Education on atmospheric processes by generation of new data using mobile sensors

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  - Play, technology, discovery, …
- Long-term atmospheric CO2 measurements for science outreach at Mataró Museum
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  - New knowledge shared (we are all peers).
- Air Enquirer: low cost sensors for atmospheric applications
  - Instruments thought for education used to obtain scientific results.
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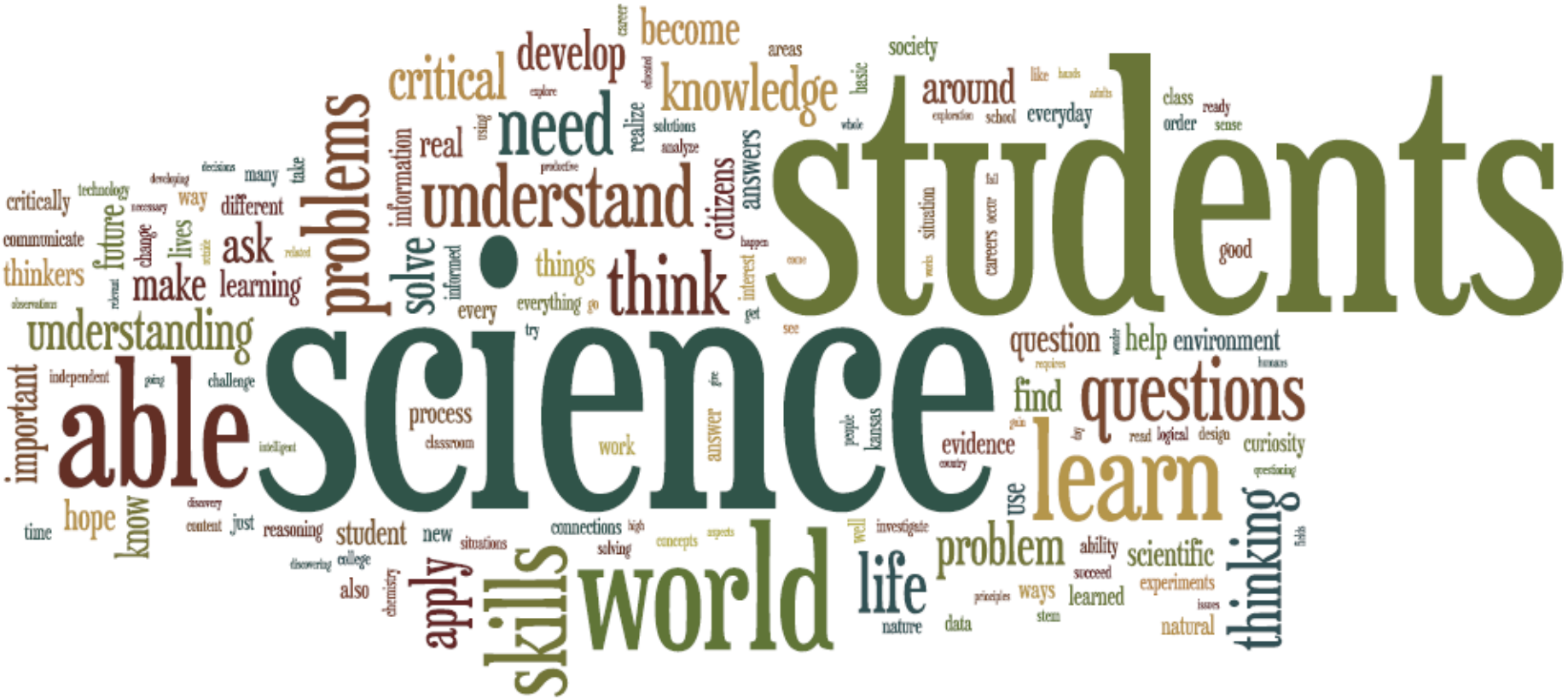
Introduction

To the infinity and beyond.

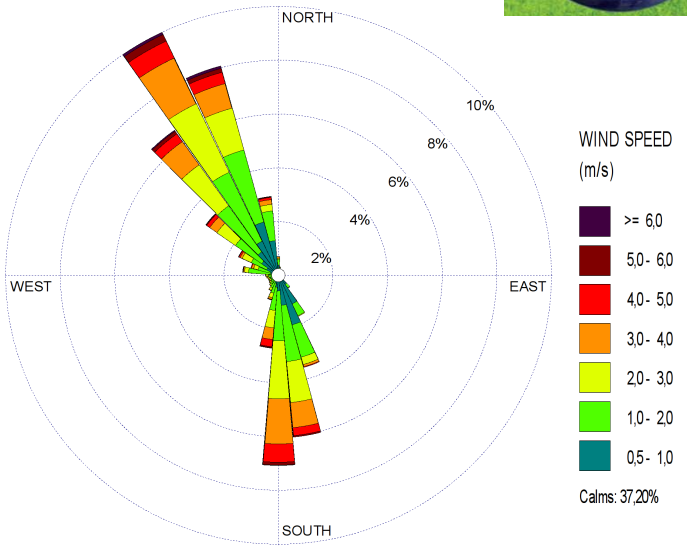
The role of play, technology and discovery.



source: http://community.ksde.org/Default.aspx?tabid=5918

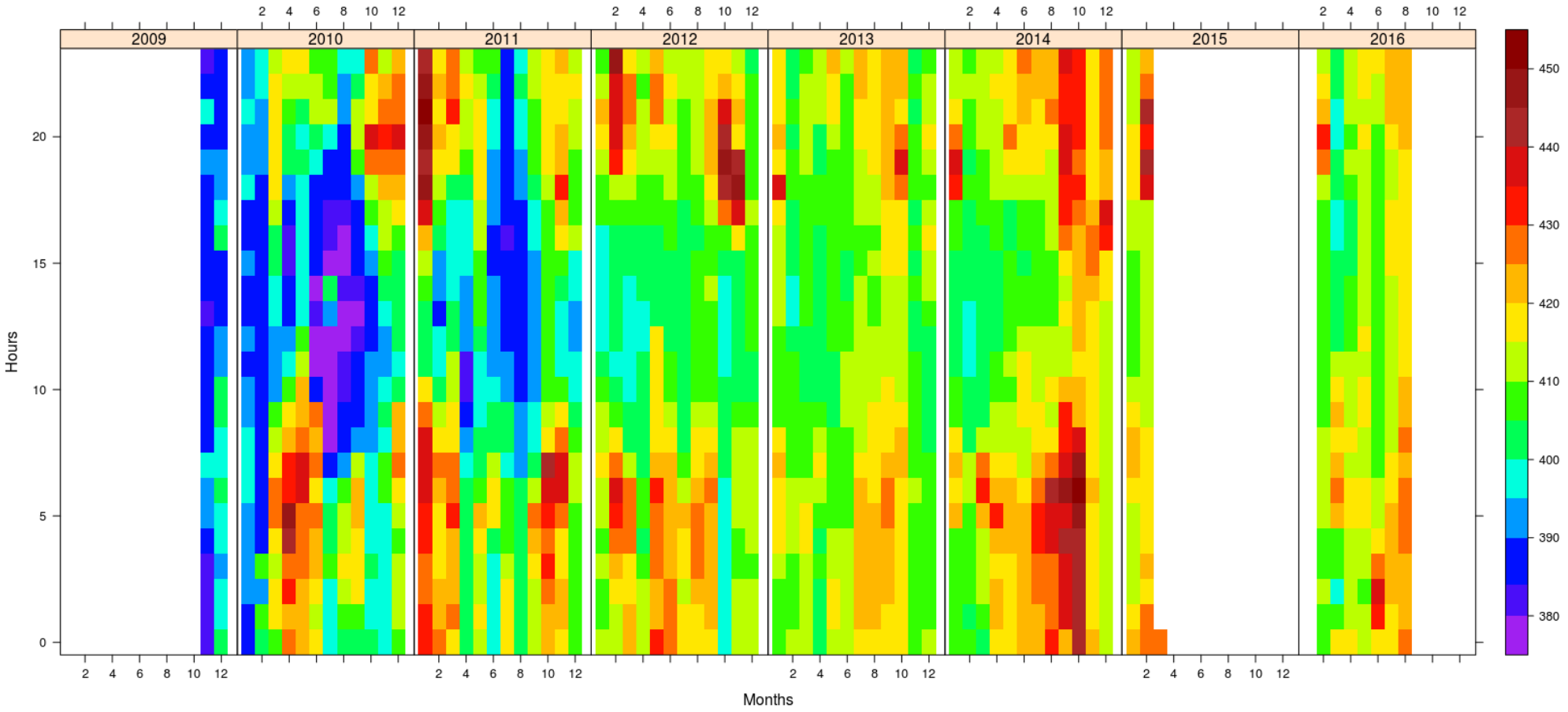
Measurements at Mataró Museum: Citizens under Climate Change

Measurements of temperature, relative humidity, pressure, rain, wind speed and wind direction and CO2 concentration are being taken at the roof of the City of Mataró Museum building since 2009.



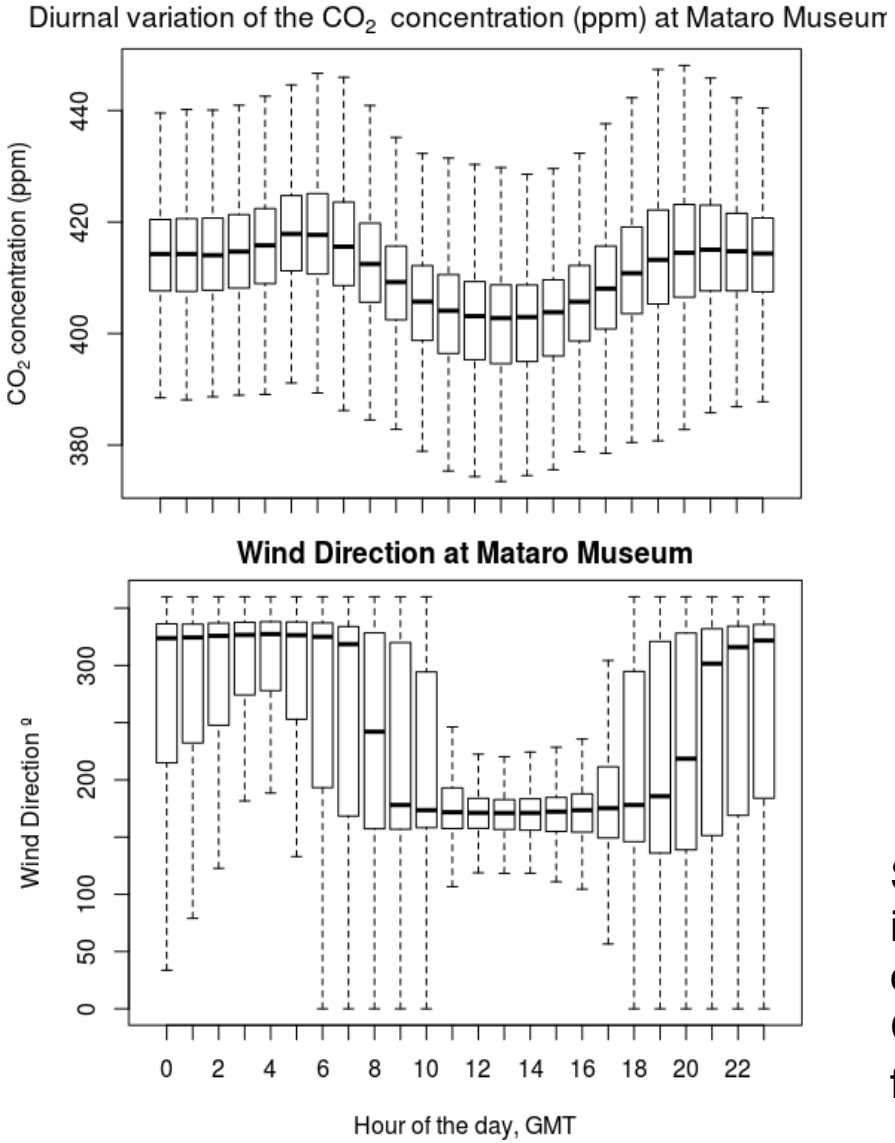
A periodically calibrated Vaisala Carbocap is used for CO_2 measurements. A Davis station is used for obtaining meteorological data.

Measurements of CO_2 at the Mataró Museum's roof shown and discussed in an exhibition at the ground.



CO_2 concentration (ppm) measured at Mataró Museum: the pixel color represents monthly means (along the years, X axis) for each hour time in the daily cycle (Y axis)

Measurements at Mataró Museum

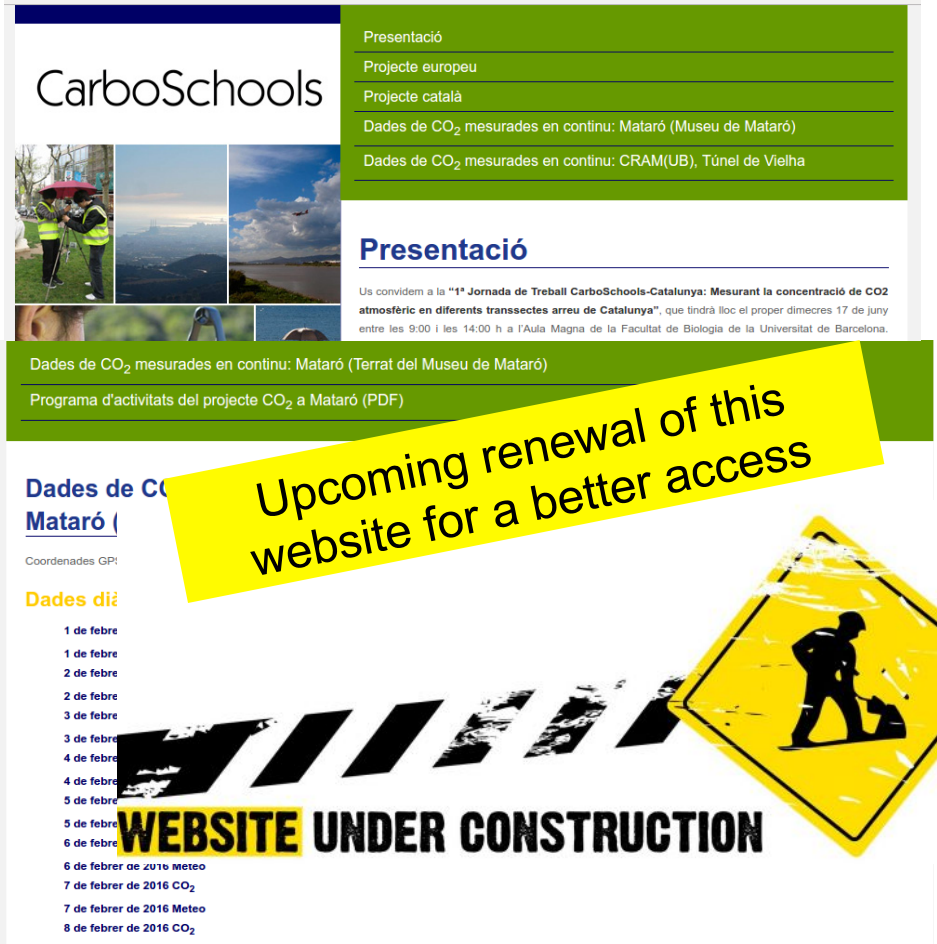


Data obtained are discussed with local students and citizens.

Sources and sinks of anthropogenic emissions, influence of local winds (air-sea breezes) and the overall variability of daily, seasonal and annual CO_2 concentration measurements are accounted for in the discussion of the results.

Measurements at Mataró Museum: Daily data in an open website:

www.carboschools.cat



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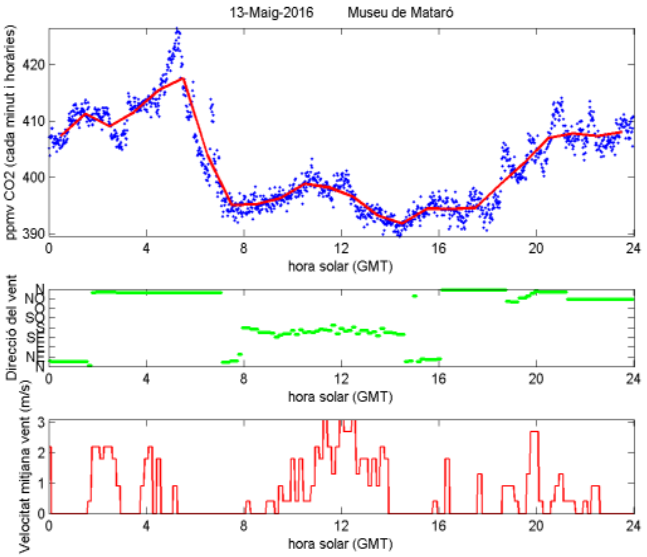
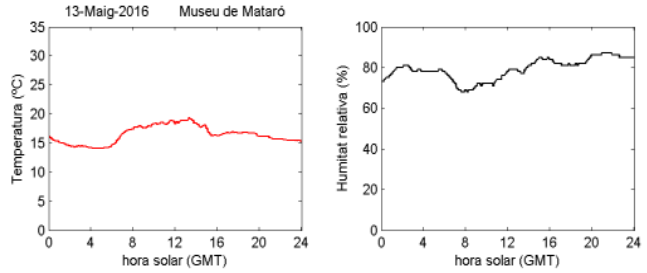
CO_2 i vent



AMPLIAR

Dades meteorològiques

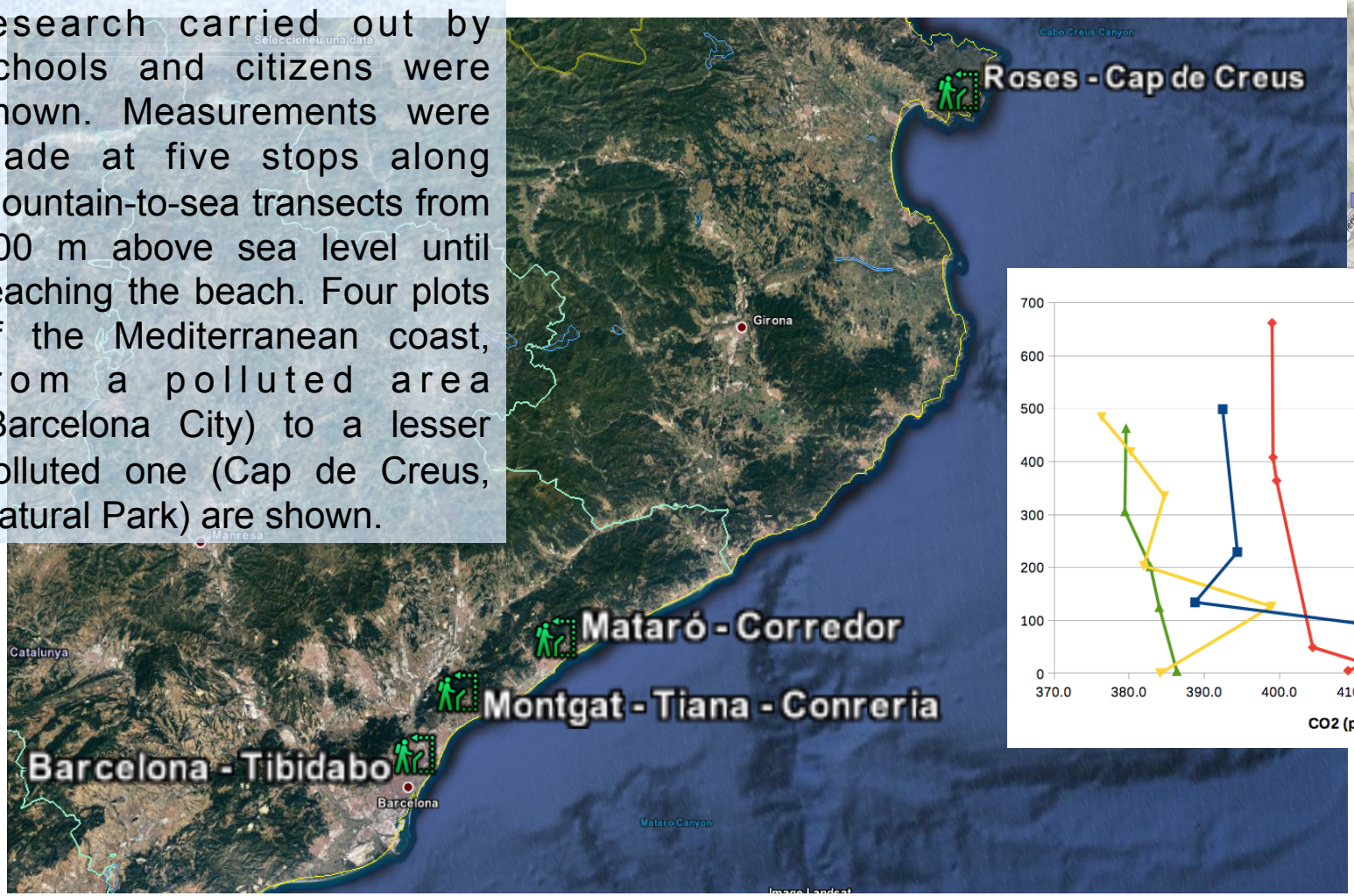


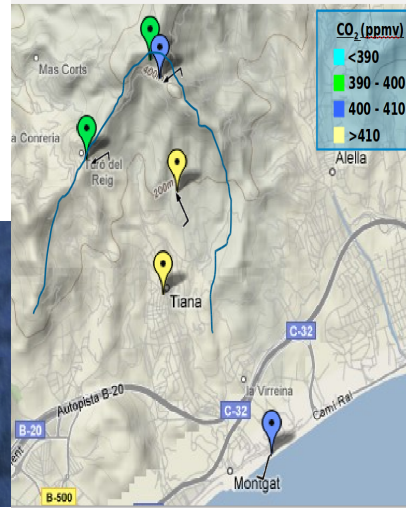
Pupils, Teachers and Scientists Partnership.

Funded by the Carboschools+ European project, activities focused on the atmospheric Carbon Cycle were a proof-of-concept for the Pupils-Teachers-Scientists Partnership. Pupils proposed and chosen the research questions, help was provided by Scientists, Teachers checked the feasibility of the query as for the pupils' skills required. Activities were conducted using CO2 Vaisala Carbocap sensors and portable meteorological instrumentation (Kestrel, Skywatch). All the schools met in a final scientific workshop for the presentation and discussion of results.

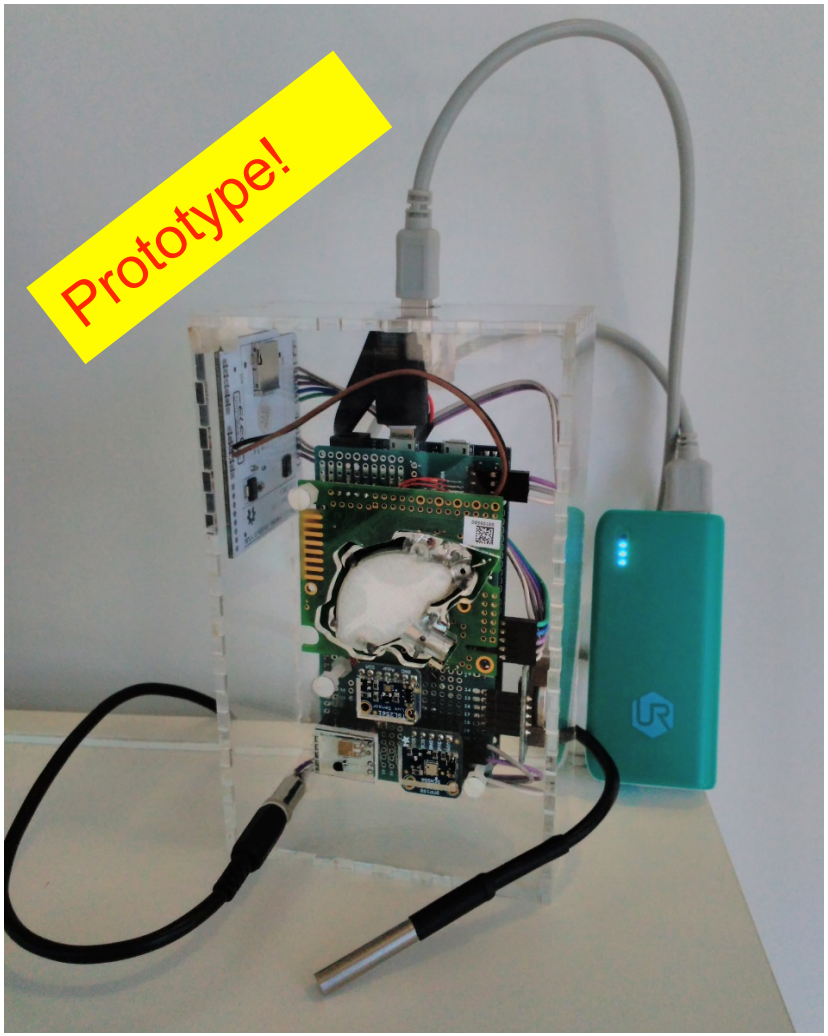
Research activities with pupils, teachers, laymen and scientist

Results from the scientific research carried out by schools and citizens were shown. Measurements were made at five stops along mountain-to-sea transects from 500 m above sea level until reaching the beach. Four plots of the Mediterranean coast, from a polluted area (Barcelona City) to a lesser polluted one (Cap de Creus, Natural Park) are shown.





Air Enquirer:
low cost sensors integrated for atmospheric applications



Sensors

CO_2 Sensor
IR/VIS Light Sensor
Humidity Sensor
Pressure Sensor
Temperature Sensor (PT100)

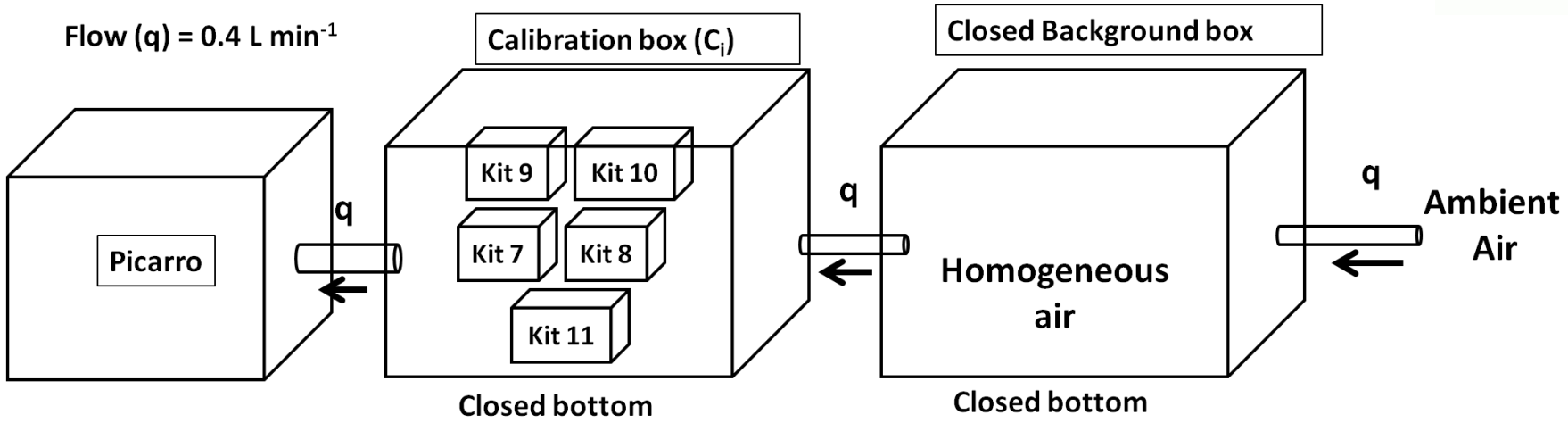
Technical Characteristics

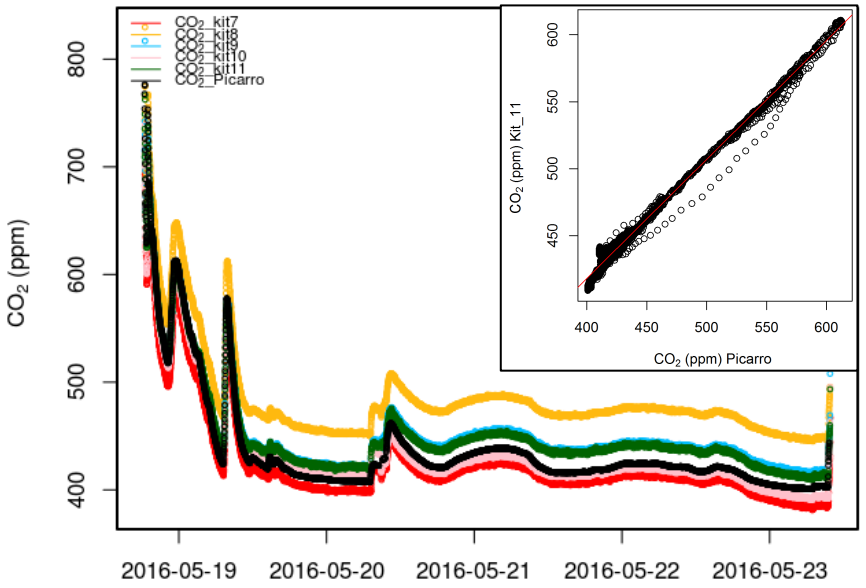
Screen
MicroSD card
Real Time Clock
External Battery
Based on Arduino Technlogy

eduCaixa
Obra Social "la Caixa"

Air Enquirer: calibration

Calibration of the CO_2 sensor of a set of Air-Enquirers.

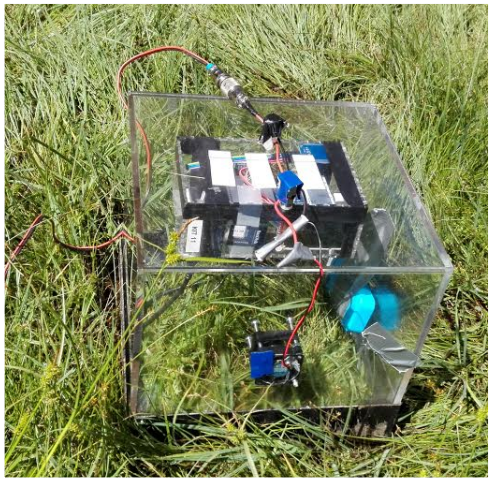


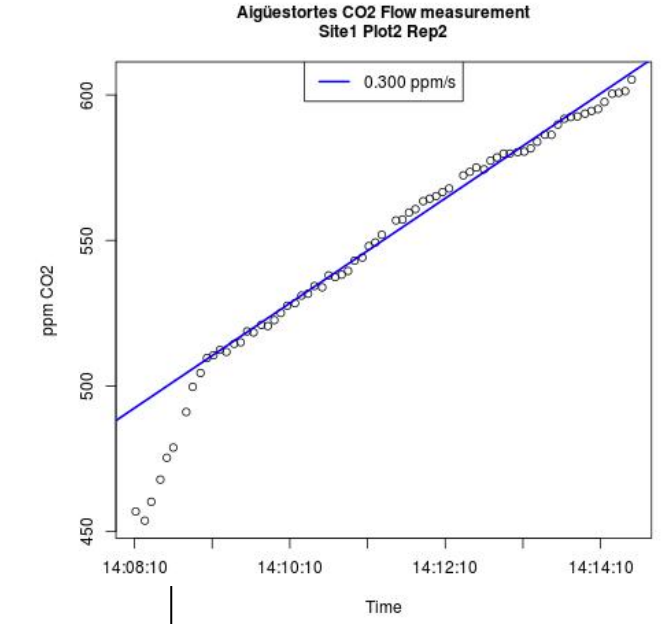


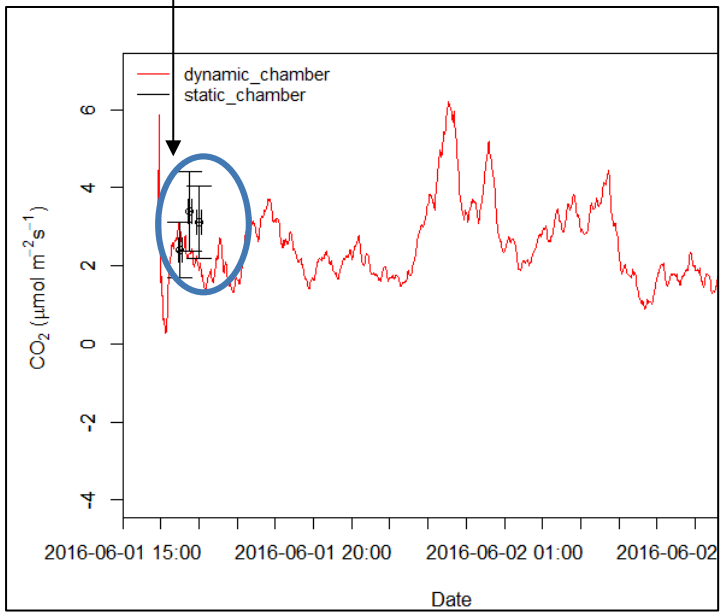
CO_2 measured by the sensor was converted to dry CO_2 (ppm) and fitted with a CRDS system, previously calibrated with WMO standards. A multivariate statistical approach was conducted to minimise environmentally sourced errors. Air-Enquirers with high residual errors were discarded.

Kit	Constant	CO_2 dry (ppm)	Temp. (^{o}C)	Pressure (hPa)	H_2O (ppm)	RSE
7	59.15	1.10	-0.39	-0.08	-0.0006	3.24
8	52.53	1.06	-1.59	-0.08	-0.001	2.68
9	93.22	1.10	-1.15	-0.13	-0.001	2.19
10	49.26	1.09	1.30	-0.14	-0.0005	5.42
11	13.55	1.10	-0.57	-0.05	-0.001	1.99

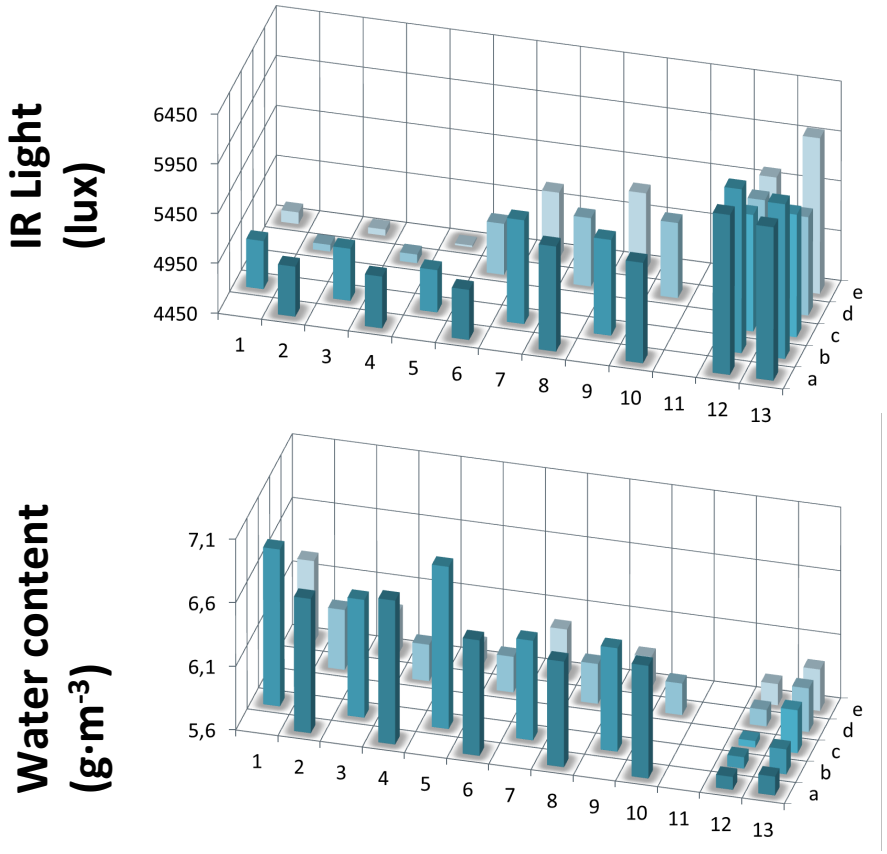
Air Enquirer applications: CO_2 Soil Flux. Closed and Dynamic Chambers





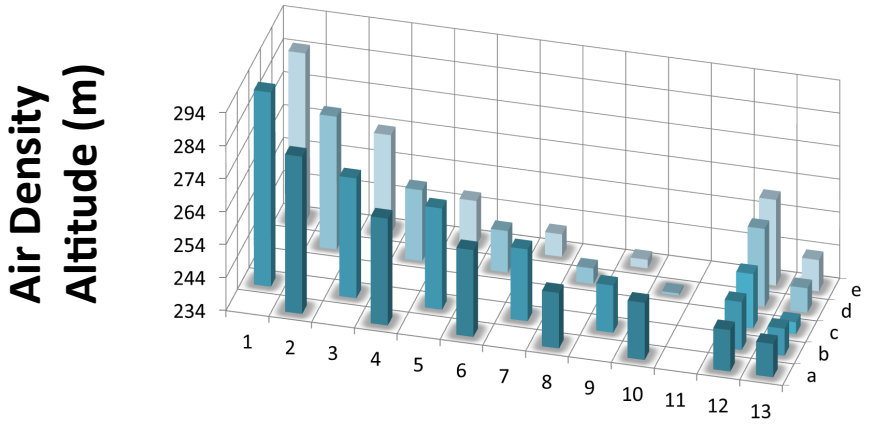


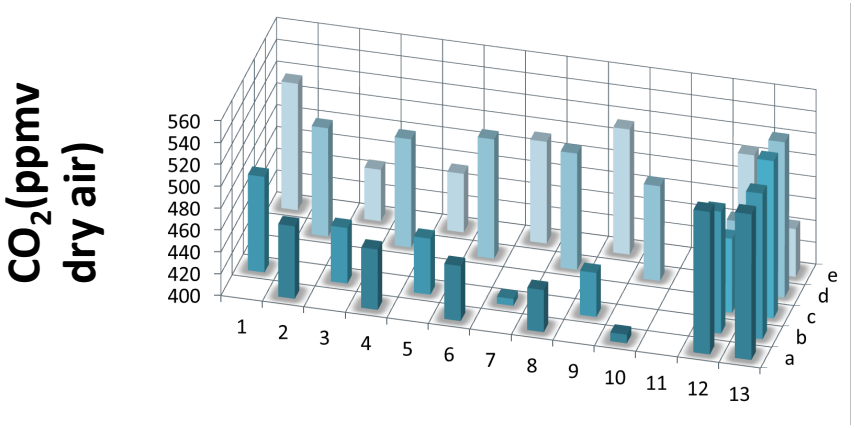
Air Enquirer applications: Atmospheric structure. Vertical gradients and horizontal variability



The Air Enquirer was set up on drones in order to test its capability to detect changes in the lower atmospheric layer physical properties.

Air Enquirer applications: Vertical atmospheric structure

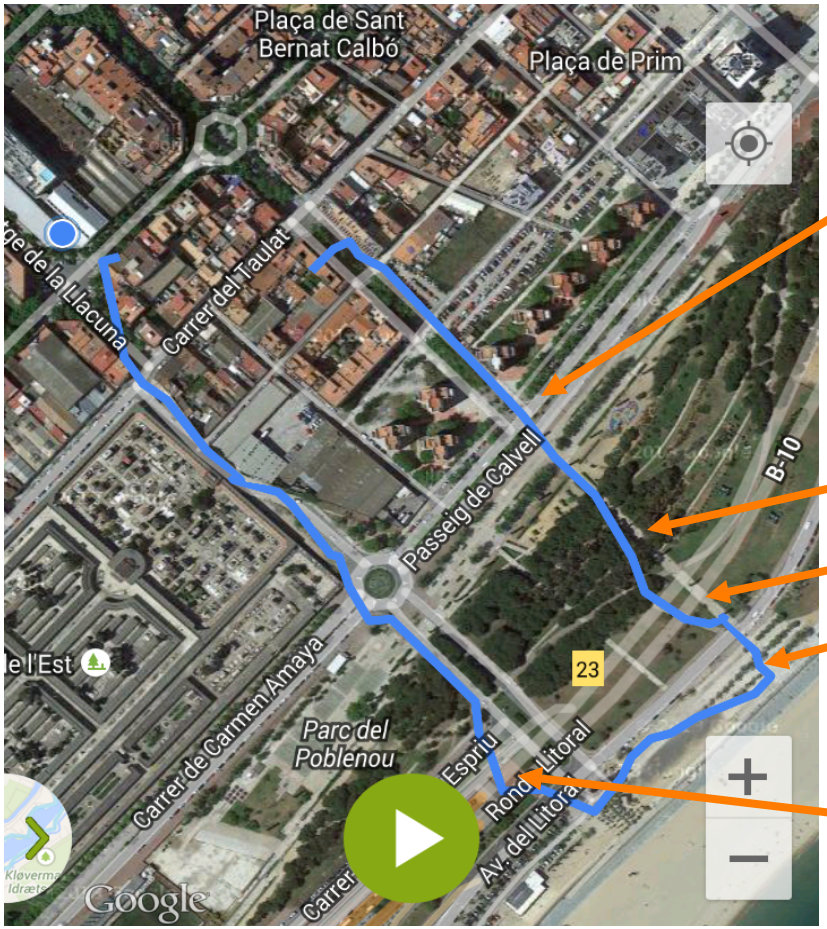




The Air Enquirer was set up on drones in order to test its capability to detect changes in the lower atmospheric layer physical properties.

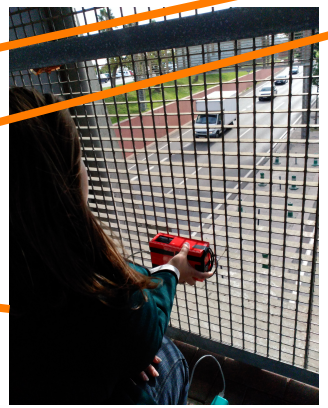
Air Enquirer applications: Urban Metabolism

The Air Enquirer was used to characterize transects reflecting the environmental patchiness of urban areas, including streets, public parks (tree and grass), ring roads and the beach.

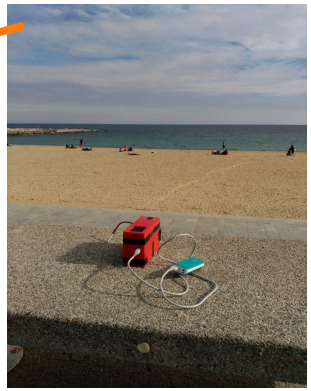


STREET

PARC WITH CANOPY



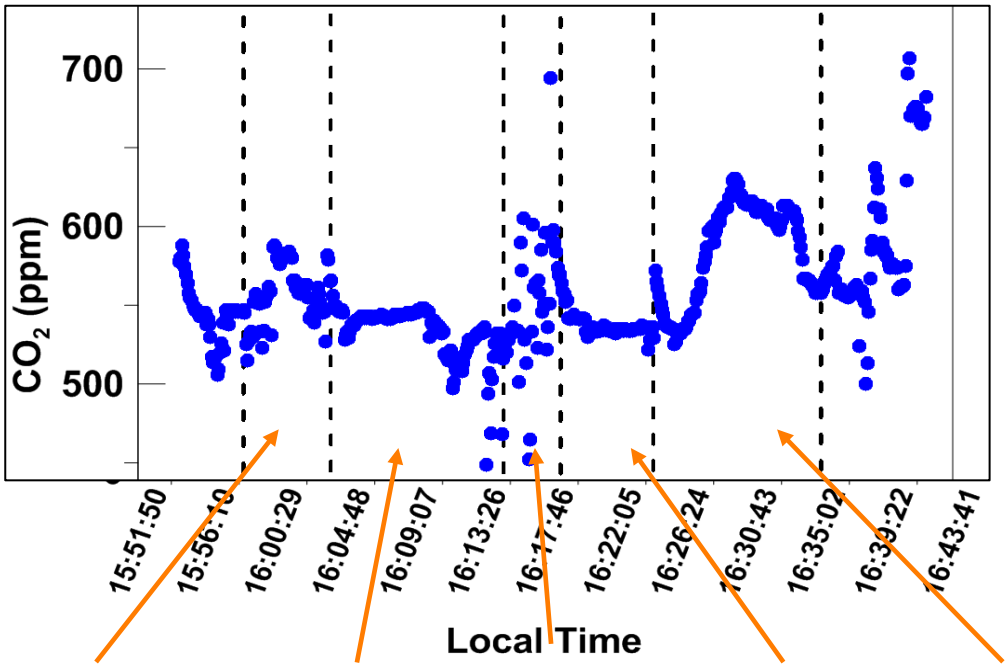
RING ROAD

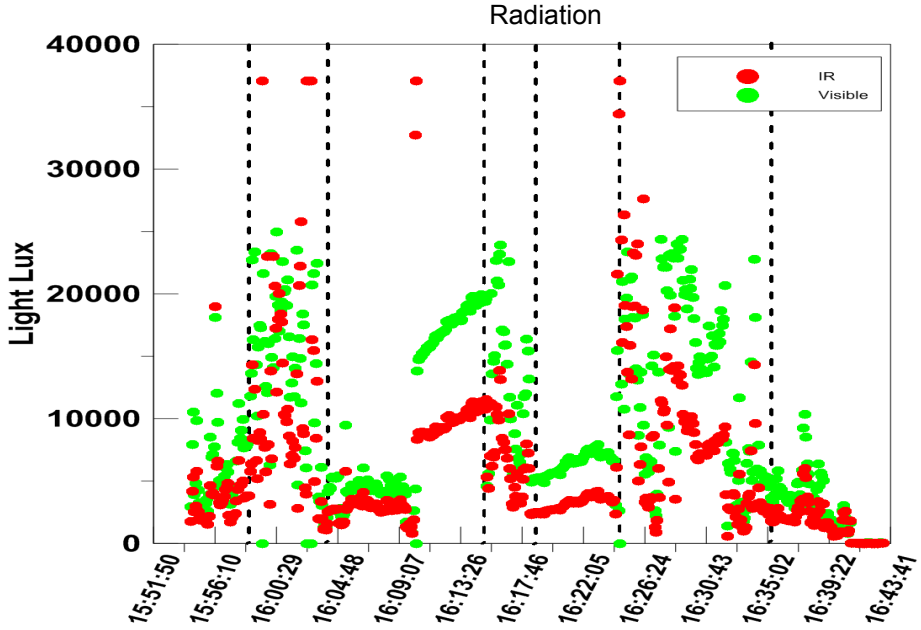


BEACH

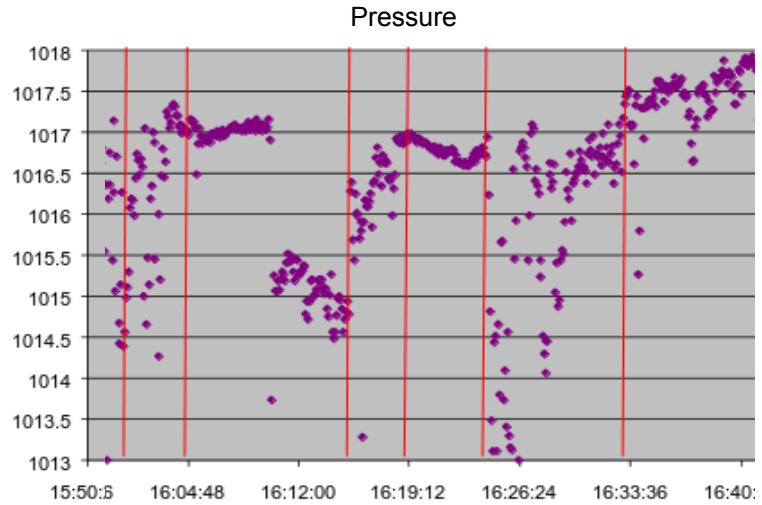
OPEN PARC

Air Enquirer applications: transects and urban metabolism





STREET | PARC WITH CANOPY | OPEN PARC | BEACH | RING ROAD



Conclusions

- The way IC3 approaches to educational science is through ***the generation of new scientific knowledge*** in a **partnership of pupils, teachers and scientists**.

- Since 2009, under international and local educational projects, pupils through this partnership have studied ***the vertical distribution of air masses, the behavior of local winds and the CO_2 emissions in cities, mountains, crops, forest and coastal zones***.

- The use of multiple arrays of a new cheap equipment (**Air Enquirer**) with multiple sensors (**T, %RH, P, Radiation (IR/visible), CO_2**) allows targeting the ***horizontal variability, the vertical structure and the spatial distribution of air parcels*** in relationship with multiple environmental parameters.

- The strategy of **intercalibration** of the “Air Enquirer” sensors improves both the **reproducibility** of the measurements and the **intercomparison** of results between many instruments in different environments.

- **A network of many schools** using the “Air-Enquirers” **enables sharing both results and knowledge** obtained by each one in different environments.

Thanks for your attention

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