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

COST Action TD1105

WGs and MC Meeting at LINKOPING, 3 - 5 June 2015

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

Extended Performance Analysis of a Sensor Unit for O_3 and NO_2 and Operation of a Small Static Sensor Network in Zurich, Switzerland

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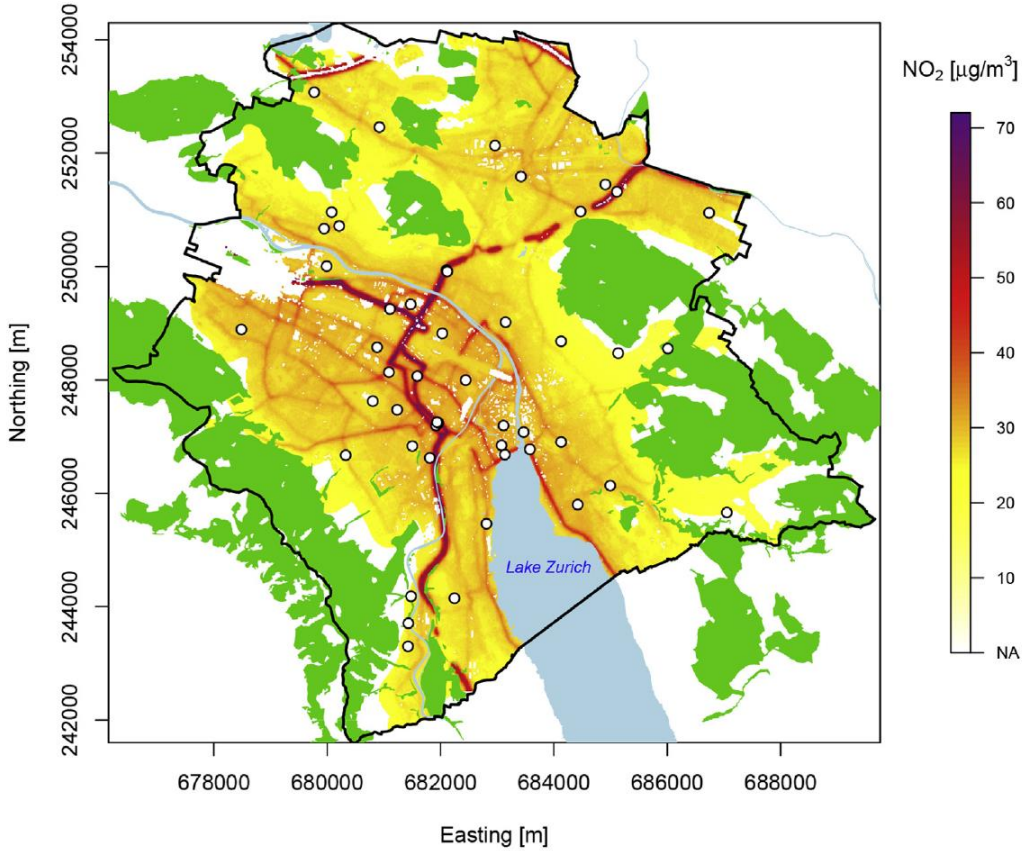
Motivation - our main interest in sensor technologies



Annual NO_2 (10m x 10m) in Zurich, Switzerland

Mueller et al. Atmos. Environ. (2015)

Assessment of the variability of air pollutant concentrations in cities with high spatio-temporal resolution (e.g. 10m, 10min) based on sensor data (static or mobile)

⇒ **How good are available sensors ?**

⇒ **How to operate a sensor network (how to guarantee sufficiently good data quality) ?**

Michael's talk WG3 session!

How good are available sensors ?
Sensor tests at a suburban reference site (Duebendorf)

Sensor Tests at AQ-Reference site in Duebendorf (suburban site)

Rolling 7-d correlation coefficient of sensor and reference instrument

Some sensors…

→ **change response behaviour during operation**

→ **work!**

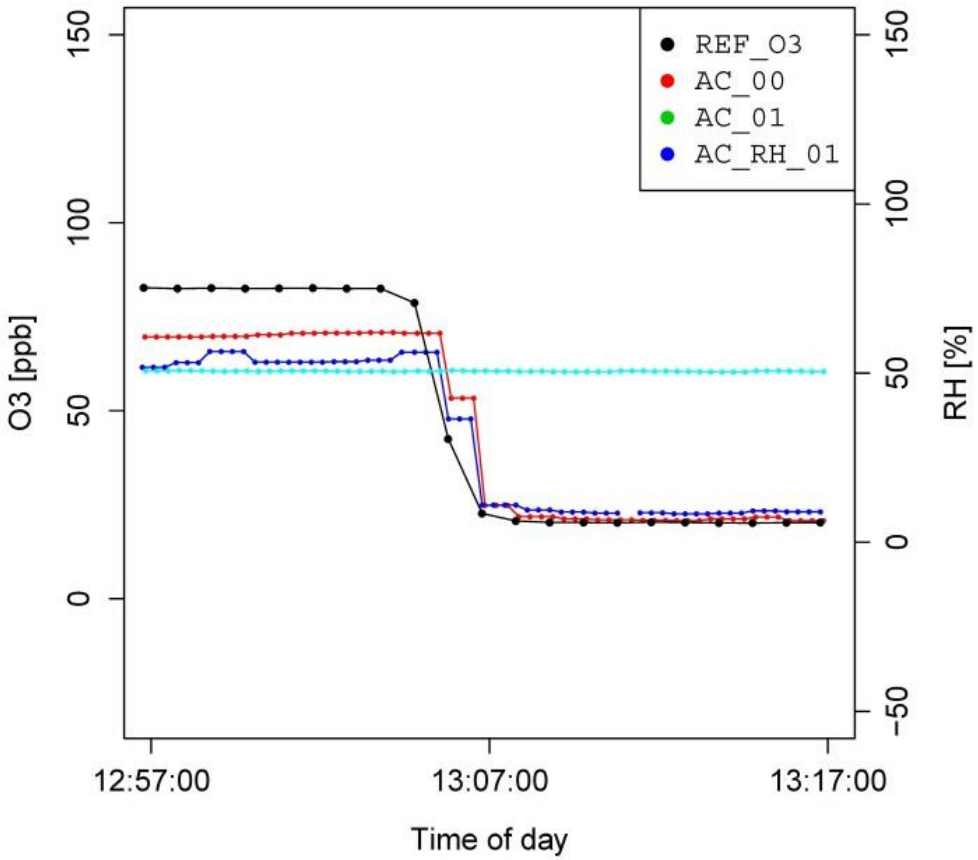
→ **don't work!**

Aircube

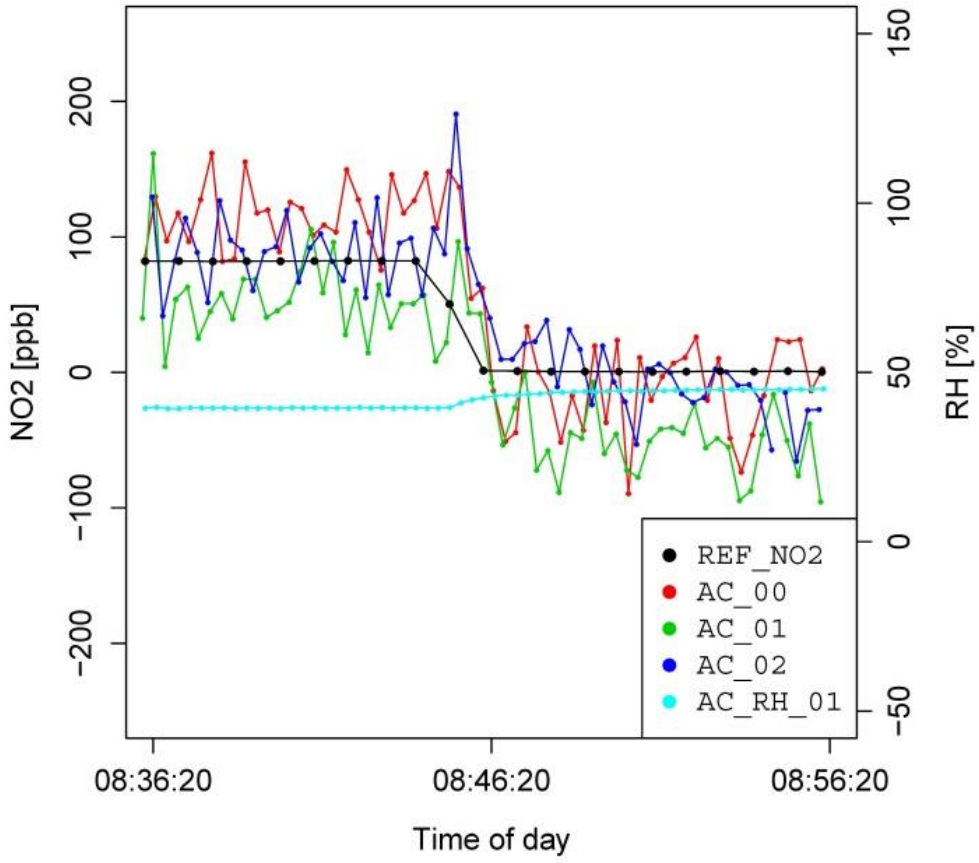
- 2x Aeroqual O_3 SM50
- 3x Alphasense NO_2 B42F
- Temperature
- Relative humidity

- GSM module for data transmission

Lab tests – response time (20s values)

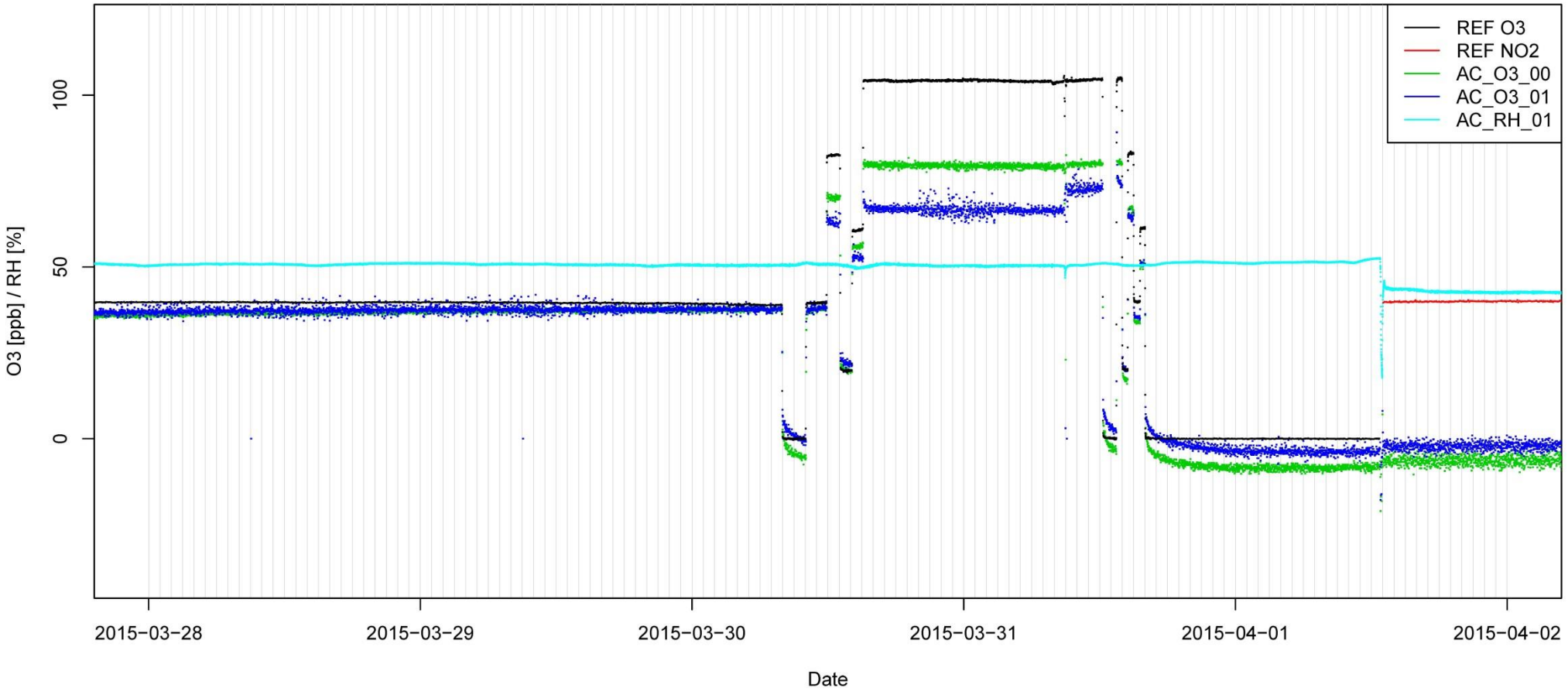


Lab tests – response time (20s values)



Lab tests – noise level

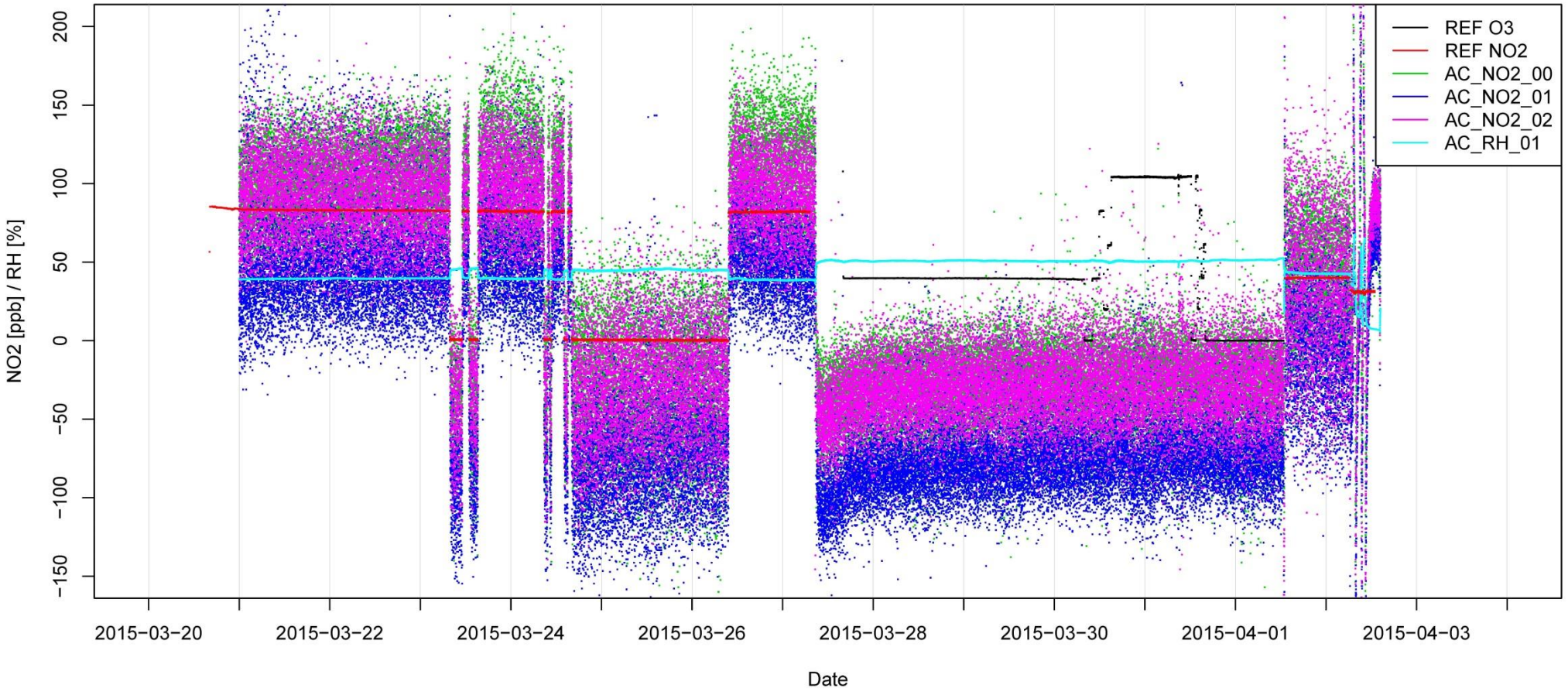
O_3 - Aeroqual SM50



s.d. ≈ 1ppb (60s values)

Lab tests – noise level

NO_2 - Alphasense B42F

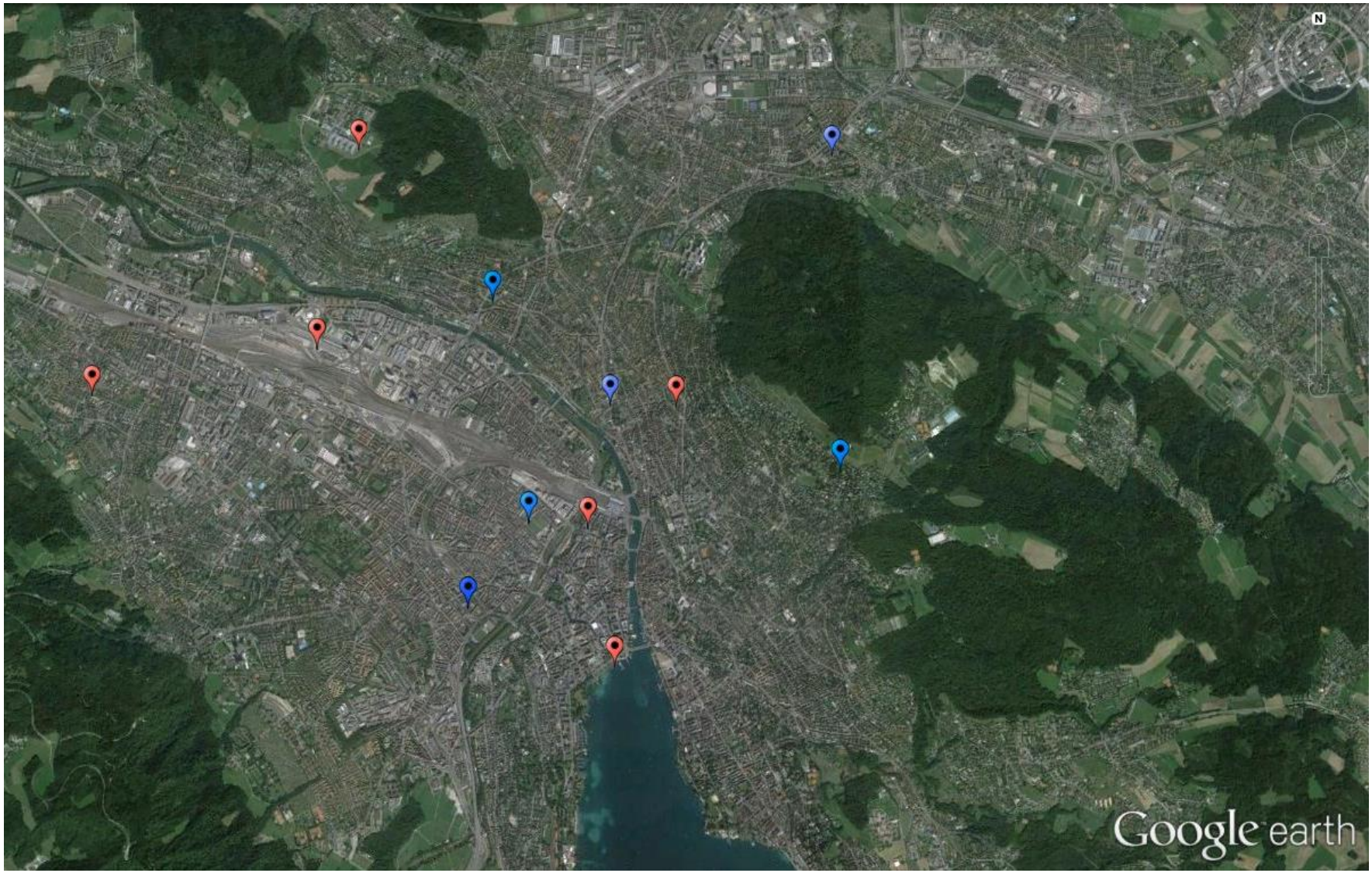


s.d. ≈ 25ppb (20s values)

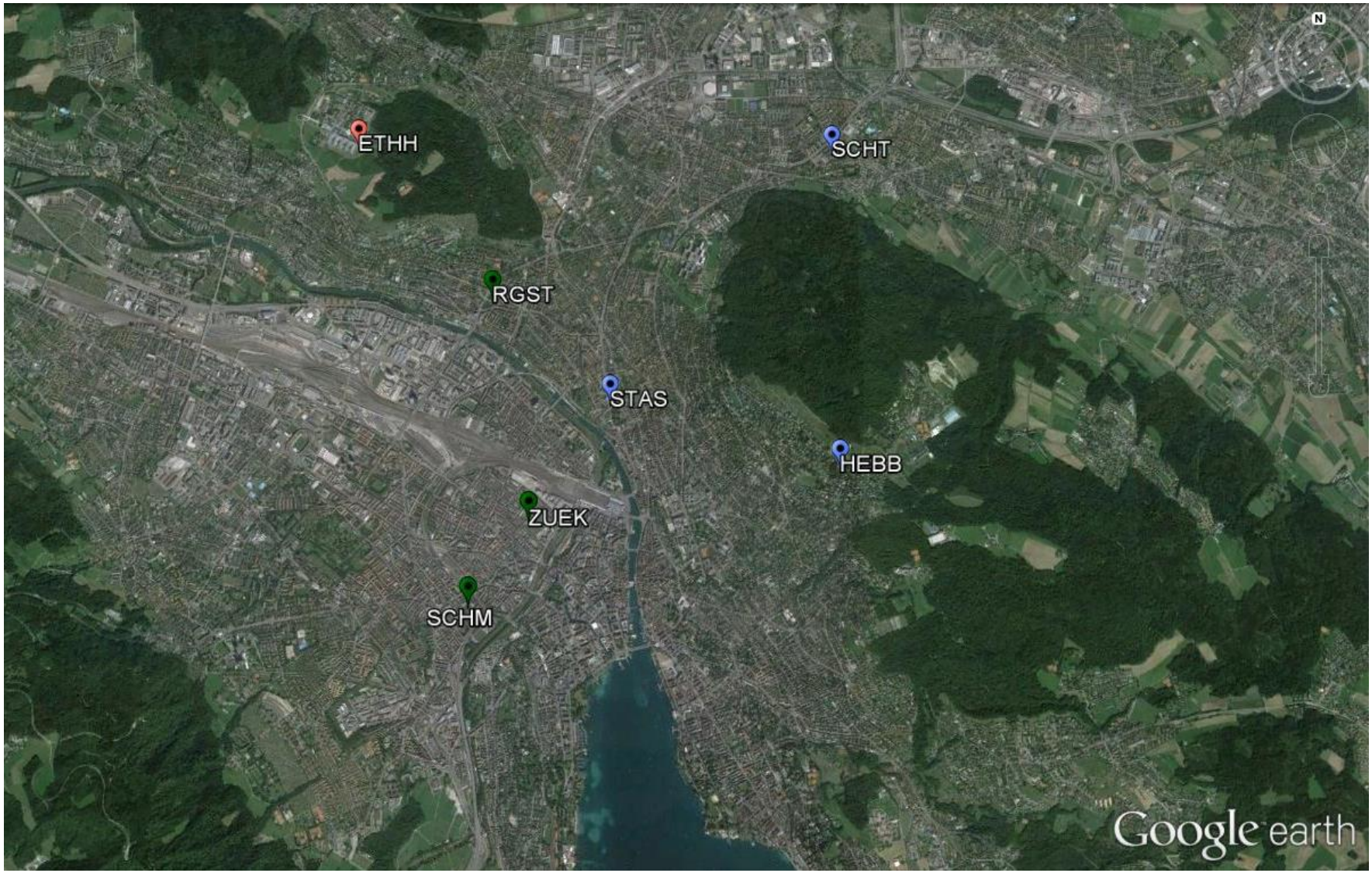
Mobile applications of sensors:

- **Are challenging (requires short response time, use of single values)**
- **Suitability of sensors must be checked**

Small sensor network in Zurich (mid of June 2015)



Small sensor network in Zurich (currently)



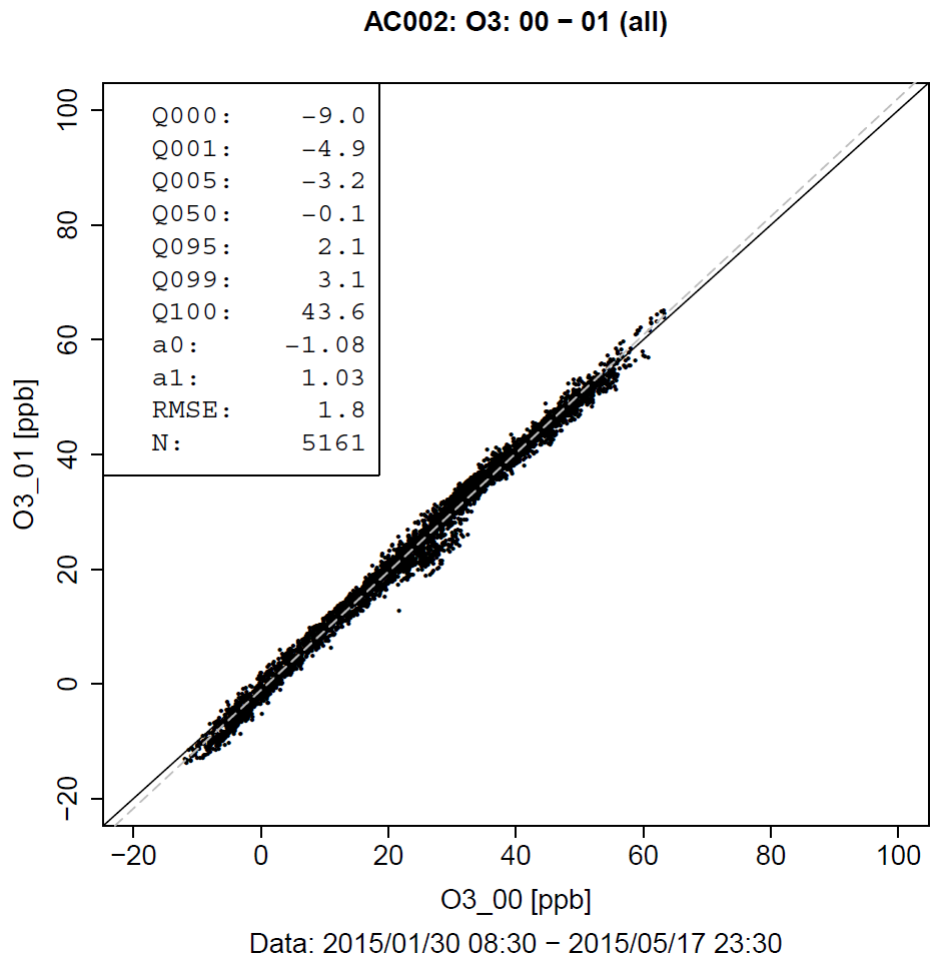
Sensor calibration at AQ monitoring sites

- 6 sensor pairs at 3 different AQ monitoring sites
  - 2 roadside sites
  - 1 urban background site

- Calibration period: Feb – May 2015
  - Large range of meteorological conditions

Comparison of two identical O_3 sensors

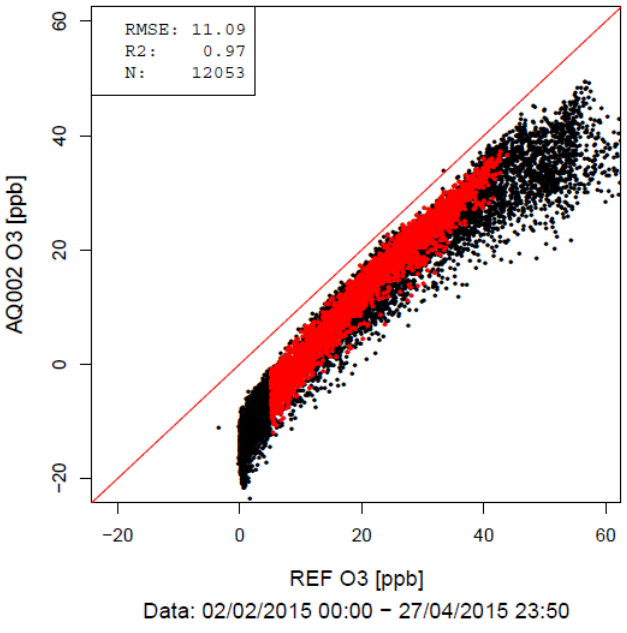
(at urban background site, 30min values, 30.01. – 17.05.2015)



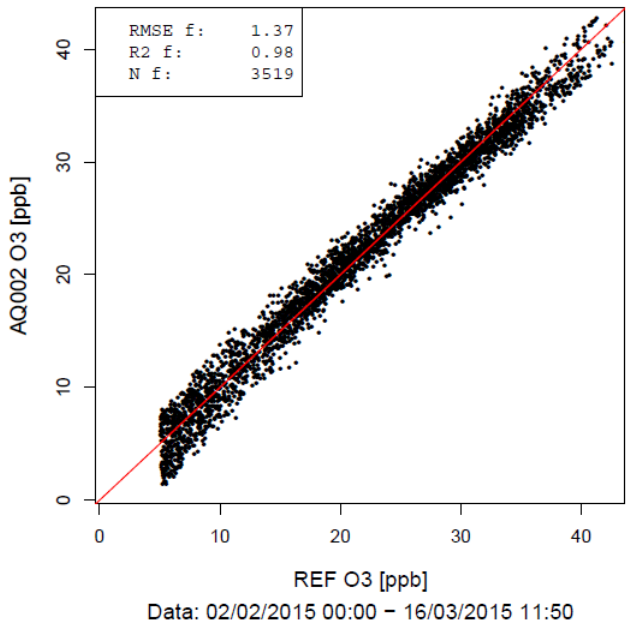
Comparison of O_3 sensor vs. reference instrument

(at urban background site, 10min values, 02.02. – 27.04.2015)

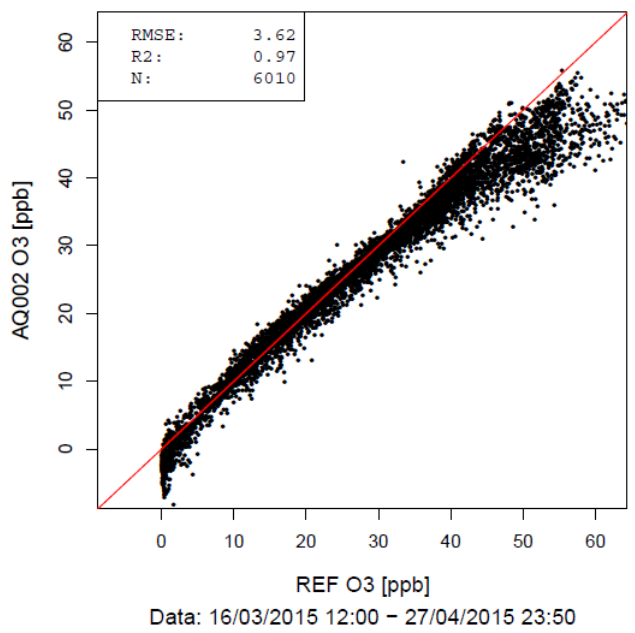
raw data (red for calibration)



calibrated (only red values)

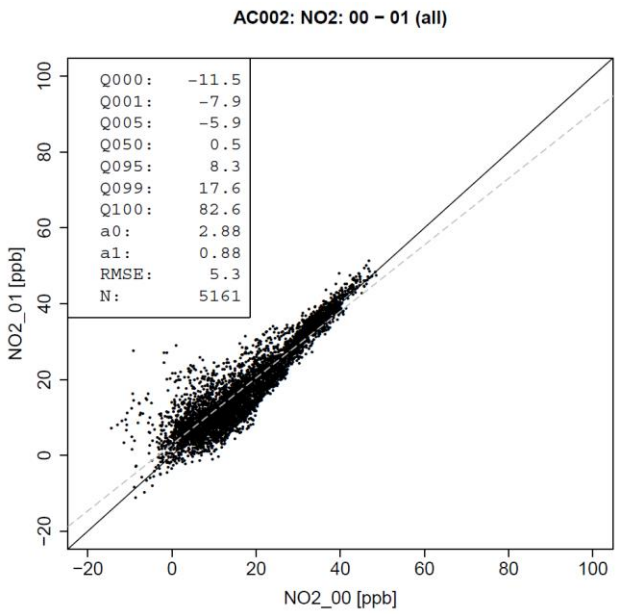


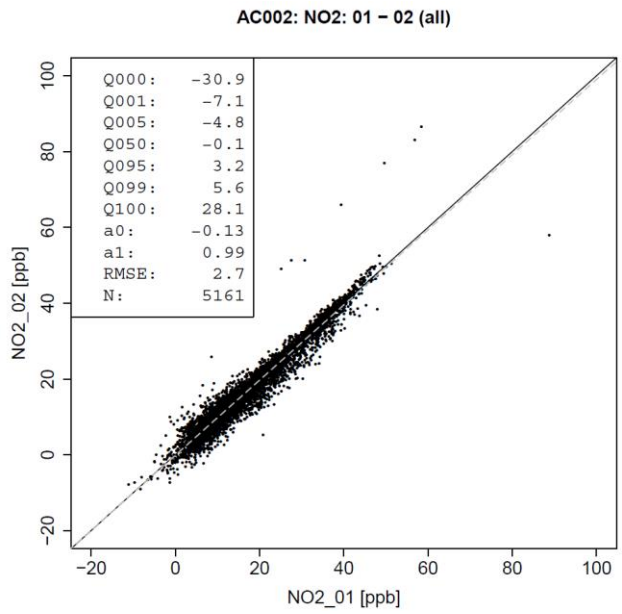
corrected (remaining values)

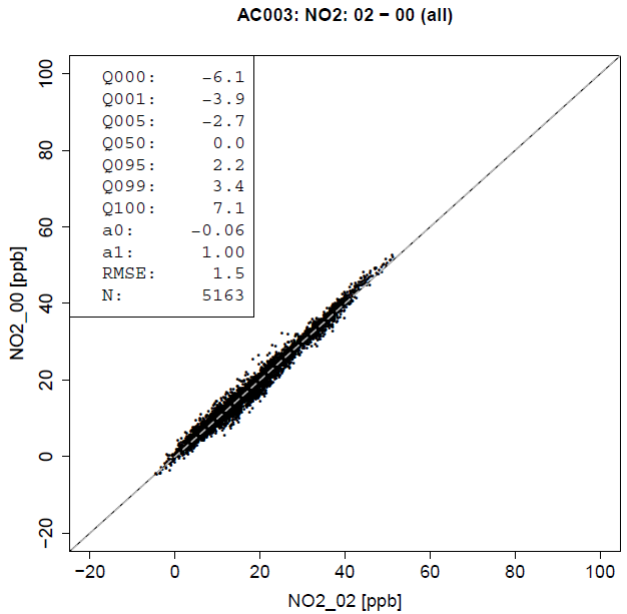


Comparison of three identical NO_2 sensors

(at urban background site, 30min values, 30.01. – 17.05.2015)



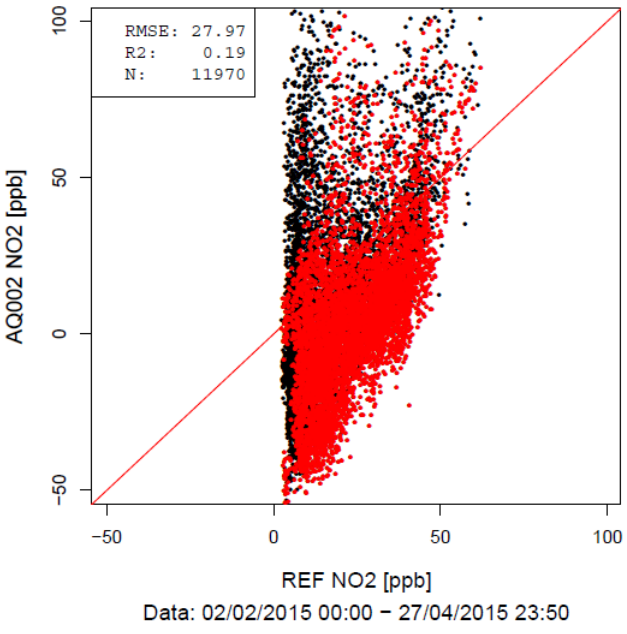




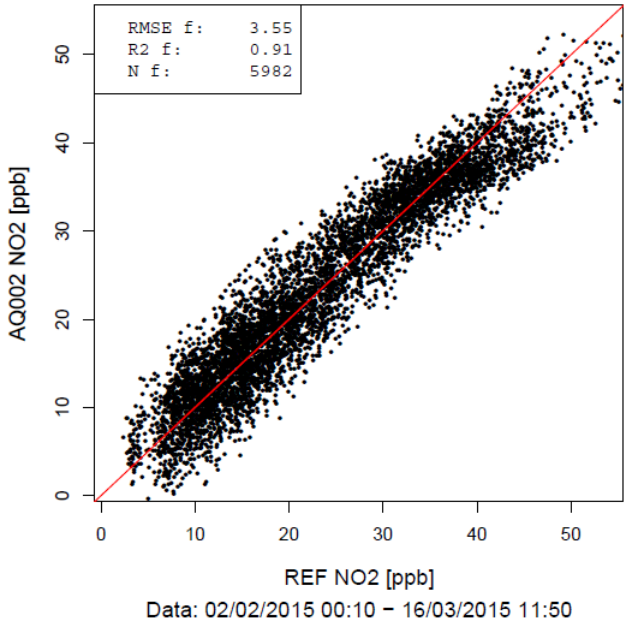
Comparison of NO_2 sensor vs. reference instrument

(at urban background site, 10min values, 02.02. – 27.04.2015)

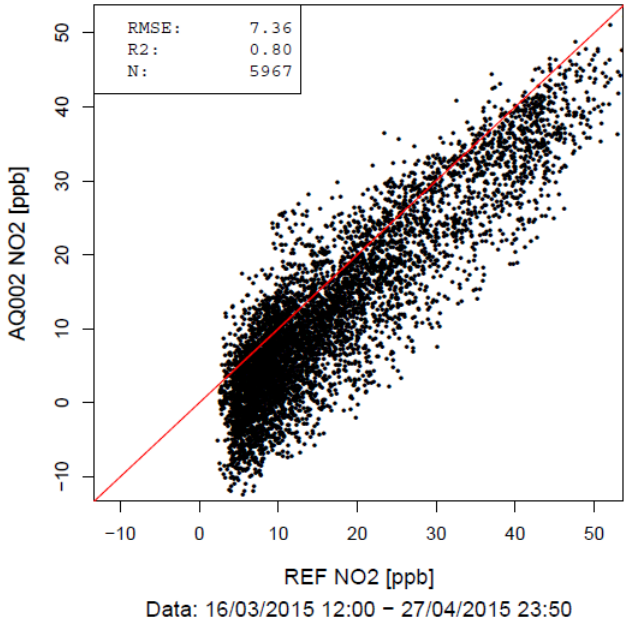
raw data (red for calibration)



calibrated (only red values)



corrected (remaining values)



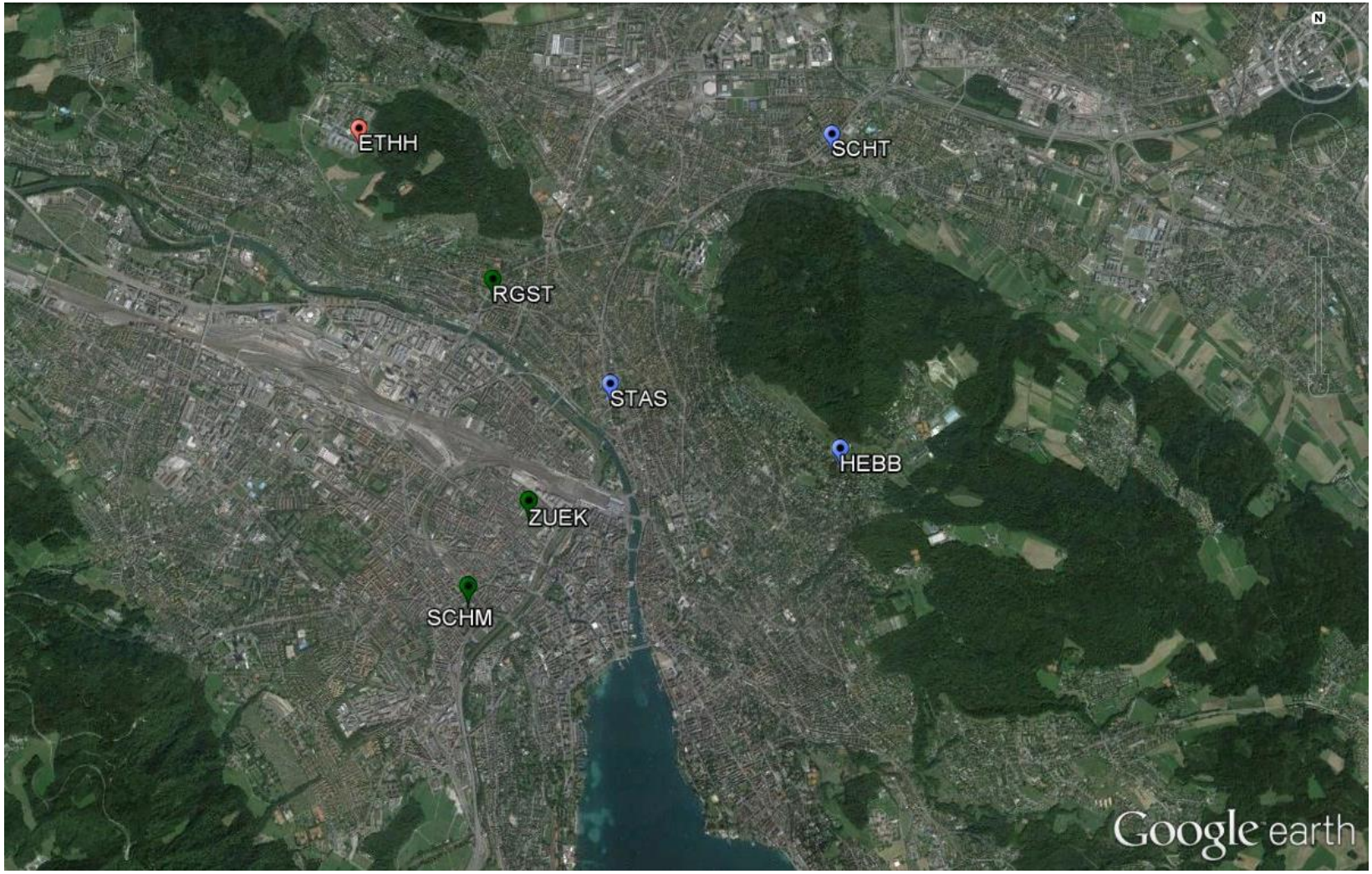
Before using sensors for AQ measurements …

… sensors should individually be «calibrated» based on parallel measurements with reference instruments

- **determine and apply a correction function**
- **correction function might include factors such as temperature, humidity, and other trace gases**

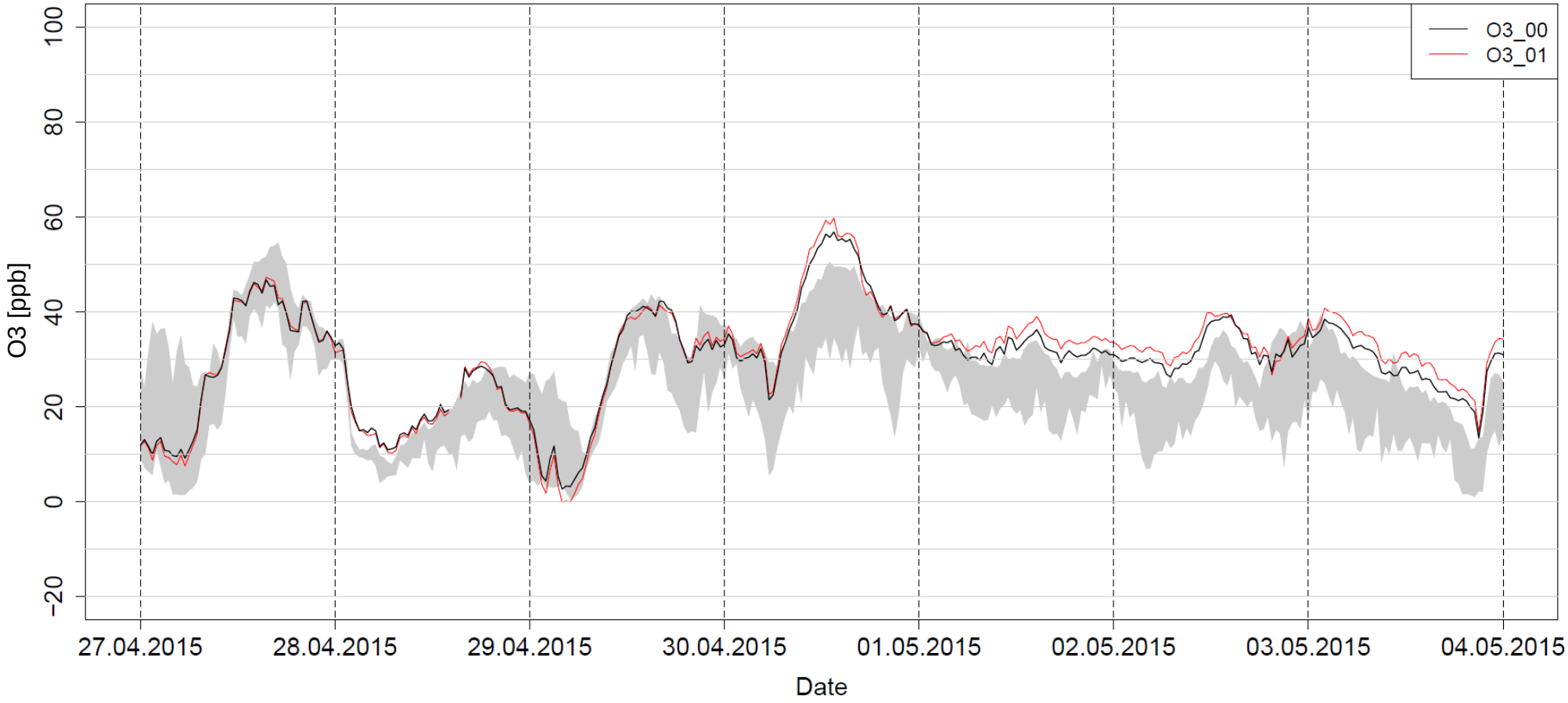
Observation of sensor behaviour/performance in a network

- redundant information from multiple identical sensors
- comparison to reference instruments



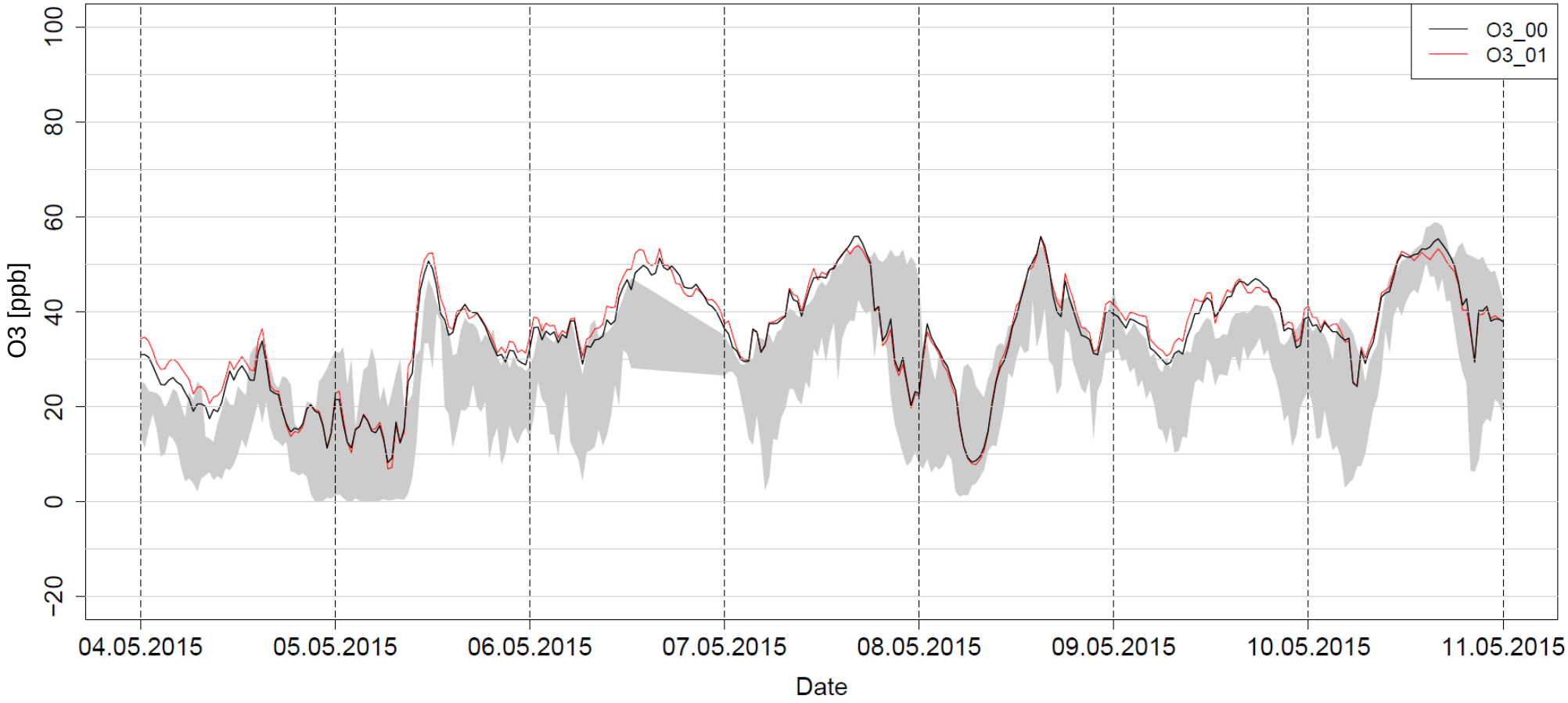
O_3 time series (30min values)

Sensors at ETHH and max/min of instruments at reference sites (grey)



O_3 time series (30min values)

Sensors at ETHH and max/min of instruments at reference sites (grey)



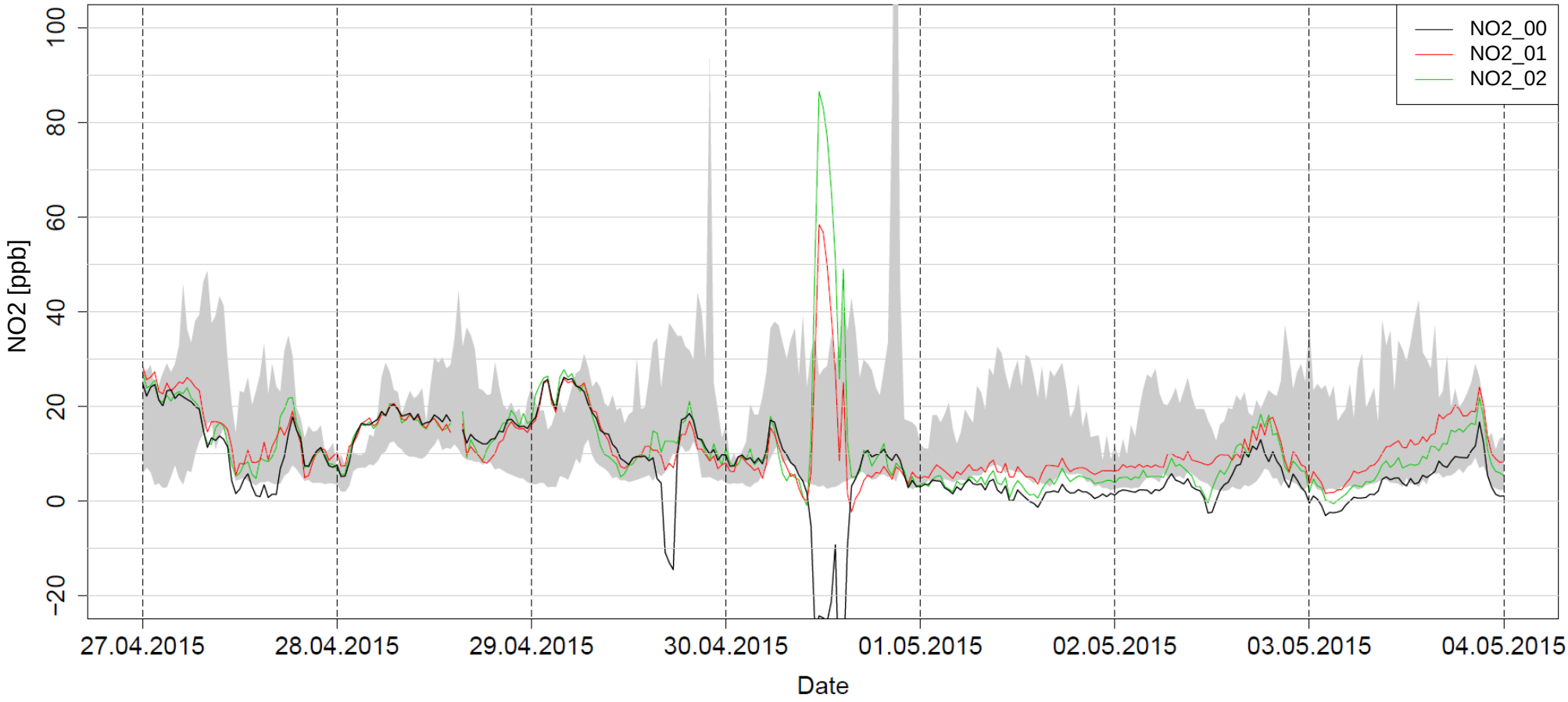
O_3 time series (30min values)

Sensors at ETHH and max/min of instruments at reference sites (grey)

How about NO_2 ?

NO_2 time series (30min values)

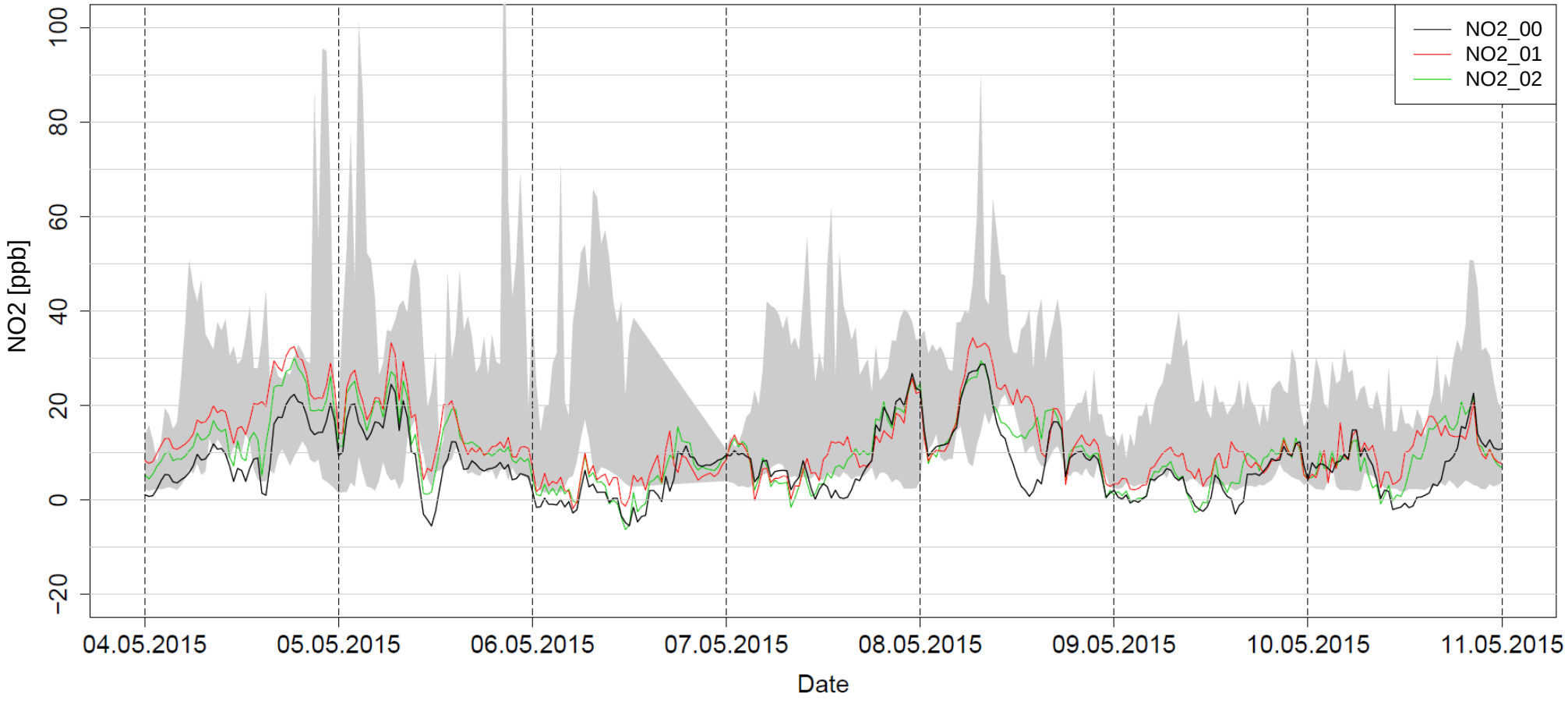
Sensors at ETHH and max/min of instruments at reference sites (grey)



note: low NO_2 levels at ETHH !

NO_2 time series (30min values)

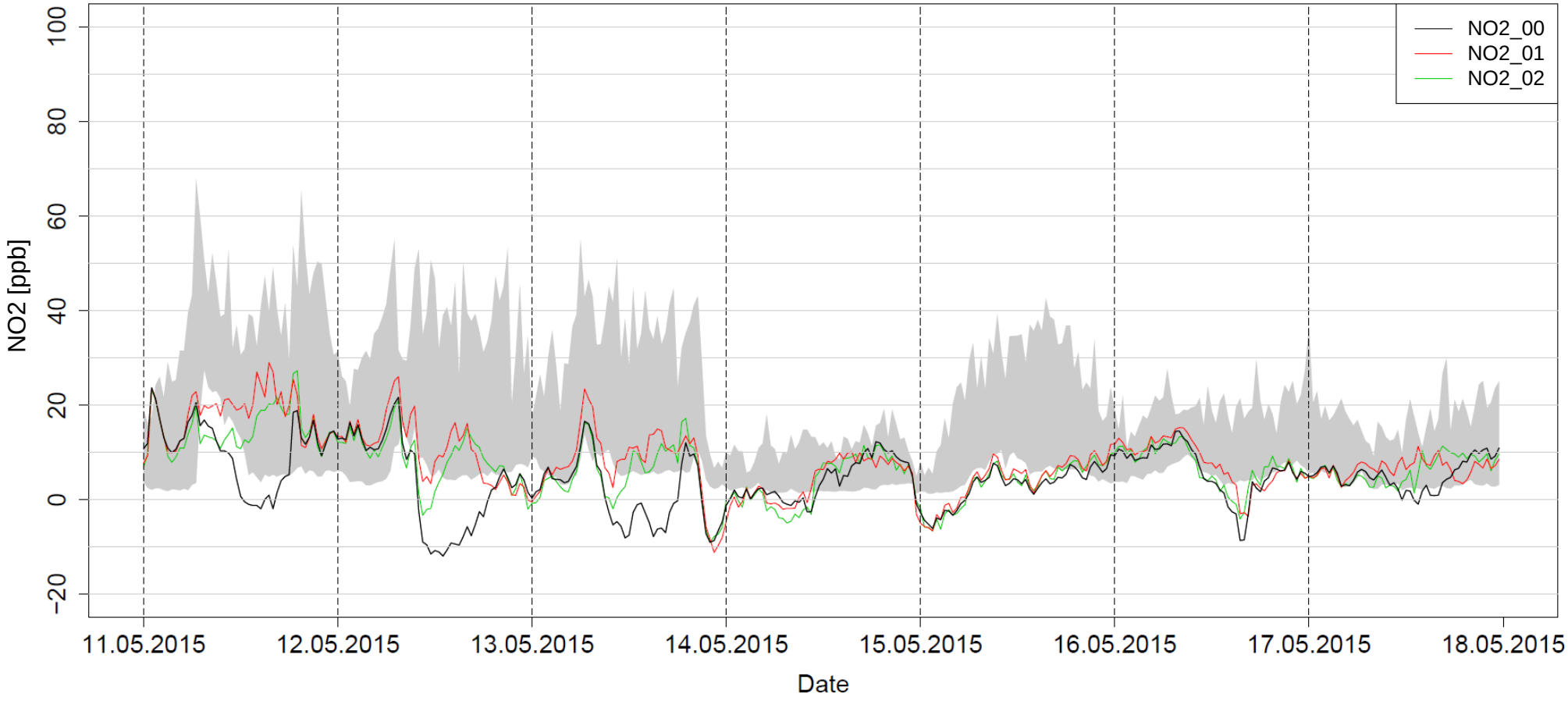
Sensors at ETHH and max/min of instruments at reference sites (grey)



note: low NO_2 levels at ETHH !

NO_2 time series (30min values)

Sensors at ETHH and max/min of instruments at reference sites (grey)

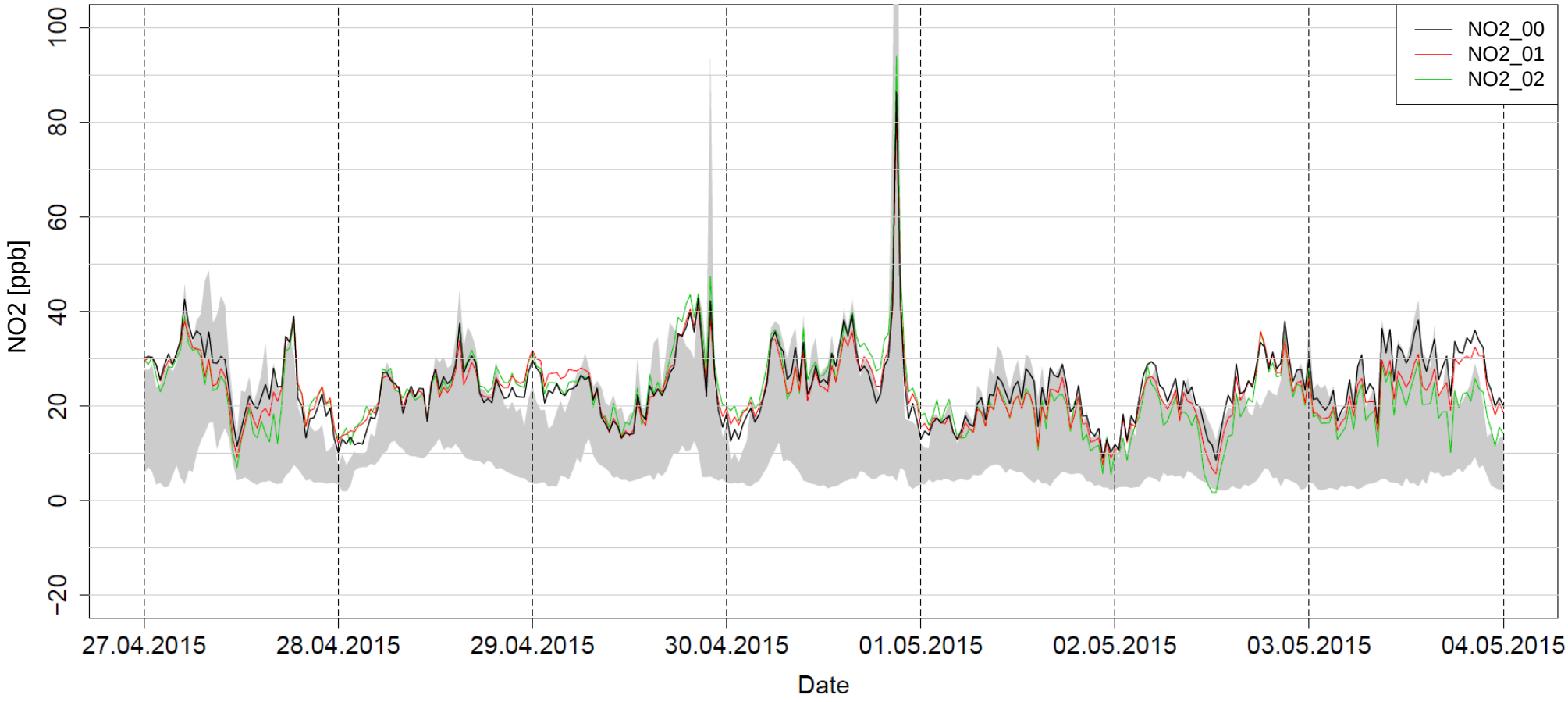


note: low NO_2 levels at ETHH !

NO_2 at urban traffic site RGST

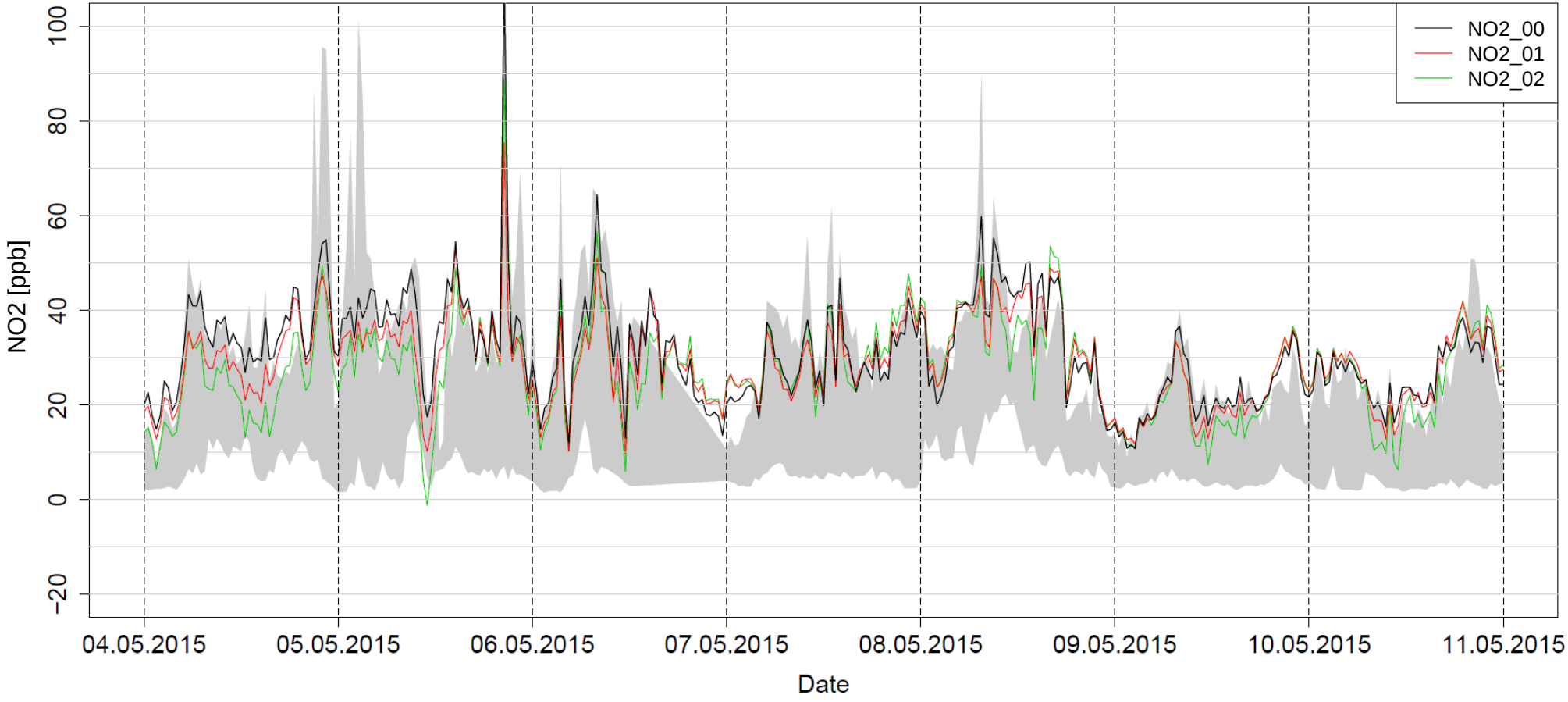
NO_2 time series (30min values)

Sensors at RGST (traffic site) and max/min of instruments at reference sites (grey)



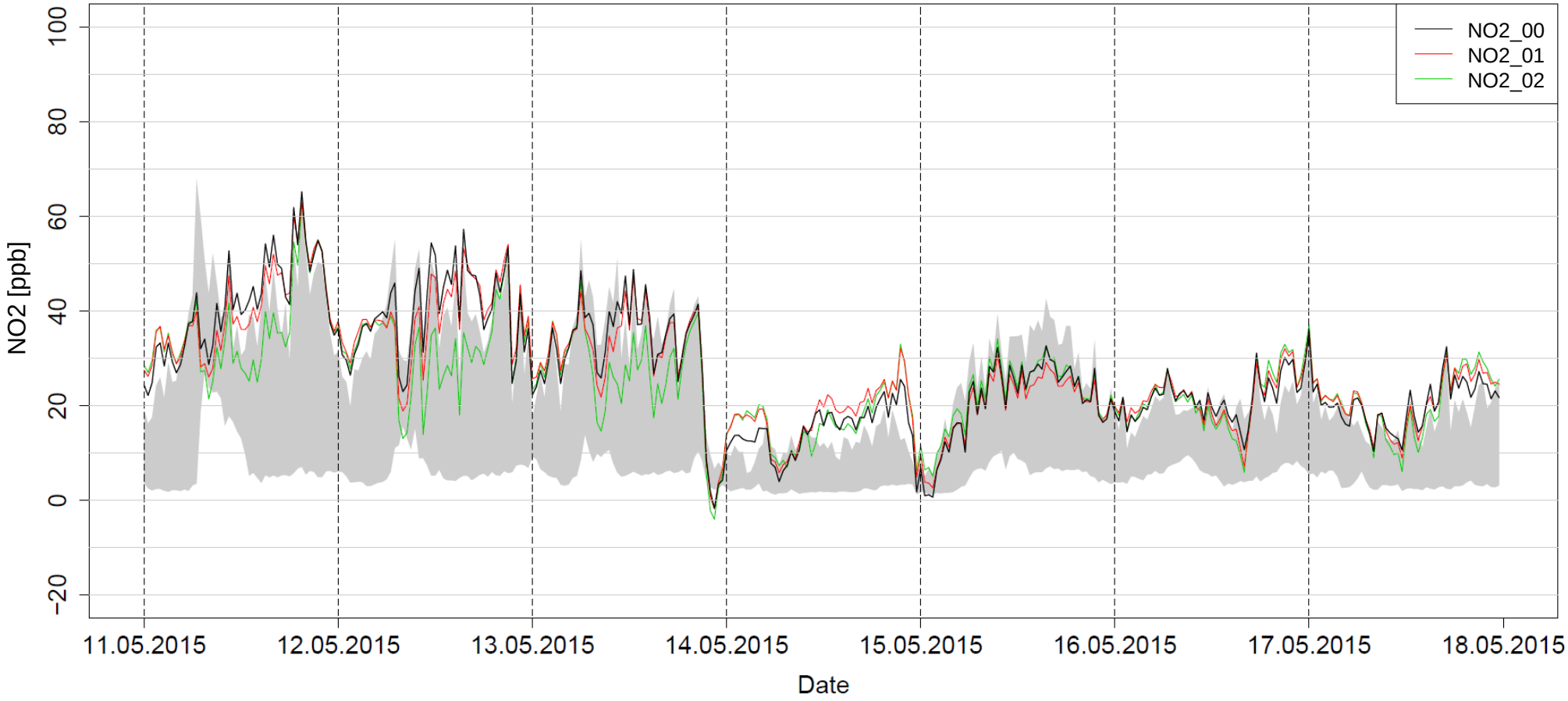
NO_2 time series (30min values)

Sensors at RGST (traffic site) and max/min of instruments at reference sites (grey)

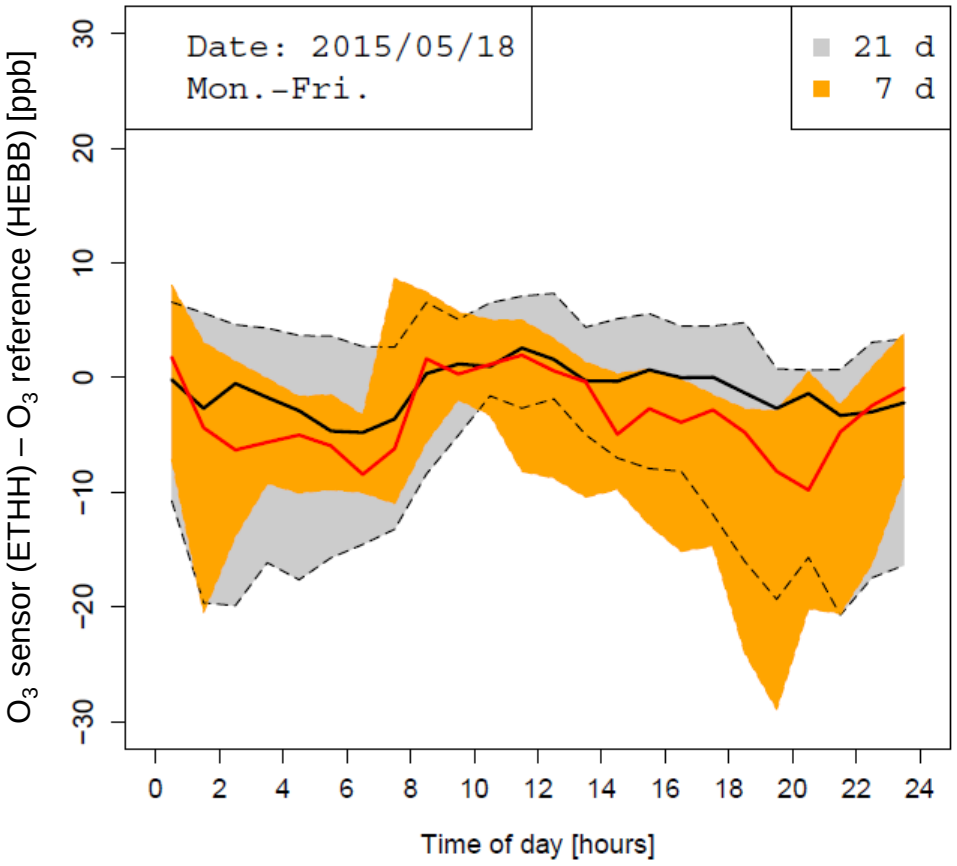


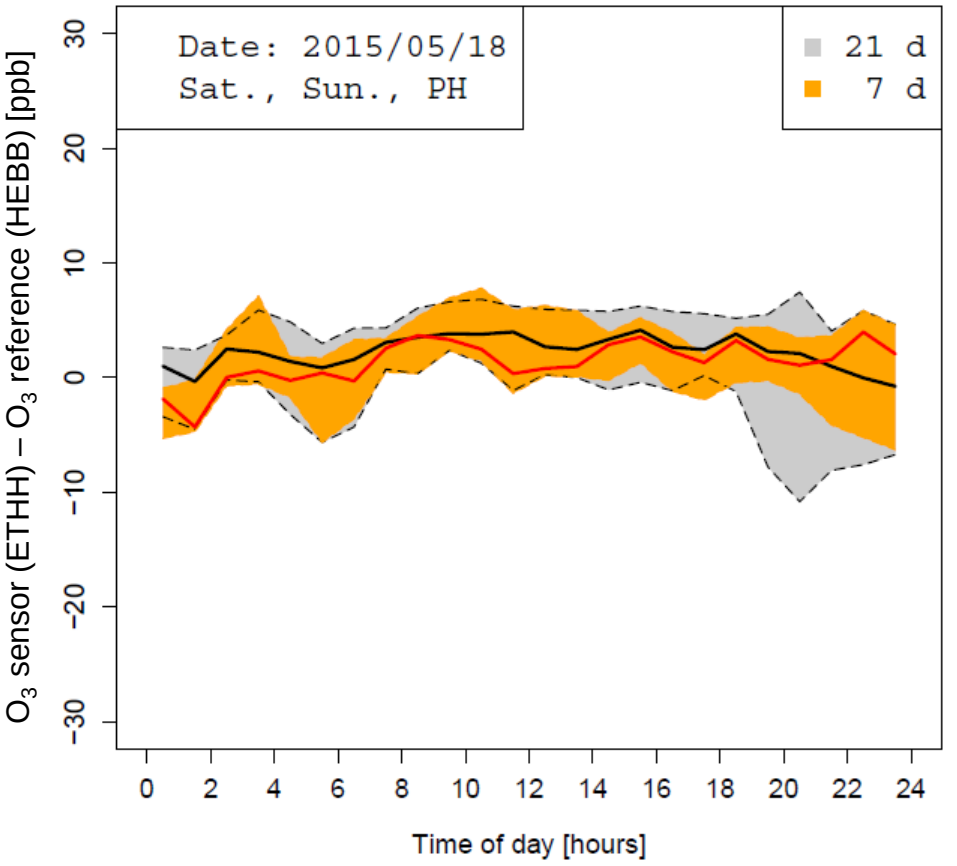
NO_2 time series (30min values)

Sensors at RGST (traffic site) and max/min of instruments at reference sites (grey)

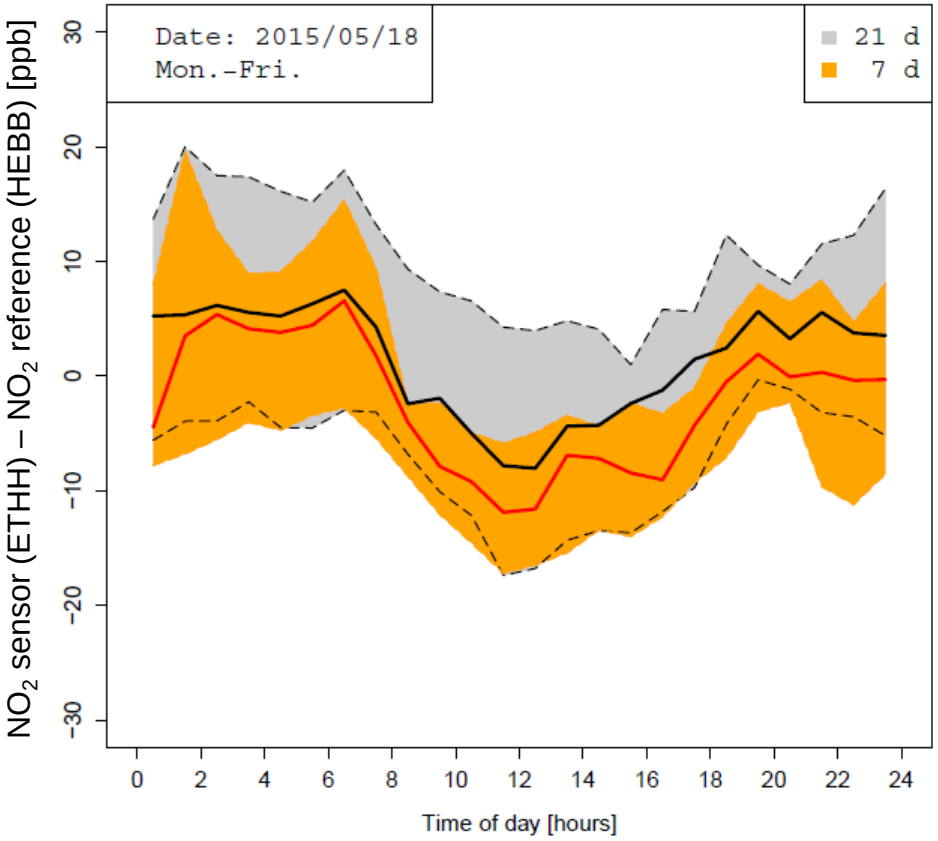


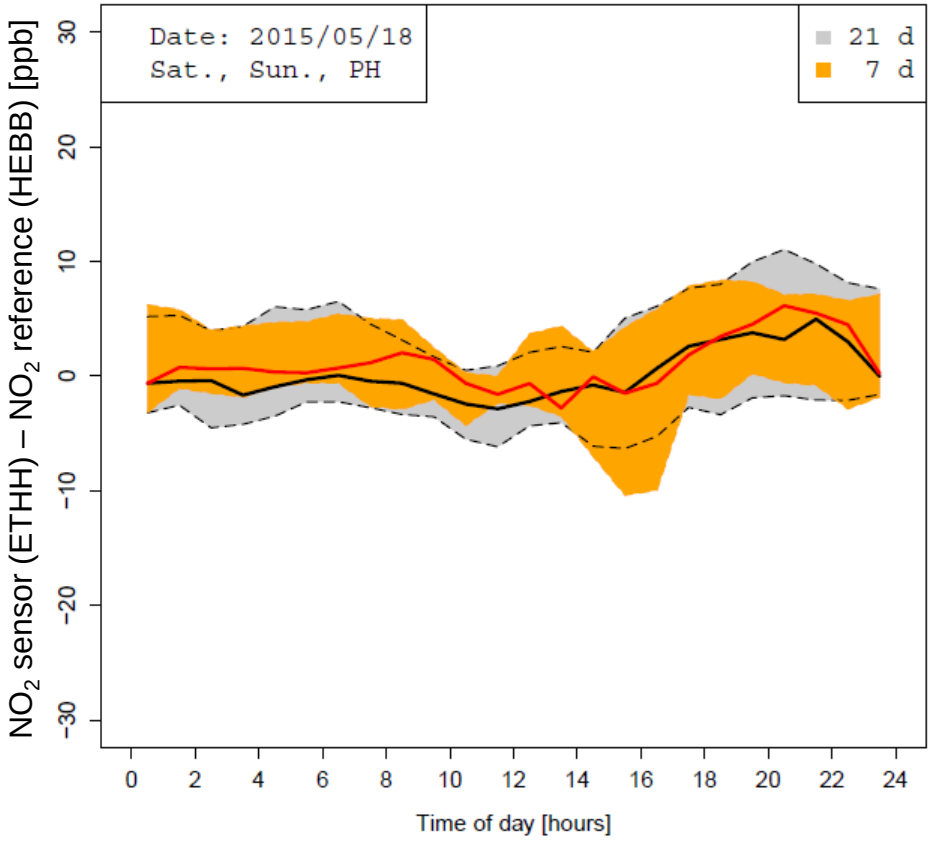
Difference of O_3 at sensor node (ETHH) and reference site (HEBB)





Difference of NO_2 at sensor node (ETHH) and reference site (HEBB)





Conclusions

- Sensors suitable for ambient AQ measurements are available
  - Increased requirements for mobile applications (e.g. short response time and low noise level)
  - Manufacture calibration of sensors are not sufficient
  - Calibration/correction function of individual sensors must be determined (e.g. from parallel measurements with reference instruments)
- Long-term behaviour of data quality largely unknown
  - Operation of sensor networks require novel concepts for assurance of the data quality from individual sensors
  - Concepts might be based on comparison to reference sites and/or high redundancy of sensor data

Thank you !