Air Pollution Monitoring in the UK

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Introduction

• Brief resumé of UK monitoring networks
• Monitoring the air pollution burden
• Impacts monitoring
  – Freshwaters
  – Terrestrial
• Enough monitoring?
Air Quality Network

- Automatic
  - >100 urban & rural sites for O3, NOx, NO2, NO, CO, SO2, pm10

- Non-automatic
  - >1100 urban sites for NO2 using diffusion tubes
  - >220 mainly urban sites for SO2 / smoke
Acid Deposition Network

- Wet deposition c.40 rural sites
- SO2 c. 50 sites
- NO2 c. 30 sites
- SO4 aerosol c.10 sites
- NH3 c. 100 sites
- Nitric acid c.12 sites
- + ECN sites for wet dep + NO2
Deposition Mapping Procedure

Wet deposition

Interpolation from site mean concentrations

Combine with rainfall data

Modify for orographic effects (empirical relationship)

Map to 5 km grid

nss SO₄
Deposition Mapping Procedure

Dry deposition NOX & SO2

Interpolation from site concentrations + Urban enhancement

Process based deposition model

5 receptor types (arable, grassland, moorland, forest & urban)

Map to 5 km grid
Deposition Mapping Procedure

Dry deposition NH3

Derived from emissions data via FRAME model
Calibration vs rural site data
Process based deposition model
5 receptor types (arable, grassland, moorland, forest & urban)
Map to 5 km grid
But....

- Relatively coarse scale resolution
- 5 ‘generic’ land cover types
- Hides considerable within square variability

SSSI boundaries
5 km grid
Point source NH3 emissions
Complex Terrain

SO$_4^{2-}$ concentration (µeq l$^{-1}$)

- Snowdon 900m (cloud): 106
- Snowdon 900m (rain): 48
- Moel Hebog 782m (cloud): 132
- Moel Hebog 782m (rain): 56
- Caernarfon 65m (rain): 46
- Llyn Llydaw 430m (rain): 34

SO$_4$ deposition (kgS / ha / year)

- Above: 17.5
- 15.0 – 17.5
- 12.5 – 15.0
- 10.0 – 12.5
- 7.5 – 10.0
- 5.0 – 7.5
- 2.5 – 5.0
- Below: 2.5

20 km x 20 km

SW - NE Transect

- Seeder cloud
- Seeder rain
- Orographic feeder cloud (scavenging of feeder cloud)
- Air flow
- Snowdon
- Craig Wen
- Moel Hebog
- Beddgelert
- Llyn Llydaw
Rural and Urban O3 Monitoring Sites

20 Rural Sites

>70 Urban Sites

20 Rural Sites >70 Urban Sites
Mapping UK Ozone Levels

- During the afternoon “well-mixed” period ozone monitoring sites measure concentrations representative of a wide geographical area:
  - interpolate the variable calculated during this well-mixed period to give a low resolution base map.

- The degree of nocturnal O$_3$ depletion at a site can be related to windspeed and the site’s altitude. Hence the “well-mixed” map is modified to account for the diurnal cycle in O$_3$ concentration:
  - apply derived altitude relationship to the well-mixed map with a 1 km x 1km scale altitude map of the UK to obtain a map of the required variable at high resolution, eg:

  \[ \text{AOT40 Wheat} = \text{AOT40 wheat well-mixed} \times (1.42 + 7.4 \times 10^{-3} \text{altitude}) \]

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### Mapping UK Ozone Levels

#### 1996 Annual Mean

- **O$_3$ concentration, ppb**
  - 0-200 m a.s.l (7 sites)
  - 200-600 m a.s.l (6 sites)
  - >= 600 m a.s.l (2 sites)

- **Hour (UTC)**
  - 0-2400

- **Windspeed, ms$^{-1}$**
  - 0-15

#### Altitude (m a.s.l.)

- **Annual average**

- \[ u = 8.6 \times 10^{-3} \text{ alt.} + 3.14, r^2 = 0.7 \]
Red areas indicate exceedance of the critical level.
The UK Acid Waters Monitoring Network

(www.ukawmn.ucl.ac.uk)
Llyn Llagi Snowdonia

The UK Acid Waters Monitoring Network

• Established 1988
• Chemistry:
  • streams – monthly
  • lakes – quarterly
• Aquatic biology
  • streams & lakes annually
Other sites

FR / EA forest sites
Acid sensitive area
10 forest sites
2 moorland sites
monthly chemistry
1992 - present

Macaulay Institute, Freshwater Fisheries Lab – Scotland
CEH Windermere – Lake District
CEH Wallingford / Bangor / EA – mid Wales
Environmental Change Network

12 Terrestrial Sites
42 Freshwater Sites
Environmental Change Network

Climate & Atmospheric deposition
Soil & soil water chemistry
Vegetation & Site management
Vertebrates & Invertebrates

Soil acidification / recovery?
Nitrogen enrichment effects?
Ozone impacts?

Soil water sampling
Vegetation at Moor House
Repeated surveys

- **Landcover**
  - Countryside Survey
  - > 250 1 km squares

- **Lichens**
  - British Lichen Soc
  - 10 km grid

- **Soils**
  - NSI – 5692 points @ 5 km grid
  - RSS – Farm based

- **Water**
  - Welsh Acid Waters Survey - 77 sites 1984 & 1995

![Graph showing mean change in pH (+1 s.e.)](image)
Enough monitoring?

- Adequate network to define broad spatial patterns & temporal changes in S & N deposition across UK

- Limitations for site-specific assessment
Enough monitoring?

- Evaluate impacts & recovery
- Verify evidence-based policy
- Validate & inform modelling
- Reveal the unexpected

Fresh waters – OK
Forest / trees – acceptable
Semi-natural veg – could do better
Soils – could do better