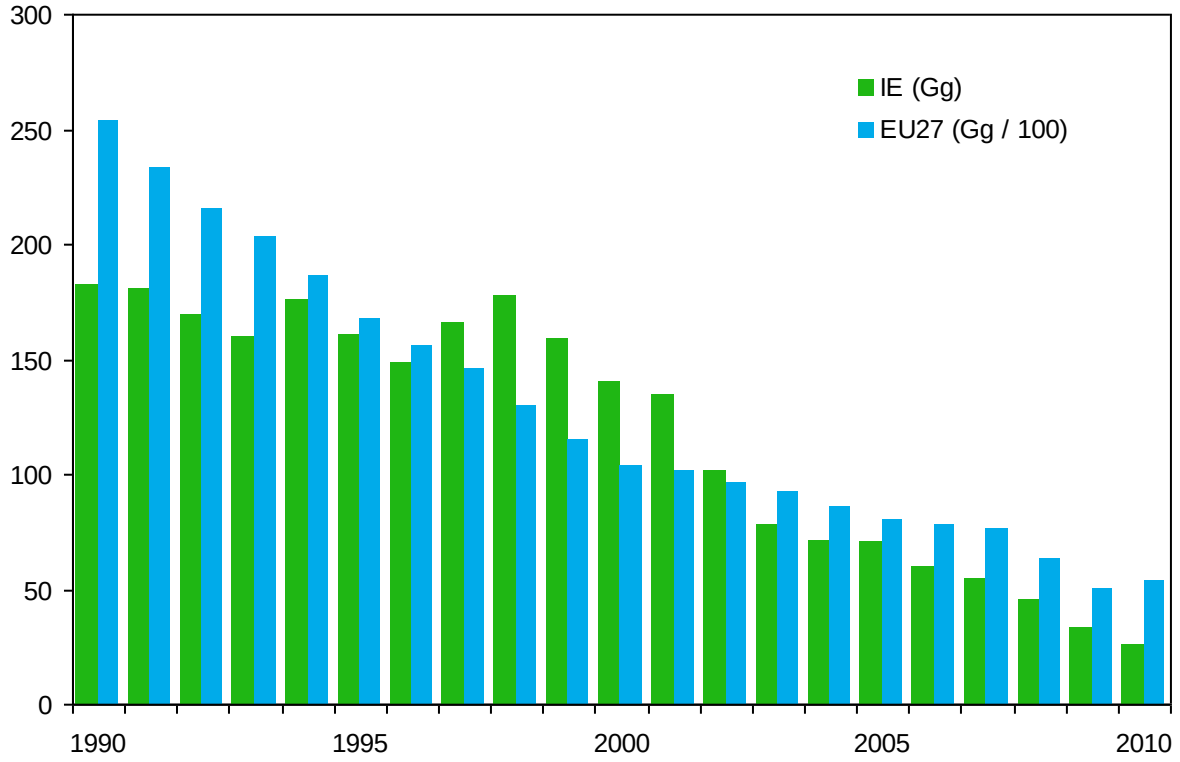
acidification and recovery

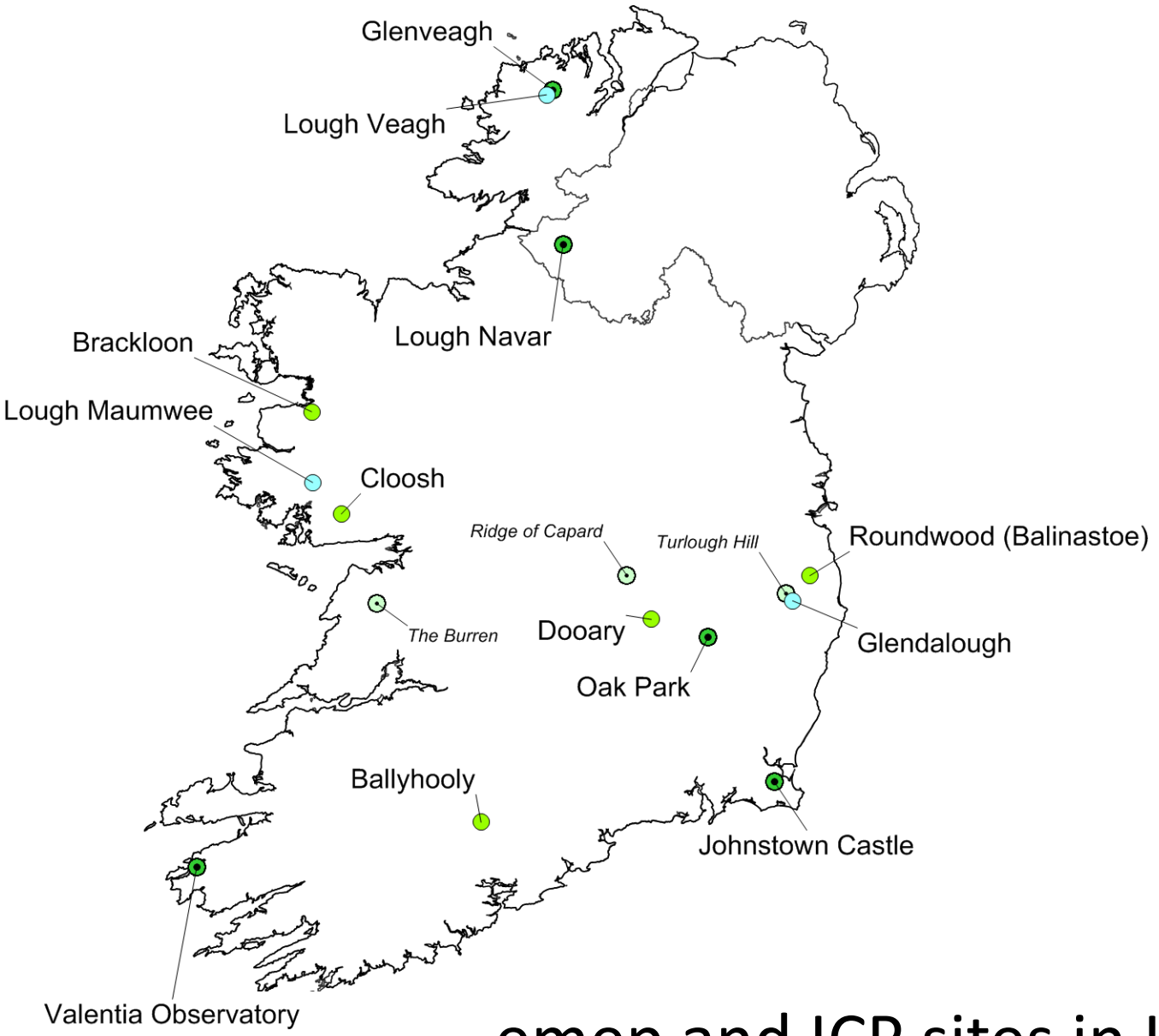
observations from EMEP and ICP sites in Ireland

julian aherne, james johnson, ted farrell, jim bowman…

22nd ICP IM Task Force Meeting & Workshop
Westport, Mayo [07 May 2014]



emissions of sulphur dioxide 1990–2010



emep and ICP sites in Ireland

RAIN. TABLE XI.—*Summary of Results.*

AVERAGES. PROPORTION OF HYDROCHLORIC TO SULPHURIC ACID (CHLORIDES TO SULPHATES).

	Proportion of Hydrochloric to Sulphuric Acid.
Ireland—Valentia	1 to ·056
England—Sea-coast country places, west	1 „ ·10
Scotland „ „ west	1 „ ·294
Waterloo, near Liverpool	1 „ ·31
Scotland, average sea-coast country places	1 „ ·447
„ Sea-coast country places, east	1 „ ·593
„ Inland „	1 „ ·61
Runcorn	1 „ ·92
England—Inland country places	1 „ 1·38
Scotland—Towns (Glasgow not included)	1 „ 2·82
St. Helen's	1 „ 3·48
Liverpool	1 „ 3·90
England—Towns	1 „ 3·94
Newcastle-on-Tyne	1 „ 5·47
Manchester, 1869	1 „ 7·08
Birkenhead	1 „ 7·31
Manchester, average of 1869 and 1870	1 „ 7·68
Glasgow	1 „ 7·82
Manchester, 1870	1 „ 8·29
German specimens	1 „ 12·49
London, 1869	1 „ 16·45
Near an Alkali-Works	1 „ 21·56
Darmstadt—Germany	1 „ 29·98

AIR AND RAIN.

THE BEGINNINGS

OF

A CHEMICAL CLIMATOLOGY.

BY

ROBERT ANGUS SMITH,

PH.D. F.R.S. F.C.S.

(GENERAL) INSPECTOR OF ALKALI WORKS FOR THE GOVERNMENT.

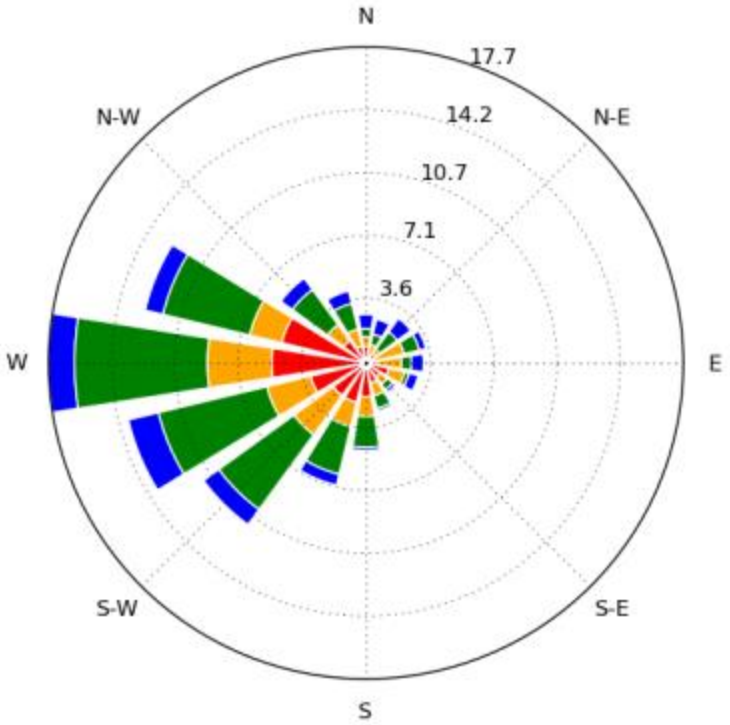
LONDON:

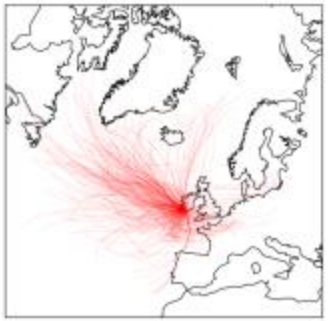
LONGMANS, GREEN, AND CO.

1872.

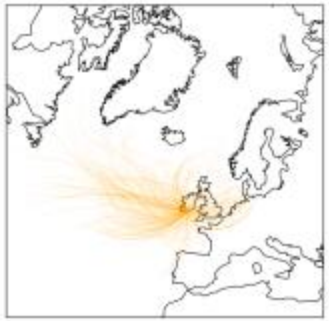

Norwegian Sea
Greenland
Iceland
Sweden
Finland
Norway
North Sea
Denmark
United Kingdom
Ireland
Belarus
Poland
Germany
Ukraine
Austria
France
Romania
Bay of Biscay
Italy
Spain
Greece
Turkey
Portugal
NL
Gulf of St Lawrence
NB
PE
NS
ME
NH
MA
RI
NJ
North

back-trajectories arriving at the west coast (Cork) during 2009

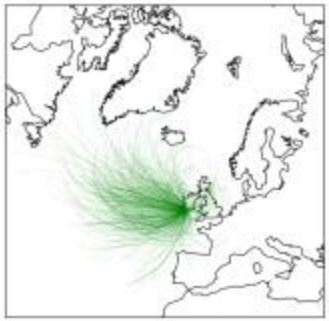




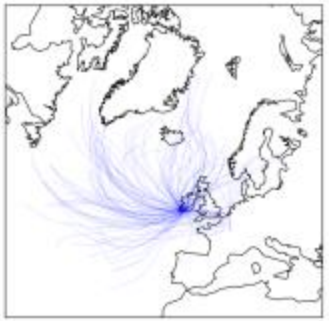
99 days



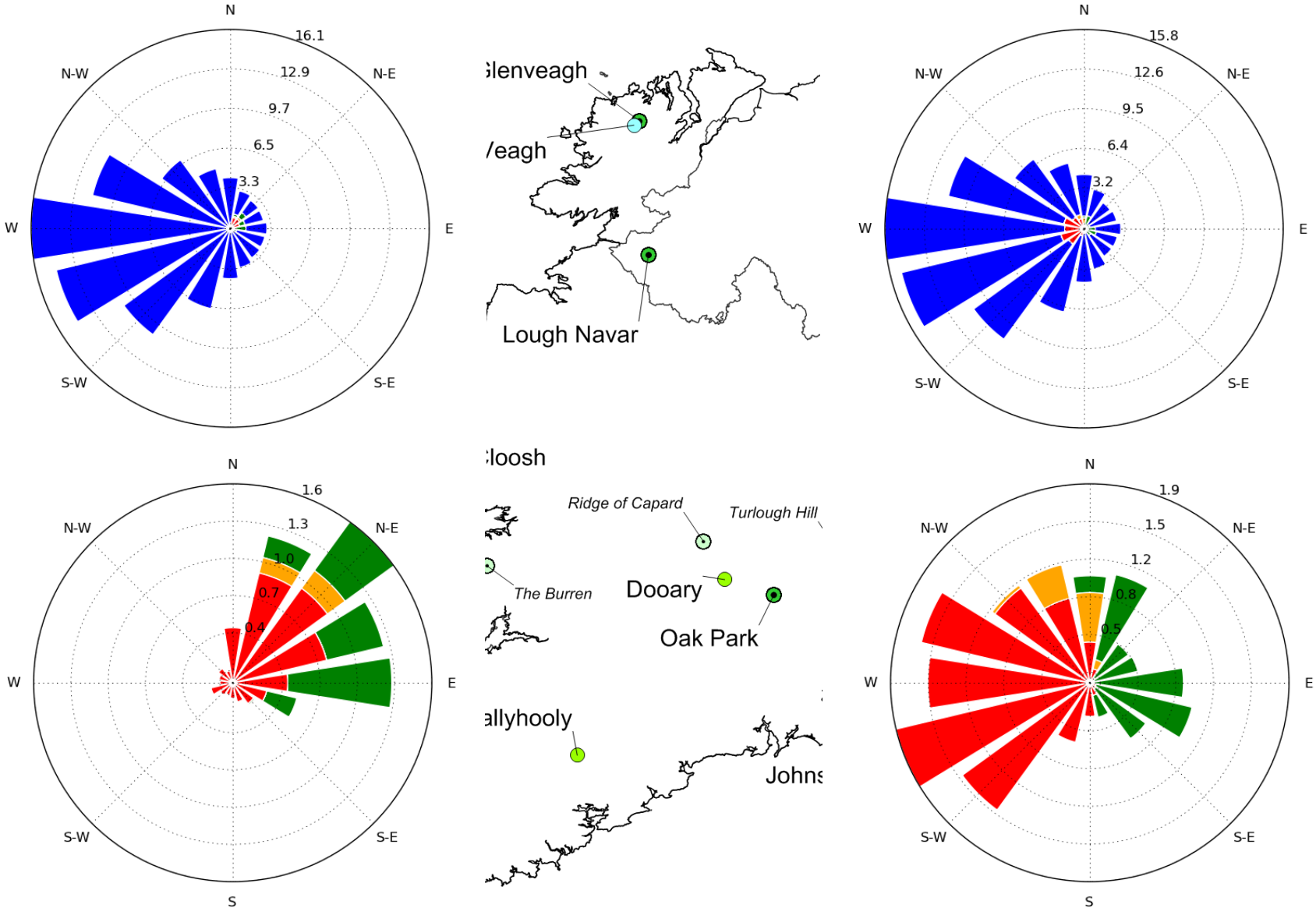
79 days



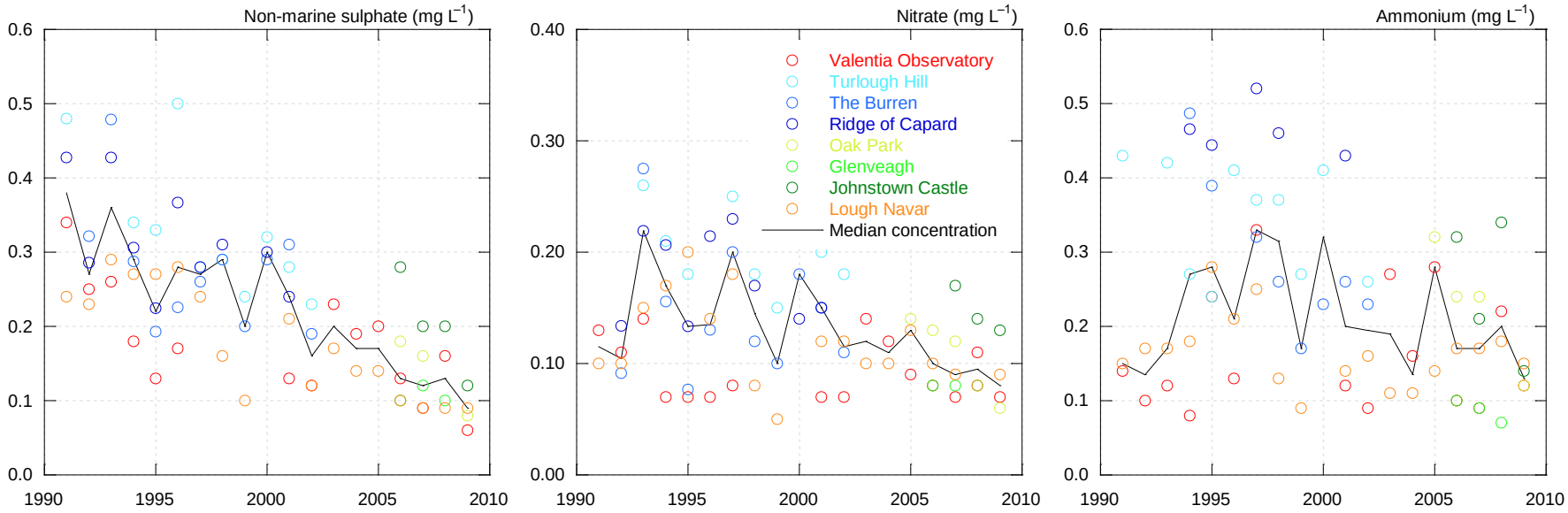
132 days



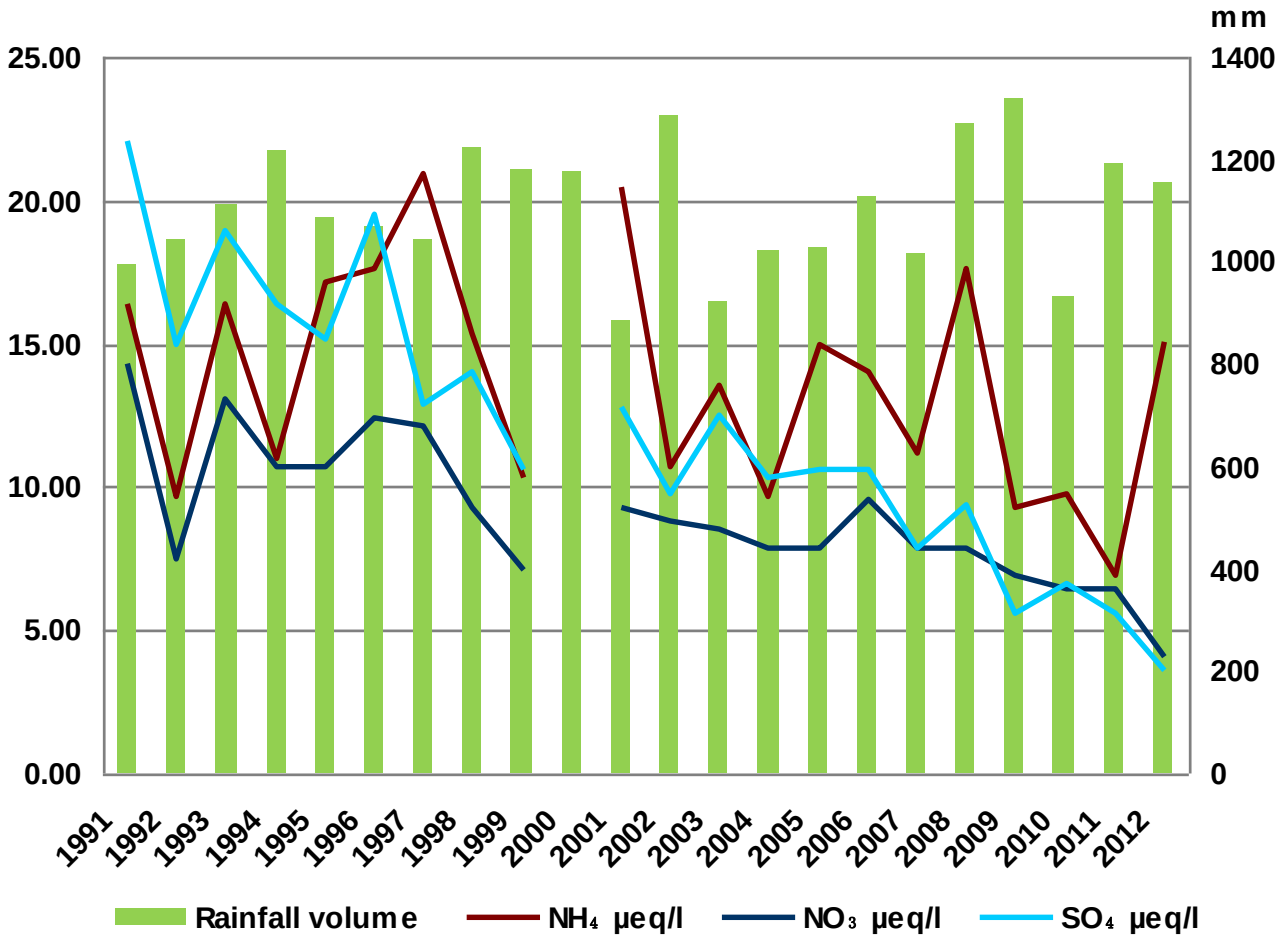
43 days

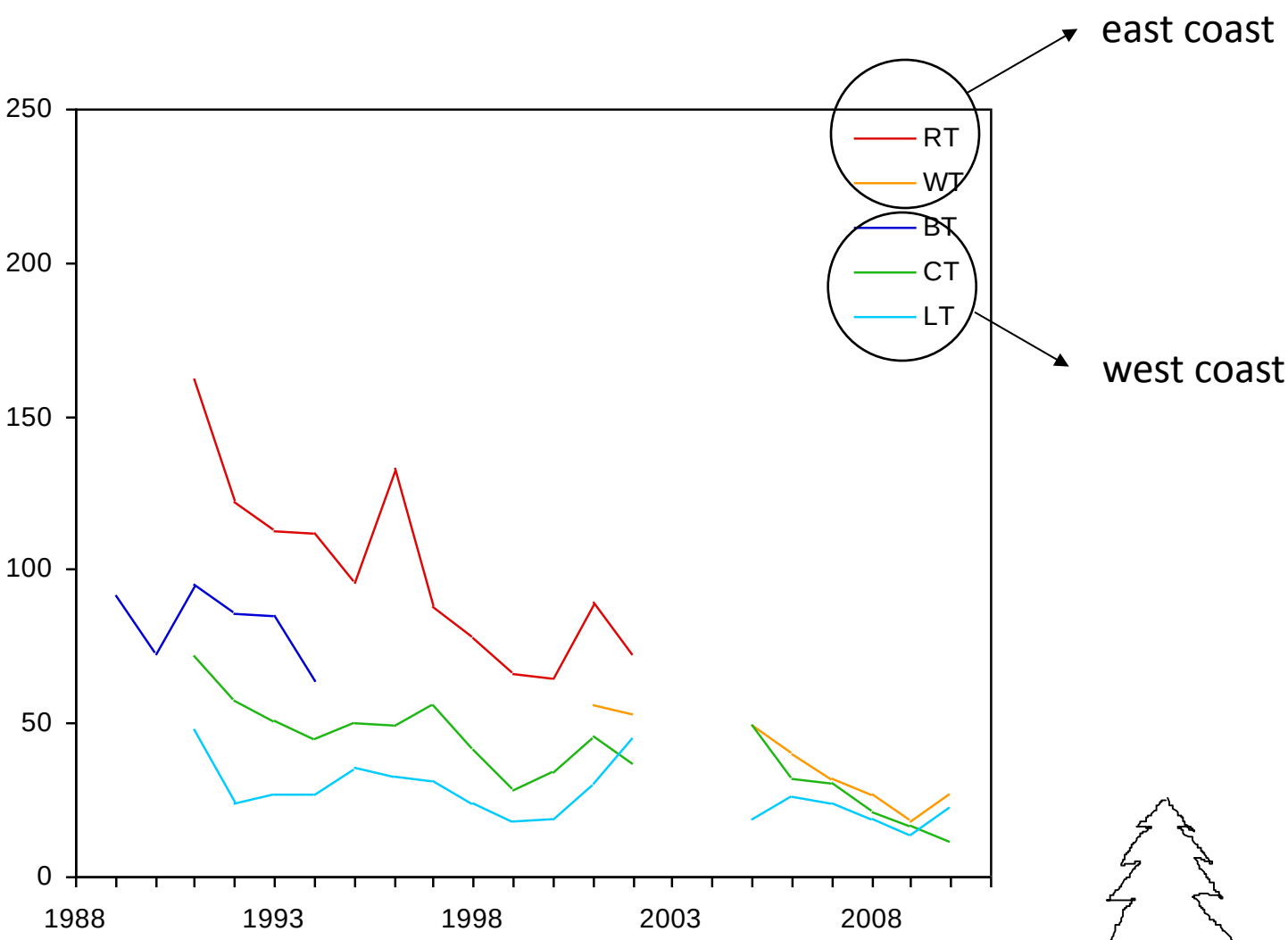


two-day back-trajectories estimated every six hours during the period 1989–2009
Republic of Ireland (red), northern Ireland (orange) and Great Britain (green) only

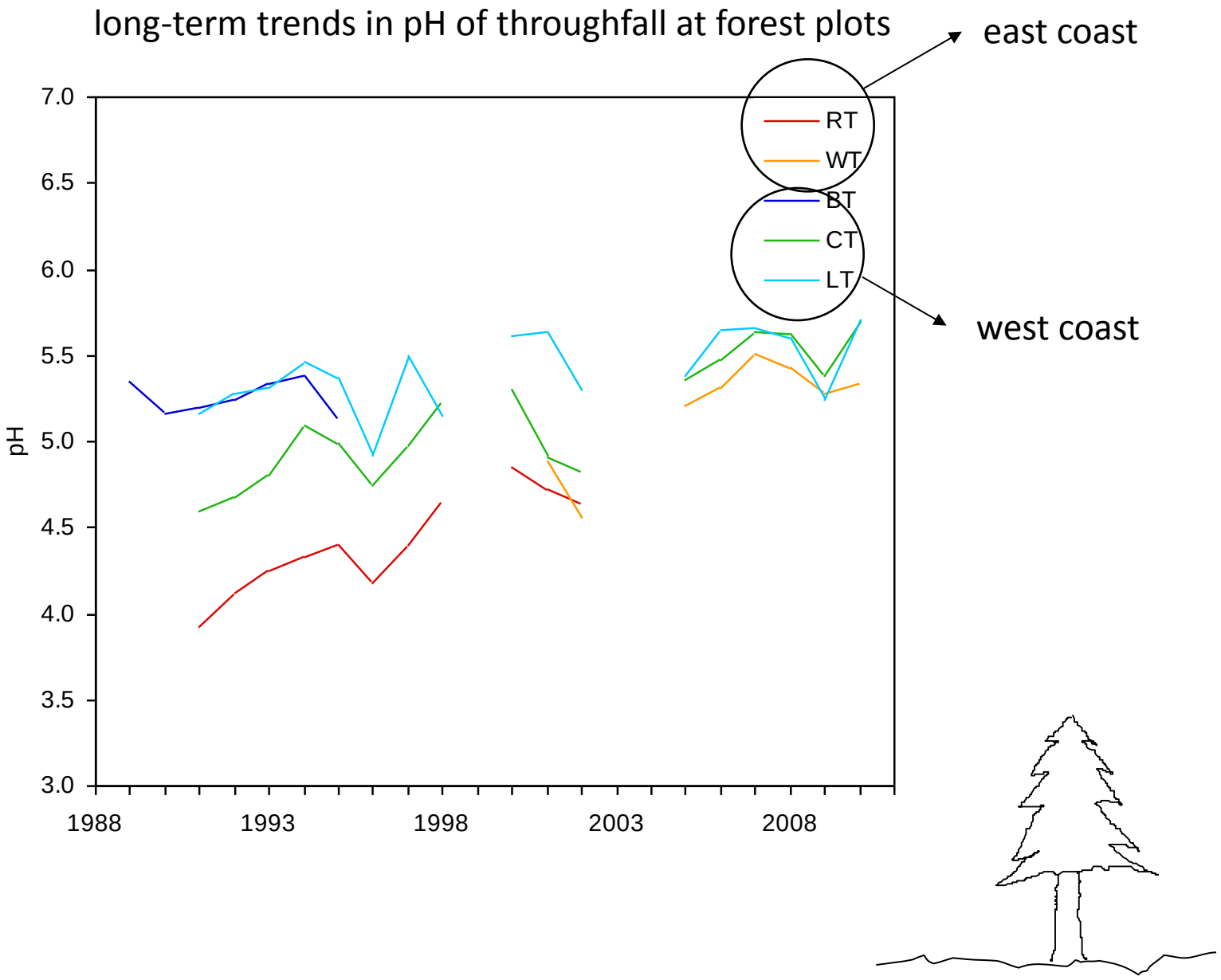


atmospheric deposition | long-term annual trend (1991–2009) in non-marine sulphate, nitrate and ammonium concentration in precipitation (mg L^{-1}) at EMEP stations

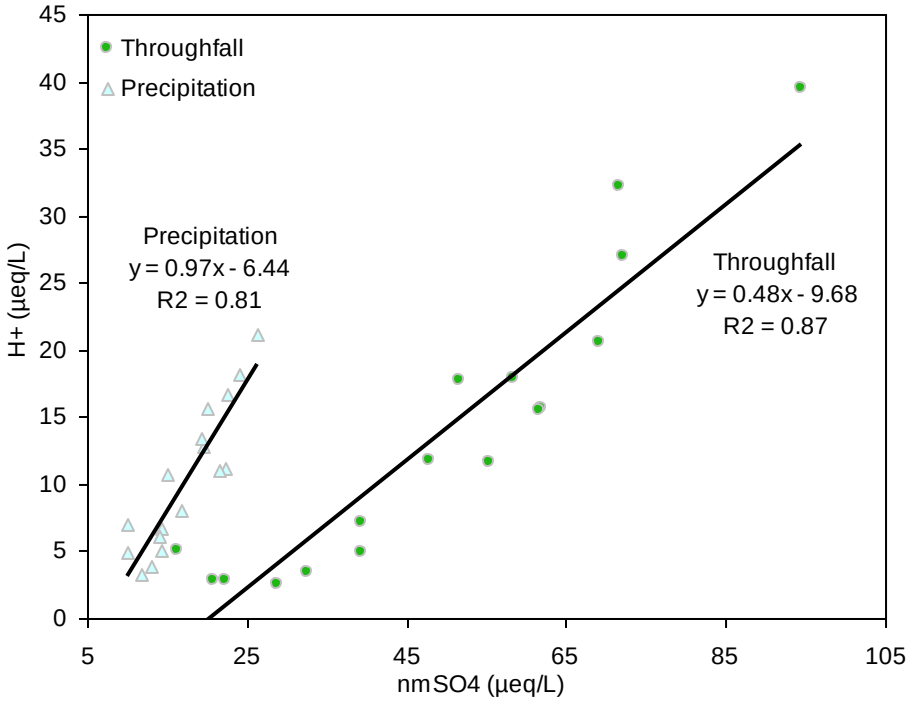

mm
25.00
20.00
15.00
10.00
5.00
0.00
1400
1200
1000
800
600
400
200
0
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Rainfall volume
NH4 µeq/l
NO3 µeq/l
SO4 µeq/l



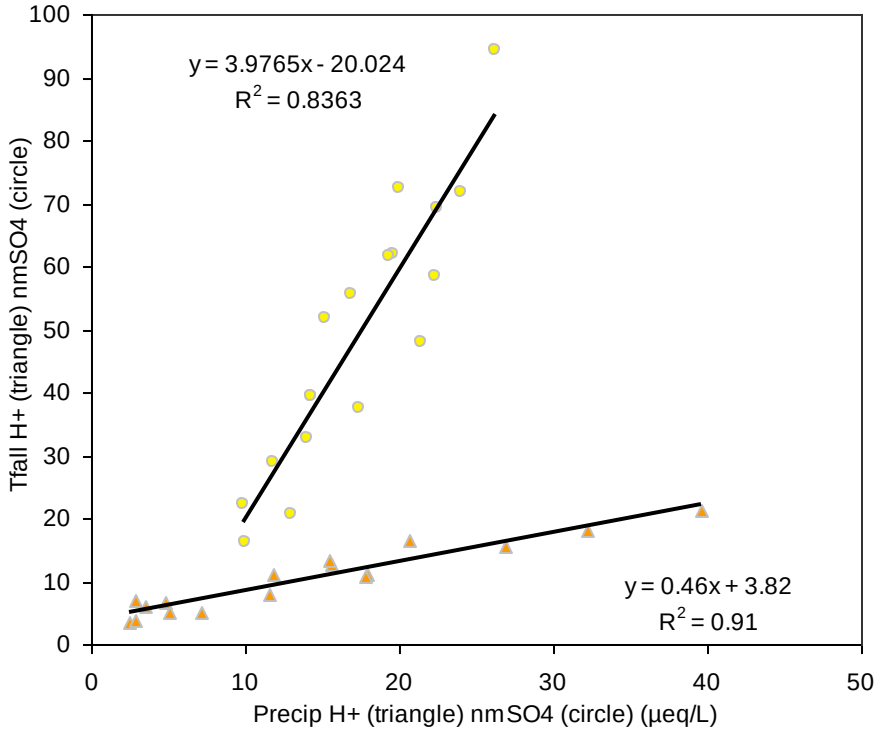
long-term trends in sulphate concentration (µeq L^{-1}) of throughfall at forest plots


long-term trends in pH of throughfall at forest plots
east coast
west coast
RT
WT
BT
CT
LT
pH
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
1988
1993
1998
2003
2008

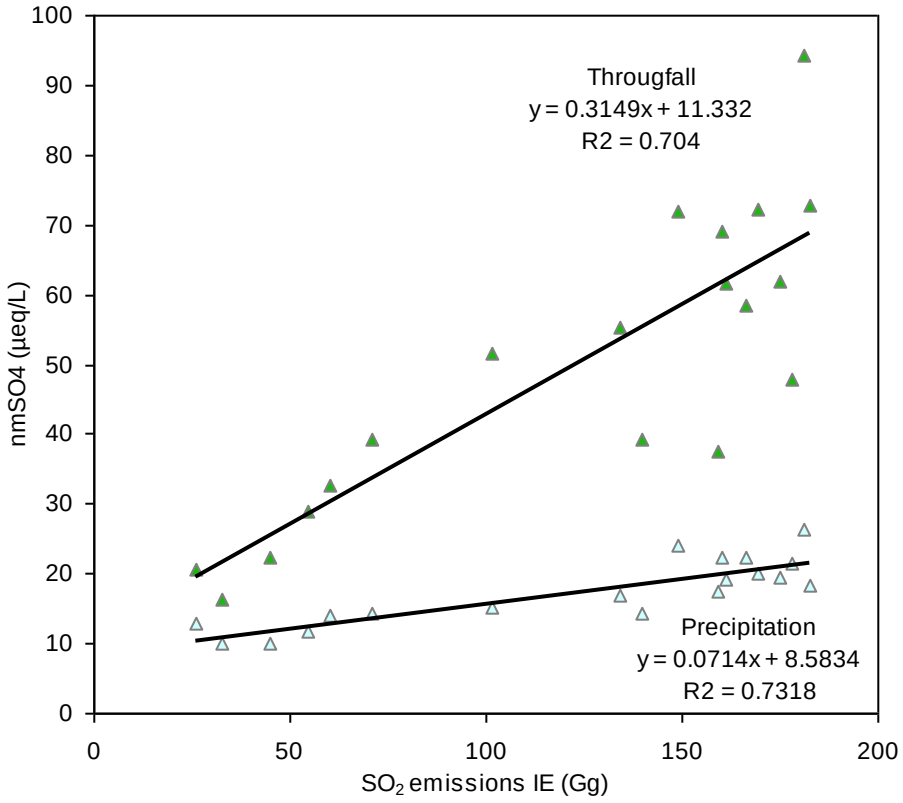
average relationship between pH and sulphate in throughfall [rainfall] at forest plots

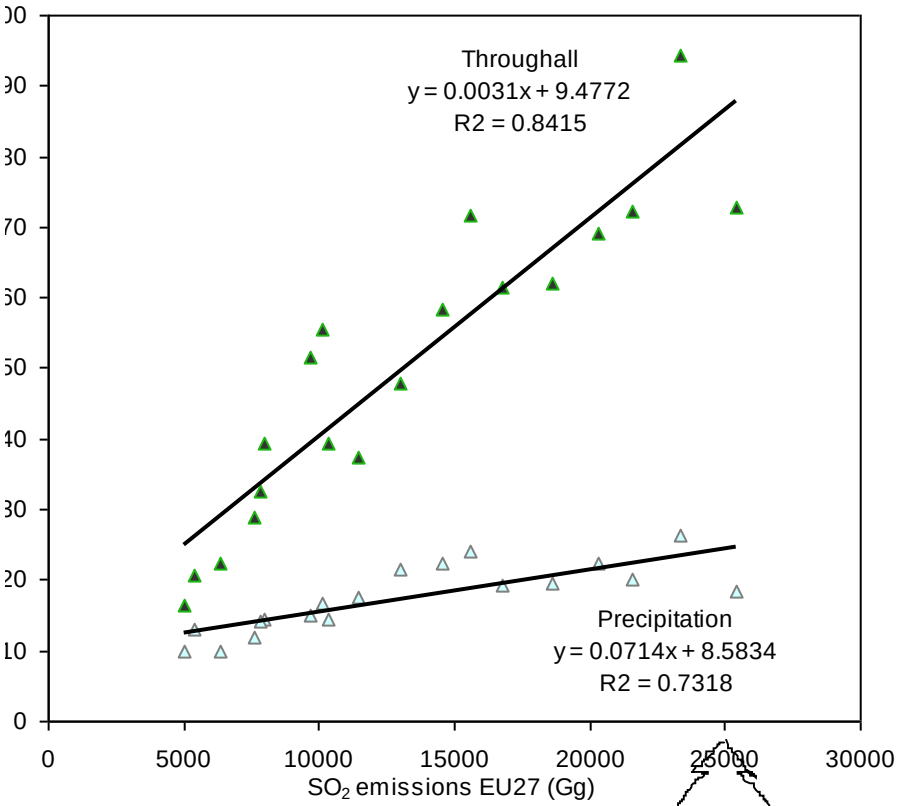


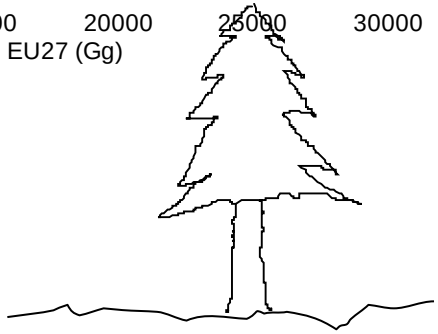
average relationship between precipitation and throughfall at forest plots



relationship of between precipitation [throughfall] with emissions



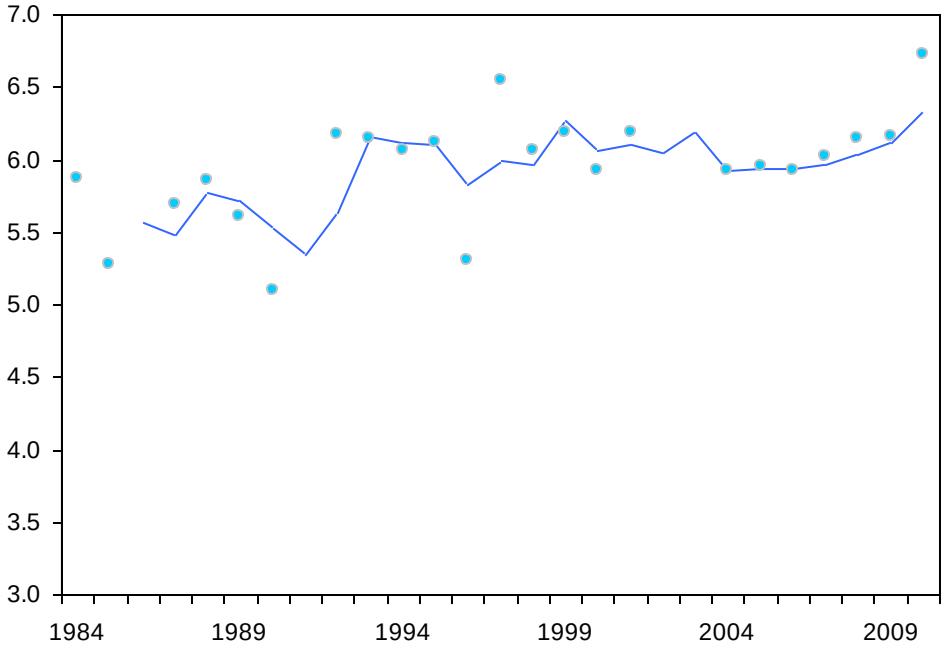




upper lake, glendalough, co. wicklow

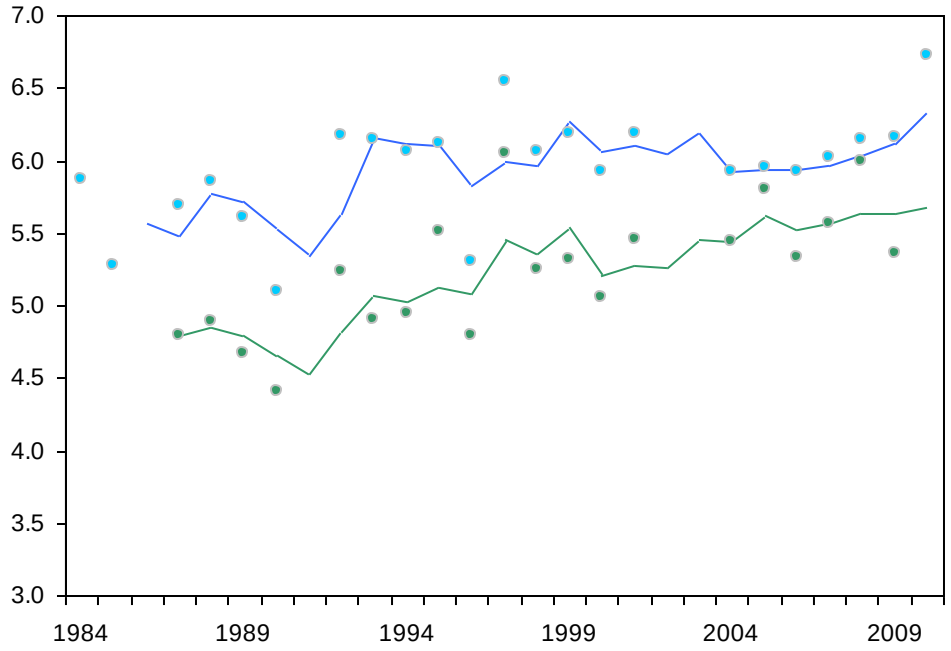
Long-term trend in surface acidity [pH] and relationship to regional precipitation and throughfall acidity signal

pH: mid-lake observations [1984–2010]



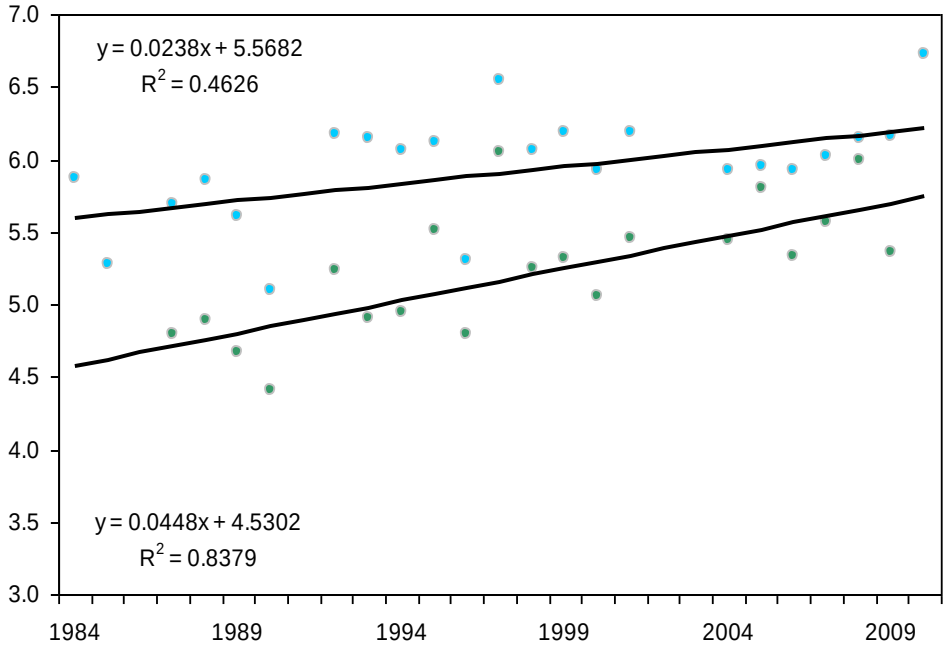
data source: Jim Bowman, EPA

pH: mid-lake observations [1984–2010]
pH: inflow 3 [1984–2010]



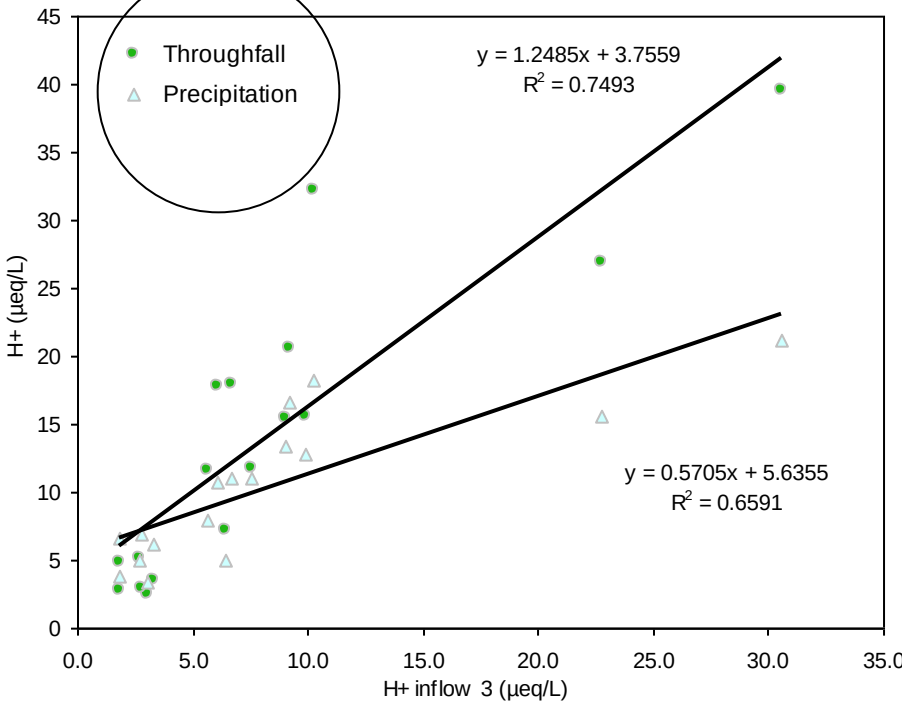
data source: Jim Bowman, EPA

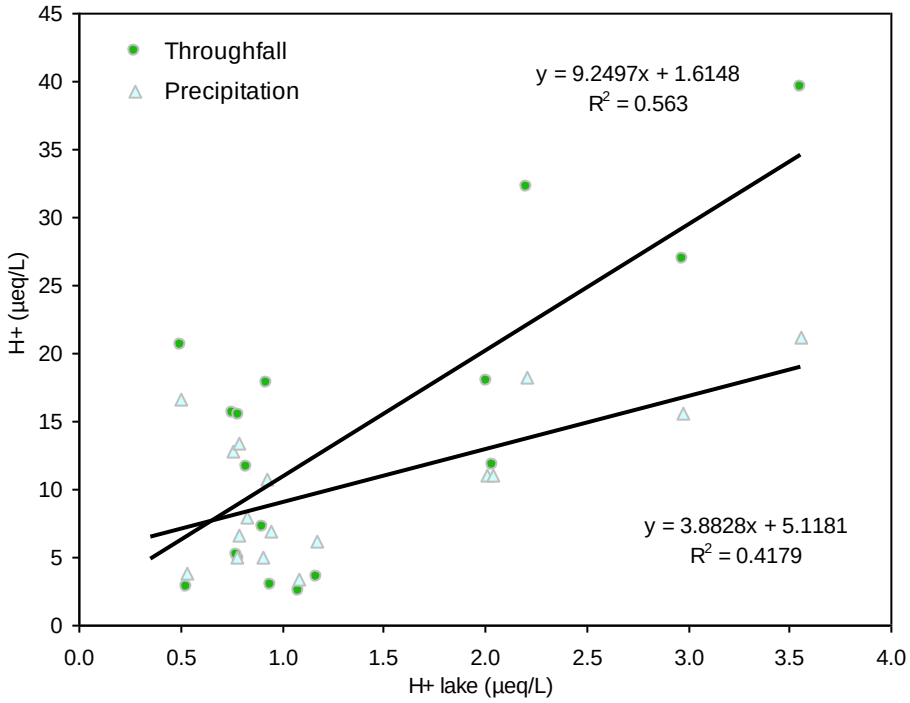
pH: mid-lake observations [1984–2010]
pH: inflow 3 [1984–2010]

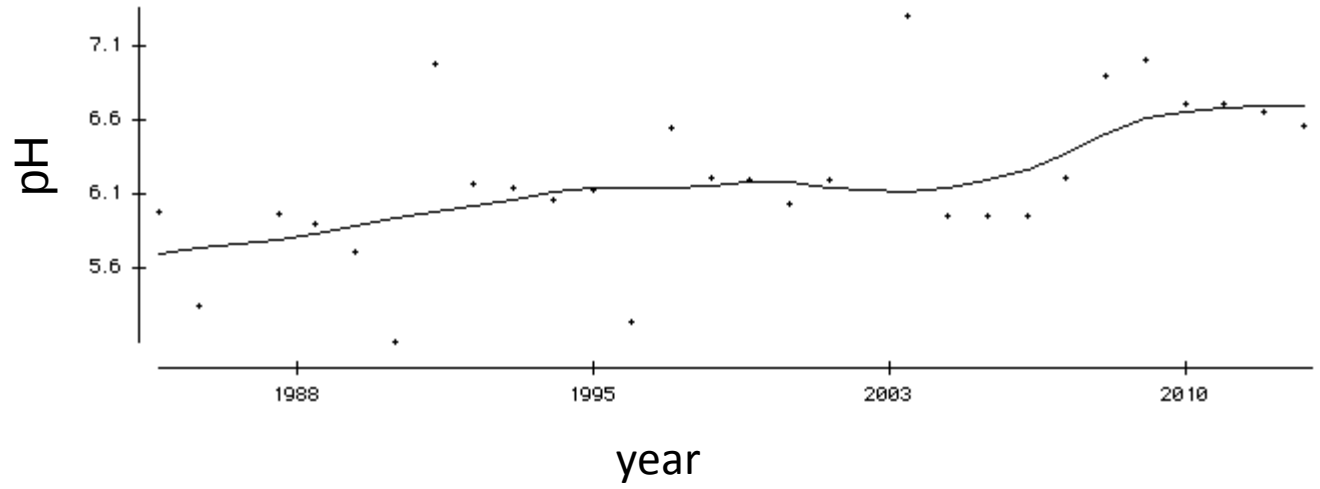


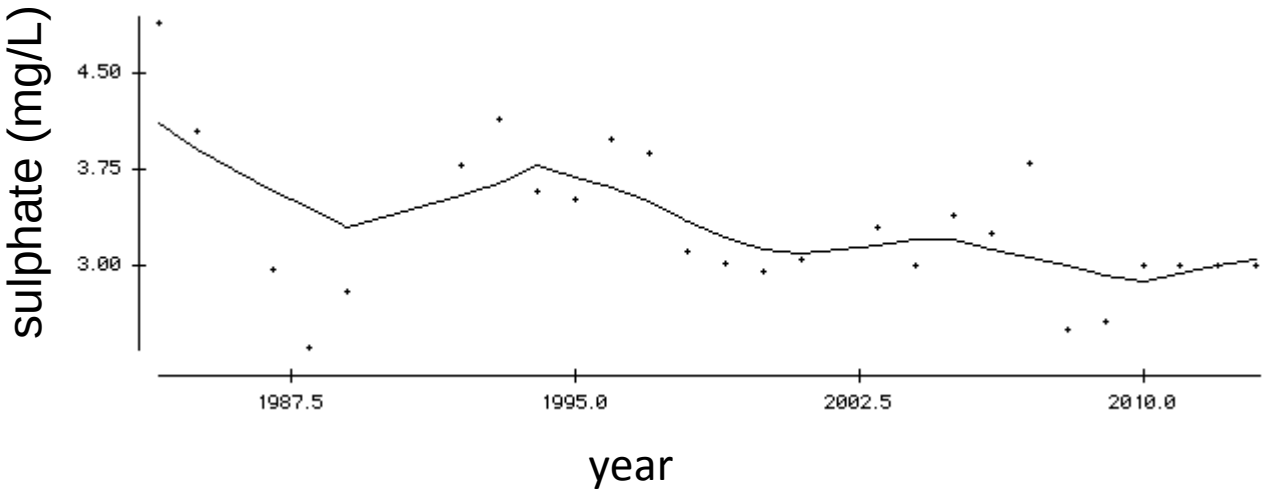
data source: Jim Bowman, EPA

forest monitoring plots

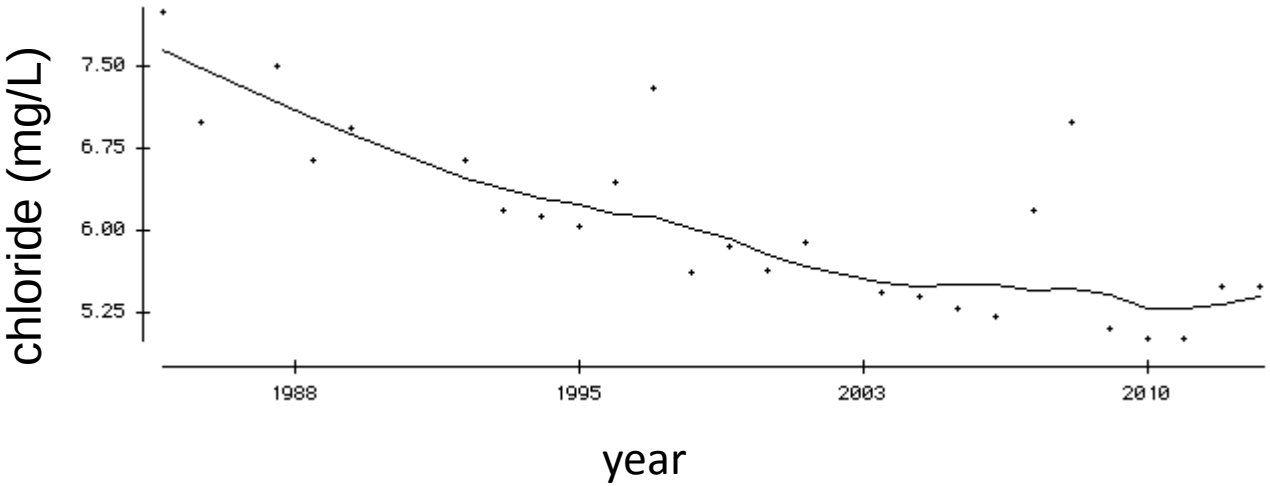


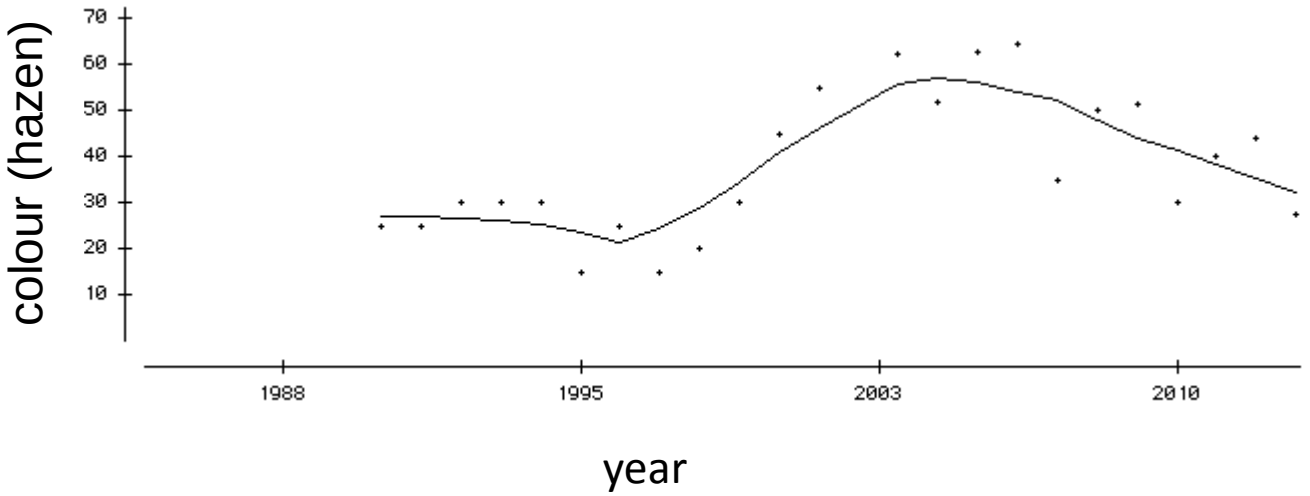




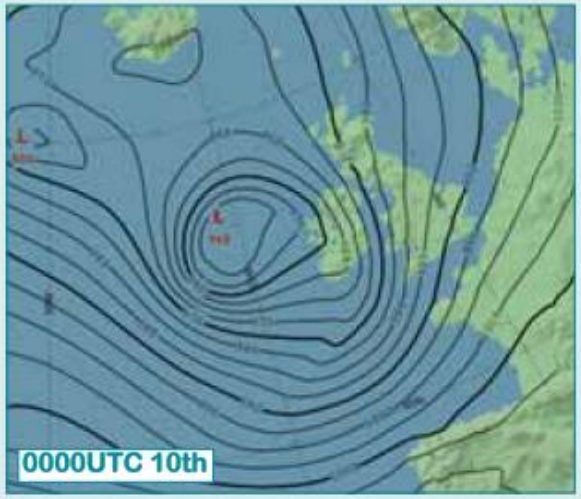


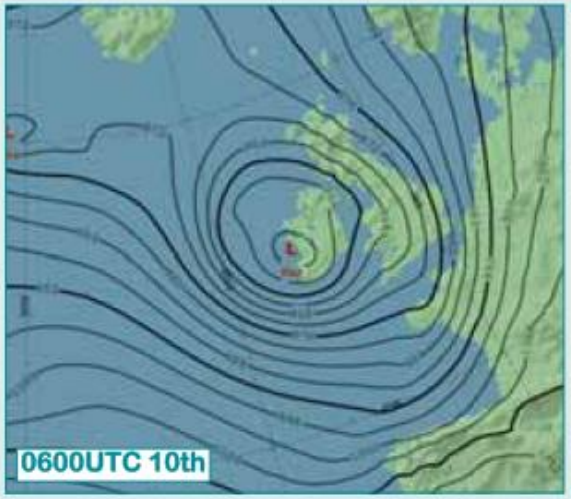
warning! poor-quality slide

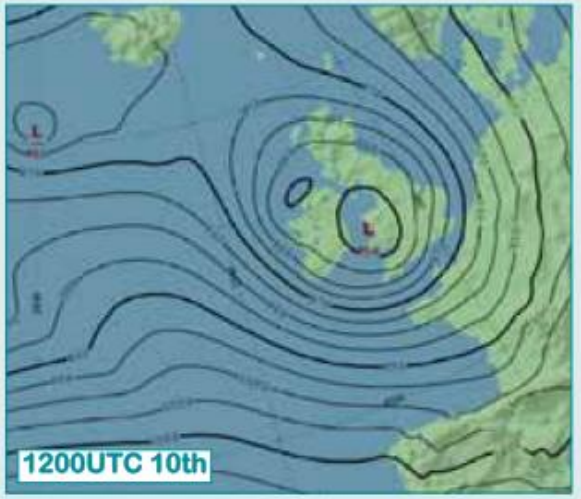

chloride (mg/L)
7.50
6.75
6.00
5.25
1988
1995
2003
2010
year


colour (hazen)
70
60
50
40
30
20
10
1988
1995
2003
2010
year

Lowest March pressure on record for Ireland on 10th



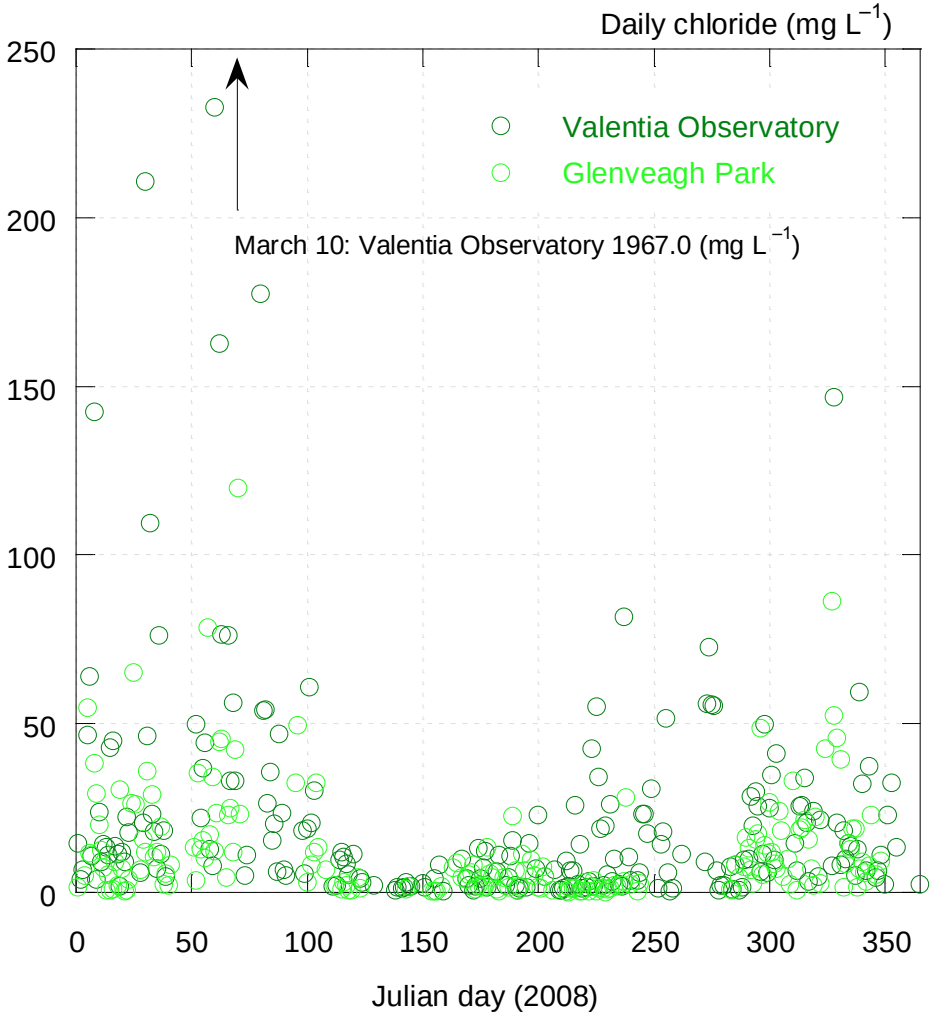


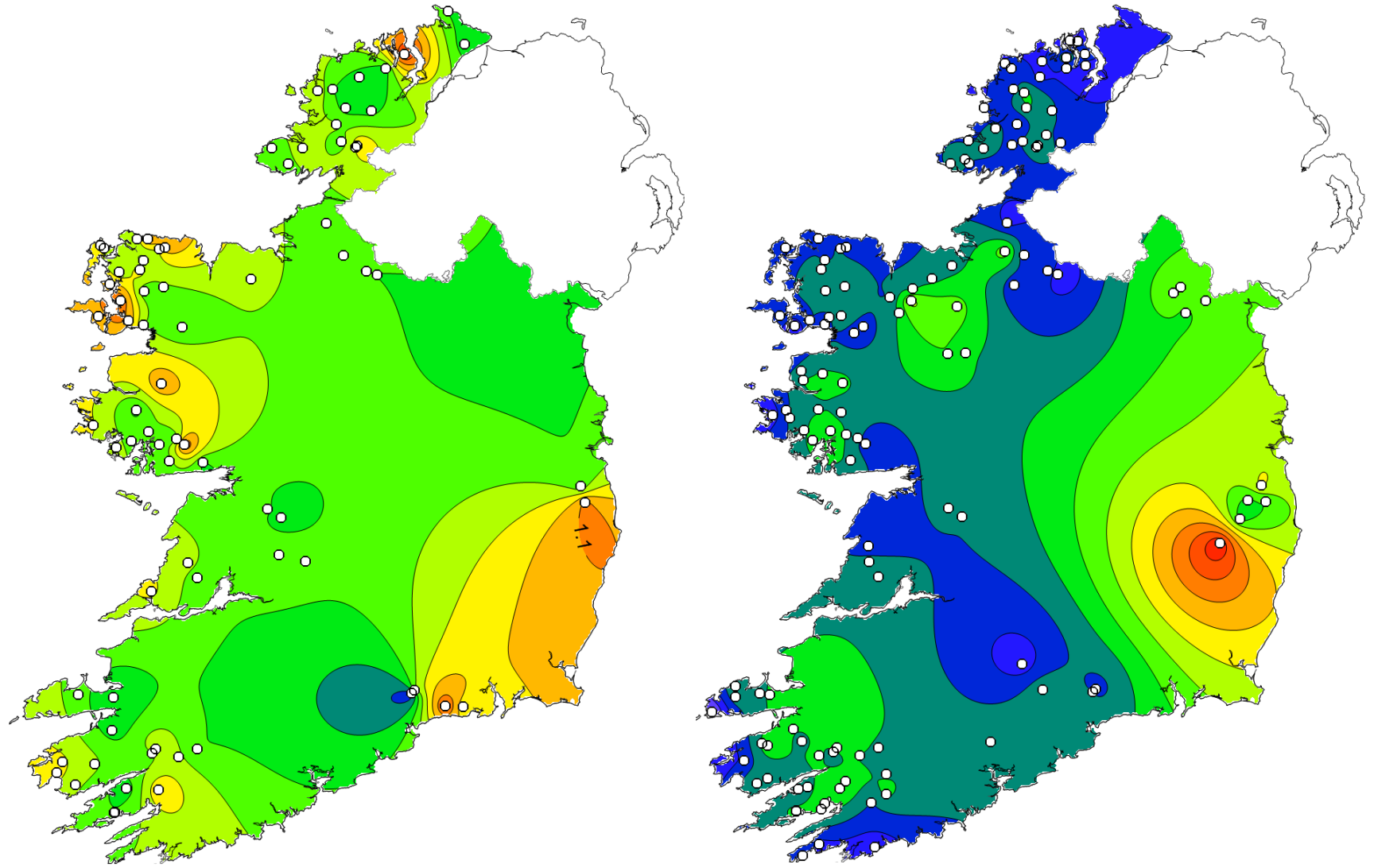


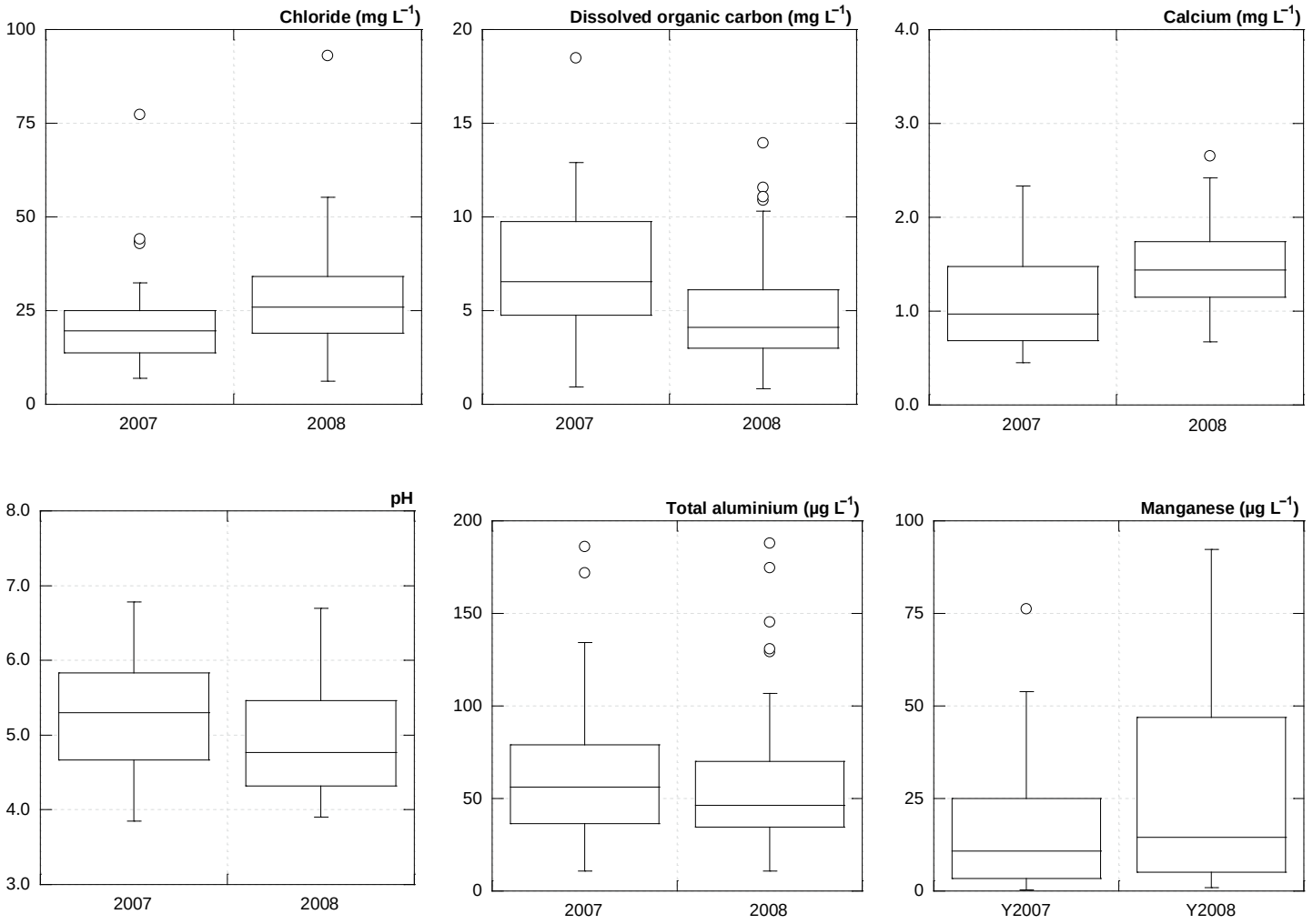
MET éireann

"*Lowest March pressure on record for Ireland on 10th*" Met Eireann, Monthly Weather Bulletin, March 2008.

"*Deep depressions passing close to or over Ireland brought very unsettled conditions, with strong winds and spells or rain or showers each day. All areas received heavy rain between the 9th and 11th… The same period produced very strong winds…*"




1:1
Na:Cl ratio
1.25
1.20
1.15
1.10
1.05
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60



box-plot comparison of paired lake chemistry (n ~ 50) observations from the 2007 and 2008 surveys, before and after the 10 March 2008 sea-salt event.

During the last two to three decades, the (acid-base) hydrochemistry of forests and lakes have responded to changes in atmospheric deposition owing to changes in emissions of sulphur (national and international).

Trends are noisey owing to sea-salt inputs (sea-salt events) which have a profound and widespread impacts on lake chemistry (albeit temporary).

conclusions


epa
Environmental Protection Agency
An Ghníomhaireacht um Chaomhnú Comhshaoil


Department of
Agriculture,
Food and the Marine
An Roinn
Talmhaíochta,
Bia agus Mara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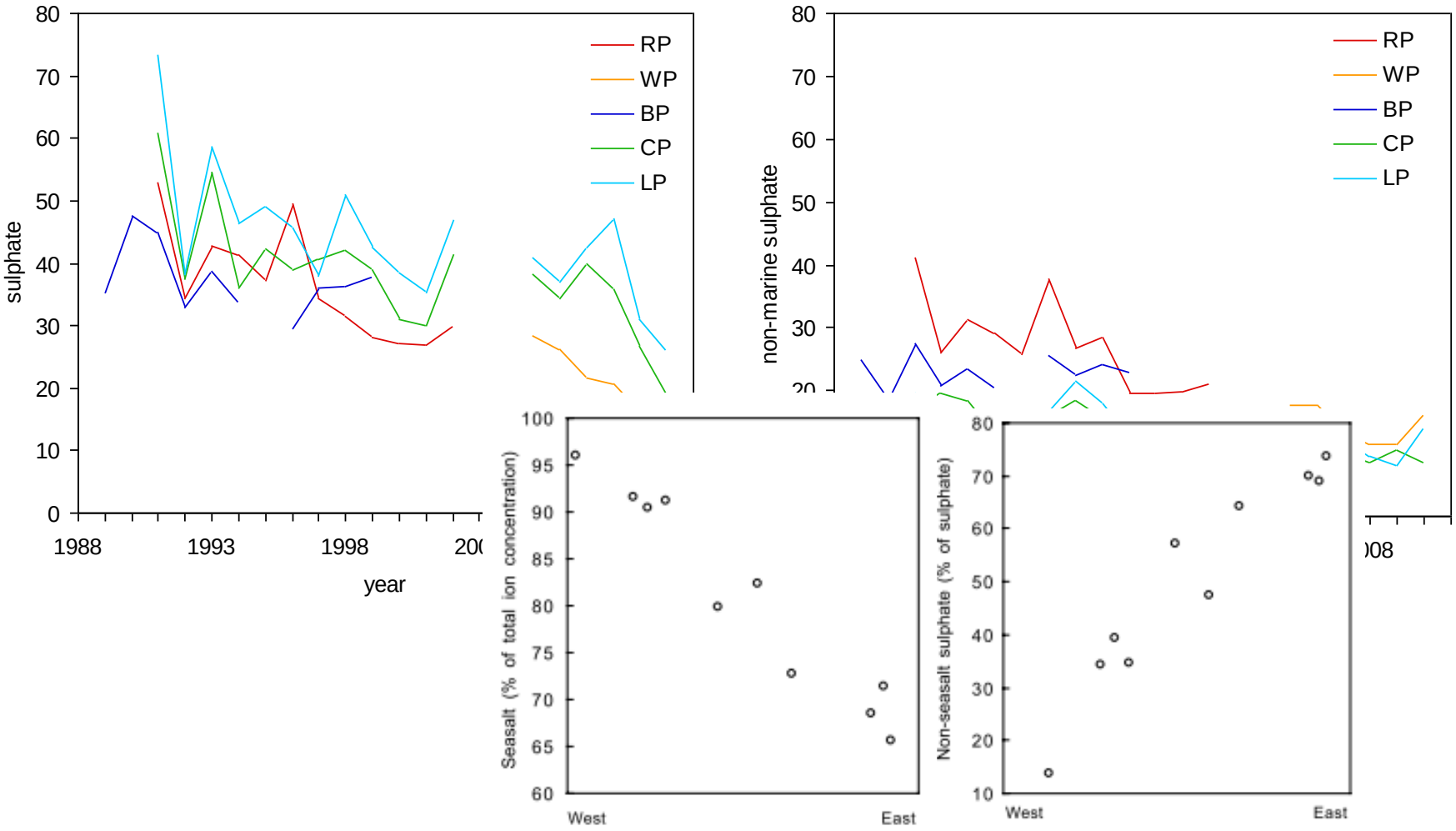
National Development Plan 2007 - 2013


coillte

long-term trends in sulphate concentration (µeq/L) in precipitation at forest plots



long-term trends in pH in precipitation at forest plots