



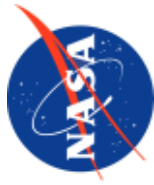
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# **Radiometric Calibration of the AWiFS Using Vicarious Calibration Techniques**

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**JACIE Civil Commercial Imagery Evaluation Workshop  
Fairfax, VA, USA  
March 21, 2007**



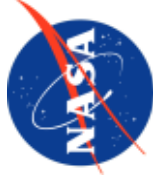
# AWiFS – Advanced Wide Field Sensor

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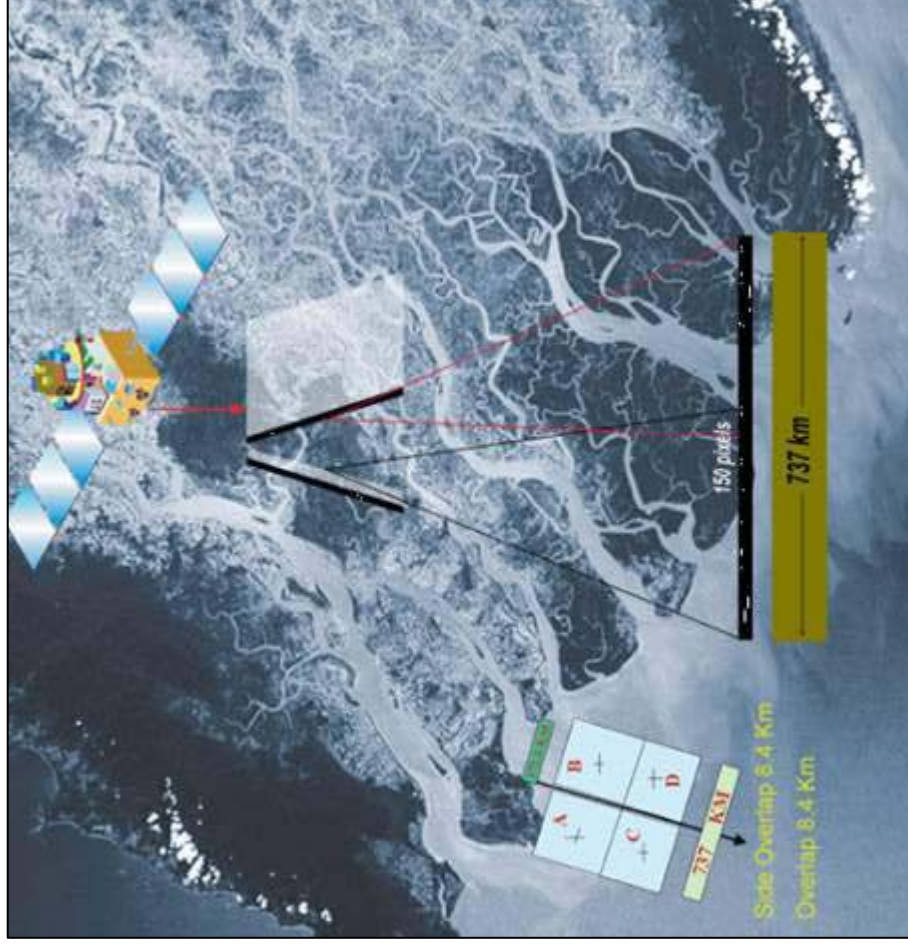
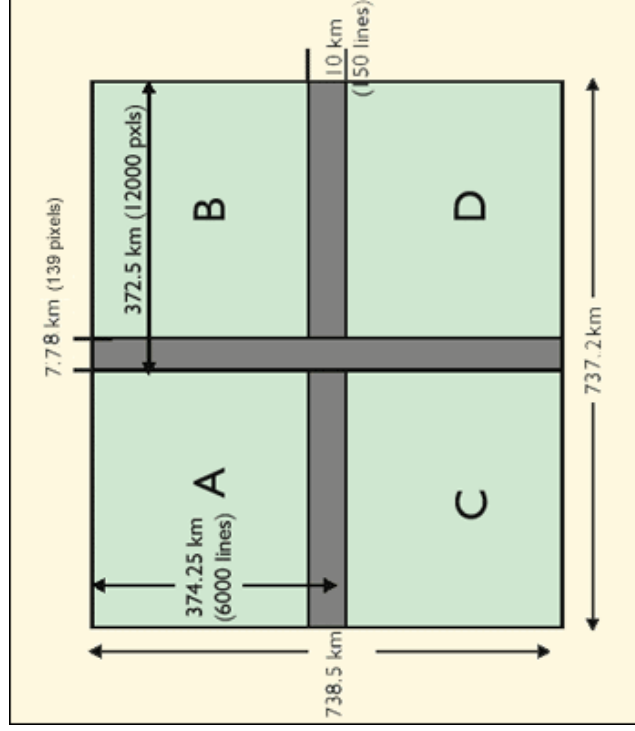
- Onboard IRS-P6 RESOURCE-SAT-1 satellite
  - Launched October 2003
  - Design life of 5 years
- Pushbroom architecture
- Four bands in the VNIR-SWIR spectral region
  - Green (0.52–0.59  $\mu\text{m}$ ), Red (0.62–0.68  $\mu\text{m}$ ), NIR (0.77–0.86  $\mu\text{m}$ ), SWIR (1.55–1.70  $\mu\text{m}$ )
- Spatial resolution: 56 m (near nadir), 70 m (near edge)
- Radiometric resolution: 10 bit
- Swath: 740 km
- Repeat time: 5 days



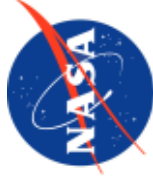
# AWiFS Collection Mode



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



# Landsat 7 – AWiFS Comparison



## Number of Samples

- Landsat 7: ~144 points per 40-acre field
- AWiFS: ~36 points per 40-acre field

## Repeat Coverage

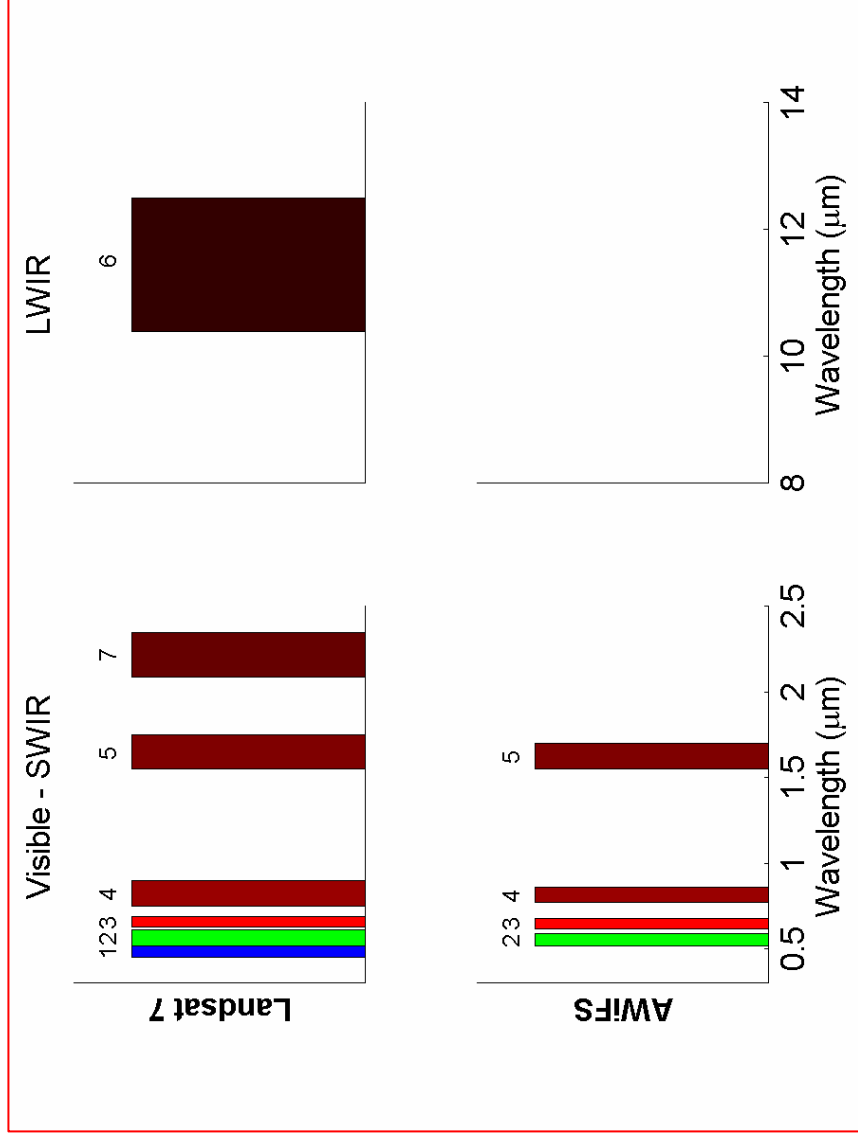
- Landsat 7: 16 days
- AWiFS: 5 days

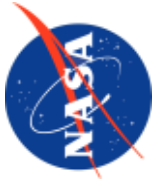
## Swath

- Landsat 7: 185 km
- AWiFS: 737 km

## Bands

- Landsat 7: 7 bands
- AWiFS: 4 bands (no blue, 2.2  $\mu\text{m}$ , thermal)

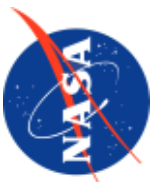




# Characterization Overview

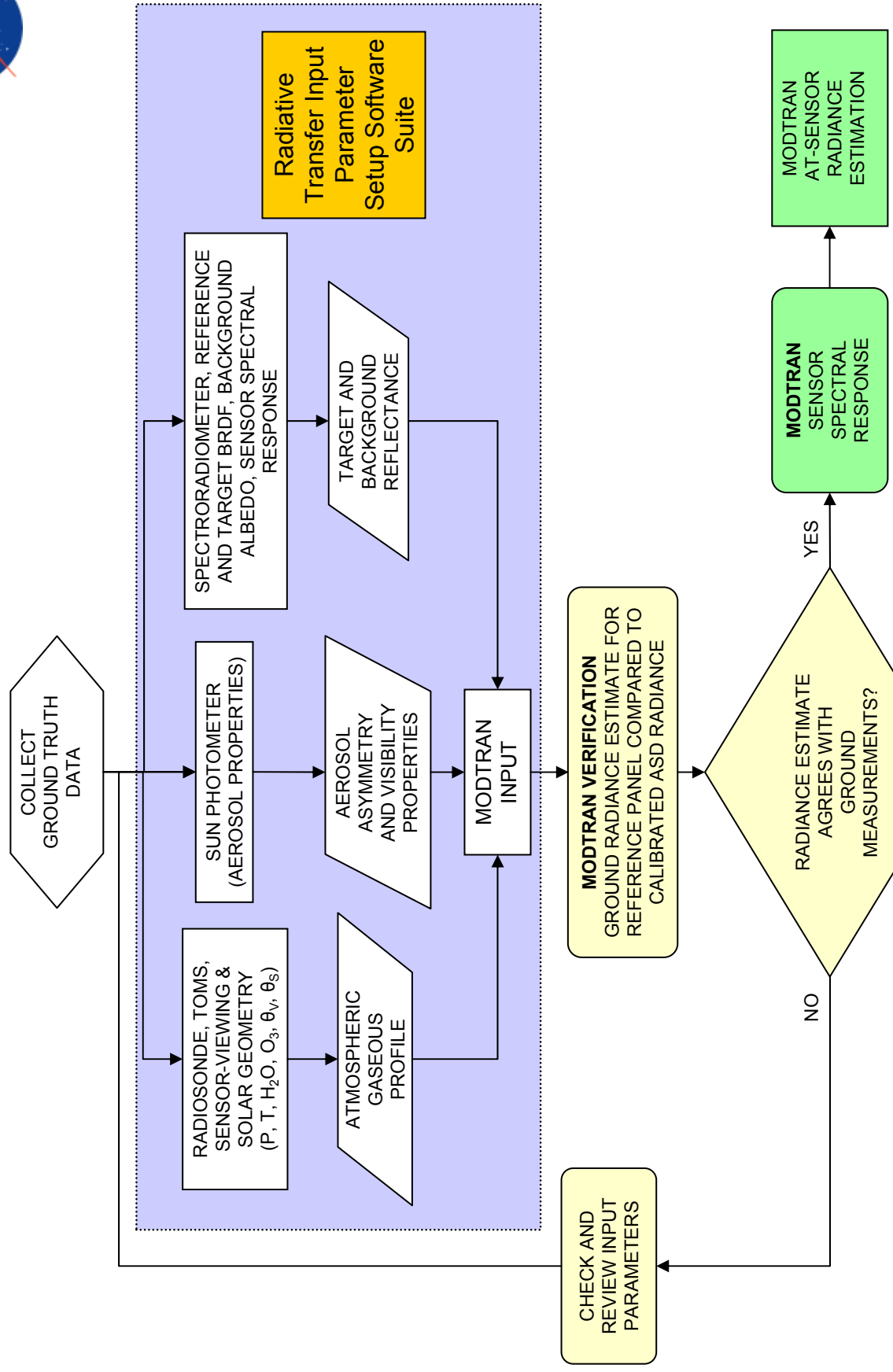
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- Objective
  - Perform radiometric vicarious calibrations of imagery and compare with vendor-provided calibration coefficients
- Vicarious reflectance-based approach used
  - Ground truth collection
    - Characterize target reflectance at time of satellite overpass
    - Characterize atmosphere at time of satellite overpass
  - Use MODTRAN radiative transport code to predict at-sensor radiance
  - Compare predicted at-sensor radiance to actual radiance acquired by sensor

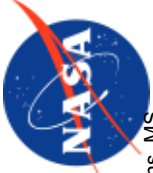


# At-Sensor Radiance Prediction Method

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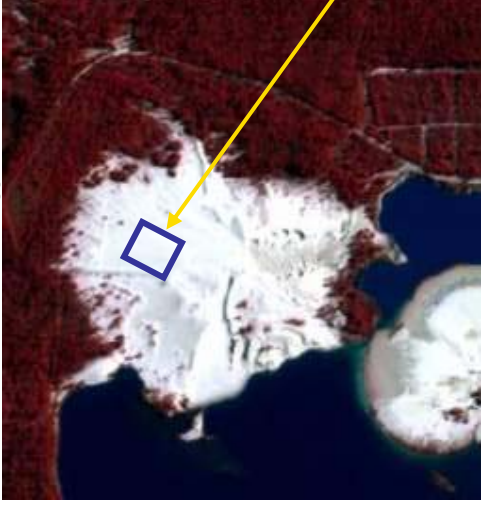
# Selected Targets



Big Level Fields, Wiggins, MS



Perkinston Gravel, Wiggins, MS

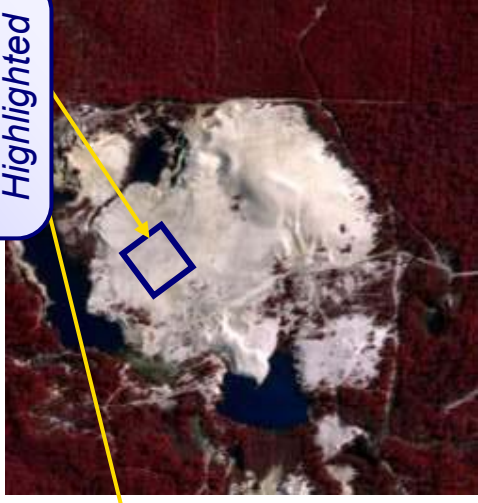


Specific Target Areas Highlighted



Clear Cut field, SSC, MS

Diamond Gravel, Wiggins, MS



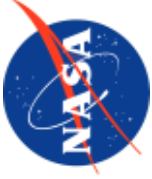
- Five selected targets of opportunity in and around Stennis Space Center are hundreds of meters across:
- Two gravel pit sand sites
  - Two large monoculture fields
  - Large tall grass field



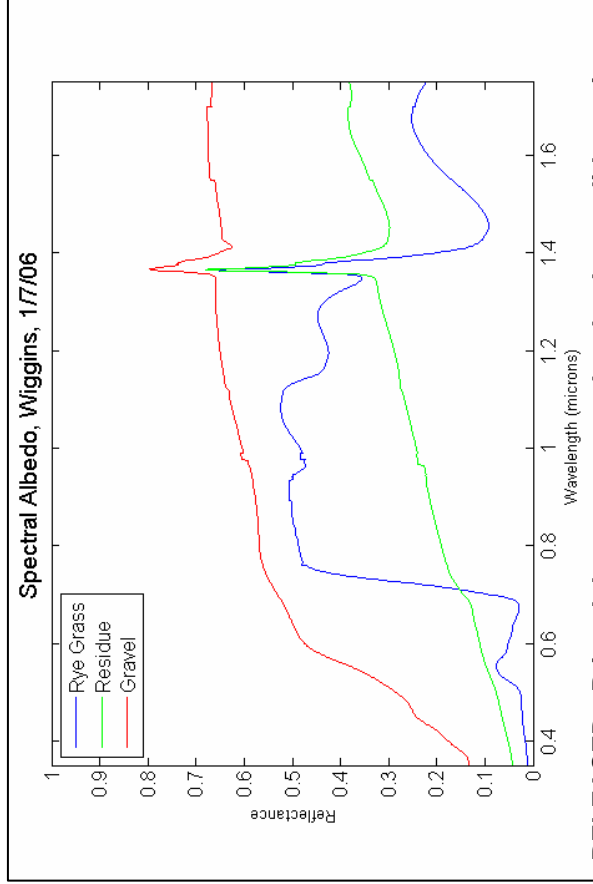
AWiFS imagery (4,3,2)  
January 7, 2006

# Ground Reflectance Measurements

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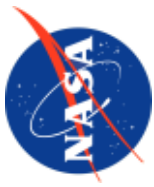


- ASD FieldSpec® FR spectroradiometer measurements of Spectralon® panels and several target areas were taken
  - ~100 m x 200 m area of a rye grass field
  - ~100 m x 100 m area of two sand sites
  - ~100 m x 200 m area of a tall grass field
- Measurements were taken along transects aligned with the sensor azimuth
  - Measurements were taken at 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 30 minutes of satellite overpass



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National Aeronautics and Space Administration





# SSC Calibration and Characterization of ASD FieldSpec Spectroradiometers

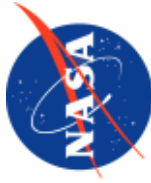
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- NASA SSC maintains four ASD spectroradiometers
  - Laboratory transfer radiometers
  - Ground surface reflectance and atmospheric measurements for field collection activities
- Radiometric Calibration
  - NIST-calibrated integrating sphere serves 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



# Atmospheric Measurements

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- Direct solar irradiance data for visibility estimation collected from early morning through solar noon with automated solar radiometers (optical depth/transmission)
- Total and diffuse solar irradiance for aerosol scattering estimation collected from early morning through solar noon with multi-filter rotating shadowband radiometers (diffuse-to-global ratio)
- Other atmospheric parameters, such as total column ozone and water vapor, determined using MODIS and OMI satellite data



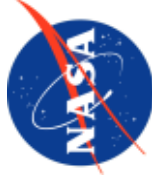
Automated Solar Radiometer



Multifilter Rotating Shadowband Radiometer

# Novel Hyperspectral Sun Photometer

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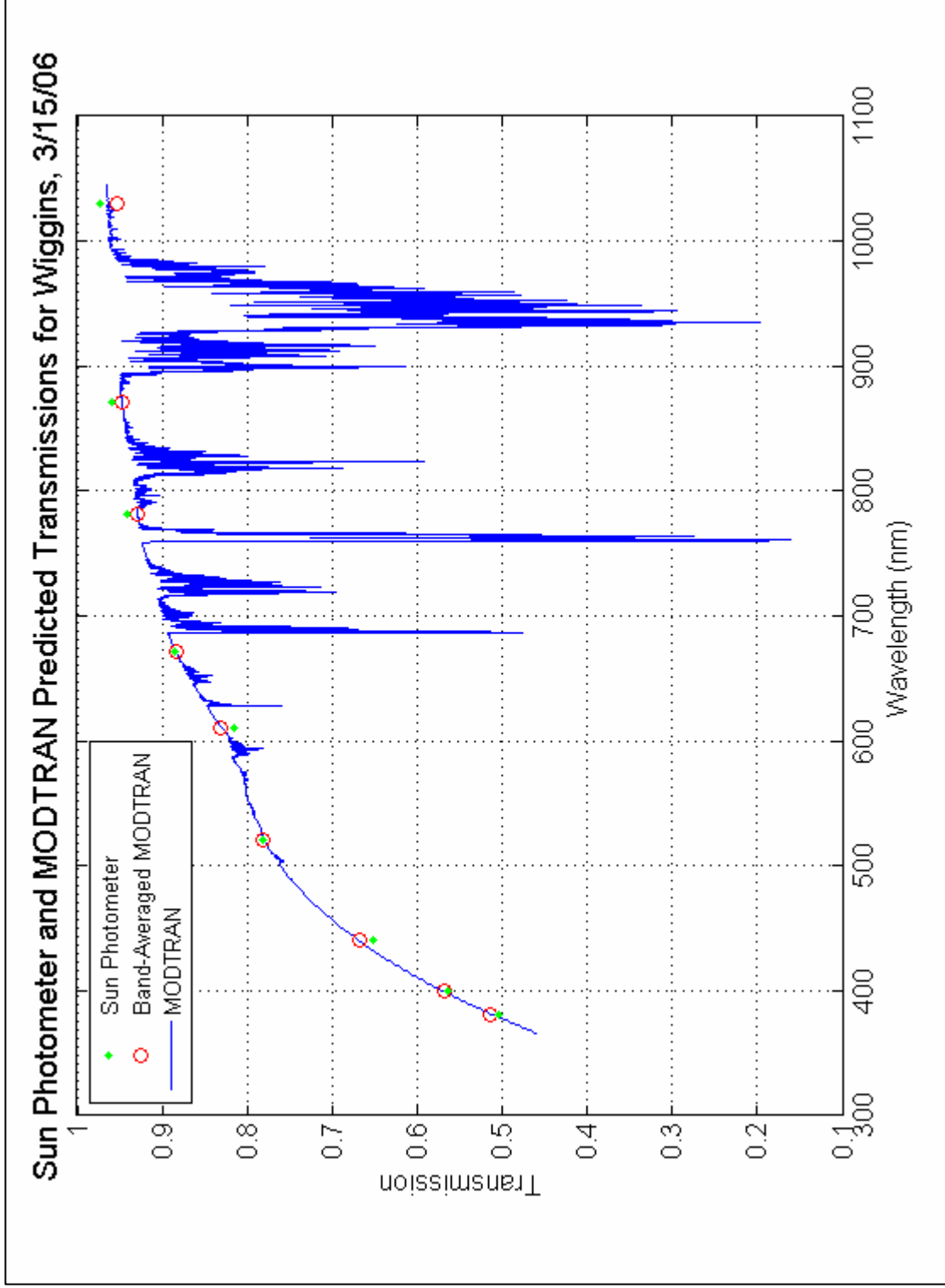
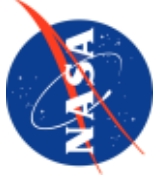
- Direct and diffuse irradiance derived from ASD radiance measurements of a characterized 99% reflectance Spectralon panel
- NIST-traceable calibration performed in laboratory
  - Instrument calibration independent of Langley regression
  - Field measurements required only at the time of overpass
- Used to measure
  - Optical depth/transmission
  - Diffuse-to-global ratio
- Technique uses equipment already in the field

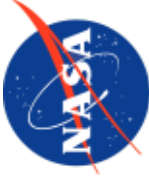


Novel Hyperspectral Sun Photometer Setup

# Visibility Estimation

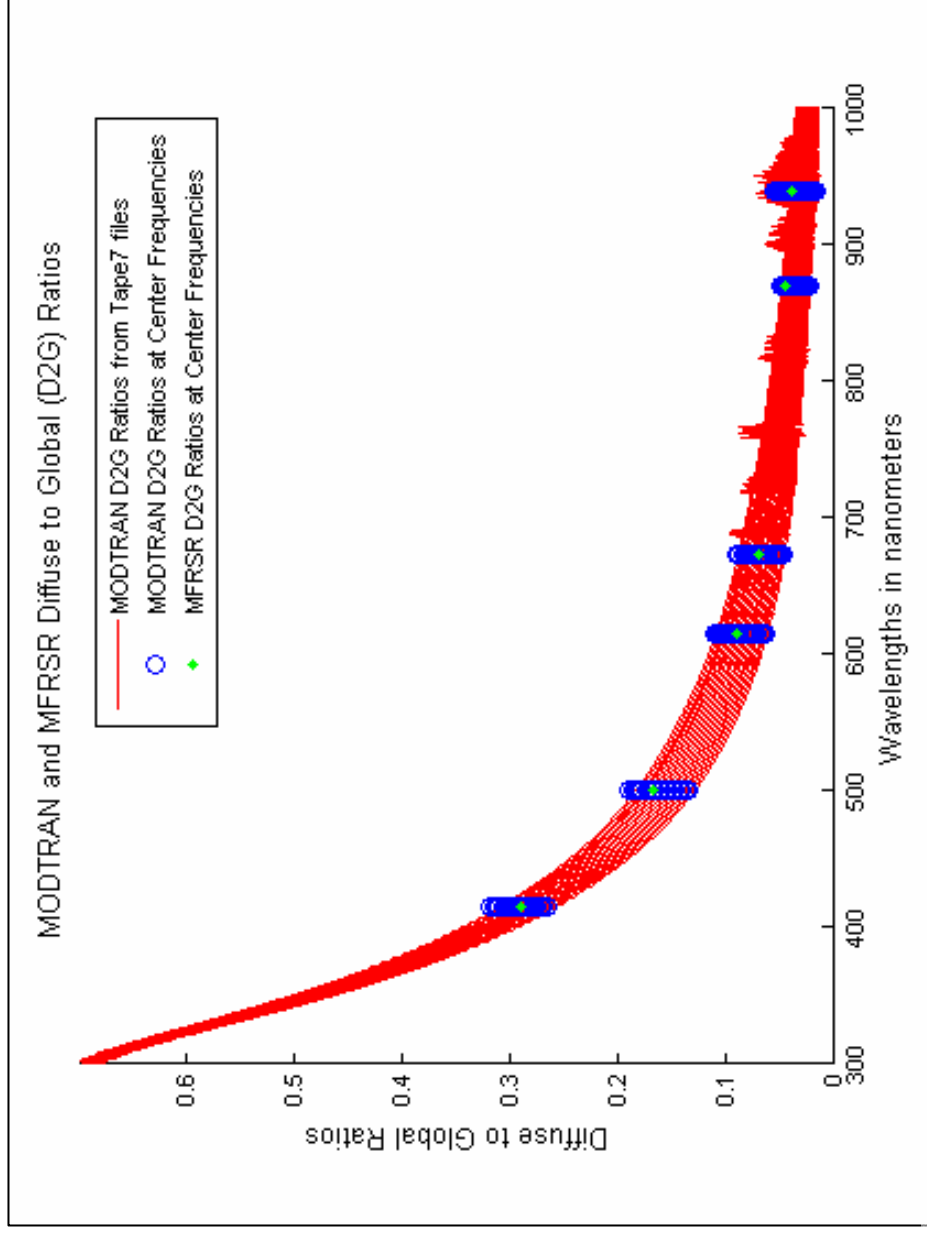
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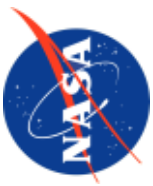




# Aerosol Scattering

The asymmetry factor for the aerosol scattering phase function is estimated by comparing MODTRAN output diffuse-to-global ratio values to MFRSR measured diffuse-to-global ratio values

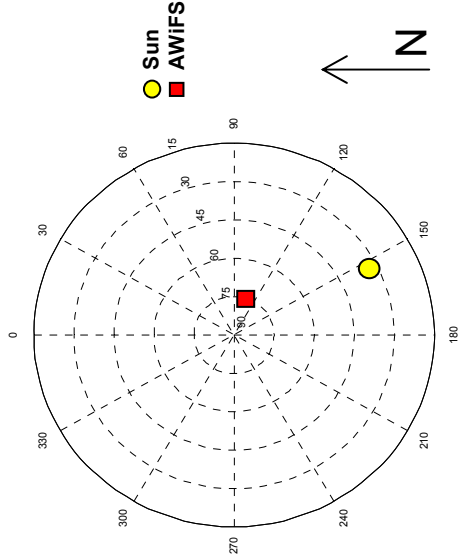




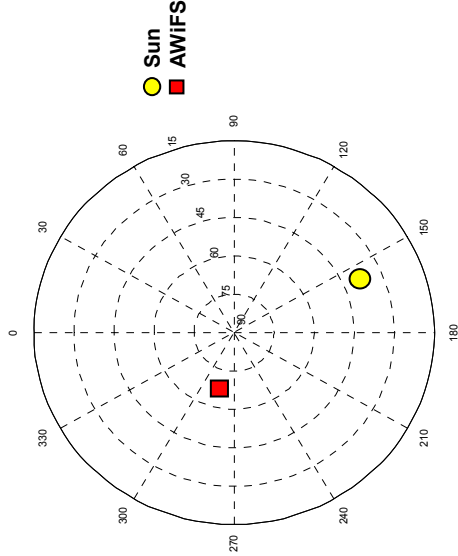
# Data Acquisitions

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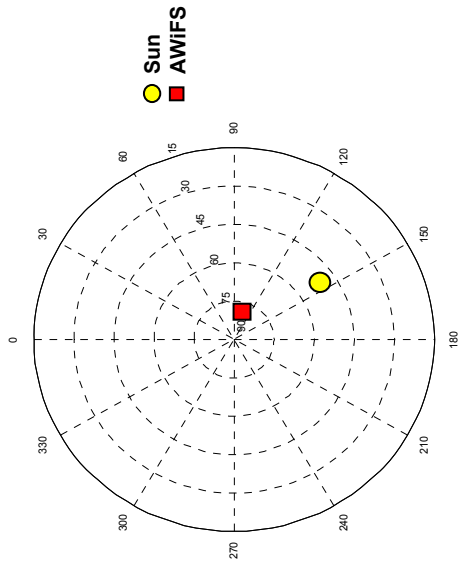
Date	Camera	Overpass Time (UTC)	Satellite Elevation	Satellite Azimuth	Sun Elevation	Sun Azimuth
Jan 7, 2006	A	16:32	74.9 deg	103 deg	32.6 deg	155.0 deg
Jan 25, 2006	B	16:57	66.5 deg	282 deg	37.4 deg	158.3 deg
Mar 15, 2006	A	16:38	81.2 deg	103 deg	51.2 deg	143.7 deg



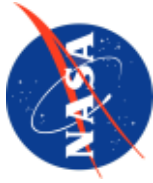
Wiggins, MS, 1/7/06



Wiggins, MS, 1/25/06

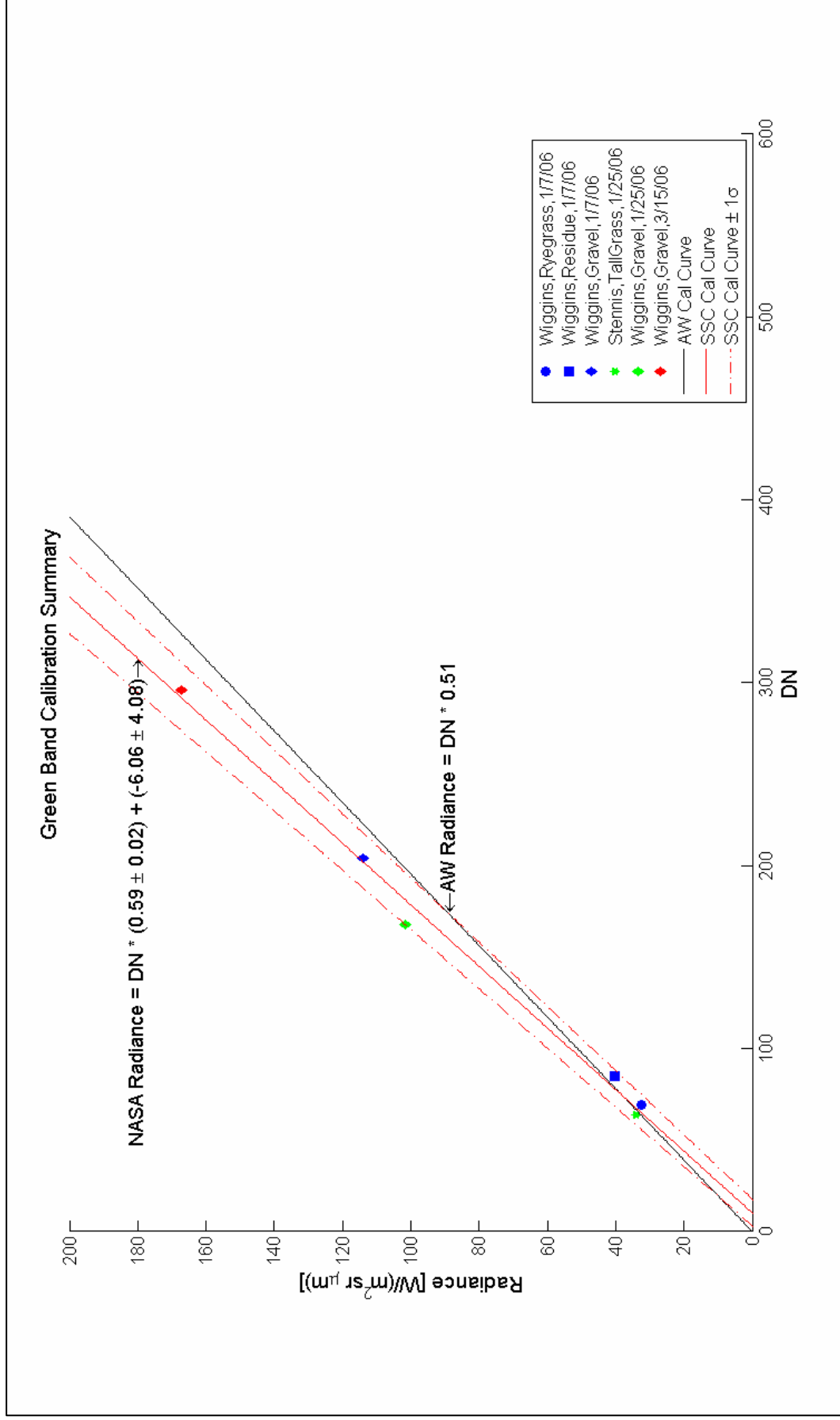


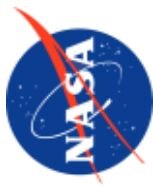
Wiggins, MS, 3/15/06



# Green Band Calibration Summary

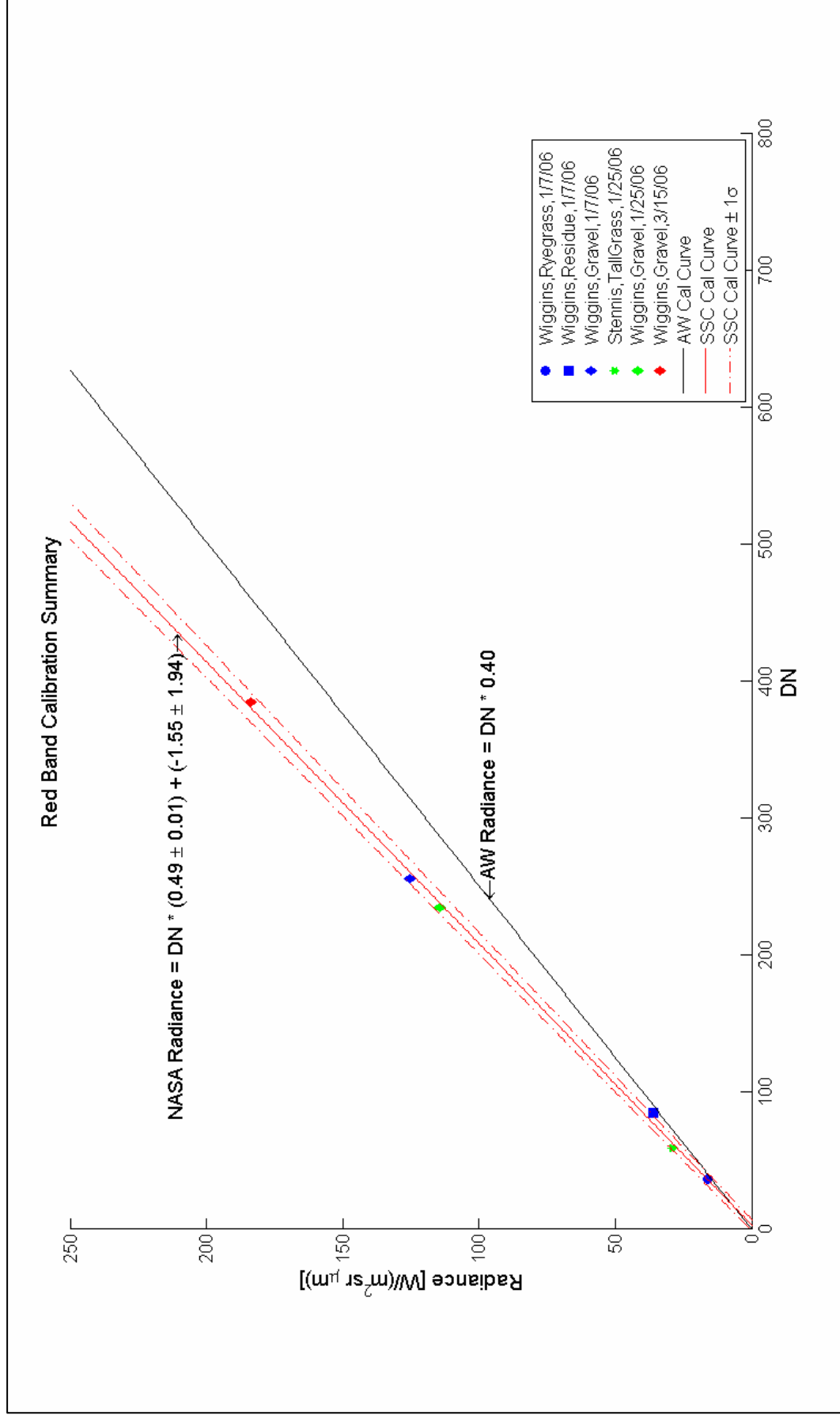
Stennis Space Center



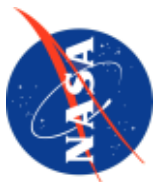


# Red Band Calibration Summary

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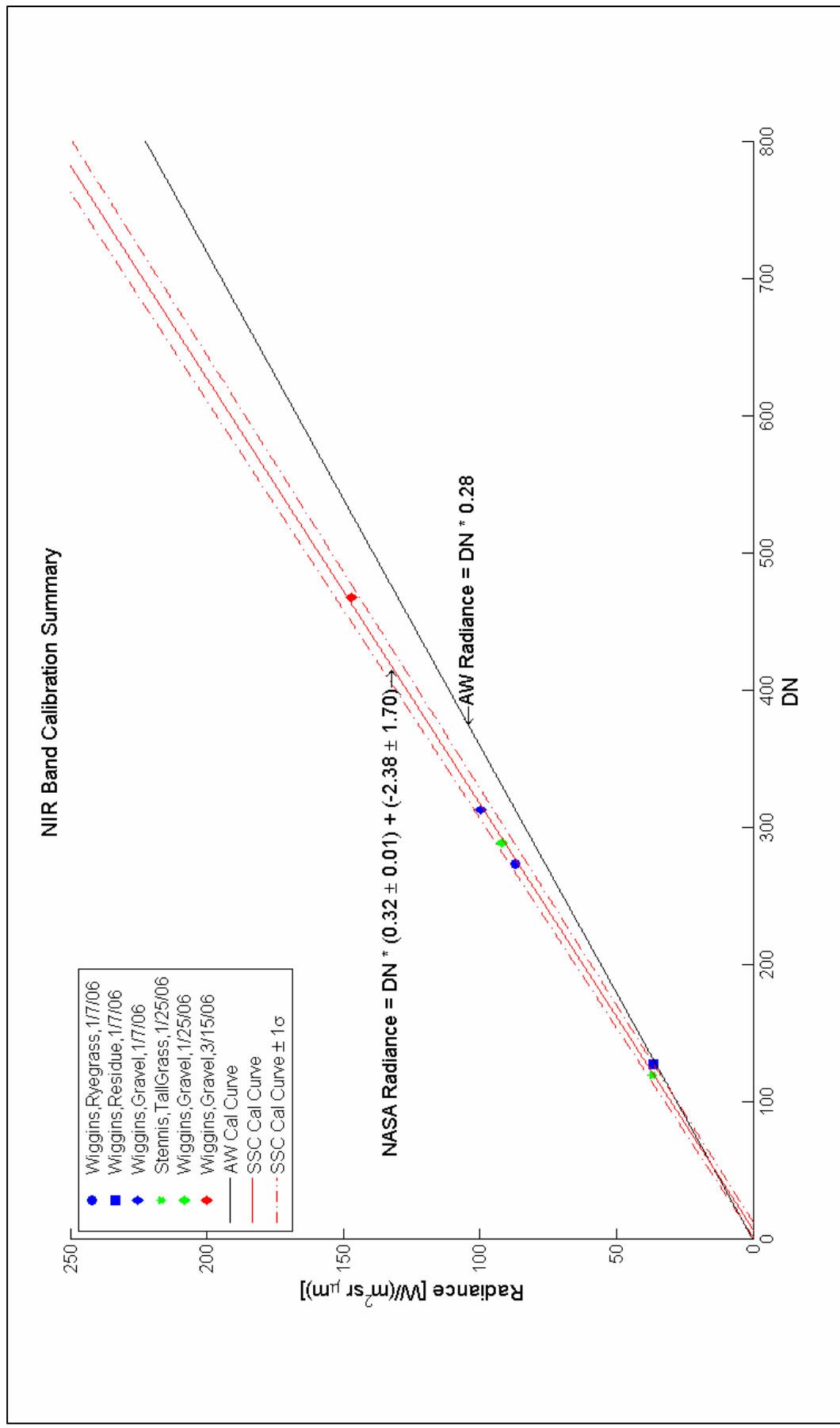


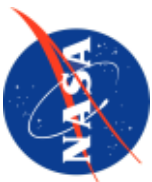




# NIR Band Calibration Summary

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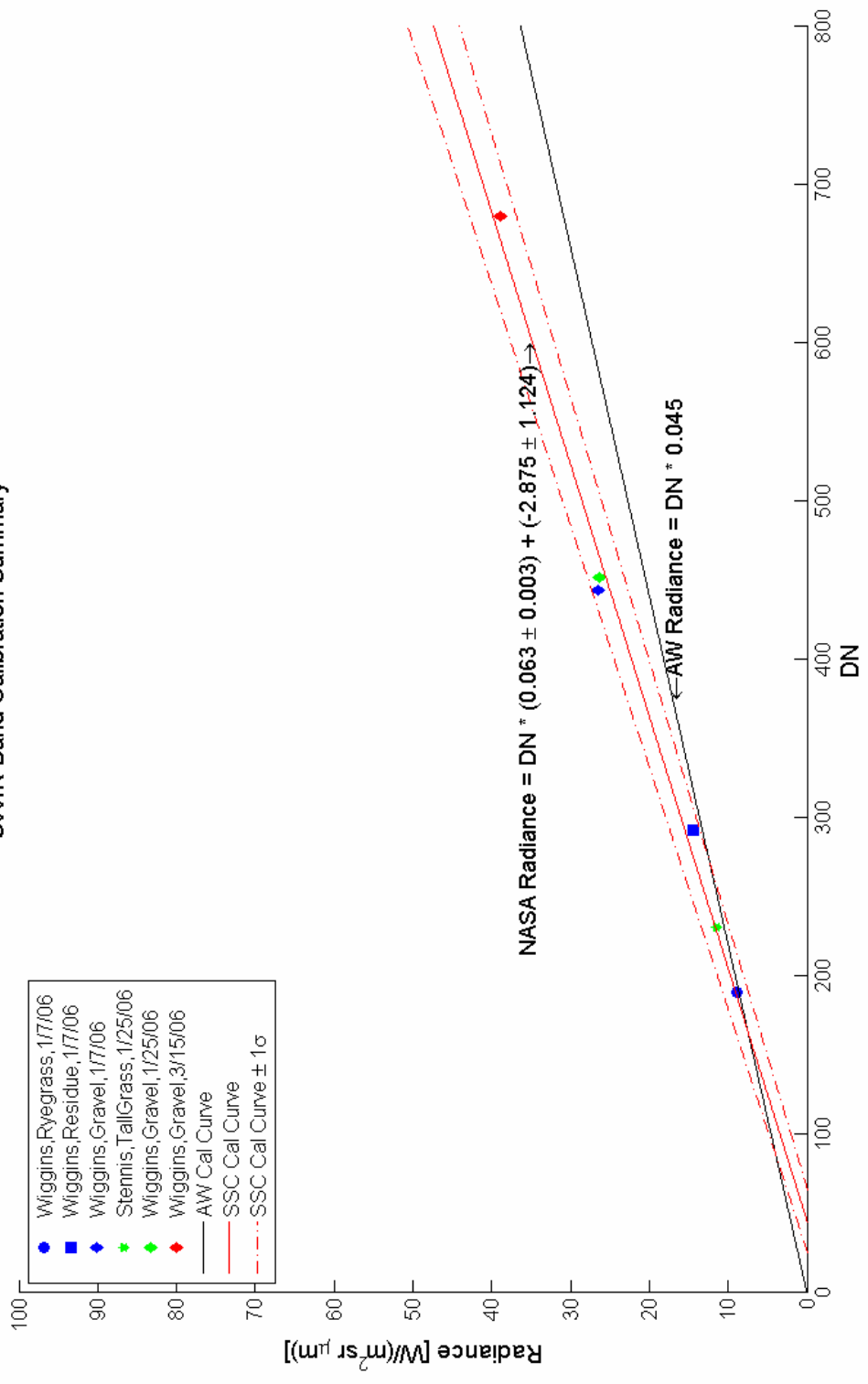


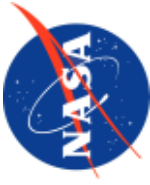


# SWIR Band Calibration Summary

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SWIR Band Calibration Summary

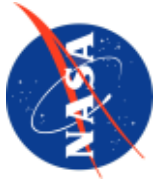




# Radiometric Calibration Coefficients

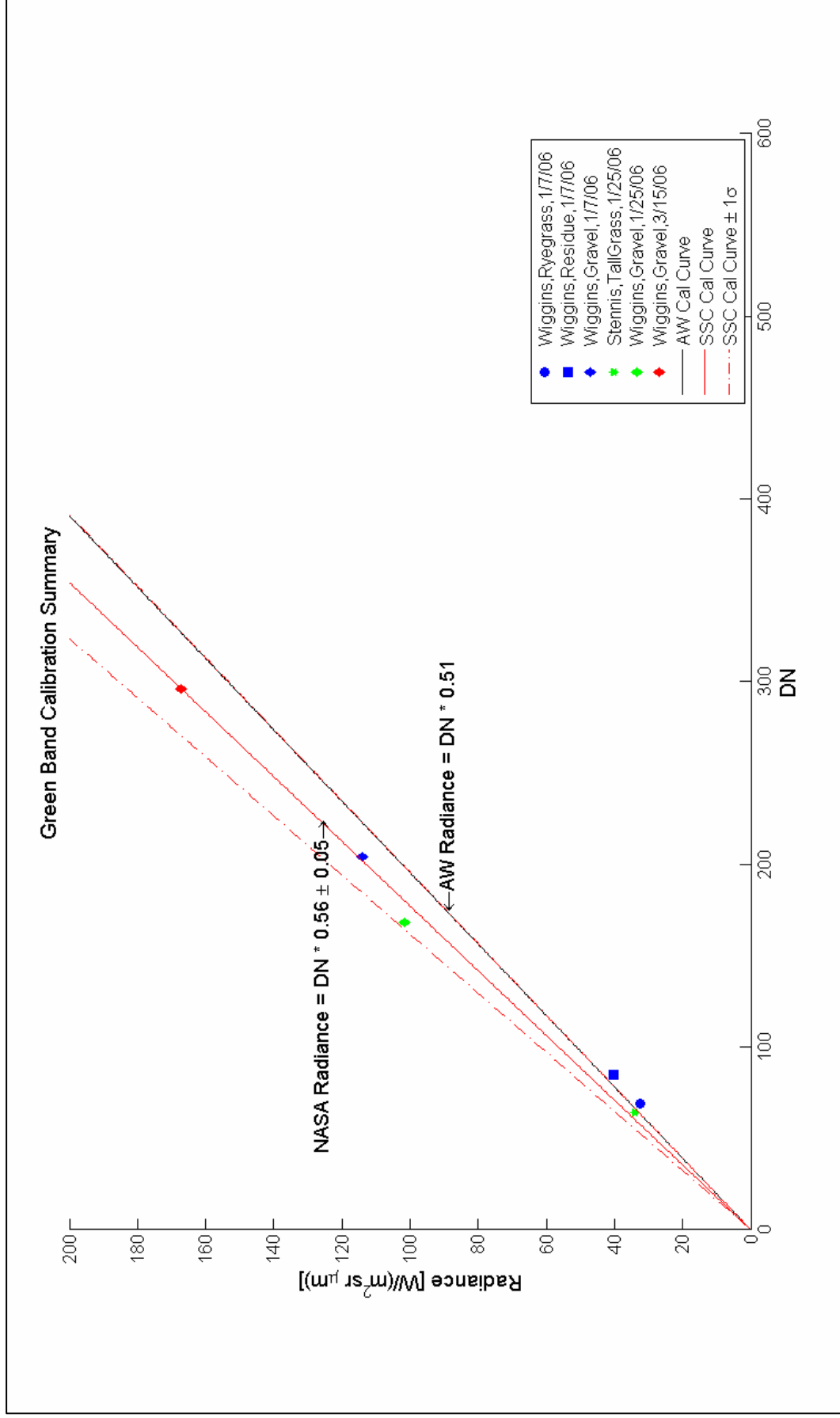
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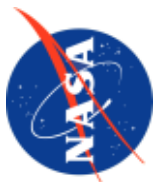
	Green	Red	NIR	SWIR
<b>NASA Estimate 2006</b>				
Cal Coeff (W/m <sup>2</sup> sr μm DN)	0.59 ± 0.02	0.49 ± 0.01	0.32 ± 0.01	0.063 ± 0.003
Offset	-6.06 ± 4.08	-1.55 ± 1.94	-2.38 ± 1.70	-2.88 ± 1.12
<b>NASA Estimate 2005</b>				
Cal Coeff (W/m <sup>2</sup> sr μm DN)	0.60 ± 0.02	0.46 ± 0.01	0.31 ± 0.02	0.056 ± 0.004
Offset	-5.49 ± 5.36	2.60 ± 3.89	-3.11 ± 6.69	-2.82 ± 2.15
<b>AWiFS Provided</b>				
Cal Coeff (W/m <sup>2</sup> sr μm DN)	0.51	0.40	0.28	0.045
Offset	0	0	0	0



# Green Band Calibration Summary (Zero-Offset)

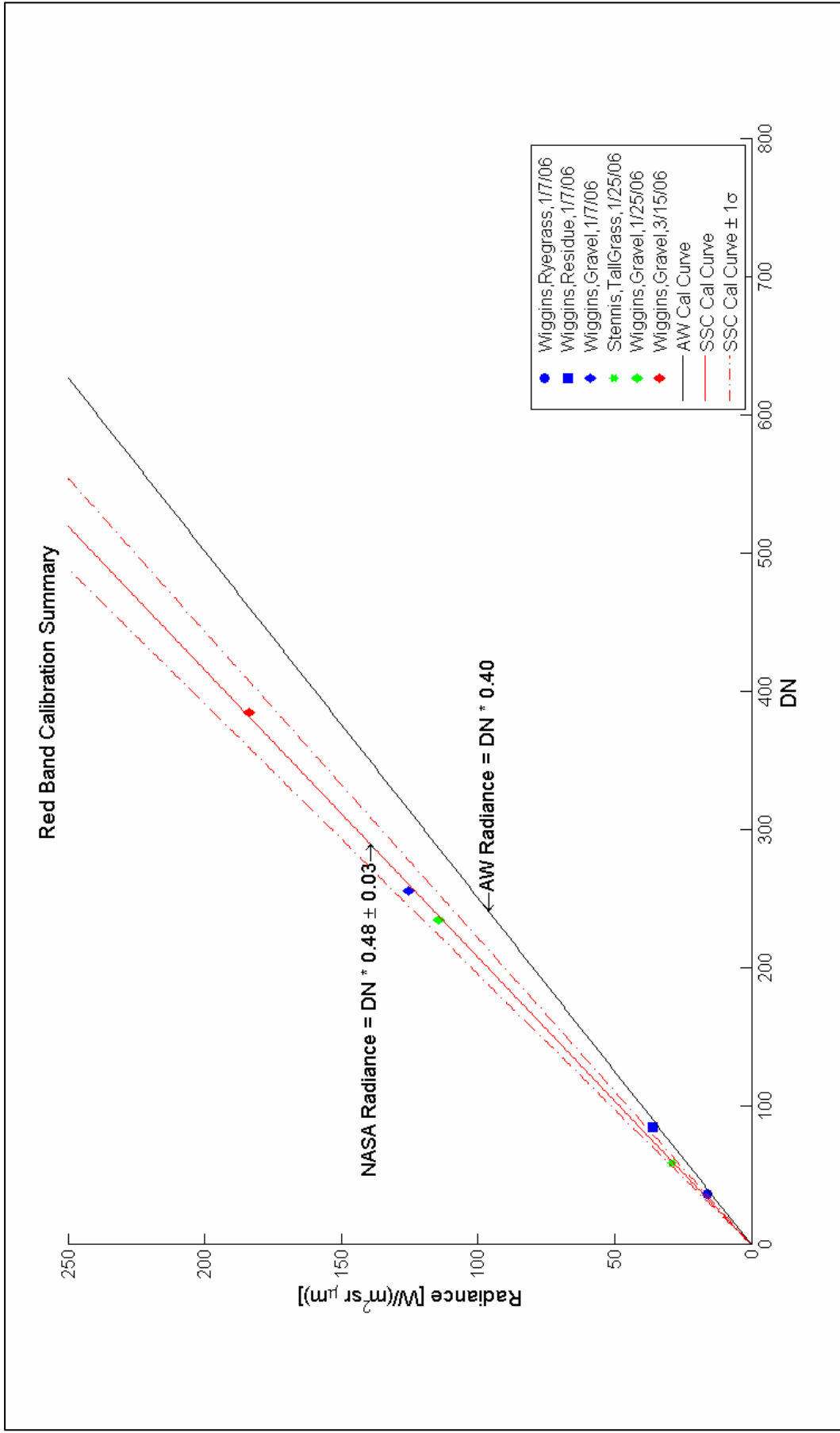
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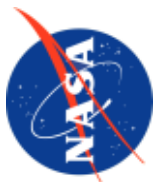




# Red Band Calibration Summary (Zero-Offset)

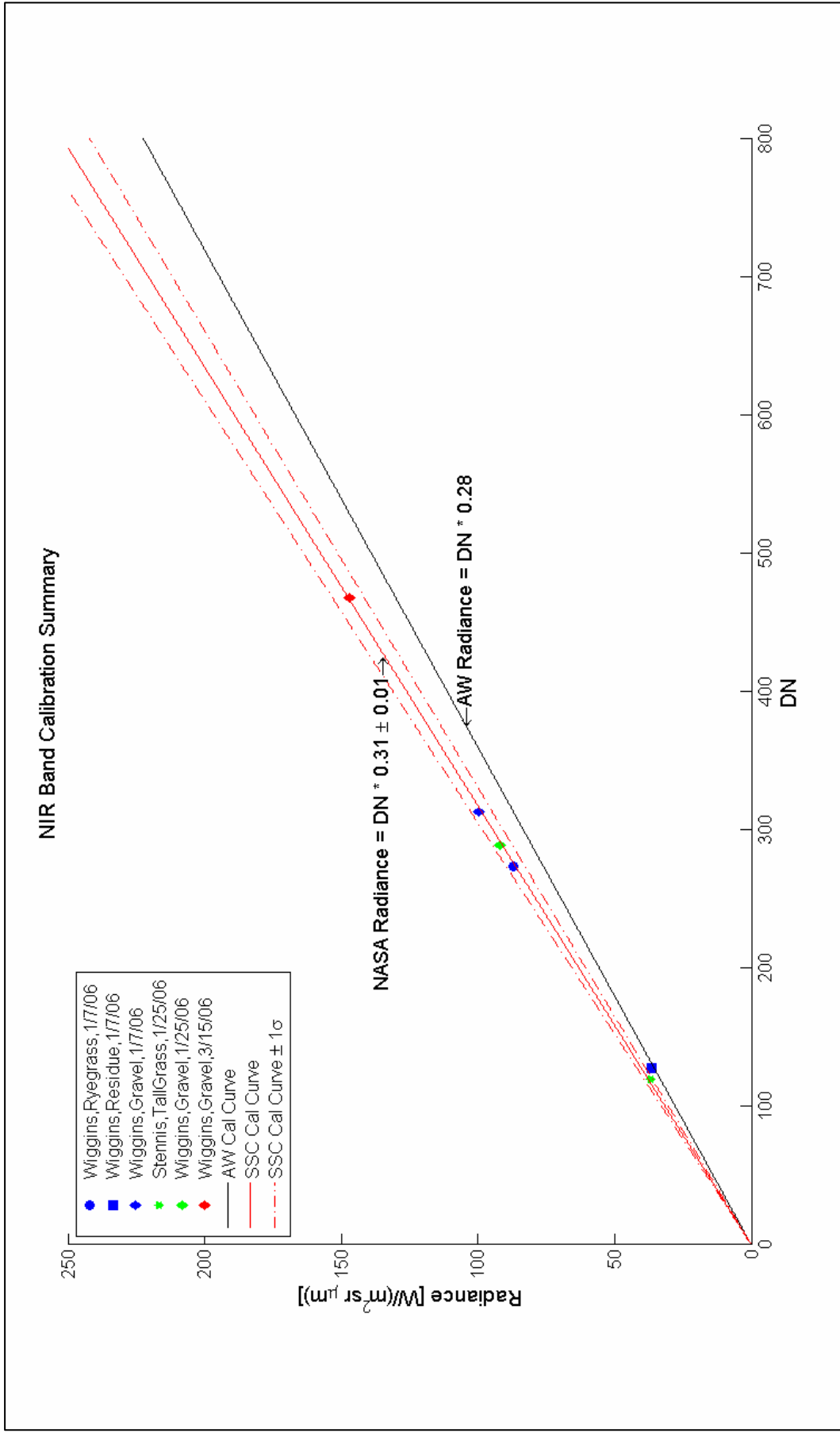
Stennis Space Center

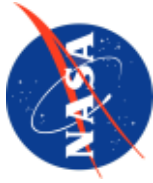




# NIR Band Calibration Summary (Zero-Offset)

Stennis Space Center

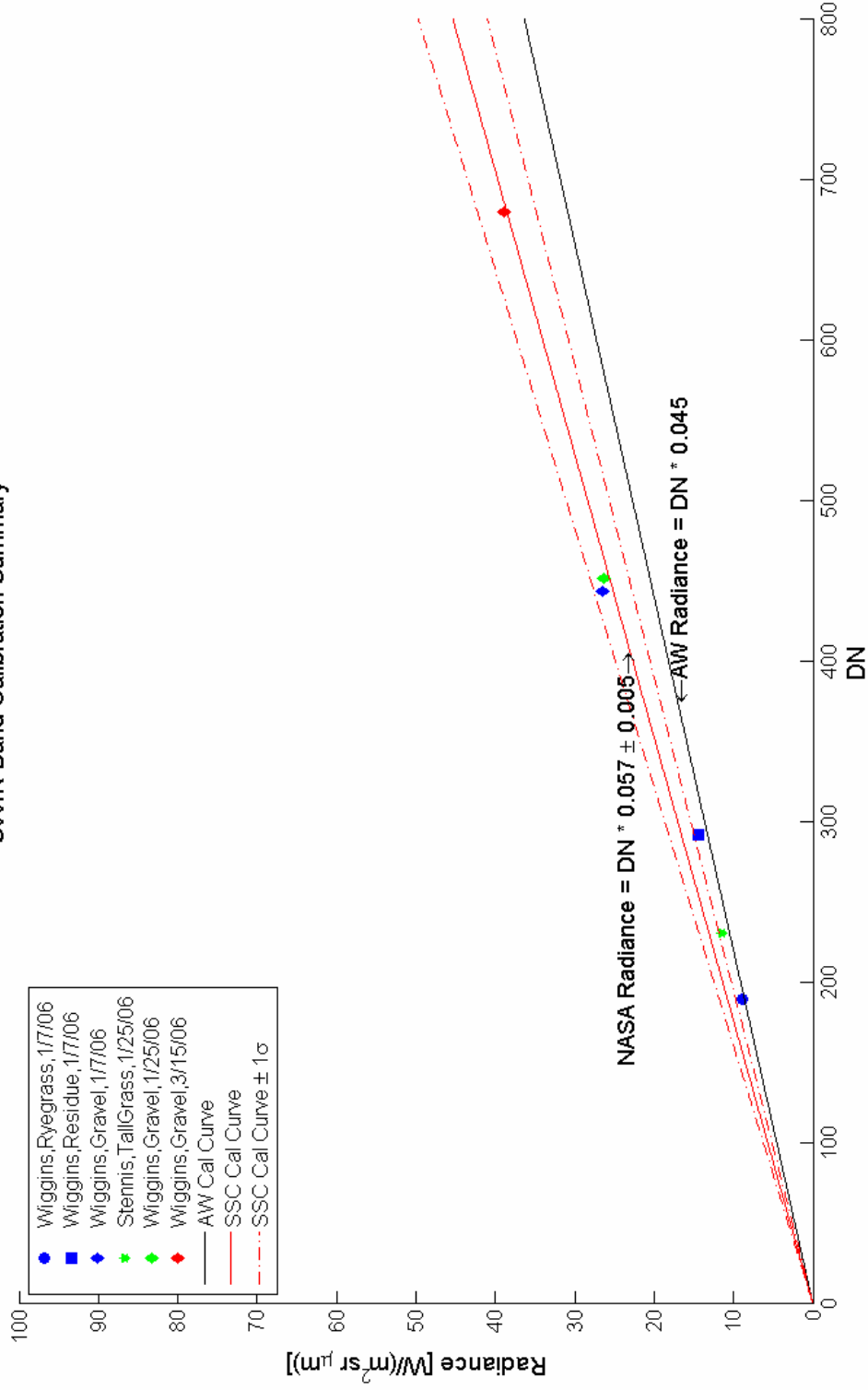




# SWIR Band Calibration Summary (Zero-Offset)

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SWIR Band Calibration Summary



# Initial Radiometric Calibration Coefficients (Zero-Offset)



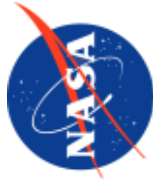
Band	<b>NASA 2006</b> Estimate [W/m <sup>2</sup> sr μm DN]	NASA 2005 Estimate [W/m <sup>2</sup> sr μm DN]	AWiFS Provided [W/m <sup>2</sup> sr μm DN]	% Difference (AWiFS vs. NASA 2006)
Green	0.56 ± 0.05	0.58 ± 0.06	0.51	8.9%
Red	0.48 ± 0.03	0.47 ± 0.05	0.40	16.7%
NIR	0.31 ± 0.01	0.30 ± 0.02	0.28	9.7%
SWIR	0.057 ± 0.005	0.052 ± 0.005	0.045	21.1%

Percent difference is calculated by  $(1 - \text{AWiFS}/\text{NASA Mean})$

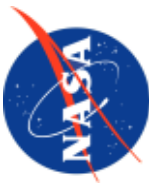


# AWiFS Results Summary

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- The AWiFS calibration coefficients agree reasonably well with the NASA estimate
  - Limited characterization points in 2006
  - Red and SWIR band percent differences will be reviewed
- The AWiFS radiometric calibration coefficients appear stable over a 1-year period (March 2005–March 2006)
- The NASA team will continue to assess AWiFS radiometric accuracy



# Contributors

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