GLAMR Calibration as an Absolute Radiometric Calibration Approach

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Courtesy of NASA Landsat calibration team and GLAMR team

Outline

- The uncertainty associated to the traditional source-based RadCal method is assessed at 2+% for radiance measurement in the reflective solar (RS) region.
- The requirement for CLARREO Pathfinder (CPF) is 0.3%.
- Detector-based RadCal using tunable laser, like GLAMR, as light source could meet this calibration requirement.
- To demonstrate and assess the capability of the GLAMR RadCal as an absolute RadCal approach, the data from Landsat-9 OLI-2 pre-launch instrument-level spectral test using GLAMR is re-visited.
- Absolute GLAMR RadCal was conducted for CPF HySICS, the first for an operational instrument.

Detector-Based Absolute Radiance Calibration using GLAMR

- Goddard Laser for Absolute Measurement of Radiance (GLAMR) is a tunable laser source, that scans the RS range of 350-2500 nm.
- GLAMR RadCal has two steps: sphere Cal to derive GLAMR detector coefficients to calculate its output radiance; instrument Cal to measure instrument detector's responsivity
- The detector's responsivity is

$$ASR_k = \frac{S(\lambda_k)}{L(\lambda_k)}$$

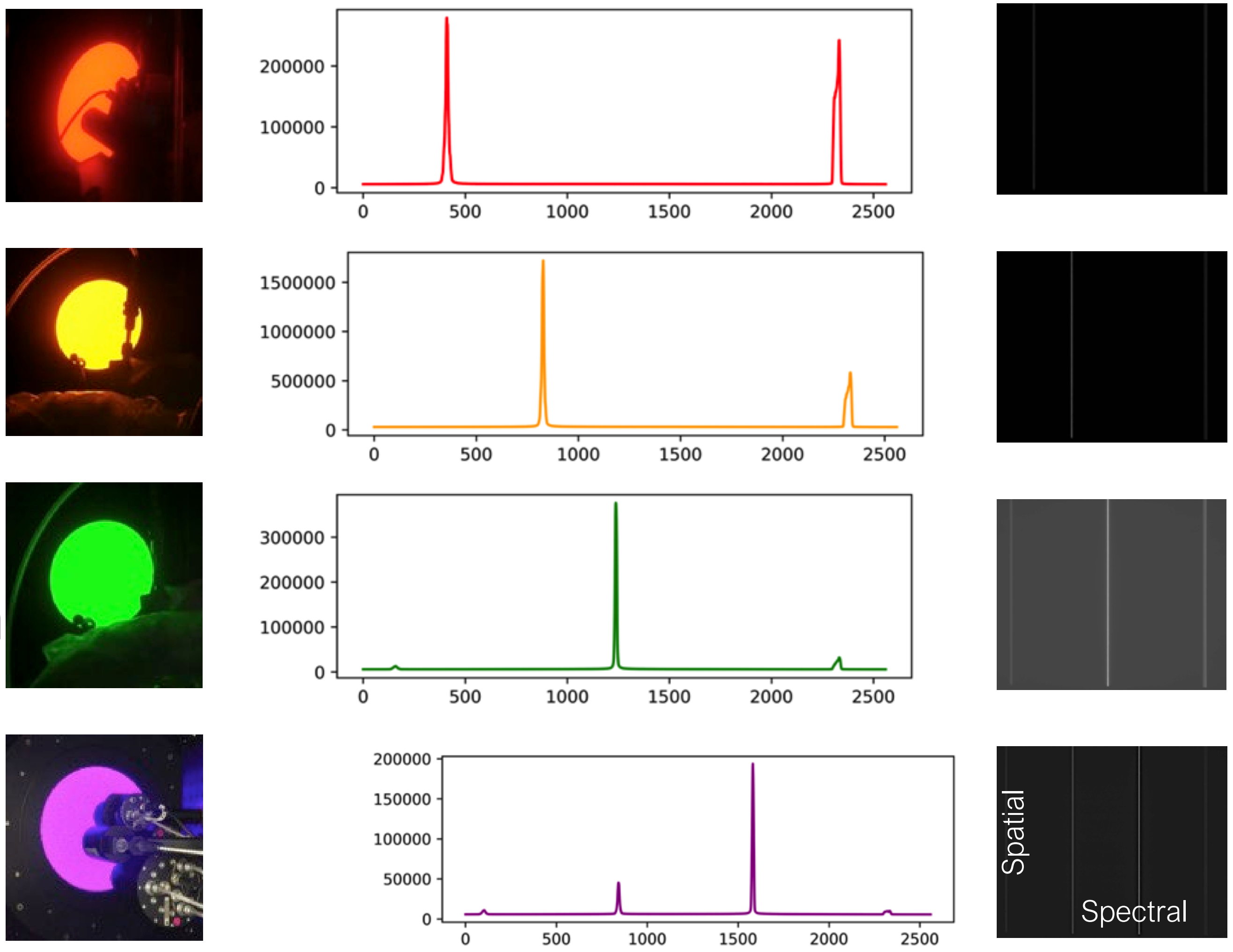
S: detector's response in DN

L: GLAMR laser radiance.

ASR: Absolute Spectral Response function

- The "band"-integrated gain is

$$g_{BI} = \sum_{k=1}^{k_{\max}} \frac{ASR_k + ASR_{k-1}}{2} [\lambda_k - \lambda_{k-1}]$$



Detector-Based RadCal: Improved Accuracy

- Detector-based GLAMR RadCal uncertainty budget (partially instrument dependent)

	UV	VIS	NIR	NIR	SWIR	SWIR	SWIR
Wavelength (nm)	350-400	400-950	950-1350	1350-1500	1500-1800	1800-2100	2100-2300
RSS Combined	0.24%	0.20%	0.38%	0.88%	0.45%	1.26%	0.55%

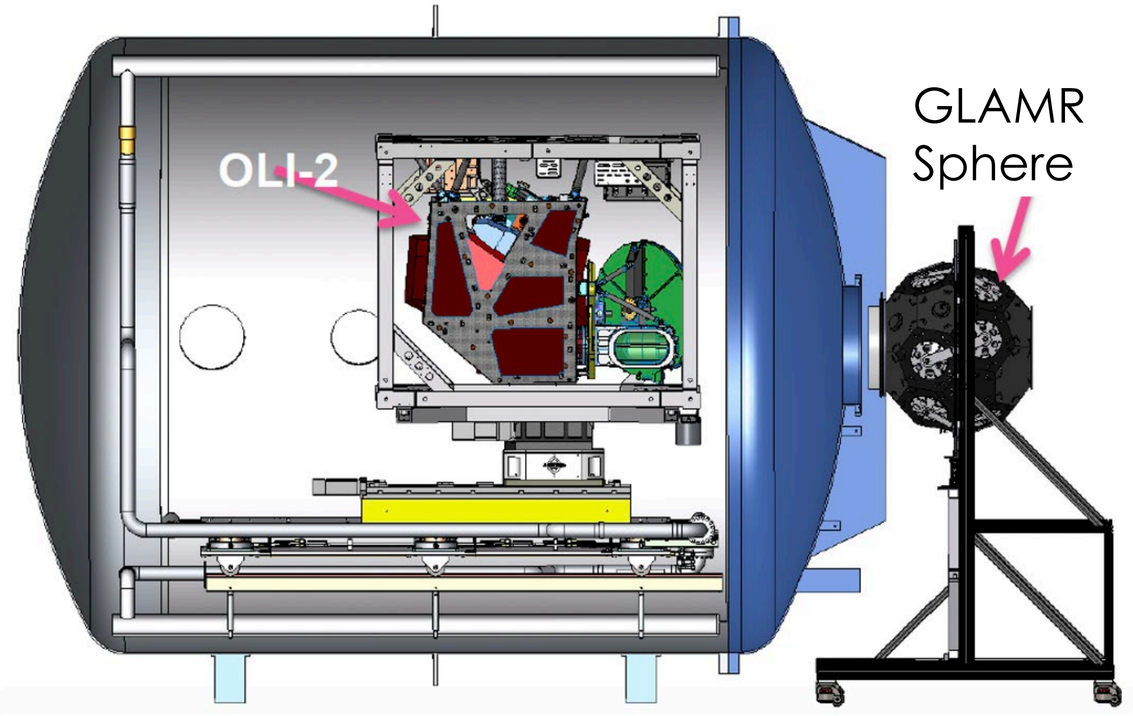
- Typical uncertainty values for existing RS instruments, calibrated by source-based approach

Instrument	Platform	Launch Year	UC Specified	UC Assessed
MODIS	Terra/Aqua	1999/2002	2% (R*) 5% (L)	1.6%-2.2%
VIIRS	S-NPP/NOAA-20/21	2011/2017/2022	2% (R)	1.2%-1.9%
OLI	Landsat-8/9	2013/2021	3% (R) 5% (L)	2.5%
OLCI	Sentinel-3 A/B	2016/2018	2% (R)	1.4%-1.9%

* R: reflectance.   L: radiance

Case Study: Landsat-9 OLI-2 GLAMR RadCal

- Pre-launch radiometric, spectral and spatial characterizations were conducted under a coordinated testing environment CATS for OLI-2
- GLAMR is required ONLY for instrument-level spectral characterization
- Official OLI-2 absolute RadCal is source-based, using a lamp-illuminated integrating sphere (DSS) as light source



OLI-2 spectral bands overview

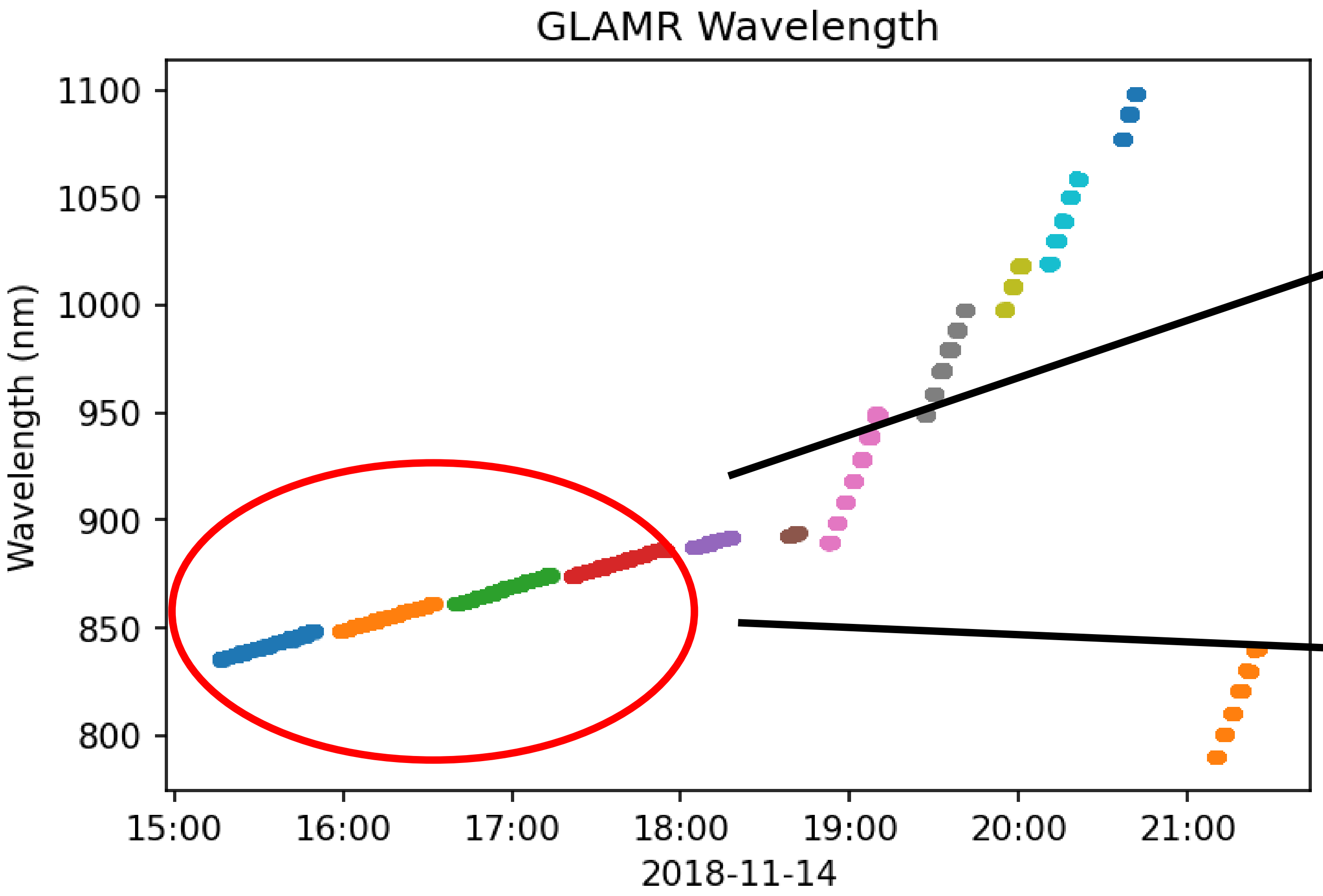
Band Name	Center Wavelength (nm)	Bandwidth (nm)	GSD (m)	SNR
Coastal/Aerosol	443	20	30	130
Blue	482	65	30	130
Green	562	75	30	100
Red	655	50	30	90
NIR	865	40	30	90
SWIR1 *	1610	100	30	100
SWIR2 *	2200	200	30	100
Pan	590	180	15	80
Cirrus *	1375	30	30	50

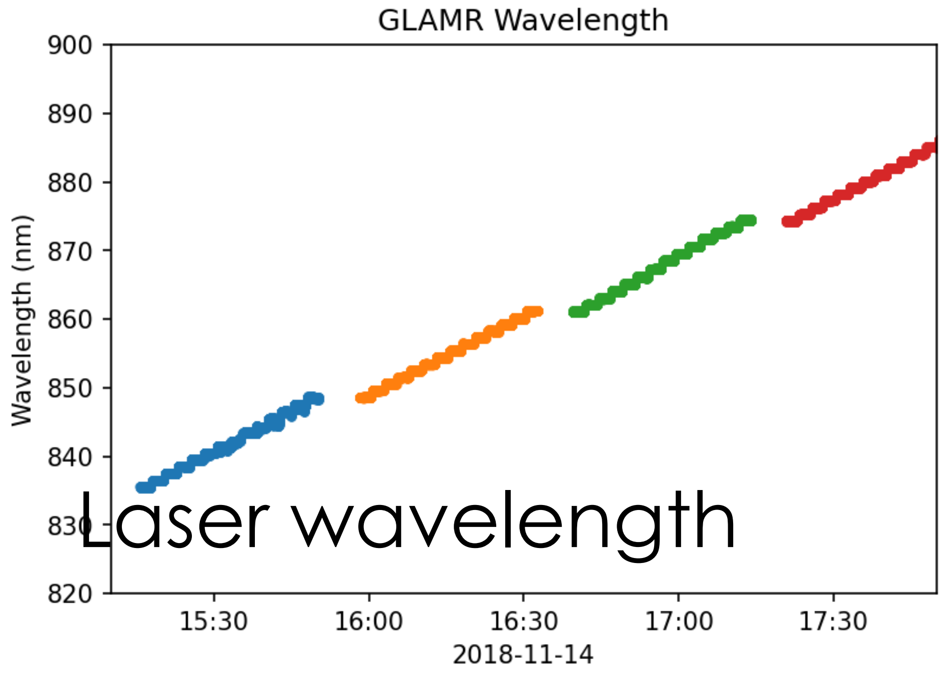
Notes: * SWIR Bands. All other bands are Visible/NIR.

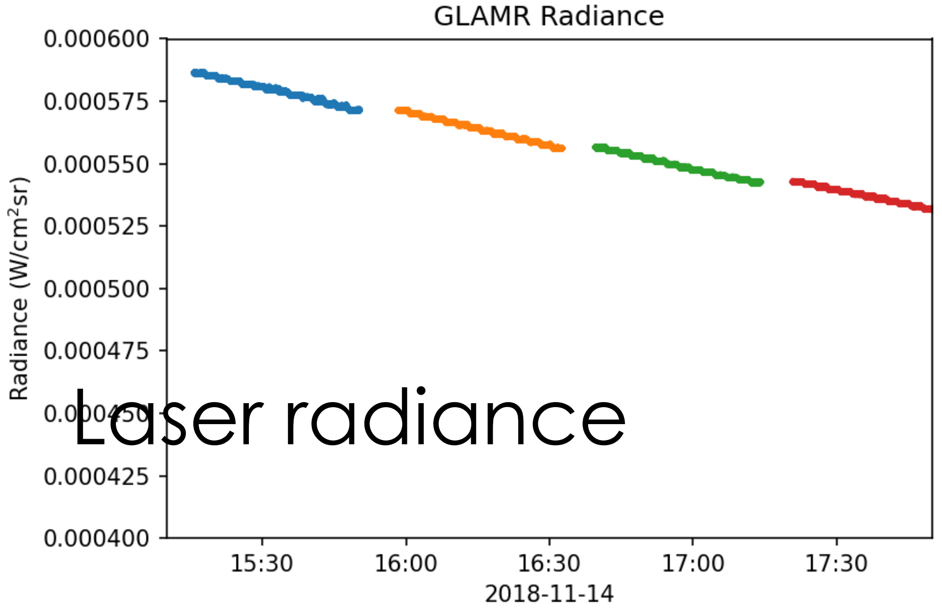
Knight, E.J., "Overview of the Operational Land Imager (OLI-2) pre-launch characterization and calibration." (2019)

GLAMR Data Collected: Samples

- Sample data for in-band measurements of NIR band (845-885 nm)
- GLAMR was operated with OPO-NIR laser
- Four segments of measurements circled
- The wavelength sampling step was set at 1-nm

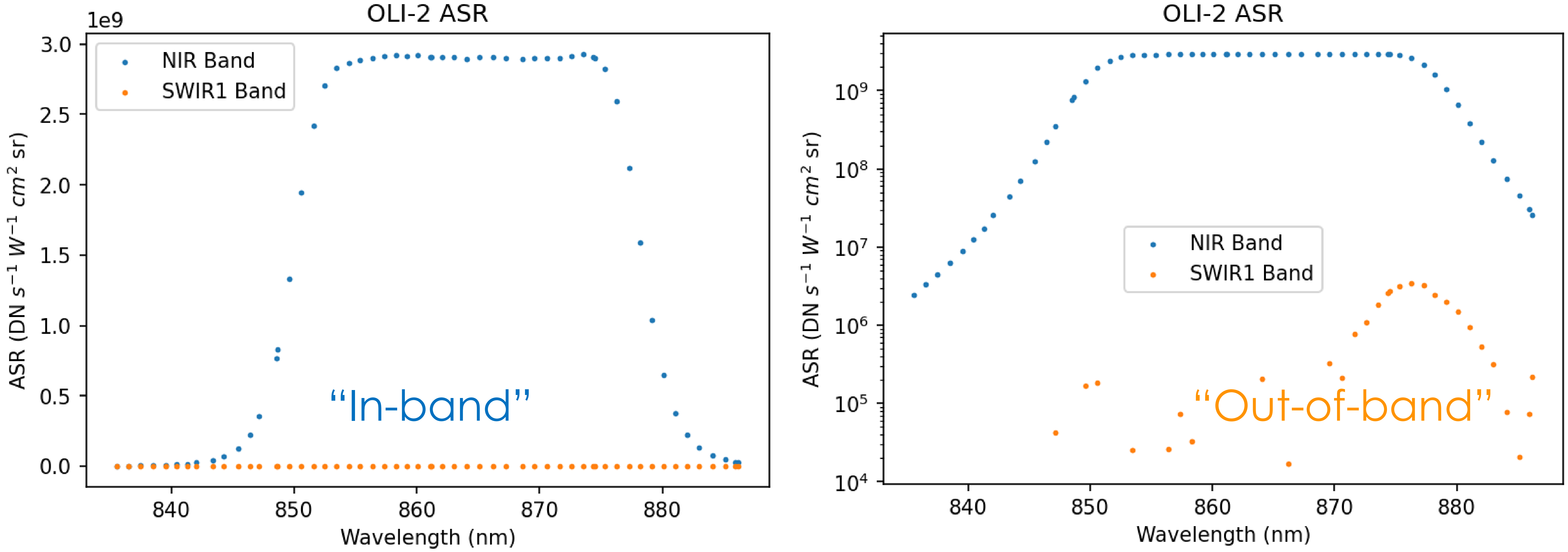






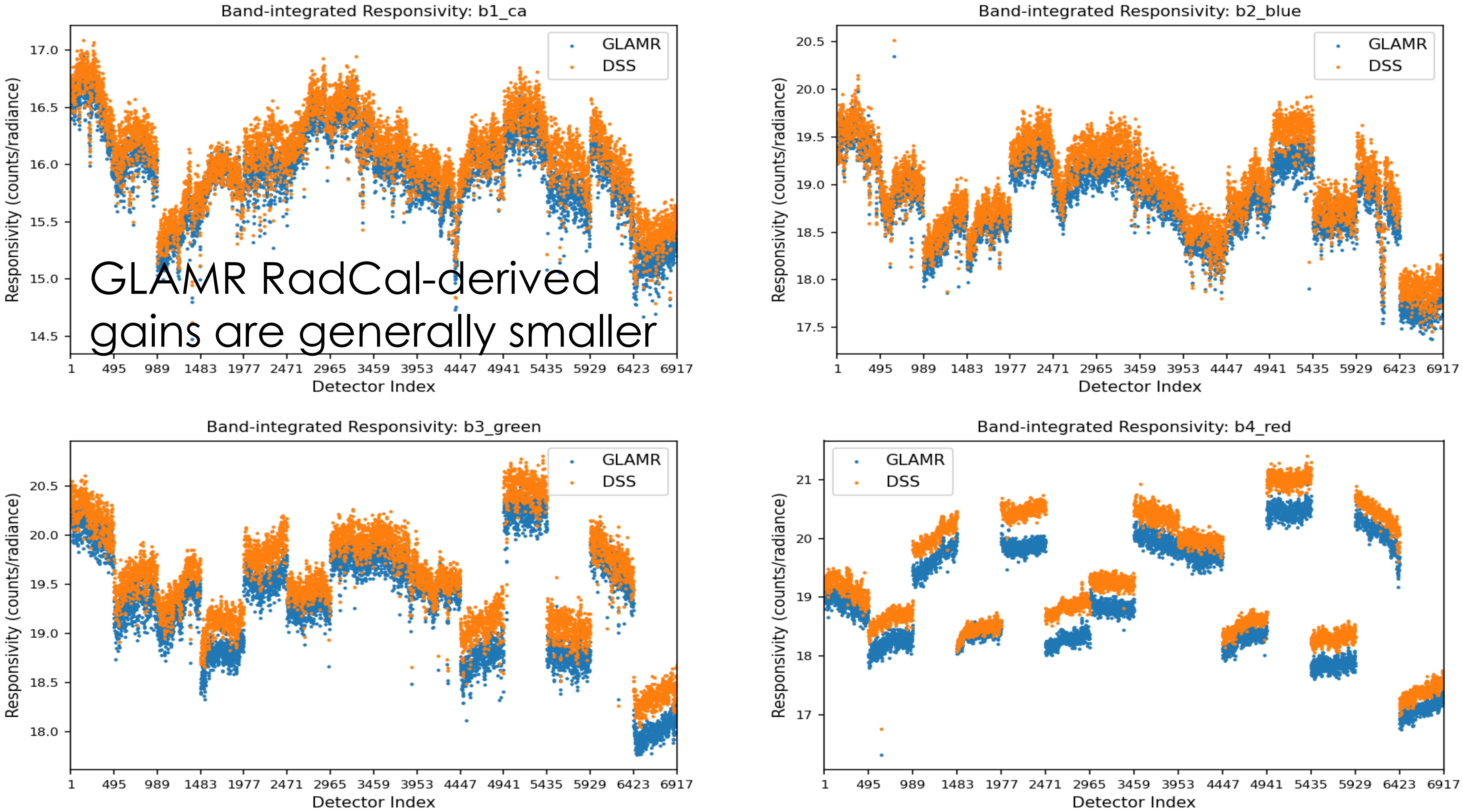
Sample ASRs from GLAMR RadCal

- At each GLAMR wavelength λ_k, the ASRs of all detectors/bands are derived. This wavelength may correspond to the "in-band" region of some bands and "out-of-band" region of other bands.

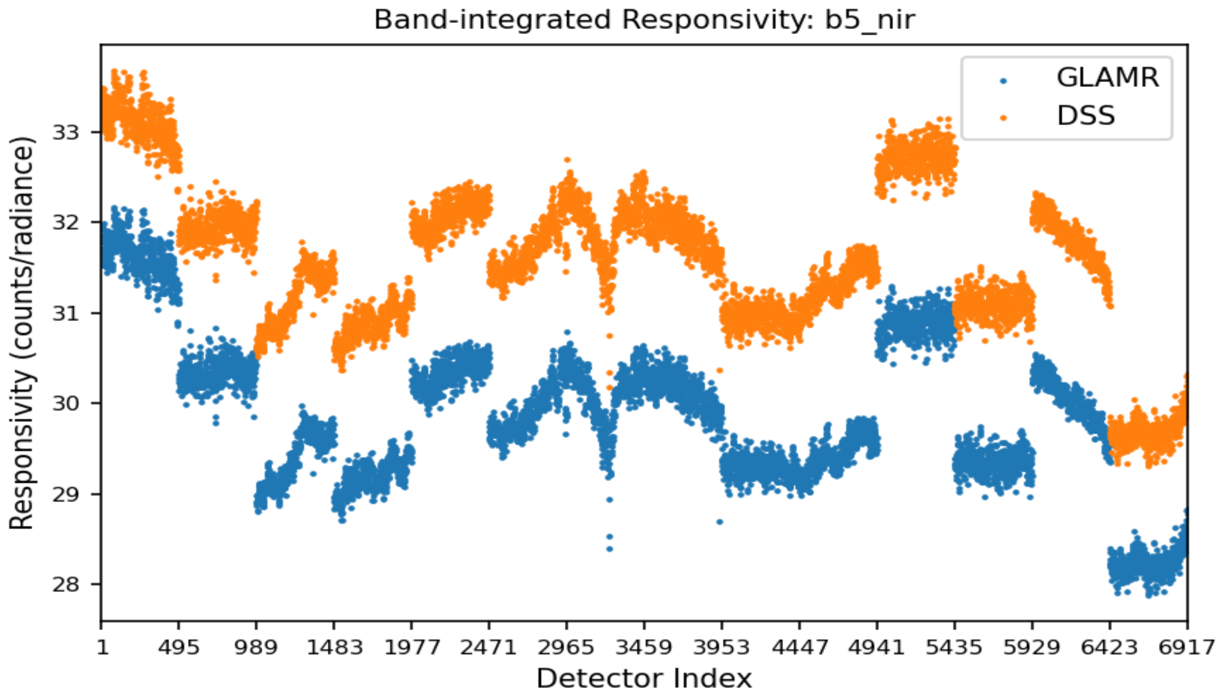


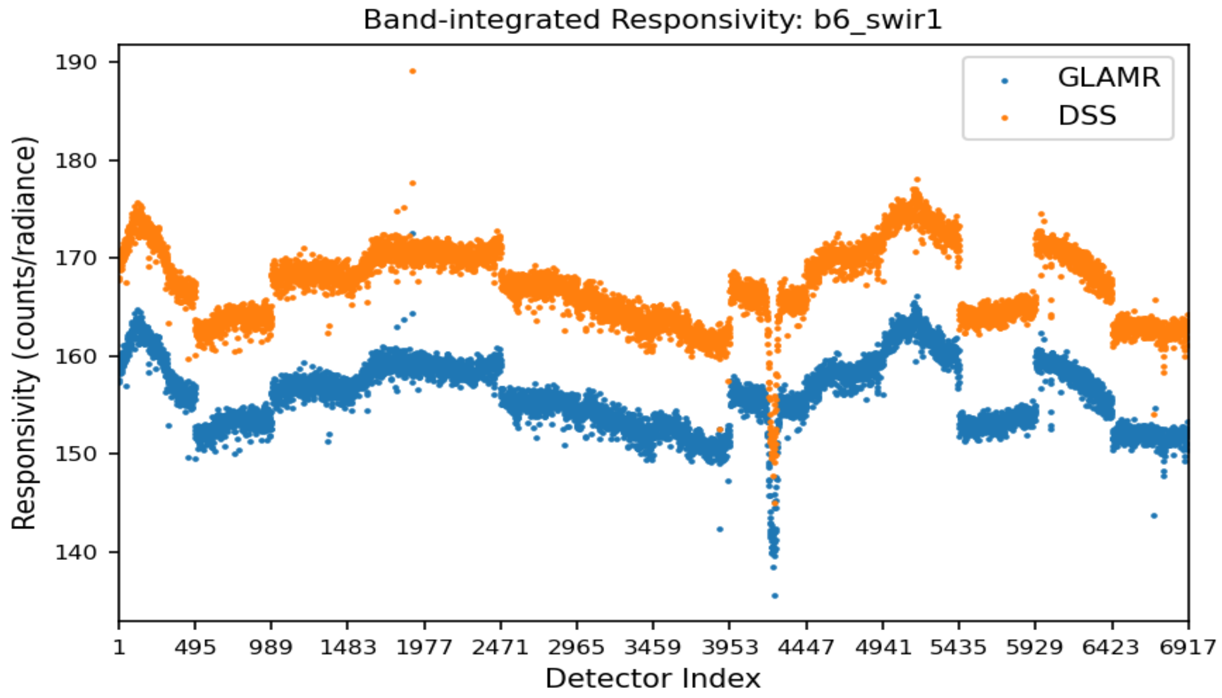
- The processing code was conveniently adapted from the software developed to process CPF GLAMR RadCal data.

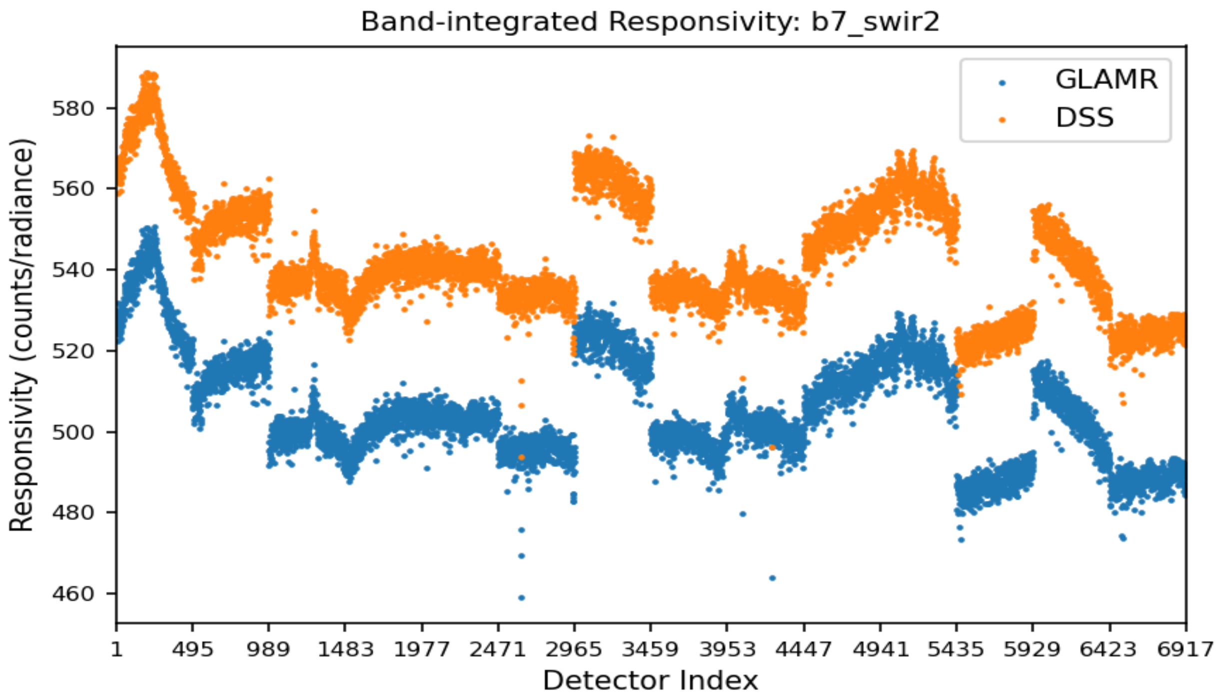
DSS Gain vs GLAMR Gain: Absolute-Scale at Pixel-Level

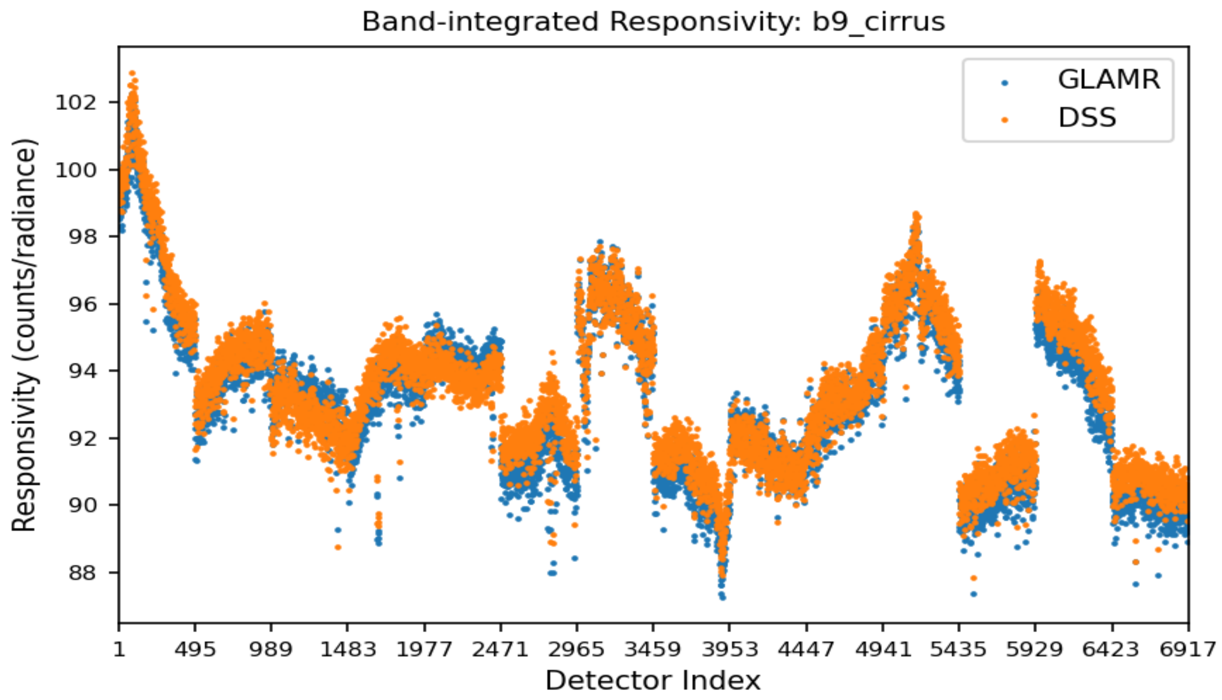


DSS Gain vs GLAMR Gain: Absolute-Scale at Pixel-Level



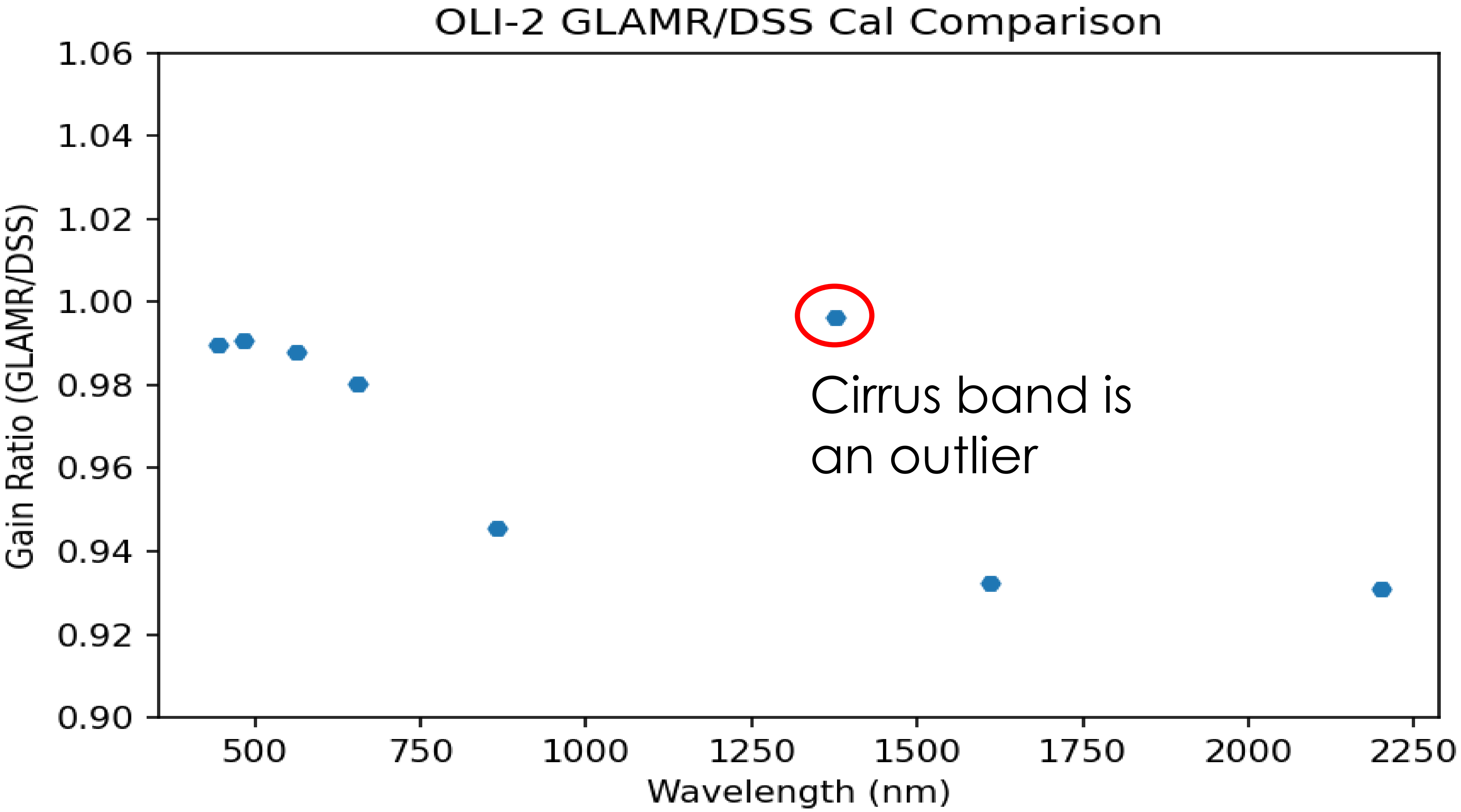




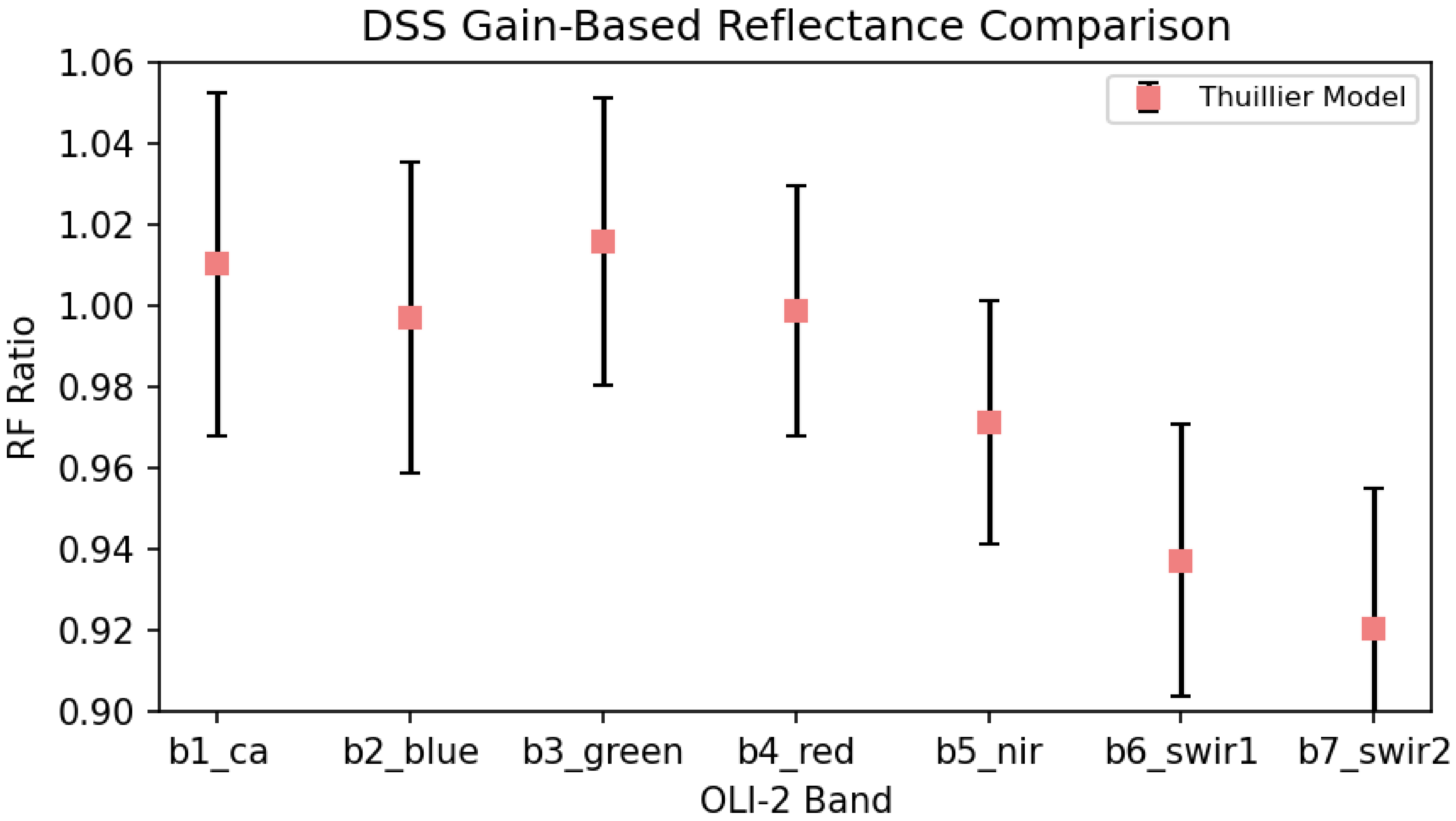


DSS Gain vs GLAMR Gain: Band-Averaged Values

- The uncertainty of DSS RadCal is assessed at ~2% (k=1) for all bands
- The GLAMR/DSS gain deviation in SWIR region is ~7%

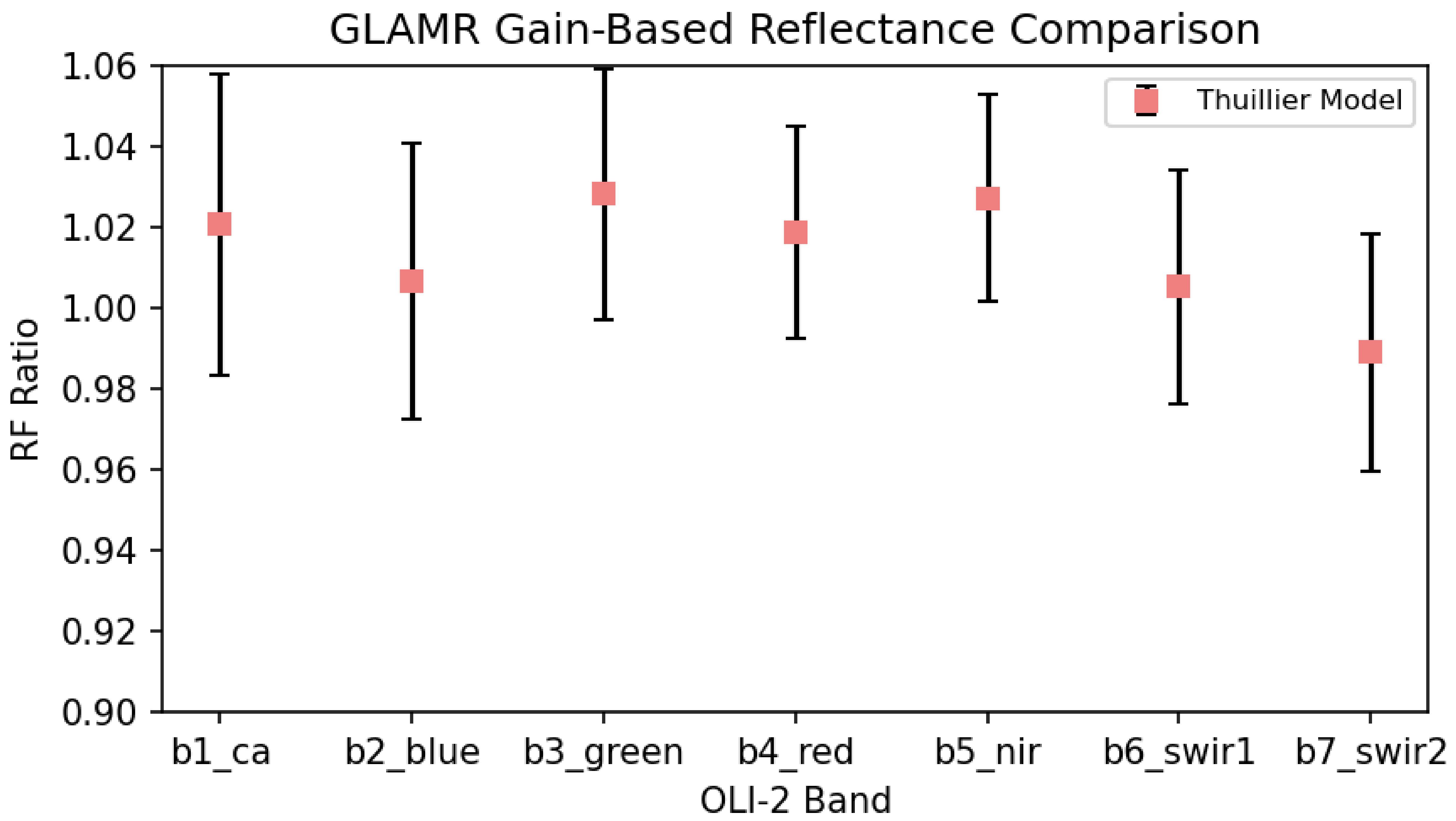


Comparison of OLI-2 Reflectance/Radiance RadCal: DSS Gain



Error bar is 1-σ fidelity range; Two SWIR bands are out-of-family.

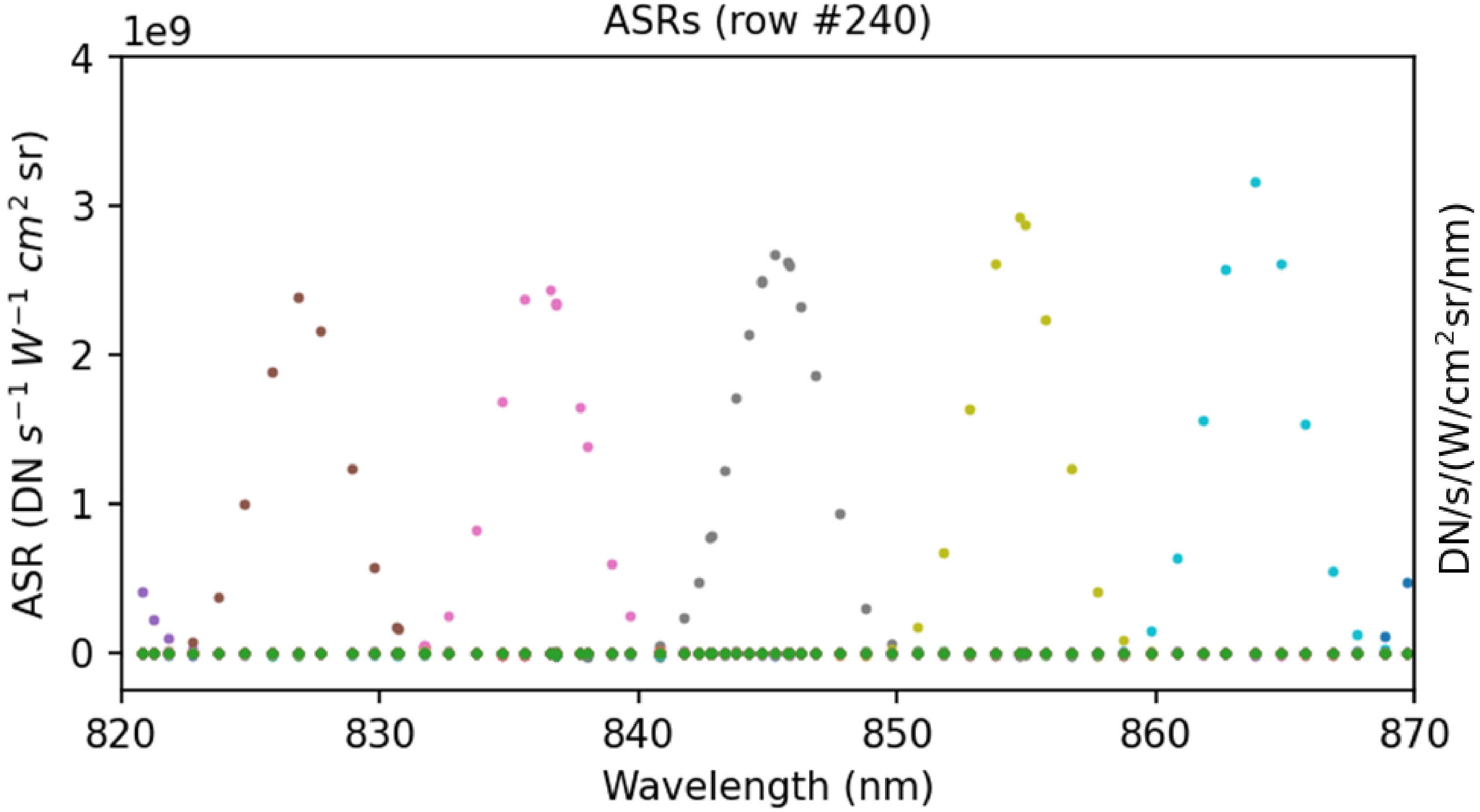
Comparison of OLI-2 Reflectance/Radiance RadCal: GLAMR Gain

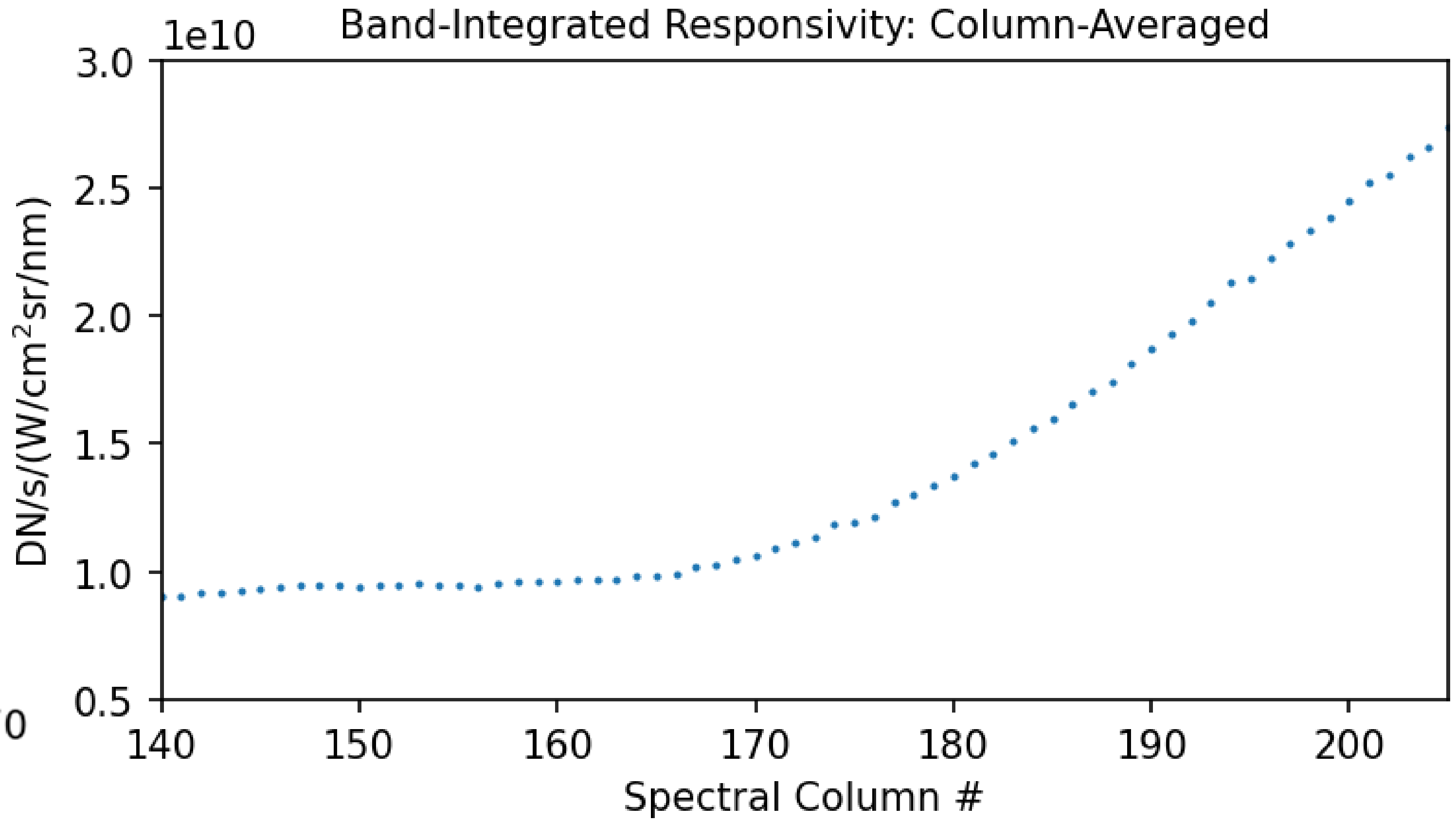


The ratio of one falls within 1-σ fidelity range for all bands

Preliminary Results from CPF HySICS GLAMR RadCal

- CPF's main payload HySICS is an Offner-Chrisp imaging spectrometer
- GLAMR RadCal of HySiCS was conducted in 2023 as part of the CPF pre-launch Independent calibration efforts
- Typical ASRs and R_{BI} measured from the calibration are shown





- The calibrated detector responsivities are being assessed and will be referenced to conduct on-orbit CPF independent calibration.

Summary

- One realization of the detector-based, absolute RadCal has been successfully achieved at NASA GSFC with the GLAMR laser system as light source.
- The uncertainty of GLAMR RadCal has been assessed to be smaller than the traditional source-based approach.
- Pre-launch calibration of OLI-2 provides an opportunity to compare these two approaches. Deviations between the derived detector gain coefficients range from ~0 for the cirrus band to ~7% for the SWIR bands.
- The root cause of these deviations is to be investigated.
- The comprehensive assessment of the GLAMR RadCal of CPF HySICS is currently underway.