Vicarious calibration results for QuickBird- 2

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Introduction

- A short background (what we do)
- Reflectance-based vicarious calibration (how we do it)
- Results for QuickBird
- Comparison with Landsat-7 ETM+ results
- Conclusions

Vicarious Calibration

- Remote Sensing Group's primary research is related to the radiometric calibration of satellite and aircraft imaging sensors
  - Critical for studies of global climate change over time
  - Ensures consistent data sets from multiple sensors

- RSG is involved in all aspects of this work
  - Assisting in prelaunch laboratory calibration design and measurements
  - Developing methods for onboard calibration
  - Inflight vicarious calibration using well-understood ground sites – an approach that does not rely on on-board calibrators (e.g., solar diffusers, lamps) to determine the relationship between incident spectral radiance and sensor output (SPOT, Landsat-5, MODIS, ASTER, Landsat-7 ETM+, GLI)

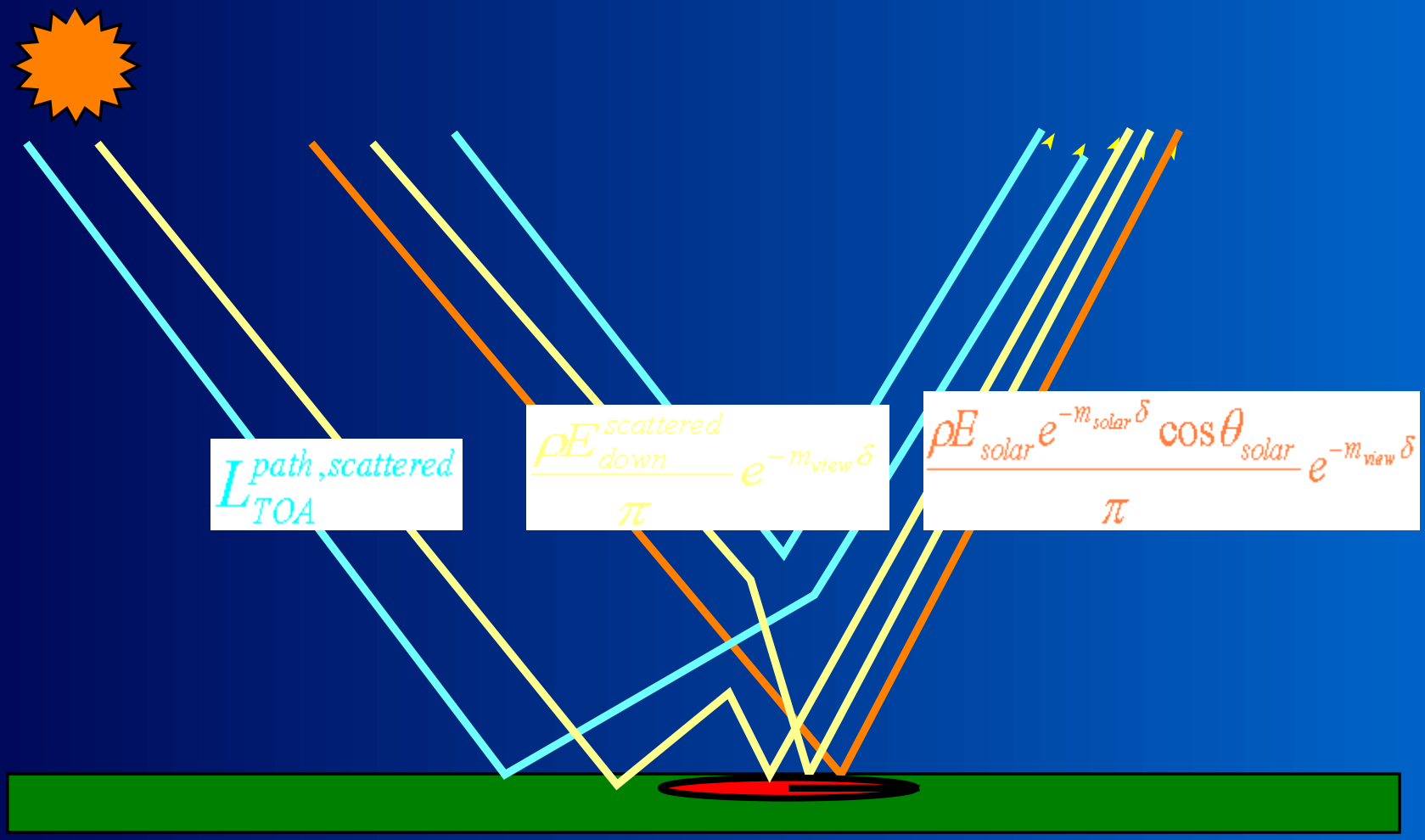
Why bother with vicarious?

Radiance validation is most critical for the accurate retrieval of geophysical parameters from temporal data sets with little to no overlap

- Realistically, absolute radiometric calibration may not be needed for some specific cases
  - Data from a single sensor with focus on change analysis
  - Multiple sensors for which significant overlap exists
- Temporal studies and inter-sensor measurements, however, critically require validated sensors
  - Biases between sensors need to be removed
  - Temporal changes in response must be tracked
- Temporal studies using multiple sensors with little to no overlap in data MUST have accurate absolute radiometric calibration

At-sensor radiance

Computer model simulates the scattering of photons in the atmosphere to the sensor



UofA Reflectance-Based

Remote Sensing Group at University of Arizona relies primarily on a reflectance-based approach

- Atmospheric characterization
  - Aerosol columnar amount and optical properties
  - Column absorber amounts (water vapor and ozone)
- Surface reflectance
  - Measurement of a preselected area from the ground
  - Use of airborne or satellite-based sensor
- Input into a radiative transfer code to predict at-sensor radiance
- Band-averaged over sensor spectral response and compared to reported radiance from sensor

Field, Laboratory, and Modeling

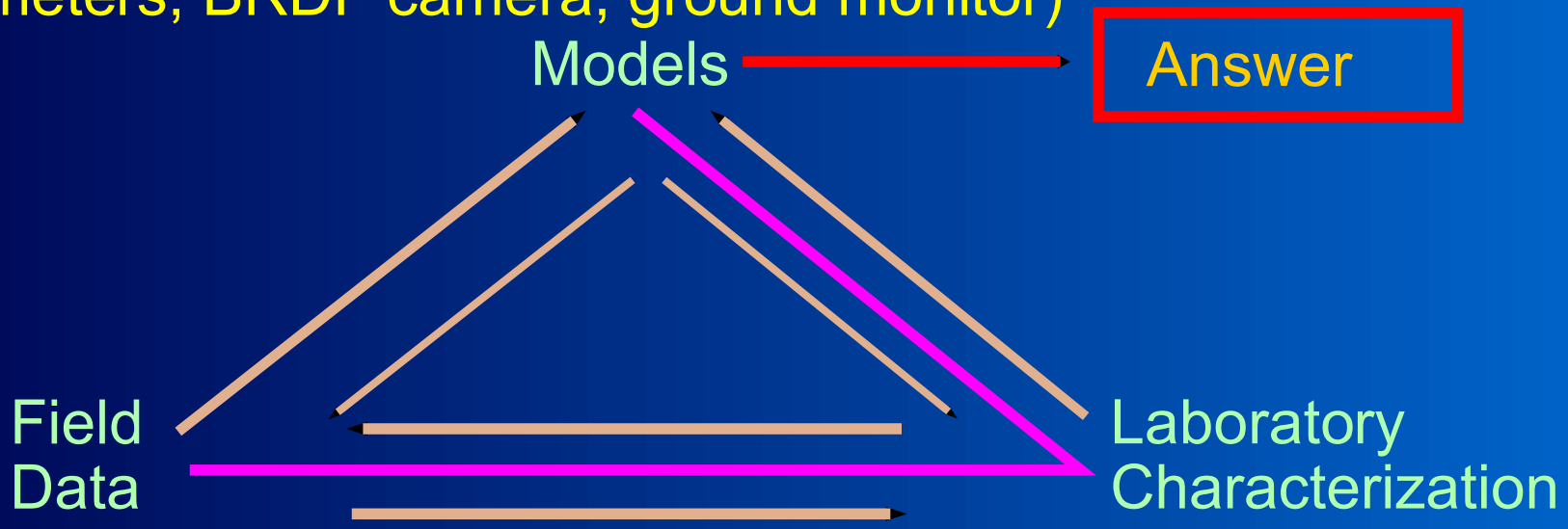
Accuracy of our results are determined by our ability to make accurate measurements

Laboratory measurements are needed to understand the instrumentation that we use

Field measurements determine the required variables

Atmospheric radiative transfer code tie everything together

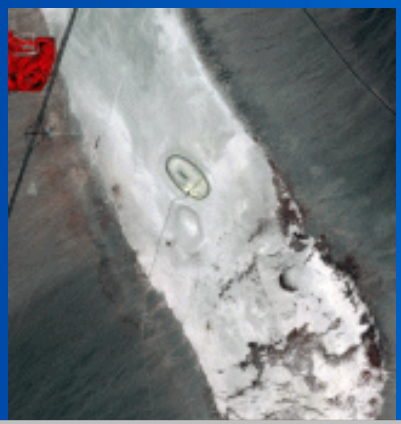
All our students do some work in each area (theses e.g, radiometers, BRDF camera, ground monitor)



Reflectance-Based Approach

Measured Surface Reflectance

Measured Atmospheric Parameters



Average Test Site Output from Imagery

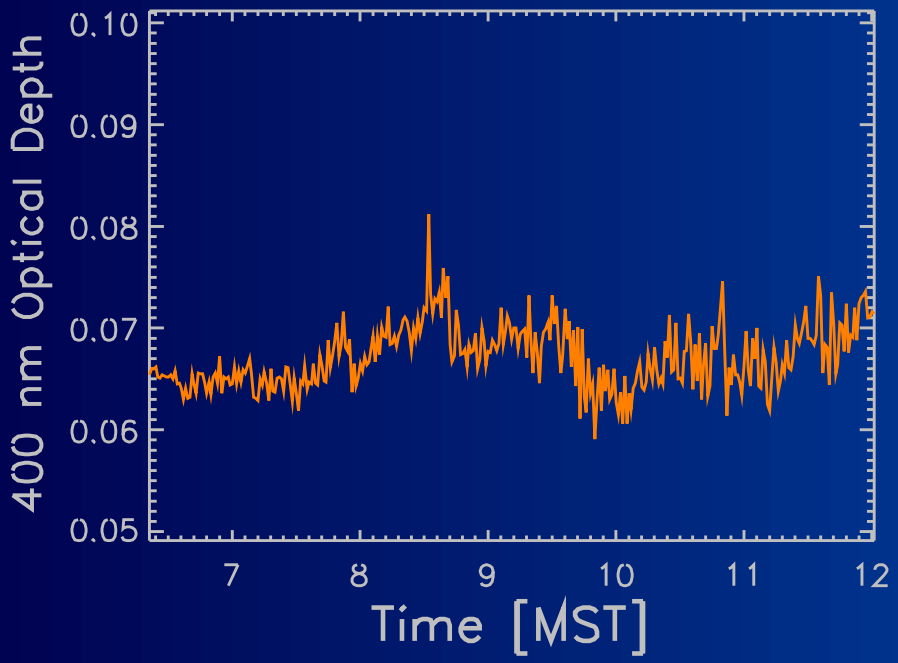
Radiative Transfer Code

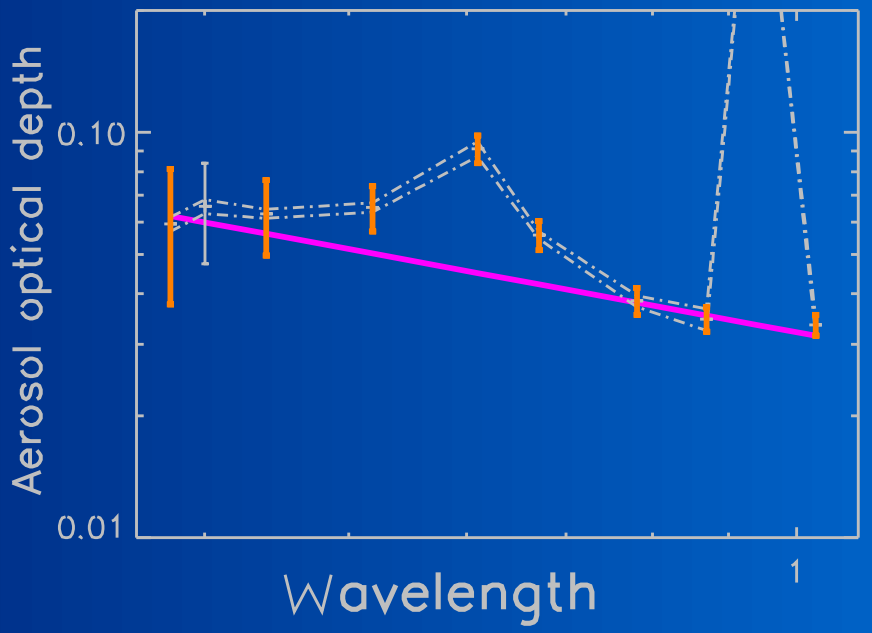
Predicted At-sensor Radiance

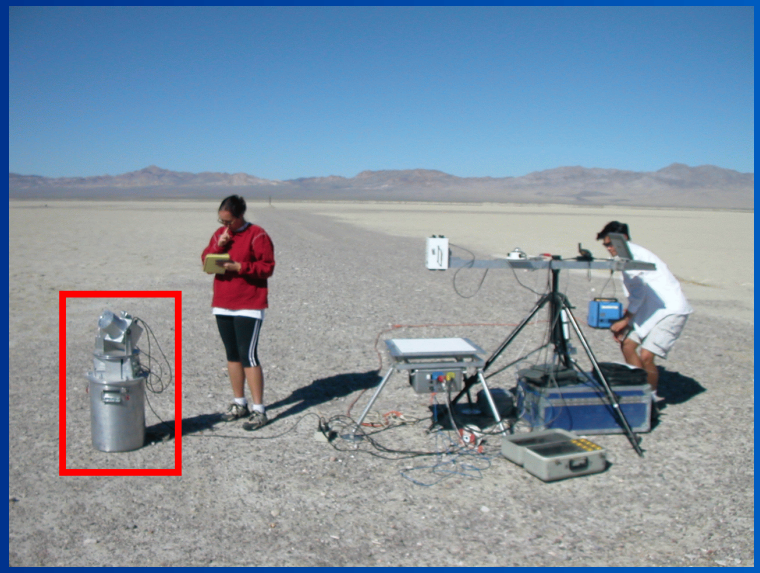
At-sensor Radiance

Evaluation of Calibration

Atmospheric Measurements







Surface reflectance

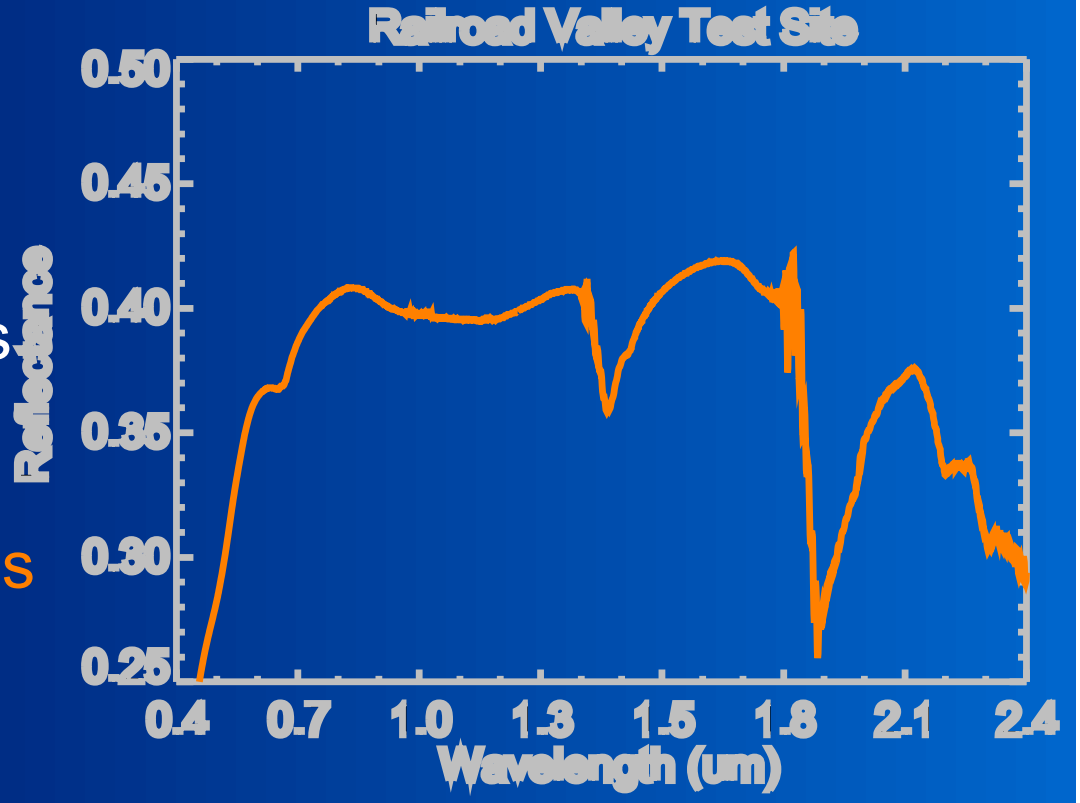
Measure a large area of the test site related to numerous pixels of the test sensor

- Measurements of the upwelling radiance of the test site are referenced to a standard of known reflectance
- Standard is characterized in the RSG's laboratory
- Instrument is a commercially available spectrometer

Surface Reflectance

Spectral reflectance is the average of all data points collected over the entire site

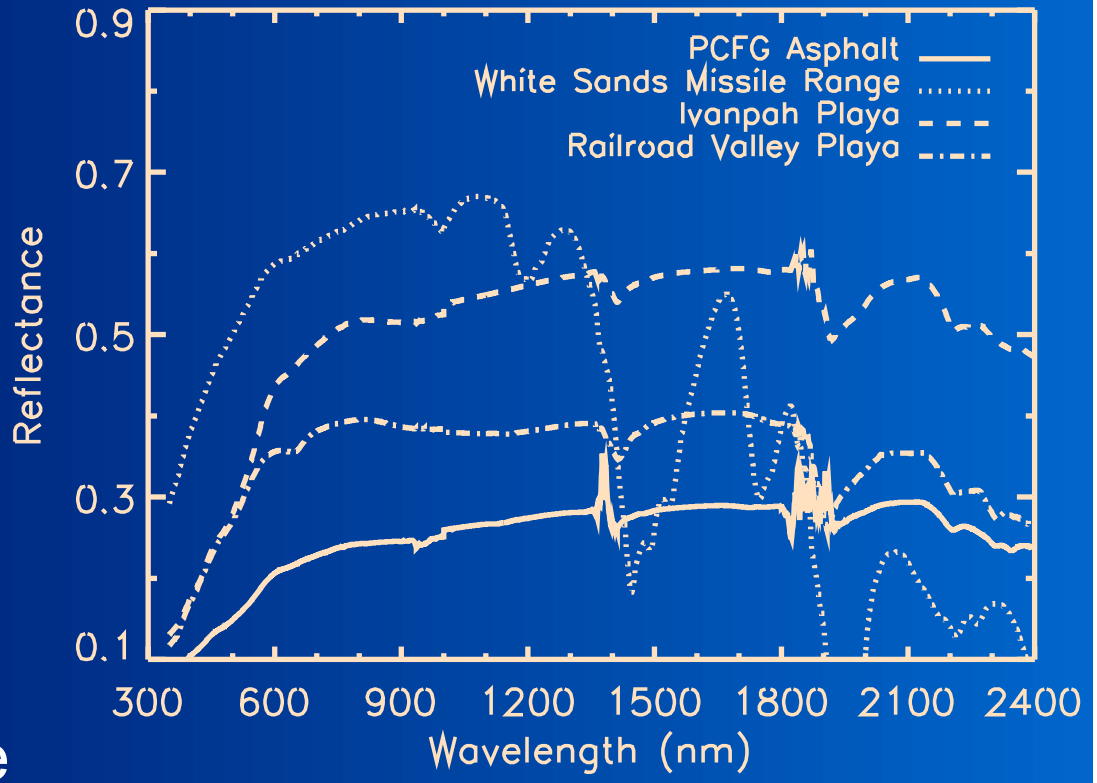
- Area covered is 300 m by 80 m for small-footprint CCD-array systems
- Takes approximately 30 minutes to collect the data set
- 480 spectra that are averages of 20 samples are collected
  - 8 spectra per 20 m
  - Reflectance standards measured every 64 spectra



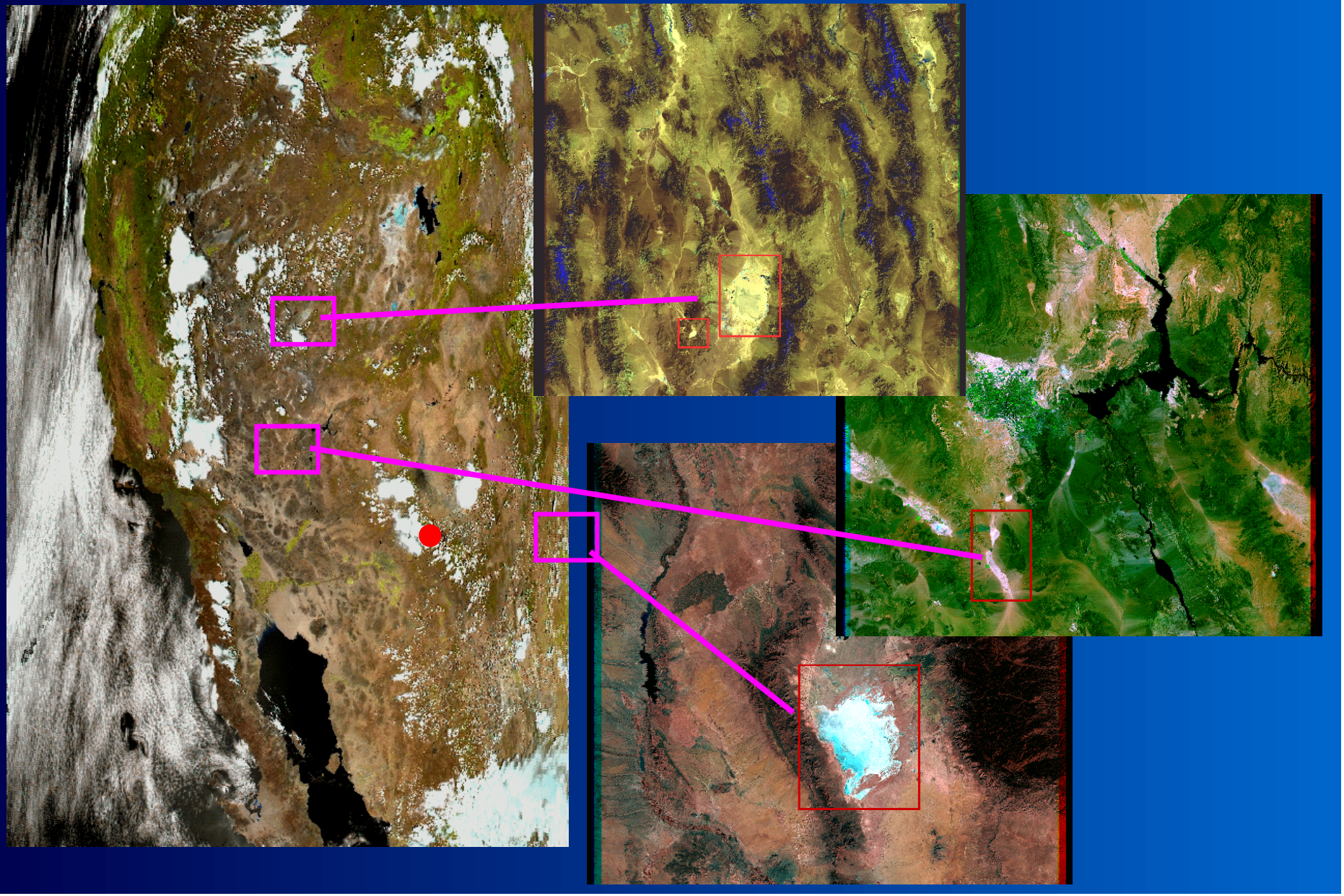
Test site characteristics

Ideal surface is flat spectrally with high reflectance, large size, low aerosol loading

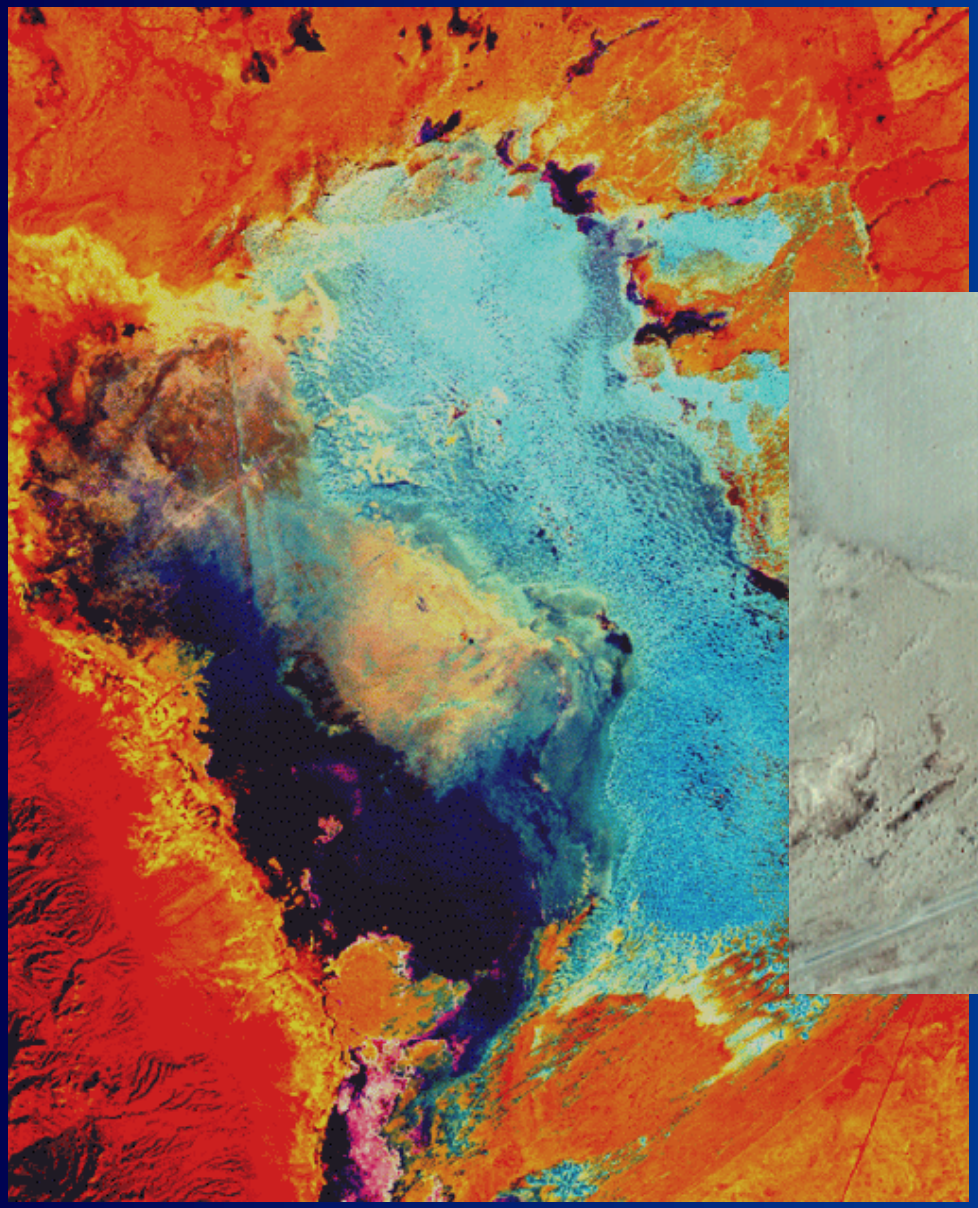
- High, flat spectral reflectance and nearly lambertian reduces uncertainties from the atmospheric characterization
- Large size with spatial uniformity reduces effects from adjacency effects and misregistration
- Accessibility and historical knowledge of site are important
- Flat spectral reflectance removes uncertainty due to sensor spectral response

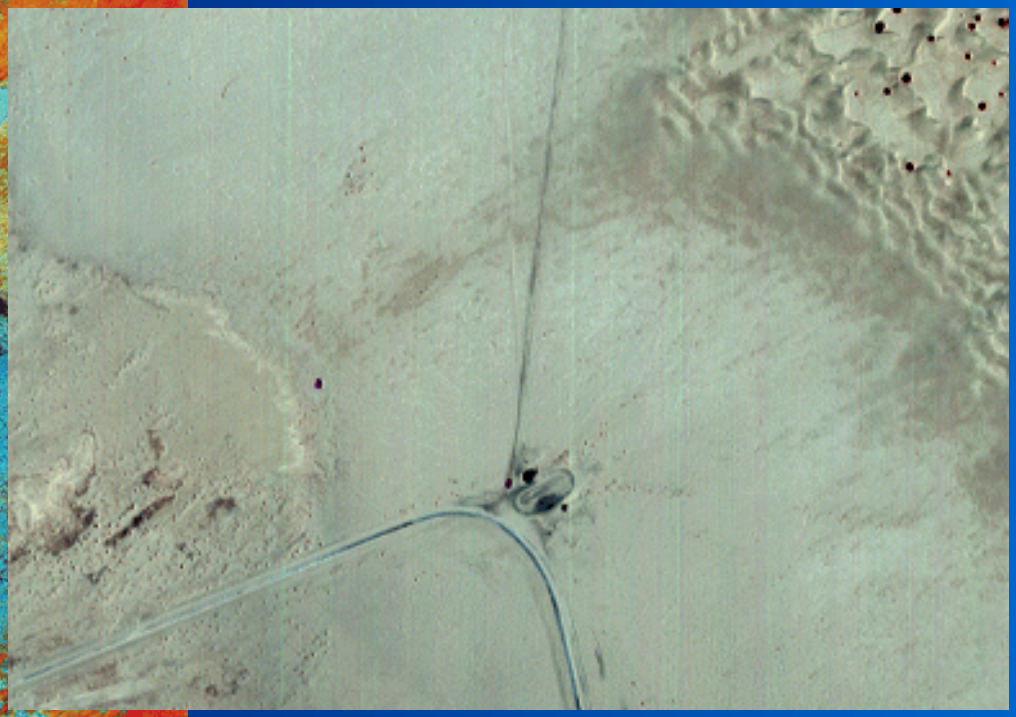


Test sites

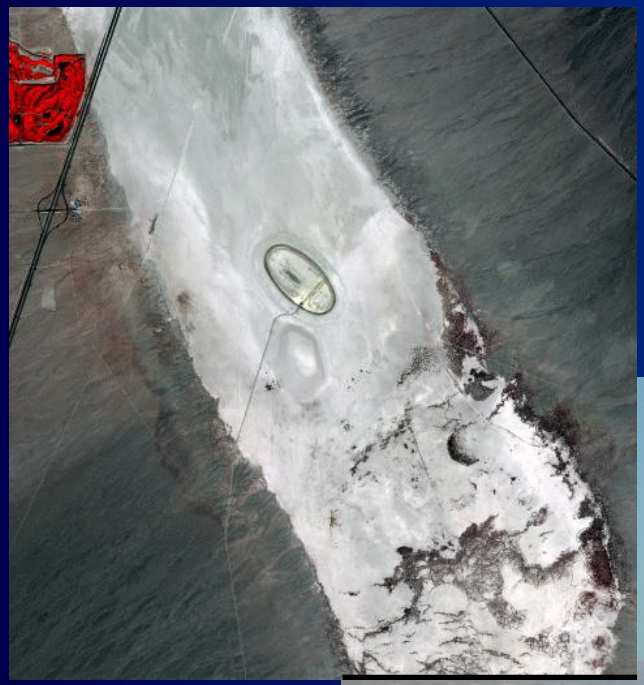


White Sands test site

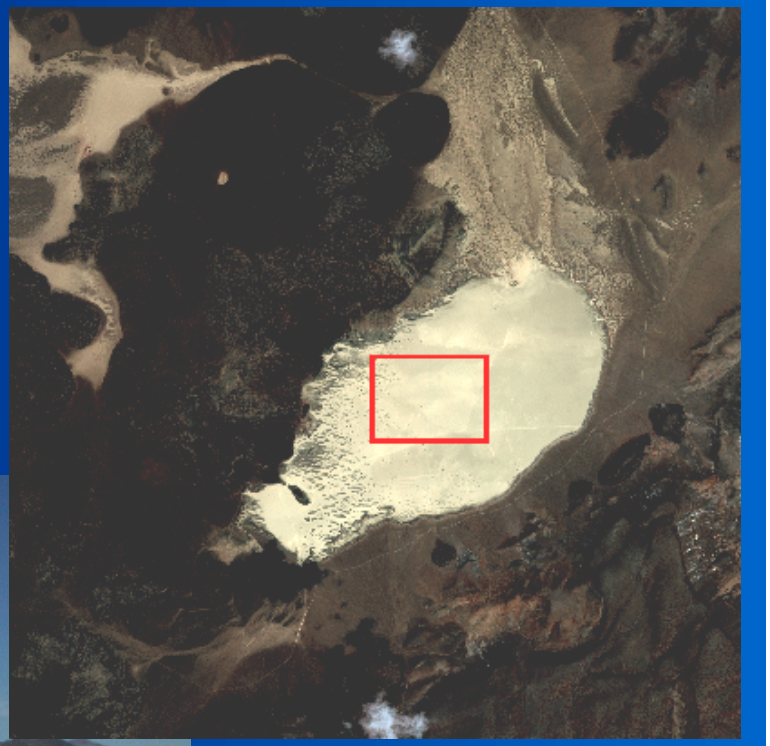


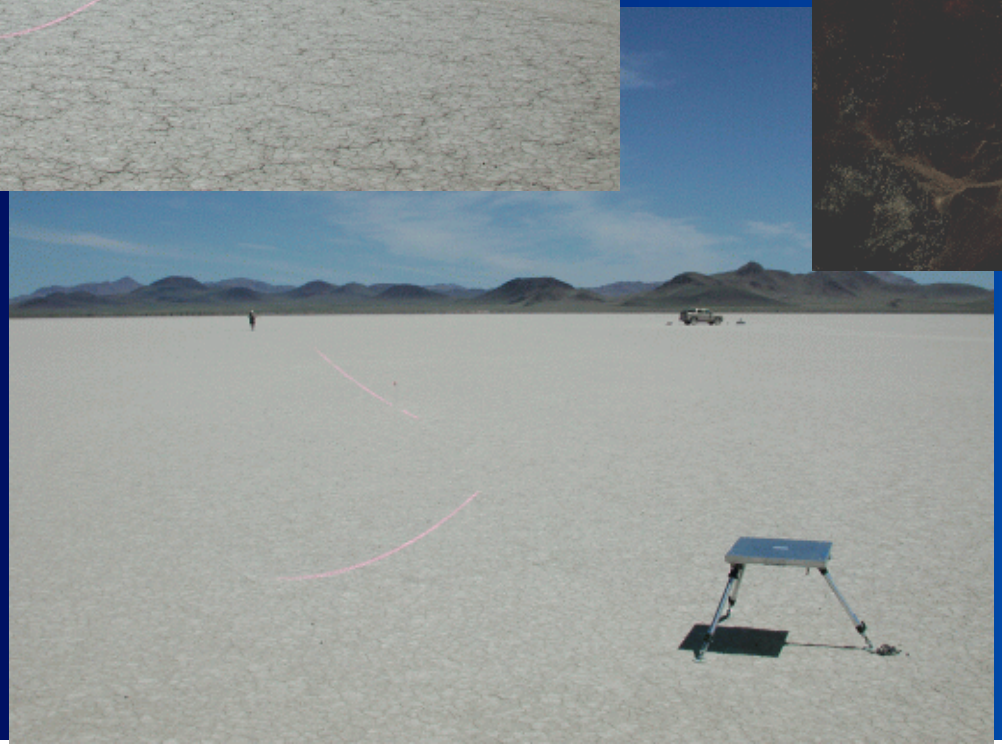


Ivanpah Playa test site

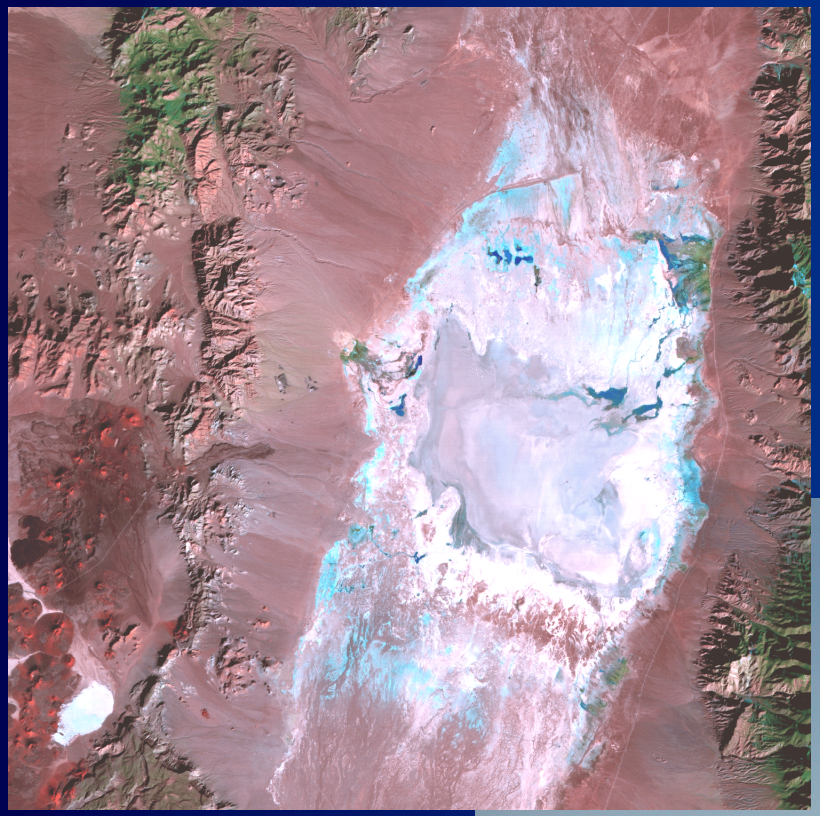


Lunar Lake test site



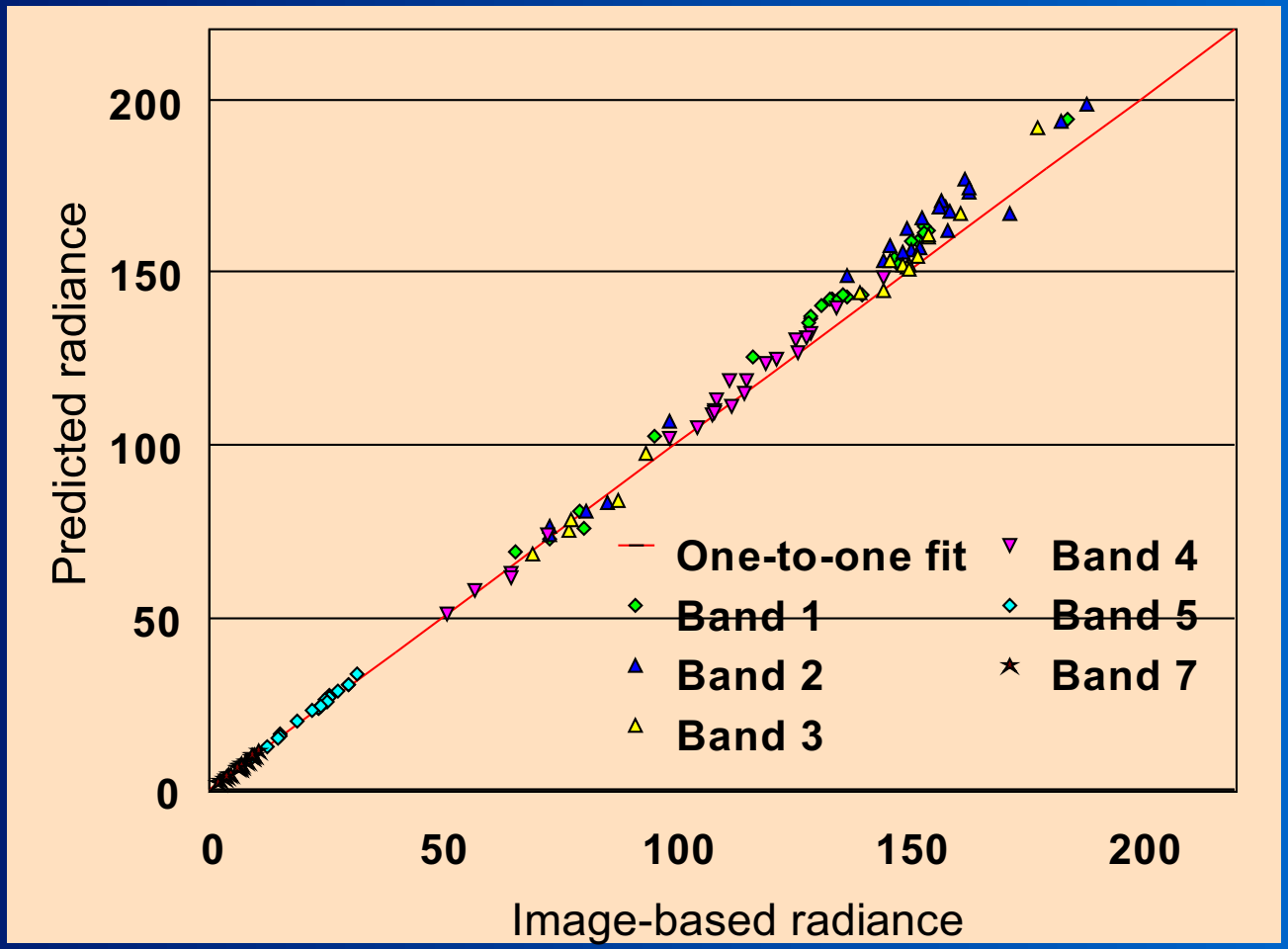


Railroad Valley Test Site



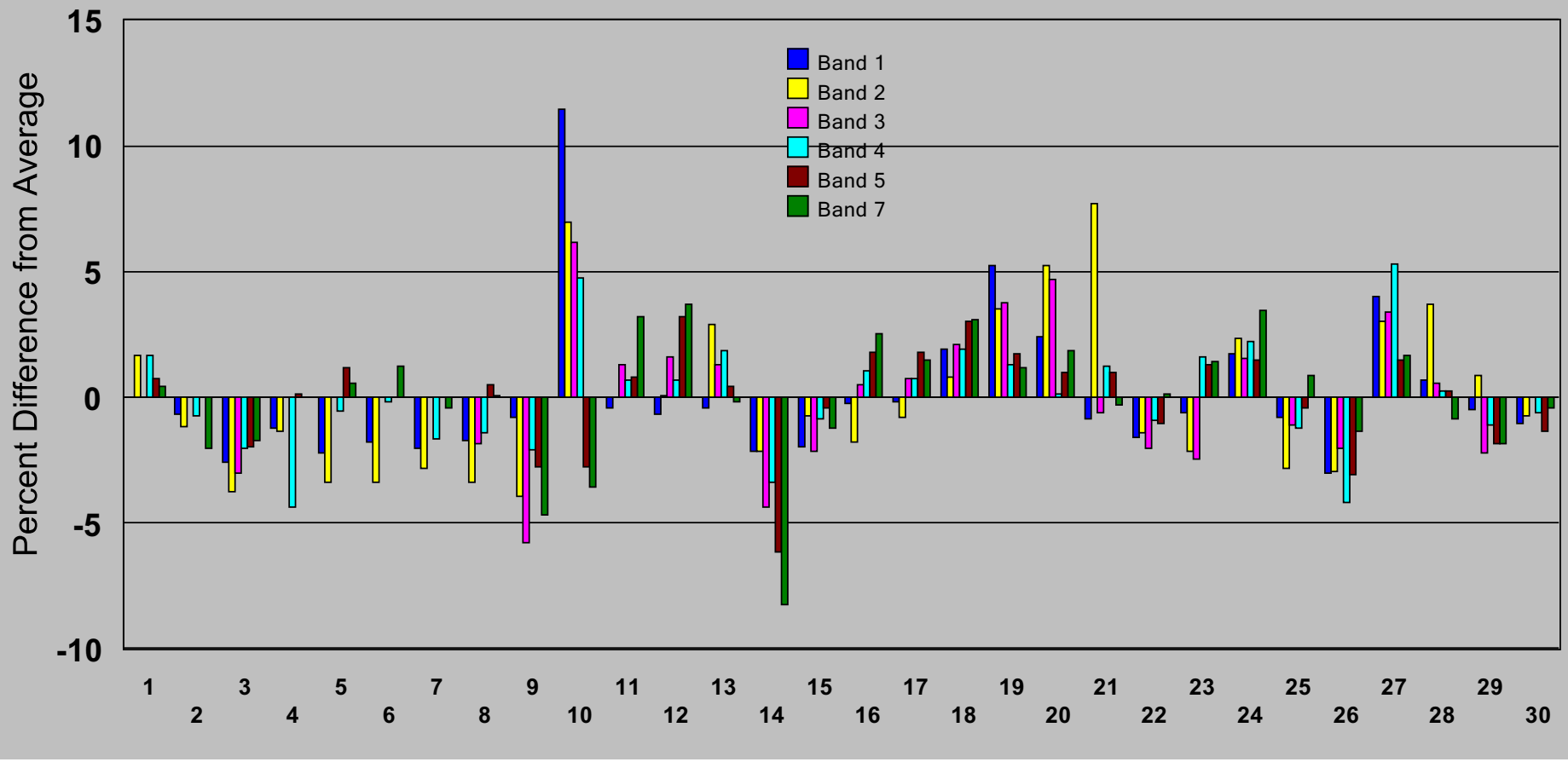
Recent results for ETM+

- Precision of vicarious results are 2-3%
- Uncertainty and sensitivity analysis indicate accuracy is 3% in visible and near infrared



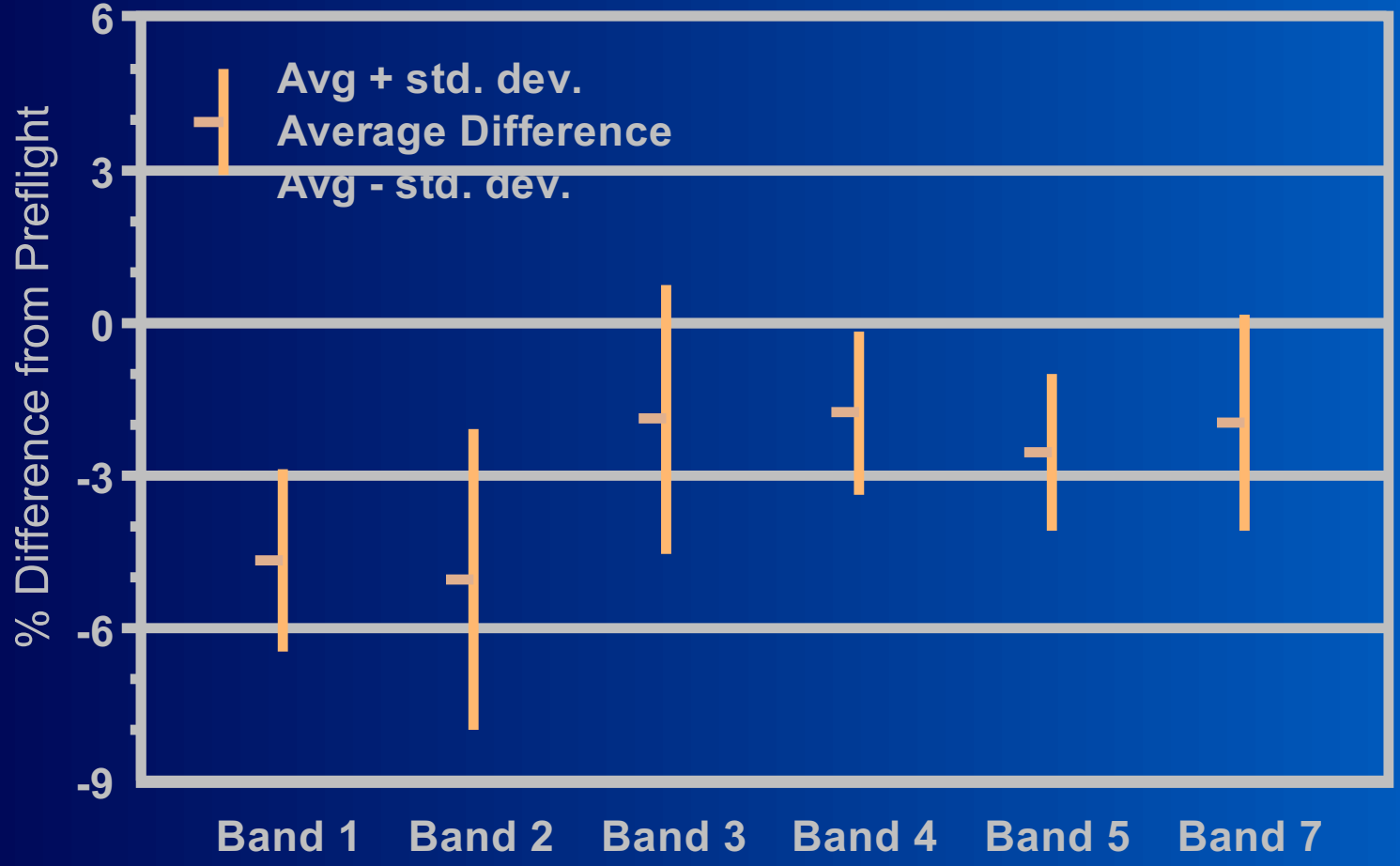
ETM+ Results

Graph below summarizes the percent difference from average for all dates and all bands for each of the 30 fully-processed data sets



Recent results - ETM+

Radiometric calibration of ETM+ has been shown to be stable since launch using both the radiance validation and onboard calibrators

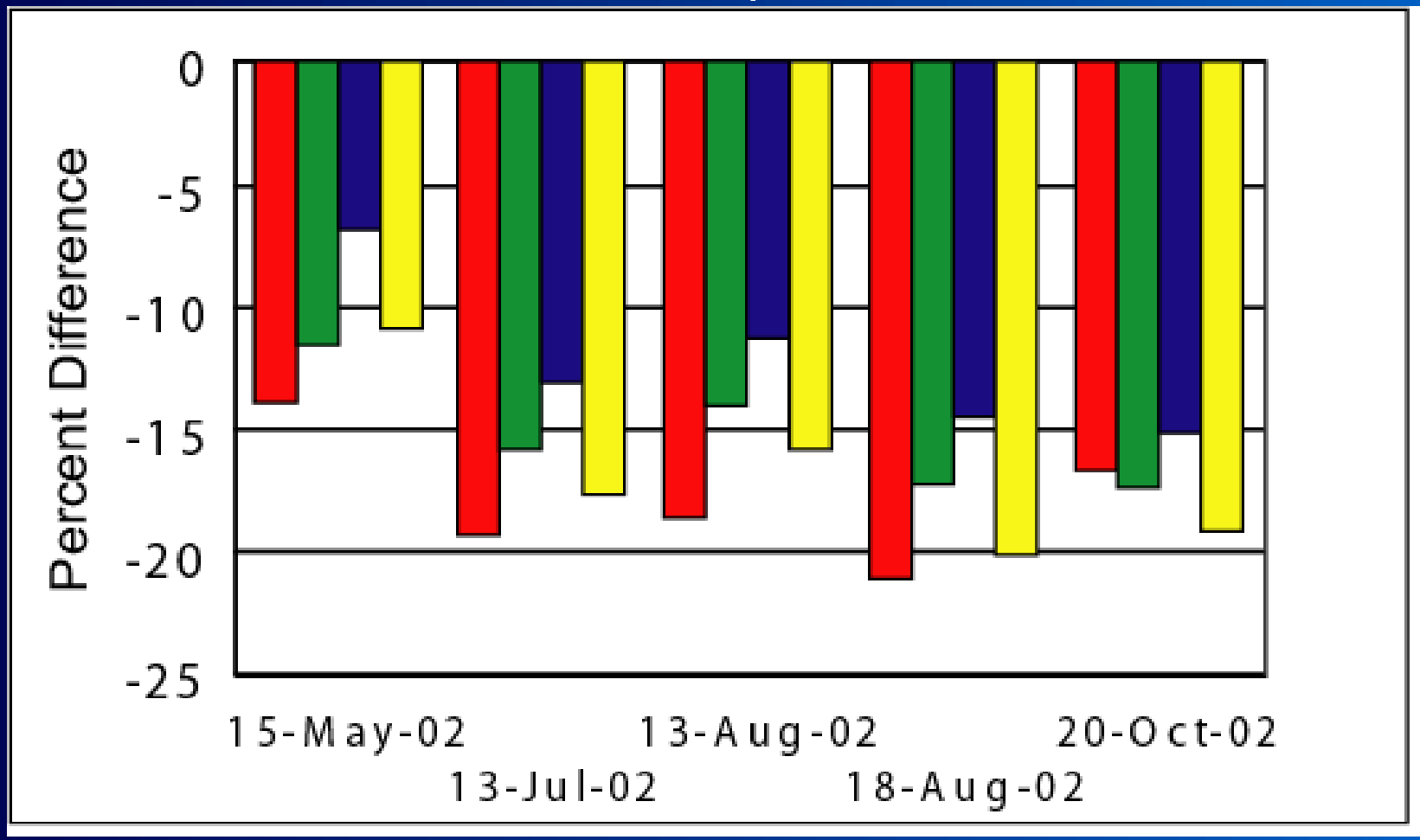


QuickBird results - 2002

5 QuickBird images and coincident ground measurements

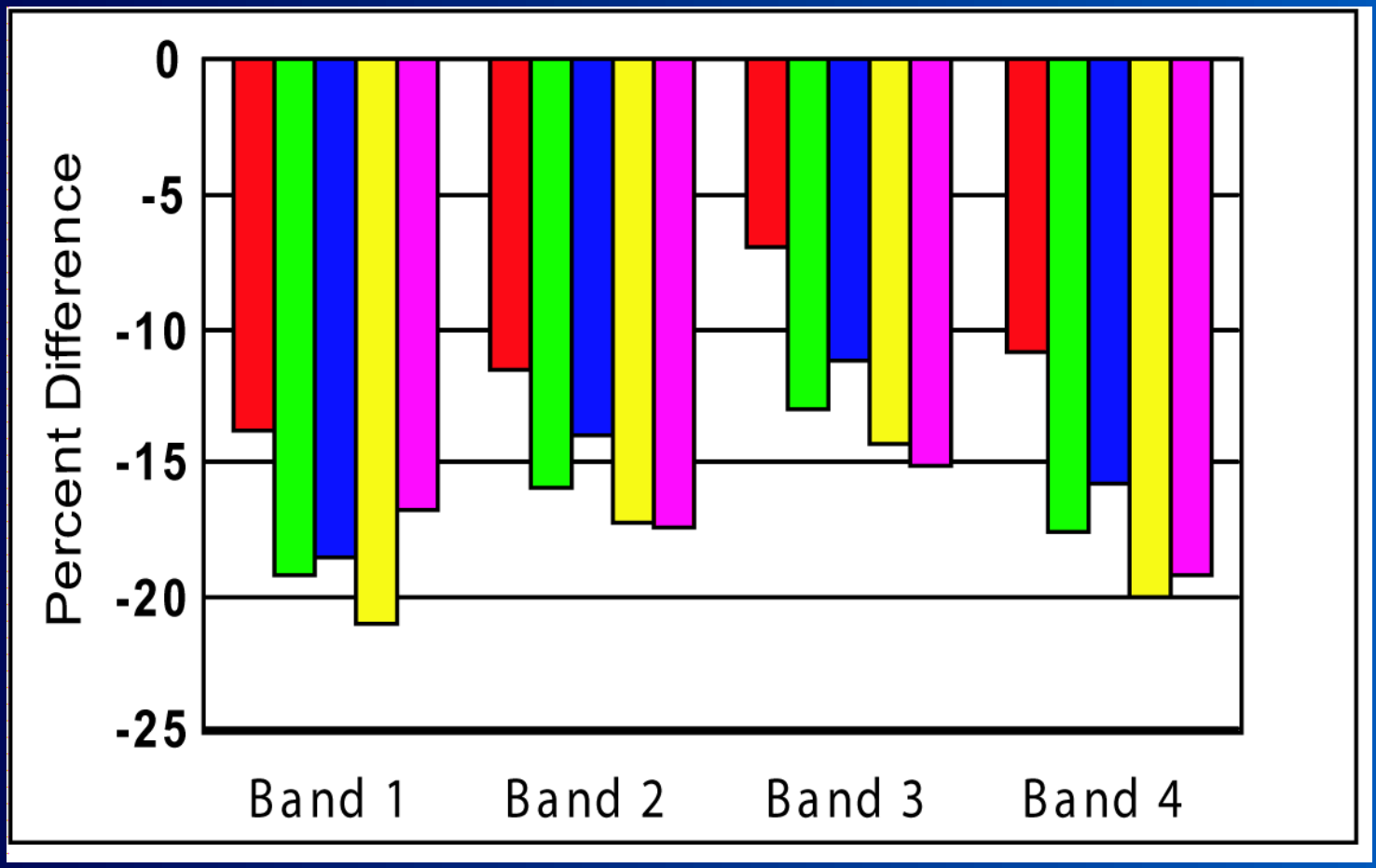
- 2 Railroad Valley
- 1 Lunar Lake
- 1 Ivanpah Playa
- 1 White Sands Missile Range

QuickBird results - 2002



% difference between vicarious predictions and reported at-sensor radiance at U of A sites.

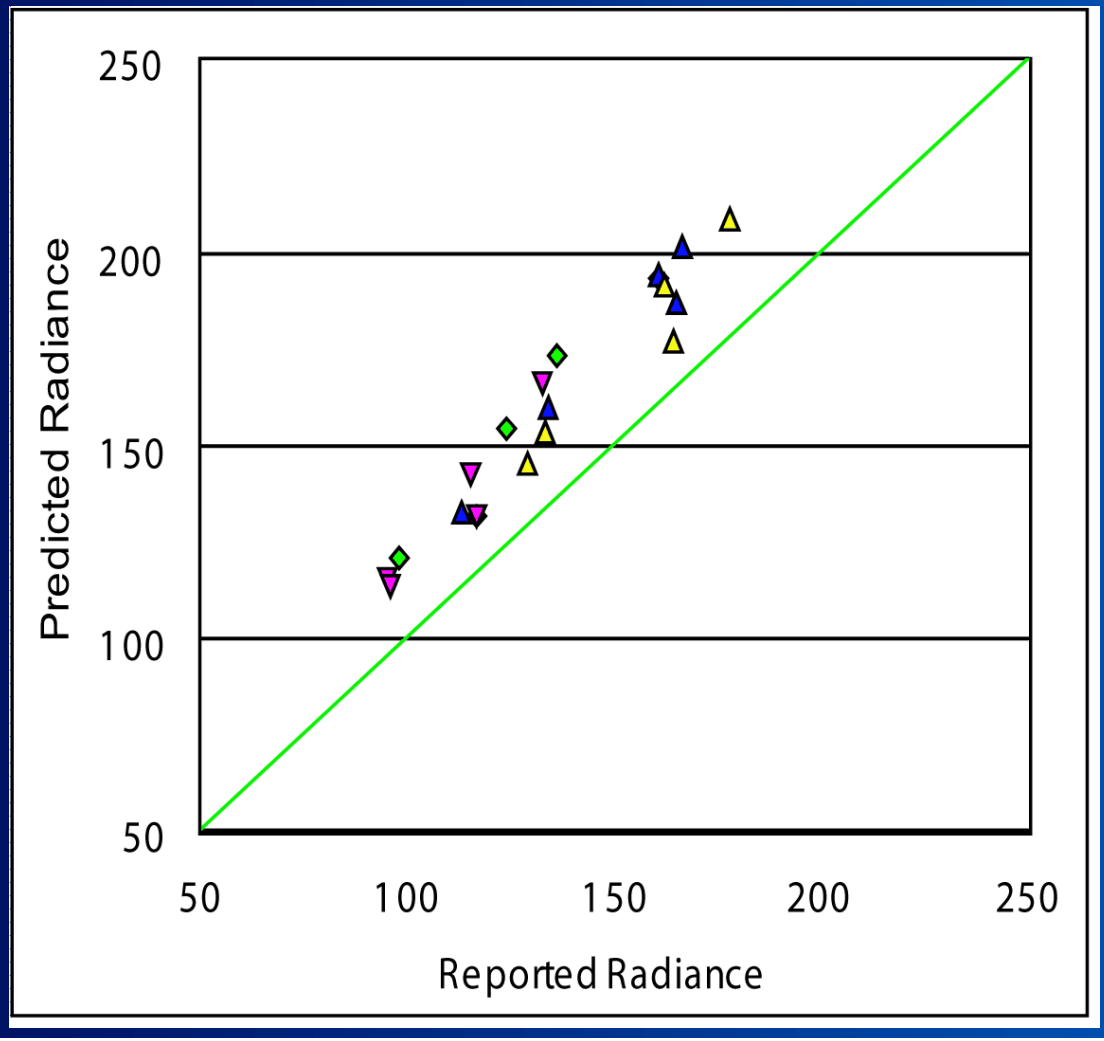
QuickBird results - 2002



% difference at each band between vicarious predictions and at-sensor radiance for all sites

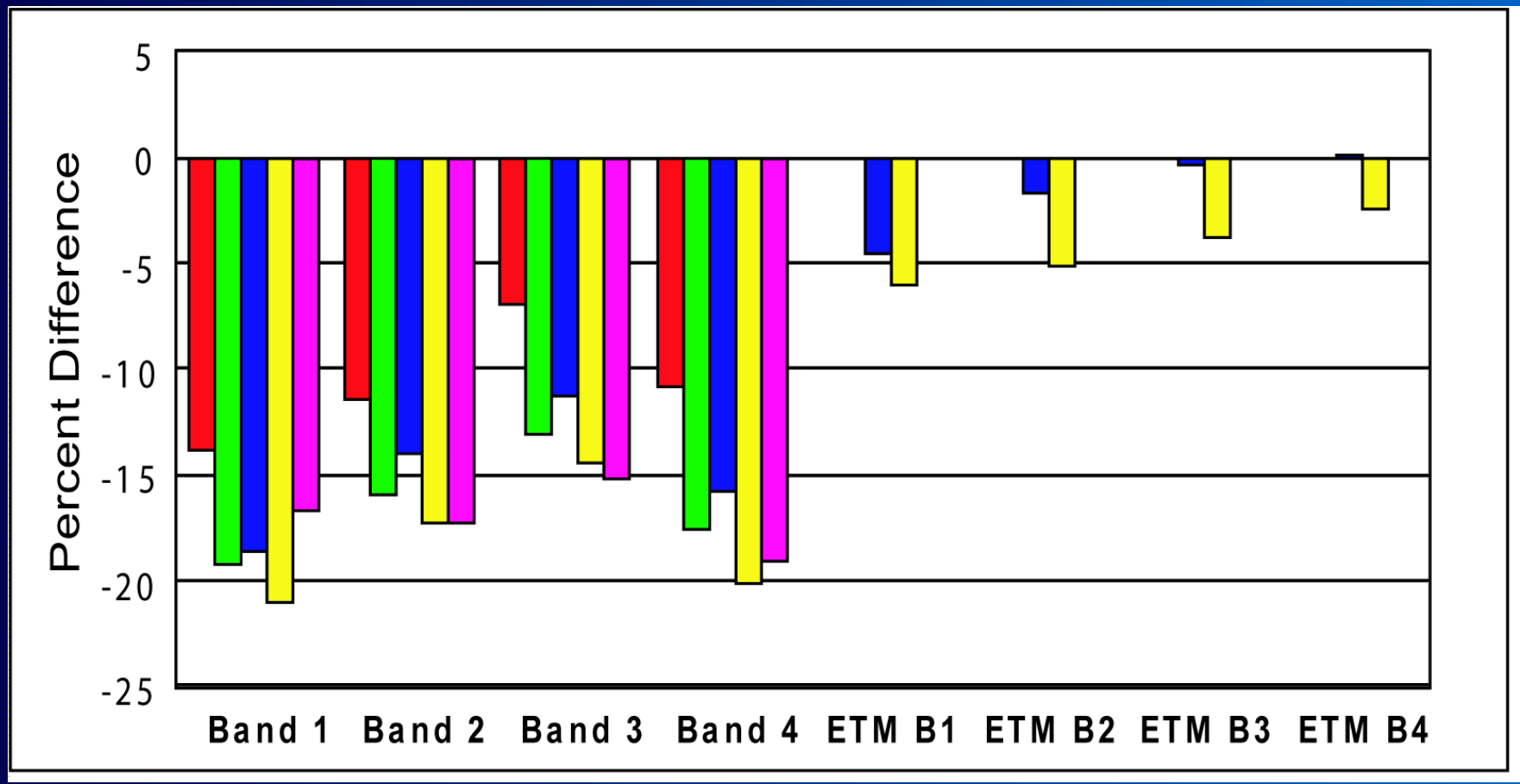
Quickbird results - 2002

Reported band-averaged spectral radiance for all bands of QuickBird from all dates versus predicted radiance from vicarious measurements



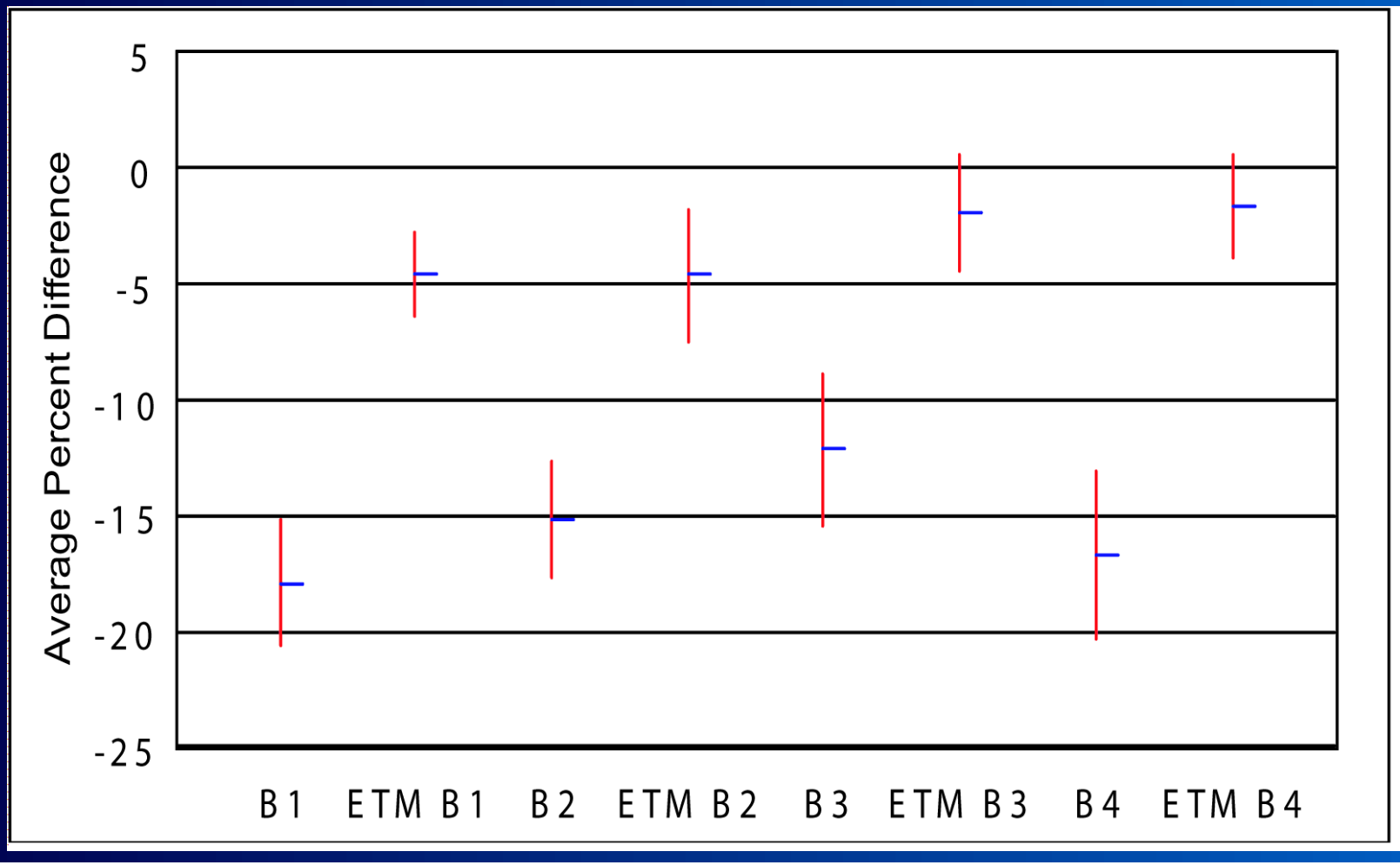
Comparison with ETM+

Same data as shown previously except including results for ETM+ bands 1-4 for August 13 at Ivanpah (coincident date as QuickBird) and August 20 at Lunar Lake (two day separation from QuickBird collection).



Comparison with ETM+

Average percent difference and standard dev. between vicarious predictions and reported Quickbird radiances. Similar results for similar bands of ETM+ shown for reference



Recent QuickBird results

Percent difference between reported and predicted band-averaged spectral radiances Ikonos sensor at indicated sites and dates for each of the multispectral bands.
Positive value indicates that reported radiance exceeds the predicted value.

	Band 1	Band 2	Band 3	Band 4
2002				
RRV May 15	-13.9	-11.5	-6.9	-10.8
RRV July 13	-19.2	-15.9	-13.1	-17.6
Ivanpah August 13	-18.6	-14.0	-11.2	-15.8
Lunar Lake August 18	-21.1	-17.2	-14.4	-20.1
WSMR October 20	-16.7	-17.3	-15.1	-19.1
AVG	-17.9	-15.2	-12.1	-16.7
Std Dev.	2.7	2.5	3.3	3.7

Conclusions

- QuickBird calibration coefficients should be altered.
- Such a step would ensure consistency between QuickBird and ETM+ (with U of A methods, changes of 13.2%, 10.6%, 10.2%, and 15.0% for bands 1, 2, 3, and 4 of Quickbird, respectively). This is likely a reasonable recommendation since QuickBird results show similar standard deviations of average percent difference as ETM+ results.