Radiometric Calibration of Ikonos by University of Arizona Remote Sensing Group

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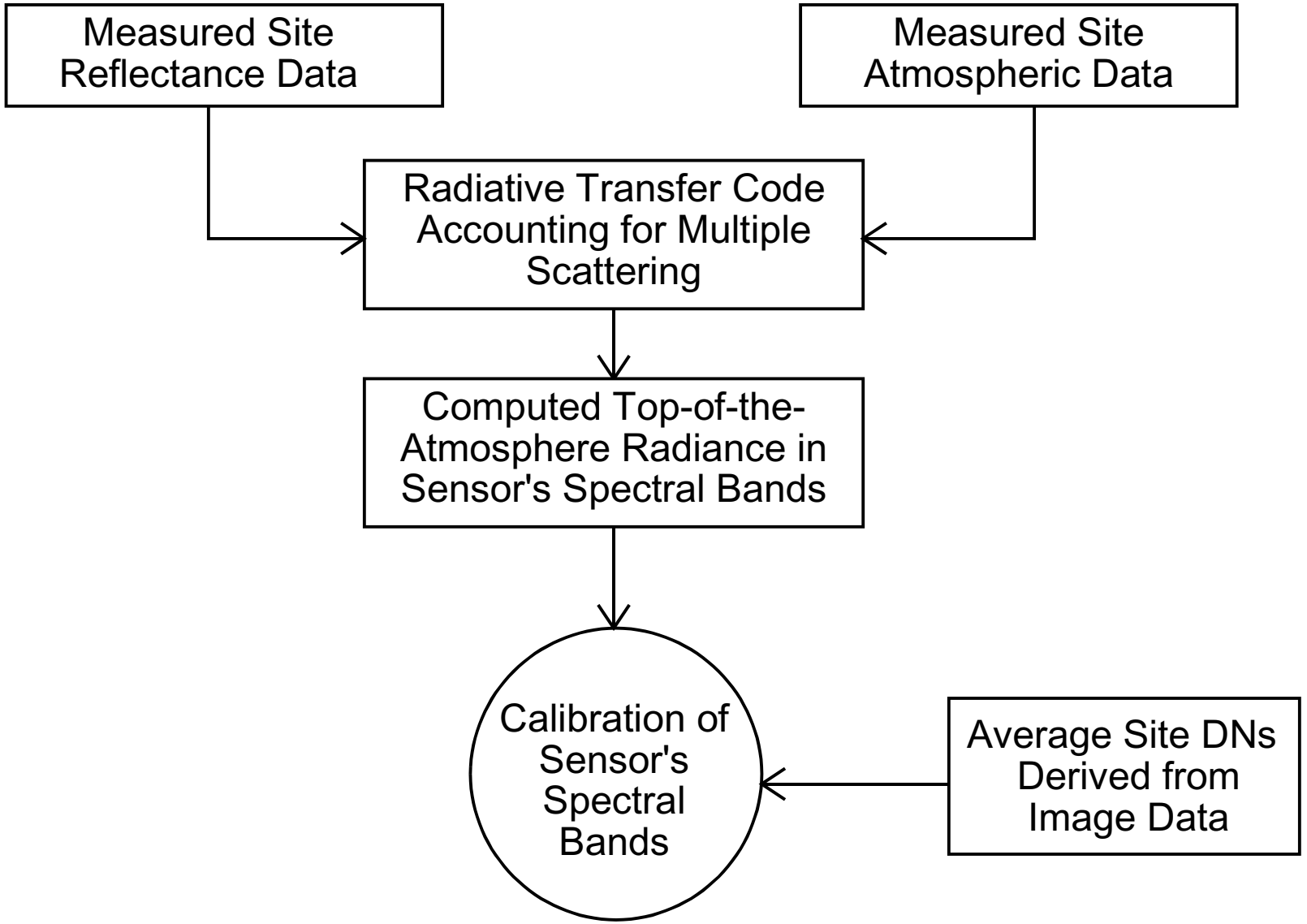
Presented to
High Spatial Resolution Commercial Imagery Workshop

March 19-21, 2001
Greenbelt, Maryland

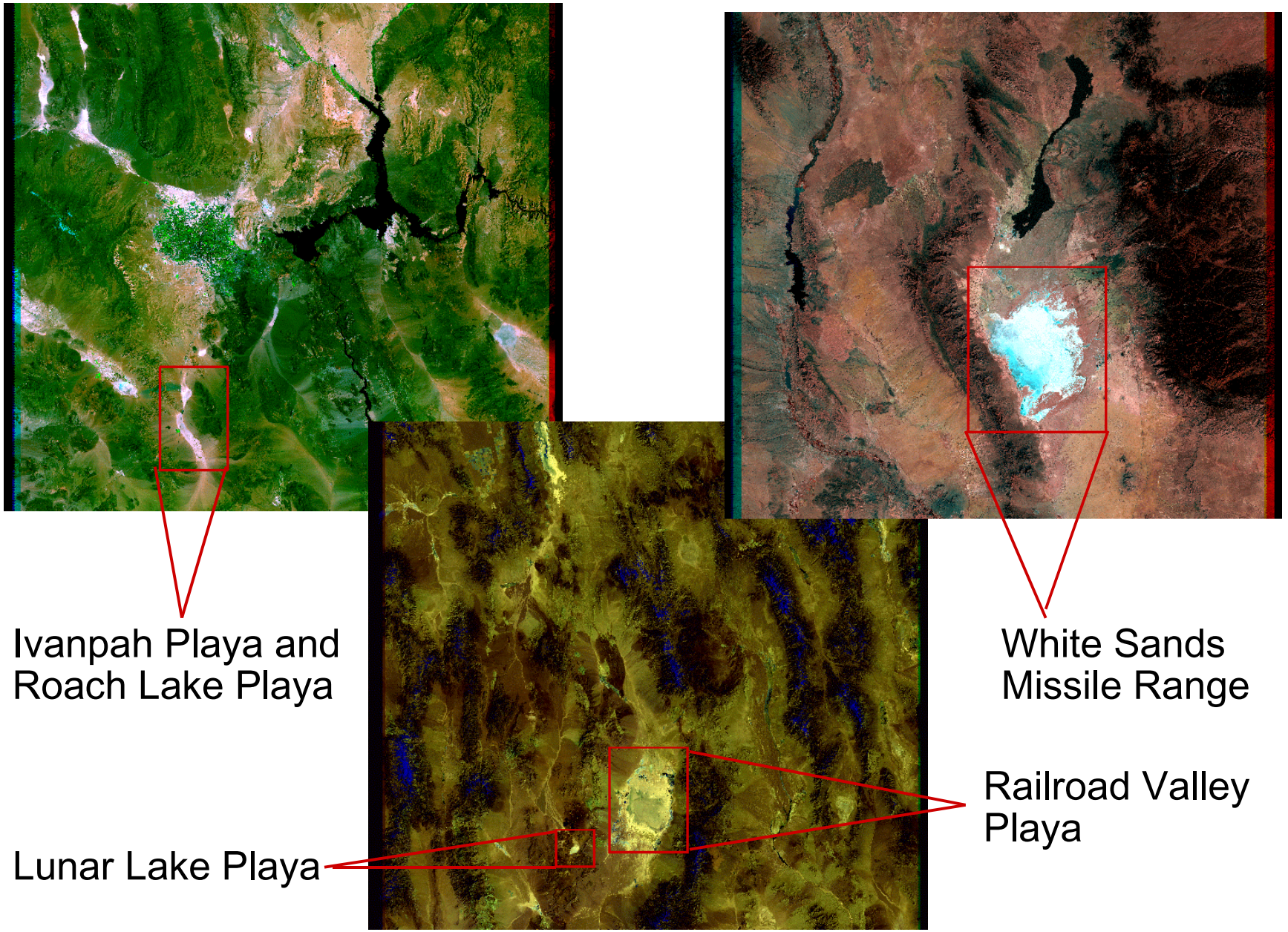
Introduction

- 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

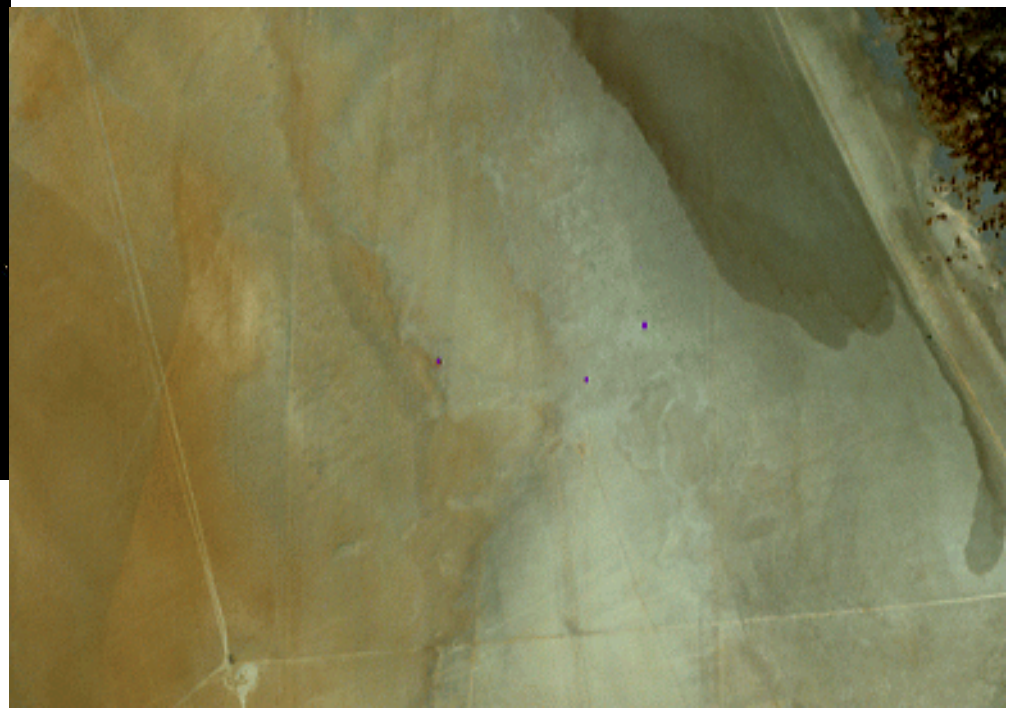
Ivanpah Playa, California

Dry lake on California-Nevada border

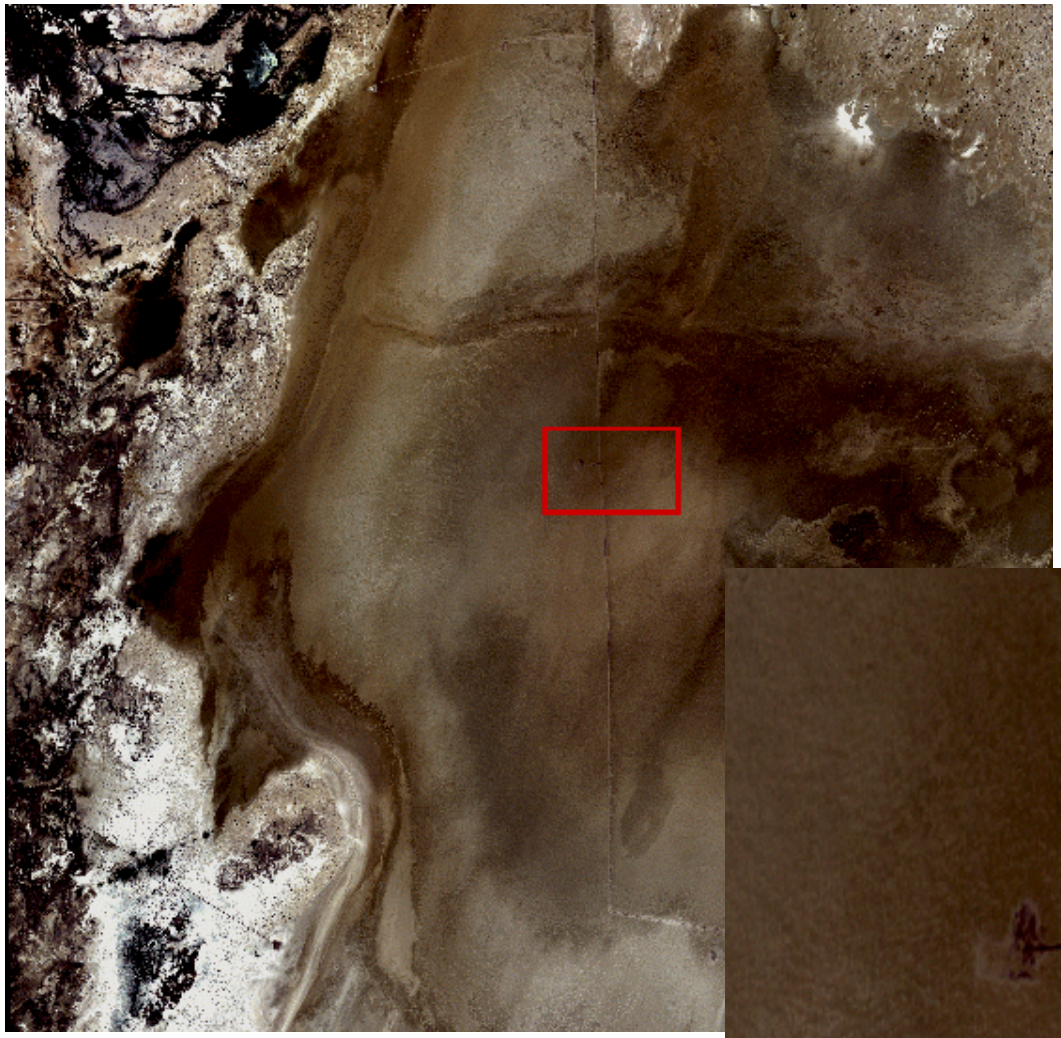
Interstate 15 traverses the lakebed

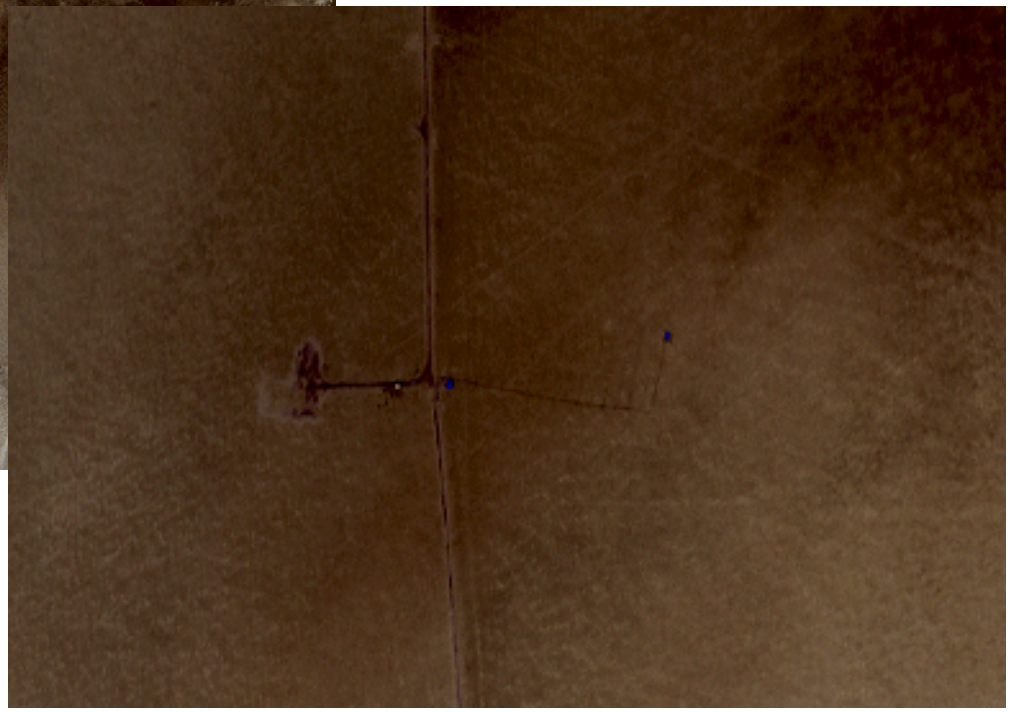
800 m elevation

3 km by 7 km in size



Railroad Valley Playa, Nevada



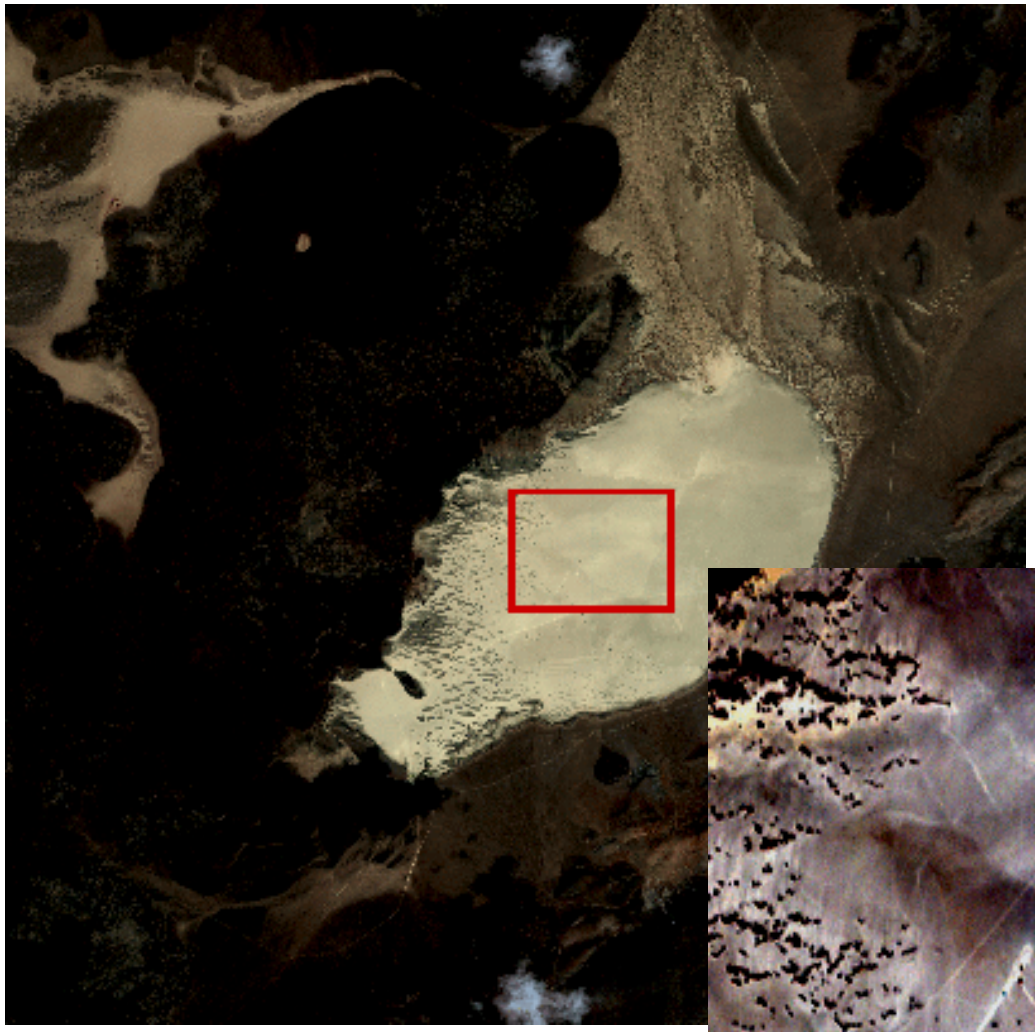


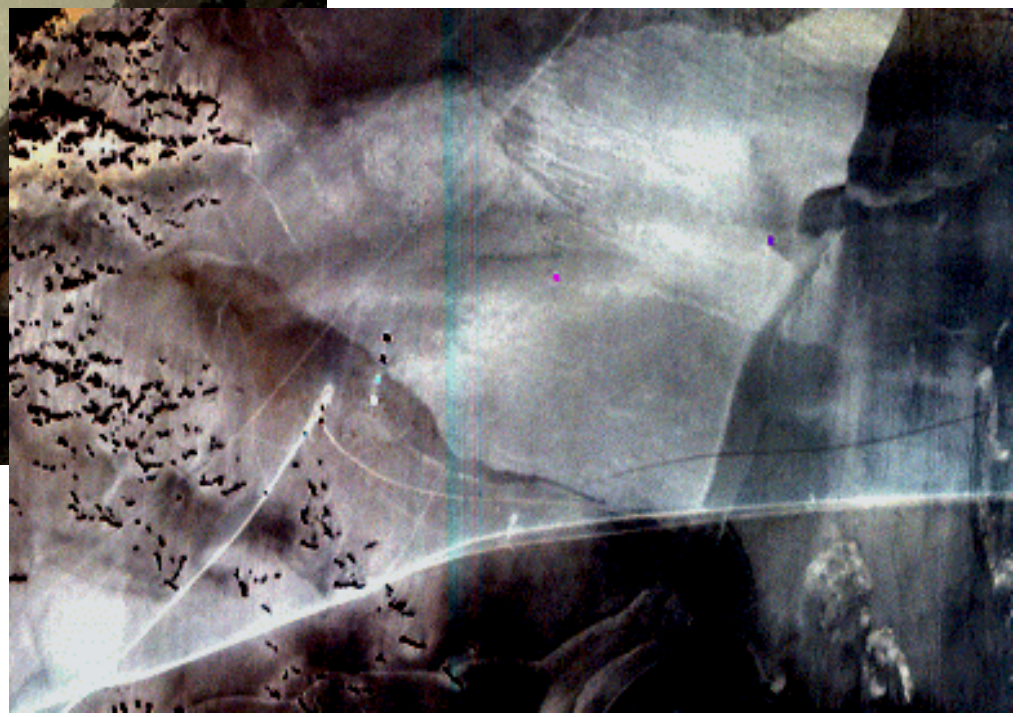
Dry lake in Central Nevada between Tonopah and Ely

1600 m elevation

15 km by 15 km in overall size

Lunar Lake Playa, Nevada





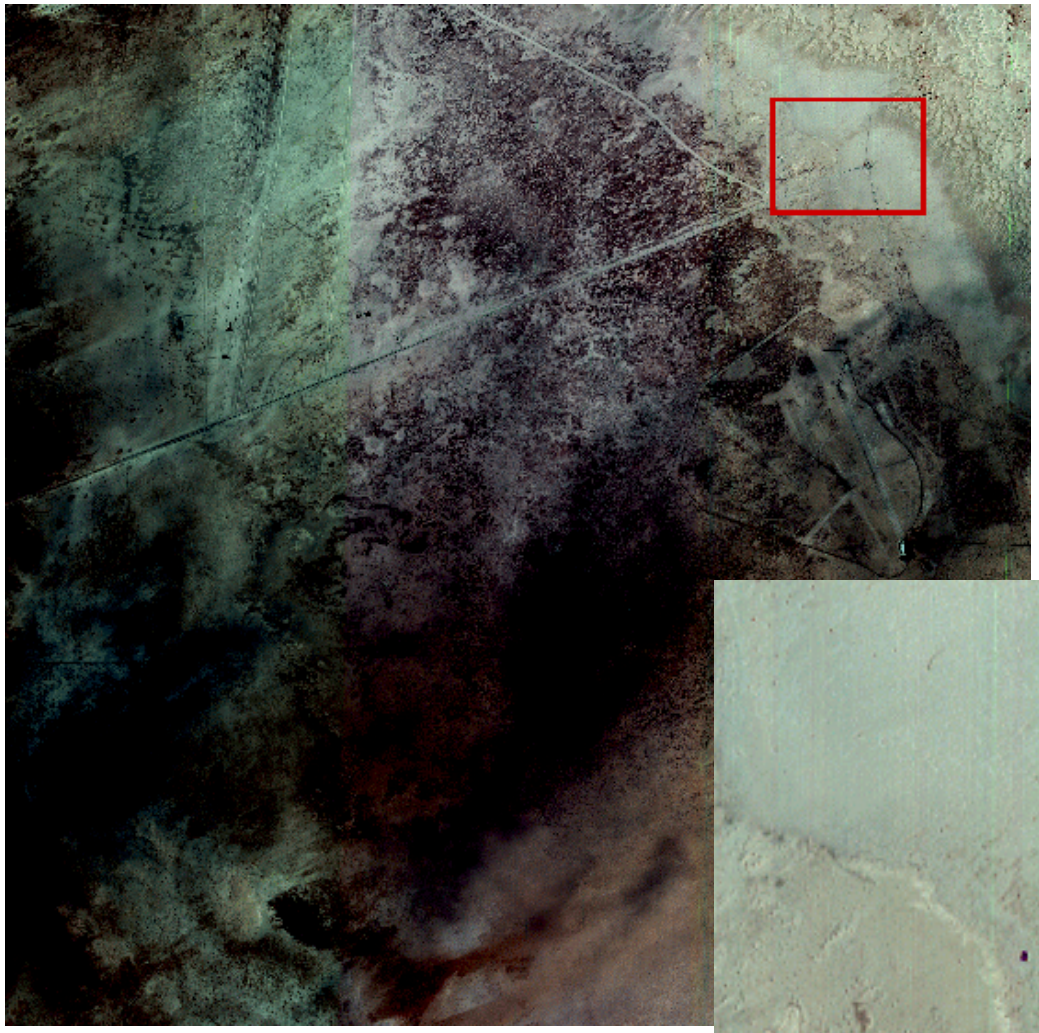
Dry lake in Central Nevada between Tonopah and Ely

1800 m elevation

3 km by 5 km in size

Most uniform of test sites

White Sands Missile Range

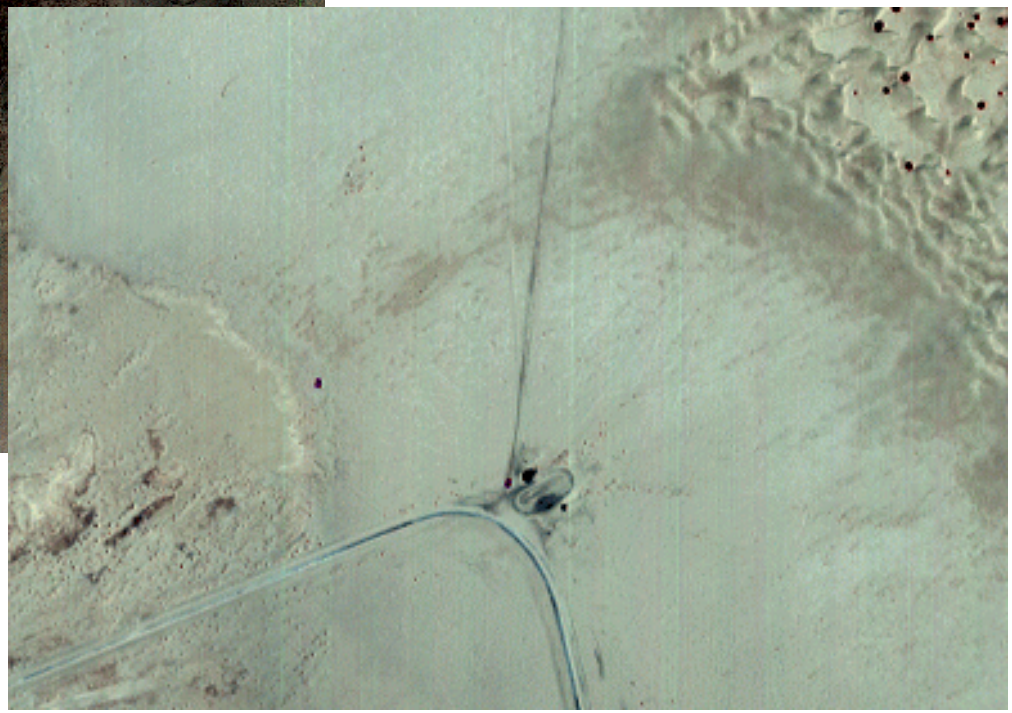


Alkali flats area of White Sands Missile Range in southeastern New Mexico

1200 m elevation

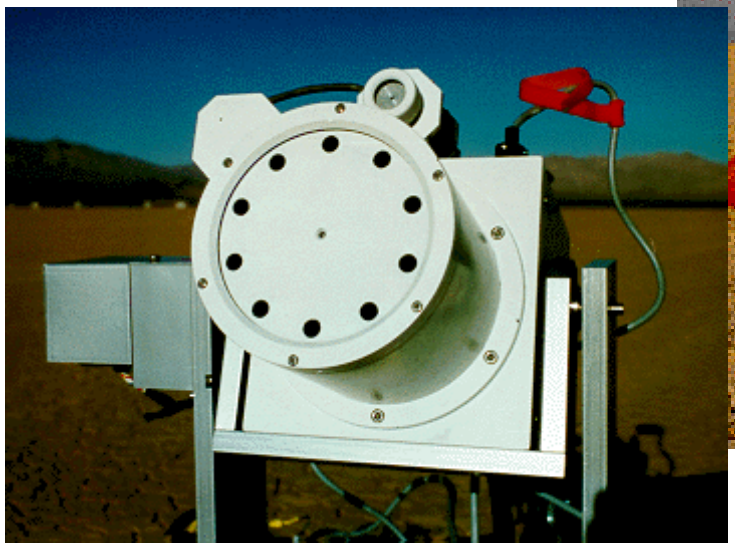
Gypsum surface

Overall size of region is 35 km by 50 km

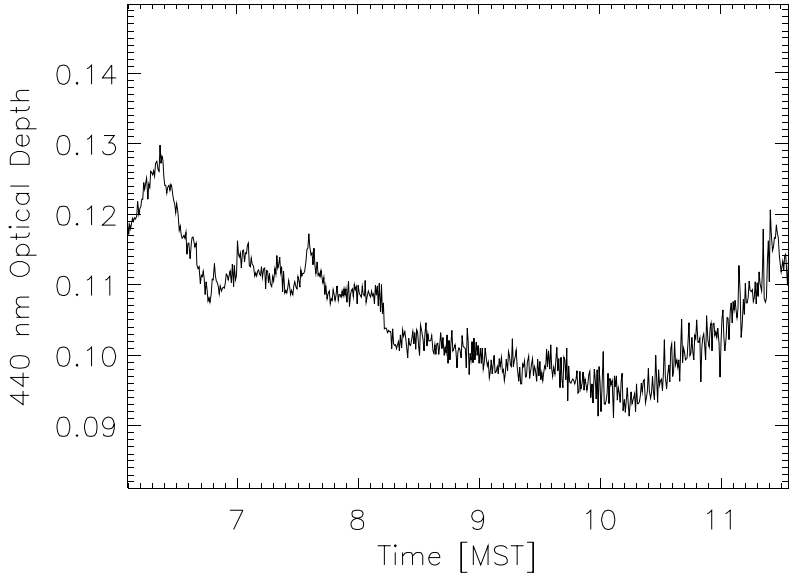


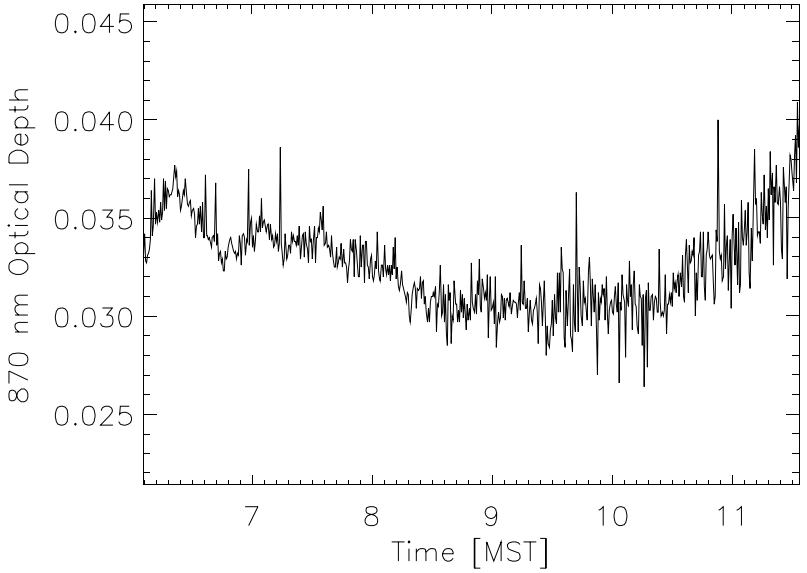
Atmospheric measurements

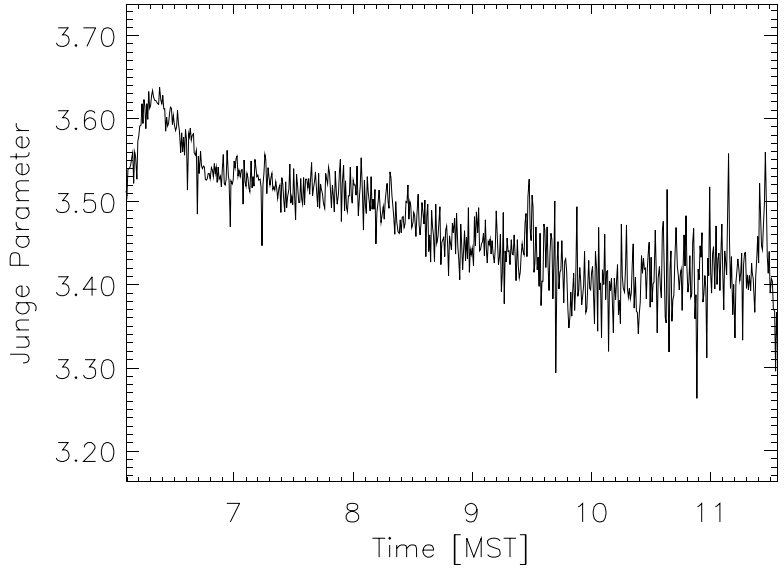
- Atmospheric measurements rely on a 10-band solar radiometer
  - Developed in the Electrical and Computer Engineering Department under supervision of John Reagan
  - Automated system with 10 separate detector/filter combinations in the visible and near-IR
- Measurements are used to retrieve spectral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

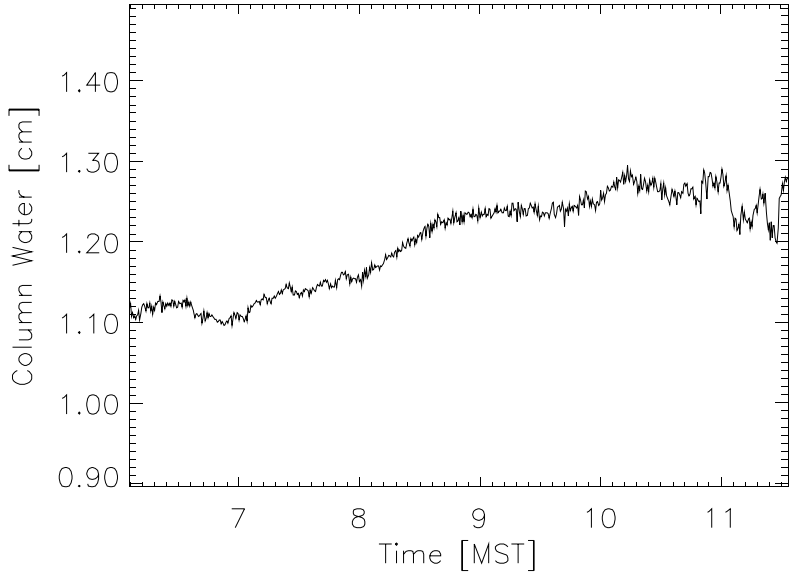


Atmospheric Results - RRV June 10, 2000









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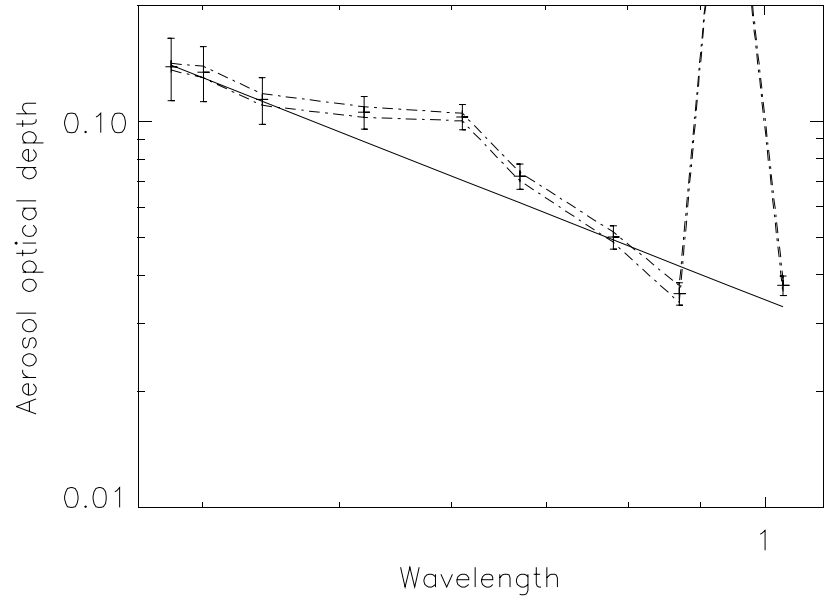

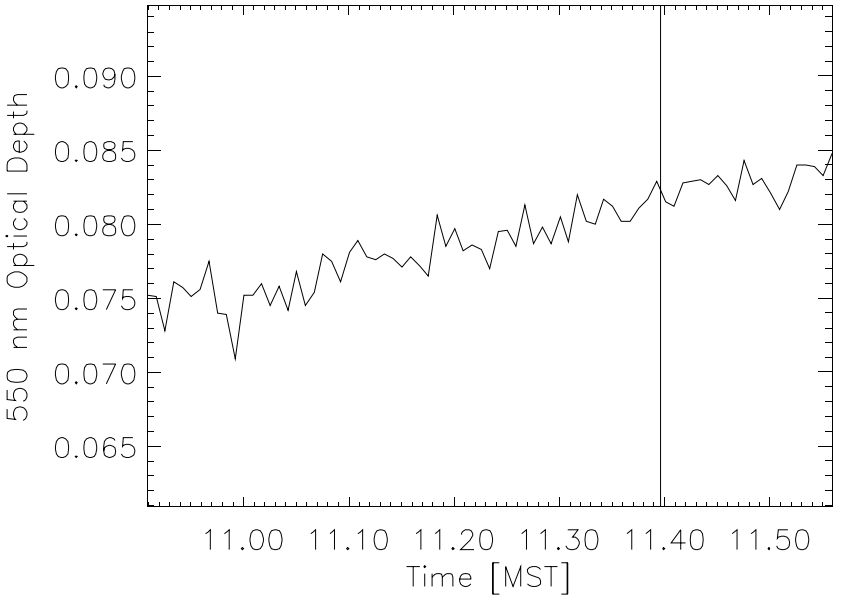

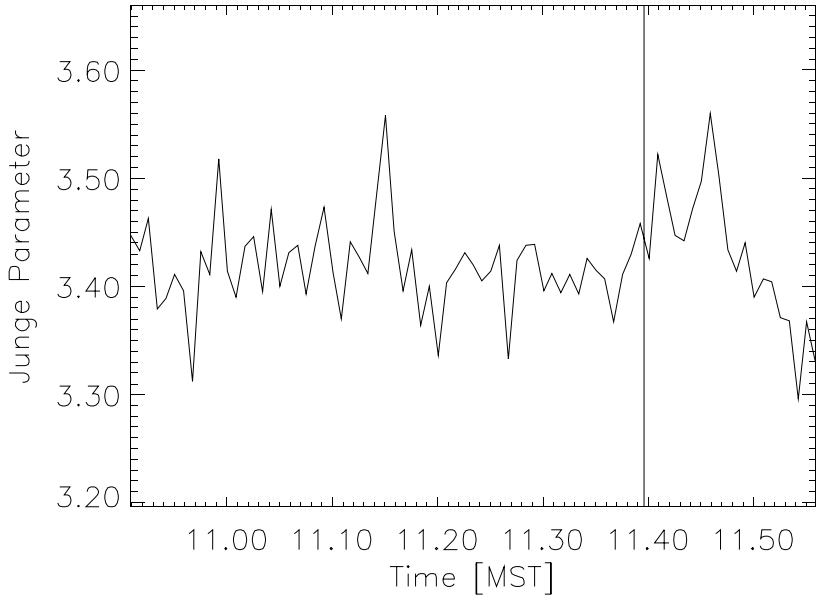

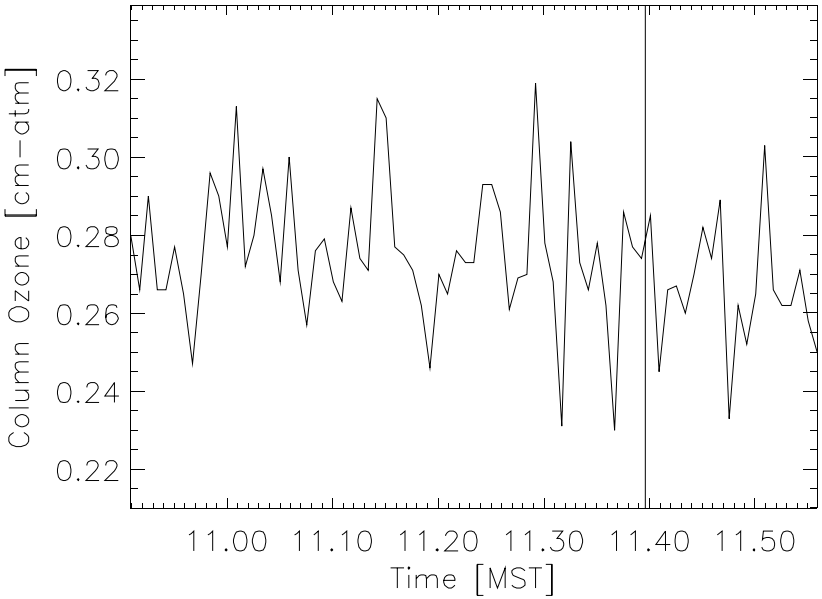

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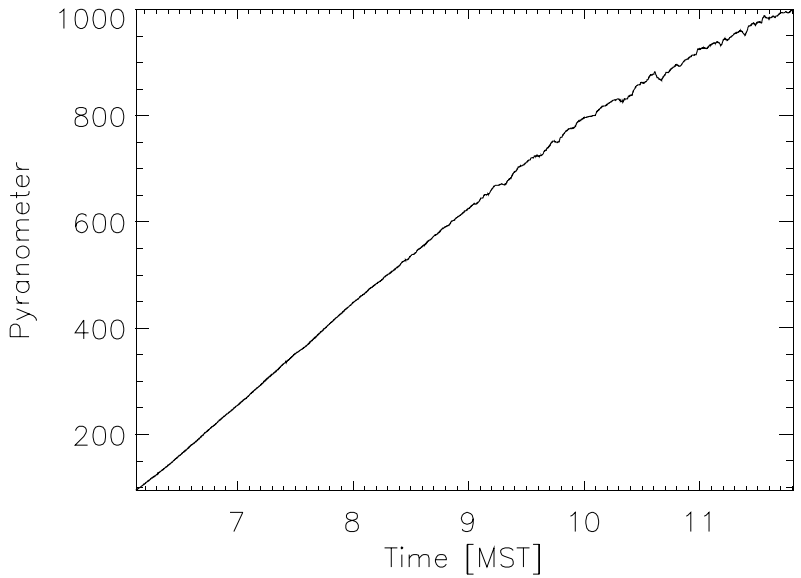
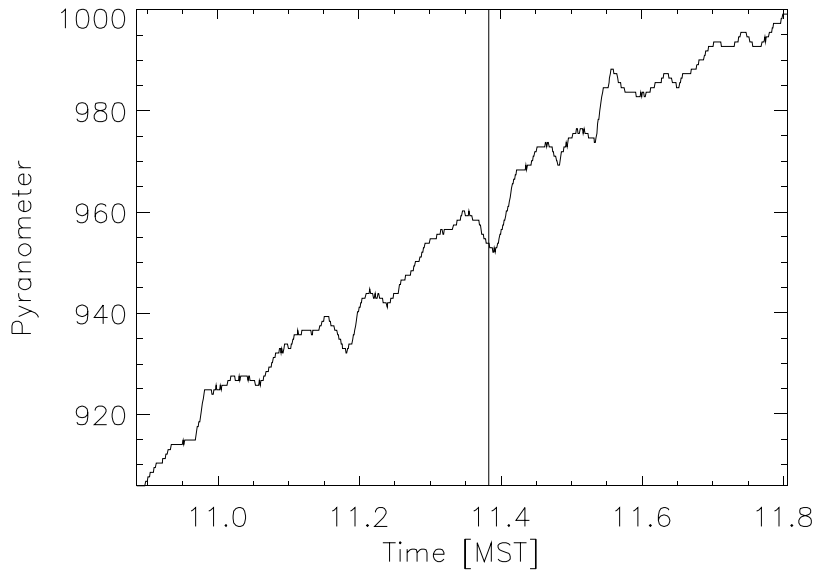
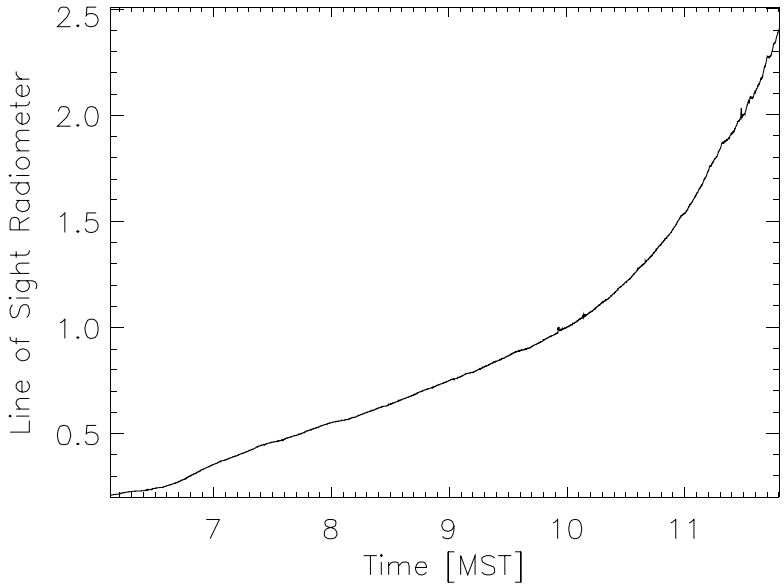
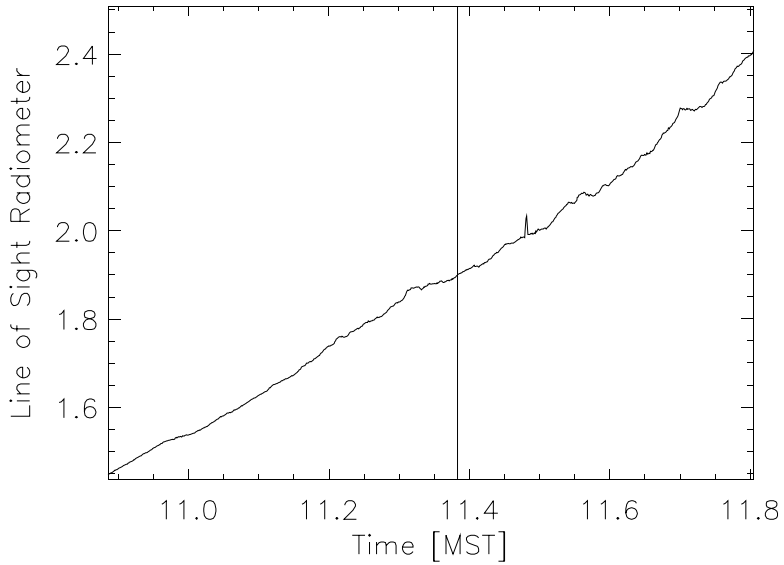
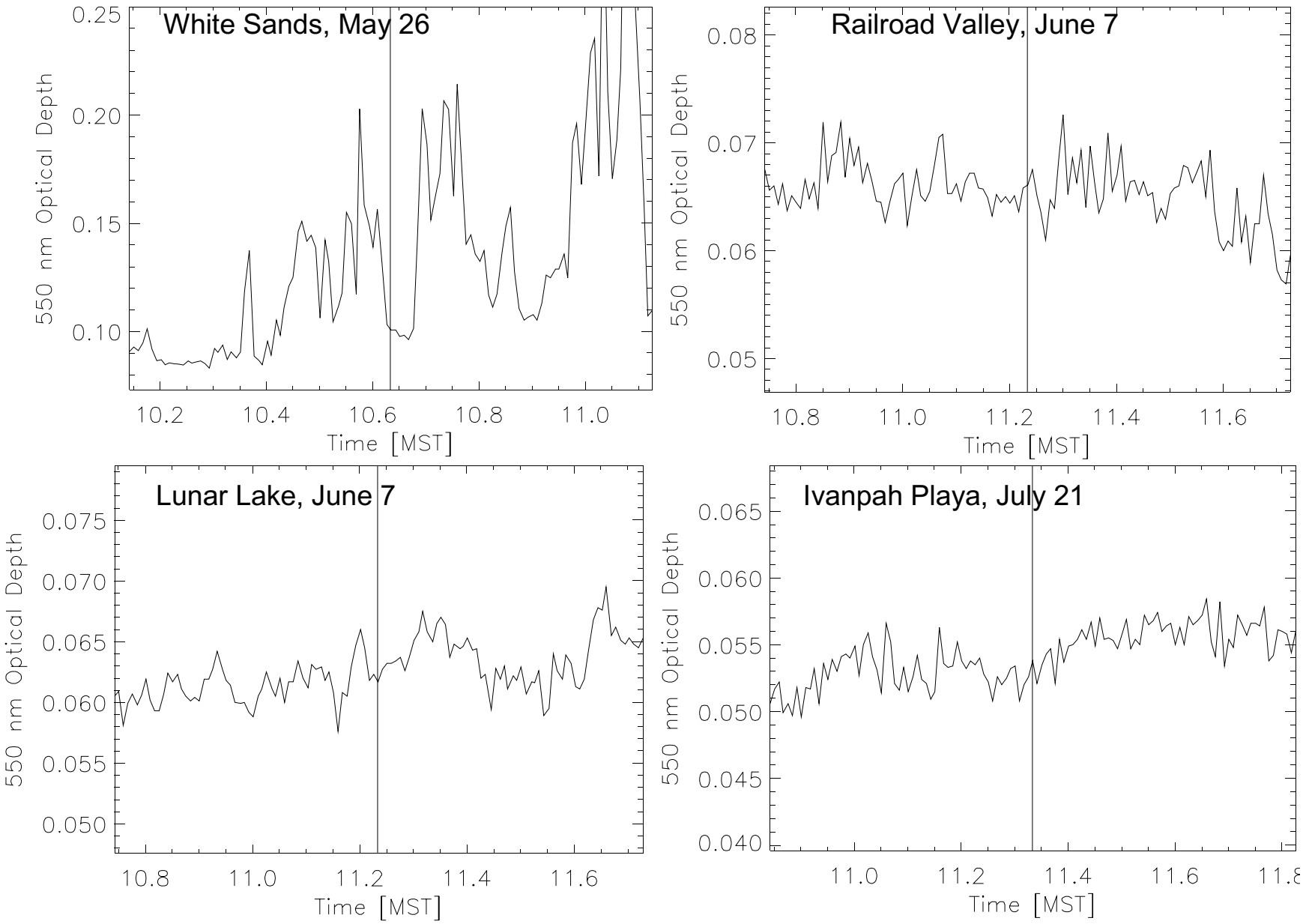








Atmospheric measurements - Comparison of days



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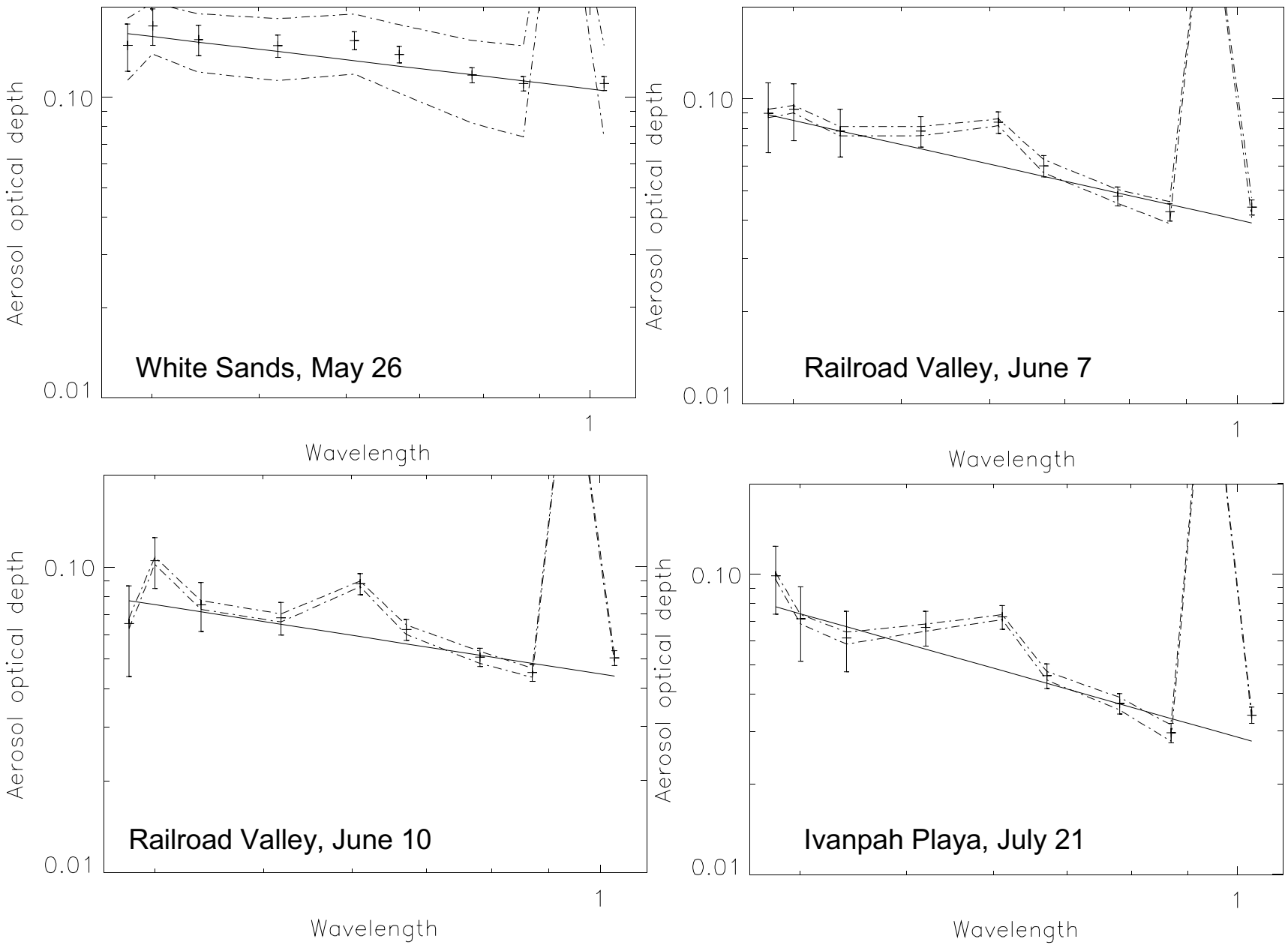
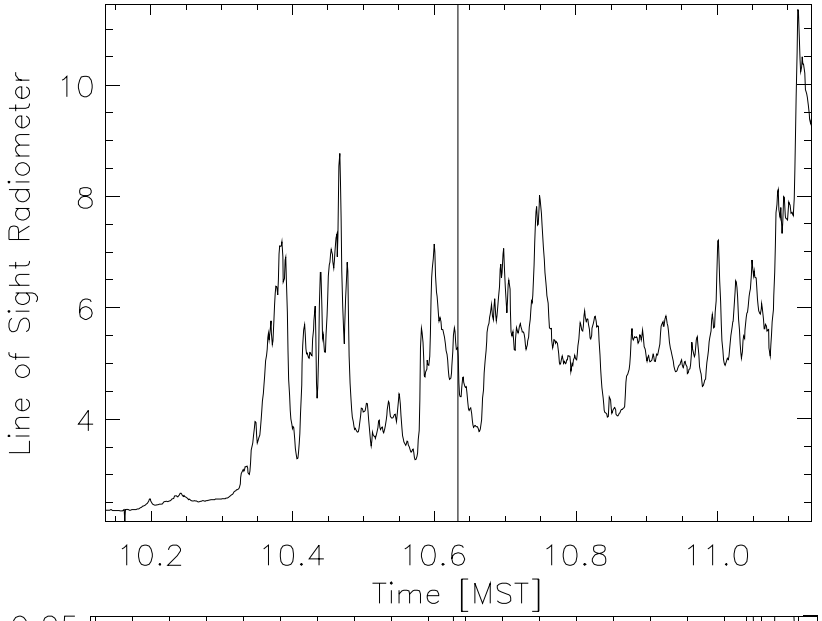
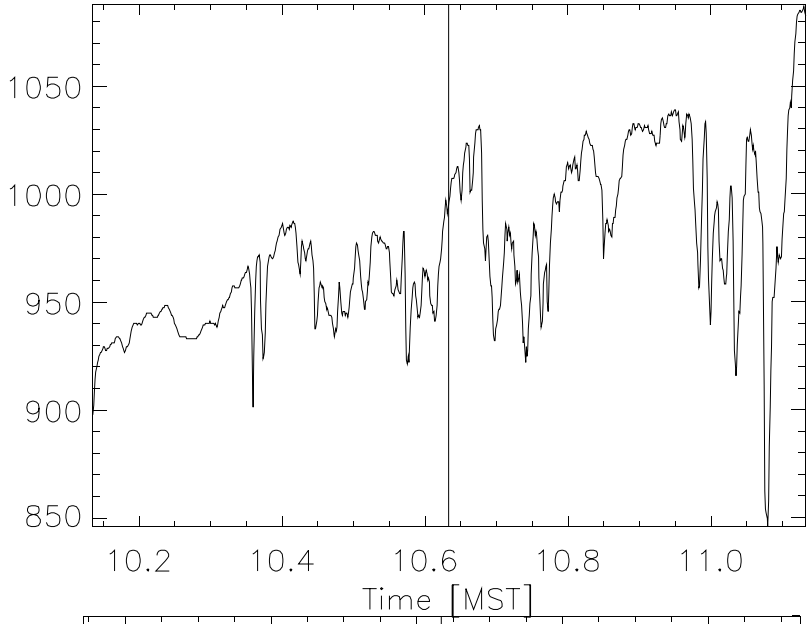
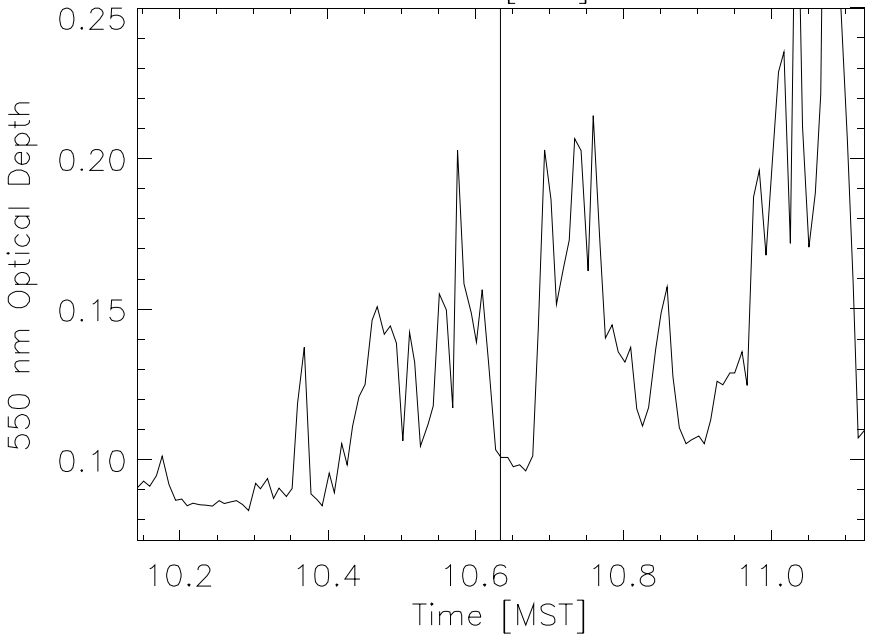
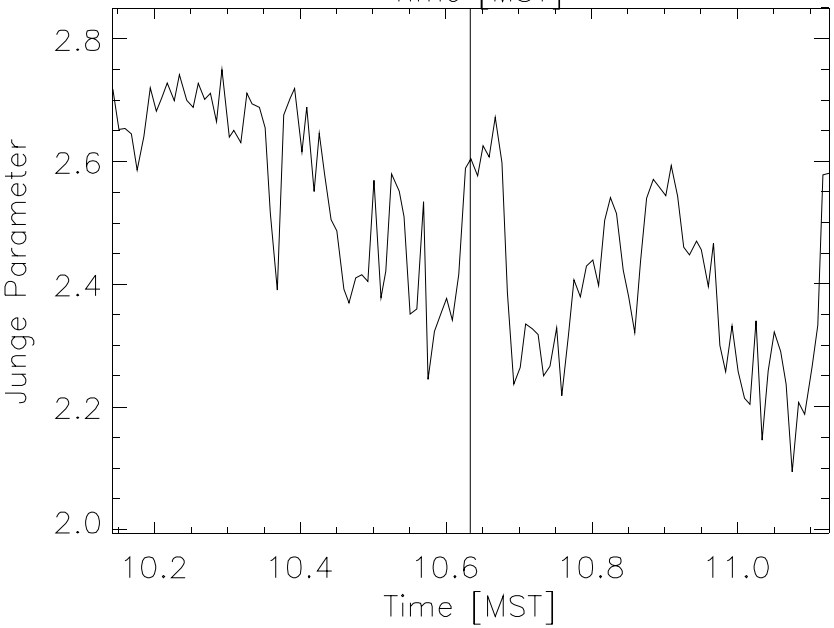


Atmospheric measurements - WSMR, 5/26







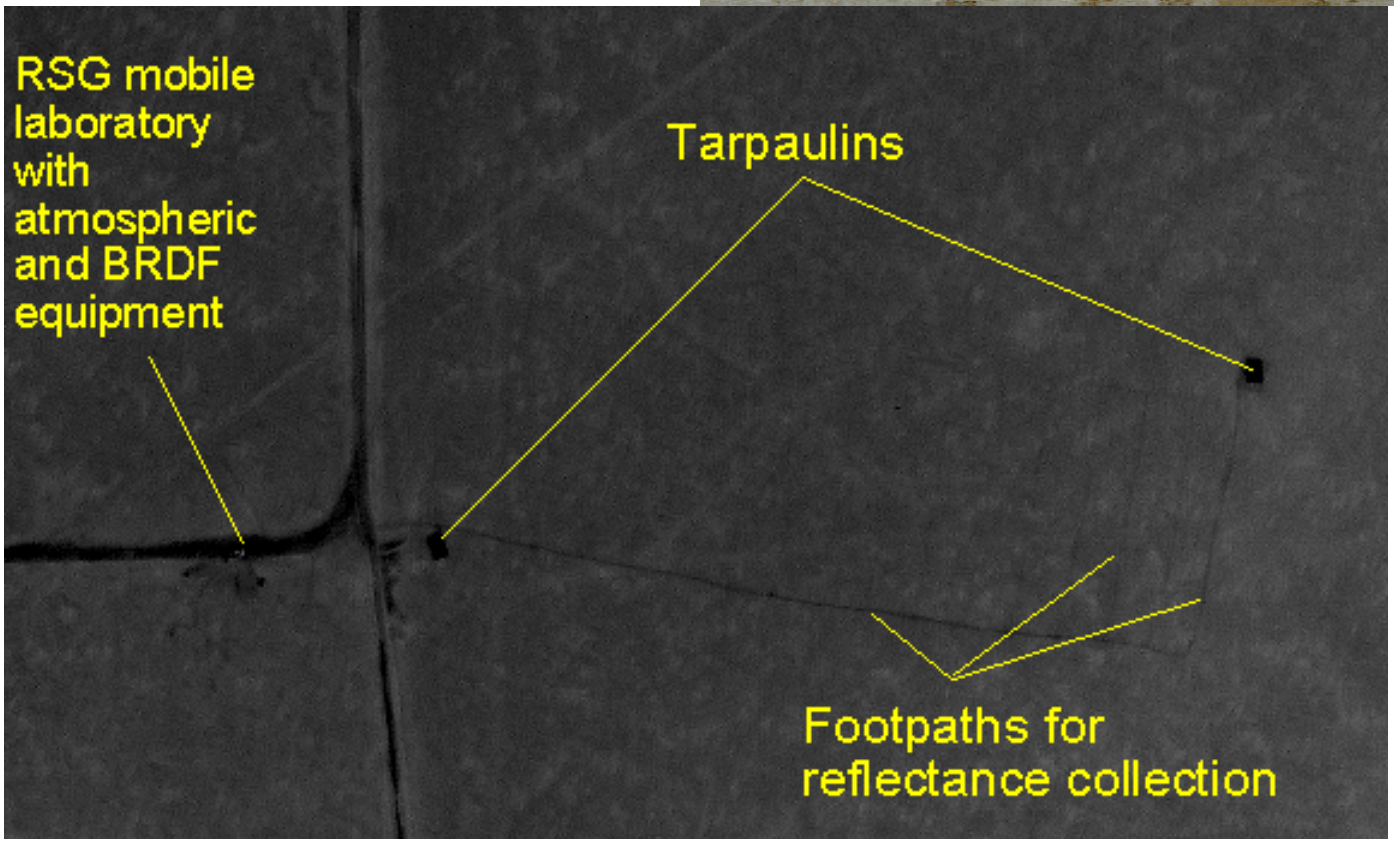


Surface reflectance measurements

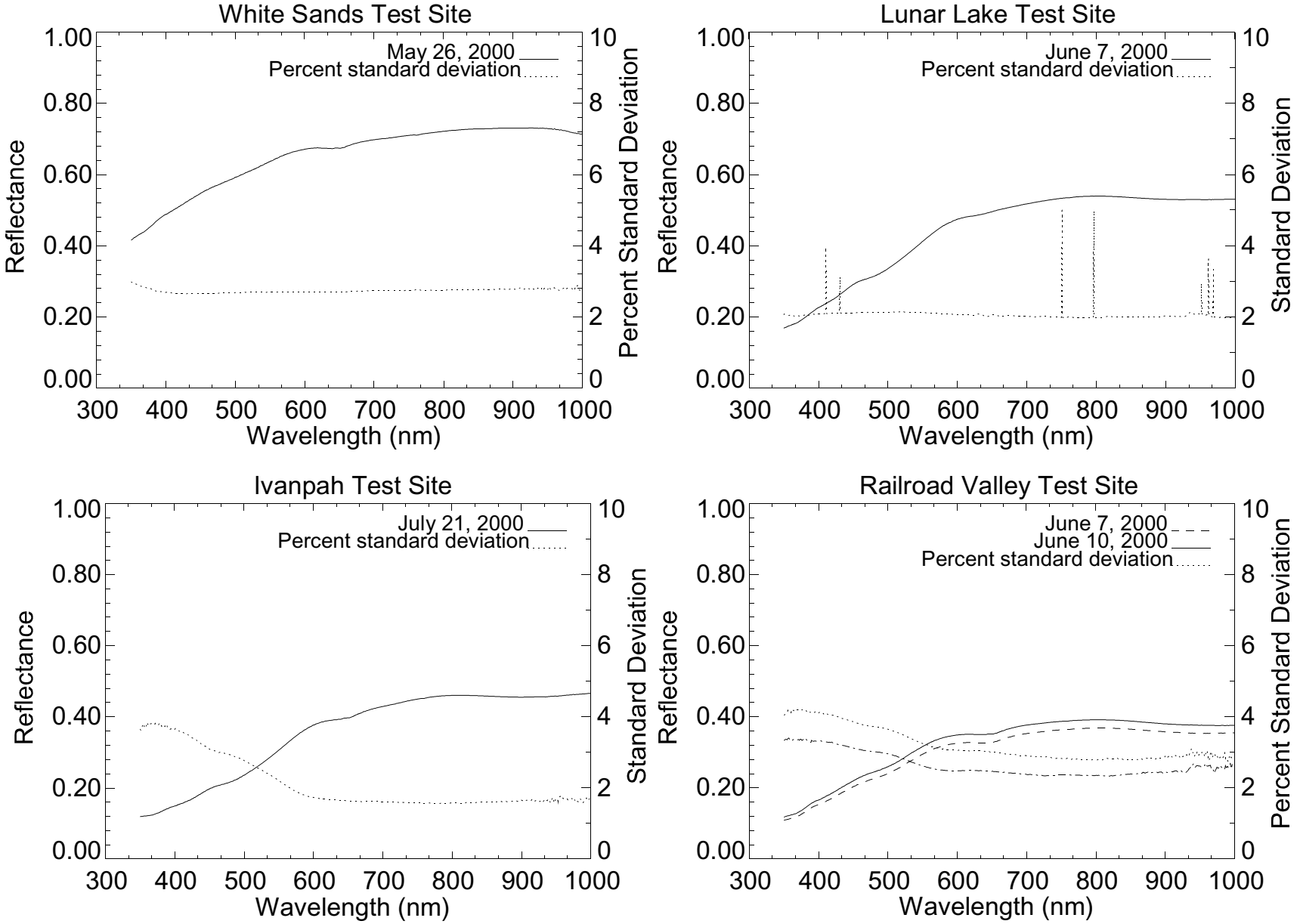
- Surface reflectance determined by referencing measurements of the upwelling radiance from the test site to those of a panel of known reflectance
  - Spectralon panel
  - Reflectance of Spectralon is characterized in the laboratory
- Radiometer is transported across the site while ollecting spectra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

Test site example

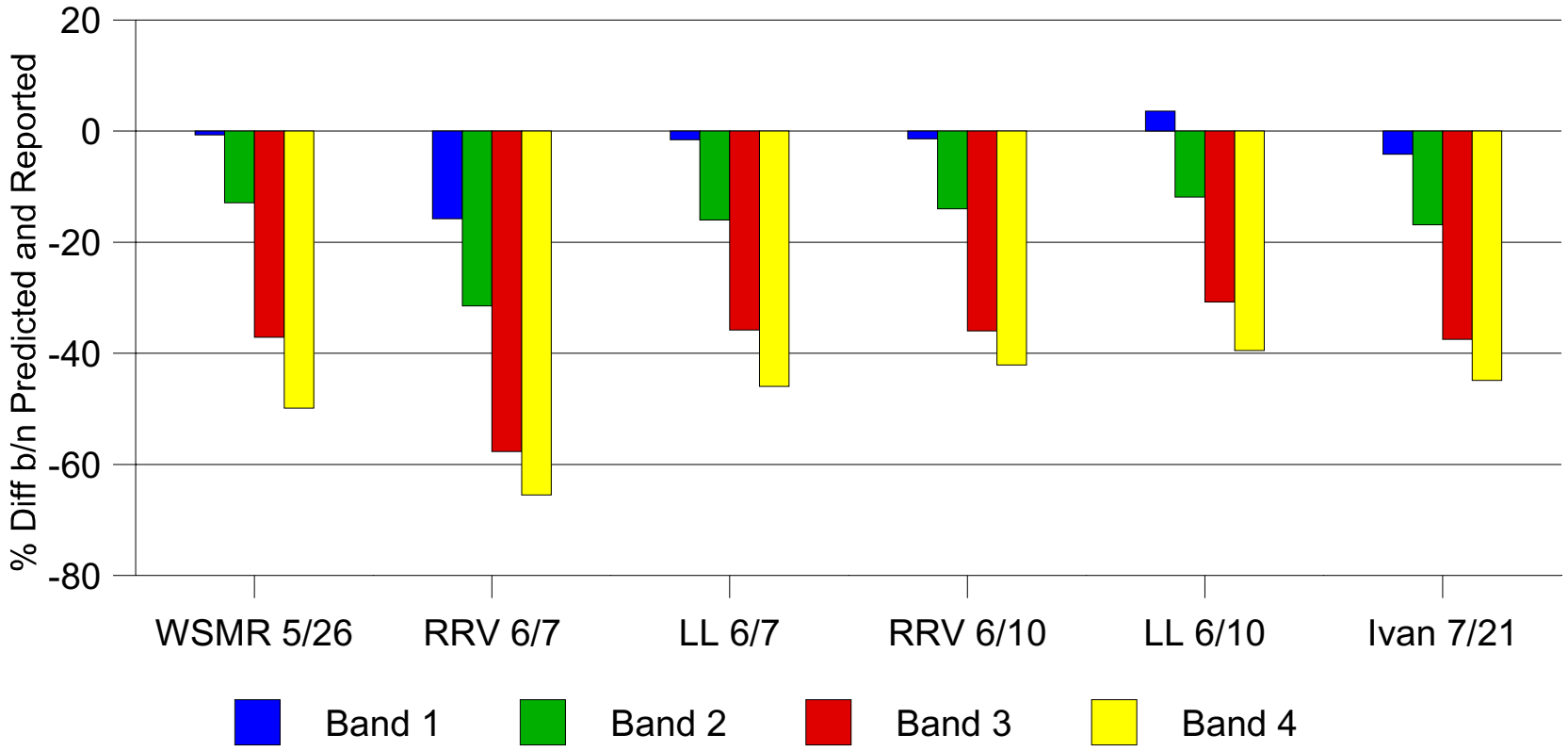
- Ikonos panchromatic imagery from Railroad Valley Playa, Nevada
- Tarpaulins mark our test site
  - Northeast and southwest corners of site
  - Long edge is 300 m in length
  - Short edge is 80 m in length
  - Size relates to 60 pixels of 20 m in size



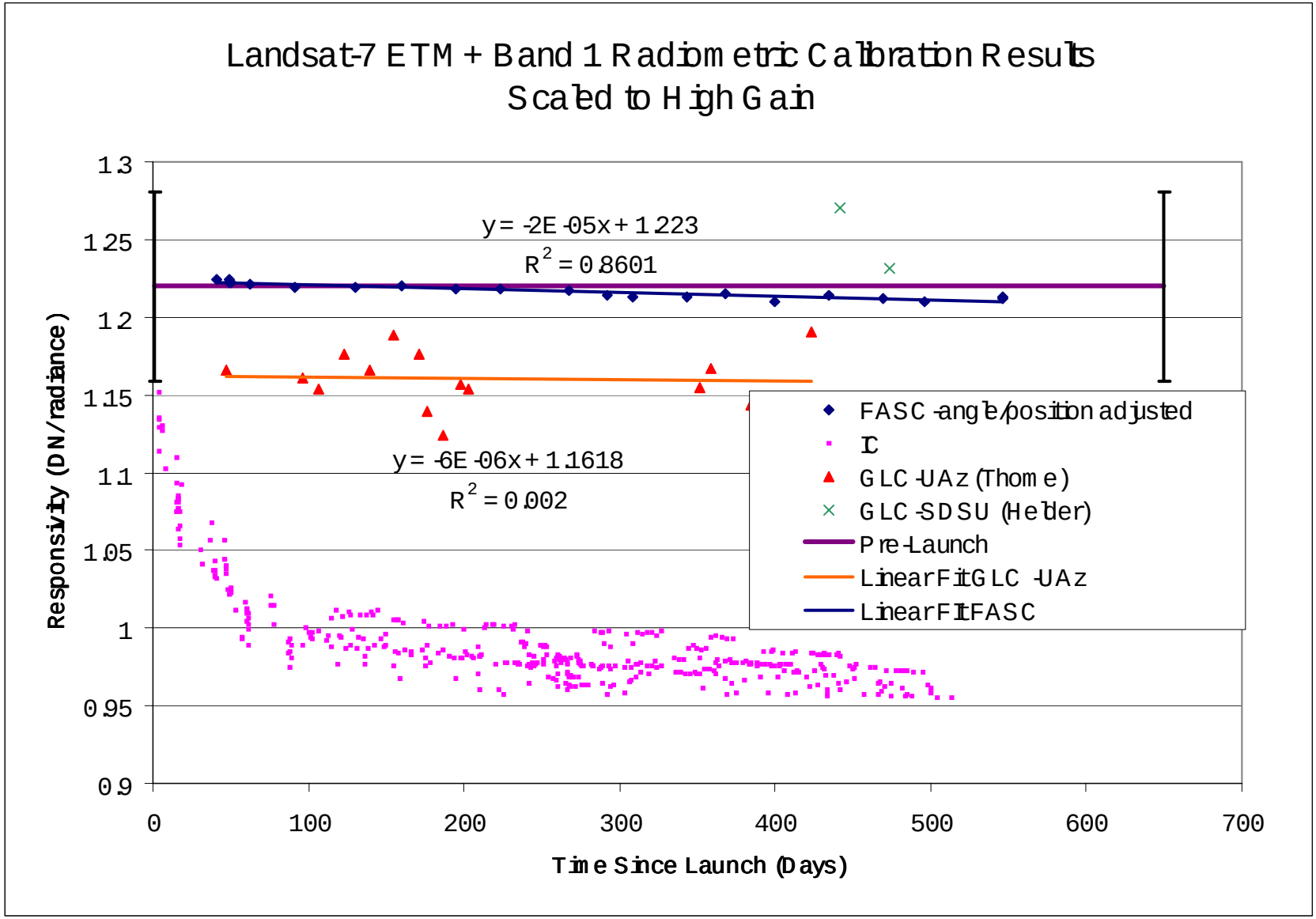
Surface reflectance results



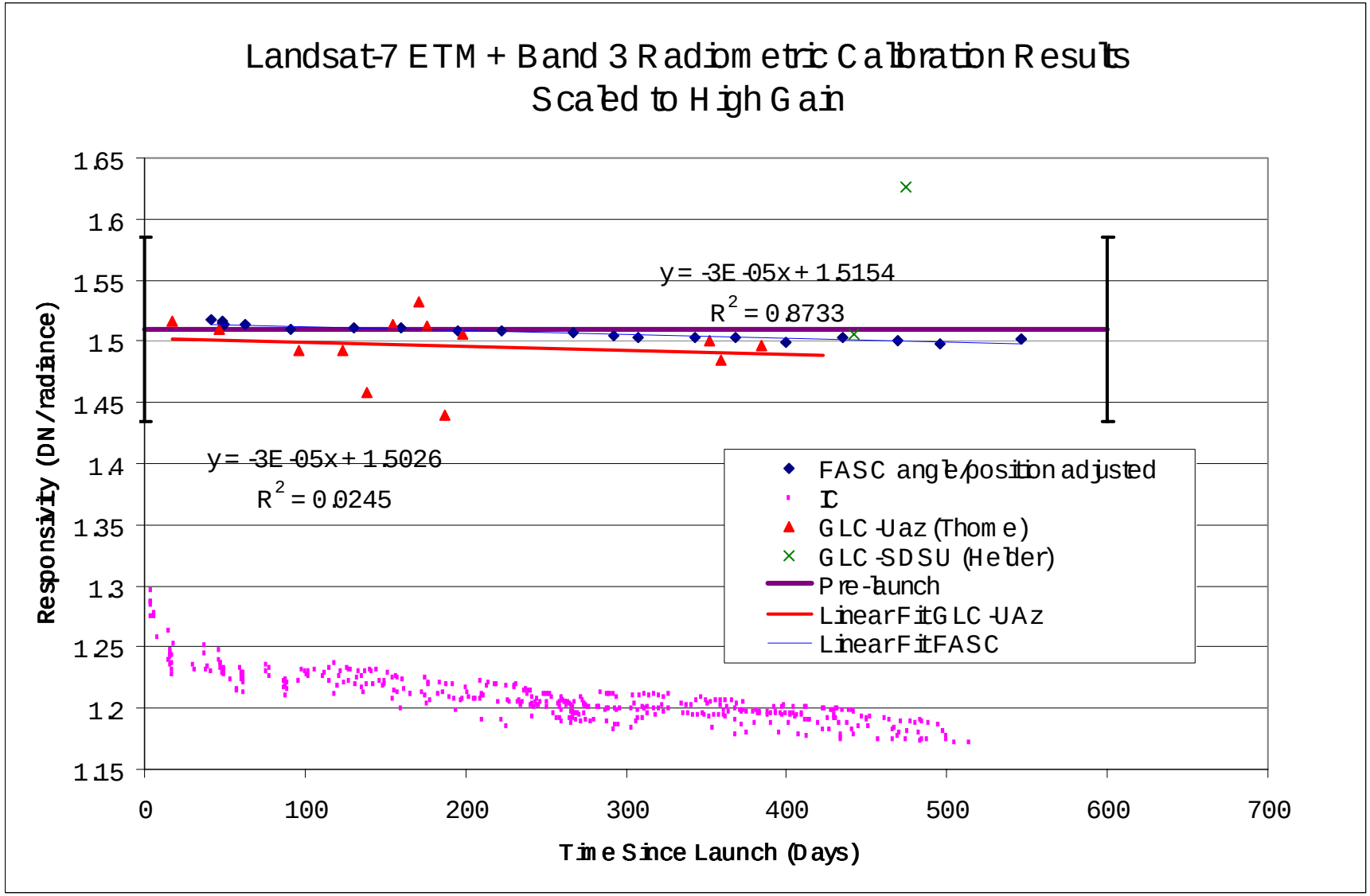
Summary of results



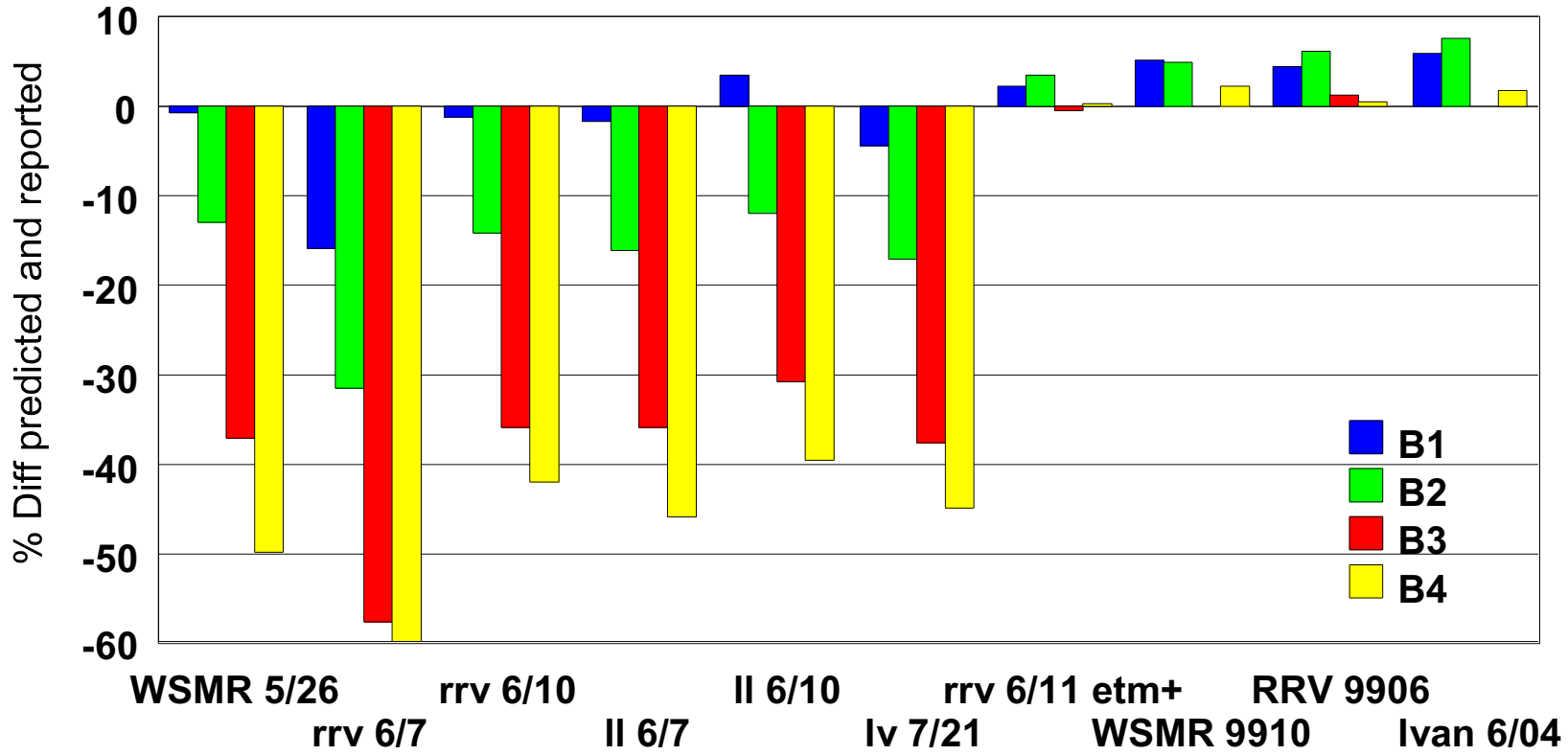
Landsat-7 results



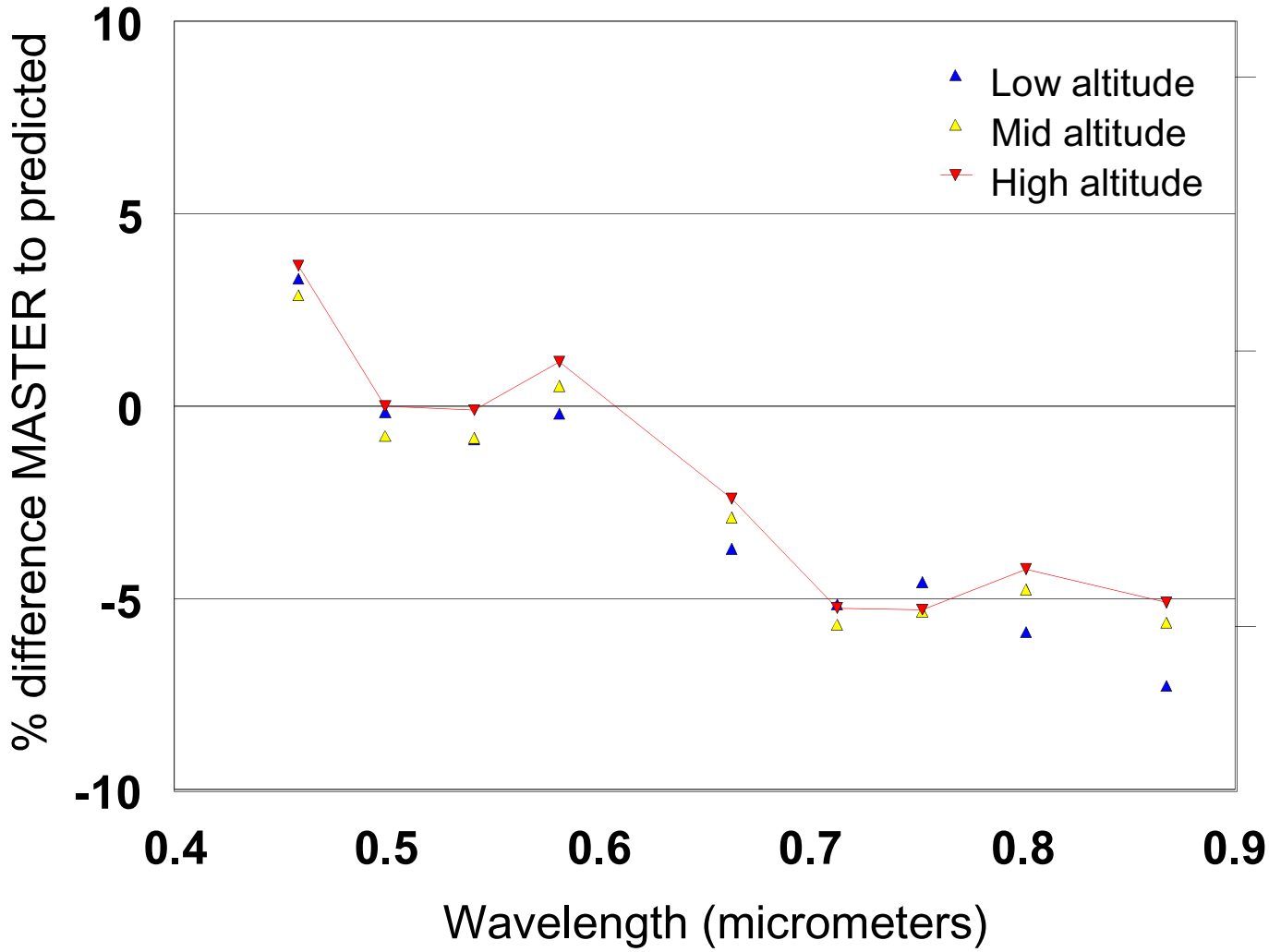
Landsat-7 results



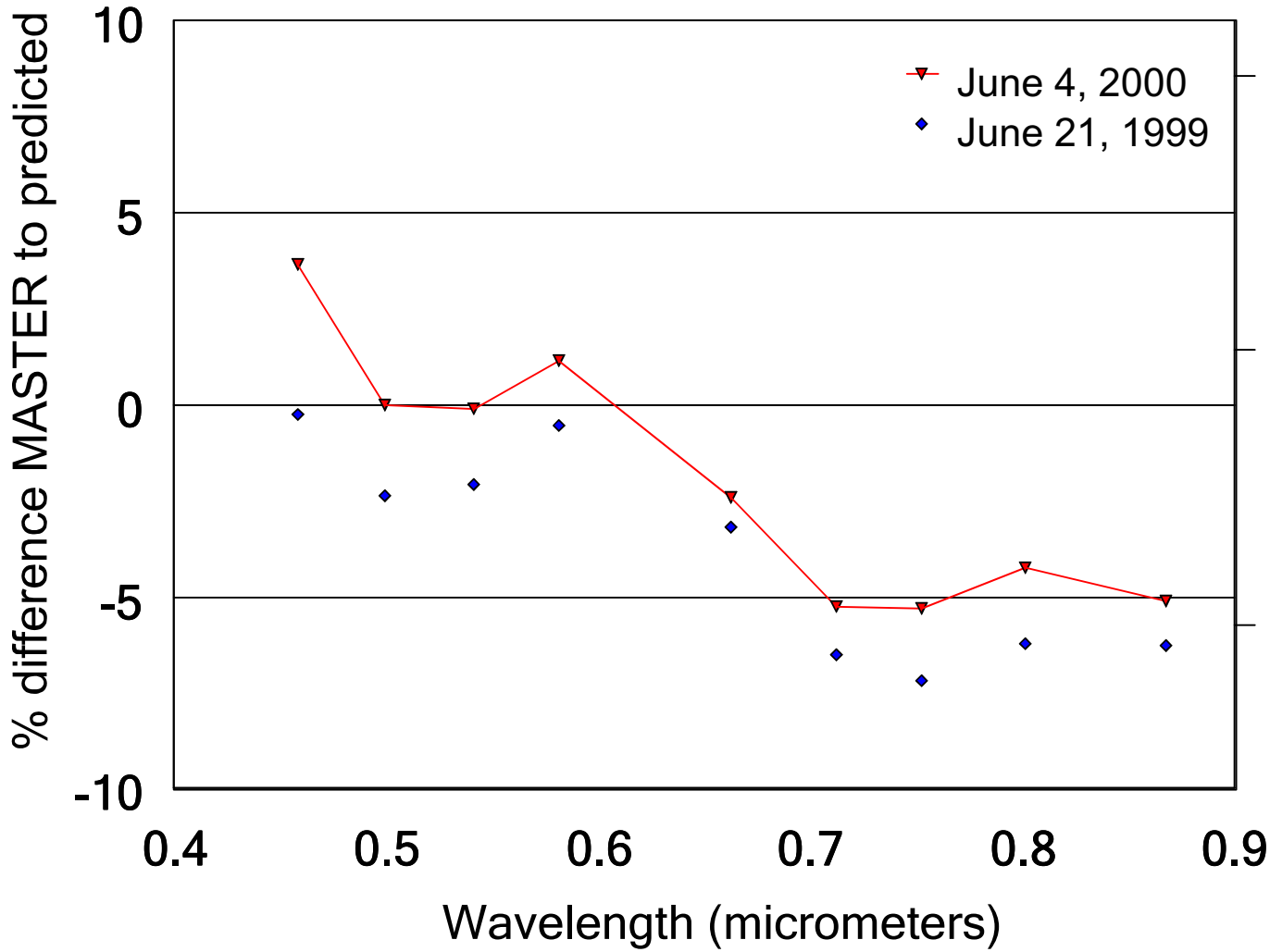
Summary of Ikonos results relative to ETM+



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