In-flight calibration of the Thermal Infrared Sensor (TIRS) on the Landsat Data Continuity Mission

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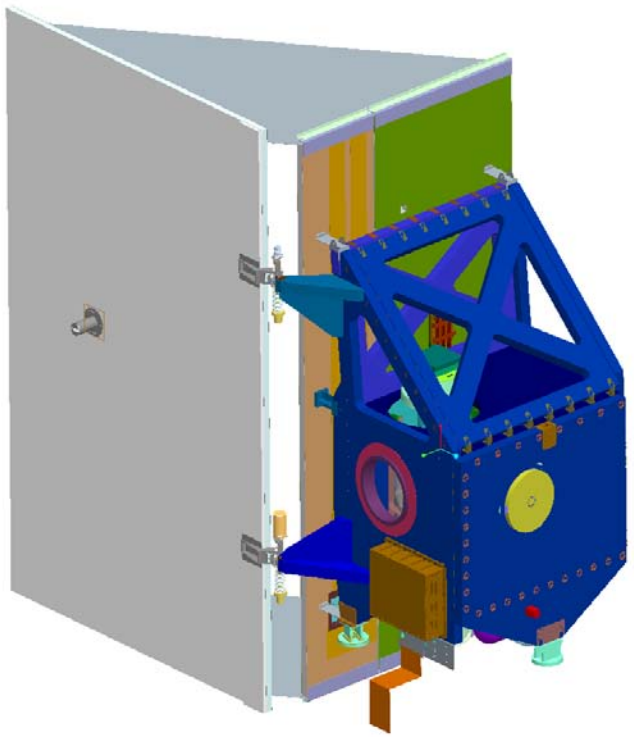
Outline

Describe in-flight calibration for the Thermal Infrared Sensor (TIRS)

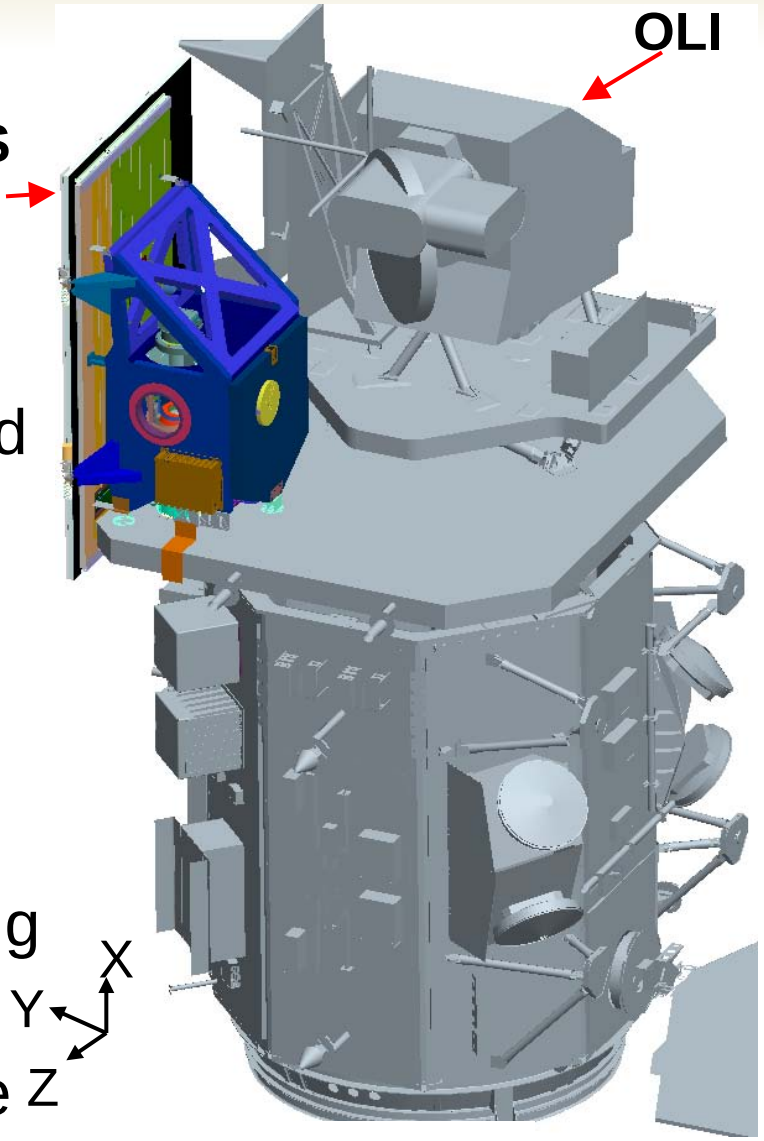
- Overview of TIRS
- On-orbit radiometric calibration
  - Onboard calibrator
  - Terrestrial sites
- On-orbit geometric and spatial calibration



LDCM overview

Landsat Data Continuity Mission continues Landsat data history

- TIRS operates in concert with but independent of Operational Land Imager
- Will produce radiometrically-calibrated, geo-located data
- United States Geological Survey/ Earth Resources Observation and Science (EROS) facility developing operational algorithms
- On orbit calibration plays key role in merging OLI and TIRS data in single data stream

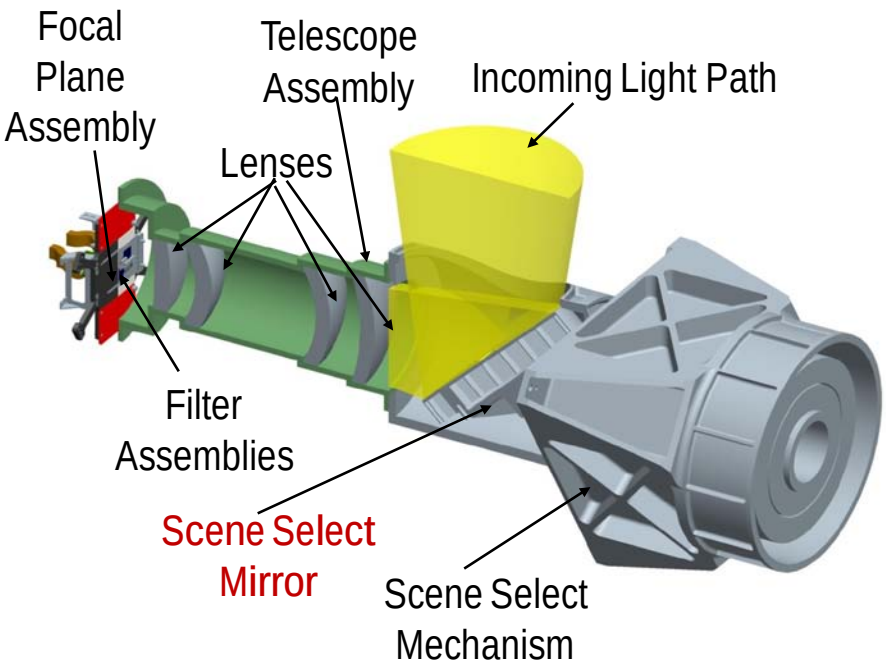


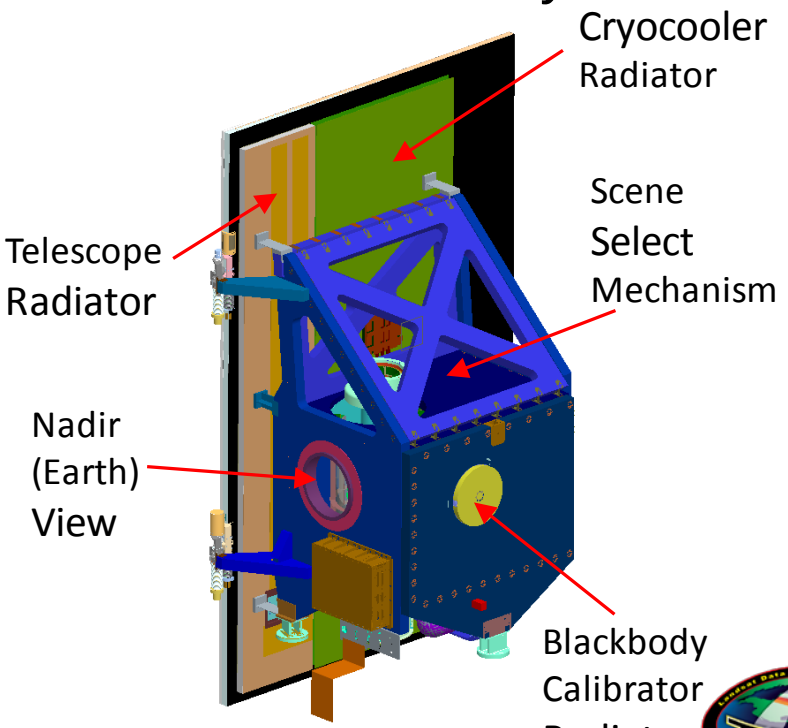
LDCM

TIRS Overview

Dual band, pushbroom system with 185-km swath width and 100-m spatial resolution

- Quantum well infrared photodetector (QWIP)
- 10.8 μm and 12 μm
- Scene-select mirror allows for nadir views of earth as well as views of deep space and onboard blackbody





On orbit calibration

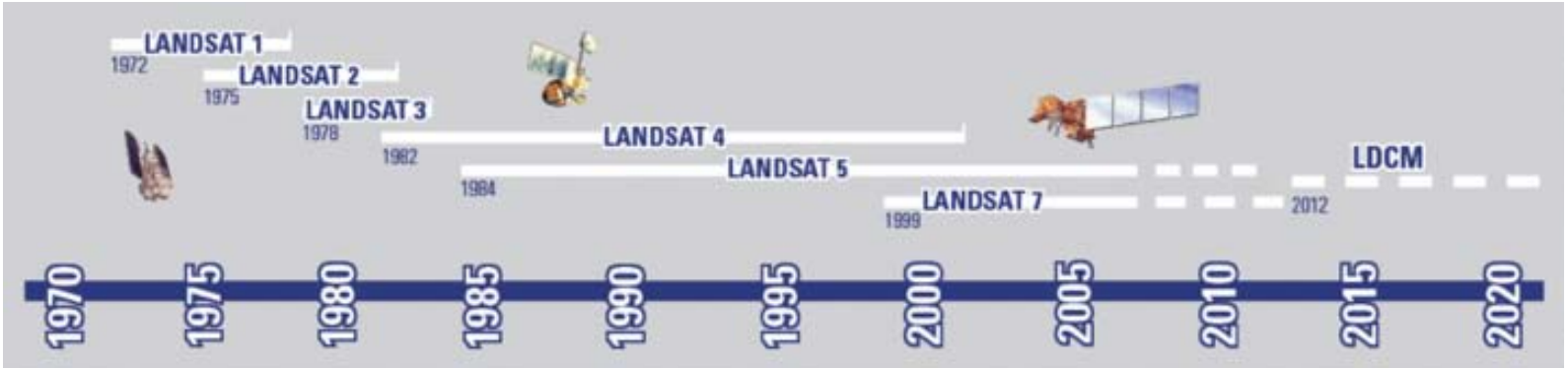
On-orbit testing will follow past efforts for similar sensors

- Verify sensor calibration and performance on orbit
- Evaluate onboard calibrator performance
- On-board blackbody is primary path to derive on-orbit radiometric calibration
- Intercomparison with ETM+ and other sensors
- Geometric approaches
  - Cold deserts for OLI to TIRS registration
  - Hot spots for band-to-band registration
  - OLI comparison
  - Lunar views (recovery time, ghosting)

On-orbit calibration of TIRS

An important goal of TIRS is to place this sensor in context with past, present, & future sensors

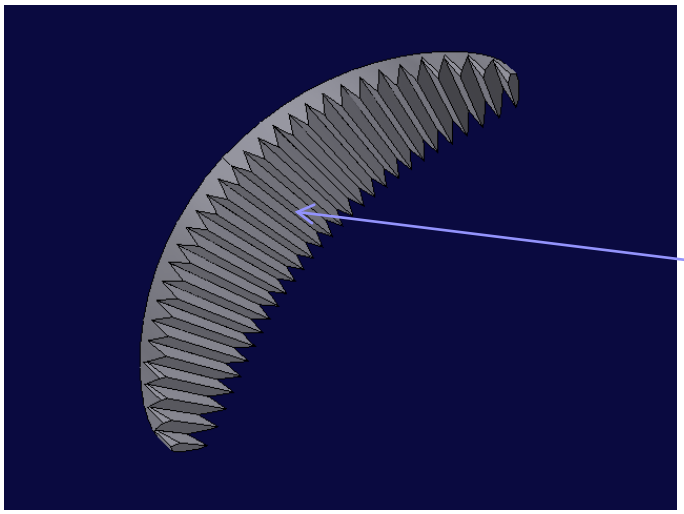
- Radiometric calibration allows TIRS to continue a long history of Landsat sensors
  - Consistency with Landat-7 ETM+ and Landsat-5 TM
  - Putting TIRS on the same radiometric scale as other earth resources sensors
- NIST traceability will allow TIRS data to be on the same scale as follow-on Landsat missions

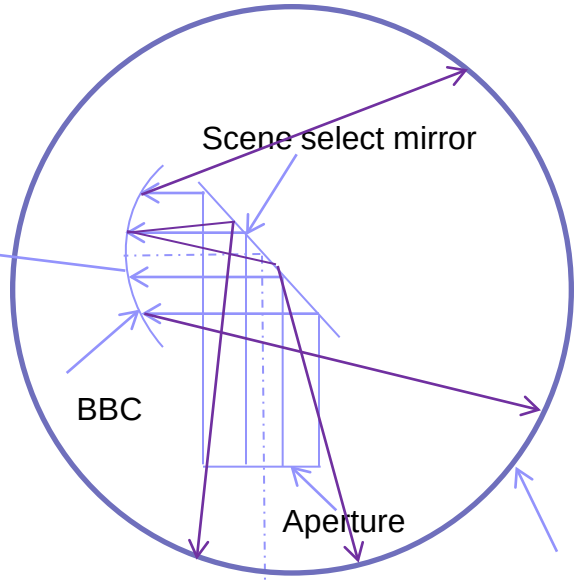


Onboard Blackbody (OBB)

OBB has similar design to that used for Moderate Resolution Imaging Spectroradiometer (MODIS)

- V-groove, "flat" plate
  - OBB surface property: 92% absorption and 8% reflection
  - Reflection is specular
- Variable temperature





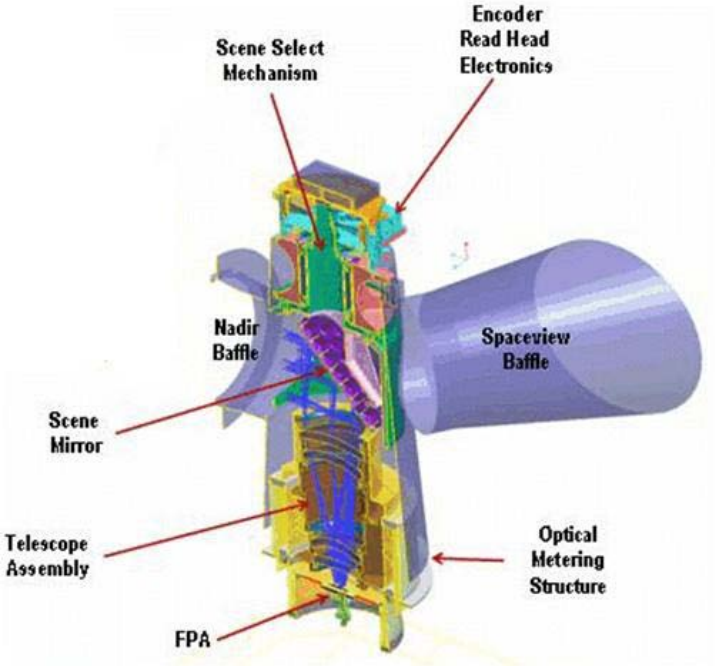
Optical modeling used to predict emissivity performance

Incident light in blue
Reflected light in purple

Onboard calibrator (OBB)

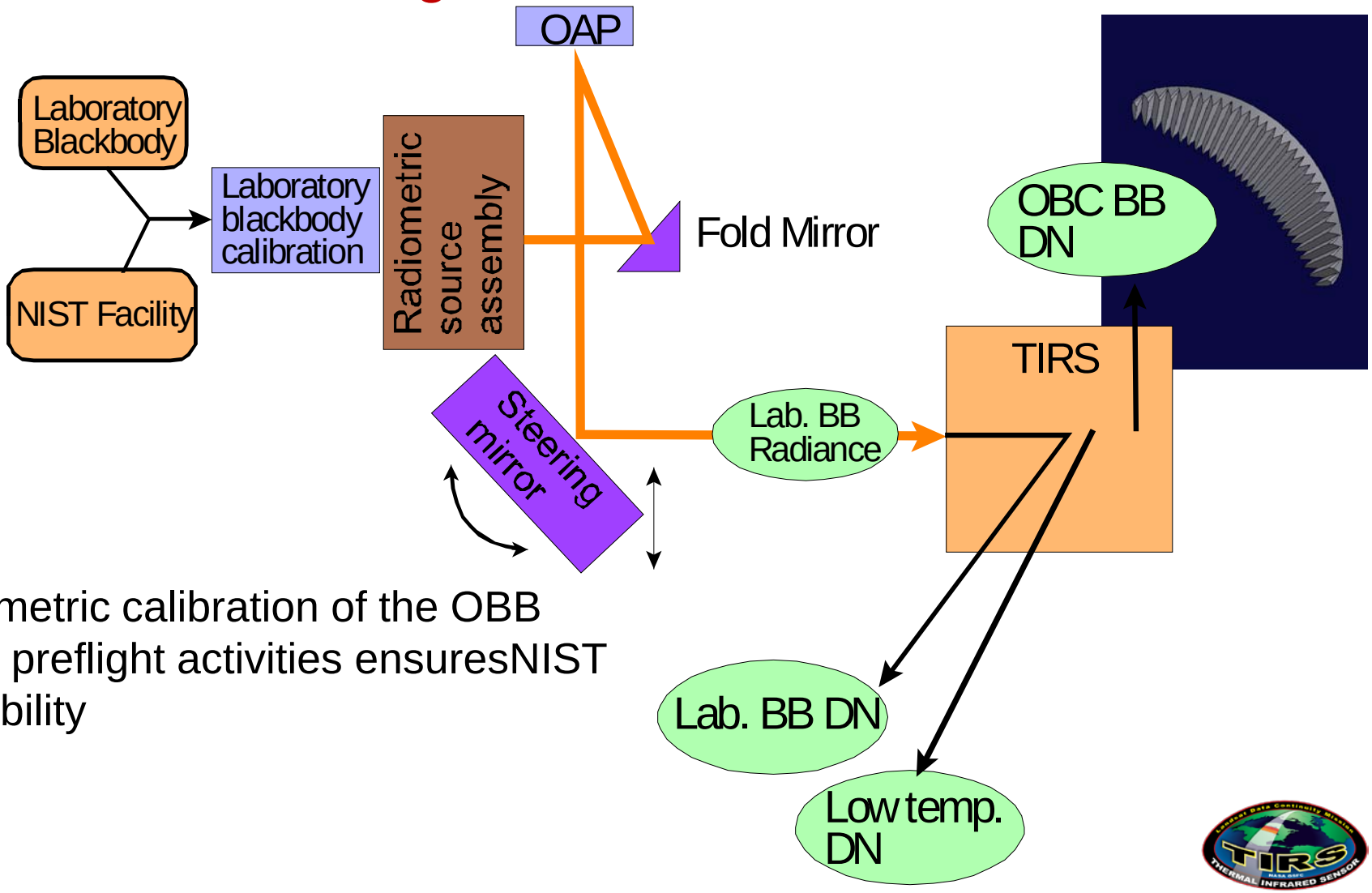
Scene-select mirror provides views to nadir (earth), space, and an on-board blackbody

- Nominal operation approach is
  - View deep space and OBB as sensor comes out of eclipse
  - Nadir view of earth for imaging
  - Repeat deep space and OBB as sensor goes into eclipse
- Frequency of OBB views can be increased if needed
- Temperature of OBB can be varied between collects



Onboard blackbody characterization

Onboard blackbody (OBB) is calibrated using TIRS as a transfer



Radiometric calibration of the OBB during preflight activities ensuresNIST traceability

Transfer to orbit

On-orbit testing will evaluate sensor calibration and noise performance on orbit

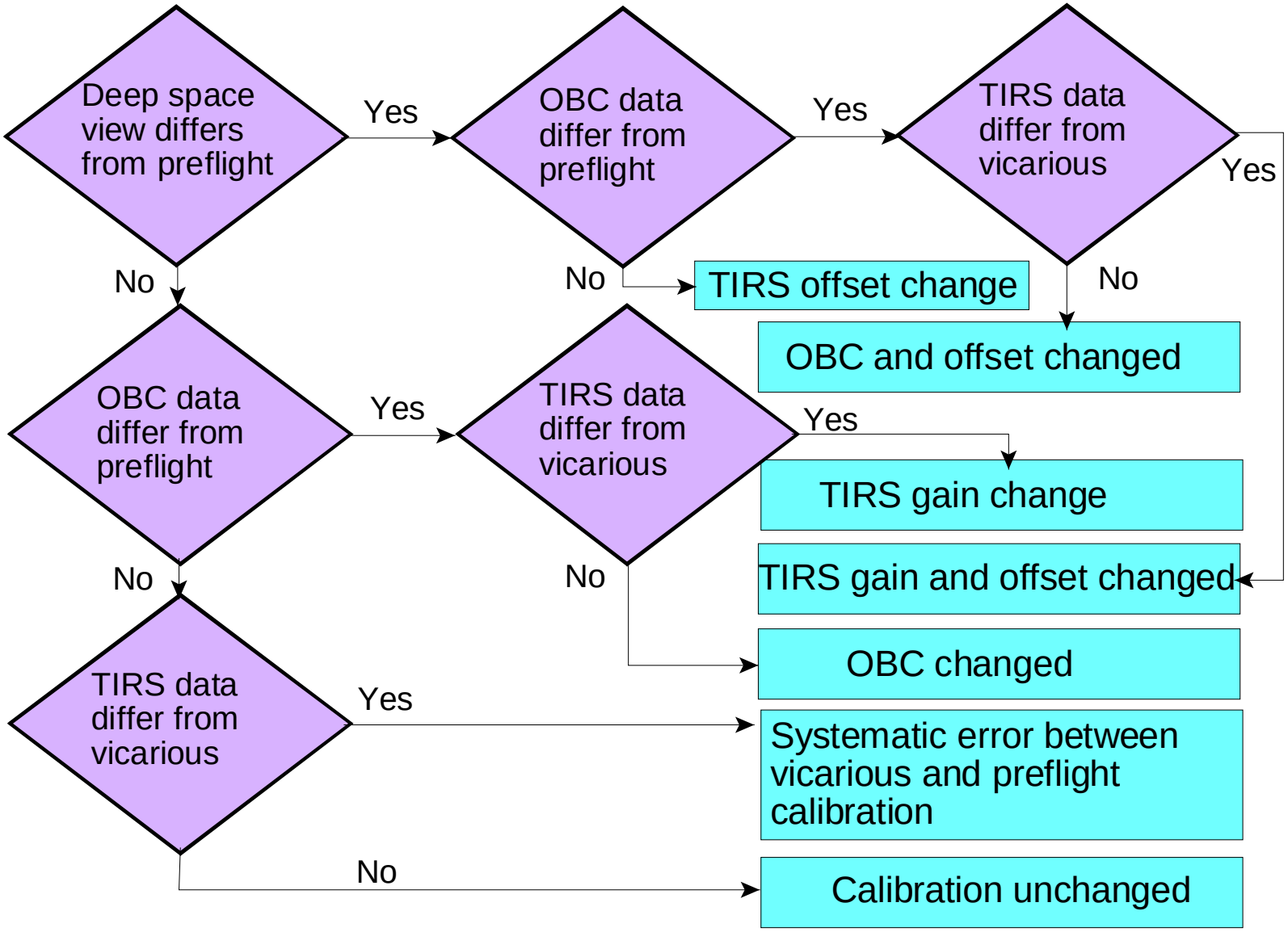
- Evaluate onboard calibrator performance
- Radiometric approaches
  - Intercomparison with ETM+
  - Ground sites
  - Intersensor comparisons
- Geometric approaches
  - Band-to-band registration
  - OLI comparison
  - Lunar approaches
- Three-month commissioning and checkout phase
  - Schedule is still under development
  - Transfer to orbit of calibration is one component

Transfer to orbit

Transfer to orbit will take place during the first 90 days of TIRS operation

- Rely on combination of deep space views, OBB collections, and vicarious calibration data
- Validate radiometric sensitivity model
- Characterize variations in detector responsivity over 2 instrument out gassing (decontamination) cycles
- Identify dead, inoperable, and out-of-spec detectors for each band
- Compare prelaunch to on orbit data
  - Deep space views
  - OBB
- ETM+ comparisons with common targets and maximum 20 minute time delay

Transfer to orbit



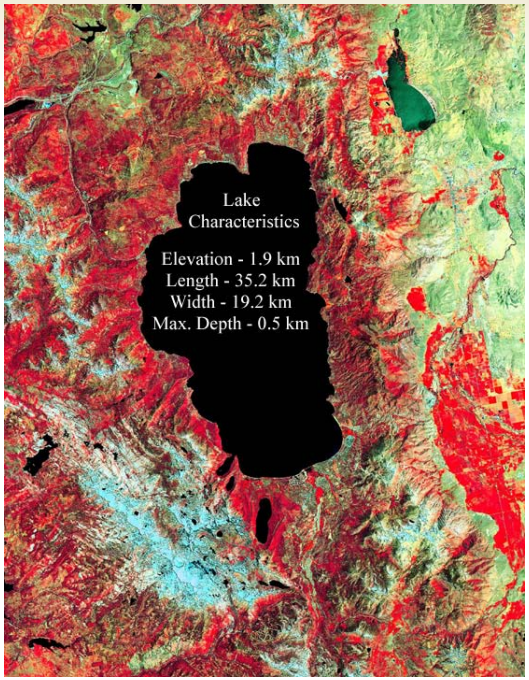
Vicarious radiometric calibration

Well established vicarious approaches planned for TIRS evaluation

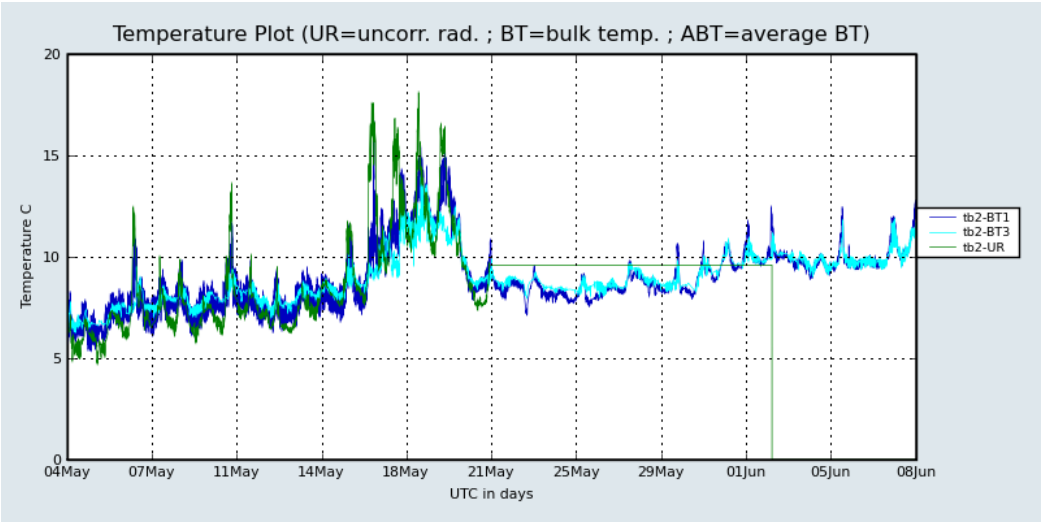
- Well-understood ground scenes
  - Simultaneous nadir overpass (SNO) approach
  - Melt ponds
  - Sea-surface temperature retrievals
- Characterized ground scenes
  - Lake Tahoe
  - Lake Ontario
  - Salton Sea
- Cross comparisons with other sensors
  - MODIS/VIIRS
  - GOES

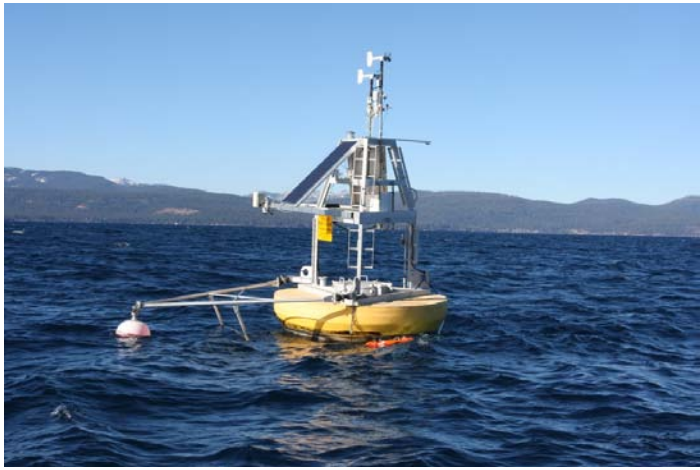
Ground sites

Concentrate on instrumented sites accessible in N.H. winter



- Lake Tahoe and Salton Sea shown to work well for ETM+ and TM
- Measure water leaving radiance
- Measure bulk temperature
- Characterize the atmosphere
- Predict at-sensor radiance

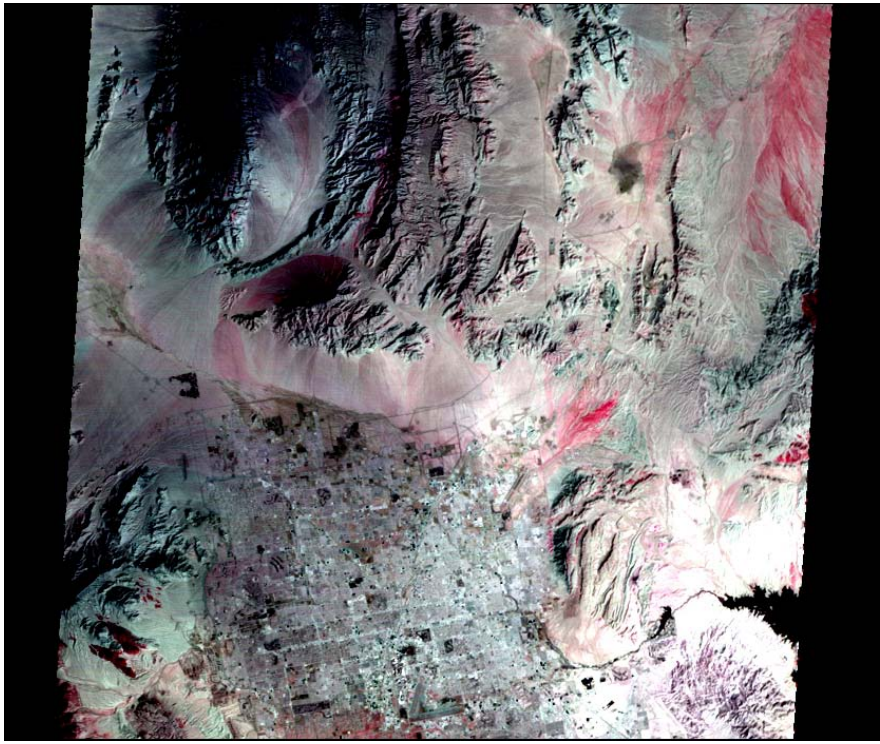




On-orbit Geometric calibration

Characterize instrument to Attitude Determination System Reference alignment

- Characterize detector arrays lines of sight
  - Relative band to band
  - Relative to reflective bands
- Ground scenes
  - Cold deserts for OLI to TIRS registration
  - Hot spots for band-to-band
- Verify spatial characteristics via linear features



Lunar views

OLI is scheduled to use the moon for radiometric calibration

- Platform maneuver required to do so
  - Monthly basis but more frequently during check out
  - TIRS will also view the moon during the same maneuvers
- Moon is high-temperature source
- Examine data related to
  - Stray light
  - Ghosting
  - Validate recovery time to return to nominal image performance

Summary

On-orbit calibration of TIRS will place it in context with past, present, & future sensors

- Effort builds on successful approaches developed for Landsat-5 TM and Landsat-7 ETM+
  - Result of long-term partnership between NASA and USGS and university collaborations
  - Past effort demonstrates that the required 2% accuracy is readily achievable with TIRS
- 90-day commissioning phase will be the key to the transfer to orbit of prelaunch calibration
  - NIST traceable
  - Geometric and radiometric characterizations
  - Cross-calibration to currently flying sensors