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Joint Research Centre

The use of the AirSensEUR platform

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Status of Air Quality Sensors and their use in (official) monitoring strategies, RIVM, Bilthoven, February 13, 2017

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Objectives of AirSensEUR

Diminishing the development cost of multi-sensor platforms

- JRC does not retain IPR, public licenses
- Open software, transparent data treatment applied to the sensor data-> traceability of the sensor data quality
- Scientific community both of interested users and/or developers
- AirSensEUR: host platform controlling sensor shields ; amperomteric sensor shield and ancillary board ready; OPC, MOx and active sampling in development
- Automatic data transmission of sensor + GPS data, node within a network of sensors and stations assuring interoperability and compliance with the INSPIRE Directive
- Complete solution: sensor configuring for many commercial sensors, correction algorithm of sensor data, DAQ, data push to web server, web server application, smartphone application

AirSensEUR high level objectives

JRC & partners are working on the AirSensEUR project since end 2014

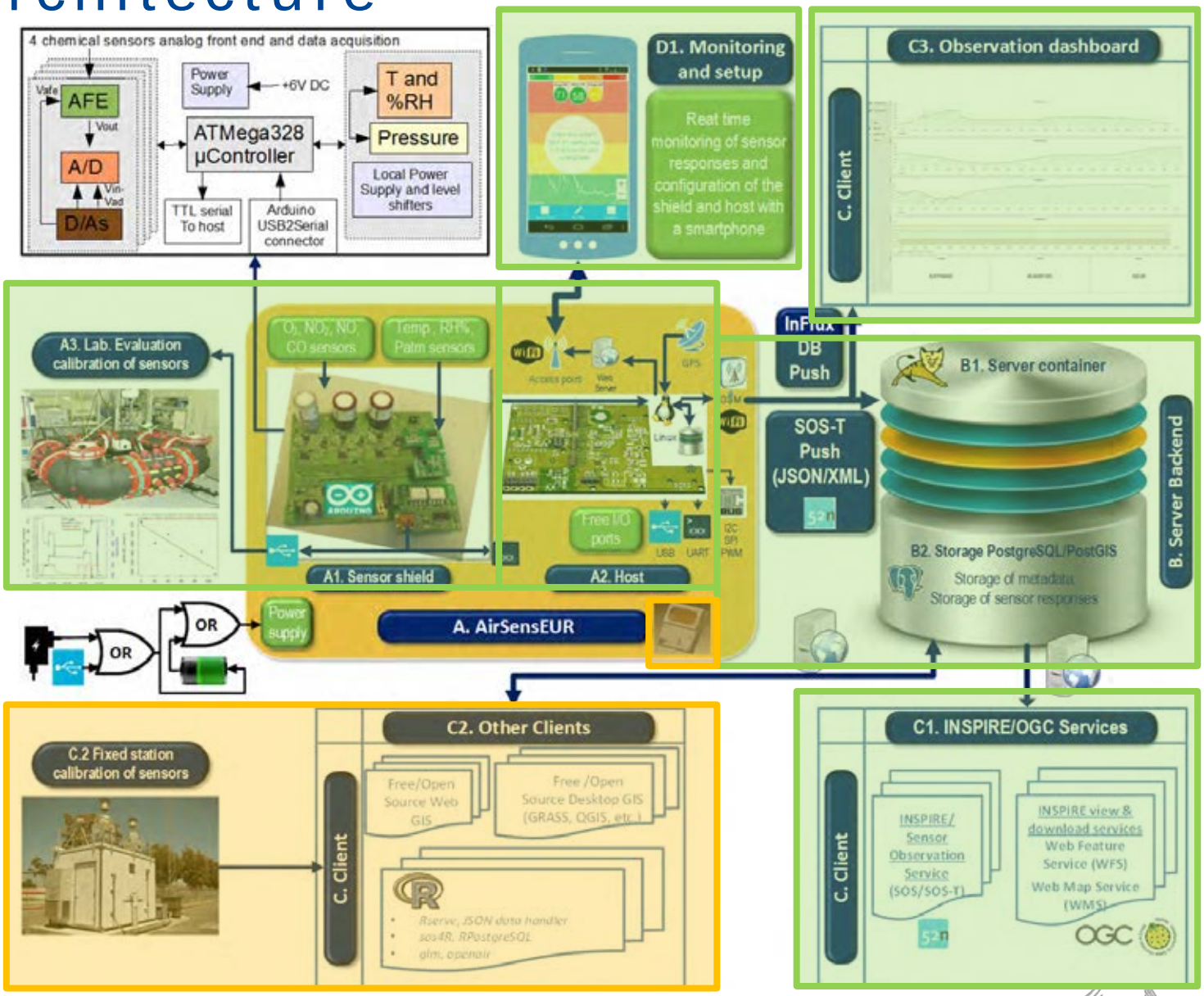
- **Objective: "Create open and interoperable sensor nodes which provide observation data",** and meet the requirements of

A) European Air Quality Directive

B) European INSPIRE Directive

- Specifications, data quality and calibration: JRC Air and Climate Unit (ERLAP, Michel Gerboles, Laurent Spinelle)
- Data management: JRC Digital Earth Unit (Alex Kotsev, Sven Schade, Max Craglia)
- Platform design and software: Liberaintentio srl (Marco Signorini)
- Growing community of sensor testers: RIVM-NL, NILU-NO, AIRPARIF-FR ...

Architecture



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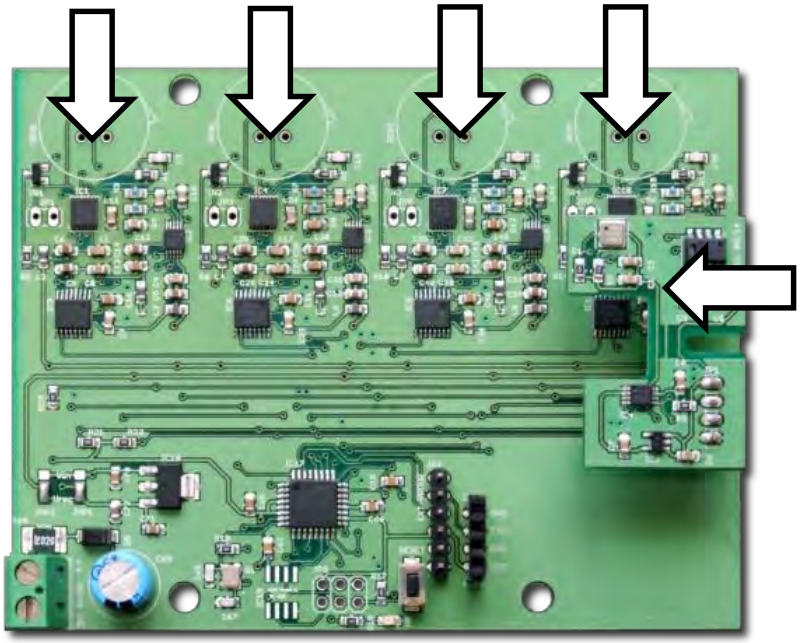
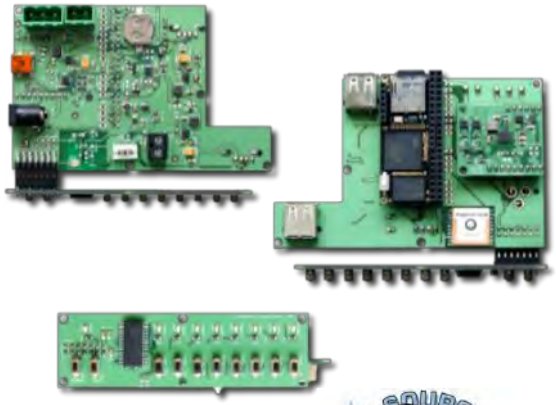
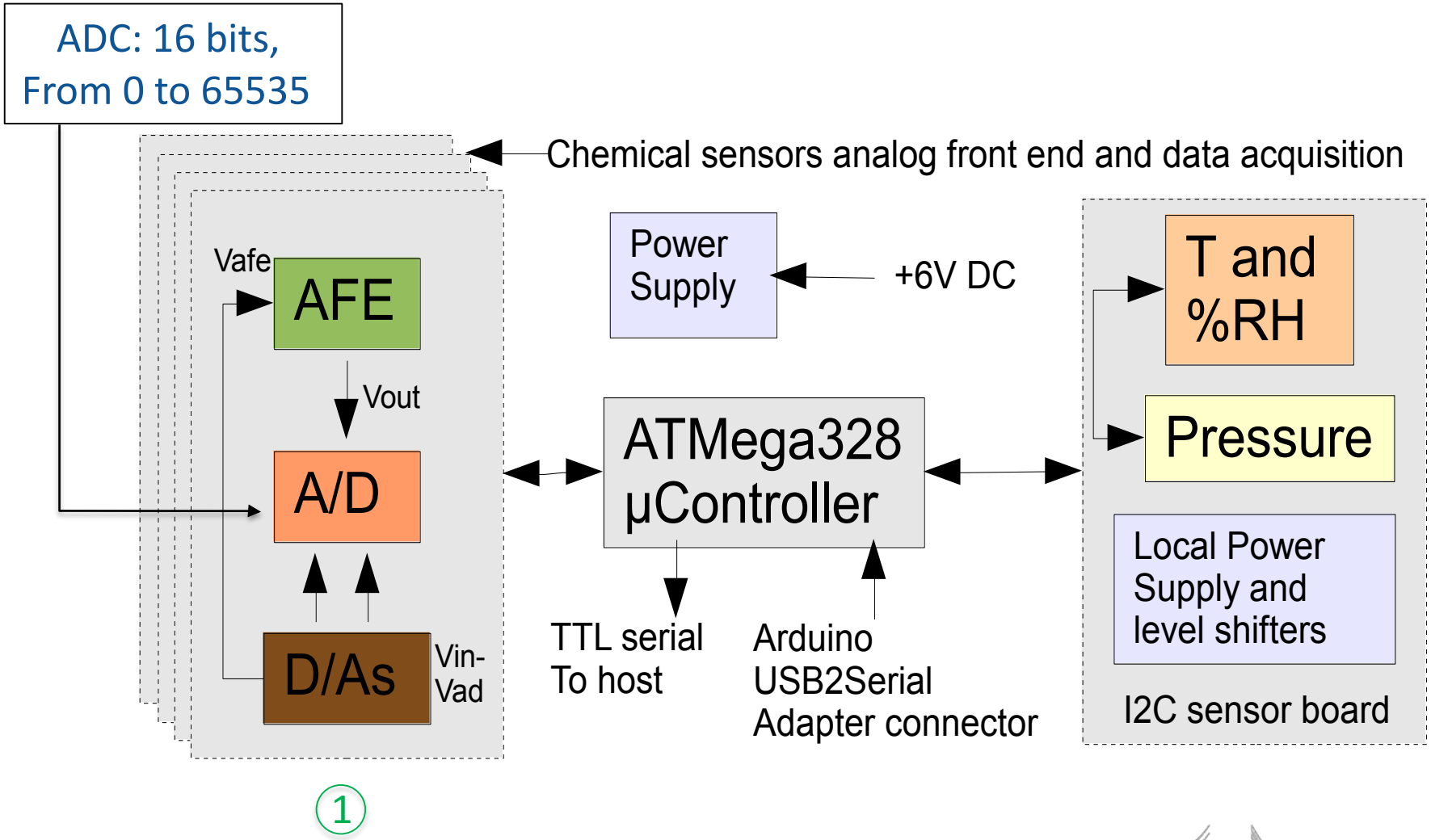
Electronic boards

- Open by design (EUPL)
- Hardware
- Software





Shield: Analogue to Digital Conversion (ADC) of sensor data



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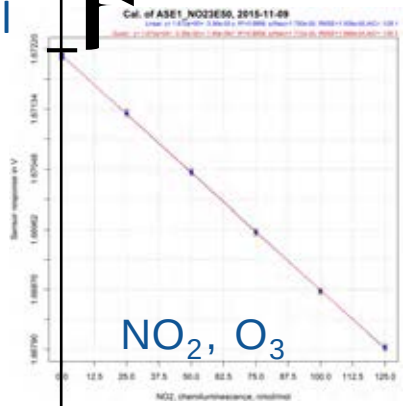
Confiuration of sensors

'Ref-' + RefAD 2^16 – 1

Selected internal zero voltage

Safety range of voltages



ADC Resolution:

$2RefAD_{mini}$ /2^16 / ($Gain_{maxi}$)

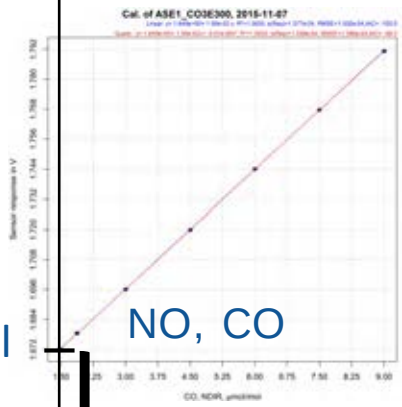
= 1V / 65536 / 350k = 0.045 nA

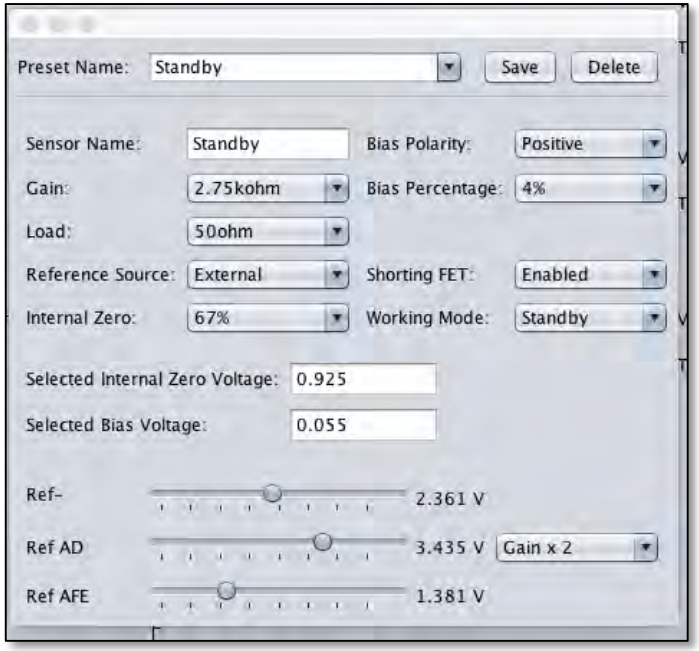
Sensor sensitivity :

> 200-1000 nA/ppm

Lod : < 1 ppb

'Ref-'





Selected internal zero voltage

'Ref-' - RefAD 0

Safety range of voltages

Sensor Voltages

Digital values

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Results

- 16 million + observations
- Teflon or 3-D printable boxing

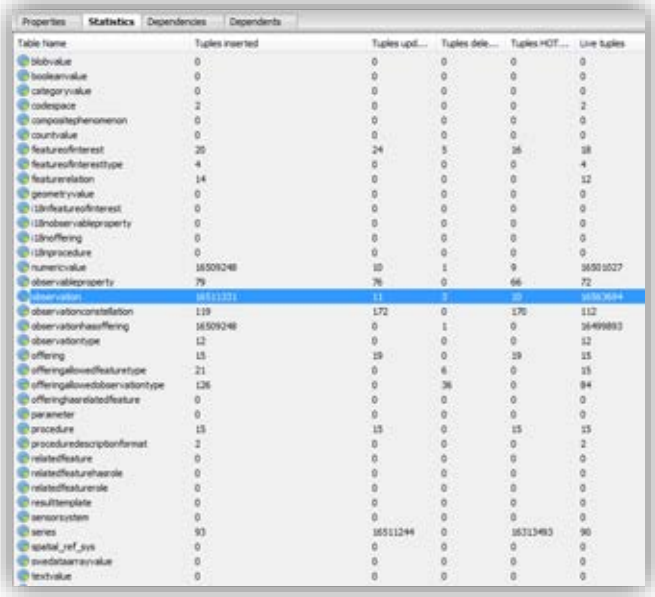

Table Name	Tuples inserted	Tuples upd...	Tuples dele...	Tuples HOT...	Live tuples
blobvalue	0	0	0	0	0
boolearvalue	0	0	0	0	0
categoryvalue	0	0	0	0	0
codespace	2	0	0	0	2
compositephenomenon	0	0	0	0	0
countvalue	0	0	0	0	0
featuresofinterest	20	24	5	16	18
featuresofinteresttype	4	0	0	0	4
featurerelation	14	0	0	0	12
geometryvalue	0	0	0	0	0
i18nfeatureofinterest	0	0	0	0	0
i18nobservableproperty	0	0	0	0	0
i18noffering	0	0	0	0	0
i18nprocedure	0	0	0	0	0
numericvalue	16509248	10	1	9	16501027
observableproperty	79	76	0	66	72
observation	16511331	11	2	10	16363694
observationconstellation	119	172	0	170	112
observationhasoffering	16509248	0	1	0	16499893
observationtype	12	0	0	0	12
offering	15	19	0	19	15
offeringallowedfeaturetype	21	0	6	0	15
offeringallowedobservationtype	126	0	36	0	84
offeringhasrelatedfeature	0	0	0	0	0
parameter	0	0	0	0	0
procedure	15	15	0	15	15
proceduredescriptionformat	2	0	0	0	2
relatedfeature	0	0	0	0	0
relatedfeaturehasrole	0	0	0	0	0
relatedfeaturerole	0	0	0	0	0
resulttemplate	0	0	0	0	0
sensorsystem	0	0	0	0	0
series	93	16511244	0	16313493	90
spatial_ref_sys	0	0	0	0	0
swedatasarrayvalue	0	0	0	0	0
textvalue	0	0	0	0	0

- Reports

Calibration , end 2016

Working draft

Shield 08-2015 Host 08-2016 Data push Draft

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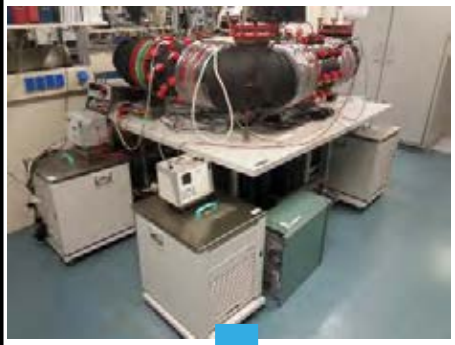
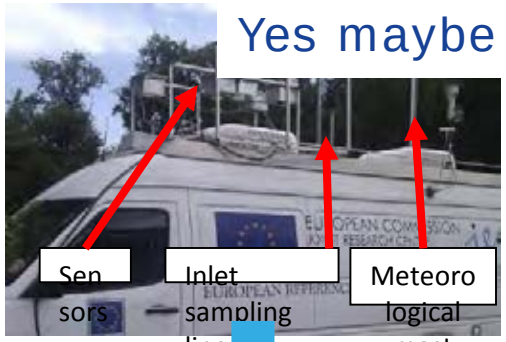
Part D calibration

Matrix resolution

Only once?
Yes maybe





Fit:

$R(NO_2)=f(RH,T,P,\ drift,\ NO_2+[]s...)$

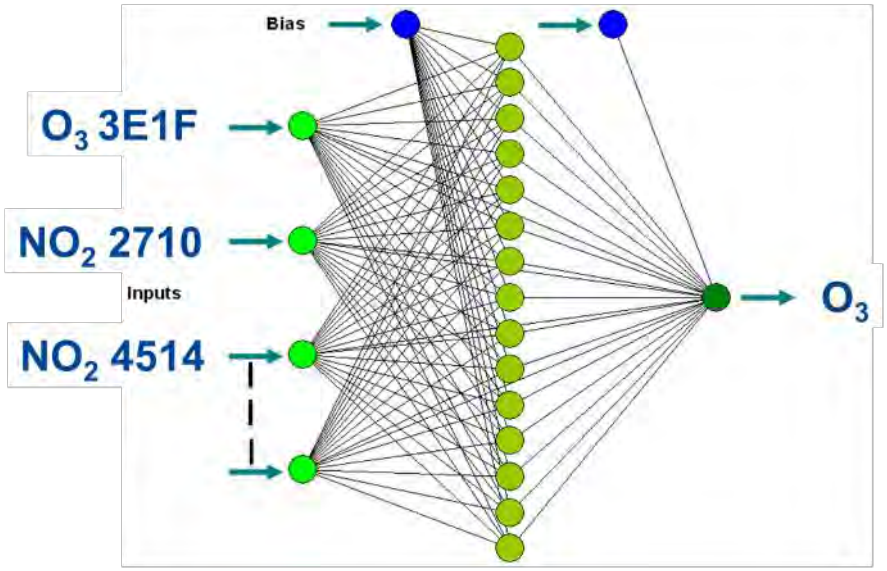
$R(CO)=f(RH,T,P,\ drift,\ CO+[]s...)$

$R(O_3)=f(RH,T,P,\ drift,\ O_3+[]s...)$

$R(NO)=f(RH,T,P,\ drift,\ NO+[]s...)$

Matrix solving to get NO_2, CO, O_3 and NO, then extrapolation

Neural Network:
Need previous field tests
CPU intensive



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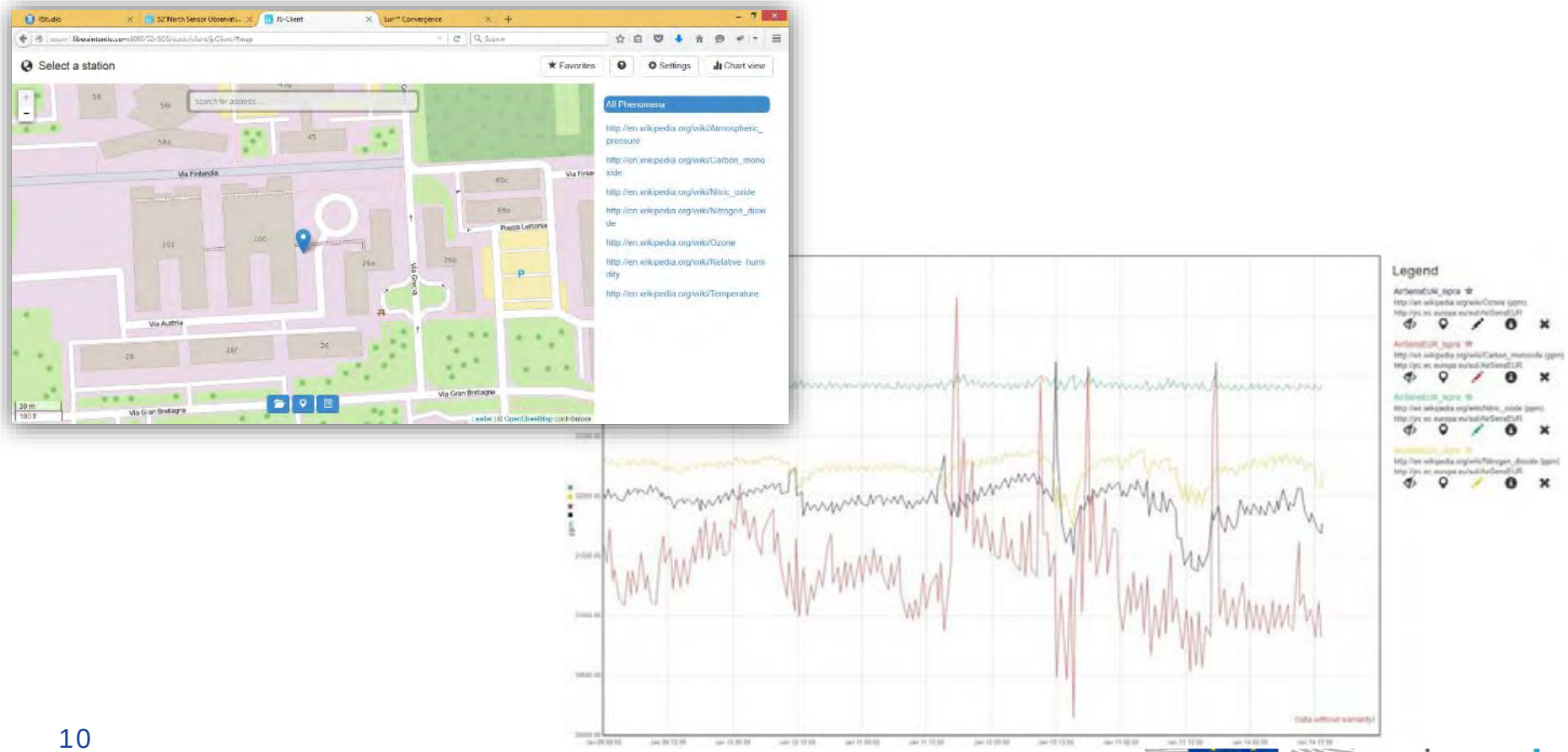
SOS-T client (Inspire implementation)

- Aggregate samples with GPS information, periodically update an external server through WiFi or GPRS channels
- Own SOS-T Java client (open source, EUPL) – consistent with the Inspire Directive



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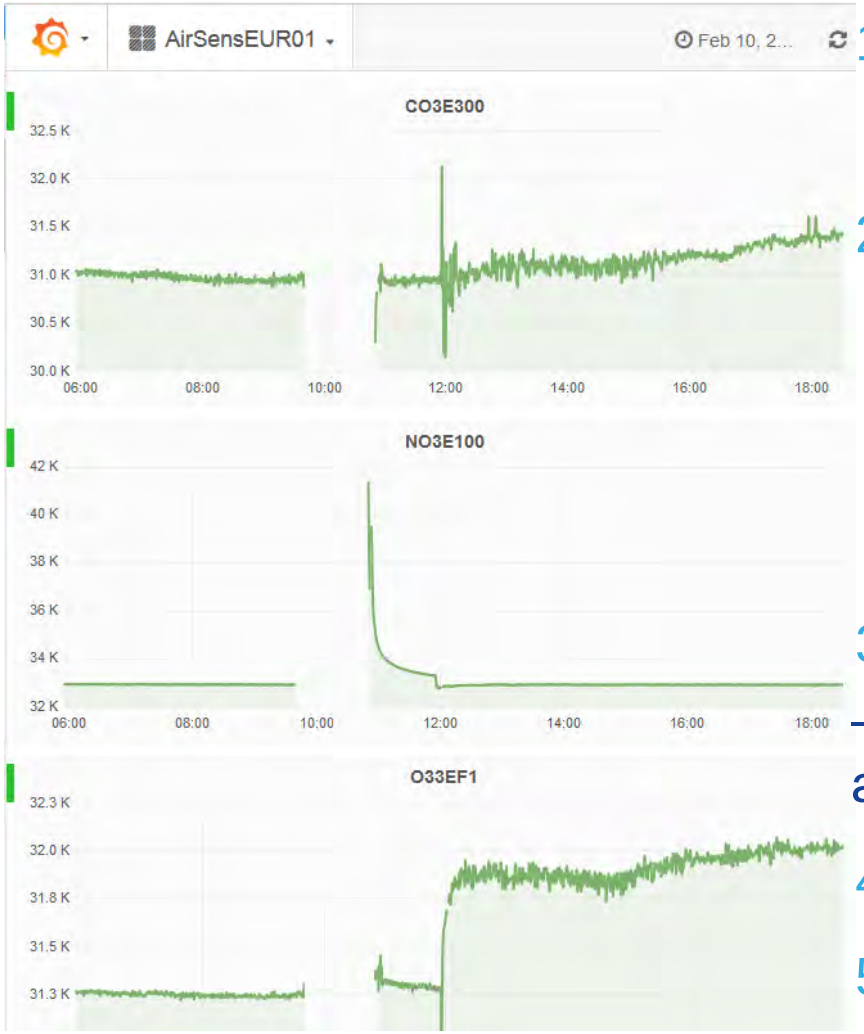
Filtering and valid data (outliers)



1. Remove negative values from reference data

2. Select valid periods for each sensors

In	End
•1 2016-10-25 15:00:00	2016-11-08 01:30:00
•2 2016-11-26 14:00:00	2016-11-29 12:30:00
•3 2016-12-03 13:00:00	2016-12-26 22:30:00
•4 2017-01-13 15:00:00	2017-02-11 13:49:00

3. Warming of sensors

– Invalid sensor data during 12 hours after every switch- on

4. Discard outliers

5. Limit temperature and humidity range

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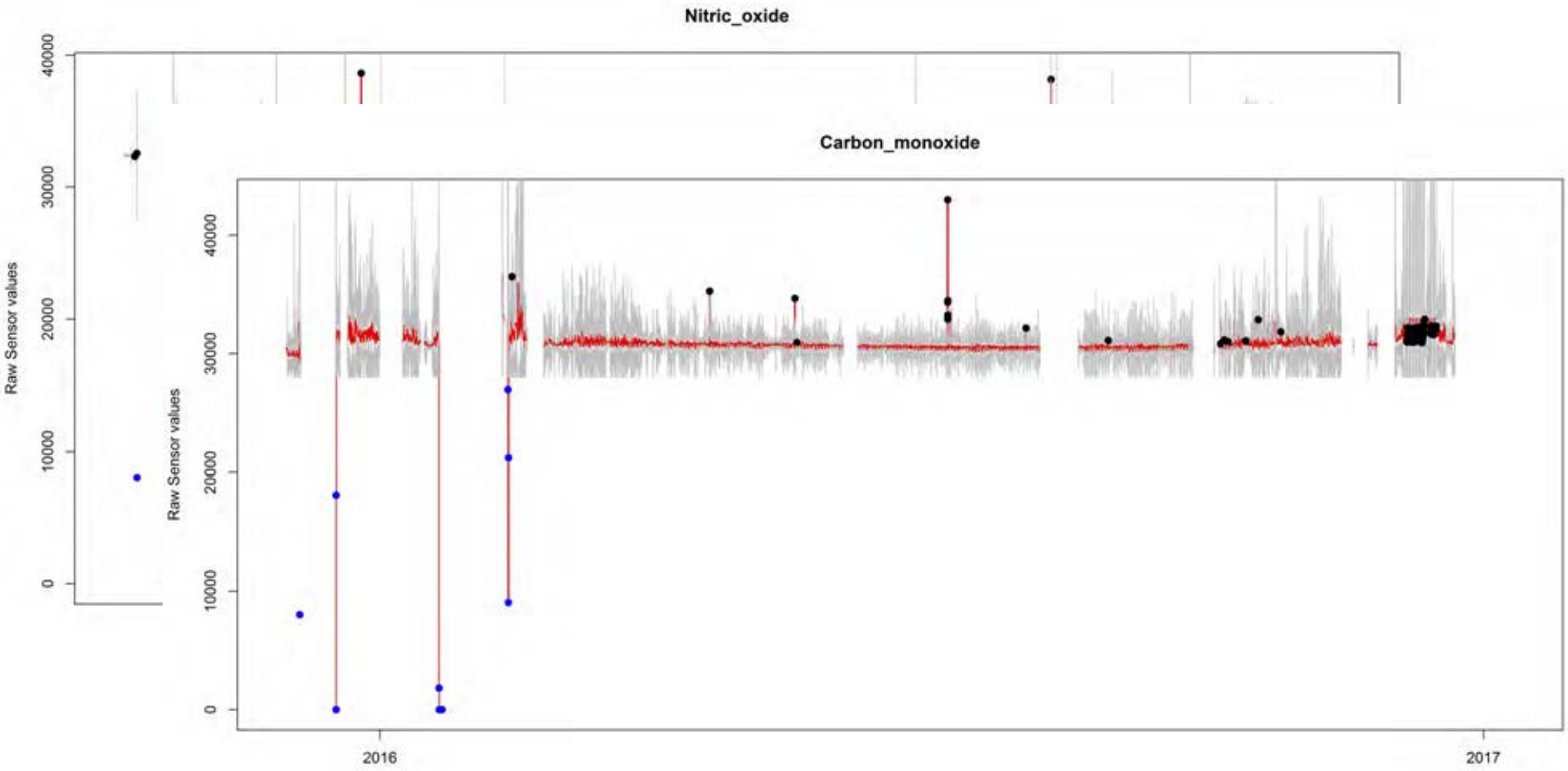
Discarding outliers (Median Average Deviation)



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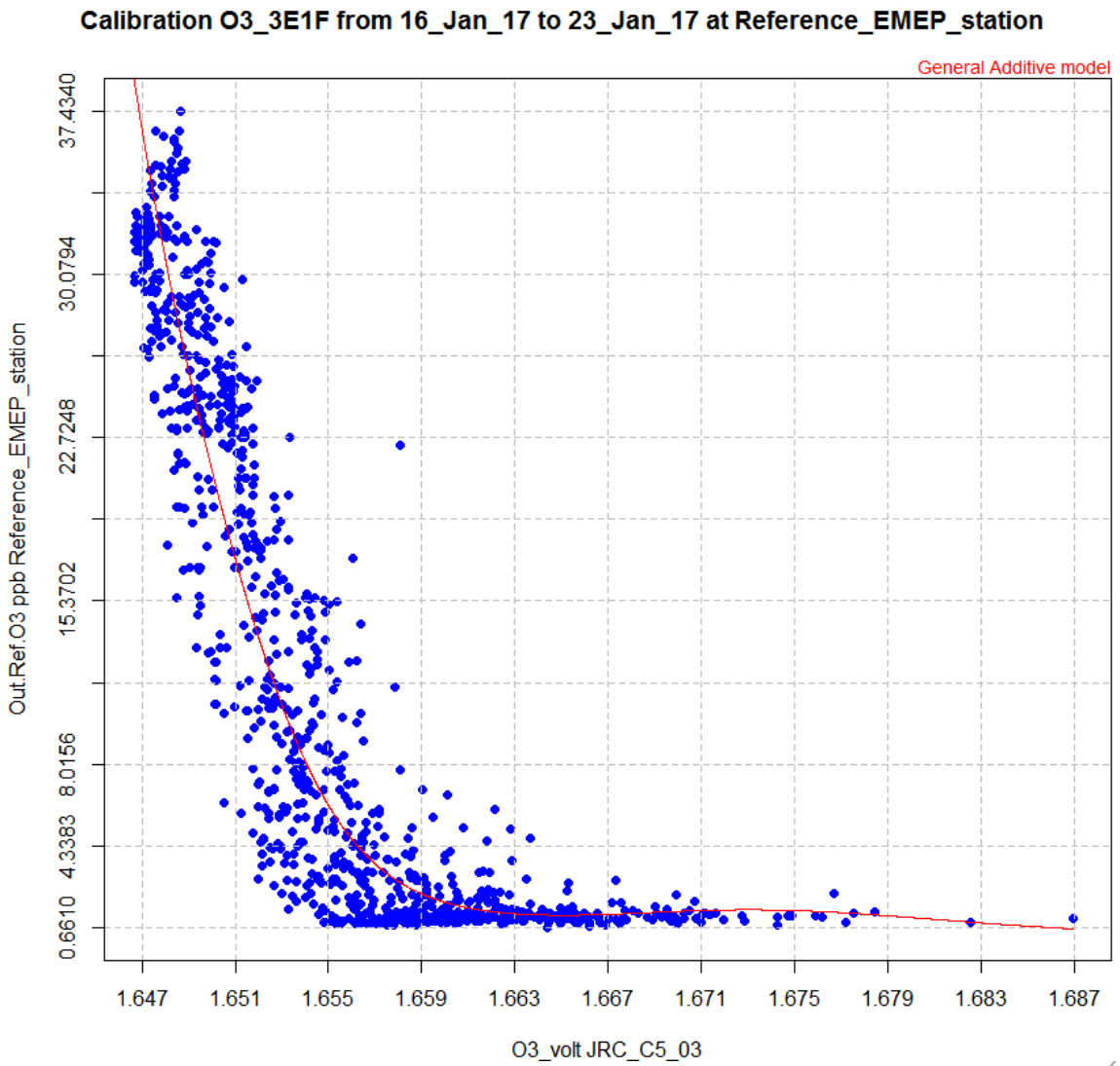
General Additive model



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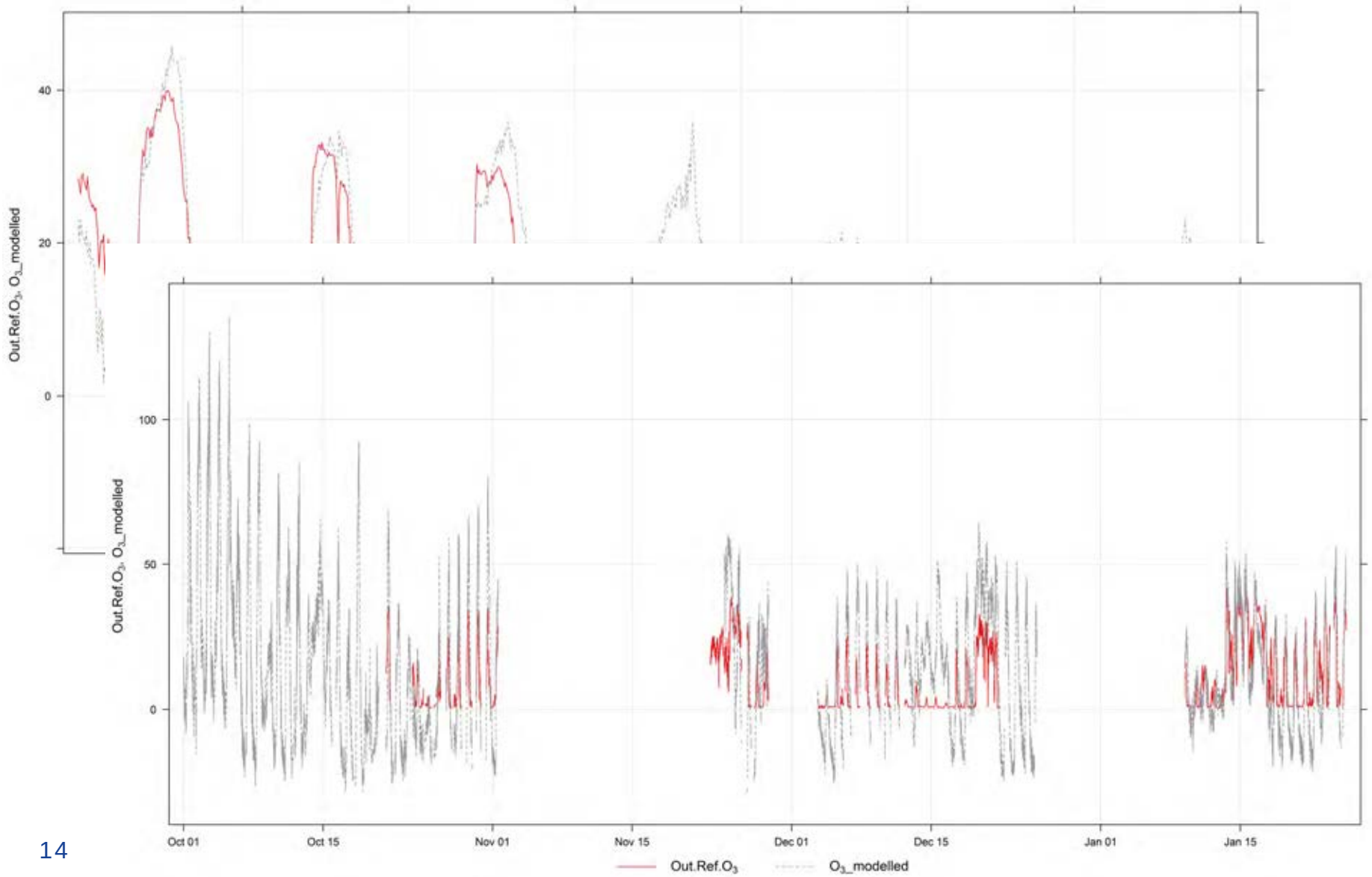
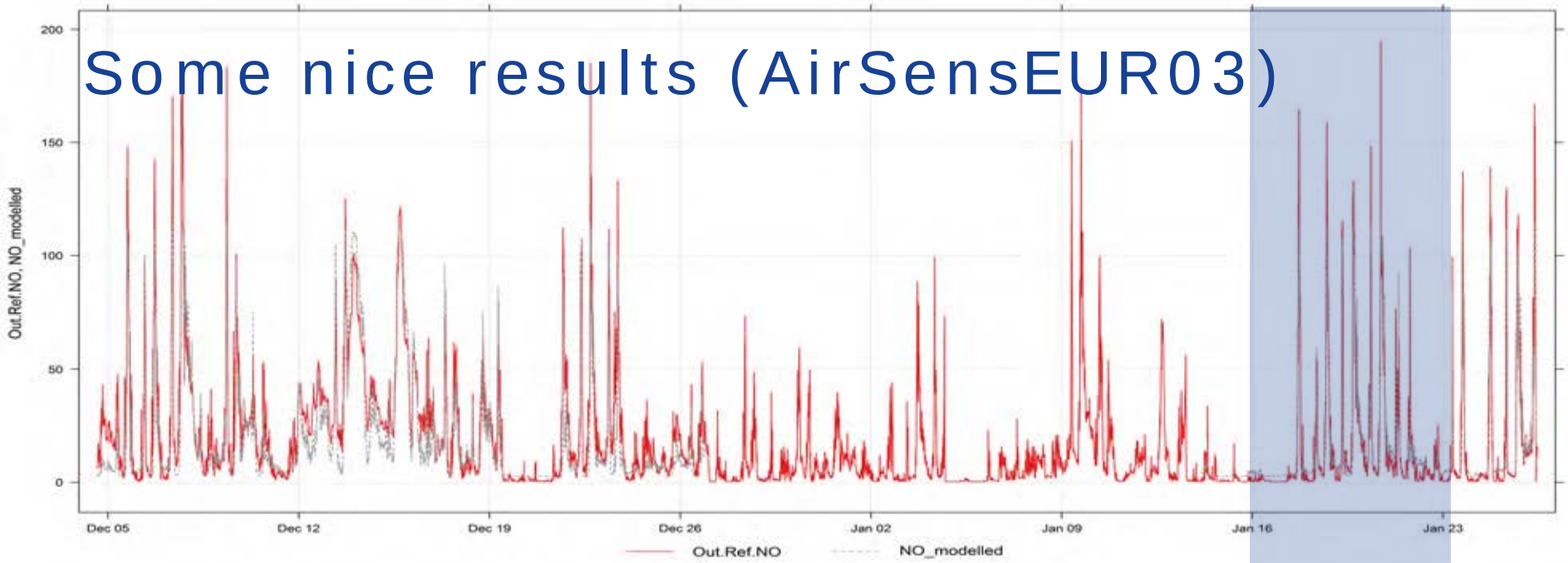
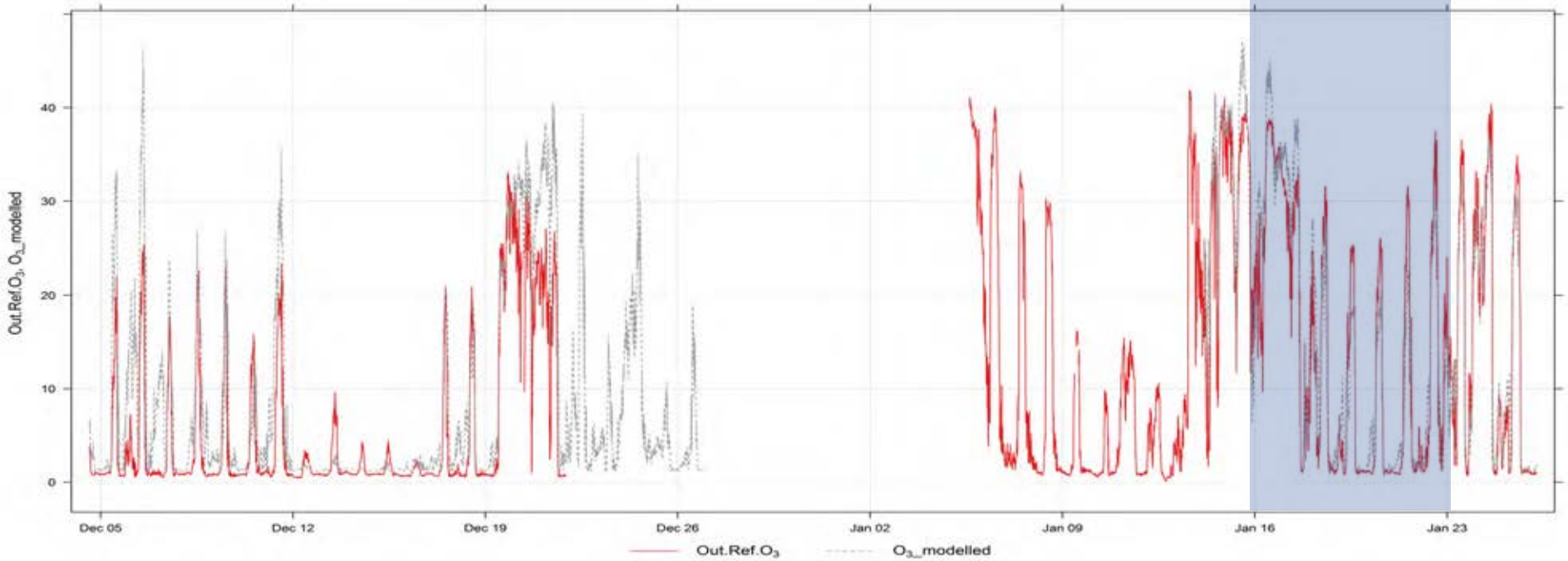
Quantile regression: remove negative values

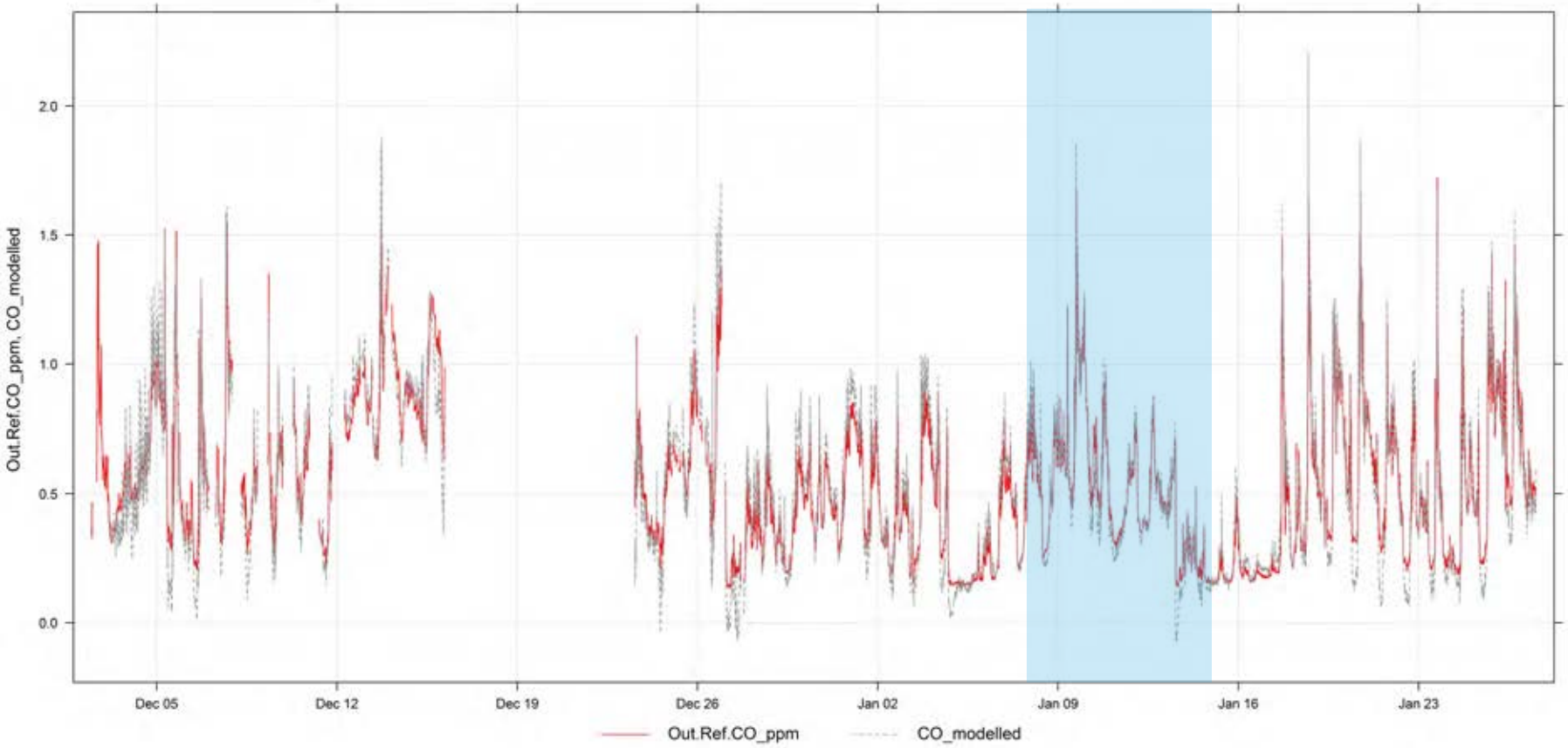


Some nice results (AirSensEUR03)





Some nice results (AirSensEUR04 CO-A4)



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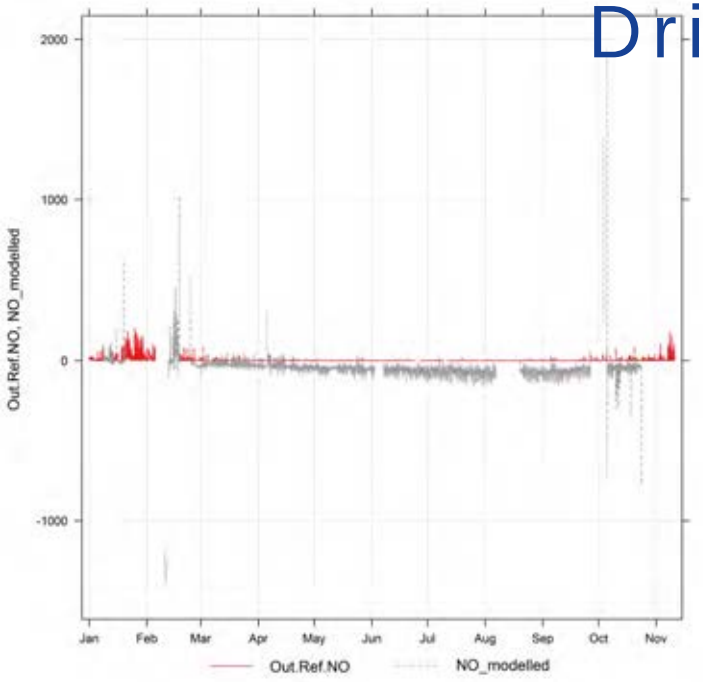
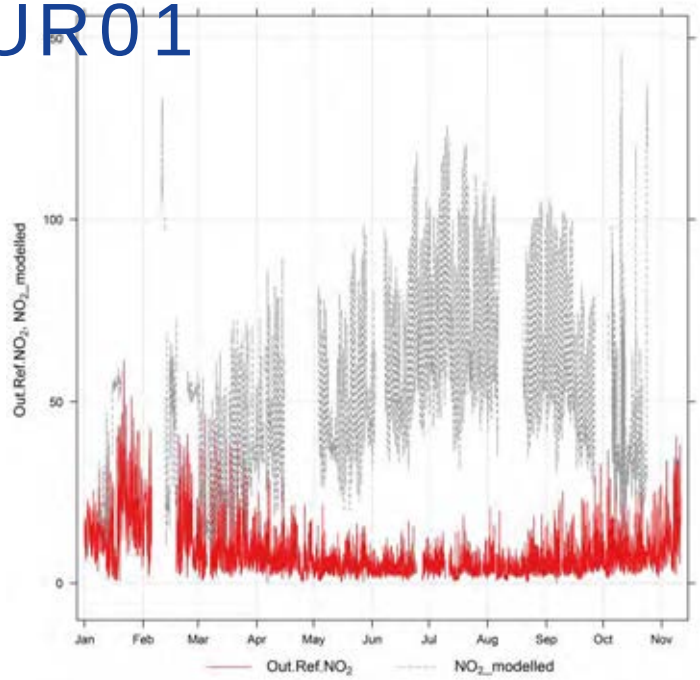
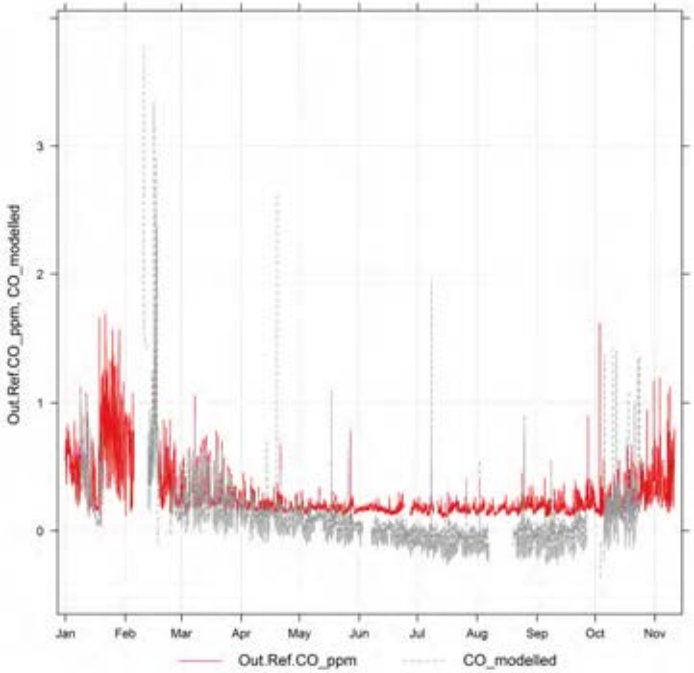
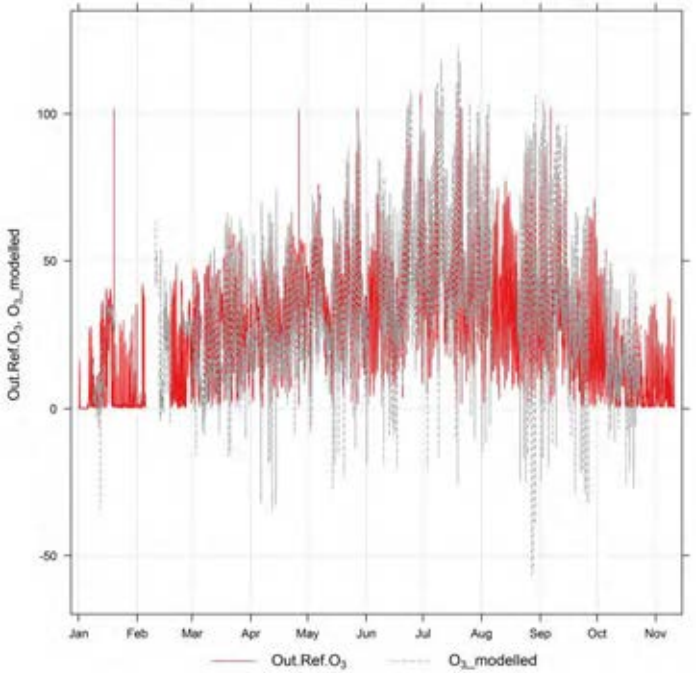
Drift AirSensEUR01









AirSensEUR Training

- 23-25 May 2016
- Leading European institutes/laboratories

•AirParif, RIVM, 52N, Ineris, IRCELINE, Geonovum, Nilu, VITO, KNMI, Ricardo

Reusable assets (SWE-specific)

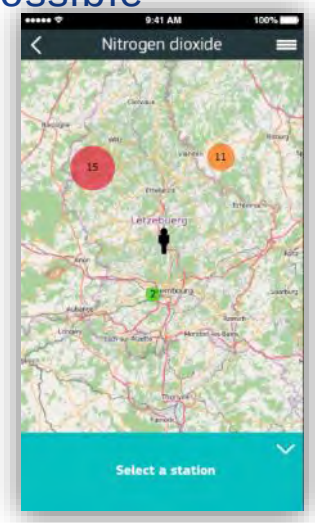
- SenseEurAir app (MyGEOSS)

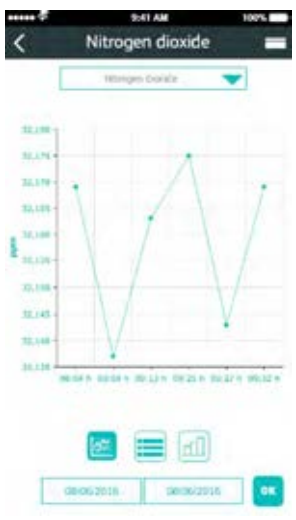
•MyGEOSS

- Develop GEOSS-based apps
- Inform European citizens on the changes affecting their local environment

•Data from 52N REST API.

•Subscription to networks is possible





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Way ahead

1. Calibration + new sensors

SOS4R (ongoing)

JRC Report on calibration

– (Part “D”)

– OPC, MOx and active sampling

2. Strengthen Community

3. Deployments (in MS)

Use case scenarios:

Local authorities

Schools

Rapid deployment

4. Pilot test in different domain

- e.g. sensing hydrogen
- Smart agriculture

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Thank for your attention

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Gerboles M. Et al., AirSensEUR: an open data/software /hardware multi-sensor platform for air quality monitoring. Part B: Host, influx datapush and assembling of AirSensEUR, 2016, EUR 28054 EN, EUR , doi:10.2790/214743, http://publications.jrc.ec.europa.eu/repository/handle/JRC102703

Kotsev A. Et al., Next Generation Air Quality Platform: Openness and Interoperability for the Internet of Things, Sensors 2016, 16, 403; doi:10.3390/s16030403, www.mdpi.com/journal/sensors

Gerboles M., et al, AirSensEUR: an open data/software /hardware multi-sensor platform for air quality monitoring. Part A: sensor shield, doi: 10.2788/30927, http://publications.jrc.ec.europa.eu/repository/handle/JRC97581

Kotsev A. et al., Sven Schade, Authoritative Environmental Observations: Findings from AirSensEUR, Conference Munster, Proceedings of the Geospatial Sensor Webs Conference 2016, Geospatial Sensor Webs, 29-31 august 2016, Munster, organized by 52°North Initiative for Geospatial Open Source Software

M. Gerboles et al., AirSensEUR: an open-designed multi-sensor platform for air quality monitoring, published online at AMA-Science.org, DOI by AMA Science, Doi: http://dx.doi.org/10.5162/4EuNetAir2015/03

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