Barcelona Supercomputing Center
Centro Nacional de Supercomputación

EXCELENCIA SEVERO OCHOA

European Research Council
Established by the European Commission

AXA Research Fund

FRAGMENT:

FRontiers in dust minerAloGical coMposition and its Effects upoN climaTe

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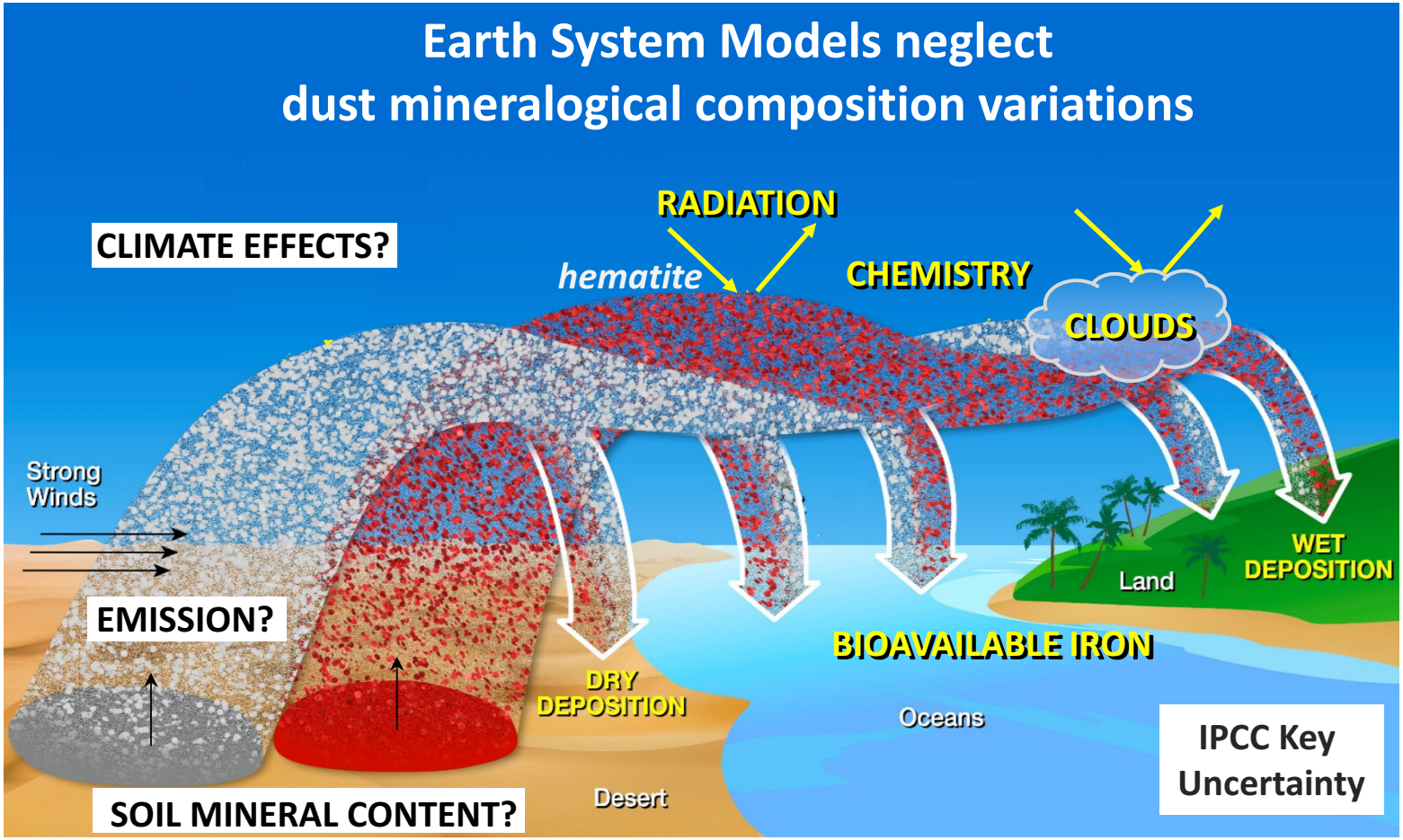
11.12.2018

AGU FALL MEETING 2018, Washington DC

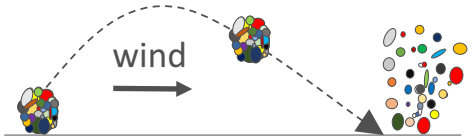
Motivation



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

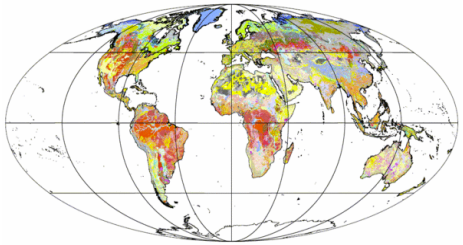
Challenges

Emission of minerals

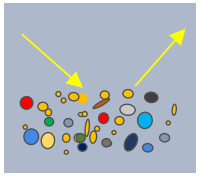


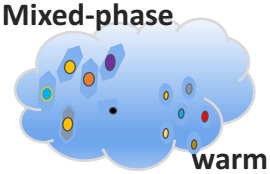
FRAGMENTation of aggregates

Global soil mineral content



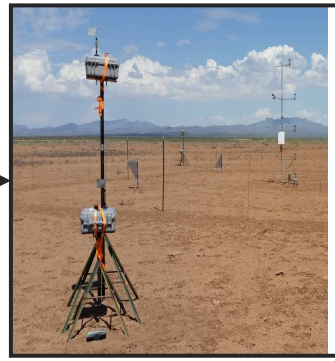
Role of mineralogy



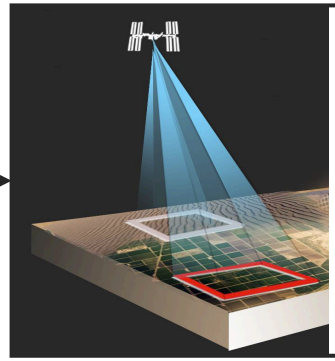


Radiation, Chemistry and Clouds

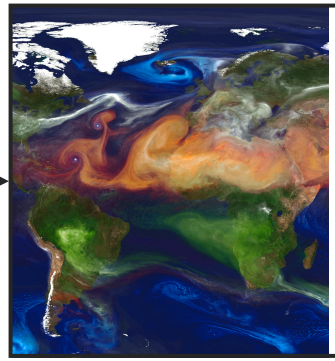
Methods



Theory
+
field campaigns
+
Laboratory analyses



Field and Lab
+
Airborne spectroscopy
+
Space-borne spectroscopy
EMIT



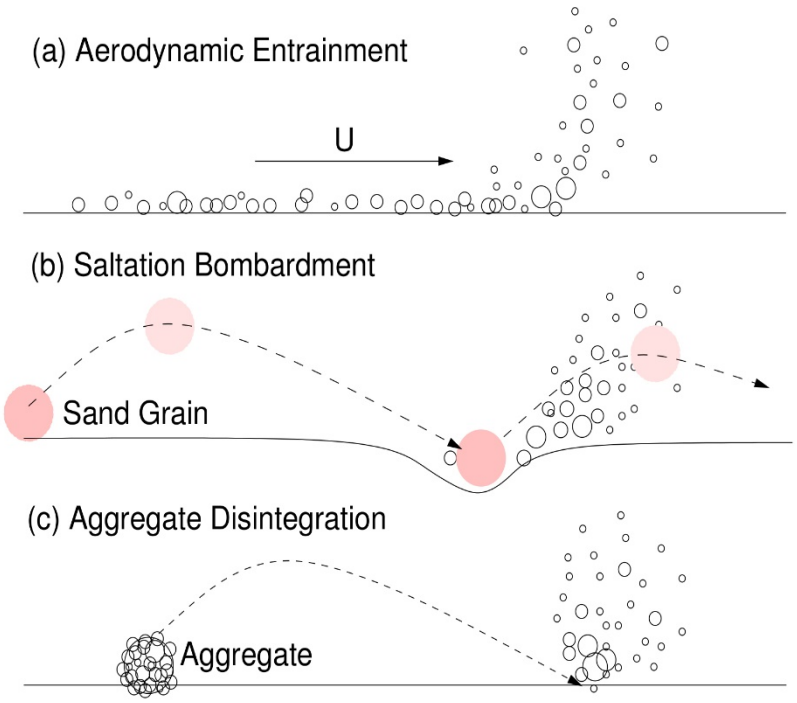
Modelling
+
State-of-the-art
+
New methodologies
EMIT

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)



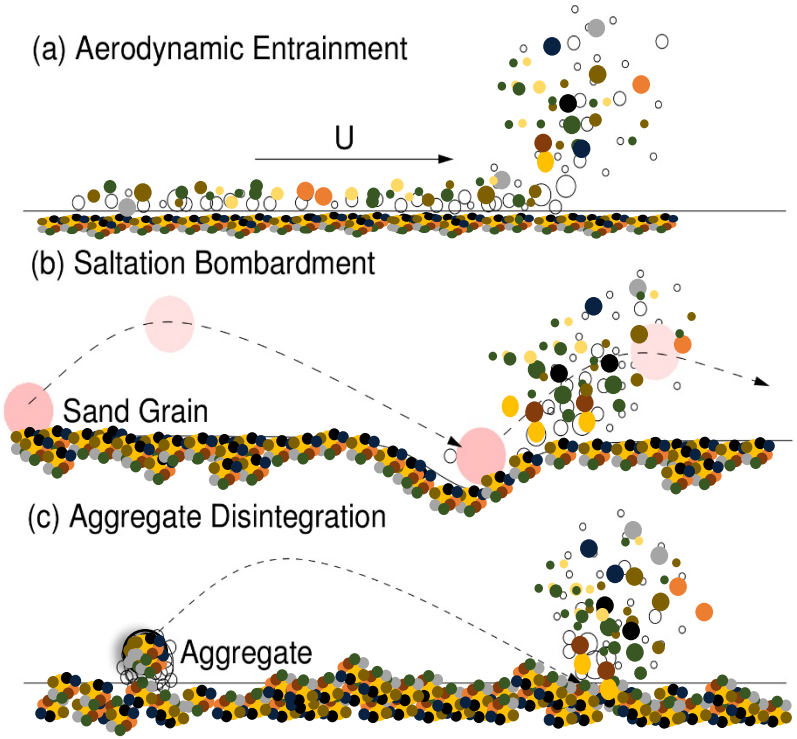
Dust emission mechanisms (Shao et al. 2008)

Emission of dust minerals

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

With consideration of mineralogy:

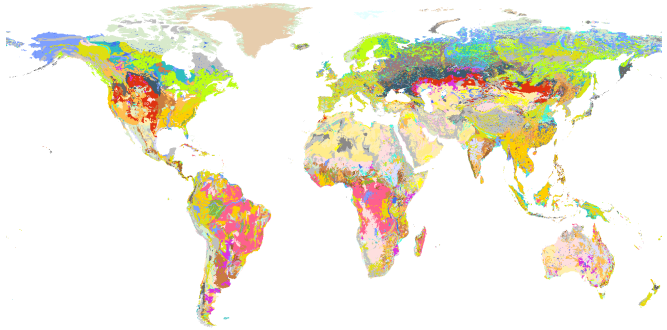
- Incomplete understanding of the physics
- Paucity and incompleteness of measurements
- Lack of (realiable) input data at global scale (e.g. soil PSDs)
- Complete lack of experimental studies tackling the relationship of the emitted PSD and soil-surface mineralogy
- Internal and external mixtures of different minerals important for climate impacts



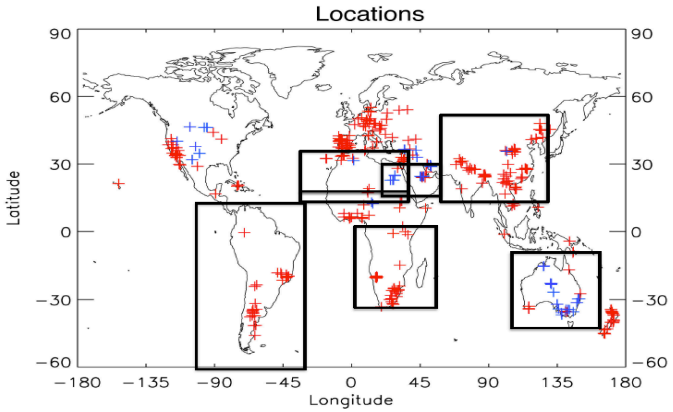
Dust emission mechanisms (Shao et al. 2008)

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.

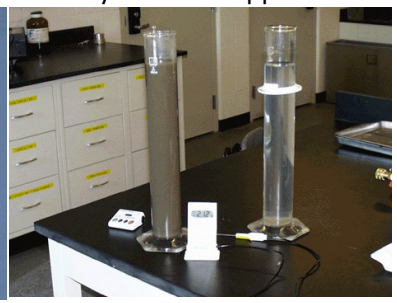


FAO soil types or units



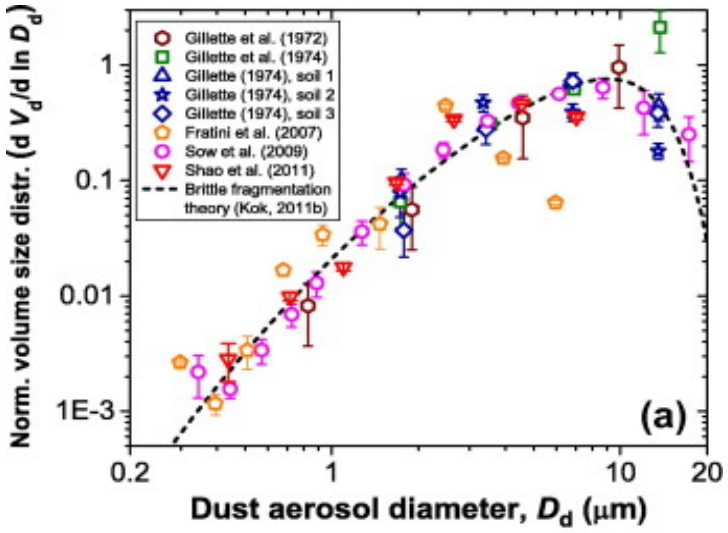
Sieves for mechanical analysis

Soil Hydrometer apparatus



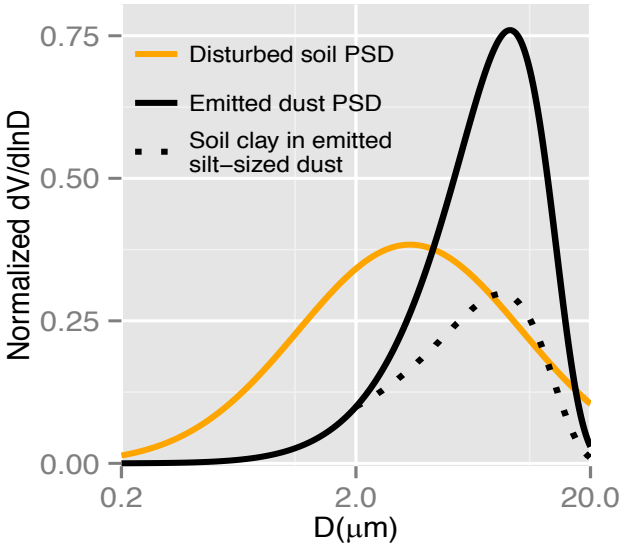
Emitted PSD and mineralogy in models

Brittle Fragmentation Theory auspicious for mineralogy as it is based on the soil dispersed PSD



Kok (2011)

$$\frac{dV}{d\ln D} = \frac{D}{C_V} u(D) \exp\left[-\left(\frac{D}{\lambda}\right)^3\right]$$



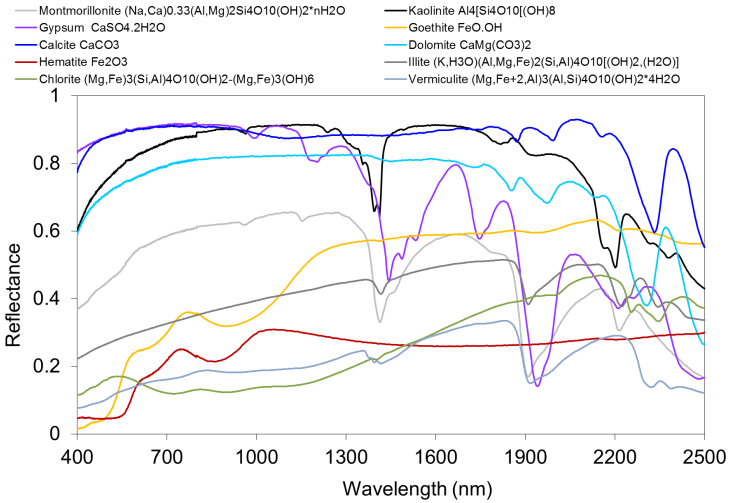
Scanza et al. (2015)

Perlwitz et al., 2015 (a,b)
Pérez García-Pando et al., (2016)

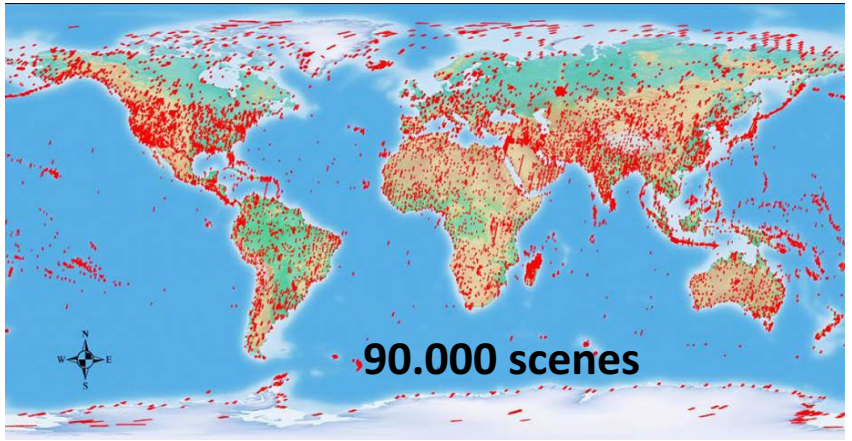
Pérez García-Pando et al., in prep

Space borne hyperspectral imaging spectroscopy

VSWIR Spectra of Dust Source Minerals

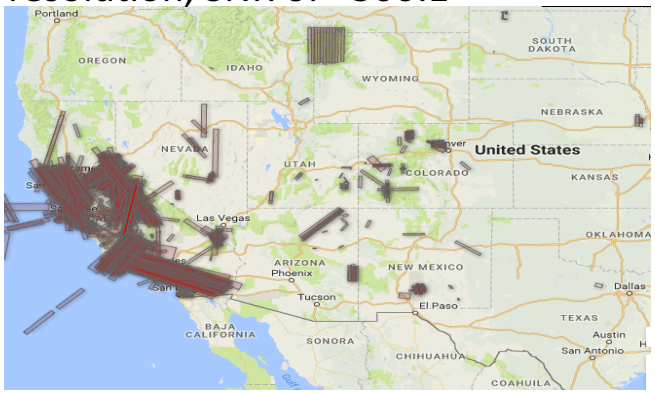


Hyperion: satellite hyperspectral sensor 0.4 to 2.5 µm, 242 spectral bands, 10nm spectral resolution, 30 m spatial with a SNR of ~50:1

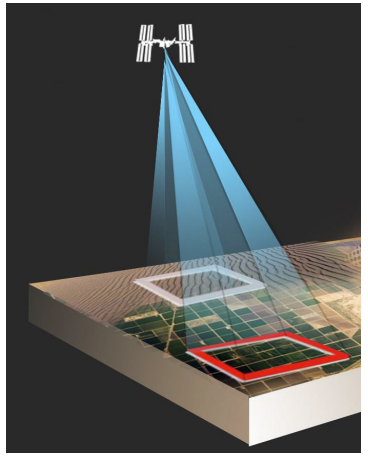


AVIRIS airborne scenes

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



Coming soon (2021)!!!
NASA FUNDED
EMIT
Earth Surface Mineral Dust Source Investigation

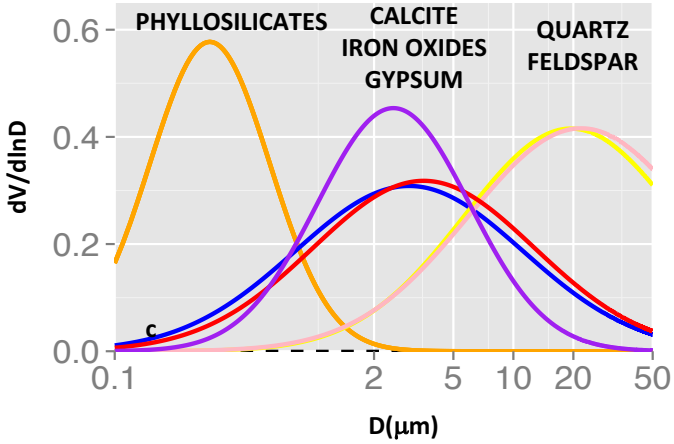


Emitted PSD of minerals

Understand emitted PSD of minerals and relationship with parent soil
Extend theoretical framework(s) and produce global model scheme

Field campaigns

Laboratory



Theory

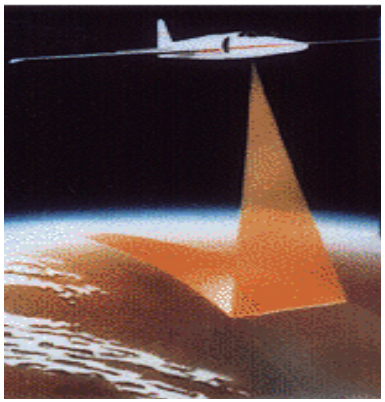
- Atmospheric Forcing
- Size-segregated and composition resolved dust fluxes
- Size-segregated and composition resolved dry and wet soil

Global soil-surface mineralogy

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

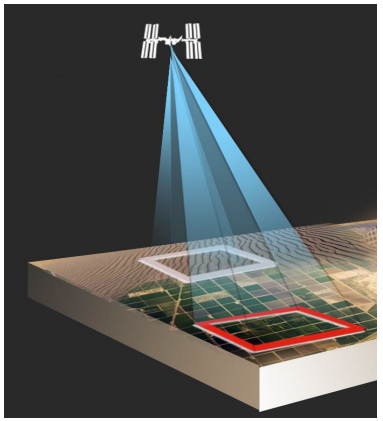
Field and lab spectroscopy

AVIRIS (US)



Airborne Spectroscopy

HYPERION/EMIT (2021)



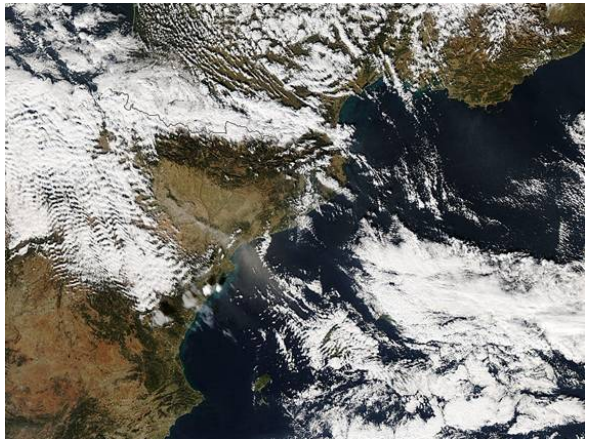
Space-borne Spectroscopy

- Point and field spectrometers
- Lab spectroscopy of soil and Aeolian samples
- Tetracorder Spectral Identification and Mapping
- Linking to size and composition resolved measurements relevant to theories of dust PSD

SUPPORT and TIMELY IMPACT EMIT

Field Campaigns: Where, Why and When?

Aragón, Spain 2019, 2021

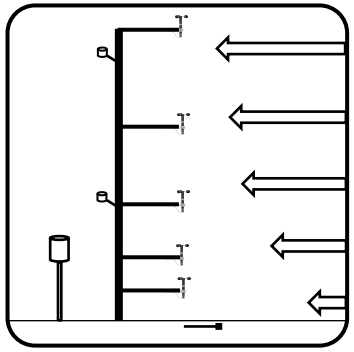


Zagora and surroundings, Morocco 2019

Salton Sea and surroundings, US 2020

Icelandic sources (HiLDA!) 2021

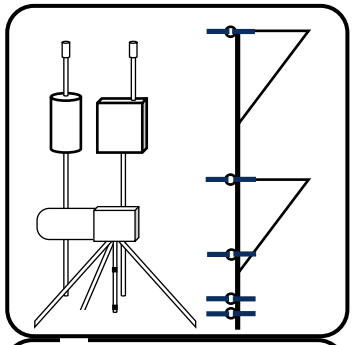
Field Campaigns: What?



Meteorology

- Atmospheric forcing
  (2D and 3D wind, temperature, turbulence, pressure)
- Soil-surface humidity
- Precipitation

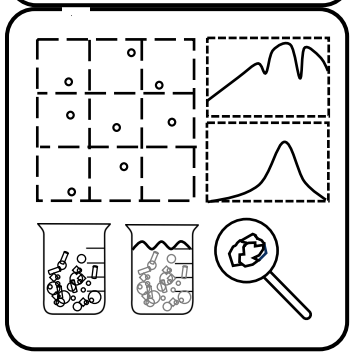
Both flux gradient &
eddy covariance methods



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)

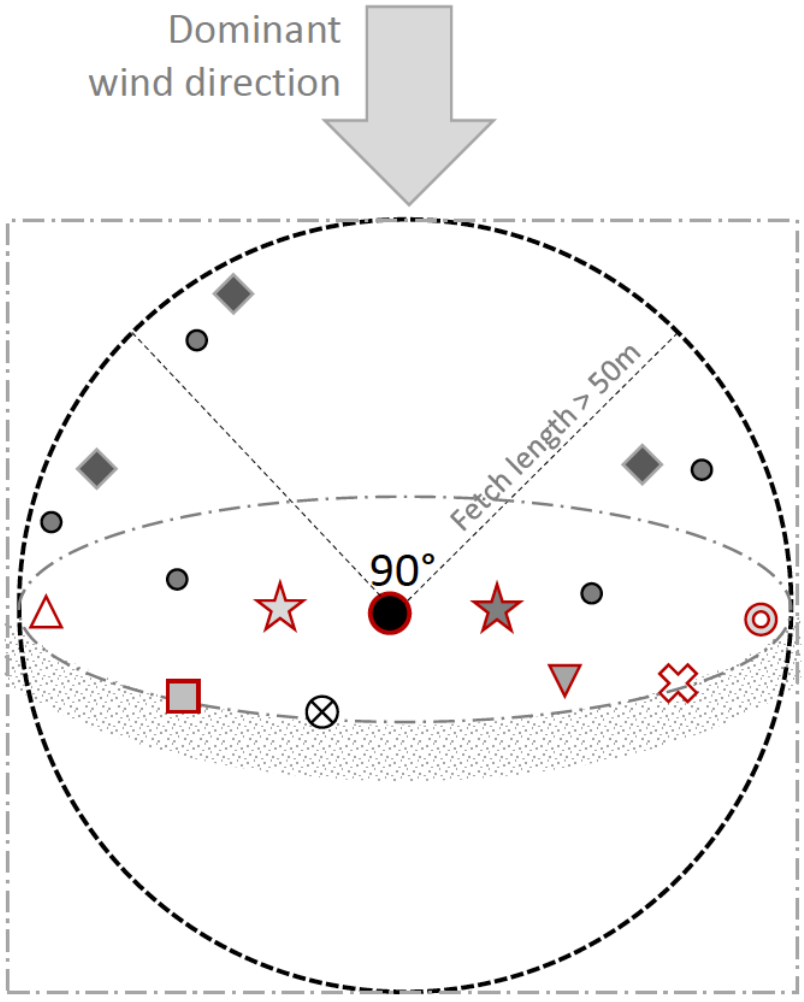
OPC´s, high volume samplers,
multistage cascade impactors



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 (XRD, TEM, BSED,..)
- Composition of soil and aeolian samples and sub samples based on spectroscopy

Proposed setup



●	6m tower: 5 cup anemometers, 1 wind vane, 4 Thermocouples, 1 RH/T sensor, P measured by FIDAS; Tower powered by solar panel and continuously running
☆	2 Optical counters (Palas Fidas) at 2 m and 4 m and 2 Cascade impactors (Moudi) at one of the two heights; ultrasonic anemometer at 2 heights; collocated OGD?
★	Optical counters (GRIMM) at two heights (same as Fidas OPCs) + ultrasonic anemometer at one (lower?) height ALTERNATIVE: two locations with one GRIMM/sonic each
◆	3 Saltation sensors, 2 or 3 heights each
●	MWAC mast (2m, 5 heights: 0.1, 0.2, 0.5, 1, 2m)
△	Radiometer
✖	Soil moisture sensor (TDR)
□	Nephelometer
◎	Aethalometer AE33
▽	PM2.5/PM10 high-volume samplers
⊗	Rain gauge

Needs power supply

Additional instrumentation

Fence?

Extra

- Optical porperties in LISA dust chamber (Paola Formenti)
- Iron solubility (Zongbo Shi)
- Ice nucleation (Ben Murray)

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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