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

COST Action TD1105

INTERNATIONAL WG1-WG4 MEETING on

New Sensing Technologies and Methods for Air-Pollution Monitoring

European Environment Agency - EEA

Copenhagen, Denmark, 3 - 4 October 2013

Action Start date: 01/07/2012 - Action End date: 30/06/2016 - Year 2: 2013-2014 (*Ongoing Action*)

WIRELESS SENSOR NETWORKS FOR AIR-POLLUTION MONITORING IN CITIES

UNIVERSITY OF CAMBRIDGE

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SIG2 Member

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COST is supported by the EU Framework Programme

ESF provides the COST Office through a European Commission contract

Scientific context and objectives

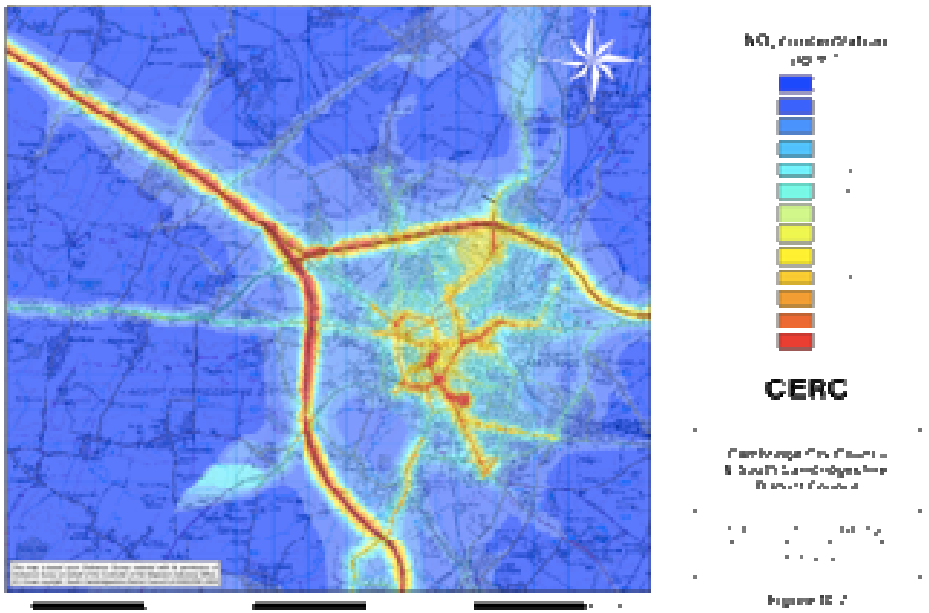
- **Atmospheric composition within urban areas has a direct effect on the air quality of an environment in which a large majority of people live and work.**
- **Atmospheric pollutants including O_3, NO_2, VOCs and PM can have a significant effect on human health.**
- **Determine potential exposure of individuals and investigate processes that lead to the degradation of air quality within the urban environment.**


Government issues Easter weekend smog alert

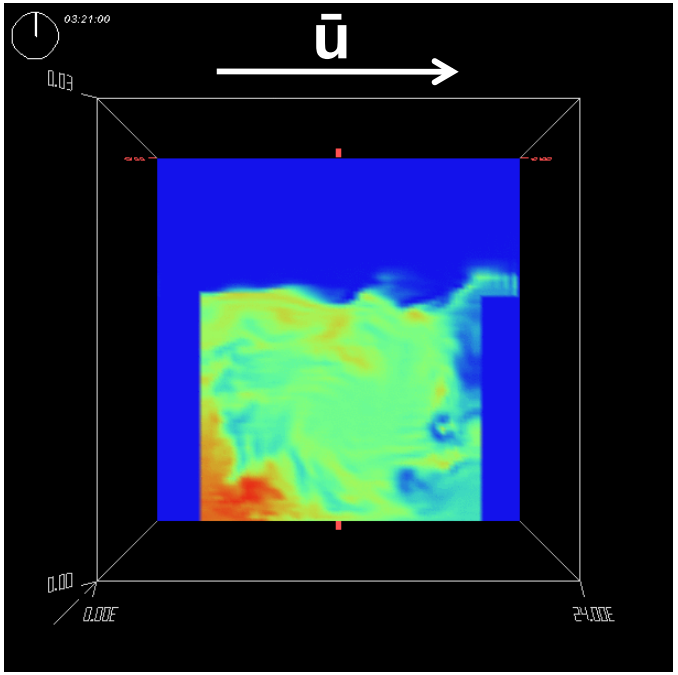
A smog warning has been issued for the Easter weekend amid fears that a combi of hot weather and pollution could cause health and breathing problems.

Scientific context and objectives

- **Air quality within urban areas is highly heterogeneous in both time and space thus characterising air pollution is complex.**
- **Fixed site automated urban networks only provide low spatial resolution measurements.**



Street canyon effects



Bright *et al.*, 2013

Scientific context and objectives

- Deployment of a state-of-the art network of low-cost air pollution sensors.
- Provision of pollution data for science and policy applications.
- Comparison of data with emission inventories and pollution models.
- Source attribution.
- Creation of novel tools for data mining, network calibration, data visualisation and interpretation.
- Optimisation of sensor network for different environments.

Current activities of the Partner (1/2)

- Deployment of a state-of-the art network of low-cost air pollution sensors: The Sensor Networks for Air Quality at London Heathrow Airport (SNAQ-Heathrow) project.
- ~ 36 sensor nodes located in and around the airport.
- Web: http://www.snaq.org/

UNIVERSITY OF CAMBRIDGE

University of Hertfordshire

alphasense THE SENSOR TECHNOLOGY COMPANY

MANCHESTER 1824

Heathrow

BRITISH AIRWAYS

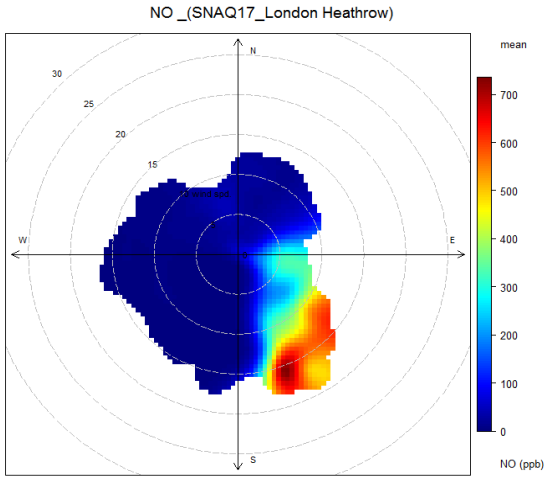
NPL National Physical Laboratory

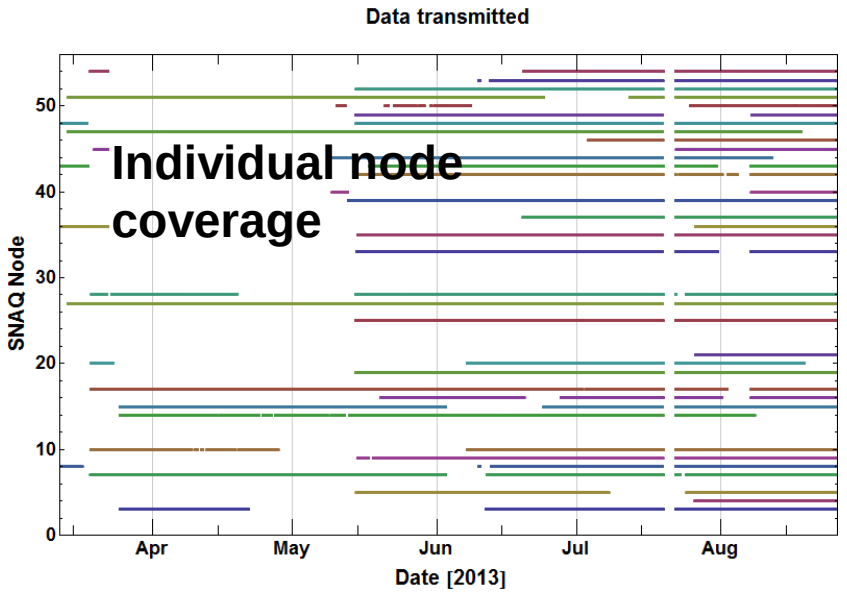
Imperial College London

Cambridge Environmental Research Consultants Environmental Software and Services

Current activities of the Partner (2/2)

- High spatial and temporal resolution data provided.
- Demonstration of the utility of a high-density, low-cost sensor network.
- Source attribution for LHR airport.
- Network calibration.
- Investigation of pollutant variability on the local or micro-scale.





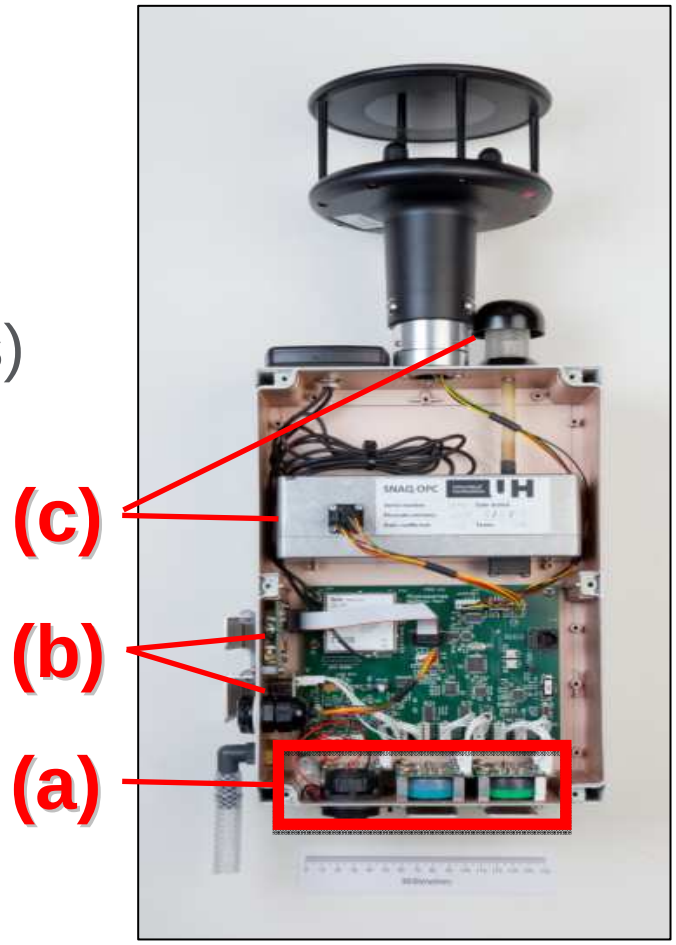
Facilities available for the Partner (1/2)

- **Instrumentation**

Chemical species:

- **(a)** Gas phase species: CO, NO, O_3, SO_2, NO_2 – (electrochemical sensors (EC) at 2 s)
- **(b)** CO_2 & total VOCs (optical at 10 s).
- **(c)** Size-speciated particulates 0.38 to 17.4 µm, optical (OPC) at 20 s

SNAQ sensor node



~49 x 22 x 16 cm. ~2.8 kg

Facilities available for the Partner (2/2)

- **Instrumentation**

Meteorology:

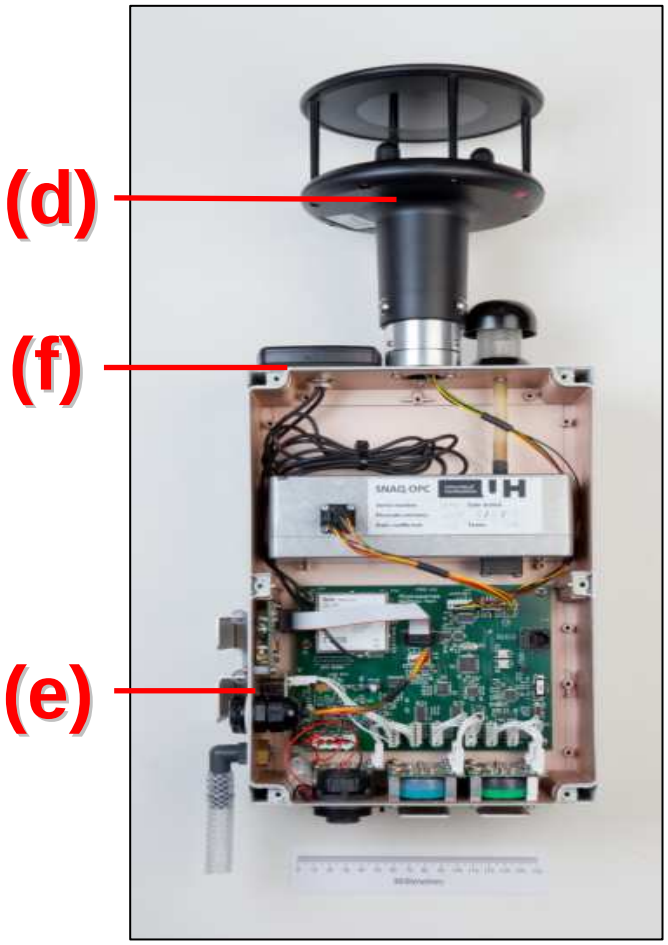
- **(d)** Wind speed and direction – Sonic anemometer.

- **(e)** Temperature and RH (probe).

Other:

- **(f)** GPS and GPRS (position and near-real time data transmission).

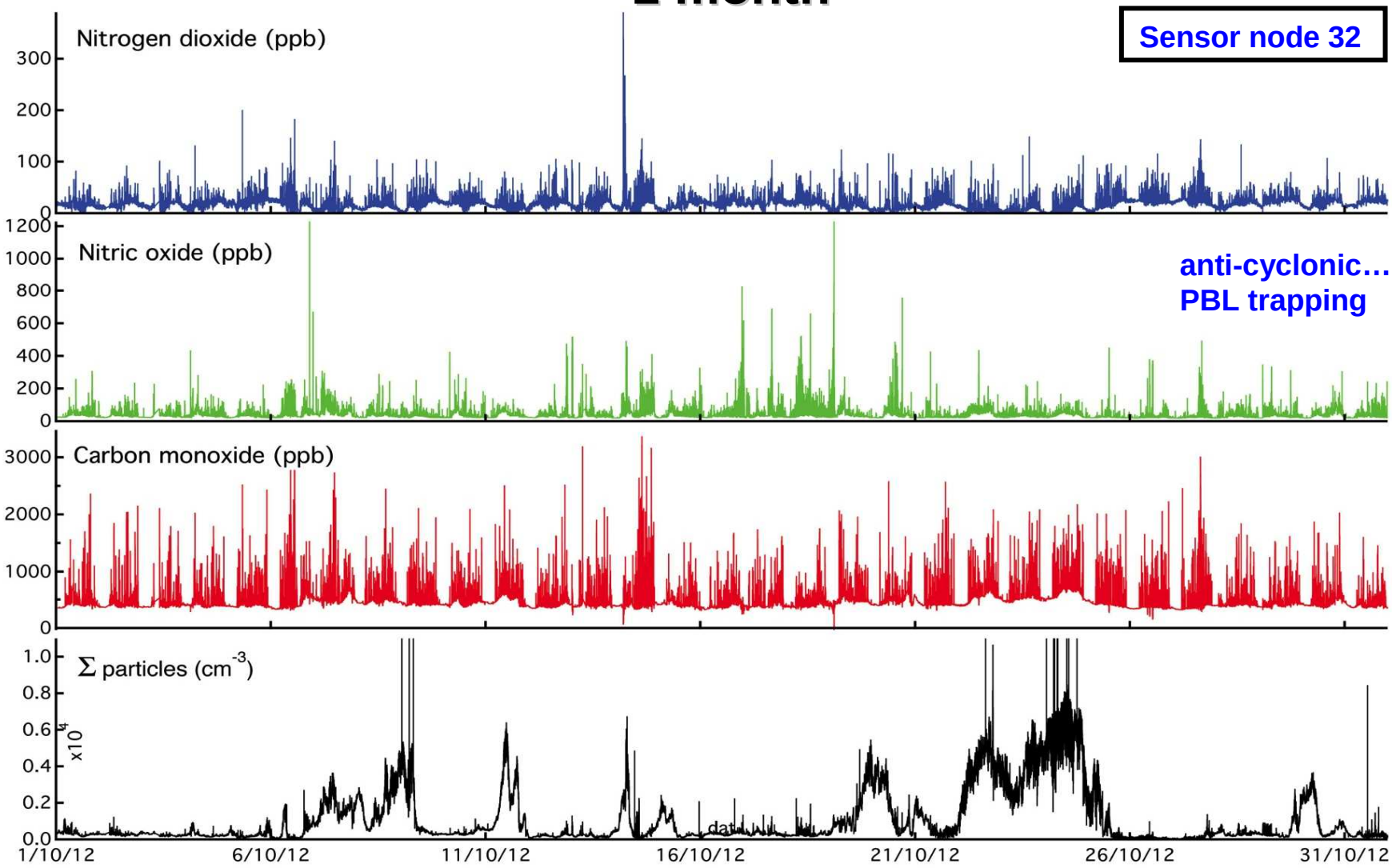
SNAQ sensor node



~49 x 22 x 16 cm. ~2.8 kg

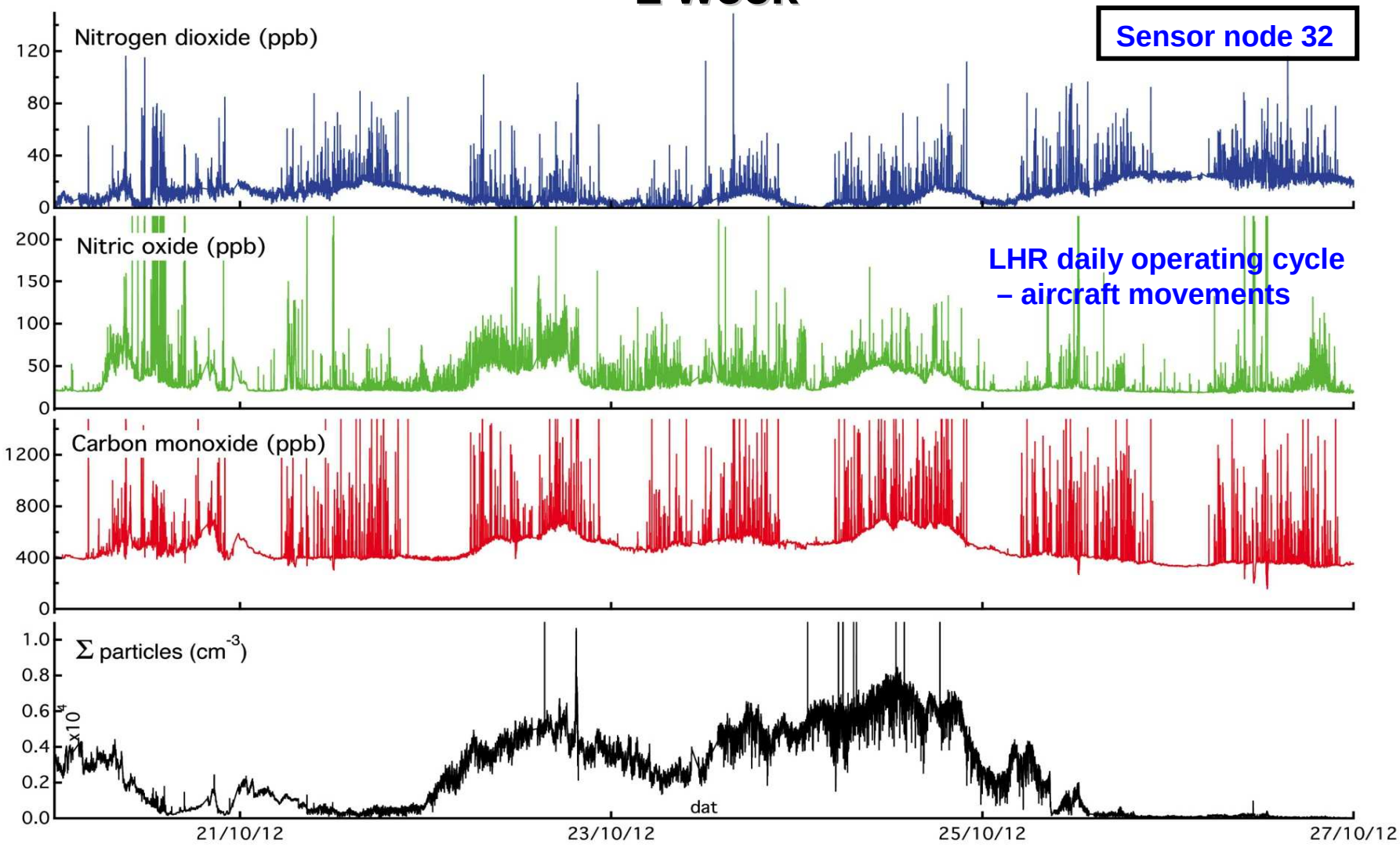
Preliminary LHR results

- 1 month

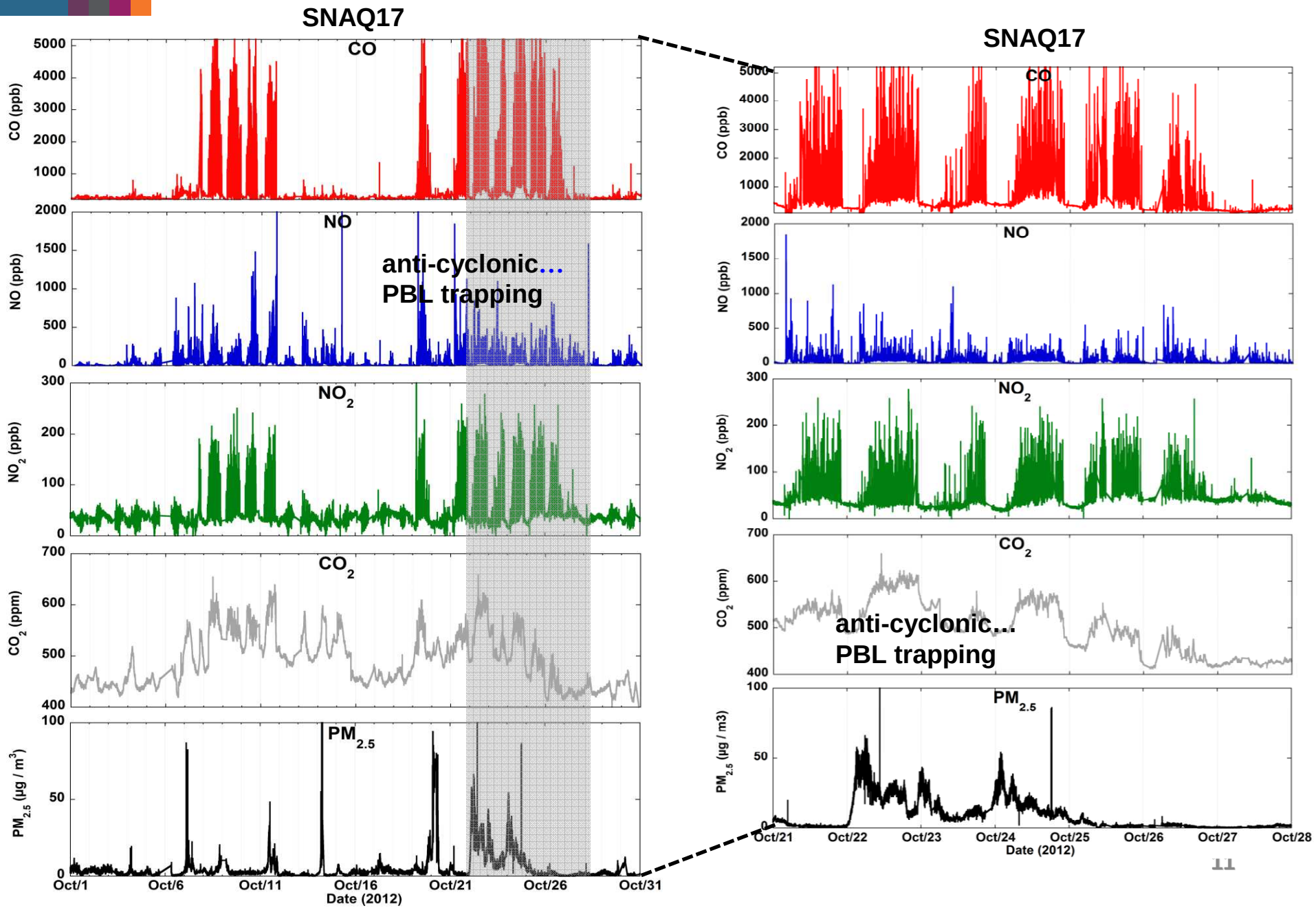


Preliminary LHR results

- 1 week

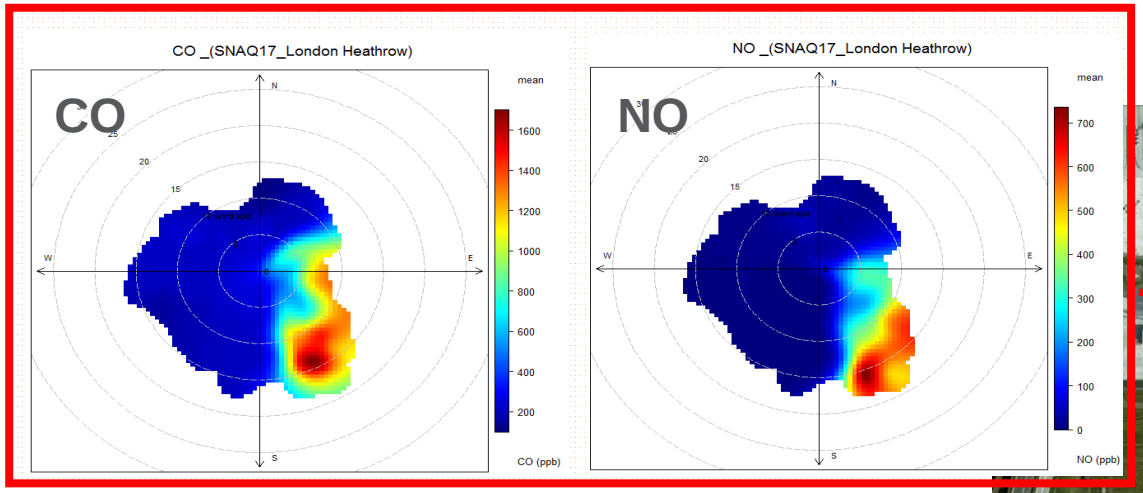


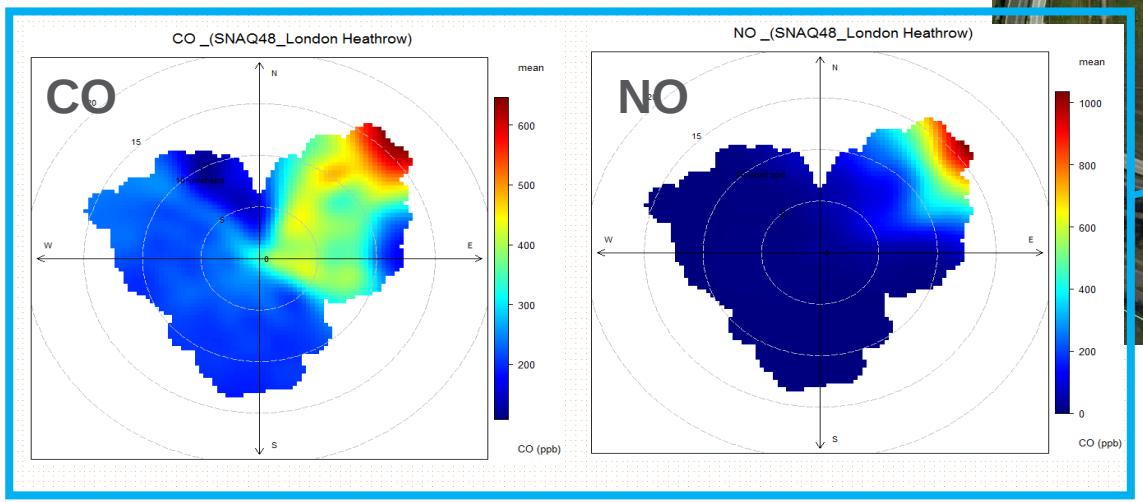
Illustrative results (LHR) – 1 month vs 1 week

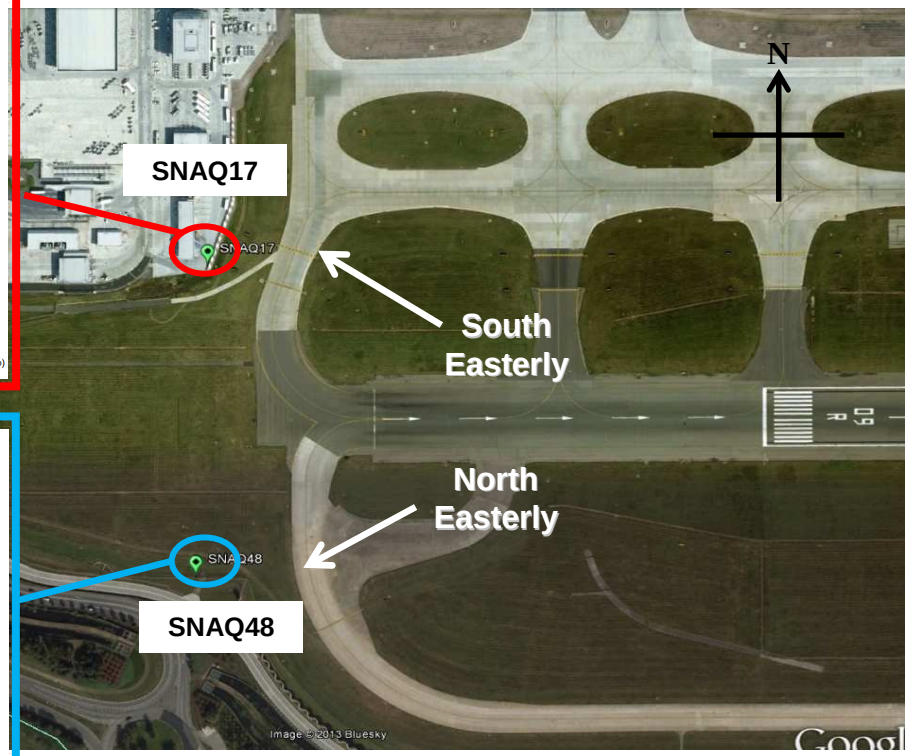


Source attribution –

Sensors at the west-end of southern runway (09R)



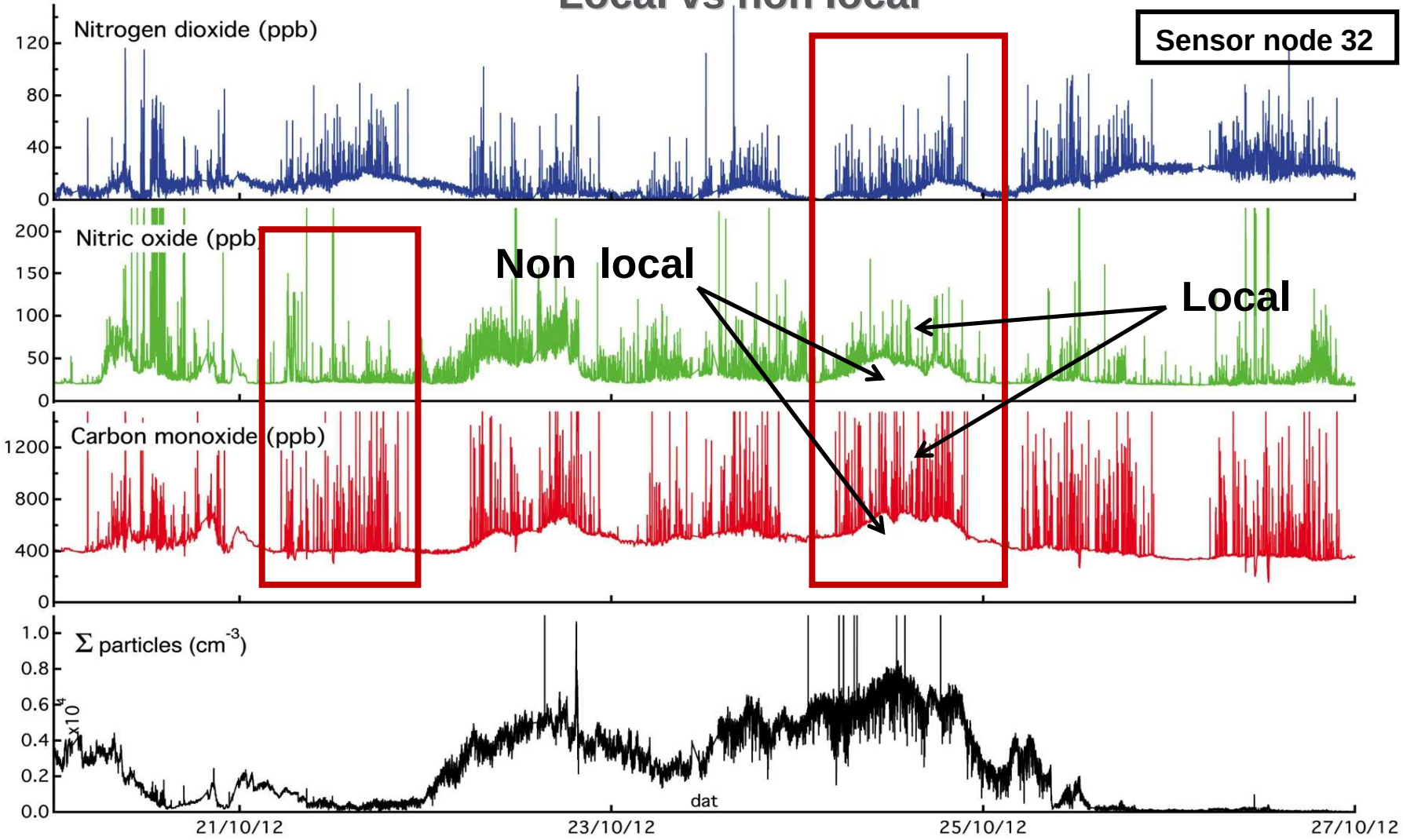




- Mirror image pollution mixing ratios observed
- High CO & NO mixing ratios (high wind speeds) indicate take-offs

Source attribution –

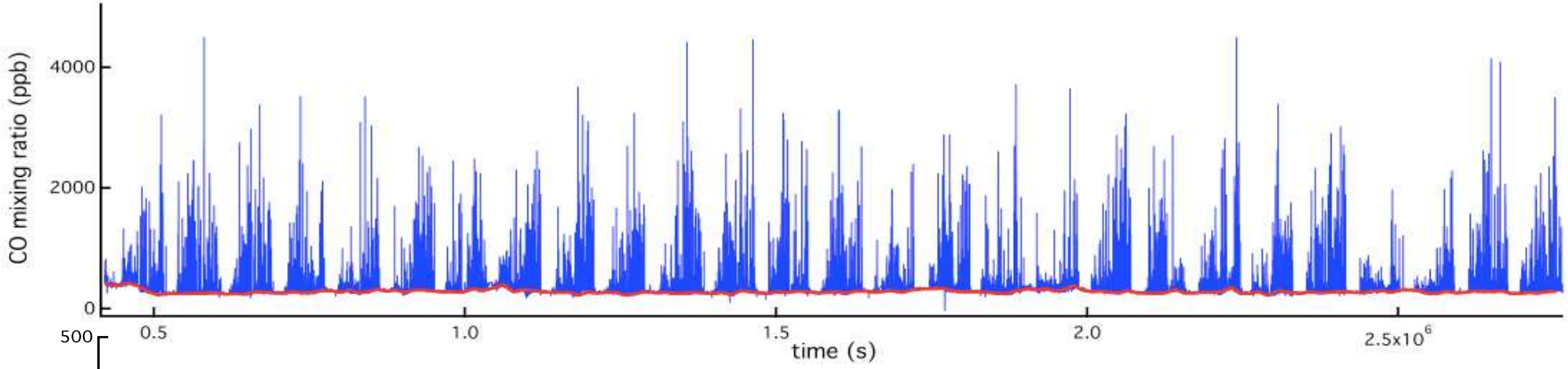
Local vs non local

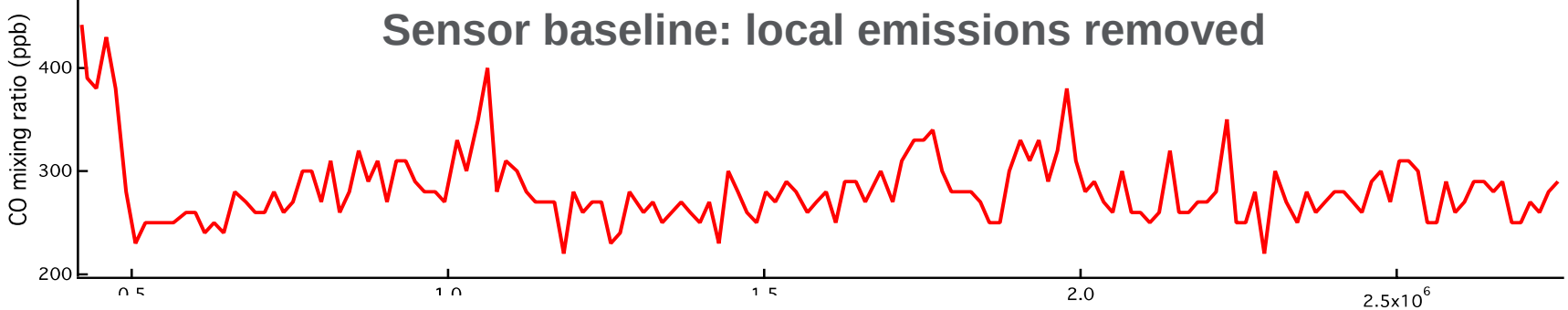


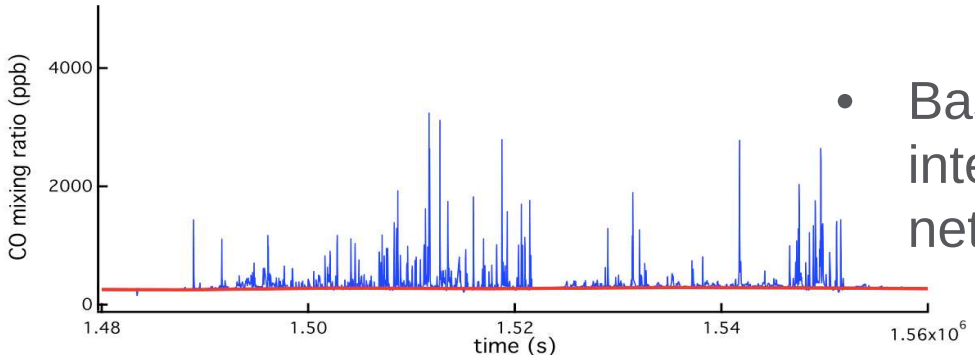
Network calibration *and* information

Network calibration

- Intermittency of emissions, *if measured at high time resolution*, allows determination of sensor 'baseline' – *local* vs *non local* sources.





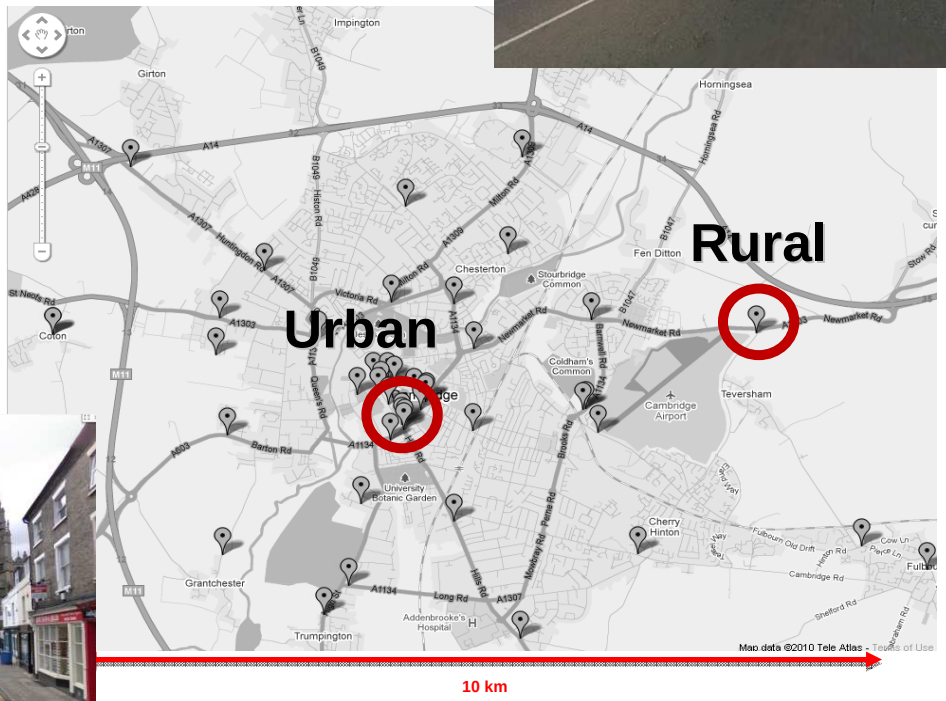


- Baselines replicated therefore method for inter-calibrating (and error checking) sensor networks.

Model optimisation -

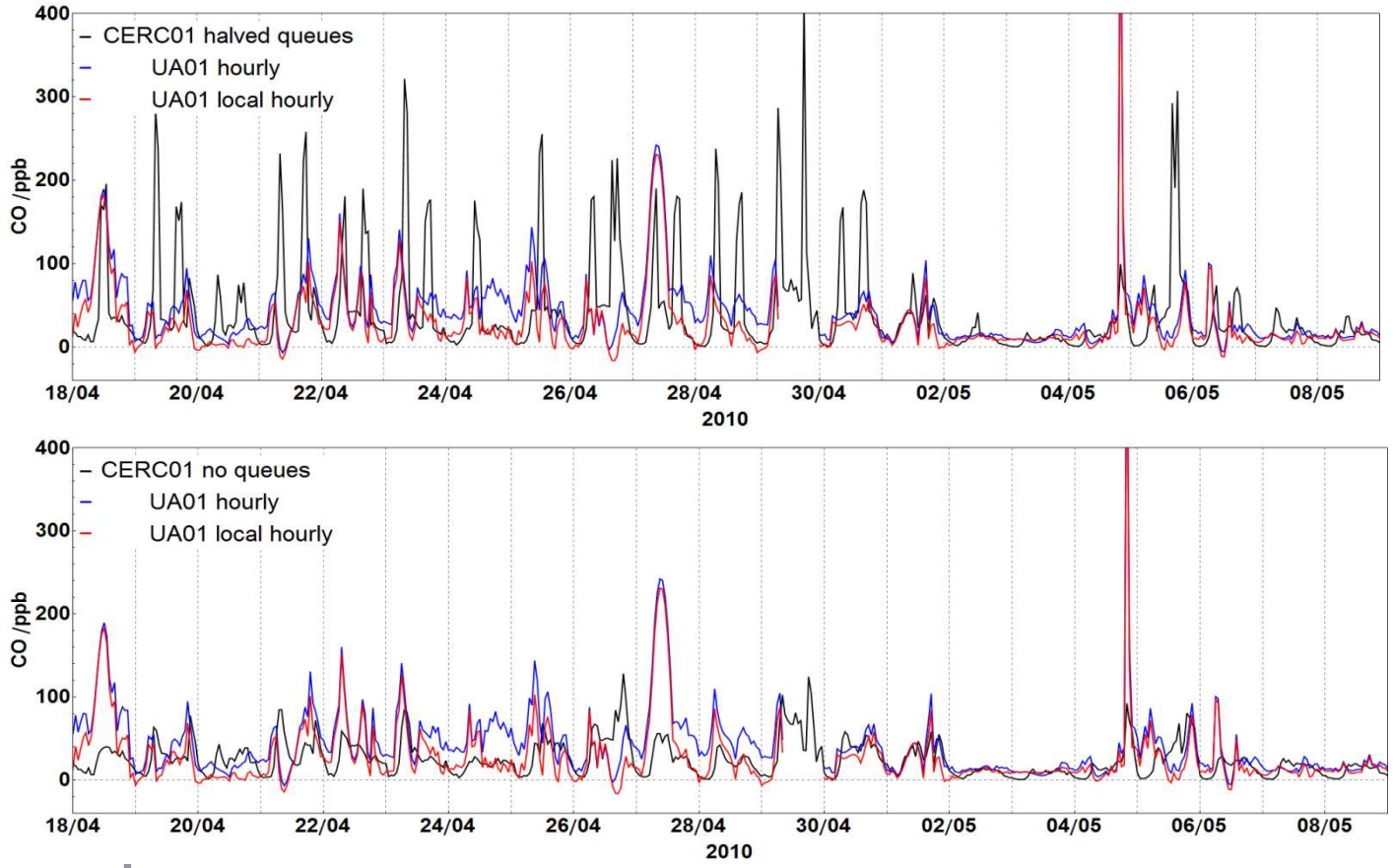
Cambridge network, spring 2010

- 3 month static deployment in Cambridge: 45 low-cost electrochemical sensors
- High spatial and temporal (10 s) resolution data set of CO, NO and NO_2
- True variability in pollution levels across an urban area
- Representativeness of AURN sites in determining exposure



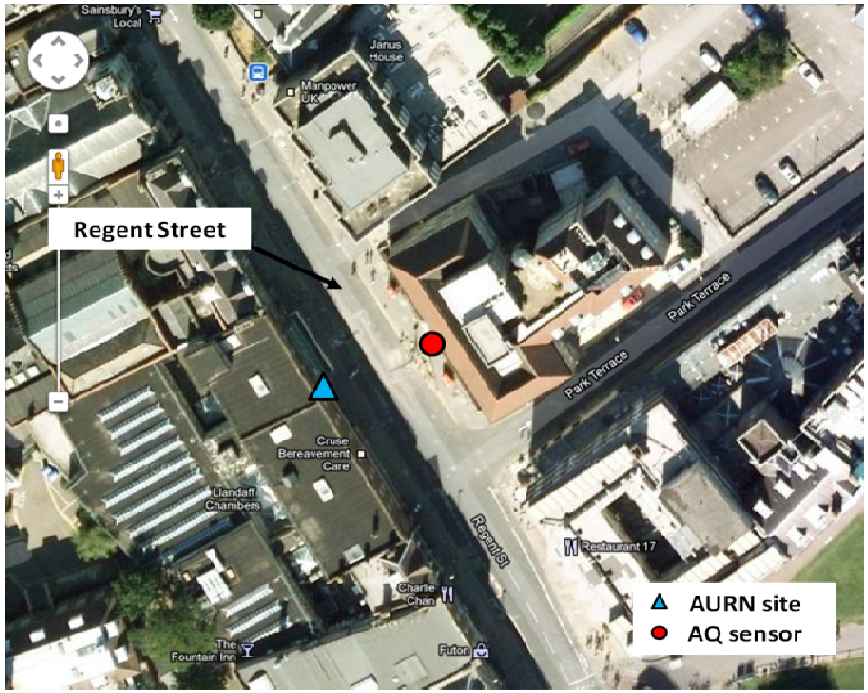
Model optimisation

- Measurements and ADMS-Urban model comparison
- CO adjustment of emissions to optimise model
- Removal of CO baselines to give local hourly



Street canyon effects

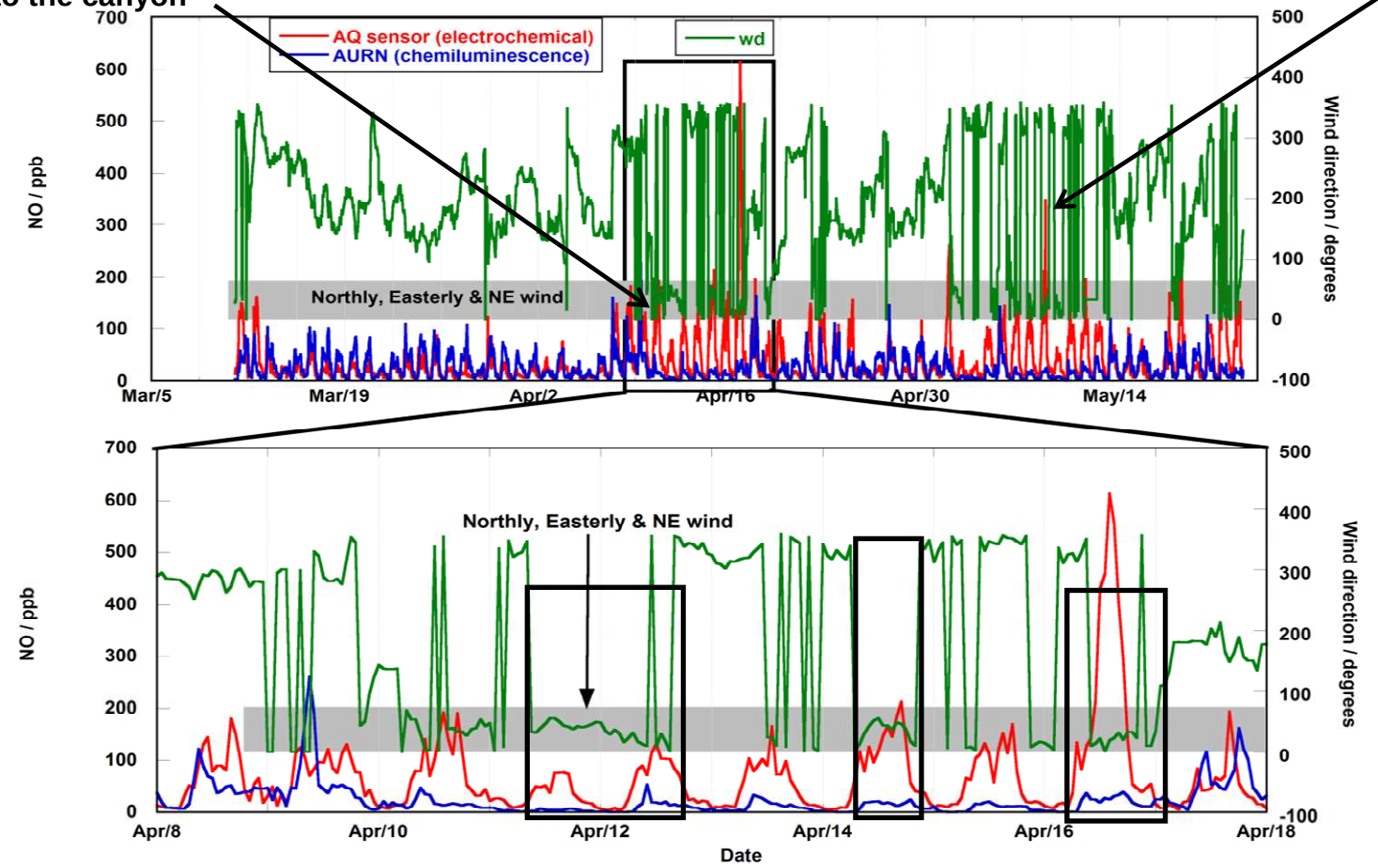
- Comparison of measurements made using a static AQ sensor unit and AURN site – Regent Street, Cambridge.
- Partial explanation of differences between ADMS model and observations?



Street canyon effects

Wind direction approximately perpendicular to the canyon

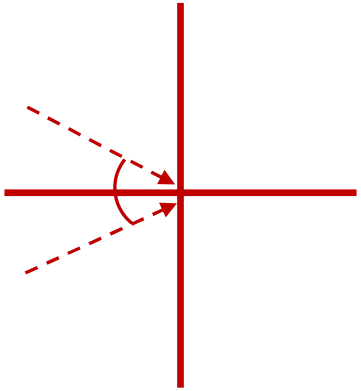
Wind direction approximately parallel to the canyon

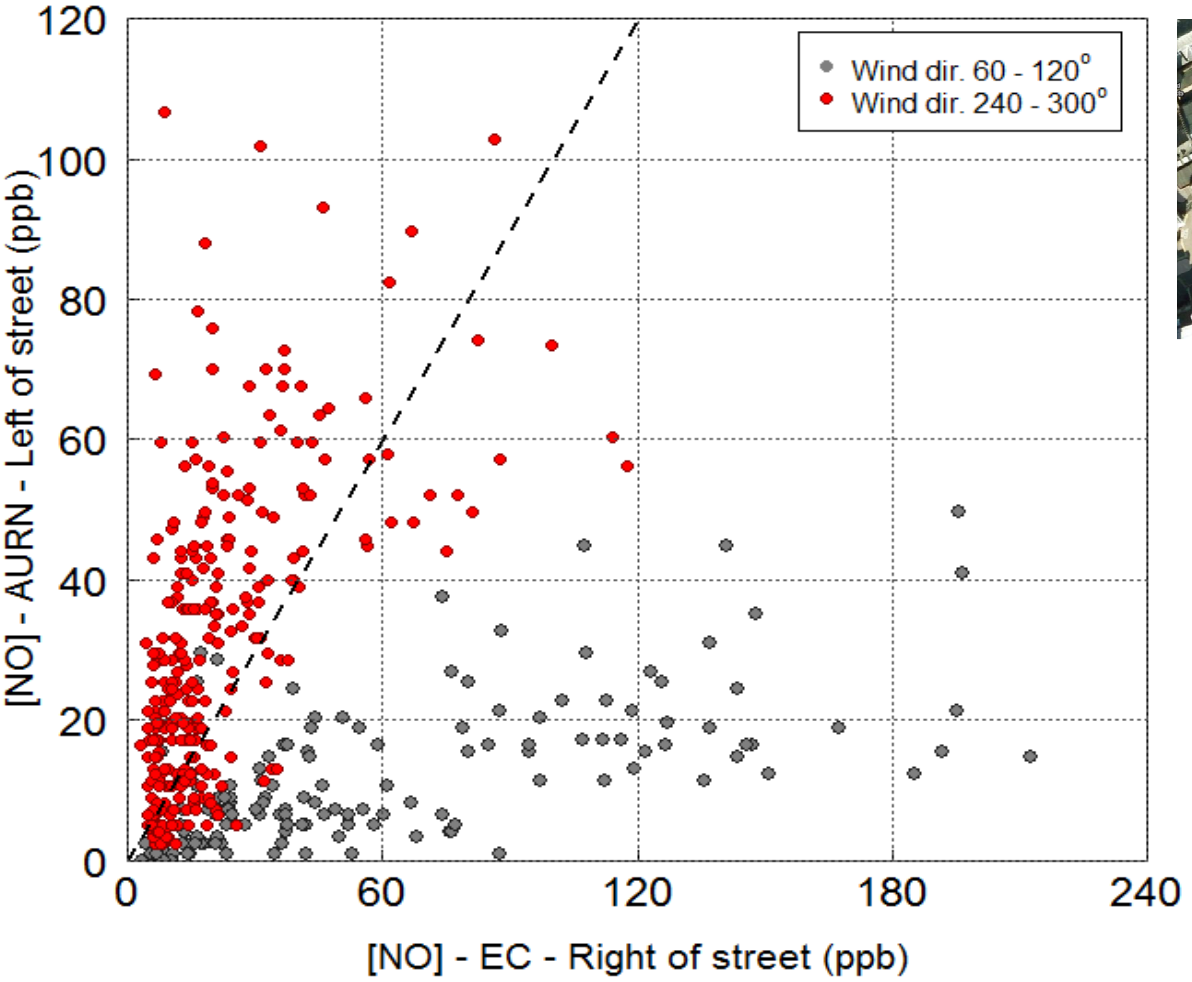


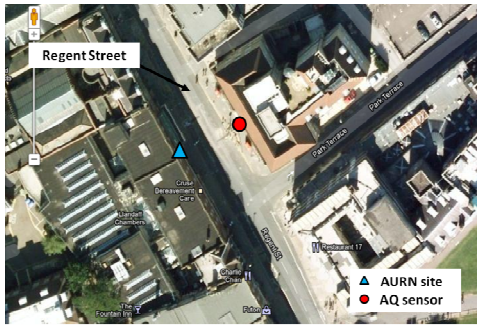
- Hourly mean wind direction and NO measurements from the AURN (chemiluminescence instrument) and AQ (electrochemical) sensor .

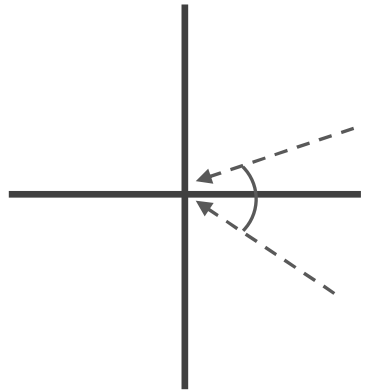
Within-canyon spatial variability

- Wind direction perpendicular relative to the street canyon axis (330º)



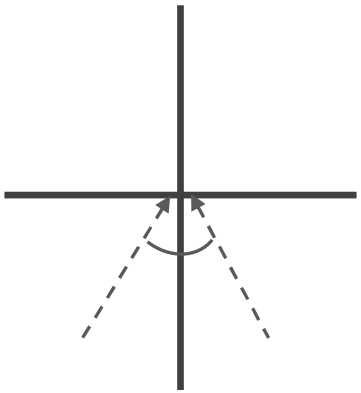


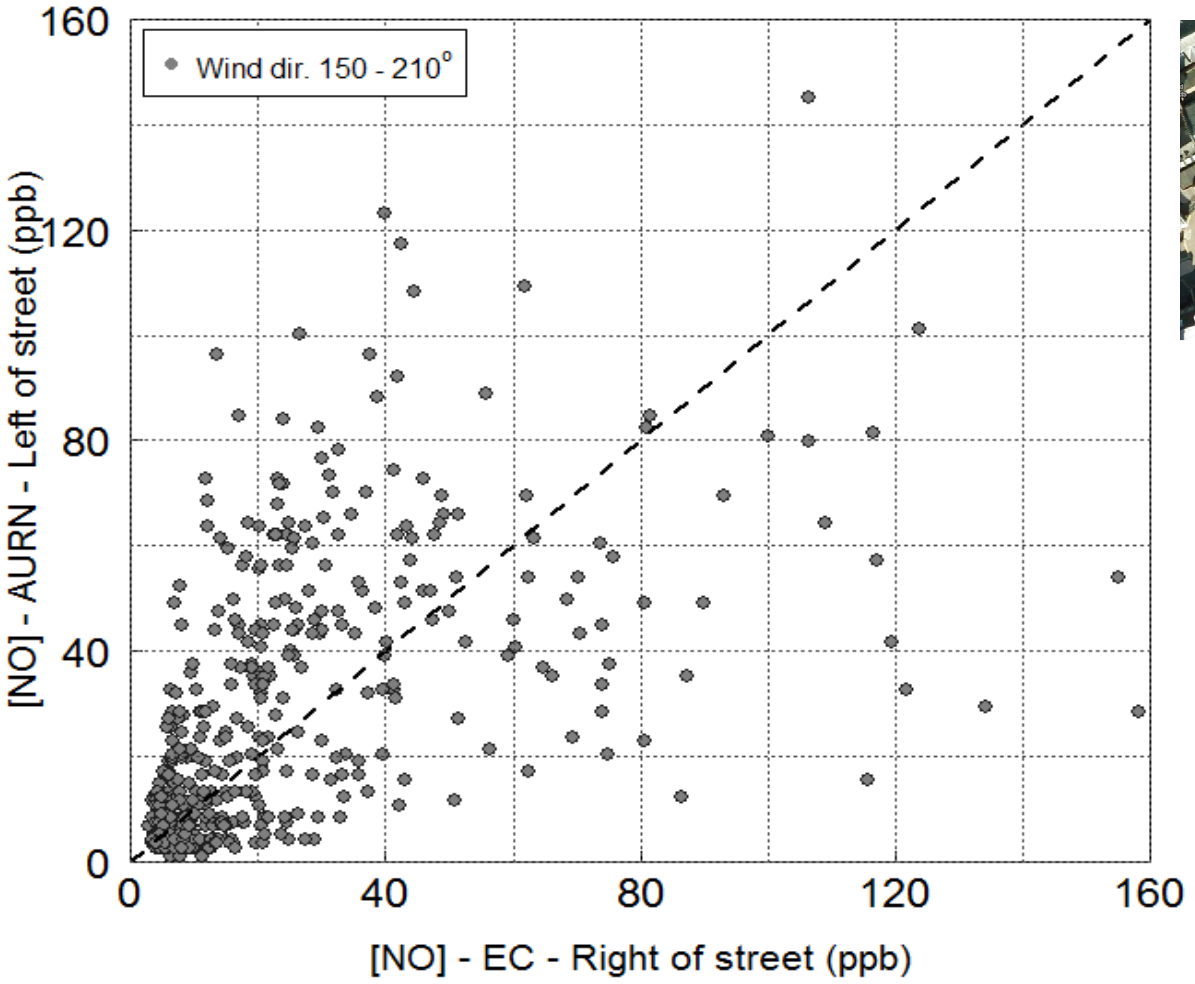


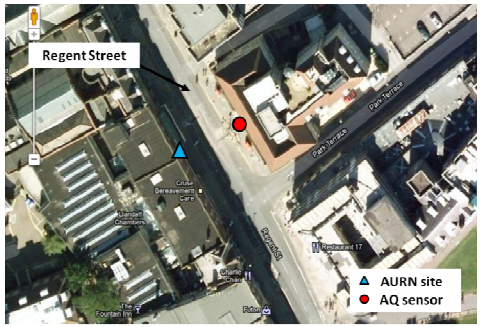


Channeling flow

- **Wind direction parallel relative to the street canyon axis (330º)**

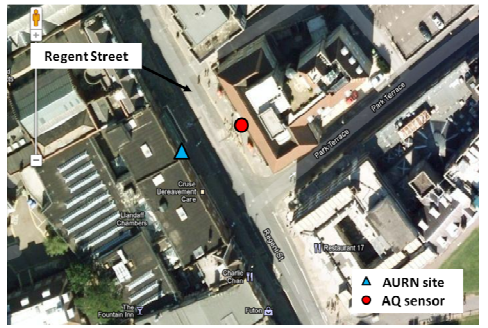




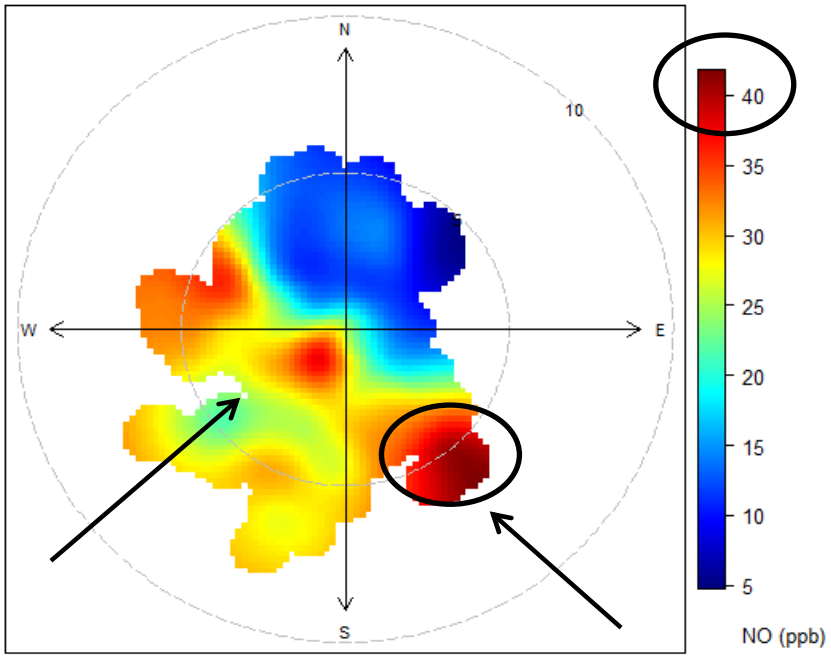


Within-canyon spatial variability

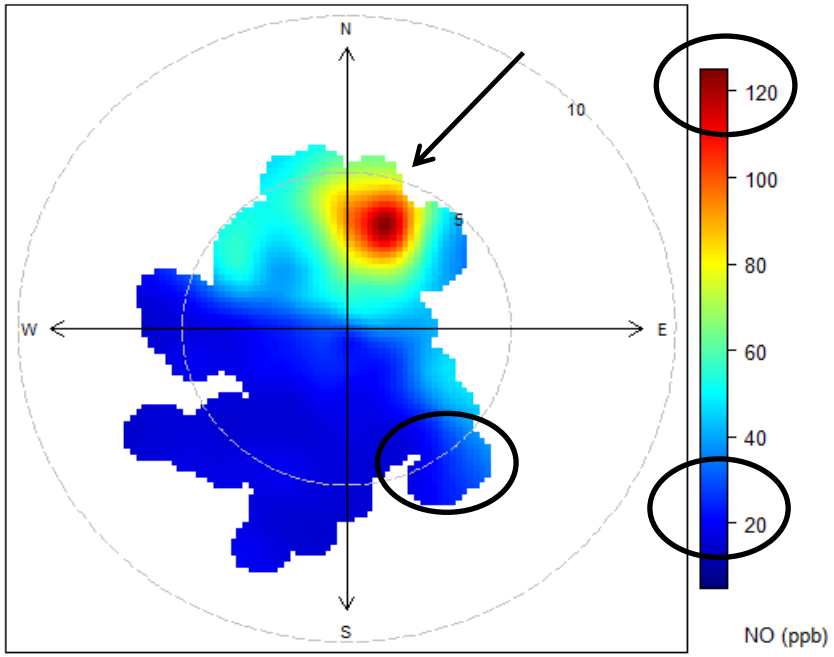
- **Bivariate polar plots of NO measurements comparing measurements between the AURN station and the EC sensor.**



NO Chemiluminescence (AURN Regent Street)



NO Electrochemical (Regent Str)



Future planned Activities

- Model verification through high (spatial and temporal) resolution observations.
- Model optimisation / source representation in models.
- Detailed analysis and source attribution – SNAQ-Heathrow
- Investigate personal exposure to pollutants.
- Citi-sense

CONCLUSIONS

- Low-cost sensor nodes equipped with GPS/GPRS – A.Q. measurements in near-real time, traditionally viewed as only achievable by costly and sparse fixed site monitoring stations.
- Demonstrated use of sensor nodes as part of static networks within urban environments - high spatial and temporal resolution data.
- Such measurements may be used to investigate personal exposure, regional changes in pollution levels, canyon effects and to perform model optimisation.
- Sensors require careful calibration (baseline levels, temperature and humidity effects).
- Sensor cross-sensitivity.

Acknowledgements

- **Cambridge Mobile Sensor Team:** Rod Jones, Lekan Popoola, Iq Mead, Gregor Stewart, Ines Heimann, Nahum Clements, Matt McLeod, Ray Freshwater, Mark Hayes, Shaun Hurst.

- **University of Hertfordshire:** Paul Kaye, Edwin Hirst, Warren Stanley.

- **University of Manchester:** Paul Williams.

- **Imperial College:** Robin North, Jeremy Cohen.

- **Alphasense:** John Saffell. Ronan Baron.