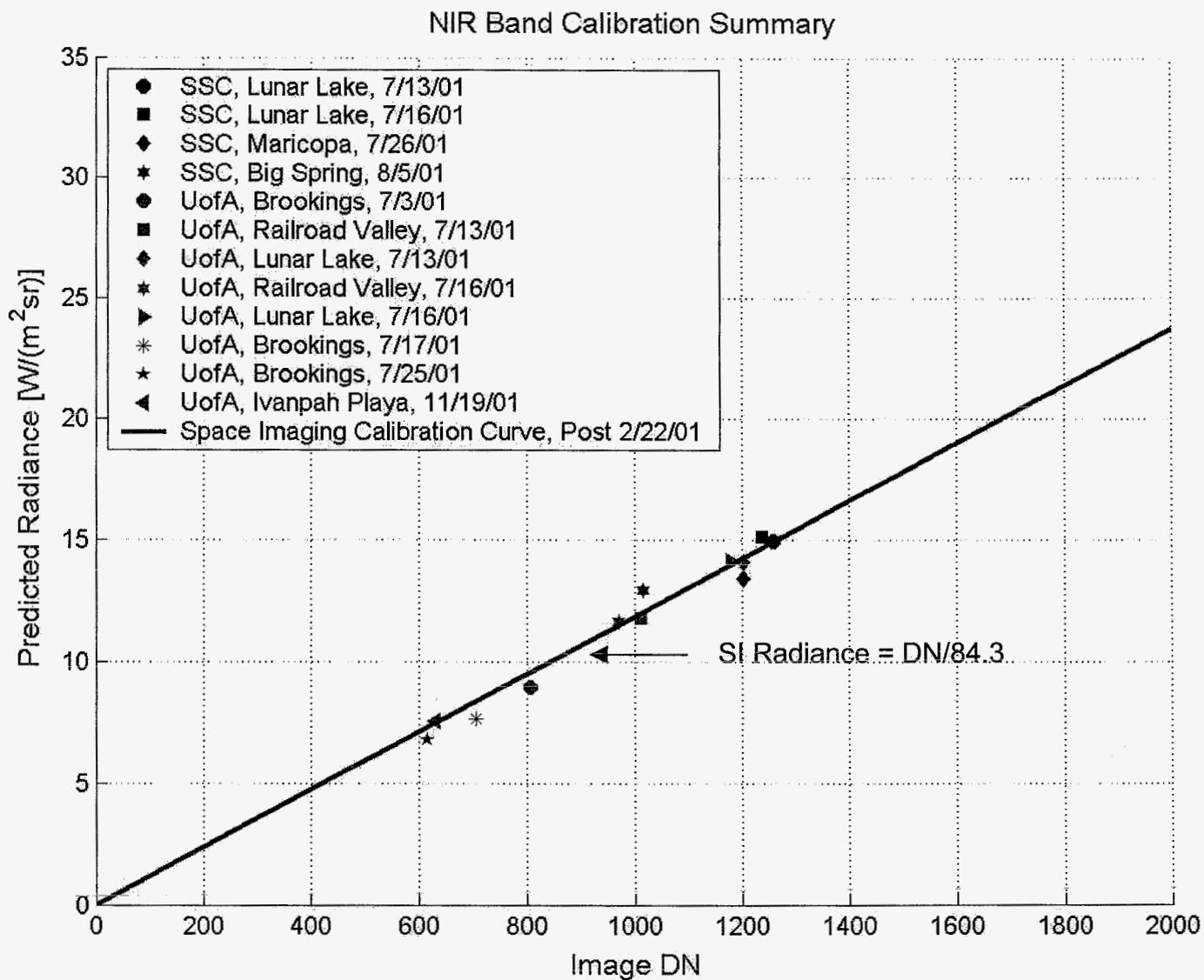
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IKONOS NIR Band Calibration Summary

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NASA Radiometric Characterization Summary

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Band	NASA Gain	Space Imaging Gain	<u>NASA Gain</u> SI Initial Gain
1	63.3	63.7	0.99
2	64.9	57.3	1.13
3	84.0	66.3	1.27
4	74.6	50.3	1.48

Units of Gain = $[W / (m^2 sr)] / DN$



Summary

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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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