IKONOS Radiometric Characterization Lunar Lake Playa, Nevada

Mary Pagnutti

Lockheed Martin Space Operations
NASA Stennis Space Center

March 19 - 21, 2001

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

Co-Contributors

Slawek Blonski	LMSO, Stennis
Debbie Fendley	Data Star, Stennis
Michelle Kelly	LMSO, Stennis
Robert Ryan	LMSO, Stennis
Chris Schera	LMSO, Stennis
Bill Smith	Data Star, Stennis
Vicki Zanoni	NASA, Stennis
Kurt Thome	University of Arizona

Lunar Lake Characterization Overview

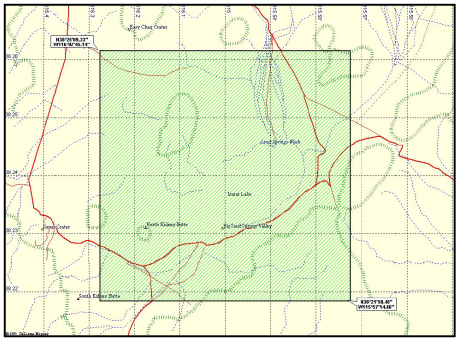
- **Objective**
  - Perform radiometric vicarious calibrations of IKONOS imagery and compare with Space Imaging calibration coefficients

- **Approach**
  - Utilize well-characterized dry lake bed in Nevada. Site is widely used by the NASA science community for radiometric characterization of airborne and spaceborne sensors
  - Compare measurement techniques and data processing methods with other recognized groups
  - Leverage characterization activity with other field measurement programs

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 38.4º N, 116.0º W.

General Scene w/ Tarps



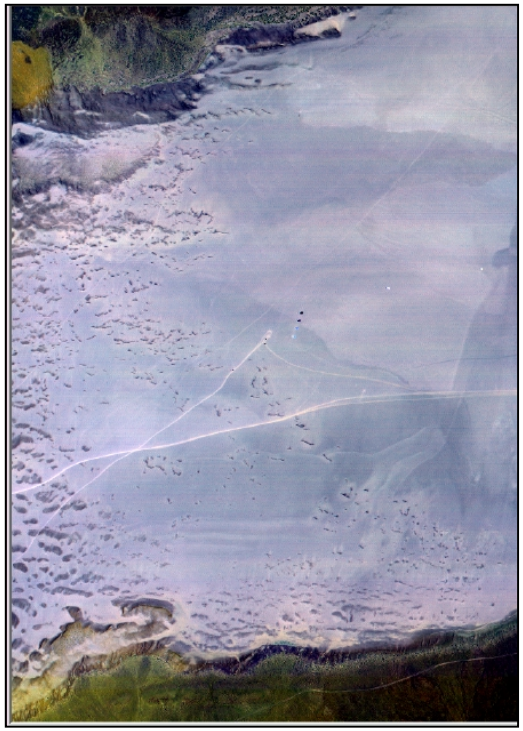
IKONOS Image Area 8km x 8km

Purpose: Radiometric characterization, Intercomparison with Landsat 7

Targets: 4 - 8 meter square grayscale tarps (64%, 48%, 8%, 4%)

In-Situ Instrumentation: ASD spectroradiometers, Reagan sun photometer, radiosonde

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



ATLAS Imagery
(8,7,1 as R,G,B)
June 7, 2000

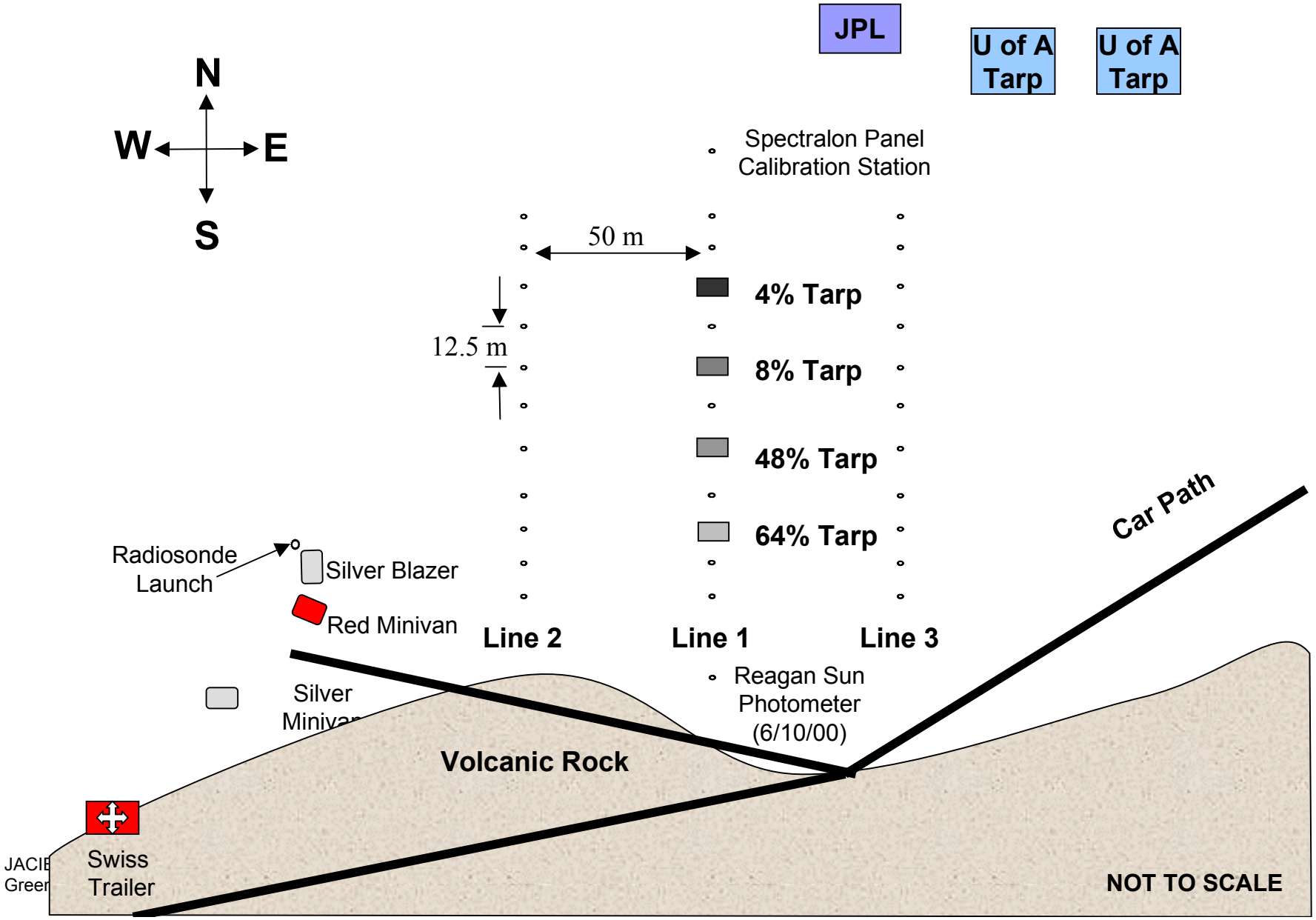
Vicarious Calibration Method

- **Reflectance-based Approach**
  - Characterize surface reflectance at time of satellite overpass
  - Characterize atmosphere at time of satellite overpass
  - Use surface and atmospheric characterization to predict at-sensor radiance
  - Compare predicted at-sensor radiance to actual radiance acquired by sensor

Site Equipment

- **CRSP FieldSpec FR Spectroradiometer**
- **Modified FieldSpec FR Spectroradiometer**
  - Provided by Boeing Aerospace Corp.
- **Reagan Sun Photometer**
  - Provided by University of Arizona
- **Radiosonde**
- **Trimble GPS**
- **Reflectance Tarps (for ATLAS characterization)**
  - 4%, 8%, 48%, 64% reflectance, 8 m x 8 m
- **Spectralon Calibration panels**
  - 99% reflectance, 10 in. X 10 in.
  - 50% reflectance, 12 in. X 12 in.
  - 10% reflectance, 12 in. X 12 in.
  - Dyprosium oxide, 4 in. X 4 in. - wavelength calibration

Lunar Lake Setup



Data Acquisitions

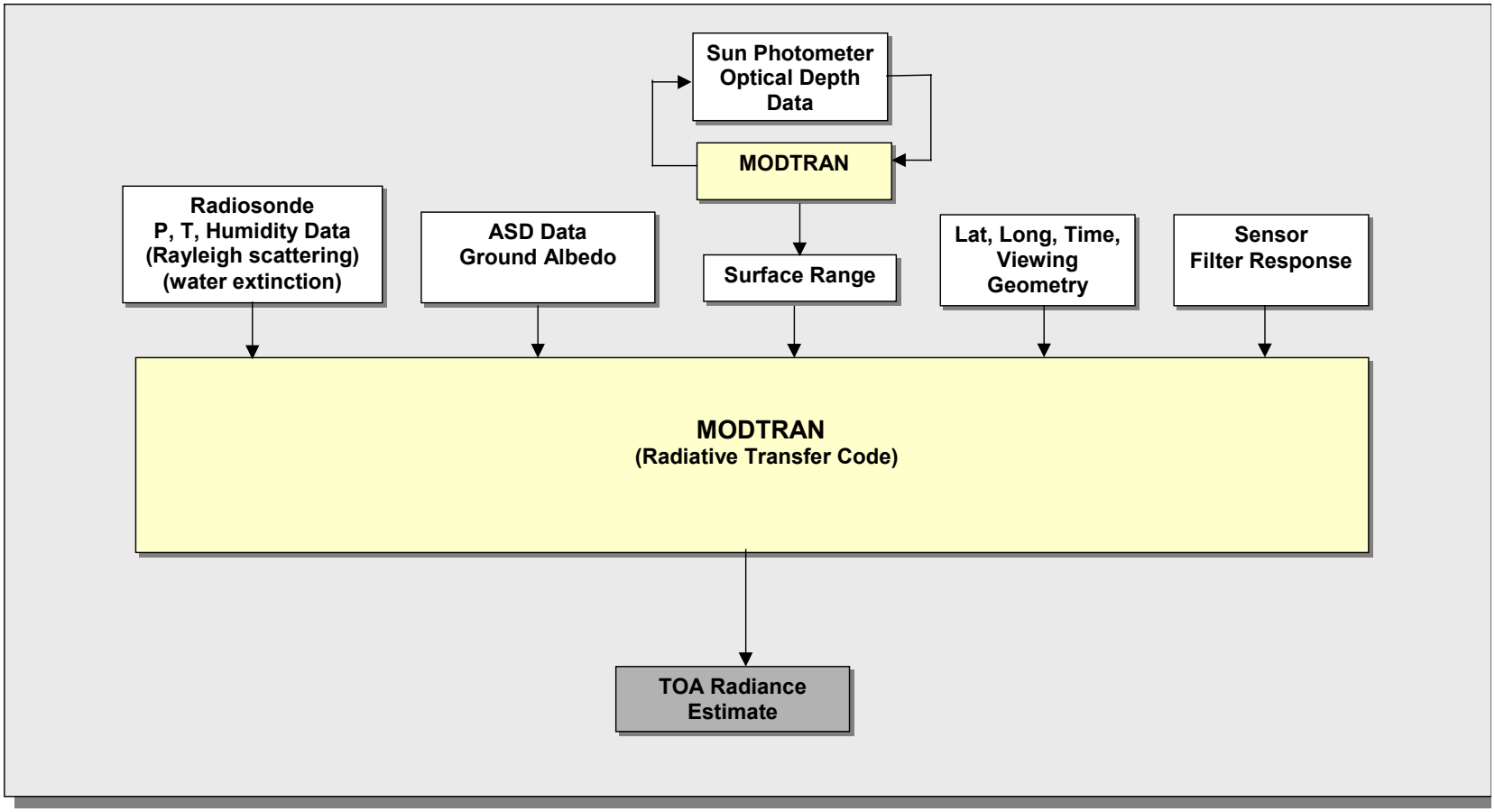
- **June 7**
  - Weather conditions
    - Little to no cloud cover
    - Extreme wind
  - U of AZ provided solar radiometer measurements taken at nearby site (Railroad Valley)
  - ASD measurements taken for 2 transects - Line 1 and Line 2
- **June 10**
  - Weather conditions
    - Little to no cloud cover
  - U of AZ provided solar radiometer on site
  - ASD measurements taken for 2+ transects - Line 1, Line 2, and selected points along Line 3

Procedures

- **ASD measurements**
  - 11 measurement stations per transect, 3 transects
  - 99%, 50%, 10%, and dysprosium oxide calibration measurements at start of each transect
  - 99% calibration measurement taken before each station
  - Dark current taken after each station
  - 10 data readings taken at each calibration, dark current, and measurement station
- **Atmospheric measurements**
  - Collect solar radiance data from early morning through post-sensor acquisition
  - Radiosonde launch near time of sensor overpass
- **GPS survey of sunphotometer, radiosonde launch site, transect measurement stations, reflectance targets, and other landmarks**
- **IKONOS Spacecraft overpass at approx. 11:30 AM local time**

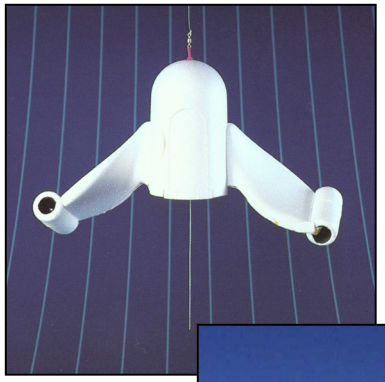
IKONOS Image of Lunar Lake

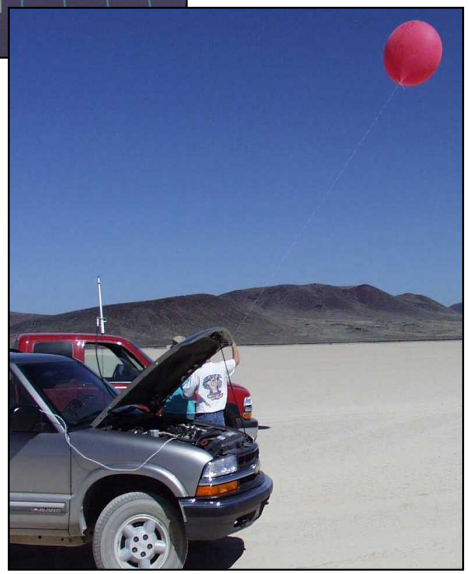
TOA Radiance Estimation

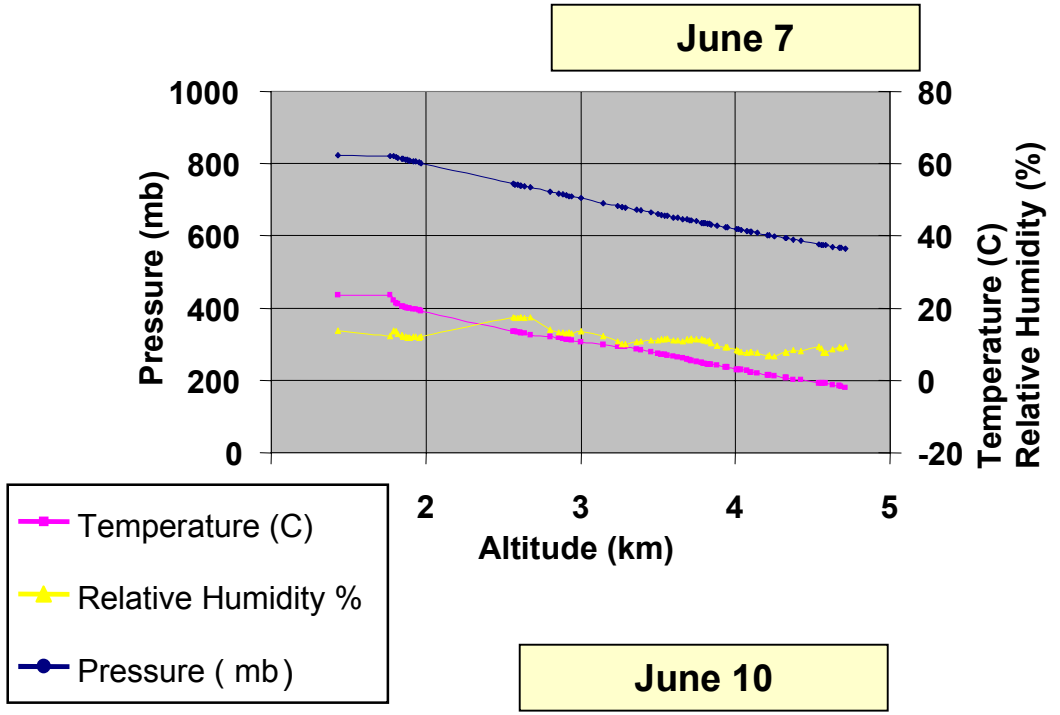


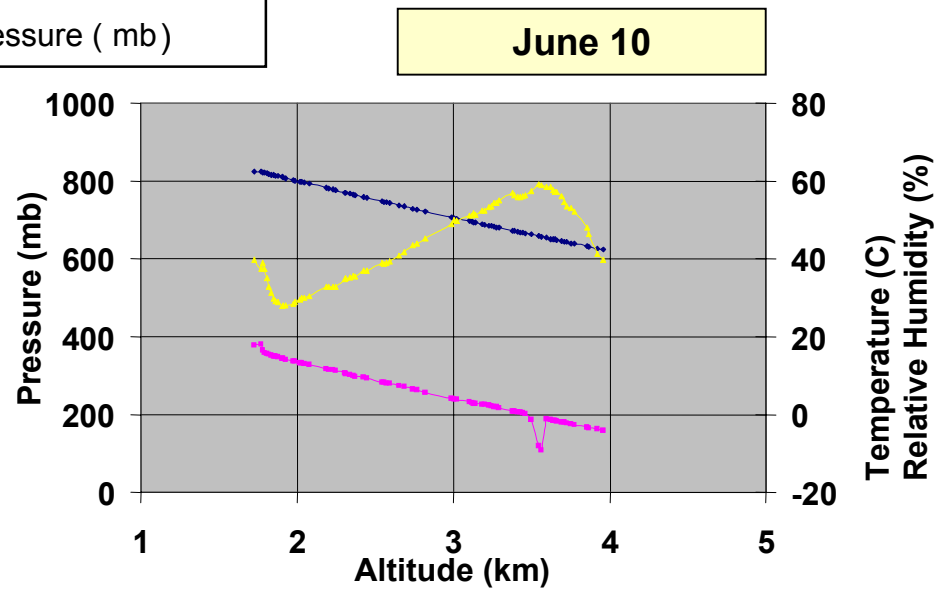
Top of Atmosphere Radiance

Radiosonde Data









June 10th Reagan Sun Photometer Data

Stennis Space Center

BAND	WAVELENGTH (microns)	AVG. TOTAL OPTICAL DEPTH	ONE STD DEV.	# POINTS
1	0.3794	0.4876	0.0028	20
2	0.4003	0.4240	0.0030	20
3	0.4401	0.3125	0.0027	20
4	0.5187	0.2131	0.0023	20
5	0.6106	0.1809	0.0017	20
6	0.6712	0.1203	0.0018	20
7	0.7811	0.0943	0.0013	20
8	0.8697	0.0717	0.0013	20
9	0.9394	0.8033	0.0159	20
10	1.0300	0.0662	0.0013	20

Provided by University of Arizona

924.0000	**9.9999**	**Average pressure and standard deviation (milibar)**
2.8409	**0.0199**	**Average Junge Par and standard deviation**
0.0938	**0.0017**	**Average Ref. OD and standard deviation**
0.3617	**0.0165**	**Average Ozone and standard deviation**
1.0909	**0.0433**	**Average Column H_2O and standard deviation**
20.0000	**9.9999**	**Average temperature and standard deviation °C**

June 7th Spectroradiometer Data

Stennis Space Center

Spectral range: 350 - 2500 nm

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

Sampling interval: 1.4 nm between 350-1000 nm, 2 nm between 1000-2500 nm.

Spectral resolution: 3 nm@700 nm, 10 nm@1500 nm, and 10 nm@2100 nm.

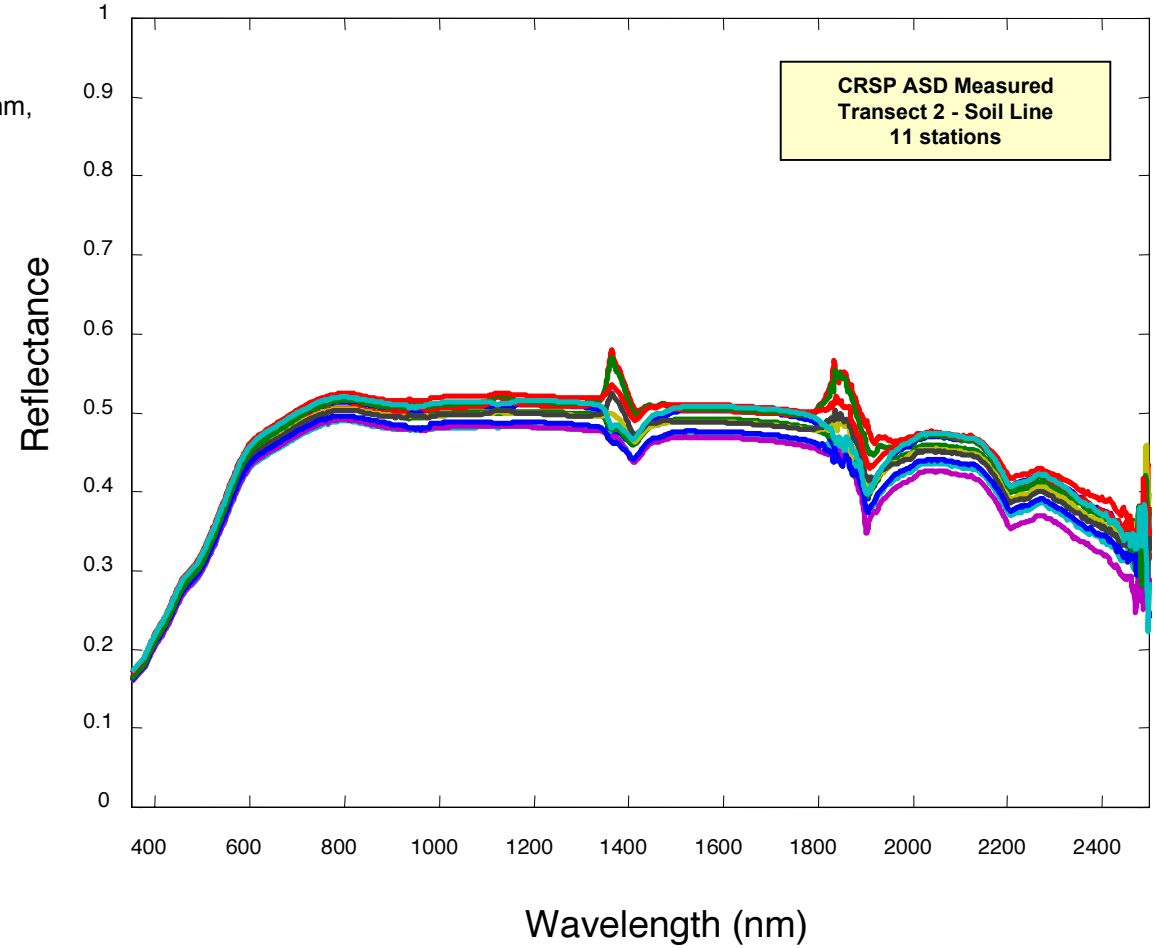
Number of channels: 512 channels prior to interpolation

Wavelength accuracy: +/-1 nm

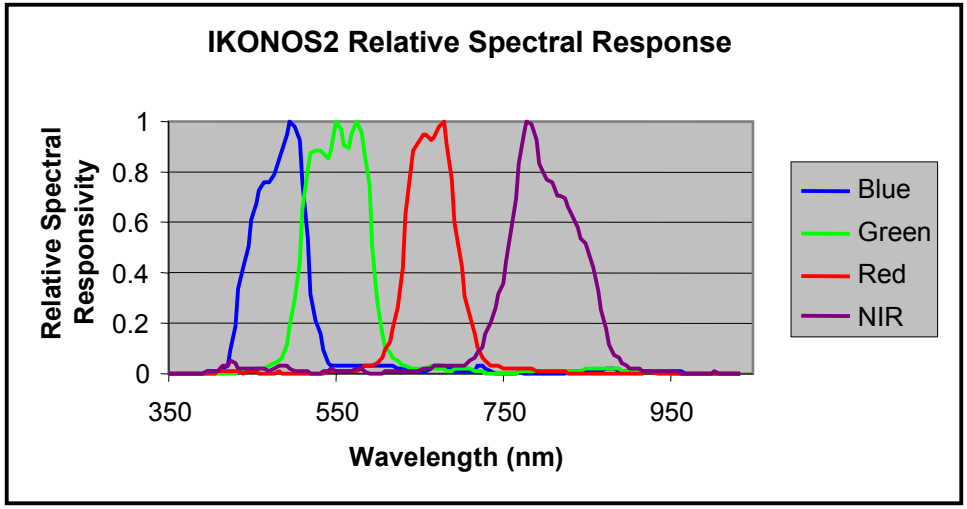
Sensor linearity: +/-1%

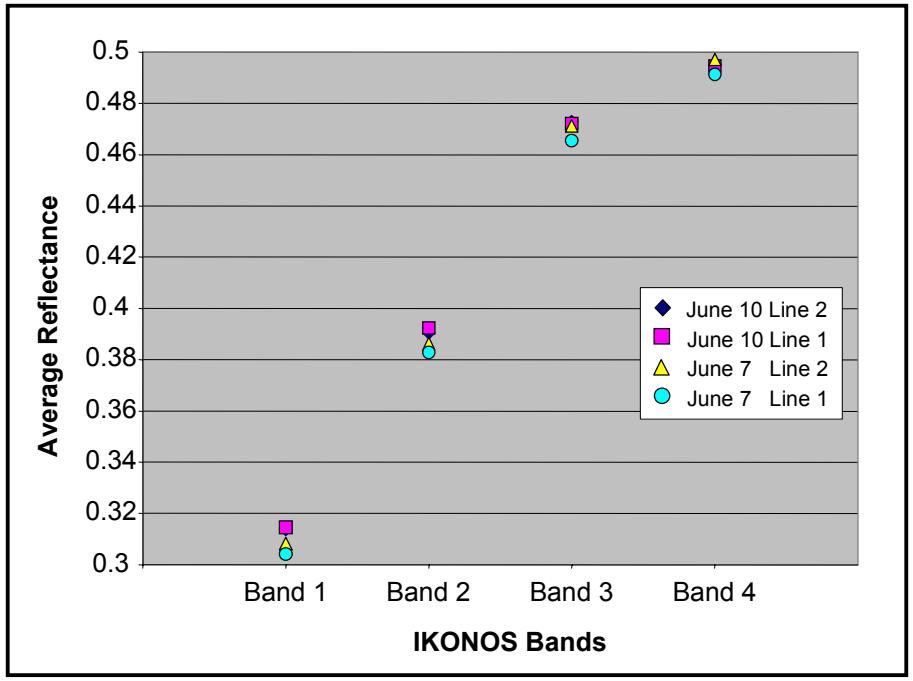
Fiber length: 1 meter.

Scan time: A new spectrum is generated every 0.1 seconds for the entire spectral range.



IKONOS In-Band Soil Reflectance





Lunar Lake IKONOS Radiometric Assessment

Stennis Space Center

Lunar Lake, NV
June 7th, 2000
Using Soil Reflectance Measurements

Band (nm)		NASA Estimate (W/m^2sr)	IKONOS Measurement* (W/m^2sr)	% Difference
1	445 - 516	12.560	12.991	3.43%
2	506 - 595	16.987	20.515	20.77%
3	632 - 698	13.531	17.711	30.90%
4	757 - 853	14.153	21.536	52.16%

Percent difference is calculated by: abs(1 - IKONOS/NASA)

* using initial Space Imaging calibration coefficients

Lunar Lake IKONOS Radiometric Assessment

Stennis Space Center

Lunar Lake, NV
June 10th, 2000
Using Soil Reflectance Measurements

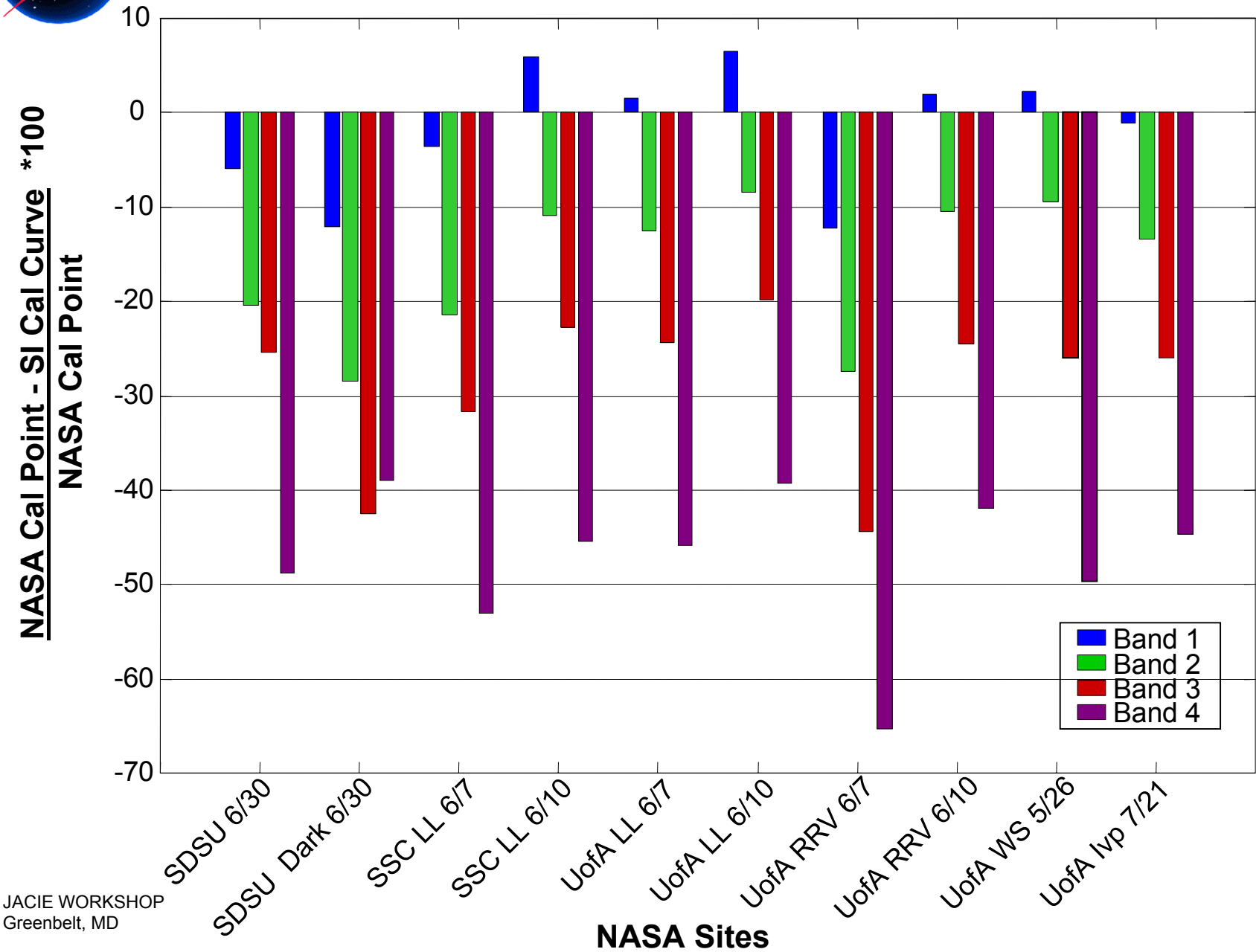
Band (nm)		NASA Estimate (W/m^2sr)	IKONOS Measurement* (W/m^2sr)	% Difference
1	445 - 516	12.841	12.029	6.32%
2	506 - 595	17.280	19.075	10.39%
3	632 - 698	13.642	16.712	22.50%
4	757 - 853	14.053	20.442	45.46%

Percent difference is calculated by: abs(1 - IKONOS/NASA)

* using initial Space Imaging calibration coefficients

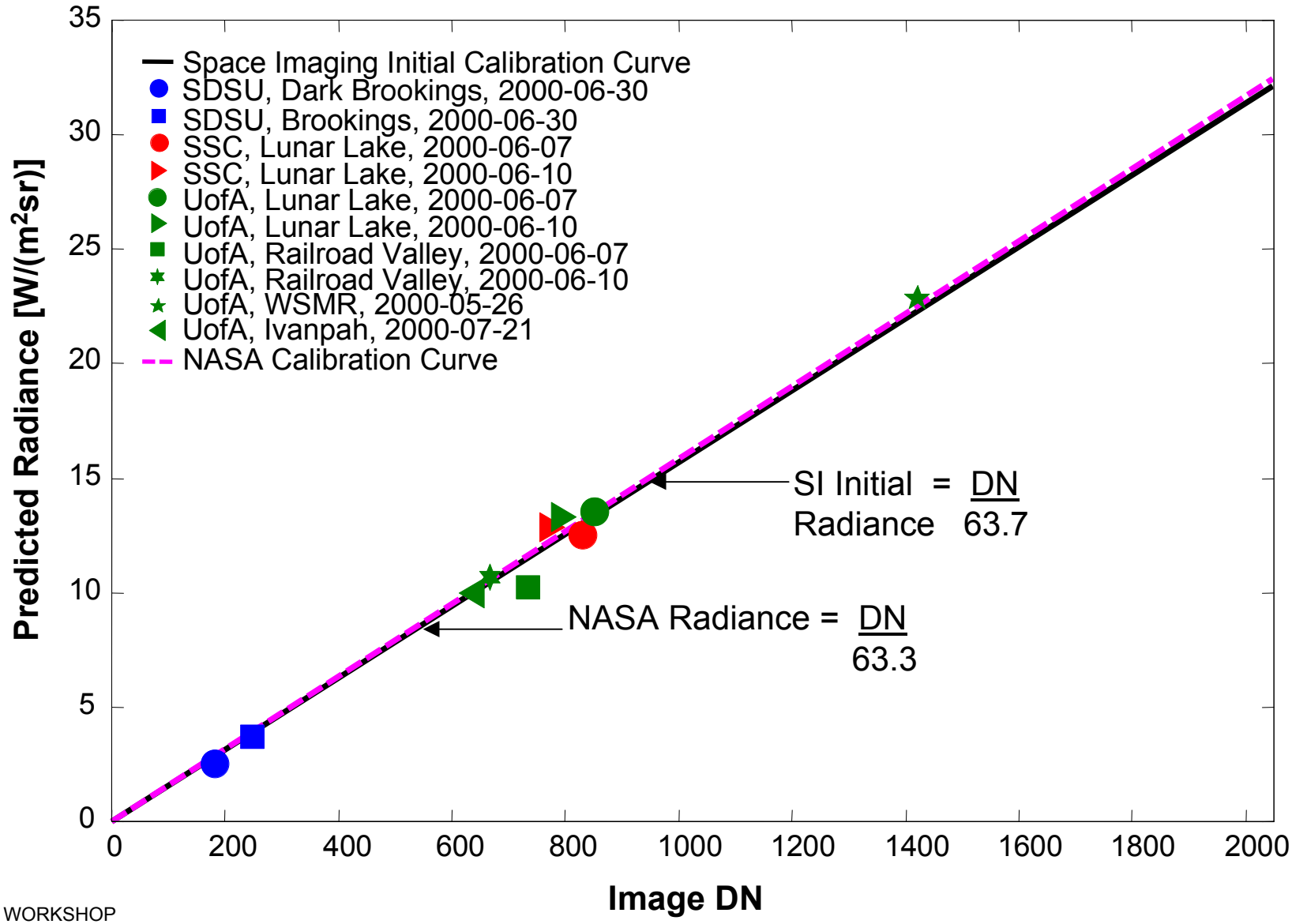
% Diff. of SI Initial Cal Curve & NASA Cal Points

Stennis Space Center



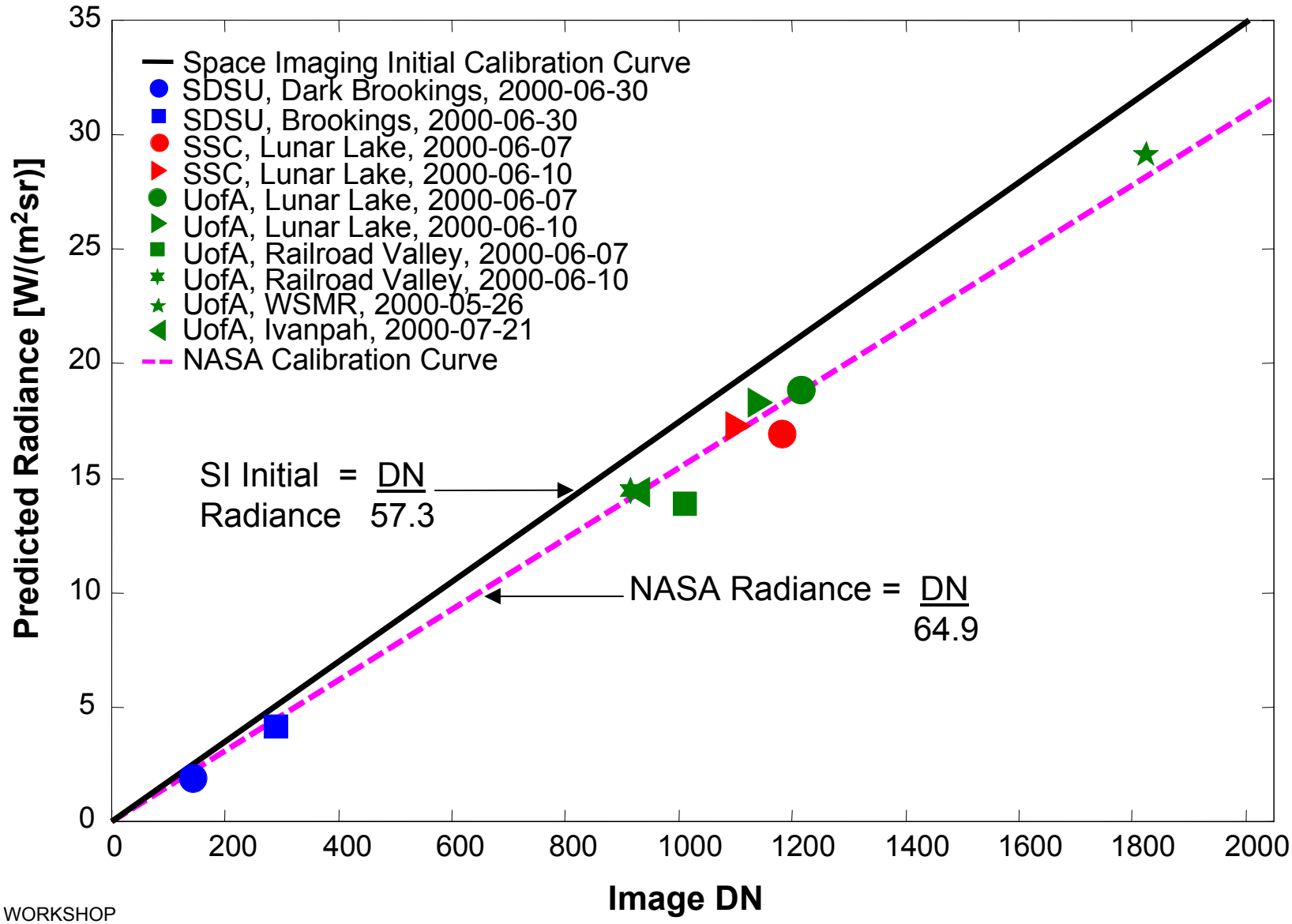
IKONOS Blue Band Calibration Summary

Stennis Space Center



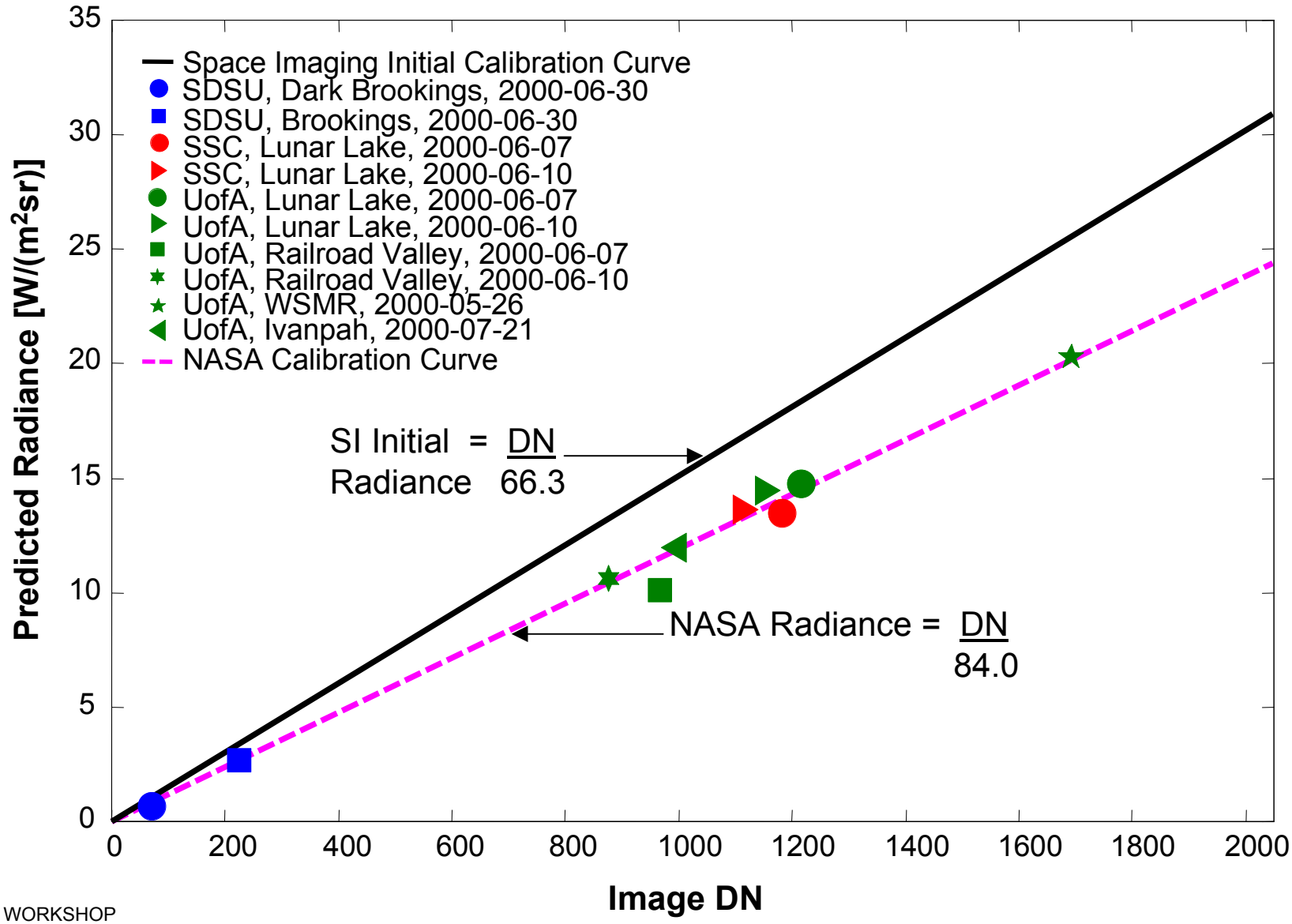
IKONOS Green Band Calibration Summary

Stennis Space Center



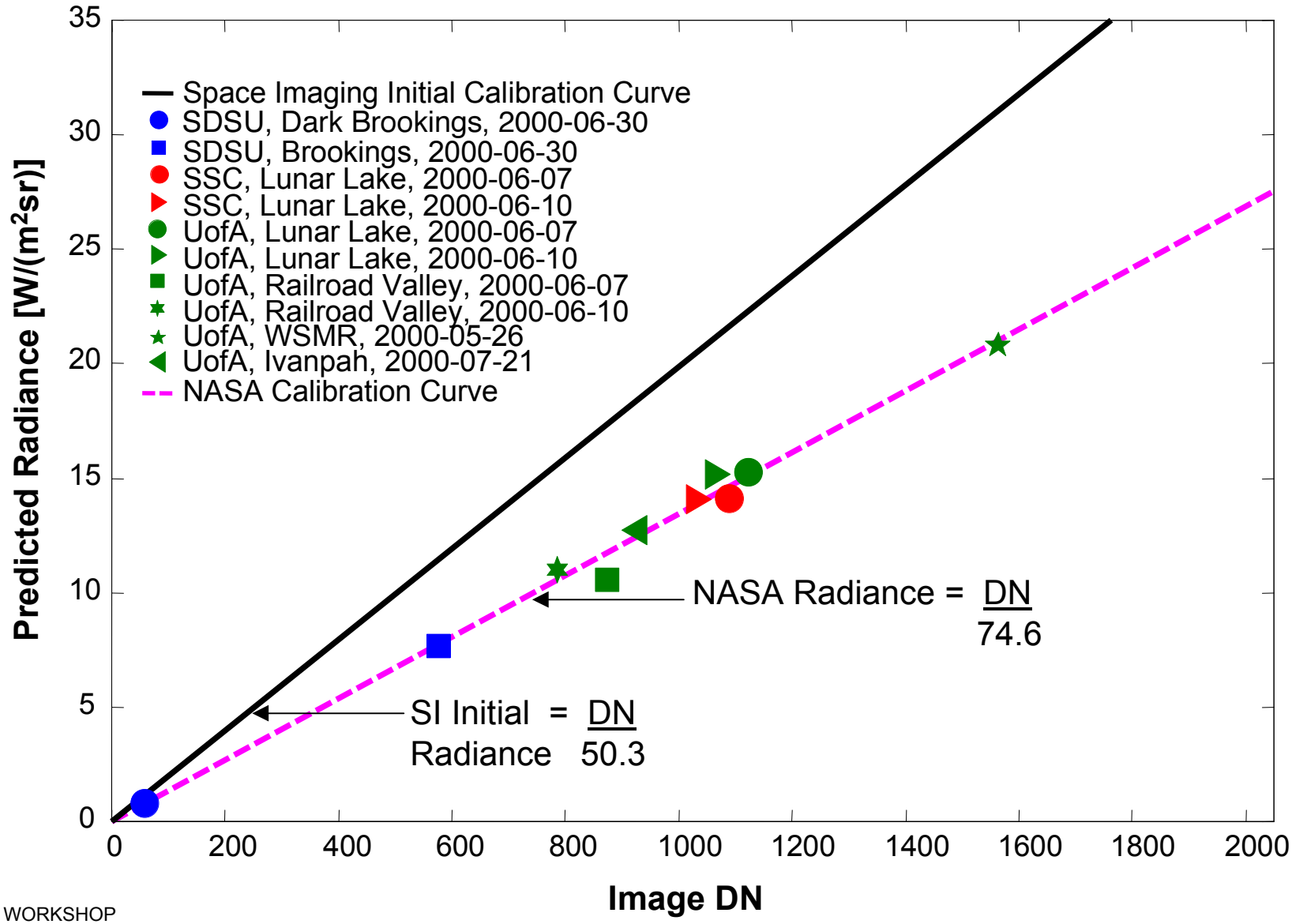
IKONOS Red Band Calibration Summary

Stennis Space Center



IKONOS NIR Band Calibration Summary

Stennis Space Center



NASA Radiometric Characterization Summary

Stennis Space Center

Band	NASA Gain	Initial Space Imaging Gain	NASA Gain / 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

- **Original Space Imaging provided calibration coefficients in the Red and NIR bands disagree significantly with NASA derived coefficients**
  - Three different NASA teams using complimentary methods show similar discrepancies
  - Present assessment based upon several measurements taken over a short time period. Difficulties in tasking with ground teams have hampered a long term systematic assessment
  - This level of error may have significant implications for the science community

Summary

- **As a result of this discrepancy, Space Imaging is re-evaluating their on-orbit stellar calibration method/results**
  - Expect SI to release updated calibration coefficients in near future
- **NASA Team will continue to evaluate IKONOS radiometry**
  - Periodic calibrations required to ascertain stability
    - Reflectance-based vicarious calibration approach
    - Radiance based approach utilizing uniform stable sites and existing well calibrated satellites (L7)
  - Work to resolve radiometric calibration differences between NASA Team and Space Imaging