# The CITI-SENSE Study 2012-2016

## Lessons Learned from a "Citizen Science" study

Alena Bartonova, PhD on behalf of the CITI-SENSE consortium

CITI-SENSE coordinator

alena.bartonova@nilu.no

NILU - Norwegian Institute for Air Research

Health Effects Institute Annual Meeting
1. May 2017

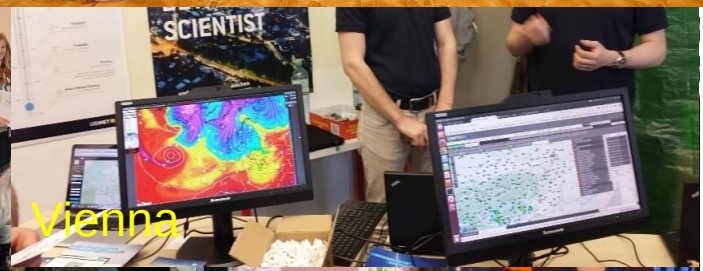
# The people behind CITI-SENSE

NILU
CREAL centre de recerca en epidemiologia ambiental
IOM
ibatuz
Saltlux
Geotech
RESEARCH INSTITUTE NATURE AND FOREST
DUNAV NET
Ateknea Solutions
UhoPPer
KICT
sensing &control Software for Seamless Connectivity
Obeo
Institute of Experimental Medicine AS CR, v.v.i. EU Centre of Excellence
QUT
AirBase
IJS
Snowflake software
UBIMET
TECHNION Israel Institute of Technology
tecnalia Inspiring Business
SINTEF
PVDH
ASTMA- OG ALLERGIFORBUNDET – gjør livet lettere

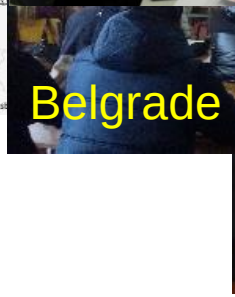
# CITI-SENSE in 9 European cities

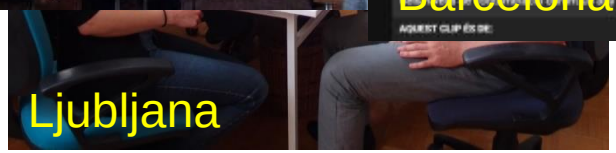







CITI-SENSE

9 tenants' associations

3 universities
7 secondary schools
17 elementary schools
54 kindergartens

# EUROPE

9 cities

9,4 million observations
(9/2015-9/2016)

>1.200 CityAir-app-users
2036 reported perceptions, app still running!

324 air sensor units in network at one time

Additional sensor clusters

>50 public places volunteers

327 portable sensor pack LEO-volunteers

1530 answers (questionnaire on air quality knowledge and views)

>300 evaluations of products

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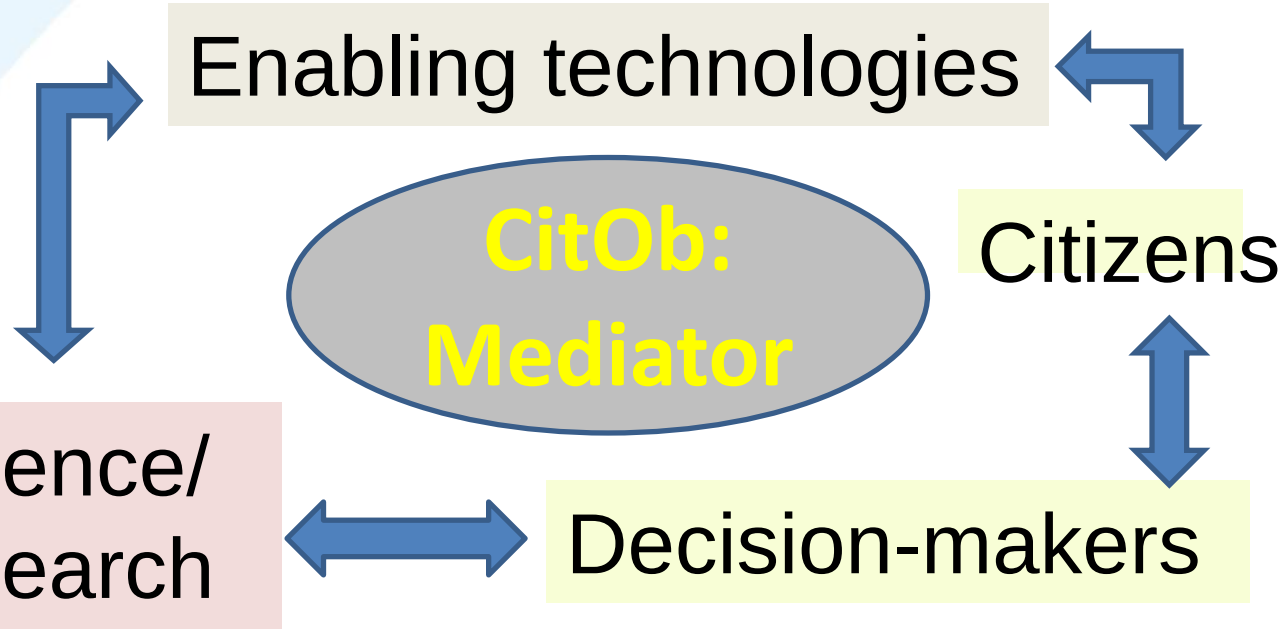
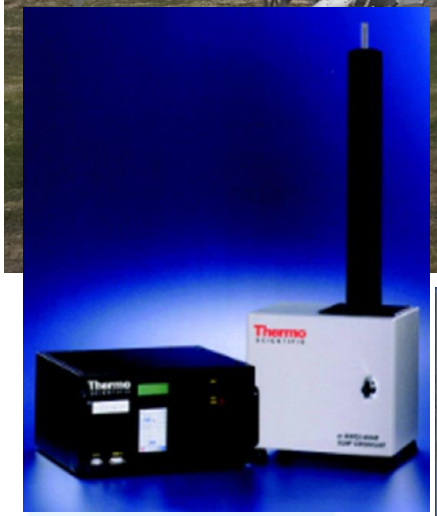
# CITI-SENSE

**Development of sensor-based Citizens' Observatory (CitOb) Community for improving quality of life in cities**



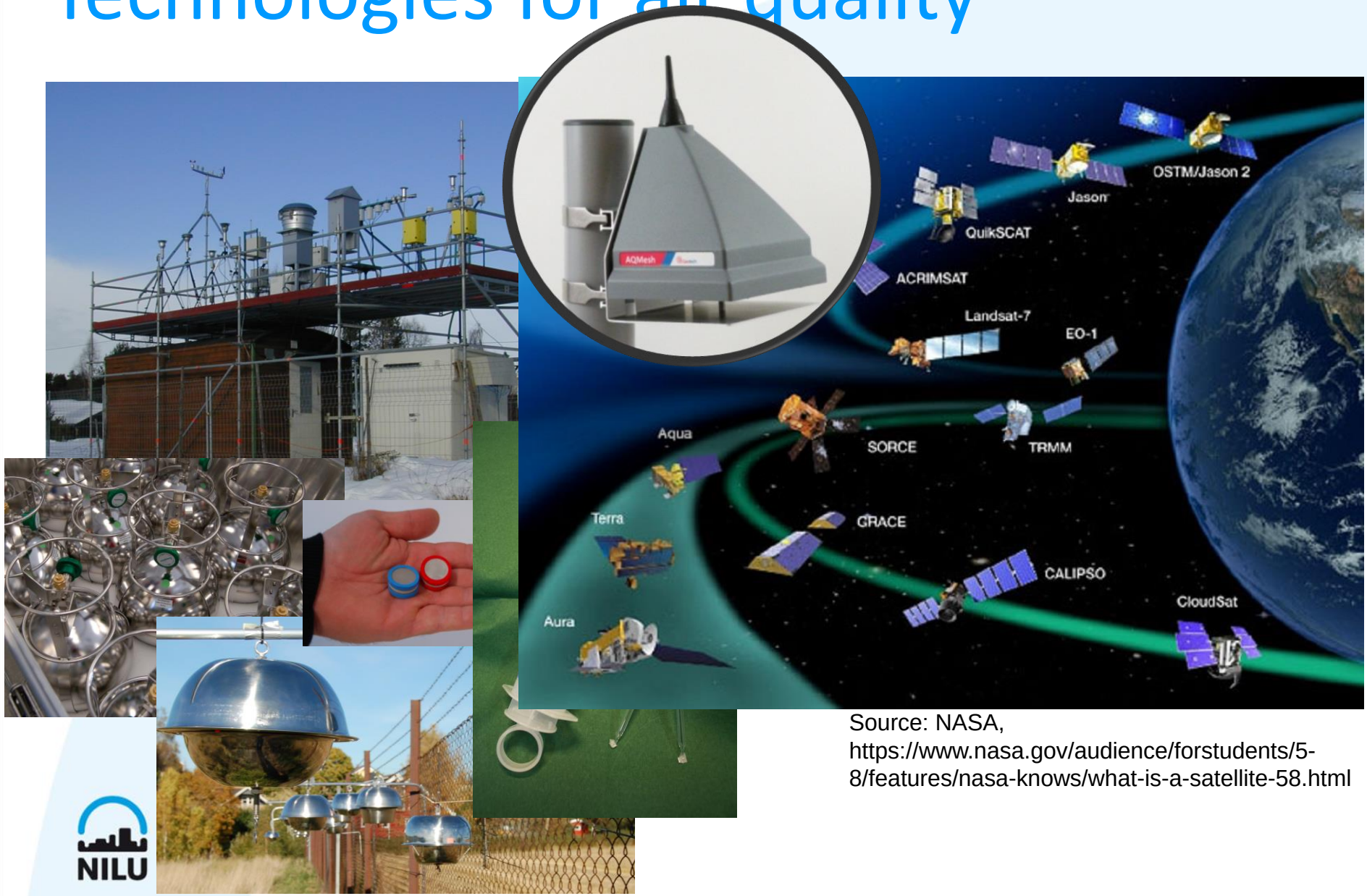
# Technologies for air quality






# Technologies for air quality




Source: NASA, https://www.nasa.gov/audience/forstudents/5-8/features/nasa-knows/what-is-a-satellite-58.html

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# Why we assess air

| Purpose | Responsibility | Quality require-ments | Data public? |
|---|---|---|---|
| Compliance with Directive 2008/50/EC | Authorities | yes | yes |
| SEA/impact assessment | Project owner | yes | no |
| Polluting activities - compliance | Project owner | yes | no |
| Public information | Authorities, others | yes, no | yes, no |
| Indoor environment | Owner/Occupant | no | no |
| Information for private actors | Private actors | no | no |
| Research | Researchers | yes | yes |

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# Calibration/QA/QC

| Who | What |
|---|---|
| Sensor provider | • Quality control of sensor before shipping; Algorithms to convert signal to concentration |
| Sensor device manufacturer | • Algorithms to convert signal to concentration;<br>• Some providers: Quality control before shipping – calibration curve |
| Sensor device lay user | • Access to manufacturer-calibrated concentrations;<br>• Access to individual instrument data |
| Sensor device professional user | • Some providers: access to signal (raw data);<br>• Laboratory testing to support QA/QC;<br>• Co-location with regulatory monitoring – additional calibration curve<br>• Co-location at deployment site – additional calibration curve |

# CITI-SENSE Full Deployment AQ

AirBase DunavNET

Institut "Jožef Stefan" Ljubljana, Slovenija

| Location/Provider | EI AQMESH outdoors | ATEKNEA portable | AS indoor | OBEO (Radon) |
|---|---|---|---|---|
| Barcelona | 25 + 5* | 11 | - | - |
| Belgrade | 25 | 11 | 12 | 4 |
| Edinburg | 24 | 11 | 12 | 4 |
| Haifa | 24 | 11 | - | - |
| Ljubljana | 12 + 6* | 11 | 12 | 4 |
| Oslo | 24 | 11 | 12 | 4 |
| Vienna | 24 | 11 | - | - |
| Ostrava | 16 | 9 | - | - |
| **Total** | **174** | **86** | **48** | **16** |
| **Total of 324 units** | | | | |

* From pilot, not accounted for in the total



ENVIRONMENTAL Instruments

Ateknea Solutions

atmospheric sensors AS

OBEO

# Typical deployment, air quality

Static AQMesh platform


Portable LEO platform

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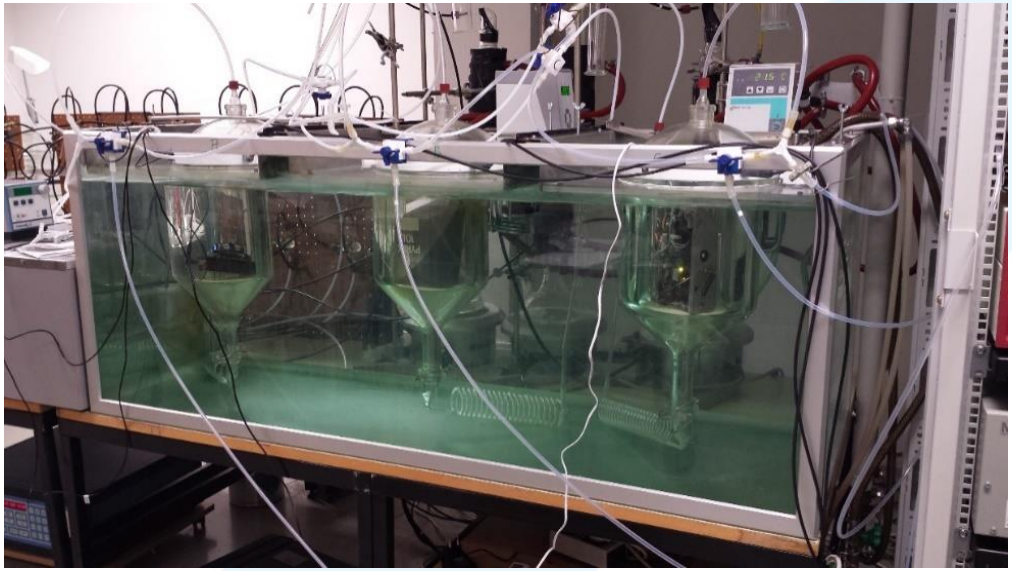
# Data quality: calibration in the laboratory and in the field



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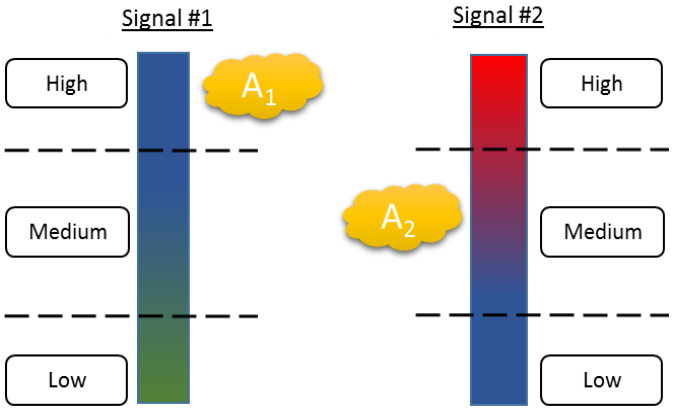
An evaluation tool kit of air quality micro-sensing units

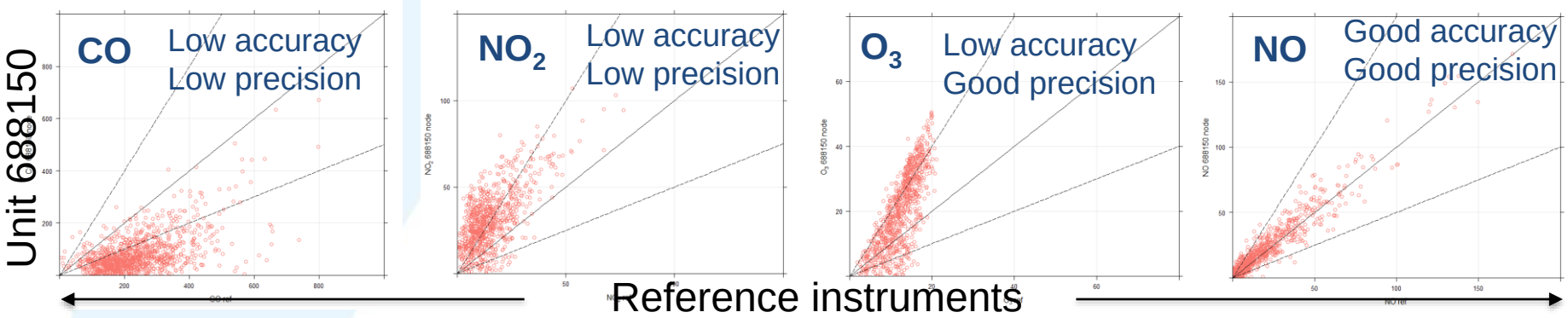
Barak Fishbain[a], Uri Lerner[a], Nuria Castell[b], Tom Cole-Hunter[c, d], Olalekan Popoola[e], David M. Broday[a], Tania Martinez Iñiguez[c, d], Mark Nieuwenhuijsen[c], Milena Jovasevic-Stojanovic[f], Dusan Topalovic[f, g], Roderic L. Jones[e], Karen S. Galea[h], Yael Etzion[a], Fadi Kizel[a], Yaela N. Golumbic[a, i], Ayelet Baram-Tsabari[j], Tamar Yacobi[a], Dana Drahler[a], Johanna A. Robinson[l, m], David Kocman[l], Milena Horvat[l], Vlasta Svecova[k], Alexander Arpaci[l], Alena Bartonova[b]
[a] The Technion Center of Excellence in Exposure Science and Environmental Health (TCEEH), Faculty of Civil and Environmental Engineering, Technion – Israel Institute of Technology, Haifa, Israel
[b] Norwegian Institute for Air Research (NILU), Kjeller, Norway




$A_1(t)$ & $A_2(t)$ in the same segment -> Match score = 1
$A_1(t)$ & $A_2(t)$ not in the same segment -> Match score = 0

# Field evaluation results: calibration

| AQMesh unit | Parameter | Correl. (lab) | Correl. (field) | Slope (lab) | Slope (field) | Interc. (lab) [ppb] | Interc. (field) [ppb] |
|---|---|---|---|---|---|---|---|
| 688150 | CO | 0.99 | 0.58 | 0.86 | 0.88 | 0.07 | 166 |
| | NO | 0.99 | 0.96 | 0.97 | 0.93 | -1.13 | -0.12 |
| | $NO_2$ | 0.99 | 0.65 | 1.22 | 0.38 | -1.02 | 3.8 |
| | $O_3$ | 0.99 | 0.81 | 1.16 | 0.26 | -1.27 | 7.2 |
| 864150 | $NO_2$ | 0.96 | 0.30 | 1.21 | 0.2 | 3.85 | 16 |
| | $O_3$ | 0.99 | 0.32 | 0.99 | 0.11 | 3.25 | 9 |




- Good performance in the laboratory is not indicative of good performance in the field.
- Correlations significantly lower in the field than in the laboratory.
- Necessary to calibrate the sensors in the field.

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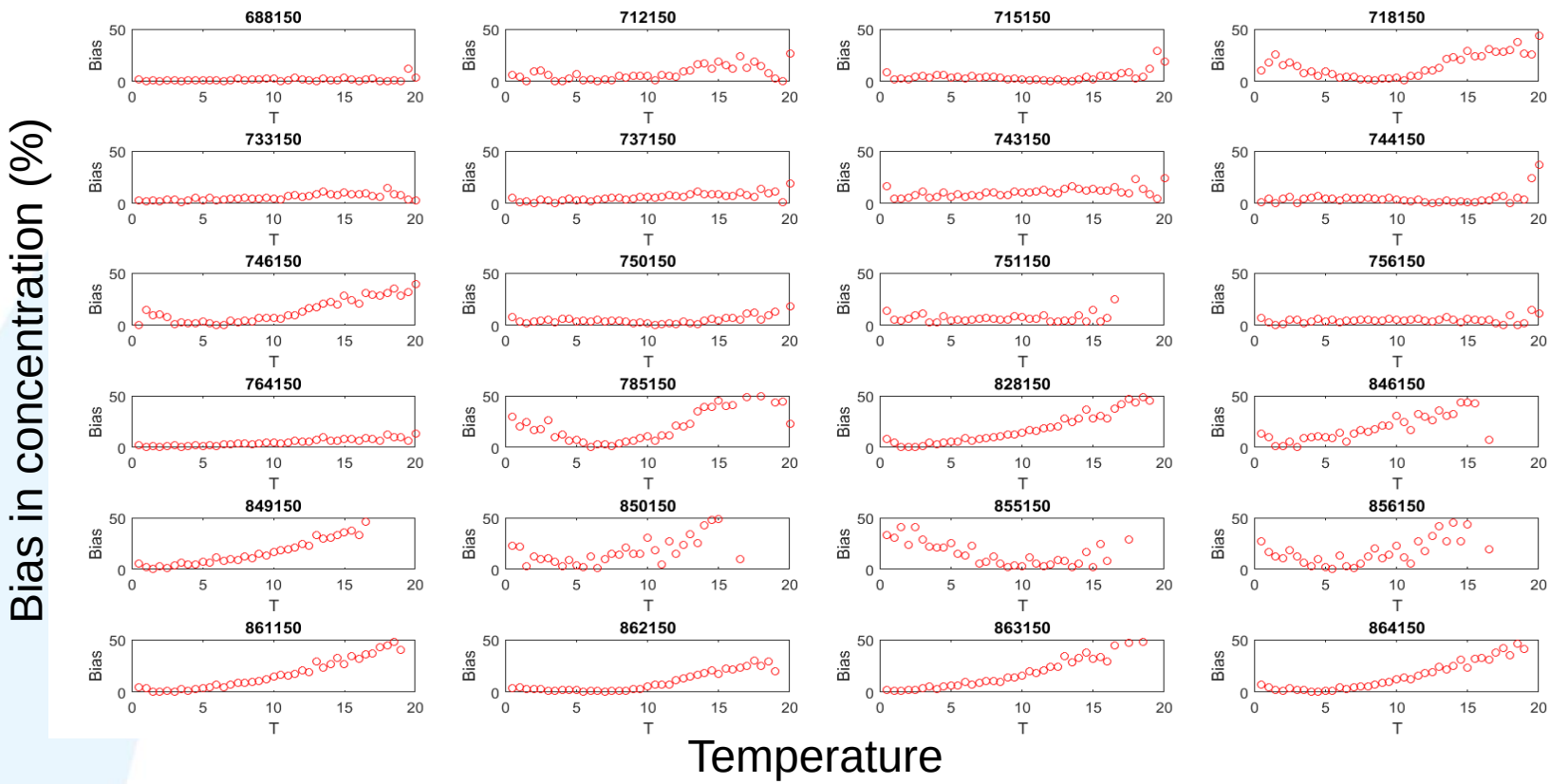
# Field evaluation: dependence on meteorological conditions

- The response of each sensor to weather is unique -> individual evaluation.
- Possible false increases in concentrations due to changes in temperature.



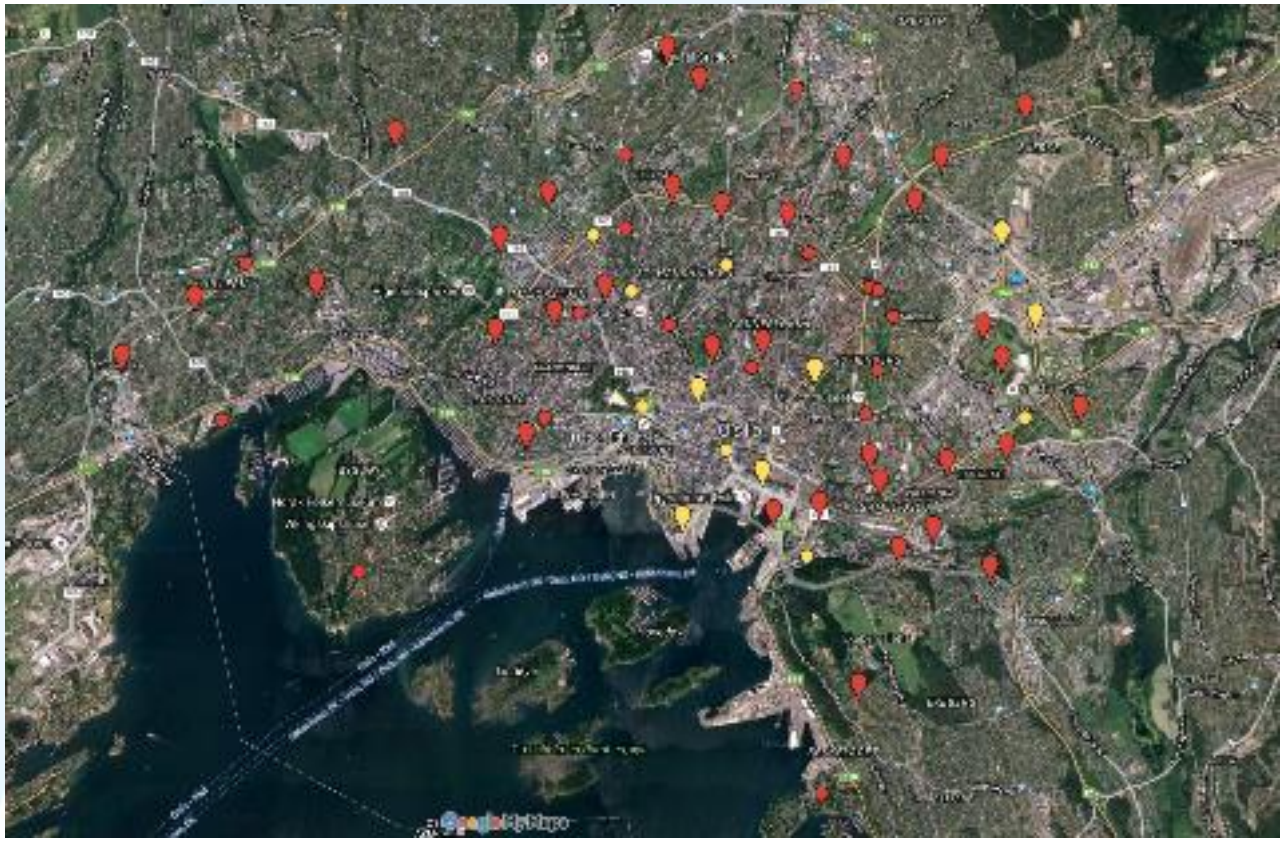
# Field evaluation: dependence on the location

- Linear calibration parameters differ depending on location (traffic-saturated environment or traffic-calm environment).
- Perform in-situ calibration at the deployment site?

| Node 688150 | CO | NO | $NO_2$ | $O_3$ | $PM_{10}$ | $PM_{2.5}$ |
|---|---|---|---|---|---|---|
| Coef. determination ($r^2$) Lab | 0.99 | 0.99 | 0.99 | 0.99 | - | - |
| Coef. determination ($r^2$) Field (dense traffic) | 0.34 | 0.92 | 0.42 | 0.65 | 0.53 | 0.40 |
| Coef. determination ($r^2$) Field (calm traffic) | - | 0.24 | 0.15 | - | 0.68 | 0.84 |
| Slope Lab | 0.86 | 0.97 | 1.22 | 1.16 | - | - |
| Slope Field (dense traffic) | 0.88 | 0.93 | 0.38 | 0.26 | 1.30 | 0.51 |
| Slope Field (calm traffic) | - | 0.27 | 0.09 | - | 2.10 | 1.90 |
| Intercept Lab | 0.07 | -1.13 | -1.02 | -1.27 | - | - |
| Intercept Field (dense traffic) | 166 | -0.12 | 3.80 | 7.20 | 5.60 | 3.30 |
| Intercept Field (calm traffic) | - | 4.20 | 6.90 | - | -1.30 | 0.98 |

# Detailed air quality maps: Oslo

AQMesh deployed in 51 kindergartens and 13 streets



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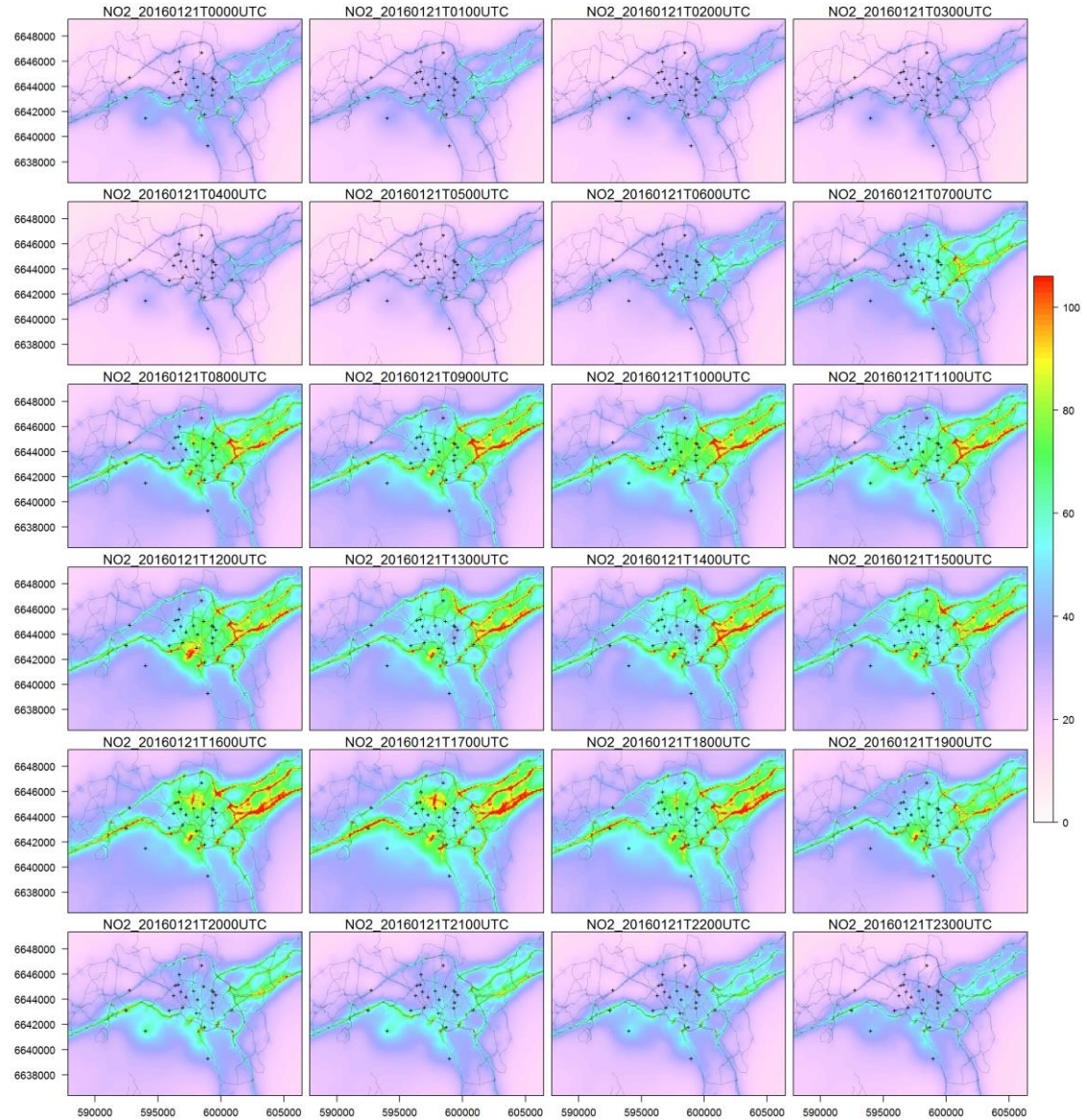
# Detailed air quality maps: Oslo

AQMesh deployed in 51 kindergartens and 13 streets

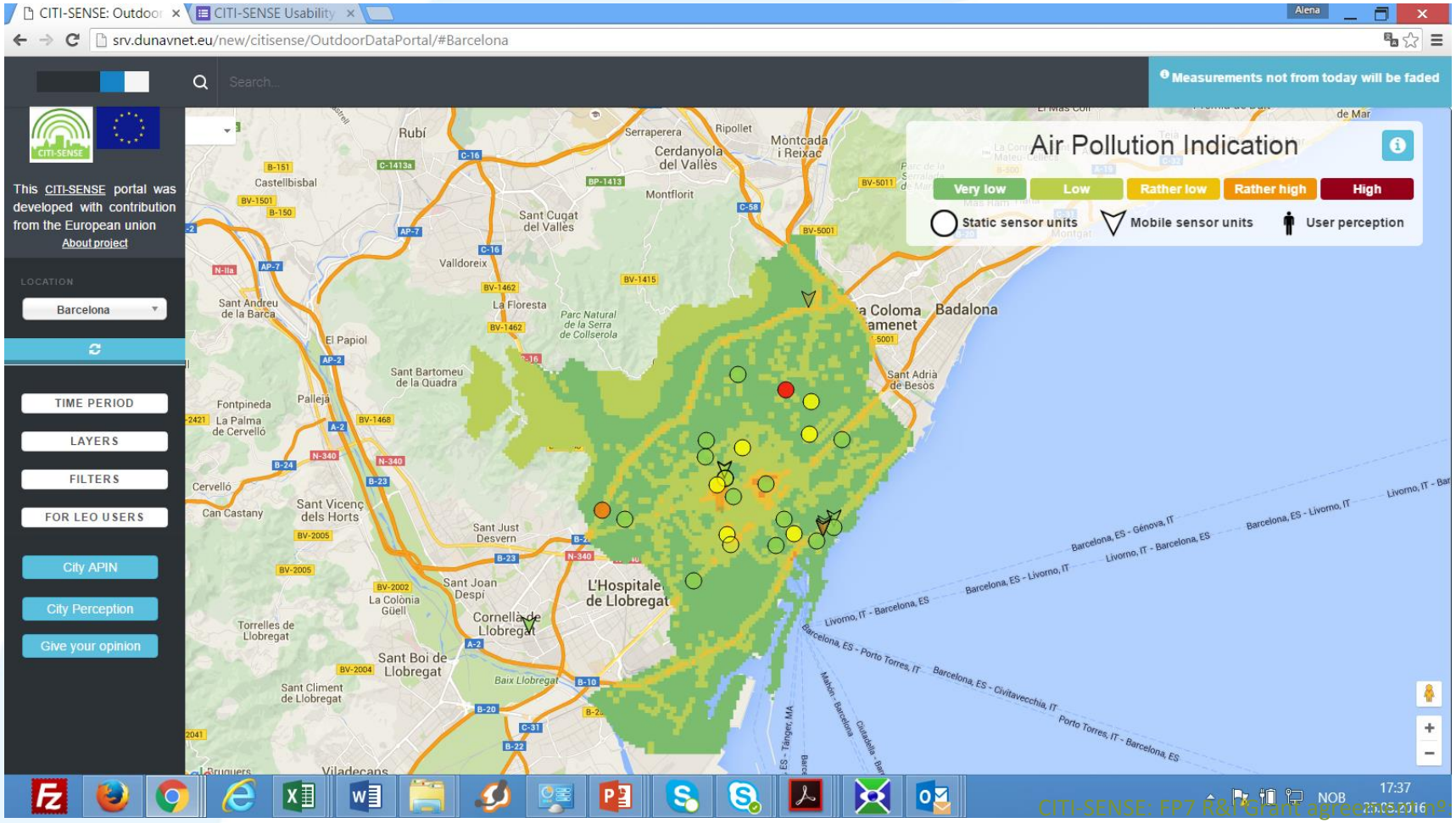
$NO_2$ concentrations were used in a data assimilation procedure, combining a base map (annual average) obtained from dispersion models and the sensor output. This resulted in a hourly map of concentrations for the Oslo area (ca 23x18 km$^2$)

Schneider et al (2017) Mapping urban air quality in near real-time using observations from low-cost sensors and model information. *Environment International* (accepted May 2017)

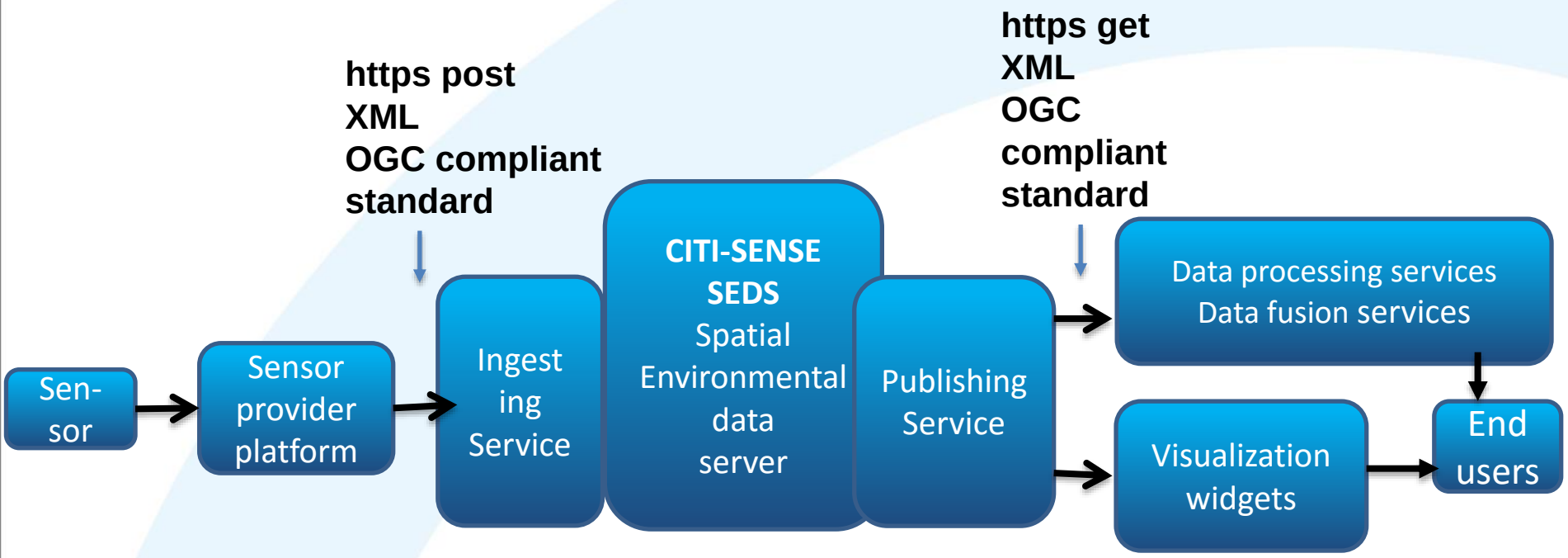


# Air quality on a map

The challenge is to provide in near-real time air quality info from different sources (sensors, monitors, models, perception) and to communicate how the differences In technologies and origin of data affect the results and the comparisons.



# Information Technology backbone: Simplified platform architecture

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# Lessons (citizen's observatory)

CitOb can be seen as an infrastructure – support to data collection, data transmisison to repository and data interpretation

Users: why should they support CitOb and participate; show added value; recruitment strategies;

- authorities
- public and their representatives (NGOs)

Technological aspects

- solvable but need to manage expectations
- need to assess and communicate the quality of collected information – (manage expectations)

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# Lessons (CitOb for governance)

Governance: of what?

Role of authorities: why should they need more information? And what are the technical requirements for such information?

Role of the public: why should they get involved, and how to make sure we do not provide «alternative facts»?

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# Lessons (participants)

What motivates the participants?

- Why are they interested and what do they need to know
- How do we engage others than those like us?
- Campaigns vs long-term engagement: reasons for participating may differ

Special user groups: obvious entry point

- Schools
- Patient organisations
- Civic groups such as activists, bicyclists, others
- Citizen science

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# Lessons (providing information)

**How do we address people** who want to know about air quality

- Combining sources of information:
  - Regulatory data and information
  - Other earth observations
  - Citizen science
  - Perception, attitudes

How do we **combine results** obtained by technologies used for different purposes (regulatory, remote sensing, modeling, citizen science)

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# Lessons (technologies)

Define **purpose first**: Technology is «fit for purpose» – what is the purpose? If not defined, expectations will not be met

**Uncertainty** of the data must be understood; it affects e.g., what visualisation products can be made

Must ensure **stable communication** between devices and data platform

Implementing information flow requires **standardization** of codes (sensor > platform > product > user)

**Support** to sensor **deployment** and operation and communication infrastructure needs to be in place

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# Lessons (benefits to users)

**Simple access to (simple) information** about air pollution, here and now, will raise awareness and increase interest and participation in air pollution governance

Use of **microsensors can contribute** to reducing individual's exposure - I can «see» where pollution is high (and thus perhaps avoid being there?)

Supports dialogue, e.g., between the city and the inhabitants

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# Contributing to GEOSS*

## alias - How do I use other people's data?

**Metadata** – sufficient to describe your data?

**Data pedigree**: how were the data generated, what are their parameters - precision, accuracy, technologies used

How do «episodic» data contribute to monitoring? To environmental information?

Research team: needs time to make sense of data

*GEOSS – Global Earth Observations System of Systems

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# Acknowledgements

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Slides contributed by Nuria Castell,

Philipp Schneider, Mirjam Fredriksen,

Leonardo Santiago and other consortium members.

NILU Norsk institutt for luftforskning

# Where to find us

General contact: alena.bartonova@nilu.no

Web page http://co.citi-sense.eu

- Codes, widgets
- Questionnaires
- Sensor devices
- Publications
- Brochures

CityAir App: iTunes, AppStore


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