

Laboratory experimental simulation activity: a key contribution to constrain the estimate of the aerosol-radiation interaction

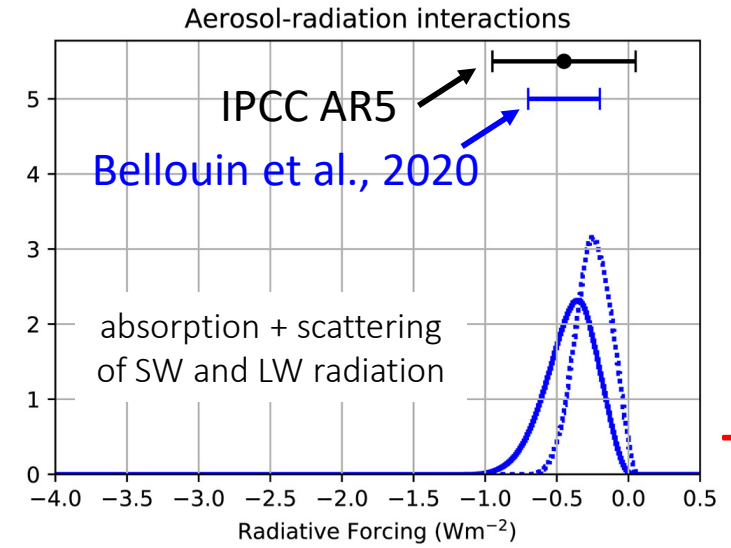
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LISA, UMR CNRS 7583, Université Paris-Est-Créteil, Université de Paris,
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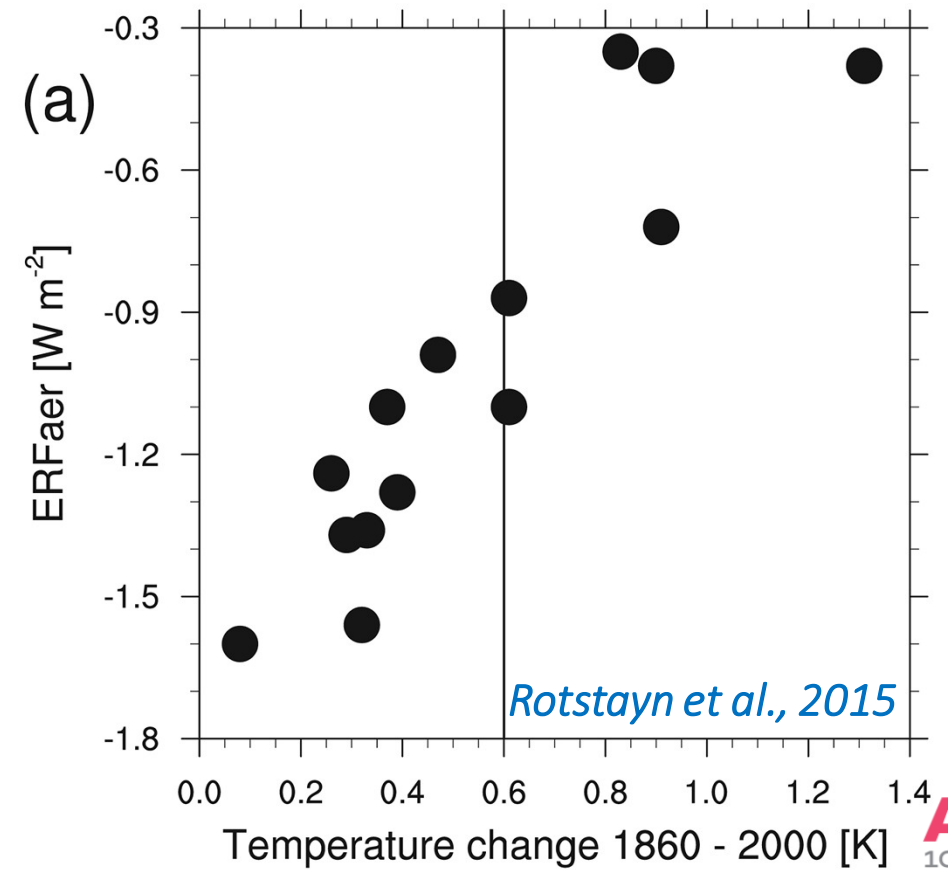
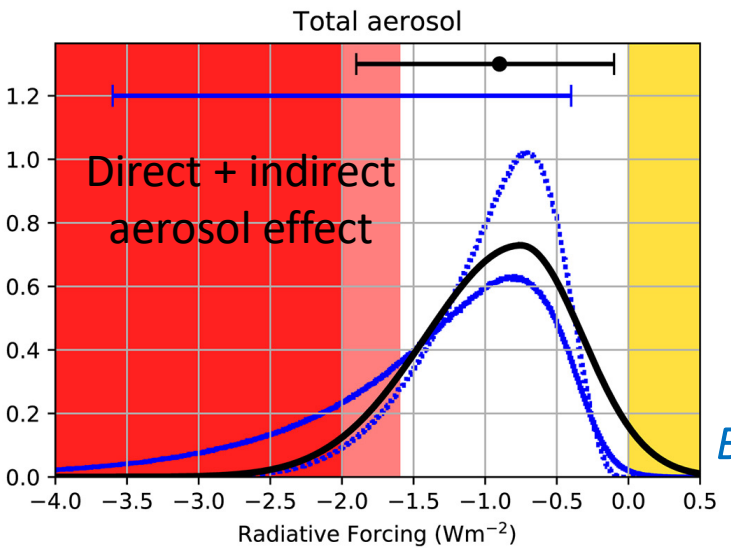
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Aerosols crucially contribute to the uncertainty in the climate forcing assessment

Earth's **surface T increase** since preindustrial times
 $1.0 \pm 0.2 \text{ }^\circ\text{C}$ *Allen et al., 2018*
(GHGs warming + aerosol cooling)

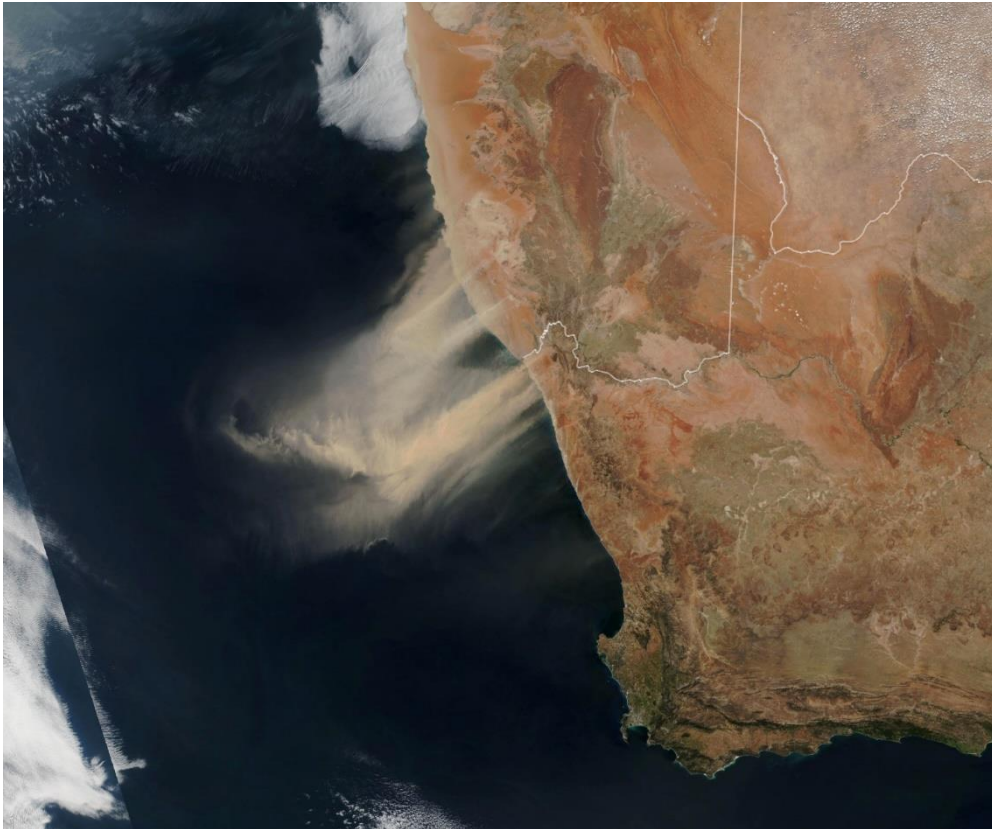


GHGs
+2.83 Wm^{-2}



Globally-relevant aerosol species dominating the regional & global direct radiative perturbation

Mineral dust

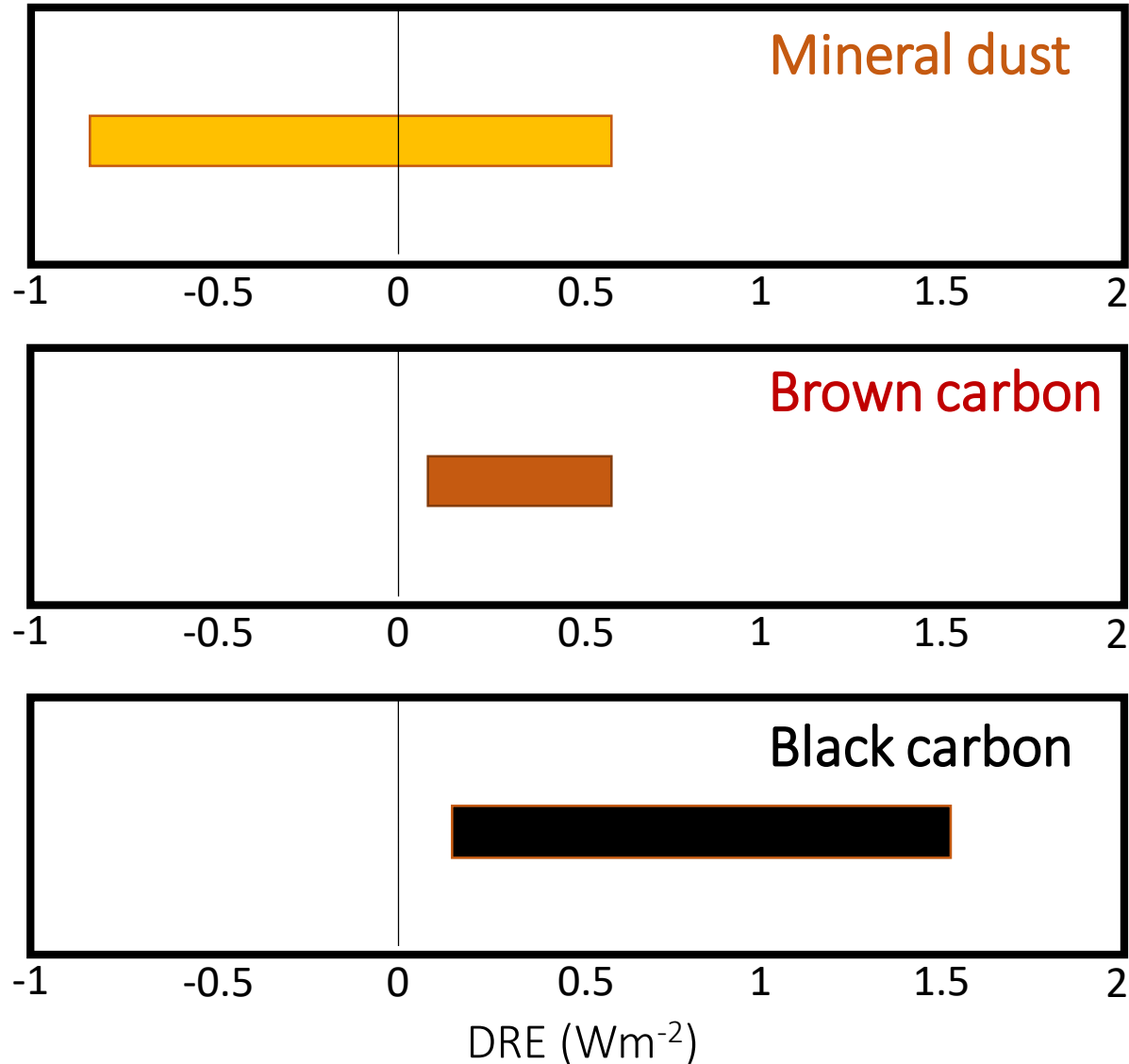


Black and brown carbon



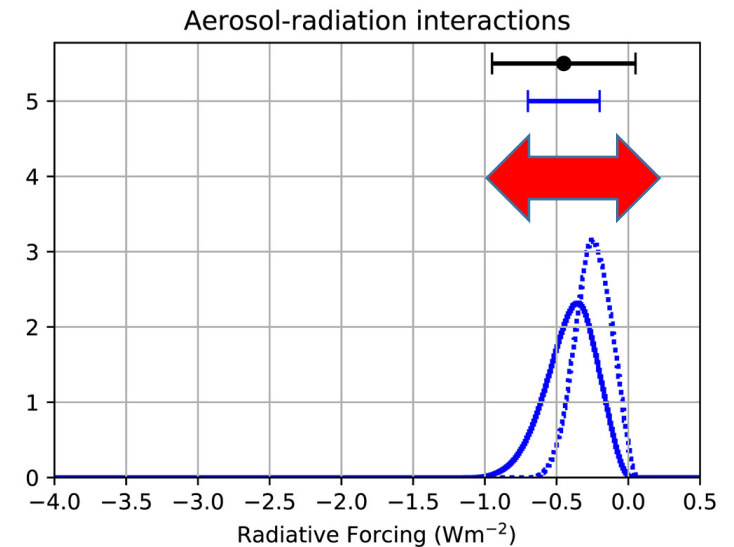
<https://worldview.earthdata.nasa.gov>

Unconstrained aerosol direct radiative effect (DRE) for these light-absorbing aerosol species



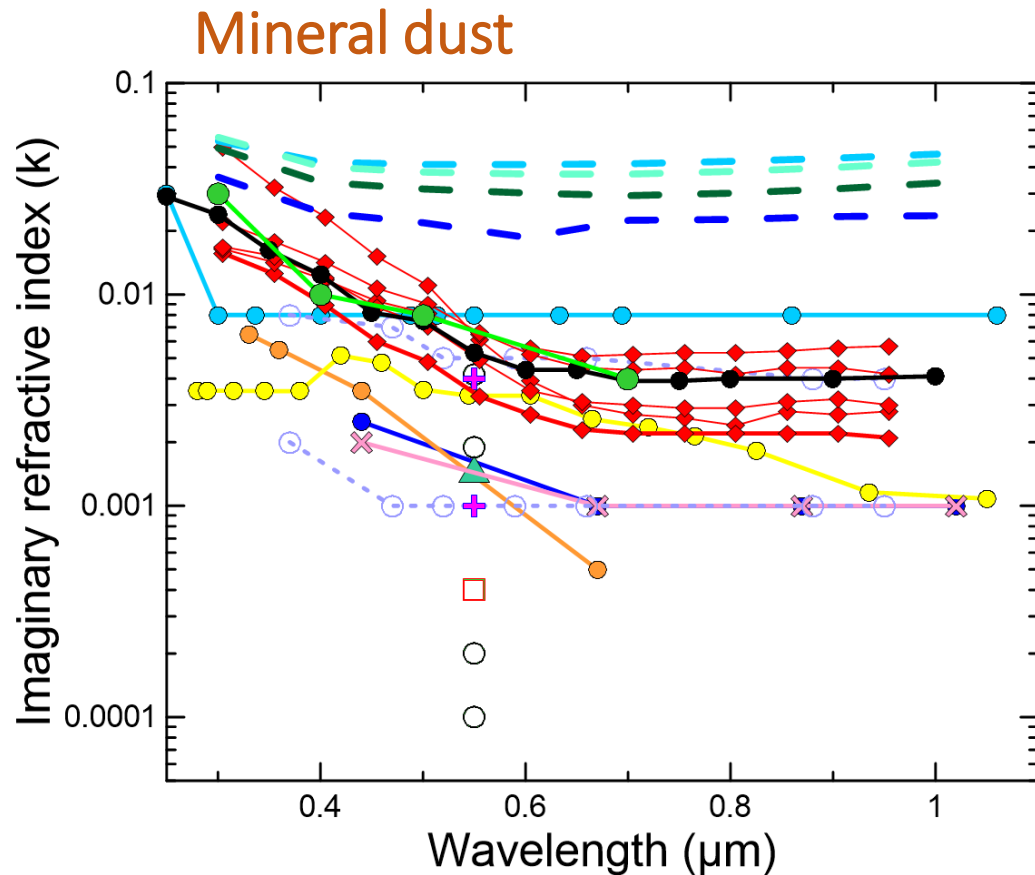
Range of model estimates of the global annual mean DRE at the top of the atmosphere

DRE magnitude (?)
DRE sign (?)

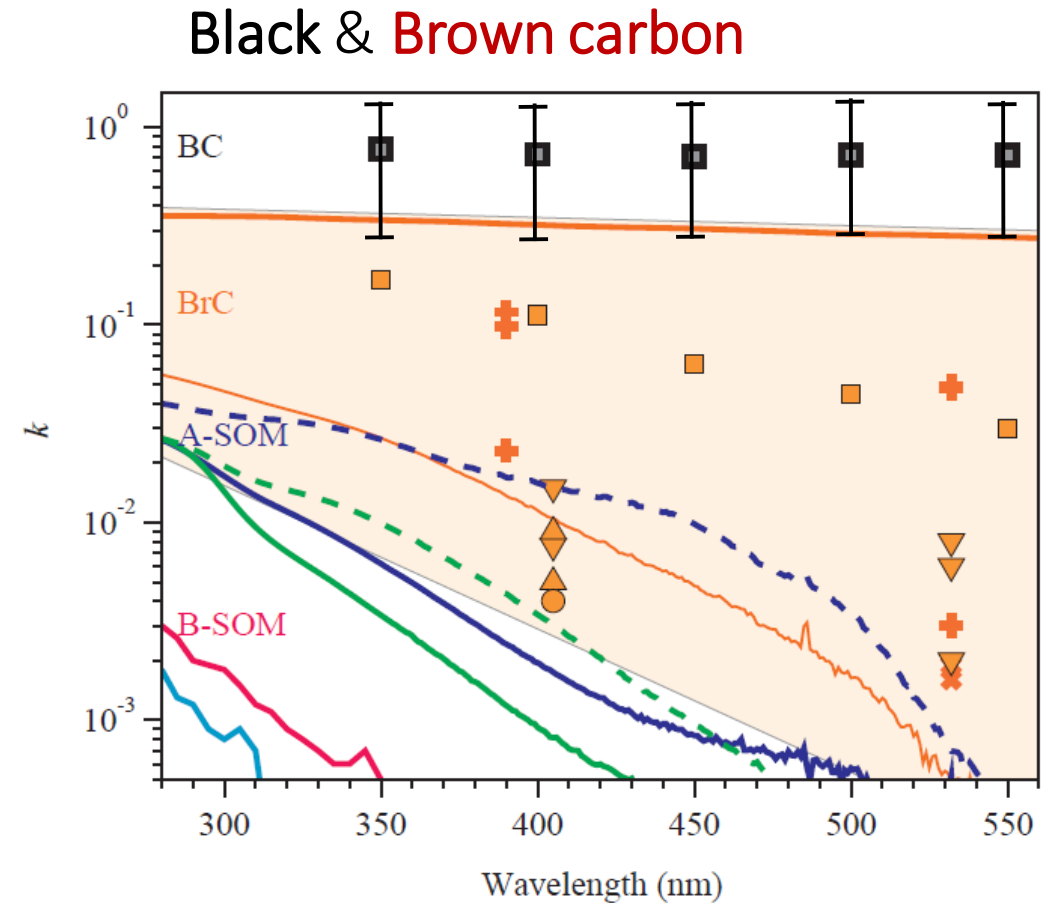


Optical properties contribute to the DRE spread

Complex refractive index (CRI) = $n-ik$

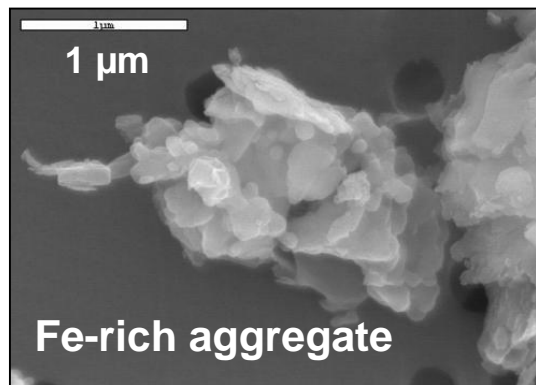


Di Biagio et al., 2019

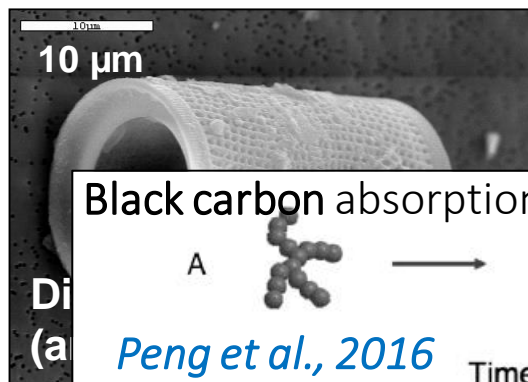


Liu et al., 2015

Dependency on particle composition, size, shape and mixing state, all varying with aerosol source, formation and ageing



Example of two minerals con



SOA from different precursors and oxidants



Laskin et al., 2010

Black carbon absorption increase with coating



Peng et al., 2016

Time (Houston)

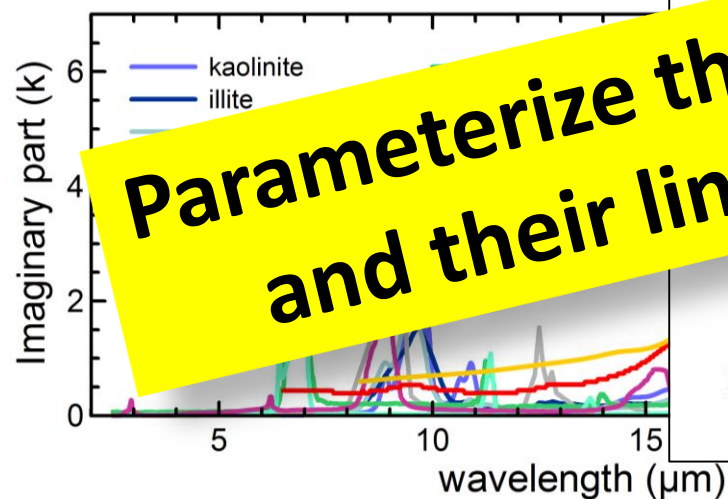
0 9 hr



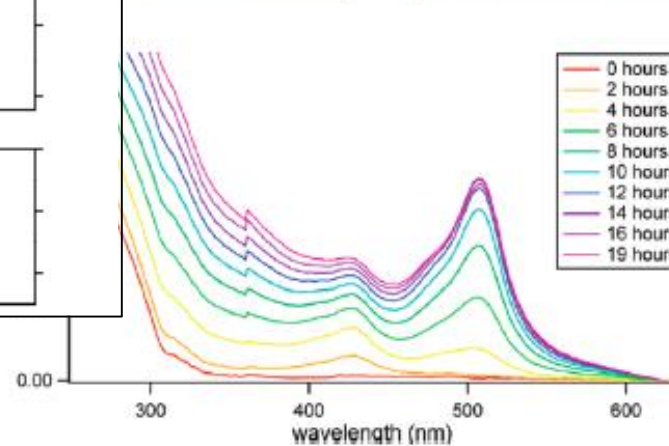
particle shape factor



D Absorption enhancement



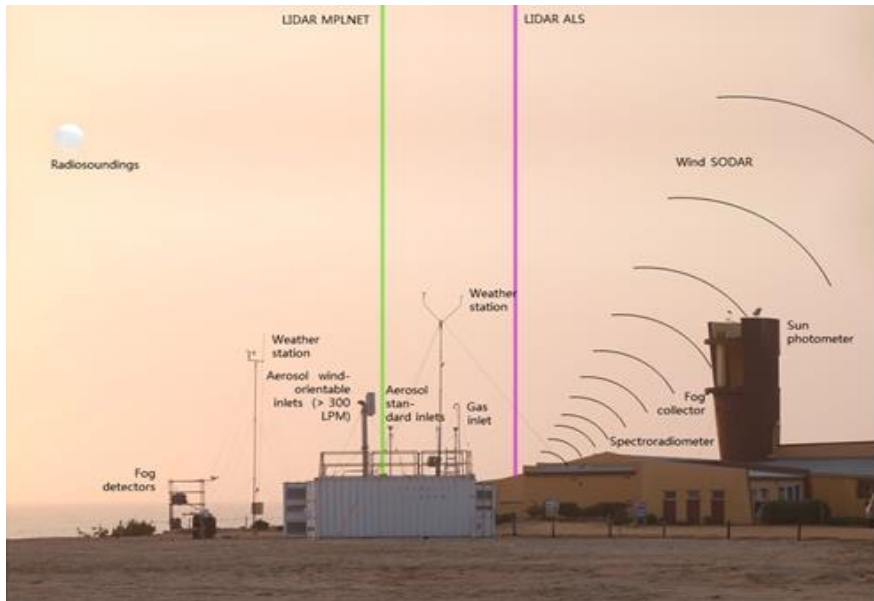
Di Biagio et al., 2014



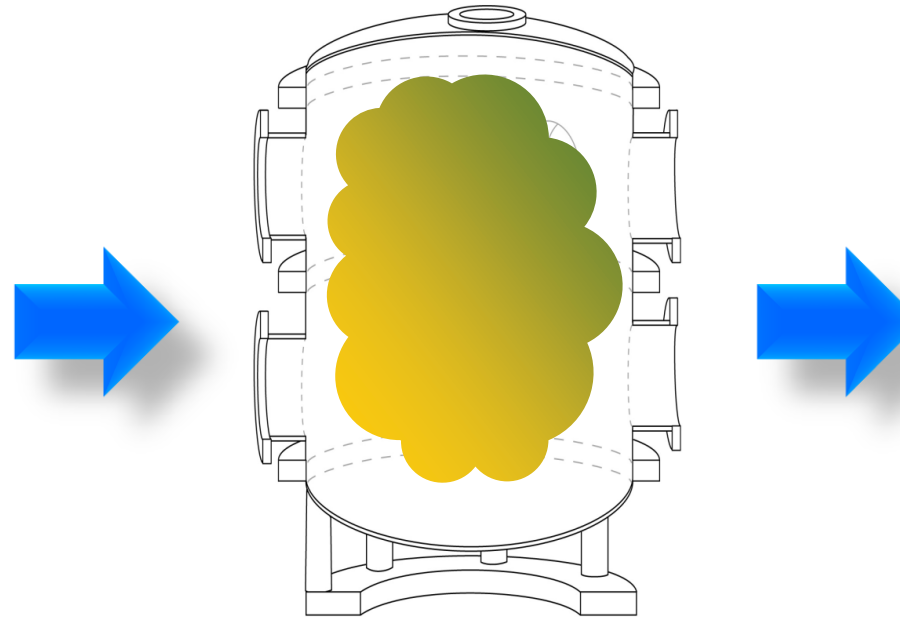
Parameterize the variability of spectral optical properties and their link to the particle physico-chemical state

The simulation chamber approach to elucidate the climate-relevant properties of atmospheric aerosols and their dependence on the particle physico-chemical state

Field information



Chamber investigation



Reproduce in the laboratory the atmospheric complexity (BUT IN A CONTROLLED WAY)

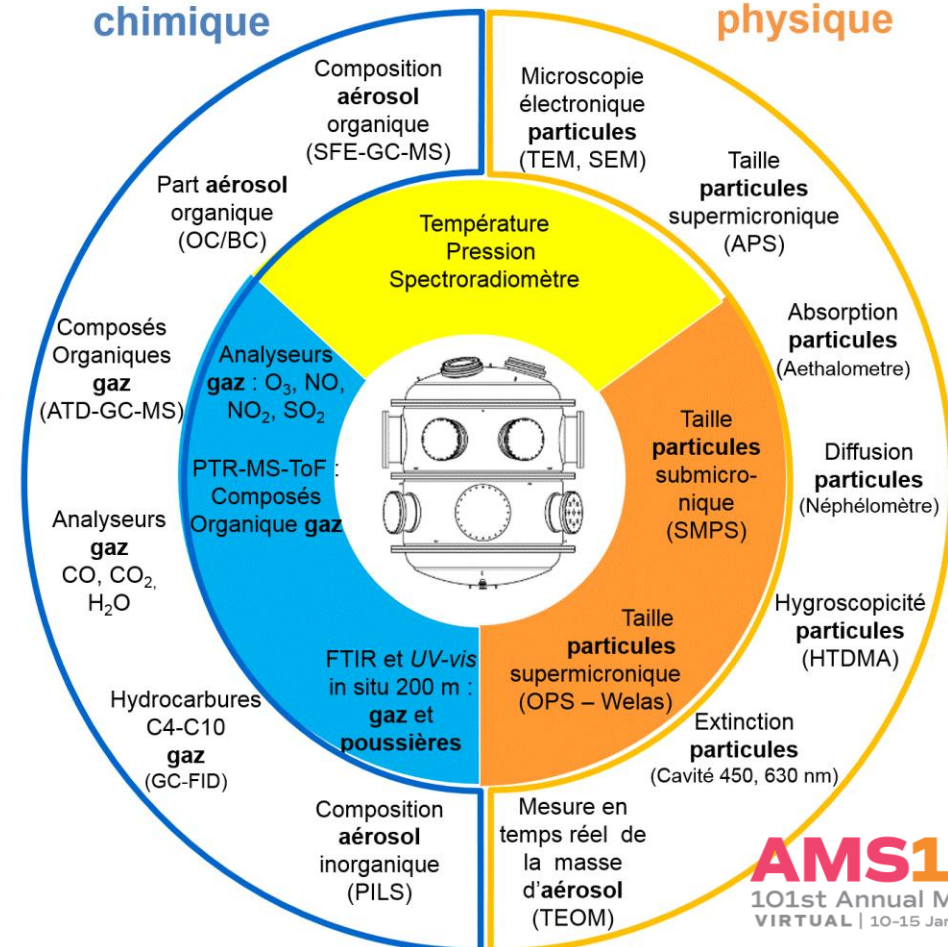
Models
Remote sensing



- Stainless steel, 4.2 m³
- Controlled conditions (RH, T, p, irradiation, gas mixtures)
- >24h aerosol lifetime

Caractérisation chimique

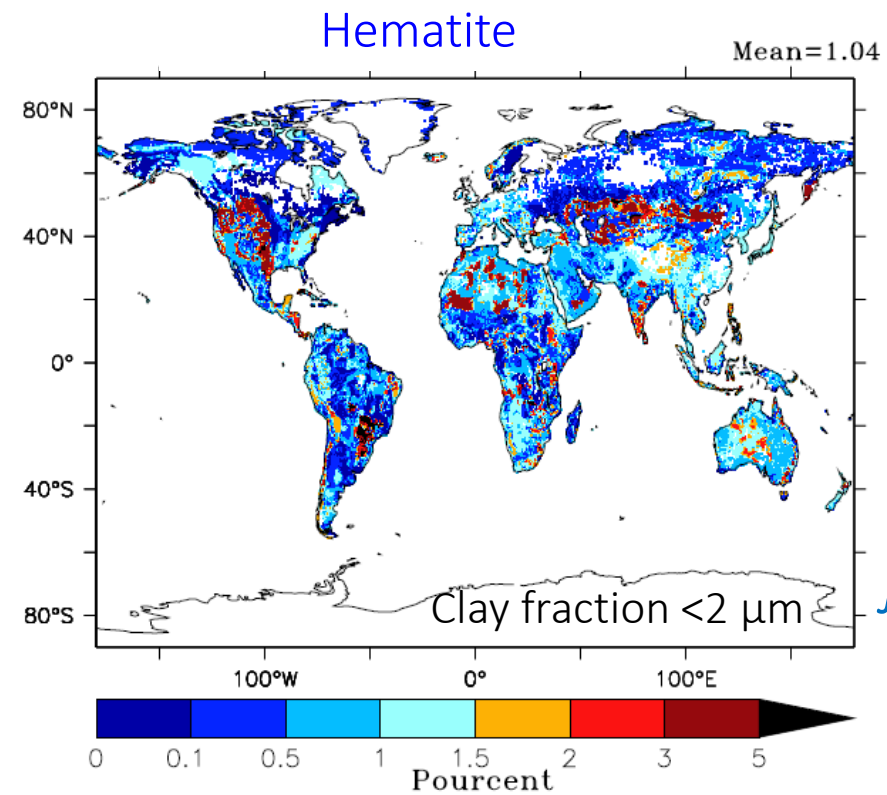
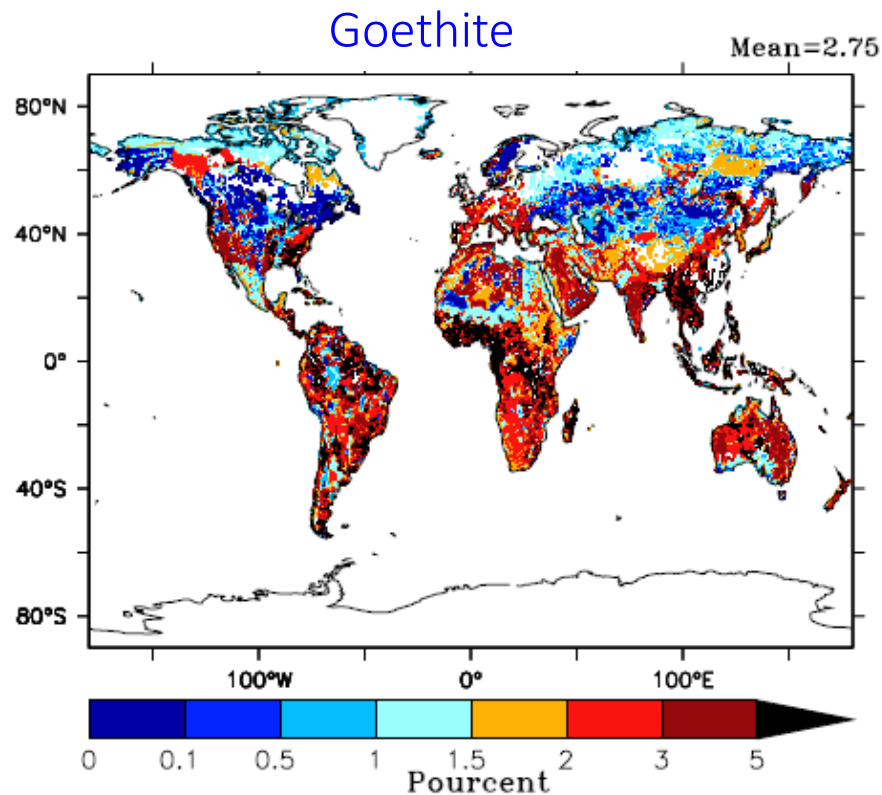
Caractérisation physique



RED-DUST

a laboratory-based project targeting the absorption properties of mineral dust

Representation of the global soil mineralogical composition



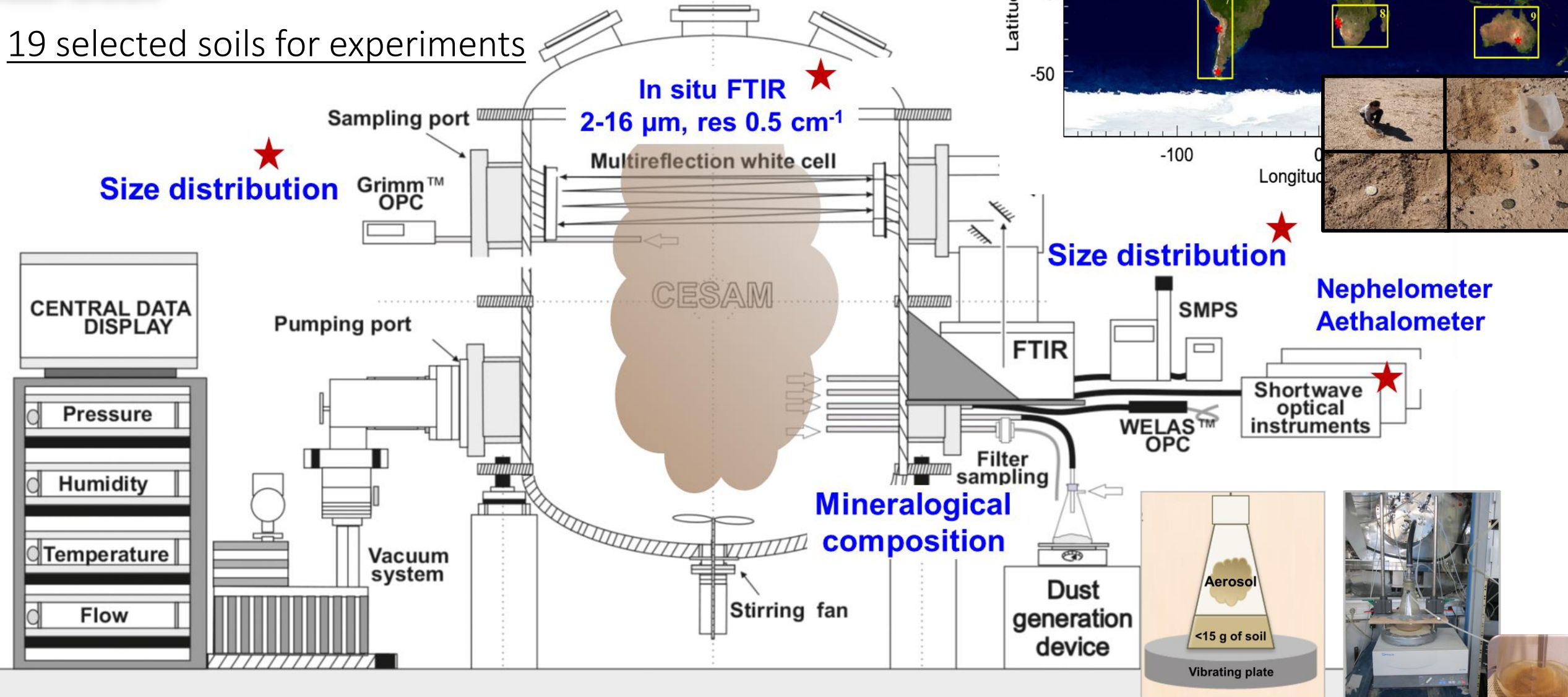
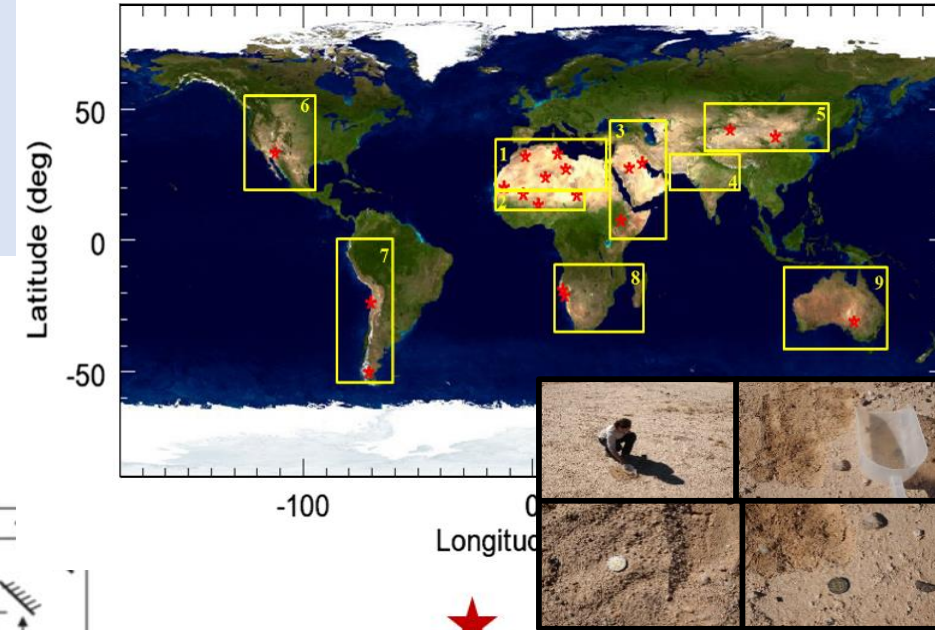
Journet et al., 2014

Global soil mineralogical database

Mineral dust experiments

RED-DUST

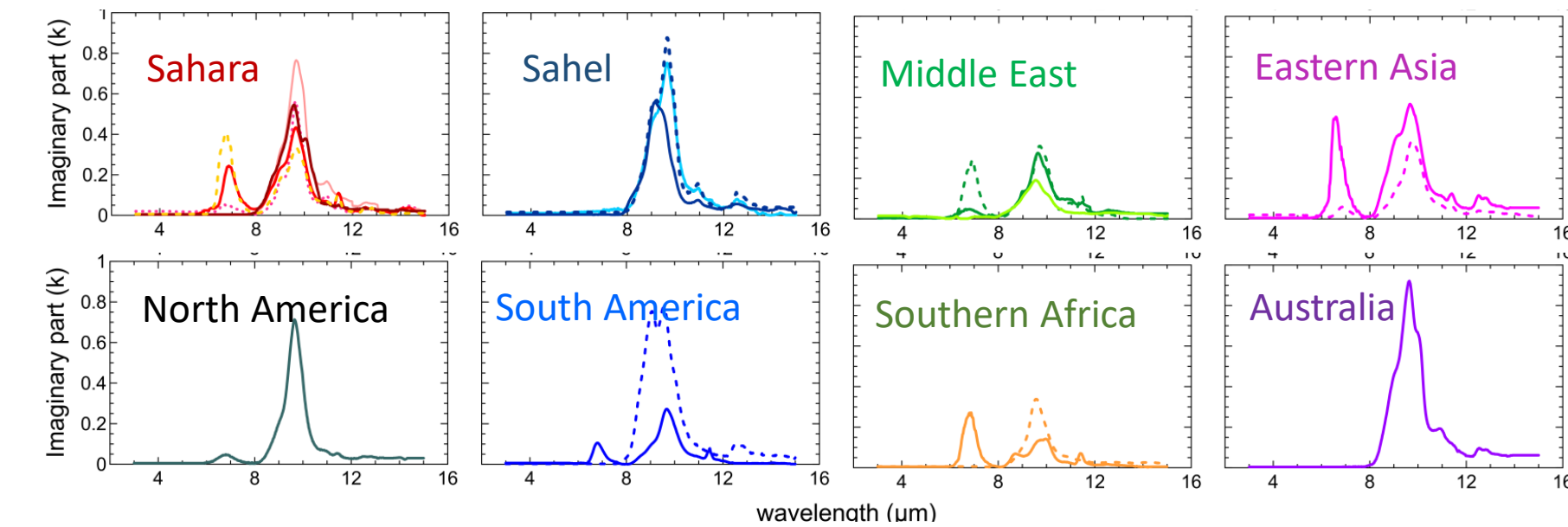
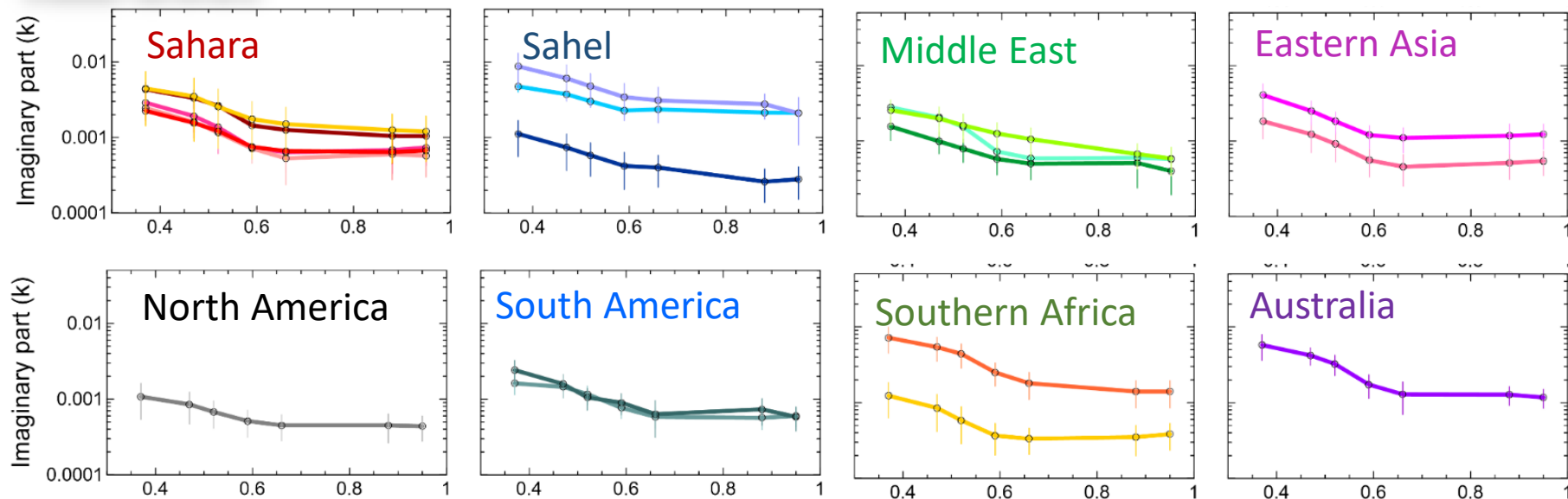
19 selected soils for experiments



The source-dependent complex refractive index for global mineral dust aerosols

RED-DUST

First global dataset of
dust SW and LW CRI

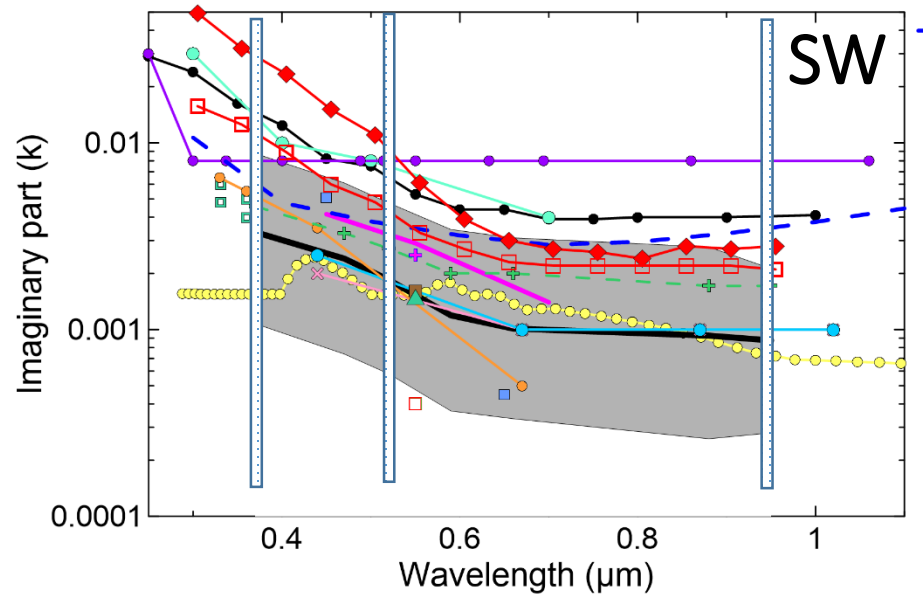


Complex refractive index vs mineral dust mineralogy

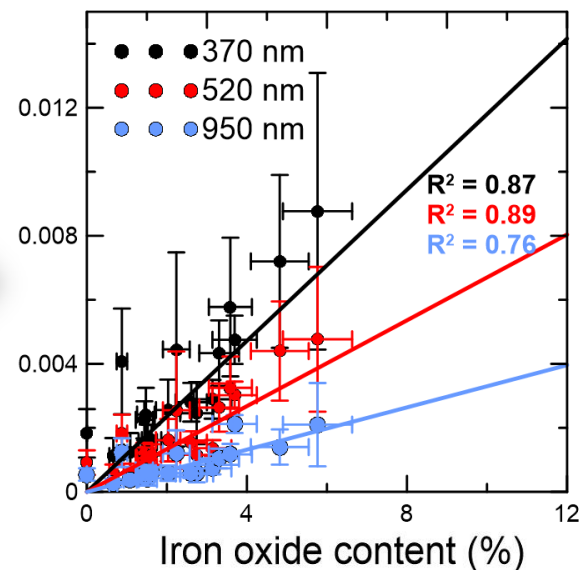
RED-DUST

Di Biagio et al., 2017, 2019

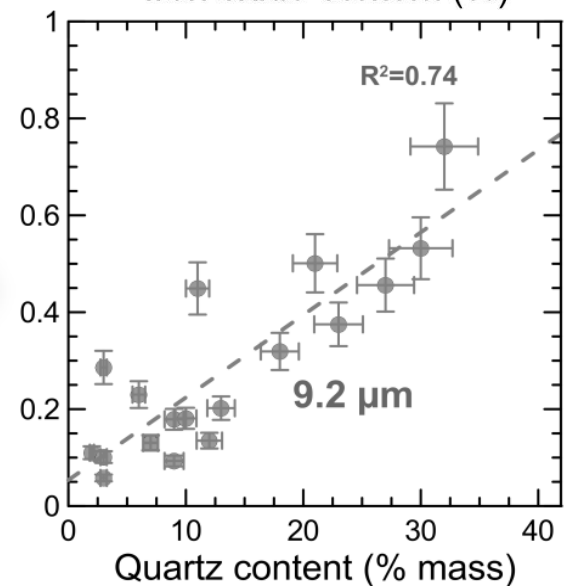
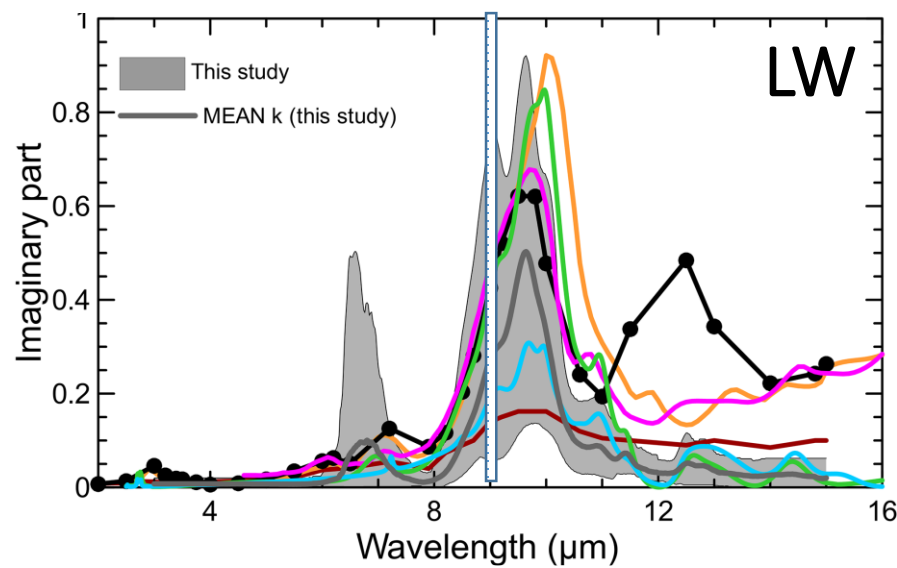
Spectral and mineralogical dependence



Parameterization



Models
Remote sensing



From the chamber to the LMDzOR-INCA global model

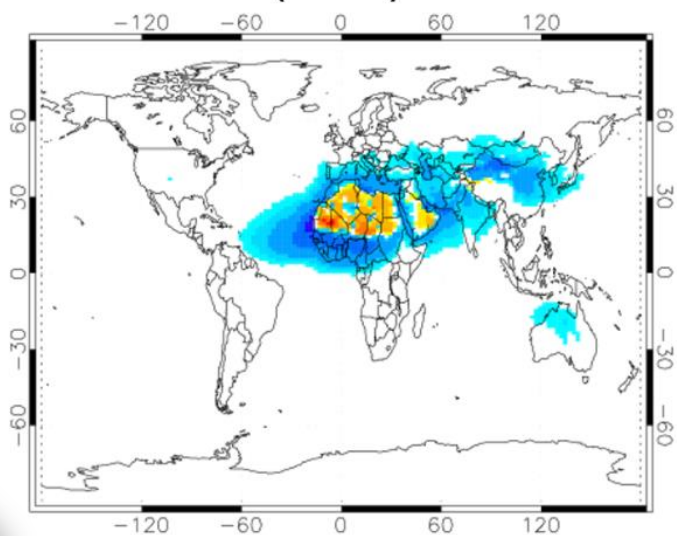
Di Biagio et al., GRL, 2020 **RED-DUST**

Dust CRI
from
CESAM

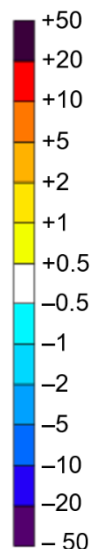
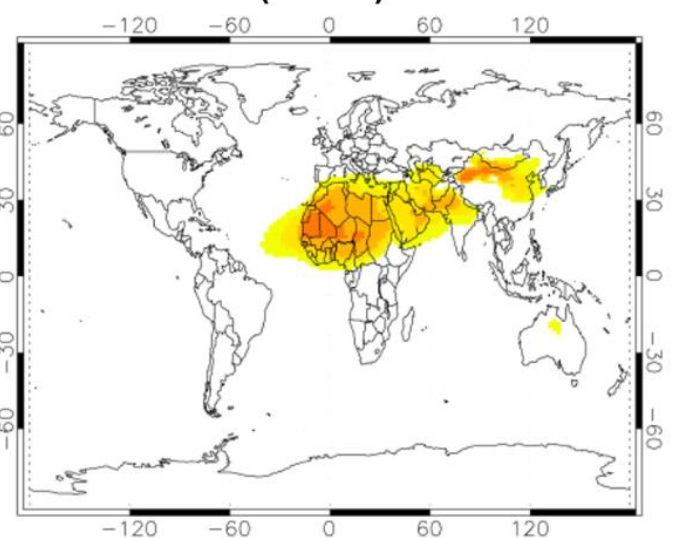


into the
LMDz
global
model

TOA DRE SW ($W m^{-2}$)

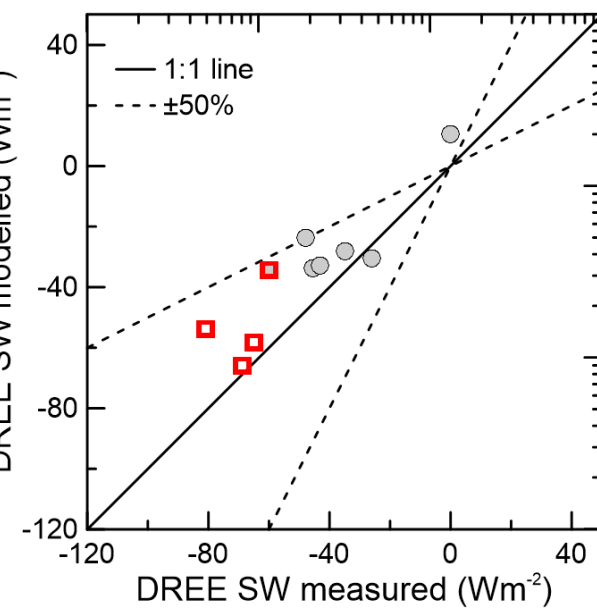
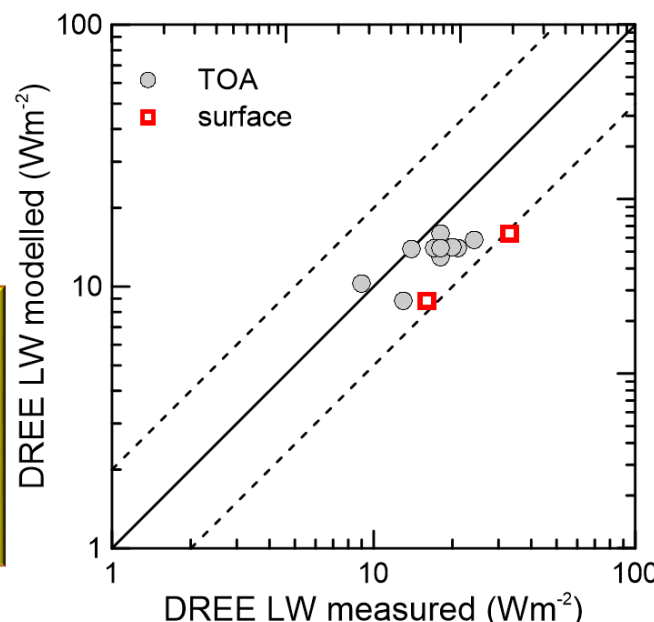
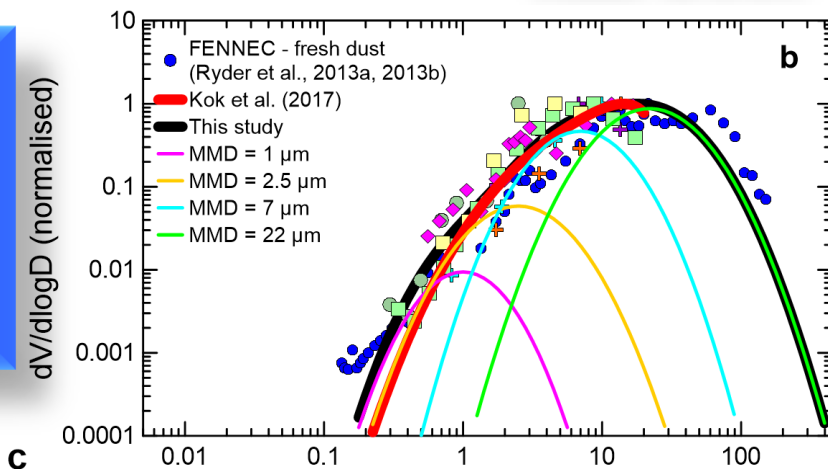


TOA DRE LW ($W m^{-2}$)



- Emitted size distribution fitting observations
- Including $D > 20 \mu m$
- Including LW scattering
- Global AOD matches obs

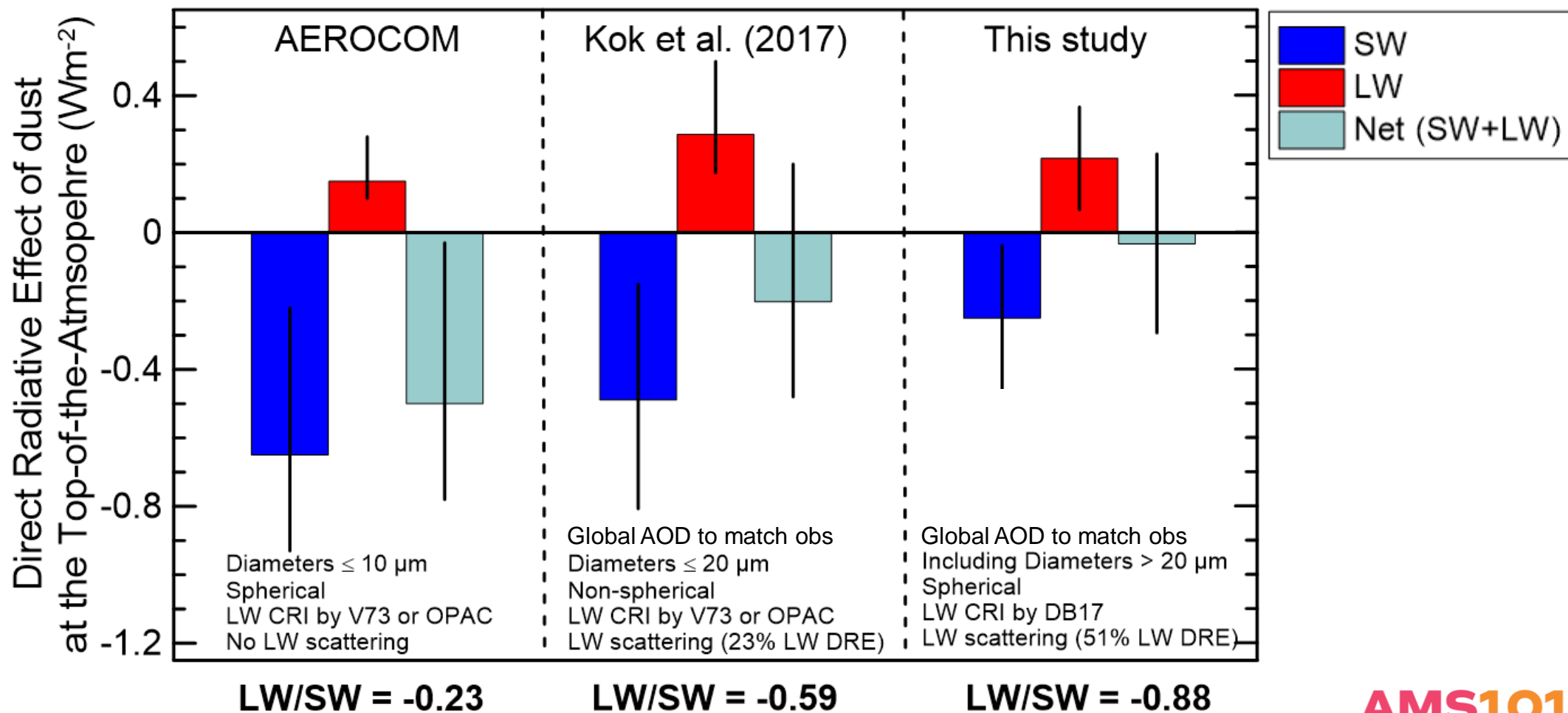
**Agreement
with satellite
retrieved
dust DRE**



From the chamber to the LMDzOR-INCA global model

Di Biagio et al., GRL, 2020 **RED-DUST**

Towards an observationally constrained dust DRE



Dust CRI from CESAM



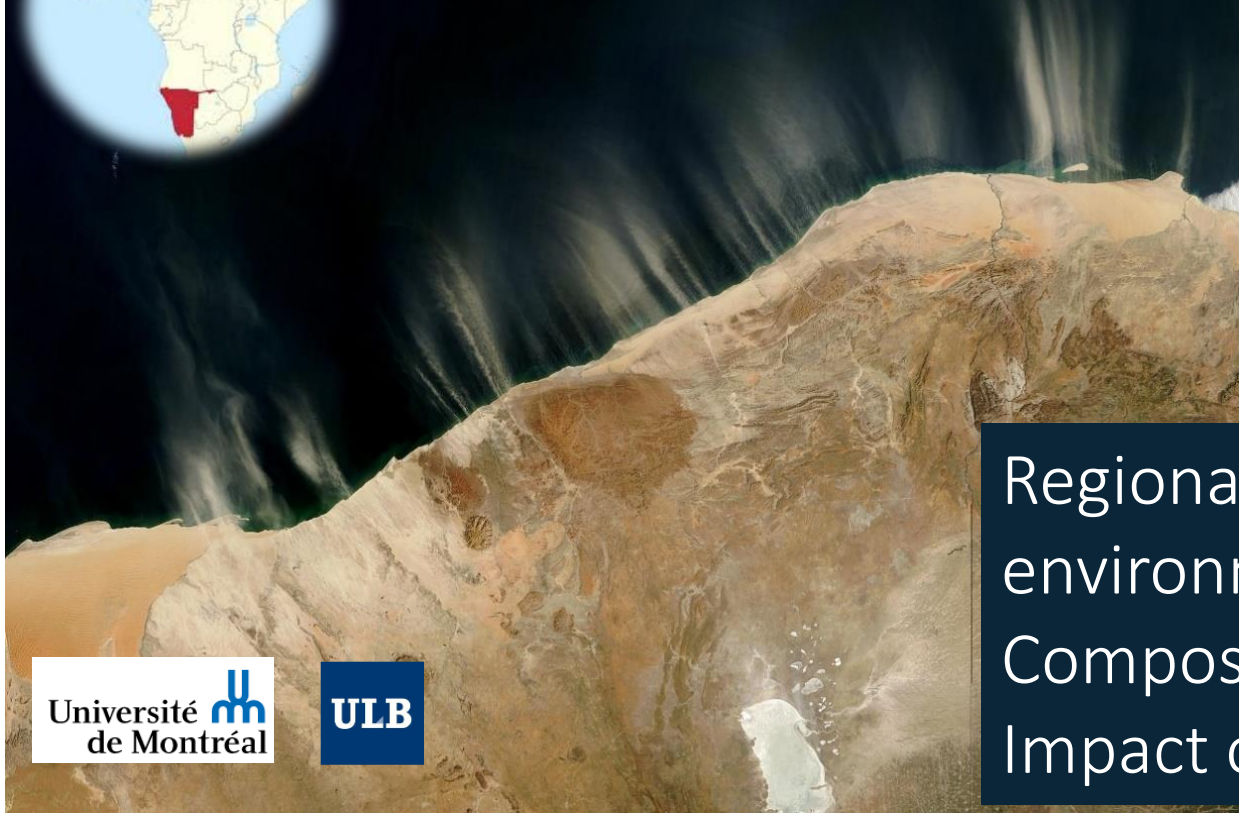
into the LMDz global model

Applying the same strategy to investigate: High-Latitude/Southern Hemisphere dust

Namibian dust

Namibia, the strongest source of dust in southern Africa

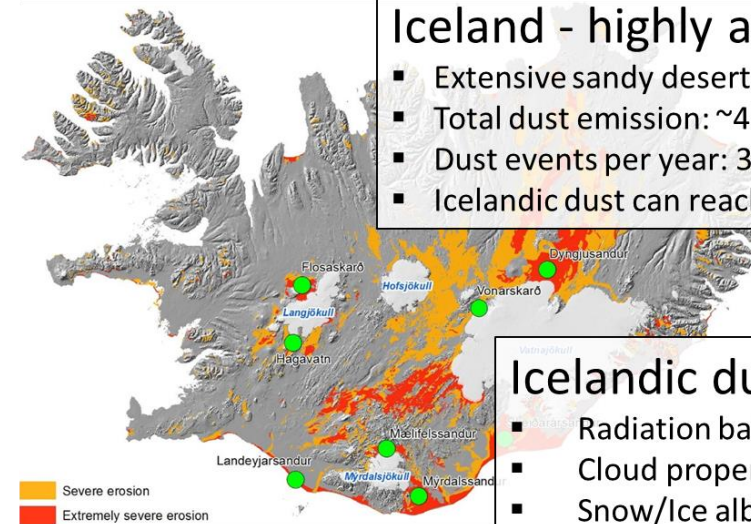
- ~ 5% of global emission (Ginoux et al., 2012)
- Strong mineralogical variability
- Stratification and mixing with biomass burning



Icelandic dust

Iceland - highly active source of dust

- Extensive sandy deserts (22,000 km²)
- Total dust emission: ~4 Tg/yr
- Dust events per year: 30-135
- Icelandic dust can reach Europe and high Arctic



Icelandic dust impacts:

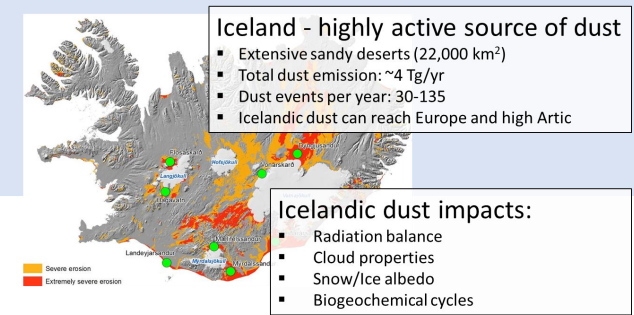
- Radiation balance
- Cloud properties
- Snow/Ice albedo
- Biogeochemical cycles

Regional-scale processes in climate sensitive environments

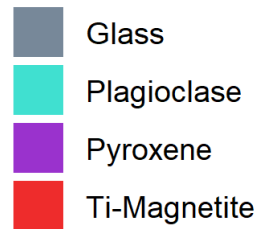
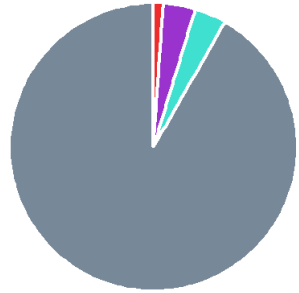
Composition and mineralogy studies

Impact on climate, limited knowledge exists

Icelandic dust experiments



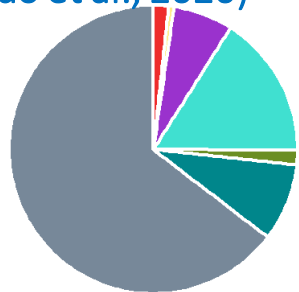
A. MIR45
(Baldo et al., 2020)



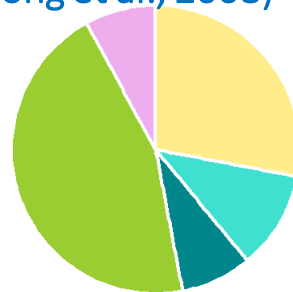
C. African desert dust
(Shi et al., 2011)



B. Land1
(Baldo et al., 2020)



D. Asian dust
(Jeong et al., 2008)



- Pl (Anorthite) and Px (Augite) - main minerals
- Glass fraction 60-90 wt%
- Magnetite 1-2 wt%
- Low degree of chemical weathering with low FeD (Hematite+Goethite) and amorphous Fe



Our results reveal the fundamental differences in composition and mineralogy of Icelandic dust from low latitude dust

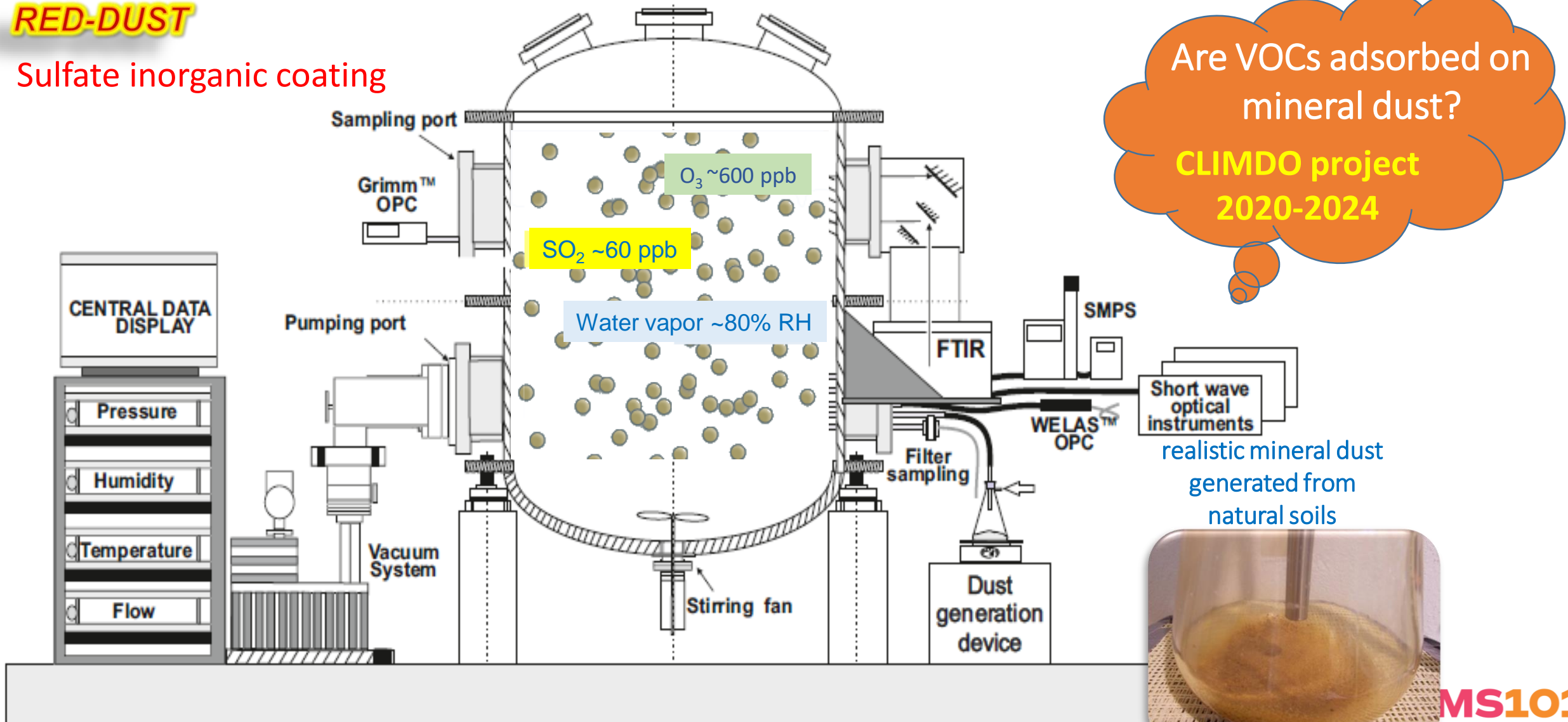


Analysing the impact on spectral SW and LW optical properties

Which is the impact of chemical ageing on dust properties?

RED-DUST

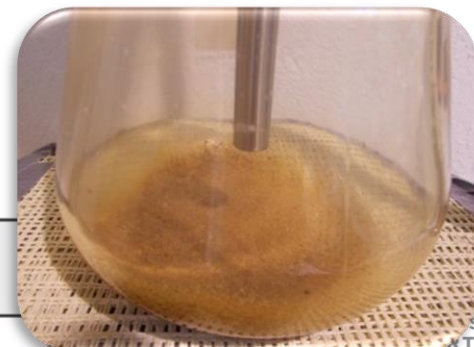
Sulfate inorganic coating



Are VOCs adsorbed on mineral dust?

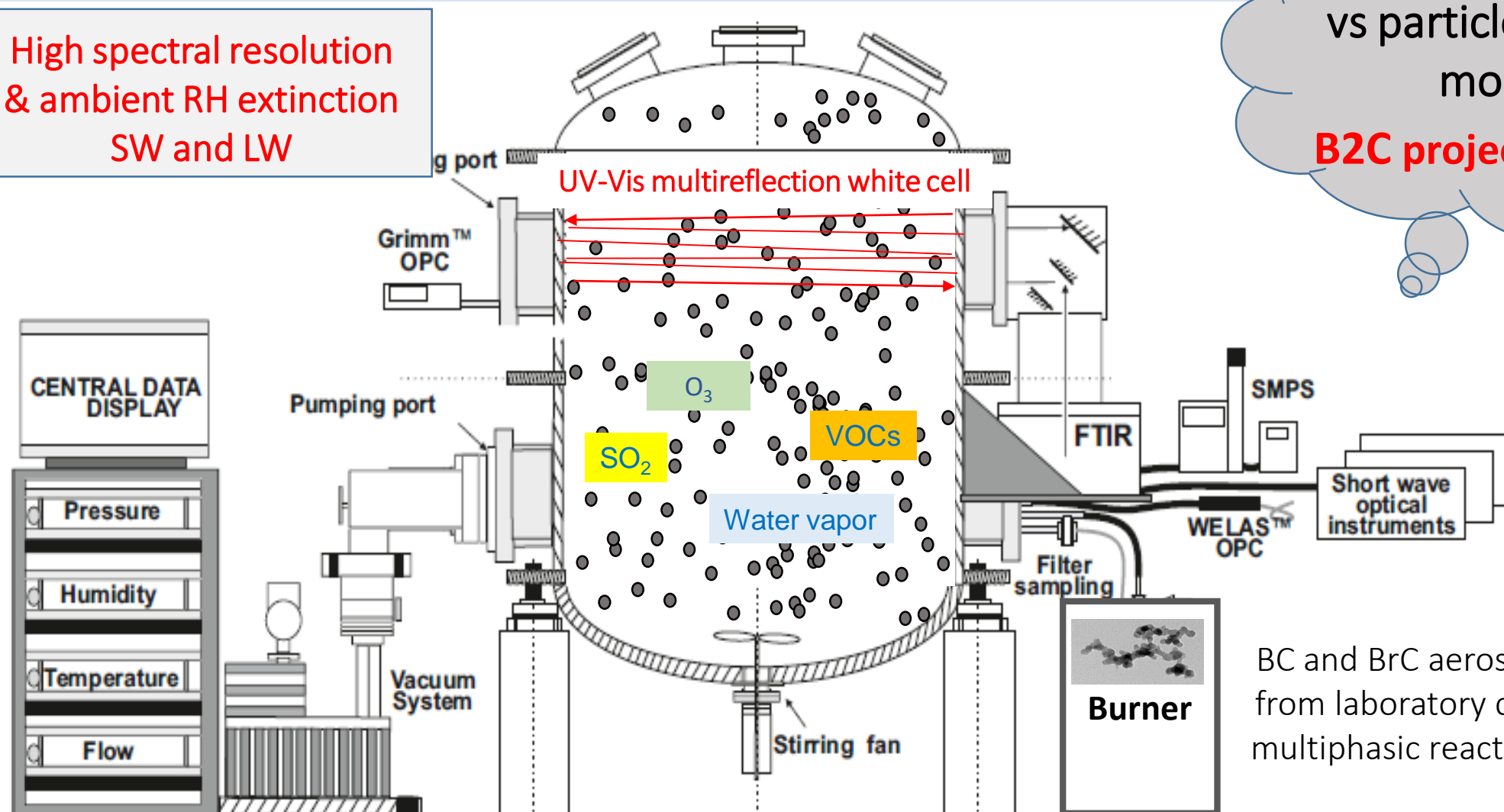
CLIMDO project
2020-2024

realistic mineral dust
generated from
natural soils



Black and brown carbon experiments

High spectral resolution
& ambient RH extinction
SW and LW



BC and BrC optical properties
vs particle chemistry and
morphology?

B2C project 2020-2024

BC and BrC aerosols generated
from laboratory combustion or
multiphase reactions in CESAM

Take home messages

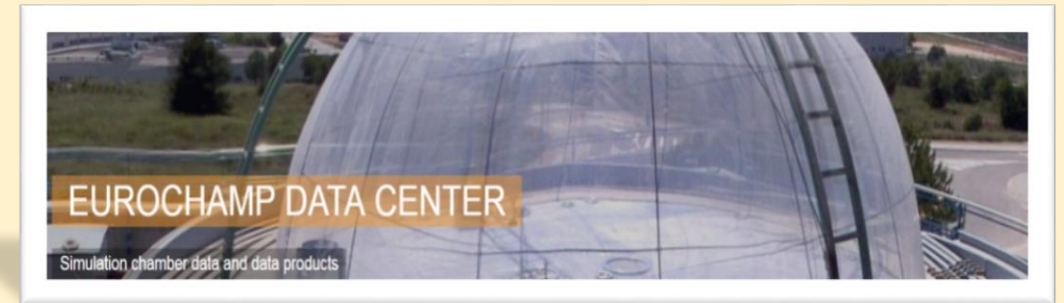
Simulation chambers are powerful tools to investigate aerosol properties: they help to interpret field data and to make the link between spectral optical properties and aerosol composition/aging to provide parameterizations to climate models and remote sensing

Eurochamp-2020 – Network of European chambers (www.eurochamp.org)



Trans-national access (TNA)
to 16 chambers and 4
calibration centers

« *Remote access* »
innovation in response to
the COVID crisis



Data center providing open access to experimental data & advanced analytical resources including aerosol climate-relevant properties, SSA, CRI, MAC, MEC...



Apply for TNA

Several projects on mineral dust, BC and BrC aerosols