# Ground-reference calibration results for MODIS

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Presented at
MODIS Science Team Meeting

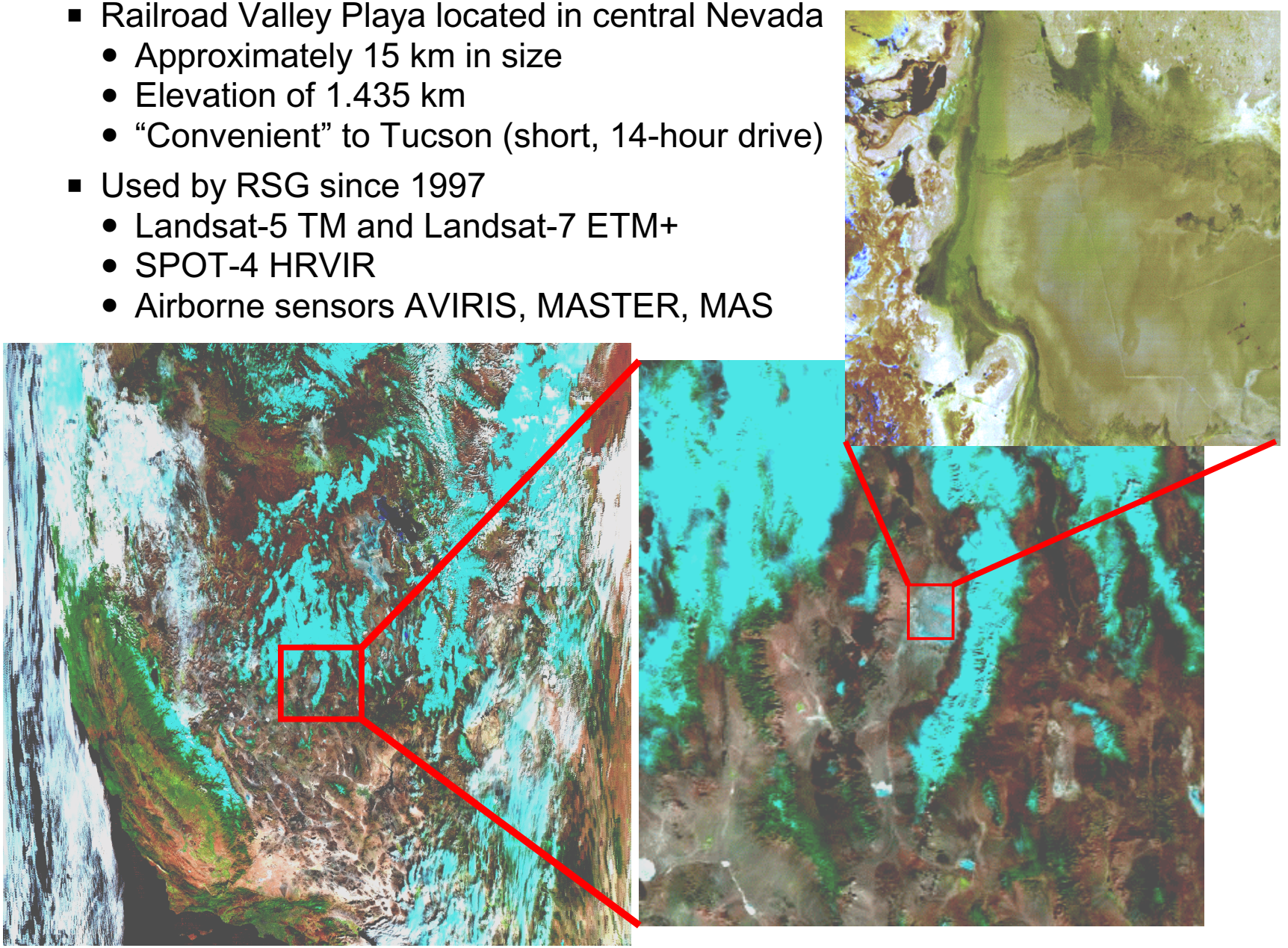
BWI, Maryland
December 18-19, 2001

# Introduction

- Vicarious calibration results of the Remote Sensing Group at the University of Arizona
- Reflectance-based method
  - Surface reflectance measurements and atmospheric transmittance data are used as input to a radiative transfer code
  - Radiative transfer code used to predict at-MODIS radiances
  - Compare predicted radiances to MODIS radiances from Level 1B
- Cross-calibration to ETM+

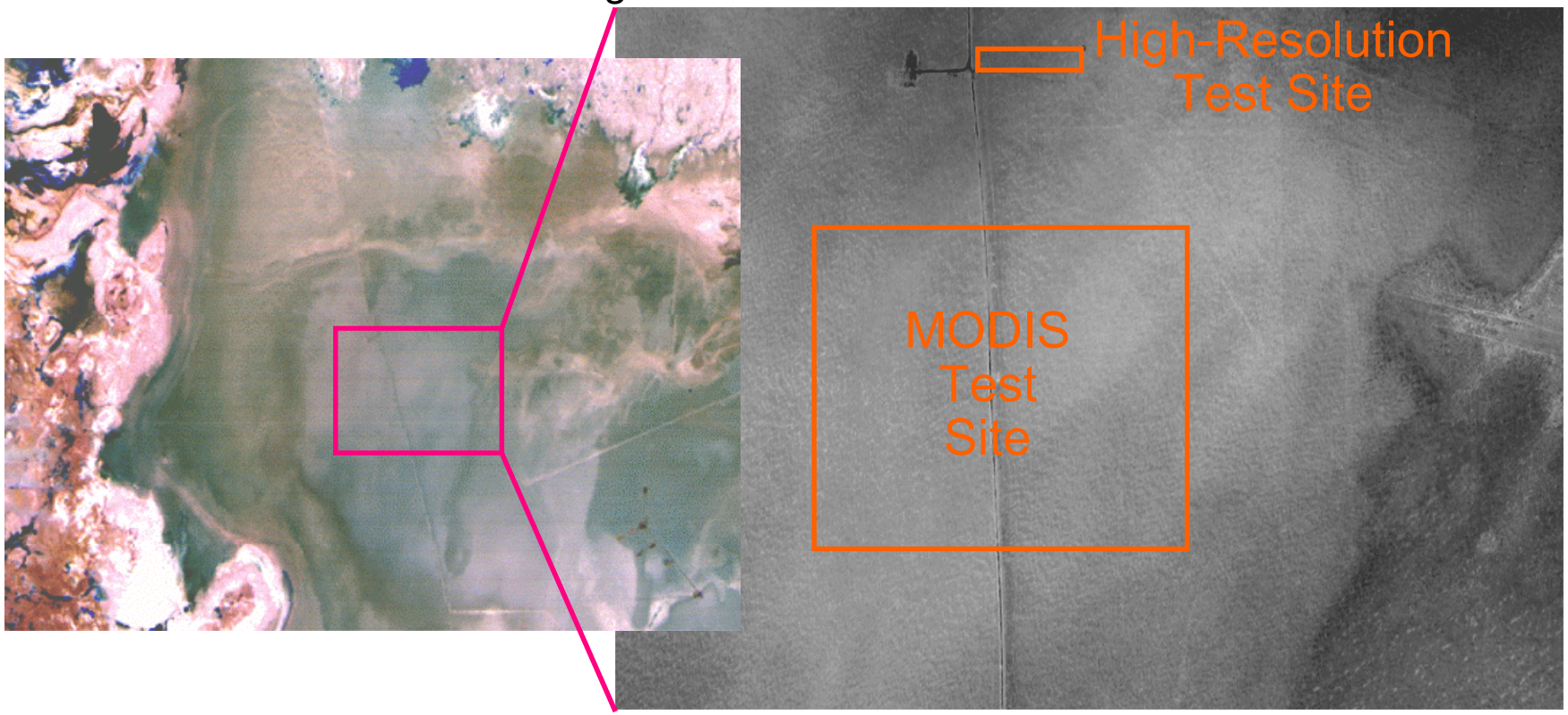
# Railroad Valley test site

- Railroad Valley Playa located in central Nevada
  - Approximately 15 km in size
  - Elevation of 1.435 km
  - “Convenient” to Tucson (short, 14-hour drive)
- Used by RSG since 1997
  - Landsat-5 TM and Landsat-7 ETM+
  - SPOT-4 HRVIR
  - Airborne sensors AVIRIS, MASTER, MAS



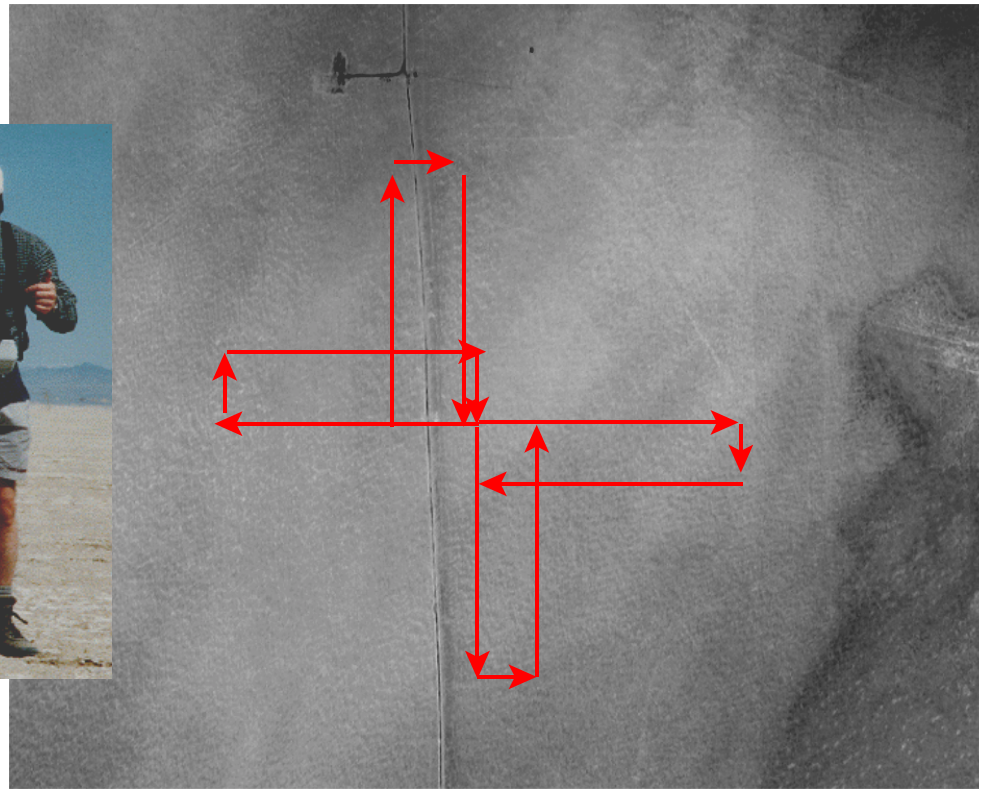
# Railroad Valley test site

- Sites are selected based on homogeneity and logistics
- High-resolution sites are located near an area that is suitable for the group's mobile laboratory
  - Two sites are used based on pushbroom and whiskbroom sensors
  - Poorer spatial homogeneity is not a large factor because the surface reflectance of the site is oversampled
- MODIS site requires better spatial homogeneity
  - Location near road allows easy placement of reference panel
  - MODIS site selected using Landsat-5 TM data

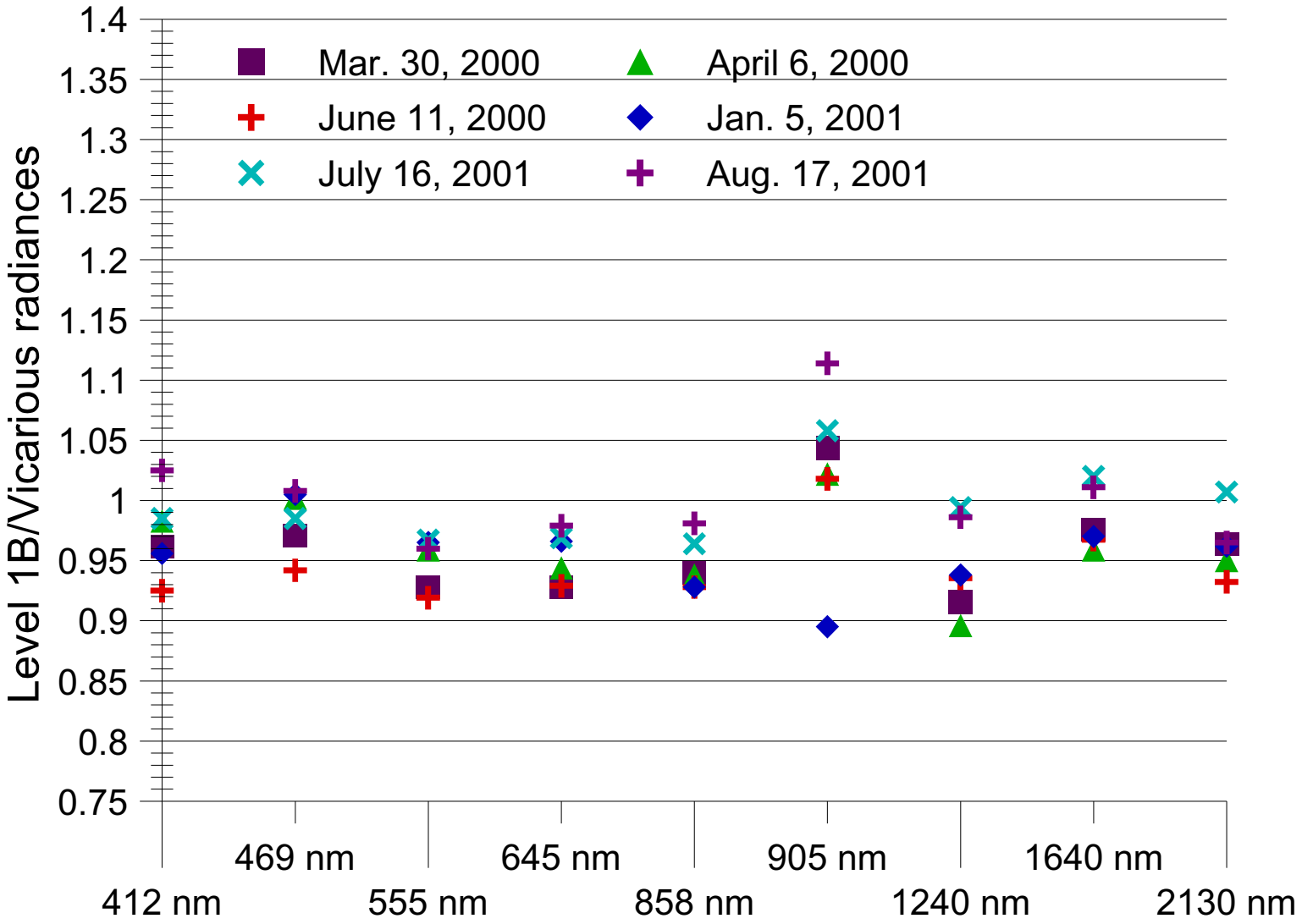


# Surface reflectance retrieval

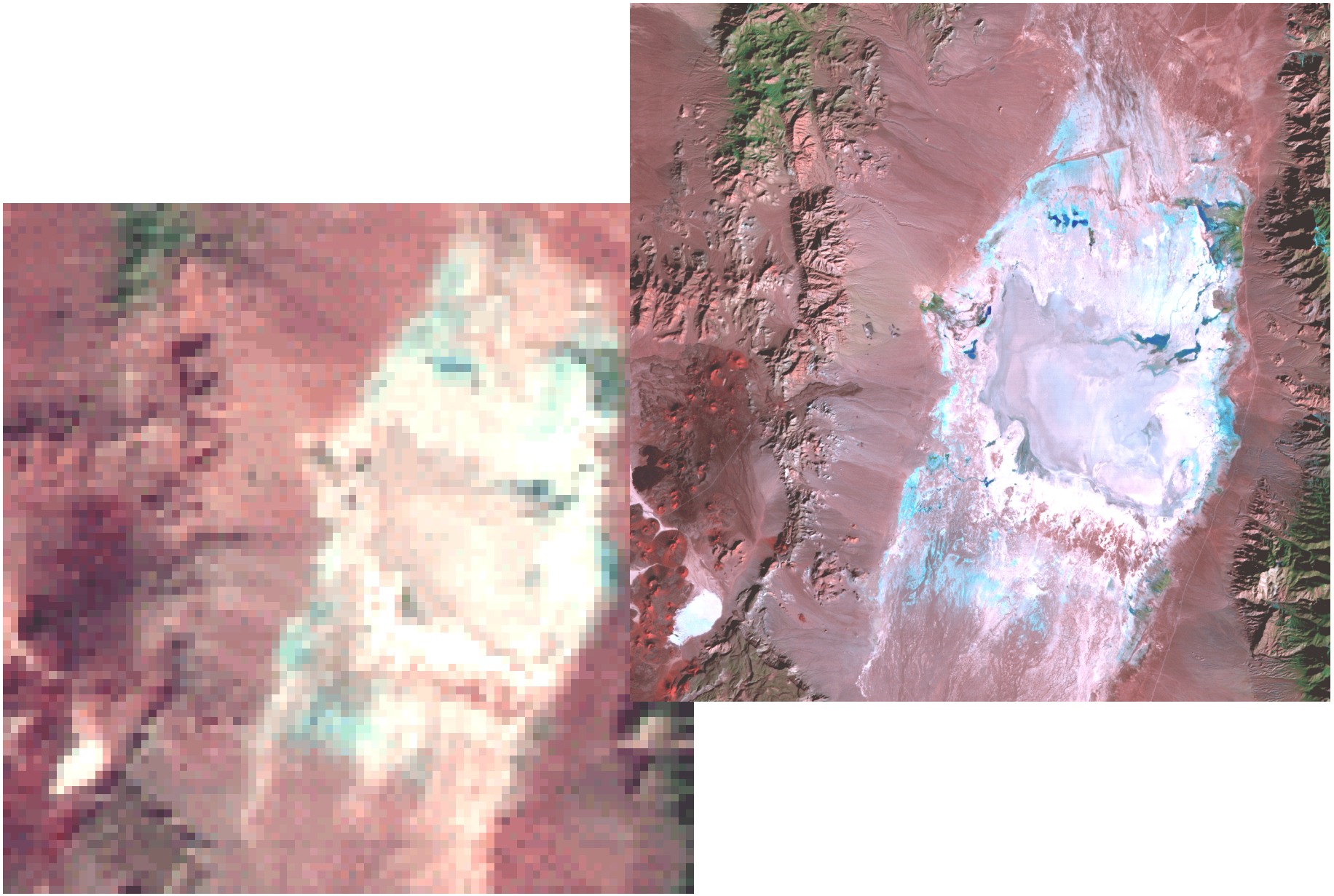
- Surface reflectance is found by referencing measurements of upwelling radiance from the test site to those of a panel of known reflectance
  - Reference panels are Spectralon
  - Radiometer reports data at 1-nm intervals from 350 to 2500 nm
- Directional reflectance effects are taken into account by pointing a radiometer to simulate the satellite view direction
- For MODIS, the sampling strategy is significantly different than for small-spatial resolution sensors with 8 paths of 500 m in length separated by 100 m



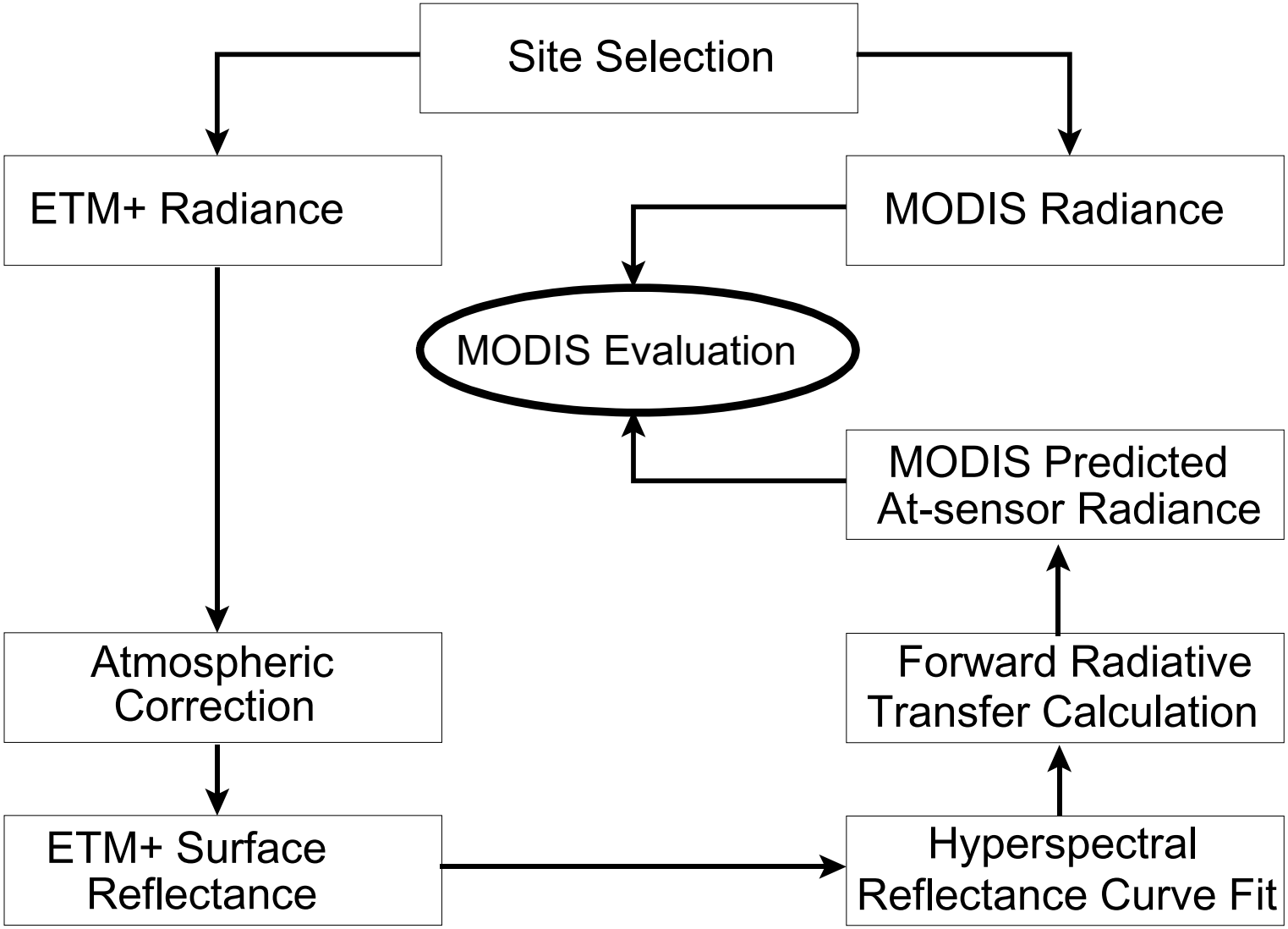
# Reflectance-based



# Railroad Valley test site - January 5, 2001

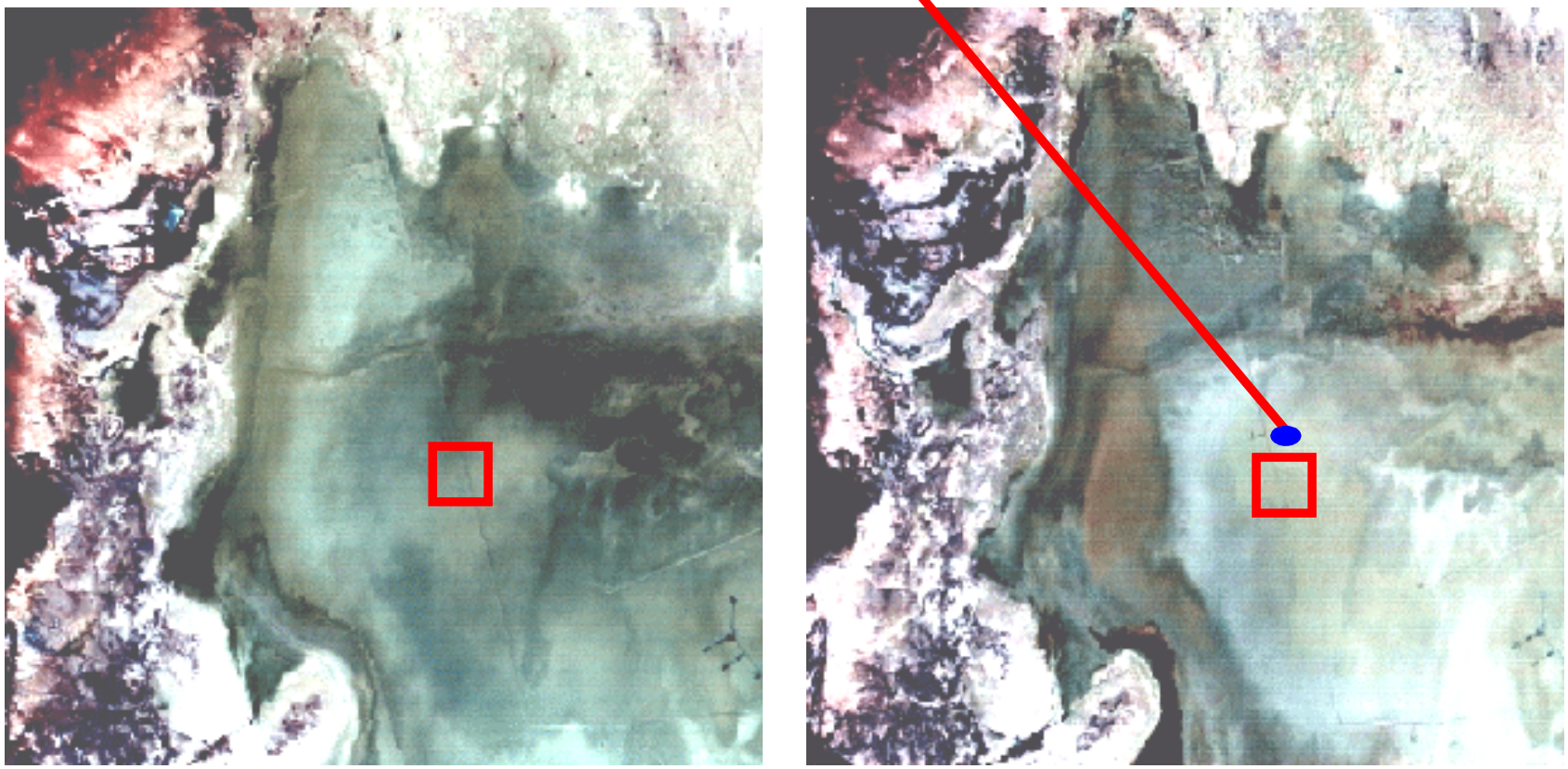


# Cross-comparison method



# Test site used

Location of high-resolution test site

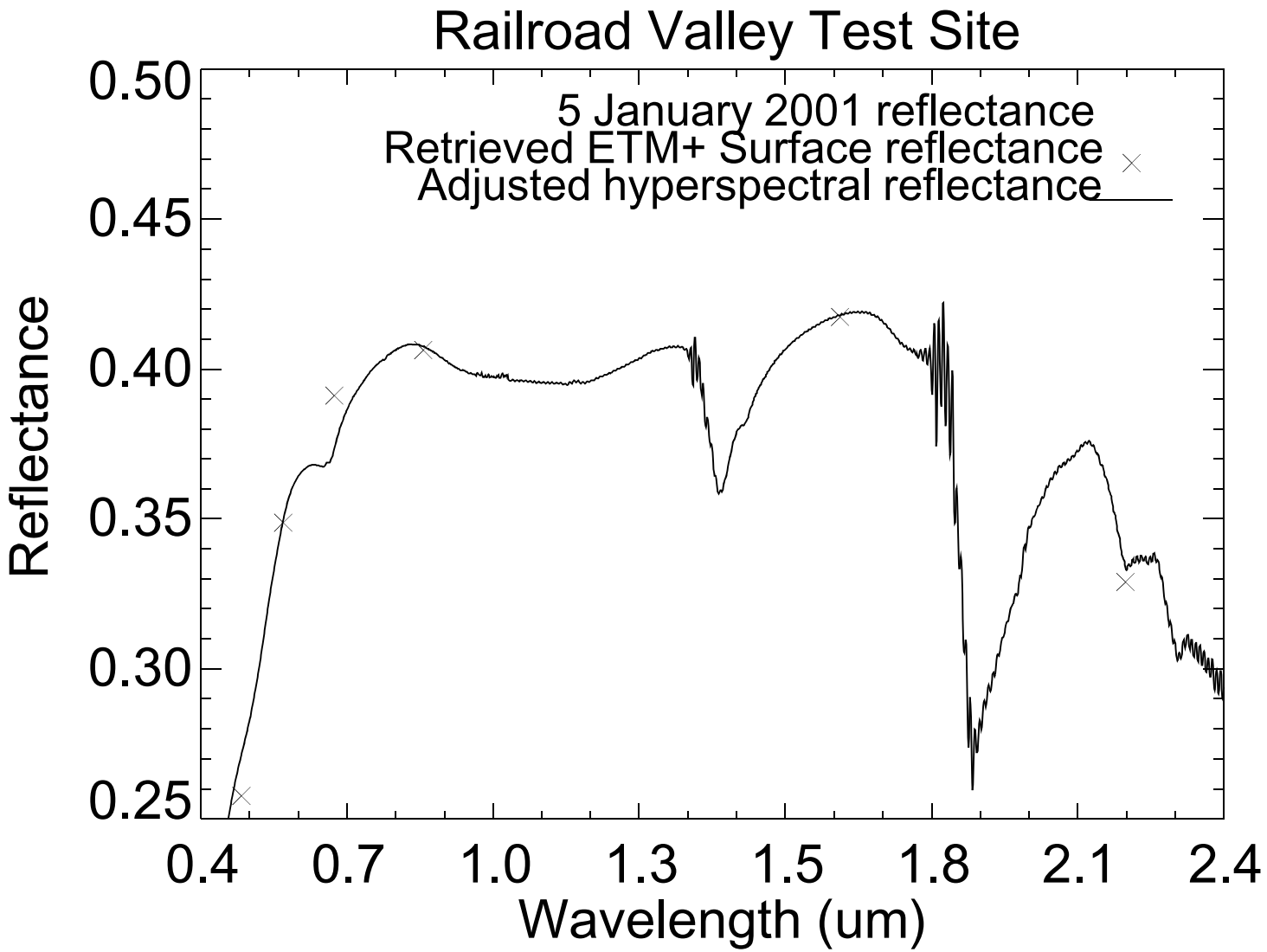


June 11, 2000

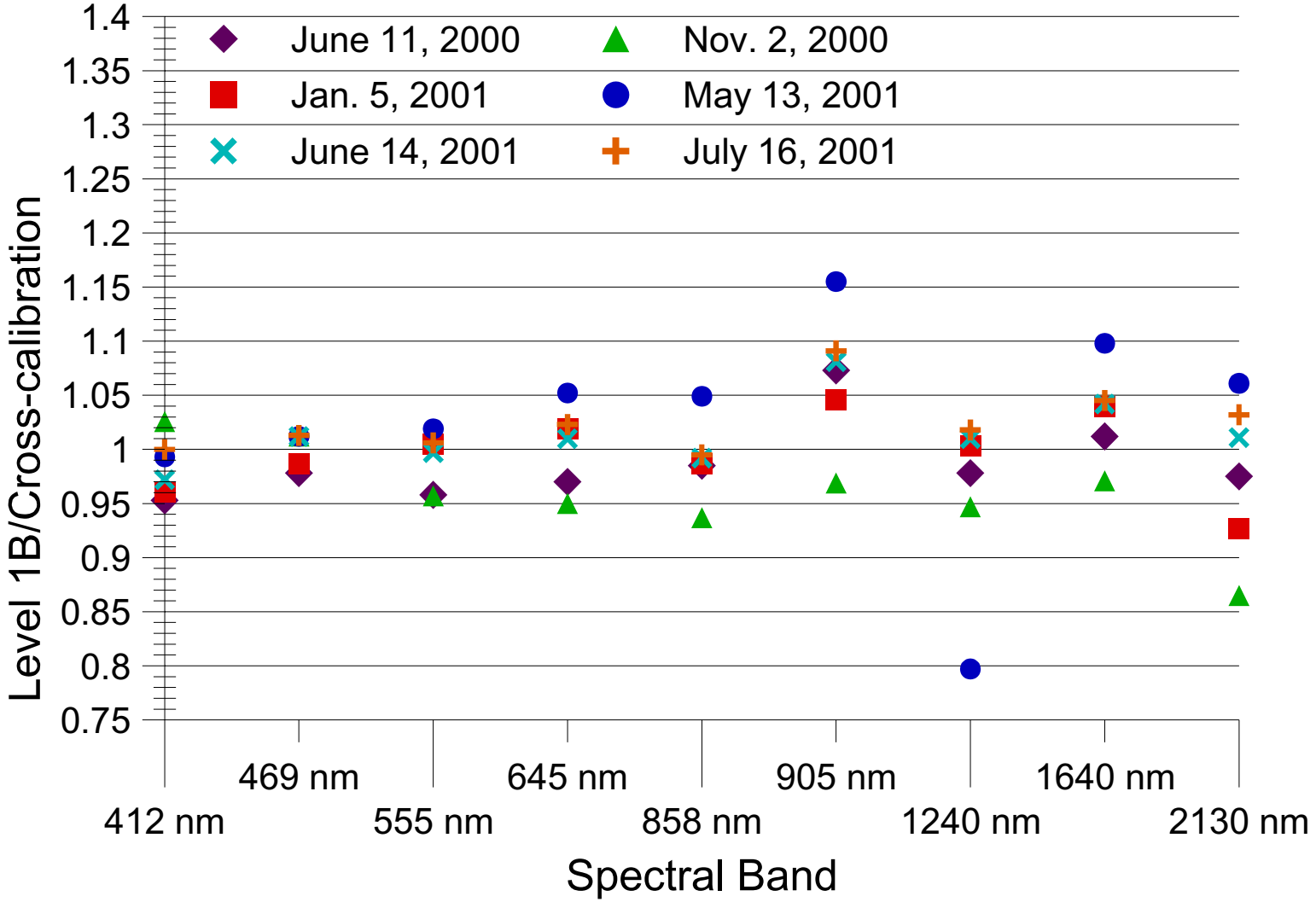
January 5, 2001

Red boxes indicate 1-km MODIS area used for cross-calibration

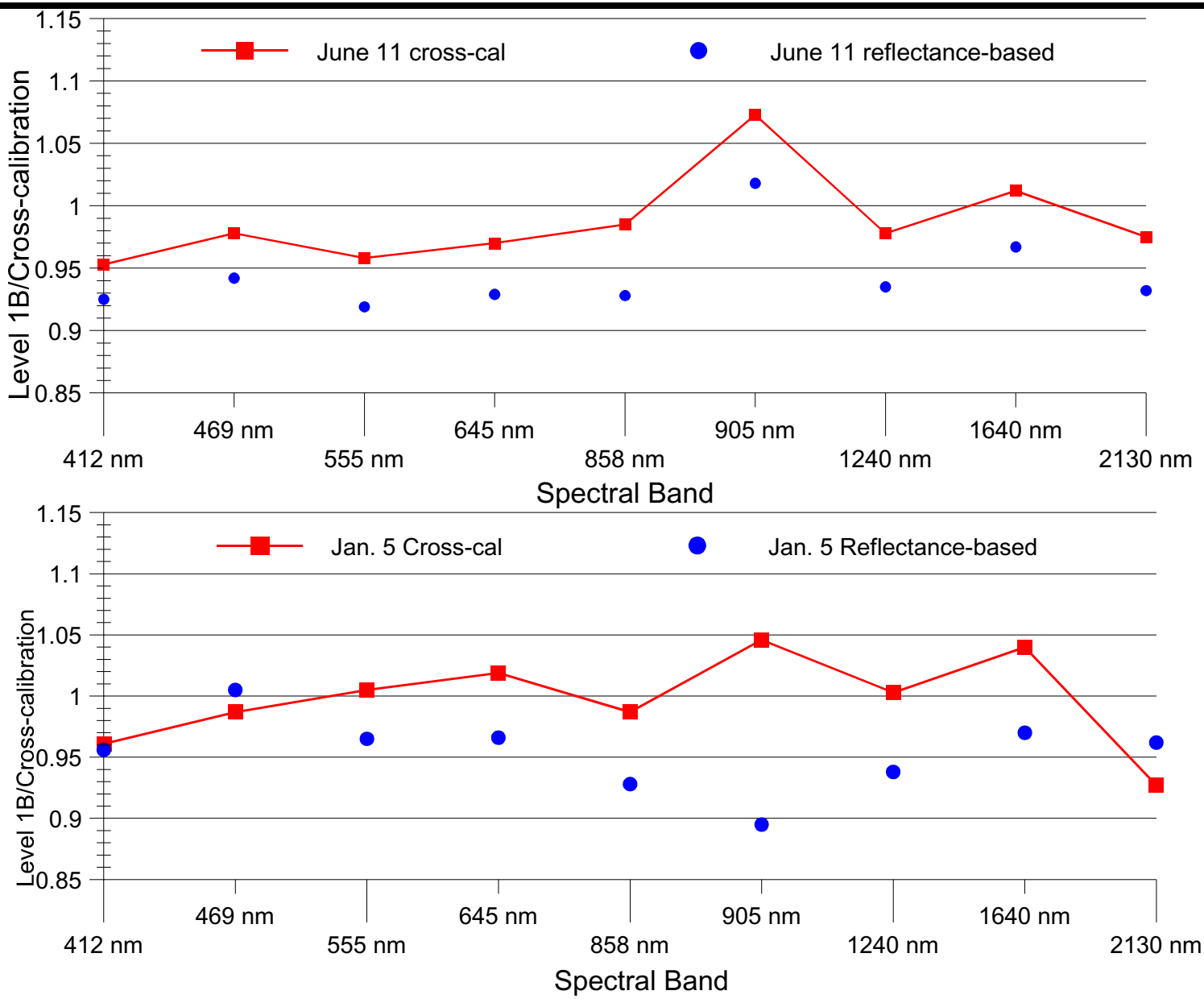
# Hyperspectral reflectance curve fit



# Cross-comparison to ETM+



# Comparison with reflectance-based results

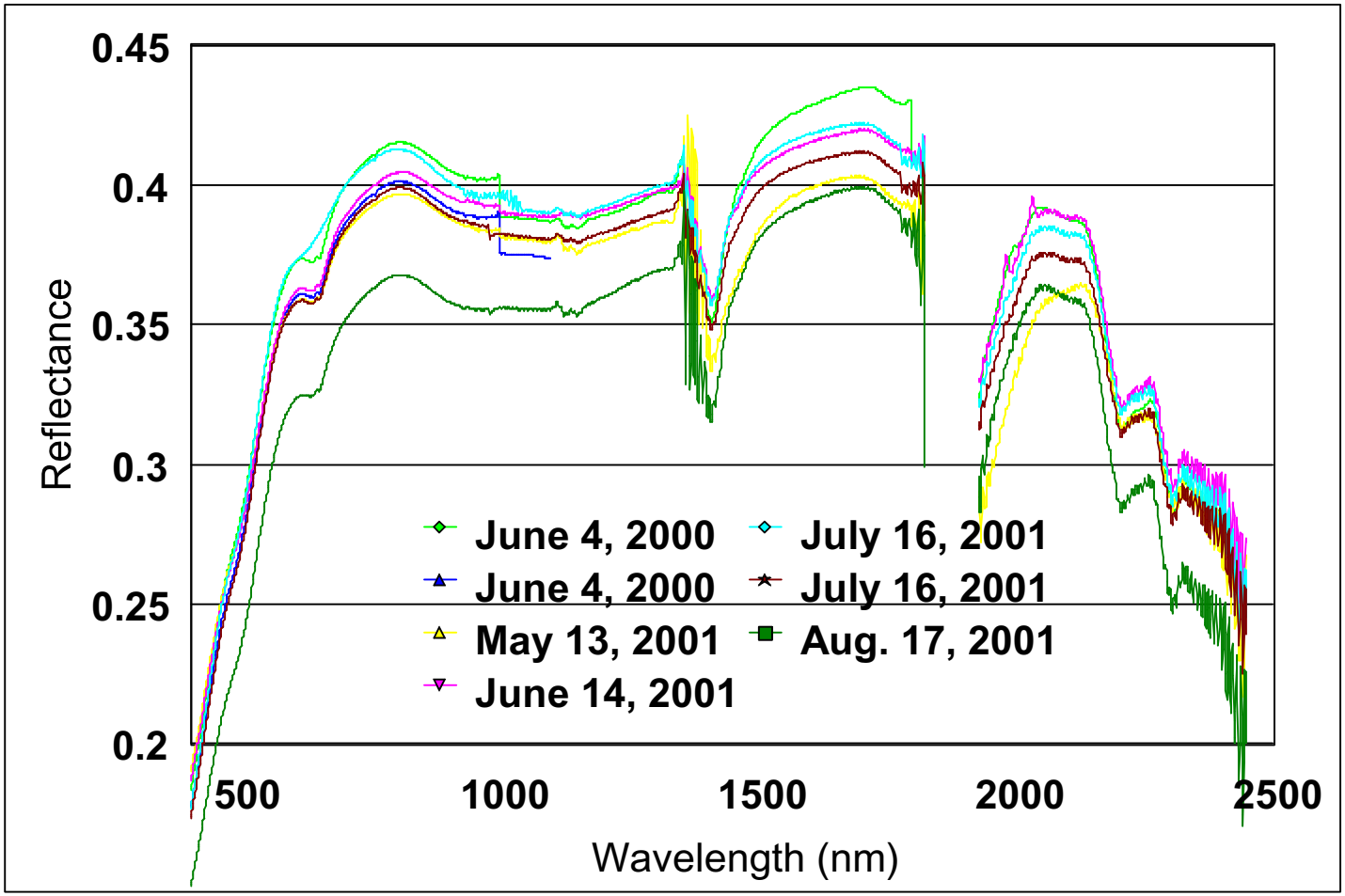


# Reflectance-based- no ground personnel

- Basic meteorological station has been operated at the site since April 2001
  - Temperature, humidity, pressure, wind speed direction
  - Pyranometer
  - Rain gage
- Aeronet Cimel solar radiometer deployed June 2001
- Possible to use these data with an assumption of the surface reflectance to predict at-sensor radiance

# Surface reflectance assumption

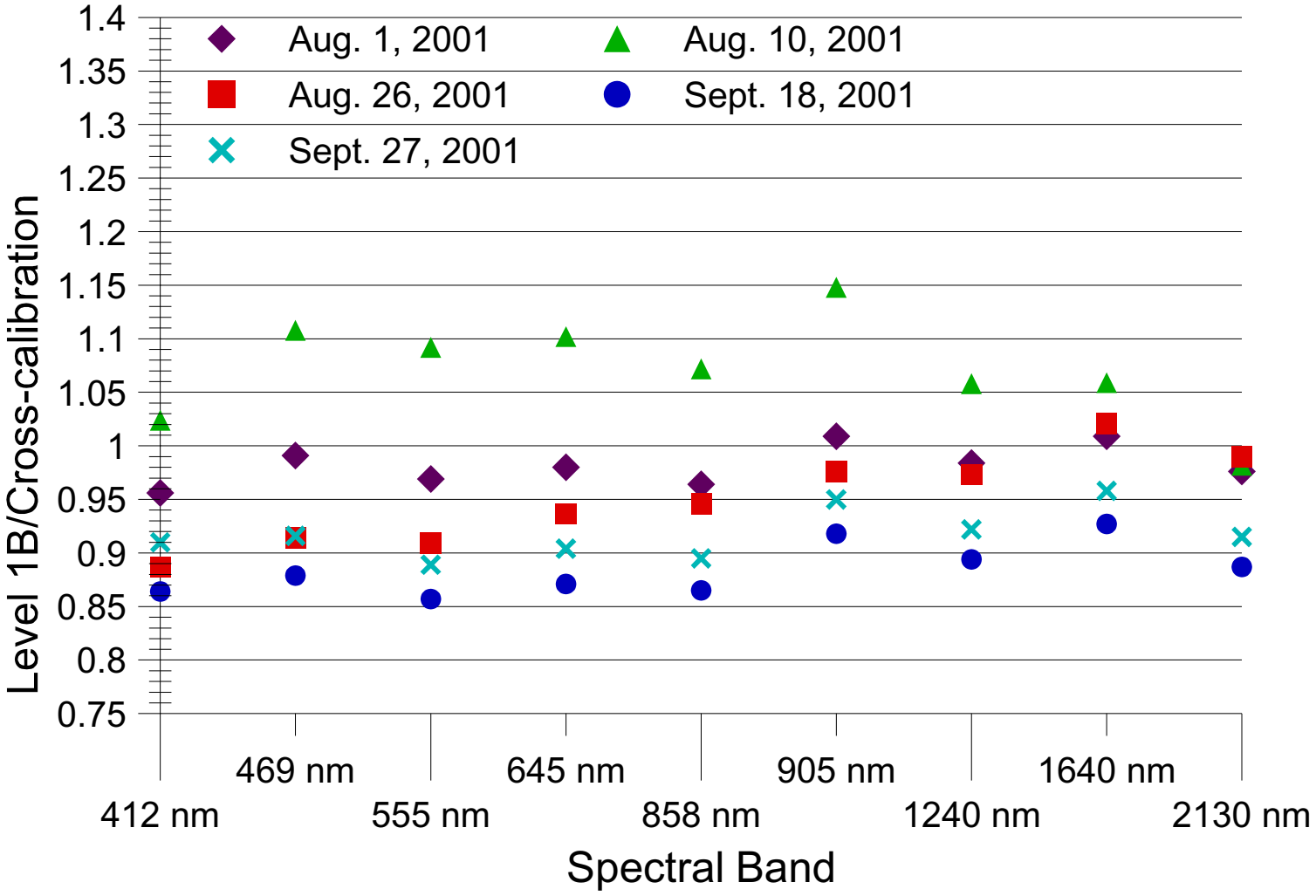
- Work over past three years indicates that summer time reflectance for a dry surface is “constant” to within 3% of the reflectance
- Difficulty is surface reflectance changes significantly due to rainfall



# No ground personnel approach

- First attempt is to declare a wet and dry reflectance
  - Found it takes about 7 days in summer for playa to “dry” out
  - Wet reflectance based on August 17 measurements that occurred five days after rain
  - Dry reflectance average of all other dates used for cross-comparison and reflectance-based approach
- Looked at five dates
  - August 1, 2001 - No rain for 3 weeks prior to measurement set
  - August 10, 2001 - 0.10 inches rain previous day
  - August 26, 2001 - Last rain Aug. 12-13, 0.10 inches
  - Sept. 18, 2001 - Rain Aug. 30 and Sept. 2 for total of 0.4 inches
  - Sept. 27, 2001 - Last rain Sept. 2
- Based on this, assumed dry reflectance for all dates but Aug. 10
- Cimel data used to determine Junge parameter and column water vapor
- Ozone amount assumed to be 0.250 cm-atm for all dates

# Remote-based measurements



# Conclusions

- Reflectance-based results show “precision” of better than +/- 5% except for 905 nm band which has higher variability
- Biases seen between MODIS and reflectance-based results
  - Vicarious predicts radiance that are on average 2-5% higher than MODIS
  - 905 nm only band where vicarious values lower (about 3%)
  - Most optimistic accuracy assessment of reflectance-based approach is 3% (for high spatial resolution sensors)
  - Even with this accuracy, vicarious and image-based data agree better than the combined uncertainties
  - Results are very encouraging for the direct reflectance-based calibration approach
- Cross-comparison results with ETM+ show agreement between the two sensors to better than 2% on average
  - Excluding 905 nm band
  - Excludes 1240 nm data point from May 13
  - More variabilty in SWIR bands - probably due to reflectance prediction

# Conclusions and Future Work

- Early results from “remote” calibrations are encouraging
  - Need better surface reflectance model versus rainfall and time
  - Evaluate the spectral changes with surface moisture
  - Will be especially useful to fill in gaps in cases when field campaigns unsuccessful due to poor weather
- Future plans
  - Cross-calibration to ASTER (still attempting to understand the behavior of ASTER)
  - Better reflectance prediction approach using ETM+ (or MODIS)
  - Cross-calibration to Landsat-5 TM
  - These approaches should help for calibration of FM1
    - Understanding the surface reflectance model will allow PFM and FM1 to be cross-compared more easily
    - BRDF data are being processed to evaluate this effect
- MCST has successfully tracked changes in sensor response for reflective bands

# Atmospheric correction of ETM+ data