



Radiometric calibration of DigitalGlobe sensors using automated in-situ measurements

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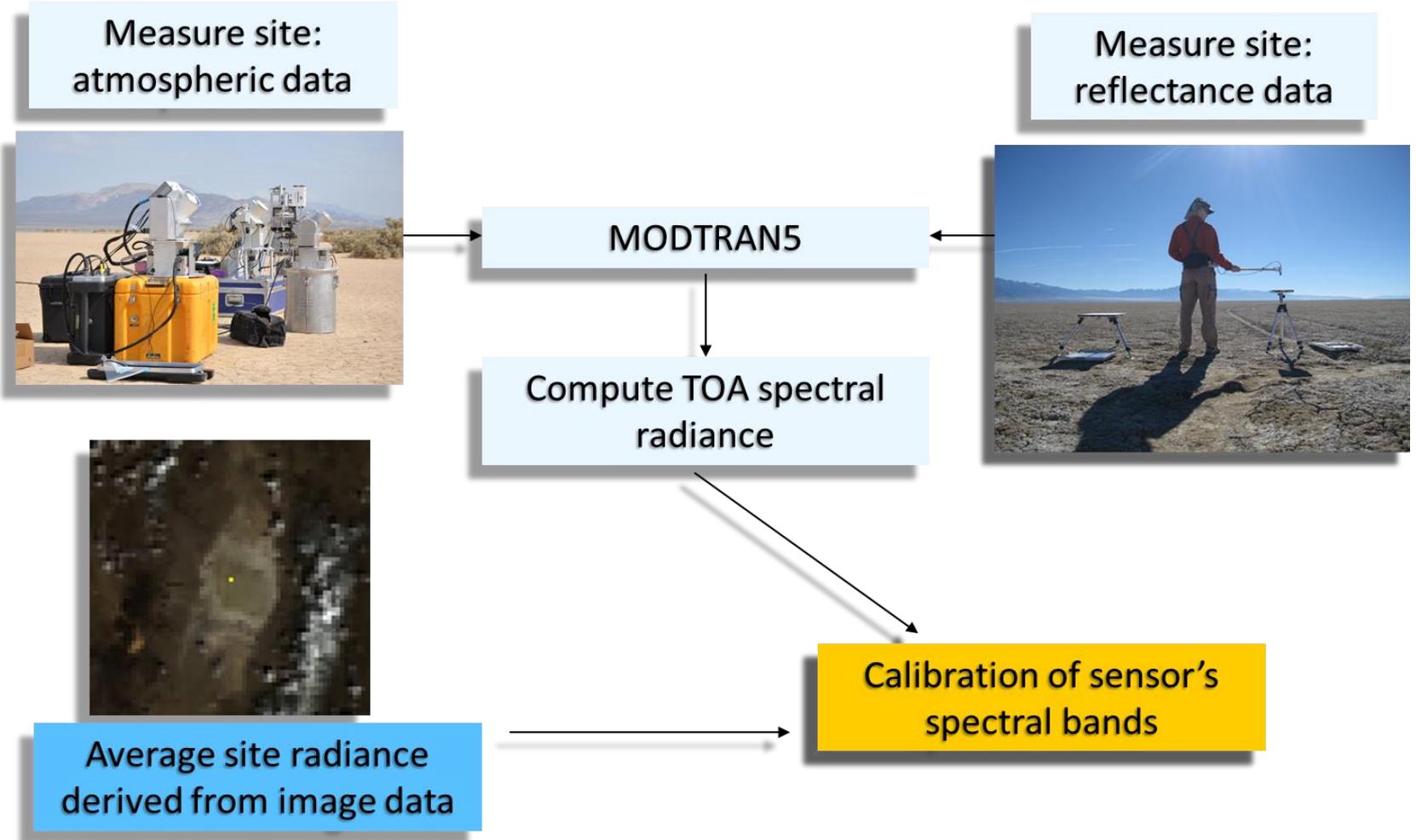
Introduction

- Vicarious calibration
 - Broad term used to describe independent radiometric calibration
 - In situ measurements
 - Lunar observations
 - Pseudo-invariant calibration sites (PICS)
 - Cross calibration
- Generally meant to describe calibration independent of onboard calibration systems

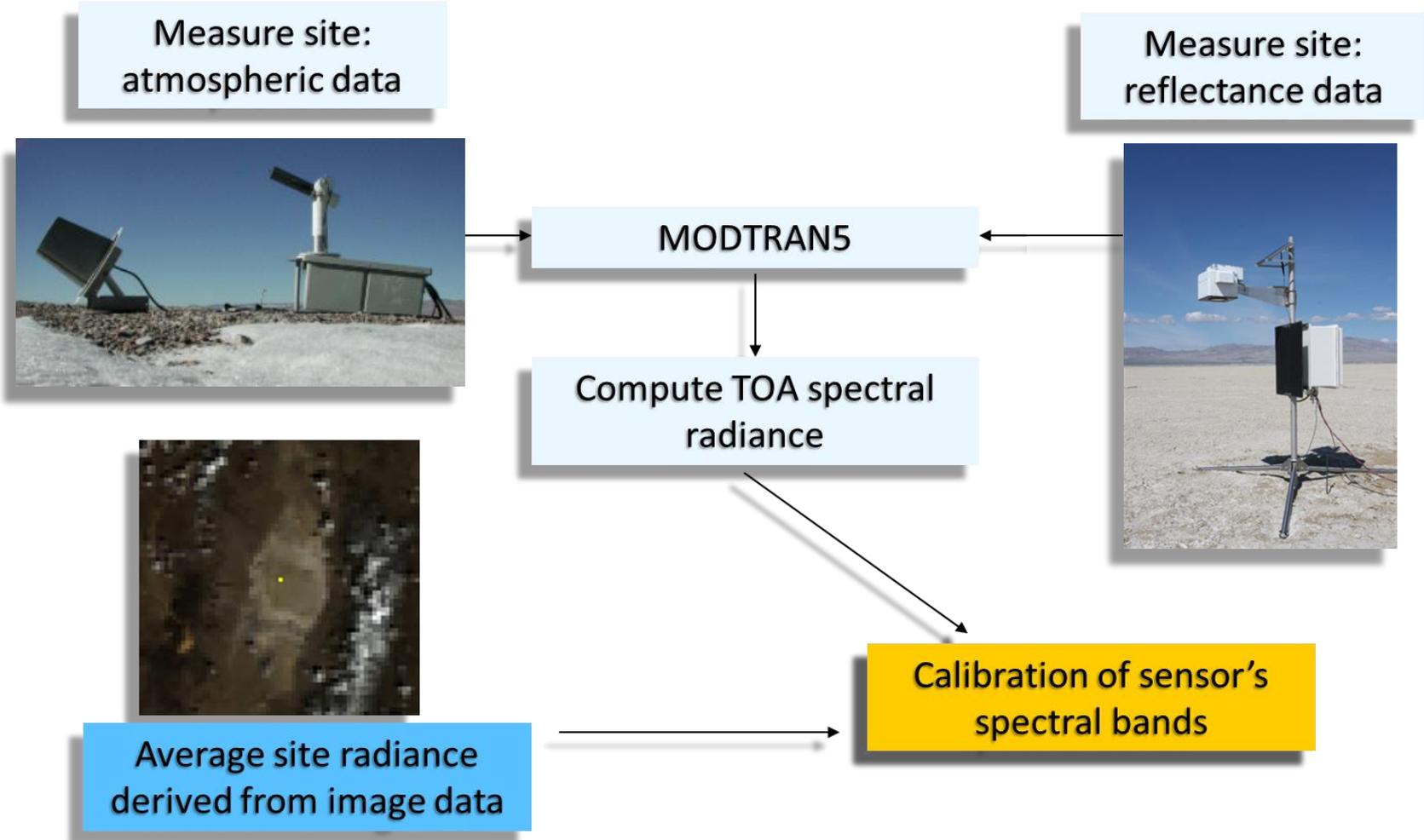
Introduction

- U. Arizona Remote Sensing Group (RSG) has been using reflectance-based approach for ~25 years
 - Combination of atmospheric and surface reflectance measurements
 - Requires radiative transfer code to determine atmospheric transmission
- RSG personnel performed dedicated field campaigns coinciding with specific satellite overpasses to collect necessary data
- Developed an automated system – RadCaTS – to provide necessary data to perform vicarious calibration

Reflectance Based Approach – Field Campaign

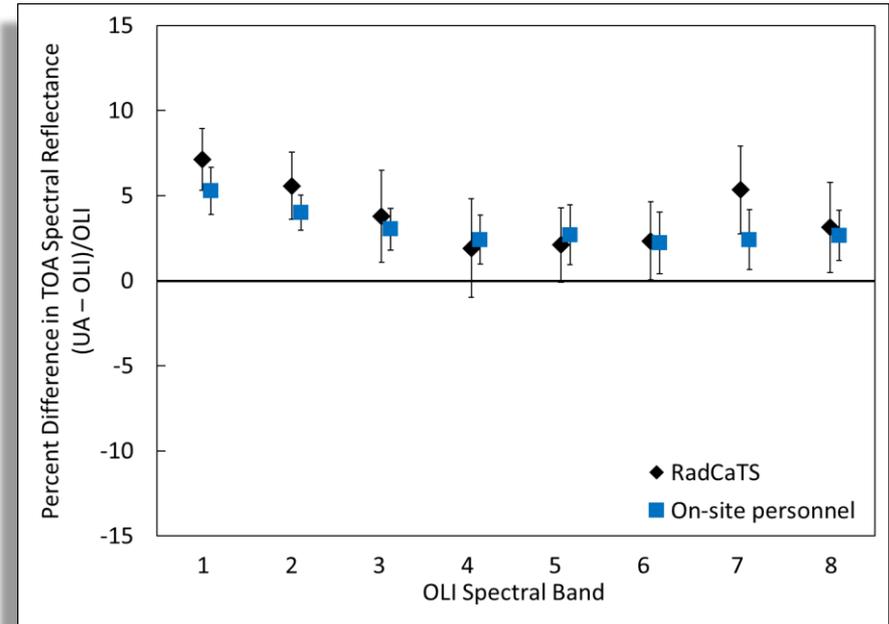
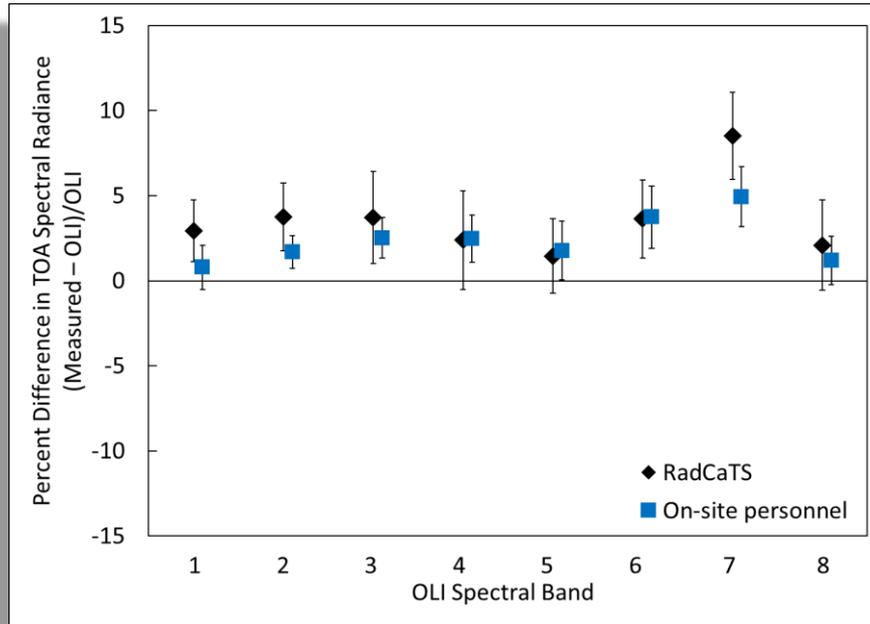


Reflectance Based Approach – RadCaTS



Reflectance Based Approach - Comparison

- Consistent results between the two approaches gives confidence in RadCaTS system



RadCalNet Approach

- RadCalNet: Multiple automated in-situ measurement sites operated independently using same methodology and processing chain with known and documented uncertainties
 - Product provided to users: TOA reflectance
 - 400-2500 nm (10 nm spectral sampling)
 - Defined for 50 m spatial area
 - Nadir view
 - 13 times per day: 9:00-15:00 local every 30 min
- CEOS Working Group on Calibration and Validation developing such a network from member agencies

*Talks in afternoon session will provide more detail on RadCalNet

RadCalNet Example

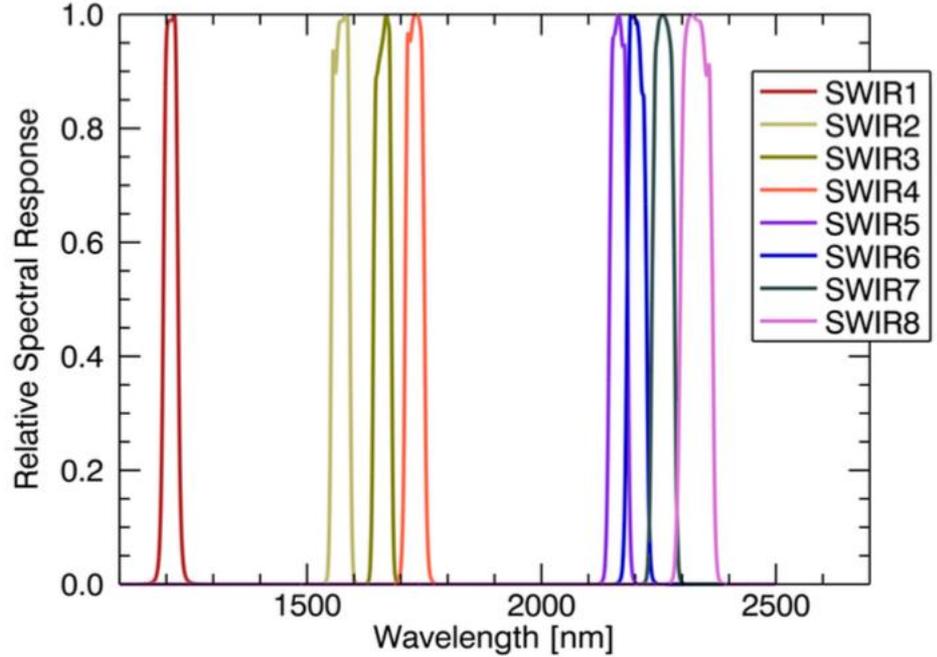
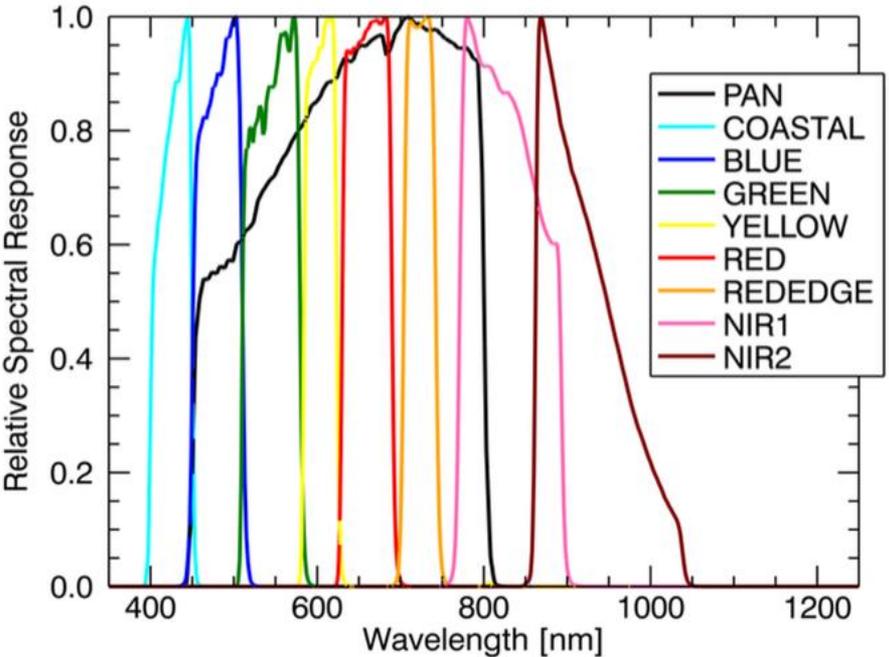
- RadCalNet aims to begin data production for beta users in fall 2016
- Objective: Use DigitalGlobe Worldview-3 images of Railroad Valley site to evaluate RadCalNet
 - High spatial resolution
 - VIS/NIR & SWIR
- Several days of images provided for Sept & Oct 2014
 - To mimic intended use of RadCalNet data concentrate on results for a single GVR

DigitalGlobe Worldview-3

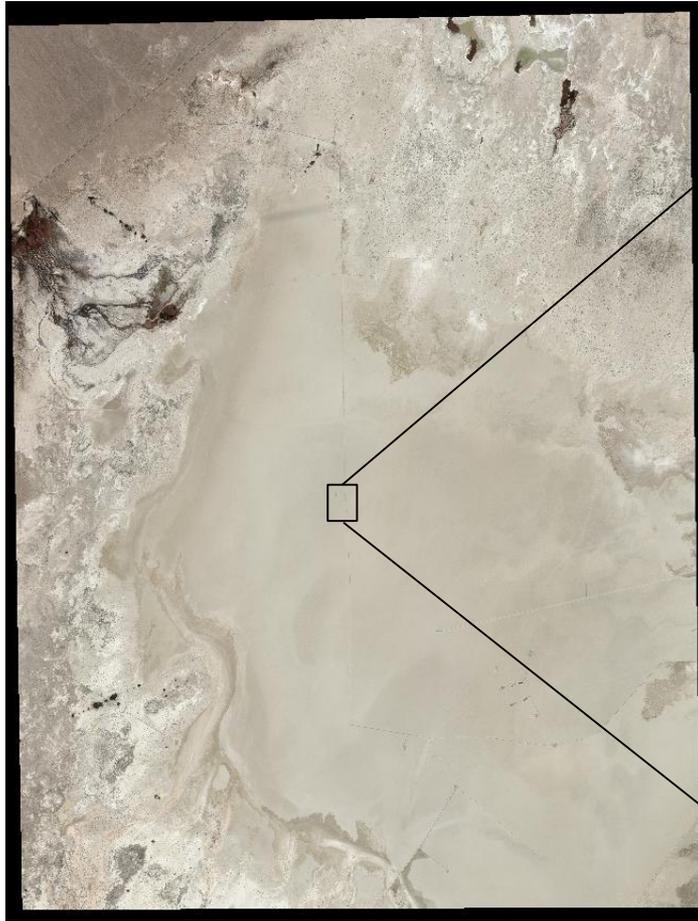
- Launched 2014
- Orbit
 - Altitude: 617 km
 - Sun Synchronous
 - 10:30 am descending node
- Spectral
 - 8 Vis/NIR bands (400-1040 nm)
 - 8 SWIR bands (1195-2365 nm)
- Spatial
 - Vis/NIR: 1.24 m
 - SWIR: 3.7 m



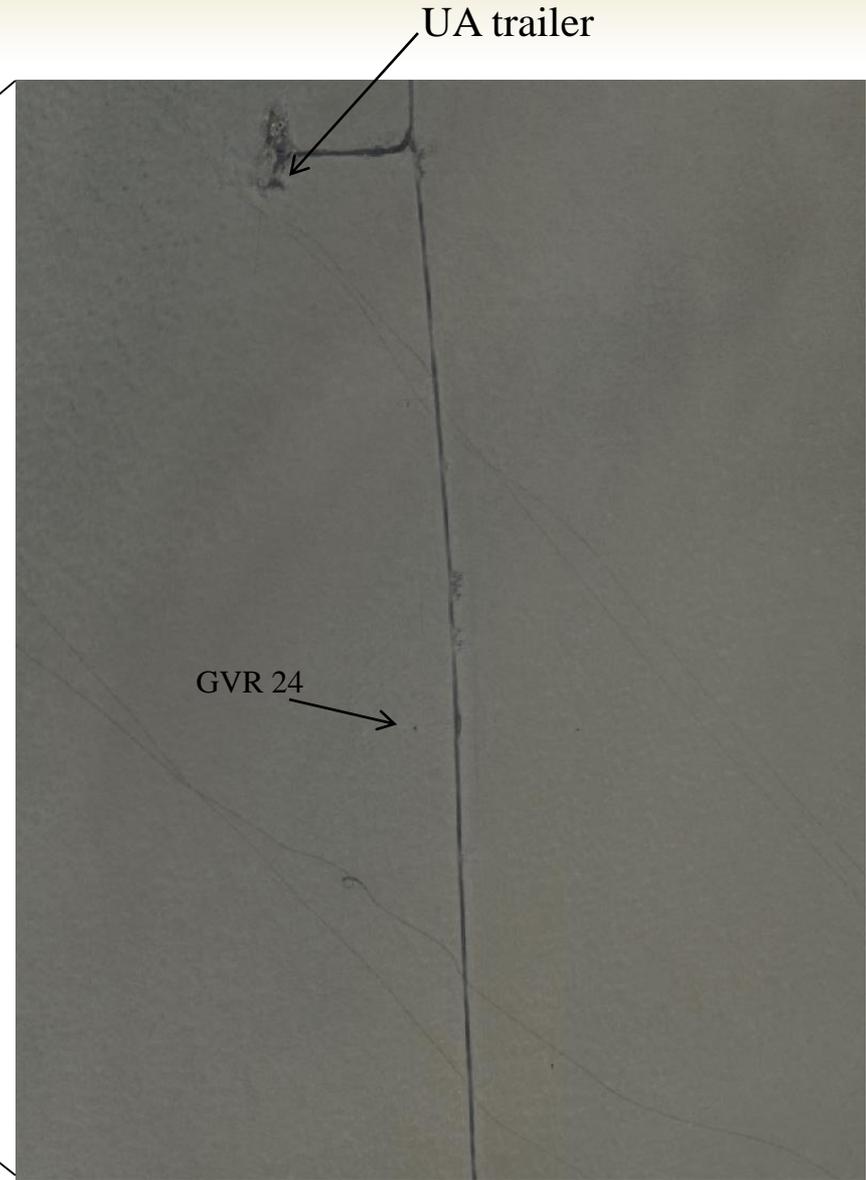
DigitalGlobe Worldview 3 – Spectral Bands



Railroad Valley, NV

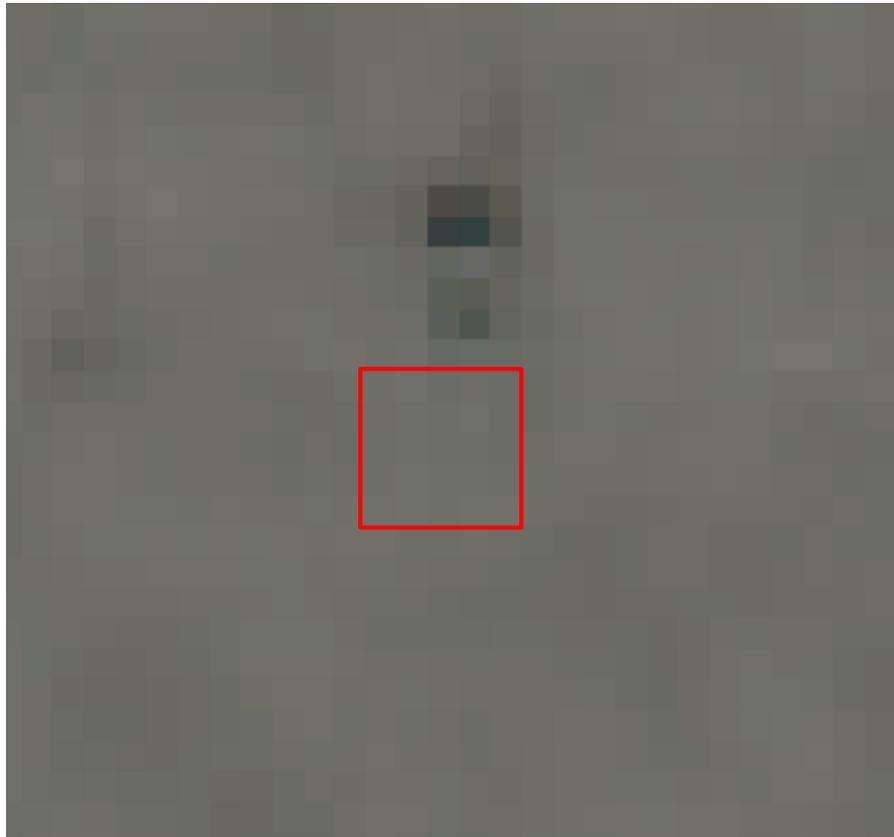


2014-10-15 18:33:10
Solar Zenith Angle = 48.7



Methodology

- Extract and average DNs from Worldview image
 - 5x5 pixel area near GVR location



Methodology

- Convert DN to Radiance (L) using calibration coefficients for each band

$$L = GAIN * DN * \left(\frac{abscalfactor}{effectivebandwidth} \right) + OFFSET$$

- Calculate TOA Reflectance, $\rho(TOA)$

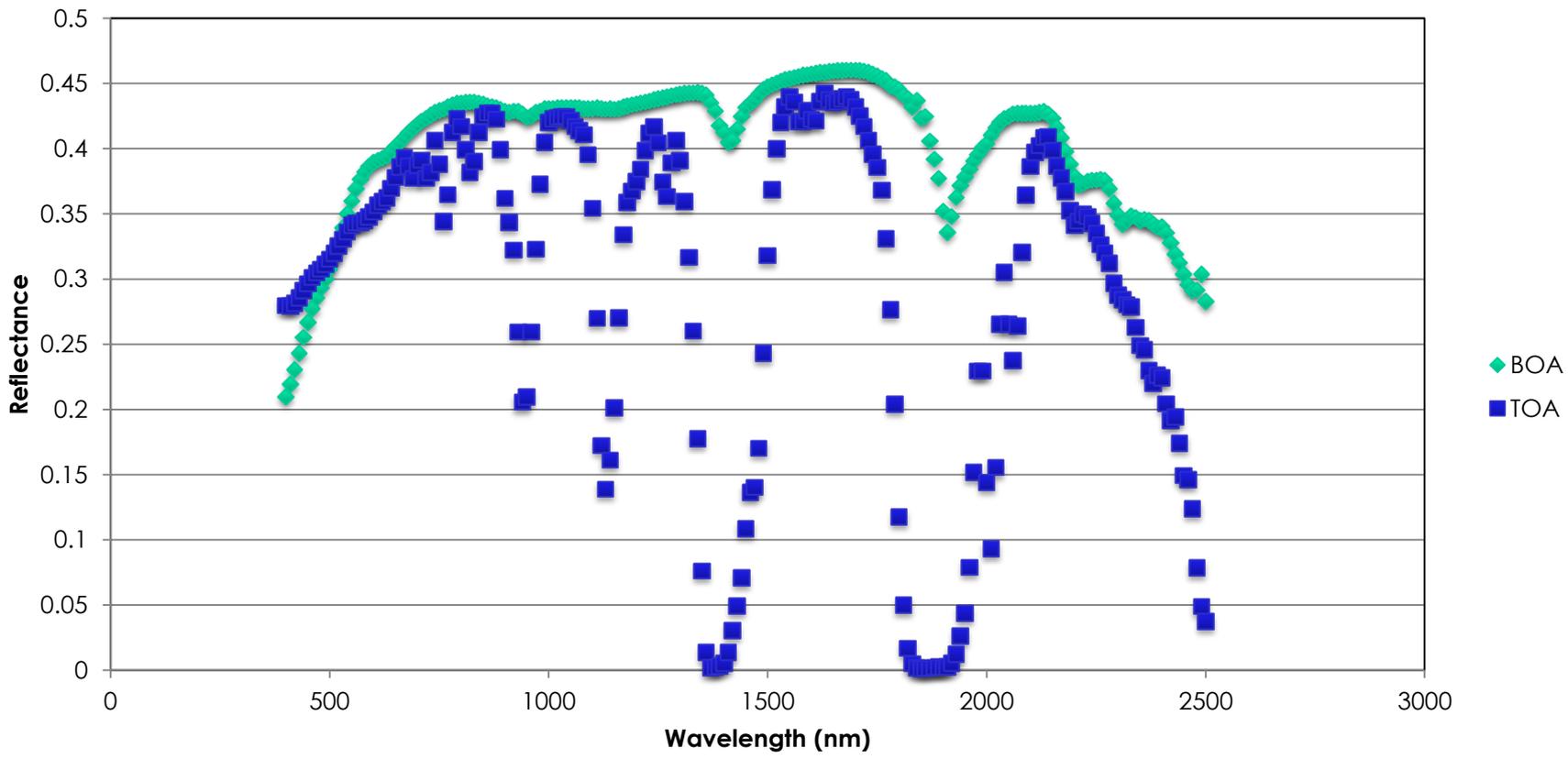
$$\rho(TOA)_\lambda = \frac{L_\lambda d^2 \pi}{E_\lambda \cos \theta_s}$$

d = Earth-Sun Distance

θ = solar zenith angle

E = solar irradiance

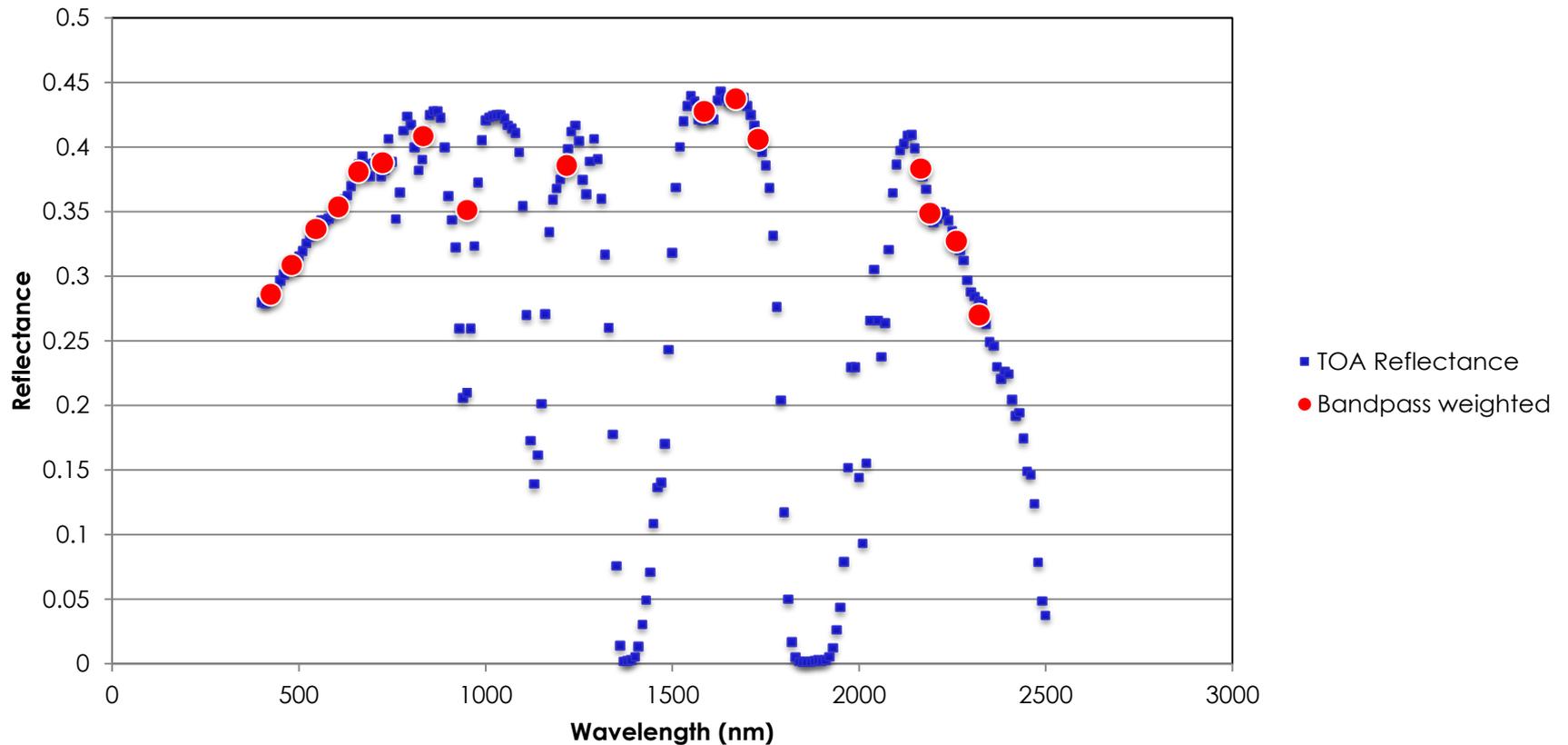
RadCalNet BOA/TOA Reflectance



2014-10-15 18:30:00

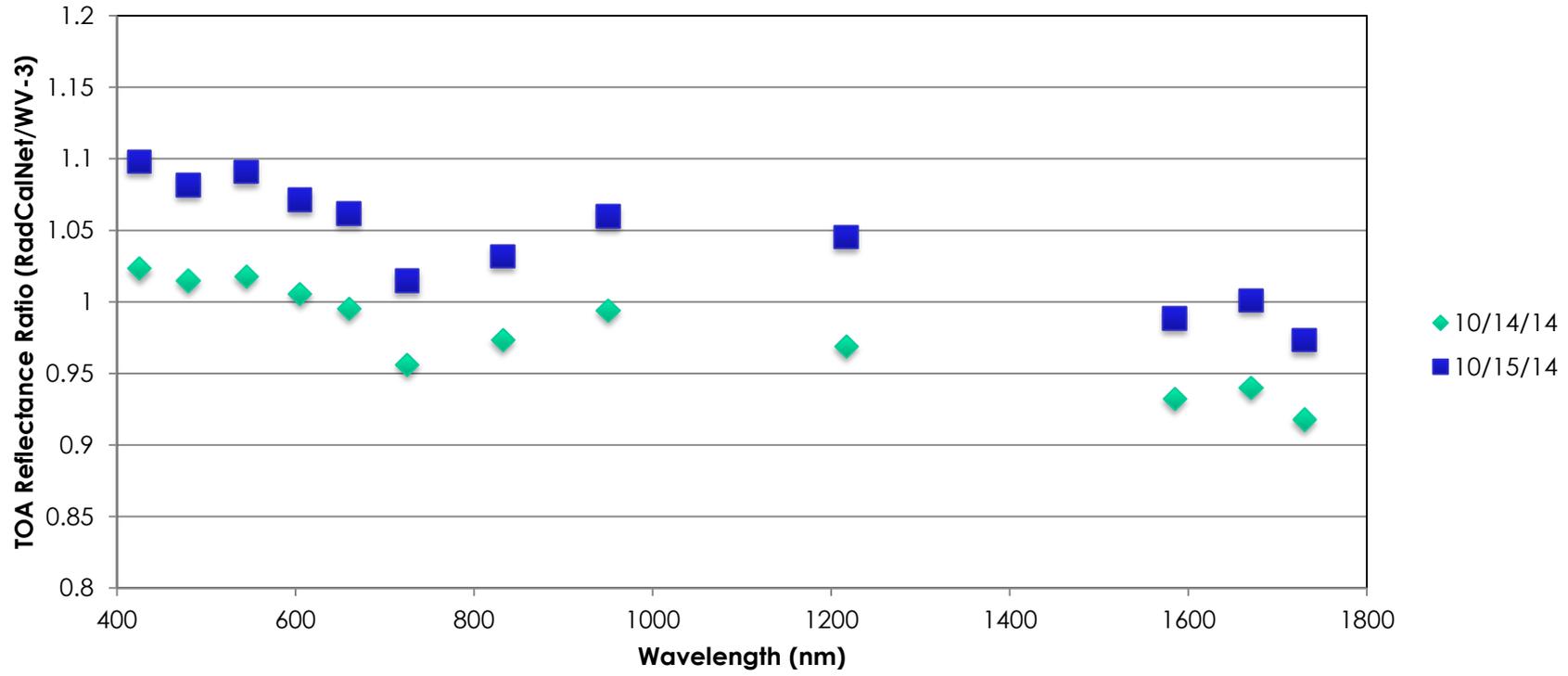
RadCalNet TOA Reflectance

Convolve Worldview-3 RSR info with RadCalNet data to generate TOA reflectance for each band

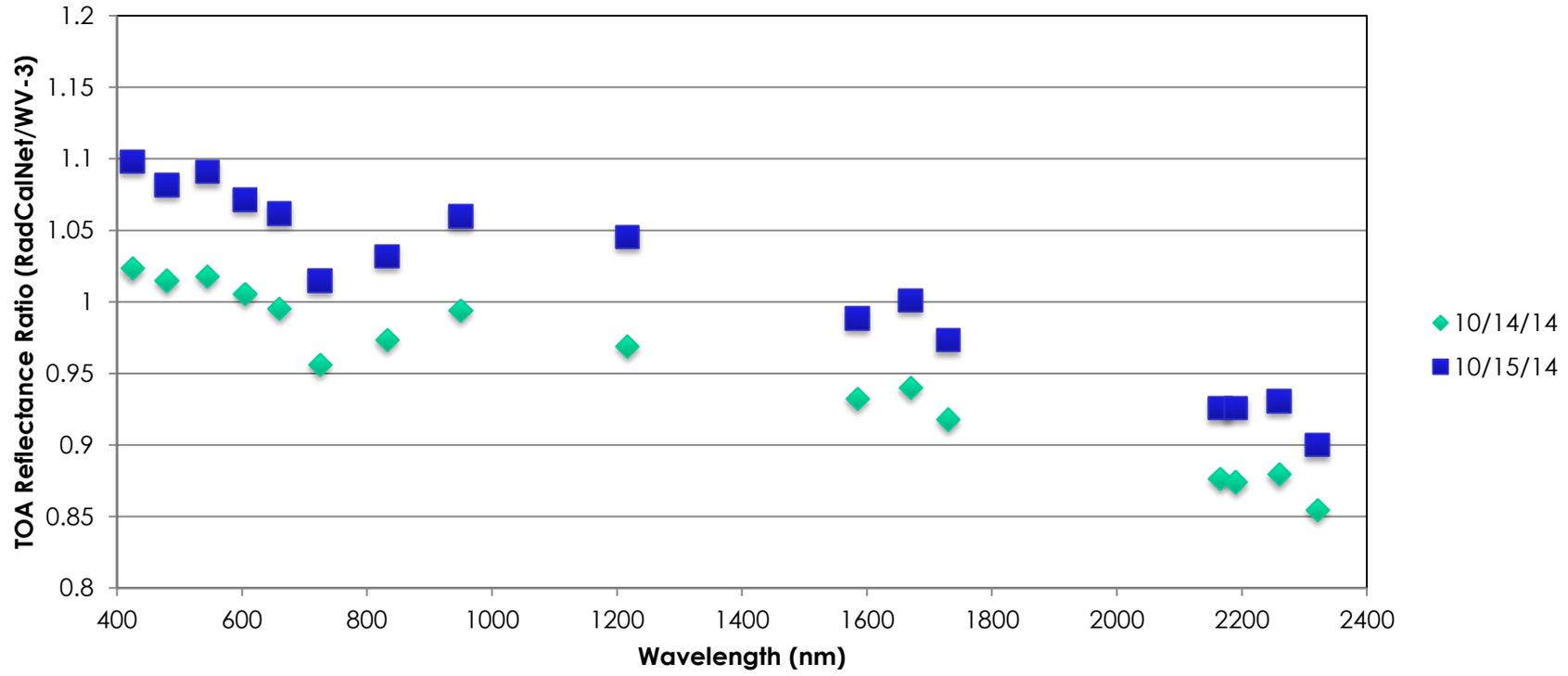


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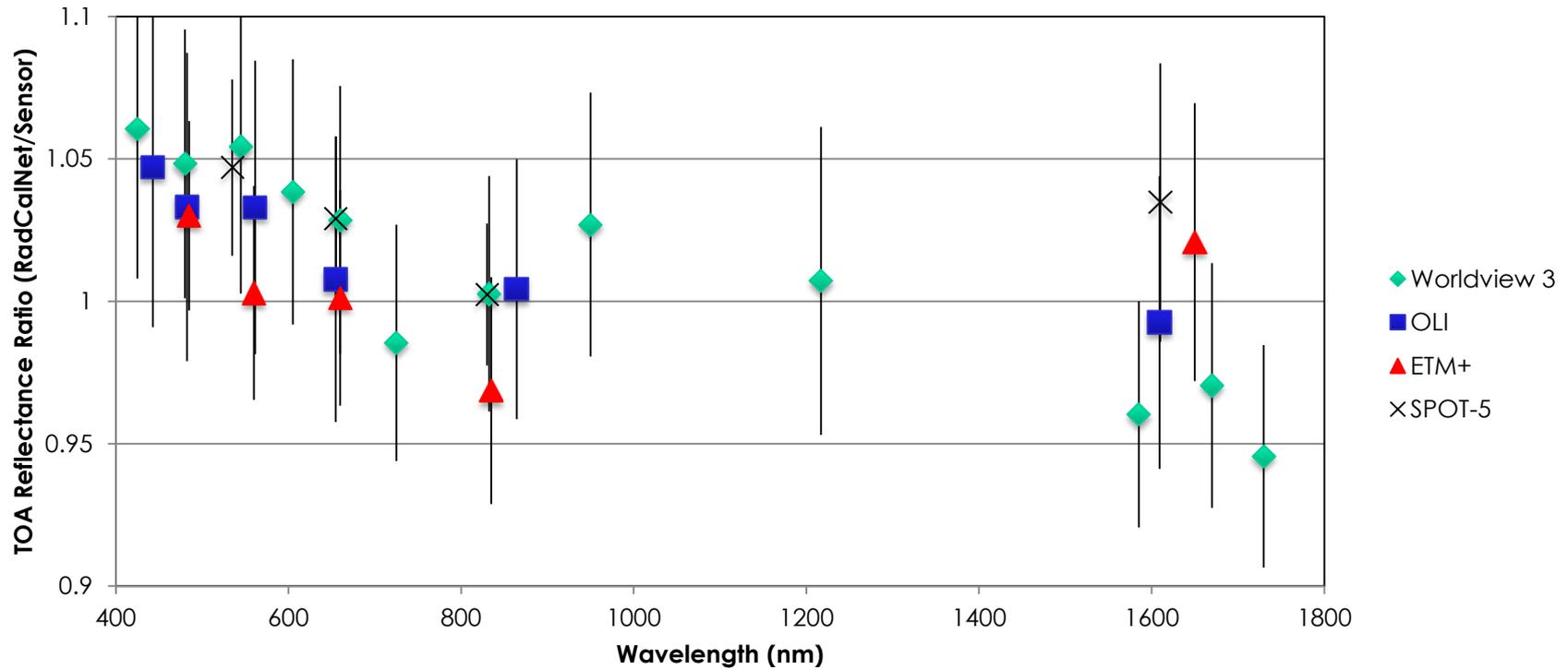
RadCalNet vs Worldview-3



RadCalNet vs Worldview-3

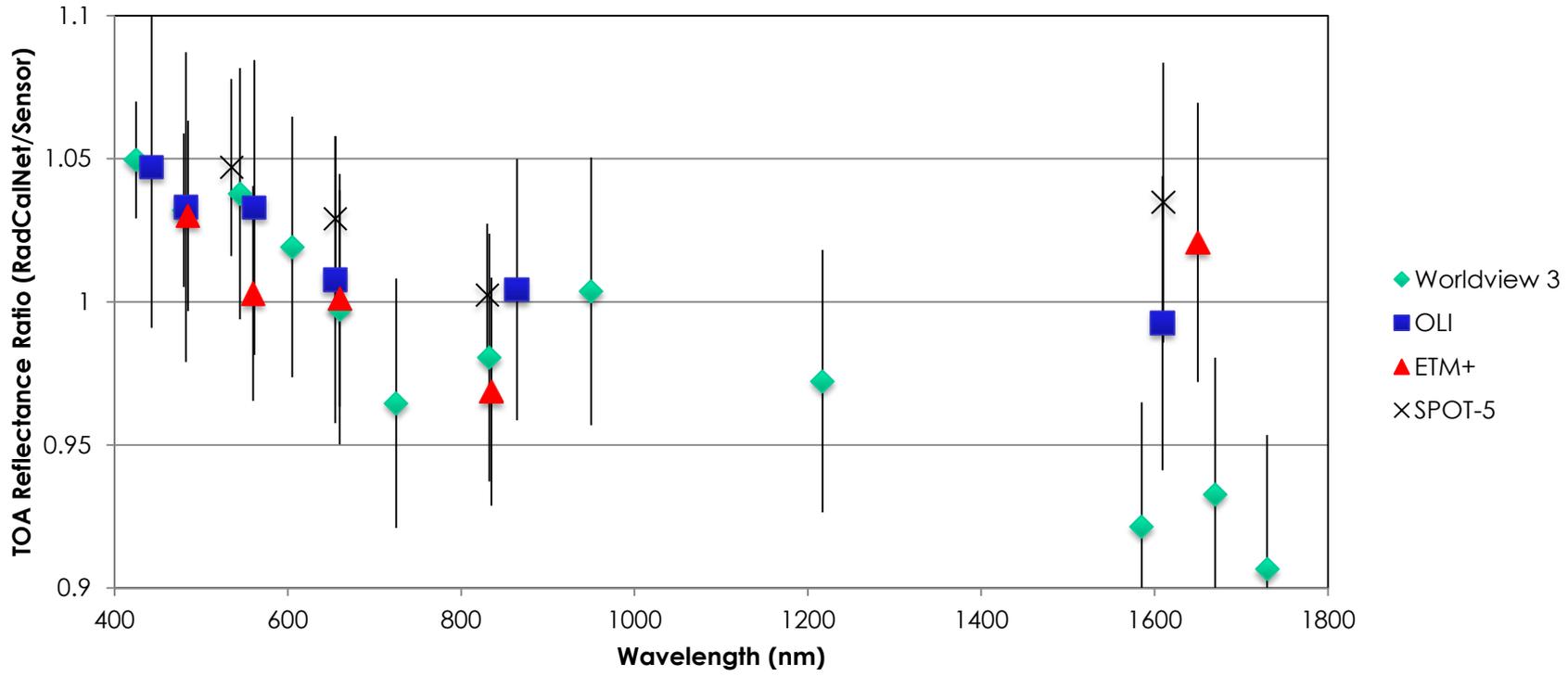


RadCalNet vs Multiple Sensors



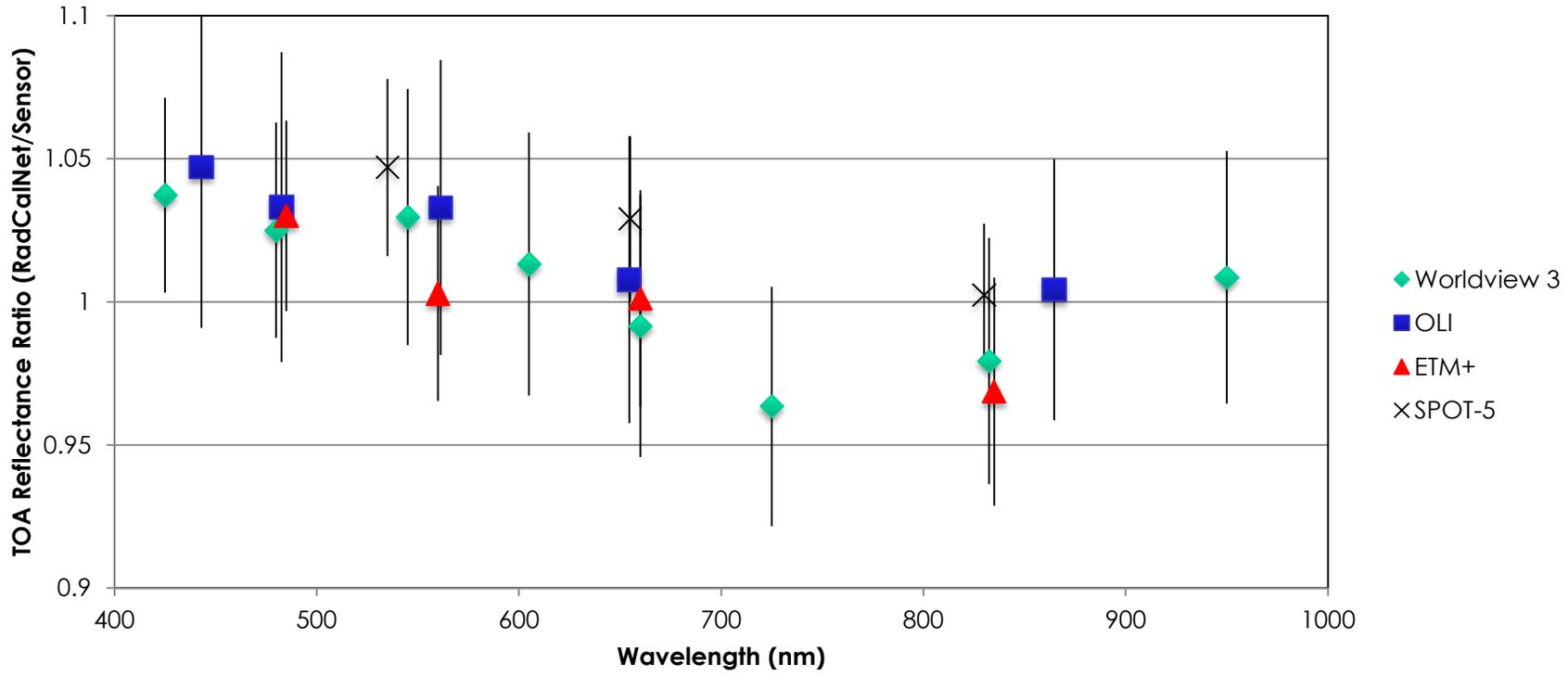
*Worldview-3 data for single GVR, 2 days, other sensors derived from average of 3 GVRs on multiple days

RadCalNet vs Multiple Sensors



*Worldview-3 data derived from average of 3 GVRs

RadCalNet vs Multiple Sensors – VIS/NIR



*All sensors derived from average of 3 GVRs for 6 days

Summary

- Agreement between RadCalNet and Worldview-3 is consistent with that seen from other sensors for Railroad Valley
- RadCalNet data is a soon-to-be-available tool that will allow radiometric calibration of moderate to high resolution sensors as long as the sensors view the site
 - SI-traceable scale with understood uncertainties
 - Working with multiple groups to assess RadCalNet products
 - Documenting the methodologies to produce a users guide