Performance of the proposed HyspIRI TIR bands for accurate compositional identification of eolian dust, ash and sand

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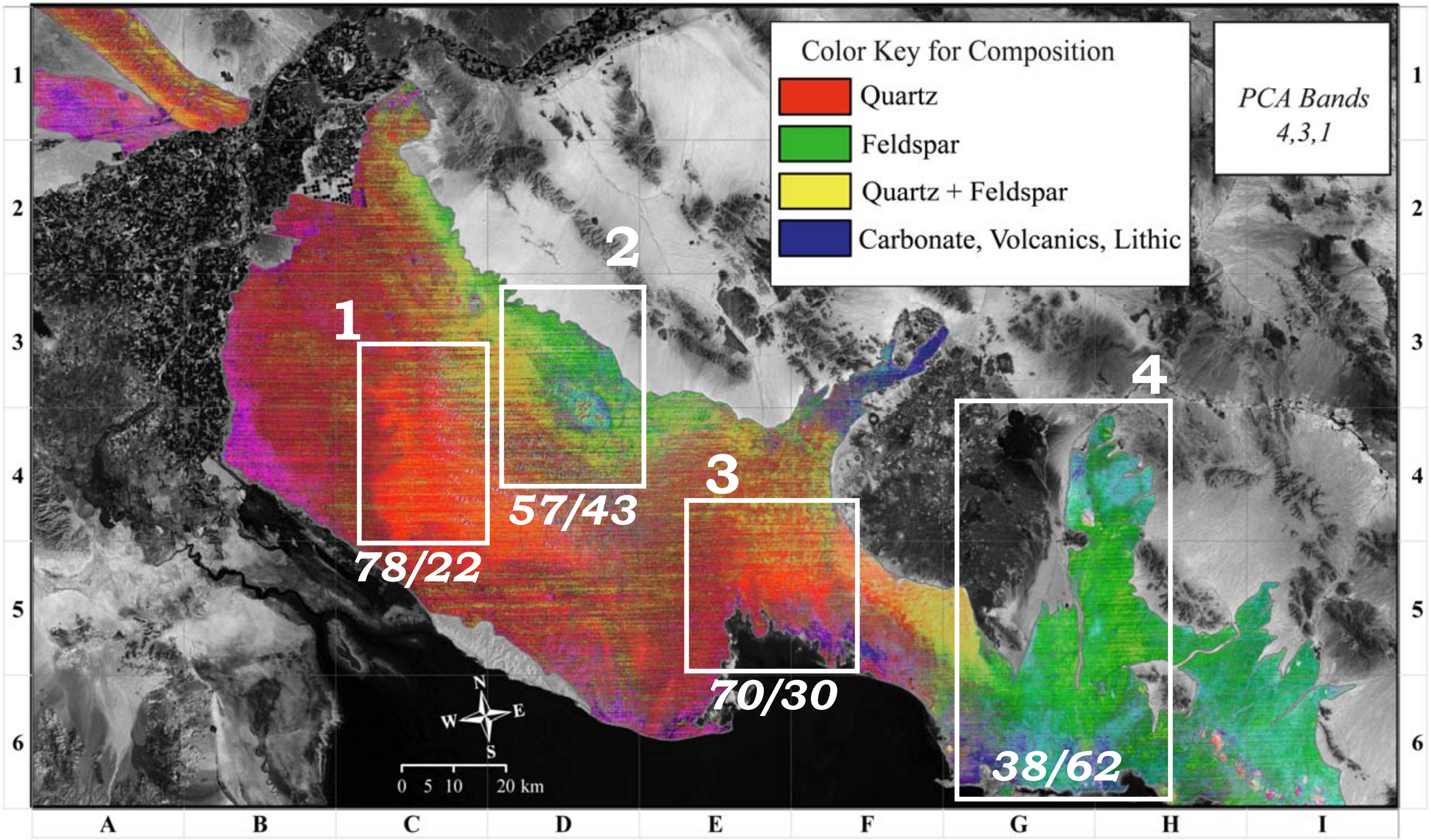
2. University of Pittsburgh, Pittsburgh, PA
3. Smithsonian, Center for Earth and Planetary Studies (CEPS)

Presentation Outline

- Explore previous ASTER TIR work used to study eolian systems and dust with respect to HyspIRI science
- Demonstrate how HyspIRI TIR data are suited to map surface composition relevant to dust source mapping (TQ1) and volcanic ash (TQ5)
- Demonstrate the relevance of HyspIRI thermal infrared data to climate science
- How is the identification of mineral composition affected by the choice of band positions?
- How are TIR data are affect the spectral signature of dust and sand?

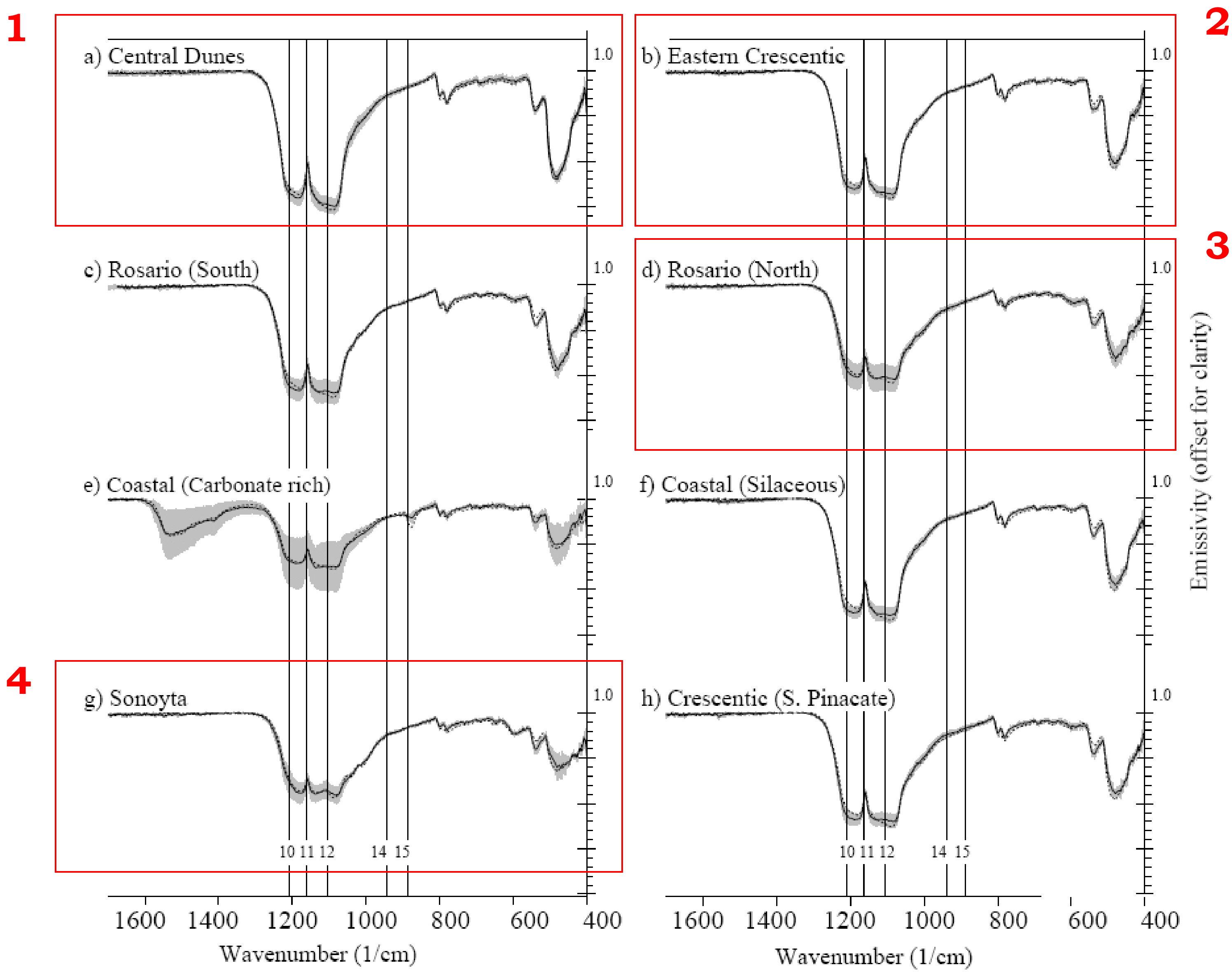
Previous Work: ASTER TIR Spectral Mapping



Ratio of Quartz to Feldspar

Scheidt et al. 2010 (submitted)

Previous Work: ASTER TIR Spectral Mapping



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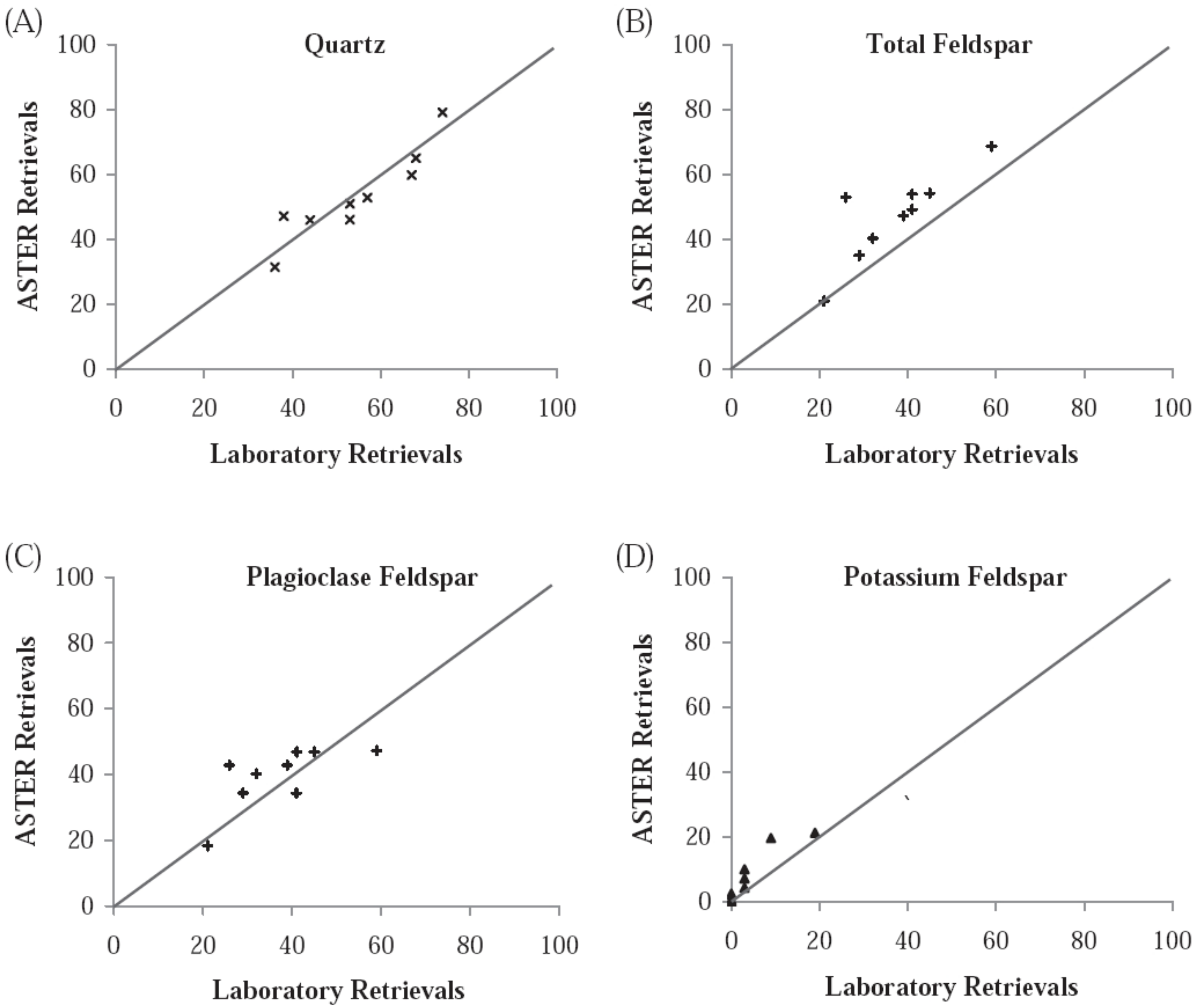
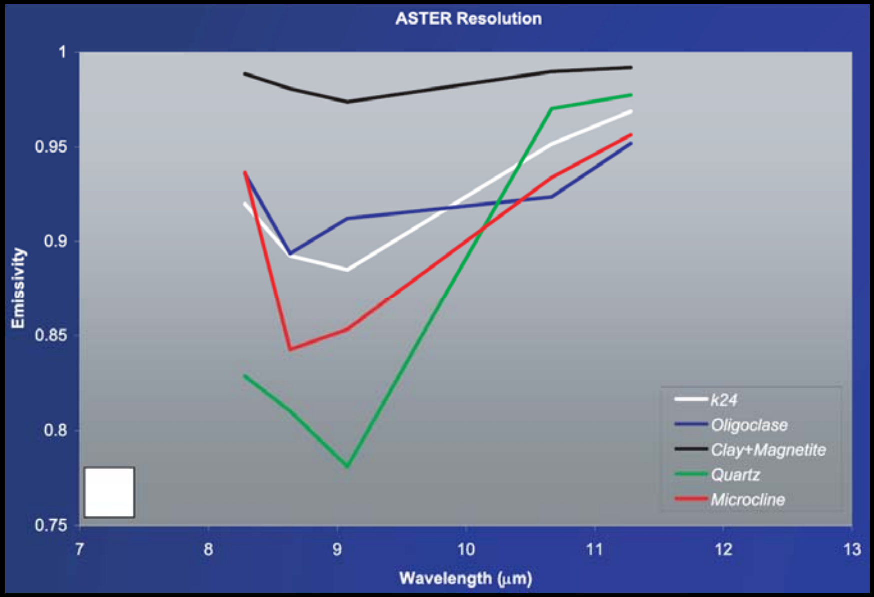
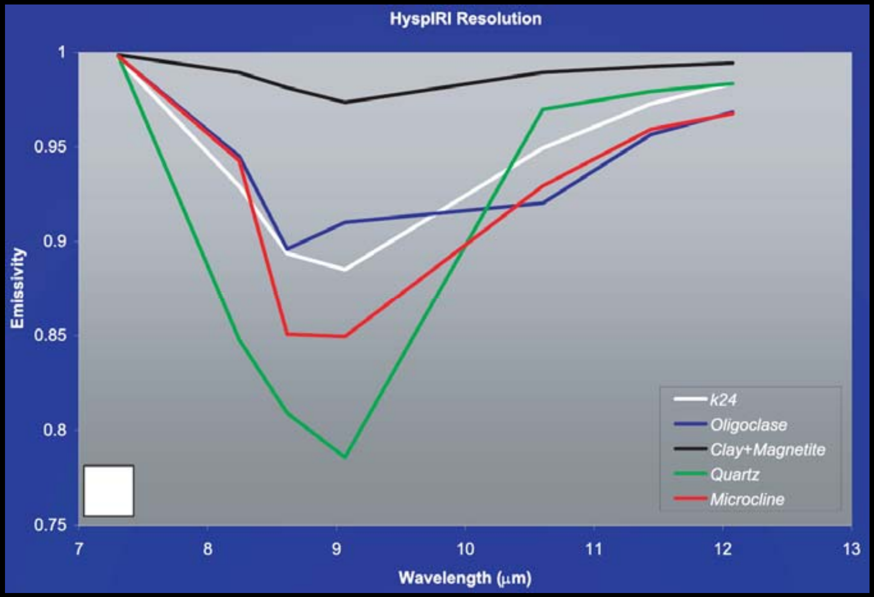
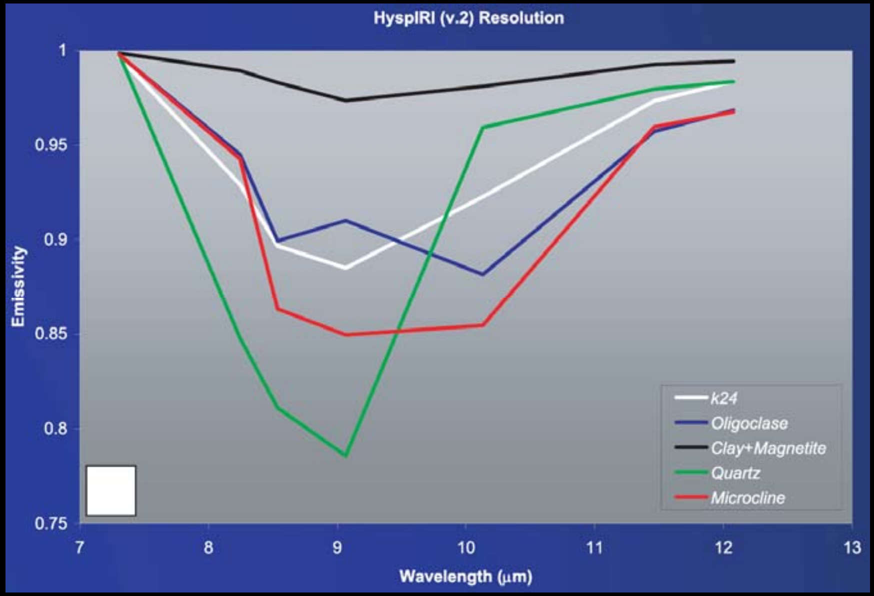


Scheidt et al. 2010 (submitted)

Previous HyspIRI Work: Kelso Dunes

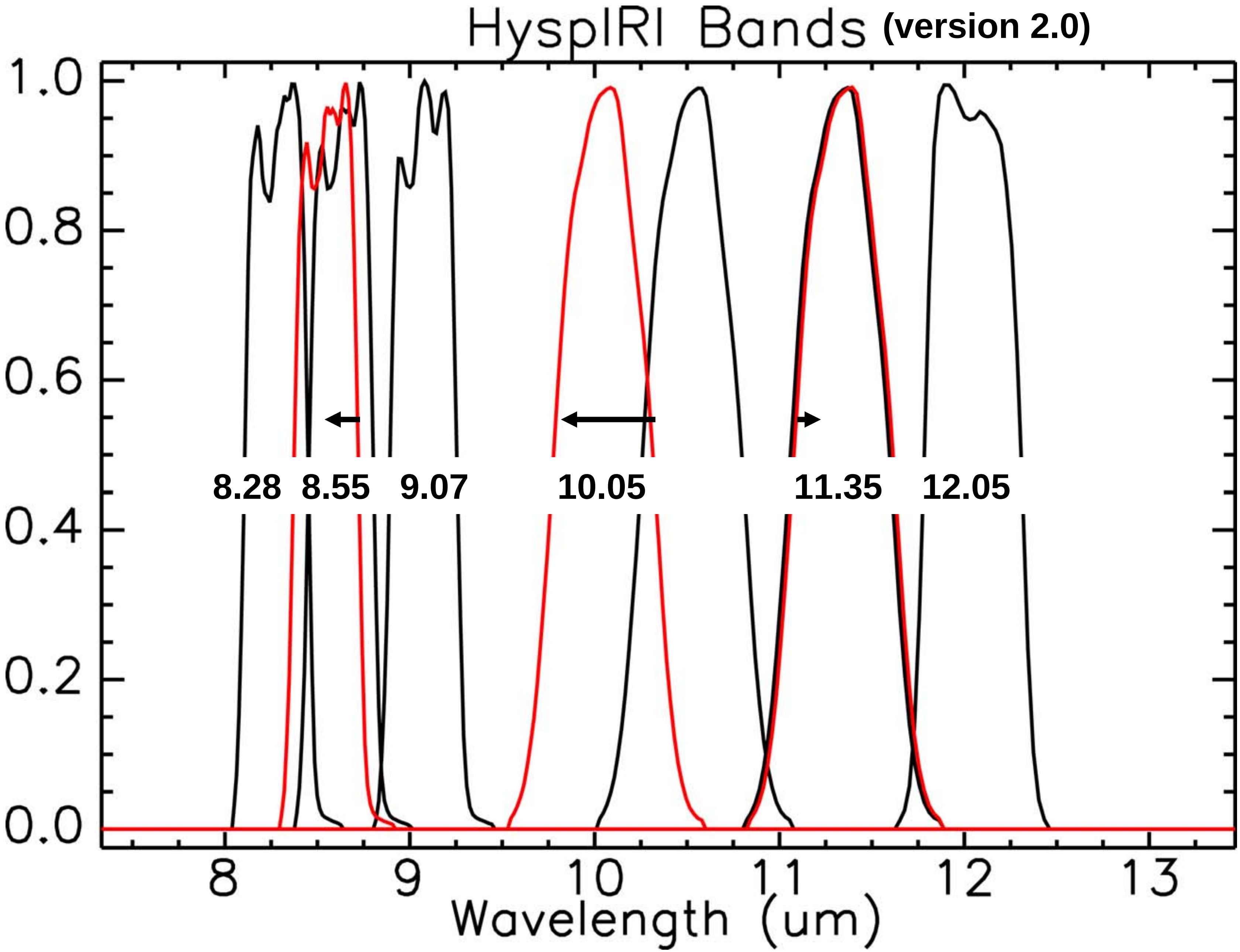




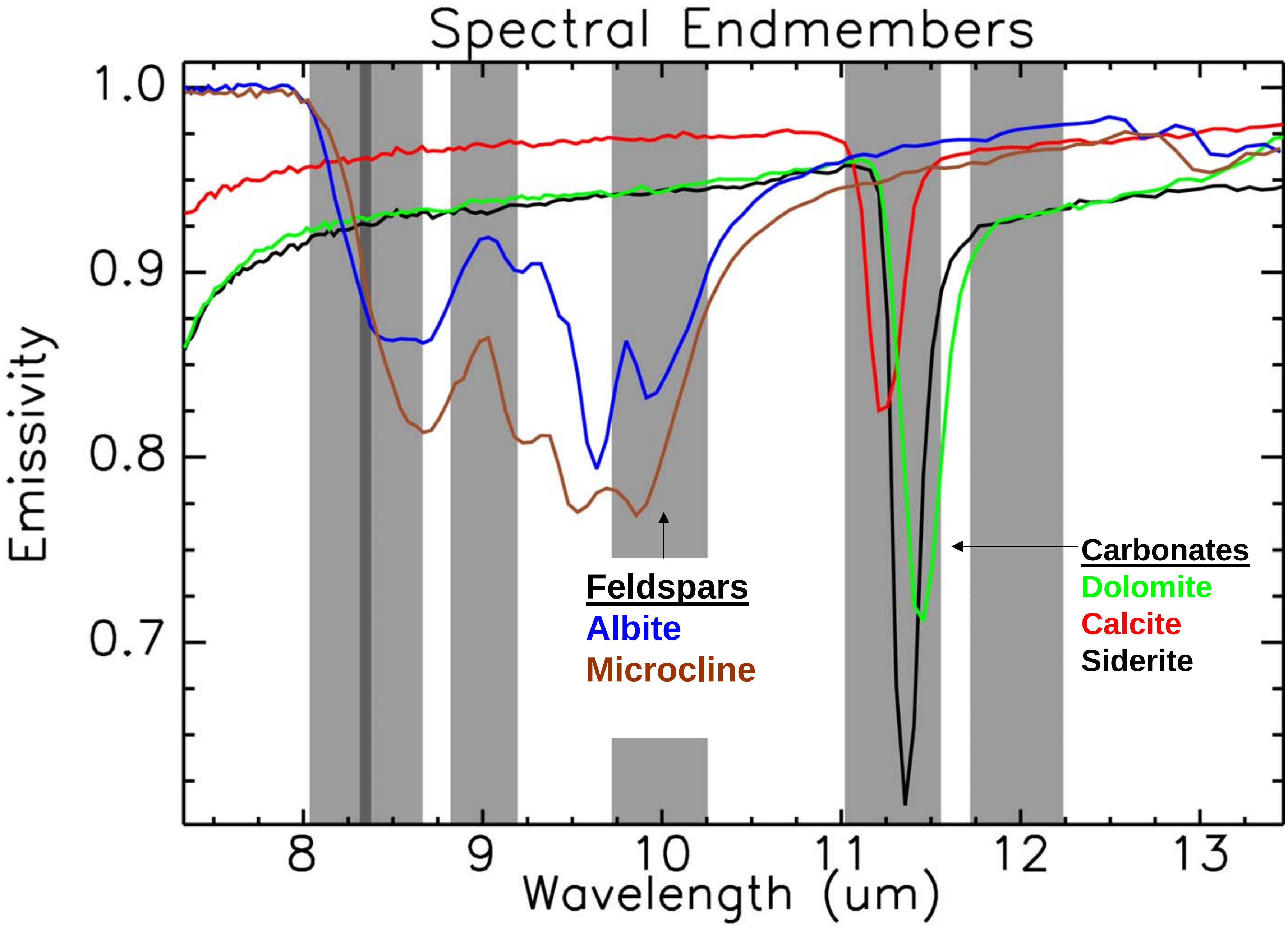


Using resampled MASTER data to HyspIRI v.2 greatly improved spectral mapping results

Presented at the last HyspIRI Workshop by M. Ramsey

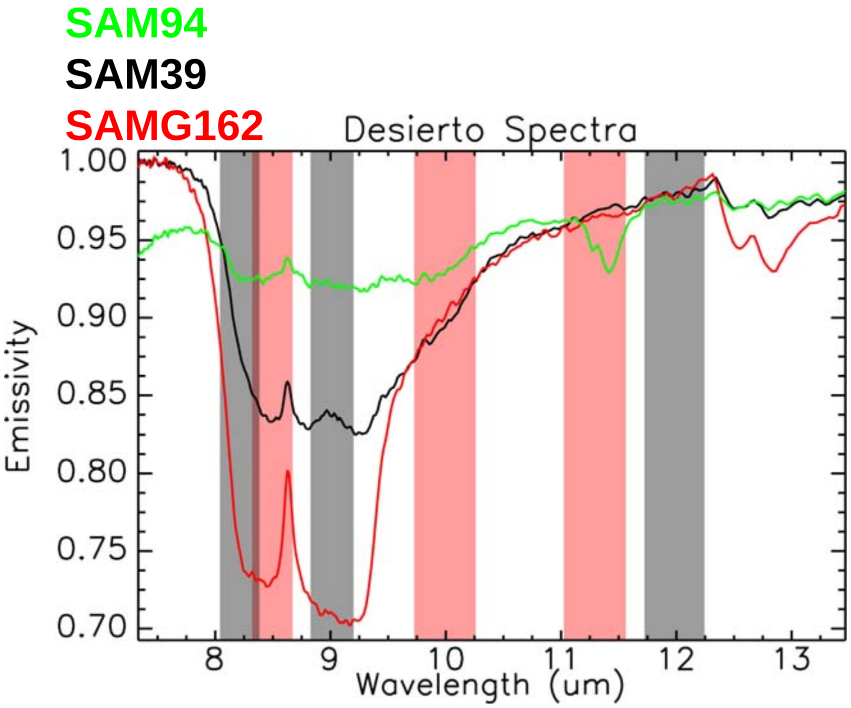


HyspIRI Bands (version 2.0)
1.0
0.8
0.6
0.4
0.2
0.0
8.28
8.55
9.07
10.05
11.35
12.05
8
9
10
11
12
13
Wavelength (um)



Spectral Endmembers
Emissivity
Wavelength (um)
1.0
0.9
0.8
0.7
8
9
10
11
12
13
Feldspars
Albite
Microcline
Carbonates
Dolomite
Calcite
Siderite

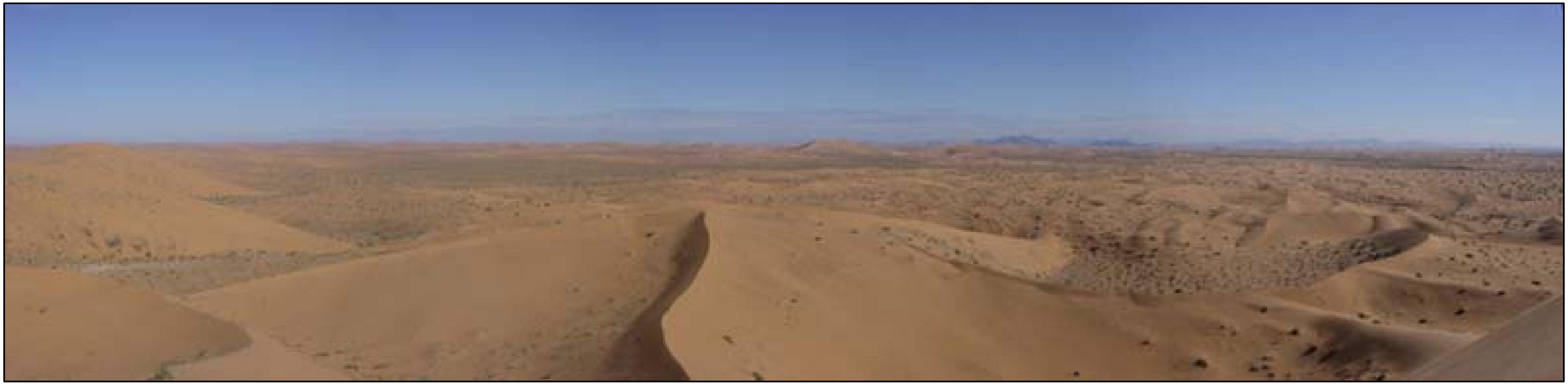
Preliminary Results of Hyspiri Resampling



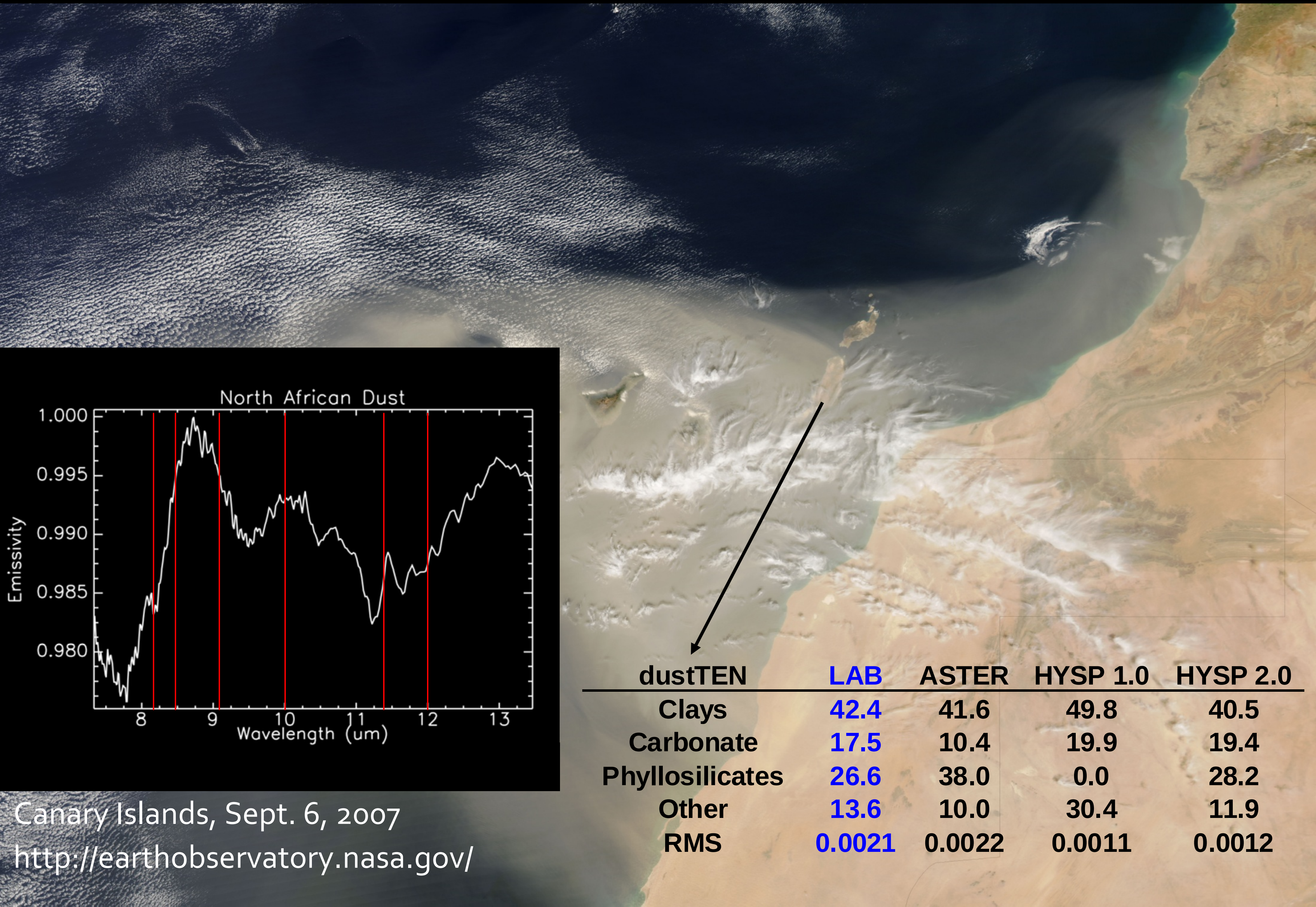
SAM94	LAB	ASTER	HYSP 1.0	HYSP 2.0
Carbonate	45.9	42.9	44.2	42.3
Feldspar	32.0	17.7	28.4	33.8
Quartz	22.1	39.4	27.3	23.9
RMS	0.0026	0.0017	0.0020	0.0022

SAM39	LAB	ASTER	HYSP 1.0	HYSP 2.0
Feldspar	64.1	74.0	72.4	65.9
Quartz	35.9	26.0	27.6	34.1
RMS	0.0038	0.0000	0.0011	0.0021

samG162	LAB	ASTER	HYSP 1.0	HYSP 2.0
Quartz	67.9	64.8	62.4	62.0
Feldspar	32.1	35.2	37.6	38.0
RMS	0.0026	0.0063	0.0037	0.0036



HyspIRI Advantage: Capture Large Dust Storms

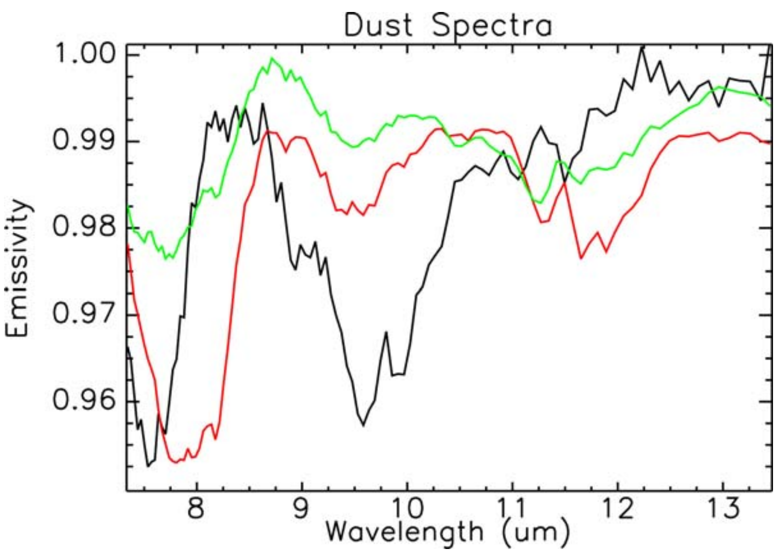


dustTEN	LAB	ASTER	HYSP 1.0	HYSP 2.0
Clays	42.4	41.6	49.8	40.5
Carbonate	17.5	10.4	19.9	19.4
Phyllosilicates	26.6	38.0	0.0	28.2
Other	13.6	10.0	30.4	11.9
RMS	0.0021	0.0022	0.0011	0.0012

Canary Islands, Sept. 6, 2007
http://earthobservatory.nasa.gov/

Dust Spectral Unmixing

CH9	LAB	ASTER	HYSP 1.0	HYSP 2.0
Phyllosilicates	61.7	58.7	34.6	55.9
Carbonate	11.4	0.0	17.8	6.6
Sulphates	14.4	0.0	47.6	37.5
Other	12.6	41.3	0.0	0.0
RMS	0.0034	0.0006	0.0024	0.0023

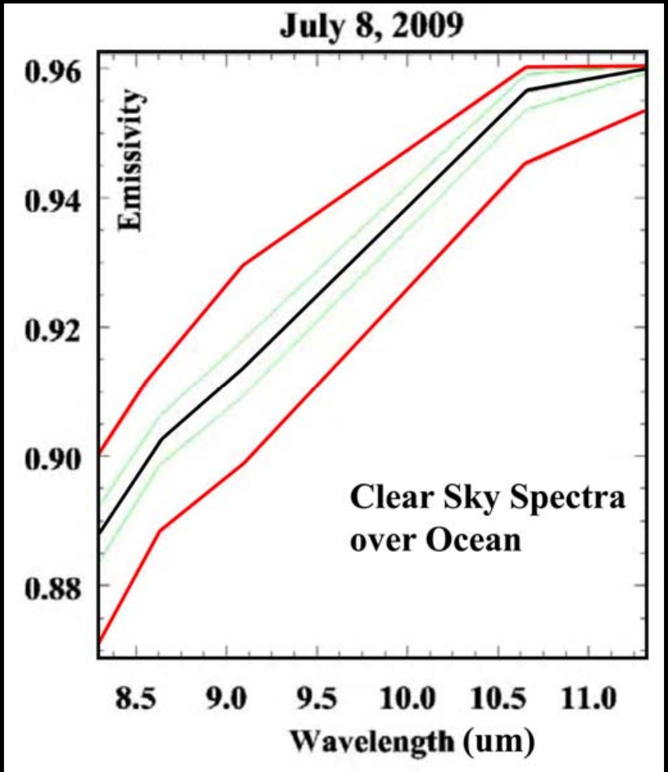


dustKW1	LAB	ASTER	HYSP 1.0	HYSP 2.0
Clays	54.2	51.8	50.5	50.8
Carbonate	23.1	19.7	24.6	32.8
Phyllosilicates	22.7	28.5	24.9	16.4
RMS	0.0027	0.0017	0.0023	0.0024

dustTEN	LAB	ASTER	HYSP 1.0	HYSP 2.0
Clays	42.4	41.6	49.8	40.5
Carbonate	17.5	10.4	19.9	19.4
Phyllosilicates	26.6	38.0	0.0	28.2
Other	13.6	10.0	30.4	11.9
RMS	0.0021	0.0022	0.0011	0.0012

Dust Affects on ASTER Spectra

Affect of Dust on ASTER Emissivity



Field Validation of ASTER data

- Collecting measurements of LW sky-radiance with ground-based FLIR camera (7-14 µm)
- Coincident downward-looking MODIS, AIRS, ASTER and other A-Train instruments
- Site of AERONET Station at Izaña Atmospheric Observatory, Tenerife, Spain from July 4 – August 4, 2009

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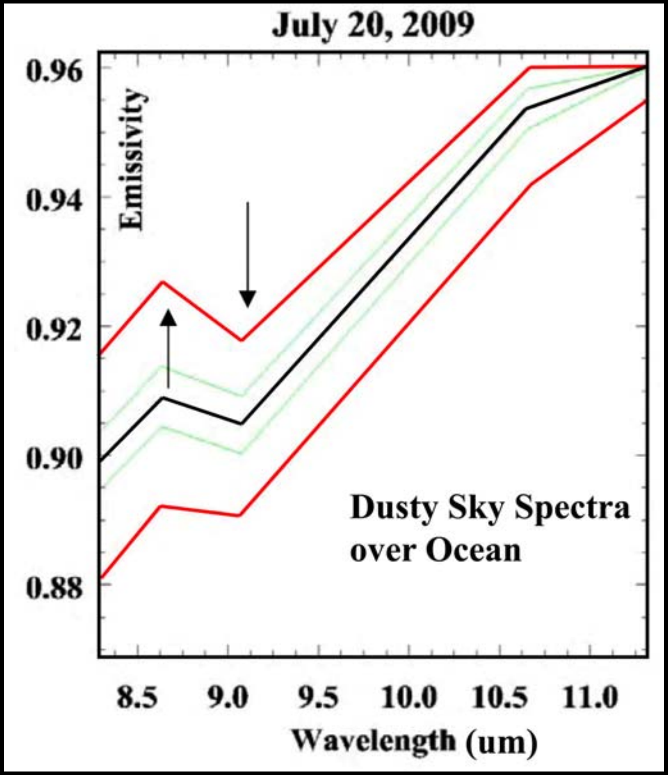

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Dust Enhancement Algorithm in TIR Imagery

- Use brightness temperature differences in the TIR wavelength regions to enhance the appearance of dust.

- <u>SEVIRI Band Stretch</u>

		MIN	MAX (K)
– Red:	BT(12.0 um) – BT(10.8 um)	-4	+2
– Green:	BT(10.8 um) – BT(98.7 um)	0	+15
– Blue:	BT(10.8 um)	261	289

- <u>ASTER Band Stretch</u>

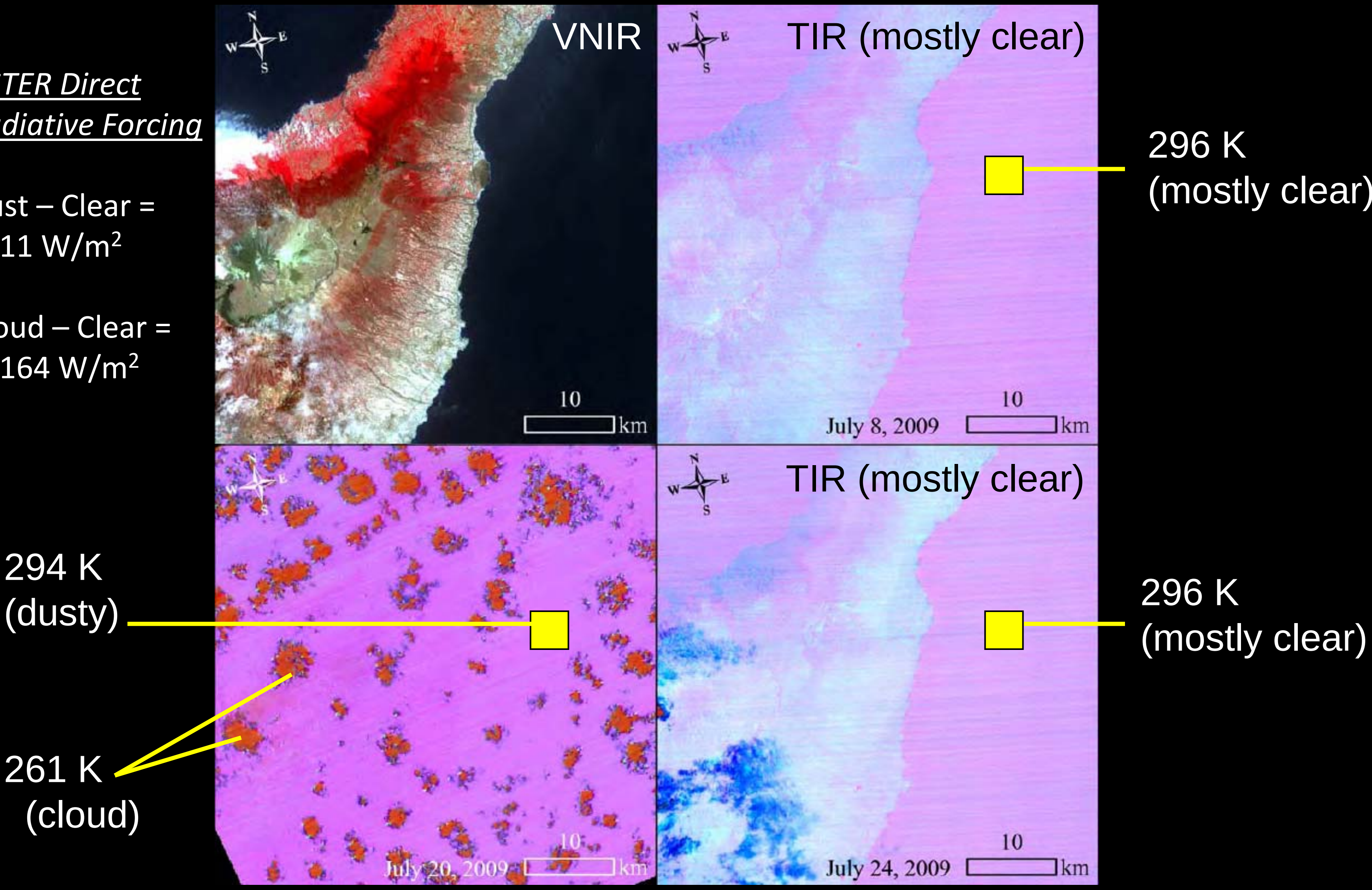
		MIN	MAX (K)
– Red:	BT(11.32 um) – BT(10.65 um)	-4	+1
– Green:	BT(10.65 um) – BT(8.63 um)	-3	+5
– Blue:	BT (10.65 um)	260	289

ASTER Dust Enhancement Example

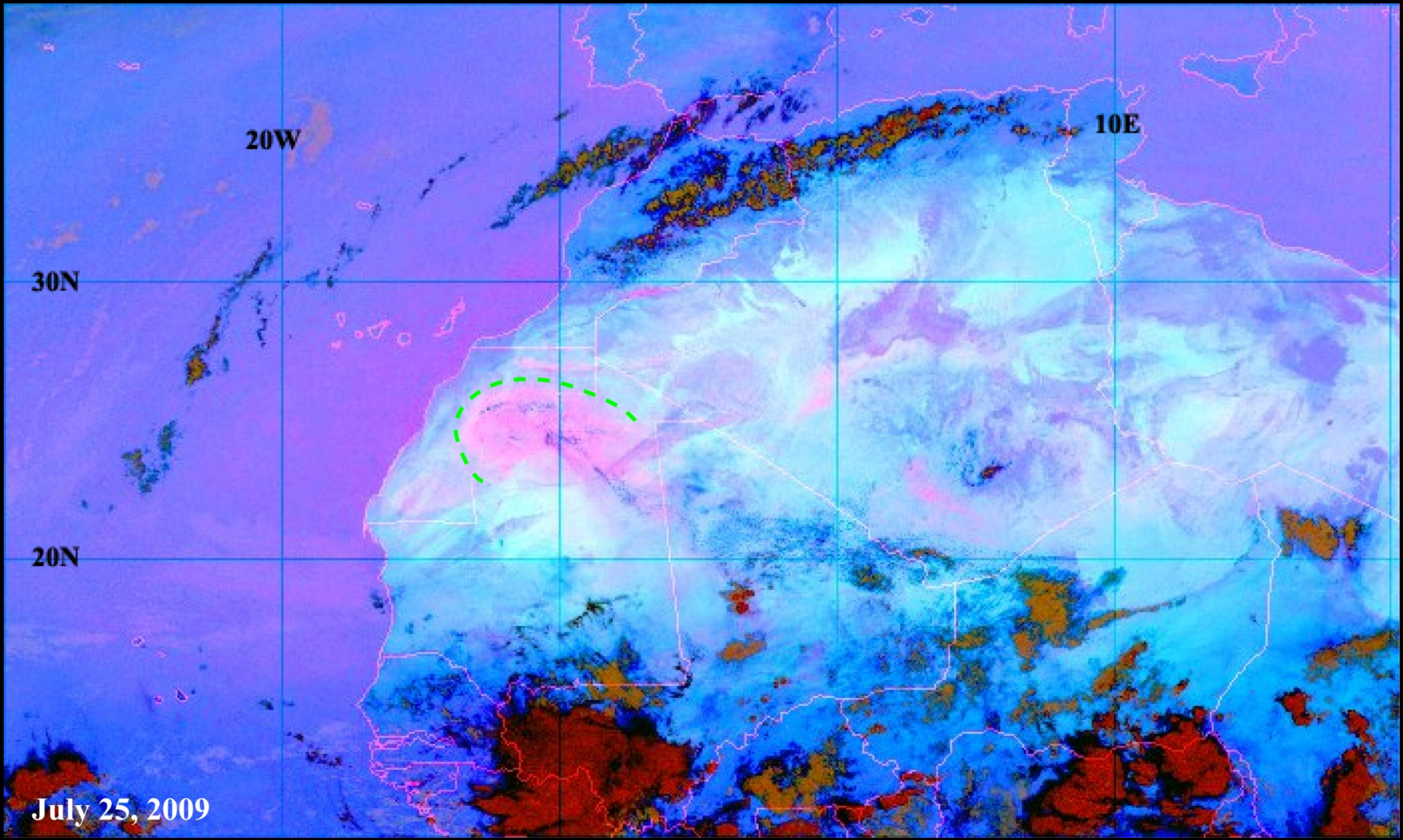
<u>ASTER Direct Radiative Forcing</u>

Dust – Clear = $-11\ W/m^2$

Cloud – Clear = $-164\ W/m^2$

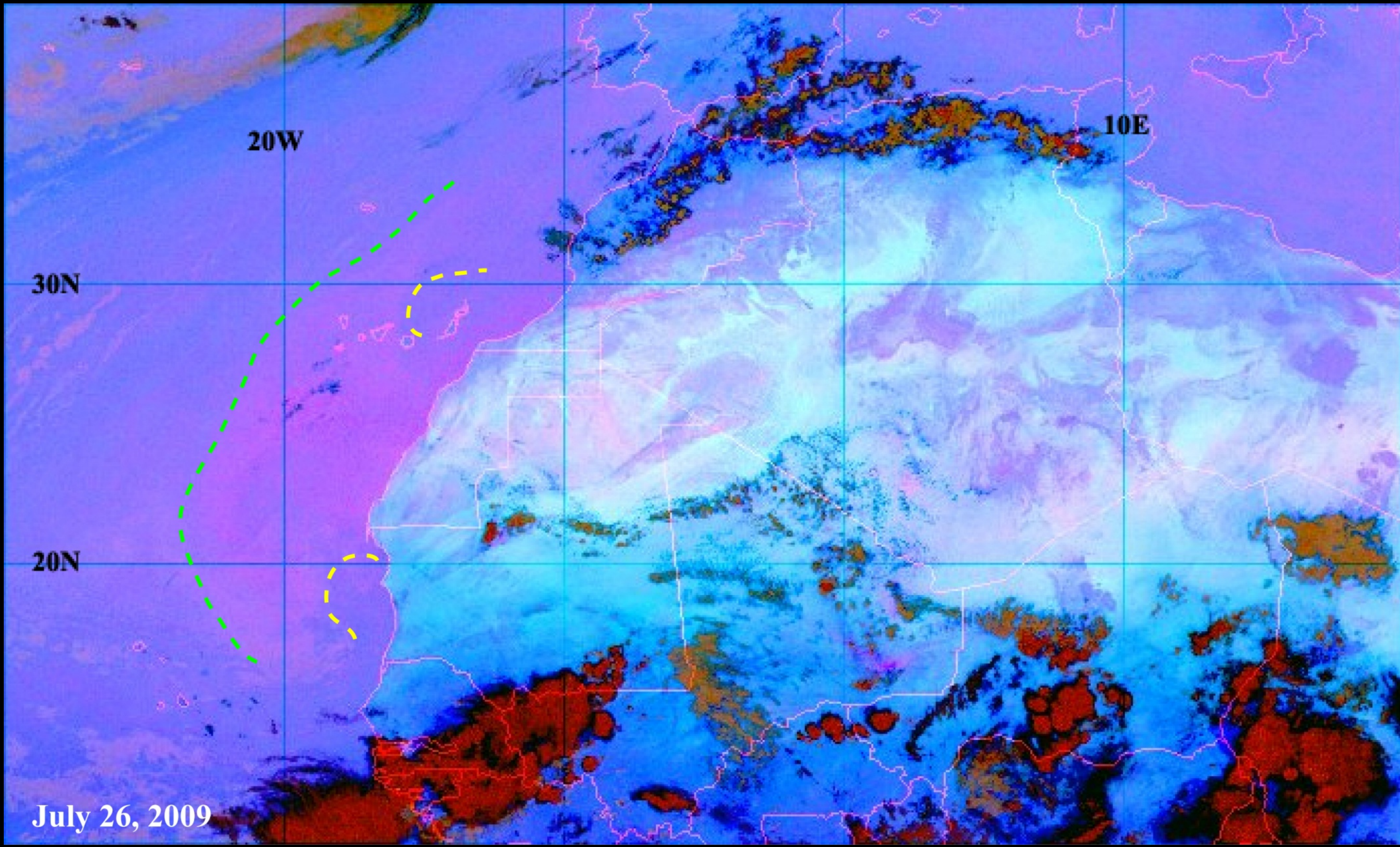


SEVIRI Dust Enhancement Product



cold, thick high clouds | thick, mid-level cloud | low-level clouds | thin cirrus cloud | thin mid-level cloud | low-level cloud (warm) | dust

SEVIRI Dust Enhancement Product



cold, thick high clouds | thick, mid-level cloud | low-level clouds | thin cirrus cloud | thin mid-level cloud | low-level cloud (warm) | dust

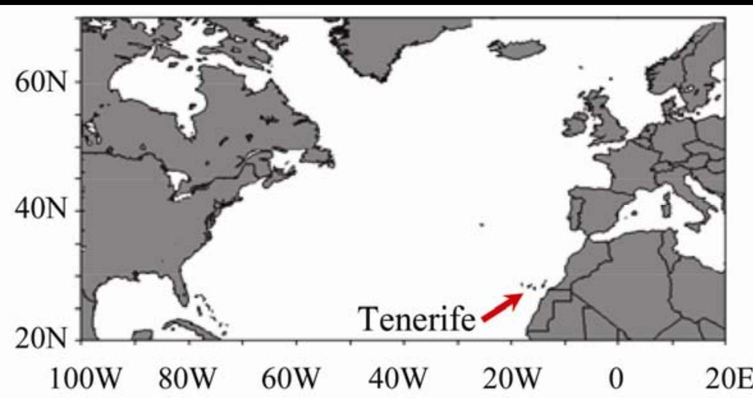
Conclusions

- HyspIRI's swath width, spatial, spectral and temporal resolutions are highly suited for imaging global eolian processes.
- Mapping dust source composition and imaging dust plumes in the TIR addresses the following:
  - The effects of dust on climate and the uncertainty of dust's radiative effects.
  - ecosystem responses to dust, which may be either beneficial or adverse.
- New band positions appear to improve linear spectral unmixing results.

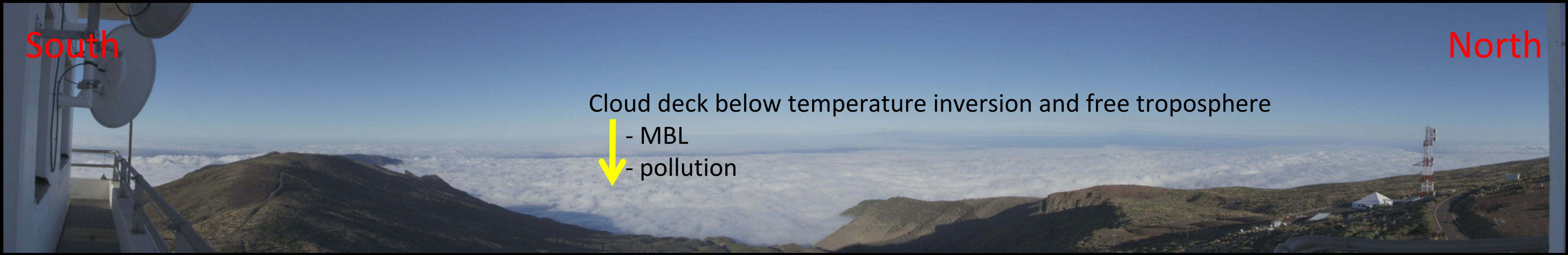
…further rigorous analysis of spectral data is needed to determine the best band positions for mapping the widest array of compositions.

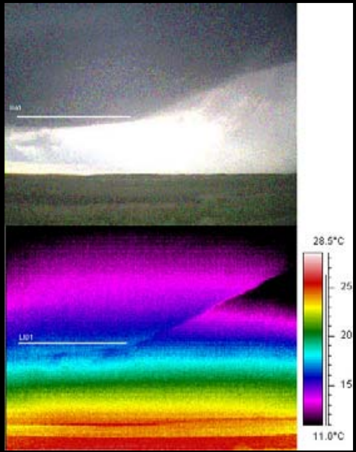
Extra Slides

Validation of TIR Remote Sensing of Dust



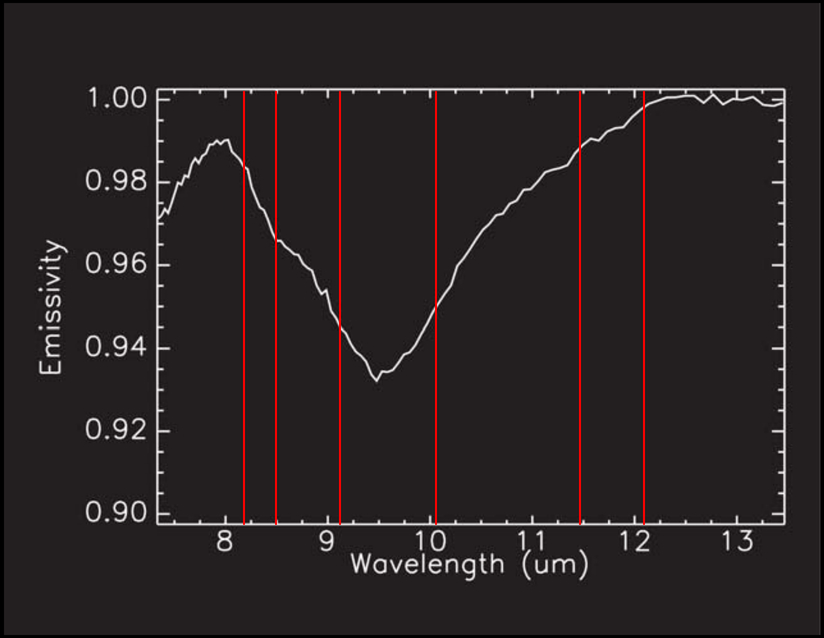
- Collaboration with
    Meteorological State Agency (AEMET)
- Sergio Rodriguez
    Head of Aerosol Program





Tanamachi et al. 2006

Eyjafjallajökull Ashfall



E. Mercurio

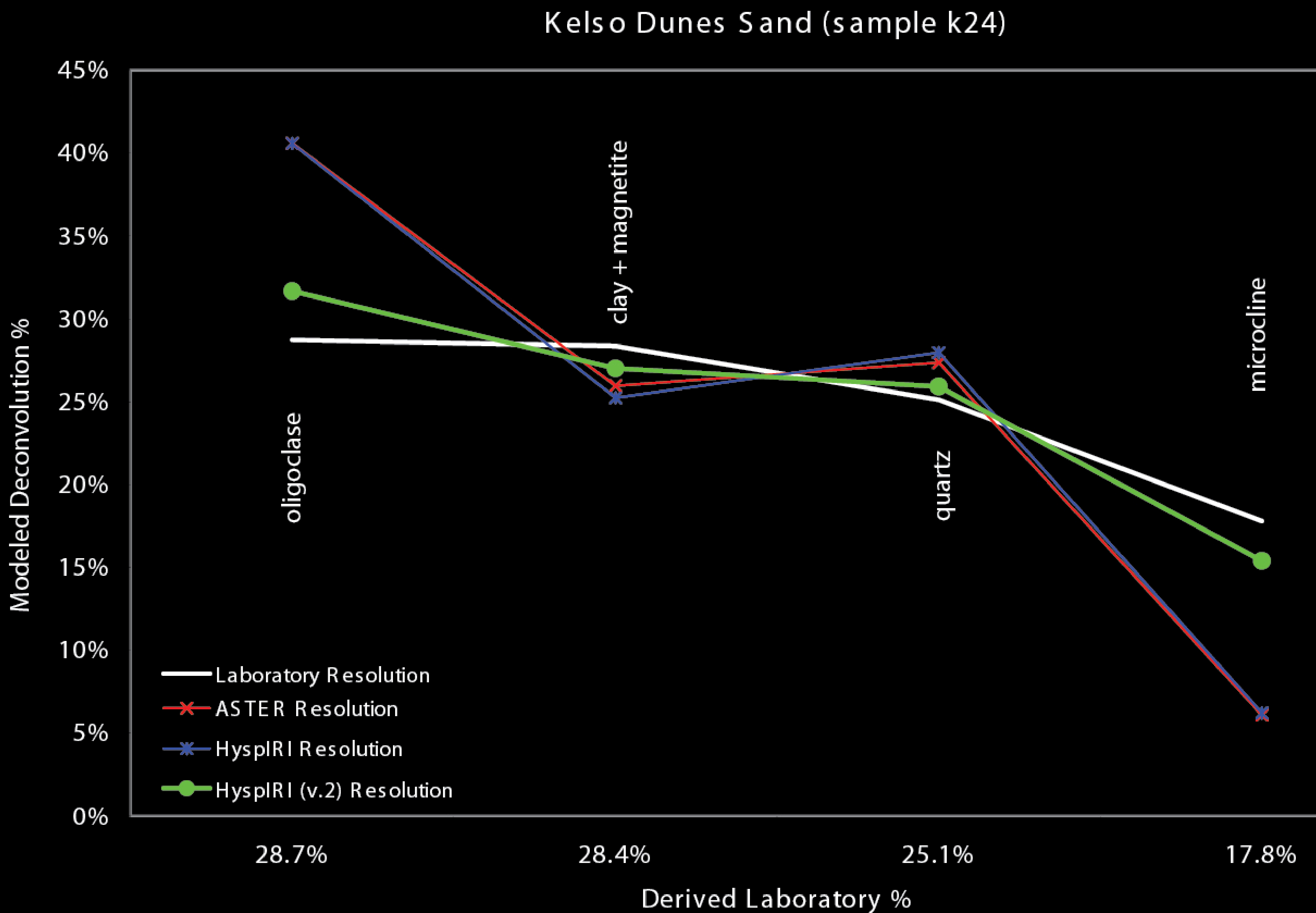
E. Mercurio

Ash samples were collected in August 2010 at Markarfljót, a glacial outwash plain that drained the April-May Eyjafjallajökull eruption materials.

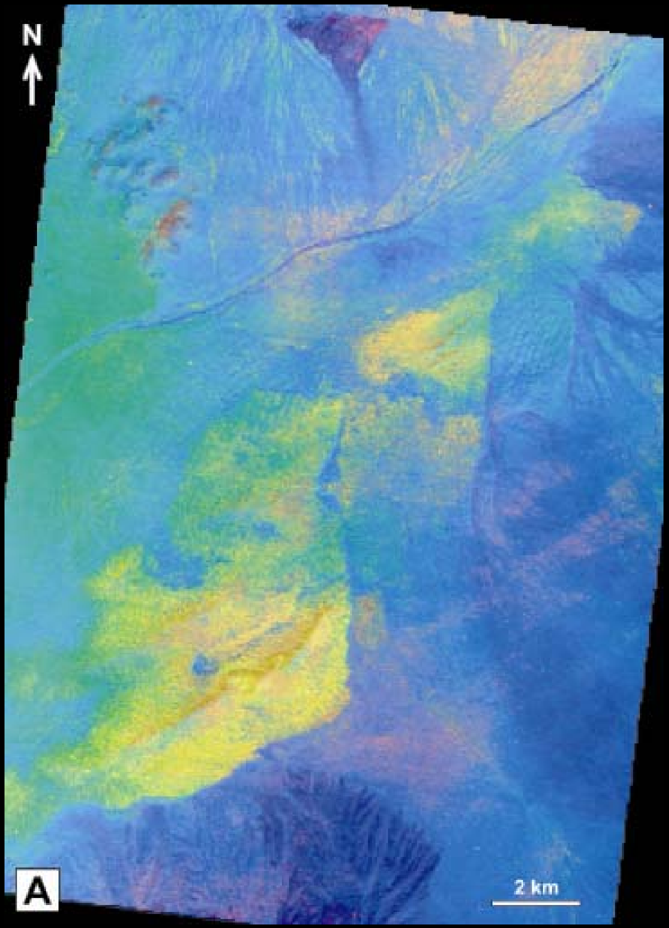
April 19, 2010 Eruption, NASA Earth Observatory

E. Mercurio, Iceland sample contributor at Markarfljót waterfall.

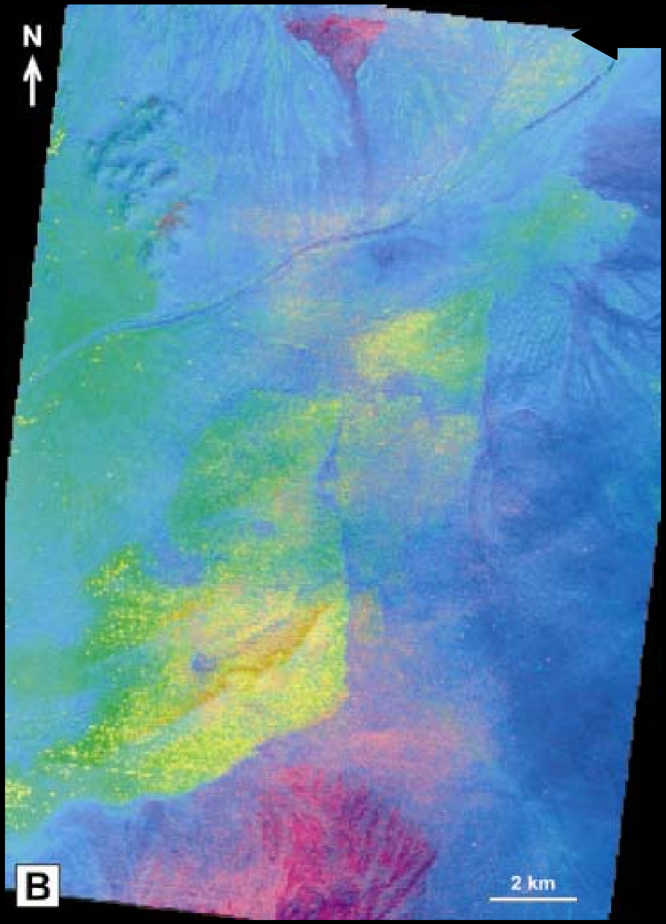
Improved Accuracy for Spectral Unmixing



Improved Spectral Mapping using Resampled MASTER TIR Data



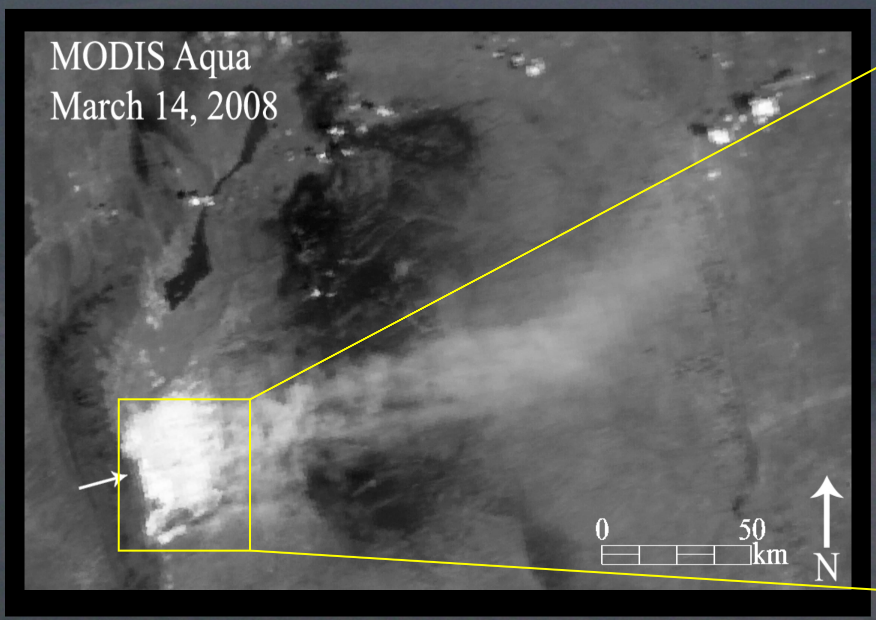
Resampled Data to HyspIRI



Resampled Data to HyspIRI v2

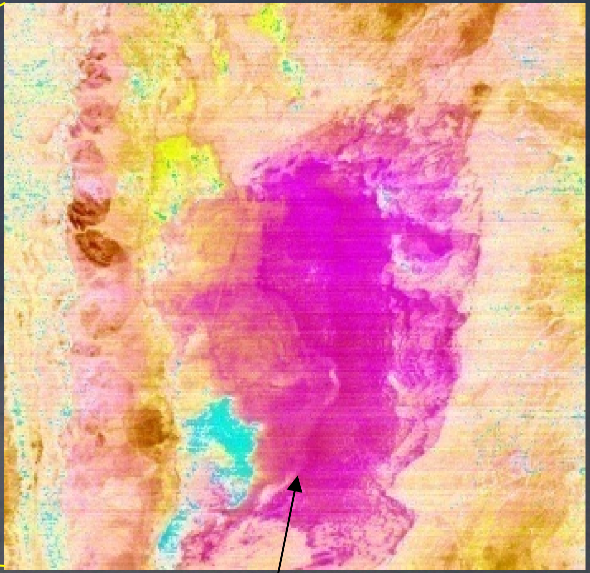
M. Ramsey 2010

White Sands Gypsum Dune Field



Dust storm from White Sands

Decorrelation Stretch
(Bands 14,12,10), April 27, 2008



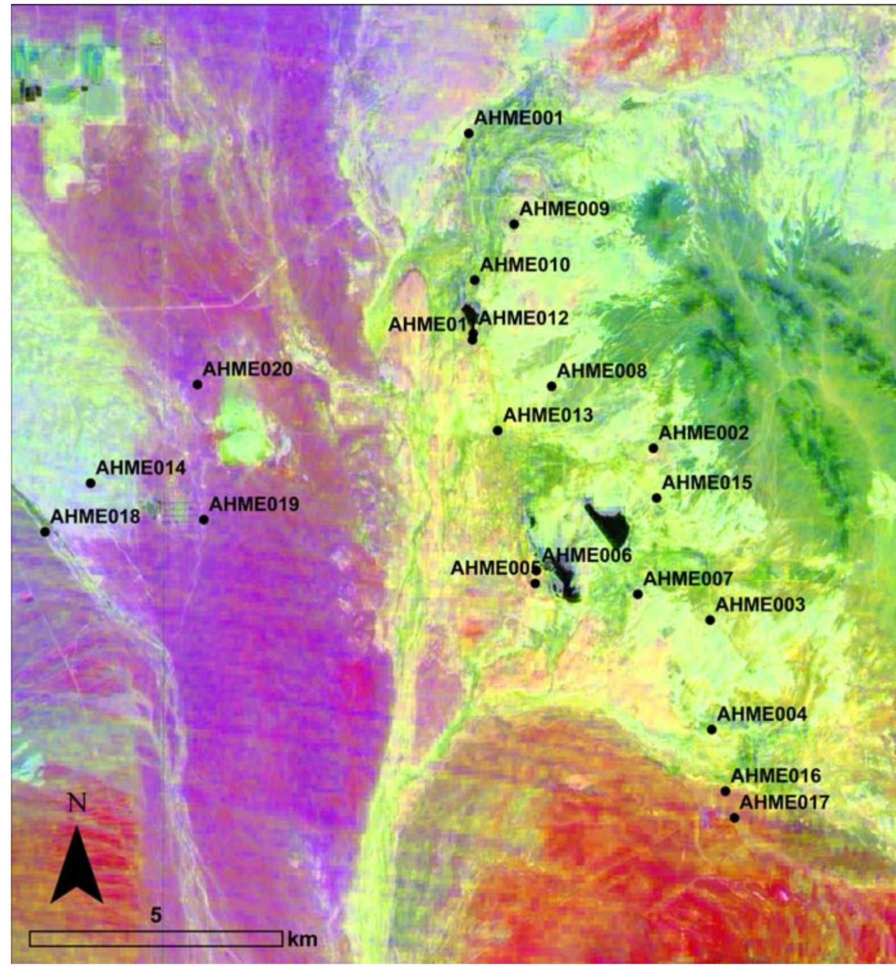
Fairly uniform composition

Ash Meadows National Wildlife Refuge

Amargosa Dunes, NV

- Dunes are under study by Nicholas Lancaster, Desert Research Institute
- Geomorphic analysis of small dunes using GPS
- Using TIR spectral analysis
- Validation using XRD and XRF geochemical measurements
- Highly varied sand composition

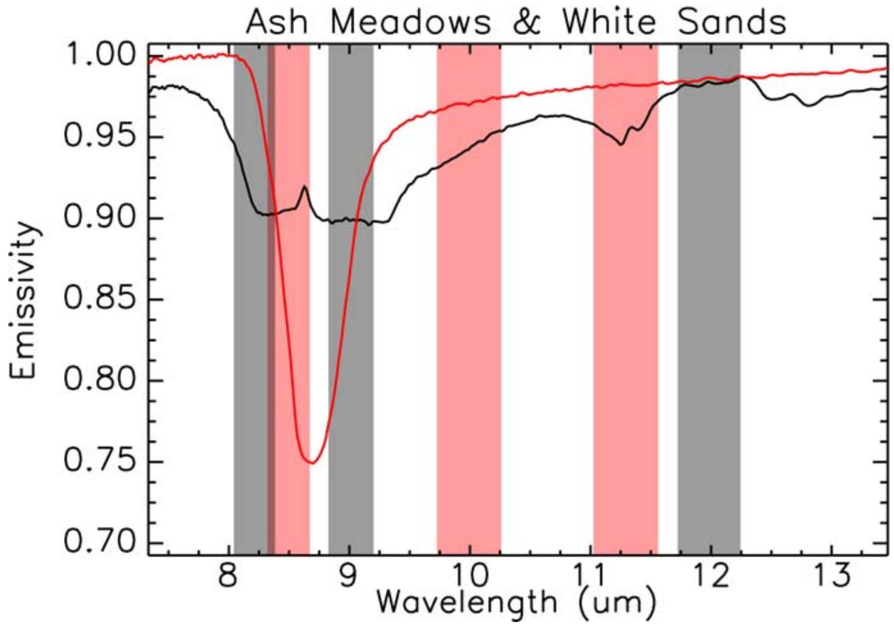
Decorrelation Stretch of ASTER Bands 14, 12 and 10



Preliminary Results of Hyspiri Resampling

Ash Meadows

AHME008	LAB	ASTER	HYSP 1.0	HYSP 2.0
Feldspar	44.8	42.9	45.3	41.0
Carbonate	37.2	41.4	40.7	43.5
Quartz	18.1	15.7	14.0	15.5
RMS	0.0029	0.0008	0.0012	0.0010



White Sands

WHSA001	LAB	ASTER	HYSP 1.0	HYSP 2.0
Sulphates	89.6	88.4	88.6	88.2
Other	9.7	11.6	9.6	11.8
Carbonate	0.7	0.0	1.8	0.0
RMS	0.0034	0.0074	0.0022	0.0015

HyspIRI Advantage: Capture Large Dust Storms