

Radiometric Calibration and Surface Reflectance Validation of MODIS and VIIRS

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THE UNIVERSITY OF ARIZONA
Wyant College
of Optical Sciences



Topics

- Radiometric Calibration Test Site (RadCaTS)
- Current status of RadCaTS
- Radiometric calibration and surface reflectance validation results
- Summary and future work

Introduction to RadCaTS

- Developed as an automated ground-based vicarious calibration system
- Originally designed to supplement reflectance-based approach
 - Portable spectroradiometers, reference panels (surface reflectance)
 - Solar radiometers, ancillary weather equipment (atmospheric measurements)
 - Requirement: we have to be on site to deploy instruments
- RadCaTS uses a combination of custom and commercially-available instruments
 - GVR: ground-viewing radiometer (designed and built at U of Arizona)
 - Cimel CE318-T solar lunar photometer (AERONET)
 - Weather station
 - Wireless base station, connected to U of Arizona via satellite uplink

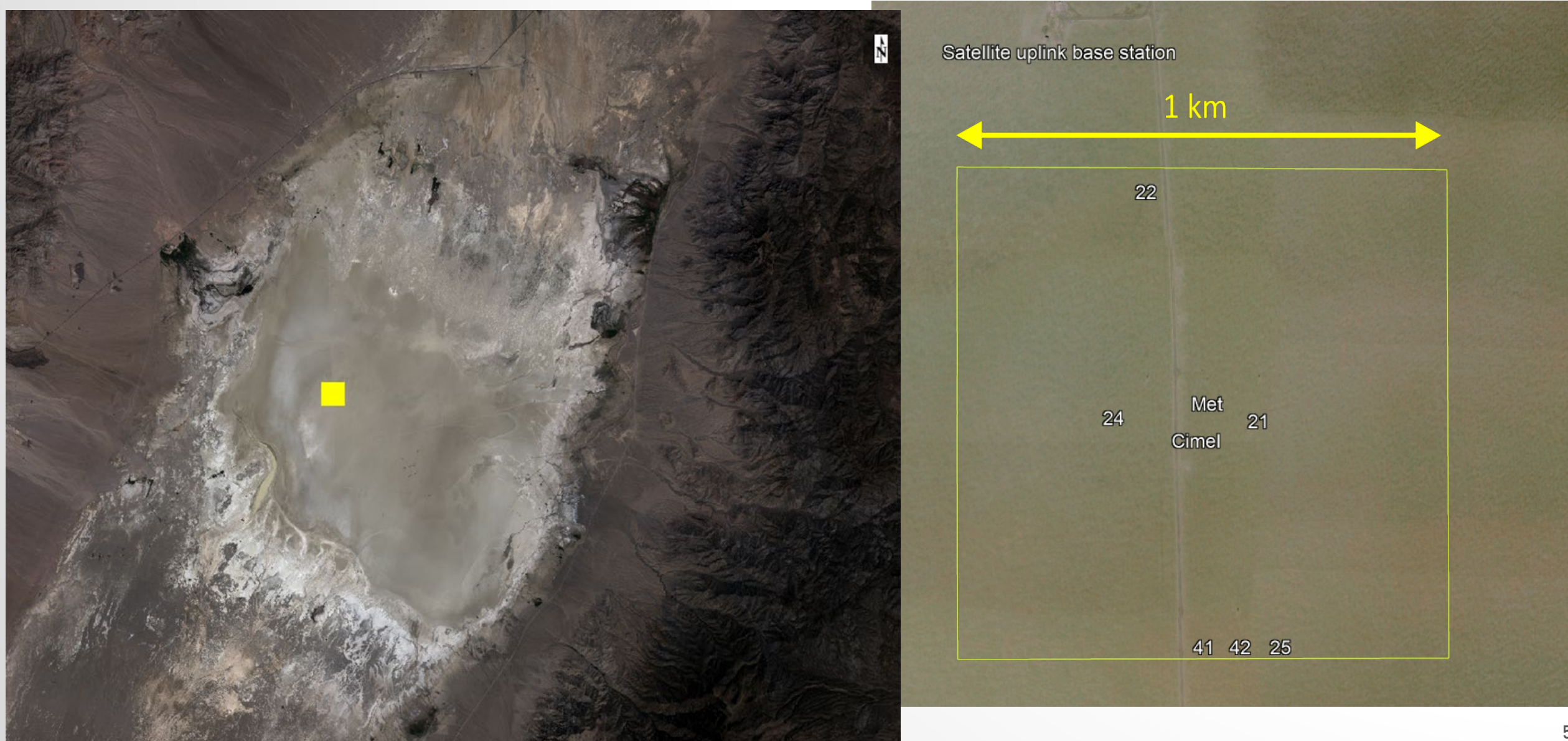


Current Status of RadCaTS

- Primary method for U of Arizona in situ data collection
- Instruments are combination of custom and commercially-available
 - GVR: ground-viewing radiometer (designed and built at U of Arizona)
 - Cimel CE318-T solar lunar photometer (AERONET)
 - Weather station
 - Wireless base station, connected to U of Arizona via satellite uplink

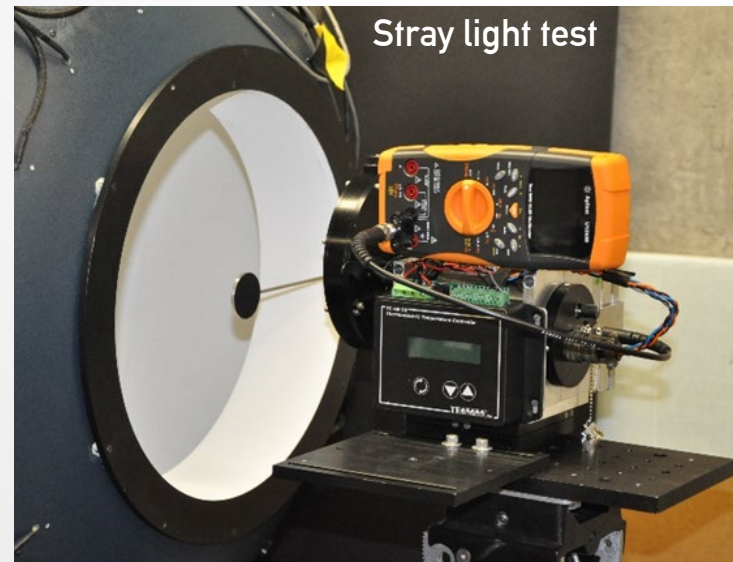
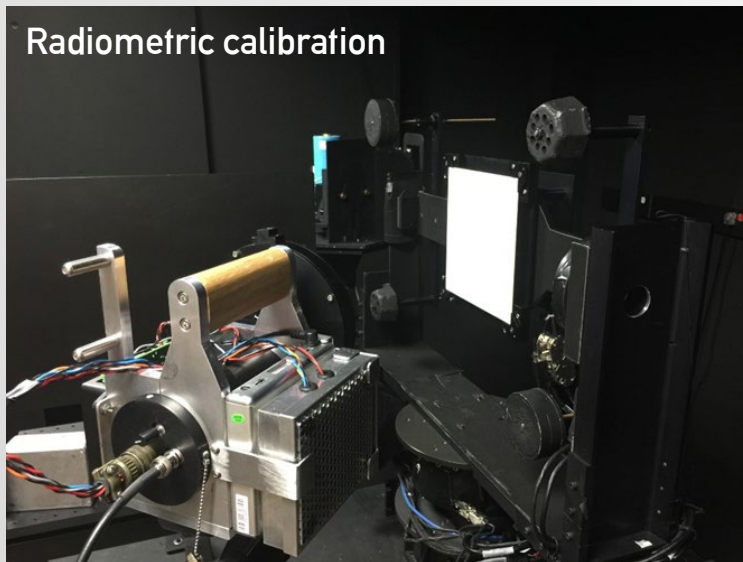


RadCaTS Instrument Locations



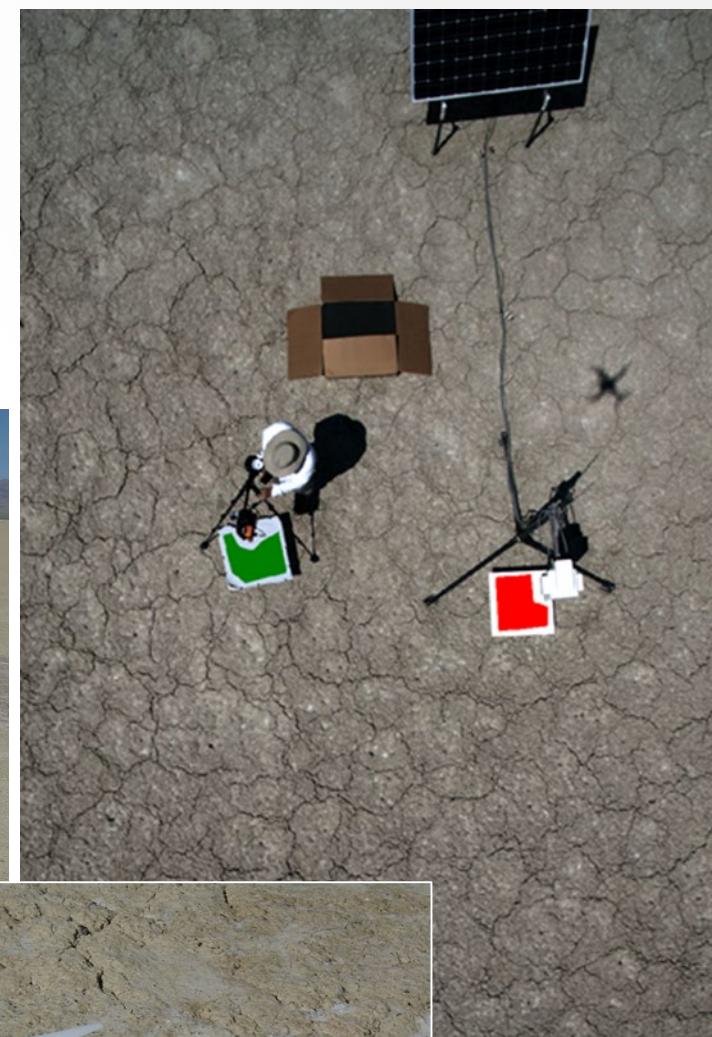
Field Radiometer for On-Site Calibration

- Calibration Test Site SI-Traceable Transfer Radiometer (CaTSSITTR)
- Same seven VNIR bands as RadCaTS ground-viewing radiometer
 - 400, 450, 500, 550, 650, 850, 1000 nm
- One-person operation, wireless data logging
- Temperature-controlled focal plane (35 °C)
- Travelling transfer radiometer for test site intercomparison and uncertainty analysis (e.g. [RadCalNet](#))



Support Instrumentation

- Commercial UAS for spatial uniformity analysis (SPIE 2017)



Other Instrumentation

- Web camera (Campbell Scientific CCFC)
 - Installed in May 2018, views south
 - Images collected at 09:00–15:00 local standard time (17:00–23:00 UTC)
 - Every 30 minutes
 - [Images are now available on RadCalNet data portal](#)
- Images currently stored on site with option to download to U of Arizona



Dust storm (29 Jul 2018)



Clear (11 Jun 2019)



Snow (17 Feb 2019)





Rain (22 May 2019)



CEOS WGCV Radiometric Calibration Network (RadCalNet)

- Online data portal went live in Jul 2018: www.radcalnet.org
 - TOA reflectance from 09:00–15:00 local standard time
 - 400 nm to 2500 nm, $\Delta\lambda = 10$ nm
 - Surface reflectance and atmospheric data are also available
- RadCalNet forum: forum.radcalnet.org (announcements, FAQs, documentation, etc.)

 Committee on Earth Observation Satellites
Jeff Czaplá-Myers

Welcome to the Radiometric Calibration Network portal

The portal provides access to all RadCalNet datasets, allowing users to visualize and download data acquired by the four instrumented reference test sites.

- University of Arizona's site at Railroad Playa, Nevada, USA,
- AoE's site at Baotou, China,
- the CNES site at La Crau, France,
- the new ESA/CNES site in Gobabeb, Namibia.

These test sites provide nadir-view top-of-atmosphere reflectance at 30 minute intervals from 9am to 3pm local standard time at 10 nm intervals from 400 nm to 2500 nm. This is calculated from ground nadir-view reflectance measurements, and atmospheric measurements such as surface pressure, columnar water vapour, columnar ozone, aerosol optical depth and the Angstrom coefficient. Correction to top-of-atmosphere will be performed for all sites in the same way using Modtran.

The data are provided in a text format, defined in [R2-RadCalNetRequirements-DataFormatSpecification_V8.pdf](#).

To download data from a site, please select a site.

To download complete data sets, please press the hyperlink [download all data](#). Users are also asked to consider RadCalNet data policies especially providing appropriate citations when displaying data downloaded from this site.

A quickstart guide for new users and for becoming a new RadCalNet site is available here : [RadCalNetQuickstartGuide_20180702.pdf](#).

Please check the latest announcements, FAQ and discussions on the RadCalNet's [forum](#).


Please select a site :

Railroad Valley Playa



La Crau

Gobabeb

Baotou



RadCalNet Documents

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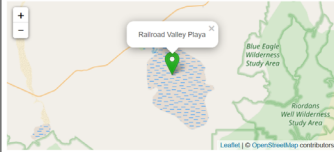
Railroad Valley Playa

[return to site list](#)

Access data

[Access data display and daily data download](#)

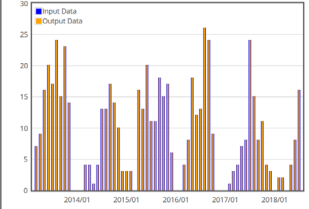
Geolocation



Site description

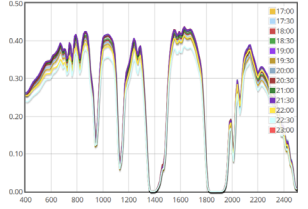
Railroad Valley Playa	Google earth site location : RVUS.kmz
Latitude	38.497
Longitude	-115.69
Altitude	1435m
Characteristics	The RadCalNet top-of-atmosphere reflectance spectra are representative of a square of 1km x 1km

Available data by month



Last output data

RVUS00_2018_206_v02.03.output



Data file version

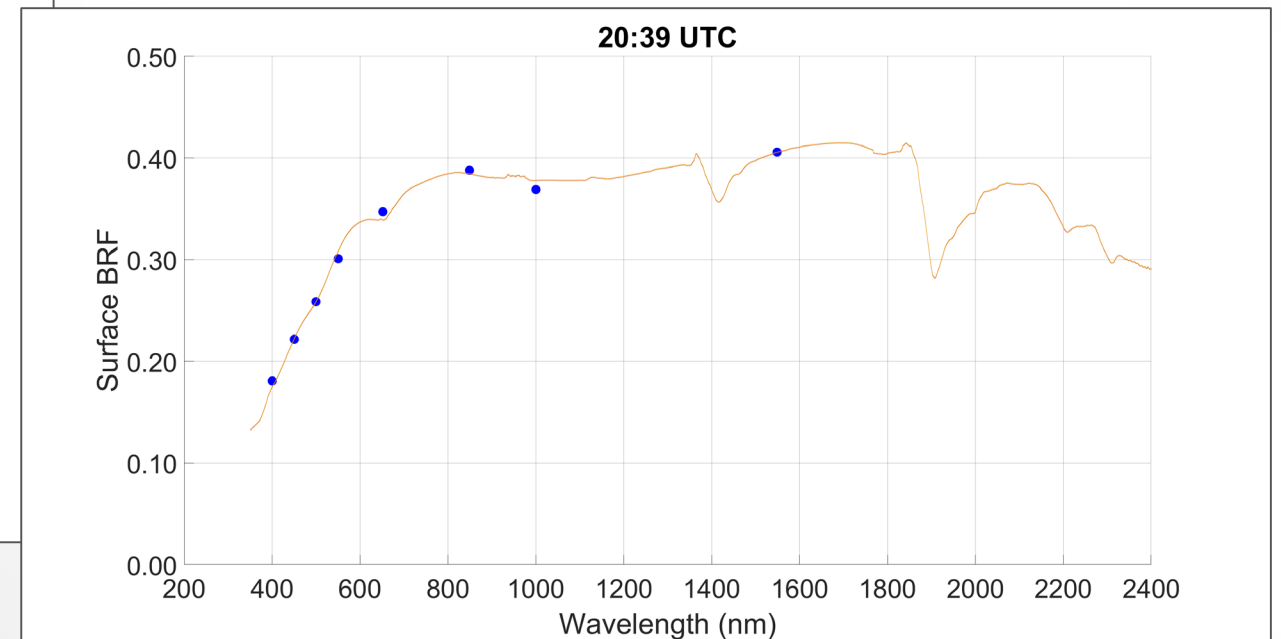
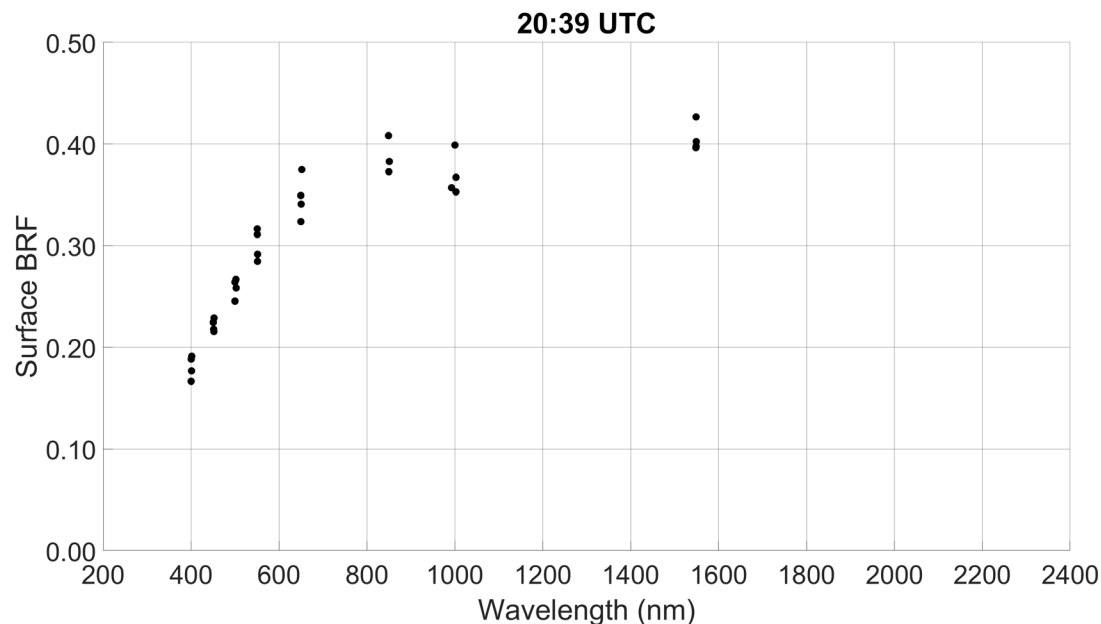
[Download version list](#)

Documentation

[Site Documentation](#)

Surface Reflectance Determination at RadCaTS

- For a given time of interest:
 - Determine surface reflectance in each of GVR's 8 spectral bands
 - Determine the average for each of the 8 bands
 - Convert the multispectral results to hyperspectral by fitting to library of data collected from ~2000–present using portable spectroradiometer (e.g. ASD)



RadCaTS Surface Reflectance QA

- 'Good-Bad Day' QA Criterion ([old method](#))

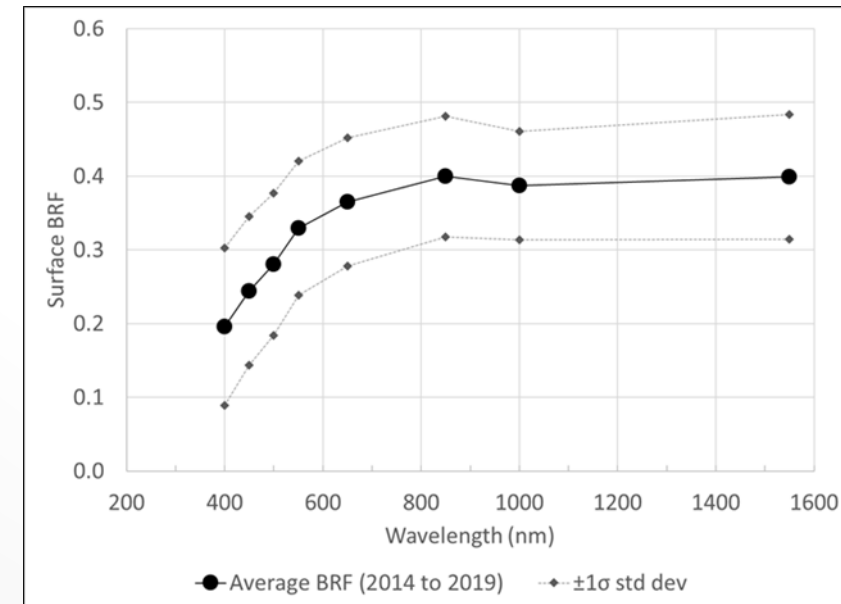
- If $0.9 < \text{Angstrom exponent} < 1.5$: **good day**
- Else: **bad day**
- **Problem**: too many good days were excluded

Site	2013	2014	2015	2016	2017	2018	2019	Total
RVUS	145	83	133	114	88	149	18	730

- New criteria ([current method](#))

- Developed for use with Railroad Valley results for RadCalNet
- If $\text{AOD}_{550 \text{ nm}} < 0.16$
and BRF_{GVRs} is within $\pm 1\sigma$ of the 2014–2019 average: **good day**
- Else: **bad day**

Site	2013	2014	2015	2016	2017	2018	2019	Total
RVUS	193	234	222	221	262	230	65	1427



MODIS and VIIRS Cal/Val Imagery

Source

- [LAADS DAAC](#)

Radiometric Calibration

- Terra & Aqua MODIS: Collection 6.1 (2013–2019)
- SNPP VIIRS: Collection 1 (Archive 5110) (2013–2019)
- NOAA-20 VIIRS: Collection 2 (Archive 5200) (2018–2019)

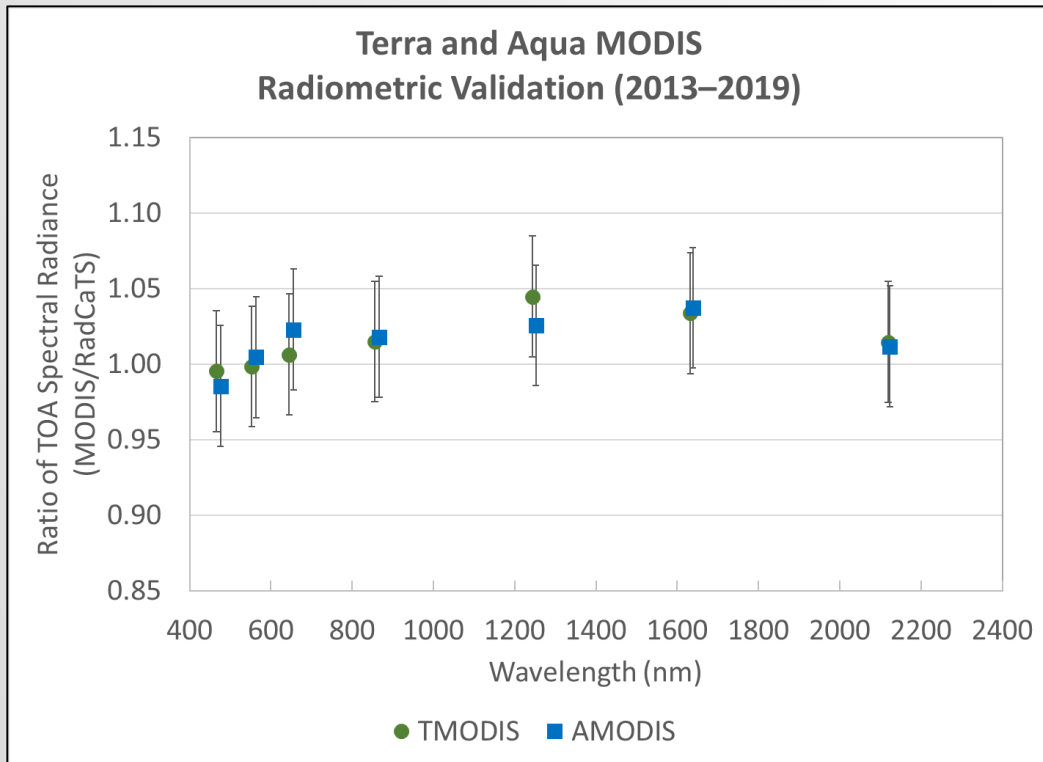
Surface Reflectance Validation

- Terra & Aqua MODIS: Collection 6 (2013–2019)
- SNPP VIIRS: Collection 1 (Archive 5000) (2013–2019)
- NOAA-20 VIIRS: no imagery

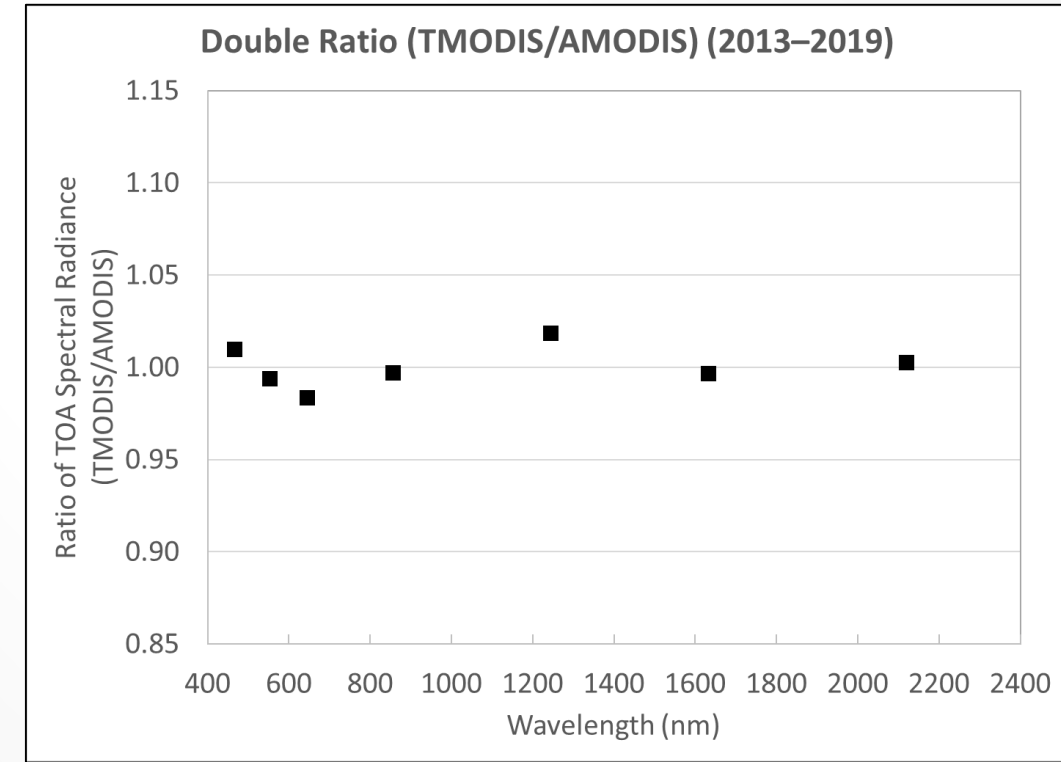
MODIS Results

Current MODIS Radiometric Calibration Results

- 2013–2019
- TMODIS: N=118, AMODIS: N=84



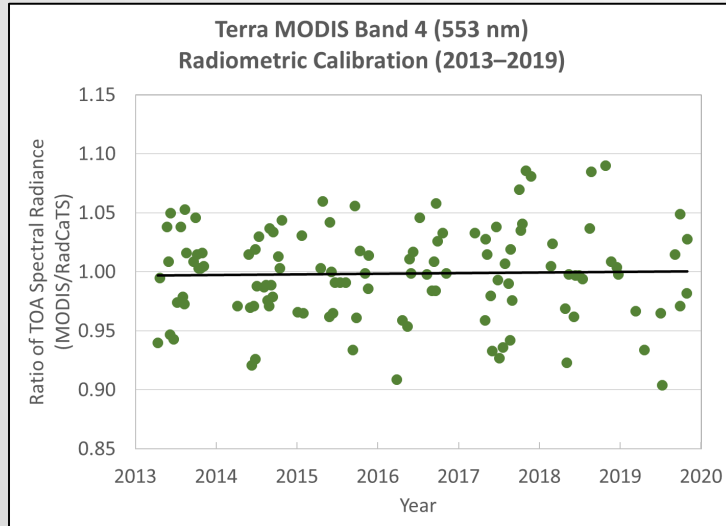
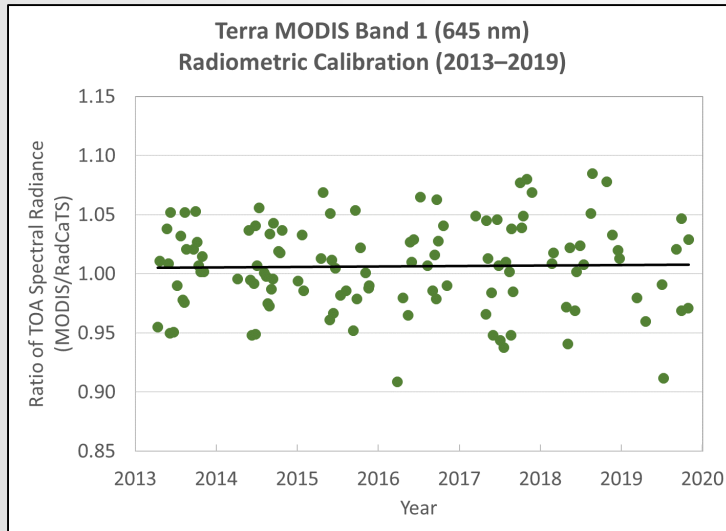
Double ratio to remove RadCaTS



- MODIS Bands 1–7
- Double ratio: $(\text{TMODIS}/\text{RadCaTS})/(\text{AMODIS}/\text{RadCaTS}) = \text{TMODIS}/\text{AMODIS}$

Radiometric Calibration Results (Temporal Example)

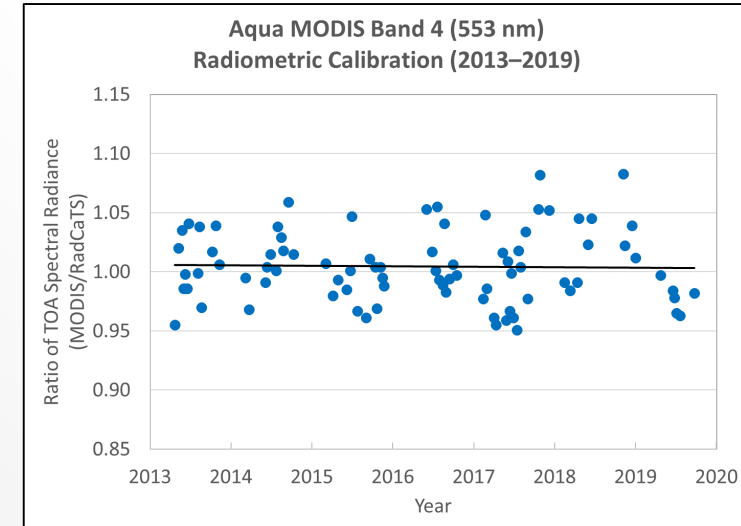
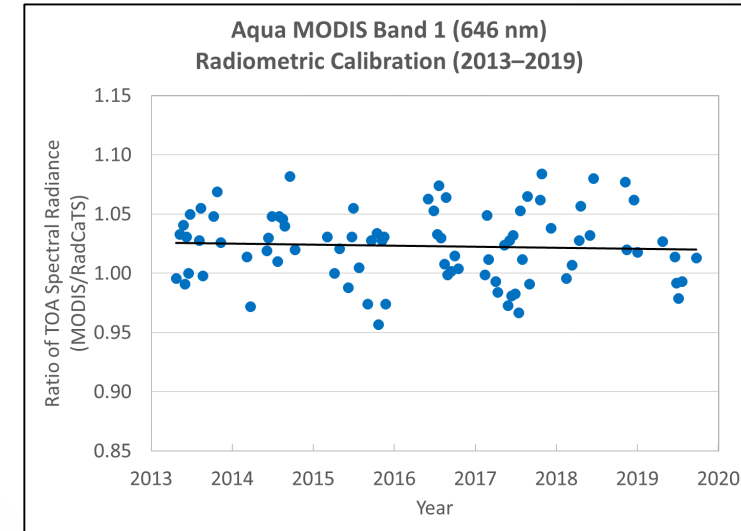
Terra MODIS



Band 1 (645 nm)

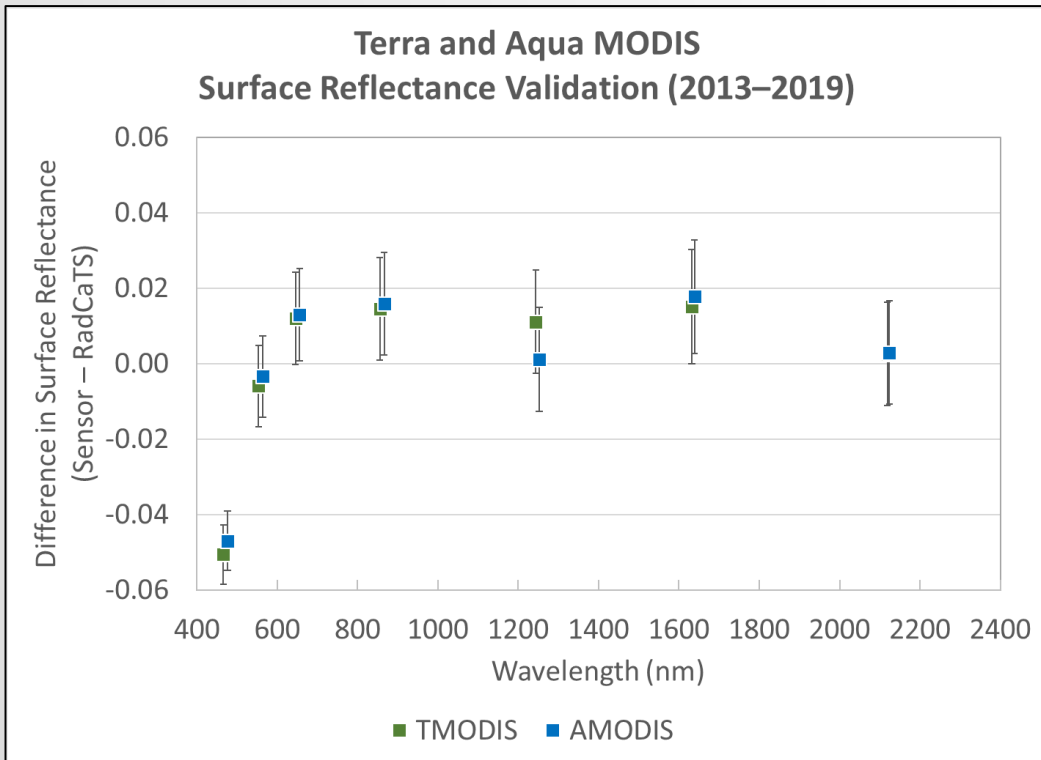
Band 4 (553 nm)

Aqua MODIS

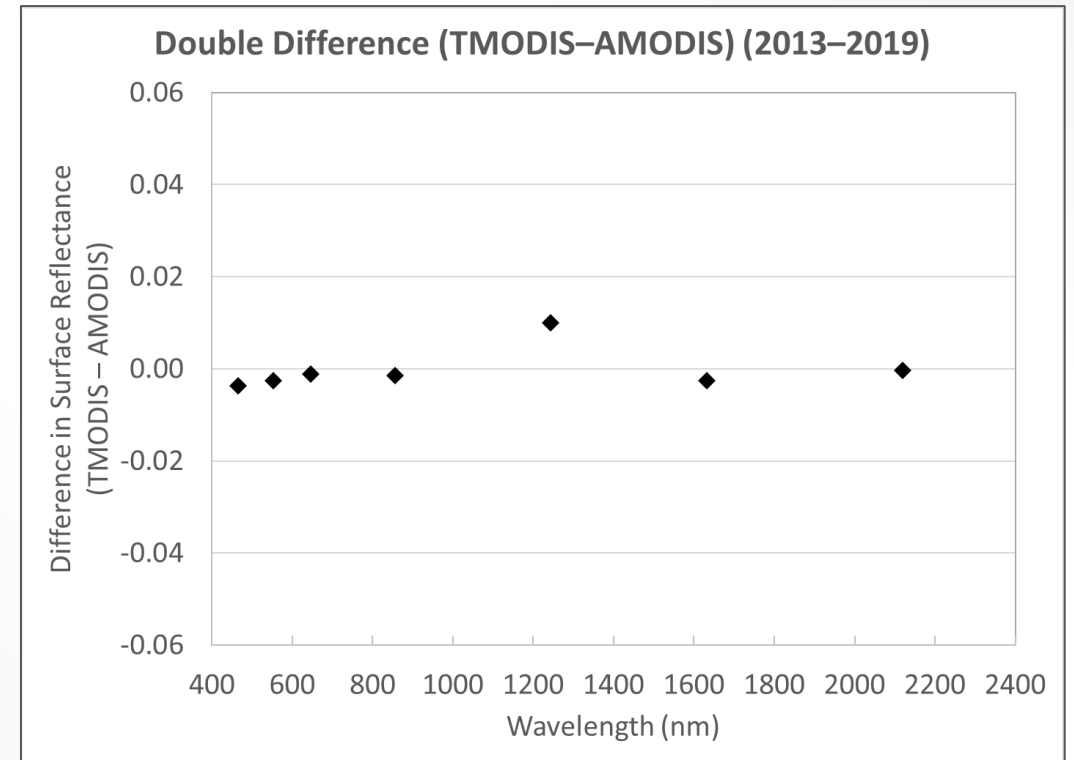


Current MODIS Surface Reflectance Validation Results

- 2013–2019
- TMODIS: N=118, AMODIS: N=84



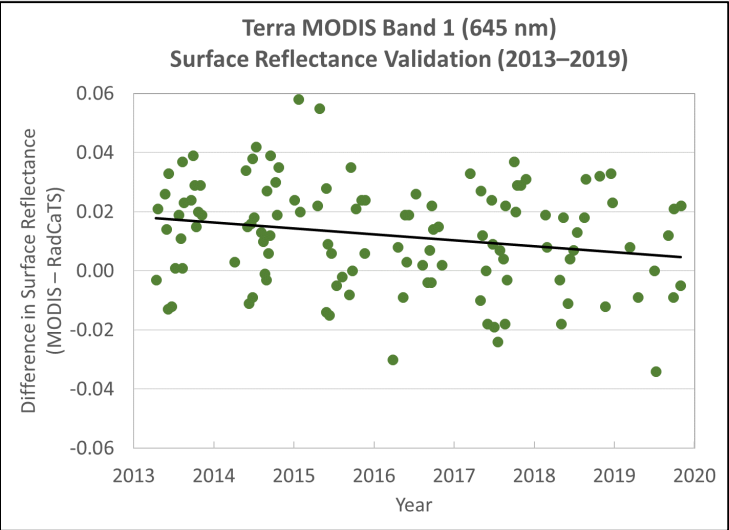
Double difference to remove RadCaTS



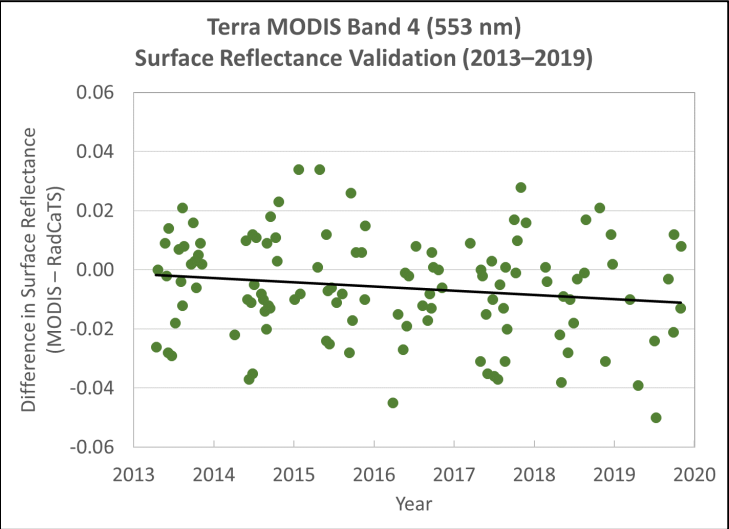
- MODIS Bands 1–7
- Double difference: $(\text{TMODIS} - \text{RadCaTS}) - (\text{AMODIS} - \text{RadCaTS}) = \text{TMODIS} - \text{AMODIS}$

Surface Reflectance Validation Results (Temporal Example)

Terra MODIS

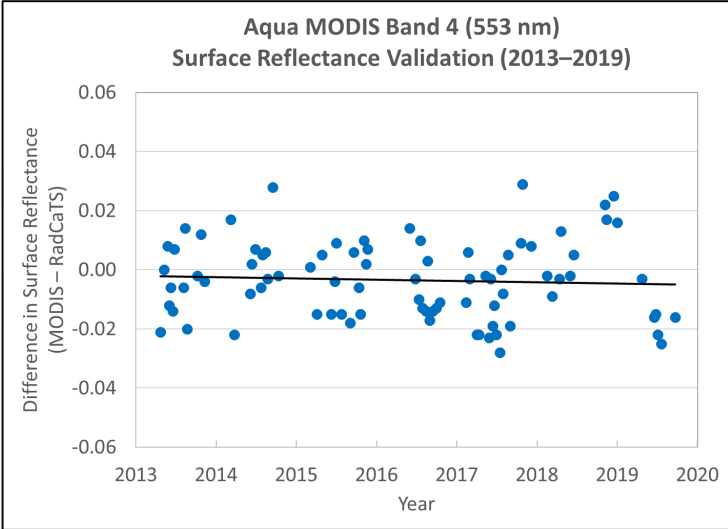
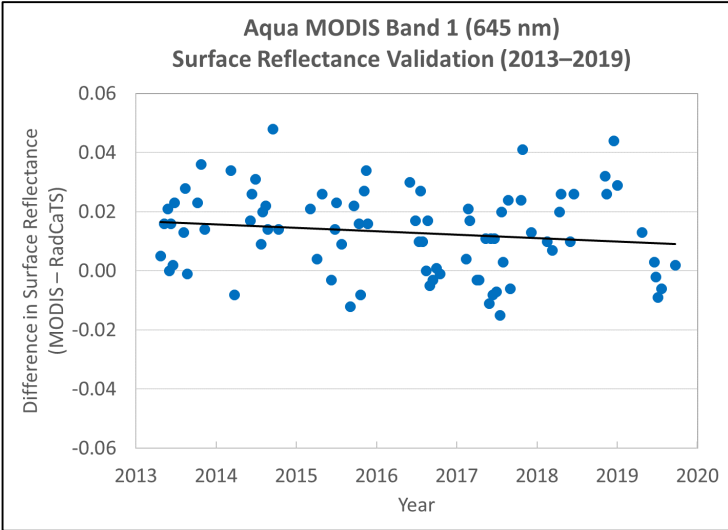


Band 1 (645 nm)



Band 4 (553 nm)

Aqua MODIS

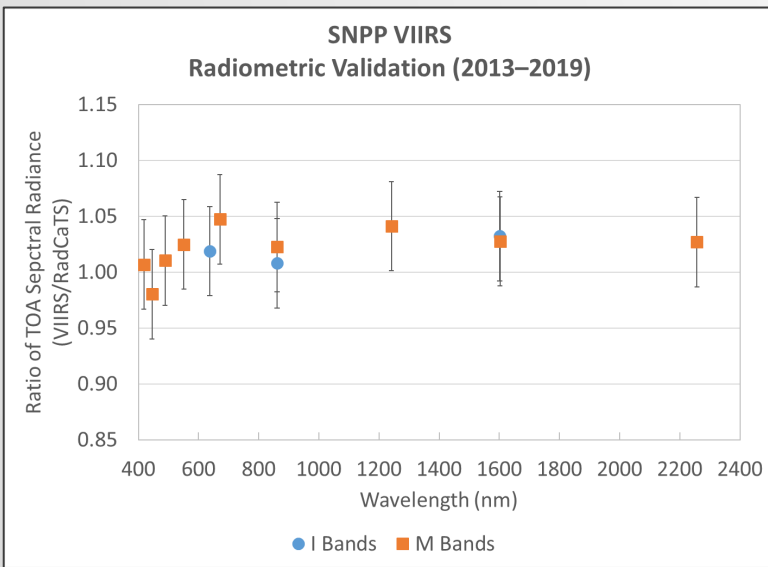


VIIRS Results

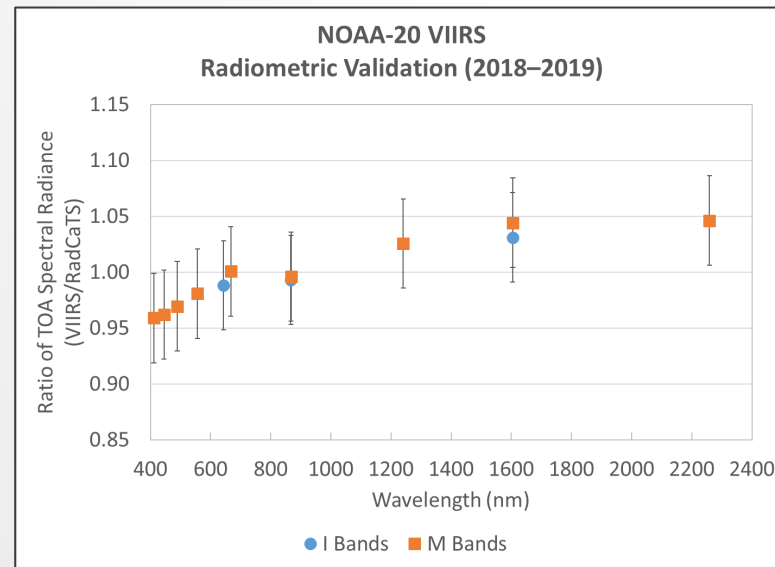
Current SNPP and NOAA-20 VIIRS Radiometric Calibration Results

- 2013–2019 (SNPP), 2018–2019 (NOAA-20)
- SNPP VIIRS: N=70, NOAA-20 VIIRS: N=18

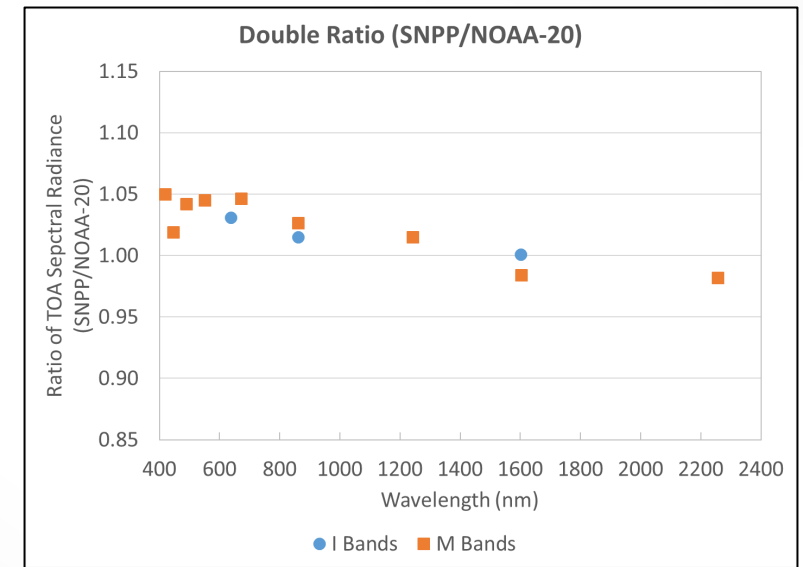
SNPP VIIRS



NOAA-20 VIIRS



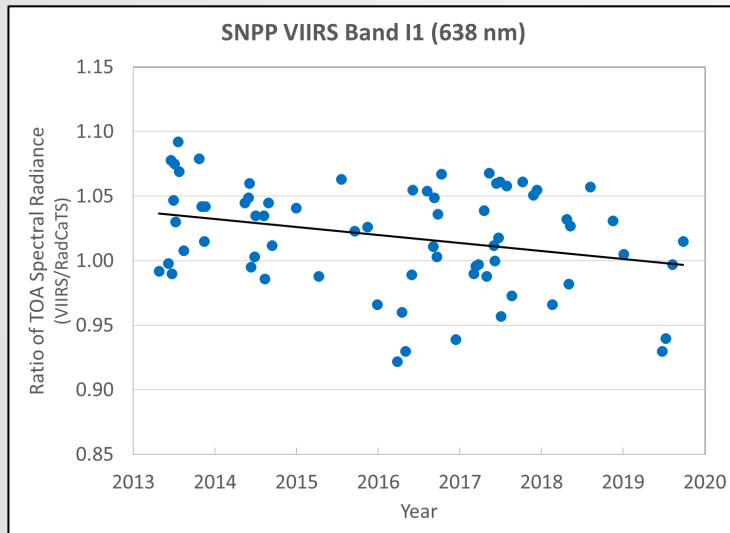
Double Ratio to Remove RadCaTS



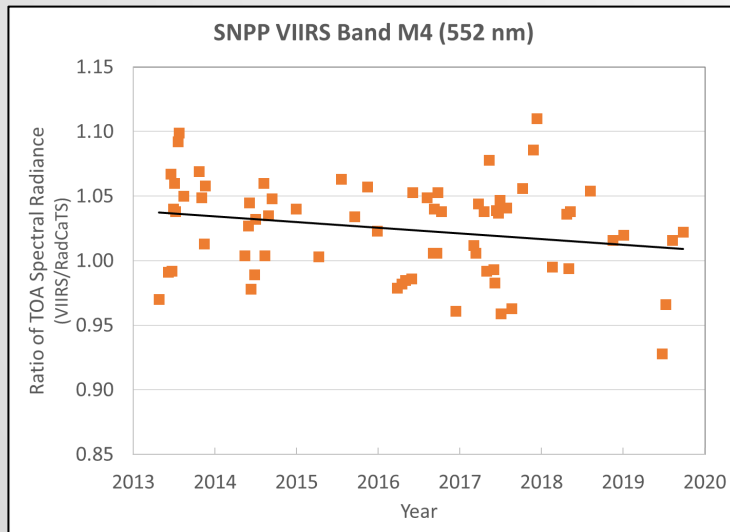
- VIIRS Bands: I1–I3, M1–M5, M7, M8, M10, M11
- Double ratio: $(\text{SNPP/RadCaTS})/(\text{N20/RadCaTS}) = \text{SNPP/N20}$

Radiometric Calibration Results (Temporal Example)

SNPP VIIRS

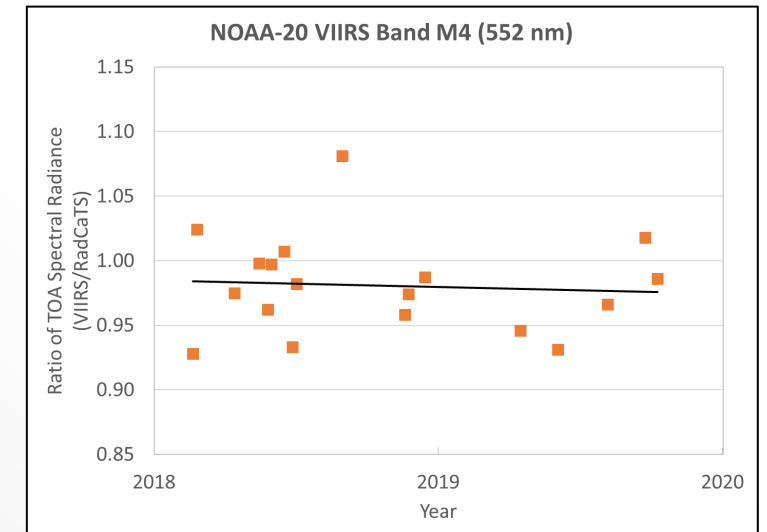
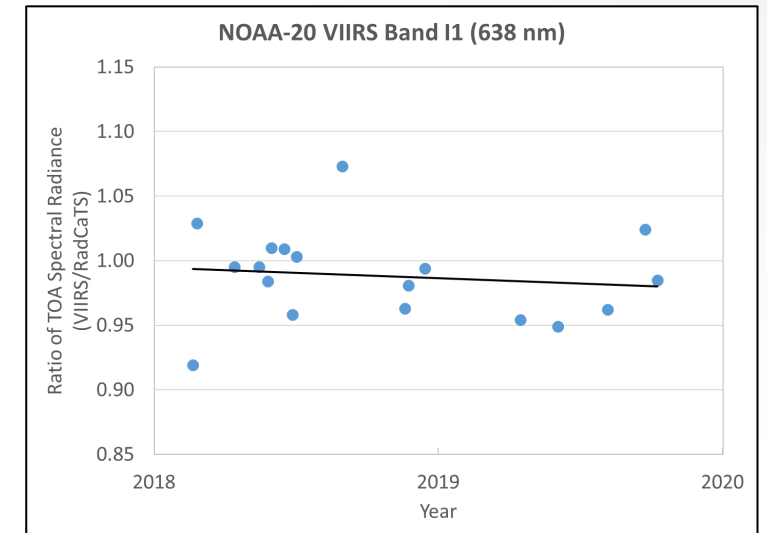


Band I1 (638 nm)



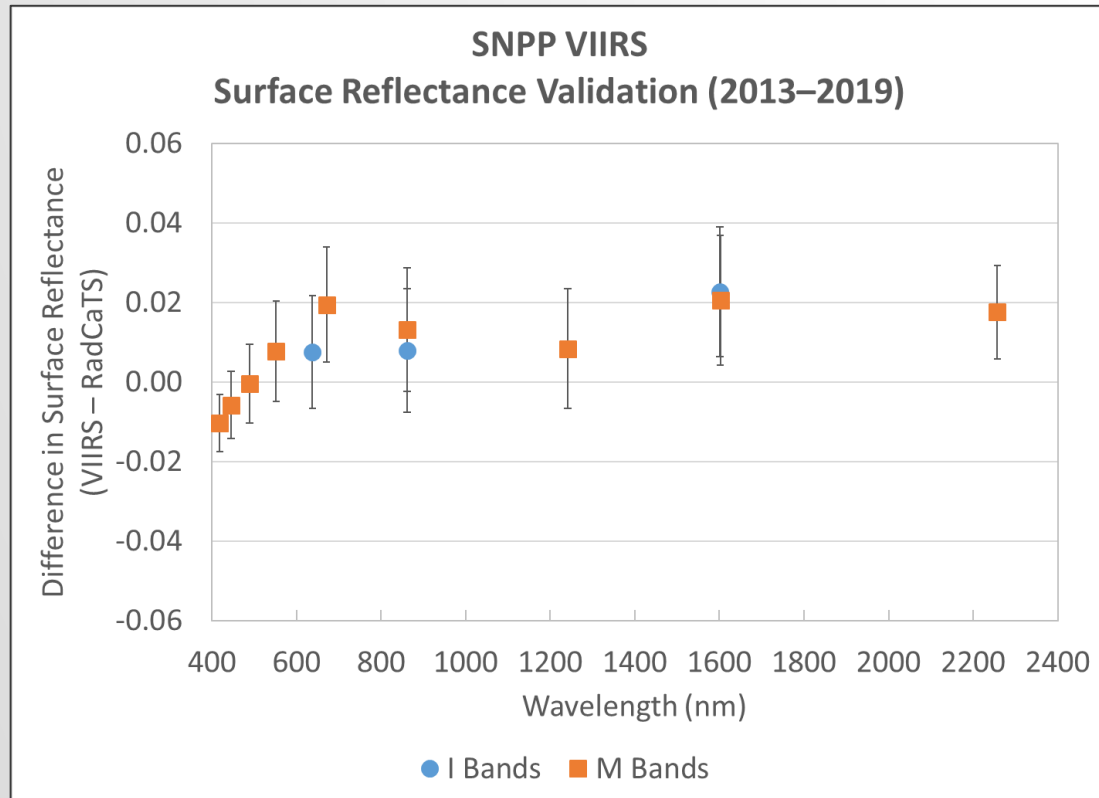
Band M4 (552 nm)

NOAA-20 VIIRS



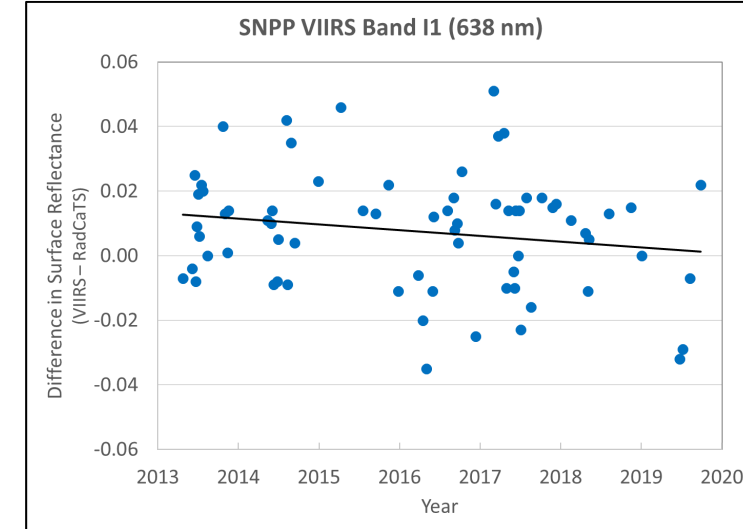
Current SNPP VIIRS Surface Reflectance Validation Results

- 2013–2019
- N=70

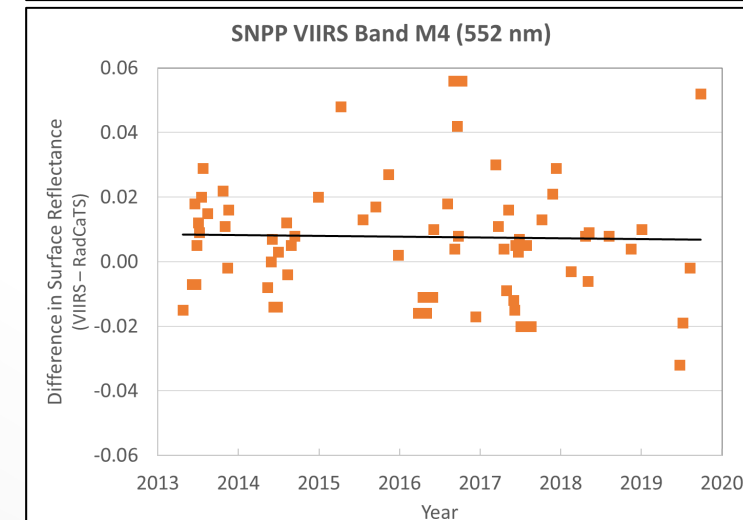


Band I1 (638 nm)

Temporal Examples



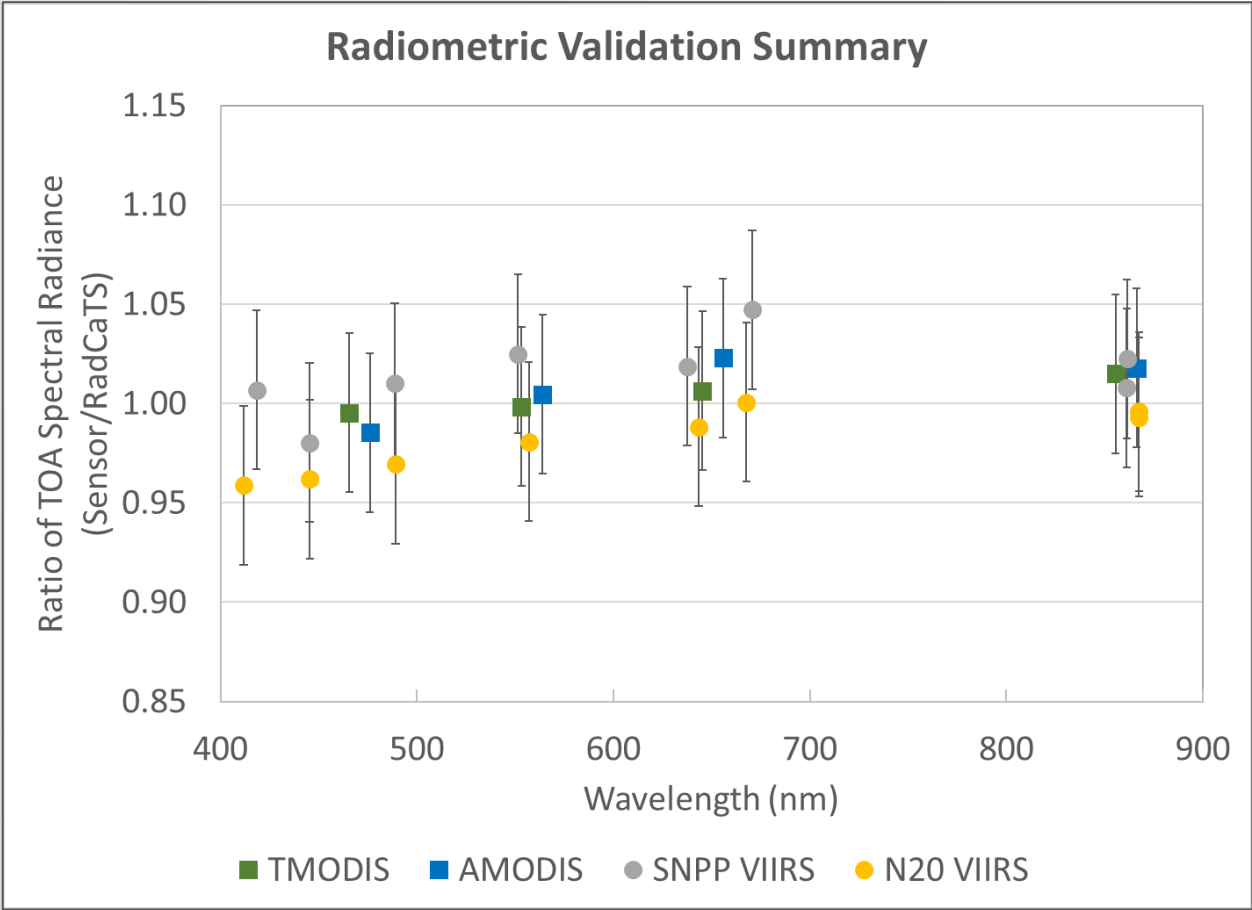
Band M4 (552 nm)



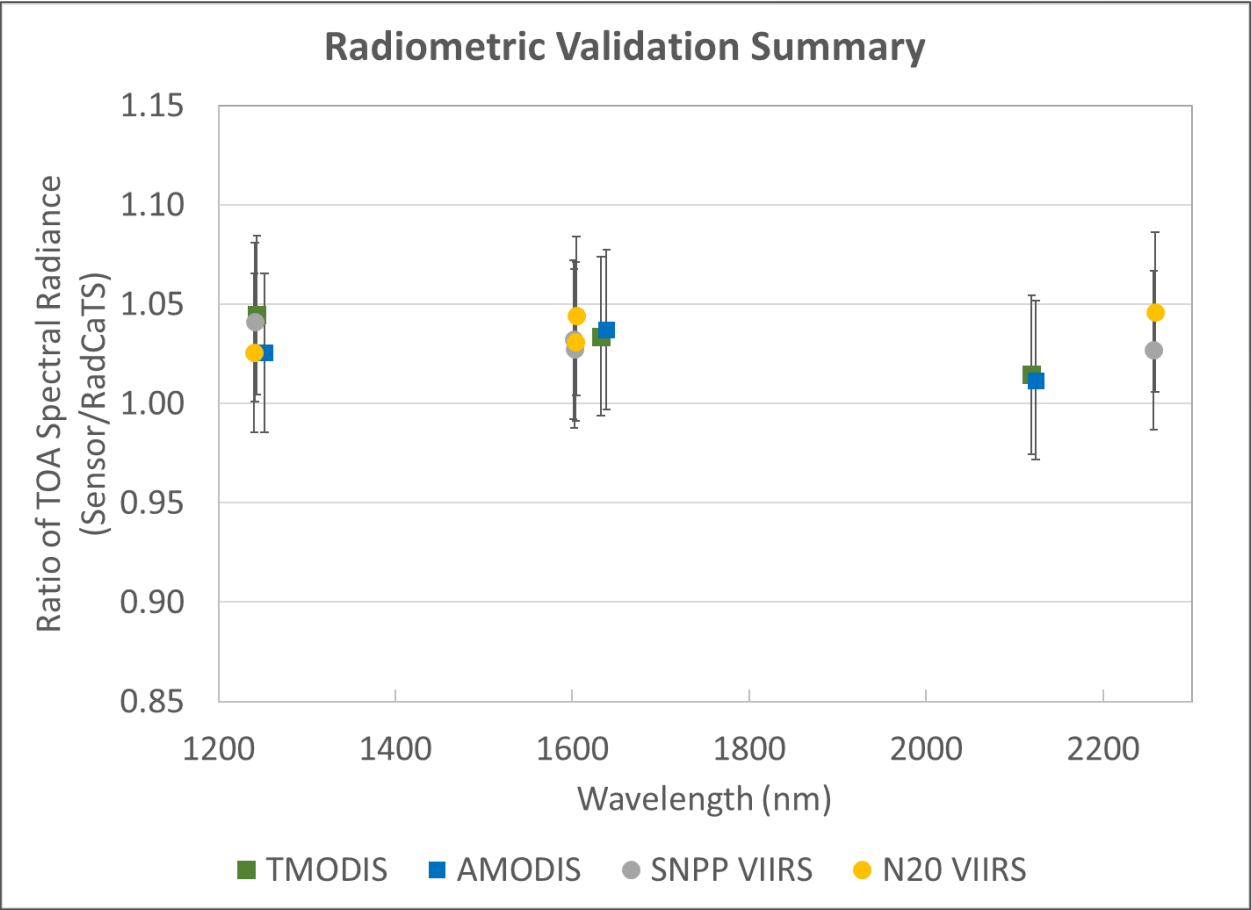
Recap

Summary of All Radiometric Calibration Results

VNIR



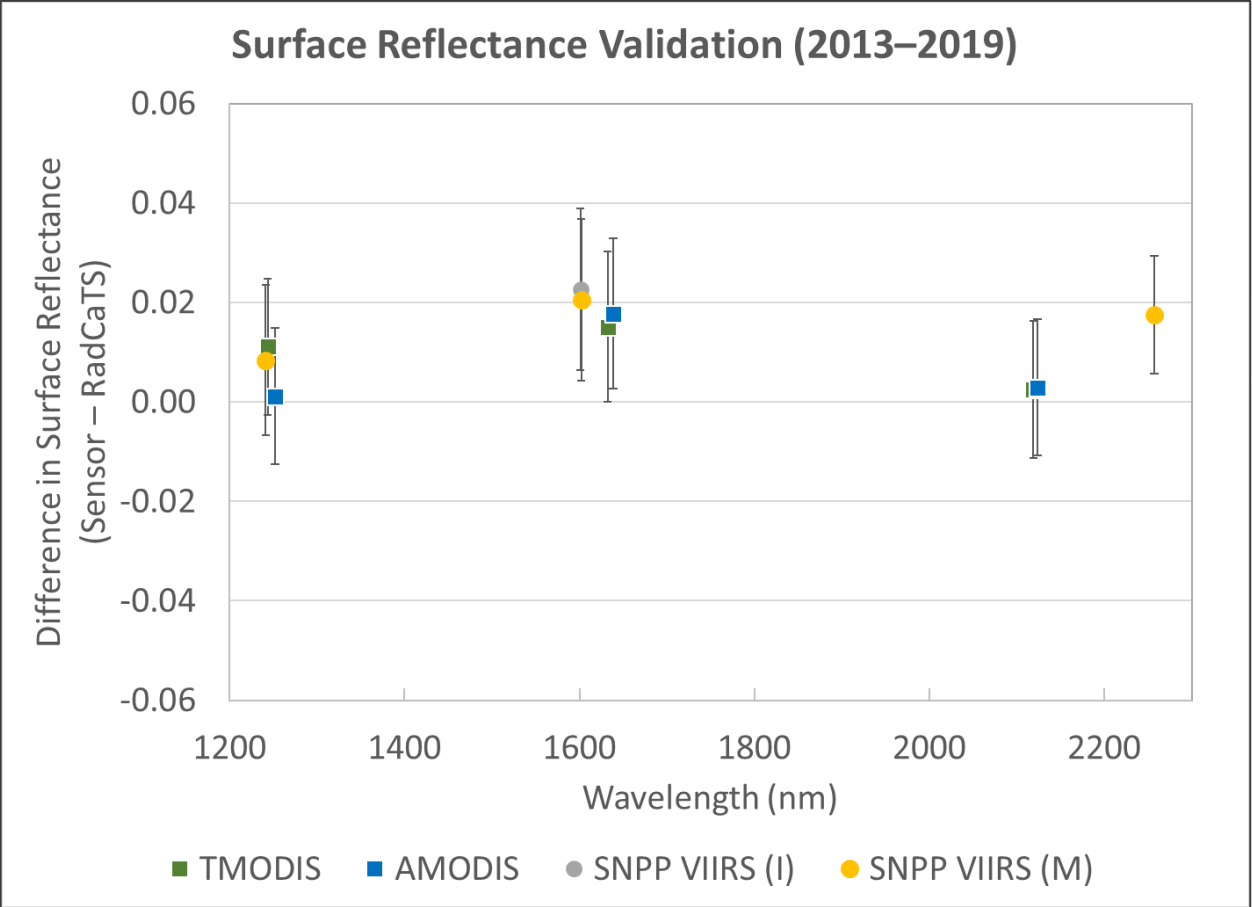
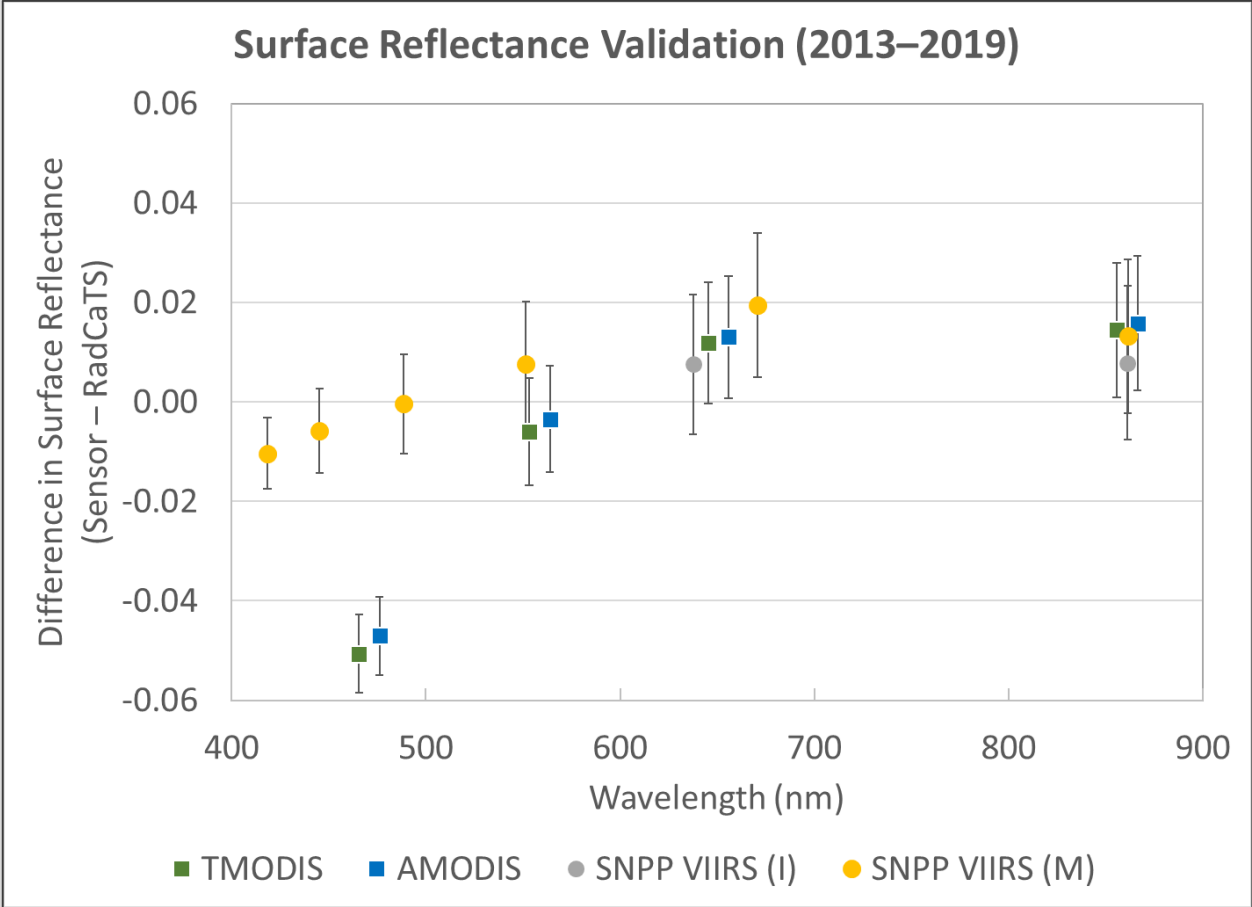
SWIR



Summary of All Surface Reflectance Validation Results

VNIR

SWIR



Summary

- RadCaTS continues to be operational, with daily data collection
- Surface reflectance results are uploaded to NASA GSFC for further processing to TOA reflectance for RadCalNet
- One new ground-viewing radiometer will be deployed in 2020
 - 5 nadir viewing configuration
 - 1 GOES-East
 - 1 GOES-West
- BRDF correction will continue to be developed and integrated in processing code
- Headwall UAS will be deployed at RadCaTS for spatial and BRDF studies
- GVR head translation stage continuing to be developed
- Analysis will be updated to include NOAA-20 VIIRS surface reflectance when available

Thanks!

- 
- An aerial photograph showing a research station in a vast, flat, arid landscape. Two people are standing near a small structure with solar panels. A long, straight path leads from the foreground towards the station. In the background, a range of mountains is visible under a clear sky.
- The authors would like to thank NASA for funding this work (NASA Research Grant 80NSSC18K0614), and AERONET for processing and distributing the Cimel data
 - We would also like to thank the Bureau of Land Management (BLM), Tonopah, Nevada office, for assistance and access to Railroad Valley