

# UK Eutrophying and Acidifying Atmospheric Pollutants Monitoring networks

## UKEAP

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# UK Eutrophying & Acidifying atmospheric Pollutants (UKEAP)

## OBJECTIVES:

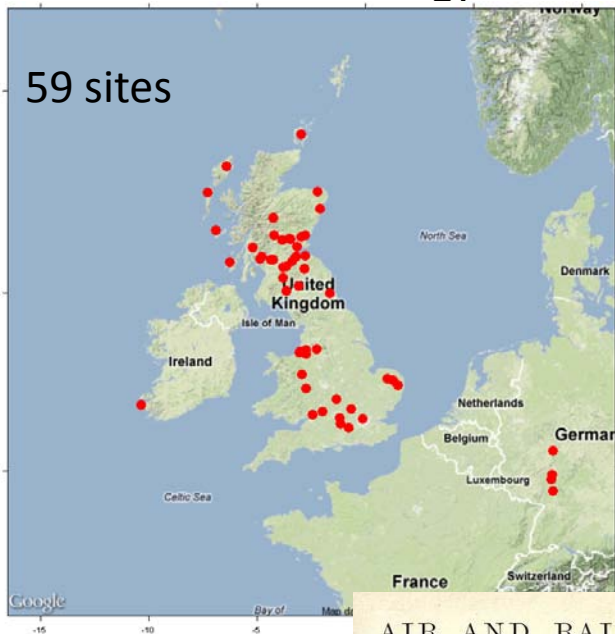
➤ Monitoring of concentrations and deposition of **eutrophying** and **acidifying** species in air and precipitation in rural areas of the UK with sufficient spatial and temporal resolution to allow:

- *Evaluation of policy measures to reduce concentration and deposition;*
- *Assessment of risks to ecosystems and exceedences of critical loads;*
- *Estimation of secondary components of  $PM_x$ .*

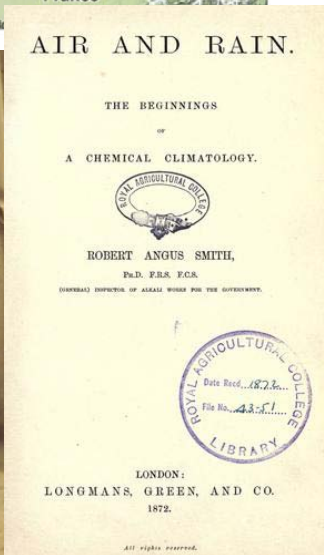
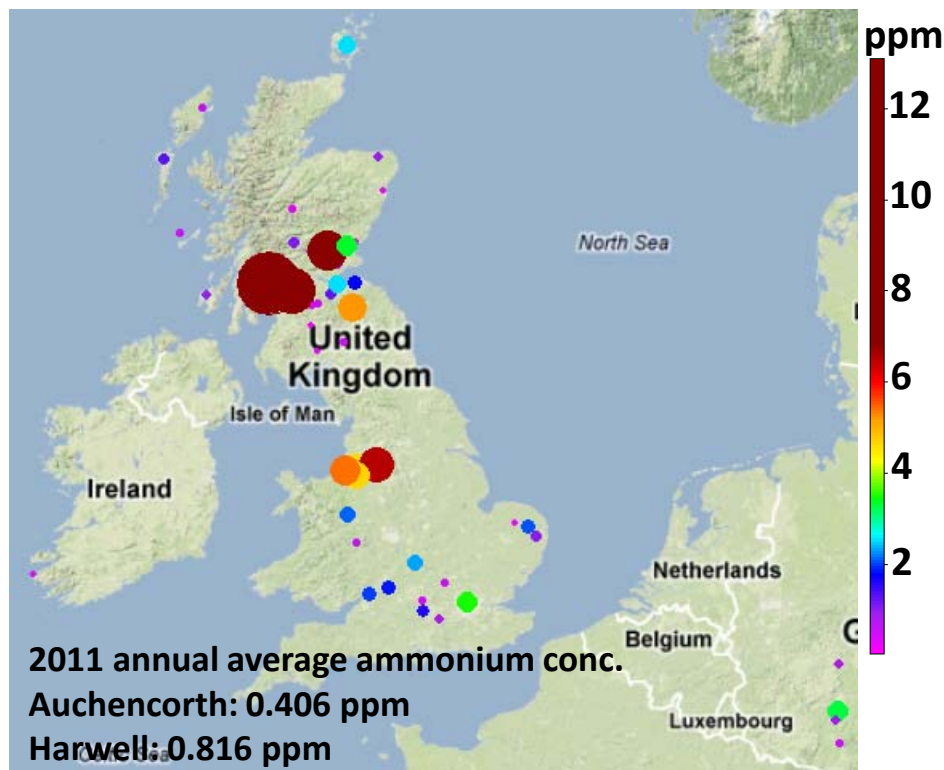
➤ Provide UK input to the European Monitoring and Evaluation Programme (<http://www.emep.int/>)

# Historic note: monitoring is not so new...

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



Ammonium Concentration 1869 - 1870



THE UNIVERSITY of EDINBURGH



# Policy drivers

## UNECE Gothenburg Protocol: 1999, revised 2012

- protocol to reduce acidification, eutrophication and ground-level ozone
- 1999: 2010 Emission ceilings set for NH<sub>3</sub>, SO<sub>2</sub>, NO<sub>x</sub>, O<sub>3</sub>.
- 2012: 2005-2020 emission cuts agreed:

NH<sub>3</sub>: 6%

SO<sub>2</sub>: 59%

NO<sub>x</sub>: 42%

VOCs: 28%

PM: 22%.

## National Emissions Ceilings Directive 2001/81/EC (NECD)

- 2001: National emission ceilings set for NH<sub>3</sub>, SO<sub>2</sub>, NO<sub>x</sub>, 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 Networks

NAMN

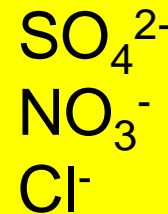
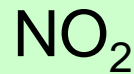
AGANet

NO<sub>2</sub>-net

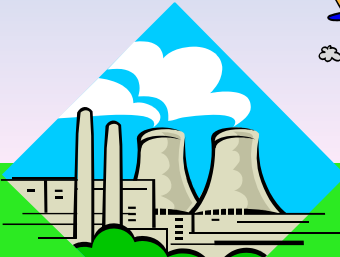
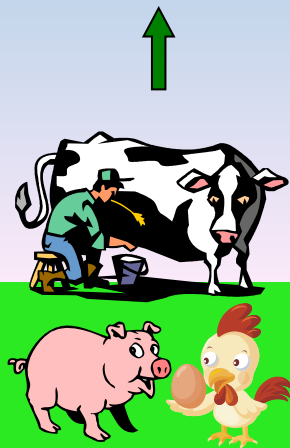
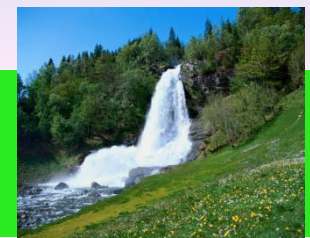
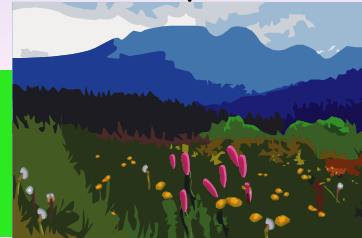
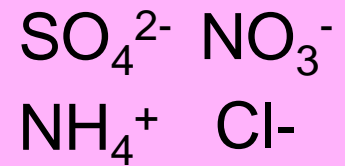
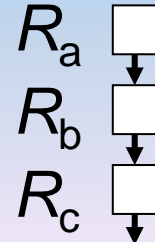
Precip-net

Particles

Wet Deposition



Dry Deposition



# UKEAP: Component networks

## NAMN 85 sites



NAMN  
● DELTA  
● ALPHA  
● Both



ALPHA

## AGANet 30 sites



AGANet  
● AGA



## Precip-Net 39 sites



Precip-Net  
● Bulk rain sites  
● Daily wet-only



## NO<sub>2</sub>-Net 24 sites



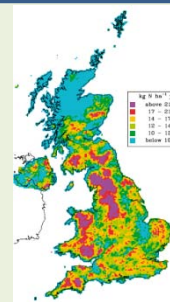
NO<sub>2</sub>-Net  
● NO<sub>2</sub> Diffusion Tube Sites



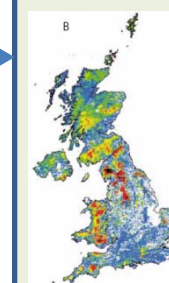
	NAMN	AGANet	Precip-Net	NO <sub>2</sub> -Net
Method	DELTA / ALPHA	DELTA	Bulk rain collector	Diffusion Tubes
Resolution	Monthly	Monthly	2-weekly (daily at 2 sites)	4-weekly
Species	NH <sub>3</sub> NH <sub>4</sub> <sup>+</sup>	HNO <sub>3</sub> , SO <sub>2</sub> , HCl, NO <sub>3</sub> <sup>-</sup> , SO <sub>4</sub> <sup>2-</sup> , Cl <sup>-</sup> , Na <sup>+</sup> , Ca <sup>2+</sup> , Mg <sup>2+</sup>	pH, conductivity, NH <sub>4</sub> <sup>+</sup> , NO <sub>3</sub> <sup>-</sup> , PO <sub>4</sub> <sup>3-</sup> , SO <sub>4</sub> <sup>2-</sup> , Cl <sup>-</sup> , Na <sup>+</sup> , K <sup>+</sup> , Ca <sup>2+</sup> , Mg <sup>2+</sup>	NO <sub>2</sub>
Inception	1996	1999	1985	1984

# Measurement data uses

UKEAP monitoring measurements



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

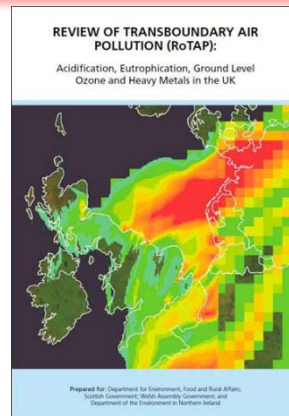


Critical Loads and levels calculations and exceedence mapping

Submitted to databases

EMEP  
OSPAR  
UK-Air  
UK Pollutant Deposition

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



Public access to data

Air pollution information service  
APIS



<http://www.apis.ac.uk/>

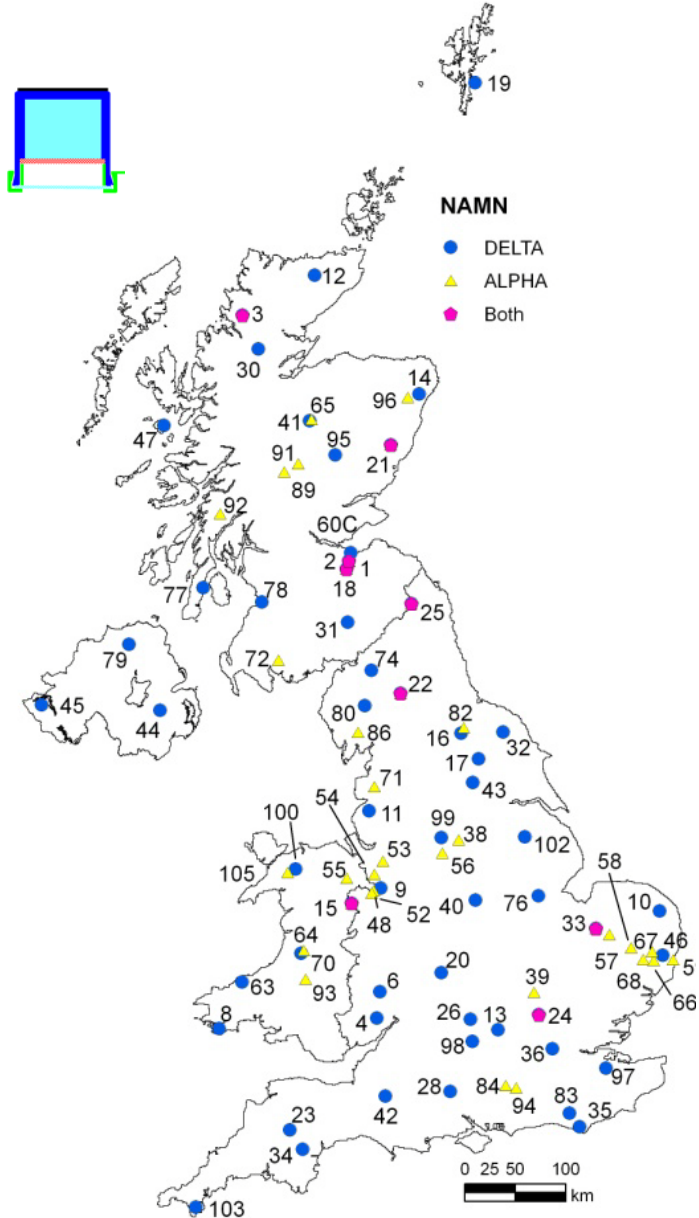
Local Environmental Impact Assessments

Screening tools  
e.g. SCAIL



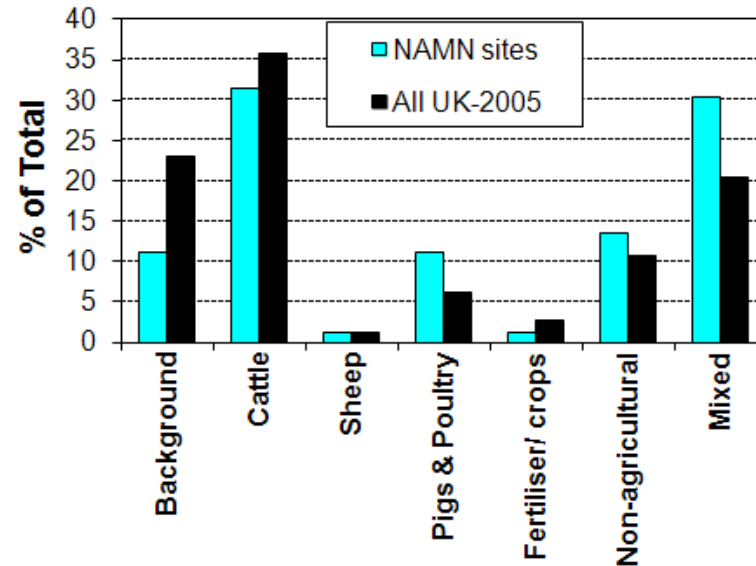
<http://www..scail.ceh.ac.uk/>

# National ammonia monitoring network NAMN



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

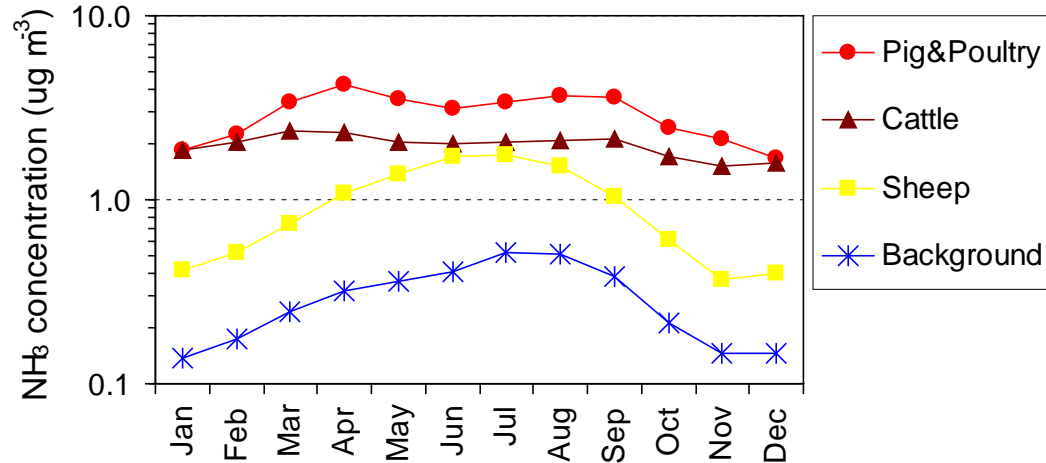




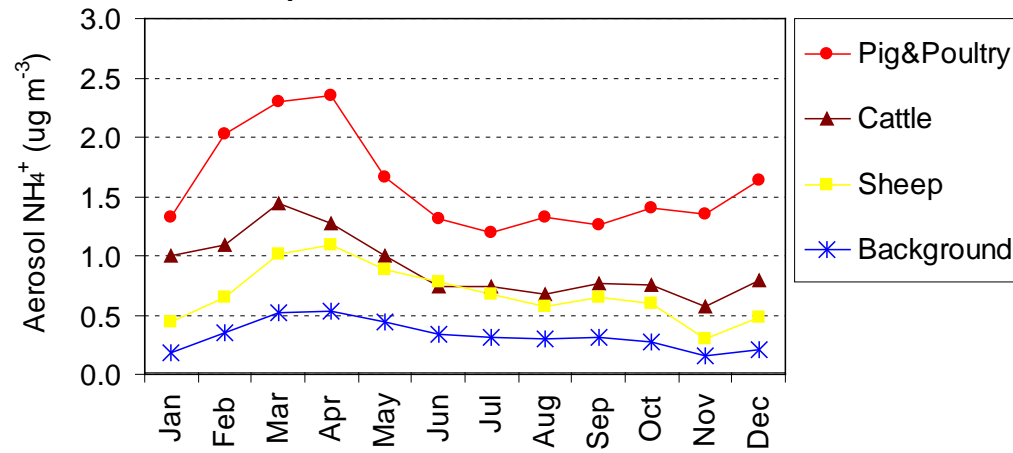


# Annual cycles in NH<sub>3</sub>

## NH<sub>3</sub> temporal trends

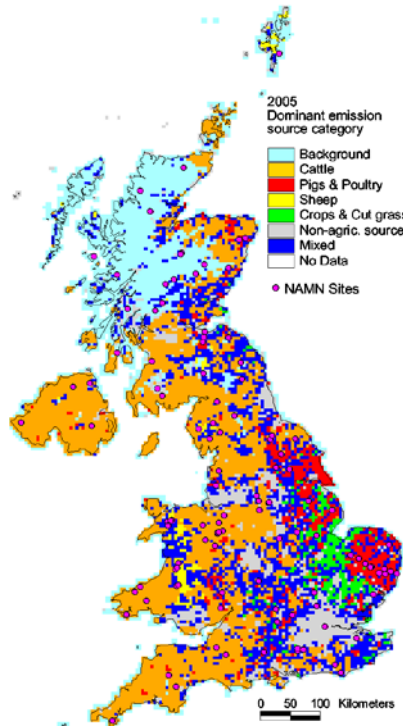


## NH<sub>4</sub><sup>+</sup> temporal trends

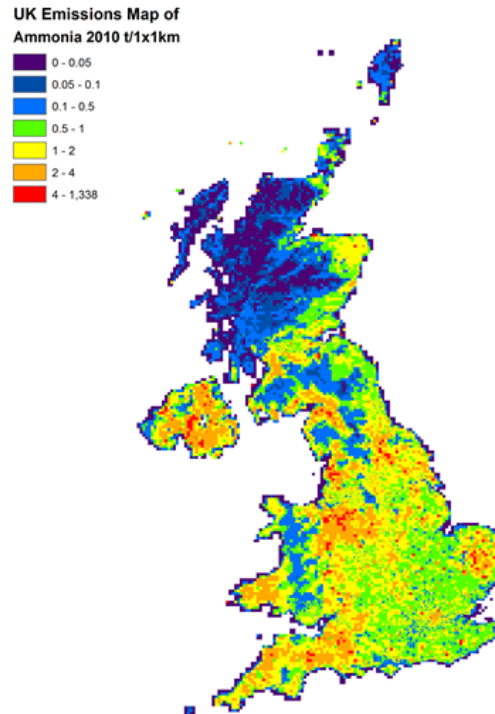


# NAMN: UK Mapping

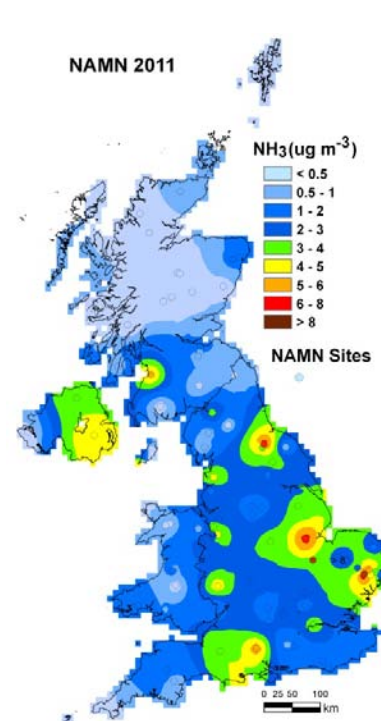
## NH<sub>3</sub> Emission Source Category Map



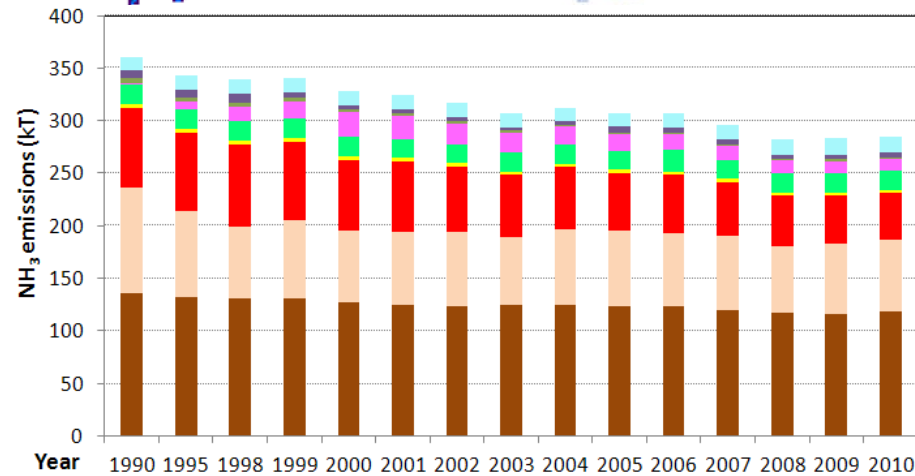
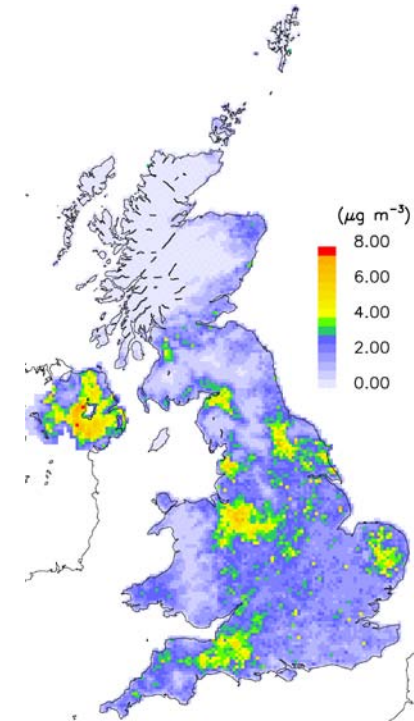
## NH<sub>3</sub> Emissions Map



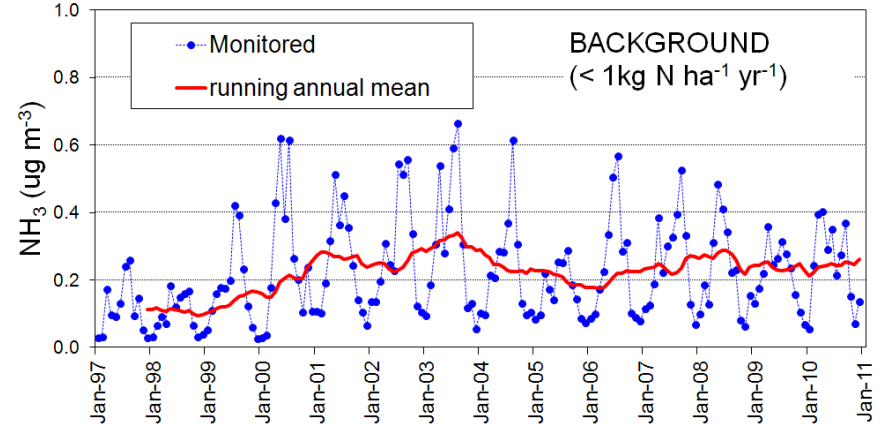
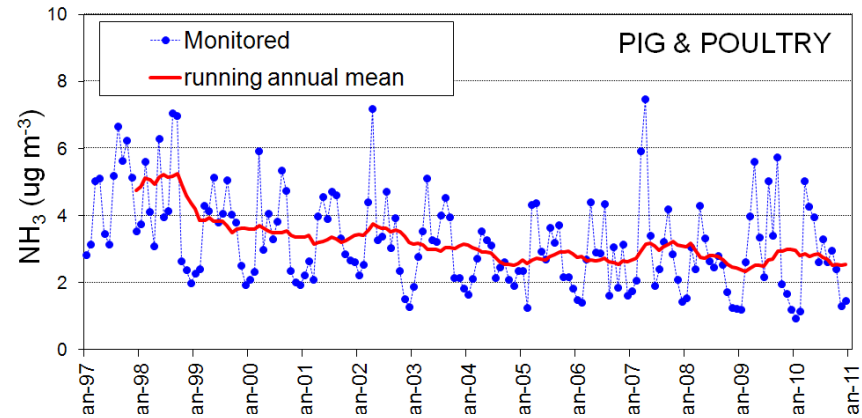
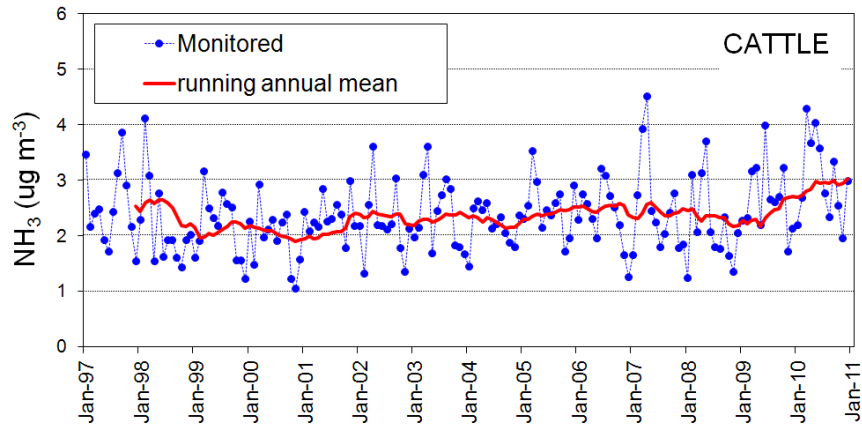
## NAMN 2011



## FRAME

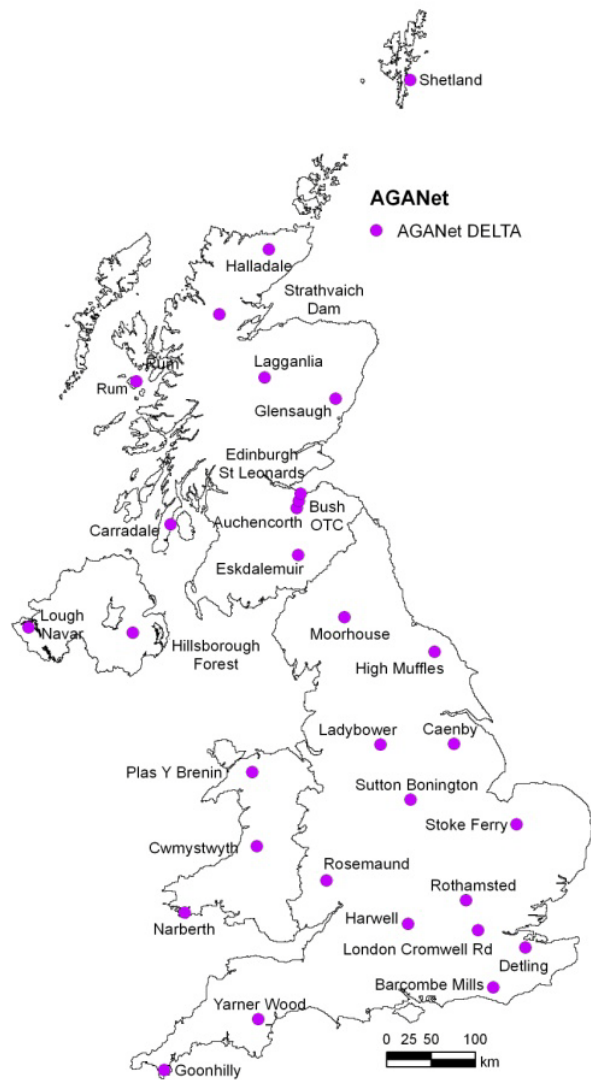


# NAMN: Time series



% Change 2010/1998	CATTLE	PIG & POULTRY	BACKGROUND
NAEI	-9.3 %	-42.5 %	-
NAMN	+38.5 %	-38.5 %	+ 152 %

# 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

DH2

DA1

DA2

DH1



**1. Basic filter**  
NO<sub>3</sub>, NO<sub>2</sub>, SO<sub>4</sub>,  
Cl, Na, Ca, Mg

**2. Acid filter**  
NH<sub>4</sub>

# DELTA System

## New DELTA system

### Current Design



DH2

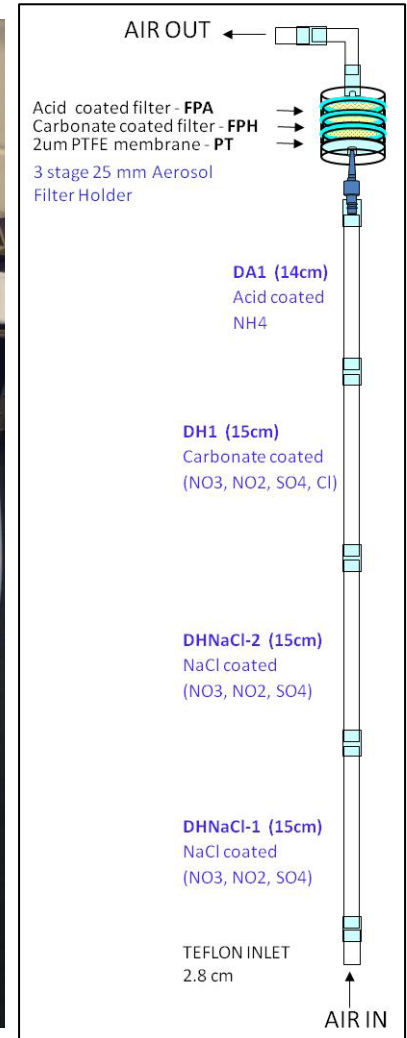
DA1

DA2

DH1

**1. Basic filter**  
NO<sub>3</sub>, NO<sub>2</sub>, SO<sub>4</sub>,  
Cl, Na, Ca, Mg

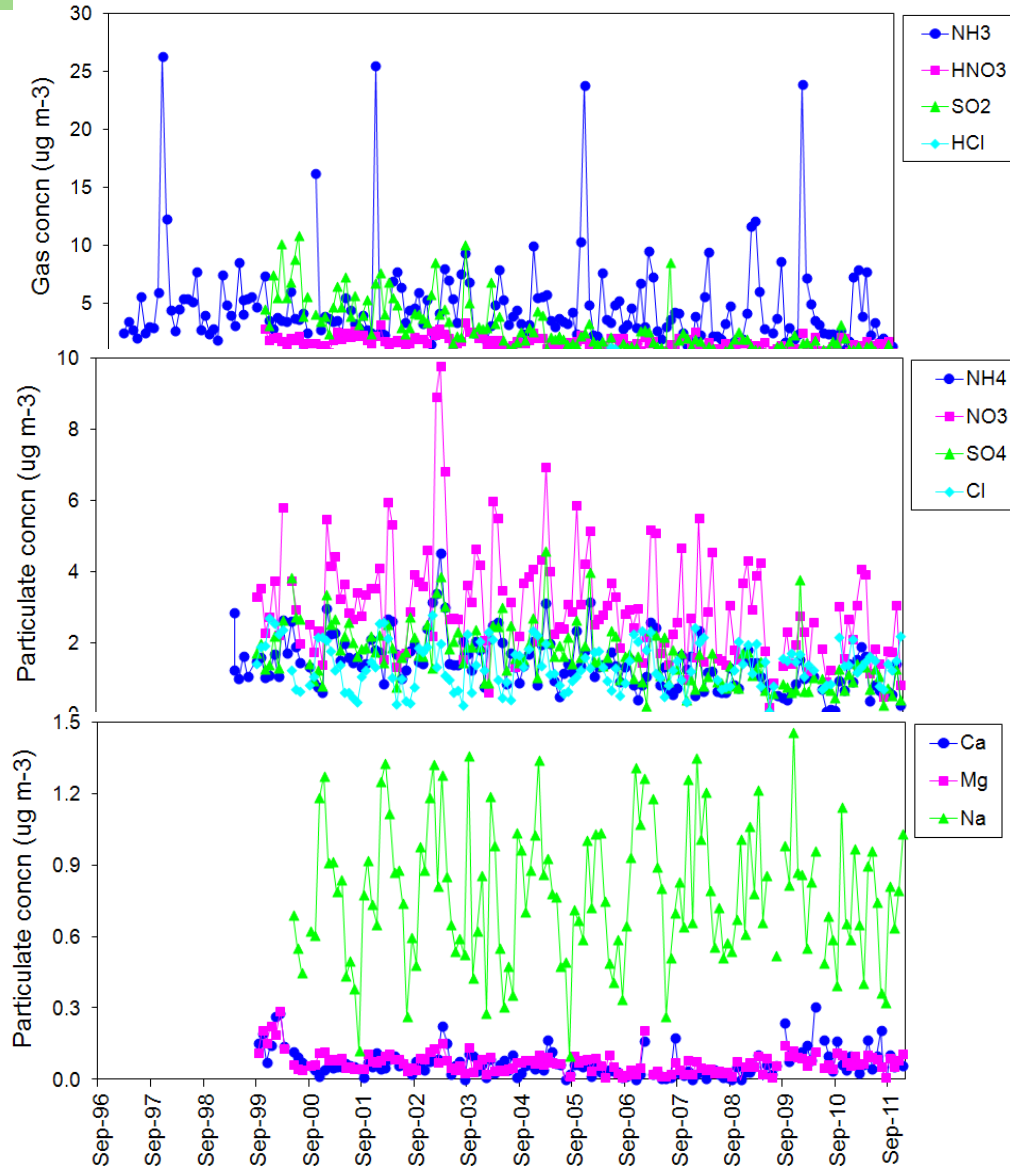
**2. Acid filter**  
NH<sub>4</sub>



### Sutton Bonington

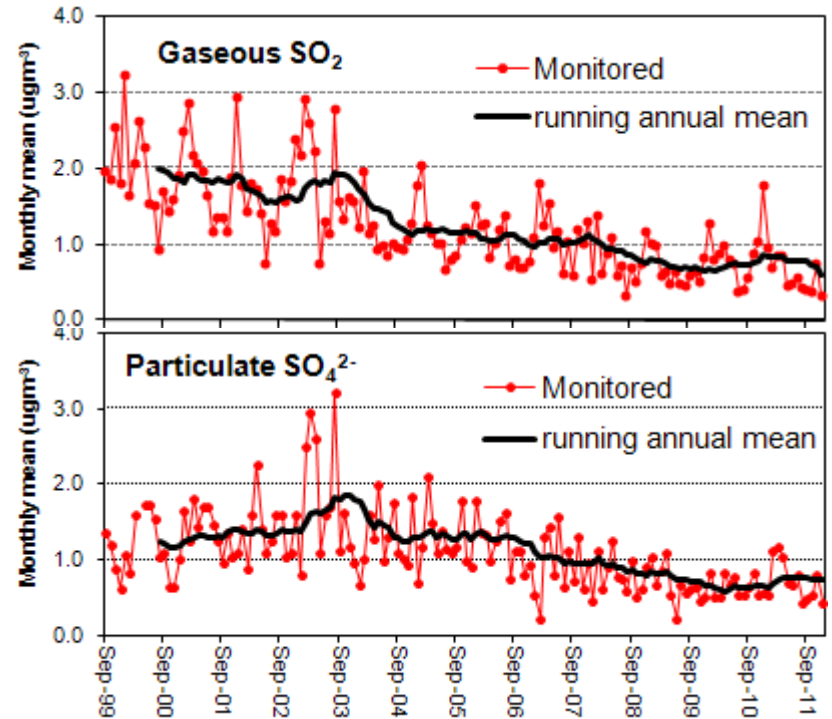
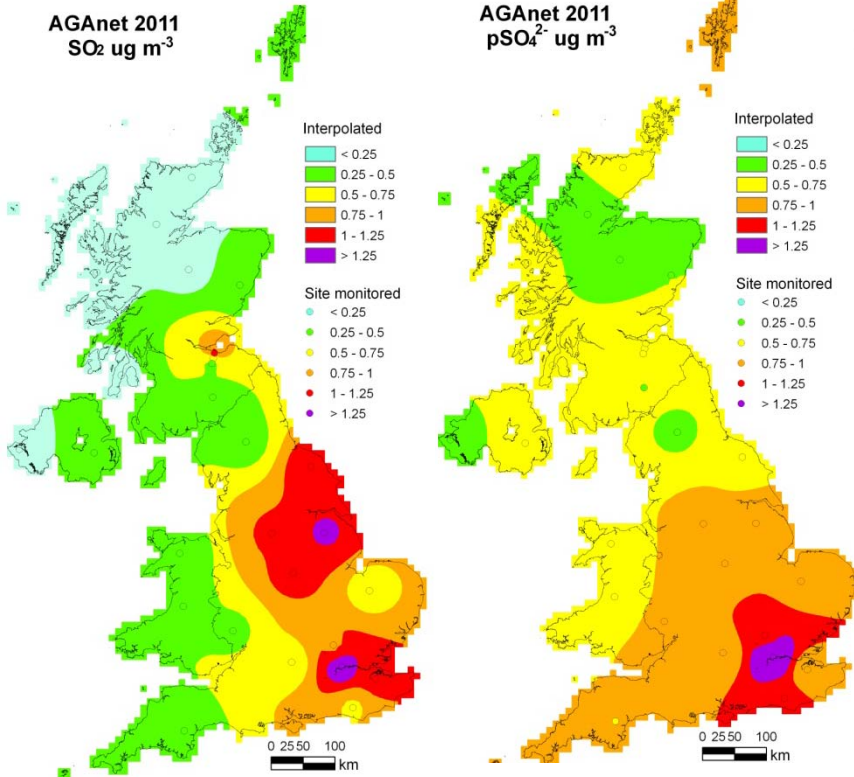
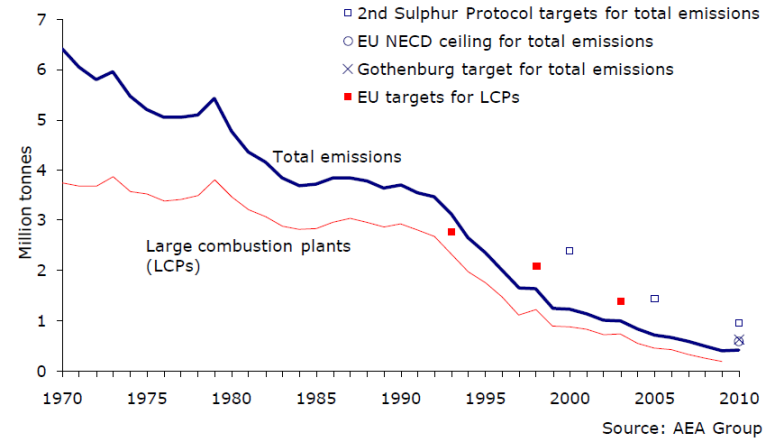
Site no: 40  
NGR: SK505268  
Method: DELTA

Site Environment: Agricultural field; dairy farm in vicinity  
Other measurement:  
Site Operator: Nottingham University



# AGANet: UK Sulphur changes

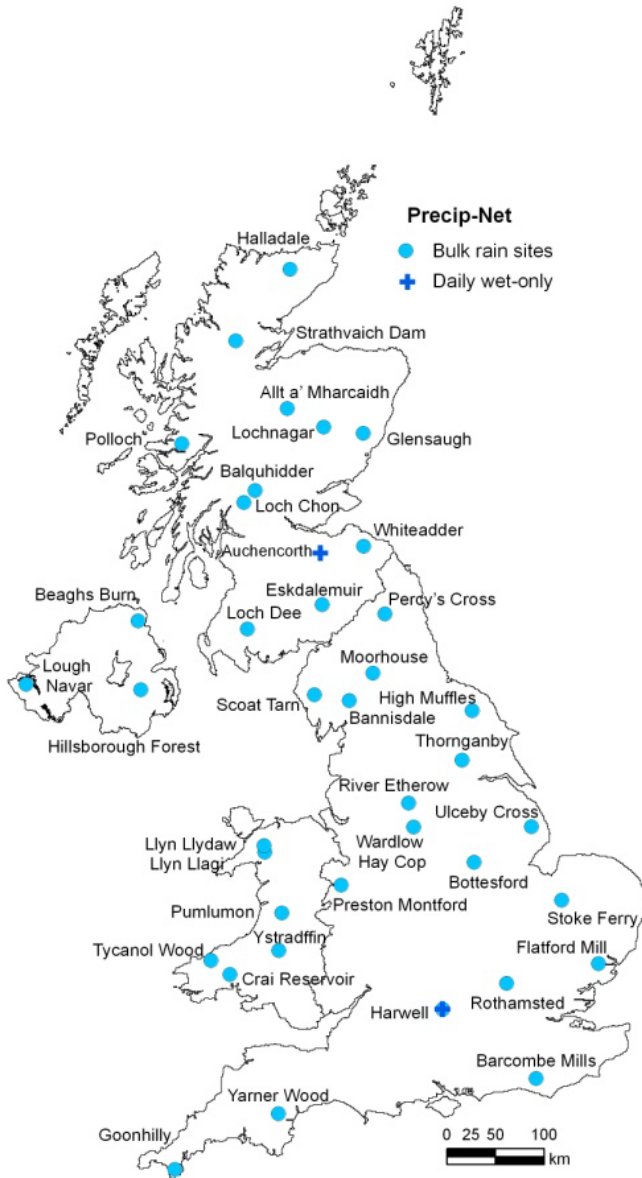
## UK SO<sub>2</sub> emissions and targets: 1970 – 2010



Source: Defra National Statistics Release: Emissions of air pollutants in the UK, 1970 to 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:  
 Longitude: 53 55 41 N  
 Altitude (m): 01 44 05 W  
 Rainfall (mm): 350  
 811

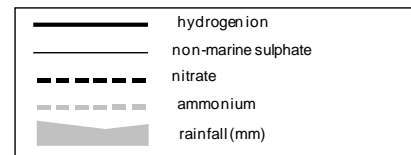
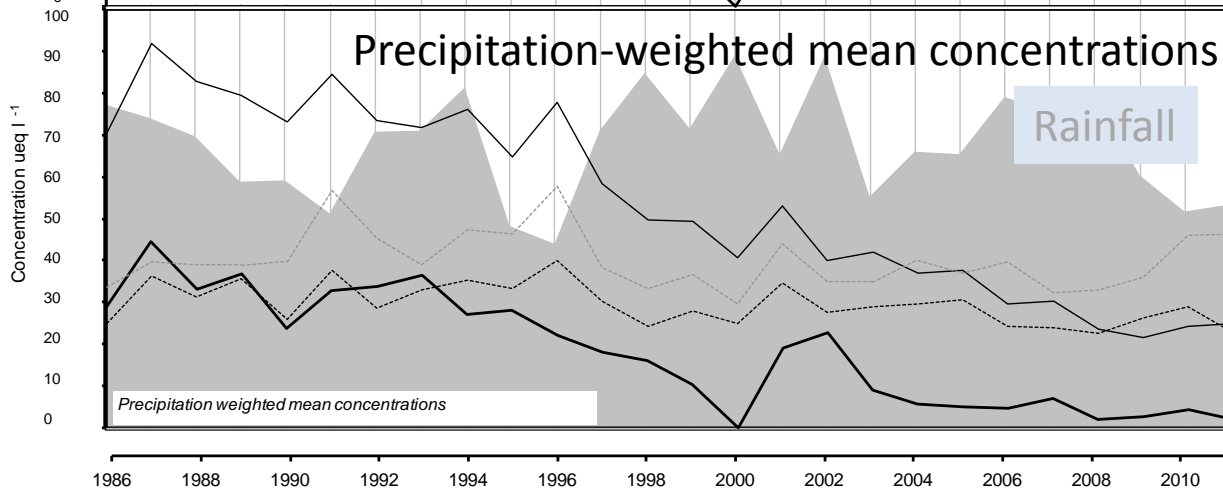
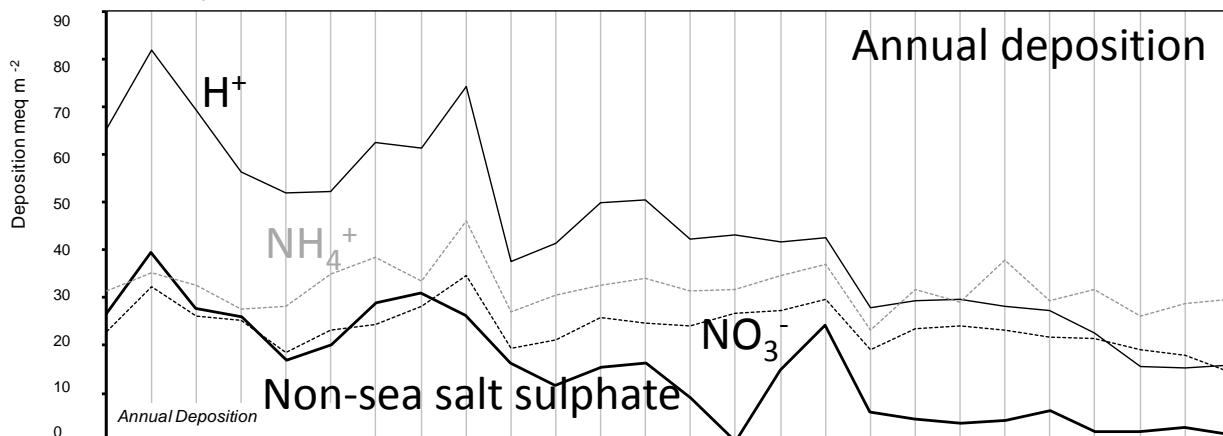
Site Environment:  
 Open moorland

Other measurements:  
 DT, Met

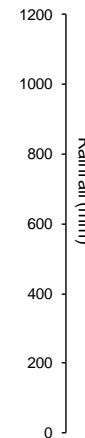
Site Operator:  
 Natural England



[30 year mean 1940 - 1971]



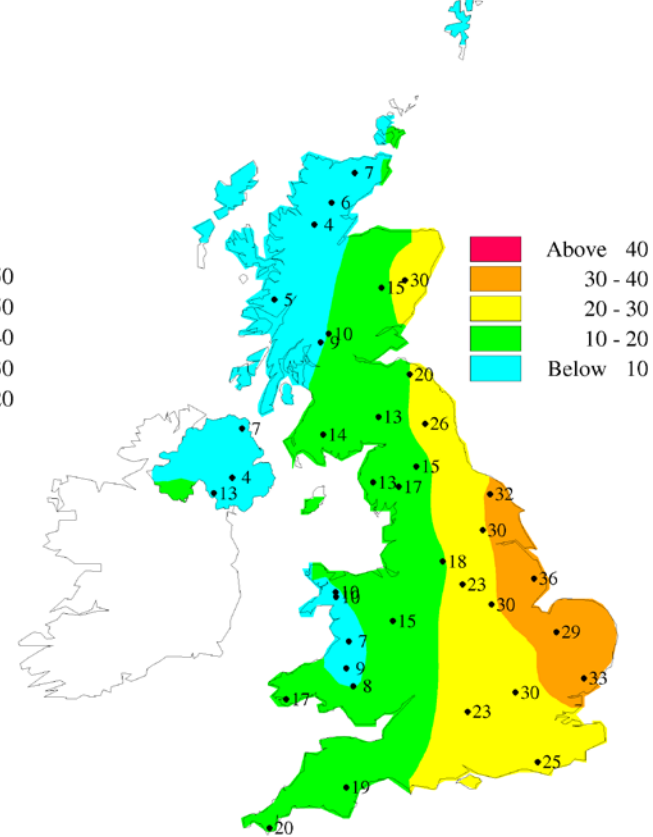
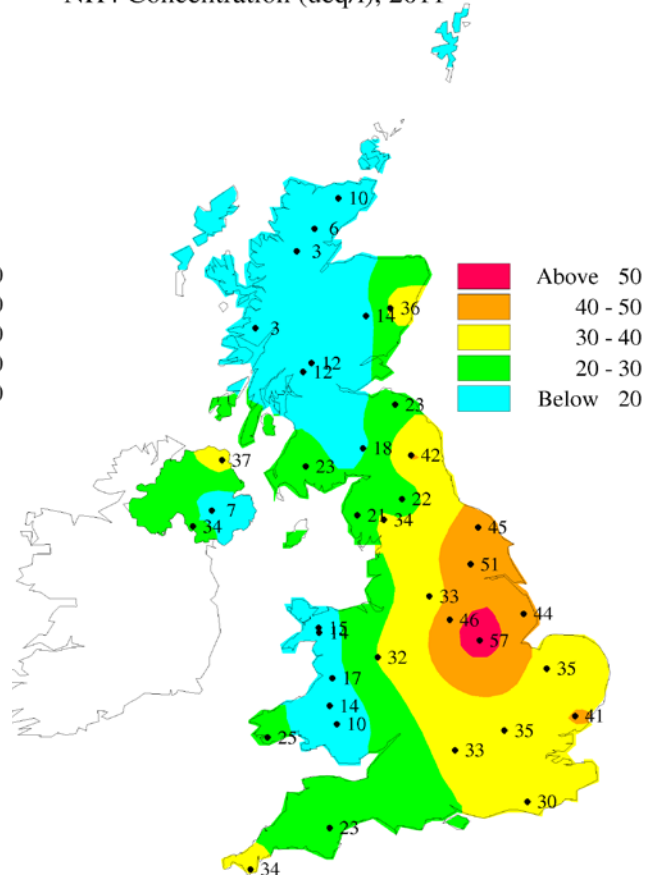
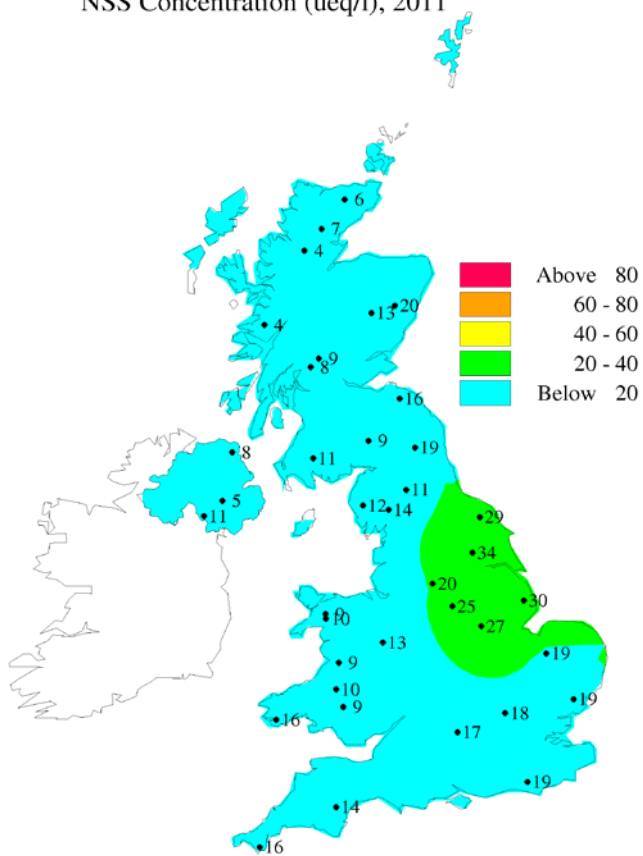
long-term trends in concentration (+x = increase; -x = decrease)	
hydrogen ion	-1.55 ueq/l (-4.05%/year): 25 years' data +++++ Very strong trend detected
non-marine sulphate	-2.77 ueq/l (-3.12%/year): 26 years' data +++++ Very strong trend detected
nitrate	-0.33 ueq/l (-0.98%/year): 26 years' data + Significant trend detected
ammonium	-0.16 ueq/l (-0.38%/year): 26 years' data - No significant trend detected



NSS Concentration (ueq/l), 2011

NH4 Concentration (ueq/l), 2011

NO3 Concentration (ueq/l), 2011

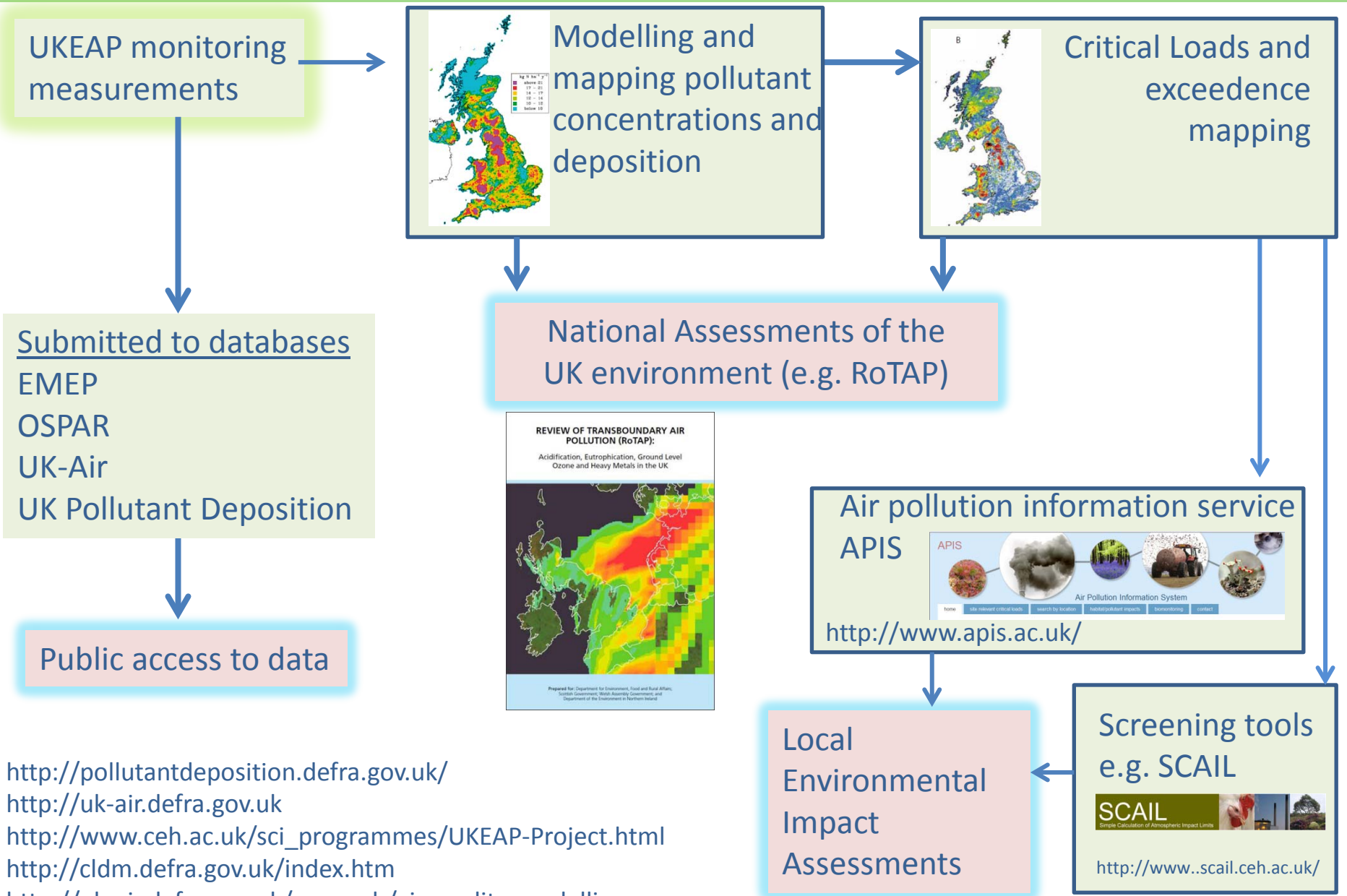


# NO<sub>2</sub>-Net



Site Name	2011 Concentrations	Data capture
Allt a'Mharcaidh	1.55	100%
Balquhider 2	2.63	97%
Bannisdale	4.73	100%
Barcombe Mills	10.7	100%
Driby 2	11.6	100%
Eskdalemuir <sup>T</sup>	3.49	100%
Flatford Mill	12.4	99%
Forsinain 2/Halladale	2.07	92%
Glensaugh	3.42	100%
Goonhilly	4.56	99%
Harwell <sup>T</sup>	12.2	100%
High Muffles	7.73	100%
Hillsborough Forest	7.39	100%
Llyn Llydaw	3.07	100%
Loch Dee	3.75	75%
Lough Navar	2.07	100%
Moorhouse	4.8	100%
Percy's Cross	5.23	92%
Polloch	1.42	100%
Pumlumon	4.2	100%
Strathvaich Dam	1.19	100%
Tycanol Wood	3.52	96%
Whiteadder	3.62	100%
Yarner Wood <sup>T</sup>	4.93	100%

# Measurement data uses



- <http://pollutantdeposition.defra.gov.uk/>
- <http://uk-air.defra.gov.uk>
- [http://www.ceh.ac.uk/sci\\_programmes/UKEAP-Project.html](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>

# 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://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](mailto:ukeap@ceh.ac.uk)

# European Measurement and evaluation programme

## 313 sites

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

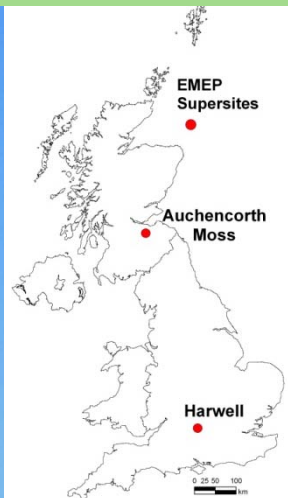
Level 2 Sites

Located in areas thought to have “minimal local emissions”

## 31 UK Sites



# 2 UK EMEP supersites - Auchencorth Moss and Harwell



Measurement	Method
Water-soluble gases + particles at PM2.5 & PM10	MARGA
Black carbon PM2.5	Aethalometer
NO/NO2	Photolytic converter
Meteorology (wind speed, dir'n., temp., RH, precip'n)	Automated met station
Ozone	UV photometer
PM2.5 and PM10 mass (daily)	Filter (gravimetric)
PM2.5 and PM10 mass (hourly)	TEOM/FDMS
PAH (vapour and particle)	Digitel hi-vol
PAH (precipitation)	Bulk sampler
TOMPS (air)	Hi-vol
Hydrocarbons (C <sub>2</sub> – C <sub>8</sub> )	Online GC-FID
Particle size and number	SMPS
Mercury (elemental) in air	CVAF
Mercury (speciated) in air	CVAF
Mercury (precipitation)	CVAF
Heavy metals PM10 (air)	ICP-MS
Heavy metals (precip'n)	ICP-MS
Ozone, NOx, SO <sub>2</sub> fluxes	Automated analyzers
Trace gas fluxes	CoTAG
ECOC (weekly)	Filter

<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  $\text{NH}_x$  are the dominant driver of ecological effects of deposited N, and the importance of  $\text{NH}_x$  is predicted to increase relative to oxidised N, as  $\text{NO}_x$  emissions decrease further



**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 -11<sup>th</sup> October 2013**  
*Includes tour of CEH Laboratories! ☺*