European Network on New Sensing Technologies for Air Pollution Control and Environmental Sustainability - *EuNetAir*

COST Action TD1105

4th International Workshop *EuNetAir* on *Innovations and Challenges for Air Quality Control Sensors*

FFG - Austrian Research Promotion Agency - Austrian COST Association

Vienna, Austria, 25 - 26 February 2016

Use of novel sensor technologies in the environmental health and climate change domain

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MC Member and WG Member

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NILU / Norway

COST is supported by the EU Framework Programme

ESF provides the COST Office through a European Commission contract

CITI-SENSE and Citi-Sense-MOB projects

- Development of sensor-based Citizen's Observatories for improving the quality of life in cities
- Collaborative Project funded by FP7
- 27 project partners from Europe, South Korea, and Australia
- Case studies at 9 locations throughout Europe

Citi-Sense-MOB

- Mobile services for environmental and health citizens' observatory
- EMMIA project
- 5 project partners from Norway
- Case study in Oslo

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Air pollution is a major environment-related health threat


Smog in Paris (Author: AFP).

Air pollution and lung cancer incidence in 17 European cohorts: prospective analyses from the European Study of Cohorts for Air Pollution Effects (ESCAPE)

Ole Raaschou-Nielsen, Zorana J Andersen, Rob Beelen, Evangelia Samoli, Massimo Stafoggia, Gudrun Weinmayr, Barbara Hoffmann, Paul Fischer, Mark J Nieuwenhuijsen, Bert Brunekreef, Wei W Xun, Klea Katsouyanni, Konstantina Dimakopoulou, Johan Sommar, Bertil Forsberg, Lars Modig, Anna Oudin, Bente Oftedal, Per E Schwarze, Per Nafstad, Ulf De Faire, Nancy L Pedersen, Claes-Göran Östenson, Laura Fratiglioni, Johanna Penell, Michal Korek, Göran Pershagen, Kirsten T Eriksen, Mette Sørensen, Anne Tjønneland, Thomas Ellermann, Marloes Eeftens, Petra H Peeters, Kees Meliefste, Meng Wang, Bas Bueno-de-Mesquita, Timothy J Key, Kees de Hoogh, Hans Concin, Gabriele Nagel, Alice Vilier, Sara Grioni, Vittorio Krogh, Ming-Yi Tsai, Fulvio Ricceri, Carlotta Sacerdote, Claudia Galassi, Enrica Migliore, Andrea Ranzi, Giulia Cesaroni, Chiara Badaloni, Francesco Forastiere, Ibon Tamayo, Pilar Amiano, Miren Dorronsoro, Antonia Trichopoulou, Christina Bamia, Paolo Vineis, Gerard Hoek**

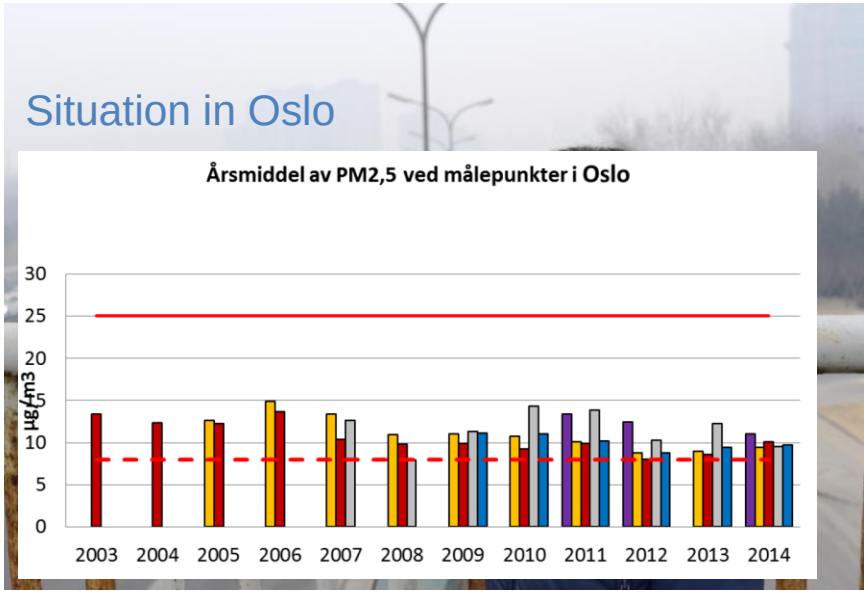
Summary

Background Ambient air pollution is suspected to cause lung cancer. We aimed to assess the association between long-term exposure to ambient air pollution and lung cancer incidence in European populations.

Chronic effects of air pollution on respiratory health in Southern California children: findings from the Southern California Children's Health Study

Zhanghua Chen[1], Muhammad T. Salam[1], Sandrah P. Eckel[2], Carrie V. Breton[1], Frank D. Gilliland[1]

Situation in Oslo



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Reference Air Quality Monitoring

- Very accurate
- Large
- Complex to operate
- High-maintenance
- Expensive
- Very sparse

Bidgee

Satellite Air Quality Monitoring

- Global data coverage
- Large
- Complex to operate
- High-maintenance
- Expensive
- Low resolution

NASA

Low-cost Air Quality Monitoring

- Small
- Easy to operate
- Medium/Low-maintenance
- Ubiquitous monitoring
- Personal monitoring

New services

- Air quality where you are
- High-resolution maps
- Personalized information

Eivind

Implementation

Ruter#

Nobina

Public & Private Sectors

Sensor platform
NO_2, NO, CO, O_3,
PM_{10}, $PM_{2.5}$, RH, T, Noise

GNSS

Data Services
Processing raw data, fusion, modelling

Cloud services

Data storage

User services

Data providers

VGI

AQ Models

Traffic situation

Citizen Participation
Participatory Governance through Social Media

Citizens
Special Interest Groups

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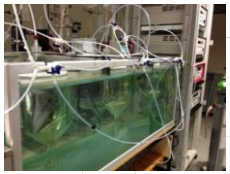
AQMesh performance evaluation



24 AQMesh platforms field co-location results
13 April to 24 June 2015

R^2	NO2	O3	NO	CO
688150	0.42	**0.65**	**0.92**	0.34
712150	0.31	0.3	**0.78**	0.36
715150	0.13	0.27	**0.91**	0.41
718150	0.24	**0.53**	**0.62**	0.32
733150	0.23	0.15	**0.93**	0.38
737150	0.23	**0.57**	**0.94**	0.34
743150	0.16	**0.5**	**0.95**	0.41
744150	0.35	0.048	**0.86**	0.27
746150	0.21	**0.6**	**0.68**	0.39
750150	0.22	**0.61**	**0.87**	0.42
755150	0.29	**0.49**	**0.84**	0.39
756150	0.13	0.23	**0.94**	0.37
764150	0.045	0.0088	**0.95**	0.39
785150	0.28	0.19	0.36	0.25
828150	0.062	0.16	**0.75**	0.35
846150	**0.51**	0.24	**0.63**	**0.45**
849150	0.3	0.3	**0.75**	0.34
850150	0.38	0.26	**0.53**	0.43
855150	0.32	0.29	0.41	0.22
856150	0.37	0.27	**0.55**	0.35
861150	0.28	**0.49**	**0.73**	0.35
862150	0.28	0.3	**0.67**	0.34
863150	0.18	0.31	**0.74**	0.36
864150	0.091	0.1	**0.74**	0.43

In bold $r^2 \geq 0.5$

$R^2 > 0.5$

NO_2: 1 unit
O_3: 8 units
NO: 22 units
CO: 1 unit

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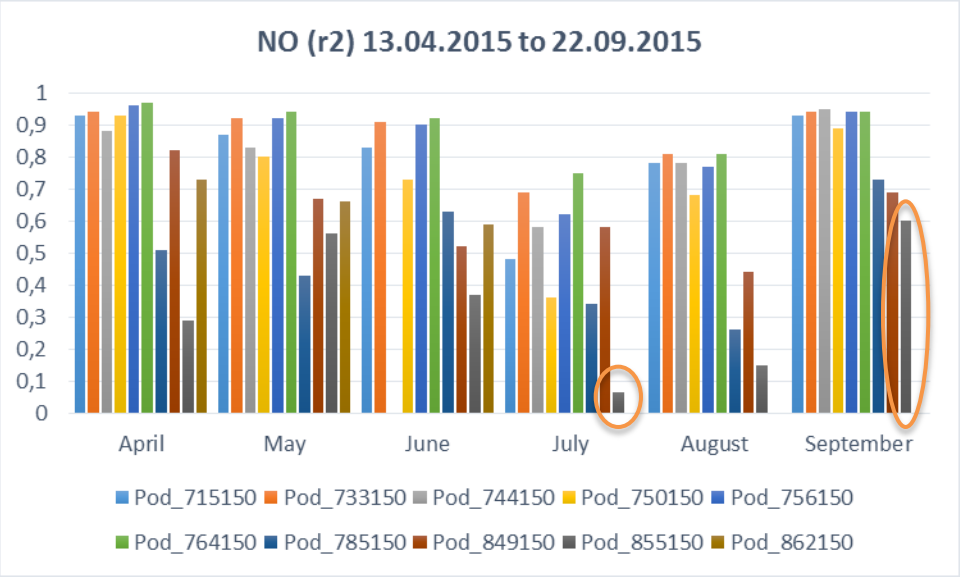
AQMesh performance evaluation: variability

The performance of the sensors varies with:

1. The location (background / traffic).
    - Lower performance in background stations for NO.
    - Improved performance in background stations for PM10 and PM2.5
2. The meteorological conditions
    - Variation month to month in r^2, gradient and offset

Monthly variation r^2 for NO



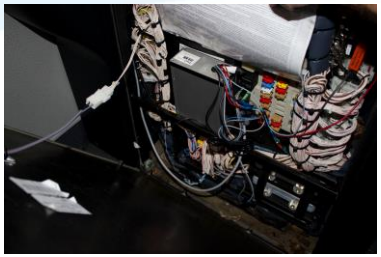
Sensors mounted on buses

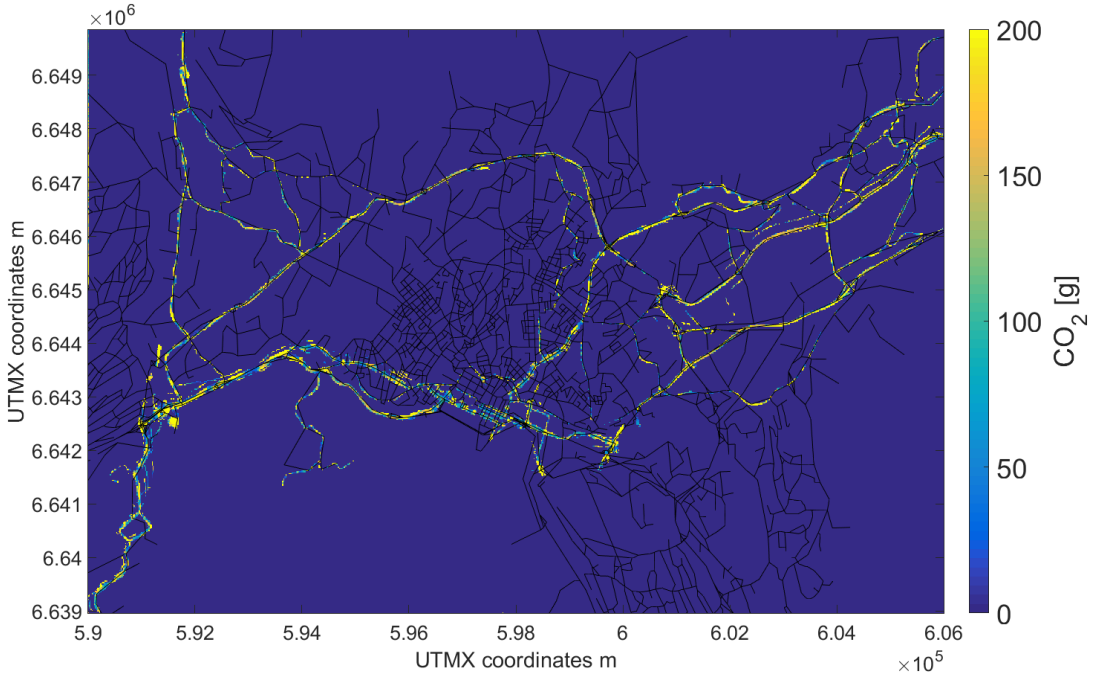
Air Quality Platform

- NO_2 and CO
- Internal T and RH
- Time Stamp

On Board System

- Speed and fuel consumption
- GPS
- Time Stamp





High-resolution CO_2 emission maps

Sensors mounted on bikes, strollers, backpacks

CairSense
- NO_2/O_3
- Time stamp

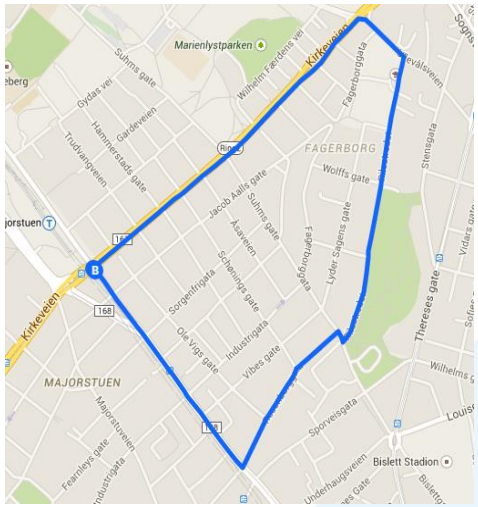
DunavNET
- NO_2, NO, O_3
- Time stamp
- GPS

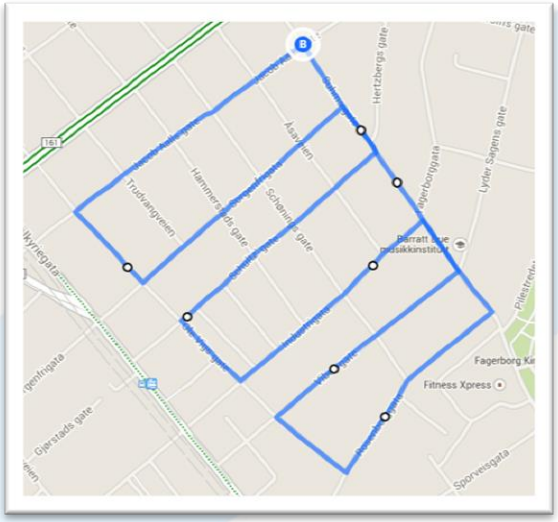
Ateknea
- NO_2, NO, O_3
- Time stamp
- GPS (Bluetooth)

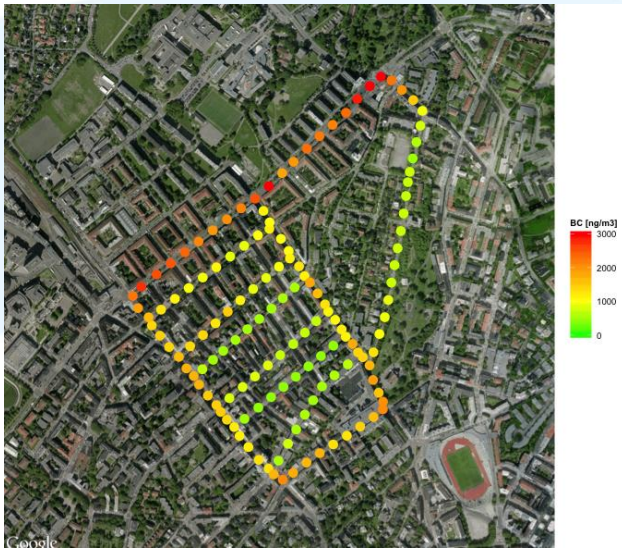
TSI Dusttrack
- PM10, PM2.5
- Time stamp

microAeth AE51
- Black Carbon
- Time stamp

Mapping air pollution with mobile sensors

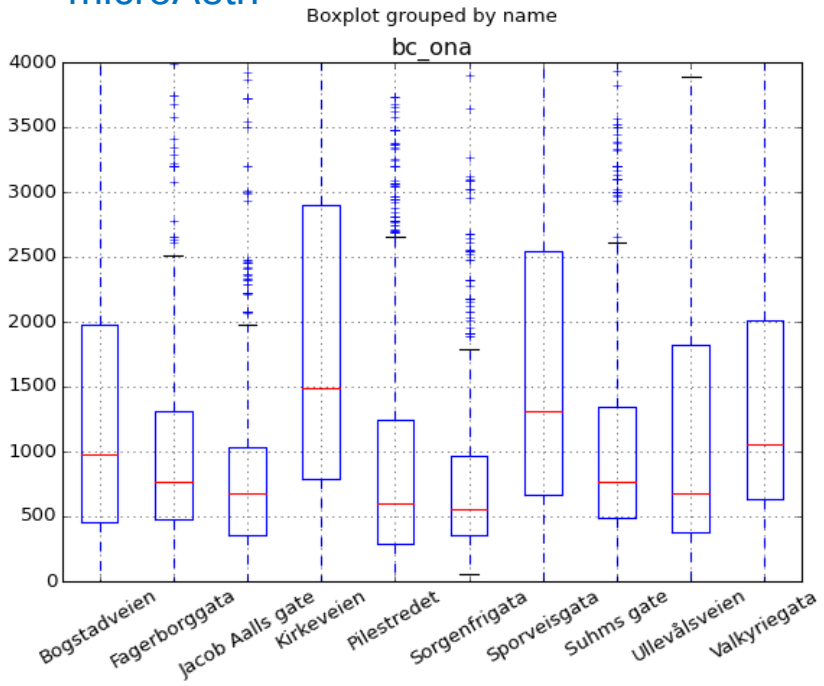




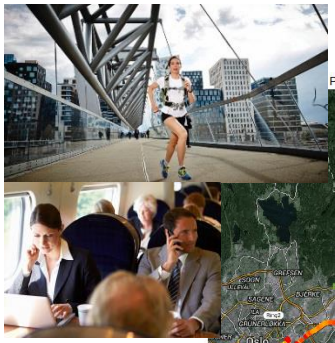


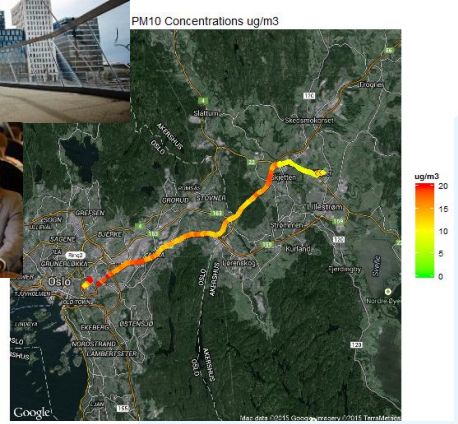
AQ e-bike: DunavNET

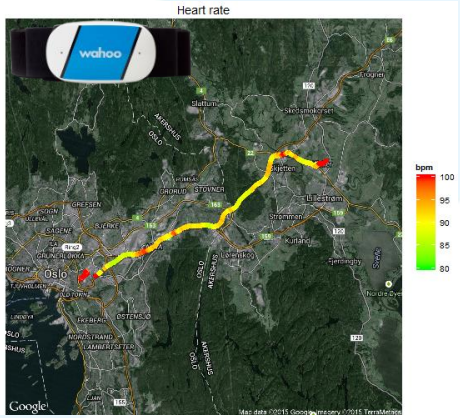
microAeth



Personal exposure estimates







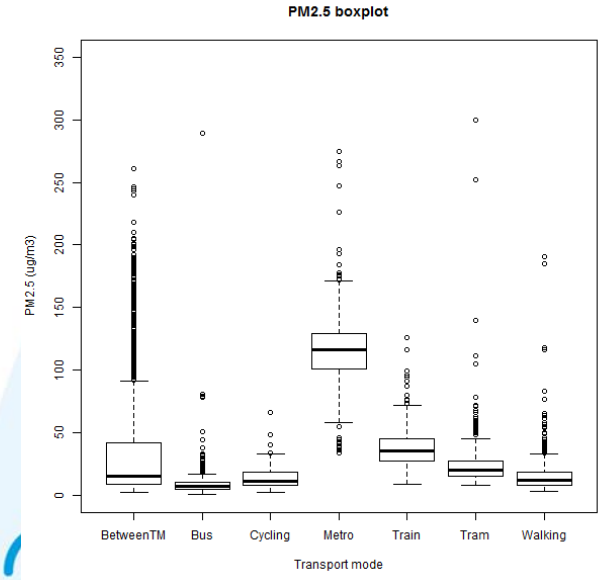
Personal exposure

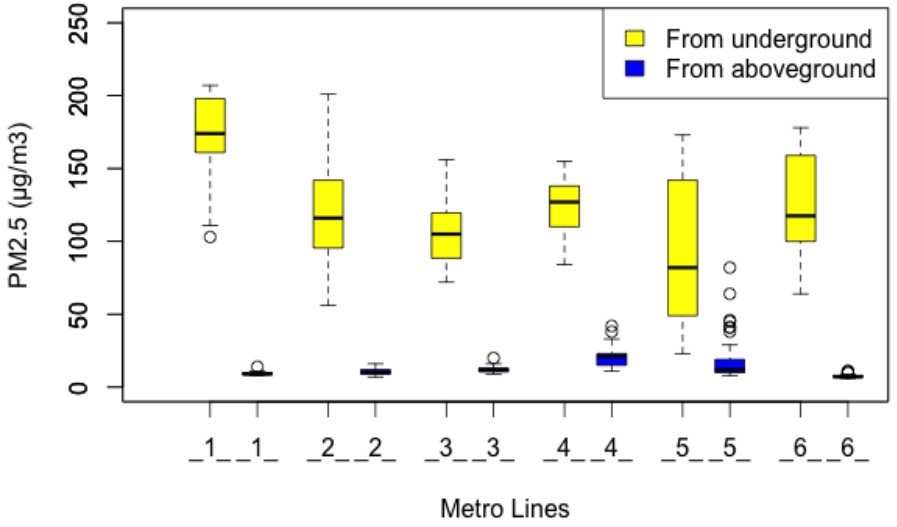
Wearable sensors + Smartphone

The data collected by the sensor is combined with GPS data to estimate exposure

+Heart rate monitor

Inhaled dose can be estimated if we know the subject's heart rate





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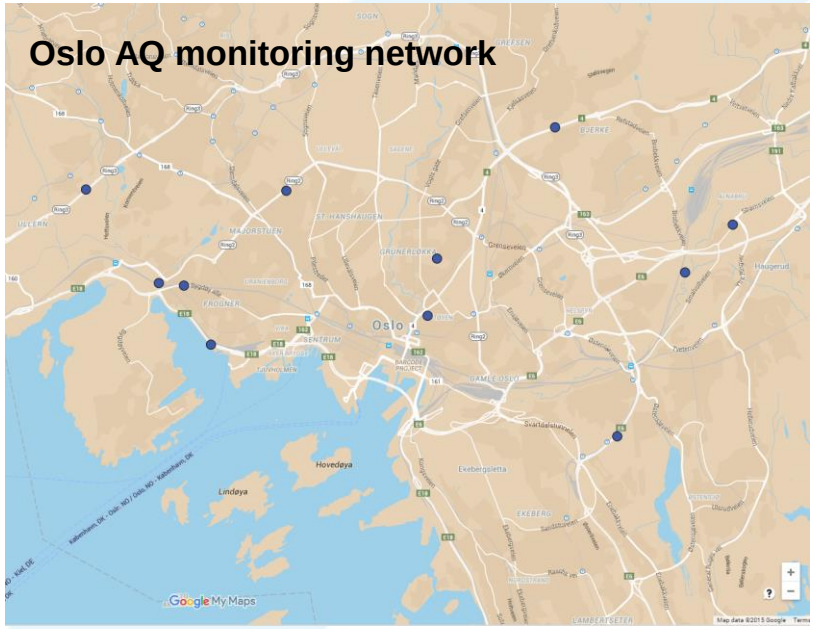
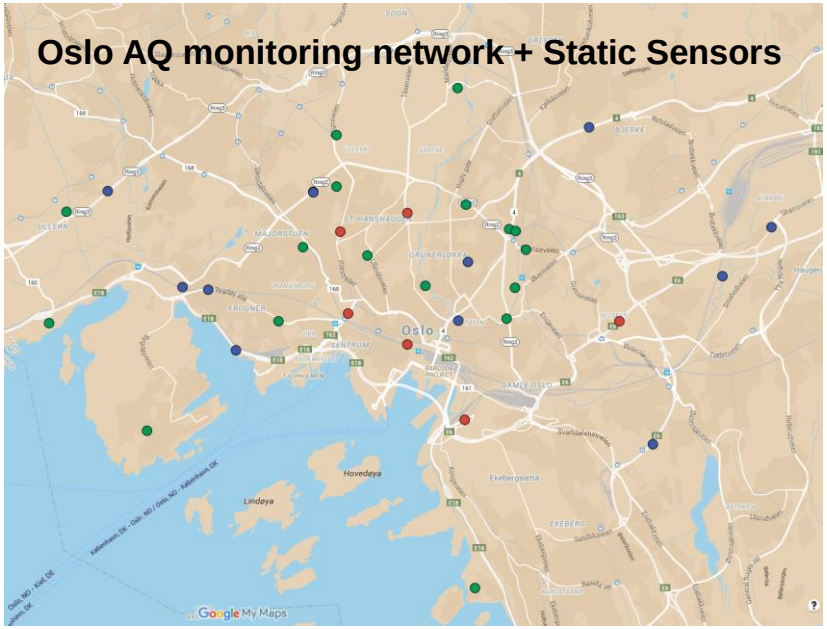
Sensors mounted in kindergartens

AQMesh Sensor

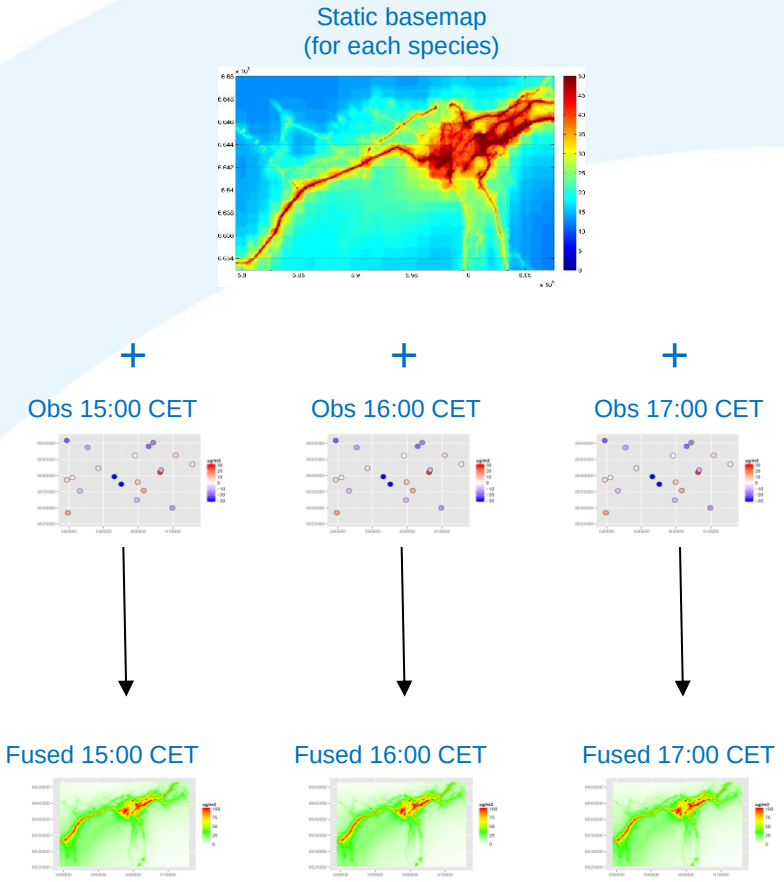
- NO, NO_2, O_3, CO, OPC (PM_{10}, $PM_{2.5}$)
- Noise
- Temperature, Pressure, RH
- Time Stamp





Mapping of urban AQ: data fusion model + sensor

- A static basemap is created for each location and each species of interest to show the long-term spatial patterns
- This basemap is then modified according to the observations made by the static AQMesh sensors
- This is essentially a location-dependent level-shift of the basemap
- The final result are hourly maps with the current best guess for the NO_2/PM_{10}/$PM_{2.5}$ concentration field



Basemap: Provides information about general spatial patterns

AQMesh observations: Provide information about current state of atmosphere at a few sampling locations

Fused map: Value-added product providing a best guess of current state of atmosphere for the entire domain

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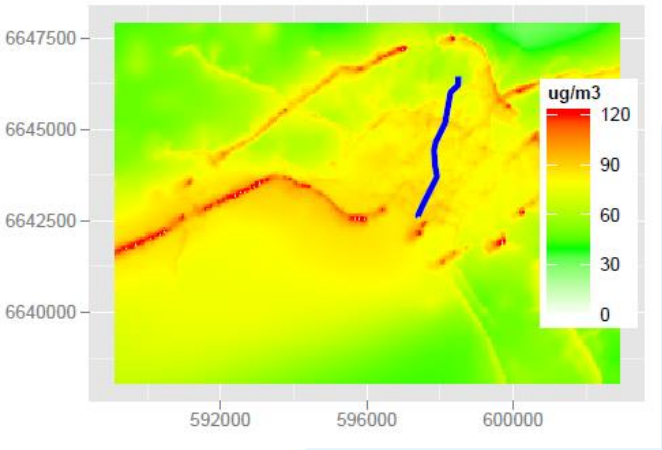
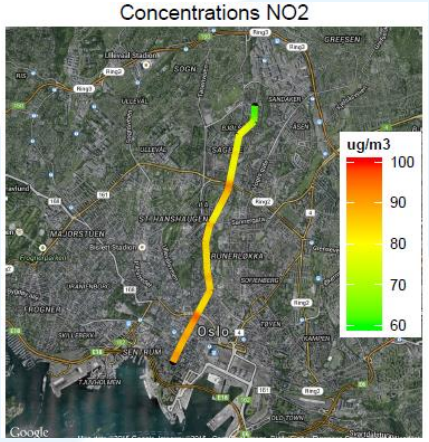
Indirect personal exposure estimates

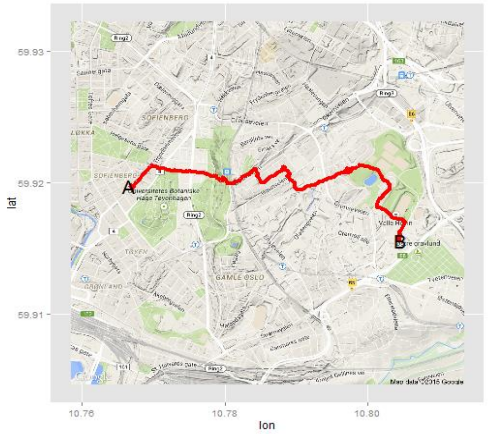


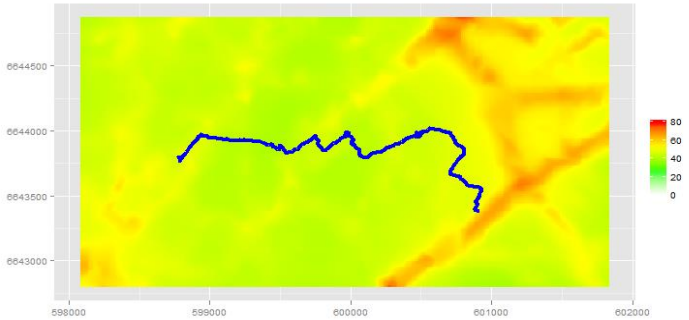


The concentrations are extracted from the up-to-date concentration map and combined with GPS data (i.e. from mobile phone).

Inhaled dose can also be estimated if the subject is carrying a heart rate monitor

User can also plan routes and obtain the concentration along that route.





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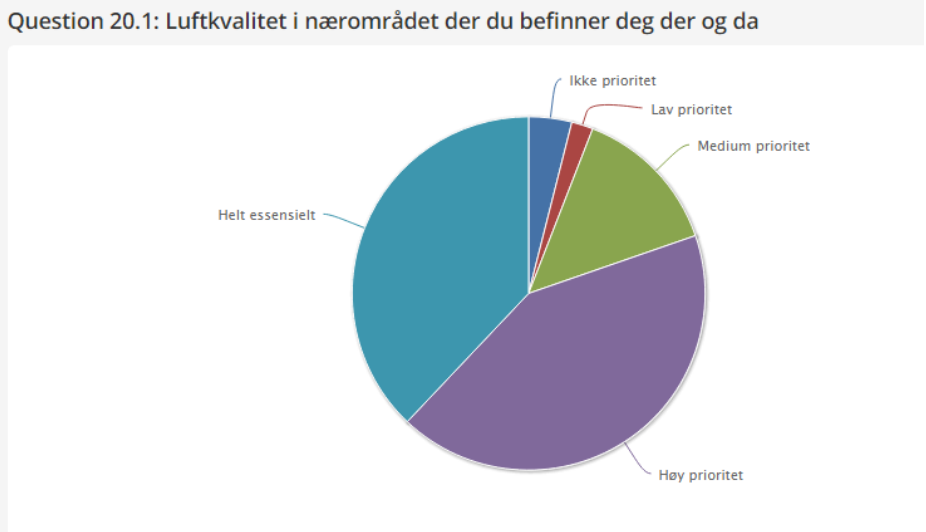
Conclusions

- Crowdsourcing and low-cost sensor technologies systems offer the possibility to enhance existing monitoring networks.
- Data fusion techniques provide an automated, operational, near-real-time system for mapping the observations onto a spatial grid.
- Wearable air quality sensors have potential to provide personal exposure/dose estimates.
- Challenges include precision and accuracy of the low-cost sensors measurements.

- People is interested in receiving air quality information where they are!

- Low-cost sensors offer the possibility to engage citizens in AQ monitoring and contribute to create more awareness about air pollution issues.



Results from the survey on AQ Perception.

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Thank you for your attention

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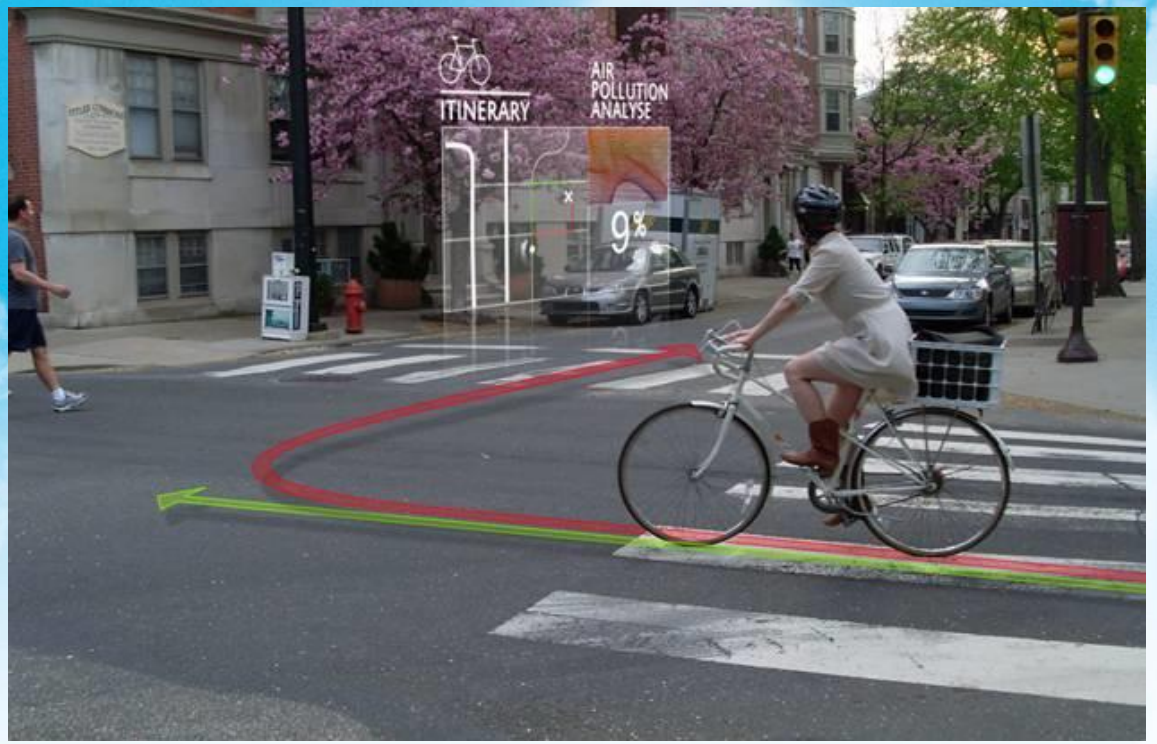

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