eclaire

Effects of climate change on air pollution impacts and response strategies for European ecosystems

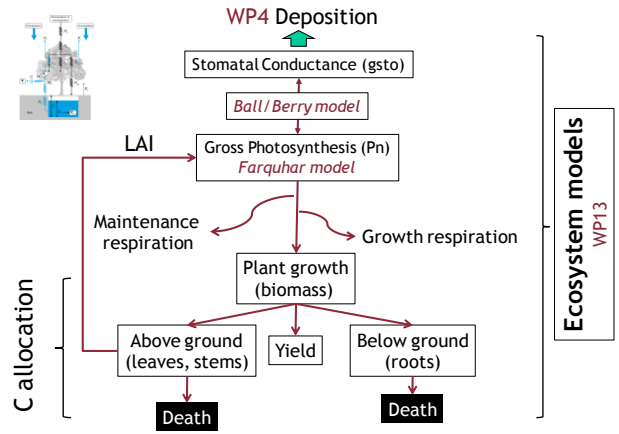
SEVENTH FRAMEWORK PROGRAMME

C3 Ecological processes and thresholds Overview of activities and progress

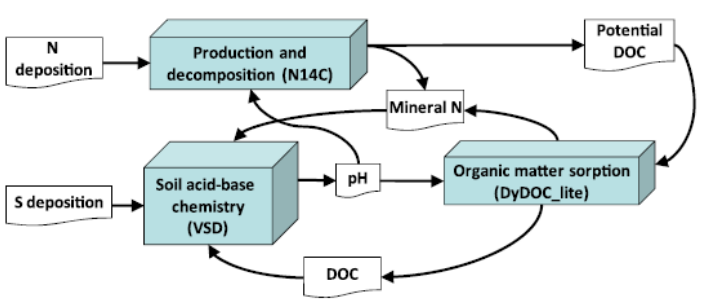
Gina Mills*, Lisa Emberson, Elena Paoletti, Chris Evans, Viki Bermejo, Sue Owen, Claus Beier

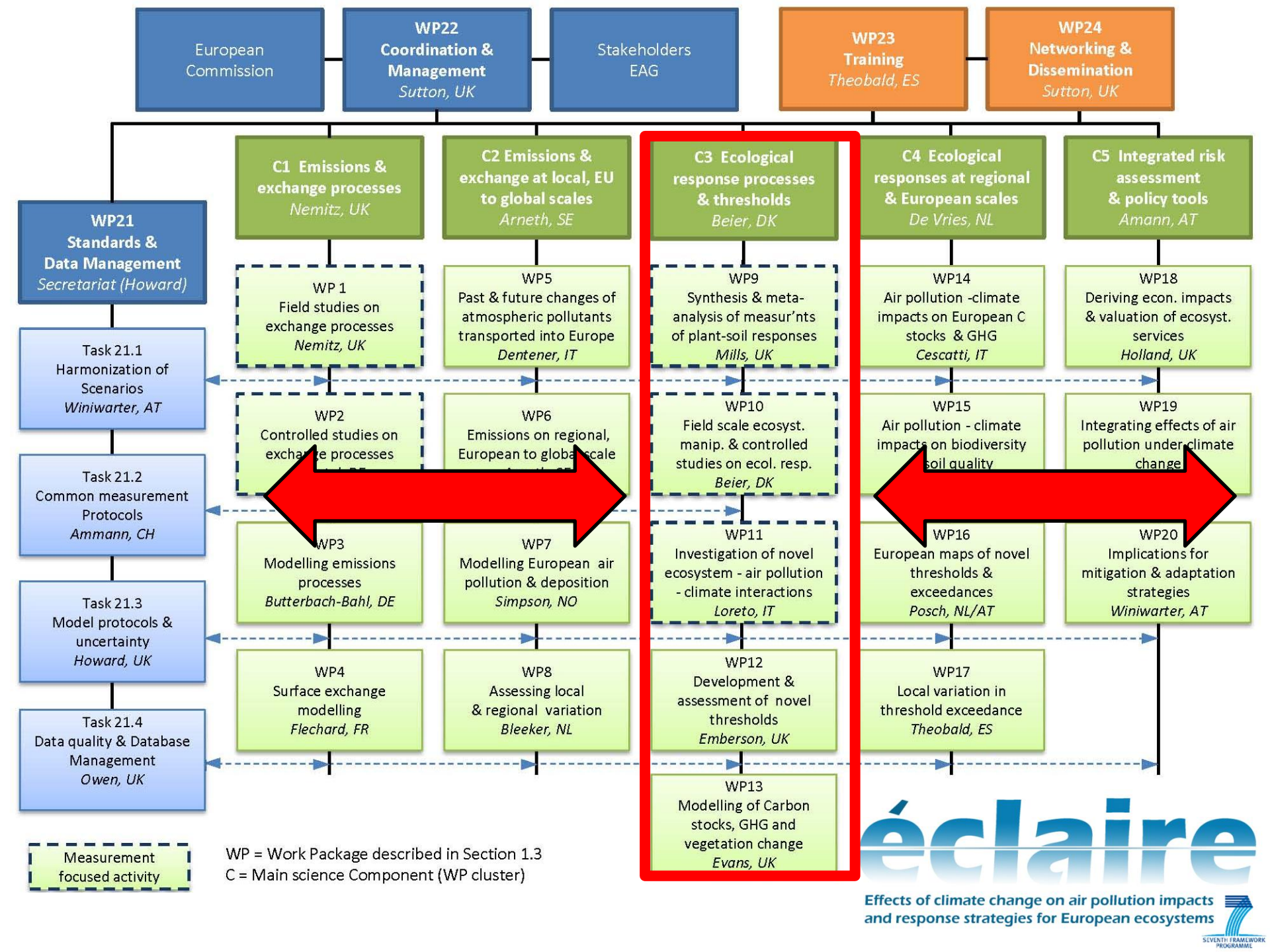
and many others

*gmi@ceh.ac.uk



ECLAIRE General Meeting 22nd to 24th October 2013
Zagreb, Croatia



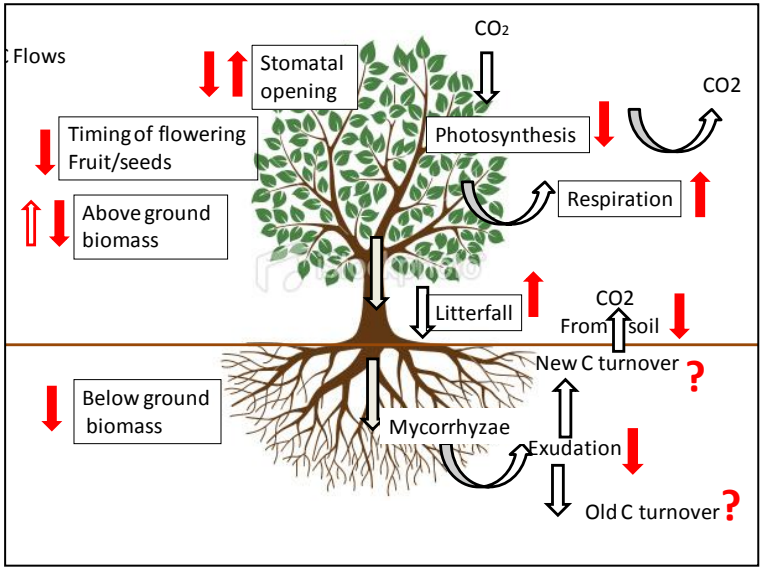

European Commission
WP22 Coordination & Management Sutton, UK
Stakeholders EAG
WP23 Training Theobald, ES
WP24 Networking & Dissemination Sutton, UK
C1 Emissions & exchange processes Nemitz, UK
C2 Emissions & exchange at local, EU to global scales Arneth, SE
C3 Ecological response processes & thresholds Beier, DK
C4 Ecological responses at regional & European scales De Vries, NL
C5 Integrated risk assessment & policy tools Amann, AT
WP21 Standards & Data Management Secretariat (Howard)
WP 1 Field studies on exchange processes Nemitz, UK
WP5 Past & future changes of atmospheric pollutants transported into Europe Dentener, IT
WP9 Synthesis & meta-analysis of measur'nts of plant-soil responses Mills, UK
WP14 Air pollution -climate impacts on European C stocks & GHG Cescatti, IT
WP18 Deriving econ. impacts & valuation of ecosyst. services Holland, UK
Task 21.1 Harmonization of Scenarios Winiwarter, AT
WP2 Controlled studies on exchange processes
WP6 Emissions on regional, European to global scale
WP10 Field scale ecosyst. manip. & controlled studies on ecol. resp. Beier, DK
WP15 Air pollution - climate impacts on biodiversity soil quality
WP19 Integrating effects of air pollution under climate change
Task 21.2 Common measurement Protocols Ammann, CH
WP3 Modelling emissions processes Butterbach-Bahl, DE
WP7 Modelling European air pollution & deposition Simpson, NO
WP11 Investigation of novel ecosystem - air pollution - climate interactions Loreto, IT
WP16 European maps of novel thresholds & exceedances Posch, NL/AT
WP20 Implications for mitigation & adaptation strategies Winiwarter, AT
Task 21.3 Model protocols & uncertainty Howard, UK
WP4 Surface exchange modelling Flechard, FR
WP8 Assessing local & regional variation Bleeker, NL
WP12 Development & assessment of novel thresholds Emberson, UK
WP17 Local variation in threshold exceedance Theobald, ES
Task 21.4 Data quality & Database Management Owen, UK
WP13 Modelling of Carbon stocks, GHG and vegetation change Evans, UK
Measurement focused activity
WP = Work Package described in Section 1.3
C = Main science Component (WP cluster)
éclaire
Effects of climate change on air pollution impacts and response strategies for European ecosystems
SEVENTH FRAMEWORK PROGRAMME

C3 Current activities

O_3, N, CO_2, drought, warming

Data collation and analysis

Published literature (WP9)
ICP Forests (WP9)
Ecosystem experiments (WP10,11)
Controlled exposure expts (WP11)



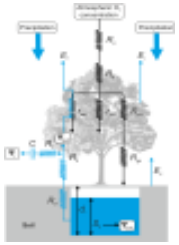
Model development

DO3SE – C (WP12)
MADOC (WP13)
FORSPACE-VSD+(WP13)
JULES (WP13)
Etc.

C3 Outputs in 2014/15

Multi-pollutant models
Novel thresholds – ecosystem processes and services
Environmental constraints of leaf processes
Linked models for application in C4

C3: Developing DO_3SE



WP4 Deposition

Stomatal Conductance (gsto)

Ball / Berry model

LAI

Gross Photosynthesis (Pn)
Farquhar model

Maintenance respiration

Growth respiration

Plant growth (biomass)

Above ground (leaves, stems)

Yield

Below ground (roots)

Death

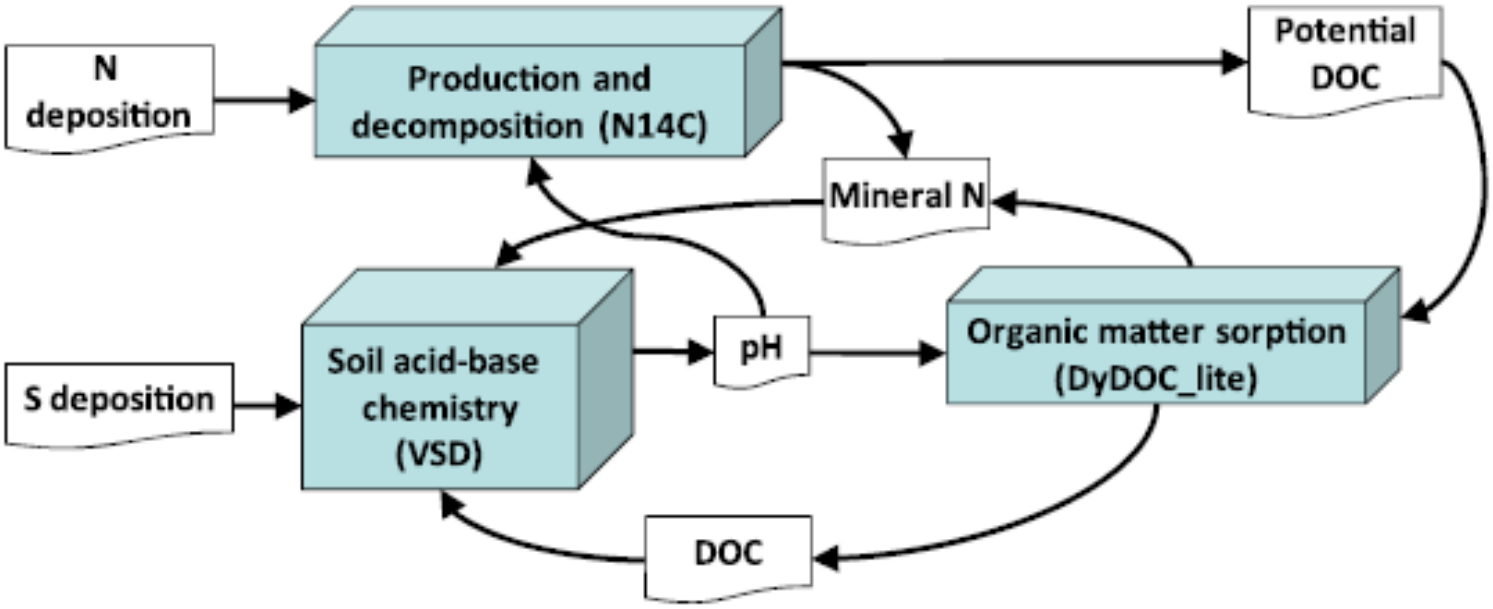
Death

C allocation

Ecosystem models
WP13

C3: Developing MADOC

+ Ozone



Environmental Pollution 184 (2014) 271–282

Contents lists available at ScienceDirect

Environmental Pollution

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

Predicting nitrogen and acidity effects on long-term dynamics of dissolved organic matter

E.C. Rowe [a,*], E. Tipping [b], M. Posch [c], F. Oulehle [a,d], D.M. Cooper [a], T.G. Jones [e], A. Burden [a], J. Hall [a], C.D. Evans [a]

C3 Data sources for modelling

WP9 Data mining from published papers

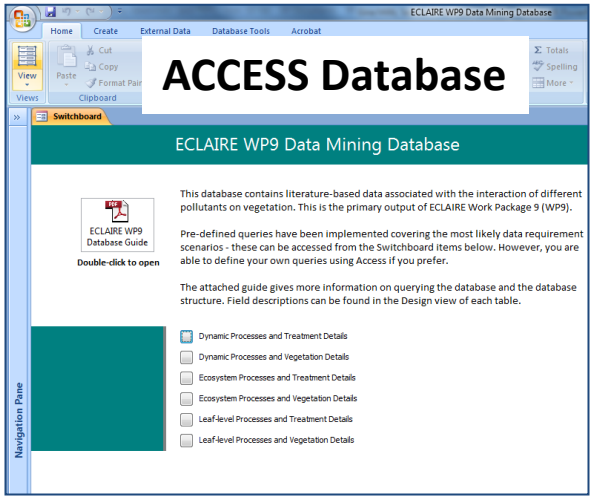
Since the Edinburgh GA

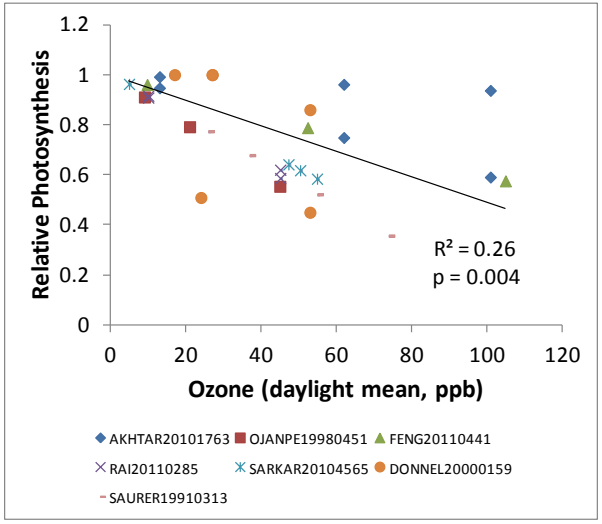
- Searches of Web of Science
- Template designed
- Data mining conducted for selected receptors
- Data brought together into one database
- First stage analysis being conducted.....

...And incorporated into Models

From:

To:





Coordinated by
Gina Mills and Sue Owen, CEH

WP9 Wim DeVries and colleagues, The Netherlands

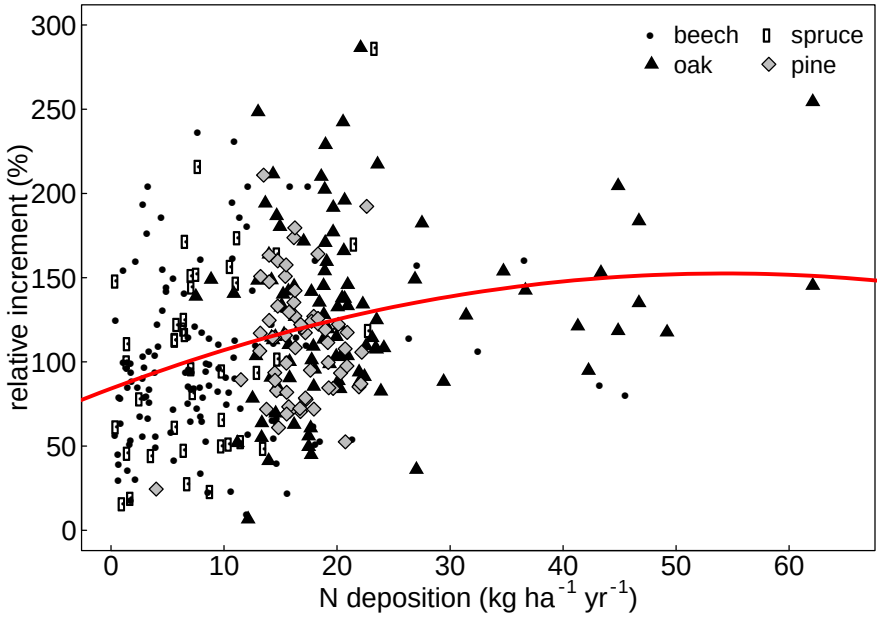
Integrated analysis of 15 years (1995 to 2010) of forest growth and deposition data at ICP Forest plots

Aim:

To derive quantitative relationships between

- Growth and carbon sequestration by trees and
- N, S deposition and O_3 exposure (POD1)

Accounting for differences in climatic conditions.



Non-linear model: R^2=0. 07, p <0.001

→ **Saturated increment at high N deposition levels**

WP10

C3 Ecosystem Experiments

Grassland

FDEA-ART (CH)
CIEMAT (ES)

Agriculture

CIEMAT (ES)
DTU (DK)

Shrubland

DTU (DK)

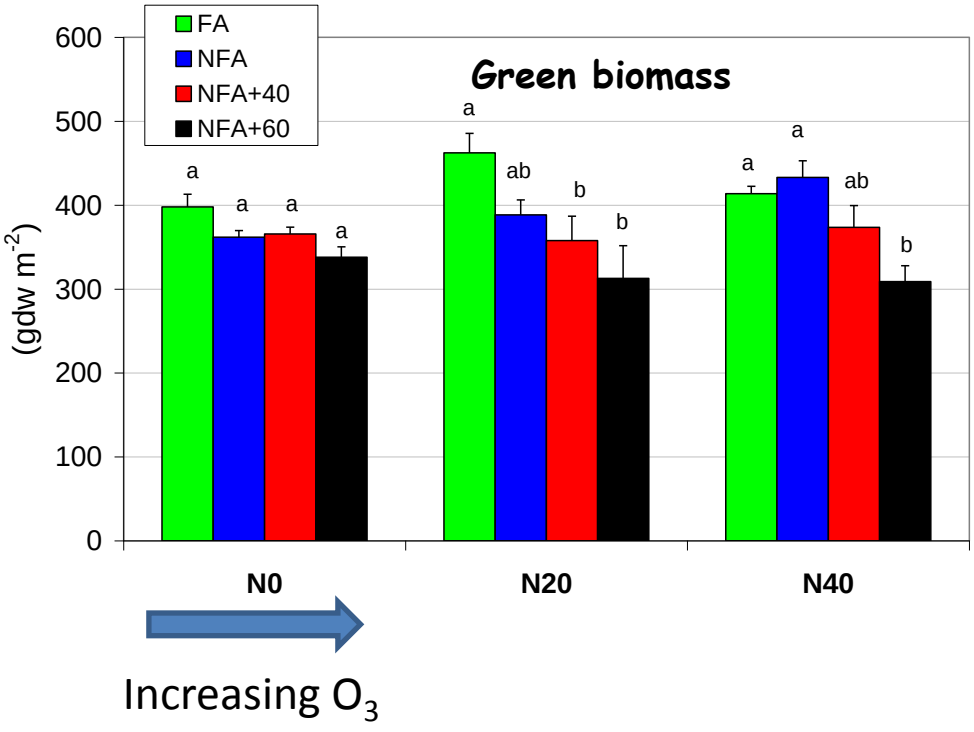
Forest

CEH Bangor (UK)
UNICATT (IT)

Treatments & response measurements

WP10 Viki Bermejo and colleagues, Spain

Vegetation: Annual pasture
Treatments: 4 x O3, 3 x N
Foci: gas exchange, C allocation, nutritional qualities



Interactions between Ozone and Nitrogen

- No canopy biomass response to ozone at low N
- Increasing O_3 decreased biomass at medium and high N

- No response to added N at high O3

WP10 Leafy crops response to O_3 and N

Experiments 2013 –screening O3 sensitivity species/cultivats

4 species /14 cultivars

Two experimental OTCs sites in contrasting Mediterranean climate

Species ranking sensitivity based in foliar symptoms:

Chard > Spinach > Endive > Lettuce

Ozone effects on chard and spinach (lettuce and endive still on progress)

Reduced gs and A

Reduced commercial yield

Reduced commercial/non commercial biomass rate

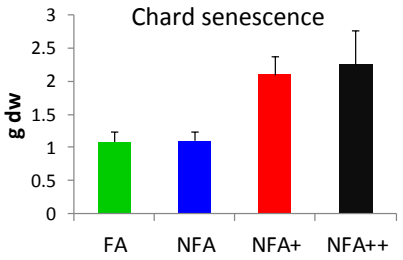
O_3 sensitivity of cvs is not directly related to gs

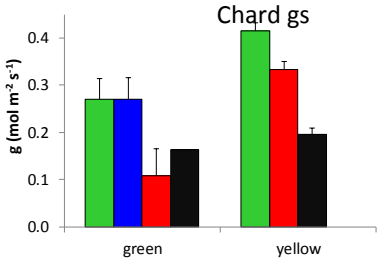
In progress:

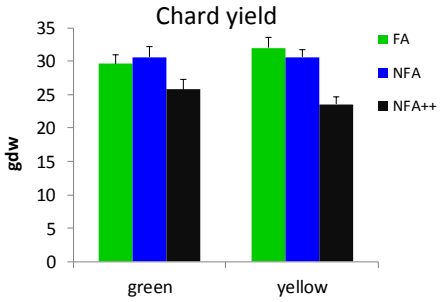
A/Ci and A/PAR curves

C/N

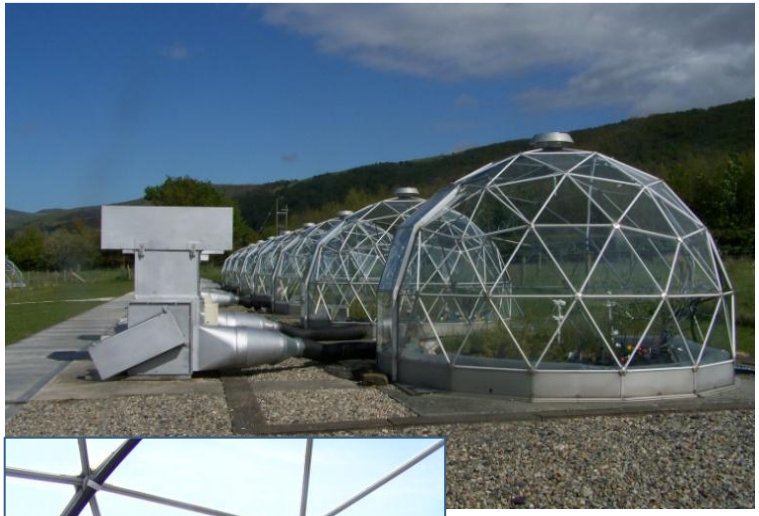
AA/DHA



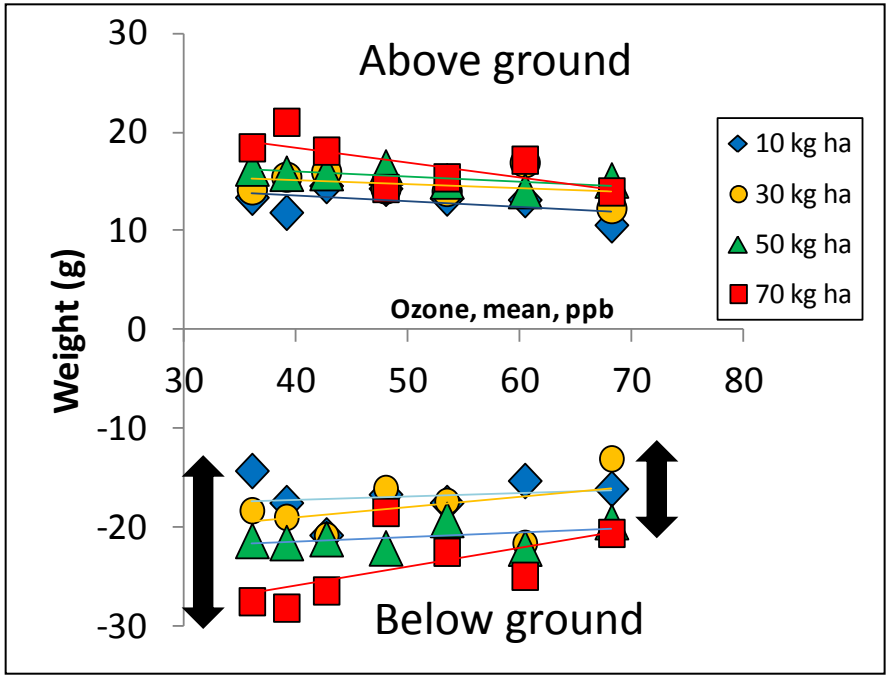


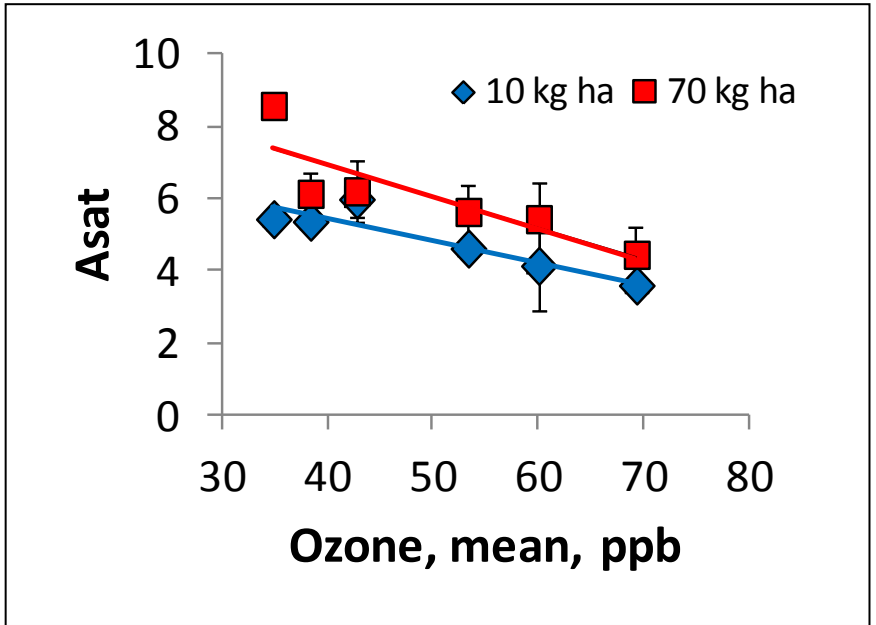


WP10 Gina Mills, Felicity Hayes and colleagues, UK



7 x O3, 4 X N treatments





WP10

Giacomo Gerosa and colleagues, Italy

June 2012

Quercus robur	*Vcmax*	*Amax*	*CO2 Comp Point*	*Respiration*	*Pn*
OZ++	-34.6%	-28.6%	+18.3%	-23.1%	-37%
NDep	*+13.2%*	*+34.1%*	*-13.2%*	*+0.4%*	*-1%*
OZ++ x NDep	+9.1%	-7.9%	-3.9%	+3.7%	+2%

Carpinus betulus	*Vcmax*	*Amax*	*CO2 Comp Point*	*Respiration*	*Pn*
OZ++	-13.0%	+14.3%	+24.9%	+9.2%	+2%
NDep	*+7.9%*	*+10.3%*	*-24.7%*	*-16.5%*	*+21%*
OZ++ x NDep	-3.8%	+9.8%	-19.8%	-20.4%	+1%

Sept 2012

Quercus robur	*Vcmax*	*Amax*	*CO2 Comp Point*	*Respiration*	*Pn*
OZ++	-26.0%	-33.0%	+15.7%	-16.2%	-43%
NDep	*+14.8%*	*-7.5%*	*-5.6%*	*+6.9%*	*+15%*
OZ++ x NDep	-24.6%	-10.0%	+17.6%	-11.3%	-1%

WP10 Jürg Fuhrer, Seraina Bassin and colleagues, Switzerland

Crossfactorial split-plot design (3 ozone levels x 5 nitrogen loads)

9 ozone fumigation rings
ambient, 1.2*amb., 1.6*amb.

20 monoliths per fumigation ring
+0, +5, +10, +25, +50 kg N ha^{-1} y^{-1}

Examples of significant effects of N:
Above and below ground biomass, functional group composition, leaf parameters, leaf and root litter quality

Examples of significant ozone effects:
Leaf parameters, soil microbial composition, NDVI

WP10 Claus Beier and colleagues, Denmark, heathland

Long-term CO2 x Temp x warming x drought interaction experiment

Ozone (+ approx. 30 ppb) added to individual plants for 6 weeks

Some effects:

Ozone alone decreased photosynthesis but increased stomatal conductance

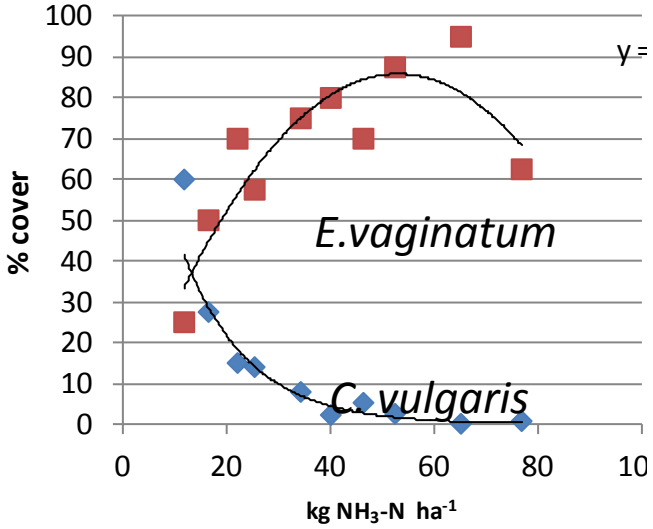
- Antagonistic effects of TxD, TxDxCO2, TxDxO3 – often negatively skewed

- Synergistic negative effects of TxO3 and DxO3

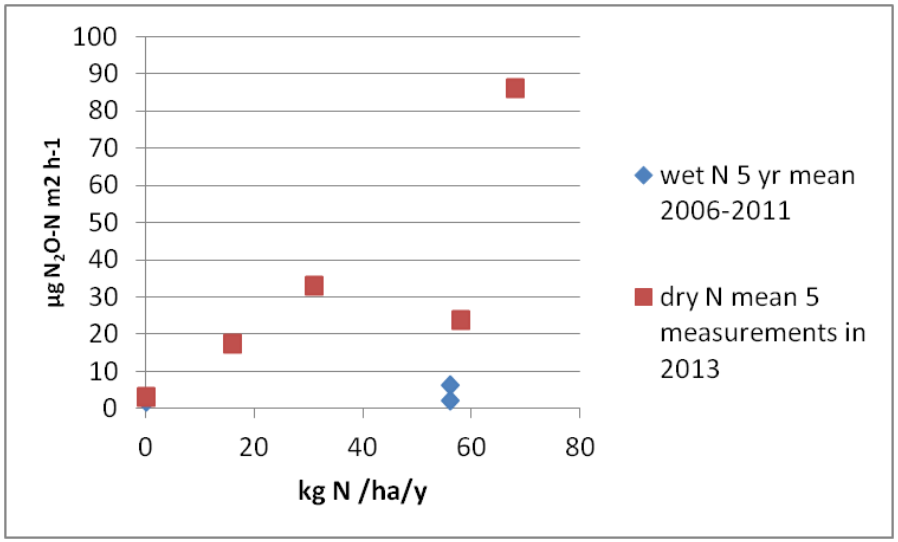
WP11 Lucy Sheppard and colleagues, UK

Nitrogen Form experiment at Whim Bog

- Ammonia deposition irrespective of N dose gives significantly more N_2O
- Link to vegetation ? Coincides with loss *of C. vulgaris* and increased E. vaginatum

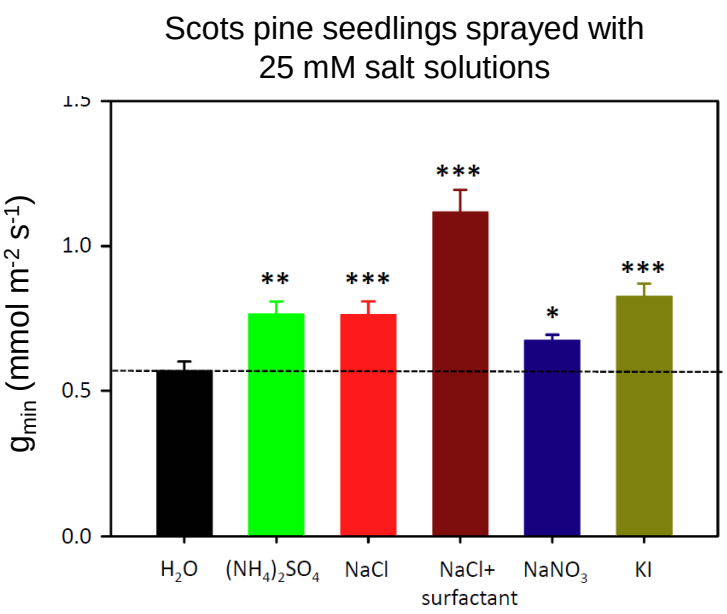


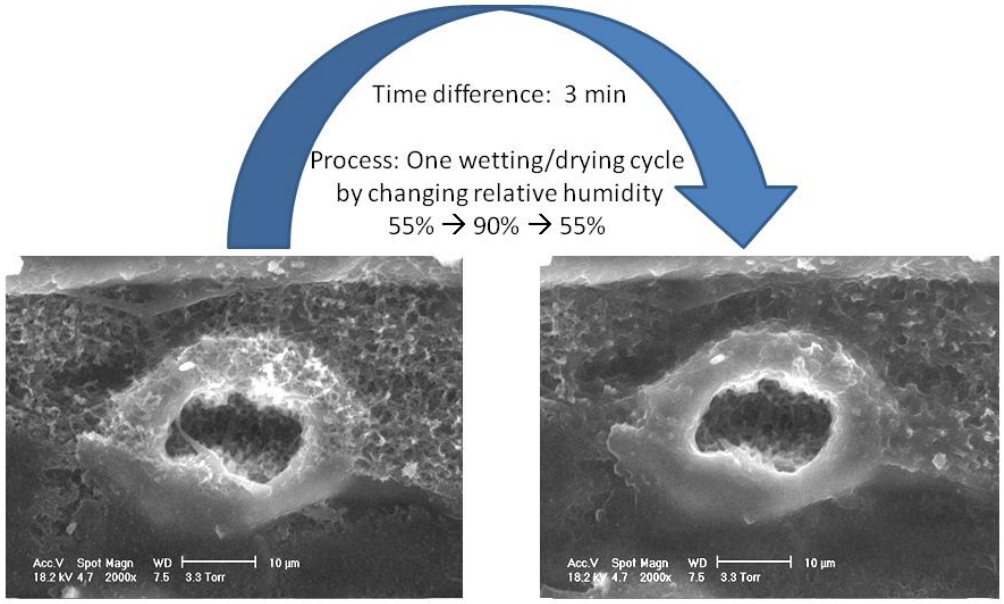
Calluna cover in relation to NH_3-N



Dry ammonia greatly increases N2O

WP11 Jürgen Burkhardt and colleagues, Germany





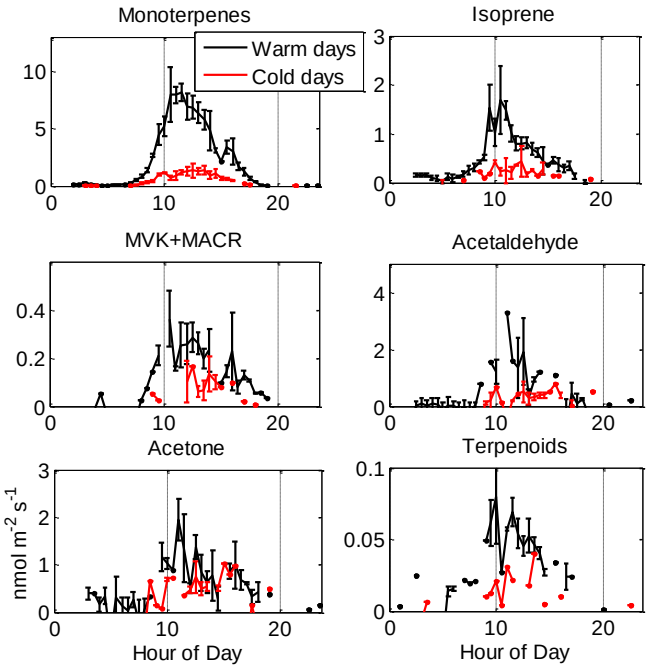
Burkhardt & Pariyar, *Env. Poll.,* 2013

→ Aerosol deposition from polluted air may decrease plant drought tolerance

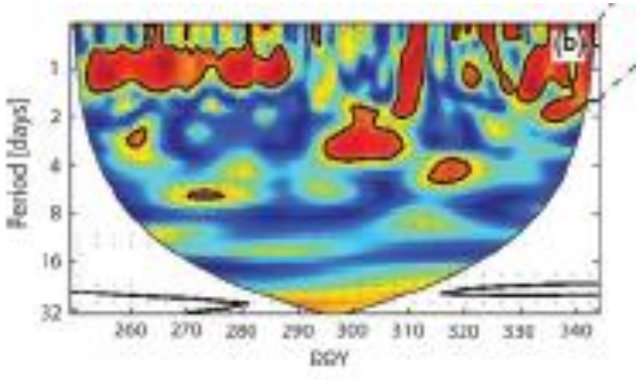
- this may not have been recognized (misinterpreted) in the past
- play a role in different types of forest decline:
  - central Europe and eastern USA ('air pollution type'),
  - Italy ('polluted sea salt' type)
  - western USA (by 'global change type drought' (van Mantgem et al., *Science,* 2009))

WP11

Elena Paoletti and colleagues, Italy,

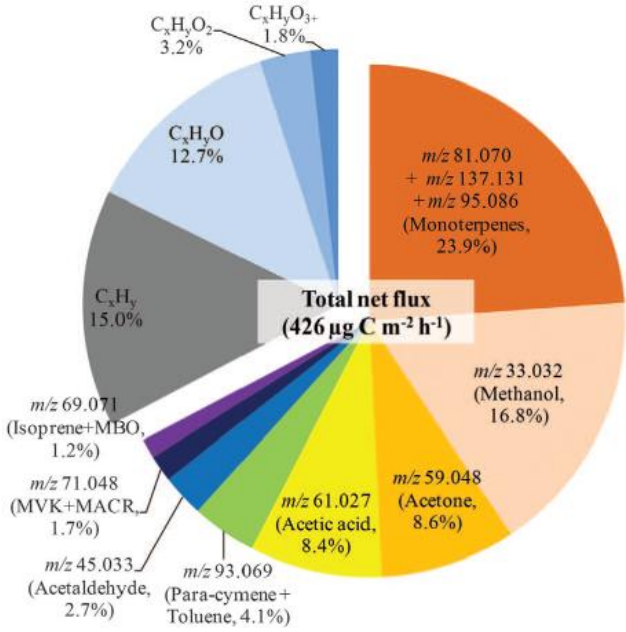


Ozone fluxes peak during the day because primary emitted BVOC depend on light and temperature



Ozone impacts on GPP can be detected within the day of exposure/uptake

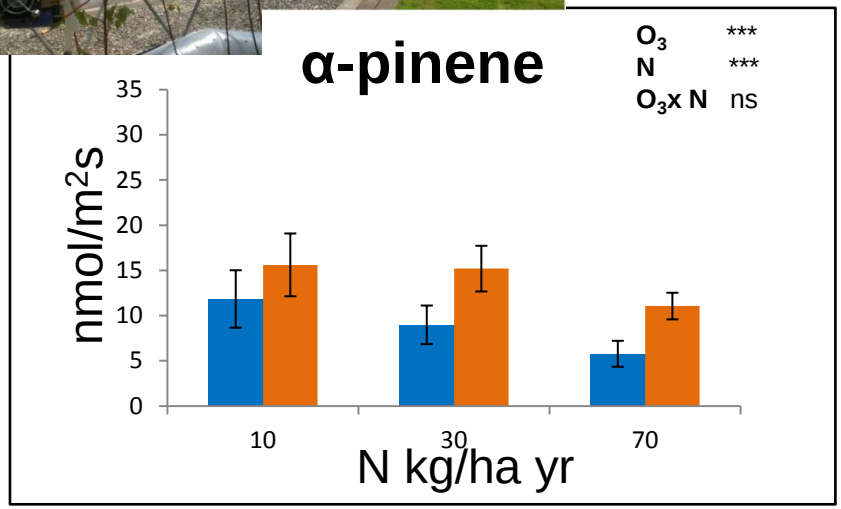
PTR-TOF shows an extreme variability of BVOCs, which is not incorporated in current global climate models and atmospheric VOC budgets

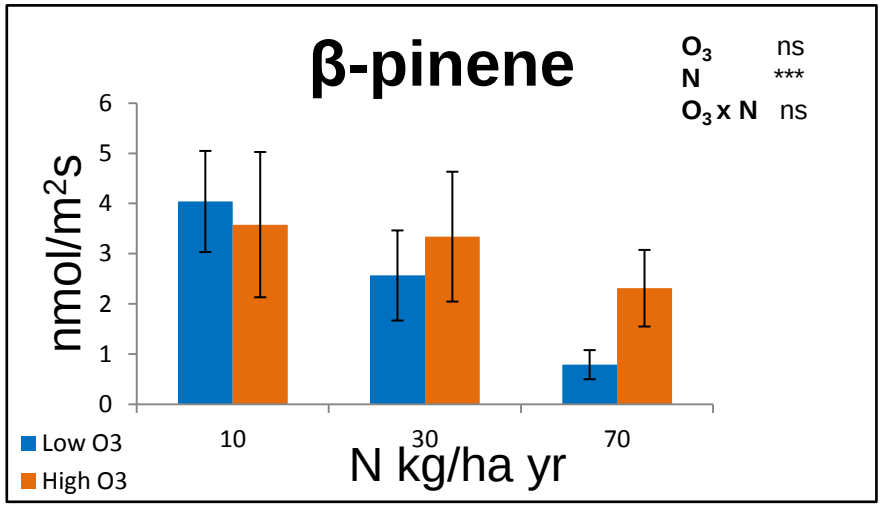


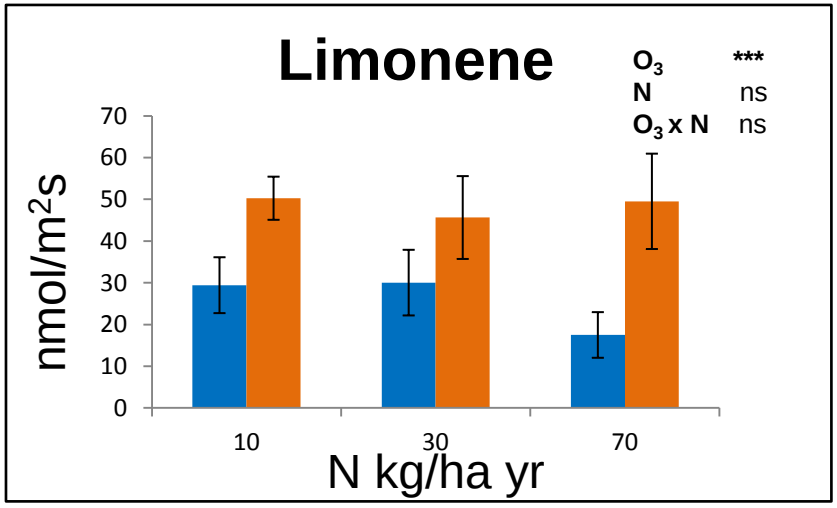
BVOC and ozone/nitrogen pollution in birch

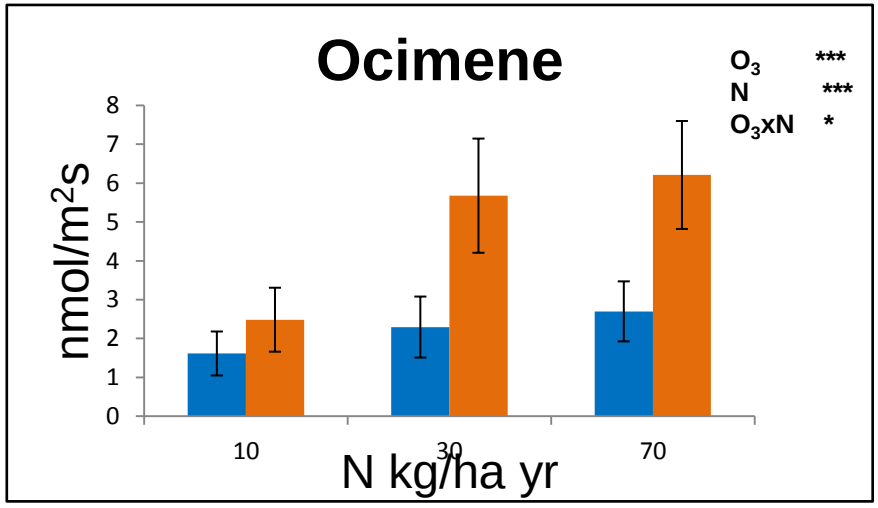
in collaboration with CEH Bangor

Preliminary results





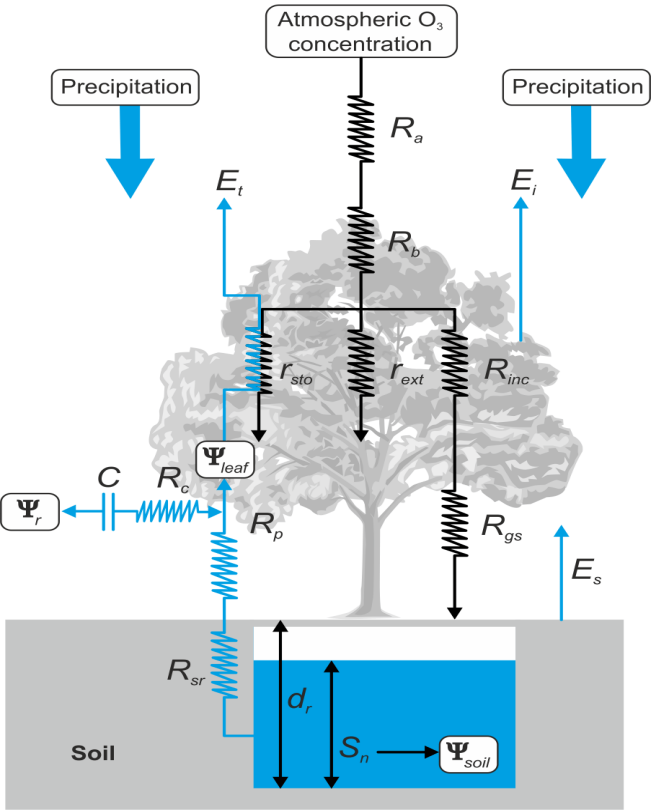




BVOC emission from silver birch decreased with increasing N and increased with O3

C3 modelling activities

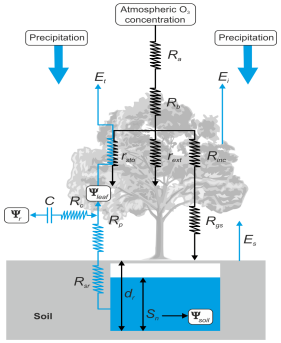
WP12 Lisa Emberson and colleagues, UK



New developments for DO_3SE

- Linking stomatal ozone flux to C assimilation and plant growth
- Hybrid 'multiplicative-A_{net}_g_{sto}' version incorporates effects of soil moisture stress and phenology
- Includes energy balance model for soil-plant-atmosphere system
- And new modules accounting for surface wertness

WP12 DO$_3$SE Model Application



The DO$_3$SE model will be used to simulate conditions within the 'site-specific' C3 experiments…

Site	Country	Vegetation type	Site design	Met data	Evaluation data	Parameterisation data
Alpflix	Switzerland	Sub alpine grassland	Field	✓	×	×
Bangor	UK	Birch	Solardome	✓	✓	✓
Brandberg	Denmark	Machis?	Mini FACE	✓	-	-
Curno	Italy	Hornbeam	OTC	✓	✓	✓
Santa Olalla	Spain	Dehesa	OTC?	✓	✓	✓

Data uploaded during Aug/Sept 2013

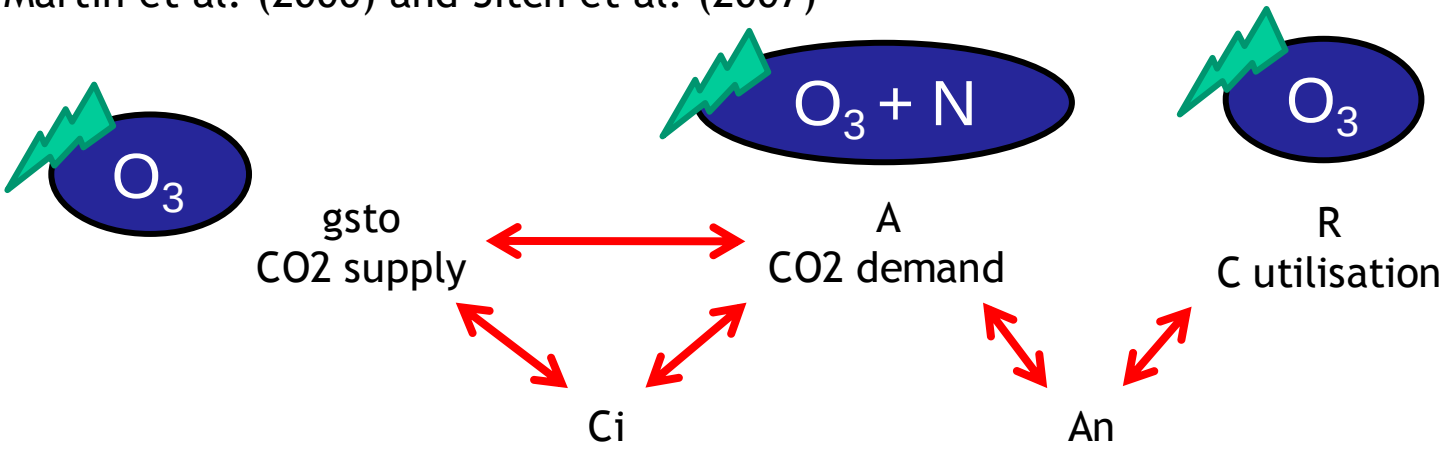
Additional datasets likely to become available soon

✓ = data already available; × data will not be available; - data to be uploaded

WP12 Lina Mercado and colleagues, UK
Koen Kramer and colleagues, The Netherlands

Photosynthesis algorithms in FORSPACE and JULES being developed to include O_3 effects

Build on Martin et al. (2000) and Sitch et al. (2007)



A-Ci, A-Q curves…..Vcmax : Jmax
An measurements
Dark Respiration
C:N ratios…link to Rubisco activity
CO2 fluxes (Canopy)

WP13 Chris Evans, Ed Rowe and colleagues, UK

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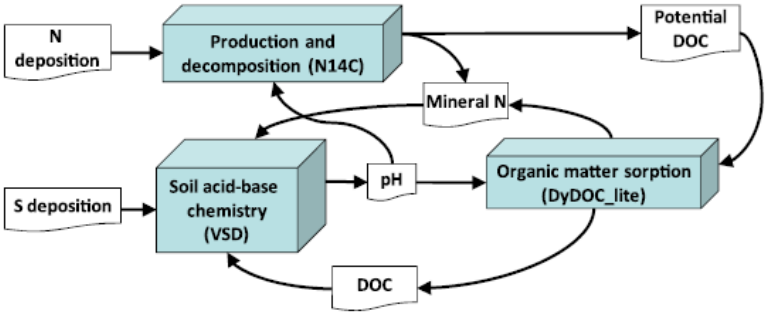
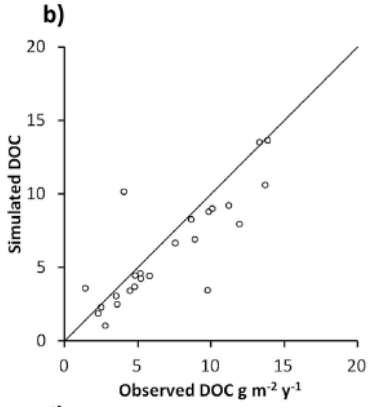
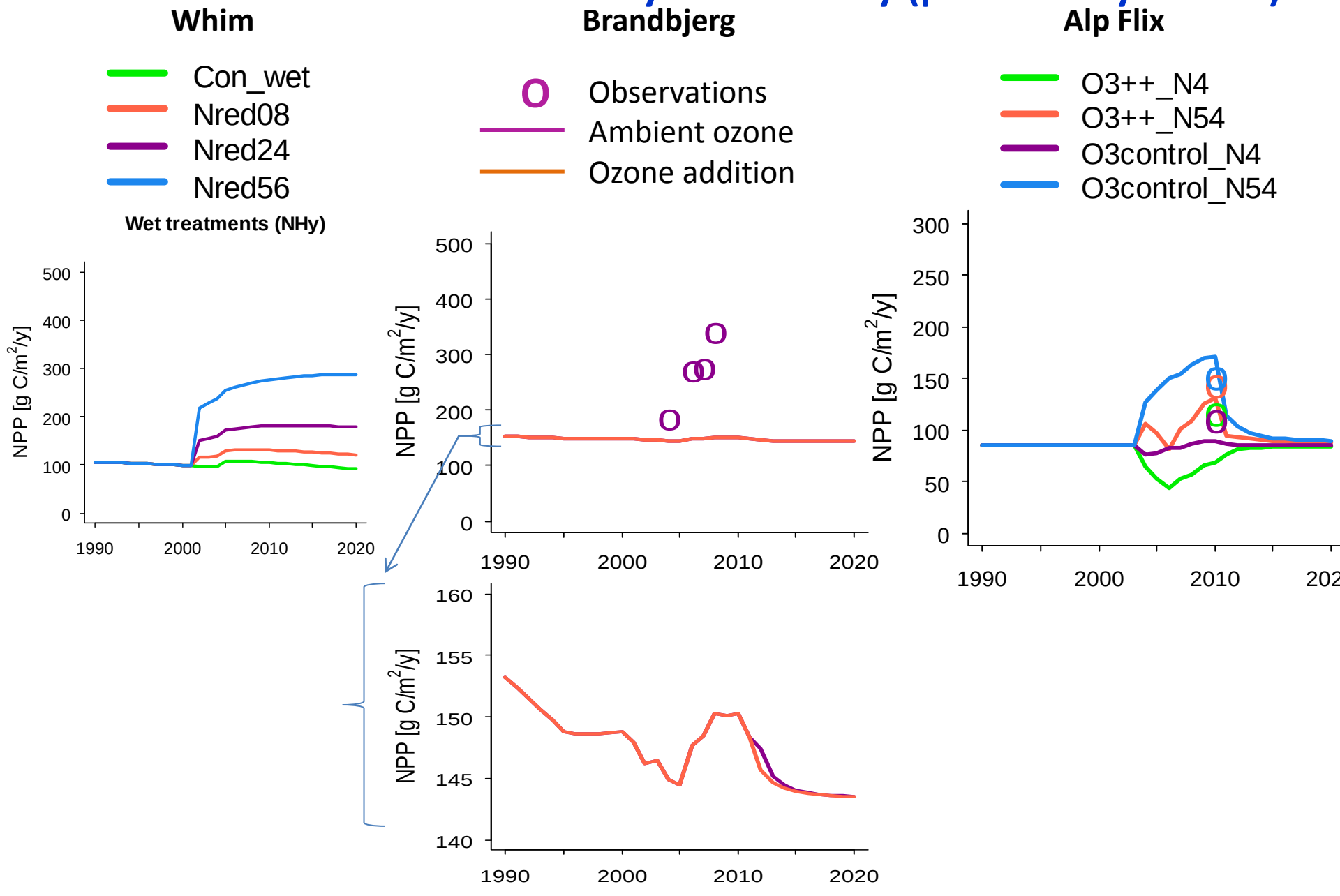


- Model description, with initial testing and application at UK sites, now published
- Response functions for NPP and litter quality vs O_3 now added to the model
- Data from WPs 9-10 used to define response functions for key species
- Test applications in progress for WP10-11 field experiments



WP13: Ed Rowe and Kasia Sawicka, UK

Initial MADOC runs – Net Primary Productivity (preliminary results)



WP13 Chris Evans and colleagues, UK

Integrated model testing

- Data suitable for model testing have now been collated (this took a while...)
- Joint site-based model testing protocol developed between C3 and C4
- First phase of MADOC and FORSPACE-VSD+ testing on the three C3 'field-scale' experiments (Whim, Brandbjerg, Alp Flix)

- DO3SE testing also on all C3 'pot-scale' experiments
- Additional (e.g. long-term monitoring) sites to be included in subsequent testing
- Outputs to be compared to DGVM outputs from nearest analogous grid cell
- Other models welcomed to undertake parallel site-specific testing

Current status for C3:

On track ....

- ❑Data collation from literature, data bases and experiments moving into final phase
- ❑ Model developments and linkages under way
- ❑ Next year – Novel thresholds identified and models developed for use in large-scale modelling

C3-related sessions

Ten key questions identified that we hope to answer (at least in part) at this meeting

Session4 (C3 only) : Linking modelling with experimental data

Sessions 5 and 6 (C3 and C4) Data mining and model development at local scale

Session 7 (C1 and C3) Leaf exchange processes

Session 8 (C3, C4, C5) Novel thresholds and model endpoints

Session 9: Work-plan for next year

Session 7 (C1 and C3) Leaf exchange processes

Key Q6: How do we integrate knowledge collected in C3 (on pollutant interactions) to inform knowledge on deposition/exchange processes in C1 (and vice versa)?
Key Q7: What level of complexity might be appropriate here (e.g. multi-layer models; multi-pollutant interactions; bi-directional exchange)?

Session 8 (C3, C4, C5) Novel thresholds and model endpoints

Key Q8: What are our endpoints/thresholds – which are most relevant (and possible), and how do they relate to ecosystem services and C5 work?
Key Q9: How do we deal with interactions (O3, N, aerosols, climate etc.)?
Key Q10: How to achieve linkages between DO3SE and DGVMs (either as linked models or as linked inputs/outputs), and DO3SE and MADOC

Session 9: Work-plan for next year