

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

COST Action TD1105

WGs and MC Meeting at ISTANBUL, 3-5 December 2014

Action Start date: 01/07/2012 - Action End date: 30/06/2016

Year 3: 1 July 2014 - 30 June 2015 (*Ongoing Action*)

COMPARISON OF LOW COST SENSORS AND REFERENCE EQUIPMENT IN LABORATORY AND IN REAL-WORLD. FIRST EXPERIENCES IN OSLO, NORWAY



Nuria Castell

WG3 Member, Sub-WG3 Leader and MC Member

NILU / Norway



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Nuria Castell and Philipp Schneider
(ncb@nilu.no, ps@nilu.no)



Norsk institutt for luftforskning
Norwegian Institute for Air Research



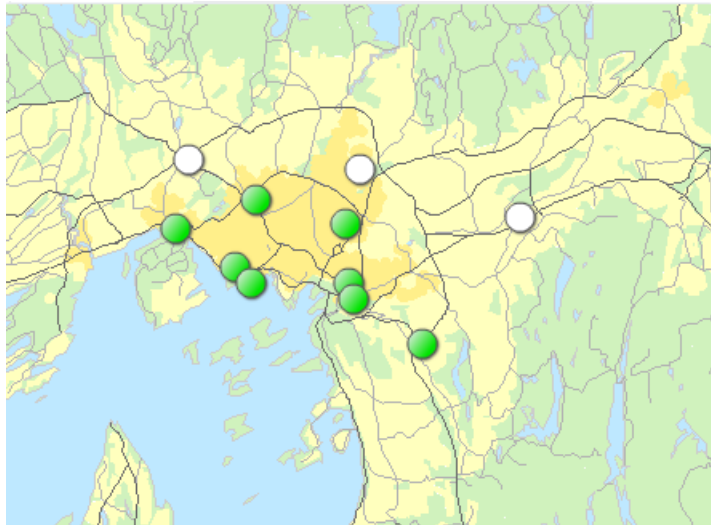
Our vision

Important problems:

Quality of life in cities
Health effects from traffic pollution

Decreasing air pollution
Increasing quality of life

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

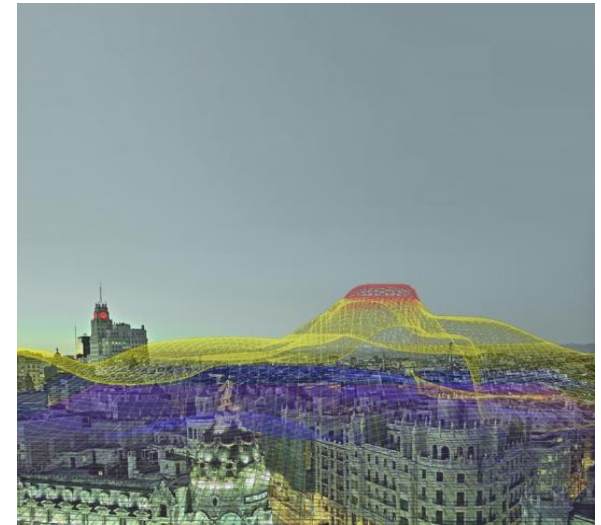
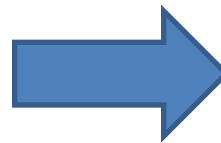


Opportunities and challenges:

Small, low-cost sensors
Information and Communication Tech.

Participatory Urbanism
Citizens' Empowerment

Increased spatial coverage
Complementary air quality data
Personalized data

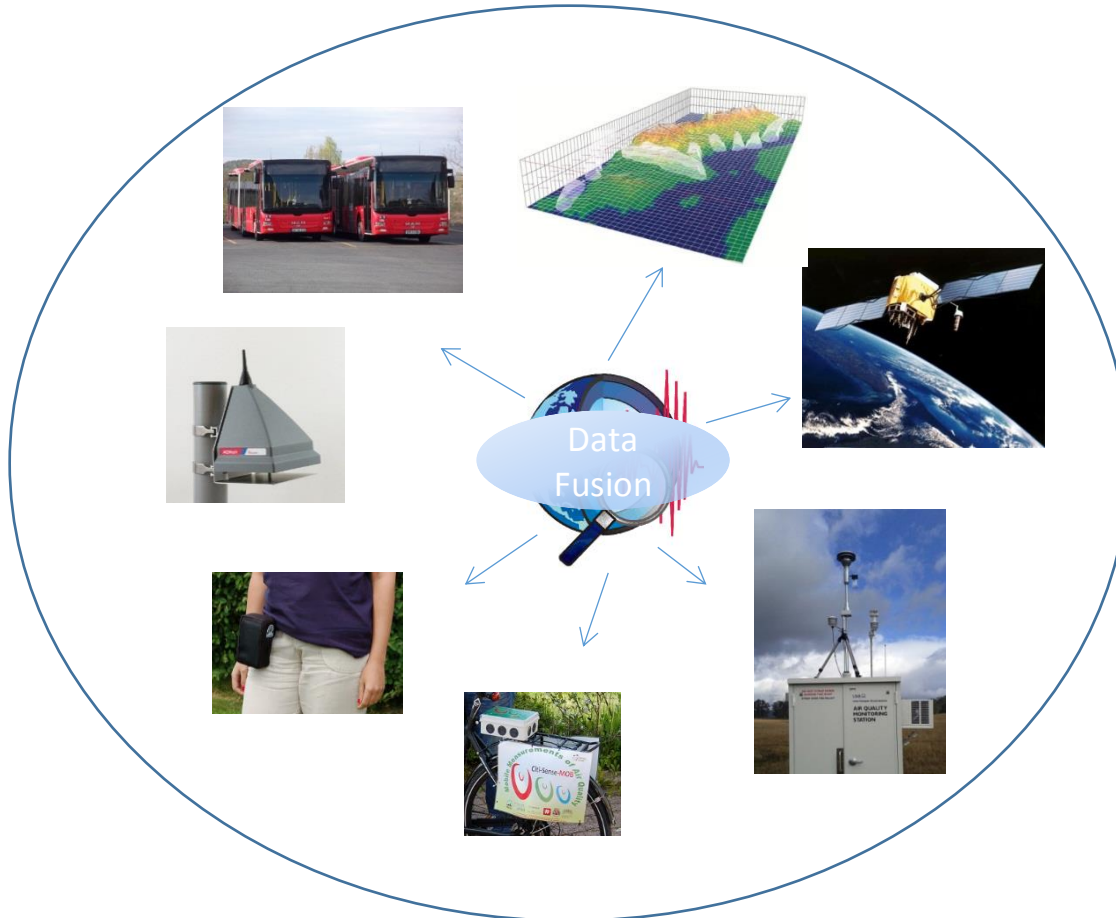


Our approach

Innovative technology to continuously sense, measure and communicate environmental data



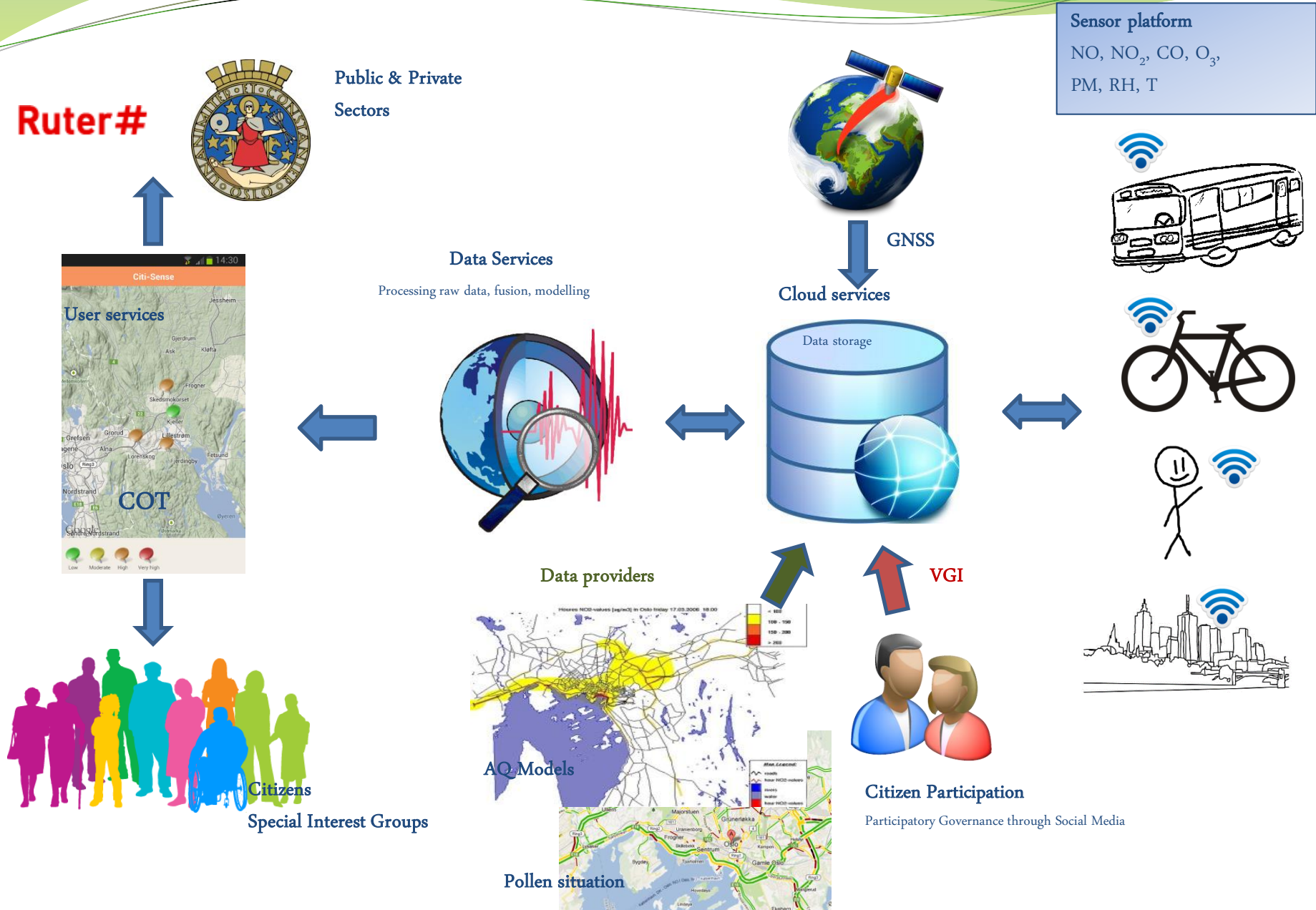
Real-time city management
Citizen participation / empowerment
Data where *you* are



Data visualization



How are we going to implement it?



Sensor platforms employed



Ateknea PSP (On person)

130 x 75 x 50 mm
300 gr
Bluetooth



Dunavnet EB700 (On bikes)

225 x 150 x 100 mm
500 gr
GPRS

Environmental Parameters

CO, NO₂, O₃, temperature, humidity

Power consumption

3.7V LiPo 1300mAh, battery life about 24 hrs

Environmental Parameters

CO, CO₂, NO, NO₂, O₃, SO₂, pressure, temperature, humidity

Power consumption

External supply of 8-28V DC



ADN & IA Cated NanoEnvi (On buses)

150 x 140 x 100 mm &
500 x 390 x 190 mm
GPRS



GeoTech AQMesh (Static sensors)

170 x 180 x 140 mm
2000 gr
GPRS

Environmental Parameters

CO, NO₂, Temperature and humidity

Power consumption

External supply of 12-24V DC

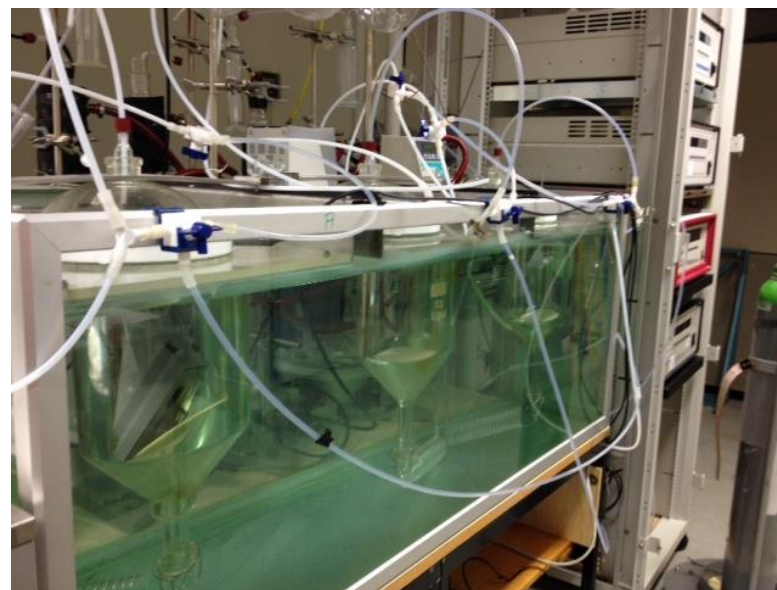
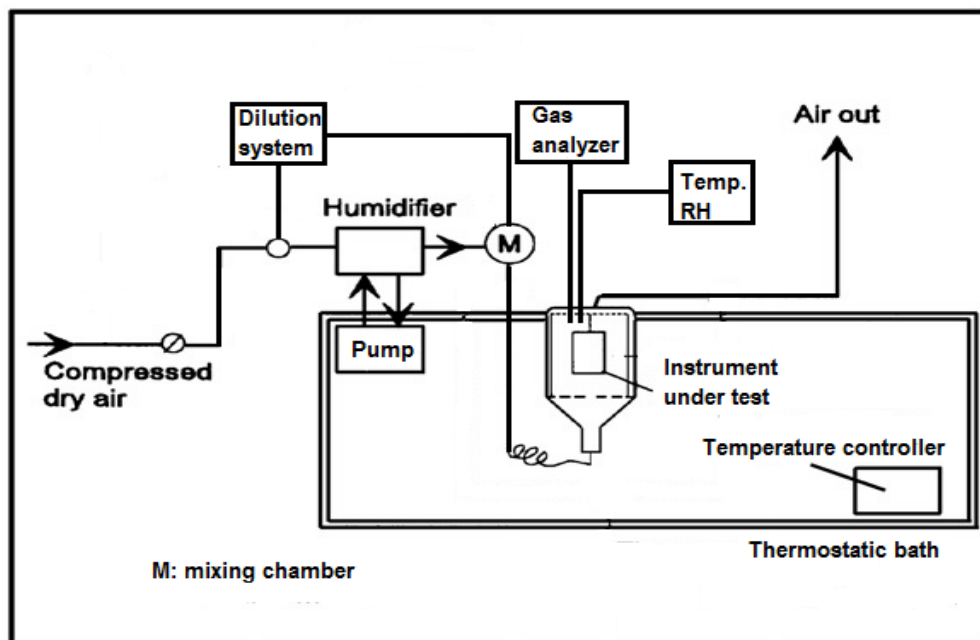
Environmental Parameters

CO, NO, NO₂, O₃, Pressure, Temperature, Humidity

Power consumption

Lithium battery, battery life about 1 year (transmission 15min)

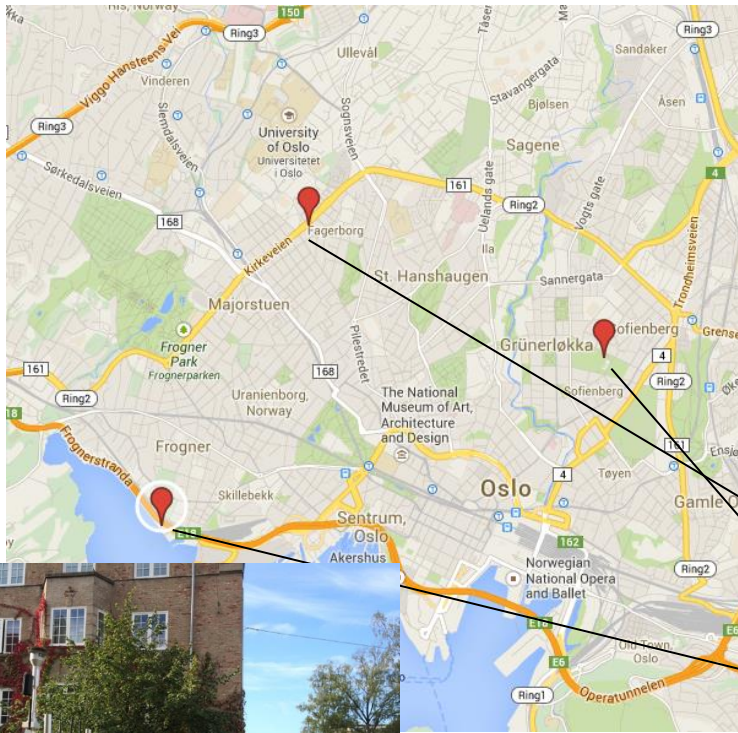
Performance in laboratory



Instrument type	Instrument	Measurement principle
O ₃ analyzer	Teledyne API 400	UV photometry
SO ₂ analyser	Teledyne API 100A	UV fluorescence
CO analyzer	Teledyne API 300E	IR absorption, GFC
NO _x analyzer	ML 9841A	Chemiluminescence
Temperature sensor	Rotronic Hygroclip2-S	Pt100
RH sensor	Rotronic Hygroclip2-S	Hygromer sensor
Dilution system	EnviroNics Series 100	Dilution by MFCs

Performance in real-world conditions

- 5 static units were tested co-located with air quality monitoring stations.



From	To	Station
13/02/2014	03/06/2014	Kirkeveien
04/06/2014	20/06/2014	Sofienberg
25/06/2014	03/09/2014	Hjortnes
15/09/2014	now	Kirkeveien

Station	Parameters
Kirkeveien	PM10, PM2.5, NO, NO ₂ , NO _x , CO
Sofienberg	PM10, PM2.5
Hjortnes	PM10, PM2.5, NO, NO ₂ , NO _x

Description of the sites



Kirkeveien

High traffic (ADT:20200)

High residential

Altitude: 58m



Sofienberg

Urban background (ADT:0)

Urban green area

Altitude: 23 m



Hjortnes

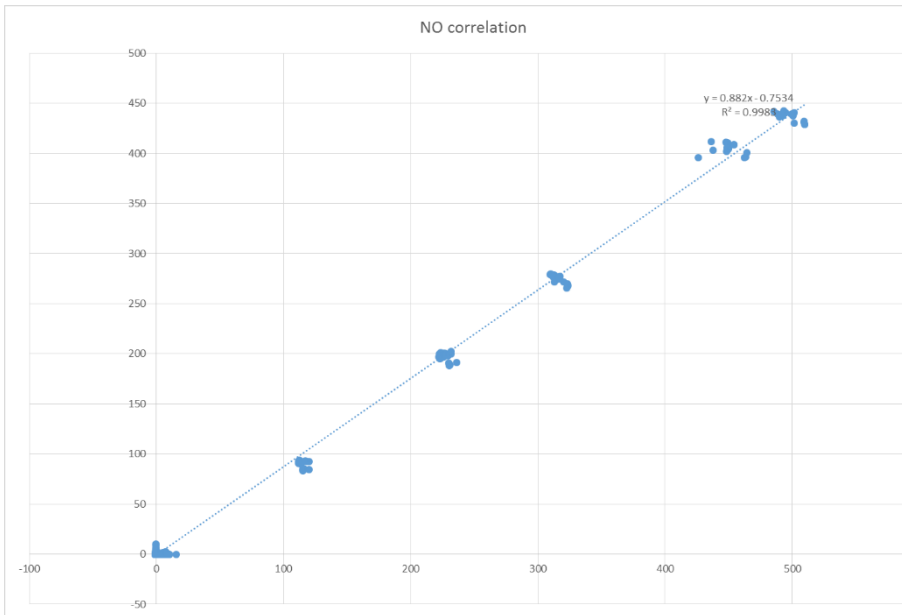
Super traffic(ADT:73100)

Commercial, High residential

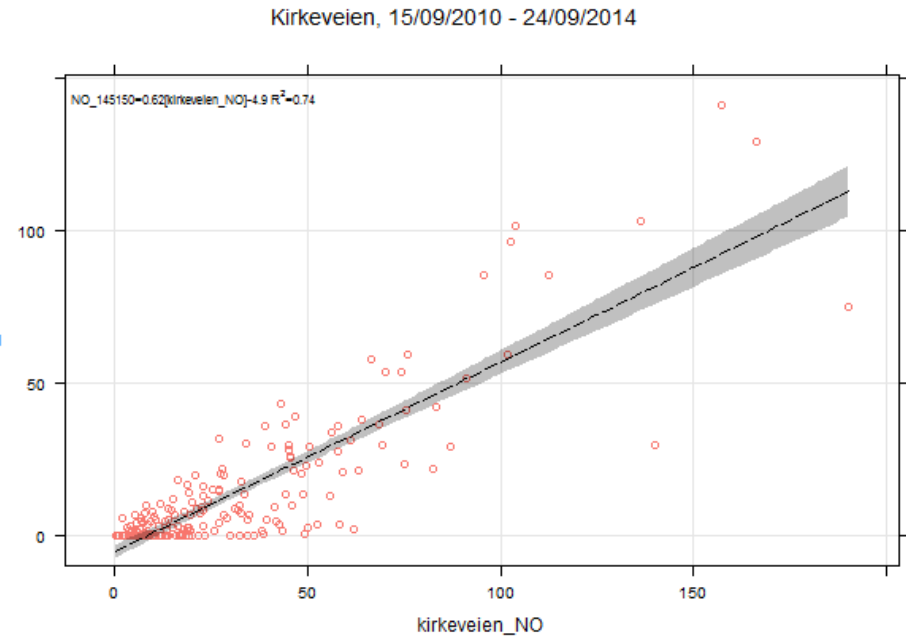
Close to harbour

Altitude: 3 m

Performance static platform: NO



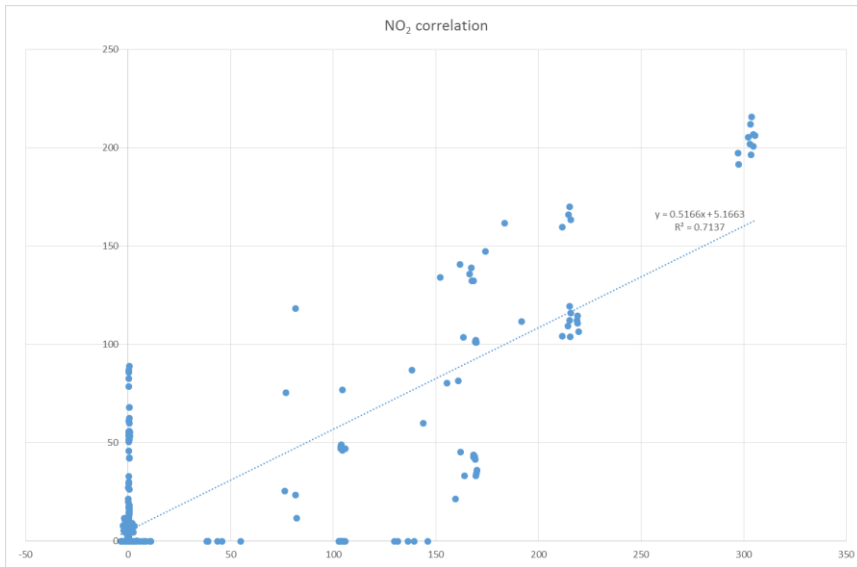
Laboratory
 $y = 0.882x - 0.7534$
 $R^2 = 0.9983$



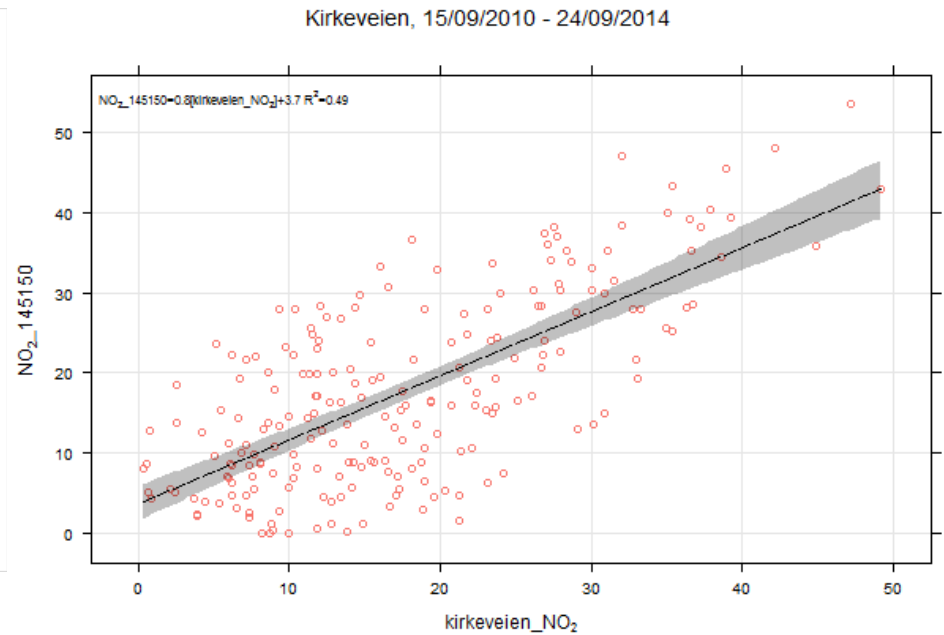
Field
 $y = 0.62x - 4.9$
 $R^2 = 0.74$

MB: -16 ppb
RMSE: 23 ppb
R (pearson): 0.86

Performance static platform: NO₂



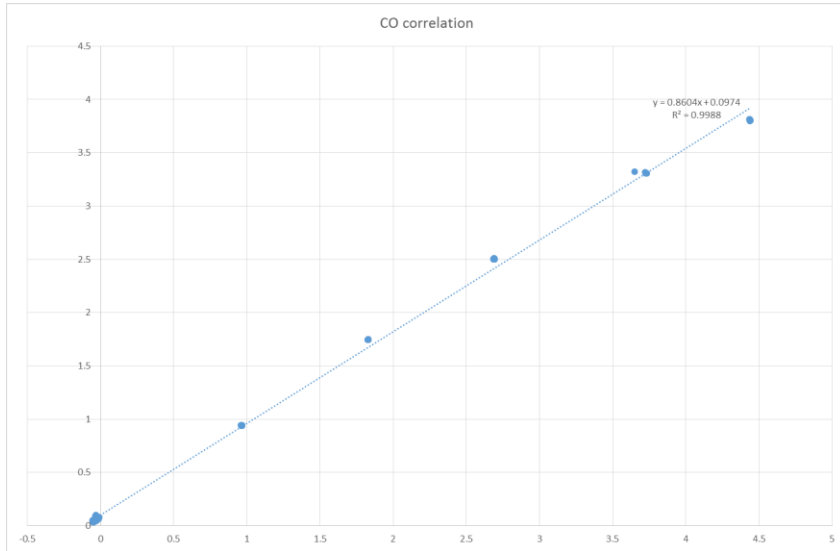
Laboratory
 $y = 0.5166x + 5.1663$
 $R^2 = 0.7137$



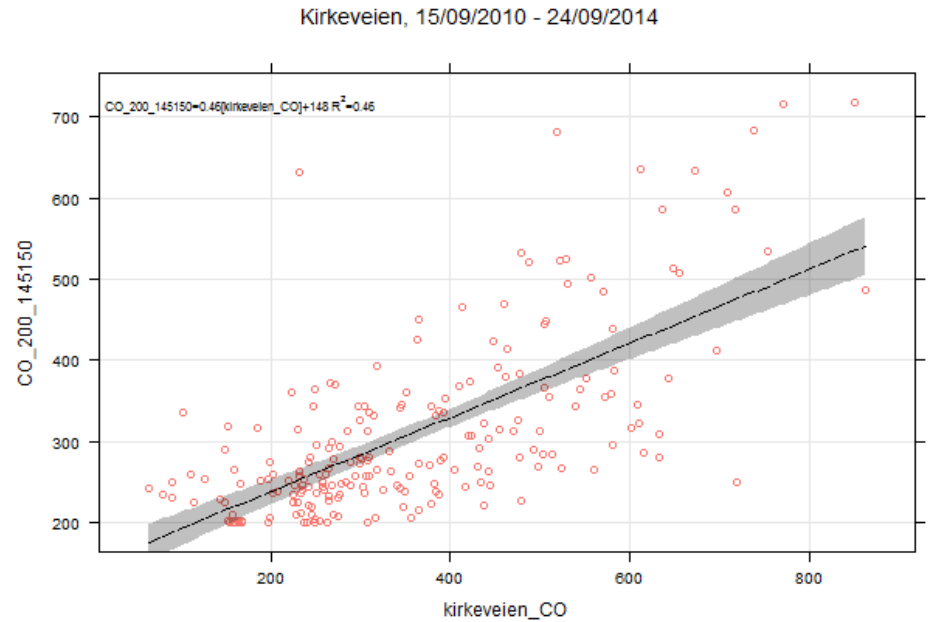
Field
 $y = 0.8x + 3.7$
 $R^2 = 0.49$

MB: 0.15 ppb
RMSE: 8.5 ppb
R (pearson): 0.70

Performance static platform: CO



Laboratory
 $y = 0.8604x + 0.0974$
 $R^2 = 0.9988$

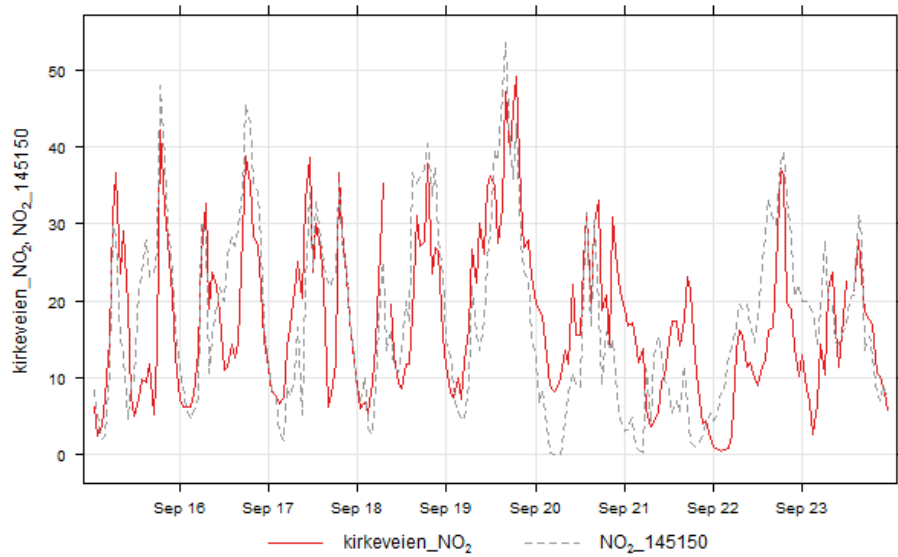


Field
 $y = 0.46x + 148$
 $R^2 = 0.46$

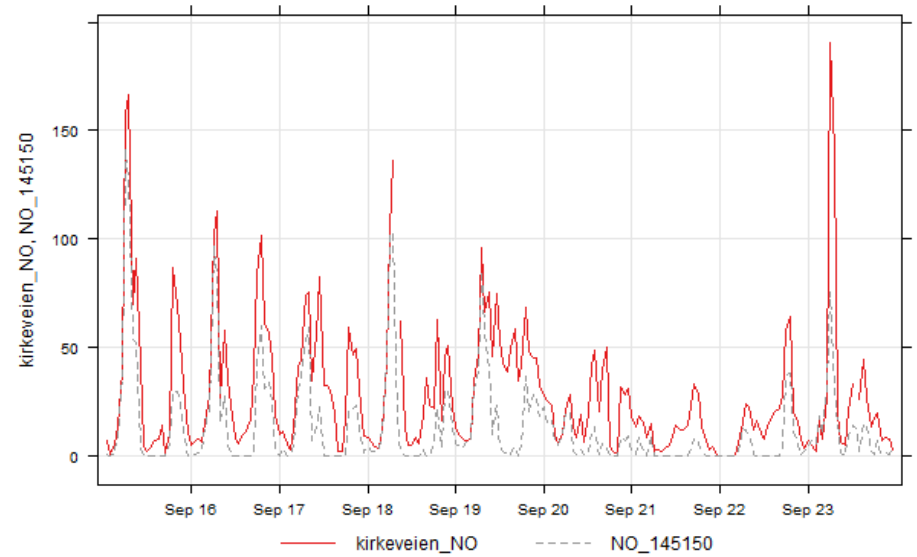
MB: -47.98 ppb
RMSE: 128.47 ppb
R (pearson): 0.68

Co-location hourly time plots

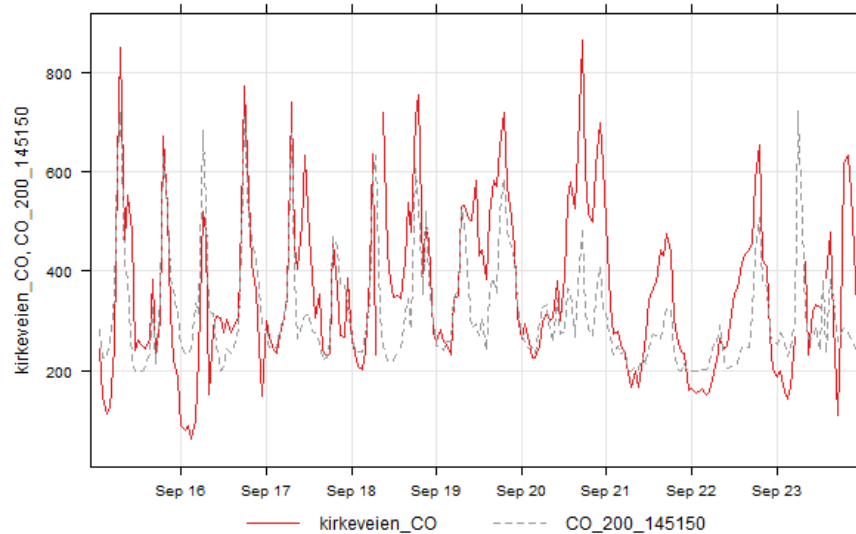
Kirkeveien, 15/09/2010 - 24/09/2014



Kirkeveien, 15/09/2010 - 24/09/2014



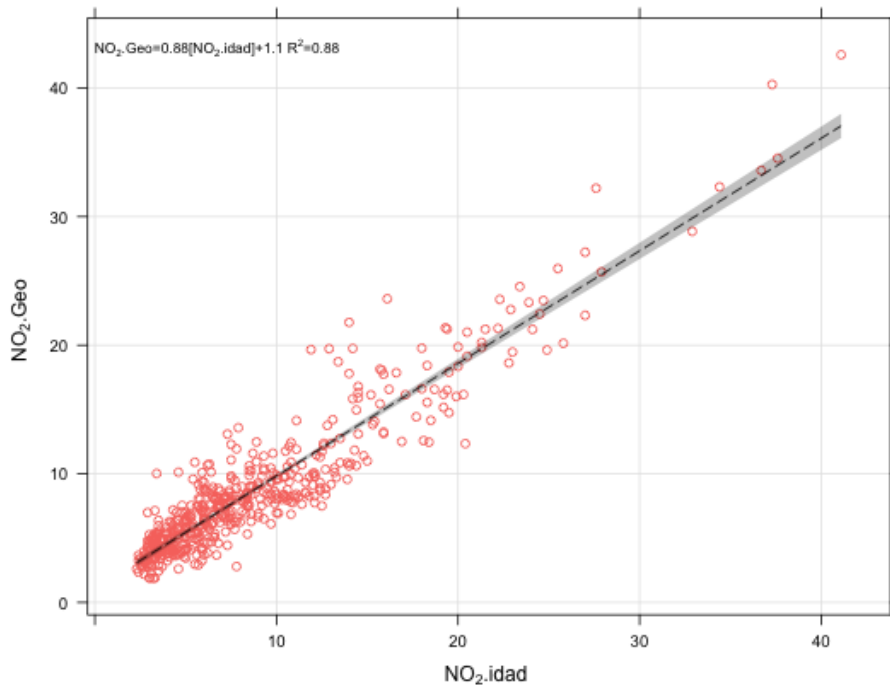
Kirkeveien, 15/09/2010 - 24/09/2014



First results from new Alphasense NO₂ and O₃ sensors

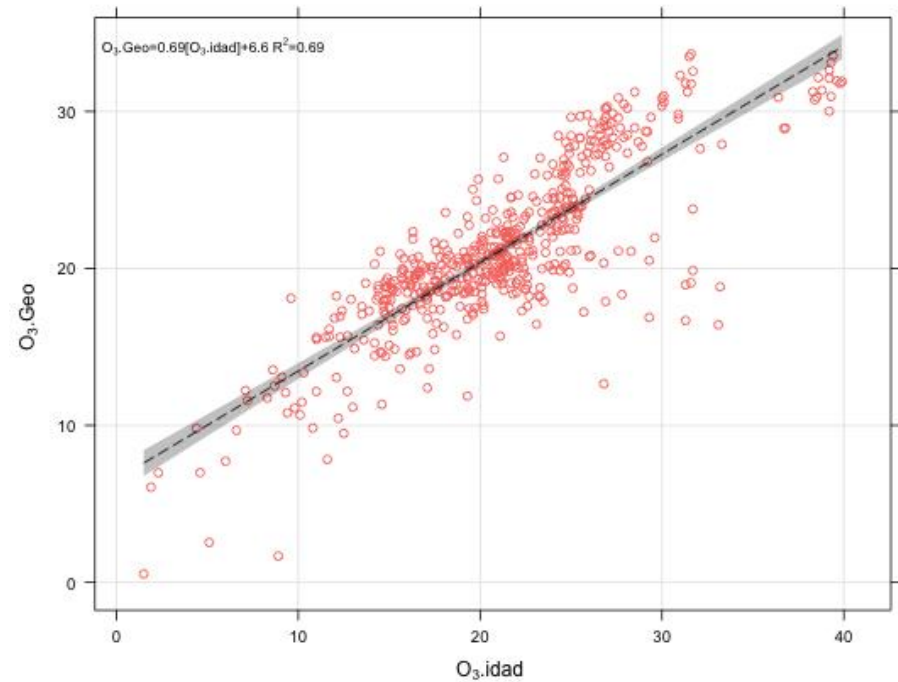
Aveiro Intercomparison

13-18/10/2014, Aveiro



Field NO₂
R²= 0.88
(previous sensor R²= 0.49)

13-18/10/2014, Aveiro

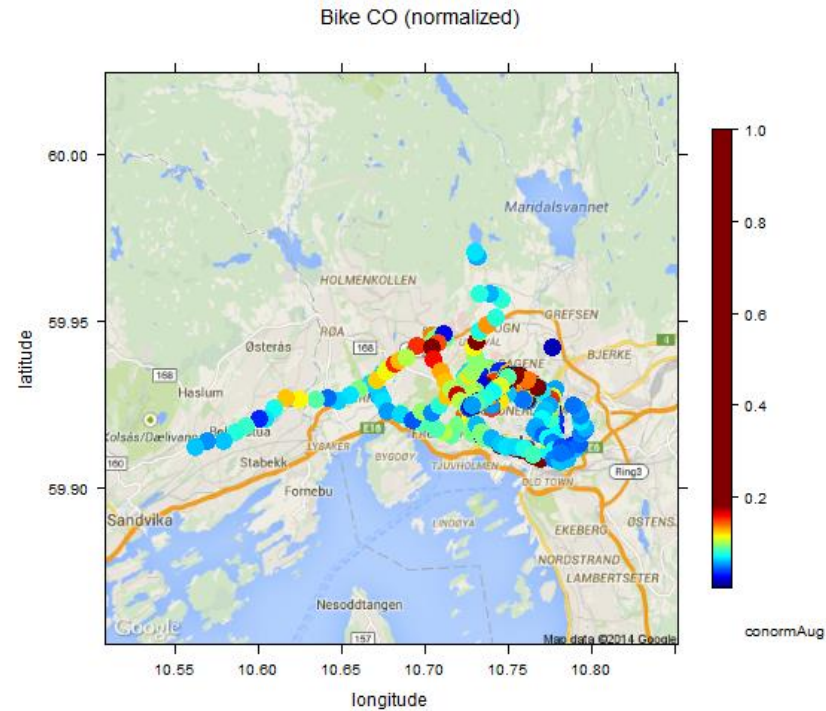


Field O₃
R²= 0.69

First road trials with the bicycle and the buses

Laboratory results

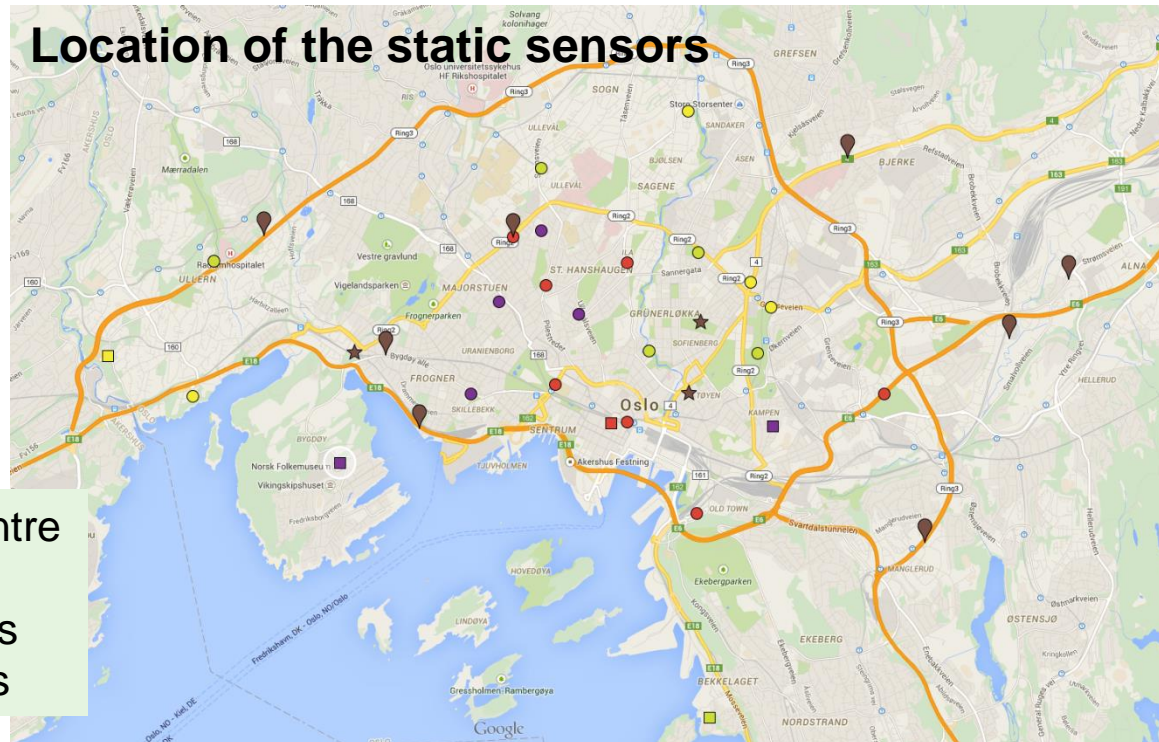
Pollutants	Bus (R^2)	Bicycle (R^2)
CO	0.92	0.99
NO ₂	0.99	0.95
NO		0.80
O ₃		0.89



Full deployment of sensors in 2015

Platform	N. units	Pollutants	Other
Bus	8	NO ₂ , CO	Temp, HR
Bicycle	1	O ₃ , NO ₂ , NO, CO ₂ , PM2.5, PM10	Temp, HR
Personal	11	O ₃ , NO ₂ , CO	Temp, RH
Static	21	O ₃ , NO ₂ , CO, NO, PM10, PM2.5	Temp, RH, Press, Noise

Location of the static sensors



Bus: Nobina lines passing city centre

Bicycle: Volunteers

Personal: parking wars, volunteers

Static: kindergartens, street lamps

Conclusions

- Results from laboratory:
 - High correlation ($r^2=0.99$) and good linear response for NO and CO.
 - Lower correlation ($r^2=0.7$) and higher dispersion for NO₂. Interferences with O₃ in the chamber that lowered the correlation.

Conclusions

- Static sensors have been co-located during three periods at two traffic stations: March-May (Kirkeveien); July-August (Hjortnes), and September (Kirkeveien).
- Results for NO sensor show that:
 - The overall correlation is between 0.7 and 0.9
 - Changes in correlation over time due to environmental conditions
 - The sensor captures the temporal pattern, rush hours and weekend effect
- Results for NO₂ sensor show that:
 - The overall correlation is between 0.3 and 0.7
 - Changes in correlation over time due to environmental conditions
 - New NO₂ sensor that includes O₃ filtering shows a good performance in field with correlation higher than 0.8.

Thank you for your attention



Nuria Castell
ncb@nilu.no

www.citi-sense.eu

www.citi-sense-mob.eu

 oslocitizensobservatory