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EMIT
Earth Surface Mineral Dust Source Investigation

The Earth Surface Mineral Dust Source Investigation (EMIT)

(Photo: Todd Morris/Flickr)

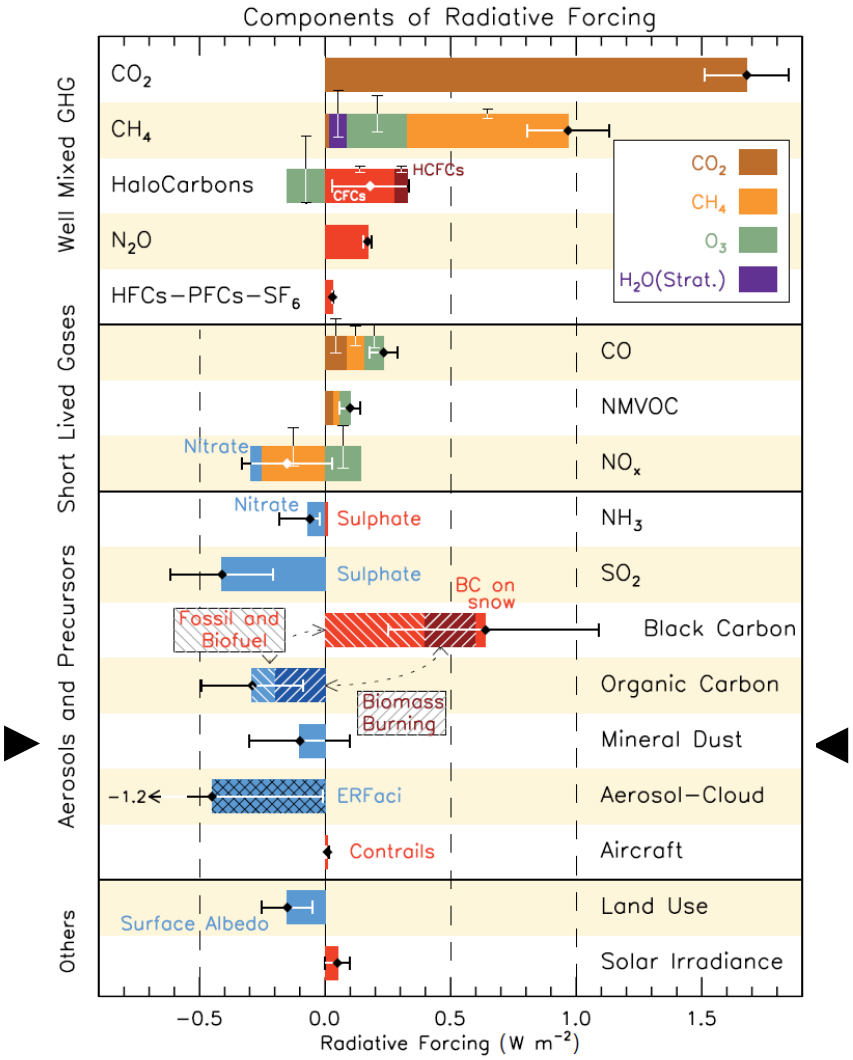
(Photo: Ianz/Flickr)

Robert O. Green, the EMIT and Imaging Spectroscopy Teams

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

Mineral Dust in the Earth System

IPCC AR5, 2015, Figure 8.17



- Mineral dust emitted from the surface impacts a broad set of elements of the Earth system including radiative forcing.
- Different mineral compositions of the emitted dust lead to different physical, chemical and radiative impacts.
- Accurate Earth System Models are required to understand the role of mineral dust now and in the future.
- The mineral composition of the Earth's dust source regions is currently uncertain.

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The Mineral Dust Cycle

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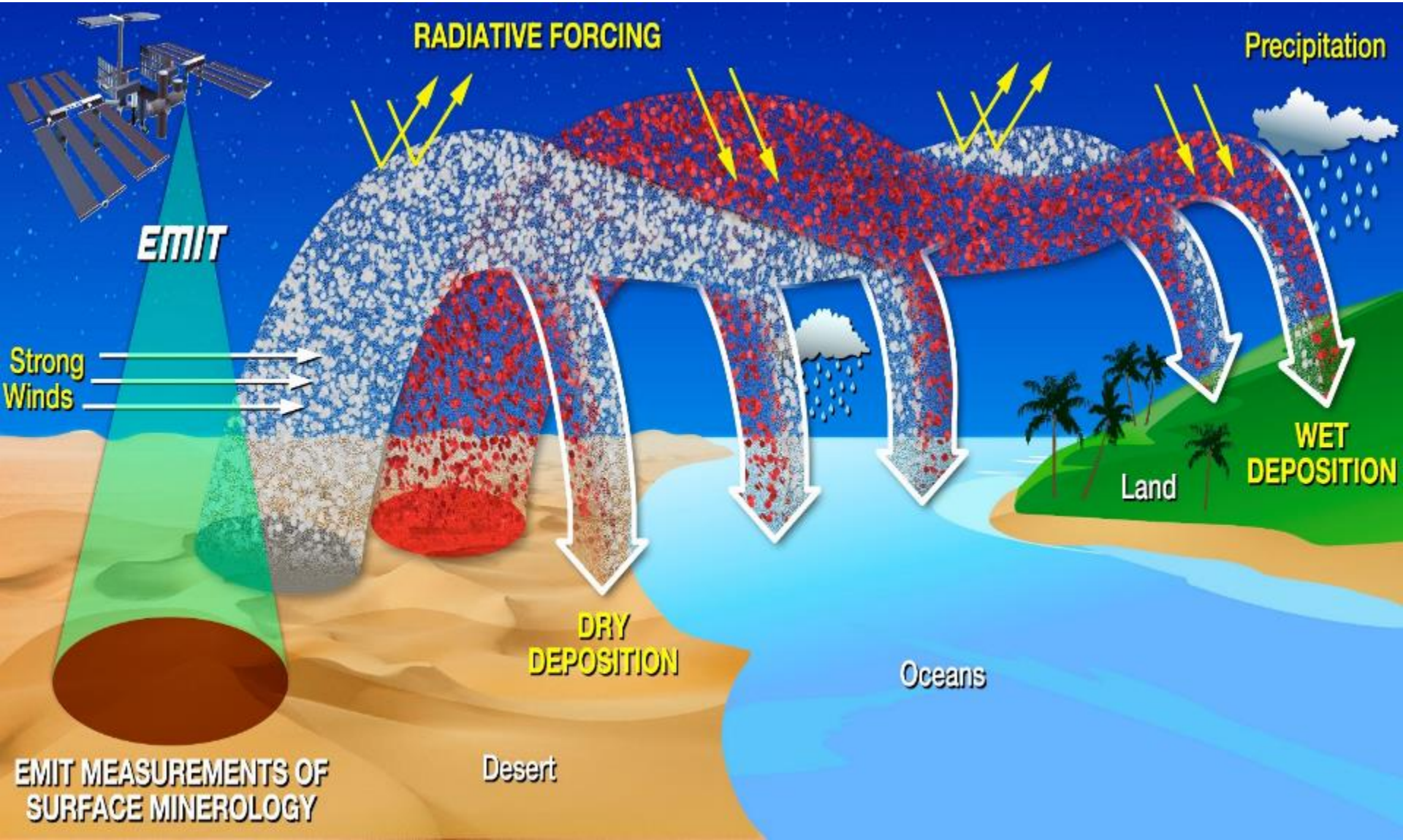
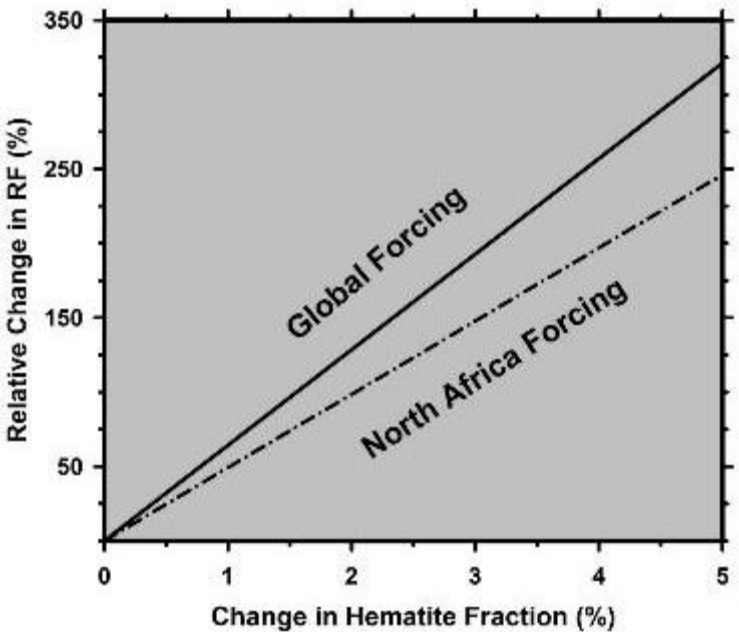


Mineral Dust and Radiative Forcing

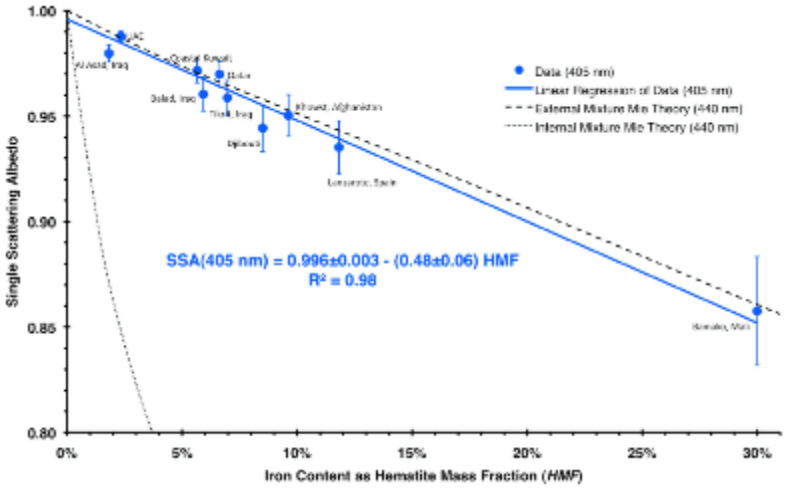
The relative abundance of the mineral hematite in dust source regions has a significant impact on dust-related radiative forcing

- 2% increase in the hematite content of North Africa (NA) source region results in increases of 130% and 100% in simulations of global (solid line) and regional forcing over NA (broken line) [Modeling courtesy of R. Scanza, Cornell University, 2015]



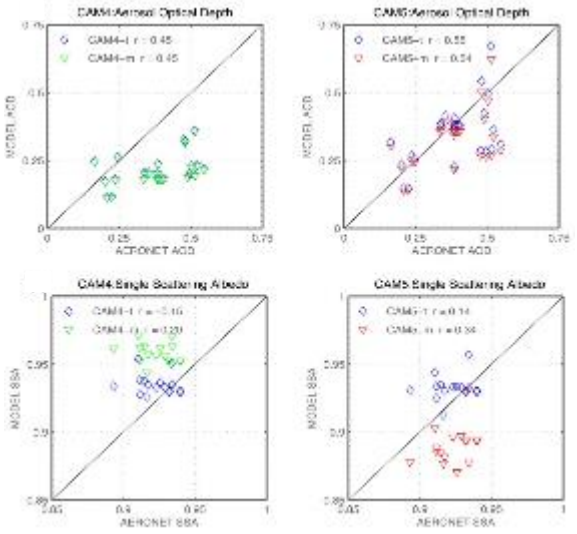
Large variation in hematite mass fraction (HMF) over arid dust source regions (Moosmuller wt al., 2012)

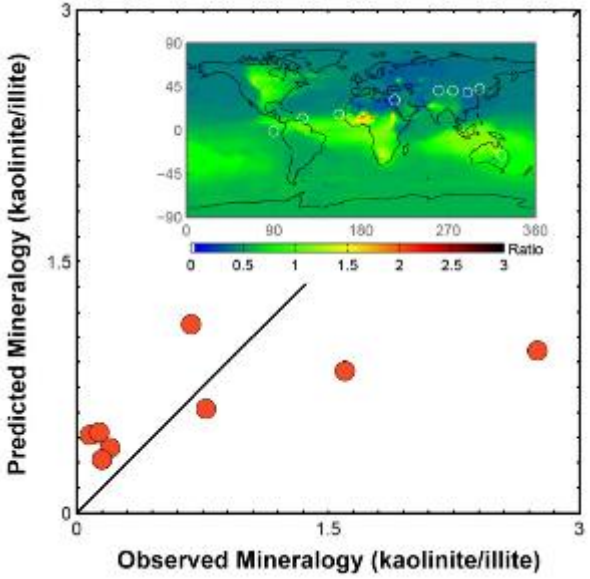
- United Arab Emirates: ~2% HMF
- Afghanistan: ~10% HMF
- Mali : 30% HMF



Current Tests of ESM Skill

- Impact of dust mineralogy in the Community Atmosphere Model (CAM4/5) on forecast skill of the Community Earth System Model (CESM)
- Forecasts of AOD and SSA are not well-correlated with AERONET-based retrievals
- Forecasts of mineralogy of dust deposits are not well-correlated with observed mineralogy





(*Figures modified from Scanza et al., 2015*)

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EMIT Science Team

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Investigator	Institution	Role
Robert O. Green	JPL California Institute of Technology	PI
Natalie Mahowald	Cornell University	Deputy PI
Roger Clark	Planetary Science Institute	Co-I
Bethany Ehlmann	California Institute of Technology	Co-I
Paul Ginoux	NOAA, Princton University	Co-I
Olga Kalashnikova	JPL California Institute of Technology	Co-I
Ron Miller	NASA GISS, Columbia University	Co-I
Greg Okin	University of California Los Angeles	Co-I
Thomas Painter	JPL California Institute of Technology	Co-I
Carlos Perez	NASA GISS, Columbia University (BSC)	Co-I
Vincent Realmuto	JPL California Institute of Technology	Co-I
Gregg Swayze	US Geological Survey	Co-I
David Thompson	JPL California Institute of Technology	Co-I
Elizabeth Middleton	NASA GSFC	Collaborator
Luis Guanter	German Centre for Geosciences (GFZ)	Collaborator
Eyal Ben Dor	University of Tel Aviv	Collaborator

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FAO Soil Map Compared to NASA VSWIR Imaging Spectroscopy

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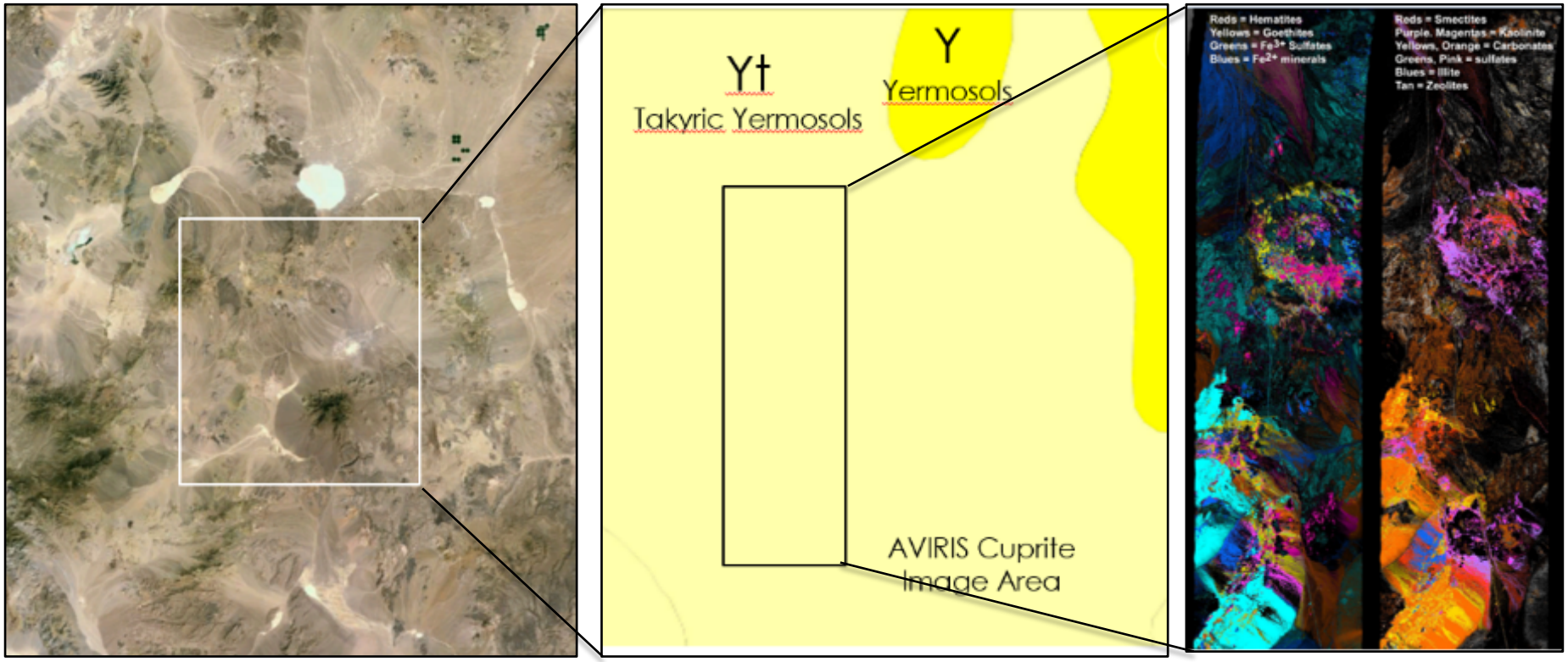
Cuprite, Nevada Region

FAO Soil Map

VSWIR Imaging Spectroscopy



Imaging spectroscopy provides a tested method for direct comprehensive measurement of the mineral composition for the Earth's mineral dust source regions.

Earth System Models and Mineral Dust

- Earth System Models are used to simulate, understand and investigate the past, present and future state of the Earth system.
- Until recently, ESMs have modeled mineral dust as a single bulk composition. However:
  - Different minerals have different physical, chemical and optical characteristics.
  - Mineral dust optical properties (complex refractive index) have a strong influence on the radiative forcing impact.
- Today ESMs (e.g. NSF-CESM and GISS-ModelE2) are being adapted to accept more complex representations of the mineral dust and related source regions on the Earth's surface.

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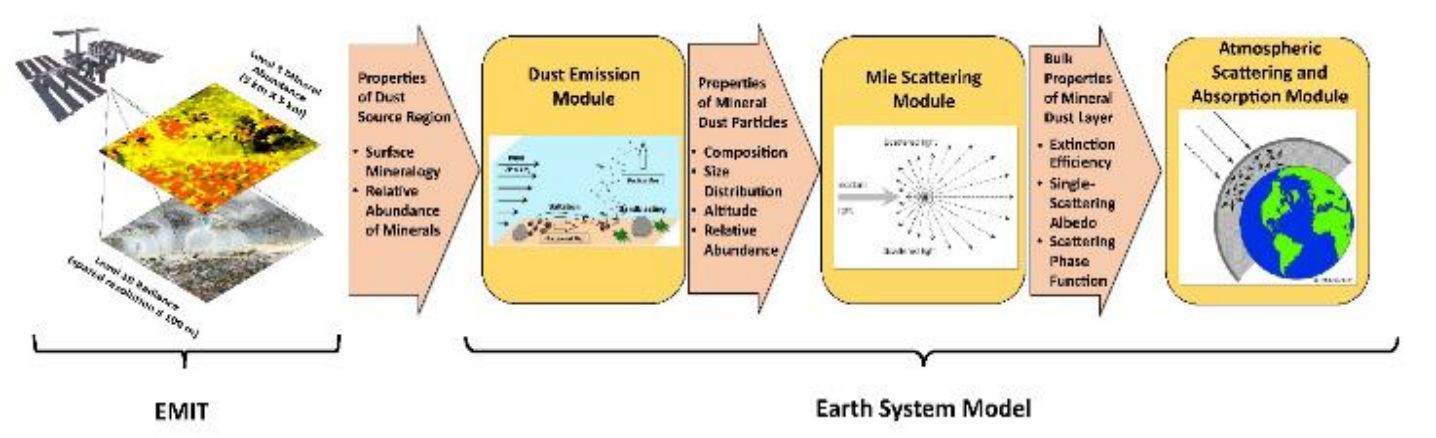
Earth System Models are ready to accept more detailed Earth surface mineral dust source information.



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Identified Minerals of Key Interest

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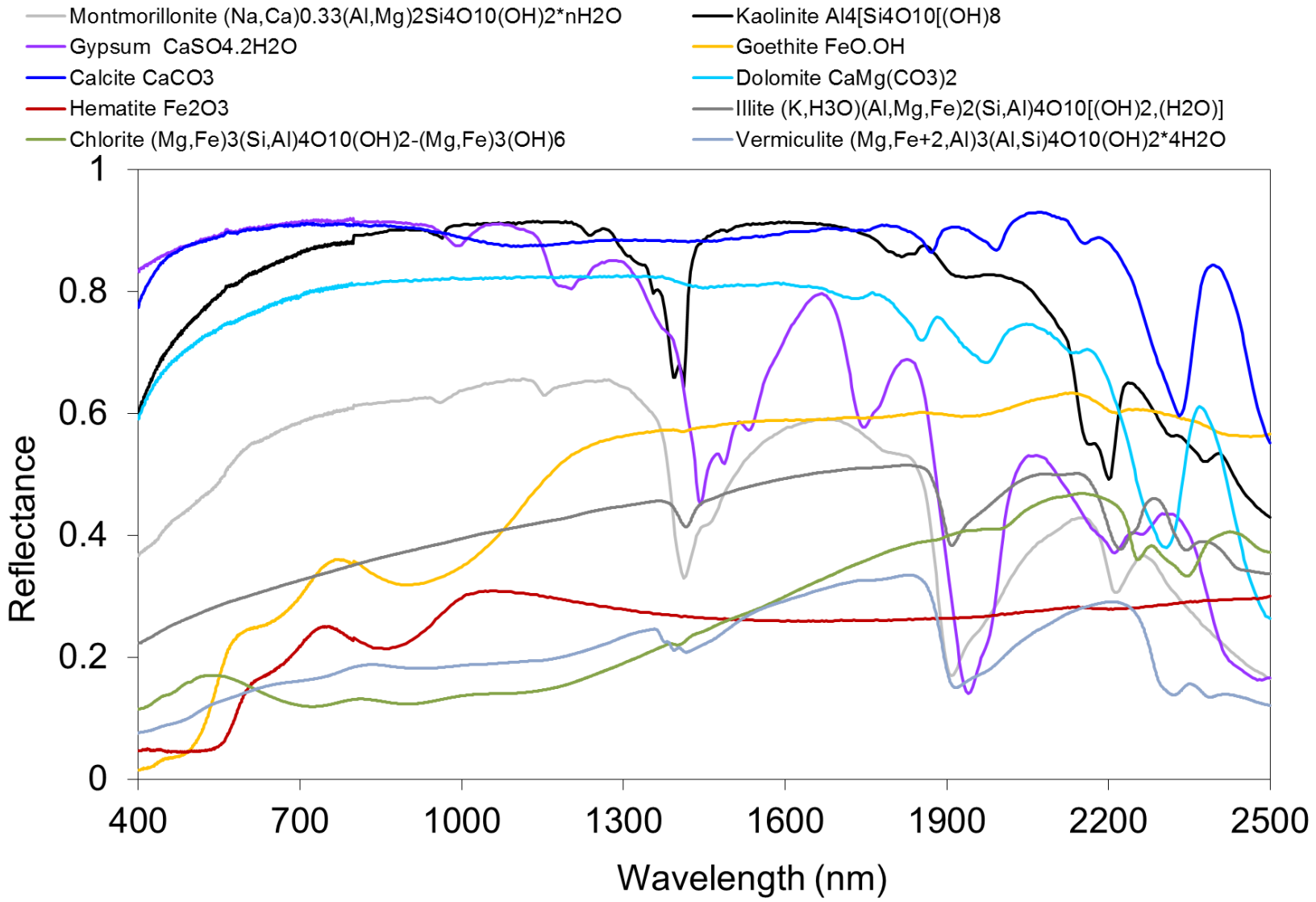

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Minerals can be Mapped with Imaging Spectroscopy

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International Space Station

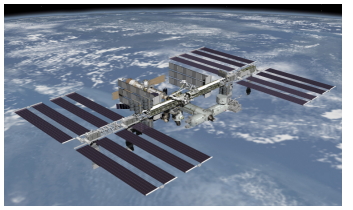
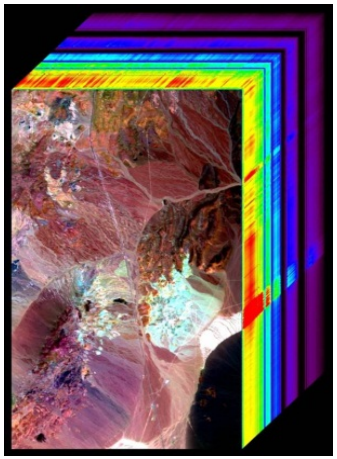
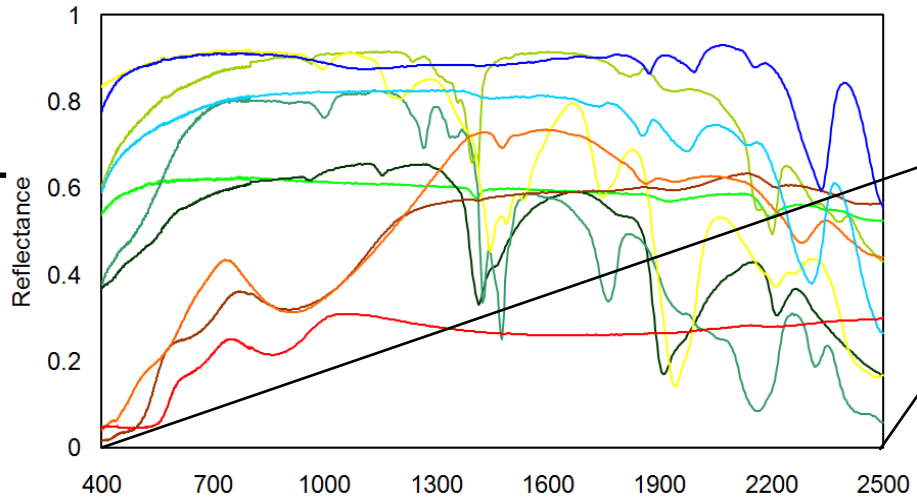


Image Cube



1000s of Parallel Spectrometers



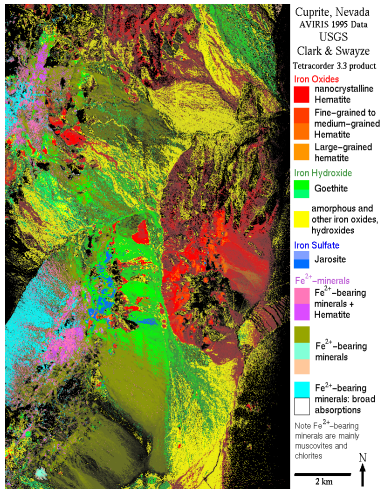
Detector Array

Spectrometer

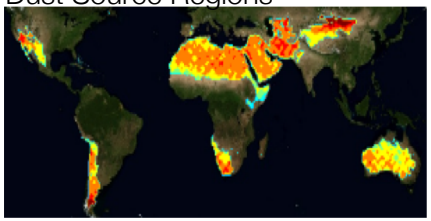
Slit

Telescope

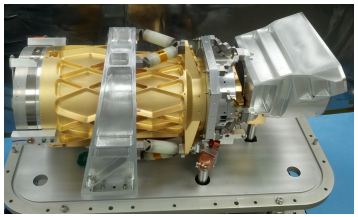
Mineral Map

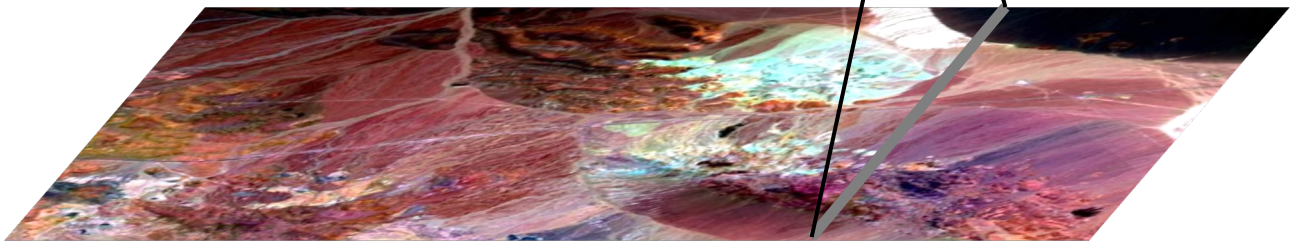


Dust Source Regions



Prototype Spectrometer





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Mineral Composition Retrievals in the Salton Sea, CA Dust Source Region

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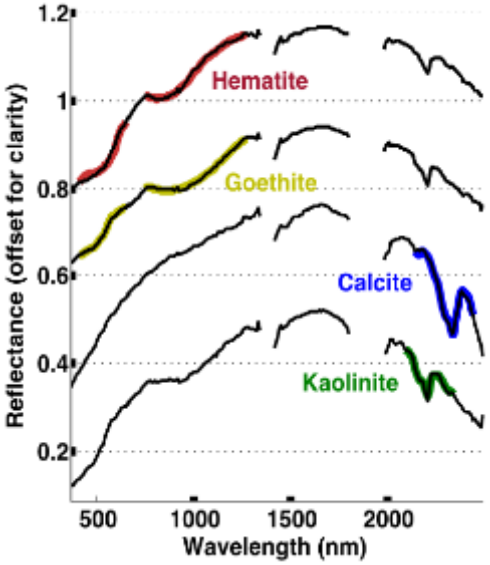
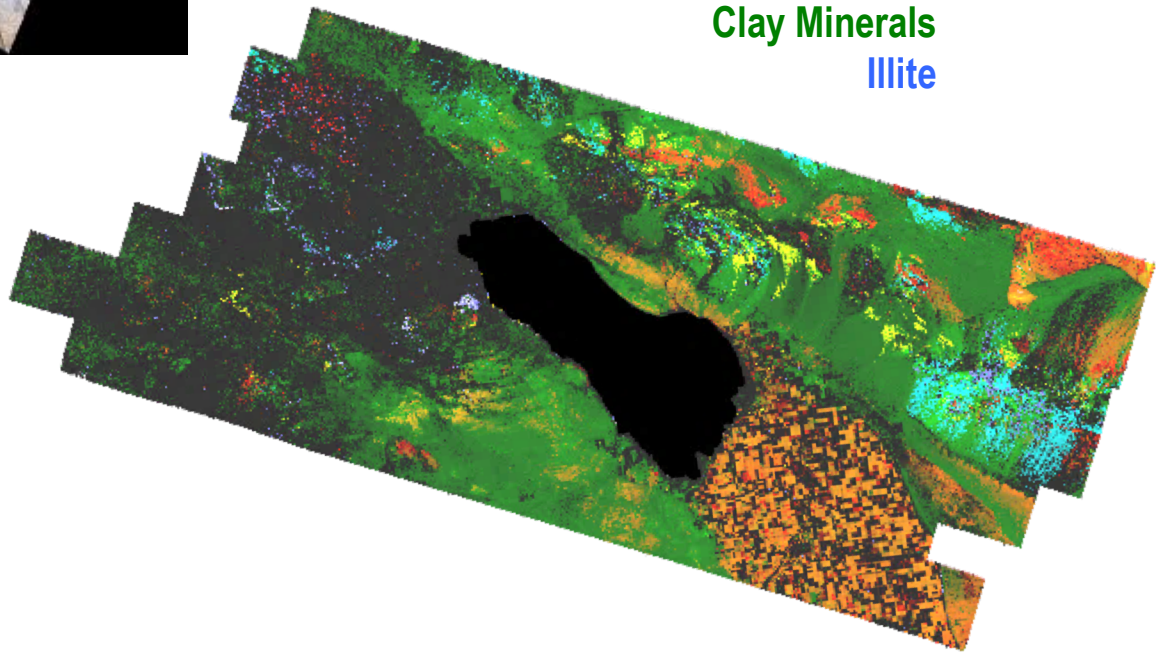
AVIRIS imaging spectroscopy measurements of the Salton Sea region in Southern California acquired as part of the NASA HyspIRI campaign.



Hematite
Goethtite
Carbonates
Clay Minerals
Illite



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Validating the Spectroscopy at Salton Sea, CA

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Existing Mineralogy versus Imaging Spectroscopy

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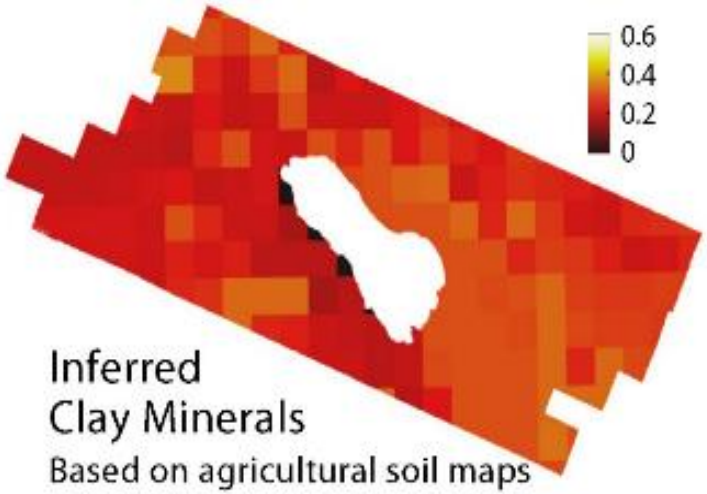
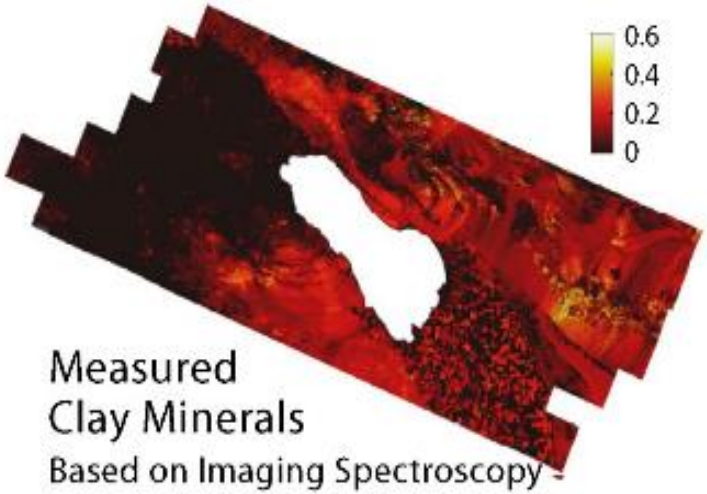
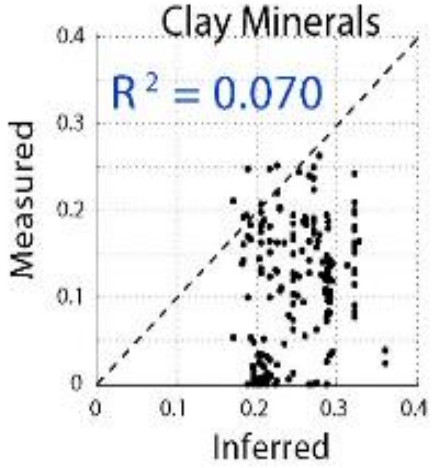
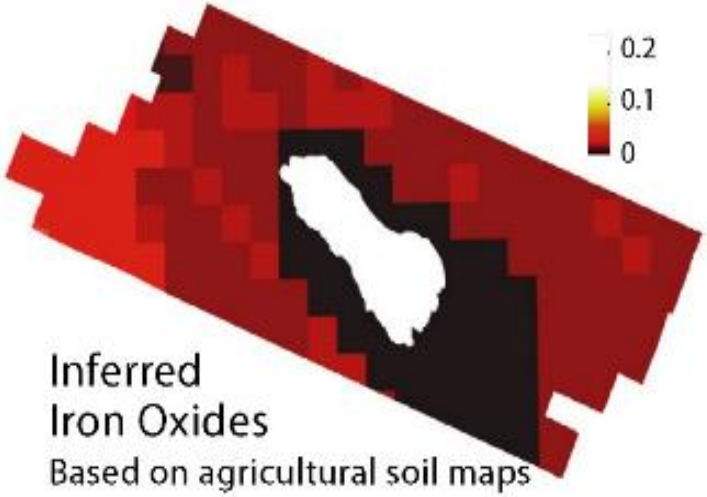


Inferred
Clay Minerals
Based on agricultural soil maps

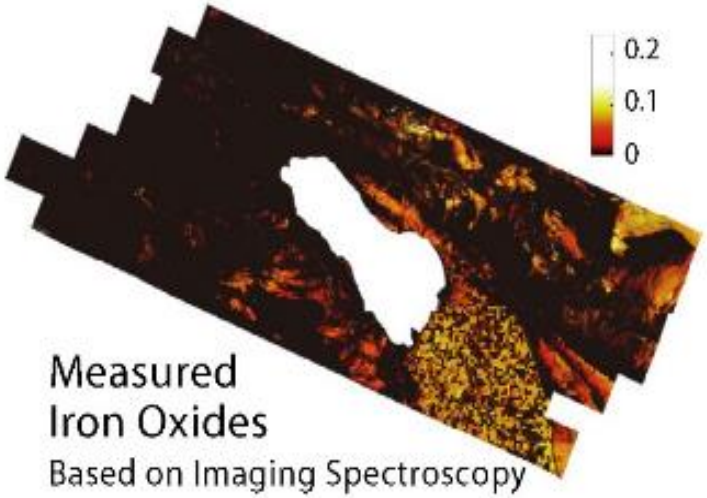


Measured
Clay Minerals
Based on Imaging Spectroscopy

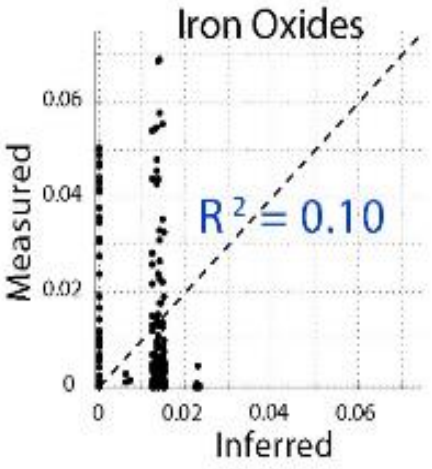




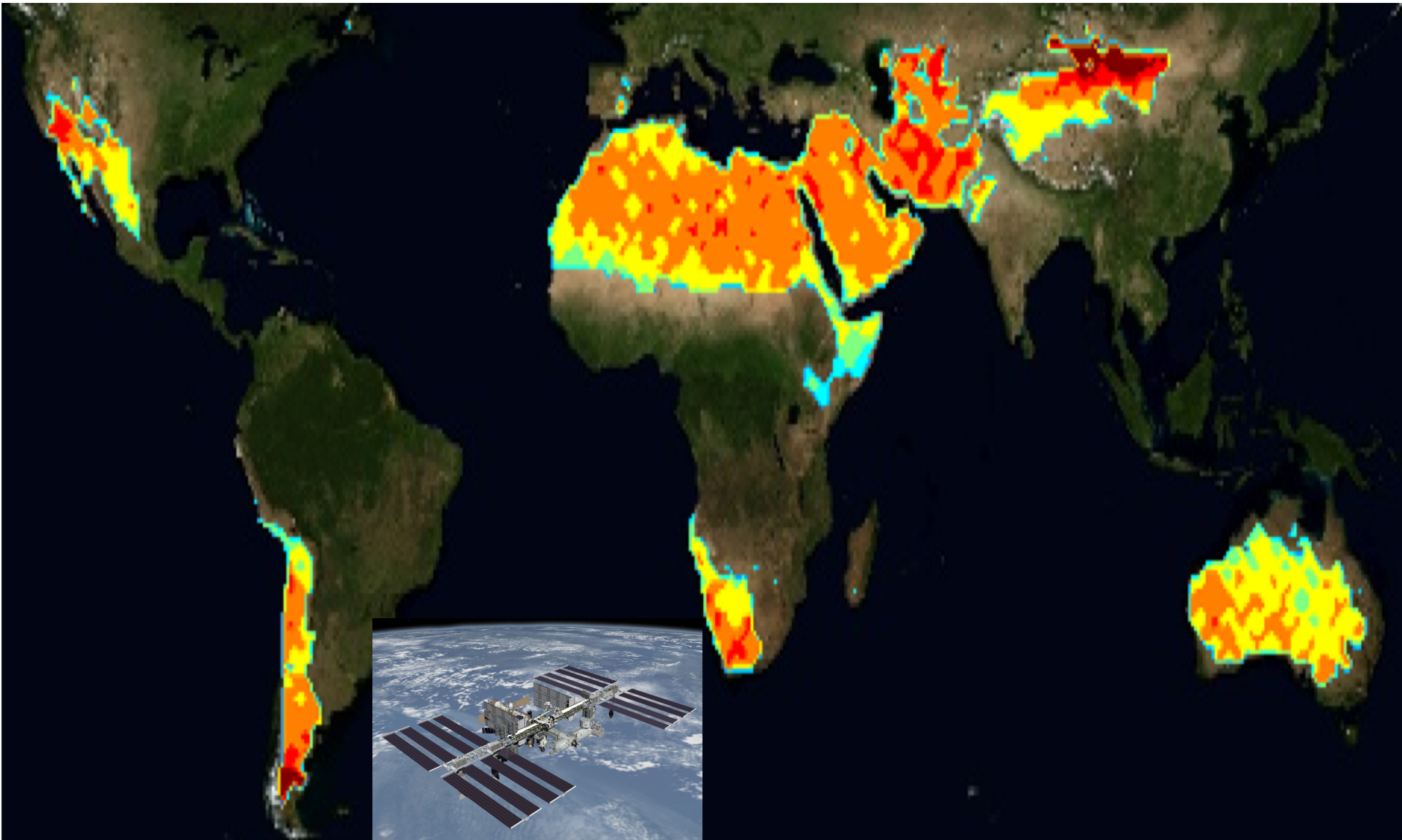
Inferred
Iron Oxides
Based on agricultural soil maps



Measured
Iron Oxides
Based on Imaging Spectroscopy



Arid Land Dust Sources Regions



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EMIT Planned for ISS in 2021 (Arid Lands)

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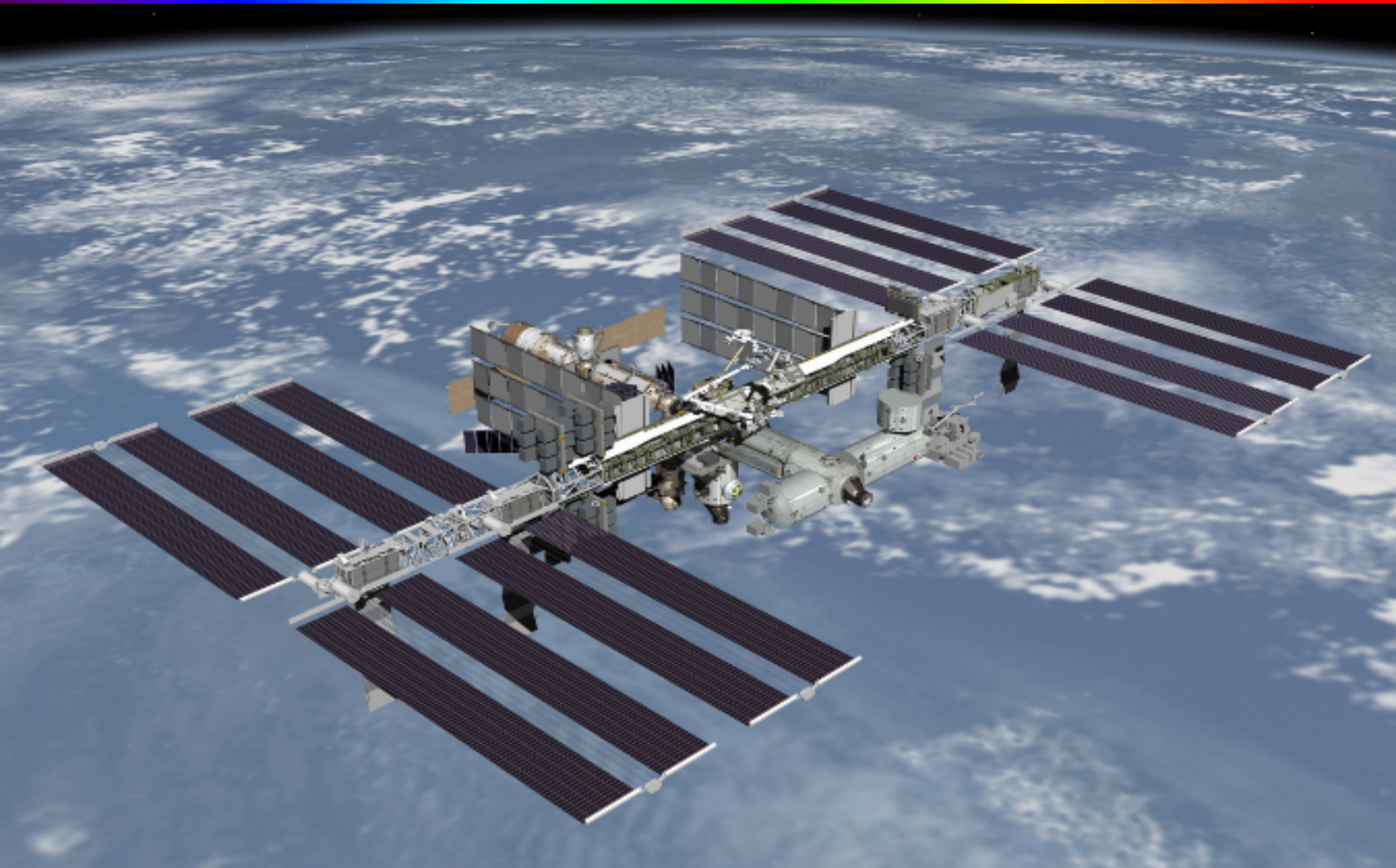

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Instrument Overview

EMIT is a Class C implementation of a mature F/1.8 VSWIR-Dyson Spectrometer that leverages NASA Research and Technology investments, including the ESTO IIP SWIS Dyson spectrometer.

EMIT measurement

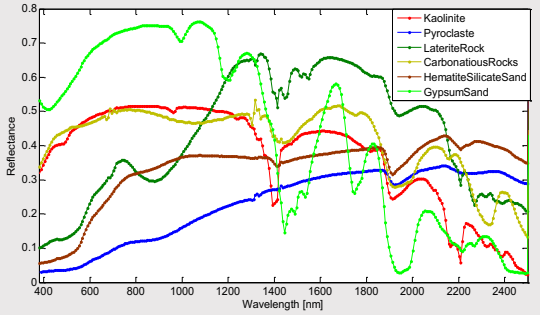
Spectral: 380-2510 nm

Radiometric: ≥100 SNR in retrieval wavelengths, without saturation over bright land

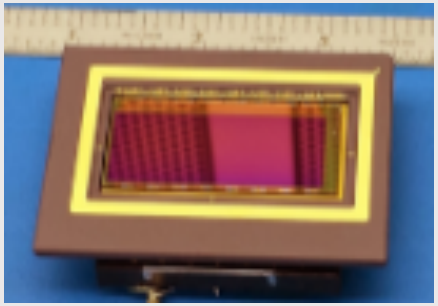
Spatial: 30 m sampling

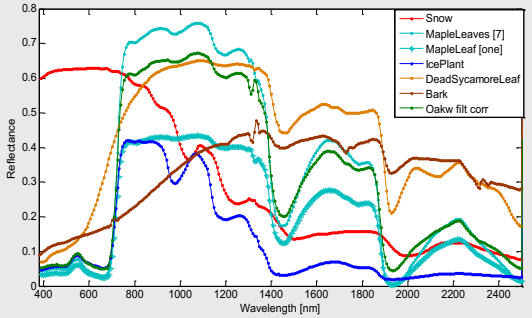
Spectrometer

VSWIR-Dyson Spectra



VSWIR Detector





JPL NASA National Aeronautics and Space Administration Goddard Institute for Space Studies New York, N.Y. Cornell University NOAA PSI UCLA USGS science for a changing world BSC Barcelona Supercomputing Center Centro Nacional de Supercomputación

Summary and Conclusion (1)

- The mineral dust cycle impacts many elements of the Earth system.
- To understand these impacts and predict how they may change in future climate scenarios the dust cycle must be modeled.
- Current Earth system models now incorporate the mineral dust cycle, however the predictions do not match observations.
- A key problem is poor constraint of the surface mineral dust composition for the dust source regions of the Earth

Summary and Conclusion (2)

- As tested with the Salton Sea measurements, VSWIR imaging spectroscopy provides a direct and straight-forward method to measure the surface mineral dust source composition.

- This spectroscopic approach can reduce uncertainty in global models by delivering comprehensive measurement of the surface mineral composition of dust source regions. Factors of 10^6 improvement in knowledge can be achieved.

- New accurate and comprehensive constraints can also improve prediction of the evolution of mineral dust sources and Earth system feedbacks under differing future climate scenarios.

- EMIT is scheduled to launch in 2021

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Questions

California Dust Storm 6 April 2018

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