Radiometric Calibration of Ikonos by University of Arizona Remote Sensing Group

K. J. Thome
Remote Sensing Group, Optical Sciences Center
University of Arizona
Tucson, Arizona 85721

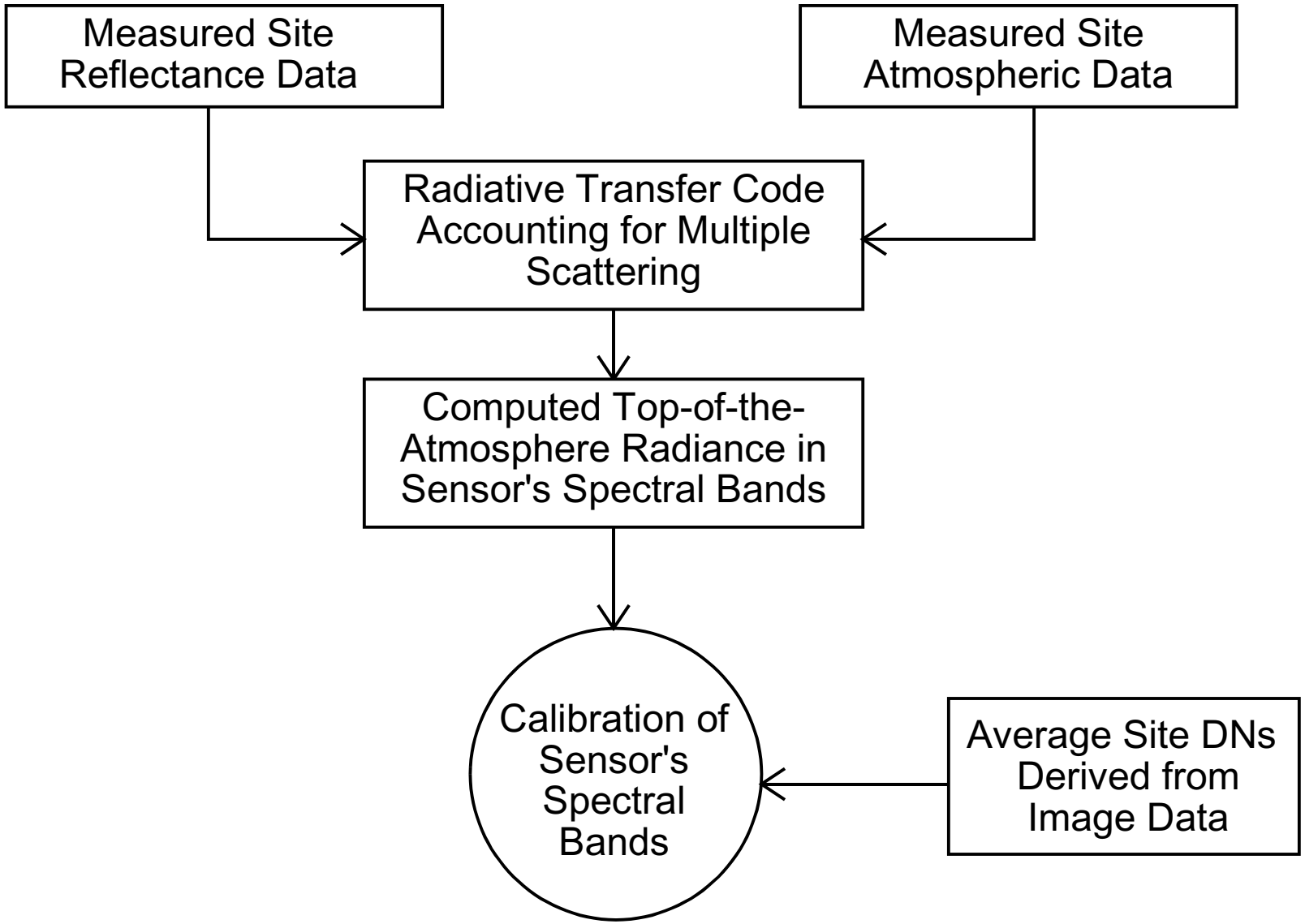
Presented to
High Spatial Resolution Commercial Imagery Workshop

March 19-21, 2001
Greenbelt, Maryland

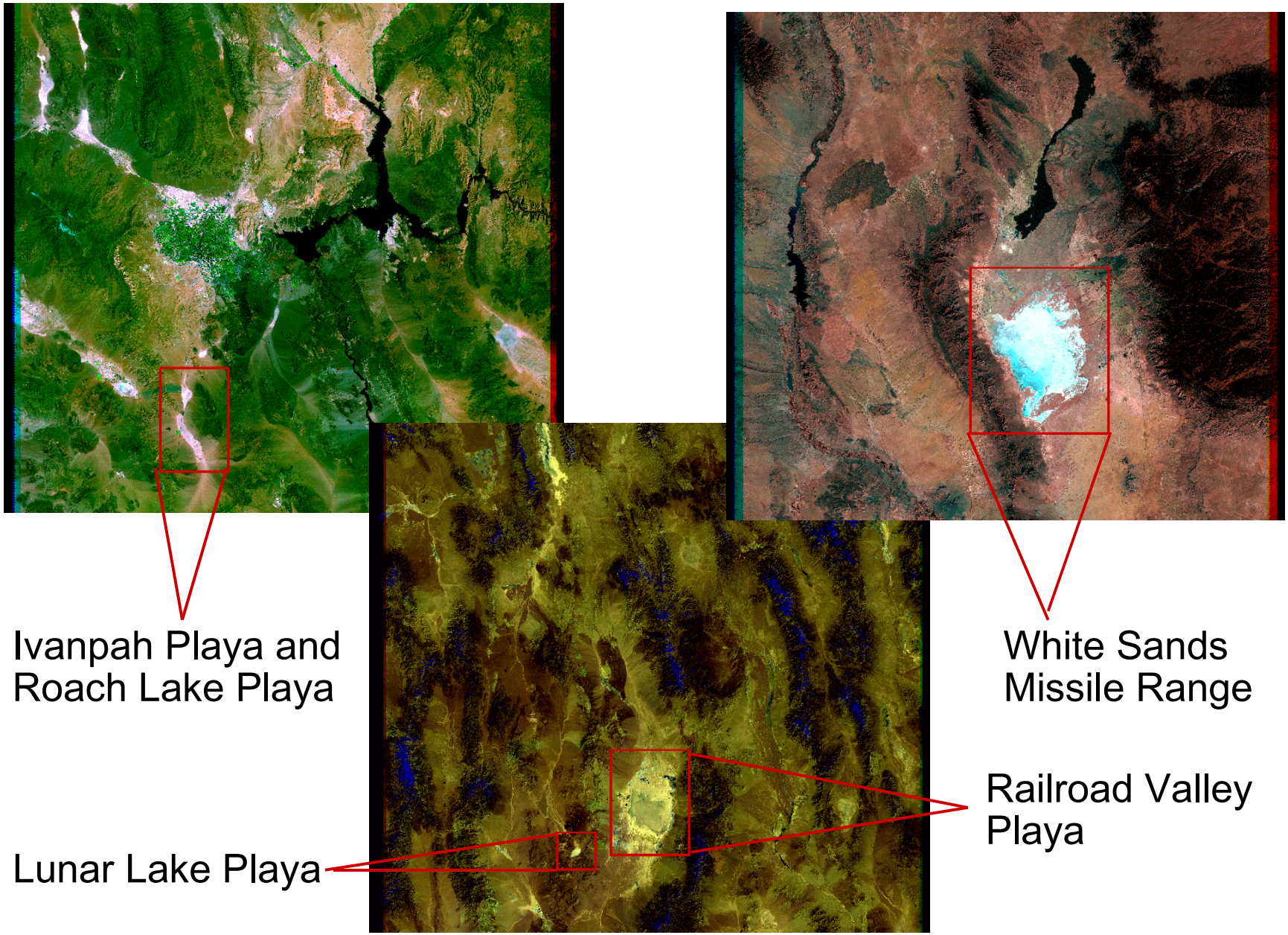
Introduction

- Describe the reflectance-based results for the multi-spectral bands of Ikonos
  - Brief description of the method
  - Test sites used
- Results
  - Six data sets from 2000
    - May 26 - White Sands Missile Range
    - June 7 - Lunar Lake Playa
    - June 7 - Railroad Valley Playa
    - June 10 - Lunar Lake Playa
    - June 10 - Railroad Valley Playa
    - July 21 - Ivanpah Playa
  - Summarize the atmospheric measurements
  - Reflectance results from the different test sites
- Show results from work with other sensors for comparison
  - Landsat-7 Enhance Thematic Mapper Plus (ETM+)
  - MODIS-ASTER (MASTER) airborne simulator -hyperspectral system

Reflectance-based approach



Test sites


Ivanpah Playa and
Roach Lake Playa
White Sands
Missile Range
Railroad Valley
Playa
Lunar Lake Playa

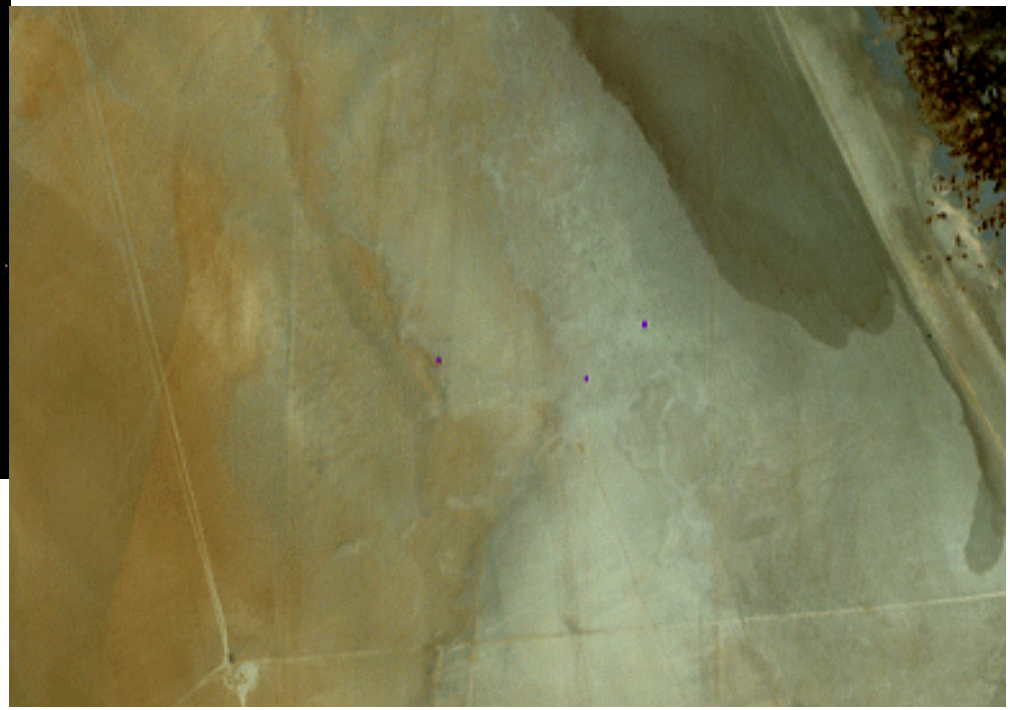
Ivanpah Playa, California

Dry lake on California-Nevada border

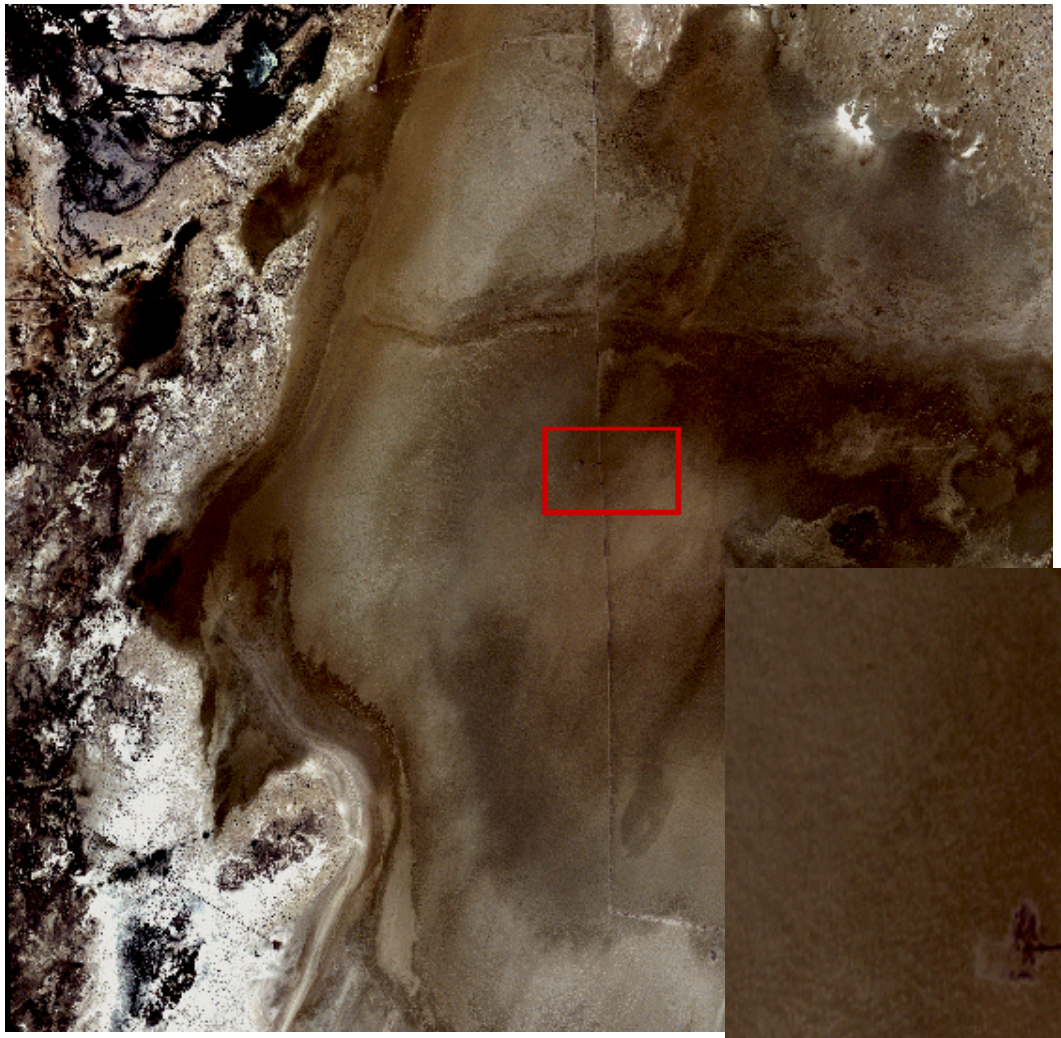
Interstate 15 traverses the lakebed

800 m elevation

3 km by 7 km in size



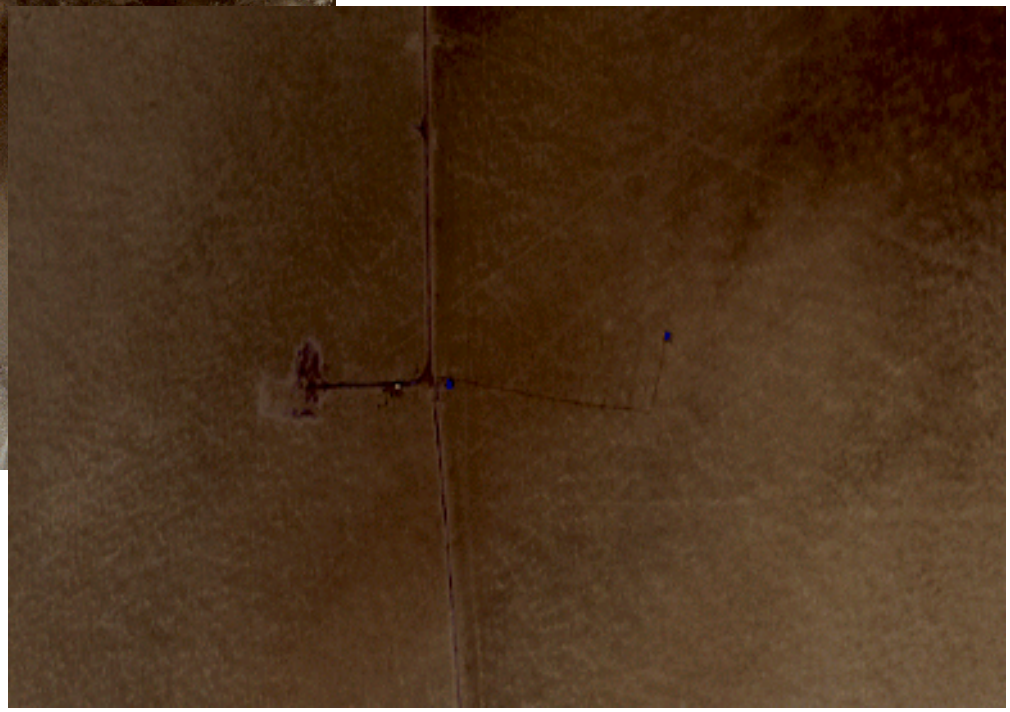
Railroad Valley Playa, Nevada



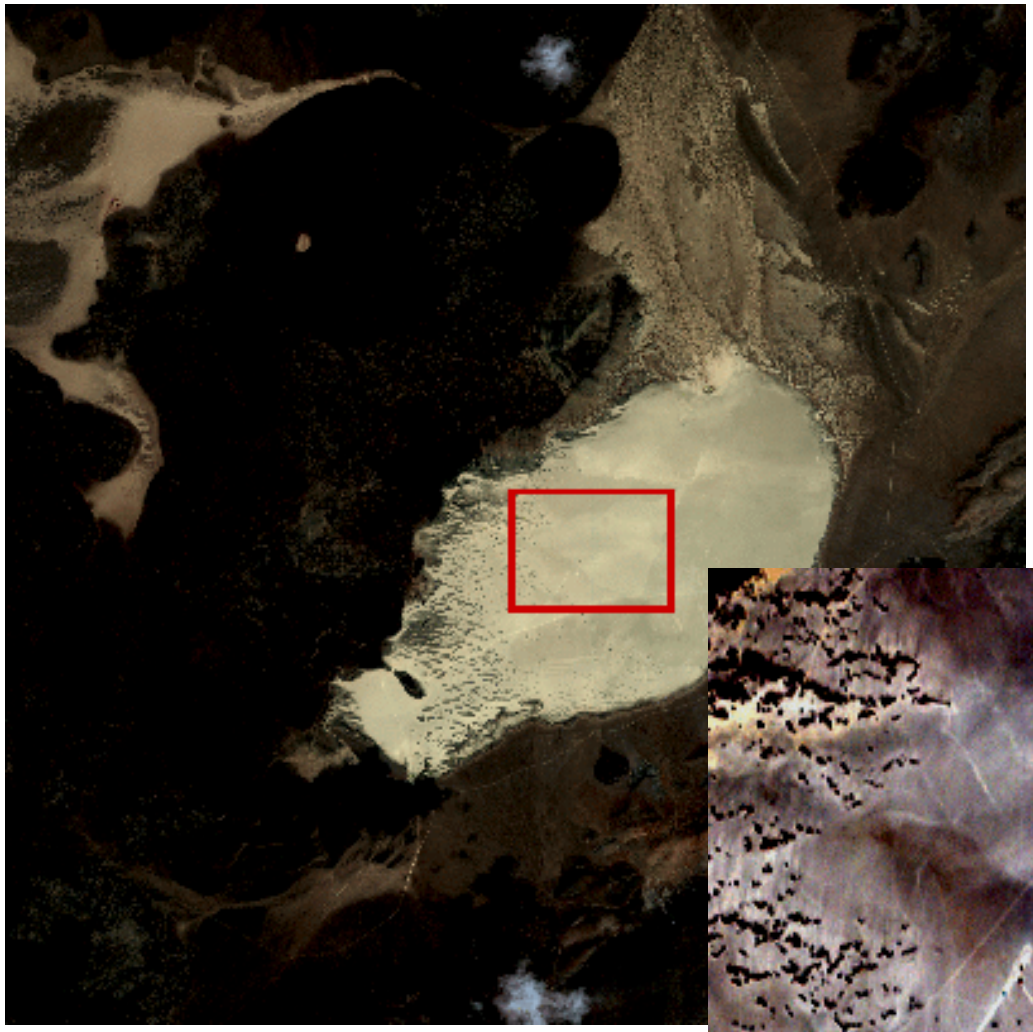
Dry lake in Central Nevada between Tonopah and Ely

1600 m elevation

15 km by 15 km in overall size



Lunar Lake Playa, Nevada

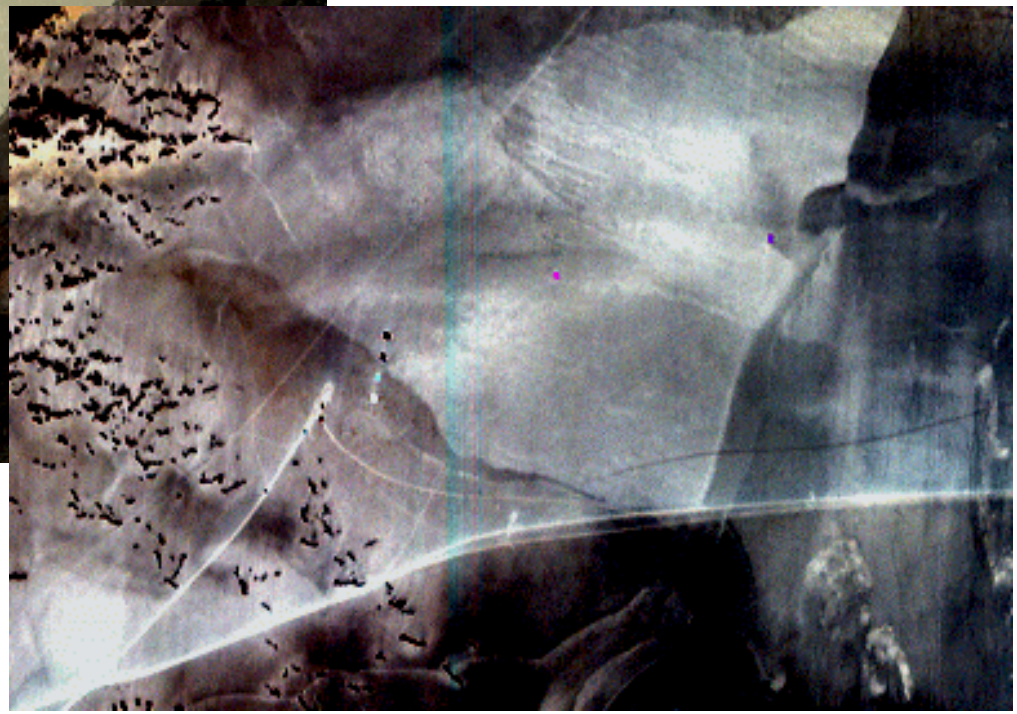


Dry lake in Central Nevada between Tonopah and Ely

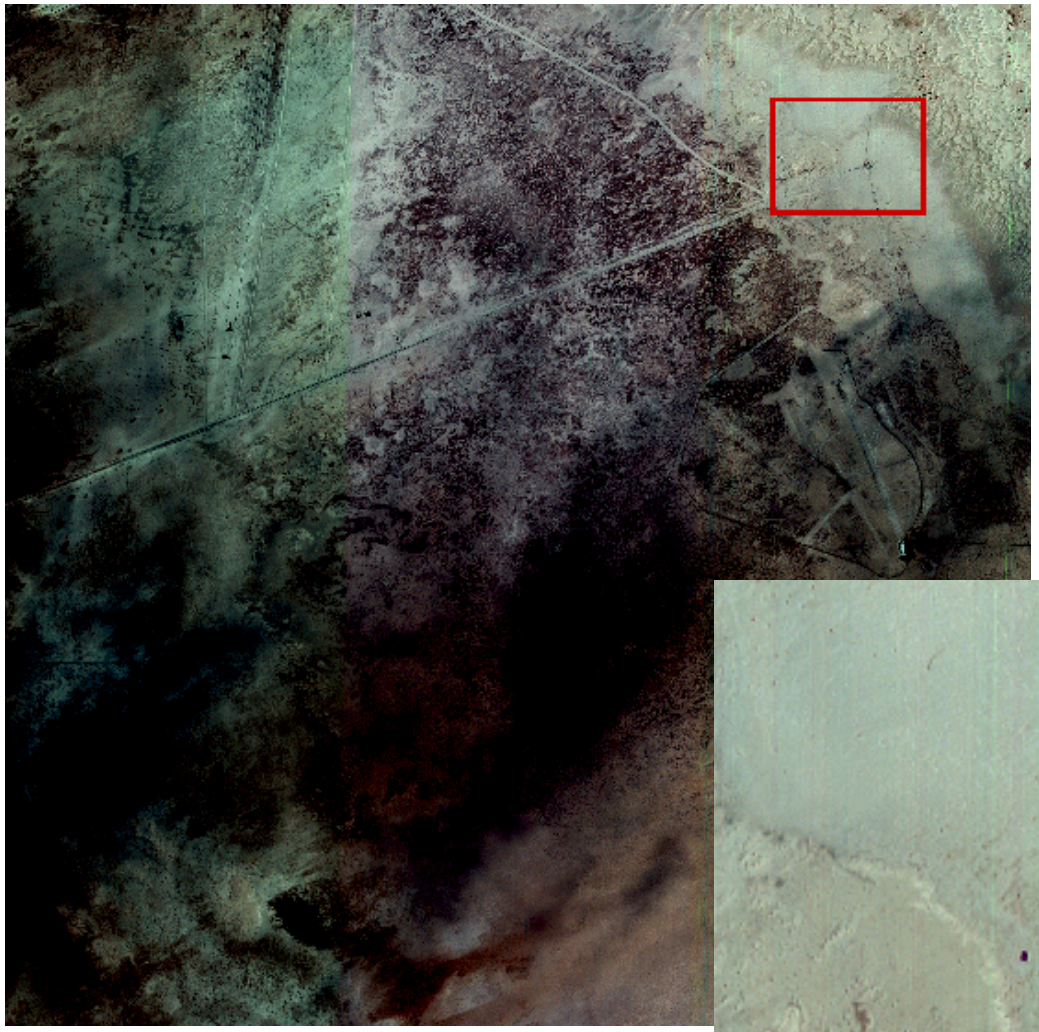
1800 m elevation

3 km by 5 km in size

Most uniform of test sites



White Sands Missile Range

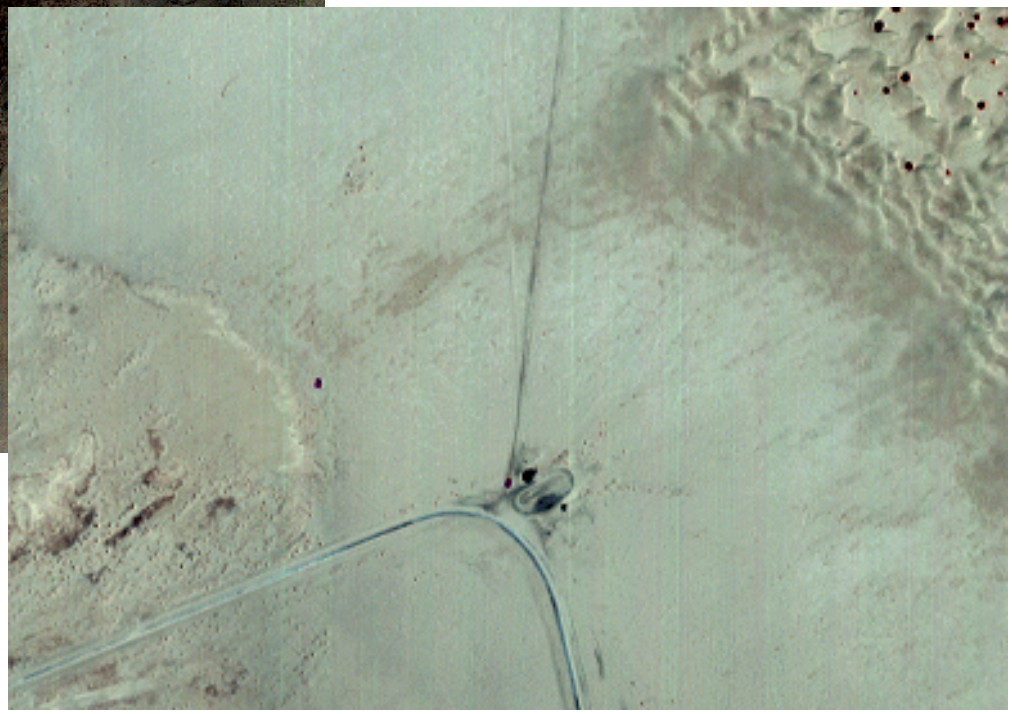


Alkali flats area of White Sands Missile Range in southeastern New Mexico

1200 m elevation

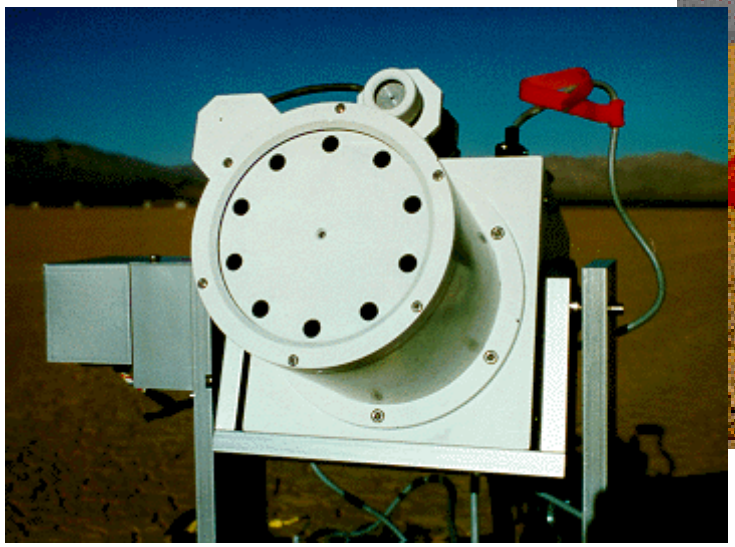
Gypsum surface

Overall size of region is 35 km by 50 km

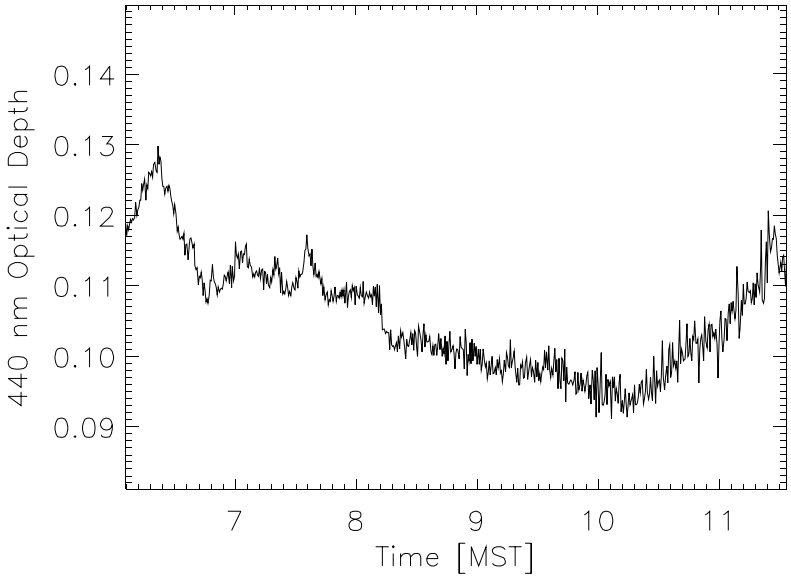


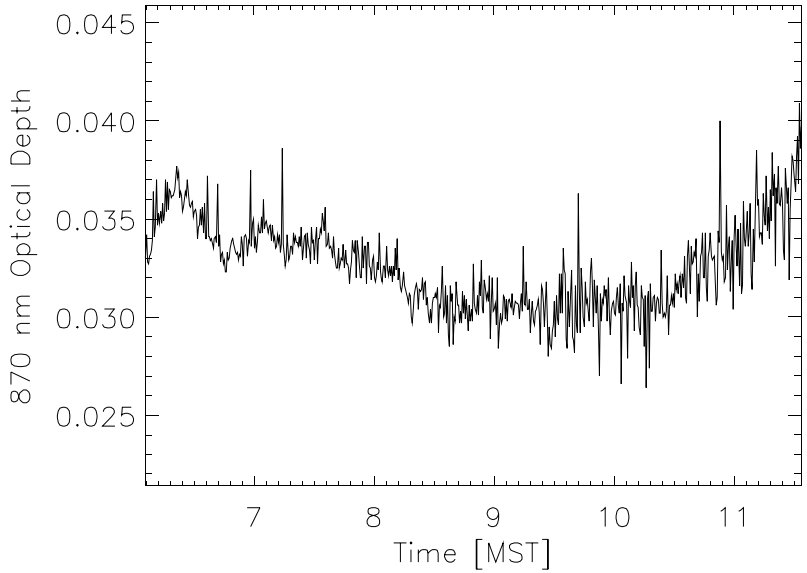
Atmospheric measurements

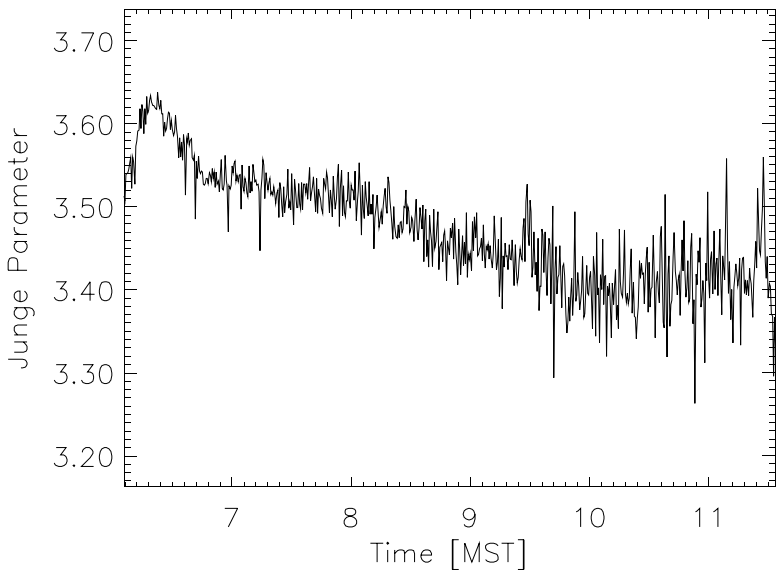
- Atmospheric measurements rely on a 10-band solar radiometer
  - Developed in the Electrical and Computer Engineering Department under supervision of John Reagan
  - Automated system with 10 separate detector/filter combinations in the visible and near-IR
- Measurements are used to retrieve spectral transmittance
- Spectral transmittanceis inverted to obtain
  - Aerosol loading
  - Aerosol size distribution
  - Column ozone
  - Column water vapor

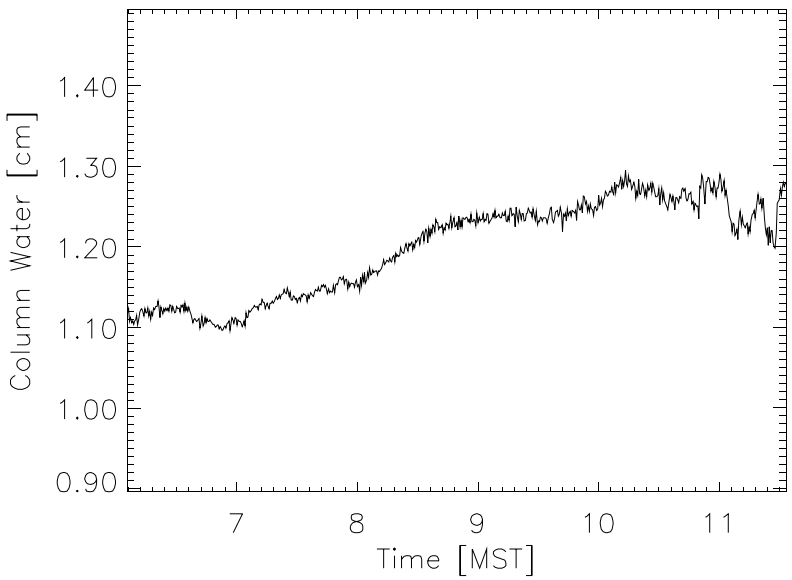


Atmospheric Results - RRV June 10, 2000

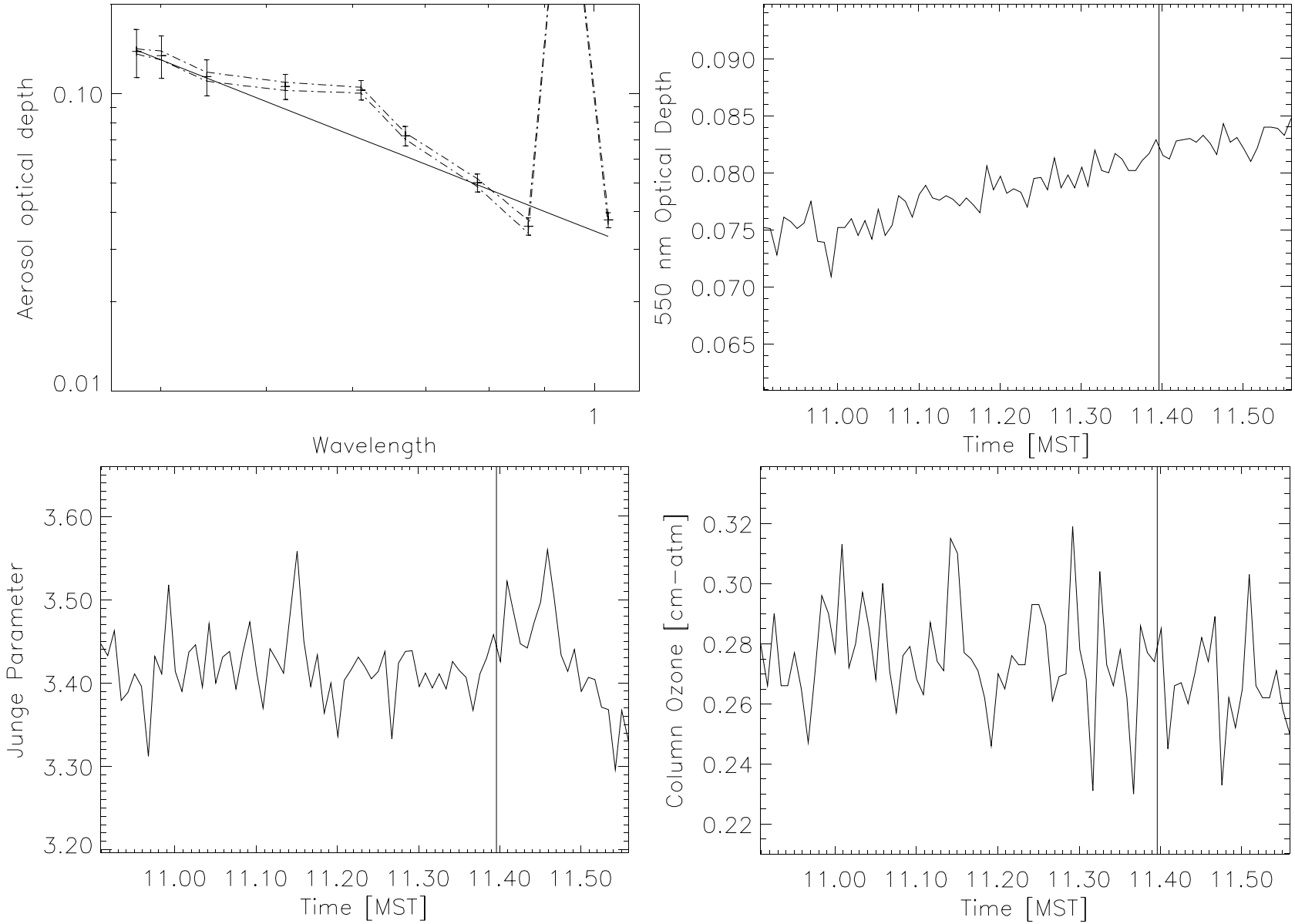




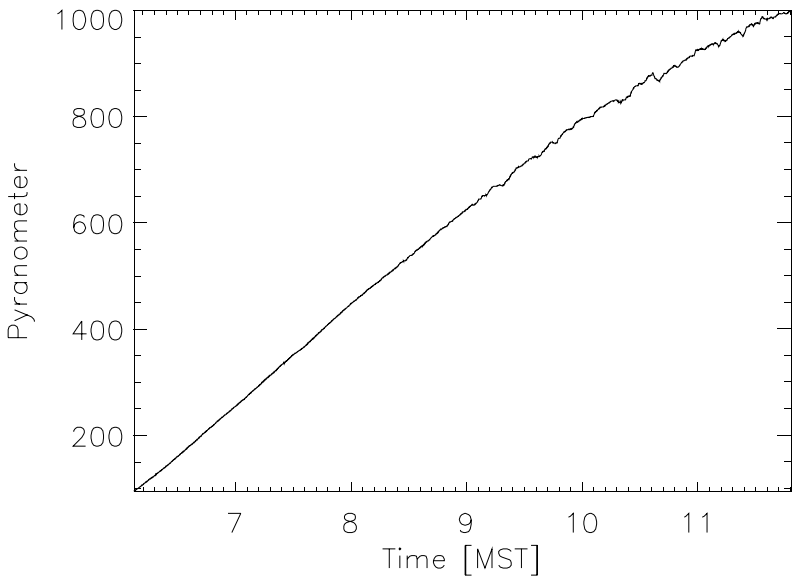


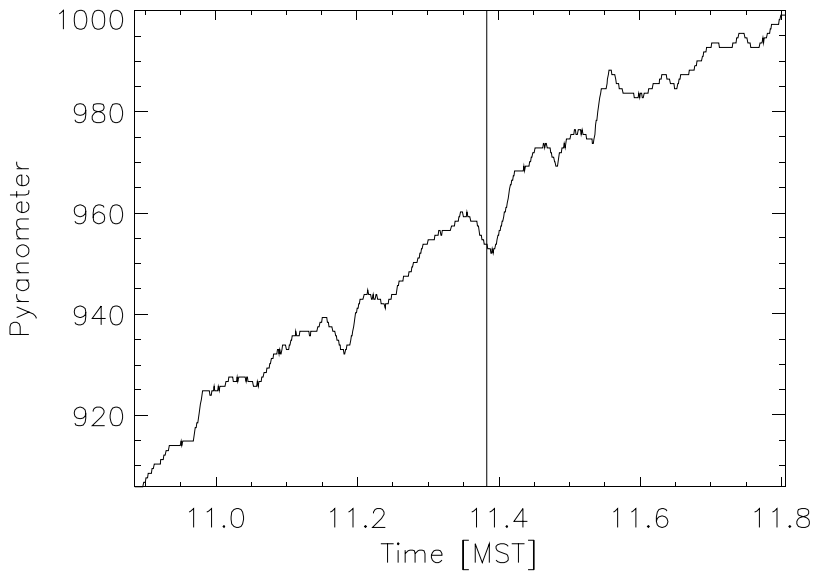


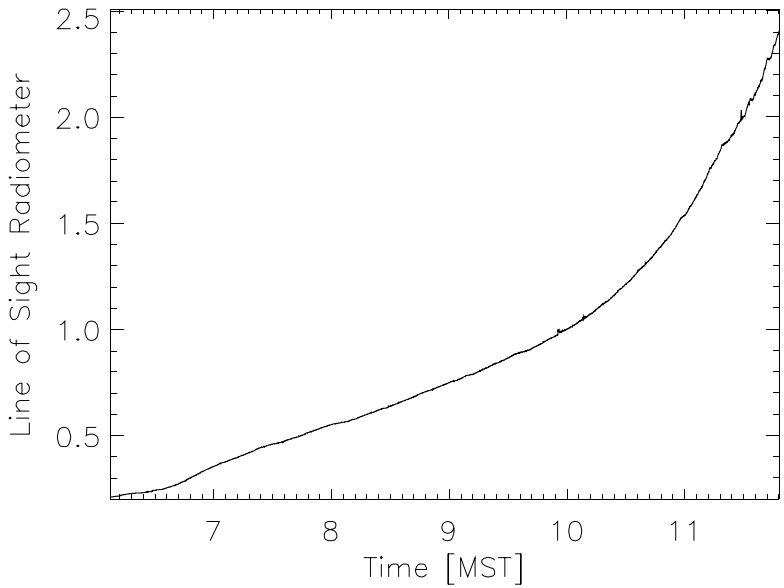
Atmospheric Results - RRV - June 10, 2000

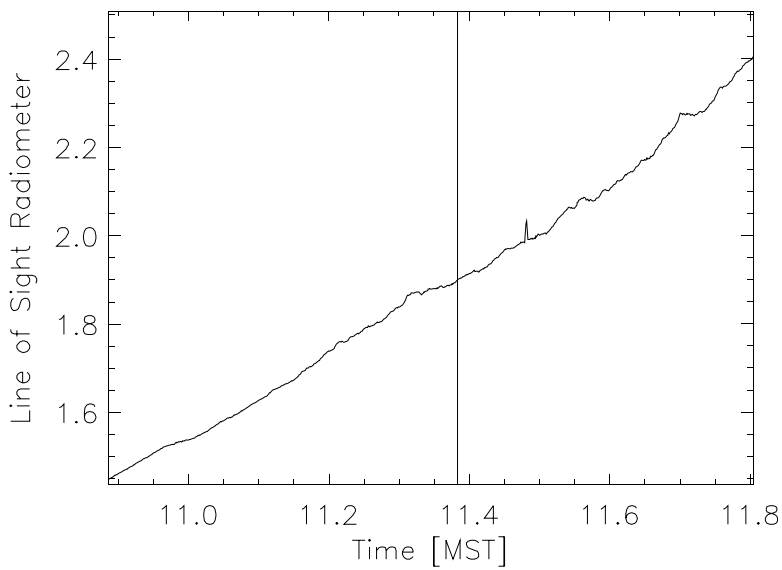


Atmospheric measurements - RRV June 10, 2000

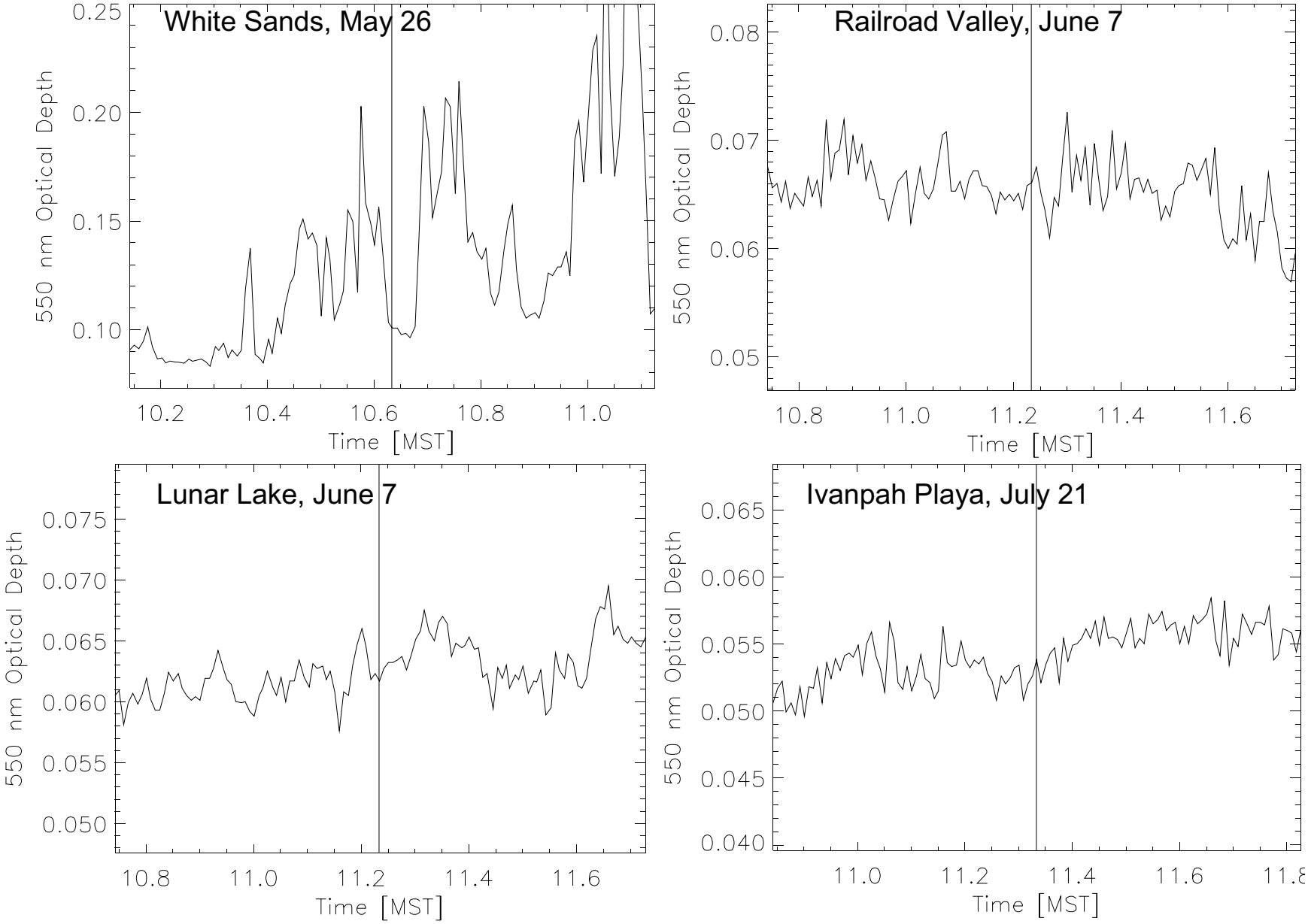




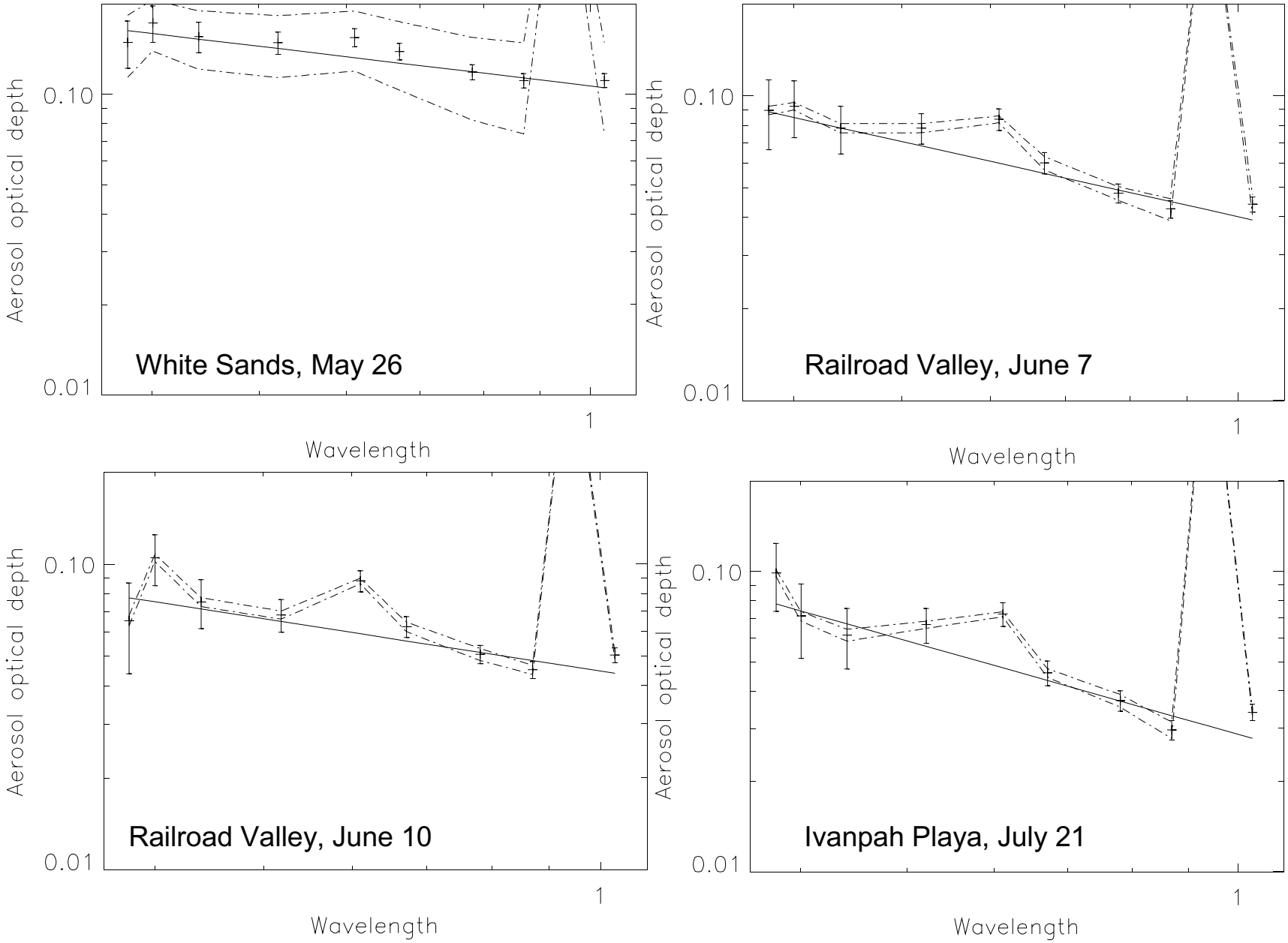




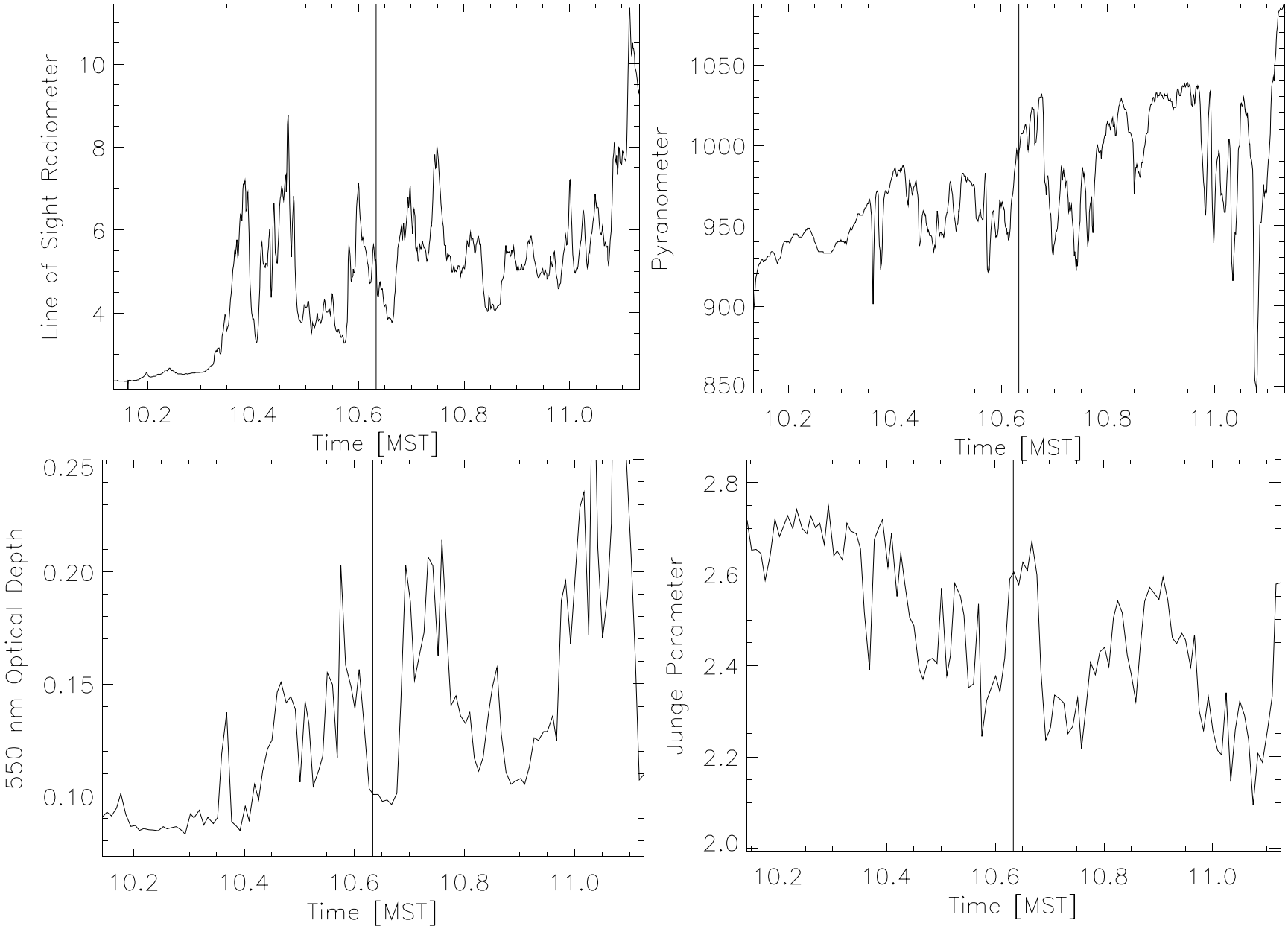
Atmospheric measurements - Comparison of days



Atmospheric measurements - Comparison of days



Atmospheric measurements - WSMR, 5/26

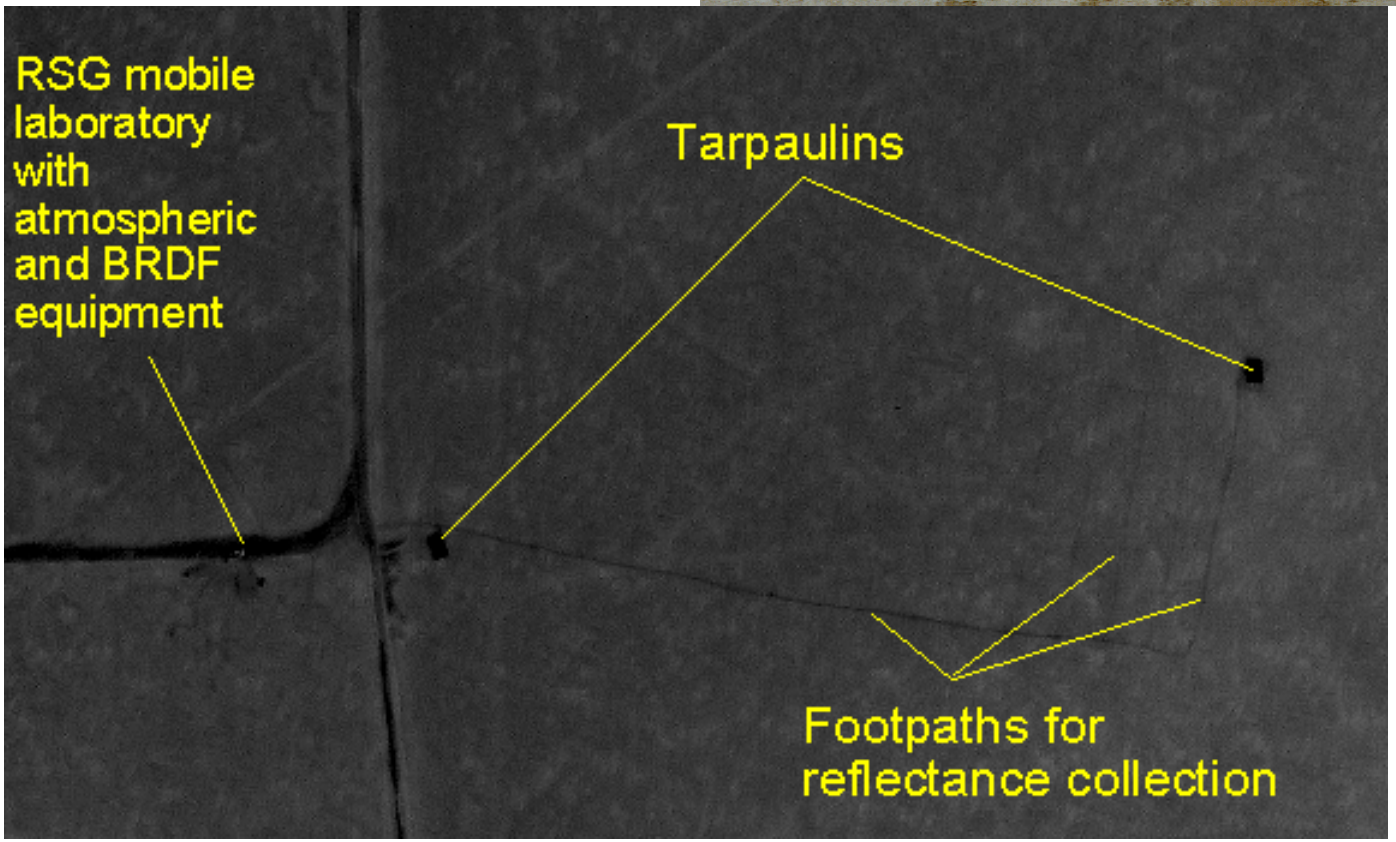


Surface reflectance measurements

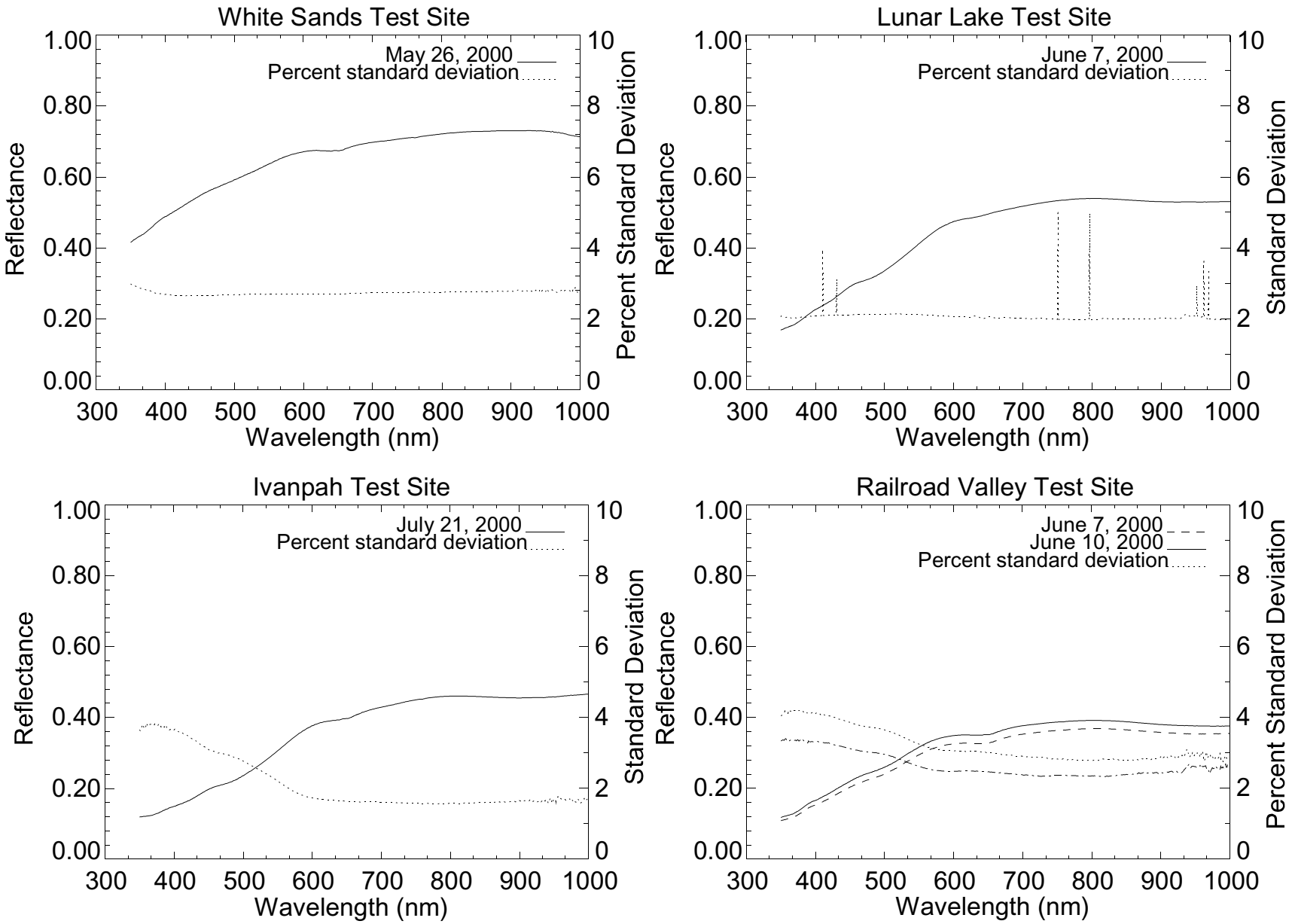
- Surface reflectance determined by referencing measurements of the upwelling radiance from the test site to those of a panel of known reflectance
  - Spectralon panel
  - Reflectance of Spectralon is characterized in the laboratory
- Radiometer is transported across the site while ollecting spectra
  - ASD FieldSpec FR
  - Samples radiance from 350-2500 nm

Test site example

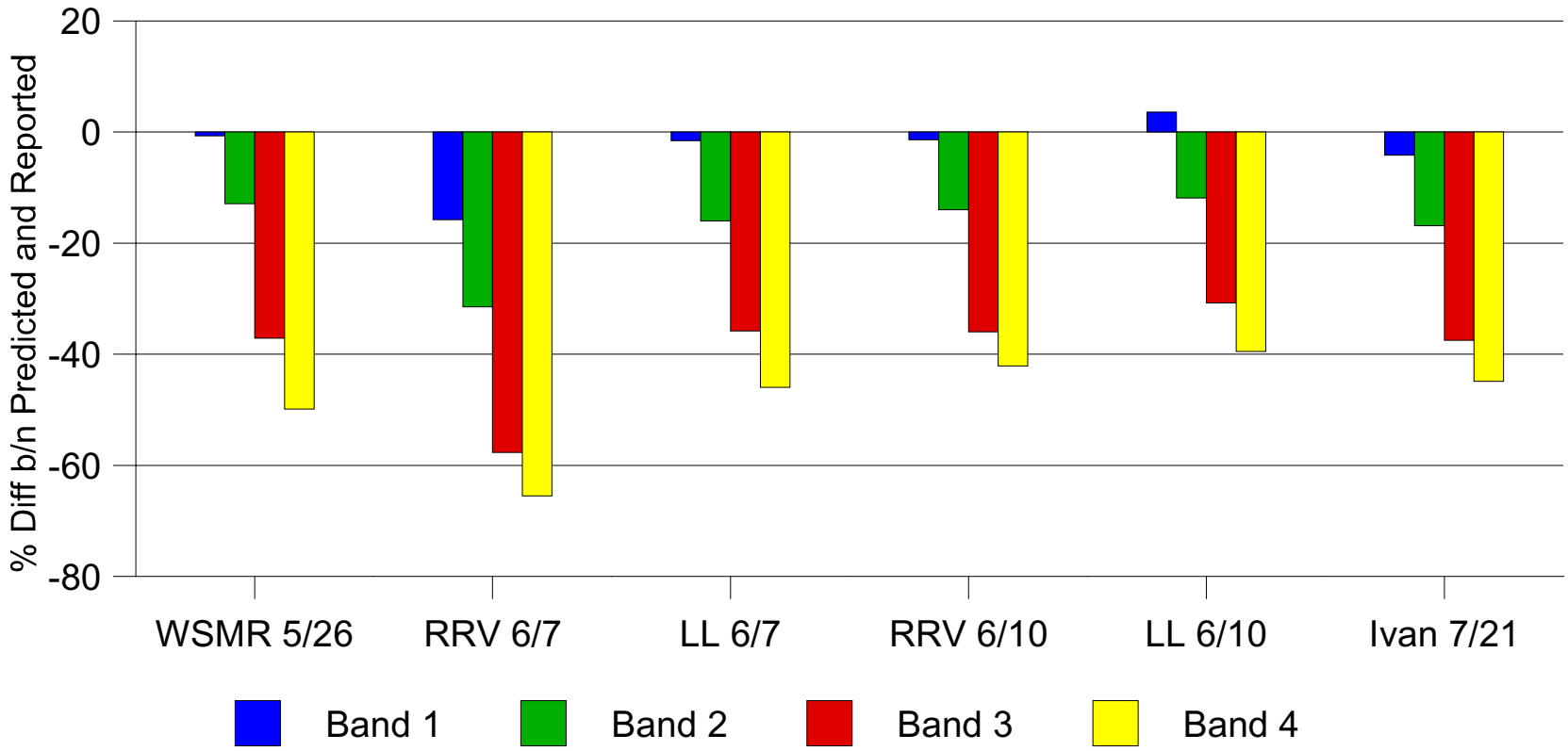
- Ikonos panchromatic imagery from Railroad Valley Playa, Nevada
- Tarpaulins mark our test site
  - Northeast and southwest corners of site
  - Long edge is 300 m in length
  - Short edge is 80 m in length
  - Size relates to 60 pixels of 20 m in size



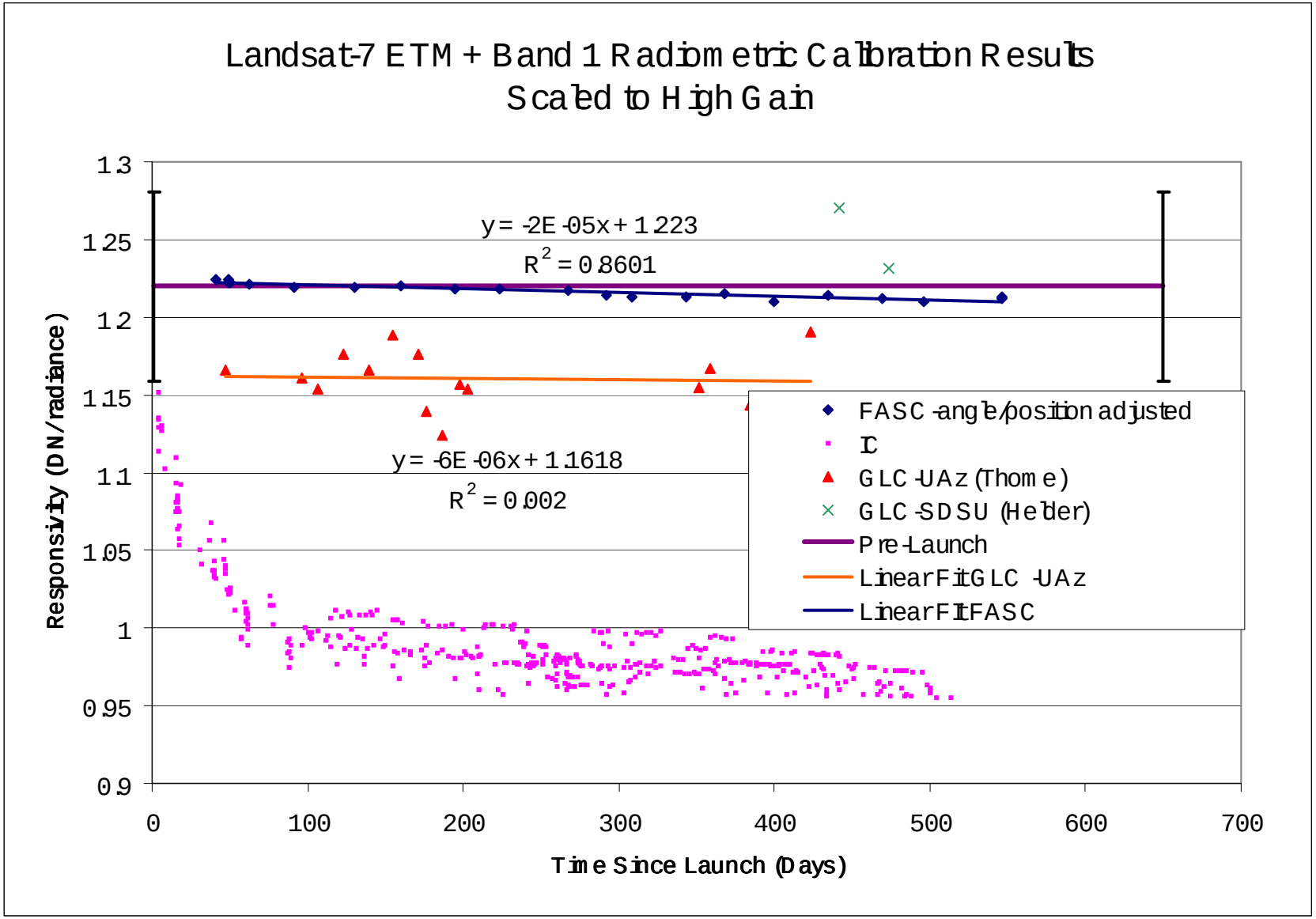
Surface reflectance results



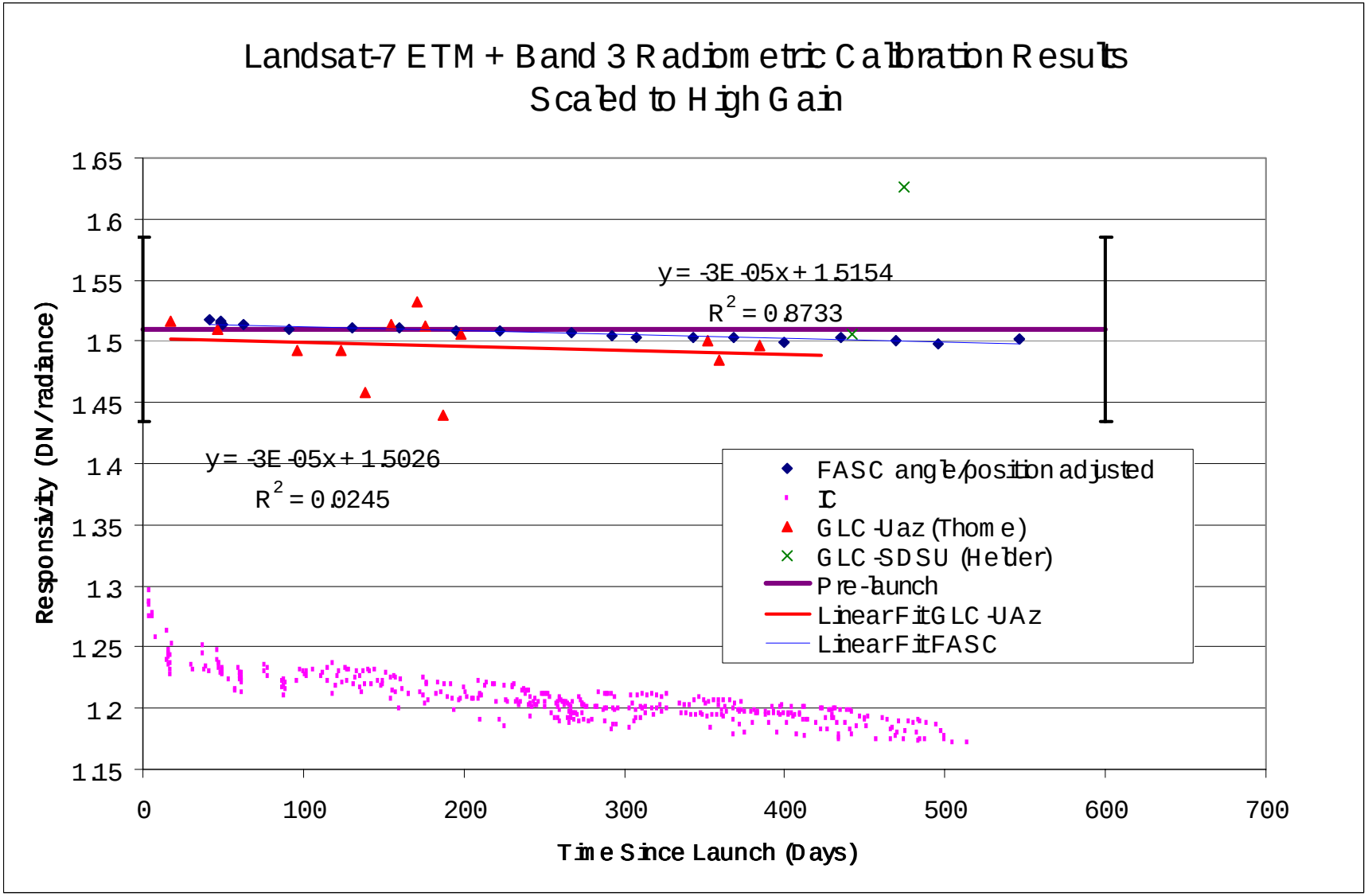
Summary of results



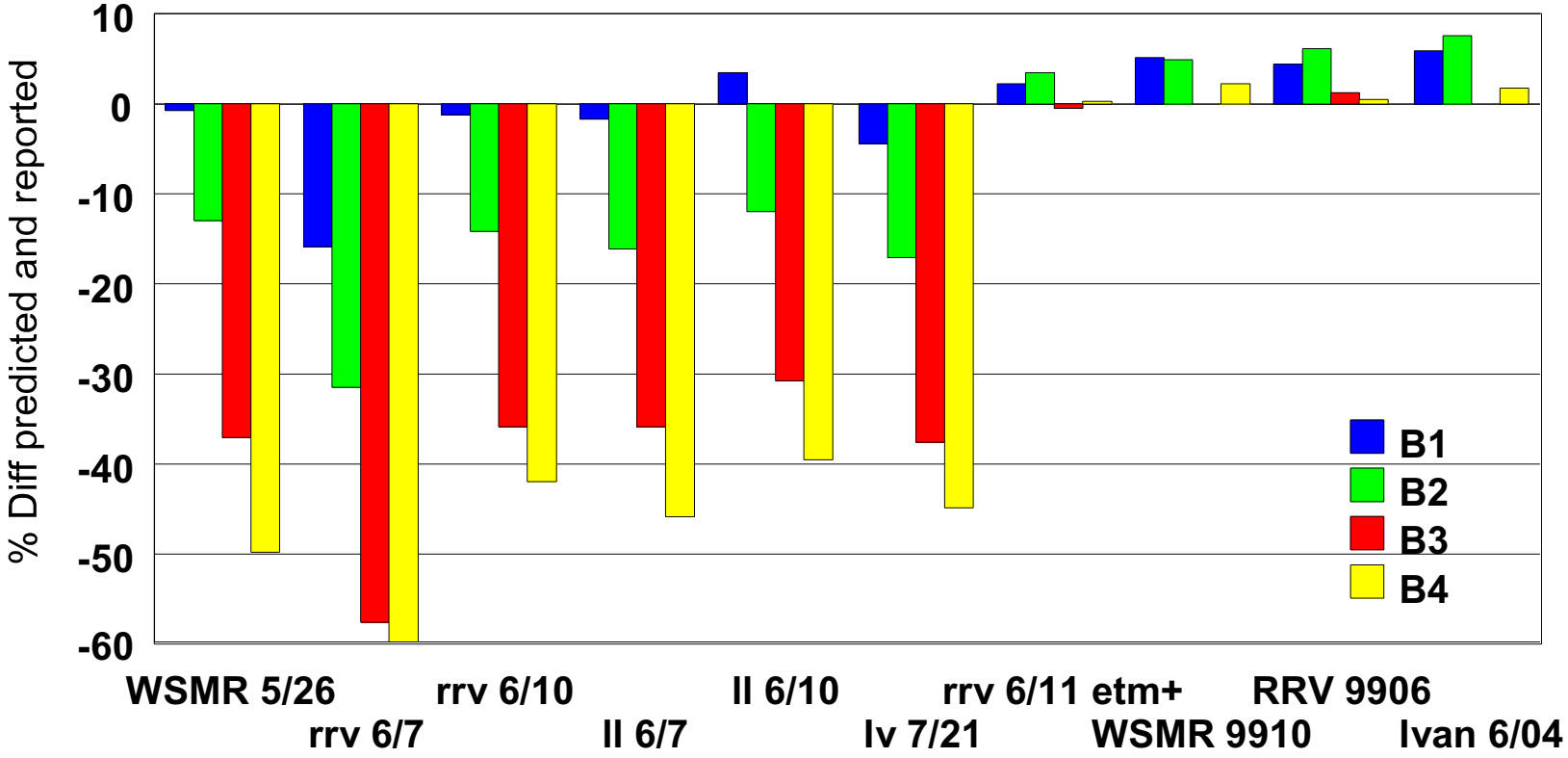
Landsat-7 results



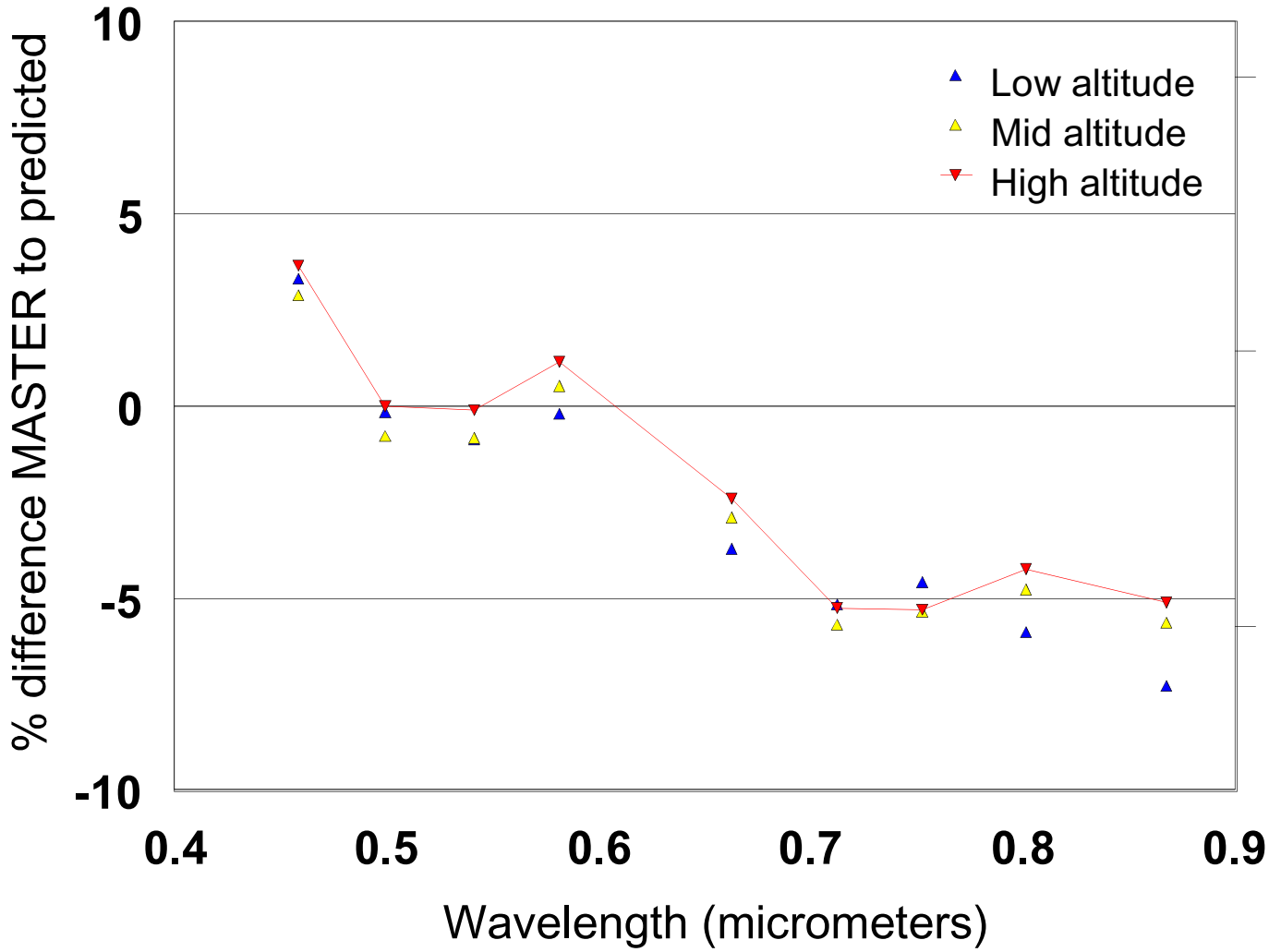
Landsat-7 results



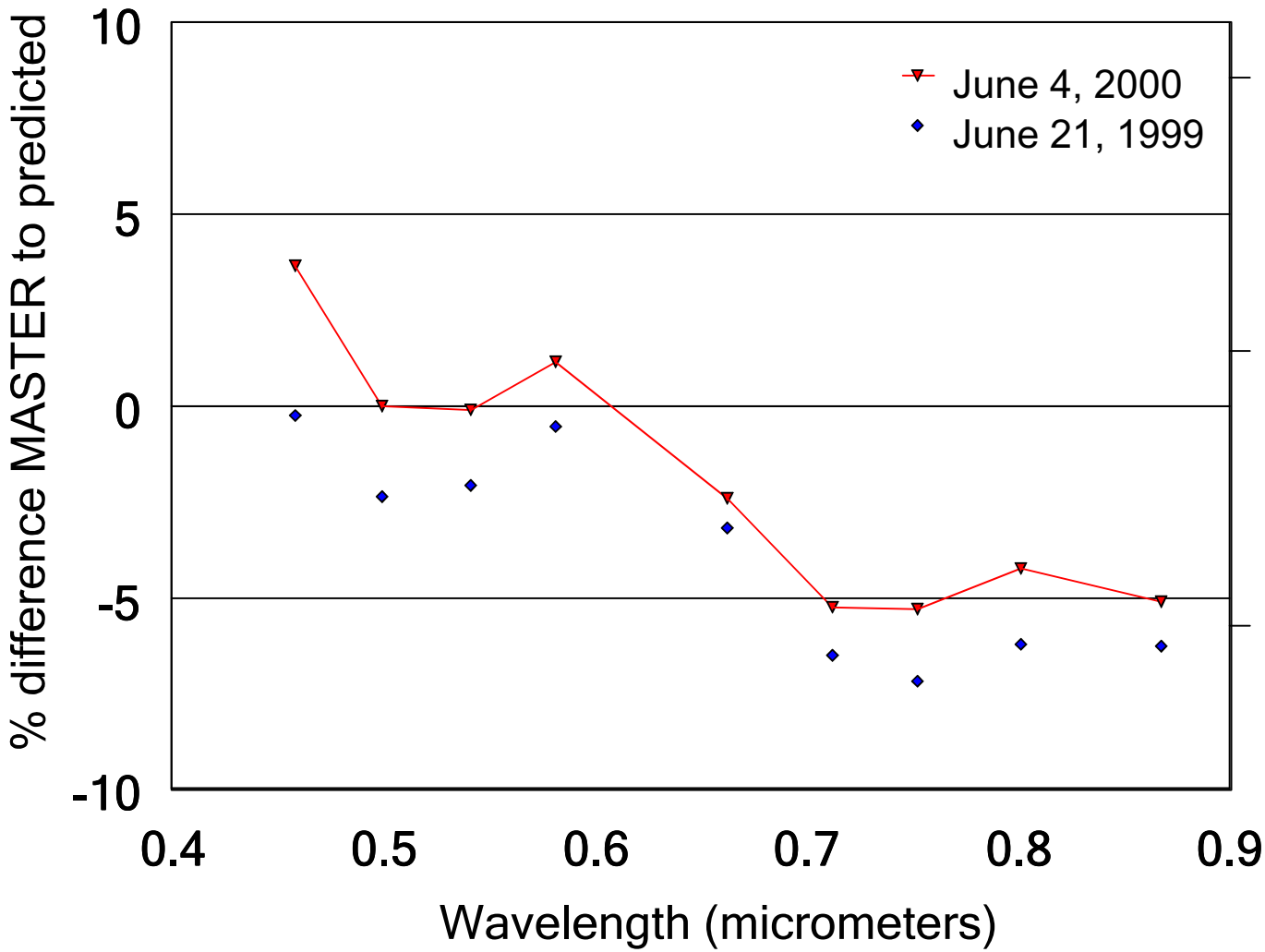
Summary of Ikonos results relative to ETM+



June 4 MASTER results



MASTER results



Conclusions and Final Remarks

- Strong evidence indicates that the responsivity of Ikonos as given in the radiometric documentation for MSI does not correspond well with actual sensor response
  - Refers to bands 2, 3, and 4 of MSI
  - Need to evaluate the time-dependent behavior of this “degradation”
    - Determine whether this is a one time effect due to launch and instrument is now stableor is there a steady degradation with time
    - Over the two months of this work, the sensor appears stable
  - Spectral degradation (largest in band 4 and smallest in band 1) is different from the effect seen in the past
    - Landsat-5 TM and SPOT HRV show largest degradation in blue and green
    - More recently, ASTER and MODIS give indications of degradation which is larger at shorter wavelengths
    - Largest preflight calibration uncertainties are typically in the blue part of the spectrum due to low lamp output
- Preflight radiometric results should be examined to determine if a bias was introduced into the measurements
- Radiometrically, Ikonos has great promise for quantitative analysis at high spatial resolutions and the trials and tribulations of the early Landsat program should be used as a lesson to achieve this promise as rapidly as possible

Conclusions and final remarks

- Calibration and validation are critical to all programs
  - Help to understand how the sensor behaves as a supplement to the preflight calibration and characterization
  - Vital to long-term monitoring programs especially if there will be multiple platforms over many years or multiple sensors with different designs
  - Cal/val plays an especially key part of NASA's Earth Observing System
- Important to do both preflight and postlaunch calibrations
  - Postlaunch is critical for studying degradation of sensors over time
  - Preflight work is instrumental in understanding sensor behavior (that is characterization as well as calibration)
  - Postlaunch calibration can determine if the transfer to orbit of the preflight calibration occurred smoothly
  - Vicarious calibration/radiance validation are critical in the absence of onboard calibration, but also important if onboard calibration is present
- This can become more difficult to justify in a market-driven commercial environment
  - Quantitative science may play a small role in the overall customer base
  - However, it is difficult to predict how data will be used in the future, so even in non-profitable cases there can be intangible benefits
  - If only they had placed an onboard calibrator for the reflective bands of AVHRR