A Mission Calibration Plan to Support Products

K. Thome
Goddard Space Flight Center

R. Green, S. Hook
Jet Propulsion Laboratory

Introduction

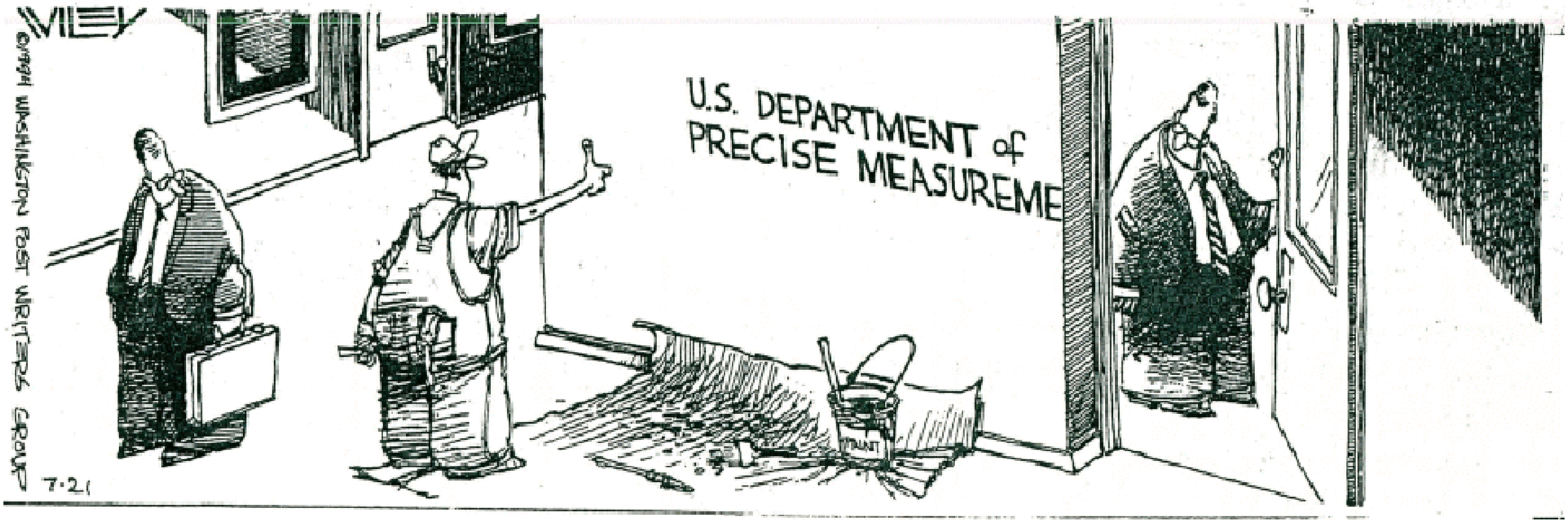
Calibration and validation of HyspIRI plays a key role in the success of the mission

- Present an overview of general approaches for prelaunch and inflight characterization/calibration applicable to HyspIRI sensors
- Discuss both reflective and emissive bands
- Talk overview
  - NIST and SI traceability
  - General calibration philosophy
  - Prelaunch approaches
    - Transfer radiometers
  - Inflight
    - Calibration
    - Validation

Accuracy

Terms accuracy and precision can be sources of contention in discussions

- Accuracy is essentially how well the results agree to the actual value
- Precision is how well individual measurements agree with each other
- Repeatability is used interchangeably with precision



Traceability

NIST and SI traceability are playing a larger role to ensure climate quality data sets

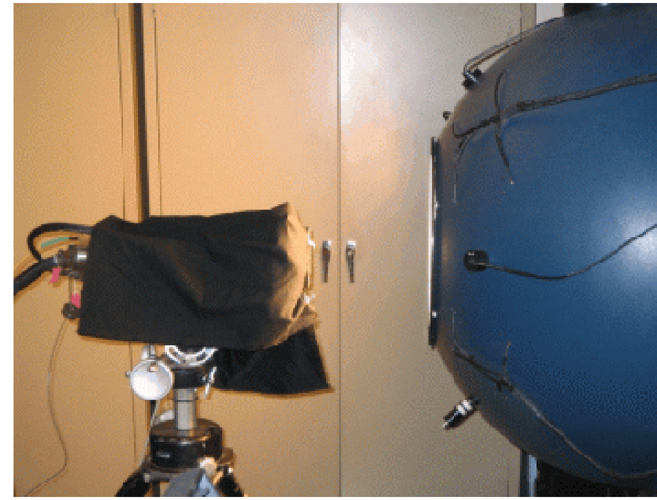
- SI Traceability requires the establishment of an unbroken chain of comparisons to stated references – NIST Website
  - "Unbroken chain of comparisons" means:

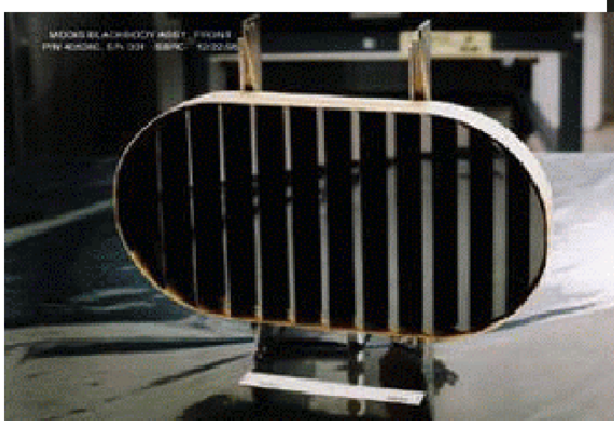
    "the complete, explicitly described, and documented series of comparisons that successively link the value and uncertainty of a result of measurement with the values and uncertainties of each of the intermediate reference standards and the highest reference standard to which traceability for the result of [the] measurement is claimed."
- NIST traceability is maintained through adherence to a documented set of protocols developed by NIST
  - Done properly, should lead to SI traceability
  - Can still lead to biases between laboratories operating under protocols of different national measurement institutes

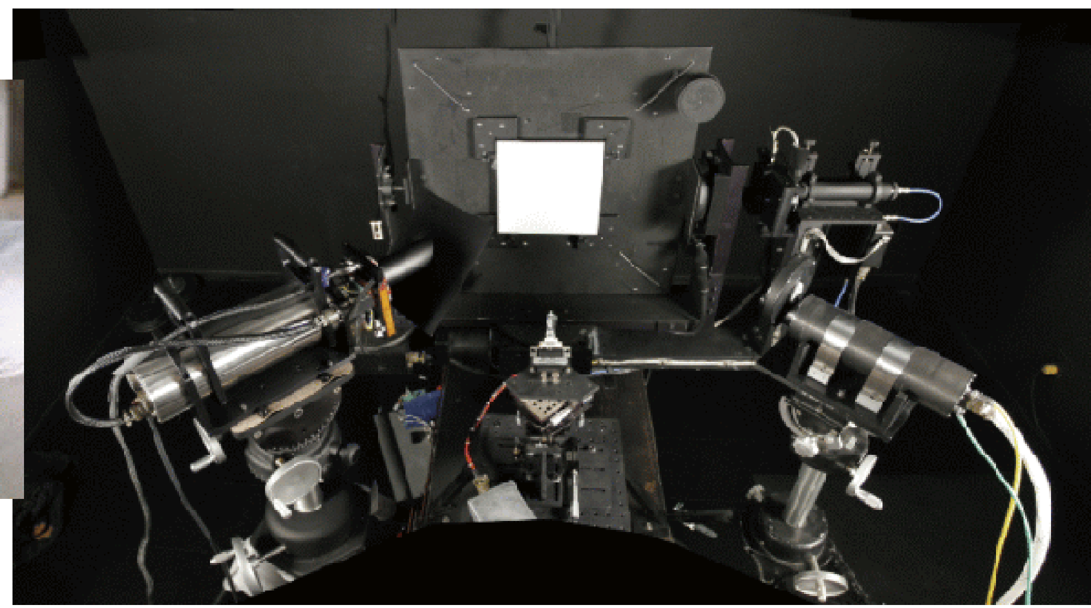
Source-based calibration

Preflight and inflight calibration require sources of known output

- Blackbodies in the thermal emissive
- Lamps and sphere sources in reflective
- Cross-calibration requires moving the sources from place to place



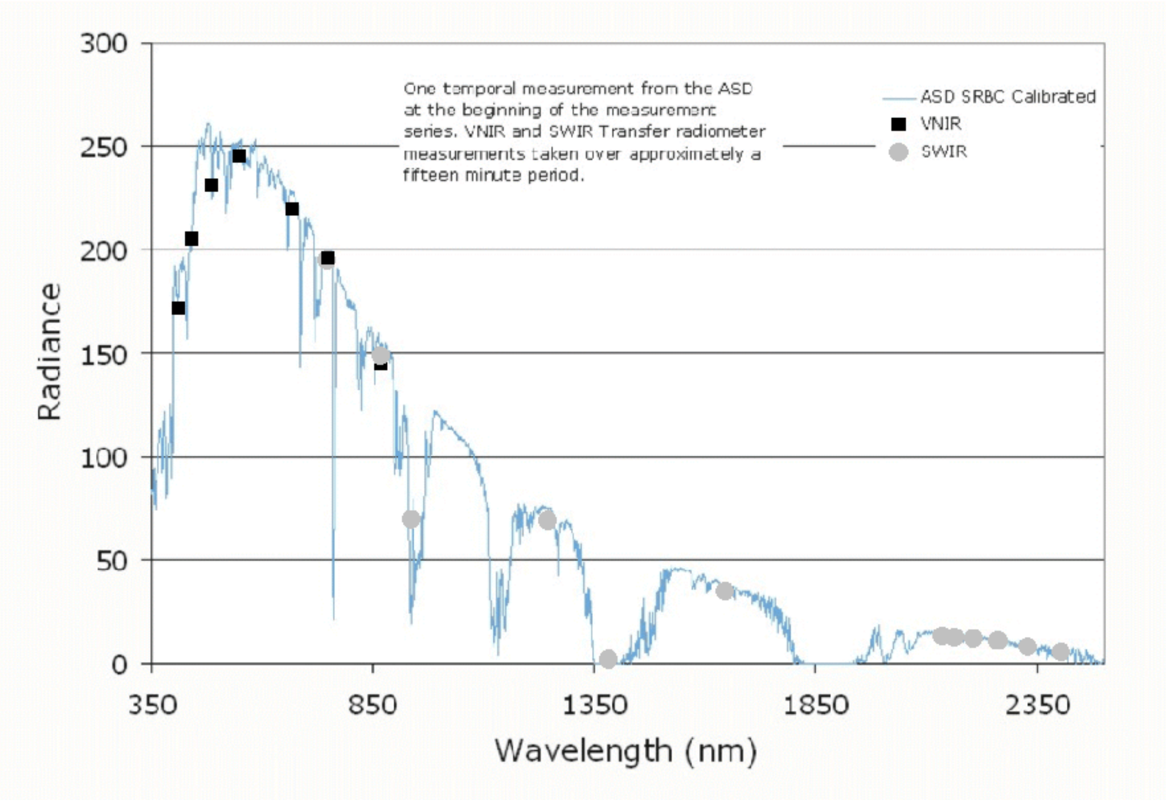




ARTEMIS solar-based example

Solar-based calibration approach was used for the preflight calibration of ARTEMIS

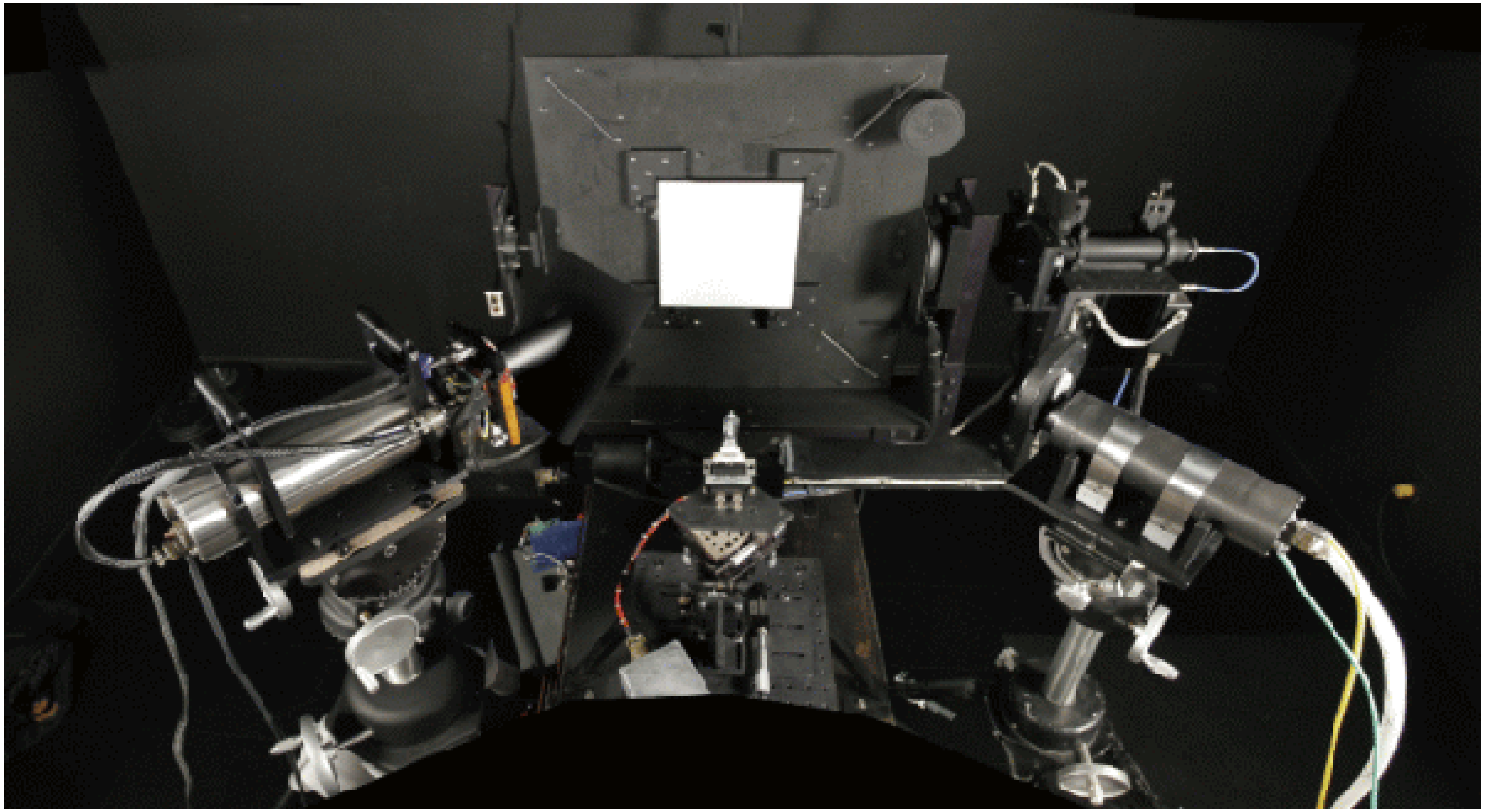
- Sensor viewed a large Spectralon panel
- Output radiance from the panel measured by transfer radiometers



Detector-based approaches

Detector-based approaches assume that radiometers can be used to assess a given source

- Detectors tend to degrade more slowly than lamp sources
- Radiometers more robust and portable than some sources



Inflight calibration

Vicarious approaches are useful for inflight cailbration since they do not degrade with time

- Approaches suggested for HyspIRI are
  - Deep space views
  - Lunar approaches have been successful for several sensors
  - Invariant scenes
  - Predictable scenes
  - In situ measurement approaches
  - Cross calibration
- Methods have been shown to work well in the past
  - Reflective and emissive bands
  - Multispectral and hyperspectral
- Approaches can be used for spectral, radiometric, and geometric calibration

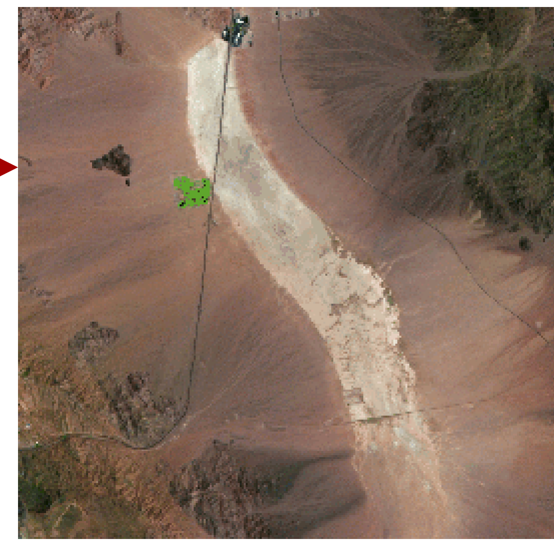
Inflight - vicarious

Measurements of surface reflectance of a homogeneous test site

Measurements of atmospheric conditions

RTC Code

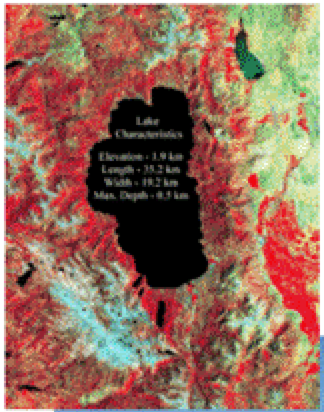
Predict at-sensor radiance for a selected area of the site and compare to imagery

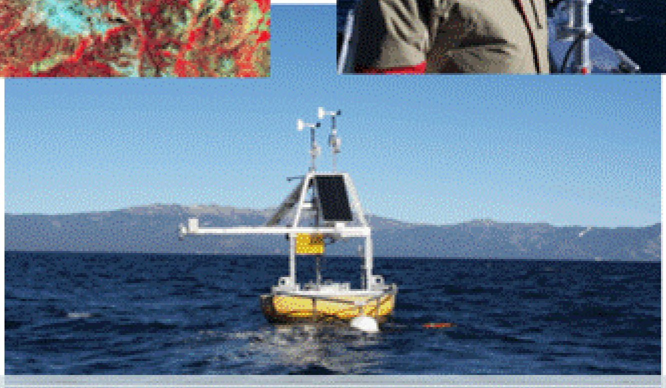


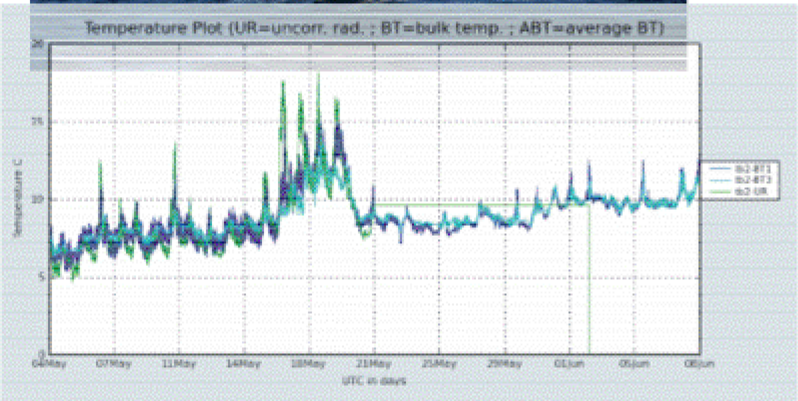
Instrumented sites

Tahoe site is an excellent example of a ground measurement site

- Measure water leaving radiance
- Measure bulk temperature
- Characterize the atmosphere
- Predict at-sensor radiance
- Similar work in Great Lakes







Spectral and Geometric calibration

Spectral and geometric calibration takes place prelaunch and on orbit as well

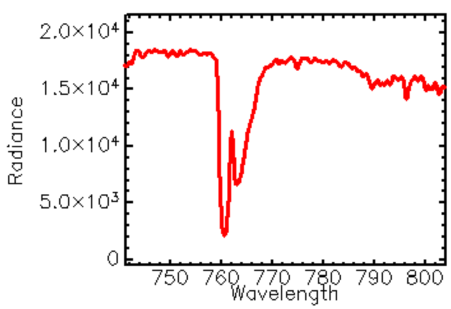
- Alignment between emissive and reflective bands
- Center wavelength and band shapes

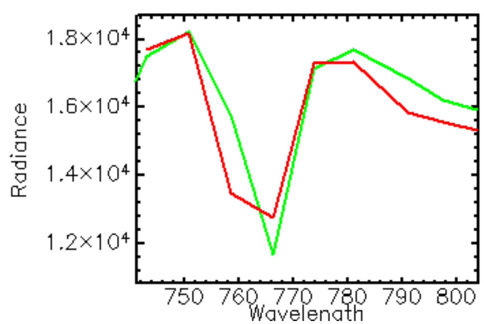
1. Convolve SRF with High Resolution MODTRAN™ Model

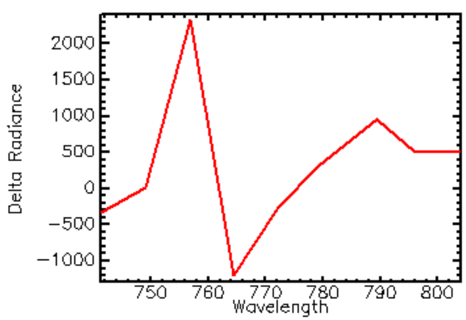
2. Normalize Data (Green) to Model (Red)

3. Subtract Data from Model
Fit Straight Line
Compute Statistics

4. Shift Band Centers
Repeat Steps 1-4







Product validation

An important part of the sensor calibration will be to use product validation

- Validation of the data products permits further understanding of the sensor's behavior
  - More realistic scenes
  - Inter-band and inter-sensor differences
  - Expansion of areas for in situ collections
- MODIS provides a good example
  - NDVI used to cross-compare between sensors
  - Ocean products have found polarization sensitivities
- Should not permit product validation to be used as a substitute for sensor calibration
  - Separate sensor effects from algorithmic effects
  - Traceability is more difficult

Summary

Products should be used to determine the required calibration accuracy and precision

- Requirements will determine specific types of calibration needed
  - 0.5 K accuracy is currently being achieved on regular basis
  - 2-3% in reflectance in bands without strong atmospheric absorption
  - Better accuracy will require new approaches to laboratory and onboard calibrators
- Specific sensor design will determine the specific tests
  - Onboard calibrator approaches
  - Focal plane designs
- Calibration plan should include methods that allow comparisons to later sensors