



Stennis Space Center

NASA Radiometric Characterization

Kara Holekamp

**Science Systems and Applications, Inc.
John C. Stennis Space Center, MS 39529
phone: 228-688-3840
e-mail: kara.holekamp@ssc.nasa.gov**

**High Spatial Resolution Commercial Imagery Workshop
Reston, Virginia, USA
November 9, 2004**



Contributors

Stennis Space Center

NASA, Stennis Space Center

Troy Frisbie

Tom Stanley

Vicki Zanoni

Science Systems and Applications, Inc., Stennis Space Center

Slawomir Blonski

Mary Pagnutti

Ruby Stubbs

Brennan Grant

Kenton Ross

Steve Tate

Kelly Knowlton

Robert E. Ryan

Computer Sciences Corporation, Stennis Space Center

Debbie Fendley

Jeffrey Russell

Ronald Vaughan

Lockheed Martin

David Carver

Dean Noel

Charles Smith

Jerry Gasser

Richard Sellers

Wes Tabor

Randy Greer

South Dakota State University

David Aaron

Dennis Helder

Students from the SDSU
Image Processing Laboratory

University of Arizona

Chris Cattrall

Kurt Thome

Students from the UofA
Remote Sensing Group

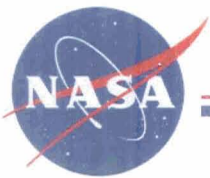
This work was directed by the NASA Applied Sciences Directorate (formerly the Earth Science Applications Directorate) at the John C. Stennis Space Center, Mississippi. Participation in this work by Lockheed Martin Space Operations – Stennis Programs was supported under contract number NAS 13-650. Participation in this work by Computer Sciences Corporation and by Science Systems and Applications, Inc., was supported under NASA Task Order NNS04AB54T.

Outline



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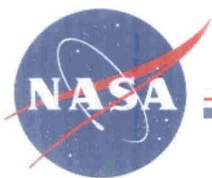
- Characterization Overview
 - Vicarious Calibration
 - MODTRAN
- Ground Truth Data Collection
 - Stennis Space Center, MS
 - Brookings, SD
- Data Processing Methods
 - Data Processing for MODTRAN
- QuickBird Characterization
 - Data Collections
 - Results
- OrbView-3 Characterization
 - Data Collections
 - Results



Characterization Overview

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- Objective
 - Perform radiometric vicarious calibrations of imagery and compare with vendor-provided calibration coefficients
- Approach
 - Use multiple, well-characterized sites
 - 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 (provided ground-truth data)

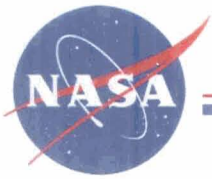


Data Providers

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- DigitalGlobe, Inc.
 - Imagery acquired by the QuickBird sensor
 - Data purchased by NASA through the Scientific Data Purchase project
 - Independent characterization is a continuation of the previous year

- OSC/ORBIMAGE, Inc.
 - Imagery acquired by the OrbView-3 sensor
 - Data received through a Space Act Agreement among NASA, Orbital Sciences Corporation, and ORBIMAGE, Inc.
 - Independent characterization performed on pre-initial on-orbit checkout (pre-IOC) data



Vicarious Calibration Method

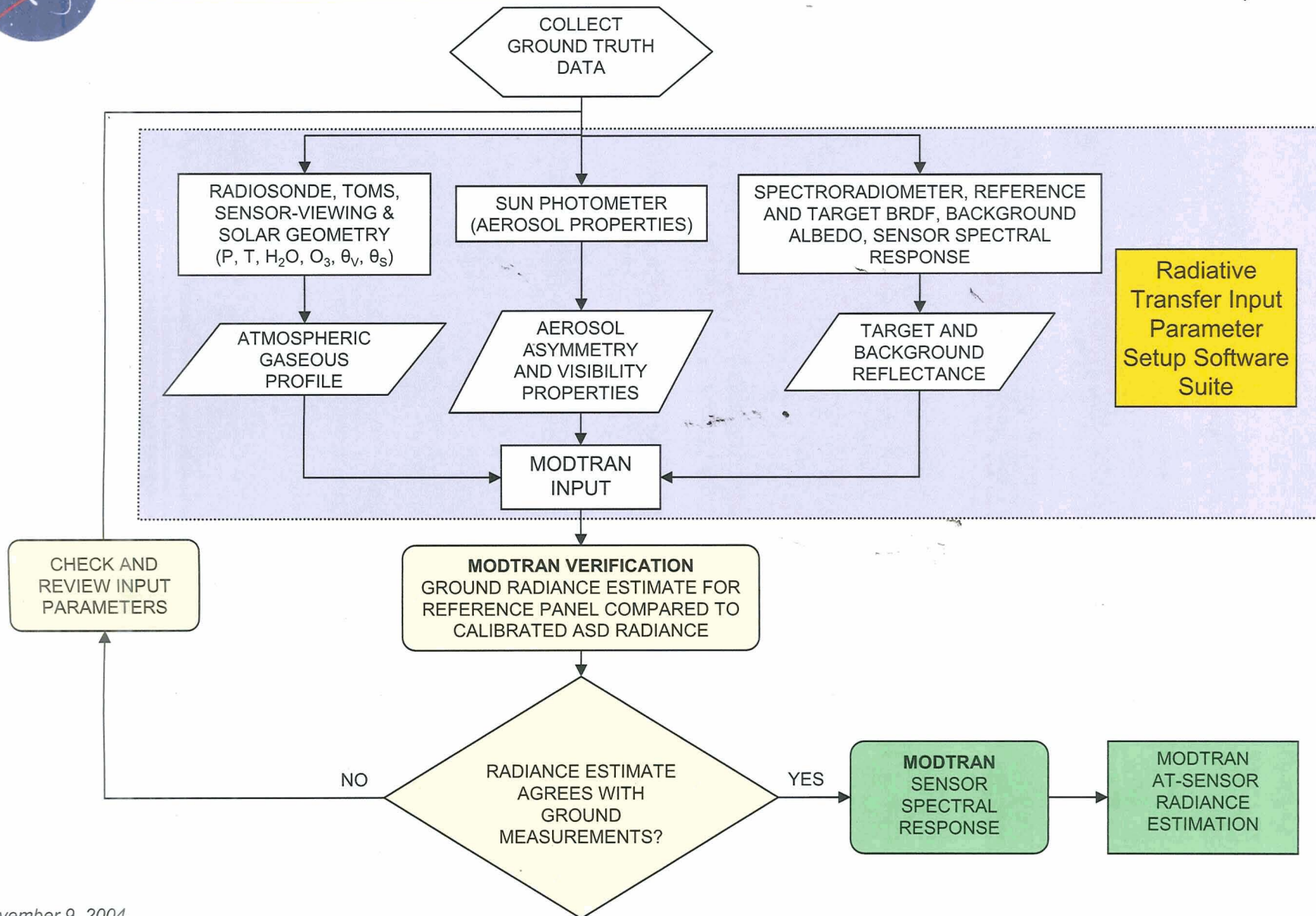
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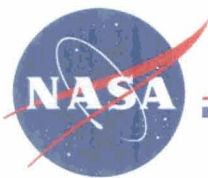
- Reflectance-based approach
 - Ground truth collection
 - Characterize target reflectance at time of satellite overpass
 - Measurements taken of target area and a 99% reflectance Spectralon® panel (Jackson BRDF model)
 - Laboratory measurements of target BRDF
 - Characterize atmosphere at time of satellite overpass
 - Radiosonde data used to determine Rayleigh scattering and water vapor 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



At-Sensor Radiance Prediction Method

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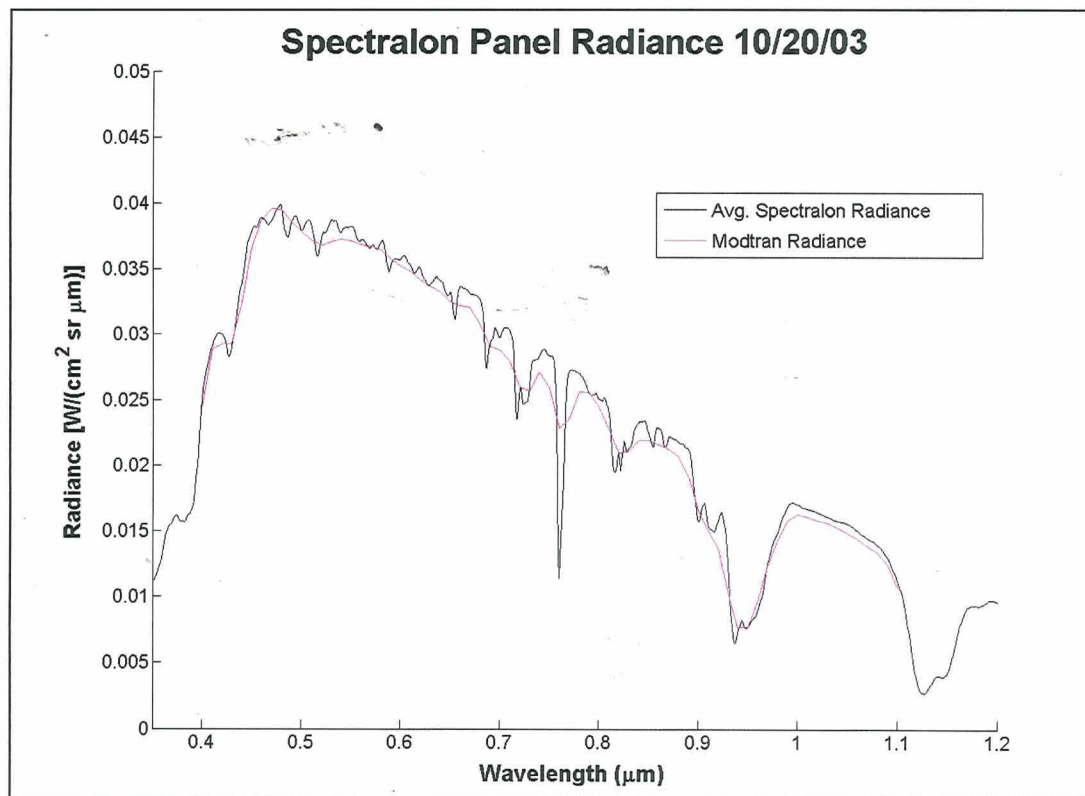
Comparison to Spectralon Panel

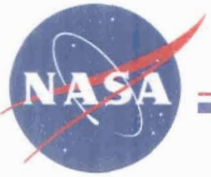
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- Verification of parameters used to generate MODTRAN at-sensor radiance estimate
 - Measuring the radiance of Spectralon panel with a well-calibrated spectroradiometer is a way of measuring atmospheric global and diffuse irradiance
 - Use ground truth data and geometry modeling an ASD FieldSpec FR spectroradiometer measuring a 99% reflectance Spectralon panel as input to MODTRAN to predict radiance
 - Compare MODTRAN-calculated radiance to actual radiance measured from Spectralon panel to verify the atmospheric model



November 9, 2004





Ground Truth Data Collections

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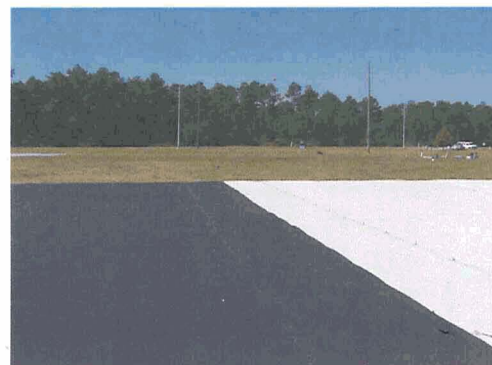
- Ground truth data collection occurred at five sites over the 2003-2004 season
 - Data collections by University of Arizona (described in previous presentation)
 - White Sands Missile Range, NM
 - Ivanpah Playa, CA
 - Railroad Valley, NV
 - Data collections by NASA
 - Stennis Space Center, MS (SSC)
 - Data collections by South Dakota State University
 - Brookings, SD



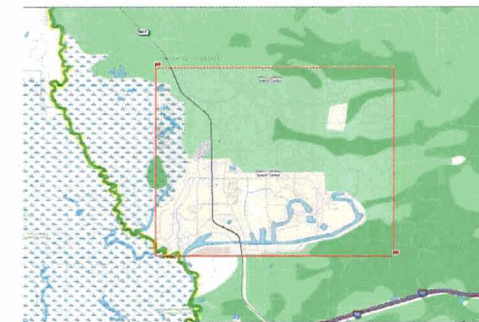
NASA Stennis Space Center, MS

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- **Site:** Scattered buildings within a heavily wooded area; manmade reservoirs and canals
- **Elevation:** 5.5–10 m
- **Centerpoint:** 30.356° N, 89.62° W
- **In-situ Instrumentation:** Analytical Spectral Devices FieldSpec FR spectroradiometers, Yankee multifilter rotating shadowband radiometers (MFRSRs), automated solar radiometers (ASRs), Sippican radiosonde, full sky imager, 20-m x 20-m radiometric tarps, 99% reflectance Spectralon panels



General Scene



SSC Image Area
8.5 km x 8 km



OrbView-3 True-Color Imagery
September 28, 2003

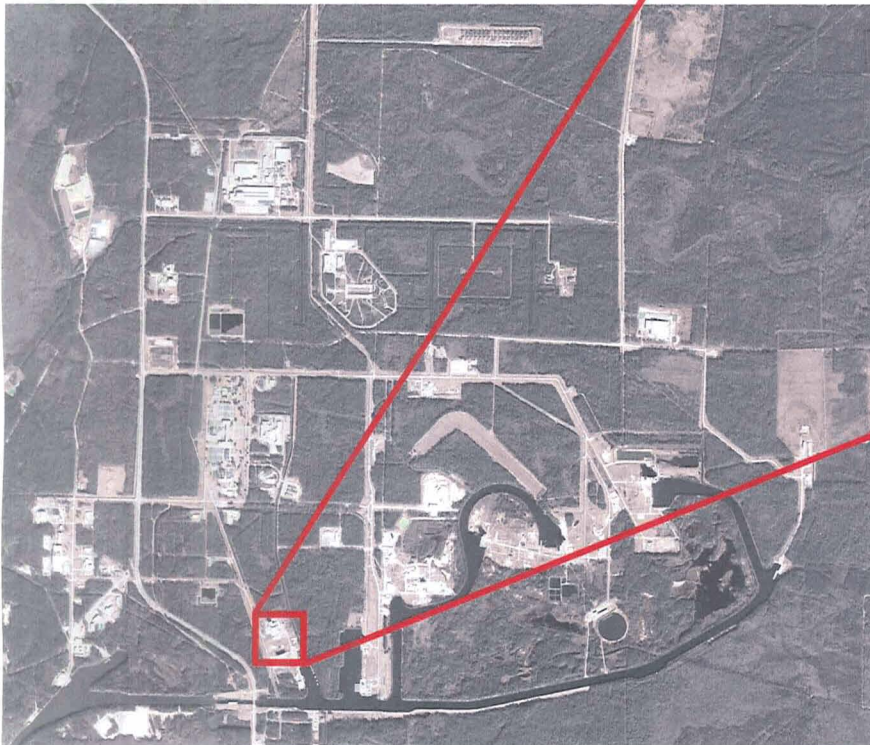
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NASA SSC Target Field

Stennis Space Center

QuickBird image acquired
January 10, 2004
True-Color Pan-Sharpned



November 9, 2004

Includes material © DigitalGlobe™

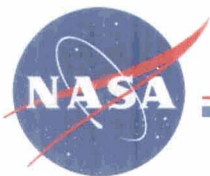


Radiometric Tarps

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- Four 20-m x 20-m tarps with reflectance values of approximately 3.5%, 22%, 34%, and 52% within spectral measurement range
- Peak-to-peak variation in reflectance less than 10% within any 100-nm spectral band within spectral measurement range
- Less than 10% variation in reflectance values when measuring tarps from 10° to 60° off axis within spectral measurement range
- Spectral measurement range of 400 to 1050 nm
- Each side is straight to within ± 6.0 cm over the 20-m length
- Each tarp has 60 square witness samples measuring 30.5 cm x 30.5 cm



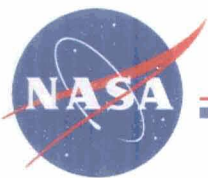


ASD FieldSpec FR Spectroradiometer Measurements

Stennis Space Center



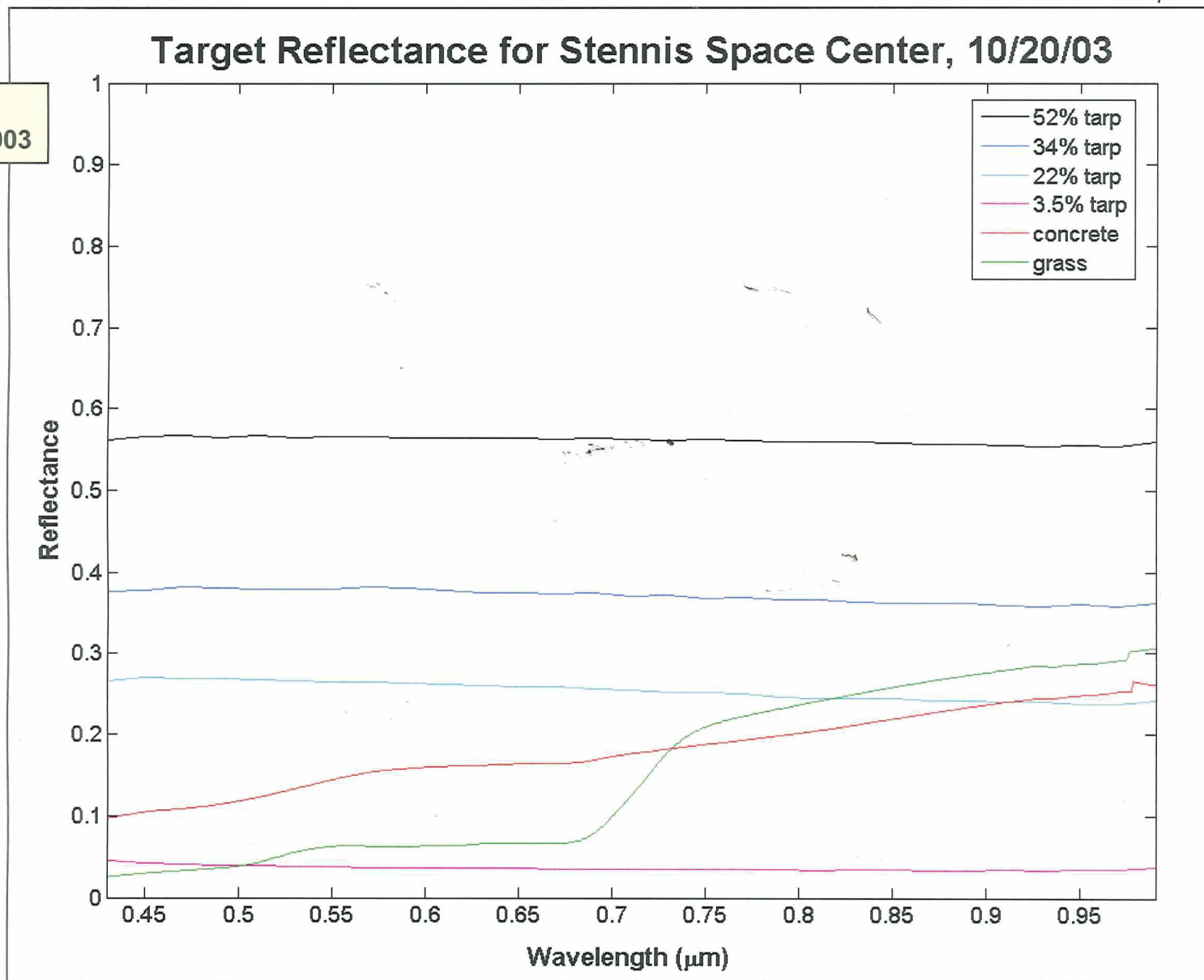
- Measurements of several target areas were taken
 - ~35-m x 15-m area of a grassy field
 - ~30-m x 20-m area of a concrete parking lot
 - Up to four 20-m x 20-m radiometric tarps (3.5%, 22%, 34%, and 52% reflectance)
- Measurements were taken along transect lines (grass and concrete) or tarp perimeter
 - All measurements were taken while walking to increase spatial averaging
 - Periodic Spectralon panel measurements were taken
 - ASD FieldSpec FR spectroradiometer optimization and dark current measurements were taken before and during target measurements.
- All data were acquired within 30 minutes of satellite overpass

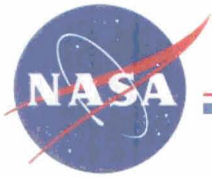


Spectroradiometer Data

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NASA SSC
October 20, 2003





Atmospheric Measurements

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- Solar irradiance data collected from early morning through post-sensor acquisition
 - One MFRSR and one ASR acquired data from the measurement field
 - One MFRSR acquired data from a building rooftop approximately 2 miles away
- Radiosonde launched near satellite overpass time
 - Data acquired up to 3 km on 9/28/03
 - Data acquired over 20 km on 10/20/03 and on 1/10/04



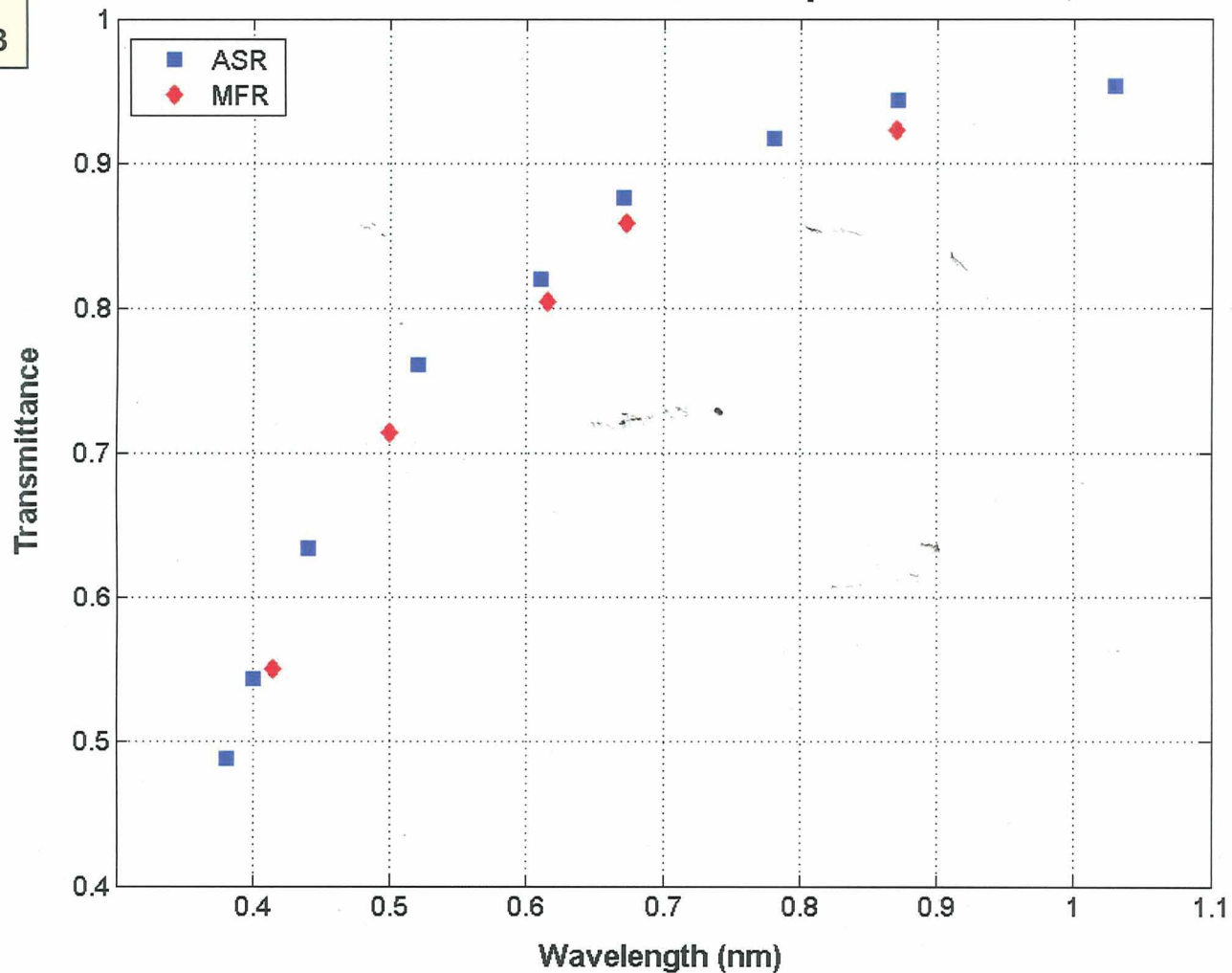


ASR/MFRSR Transmission Values

Stennis Space Center

NASA SSC
October 20, 2003

Transmission Values for Stennis Space Center, 10/20/03

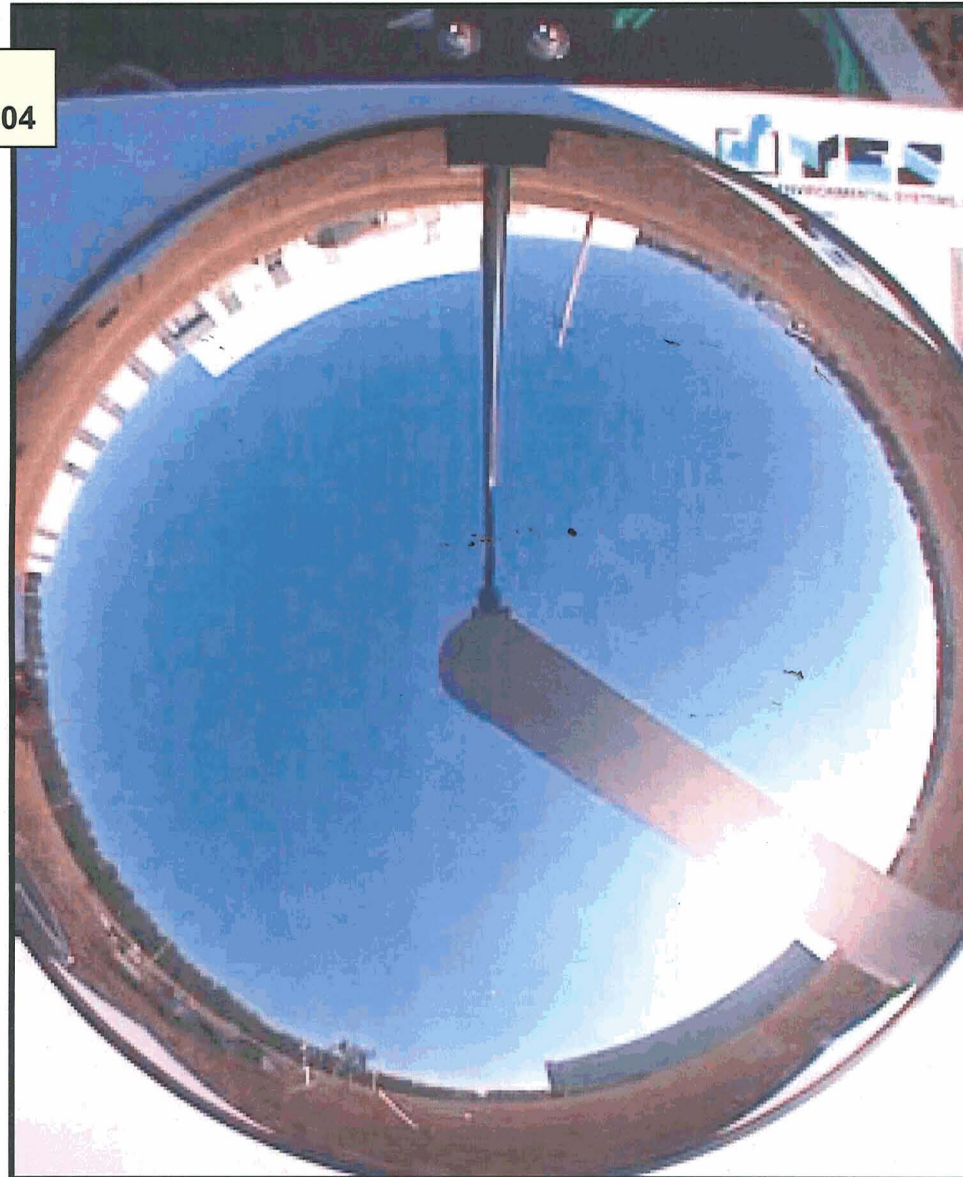




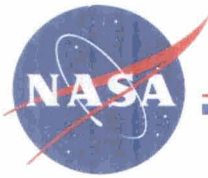
Full Sky Imager

Stennis Space Center

NASA SSC
January 10, 2004



November 9, 2004



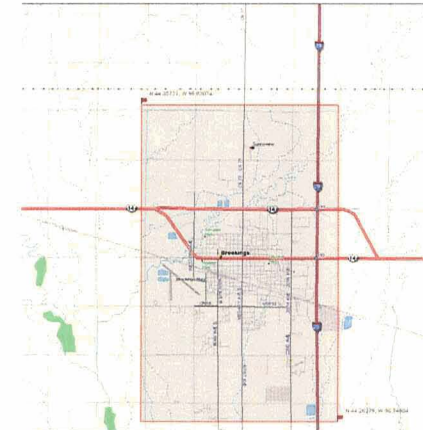
Brookings, South Dakota

Stennis Space Center

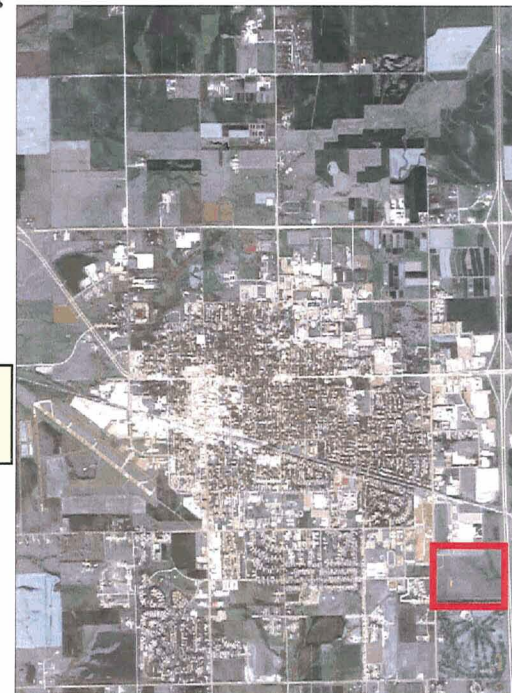
- **Site:** Grass field beside 3M plant on the outskirts of the city of Brookings
- **Elevation:** approx. 500 m
- **Centerpoint:** 44.3° N, 96.8° W
- ***In-Situ* Instrumentation:** ASD FieldSpec FR spectroradiometers, Yankee MFRSRs, automated solar radiometer, 20-m x 20-m radiometric tarps, 99% reflectance Spectralon panels



General Scene



Brookings Image Area
6.5 km x 10.5 km



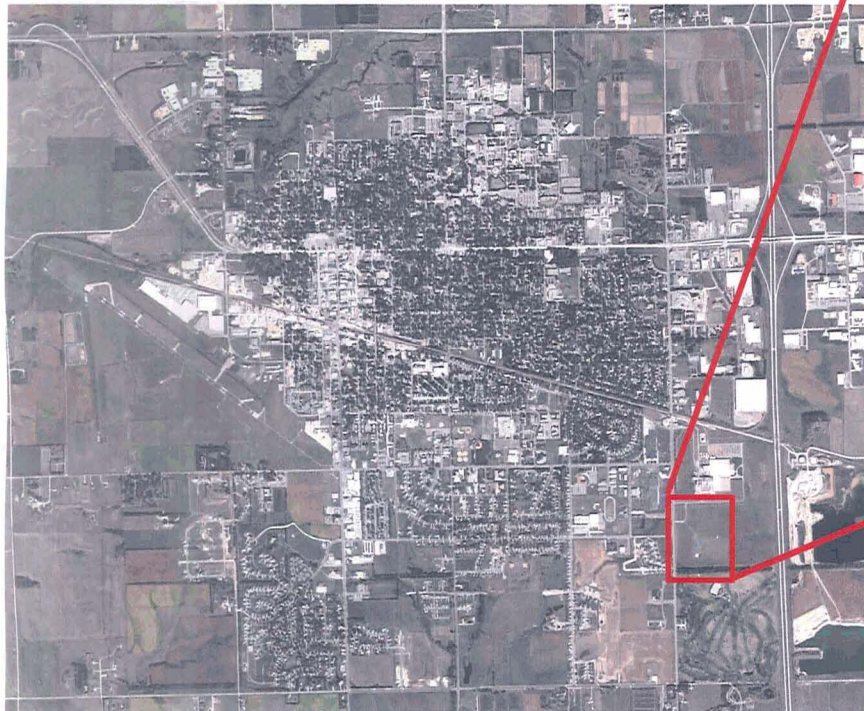
QuickBird Imagery
August 23, 2003



Brookings, SD, Target Field

Stennis Space Center

QuickBird image acquired
September 15, 2003
True-Color Pan-Sharpened



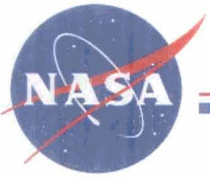


ASD FieldSpec FR Spectroradiometer Measurements

Stennis Space Center

- ASD FieldSpec FR spectroradiometer measurements of several targets were taken
 - ~150-m x 150-m area of a grassy field
 - Two 20-m x 20-m radiometric tarps (3.5% and 52% reflectance) for the 9/15/03 collect
- Measurements were taken along transect lines (grass) or tarp perimeter
 - All measurements were taken while walking to increase spatial averaging
 - Periodic Spectralon panel measurements were taken
 - Before and during target measurements, the instrument was optimized and dark current measurements were made
- All data were acquired within 30 minutes of satellite overpass

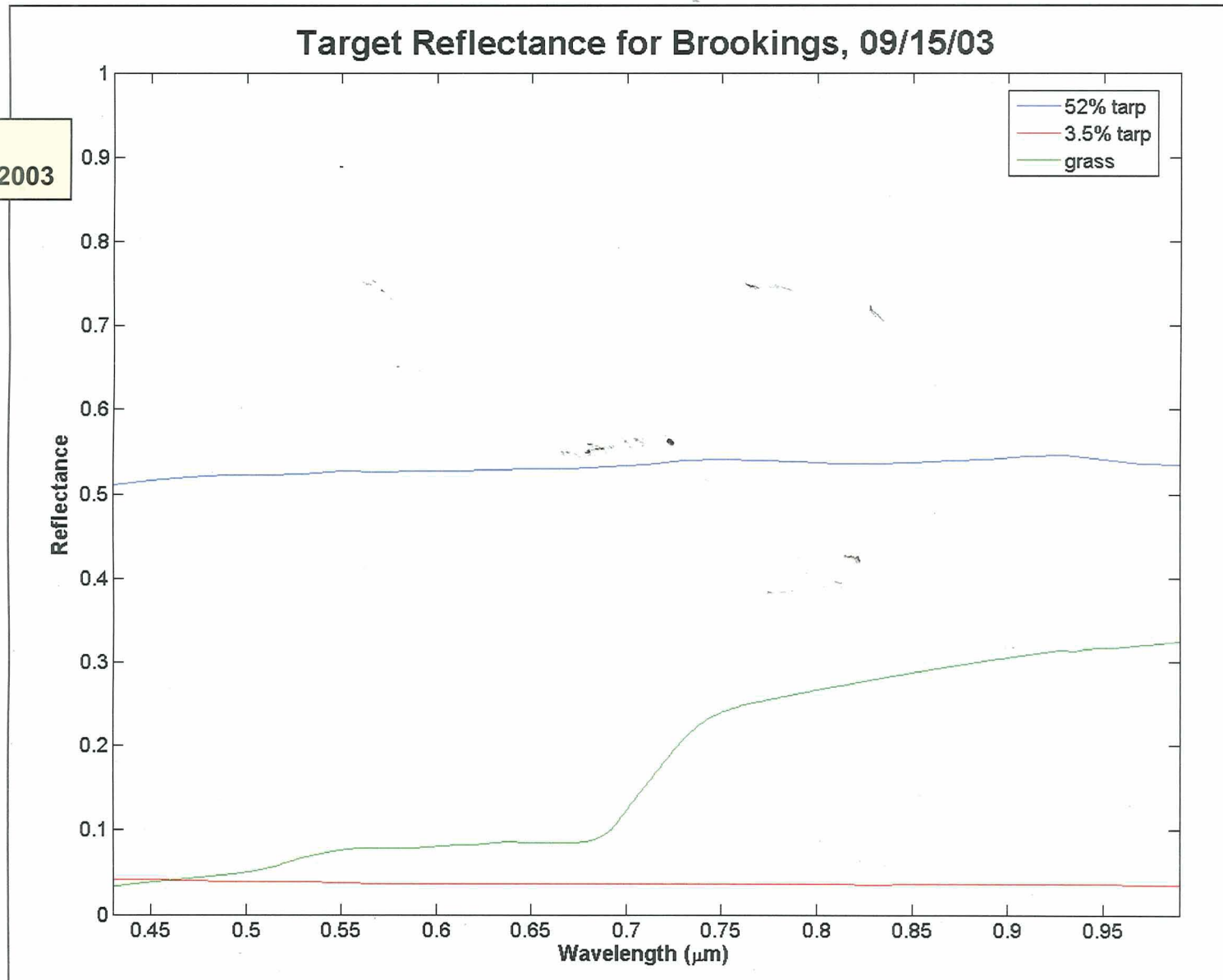


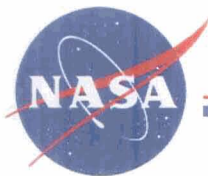


Spectroradiometer Data

Stennis Space Center

Brookings, SD
September 15, 2003

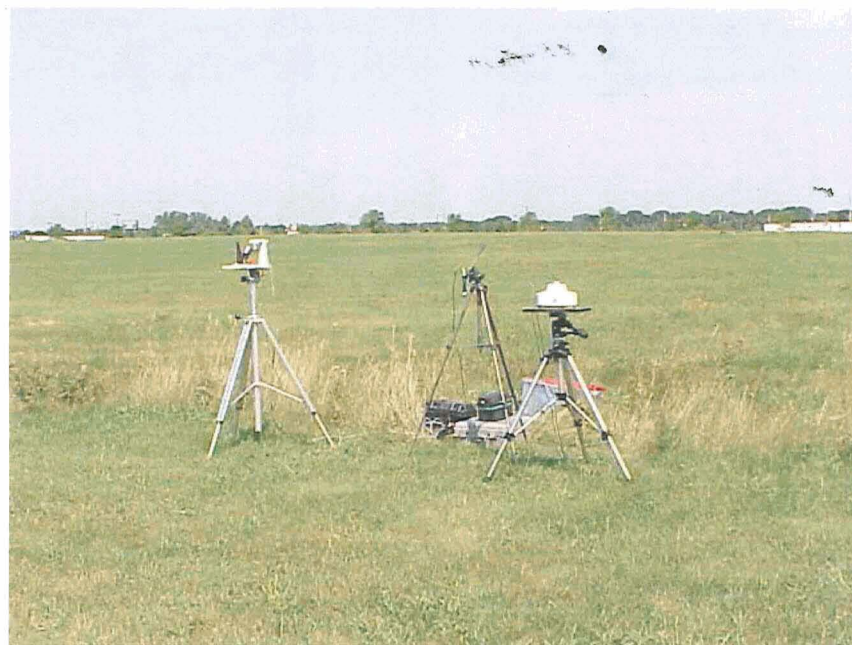


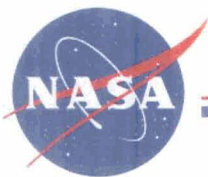


Atmospheric Measurements

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- Solar irradiance data collected from early morning through post-sensor acquisition
 - Two MFRSRs acquired data in the measurement field
 - One ASR was used on 8/23/03; two ASRs were used on 9/15/03 and on 10/20/03 to acquire data in the measurement field

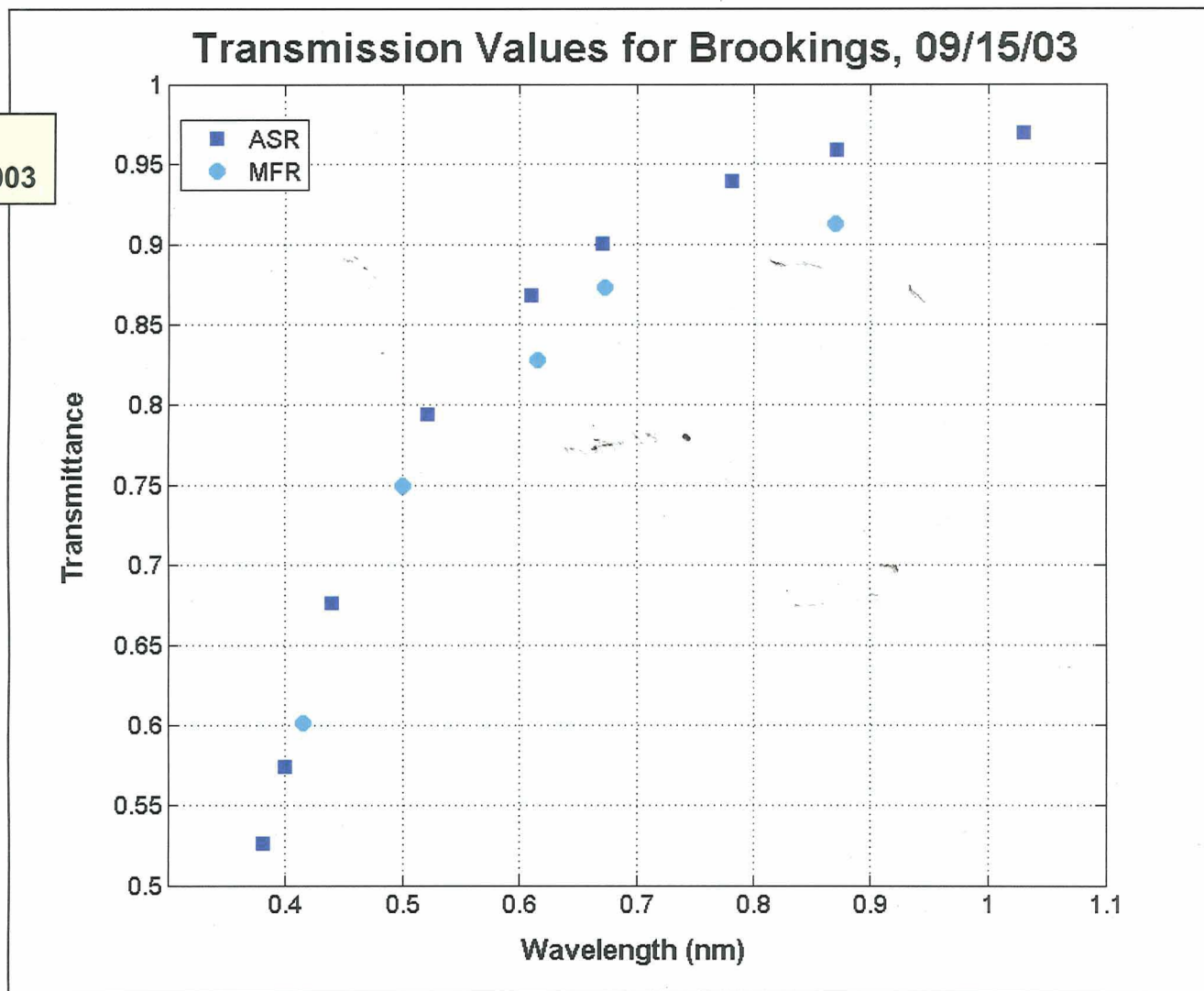


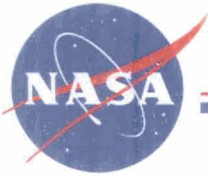


ASR/MFRSR Transmission Values

Stennis Space Center

Brookings, SD
September 15, 2003





Additional Data Processing

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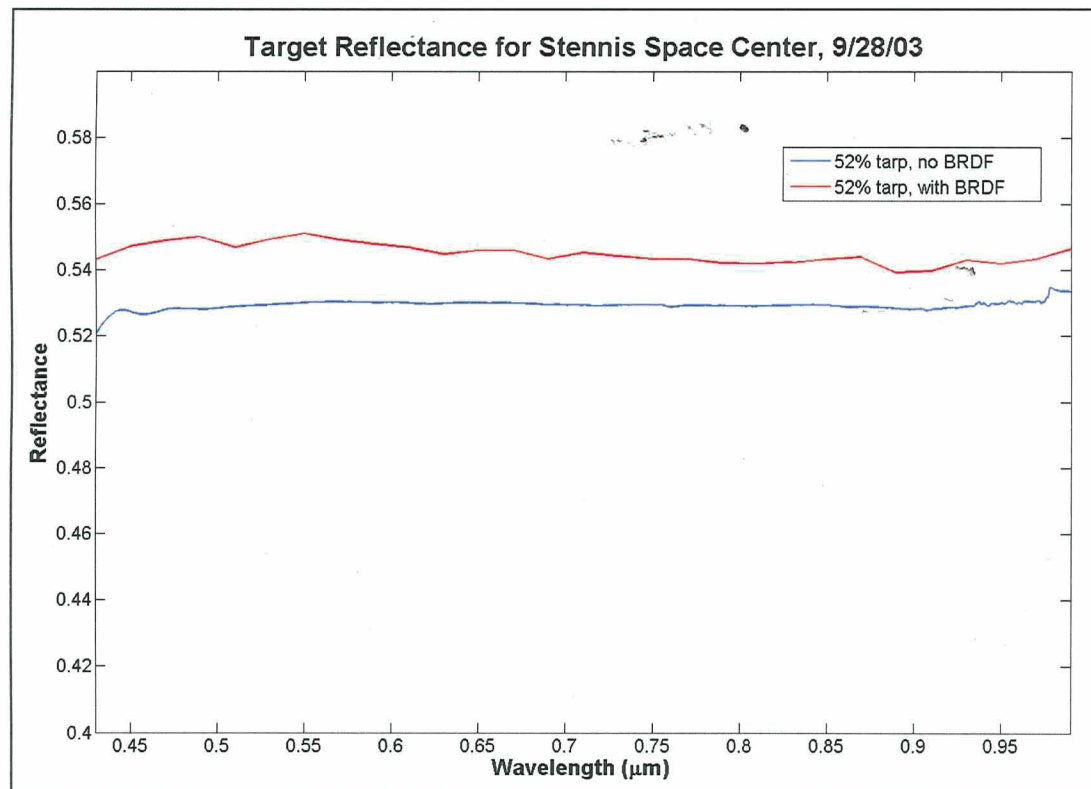
- Data processing to calculate additional MODTRAN input parameters
 - Incorporation of laboratory-measured target BRDF
 - Estimation of visibility
 - Estimation of aerosol asymmetry

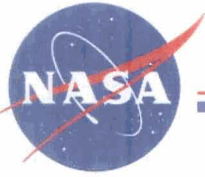


BRDF Correction

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- BRDF of radiometric tarp witness samples measured in laboratory
 - Witness samples removed from tarps after ground truth data collection
 - Sun and satellite geometry recreated in the laboratory to determine BRDF correction factors for each radiometric tarp
- Calculated correction factors incorporated into reflectance data files



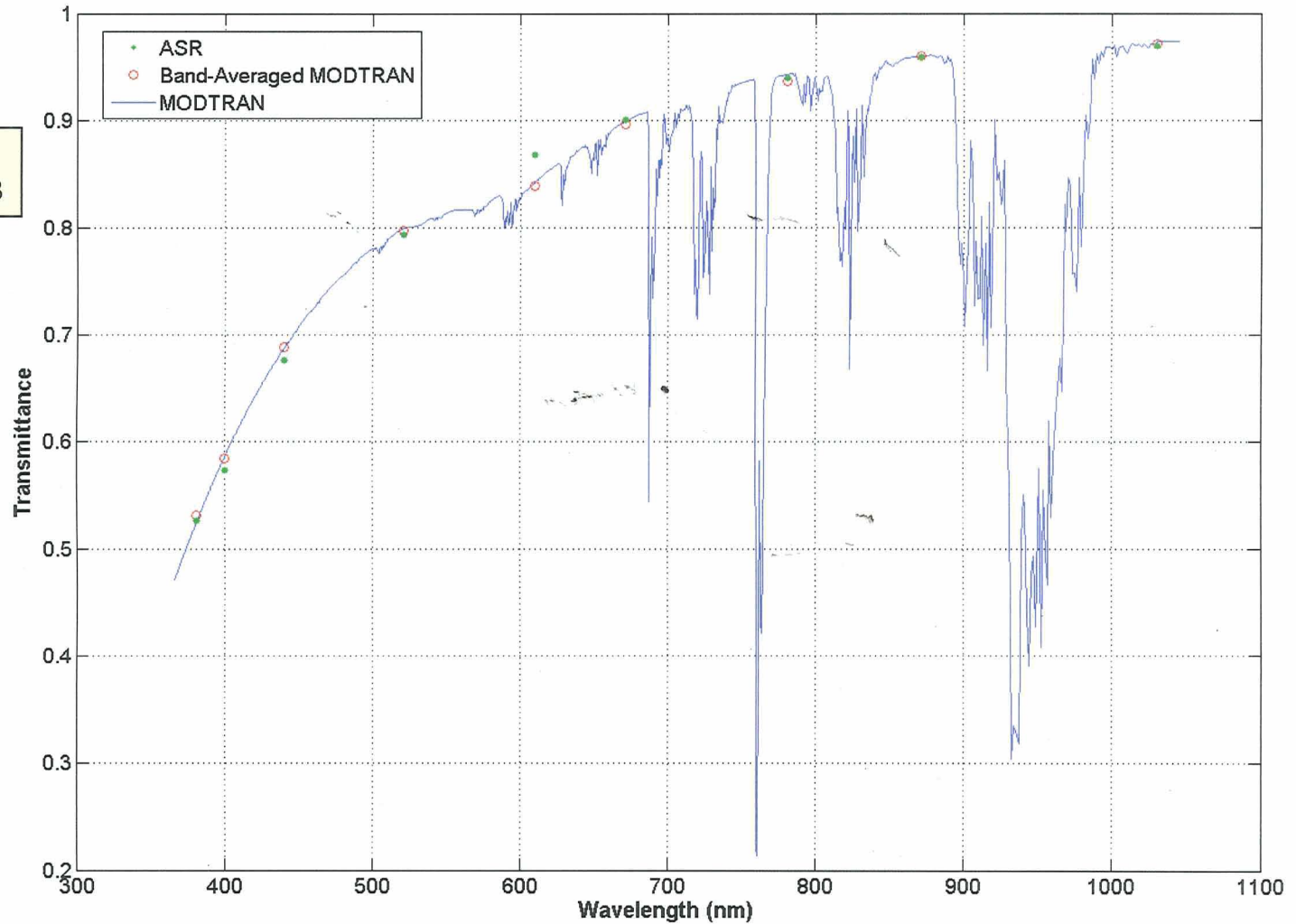


Visibility Estimation

Stennis Space Center

Brookings, SD
September 15, 2003

ASR and MODTRAN Predicted Transmissions for Brookings, 09/15/03





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

