Il progetto MIAMI: realizzazione di un campionatore mobile per il particolato atmosferico basato sulle nuove tecnologie IoT.

Giancarlo Della Ventura[a,b], Augusto Marcelli[b], Alessandro Cecili[a] e Fernando Gozzi[a]

[a] Universita' degli Studi di Roma Tre, Dipartimento di Scienze (Italy)
[b] Istituto Nazionale di Fisica Nucleare - Laboratori Nazionali di Frascati (Italy)

Earth atmosphere (source: NASA)

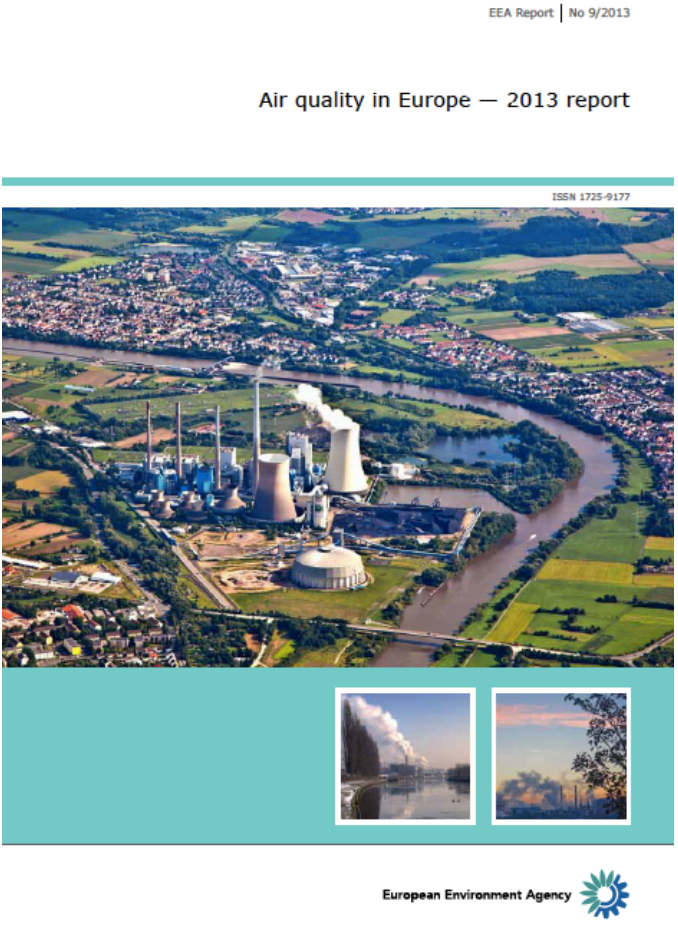
MIAMI: Monitoraggio Inquinamento Atmosferico Montagna Italiana

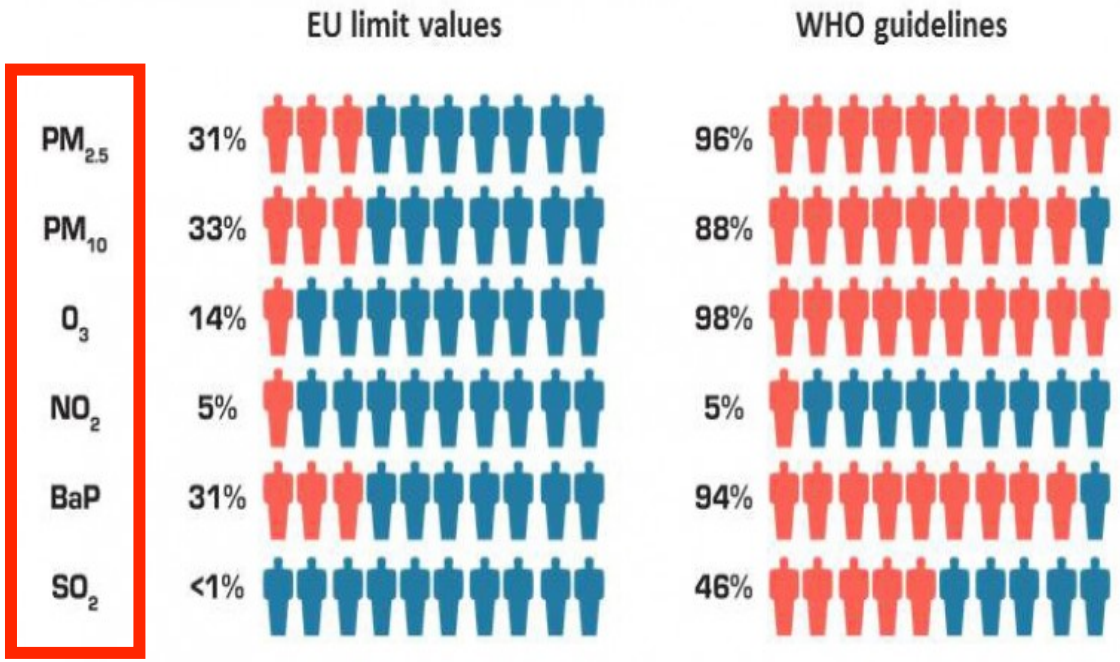
Why? The project is aimed at defining a model for background levels based on the analysis of areas free from anthropogenic pollution

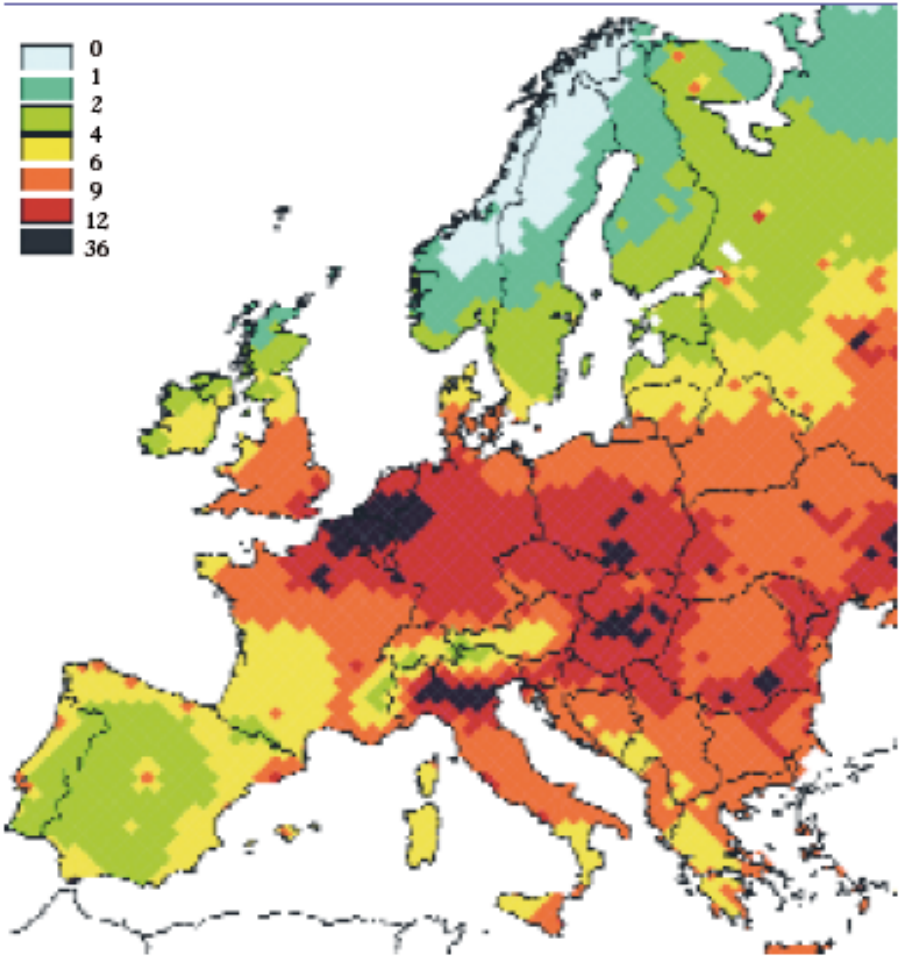
How? By using low-cost mobile devices able to provide (1) real-time and (2) reliable pollutant monitoring and (3) pollutant sampling

The framework of problems we are addressing:

Micro to nanomaterials (including VOCs) present in the environment; these represent a major treat for the human life







Espected reduction of life (in months) due to atmospheric pollution; Data from CAFE (Clean Air For Europe) project

Table 10.1 Premature deaths attributable to $PM_{2.5}$, NO_2 and O_3 exposure in 41 European countries and the EU-28 in 2013

Country	Population	$PM_{2.5}$		NO_2		O_3	
		Annual mean (c)	Premature deaths	Annual mean (c)	Premature deaths	SOMO35 (c)	Premature deaths
Austria	8 451 860	15.7	6 960	19.3	910	5 389	330
Belgium	11 161 642	16.6	10 050	23.6	2 320	2 520	210
Bulgaria	7 284 552	24.1	13 700	16.5	570	4 082	330
Croatia	4 262 140	16.8	4 820	15.8	160	5 989	240
Cyprus	865 878	17.1	450	7.3	< 5	7 900	30
Czech Republic	10 516 125	19.6	12 030	17.1	330	4 266	370
Denmark	5 602 628	9.6	2 890	13.0	60	2 749	110
Estonia	1 320 174	7.8	690	10.8	< 5	2 545	30
Finland	5 426 674	5.9	1 730	9.4	< 5	2 011	80
France	63 697 865	14.5	45 120	18.7	8 230	4 098	1 780
Germany	80 523 746	14.2	73 400	20.4	10 610	3 506	2 500
Greece	11 003 615	19.7	13 730	14.6	1 490	8 532	840
Hungary	9 908 798	18.2	12 890	16.8	390	4 604	460
Ireland	4 591 087	9.2	1 520	11.6	30	2 043	50
Italy	59 685 227	18.2	66 630	24.5	21 040	6 576	3 380
Latvia	2 023 825	12.8	2 080	13.7	110	2 614	60
Lithuania	2 971 905	13.9	3 170	11.5	< 5	2 703	90
Luxembourg	537 039	14.3	280	23.4	80	3 167	10
Malta	421 364	12.5	230	12.0	< 5	7 403	20

Where do these pollutants come from?

Some sources are anthropogenic

But most are natural

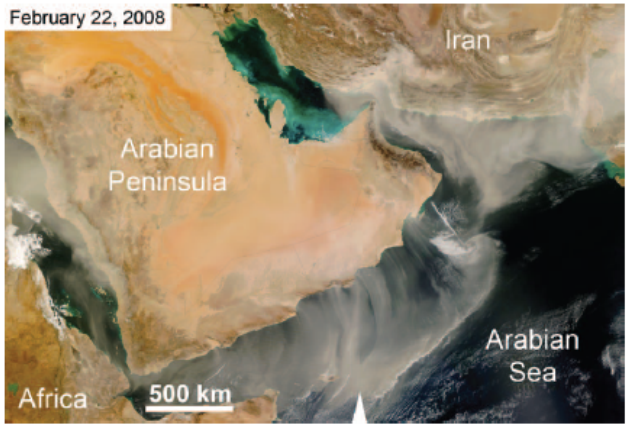


FIGURE 3 Satellite image of a dust storm, generated by north-westerly *shamal* winds, extending from the horn of Africa to India. Visible dust sheets blow from the Arabian Peninsula, as well as from Iran and Pakistan (top right). Dust streamers extend across the waters of the Red Sea (left), Persian Gulf (centre) and Arabian Sea. SATELLITE IMAGE COURTESY OF NASA

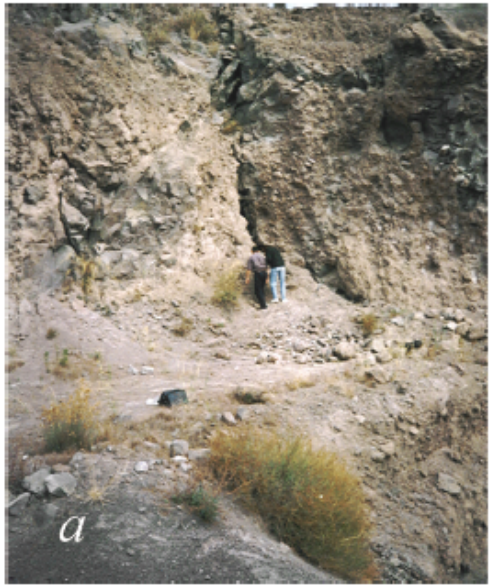


FIGURE 6 Dust cloud enveloping Riyadh, Saudi Arabia (March 10, 2009). AFP/GETTY IMAGES

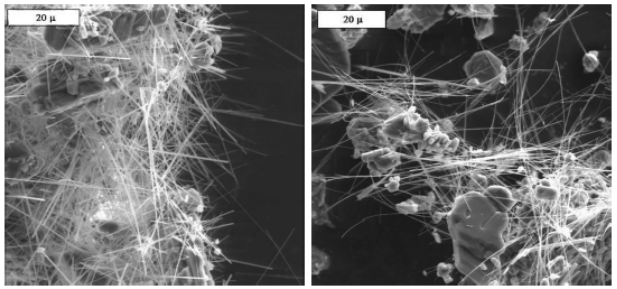


Fig. 3 – SEM photographs of two examples of fibrous amphiboles from Biancavilla: sample 3 (left), and sample 4 (right). The other associated minerals prevalently are alkali-feldspars, clinopyroxenes, fluorapatite and Fe-Ti oxides.

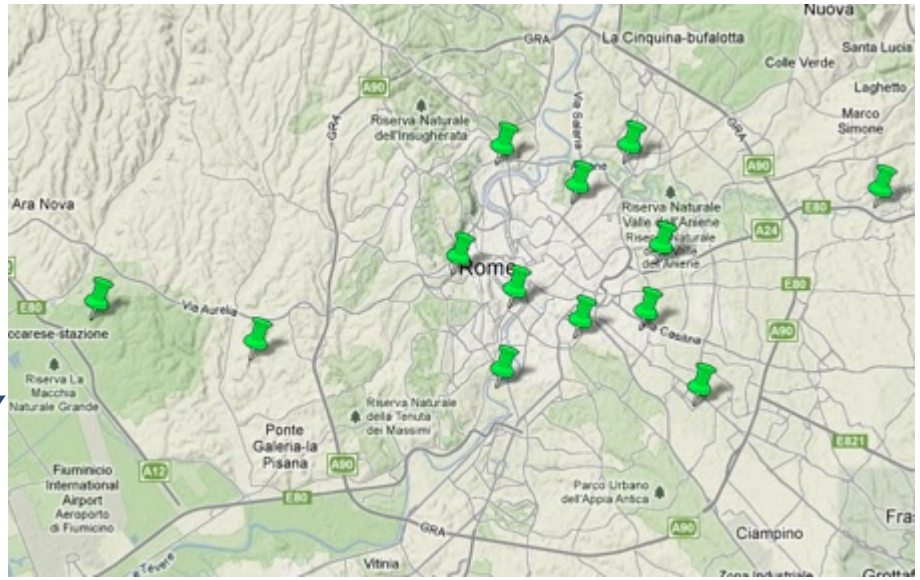
PM monitoring

PM is typically monitored at fixed stations using HVS

Fixed stations are expensive, large, and sparsely deployed

Air quality networks comprise a few number of fixed stations

Each station is representative of a large area



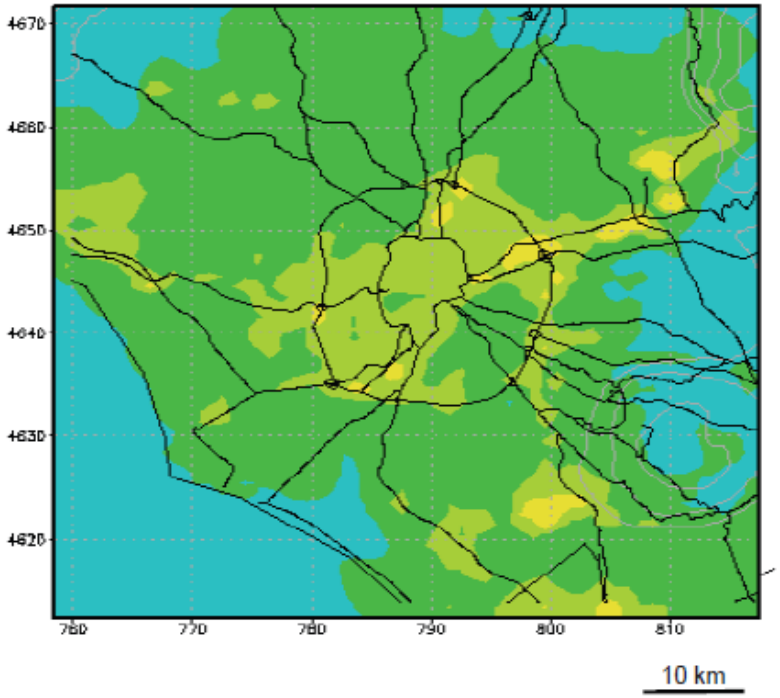
ROME AIR QUALITY NETWORK

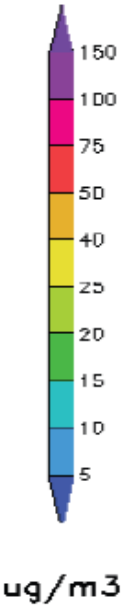
The evolution: Mobile monitoring of PM

PM show considerable spatial variability (in space and time) in urban areas

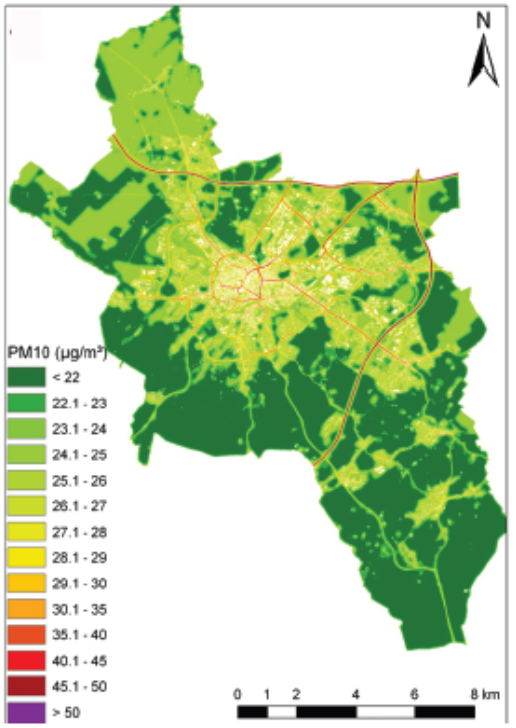
Network of fixed stations cannot reproduce this variability

Mobile monitoring is required to increase spatial resolution and improve PM maps/forecast models





Source: ARPA LAZIO



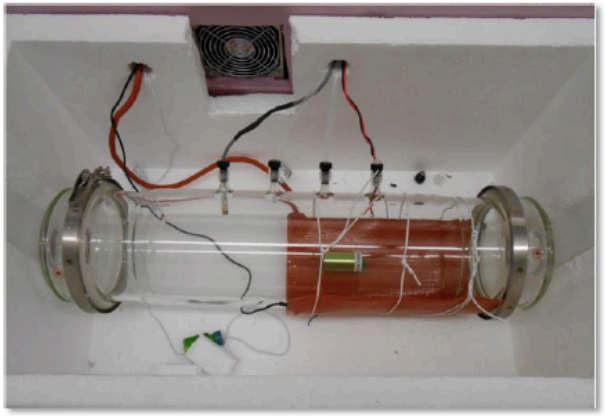
Source: Merbitz et al., 2012

Indoor pollution

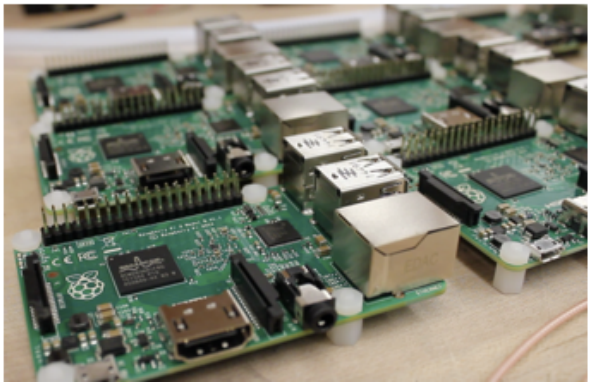
A possible solution:

Low Cost Sensors

- ***Pros:*** Low cost allows for different applications than traditional monitors
- ***Cons:*** Without testing, questions about data quality, reproducibility, etc.
- Lots of current research on low cost sensors:
  - Calibration
  - Interferences
  - Drift
  - Reproducibility



Typical sensor testing setup, EPA ORD



Low-cost sensors

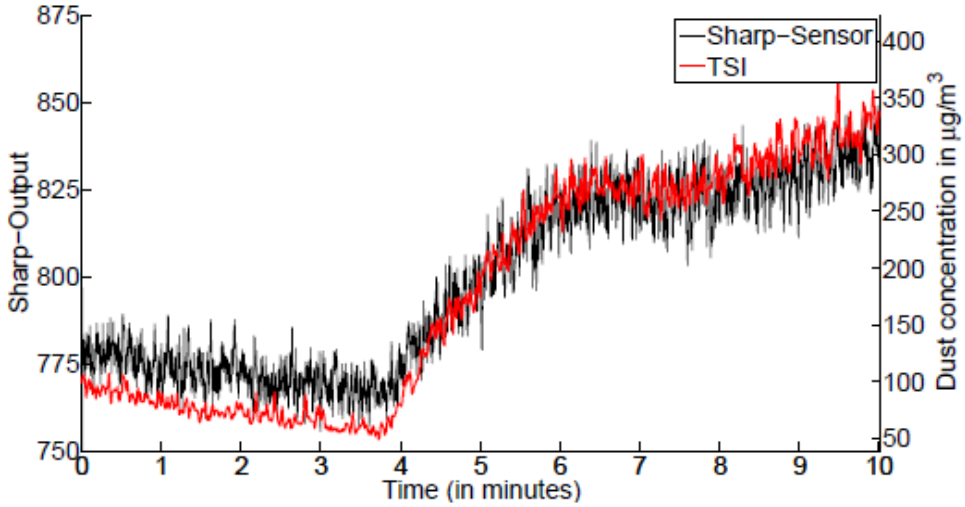
PROS: low-cost, easy to use, small dimension, low power demand, large scale distribution, participatory monitoring

CONS: low accuracy and stability, high noise, only TSP

Low accuracy can be improved by appropriate calibration

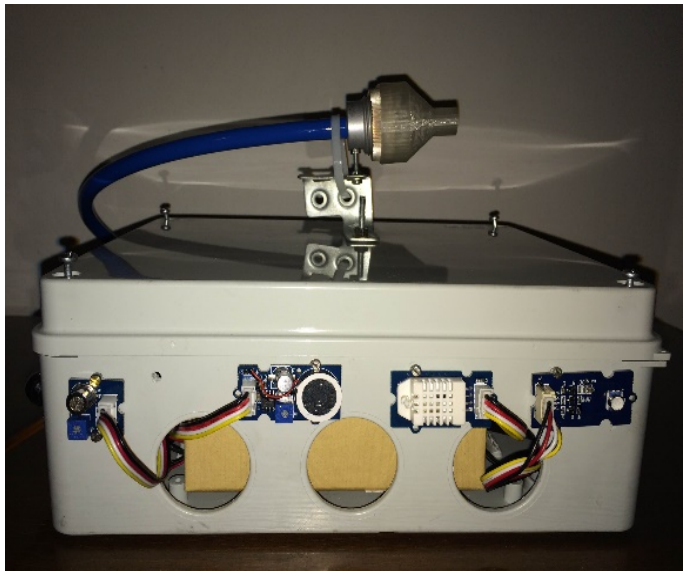
Sharp GP2Y1010

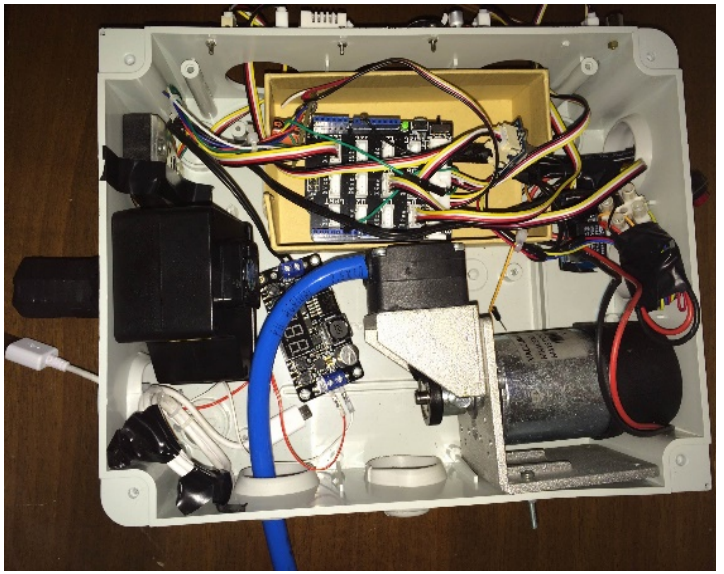
SYhitech DSM501



Budde et al. 2013

SPARCO: Sensor for PArticulate COllection and analysis





Sparco is equipped with:

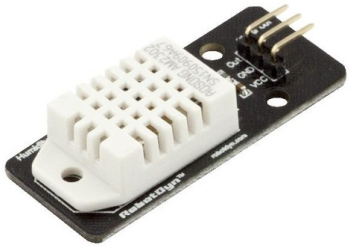
Alphasense OPC-N2: optical particle counter for PM10, PM2.5 and PM1

Sharp GP2Y1010 TSP collector

Environmental sensors for T, Rh

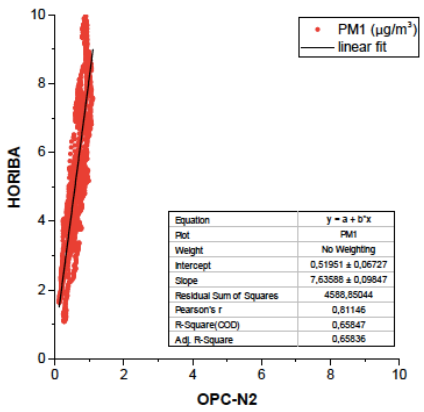
Gas: VOCs and CO_2

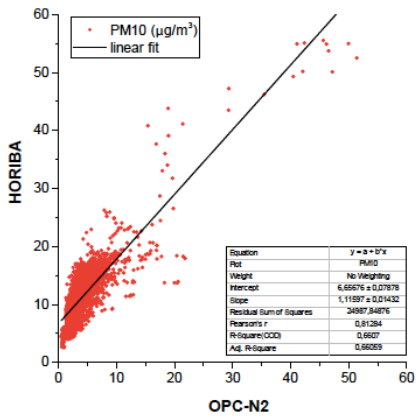
GPS positioning



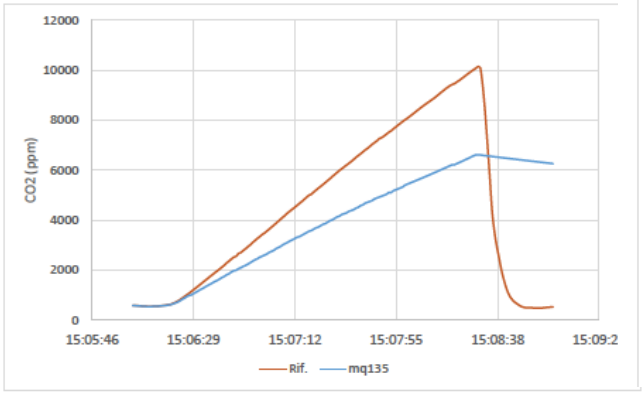
All sensors are handled via a Arduino platform and data are real-time transferred to PC or mobile media (smartphones, tablets) to be analysed and visualized using GIS applications

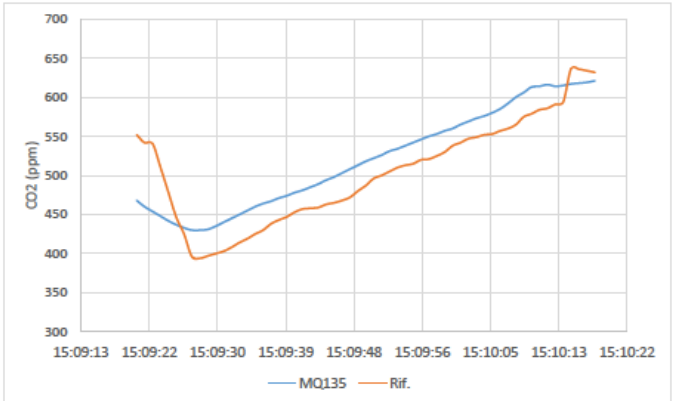
Sensors calibration: PM (thanks to Certema, GR)



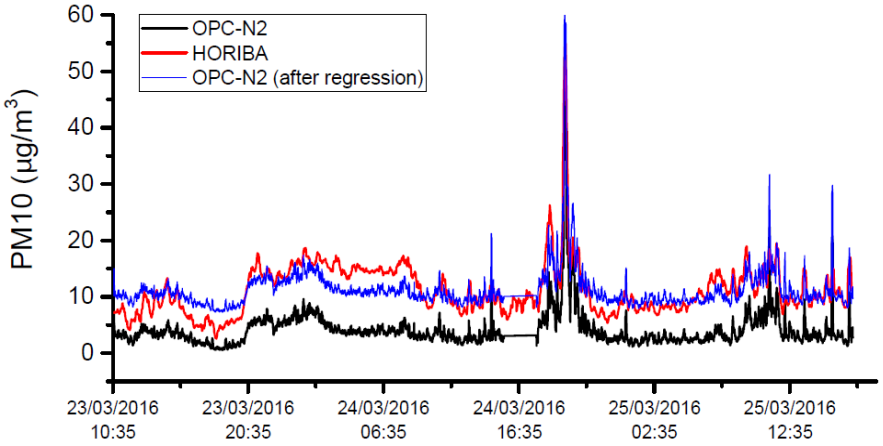


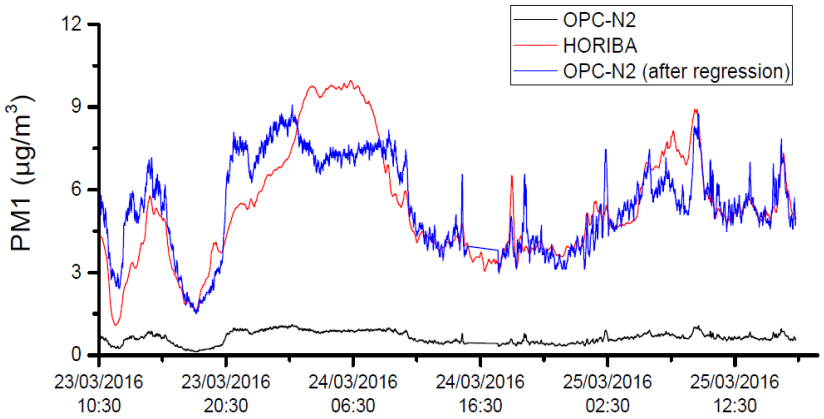
Sensors calibration: CO2

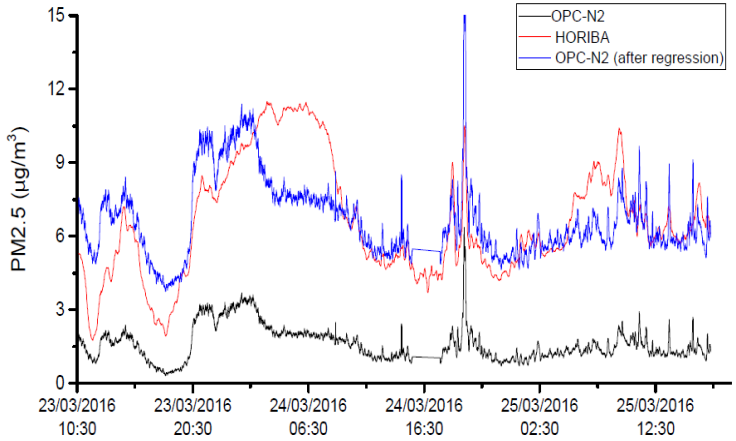




Sensors calibration: PM

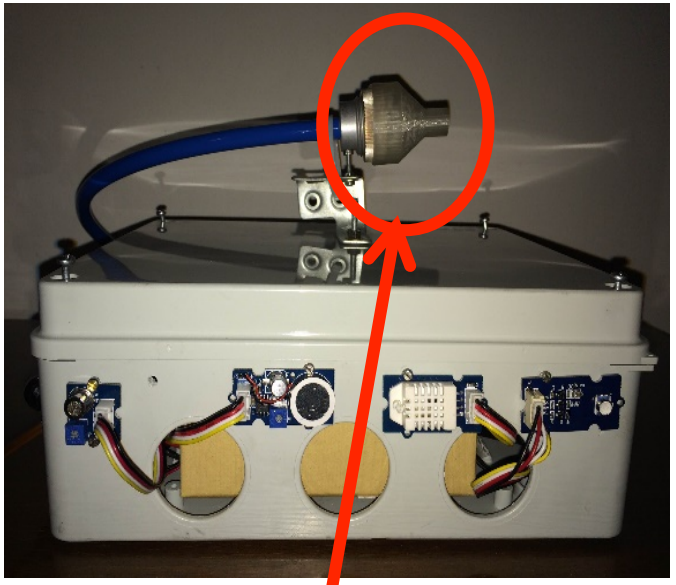


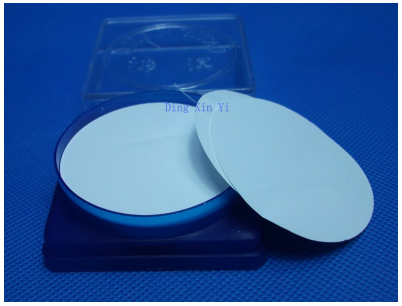




We want to know how much, but especially what: PM sampling

Micropumping system





Polycarbonate filters

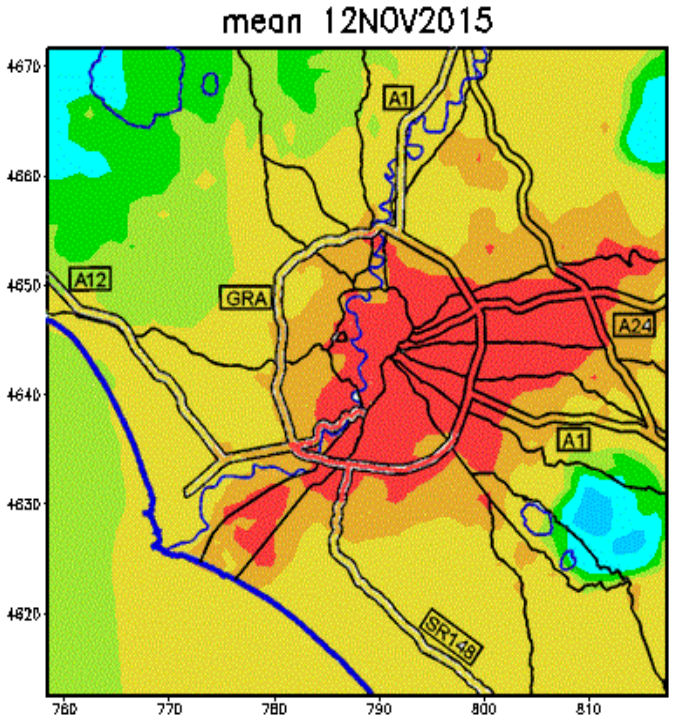
SEM

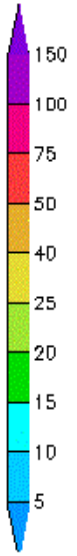
FTIR

Raman

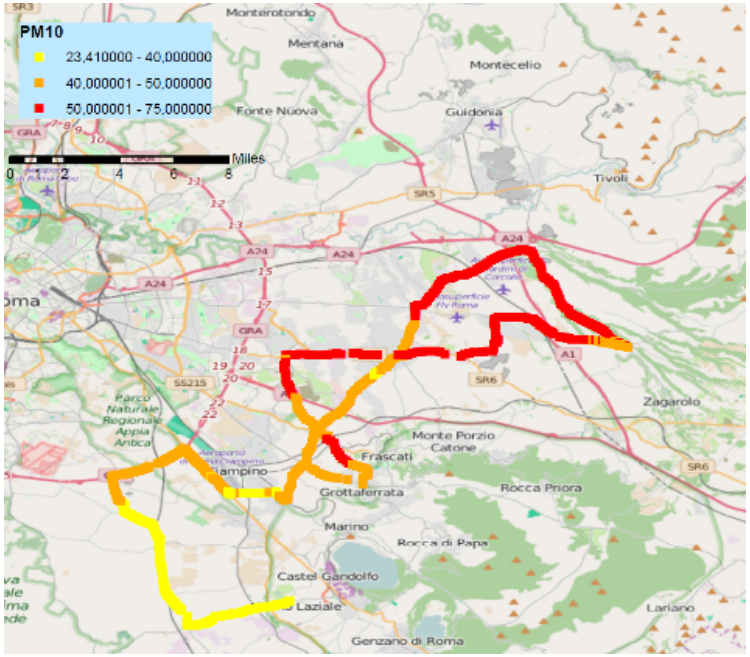
AIR

SPARCO: test on Colli Albani metropolitan area





ug/m3



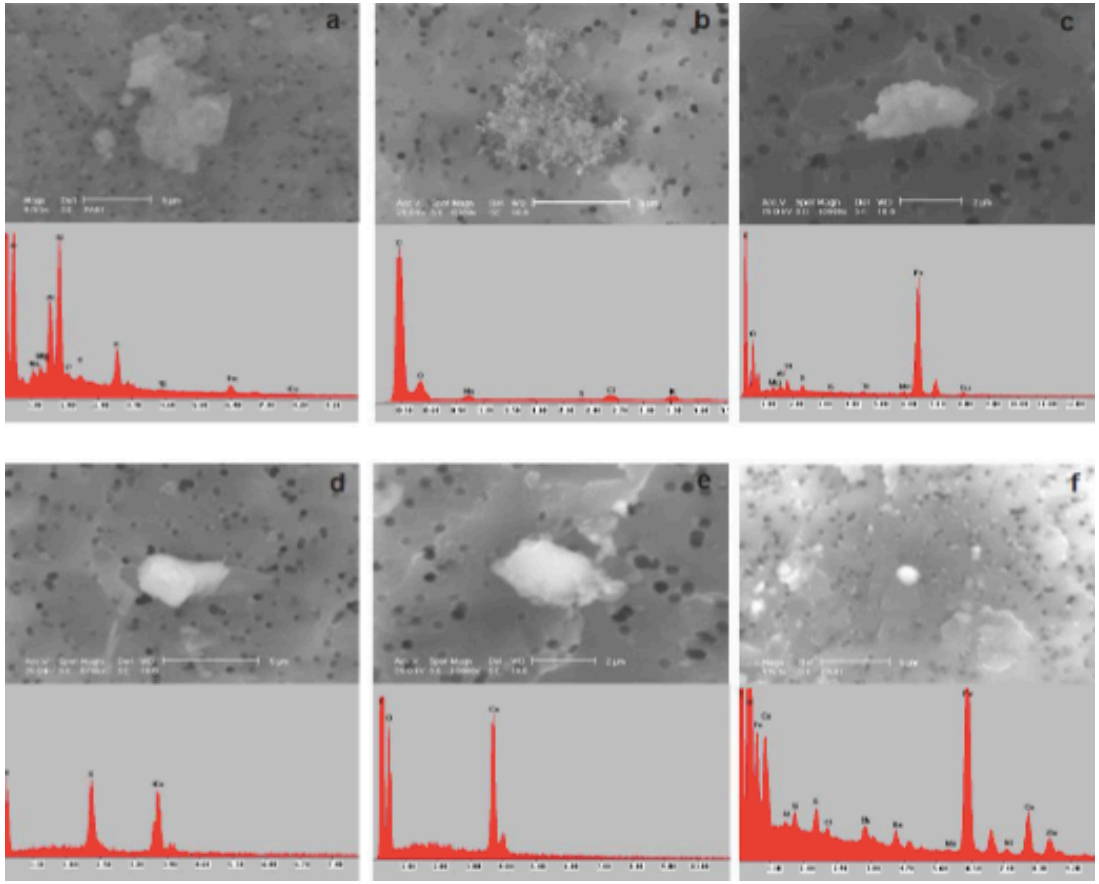
SPARCO: test on Colli Albani metropolitan area

PM1

PM2.5

PM10

SPARCO: SEM analyses

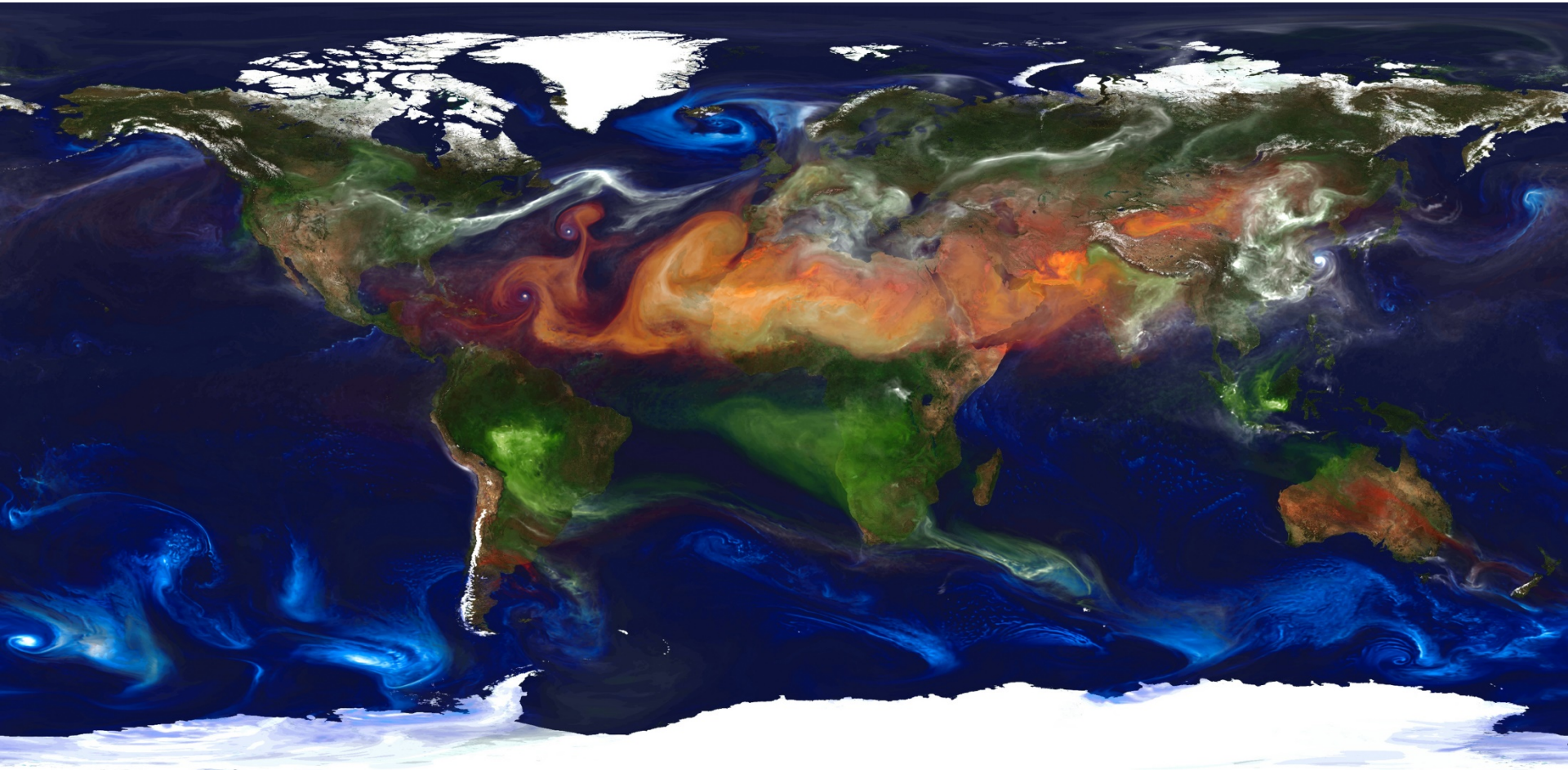


Perspectives

The next generation of mobile air quality devices will have to answer to several issues, e.g.:

- Improvement of spatial and temporal resolution
- Time-resolved chemical characterization of PM with mobile devices
- Participatory approach to air quality monitoring

THANK FOR YOUR ATTENTION



NASA – GEOS-5