Review of Transboundary Air Pollution (RoTAP)

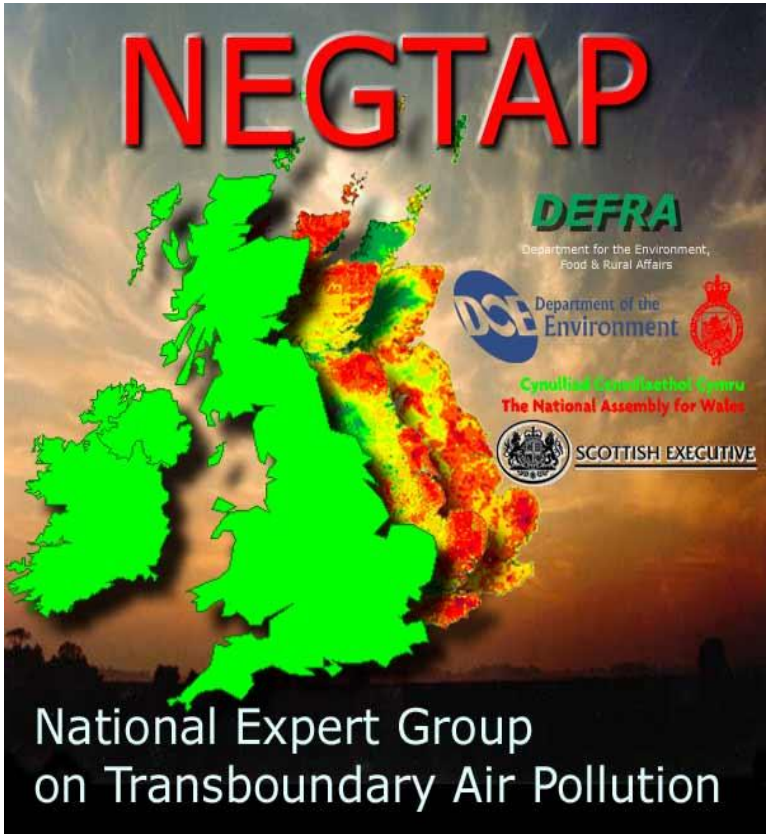
David Fowler

Chair of RoTAP

Outline

- Present an update of the Review of Transboundary Air Pollution (RoTAP)

National Expert Group on Transboundary Air Pollution (NEGTAP, 2001)



NEGTAP Report published in 2001
Provided a detailed description of :

- acid deposition
- eutrophication
- ground level ozone

Analysed data to 1999

RoTAP Project began in February 2008 with the aim of reviewing the current UK status of :

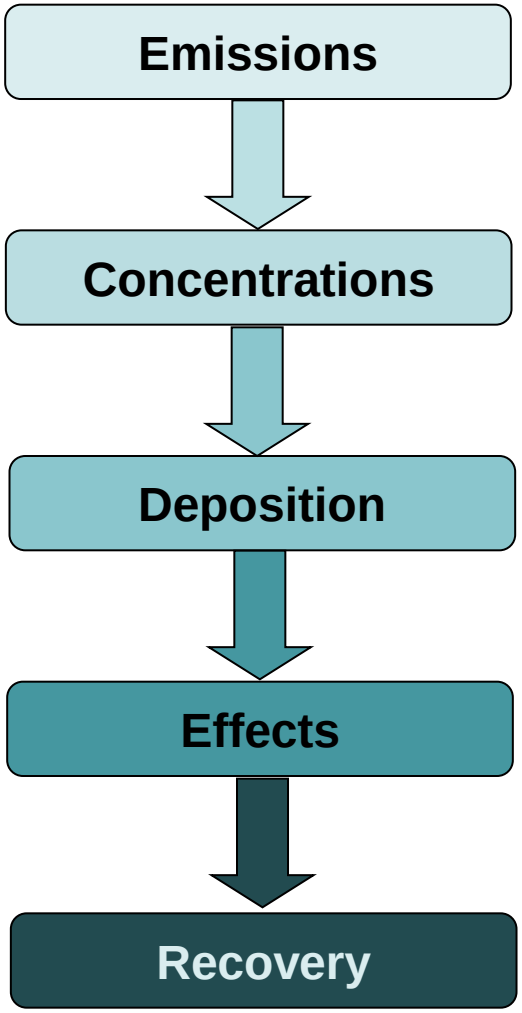
- acid deposition
- eutrophication
- ground level ozone
- heavy metals

Stucture of the RoTAP Report

1) Introduction
2) Emissions
3) Concentrations & Deposition
4) Modelling Concentrations and Deposition
5) Effects on Soils, Freshwater Vegetation
6) Heavy Metals
7) European & Global Perspectives
8) Recovery
9) Recommendations

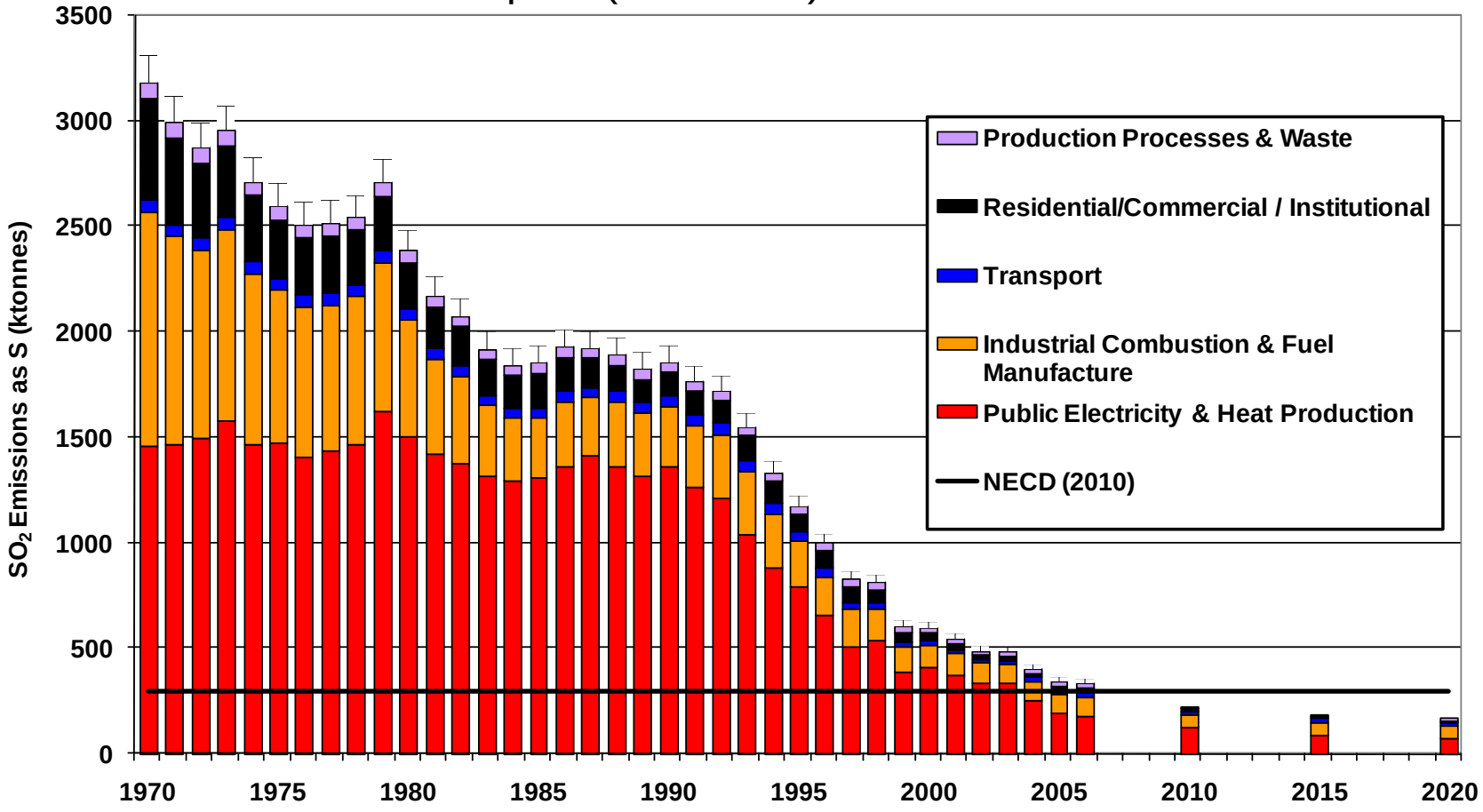
Executive & Technical Summary

Summary for Policy Makers

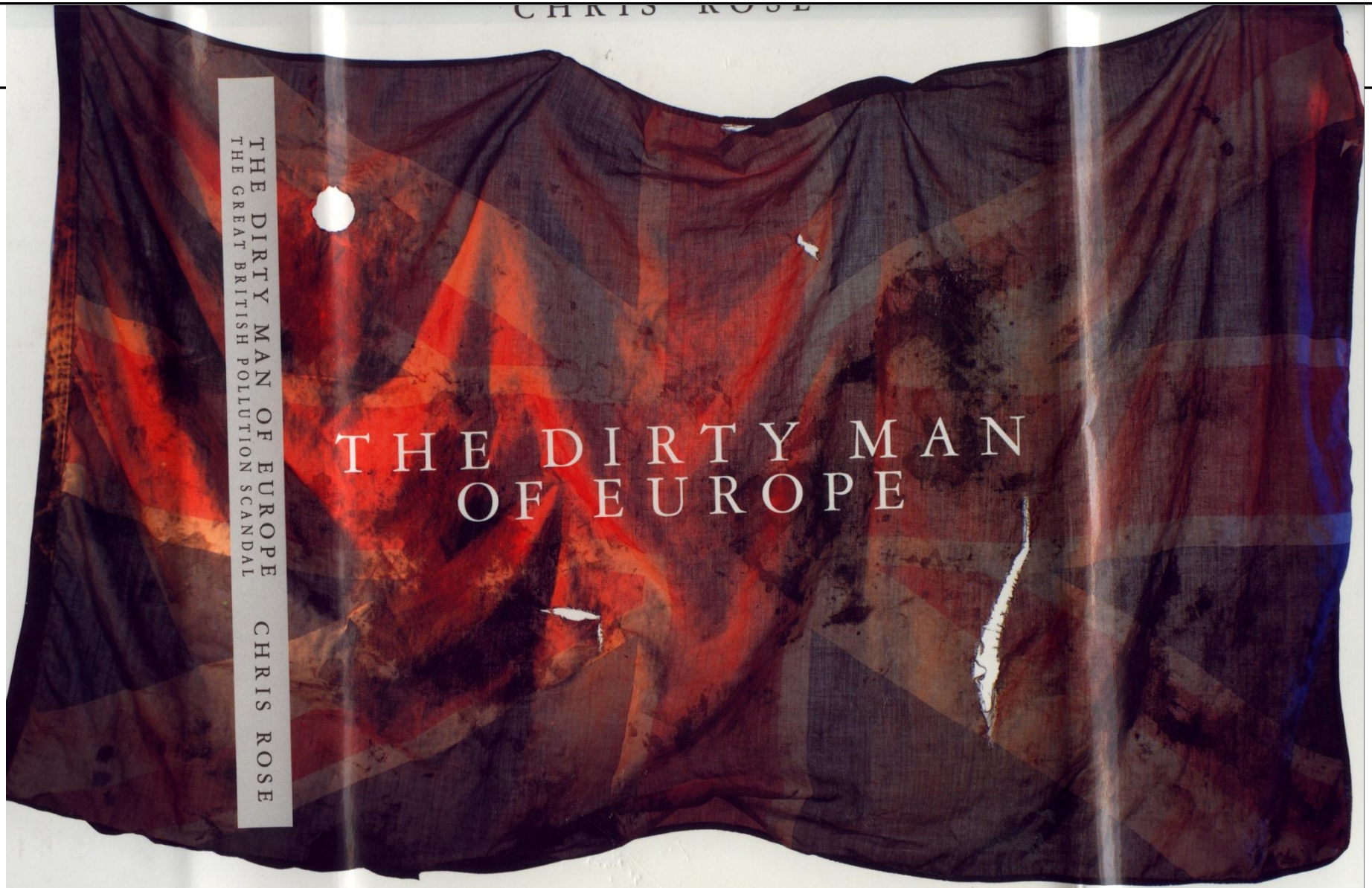


Acidification

UK Emissions of sulphur (ktonnes S)



CHRIS ROSE



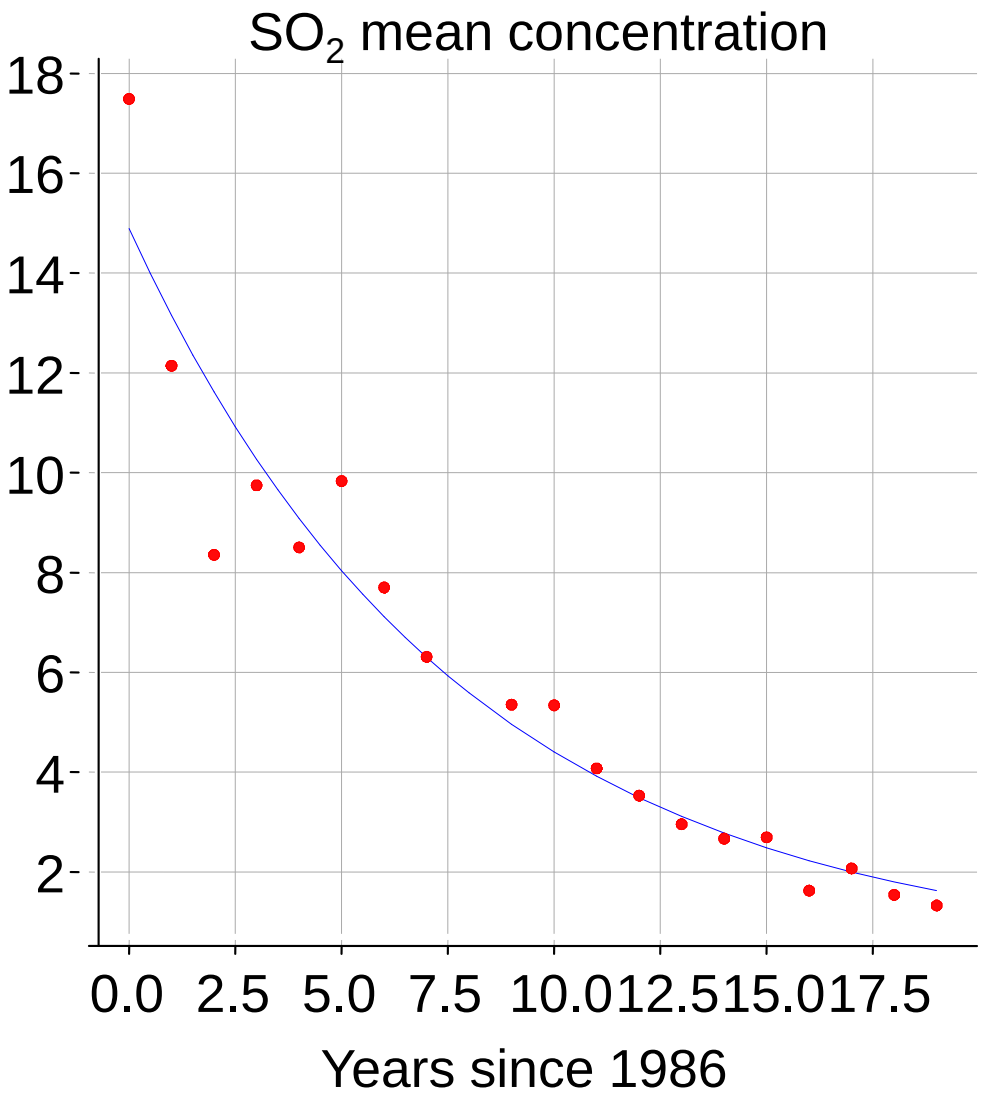
THE DIRTY MAN OF EUROPE

THE GREAT BRITISH POLLUTION SCANDAL

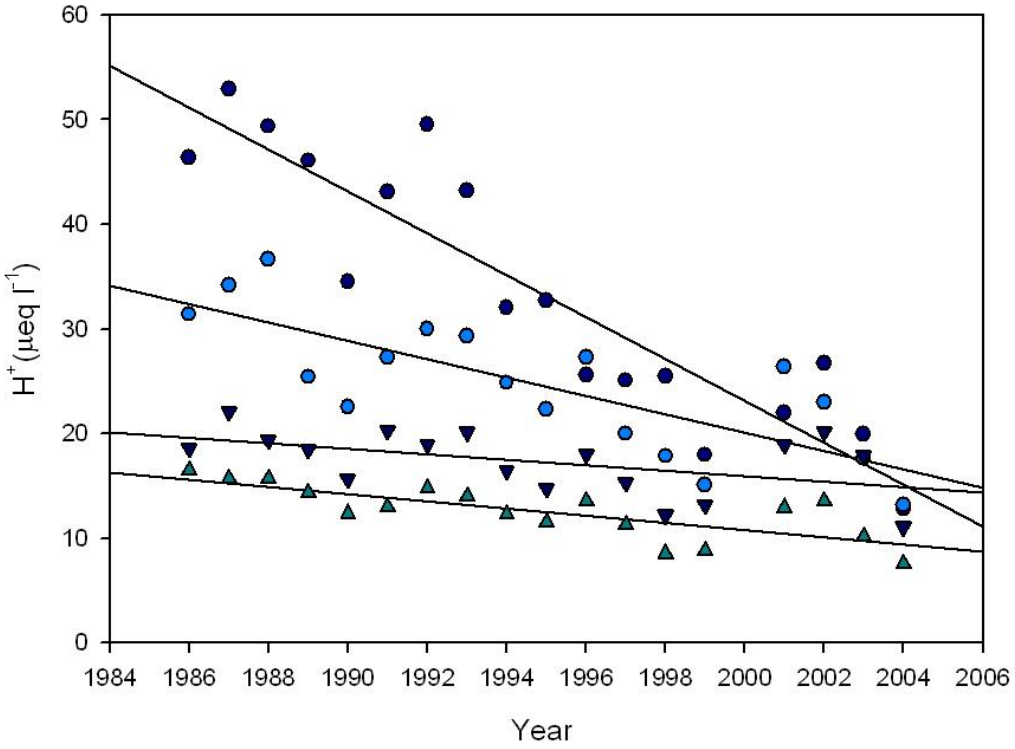
THE DIRTY MAN OF EUROPE
THE GREAT BRITISH POLLUTION SCANDAL
CHRIS ROSE

0-671-71059-1

Trend in SO_2 Concentrations

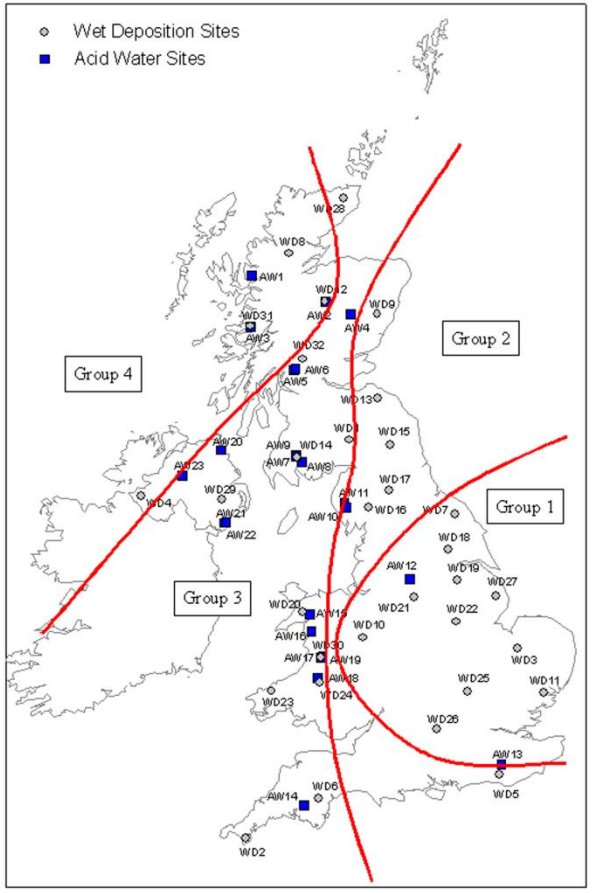


Acidity in UK Precipitation 1986-2004

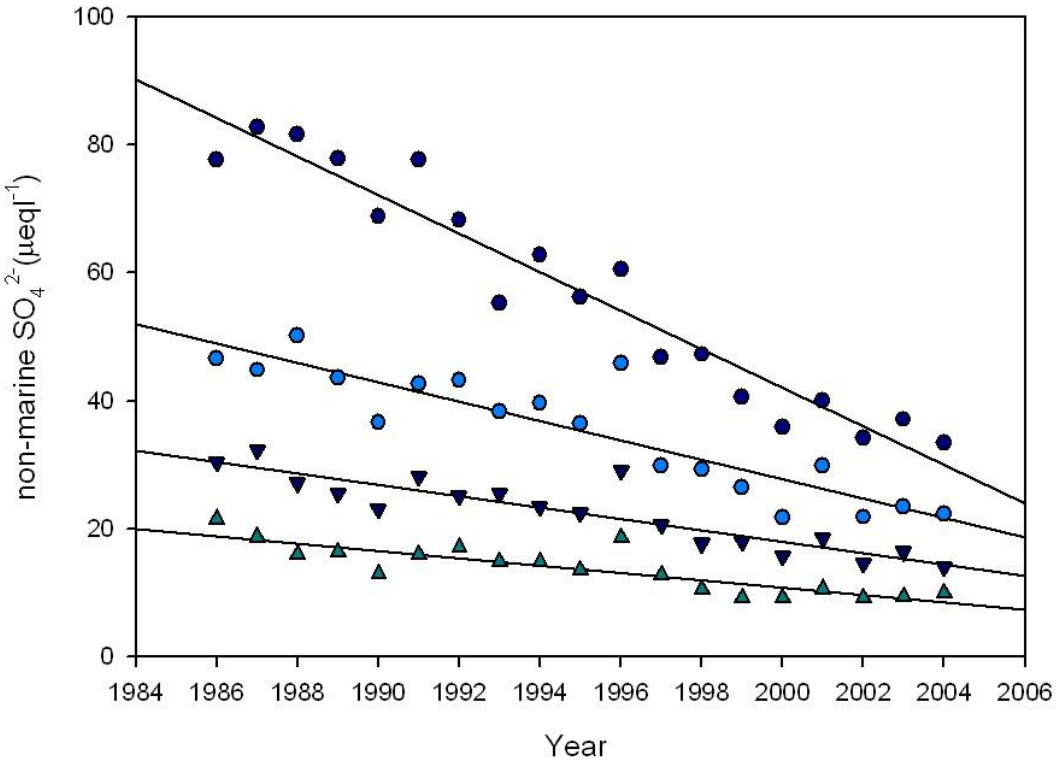


Group 1: C = -2.0034 (Y-1995) + 33.22 , R^2 = 0.830 , p = 0.000
Group 2: C = -0.8769 (Y-1995) + 24.58 , R^2 = 0.597 , p = 0.000
Group 3: C = -0.2598 (Y-1995) + 16.70 , R^2 = 0.233 , p = 0.037
Group 4: C = -0.3441 (Y-1995) + 12.60 , R^2 = 0.578 , p = 0.000

C = Concentration , Y = Year

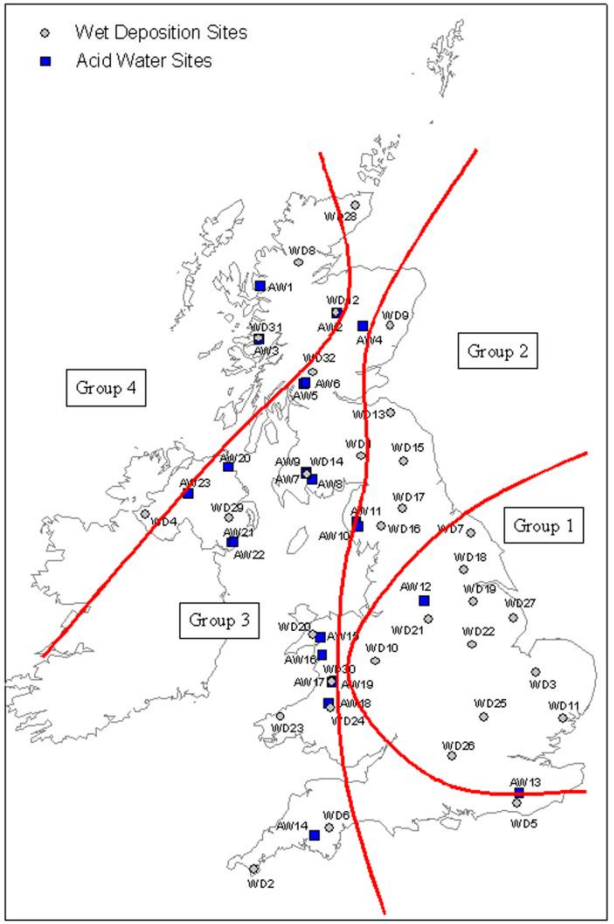


Non-marine Sulphate in precipitation 1986-2004

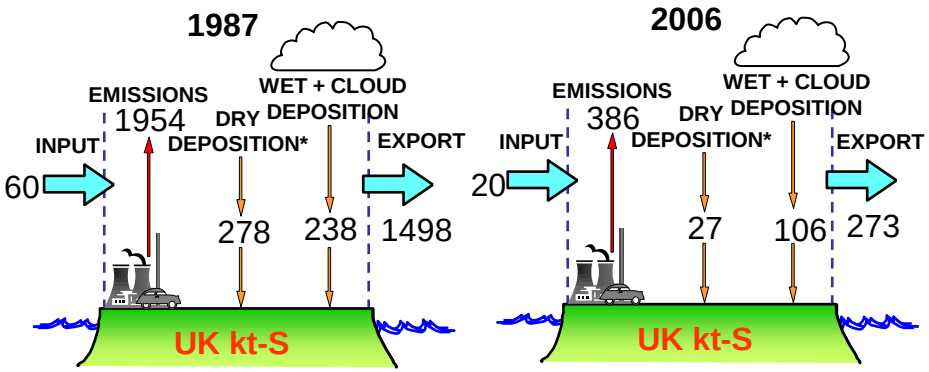


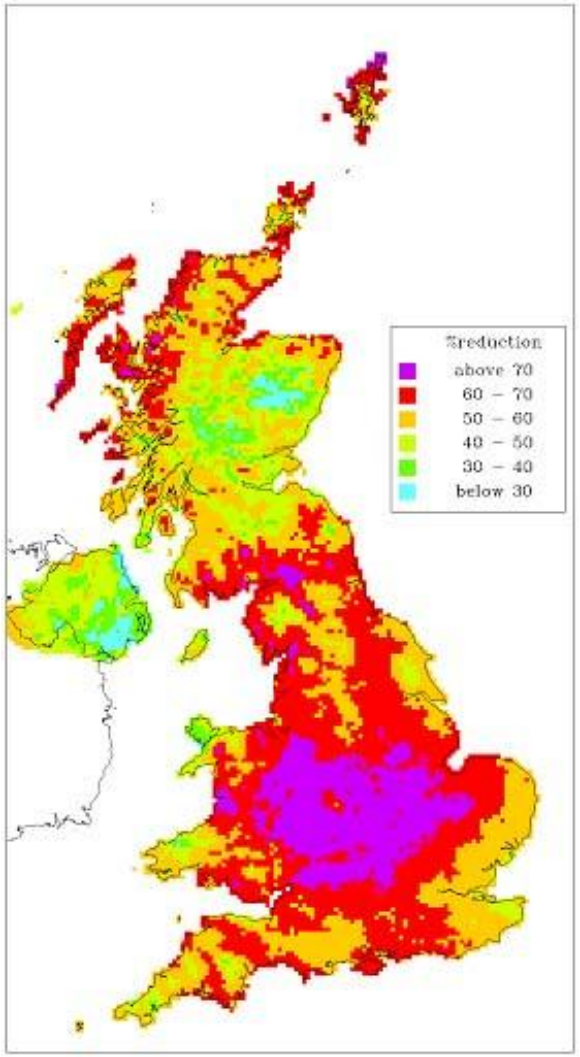
Group 1: C = -3.0120 (Y-1995) + 57.06 , R^2 = 0.932 , p = 0.000
Group 2: C = -1.5127 (Y-1995) + 35.16 , R^2 = 0.806 , p = 0.000
Group 3: C = -0.8920 (Y-1995) + 22.46 , R^2 = 0.806 , p = 0.000
Group 4: C = -0.5757 (Y-1995) + 13.50 , R^2 = 0.737 , p = 0.000

C = Concentration , Y = Year



Changes in UK Sulphur Budget





What are the consequences for effects?

The benefits of the reduced emissions are greatest in the lowlands and urban areas and least in the uplands (Wales, Scotland)

Acidification in the UK

- The large reduction in emissions and deposition of sulphur has reduced acidity in UK soils
- Freshwaters show reduced acidity, sulphur and ANC has increased
- Evidence of biological recovery is widespread in the UK

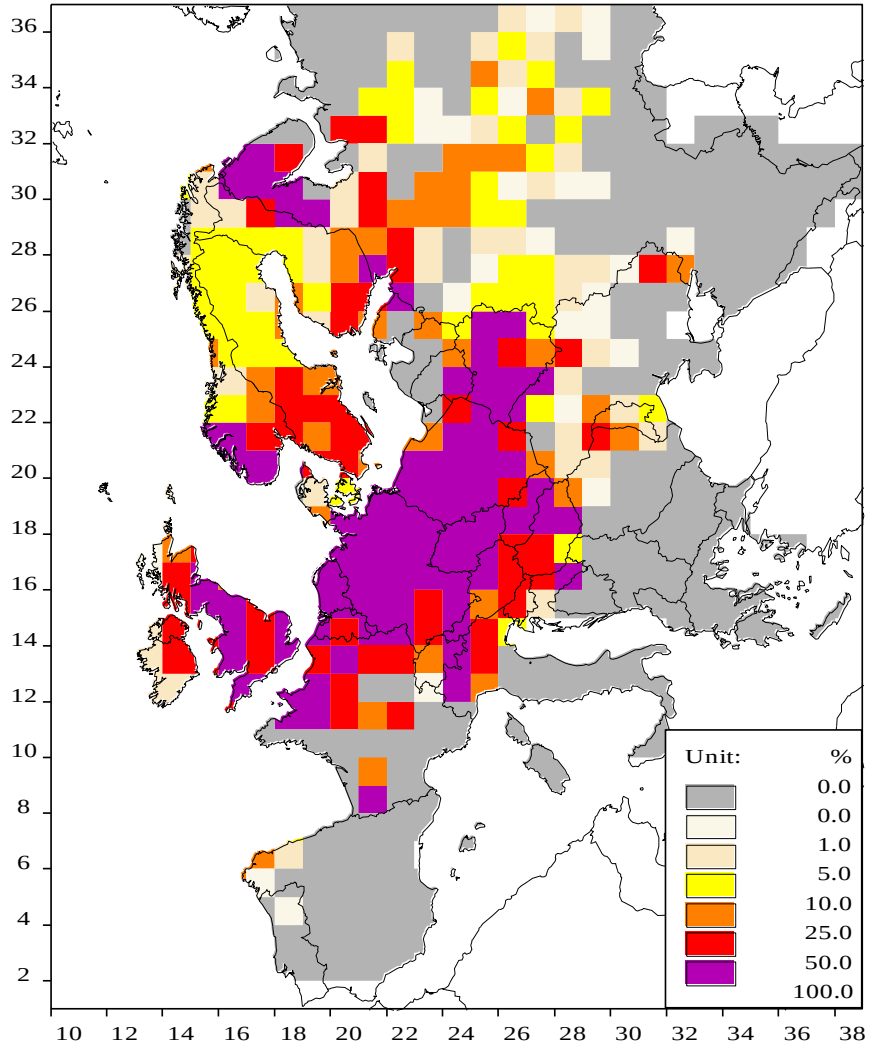
But

- While the area of broad habitat exceeded for acidity has declined from 71% in 1996-8, to 58% in 2004-6 it will still be 40% in 2020……..
- So recovery has some way to go

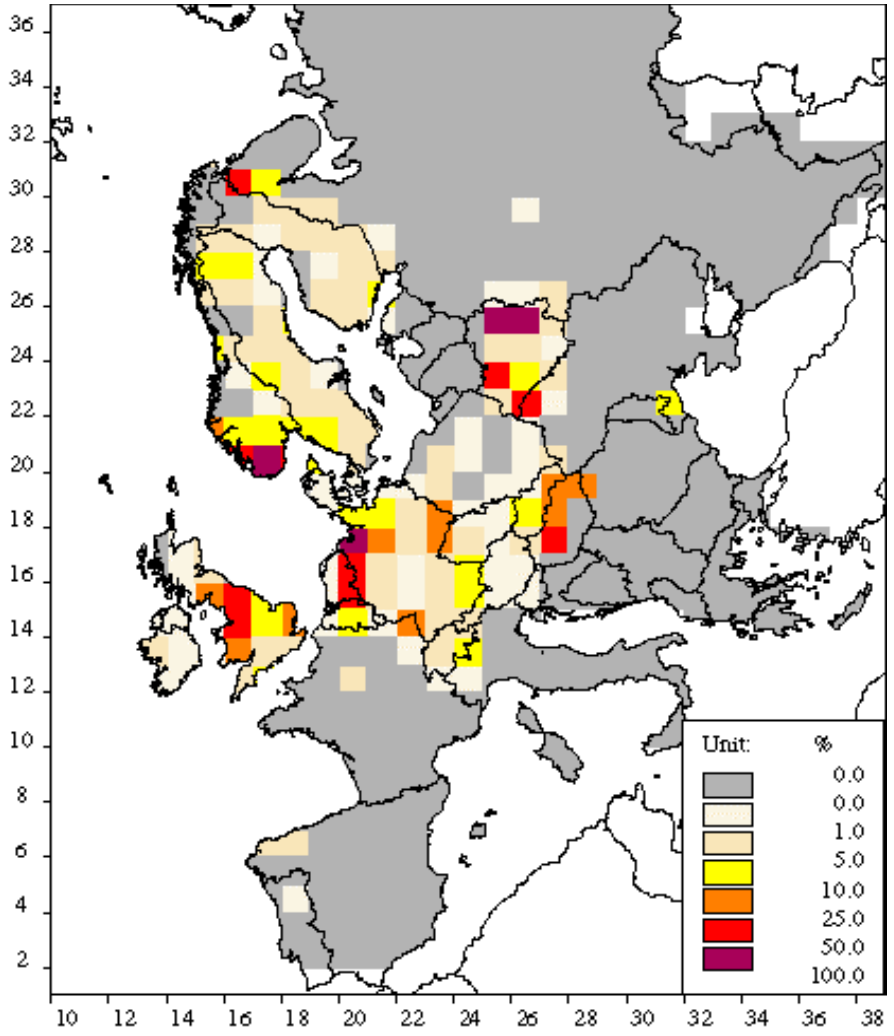
ENVIRONMENTAL IMPACTS

% Ecosystems not protected against acidification

1990



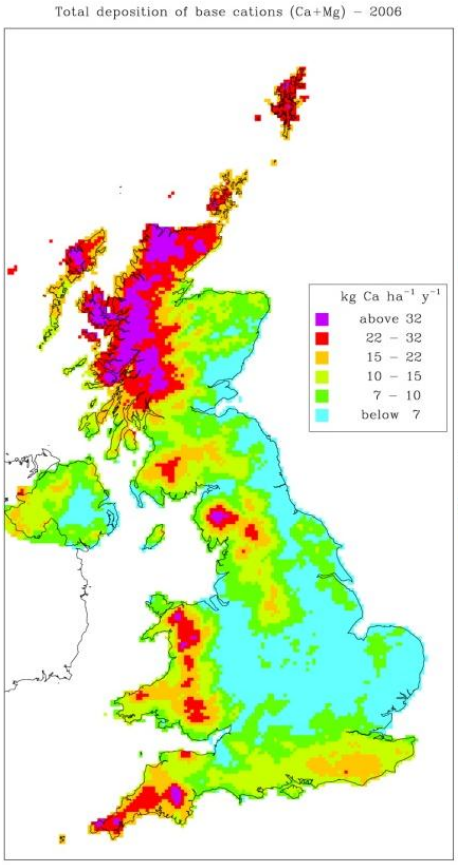
2010

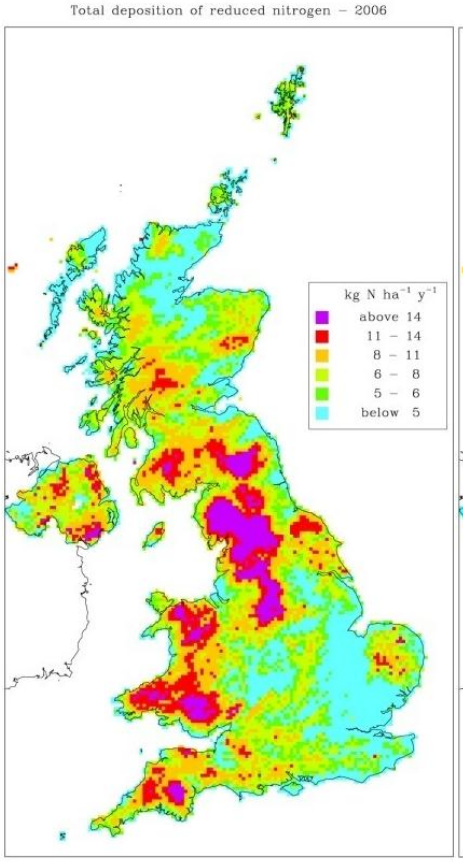


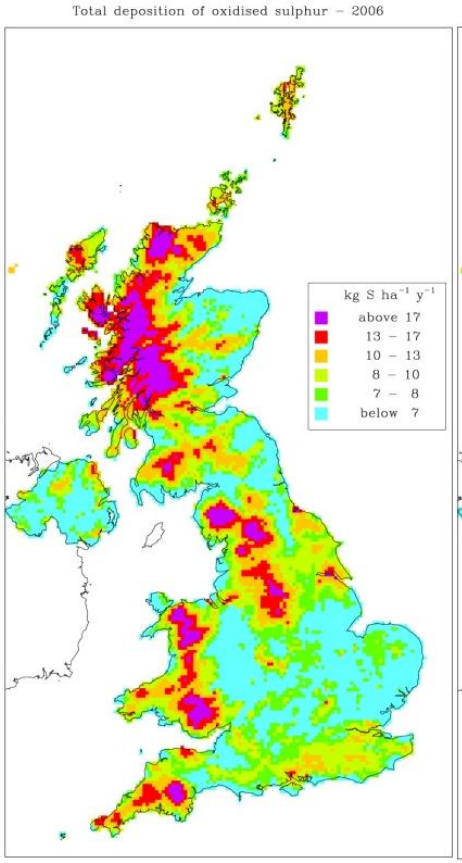
Sulphur and Acidification

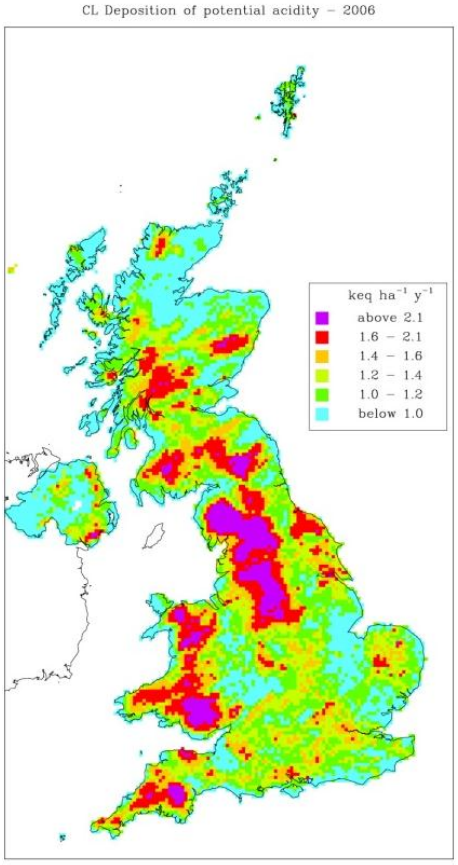
- A success policy story, very large emission reductions achieved, the UK atmosphere is much cleaner (WRT S and acidity) but the recovery process is slow especially the ecological recovery and the end point of the trajectory may differ from pre-acidification…..the chemical and physical climates will be very different
- Substantial outputs of the science in peer reviewed publications, and opportunities for more from the high quality measurements and the time series (evidence based policy well supported).
- But there are surprises

64 maps of concentration and deposition of the gases, aerosols and wet deposition components





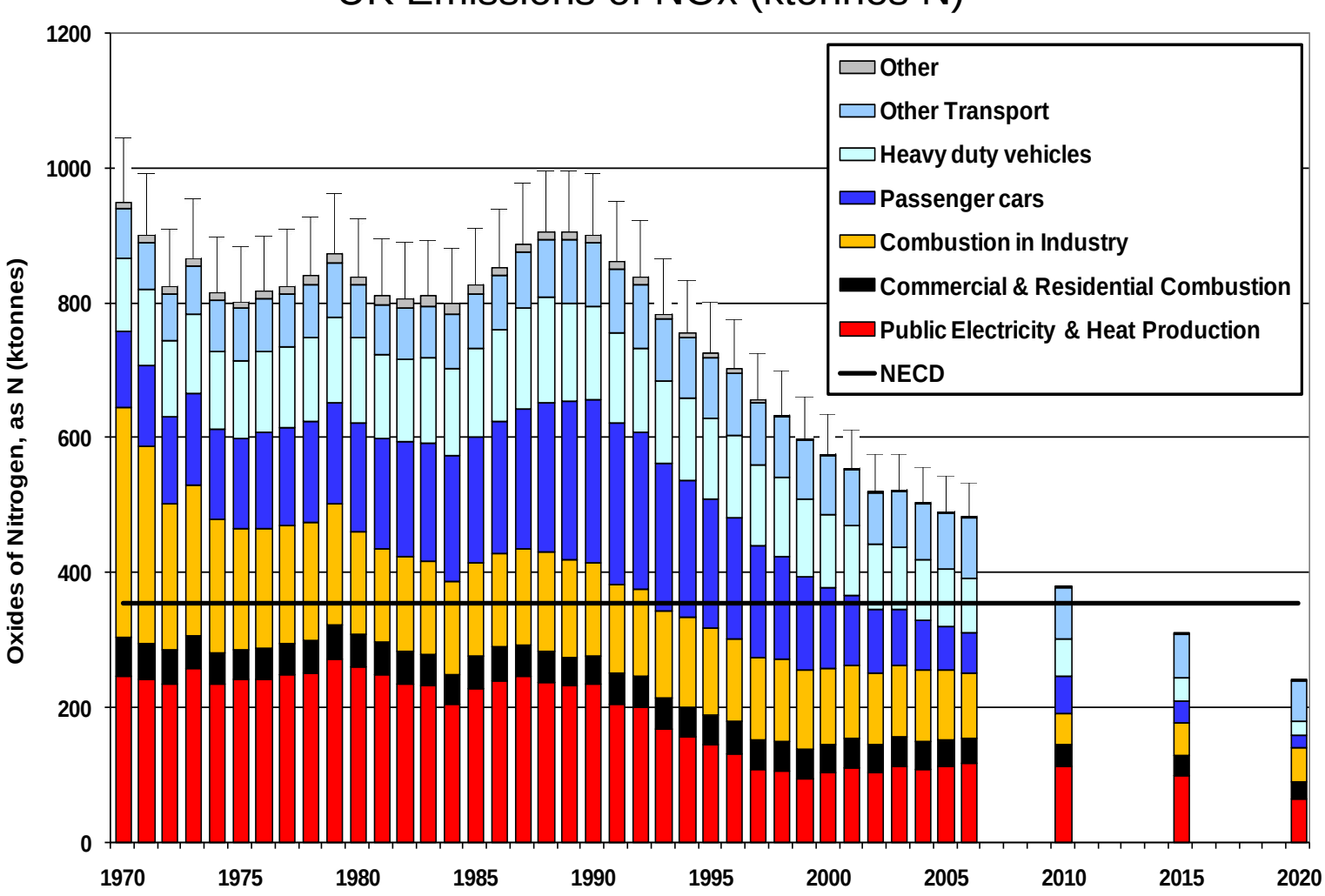




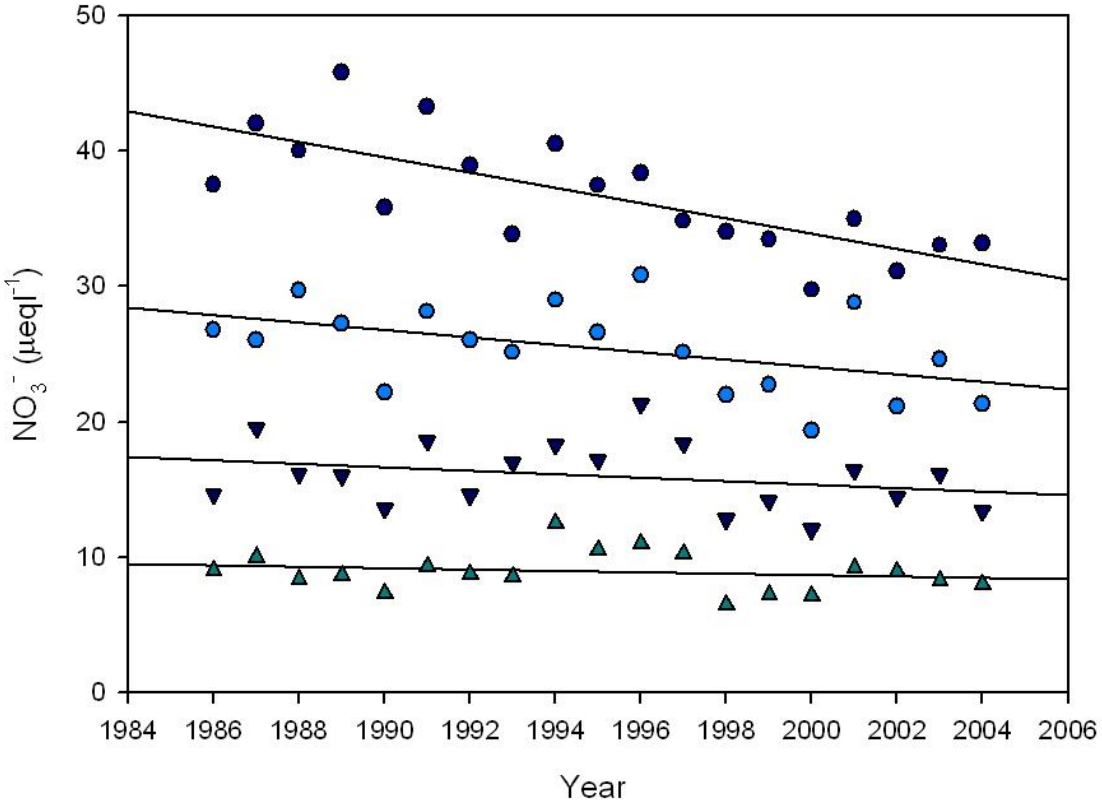
Eutrophication

- Oxidized and reduced Nitrogen

Eutrophication – NO_x



Nitrate in precipitation 1986-2006

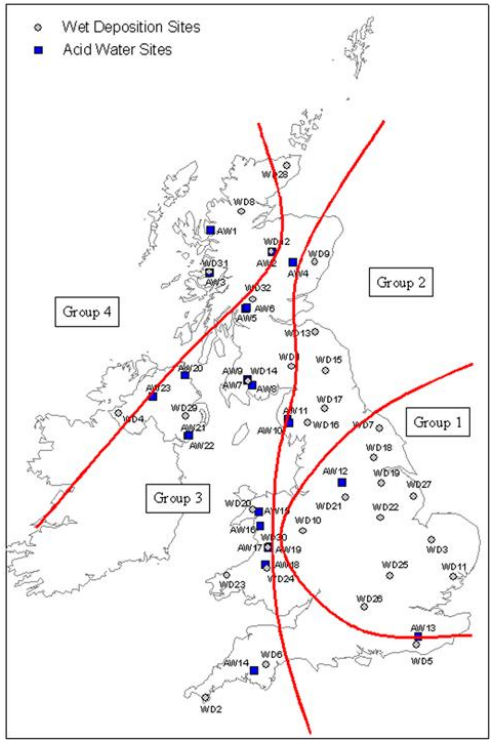


Group 1: C = -0.5663 (Y-1995) + 37.23 , R^2 = 0.557 , p = 0.000
Group 2: C = -0.2757 (Y-1995) + 24.98 , R^2 = 0.229 , p = 0.031
Group 3: C = -0.1274 (Y-1995) + 15.84 , R^2 = 0.085 , p = 0.199
Group 4: C = -0.051 (Y-1995) + 8.56 , R^2 = 0.038 , p = 0.422

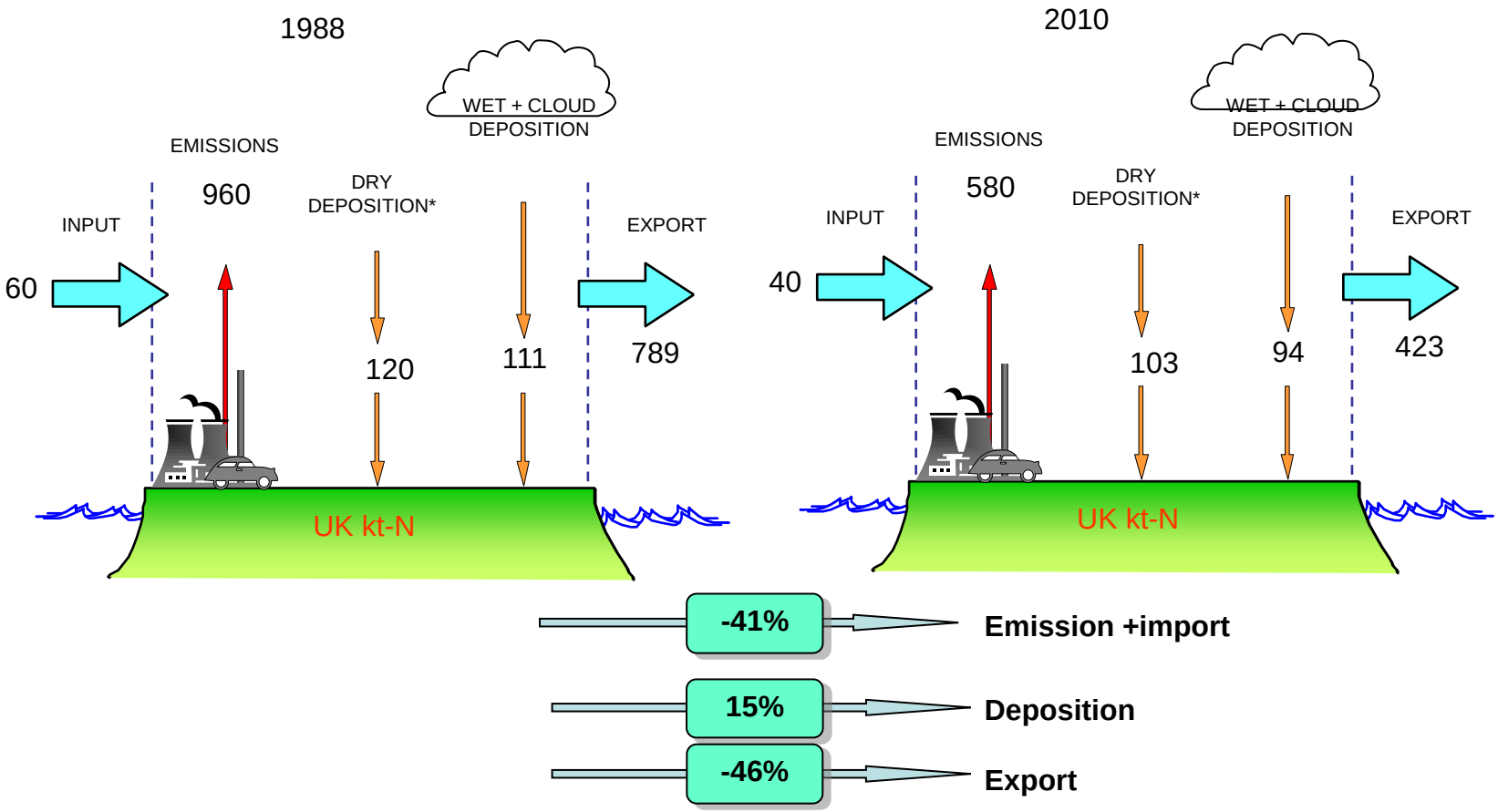
C = Concentration , Y = Year

Trends in Group 1 and 2 are significant at α = 0.05 level

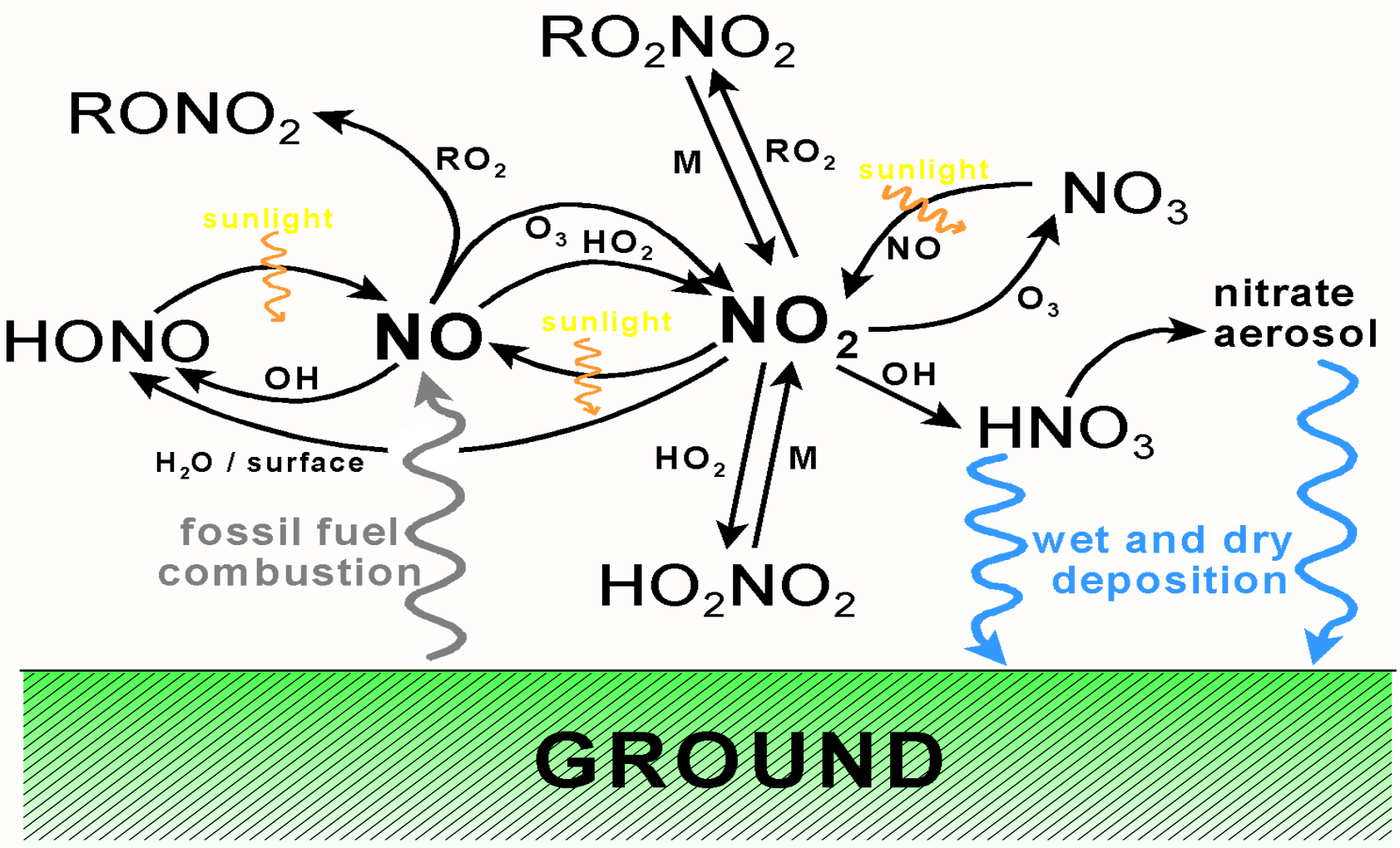
Trend in Group 2 was not significant for 1986 -2001

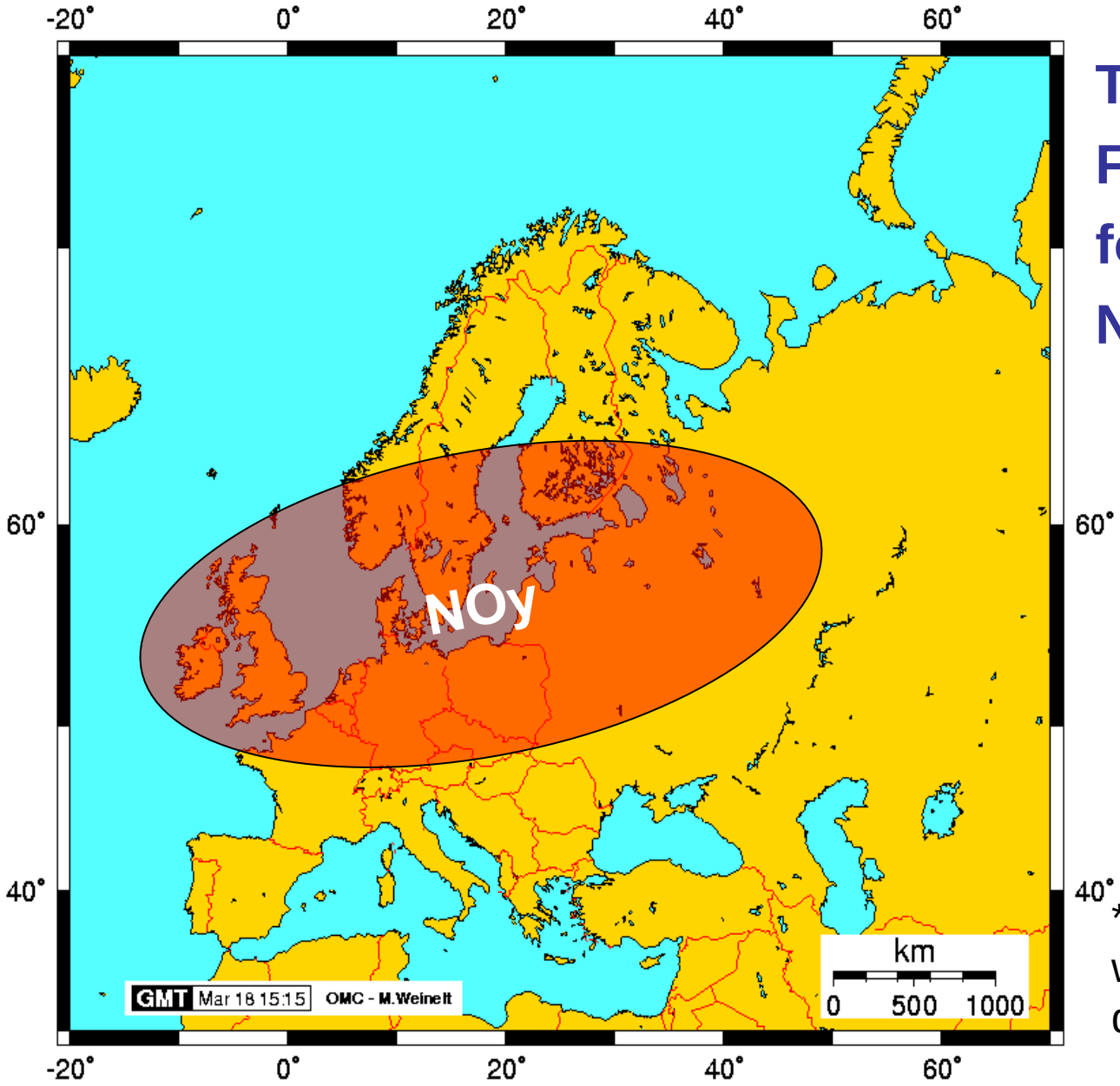


Eutrophication – NO_x (units k tonnes-N)



What has caused the observed changes in the oxidized N budget over the UK?

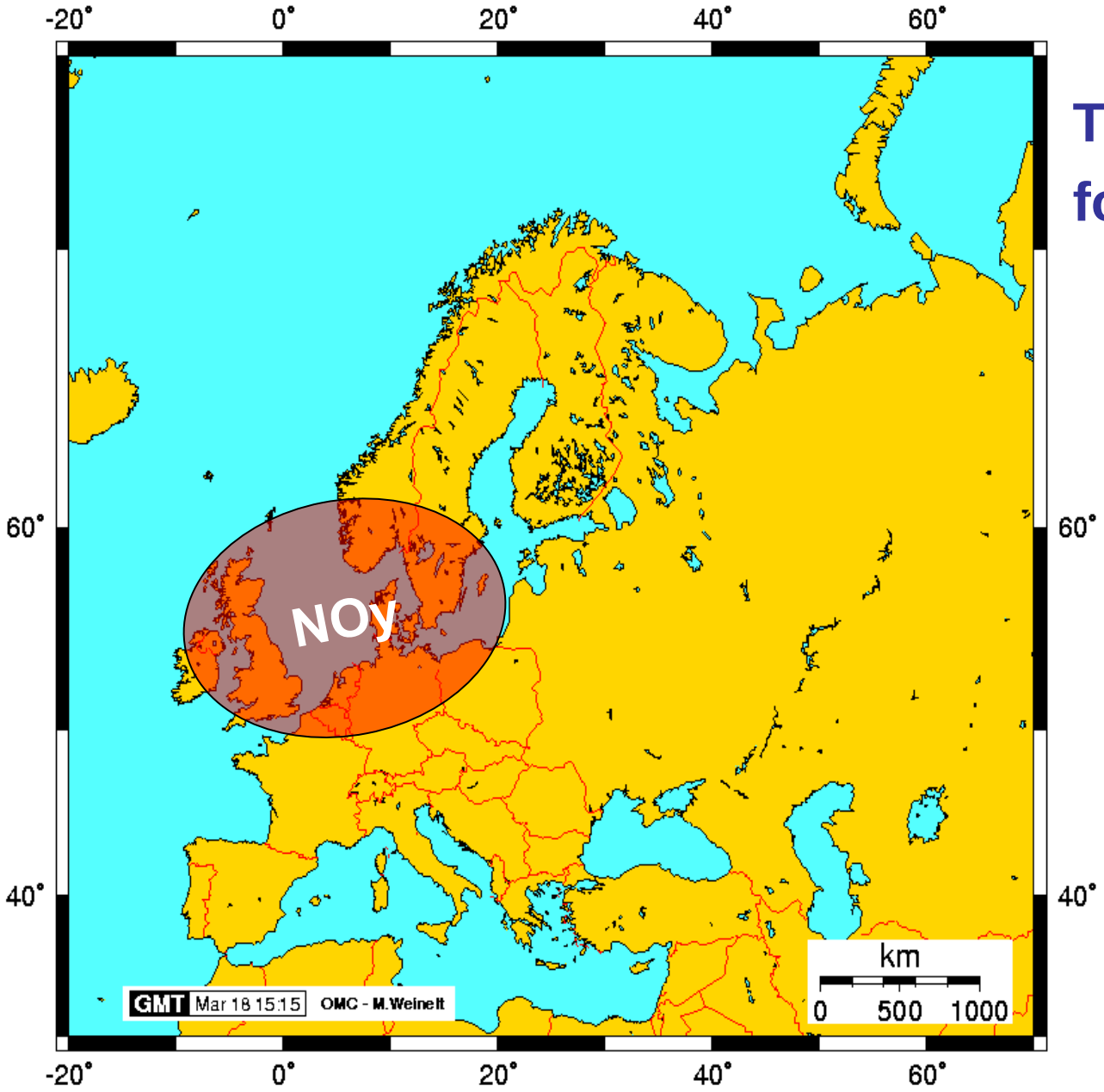




The UK Footprint* for NOy and NHx 1987-9

*The area within which ~70% of the deposition occurs

The UK Footprint for NOy 2010



What are the effects of the deposited N

Negative

- Changes in species composition of semi-natural flora
- NO_3 leaching to soil and freshwater
- Acidification
- Enhance emissions of N_2O

Positive

- Sequestration of carbon through enhancing primary productivity

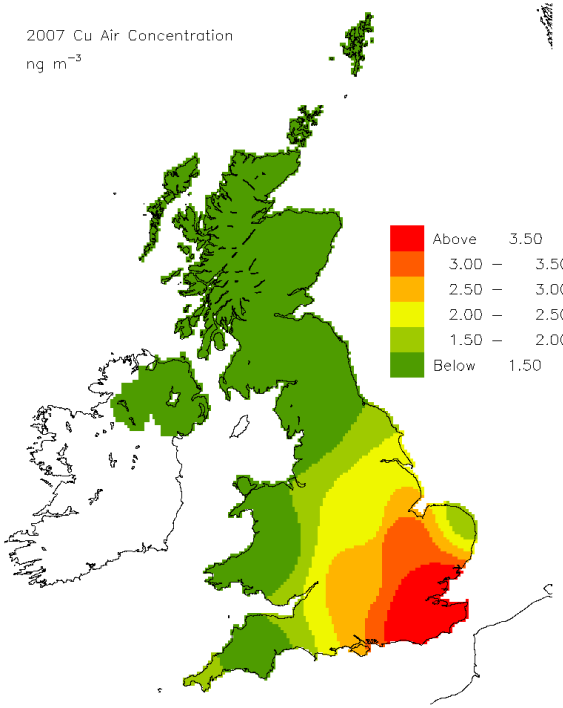
Effects of Nitrogen deposition

- Critical loads for effects of nitrogen deposition on sensitive habitats are exceeded over 60% of their area in the UK, and is expected to decline to 49% by 2020s
- There is strong evidence that N deposition has reduced the diversity of plant species per unit area in a range of habitats of high conservation value.
- Not all forms deposited N are equally damaging, and dry deposition of NH_3 is more damaging than wet deposition of reduced or oxidized N

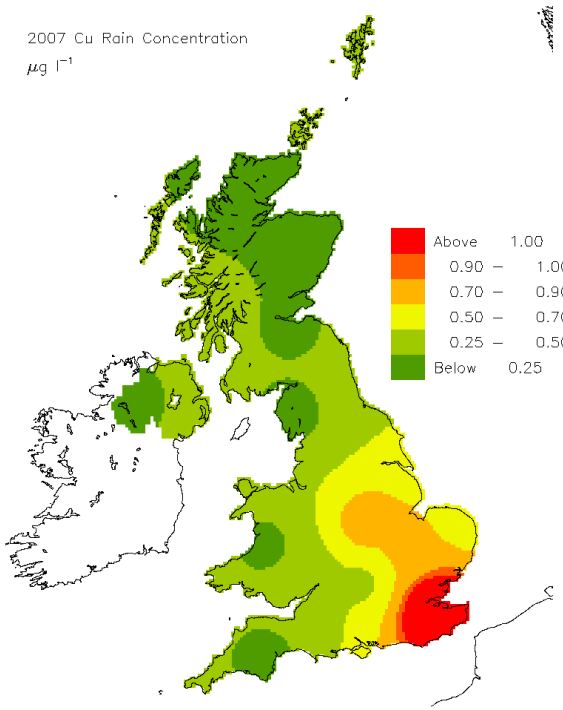
Heavy metals in the UK

- The first comprehensive assessment of metal emission, concentration and deposition in the UK,
- 5 years of data, concentrations in rain, aerosol (and gas phase for Hg)
- UK atmospheric budget and export
- 26 metals including Cu, Zn, Pb, Cd, V, As, Cr

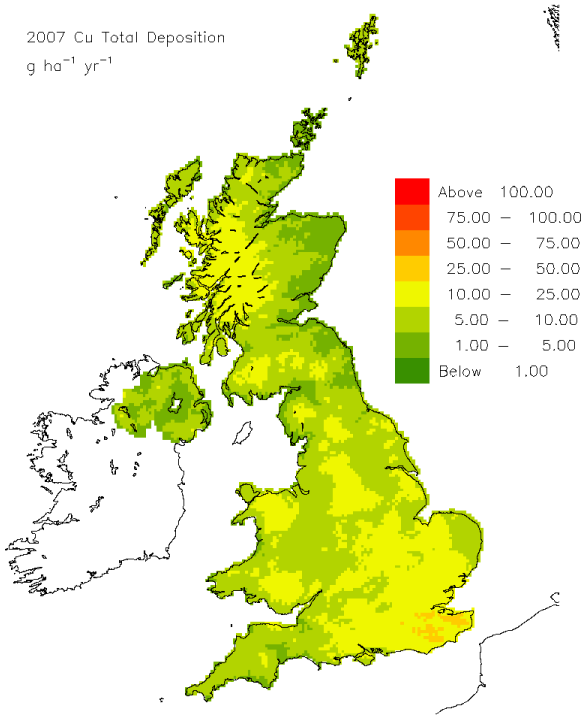
Heavy metals – UK Maps



Cu concentration in air



Cu concentration in rain



Cu Total Deposition

Heavy metals –Comparing UK Emissions and Deposition

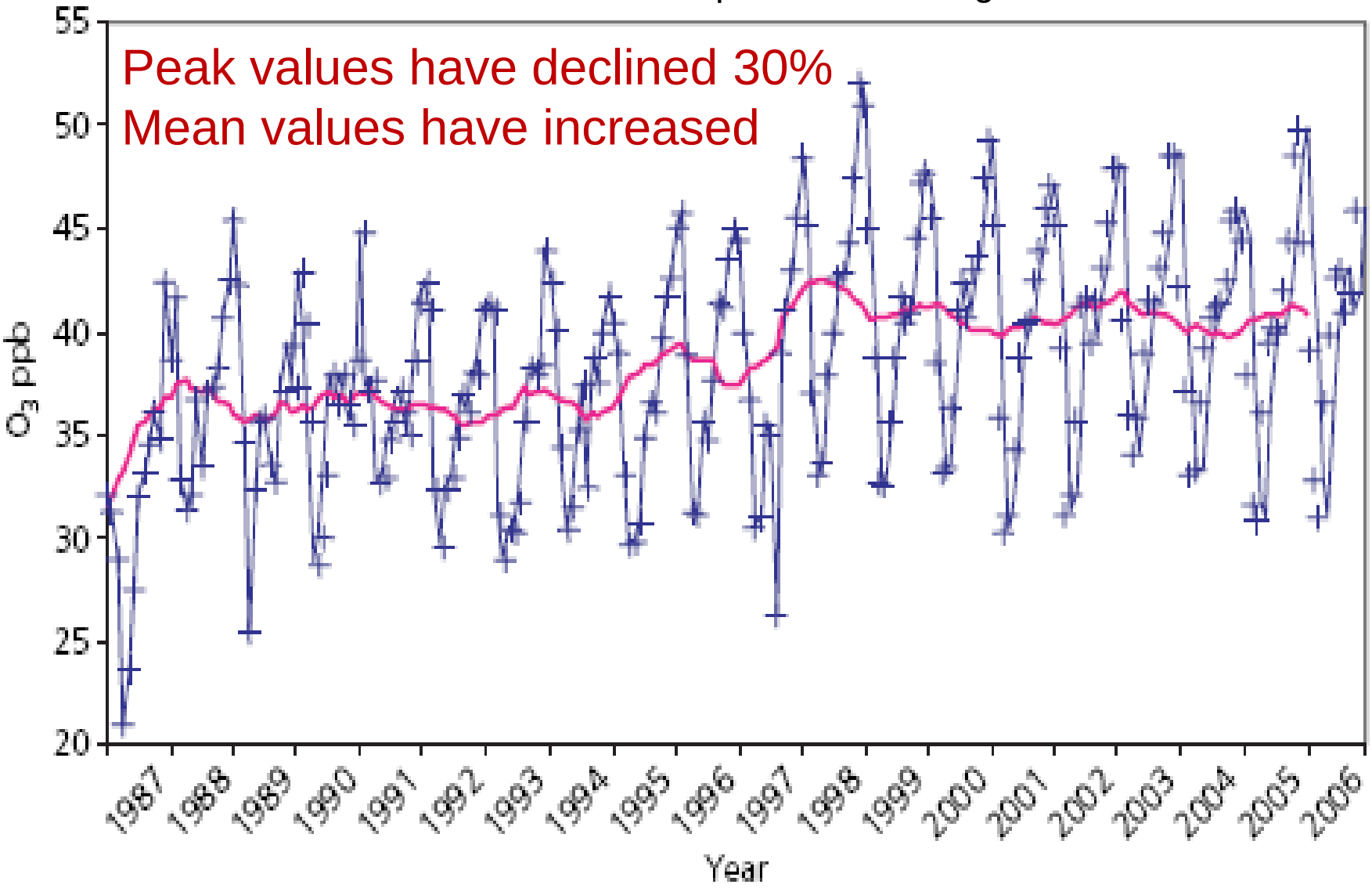
T y^{-1}	As	Cd	Cr	Cu	Ni	Pb	Se	V	Zn	Hg
Emissions NAEI	14	4	36	60	87	118	49	960	461	7.6
Import	3	2	18	32	18	35	19	-	344	-
Measured Deposition	73	10	52	333	155	398	85	203	2190	1.8
Ratio of Deposition/ Emissions	5.2	2.5	1.4	5.6	1.8	3.4	1.7	0.21	4.7	0.24

Metals in the UK atmosphere

- The official emission inventories (NAEI)are not adequate to explain the observed concentrations and deposition in the UK
- The differences between observed concentrations and deposition and the NAEI vary but for Cu, Zn, Pb and As, the difference is approximately a factor of 4
- While we have some good ideas, we really do not know the additional sources of this metal, so the effect of new control measures would be uncertain.
- Critical loads based on ecosystem effects have been calculated for Pb, Cd, Cu, Ni and Zn for 6 UK habitats.

Ground Level Ozone

Measured at Mace Head, line represents running 12 month mean

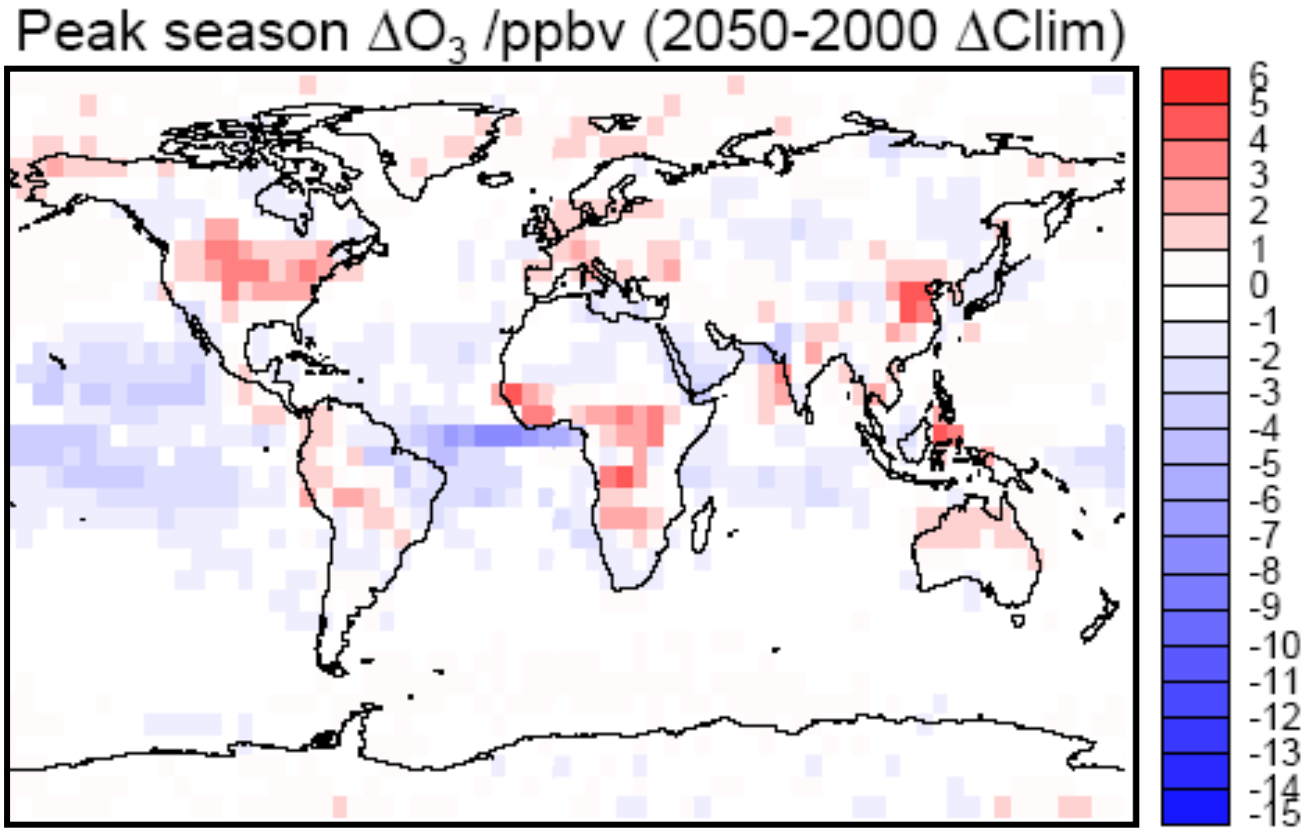


Ozone remains a major problem

Present-day annual ozone impacts in EU:

- 20,000 deaths brought forward
- 20 million respiratory hospital days
- 50 million restricted activity days in young adults due to respiratory symptoms
- €6.7 billion loss of arable crops
- Semi-natural vegetation shows the same sensitivity to ozone as crop plants

Projected changes in surface O_3 (2050-2000) during the peak O_3 season due to *climate change*



Mean of 3 models

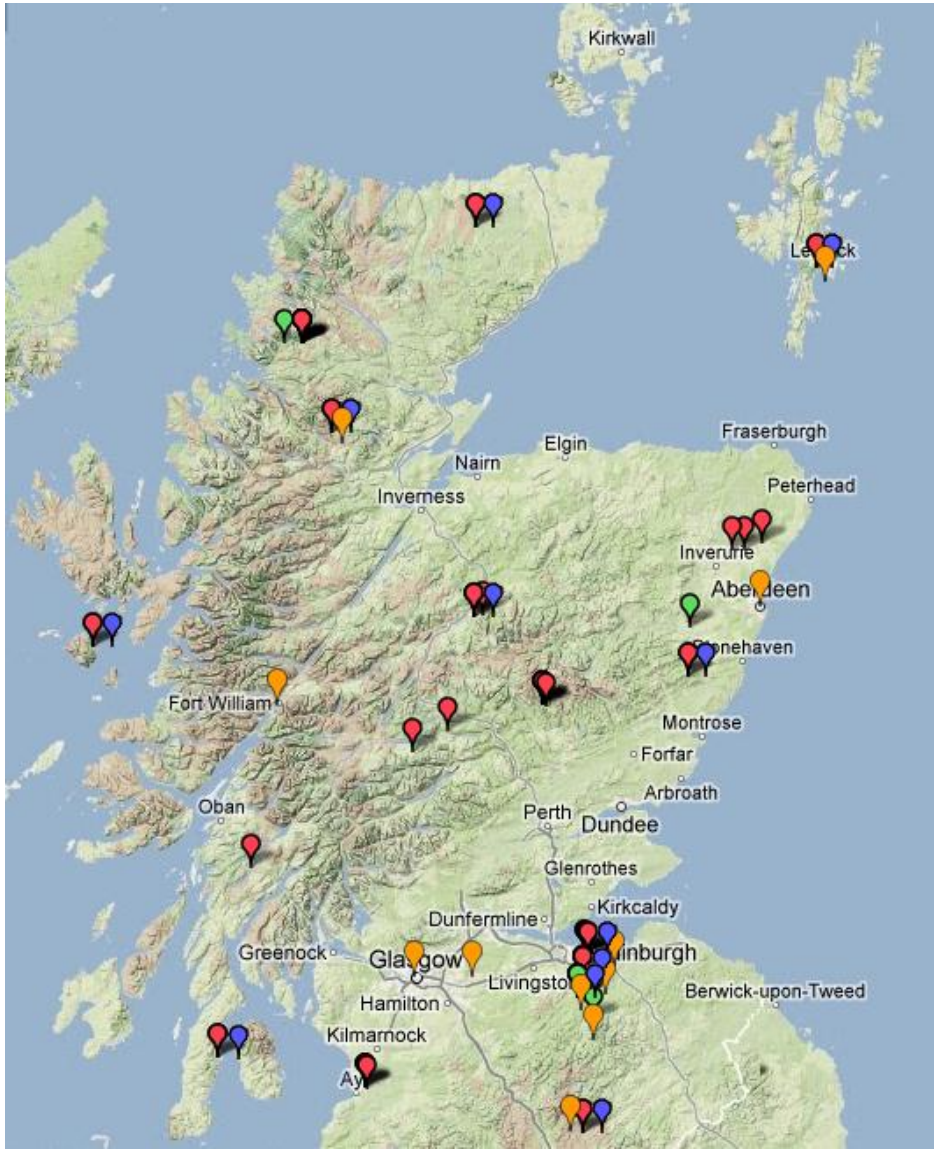
Impact of 2000-2050 climate change only (prescribed future climate: HadGEM SRES A1B)

The RoTAP analysis has been applied across the UK.

The budget values are presented for the UK……but these would not necessarily show the same trends as regional or country trends within the UK.

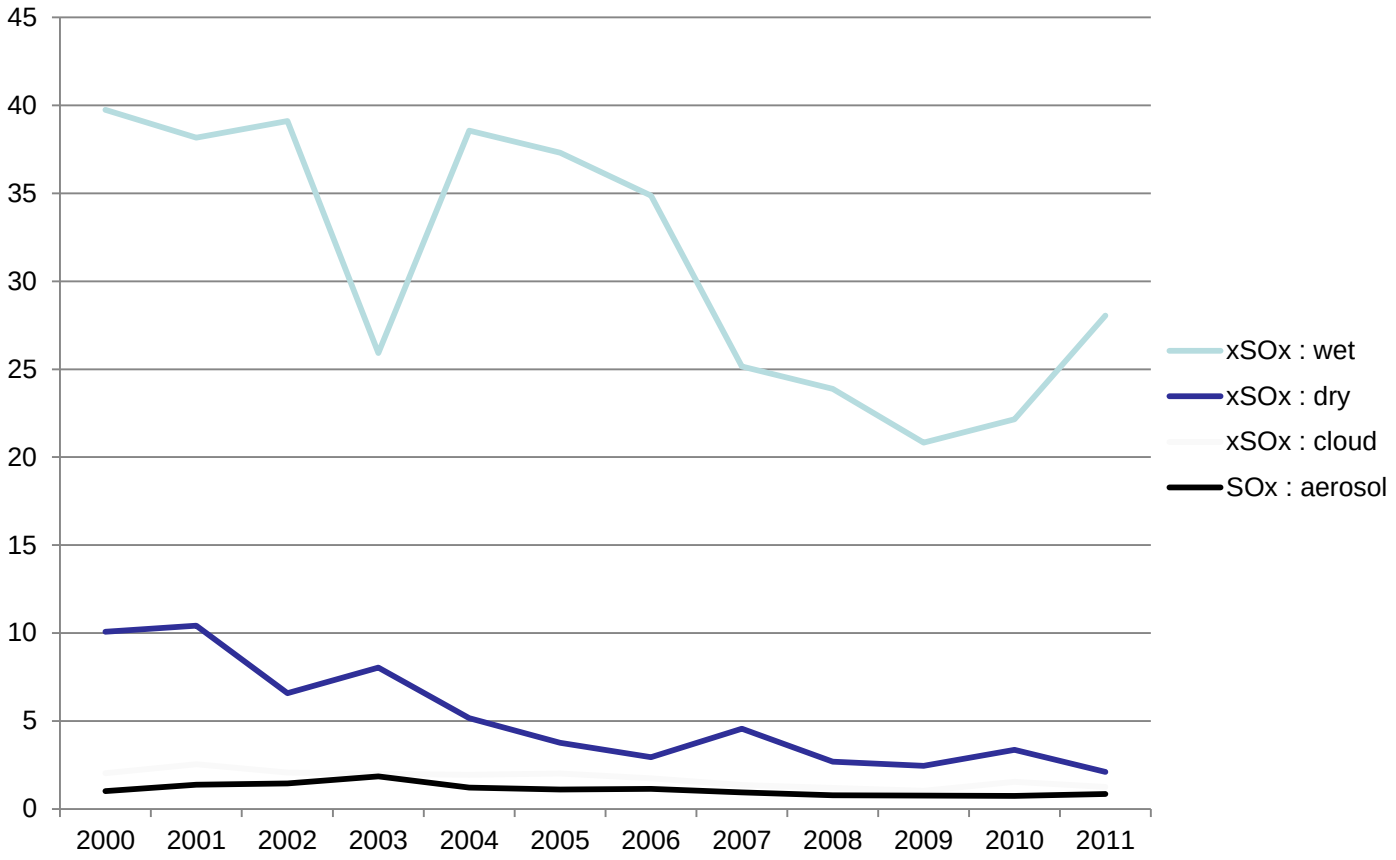
For Scotland:

Scottish Monitoring Sites

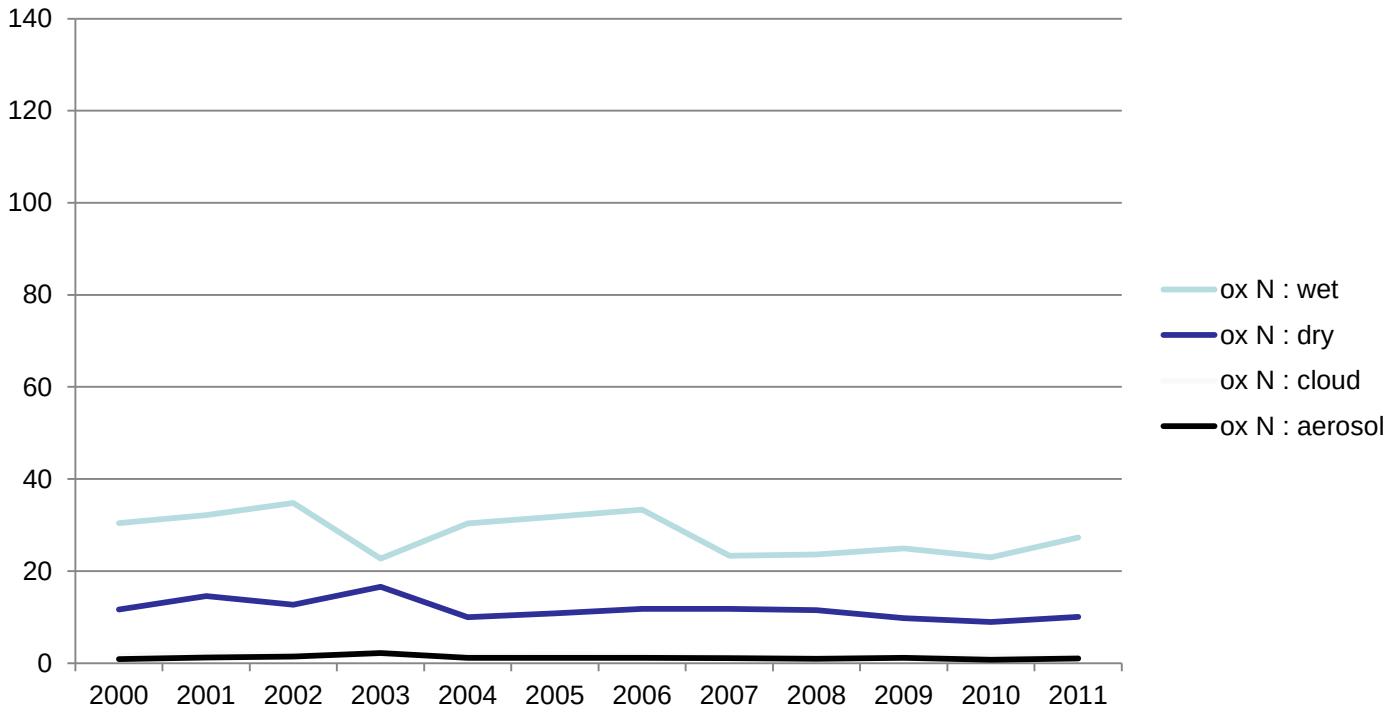


- Ammonia Monitoring Sites
- Acid Gases and Aerosols Sites
- Heavy Metals Monitoring Sites
- Ozone Monitoring Sites

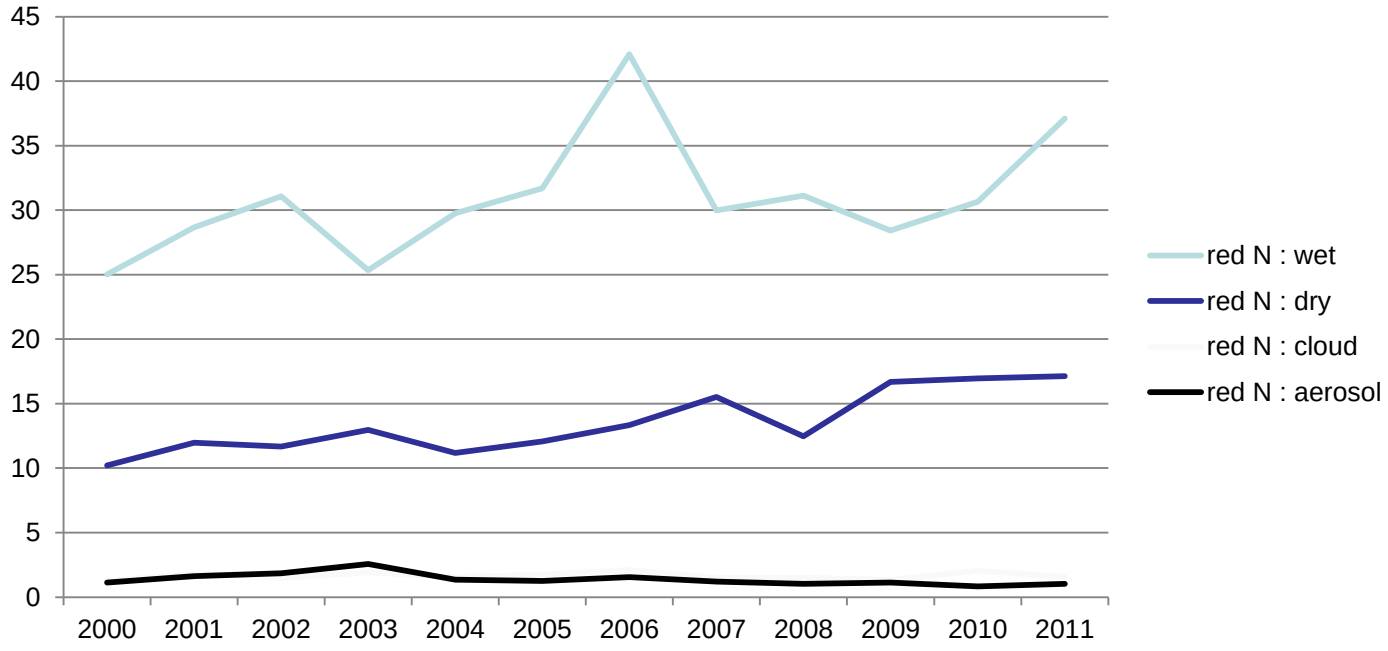
Scottish budget SOx



Scottish budget NOy



Scottish budget NHx



Summary

Acidification:	A success story, but recovery is slow and the potential acidification from N dep remains.
Eutrophication:	Substantial reductions in N emissions have led to small benefits within the UK, there is more to do, on both oxidized and reduced N
Ozone:	Ozone remains a serious problem in the UK, and reduction of background ozone requires control at hemispheric scale.
Metals:	The sources of metals in the UK atmosphere need to be quantified and the emission inventory revised

Summary

Deposition budget trends at the UK scale conceal trends at regional scale which are important both in revealing scientific features of the trend and have significant policy implications