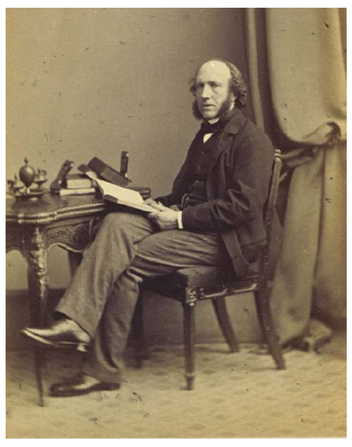
Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL
enquiries@ceh.ac.uk
www.ceh.ac.uk

Chemical climatology: A case study for ozone

Christopher S. Malley[1,2], Gina Mills[1], Christine F. Braban[1], and Mathew R. Heal[2]

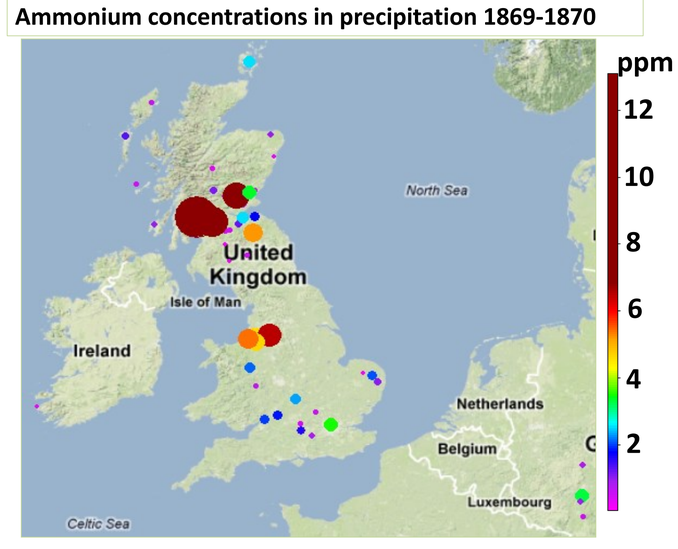
[1]NERC Centre for Ecology & Hydrology, UK; [2]School of Chemistry, University of Edinburgh, UK

Historical perspective



• In 1872, Robert Angus Smith published *Air and Rain: Beginnings of a chemical climatology*[1].

Air and Rain assessed the health impact in cities using spatial/temporal trends and source apportionment.



Chemical climatology framework[3]

• Standard impact-focused approach used *e.g. Köppen-Geiger meteorological climate*[2]

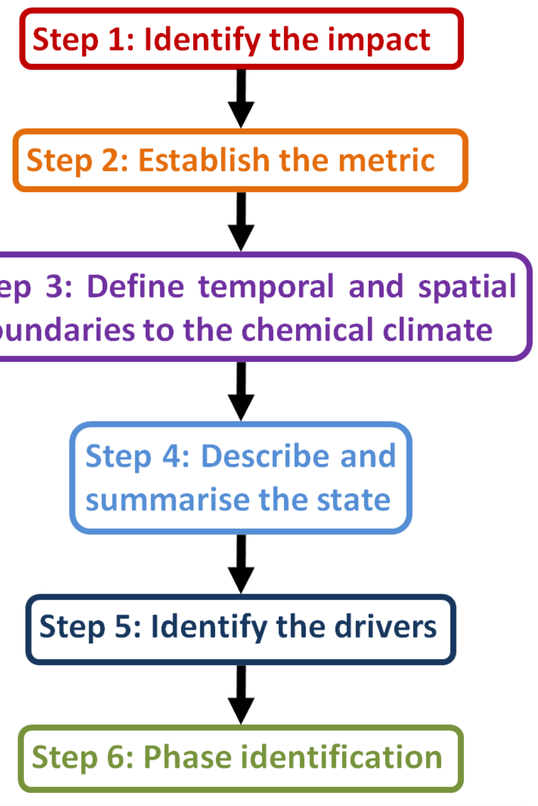
• Three basic components :

➢ **Impact**: atmospheric composition effects

➢ **State**: identify temporal/spatial atmospheric composition variations relevant to impact.

➢ **Drivers**: Characterise determinants of atmospheric composition state & impact.

• Significant impact changes demarcate chemical climate **phase** changes.



Ozone impacts case study: Harwell and Auchencorth EMEP supersites

Auchencorth (data: 2007-2013)

Harwell (data: 1990-2013)

Impact metrics:

Human health[4]
SOMO10/35
(Sum of daily max 8 hr O_3 above 10 /35ppb)

Vegetation[5]
PODy
(accumulated stomatal flux of O_3 above threshold)

State:

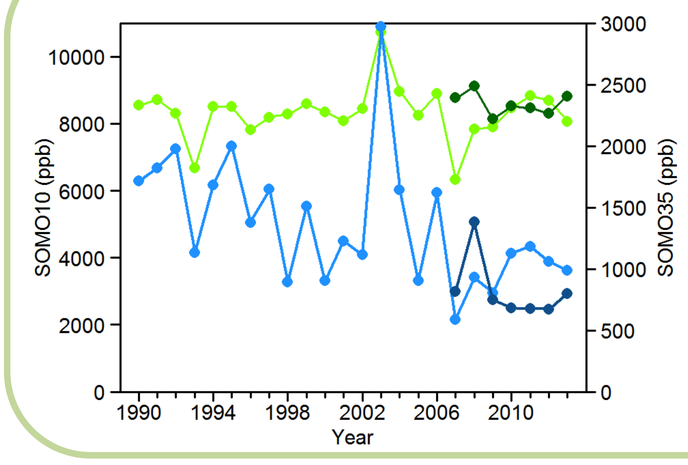
•Monthly contribution to metric
• Diurnal O_3 & NO_x variation

Drivers:

• Temperature
• Back trajectory origin
• NO_x emissions exposure

O_3 Human Health impact: SOMO10/35

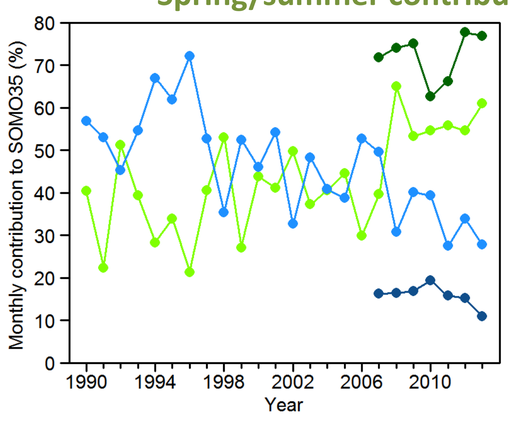
SOMO10/35 changes over time



Harwell
• Significant decrease in SOMO35 (-2.2% y^{-1}) , no trend in SOMO10.

Auchencorth
• Lower SOMO35 and similar SOMO10 compared to Harwell

Spring/summer contributions to SOMO35 over time



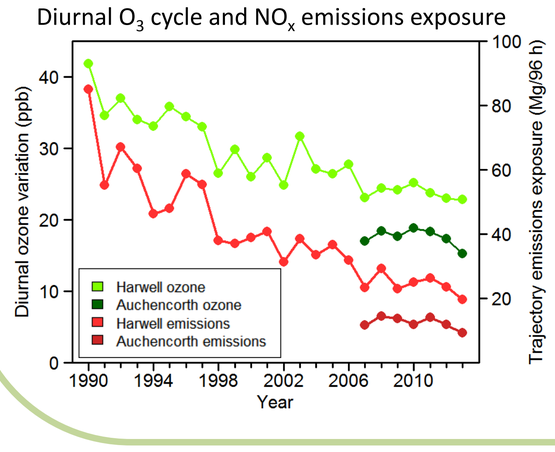
Harwell
• Decreasing summer contribution to SOMO35, increasing spring contribution.

Auchencorth
• Larger spring contribution, smaller summer contribution *c.f.* Harwell

Spring: March-April-May
Summer: June-July-August

Chemical contributions to SOMO35 over time

Diurnal O_3 cycle and NO_x emissions exposure



Harwell
• Decreasing O_3/NO_x cycle amplitude
• Decreasing contribution from regional O_3

Auchencorth
• Smaller O_3/NO_x cycle amplitude *c.f.* Harwell
• Greater hemispheric influence at Auchencorth

O_3 vegetation impact: PODy

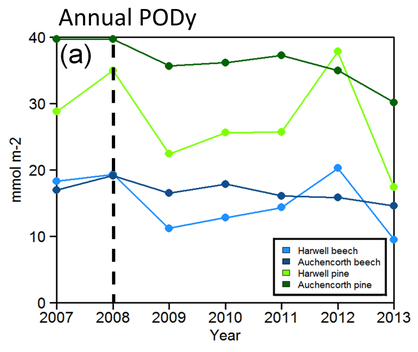
Average PODy and response for four vegetation types for 2007-2013

Average 2007-2013	Wheat PODy (mmol m^{-2})	Wheat yield reduction (%)	Potato PODy (mmol m^{-2})	Potato tuber reduction (%)	Beech PODy (mmol m^{-2})	Beech biomass reduction (%)	Scots pine PODy (mmol m^{-2})
Harwell	1.1 ± 0.9	4.3 ± 3.3	2.1 ± 0.9	2.7 ± 1.1	15.1 ± 4.2	16.6 ± 4.6	27.5 ± 7.0
Auchencorth	1.0 ± 0.4	3.7 ± 1.4	1.0 ± 0.4	1.3 ± 0.5	16.7 ± 1.5	18.4 ± 1.6	36.2 ± 3.3

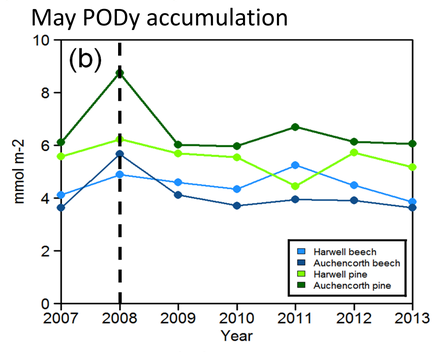
• No significant changes in PODy for any vegetation at Harwell over the period
• PODy higher at Auchencorth for forest trees, higher at Harwell for crops.

Case study: Influence of regional O_3 production on beech & Scots pine impacts in May 2008

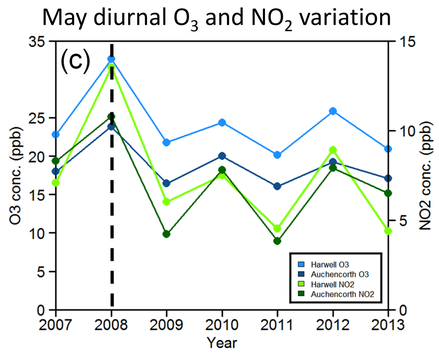
Annual PODy



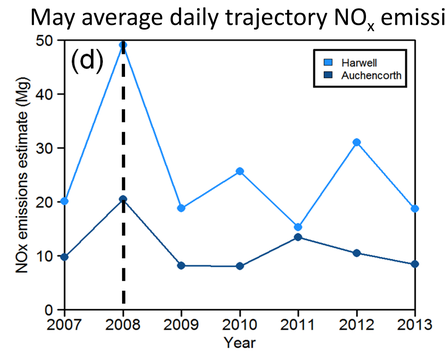
May PODy accumulation



May diurnal O_3 and NO_2 variation



May average daily trajectory NO_x emissions estimate.



• Increased regional O_3 production in May 2008
• Vegetation impact elevated at Auchencorth but not Harwell
• More favourable plant condition (e.g. higher soil water potential) at Auchencorth

References [1] Angus Smith, R., 1872. Air and Rain: The Beginnings of a Chemical Climatology. Longmans, Green and co., London.[2] Peel, M. C., Finlayson, B. L., McMahon, T. A., 2007. Updated world map of the Koppen-Geiger climate classification. Hydrol. Earth Syst. Sc. 11, 1633-1644. [3] Malley, C.S., Braban, C.F., Heal, M.R., 2014. New Directions: Chemical climatology and assessment of atmospheric composition impacts. Atmos. Environ. 87, 261-264., [4] REVIHAAP, 2013. Review of evidence on health aspects of air pollution – REVIHAAP Project technical report. World Health Organization (WHO) Regional Office for Europe, Bonn. [5] LRTAP Convention, 2010. In: Mills, G., et al. (Eds.). Chapter 3 of the LRTAP Convention Manual of Methodologies for Modelling and Mapping Effects of Air Pollution. Available at: http://icpvegetation.ceh.ac.uk/.

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