Catalog of Worldwide Test Sites for Sensor Characterization

http://calval.cr.usgs.gov/sites_catalog_map.php

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Scope of Test Sites

- Test sites are central to any future Quality Assurance/Quality Control (QA/QC) strategy
- Test sites provide a convenient means of obtaining information to verify sensor performance
- Test sites are the only practical means of deriving knowledge of biases between sensors
- Test sites allow, at some level, a means of bridging anticipated data gaps caused by lack of measurement continuity, due to lack of co-existent in-flight sensors

Characteristics of Sensors which can Benefit from Test Sites

- Gain
- Stability
- Modulation Transfer Function (MTF)
- Uniformity
- Stray light
- Polarization
- Spectral
- Signal-to-Noise Ratio (SNR)
- Geolocation
- Camera model
- Band-to-band
- Internal Geometry

Well-Established Site Selection Criteria for Radiometry Test Sites

- High spatial uniformity over a large area (within 3%)
- Surface reflectance [0, 1] greater than 0.3
- Flat spectral reflectance
- Temporally invariant surface properties (within 2%)
- Horizontal surface with nearly lambertian reflectance
- At high altitude, far from ocean, urban, and industrial areas
- In arid regions with low probability of cloud cover

CEOS Reference Standard Test Sites

- The instrumented sites are primarily used for field campaigns to obtain radiometric gain. These sites can serve as a focus for international efforts, facilitating traceability and cross-comparison to evaluate biases of in-flight sensors in a harmonized manner
- The pseudo-invariant desert sites have high reflectance with low aerosol loading and practically no vegetation. Consequently, these sites can be used to evaluate the long-term stability of a sensor and facilitate cross-comparison of multiple sensors

CEOS Reference Standard Test Sites

#	Site Name	Center Latitude	Center Longitude	Point Of Contact (POC)	Affiliation	Email
Instrumented Sites						
1	Railroad Valley Playa	38.50	-115.69	Kurtis J. Thome	NASA/GSFC	kurtis.thome@nasa.gov
2	Ivanpah Playa	35.57	-115.40	Kurtis J. Thome	NASA/GSFC	kurtis.thome@nasa.gov
3	Lower Frenchman Flat	36.81	-115.93	Carol J. Bruegge	NASA/JPL	Carol.J.Bruegge@jpl.Nasa.Gov
4	La Crau	43.56	4.86	Patrice Henry	CNES	patrice.henry@cnes.fr
5	Dunhuang	40.13	94.34	Xiuqing Hu	NSMC/CMA	huxq@cma.gov.cn
6	Negev, Southern Israel	30.11	35.01	Arnon Karnieli	Ben Gurion University	karnieli@bgu.ac.il
7	Tuz Golu	38.83	33.33	Selima Gurol	TUBITAK UZAY	selime.gurol@uzay.tubitak.gov.tr
8	Dome C	-74.50	123.00	Stephen Warren	University of Washington	sgw@atmos.washington.edu
Pseudo-Invariant Test Sites						
1	Libya 4	28.55	23.39	Patrice Henry	CNES	patrice.henry@cnes.fr
2	Mauritania 1	19.40	-9.30	Patrice Henry	CNES	patrice.henry@cnes.fr
2	Mauritania 2	20.85	-8.78	Patrice Henry	CNES	patrice.henry@cnes.fr
3	Algeria 3	30.32	7.66	Patrice Henry	CNES	patrice.henry@cnes.fr
4	Libya 1	24.42	13.35	Patrice Henry	CNES	patrice.henry@cnes.fr
5	Algeria 5	31.02	2.23	Patrice Henry	CNES	patrice.henry@cnes.fr

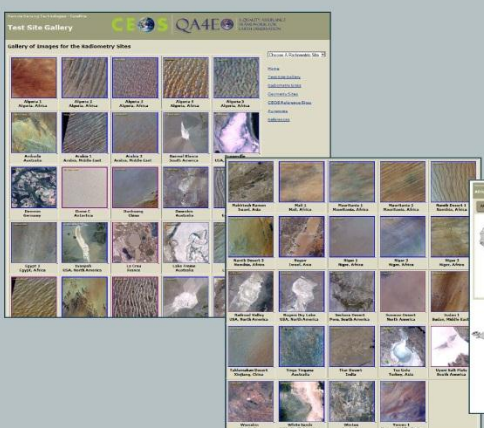
Summary

- The test site catalog provides a comprehensive list of prime candidate terrestrial targets for consideration as benchmark sites for the postlaunch calibration of space-based optical sensors
- The online test site catalog provides easy public Web site access to this vital information for the global community
- The incompleteness of available information on even these prime test sites is an indication that much more coordination and documentation are still needed to facilitate the wider use of calibration test sites in remote sensing

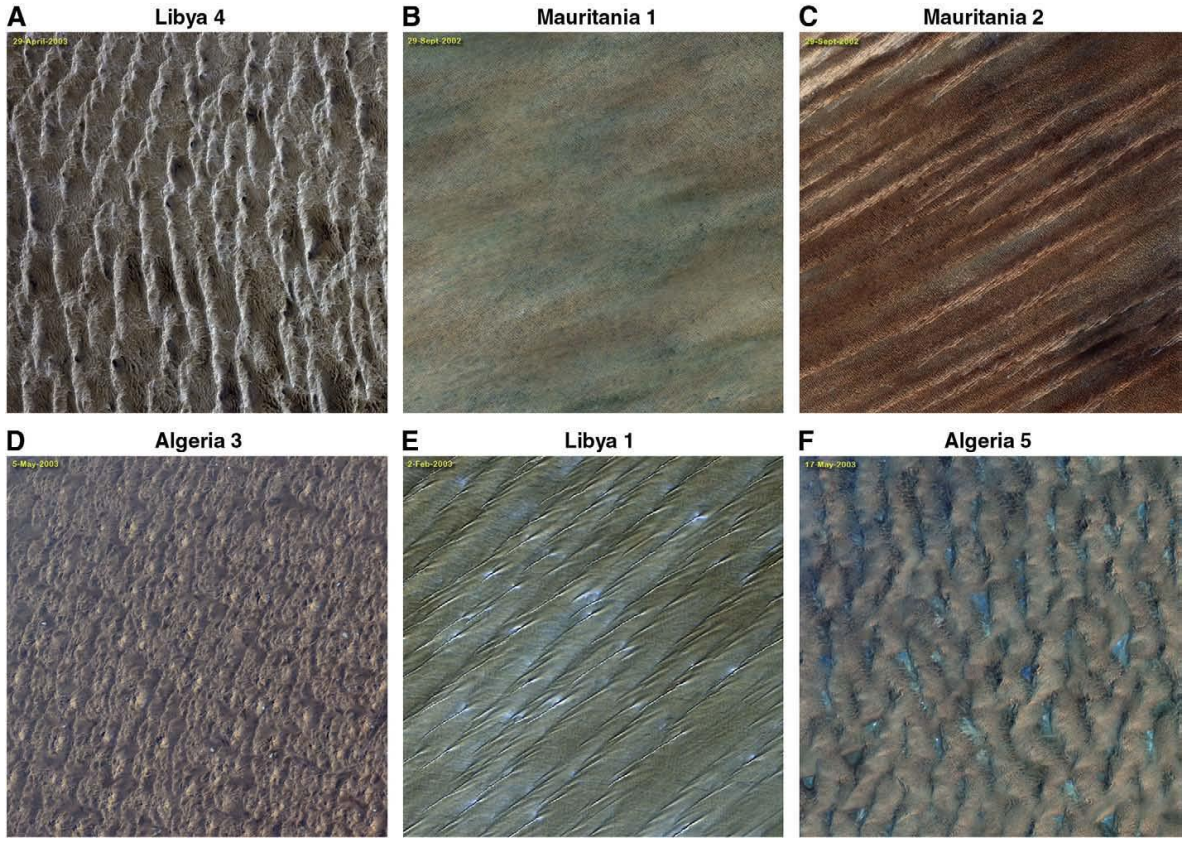
Proposed Future Plans

- Gather complete site characterization data & define core measurements (eg. Instruments)
- Create an operational network of land sites ("Landnet") & develop online data access infrastructure
- Encourage agencies to acquire, archive, and provide data over the CEOS sites
- Integrate the catalog into the CEOS Cal/Val portal
- Establish traceability chain for primary site data
- Develop "best practice" guidance on site characterization and its use

Online Test Site Catalog



CEOS Reference
Pseudo-invariant Calibration Sites (PICS)



- These site exhibits good spatial uniformity, temporal stability, no vegetation, low aerosol loading, and has minimal cloud cover
- PICS are used to evaluate the long-term stability of a instrument and to facilitate inter-comparison of multiple instruments

CEOS Reference Instrumented Sites

These instrumented sites are primarily used for field campaigns to obtain radiometric gain, and these sites can serve as a focus for international efforts, facilitating traceability and inter-comparison to evaluate biases of in-flight and future instruments in a harmonized manner

Measurement needs for automated site characterization

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May 8-10, 2012

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Background

Justifications for automated measurements are well established

- Automated sites can combine accuracy of in situ with flexibility of invariant scene
- Automated ground systems are always collecting so results are available when the on-orbit sensor needs them
- Questions that still exist are
  - What are the measurements needed?
  - What is the trade between cost and accuracy?
  - Are a few highly-instrumented sites better than more sites with less instrumentation?

RadCaTS

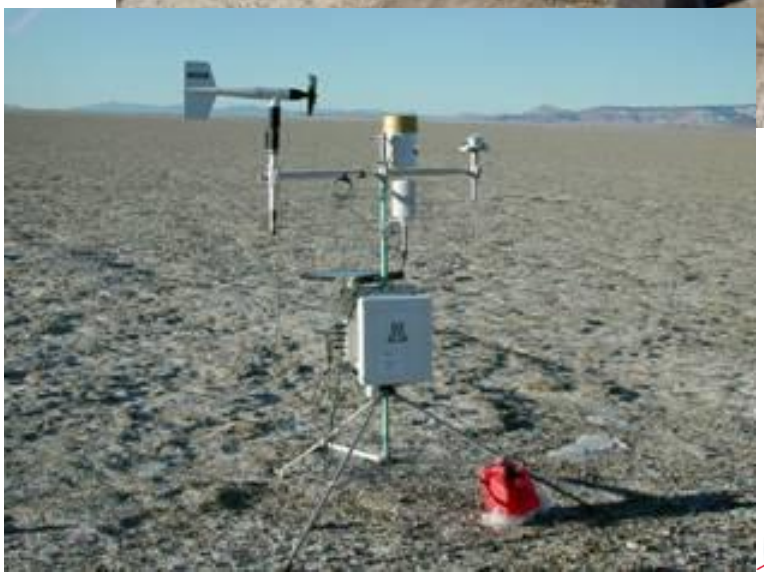
Radiometric Calibration Test Site is the UofA's autonomous, reflectance-based site

- Original proposed approach relied on a central core site
  - Highly instrumented for maximum spatial and spectral detail
  - Used for high-spatial-resolution sensors (< 4 m)
- Node sites
  - Smaller instrument suite
  - Designed to give spatial information
  - Used for low-spatial-resolution sensors (> 250 m)
  - Combine the two for moderate resolutions

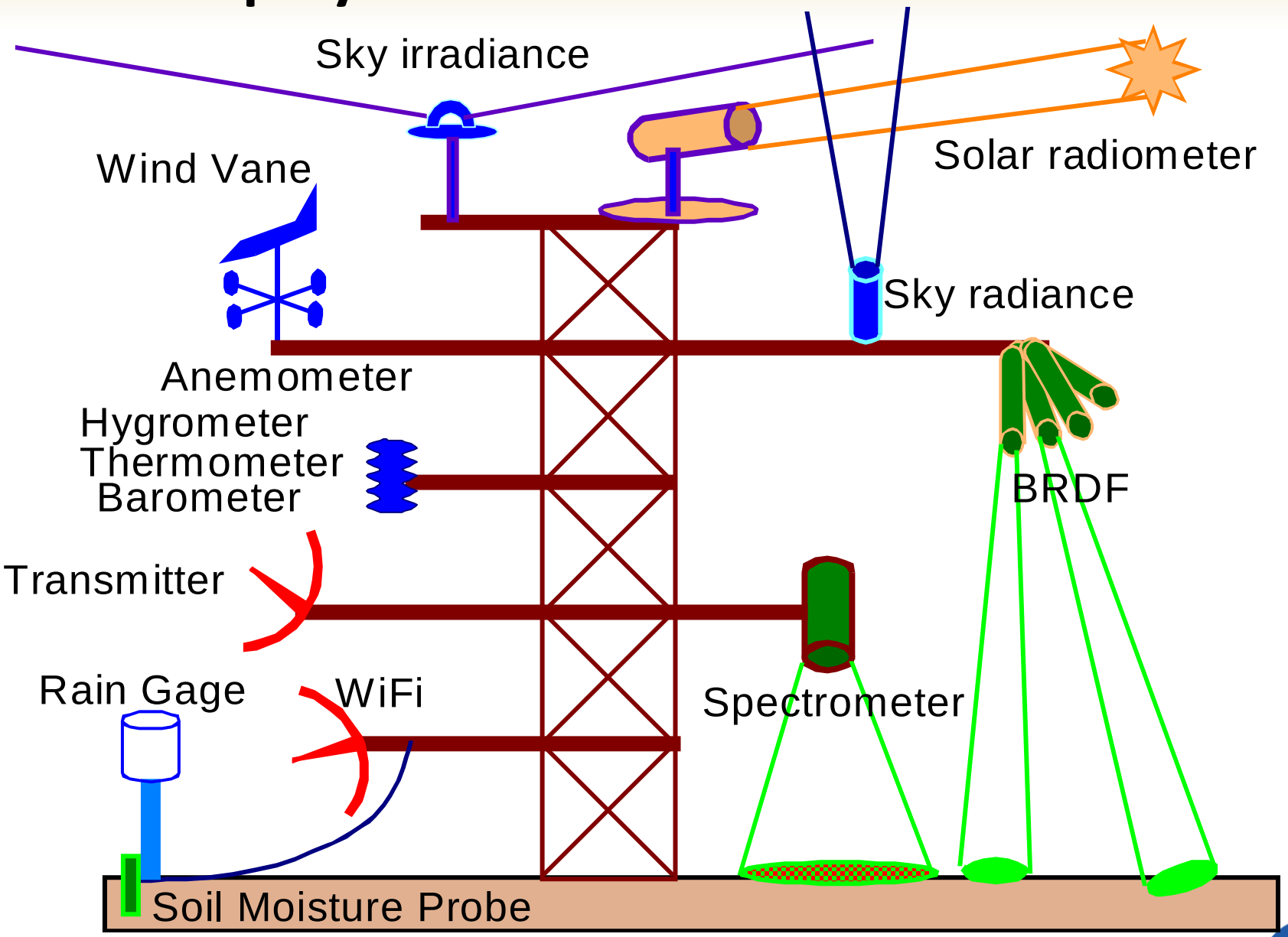
Current instrumentation

Currently a suite of instruments to obtain atmospheric and surface information

- Atmospheric data from Cimel sun photometer
  - Atmospheric optical depth
  - Angstrom exponent
  - Water vapor
- Weather information from meteorological station
  - Temperature
  - Pressure
  - Precipitation



Core site deployment



Unlimited budget approach

Fully instrumented suite with modest redundancy would be ~$1.6M for startup

- Costs are those for purchase and deployment including planned redundancy of key components and to examine spatial aspects of the validation problem

Portable tower for deployment including costs to incorporate equipment	$50K
6 Digital camera systems for sky and ground monitoring including remote operation setup	$15K
6 Multispectral, sky irradiance monitor	$100K
6 Multispectral ground monitor radiometer	$100K
3 Field spectrometer for continuous deployment	$200K
3 Multispectral thermal-infrared radiometers	$100K
Enclosure and hardware for field spectrometers	$100K
Microwave profiler	$100K
3 GPS water vapor retrieval systems	$150K
Cimel Sun Photometer	$100K
MPL net capable lidar system	$100K
Sky imager	$30K
BRDF imager	$40K
Metorological station	$10K
Wireless data connectivity	$100K
3 Feld calibration sources for spectrometers	$150K
Field references of varying sizes including Spectralon panels and field tarpaulins	$100K
Power generation	$50K

- Maintenance costs would be additional on a year-to-year basis

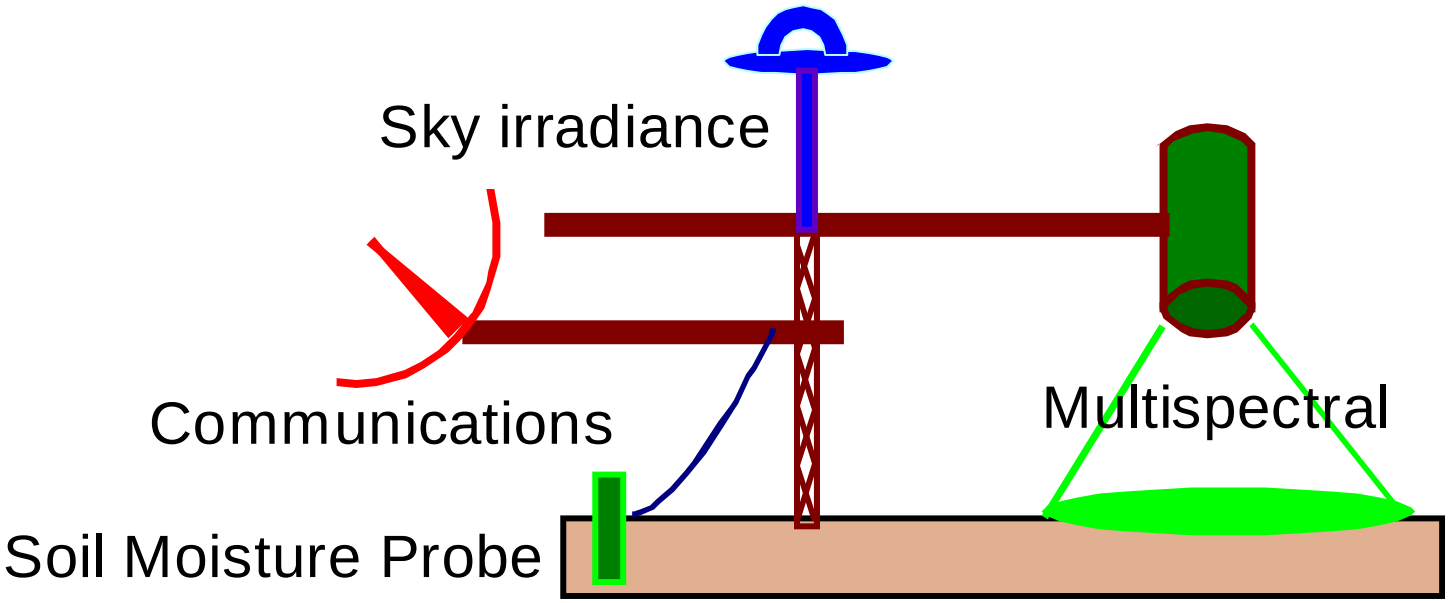
Minimum set of measurements needed for a reflectance-based approach

- Impact of assumptions on uncertainties must be evaluated
- Numbers of data collections is key factor
- Sites with reflectance > 0.2
  - Site reflectance is most important
    - BRDF
    - Spectral
    - Spatial
    - Temporal
  - Aerosol effects can be viewed as random
    - Aerosol absorption changes with time

Further scaled node

Many sites could omit the atmospheric aerosol measurements

- Sky irradiance still desired for reflectance retrieval
- Soil moisture probe replaces weather station



Minimal budget

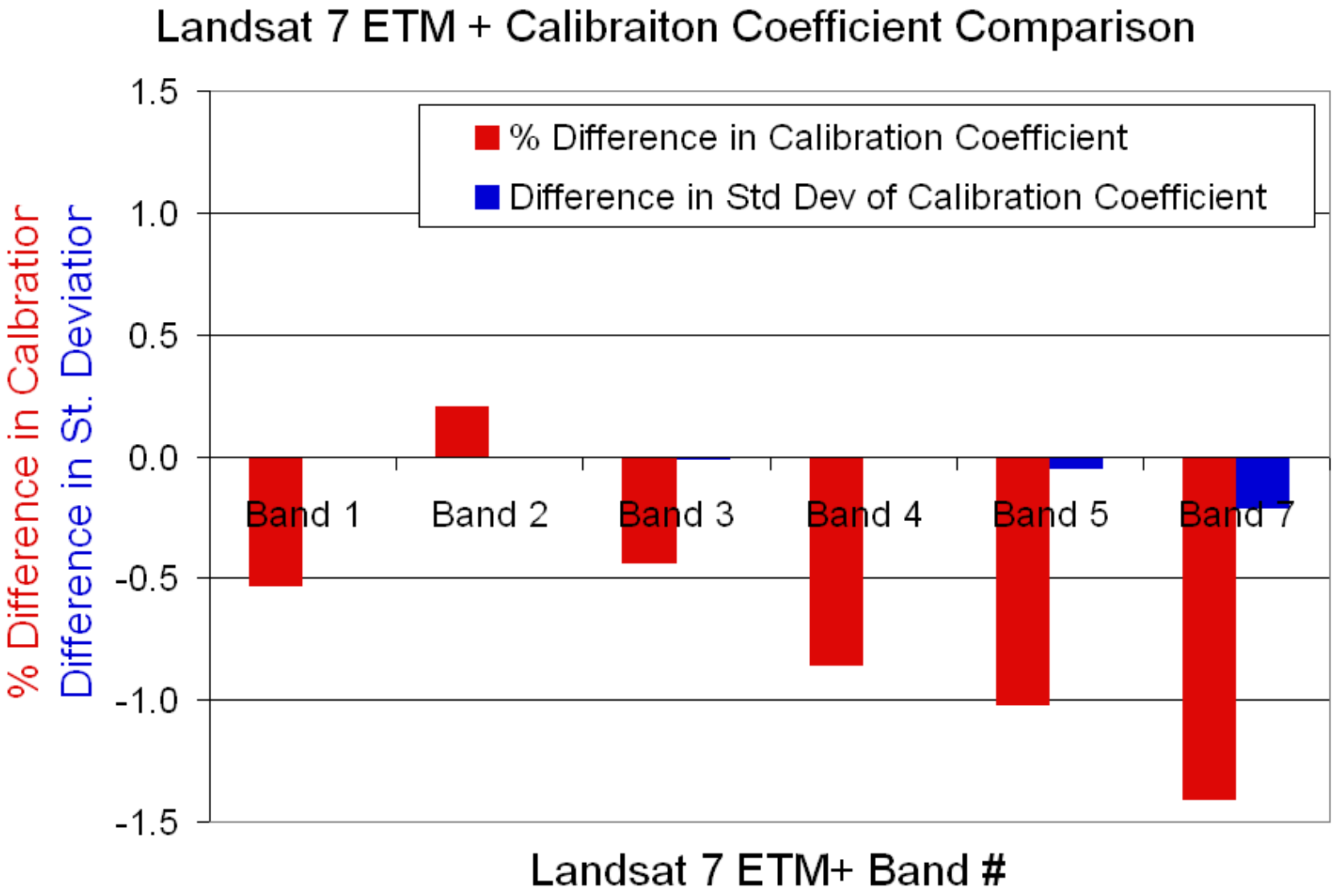
Costs for minimum set of measurements would be $50K

- Portable tower for deployment including costs to incorporate equipment $5K
- 2 Digital camera systems for sky and ground monitoring including remote operation setup $5K
- 1 Multispectral, sky irradiance monitor $15K
- 1 Multispectral ground monitor radiometer $15K
- Soil moisture probe and data logger $5K
- Power generation $5K

- Irradiance and ground monitor costs are optimistic based on custom builds – no commercial product is currently available

- **Data connectivity and year-to-year maintenance not included**

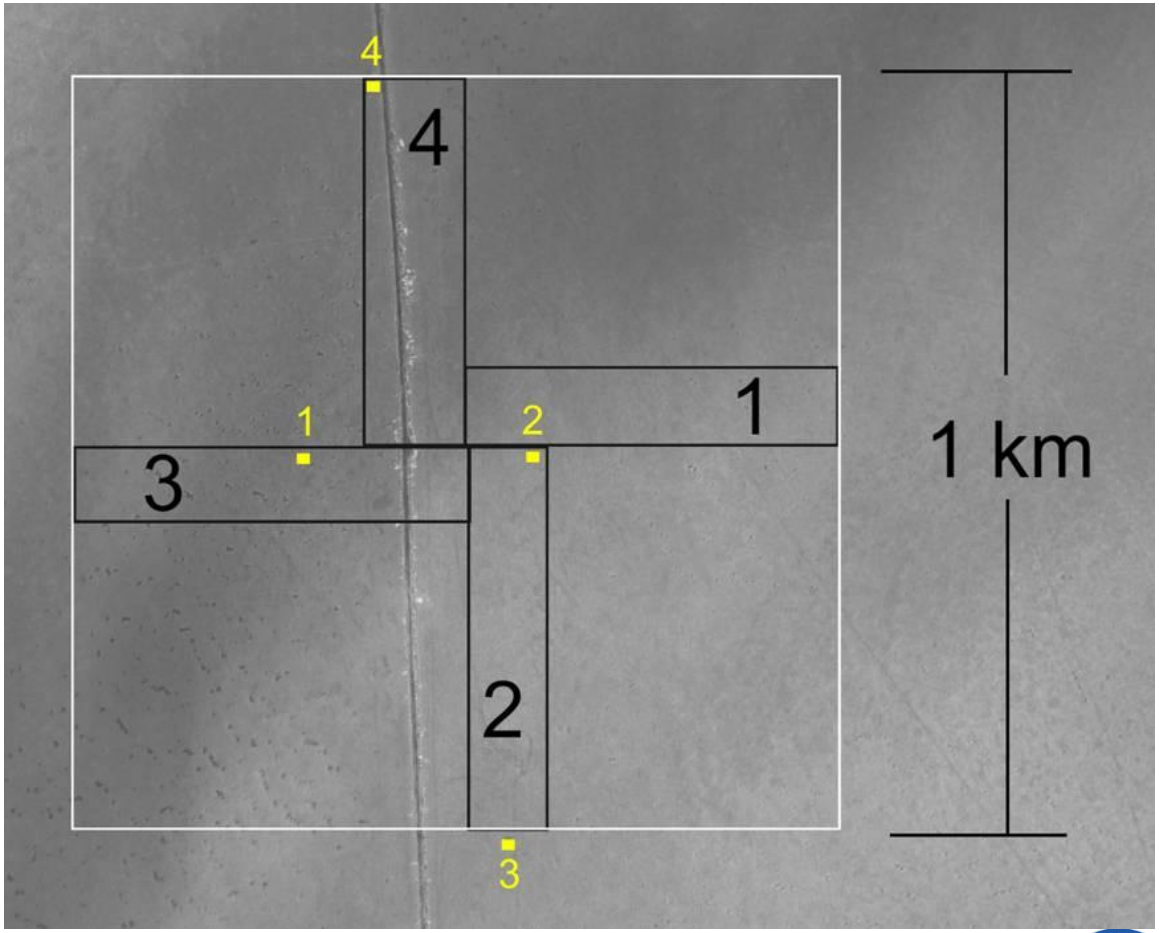
Impact of using average atmospheric conditions



Spatial sampling impact

A big issue with the large-footprint results is the number of spatial samples needed

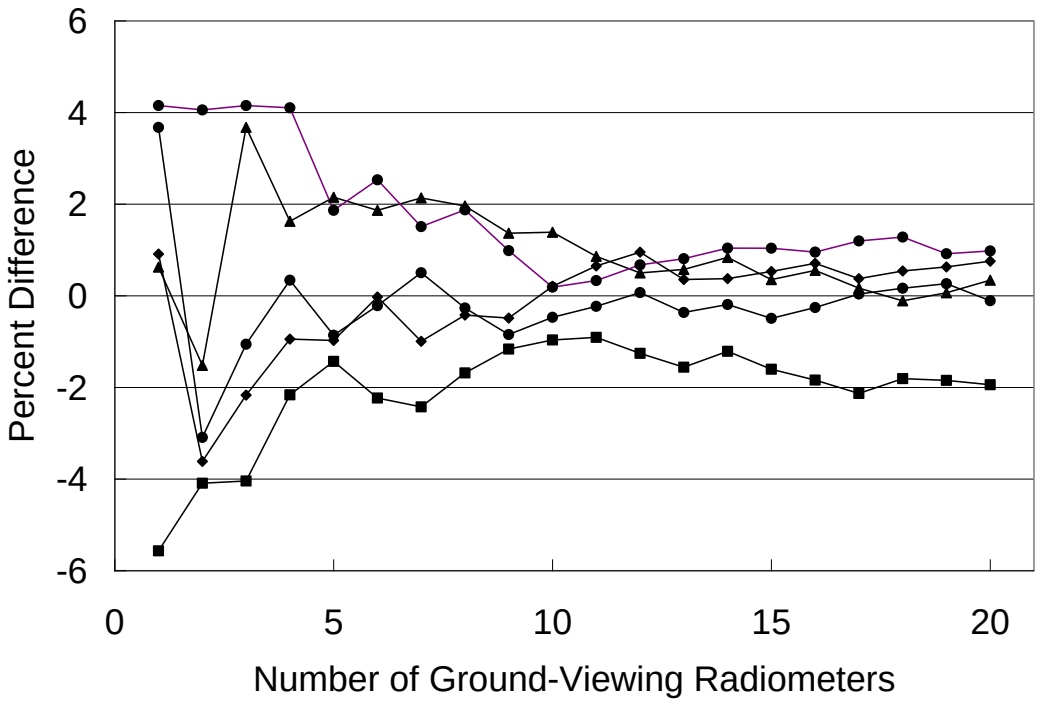
- Cost limited deployment of more radiometers
- Use of high-resolution imagery can assess number of radiometers needed
- Single scene evaluated at this point



Optimal radiometer number

Vary number of radiometer locations from 1 to 20

- Randomly selected pixel agrees with entire site to better than 10%
- Four radiometers produces the same uncertainty as 20 radiometers
- Evaluation only examined the panchromatic band
- Further work with more scenes and multispectral data



Summary

Automated ground measurement approaches are a useful means for radiometric calibration

- Groups have also succeeded in developing sites
  - Stennis Space Center facility
  - JPL facility at Lake Tahoe and Frenchman Flat
  - UofA at RRV Playa
  - High and low spatial resolution
  - BRDF correction
- Vicarious calibration data can be collected at the convenience of the sensor scheduler
- Allows intercomparisons between sensors without need for coincident data collections
- Costs are driven by desired level of site understanding and year-to-year maintenance