Use of low-cost sensors and sensor networks in academic research

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Outline of Presentation

- Heathrow airport
  - source apportionment
  - direct emission index determination
  - ADMS model comparison/projection
- Cambridge AQMesh deployment
  - ‘Out of box’ performance
  - Interventions: what works?
- Cautionary tale?
  - NOx anomalies

Sensor network system at Heathrow airport (SNAQ)

- 40 sensor nodes, GPRS
- NO, NOx, CO, CO2, SO2, O3, VOCs, PM

What do results look like?

1 month of data

NOx comparison

Airport diurnal operational pattern, runway use, meteorological effects

Field comparison with reference instrument (LHR2)

Single location, multiple sensors

(- still a 'network'....)

DPC (number / cc)

© OpenAir!
Direct determination of transport activities
Medium CO₂, low NOₓ, medium CO – taxiing
High CO₂, high NOₓ, medium CO – take offs
Also PM apportionment....

Use network to separate local and non-local sources ⇒ source location

Characterisation of pollution sources
Local (single SNAQ node)
Baseline: NO₂ only (network response): easterly direction
Features
• London plume
• Road traffic diurnal profile
Pollution predominantly from long range transport (road traffic)

Observational determination of emission indices:

Projection of airport expansion impacts
2012 (total)
2012 (airport only + traffic)
2012 3rd runway (airport only)
• NO₂ near/marginally above threshold except near major roads
• Airport (related) emissions contributes small fraction outside the airport perimeter
• 3rd runway (2012 emissions) increases NO₂ by 2.4 ppb (2030 emissions marginally lower)
⇒ Non airport pollution dominates
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  - Interventions: what works?

- Cautionary tale?
  - NO₂ anomalies

Cross network performance (NO₂)
(pre-deployment)

Gradients = 0.94 ± 0.07
Intercepts = 0.34 ± 0.47ppb
R² = 0.8 ± 0.11

NO₂ Gonville Place (reference) comparison

PM₂.₅ Gonville Place (BAMS) comparison

AQMesh
ADMS
Gradient Intercept R²
AQMesh 1.05 -2.25 0.58
ADMS 0.61 6.58 0.51

Gradient Intercept R²
AQMesh 0.74 8.36 0.77
ADMS 0.64 6.65 0.50

NOₓ ADMS-AQMesh comparisons – all sites

PM ADMS-AQMesh comparisons – all sites

Model ~ captures observed spatial gradients
⇒ local (spatially heterogeneous) sources

Model ~ captures (lack of) spatial gradients
⇒ dominated by non-local sources
**PM$_{2.5}$ – all sites: variability explained**

- Variability replicated at all sites (reference, AQMesh)
- PM$_{2.5}$ dominated by non-local sources
- (NO$_2$ dominated by local sources)

⇒ NO$_2$: local intervention will work
⇒ PM: local intervention will not work

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**Anomalous NO$_2$ period…….**

Clear evidence of an air mass change….

**What can the sensor networks tell us?**

Reference network: 5 sites (chemiluminescence)

AQMesh network: 17 sites (electrochemical)

Not very scientific, but…
Gonville reference and AQMesh at the high ends of their respective networks (polluted site)…..
but no obvious shift (> 15ppb) in either methodology….

**Other similar episodes (now including O$_3$)?**

Cambridge 2017

uncannily similar…..

London 2012

(James Lee)

But…..
Other similar episodes (now including O₃)?

Cambridge 2017

London 2012

uncannily similar.....

But..... “York NOₓ” is optical NOₓ converter.....
Q: is molybdenum converter converting NOy ⇒ NOx...?

Sensors and sensor networks:

- Heathrow airport
  - Importance of network (and CO₂) for source apportionment/emission indices

- Cambridge AQMesh deployment
  - “Out of box” performance ‘good’
  - Interventions: what works locally, and what doesn’t

- Cautionary tale?
  - NO₂ anomalies: suggestive, but not proof......
  - Cautionary tale, but for whom????

Acknowledgements:

Cambridge team
CERC
Cambridge City
Cambridge County
HAL
BA
Alphasense
AQMesh
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