Role of imaging spectrometer data for model-based cross-calibration of imaging sensors

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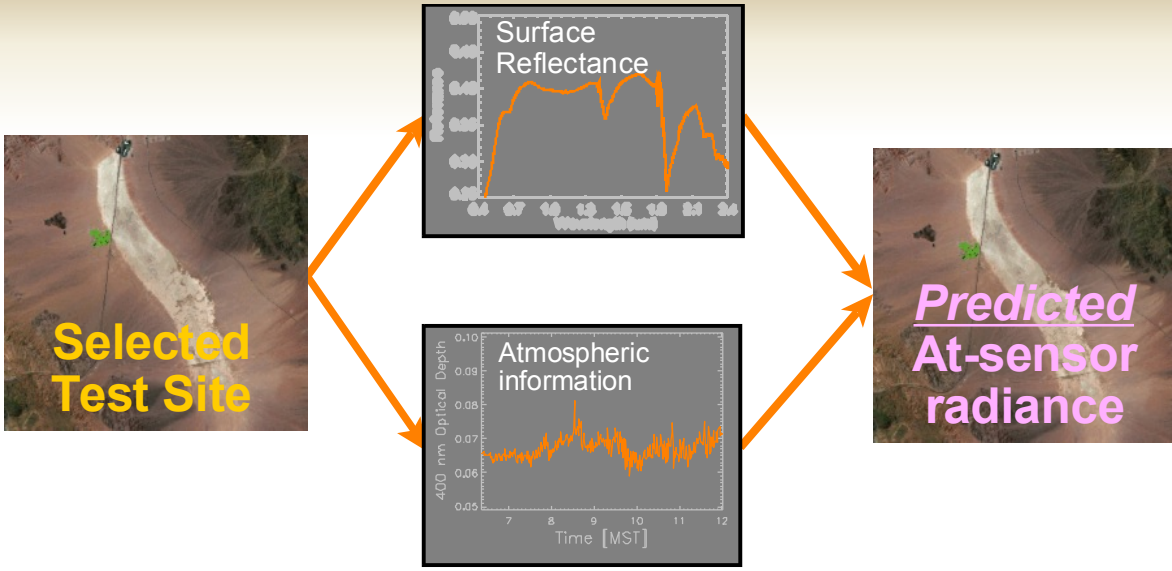
Talk overview

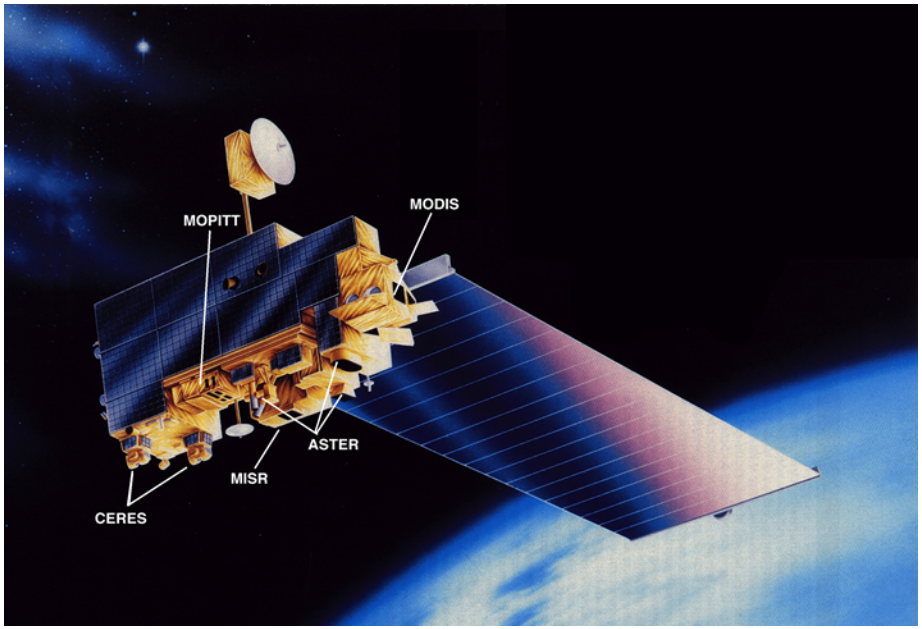
Discuss SI-traceable cross-calibration approach relying on test site characterization



- Site characterization benefits from imaging spectrometry to determine spectral bi-directional reflectance of a well-understood surface
- Outline
  - Cross calibration approaches
  - Uncertainties
  - Role of imaging spectrometry
  - Model-based site characterization

Need for cross-calibration

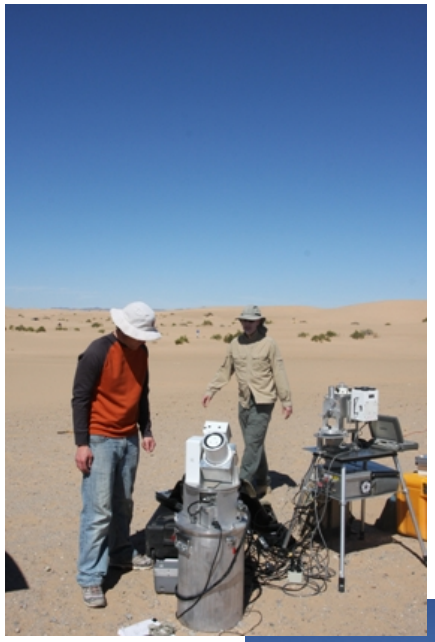
Assume that a single sensor does not give all of the data needed for a science question



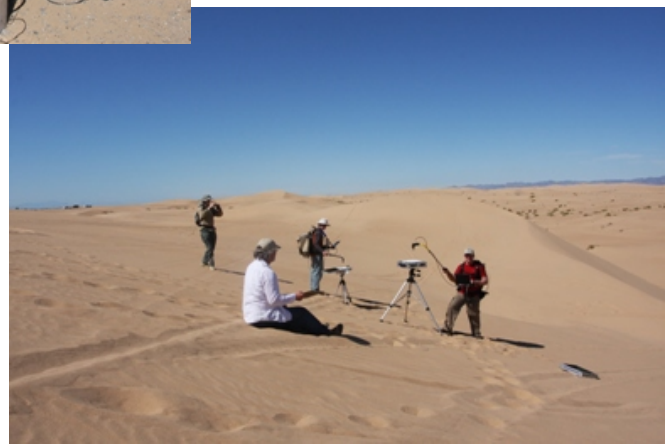
- Multi-sensor applications benefit from having all sensors on the same radiometric scale
- Consider Terra platform for which the synergy of multiple sensors is a key to the mission's success

Best of both worlds

Combine philosophy of in-situ measurements with invariant site approaches



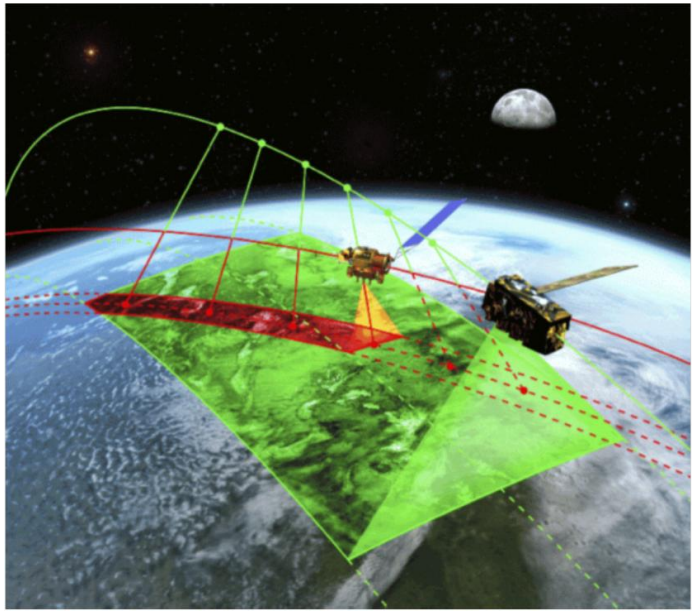
- Site measurements become basis for a physically-based model
  - Atmospheric
  - Surface
- Allows for an SI-traceable result
- **Requires innovative measurement approaches**



On-orbit cross calibration

Recent years have seen great advancements in approaches for cross-calibration

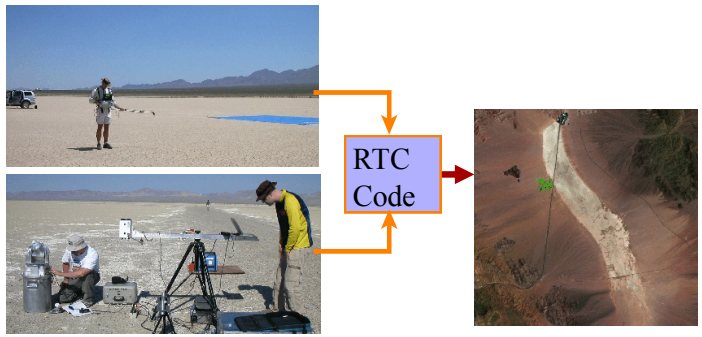
- Typically near-coincident views
  - Simultaneous Nadir Overpasses at Arctic sites
  - Chance coincidence at mid-latitude sites
- More recent work has emphasized methods that do not require simultaneous data collections
  - Invariant scene approaches
  - In-situ ground measurement methods
- Methods with SI traceability do not require sensor data to overlap in time

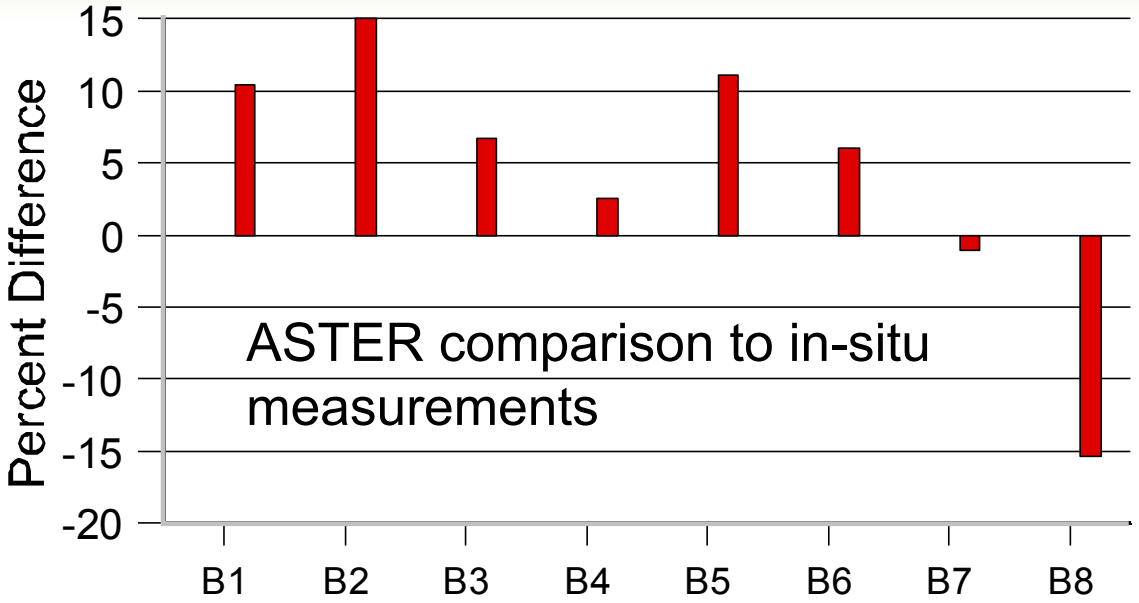


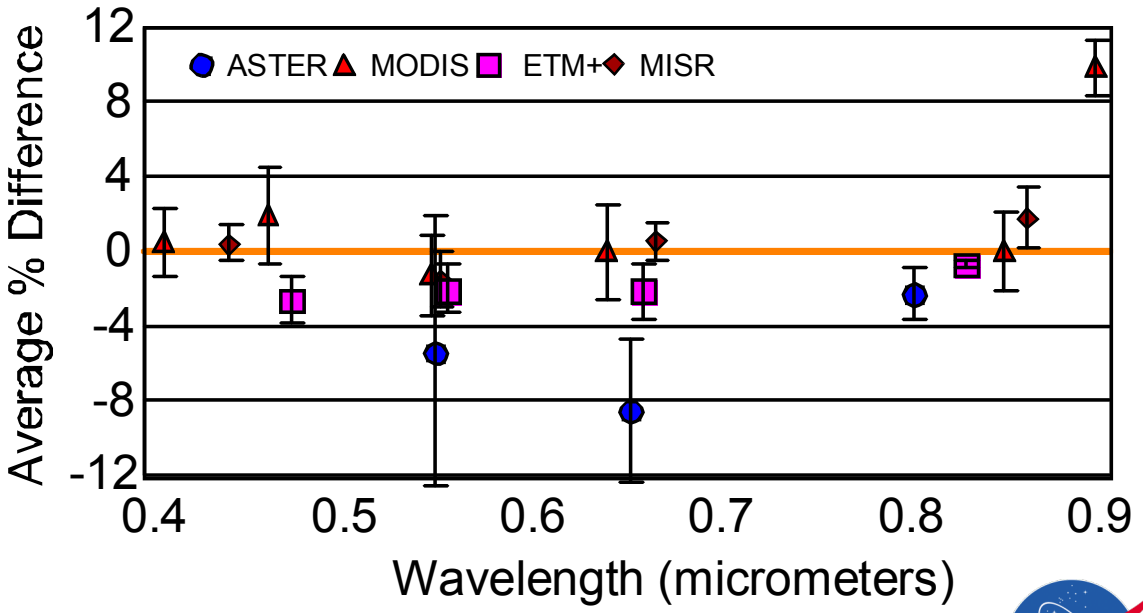
Calibration relative to in-situ

Calibration to SI-traceable, ground-based measurements

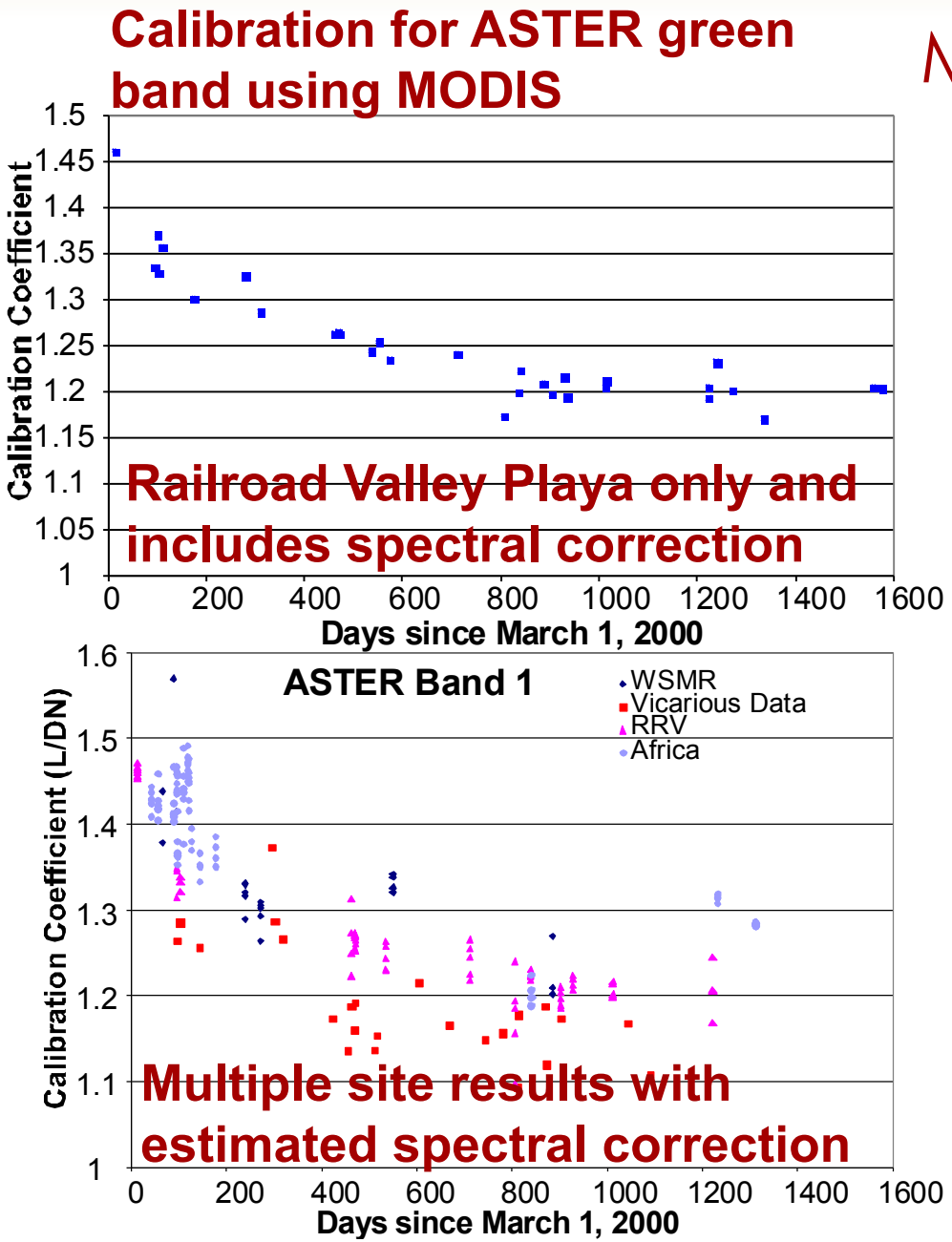
- Cross-calibration relative to in-situ data
- Requires sensors at ground site at overpass time







Coincident view cross-calibration



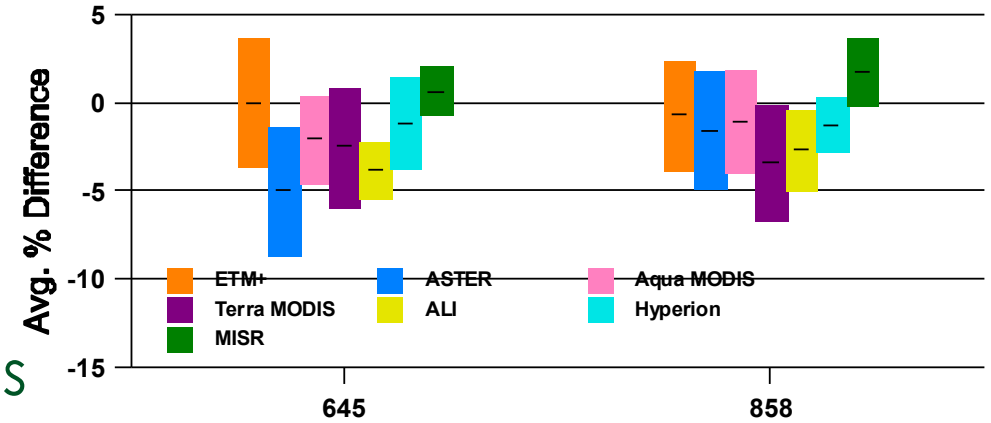
MODIS and ASTER offer same platform, coincident views, similar bands

- ASTER Band 1 (green band) results using MODIS
- Scatter caused by
  - Spectral band differences
  - Registration effects
- Lower graph includes in-situ results

Cause of scatter

Multidimensionality of the at-sensor radiance and non-identical sensors cause scatter

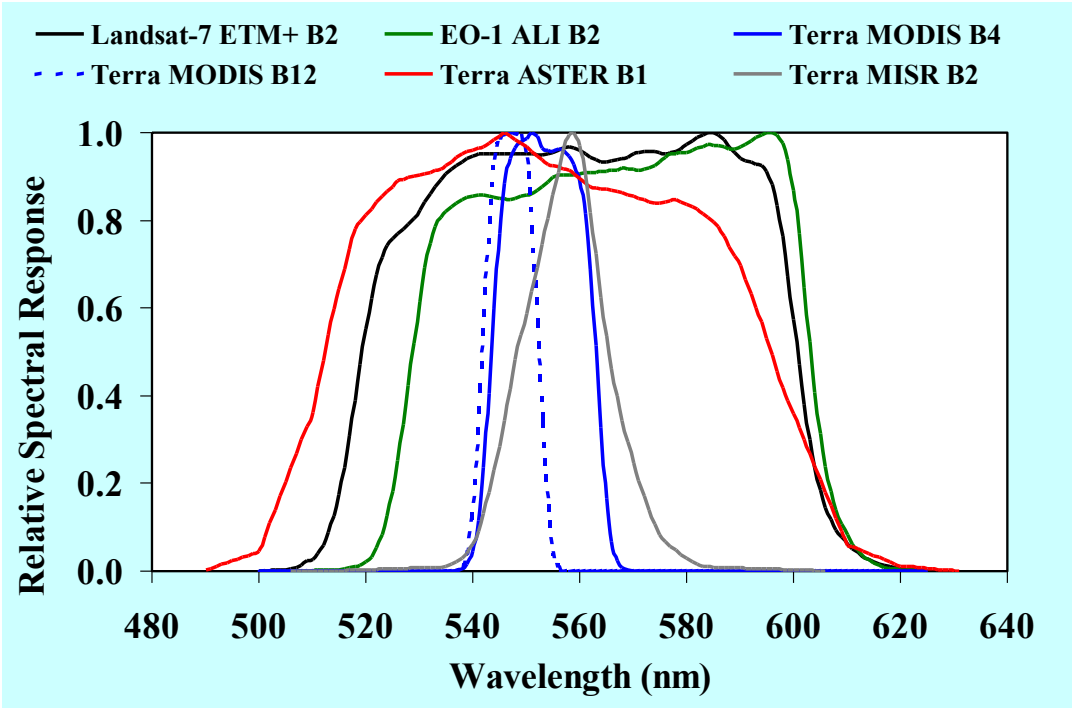
- View/solar geometry differences
  - Surface reflectance changes (BRDF)
  - Atmospheric effects
- Temporal differences
  - Solar angle
  - Surface reflectance
  - Atmospheric changes



- Spatial differences and registration effects
- Spectral differences
- Sensor effects
- All successful methods attempt to account for these effects or minimize the sensitivity

Spectral band differences

ETM+ Band 2 Analogs	A	B	C	D	E	F
A: Landsat-7 ETM+ B2	1	0.996	1.005	0.990	0.988	0.989
B: EO-1 ALI B2		1	1.009	0.994	0.992	0.993
C: Terra ASTER B1			1	0.985	0.983	0.984
D: Terra MODIS B4				1	0.998	0.999
E: Terra MODIS B12					1	1.001
F: Terra MISR B2						1

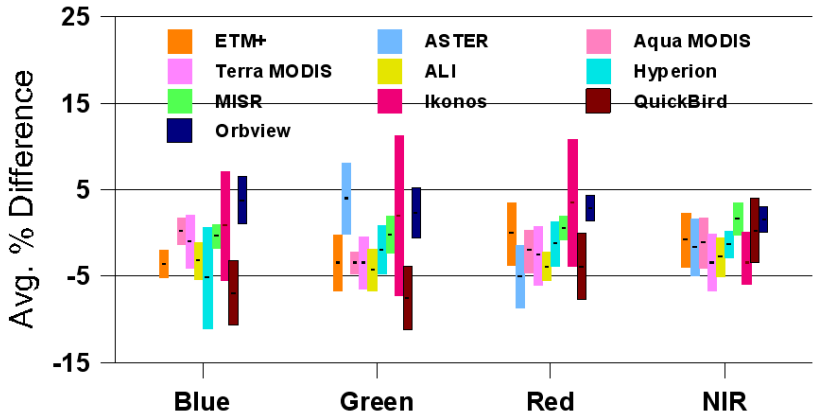


Uncertainty due to spectral differences decrease as **hyperspectral** data of sites are accumulated

Ground data, Hyperion, SCIAMACHY

Site characterization

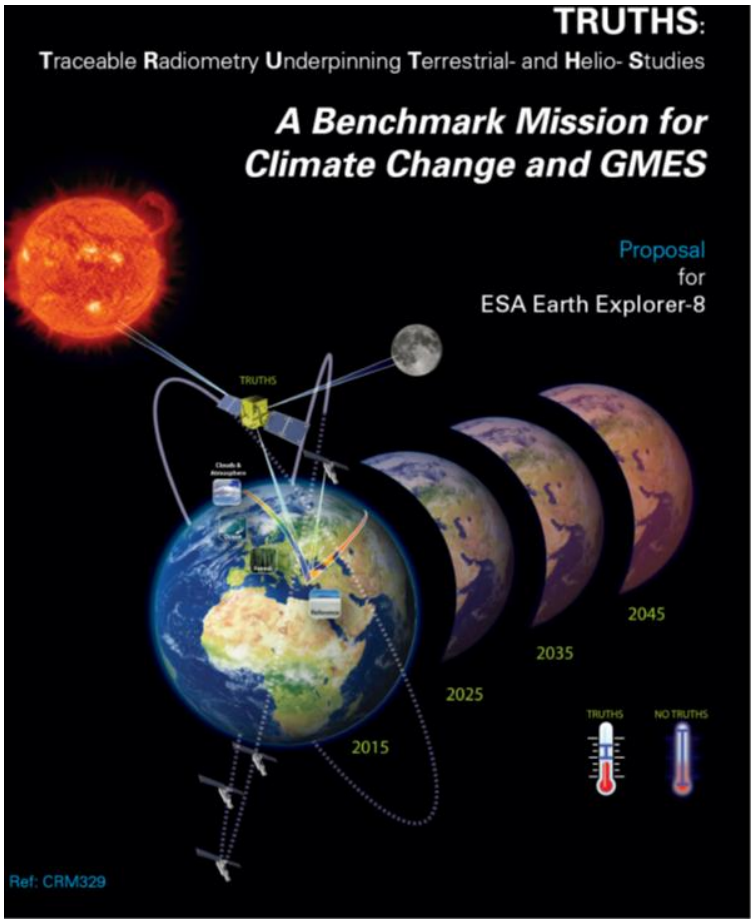
Imaging spectrometry can provide key measurements to understand test sites

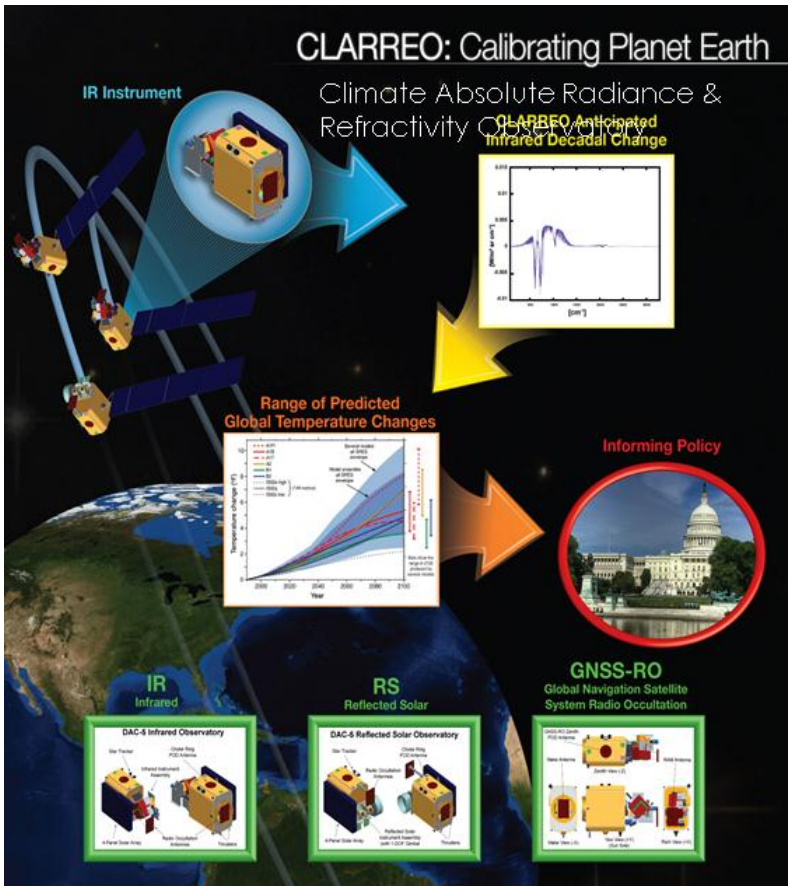


- Cannot decouple
  - On-orbit sensor effects
  - Atmospheric variability
  - Surface variability
- Past results indicate that all three play a role
  - Note that the comparison of sensors improves in the NIR
  - Bands with highest SNR for on-orbit and ground-based sensors
  - Atmospheric effects are not as dominant
- Sensors to do this need to be improved

Site characterization

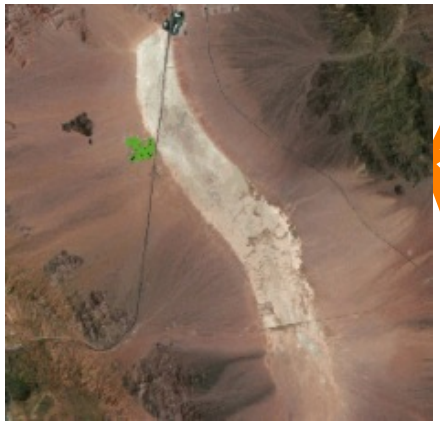
Well-characterized imaging spectrometers such as CLARREO or TRUTHS or HyspIRI can provide site characterizations for SI-traceable cross calibrations





Basic approach

Selected Test Site



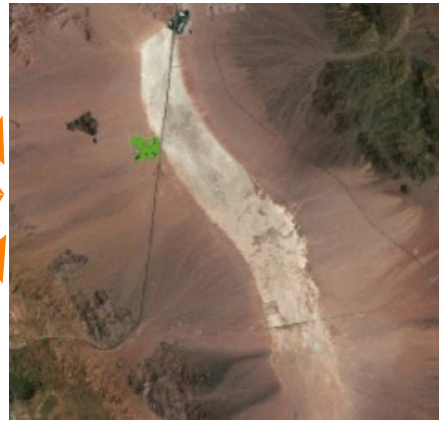
Ground-based Measurements

Satellite-based Measurements

Airborne-based Measurements

Model-based "Measurements"

Predicted At-sensor radiance



Radiance is for arbitrary
1) Time
2) View angle
3) Sun angle

SI-Traceable with documented error budget and uncertainty

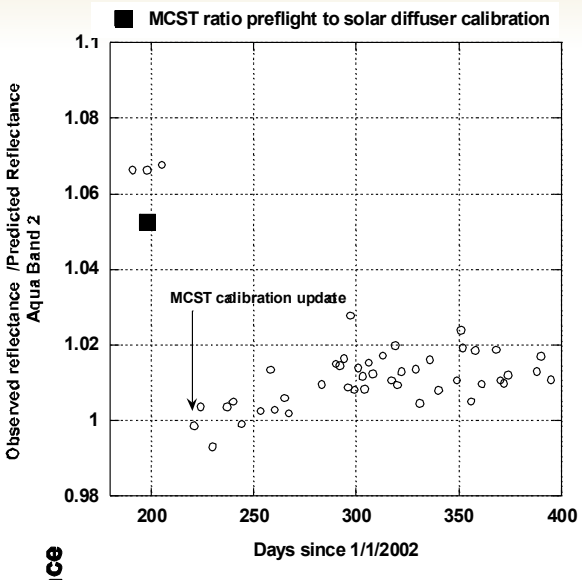
Emphasizes the source radiance

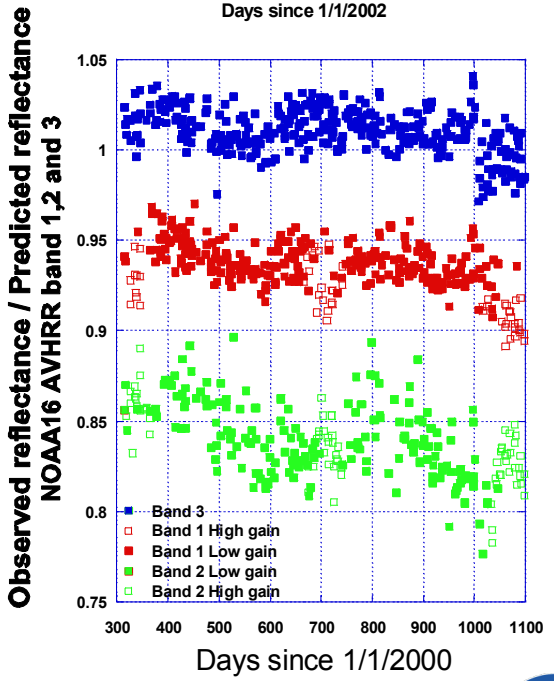
Moves away from one-to-one cross calibrations and empirical only

Model-based measurements

Others have used a similar pathway

- Dome C empirical corrections for BRDF and atmospheric effects
- Inclusion of BRDF models in desert site work for MODIS, AVHRR, MSG
  - Surface BRDF model corrected by Terra MODIS or POLDER
  - Includes atmospheric corrections based on climatological values
- Coupling automated data with surface models
- Deep convective cloud calculations in radiance

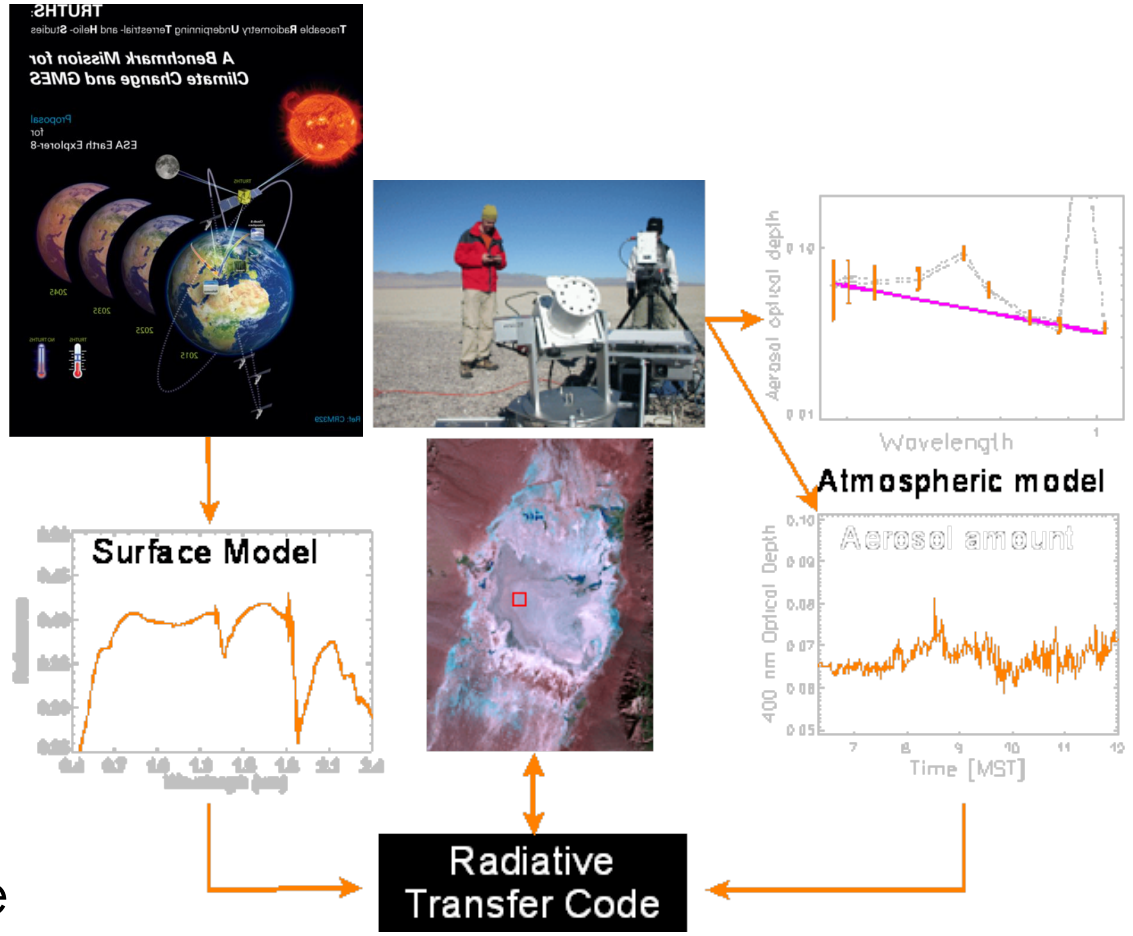




Key measurements

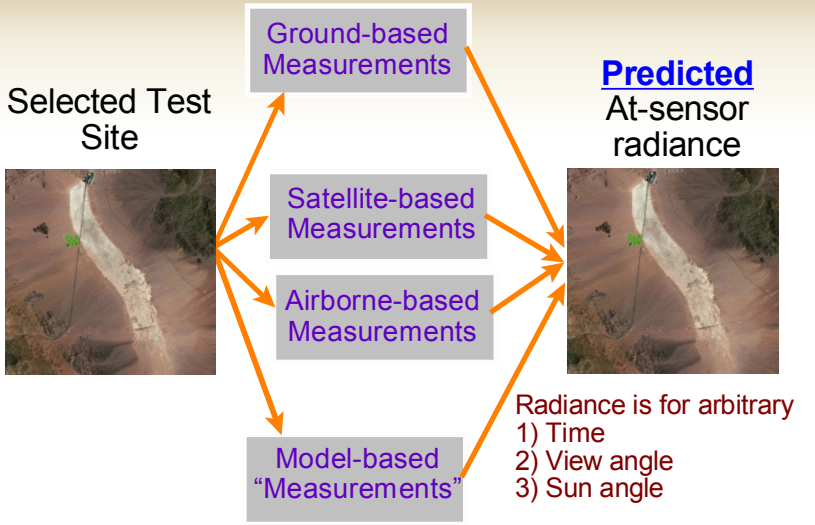
Spectral and directional reflectance of surfaces are highest priority

- Temporal sampling
  - directional reflectance (or at least validation)
  - Site stability
- Imaging provides spatial information
- Spectral samples aggregated to simulate bands
- Imaging spectrometry can lead to knowledge of surface morphology



Summary

Switch from sensor-centric to SI-traceable source-centric mentality is key



- One-by-one empirical comparisons between sensors have been successful but have limits
- Combination of physically-based modeling and empirical data is not be trivial
- Inclusion of highly-accurate, imaging sensors is necessary to develop the physical models
- **Imaging spectrometry provides the best opportunity to determine the spectral reflectance factor**
- Method will provide improved relative calibration precision and absolute calibration that has the capability of matching current methods