

MODIS/VIIRS Cal/Val Using RadCaTS

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University of Arizona

MODIS/VIIRS Calibration Workshop
25–26 Feb 2021

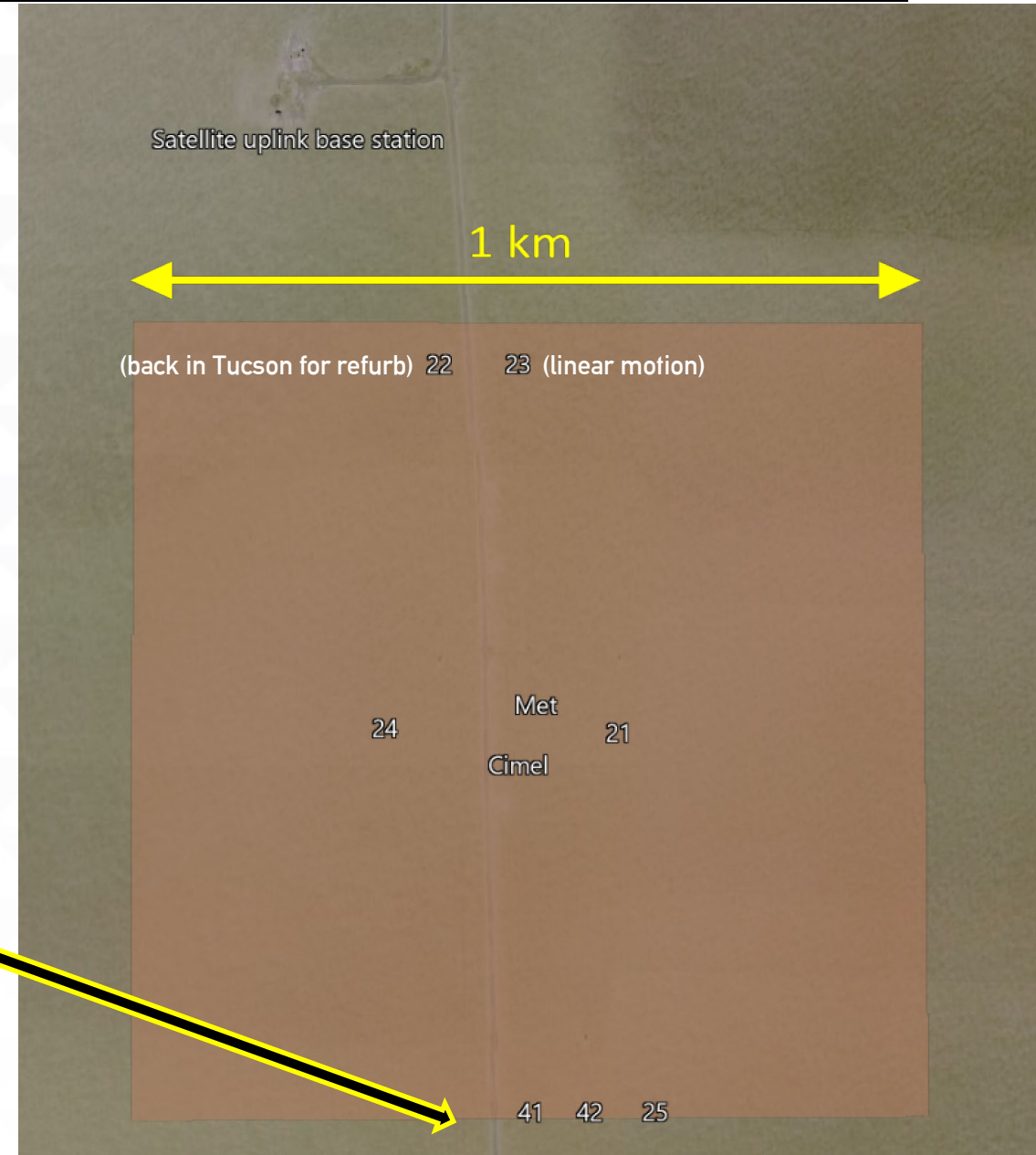
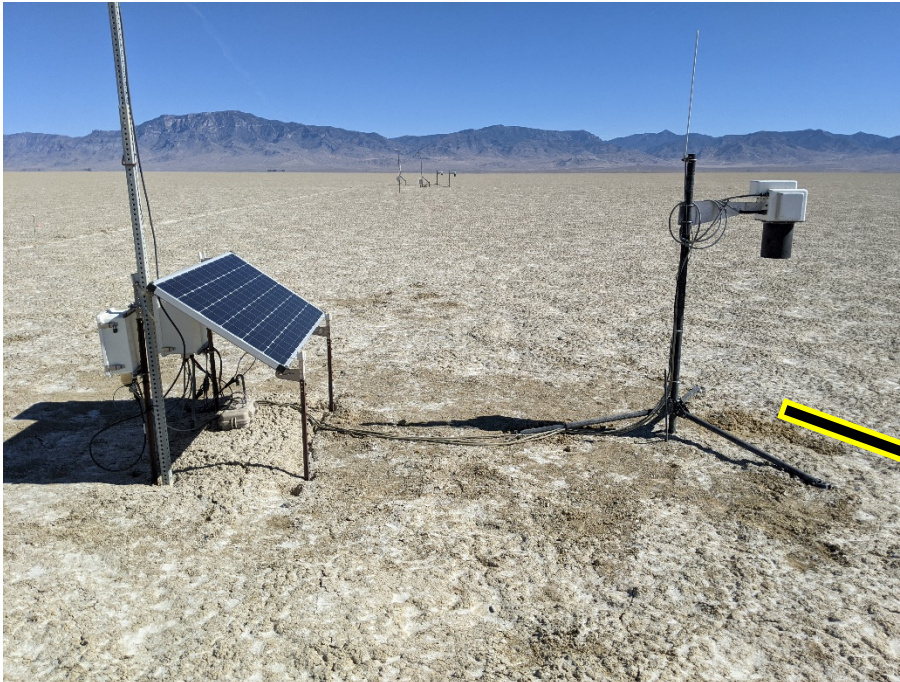


- The Radiometric Calibration Test Site (RadCaTS)
- Current status of RadCaTS
- Radiometric calibration and surface reflectance validation results
- Summary and future work



- UArizona is using the Radiometric Calibration Test Site (RadCaTS) at Railroad Valley, NV, as the primary data collection site
- RadCaTS has been in operation in its current form since 2012
- Previous studies were used to determine amount and placement of GVRs for spatial sampling similar to traditional reflectance-based approach
- Reflectance-based approach and RadCaTS are two independent methods
 - Reflectance-based:
 - Surface reflectance: ratio method of surface to reference panel
 - Automated solar radiometer used for atmospheric measurements
 - RadCaTS
 - Surface reflectance: absolutely-calibrated multispectral radiometers
 - AERONET Cimel solar/lunar photometer used for atmospheric measurements
- MODTRAN used to determine atmospheric propagation in both cases

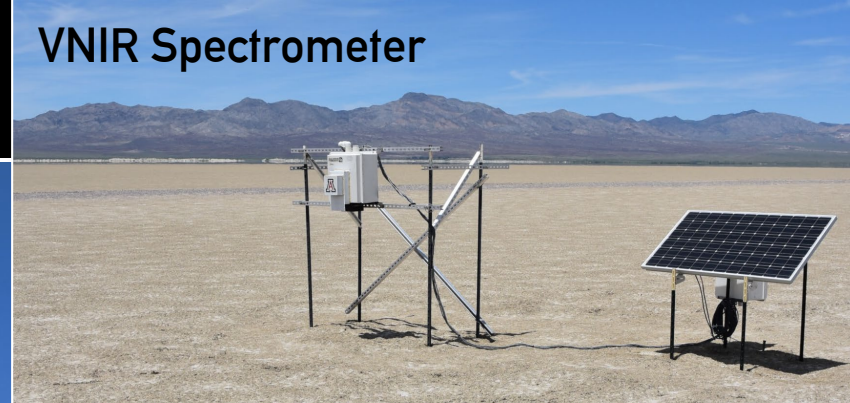
- 7 ground-viewing radiometers (GVRs)
 - All in nadir viewing configuration (as of 18 Oct 2020)
 - Monitoring ground under 41 and 42 to determine when to include in processing (recently moved from GOES-E and -W config)
 - One GVR (23) has 80 cm of linear motion
- 1 VNIR spectroradiometer (SpAM)
- 2 Cimel sun photometers (314 and 786)
- Met station
- Satellite uplink
- Web camera



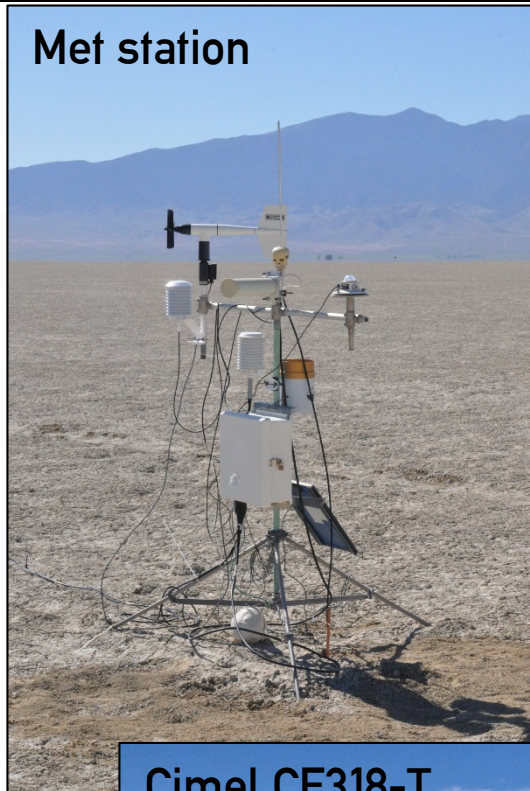


Equipment at RadCaTS

VNIR Spectrometer



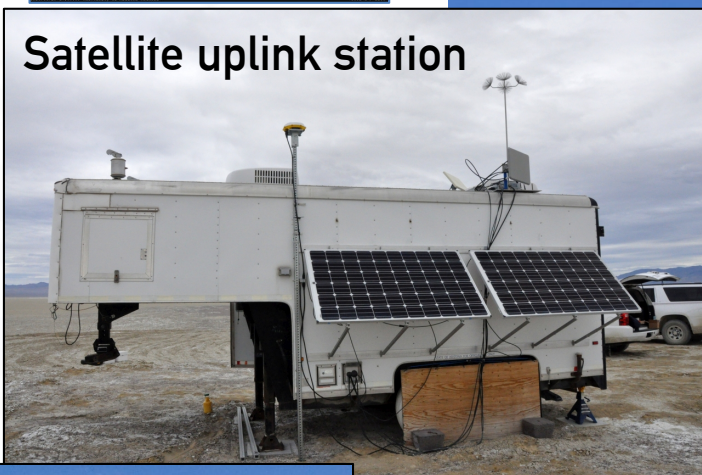
Met station



Web cam



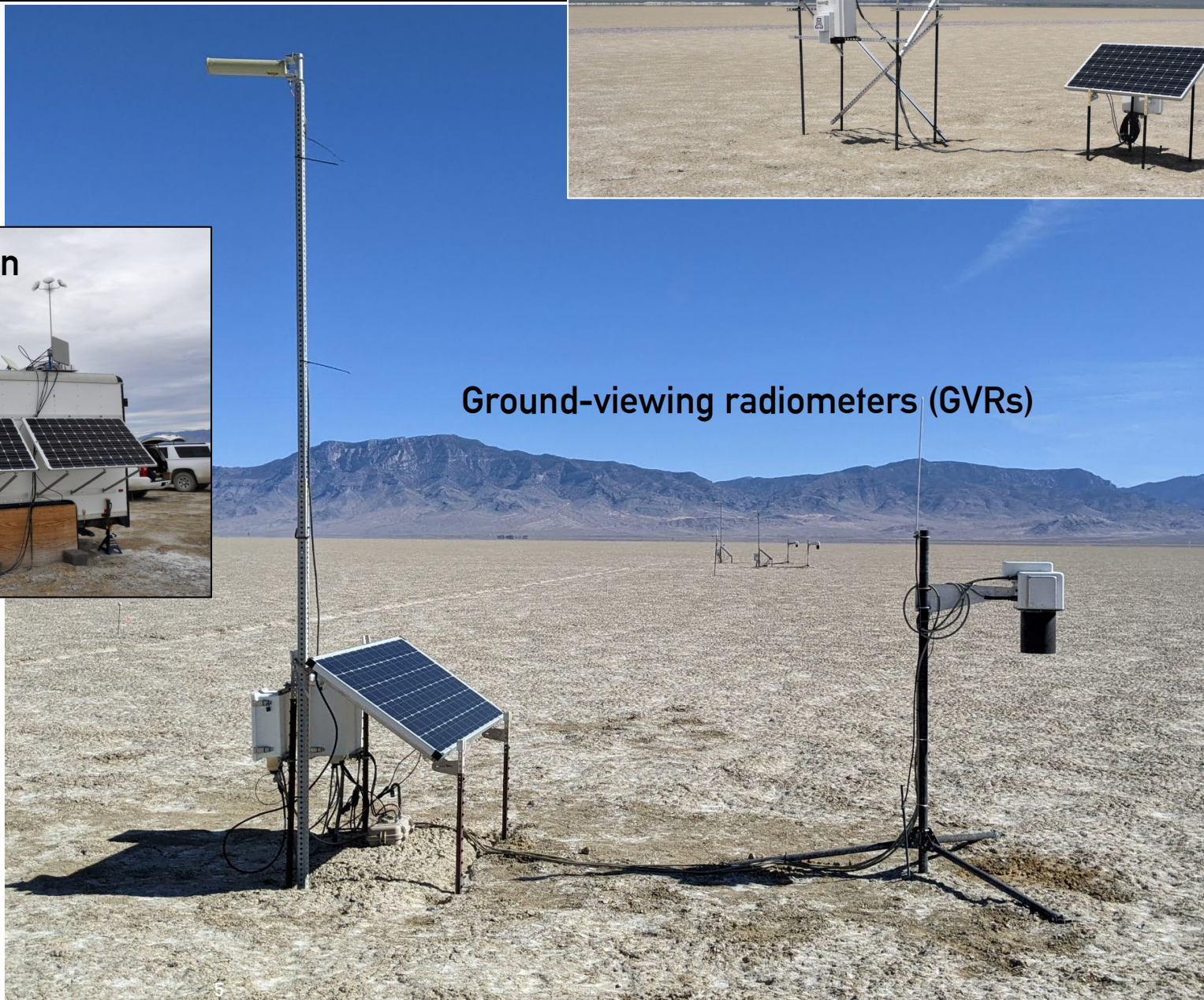
Satellite uplink station



Cimel CE318-T

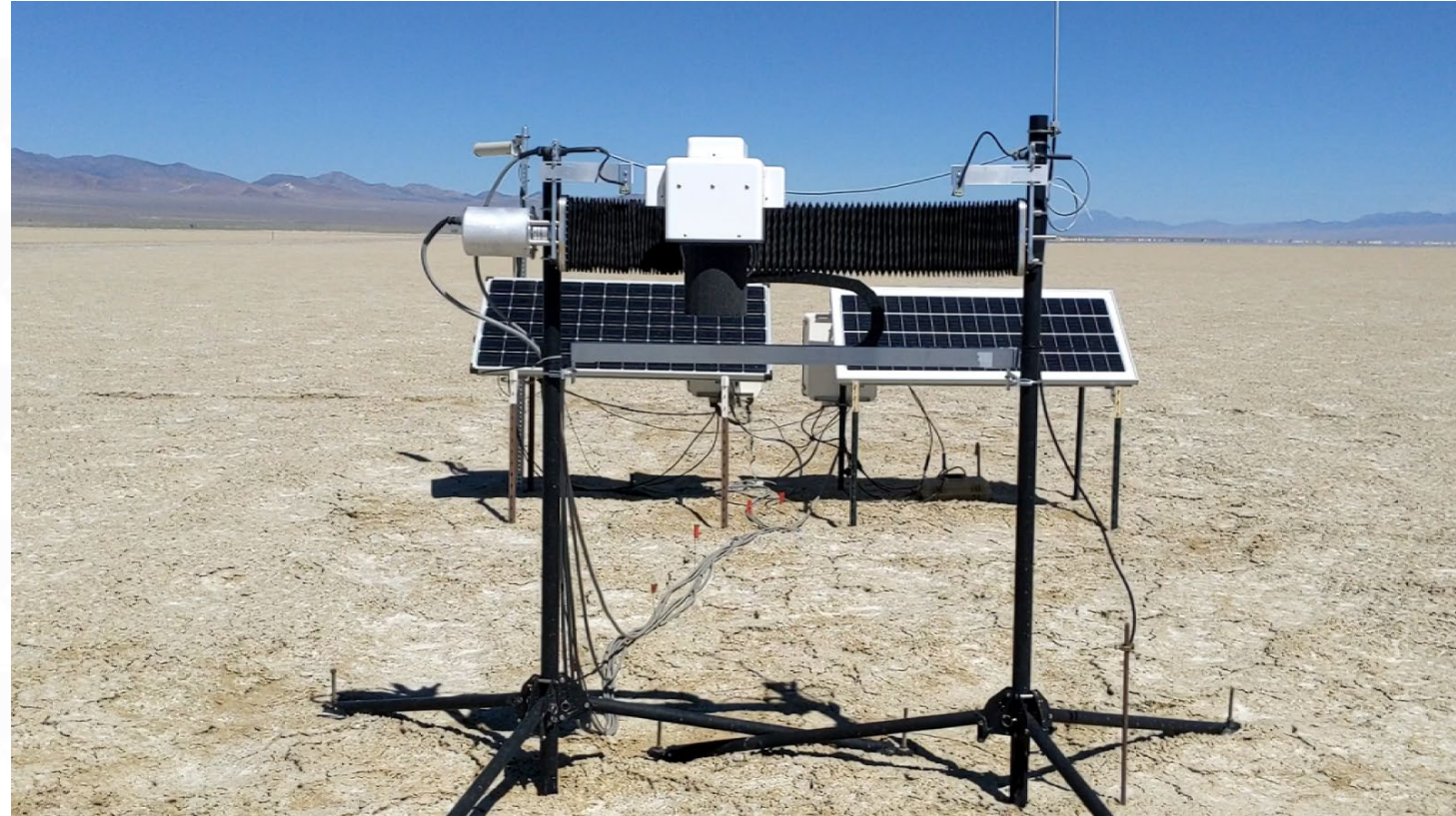


Ground-viewing radiometers (GVRs)



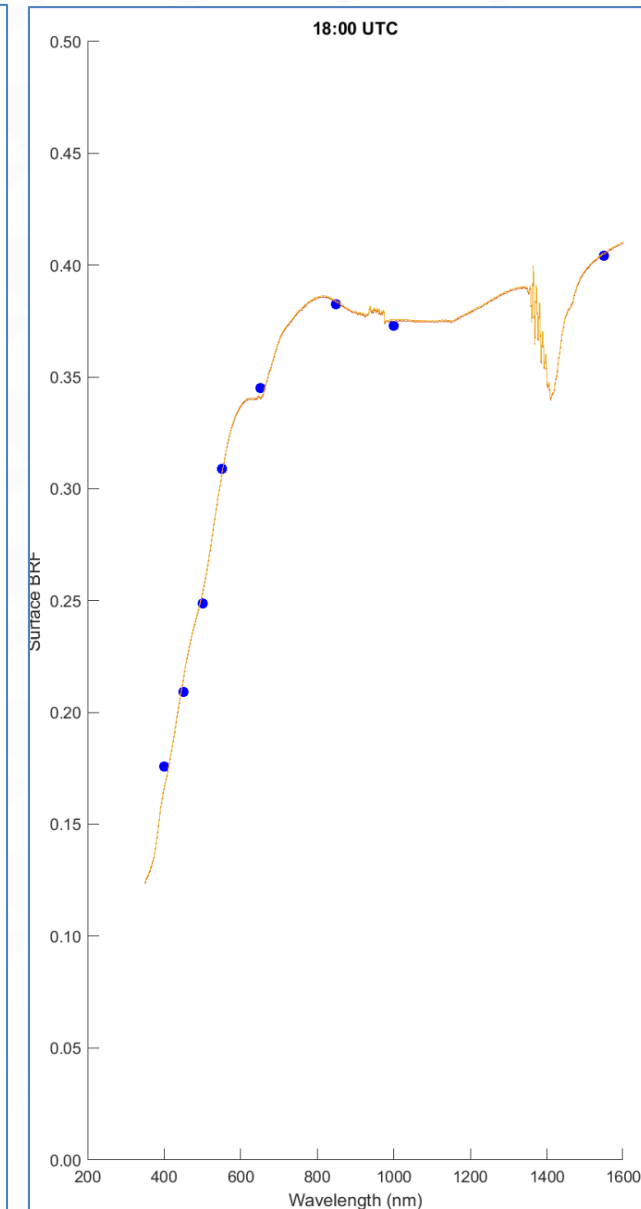
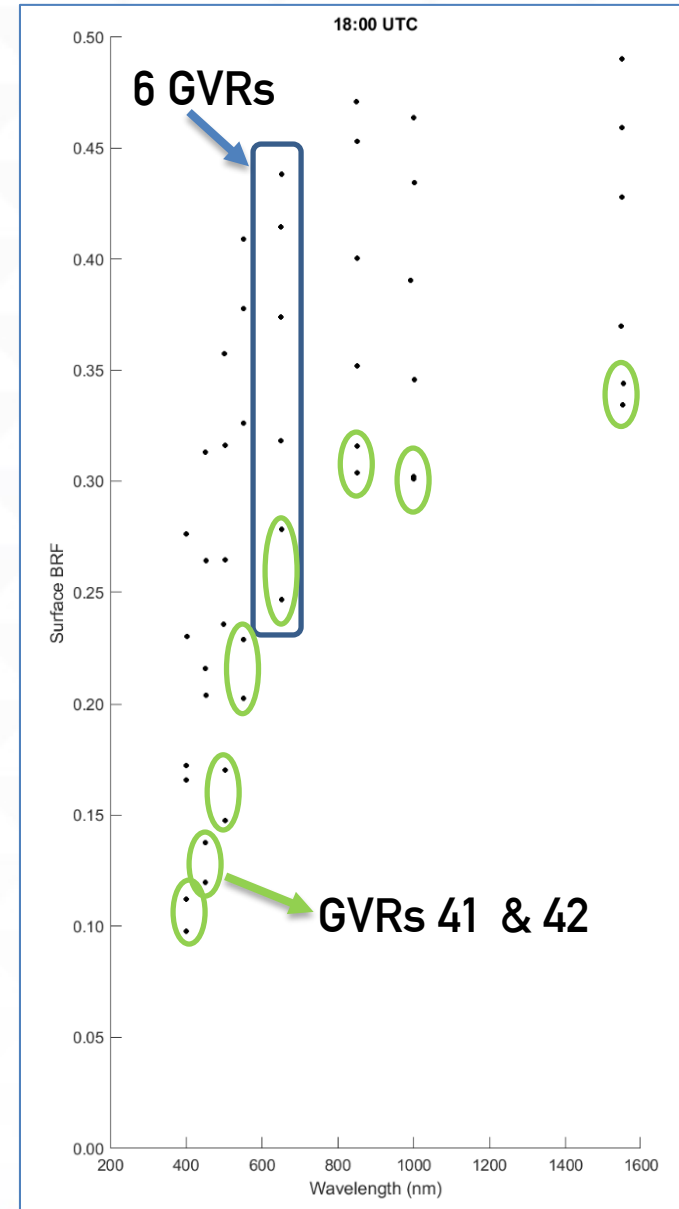
GVR 23: Linear Motion

- Operating since Mar 2020
- Same 10° field of view as current GVRs
- Mounted at same height as current GVRs
- Translation: ~ 80 cm at a rate of 0.5 cm s^{-1}
- Data collected every 10 s (equivalent to 5 cm)
- 6.8 minutes for full lap
- Operates from 16:00–23:00 UTC



Surface Reflectance Determination at RadCaTS

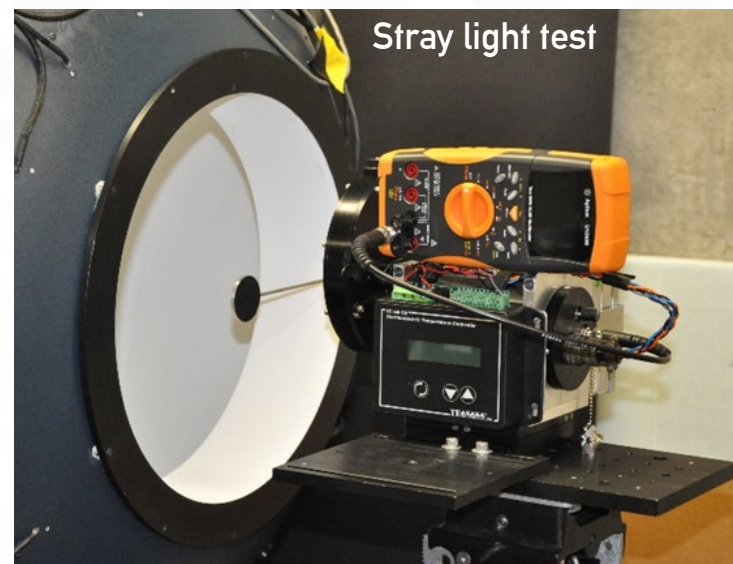
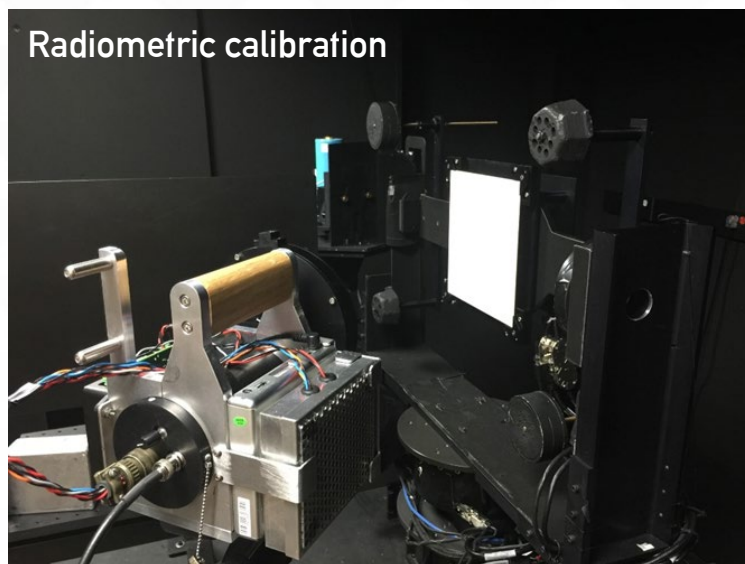
- For a given time of interest:
 - Determine surface reflectance in each of GVR's 8 spectral bands
 - Determine the average for each of the 8 bands
 - Convert the multispectral results to hyperspectral by fitting to library of data collected from 2000–present using portable spectroradiometer (e.g. ASD)
 - GVR 41 and 42 are currently showing low BRF due to surface disturbance during installation. Will monitor and include them when surface dries.
 - **Note:** graphs are from 4 Nov 2020. Low sun angle. Two lowest BRFs in each band are due to 'watered' area under GVRs 41 and 42.





Support Instrumentation and Measurements

- 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)



Field deployment at
RadCaTS



Field deployment at
Pinnacles, Australia



- UAS
 - Laboratory calibration of Headwall hyperspectral instrument
 - Spectral
 - Radiometric
 - Temporal stability
 - Deployment at Railroad Valley and partner sites for BRDF and spatial uniformity analysis
 - RRV field measurements and comparison to previous PARABOLA-III and ULGS-II results
 - Spatial uniformity comparison with GVR linear motion system



- 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.)

RadCalNet Committee on Earth Observation Satellites Jeff Czajla-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 Valley 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

RadCalNet Committee on Earth Observation Satellites Jeff Czajla-Myers

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](#)



- **Source:**
 - LAADS DAAC
- **Radiometric Calibration**
 - Terra & Aqua MODIS: Collection 6.1 (2013–2021)
 - SNPP VIIRS: Collection 1 (Archive 5110) (2013–2021)
 - NOAA-20 VIIRS: Collection 2 (Archive 5200) (2018–2021)
- **Surface Reflectance Validation**
 - Terra & Aqua MODIS: Collection 6 (2013–2021)
 - SNPP VIIRS: Collection 1 (Archive 5000) (2013–2021)
 - NOAA-20 VIIRS: No imagery (still working on extracting from NOAA-CLASS imagery)

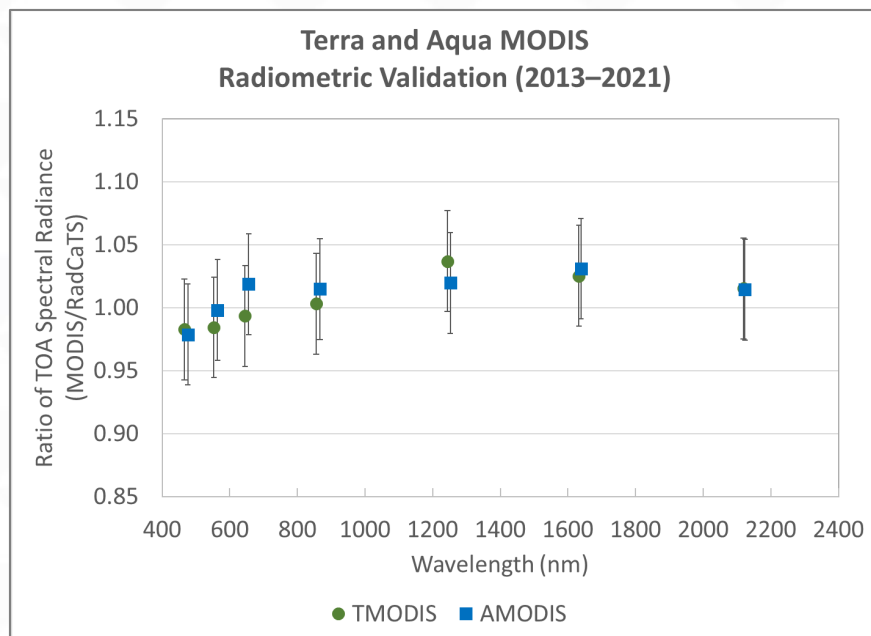


Sensor Viewing Conditions (as of 1 Jan 2021)

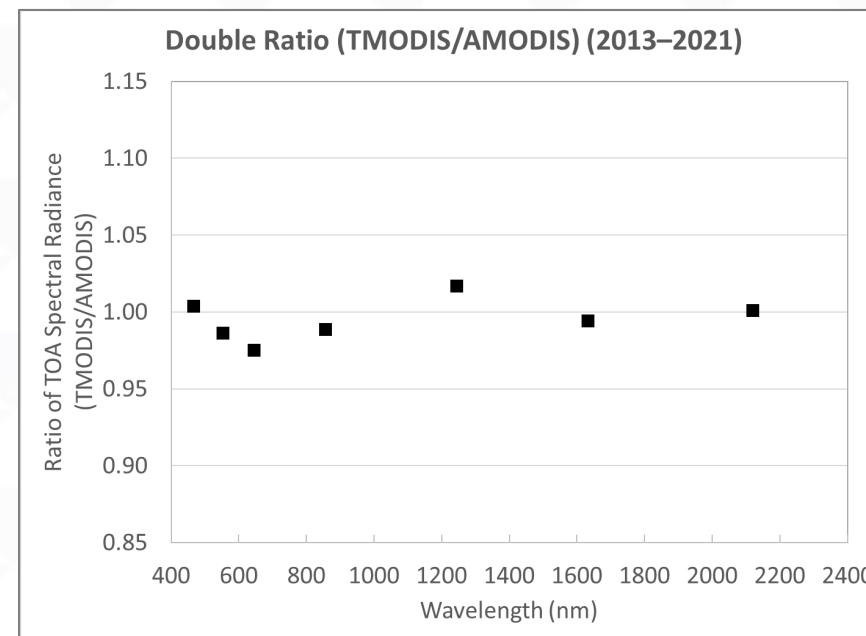


Sensor	Time (UTC)	View Zenith Angle	View Azimuth Angle (from ground)
TMODIS	18:32	13.1°	102.4°
	18:38	1.5°	103.1°
	18:44	10.2°	284.3°
AMODIS	20:48	7.3°	75.9°
	20:55	4.5°	256.9°
SNPP VIIRS	20:33	11.0°	74.7°
	20:39	0.6°	75.1°
	20:45	9.8°	256.7°
NOAA-20 VIIRS	20:33	10.9°	74.7°
	20:39	0.4°	74.7°
	20:46	9.9°	256.7°

- 2013–2021
- **TMODIS: N=135**, **AMODIS: N=112**

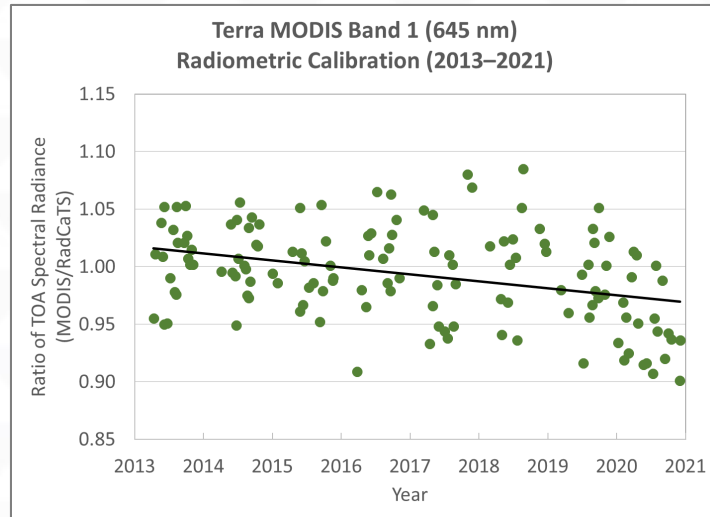


Double ratio to remove RadCaTS



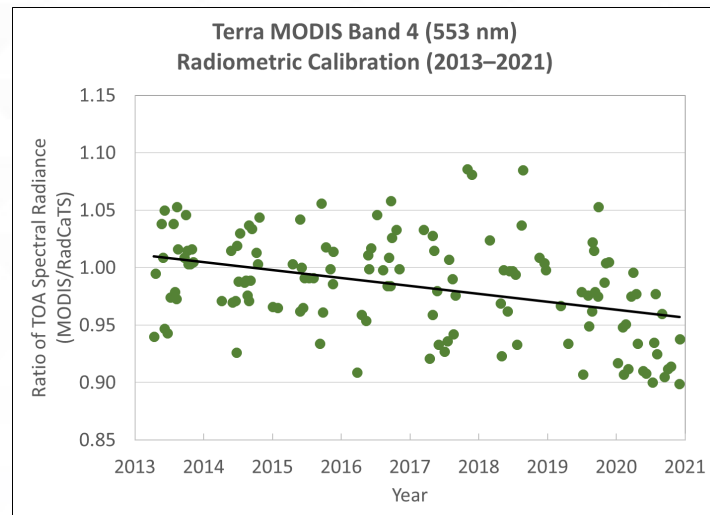
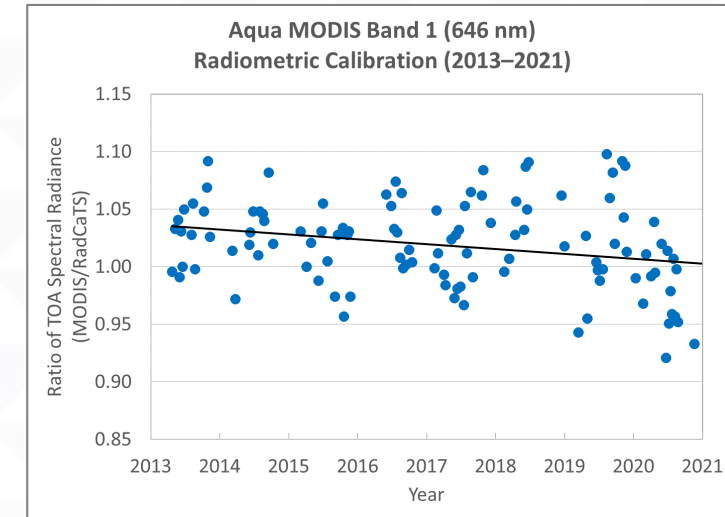
- MODIS Bands: 1–7
- Double ratio: $(\text{TMODIS}/\text{RadCaTS})/(\text{AMODIS}/\text{RadCaTS}) = \text{TMODIS}/\text{AMODIS}$

Terra MODIS

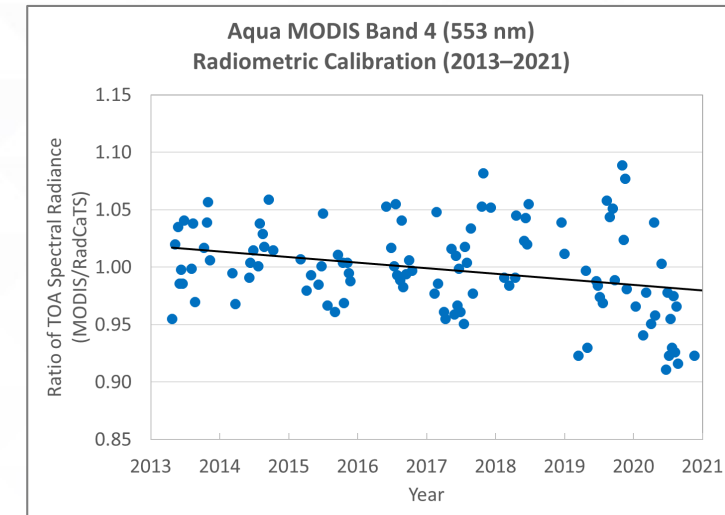


Band 1 (645 nm)

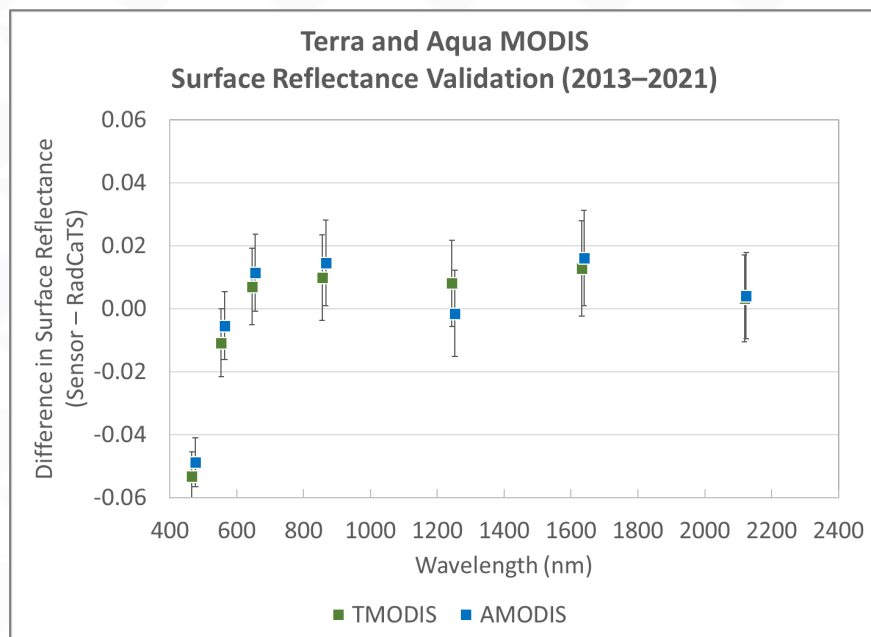
Aqua MODIS



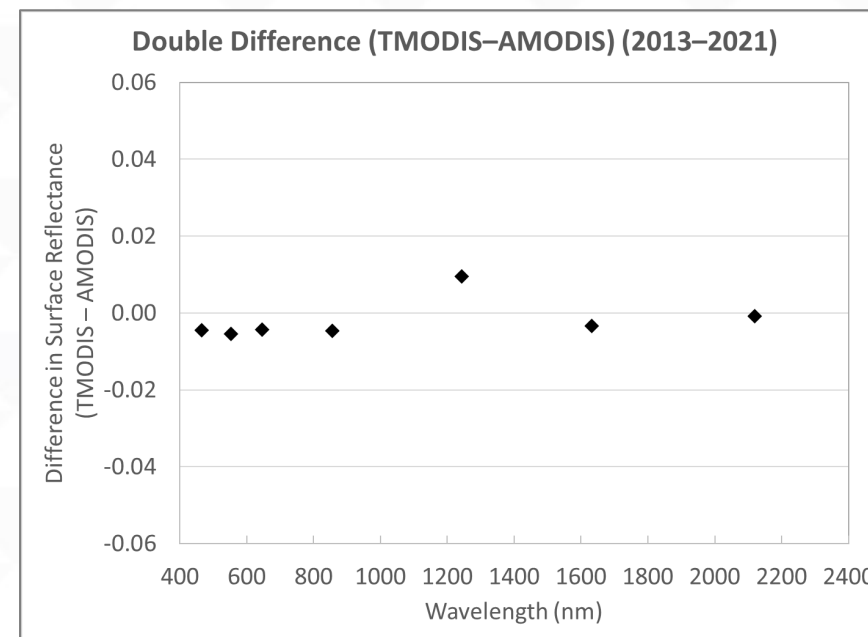
Band 4 (553 nm)



- 2013–2021
- **TMODIS: N=135**, **AMODIS: N=112**



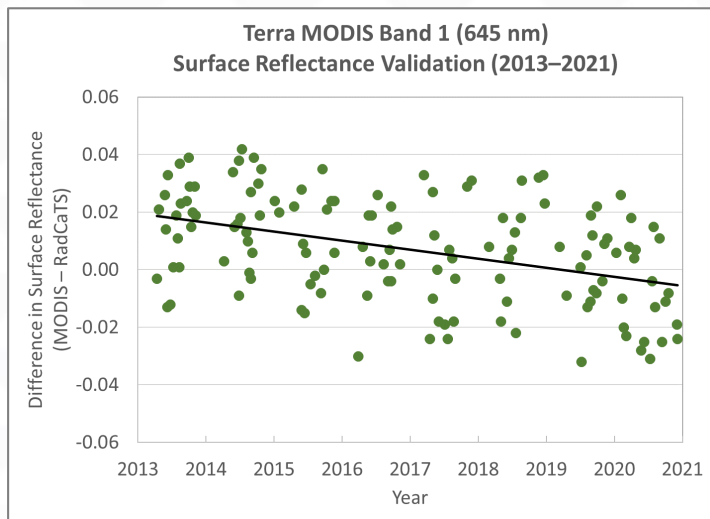
Double difference to remove RadCaTS



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

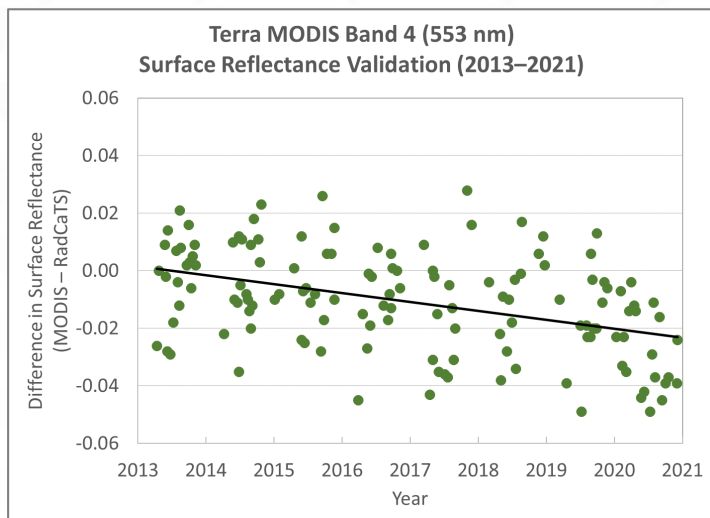
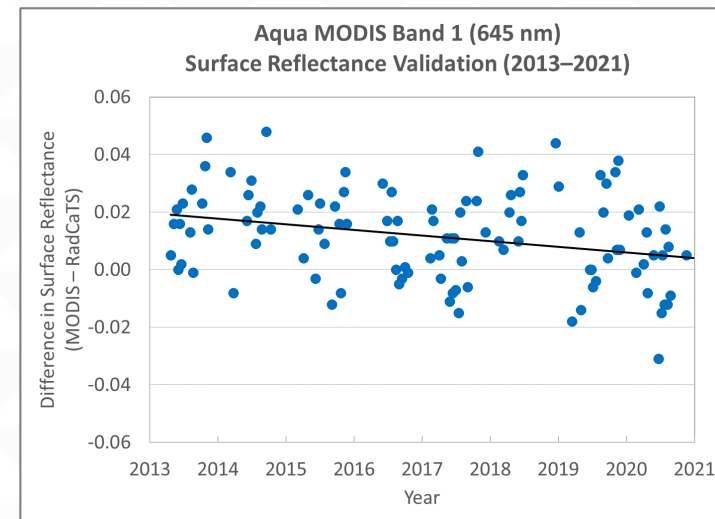
Temporal Surface Reflectance Validation Results

Terra MODIS

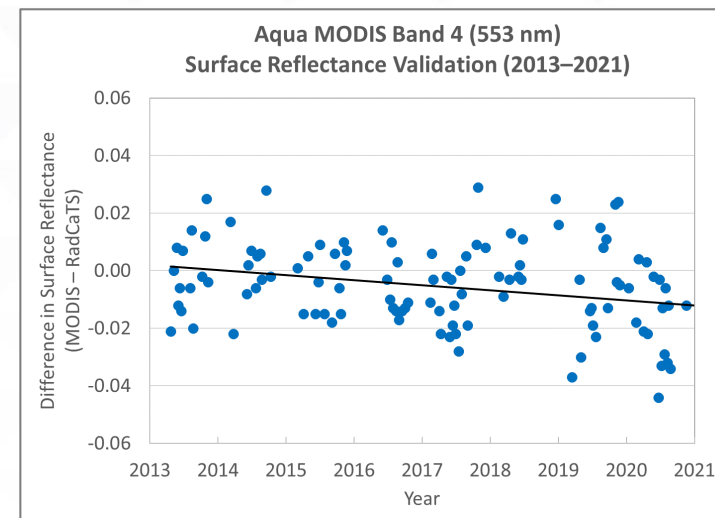


Band 1 (645 nm)

Aqua MODIS



Band 4 (553 nm)





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VIIRS Results

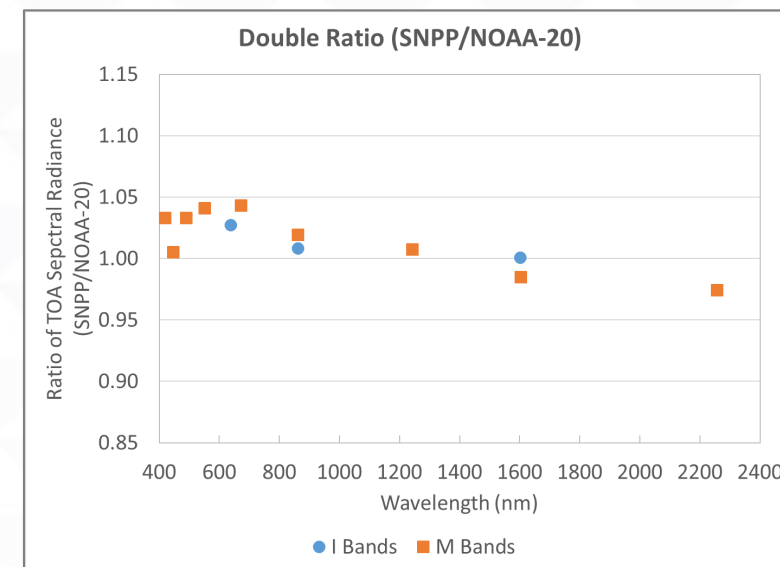
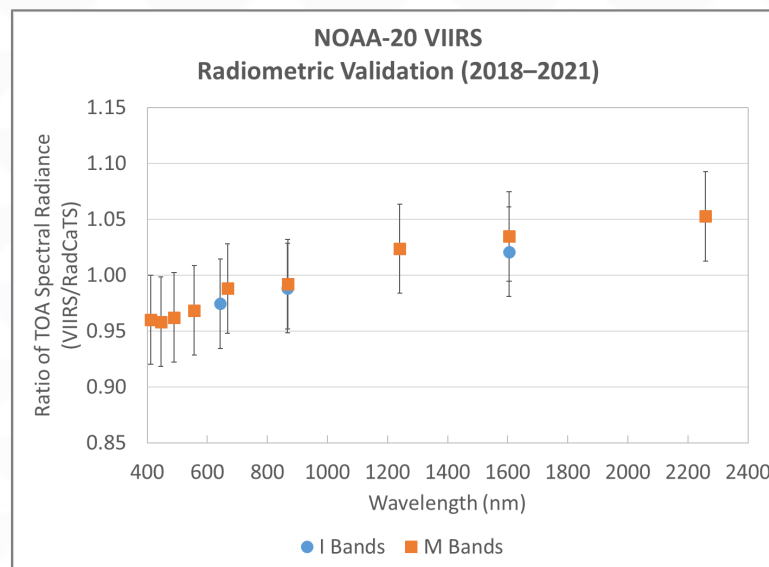
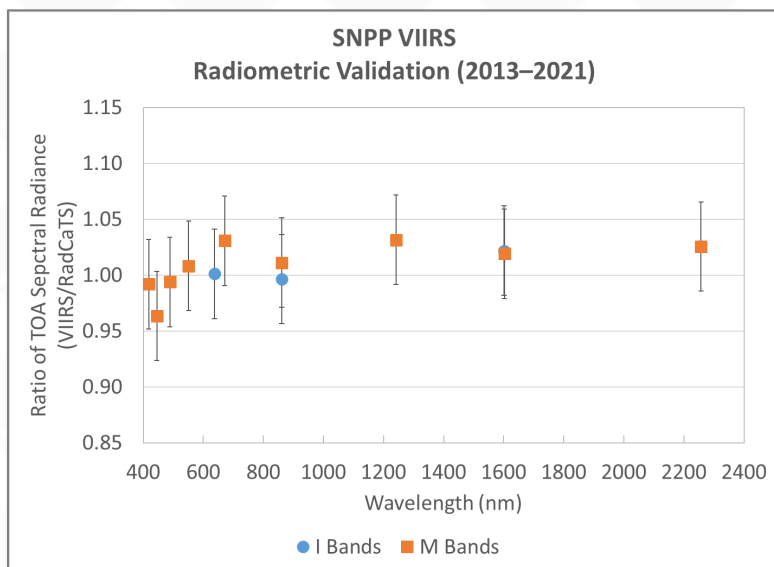


- 2013–2021 (SNPP), 2018–2021 (NOAA-20)

- SNPP: N=106

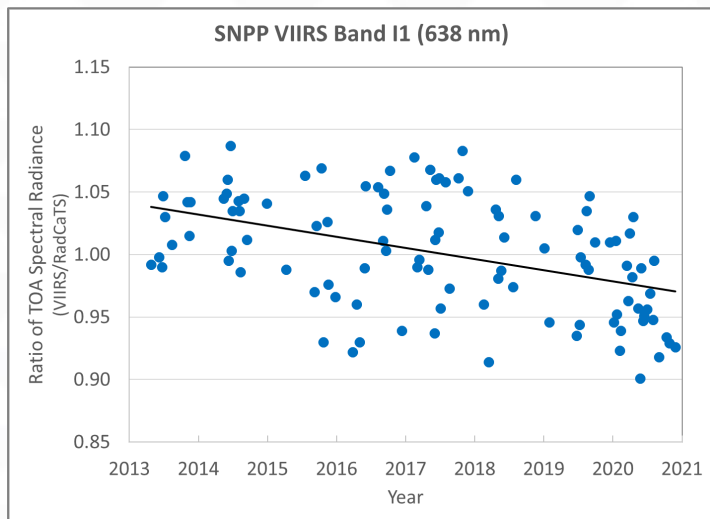
NOAA-20: N=64

Double ratio to remove RadCaTS



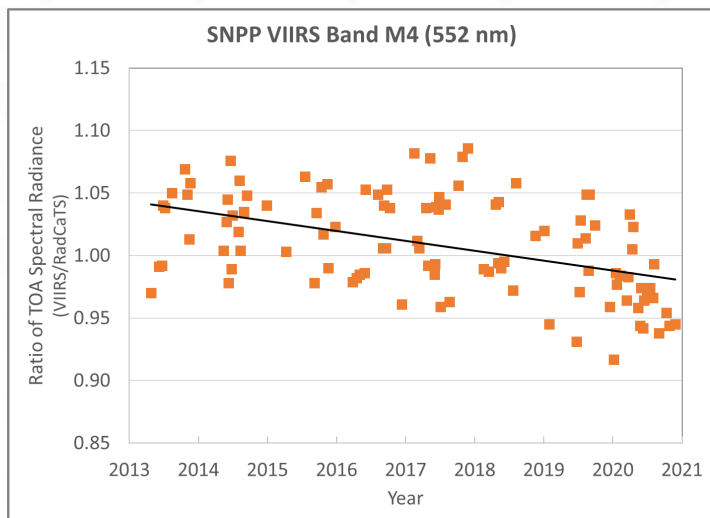
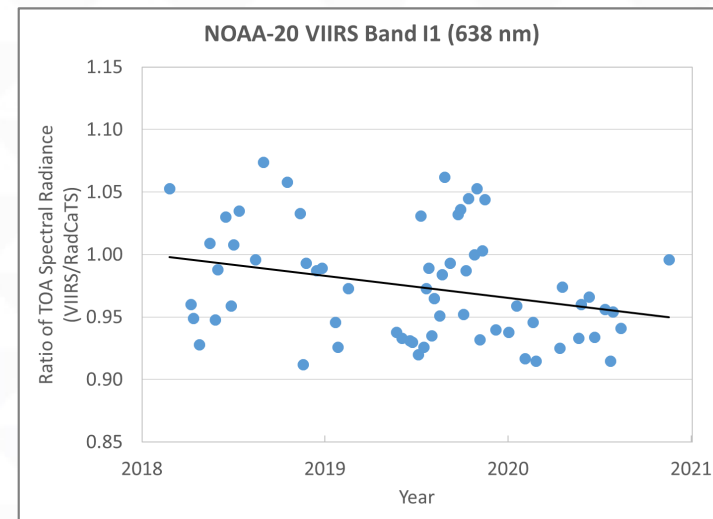
- VIIRS bands: **I1–I3**, **M1–M5**, **M7**, **M8**, **M10**, **M11**
- Double ratio: $(\text{SNPP}/\text{RadCaTS})/(\text{N20}/\text{RadCaTS}) = \text{SNPP}/\text{N20}$

SNPP VIIRS

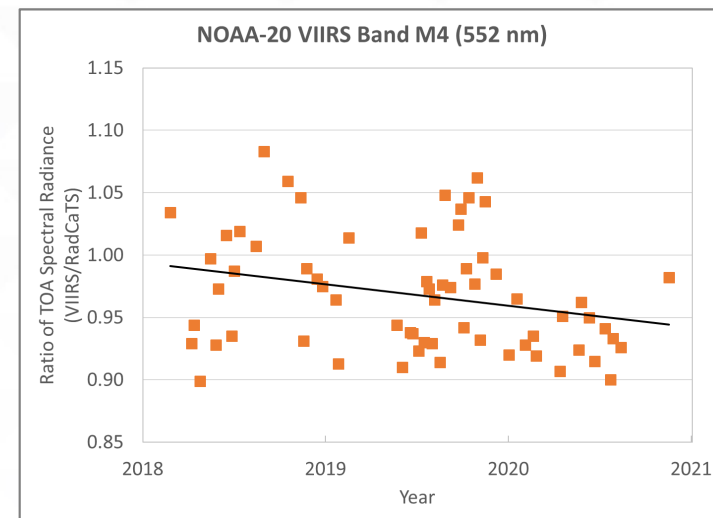


Band I1 (638 nm)

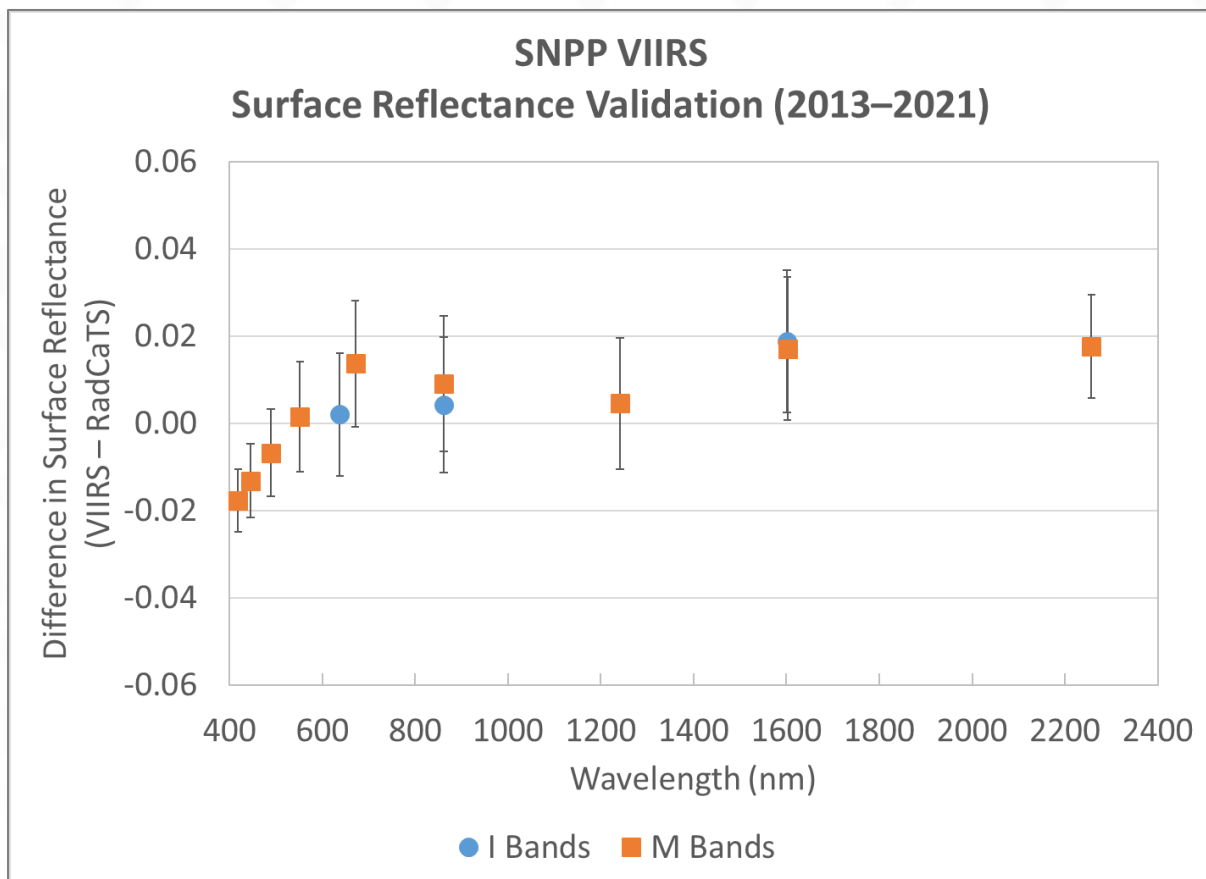
NOAA-20 VIIRS



Band M4 (552 nm)



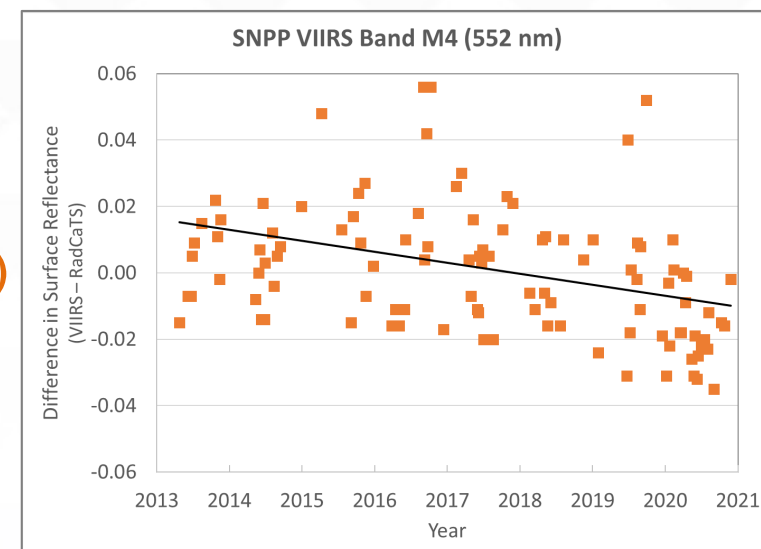
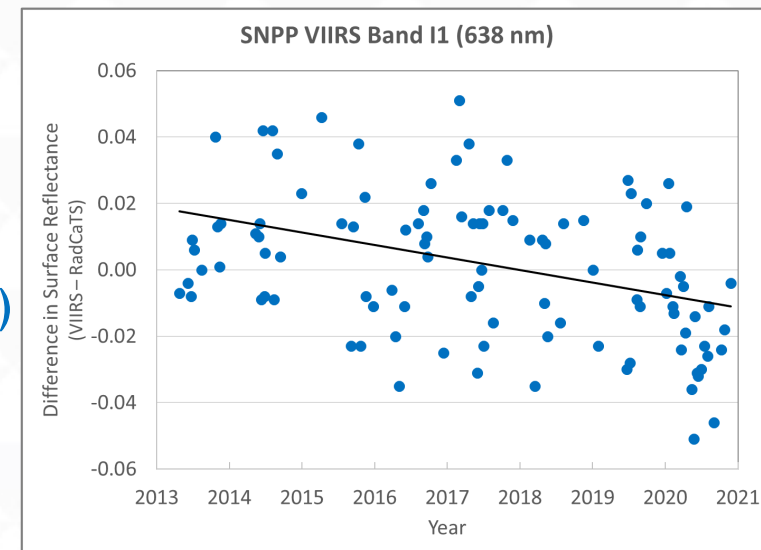
- 2013–2021
- N=106



Band I1 (638 nm)

Band M4 (552 nm)

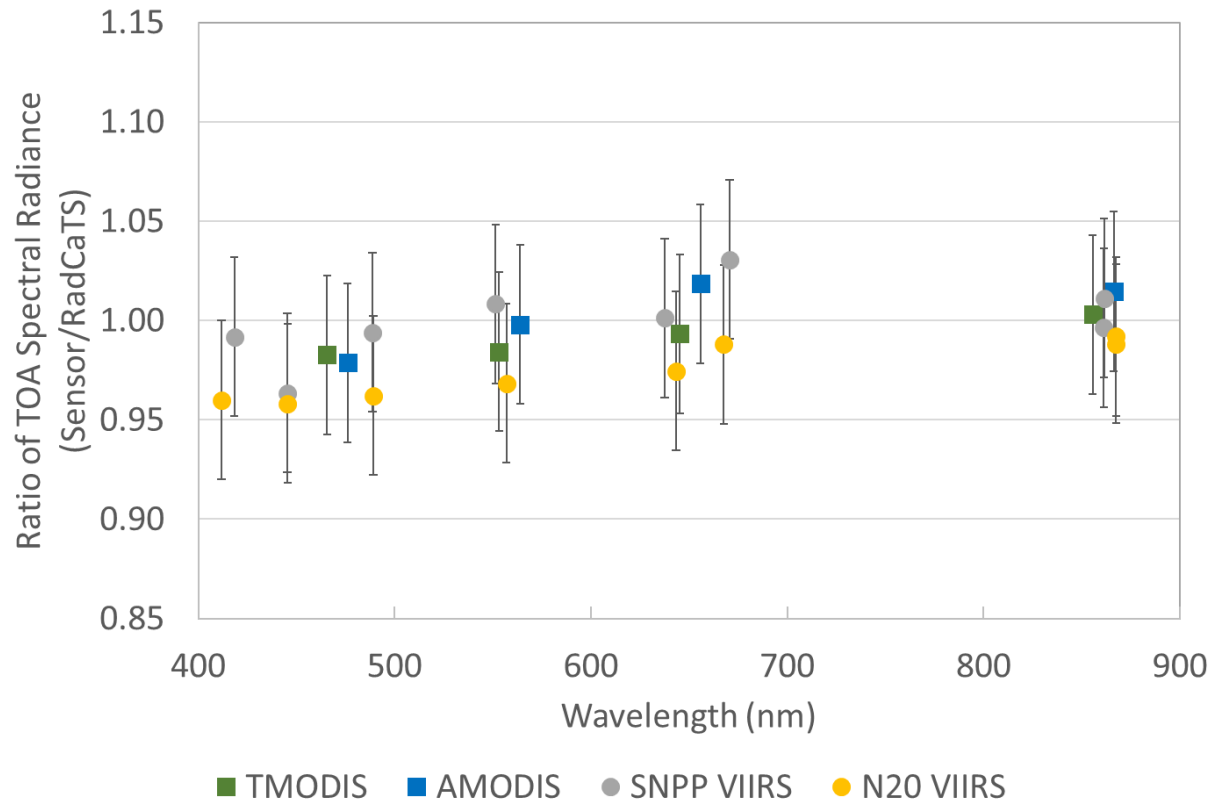
Temporal Examples



- Summary of all radiometric calibration results

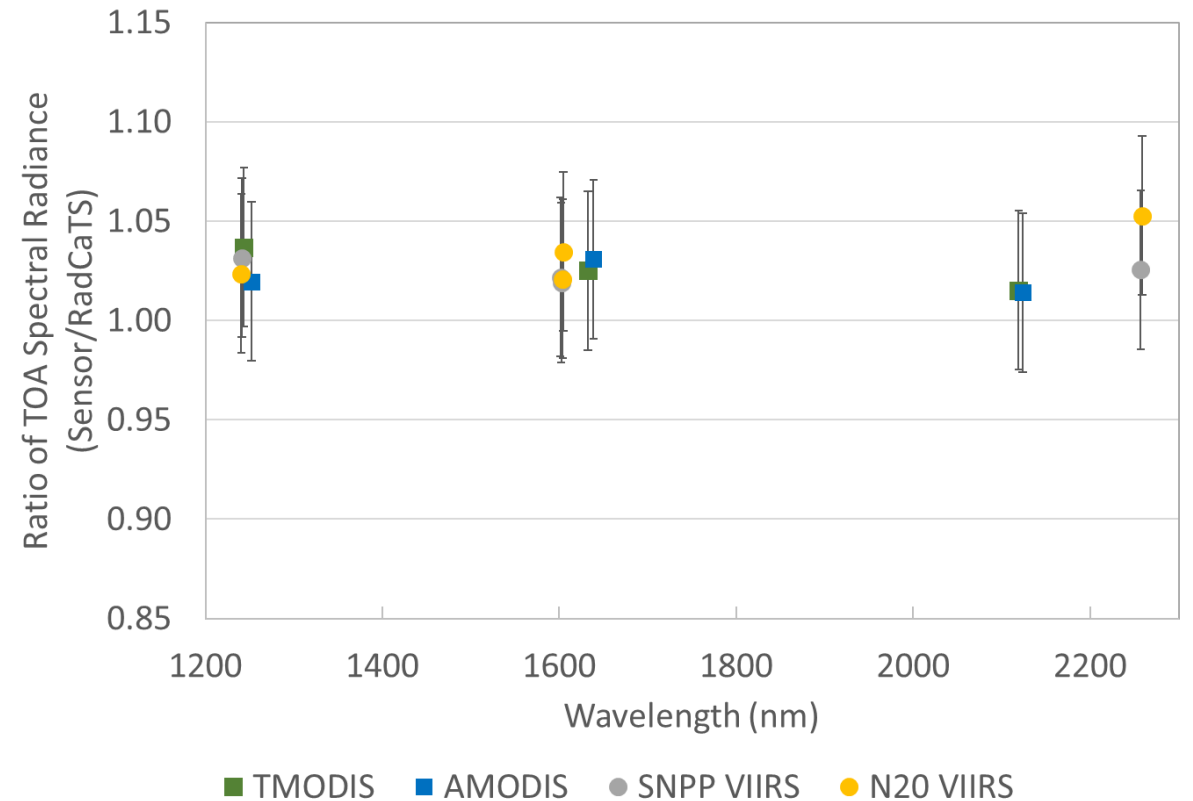
VNIR

Radiometric Validation Summary



SWIR

Radiometric Validation Summary

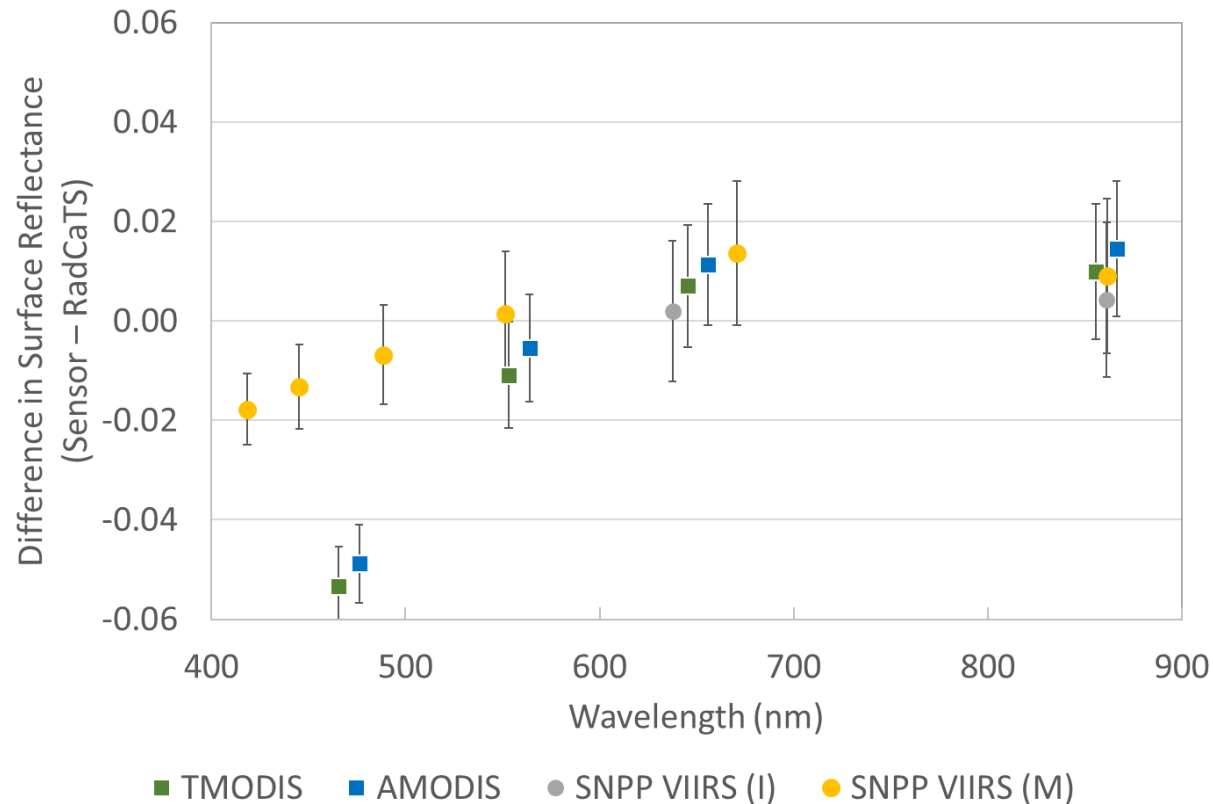


- Summary of all surface reflectance validation results

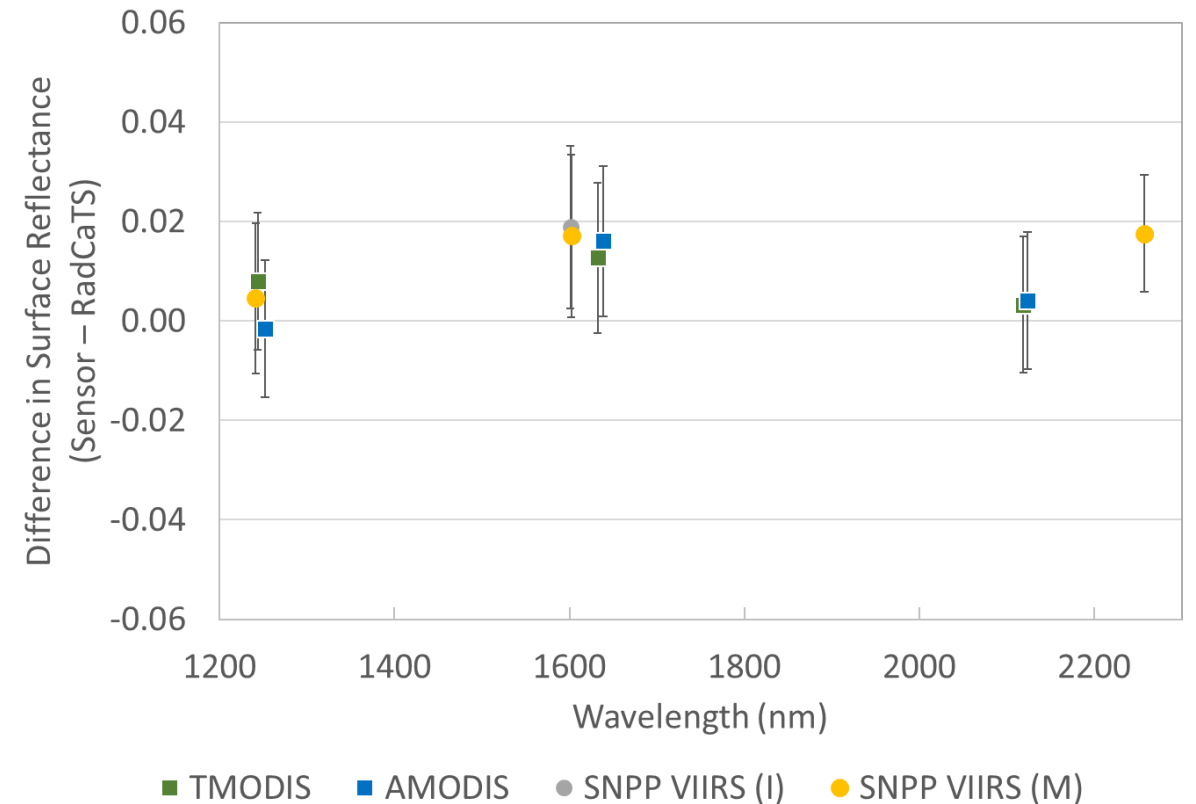
VNIR

SWIR

Surface Reflectance Validation (2013–2021)



Surface Reflectance Validation (2013–2021)



- **Conclusions**

- Terra and Aqua MODIS radiometric calibration agrees with RadCaTS to within uncertainties
- Terra and Aqua MODIS surface reflectance has bias with RadCaTS in blue band
- SNPP and NOAA-20 VIIRS radiometric calibration also agrees with RadCaTS to within uncertainties, except for NOAA-20 Band M11 (2.3 μm)
- Both pairs of sensors are in agreement to within RadCaTS uncertainty when using double ratio (or difference)

- **Upcoming work in 2021**

- Deployment of Headwall UAS for BRDF measurements at Railroad Valley
- On-site calibration of GVRs using CaTSSITTR
- Continued spatial analysis comparison with traditional reflectance-based approach and RadCaTS
- Integrate on-site VNIR spectrometer data into RadCaTS processing

Note: these results will be presented at SPIE Optics and Photonics (Aug 2021)