FRAGMENT: FRontiers in dust minerAloGical CoMposition and its Effects upon climaTe

Carlos Pérez García-Pando
&
FRAGMENT team

7/12/2019

EMIT annual meeting (JPL)

FRAGMENT Team

Research Team:

FRAGMENT, led by **Carlos Pérez García-Pando*** from the Barcelona Supercomputing Center, involves world-class experts on modelling, aerosol campaigns and analyses, mineralogy, and spectroscopy. ERC GRANT No 773051 funded by the European Research Council EU HORIZON 2020 program

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Konrad Kandler (TUDA)
Agnesh Panta (TUDA)

Ron Miller (NASA GISS)*
Robert Green (JPL)**
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Rebecca Greenberger (Caltech)
Roger Clark (PSI)*

** PI of EMIT
* Part of EMIT´s Science Team

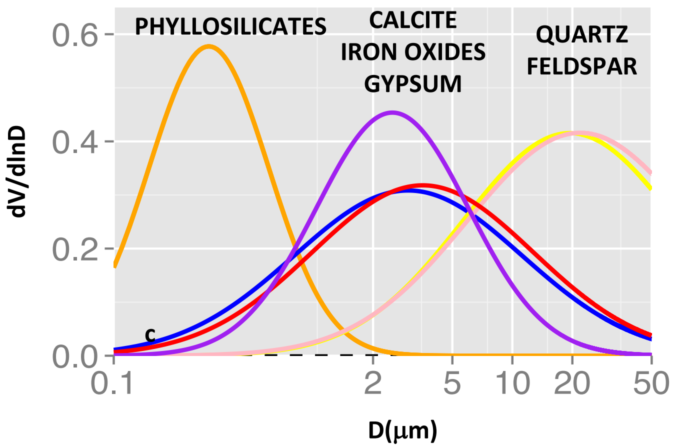
Collabarators: Vicken Etyemezian (DRI), Sylvain Dupont (INRA), Yves Balkanski (IPSL), EMIT TEAM

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

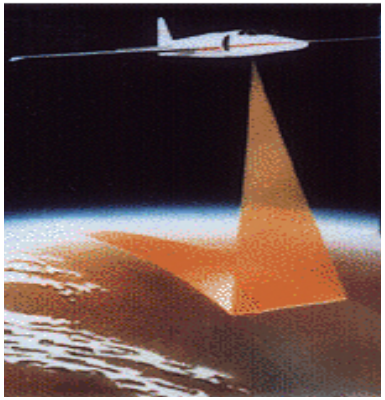
Global soil-surface mineralogy

Help constrain global soil-surface mineralogy for dust emission

Link spectroscopy of soil-surface to dust emission

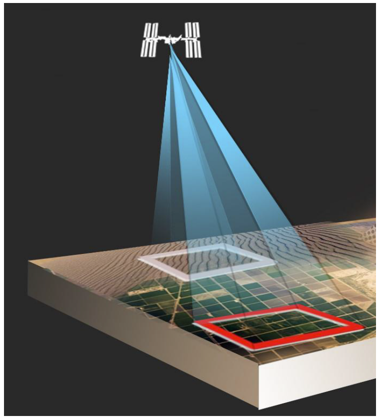
Field and lab spectroscopy

AVIRIS (US)



Airborne Spectroscopy

EMIT



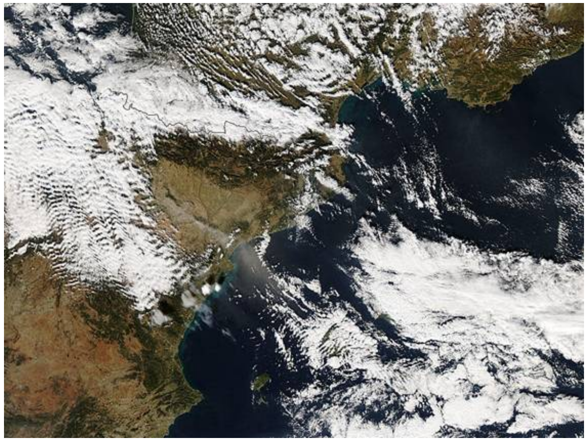
Space-borne Spectroscopy

- Point and field spectrometers
- Lab spectroscopy of soil and aeolian samples and subsamples and interpretation
- 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

Testing in Aragón, Spain 2019



M´Hamid, Zagora, Morocco 2019)

Southwest US, Spring 2020?

Icelandic sources (HiLDA!) August 2020

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……Erfoud, Morocco in 2021

M’Hamid, Morocco

M’Hamid, Morocco

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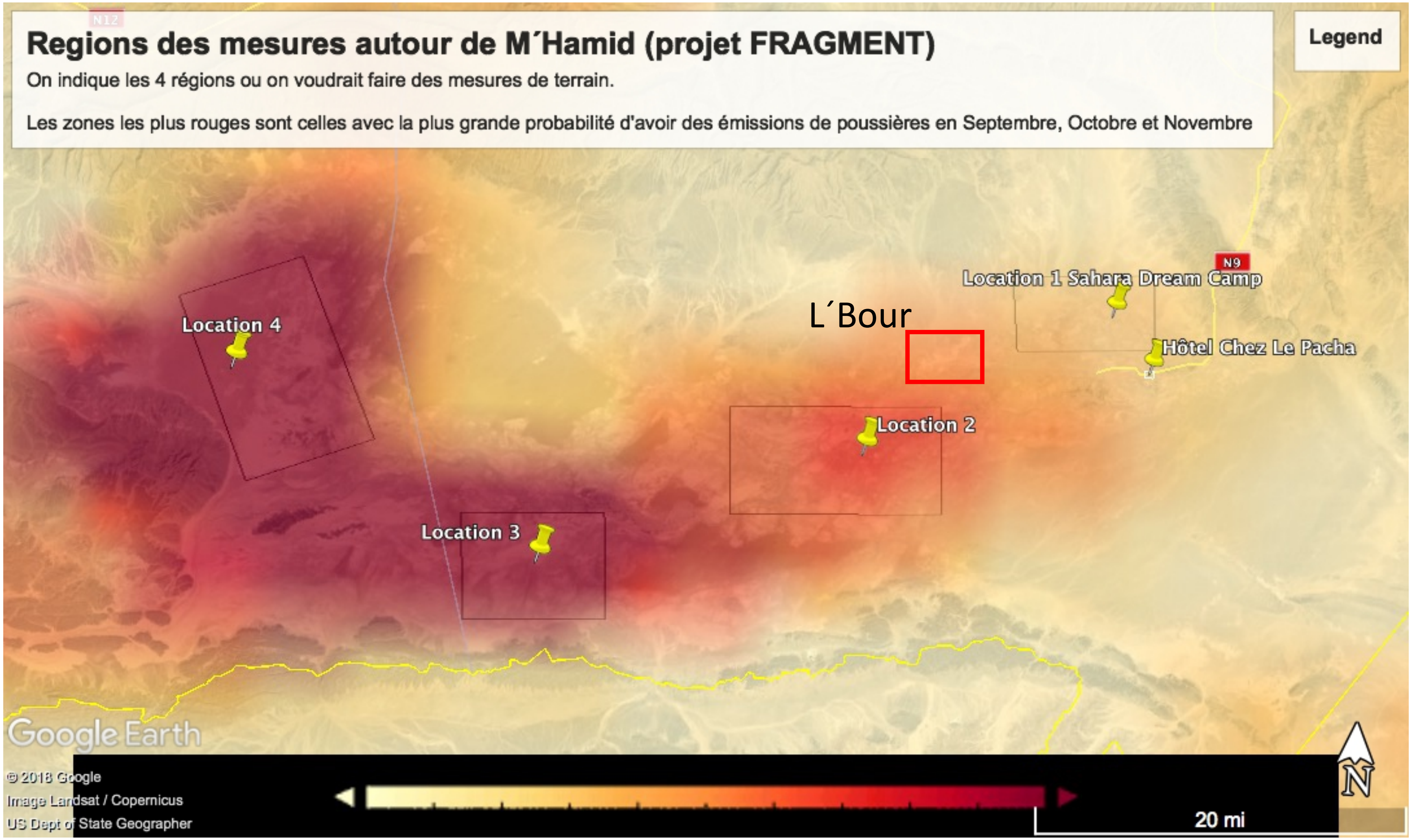
M'Hamid, Morocco

M'Hamid, Morocco



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Lake L'Bour

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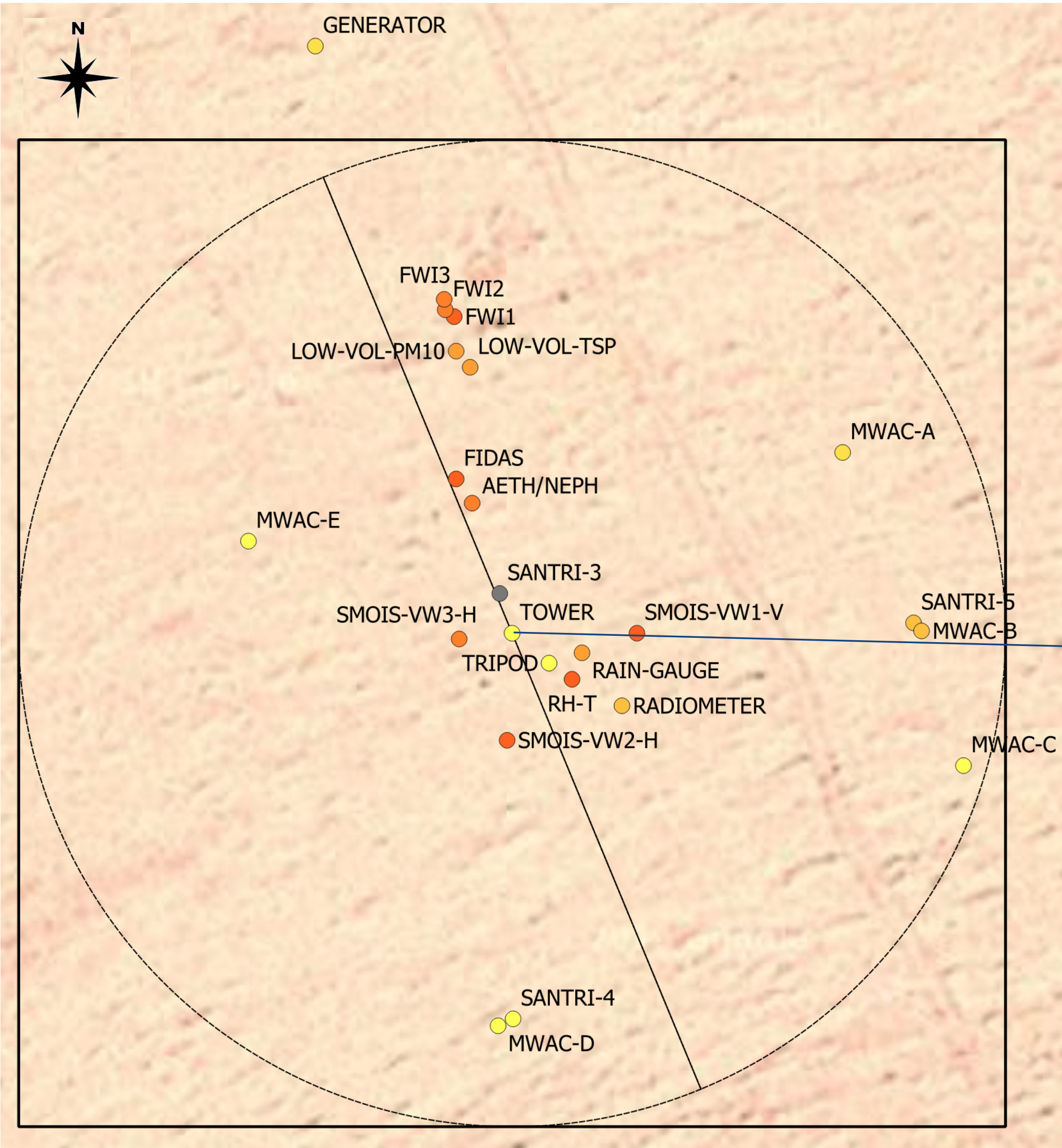
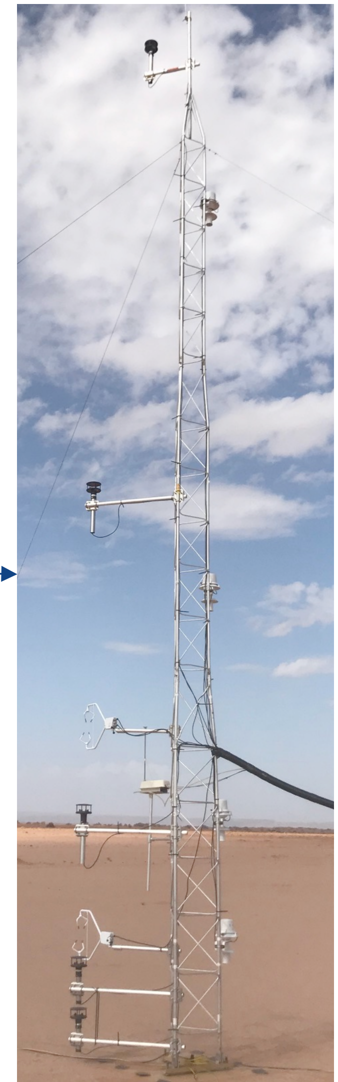
Instrumentation



10 m Tower



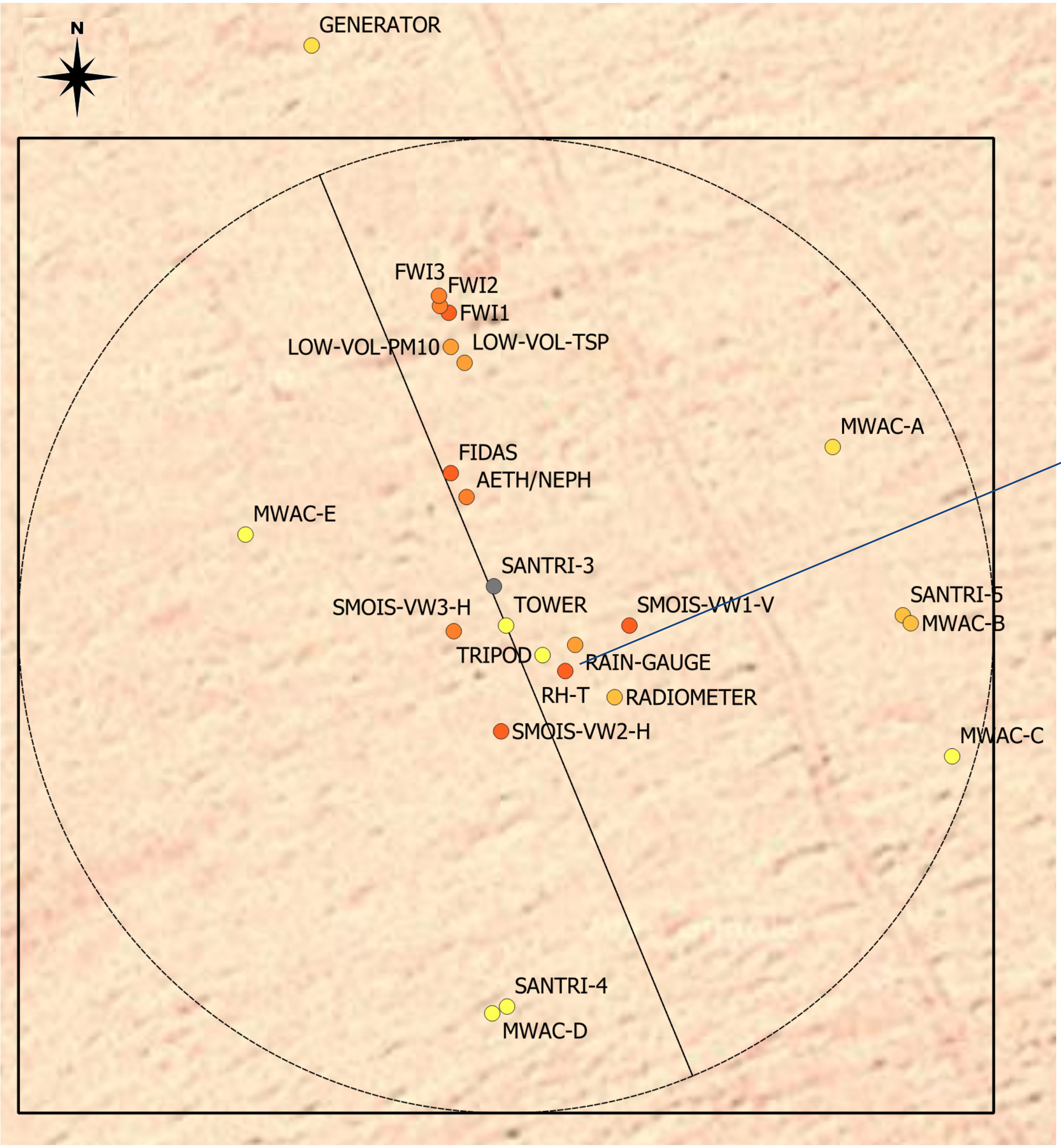
5 2D Sonic Anemometers
(2 seconds)

4 Temperature sensors
(2 seconds)

2 3D Sonic Anemometers
(50 Hz)

1 Welas optical particle counter
(1 second)

Instrumentation



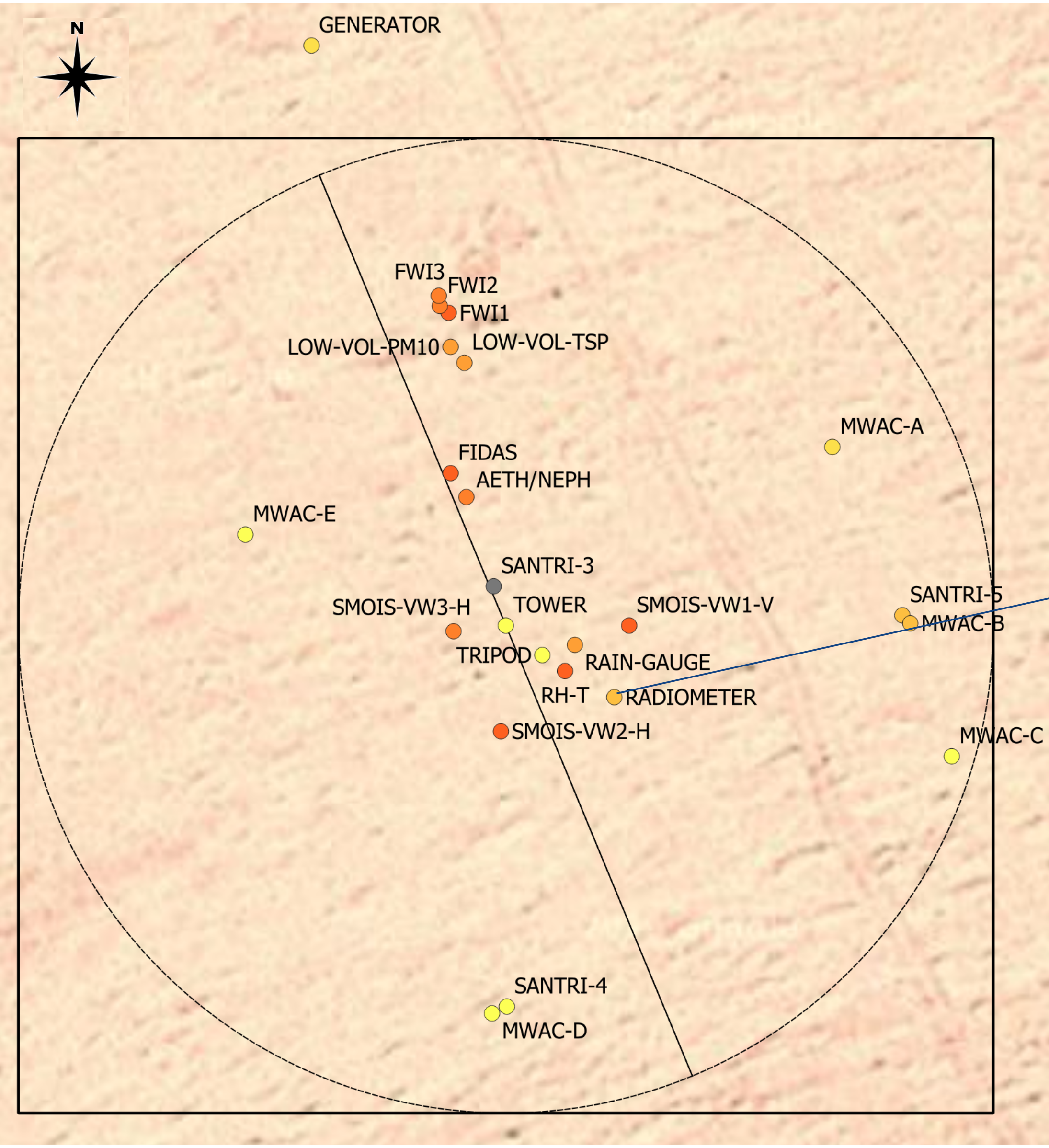
RH and Temp at 0.5 m (1 sec)

4-component Radiometer (1 sec)

3 soil moisture sensors

Rain gauge

Instrumentation



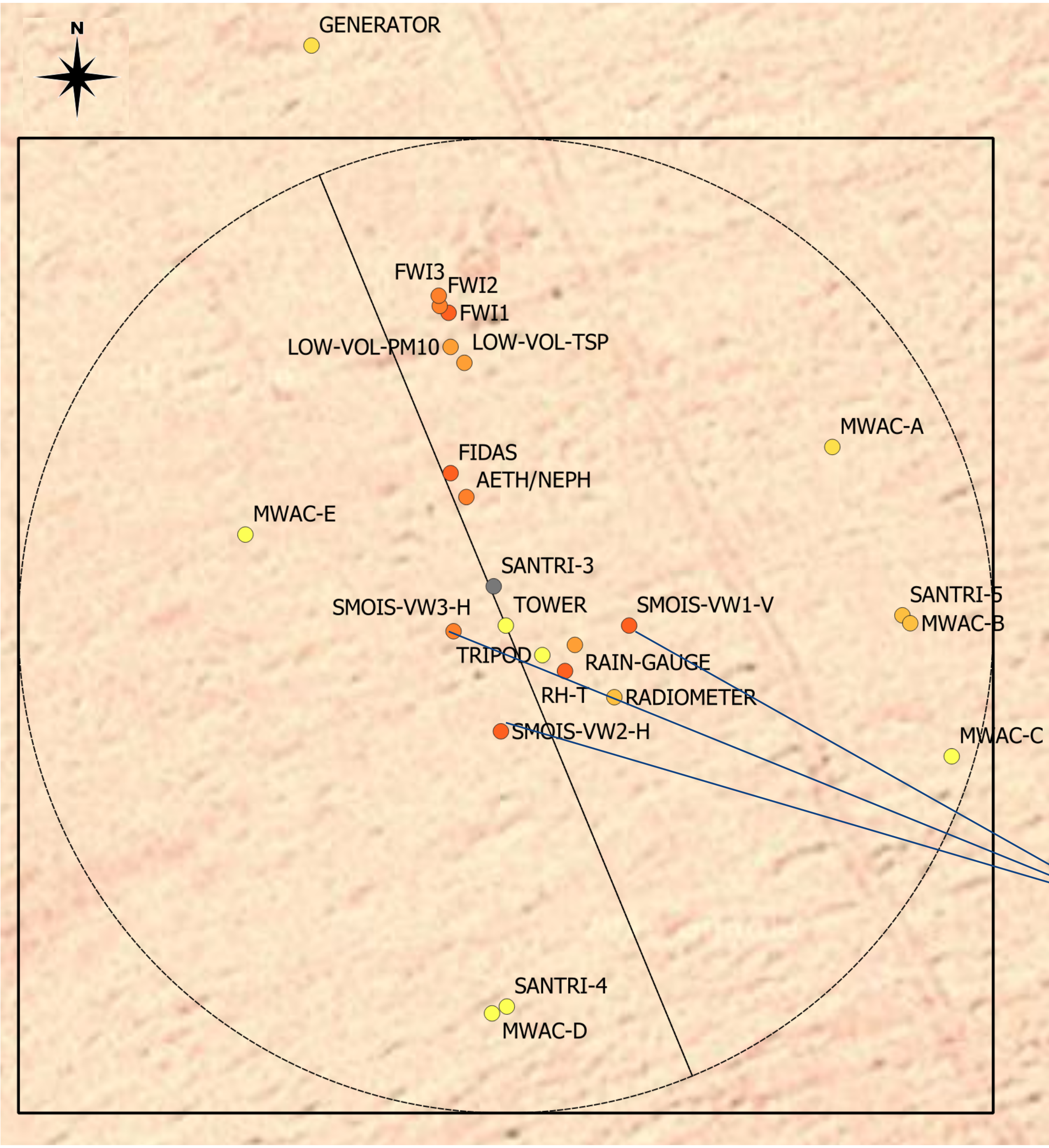
RH and Temp at 0.5 m (1 sec)

4-component Radiometer (1 sec)

3 soil moisture sensors

Rain gauge

Instrumentation



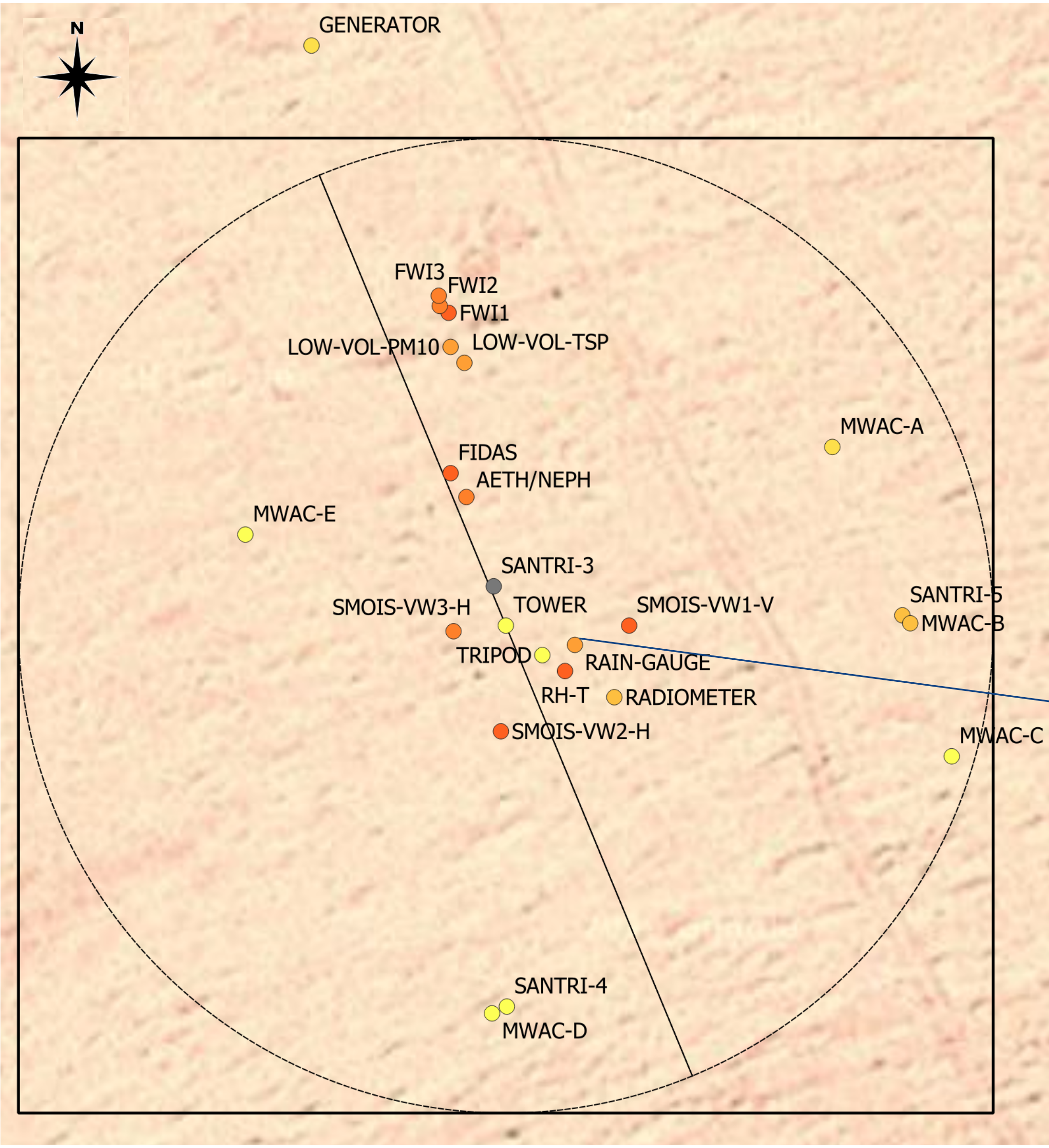
RH and Temp at 0.5 m (1 sec)

4-component Radiometer (1 sec)

3 soil moisture sensors

Rain gauge

Instrumentation



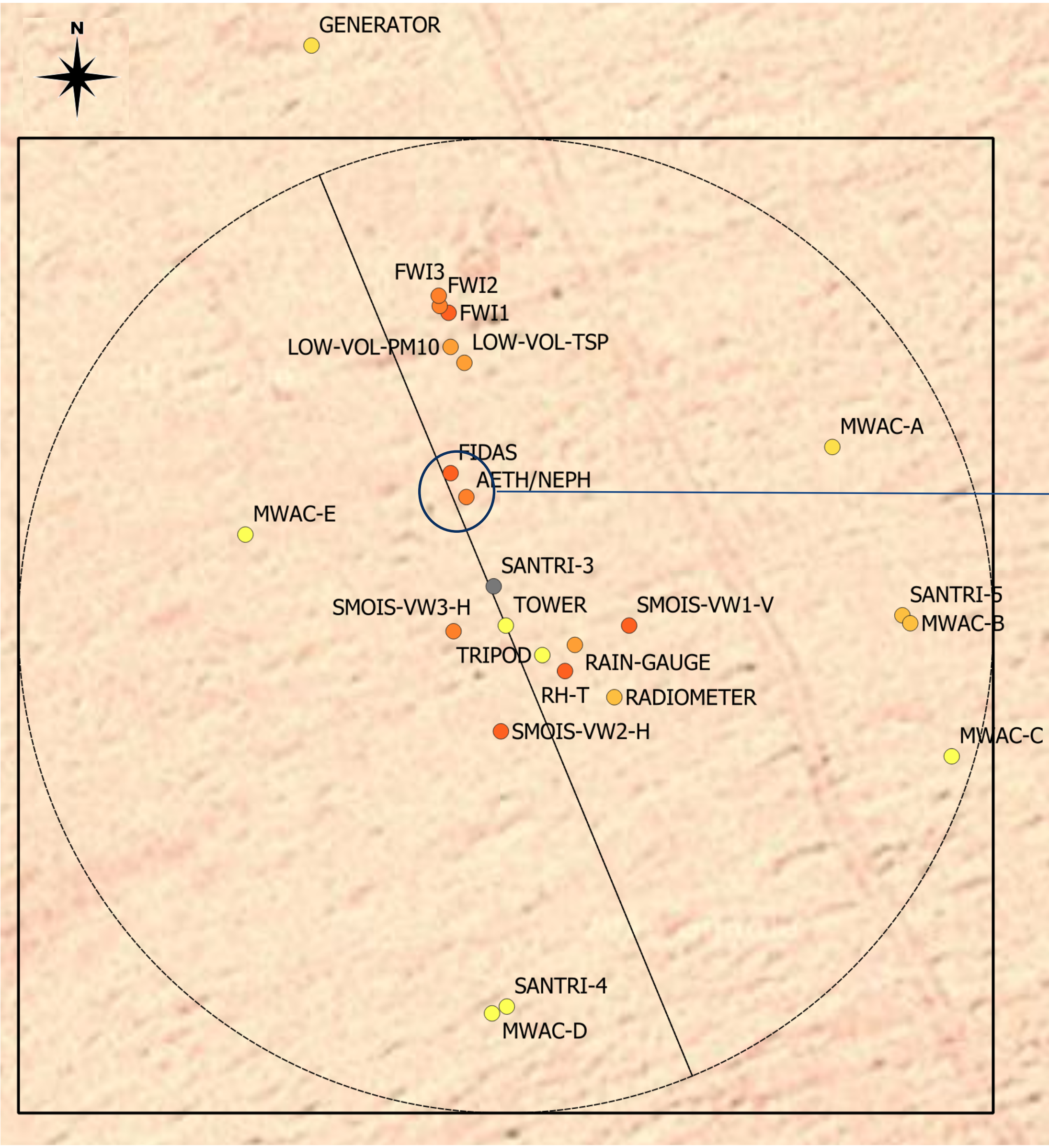
RH and Temp at 0.5 m (1 sec)

4-component Radiometer (1 sec)

3 soil moisture Sensors (1 sec)

Rain gauge

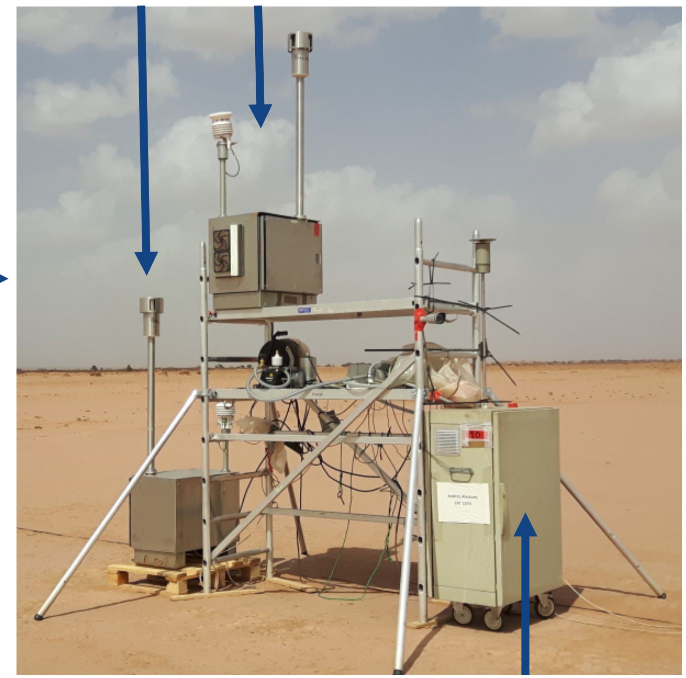
Instrumentation



FIDAS Optical Particle counters at two heights

dN/dD range 0.3 – 40 μm

1 second resolution



Polar nephelometer (AURORA 4000)

Scattering; 3 wavelengths; 7 angles

Aethalometer (AE33)

Absorption; 7 wavelengths

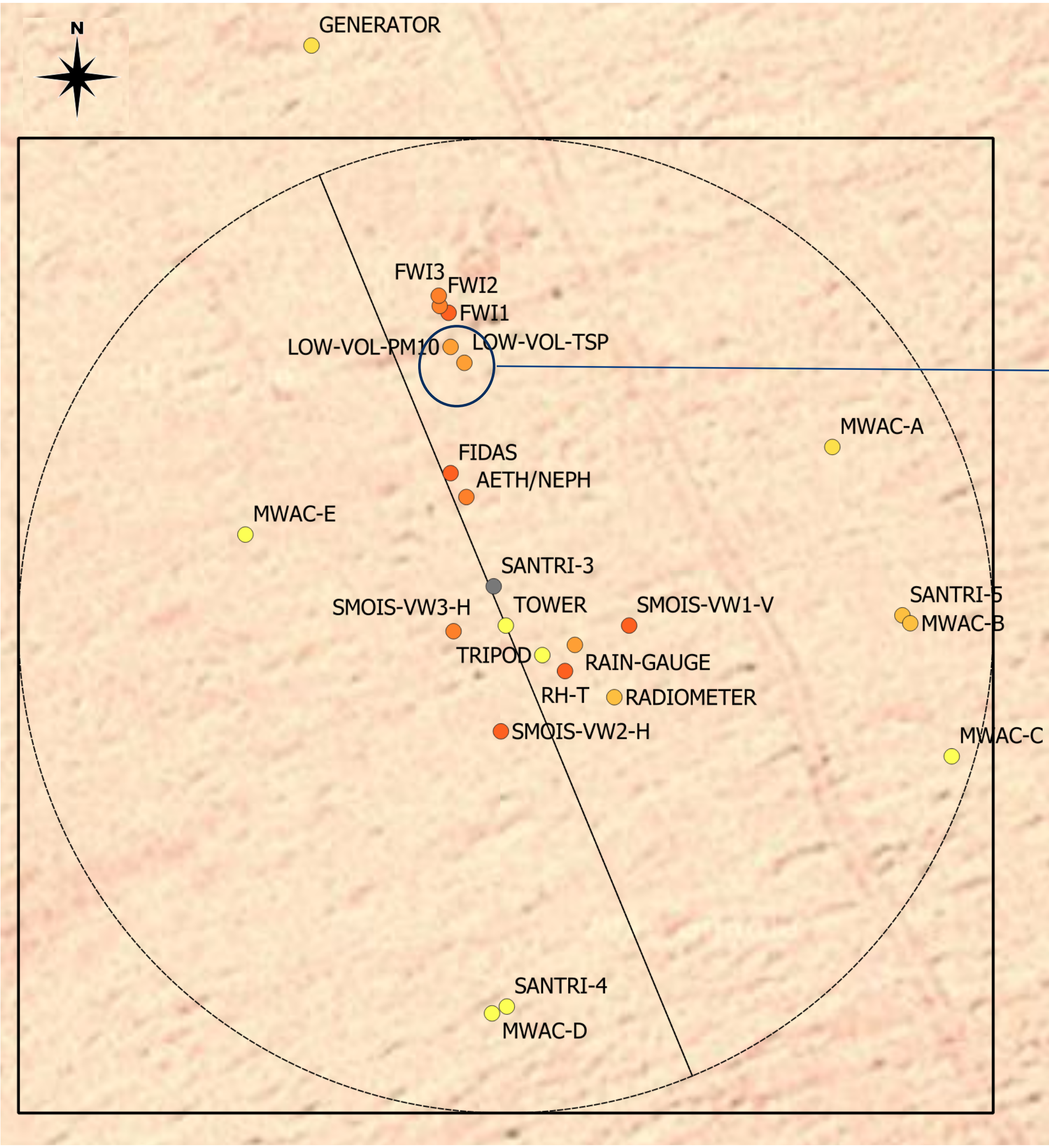
1 minute resolution

Instrumentation

2 MOUDIS
5-stage cascade impactors

>10	µm	Hours for XRD
2.5-10	µm	and chemistry
1.0-2.5	µm	
0.25-1.0	µm	Seconds for
<0.25	µm	SEM

Instrumentation



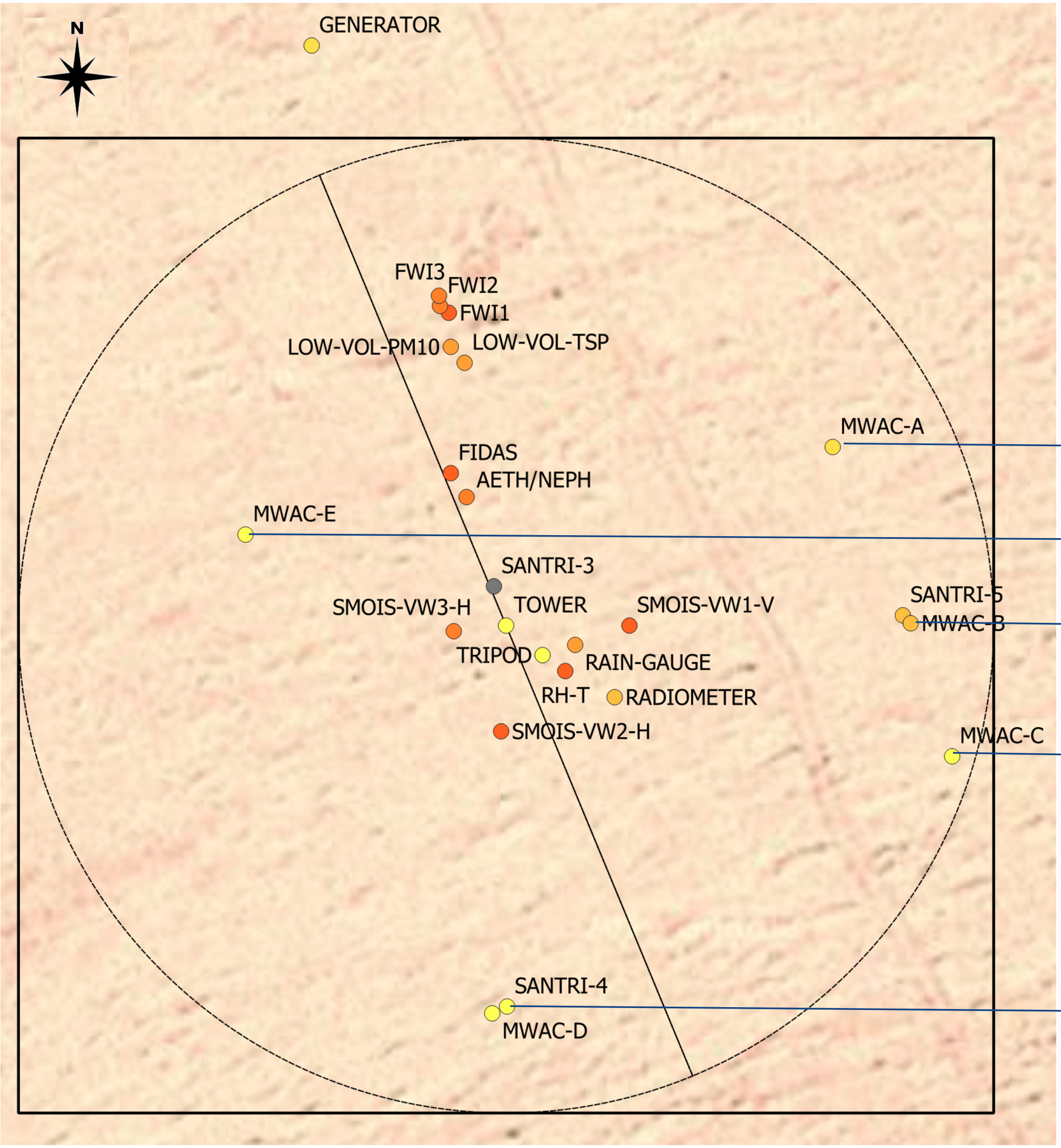
Low Volume Samplers (LVS)
TSP, PM10, PM2.5

Samples every 8 to 12 hours

Instrumentation

Free wing impactors (seconds) **and deposition plate** (hours)

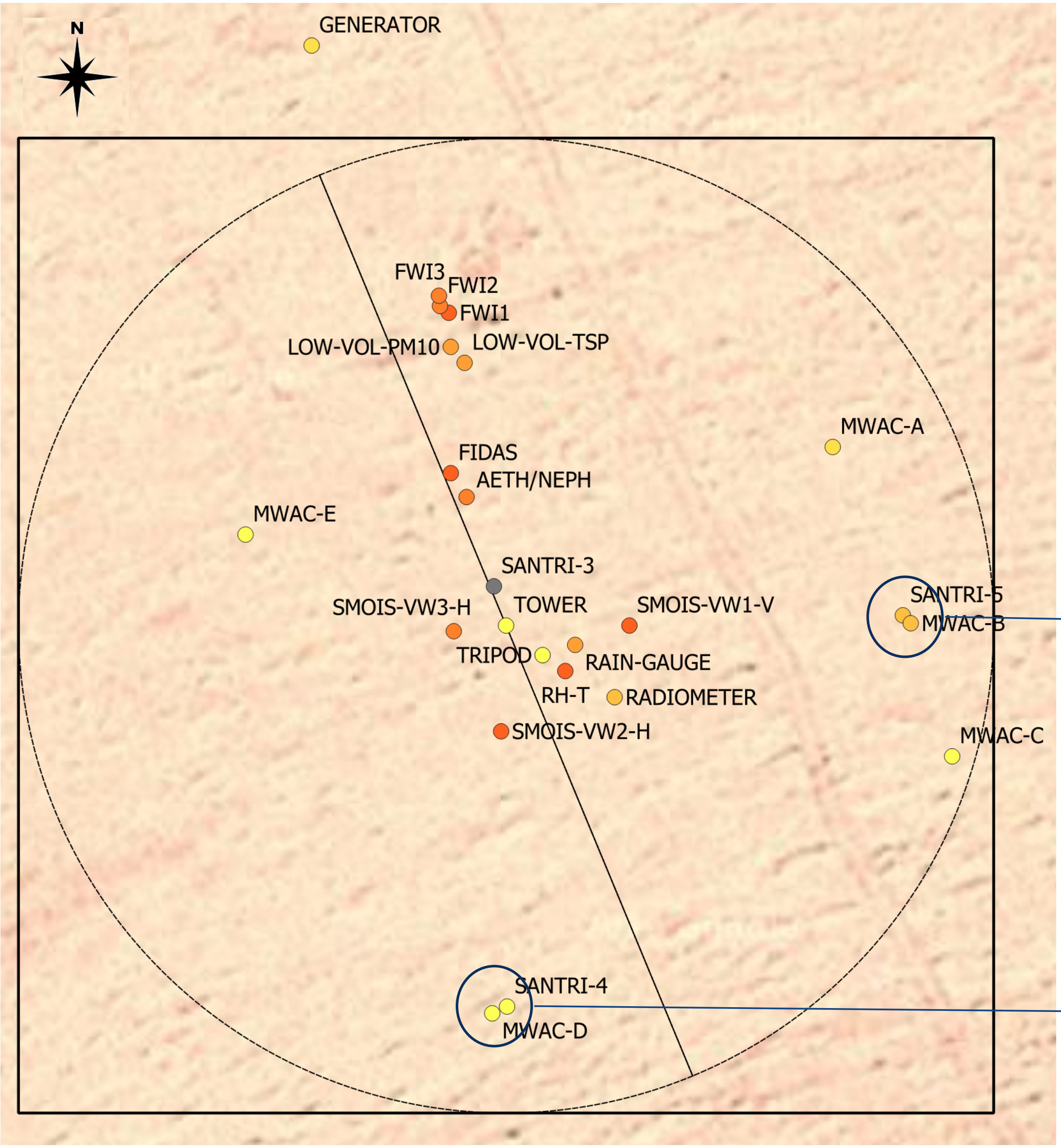
Instrumentation



5 MWAC sediment catchers

0.1, 0.2, 0.5 and 1 m
Per event basis or daily

Instrumentation



2 SANTRIs collocated with 2 MWACS

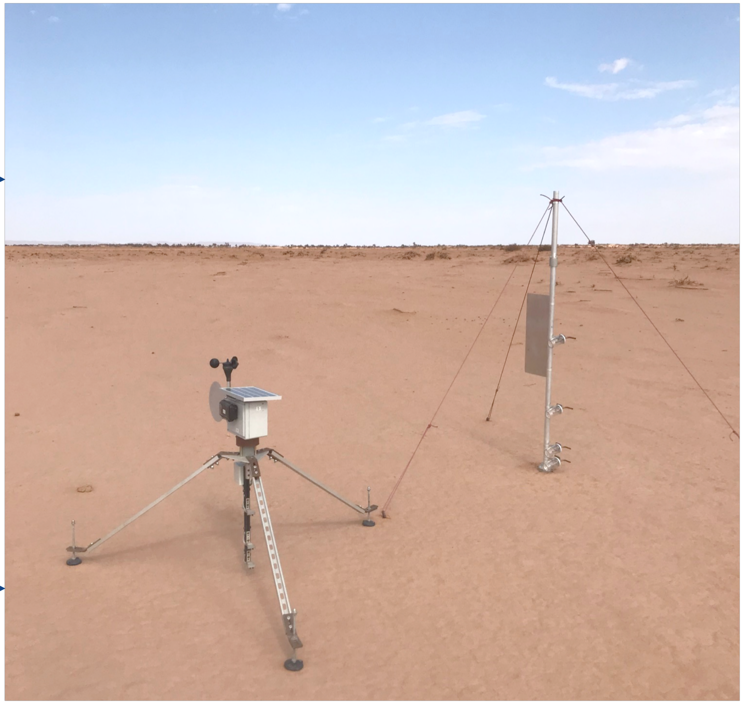
1s data

Wind Speed

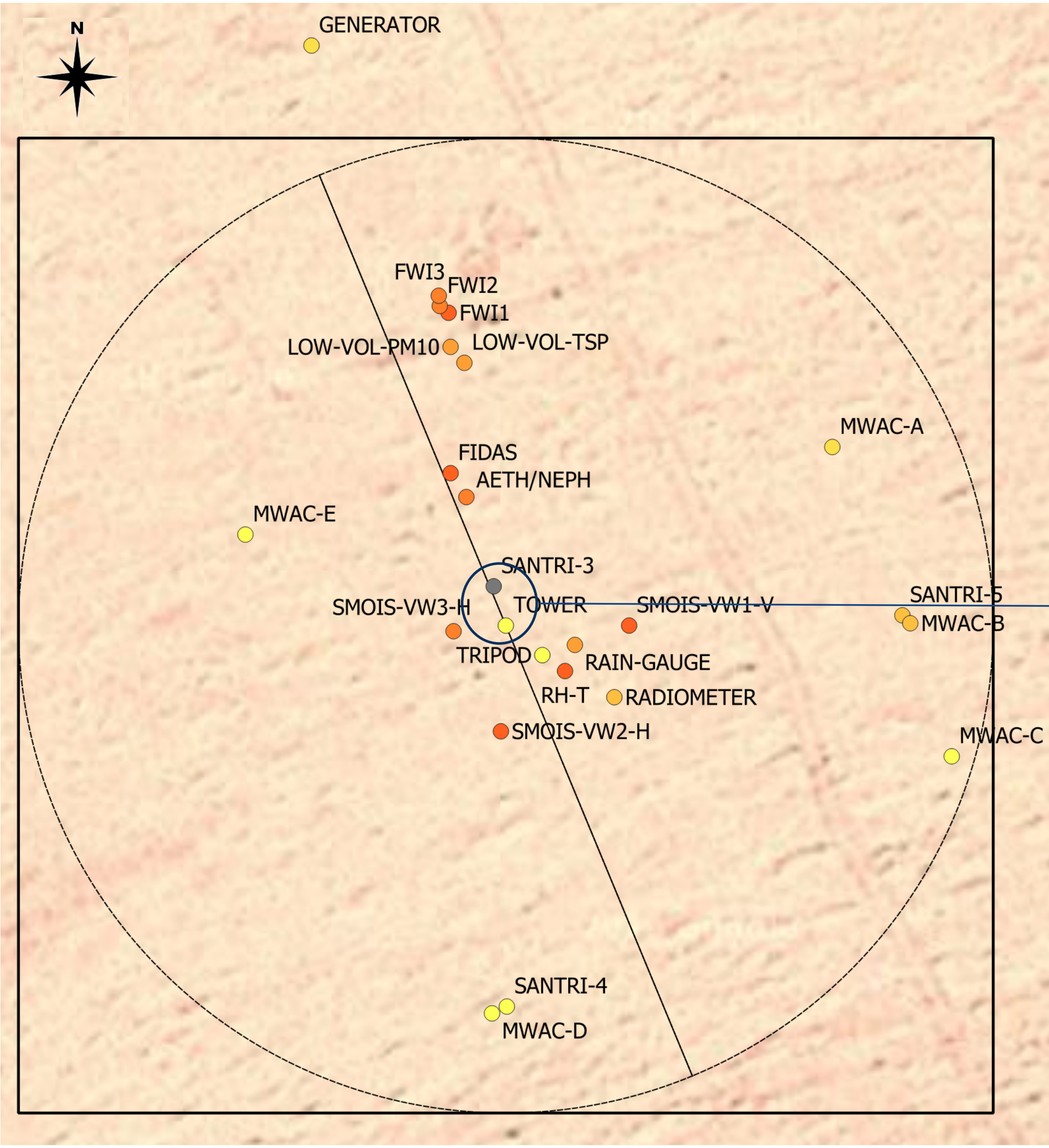
Saltation Counts per size

Sensor heights:

2 x 5cm, 1 x 15cm, 1 x 30cm



Instrumentation



1 SANTRI collocated with a 3D Sonic

10 kHz data

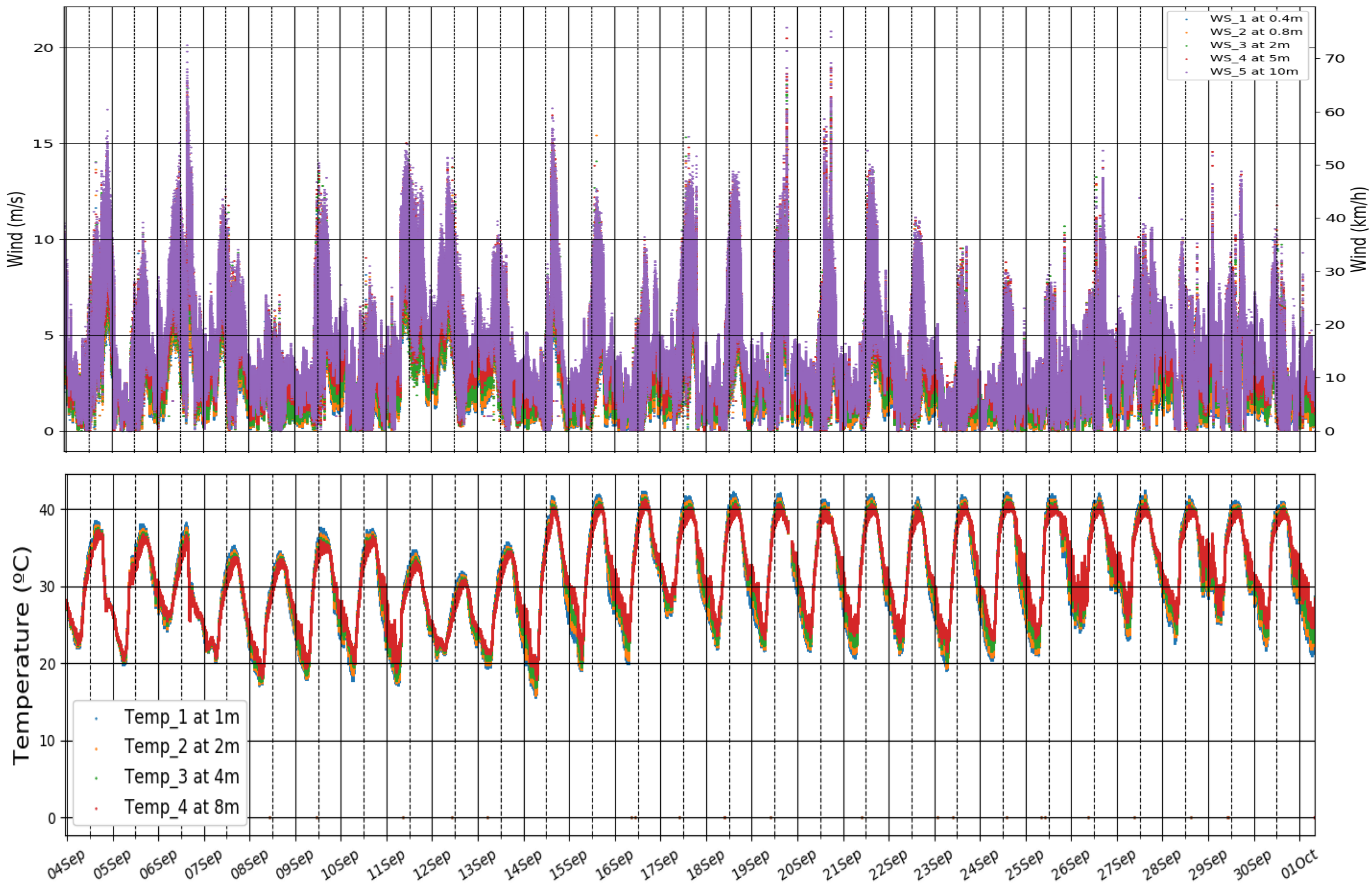
Signal Channel 1, Signal Channel 2

2 Sensors/Channels:

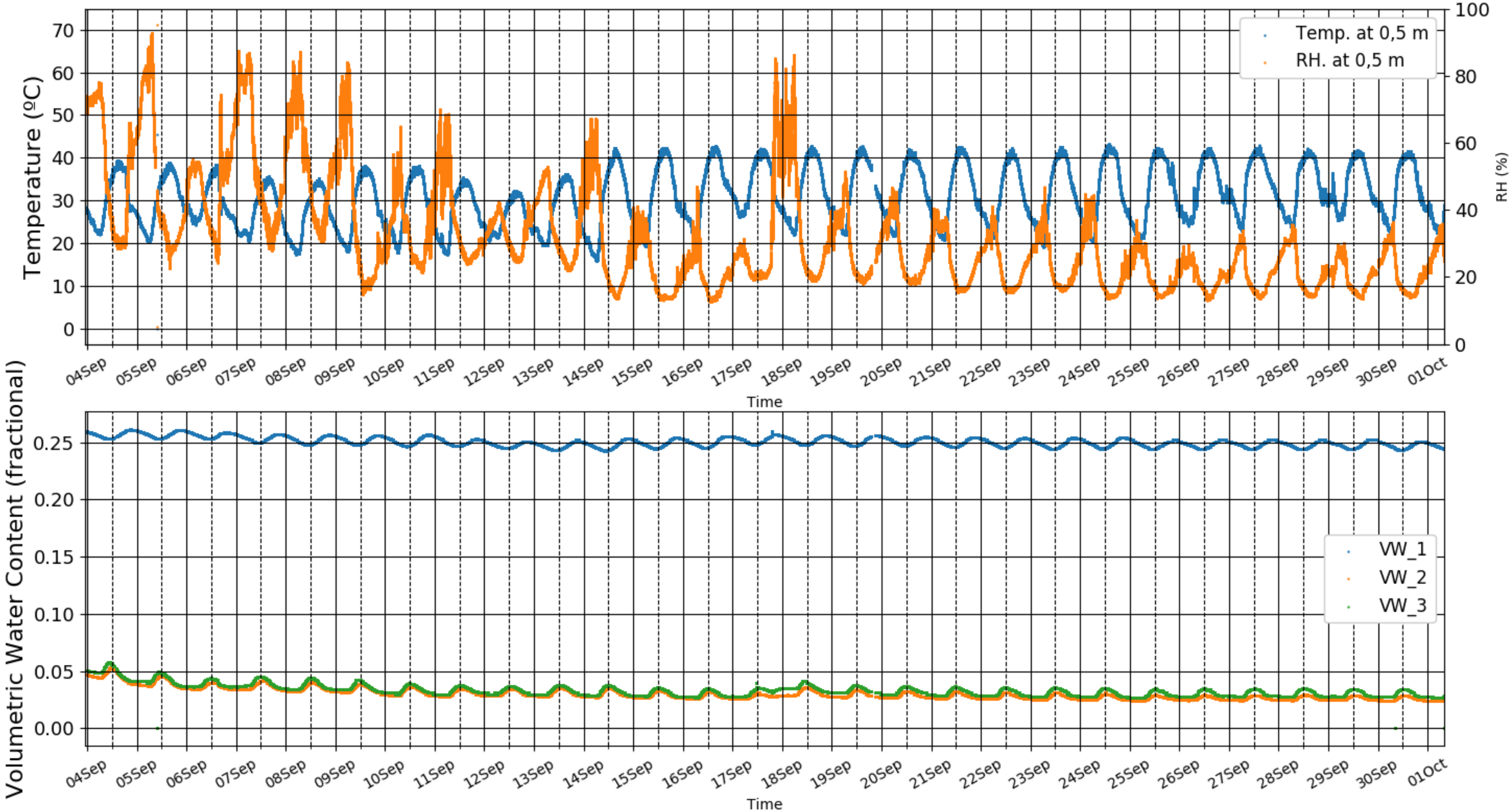
1 x 5cm, 1 x 15cm

Particle velocity?

Wind and temperature



Temp & RH at 0.5m vs VWC



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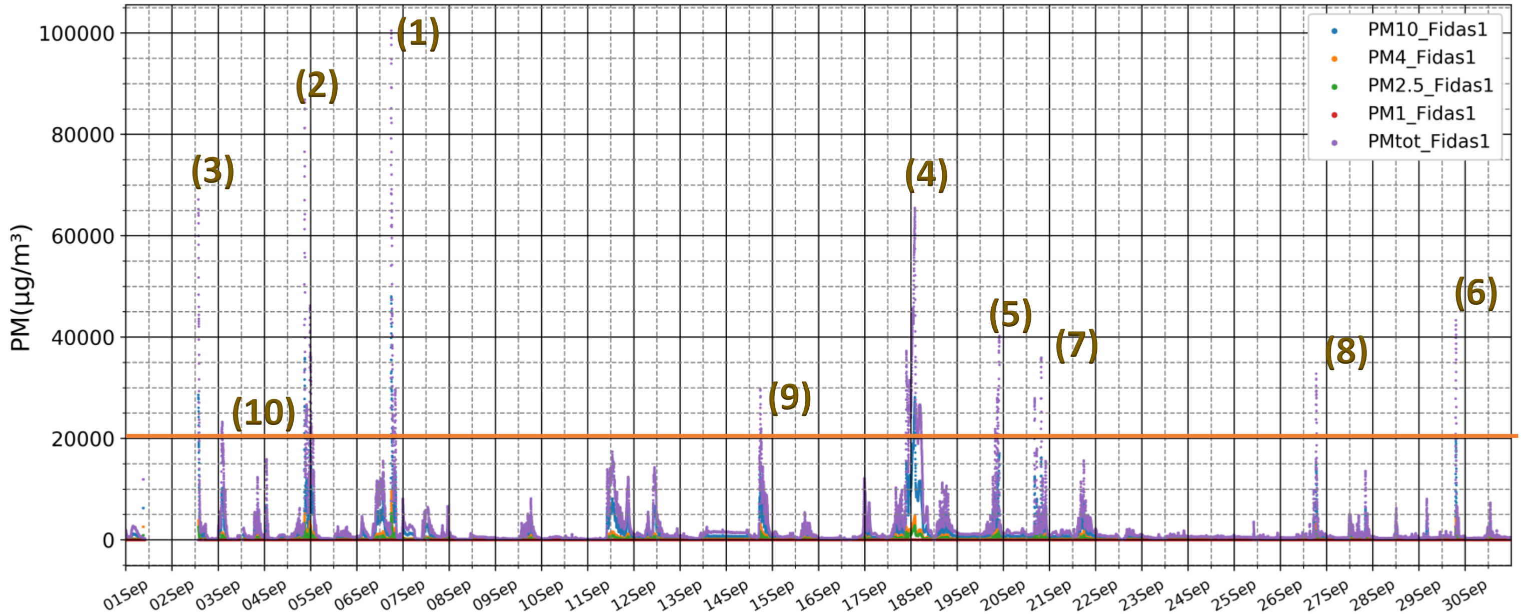
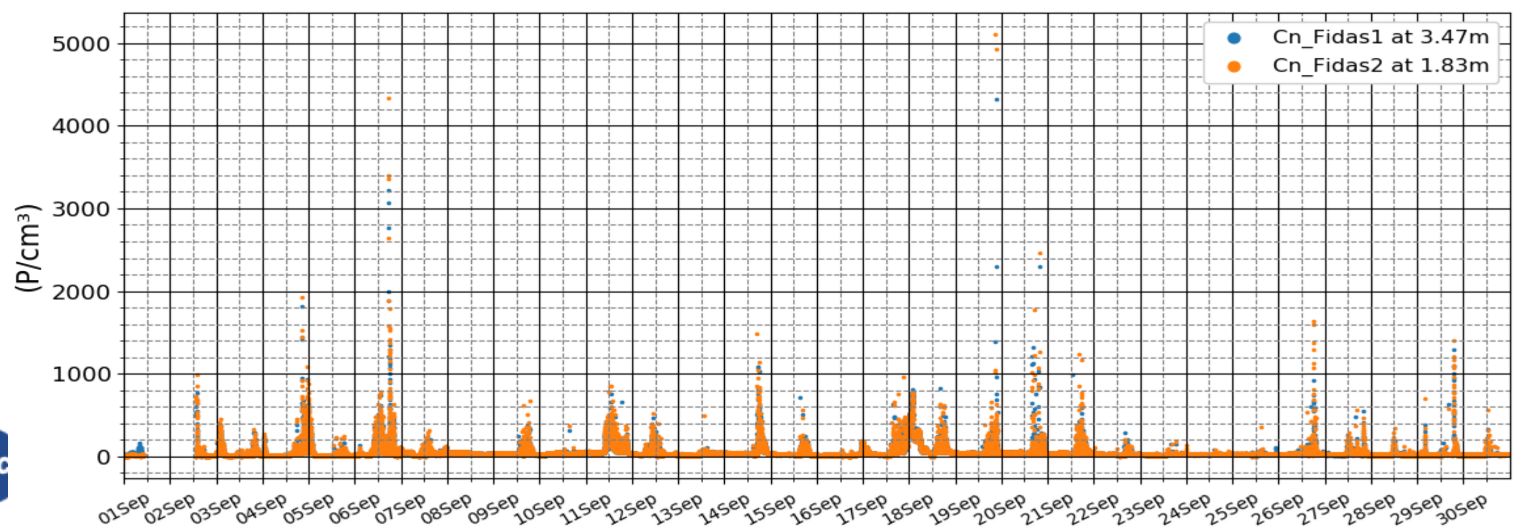
FIDAS OPCs (minute resolution)

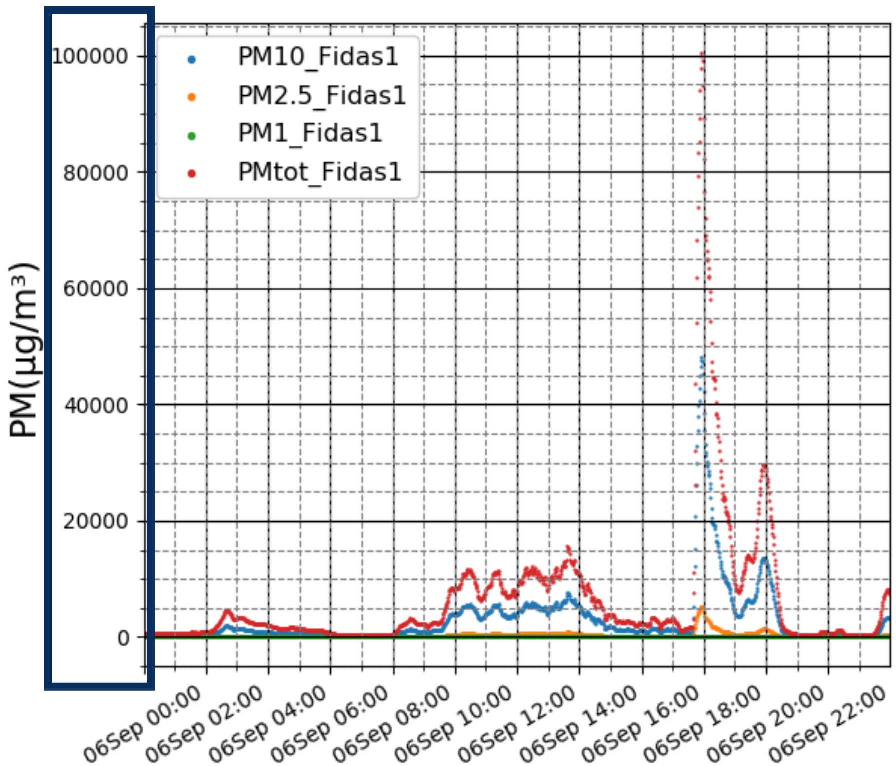
10 big dust events during the field campaign above 20.000 µg/m3 .



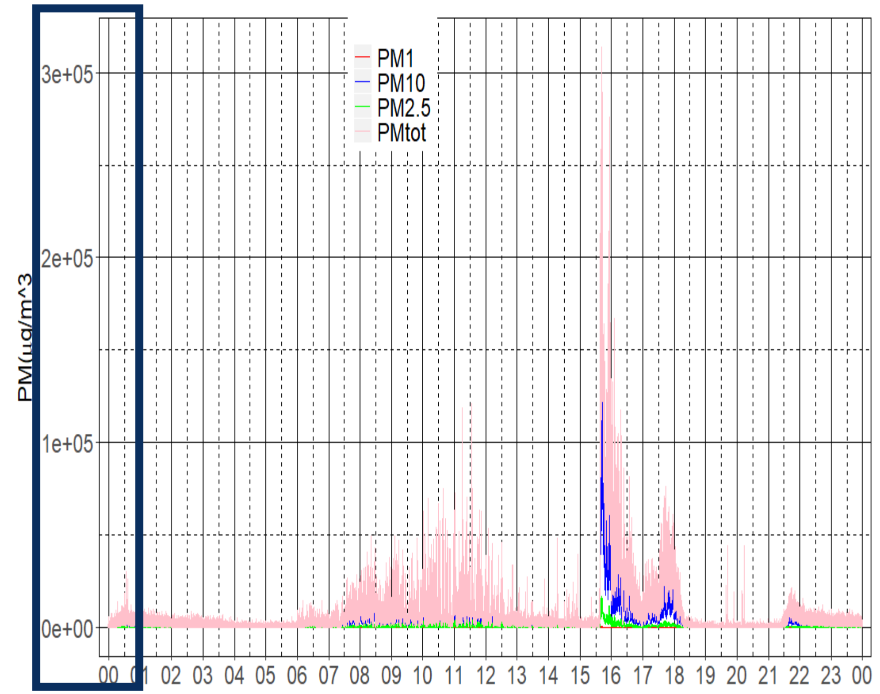


High res data

Minute data



Second data



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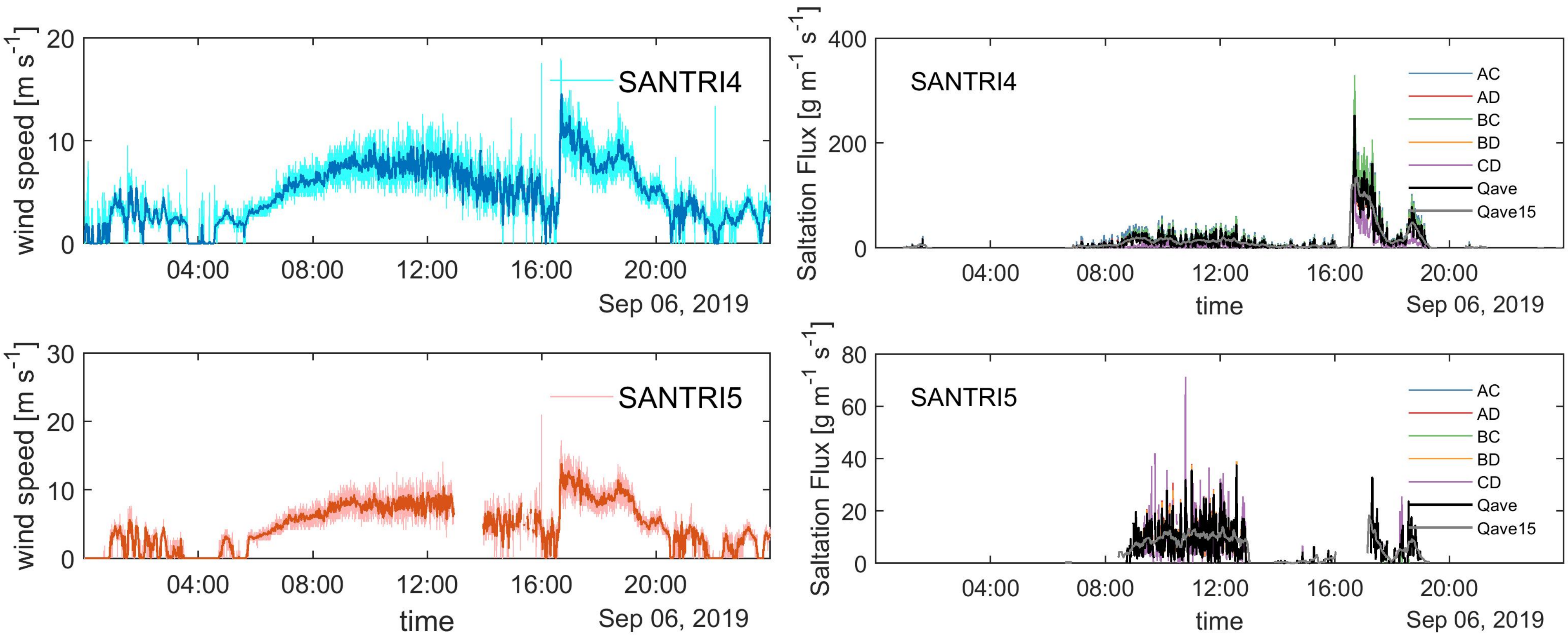
06 September 2019 diurnal winds in the morning and Haboob in the afternoon



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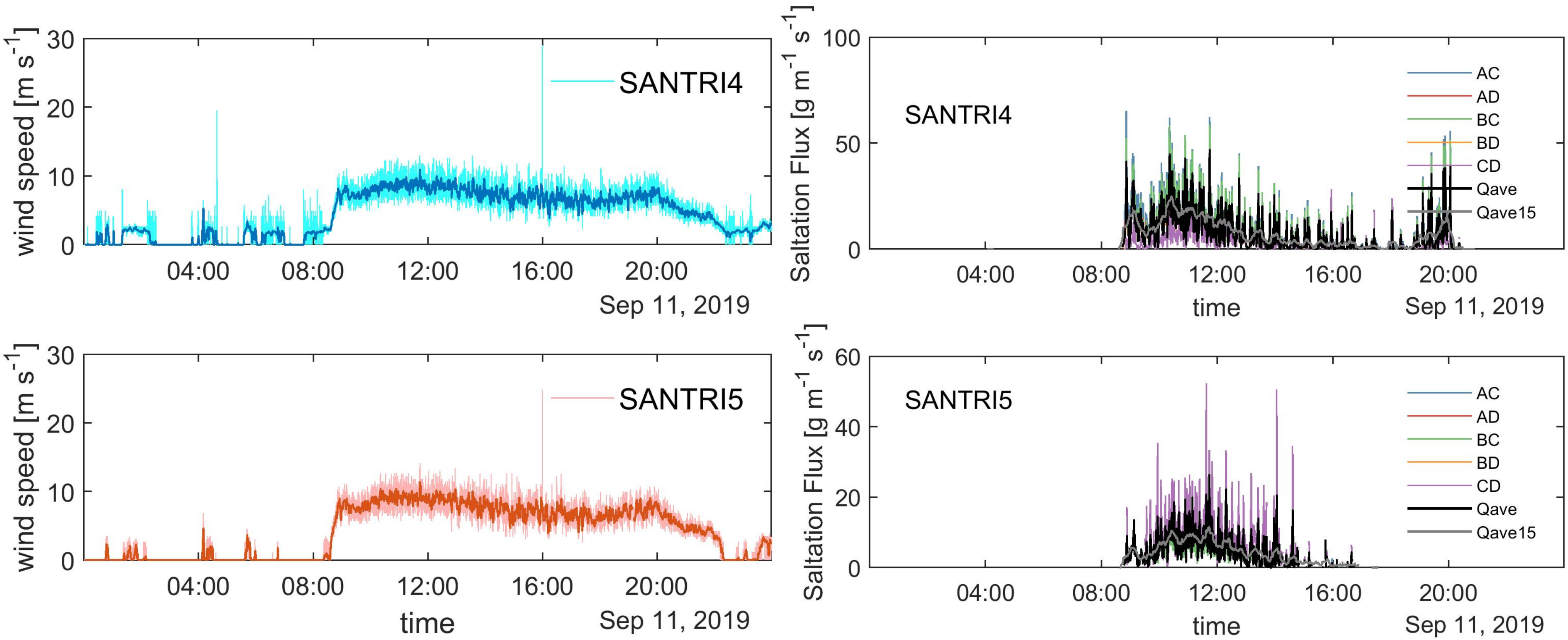
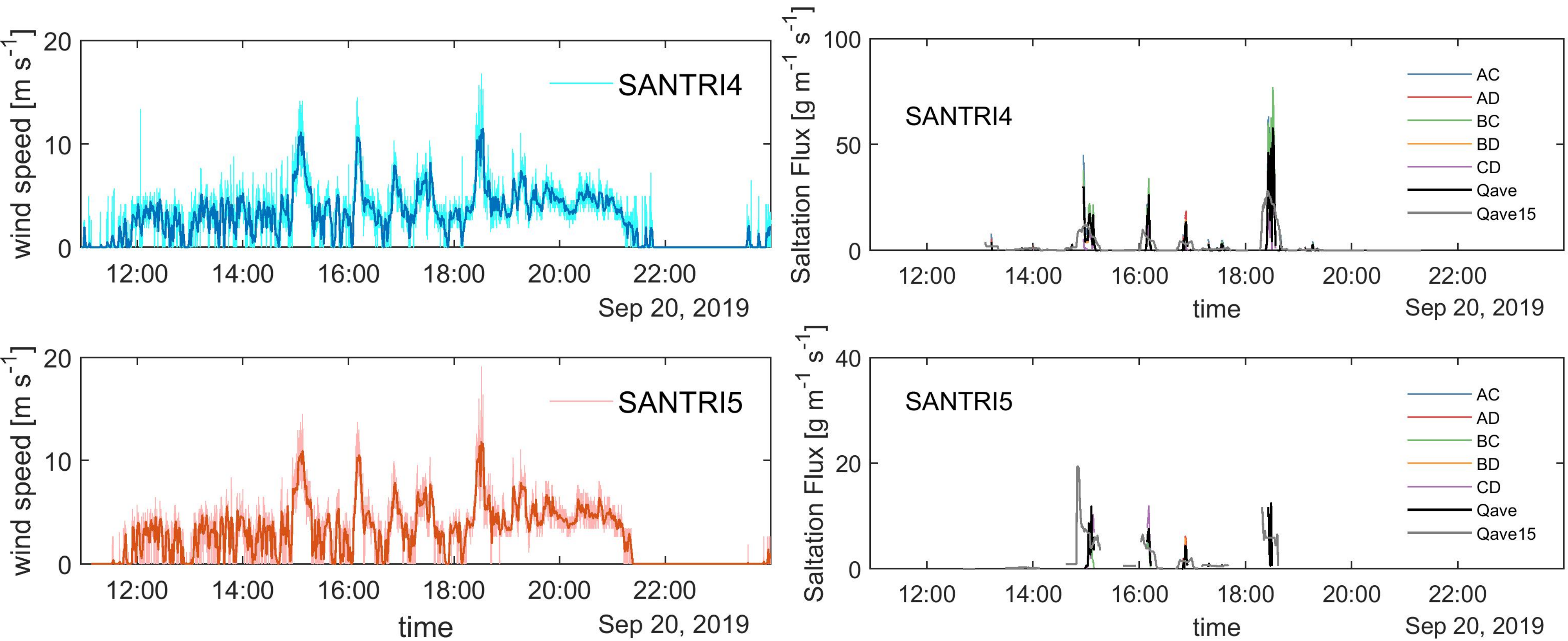
11 September 2019 – Continued Aeolian Transport



20 September – Interrupted Aeolian Transport



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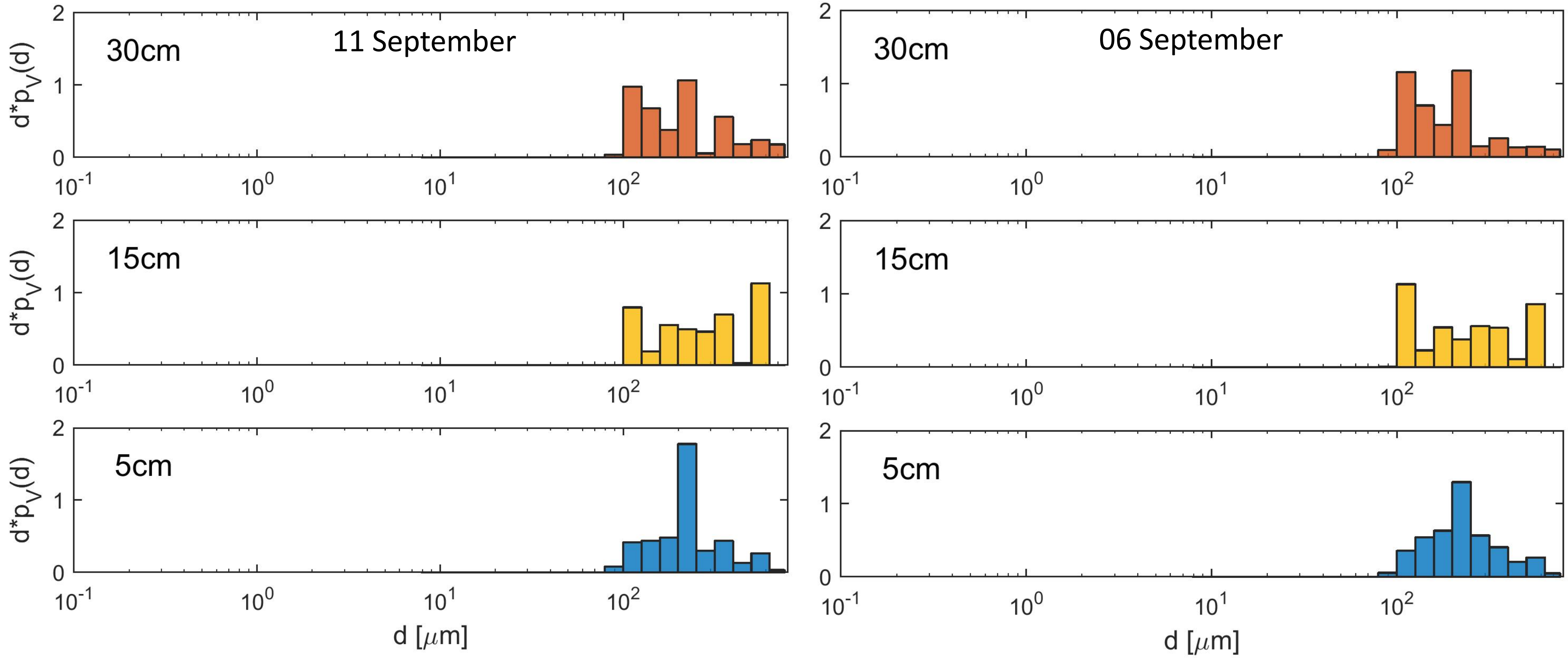
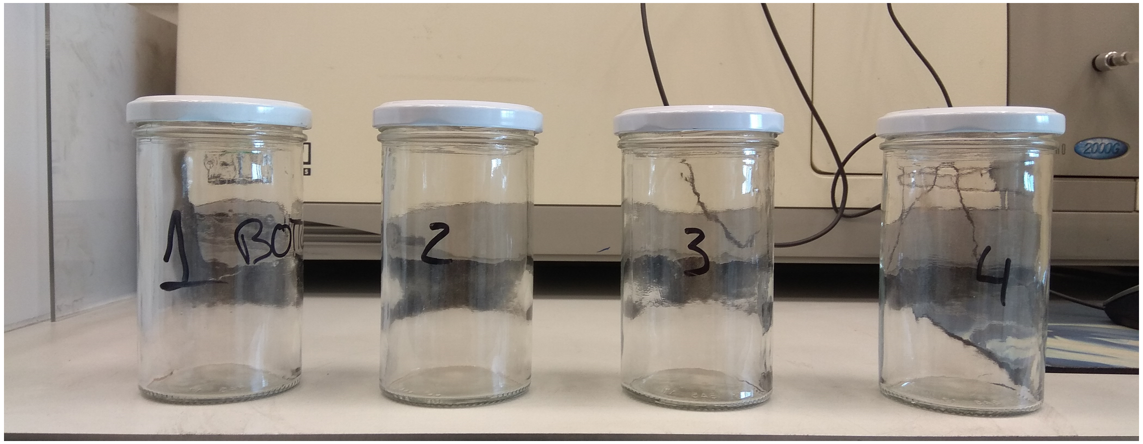
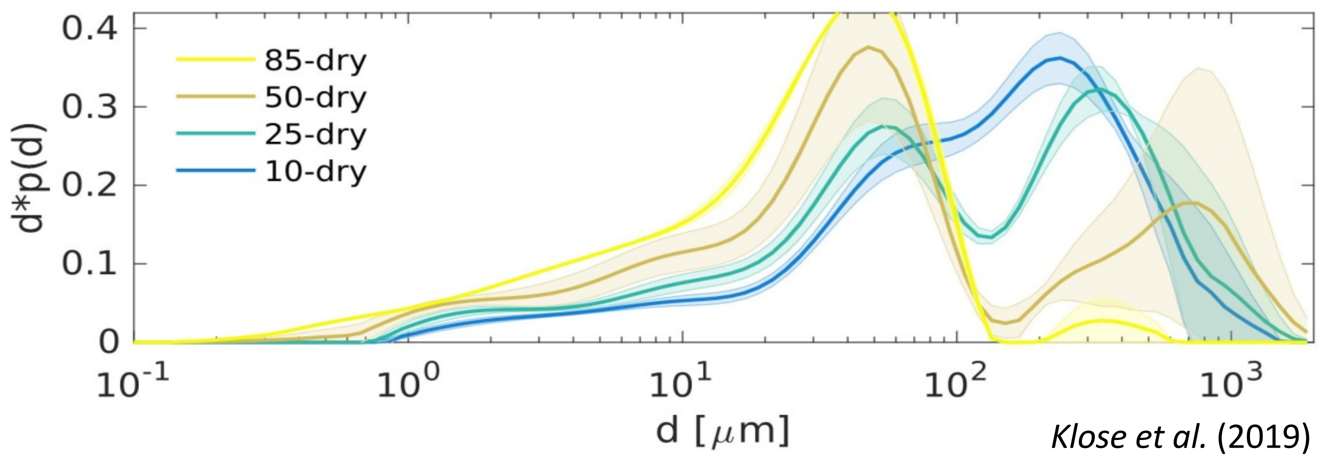
Particle-size distribution - Comparison



MWAC Particle-size distributions (different locations)





Klose et al. (2019)

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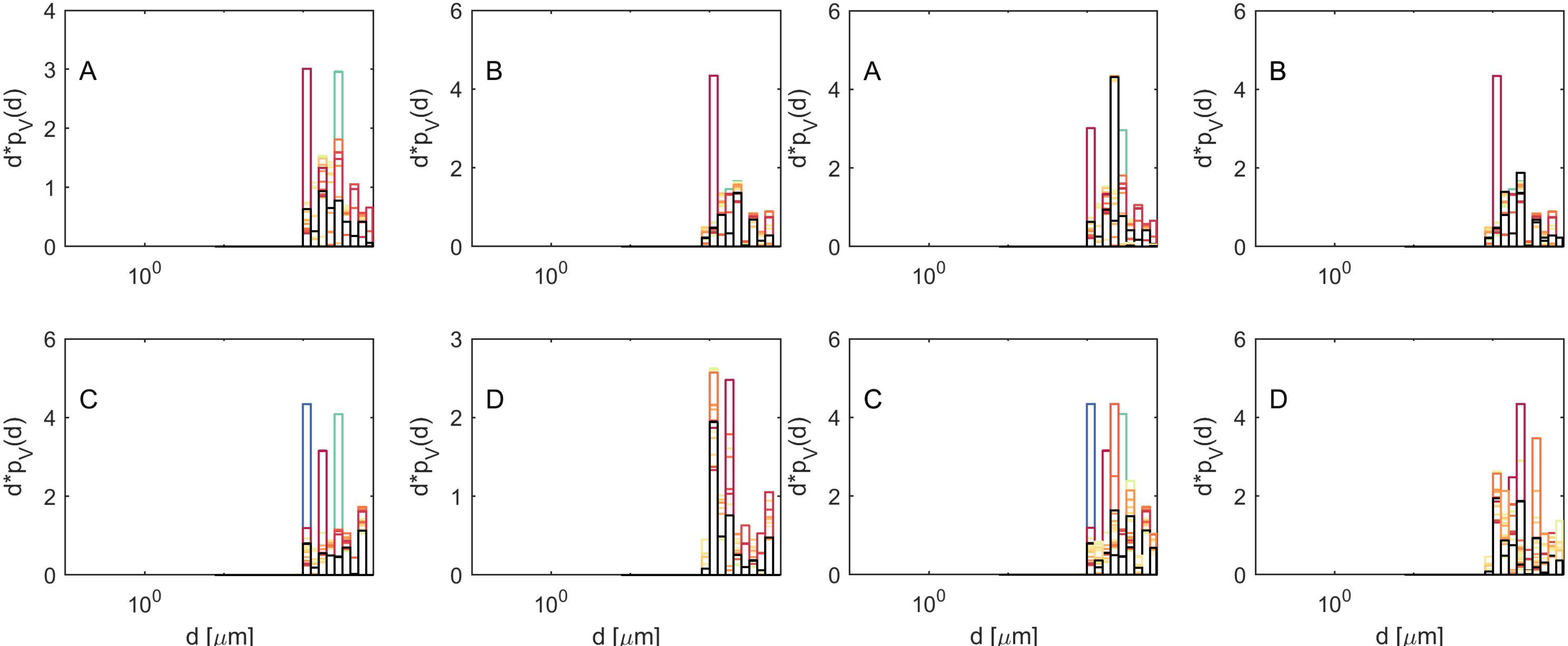
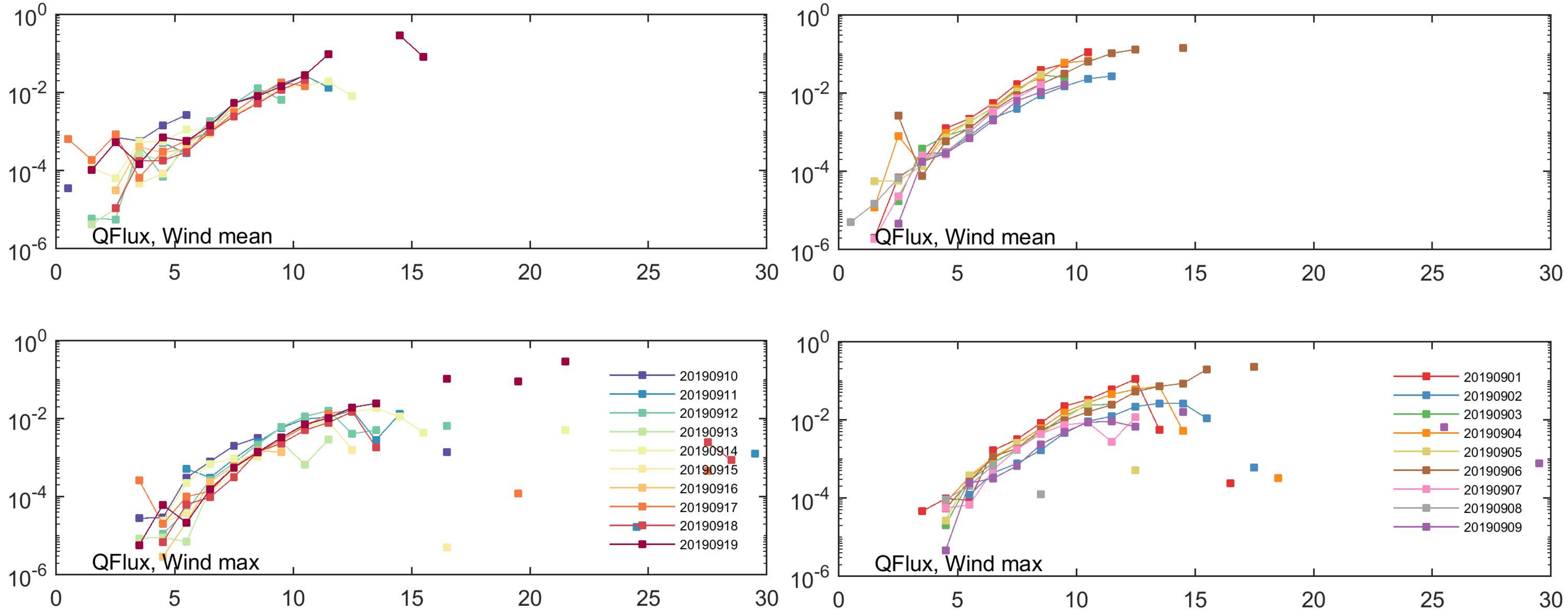
11 September 2019 – Hourly Size Distribution by Sensor



SANTRI 4

SANTRI 5

Wind Speed vs. Saltation Flux



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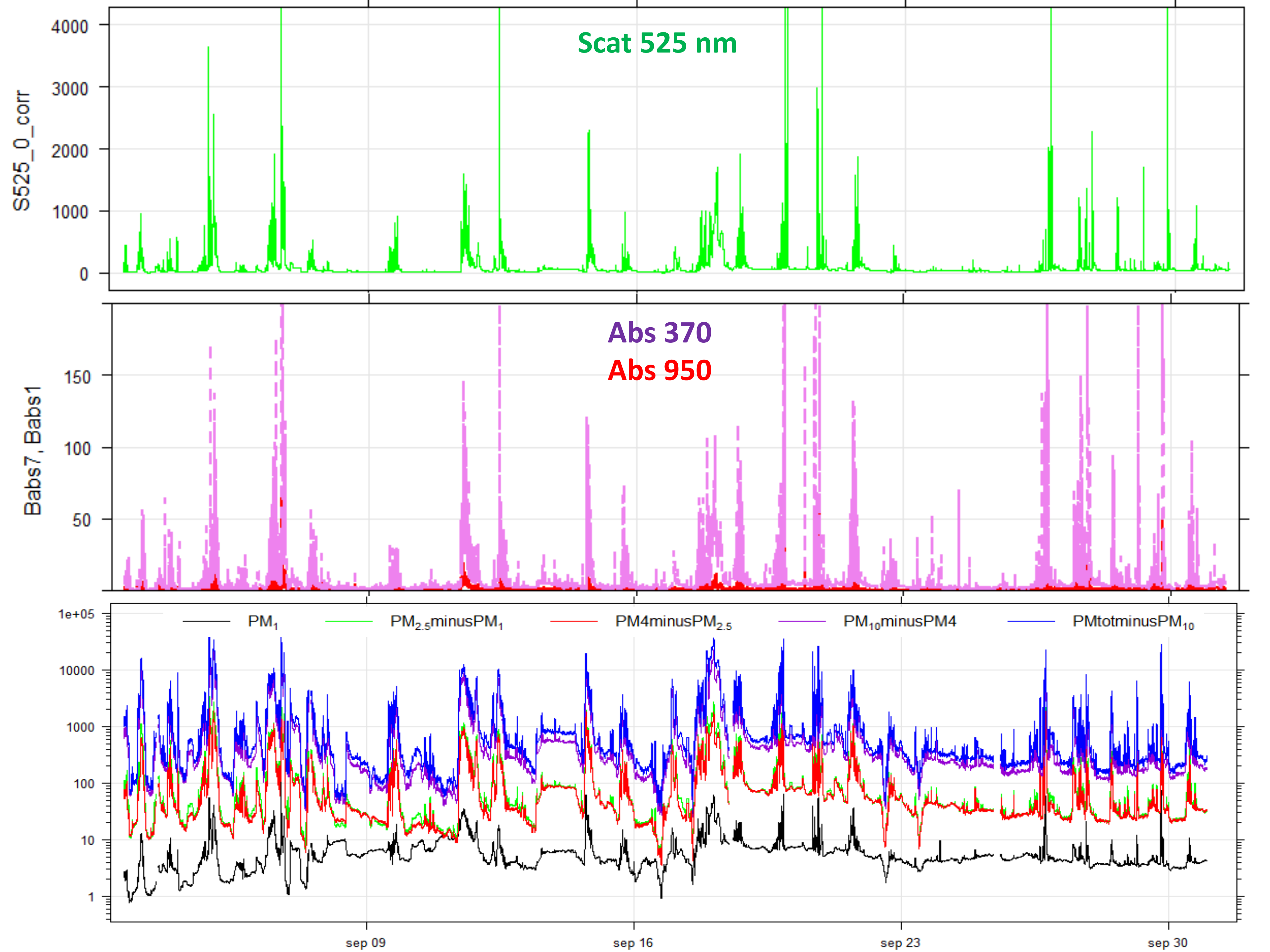
Nephelometer/Ethalometer

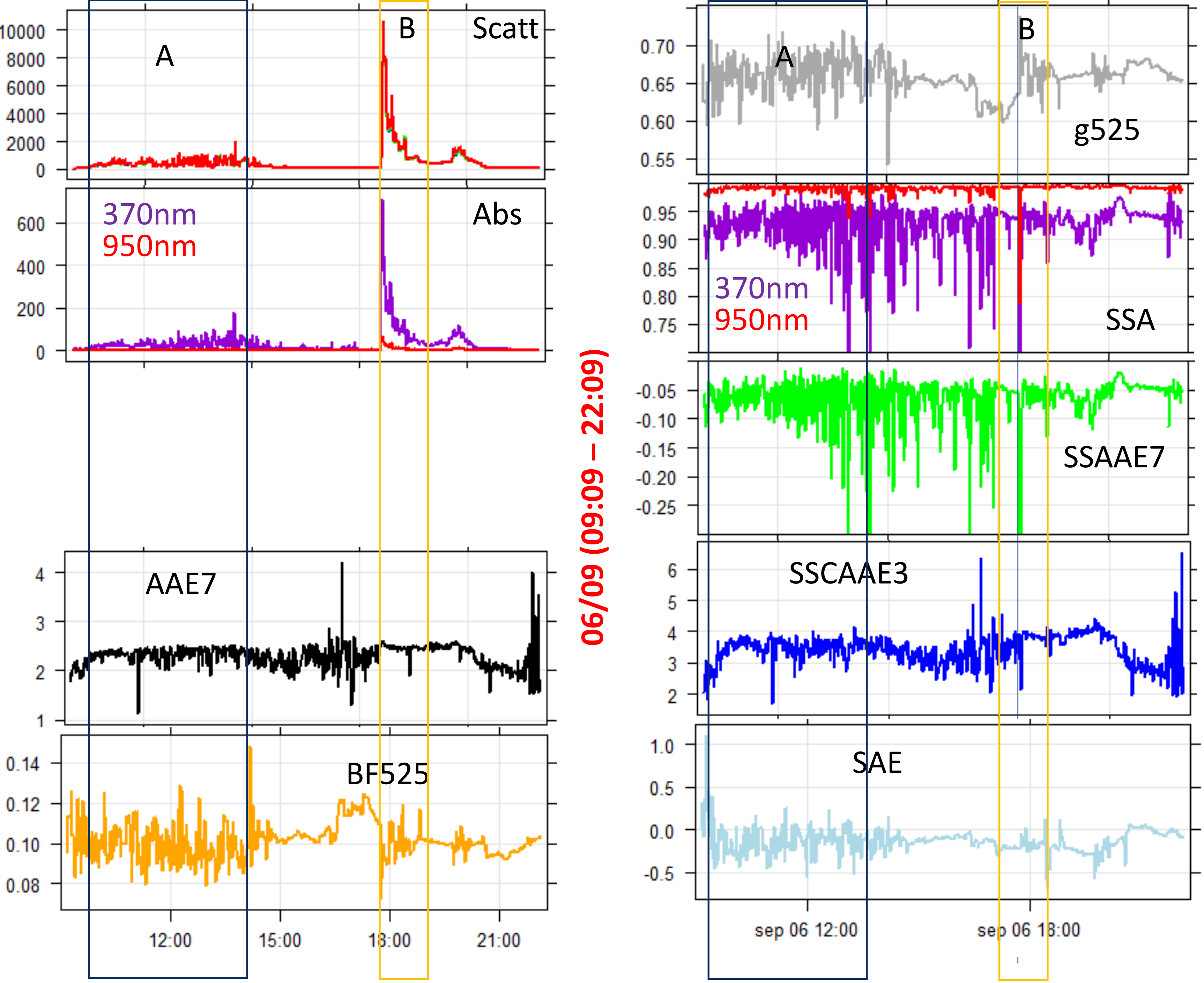
	size	composition	size & composition
❑ 3-λ scattering (450-525-635 nm)	***SAE*** (sensitive to coarse mode aerosols) ***BF* and *g*** (sensitive to lower end accumulation mode)		***SSA*** (single scattering albedo) ***SSA-AE and SSCA-AE*** (sensitive to presence of dust)
❑ 7-λ absorption (370-950 nm)		***AAE*** (sensitive to FeO_2 content)	

Extensive
(mass dependent)

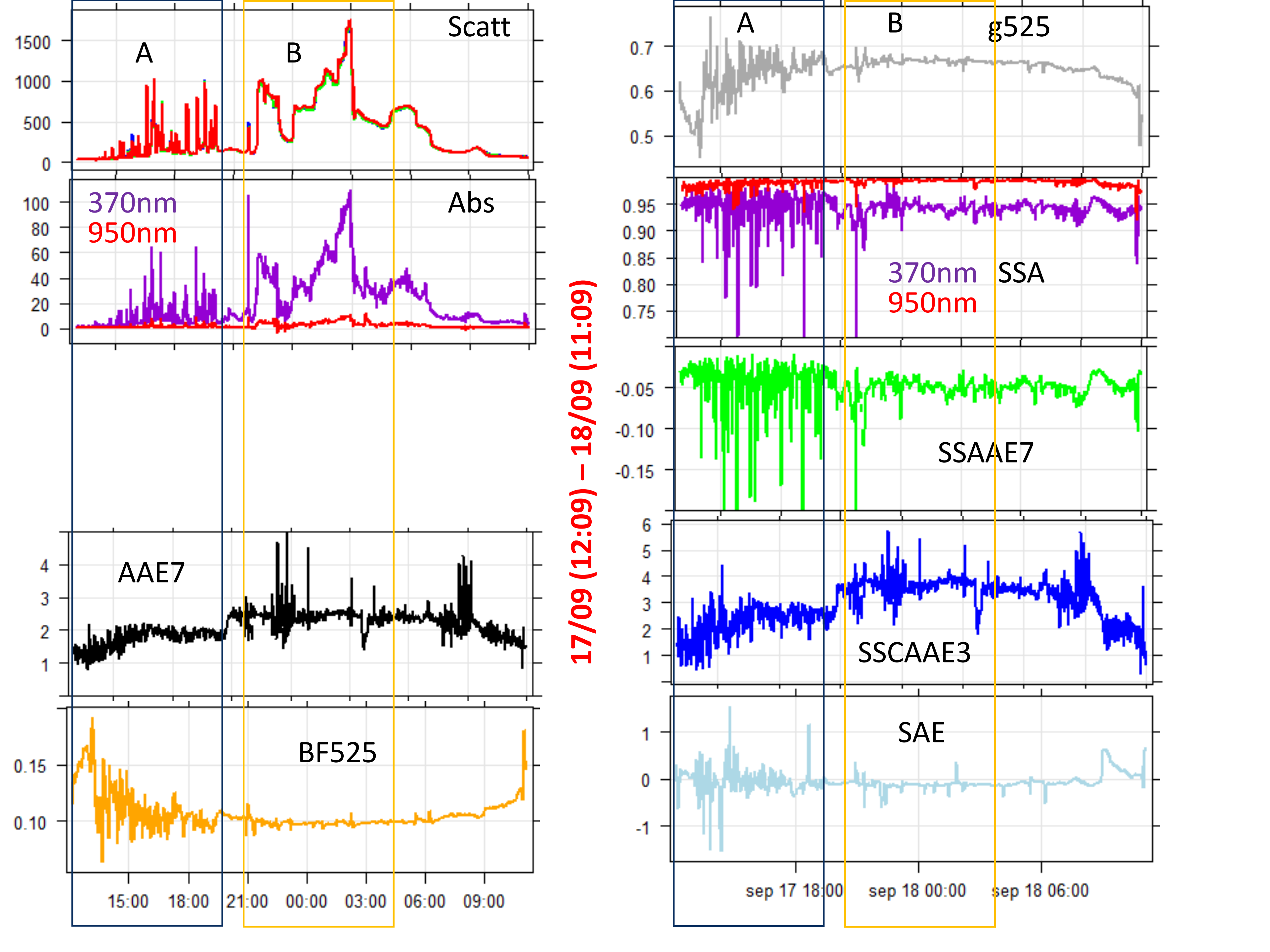
Intensive
(mass independent)



Scat 525 nm
S525_0_corr
4000
3000
2000
1000
0
Abs 370
Abs 950
Babs7, Babs1
150
100
50
PM1
PM2.5minusPM1
PM4minusPM2.5
PM10minusPM4
PMtotminusPM10
1e+05
10000
1000
100
10
1
sep 09
sep 16
sep 23
sep 30

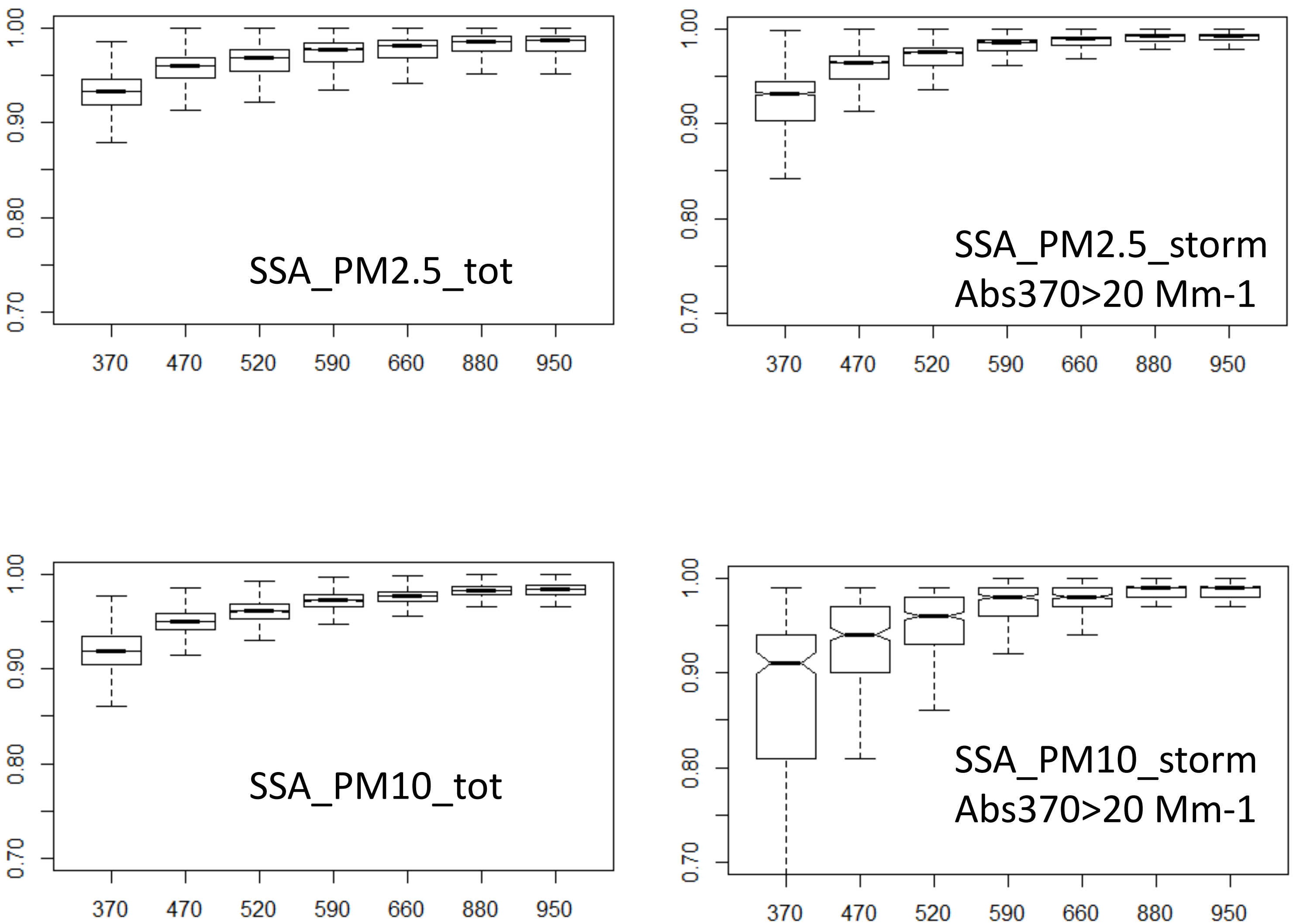


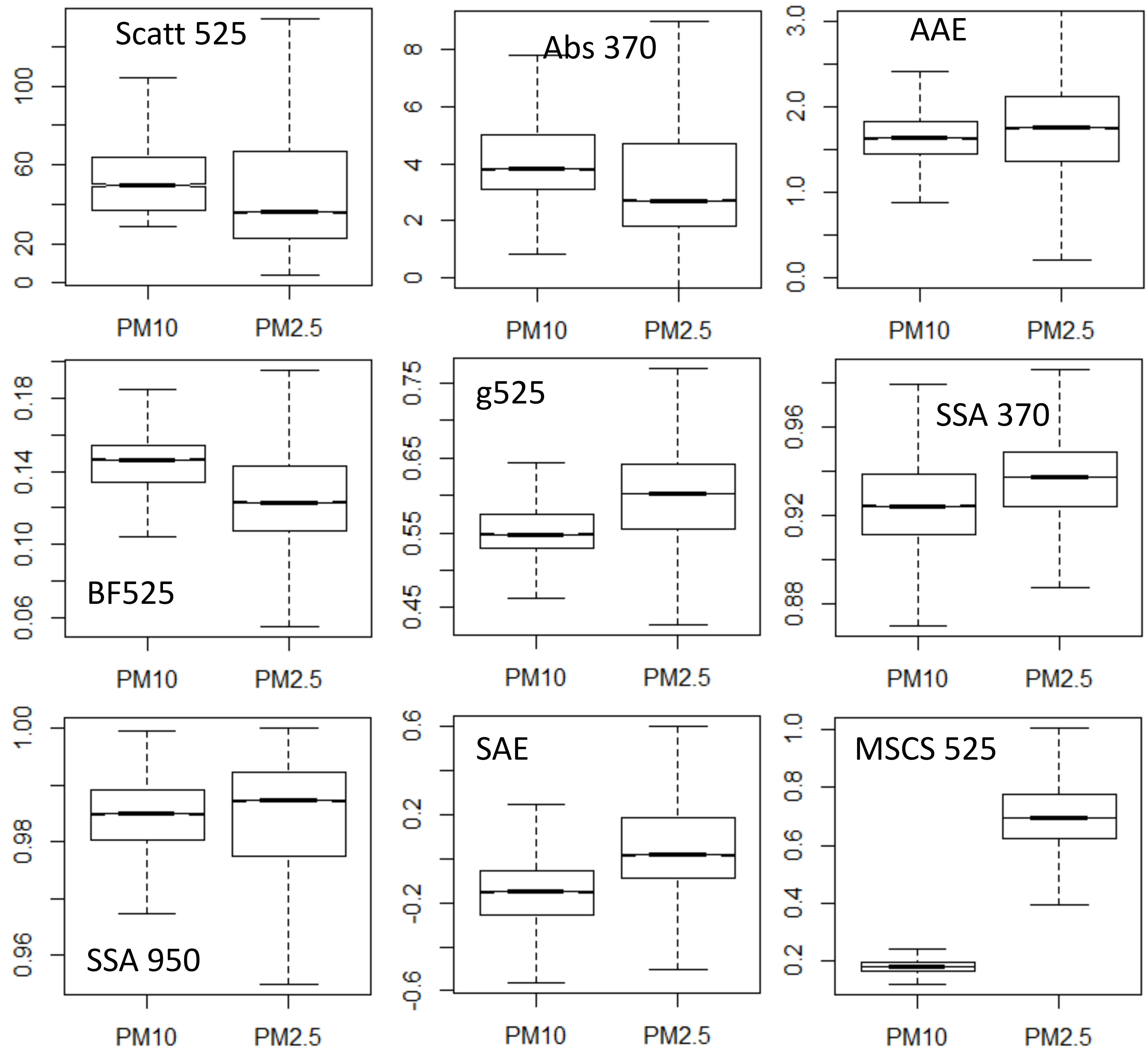
A
B
Scatt
370nm
950nm
Abs
AAE7
BF525
12:00
15:00
18:00
21:00
06/09 (09:09 – 22:09)
g525
SSA
SSAAE7
SSCAAE3
SAE
sep 06 12:00
sep 06 18:00



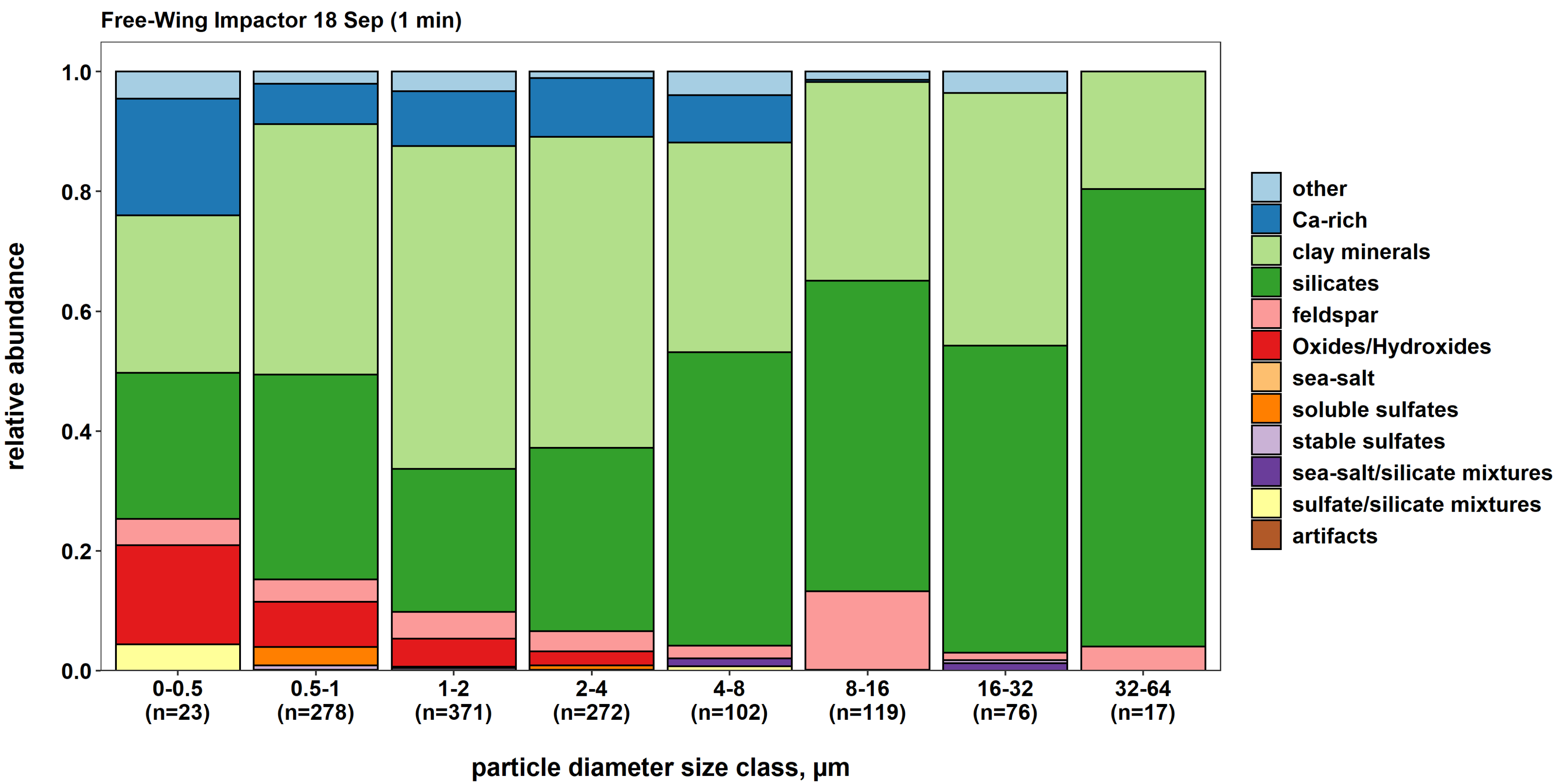
Scatt
A
B
Abs
370nm
950nm
AAE7
BF525
15:00
18:00
21:00
00:00
03:00
06:00
09:00
17/09 (12:09) – 18/09 (11:09)
g525
SSA
SSAAE7
SSCAAE3
SAE
sep 17 18:00
sep 18 00:00
sep 18 06:00

Single Scattering Albedo (SSA)

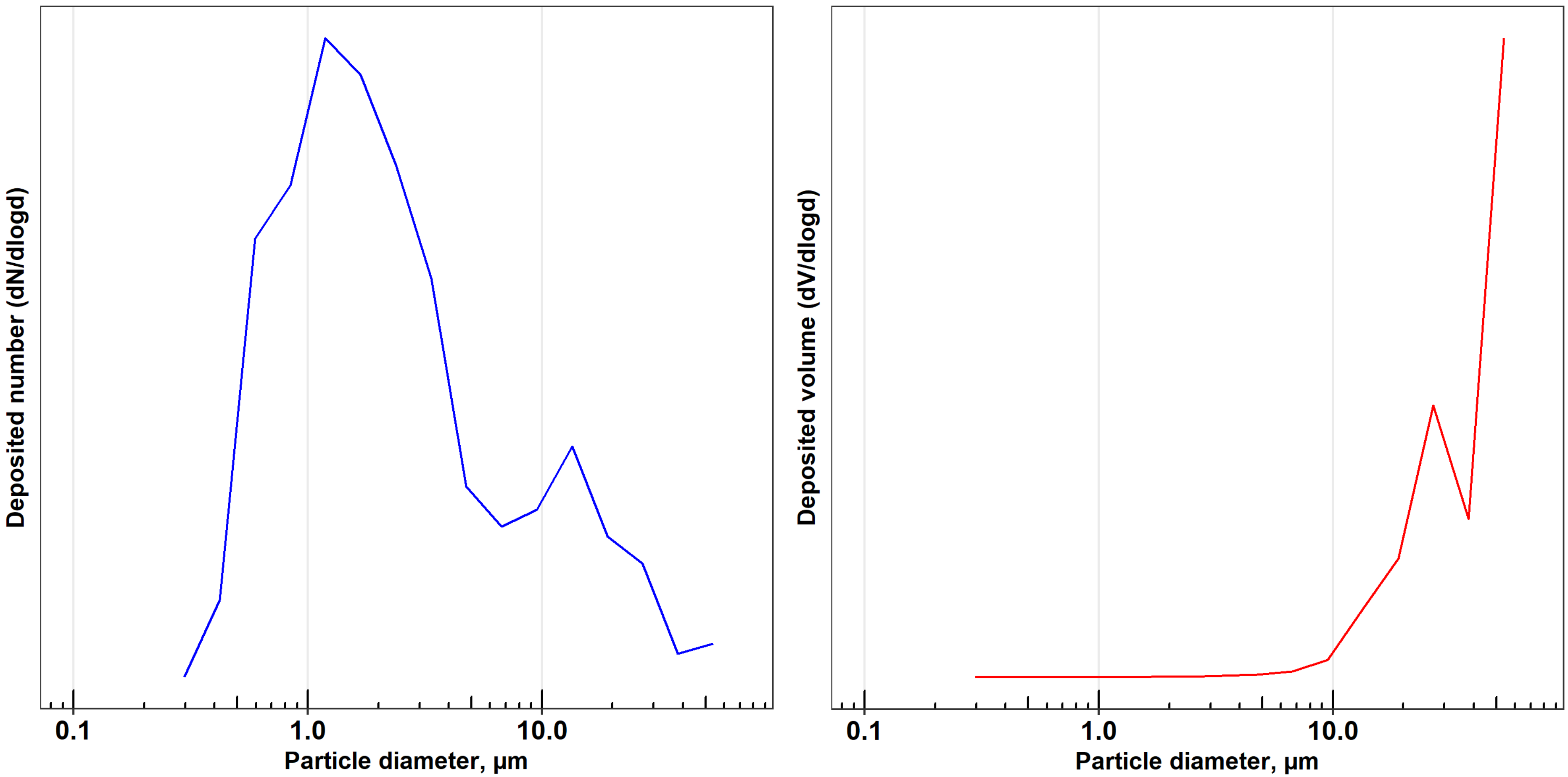



Scatt 525
Abs 370
AAE
BF525
g525
SSA 370
SSA 950
SAE
MSCS 525
PM10
PM2.5

Composition FWI (18 Sep 17:22)



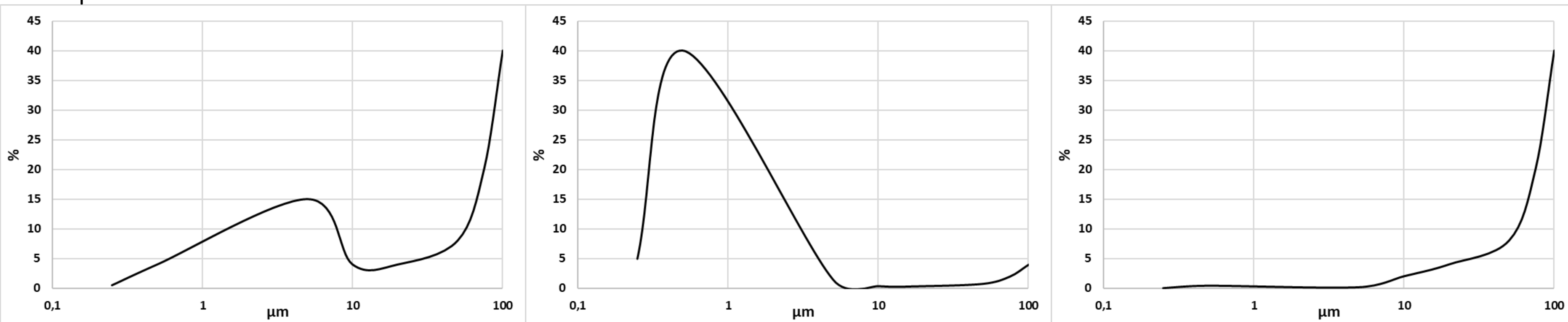
Size distribution FWI



STRATEGY FOR MOUDY AND LVS: CHEMISTRY OR MINERALOGY,

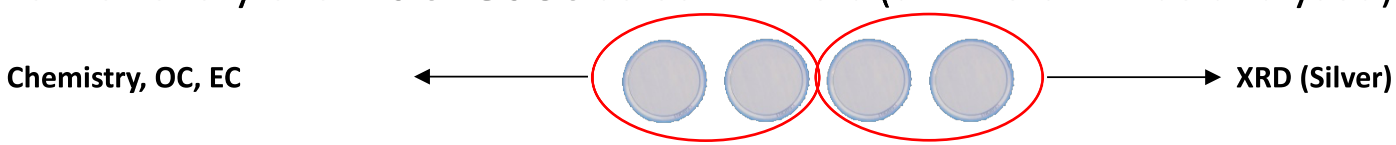
- Analyse PSD based on FIDAS, PM values and wind to determine the different types of events sampled

Examples

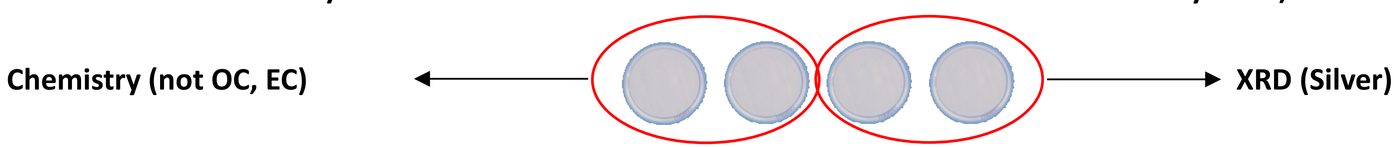


- Classify the MOUDI and LVS samples according to different event types

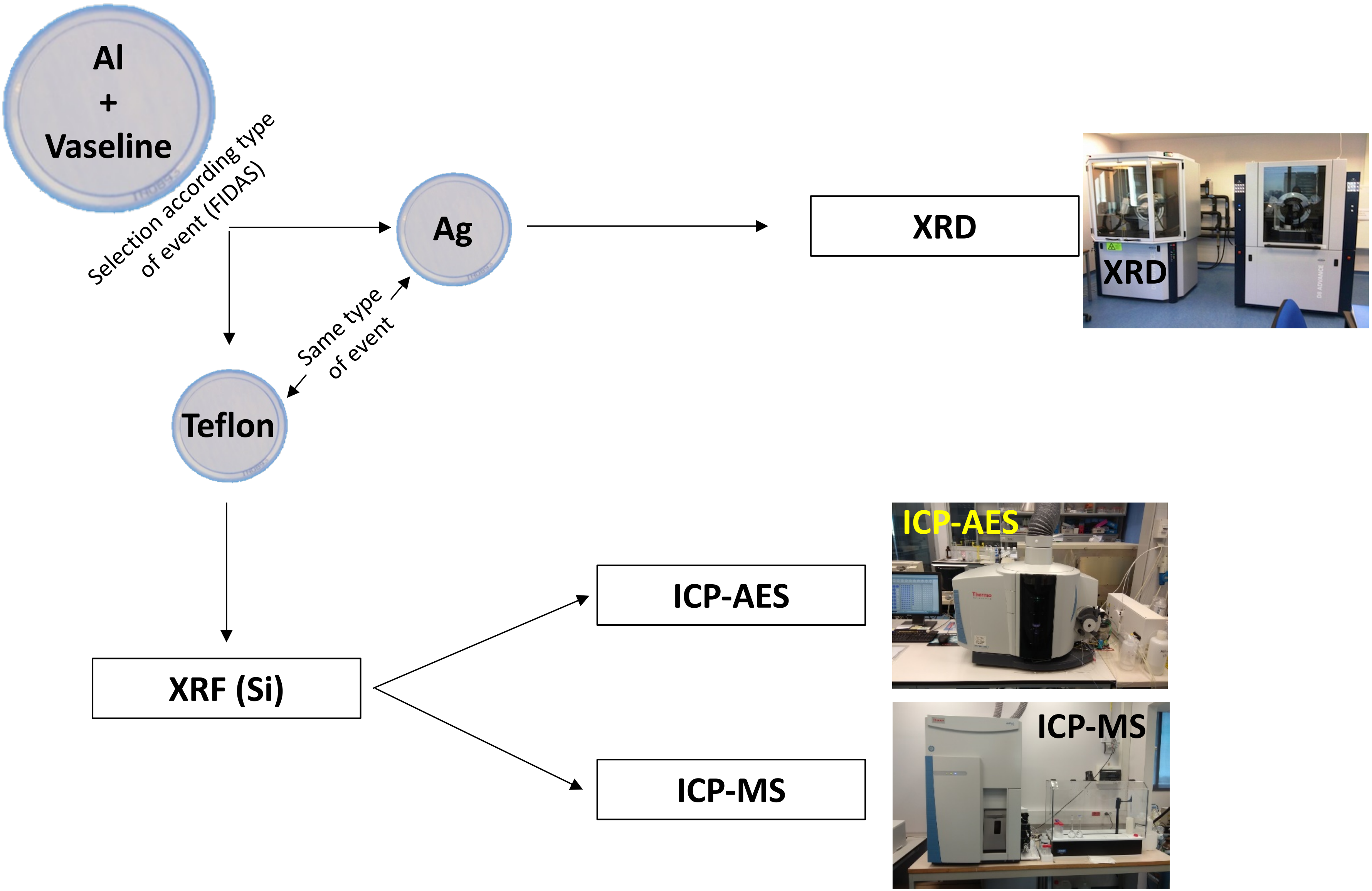
- LVS: For every event **at least** select 4 filters (all filters will be analysed):



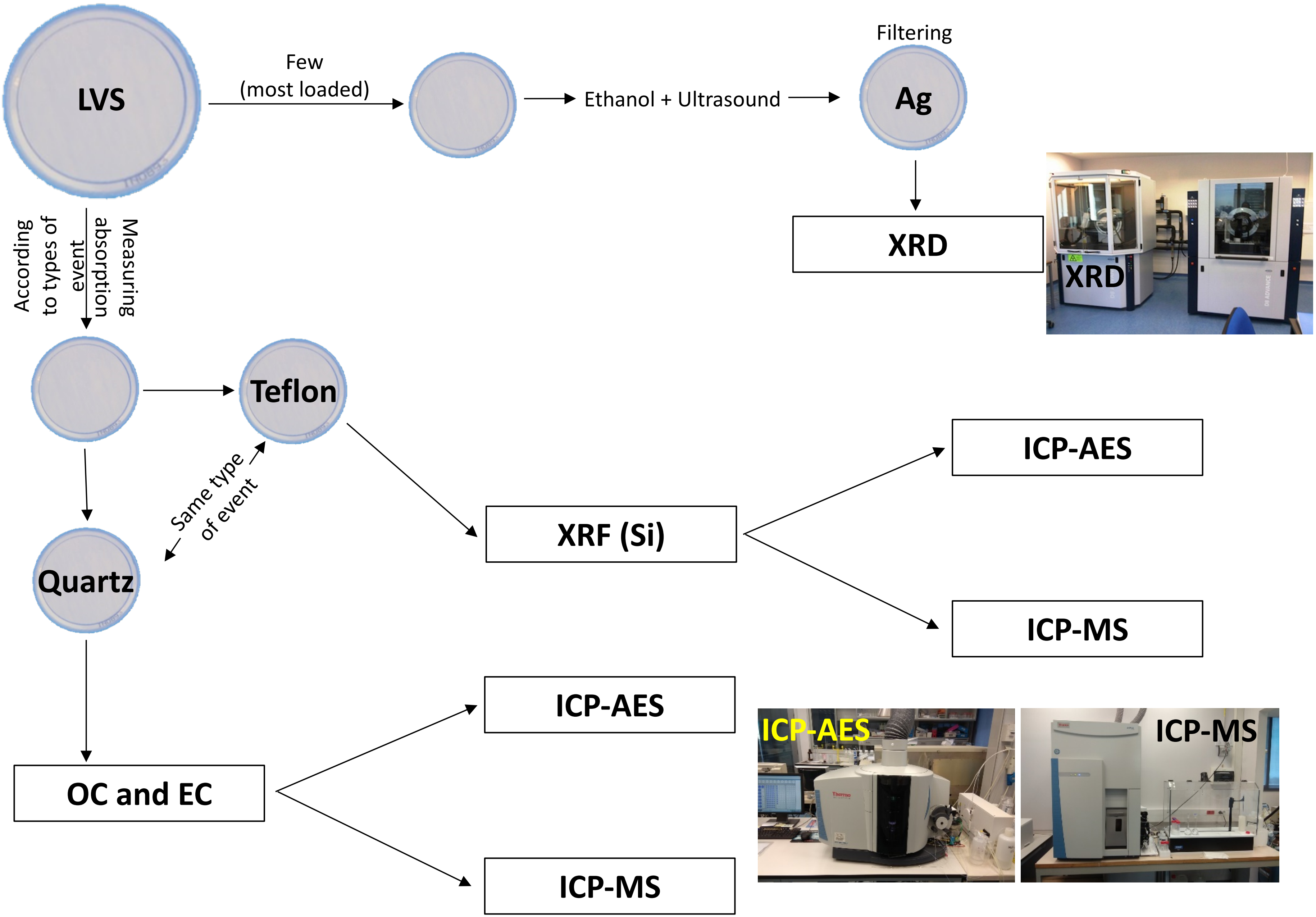
- MOUDI: For every event **at least** select 4 sets of filters analysed):



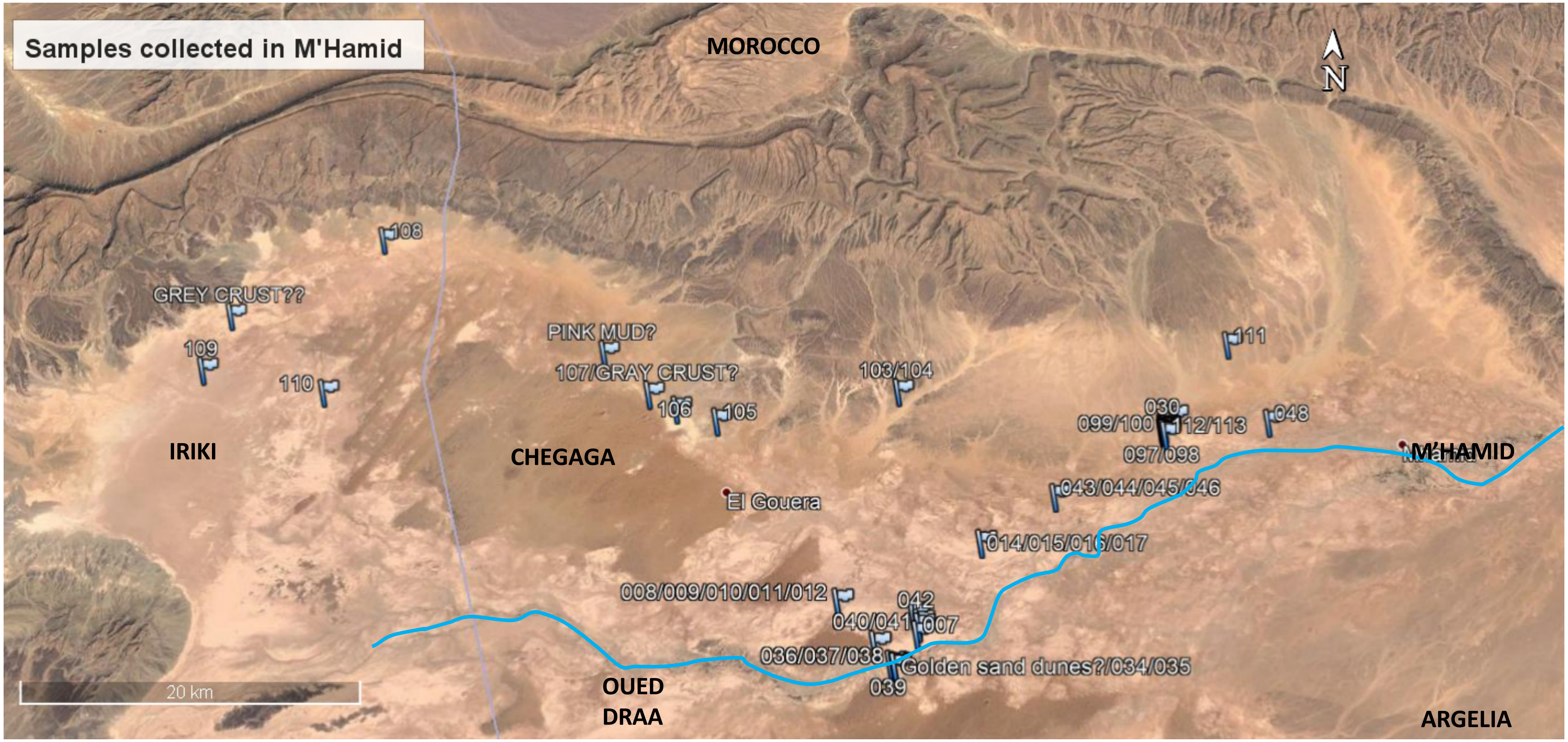
STRATEGY TO FOLLOW FOR MOUDI FILTERS



STRATEGY TO FOLLOW FOR LVS FILTERS



112 soil samples collected
27 random samples in the main site and regional samples



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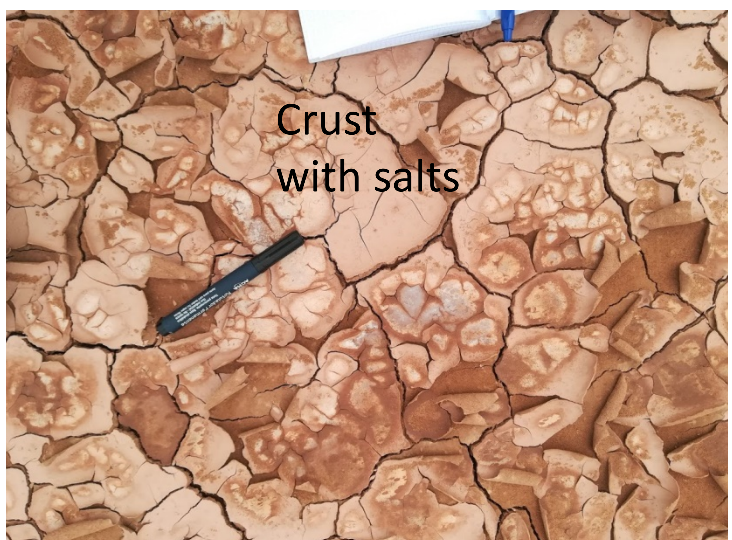
Crust: Typical mud cracks from flooding

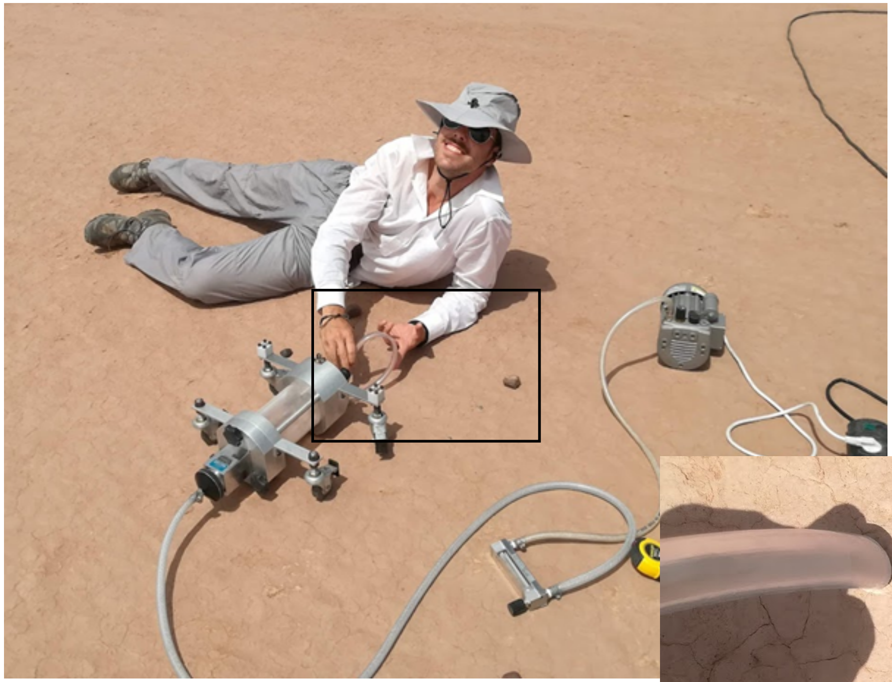
Soil: Paleo sediments from flooding plane below common crust

Common crust: Cracked surface of soil with very thin flooding crust

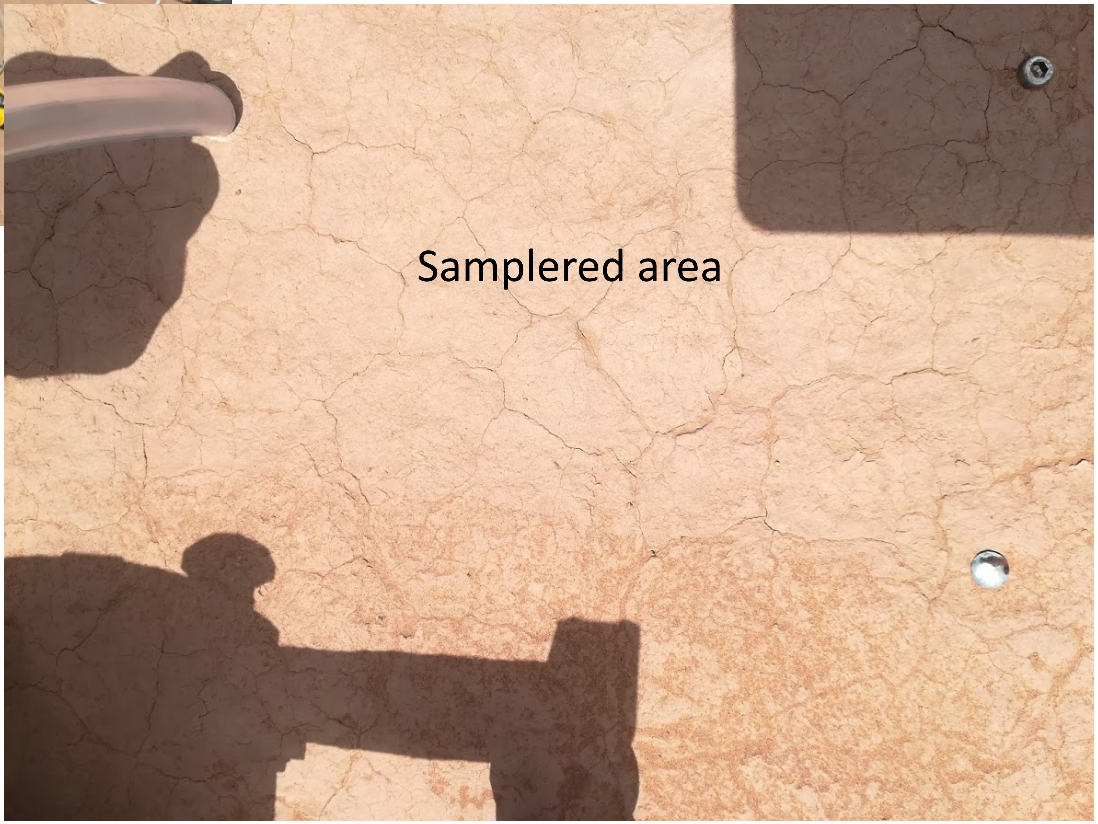


Sand retained by vegetation

DOG



- 11 samples in Polycarbonate filter

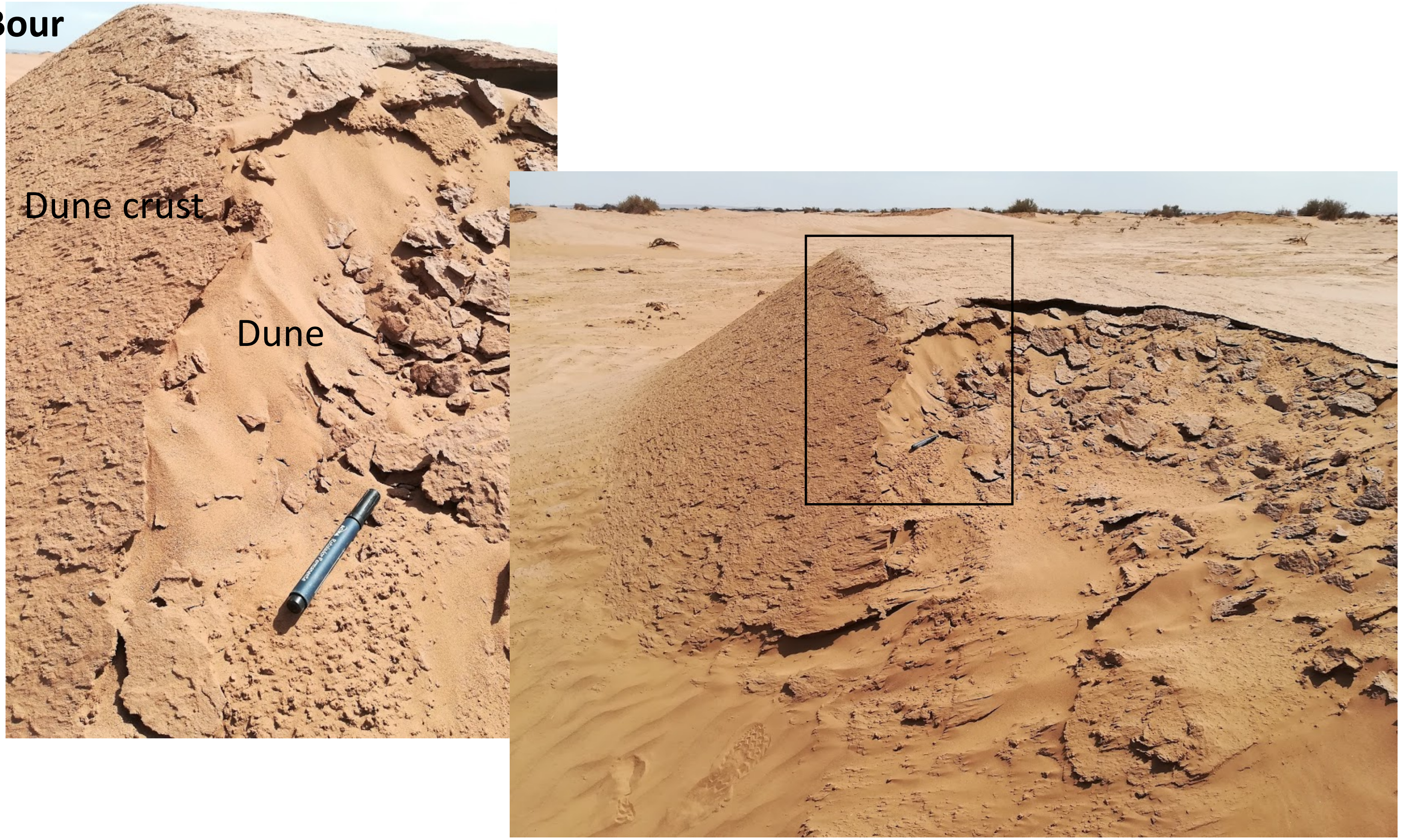


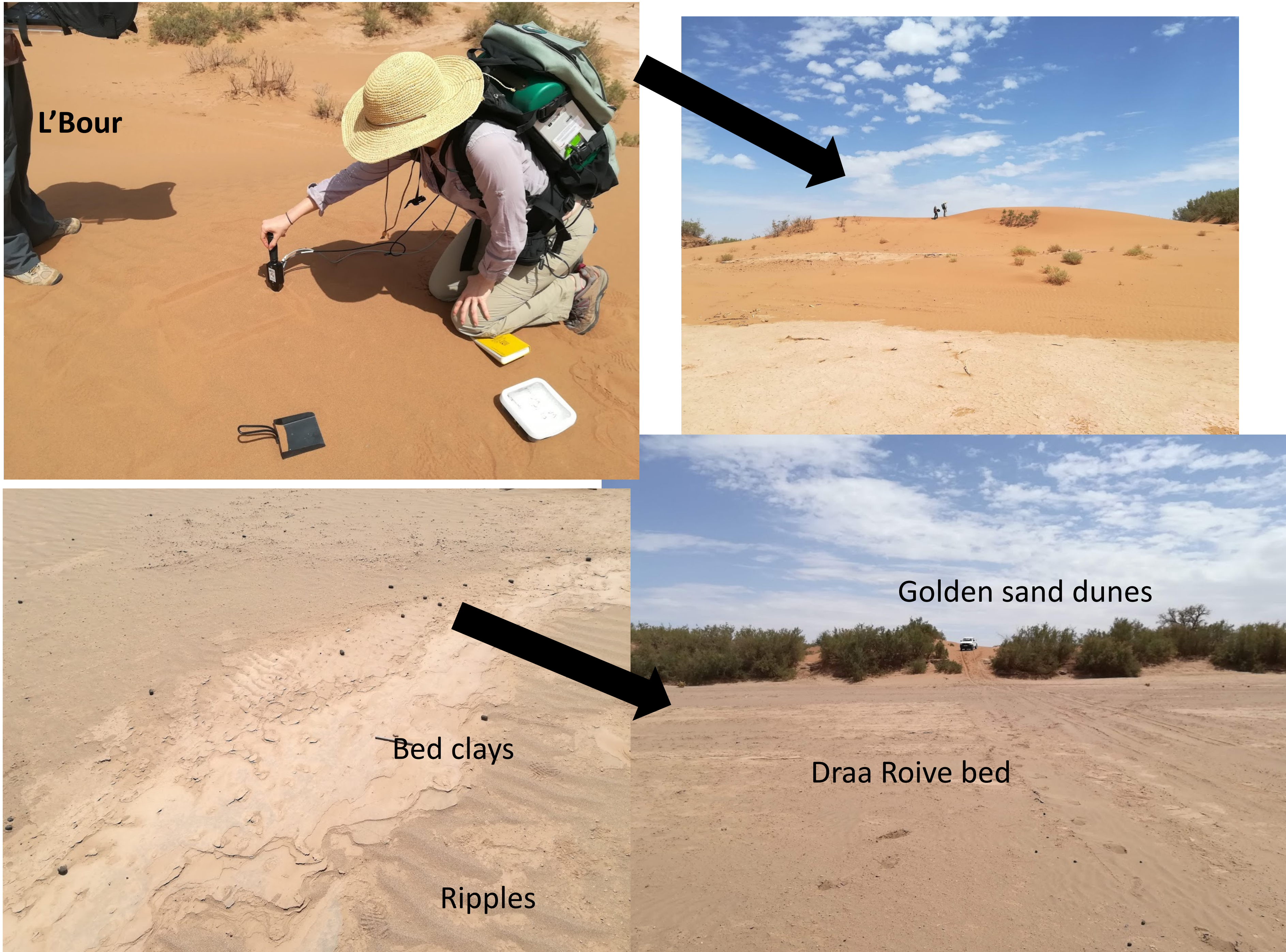
- We will analyse them for XRF, XRD and Chemistry


L'Bour
eflorescences
Crust
Common crust

Mega-mud crack at the bottom of Erg Smar

L'Bour

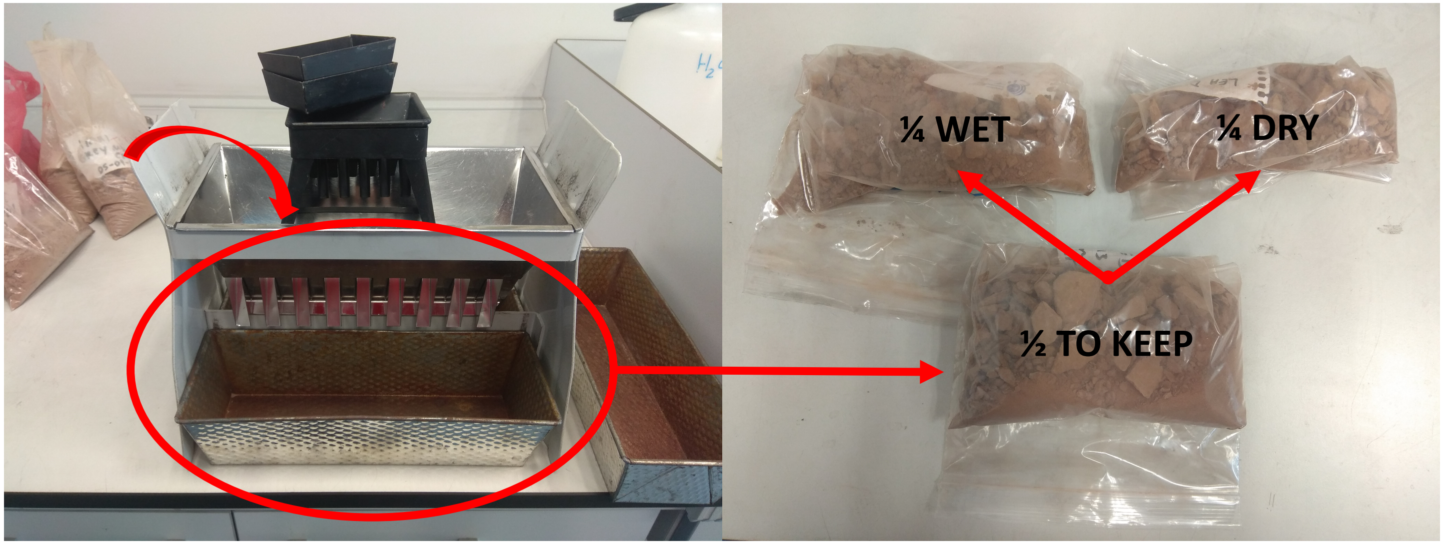



L’Bour
Golden sand dunes
Bed clays
Draa Roive bed
Ripples

Procedure

- 54 samples from random sampling (27 crust and 27 soil)
- 58 samples from the Draa Basin

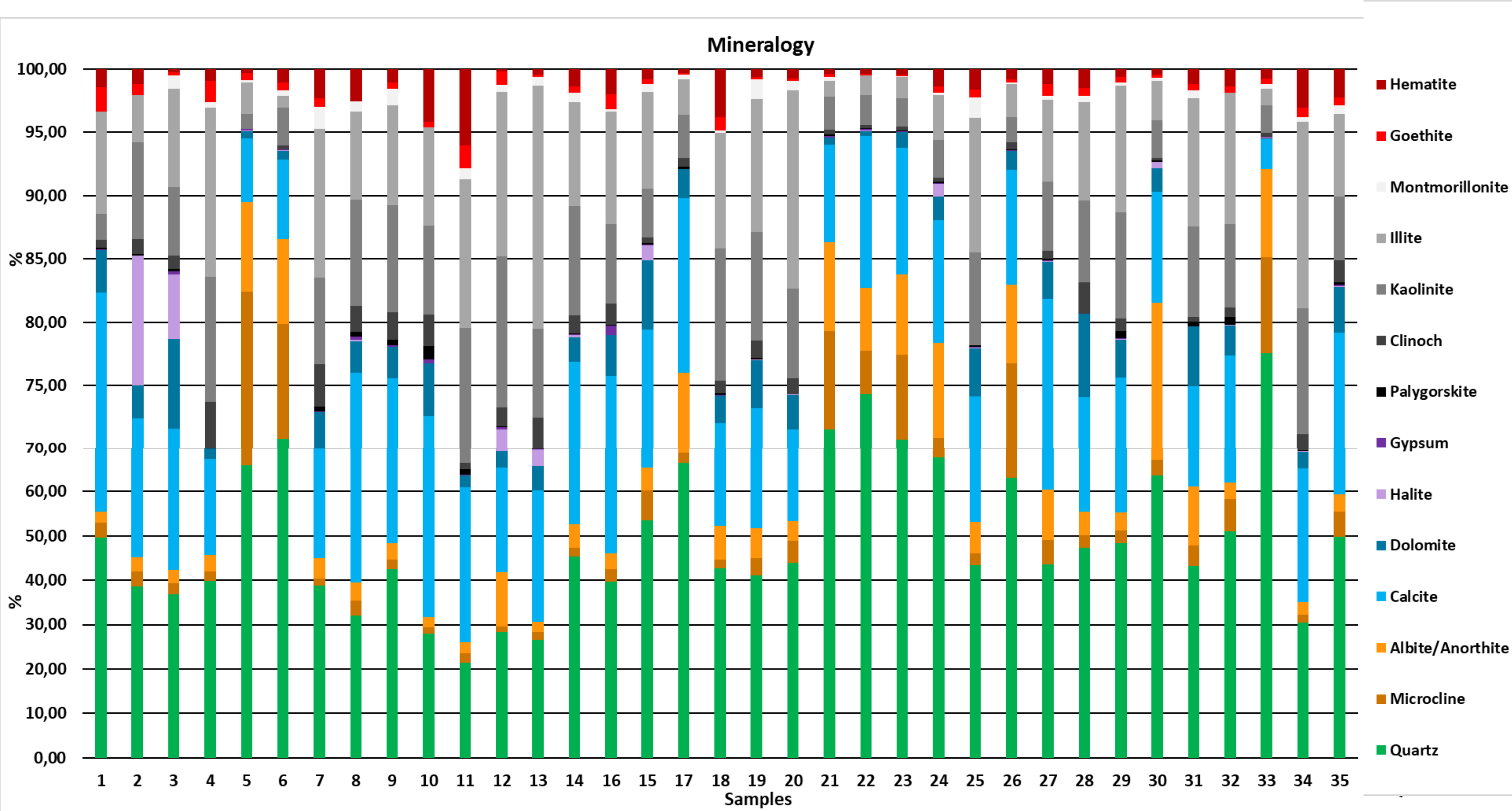
- The samples were splitted into two identical subsamples
    - 1/2 to keep
    - 1/2 splitted again:
        - 1/4 for WET analyses: Disaggregated PSD and PS separation for XRD
        - 1/4 for DRY analyses: Extraction of PM_{10} with rotor PM_{10}&$PM_{2.5}$ for XRD



Some untouched and entire crusts

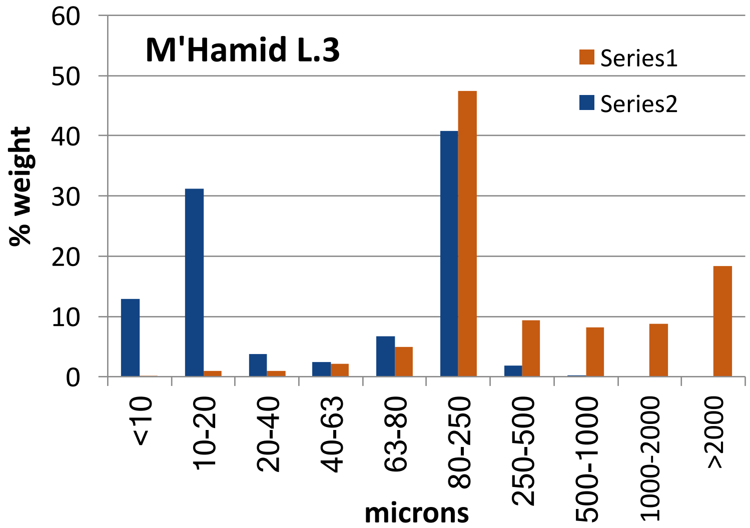
Grinded samples for XRD

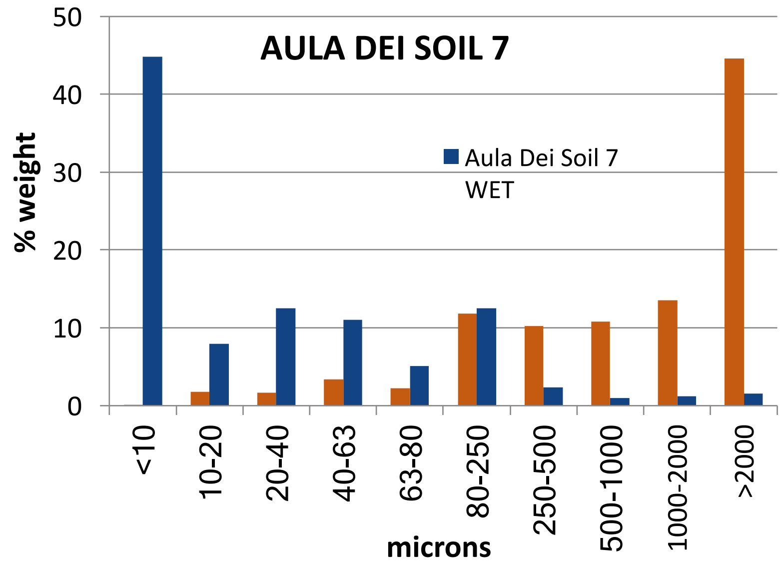
Quantitative XRD results:



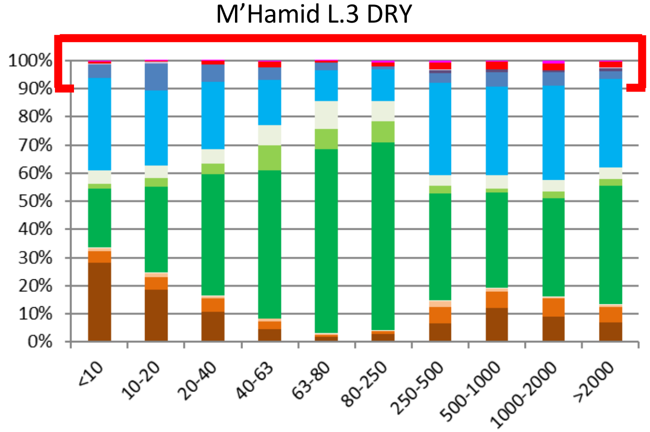
- Mainly Quartz, Calcite, Kaolinite and Illite
- Halite (NaCl) is the major salt in samples with white efluorescenses
- Hematite vary a lot, up to 6%
- Clays are represented with Illite and Kaolinite, followed by Chlorite/Clinochlore, Montmorillonite, and Palygorskite

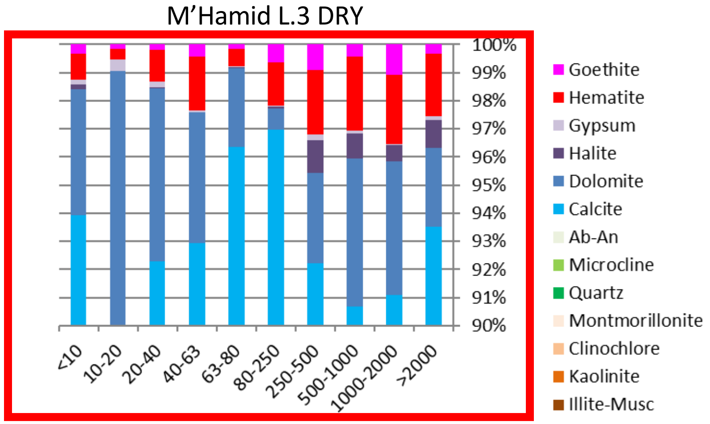
PSD in M´HAMID vs Zaragoza

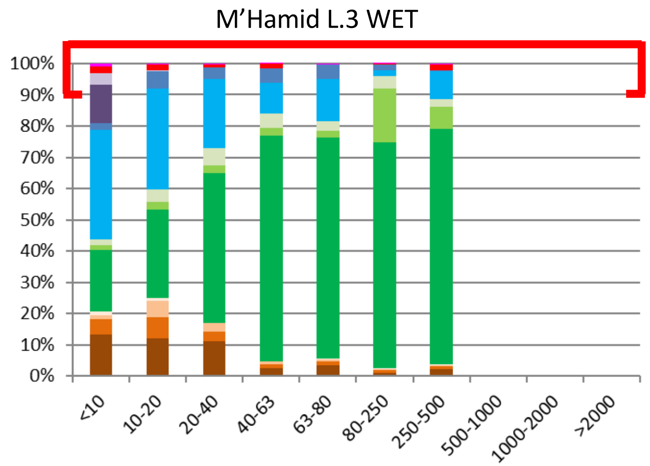


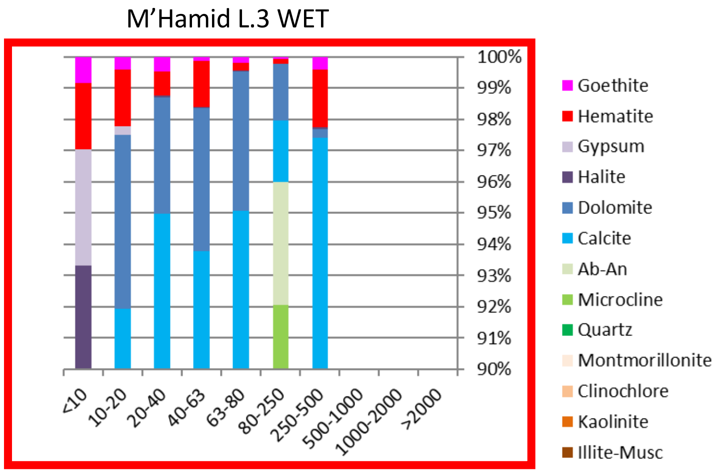


Size-resolved mineralogy









PhD Theses

- Cristina González:

In charge of the online field data

  - Evaluation of dust emission schemes (bulk dust)
  - Extending dust emission schemes to treat mineralogy
  - Adaptation of schemes to work in regional and global models

- Adolfo González:

In charge of the samples and lab analyses

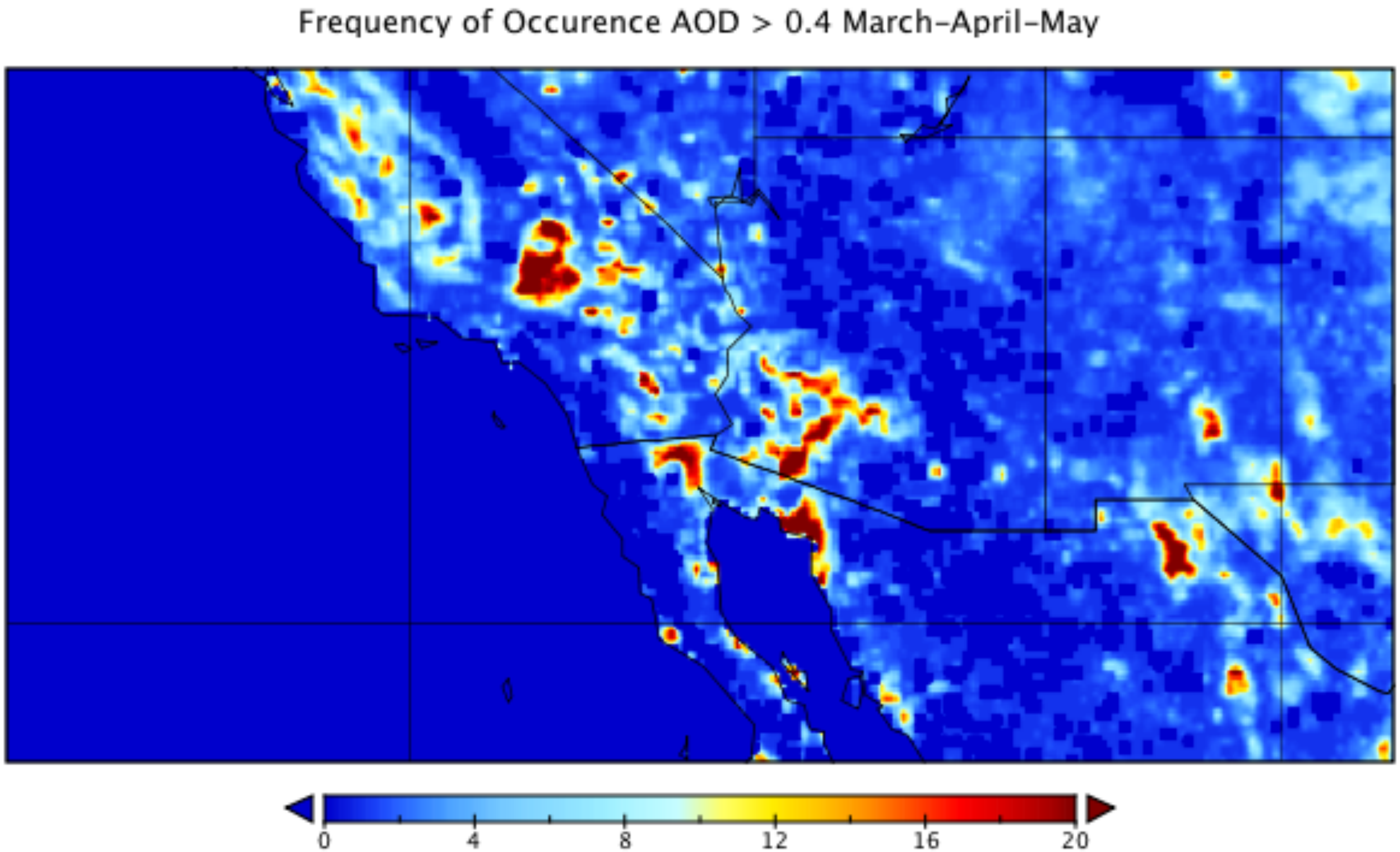
  - Exploratory analyses of the campaign data
  - Relationship between parent soil and emitted dust in terms of size distribution and mineralogy
  - Understanding the local and regional contributions to the emitted dust

- Agnesh Panta:

In charge of the electron microscopy

  - Relationship soil-emitted dust focusing on number and mixing state
  - Depending on time incursion into shape.

Southwestern US



Iceland