European Network on New Sensing Technologies for Air Pollution Control and Environmental Sustainability - *EuNetAir*

COST Action TD1105

Focus Group Meeting on

Data Analysis of Aveiro Air Quality Sensors Intercomparison

WHO Collaborating Centre (CC) for Air Quality Management and Air Pollution Control - Federal Environment Agency (FEA)

Berlin, Germany, 17 April 2015

Action Start date: 01/07/2012 - Action End date: 30/06/2016 - Year 3: 2014-15 (*Ongoing Action*)

Overview of the 1st EuNetAir Air Quality Intercomparison: Assessment of Micro-Sensors versus Reference Methods - Preliminary Results

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COST is supported by the EU Framework Programme

ESF provides the COST Office through a European Commission contract

1ST EuNetAir Air Quality Joint-Exercise Intercomparison

- **Air Quality Monitoring Campaign** in Aveiro, Portugal, from **13th to the 27th of October 2014**.

Goal: evaluation and assessment of environmental gas/PM micro-sensors versus air quality standard reference methods.




Campaign characterization

Urban traffic location in **Aveiro** city centre

15 teams from research centres, universities and companies from 12 COST Countries

IDAD Air Quality Mobile Laboratory with standard equipment and **reference** analysers

Micro-sensors systems installed side-by-side at IDAD Air Quality Mobile Laboratory

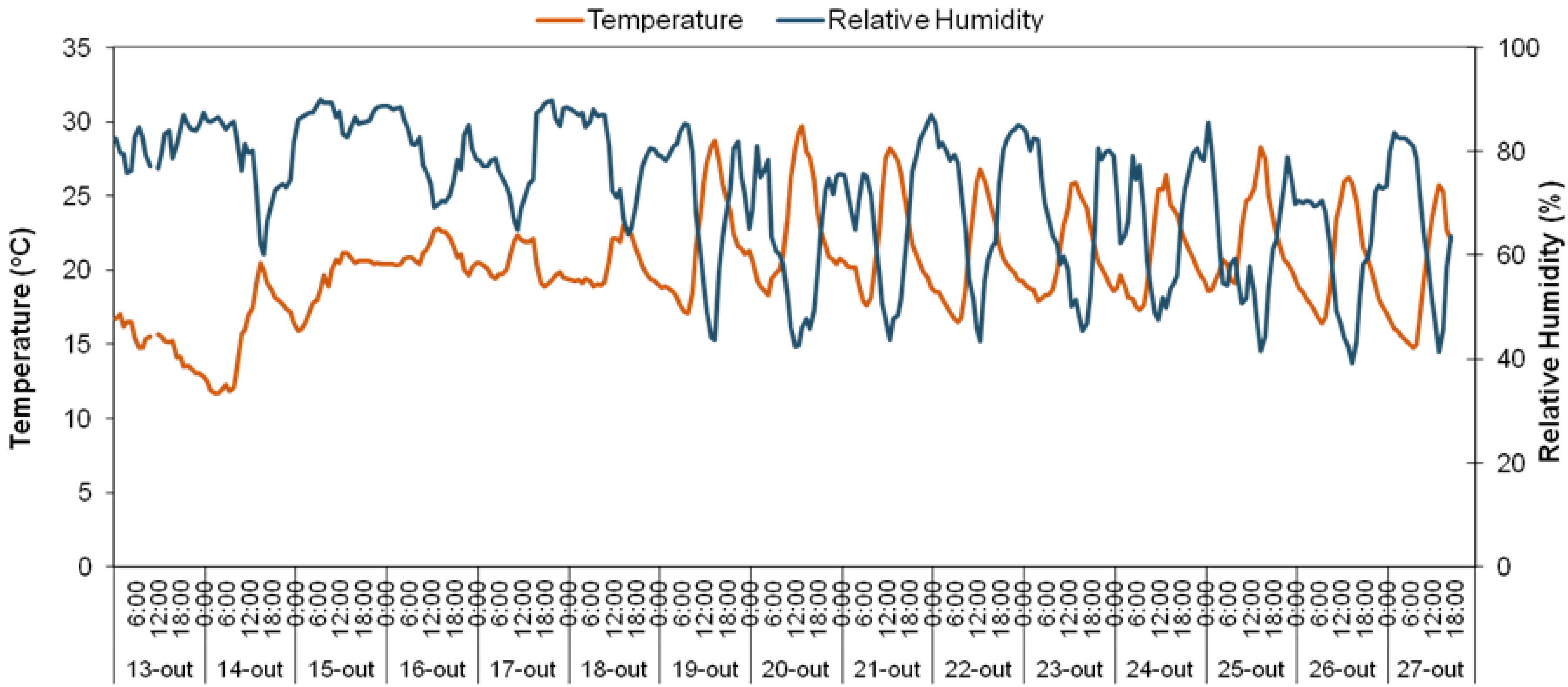
IDAD Air Quality Mobile Laboratory

Monitored variables:

- PM10 and PM2.5 (Beta-ray absorption method)
- CO (nondispersive infrared spectroscopy)
- NOx (chemiluminescence)
- Benzene (gas chromatography)
- O_3 (ultraviolet photometry)
- SO_2 (ultraviolet fluorescence)
- meteorological parameters: temperature, humidity, wind velocity/direction, solar radiation, precipitation

Environmental conditions during field campaign

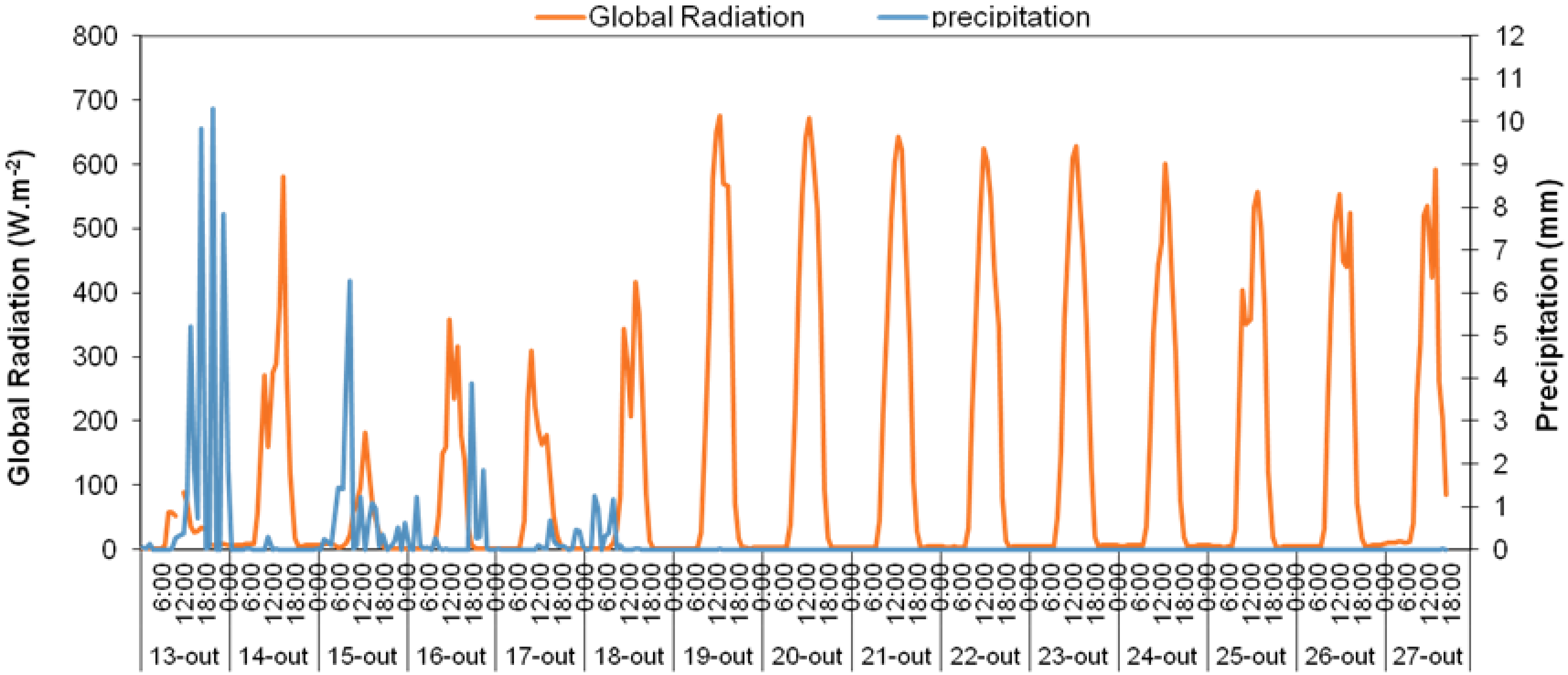
- **Temperature and Relative Humidity:**



- **First week: high relative humidity and lower temperatures.**
- **Second week: lower relative humidity and high temperatures.**

Environmental conditions during field campaign

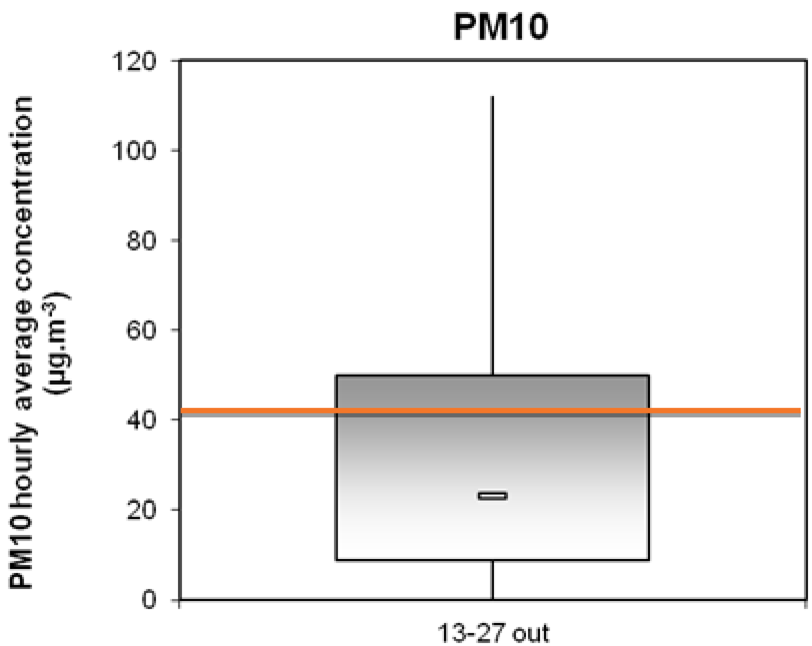
- **Other meteorological parameters:**

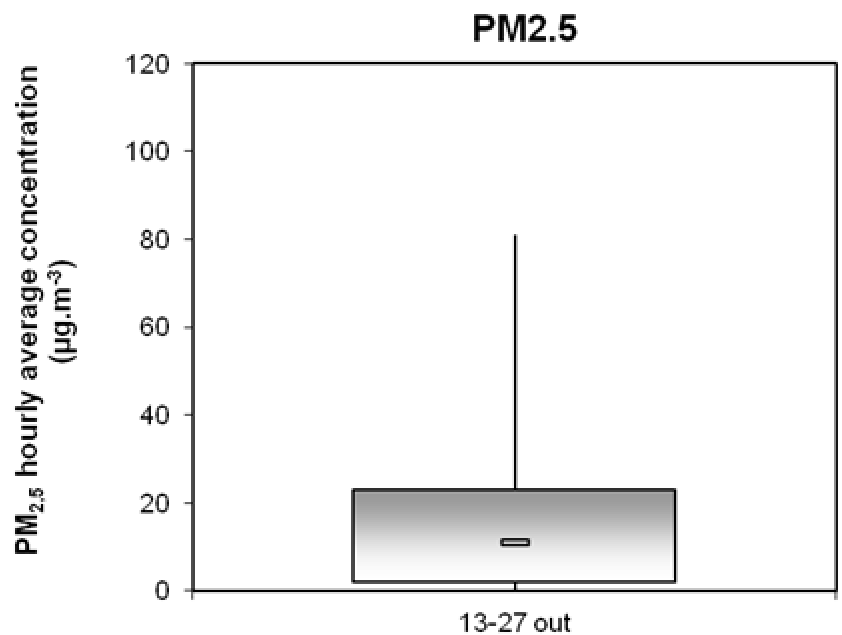


- **First week: long periods of precipitation, low global radiation and strong wind**
- **Second week: no periods of precipitation, higher global radiation and lower wind velocities.**

Environmental conditions during field campaign

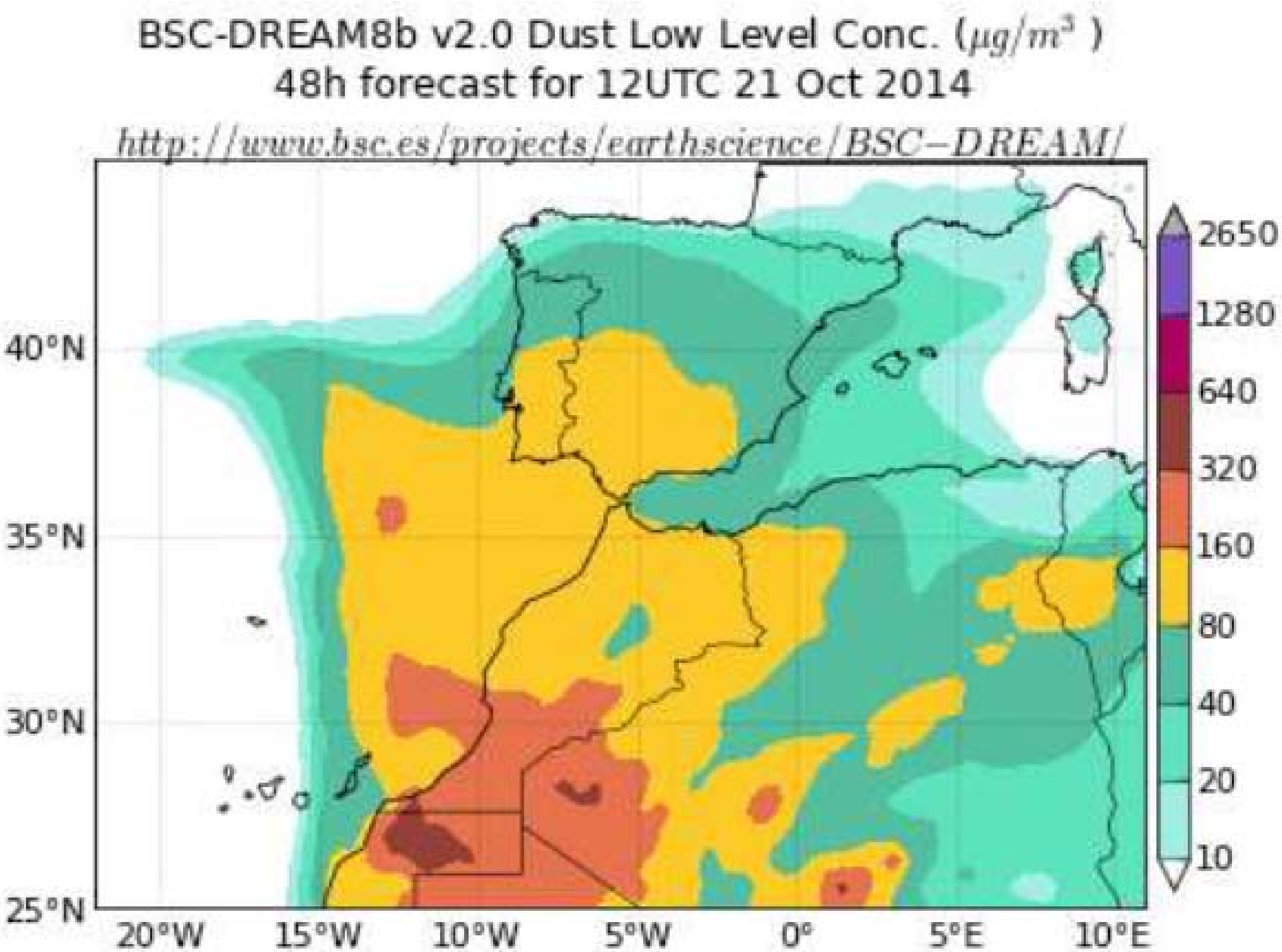
- **Particulate Matter**





- **PM10 daily limit value of 50 µg.m^{-3}** for the protection of human health **was exceeded 6 times** from the 20th to the 25th of October.

Environmental conditions during field campaign

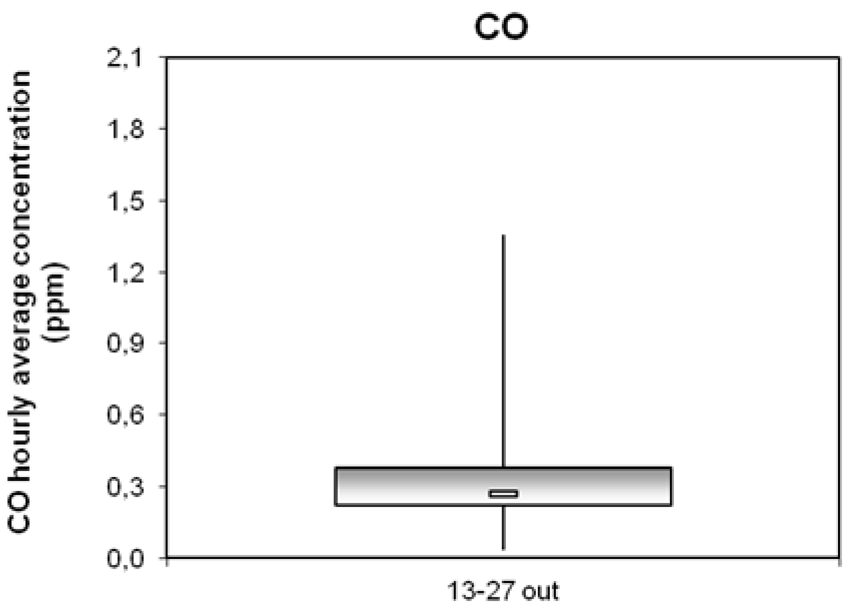


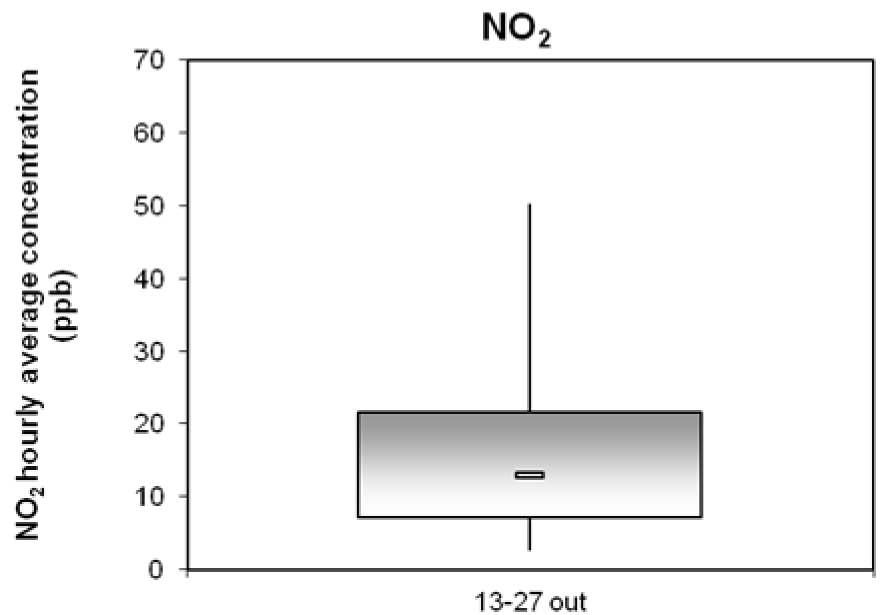
PM10 daily limit value was exceeded due to:

- **traffic emissions and meteorological conditions;**
- **occurrence of natural events due to transport of particles from North Africa, from the 18th to 31st of October.**

Environmental conditions during field campaign

- **Carbon Monoxide and Nitrogen Dioxide:**

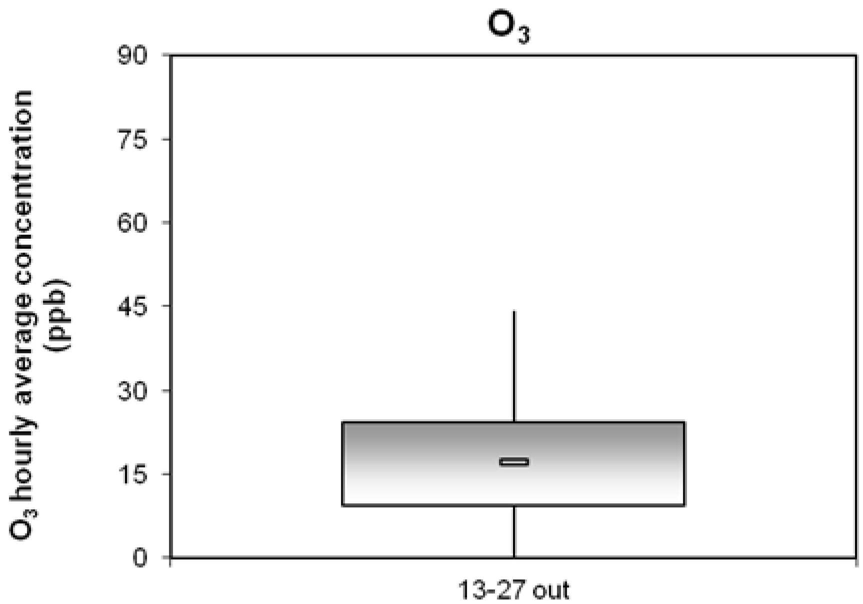


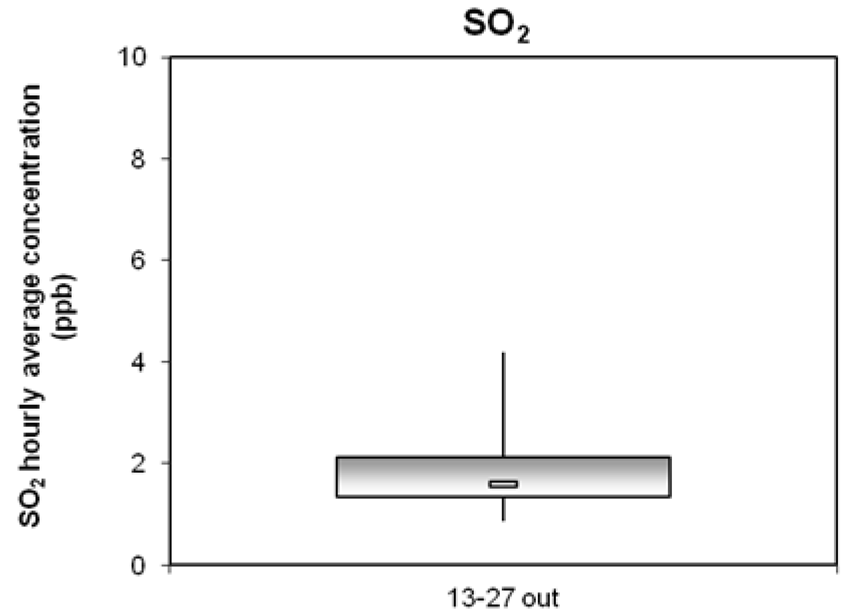


- **CO maximum daily eight hour mean limit value of 10 $mg.m^{-3}$ was not exceeded.**
- **NO_2 one hour limit value of 200 $\mu g.m^{-3}$ was not exceeded.**

Environmental conditions during field campaign

- **Ozone and Sulphur Dioxide:**





- **O_3 one hour information value of 180 µg.m^{-3} and alert thresholds value of and 240 µg.m^{-3} weren't exceeded.**
- **SO_2 one hour limit value of 350 µg.m^{-3} was not exceeded.**

Assessment of Micro-Sensors versus Reference Methods - Preliminary Results

- Micro-sensors typologies and monitored pollutants
- Correlation with reference measurements
- Correlation matrix (T, HR, other pollutants)
- Evaluation of influences in the error/uncertainty

Micro-sensors typologies and monitored pollutants

- Electrochemical sensors:
  - NO, NO_2, CO, O_3, SO_2

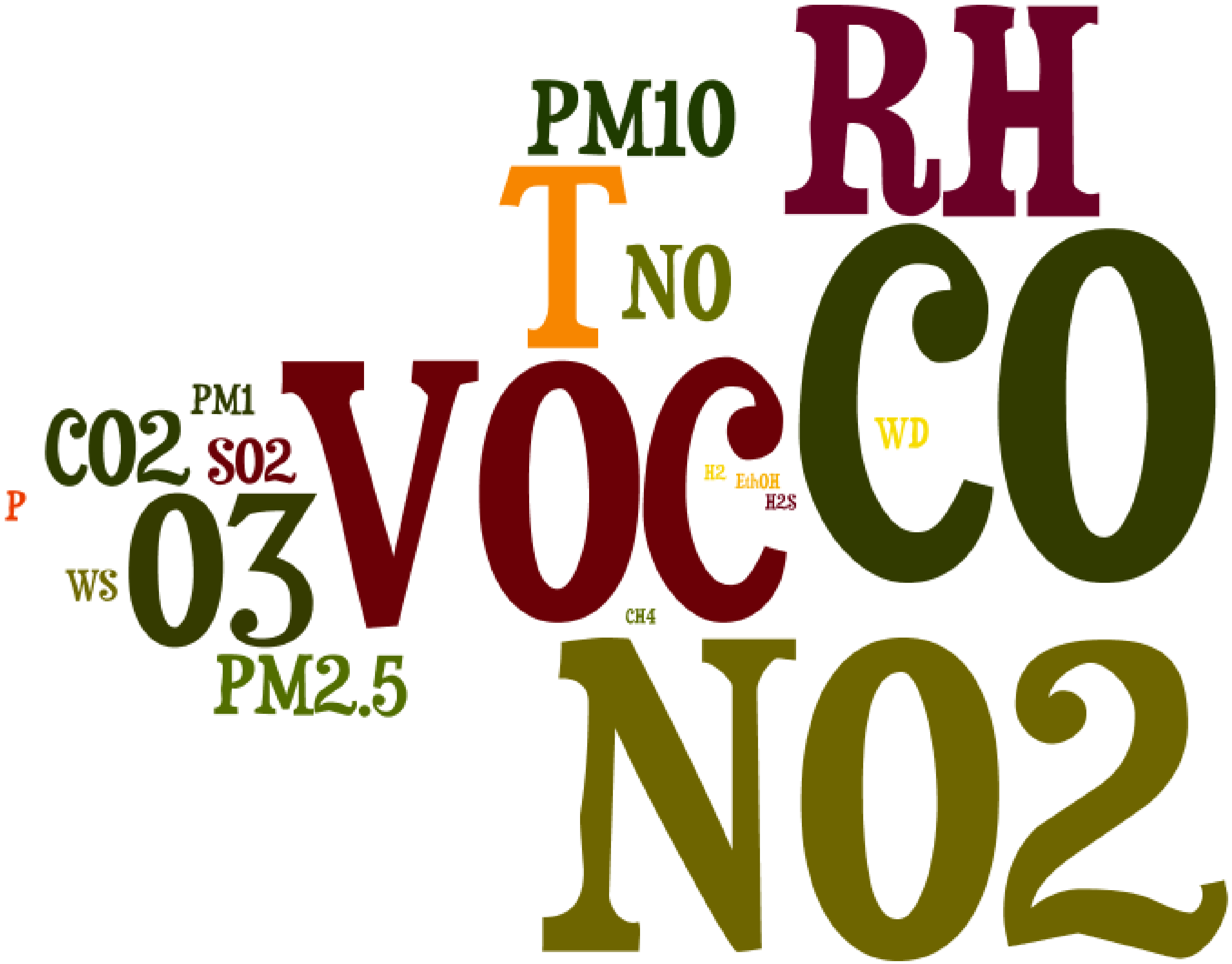
- Optical sensors:
  - PM1, PM2.5, PM10

- Metal Oxide Semiconductor based sensors (MOS):
  - NO_2, VOC, CO, O_3, SO_2

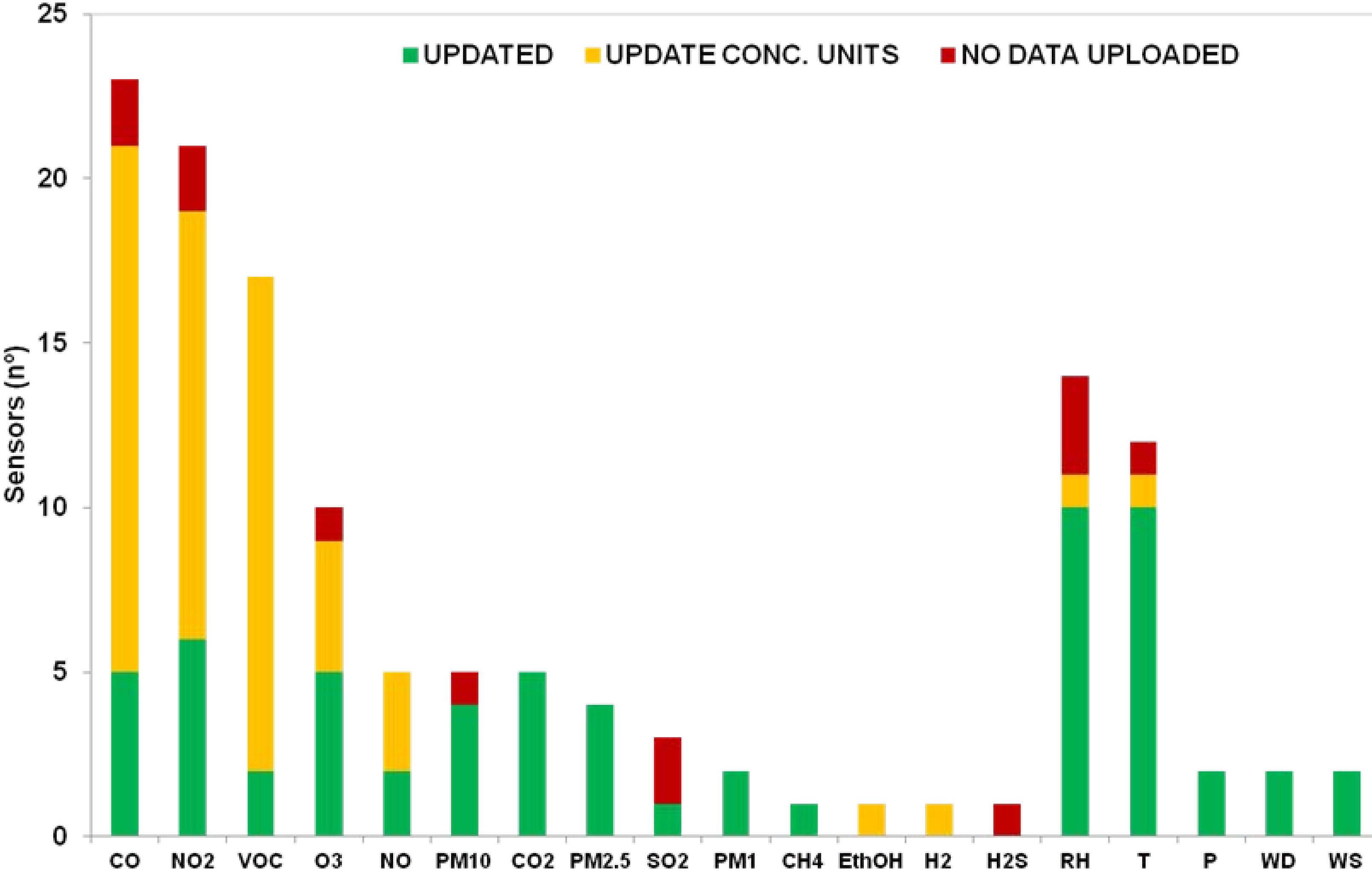
- Non dispersive infrared technology sensors (NDIR):
  - CO_2

- Photoionization detection sensors (PID):
  - VOC

Micro-sensors typologies and monitored pollutants

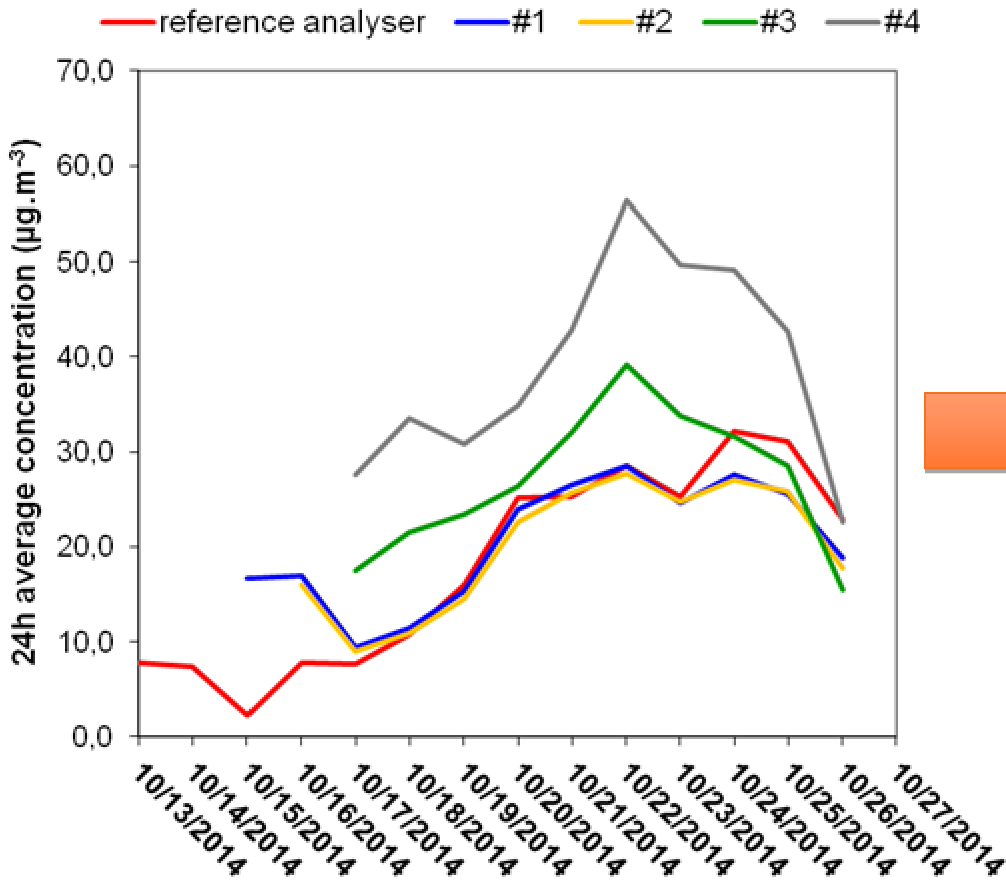


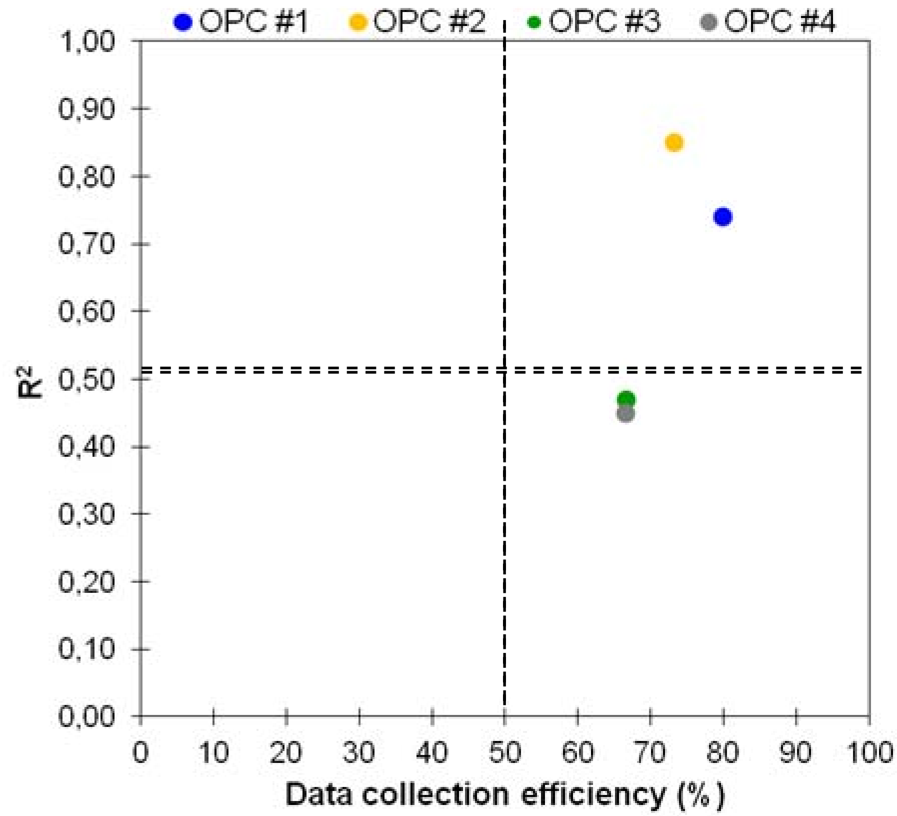
Data update status



Correlation with reference measurements

- **PM2.5:**





- **The OPC sensors for PM2.5 presented correlations varying between 0.45-0.85 and data collection efficiencies in the range of 67-80%.**

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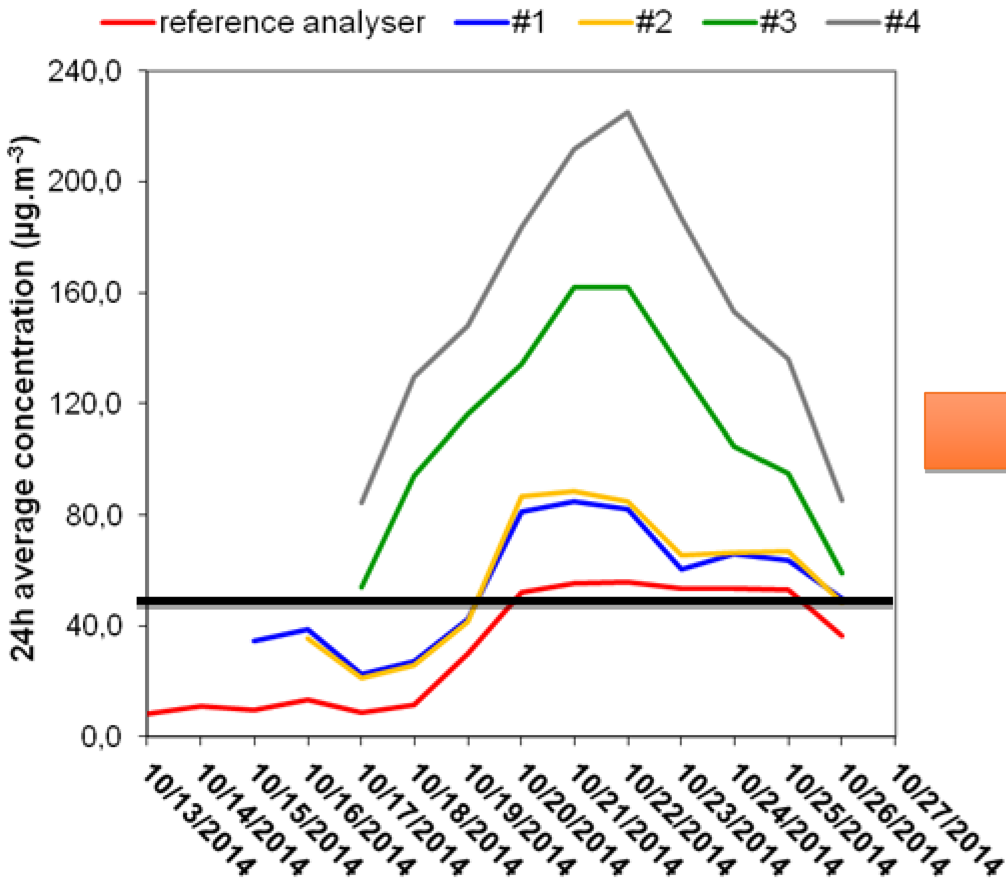
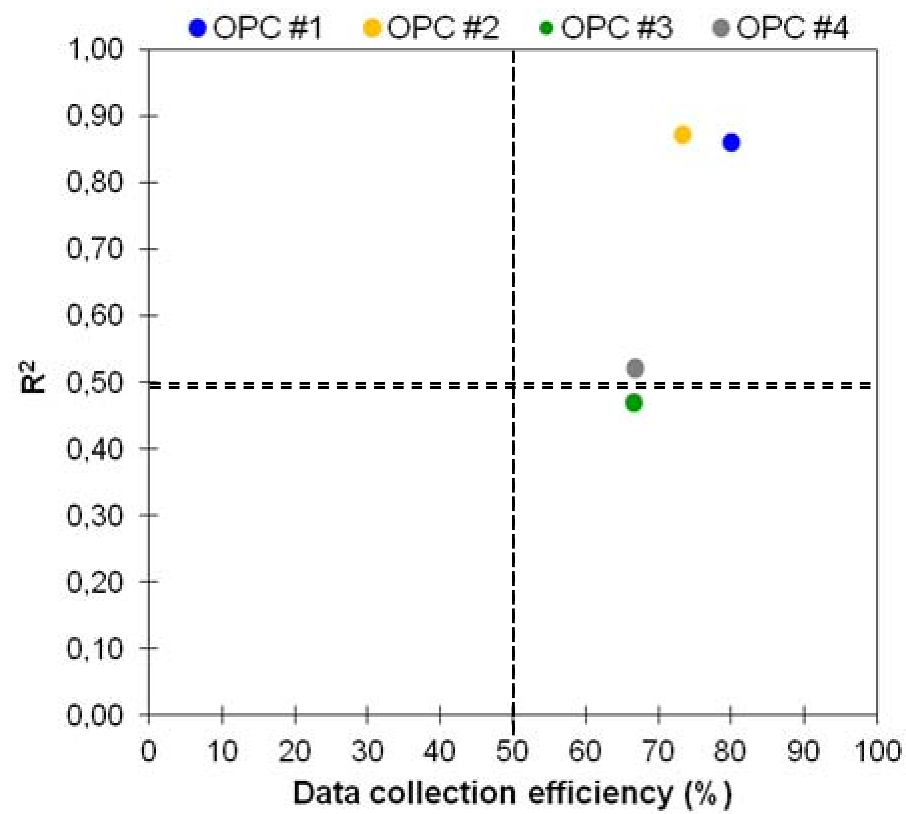
Correlation with reference measurements

- **PM10:**

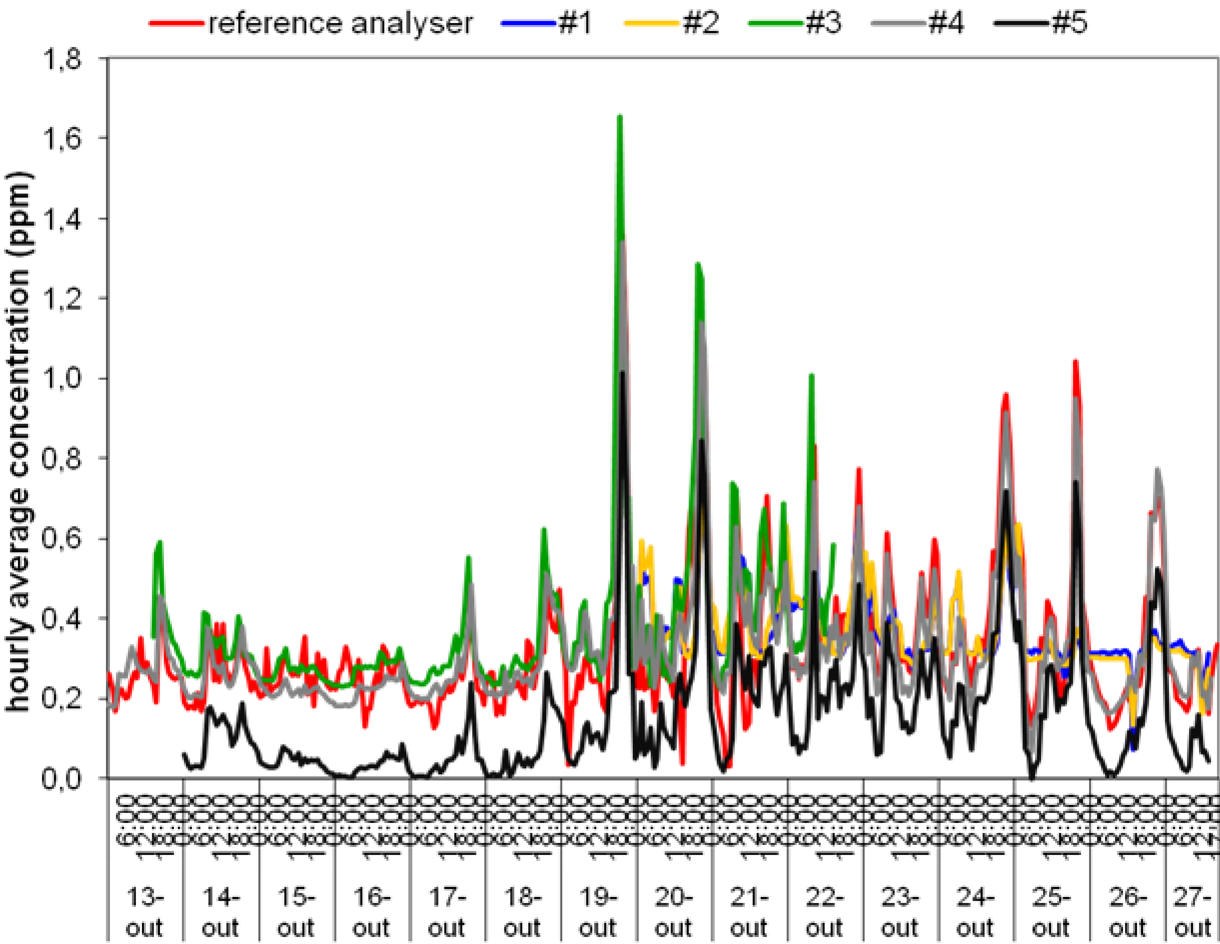


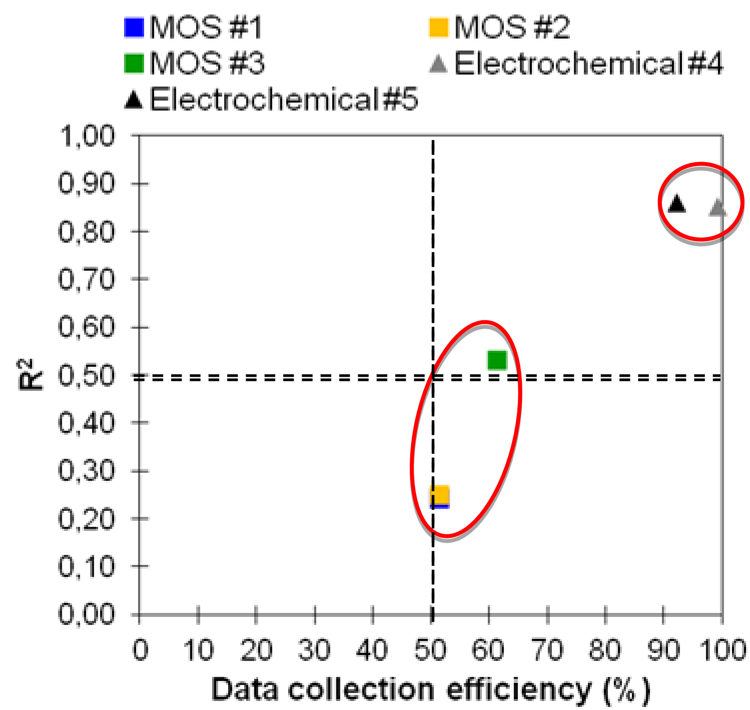


- **The OPC sensors for PM10 presented correlations varying between 0.47-0.87 and data collection efficiencies in the range of 67-80%.**

Correlation with reference measurements

- **CO:**

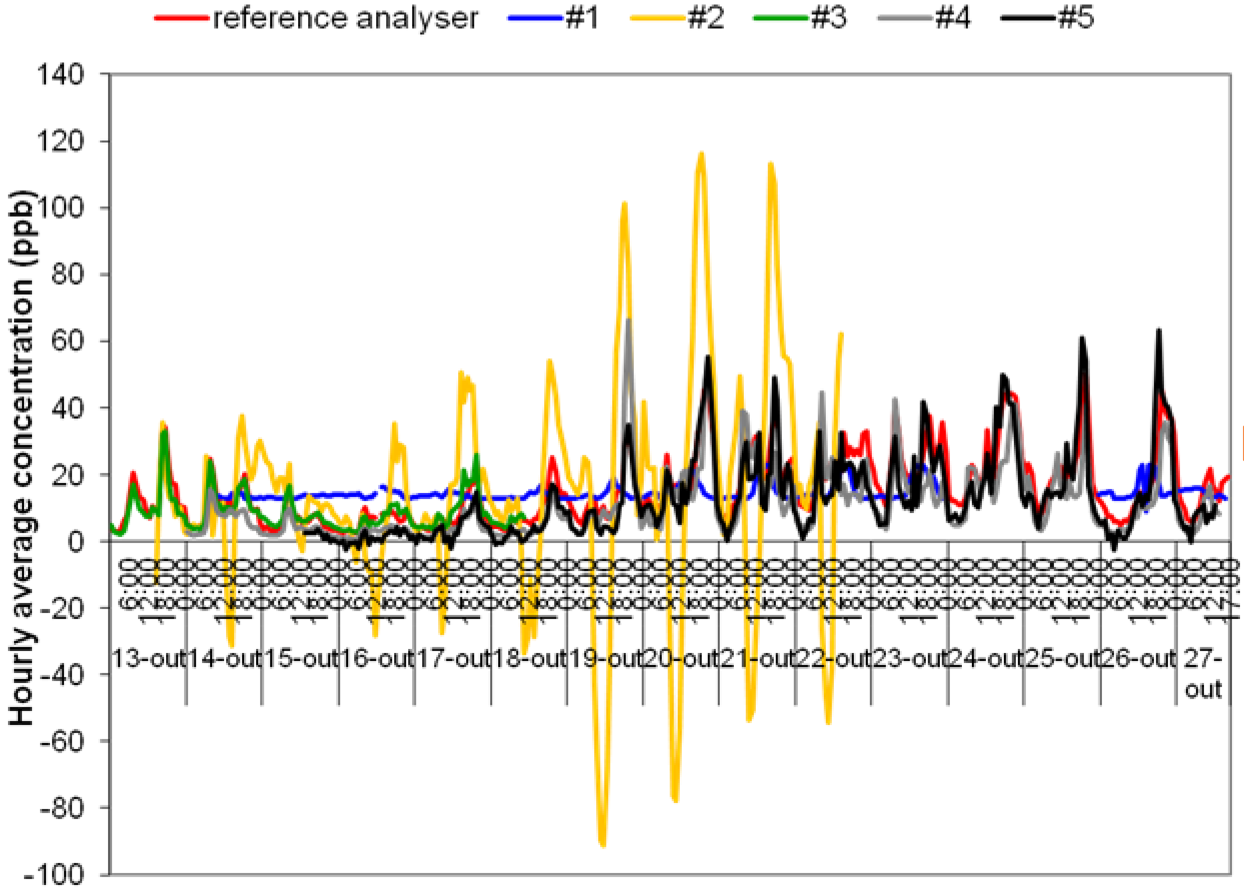


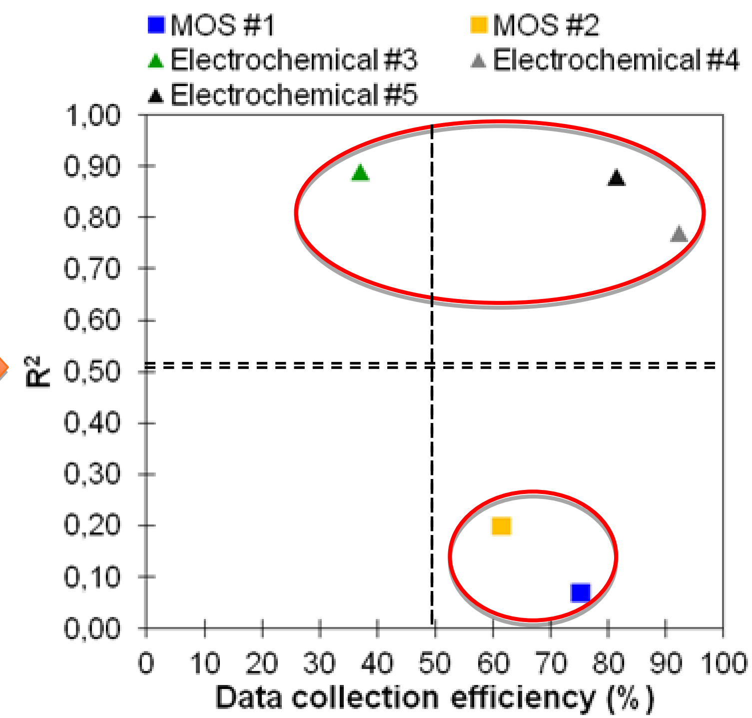


- **Electrochemical sensors showed a greater correlation with the reference method and a higher efficiency collecting data than MOS sensors.**

Correlation with reference measurements

- **NO_2:**

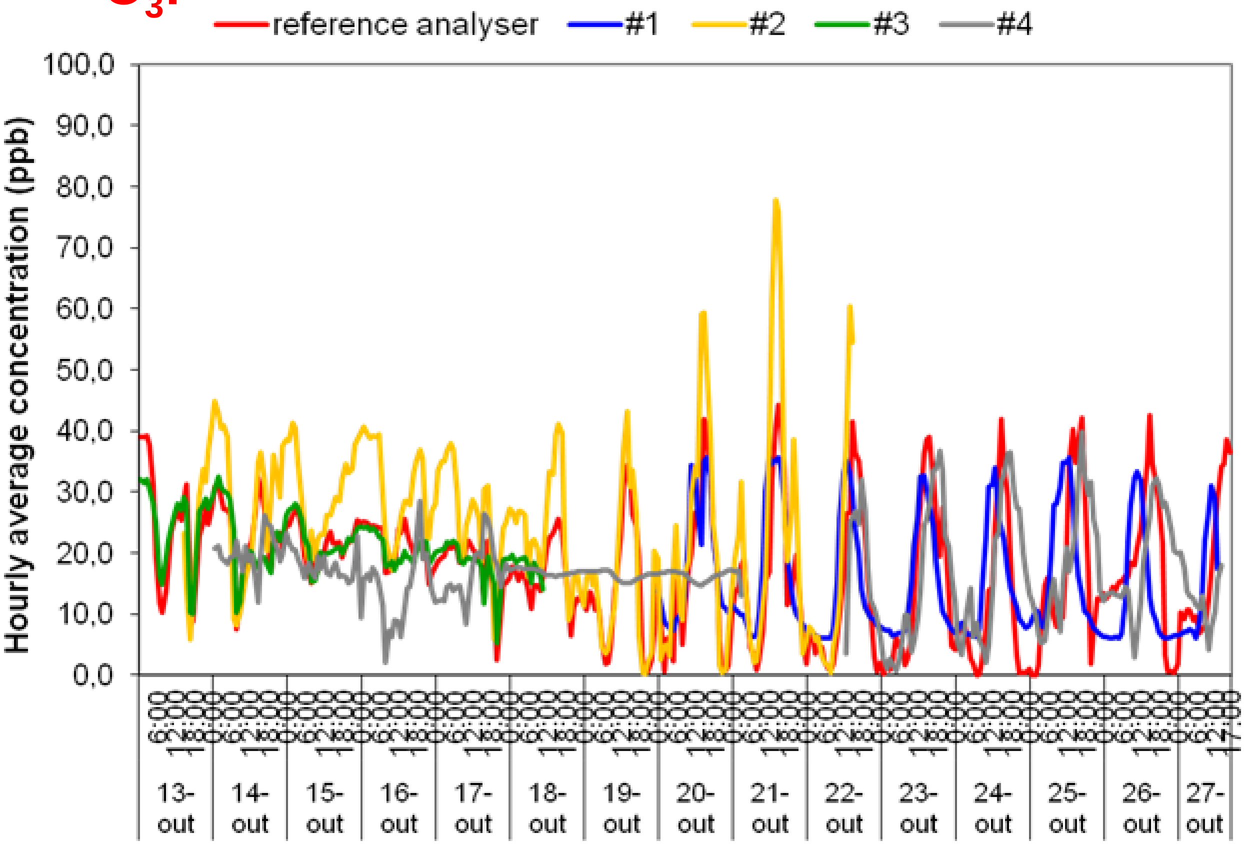


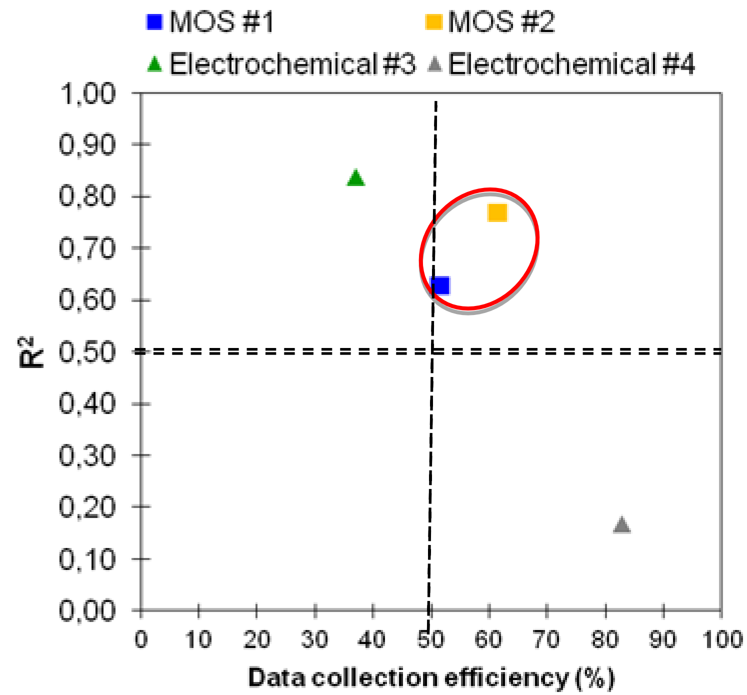


- **Electrochemical sensors showed a greater correlation with the reference method and in most cases a higher efficiency collecting data than MOS sensors.**

Correlation with reference measurements

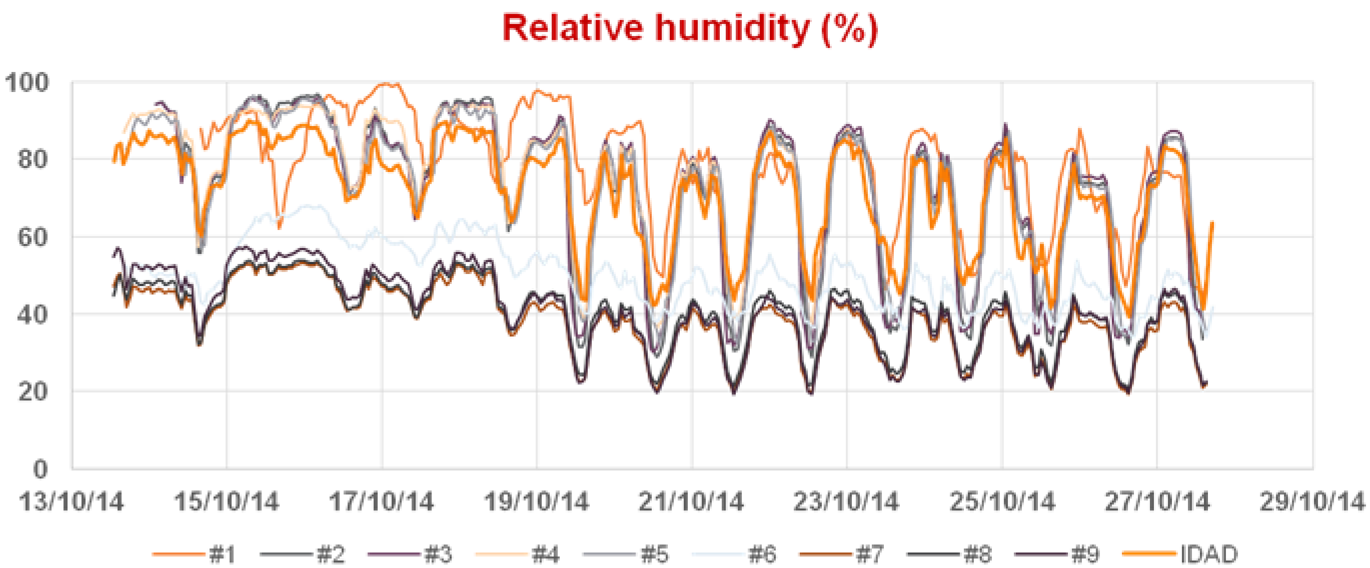
- **O_3:**

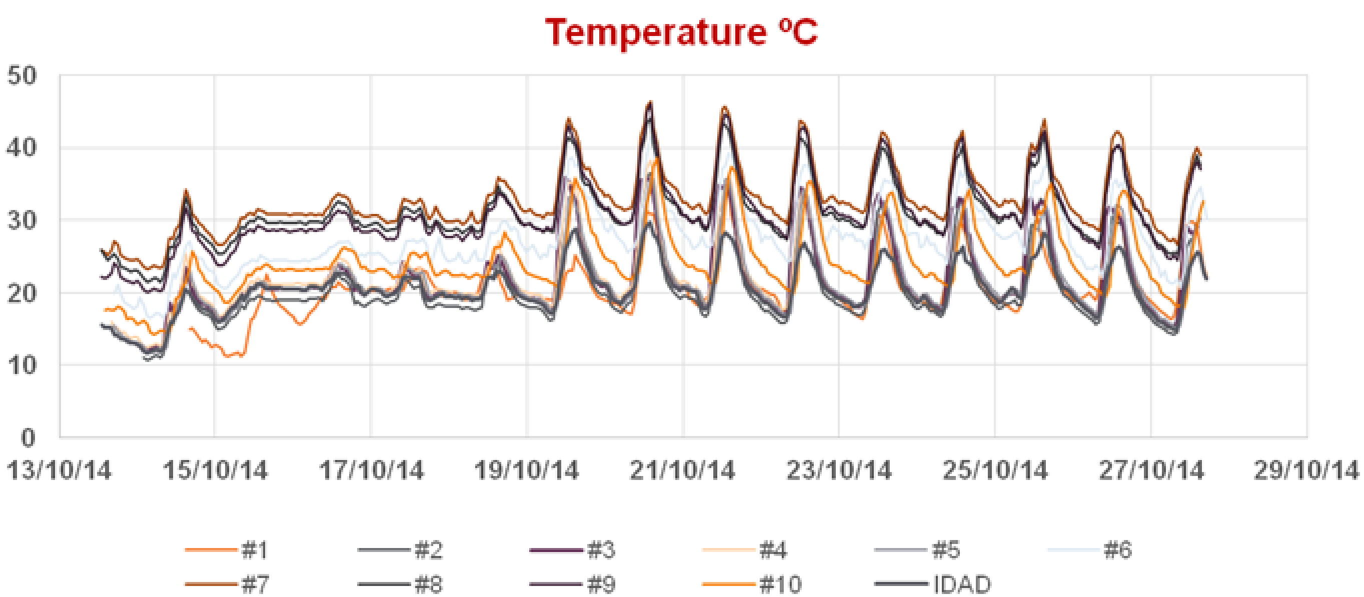




- **Electrochemical sensors: correlations between 0.17-0.84 and data collection efficiencies in the range of 37-83%**
- **MOS sensors: correlations between 0.63-0.77 and data collection efficiencies in the range of 52-62%.**

Assessment of micro-sensors - other parameters

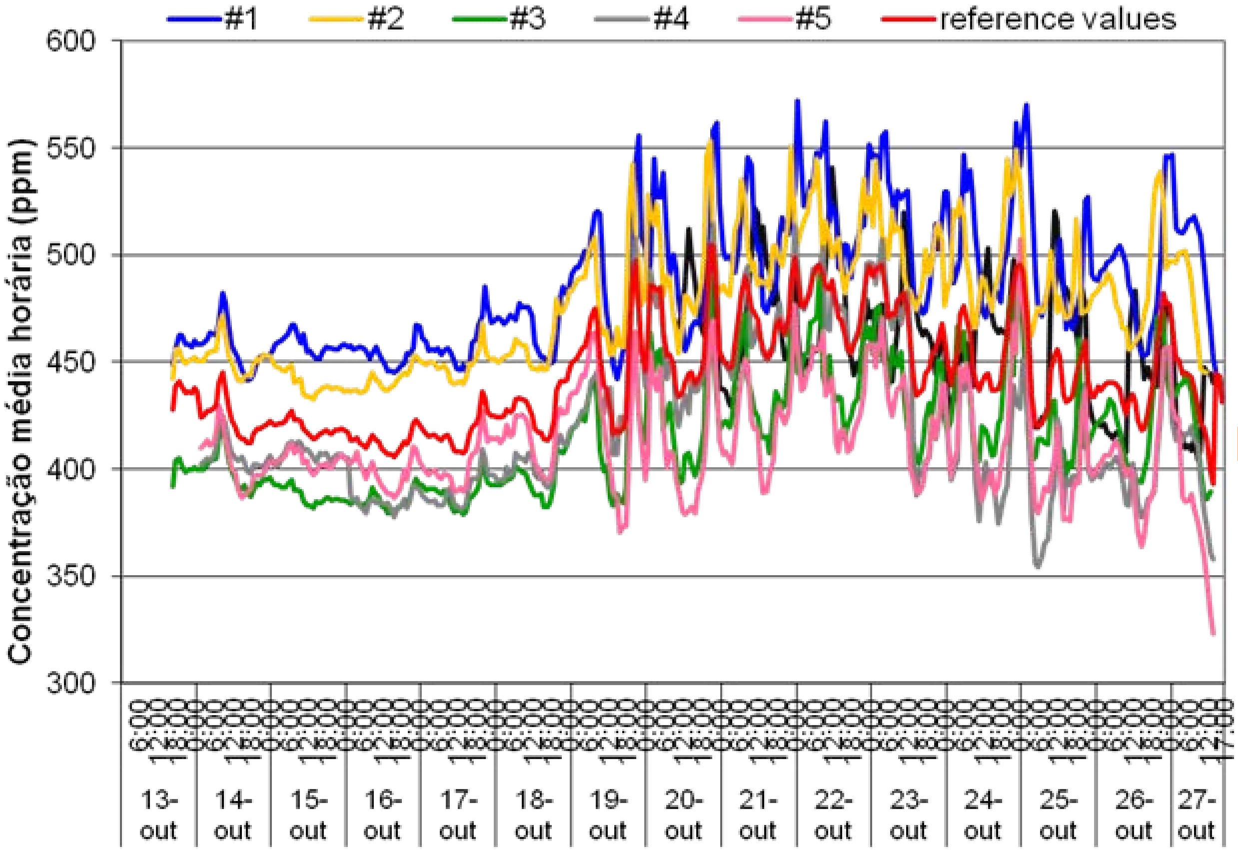


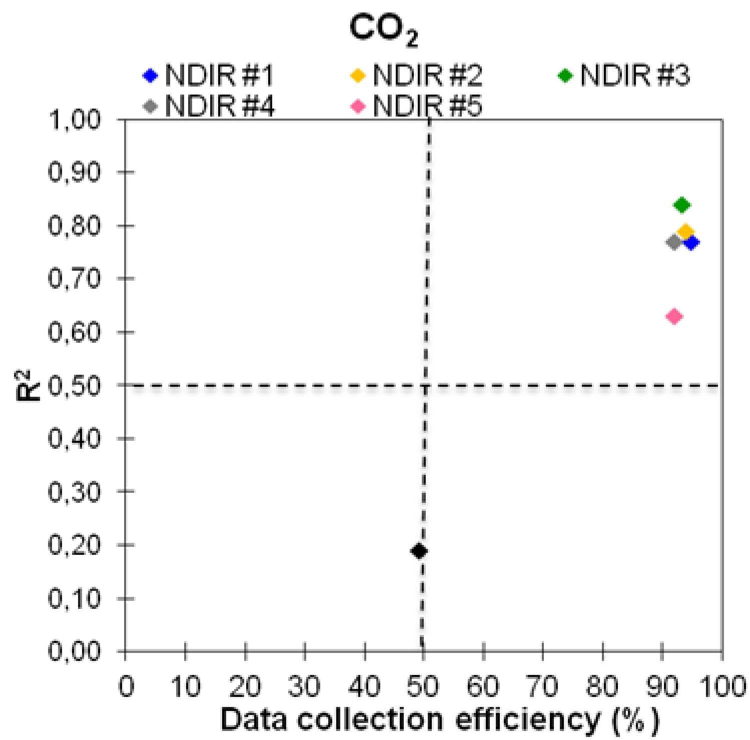


common behavior between sensors !

Assessment of micro-sensors - other parameters

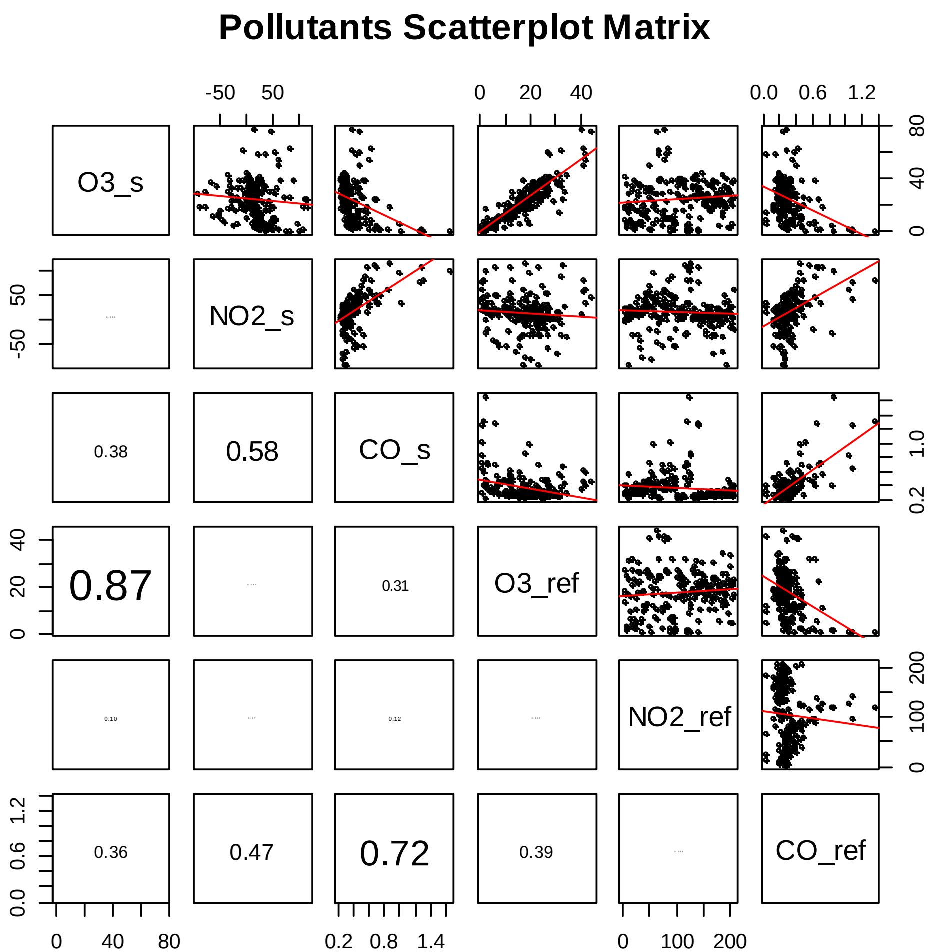
- **CO_2:**





- **NDIR sensors presented strong correlations and high data collection efficiencies, varying between 0.6-0.8 and 92-95%, excluding 1 equipment that showed lower values.**

Correlation matrix

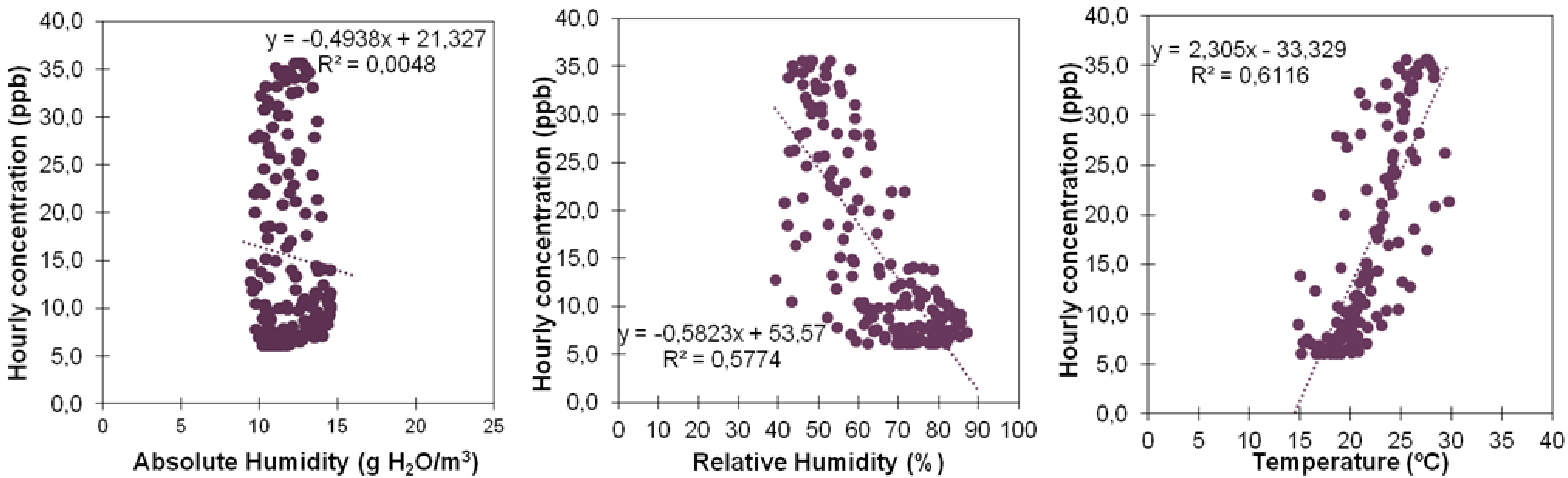


Analysis of the influence of other parameters on the micro-sensor results / **Cross sensitivity**

Example:
NO2 sensor correlation with CO vs correlation with NO2 reference equipment

Interference of meteorological parameters in micro-sensors measurements

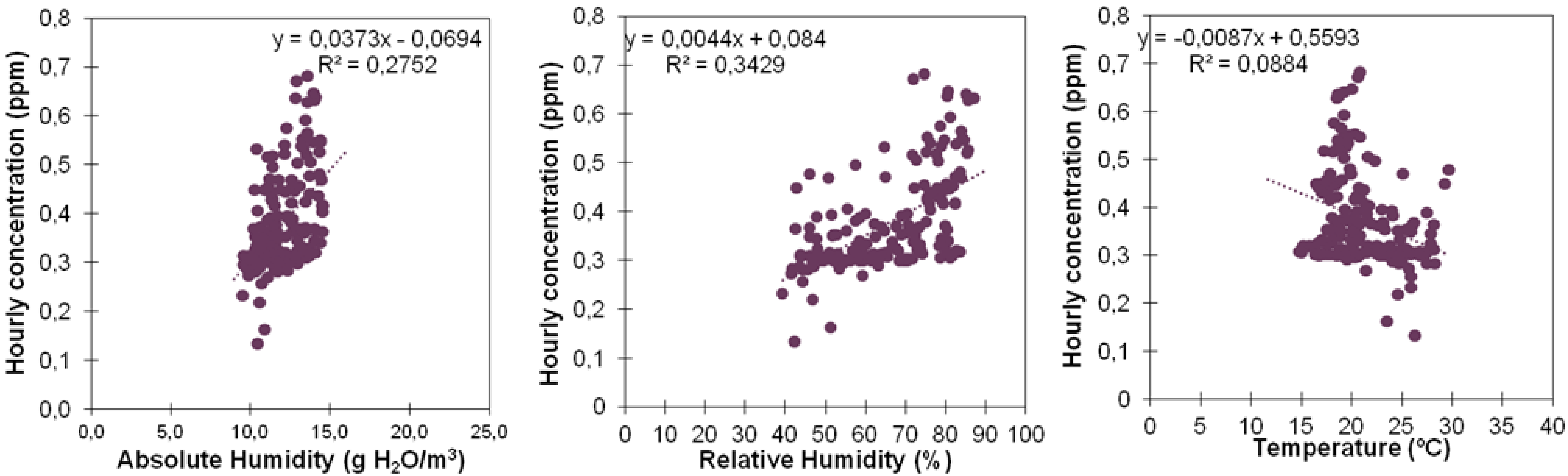
- **O_3:**



- **Good degree of linearity between hourly concentration and Temperature (R^2 = 0.6116) as well as with Relative Humidity (R^2 = 0.5774).**
- **Poor degree of linearity between hourly O_3 concentration with Absolute Humidity (R^2 = 00048).**

Interference of meteorological parameters in micro-sensors measurements

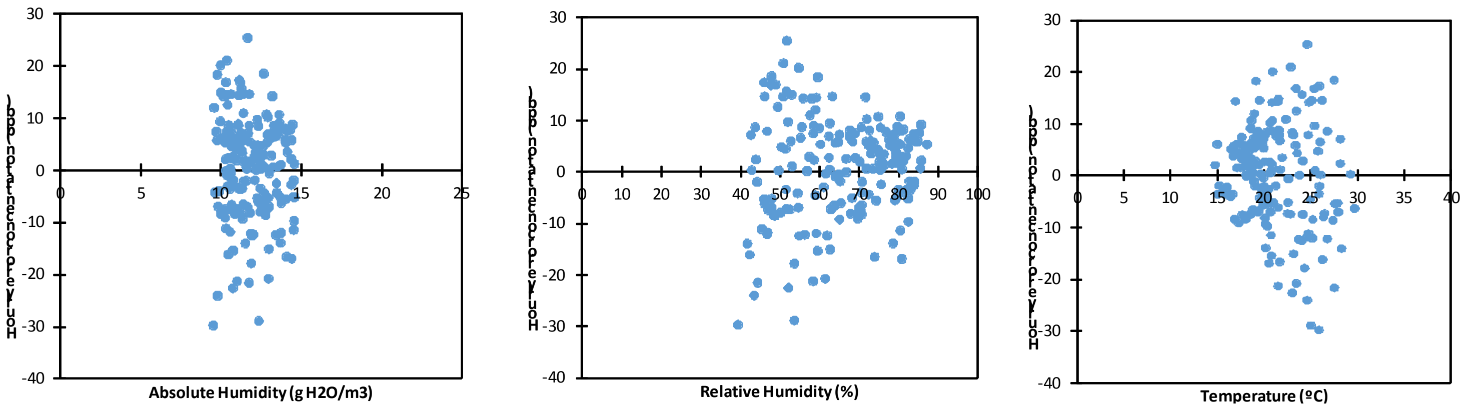
- **CO:**



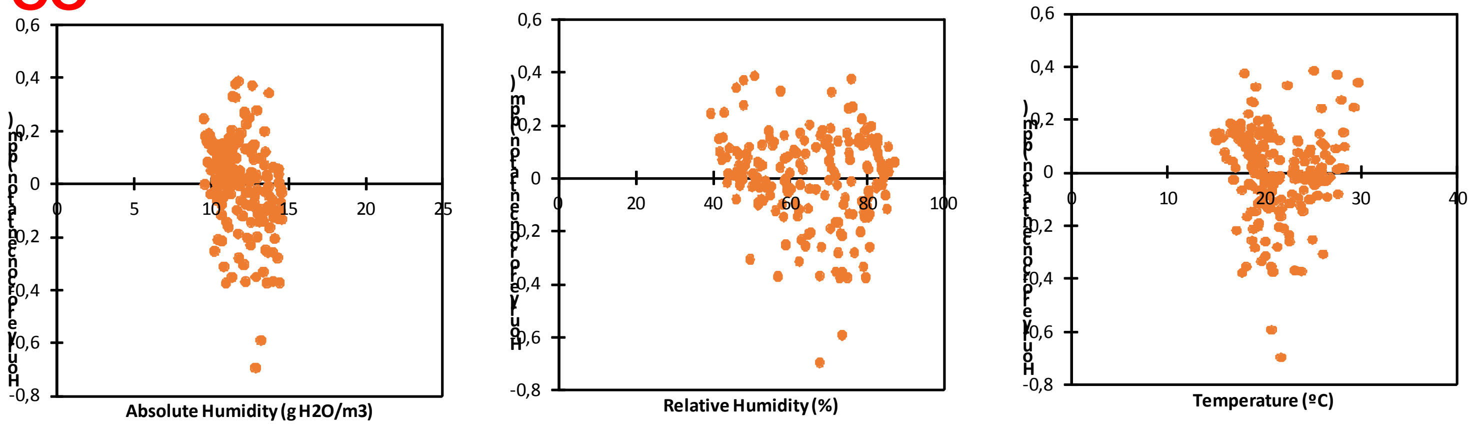
- **Weak correlation between hourly concentration and Temperature (R^2 = 0.0884).**
- **Acceptable degrees of linearity with Absolute Humidity (R^2 = 0.2752) and Relative Humidity (R^2 = 0.3429).**

Evaluation of influences in the error/uncertainty

- **O3**



- **CO**



- **Error with different distribution profiles, considering Temperature, Relative and Absolute Humidity variations.**
- **Example: O3 error (high temperatures) / CO error (high relative humidity levels)**

CONCLUSIONS

- **Results only for 7 teams out of 15!!!**
- **Strong correlation in a significant part of the measurements, between micro-sensors and standard method;**
- **Their performances allow new strategies for air quality control, validation of dispersion models or evaluation of population exposure.**
- **Problems in data collection efficiency of the sensors related to:**
  - **high relative humidity and temperatures;**
  - **intermittent communication failures;**
  - **instability and reactivity caused by interfering gases.**

CONCLUSIONS

- The present data should be complemented with **laboratory results** to determine uncertainties associated to the sensor performance, allowing a better assessment of the **field experiments results**.

- It is necessary to stablish an **evaluation protocol** approaching issues as sensitivity, selectivity (known interference), short and long term stability, parametrized sensor equations, data validation.

- The preliminary evaluation allowed the identification of:
  - Statistical data describing the measurements
  - Specific/common behavior between sensors
  - Relationships with other variables
  - Next steps: complement/update data; building database; validation and evaluation protocol, …

Thank you!

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