Air quality and effects monitoring

C.F. Braban
with contributions from many UKCEH Staff

Air quality and effects monitoring

Summarise key monitoring activities across the atmospheric domain, and provide examples of the emerging information and its application in informing scientific understanding, management and policy

Air quality and climate variables are monitored across the UK with a variety of long-term, short term and survey type measurement networks.

Environmental air pollution impacts of interest are those that will:

- cause either short-term chronic damage
- cause long-term cumulative damage to ecosystems
- drive ecosystem change

Strategic national research areas

- human health, ecosystem health, pollution and atmospheric chemistry
  - Ammonia, reactive nitrogen, particulate matter
  - Ozone, emerging pollutants
- Environmental metrology
- Infrastructure and capacity building




UK Approach

- UK air quality networks as managed through Defra and the Environment Agency relate to the substances for which emission reduction commitments are set in Annex II to the EU Air Quality Directive
  - SO_2, NO_X, O_3, NMVOC, NH_3 and $PM_{2.5}$
- Air pollution impacts on ecosystems include acidification and eutrophication of ecosystems, damage to vegetation growth and biodiversity changes
- In parallel climate changes also affect systems therefore building evidence to understand the difference and coupling between the pressures is needed.
- During 2018 and 2019 National Emissions Ceiling Directive Article 9 reporting used the existing networks including ECN, LTMN, Upland Waters, Countryside survey and National Capability funded (UKSCAPE) sites. 129 existing sites were identified
- European Research Infrastructures (eLTER, ACTRIS, ICOS)
- Ecological long term manipulation (see Ecological Continuity Trust (@ECT_UK)
- Short and medium term measurements for impact and planning assessments

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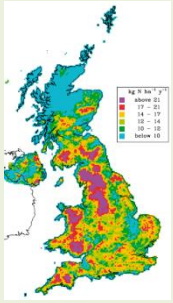
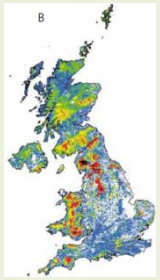
Measurements and models into policy and management

UKEAP monitoring measurements



Modelling and mapping pollutant concentrations and deposition



Critical Loads and exceedence mapping

Databases
EMEP
OSPAR
UK-Air

EU compliance modelling (PCM)
Secondary Inorganic Aerosol

National and international assessments atmospheric pollution and deposition to the environment e.g. RoTaP, UNECE

Air pollution information service APIS

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

Site data used by other UK networks:

- ECN
- LTMN
-

Public access to data

http://uk-air.defra.gov.uk
http://www.ceh.ac.uk/sci_programmes/UKEAP-Project.html
http://cldm.defra.gov.uk/index.htm
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Local Environmental Impact Assessments and planning

Screening tools e.g. SCAIL

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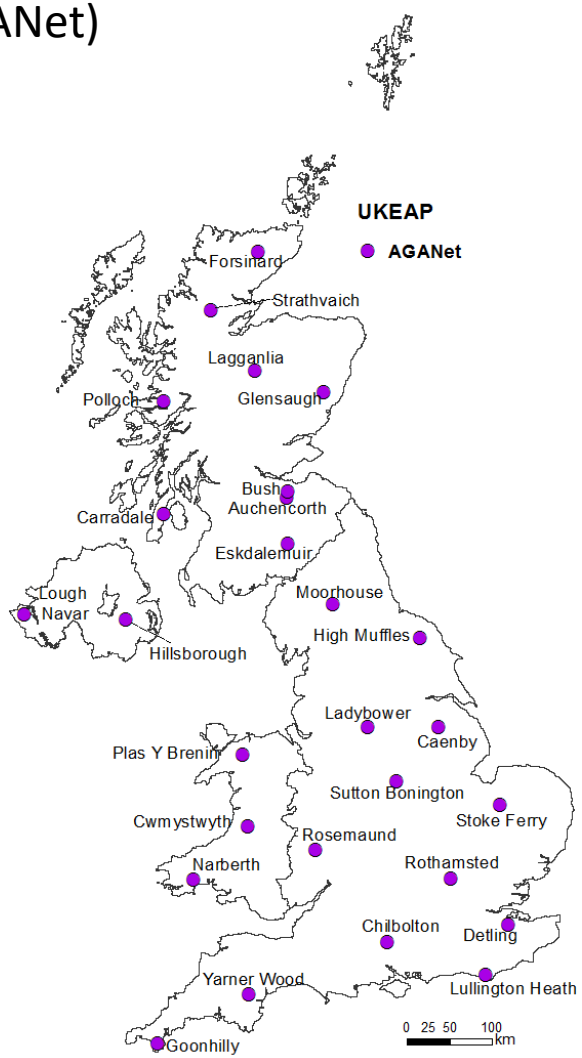
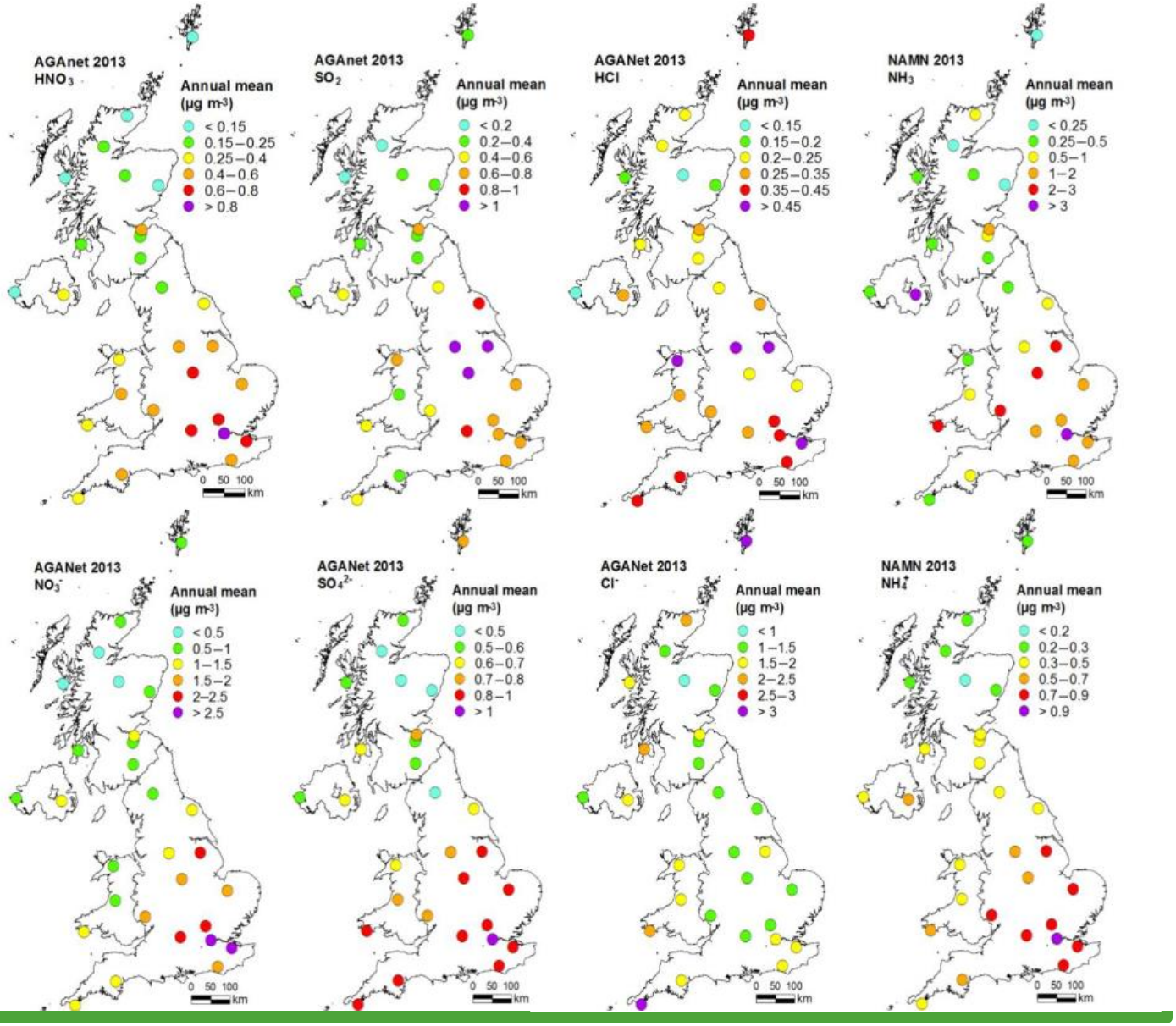
www.ceh.ac.uk

UKEAP Component networks

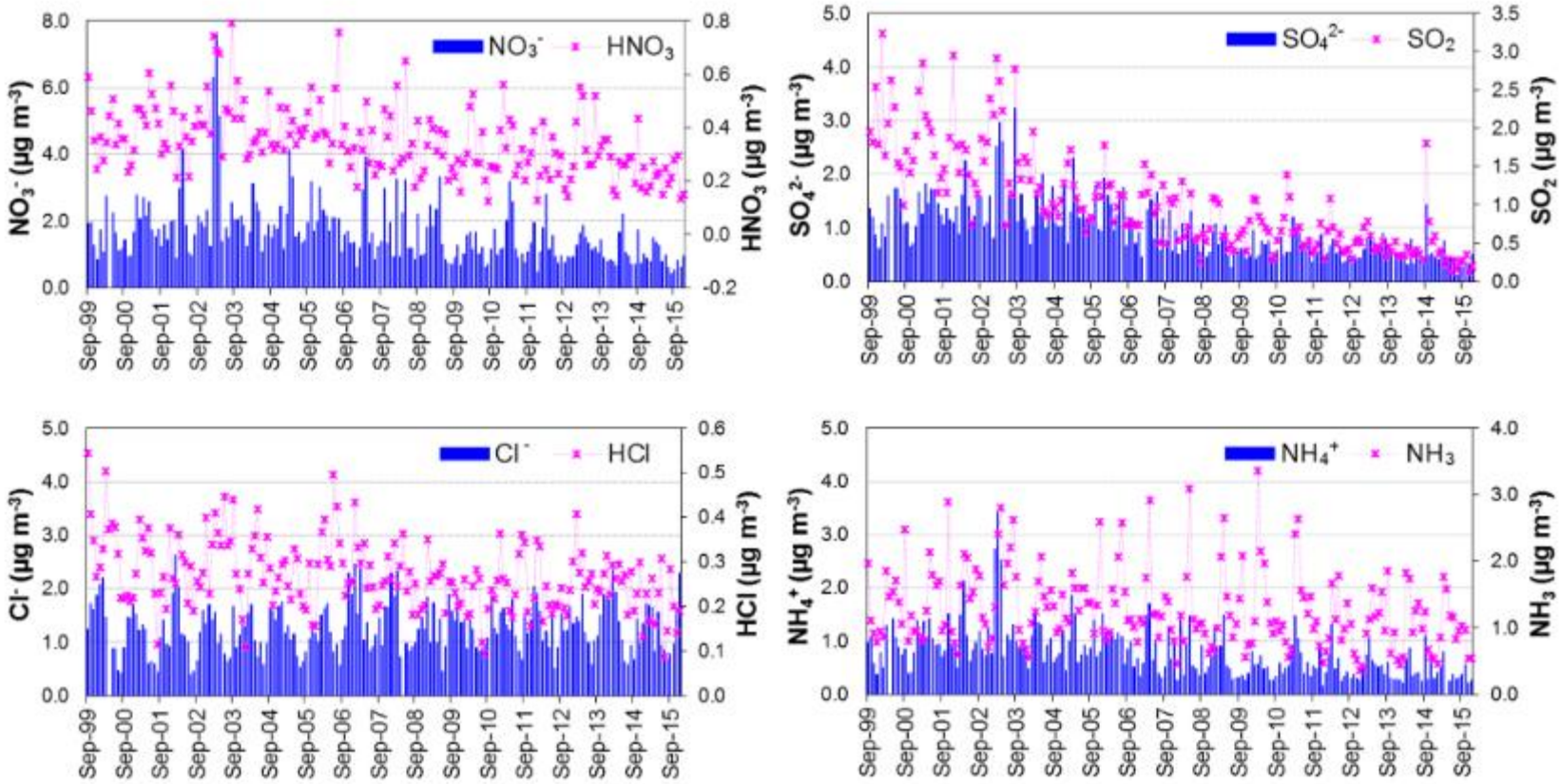
Acid Gas and Aerosol Network (AGANet)



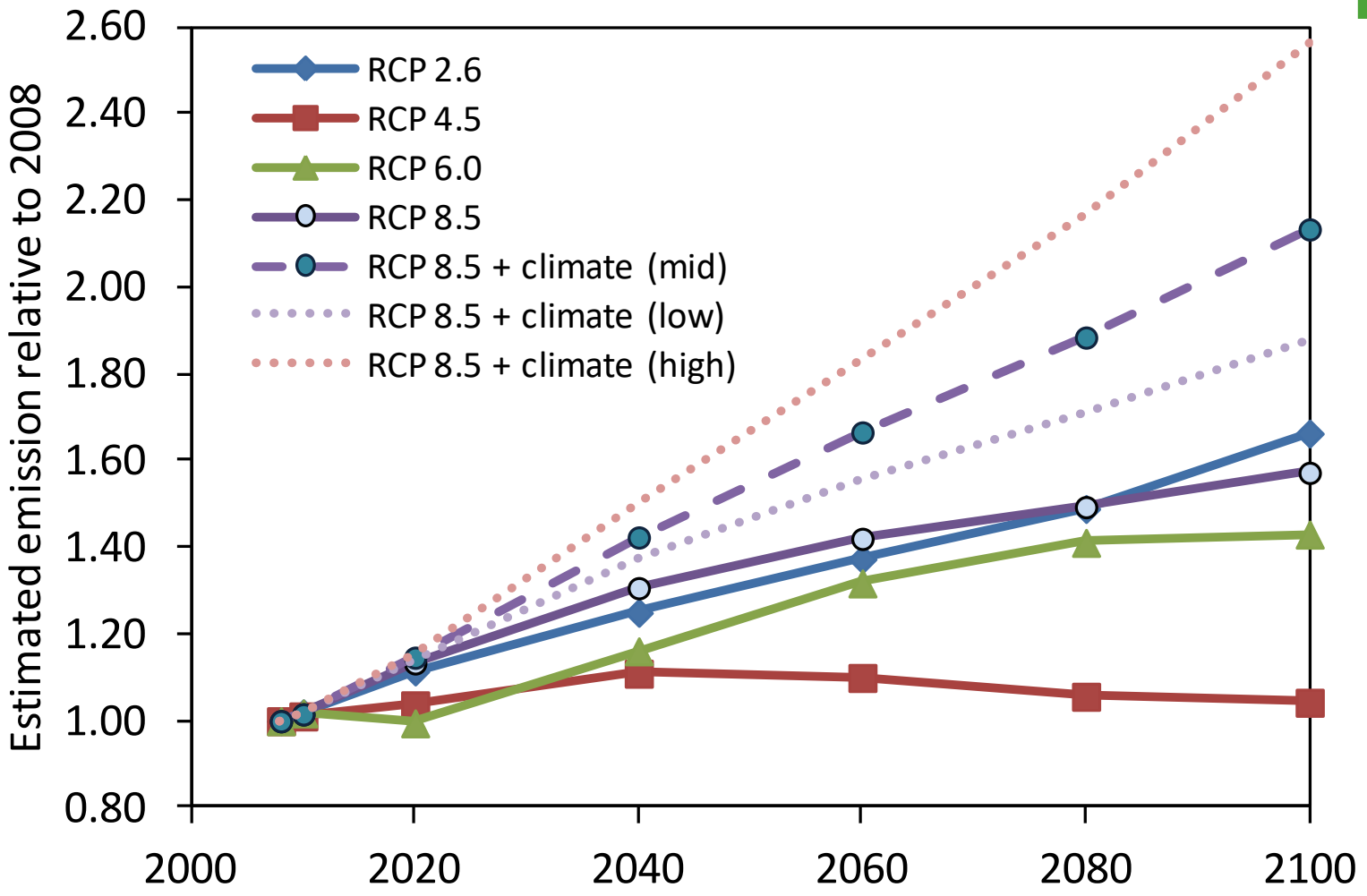
Spatially resolved long term concentrations



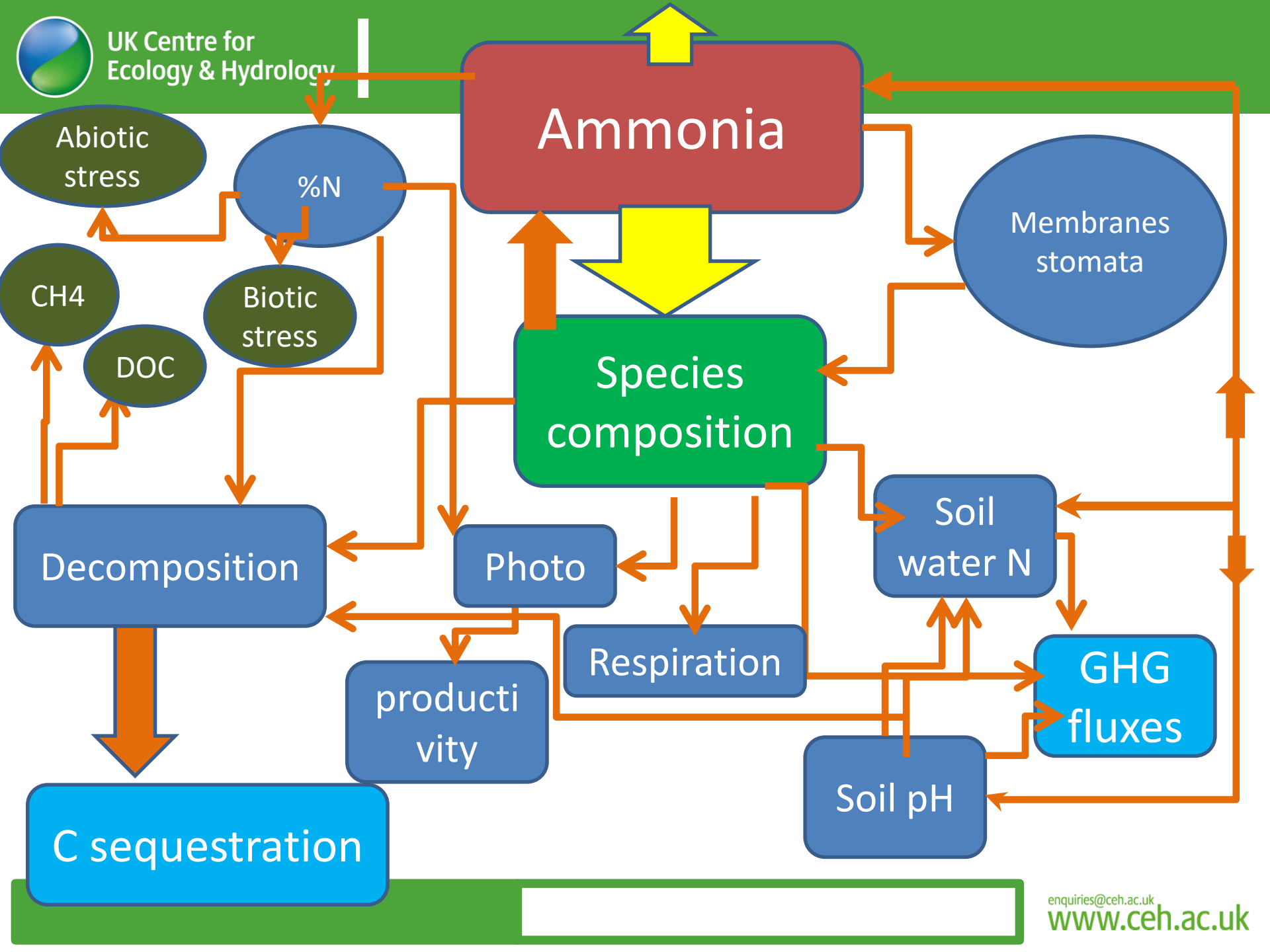
Temporal trends



Global ammonia in a future climate



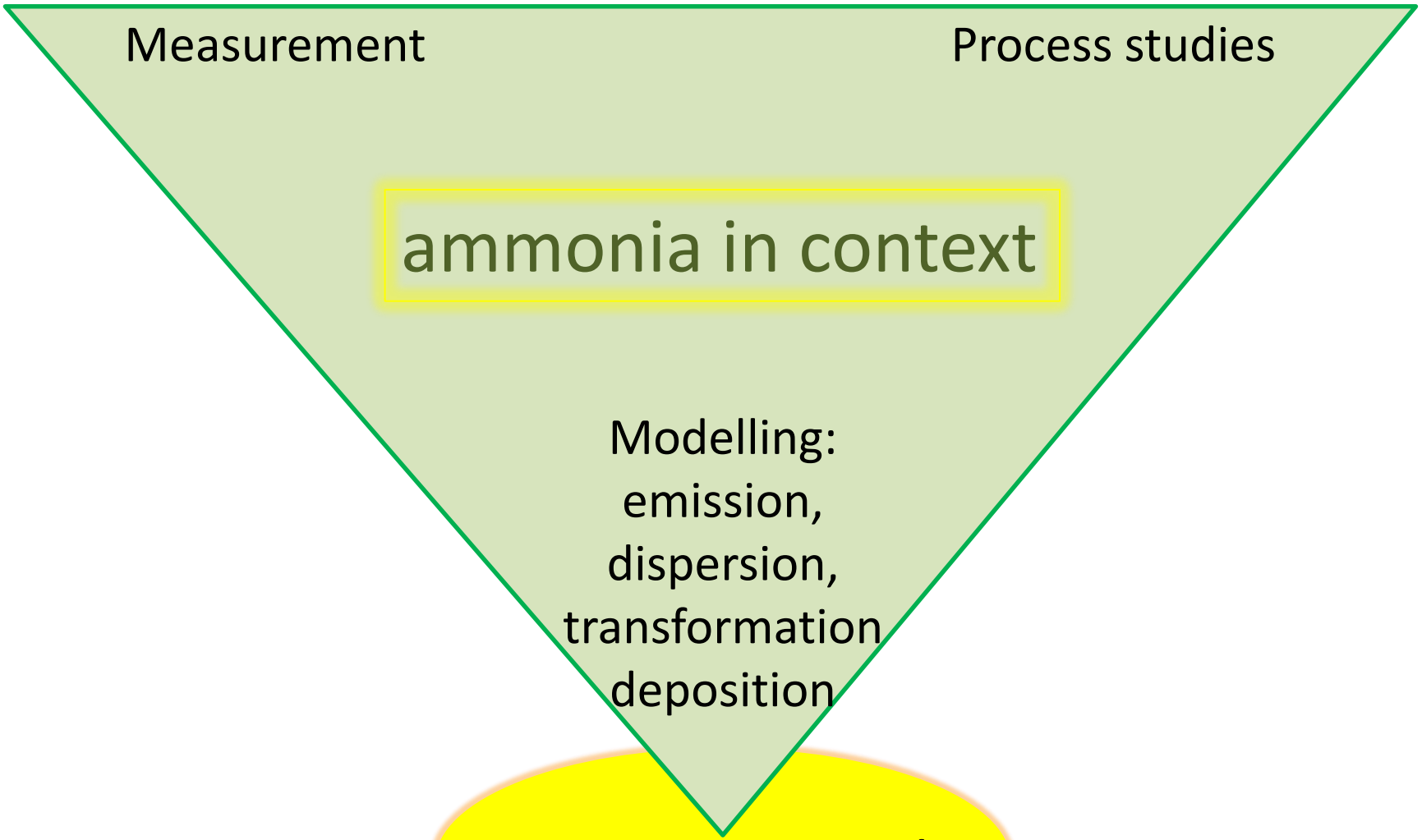
Sutton et al. Phil Trans. Roy. Soc., 2013


Ammonia
Abiotic stress
%N
Membranes stomata
CH4
Biotic stress
DOC
Species composition
Soil water N
Decomposition
Photo
Respiration
GHG fluxes
producti vity
Soil pH
C sequestration

Caveat

- There is no single ***best*** way of collecting the evidence of ammonia and its impact in the environment
- Many approaches could provide information required and it is a balance between evidence requirement, economics and practicality

Knowledge gaps in all areas



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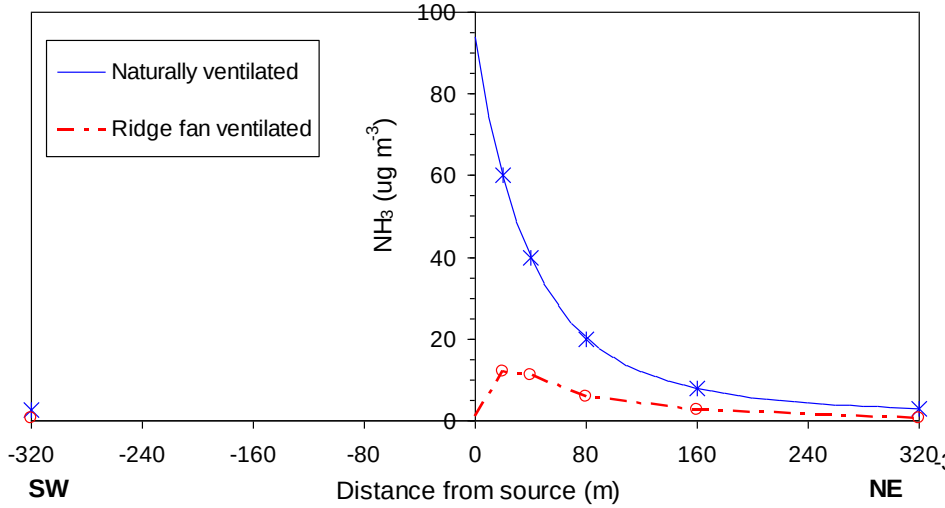
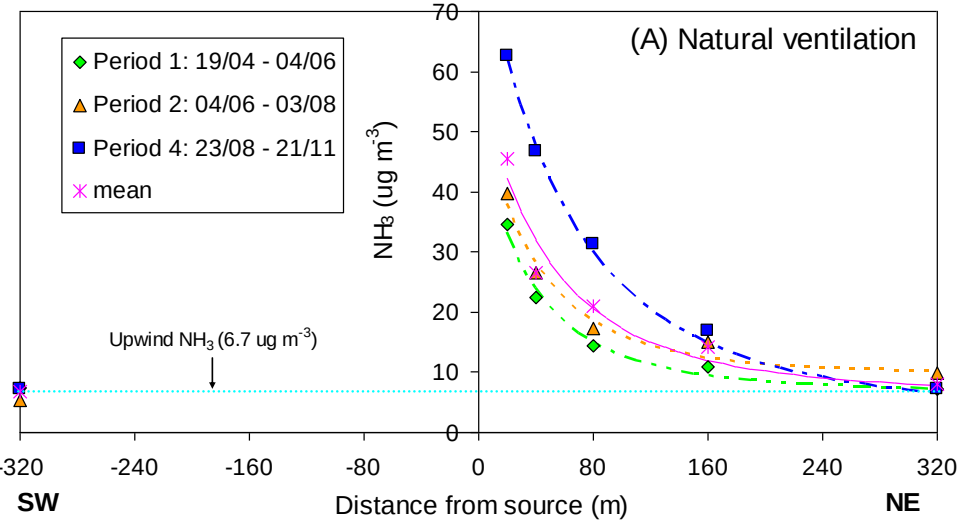
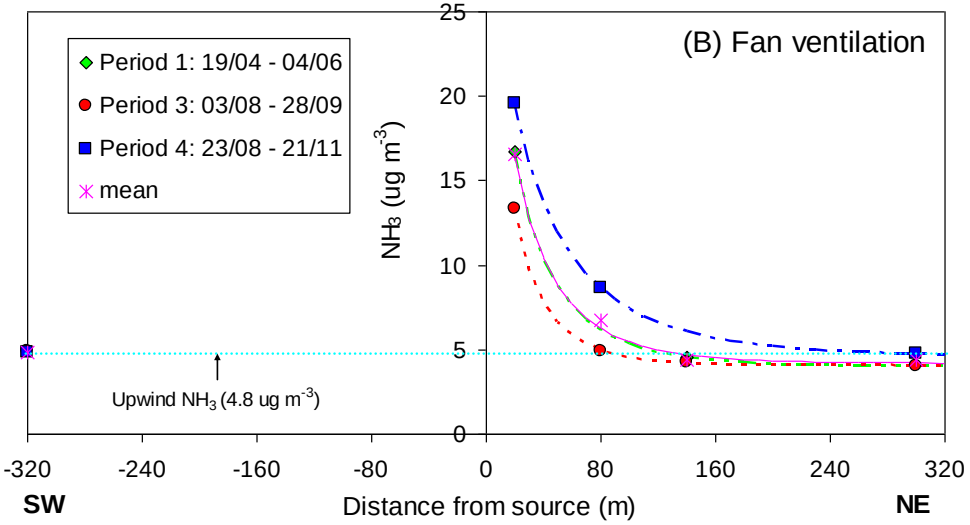
Local-scale transects: Examples

Modelled NH_3 concentrations (ADMS V3.1)



Monitored NH_3 concentrations SW- NE Transect





Tang Y.S. Rippey B., Love L & Sutton M.A. (2005) Ammonia monitoring in Northern Ireland - Comparison of ammonia concentrations downwind of two types of broiler house in Northern Ireland. Final Report to SNIFFER. (http://www.sniffer.org.uk/results.asp. Code UKPIR04)

Measurement of ammonia in context

NH_3 ⟷ NH_4

- Amines
- Co-emitted
- organics

- Reaction
- Precipitation
- consumption
- Re-emission

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Ammonia measurement challenges

Environmental Pollution 251 (2019) 668–680

Contents lists available at ScienceDirect

Environmental Pollution

journal homepage: www.elsevier.com/locate/envpol

More obvious air pollution impacts on variations in bacteria than fungi and their co-occurrences with ammonia-oxidizing microorganisms in $PM_{2.5}$☆

Xiao-Yan Fan, Jing-Feng Gao*, Kai-Ling Pan, Ding-Chang Li, Hui-Hui Dai, Xing Li

[illegible] Laboratory for Advanced Municipal Wastewater Treatment and Reuse Technology, Beijing University of Technology, Beijing, 100124,

SCIENTIFIC REPORTS

OPEN

Diversity, abundance and activity of ammonia-oxidizing microorganisms in fine particula matter

Received: 23 June 2016
Accepted: 14 November 2016
Published: 12 December 2016

Jing-Feng Gao, Xiao-Yan Fan, Kai-Ling Pan, Hong-Yu Li & Li-Xin Sun

Atmos. Chem. Phys., 18, 3641–3657, 2018
https://doi.org/10.5194/acp-18-3641-2018

Atmospheric Chemistry and Physics Open Access

Modeling reactive ammonia uptake by secondary organic aerosol in CMAQ: application to the continental US

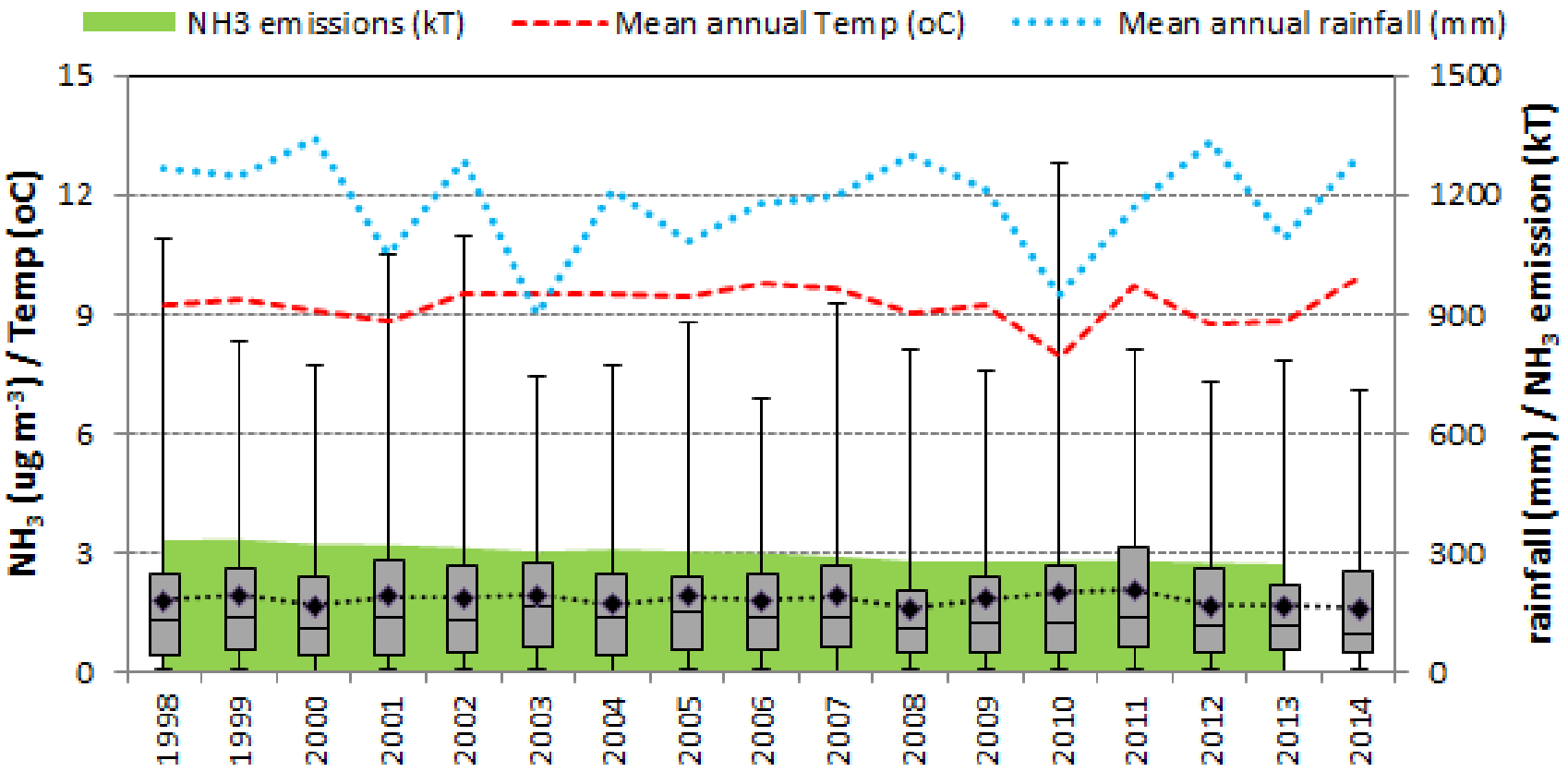
Shupeng Zhu[1], Jeremy R. Horne[1], Julia Montoya-Aguilera[2], Mallory L. Hinks[2], Sergey A. Nizkorodov[2], and Donald Dabdub[1]

[1]Computational Environmental Sciences Laboratory, Department of Mechanical and Aerospace Engineering, University of California, Irvine, Irvine, CA, 92697-3975, USA
[2]Department of Chemistry, University of California, Irvine, Irvine, CA, 92697-3975, USA

Correspondence: Donald Dabdub (ddabdub@uci.edu)

Received: 12 October 2017 – Discussion started: 6 November 2017
Revised: 1 February 2018 – Accepted: 1 February 2018 – Published: 13 March 2018

UK National Ammonia Monitoring Network



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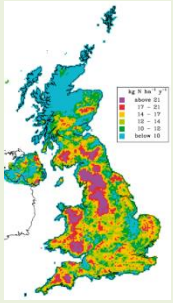

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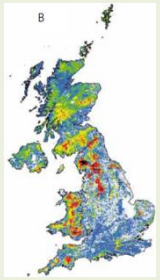

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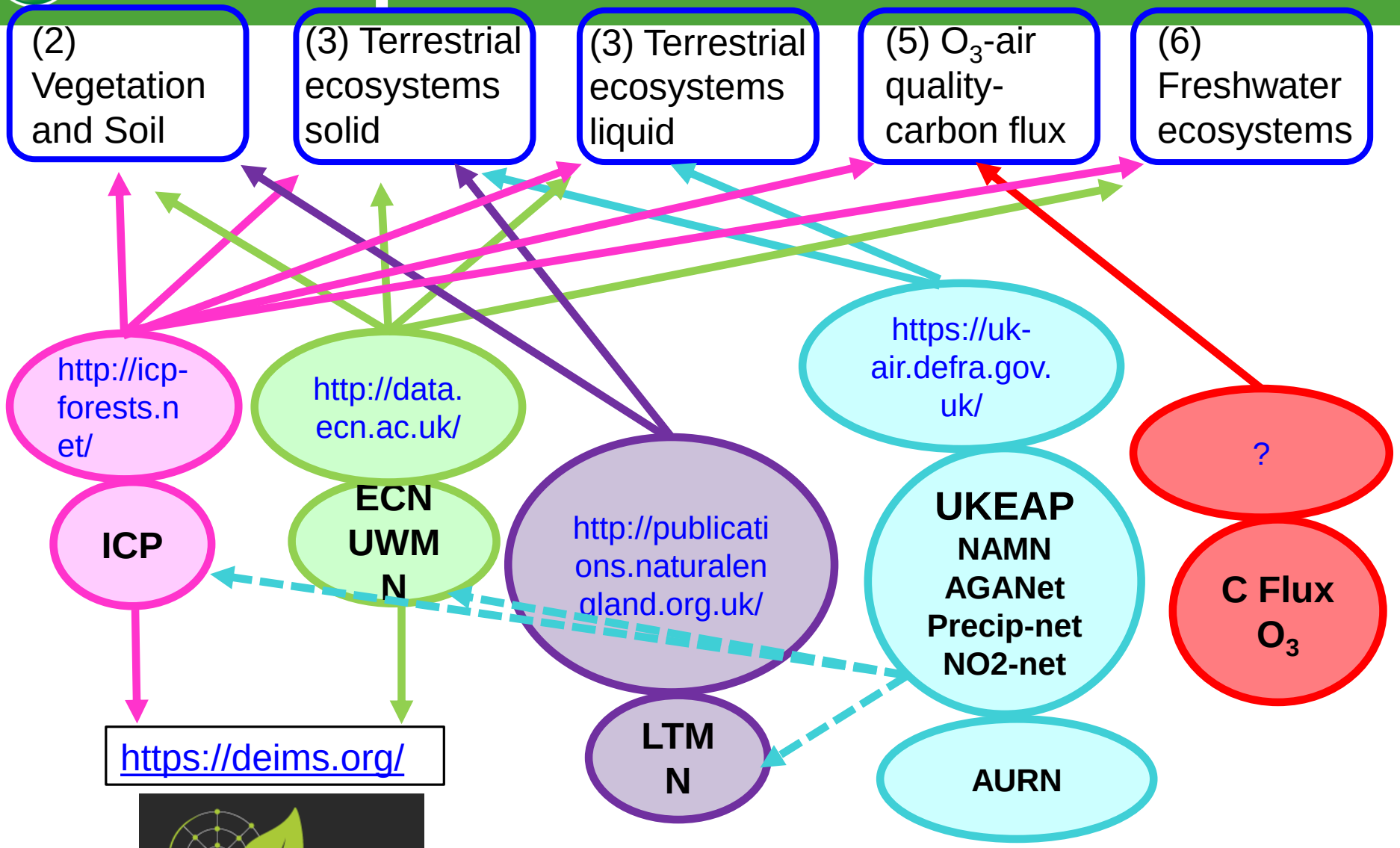
UK data: what can be reported where?



Integrating UK environmental networks to monitor air pollution impacts on terrestrial and freshwater ecosystems: A new initiative

Y.S Tang[1], C. Martin Hernandez[1], D Leaver[1], P Taylor[1], S Benham[2], D Monteith[3], S Rennie[3], C Rowland[3], D Norris[4], F Hayes[4], L Jones[4], R Keane[5], J Holdsworth[5], E Rowe[5], D Boorman[6], K Vincent[7], C Conolly[7], A Stroud[8], D Vowles[8], M.T O'Hare[1], C.F Braban[1] and M.A Sutton[1].

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INTRODUCTION

An integrated UK network will report on indicators for monitoring air pollution impacts on ecosystems, as specified under Article 9 of the National Emissions Ceilings Directive (NECD, 2016/2284) for the very first time.

OBJECTIVES

- Identify negative impacts of air pollution (*SO_x, NO_x, NH_3 and ground level ozone)* on ecosystems *(acidification, eutrophication, ozone damage or changes in biodiversity).*
- Determine the state of, and provide baseline against which any changes and recovery in ecosystem response to emissions reductions under the NECD may be assessed.
- Complement monitoring with ongoing modelling of exceedances of critical loads and levels across the EU.

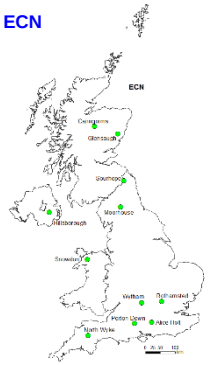
MONITORING SITES

- Selected from existing environmental networks.
- Representative of freshwater, natural and semi-natural habitats and forest ecosystem types in UK.
- Covers range of air pollutant concentrations (NO_2, NH_3, N Deposition, SO_2, Ozone).
- Supported by extensive field survey data from Biosoils, Countryside Surveys and National Plant Monitoring schemes that captures important changes across the country.

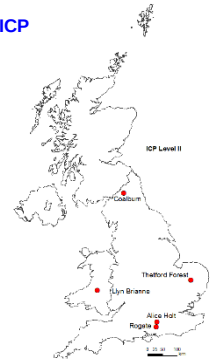
DATA REPORTING

- Monitoring data will be reported to the European Environment Agency (EEA) for the very first time this year.
- Submission deadline is 1 July 2019
- Data submission every four years thereafter.

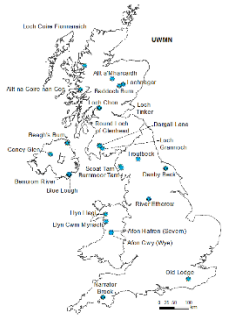
ECN



ICP

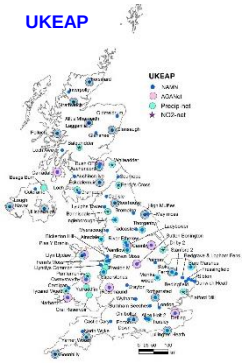


UWMN

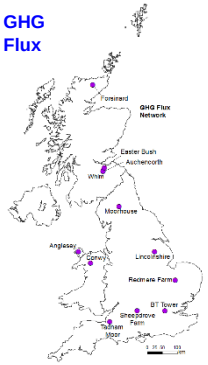


LTMN

UKEAP



GHG Flux



DATA SYNTHESIS

In collaboration with data providers, a major data collection and synthesis exercise is under way to meet the 1st July reporting deadline.

INTEGRATED DATA SYSTEM

Design and development of an integrated data system for environmental monitoring networks to support NECD Article 9 reporting.

NECD ARTICLE 9 TEMPLATES

(1) Reporting on Sites

ICP International Cooperative Programme Forests network (https://www.icp-forests.org/)
ECN Environmental Change Network (www.ecn.ac.uk)
UWMN Uplands Waters Monitoring Network (www.ecn.ac.uk)
LTMN Long-term Monitoring Network (http://publications.naturalengland.org.uk/)
UKEAP Eutrophying & Acidifying Atmos. Pollutants networks (https://uk-air.defra.gov.uk/)
GH
AU …uk/)

(2) Vegetation and Soil

(3a) Terrestrial ecosyste

(3b) Terrestrial ecosystems Soil

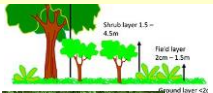
(4) Terrestrial ecosystems Liquid

(5) O_3, air quality carbon flux

(6) Freshwater ecosystems

REPORTING ON PARAMETERS FOR:

- Terrestrial vegetation
- Soil characteristics



- Acidification and eutrophication - vegetation

- Acidification and eutrophication - soil

- Acidification and eutrophication - precipitation - soil water

- O_3 POD / foliar damage
- NH_3, NO_2, SO_2
- Carbon flux

- Freshwater chemistry

Acknowledgement: This work was supported through a research partnership agreement between Defra, Natural England and the Centre for Ecology & Hydrology (CEH) ECM_54322 which builds upon work supported as part of the UK-SCAPE programme delivering National Capability through the Natural Environment Research Council award number NE/R016429/1.

enquiries@ceh.ac.uk
www.ceh.ac.uk

Key monitoring gaps

Ozone

- Modelled Ozone data used for UK
- Very few ecosystem and agricultural monitoring location
- Predicted to remain the same or increase during 21st century

Emerging pollutants

- Personal products
- Plastics (atmospheric deposition)
- “forever chemicals”
- UK frameworks key to allow sentinel sites and ecosystem change to be undertsood

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Chemical Climatology

Using environmental long-term monitoring data to assess specific impacts & identify solutions

- 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

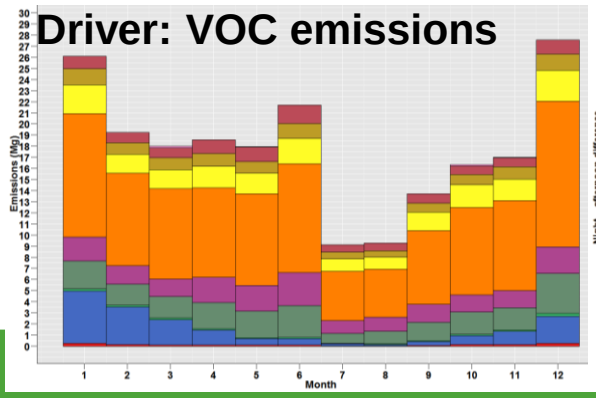
Malley, C.S., Braban, C.F., Heal, M.R., 2014a. The application of hierarchical cluster analysis and non-negative matrix factorization to European atmospheric monitoring site classification. Atmospheric Research 138, 30-40.

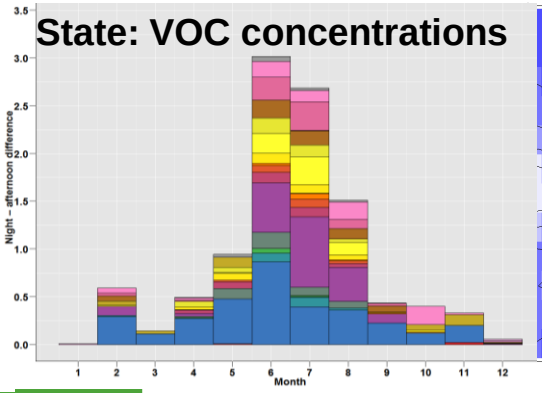
Malley, C.S., Braban, C.F., Heal, M.R., 2014b. New Directions: Chemical climatology and assessment of atmospheric composition impacts. Atmospheric Environment 87, 261-264.

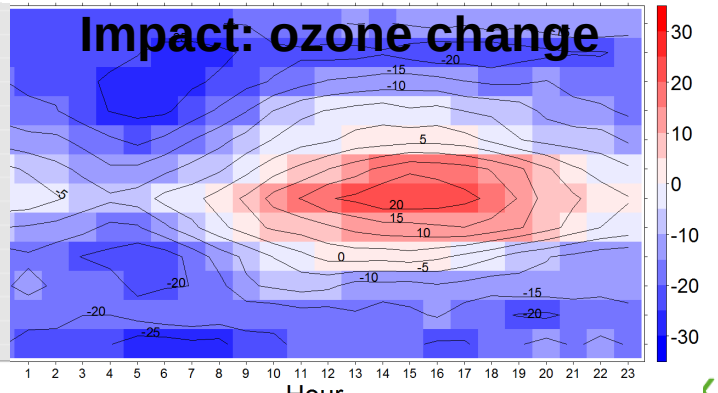
Malley, C.S., Braban, C.F., Dumitrean, P., Cape, J.N., Heal, M.R., 2015. The impact of speciated VOCs on regional ozone increment derived from measurements at the UK EMEP supersites between 1999 and 2012. Atmospheric Chemistry and Physics 15, 8361-8380

Malley, C.S., von Schneidemesser, E., Moller, S., Braban, C.F., Hicks, W.K., Heal, M.R., 2018. Analysis of the distributions of hourly NO2 concentrations contributing to annual average NO2 concentrations across the European monitoring network between 2000 and 2014. Atmospheric Chemistry and Physics 18, 3563-3587.

Developed for UK → Apply internationally: Thailand, ASEA countries, Mexico







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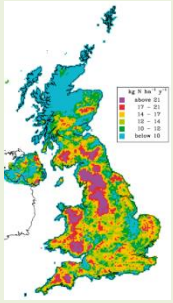

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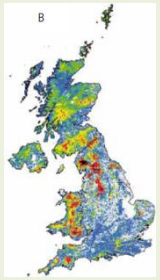

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Summary & Challenges: Rural/peri-urban

- Urban - Agriculture-ecosystem interactions key for air quality management
  - Monitoring to assess the state
  - Interventions to effect changes
  - Tension is to maintain productivity of land and economic health while reducing effects.

Identify a strategy to provide clear evidence

- Develop criteria for representative sites
- Put in place ecosystem impacts assessment to quantify potential impacts in the future.
- Work with industry, farming and communities to find the solutions

Thank you very much for your attention. ☺

Any questions.

chri2@ceh.ac.uk