Can low-cost air quality sensors help citizens to create smart cities?

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CITI-SENSE www.citi-sense.eu
Citi-Sense-MOB www.citi-sense-mob.eu

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Sensing Oslo… two EU co-funded projects

CITI-SENSE

Start: 01/10/2012

Duration: 48 months

Budget: 12M €

28 partners, 12 countries

Call: FP7-ENV-2012.6.5.1

Citi-Sense-MOB

Start: 01/09/2013

Duration: 24 months

Budget: 700K € (500K EU)

5 partners, Norway

Call: EMMIA / DG Enterprise

Pilot campaign: October 2013 – October 2014
Full deployment: October 2014 – October 2015

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CITI-SENSE and Citi-Sense-MOB Vision

Important problems:

Quality of life in cities
Health effects from traffic pollution

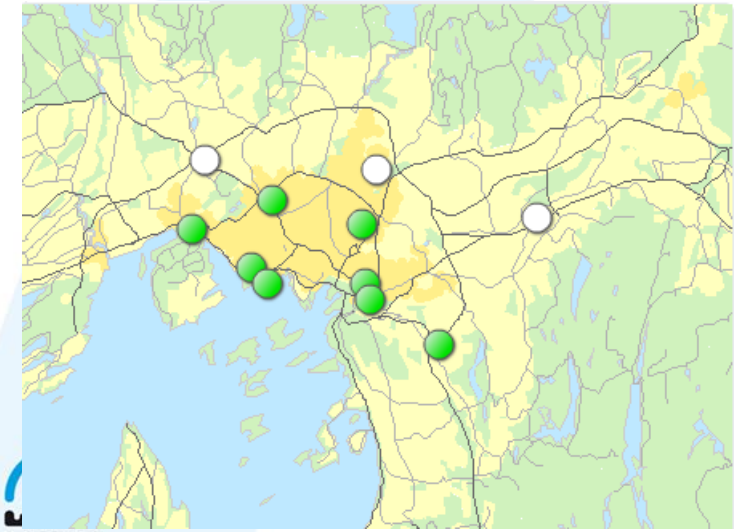
Decreasing air pollution
Increasing quality of life

Opportunities and challenges:

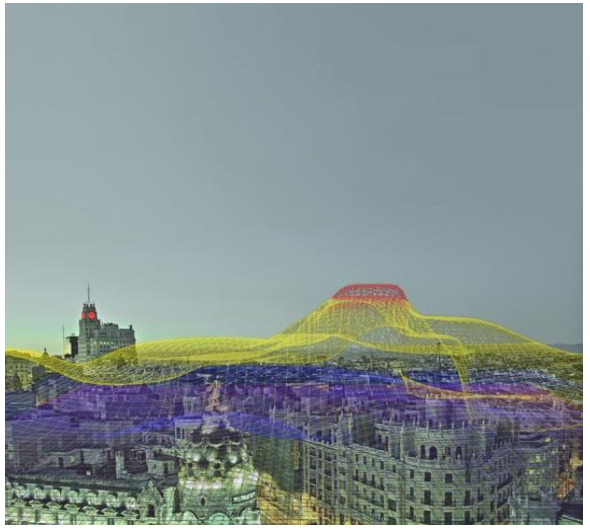
Small, low-cost sensors
Information and Communication Tech.

Participatory Urbanism
Citizens' Empowerment

Few monitoring stations
No real-time data where people are
Absence of personalized data



Increased spatial coverage
Complementary air quality data
Personalized data



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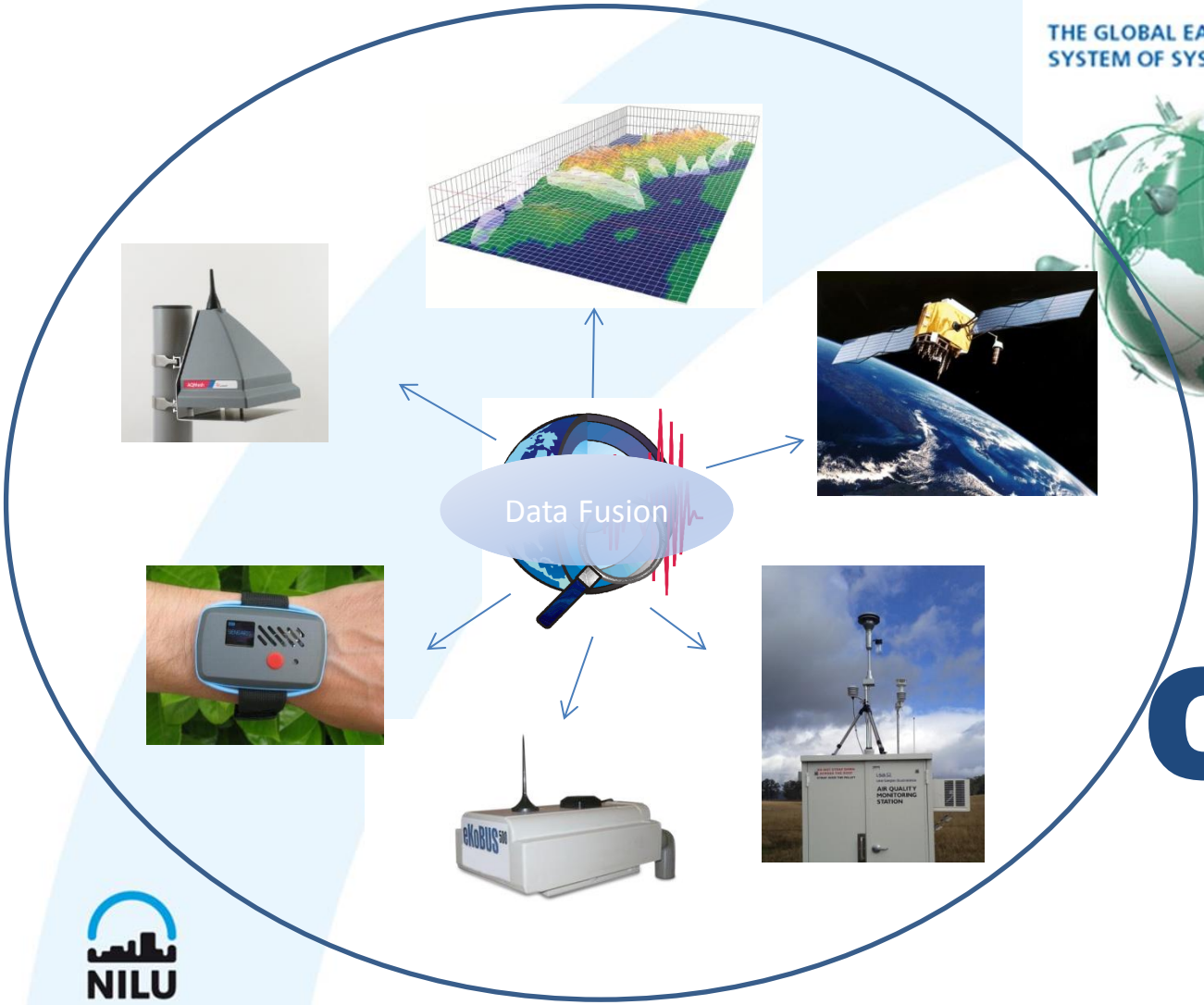
Our approach

Innovative technology to continuously sense, measure and communicate environmental data

Dynamic city infrastructure for real-time city management and sustainable progress



COT

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COT: Citizens' observation toolbox

The COT will comprise a series of applications and services for informing the public on current environmental conditions and obtaining VGI input from them.

Personalised data

Air Quality

Meteorology

UV

Personal threshold limits

Alerts

VGI

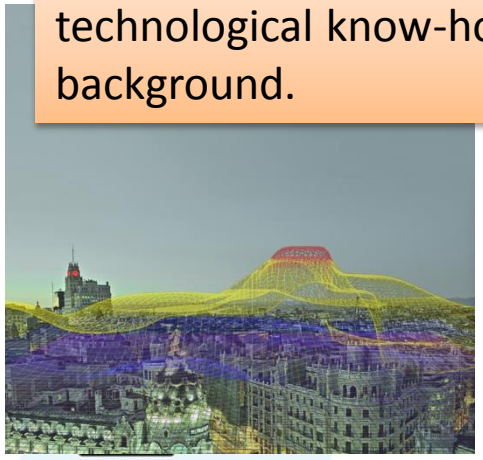
Forecasting

Pollen

Real-time

Exposure

Challenge: It requires an inter-disciplinary approach, merging scientific knowledge with technological know-how and participatory governance against an inter-cultural background.



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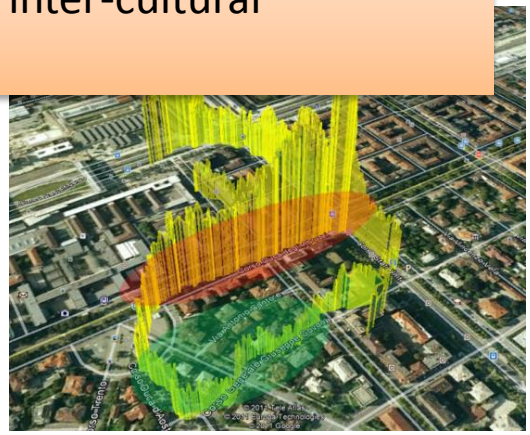
Visualizations might be helpful for making sense of data.



CITI-SENSE and Citi-Sense-MOB Impacts

Behavioural change

Greener Oslo

Public awareness

Environmental governance

Urban planning

Education

Mobility map

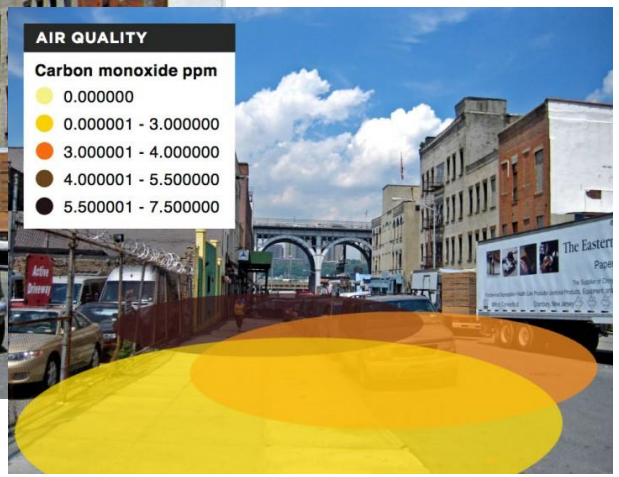
City management

Citizens empowerment

Public participation

Eco-driving

Participatory urbanism



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What will happen if citizens can measure, sense and be aware of consequences of living in a polluted city and their own contribution to the pollution?

How are we going to do it?

Sensor platform
NO_x, CO, O_3,
PM, RH, T

Ruter#

Public & Private Sectors

GNSS

Data Services
Processing raw data, fusion, modelling

Cloud services

Data storage

User services

COT

Data providers

VGI

AQ Models

Traffic situation

Citizens
Special Interest Groups

Citizen Participation
Participatory Governance through Social Media

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Challenges

- Sensor data quality
- Information and Communication in real-time
- Data visualisation
- Engaging with the citizens

The challenge is our goal

Combining new sensing technology, ICT platforms and participatory methods into useful products.

→ Condition: GEOSS interoperability

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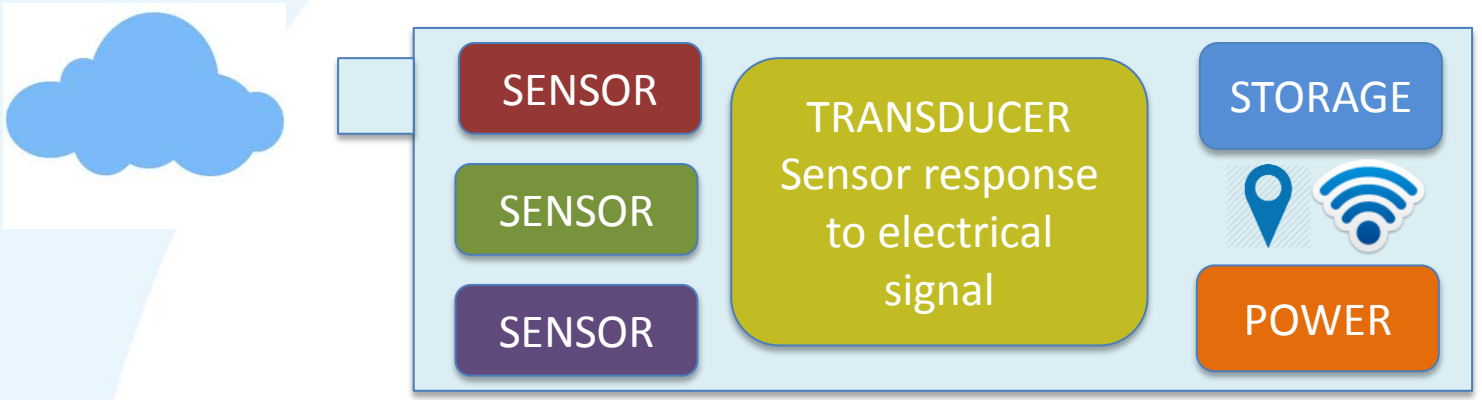
Challenge: Sensor data quality

Sensor devices are currently available to monitor a range of air pollutants and new devices are continually being introduced.

RECENT ADVANCES

1) Microelectro-mechanical system (MEMS)
2) Microfabrication techniques
3) Energy efficient sensor circuits
4) Computing power for handling Big Data

Small, lower-cost, mass-produced sensors



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Gases	Strengths	Concern 1	Concern 2	Concern 3
Electrochemical cell (EC)				
CO, O_3, NOx	Low cost, low power, small, real-time; more sensitive than MOS (metal-oxide-semiconductor) sensors	Interferences: CO, VOC, NO_2	Drift, frequent recalibration needed, 1 yr lifetime	
Metal oxide semiconductor (MOS)				
CO, O_3, NOx	Small size; stable, 1-2 yr lifetime, inexpensive	Sensitive to change of RH, T, P; cross-sensitivity	Power consumption; fragile materials	Typically less sensitive than EC
Non-dispersive infrared absorption (4.26 μm)				
CO_2	Compact, stable to changing RH and T	Sensitivity depends on path length	Calibration may be misinterpreted or inaccurate	Some single beam devices auto-calibrate as if background CO_2 is 400 ppb
Ultraviolet absorption (254 nm)				
O_3	Accuracy, stable to change in P	Size (not yet miniaturized)	Sensitive to changes in relative humidity	Cost
Particle Properties[a]				
Light Scattering	Small, inexpensive, commercially available	Not a direct mass measurement	Does not measure ultrafine particles	
Light Absorption	Handheld well established, stable, continuous	Still relatively large and costly	Requires changing a filter	
Direct Particle Mass	Small, inexpensive, direct mass concentration; FBAR, QCM	In development stage	Likely sensitive to changes in T and RH	

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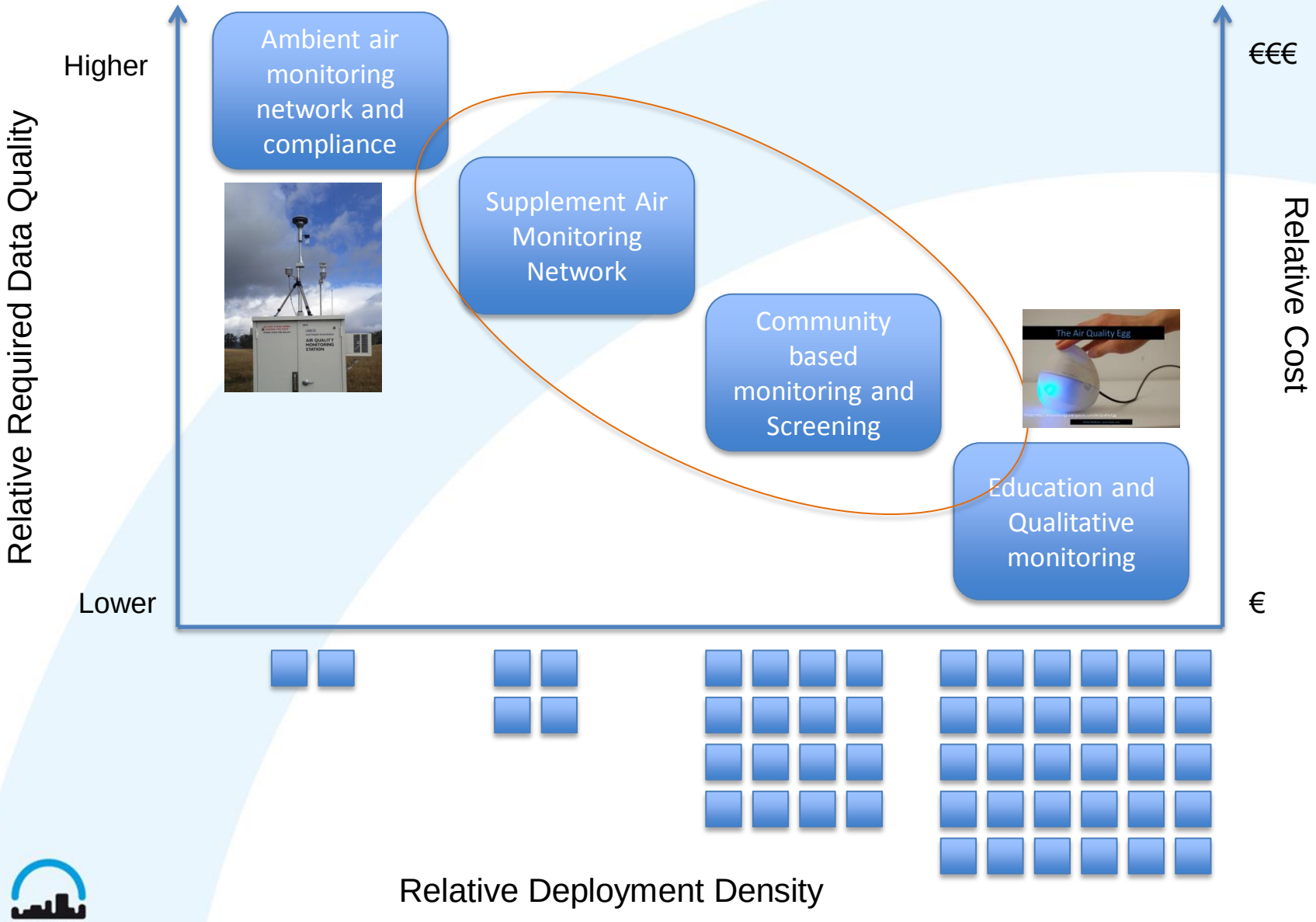
Snyder et al., Envir. Scien.& Techn., 2013

What data quality do we need?

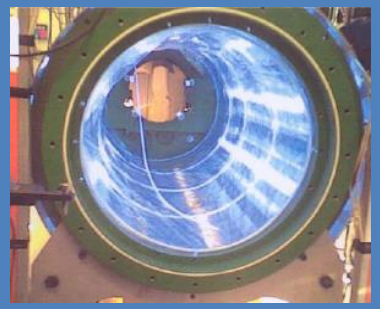


Snyder et al. Env. Sci. Tech. 2013

Challenge: Sensor performance and uncertainty

Validation and Calibration

Laboratory & Field



Provide accurate and scientifically defendable information.
Otherwise data is useless.

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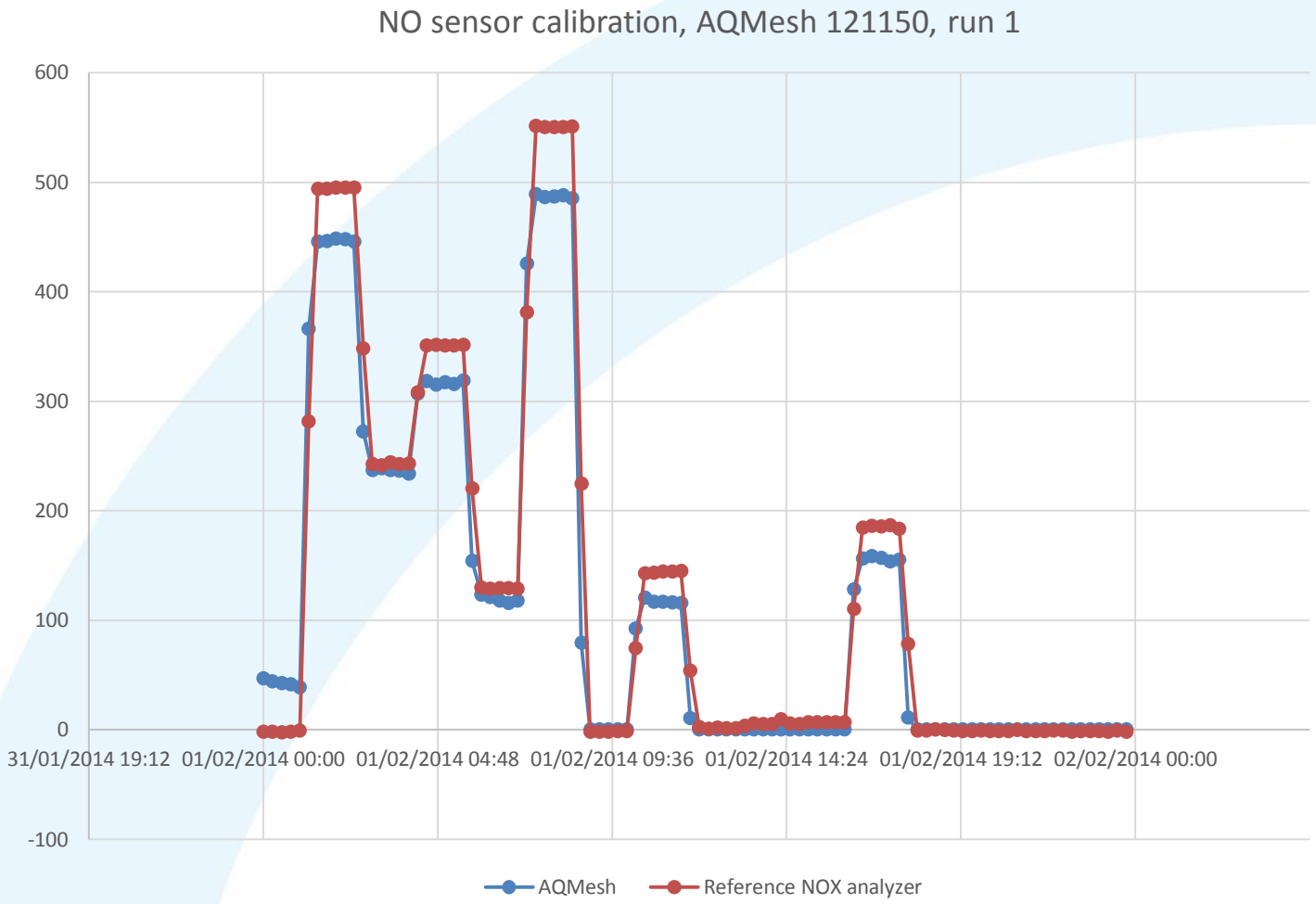
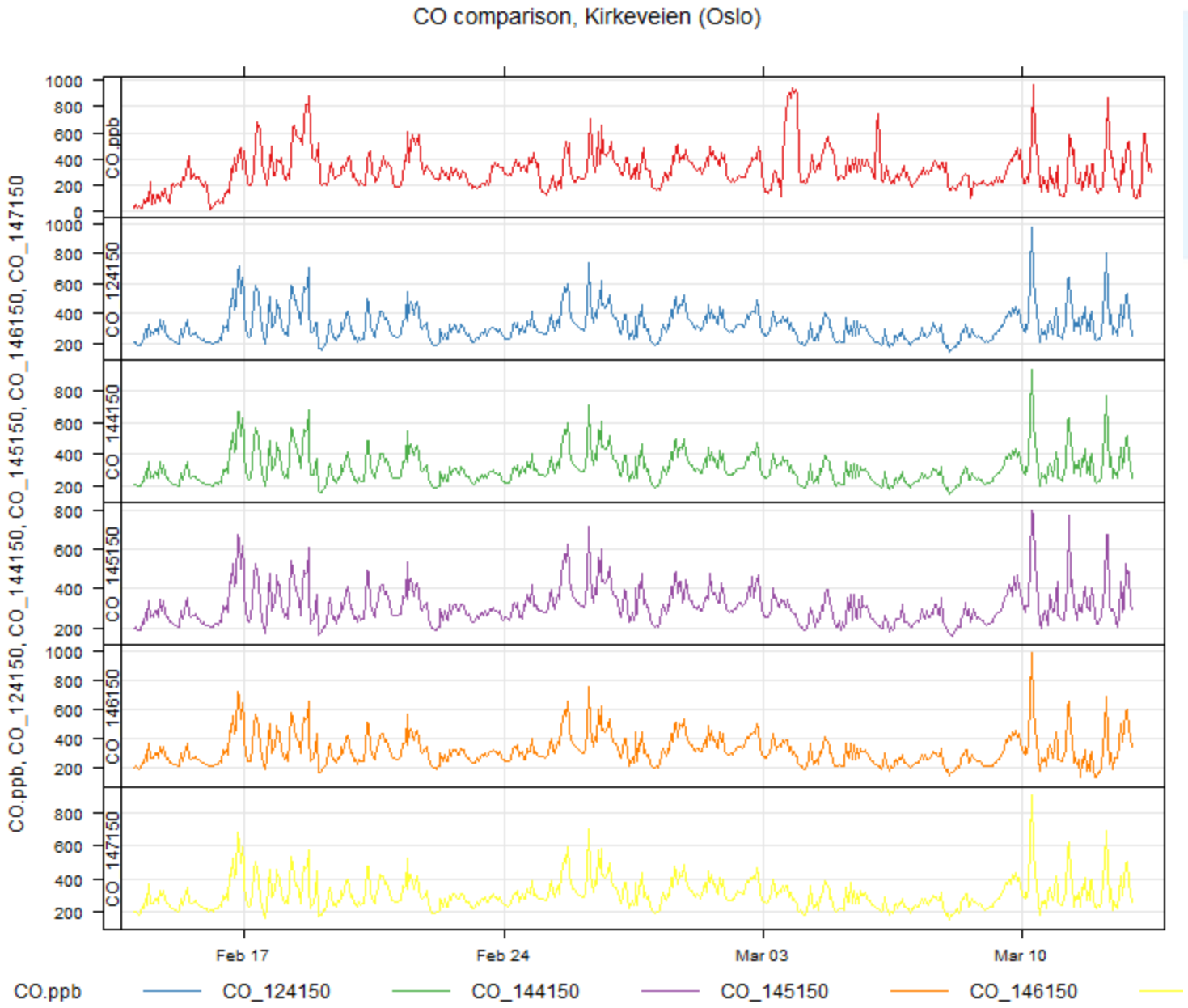
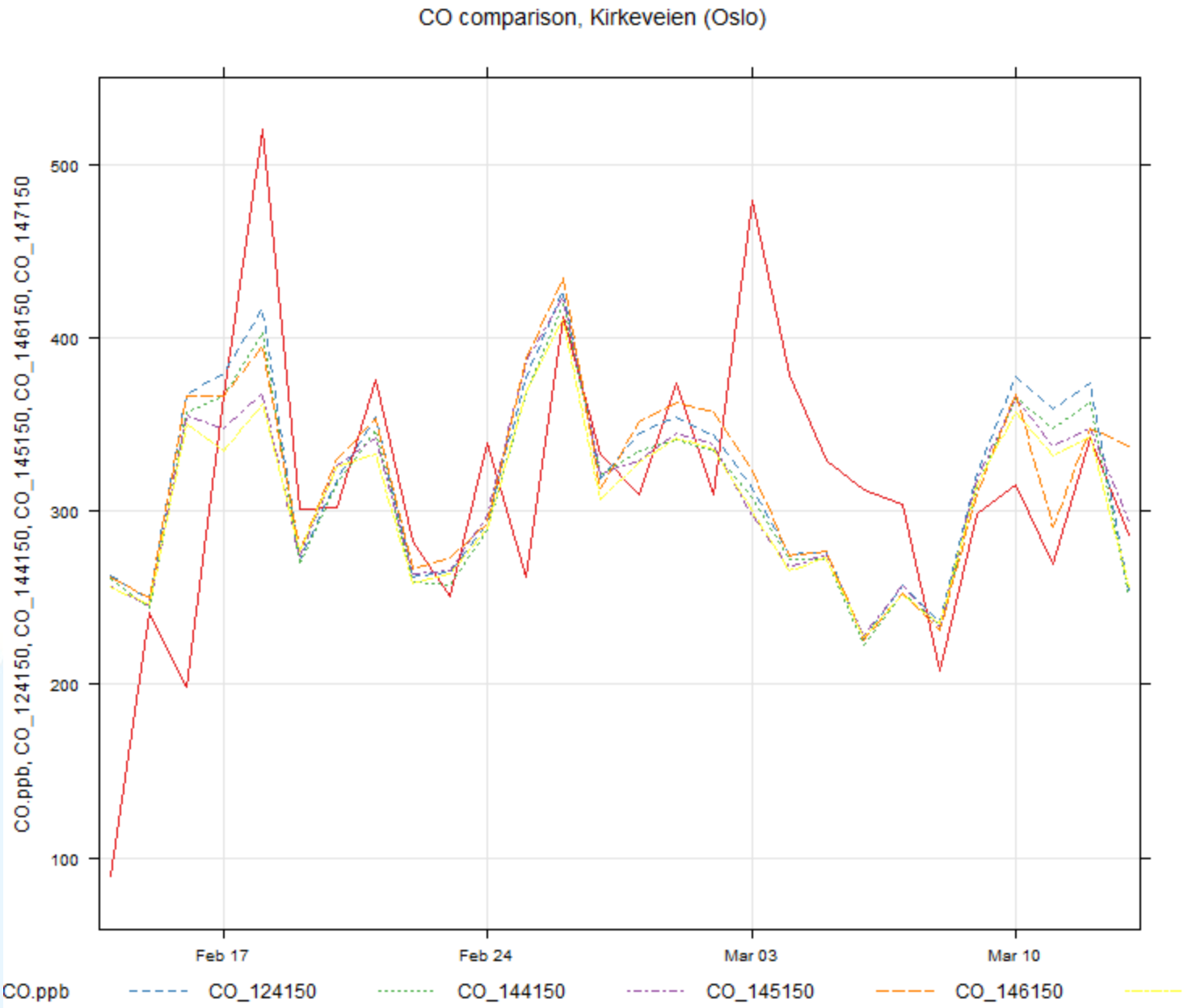
Sensor performance. Calibration at NILU laboratories



Co-location with reference equipment




CO comparison, Kirkeveien (Oslo)
CO.ppb, CO_124150, CO_144150, CO_145150, CO_146150, CO_147150
500
400
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100
Feb 17
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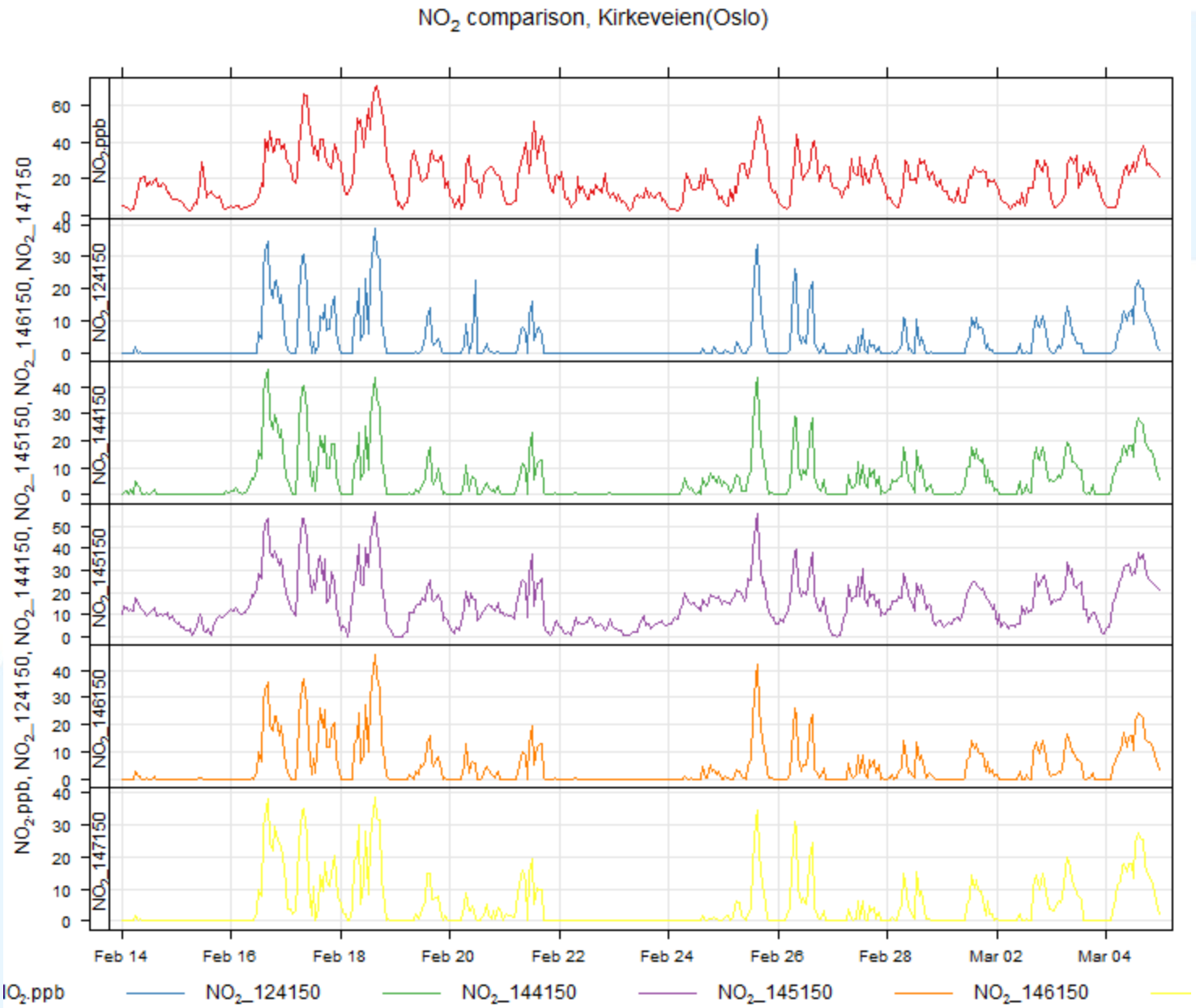
CO.ppb
CO_124150
CO_144150
CO_145150
CO_146150


NO2 comparison, Kirkeveien(Oslo)
NO2.ppb, NO2_124150, NO2_144150, NO2_145150, NO2_146150, NO2_147150
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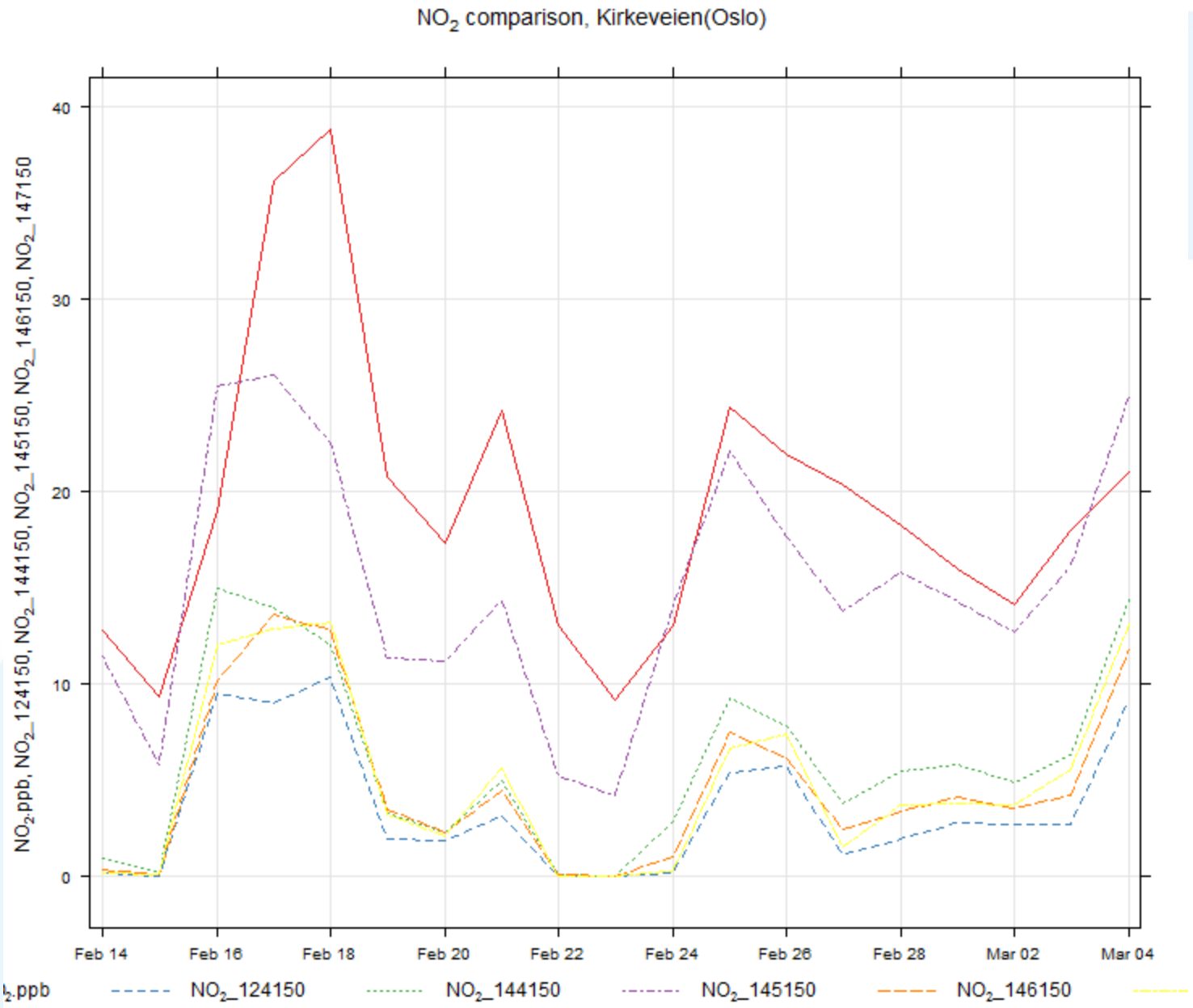
NILU


NO2 comparison, Kirkeveien(Oslo)
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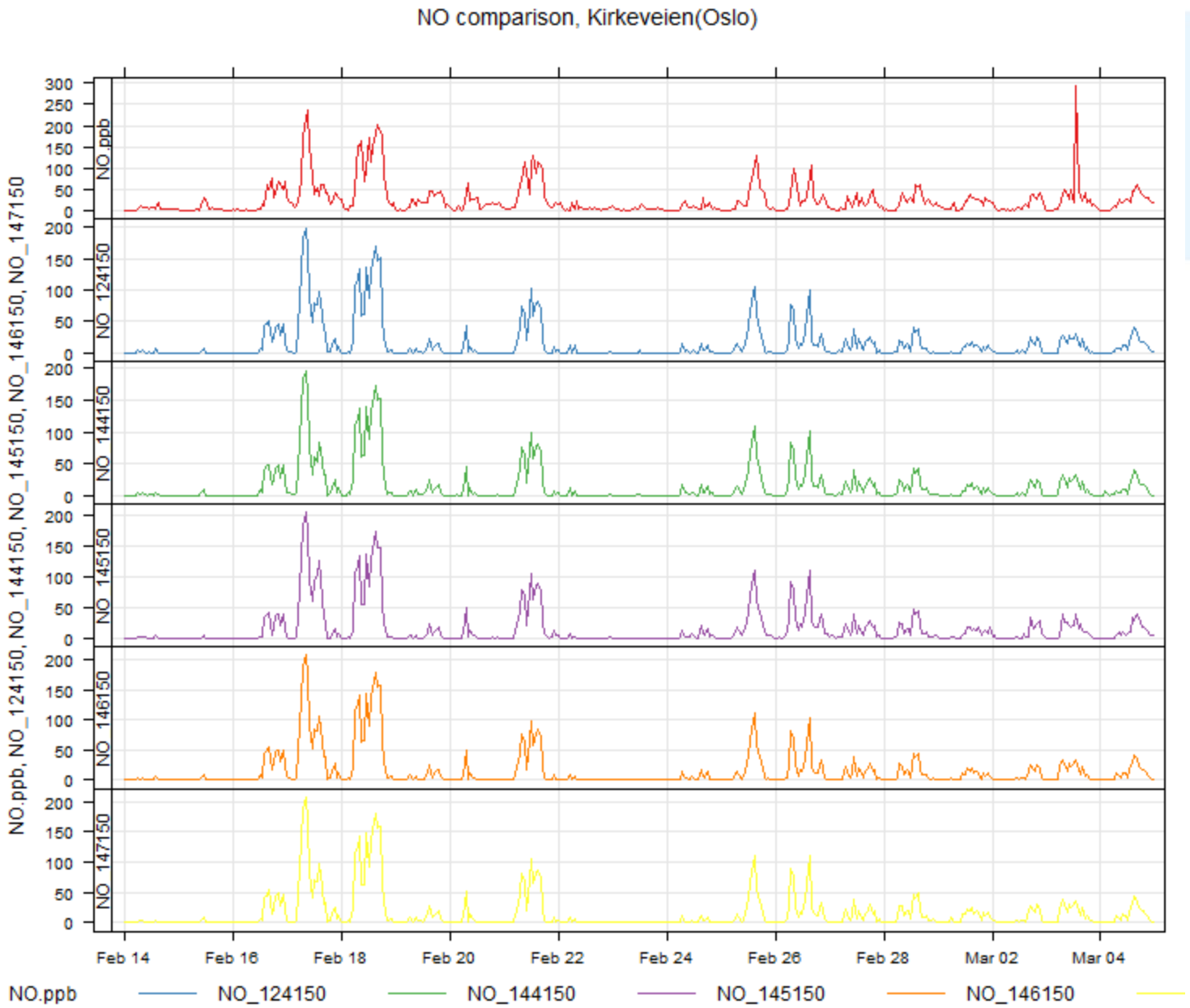
NO comparison, Kirkeveien(Oslo)
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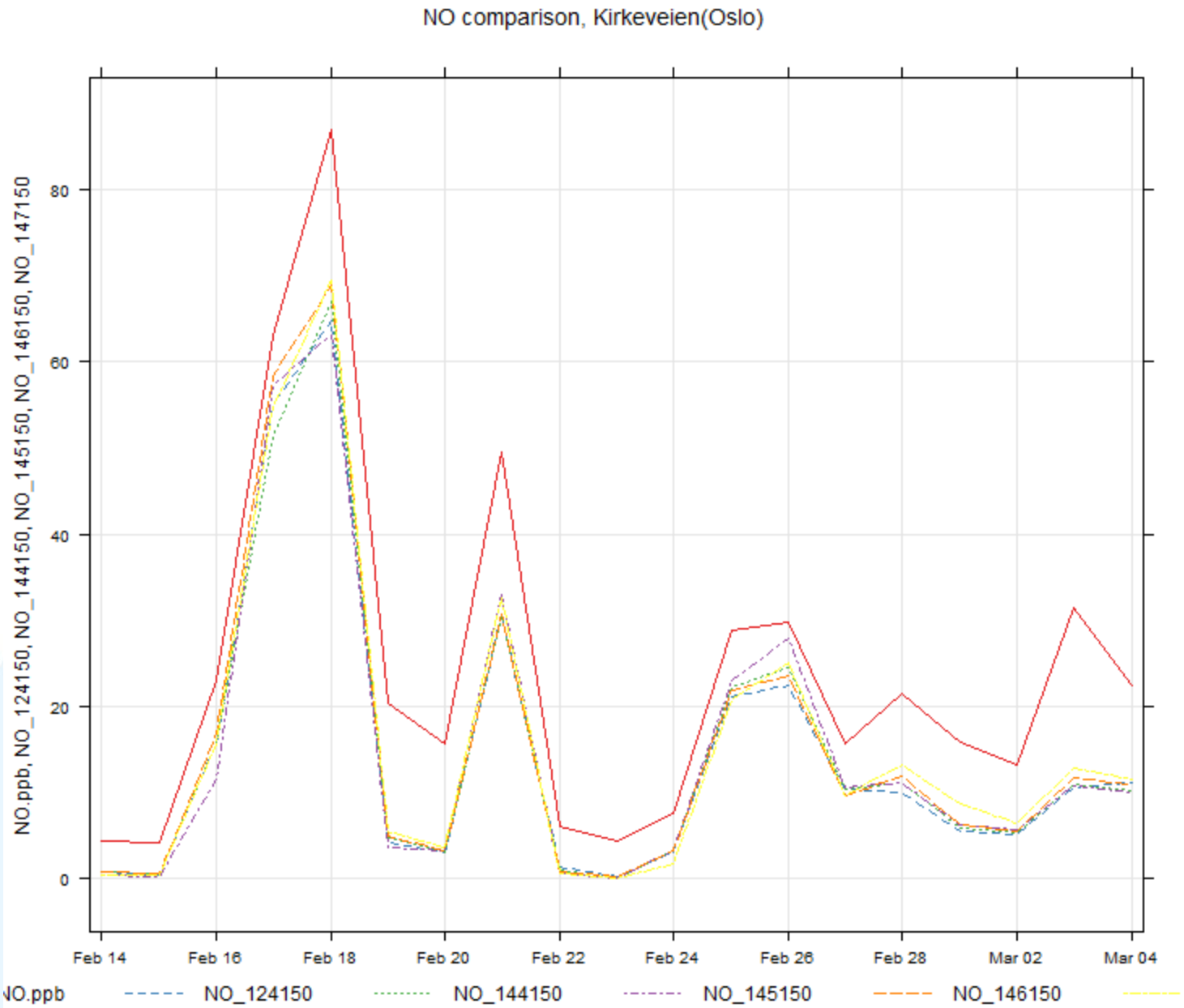
NO comparison, Kirkeveien(Oslo)
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NO.ppb
NO_124150
NO_144150
NO_145150
NO_146150

Challenge: Integration with other data

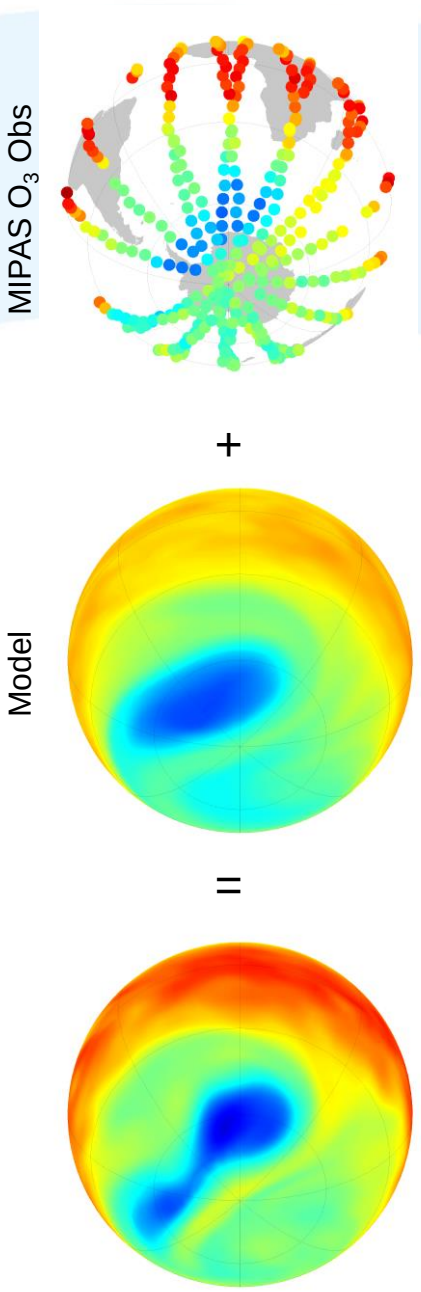
Data assimilation

Filling in gaps of observations – need a model

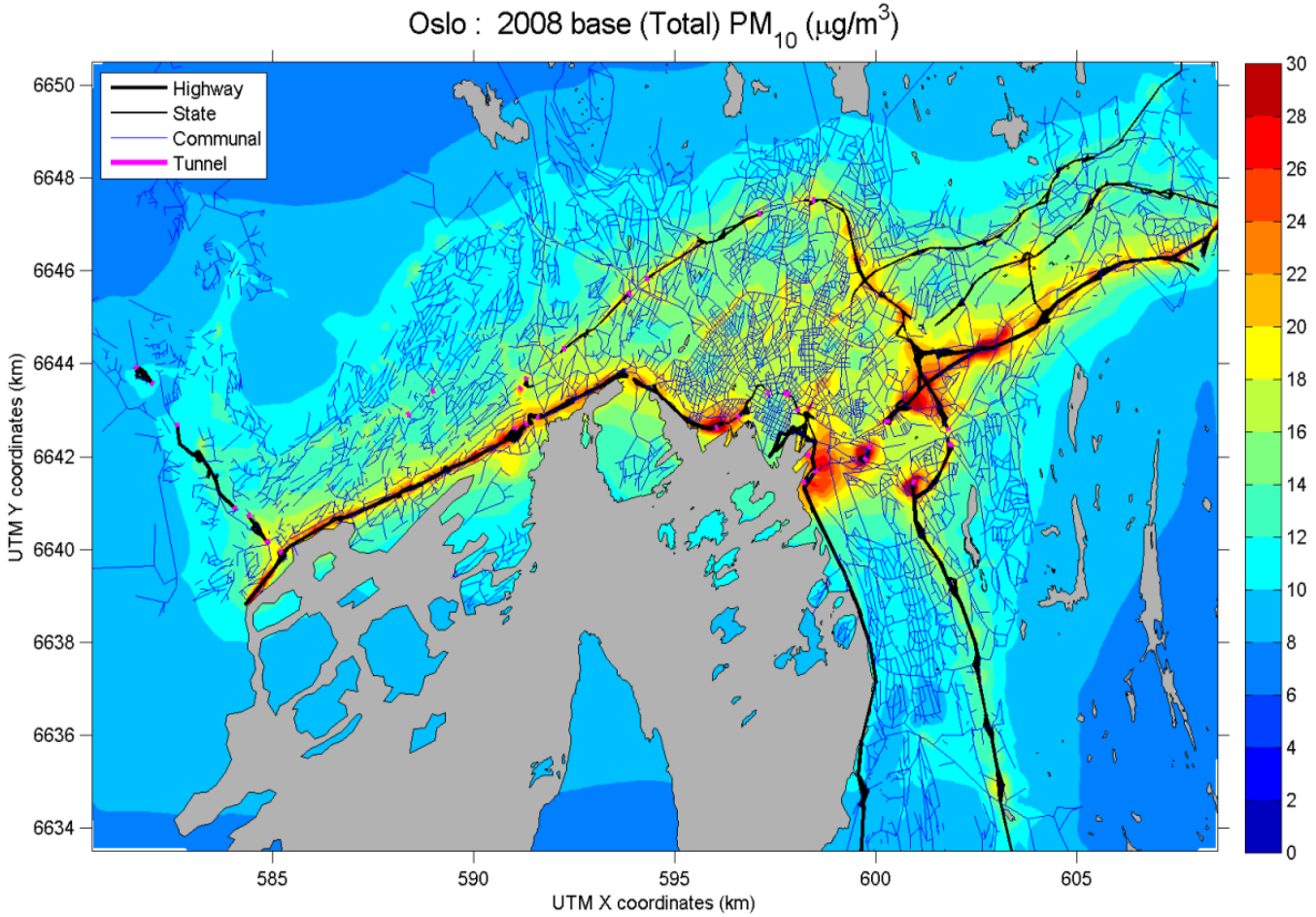
Added value:

- Observations: filling in gaps
- Model: constrain using observations

Possibility of evaluating the errors in the data



Data assimilation with AQ models and AQMN



Model results from the TRANSPHORM project in Oslo (Denby et al.)

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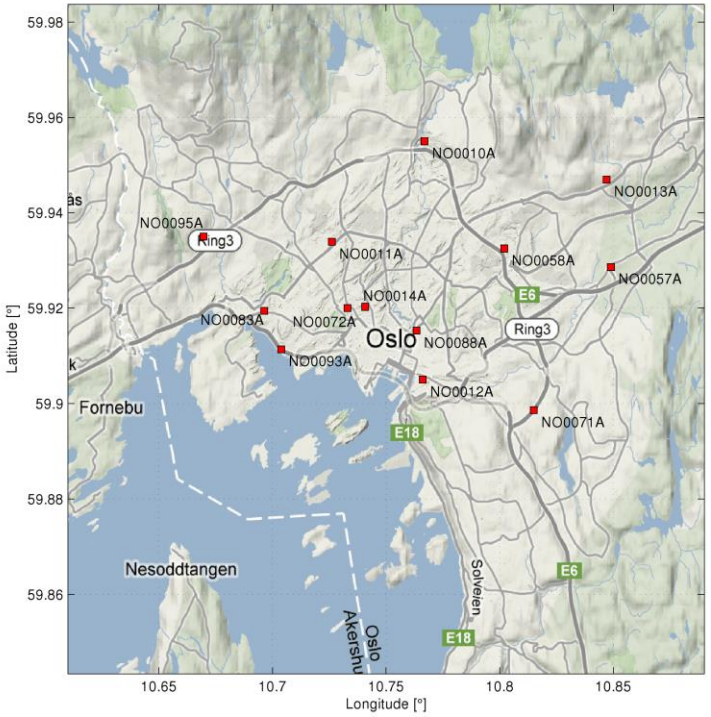
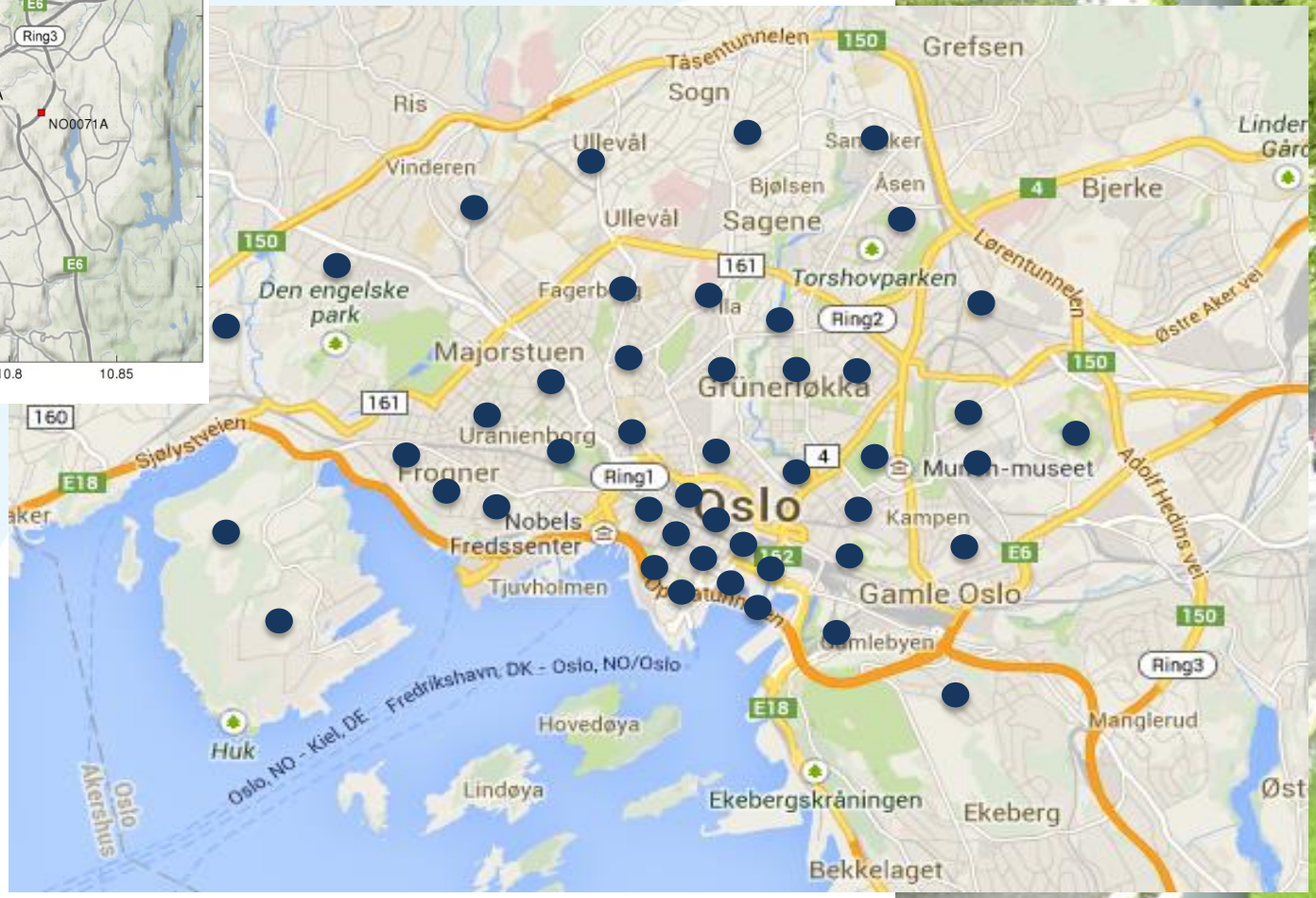
Sensing the city with static nodes



Information at citizen level



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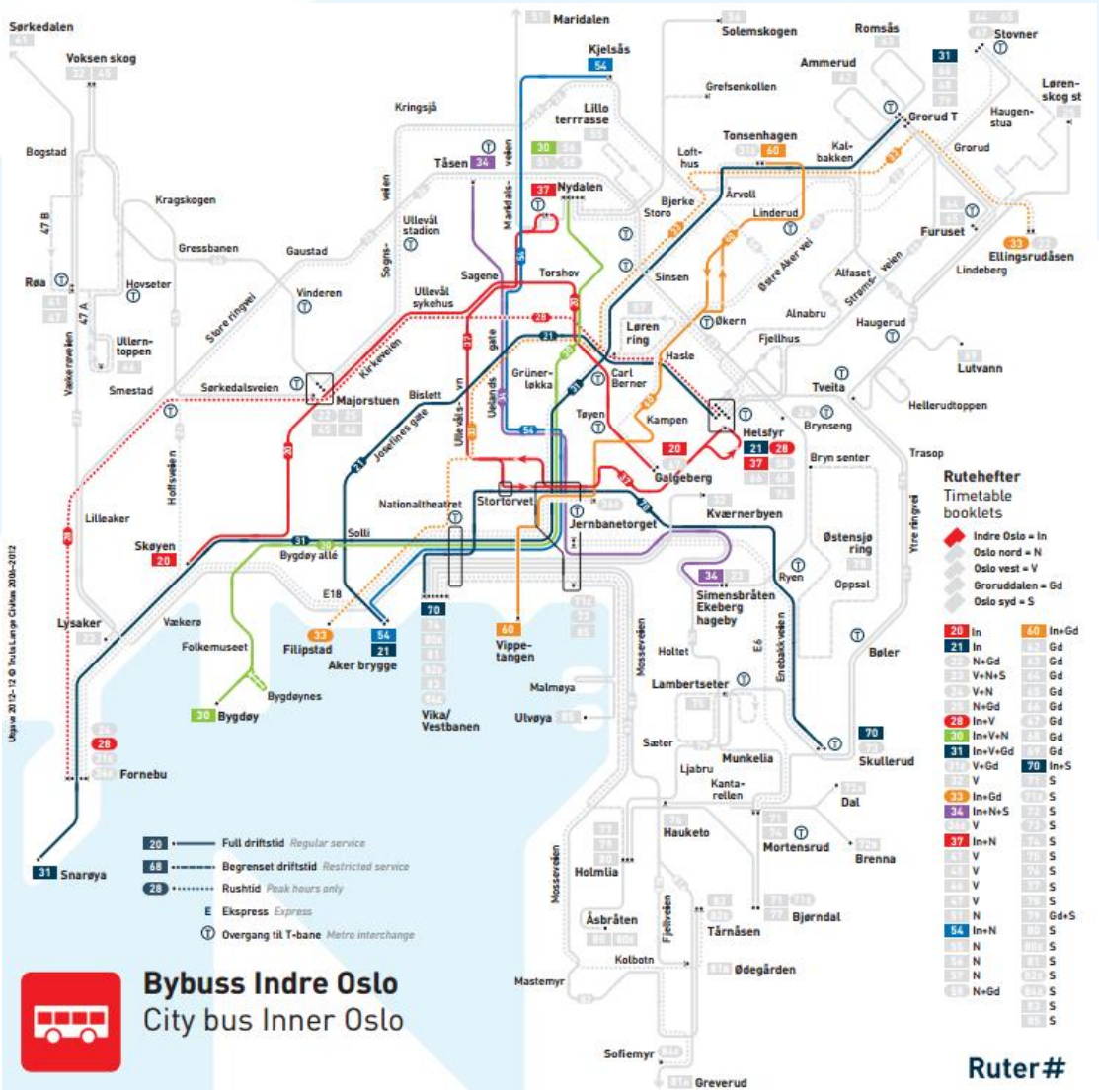
Sensing the city with buses

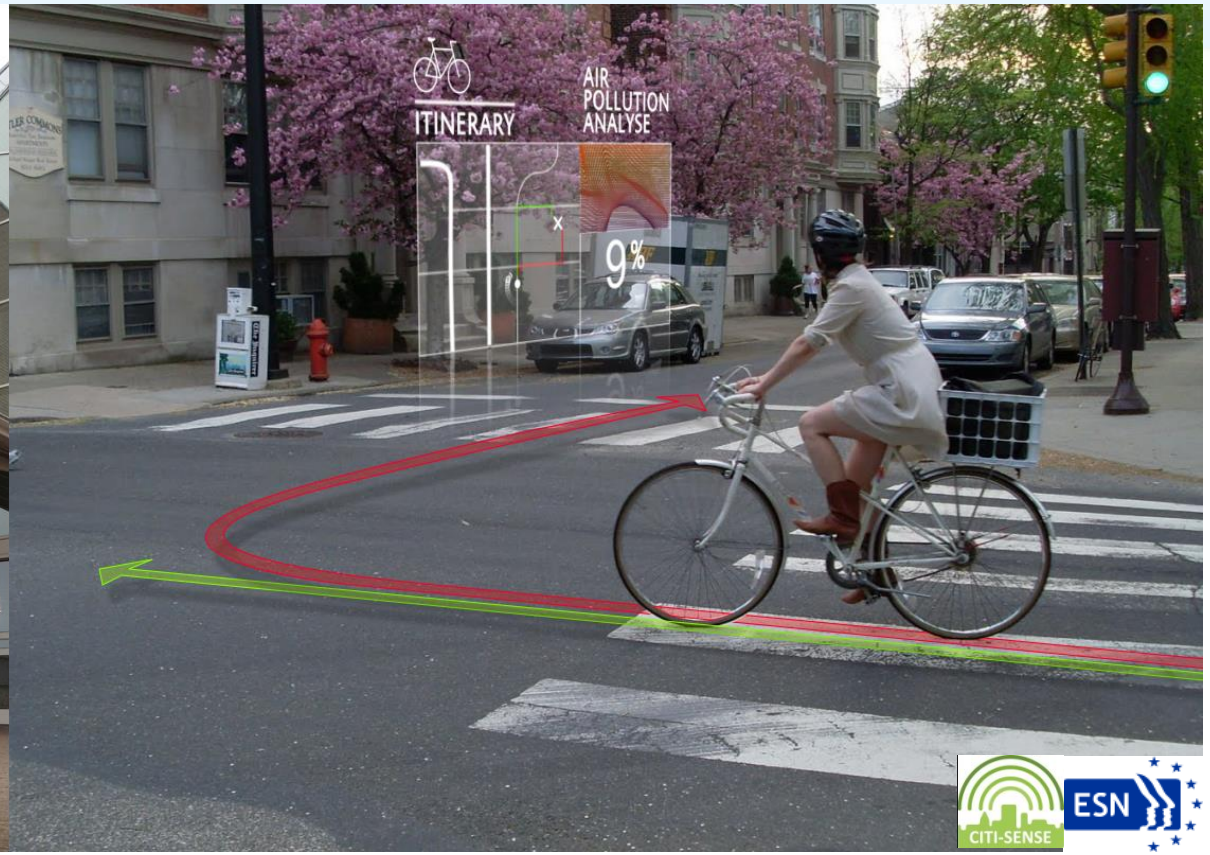
- We will employ “regular” lines
- Lines 20, 21, 31, 37 and 54 are the ones that run with higher frequency.
- 20s: are ring lines that bypass the city center.
- 30s: are radial lines through the city center

Monitoring at the source



Sensing the city with bicycles

We will measure where the people cycle



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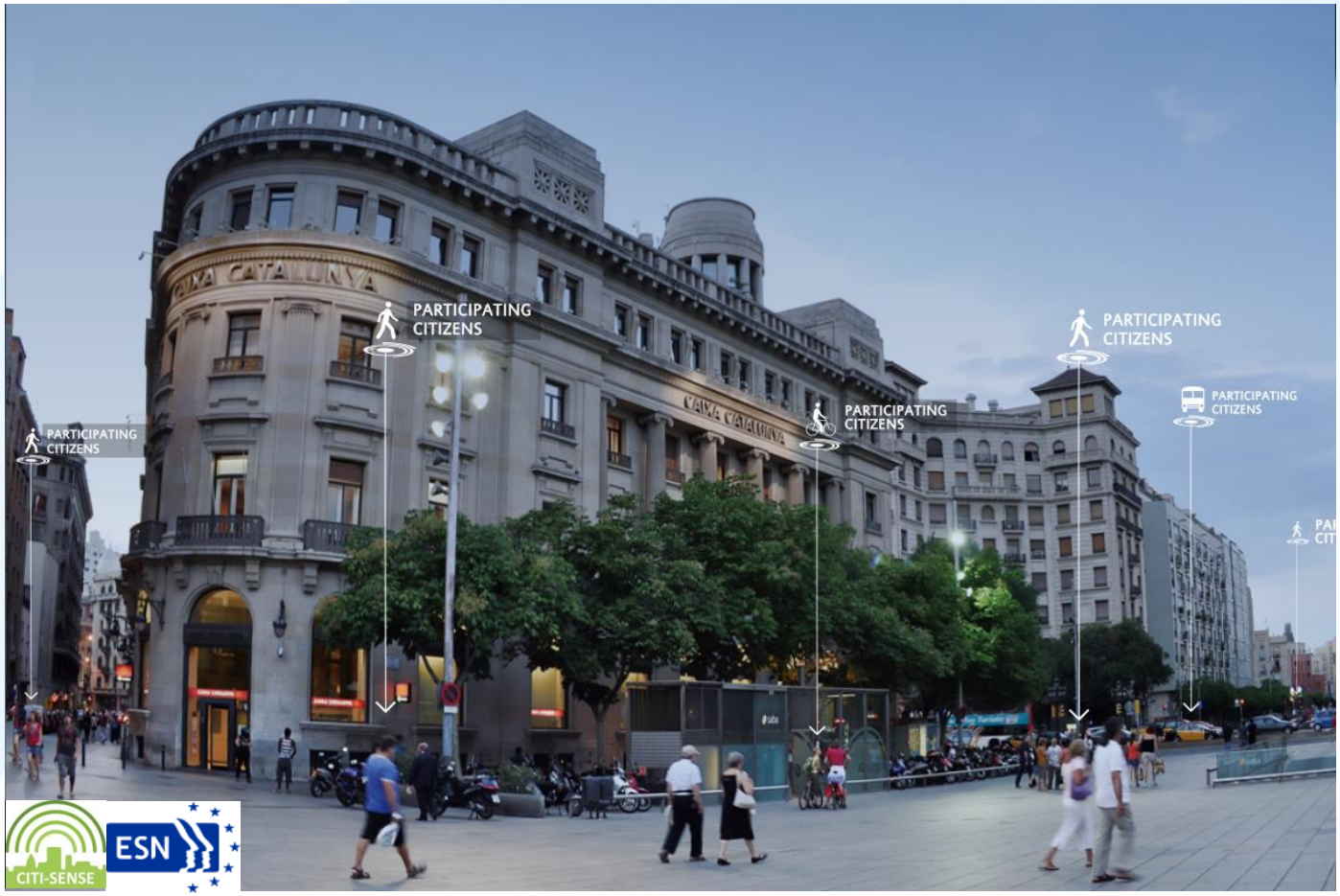
Sensing the city with people

We will measure where the people walk

NO_2+O_3

AQ
Temp

UV



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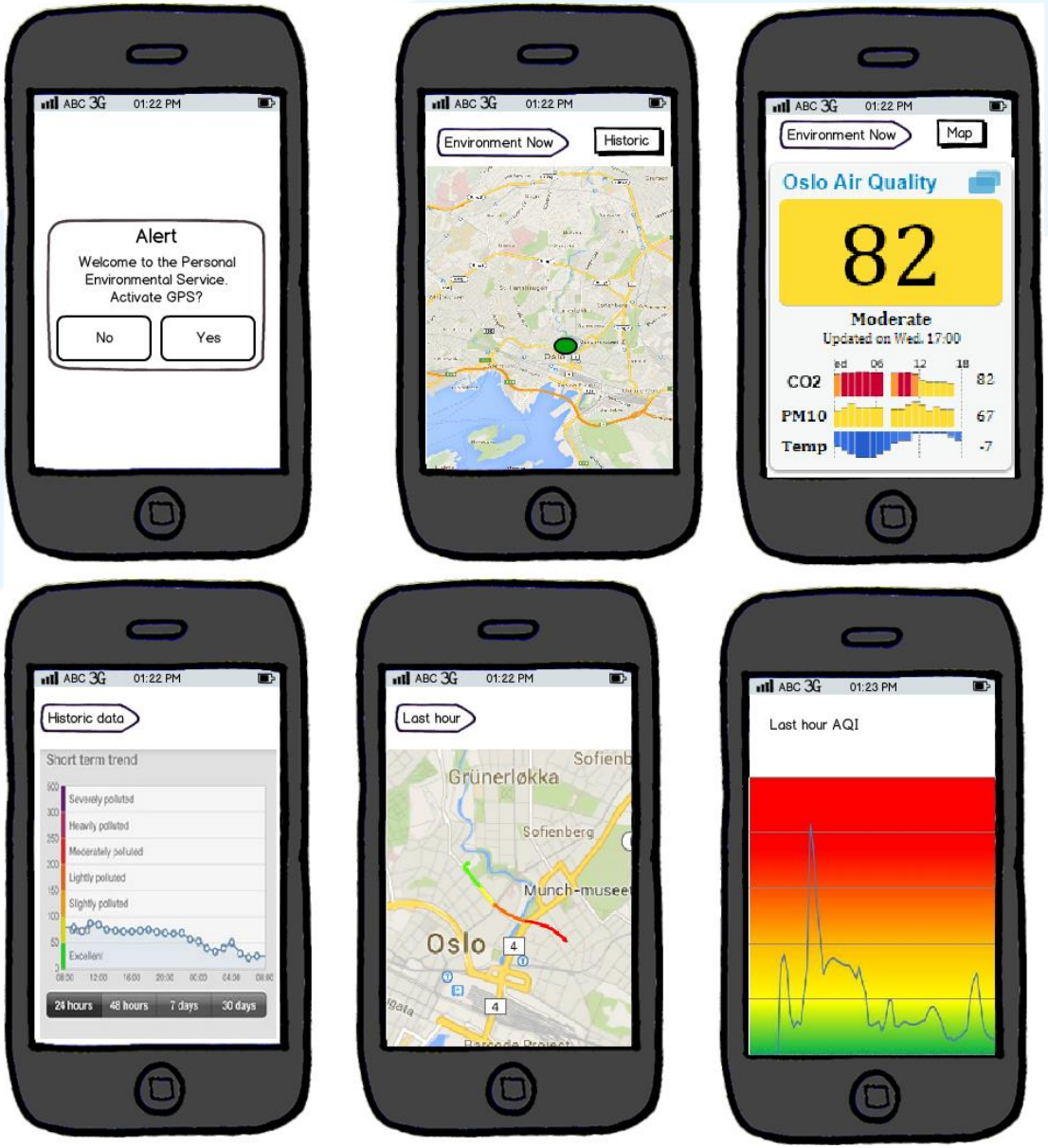
Challenge: Visualizing the data

End-user testing in real-world conditions



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CITI-SENSE: More than outdoor air quality

Indoor AQ in Schools

Users: school admin, school staff and students.

Basis for a screening/monitoring database

Sensors: CO, CO_2, Temp, VOC.

Horten videregående skole

Comfort in Public Spaces

Users: Planning process; citizen's communities

Visual, acoustic and thermal comfort, urban well-being

Sensors: Wind, Temp, UV, Noise, Photos

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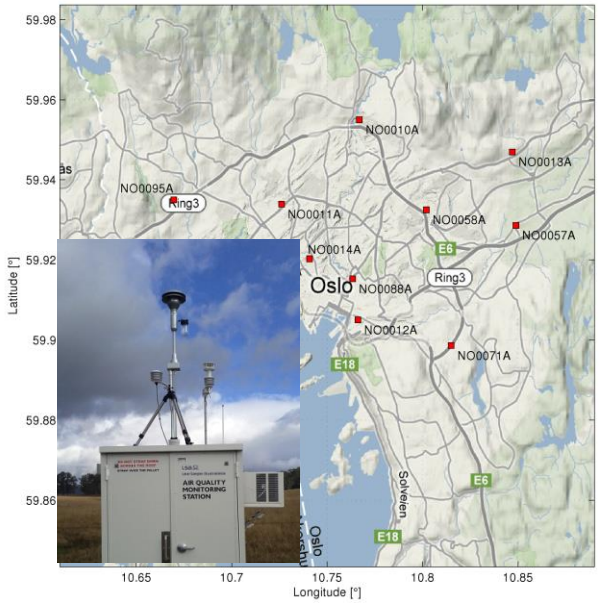
Small, lower-cost sensors bring new challenges but along with these challenges come gigantic opportunities to improve air quality management and public health.

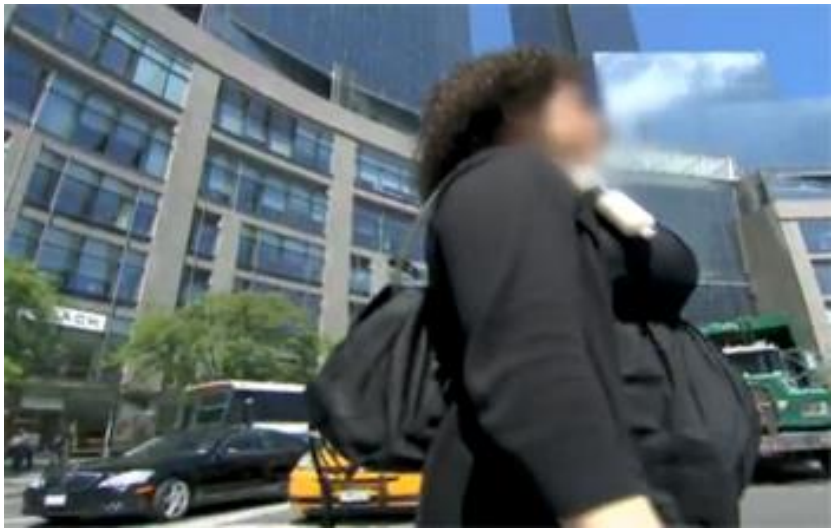
Opportunities



Supplementing routine ambient air monitoring networks

Monitoring personal exposure

Air quality sensors can be coupled with physiological sensors



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Opportunities

Monitoring at the source

Stimulate participation and encourage the dialogue

EUROPEAN GREEN CAPITAL

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Acknowledgements

CITI-SENSE and Citi-Sense-MOB consortium

Oslo Kommune

Ruter

NILU Team

Thank you for your attention

It is not just about making the data public, but also the public making the data

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