FRAGMENT:

FRontiers in dust minerAloGical coMposition and its Effects upoN climaTe

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EXCELENCIA SEVERO OCHOA

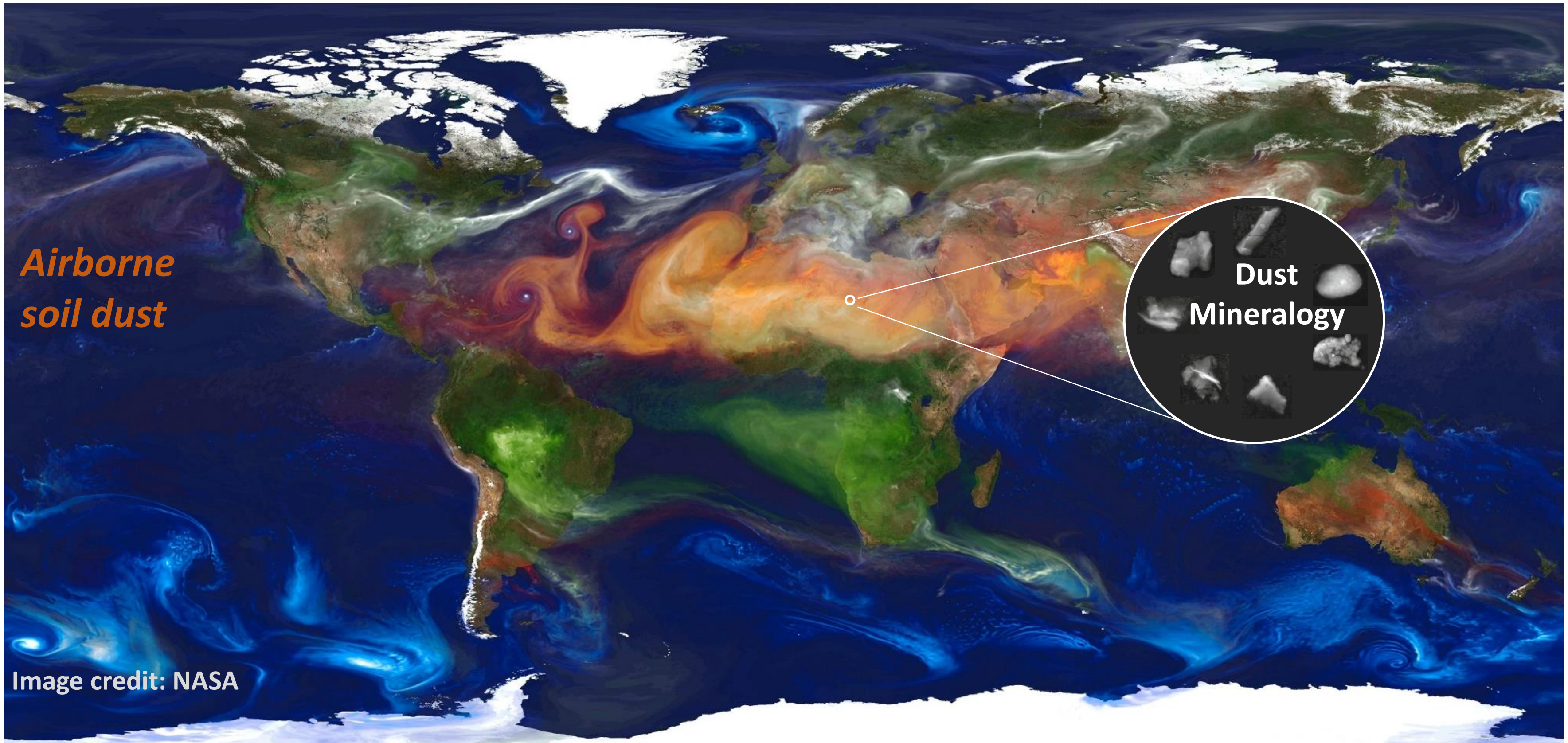
European Research Council
Established by the European Commission

AXA Research Fund

28.11.2018

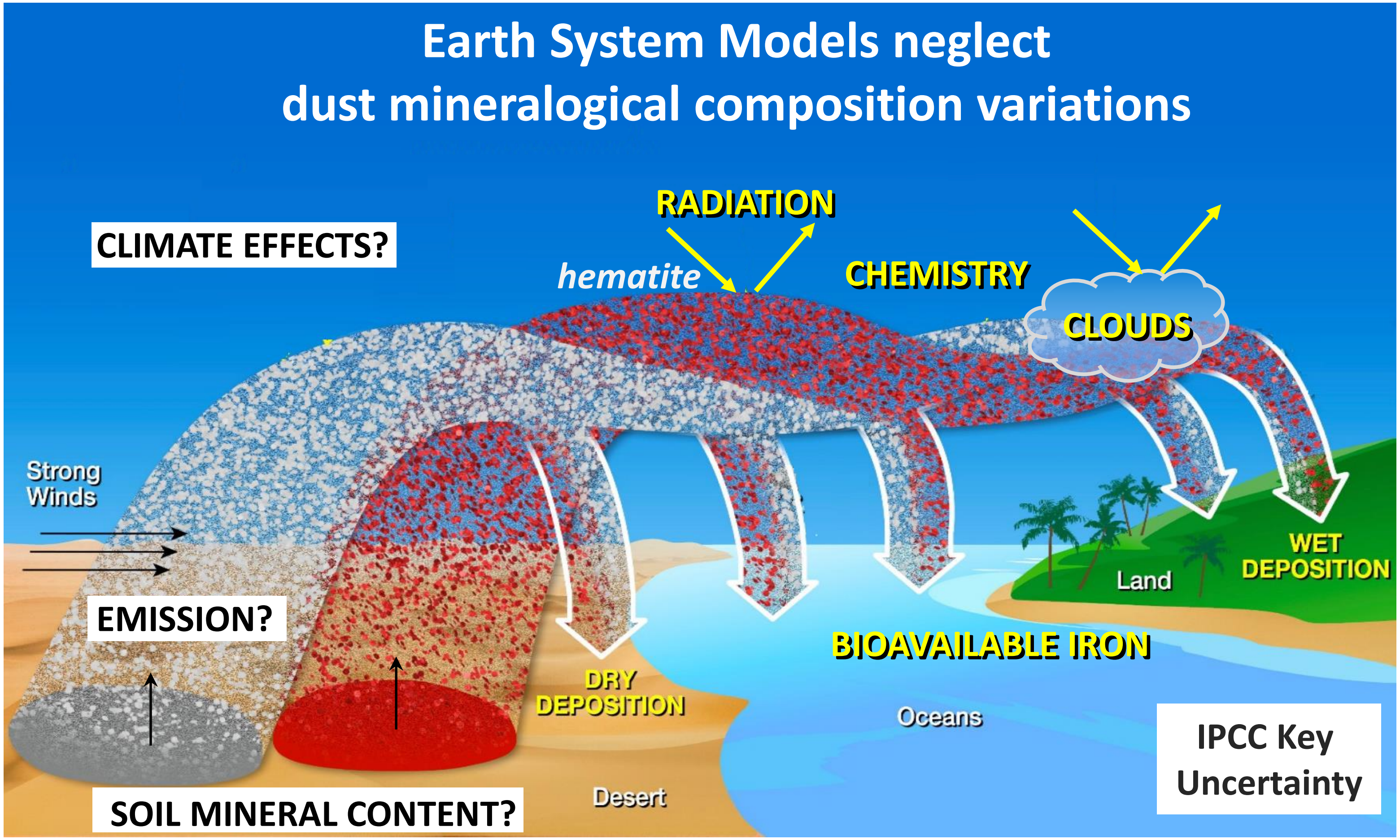
Staubtag, Darmstadt

FRAGMENT



Soil dust is the dominant particle by mass and a key component of the Earth System

Motivation



- Constrain the global dust mineralogical composition
- Understand and calculate its effects upon climate

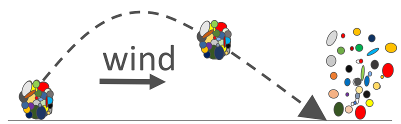
FRAGMENT Overview

Challenges

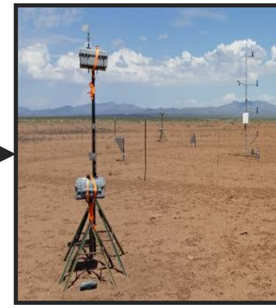
Methods

Objective 1

Emission of minerals



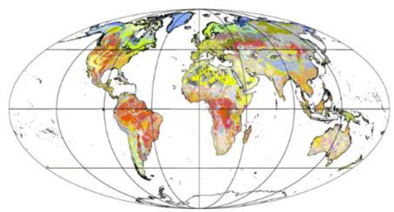
FRAGMENTation of aggregates

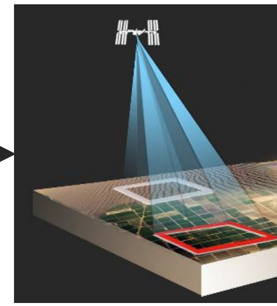


Theory
+
Field campaigns
+
Laboratory analyses

Objective 2

Global soil mineral content





Field and Lab
+
Airborne spectroscopy
+
Space-borne spectroscopy
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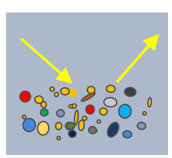
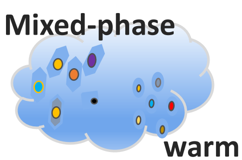
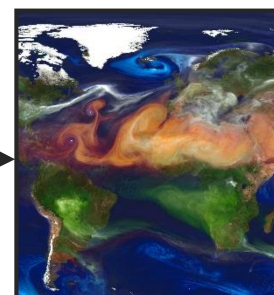
Objective 3

Role of mineralogy





Radiation, Chemistry and Clouds



Modelling
+
State-of-the-art
+
New methodologies
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EMIT: *Earth Surface Mineral Dust Source Investigation, NASA*

FRAGMENT Team

PI: Carlos Pérez García-Pando*		
WP1 – Emission	**WP2 – Soil mineral content**	**WP3 – Effects**
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A. Panta (TUDA)		*Postdoc clouds (BSC)*

Collaborators

EMIT* Science Team, V. Etyemezian (DRI), Y. Balkanski (IPSL)

S. Dupont (field campaigns), P. Formenti (Optical properties); Z. Shi (soluble iron); and others

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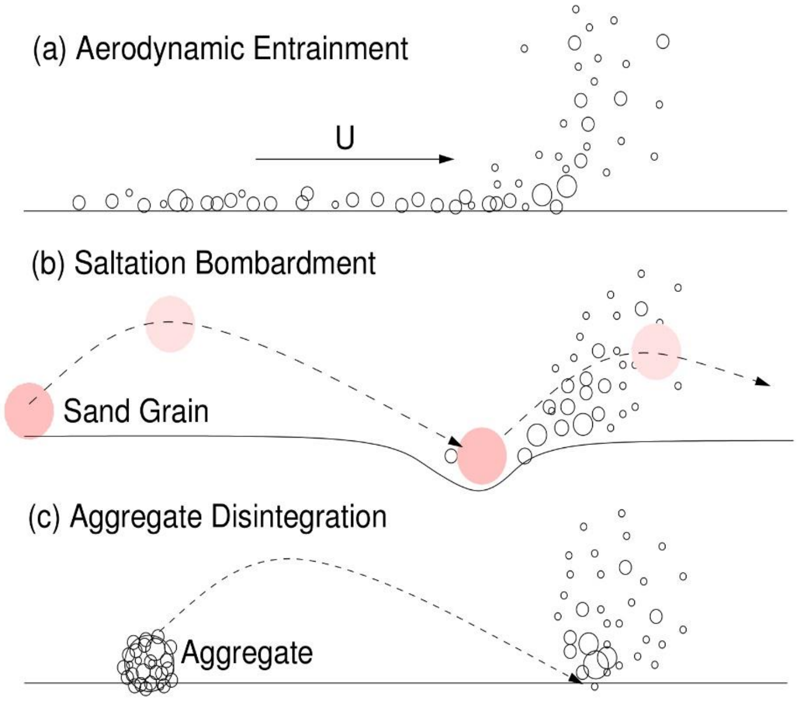
1. Emission of dust minerals

Emitted PSD of dust minerals is key to quantifying their climate effect

Without consideration of mineralogy:

- Incomplete understanding of the physics
- Paucity and incompleteness of measurements
- Lack of (realiable) input data at global scale (e.g. soil PSDs)



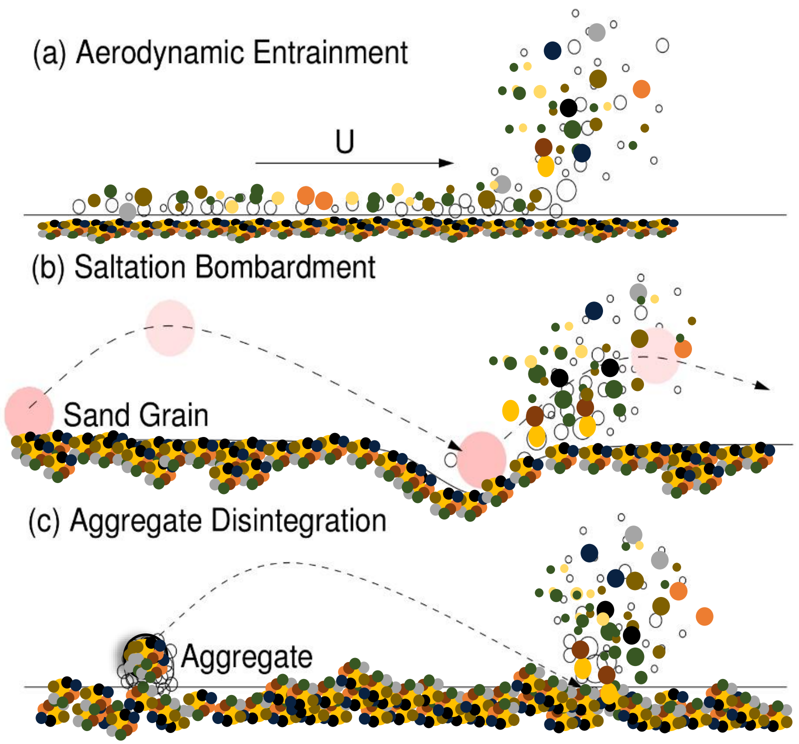
Dust emission mechanisms (Shao et al. 2008)

1. Emission of dust minerals

Emitted PSD of dust minerals is key to quantifying their climate effect

With consideration of mineralogy:

- Incomplete understanding of the physics
- Paucity and incompleteness of measurements
- Lack of (realiable) input data at global scale (e.g. soil PSDs)
- Complete lack of experimental studies tackling the relationship of the emitted PSD and soil-surface mineralogy
- Soil analysis based upon wet sieving that disturbs the soil samples
- But: Internal and external mixtures of different minerals important for climate impacts



Dust emission mechanisms (Shao et al. 2008)

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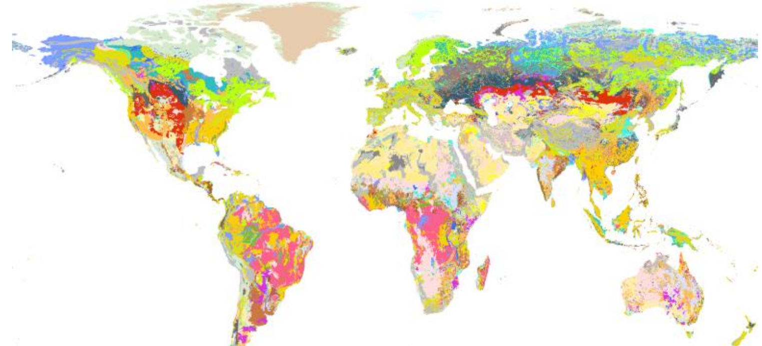
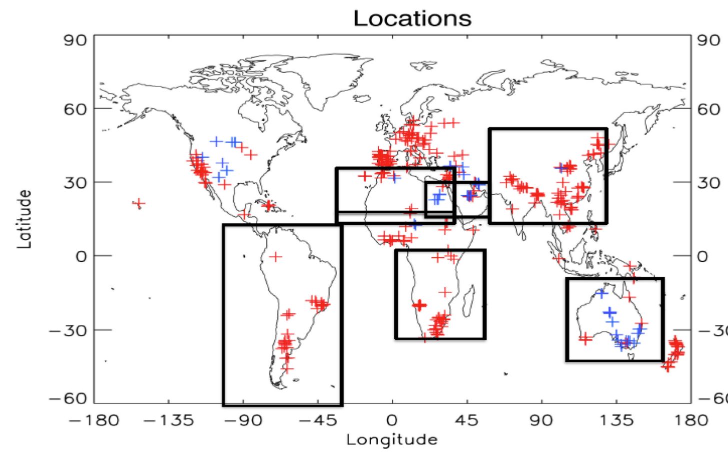
2. Mapping of soil-surface mineralogy

- Claquin et al., 1999; Journet et al., 2014
- Currently 12 key minerals estimated
- 700 soil descriptions sampling 55 % of FAO soil units
- Many regions including prolific sources not sampled
- Massive extrapolation based on soil unit/type
- A number of assumptions to overcome the lack of data: for example on hematite and goethite size
- Soil analysis based on *wet sedimentation* ("*wet sieving*"), which breaks the aggregates found in undispersed soils subject to wind erosion.



FAO soil types or units



Sieves for mechanical analysis

Soil Hydrometer apparatus

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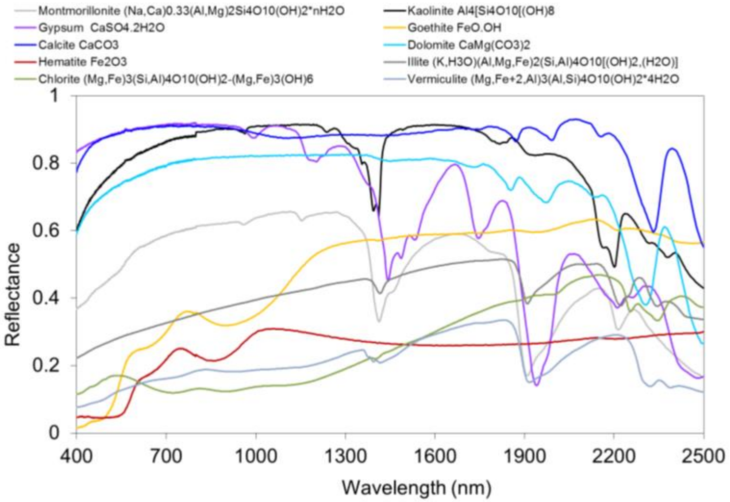
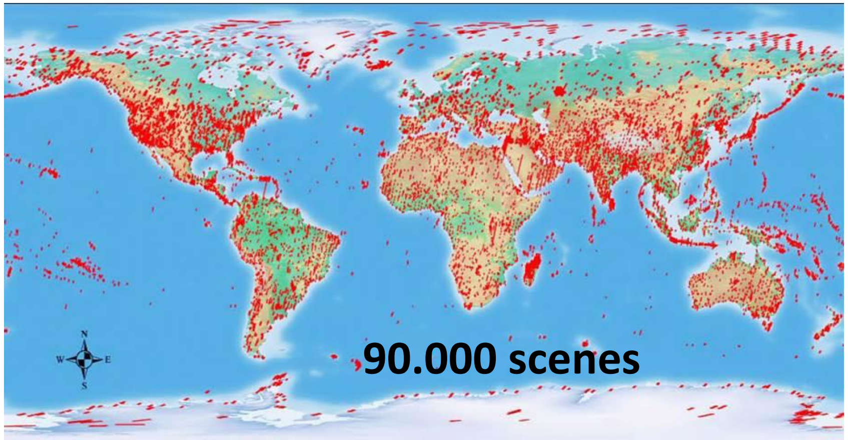
2. Space borne hyperspectral imaging spectroscopy

VSWIR Spectra of Dust Source Minerals

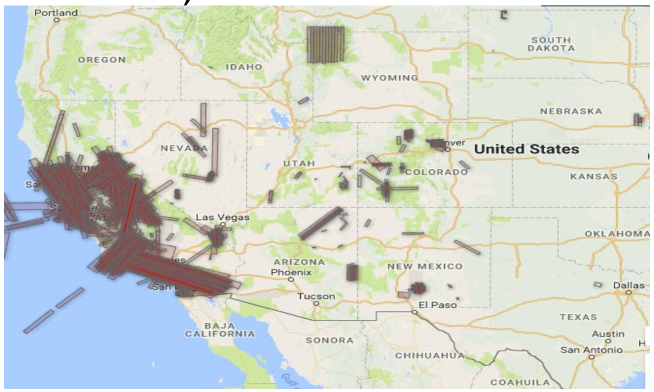


Hyperion: satellite hyperspectral sensor 0.4 to 2.5 µm, 242 spectral bands, 10nm spectral resolution, 30 m spatial with a SNR of ~50:1



AVIRIS airborne scenes

0.4–2.5 µm, 224 bands, 10 nm spectral resolution, SNR of ~500:1



Coming soon (2021)!!!

NASA FUNDED

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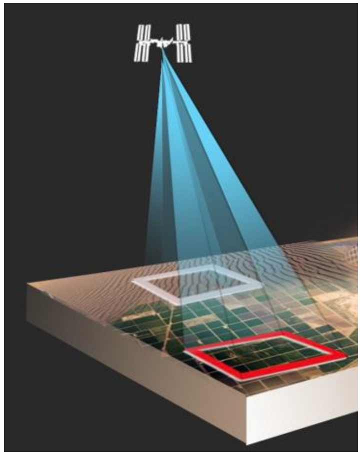
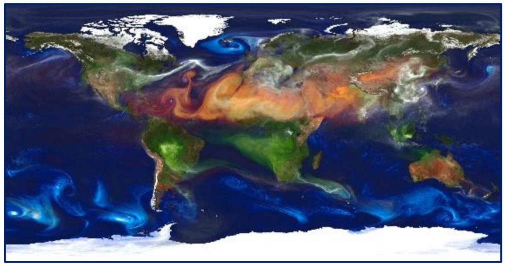
Earth Surface Mineral Dust Source Investigation



3. Modeling and effects

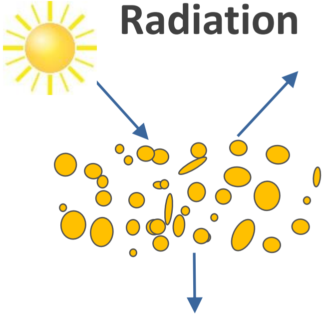
Quantify the present-day dust direct and indirect radiative forcing
Minimal representation of mineralogy in Earth System models

Modeling

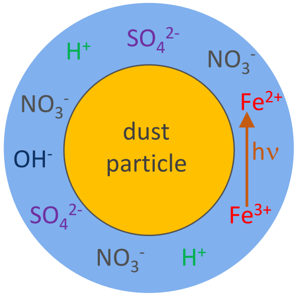


EMIT models
AEROCOM-like experiments

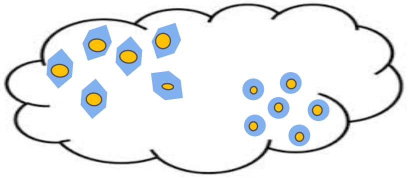
Radiation



Heterogeneous Chemistry



Clouds



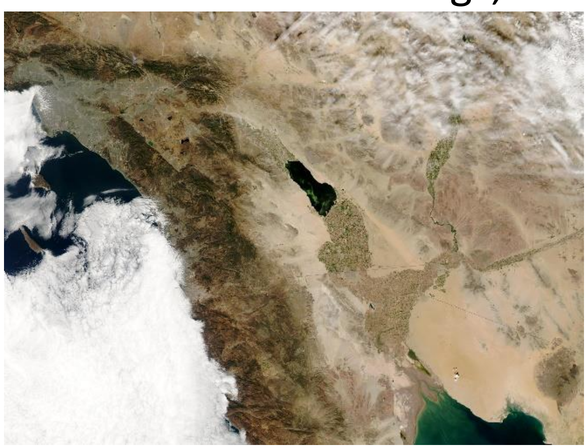
- BSC Model NMMB-MONARCH
- Co-development with GISS ModelE
- Model **constrained by new PSDs and mineral maps**
- **Data assimilation and thorough model evaluation**
- Modeling optical properties (shape and mineralogy)
- Further constraints with radiance measurements
- Using state-of-the-art schemes for chemistry and clouds

Field Campaigns: Where, Why and When?

Aragón, Spain 2019, 2021

Zagora, Morocco 2019

Salton Sea and surroundings, US 2020



Icelandic sources (HiLDA!) 2021

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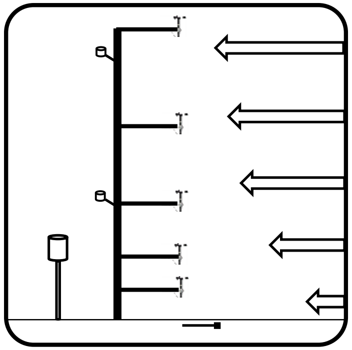
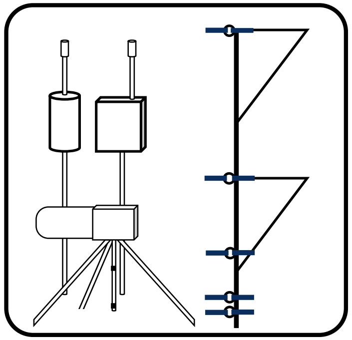
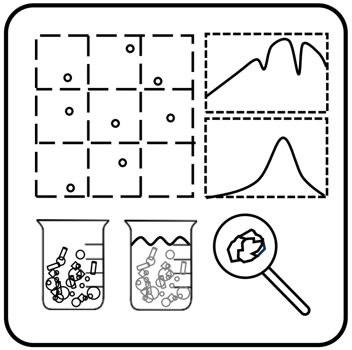
Field Campaigns: What?







Meteorology

- Atmospheric forcing (wind, temperature, turbulence)
- Soil-surface humidity
- Precipitation

Sand and Dust

- Time- and size-resolved vertical number and mass fluxes (>20 μm)
- Size-segregated samples of suspended dust (compositional fluxes)
- Saltation flux (time/size resolved and bulk)

Soil sampling and lab analysis

- Soil sampling
- Surface composition (based on reflectance spectra + tetracorder)
- Dry soil aggregate stability
- Particle-size analyses in wet and dry dispersion of soil and saltation samples
- Size-resolved mineralogy, chemistry, morphology and mixing state of soil, saltation and dust samples
- Composition of soil and aeolian samples based on spectroscopy

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Linking global soil-surface mineralogy

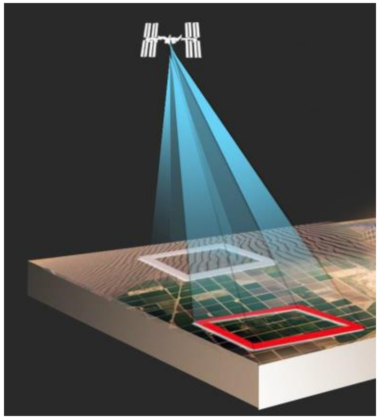
Constrain global soil-surface mineralogy
Link spectroscopy of soil to dust emission

Field and lab spectroscopy

AVIRIS (US)

Airborne Spectroscopy

HYPERION/EMIT (2021)



Space-borne Spectroscopy

- Spain, Morocco, US, Iceland
- Point and field spectrometers
- Spectroscopy of soil and airborne samples
- Tetracorder Spectral Identification and Mapping
- Linking relevant to theories on dust PSD to size and composition resolved measurements

SUPPORT and TIMELY IMPACT EMIT

Summary: FRAGMENT

- FRontiers in dust minerAloGical coMposition and its Effects upoN climate
    - Theory
    - Field experiments
    - Laboratory analyses
    - Field, lab, airborne and spaceborne spectroscopy
    - Numerical modeling
- 5 years from 1 October 2018 – 30 September 2023

→ Understanding and predicting the dust mineralogical cycle and its effects

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Thank you

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