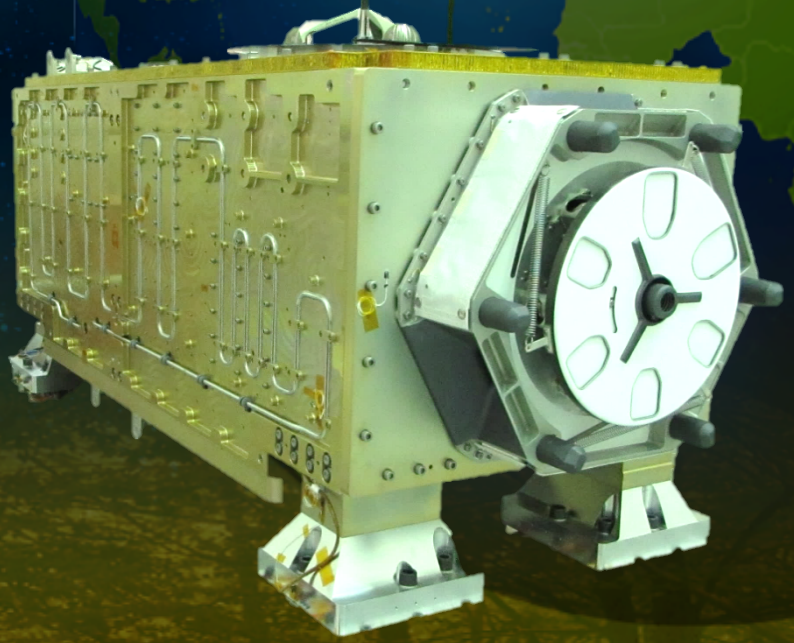
ECOSTRESS

High spatial resolution thermal infrared measurements from ECOSTRESS in support of Surface Biology and Geology (SBG) targeted observable science and applications



Glynn Hulley, Kerry Cawse-Nicholson, Joshua Fisher, Simon Hook, Vince Realmuto, Martha Anderson, Gregory Halverson, Christine Lee, the HyTES team

Jet Propulsion Laboratory,
California Institute of Technology, Pasadena, CA

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Outline

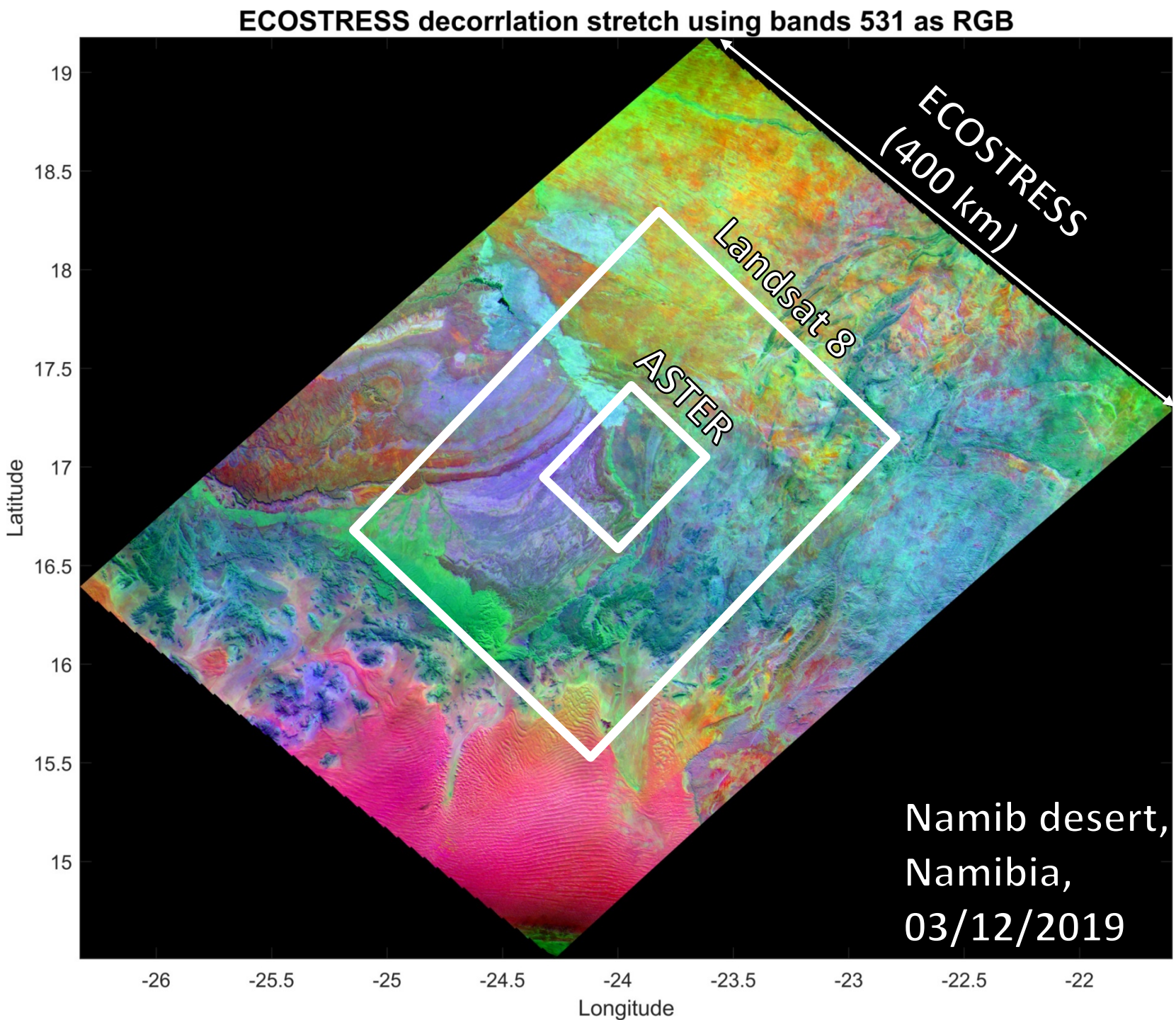
- Surface Biology and Geology (SBG)
- Surface Biology
  - ECOSTRESS
- Surface Geology
  - HyTES

The future of Thermal Infrared (TIR) space observations

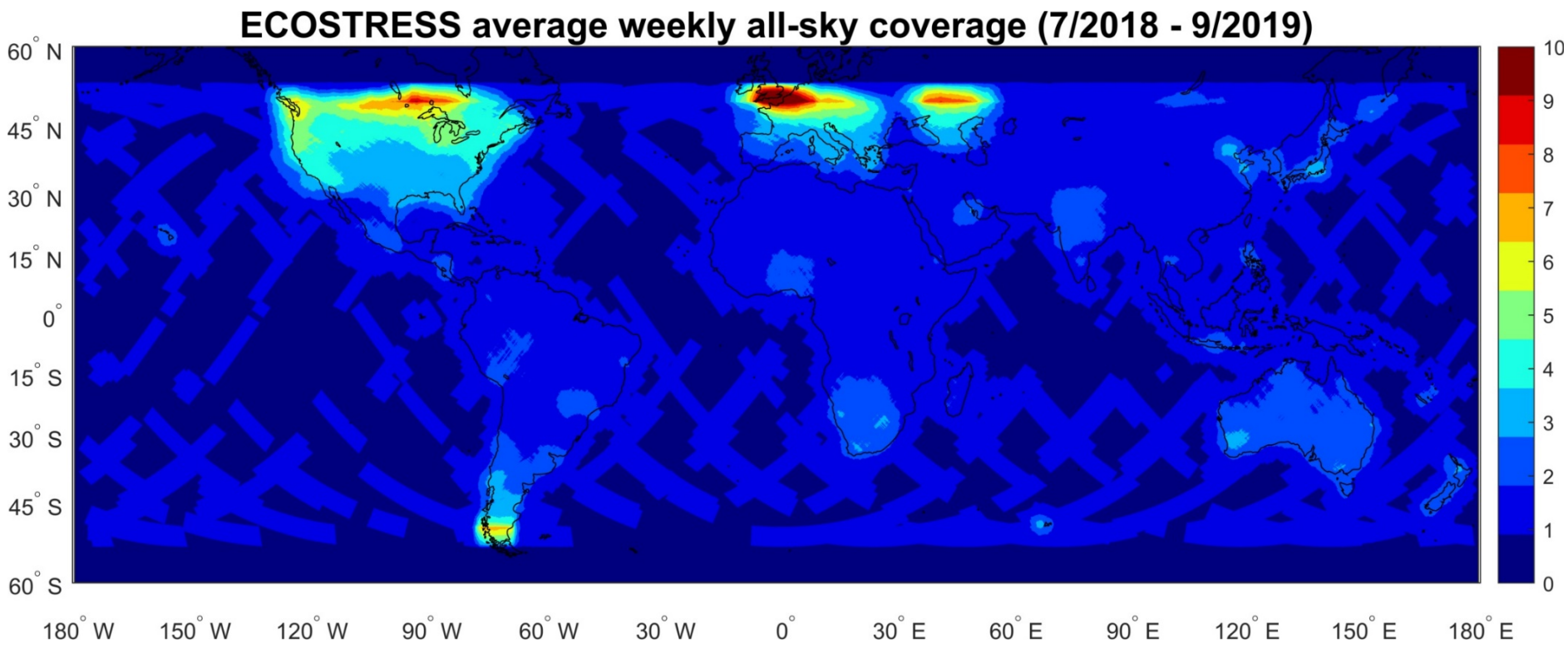
	Instrument	Platform	Agency	Resolution (m)	Revisit (days)	Overpass	Bands 8-13 µm	Launch year
Concept	SBG	tbd	NASA	50-100	2-5	tbd	5+	2026
	LSTM	tbd	ESA	50	2-3	1:00 pm	5	2026
	TIRS-3	Landsat 10	USGS/NASA	60	3-5	tbd	3+	2026
	TRISHNA	tbd	ISRO/CNES	50	3	1:00 pm	4	2024
Planned	SLSTR	Sentinel-3C Sentinel-3D	ESA	1000	Daily	10:00 am/pm	2	2021
	FCI	MTG	EUMETSAT	2000	Daily	every 10 min	4	2021
	TIRS-2	Landsat 9	USGS/NASA	100	16	10:00 am	2	2020
Operational	ECOSTRESS	ISS	NASA	70	3-5	Multiple	5	2018
	VIIRS	JPSS-1	NOAA	750	Daily	1:30 am/pm	4	2017
	SLSTR	Sentinel-3A Sentinel-3B	ESA	1000	Daily	10:00 am/pm	2	2016 2018
	GOES-16	GOES-E	NOAA	2000	Daily	15 min	2	2016
	AHI	Himawari-8	JMA/MSC	2000	Daily	10 min	3	2015
	TIRS	Landsat 8	USGS/NASA	100	16	10:00 am	2	2013
	VIIRS	S-NPP	NOAA	750	Daily	1:30 am/pm	4	2011
	AVHRR/3	Metop	NOAA	1000	Daily	9:30 am/pm	2	2007
	SEVIRI	MSG	EUMETSAT	3000	Daily	15 min	3	2002
	MODIS	Terra Aqua	NASA	1000	Daily	10:30 am/pm 1:30 am/pm	3	1999 2002
	ASTER	Terra	NASA	90	16	10:30 am	5	1999

Complimentary wavelength ranges

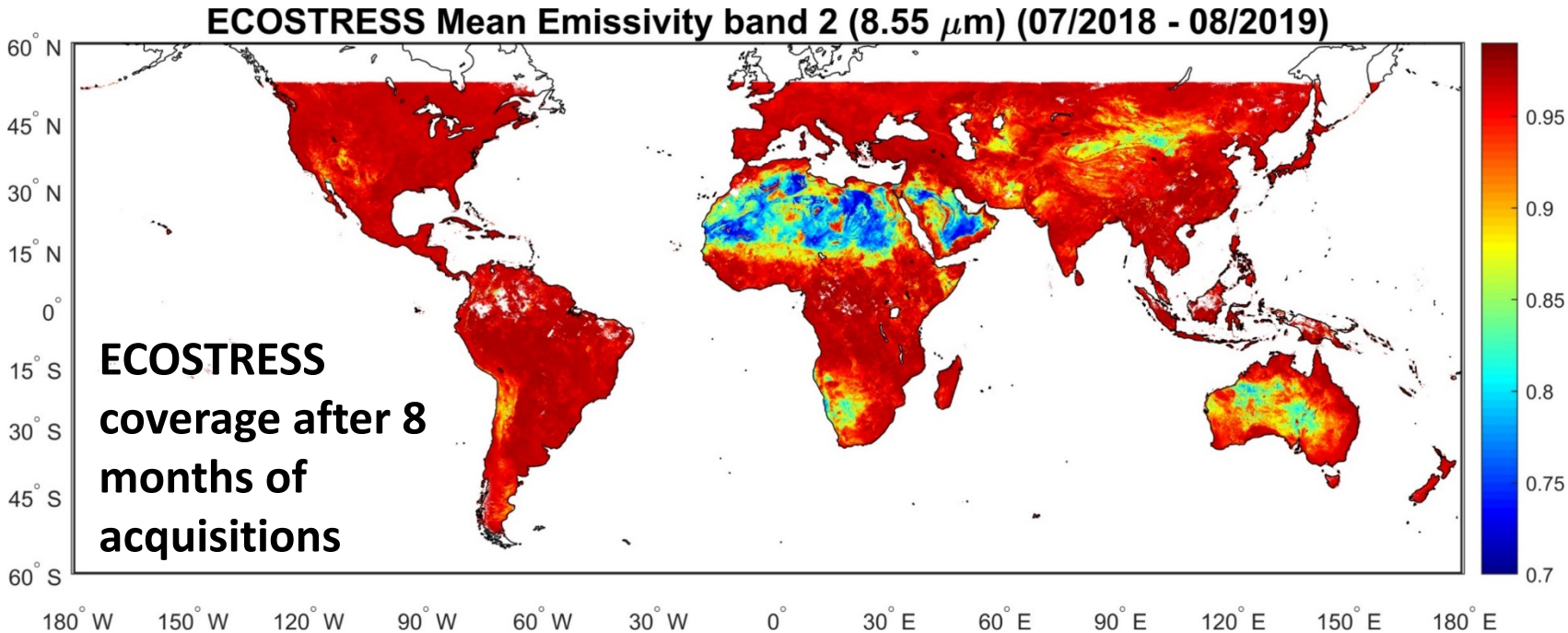
	VisNIR (0.4 – 1um)	SWIR (1-2.5um)	TIR (8-12um)
Biology	Health Greenness Species Foliar traits	Species function/type Foliar traits	Evapotranspiration Temperature
Geology	Hematite	Clays Chlorite Mica Sulphates Hydroxides	Silica Feldspar Carbonates Sulphates Phosphates


ECOSTRESS decorrlation stretch using bands 531 as RGB
ECOSTRESS
(400 km)
Landsat 8
ASTER
Namib desert,
Namibia,
03/12/2019
Latitude
19
18.5
18
17.5
17
16.5
16
15.5
15
Longitude
-26
-25.5
-25
-24.5
-24
-23.5
-23
-22.5
-22

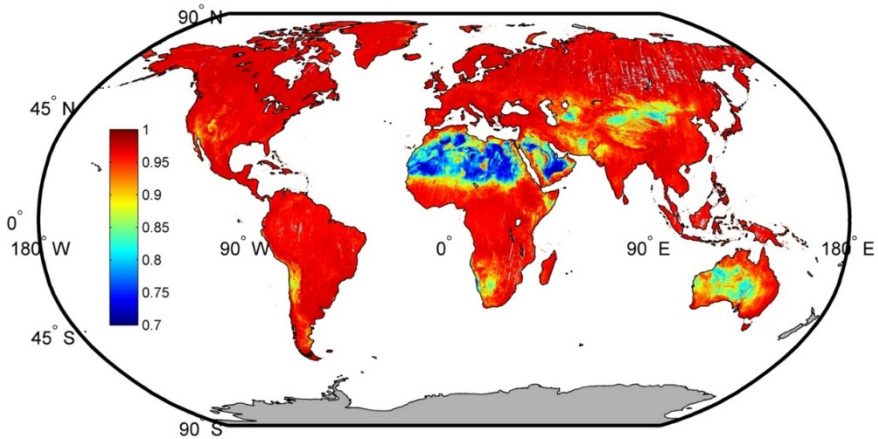
ECOSTRESS coverage



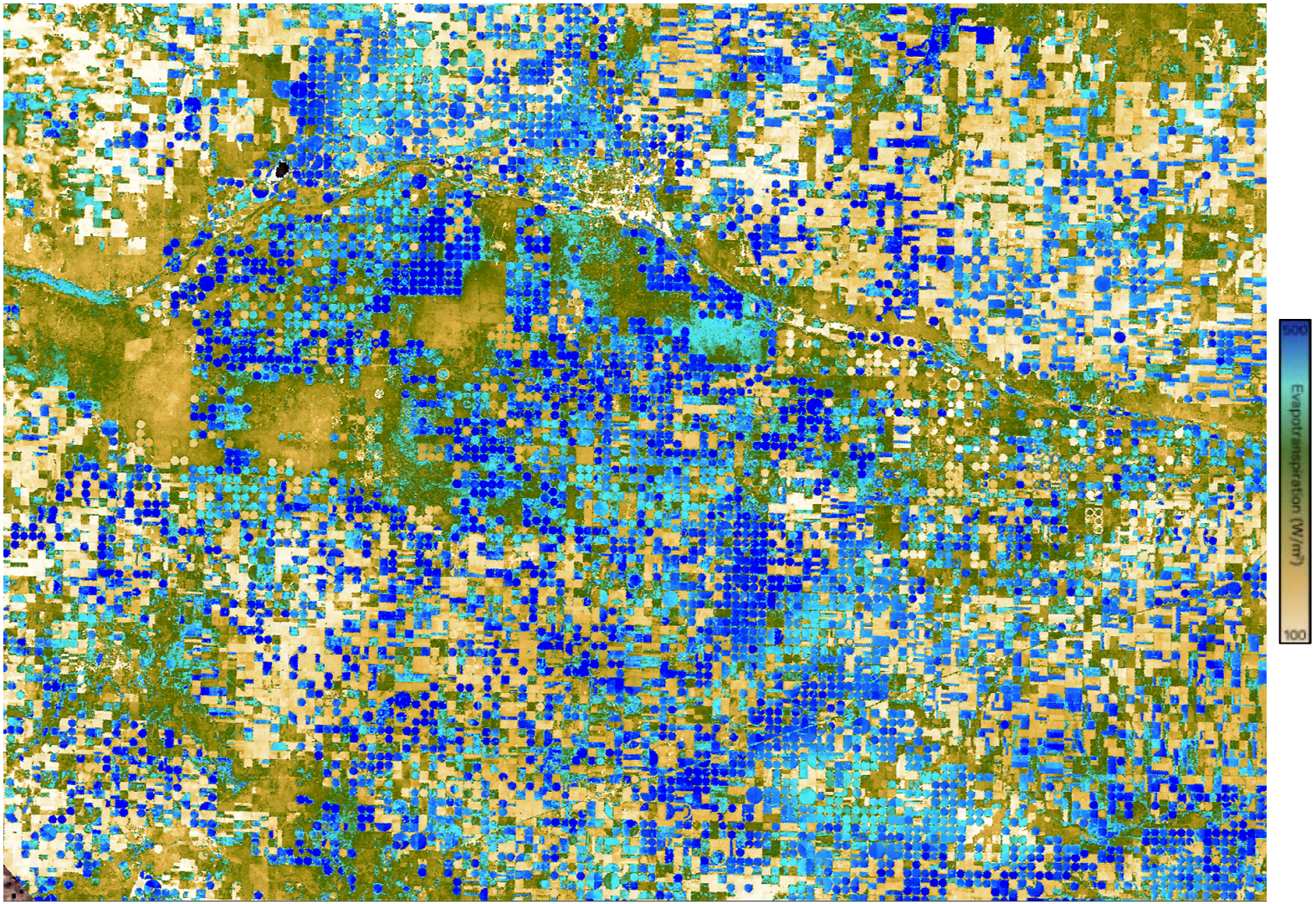
ECOSTRESS coverage



By comparison ASTER required 9 years of observations to generate a global map (2000-2008)!

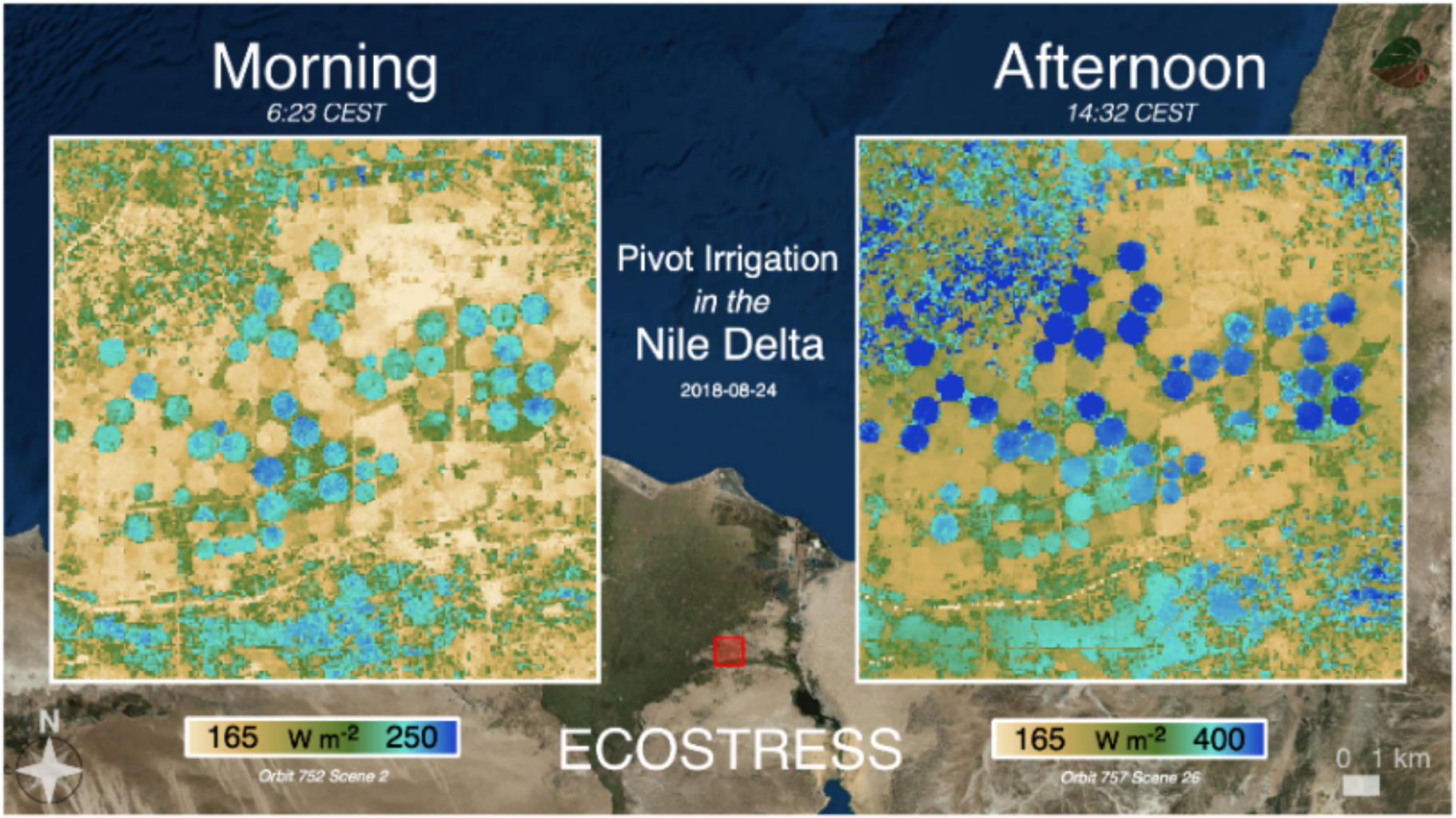


ECOSTRESS field-scale evapotranspiration

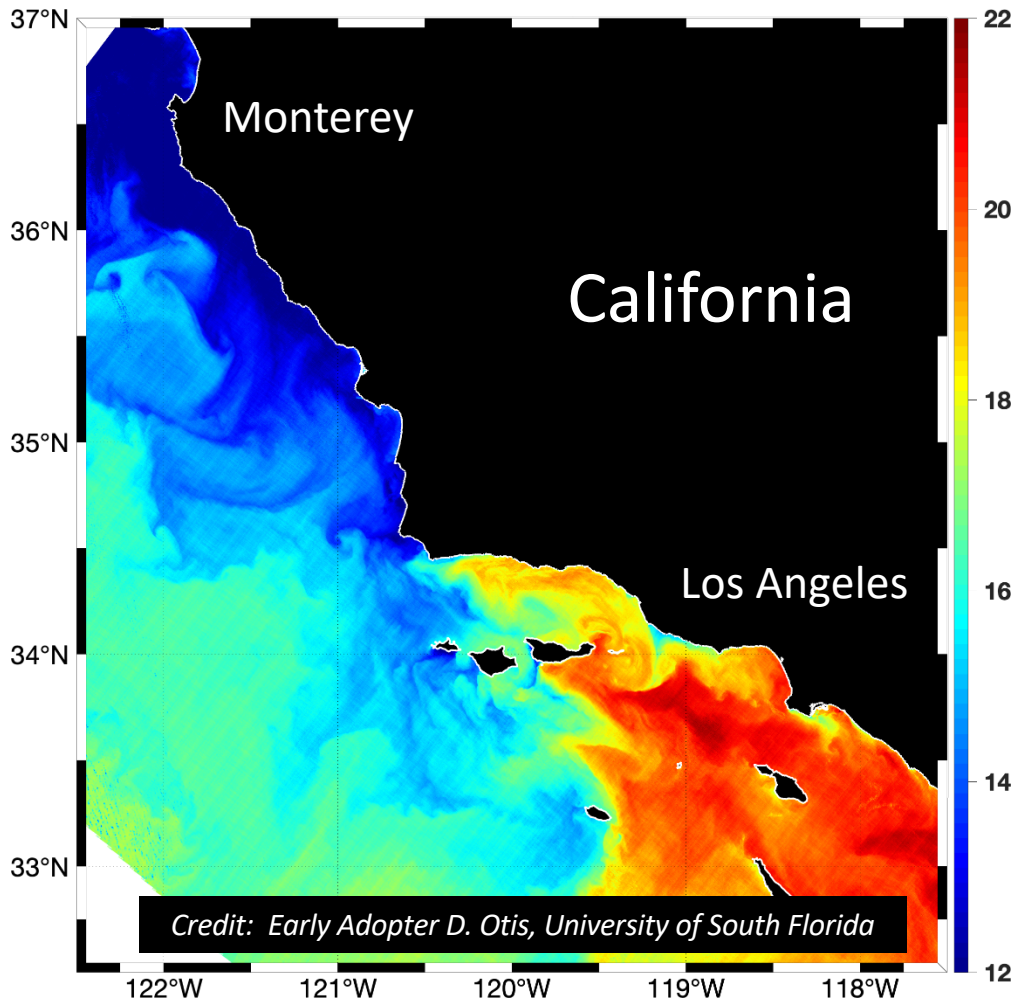


Garden City, Kansas

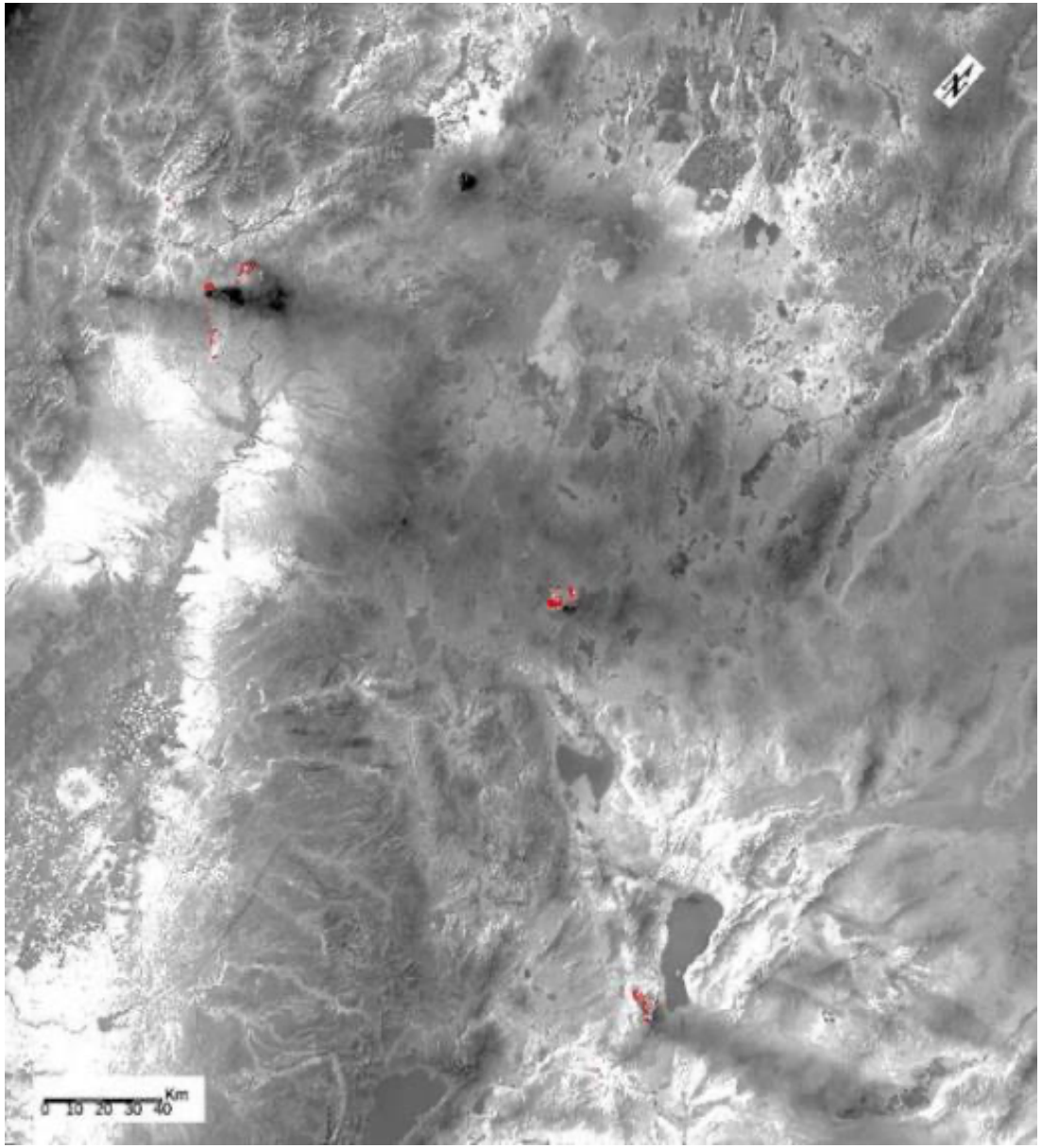
ECOSTRESS diurnal sampling

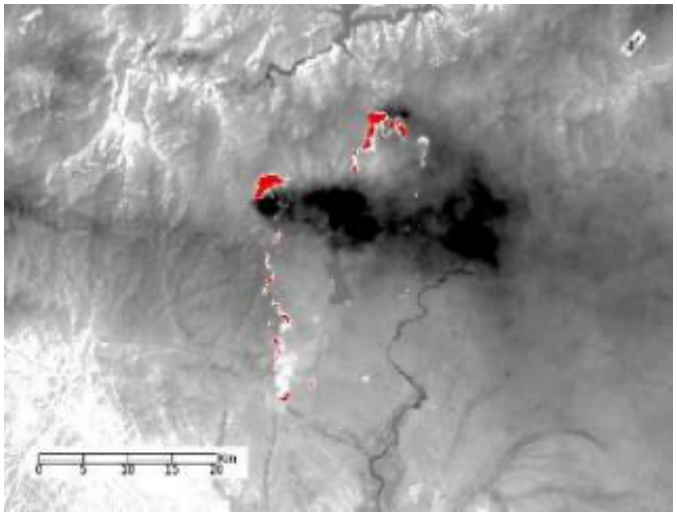


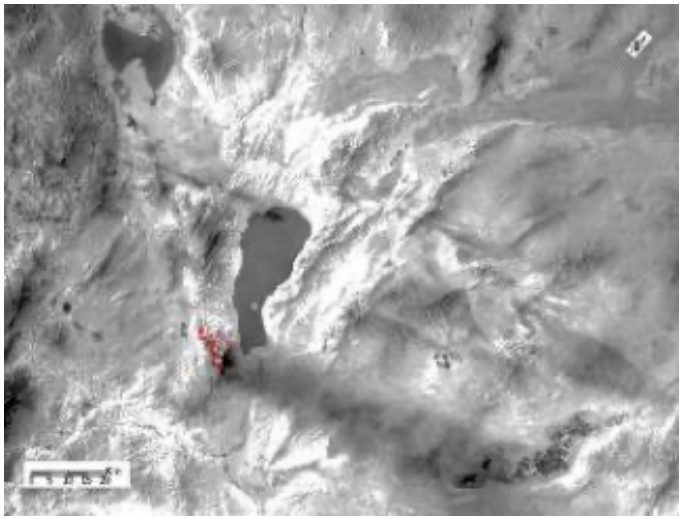
Half a century of satellite remote sensing of sea-surface temperature



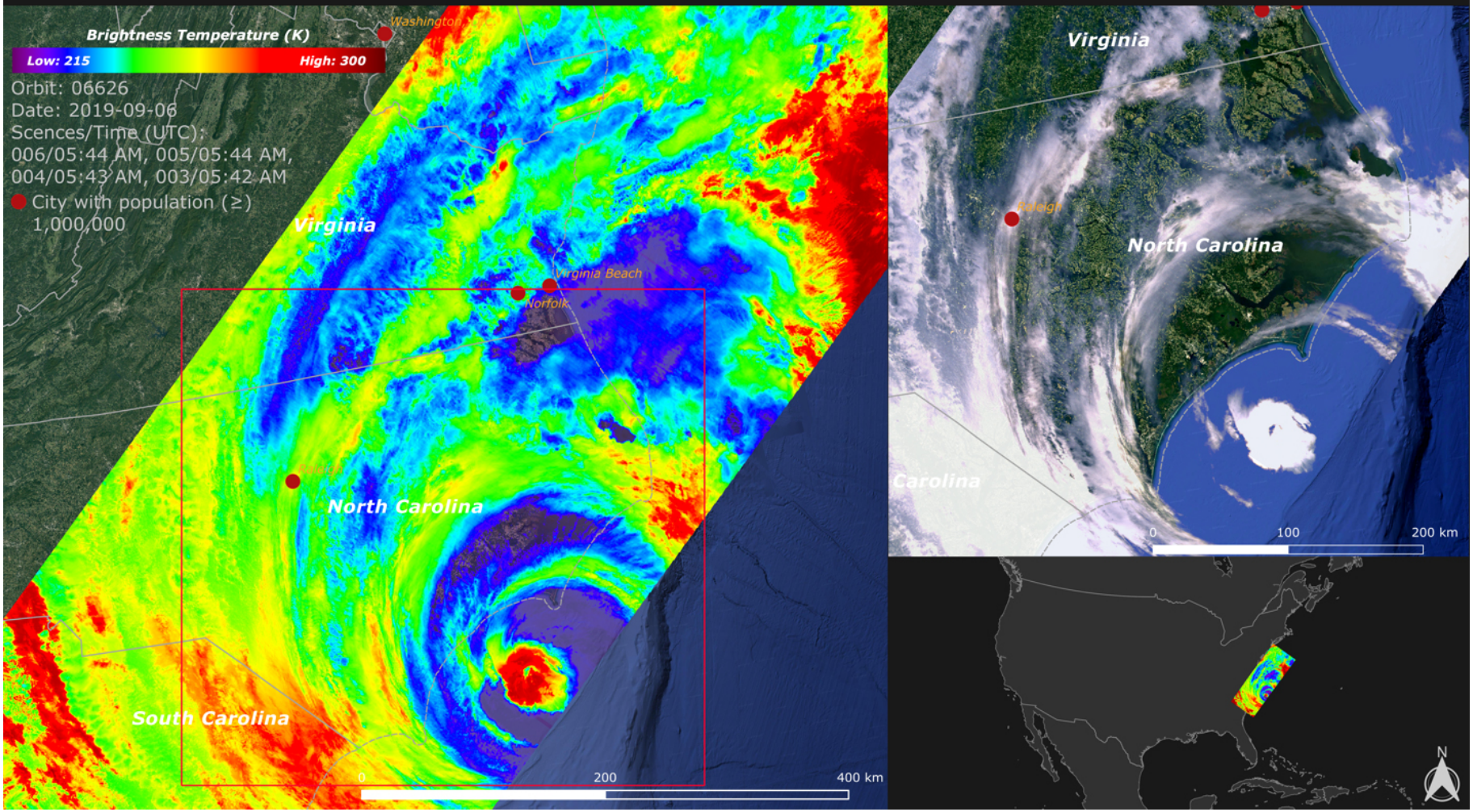
Credit: Early Adopter D. Otis, University of South Florida

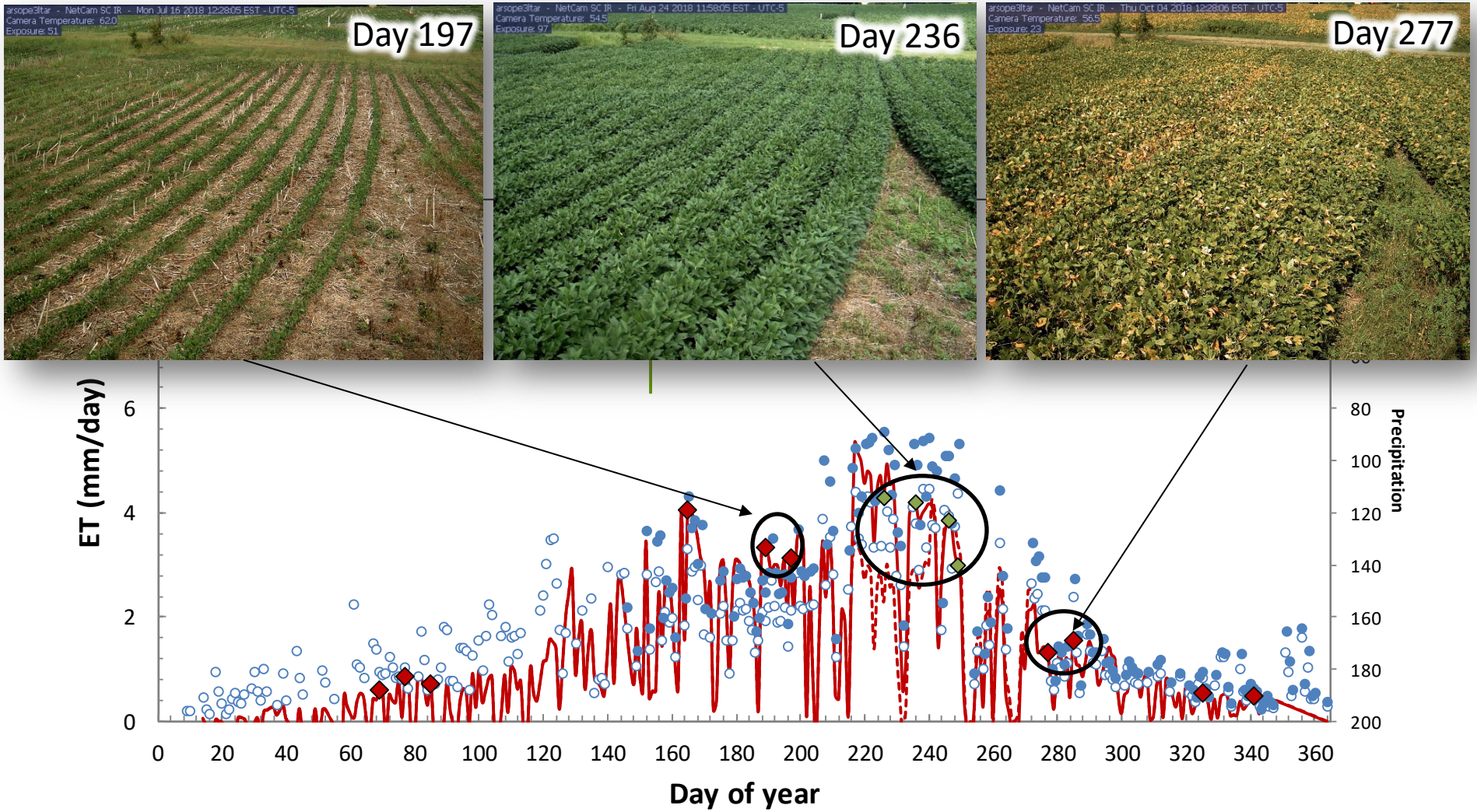

0 10 20 30 40
Km


0 5 10 15 20
Km



Hurricane Dorian as seen by ECOSTRESS



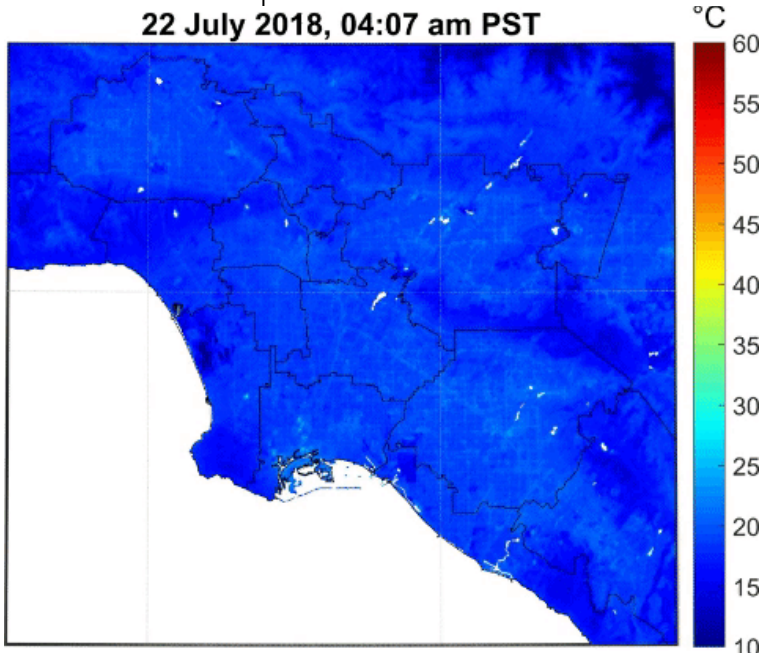

Day 197
Day 236
Day 277
ET (mm/day)
Precipitation
Day of year
0
2
4
6
80
100
120
140
160
180
200
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360

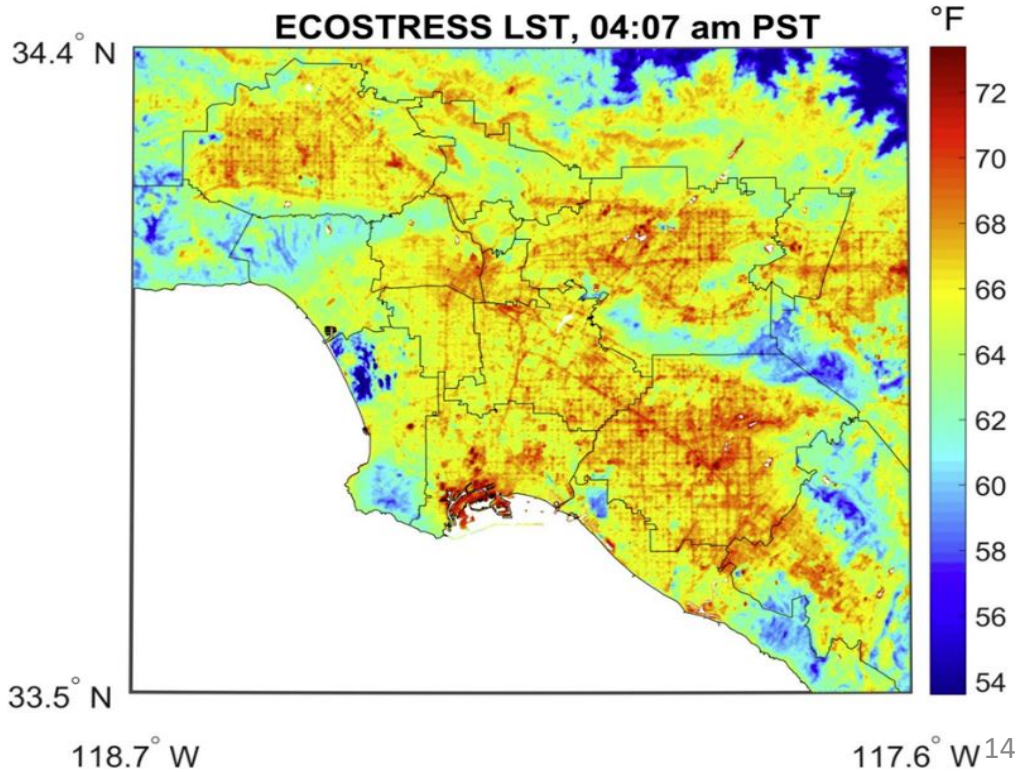
Human health and urbanization

Jet Propulsion Laboratory
California Institute of Technology

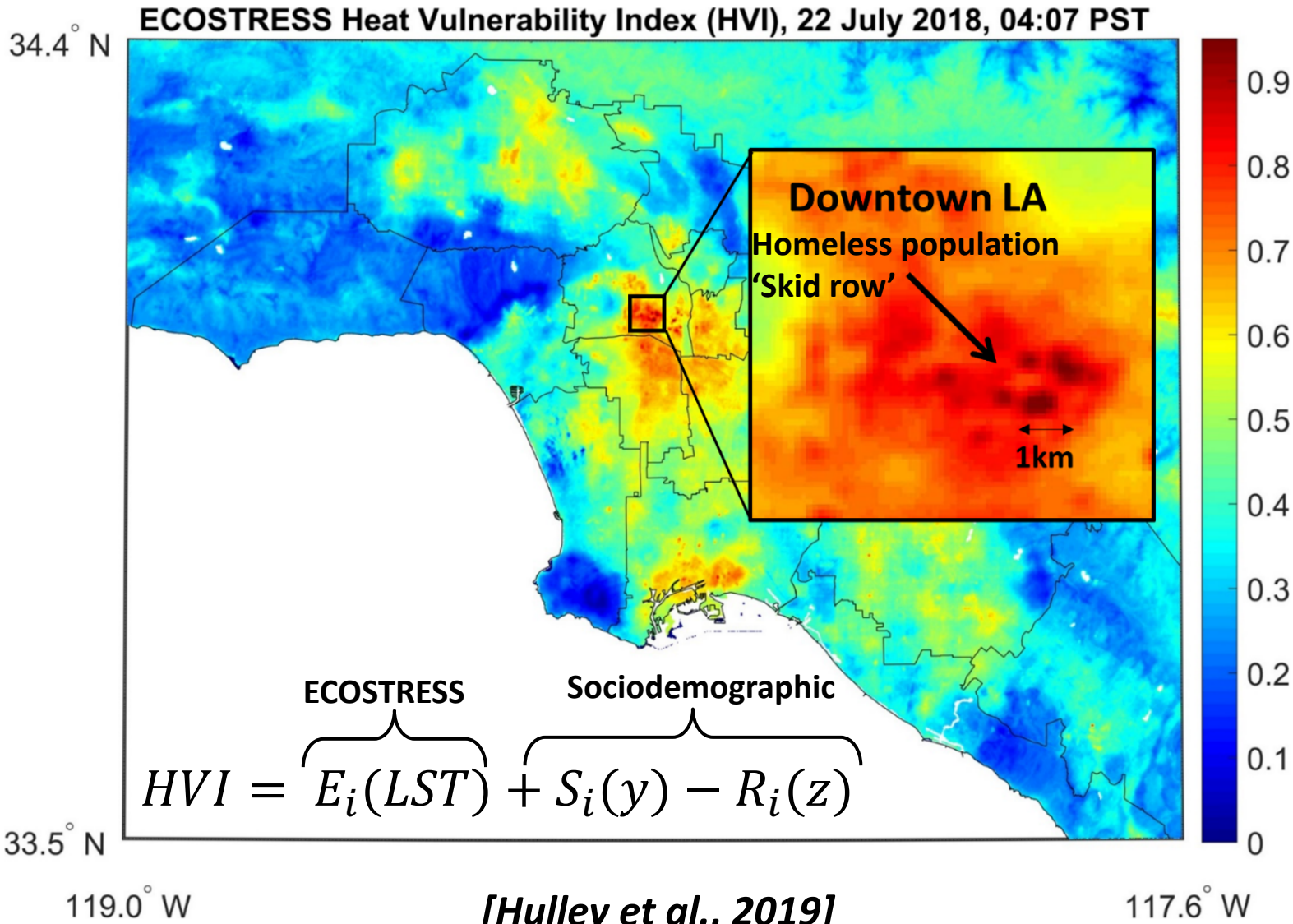
NEWS | SEPTEMBER 18, 2018

ECOSTRESS Maps LA's Hot Spots



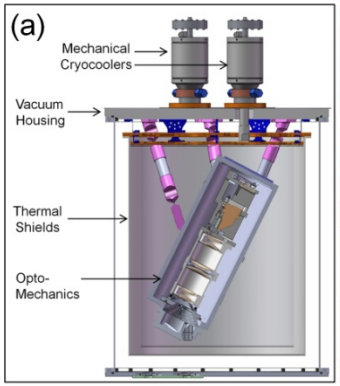


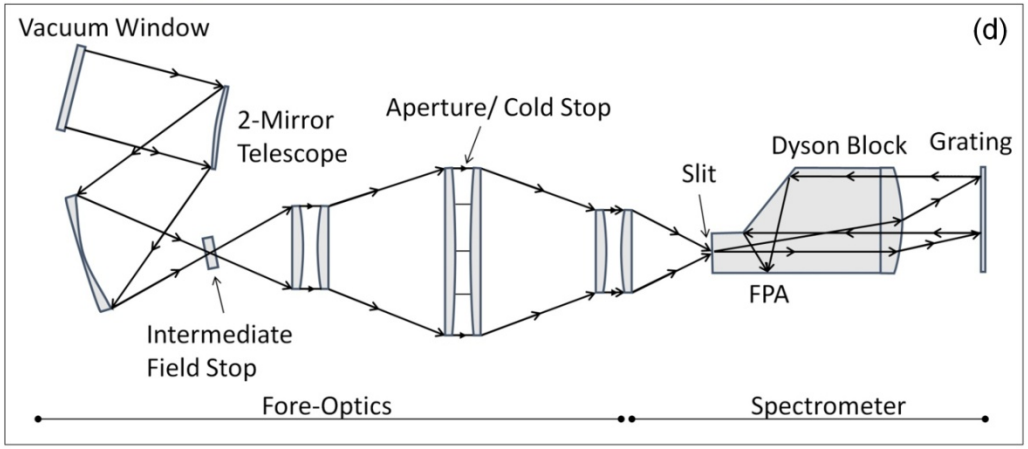
Human health and urbanization



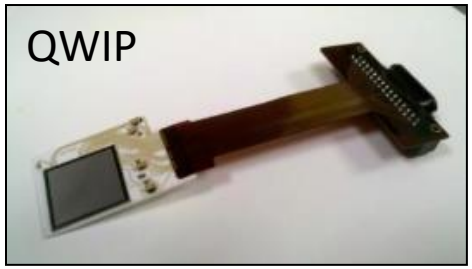
[Hulley et al., 2019]

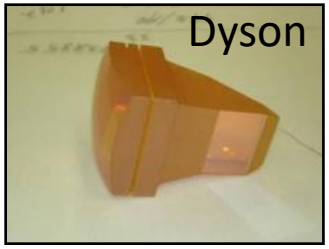
HyTES Instrument Characteristics





Instrument Characteristic	HyTES
Mass (Scanhead)[1]	12kg
Power	400W
Volume	1m x 0.5m (Cylinder)
Number of pixels x track	512
Number of bands	256
Spectral Range	7.5-12 um
Detector	Multi-stack QWIP
Total Field of View	50 degrees
Calibration (preflight)	Full aperture blackbody
Swath Width	1.8 – 3.6 km
Pixel size at 2000 m flight altitude	3.64m
Pixel size at 20,000 m flight altitude	36.4m

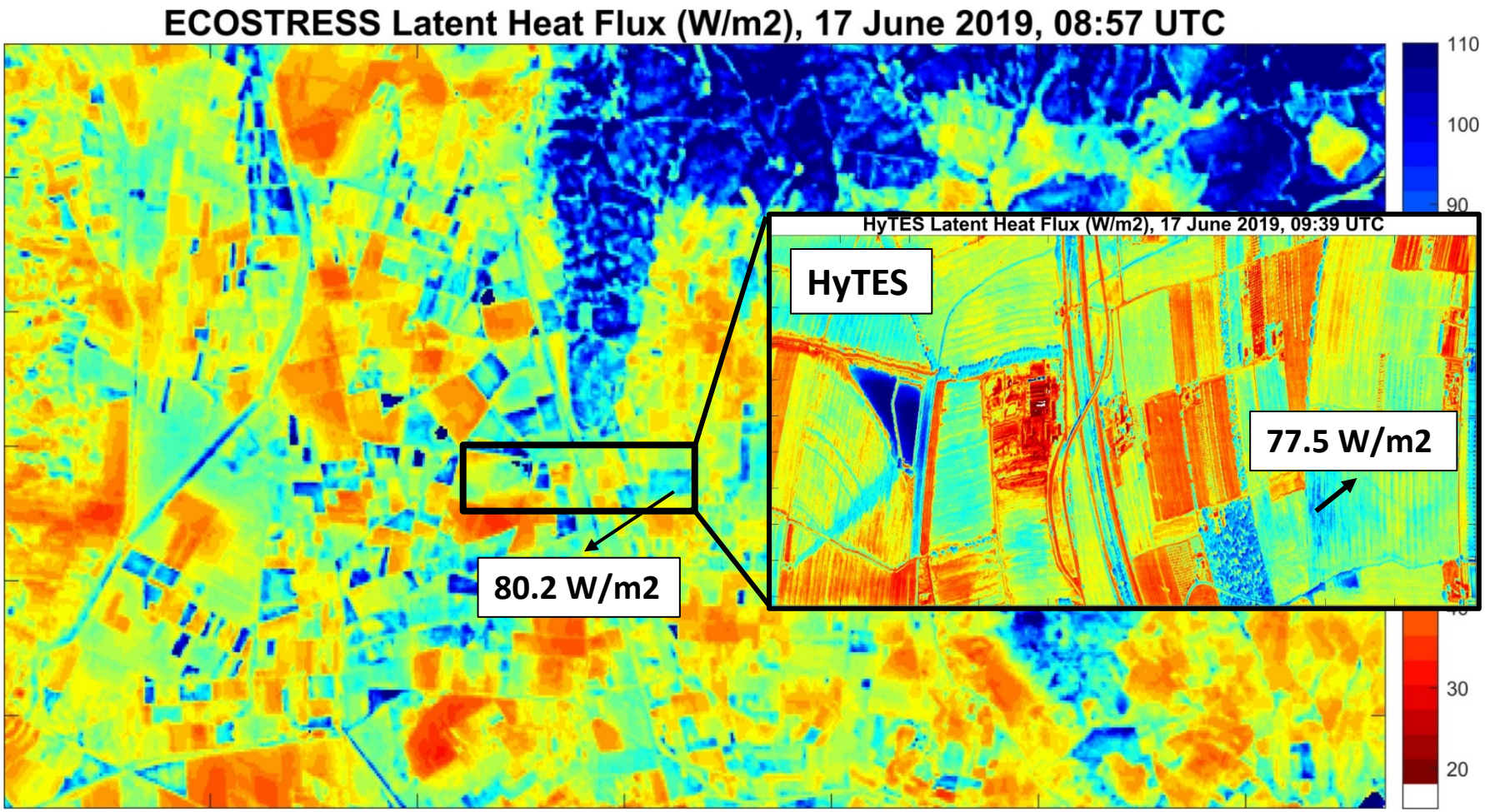




Engineering flights: 2013
Science flights: 2014 - present

ECOSTRESS and HyTES matchup: Grosseto

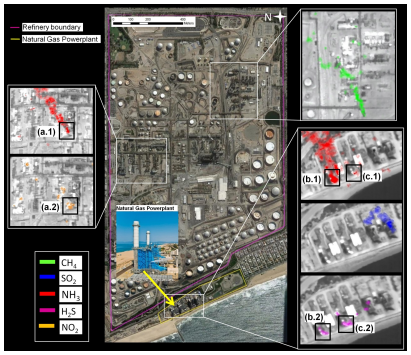
ecostress.jpl.nasa.gov



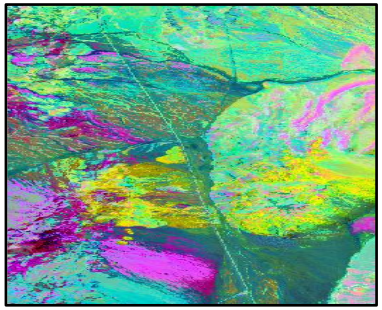
Data Coverage

California, Western U.S., Hawaii, England, Italy

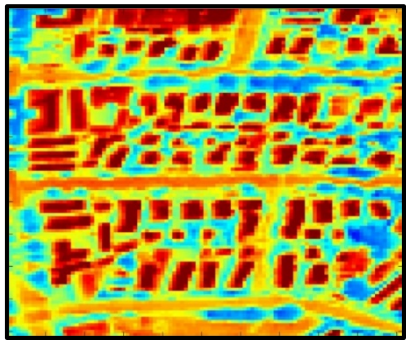
Science Focus Themes



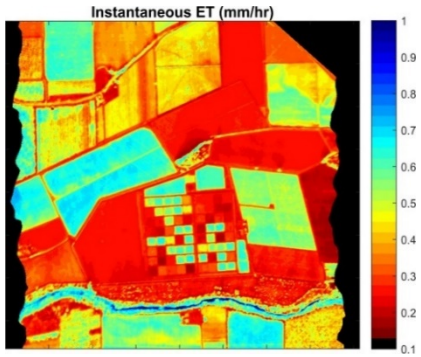
Multi-species gas detection
Hulley et al. 2016



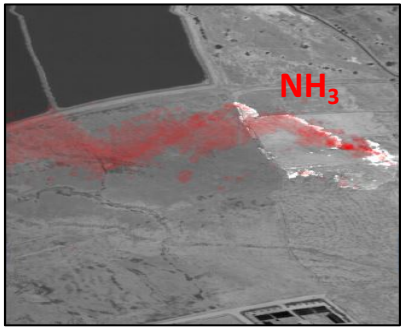
Mineral Mapping
Cawse-Nicholson et al. 2019
Kruse et al. 2015



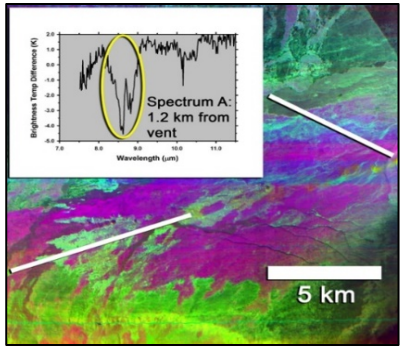
Urban Heat Islands
Quantification, attribution
Hulley et al. 2019



Surface energy balance
evapotranspiration

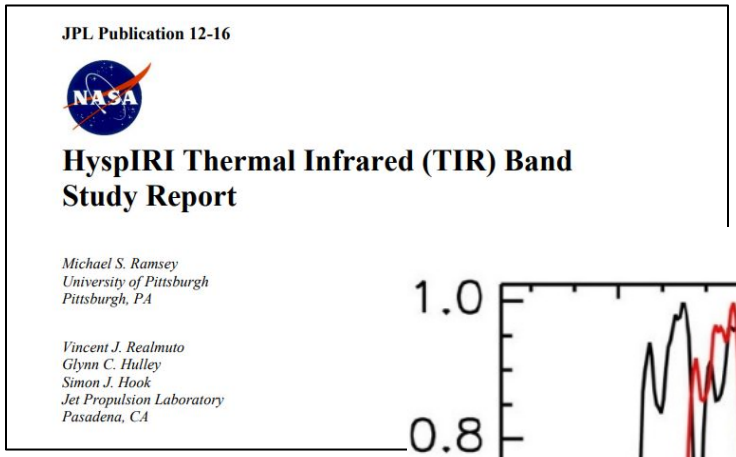


Fire emissions
detection and quantification.
Kuai et al. 2019



Volcano monitoring
and SO2 retrievals
Realmuto et al. 2017

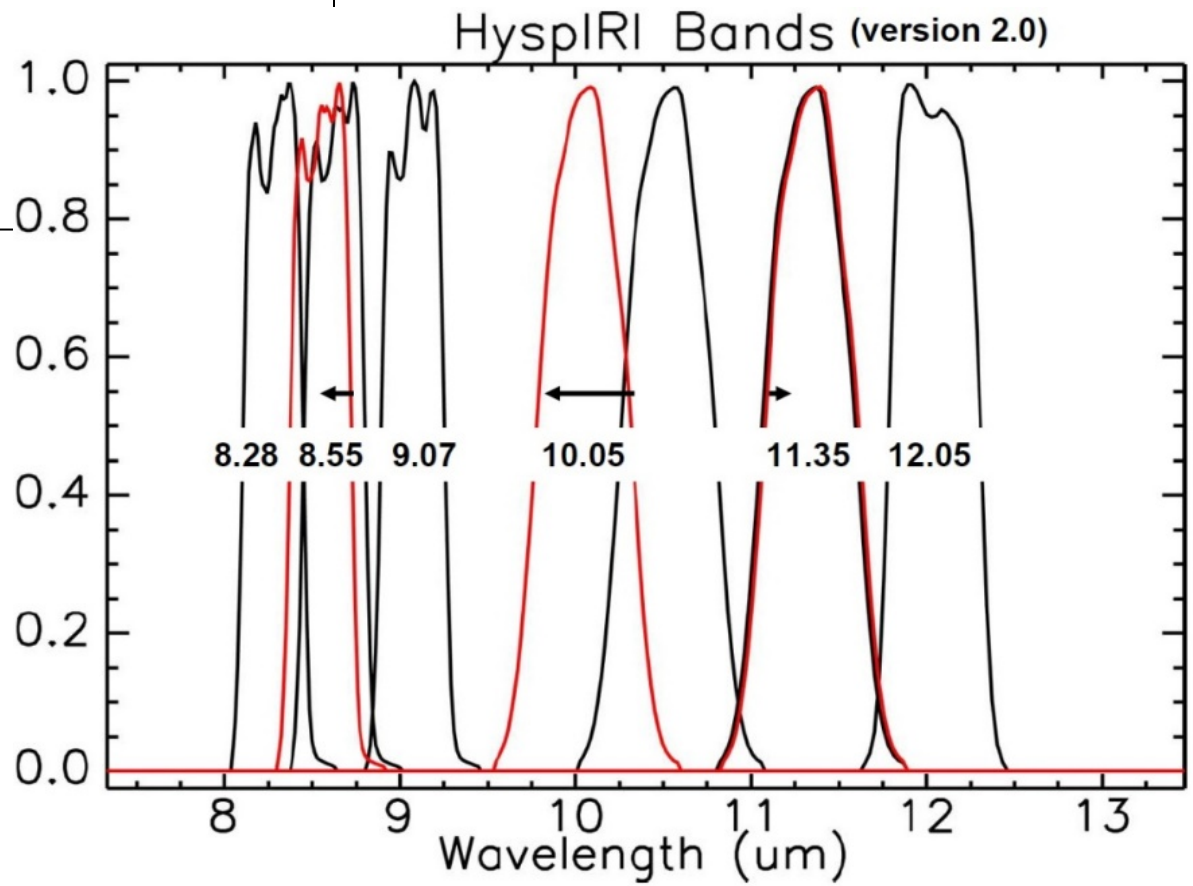
Optimal TIR band positions for geologic mapping


JPL Publication 12-16

HyspIRI Thermal Infrared (TIR) Band Study Report

Michael S. Ramsey
University of Pittsburgh
Pittsburgh, PA

Vincent J. Realmuto
Glynn C. Hulley
Simon J. Hook
Jet Propulsion Laboratory
Pasadena, CA



Optimal TIR band positions for geologic mapping

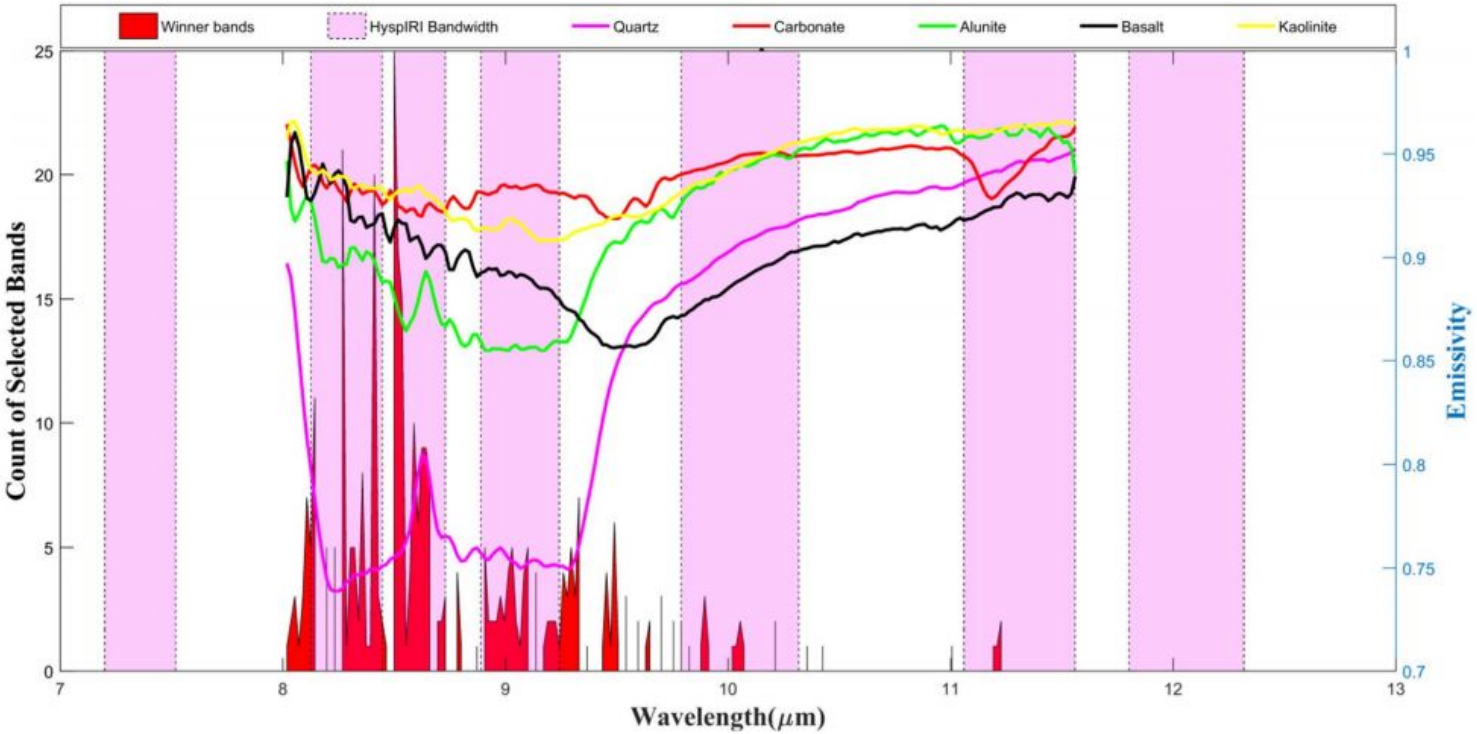
Contents lists available at ScienceDirect

Remote Sensing of Environment

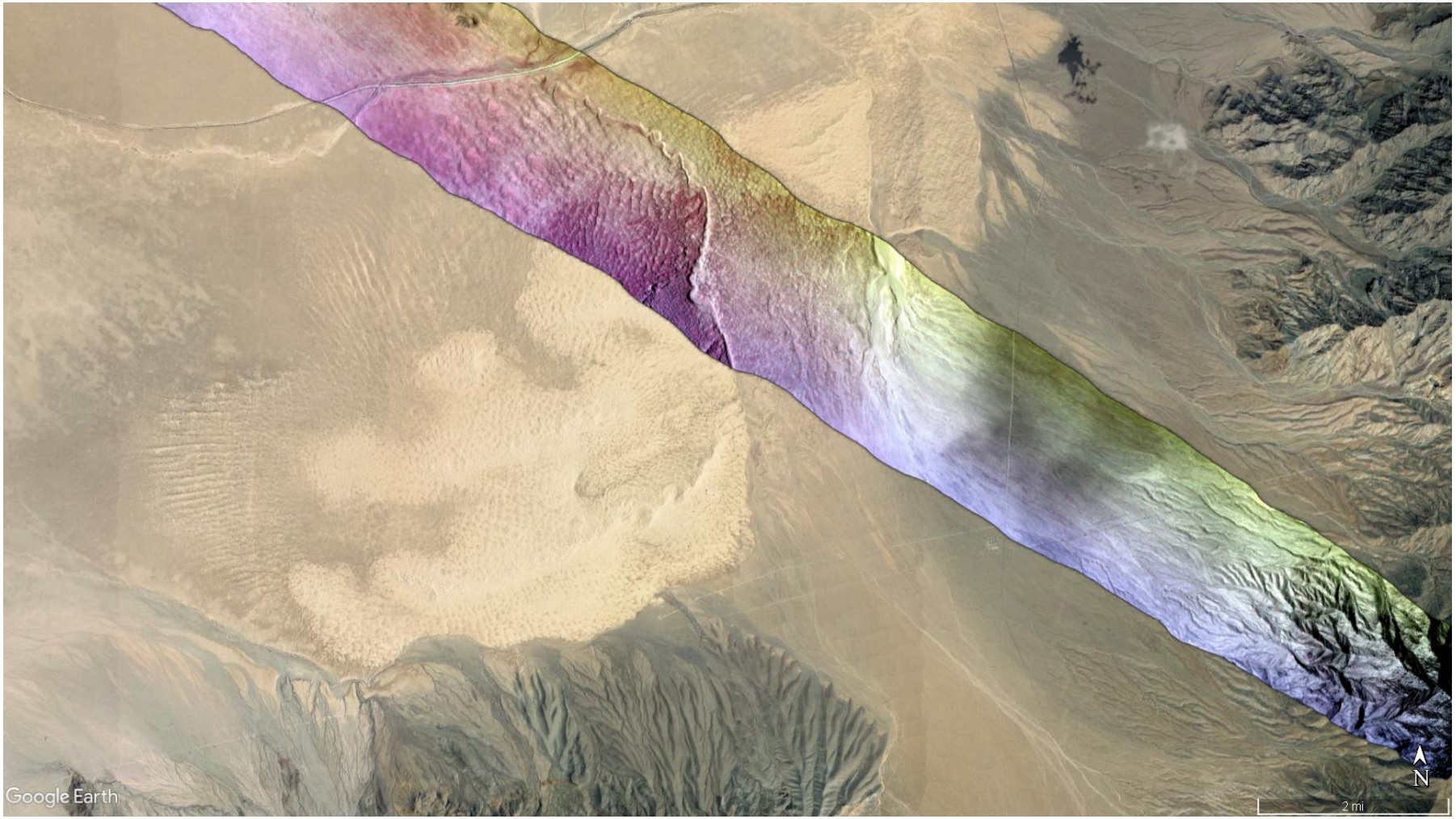
journal homepage: www.elsevier.com/locate/rse

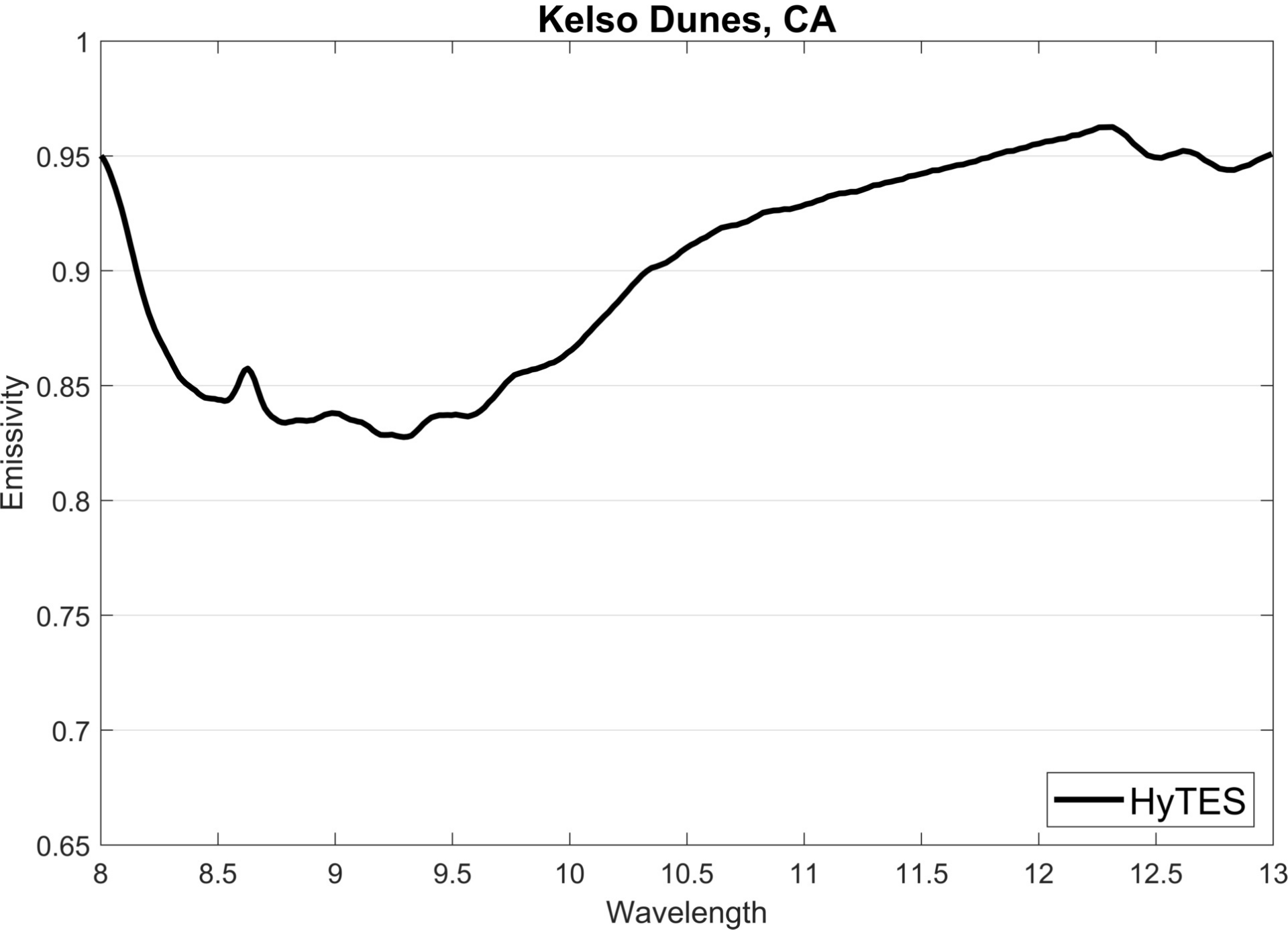
Selection of HyspIRI optimal band positions for the earth compositional mapping using HyTES data

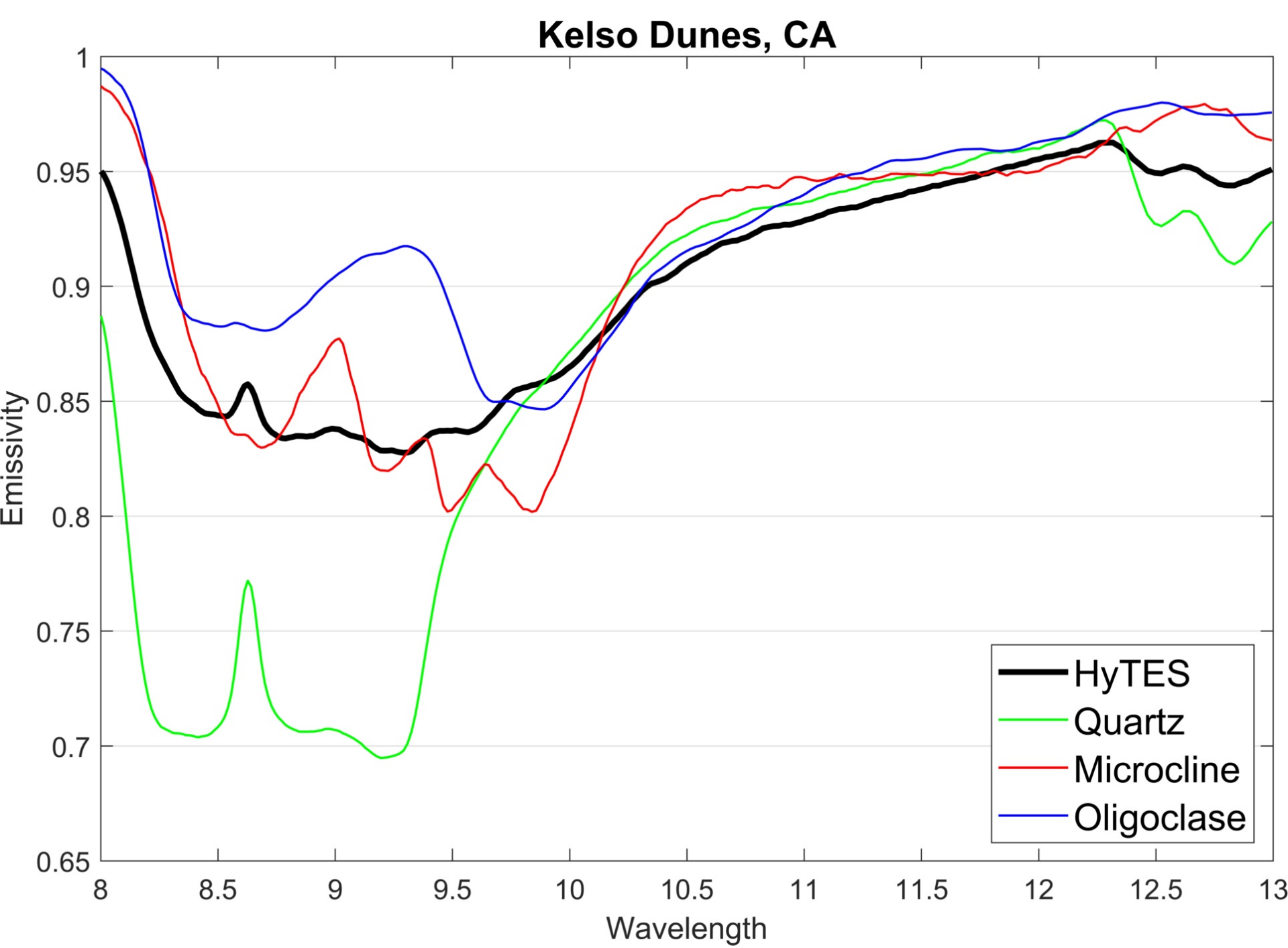
Arshad Iqbal[a], Saleem Ullah[a,*], Noora Khalid[a], Waqar Ahmad[b,h], Ijaz Ahmad[c,h],

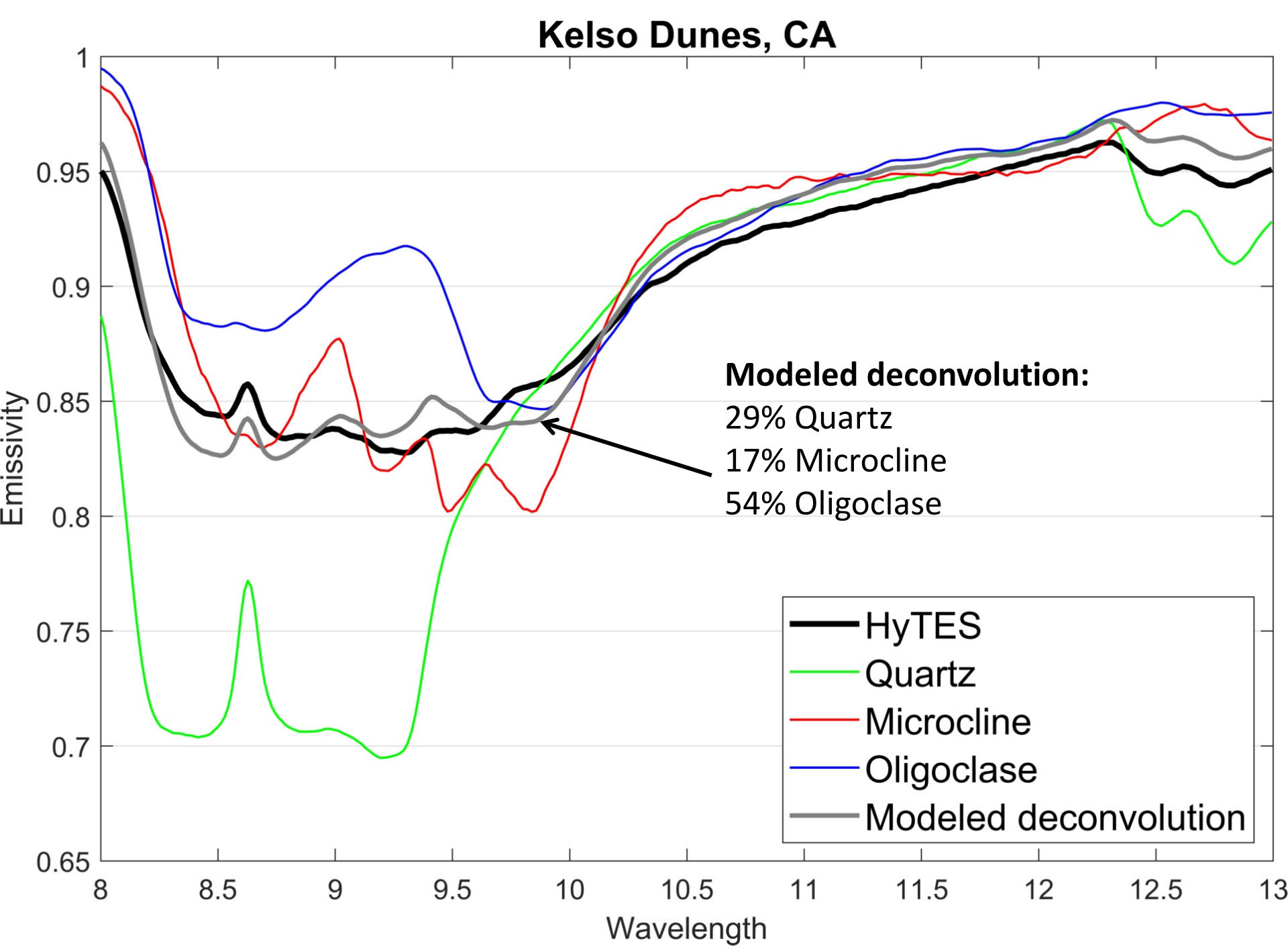


HyTES kelso Dunes case study

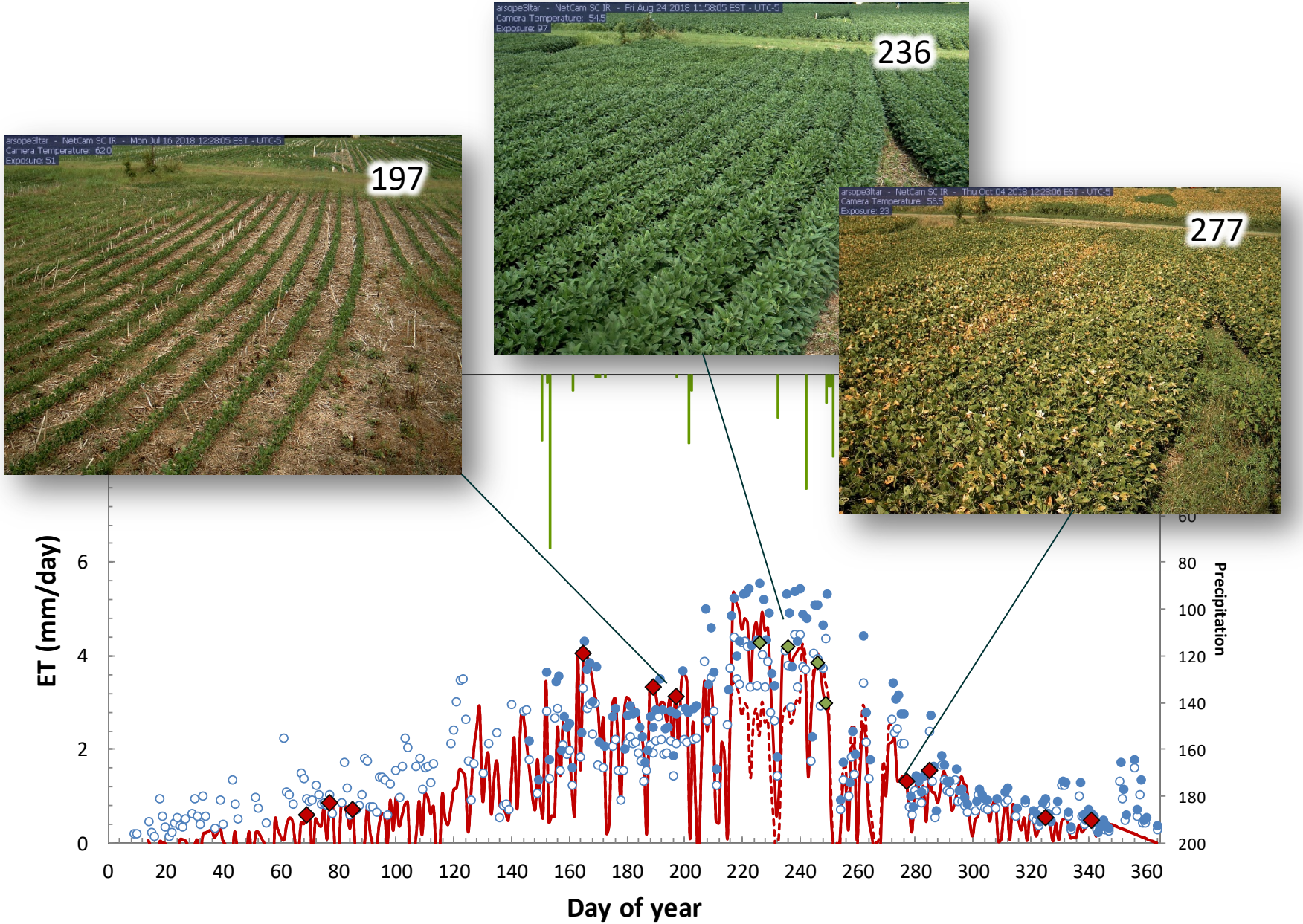


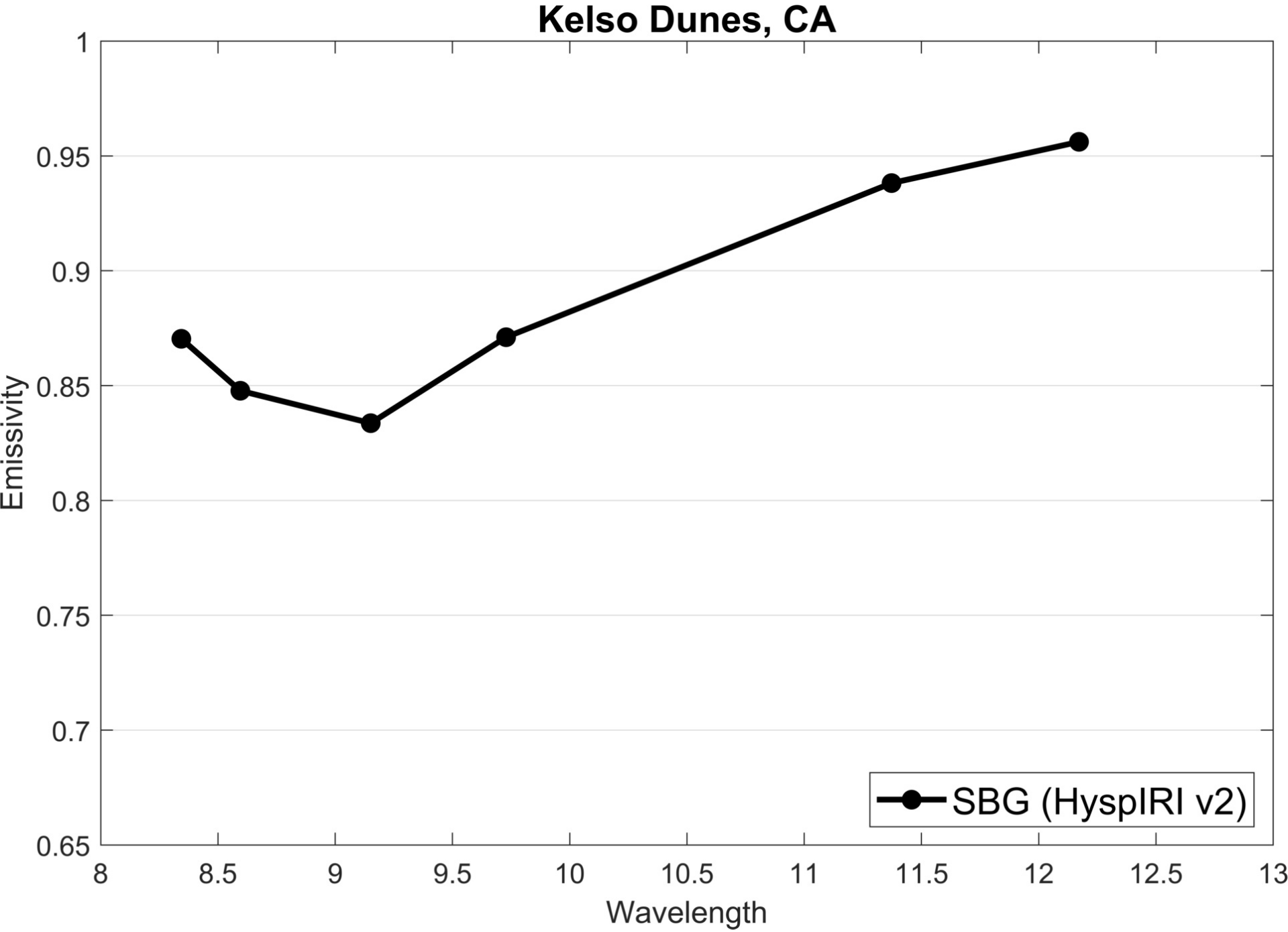

Kelso Dunes, CA
Emissivity
Wavelength
HyTES
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
8
8.5
9
9.5
10
10.5
11
11.5
12
12.5
13

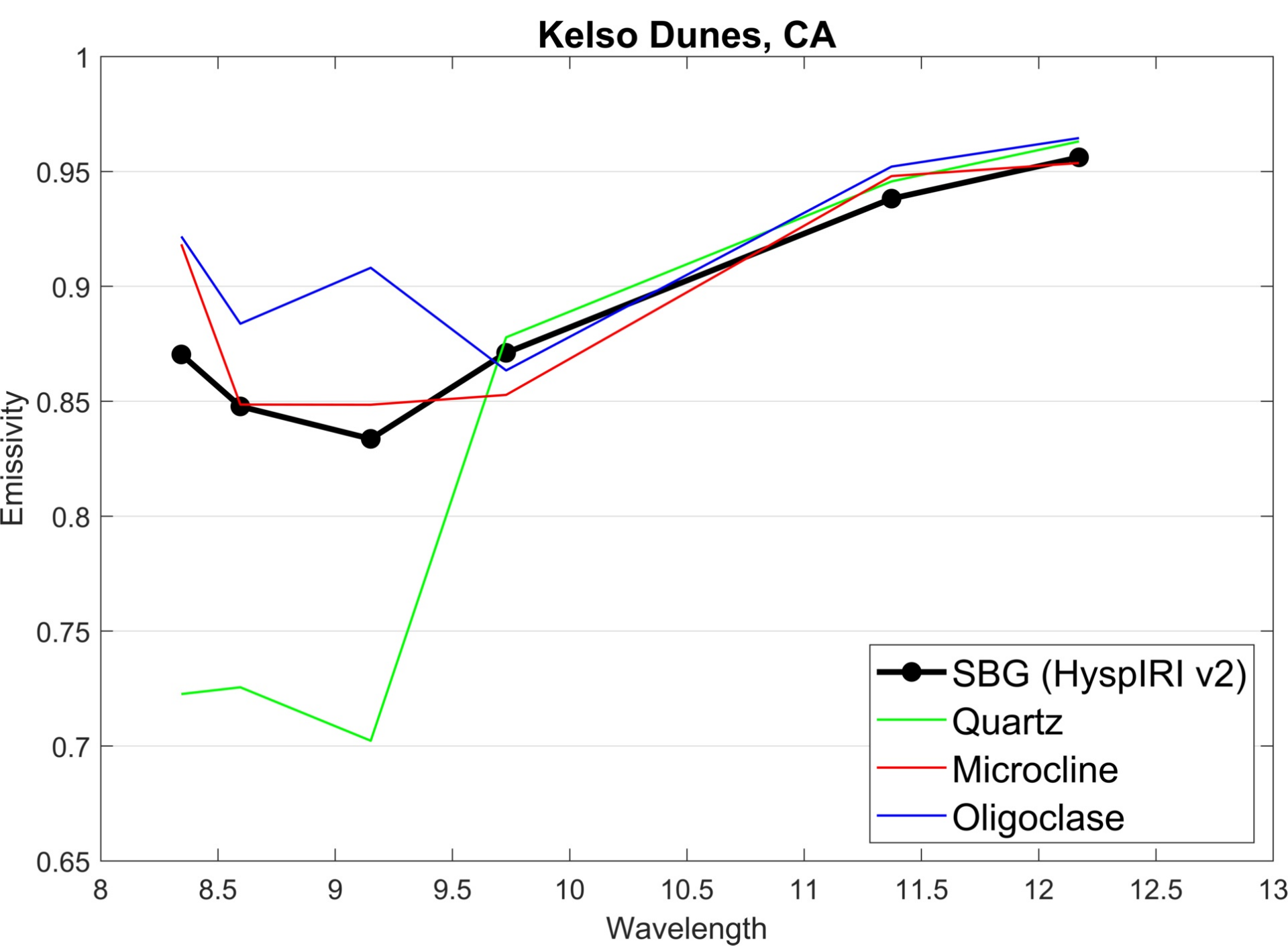

Kelso Dunes, CA
Emissivity
Wavelength
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
8
8.5
9
9.5
10
10.5
11
11.5
12
12.5
13
HyTES
Quartz
Microcline
Oligoclase

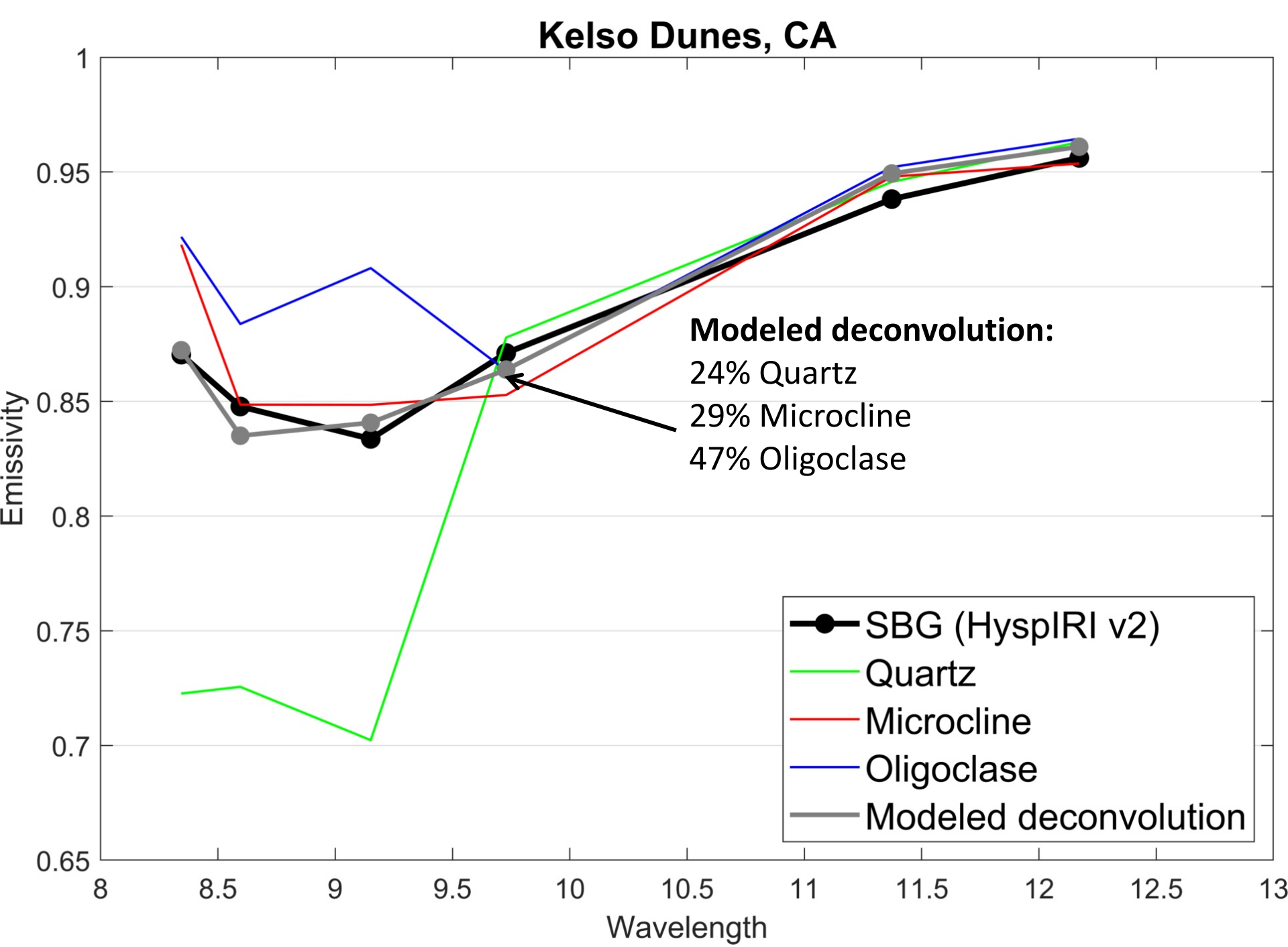

Kelso Dunes, CA
Emissivity
Wavelength
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
8
8.5
9
9.5
10
10.5
11
11.5
12
12.5
13
Modeled deconvolution:
29% Quartz
17% Microcline
54% Oligoclase
HyTES
Quartz
Microcline
Oligoclase
Modeled deconvolution

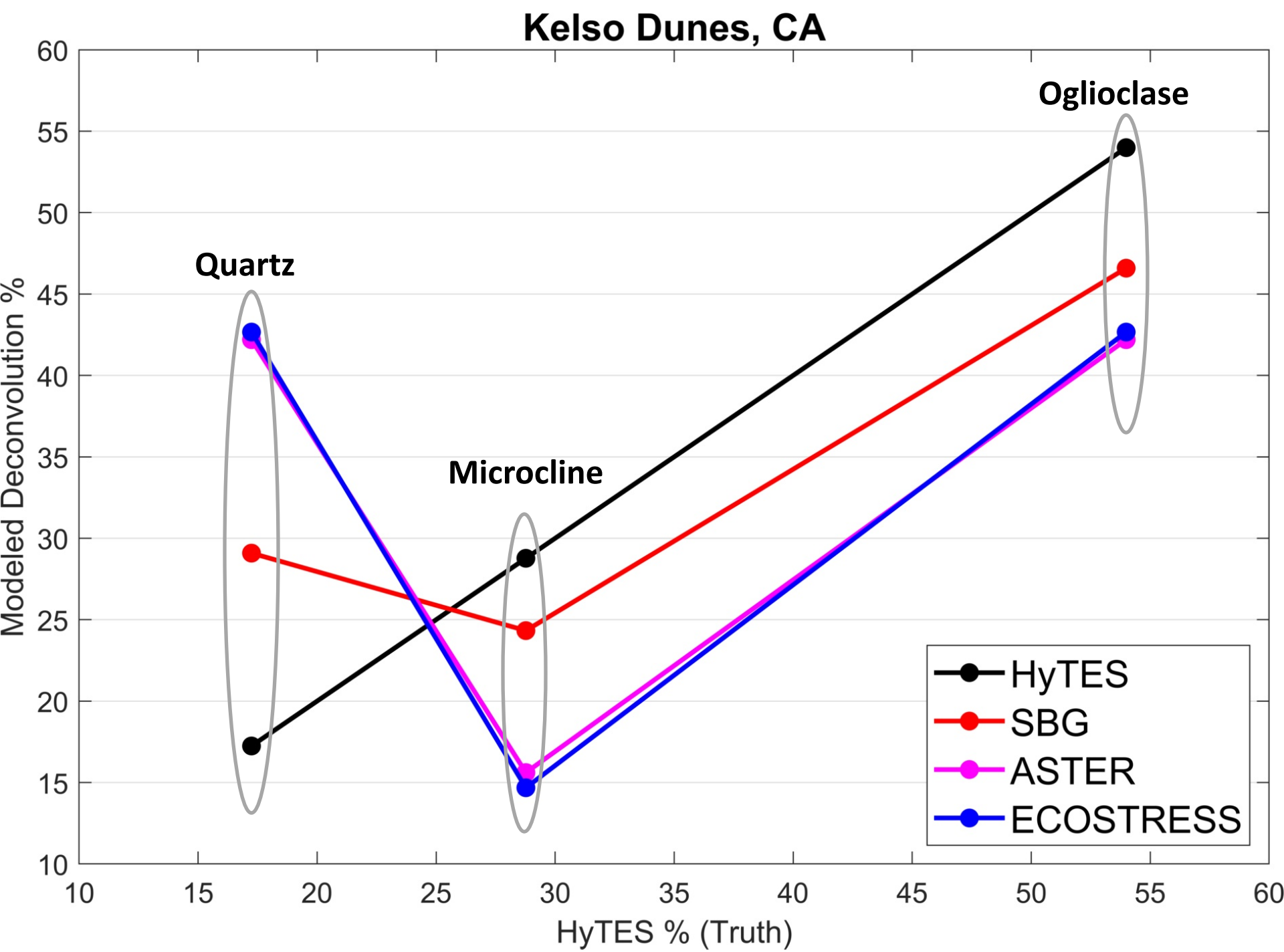
Impacts on performance




Kelso Dunes, CA
Emissivity
Wavelength
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
8
8.5
9
9.5
10
10.5
11
11.5
12
12.5
13
SBG (HyspIRI v2)


Kelso Dunes, CA
Emissivity
Wavelength
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
8
8.5
9
9.5
10
10.5
11
11.5
12
12.5
13
SBG (HyspIRI v2)
Quartz
Microcline
Oligoclase


Kelso Dunes, CA
Emissivity
Wavelength
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
8
8.5
9
9.5
10
10.5
11
11.5
12
12.5
13
Modeled deconvolution:
24% Quartz
29% Microcline
47% Oligoclase
SBG (HyspIRI v2)
Quartz
Microcline
Oligoclase
Modeled deconvolution


Kelso Dunes, CA
Quartz
Microcline
Oglioclase
HyTES
SBG
ASTER
ECOSTRESS
Modeled Deconvolution %
HyTES % (Truth)
10
15
20
25
30
35
40
45
50
55
60