UK Eutrophying and Acidifying Atmospheric Pollutants Monitoring networks

UKEAP

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OBJECTIVES:
 Monitoring of concentrations and deposition of **eutrophying** and **acidifying** species in air and precipitation in rural areas of the UK with sufficient spatial and temporal resolution to allow:
  • *Evaluation of policy measures to reduce concentration and deposition*;
  • *Assessment of risks to ecosystems and exceedences of critical loads*;
  • *Estimation of secondary components of PM$_x$*.

 Provide UK input to the European Monitoring and Evaluation Programme (http://www.emep.int/)
Historic note: monitoring is not so new…

1872: Air and Rain: The Beginnings of a Chemical Climatology

59 sites

Ammonium Concentration 1869 - 1870

2011 annual average ammonium conc.
Auchencorth: 0.406 ppm
Harwell: 0.816 ppm
Policy drivers

- protocol to reduce acidification, eutrophication and ground-level ozone
- 2012: 2005-2020 emission cuts agreed:

<table>
<thead>
<tr>
<th>Gas</th>
<th>Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>NH$_3$</td>
<td>6%</td>
</tr>
<tr>
<td>SO$_2$</td>
<td>59%</td>
</tr>
<tr>
<td>NO$_x$</td>
<td>42%</td>
</tr>
<tr>
<td>VOCs</td>
<td>28%</td>
</tr>
<tr>
<td>PM</td>
<td>22%</td>
</tr>
</tbody>
</table>

National Emissions Ceilings Directive 2001/81/EC (NECD)
- 2001: National emission ceilings set for NH$_3$, SO$_2$, NO$_x$, VOCs.
- Areas with critical loads of acid depositions reduced by >50% c.f. 1990.
- Under revision.

EU Integrated Pollution Prevention and Control Directive (IPPC) 2008/1/EC
- This requires pig and poultry farms (above stated size thresholds) to reduce emissions using Best Available Techniques.

Reduction of particulate matter in the UK
- Human health effects
- Reduced atmospheric visibility
- Radiative forcing
## UKEAP: Component networks

<table>
<thead>
<tr>
<th></th>
<th>NAMN 85 sites</th>
<th>AGANet 30 sites</th>
<th>Precip-Net 39 sites</th>
<th>NO$_2$-Net 24 sites</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Method</strong></td>
<td>DELTA / ALPHA</td>
<td>DELTA</td>
<td>Bulk rain collector</td>
<td>Diffusion Tubes</td>
</tr>
<tr>
<td><strong>Resolution</strong></td>
<td>Monthly</td>
<td>Monthly</td>
<td>2-weekly (daily at 2 sites)</td>
<td>4-weekly</td>
</tr>
<tr>
<td><strong>Species</strong></td>
<td>NH$_3$, NH$_4^+$</td>
<td>HNO$_3$, SO$_2$, HCl, NO$_3^-$, SO$_4^{2-}$, Cl$^-$, Na$^+$, Ca$^{2+}$, Mg$^{2+}$</td>
<td>pH, conductivity, NH$_4^+$, NO$_3^-$, PO$_4^{3-}$, SO$_4^{2-}$, Cl$^-$, Na$^+$, K$^+$, Ca$^{2+}$, Mg$^{2+}$</td>
<td>NO$_2$</td>
</tr>
<tr>
<td><strong>Inception</strong></td>
<td>1996</td>
<td>1999</td>
<td>1985</td>
<td>1984</td>
</tr>
</tbody>
</table>
Measurement data uses

UKEAP monitoring measurements

Modelling and mapping pollutant concentrations and deposition (CBED, FRAME, PCM)

Critical Loads and levels calculations and exceedence mapping

Submitted to databases
EMEP
OSPAR
UK-Air
UK Pollutant Deposition

National assessments of the UK environment (e.g. RoTAP)

Air pollution information service
APIS
http://www.apis.ac.uk/

Local Environmental Impact Assessments

Screening tools e.g. SCAIL
http://www..scail.ceh.ac.uk/

Public access to data
Sites selected such that:
- No proximity to large scale sources
- Higher density of sites in regions where ammonia is of interest, e.g. East Anglia
- 29 sites are on NNR/LNRs or research sites
- 11 on ECN sites
- 11 on AURN sites
- 2 urban sites

NAMN

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- Higher density of sites in regions where ammonia is of interest, e.g. East Anglia
- 29 sites are on NNR/LNRs or research sites
- 11 on ECN sites
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- 2 urban sites
Sheffield Museum
Site no: 38B
NGR: SK339873
Method: ALPHA

Site Environment: Met station in urban park
Other measurement
Operator: Weston Park Museum

Gas concn (µg m⁻³)

- NH₃ (blue)
- HNO₃ (pink)
- SO₂ (green)
- HCl (cyan)

Time span: Sep-96 to Sep-11
Annual cycles in \( \text{NH}_3 \)

**NH\(_3\) temporal trends**

![NH\(_3\) temporal trends graph](image)

**NH\(_4^+\) temporal trends**

![NH\(_4^+\) temporal trends graph](image)
NAMN: Time series

<table>
<thead>
<tr>
<th>% Change 2010/1998</th>
<th>CATTLE</th>
<th>PIG &amp; POULTRY</th>
<th>BACKGROUND</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAEI</td>
<td>-9.3 %</td>
<td>-42.5 %</td>
<td>-</td>
</tr>
<tr>
<td>NAMN</td>
<td>+38.5 %</td>
<td>-38.5 %</td>
<td>+ 152 %</td>
</tr>
</tbody>
</table>
Acid gases and Aerosol Network (AGA-Net)

Sites selected such that:
- Co-located with NAMN sites
- Sufficient coverage across UK to allow kriging of data
- 2 urban sites

1. Basic filter
   NO₃, NO₂, SO₄, Cl, Na, Ca, Mg

2. Acid filter
   NH₄
DELTA System

Current Design

1. Basic filter
   NO3, NO2, SO4, Cl, Na, Ca, Mg

2. Acid filter
   NH4

New DELTA system

1. Basic filter
   NO3, NO2, SO4, Cl, Na, Ca, Mg

2. Acid filter
   NH4

DH2

DA1

DA2

DH1

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL
AGANet: UK Sulphur changes

UK SO$_2$ emissions and targets: 1970 – 2010

Precip-Net

Sites selection (before my time!)
- driven by acid rain issues of the 1980s
- UK coverage for mapping purposes
Wardlow Hay Cop

2011

Site Code: 5120
Easting: 4177
Northing: 3739
Latitude: 53 55 41 N
Longitude: 01 44 05 W
Altitude (m): 350
Rainfall (mm): 811

Site Environment:
Open moorland

Other measurements:
DT, Met

Site Operator:
Natural England

Precipitation weighted mean concentrations

Deposition meq m\(^{-2}\)

Rainfall (mm)

Hydrogen ion
Non-sea salt sulphate
Ammonium
Nitrate

Long-term trends in concentration
(+x = increase; -x = decrease)

Hydrogen ion
-1.55 ueq/l (-4.05 %/year): 25 years' data
+++++ Very strong trend detected

Non-marine sulphate
-2.77 ueq/l (-3.12 %/year): 26 years' data
+++++ Very strong trend detected

Nitrate
-0.33 ueq/l (-0.98 %/year): 26 years' data
+ Significant trend detected

Ammonium
-0.16 ueq/l (-0.38 %/year): 26 years' data
- No significant trend detected
<table>
<thead>
<tr>
<th>Site Name</th>
<th>2011 Concentrations</th>
<th>Data capture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allt a'Mharcaidh</td>
<td>1.55</td>
<td>100%</td>
</tr>
<tr>
<td>Balquhidder 2</td>
<td>2.63</td>
<td>97%</td>
</tr>
<tr>
<td>Bannisdale</td>
<td>4.73</td>
<td>100%</td>
</tr>
<tr>
<td>Barcombe Mills</td>
<td>10.7</td>
<td>100%</td>
</tr>
<tr>
<td>Driby 2</td>
<td>11.6</td>
<td>100%</td>
</tr>
<tr>
<td>Eskdalemuir^T</td>
<td>3.49</td>
<td>100%</td>
</tr>
<tr>
<td>Flatford Mill</td>
<td>12.4</td>
<td>99%</td>
</tr>
<tr>
<td>Forsinain 2/Halladale</td>
<td>2.07</td>
<td>92%</td>
</tr>
<tr>
<td>Glensaugh</td>
<td>3.42</td>
<td>100%</td>
</tr>
<tr>
<td>Goonhilly</td>
<td>4.56</td>
<td>99%</td>
</tr>
<tr>
<td>Harwell^T</td>
<td>12.2</td>
<td>100%</td>
</tr>
<tr>
<td>High Muffles</td>
<td>7.73</td>
<td>100%</td>
</tr>
<tr>
<td>Hillsborough Forest</td>
<td>7.39</td>
<td>100%</td>
</tr>
<tr>
<td>Llyn Llydaw</td>
<td>3.07</td>
<td>100%</td>
</tr>
<tr>
<td>Loch Dee</td>
<td>3.75</td>
<td>75%</td>
</tr>
<tr>
<td>Lough Navar</td>
<td>2.07</td>
<td>100%</td>
</tr>
<tr>
<td>Moorhouse</td>
<td>4.8</td>
<td>100%</td>
</tr>
<tr>
<td>Percy's Cross</td>
<td>5.23</td>
<td>92%</td>
</tr>
<tr>
<td>Polloch</td>
<td>1.42</td>
<td>100%</td>
</tr>
<tr>
<td>Pumplumon</td>
<td>4.2</td>
<td>100%</td>
</tr>
<tr>
<td>Strathvaich Dam</td>
<td>1.19</td>
<td>100%</td>
</tr>
<tr>
<td>Tycanol Wood</td>
<td>3.52</td>
<td>96%</td>
</tr>
<tr>
<td>Whiteadder</td>
<td>3.62</td>
<td>100%</td>
</tr>
<tr>
<td>Yarner Wood^T</td>
<td>4.93</td>
<td>100%</td>
</tr>
</tbody>
</table>
Measurement data uses

- UKEAP monitoring measurements
- Modelling and mapping pollutant concentrations and deposition
- Critical Loads and exceedence mapping
- National Assessments of the UK environment (e.g. RoTAP)
- Submitted to databases:
  - EMEP
  - OSPAR
  - UK-Air
  - UK Pollutant Deposition
- Public access to data:
  - http://pollutantdeposition.defra.gov.uk/
  - http://uk-air.defra.gov.uk
  - http://www.ceh.ac.uk/sci_programmes/UKEAP-Project.html
  - http://uk-air.defra.gov.uk/research/air-quality-modelling

- Air pollution information service (APIS)
  - http://www.apis.ac.uk/
- Screening tools (e.g. SCAIL)
  - http://www.scail.ceh.ac.uk/
- Local Environmental Impact Assessments
Where to get UKEAP data....

http://uk-air.defra.gov.uk

http://pollutantdeposition.defra.gov.uk/

http://www.ceh.ac.uk/sci_programmes/UKEAP-Project.html

http://cldm.defra.gov.uk/index.htm

http://uk-air.defra.gov.uk/research/air-quality-modelling

Email: ukeap@ceh.ac.uk
313 sites

- Acidifying and eutrophying pollutants
- Particulate matter
- Ground-level ozone
- Heavy metals
- Volatile organic compounds
- Persistent organic pollutants

31 UK Sites

Located in areas thought to have “minimal local emissions”
<table>
<thead>
<tr>
<th>Measurement</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water-soluble gases + particles at PM2.5 &amp; PM10</td>
<td>MARGA</td>
</tr>
<tr>
<td>Black carbon PM2.5</td>
<td>Aethalometer</td>
</tr>
<tr>
<td>NO/NO2</td>
<td>Photolytic converter</td>
</tr>
<tr>
<td>Meteorology (wind speed, dir’n., temp., RH, precip’n)</td>
<td>Automated met station</td>
</tr>
<tr>
<td>Ozone</td>
<td>UV photometer</td>
</tr>
<tr>
<td>PM2.5 and PM10 mass (daily)</td>
<td>Filter (gravimetric)</td>
</tr>
<tr>
<td>PM2.5 and PM10 mass (hourly)</td>
<td>TEOM/FDMS</td>
</tr>
<tr>
<td>PAH (vapour and particle)</td>
<td>Digitel hi-vol</td>
</tr>
<tr>
<td>PAH (precipitation)</td>
<td>Bulk sampler</td>
</tr>
<tr>
<td>TOMPS (air)</td>
<td>Hi-vol</td>
</tr>
<tr>
<td>Hydrocarbons (C₂ – C₈)</td>
<td>Online GC-FID</td>
</tr>
<tr>
<td>Particle size and number</td>
<td>SMPS</td>
</tr>
<tr>
<td>Mercury (elemental) in air</td>
<td>CVAF</td>
</tr>
<tr>
<td>Mercury (speciated) in air</td>
<td>CVAF</td>
</tr>
<tr>
<td>Mercury (precipitation)</td>
<td>CVAF</td>
</tr>
<tr>
<td>Heavy metals PM10 (air)</td>
<td>ICP-MS</td>
</tr>
<tr>
<td>Heavy metals (precip’n)</td>
<td>ICP-MS</td>
</tr>
<tr>
<td>Ozone, NOx, SO₂ fluxes</td>
<td>Automated analyzers</td>
</tr>
<tr>
<td>Trace gas fluxes</td>
<td>CoTAG</td>
</tr>
<tr>
<td>ECOC (weekly)</td>
<td>Filter</td>
</tr>
</tbody>
</table>

http://pollutantdeposition.defra.gov.uk/emep
Summary

- UKEAP measurements underpin the capability to understand changes in rural air quality across the UK;
- It should be possible for significant future UK mitigation, emissions reductions and ecosystem exposure to be observed;
- S deposition is a driver of the acidifying input for sensitive catchments and to critical load exceedance and has been most important historically;
- Inputs of NH$_x$ are the dominant driver of ecological effects of deposited N, and the importance of NH$_x$ is predicted to increase relative to oxidised N, as NO$_x$ emissions decrease further.
Acknowledgements

Defra for funding the UKEAP network
UKEAP Local Site Operators
CEH colleagues
Supporting funds from NERC

http://pollutantdeposition.defra.gov.uk/ukeap
http://uk-air.defra.gov.uk
http://www.rotap.ceh.ac.uk/home

UKEAP LSO and Stakeholder Meeting,
CEH Lancaster
10 -11th October 2013
Includes tour of CEH Laboratories! 😊