Initial Radiometric Calibration of the AWiFS using Vicarious Calibration Techniques

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ResourceSat – AWiFS and LISS Data
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NASA Radiometric Calibration Team

Stennis Space Center

- NASA Stennis Space Center
  - Applied Sciences Directorate
    Stennis Space Center, MS
- University of Arizona
  - Remote Sensing Group
    Tucson, AZ
- South Dakota State University
  - Physics and Electrical Engineering Departments
    Brookings, SD

NASA Radiometric Calibration Team Benefits

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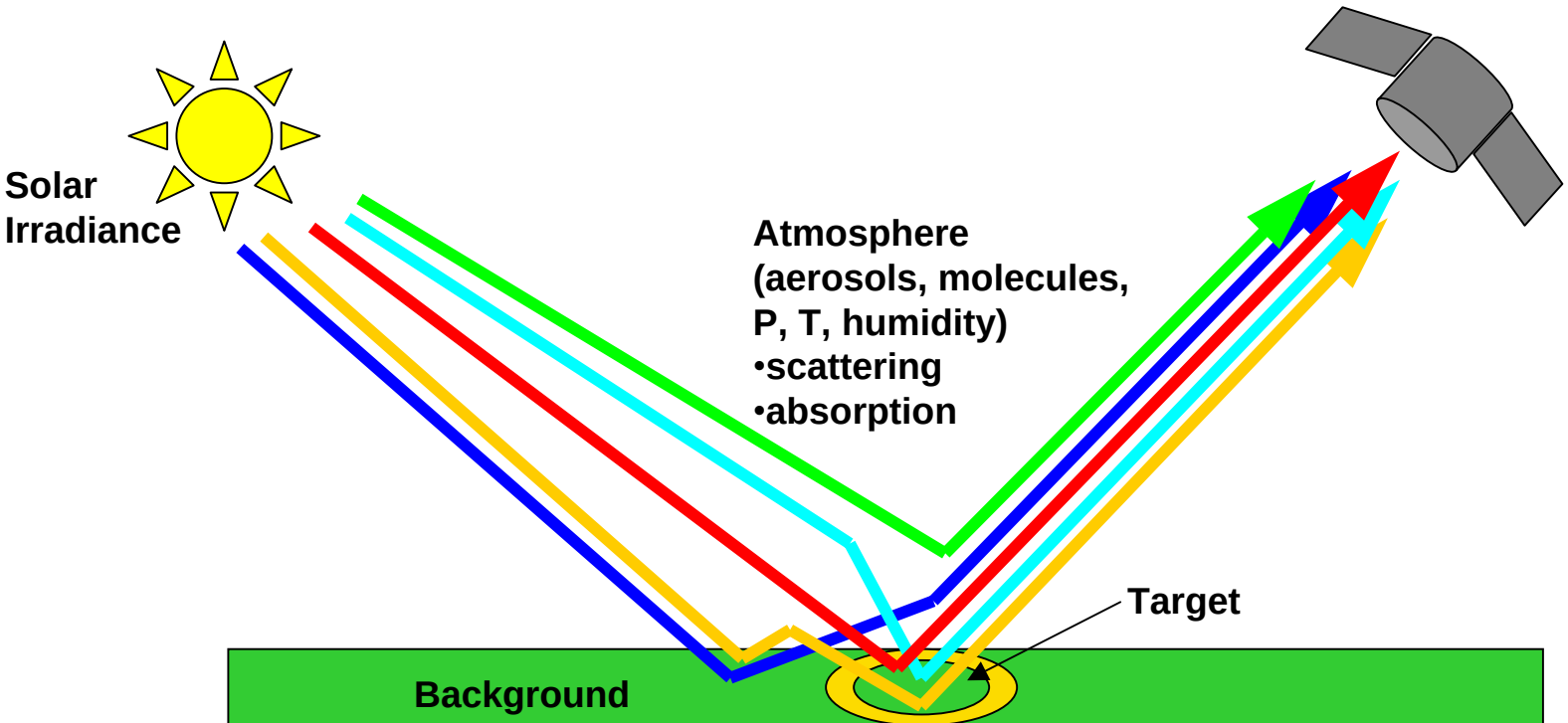
- Three independent groups employed similar approach but different tools and techniques.
  - Checks and balances between groups
  - Removes/reduces any bias associated with one individual group or set of techniques.

- Multiple study sites were utilized.
  - Removes/reduces any bias associated with a single study site.
  - Radiance values found within these study site scenes span the dynamic range of the sensor.

Reflectance-based Vicarious Calibration Approach

- Measure target/ground reflectance coincident with the satellite acquisition
- Measure atmospheric aerosols, and pressure, temperature and water vapor profiles coincident with the satellite acquisition.
- Use these measurements along with acquisition geometry/location parameters as input into a radiative transfer model to predict at-sensor radiance.



Advanced Wide Field Sensor (AWiFS)

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Advanced Wide Field Sensor (AWiFS) is multi-spectral camera that operates in the Visible, Near Infra Red and Short Wave Infra Red spectral bands. AWiFS is a unique camera having the capability to take the imagery of the world repeatedly every 5 days with a very high radiometric resolution.

MISSION:

- RESOURCESAT-1 (IRS-P6) – Oct. 2003

HERITAGE:

- WiFS on IRS 1-C and 1-D

PRODUCT SUMMARY:

- VNIR and panchromatic imagery

VITAL FACTS:

- Instrument: high-resolution linear imaging self-scanner
- Bands (4): 0.52-0.59, 0.62-0.68, 0.77-0.86, 1.55-1.70 µm
- Spatial Resolution: 56 m (near nadir), 70 m (near edge)
- Radiometric Resolution: 8 bit and 10 bit
- Swath: 740 km
- Repeat Time: 5 days
- Design Life: 5 yrs

OWNER:

- India, NRSA

SALES (outside India):

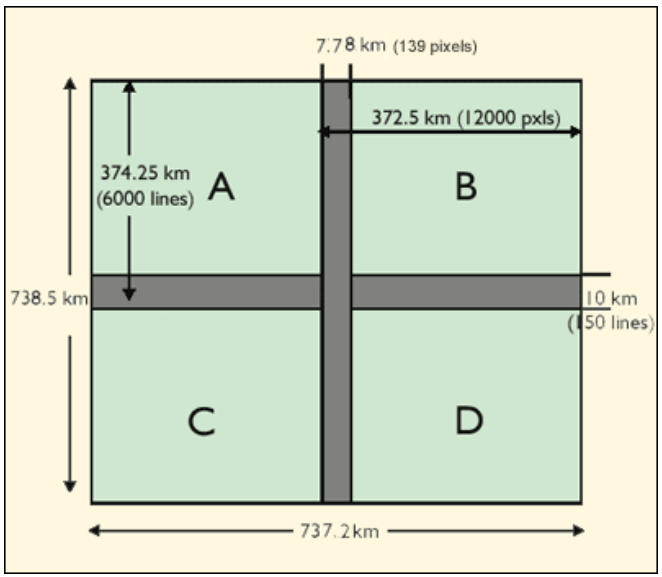
- GeoEye

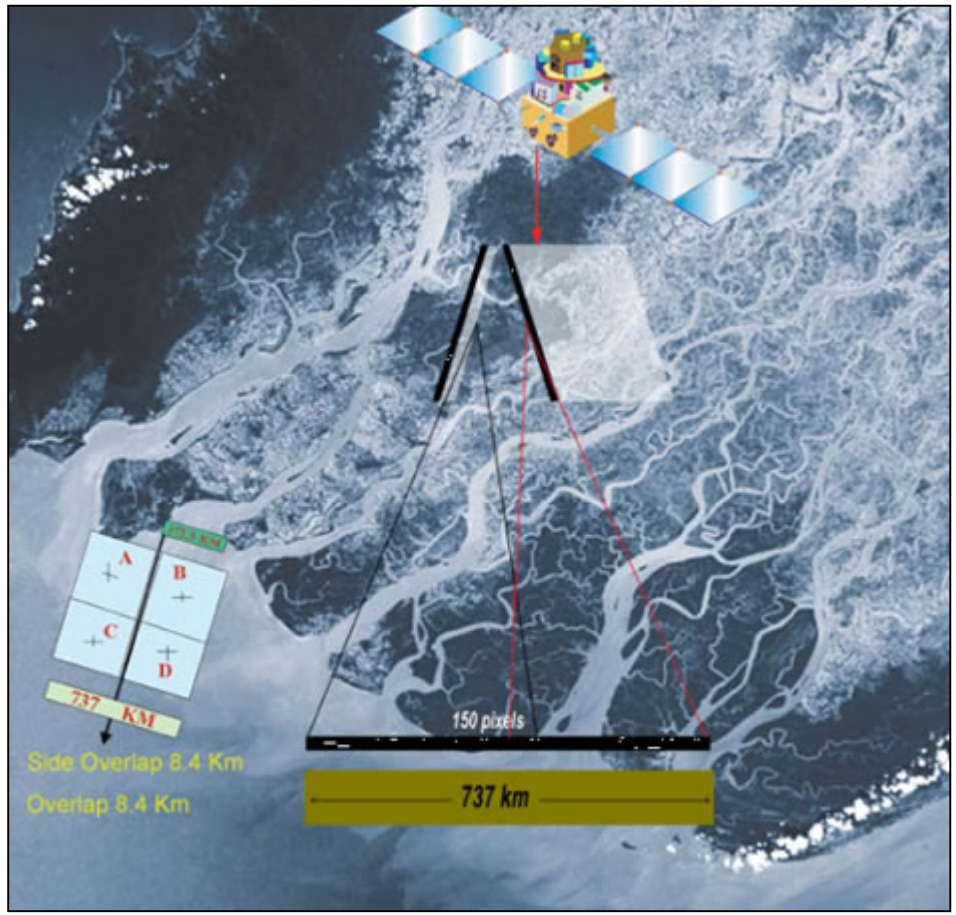
LINKS:

- Sensor Site: http://www.nrsa.gov.in/engnrsa/p6book/system/sys_payload_awifs.htm
- Data Site http://www.spaceimaging.com/products/irs/RESOURCESAT/products.htm

AWiFS Collection Approach

The AWiFS camera is split into two separate electro-optic modules (AWiFS-A and AWiFS-B) tilted by 11.94 degrees with respect to nadir





Selected Targets – Wiggins, MS

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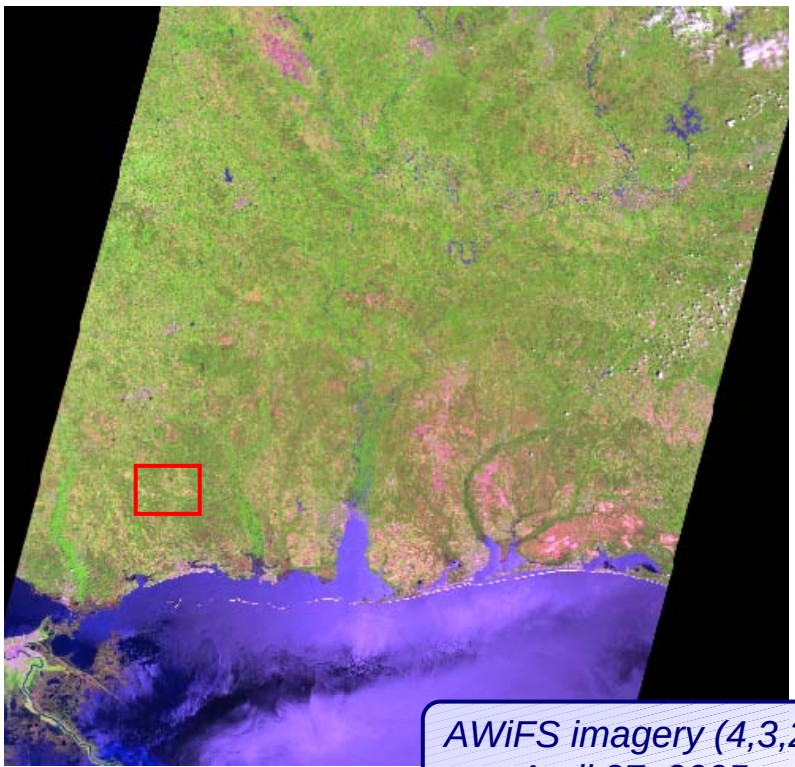
Four selected targets of opportunity near Stennis Space Center are hundreds of meters across:

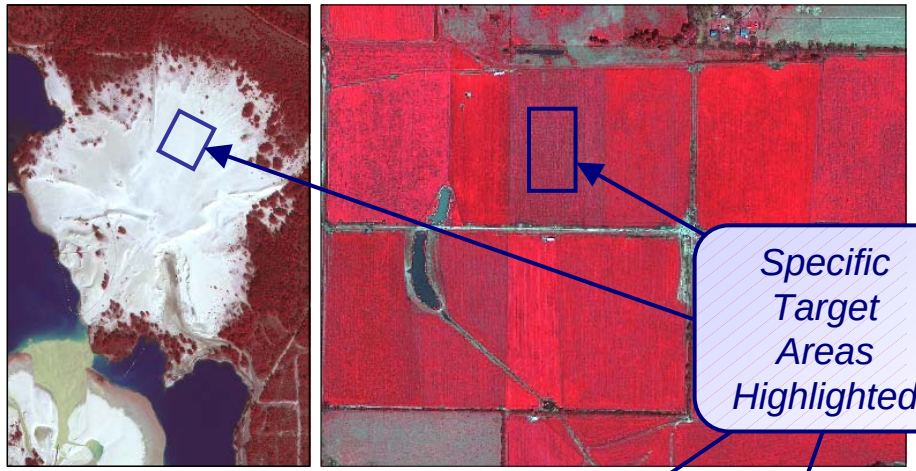
- Two gravel pit sand sites
- Large monoculture fields
- Cut grass amateur golf course



AWiFS imagery (4,3,2)
April 27, 2005

Gravel Pit Sand
near Perkinston, MS

Rye Grass Field
near Big Level, MS

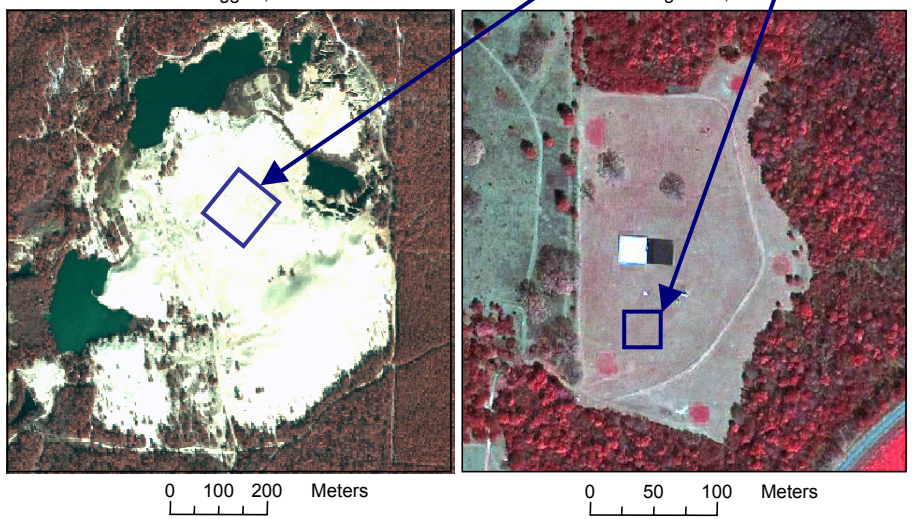


Specific Target Areas Highlighted

Includes material © Space Imaging, LLC

Gravel Pit Sand
near Wiggins, MS

Grass Field
near Big Level, MS



Includes material © DigitalGlobe, Inc.

Selected Targets - Park Falls, WI

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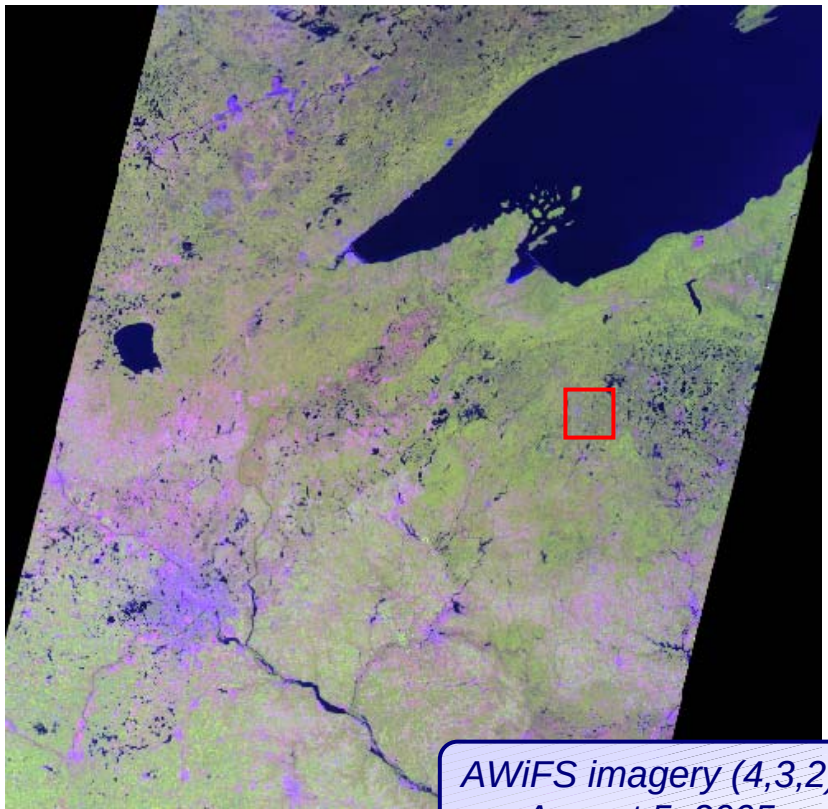
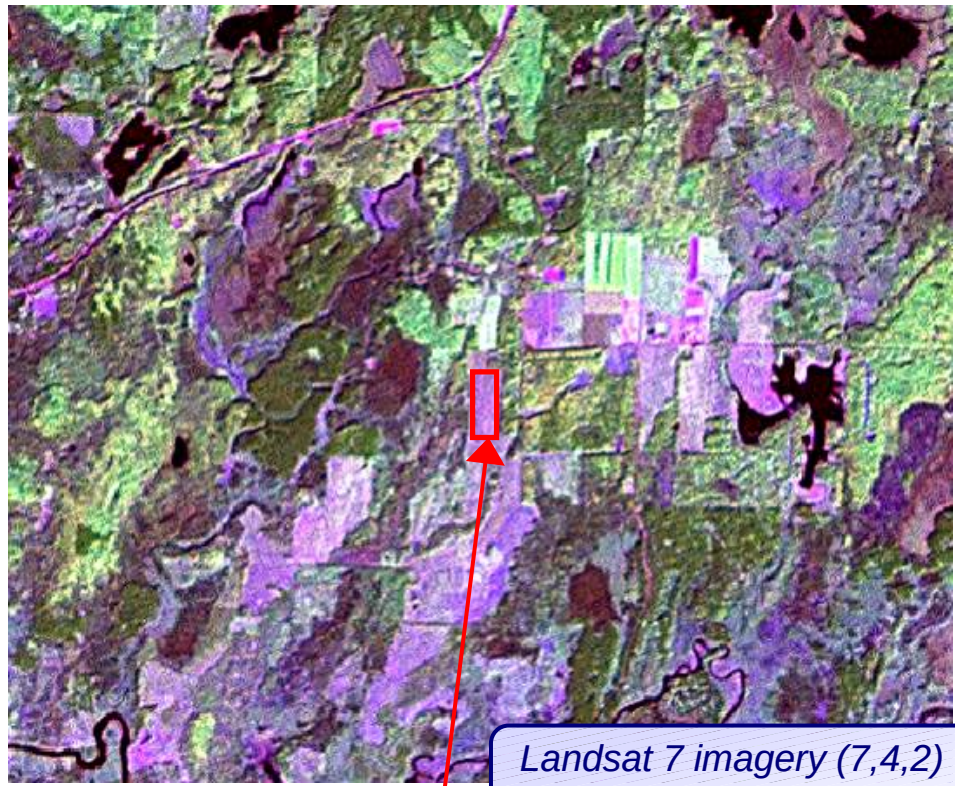
A target of opportunity was found near an Aerosol Robotic Network (AERONET) site near Park Falls

- Large grass field



AWiFS imagery (4,3,2)
August 5, 2005



Landsat 7 imagery (7,4,2)
August 5, 2005

Target field 150 m x 400 m

U.S. Southwest Acquisition Sites

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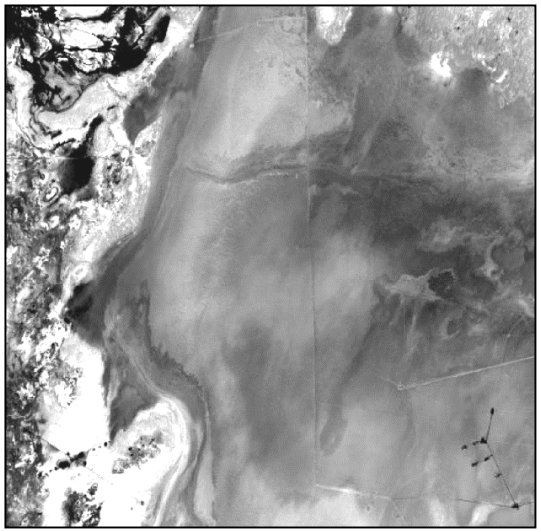


Railroad Valley, NV
38.51 °N, 115.69 °W

Bright and Uniform

High reflectance minimizes atmospheric uncertainties

High Elevation

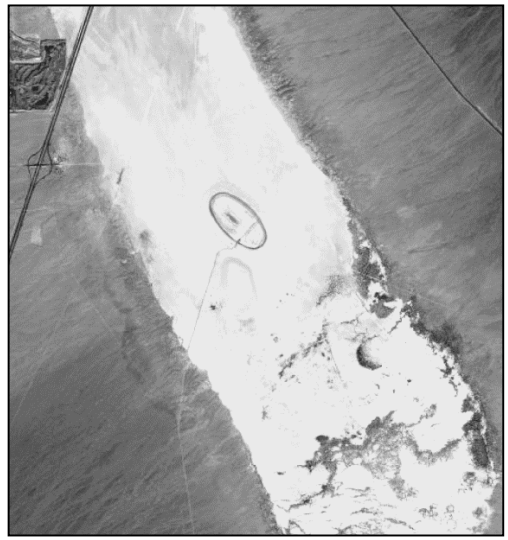
All acquisition sites above 3500 ft elevation

Minimal Precipitation and Cloud Cover

Maintains stability and increases chance of acquisition

Large

Minimizes adjacency effects



Ivanpah, CA
35.53 °N, 115.38 °W

THE UNIVERSITY OF ARIZONA
TUCSON ARIZONA

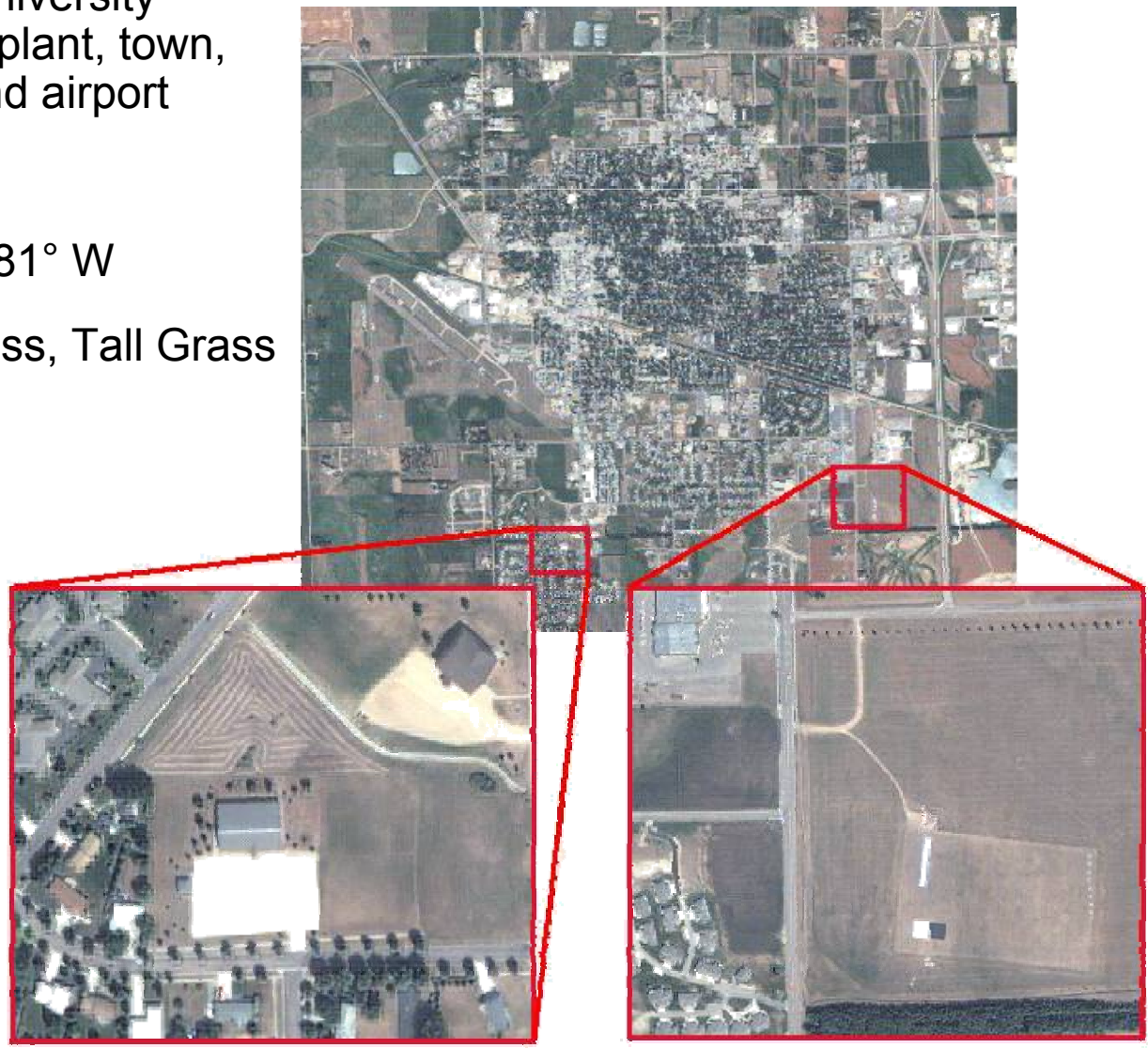
Brookings, SD, Acquisition Site

Site: South Dakota State University campus, 3M manufacturing plant, town, surrounding grassy fields and airport

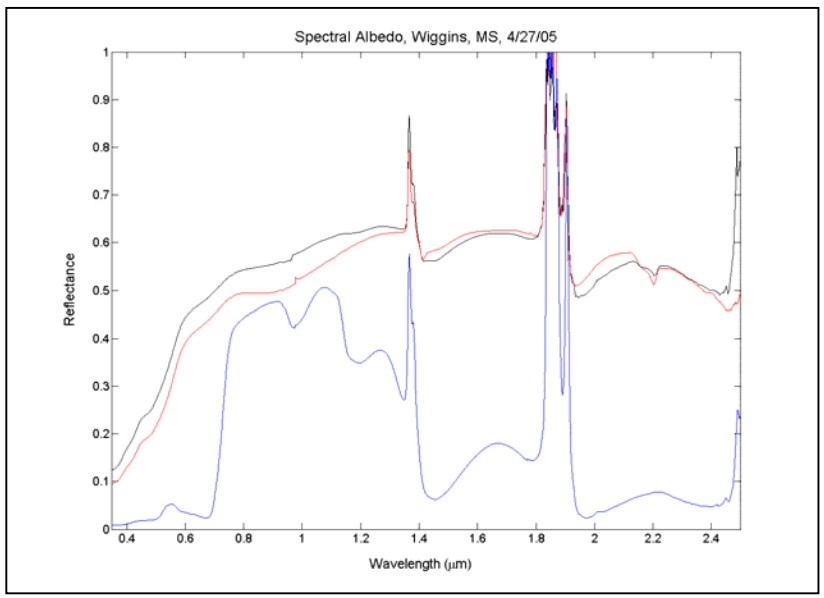
Elevation: 500 m

Center Point: 44.30° N, 96.81° W

Targets Evaluated: Cut Grass, Tall Grass



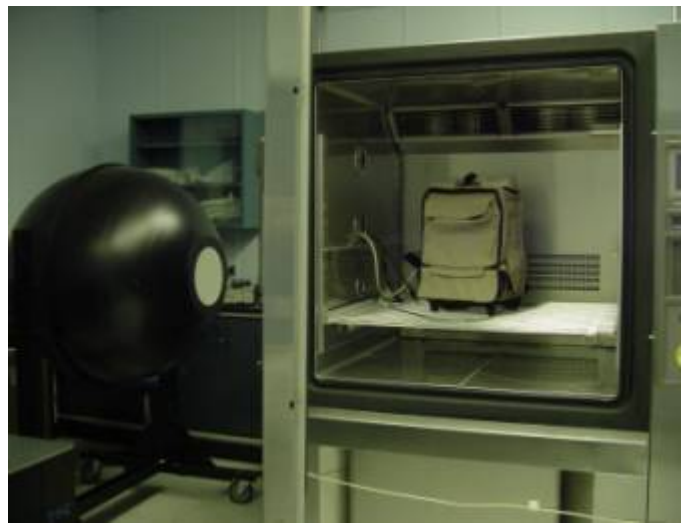
Ground Reflectance Measurements



- ASD FieldSpec® FR spectroradiometer measurements of Spectralon® panels and several target areas were taken
  - ~50 m x 50 m area of a grassy field/golf course
  - ~100 m x 200 m area of a rye grass field
  - ~100 m x 100 m area of two sand sites
- Measurements were taken along transects aligned with the sensor azimuth
  - Measurements were taken at nadir and satellite elevation angles to account for BRDF effects
  - All measurements were taken while walking to increase spatial averaging
  - Periodic Spectralon panel measurements were taken
- All data were acquired within 40 minutes of satellite overpass

SSC Calibration and Characterization of ASD FieldSpec Spectroradiometers

- NASA SSC maintains four ASD FieldSpec FR spectroradiometers
  - Laboratory transfer radiometers
  - Ground surface reflectance for V&V field collection activities
- Radiometric Calibration
  - NIST-calibrated integrating sphere serves as source with known spectral radiance
- Spectral Calibration
  - Laser and pen lamp illumination of integrating sphere
- Environmental Testing
  - Temperature stability tests performed in environmental chamber



Novel Hyperspectral Sun Photometer

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- Novel hyperspectral sun photometer is capable of acquiring measurements comparable to both ASRs and MFRSRs by making use of the laboratory radiometric calibration of the FieldSpec FR spectroradiometers
  - Optical Depth/Transmission
  - Diffuse-to-Global Ratio
- Sun photometer developed with fewer limitations than current sun photometers, utilizing equipment already used in the field
  - Radiometrically calibrated FieldSpec FR spectroradiometers
  - 99% reflectance Spectralon panels
- Measurements are made only at the time of overpass, thus reducing the impact of a changing atmosphere on the calculation of optical depth

	SSC 1/10/04 - 16:33 GMT			
	ASR 27	ASD	Difference	Percent Difference
Band	Generated	Generated	ASR-ASD	1 - (asd/asr)
380 nm	0.588	0.5982	-0.010	-1.74%
400 nm	0.495	0.4852	0.010	1.99%
440 nm	0.366	0.3216	0.044	12.14%
520 nm	0.224	0.1988	0.025	11.25%
610 nm	0.161	0.1563	0.005	2.91%
670 nm	0.108	0.1002	0.008	7.26%
780 nm	0.07	0.0691	0.001	1.33%
870 nm	0.049	0.0508	-0.002	-3.58%
		RMS 1:8	0.019	

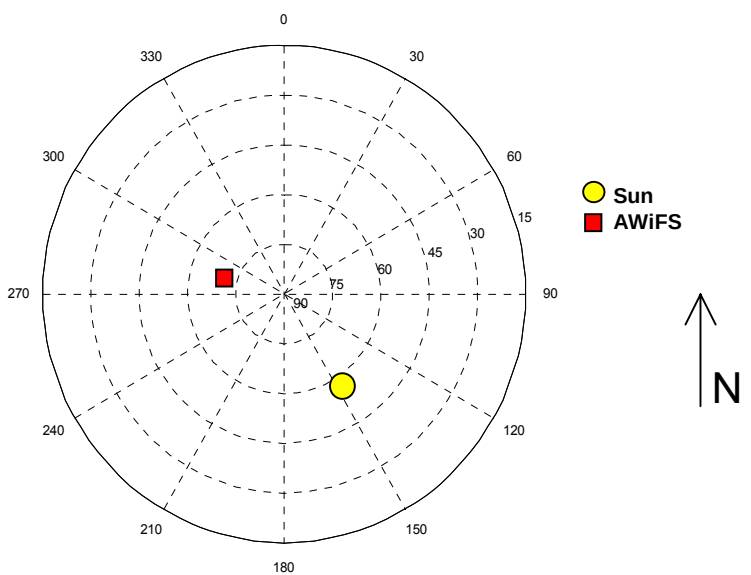
Sample Results

Novel Hyperspectral Sun Photometer Setup

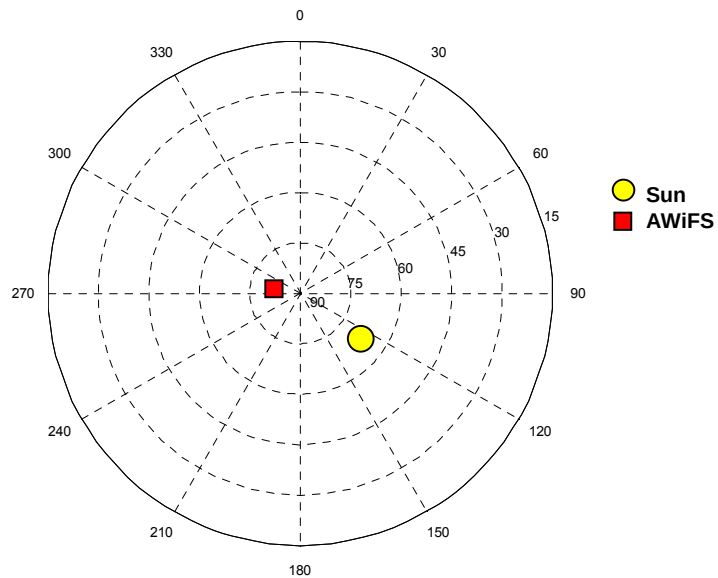
Data Acquisitions – Wiggins, MS

Stennis Space Center

Date	Camera	Overpass Time (UTC)	Satellite Elevation	Satellite Azimuth	Sun Elevation	Sun Azimuth
Mar 24, 2005	B	16:59	71.1 deg	285 deg	57.2 deg	149.8 deg
Apr 27, 2005	B	16:50	84.5 deg	285 deg	67.7 deg	135.4 deg



Wiggins, MS, 3/24/05

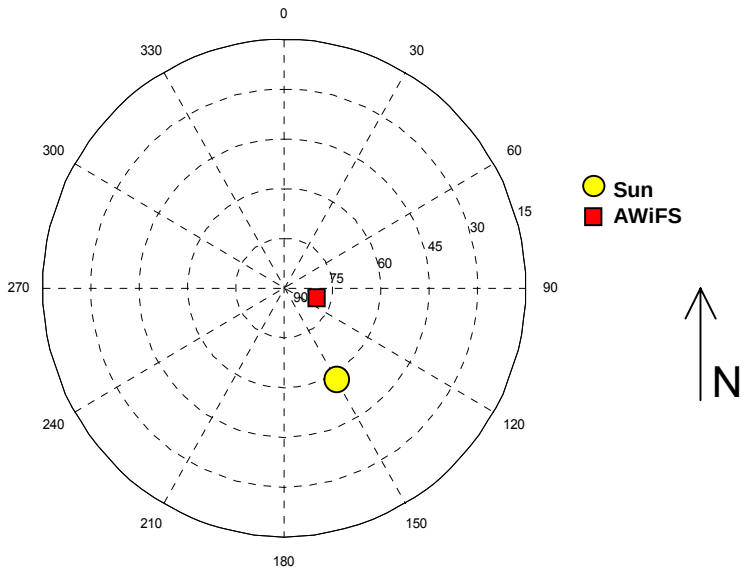


Wiggins, MS, 4/27/05

Data Acquisitions – Park Falls, WI

Stennis Space Center

Date	Camera	Overpass Time (UTC)	Satellite Elevation	Satellite Azimuth	Sun Elevation	Sun Azimuth
Aug 5, 2005	A	17:02	83.9 deg	103 deg	57.8 deg	149.7 deg



Park Falls, WI, 8/5/05

MODTRAN At-Sensor Radiance Prediction Process

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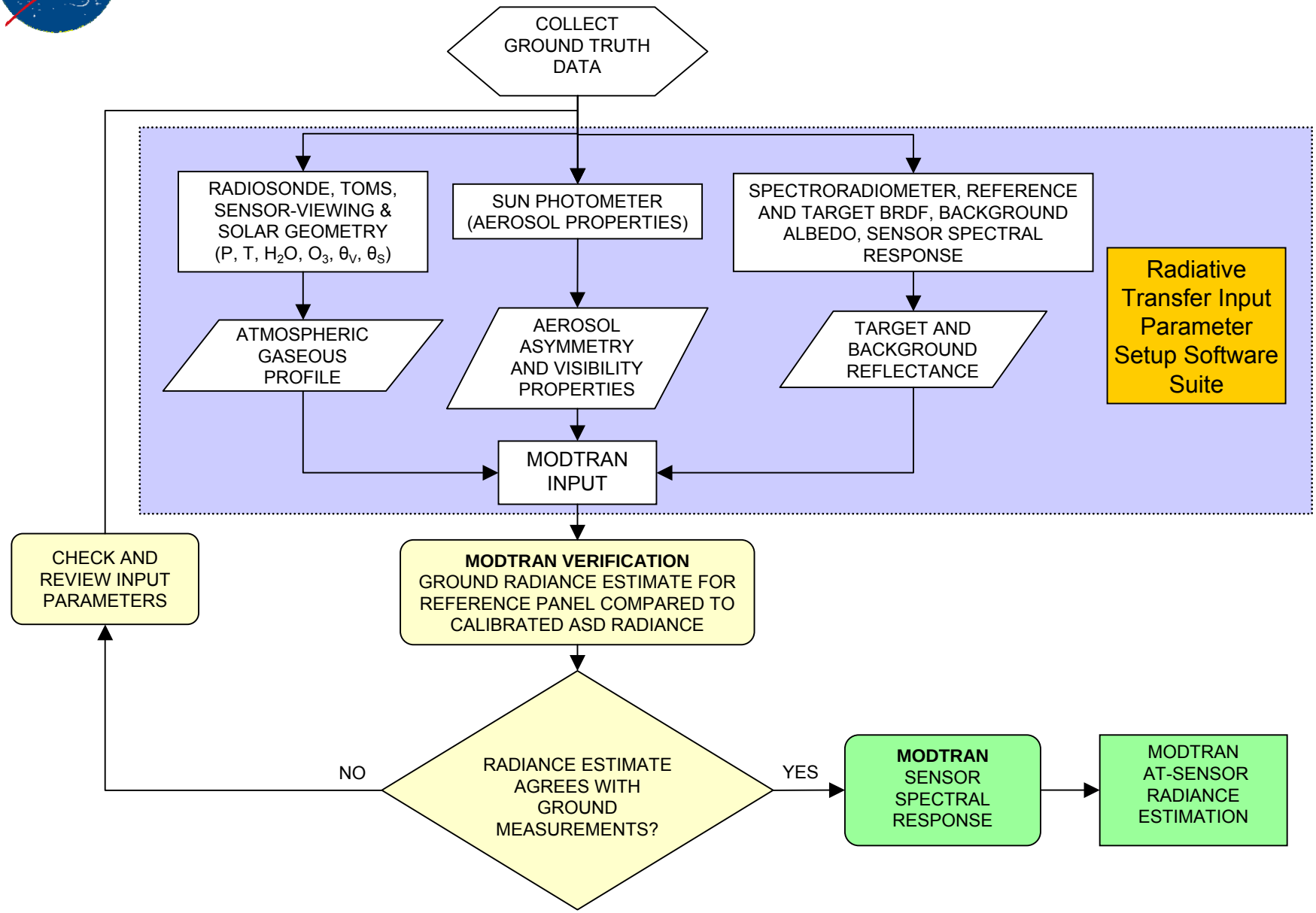
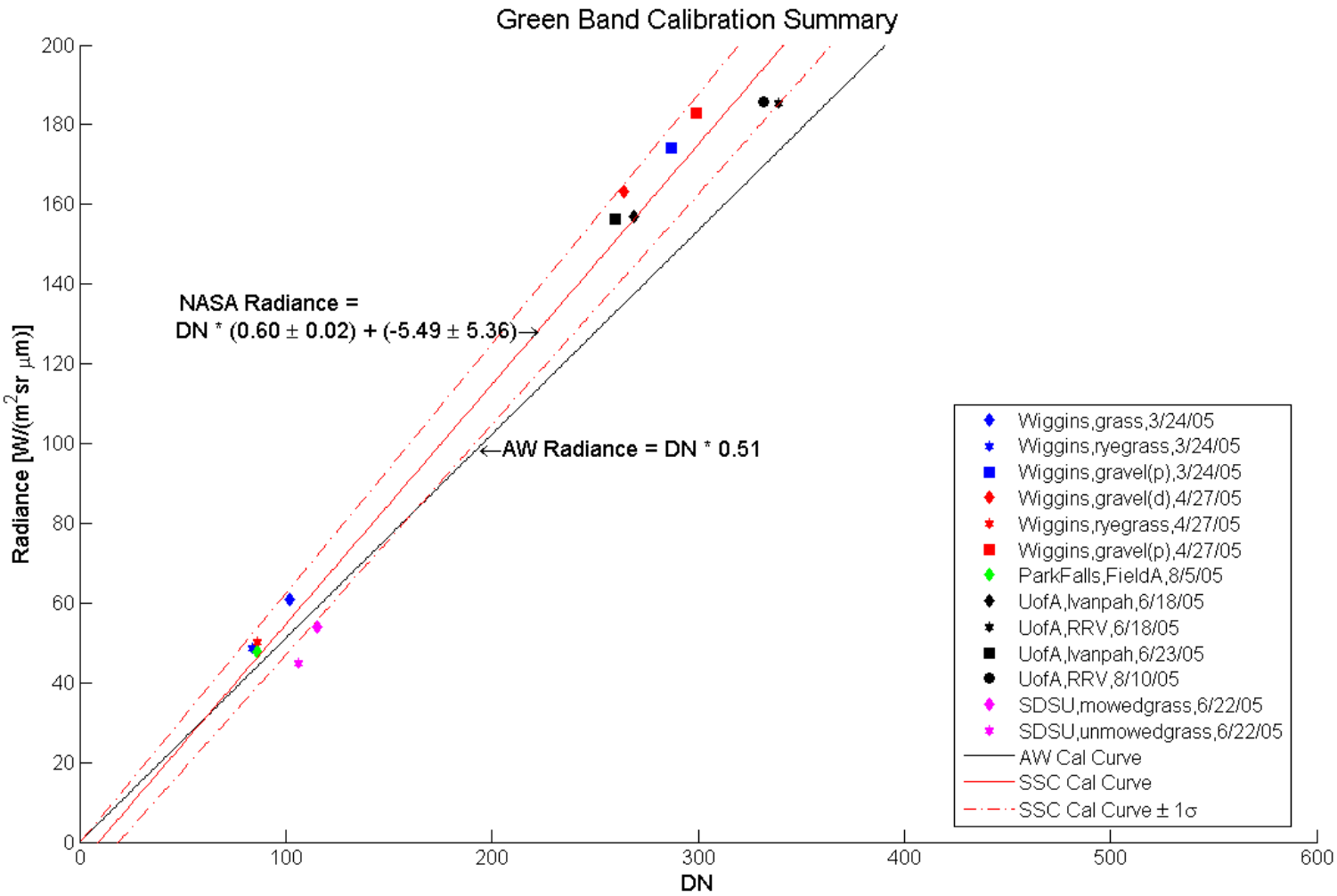
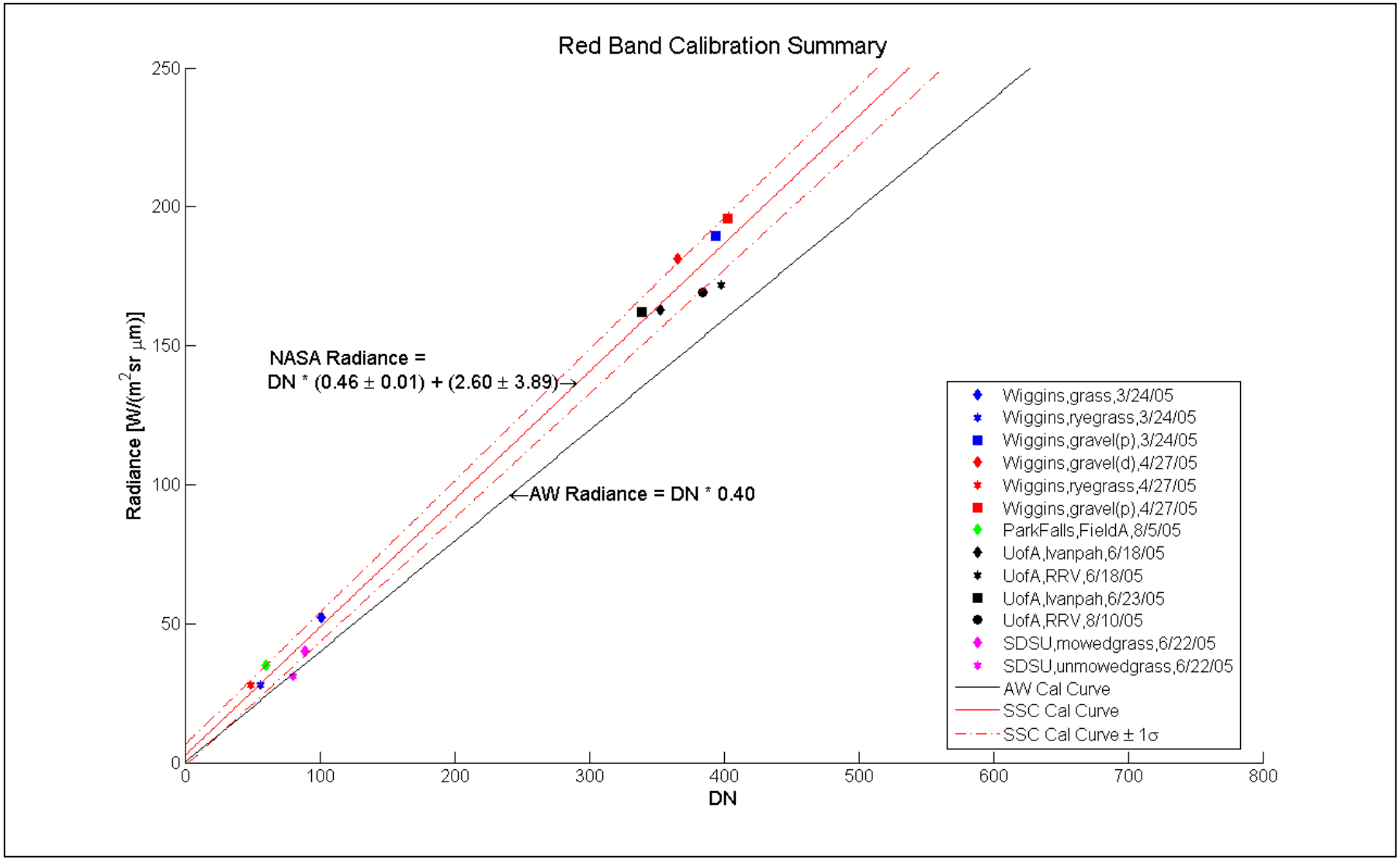


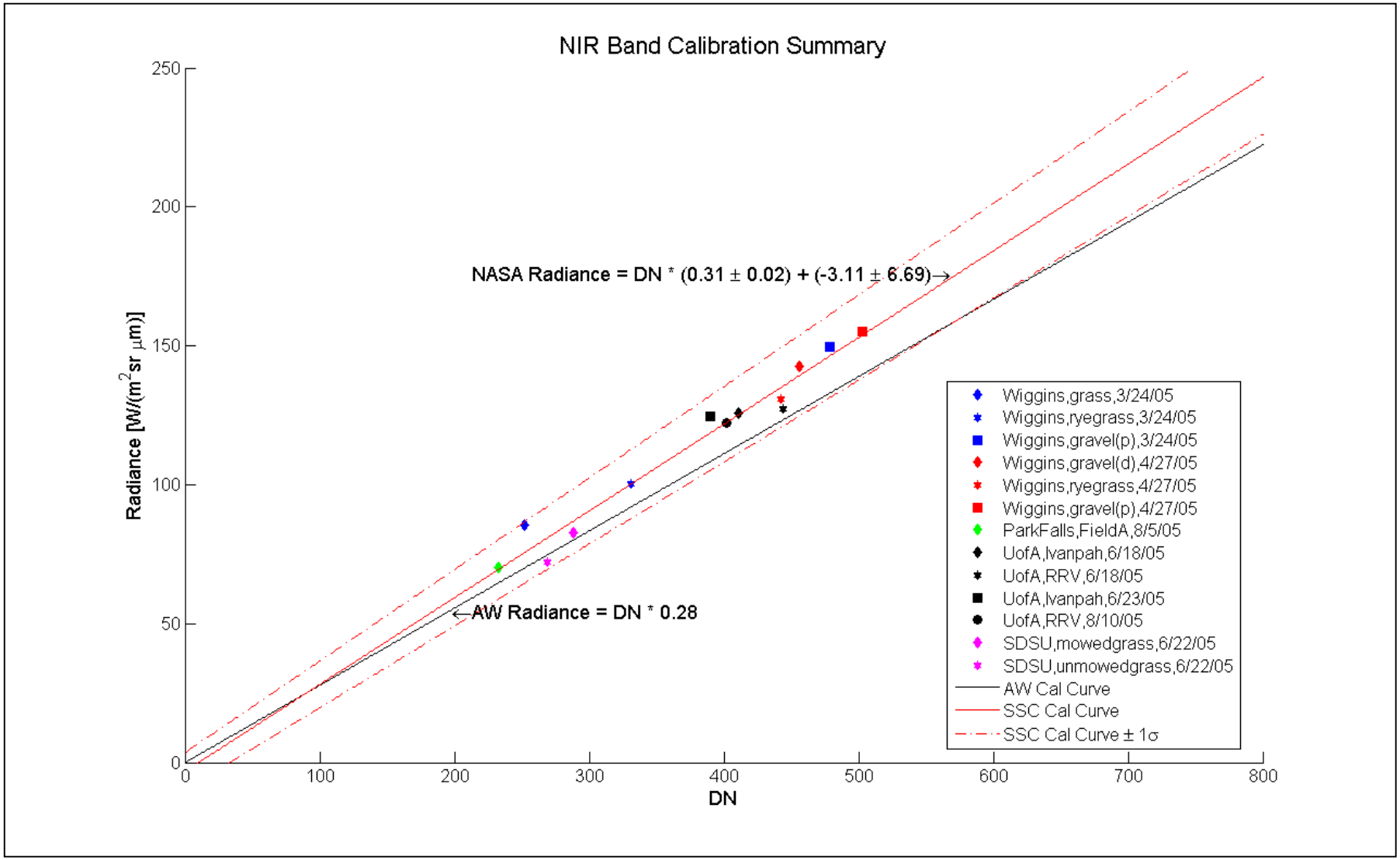
Green Band Calibration Summary



Red Band Calibration Summary

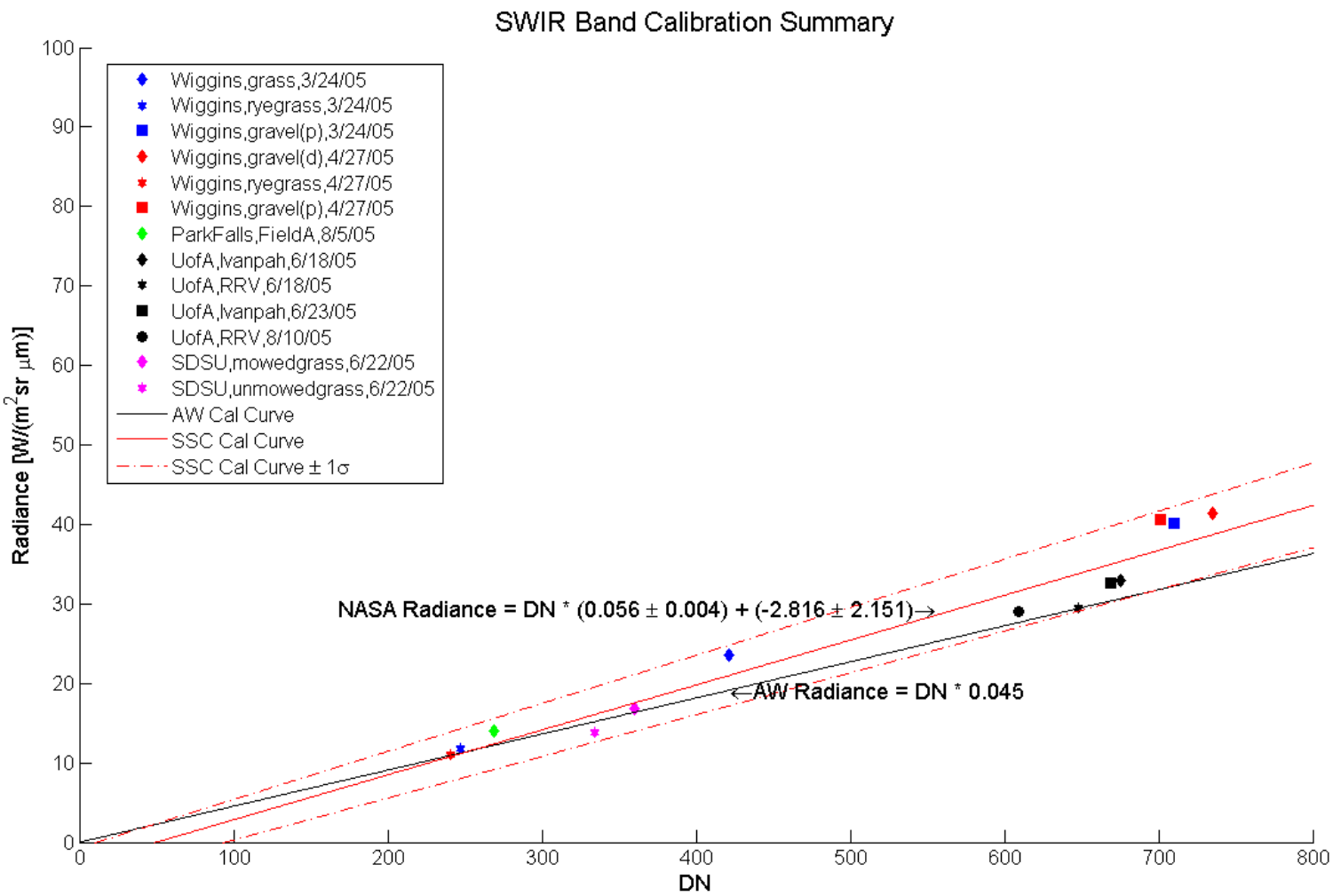


NIR Band Calibration Summary



SWIR Band Calibration Summary

Stennis Space Center



Initial Radiometric Calibration Coefficients

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	Green	Red	NIR	SWIR
NASA Estimate Cal Coeff (W/m^2 sr μm DN) Offset	0.60 ± 0.02 -5.49 ± 5.36	0.46 ± 0.01 2.60 ± 3.89	0.31 ± 0.02 -3.11 ± 6.69	0.056 ± 0.004 -2.82 ± 2.15
AWiFS Provided Cal Coeff (W/m^2 sr μm DN) Offset	0.51 0	0.40 0	0.28 0	0.045 0

AWiFS Results Summary

- The NASA team of University of Arizona, South Dakota State University, and NASA SSC produce consistent results
- The AWiFS calibration coefficients agree reasonably well with the NASA team estimate
- The NASA team will continue to assess AWiFS radiometric accuracy

Contributors

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