

### Low Cost Sensor Networks for Air Quality Monitoring

Rod Jones, University of Cambridge  
rlj1001@cam.ac.uk

**UNIVERSITY OF CAMBRIDGE**

### Low Cost Sensor Networks for Air Quality Monitoring (NOx 'eating' coatings)

Rod Jones, University of Cambridge  
rlj1001@cam.ac.uk

**UNIVERSITY OF CAMBRIDGE**

### Photocatalytic NOx removal in the urban environment

Atmospheric Environment 40 (2006) 1028–1031

Contents lists available at ScienceDirect  
Atmospheric Environment journal homepage: [www.elsevier.com/locate/atmenv](http://www.elsevier.com/locate/atmenv)

Short communication  
Solar driven nitrous acid formation on building material surfaces containing titanium dioxide: A concern for air quality in urban areas?  
Justin M. Langridge<sup>a</sup>, R. Joel Gustafson<sup>b</sup>, Paul T. Griffiths<sup>b</sup>, R. Anthony Cox<sup>b</sup>, Richard M. Lambert<sup>b</sup>, Rodger L. Jones<sup>a</sup>

TiO<sub>2</sub> surfaces are well known photo-catalysts  
Surfaces incorporating TiO<sub>2</sub> nanoparticles increasingly used for removal of NOx and volatile organic compounds (VOCs)

Nitrous acid (HONO) known to be formed in the atmosphere by heterogeneous processes, including mineral dust containing TiO<sub>2</sub> (mechanism?)  
(HONO photolysis can provide an additional source for atmospheric OH)

**UNIVERSITY OF CAMBRIDGE**

### Methodology: Cavity Enhanced Absorption Spectroscopy (CEAS) – ultra sensitive spectroscopy

- Unambiguous spectral detection/attribution of HONO and NO<sub>2</sub>
- HONO detection limit ~ 0.25 ppb in 15s (NO<sub>2</sub> ~ 0.5ppb)

**UNIVERSITY OF CAMBRIDGE**

### Experimental Arrangement

**• Substrate area** 105 cm<sup>2</sup> (**Pilkington self cleaning glass**)  
**• Illumination at**  $\lambda = 370$  nm,  $\sim 6\text{Wm}^{-2}$  (< 20% of solar intensity)

**UNIVERSITY OF CAMBRIDGE**

### Typical Results: good news

Initial conditions: ~80 ppb NO<sub>2</sub> / 44% RH

Clear evidence of photo-catalytic reduction of NO<sub>2</sub> (under laboratory conditions ~ 5% of sunlight)

**UNIVERSITY OF CAMBRIDGE**

### Typical Results: hang on.....

Initial conditions: ~80 ppb NO<sub>2</sub> / 44% RH

NO<sub>2</sub> conversion to HONO observed (45-75% yield)

**UNIVERSITY OF CAMBRIDGE**

### Why is HONO production an issue?

$\text{HONO} + \text{sunlight} \rightarrow \text{OH} + \text{NO}$   
 $(+\text{O}_3) \rightarrow \text{NO}_2$

⇒ HONO formation makes the photocatalytic NOx removal process less efficient

⇒ increases OH (the main oxidant)  
 ⇒ Increases in OH concentrations accelerate pollution chemistry

**UNIVERSITY OF CAMBRIDGE**

### Box model results: UK summer

• ~ 25% reduction in NO<sub>x</sub> (NO + NO<sub>2</sub>) – about half of what expected

• ~ 2 fold enhancement in OH, including morning peak (accelerates the ozone production)

**UNIVERSITY OF CAMBRIDGE**

Welsh Air Quality Forum, 25-9-2014

### Conclusions

- Photocatalytic removal of NO<sub>2</sub> on TiO<sub>2</sub> surfaces does work.....
- But, HONO is produced, reducing the NO<sub>x</sub> reduction yield and producing OH

⇒ Need to consider the full consequences

**UNIVERSITY OF CAMBRIDGE**

Welsh Air Quality Forum, 25-9-2014

### Development of sensors and sensor networks

- Cost/ease of deployment
- Information content (location)

**UNIVERSITY OF CAMBRIDGE**

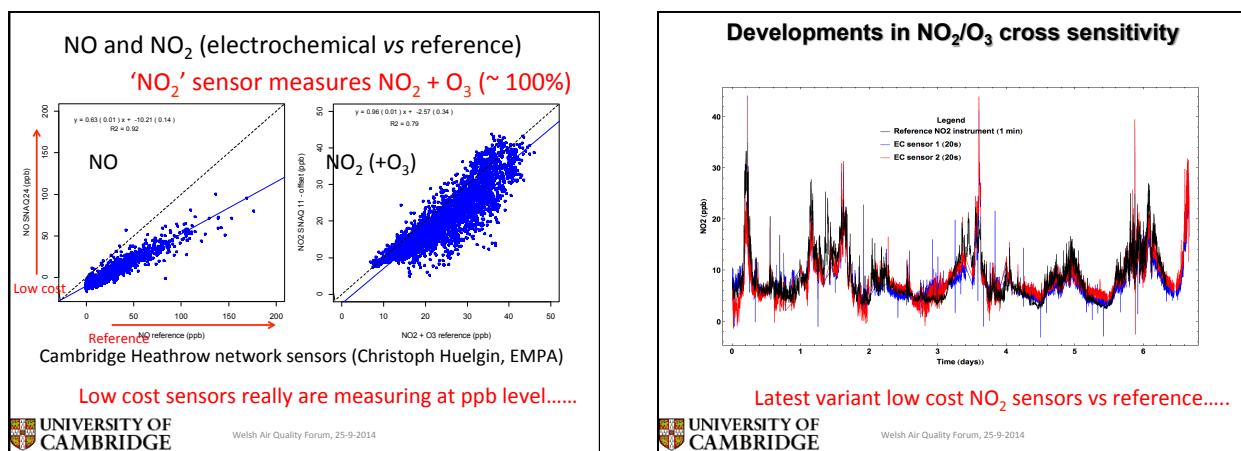
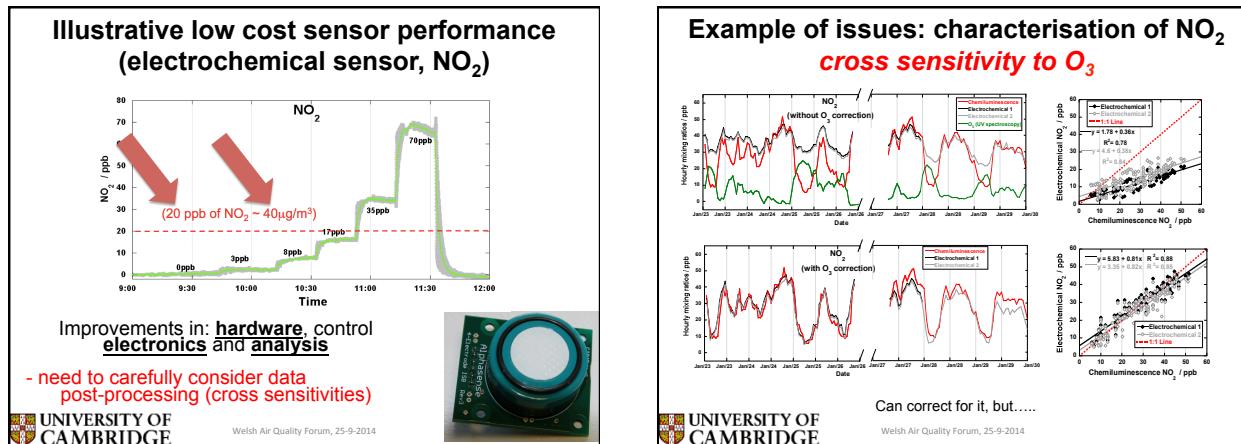
Welsh Air Quality Forum, 25-9-2014

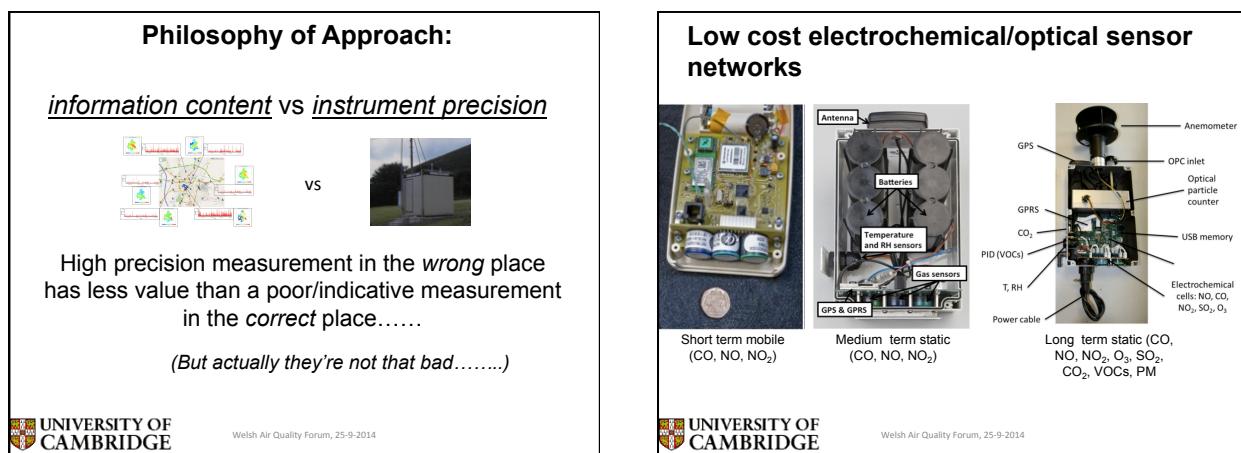
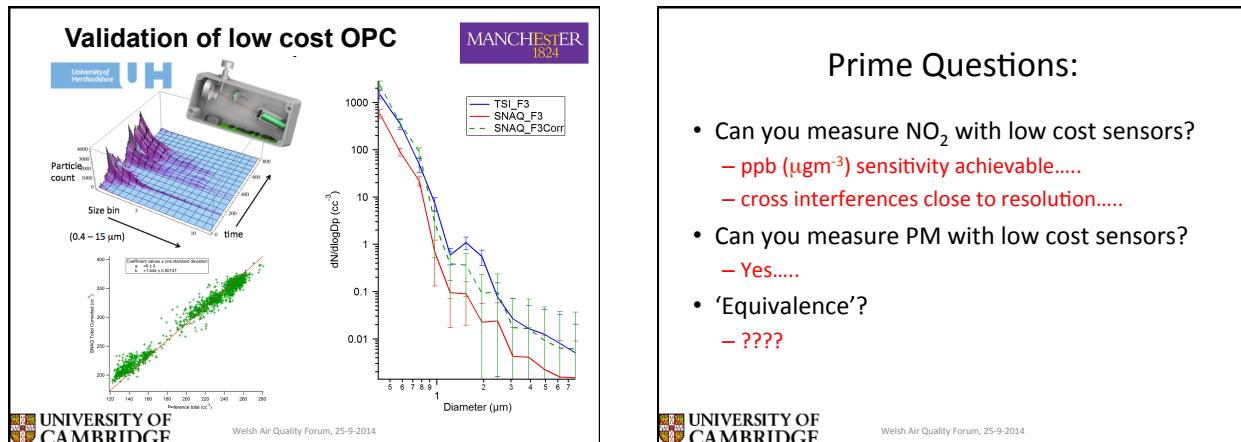
### Prime Questions:

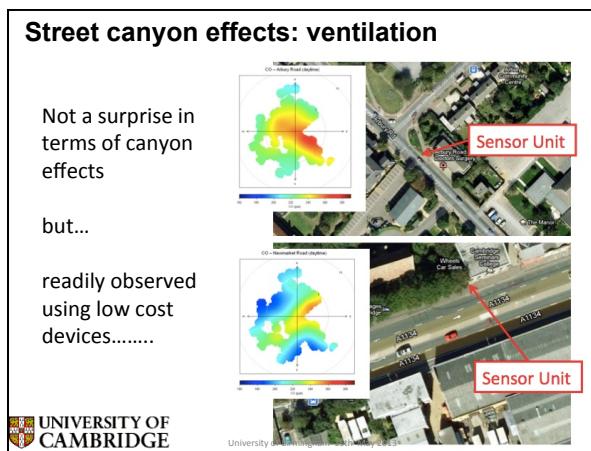
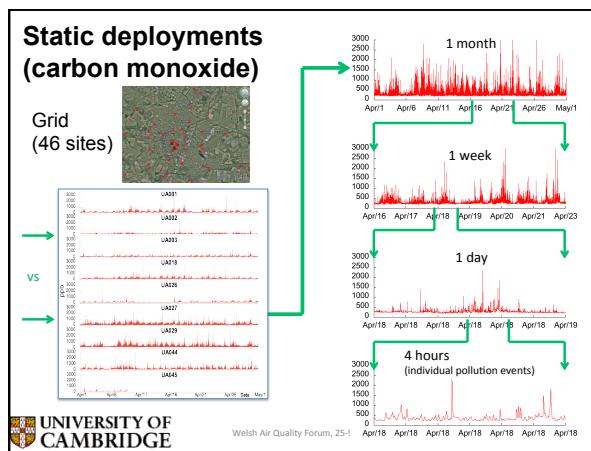
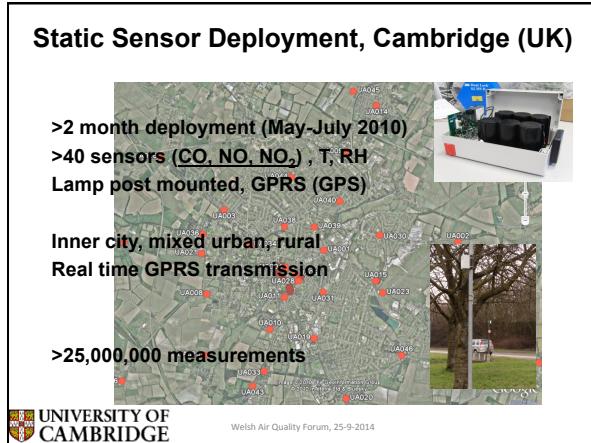
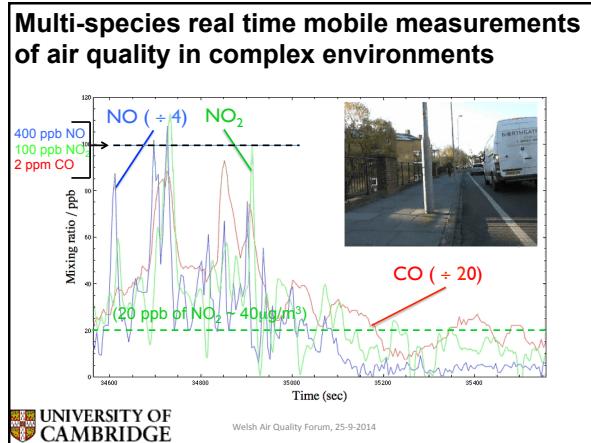
- Can you measure NO<sub>2</sub> with low cost sensors?
- Can you measure PM with low cost sensors?
- Certification and 'equivalence'?

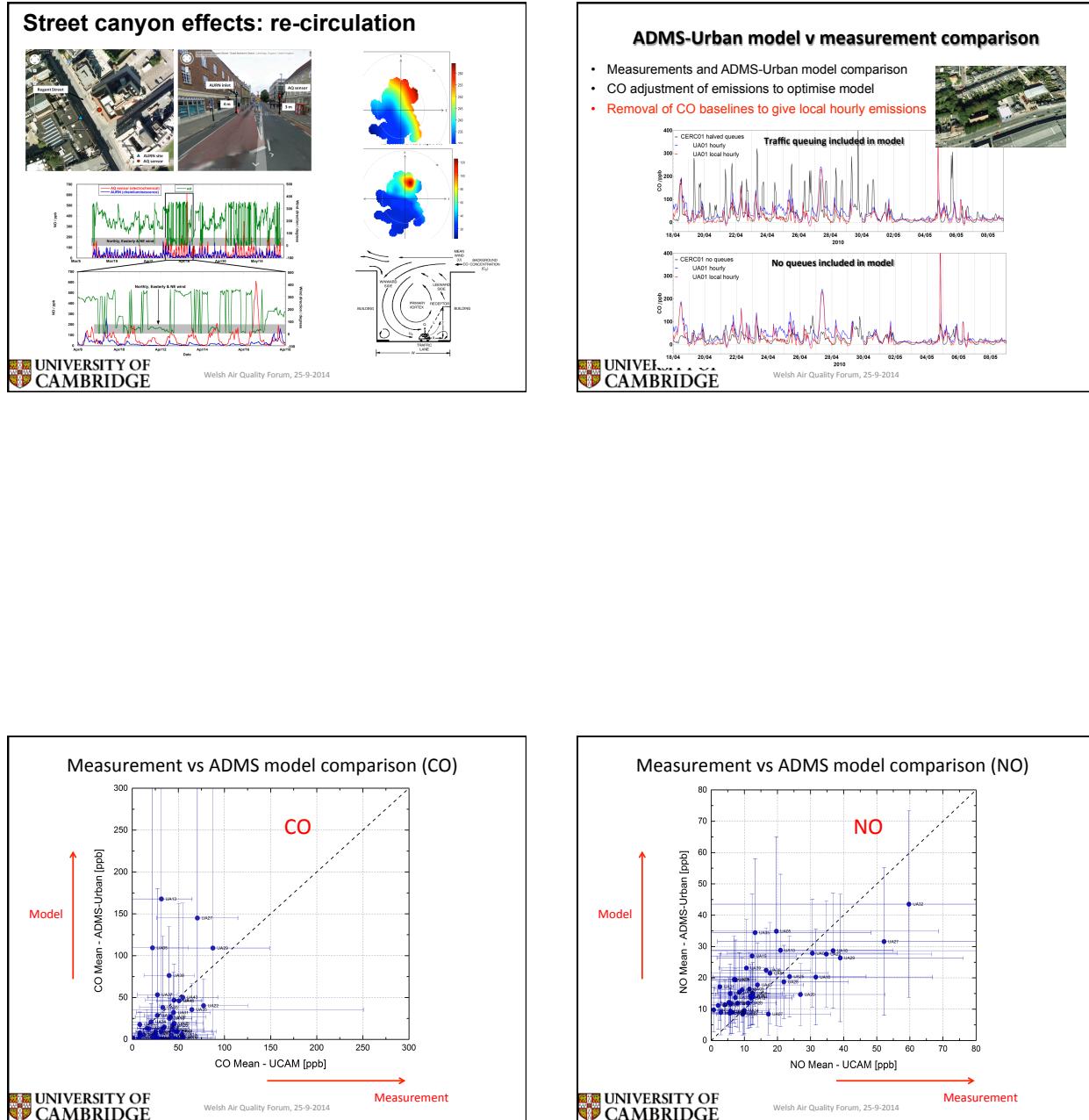
**UNIVERSITY OF CAMBRIDGE**

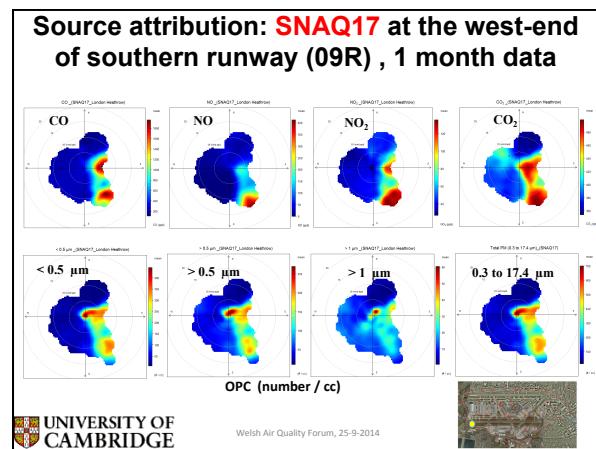
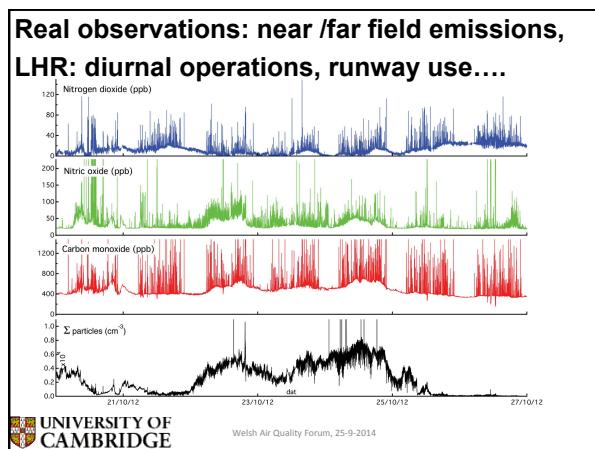
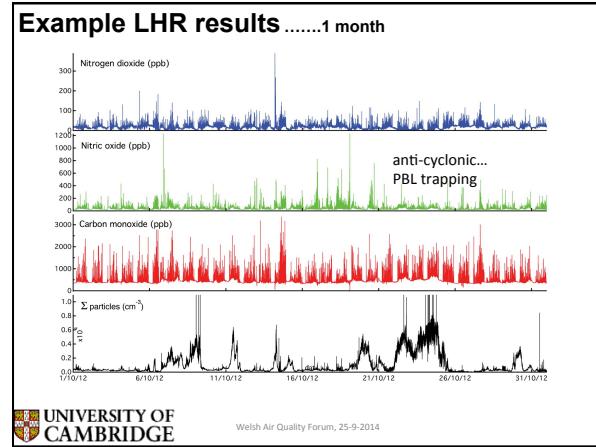
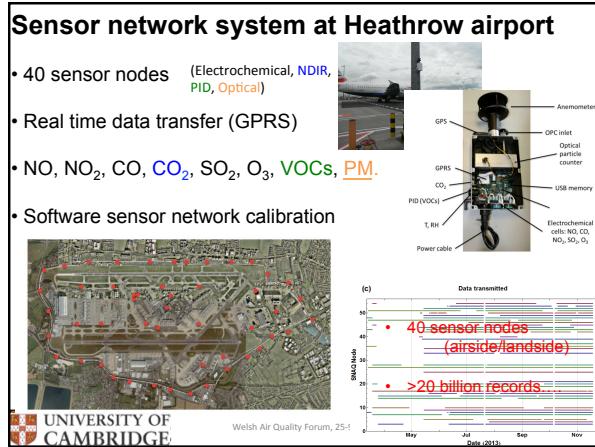
Welsh Air Quality Forum, 25-9-2014

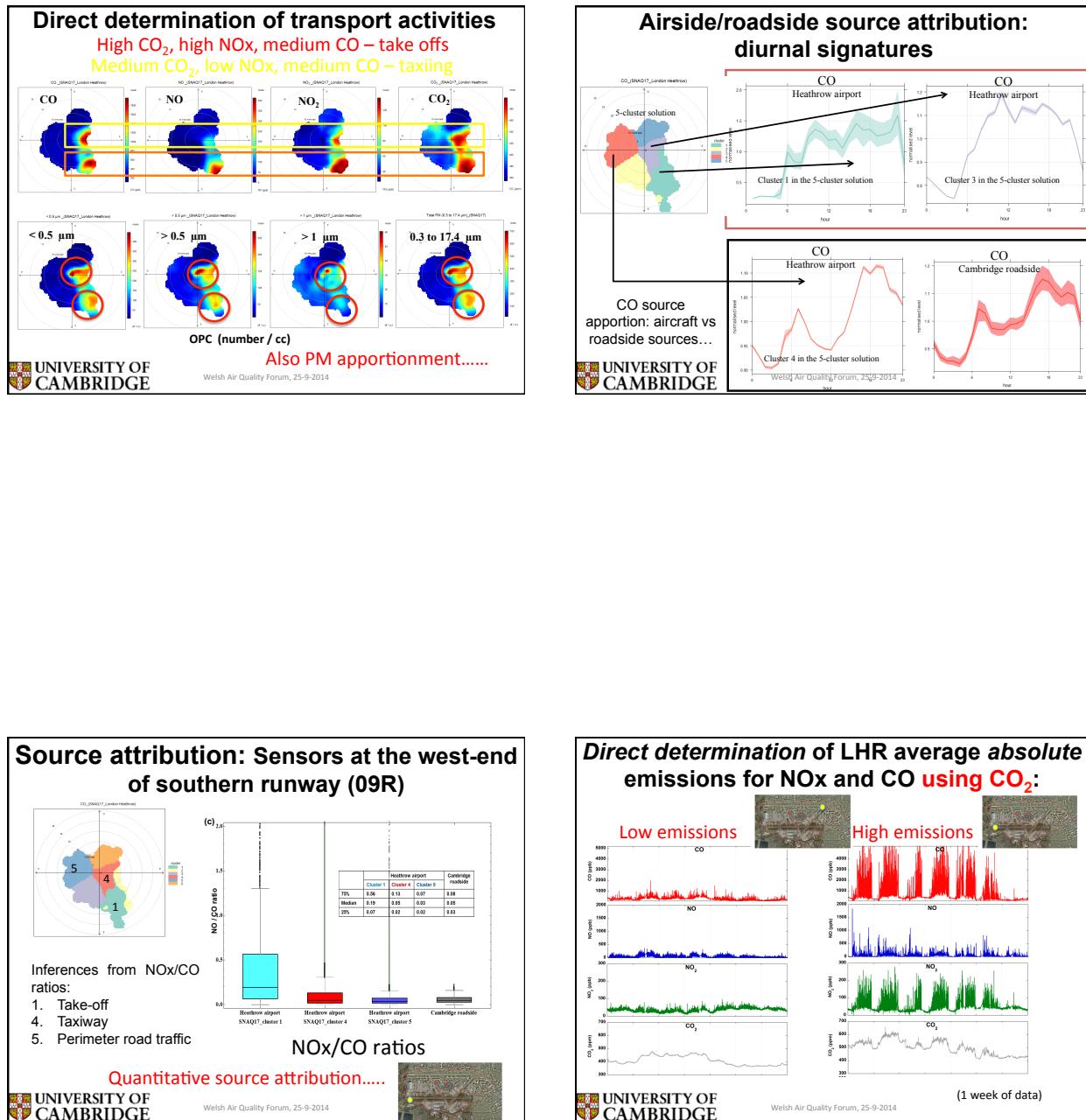


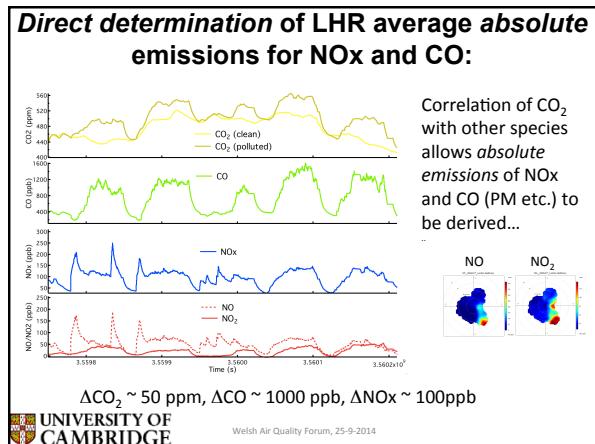












### Bottom line

- Low cost sensors/sensor networks viable for A/Q monitoring – gases, PM
- Some outstanding issues.....
- Source attribution (gas phase, PM)
- Optimised approaches for model constraint/comparison/validation
- Moving towards real time personal exposure (another story)

**Low cost sensors, sensor networks emerging as effective tools for environmental monitoring/model validation.**



Welsh Air Quality Forum, 25-9-2014

### Acknowledgements

Justin Langridge, Tony Cox and the CRDS team

Iq Mead  
Lekan Popoola, Shaun Hurst, Gregor Stewart, Vivien Bright, Ines Heimann,  
Greg Walters, (All UCAM)

John Saffell (Alphasense)

.....  
Spencer Thomas, David Vowles (HAL/BAA, BA)

Jo Dicks, Anita Harris (Cambridge City Council)

Mark Hayes, Mark Calleja  
Robin North/John Polak

Jeremy Cohen

Paul Kaye and UH team

Alastair Forbes/Martin Milton (NPL)

Paul Williams (UMAN)

David Carruthers (CERC)

.....

Funding Agencies: NERC, EPSRC



Welsh Air Quality Forum, 25-9-2014