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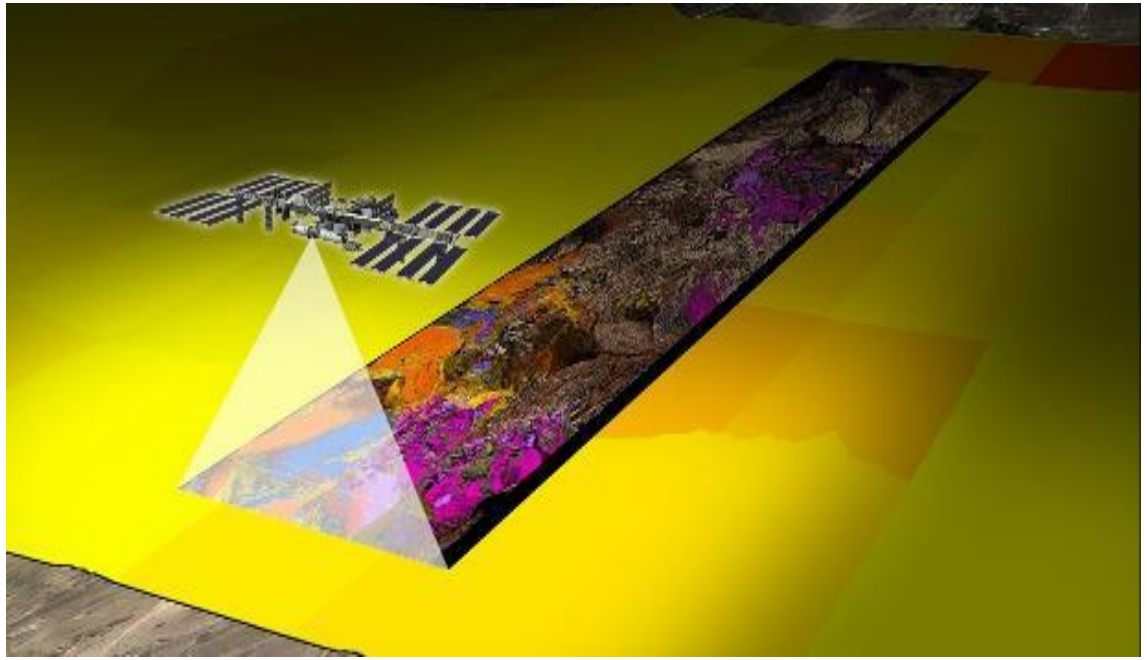
Status of the Earth Surface Mineral Dust Source Investigation Imaging Spectroscopy Mission



Robert O. Green[1], Natalie Mahowald[2], David R. Thompson[1], Roger Clark[3], Bethany Ehlmann[4], Paul Ginoux[5], Olga Kalashnikova[1], Ron Miller[6], Greg Okin[7], Thomas H. Painter[7], Carlos Perez Garcia-Pando, Vincent Realmuto[1], Gregg Swayze[9], Eyal Ben Dor[10], Philip G. Brodrick[1], Longlei Li[2], Nimrod Camron[1], Benjamin Phillips[11], and Kevin Reath[11]

[1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA, [2]Cornell University, Ithaca, NY, USA, [3]Planetary Science Institute, Tucson, AZ, USA, [4]California Institute of Technology, Pasadena, CA, USA, [5]Princeton University, Princeton, NJ, USA, [6]NASA Goddard Institute for Space Studies, New York, NY, USA, [7]University of California Los Angeles, Los Angeles, CA, USA, [8]Barcelona Supercomputing Center, Barcelona, Spain, [9]US Geological Survey, Golden, CO, USA, [10]University of Tel Aviv, Tel Aviv, Israel, [11]NASA Headquarter, Washington, DC, USA

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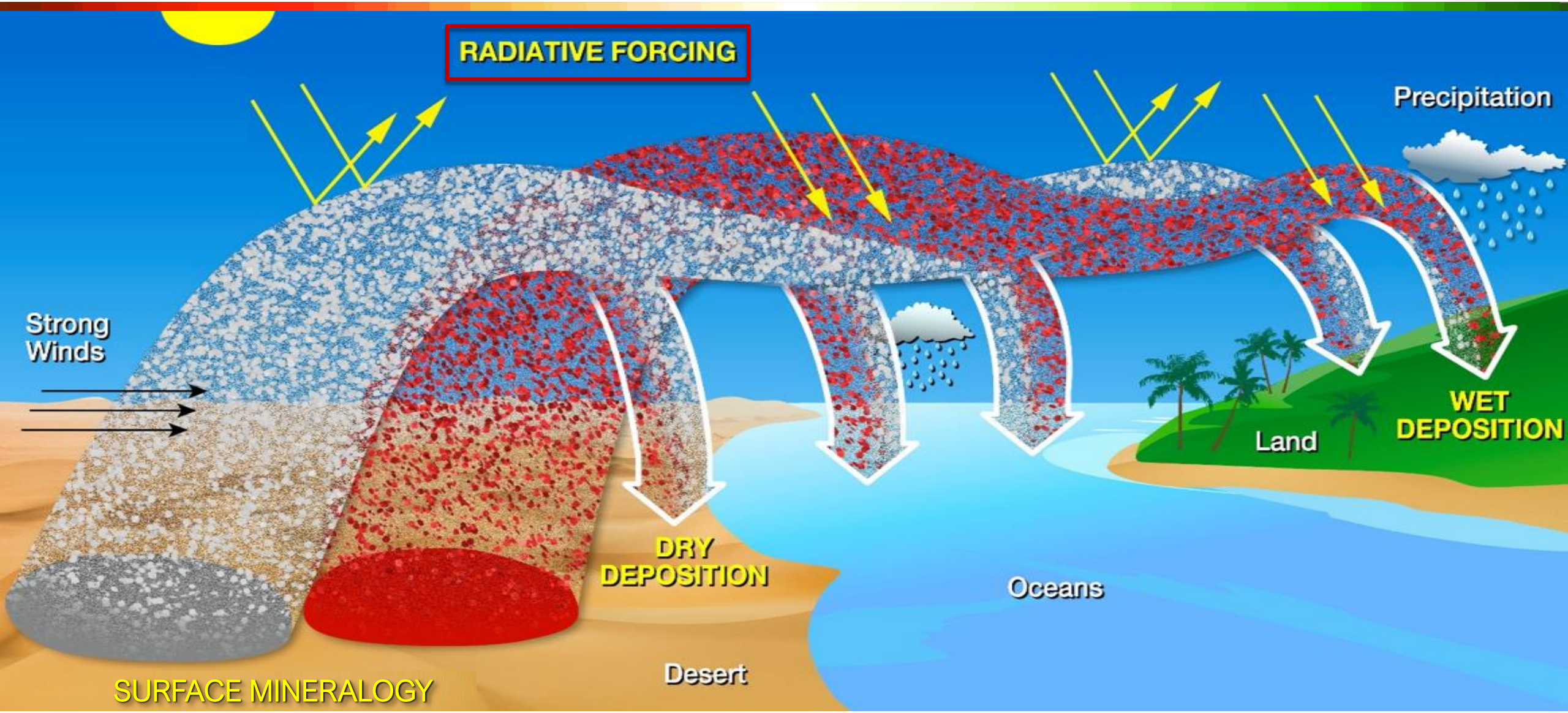
Earth's Mineral Dust Cycle



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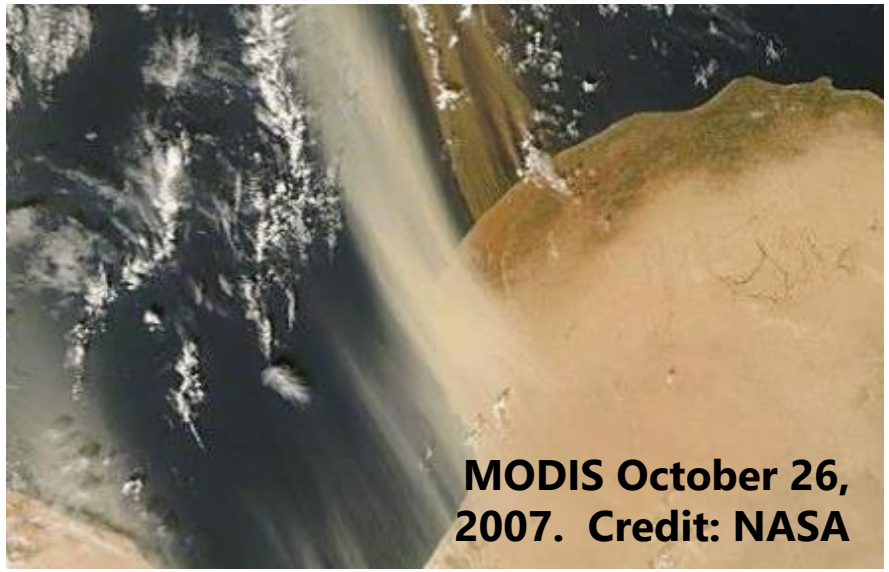
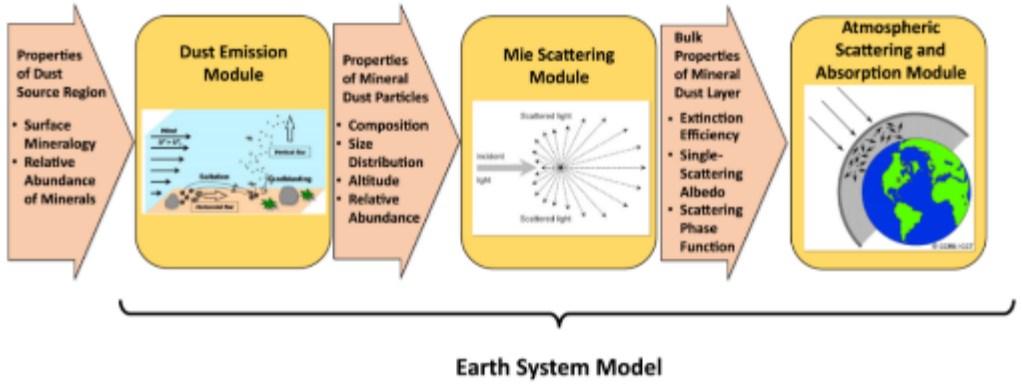
EMIT Science Objectives

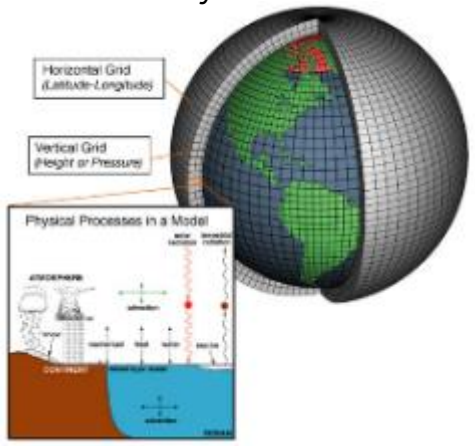


1) Constrain the sign and magnitude of dust-related RF at regional and global scales.
EMIT achieves this objective by acquiring, validating and delivering updates of surface mineralogy used to initialize Earth System Models.

2) Predict the increase or decrease of available dust sources under future climate scenarios.
EMIT achieves this objective by initializing Earth System Model forecast models with the mineralogy of soils exposed within at-risk lands bordering arid dust source regions.



Earth System Models



Dust in Earth System Models

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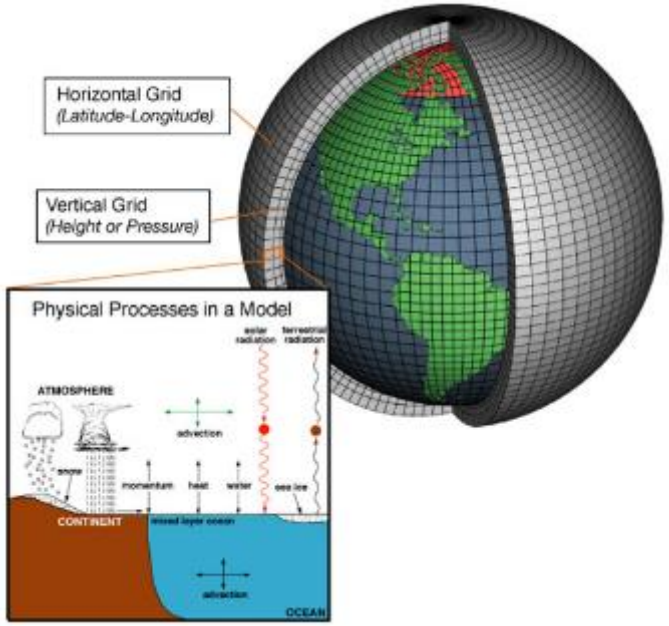
Earth System Model

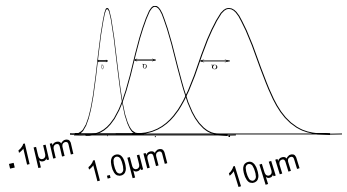


CESM:
- CAM4/CAM5: minerals + mineral RF
- CAM6/E3SM: minerals + mineral RF

GISS: minerals/dust+dust RF
GFDL and Monarch

- Traditionally: Model an 'average' mineral aerosol
- However, mineral aerosols are from different minerals depending on surface composition

Aerosol



In 3 aerosol size modes

(Zender et al., 2003; Mahowald et al., 2006;Liu et al., 2011)

Each mineral has different properties and interactions with Earth System

Illite

hematite

Iron oxides:
Absorb short wavelength (SW), iron for ocean biogeochemistry, low pH

kaolinite

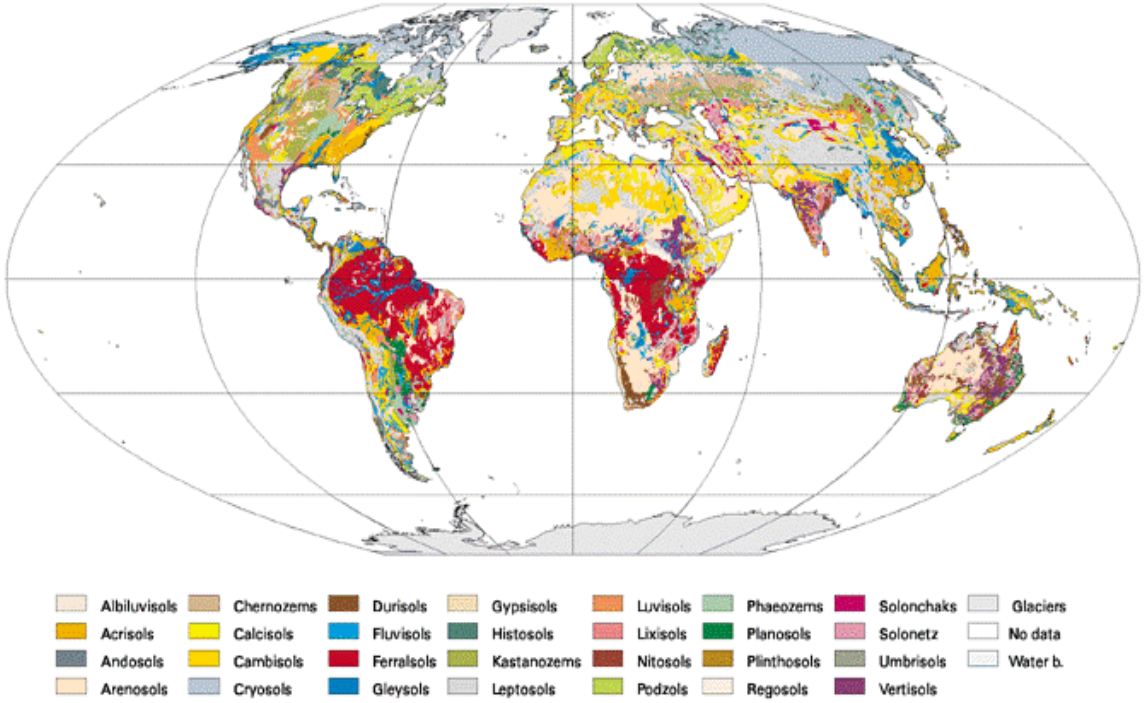
Kaolinite:
Reflects SW, high pH

montmorillonite

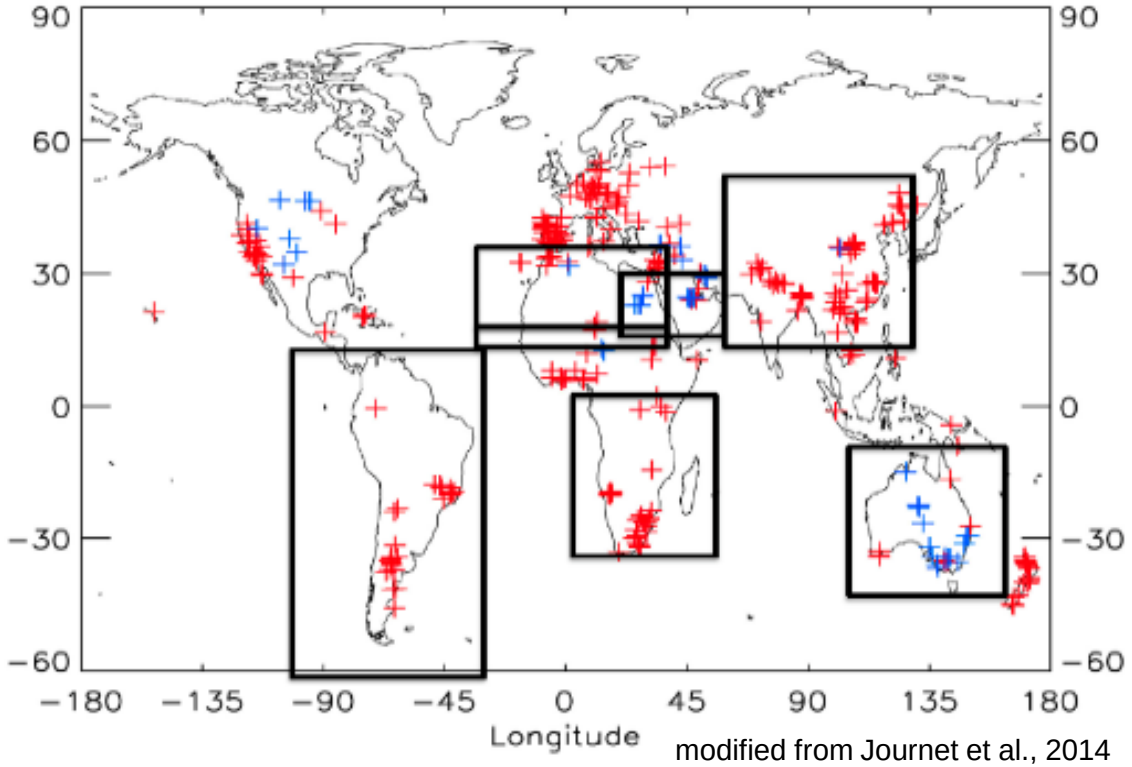
Clays, large particles:
Reflects SW

Example: Current Mineral Dust Source Information

UN Food and Agriculture Organization (FAO)
Soil Map Interpolated/Extrapolated



Current Soil Sample Locations



modified from Journet et al., 2014

Challenge: Using FAO soil data sets and “Average” soil properties from ≤5000 soils samples (mostly not in deserts) doesn’t fully capture actual distribution and diversity of the mineral dust source regions.

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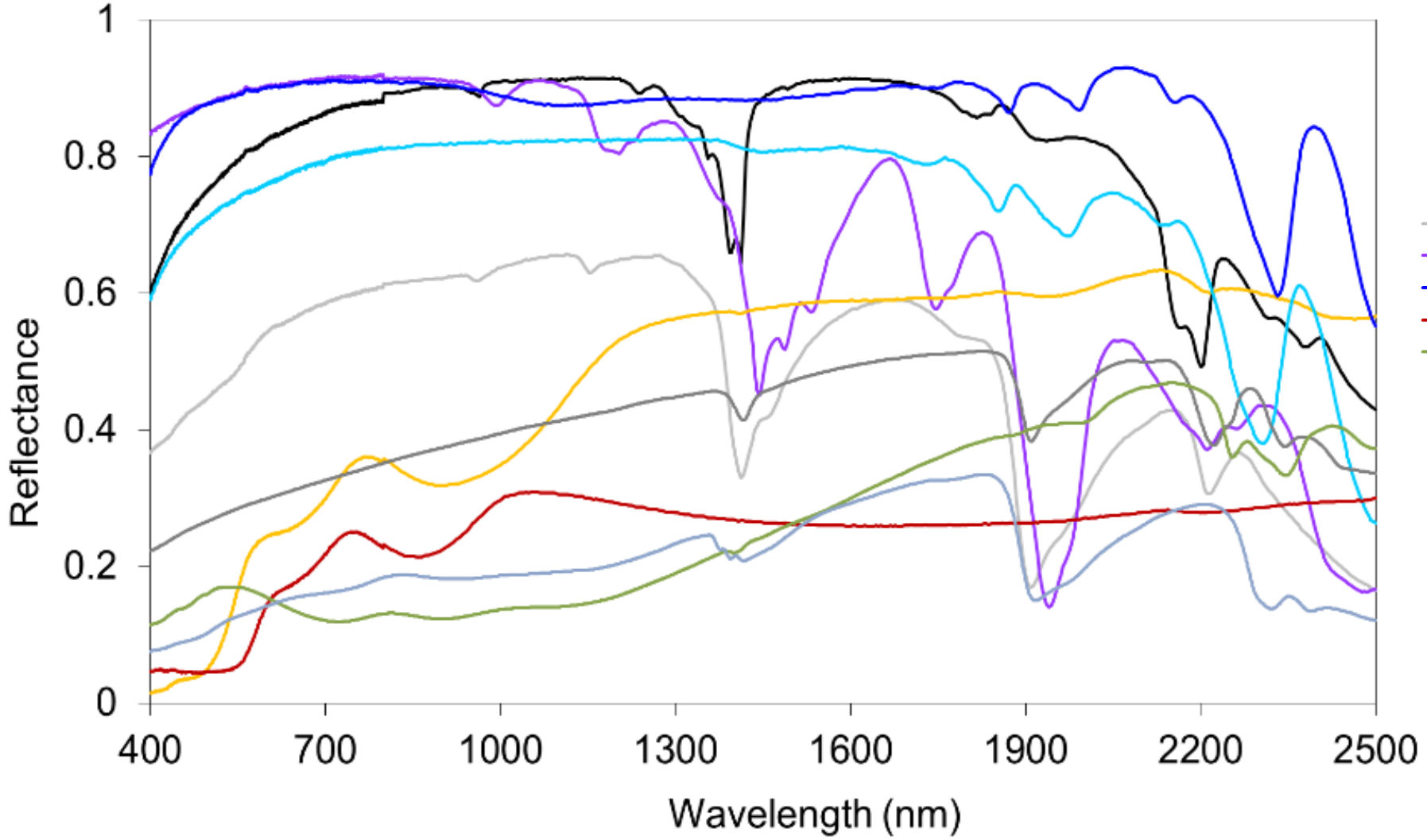
EMIT Will Use Imaging Spectroscopy
Dust Minerals have Distinct Spectral Signatures



Kaolinite Al4[Si4O10[(OH)8
Goethite FeO.OH
Dolomite CaMg(CO3)2
Illite (K,H3O)(Al,Mg,Fe)2(Si,Al)4O10[(OH)2,(H2O)]
Vermiculite (Mg,Fe+2,Al)3(Al,Si)4O10(OH)2*4H2O

Montmorillonite (Na,Ca)0.33(Al,Mg)2Si4O10(OH)2*nH2O
Gypsum CaSO4.2H2O
Calcite CaCO3
Hematite Fe2O3
Chlorite (Mg,Fe)3(Si,Al)4O10(OH)2-(Mg,Fe)3(OH)6




Visible to Short Wavelength Infrared Spectral Range (VSWIR) [400 to 2500 nm]

NASA Imaging Spectroscopy Offers a Tested Approach to Measure Surface Mineralogy

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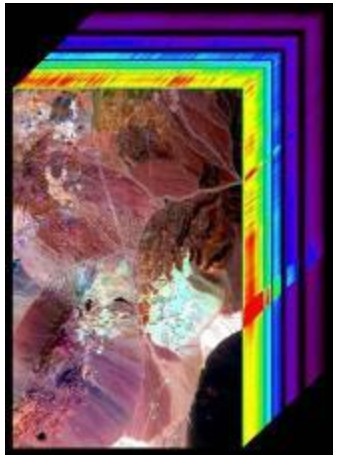
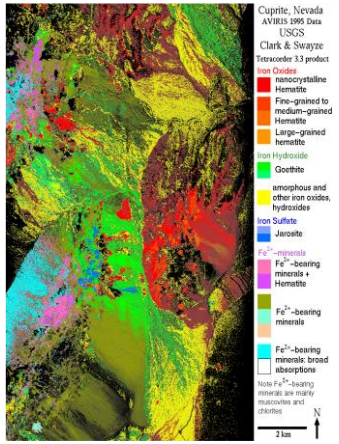
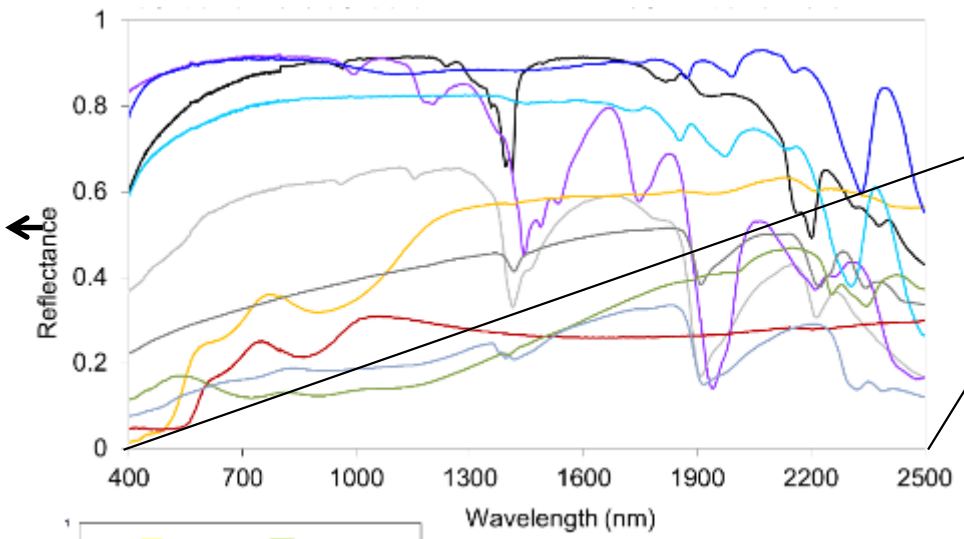
Calibrated Image Cube

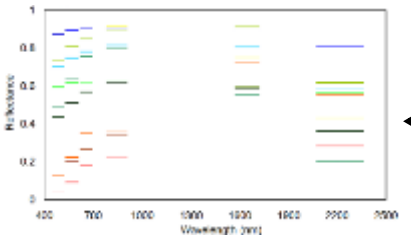


Material Map

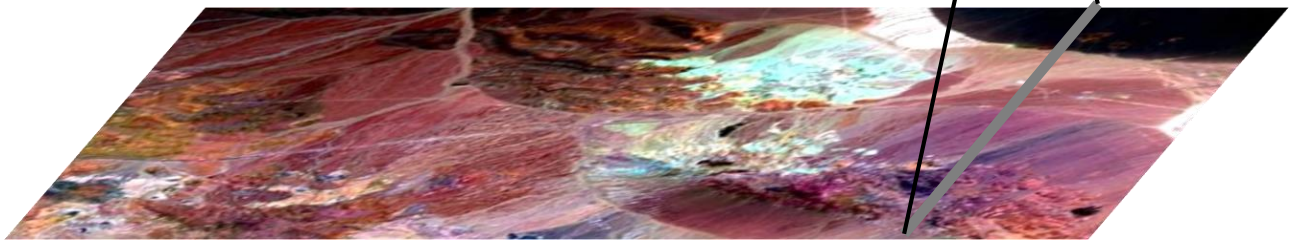


1000s of Parallel Spectrometers





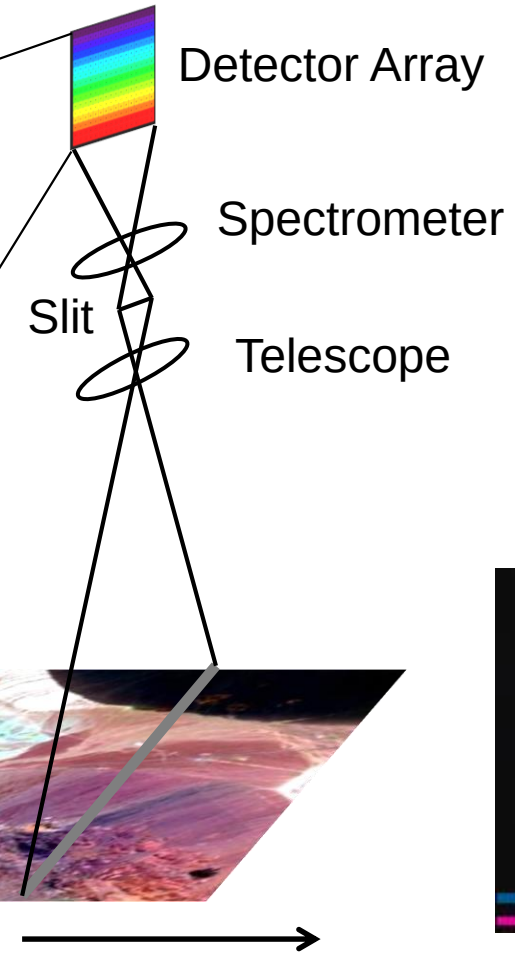
← Multispectral



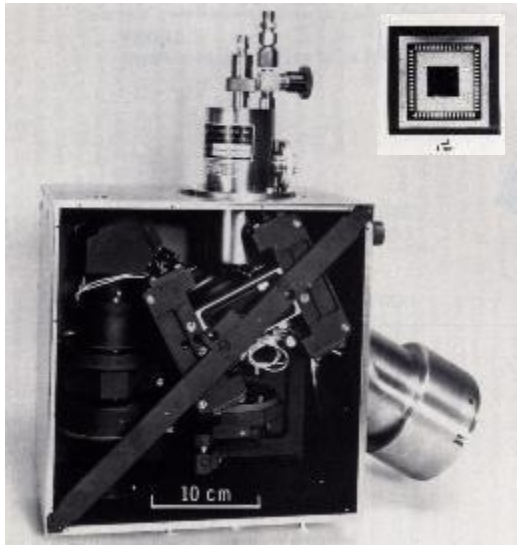
Space

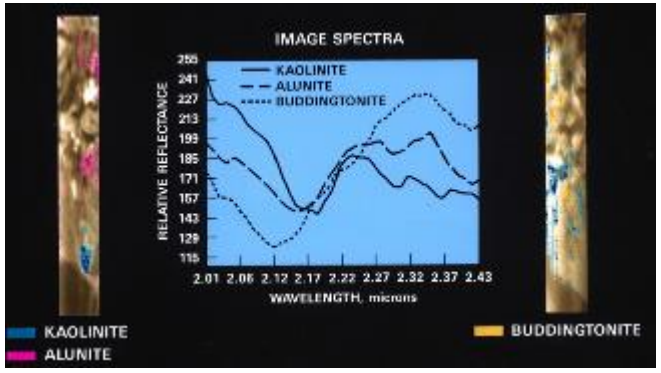
Airborne

Ground



First Imaging Spectrometer (AIS)





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FAO Soil Map Compared to Airborne VSWIR Imaging Spectroscopy at Cuprite, Nevada

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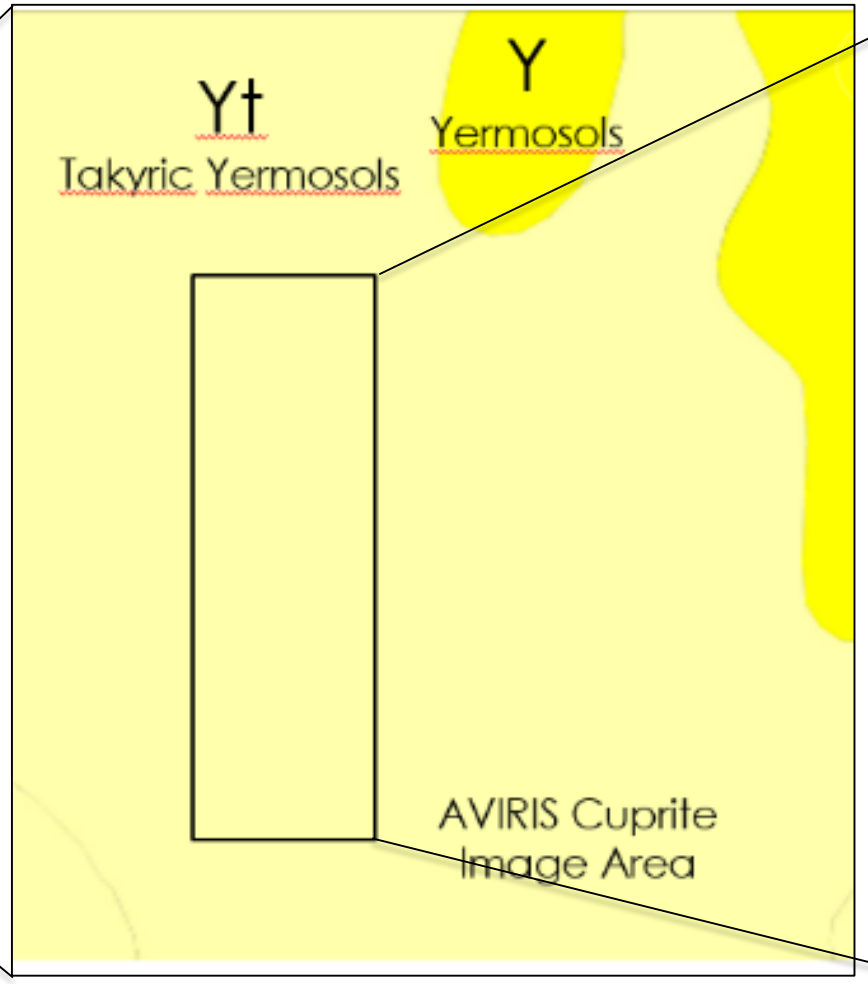
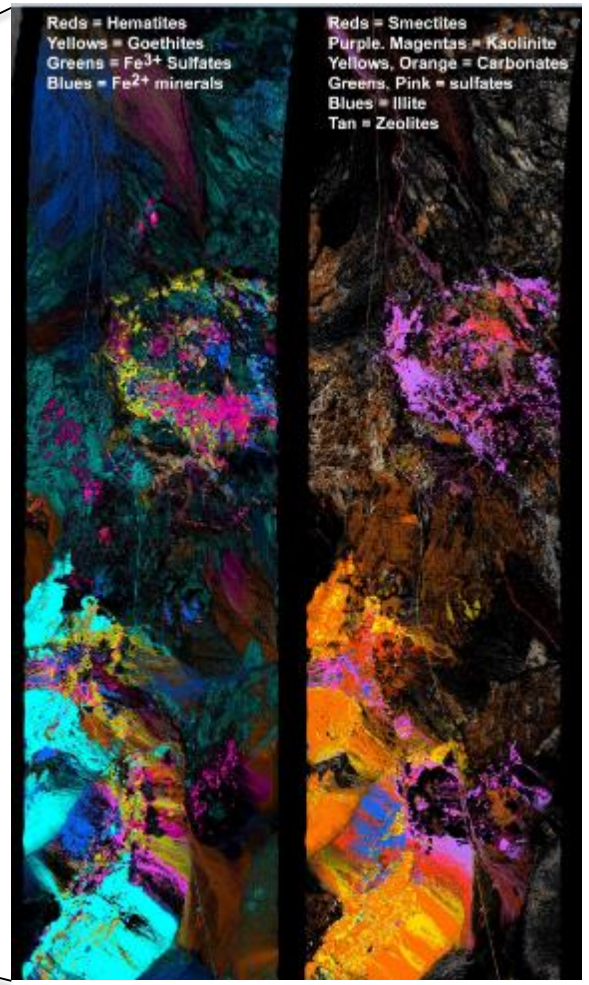
Cuprite, Nevada Region

FAO Soil Map



VSWIR Imaging Spectroscopy



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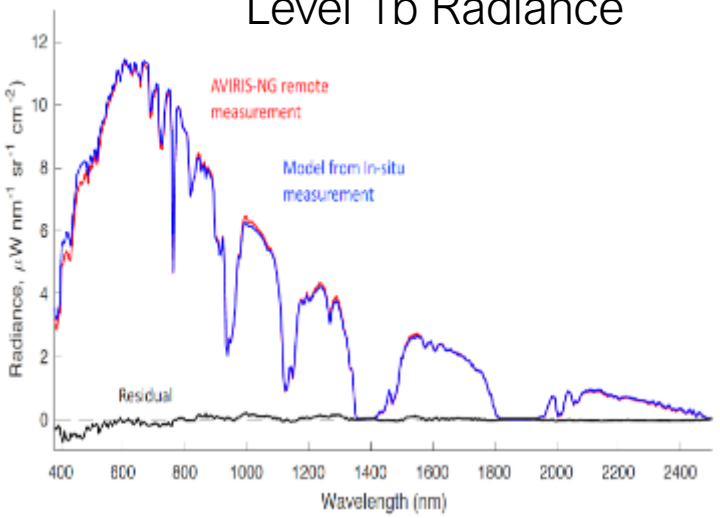
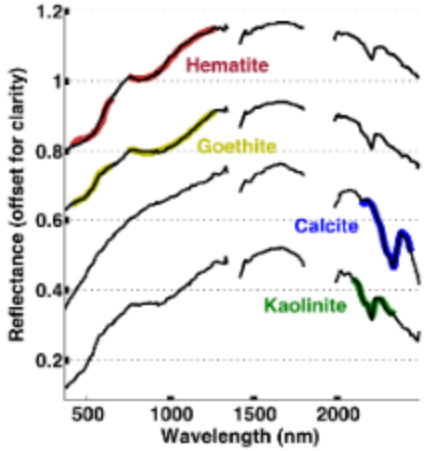
EMIT Data Products and Testing Builds on Decades of Airborne Imaging Spectrometer Measurements

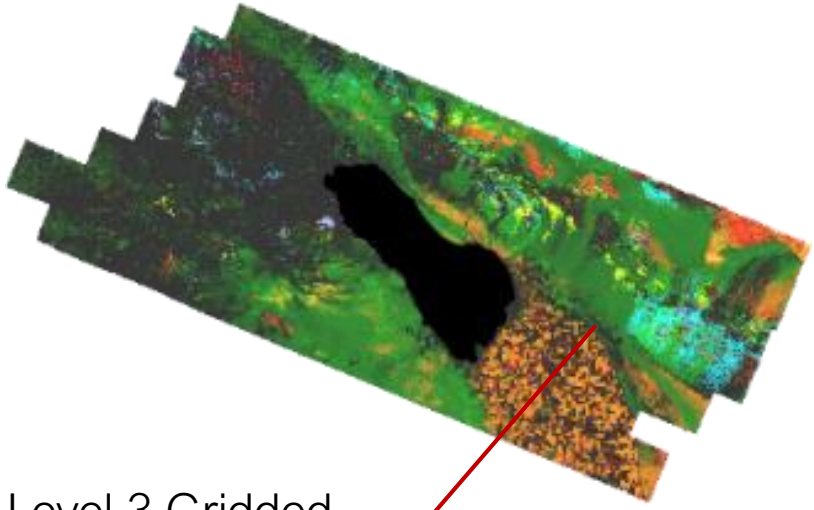
Level 1b Radiance



Level 2a Reflectance

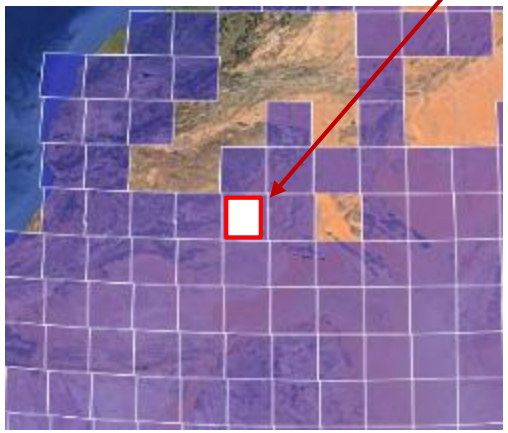


Level 2b Mineralogy

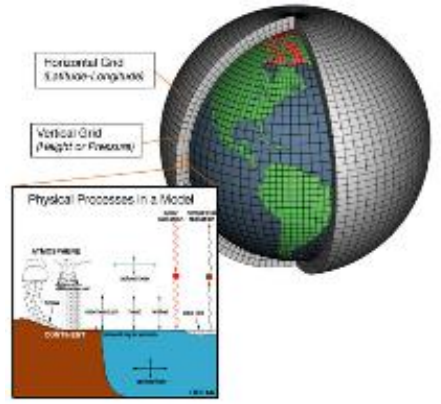


Field Spectroscopy with Laboratory/Analyses

Level 3 Gridded



Level 4 Model Runs



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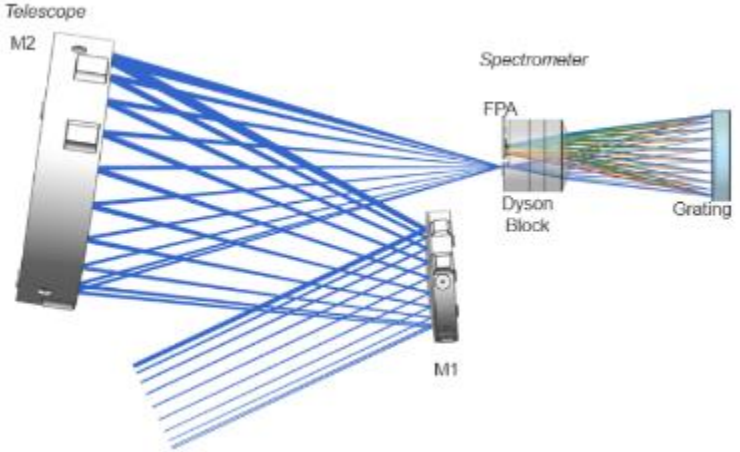
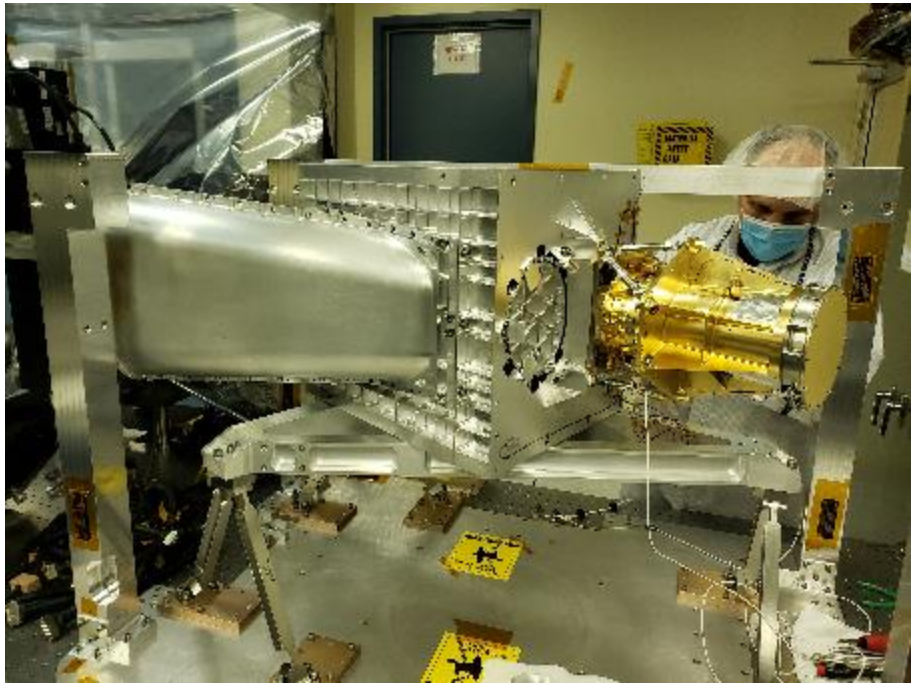
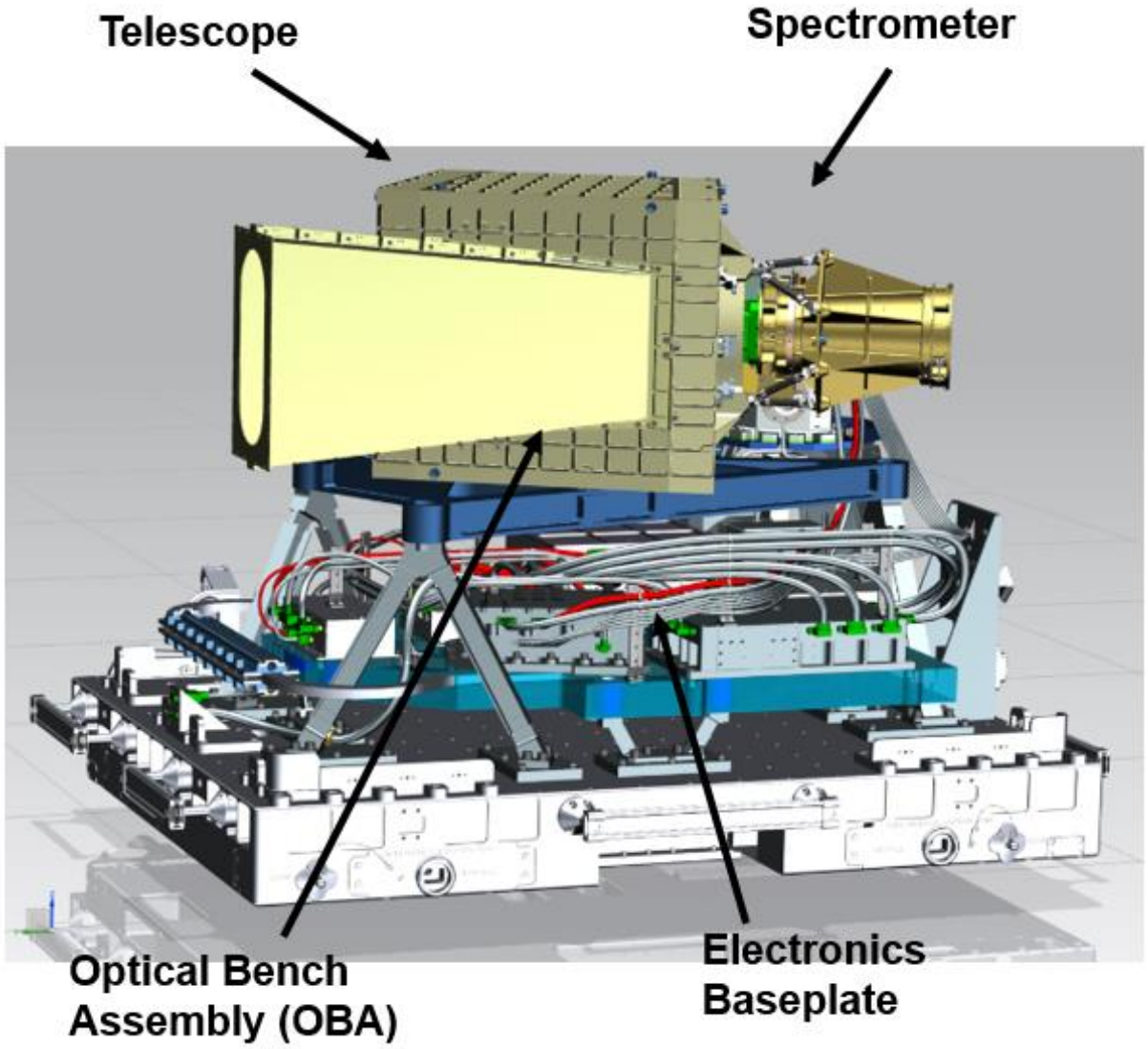
The EMIT Instrument is Well Along in Development

Telescope and F/1.8 Dyson Imaging Spectrometer





Payload Design



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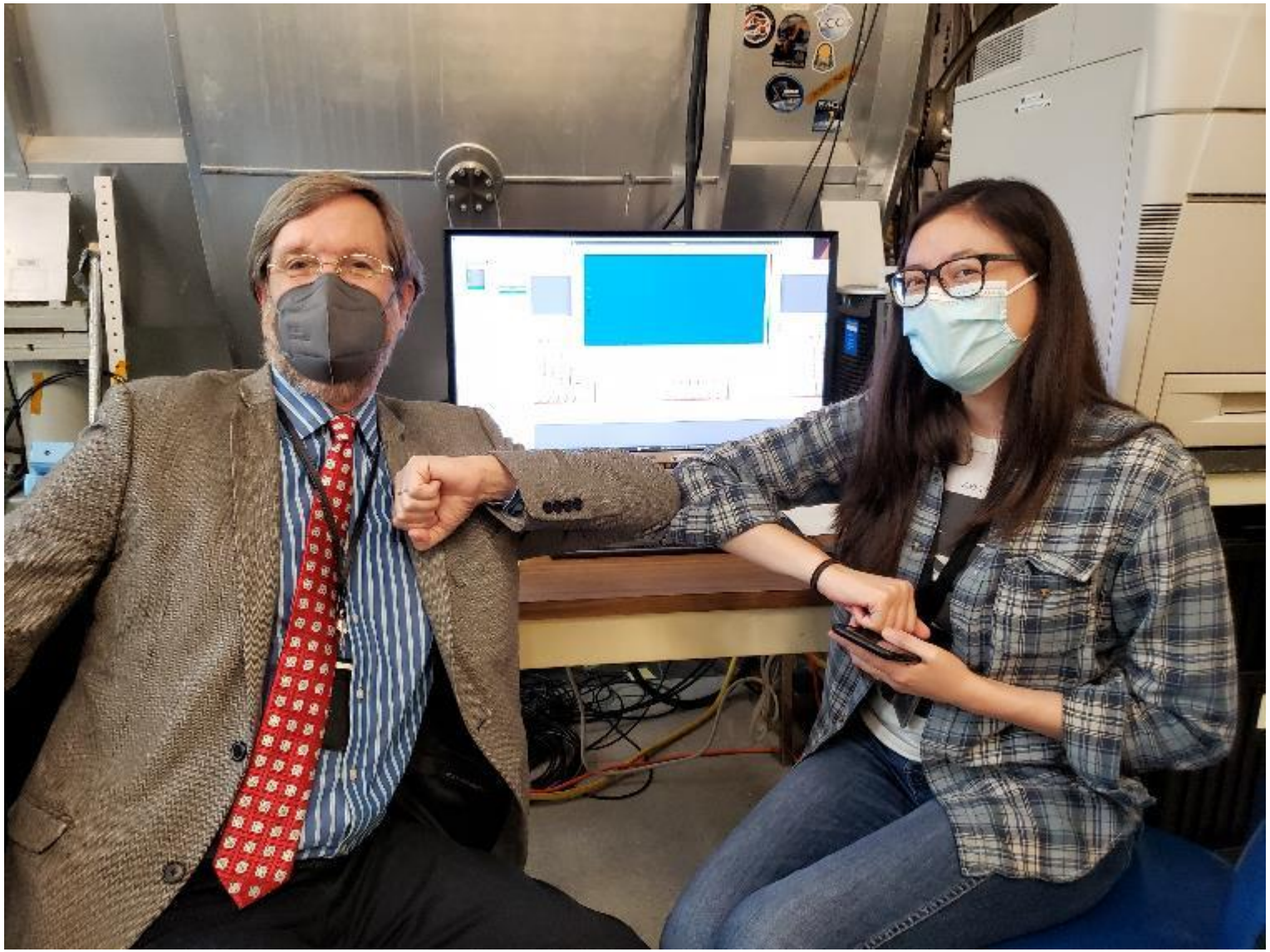
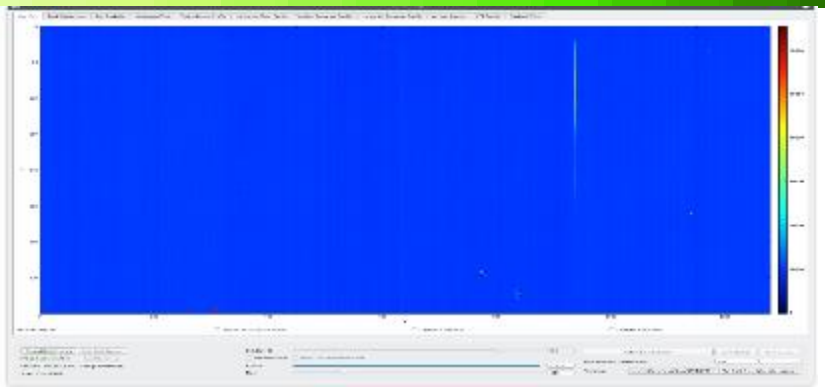
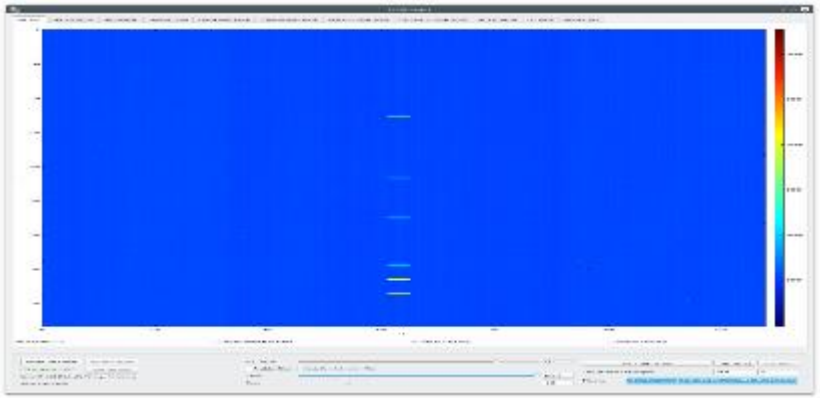
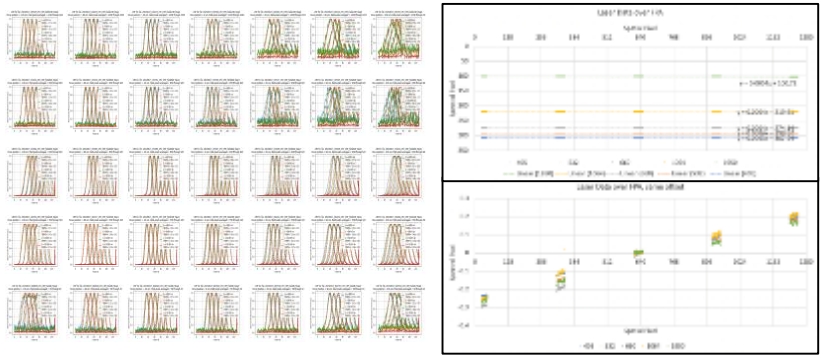
Live EMIT Spectra with Christine Bradley 20210817









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EMIT will Begin Measuring Spectra from the ISS in 2022

EMIT in Enclosure

Planned SpaceX Launch

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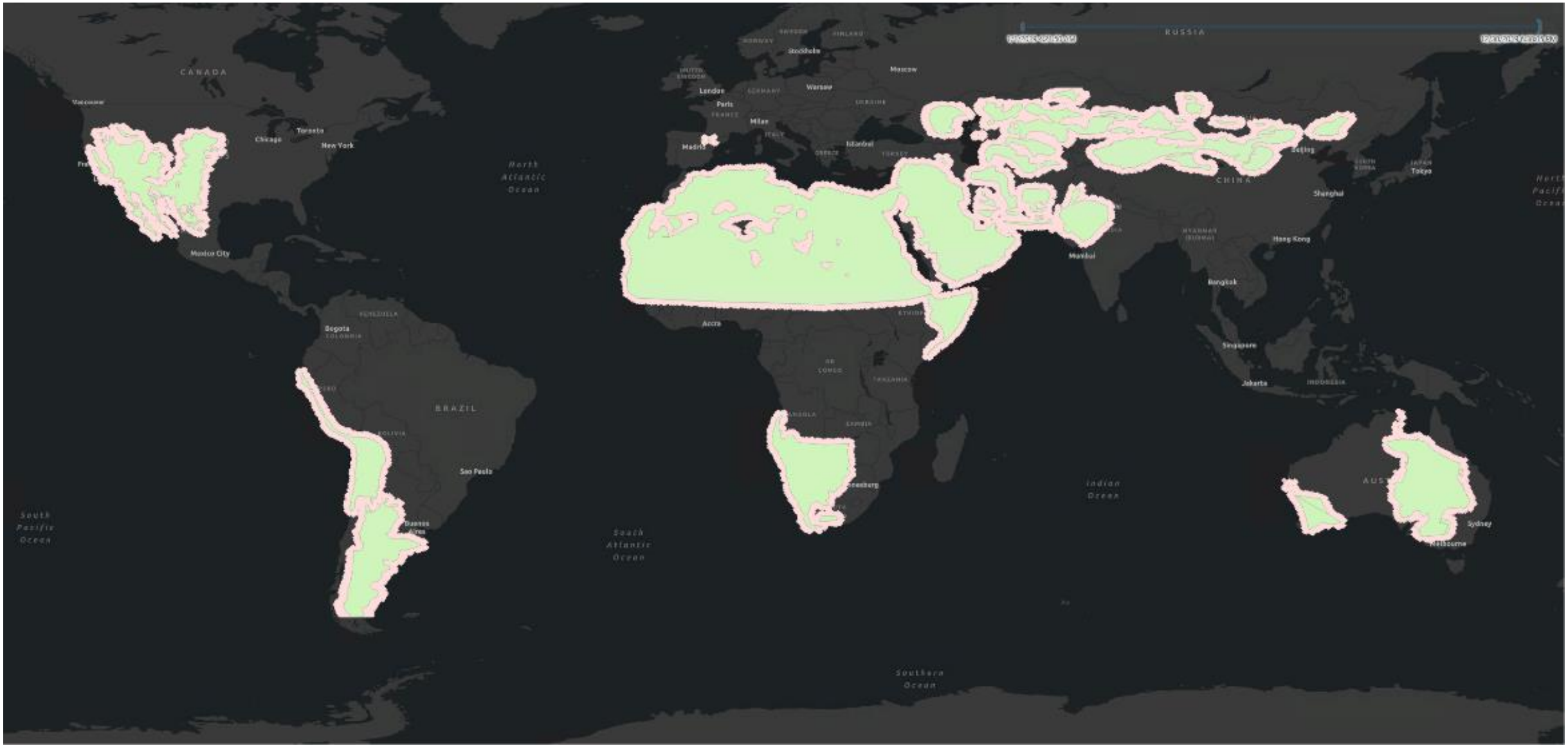
EMIT Planned Arid Land Coverage Area



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EMIT Dust Source Surface Mineralogy

EMIT on the ISS delivers >10^9 direct spectroscopic observations of arid land surface

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EMIT Data Products to NASA LP DAAC

Data Product	Description	Initial Availability to NASA DAAC	Median Latency in Product Availability to NASA DAAC after Initial Delivery	NASA DAAC Location
Level 0	Raw collected telemetry	4 months after IOC	2 months	LP DAAC
Level 1a	Reconstructed, depacketized, uncompressed data, time referenced, annotated with ancillary information reassembled into scenes.	4 months after IOC	2 months	LP DAAC
Level 1b	Level 1a data processed to sensor units including geolocation and observation geometry information	4 months after IOC	2 months	LP DAAC
Level 2a	Surface reflectance derived by screening clouds and correction for atmospheric effects.	8 months after IOC	2 months	LP DAAC
Level 2b	Mineralogy derived from fitting reflectance spectra, screening for non-mineralogical components.	8 months after IOC	2 months	LP DAAC
Level 3	Gridded map of mineral composition aggregated from level 2b with uncertainties and quality flags	11 months after IOC	2 months	LP DAAC
Level 4	Earth System Model runs to address science objectives	16 months after IOC	2 months	LP DAAC

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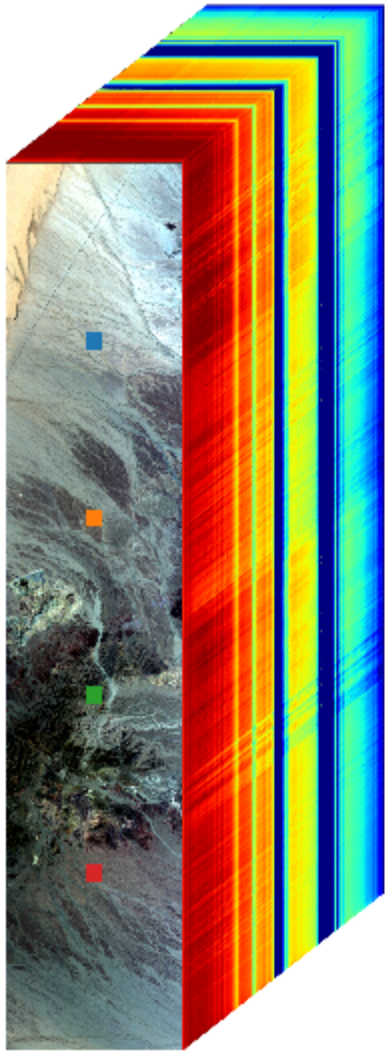
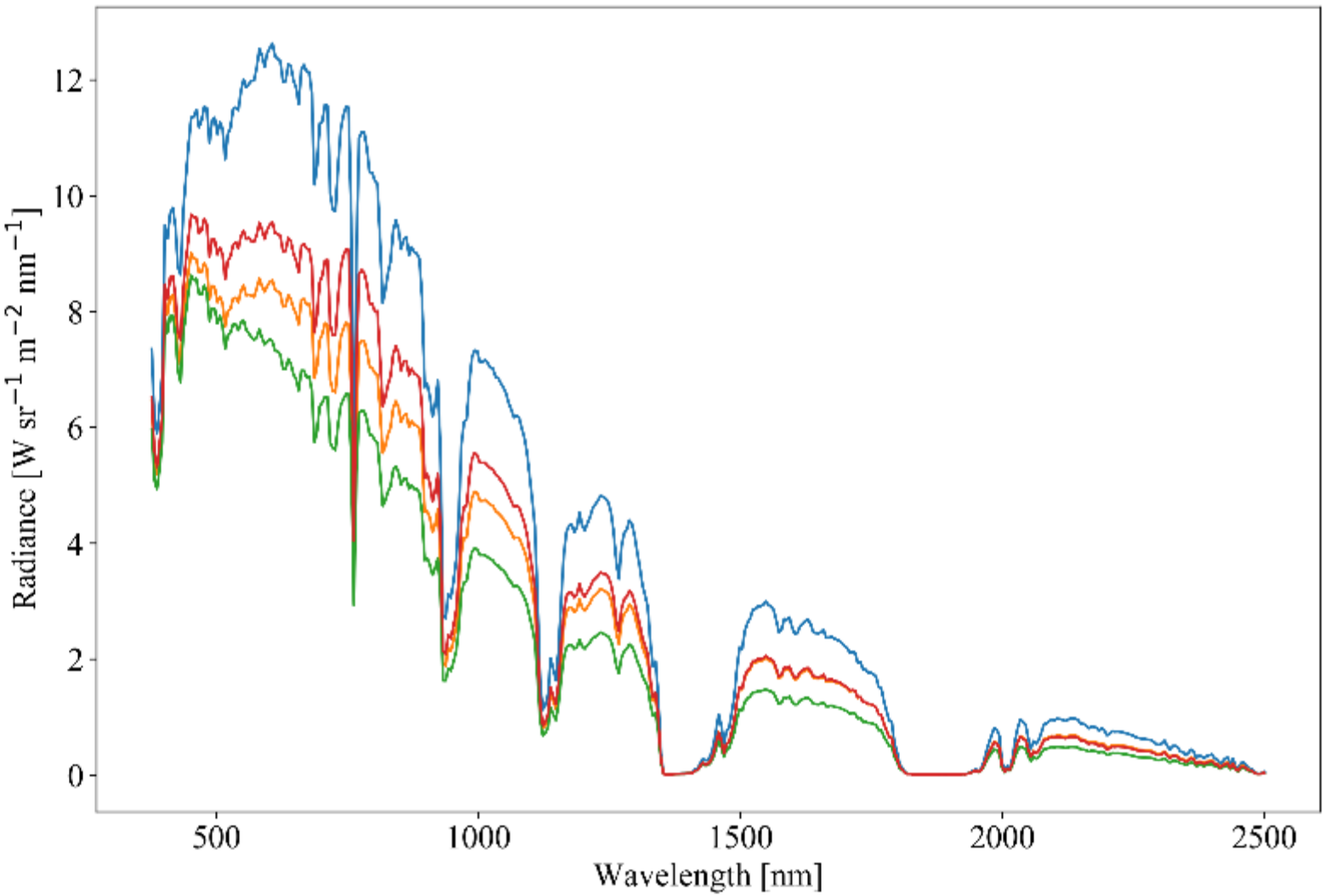
L1B Outputs (Radiance)





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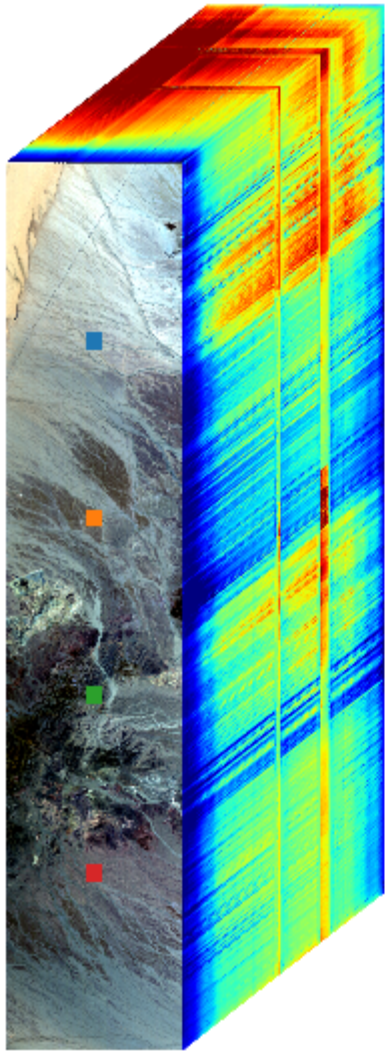
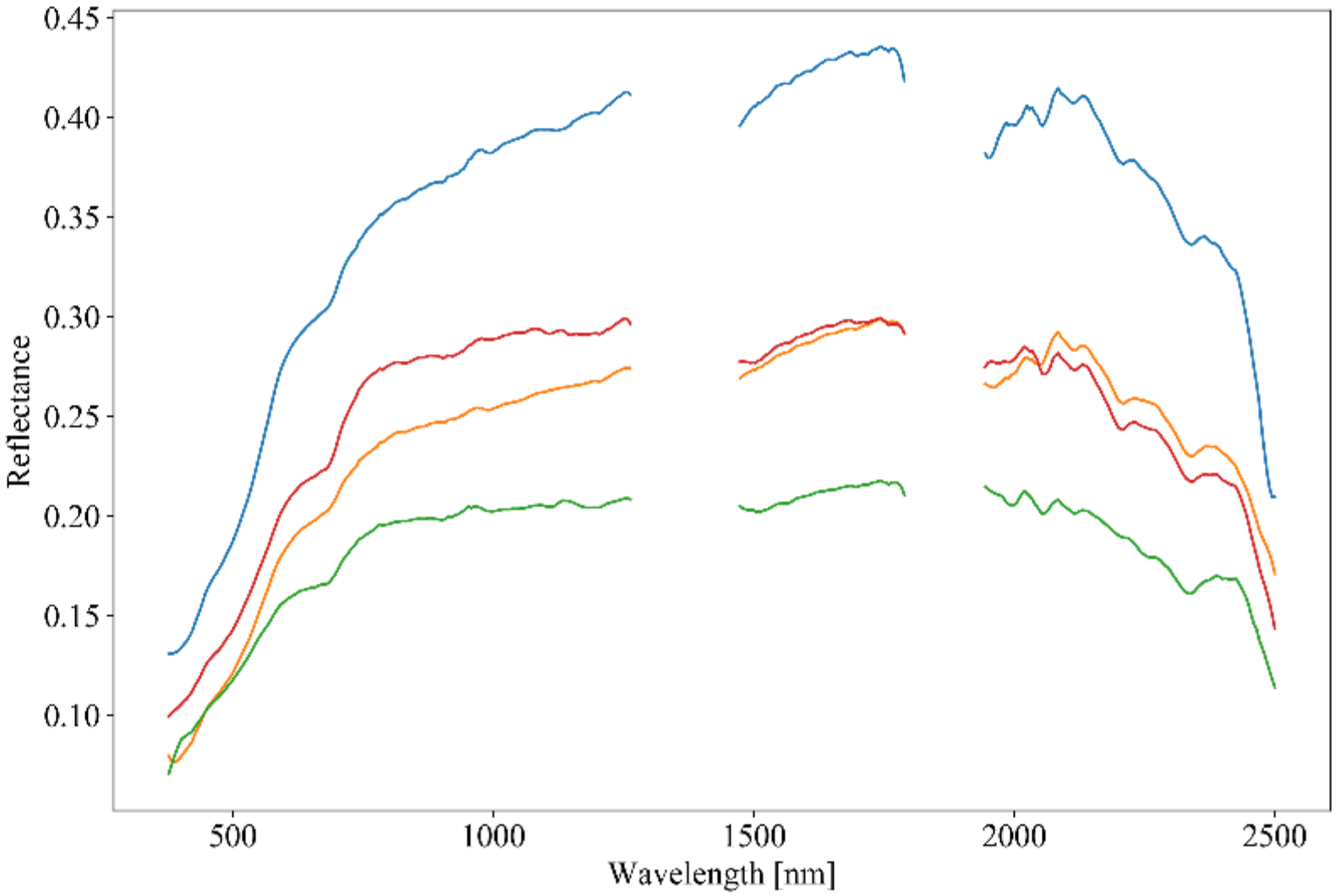
L2A Outputs (Reflectance)





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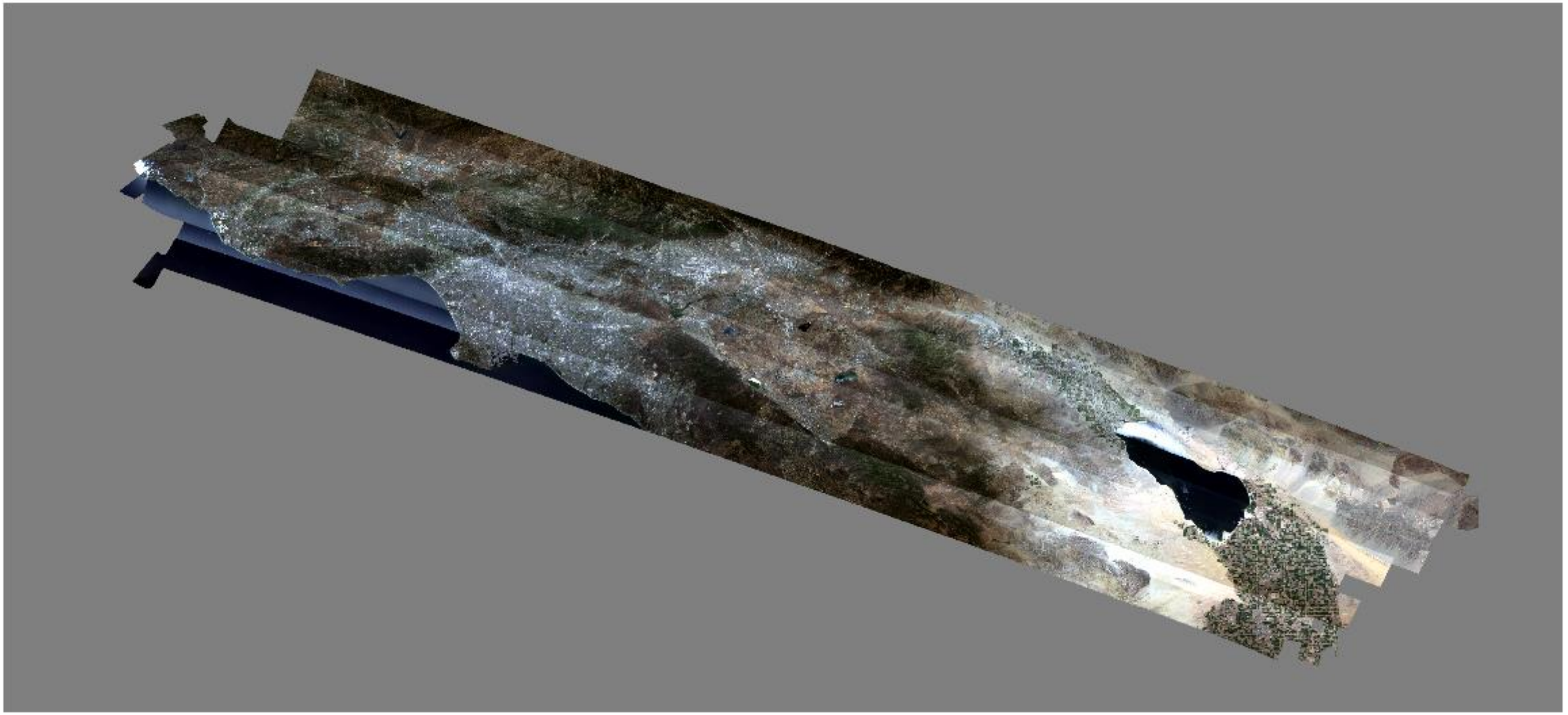
L2A Outputs (RGB, orthorectified)

RGB



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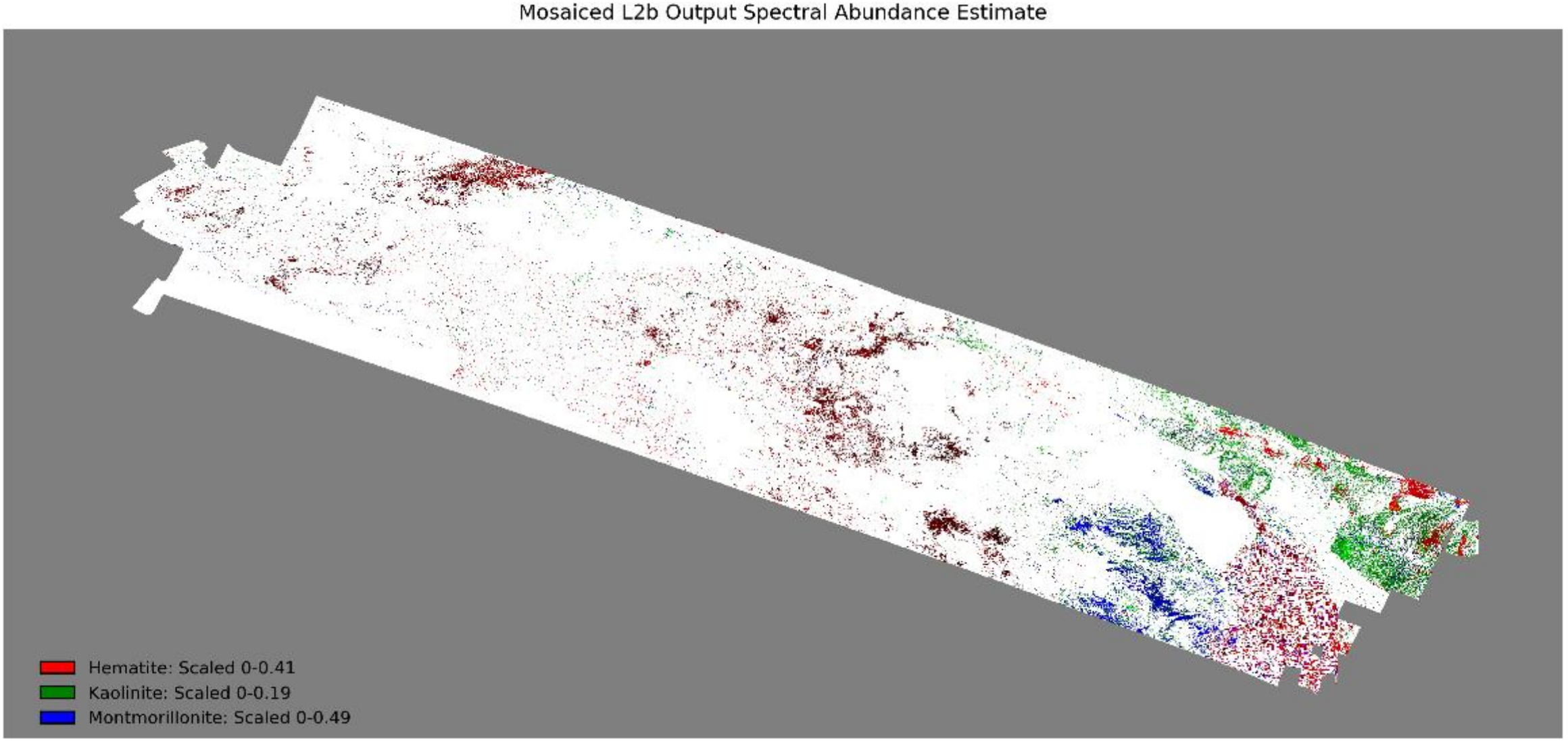
L2B Outputs (orthorectified)



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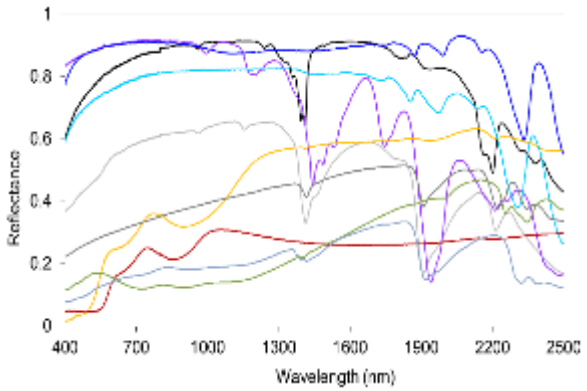
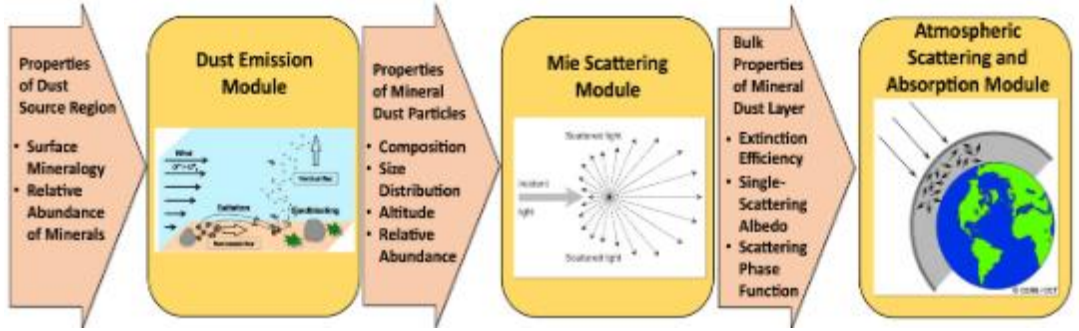
Summary: EMIT Science Flow to Objectives

Surface Spectroscopy

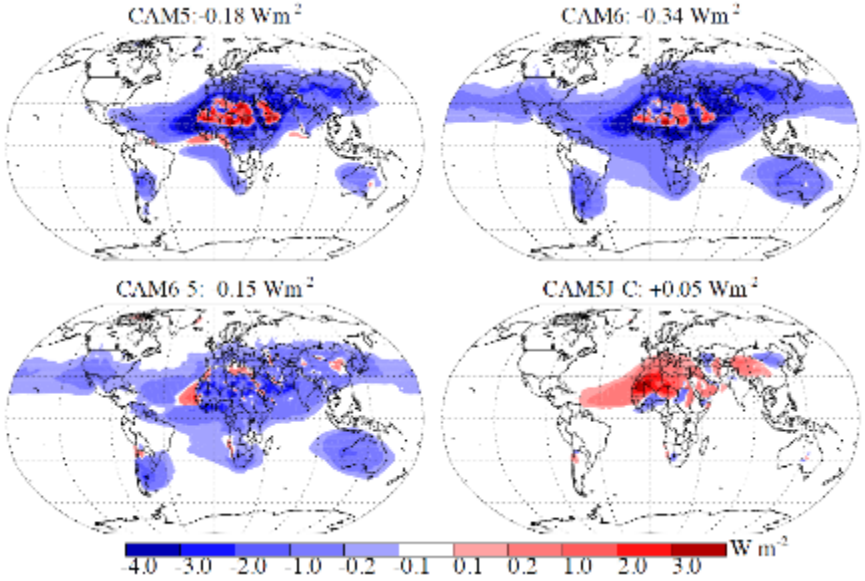


Mineral composition for models

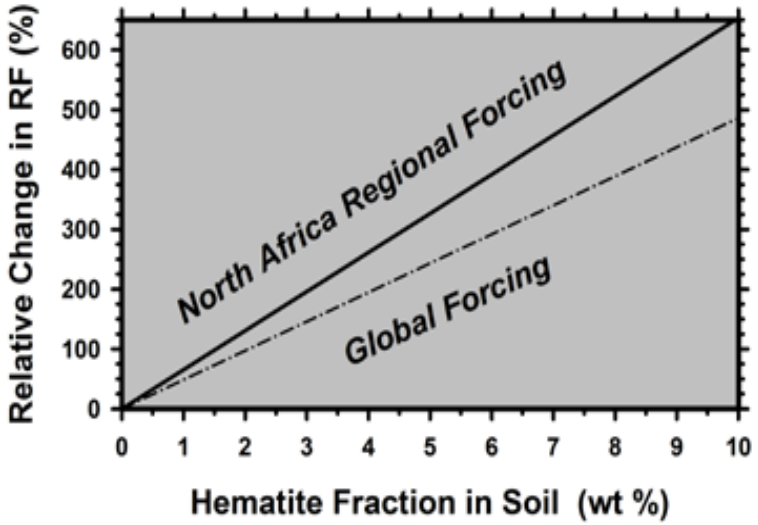
Update mineralogy in ESMs



Model Runs



RF Predictions



Objectives

1) Constrain the sign and magnitude of dust-related RF at regional and global scales.

2) Predict the increase or decrease of available dust sources under future climate scenarios.