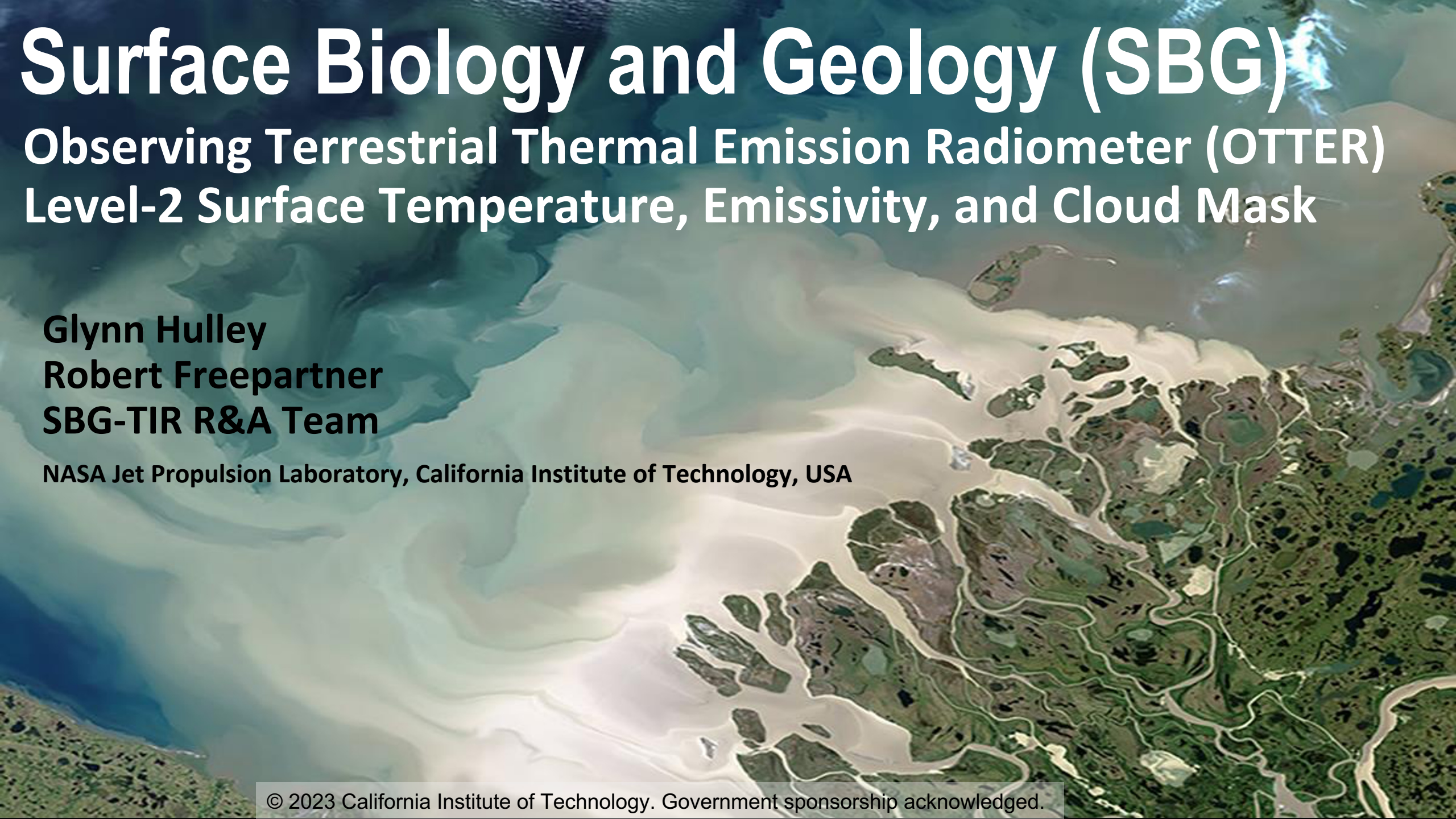
Surface Biology and Geology (SBG)

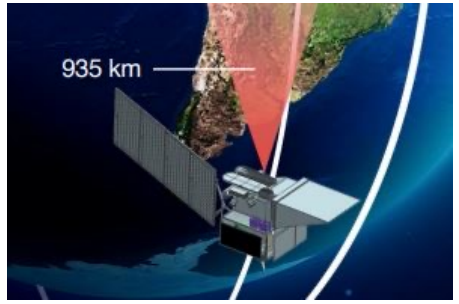
Observing Terrestrial Thermal Emission Radiometer (OTTER) Level-2 Surface Temperature, Emissivity, and Cloud Mask

Glynn Hulley
Robert Freepartner
SBG-TIR R&A Team

NASA Jet Propulsion Laboratory, California Institute of Technology, USA



NASA Surface Temperature and Emissivity Algorithm Heritage

	ASTER (2000)	MODIS (2000/2002) VIIRS (2011/2017/2022)	ECOSTRESS (2018)	HyTES (2013)	Surface Biology Geology OTTER (2027)
					
Platform	Terra	Aqua, Terra, S-NPP, NOAA-20, NOAA-21	International Space Station	Twin Otter/ER2	OTTER
TIR bands	5	3	5	256	6 (+2 MIR)
Algorithm	TES	TES	TES	TES	TES: land surfaces Split-window: water surfaces
Temporal	16 day	Twice Daily (1:30am/pm)	3-5 days	Campaigns	3 days
Spatial	90 m	1000 m	70 m	1- 10 m	60 m

TES = Temperature Emissivity Separation (TES) algorithm [Gillespie et al. 1998]

SBG OTTER Level-2 product data layers

JPL D-XXXXX

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Level 2 Algorithm Theoretical Basis Document (ATBD)

Version 1
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Glynn Hulley
Jet Propulsion Laboratory
California Institute of Technology

JPL D-XXXXX

National Aeronautics and
Space Administration
JPL
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California 91109-8099
California Institute of Technology

	Units
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	cm
	1=water 0=land
	1=cloud 0=clear
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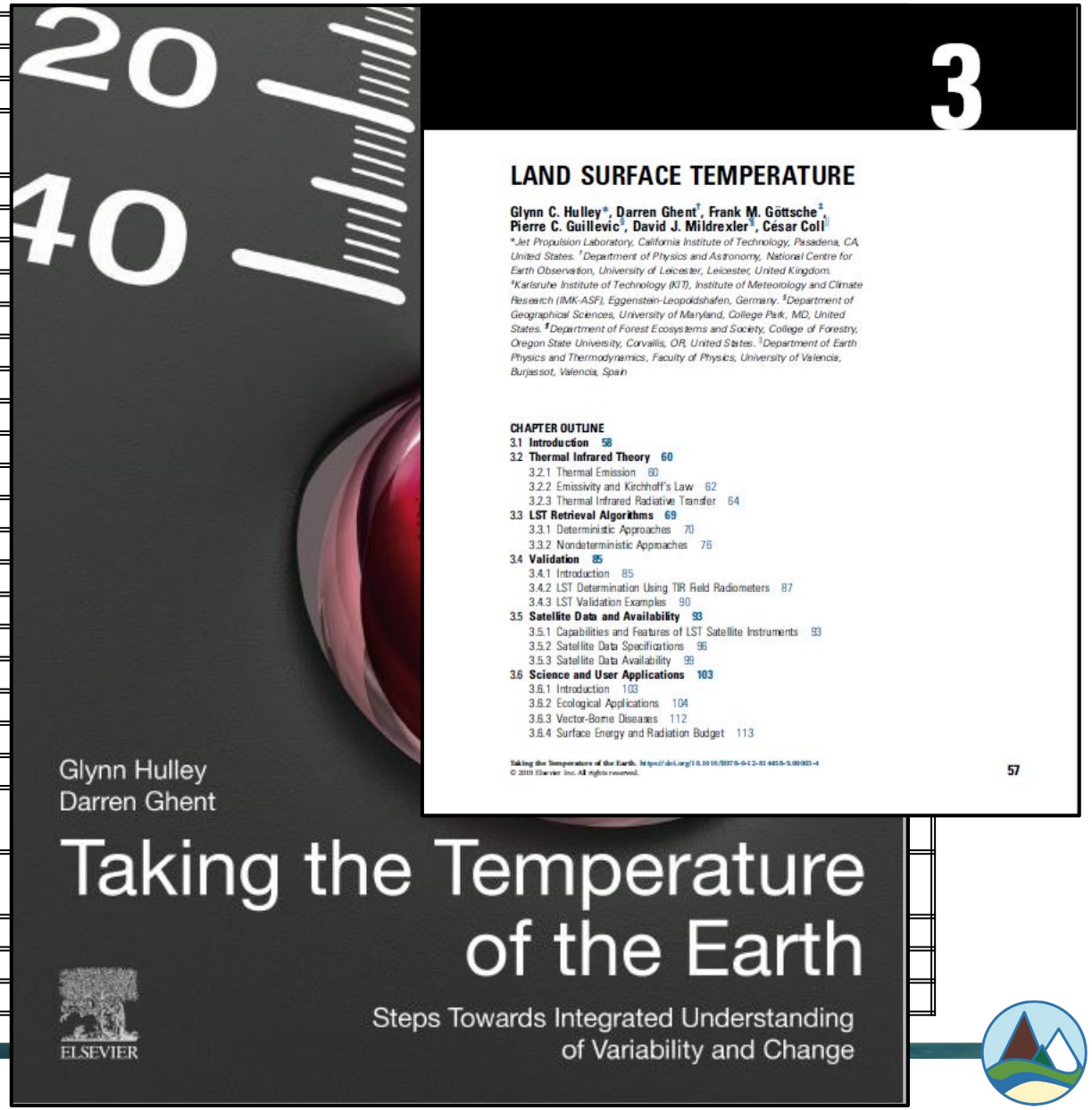
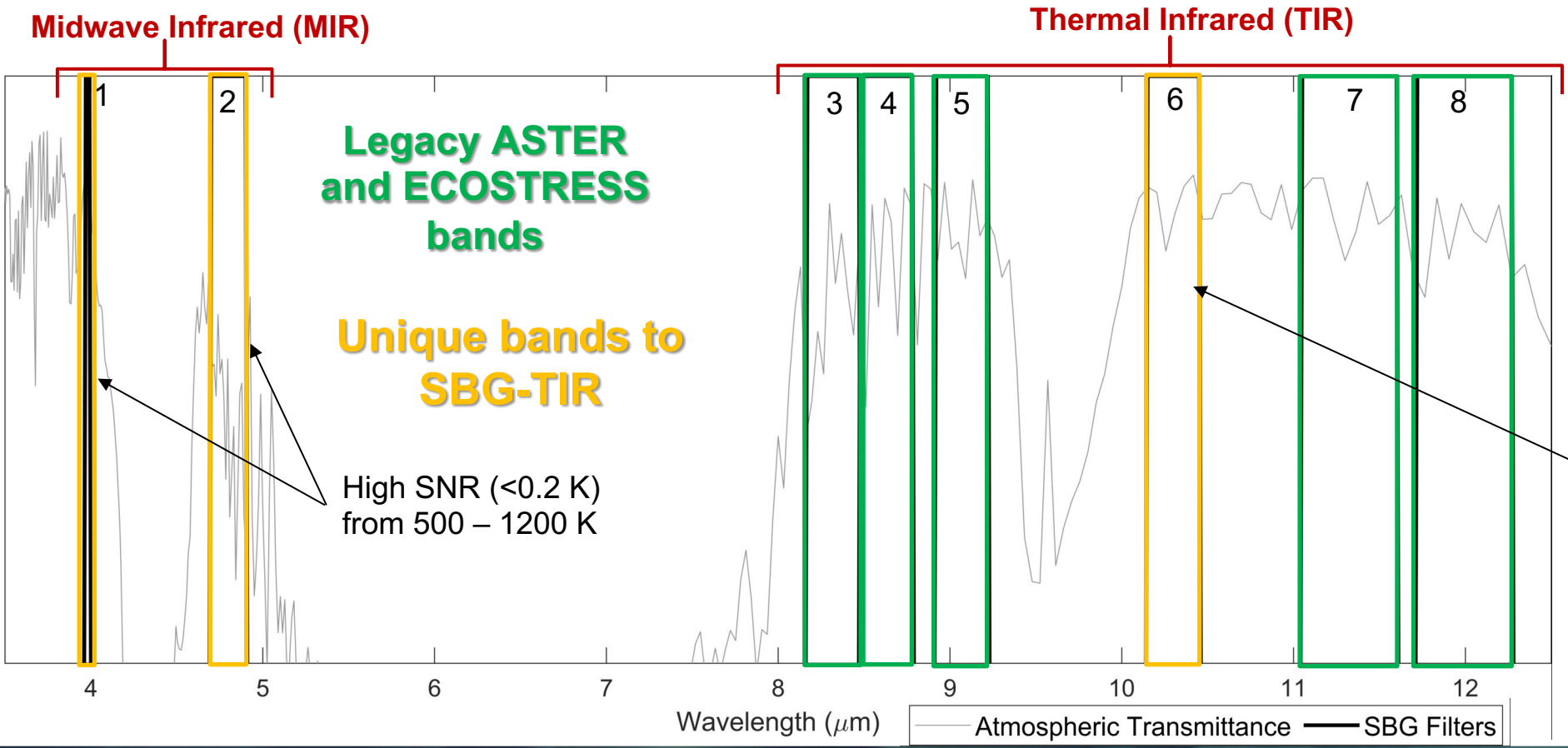
	degrees



SBG OTTER bands and science uses

Band uses

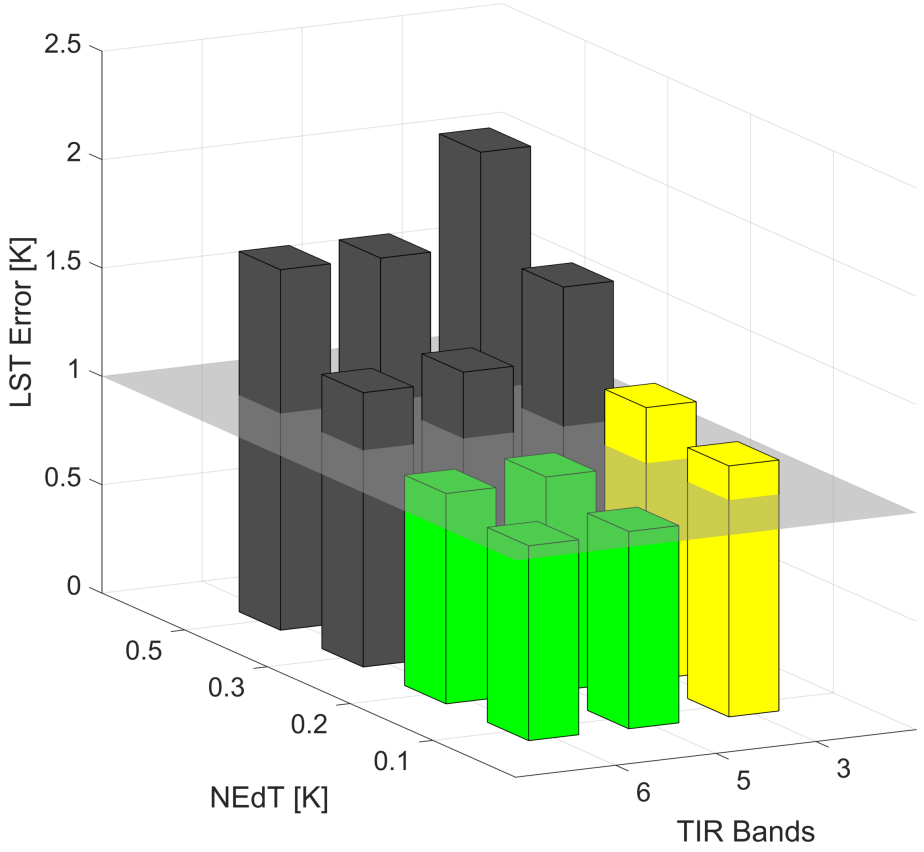
- Surface temperature/emissivity: 1, 3, 4, 5, 6, 7, 8
- Evapotranspiration: 3, 4, 5, 6, 7, 8
- Volcanic activity: 1, 2, 3, 4, 5, 6, 7, 8
- Surface composition: 1, 3, 4, 5, 6, 7, 8
- Elevated Temperature Features: 1, 2, 7, 8



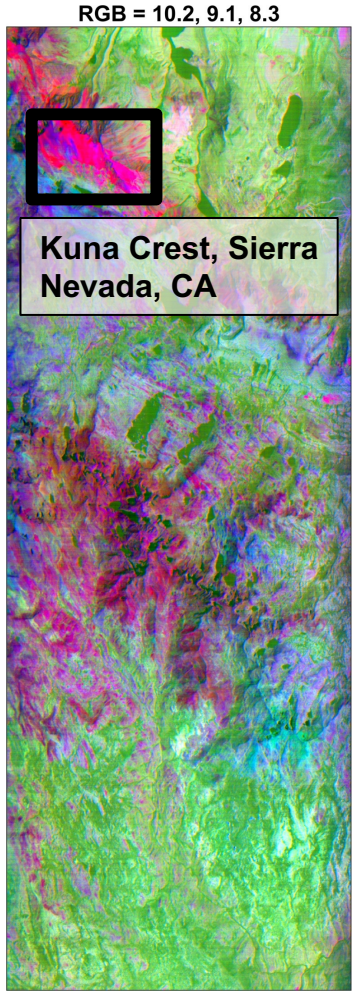
- Surface mineral composition
- Volcanic plume composition

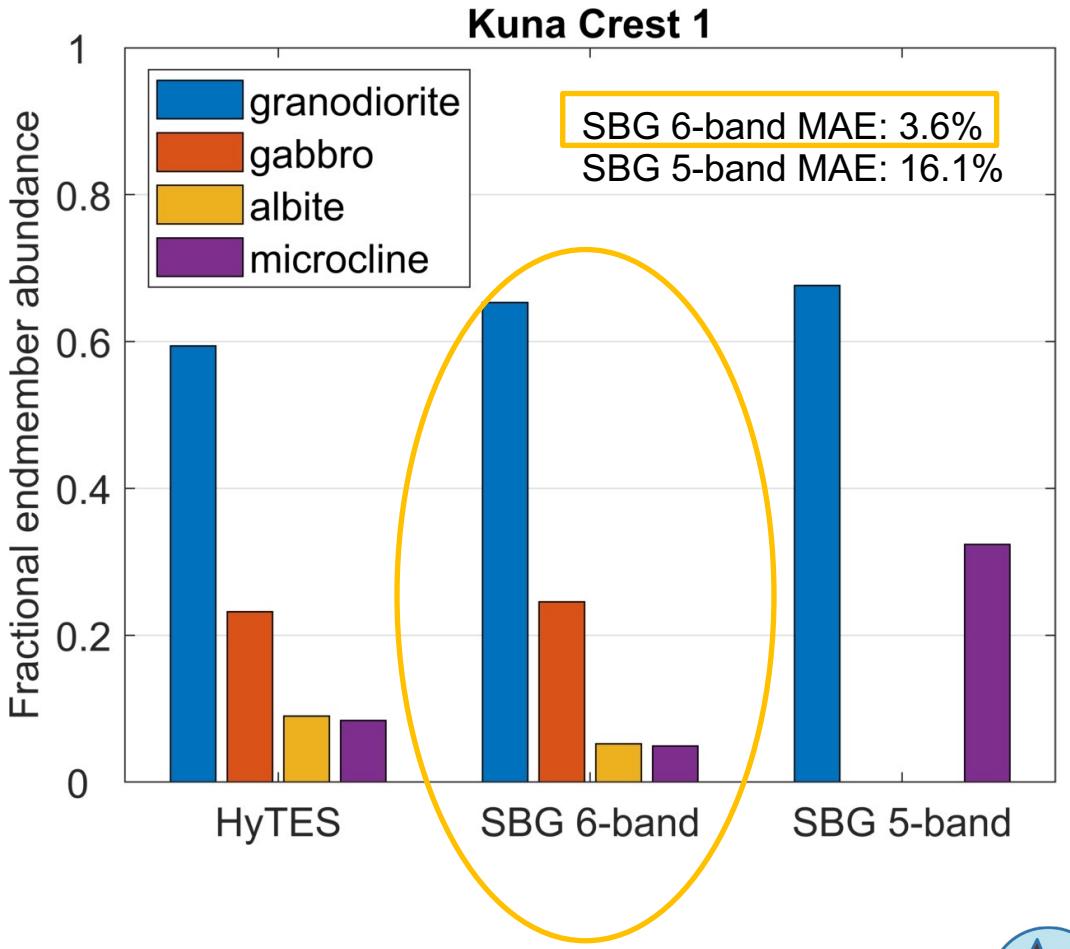
Demonstrated need for more TIR bands

Improved LST accuracy <1 K



Improved surface composition mapping

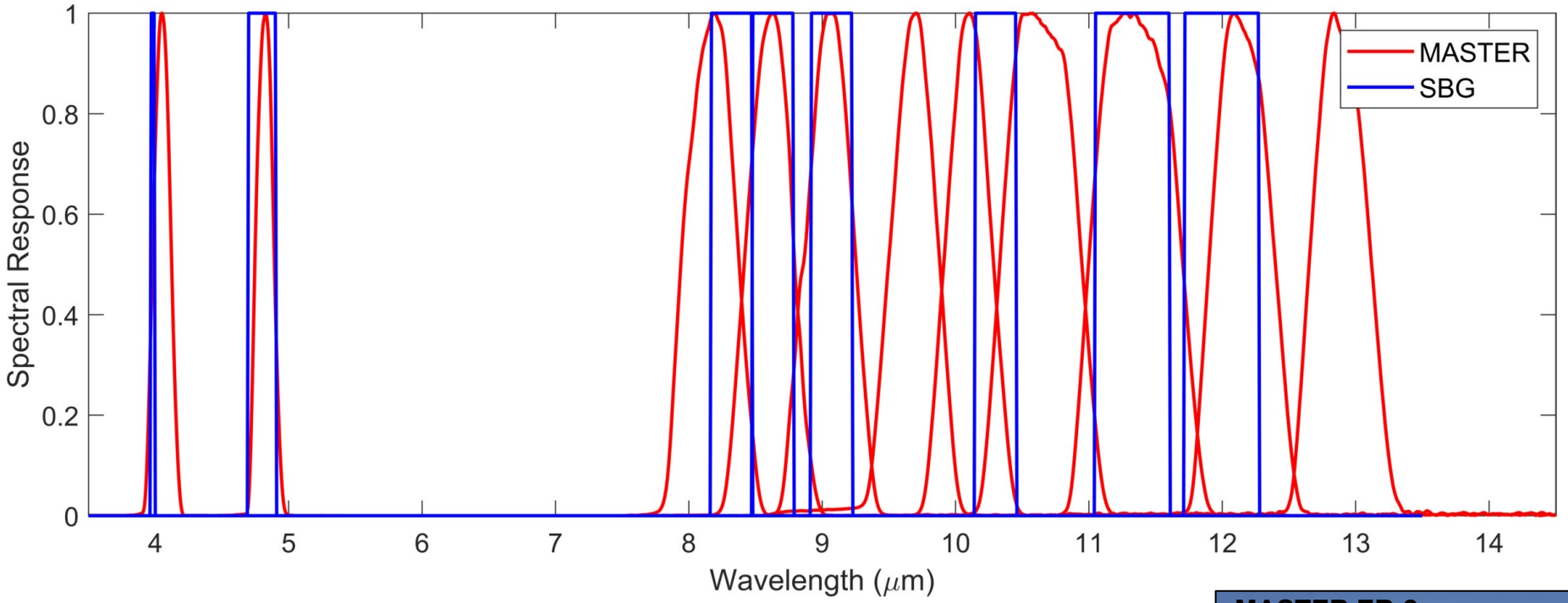




Simulated SBG TIR data from MASTER airborne

MASTER IR bands

Band	Wavelength (micron)
32	4.05
37	4.82
42	8.15
43	8.59
44	9.02
45	9.64
46	10.1
47	10.6
48	11.32
49	12.14
50	12.85

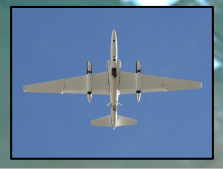


Example regression for two bands:

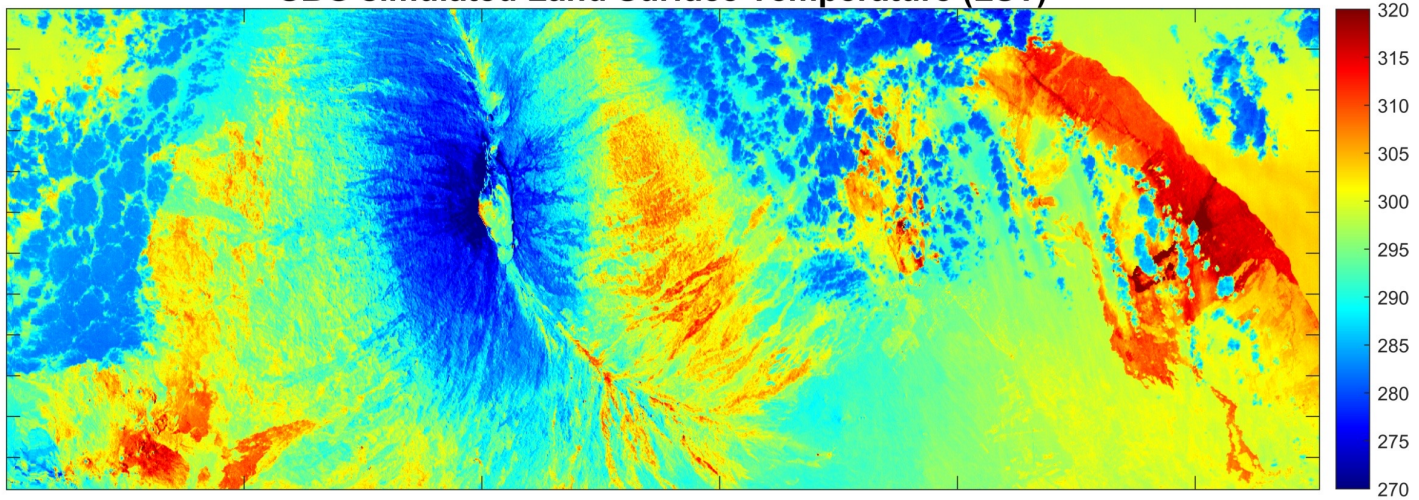
SBG band 1: $\epsilon_{SBG\ 1} = c1\ \epsilon_{MASTER\ 32} + c2$

SBG band 6: $\epsilon_{SBG\ 6} = b1\ \epsilon_{MASTER\ 46} + b2\ \epsilon_{MASTER\ 47} + b3$

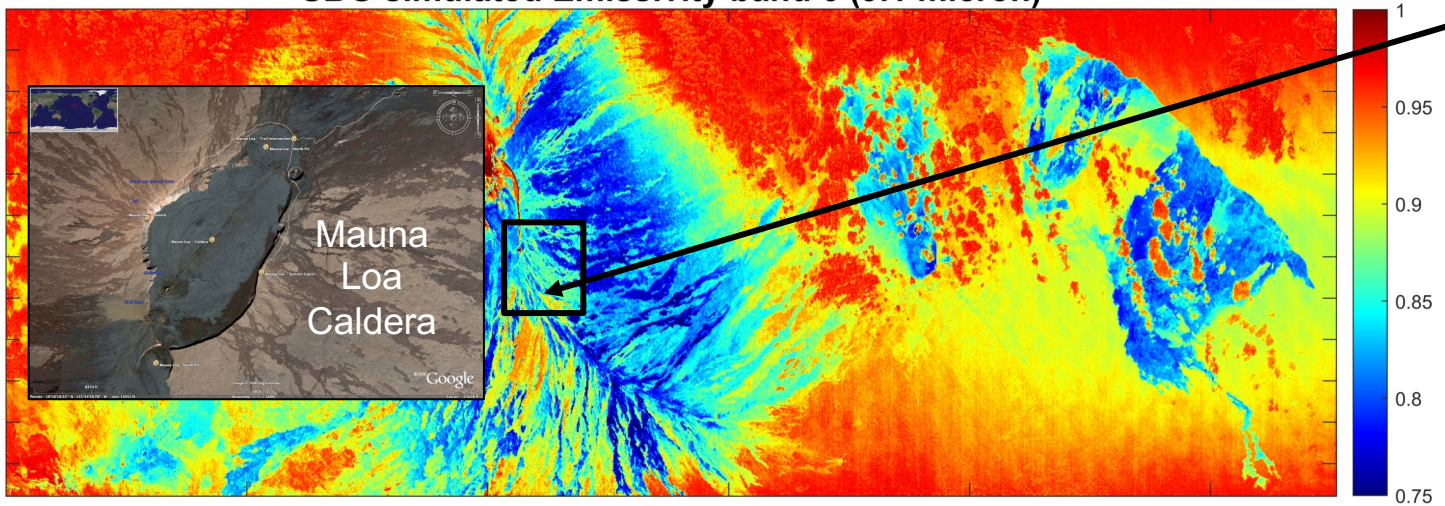
Simulated SBG TIR data from MASTER airborne



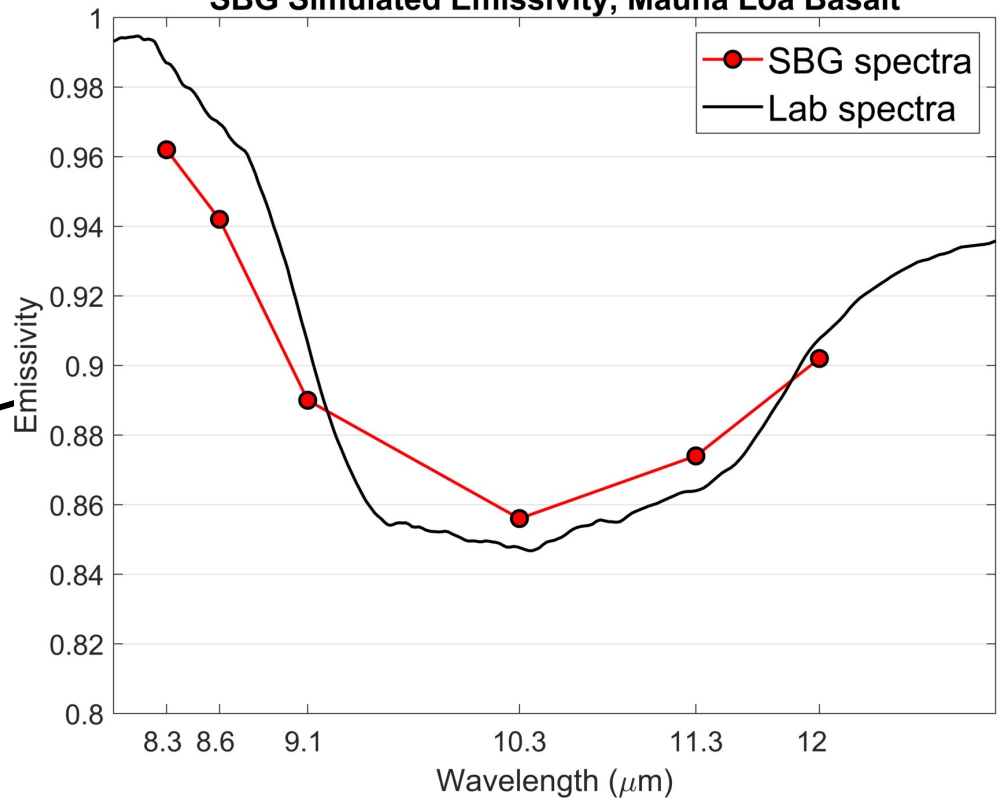
SBG simulated Land Surface Temperature (LST)



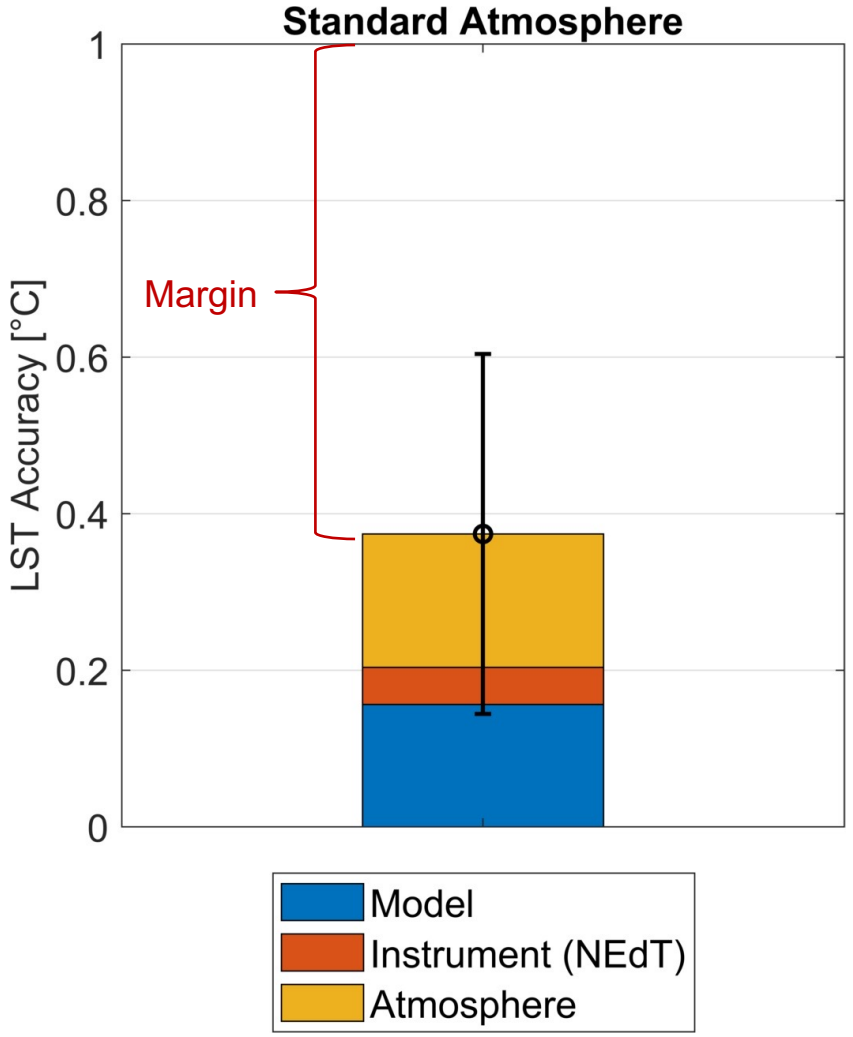
SBG simulated Emissivity band 6 (9.1 micron)

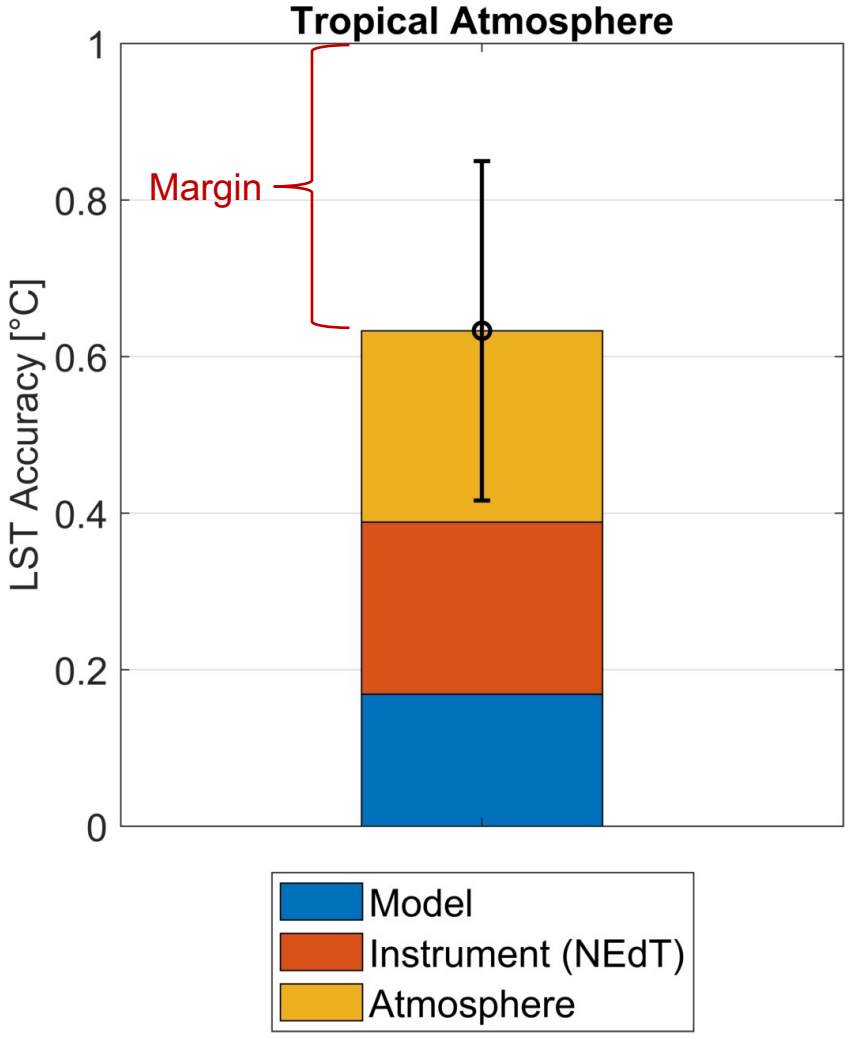


SBG Simulated Emissivity, Mauna Loa Basalt



LST&E Uncertainty Quantification





Simulation run details:

150 rocks, soils, sands, vegetation spectra from ECOSTRESS spectral library

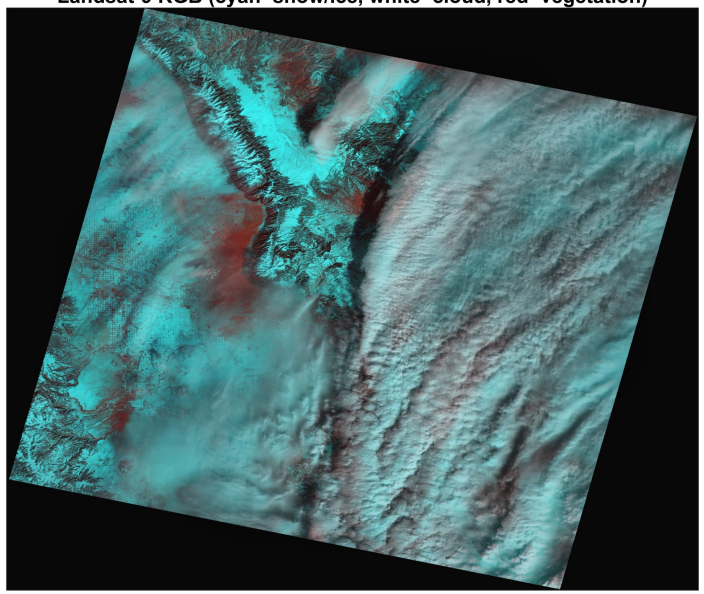
10,000 Monte Carlo simulations with 10% and 1 K random error on humidity and air temperature, respectively.

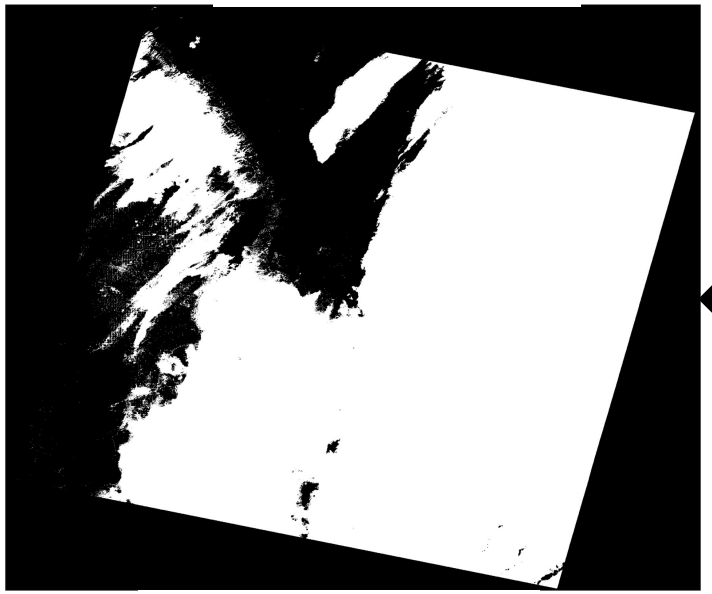
NEdT = 0.2 K per band (instrument noise)

See details in *Hulley et al., (2023) SBG L2 ATBD*, Temperature Emissivity Uncertainty Simulator (TEUSim)

SBG OTTER Cloud Mask

Landsat-9 RGB (cyan=snow/ice, white=cloud, red=vegetation)

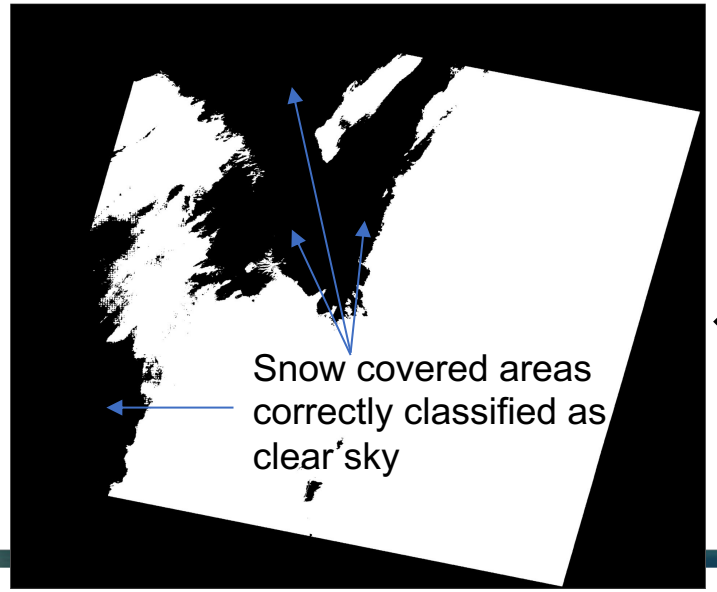




Landsat-9 FMask
VSWIR+TIR bands
Threshold based approach

	Landsat Fmask ('truth')	ECOCLOUD
Percent cloud	71.4%	72.1%
Commission error	0%	5.7%
Omission error	0%	4.8%

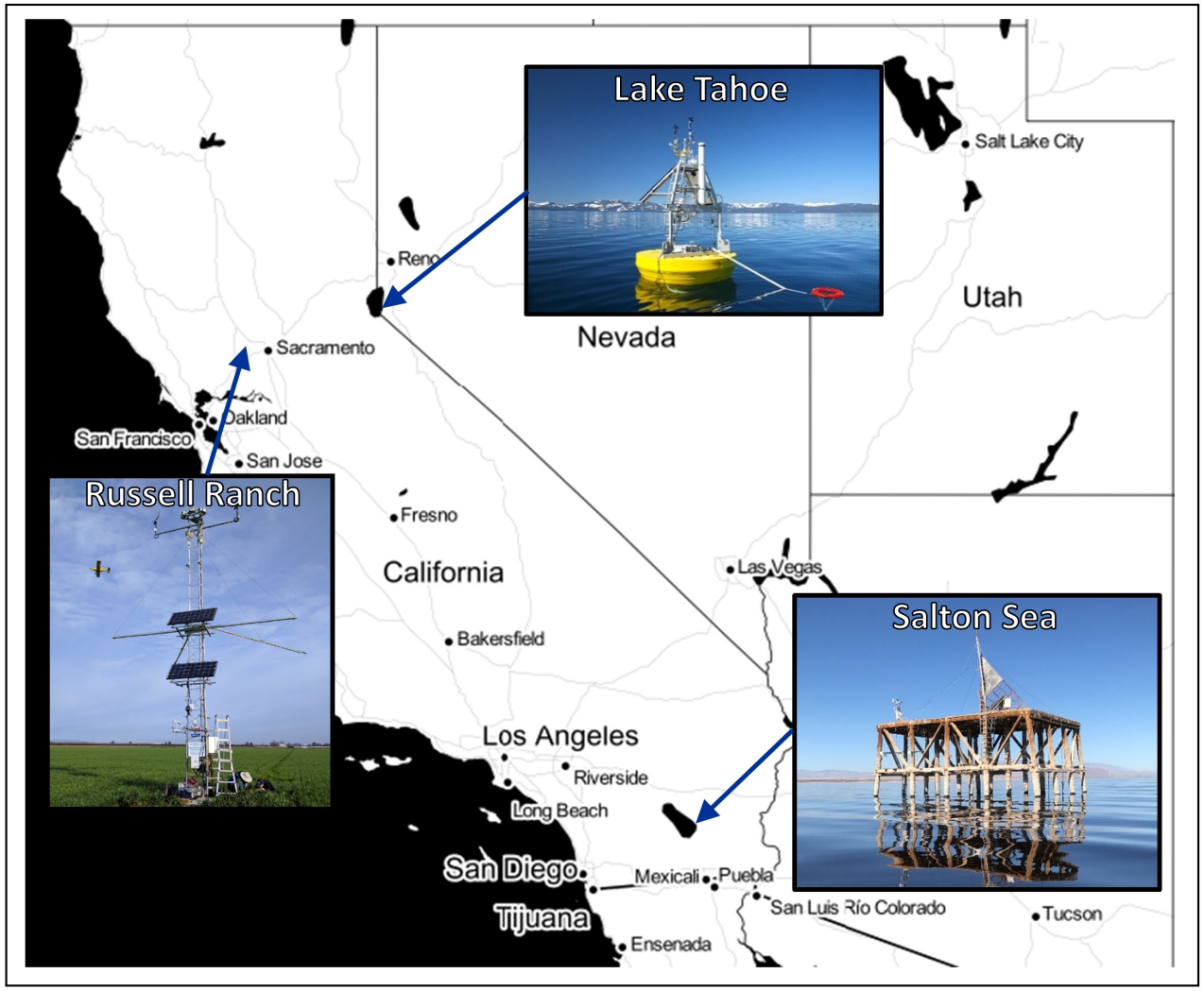
Negligible differences at the Landsat Fmask uncertainty level (~5%)



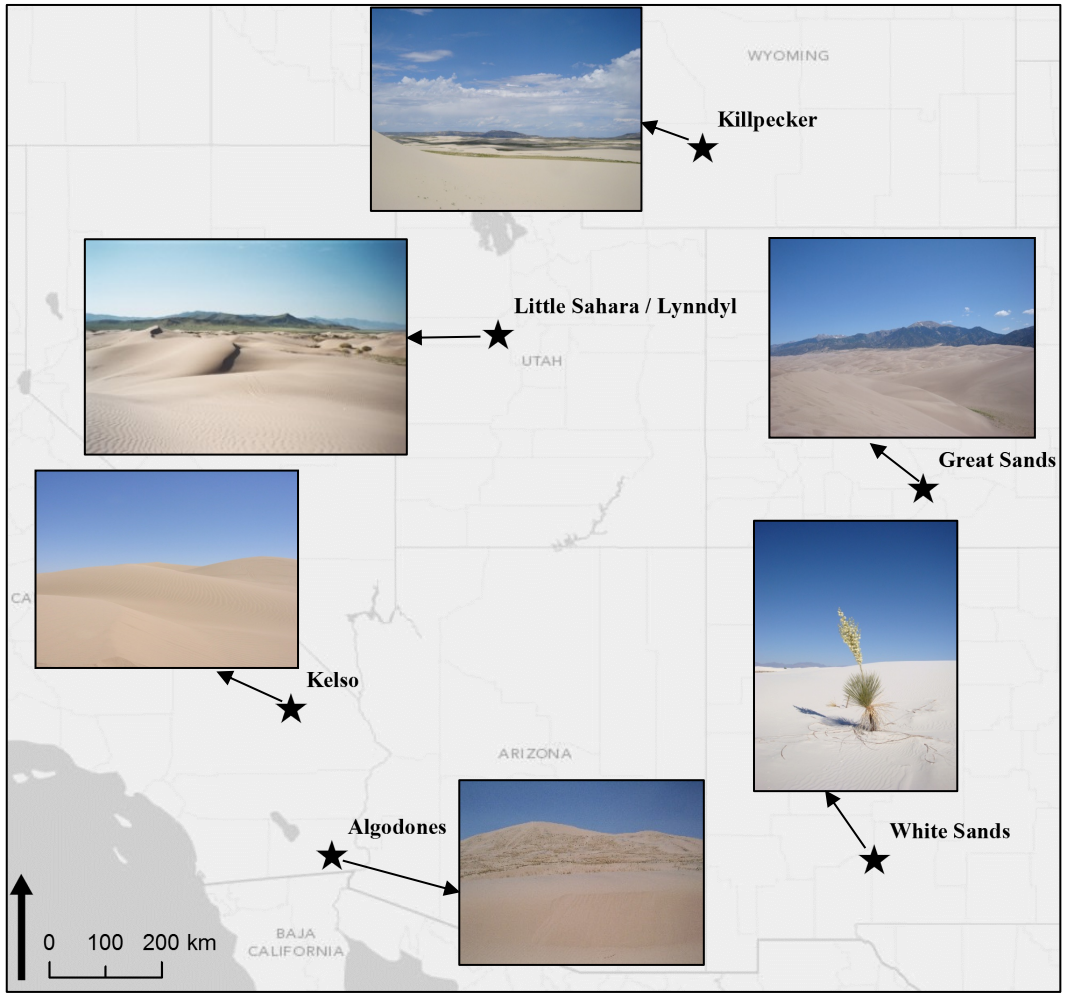
SBGCLOUD
2 VNIR + 2 TIR bands
ML approach
(Random forest)

SBG LST&E Validation

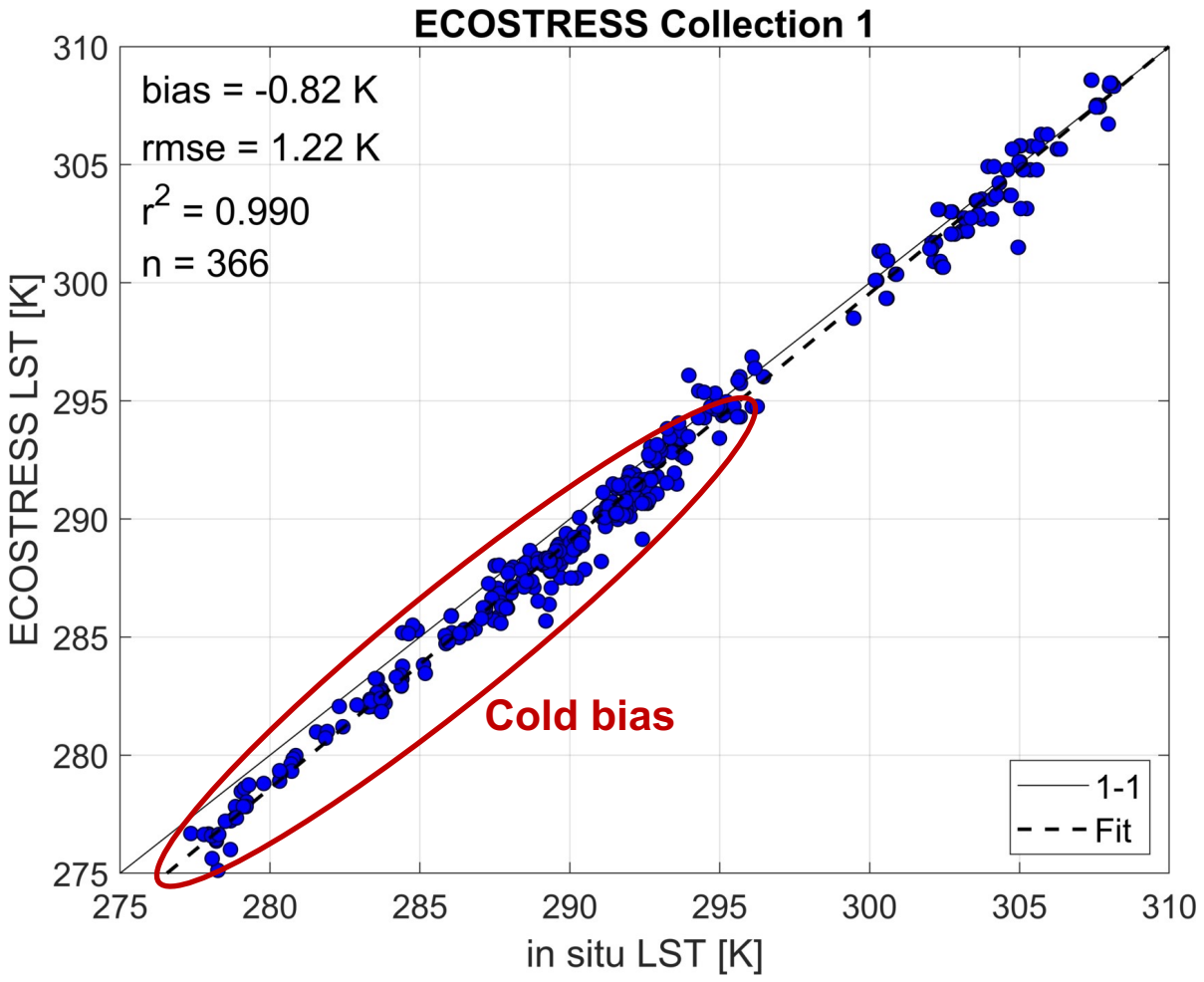
JPL automated cal/val sites

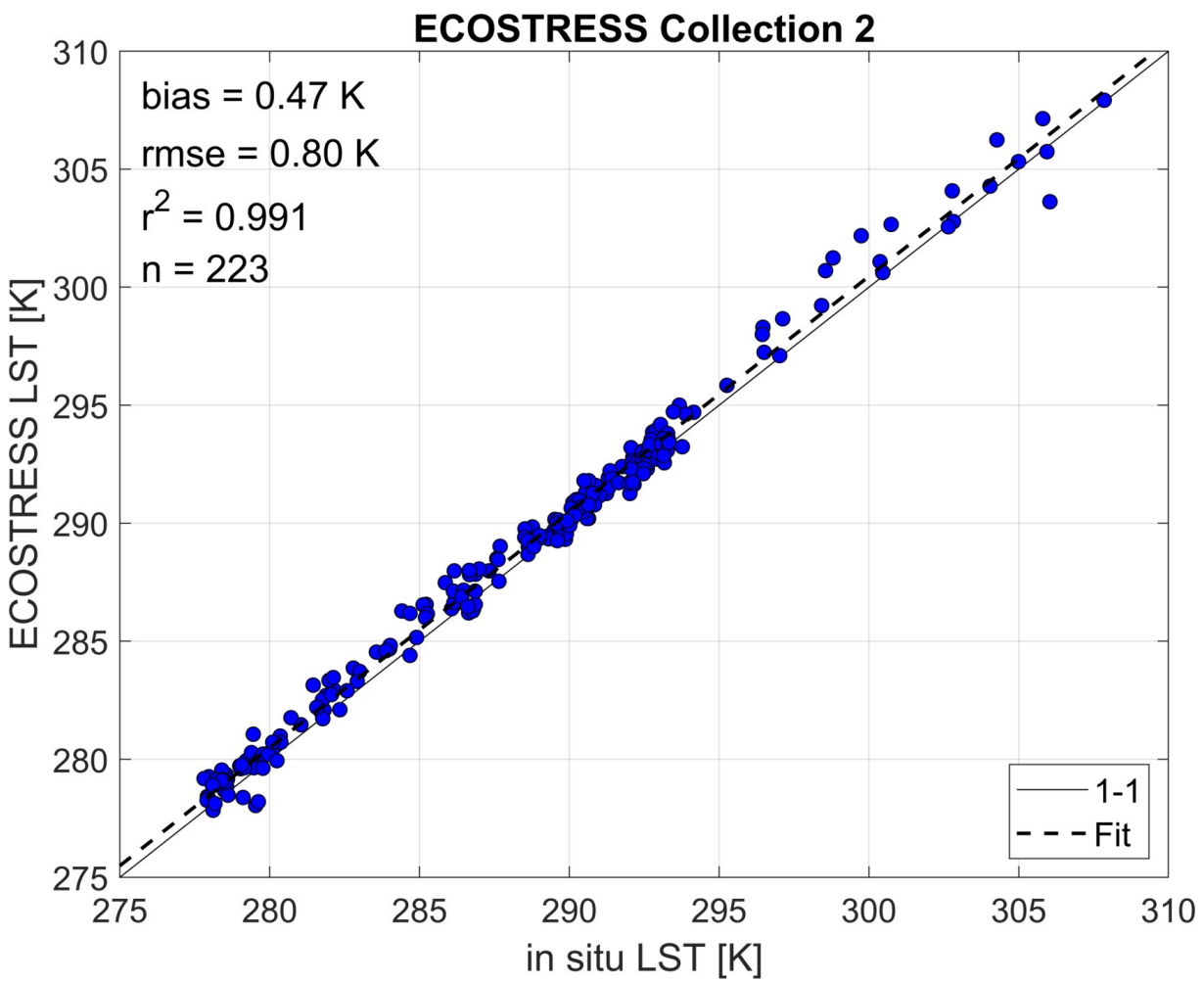


Pseudo-invariant sand dune sites



SBG LST&E Validation

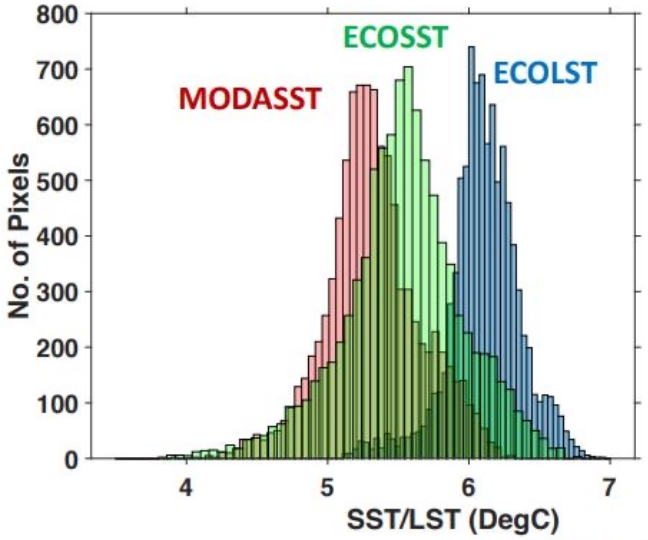


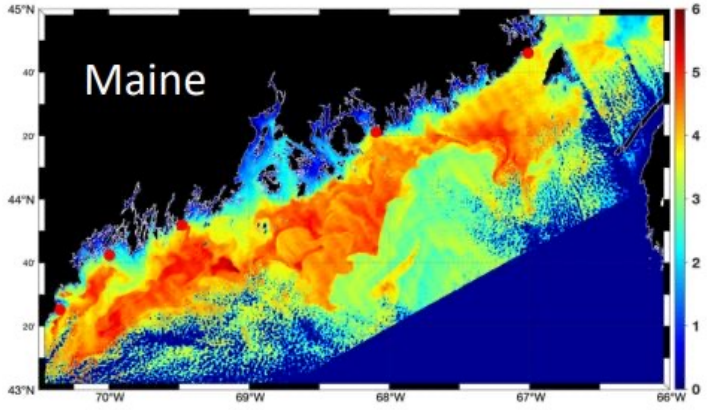


LST&E Algorithm Improvements for SBG

(1) Hybrid LST/SST algorithm

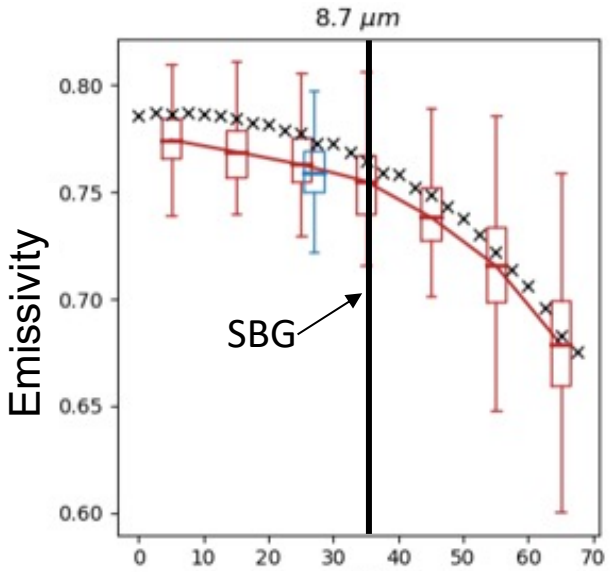
Otis and Hulley, 2021





(2) Emissivity anisotropy

Ermida and Hulley, 2020

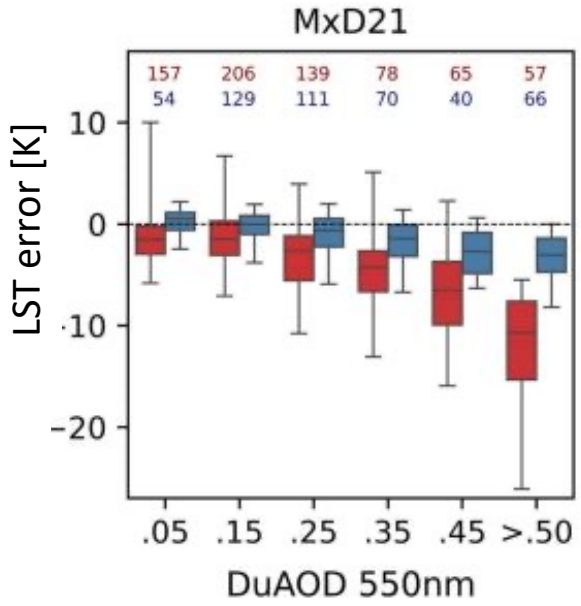


VZA-dependent TES calibration curve:

$$\epsilon_{min} = a_1 + a_2 MMD^{a_3 + b_2 VZA^{b3}}$$

(3) High aerosol dust loading

Stante et al. 2023



Improve atmospheric correction:

- RTTOV radiative transfer model
- AOD information (models, satellite)
- Uni. of Lisbon collaboration