


European Network on New Sensing Technologies for Air Pollution Control
and Environmental Sustainability - *EuNetAir*
COST Action TD1105

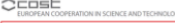
WGs and MC Meeting at ISTANBUL, 3-5 December 2014
Action Start date: 01/07/2012 - Action End date: 30/06/2016
Year 3: 1 July 2014 - 30 June 2015 (*Ongoing Action*)


**ENVIRONMENTAL MEASUREMENTS USING
LOW COST SENSORS:
LATEST RESULTS AND FUTURE DIRECTIONS**


 UNIVERSITY OF
CAMBRIDGE


Rod Jones
SIG 2 Chair
University of Cambridge
Department of Chemistry

The other Cambridge!

 COST
EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

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

 COST is supported
by the EU Framework Programme

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through a European Commission contract

Disclaimer

The failures in presenting these excellent data sets in a coherent and convincing way is *entirely the fault of the presenter* and in no way should reflect on the excellence of the research team members....

Acknowledgements


(Iq), Lekan, Viv, Ines, (+ Paul Smith, Josh Shutter, Ray Freshwater);
Adam Durant + colleagues (volcanoes), Grant Allen (landfill)
EMPA (Christoph, Michael), CERC,
Alphasense, SenseAir

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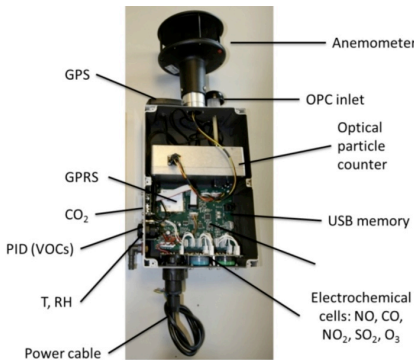


Sensor network system at Heathrow airport

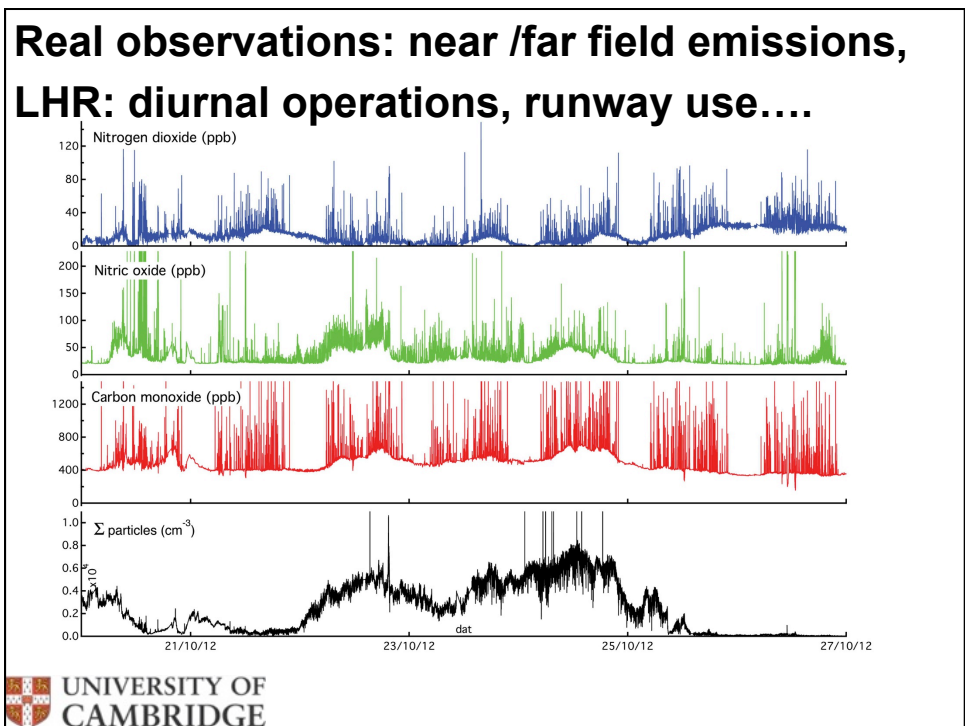
- 40 sensor nodes (Electrochemical, NDIR, PID, Optical)
- Real time data transfer (GPRS)
- NO, NO₂, CO, CO₂, SO₂, O₃, VOCs, PM.
- Software sensor network calibration



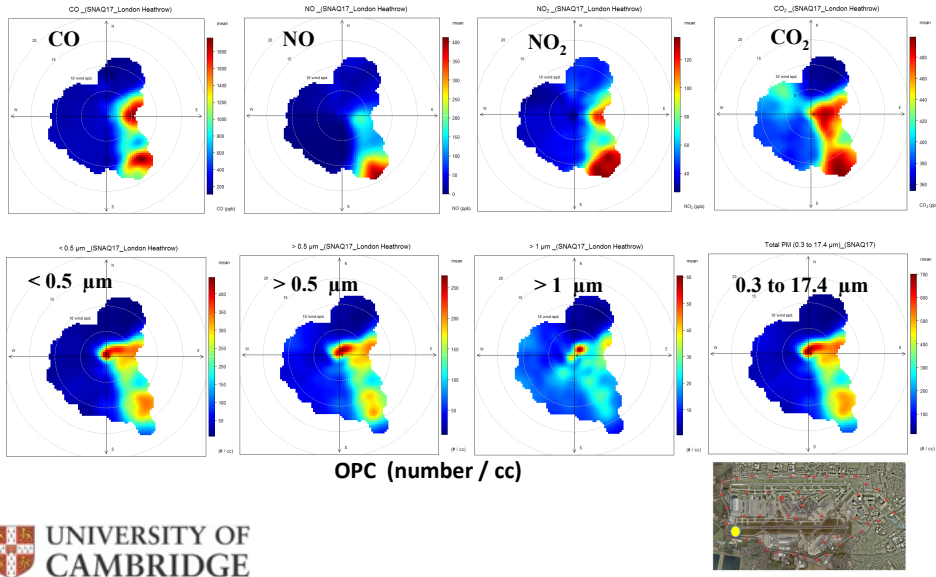
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Date: (2013)



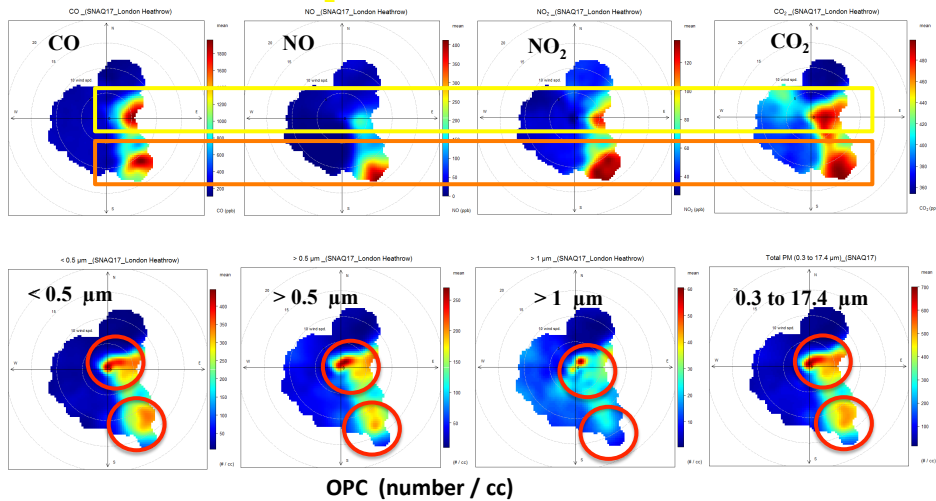
Source attribution: **SNAQ17** at the west-end of southern runway (09R) , 1 month data

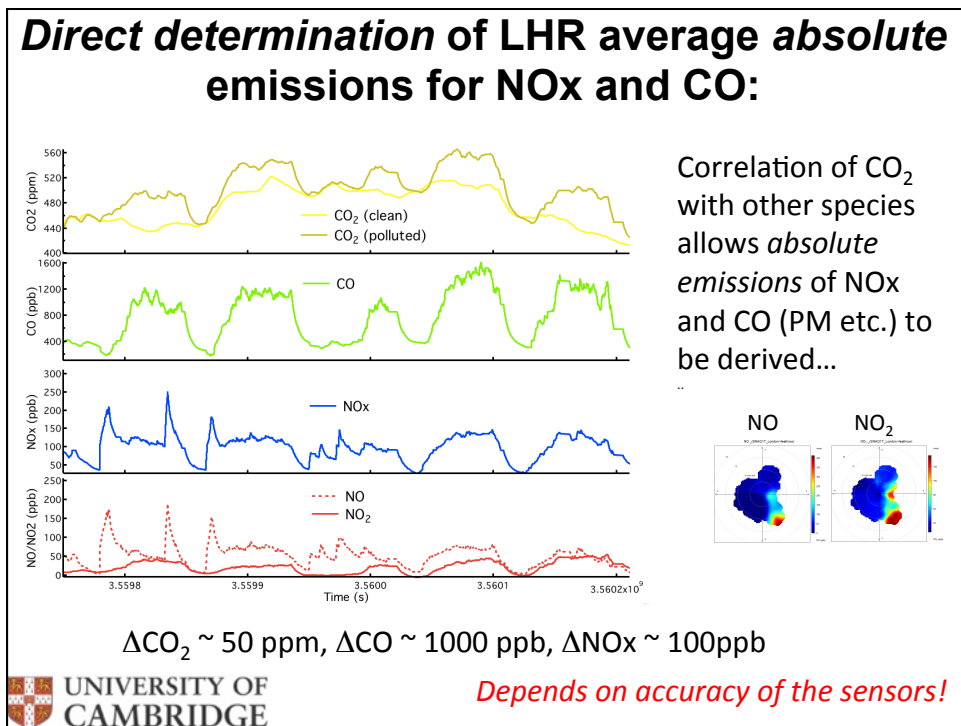
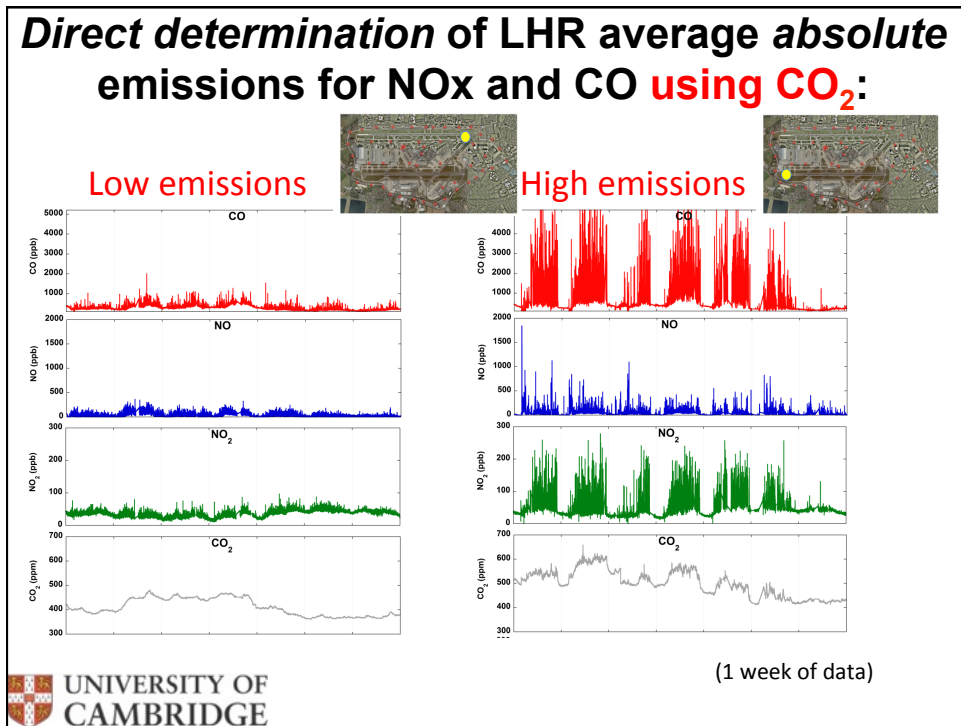


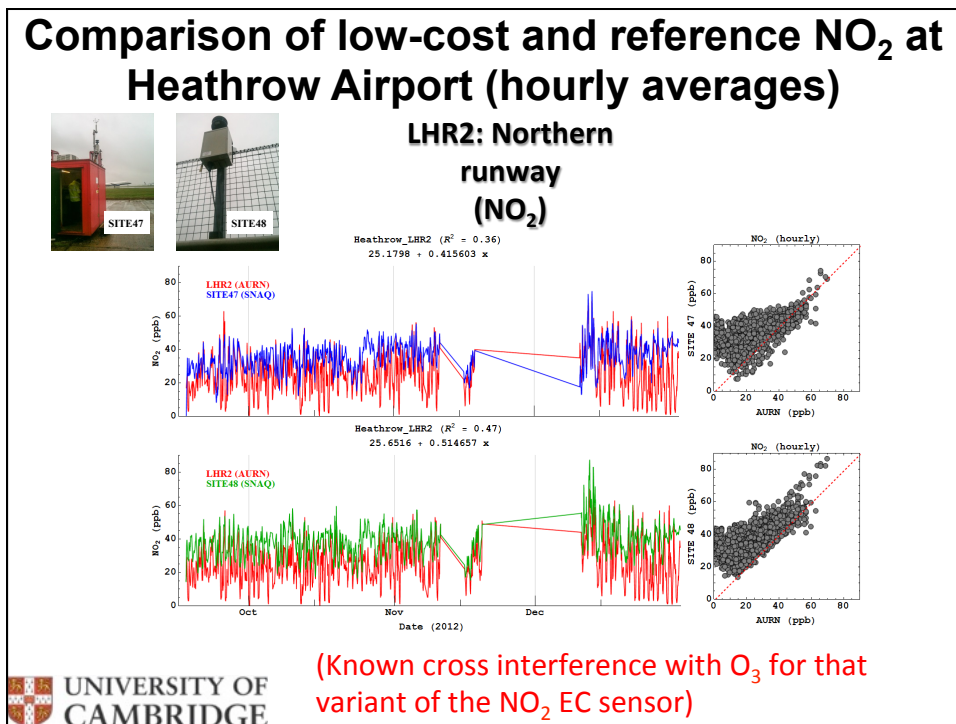
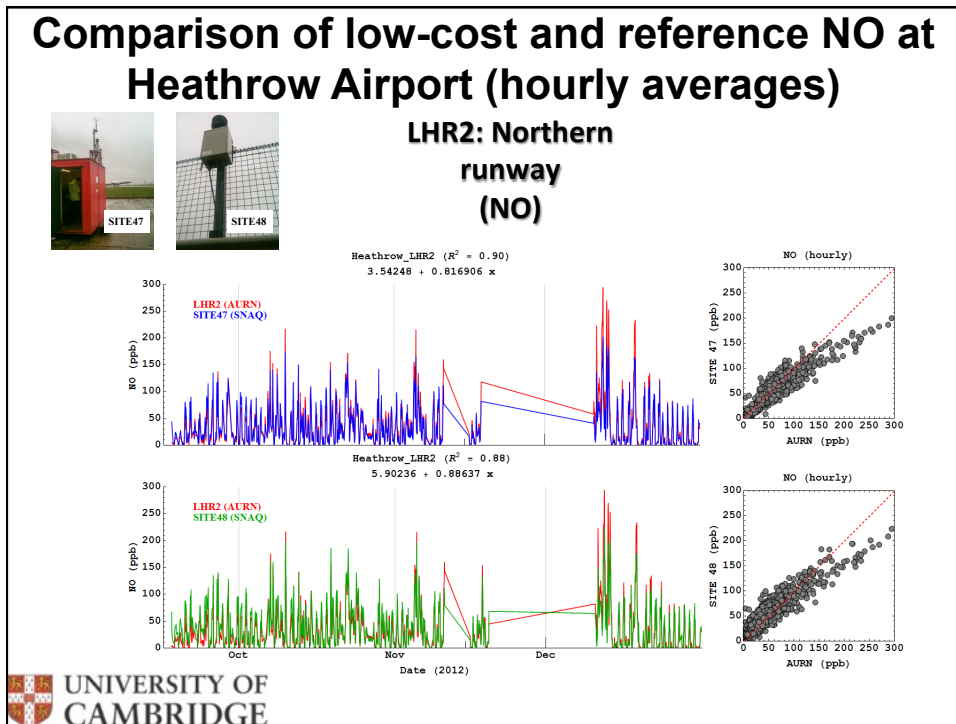
Direct determination of transport activities

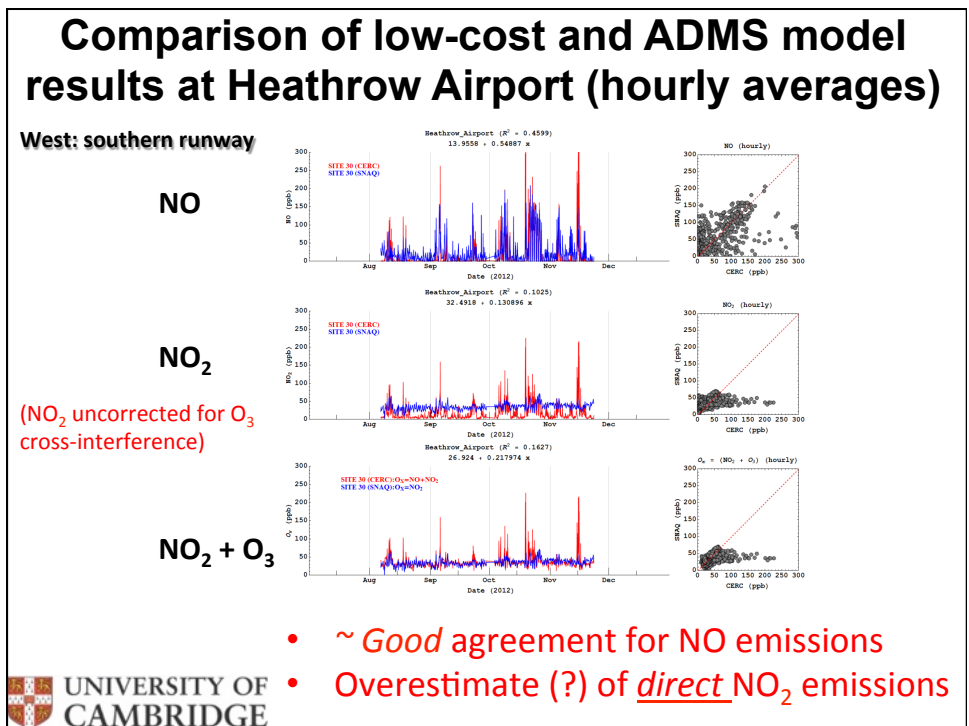
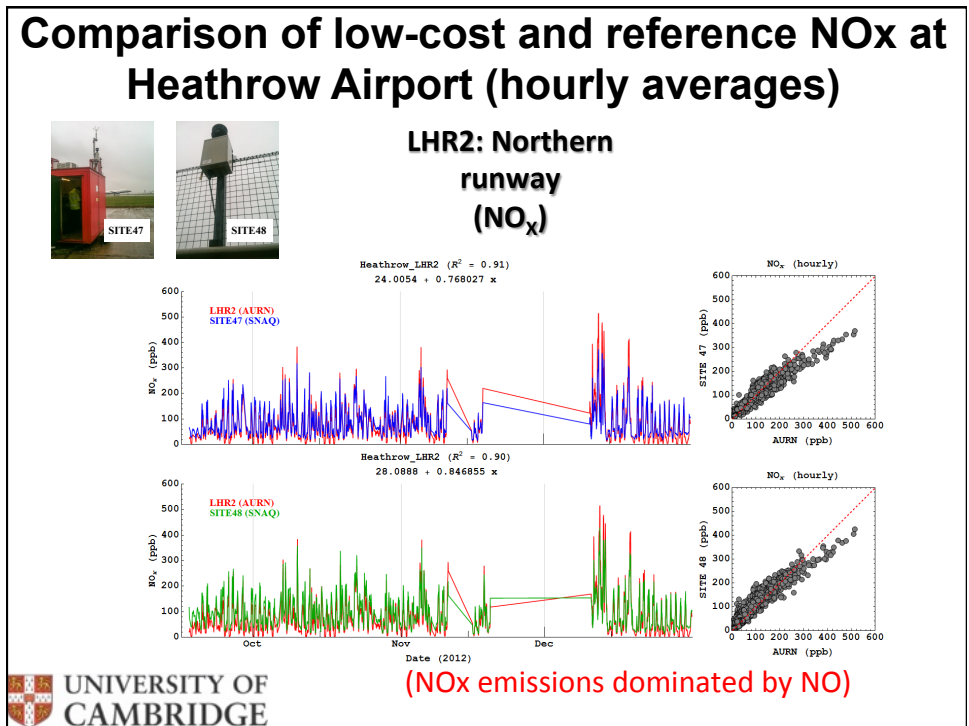
High CO₂, high NO_x, medium CO – take offs

Medium CO₂, low NO_x, medium CO – taxiing







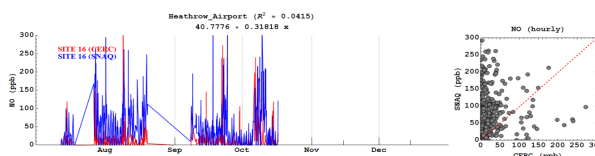


Comparison of low-cost and ADMS model results at Heathrow Airport (hourly averages)

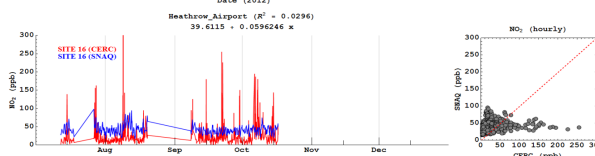
Terminal 3



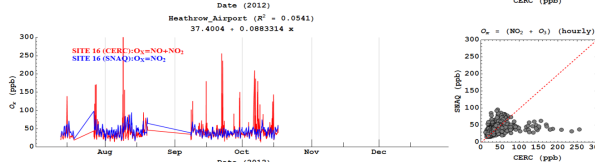
NO



NO₂



NO₂ + O₃

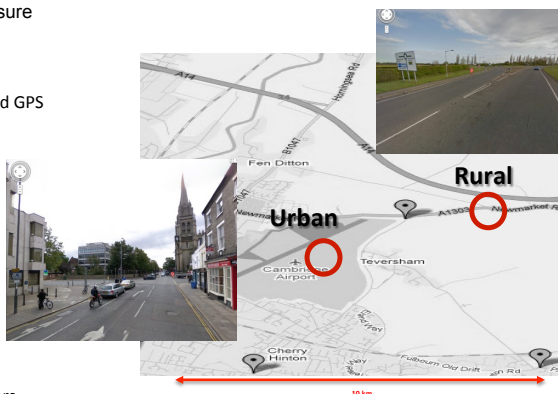
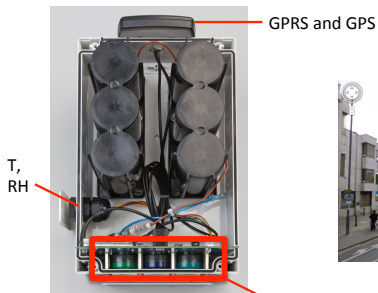


- Poor agreement for NO emissions
- Overestimate (?) of direct NO₂ emissions



High density sensor networks: Cambridge deployment, 2010

- 3 month static deployment in Cambridge: 45 low-cost electrochemical sensors (11/03/2010 – 30/05/2010)
- High spatial and temporal (10 s) resolution data set of CO, NO and NO₂, temperature and relative humidity
- Determine true variability in pollution levels across an urban area and representativeness of AURN sites in determining exposure

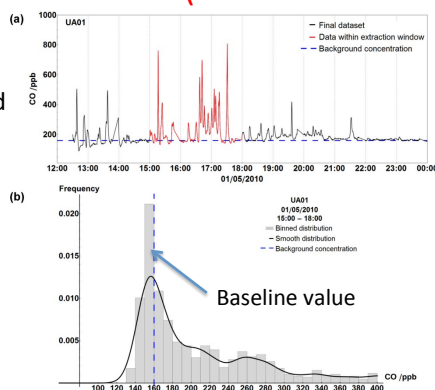


Smart data analysis: extraction of sensor measurement 'baseline' for different species/locations

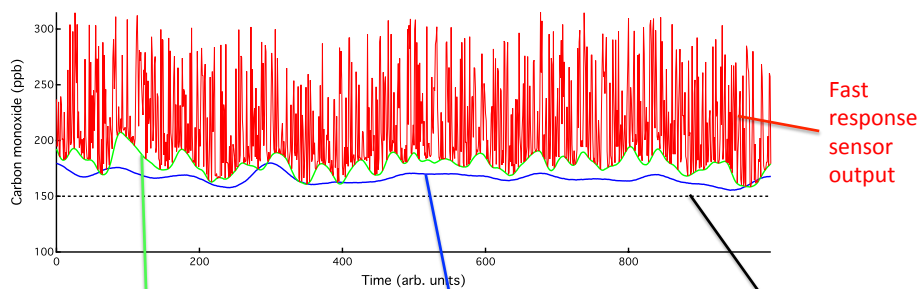
Why? - allows data-based separation of spatial scales of emissions for source attribution (and network calibration)

Steps:

- 1) Select data window (red in figure)
- 2) Take most probable value (maximum in histogram) as baseline
- 3) Define baseline for period.



Schematic illustration of purely data-based scale separation



Far field emissions
(from low pass filter
for each sensor)

Regional background
(determined from the
minimum baseline from
sensor network)

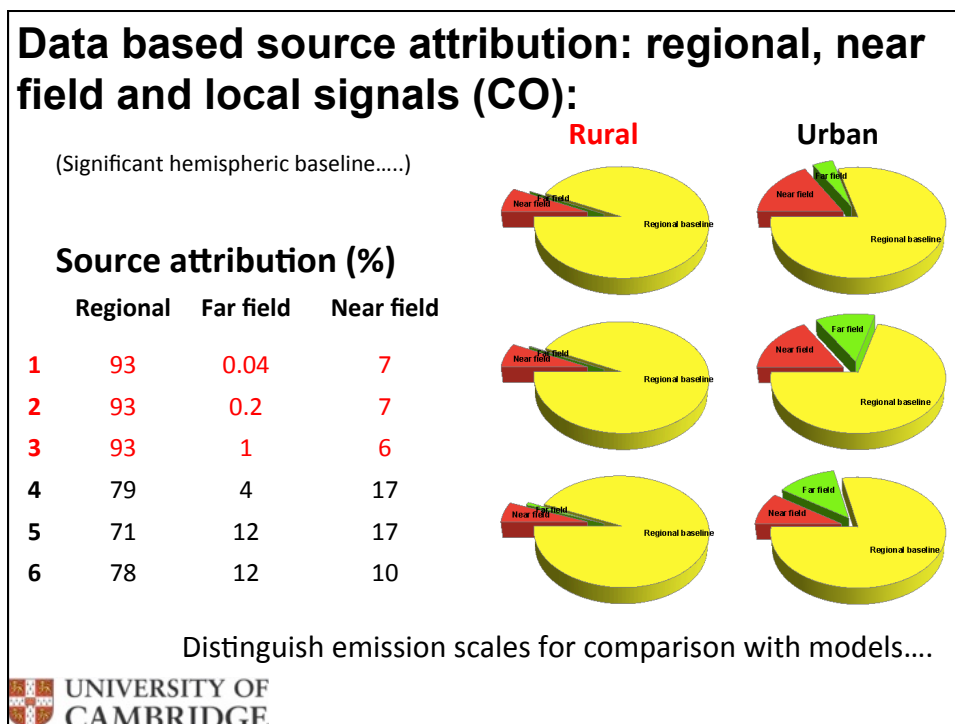
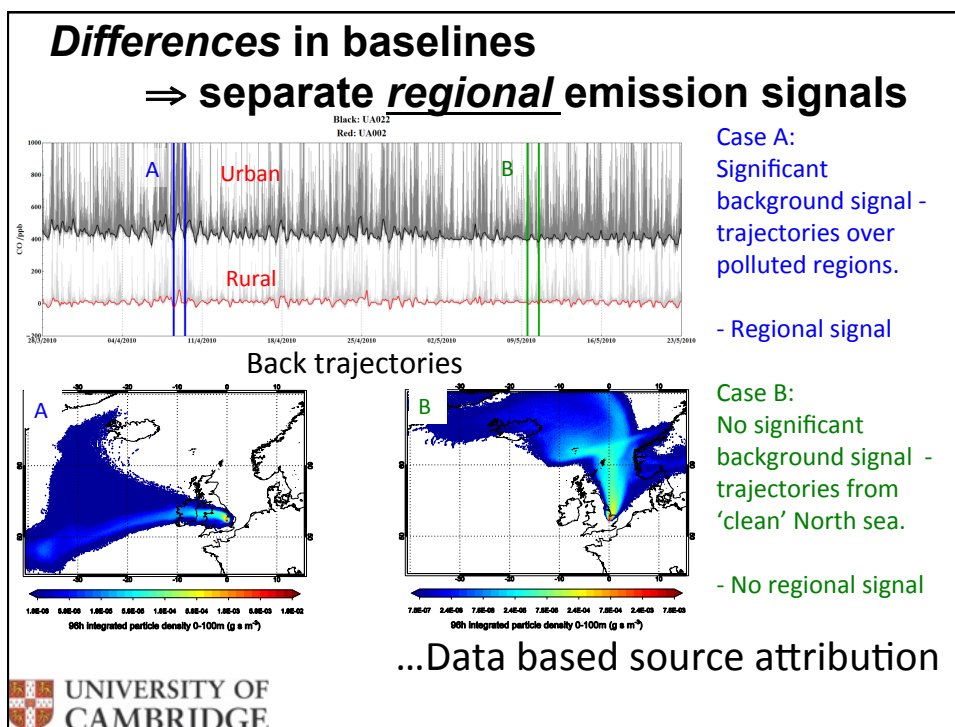
Hemispheric background
(arbitrary level, significant
for e.g. CO).

Near field emissions = red - green (insufficient time to disperse)

Far field emissions = green - blue (dispersed, individual to sensor)

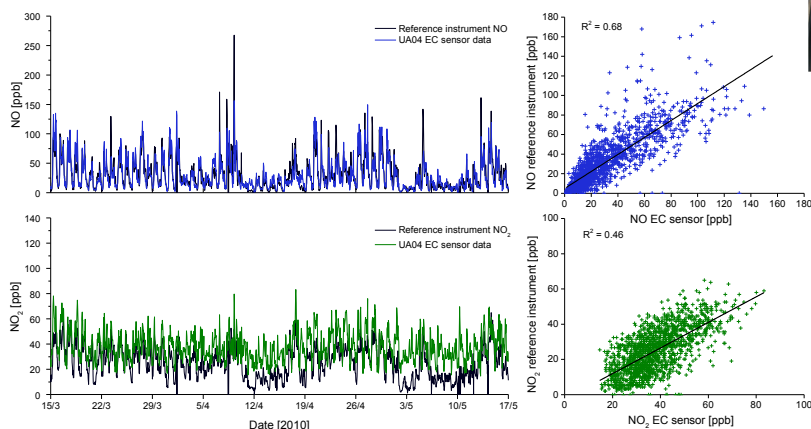
Regional background = blue (common to sensor network)





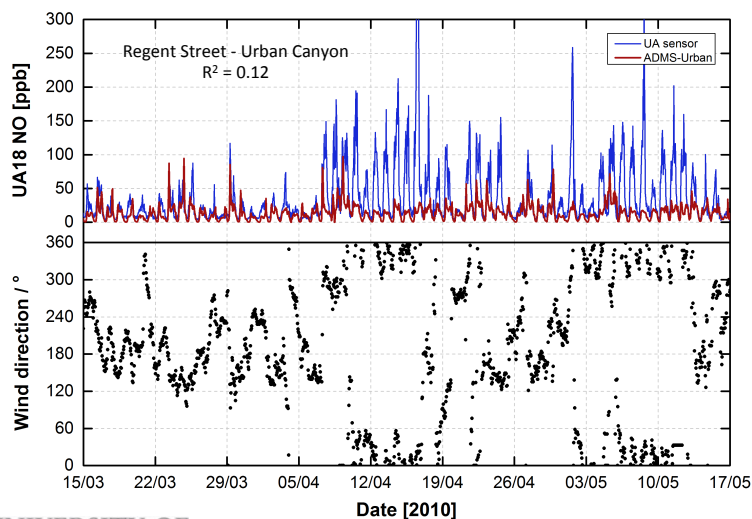
Measurements co-located with reference (AURN) (UA04 – Parker Street)

- AURN inlet at approximately 1m a.g.l. **co-located** with sensor UA04.
- Good agreement between sensors over 9 week period for NO ($R^2 = 0.68$).
- Cross-sensitivity effects inherent in NO₂ measurements ($R^2 = 0.46$).



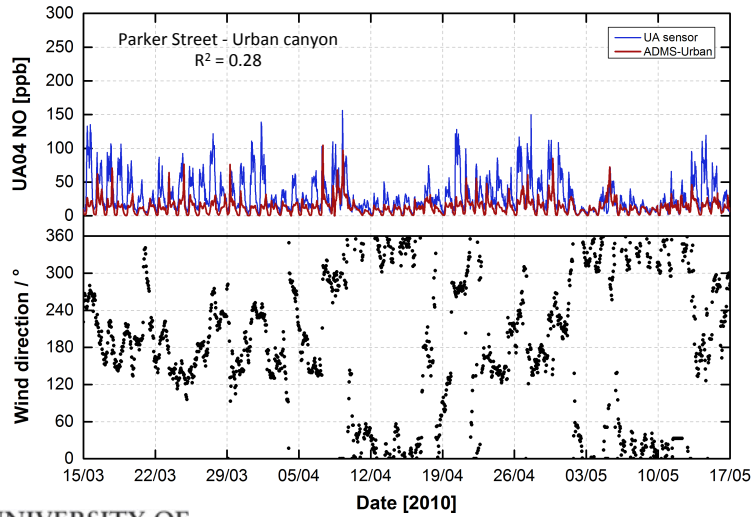
ADMS-Urban model v measurement comparison

- Comparison between EC measurements and ADMS-Urban dispersion model (half-queues).
- Best agreement between model and measurements observed when wind is parallel to street axis.
- Significant differences when canyon effects and primary vortex is likely.

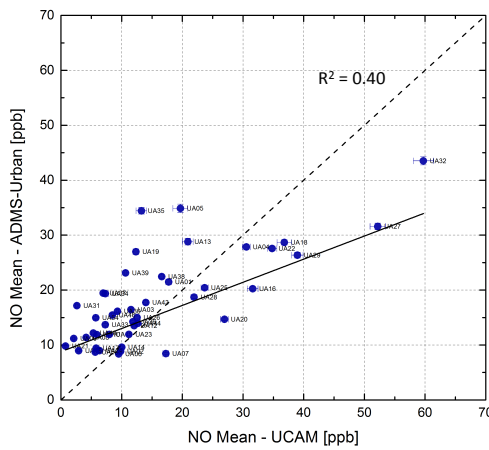


ADMS-Urban model v measurement comparison

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ADMS-Urban model v measurement comparison



- Agreement encouraging but conceals significant errors associated with canyon effects
- Improvements to OSPM?

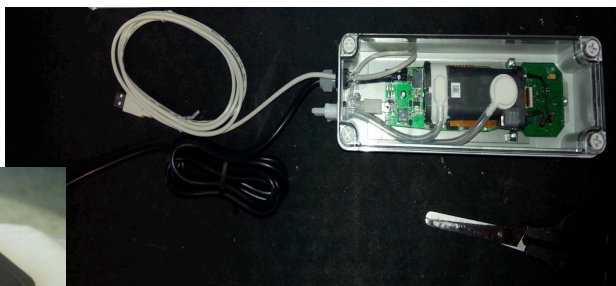


Looking forward

- Low cost high sensitivity NDIR instruments
- Health studies

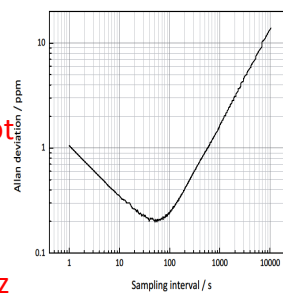
Low cost CH₄/CO₂ sensors (non-dispersive IR)

 **SenseAir**[®]
Sensors for Life

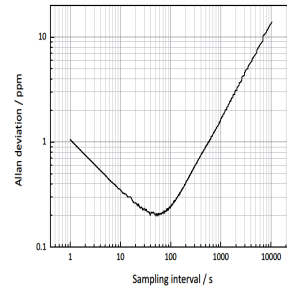
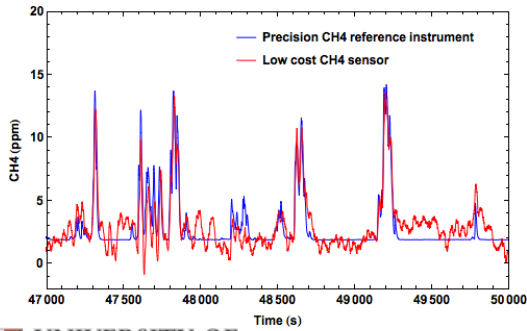
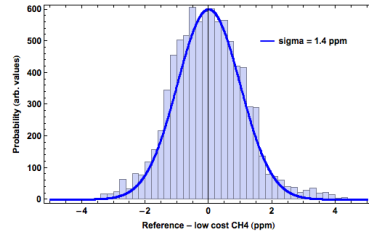


Allan variance plot
for CH₄ sensor

~ 1 ppm at 1 Hz
0.2 ppm at 0.01Hz



Real world performance (prototype CH₄), 1 sec

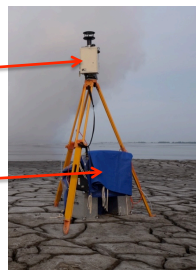


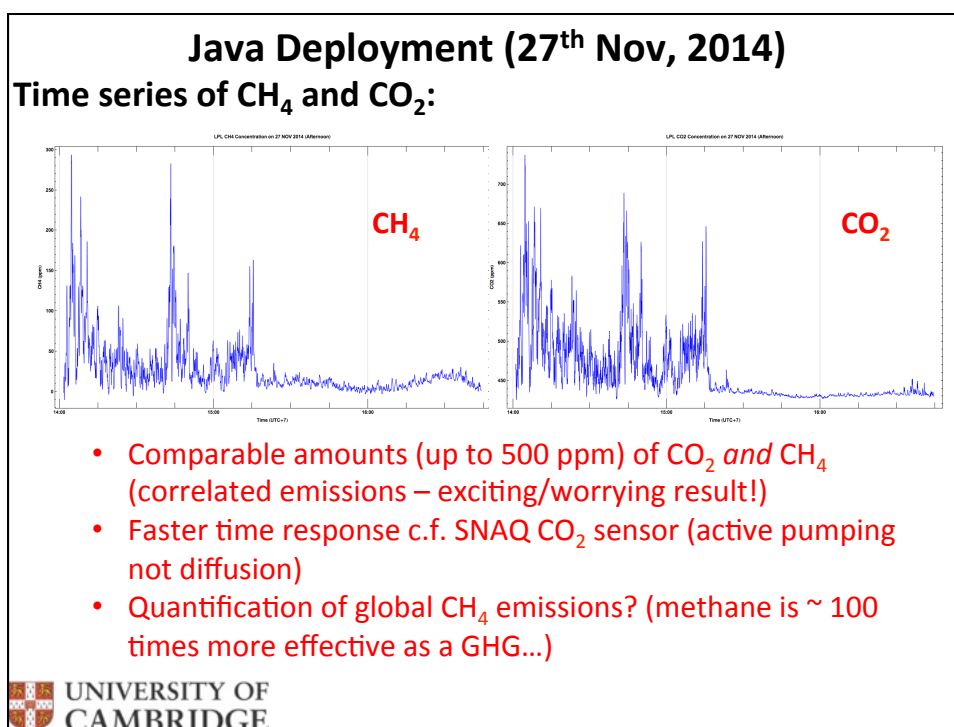
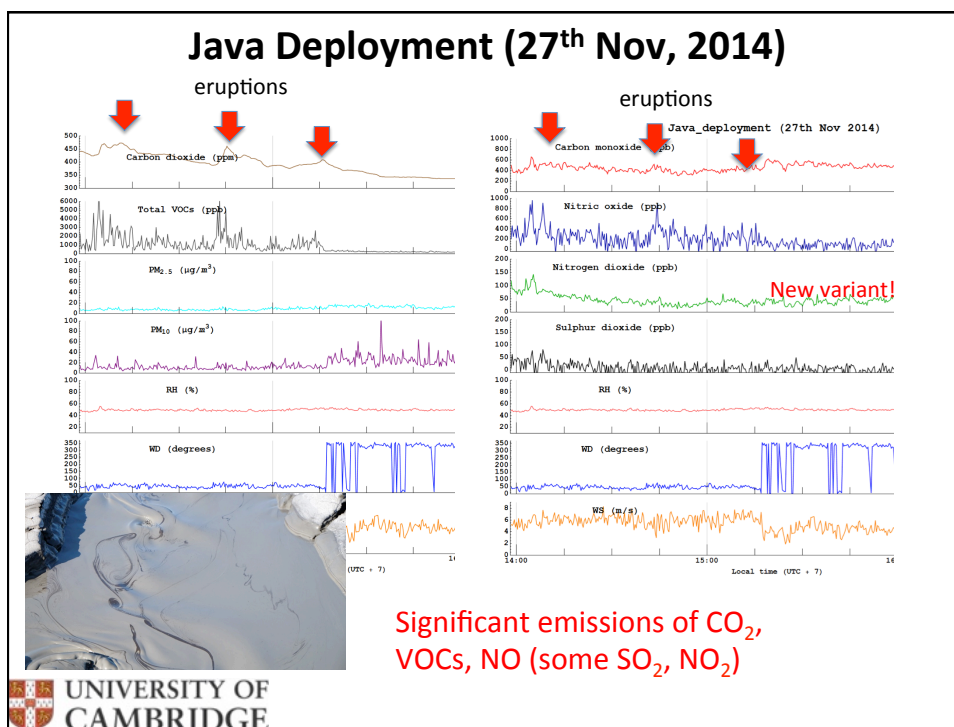
Volcanic emissions (fracking): Java Deployment (27th Nov, 2014)



SNAQ box

NDIR CH₄/CO₂








Personal monitors for health studies (including indoors!)

(UK Medical Research Council funded COPD cohort study)

- O₃, NO₂, NO, CO
- Size speciated PM
- GPS
- Accelerometer
- Noise
- GPRS

atmospheric
sensors 



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Conclusions?

- Significant progress with low-cost sensors moving towards fully quantified devices (formal?)
- Significant progress *with the tools for exploiting them*
- New instruments (and opportunities) in prospect.....

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