The 2003 Wake-up Call: Predictable?

O₃ > 100 ppb on 6 consecutive days

Estimated up to 700 extra deaths attributable to air pollution (O₃ and PM10) in UK during this period

Ozone ppbv

101 - 109
93 - 101
84 - 93
76 - 84
68 - 76
60 - 68
52 - 60
43 - 52
35 - 43

2pm, 6th Aug, 2003

Compiled from UK ozone network data

Isoprene (ppt)

Stagnant airmass flow

“Normal” airmass flow

Temperature (°C)

Isoprene c/o Ally Lewis

Thanks to M Pilling, T Kurosu, K Chance, R Martin, R Sokhi, A Lewis
Resolution of new satellite data allows study UK AQ from space

GOME NO$_2$ @ 1x1°

SCIA NO$_2$ @ 0.4x0.4°, Aug 2004

NAEI NO$_x$ emissions as NO$_2$, 2002

Data from OMI even better (not shown)

GOME and SCIA NO$_2$ c/o R. Martin

Challenges...

Length of day [hours]

Edinburgh, 56N

Denver, 40N

Cloud cover [%], ISCCP August 83-04
“Expect harmful levels of ozone and PM2.5 over the next couple of days; please keep small children and animals inside. Transatlantic pollution represents 20% of today’s UK surface ozone.”

General public only interested in pollution levels at 1.8m above surface

• Numerical Chemical Weather Prediction (NCWP): PM, O\textsubscript{3}, NO\textsubscript{x}

• Guiding AQ and Climate Policy: PM, O\textsubscript{3}, NO\textsubscript{x}?  

<table>
<thead>
<tr>
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<th>UK AQ strategy</th>
<th>EU directive</th>
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<tbody>
<tr>
<td>Annual mean stats</td>
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<tr>
<td>NO\textsubscript{2} (ann mean)</td>
<td>40 µg m\textsuperscript{-3} (21ppb)</td>
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<tr>
<td>PM\textsubscript{10} (ann mean)</td>
<td>40 µg m\textsuperscript{-3} (2004) 20 µg m\textsuperscript{-3} (2010)</td>
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<td>O\textsubscript{3} (8-hour run. mean)</td>
<td>100 µg m\textsuperscript{-3} (50ppb) as daily max by end 2005 (max exceed 10/year)</td>
<td>120 µg m\textsuperscript{-3} (60ppb) by 2010 (max exceed &lt;25 mean of 3 years)</td>
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Currently no strong commitment to PM2.5(!)

(Current instruments probably not accurate enough to monitor AQ standards)

• Some addtn science: surface fluxes, aerosol-chemistry processes, dynamics
The increasing role of BVOCs: constraints from OMI HCHO?

OMI HCHO

Relating HCHO to BVOC emissions

NO + RO₂ → NO₂ + RO, Aug 2003

c/o Jenny Stanton

0.5-1 ppb isoprene = 1-5x10^{12} molec cm^{-2} s^{-1}
(cf. SE USA 5-7x10^{12} molec cm^{-2} s^{-1})
UK PM: primary and secondary sources

- Unclear what PM characteristics affect health
- Secondary PM is formed from:
  - Oxidation of organic compounds
  - Oxidation of SO$_2$
  - Difficult to estimate in inventories – need models and data
- Liu et al. MISR work relevant?
  - Assume dominant aerosol type in column
- Also strong regional contributions to PM:
  - Saharan desert dust
  - Sea salt aerosol
  - Secondary organic PM

$$\text{MISR}_{\text{Surface}} \ PM2.5 = \ \text{Model}_{\text{Surface}} [\text{PM2.5}] \times \frac{\text{MISR AOT}}{\text{Model AOT}}$$

More formal (general) model/data melding probably necessary
Current Development in Modelling UK AQ

• UK currently using MODELS 3 (MM5 + CMAQ) for AQ

1) UM mesoscale CTM

2) Unified heterogeneous chemistry scheme

AQ-climate links

Global vs urban chemistry?
Subgrid scale processes?

• Similar equations for data assimilation and inverse modelling

\[ J(x) = \frac{1}{2}(y_o - H(x))^T(E+F)^{-1}(y_o-H(x)) + \frac{1}{2}(x-x_b)^TB^{-1}(x-x_b) \]

• Multi-species analyses – inter-species error covariance?
• Radiance versus retrieved products?
• Limit of linearization of non-linear oxidant chemistry?