Size distribution of emitted dust in Morocco

Cristina González-Flórez [1], Martina Klose [2], Andrés Alastuey [3], Sylvain Dupont [4], Vic Etyemezian [5], Adolfo González-Romero [1,3], Konrad Kandler [6], George Nikolich [5], Marco Pandolfi [3], Agnesh Panta [6], Xavier Querol [3], Cristina Reche [3], Jesús Yus-Díez [3,7], and Carlos Pérez García-Pando [1,8]

(1) Barcelona Supercomputing Center (BSC), Barcelona, Spain
(2) Karlsruhe Institute of Technology (KIT), Institute of Meteorology and Climate Research (IMK-TRO)
(3) Institute of Environmental Assessment and Water Research (IDAEA-CSIC), Barcelona, Spain
(4) INRAE, Bordeaux Sciences Agro, ISPA, F-33140 Villenave d'Ornon, France
(5) Desert Research Institute, Las Vegas, NV, USA
(6) Technical University of Darmstadt (TUDa), Darmstadt, Germany
(7) Universitat de Barcelona (UB), Departament de Física Aplicada, Grup de Meteorologia, C/Martí i Franquès, 1,08028, Barcelona, Spain
(8) Catalan Institution for Research and Advanced Studies (ICREA), Barcelona, Spain

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Atmospheric Mineral Dust Emission

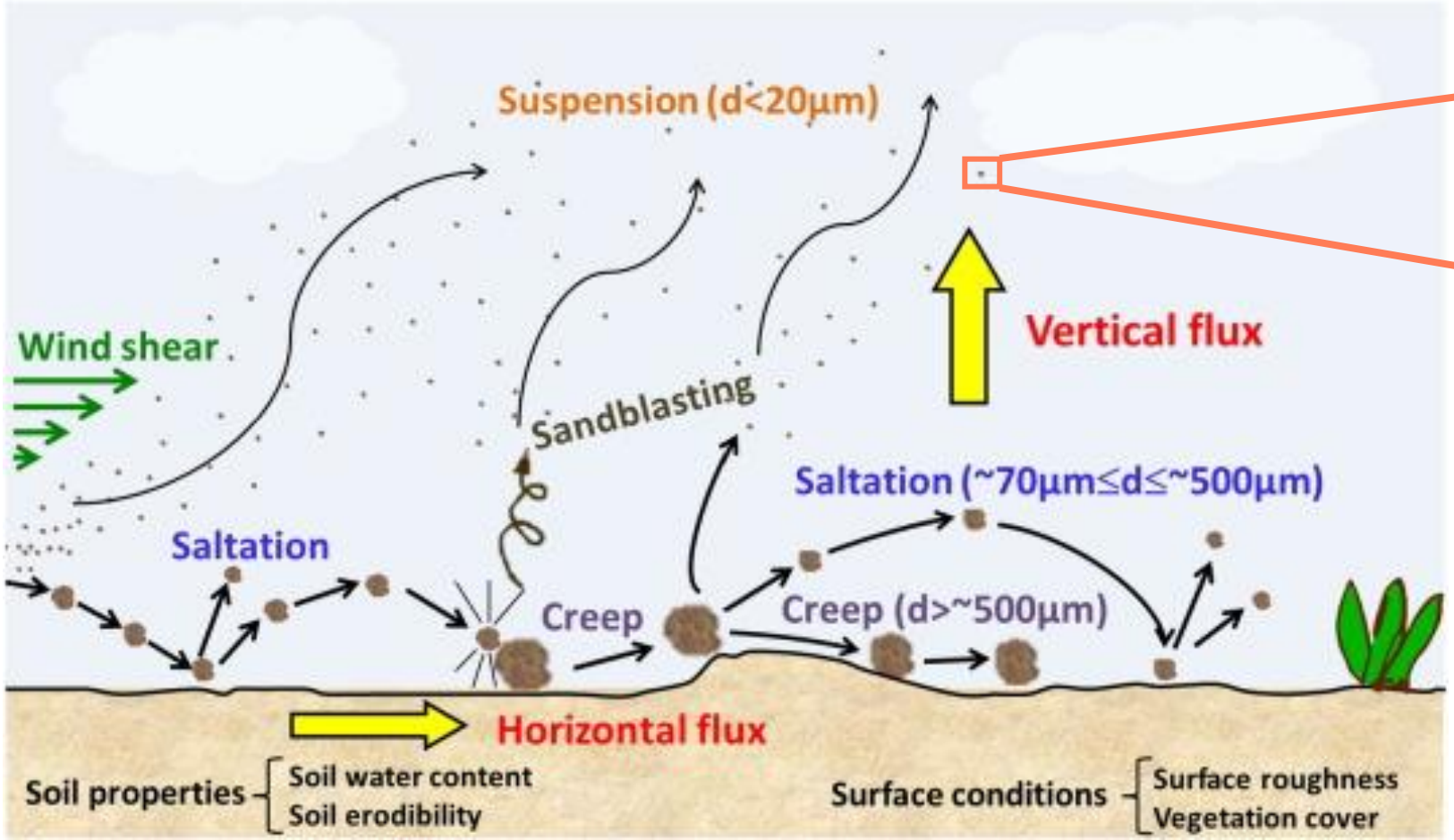
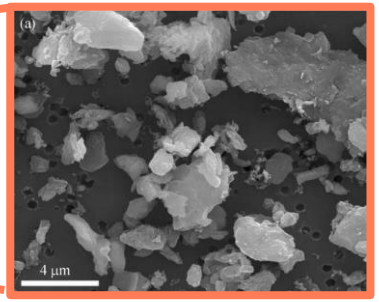


Image credit: modified from Gherboudj et al., 2016

Particle Size Distribution (PSD)



- Atmospheric mineral dust is the most important aerosol by mass and a key player in the Earth system.
- Dust PSD at emission is a key parameter for modelling its atmospheric cycle and estimate its climate forcing.

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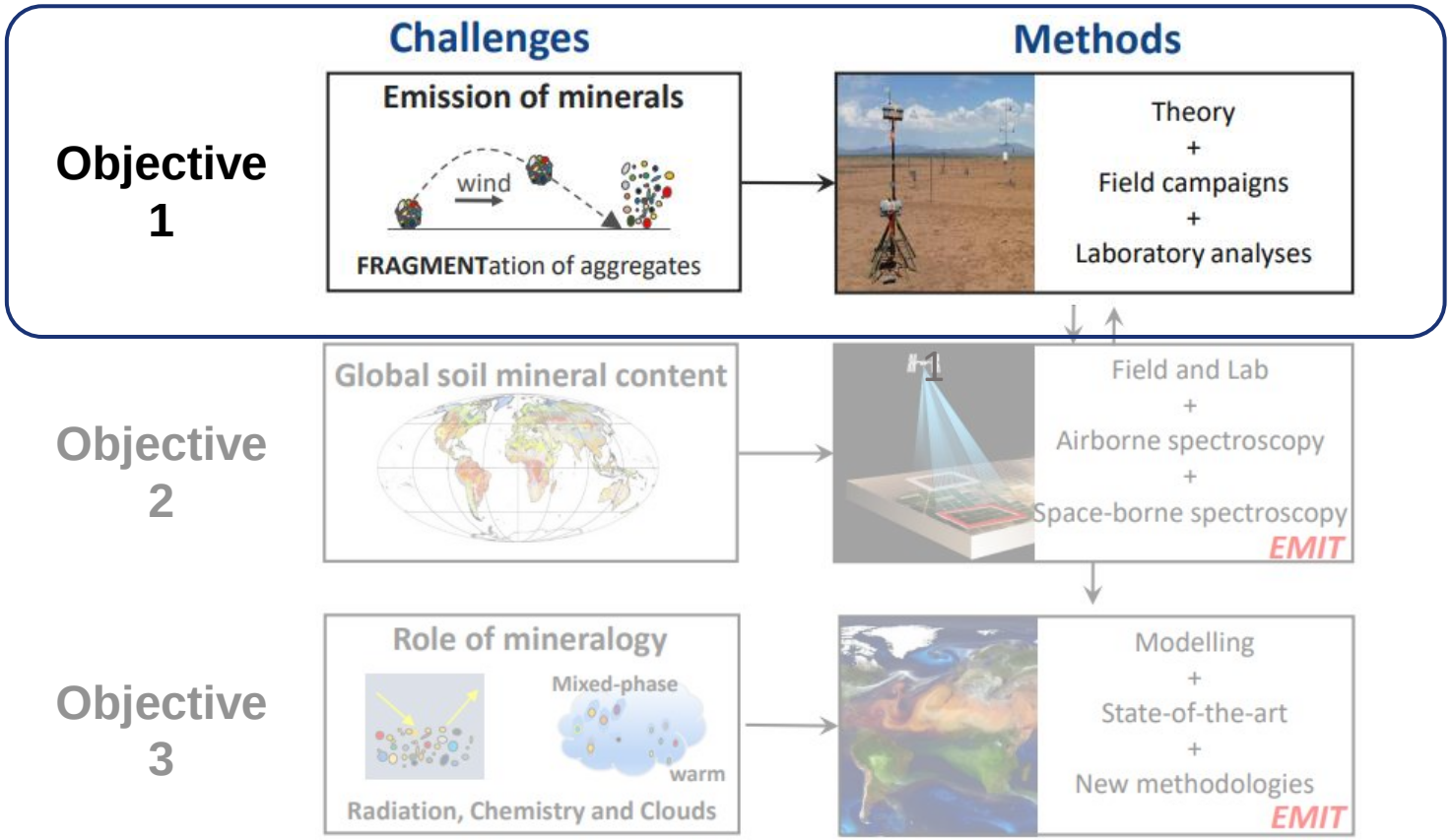

Image credit: C. Pérez García-Pando (PI of FRAGMENT)

Host institution:

Barcelona Supercomputing Center
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Partner institutions:

CSIC
Consejo Superior de Investigaciones Científicas

Technische Universität Darmstadt

Other collaborators:

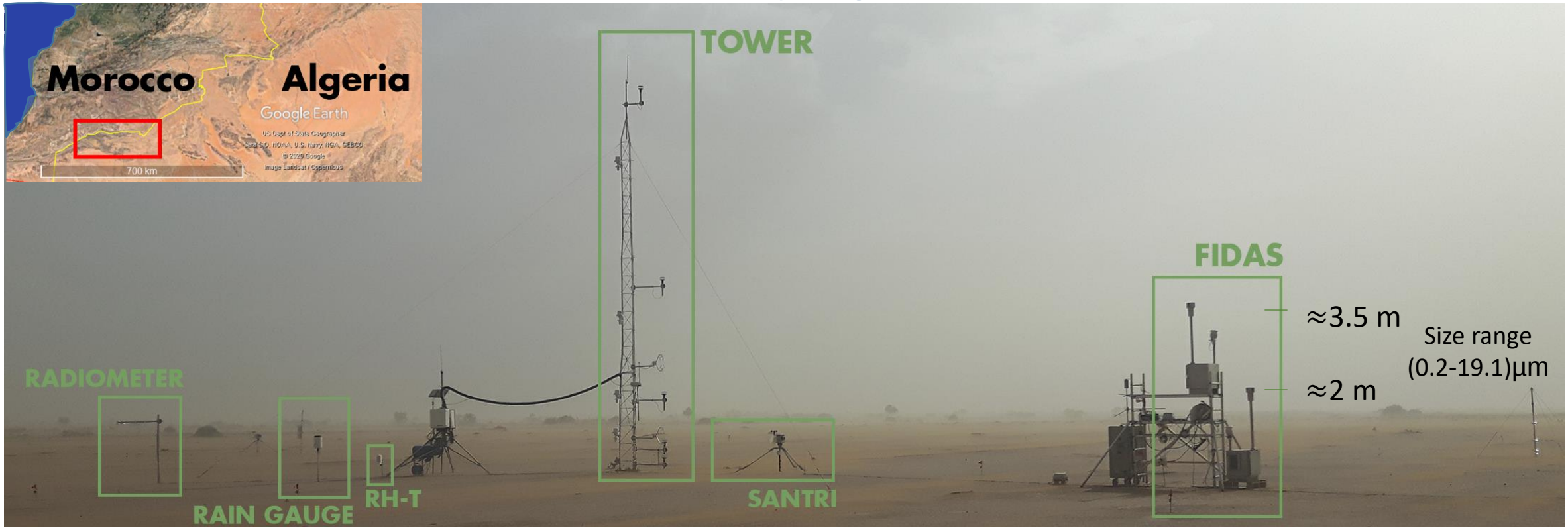
NASA

Caltech

JPL Jet Propulsion Laboratory California Institute of Technology

Marrakech Université Cadi Ayyad

Measurement field campaign in Morocco (2019)



u_*: Friction velocity z_0: Roughness length
L: Obukhov length κ: Von Karman constant
ψ_m: Correction for atmospheric stability
$F_d(D_i)$: Size segregated diffusive flux
c_u: Upper fidas concentrations
c_l: Lower fidas concentrations

$u_*, z_0, L \rightarrow$ **Law of the wall method**

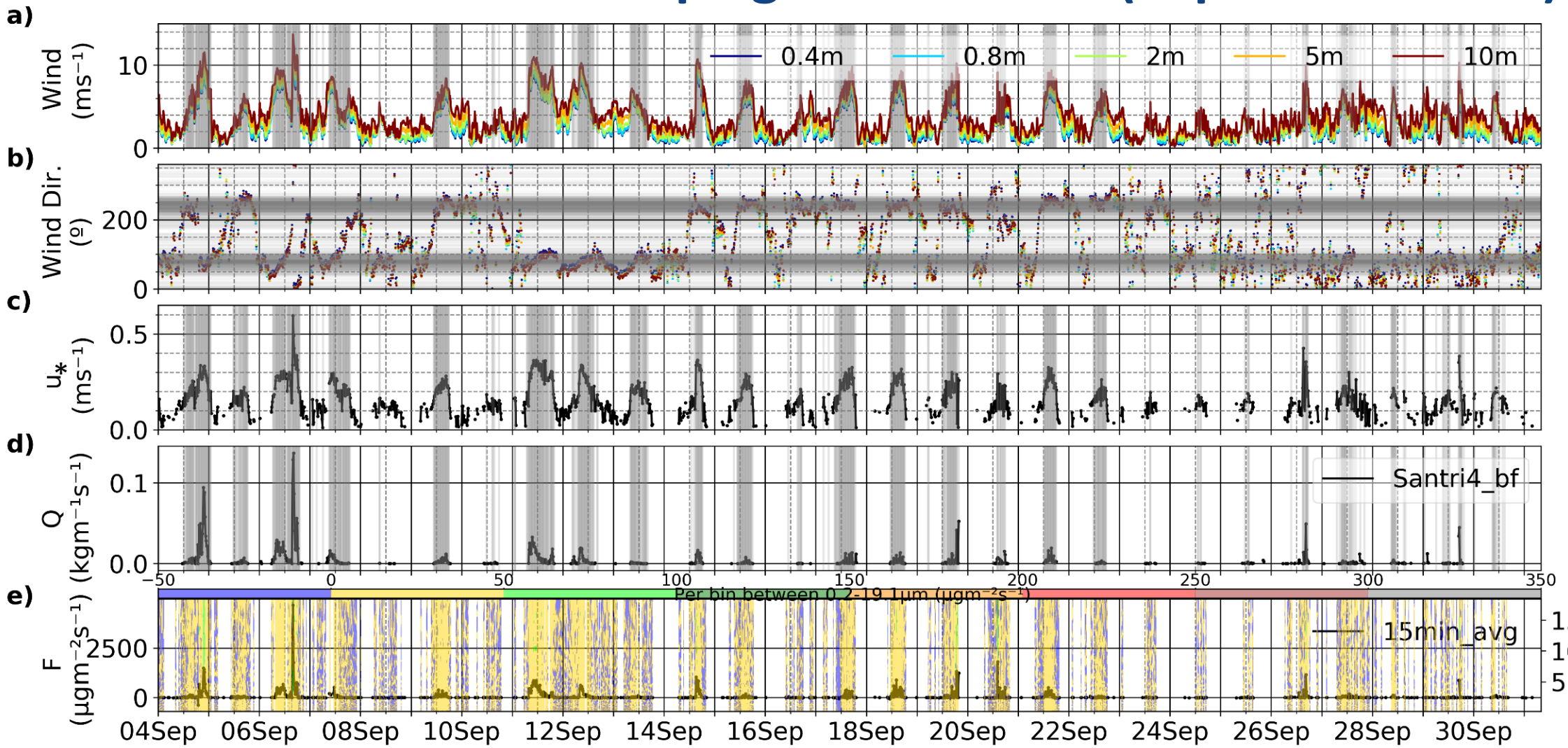
$$\bar{U}(z) = \frac{u_*}{\kappa}\kappa\left[\ln\left(\frac{z}{z_0}\right) - \psi_m\left(\frac{z}{L}\right) + \psi_m\left(\frac{z_0}{L}\right)\right]$$

$F_d(D_i) \rightarrow$ **Gradient method**

$$F_d(D_i) = u_*\kappa\frac{c_u(D_i) - c_l(D_i)}{\ln\left(\frac{z_u}{z_l}\right) - \psi_m\left(\frac{z_u}{z_l}\right) + \psi_m\left(\frac{z_l}{z_l}\right)}$$

(Sow et al., 2009; Ishizuka et al., 2014; Khalfallah et al., 2020; Dupont et al., 2021)

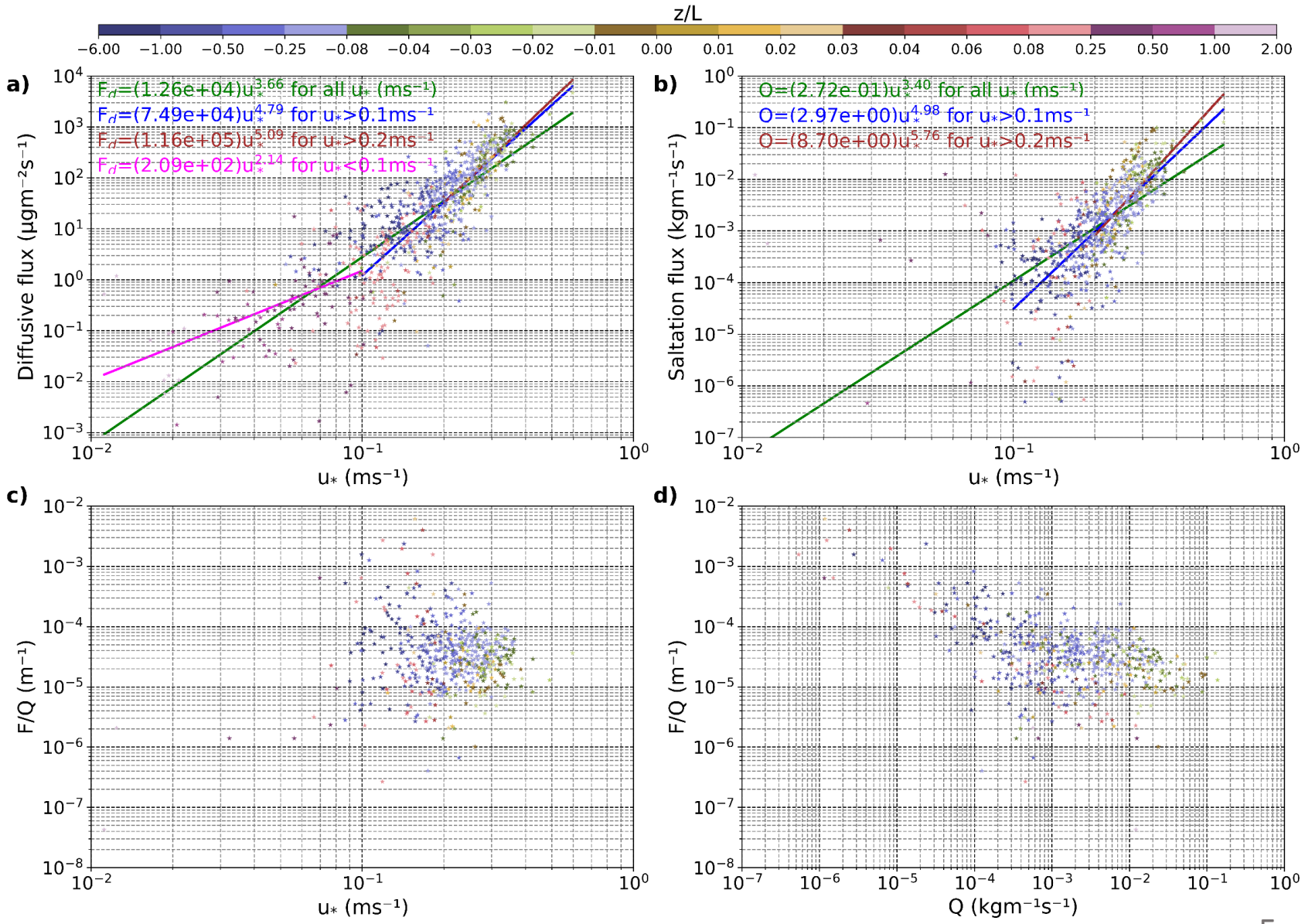
Overview of the campaign in Morocco (September 2019)



Periods in which $u_* > 0.15$ ms^{-1}

Dust emission assessment

- Saltation was quite frequent but sandblasting efficiency was not so high compared to the literature due to the soil type (paved sediment).
- Highest F and Q values correspond to more unstable and close to neutrality conditions.
- F and Q increase with u_*. $\mathrm{F} \propto u_*^{3.66}$ and $\mathrm{Q} \propto u_*^{3.40}$.
- F/Q seems rather independent of u_*.
- F/Q appears rather independent of Q for $\mathrm{Q} > 10^{-4}\ \mathrm{kgm^{-1}s^{-1}}$.



Wind directions

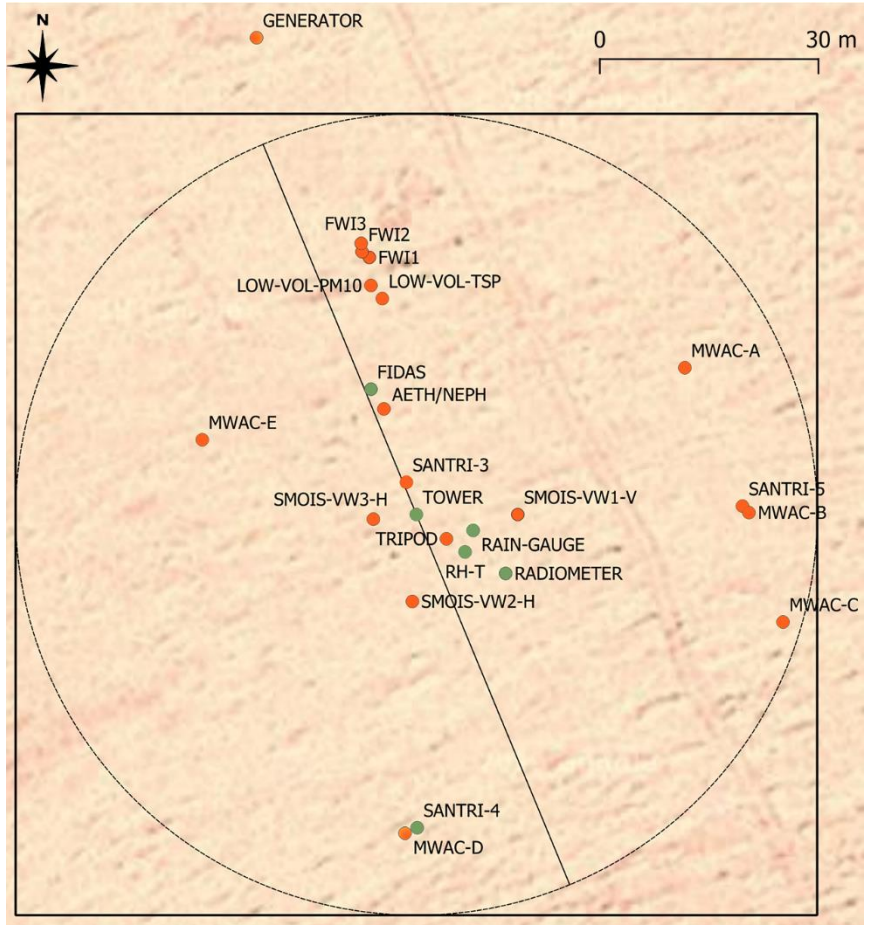
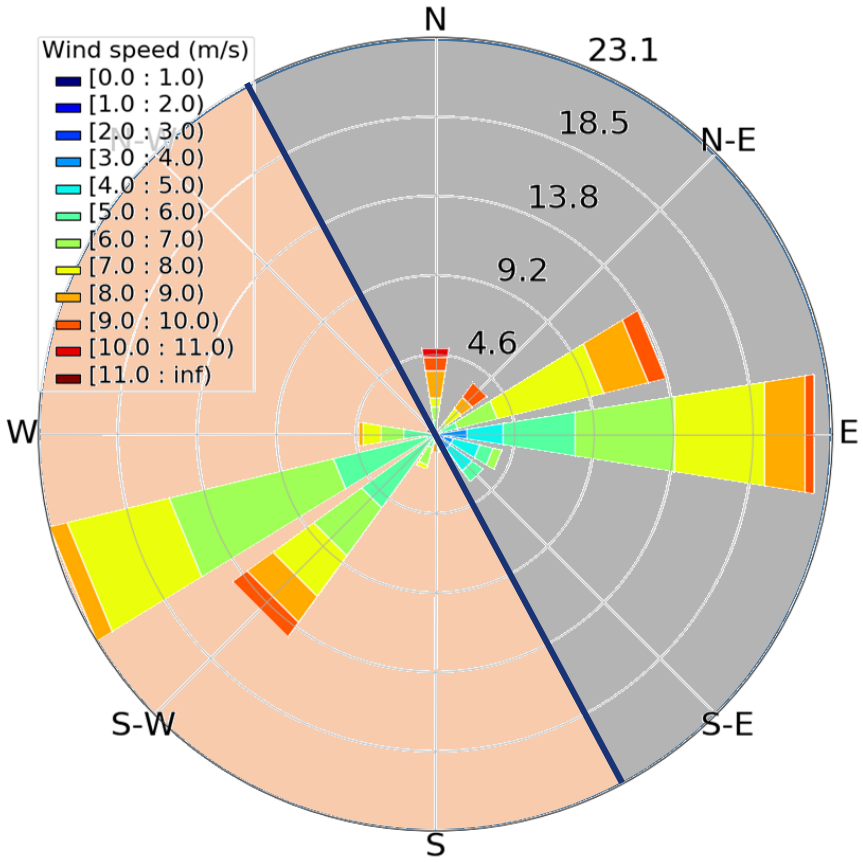


Image credit: M.Klose

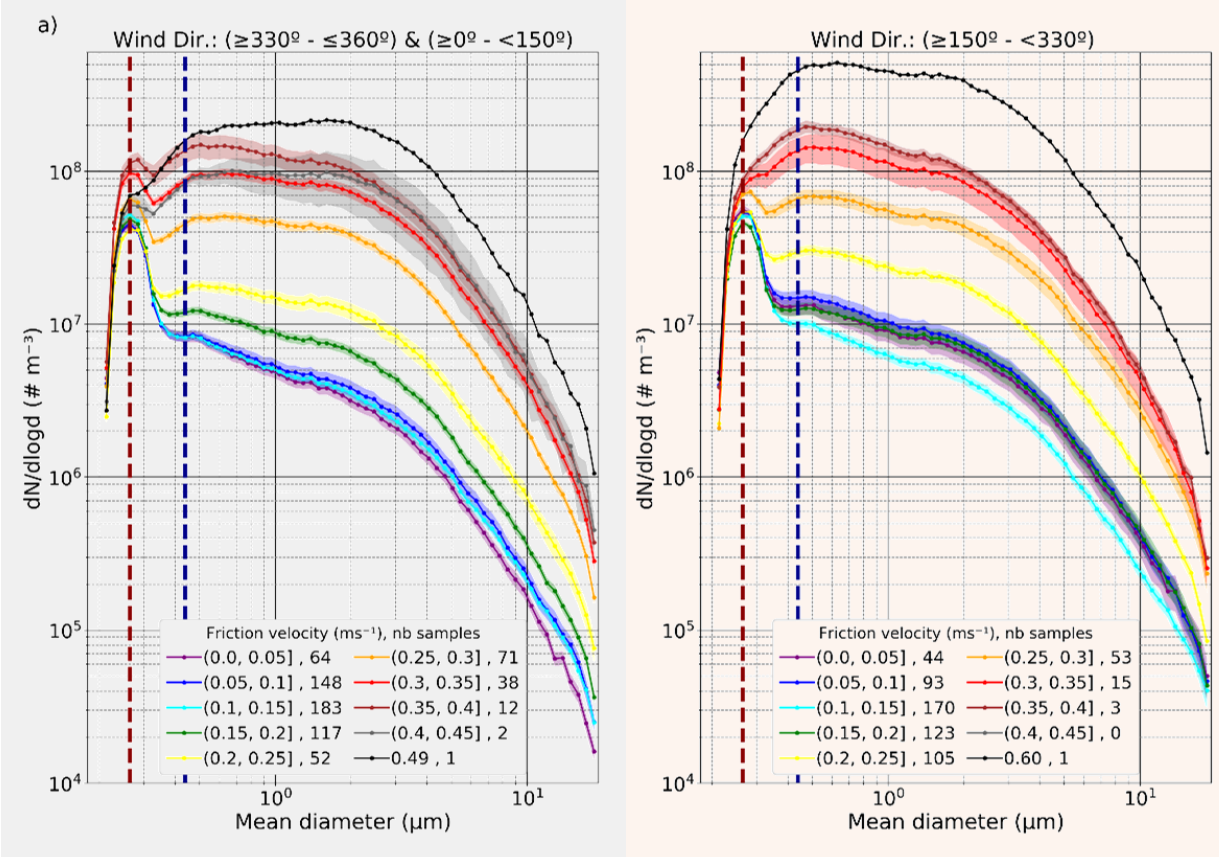
Wind at 2 m



There were two prevailing wind directions, one centered around 80º (more aligned with M'hamid location) and another one centered around 240º (Saharan desert direction). As a result, PSDs were classified in two wind direction groups, 330º-150º and 150º-300º.

Averaged PSDs in number for different u_* intervals based on 15 min samples

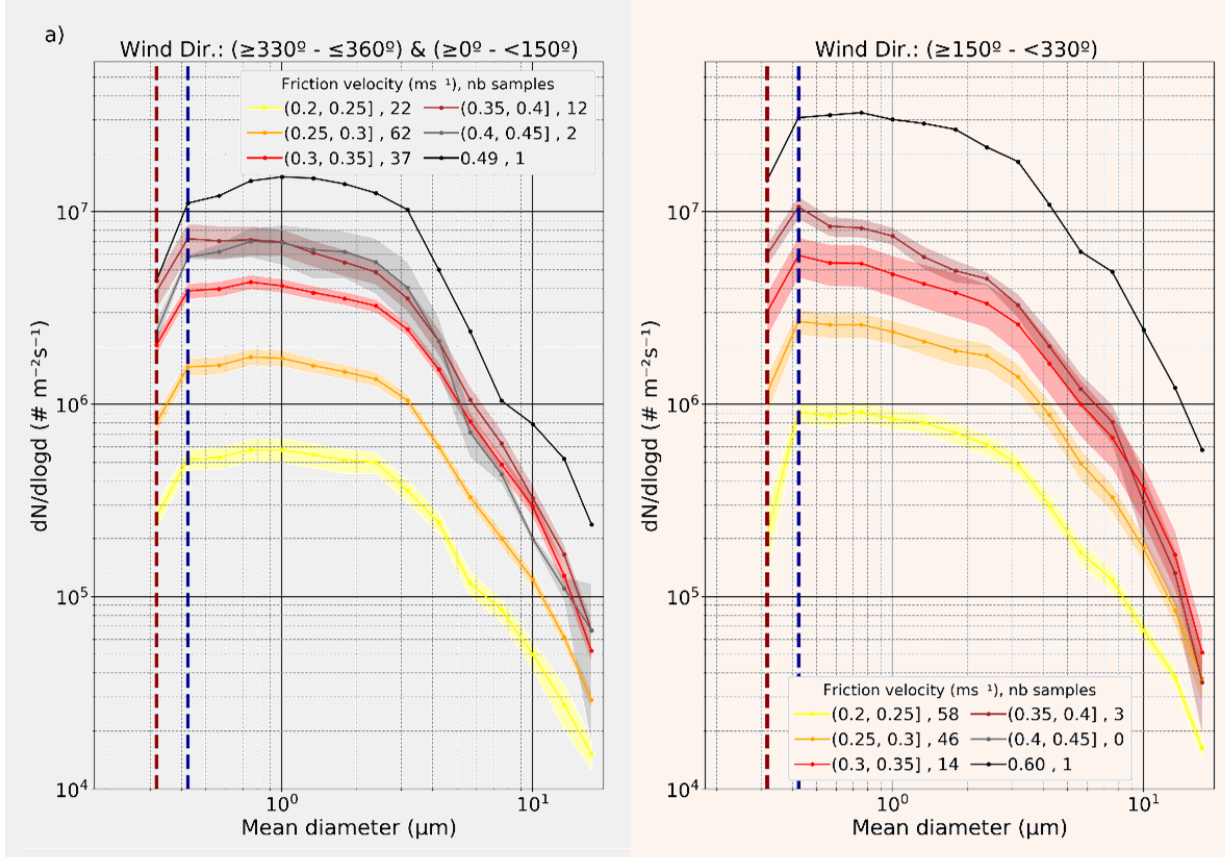
2 m height concentrations



Lowest diameter for which fidas is considered efficient

End of the anthropogenic mode

Diffusive flux



Lowest diameter for which fidas is considered efficient

End of the anthropogenic mode

Averaged PSDs in number for different u_* intervals based on 15 min samples

Data

PSDs were classified in two wind direction groups, 330º-150º and 150º-300º.

2 m height concentrations

Samples from the whole campaign

Diffusive flux

Samples in which $u_* > 0.2$ ms^{-1} and F is positive in all the bins above 0.42 µm

Results

In both wind directions:

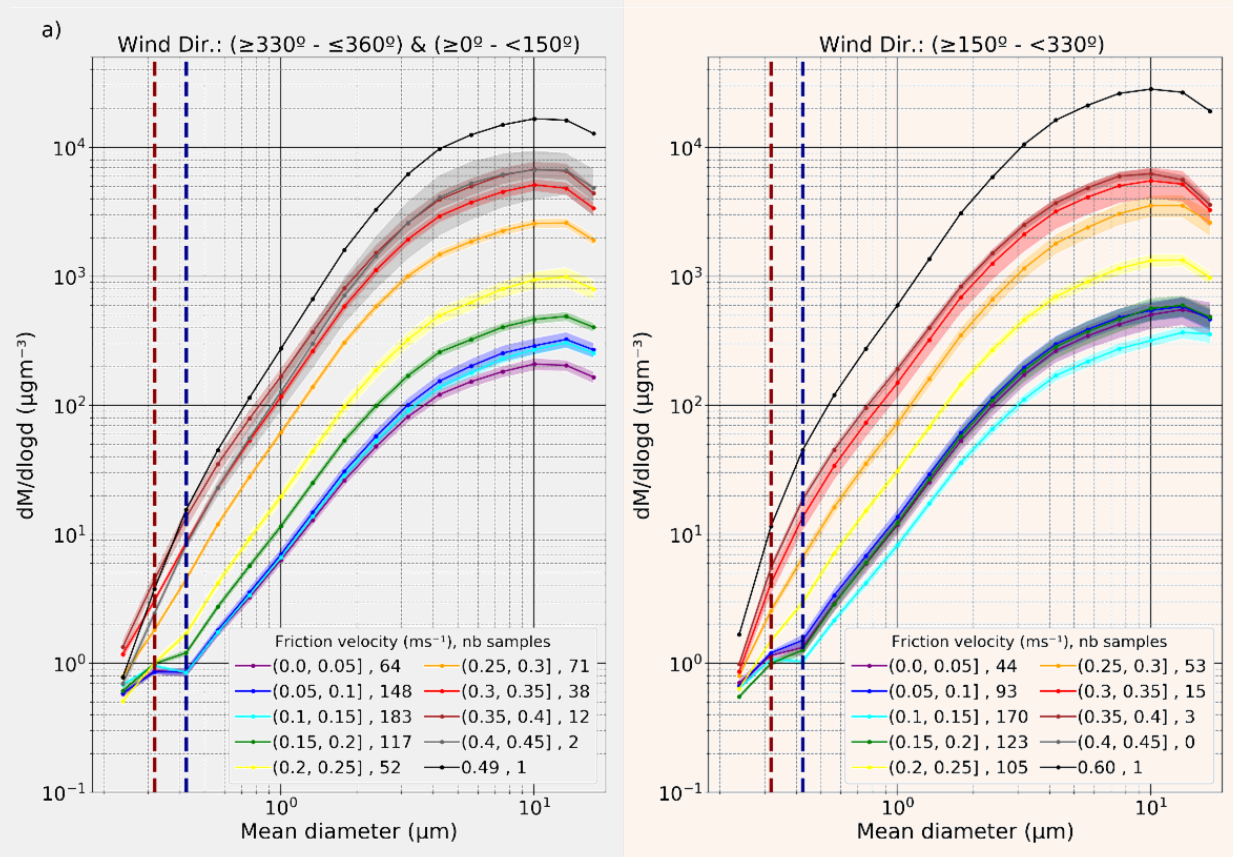
- General increase in the number concentrations with u_* in all the size bins.
- Larger number of finer particles (0.4-3 µm) than coarser particles (3-19 µm).
- Very slightly reduction of particles around 6-8 µm in diffusive flux that could be related to the dependence of the deposition velocity on the particle size and u_*.

Differences between wind directions:

- Lower concentrations for 330º-150º than for 150º-300º.
- Flatter slope from 0.4 to 2 µm for 330º-150º curves show a than for 150º-300º.

Averaged PSDs in mass for different u_* intervals based on 15 min samples

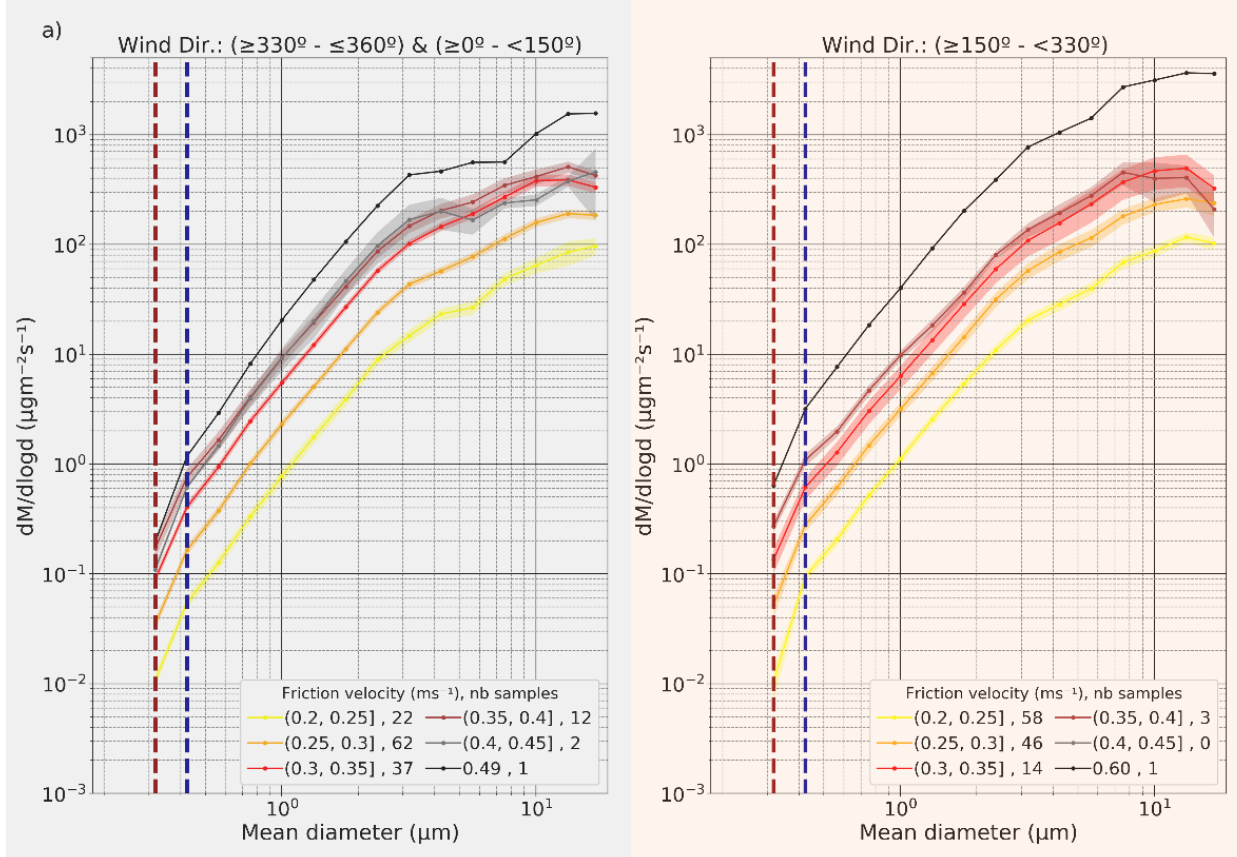
2 m height concentrations



Lowest diameter for which fidas is considered efficient

End of the anthropogenic mode

Diffusive flux



Lowest diameter for which fidas is considered efficient

End of the anthropogenic mode

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Averaged PSDs in mass for different u_* intervals based on 15 min samples

Data

PSDs were classified in two wind direction groups, 330º-150º and 150º-300º.

2 m height concentrations

Samples from the whole campaign

Diffusive flux

Samples in which $u_* > 0.2$ ms^{-1} and F is positive in all the bins above 0.42 µm

Results

In both wind directions:

- Mass is dominated by coarser particles.
- As u_* increases, higher increase of coarser particles compared to finer particles for 2 m height concentrations.
- For diffusive flux the increase is almost proportional in all size ranges.

Differences between wind directions:

- Lower concentrations for 330º-150º than for 150º-300º.

- The first **field campaign** within **FRAGMENT** project was conducted in **Morocco**, in **September 2019**.
- During the campaign dust emission occurred quite frequently under different dynamical conditions.
- **Two prevailing wind directions** were identified, one centered around 80º (more aligned with M'hamid El Ghizlane, the closest town) and the other around 240º (Saharan desert direction).
- Our sandblasting efficiency was not so high compared to the literature even if saltation was very frequent.
- Our analyses show **some variability in the size distribution** of dust at emission due to **wind direction**.
- Two main **differences between PSDs from 2 m height concentrations and diffusive flux**:

  1) **Slightly reduction of particles around 6-8 µm in diffusive flux** that could be related to the dependence of the deposition velocity on the particle size and u_*

  2) **As u* increases**, for **2 m height concentrations** there is a **higher increase of coarser particles compared to finer particles** whereas for **diffusive flux** the increase is almost **proportional** in all size ranges.

Thank you

cristina.gonzalez@bsc.es

Image credit: K.Kandler