MINKE

Metrology for Integrated marine maNagement and Knowledge-transfer nEtwork

INFRAIA-02-2020: Integrating Activities for Starting Communities

EUROPEAN COMMISSION

Project funded by the European Commission within the Horizon 2020 Programme (2014-2020)
Grant Agreement No. 101008724

Requirements

SCK (different variants)

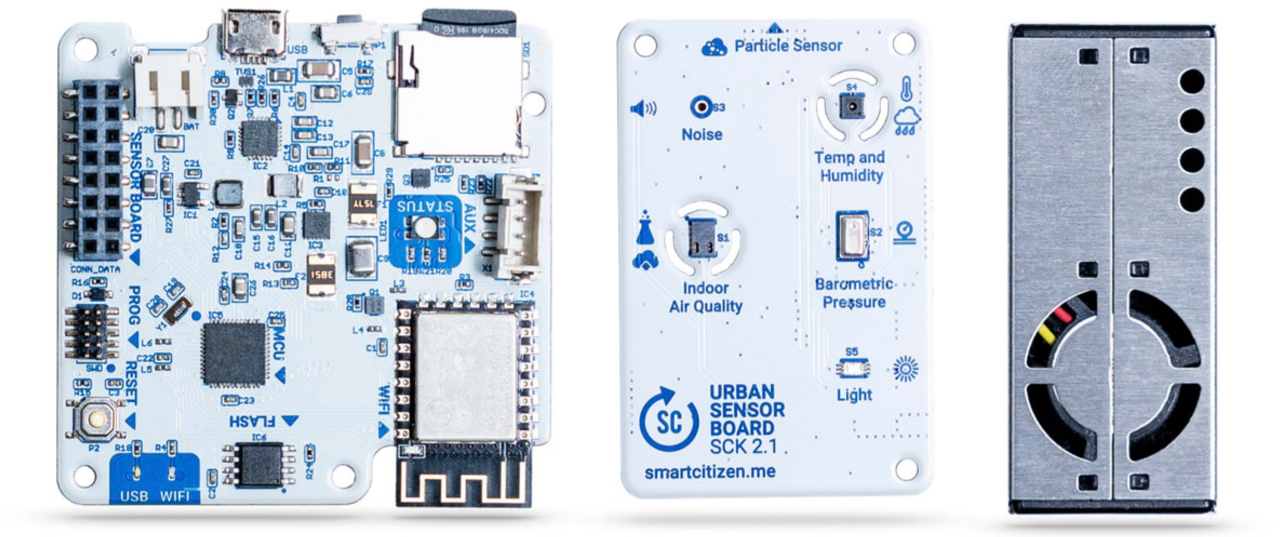
Air Sensors

Air Sensors

What are we measuring

The air sensors measure some weather and air pollution parameters:

- Air temperature and relative humidity
- Pressure
- Light Intensity
- PM (1, 2.5, 10)
- Noise (different scales – A, C, Z)
- tVOC



EUROPEAN COMMISSION
Grant Agreement No. 101008724
Project funded by the European Commission within the Horizon 2020 Programme (2014-2020)

Air Sensors

Temperature/Humidity

Temperature

A measure of how hot or cold air is

Relative humidity

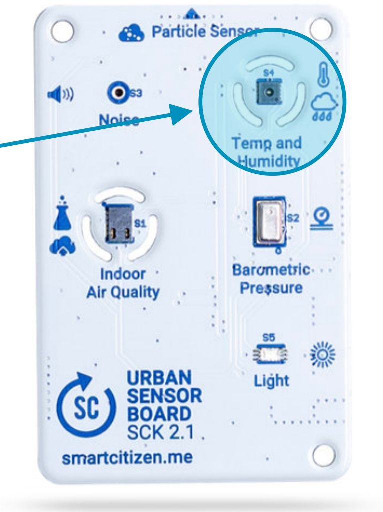
The ratio of how much water vapour is in the air and how much water vapour the air could potentially contain at a given temperature:

- It varies with the temperature of the air: colder air can hold less vapour.

The sensor

A digital thermometer in two different formats.

- One sensor in the urban board
- One external probe for more accurate readings



Both sensors are the same, only that the external probe is not affected by the enclosure or the electronics

- RH range: 0-100% RH
- RH resolution: 0.03%
- RH repeatability: 0.1%,
- T range: -40 to +125°C with
- T resolution: 0.01 degC
- T repeatability: 0.1%.

No calibration or drift!

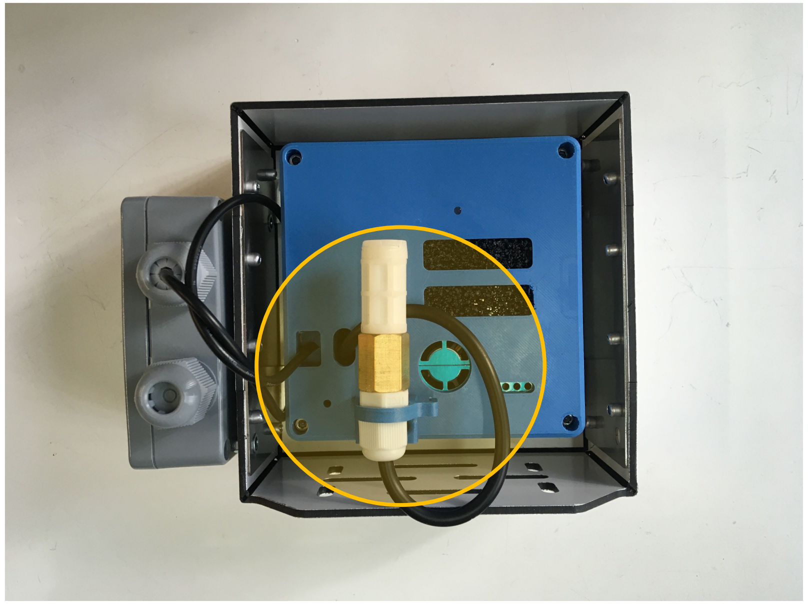
EUROPEAN COMMISSION
Grant Agreement No. 101008724
Project funded by the European Commission within the Horizon 2020 Programme (2014-2020)

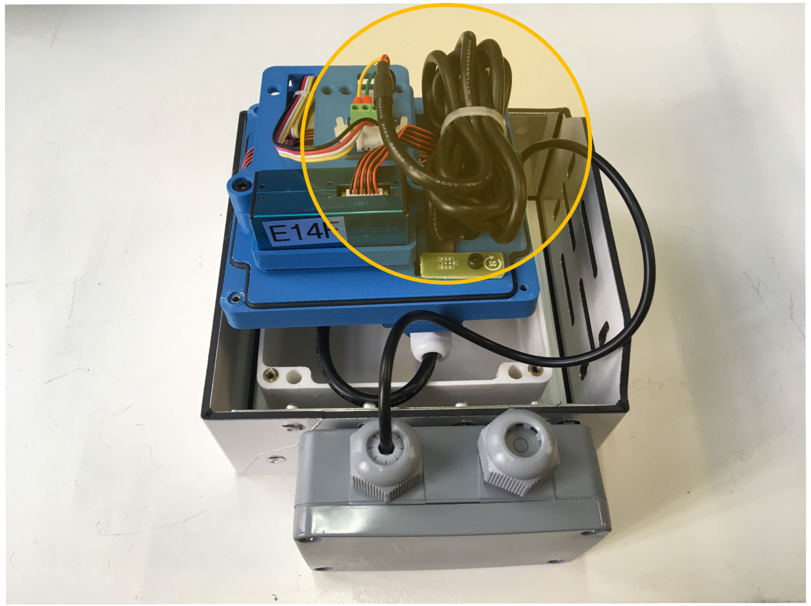
Air Sensors

Temperature/Humidity

External probe

The probe can be installed under the sensor or anywhere else. A holder is provided for convenience, and can be detached if needed.





MINKE

EUROPEAN COMMISSION
Grant Agreement No. 101008724
Project funded by the European Commission within the Horizon 2020 Programme (2014-2020)

Air Sensors

Pressure

Is the pressure within the atmosphere of Earth.

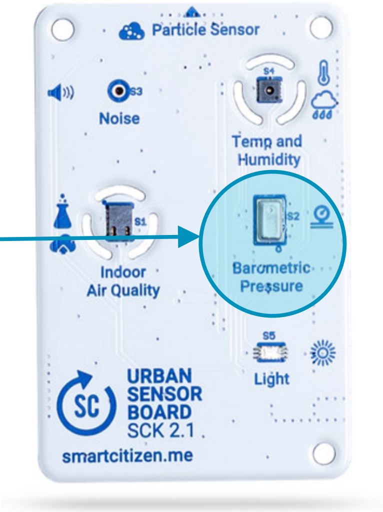
Atmospheric pressure varies widely on Earth, and these changes are important in studying weather and climate. See pressure system for the effects of air pressure variations on weather.

Together with temperature and relative humidity, it can give you absolute humidity

The sensor

NXP MPL3115A2 (digital piezoresistive absolute pressure sensor in MEMS package)

- One sensor in the urban board



Performance

- Operating range: 20-110 kPa
- Calibrated range: 50-110 kPa
- Can give AMSL data (height)

No calibration or drift!

EUROPEAN COMMISSION
Grant Agreement No. 101008724
Project funded by the European Commission within the Horizon 2020 Programme (2014-2020)

Air Sensors

Noise

The RMS of the sound pressure levels (SPL) in the air, expressed in dB

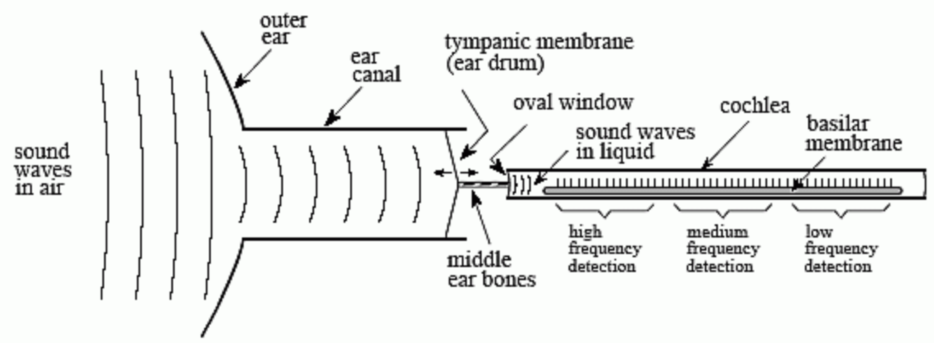
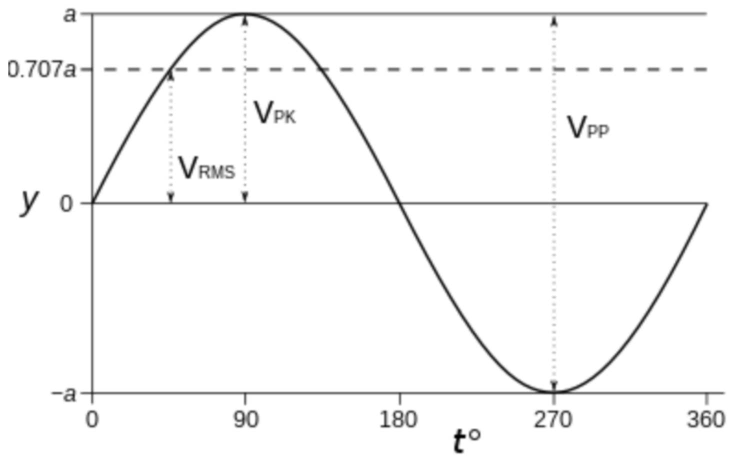


FIGURE 22-1
Functional diagram of the human ear. The outer ear collects sound waves from the environment and channels them to the tympanic membrane (ear drum), a thin sheet of tissue that vibrates in synchronization with the air waveform. The middle ear bones (hammer, anvil and stirrup) transmit these vibrations to the oval window, a flexible membrane in the fluid filled cochlea. Contained within the cochlea is the basilar membrane, the supporting structure for about 12,000 nerve cells that form the cochlear nerve. Due to the varying stiffness of the basilar membrane, each nerve cell only responses to a narrow range of audio frequencies, making the ear a frequency spectrum analyzer.

What do we measure?

Sound travels in air like a pressure wave with different frequencies

- We get samples (23ms worth at 44.1kHz)
- Pre-process them
- Isolate 256 frequencies
- Process the frequency spectrum (equalise and normalize)
- Adapt to human hearing
- Calculate RMS



MINKE
EUROPEAN COMMISSION
Grant Agreement No. 101008724
Project funded by the European Commission within the Horizon 2020 Programme (2014-2020)

Air Sensors

Noise

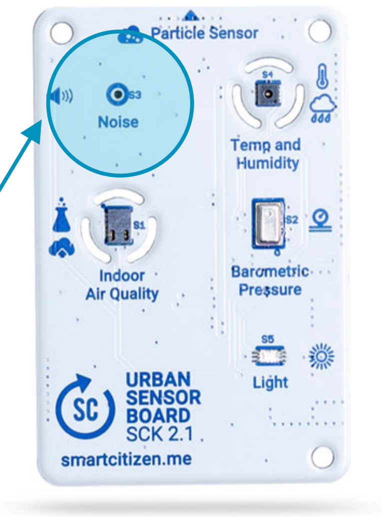
To consider

1) The microphone is **not isolated** in any way from **humidity**, dust or particles. These can affect the readings and provoke clipping in the readings (**absurdly high readings**)
2) The fact that the microphone is surface mounted on a **PCB** can make that certain frequencies **resonate** on the board and get amplified.
3) Also, the **enclosure** can resonate and amplify some frequencies

The sensor

TDK ICS43432 (digital microphone MEMS package)

- One sensor in the urban board



Performance

- Acoustic dynamic range: 87dB
- AOP: 116dB
- Sensitivity: -26dBFS

Already calibrated. No drift except in humid environments!

EUROPEAN COMMISSION
Grant Agreement No. 101008724
Project funded by the European Commission within the Horizon 2020 Programme (2014-2020)

Air Sensors

eTVOC

eTVOC stands for equivalent total volatile organic compounds and is a measurement of the total amount of any emitted gases coming from toxins and chemicals. They come from a wide range of everyday items including paints and varnishes, wax and cosmetics, cleaning and hobby products, and even cooking

The sensor

AMS CCS811 (digital metal oxide sensor)

- One sensor in the urban board

Performance

- Output range: 0 to 30000ppb

Somewhat calibrated.
Drift is important and compensated with baseline algorithms

It also has a derived metric called eCO2 (not CO2 at all!) but equivalent CO2 in terms of global warming potential

EUROPEAN COMMISSION
Grant Agreement No. 101008724
Project funded by the European Commission within the Horizon 2020 Programme (2014-2020)

Air Sensors

eTVOC: a word...

SCK V2.1 includes the AMS CCS811 for Air Quality indicative measurements for indoor air quality. However, this sensor is a complex endeavour and is affected by:

- temperature and humidity (we try to compensate for that)
- Ozone
- and it basically reacts to many toxics

Can it be calibrated? NO

These sensors are what we call Metal Oxide sensors – which are well known in certain applications, but that have plenty of limitations in accurate readings

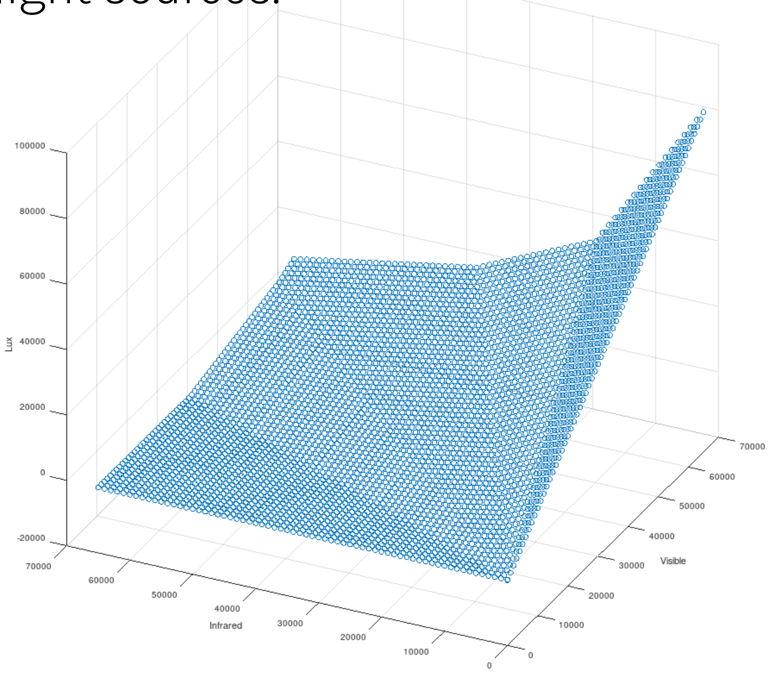
This type of sensors is not meant for fine pollution monitoring, but is more oriented for air quality indications and trends detection.

EUROPEAN COMMISSION
Grant Agreement No. 101008724
Project funded by the European Commission within the Horizon 2020 Programme (2014-2020)

Air Sensors

Ambient Light

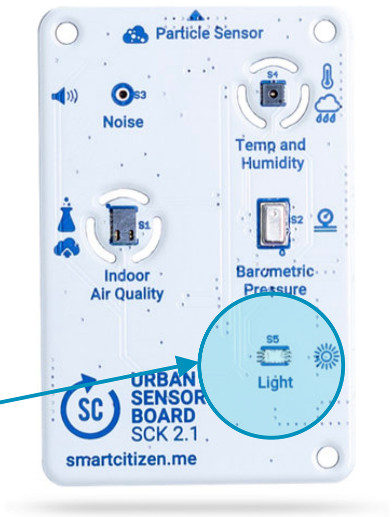
Ambient light directional sensor, with correspondence to both visible and IR light sources.



The sensor

ROHM BH1721FVC (digital light sensor)

- One sensor in the urban board



Performance

- Output range: 1-65528lx
- Measurement variation: ±15%

Calibrated.
No drift.
Directional!

MINKE
EUROPEAN COMMISSION
Grant Agreement No. 101008724
Project funded by the European Commission within the Horizon 2020 Programme (2014-2020)

Air Sensors

PM

PM contains microscopic solids or liquid droplets that are so small that they can be inhaled and cause serious health problems. Particles less than 10 um in diameter can get deep into the lungs, and some may even get into the bloodstream.

Particle measurement is extremely difficult and nowadays there is not an absolute technique.

The sensor

Plantower PMS5003 (light scattering)

- One sensor connected via the urban board

Performance

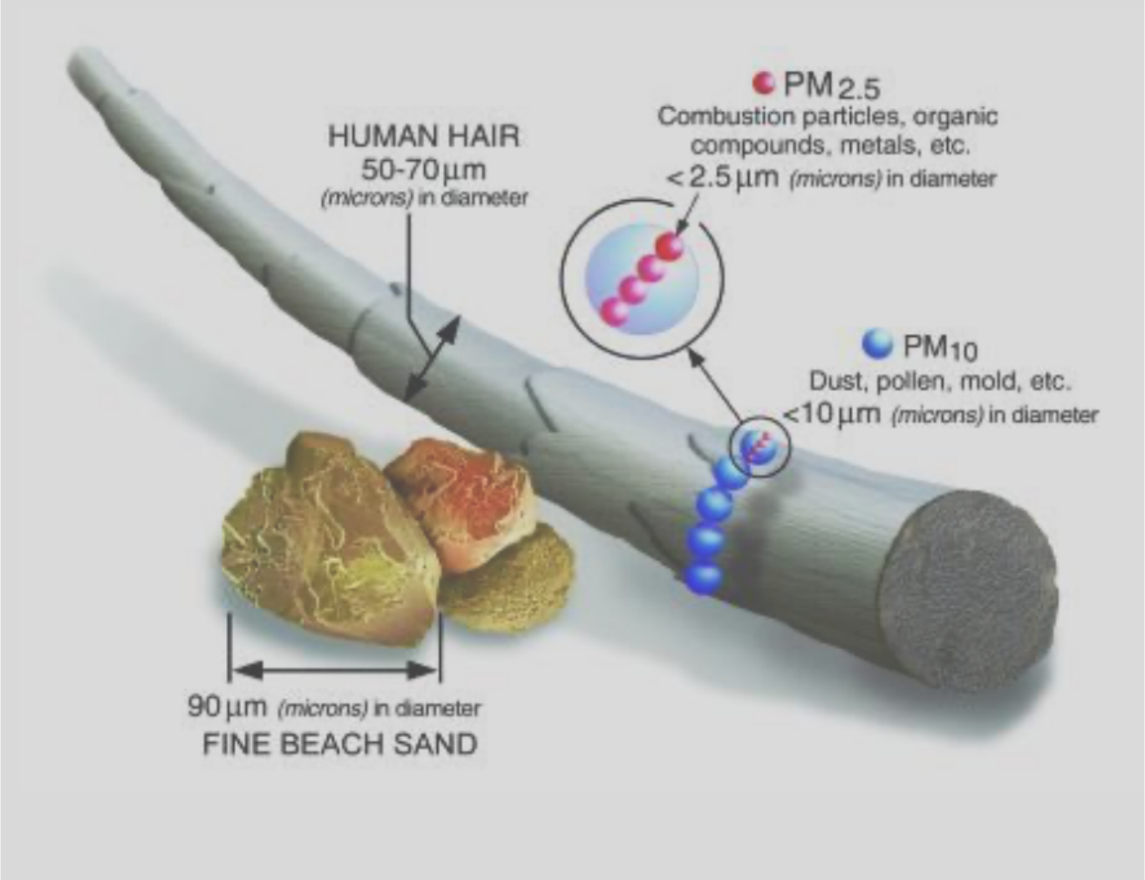
- Minimal particle diameter: 0.3um
- PM bins: PM1, PM2.5, PM10
- PN Bins: 0.3, 0.5, 1, 2.5, 5, 10 (um)
- Resolution: 1ug/m3
- Particle Effective Range: 0-500ug/m3
- Particle Max. Consistency Err:
    - ±10%@100~500µg/m3
    - ±10µg/m3@0~100µg/m3
- Reaction Time: single <1s, total 10s
- Life expectancy: >3Y

Calibrated? Drift?

EUROPEAN COMMISSION
Grant Agreement No. 101008724
Project funded by the European Commission within the Horizon 2020 Programme (2014-2020)

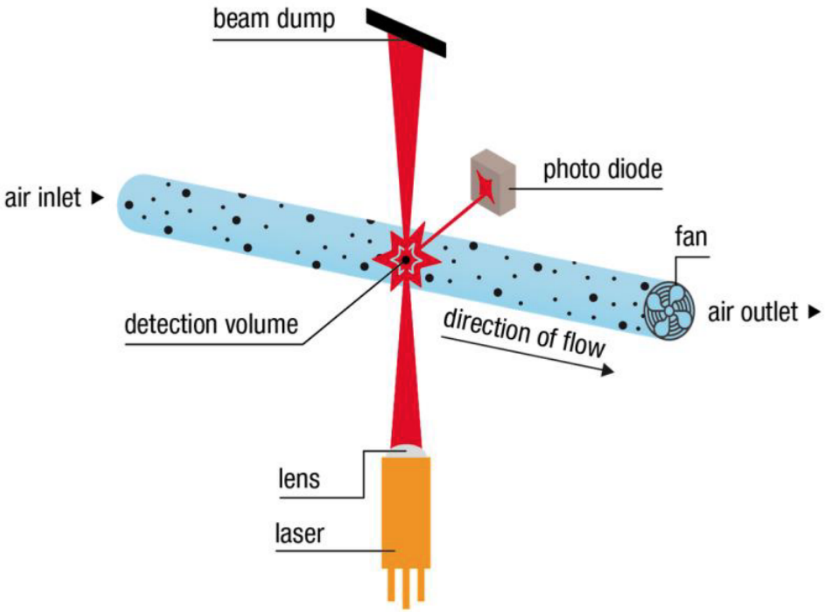
Air Sensors

PM



What the sensor does

Counts particles passing in front of diode and excited by a laser



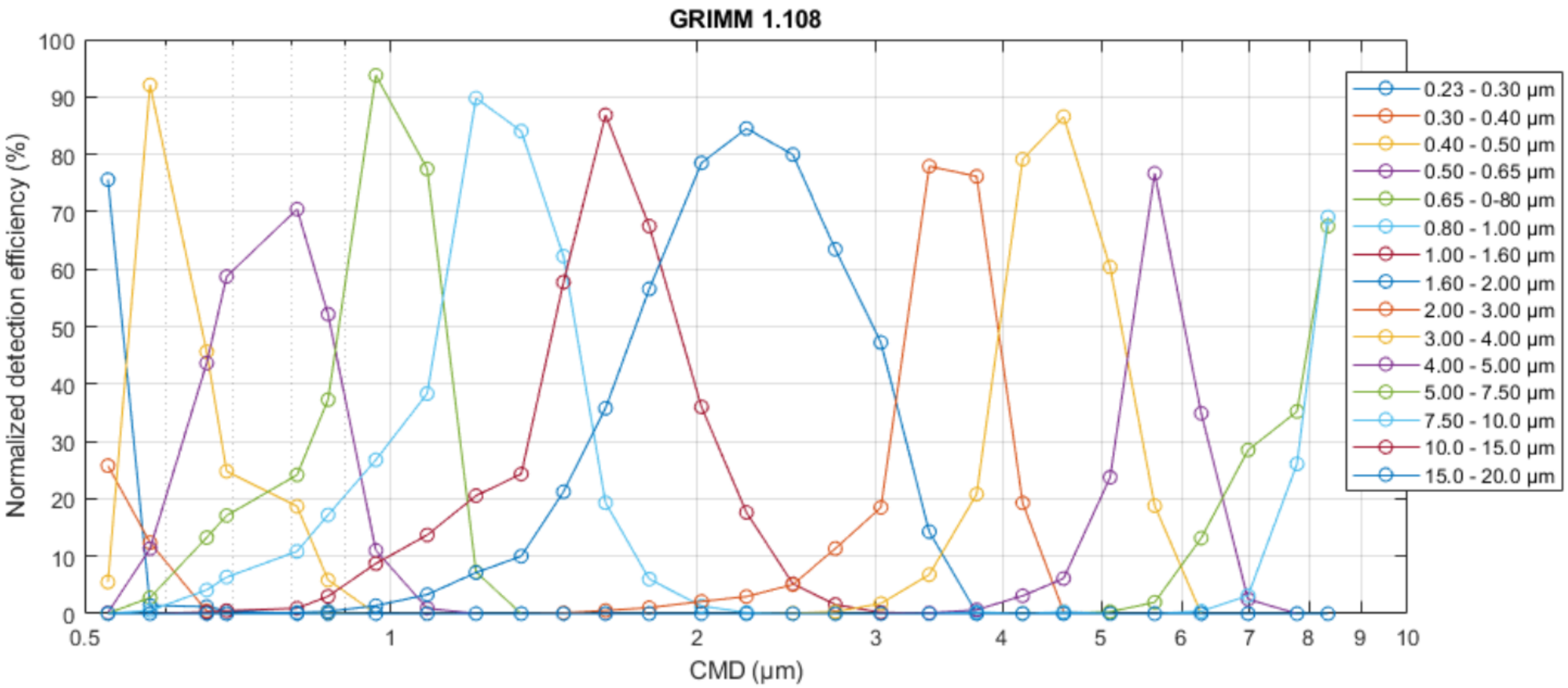
PM Assumption

- Particle shape
- Particle color (reflectivity index)
- Composition (density)

EUROPEAN COMMISSION
Grant Agreement No. 101008724
Project funded by the European Commission within the Horizon 2020 Programme (2014-2020)

Air Sensors

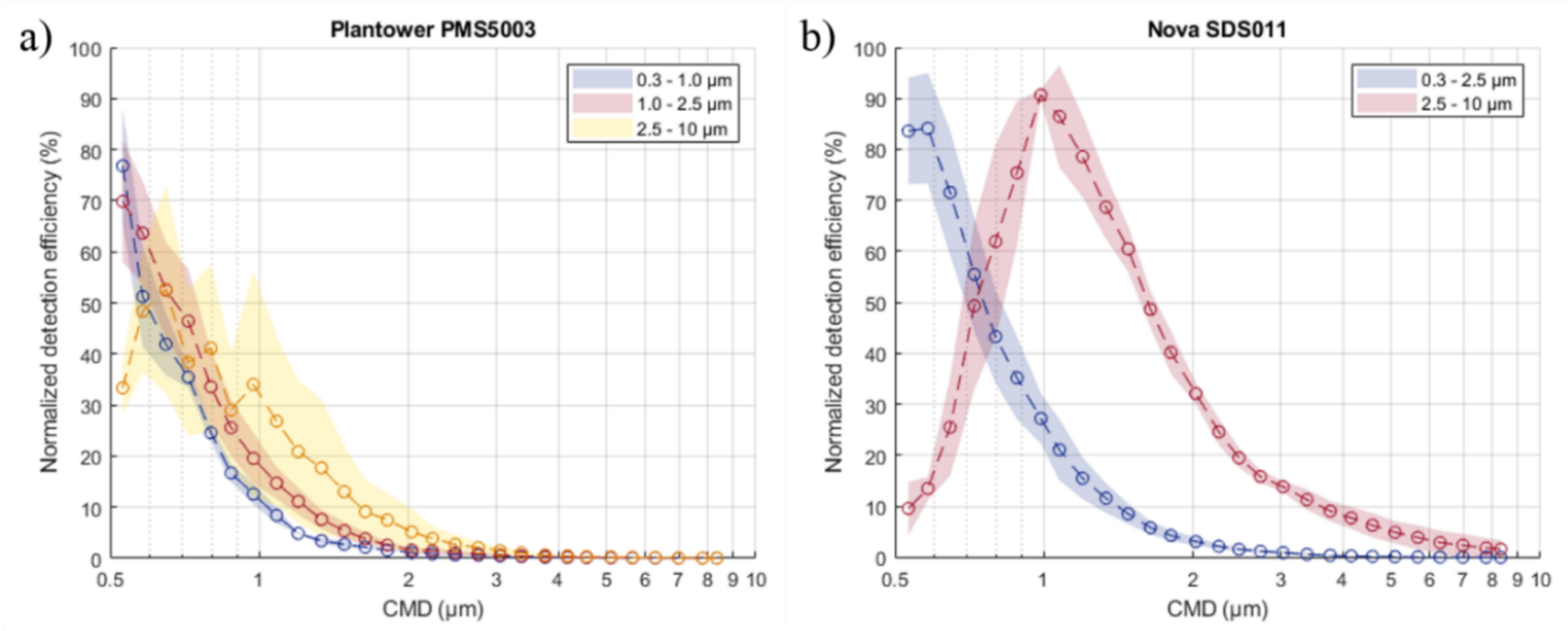
PM – Particle sizes distributions



EUROPEAN COMMISSION
Grant Agreement No. 101008724
Project funded by the European Commission within the Horizon 2020 Programme (2014-2020)

Air Sensors

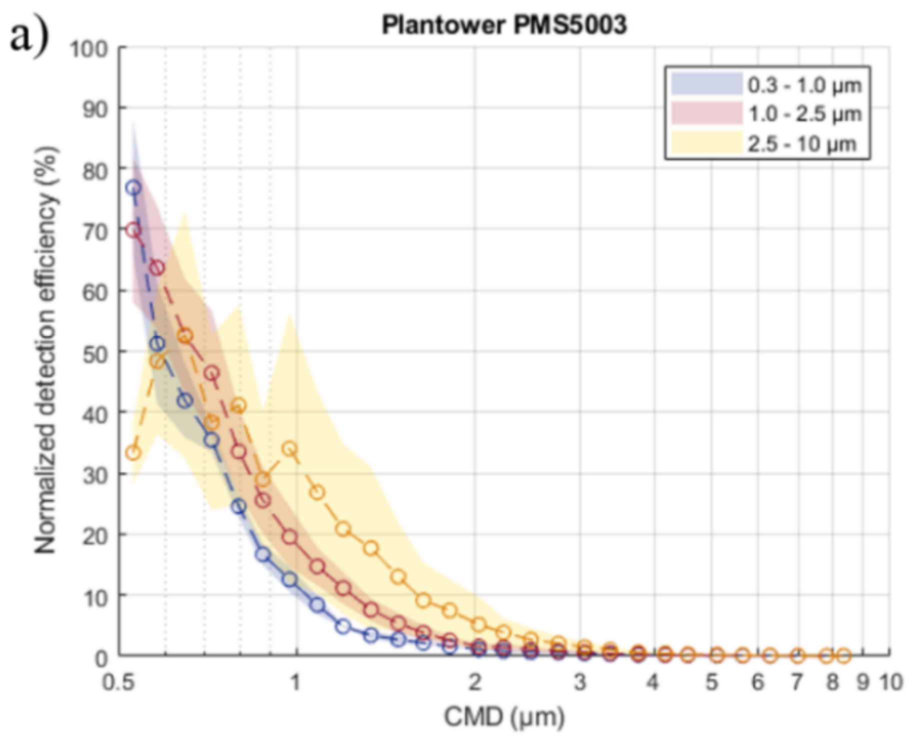
PM – Particle sizes efficiencies



EUROPEAN COMMISSION
Grant Agreement No. 101008724
Project funded by the European Commission within the Horizon 2020 Programme (2014-2020)

Air Sensors

PM – Particle sizes efficiencies



Different distributions, affect sensor accuracy

Example 1)
We have a distribution skewed mostly on mostly on smaller sizes – **we capture them all: good accuracy**

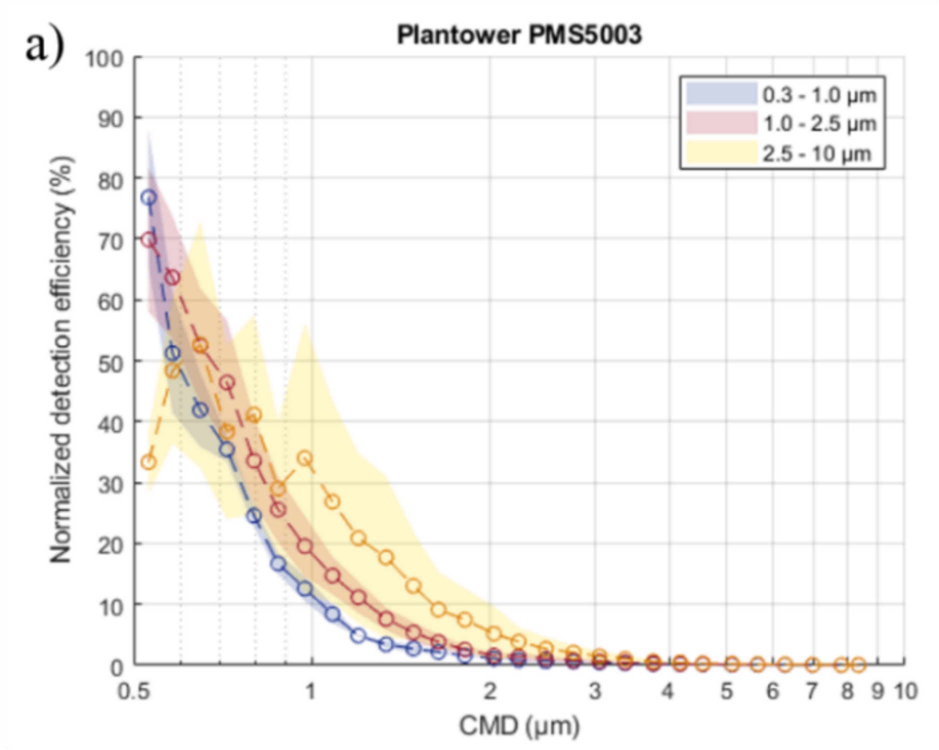
Example 2)
We have a distribution skewed mostly on mostly on larger sizes – **we don't capture any: bad accuracy**

Example 3)
We have a mix –we will measure somewhat OK **(the general case)**

EUROPEAN COMMISSION
Grant Agreement No. 101008724
Project funded by the European Commission within the Horizon 2020 Programme (2014-2020)

Air Sensors

PM – What happens with larger particles?



Two issues

1) Counting efficiency

2) Actual particle counts vs. sampling volume. For larger particles, we would need more sampling volume to be able to count same ammount. At constant volume (and limited), large particles have to be estimated from statistic distributions of normal PN distributions, with small particle input

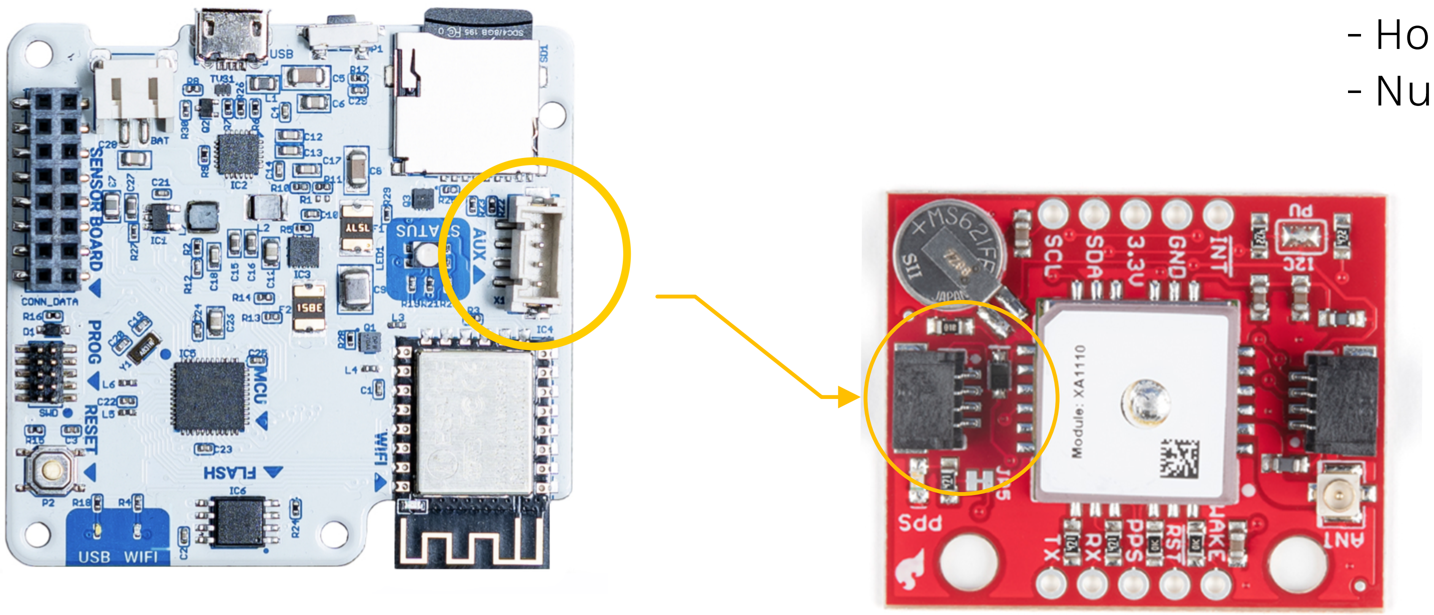
EUROPEAN COMMISSION
Grant Agreement No. 101008724
Project funded by the European Commission within the Horizon 2020 Programme (2014-2020)

Dynamic measurements

Dynamic Measurements

The GPS

An I2C GPS can be connected to the SCK through the **Auxiliary port**



GPS Readings

- Latitude, Longitude (degrees)
- Altitude (m)
- Horizontal Speed (m/s)
- GPS Fix quality (0-3)
- Horizontal dilution of position
- Number of satellites

MINKE

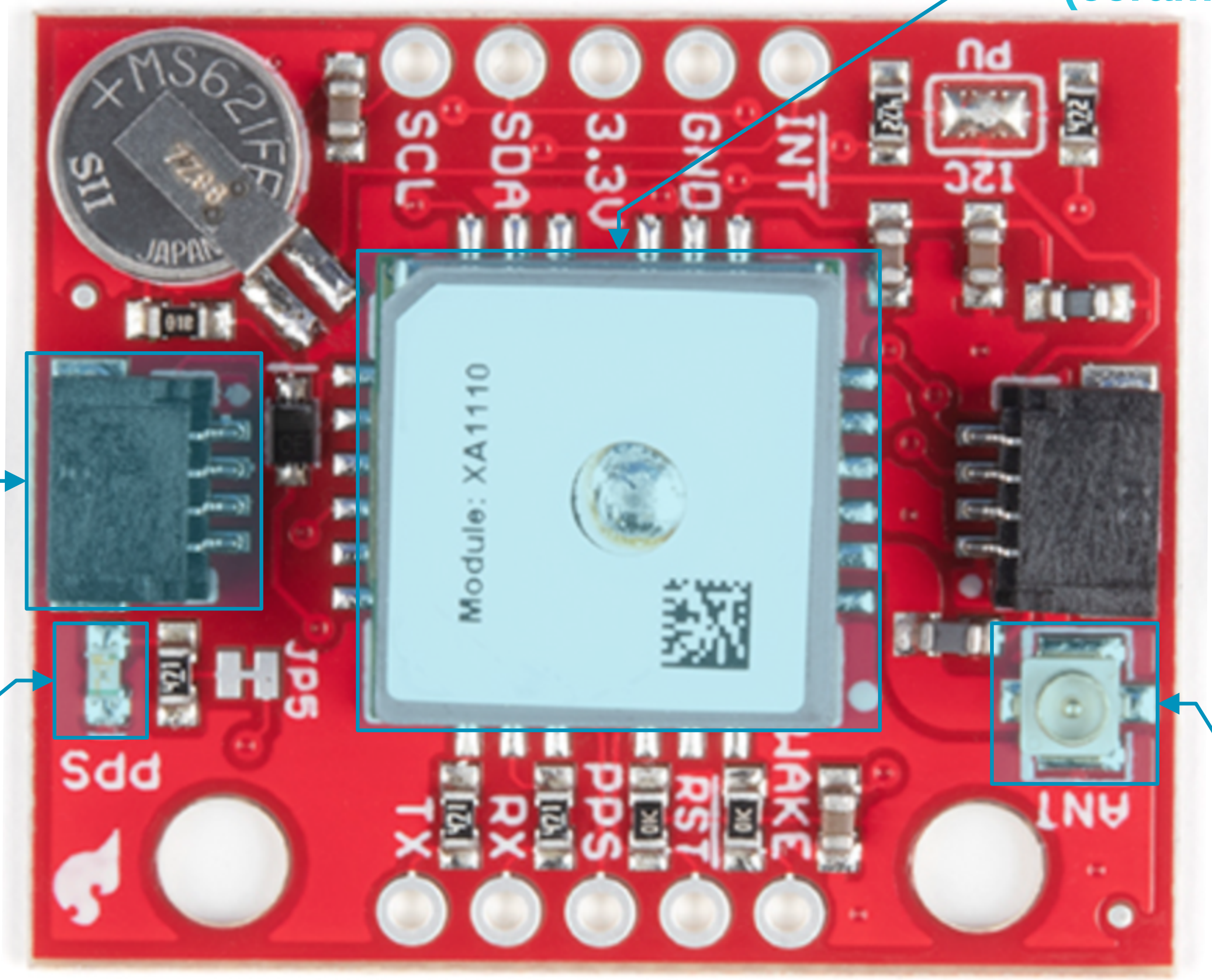
EUROPEAN COMMISSION
Grant Agreement No. 101008724
Project funded by the European Commission within the Horizon 2020 Programme (2014-2020)

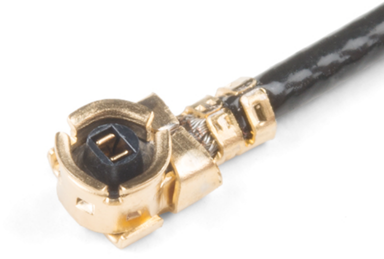
Dynamic Measurements

The GPS

Antenna (ceramic patch)

Connector to the SCK





Fix Quality indicator

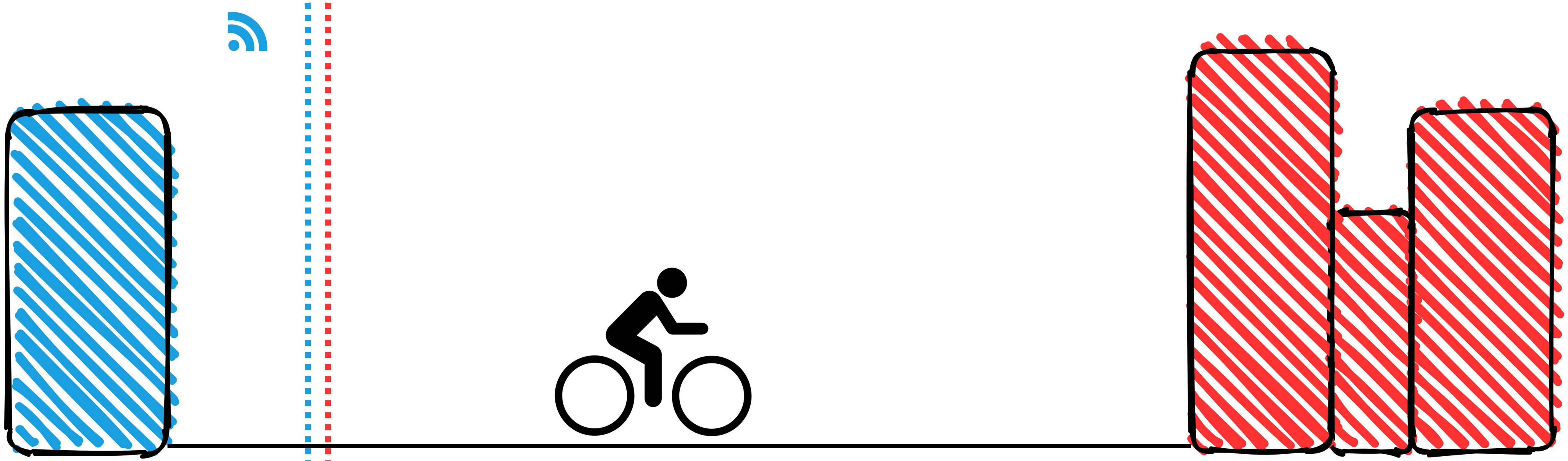
External antenna Connector (U.FL.)

MINKE

EUROPEAN COMMISSION
Grant Agreement No. 101008724
Project funded by the European Commission within the Horizon 2020 Programme (2014-2020)

Dynamic Measurements

Adapting the interval



Home or University

WiFi is available

Trip data is published in batch

Bicycle trip

Data is stored locally in Flash Memory or SD card

Recording interval 5'' when moving, 1' otherwise

MINKE

EUROPEAN COMMISSION

Grant Agreement No. 101008724
Project funded by the European Commission within the Horizon 2020 Programme (2014-2020)

Dynamic Measurements

Using different antennas

Normal deployments

We recommend at least 1 ceramic antenna (unless you have the XA1110 GPS)

Rugged stuff

An external waterproof antenna such as this one:

MINKE

EUROPEAN COMMISSION

Grant Agreement No. 101008724
Project funded by the European Commission within the Horizon 2020 Programme (2014-2020)

Dynamic Measurements

A word about privacy

If you are recording non-personal trajectories

i.e. buoys, ships, or other – nothing to worry about!

However, if you are recording personal trajectories (private individuals)

i.e. your trip to work by bike, car, or your community...

1) Contact us to make your profile *researcher*
2) This will allow you to make *private devices* (devices which data can't be downloaded except by yourself)
3) As admins of the platform, we can still download the data – eliminate all references on your profile (even create a throwaway email) if your data is private

Note:

This also applies for other types of experiments, including indoor ones

EUROPEAN COMMISSION

Grant Agreement No. 101008724
Project funded by the European Commission within the Horizon 2020 Programme (2014-2020)

Sensors in the wild

Sensors in the wild

Practical installation

Four aspects to consider

1) Where you install the sensors

2) How you power them

3) How often you record data

4) How do you store the data

EUROPEAN COMMISSION
Grant Agreement No. 101008724
Project funded by the European Commission within the Horizon 2020 Programme (2014-2020)

Sensors in the wild

Practical installation

Where you install the sensors

- Keep the sensors **powered** if they are going to be mounted in a fixed point
- Avoid areas with **moist accumulation** when possible
- Avoid **temperature and humidity transients**, specially for the eCO2/tVOC sensor
- Avoid **covering** the sensors, especially the PM sensor
- Avoid **covering** the microphone and particles to go in the **microphone** port
- Avoid **direct flow** towards the sensors. If exposed under flow conditions, have the flow go **parallel** to the sensors' surface

EUROPEAN COMMISSION
Grant Agreement No. 101008724
Project funded by the European Commission within the Horizon 2020 Programme (2014-2020)

Sensors in the wild

Practical installation

Where you install the sensors

- Avoid exhausts from air conditioning units, kitchens and others
- Protect the sensors from moisture either using filtering foam or nail polish to cover the sensor pads
- Avoid temperature transients, specially due to sun radiation

EUROPEAN COMMISSION
Grant Agreement No. 101008724
Project funded by the European Commission within the Horizon 2020 Programme (2014-2020)

Sensors in the wild

Practical installation

How you power the sensor

- [SHORT TERM]
  LiPo 3.7V Battery: default 2000mAh - large 6000mAh

- [LONG TERM]
  Mains power: through an USB adaptor (not recommended for outdoor) or a custom power supply in its enclosure

- [MORE ADVANCED]
  Solar panel: Solar Panel (size depends on latitude) MPTT DF Robot DFR0559 and an additional LiPo Battery

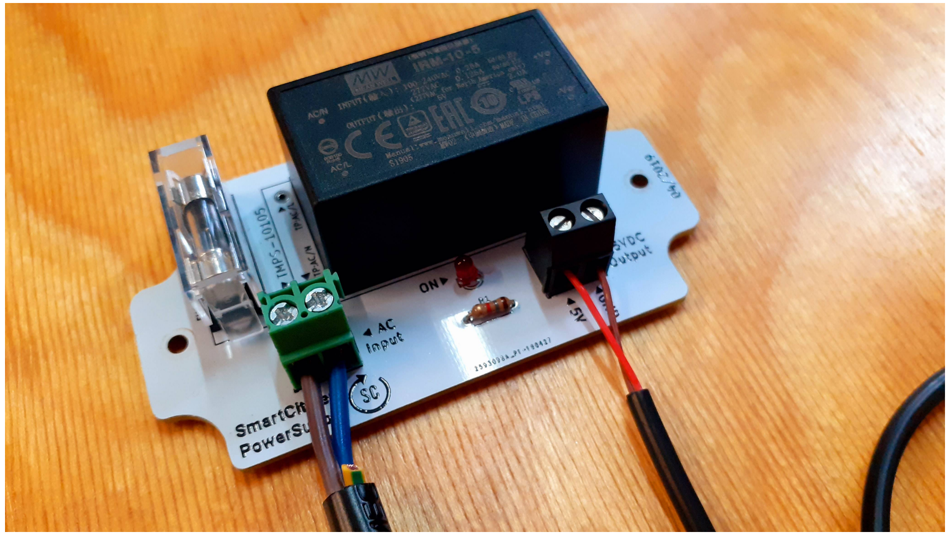
EUROPEAN COMMISSION
Grant Agreement No. 101008724
Project funded by the European Commission within the Horizon 2020 Programme (2014-2020)

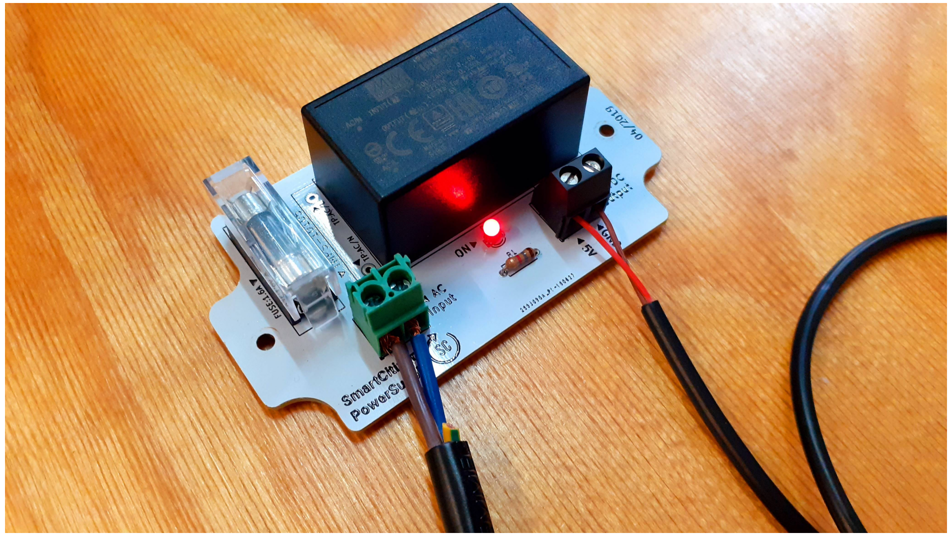
Sensors in the wild

Power

Outdoor Power Supply

- Input range:
  - 100V-240VAC 50-60Hz, max 0.25A input, 1A Fused,
  - 277VAC 0.125A, also 50-60Hz
- Output range: 5VDC, max 2.0A





EUROPEAN COMMISSION
Grant Agreement No. 101008724
Project funded by the European Commission within the Horizon 2020 Programme (2014-2020)

Sensors in the wild

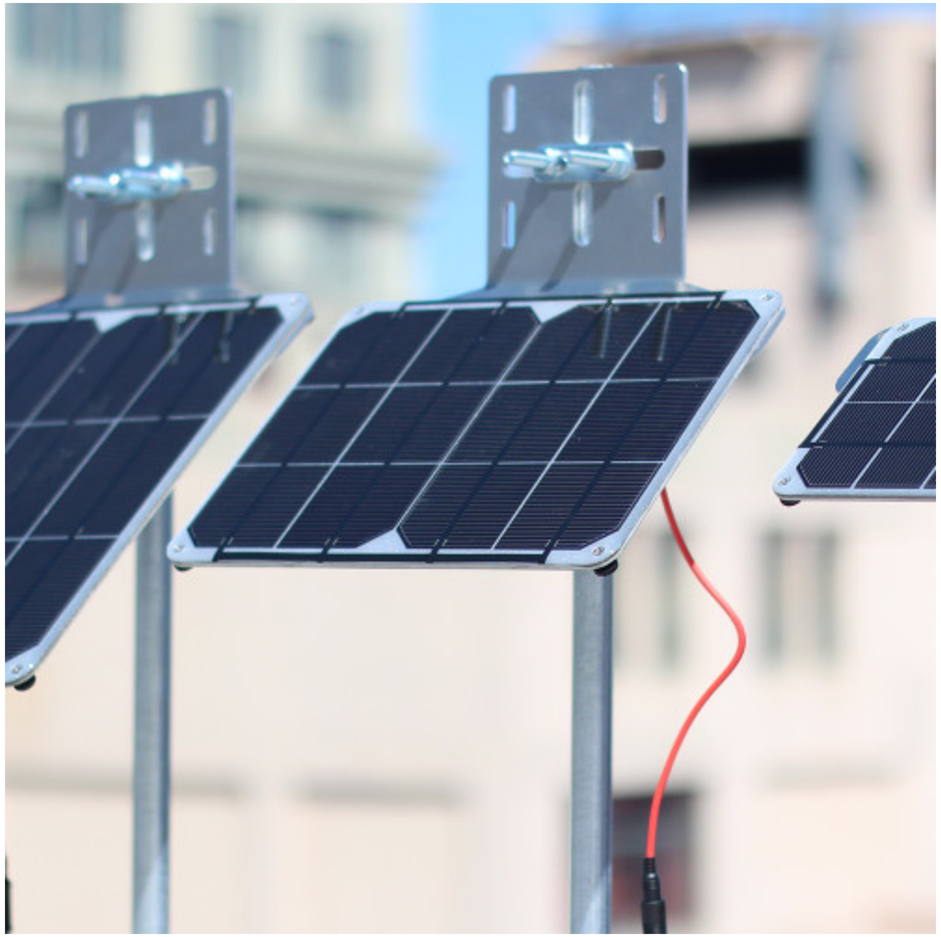
Power – Solar panel

- Solar panels should always face **true south** in the the **Northern Hemisphere and north** in the **Southern Hemisphere**

- The orientation of the solar panel with respect to the horizontal plane should be at a degree equal to your latitude plus 15 degrees in winter, or minus 15 degrees in summer (roughly)

- A bit more advanced tweaking, could achieve better efficiency for fixed solar panels. Since the winter season has the least sun, you want to make the most of it. In this case, the tilt should be designed so that the panel points directly at the sun at noon:

Tilt ~= latitude x 0.9 + 30degrees



EUROPEAN COMMISSION
Grant Agreement No. 101008724
Project funded by the European Commission within the Horizon 2020 Programme (2014-2020)

Sensors in the wild

Power – Solar panel

The size of the solar panel and battery sizes will be calculated based on:

- the amount of sun (irradiation – latitude and weather related)
- the consumption of the SCK (safe estimation is 45mA consumption for the defaults settings*)

Example:
Solar panel: 6W 6V solar panel with 4 effective h/day of sun
➝ Energy produced: 24Wh per day (max)
➝ 1W (average power)

SCK: 45mA avg. consumption
➝ 5.52Wh/day
➝ ~0.230W average power
Batteries: 4Ah to be charged in 24h at 3.7V (70% efficiency of chargers)➝ ~25Wh per day

Note:

you can determine the SCK consumption on your setup by charging the kit and seeing how long it takes to discharge a 2000mAh battery

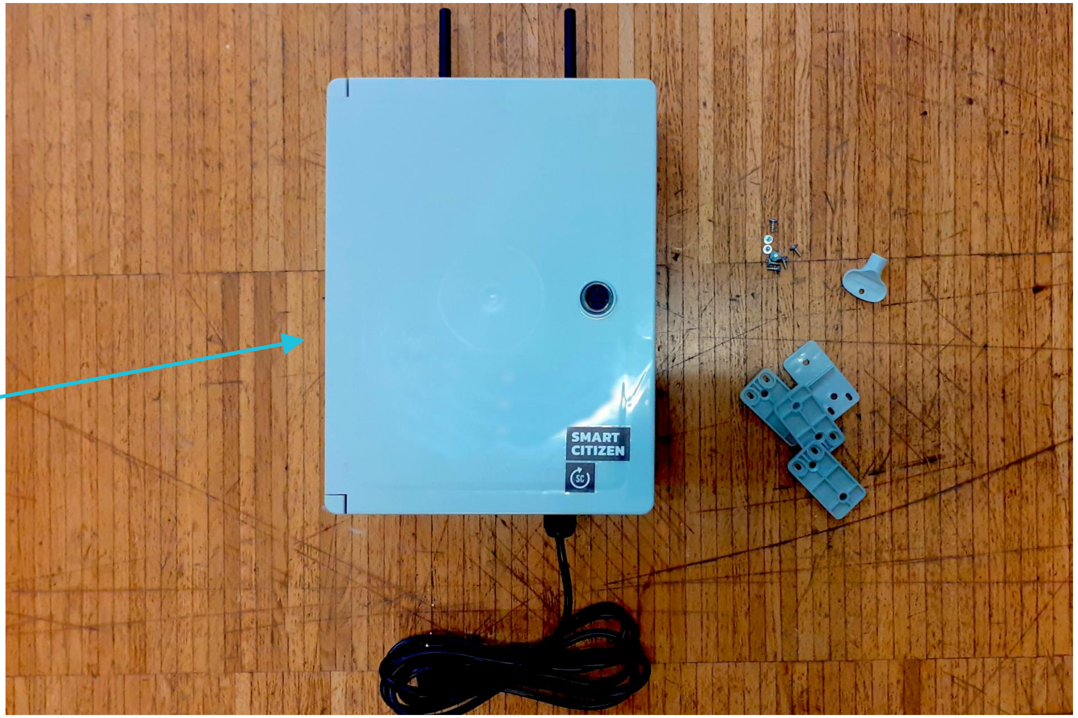
EUROPEAN COMMISSION
Grant Agreement No. 101008724
Project funded by the European Commission within the Horizon 2020 Programme (2014-2020)

Sensors in the wild

Connectivity

Reach of SCK WiFi is **limited to roughly 20m**. Options are:

1) Using a **4G Hotspot** like this one



2) Otherwise, you can use the onboard **flash to store data** and publish it with a Mobile Hotspot:

- Configure the SCK with a WiFi from an **active** mobile hotspot (on your phone)
- Make sure data is being posted online
- Deactivate hotspot and leave the sensor in **WARNING** mode
- Come back when you need to post more data! It will reconnect and post all the data after max 15’

Make sure you understand the “risks”

- If you use the flash option, you **won’t see data posted live**
- If the device runs out of battery, you will lose the time and sensor will be in **ERROR** mode (no data recorded at all)
- Better to check **frequently**

EUROPEAN COMMISSION
Grant Agreement No. 101008724
Project funded by the European Commission within the Horizon 2020 Programme (2014-2020)

Sensors in the wild

If something breaks

Enclosure / Cover
Depends on the part. If 3D printed, it can be easily replaced

Electronics
Most of the time unfixable and needs replacement

EUROPEAN COMMISSION
Grant Agreement No. 101008724
Project funded by the European Commission within the Horizon 2020 Programme (2014-2020)

And on the next session...

And on the next session...

Getting data

Basic data access

The API

Visual programming