Assessing and enabling the use of low-cost air pollution sensors in UK urban environments – The QUANT study

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Quantification of Utility of Atmospheric Network Technologies

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Overarching project aims

1. Delivery of a real-world open and fully-traceable assessment of the application of low-cost air pollution sensors and sensor networks in UK urban environments.

2. Enhance the value of low-cost sensor data for UK air quality challenges through the development of novel methods that use the unique strengths of these devices.

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WP1

Transparent assessment of commercial low-cost sensor devices in multiple UK urban environments

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- Devices cover a range of technologies and calibration approaches.
- Deployment for > 2 years allows study of seasonal variations and long-term performance.
- Sites include urban background and road-side locations.
- Data analysis approaches being developed to enhance value of low cost sensor date, whilst acknowledging limitations.

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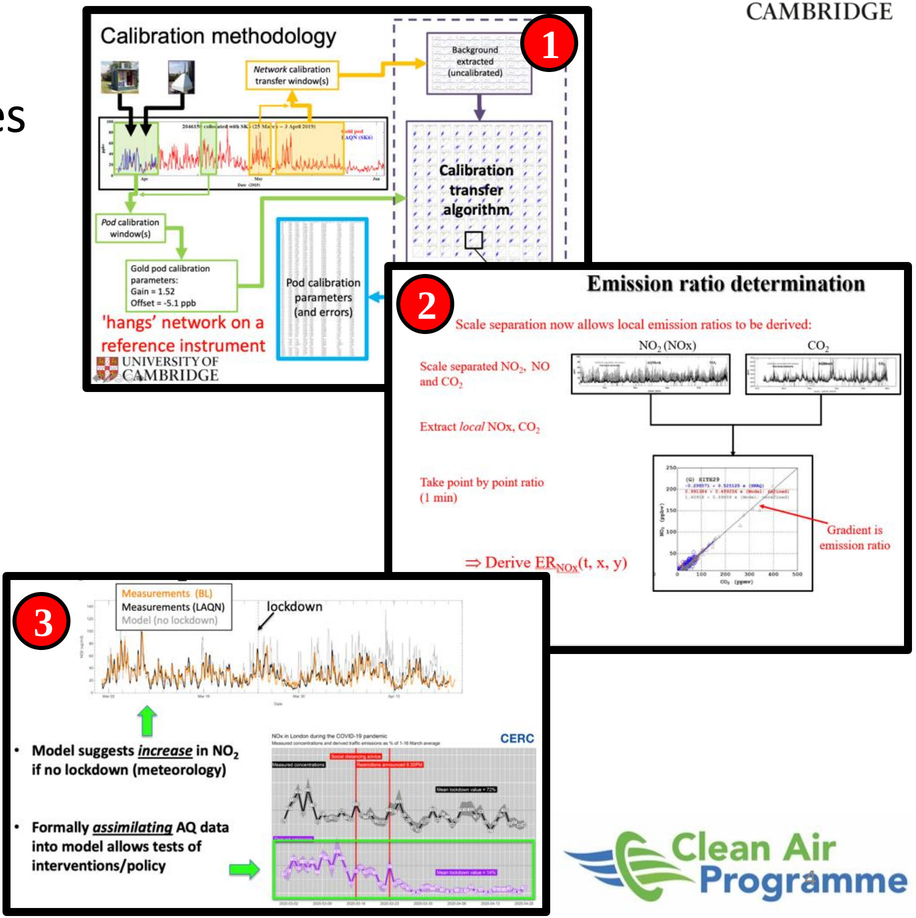
WP2

Low-cost sensor network case study

- Tested and validated method for ***cloud-based calibration*** of sensor network (gases and PM)- low cost sensors and reference instruments
- New diagnostic approaches ***using fast-temporal data***: source attribution and emission indices (relative *to ΔCO_2*)
- ***Assimilation of AQ data*** to quantify sources and trends (e.g. NO_2 sources due to Covid lockdown in the UK)



WP3

Source apportionment using low-cost sensors

- Can low cost sensors provide pollutant source information?
- Separated and identified the sources and conditions that affected the air quality at a site using data from an Optical Particle Counter.

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Towards comprehensive air quality management using low-cost sensors for pollution source apportionment

Dimitrios Bousiotis, Gordon Allison, David C. S. Beddows, Roy M. Harrison & Francis D. Pope

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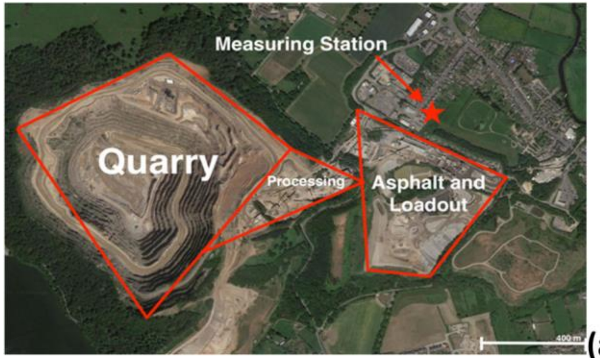

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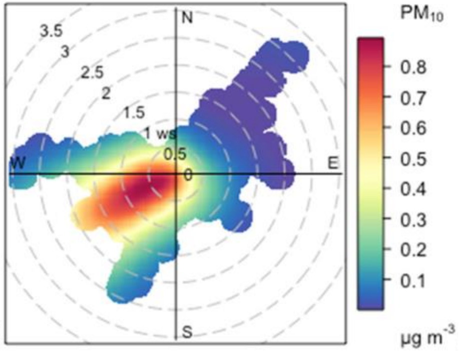

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Transparent assessment of commercial low-cost sensor devices in multiple UK urban environments

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- Commercial sensor units deployed at 3 locations for 3 years alongside research/reference grade instruments.
- 5 different commercial devices being tested
- Multiples (4-6) of each
- Cover range of technologies and calibration approaches
- All data now open access

Dr Sebastian Diez

Dr Stuart Lacy

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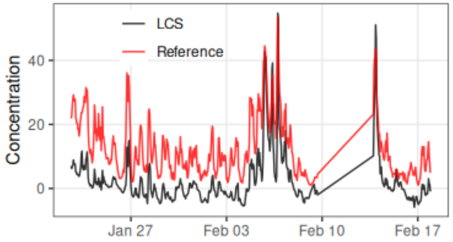
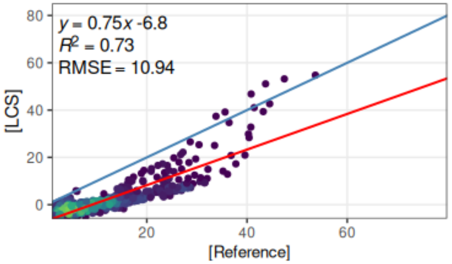
The benefits of colocation calibrations

”Out-of-box” NO_2 data





The benefits of colocation calibrations

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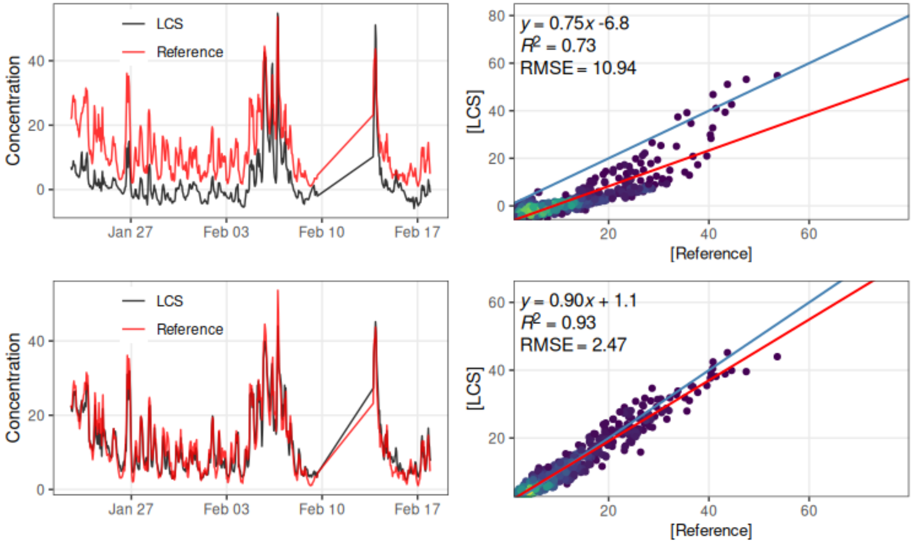
”Out-of-box” NO_2 data

Colocation calibration impact on training data



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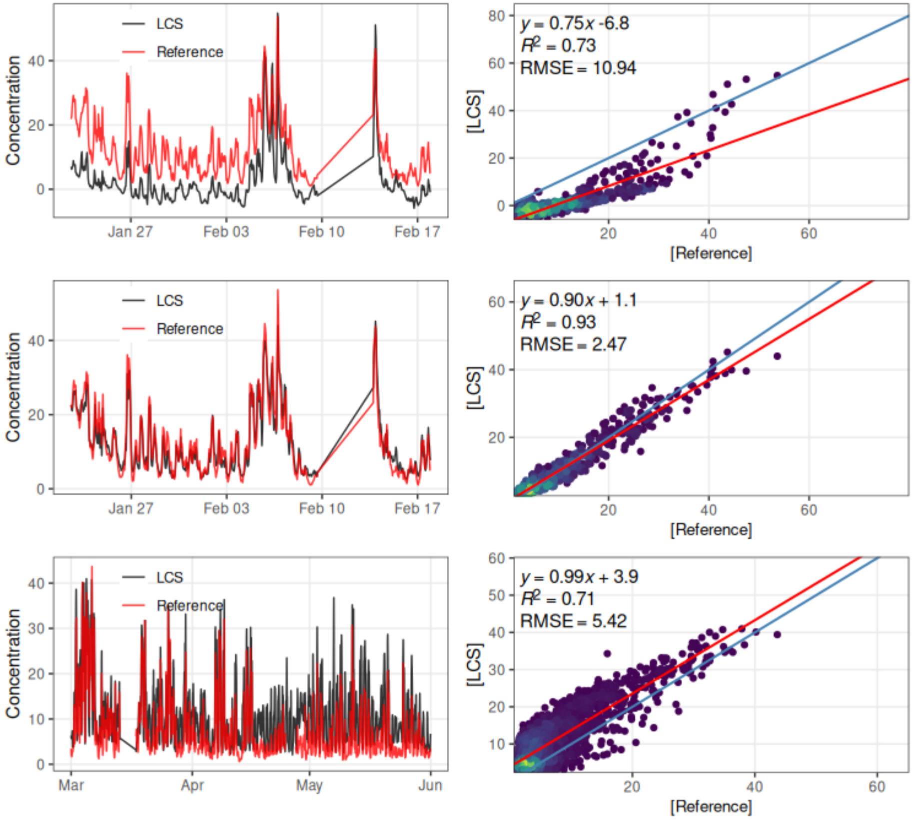
”Out-of-box” NO_2 data

Colocation calibration impact on training data

Colocation calibration impact on test data



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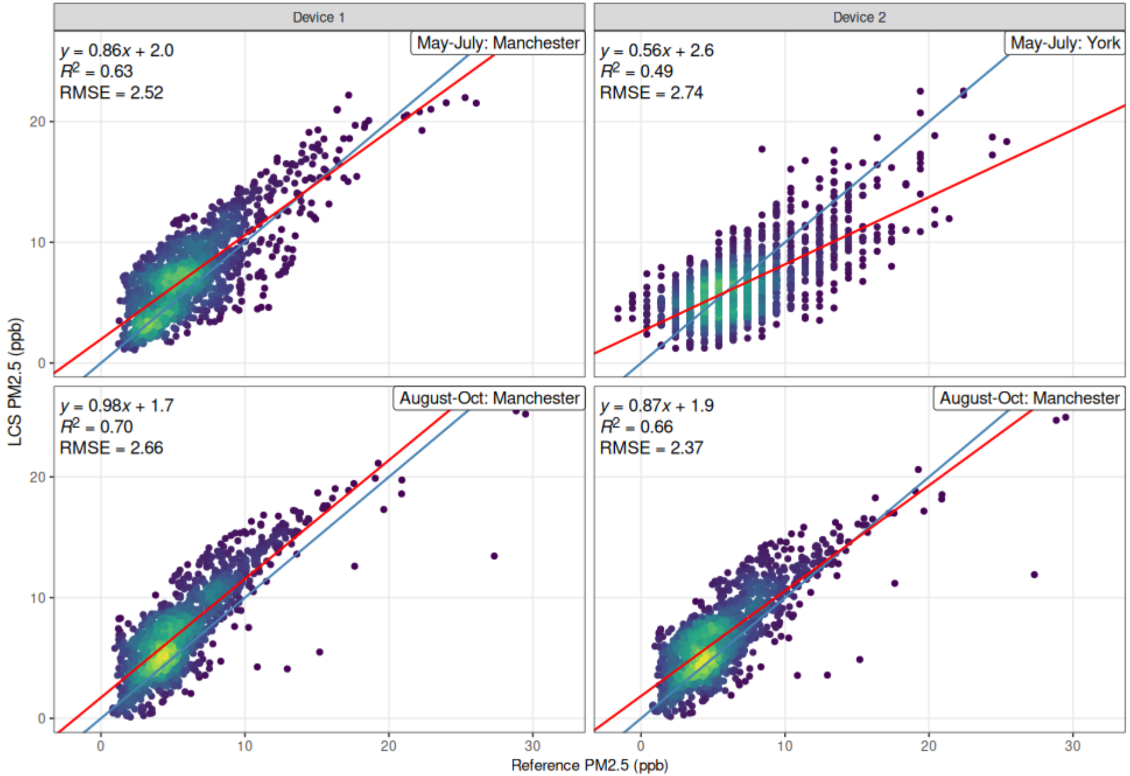
Impact on sensor location changes

Sensor calibrations can be location dependent



Inter-device precision

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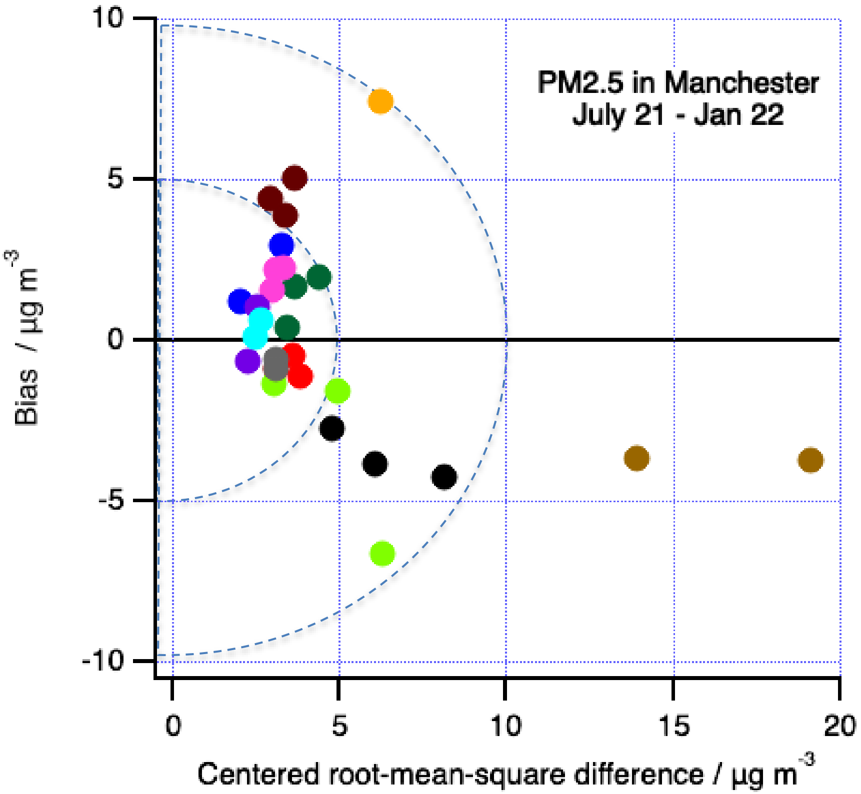

- Inter-device precision is how similar data from identical devices is when measuring the same air
- Important to understand if using multiple devices (e.g. network)

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WP1

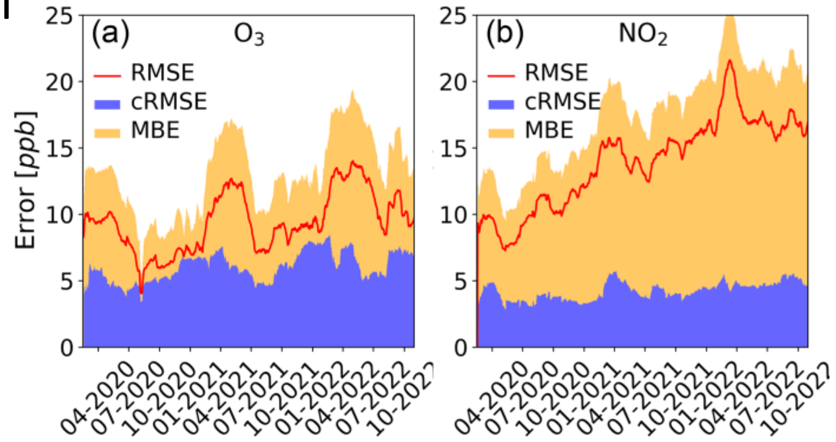
Do air quality sensors provide an affordable and reliable solution to local air quality monitoring?

- Low-cost air pollution sensors can provide useful measurements with quantified uncertainties, depending on operation
- Sensor error characteristics need to be assessed in order to understand data uncertainties
- Ultimately, end-users need to understand the data needs of the application **before** selecting an appropriate measurement tool
- Once data requirements and measurement uncertainties are understood, strategies can be implemented to improve performance

Reducing sensor bias – case study

Understanding the nature of the error is key!

- Ozone has a clear seasonal bias component (higher between March – July)
- Nitrogen dioxide shows a steadily increasing bias (drift)



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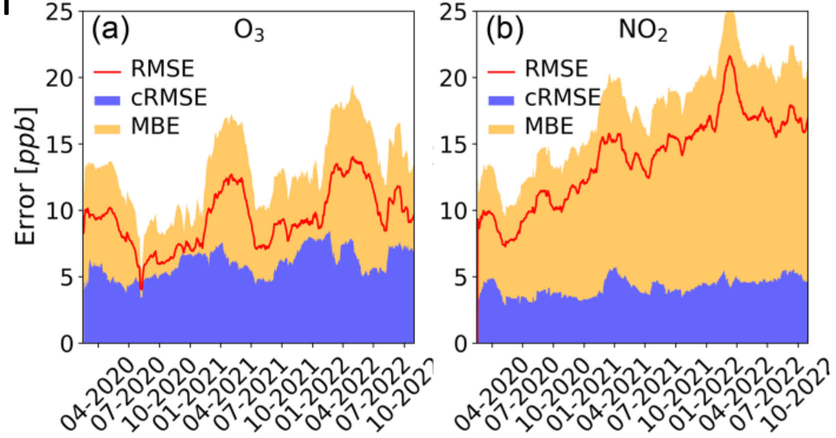

Reducing sensor bias – case study

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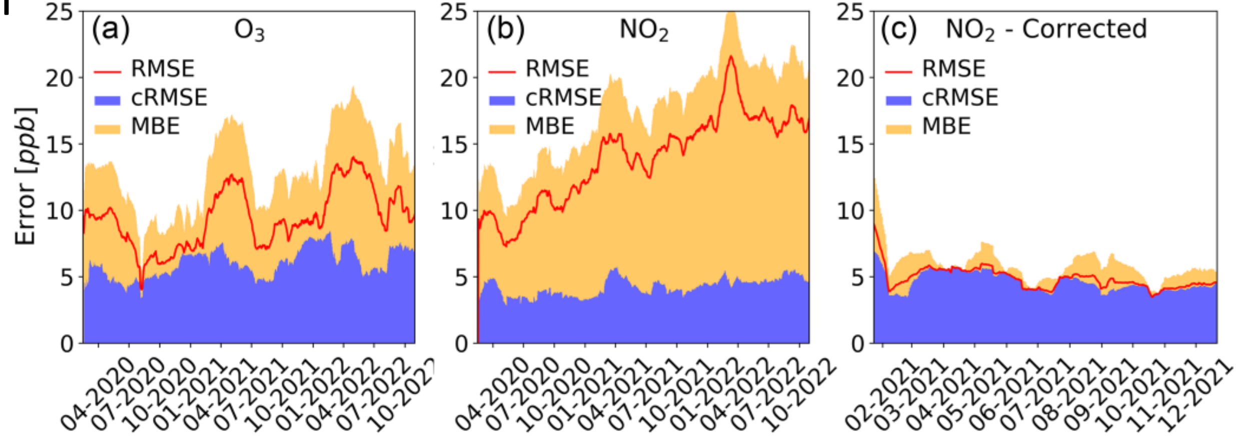

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Change point detection – case study

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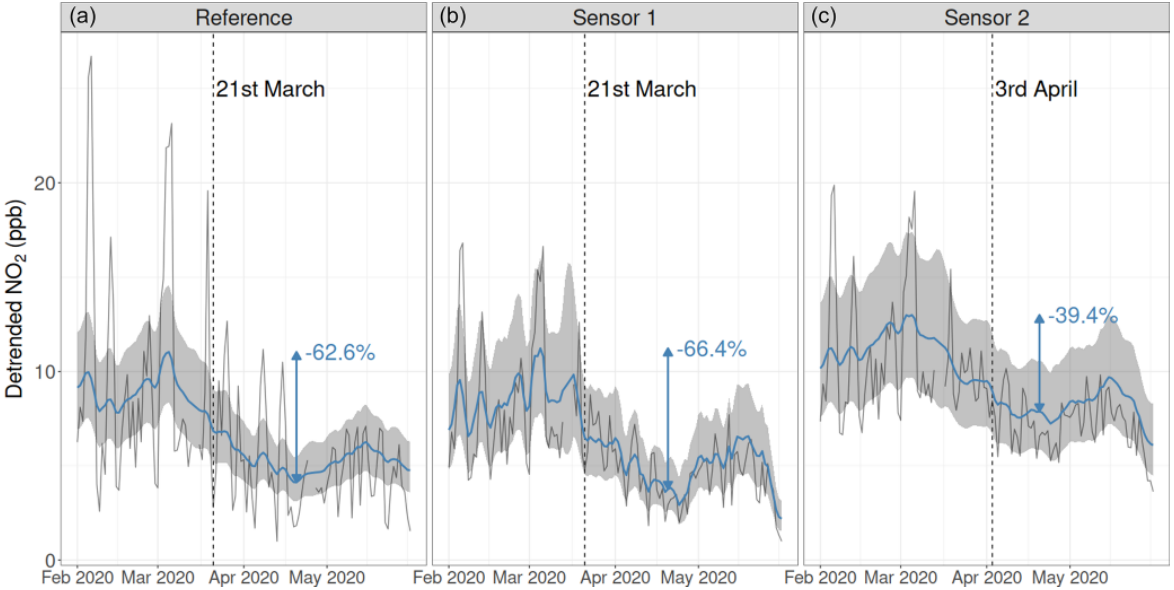
Potential sensor use case – NO_2 change point detection

- COVID-19 lockdown
- Data (black) was detrended for weather influence (blue)
- 2 of the 8 NO_2 sensors successfully identified the COVID-19 lockdown, despite only 3 months training data



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Summary

- The QUANT project worked to enable LCS use in the UK
- Unique WP1 dataset assessing LCS performance in UK urban environments
- WP2 looking at the power of the network
- WP3 using low-cost sensors to provide PM source information
- Understanding the requirements of the monitoring challenge and the uncertainty characteristics of the available tools is key!

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https://doi.org/10.5194/amt-17-3809-2024

Atmospheric Measurement Techniques
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Long-term evaluation of commercial air quality sensors: an overview from the QUANT (Quantification of Utility of Atmospheric Network Technologies) study

Sebastian Diez[1,2], Stuart Lacy[2], Hugh Coe[3], Josefina Urquiza[4,5], Max Priestman[6], Michael Flynn[3], Nicholas Marsden[3], Nicholas A. Martin[7], Stefan Gillott[6], Thomas Bannan[3], and Pete M. Edwards[2,8]

Atmos. Meas. Tech., 15, 4091–4105, 2022
https://doi.org/10.5194/amt-15-4091-2022

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Air pollution measurement errors: is your data fit for purpose?

Sebastian Diez[1], Stuart E. Lacy[1], Thomas J. Bannan[2], Michael Flynn[2], Tom Gardiner[3], David Harrison[4], Nicholas Marsden[2], Nicholas A. Martin[3], Katie Read[1,5], and Pete M. Edwards[1]

Atmos. Meas. Tech., 14, 4139–4155, 2021
https://doi.org/10.5194/amt-14-4139-2021

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Assessing the sources of particles at an urban background site using both regulatory instruments and low-cost sensors – a comparative study

Dimitrios Bousiotis[1], Ajit Singh[1], Molly Haugen[2], David C. S. Beddows[1,3], Sebastián Diez[4], Killian L. Murphy[4], Pete M. Edwards[4], Adam Boies[2], Roy M. Harrison[1,5], and Francis D. Pope[1]

Atmos. Meas. Tech., 15, 4047–4061, 2022
https://doi.org/10.5194/amt-15-4047-2022

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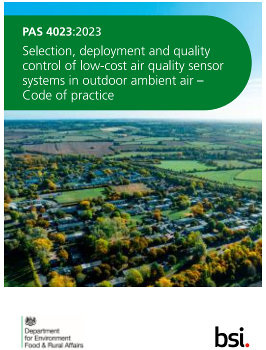
A study on the performance of low-cost sensors for source apportionment at an urban background site

Dimitrios Bousiotis[1], David C. S. Beddows[1], Ajit Singh[1], Molly Haugen[2], Sebastián Diez[3], Pete M. Edwards[3], Adam Boies[2], Roy M. Harrison[1], and Francis D. Pope[1]



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QUANT: a long-term multi-city commercial air sensor dataset for performance evaluation

Sebastian Diez[1,2], Stuart Lacy[2], Josefina Urquiza[3,4] & Pete Edwards[2]

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Thank you