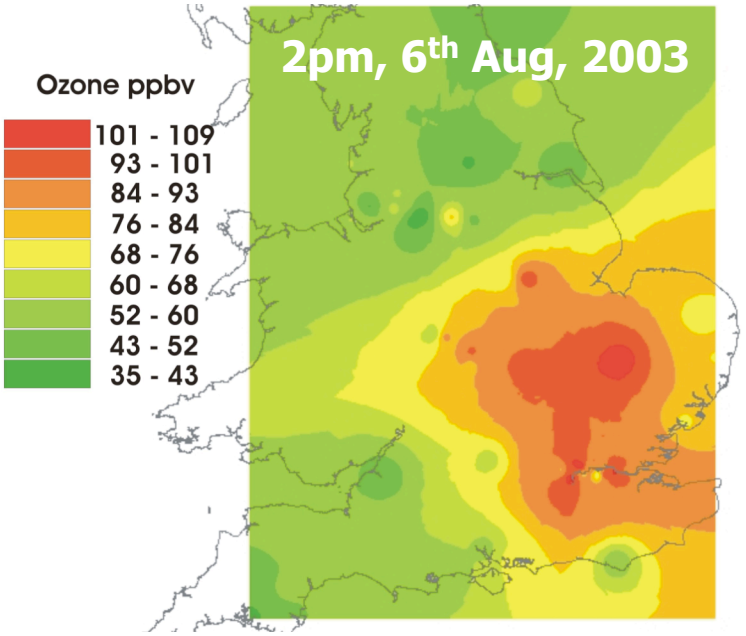
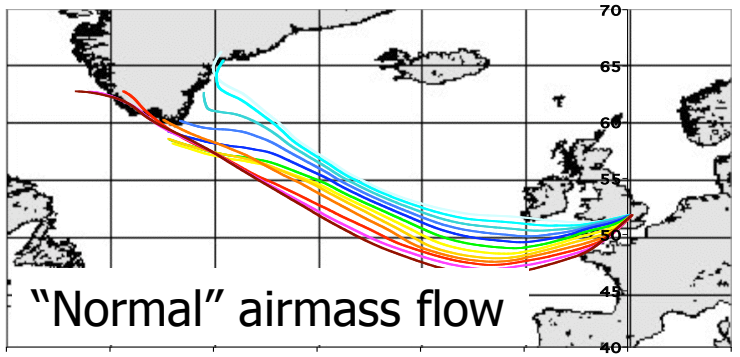
The 2003 Wake-up Call: Predictable?

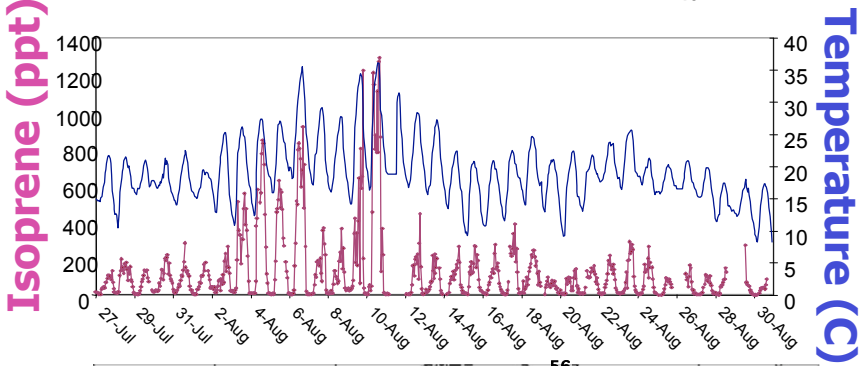
O_3 > 100 ppb on 6 consecutive days

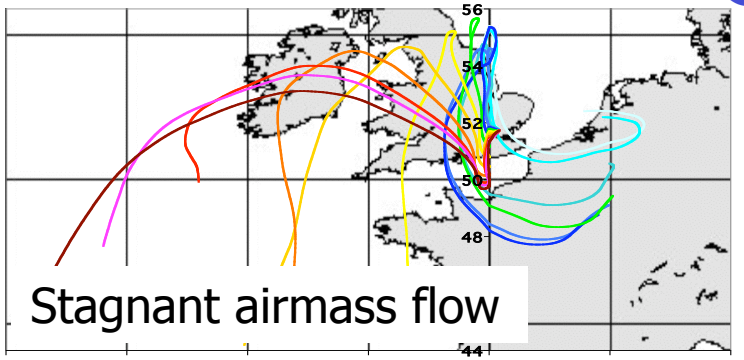
Estimated up to 700 extra deaths attributable to air pollution (O_3 and PM10) in UK during this period



Compiled from UK ozone network data



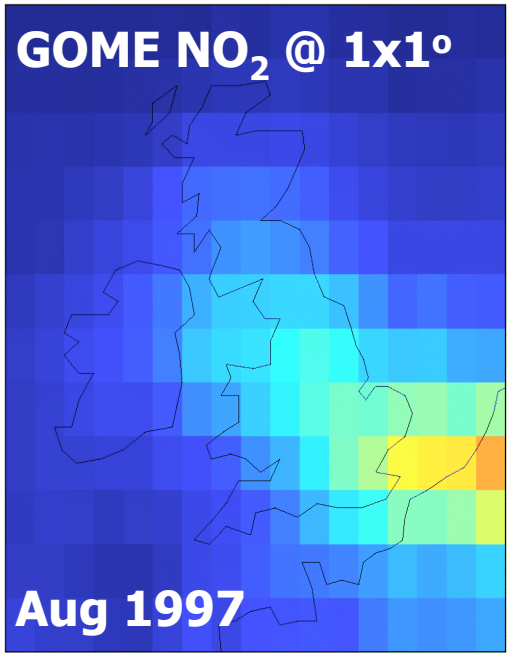


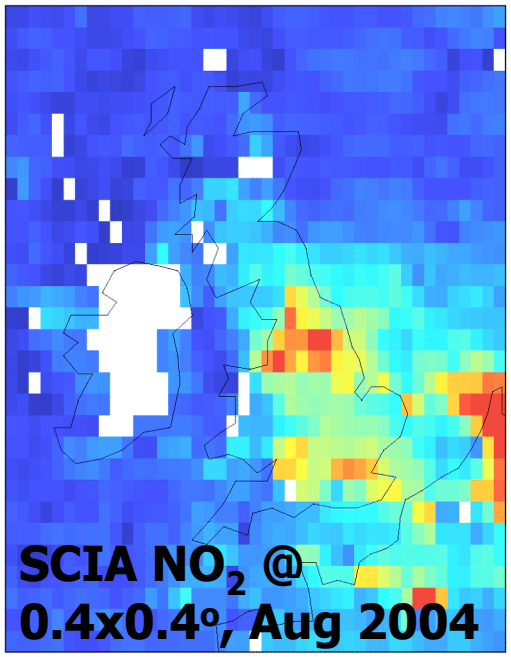


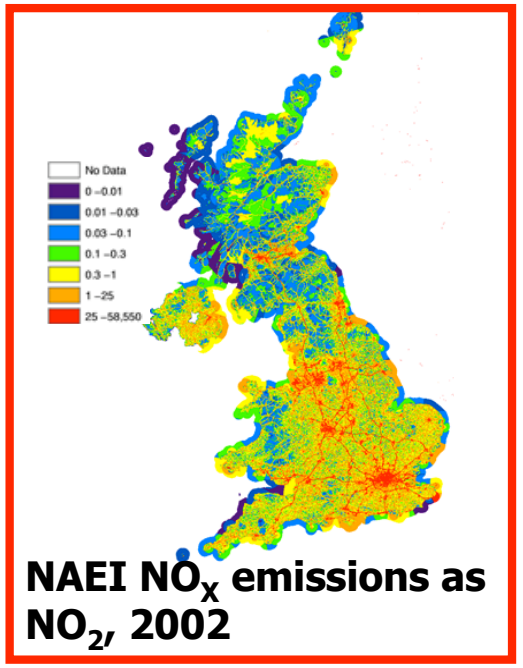
Isoprene c/o Ally Lewis

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



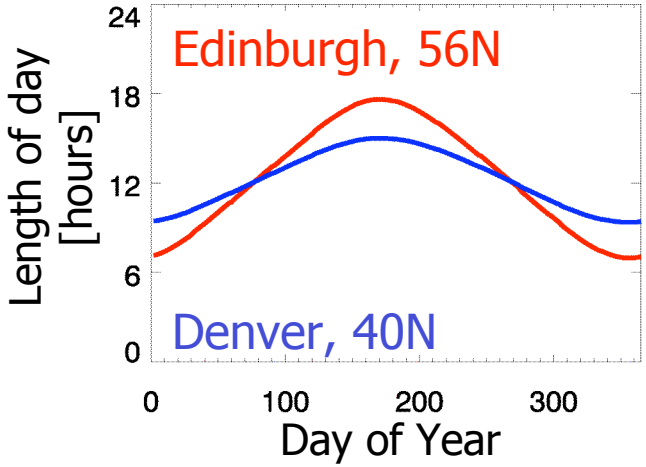


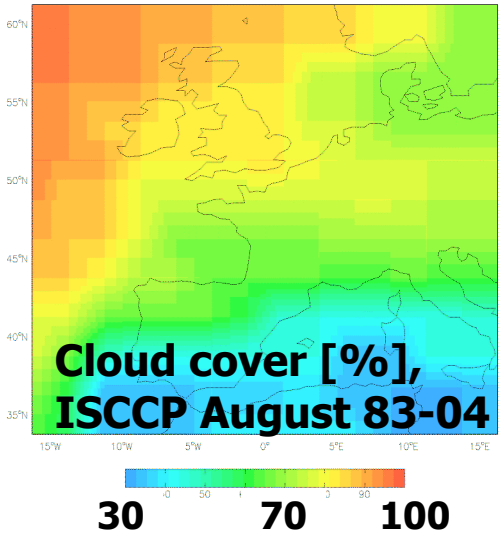


Data from OMI even better (not shown)

GOME and SCIA NO_2 c/o R. Martin

Challenges...





BBC WEATHER 2010

"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_3, NO_x
- Guiding AQ and Climate Policy: PM, O_3, NO_x?

Currently no strong commitment to PM2.5(!)

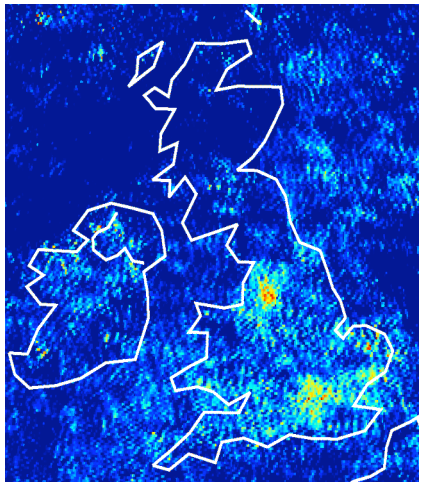
Annual mean stats	UK AQ strategy	EU directive
NO_2 (ann mean)	40 µg m^{-3} (21ppb)	
PM10 (ann mean)	40 µg m^{-3} (2004) 20 µg m^{-3} (2010)	40 µg m^{-3} (2004) 20 µg m^{-3} (2010)
O_3 (8-hour run. mean)	100 µg m^{-3} (50ppb) as daily max by end 2005 (max exceed 10/year)	120 µg m^{-3} (60ppb) by 2010 (max exceed <25 mean of 3 years)

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

- Some addtn science: surface fluxes, aerosol-chemistry processes, dynamics

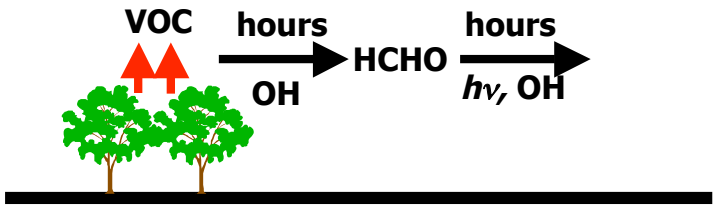
The increasing role of BVOCs: constraints from OMI HCHO?

OMI HCHO

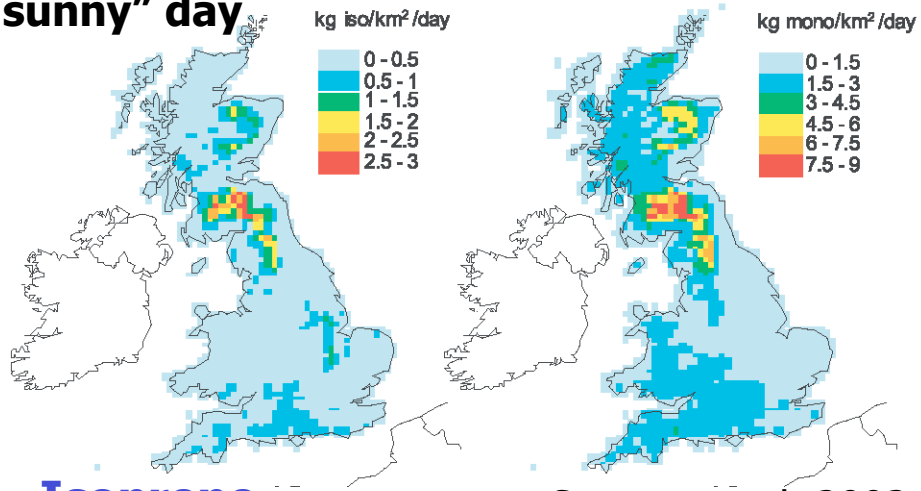


Data c/o T. Kurosu

Relating HCHO to BVOC emissions



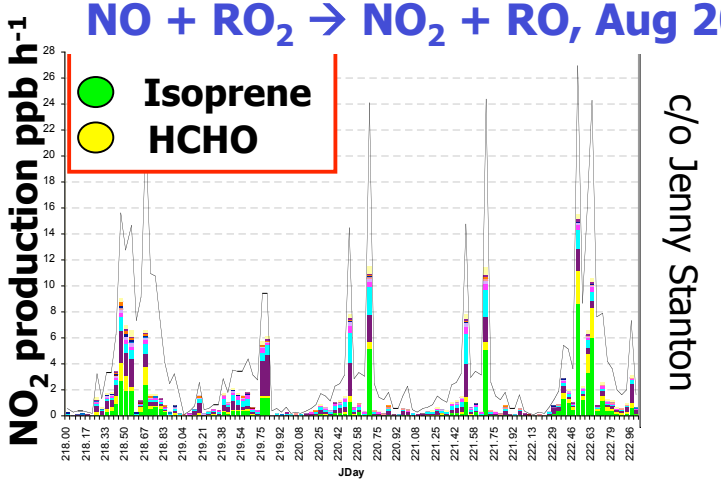
BVOC fluxes for a "hot, sunny" day



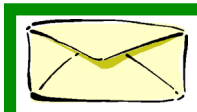
Isoprene **Monoterpenes**

Stewart et al, 2003

NO + RO_2 → NO_2 + 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})

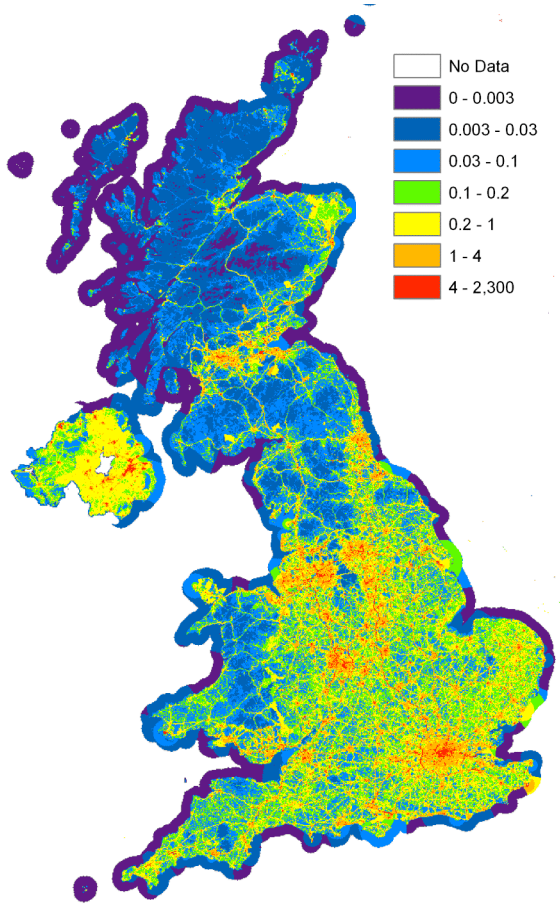
UK PM: primary and secondary sources

- 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?

$$\mathbf{MISR_{Surface}\ PM2.5 = Model_{Surface}\ [PM2.5] \times \frac{MISR\ AOT}{Model\ AOT}}$$

  - Assume dominant aerosol type in column
- Also strong regional contributions to PM:
  - **Saharan desert dust**
  - **Sea salt aerosol**
  - **Secondary organic PM**

2003 roadside PM10

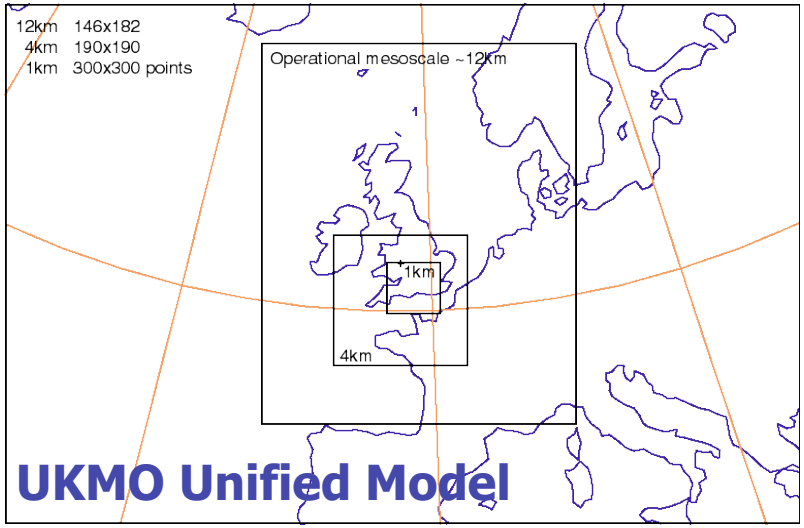


More formal (general) model/data melding probably necessary

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 Model ⟷ Chem-Clim Model

AQ-climate links

Global vs urban chemistry?
Subgrid scale processes?

Final Thoughts...

- Similar equations for data assimilation and inverse modelling

$$J(\mathbf{x}) = \tfrac{1}{2}(\mathbf{y}_o - \mathbf{H}(\mathbf{x}))^T(\mathbf{E}+\mathbf{F})^{-1}(\mathbf{y}_o-\mathbf{H}(\mathbf{x})) + \tfrac{1}{2}(\mathbf{x}-\mathbf{x}_b)^T\mathbf{B}^{-1}(\mathbf{x}-\mathbf{x}_b)$$

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