Vicarious Calibration Activity Over Southern Israel for the New Family of Orbital Hyperspectral Sensors

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Tel Aviv University

Outline

- The areas and theirs general characteristics
- Sensors used
- Spectral library (airborne 1.5m sensor, field measurements)
- Validation points
- Comparison between orbital sensors performances
  Radiometrically Spectrally and thematically
- PRISMA first image as an example
- Thermal capacity
- Call for collaboration
- Conclusions

VAL Site- Makhtesh Ramon

CAL Site- Amiaz Plain

CAL/ VAL TEST SITES ISRAEL

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Dead Sea

Amiaz plain

Radiometric calibration

Goal

Establishing of Amiaz plain and Makhtesh Ramon as Vicarious Sites for Radiometric, Spectroscopic and Thematic Calibration of hyperspectral sensors

Spectral & Thematic calibration

Makhtesh Ramon

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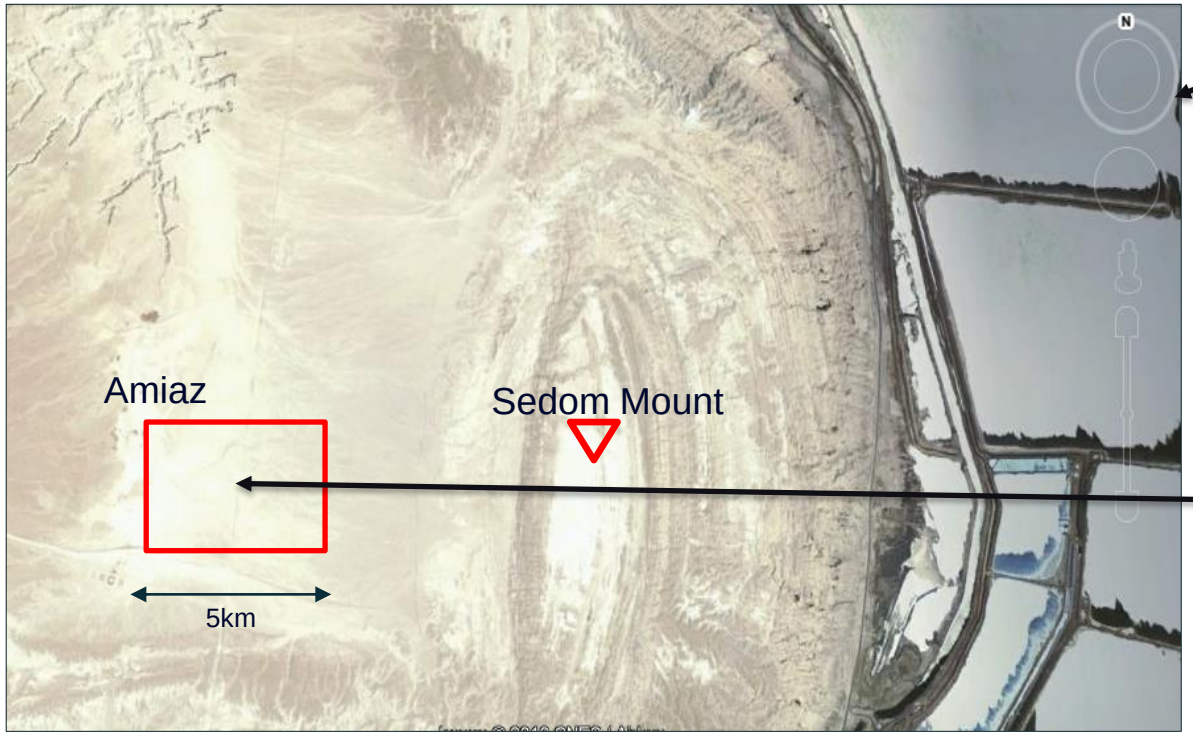
Source: Google Earth

Amiaz Playa

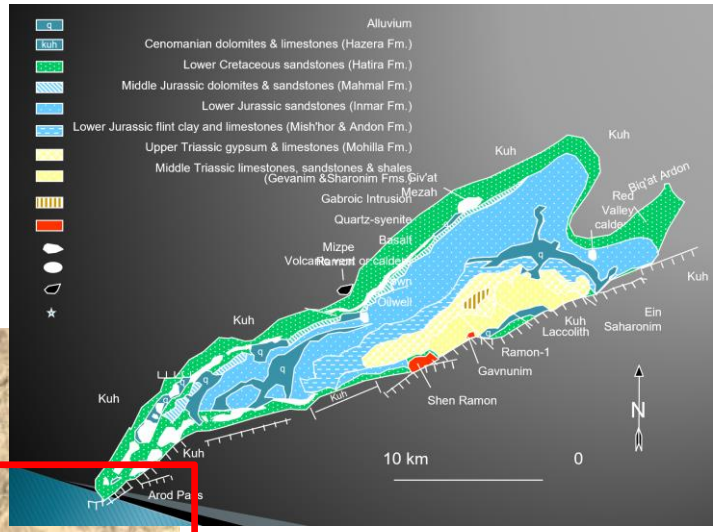
Homogeneous bright playa of silty carbonate, easy to access, ideal SVC for HSR sensors

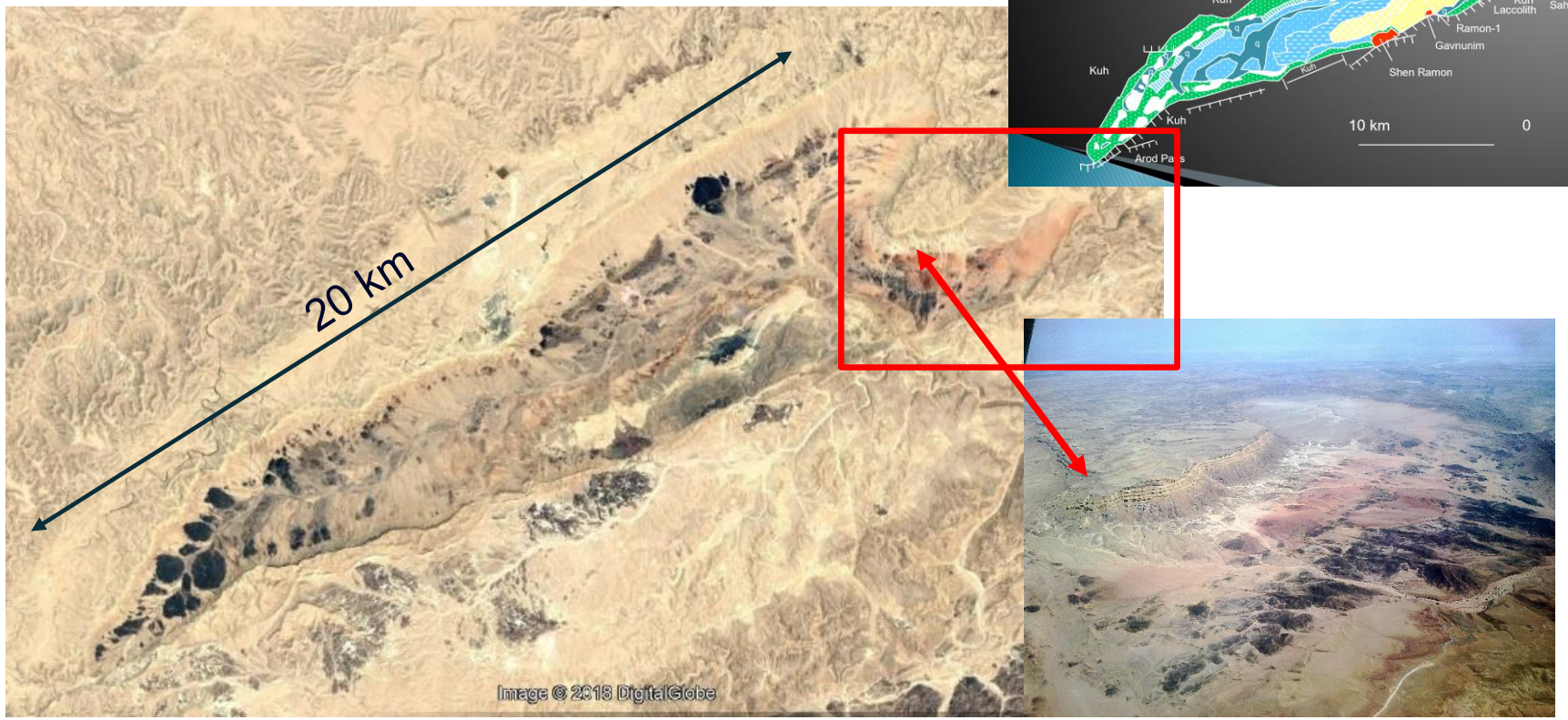


Makhtesh Ramon national park

Spectral – Thematic Calibration

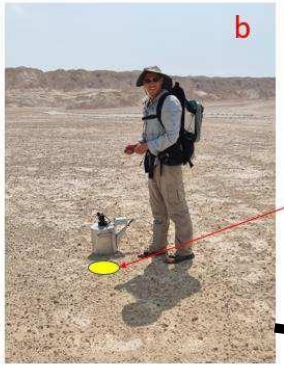
Eroded Anticline with many minerals exposed at the surface aceoss a very short distance





ASD : Bare Fiber & SoilPRO®

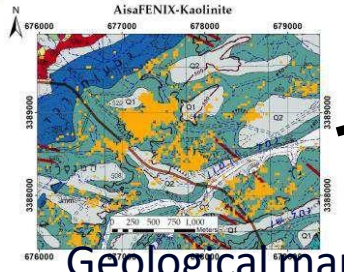
SoilPro® WR



SoilPro®

Bare fiber

Precise reflectance measurements



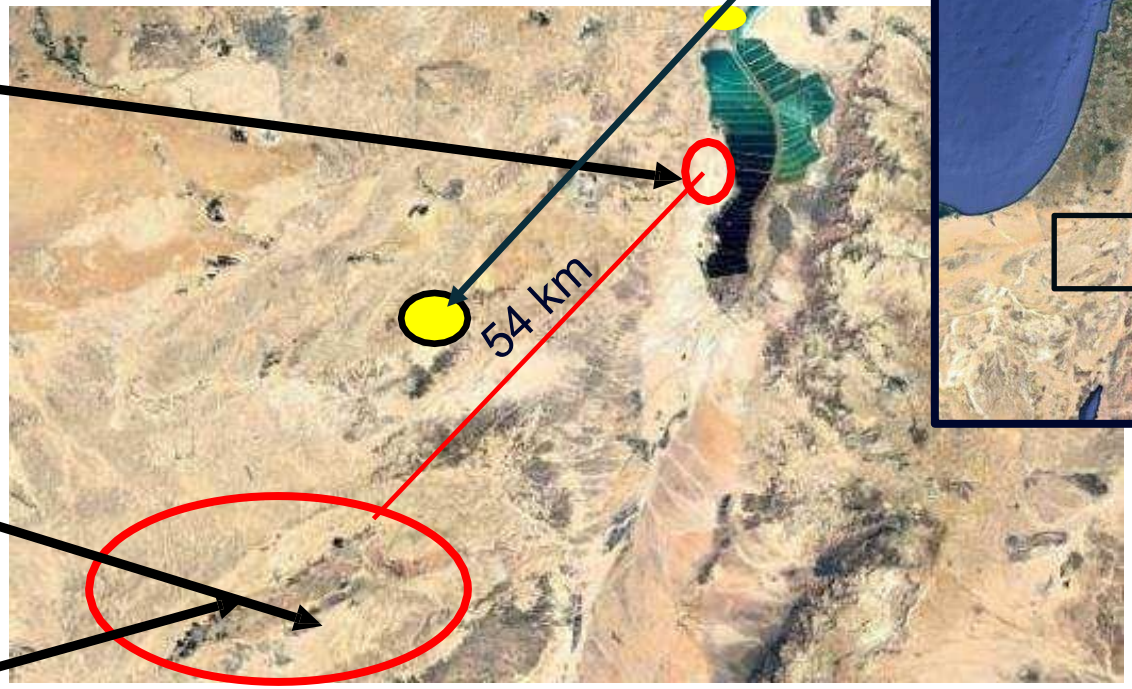
Geological map

GODDARD SPACE FLIGHT CENTER | + Visit NASA.gov

AERONET
AEROSOL ROBOTIC NETWORK

+ AEROSOL OPTICAL DEPTH | + AEROSOL INVERSION | + SOLAR FLUX | + OCEAN COLOR | + MARITIME AEROSOL

Atmosphere information



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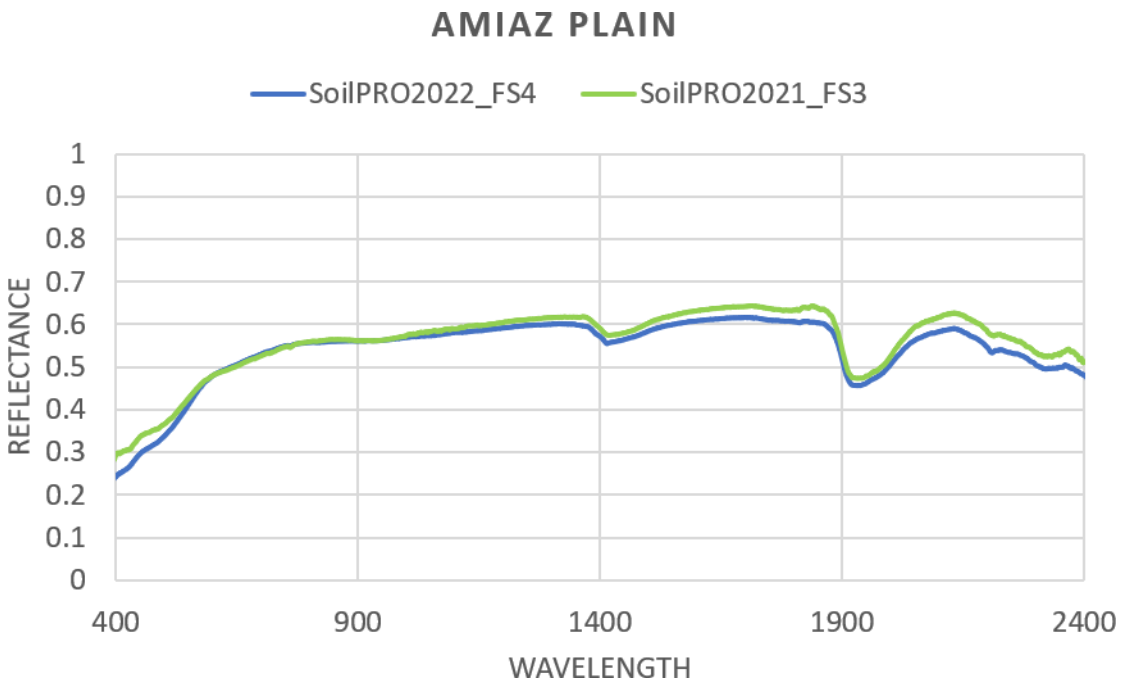
Stability over time



ASD Field Spec4 Vs.FS3 –AP August 2022-2021

Airborne Campaign

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Sensor: AisaFENIX 1K (SPECIM)

Spectral range: **VNIR**: 375-980 (175 bands)

SWIR: 970-2500 (245 bands)

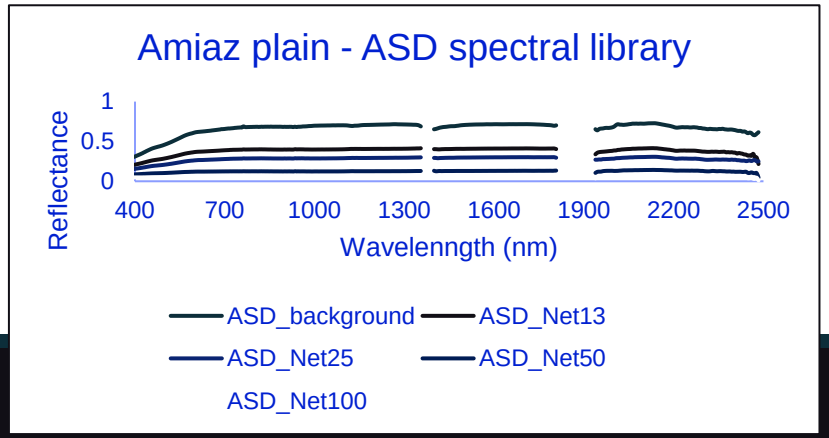
Field of View (FOV): 40°

Full-Width Half Max (FWHM): VIS- 3.4, NIR-SWIR 6.2

Bands: 420

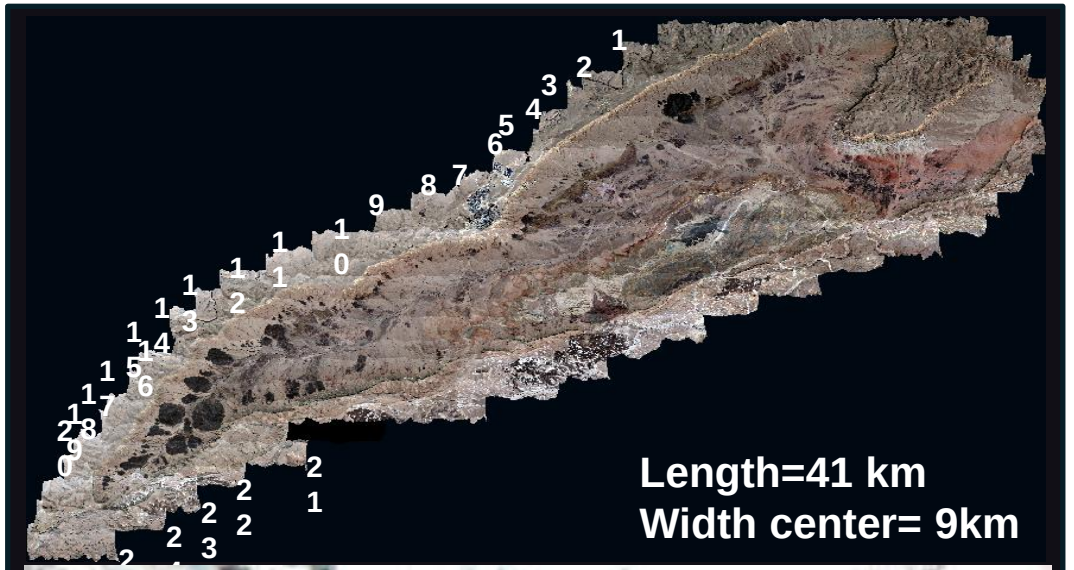
Spatial resolution: 1.5m

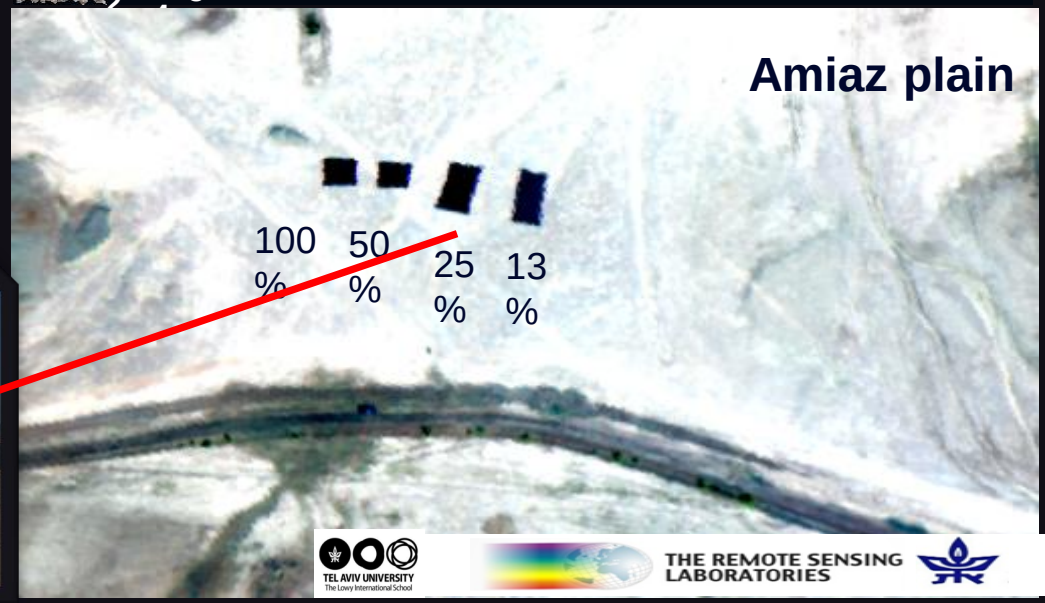
Lines : 25 MR+1 AP



Atmospheric correction: (Brook and Ben-Dor 2011)

Makhtesh Ramon





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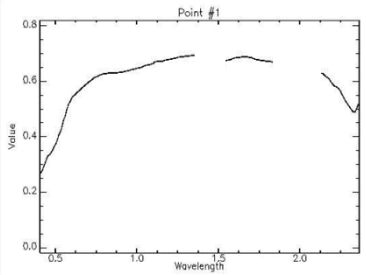
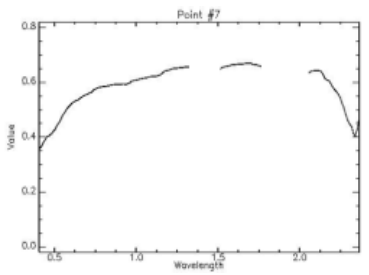
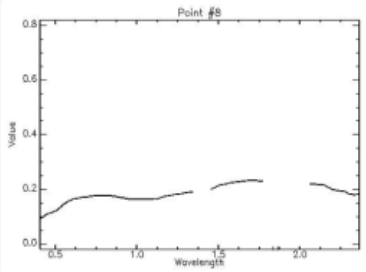
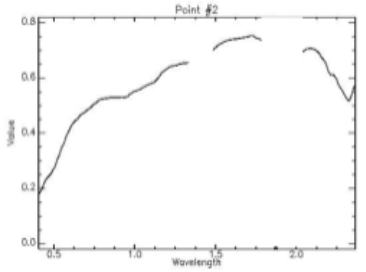
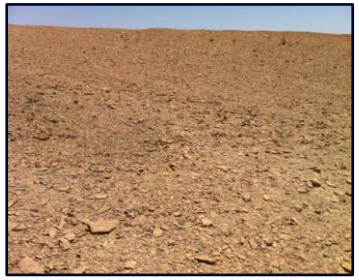
Aisa-ES

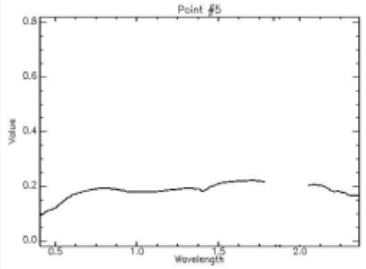

Point #1
Value
Wavelength


Point #7
Value
Wavelength


Point #8
Value
Wavelength


Point #2
Value
Wavelength




Point #5
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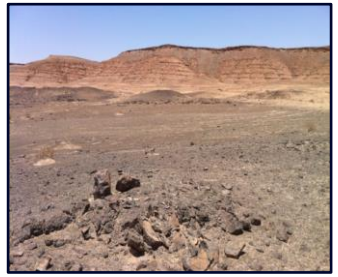
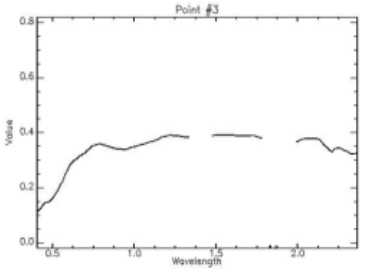
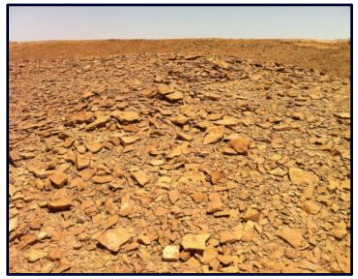
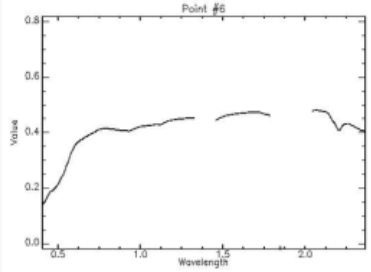
Wavelength




Point #3
Value
Wavelength

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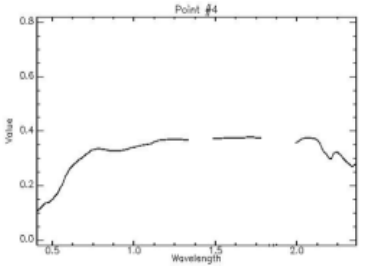
Wavelength


Point #4
Value
Wavelength

Airborne & Field Campaign products

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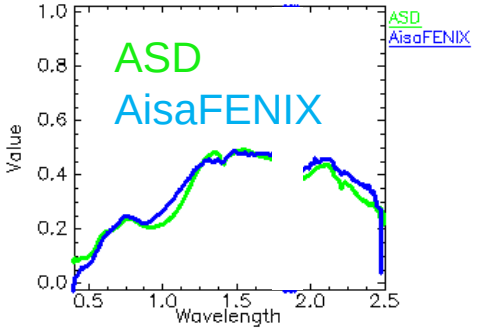
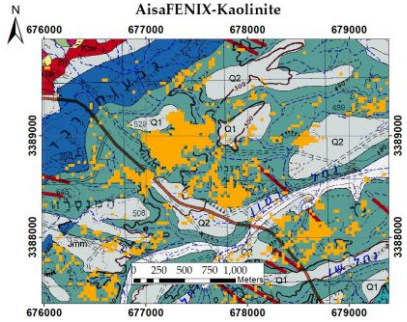
- Thematic mineral maps:
  - Iron oxides (Hematite and Goethite).
  - clay minerals (Kaolinite, Montmorillonite).
  - sulfate minerals (Gypsum).
  - carbonate (Calcite, Dolomite).

- QA- AISA FENIX field survey with experts, ground truth, routine spectral measurements, Meta data and geology and geomorphology GIS layers .





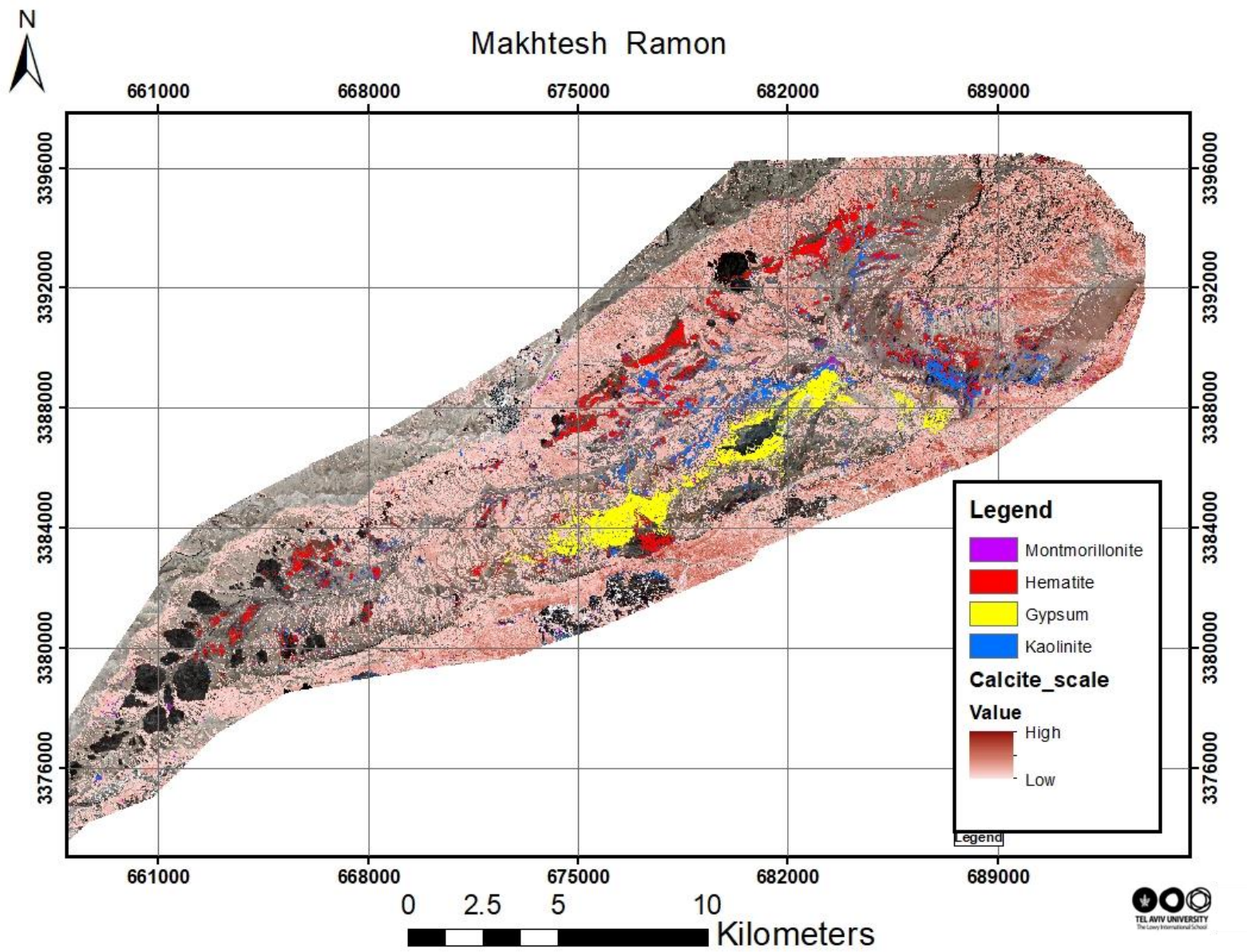
Current and future Users

ISA – Israel Space Agency (Venus)
ASI – Italian Space Agency (PRISMA)
ESA – European Space Agency (CHIME)
DLR – German Space Agency (DESIS, ENMAP)
NASA – National Space Administration (EMIT, SBG)

Updating spectral measurements by TAU every 4 months

More Users are Welcome

Minerals MR AISA-FENIX



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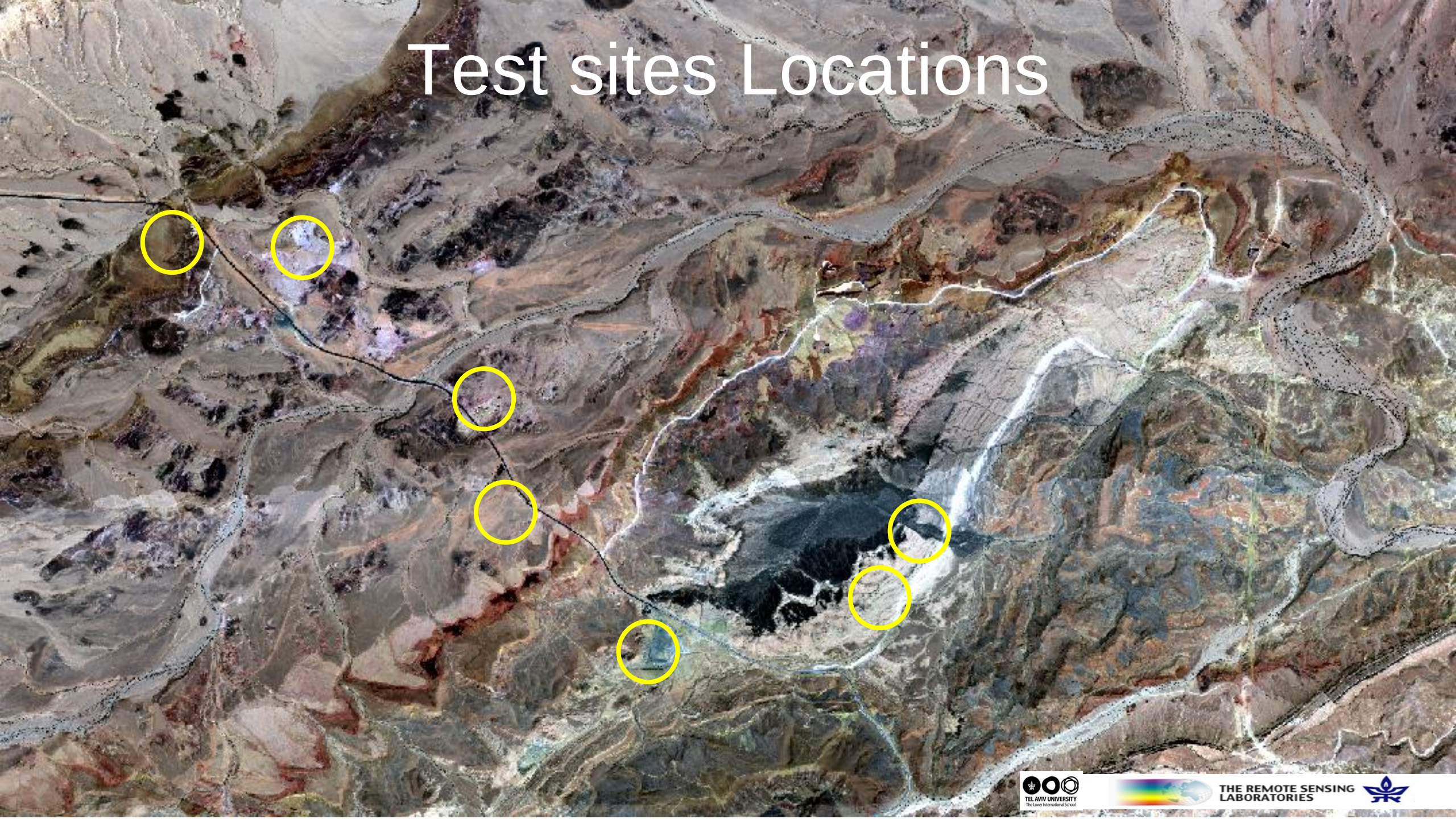
Test sites Locations



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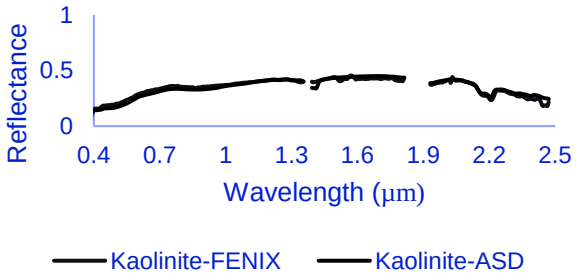
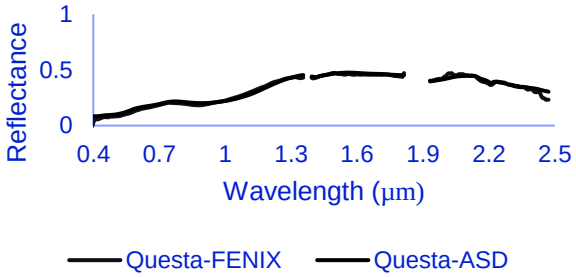
THE REMOTE SENSING LABORATORIES

Field ASD vs. FENIX 1K

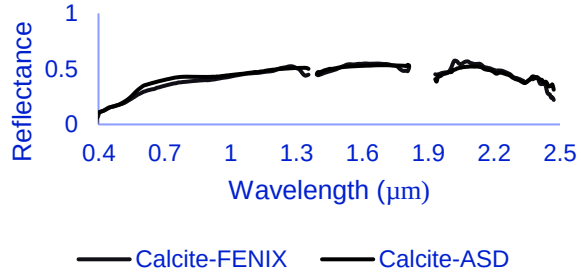
Kaolinite AisaFENIX vs. ASD



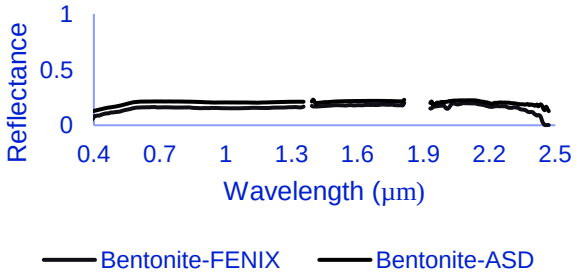
Questa AisaFENIX vs. ASD



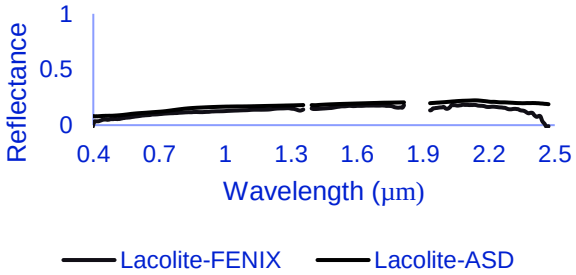
Calcite AisaFENIX vs. ASD



Bentonite AisaFENIX vs. ASD

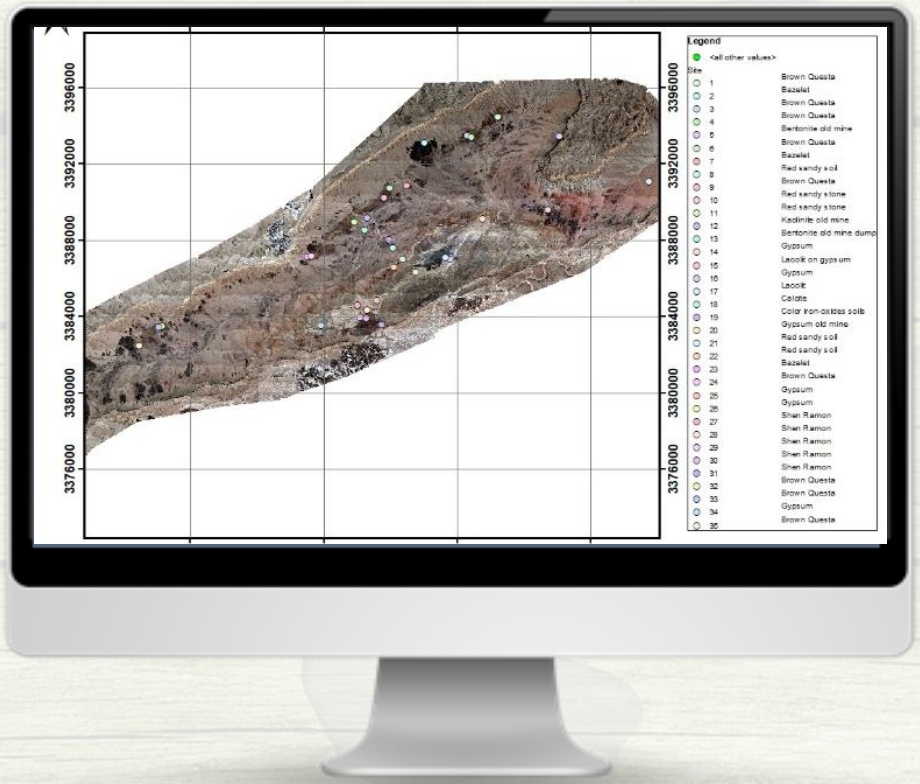


Lacolite AisaFENIX vs. ASD

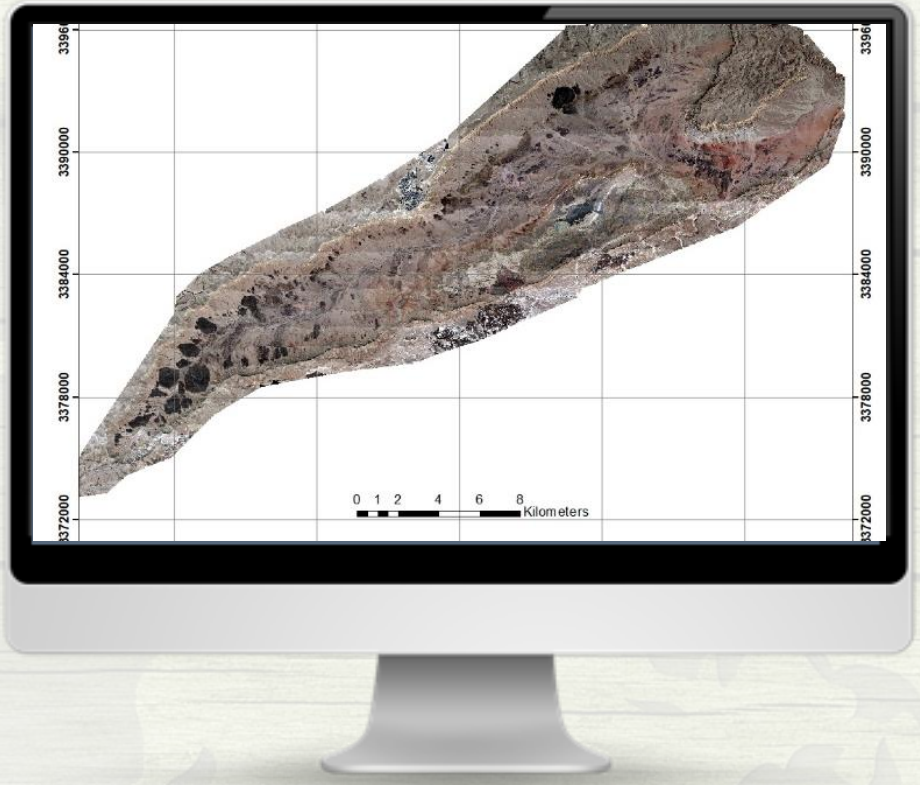


MR Spectral library

Specific Targets form AisaFENIX 1.5 m



AisaFENIX REF resampled to 30 m



For spectral calibration

Option 1 **?** **Option 2**

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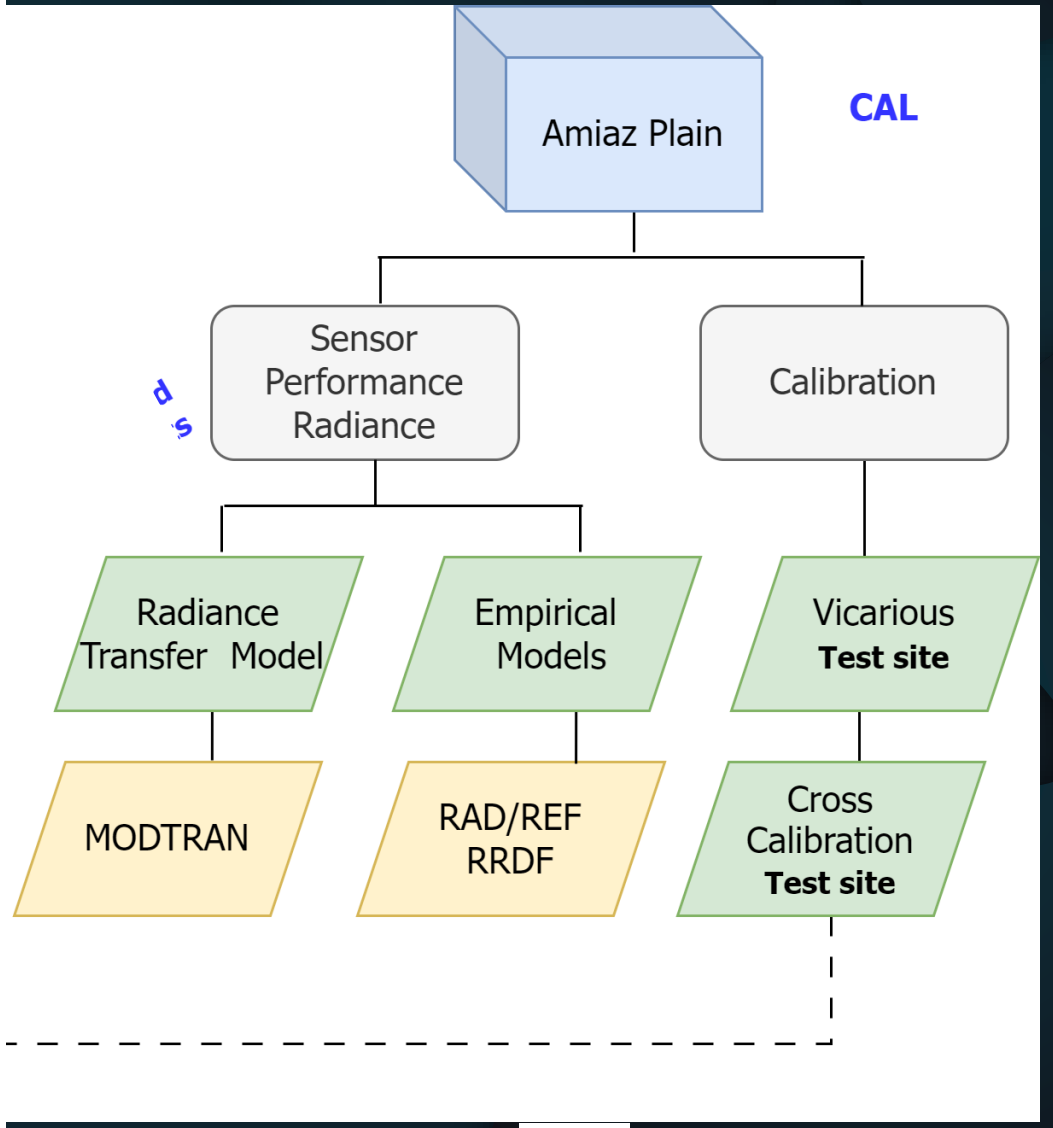
Link for Ramon Spectral Library

https://storymaps.arcgis.com/stories/bb5bf09ec7414454a012bfe9bf4b8545

CAL / VAL TEST SITES ISRAEL



Comparison of HRS Sensor Products

Using CAL/VAL Test Sites

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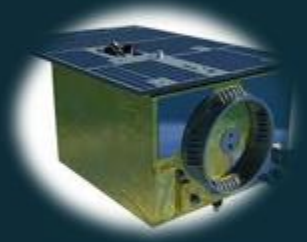
SENSORS COMPARISON

EMIT	EnMAP	PRISMA	DESIS
			
NASA	DLR	ASI	DLR
285 bands	242 bands	234 bands	235 bands
380–2500 nm	420–2450 nm	400–2500 nm	400–1000 nm
60 m GSD	30 m GSD	30 m GSD	30 m GSD

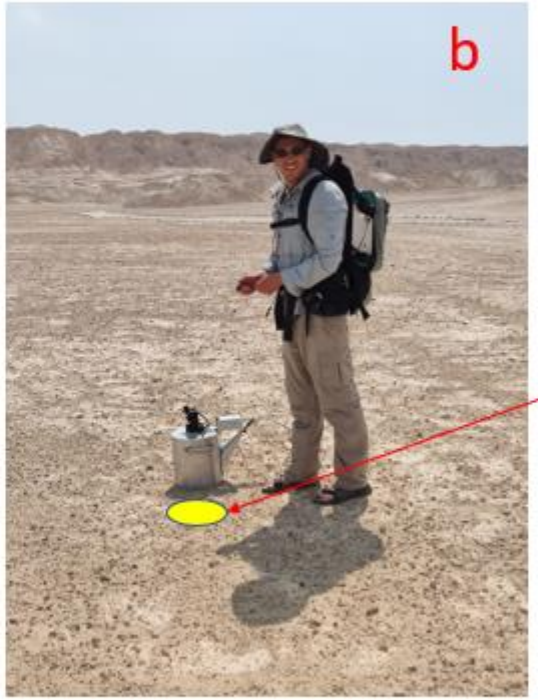
Objectives

1. To Evaluate hyperspectral sensors performances: Radiance, spectral and Thematic.
2. To find suitable pair hyperspectral sensors for cross-calibration.
3. To ensure optimal outcomes for the data applications when using multiple sensors.
4. To help the end users effectively select the most suitable sensor for their specific mapping requirements.

90X90 Cube Outlines Measurements

ASD : Bare Fiber & SoilPRO®

SoilPro® WR



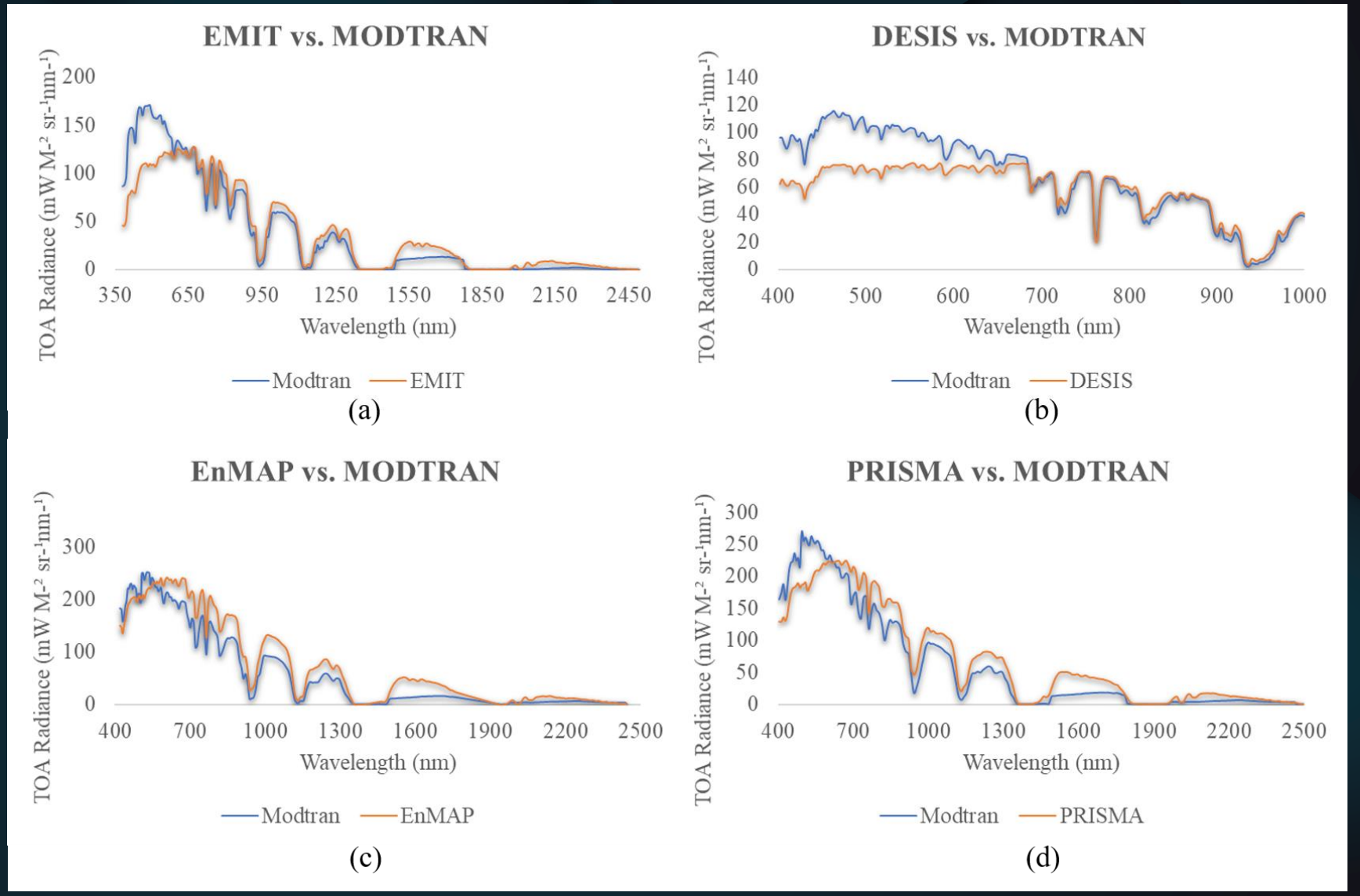
SoilPro®

Bare fiber

01

TOA RADIANCE L1 PRODUCT

AMIAZ PLAIN



POSITION OF ATMOSPHERIC ABSORBANCE MODTRAN VS. EnMAP, PRISMA, EMIT, and DESIS

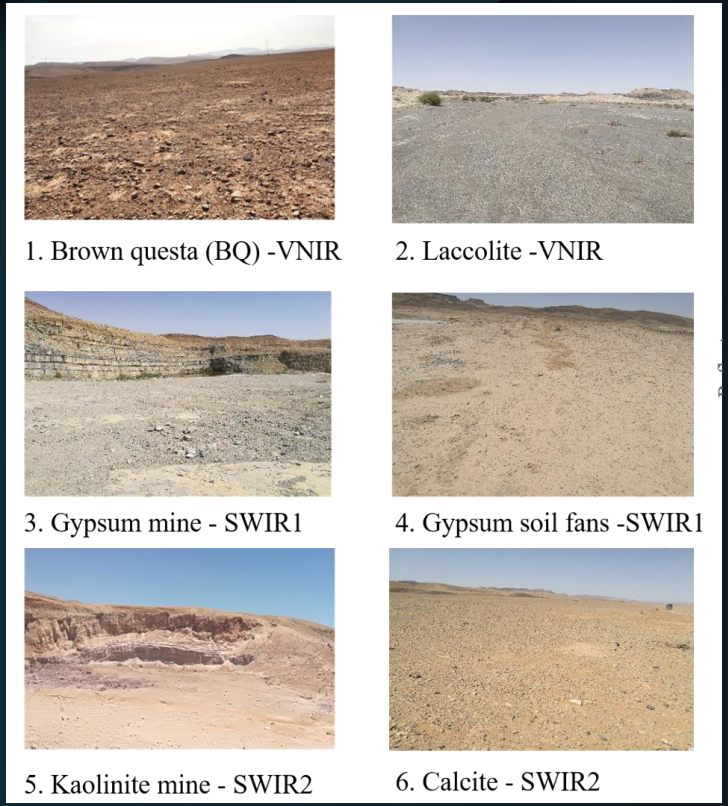
Gases and Water Vapor	MODTRAN	Expected width (nm)	EnMAP (nm)	PRISMA (nm)	EMIT (nm)	DESIS (nm)	
O2	687	687-695	692	690	693	688	
	760	760-768	763	761	760	763	Δ+3nm
	1268	1262-1269	1271	1262	1267		
CO2	1601	1599-1611	1609	1606	1610		
	2004	1999-2008	2005	2001	2004		Δ+4nm
	2055	2050-2071	2060	2061	2056		Δ+6nm
O3	574	550-640	571	563	574	574	
	602		594	588	589	602	
CH4	1666	1665-1667	1664	1667	1662		
H20	820	787–884	824	824	820	820	
	940	884-990	936	941	939	934	Δ+5nm
	1135	1063–1219	1128	1131	1126		Δ+5nm

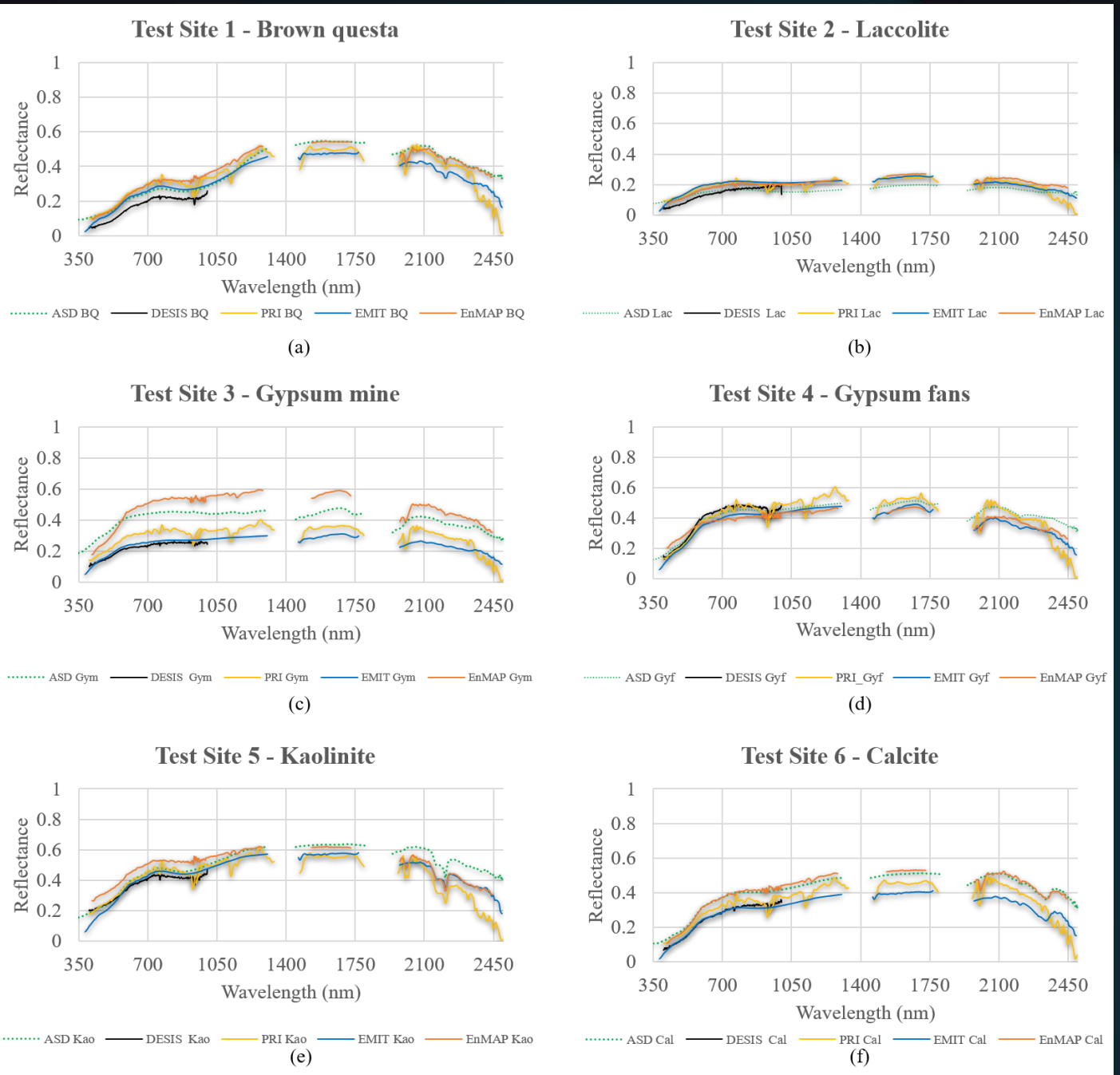
MR Routine sites for Spectral Stabilization

02

REFLECTANCE L2 PRODUCT

MR TEST SITES



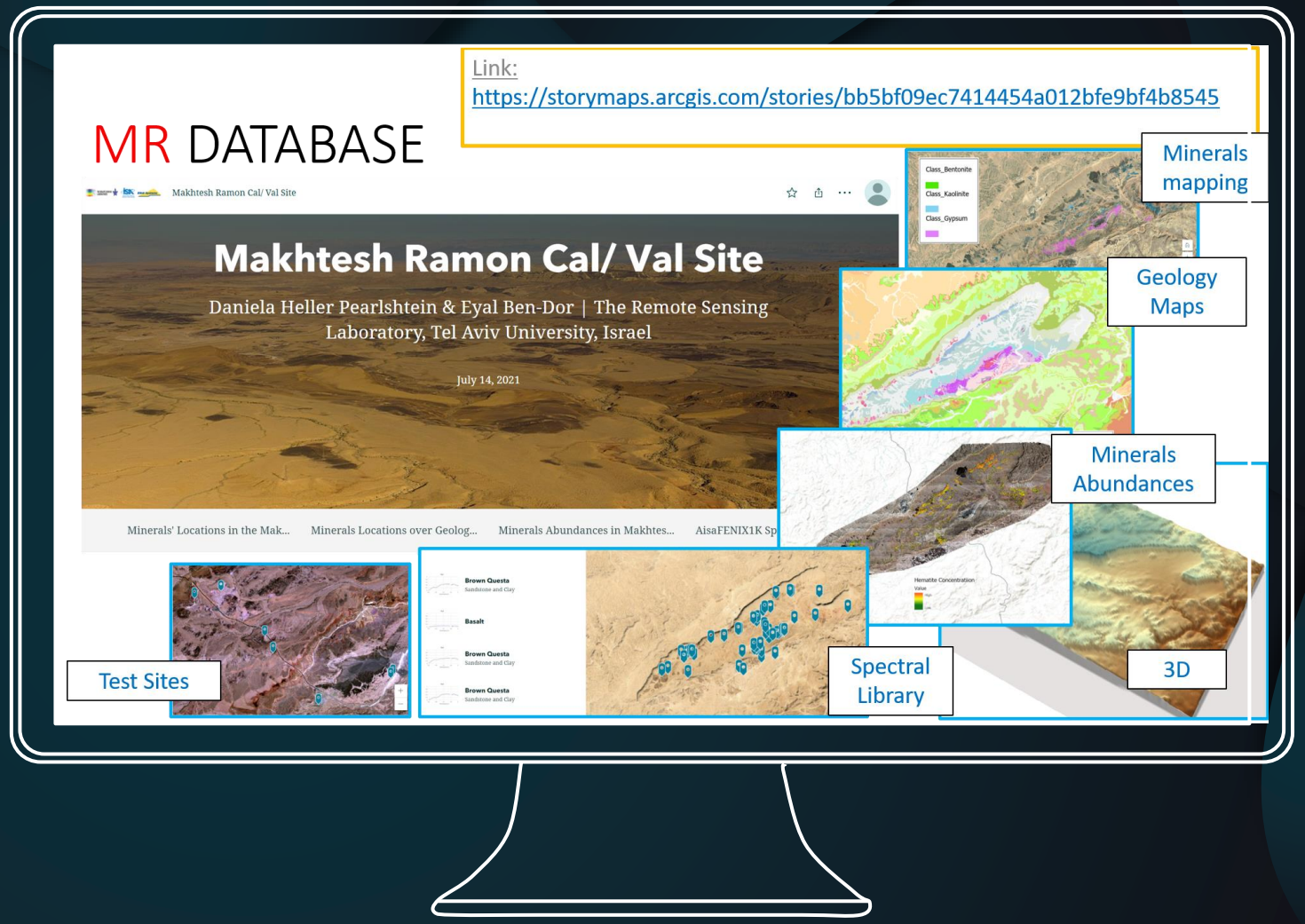


Sensor	Spectral range	No. bands	Test site	SAM	ASDS
DEISIS	VNIR	210	1	0.078	0.100
	VNIR	210	2	0.101	0.052
EnMAP	VNIR	100	1	0.070	0.020
	VNIR	100	2	0.092	0.028
	SWIR1	19	3	0.005	0.036
	SWIR1	19	4	0.006	0.007
	SWIR2	52	5	0.066	0.070
	SWIR2	52	6	0.038	0.001
PRISMA	VNIR	63	1	0.062	0.014
	VNIR	63	2	0.070	0.034
	SWIR1	32	3	0.038	0.096
	SWIR1	32	4	0.040	0.002
	SWIR2	47	5	0.251	1.217
	SWIR2	47 calcite	6	0.202	0.375
EMIT	VNIR	84	1	0.055	0.031
	VNIR	84	2	0.072	0.058
	SWIR1	41	3	0.013	0.079
	SWIR1	41	4	0.027	0.007
	SWIR2	61	5	0.041	0.098
	SWIR2	61	6	0.037	0.100

Threshold for good calibration:
SAM / ASDS< 0.1, RMSE< 0.05

03

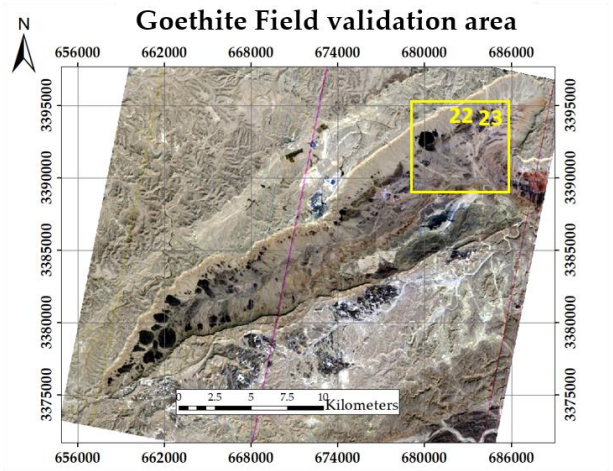
MAPPING PERFORMANCE



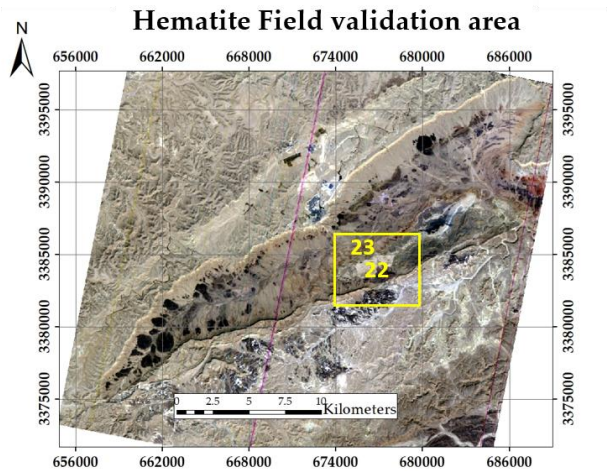
Statistical analysis of PRISMA products

$$TPR = \frac{\text{True detection for SENSOR}}{\text{True detection AisaFENIX}}$$

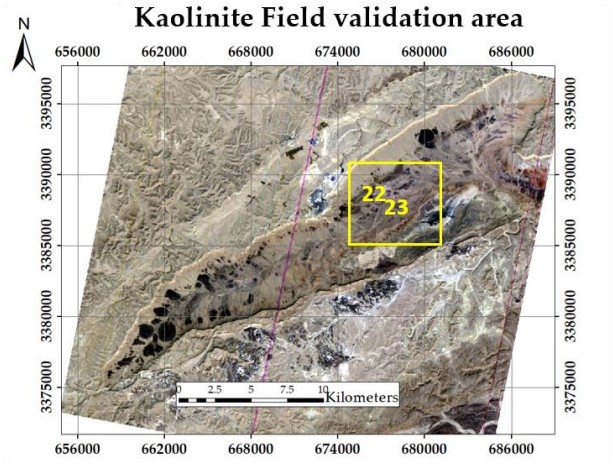
$$FPR = \frac{\text{False positive SENSOR}}{\text{Negative+ FP SENSOR}}$$



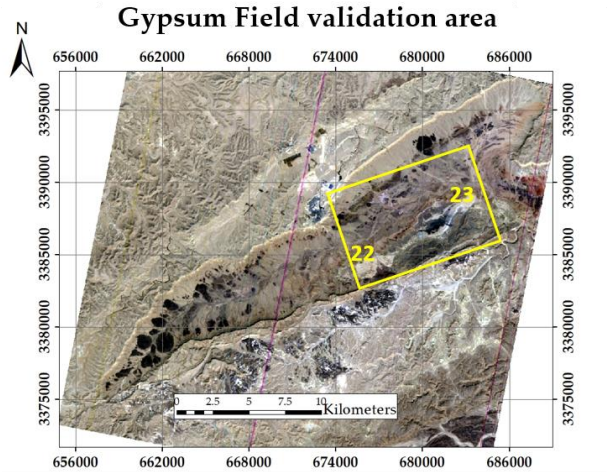
(a)



(b)

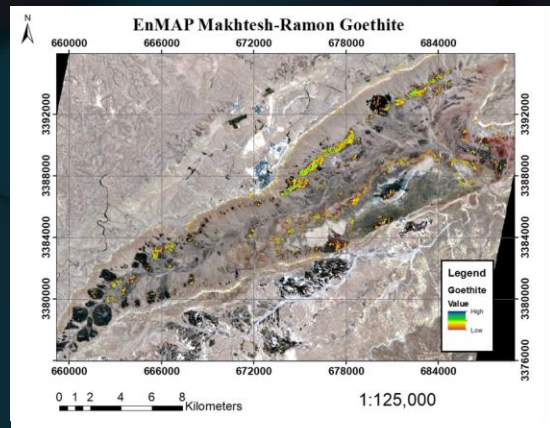


(c)

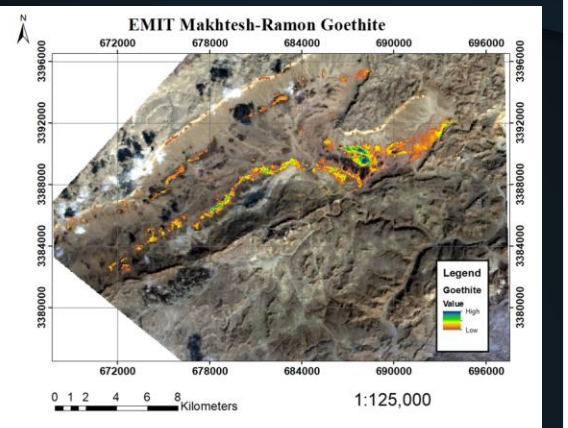


(d)

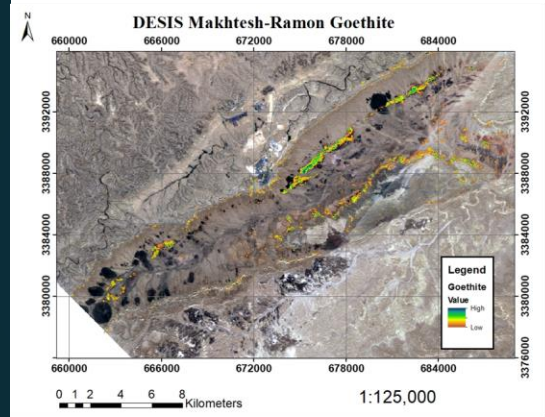
GOETHITE-
VNIR MAPPING



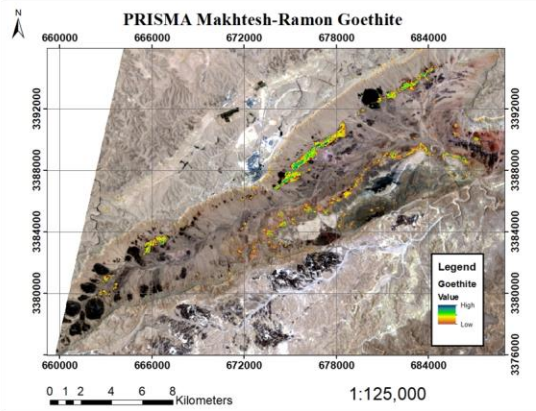
(a)



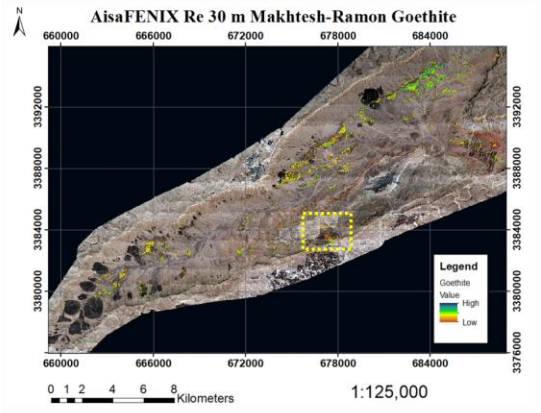
(b)



(c)



(d)



(e)

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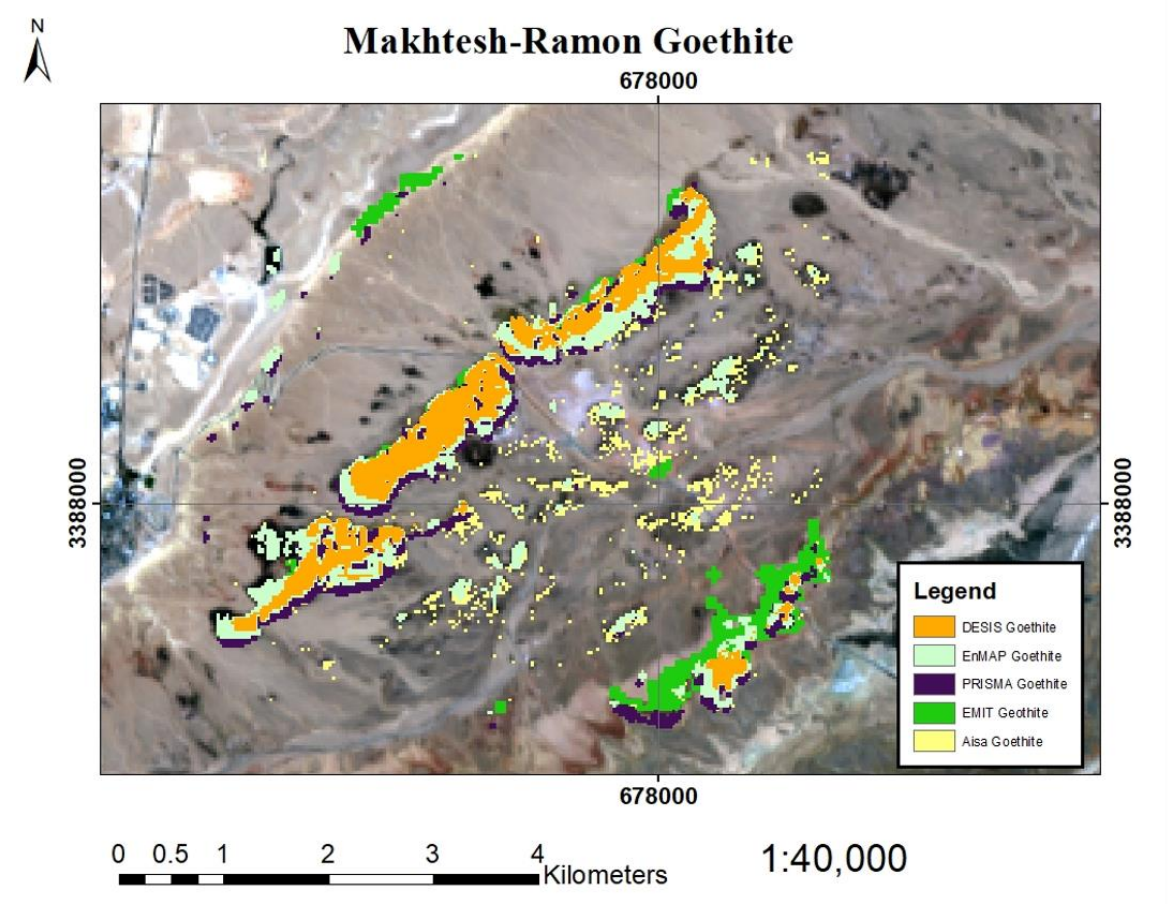
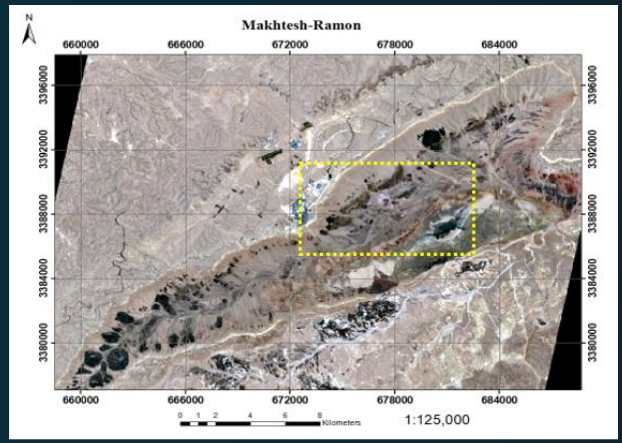
GOETHITE MAPPING (2)

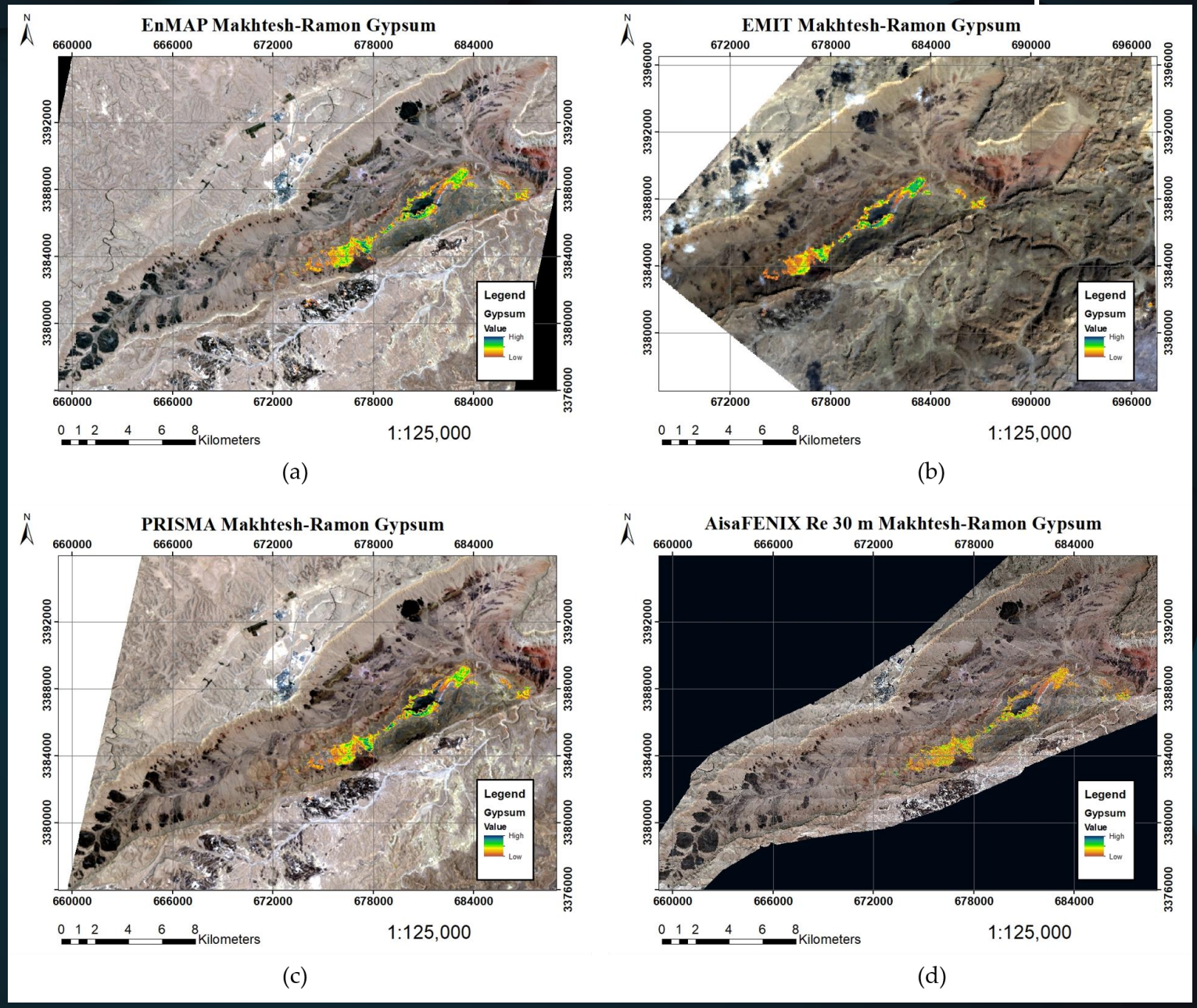




AISA + ground ASD – reference

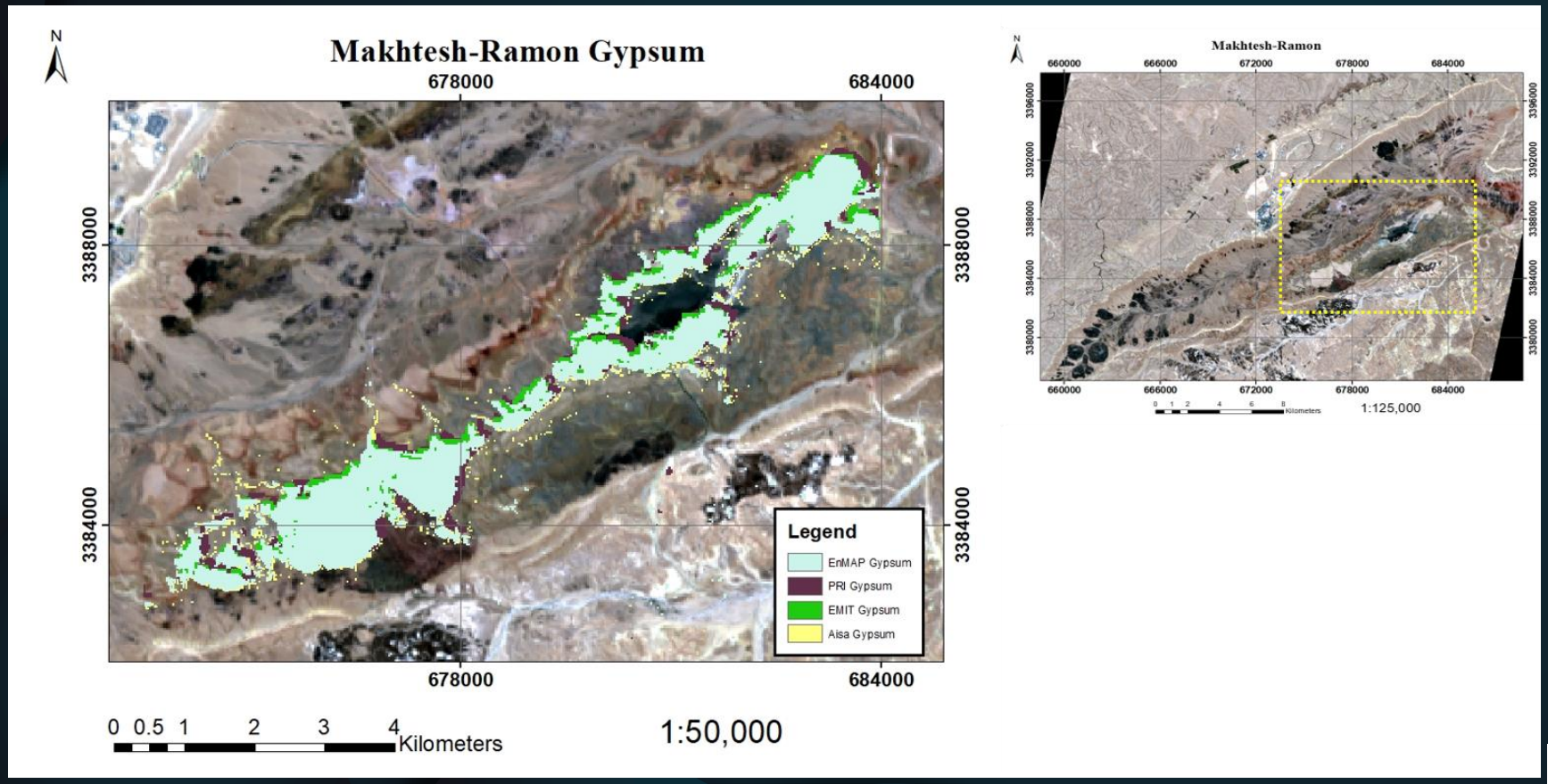
Sensors	TPR	FPR	Accuracy
DESIS	0.71	0.002	0.96
EnMAP	0.95	0.030	0.97
PRISMA	0.94	0.030	0.96
EMIT	0.80	0.020	0.96

GYPSUM-
SWIR 1 MAPPING

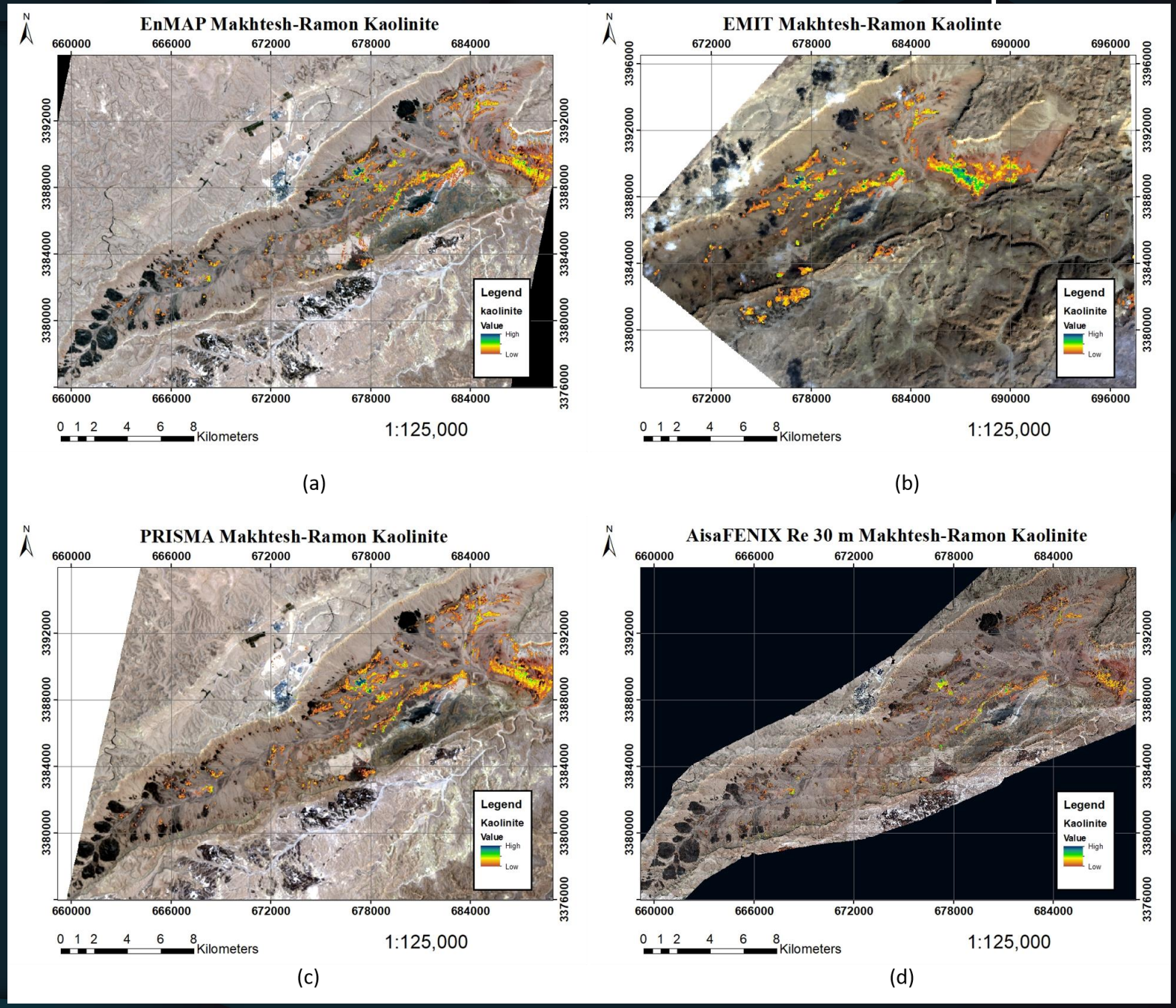


GYPSUM MAPPING (2)

Sensors	TPR	FPR	Accuracy
EnMAP	0.98	0.045	0.97
PRISMA	0.98	0.002	0.98
EMIT	0.97	0.001	0.98



KAOLINITE-
SWIR 2 MAPPING



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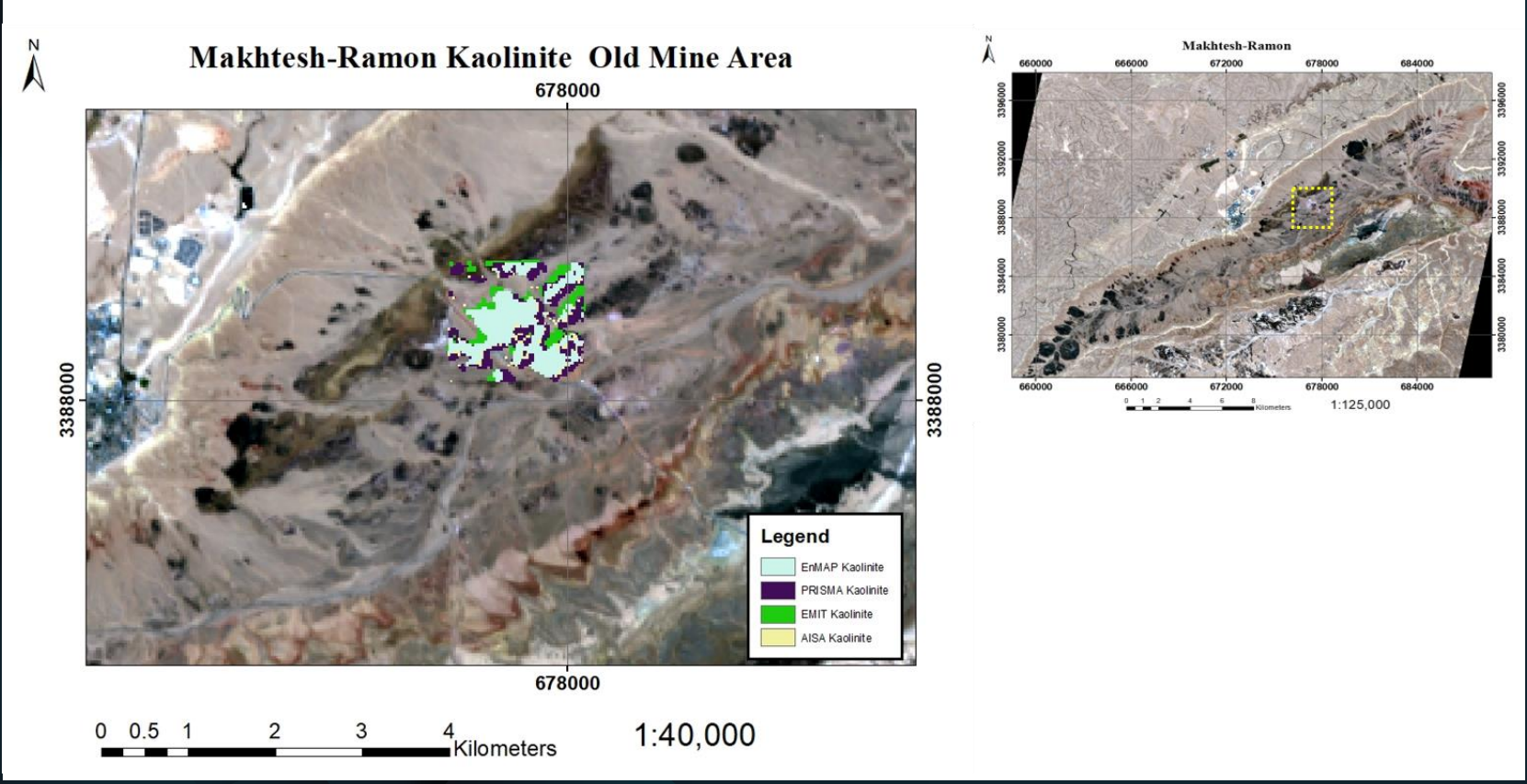
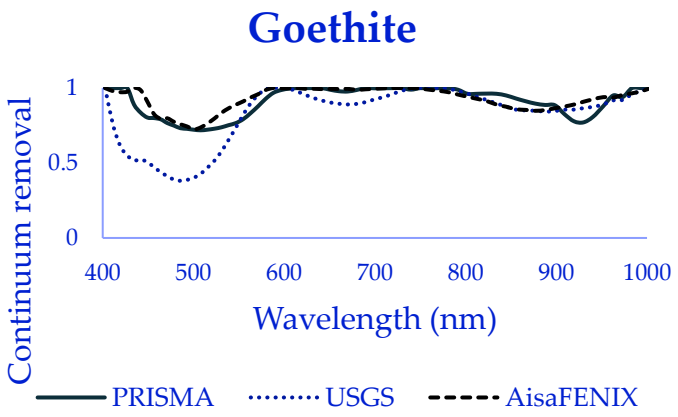
KAOLINITE MAPPING (2)

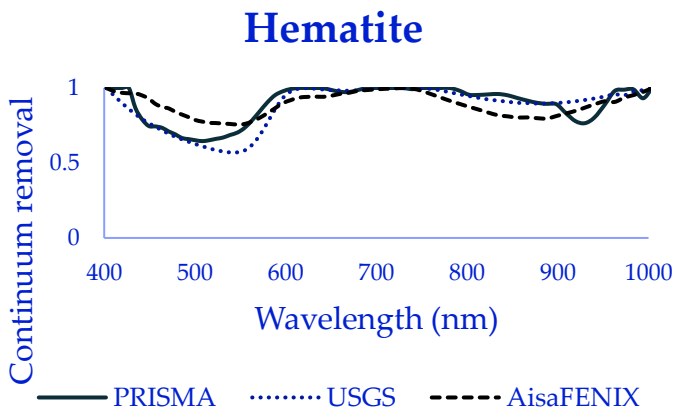
Sensors	TPR	FPR	Accuracy
EnMAP	0.98	0.050	0.95
PRISMA	0.97	0.240	0.80
EMIT	0.90	0.050	0.94



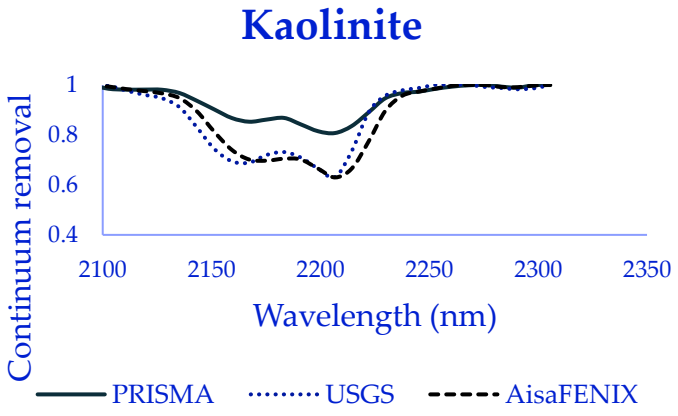
Comparison PRISMA L2, AisaFENIX to USGS



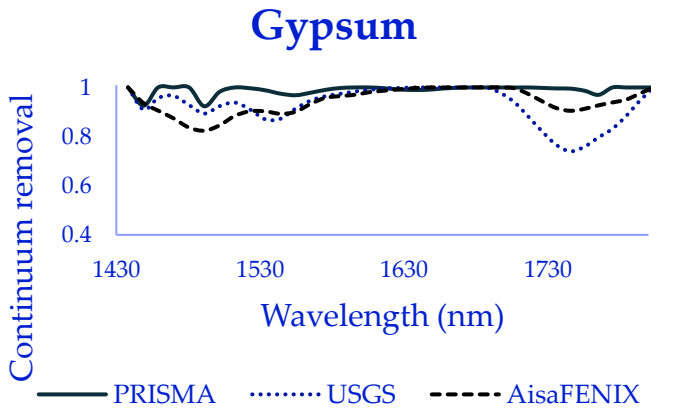
(a)



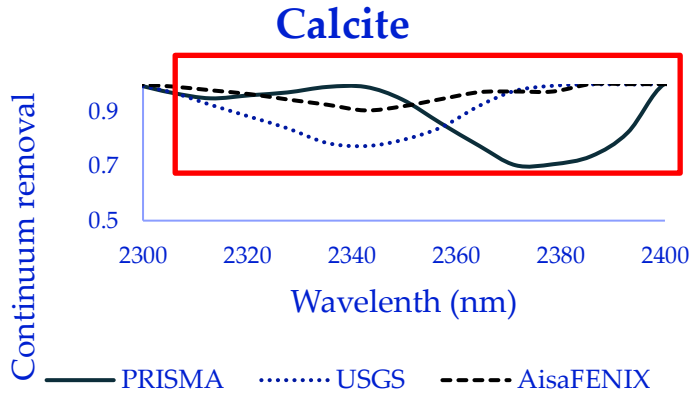
(b)



(c)



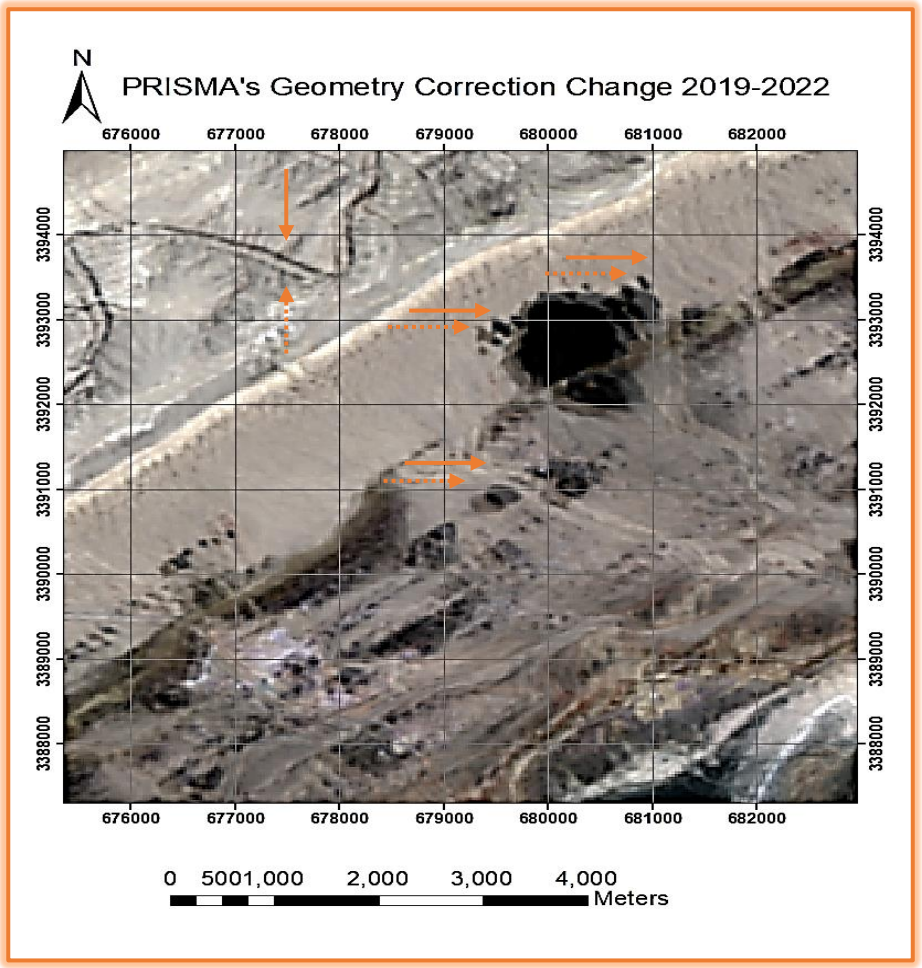
(d)

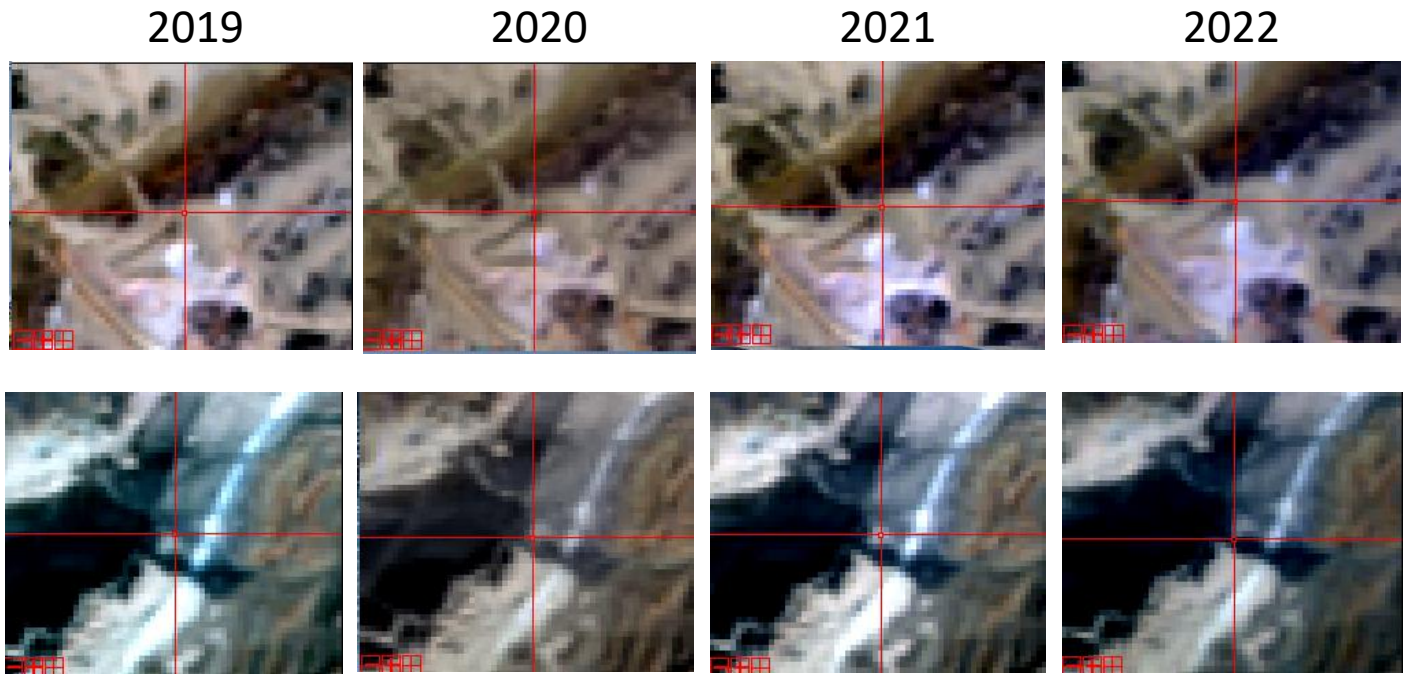


(e)

- There is a significant shift in Calcite absorbance location at PRISMA (29 nm).
- **There may be a malfunction in atmospheric correction for the long SWIR wavelength at the L2 process.**

Stability of geolocation of PRISMA L2,



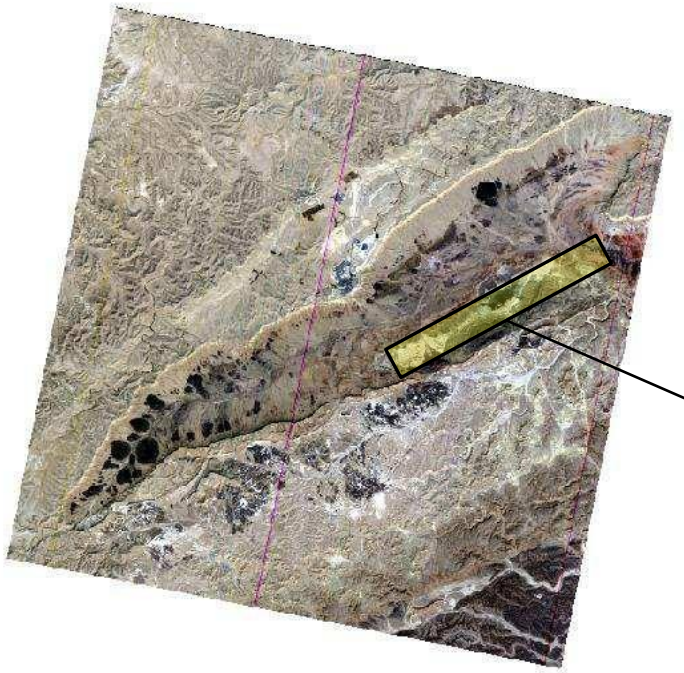


Years compared	X error (m)	Y error (m)	SD X	SD Y
2019–2020	16.8	19.7	0.69	0.37
2020–2021	243.1	66.9	0.75	1.13
2021–2022	16.9	18.3	0.43	0.23
2019–2022	238.6	95.1	0.51	1.18

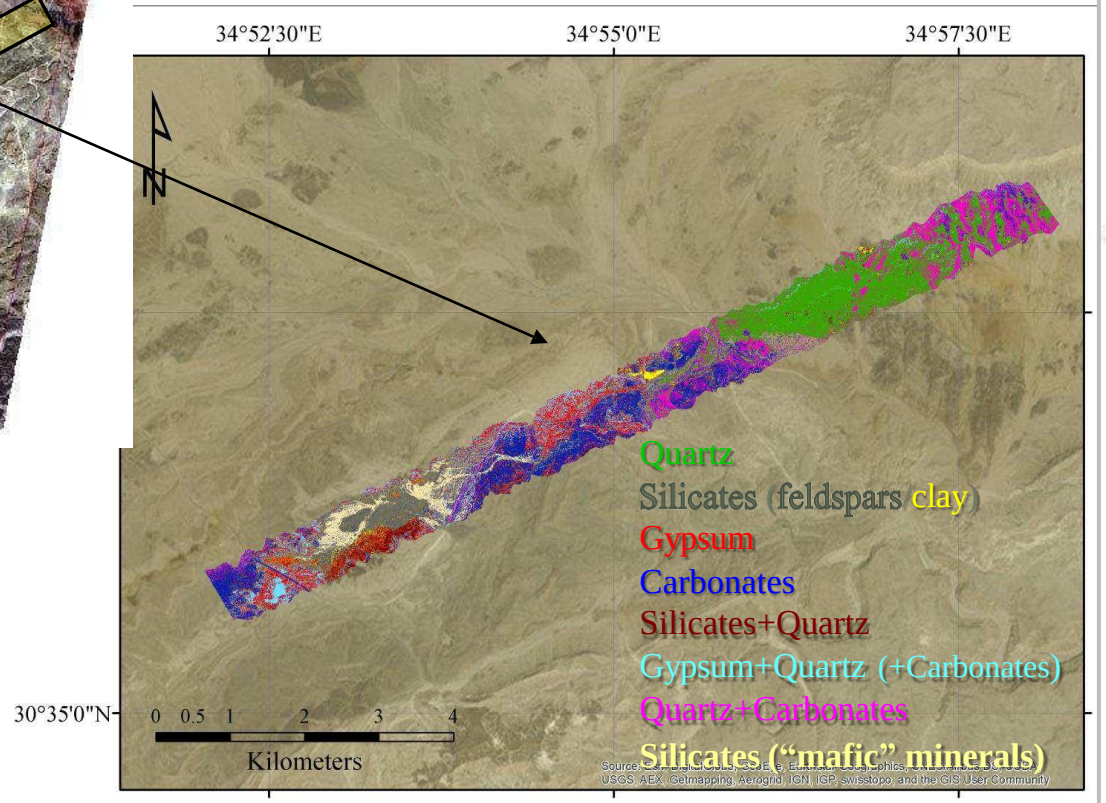
Average of 200 GCP in the image

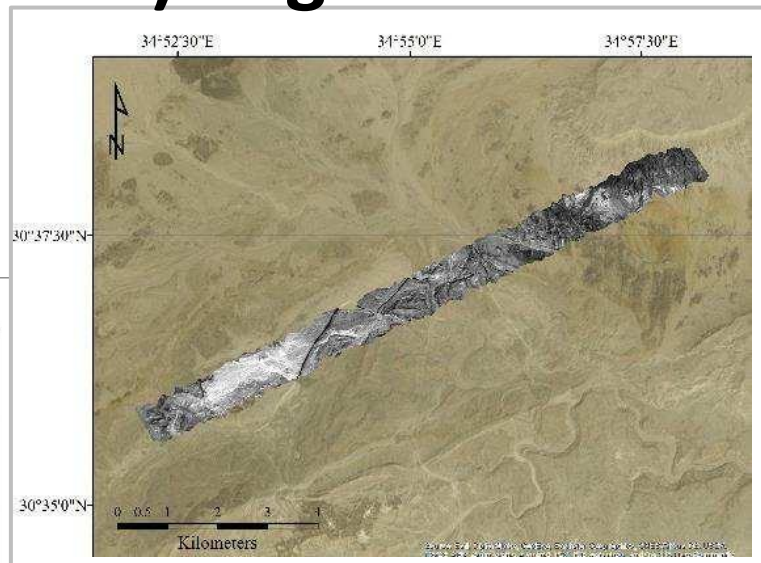
30m = 1 pixel

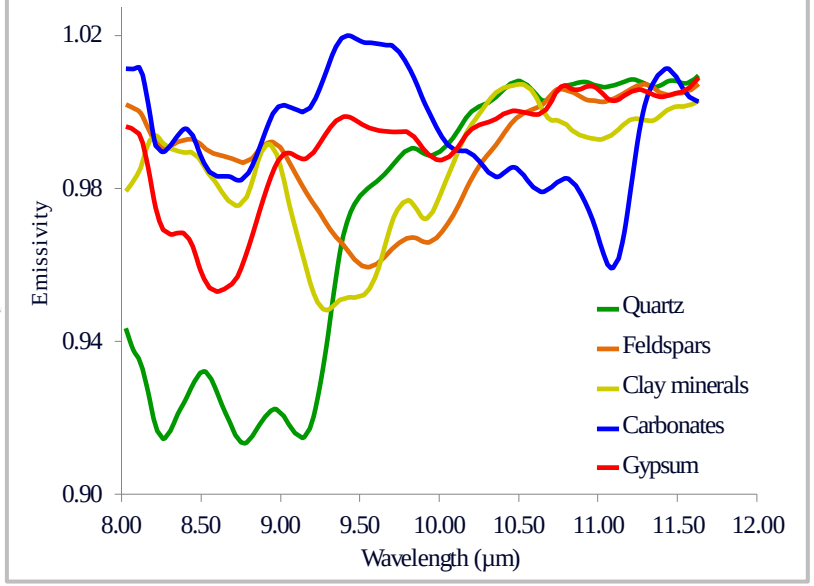
MR: Thematic Mapping in the Thermal (LWIR) Region



Using TERMCAM TELOPS ®







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CONCLUSIONS

01 EnMAP, PRISMA, EMIT, and DESIS performed well in the VNIR region in terms of thematic mapping.

02 EnMAP, EMIT, and PRISMA performed well across the SWIR region up to 2300 nm, where PRISMA L2D signal is less accurate.

03 EMIT had the best L2 (reflectance) product, providing a smooth and accurate signal without the need for pre/post-processing.

04 AP and MR can be use ,not only for optical AL/VAL process, but also for thermal sensors (mainly in MR)

Call for Collaboration

On November 2023 we will conduct a workshop at the dead sea science center for those who are interested in cal/val of HSR sensors in general and for those who want to visit, measure and sample MR and AP test sites

Partial support is available from the *Lowey International School – TAU*

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Interested fellows, please contact: bendor@post.tau.ac.il

Thank you!

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