

Conserving, Calibrating, and Enhancing the Landsat Archive

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Outline

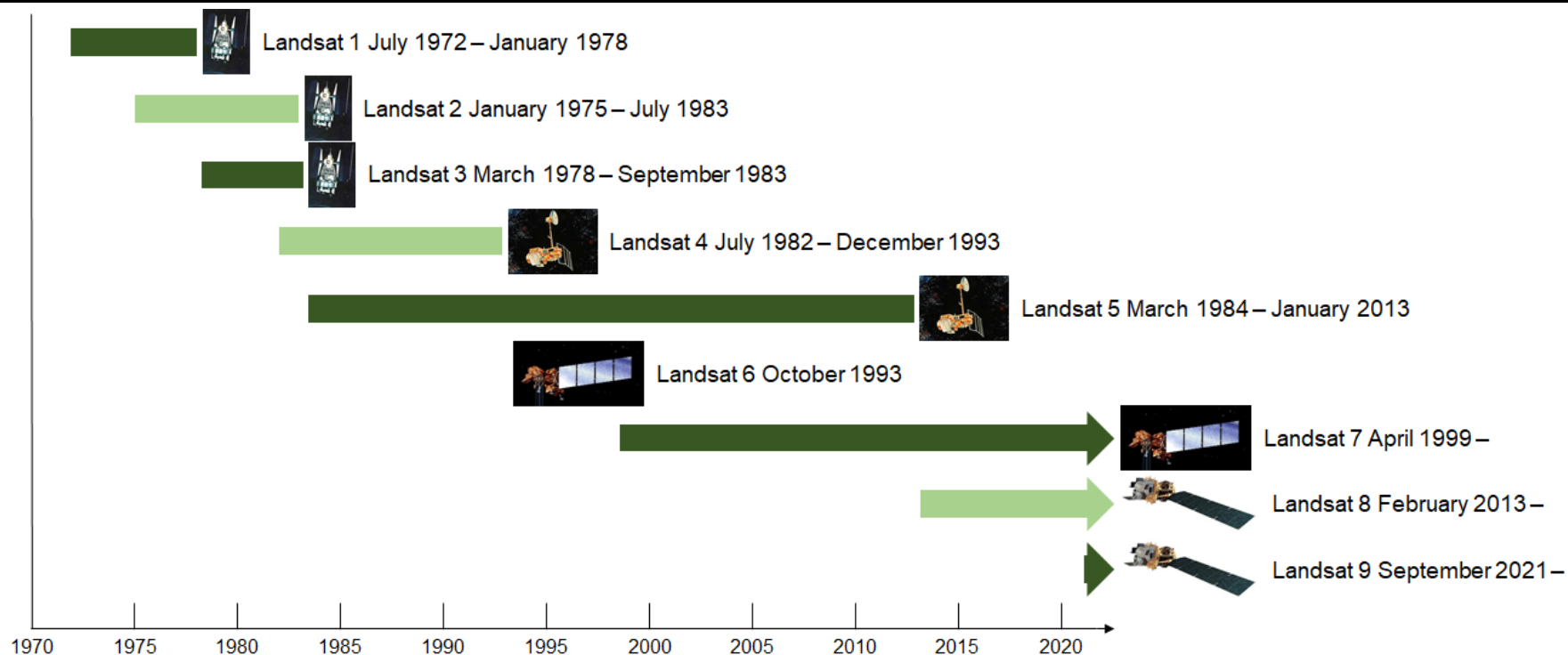
- ◆ **The Landsat Mission**
- ◆ **Continual Radiometric Improvements**
- ◆ **Continual Geometric Improvements**
- ◆ **Product Improvements**
- ◆ **Landsat 9**
- ◆ **Conclusion**

The Landsat Mission

Landsat Background

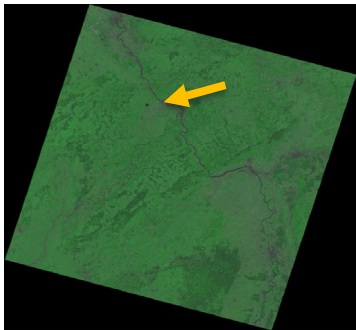
- ◆ **The U. S. Geological Survey (USGS)'s Landsat Mission, developed in partnership with the National Aeronautics and Space Administration (NASA), is the longest-running Earth-Observing satellite program.**
- ◆ **Landsat 1, originally named the Earth Resources Technology Satellite 1 (ERTS-1), was launched on July 23, 1972**
- ◆ **Landsat 9 was successfully launched on September 27, 2021**
- ◆ **The Landsat mission will reach its 50th anniversary this summer: July 23, 2022**

Landsat Missions

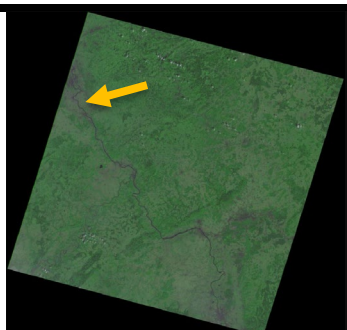


Landsat Mission Archive

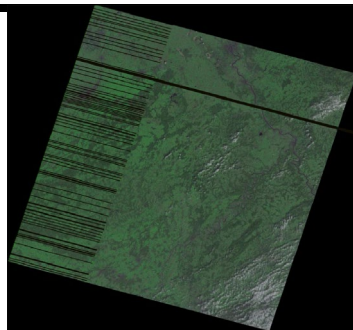
WRS-1 P211 R25 / WRS-2 P196/R25 (Bonn, Germany)



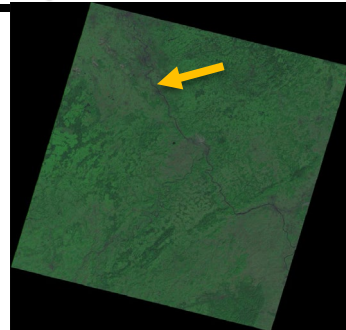
L1 MSS 7/14/1975



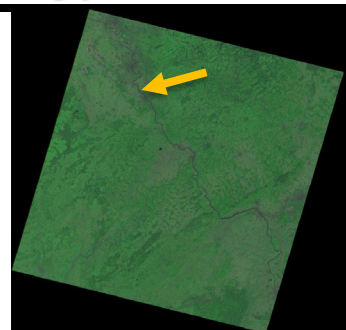
L2 MSS 8/10/1975



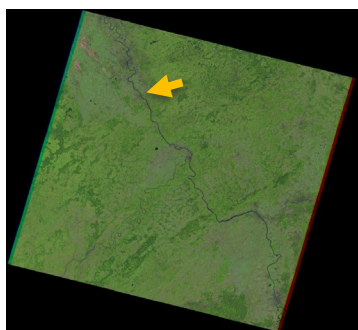
L3 MSS 2/17/1979



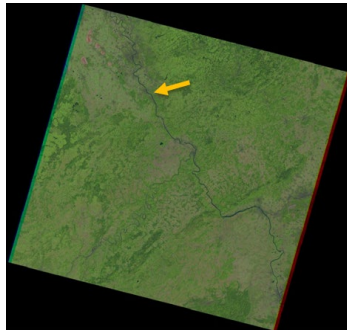
L4 MSS 9/27/1985



L5 MSS 8/5/1992



L4 TM 7/20/1989



L5 TM 8/5/1992



L7 ETM+ 7/5/2001

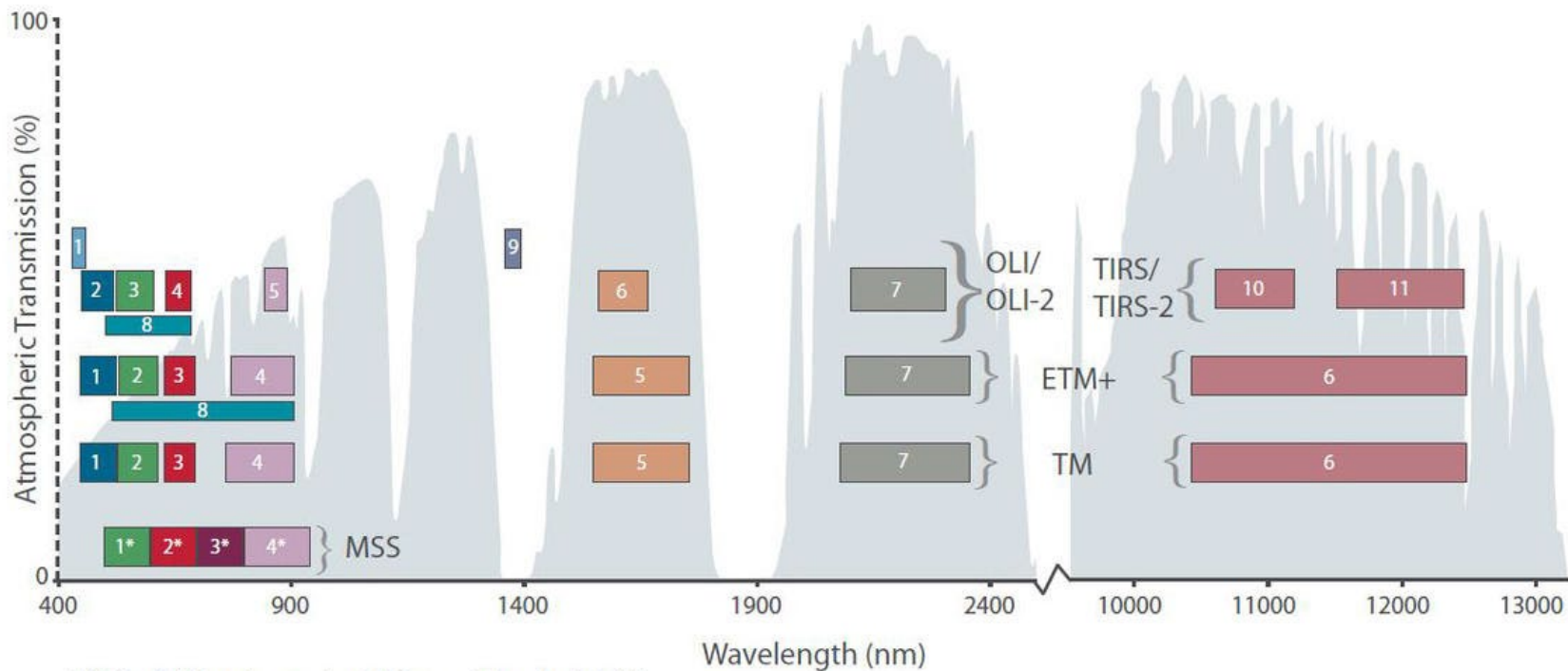


L8 OLI 9/30/2018



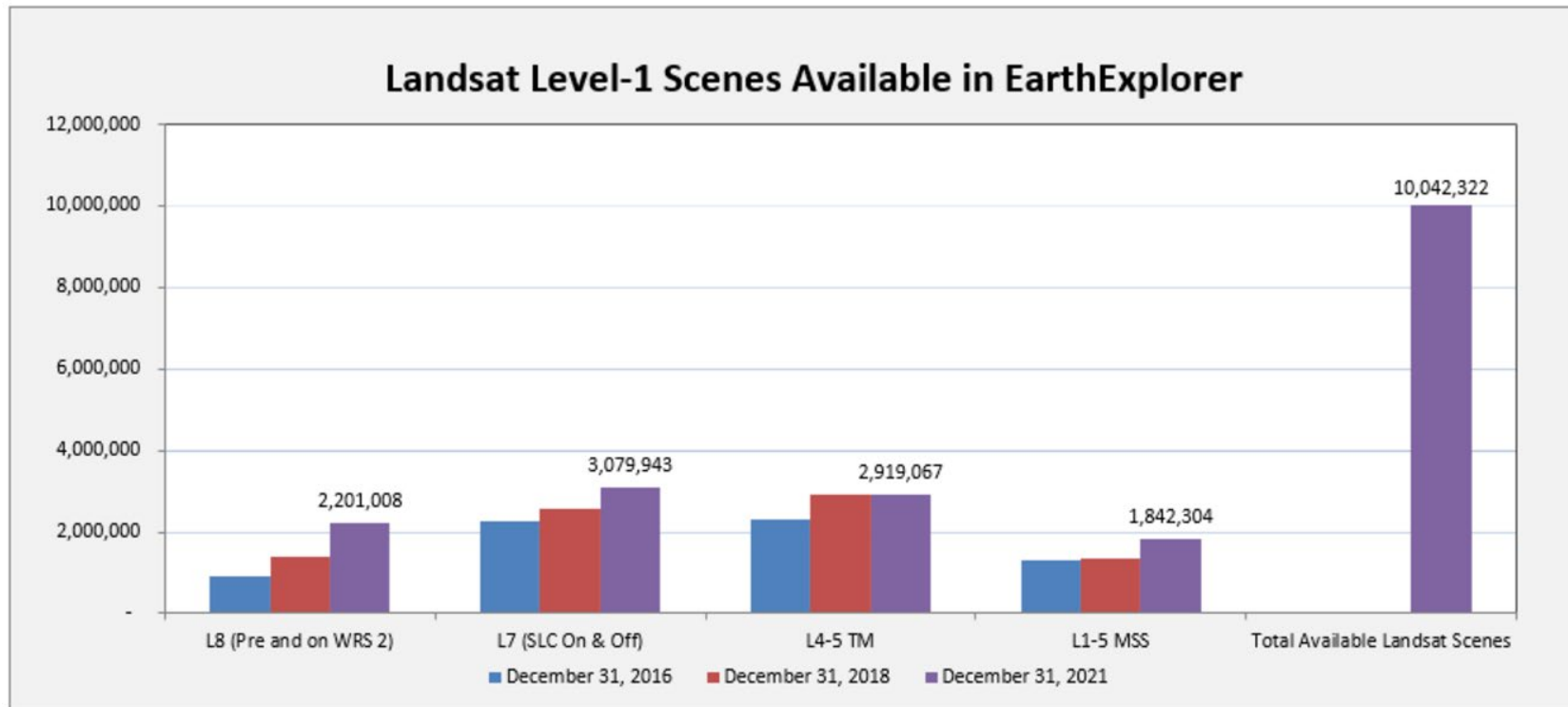
L9 OLI 3/9/2022

Landsat Spectral Bandpasses



* MSS bands 1-4 were known as bands 4-7, respectively, on Landsats 1-3

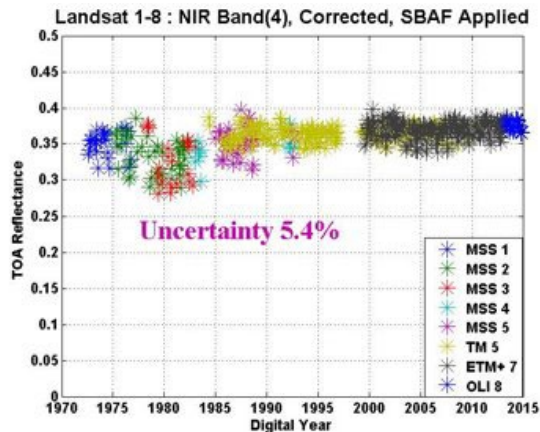
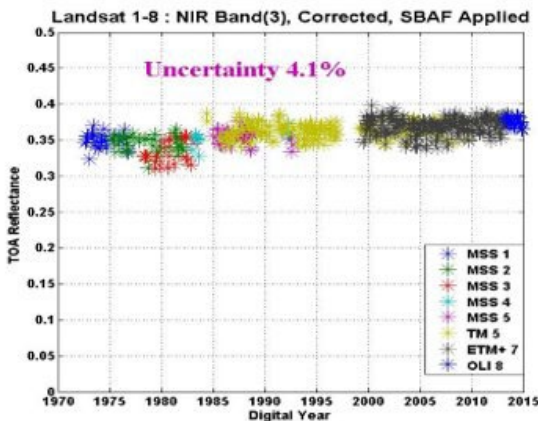
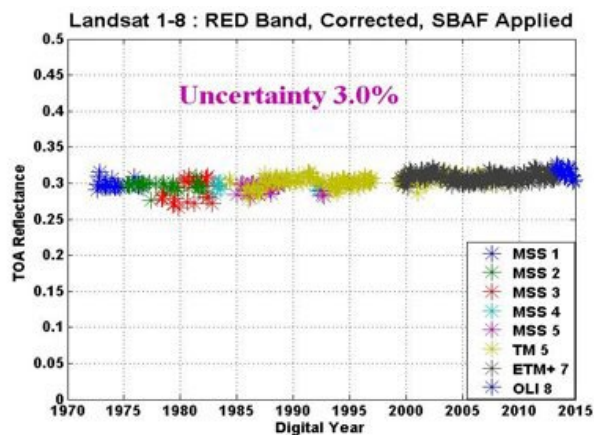
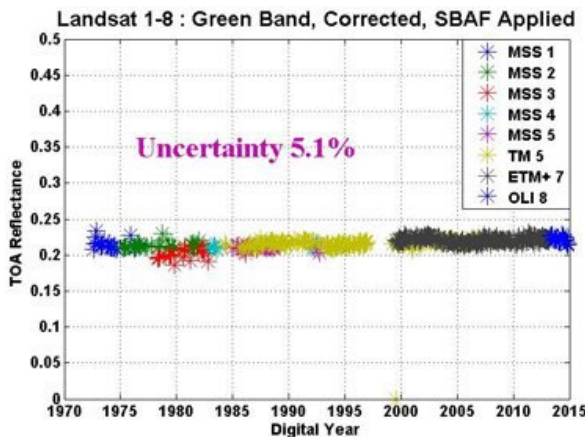
Landsat Archive



Continual Radiometric Improvements

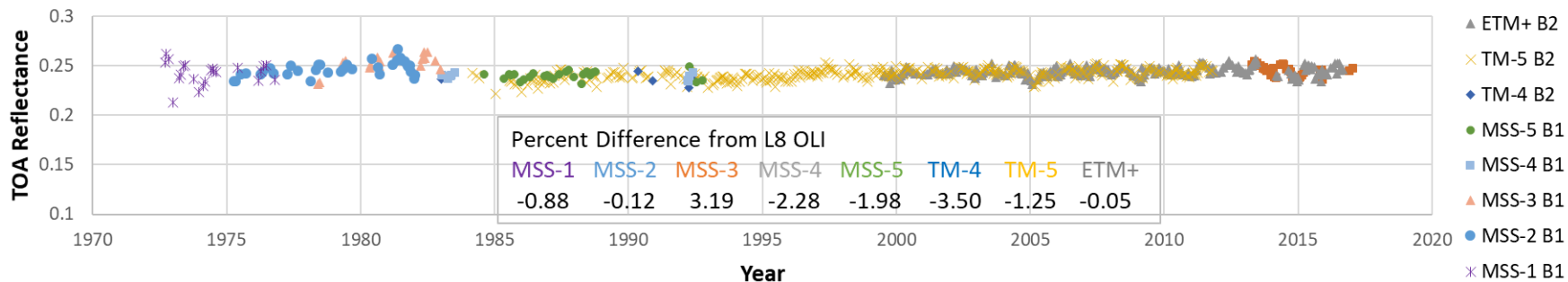
Radiometric Consistency – Before Collection 1 (2017)

Bright Target
Response –
Sonoran
Desert

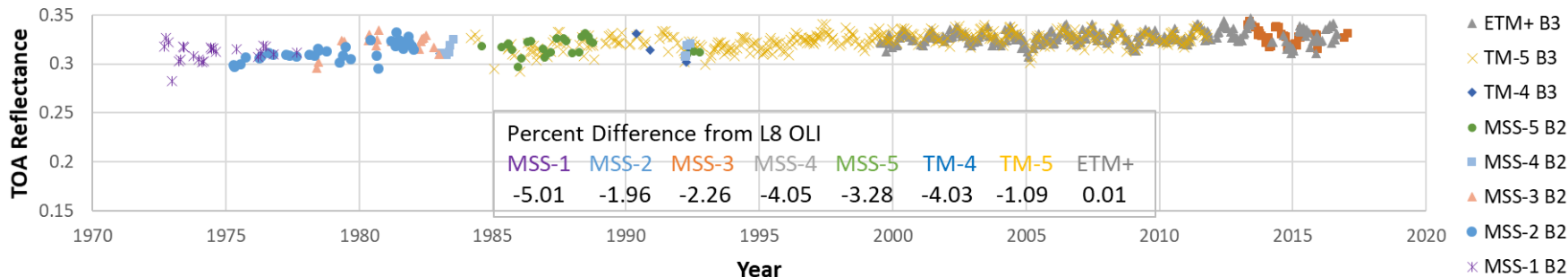


Collection 1 – Radiometric Consistency

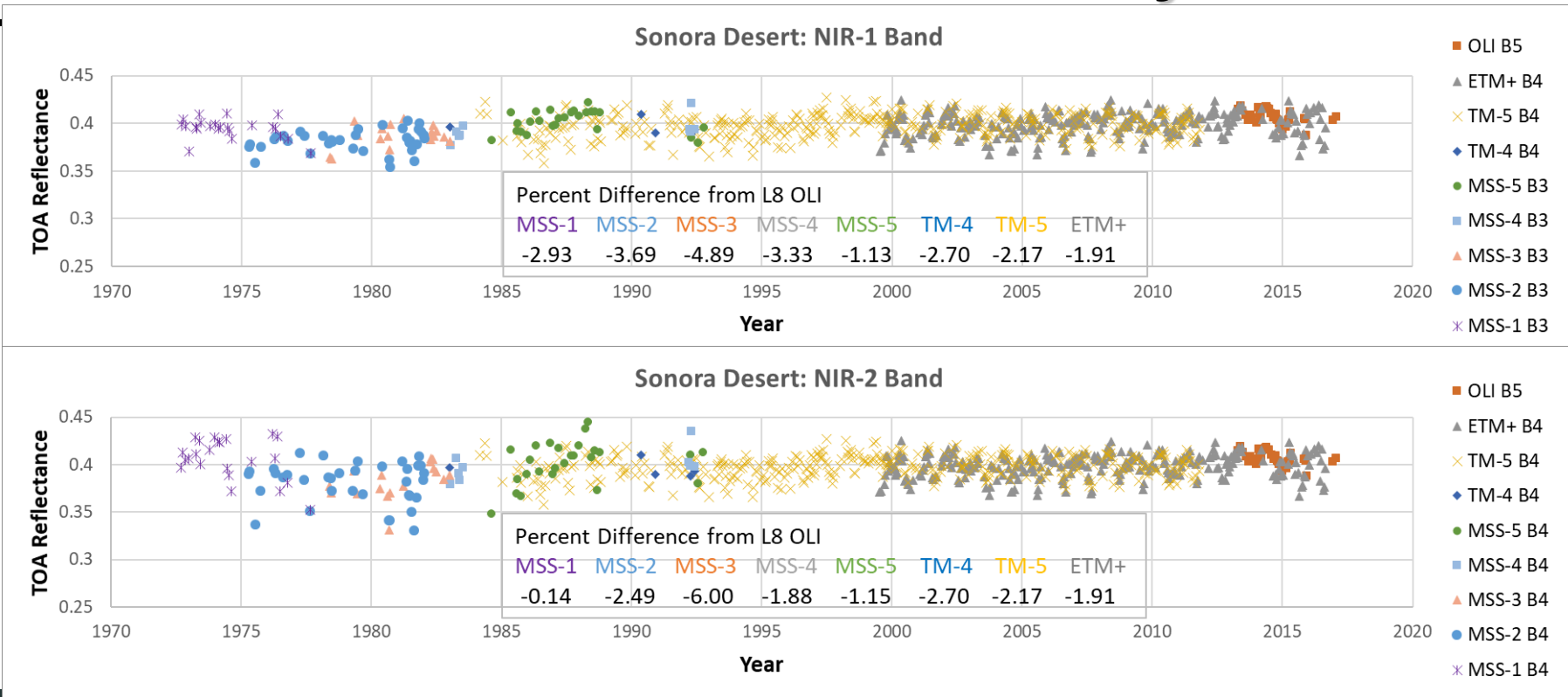
Sonora Desert: Green Band



Sonora Desert: Red Band

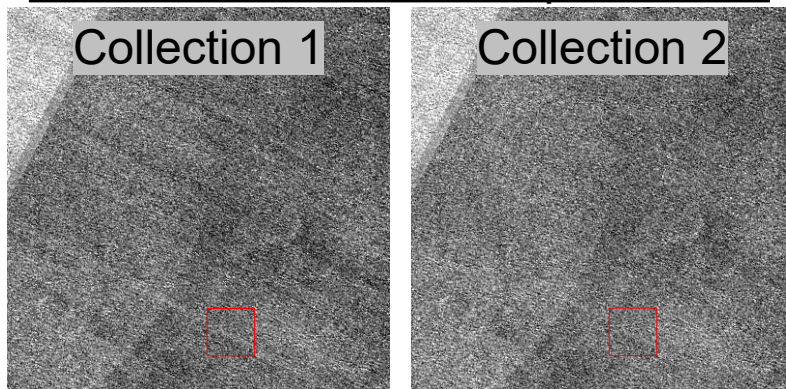


Collection 1 – Radiometric Consistency

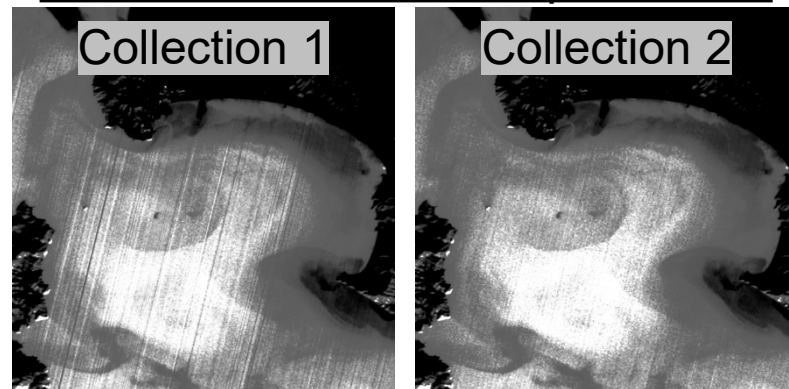


Radiometric Quality Improvements

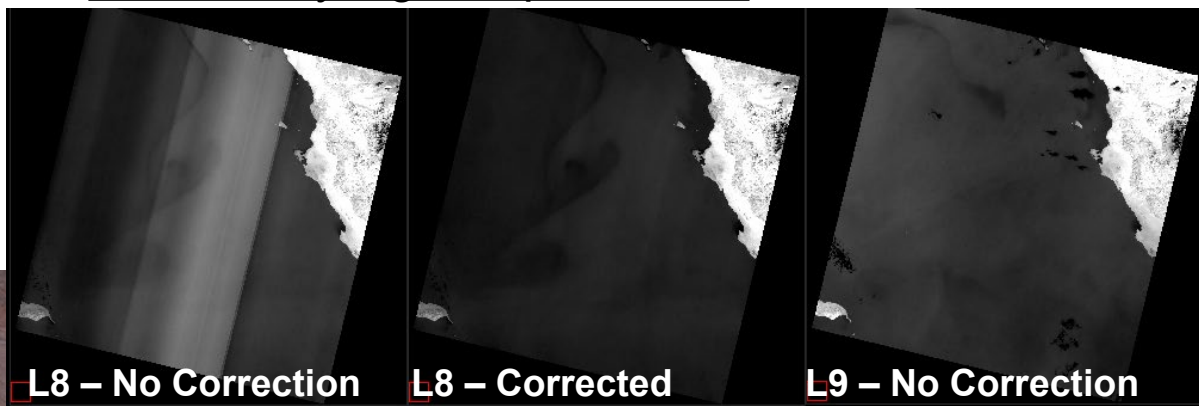
OLI - Bias Correction Improvement



TIRS - Relative Gain Improvement



TIRS- Stray Light Improvement

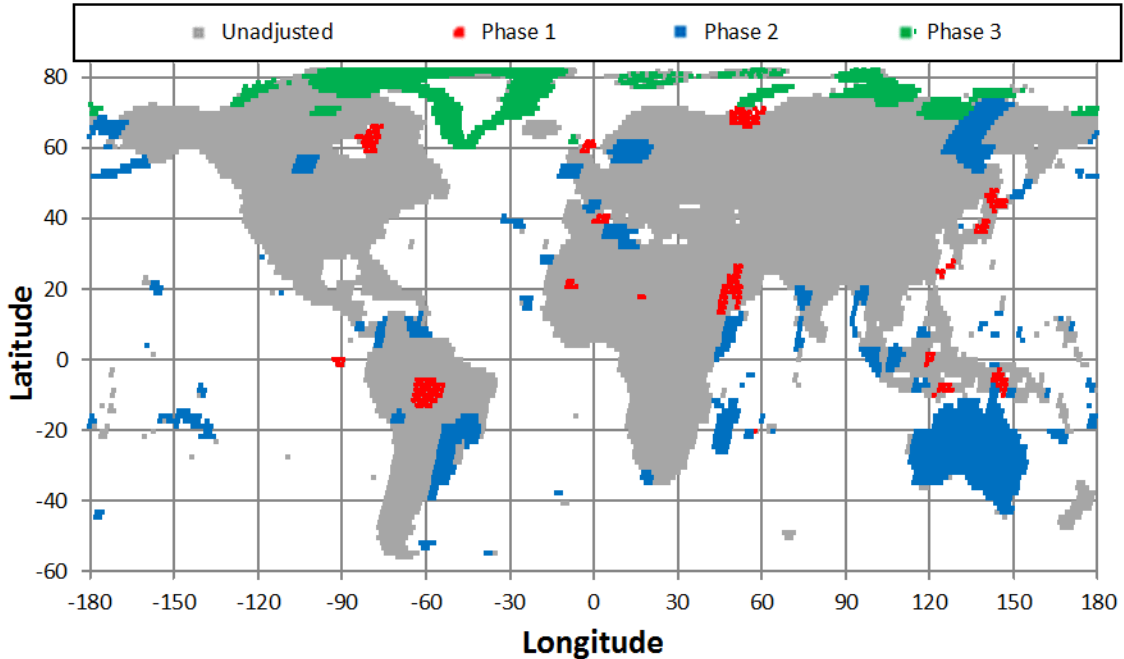


Continual Geometric Improvements

Geometric Consistency – Pre-Collection to Collection 2

Phased Ground control Improvement included in Collection 1

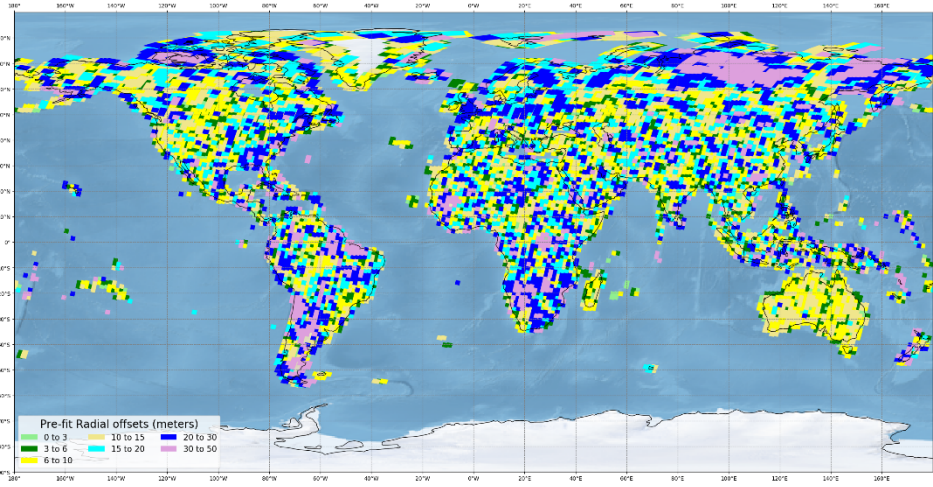
Phases improved known problematic areas due to clouds, islands, snow cover



Geometric Consistency – Pre-Collection to Collection 2

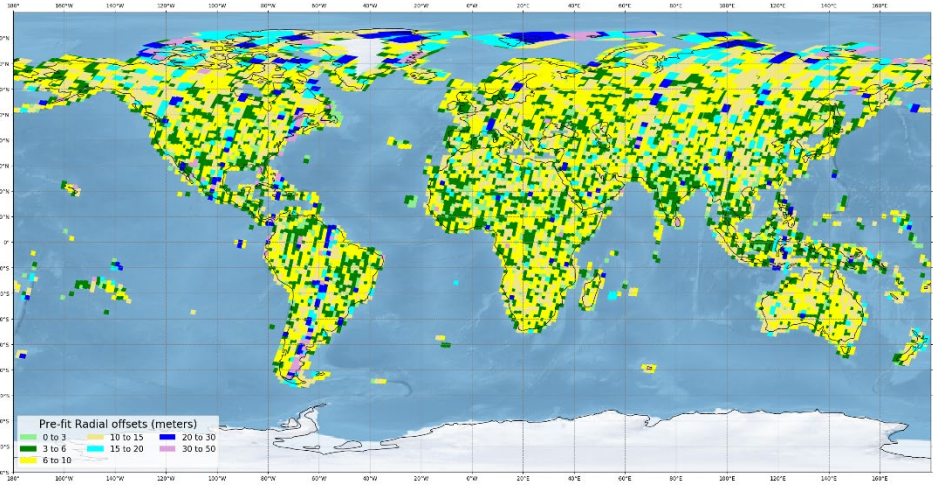
For Collection 2, the entire Landsat 1-9 ground control archive was improved and triangulated to the Sentinel 2 Global Reference Image (GRI)

Radial Mean for Collection - 1 results



Collection 1 Geodetic RMSE per path/row

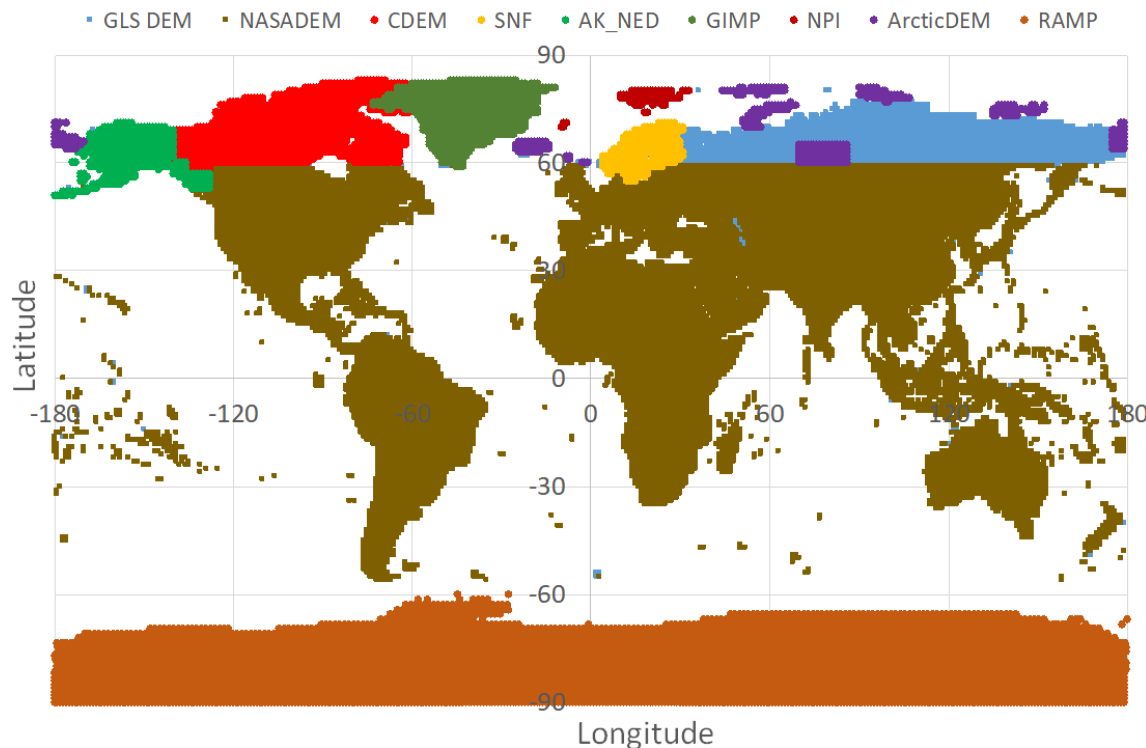
Radial Mean for Collection - 2 results



Collection 2 Geodetic RMSE per path/row

Improved Digital Elevation Model

- ◆ **Updated DEM was created using new sources**
 - ◆ New reprocessed SRTM (NASADEM)
 - ◆ National datasets in Scandinavia (SNF : Sweden, Norway, Finland)
 - ◆ Newer data in Canada (CDEM), and Alaska (AK_NED)
 - ◆ WorldView-derived ArcticDEM for high latitude regions
 - ◆ Norwegian Polar Institute (NPI) data for high latitude regions
- ◆ **Parts of Russia (GLS DEM), Greenland (GIMP), and Antarctic (RAMP) DEMs were not updated**



Product Improvements

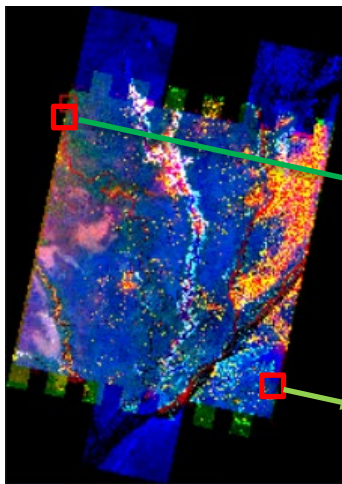
Landsat Product Improvements

- ◆ **Pre-Collection to Collection 1**
 - ◆ Consistent Calibration
 - ◆ Quality Assessment (QA) bands
 - ◆ Solar Illumination and Sensor Viewing Angle Coefficient Files
 - ◆ Improved Cloud Cover Algorithm
 - ◆ L8 Thermal Infrared Sensor (TIRS) Stray Light Correction
 - ◆ Added L4–5 TM No-Payload Correction Data (PCD) scenes
- ◆ **Collection 1 to Collection 2**
 - ◆ Surface Reflectance and Surface Temperature Products
 - ◆ Improved Georeferencing and aligned to the Sentinel 2 GRI
 - ◆ Cloud Optimized File Format

Landsat 9

Alignment

- ◆ L9 TIRS is within the OLI Field of View



RGB Image – Blue,
SWIR2, TIRS-2 10.8
Bands.

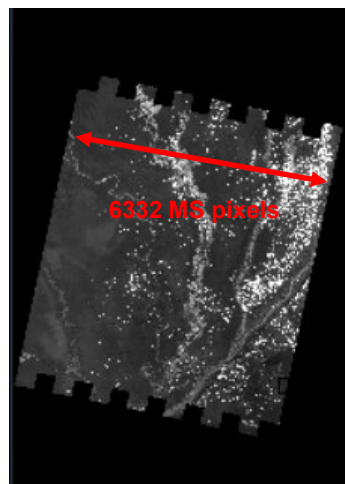
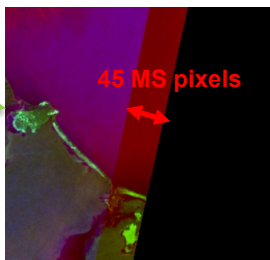
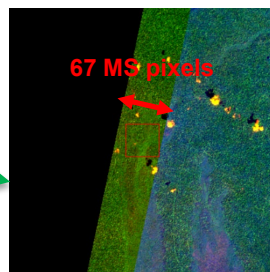


Image Blue Band.

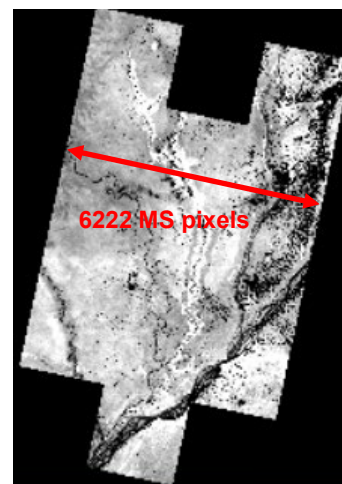


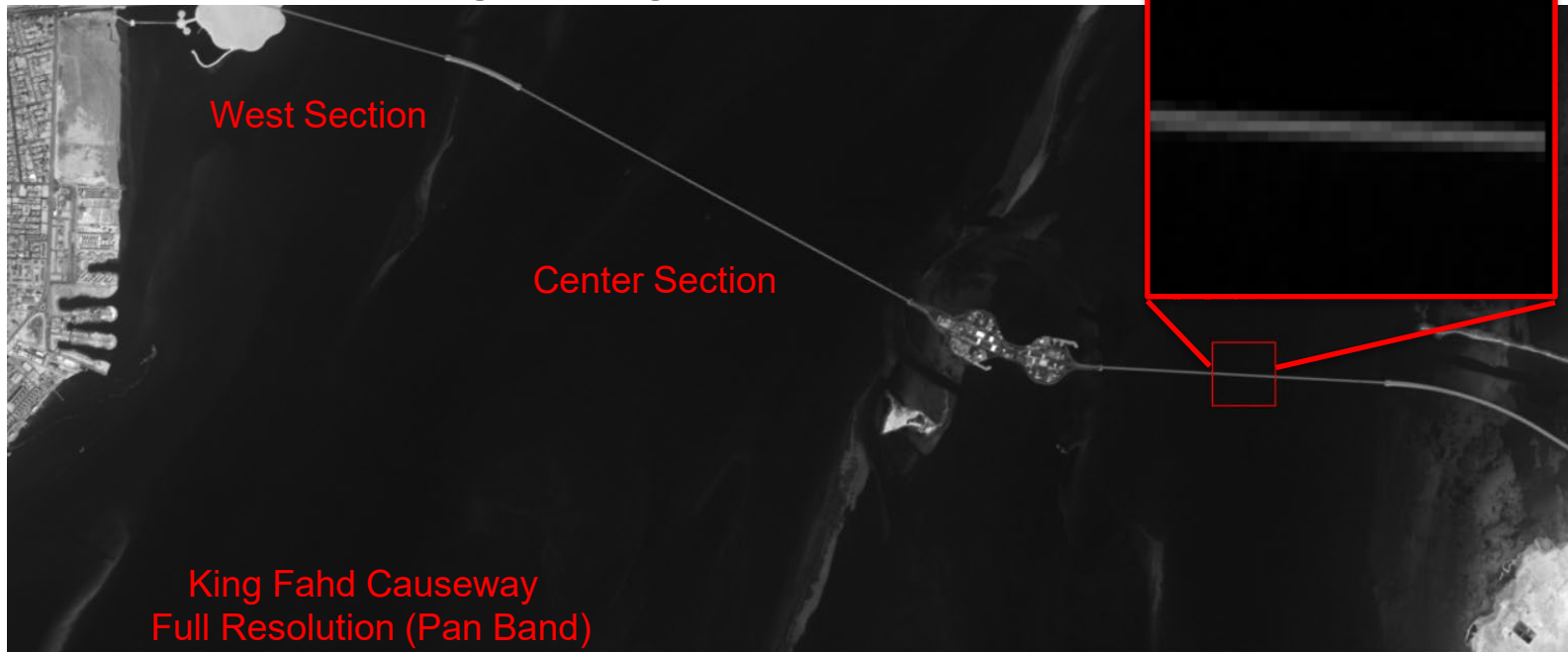
Image TIRS-2 10.8
Band.

Overlap and image extents as measured manually.

Path 181 row 060 acquired 12-10-2021

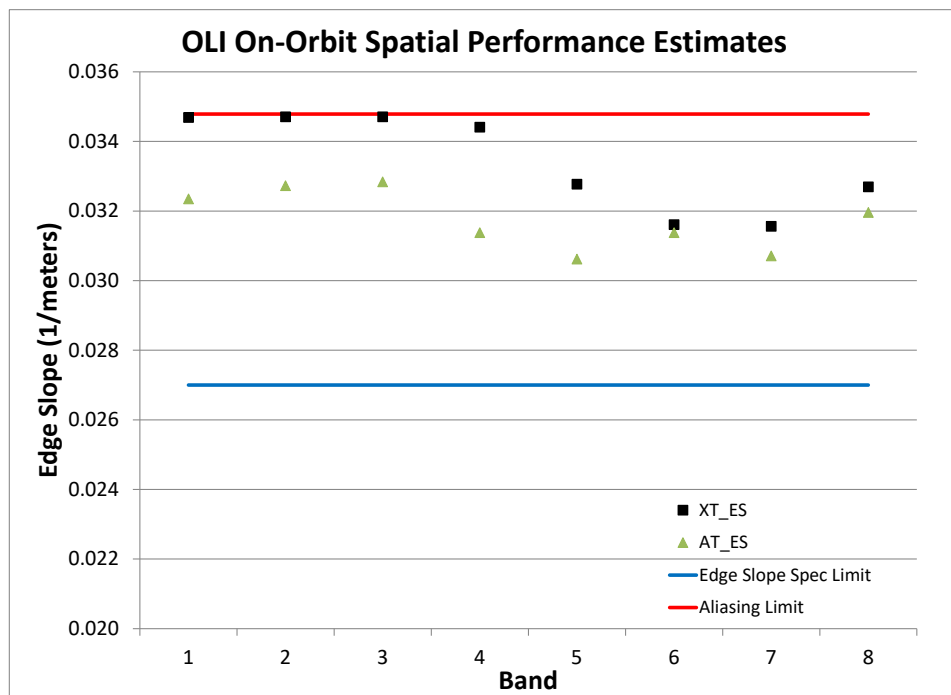
Spatial Performance

Bridge Target 163/042

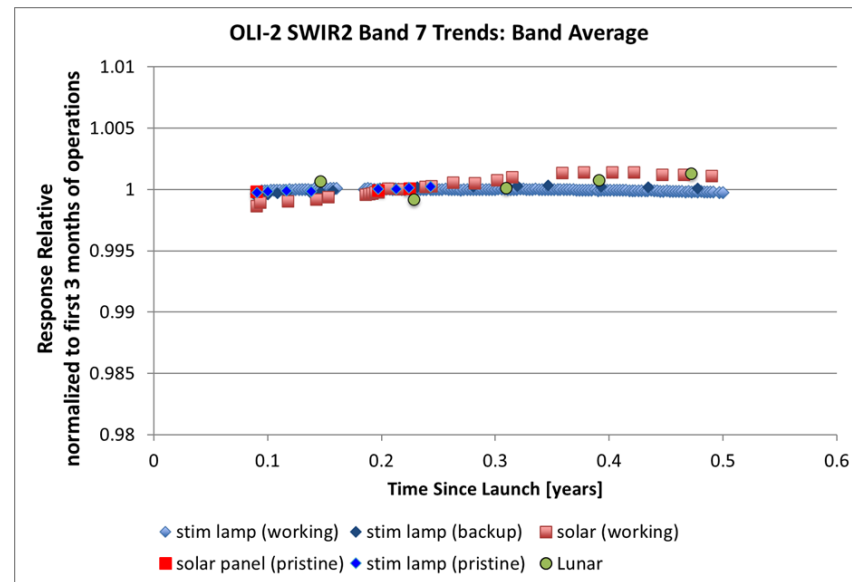
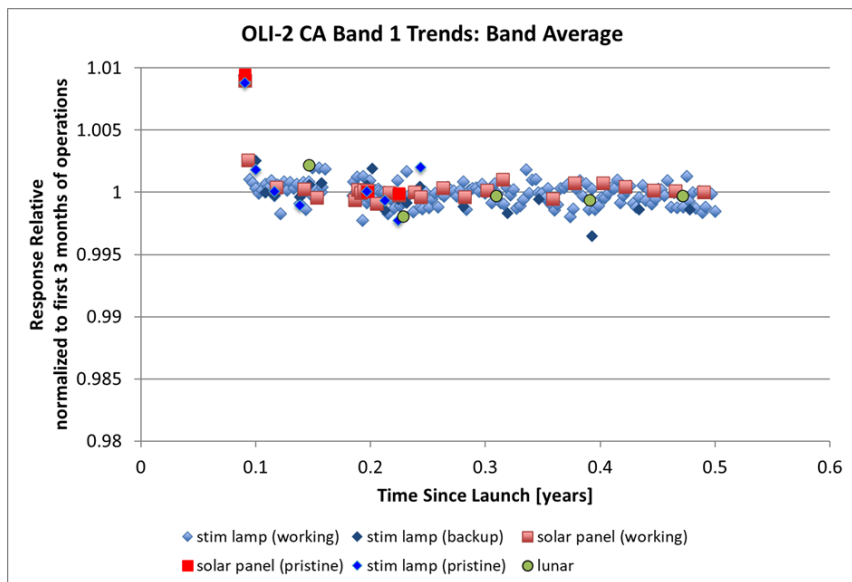


Spatial Performance

- ◆ **L9 OLI is meeting spatial edge slope and half edge extent requirements**
 - ◆ All bands well above minimum edge slope requirement
 - ◆ Some bands are close to the upper limit set by the aliasing requirement
 - ◆ Analysis based on 7 bridge target scenes

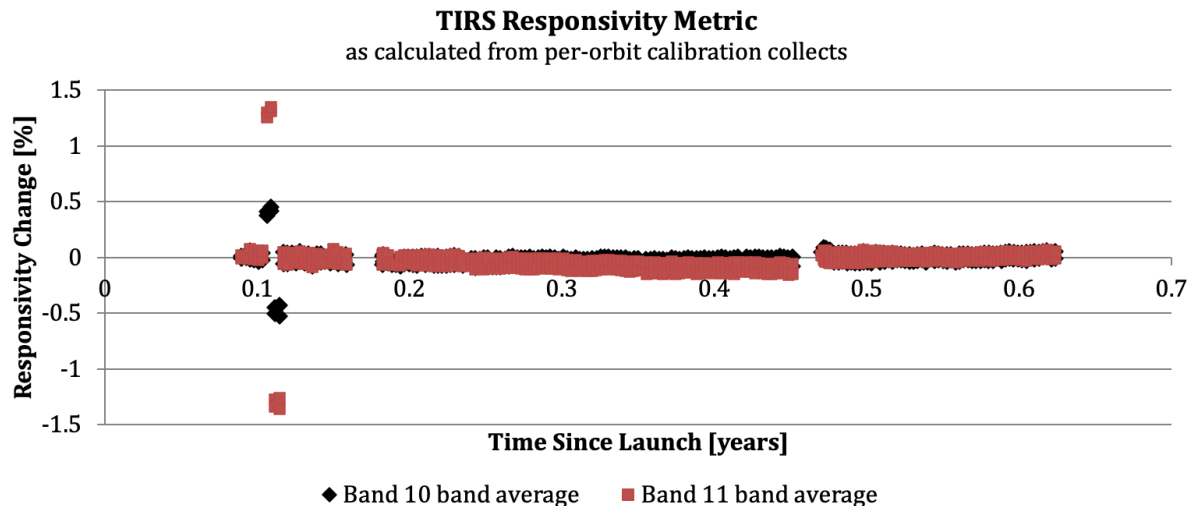


L9 OLI On-board Calibration



- ◆ All on-board calibrators are in agreement and behaving similarly to Landsat 8
- ◆ All calibration sources are currently stable
- ◆ All spectral bands are stable – no signs of degradation so far

L9 TIRS On-board Calibrator



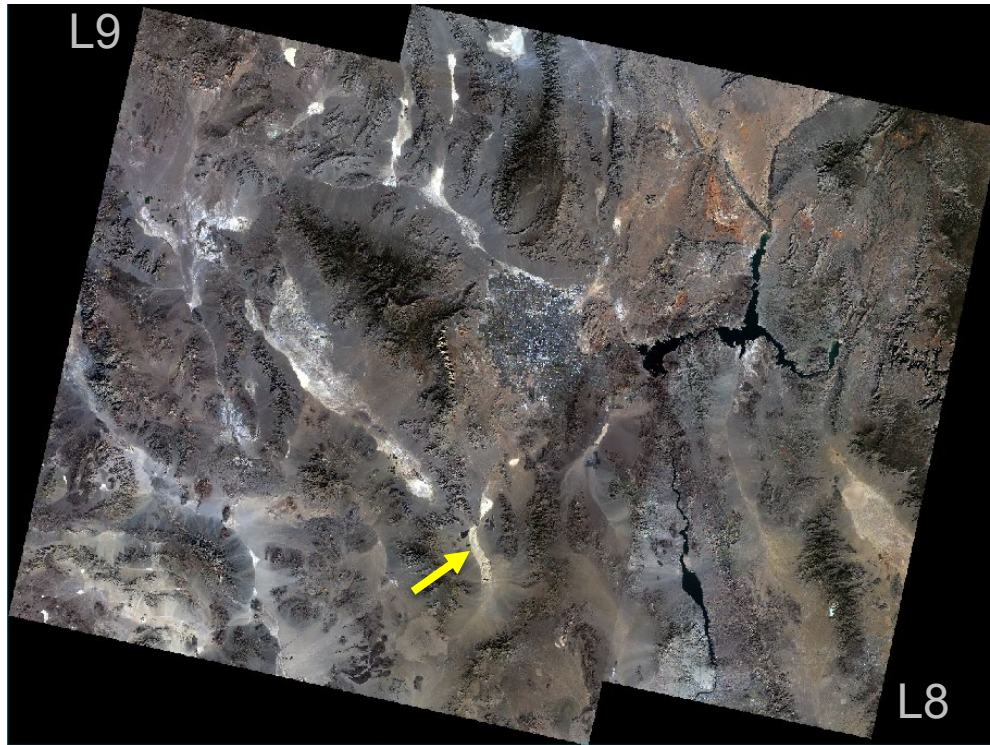
- ◆ On-board black-body responses are stable
- ◆ L9 TIRS calibration collects are performed every orbit consistent with the original L8 Ops Con

Vicarious Calibration (Underfly)



UArizona: Ivanpah Playa, CA, USA (2021/11/13)

(35.557928, -115.400128)



LC80390352021317LGN00

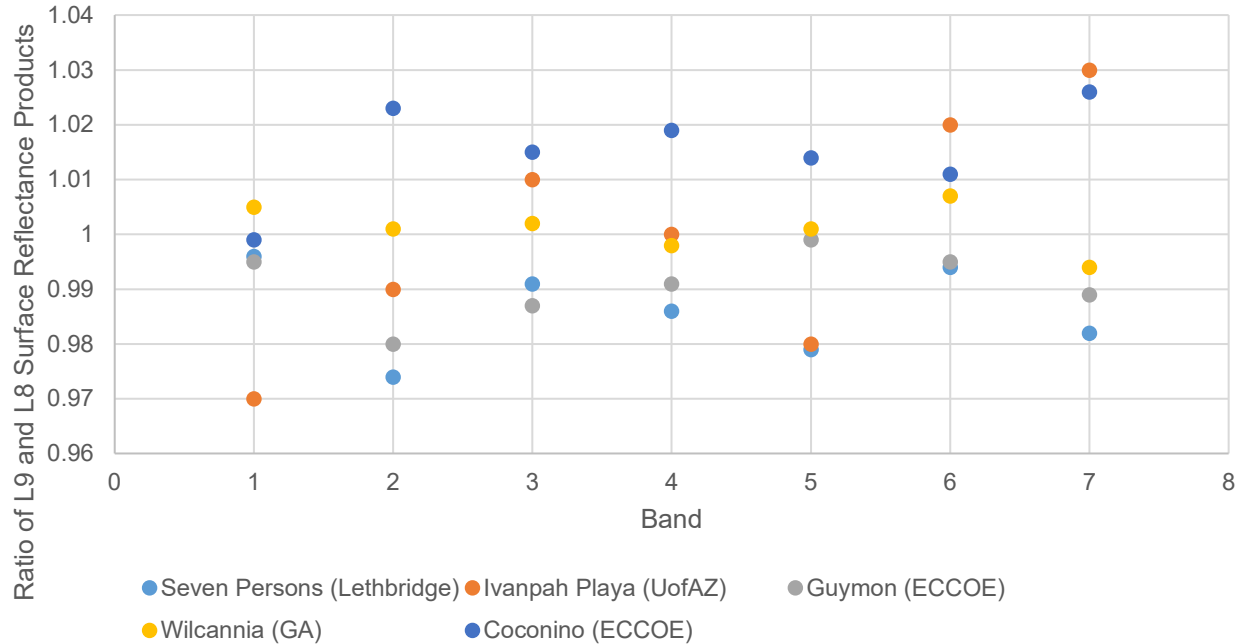
SCENE CENTER TIME: 18:15:56 UTC

LC90400352021317LGN01

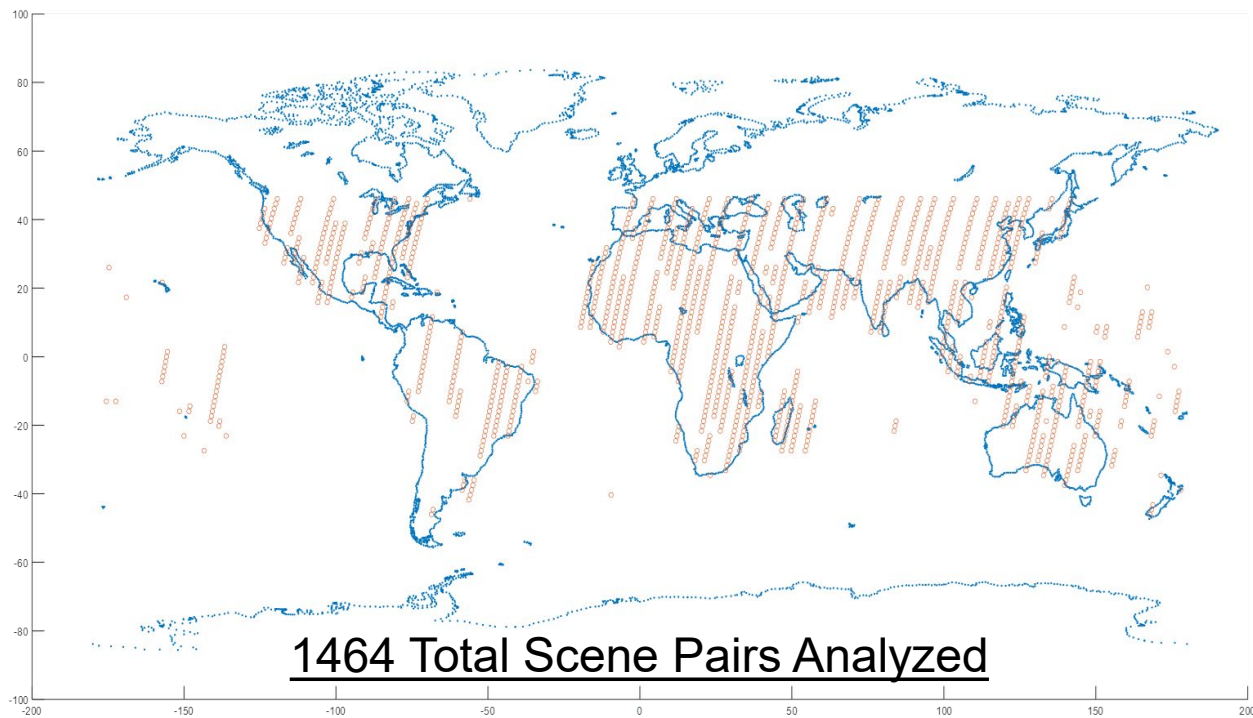
SCENE CENTER TIME: 18:19:18 UTC

L9 and L8 Product Comparison Summary Chart - OLI

Ratio of L9 and L8 Surface Reflectance Products



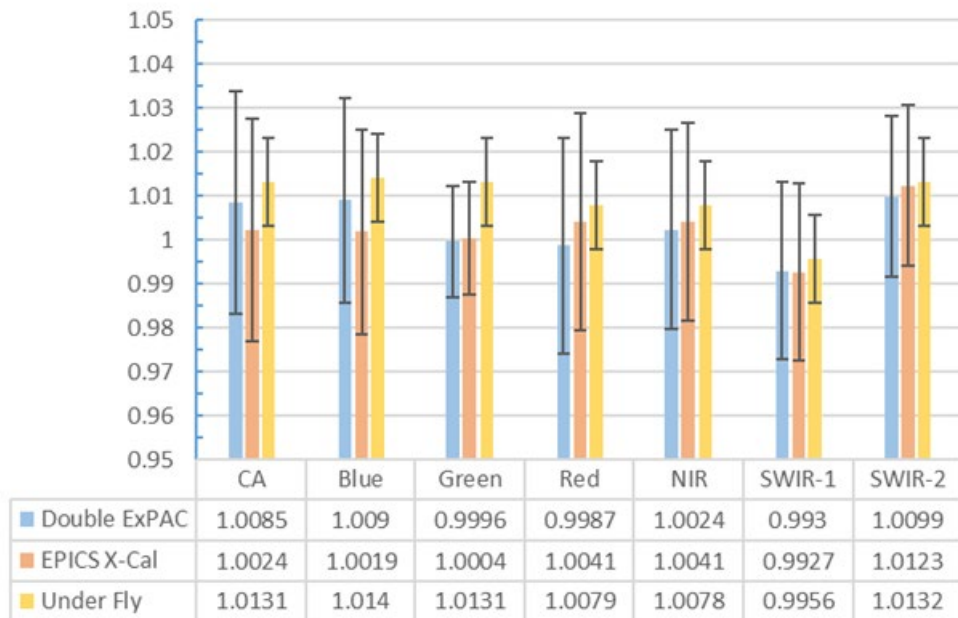
Landsat 9 vs Landsat 8 (Global Underfly)



- ◆ **Data limits and prioritization were set on Sun Elevation, Sensor View Angle Difference, and Signal Level**
- ◆ **Homogeneous ROIs in scene pairs were used**

Landsat 9 vs Landsat 8 (Global Underfly)

Relative Cross-Calibration Comparison (L8/L9)



Conclusion

- ◆ **Landsat 9 was added seamlessly to the Landsat archive**
- ◆ **Landsat data quality is continually monitored and improved by the combined Landsat Cal/Val team including the USGS, NASA Goddard, NASA JPL, Rochester Institute of Technology, South Dakota State University, and the University of Arizona**
- ◆ **The USGS continues to expand the utility and coverage of Landsat products**