AIR QUALITY SENSOR PERFORMANCE: LABORATORY AND FIELD OBSERVATIONS

Results based in EU projects CITI-SENSE and Citi-Sense-MOB

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CITI-SENSE

Citi-Sense-MOB

NILU Norsk institutt for luftforskning
Norwegian Institute for Air Research

Oslo Citizens' Observatory

Our vision

Important problems:

Quality of life in cities
Health effects from traffic pollution

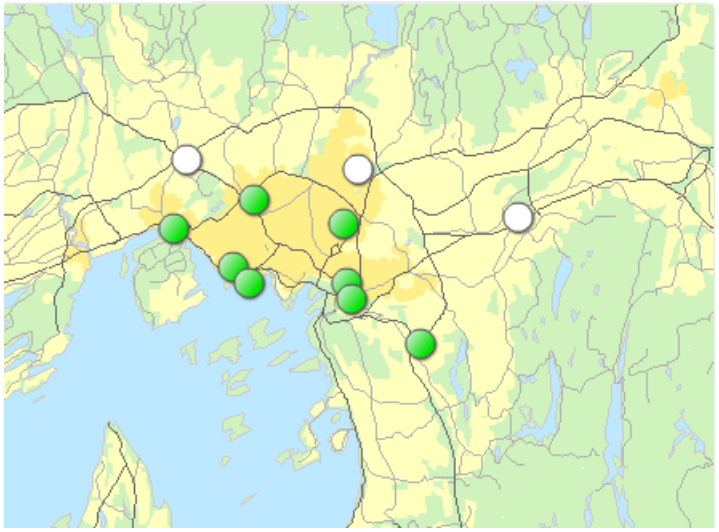
Decreasing air pollution
Increasing quality of life

Opportunities and challenges:

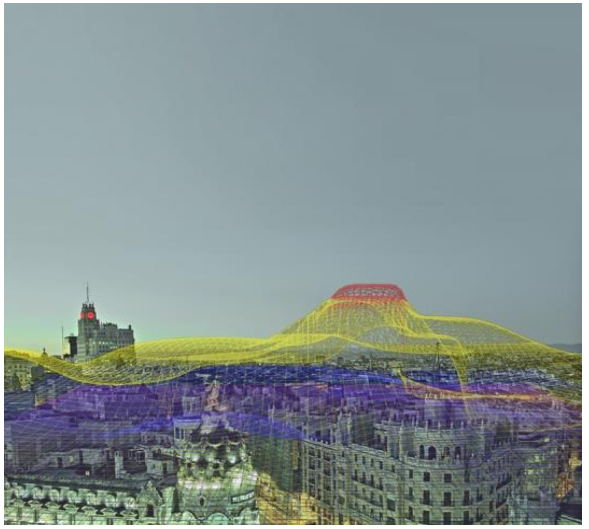
Small, low-cost sensors
Information and Communication Tech.

Participatory Urbanism
Citizens' Empowerment

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



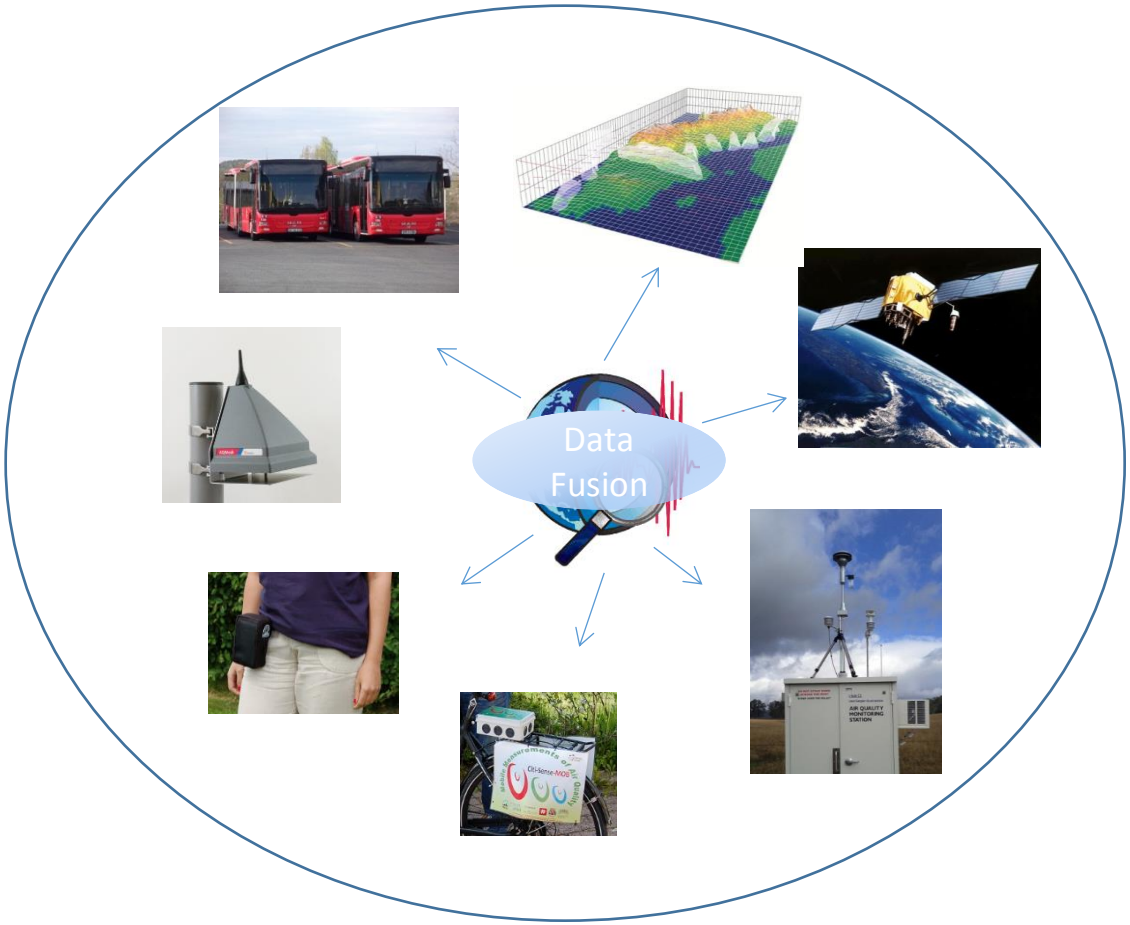
Increased spatial coverage
Complementary air quality data
Personalized data



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

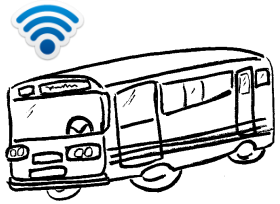
How are we going to implement it?

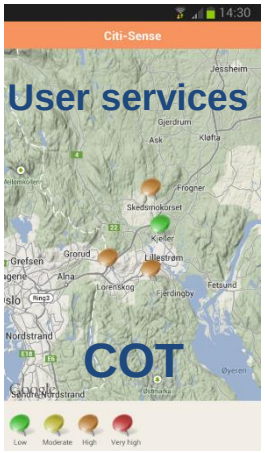
Sensor platform
NO, NO_2, CO, O_3,
PM, RH, T

Ruter#

Public & Private Sectors

GNSS

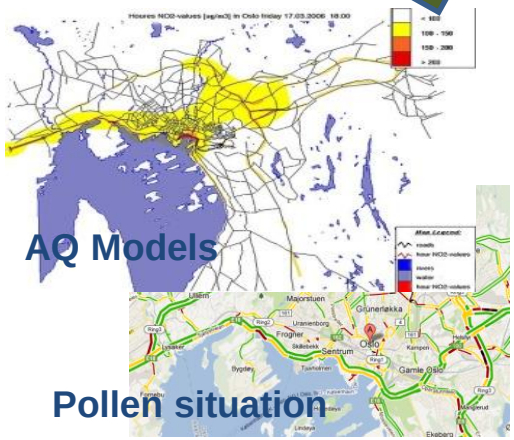




Data Services
Processing raw data, fusion, modelling

Cloud services

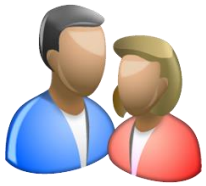
Data providers



AQ Models

Pollen situation

VGI



Citizen Participation
Participatory Governance through Social Media

Citizens
Special Interest Groups

Sensor platforms employed

Ateknea PSP
(On person)

130 x 75 x 50 mm
300 gr
Bluetooth

Environmental Parameters
CO, NO2, O3, temperature, humidity
Power consumption
3.7V LiPo 1300mAh, battery life about 24 hrs

Dunavnet EB700
(On bikes)

225 x 150 x 100 mm
500 gr
GPRS

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

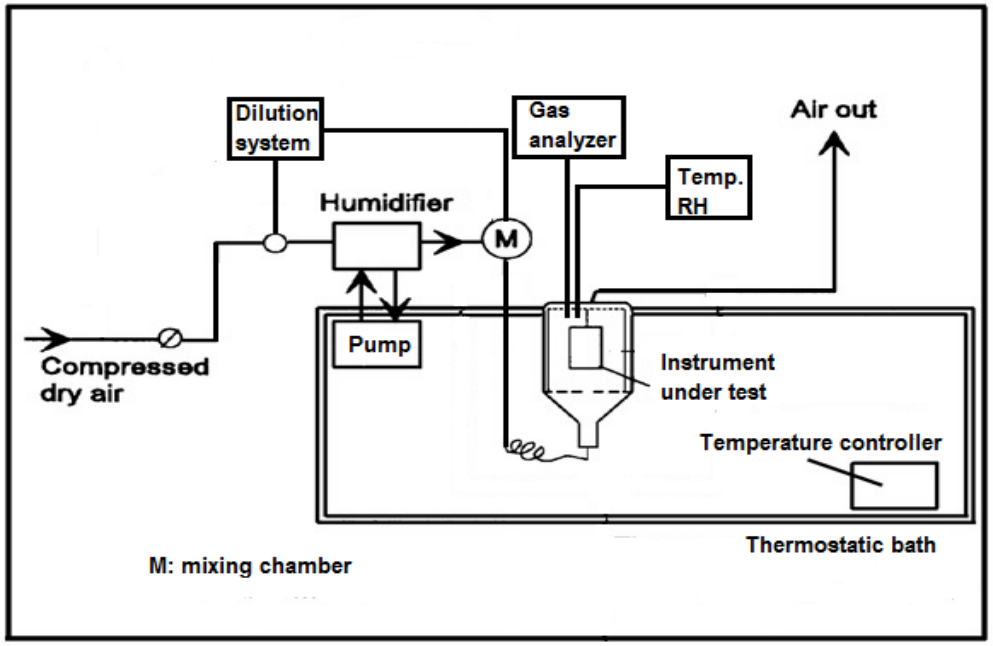
Environmental Parameters
CO, NO2, Temperature and humidity
Power consumption
External supply of 12-24V DC

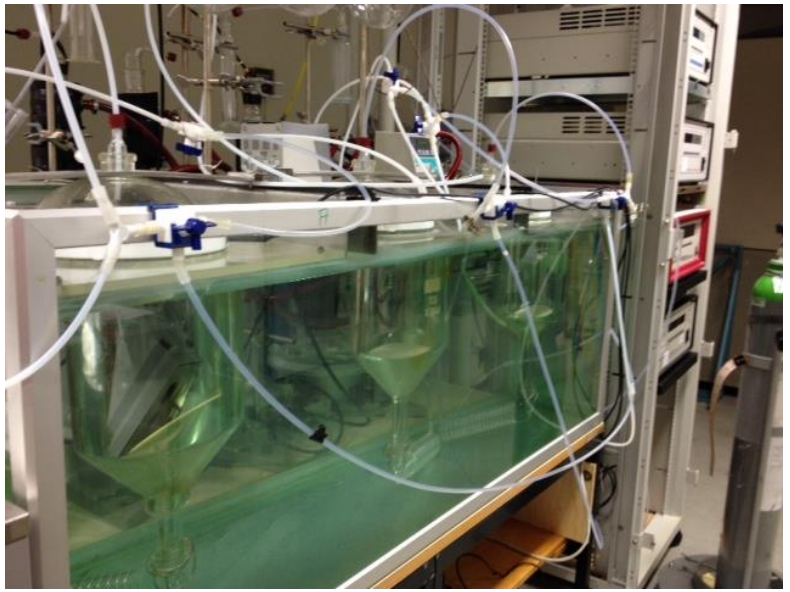
GeoTech AQMesh
(Static sensors)

170 x 180 x 140 mm
2000 gr
GPRS

Environmental Parameters
CO, NO, NO2, O3, Pressure, Temperature, Humidity
Power consumption
Lithium battery, battery life about 1 year (transmission 15min)

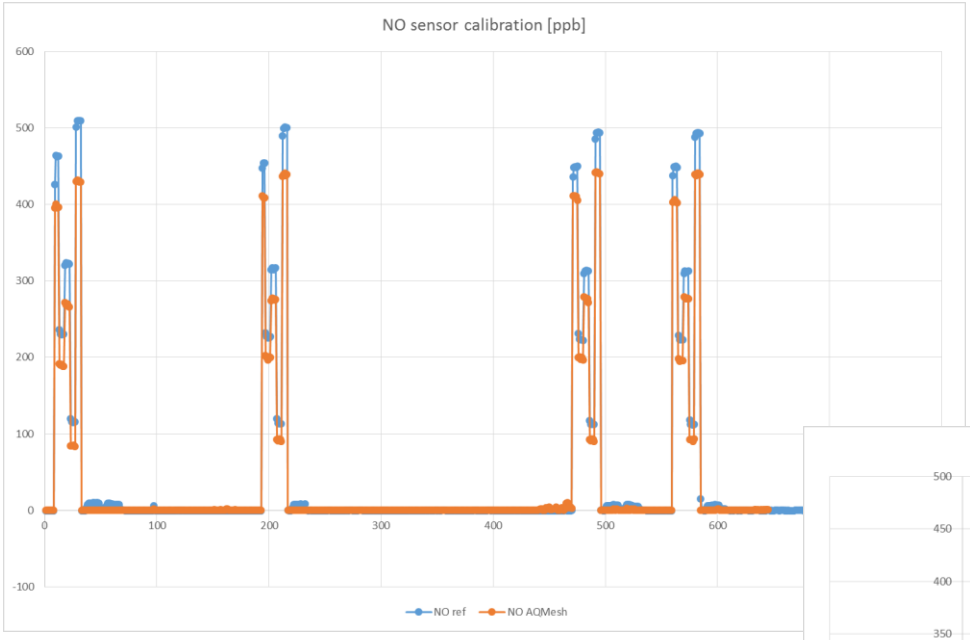
Laboratory performance Geotech platform



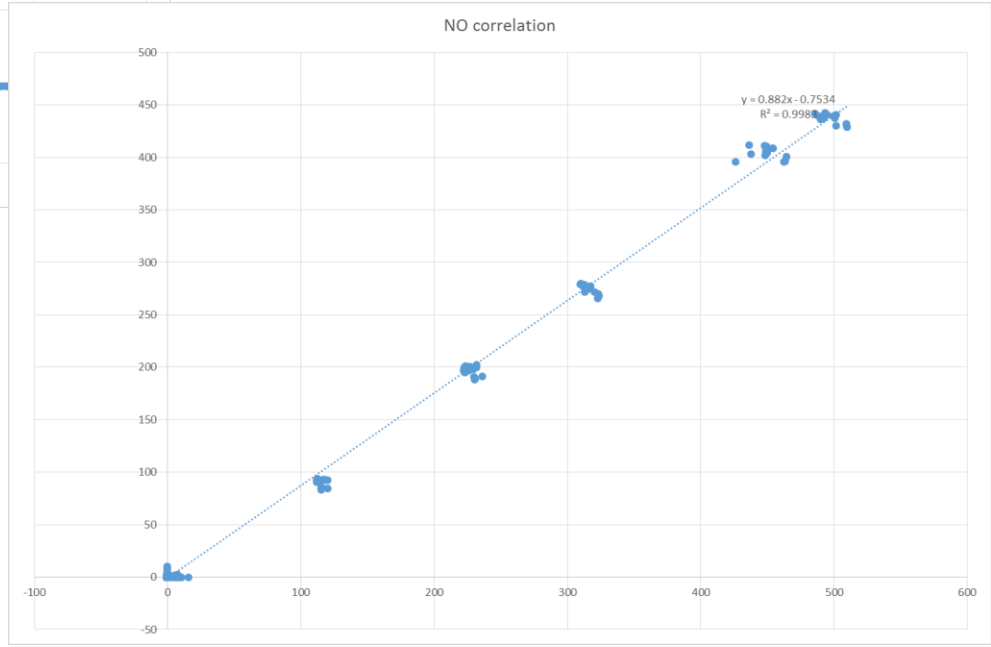


Instrument type	Instrument	Measurement principle
O_3 analyzer	Teledyne API 400	UV photometry
SO_2 analyser	Teledyne API 100A	UV fluorescence
CO analyzer	Teledyne API 300E	IR absorption, GFC
NO_x analyzer	ML 9841A	Chemiluminescence
Temperature sensor	Rotronic Hygroclip2-S	Pt100
RH sensor	Rotronic Hygroclip2-S	Hygromer sensor
Dilution system	Environics Series 100	Dilution by MFCs

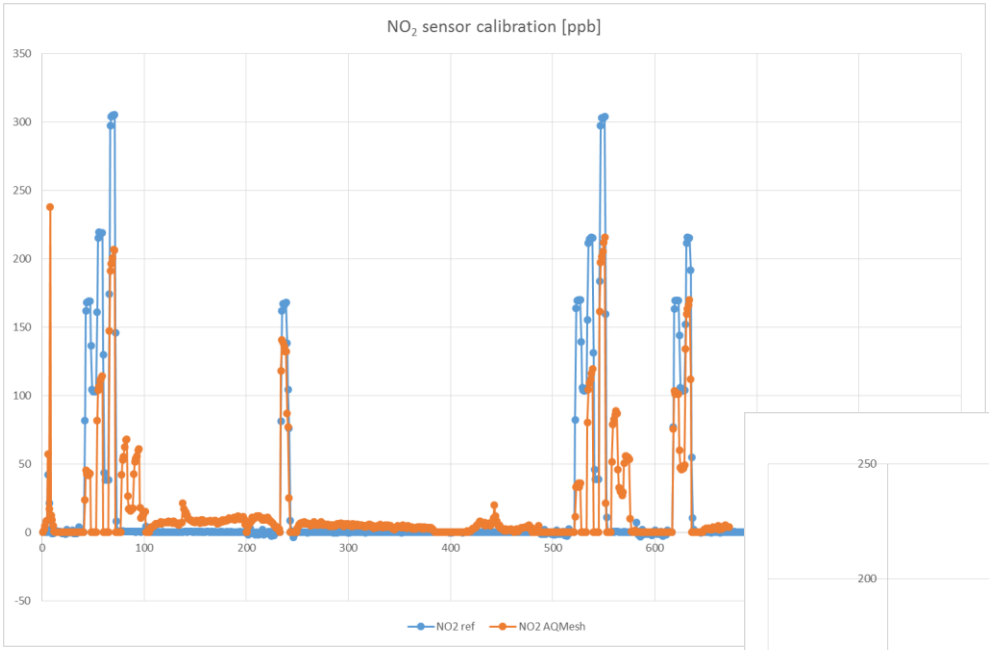
Laboratory performance Geotech platform: NO



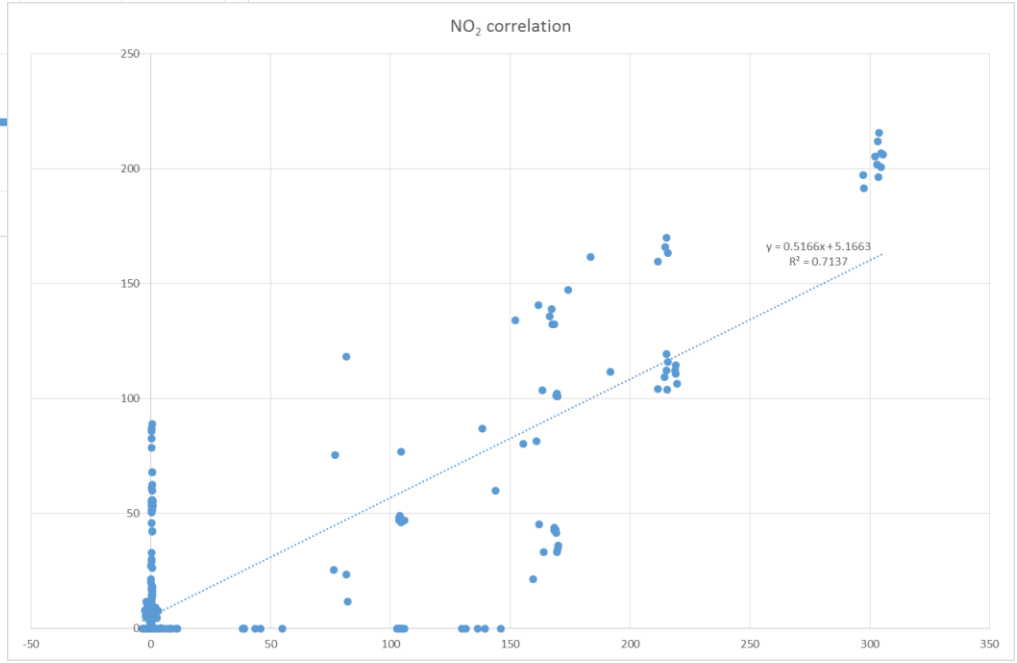
$y = 0.882x - 0.7534$
$R^2 = 0.9983$



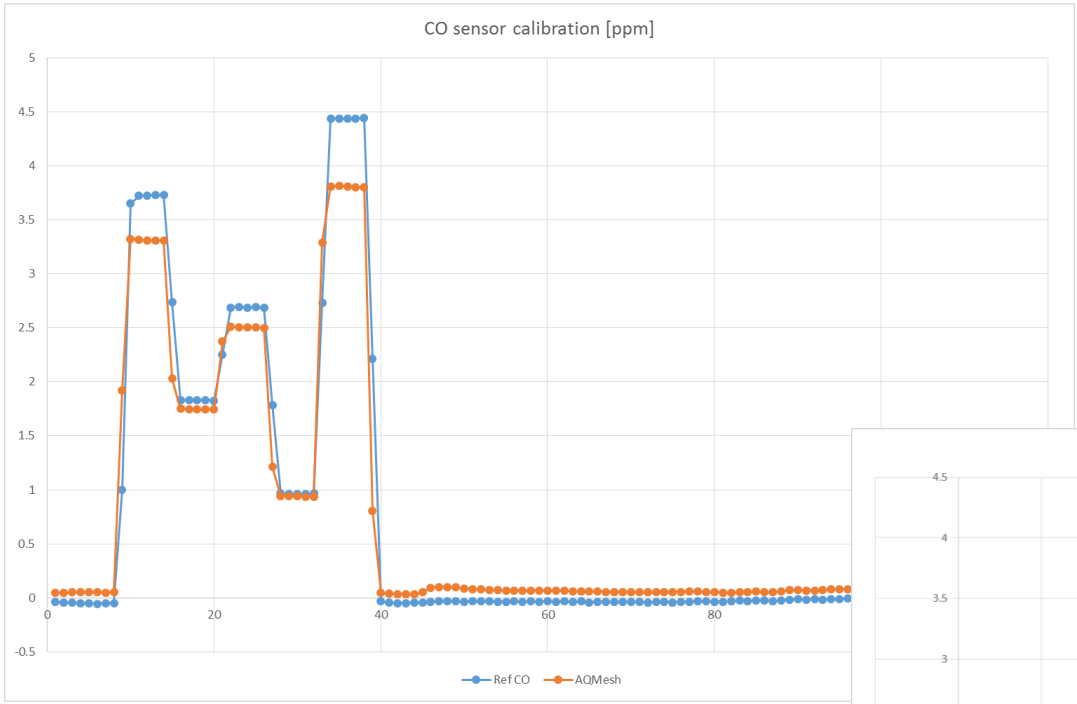
Laboratory performance Geotech platform: NO_2



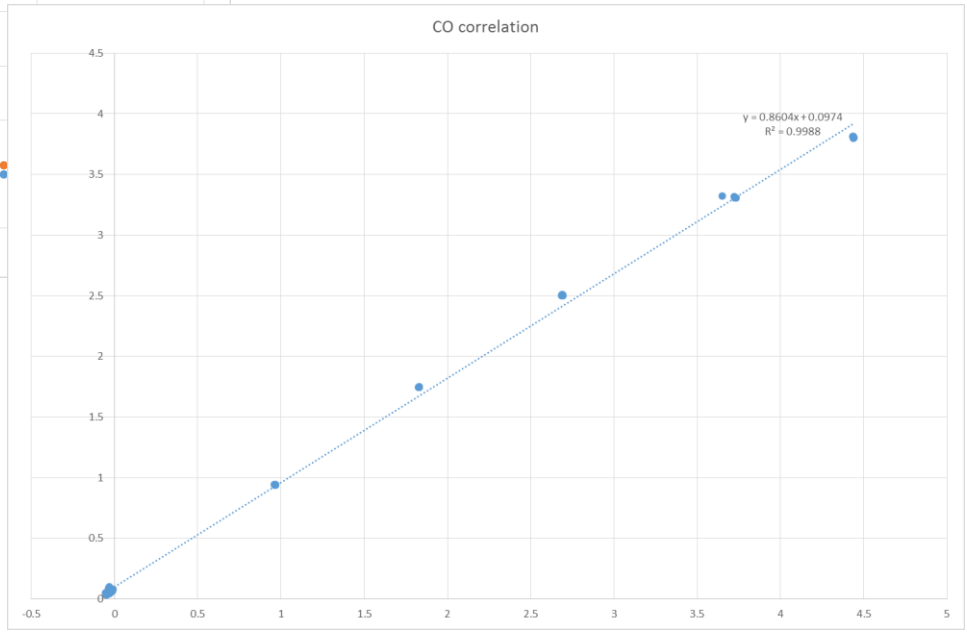
$y = 0.5166x + 5.1663$
$R^2 = 0.7137$



Laboratory performance Geotech platform: CO



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



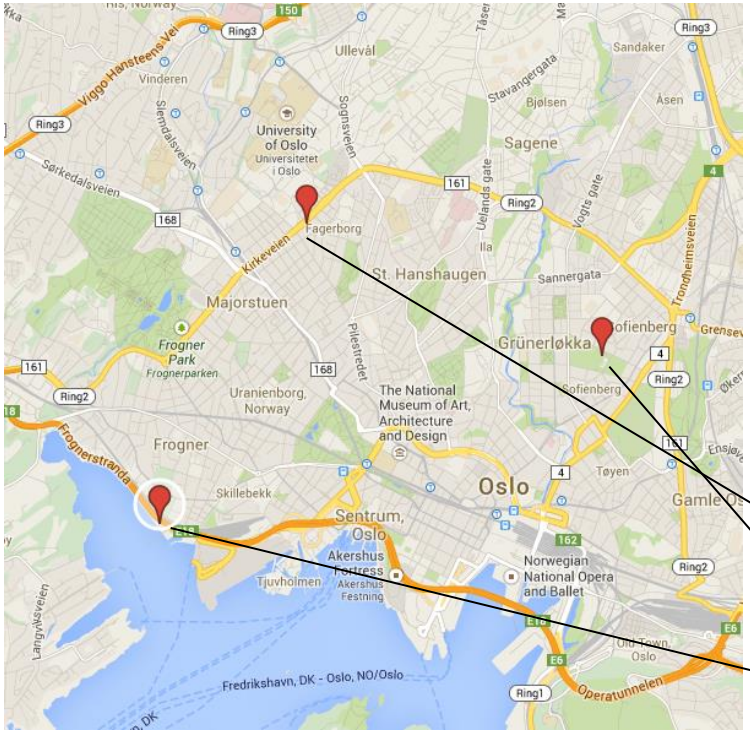
First results for the co-location of static units

5 Geotech units: NO, NO_2, O_3, CO, Temp, RH, Pressure

From: 13/02/2014

Co-location of the static units

- 5 Geotech 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, NOx, CO
Sofienberg	PM10, PM2.5
Hjortnes	PM10, PM2.5, NO, NO_2, NOx

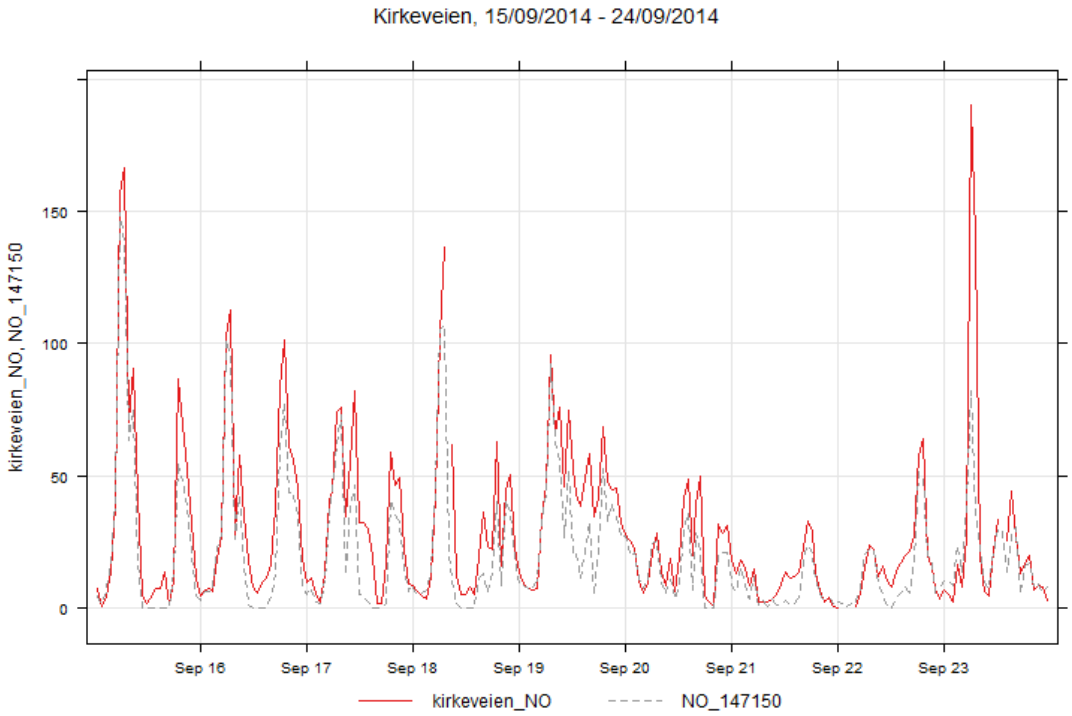
Description of the sites

Kirkeveien
High traffic (ADT:20200)
High residential
Altitude: 58m

Sofienberg
Urban background (ADT:0)
Urban green area
Altitude: 23 m

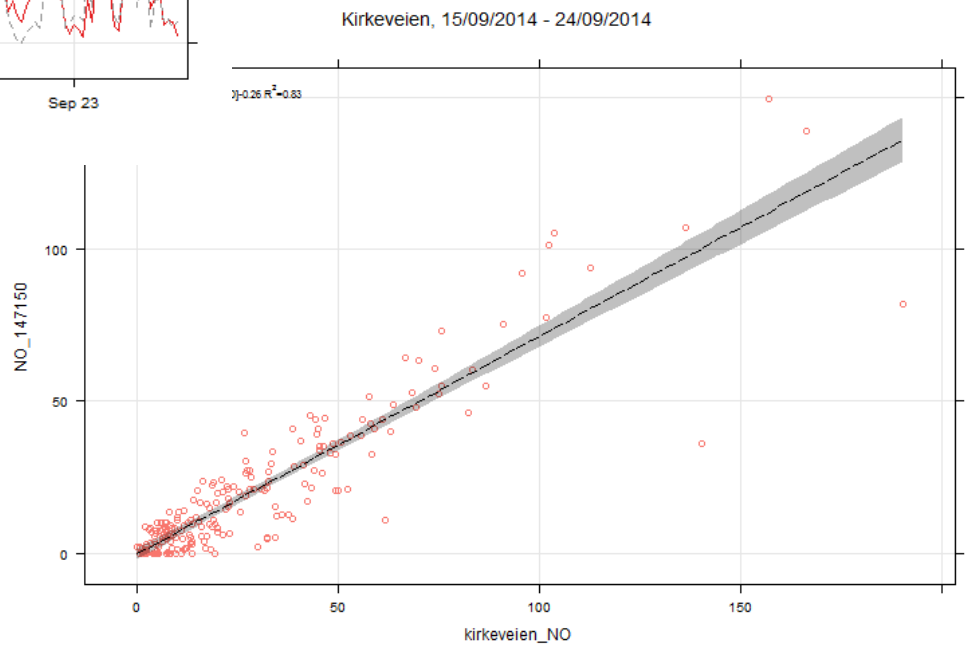
Hjortnes
Super traffic(ADT:73100)
Commercial, High residential
Close to harbour
Altitude: 3 m

Field performance Geotech platform: NO

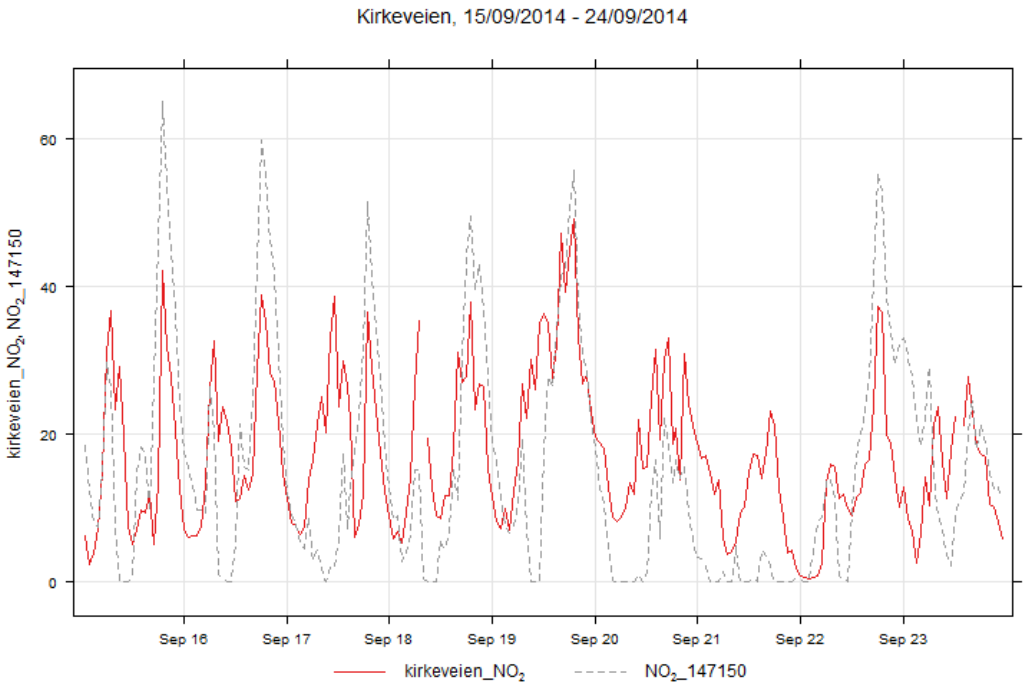


Laboratory
$y = 0.882x - 0.7534$
$R^2 = 0.9983$

Field
$y = 0.72x - 0.26$
$R^2 = 0.83$

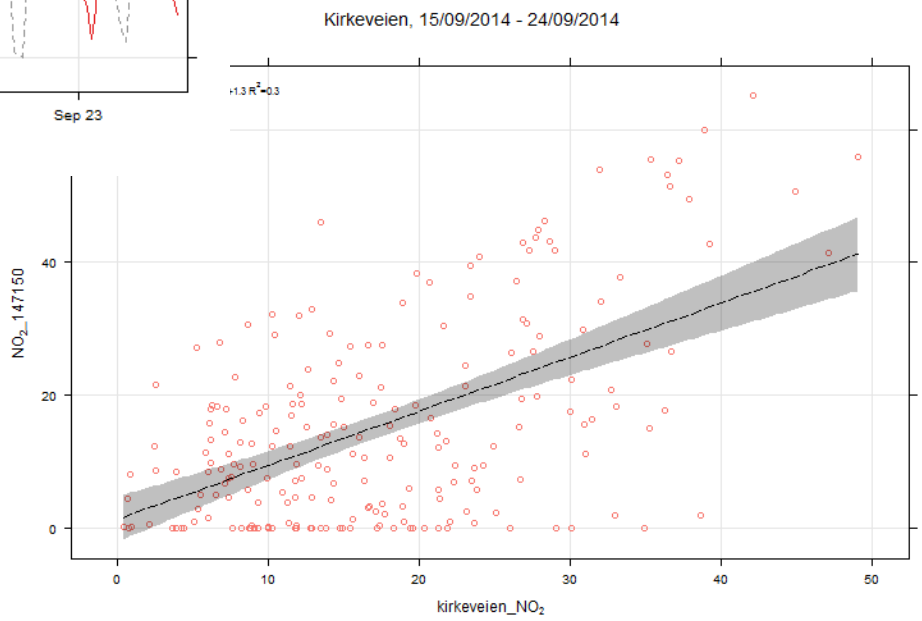


Field performance Geotech platform: NO2



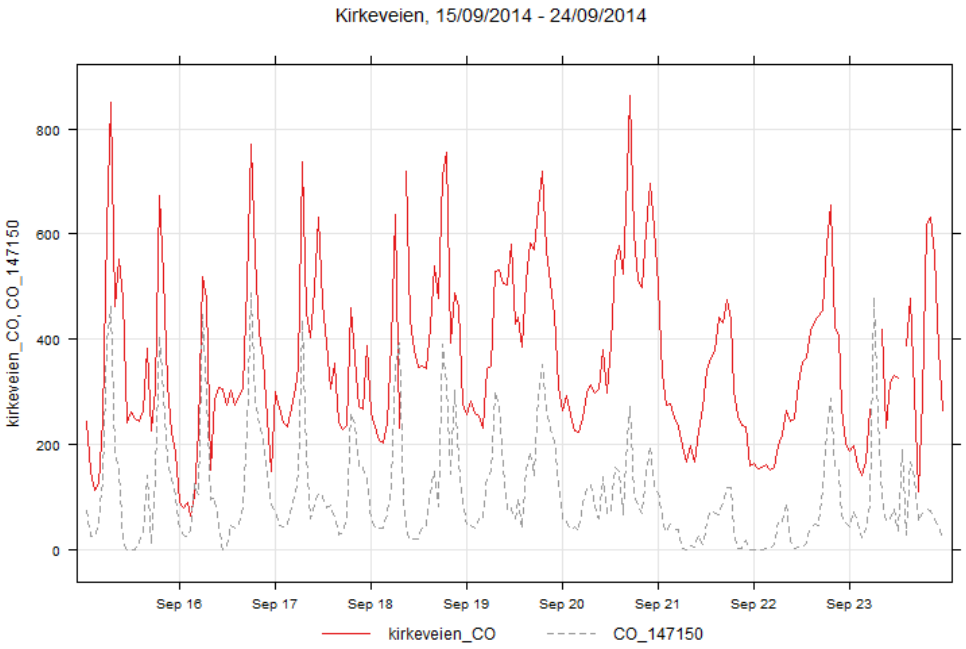
Laboratory
$y = 0.5166x + 5.1663$
$R^2 = 0.7137$

Field
$y = 0.81x + 1.3$
$R^2 = 0.3$



False zeros
Overestimation in some peacks

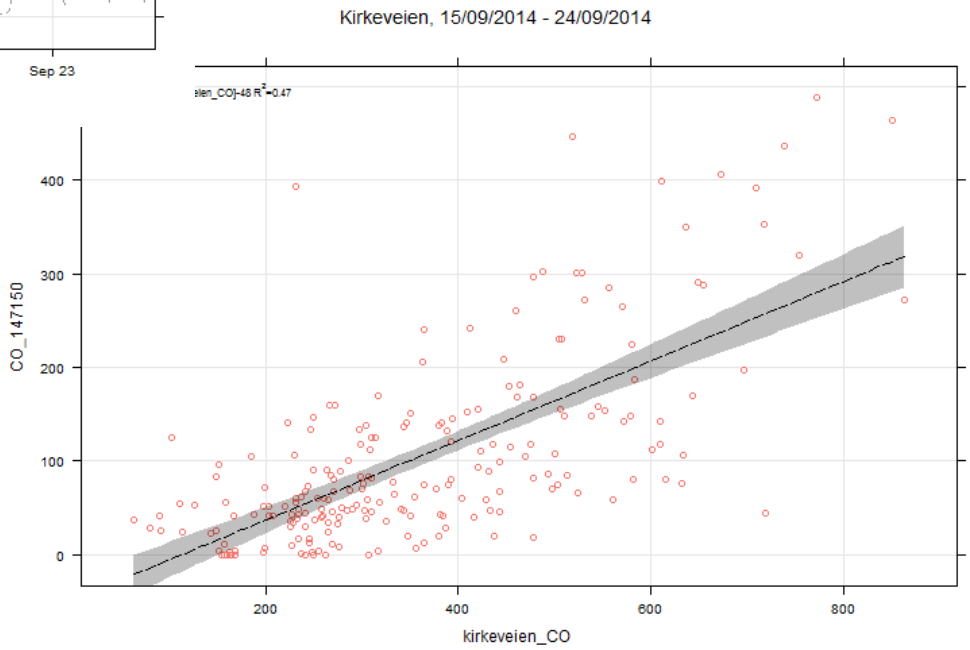
Field performance Geotech platform: CO



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

Field
$y = 0.42x - 48$
$R^2 = 0.47$

Offset about 200 ppb



Field performance Geotech platform: NO

13/02/2014 - 02/06/2014

Kirkeveien/ NO	124150	144150	145150	146150	147150
n	2558	2558	2558	1288	2558
MB	-3,38	-3,29	-8,3	-8,1	-3,74
RMSE	11,05	9,92	16,75	15,24	10,63
r	0,91	0,93	0,83	0,85	0,92

First period
MB: -3 and -8 ppb
RMSE: 10 and 17
R: 0.8 and 0.9

25/06/2014 - 03/09/2014

Hjortnes/ NO	124150	144150	145150	146150	147150
n	1670	1670	1670	1670	1670
MB	-6,6	-6,53	-16,33	-1,34	-9,3
RMSE	16,37	16,10	25,37	20,7	18,33
r	0,87	0,87	0,75	0,85	0,85

Second period
MB: -1 and -16 ppb
RMSE: 16-25
R: 0.7 and 0.9

Field performance Geotech platform: NO_2

13/02/2014 - 02/06/2014

Kirkeveien/ NO_2	124150	144150	145150	146150	147150
n	1062	2615	2615	2645	2613
MB	-11,3	-5,7	-1,45	-5,3	-8,95
RMSE	14,3	12,11	11,3	12,9	14,3
r	0,67	0,56	0,57	0,53	0,52

First period
MB: -1 and -11 ppb
RMSE: 11 and 14
R: 0.5 and 0.7

25/06/2014 - 03/09/2014

Hjortnes/ NO_2	124150	144150	145150	146150	147150
n	1679	1679	1679	1679	1679
MB	-0,15	4,01	8,9	0,7	-2,29
RMSE	18,45	19,0	18,3	18,3	17,9
r	0,45	0,46	0,51	0,43	0,45

Second period
MB: 0 and 9 ppb
RMSE: 18-19
R: 0.4 and 0.5

Temporal variation of the performance: NO

144150 NO	March 2014	April 2014	May 2014	July 2014	August 2014	15/09 - 24/09
n	742	689	726	743	736	210
MB	-2,5	-1,83	-5,57	-9,33	-5,04	-6,16
RMSE	7,6	9,93	12,36	14,57	17,8	14,9
r	0,97	0,86	0,69	0,8	0,88	0,91

145150 NO	March 2014	April 2014	May 2014	July 2014	August 2014	15/09 - 24/09
n	742	689	726	743	736	210
MB	-7,3	-8,63	-11,2	-16,4	-18,0	-16,03
RMSE	17,88	16,8	17,5	21,9	28,9	23,1
r	0,85	0,66	0,44	0,55	0,78	0,86

147150 NO	March 2014	April 2014	May 2014	July 2014	August 2014	15/09 - 24/09
n	742	689	726	743	736	210
MB	-1,87	-2,7	-6,94	-11,7	-8,5	-8,55
RMSE	7,7	10,71	13,53	16,71	20,2	16,1
r	0,97	0,84	0,65	0,77	0,86	0,9

General increase in the MB and RMSE over time

Lower correlation in May
Higher correlation in September

Temporal variation of the performance: NO2

144150 NO2	March 2014	April 2014	May 2014	July 2014	August 2014	15/09 - 24/09
N	744	720	744	744	744	213
MB	-7,6	-4,4	-4,13	-0,66	10,89	-1,93
RMSE	12,43	12,02	12,1	15,49	21,5	10,99
r	0,67	0,51	0,4	0,4	0,6	0,59

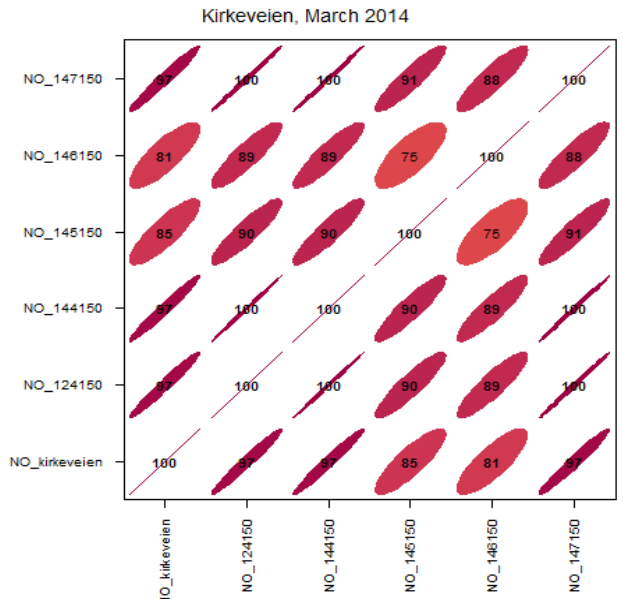
145150 NO2	March 2014	April 2014	May 2014	July 2014	August 2014	15/09 - 24/09
n	744	720	744	744	744	213
MB	-4,12	0,99	0,81	4,9	14,9	0,15
RMSE	10,8	12,14	11,31	15,83	20,6	8,53
r	0,68	0,5	0,47	0,33	0,68	0,7

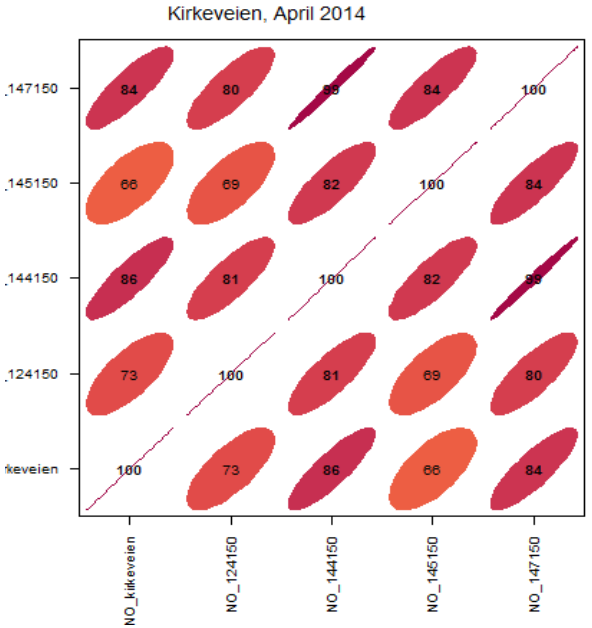
147150 NO2	March 2014	April 2014	May 2014	July 2014	August 2014	15/09 - 24/09
n	743	720	743	744	744	213
MB	-12,41	-7,23	-7,37	-7,4	4,01	-1,94
RMSE	17,43	12,73	13,48	15,6	18,9	12,9
r	0,45	0,59	0,34	0,42	0,54	0,55

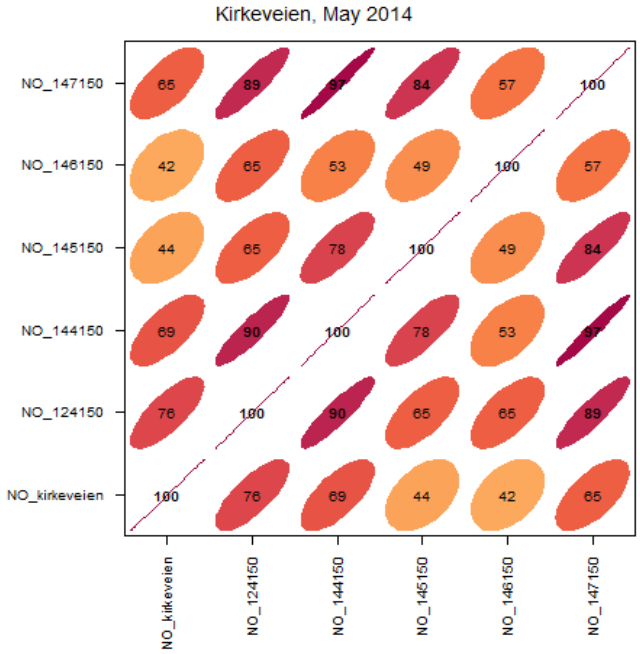
General increase in the MB and RMSE over time

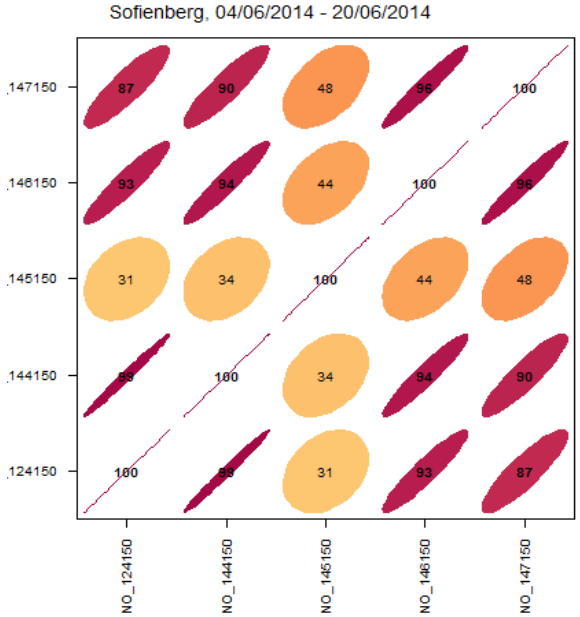
Low correlation in May and higher again in September

Pearson correlation between units and station: NO

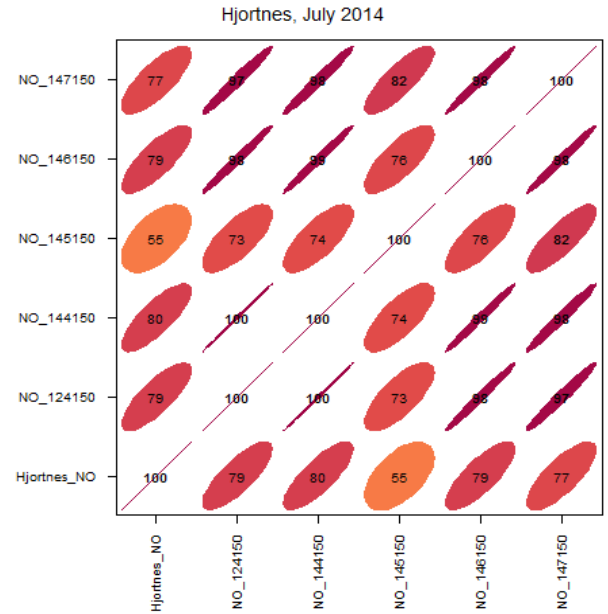


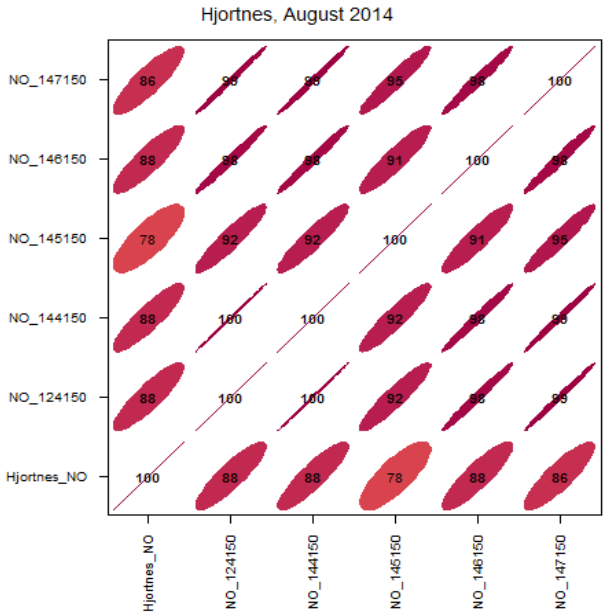


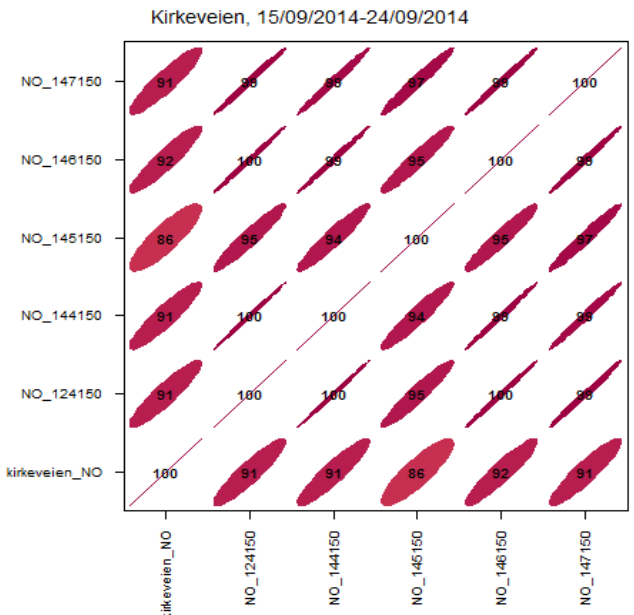




Pearson correlation between units and station: NO

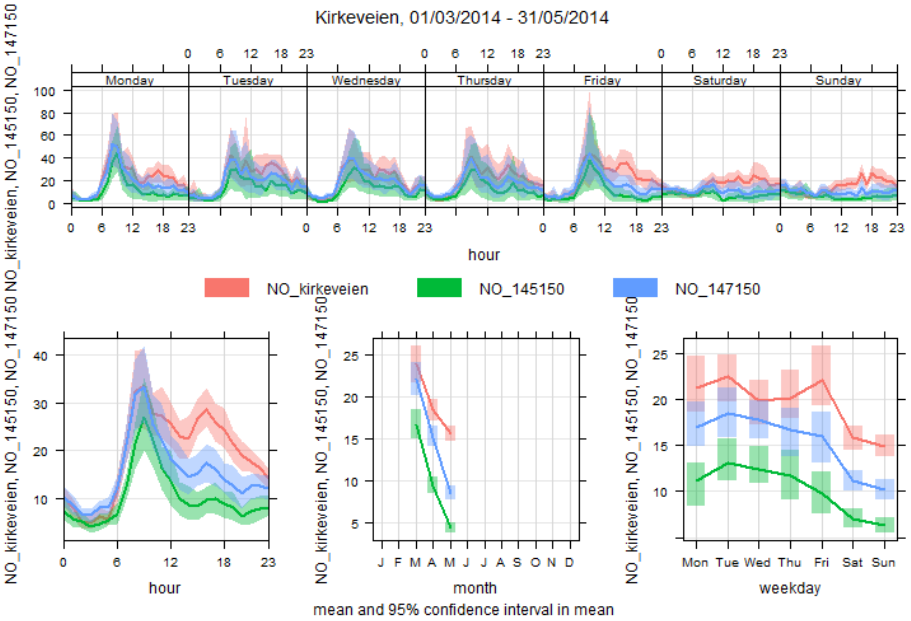




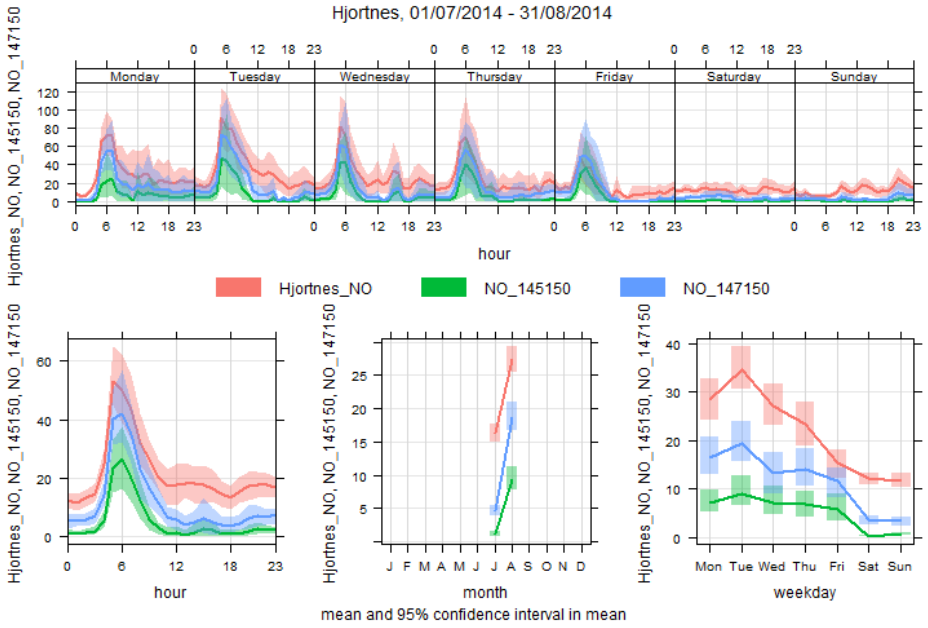


The correlation between pods varies with the time. Lower in May. Higher again in July and August.

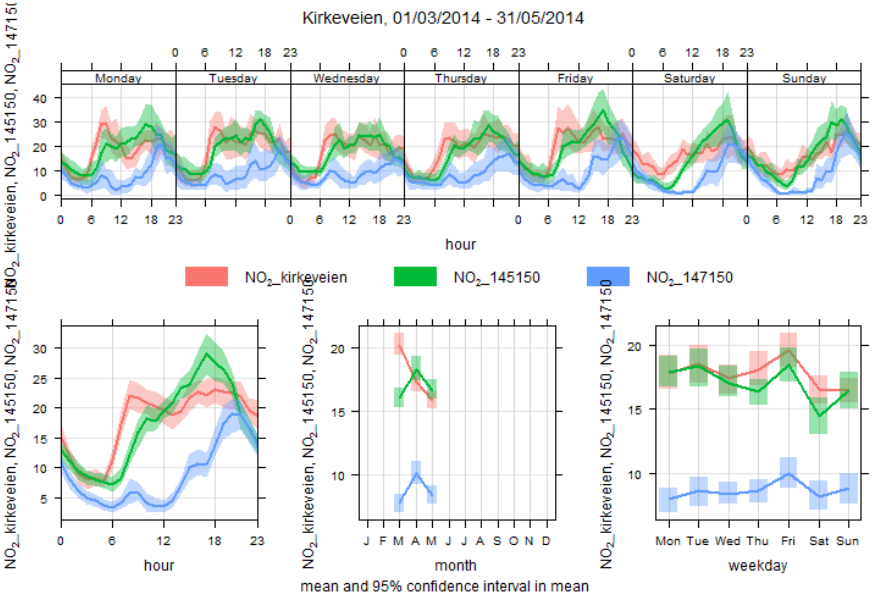
Temporal patterns (daily, weekly, monthly): NO



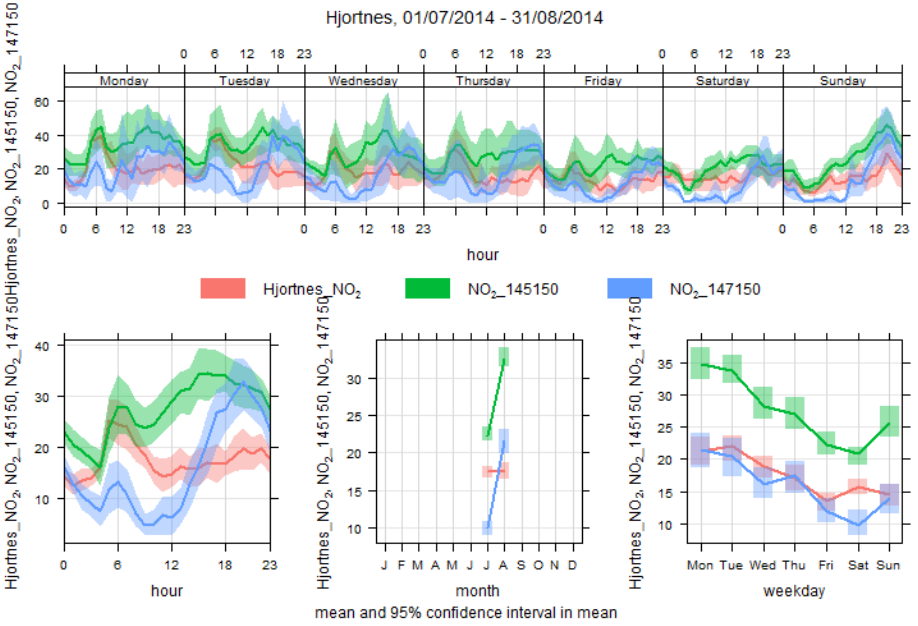
Temporal pattern for NO is well captured.
Peak in morning and afternoon
Weekend effect



Temporal patterns (daily, weekly, monthly): NO_2

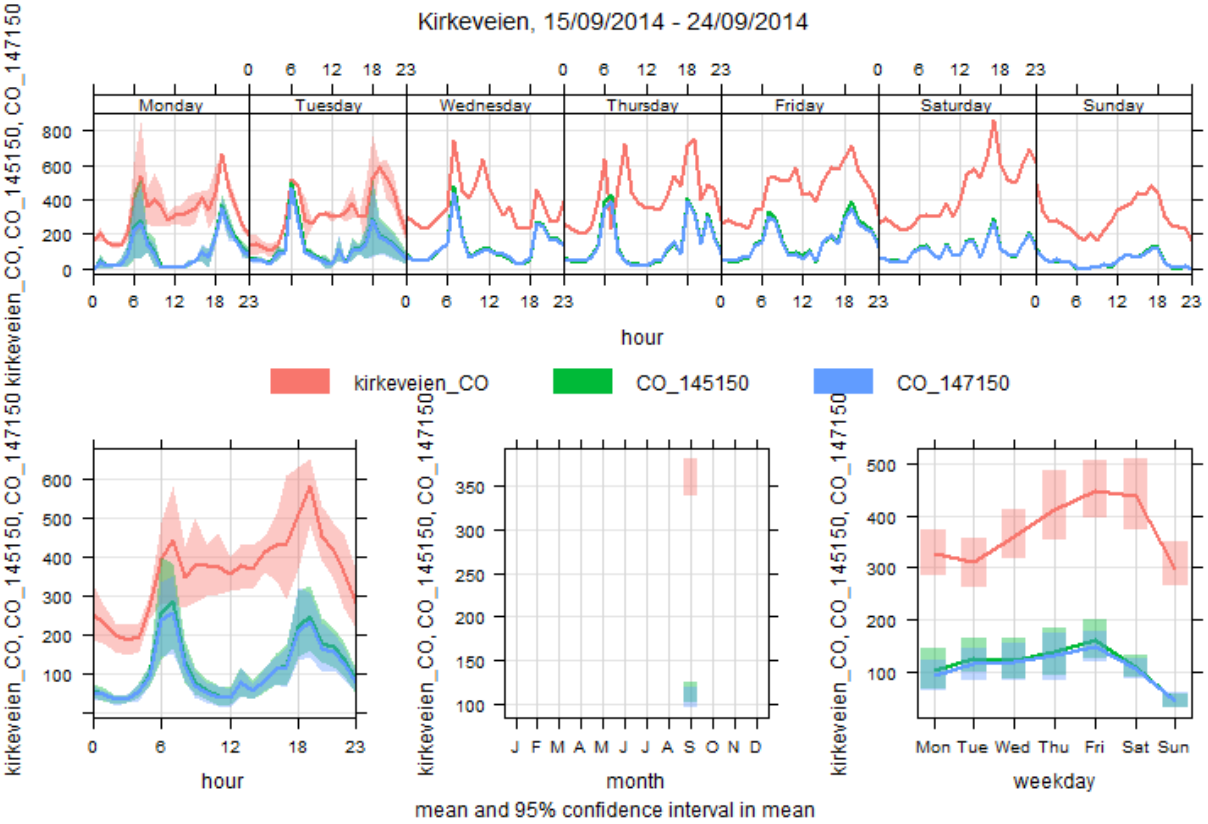


Temporal pattern for NO_2 is always well captured.
Peak in the afternoon larger than in the morning (O_3 effect?)
Peak on Sunday evening captured



Temporal patterns (daily, weekly, monthly): CO

Only data for 10 days



The temporal variation is well captured.
Peak in morning and afternoon.
Lower concentrations on Sunday.

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 NO_2. Interferences with O_3 in the chamber that lowered the correlation (need to remove these values).
- Challenges in the field comparison :
  - Only one station is measuring CO (urban traffic)
  - None of the urban traffic station measures O_3. There is a background station outside the city (Bærum)
  - None of the background stations measures NO and NO_2.
  - Meteorology is not measured in the AQ stations.

Conclusions

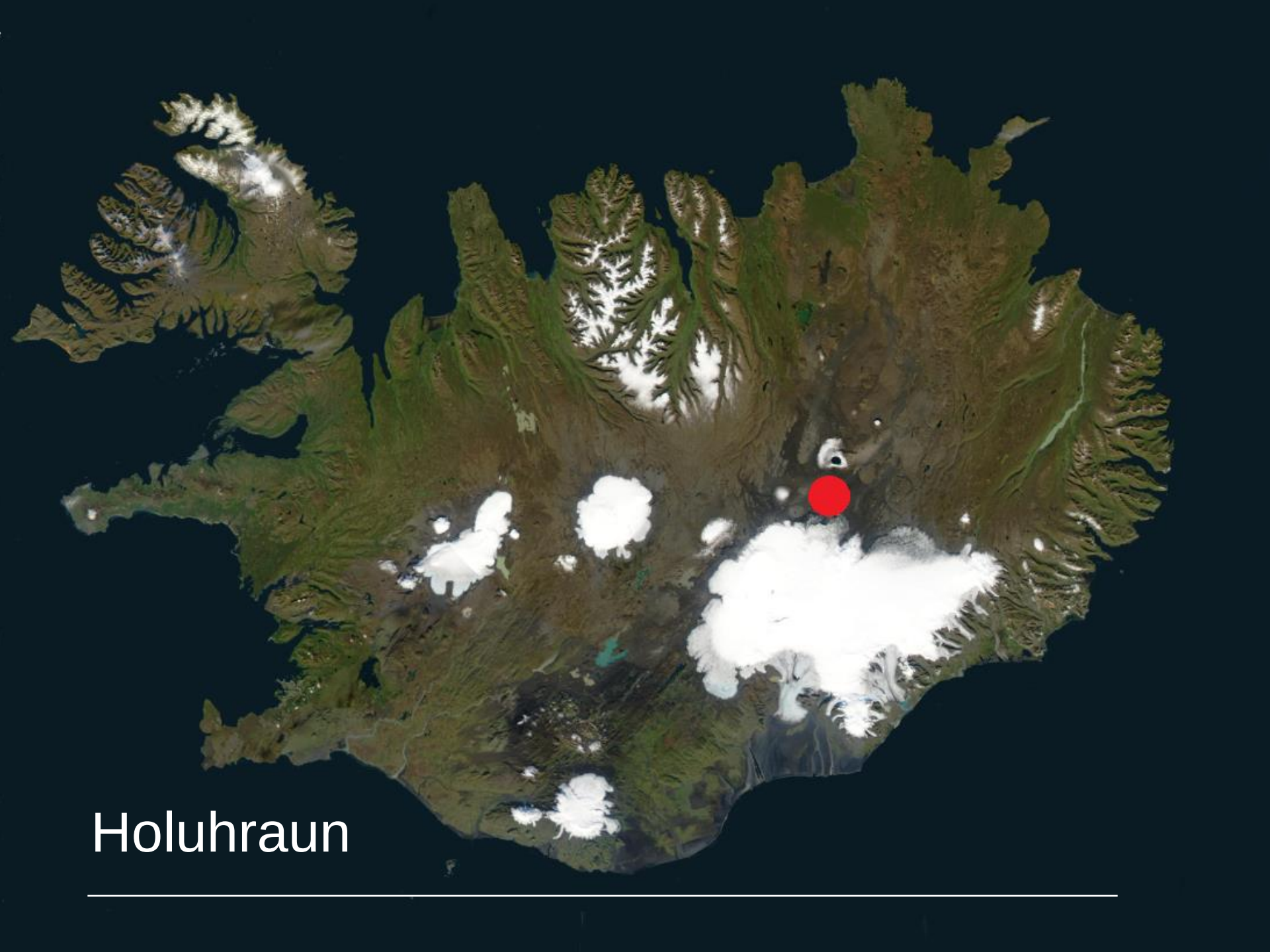
- Sensors have been co-located during three periods at two traffic stations: March-May (Kirkeveien); July-August (Hjortnes), and September (Kirkeveien).
- Results for NO sensor show that:
  - The overall correlation is between 0.8 and 0.9
  - Changes in correlation over time due to environmental conditions
  - The MB and the RMSE increases from March to September
  - The sensor captures the temporal pattern, rush hours and weekend effect
- Results for NO_2 sensor show that:
  - The overall correlation is between 0.4 and 0.7
  - Changes in correlation over time due to environmental conditions
  - The MB and RMSE increases from March to September
  - The NO_2 sensor doesn't capture the temporal pattern as well as CO and NO sensors (interferences with O_3?).

Conclusions

- Next steps:
  - Continuing with the co-location to study long-term variations in the performance of the sensors
  - Evaluate the performance of new NO_2 sensors that incorporate a filter for O_3

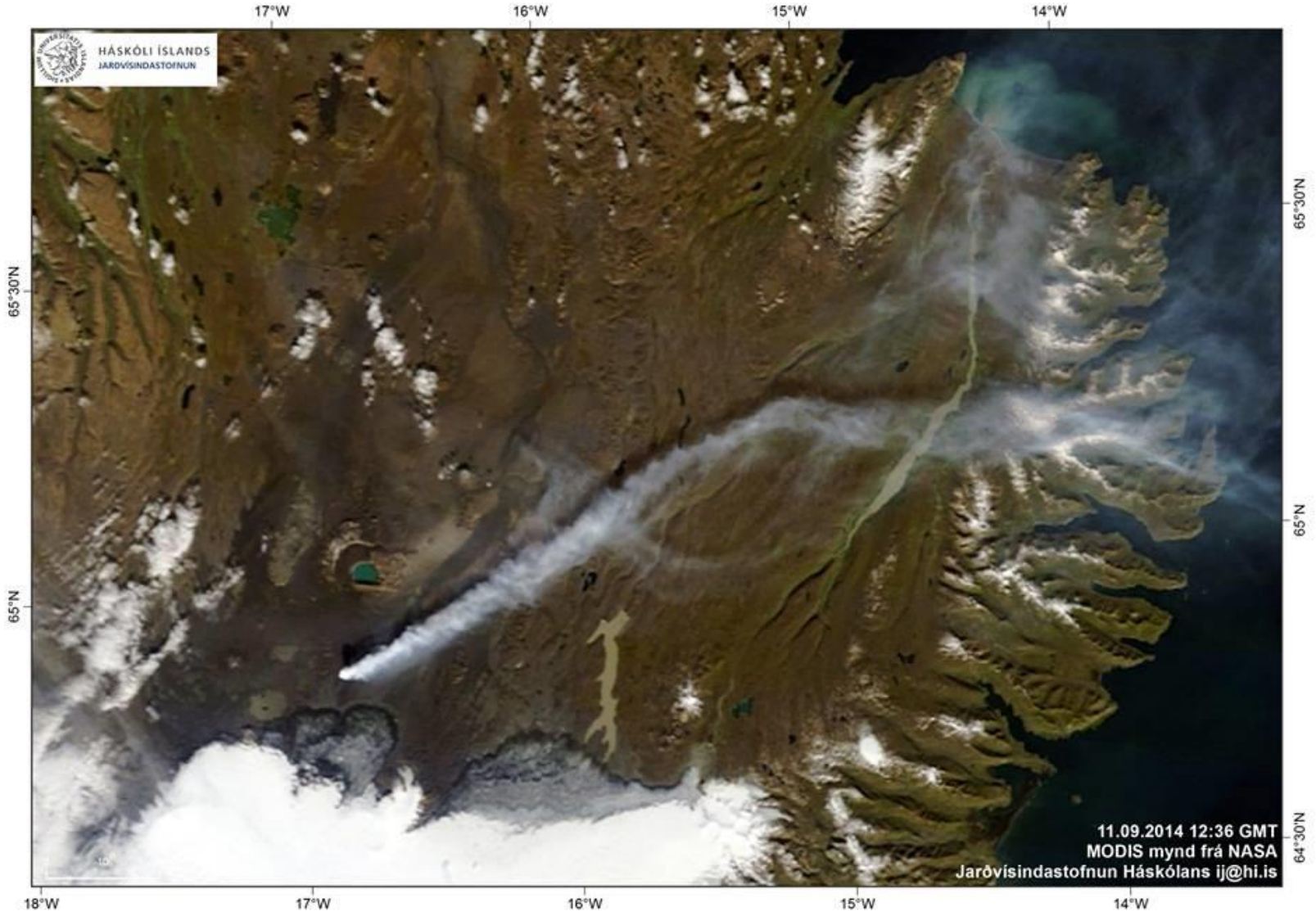
SO2 Emissions from Eruption in Holuhraun

- Eruption started August 26, no signs of it to come to an end
- Estimated SO_2 emissions 20-60 000 t/per day
- 20 measurement instruments, published on the EAI's website (www.airquality.is)
- 26 handheld instruments distributed around Iceland
- Measurements
  - 5 800 µg/m^3 highest peak measured in a populated area
  - 90 000 µg/m^3 measured flying through the plume
  - 130 000 µg/m^3 measured by scientist in the field close to the eruption



Holuhraun

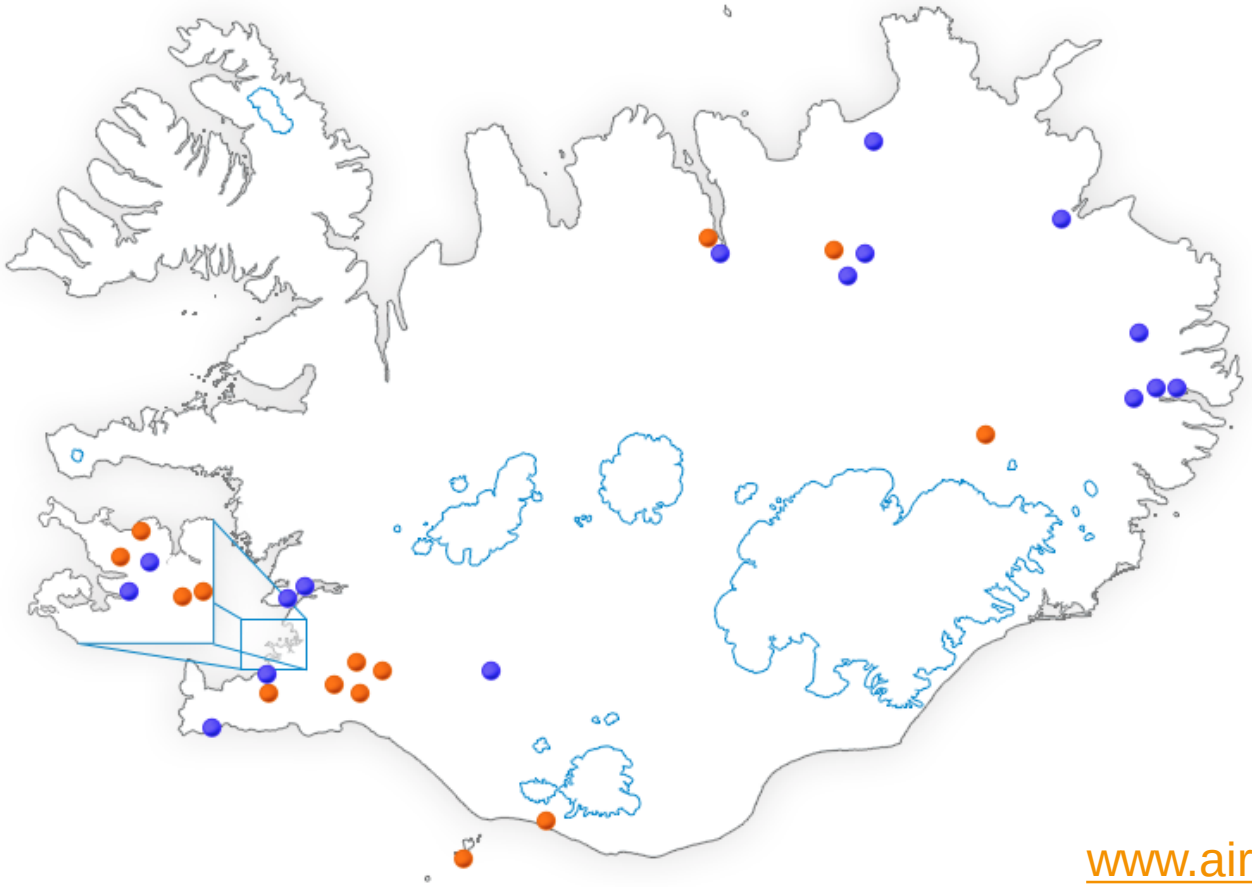
Plume


17°W
16°W
15°W
14°W
HÁSKÓLI ÍSLANDS
JARÐVÍSINDASTOFNUN
65°30'N
65°N
64°30'N
18°W
11.09.2014 12:36 GMT
MODIS mynd frá NASA
Jarðvísindastofnun Háskólans ij@hi.is

Measurement Stations - online

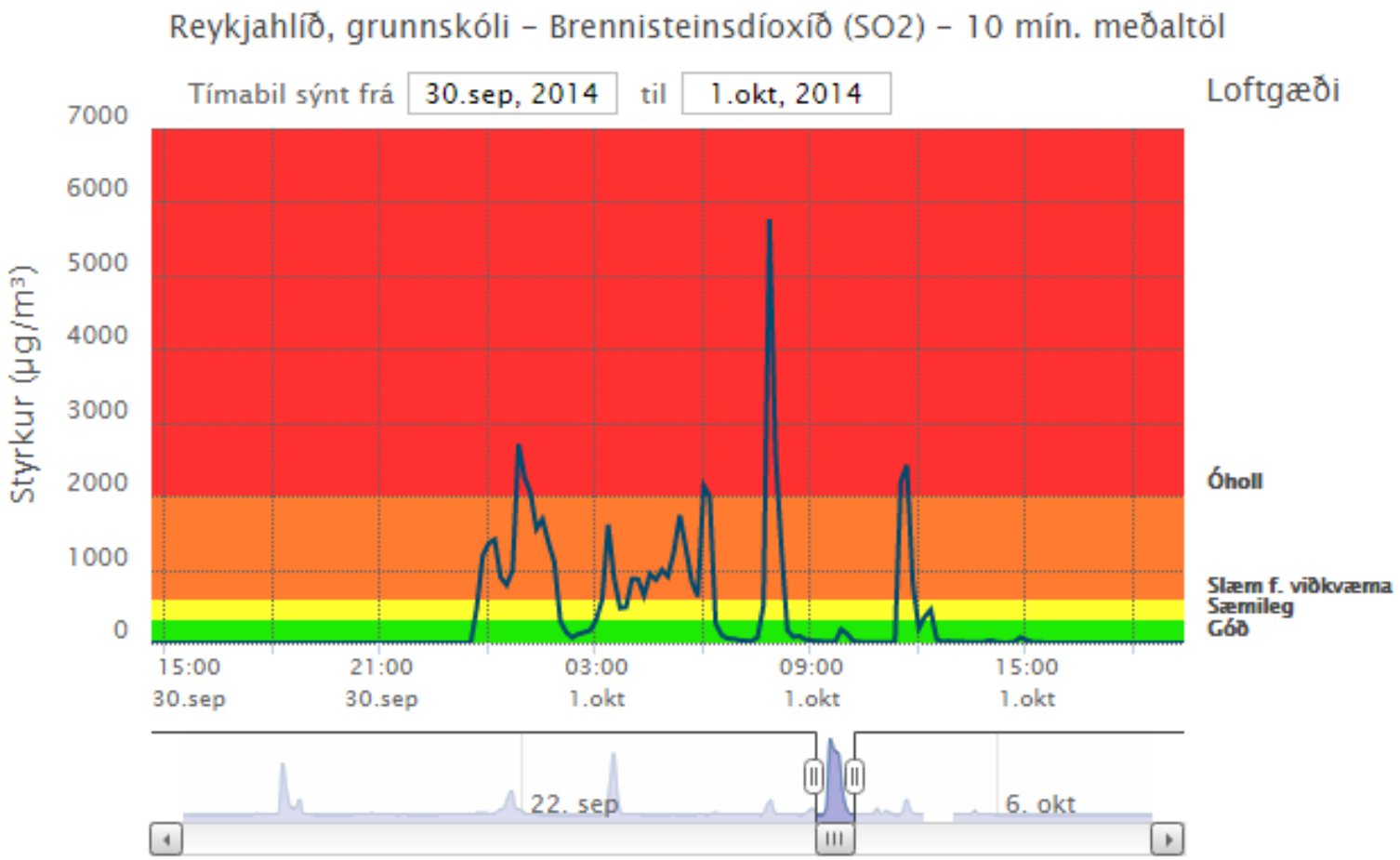
Mælingar á brennisteinsdíoxíði (SO_2) vegna eldgossins í Holuhrauni.
Sulphur dioxide (SO_2) measurements monitoring the volcanic activity near Bárðarbunga.

Aðrar mælistöðvar sem ekki mæla brennisteinsdíoxíð (SO_2).
Other stations not measuring sulphur dioxide (SO_2).

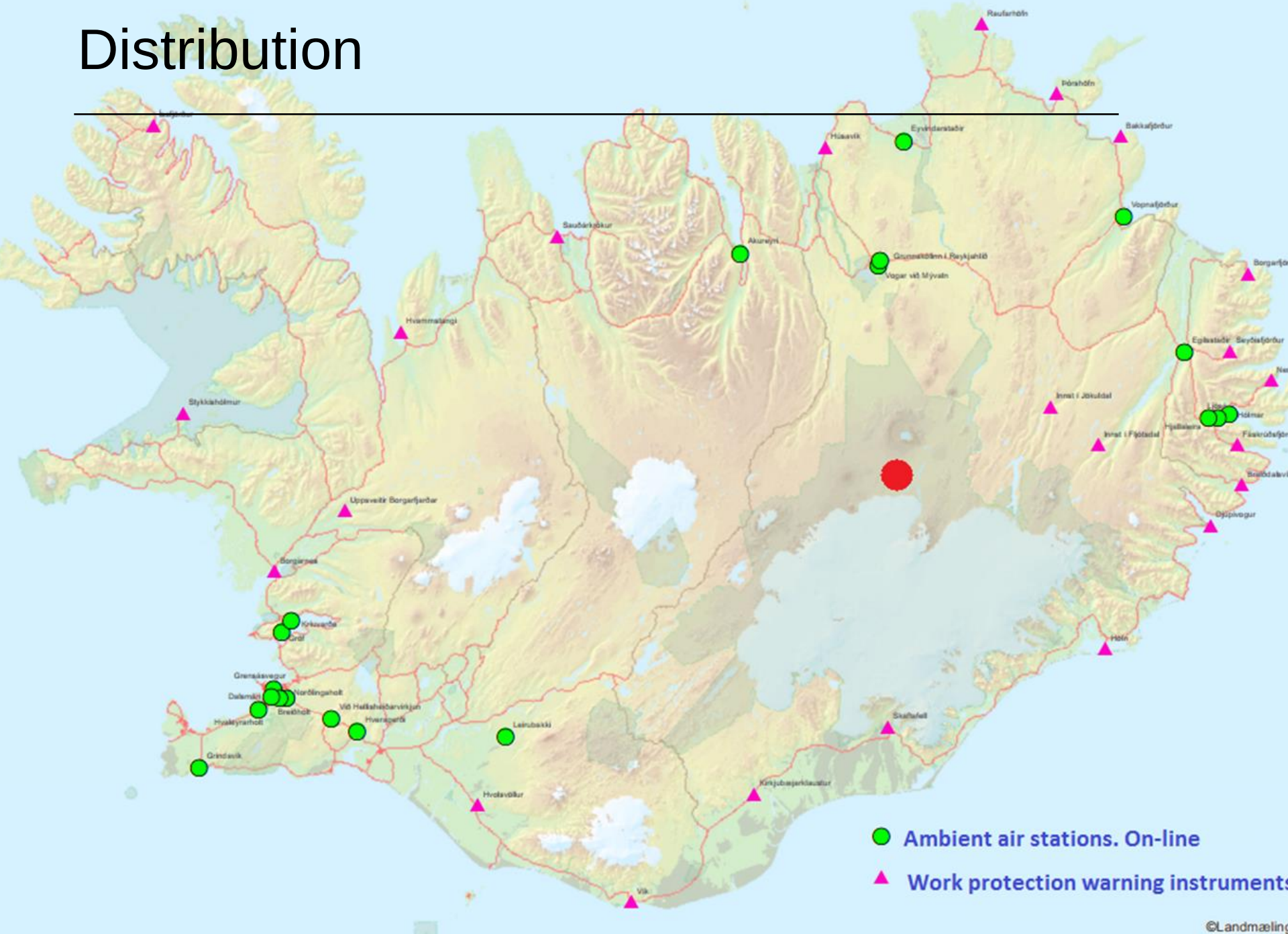


www.airquality.is

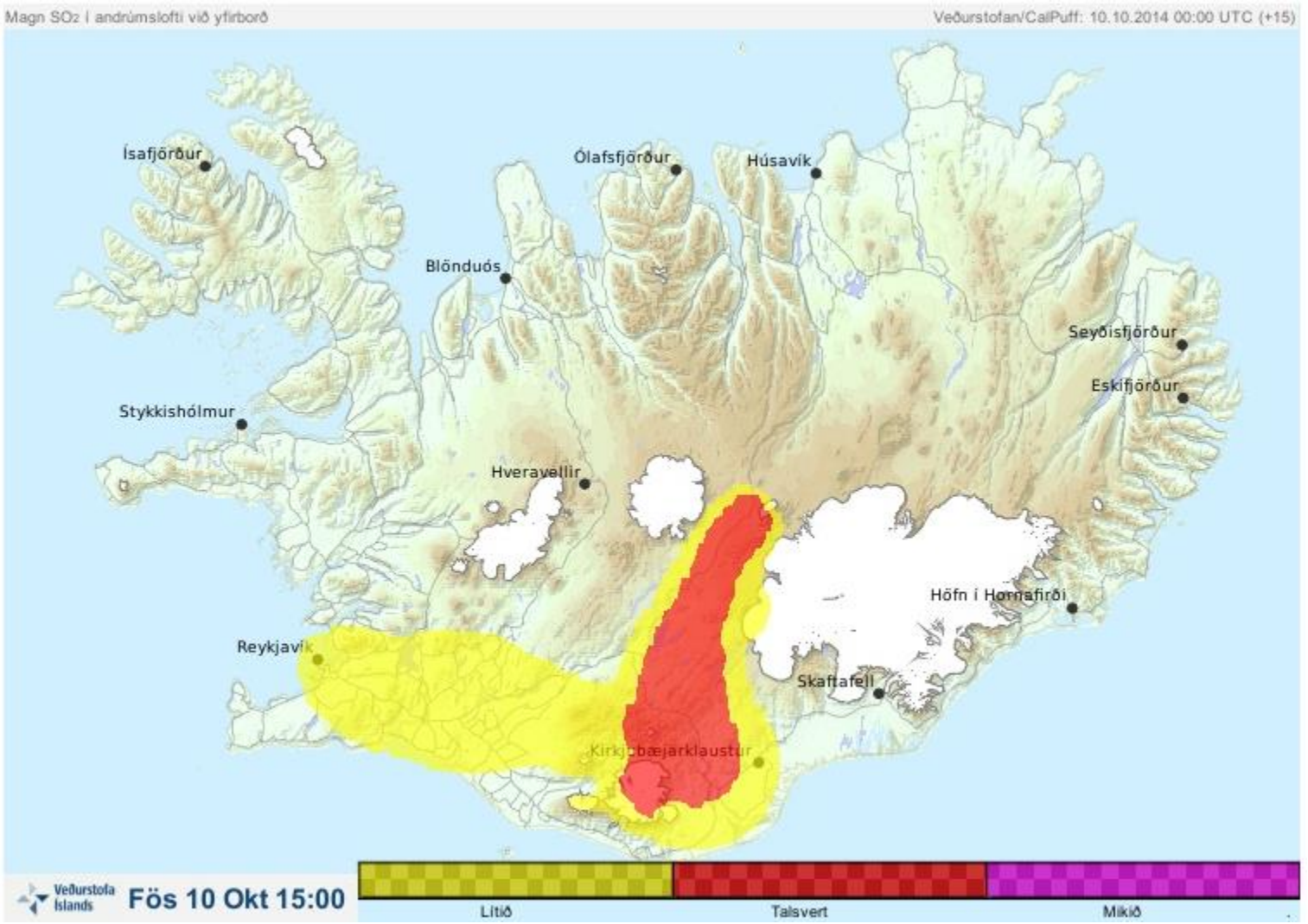
Online Measurements



Distribution



Distribution Model /Forecast



http://www.vedur.is/vedur/spar/gasdreifing

Thank you for your attention

Oslo Citizens' Observatory

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www.citi-sense-mob.eu

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NILU Norsk institutt for luftforskning
Norwegian Institute for Air Research

Citi-Sense-MOB

CITI-SENSE