Hydrosat

Onboard Calibration & Uncertainty Budget for the Hydrosat Longwave Infrared Imager (LIRI)

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for

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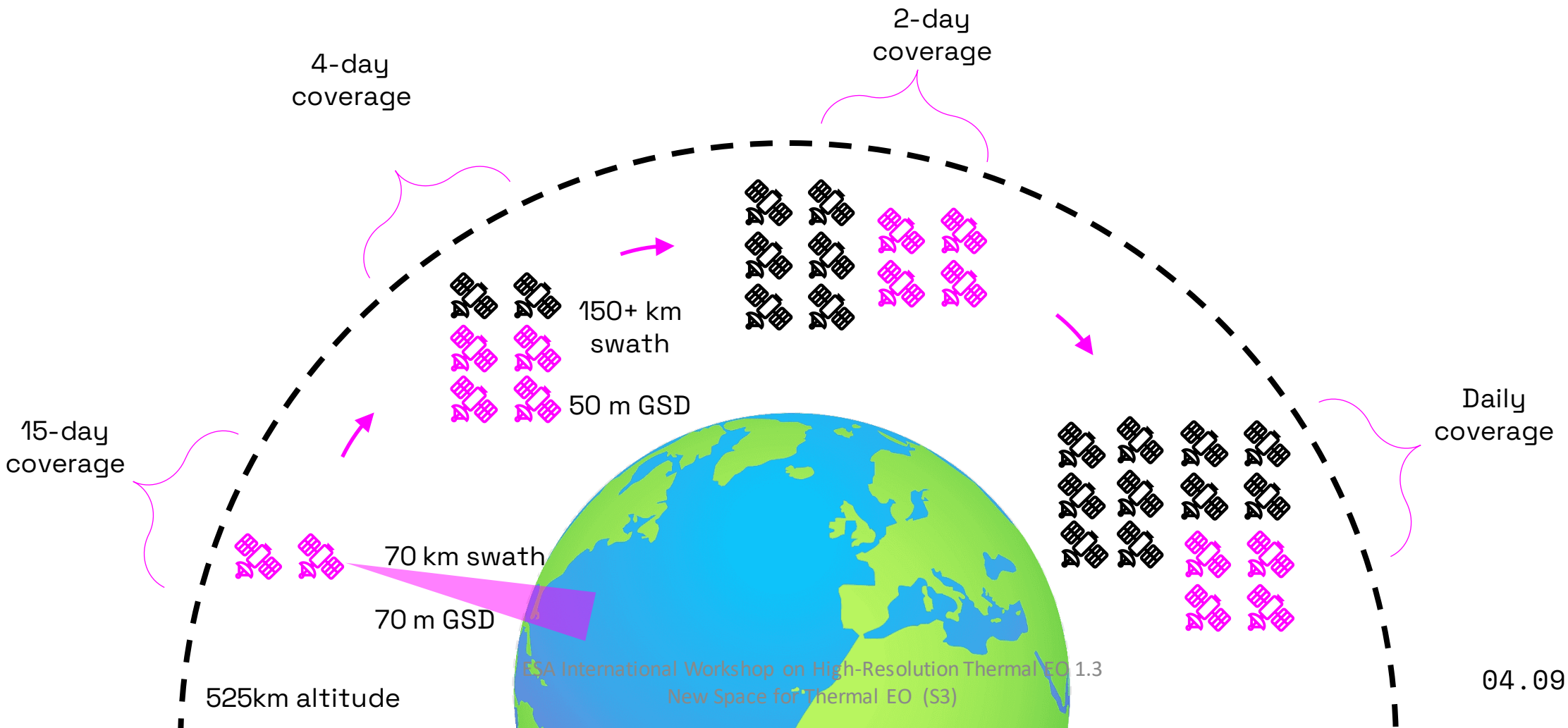
Introduction

- Pathfinder Mission & Overview
- LIRI Flight Model Overview
- LIRI Performance Estimates

Pathfinder & Constellation Mission Overview

Pathfinder & Constellation Deployment

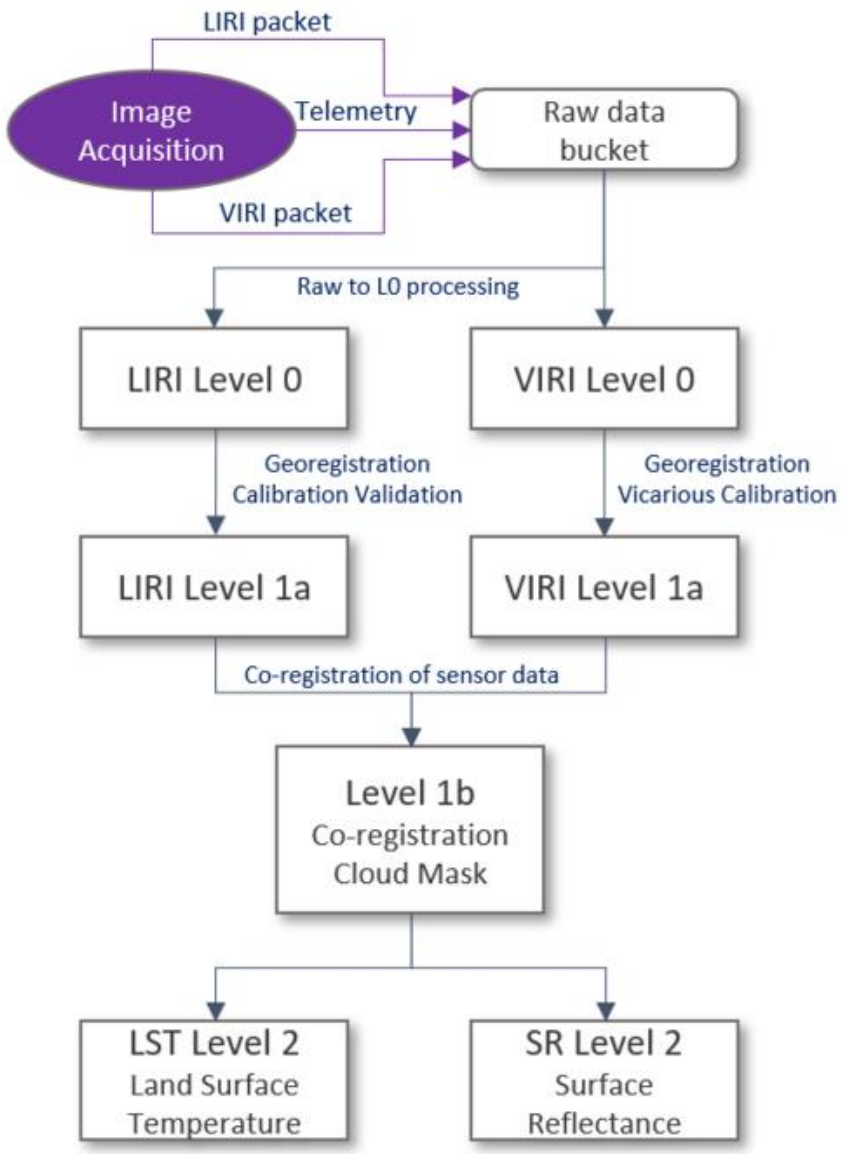


Pathfinder & Constellation Mission Specs

Requirement	Pathfinder	Constellation
Lifetime	2+ years	5+ years
Orbit Type	Sun synchronous	Sun synchronous
LTAN/LTDN	10:30 am	10:30am and 2:30pm
Orbit Altitude	525 km (TBC)	525 - 575 km
Collection Mode	Nadir monitoring	Nadir Monitoring
Coverage	Global landmass	Global landmass
Revisit	16 days	Daily
Swath	72 km	150 km
VIRI GSD	30 m	10 m
LIRI GSD	70 m	50 m

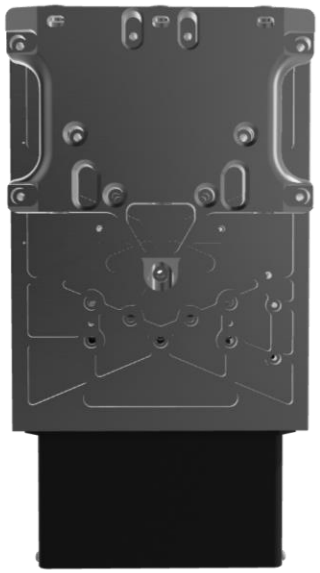
Pathfinder Data Pipeline

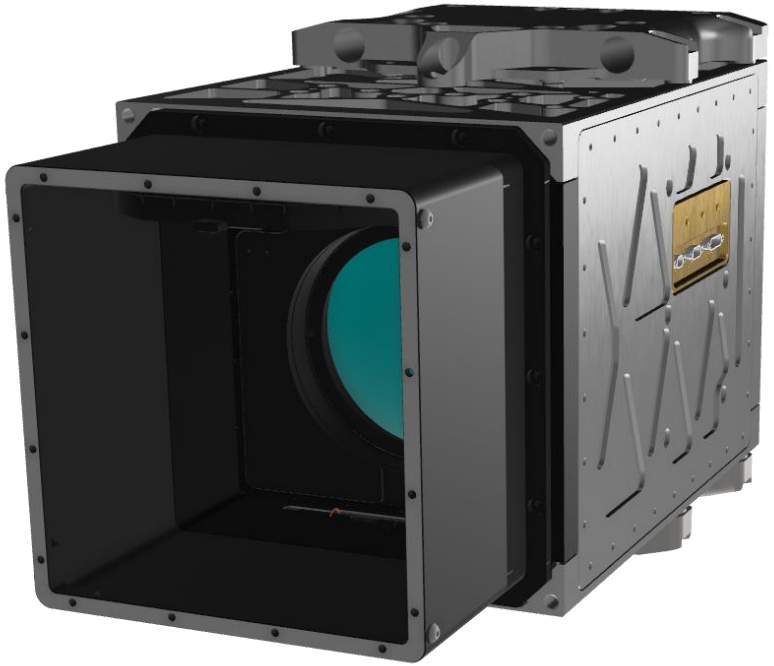
- LIRI = Longwave InfraRed Imager
  - 2 bands 10-12.5 µm
- VIRI = Visible-Near InfraRed Imager
  - 7 bands + PAN 400 – 900 nm
- Both imagers support land surface temperature (LST) retrieval
- Ground processing
  - L1 radiance calibration, applies onboard calibration data
  - L2 LST retrieval via Split Window
- Next section focuses on LIRI performance only

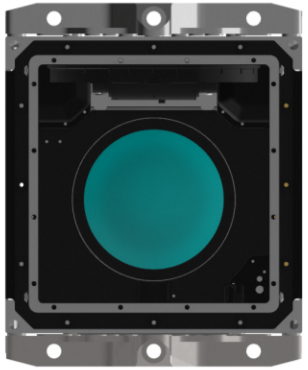


LIRI Flight Model Overview

LIRI Flight Model Details







LIRI Flight Model Details

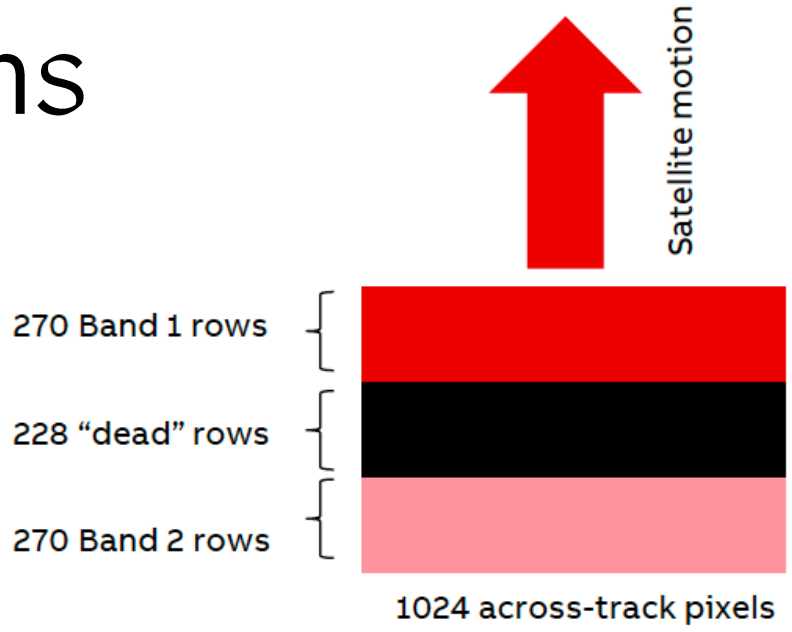
- Uncooled microbolometer detector array
- Two band butcher block spectral filter assembly
- Pushbroom imaging with time-delayed integration (TDI) to reduce noise
- Refractive, on-axis optics to reduce volume
- Detector and optics are temperature regulated and monitored
- Raw data and telemetry are sent to bus in a continuous manner
- Onboard blackbody
  - Radiometric reference calibration
  - Protective shutter
- Calibration/ cal-val opportunities
  - Blackbody, deep space collections (NUC/ L1)
  - Ocean buoys (L1 validation)
  - SURFRAD sites (L2 validation)

LIRI Imaging Specifications

Frame rate: 33 Hz

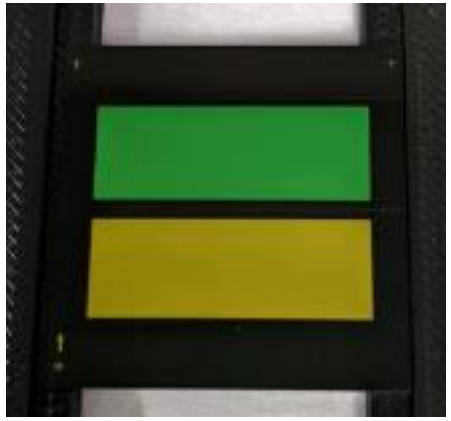
Geometric pixel size: 71 m x 71 m at nadir

Satellite moves 210 m during one frame



First-order detector & optical specs:

- Telescope focal length (126 mm)
- Telescope F/# (1.2)
- Focal plane dimensions (1024 x 768)
- Focal plane pixel pitch (17 micron)
- µbol time constant (12 ms)

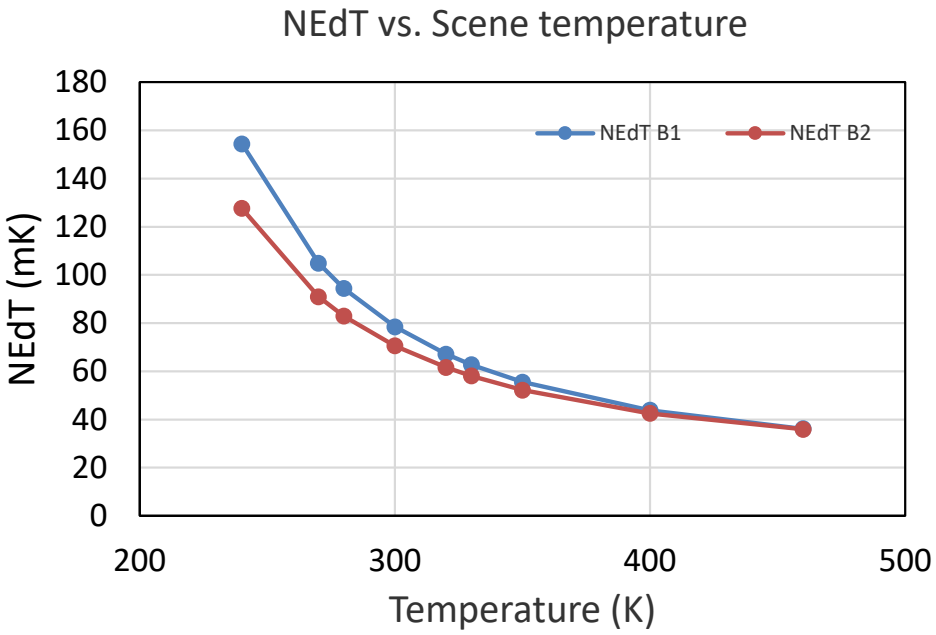


Time-delay integration (TDI)

- 270 lines per band total, all used in high-sensitivity mode
- 90 lines used in high-resolution mode

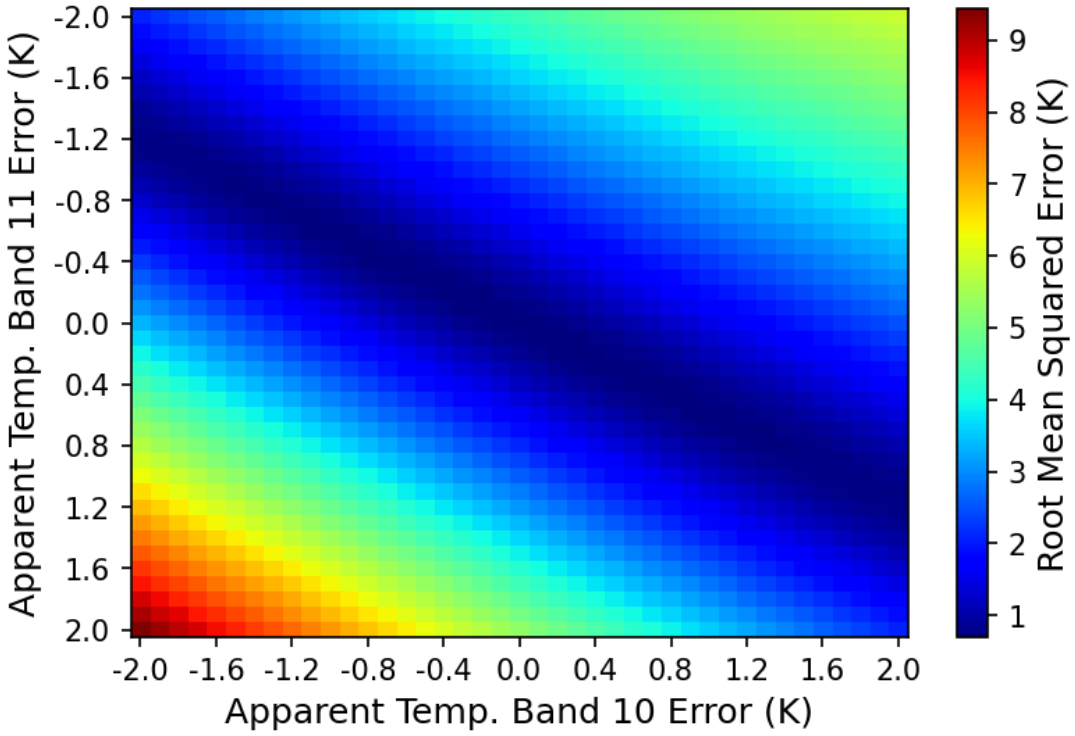
LIRI Performance Estimates

System Modeling - NEDT

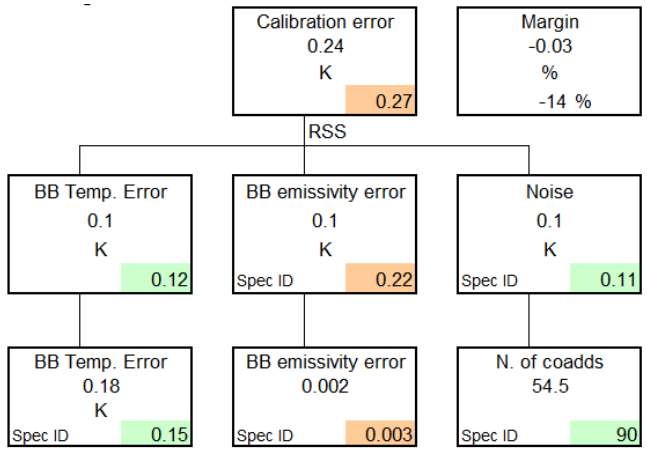


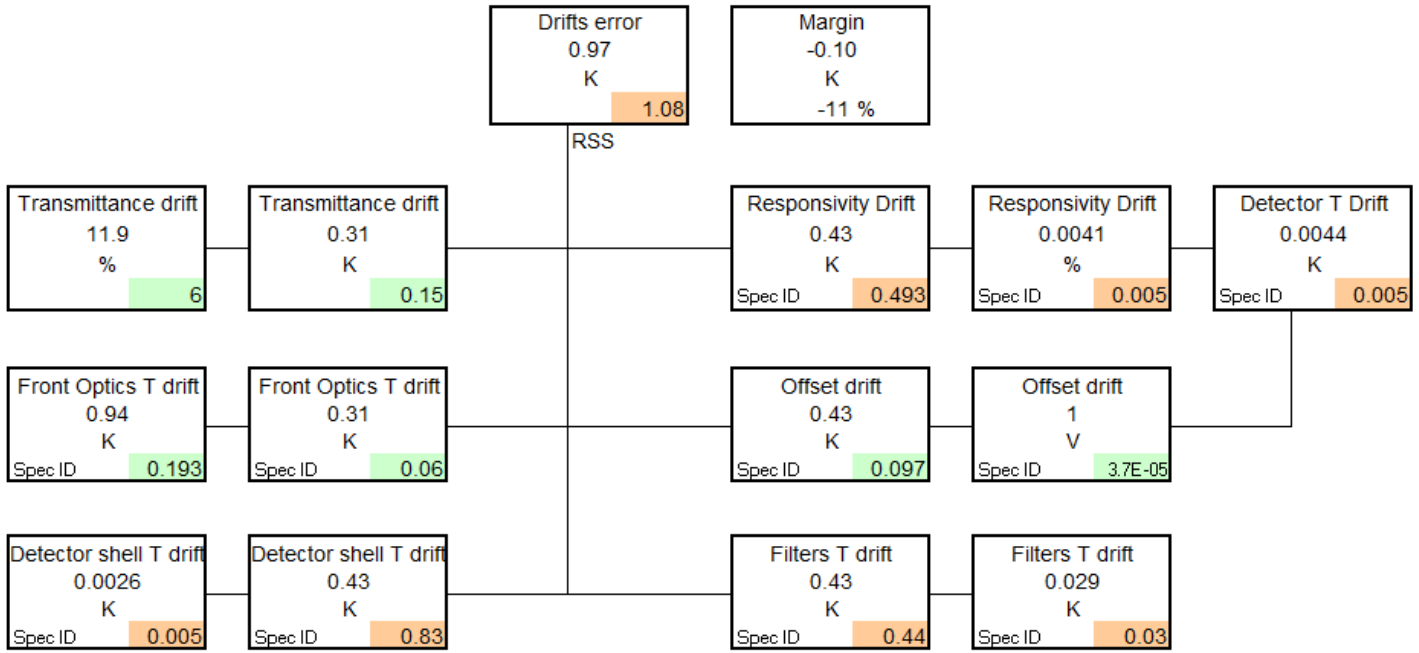
TDI stages (Binning):	Band 1 NEDT	Band 2 NEDT
90 (1x1)	149 mK	138 mK
270 (1x3)	86mK	80 mK

NEDT @ scene temperature of 280 K.



System Modeling – L1 Radiance Error





	Band 1 Error	Band 2 Error
Apparent Temperature	1.11 K	1.17 K
Relative Radiance	1.67 %	1.46 %

Radiometric error (RMS)

System Modeling – L2 LST Accuracy

Per-band estimates are propagated through split-window retrieval model.

NEDT Error			
High-Sensitivity Mode		**High Resolution Mode**	
Band 1:	**Band 2:**	**Band 1:**	**Band 2:**
86 mK	80 mK	0.150 mK	0.140 mK
LST RMSE:		LST RMSE:	
0.758 K		0.862 K	

L1 Error (+ Stray Light)		Scene Emissivity Error	
Note: same for both modes.			
Band 1:	**Band 2:**	**Band 1:**	**Band 2:**
1.67 % (2.6 %)	1.46 % (5.6 %)	1.50 %	1.50 %
LST RMSE:		LST RMSE:	
0.914 K (1.67 K)		0.970 K	

Total LST Error	
High-Sensitivity Mode	**High Resolution Mode**
1.53 K (2.11 K)	1.59 K (2.15 K)

Spatial Resolution

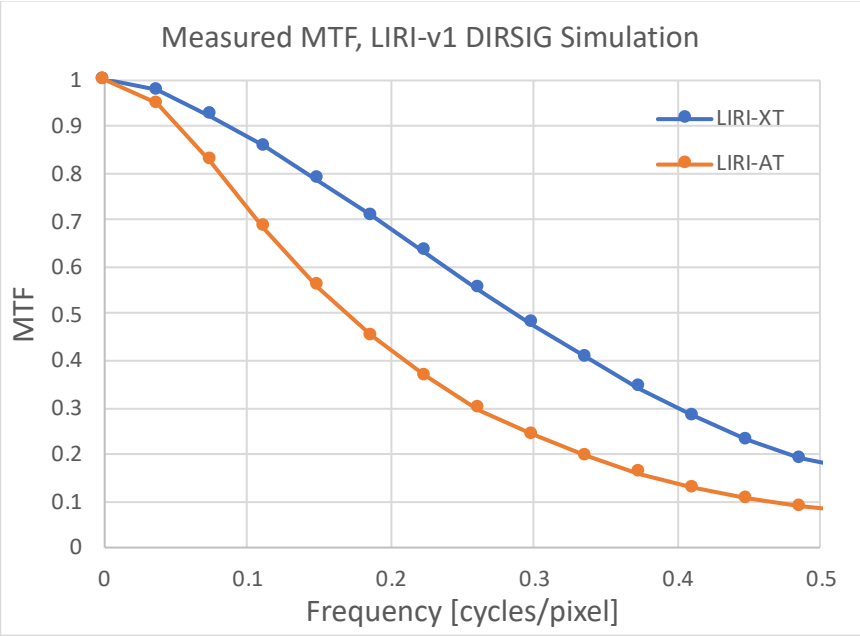


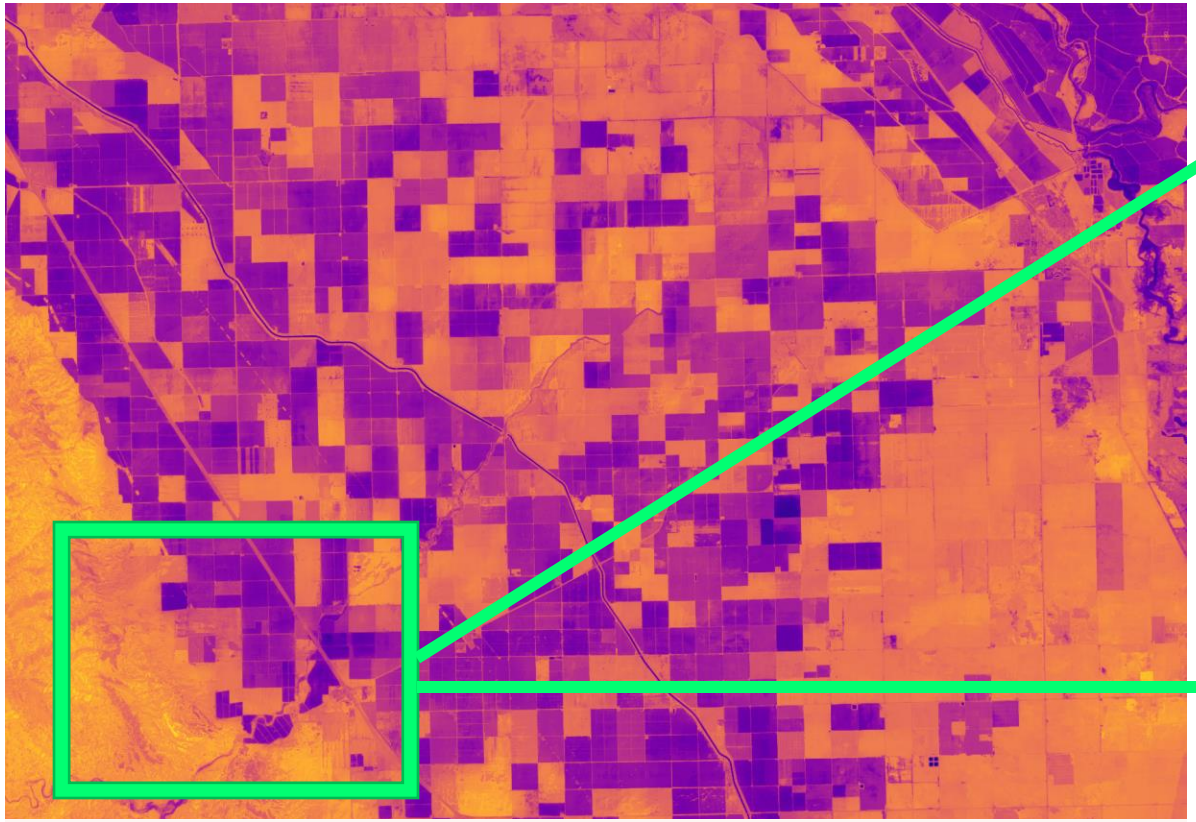
Table 12: Spatial resolution results ("Hi-Res Mode")

Parameter	Band 1	Band 2
PSF FWHM Along-track	116.9 m	120.7 m
PSF FWHM across-track	96.5 m	99.3 m
MTF along-track	0.08 at Nyquist	0.08 at Nyquist
MTF across-track	0.18 at Nyquist	0.15 at Nyquist

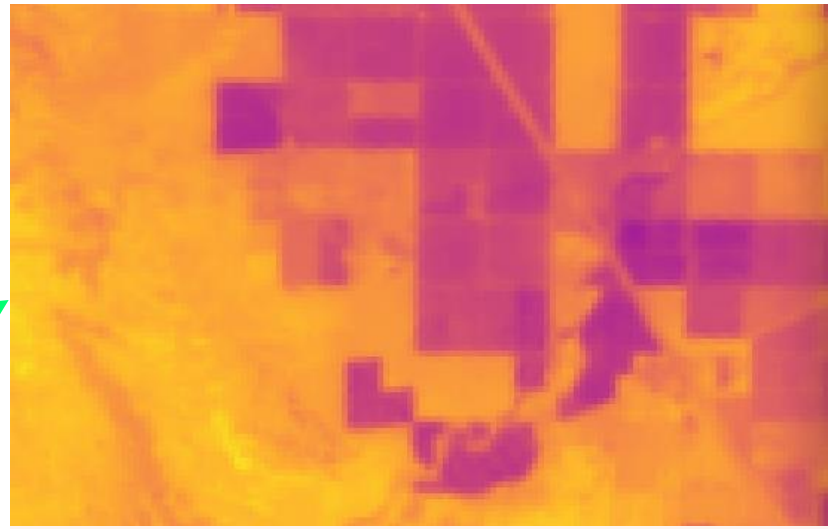
Table 13: Spatial resolution results ("Hi-Sensitivity Mode")

Parameter	Band 1	Band 2
PSF FWHM Along-track	216.7 m	220.9 m
PSF FWHM across-track	96.5 m	99.3 m

Image Simulation



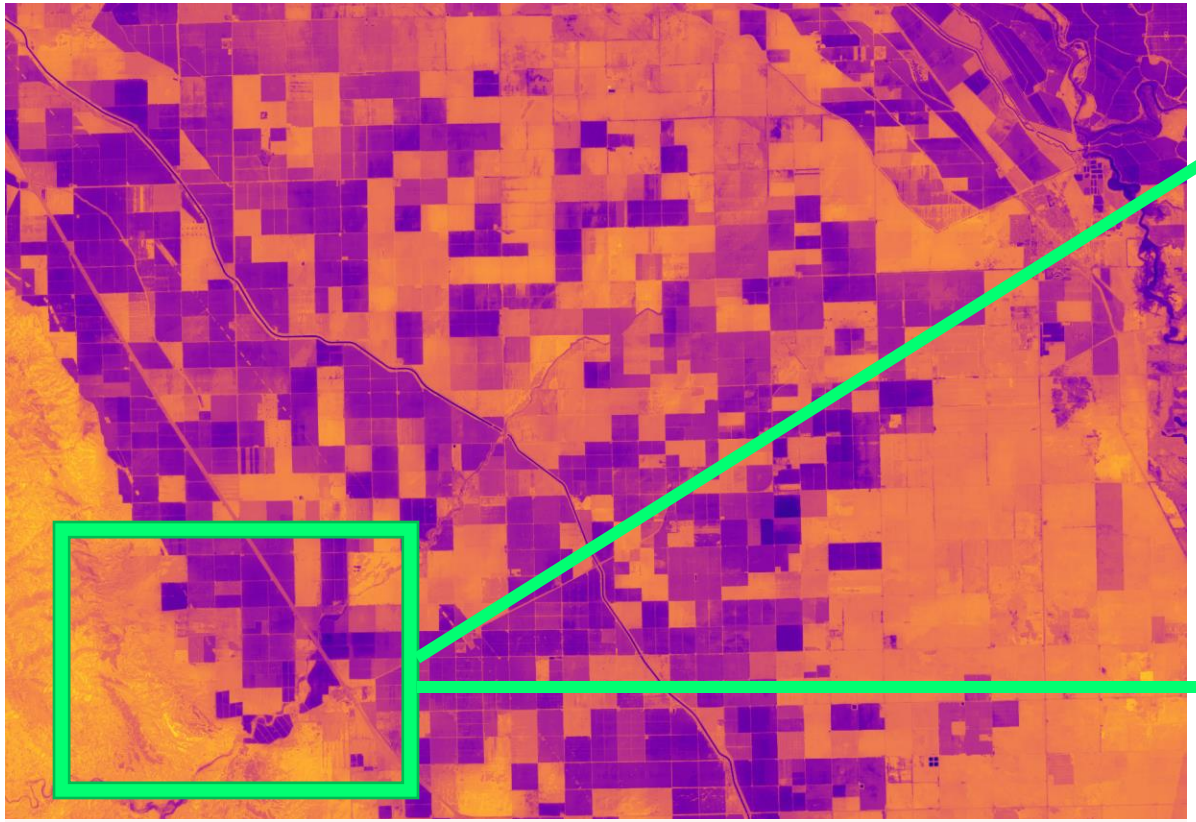
Hydrosat Daily Surface Temperature (20-meter)



LIRI L1 Simulation (70-meter)

TIRS L1 (30-meter)

Image Simulation



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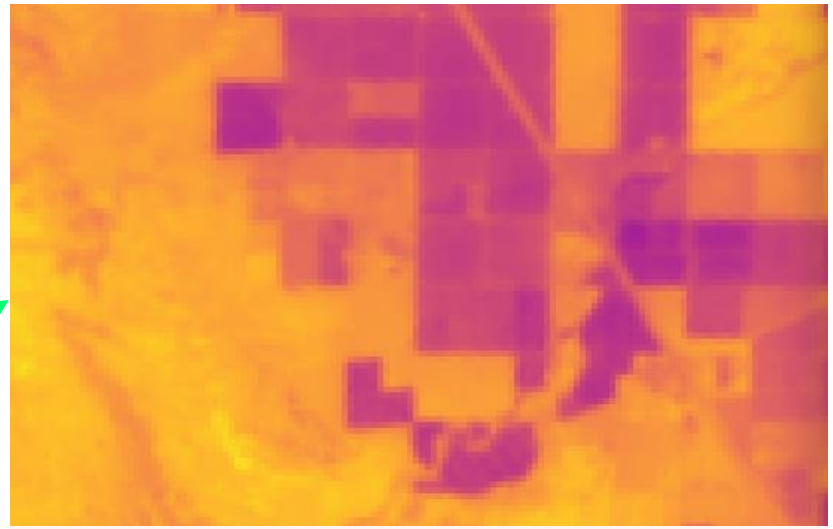
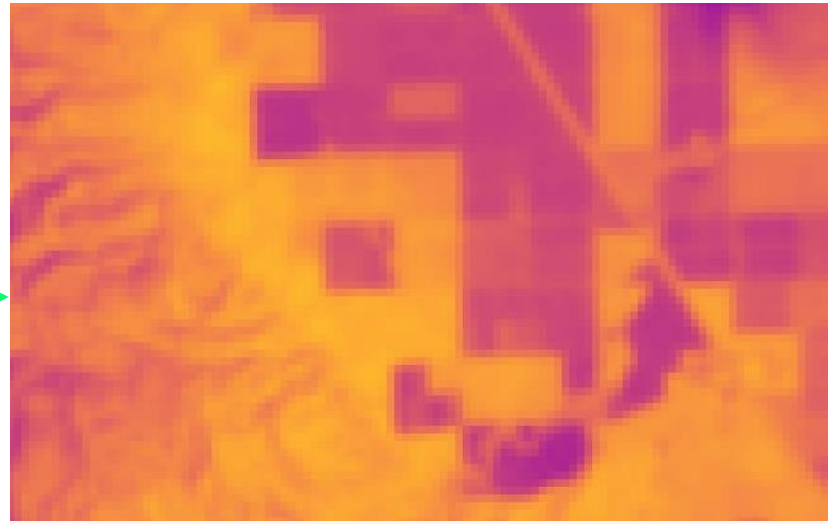


LIRI L1 Simulation (70-meter)

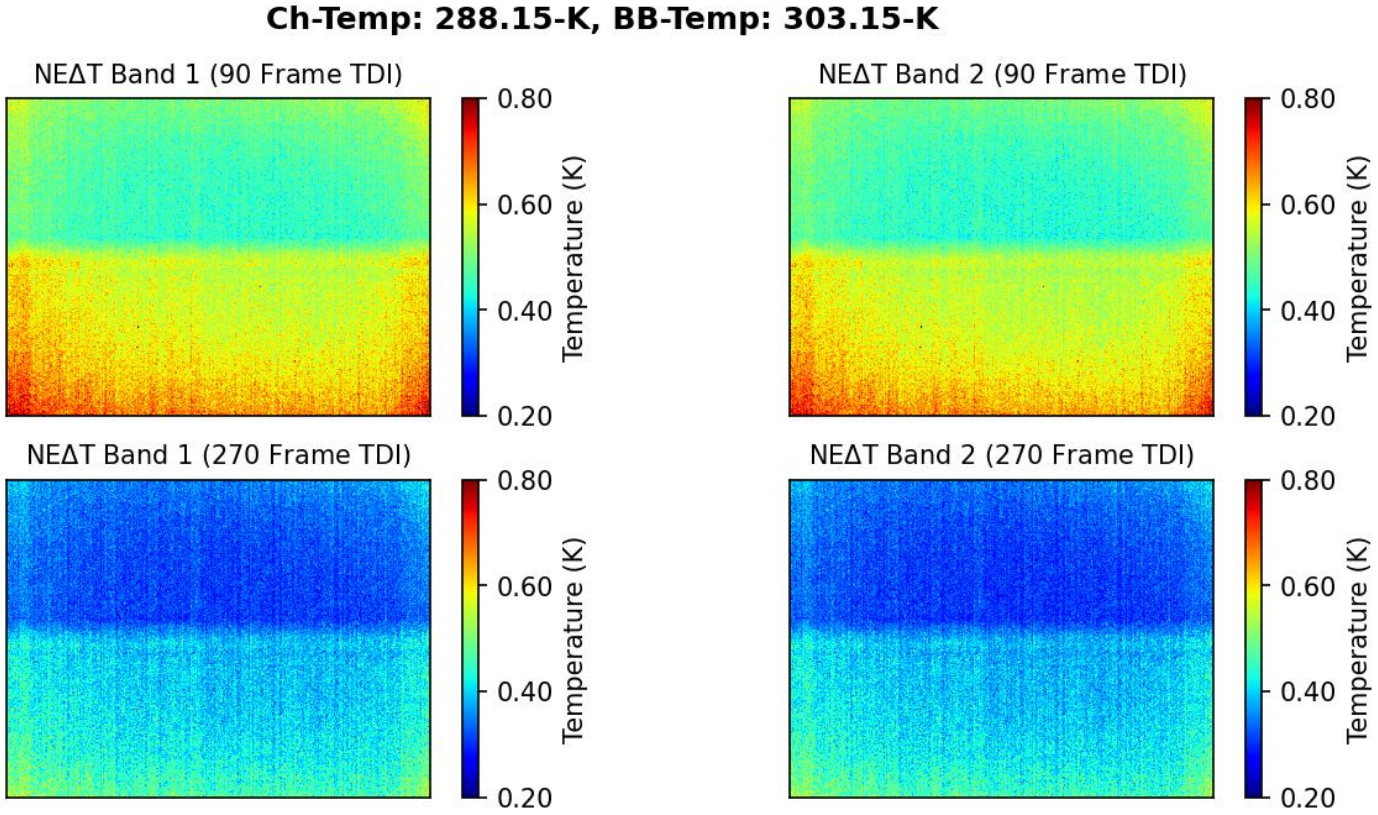


TIRS L1 (100-meter)

Conclusion

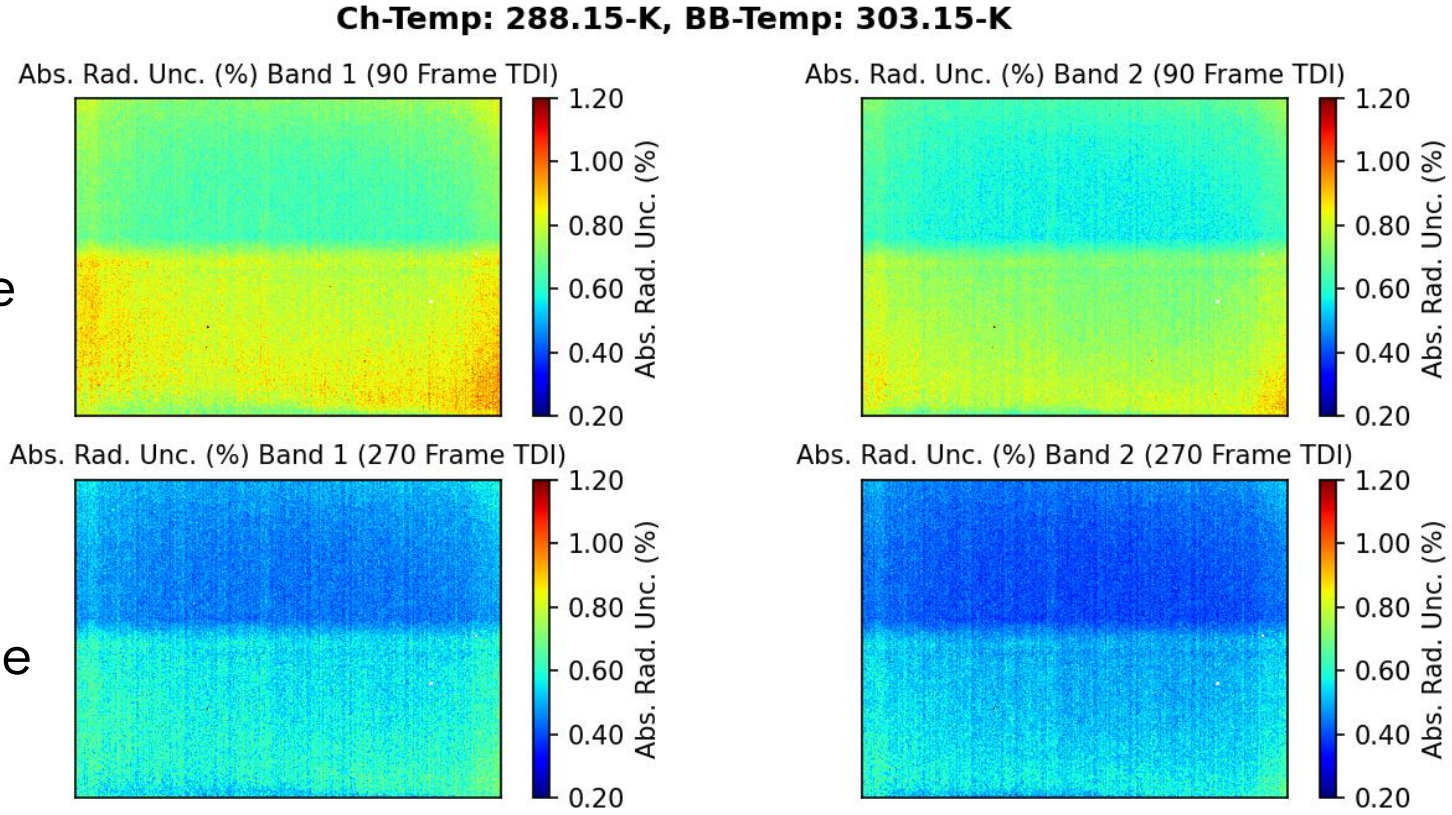
Prelim. Test Results: NEDT

- Thermal chamber testing of engineering units to validate performance
- External blackbody source
- Multi-point radiance calibration
- 2700 frame soak tests used for NEDT vs. TDI
- Similar test & analysis to be performed on FM in TVAC

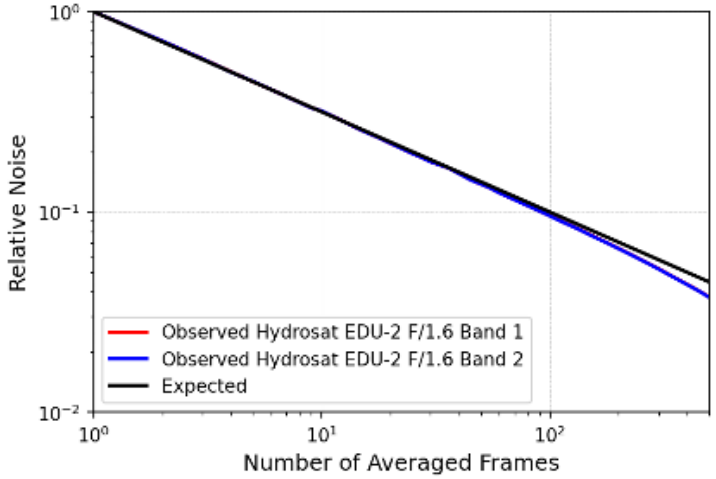


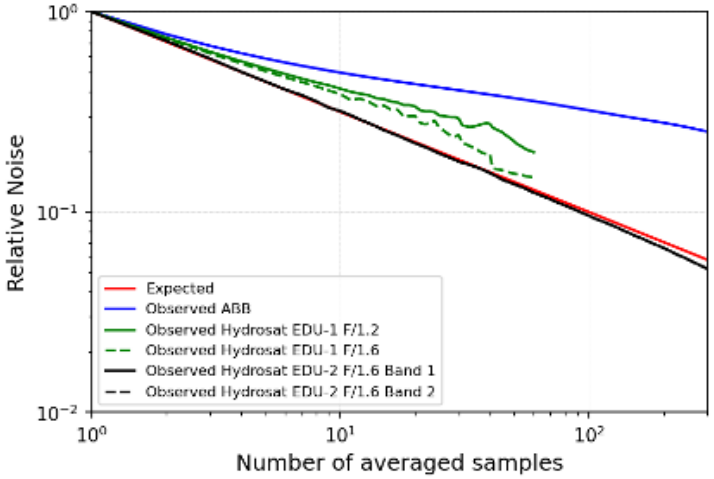
Prelim. Test Results: Radiance Accuracy

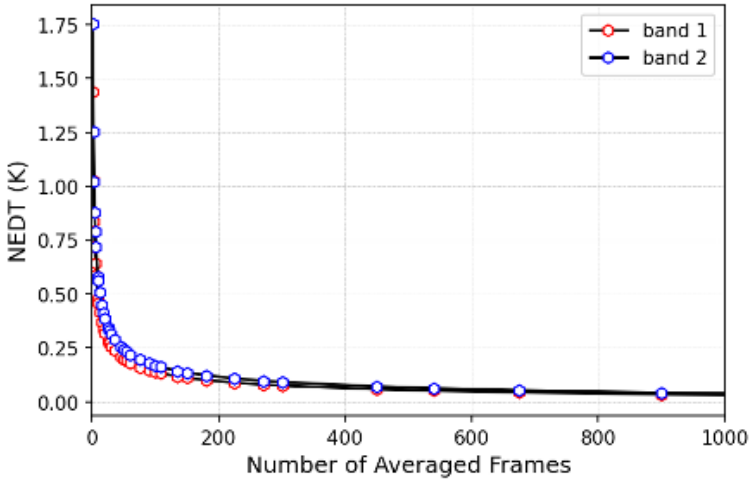
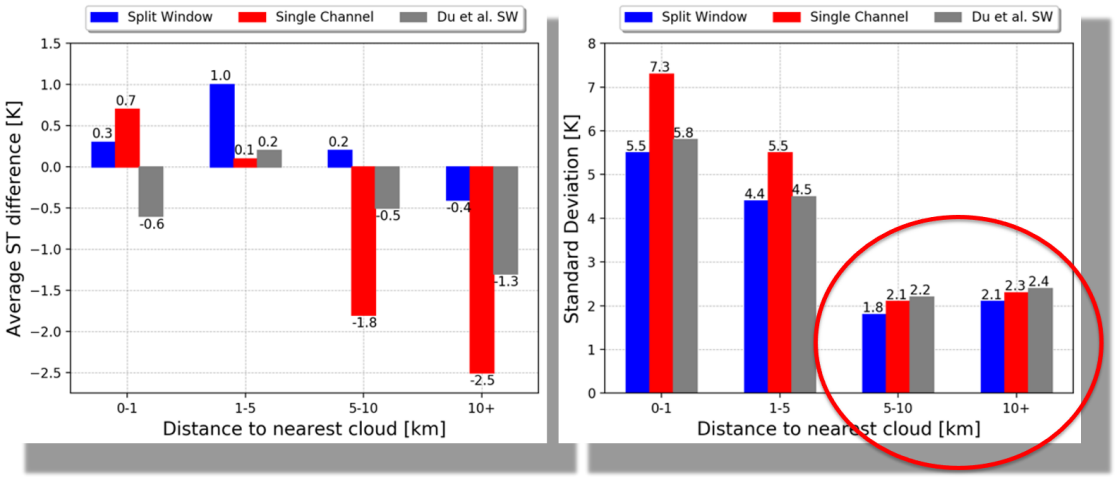
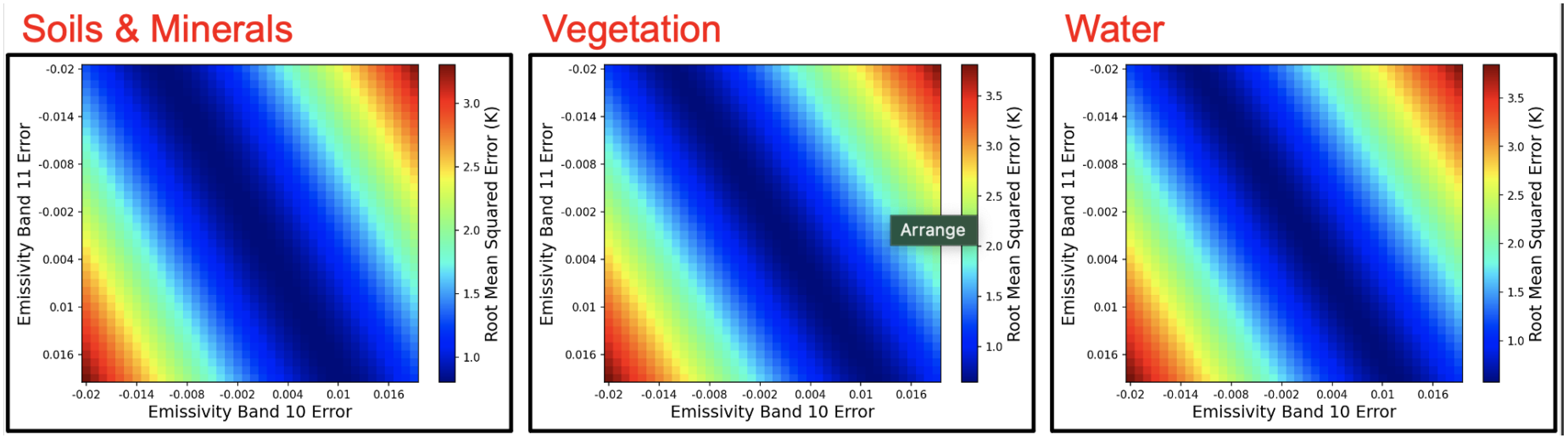
- Thermal chamber testing of engineering units to validate performance
- External blackbody source
- Multi-point radiance calibration
- 2700 frame soak tests used for NEDT vs. TDI
- Similar test & analysis to be performed on FM in TVAC



Backup: Noise Improvement Factor







Backup: Emissivity Error