MateDust Whitepaper

NASA SpaceApps Hackathon 2023

Done by:

Daria Tovstohan

Deividas Bendaravičius

Sandra Čiuladaite

Vilnius 2023

Table of Contents

Overview

The MateDust web application aims to enhance natural disaster prediction efficiency. Utilizing NASA Worldview's weather data and EMIT's Earth arid land dust source region mineral composition data, a deep learning model is trained to identify patterns and establish connections between mineral dust and weather condition changes. This culminates in the generation of an improved prediction map, enabling earlier warnings and mitigating potential harm caused by unforeseen disasters.

Current weather forecast methods

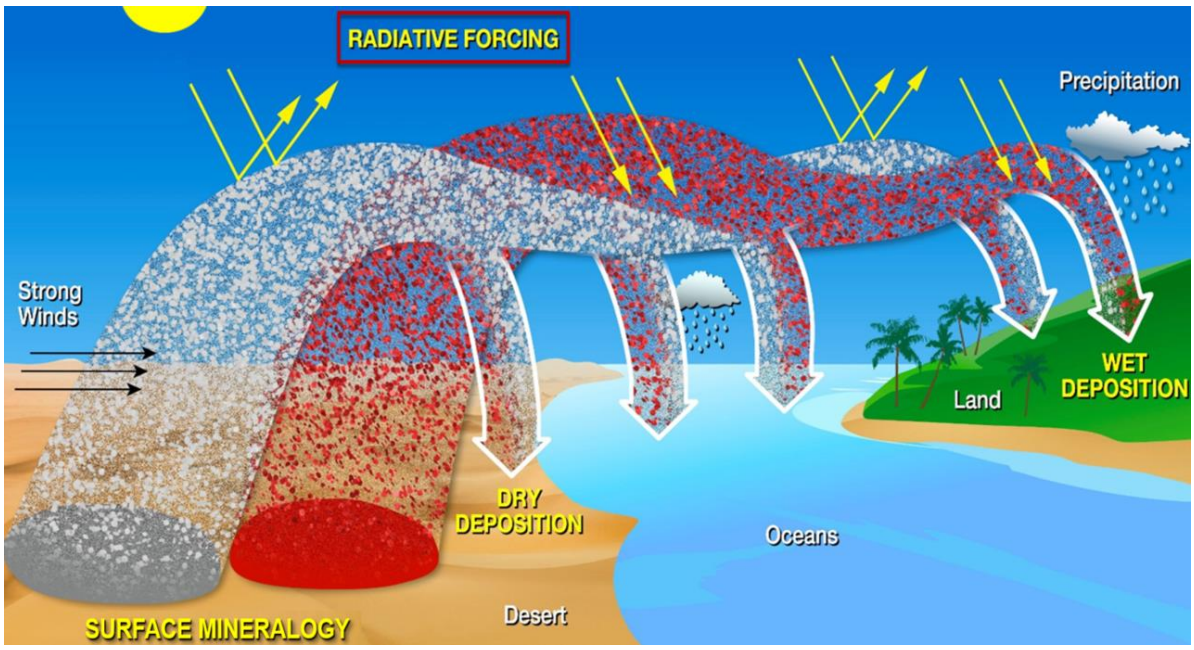
The National Oceanic and Atmospheric Administration (NOAA) Satellite Information Service, in collaboration with NASA and the U.S. Air Force, manages weather and environmental monitoring satellites, categorized as geostationary and polar-orbiting.

Geostationary Operational Environmental Satellites (GOES) provide constant coverage of the western hemisphere, stationed 35,800 km above Earth's equator, offering crucial real-time imagery for identifying severe weather, snowstorms, tropical storms, and hurricanes.

Polar Operational Environmental Satellites (POES) orbit around Earth's poles at 833 km above the surface, completing a full orbit in about 1.5 hours. Two polar satellites provide global weather imagery twice daily, aiding meteorologists in developing weather forecasts up to ten days in advance. These satellites also offer detailed storm images and support various environmental monitoring applications, such as climate research, sea surface temperature measurements, and volcanic eruption monitoring.

EMIT

In 2020, winds in Africa blew surface mineral dust into the atmosphere that then crossed the Atlantic Ocean and affected states from Florida to Texas. Mineral dust has many impacts to the Earth. Today we know mineral dust originates in the arid land regions of our planet, but we know very little about the composition. EMIT will make new measurements of the source regions to be used with advanced Earth system models to close this knowledge gap and answer key science questions.



Strong winds lift mineral dust from Earth's desert and dryland regions and carry the dust particles great distances. Depending on its color and composition, mineral dust can affect Earth's environment in different ways. Dark particles absorb sunlight and heat our planet, while light-colored particles can have a cooling effect.

Minerals containing iron tend to be dark, and those with clay tend to be lighter in color. To improve global science models and understand how dust heats and cools the Earth's environment, scientists need to know the dust's mineral composition as it blows around Earth.

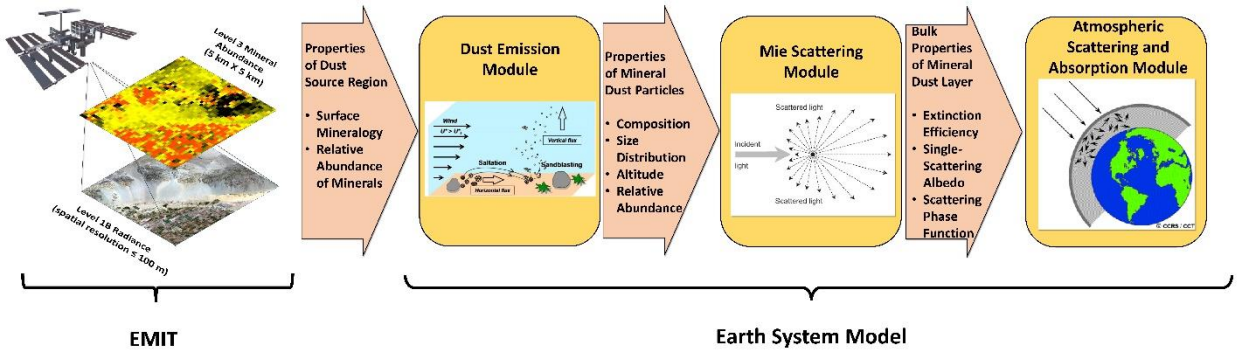
EMIT's Mission

EMIT will be the first mineral dust source observation experiment on the station and the only instrument flown on any spacecraft to date designed to exclusively study this part of the Earth's mineral dust cycle.

When strong winds on one continent stir up mineral rock dust (such as calcite or chlorite), the airborne particles can travel thousands of miles to affect entirely different continents. Dust suspended in the air can heat or cool the atmosphere and Earth's surface. This heating or cooling effect is the focus of NASA's Earth Surface Mineral Dust Source Investigation (EMIT) mission.

Mineral dust has many other effects on our planet. It can help form clouds or change atmospheric chemistry. When the dust settles in water or on land it can provide nutrients for ecosystem growth. If it falls on snow or ice, mineral dust can increase sunlight absorption and accelerate melting. Mineral dust in the air can reduce visibility or harm human health.

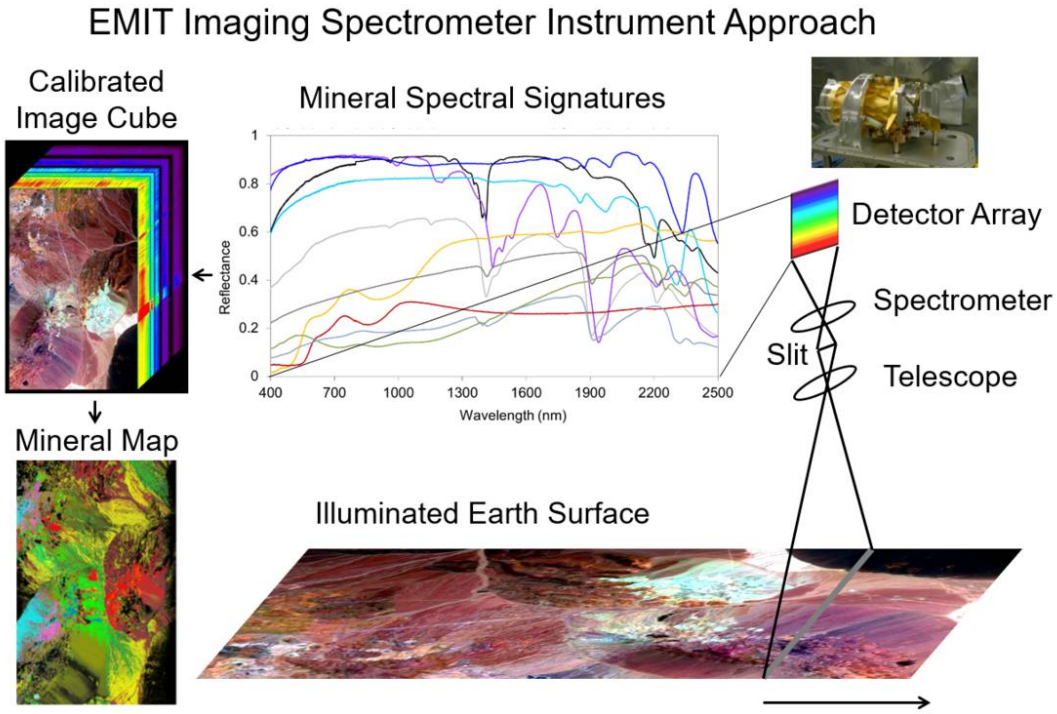
The data will allow scientists to create a new mineral map of Earth's dust-producing regions. The map will improve computer models that scientists will use to assess the regional and global heating and cooling effects of mineral dust today and in the future.



EMIT maps the minerals on Earth's surface. Measuring dust in the atmosphere can only provide a snapshot of conditions at a particular place and time. However, to predict the total influence of dust and its future impacts as the land surface changes, we need to understand the entire dust cycle. To help this effort, EMIT will measure the surface mineralogy of all arid lands in known dust-emitting regions around the planet. The EMIT science team will then use these maps, together with existing datasets, to model the distribution and composition of atmospheric dust, and its influence on Earth's climate.

Imaging Spectroscopy

An imaging spectrometer is an instrument that measures many wavelengths of light, at multiple locations, at the same time. The EMIT instrument observes about 7 times the range of the human-observable spectrum, in over 300 channels.

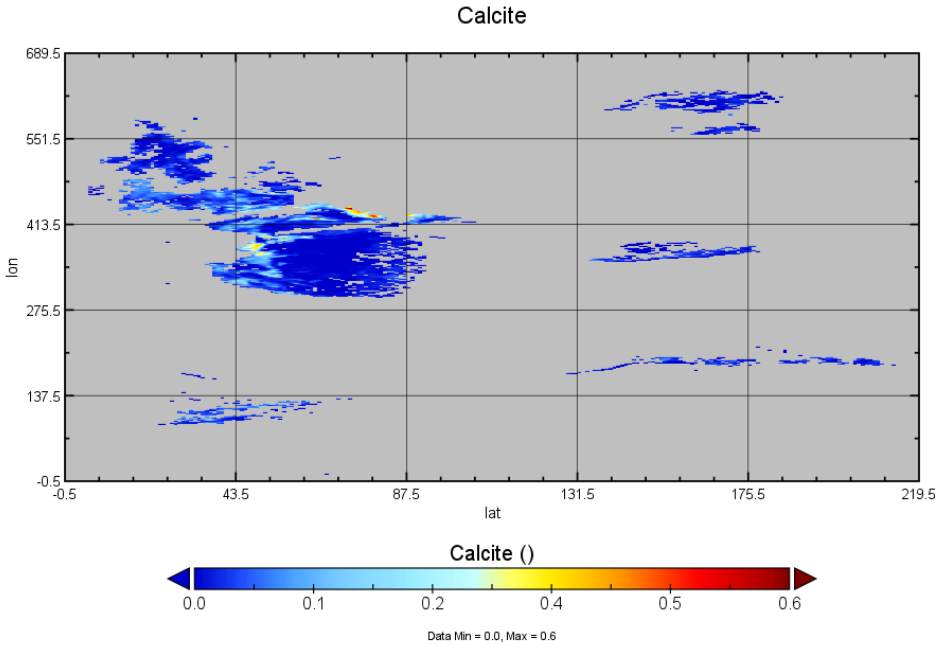


The EMIT Mission will use imaging spectroscopy across the visible shortwave (VSWIR) range to reveal distinctive mineral signatures, enabling rigorous mineral detection, quantification, and mapping. The overall investigation aims to achieve two objectives.

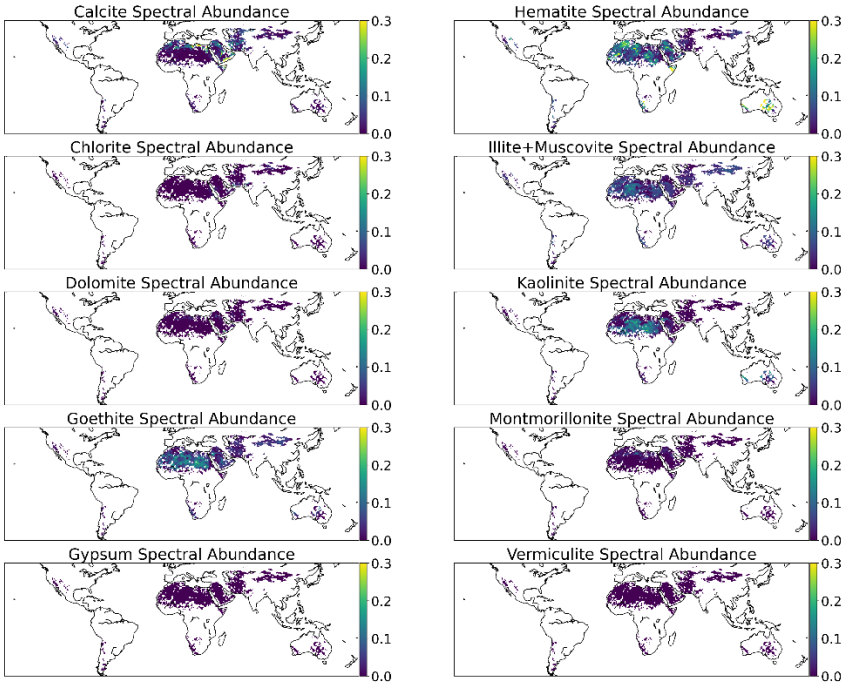
1. Constrain the sign and magnitude of dust-related RF at regional and global scales. EMIT achieves this objective by acquiring, validating and delivering updates of surface mineralogy used to initialize ESMs.
2. Predict the increase or decrease of available dust sources under future climate scenarios. EMIT achieves this objective by initializing ESM forecast models with the mineralogy of soils exposed within at-risk lands bordering arid dust source regions.

EMIT L3 Data

Singular mineral dust data



Aggregated data



References:

1. **How Reliable Are Weather Forecasts?** https://scijinks.gov/forecast-reliability/#:~:text=The Short Answer%3A,right about half the time.
2. **VISIONS: The EMIT Open Data Portal** https://earth.jpl.nasa.gov/emit/data/data-portal/coverage-and-forecasts/
3. **Nasa Worldview** https://worldview.earthdata.nasa.gov/
4. **Using Satellites for forecasting:** https://www.weather.gov/ajk/OurOffice-Sat