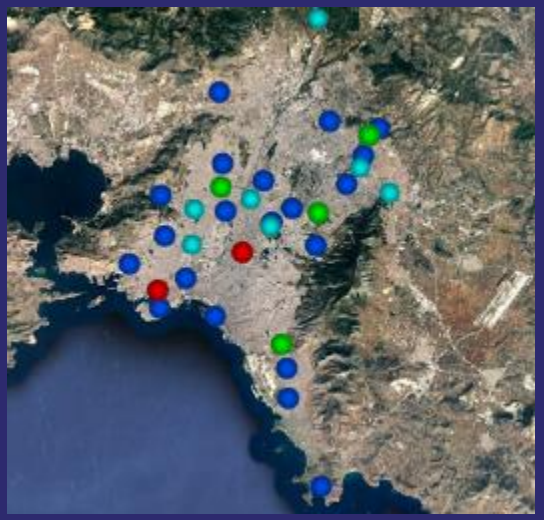
e-shape

EuroGEO Showcases: Applications Powered by Europe



Air quality monitoring through sensor-based networks in large metropolitan areas: The case of Athens, Greece

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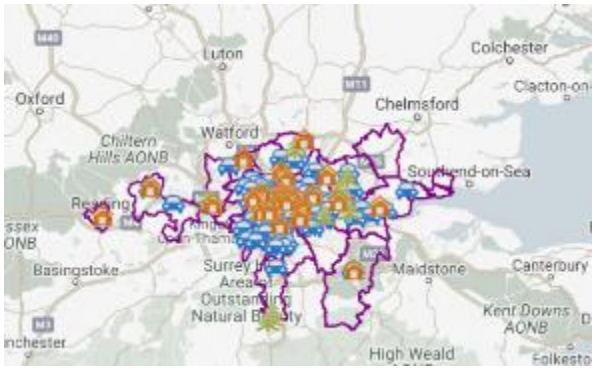
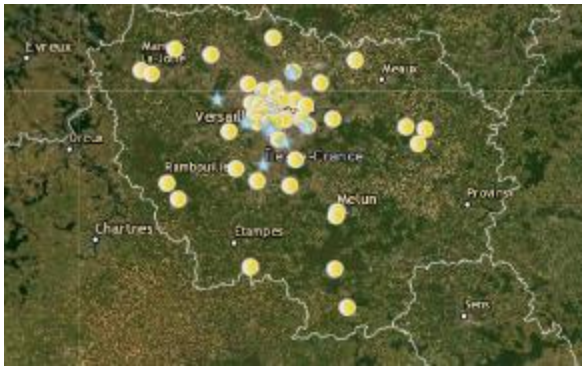
Dense Air Quality Monitoring Networks in major European cities

London Air



No. of stations: ≈ **120**

AIRPARIF



No. of stations: ≈ **70**

ARPA LOMBARDIA
Agenzia Regionale per la Protezione dell'Ambiente

No. of stations: ≈ **50**

Calidad del aire
Comunidad de Madrid

No. of stations: ≈ **50**

A less dense Air Quality Monitoring Network in a major European City

GREATER AREA OF ATHENS (GAA)

Population: 3.6 mil. (2019 – Eurostat)

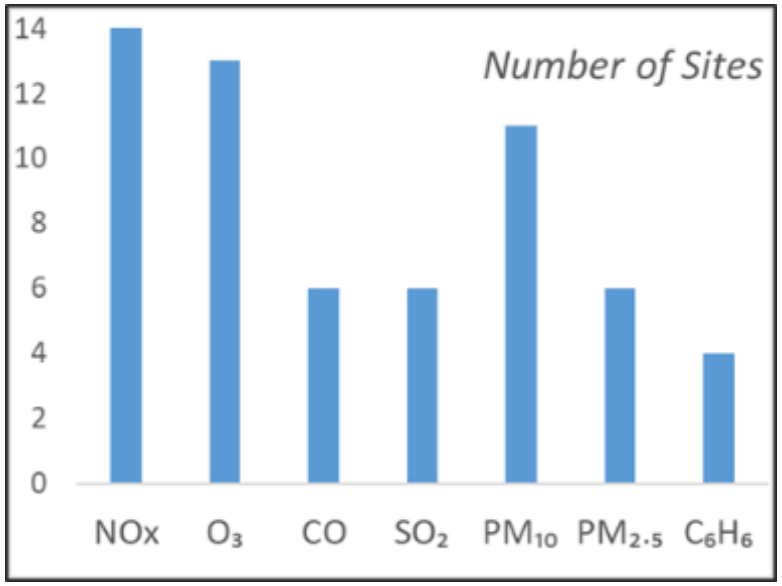
Area: 412 km^2 (Athens Basin)

Regional Units: 8

Municipalities: 56

Population Range: 18-664k *(by municipality)*

Density Range: 0.1-21.2 k/km2 *(by municipality)*



Population of agglomeration or zone (thousands)	If maximum concentrations exceed the upper assessment threshold (1)	
	Pollutants except PM	PM (2) (sum of PM_{10} and $PM_{2,5}$)
0-249	1	2
250-499	2	3
500-749	2	3
750-999	3	4
1 000-1 499	4	6
1 500-1 999	5	7
2 000-2 749	6	8
2 750-3 749	7	10
3 750-4 749	8	11
4 750-5 999	9	13
≥ 6 000	10	15

Local factors exacerbating common European AQ issues

Wintertime "smog" due to residential wood-burning

- *Research studies feature Athens as the biomass-burning capital of the EU*
- *Extreme short-term levels for $PM_{2.5}$ (>200 μgm^{-3}, hourly), with high contributions of organic compounds and black carbon*

Summertime photochemical smog

- *High ozone levels with frequent exceedances of alert and information thresholds*
- *The majority of urban background sites in the GAA each year breach the annual EU target-value*

Aging vehicle fleet – Surge of diesel-powered cars

- *A ban on private diesel cars ended in 2011, and they have since dominated new and used-car sales*
- *Greece has one of the most aged vehicle fleets in the EU (4^{th} most aged for private cars, 1^{st} most aged for trucks)*
- *Persistent AQ-standard violations for NO_2, PM_{10} at traffic sites*

Shipping emissions

- *Piraeus in the GAA is the busiest European passenger port and the 2^{nd} most busy port in the Mediterranean*

Episodic air quality events aggravate short-term exposure

Wildfire smoke impacting the urban area

- *The GAA has been affected by emissions from a wildfire event almost every summer since 2017*
- *The impact of the August 2021 wildfire lasted for over a week and led to extreme short-term $PM_{2.5}$ levels (>300 μgm^{-3})*

Industrial accidents emitting hazardous pollutants

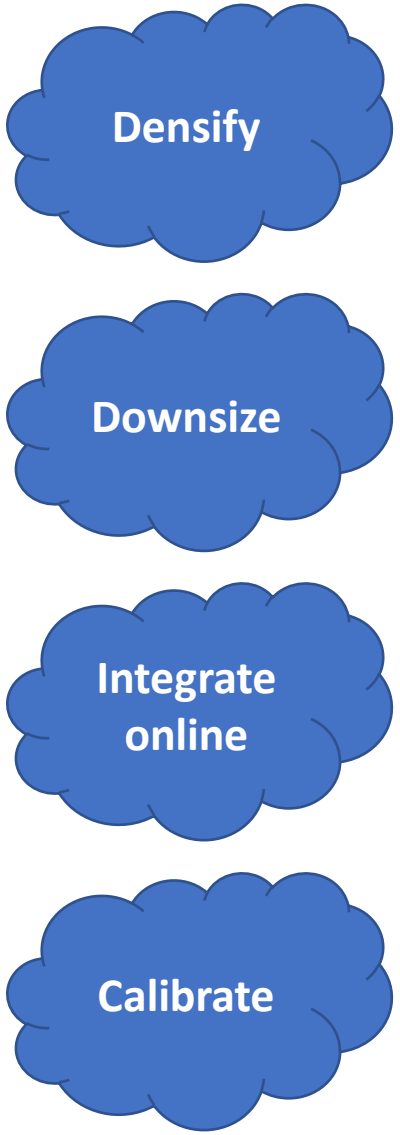
- *In the recent years (2016-2020), there have been two large scale industrial accidents in plastic-recycling plants of the GAA*
- *Atmospheric dispersion carried the plumes over the Athens basin, leading to excessive PM levels, characterized by high BC contribution*

African dust intrusions

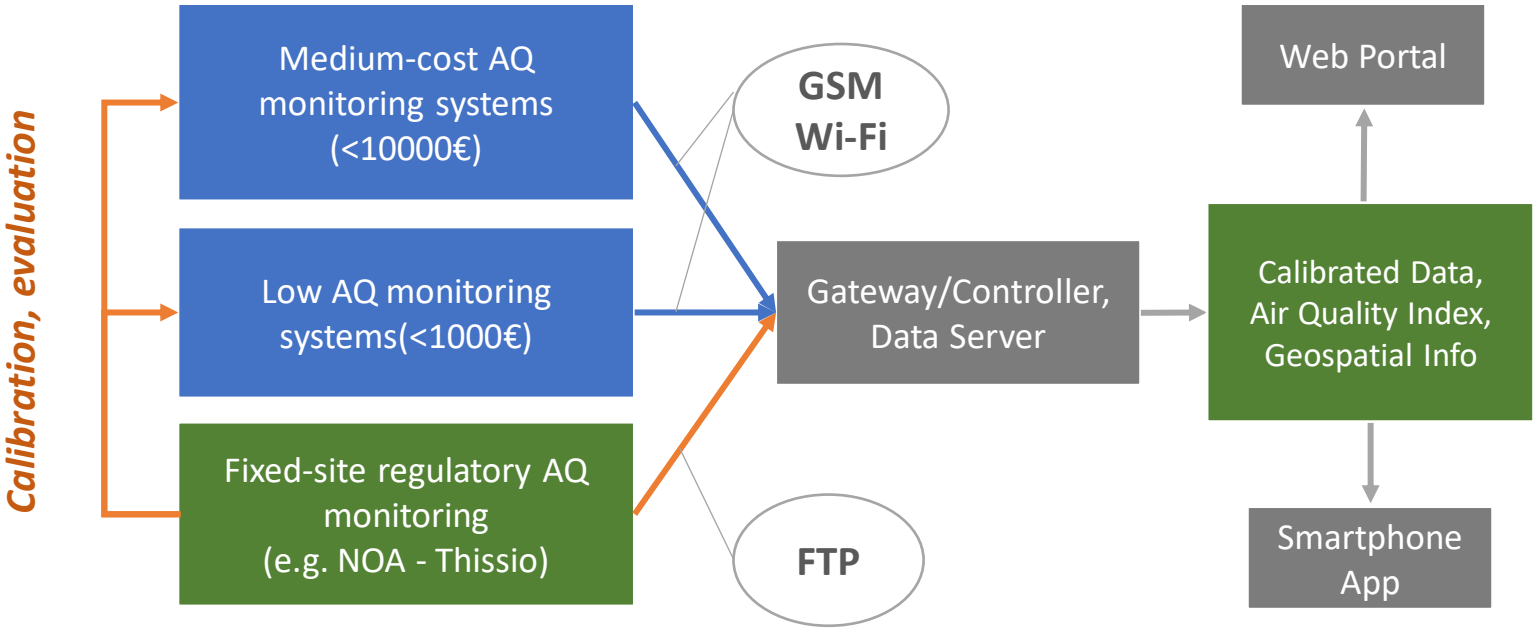
- *Dust events due to Saharan dust transport are very common in Southern Greece, especially during spring, leading to extreme PM_{10} levels and also aggravating short-term $PM_{2.5}$ exposure*

Identifying the special needs for AQ monitoring in metro areas

- Large exposed populations necessitate spatially representative measurements, to capture within-area variability and reduce exposure misclassification error
- Large areas mean that atmospheric dynamics can induce substantial intra-urban variability
- The heterogeneous urban landscape and source mixture dictate measurement at different site types
- Multiple stakeholders at different levels (governmental, regional, municipal, private sector) have different AQ management priorities and require solutions for local issues
- Large investments required to expand regulatory network
- Episodic events but also increased urban mobility call for near-real time information
- Need for IoT integration and personalized exposure information (online platforms, smartphone apps, etc.)
- ***While sensor-based solution will not substitute regulatory AQ monitoring stations for compliance assessment, it is imperative to calibrate their outputs for reliable results***



Designing an integrated AQ monitoring network in Athens



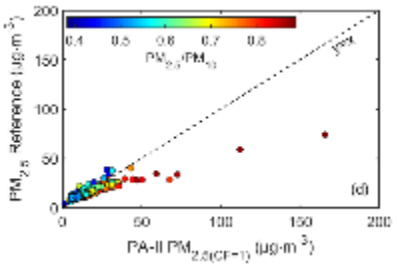
- Design and implementation of an integrated IoT network and data-visualization platform
- Products and services to inform and protect the public from excessive exposure
- Incorporation of other available monitoring networks providing calibrated data

Sensor-based monitoring instruments used by NOA in Athens

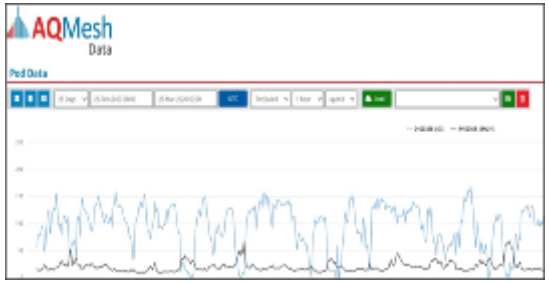
Low-cost system for $PM_{2.5}$ monitoring

PurpleAir PA-II (PMS5003)

- Low cost device, can be deployed in dense networks
- Easy to install and operate, transmits data via wi-fi to an online platform
- Real time monitoring (resolution ≈ 2 min)
- Strong correlations with $PM_{2.5}$ reference monitors (except in cases of dust)

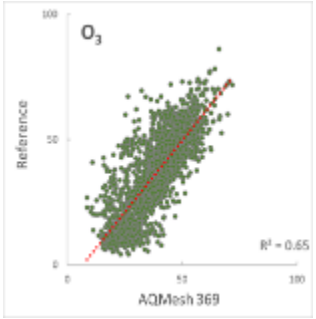


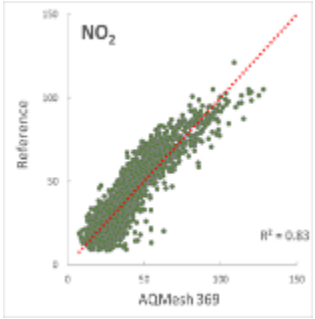
Multi-pollutant systems for O_3, NO_2, CO and PM

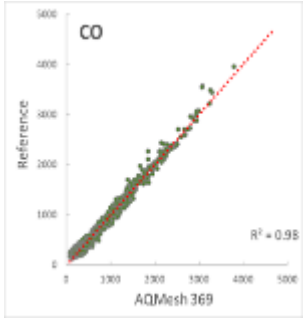


AQMesh Multi-pollutant monitor

- Alphasense electrochemical sensors for gas measurements, correcting for T interferences
- Integrated in a user platform for data access and parametrization (3G transmission, API)
- Real time monitoring (min. resolution = 5 min)
- Strong correlations with CO, NO_2 and O_3 reference monitors

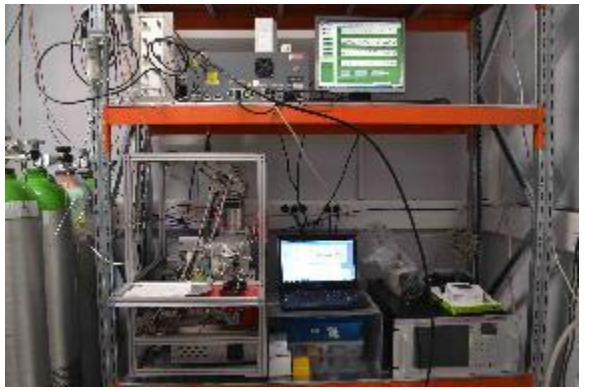






Calibration of sensor-based systems at the NOA supersite

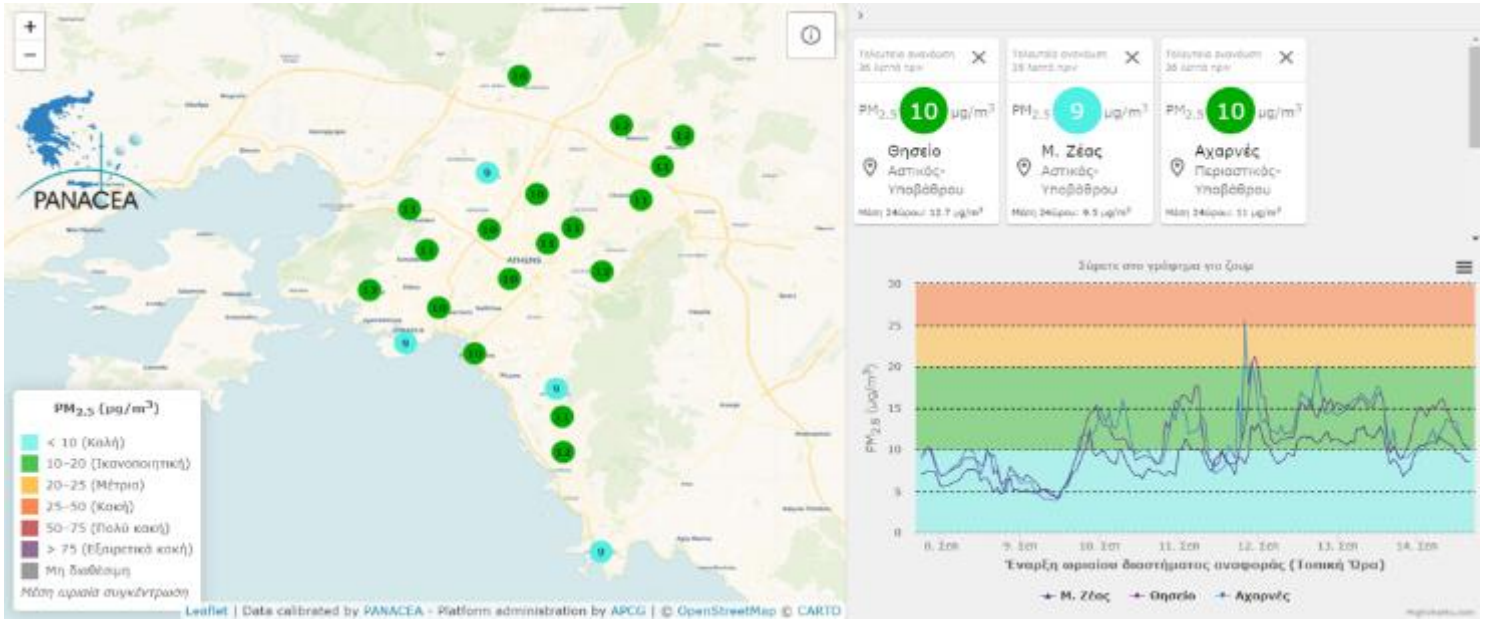
- NOA urban background supersite in Thissio, central Athens
- Concurrent operation with reference instruments using standard methods
- Statistical evaluation of sensor performance
- Linear models for correction of sensor outputs
- Examination of T, RH effects and cross-pollutant interferences
- Periodic calibration of sensors on-site (using golden-pods or the NOA mobile AQ monitoring station)



The NOA/PANACEA $PM_{2.5}$ monitoring network in Athens

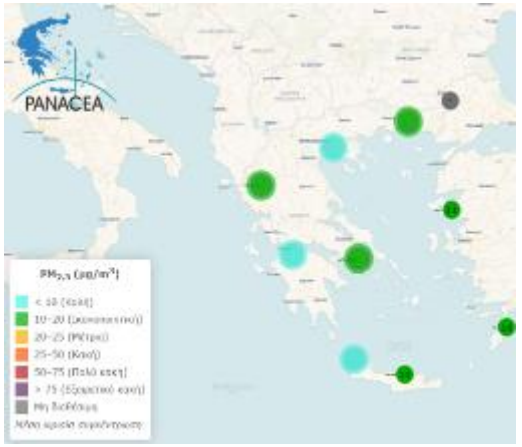
https://air-quality.gr

$PM_{2.5}$ monitoring in the GAA using low-cost sensors



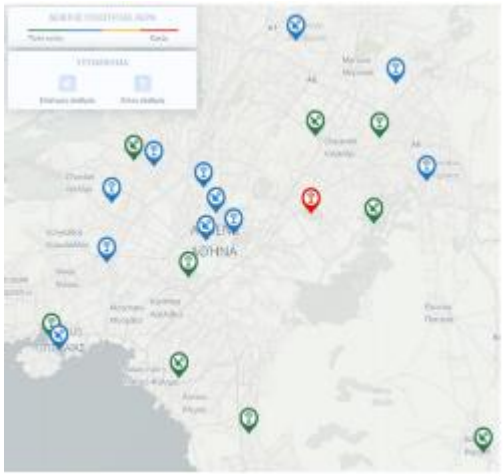
24 measurement sites in the GAA

≈ 80 measurement sites in Greek cities (in the framework of RI-PANACEA, with the cooperation of Greek Universities, such as UPatras)



The NOA/EMISSION multi-pollutant monitoring network in Athens

https://emission-web.meteo.noa.gr



O_3, NO_x, CO, PM_x measurements in the GAA, using AQMesh and custom made low-cost systems

15 measurement sites in the GAA

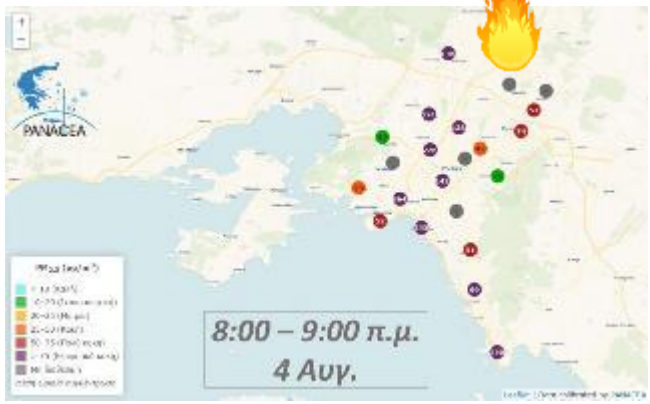
Envi4Athens (DRAXIS)

- Smartphone app for the EMISSION network
- Personalized AQI and info
- Citizen engagement

An example: The August 2021 wildfire events

Start of event

Nearing the city



Covering the basin

The utility of a sensor-based network in the context of e-shape

Pilot: S2-P3: EO-based pollution-health risks profiling in the urban environment

Target: *Blend EO platforms for AQ with socio-economic and health data, into an integrated risk assessment system to support decision making*

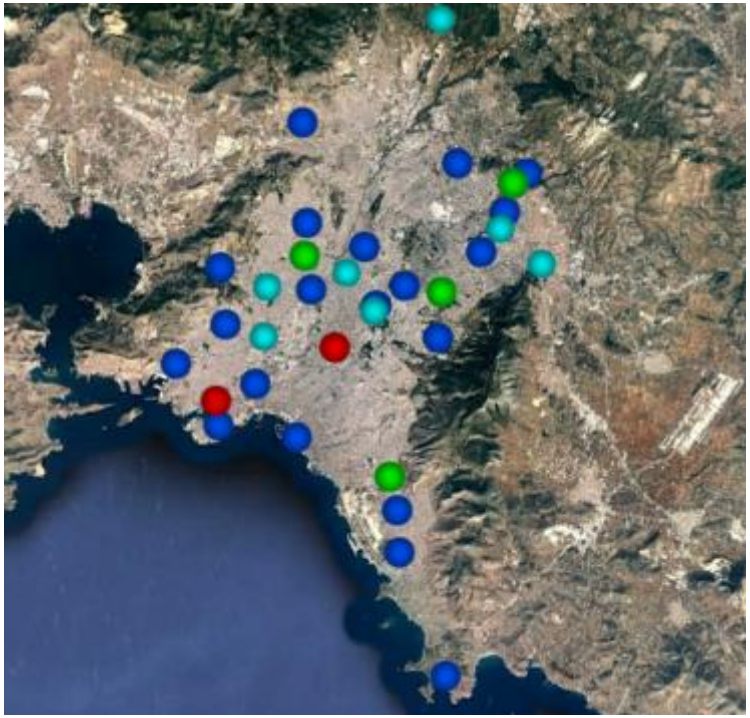
Key tools:

- *High-resolution, city-scale AQ modeling system (see upcoming presentation)*
- *Dynamic population exposure methodology*
- *Health impact assessment tools*

Possibilities opened up with AQ monitoring in high resolution

- *Improved validation and assimilation of the AQ modelling system*
- *Characterization of AQ at the municipality level*
- *Utilization of measurements in land-use regression models for spatial prediction of long-term exposure*
- *Provision of data for improved health impact assessment*

The path to an integrated network of calibrated data



- Reference sites
- Mid-cost multi-pollutant systems
- Low-cost multi-pollutant systems
- Low-cost $PM_{2.5}$ systems

Urban Traffic:	**3**
Urban Background:	**15**
Suburban Background:	**13**
Near-city Rural Background	**2**

$PM_{2.5}$ network densification

Aim → Coverage at the municipality level

e-shape

Thank you !!

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