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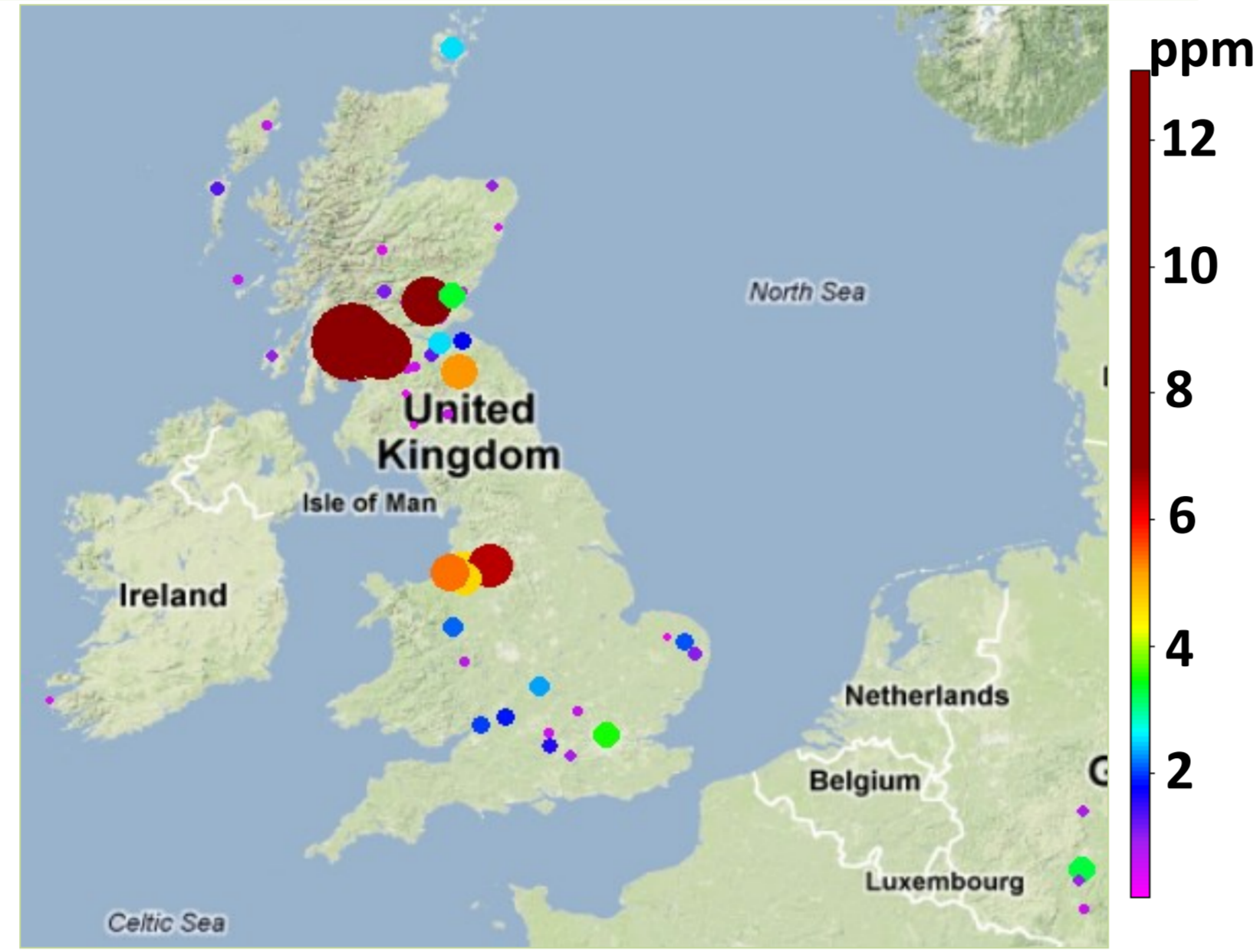
Historical perspective



• 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.

Ammonium concentrations in precipitation 1869-1870



Chemical climatology framework³

• Standard impact-focused approach used e.g. Köppen-Geiger meteorological climate²

• 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.

Step 1: Identify the impact

Step 2: Establish the metric

Step 3: Define temporal and spatial boundaries to the chemical climate

Step 4: Describe and summarise the state

Step 5: Identify the drivers

Step 6: Phase identification

Ozone impacts case study: Harwell and Auchencorth EMEP supersites



Auchencorth (data: 2007-2013)

Harwell (data: 1990-2013)

Impact metrics:

Human health⁴
SOMO10/35
(Sum of daily max 8 hr O₃ above 10 /35ppb)

Vegetation⁵
PODy
(accumulated stomatal flux of O₃ above threshold)

State:

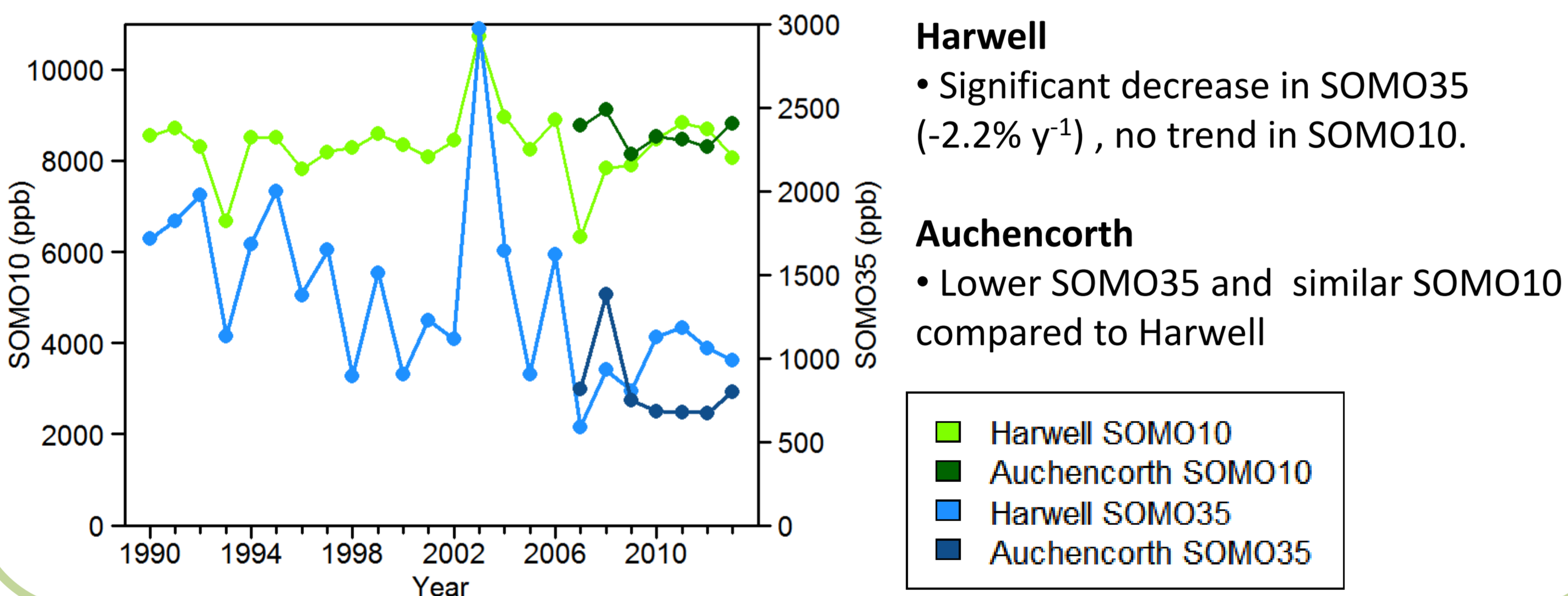
• Monthly contribution to metric
• Diurnal O₃ & NO_x variation

Drivers:

• Temperature
• Back trajectory origin
• NO_x emissions exposure

O₃ Human Health impact: SOMO10/35

SOMO10/35 changes over time



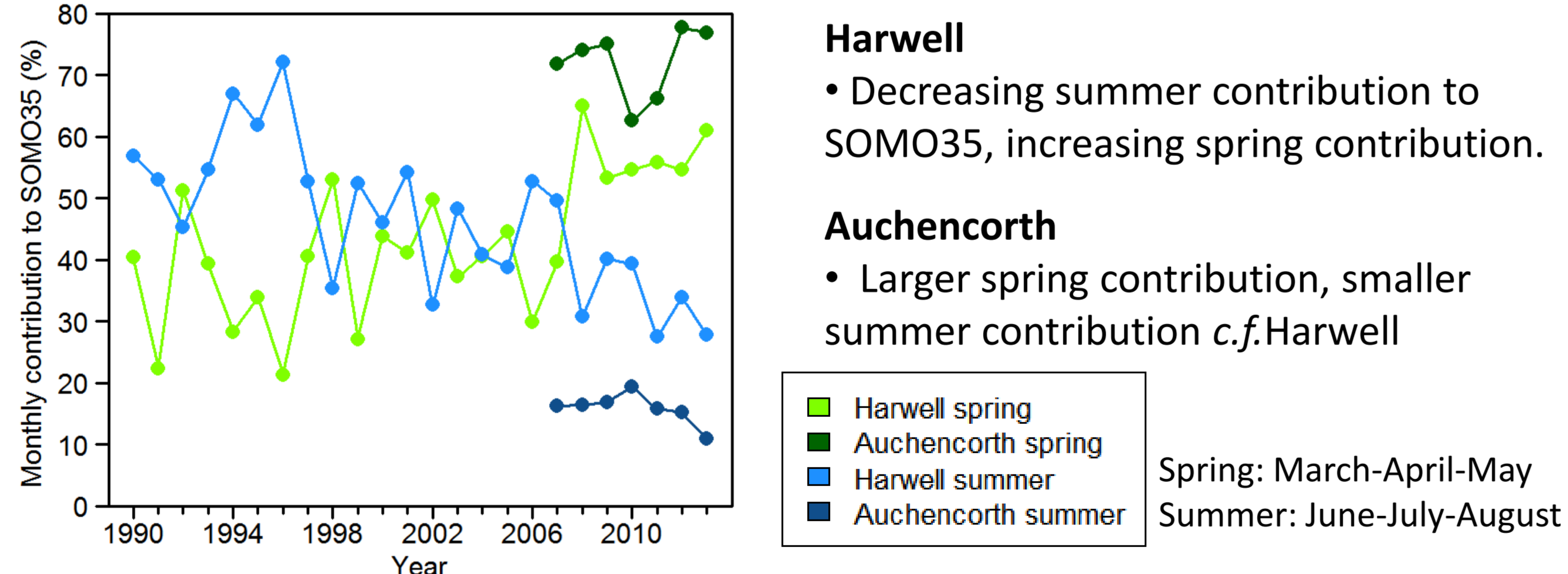
O₃ vegetation impact: PODy

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

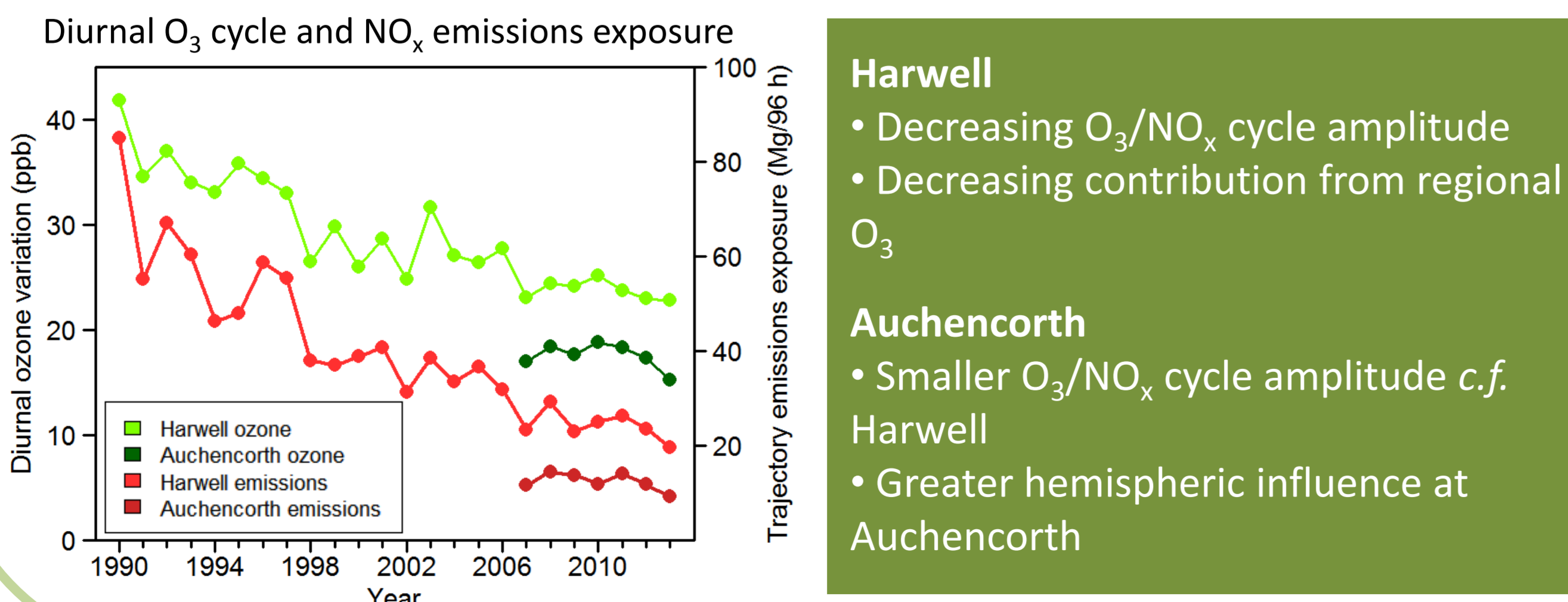
Average 2007-2013	Wheat PODy (mmol m ⁻²)	Wheat yield reduction (%)	Potato PODy (mmol m ⁻²)	Potato tuber reduction (%)	Beech PODy (mmol m ⁻²)	Beech biomass reduction (%)	Scots pine PODy (mmol m ⁻²)
Harwell	1.1 ± 0.9	4.3 ± 3.3	2.1 ± 0.9	2.7 ± 1.1	15.1 ± 4.2	16.6 ± 4.6	27.5 ± 7.0
Auchencorth	1.0 ± 0.4	3.7 ± 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.

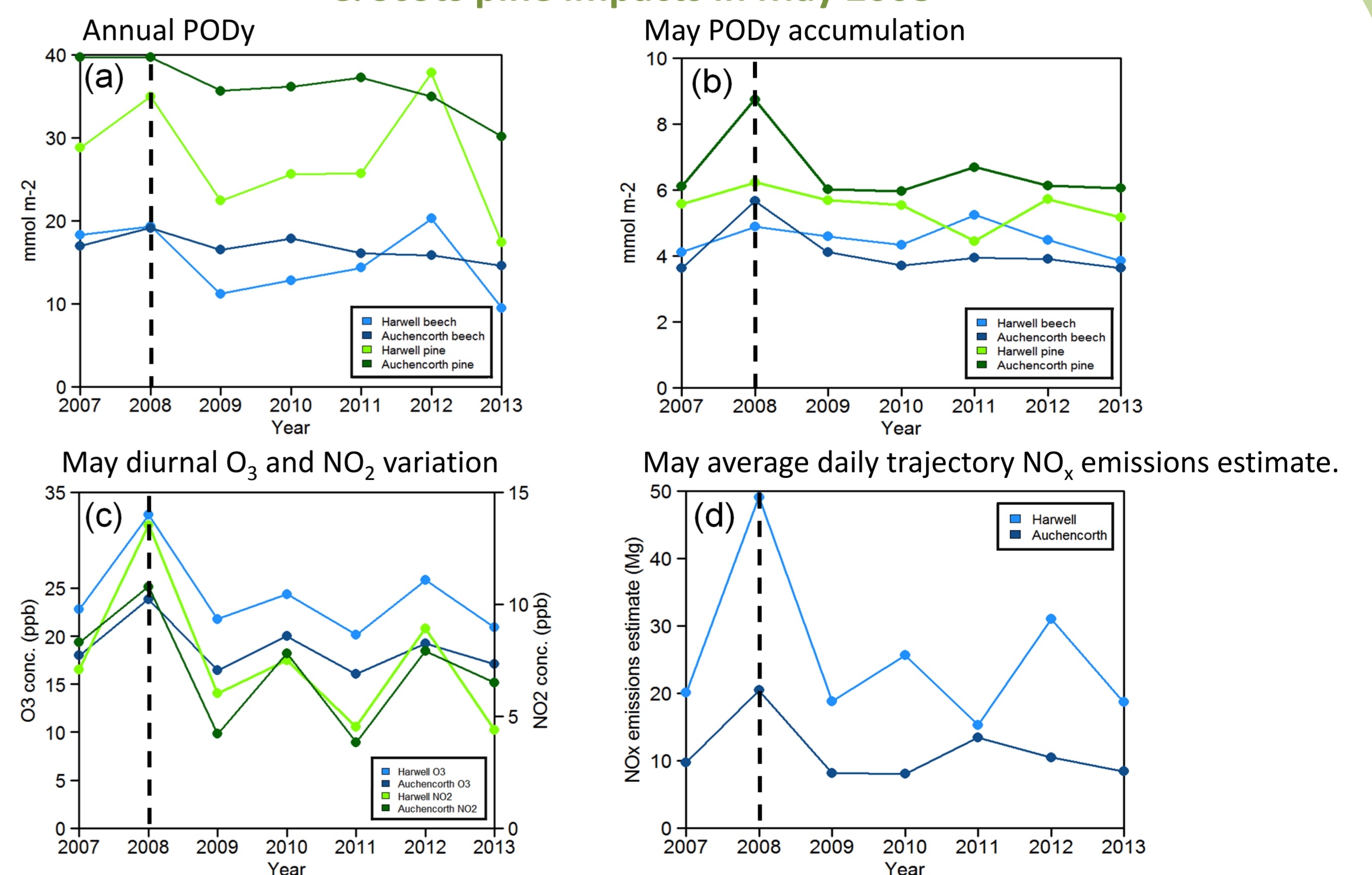
Spring/summer contributions to SOMO35 over time



Chemical contributions to SOMO35 over time



Case study: Influence of regional O₃ production on beech & Scots pine impacts in May 2008



• Increased regional O₃ 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 Köppen-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://icovervegetation.ceh.ac.uk/>.