Installation et utilisation d'instrumentation

Instalation and performance of instrumentation

(MAC2/3.5b/380)

Natalia Prats Porta

Head of the Aerosol In-Situ Group

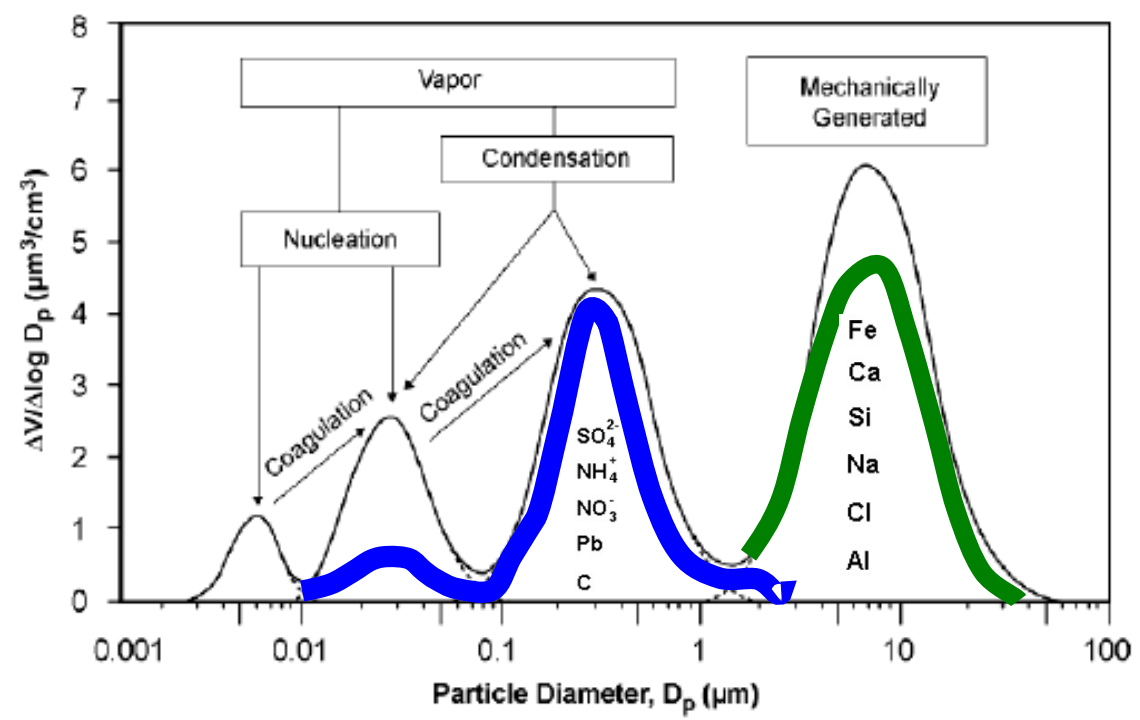
Izaña Atmospheric Research Center – AEMET

04/03/2021

Observation: size and composition

Microphysical properties: concentrations, size distribution

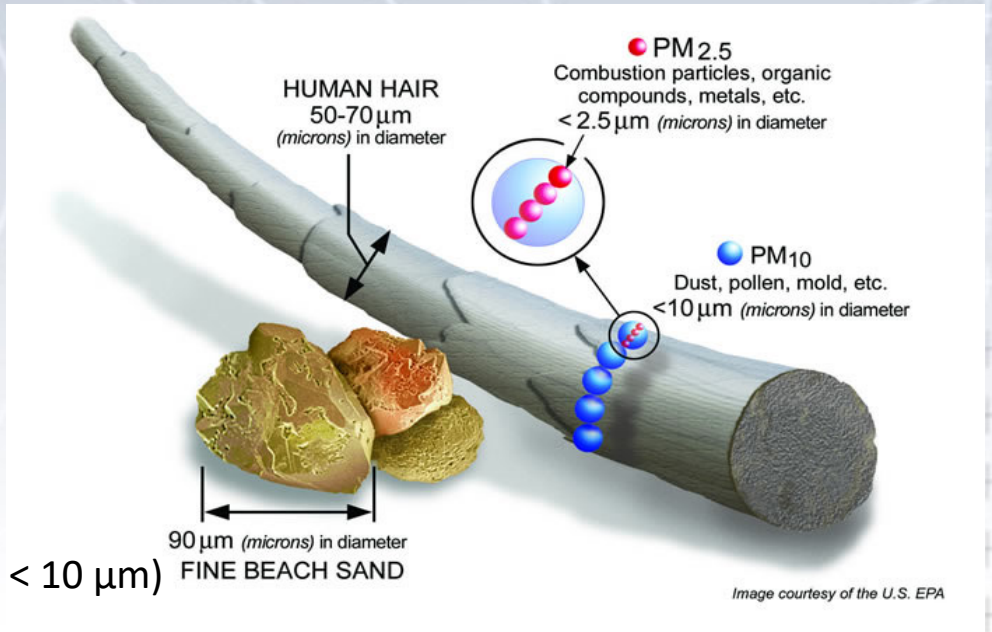
Optical properties: absortion and scattering



Size: **1nm – 100µm (10^{-9} – 10^{-4} m)**

< 1nm: ➔ **Å**

> 100µm: ➔ does not remain in suspension



In terms of Air Quality:➔ Particulate Matter PM

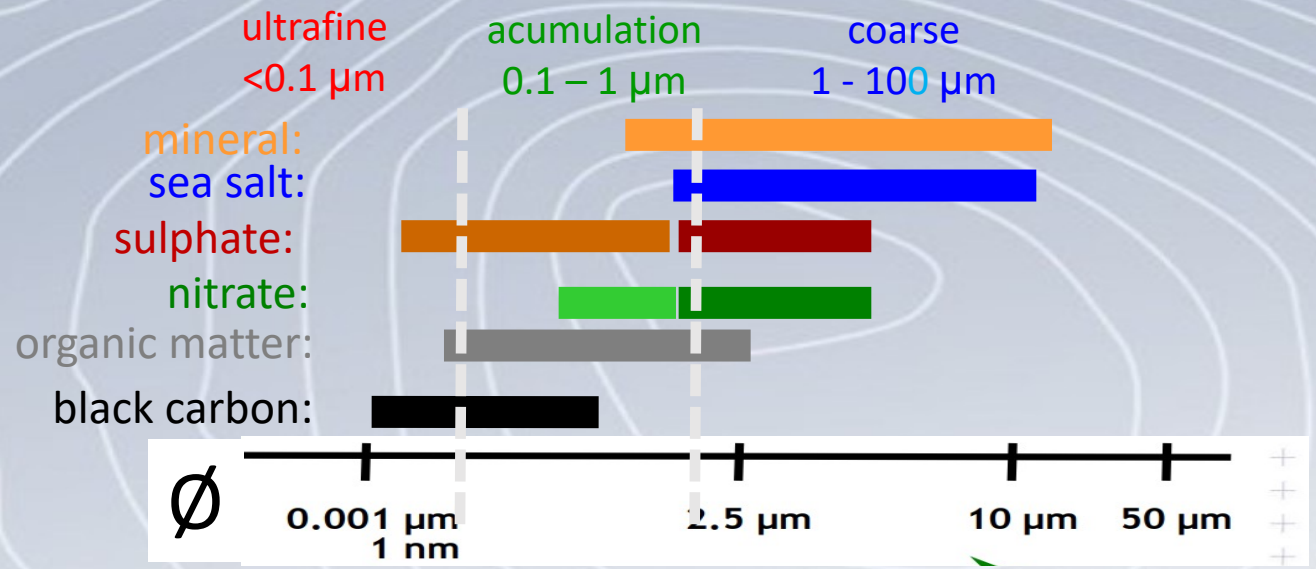
PM10 mass concentration (µg/m³) of all aerosols smaller than 10 µm (particles with Ø < 10 µm)

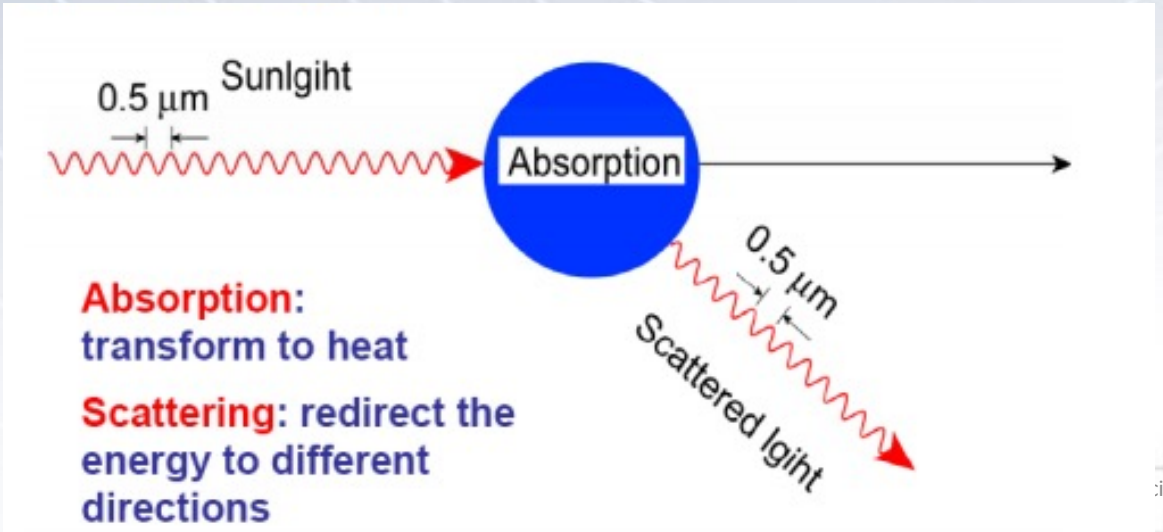
PM2.5 mass concentration (µg/m³) of all aerosols smaller than 2,5 µm (particles with Ø < 2,5 µm)

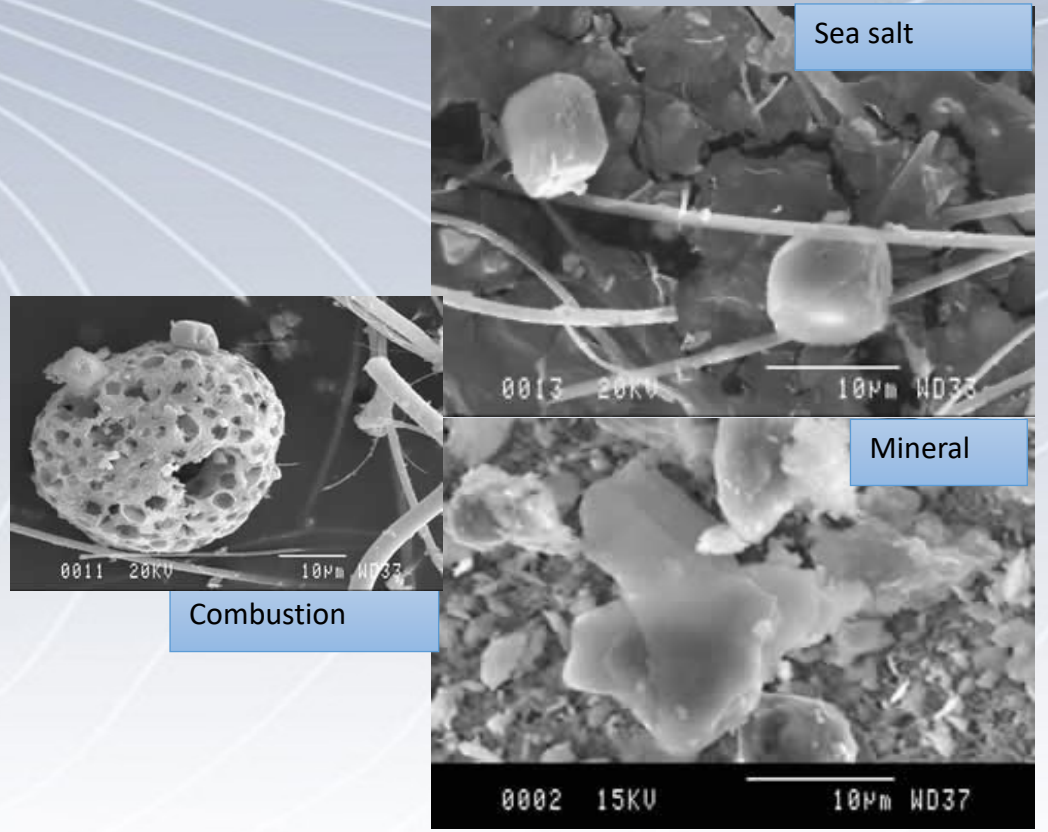
Observation: size and composition

Microphysical properties: concentrations, size distribution

Optical properties: absortion and scattering

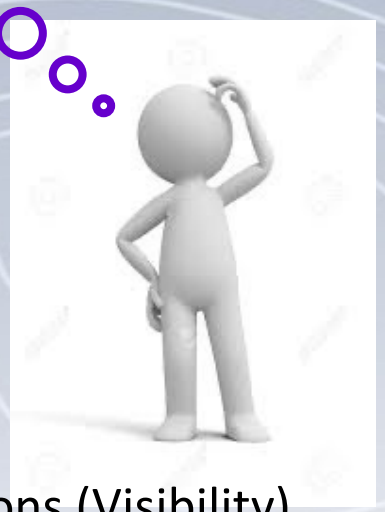






Images thanks to"Grupo de Geoquímica Ambiental del Instituto de Diagnóstico Ambiental y Estudios del Agua", CSIC

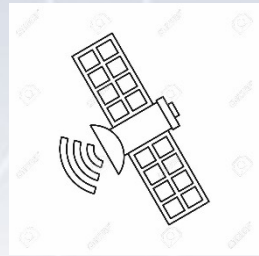
How “to observe” dust…?

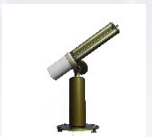


Visibility!

In-Situ measurements!

Remote sensing!





INDEX

Ground based observations

- In-situ dust estimations (Visibility)
- In-situ dust measurements
- Ground base remote sensing of dust

Satellite observations

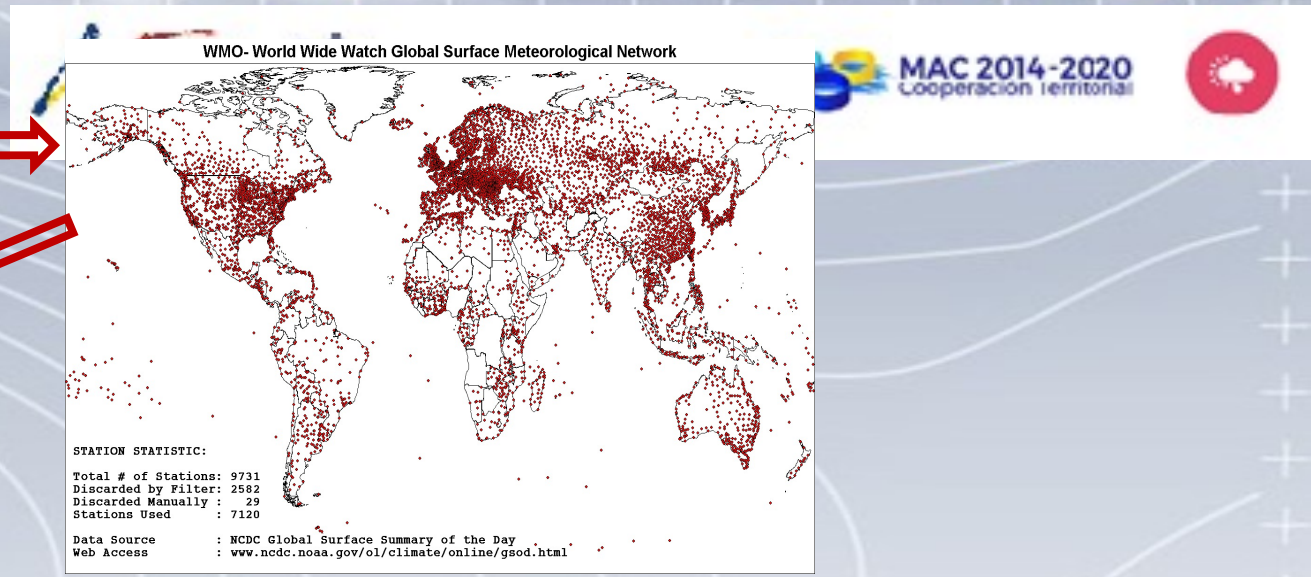
Some verification tools

Dust forecast products…
Dust-SFC-extinction → visibility
Dust-SFC-Concentration → health
DOD → column total concentration – radiative information

Summary

Visibility:
- human eye
- transmissometer

PMx concentrations:
- empirical from visibility



Summary

Visibility:
- human eye
- transmissometer

PMx concentrations:
- empirical from visibility → widespread but empirical
- Gravimetry (reference)
- automathic “standarized” (BAM & TEOM) → low density/coverage

- PMx LowCost Sensors → **Expand coverage QUALITATIVE!!!**

The suitability of such low-cost sensors for long term monitoring of PM is yet to be explored by the scientific community.

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- human eye
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Extinction (column): AOD-Alpha
- reference photometry (Cimel, PFR) → Well stablish, not enough coverage (particularly in desert regions)
- lowCost photometers (Calitoo) → In progress (promising)

Extinction (profile):
- high and low power lidars (GALION) → Well stablish, not enough coverage (particularly in desert regions)
- ceilometers → In progress (promising)

Summary

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- human eye
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Extinction (profile):
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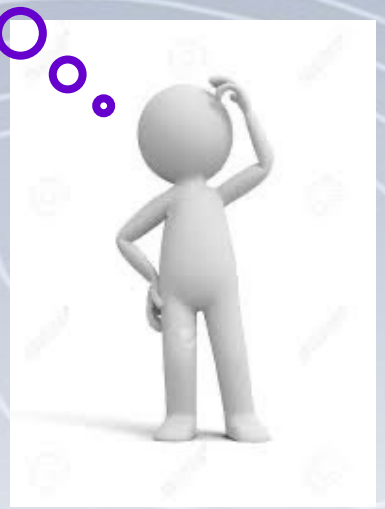
Standardization…
… for traceability and intercomparability

How “to observe” dust…?



In-Situ measurements! → PM10 (PM2.5)

PM10 Sensors

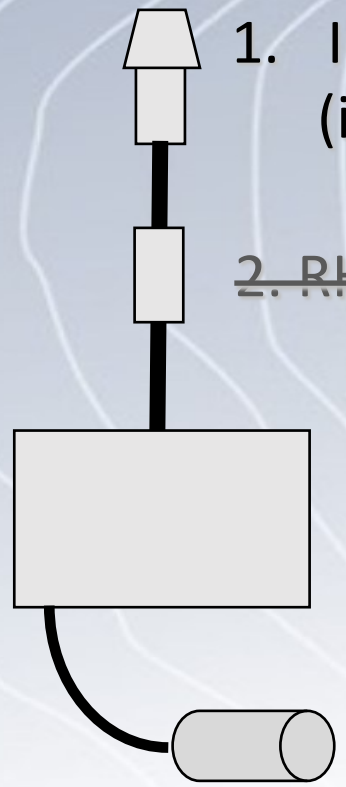
Low Cost Sensor (EXPERIMENTAL!!!)

Low-cost sensors for the measurement of atmospheric composition: overview of topic and future applications (WMO, 2018)

TEOM ~ 40.000€
BAM(BETA) ~ 20.000€
… and high qualified operator for maintenance

Common core components and functions may include:

- The sensing element or detector
- Sampling capability, e.g. pump or passive inlet
- Power systems, including batteries and voltage/power stabilization
- Sensor signal processing
- Local data storage
- Data transmission capability (WiFi, GPRS, 3/4G etc)
- Server-side software for data treatment
- Housing and weatherproofing



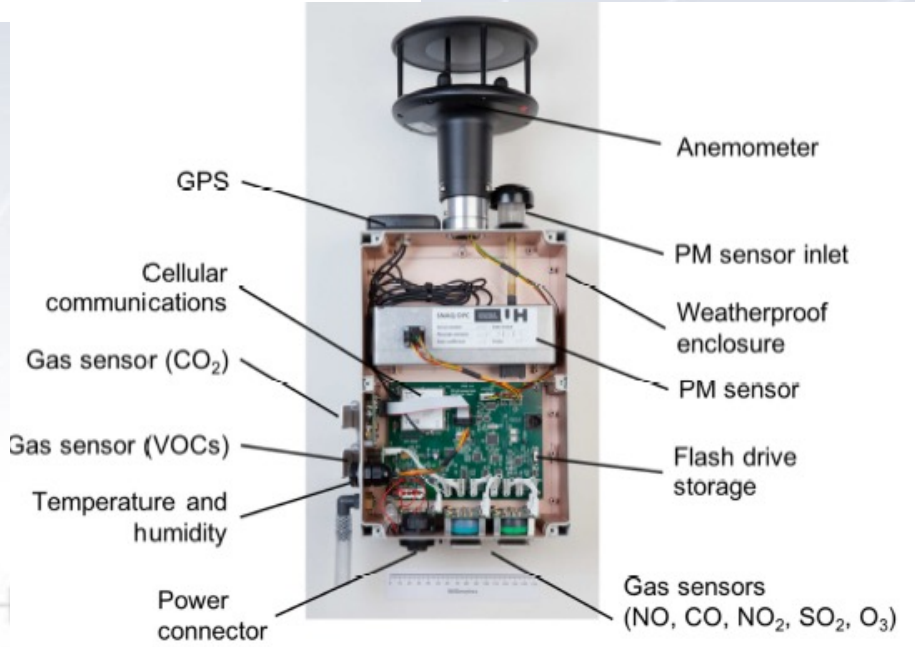
1. Impactor PM_{10} / $PM_{2.5}$ (inlet)

~~2. RH reductor / heater~~

3. Sensor

4. Sampling capability

(passive (via inlets or apertures) or active (pump or fan) systems)



PM10 Sensors

Low Cost Sensor (EXPERIMENTAL!!!)

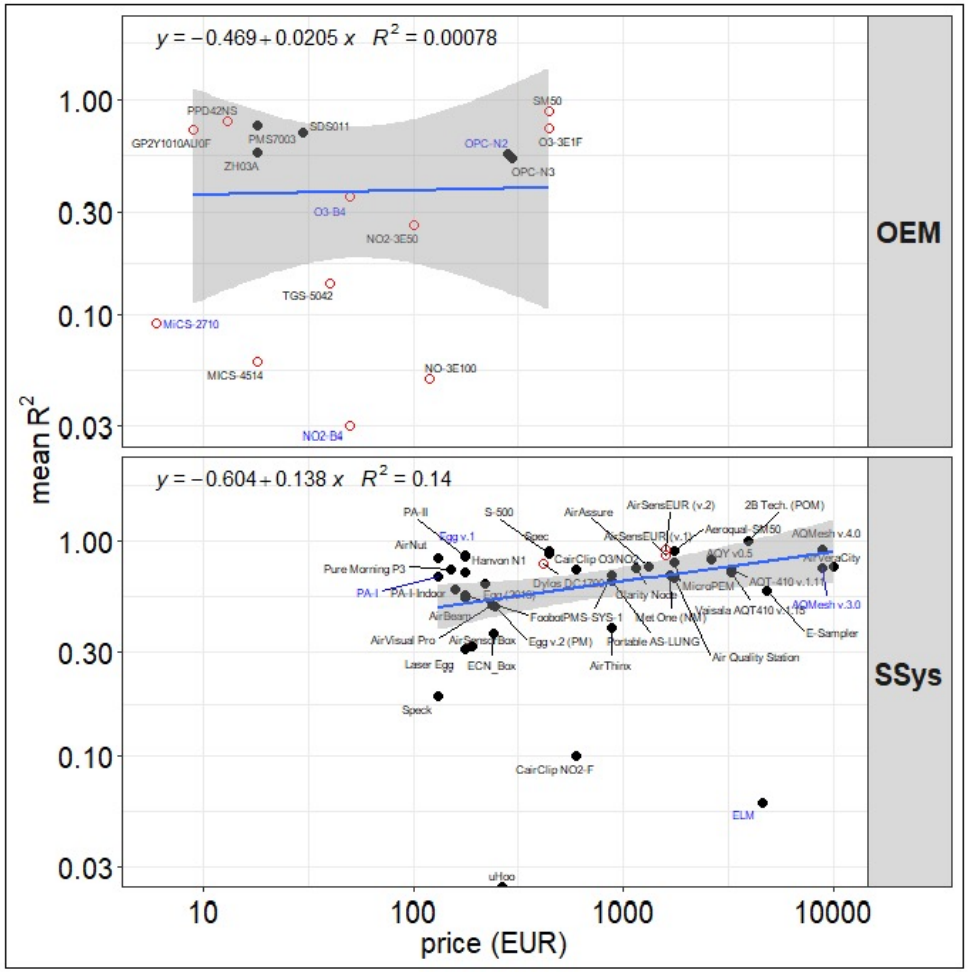


Figure 7. Relation between prices of OEMs/Sensor Systems (SS) and R^2 for field test only. Logarithmic scale has been set for both axis. Open source and black box models are indicated with open and full circles, respectively. Names of 'living' and 'non-living' sensors are indicated in black and blue colour, respectively. R^2 refers to data averaged over 1 hour. Grey shade in the fit plots indicate a pointwise 95% confidence interval on the fitted values.

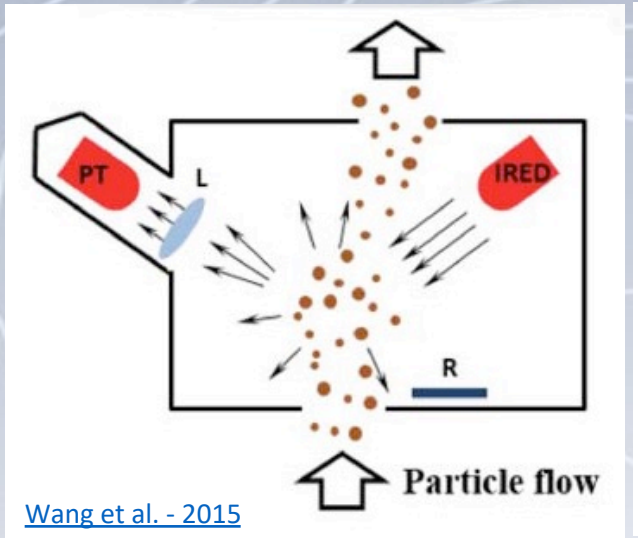
TEOM ~ 40.000€
BAM(BETA) ~ 20.000€
… and high qualified operator for maintenance

Review of sensors for air quality monitoring (JRC-EC, 2019)

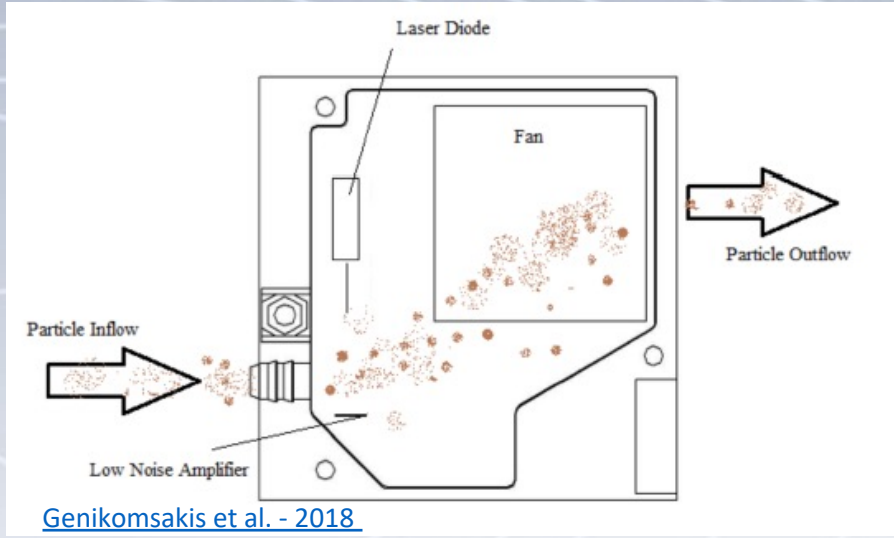
Low Cost Sensor (EXPERIMENTAL!!!)

SENSOR

optical technique for low-cost sensing due to its low cost and power requirements and quick response times



Wang et al. - 2015



Genikomsakis et al. - 2018

A number of different approaches and locations are needed to evaluate the applications and capacities where low-cost sensors can be successfully implemented.

Concentration is proportional to the scattered light intensity and a particle density and size distribution is usually assumed

In “field-measurements” → changing conditions of particle compositions, sizes, and environmental factors such as humidity and temperature

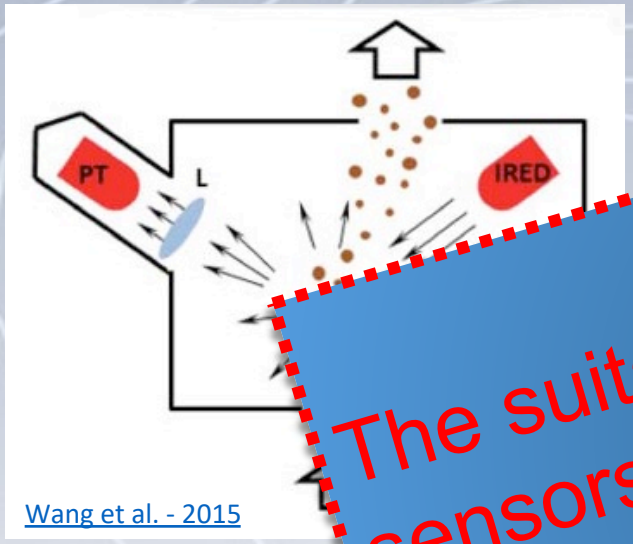
http://aqicn.org/map/

Could be a help for increase space coverage

Low Cost Sensor (EXPERIMENTAL!!!)

SENSOR

optical technique for low-cost sensing due to its low cost and power requirements and quick response times



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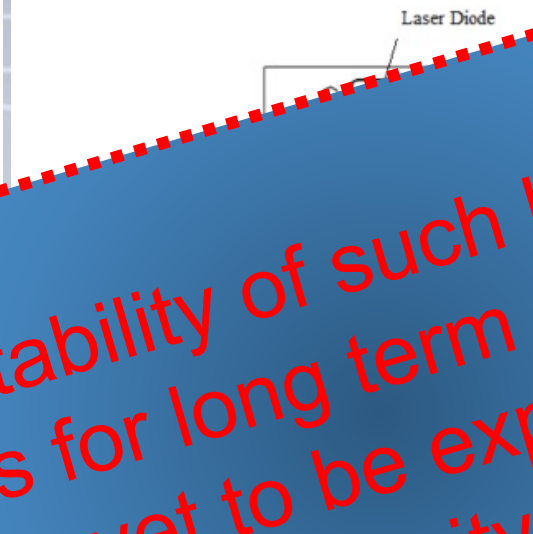

Concentration

particle density

In "field-measurements

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Could be a

or increase space coverage

The suitability of such low-cost sensors for long term monitoring of PM is yet to be explored by the scientific community.

A number of different approaches and locations are needed to evaluate the applications and capacities where low-cost sensors can be successfully implemented.

http://aqicn.org/map/

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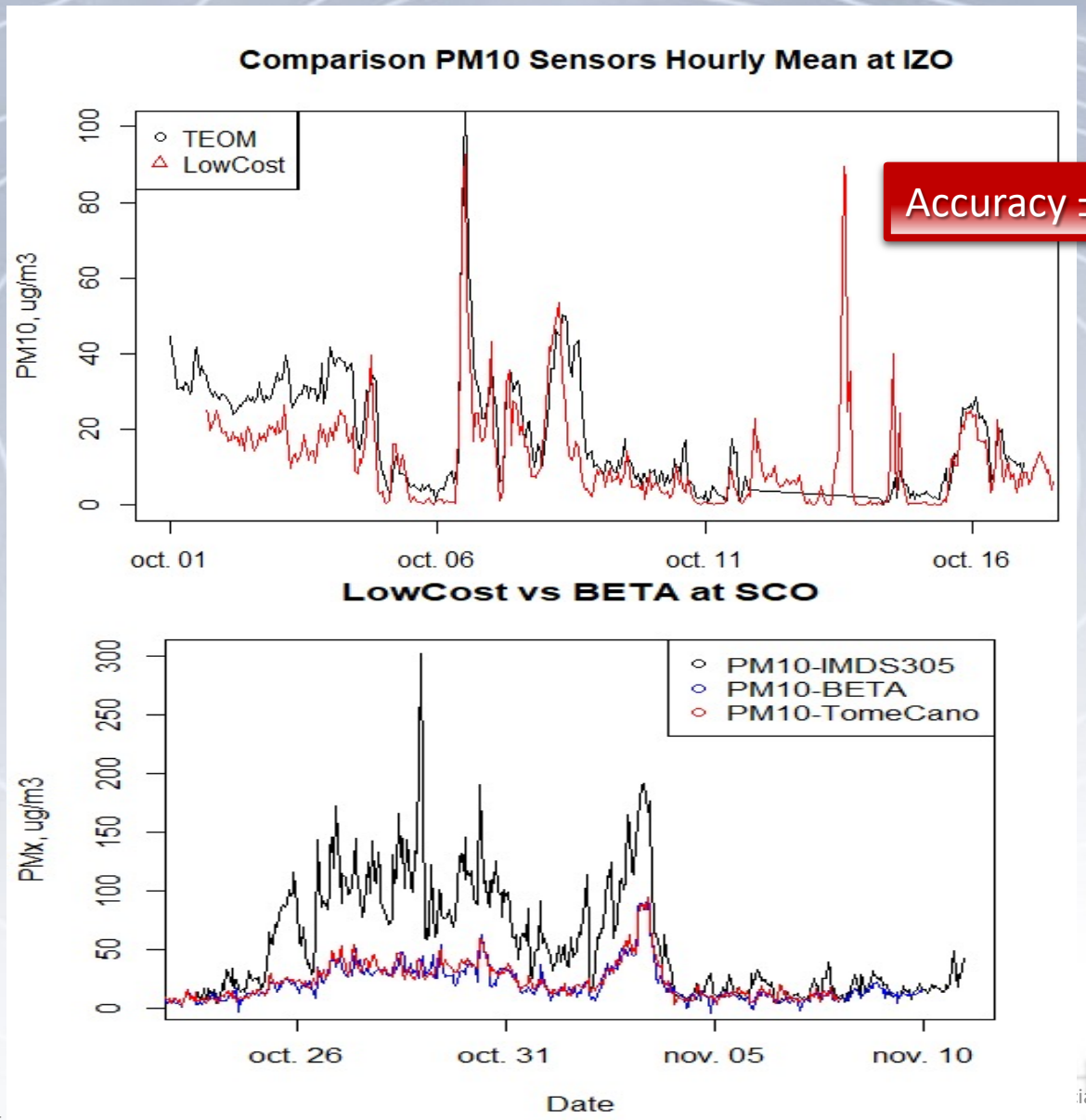
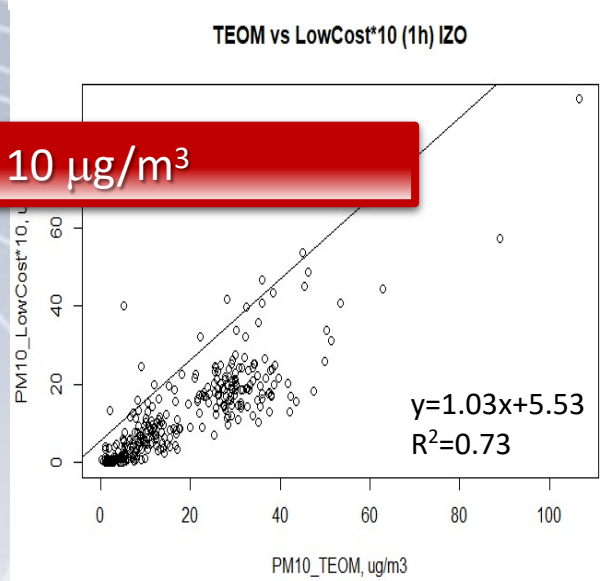
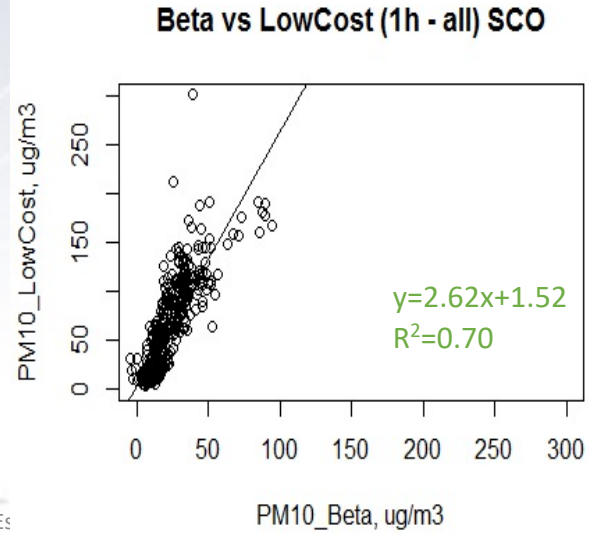
PM10 Sensors

Low Cost Sensor (EXPERIMENTAL!!!)



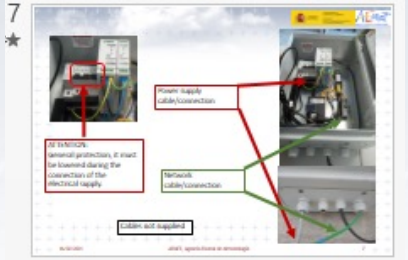
Accuracy ± 10 µg/m³





- Aerosol type (optical properties) dependent
- Humidity and Tª dependent
- Lab characterization fine but not enough
- Field characterization under conditions as similar as possible to those of the final operating site

PM10 Sensors Installation



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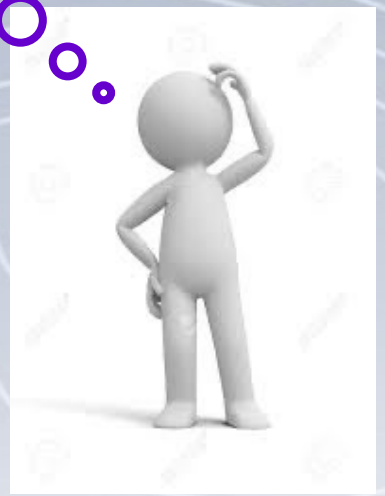


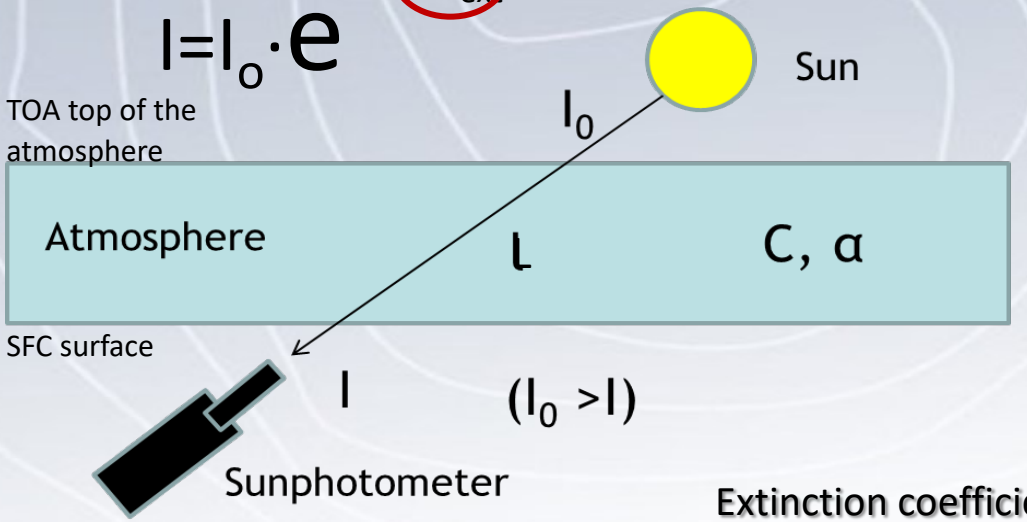
Remote Sensing! → AOD

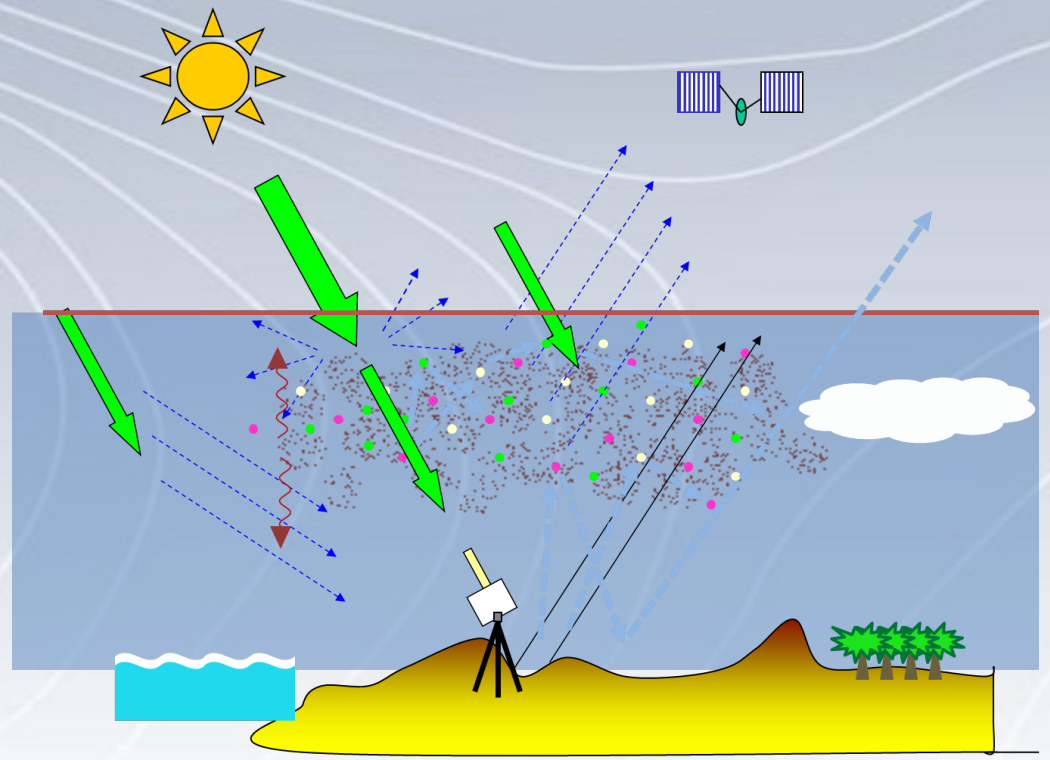
1. Photometry

More aerosols in the atmosphere cause more extinction and less energy transmitted to the surface.

Beer's Law

$$I = I_0 \cdot e^{-\sigma_{ext} \cdot L}$$





Extinction coefficient (σext): εC

Path length (L)

molar absorptivity of the absorber (ε)

concentration of absorbing species in the material (C)

aerosol particles cross-section for light extinction per unit volume of air

1. Photometry

CONCEPTS:

Aerosol Extinction: A measure of attenuation of the light passing through the atmosphere due to scattering and absorption by aerosol particles.

Extinction coefficient is the fractional depletion of radiance per unit path length (also called attenuation). It has units of km $^{-1}$.

Aerosol Optical Depth (or Thickness)

"Aerosol Optical Depth" (AOD) is the degree to which aerosols prevent the transmission of light. The aerosol optical depth or optical thickness (τ) is defined as the integrated extinction coefficient over a vertical column of unit cross section.

$$AOD = \int_{z=0}^{z=toa} \sigma_{ext}(z)dz$$

$$I = I_o \cdot e^{-\sigma_{ext} \cdot L}$$

1. Photometry

CONCEPTS:

Angstrom Exponent (α)

An exponent that expresses the spectral dependence of AOD with the wavelength of incident light (λ). The spectral dependence of aerosol optical thickness can be approximated (depending on size distribution) by:

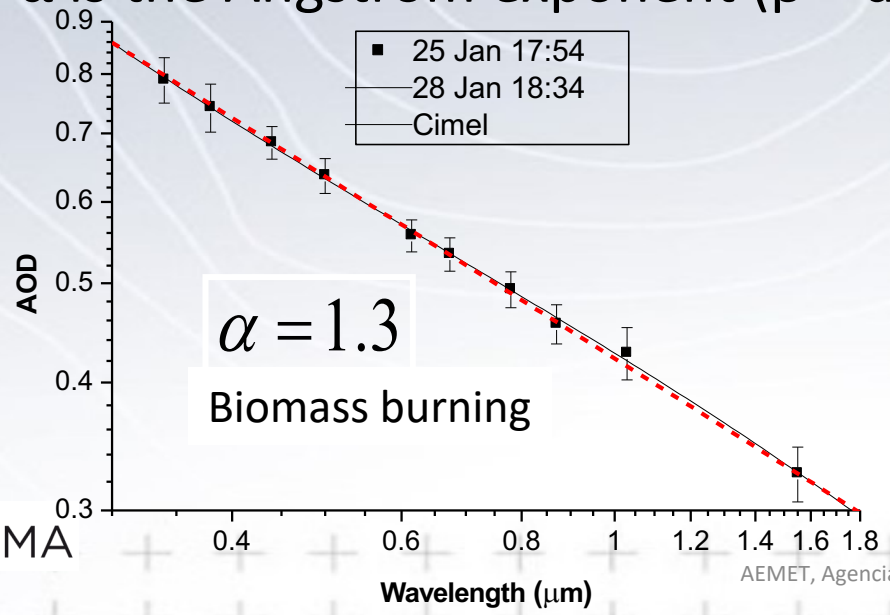
AOD → τ_a

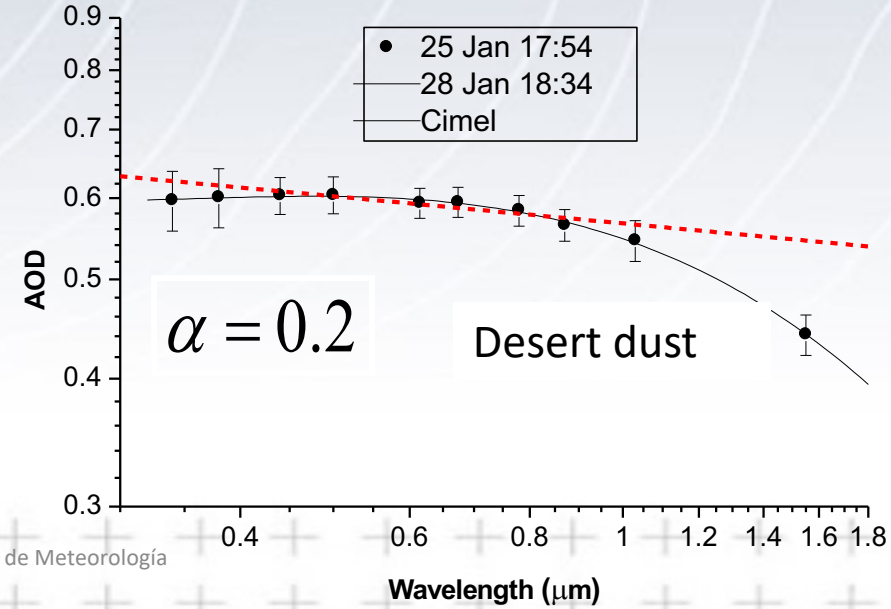
$$\tau_a = \beta \cdot \lambda^{-\alpha}$$

α >> 0.9 FINE particles

α << 0.7 COARSE particles

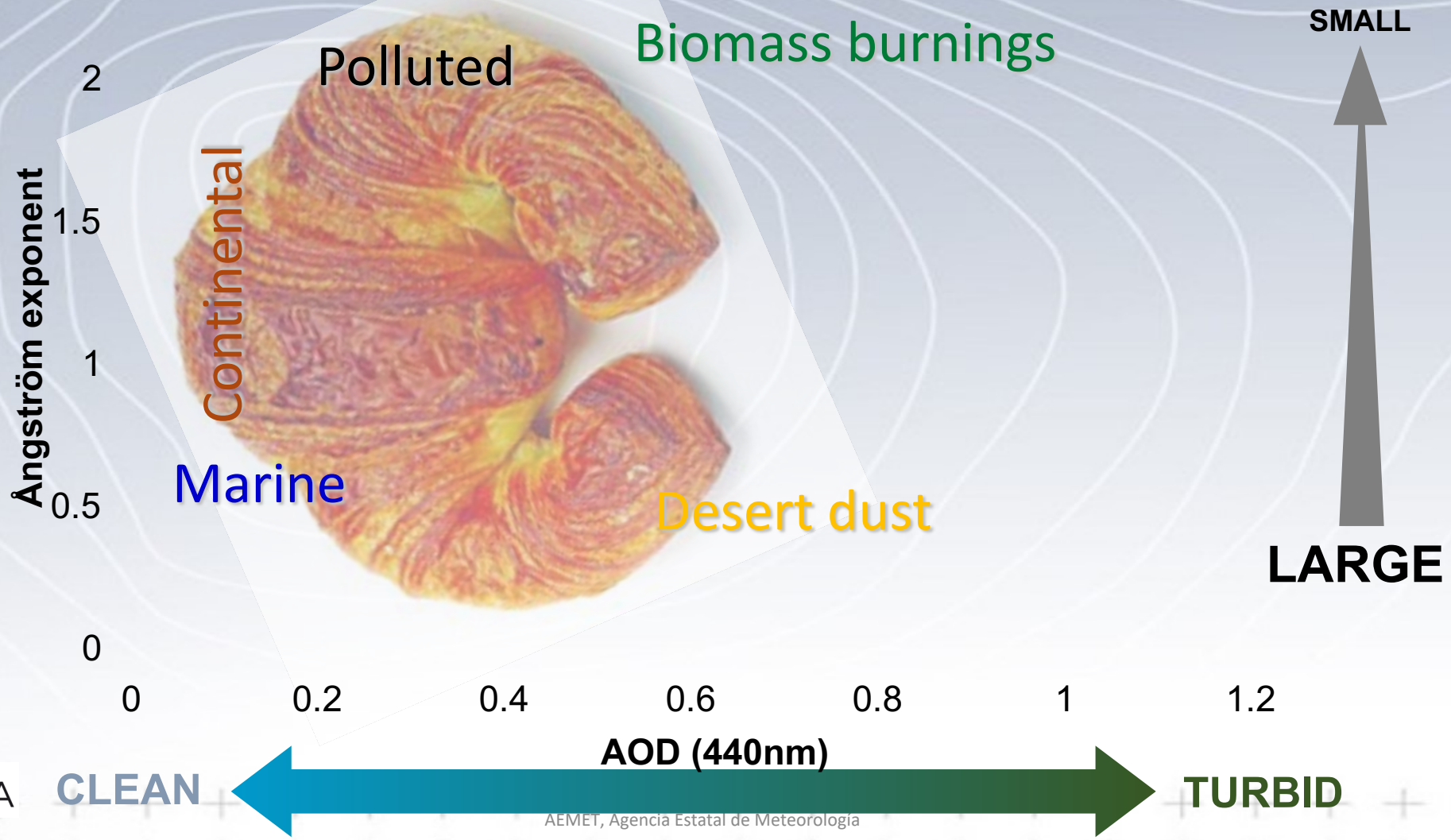
where α is the Angstrom exponent (β = aerosol optical depth at 1 μm)





1. Photometry

Aerosol Type with diagram AOD-α



Photometry: Calitoo handheld sun photometer

Reconsidering hand-held sunphotometers for reporting dust AOD?

Microtops-II, Calitoo-Tenum...

Many observations at airports (even in remote regions)
Operated by meteorological observers
Easy data transmission through WMO GTS/WIS communication system

NRT data for model evaluation and data assimilation
NRT data for satellite evaluation
NRT data for dust nowcasting

Photometry: Calitoo handheld sun photometer

Technicals characteristics:

- Light channels: 465, 540 and 619 nm
- Possible 999 measures stored in memory
- AOD calculated in real-time
- USB data download
- Free software on web site.
- Supply : 4 batteries AA (1,5V)
- Dimensions : 210 x 100 x 35 mm
- Weight : 400 g (With batteries)
- Operating temperature : -20°C to 55°C

http://www.calitoo.com

Photometry: Calitoo handheld sun photometer

Measurements

The measurement principle is to point the Sun and search for the maximum flow. The photometer keeps only the maximum measured and then calculated the optical depth.

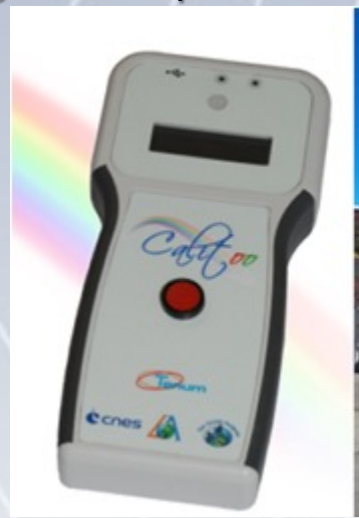
The Sun alignment is done manually. It is facilitated by the sighting device located above the display of the Calitoo.

The calculation of optical depth use raw brightness measurements, calibration coefficients, date and GPS position as well as atmospheric pressure.

Photometry: Calitoo handheld sun photometer

Products:
AOD @ 465, 540 et 619 nm
Angstrom Exponent

Calibration provided!!!
(at Izaña testbed)



First pilot experiments at:
Tamanrasset GAW Station (Algeria)
Tehran (Iran)
Aminabad Mt. Firoozkoh GAW station (Iran)

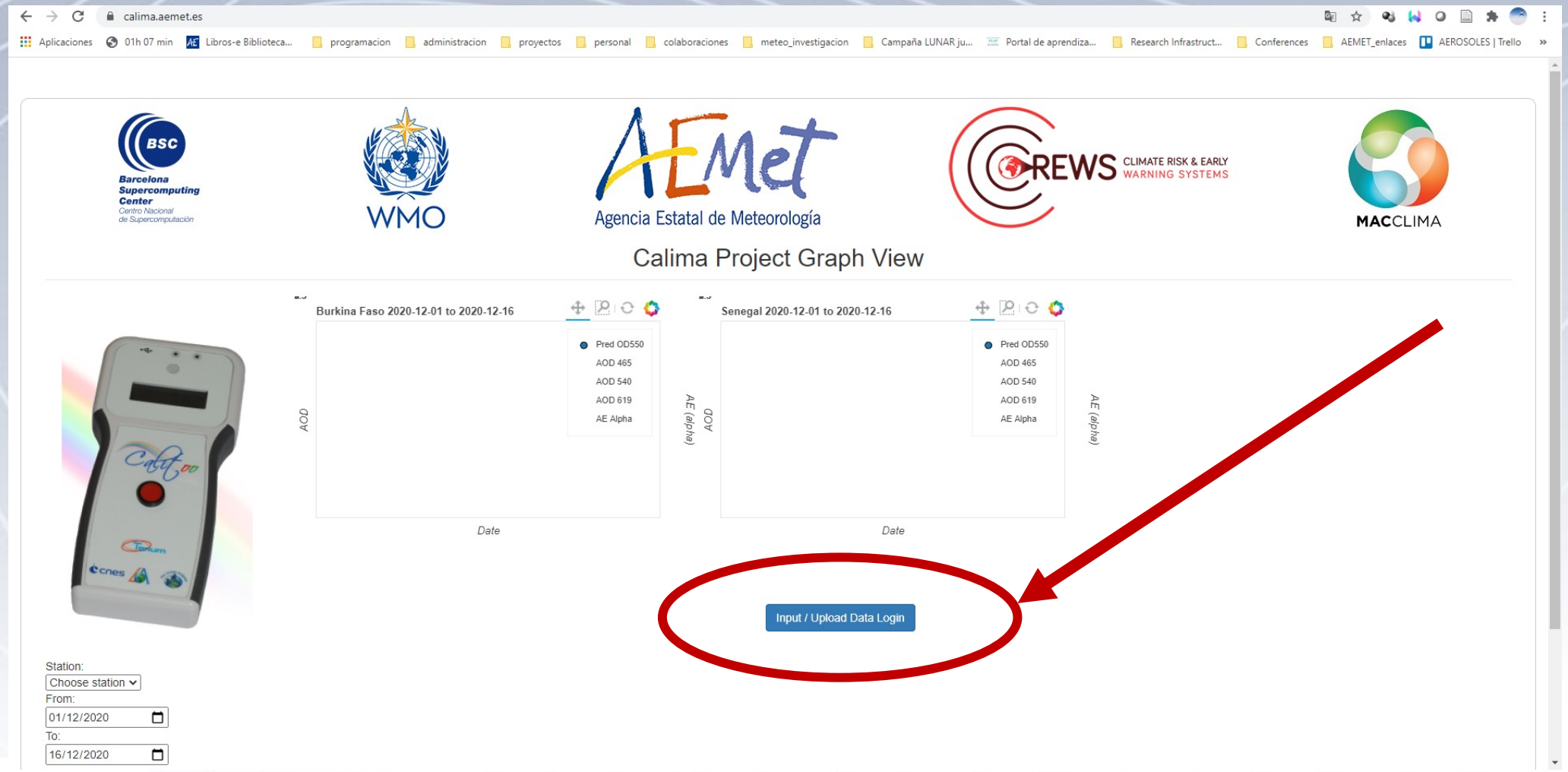
How to use it?
https://www.youtube.com/watch?v=4wCzw4rY9Hs

Data Visualization

How to upload data?
Go to https://calima.aemet.es/

Input / Upload Data Login

Click on “Input/Upload Data Login”



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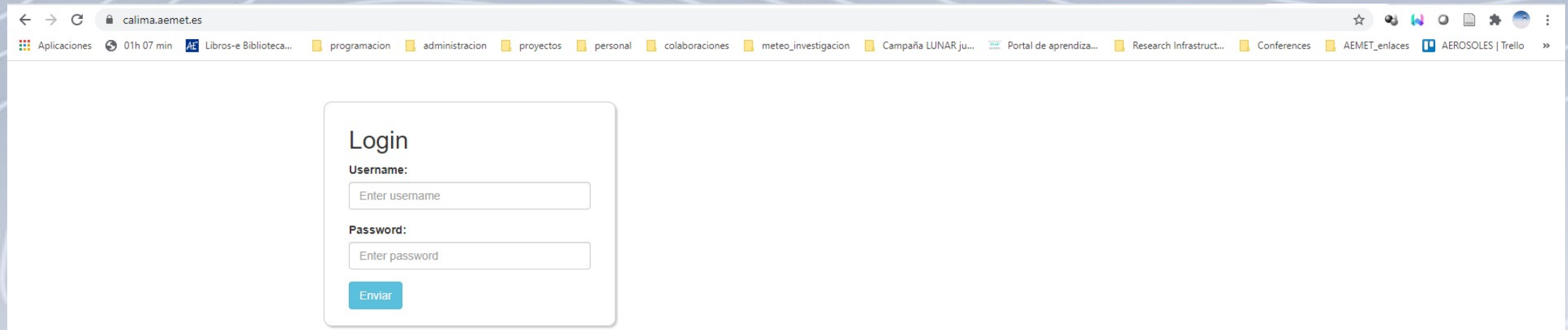
Data Visualization

How to upload data?

Enter username and password



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Data Visualization

How to upload data?

Click on “Click to upload Calitoo TXT data file”

Calima Project

Senegal

Last data:

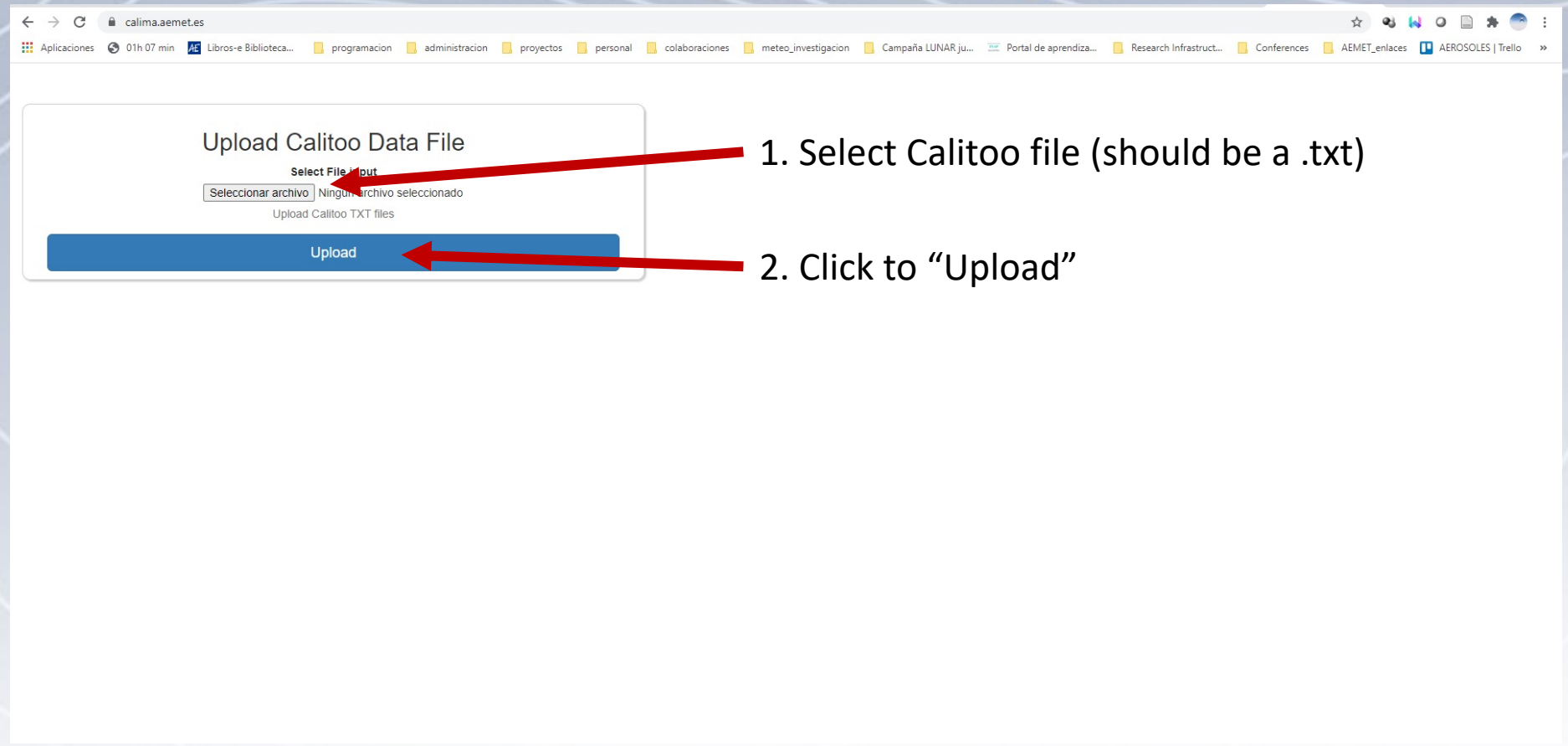
Date	dd/mm/aaaa
Time UTC	--:--
Atmospheric Pressure hPa	Enter pressure
AOD Blue 465	Value between 0 and 3
AOD Green 540	Value between 0 and 3
AOD Red 619	Value between 0 and 3
Alpha	Value between 0 and 4

Submit

Click to upload Calitoo TXT data file

Data Visualization

How to upload data?



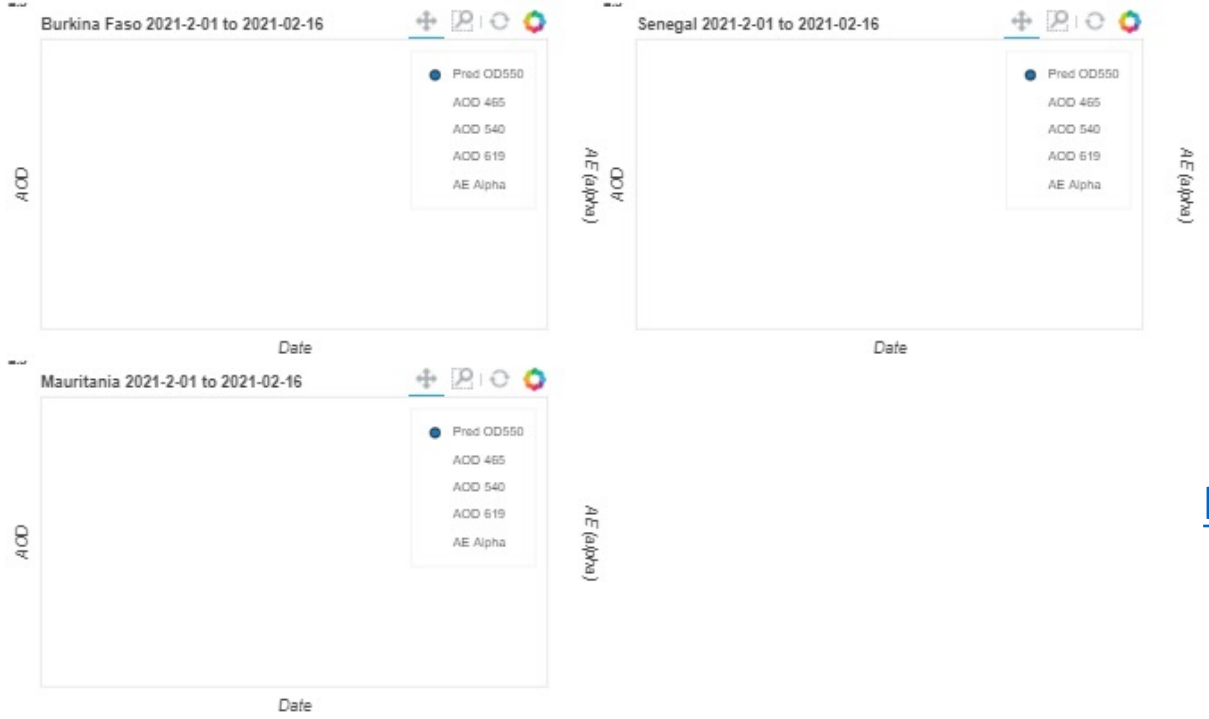
1. Select Calitoo file (should be a .txt)

2. Click to “Upload”

Data Visualization

Calima Project Graph View

Station:
Choose station
From:
mm/dd/yyyy
To:
02/16/2021
Plot Graph



https://calima.aemet.es/

Merci!

Natalia Prats Porta

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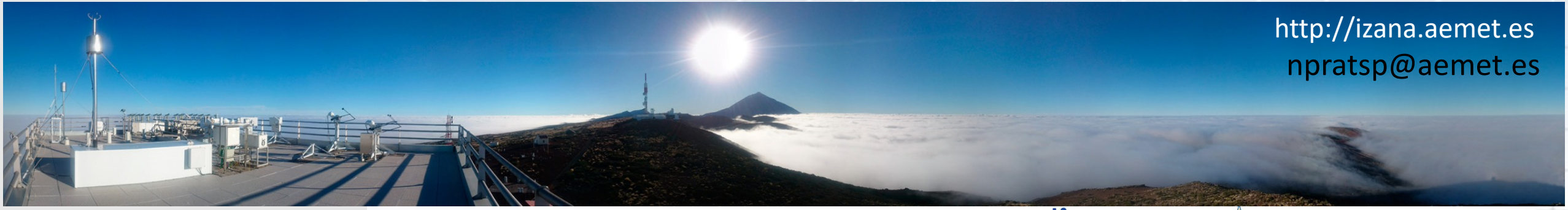
Izaña Atmospheric Research Center – AEMET



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npratsp@aemet.es

Agencia Estatal de Meteorología

WORLD METEOROLOGICAL ORGANIZATION