C3
Ecological response processes & thresholds

Claus Beier, Risoe DTU, DK

Manipulation experiments
climate change & biogeochemistry

C3
Ecological response processes & thresholds

New database - **meta-analysis** - air pollution impacts - terrestrial ecosystems

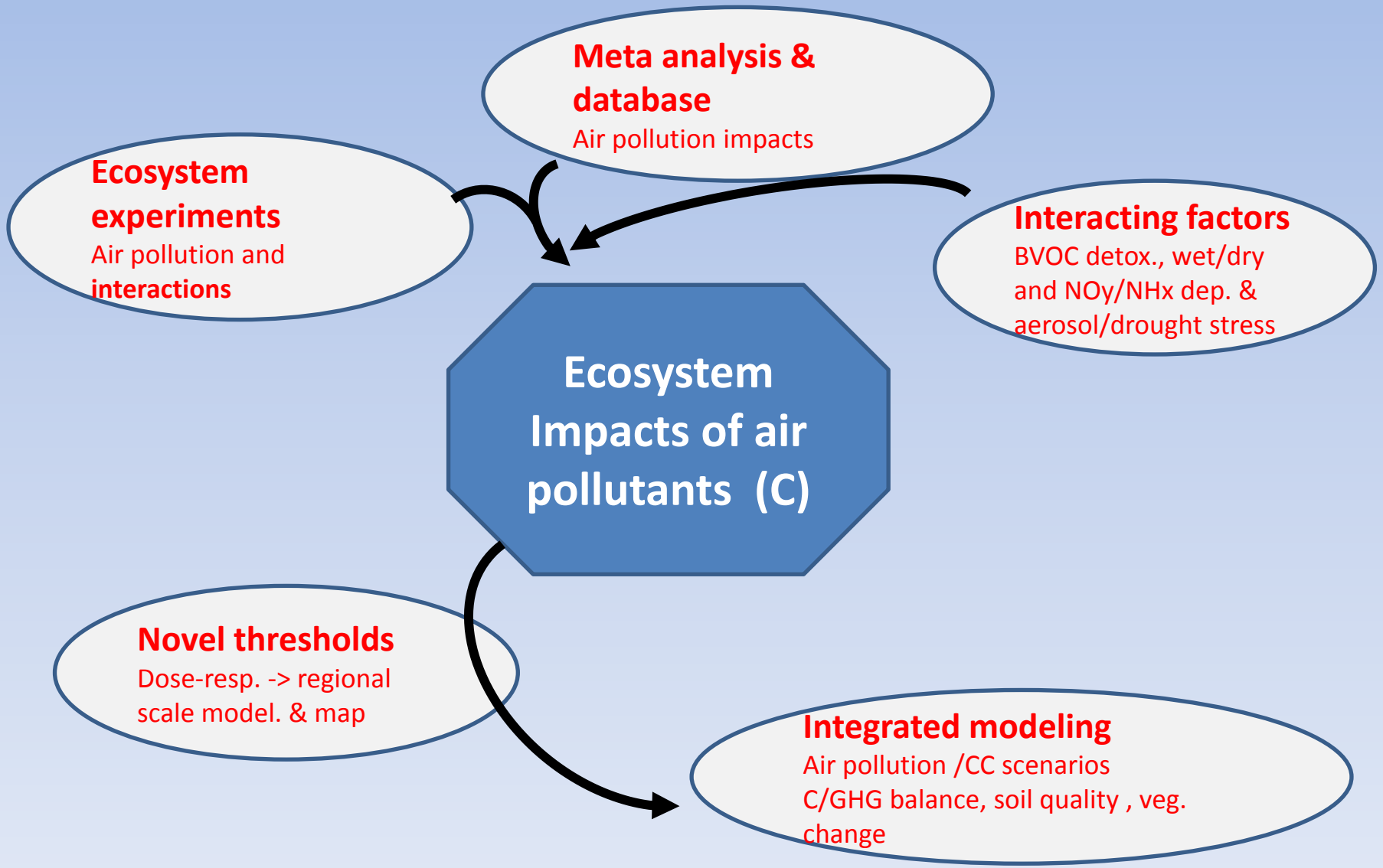
Ecosystem response experiments - plant responses and ecosystem C balance - air pollution and interacting drivers

Parametrization – **interacting novel processes** (O3-BVOC detox, wet/dry and NOy/NHx deposition, aerosol - drought stress)

Novel thresholds for key dose-response relationships

Integrated **modeling**

C3
Ecological response processes & thresholds

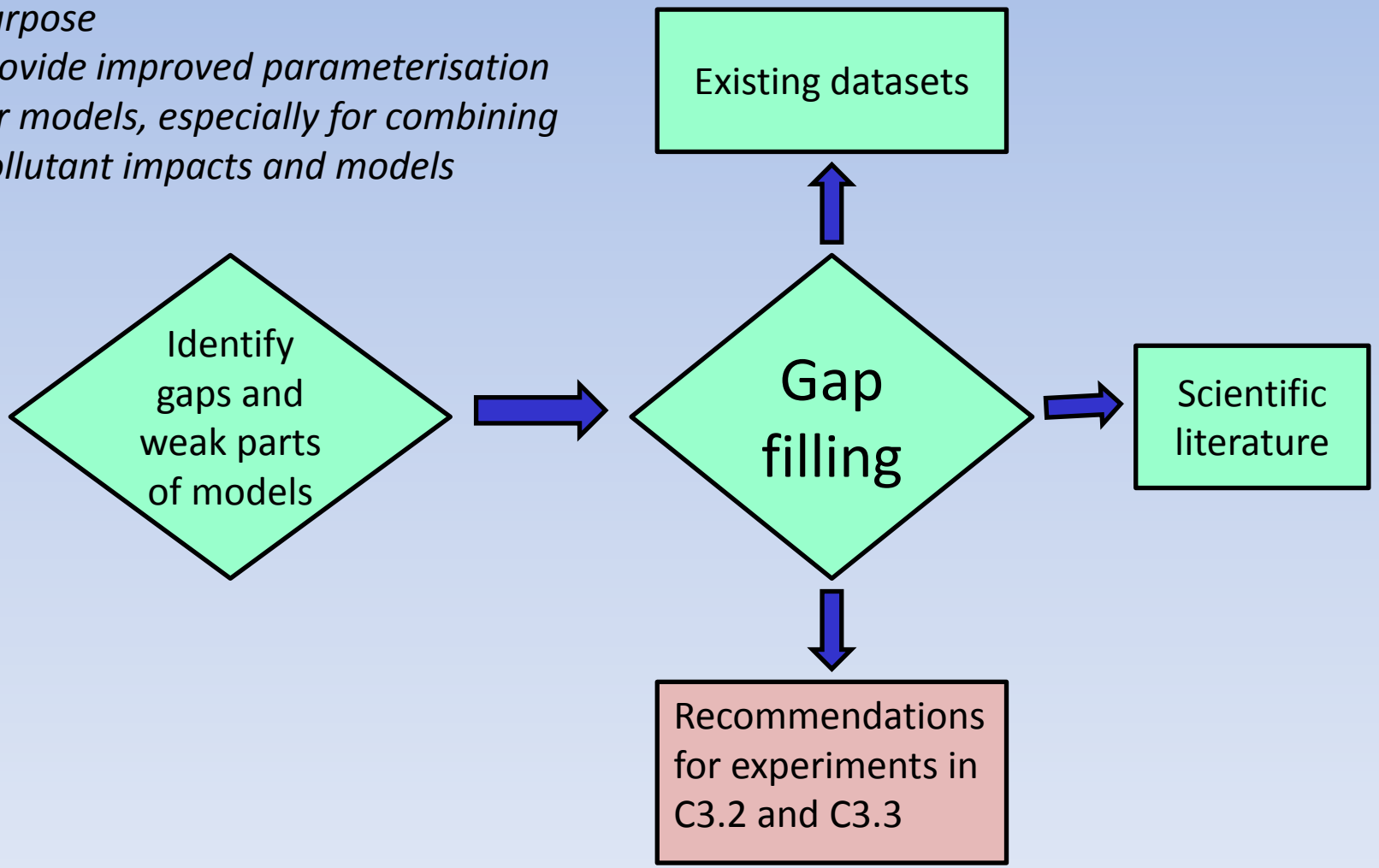


WP9
Gina Mills, CEH

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

Data mining

Purpose
Provide improved parameterisation for models, especially for combining pollutant impacts and models



What's needed versus what's there?

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

Model types

- Ozone uptake
- Soil biogeochemical
- Vegetation growth
- Large-scale veg/C/H2O
- Species occurrence

Data sources: controlled exposure experiments

Ozone (sometimes +/- drought, CO2, N fertiliser)

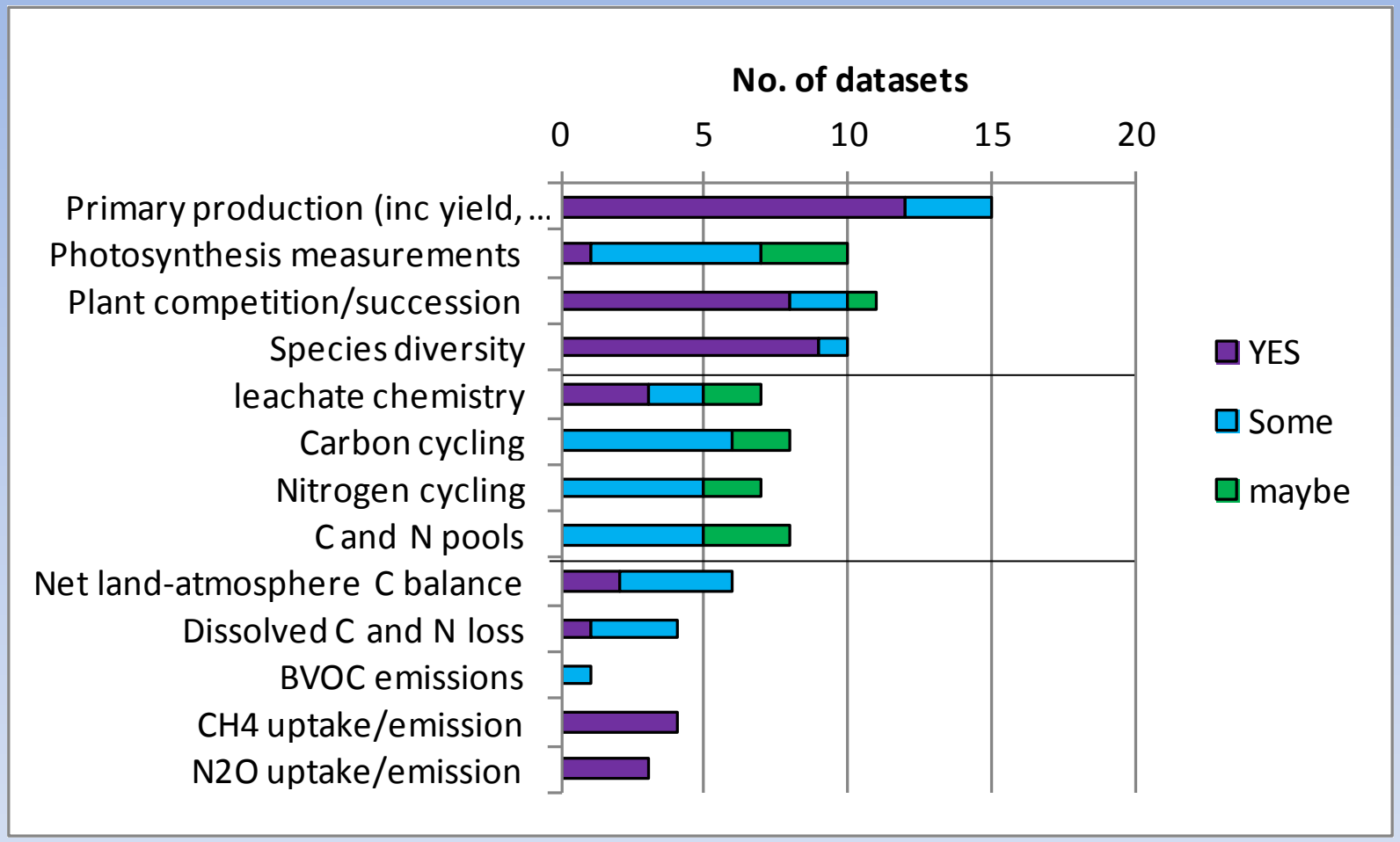
Available for wheat, potato, conifers, broad-leaved trees and grassland mixtures

ments (sometimes +/- drought)

ECLAIRE sites

Available for wetlands, dry heath, grasslands, forests?

Experimental dataset availability (list of datasets to be expanded)



- Data availability is patchy; most experiments have measured plant production, fewer have measured soil parameters and even fewer have measured GHG fluxes

What's needed versus what's there?

Model types

- Ozone uptake
- Soil biogeochemical
- Vegetation growth
- Large-scale veg/C/H2O
- Species occurrence

Data sources: open field, ambient air surveys

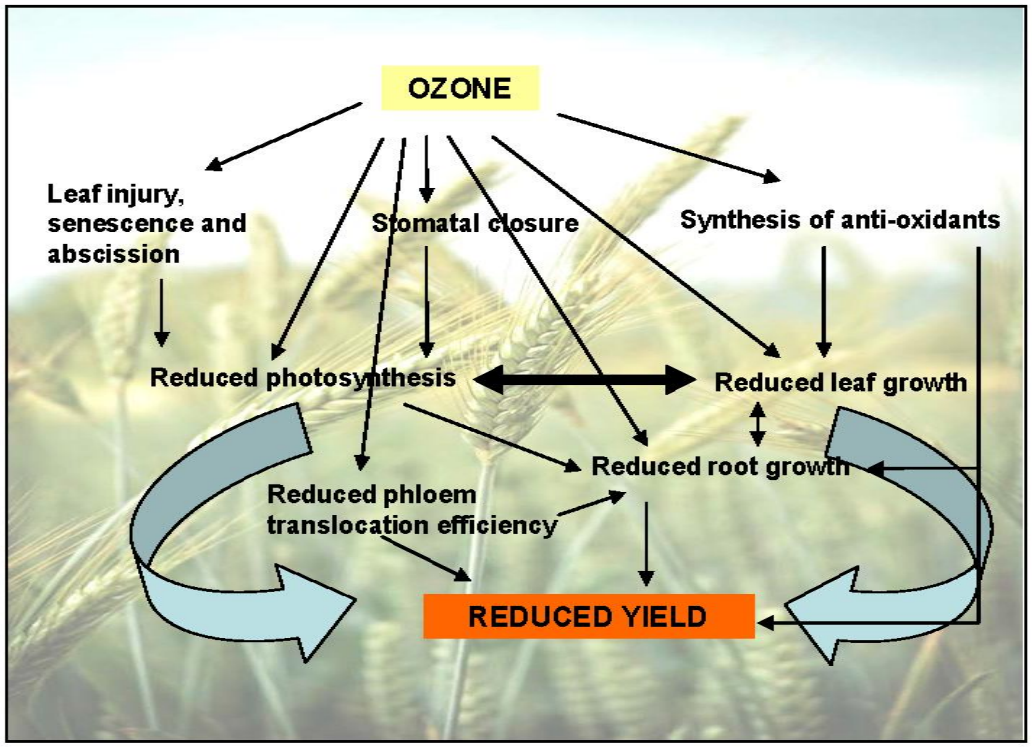
e.g. ICP Forests data from level II plots, Countryside survey data showing shifts in species composition

What's needed versus what's there?

Model types

- Ozone uptake
- Soil biogeochemical
- Vegetation growth
- Large-scale veg/C/H2O
- Species occurrence

Data sources: scientific literature



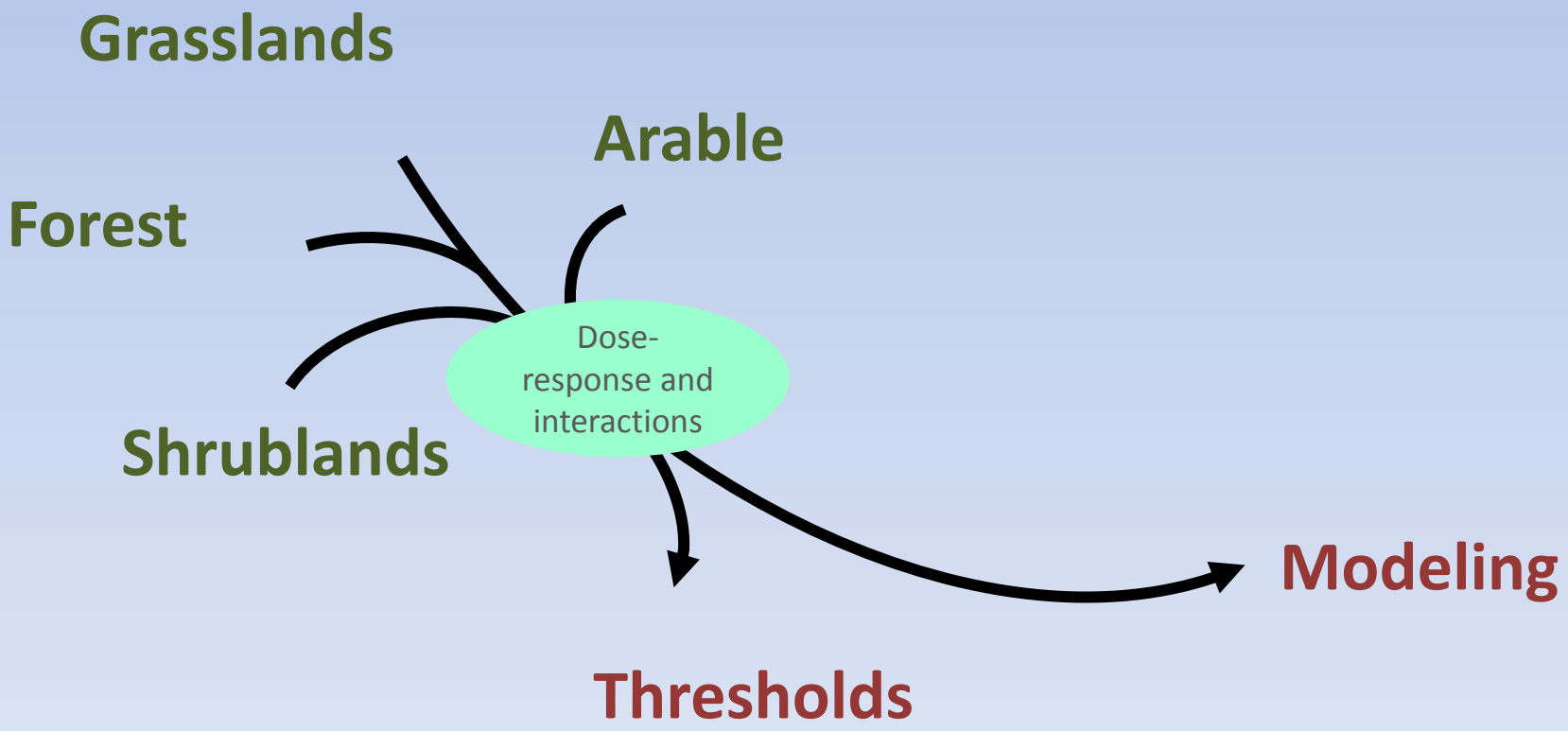
❑Find process-response data/functions for building models

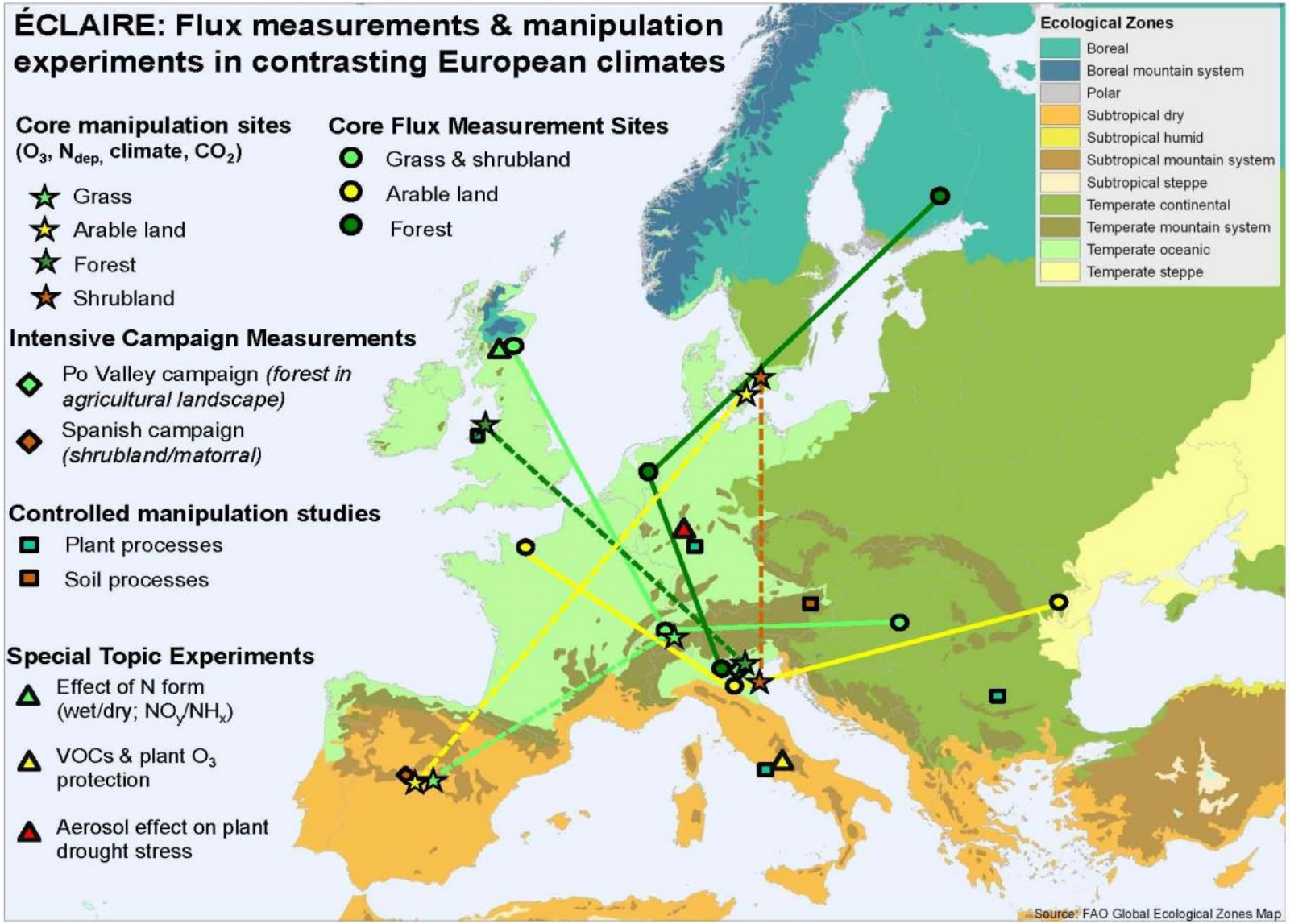
* source: Wilkinson et al., Journal of Experimental Botany, in press

WP10
Claus Beier (DTU)

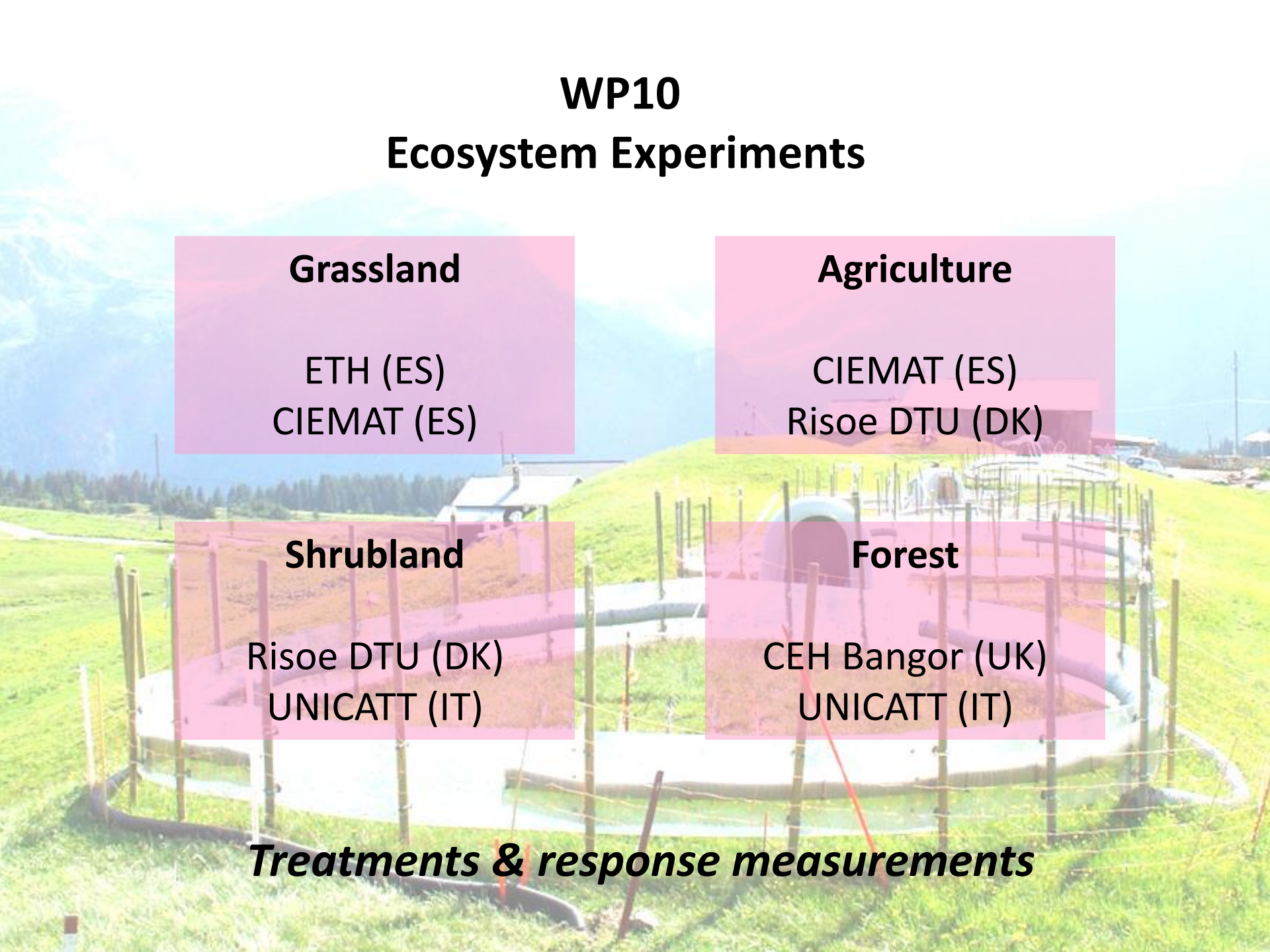
eclaire
Effects of climate change on air pollution impacts and response strategies for European ecosystems

Field scale ecosystem manipulation experiments




ÉCLAIRE: Flux measurements & manipulation experiments in contrasting European climates
Core manipulation sites
(O_3, N_{dep}, climate, CO_2)
Grass
Arable land
Forest
Shrubland
Core Flux Measurement Sites
Grass & shrubland
Arable land
Forest
Intensive Campaign Measurements
Po Valley campaign (forest in agricultural landscape)
Spanish campaign (shrubland/matorral)
Controlled manipulation studies
Plant processes
Soil processes
Special Topic Experiments
Effect of N form (wet/dry; NO_y/NH_x)
VOCs & plant O_3 protection
Aerosol effect on plant drought stress
Ecological Zones
Boreal
Boreal mountain system
Polar
Subtropical dry
Subtropical humid
Subtropical mountain system
Subtropical steppe
Temperate continental
Temperate mountain system
Temperate oceanic
Temperate steppe
Source: FAO Global Ecological Zones Map

WP10
Ecosystem Experiments



Grassland

ETH (ES)
CIEMAT (ES)

Agriculture

CIEMAT (ES)
Risoe DTU (DK)

Shrubland

Risoe DTU (DK)
UNICATT (IT)

Forest

CEH Bangor (UK)
UNICATT (IT)

Treatments & response measurements

Forest ecosystems

CEH Solardome experiments

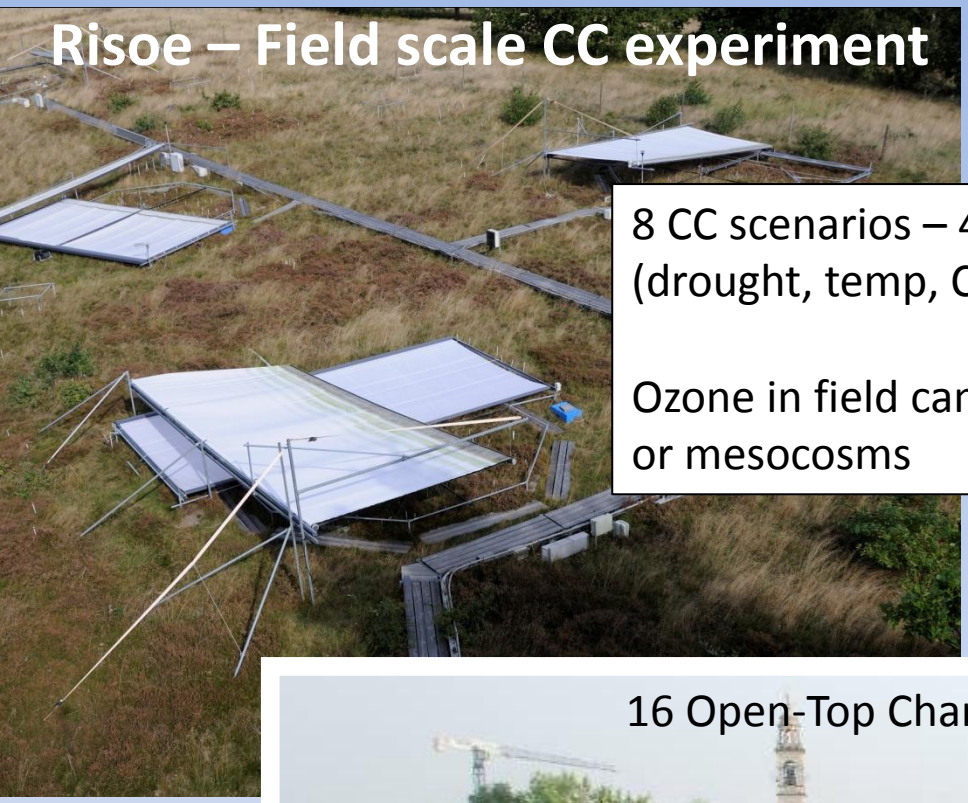
8 closely controlled ozone regimes: pre-industrial through to 2100 profiles

Ozone * drought * wet N interactions
Alder (2012) and Birch (2013)

UNICATT (IT)
Open-Top Chambers Experimental Site

16 Open-Top Chambers for ozone filtration and ozone fumigation

Shrubland ecosystems



8 CC scenarios – 48 plots (drought, temp, CO2)

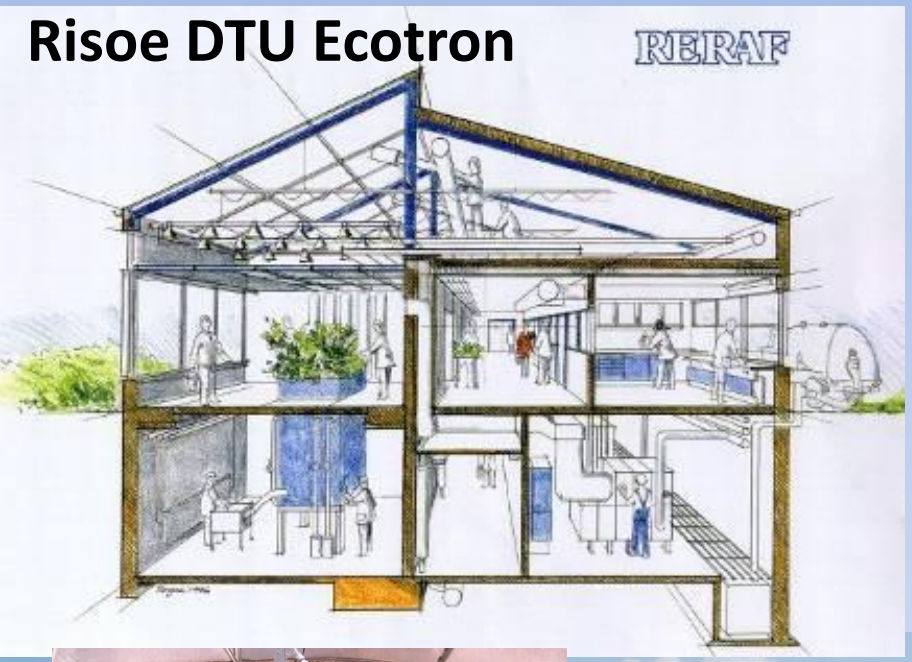
Ozone in field campaigns or mesocosms

UNICATT (IT)
Open-Top Chambers

16 Open-Top Chambers for ozone filtration and ozone fumigation

Arable ecosystems

Risoe DTU Ecotron



6 champers
CC scenarios & O3.

CIEMAT (ES)

MINISTERIO DE EDUCACIÓN Y CIENCIA

Ciemat
Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

OTC field site in the experimental farm "La Higueruela"
(Santa Olalla, Toledo, Central Spain)

Grassland ecosystems

Alp Flix – ETH (CH)

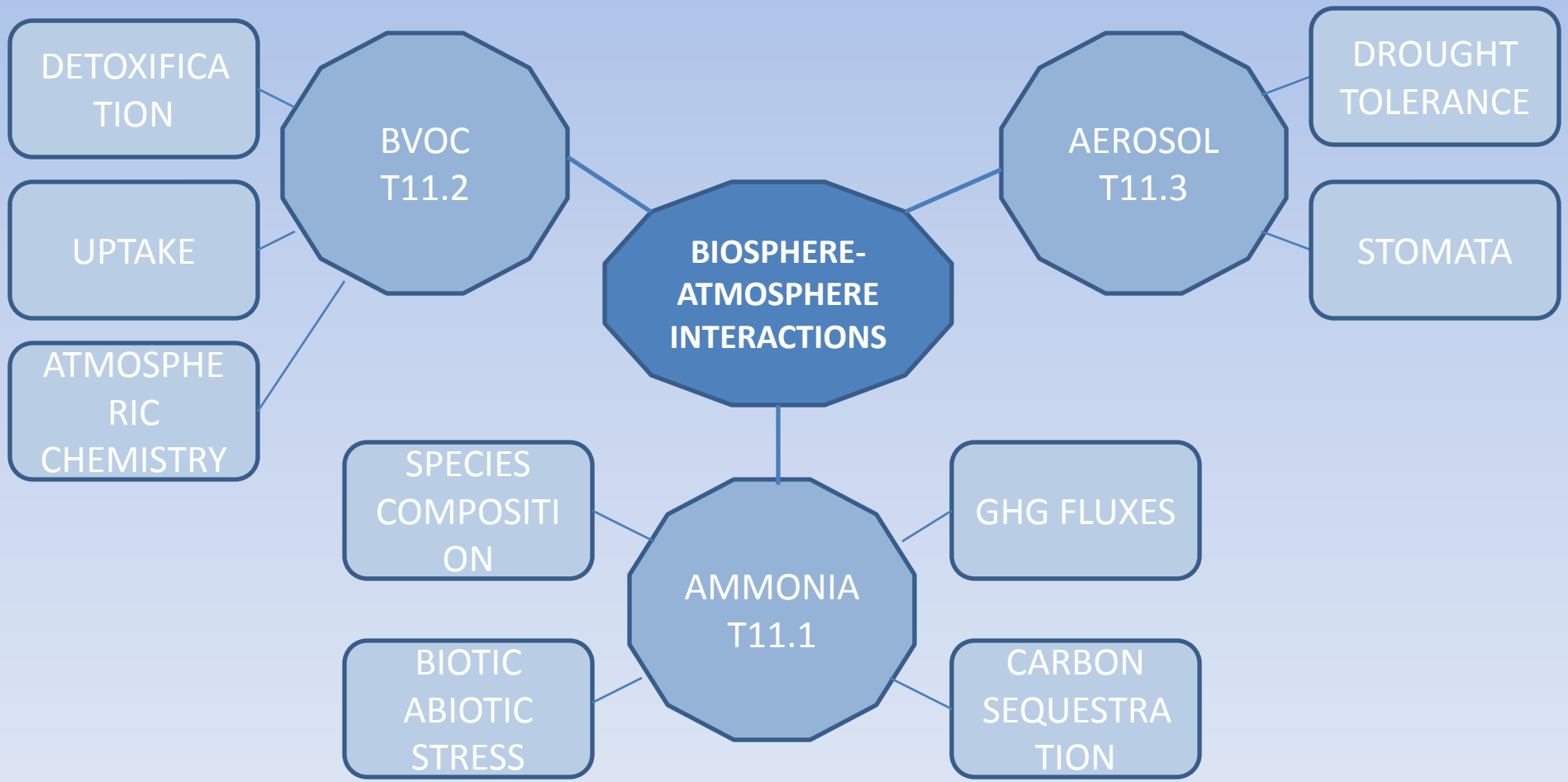
Crossfactorial split-plot design (3 ozone levels x 5 nitrogen loads)

CIEMAT (ES)

OTC field site in the experimental farm "La Higueruela" (Santa Olalla, Toledo, Central Spain)

Novel processes

Ecosystem – air pollution – climate interactions



WP11: Francesco Loreto (CNR)

Interactions with Eclaire

BIOSPHERE-ATMOSPHERE INTERACTIONS

- BVOC T11.2
  - WP9 Synthesis and meta-analysis
  - WP12 Novel thresholds
  - WP13 Modelling carbon stocks, GHGs and vegetation
  - T16.3 Maps for ozone
- AEROSOL T11.3
  - T9.1 Synthesis and meta-analysis
  - T12.4 Dose-response and thresholds
  - T16.3 Maps for ozone
- AMMONIA T11.1
  - WP12 Novel thresholds
  - WP13 Modelling carbon stocks, GHGs and vegetation
  - T14.2 Model application
  - WP15 Biodiversity and soil quality

BVOC as detoxifier of O3 in stomata

Ventilated greenhouses Bonn (DE)
Pot experiments - impact of particulate pollution on WUE

Whim Bog (UK)
Free air fumigation with reduced and oxidized N deposition

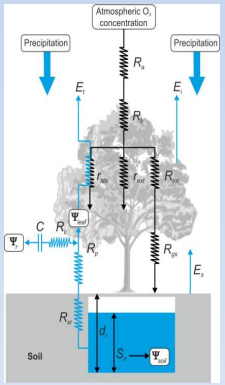
WP12

Lisa Emberson (DTU)

Development and Assessment of Novel Thresholds

WP4 Surface exchange modelling

Use the modified DO_3SE model to simulate ECLAIRE experimental studies in information from data mining (**WP9, 10, 11**)



Define and model intermediate ecosystem responses to pollution impacts (e.g. damage to photosynthesis, early senescence, altered litter chemistry)

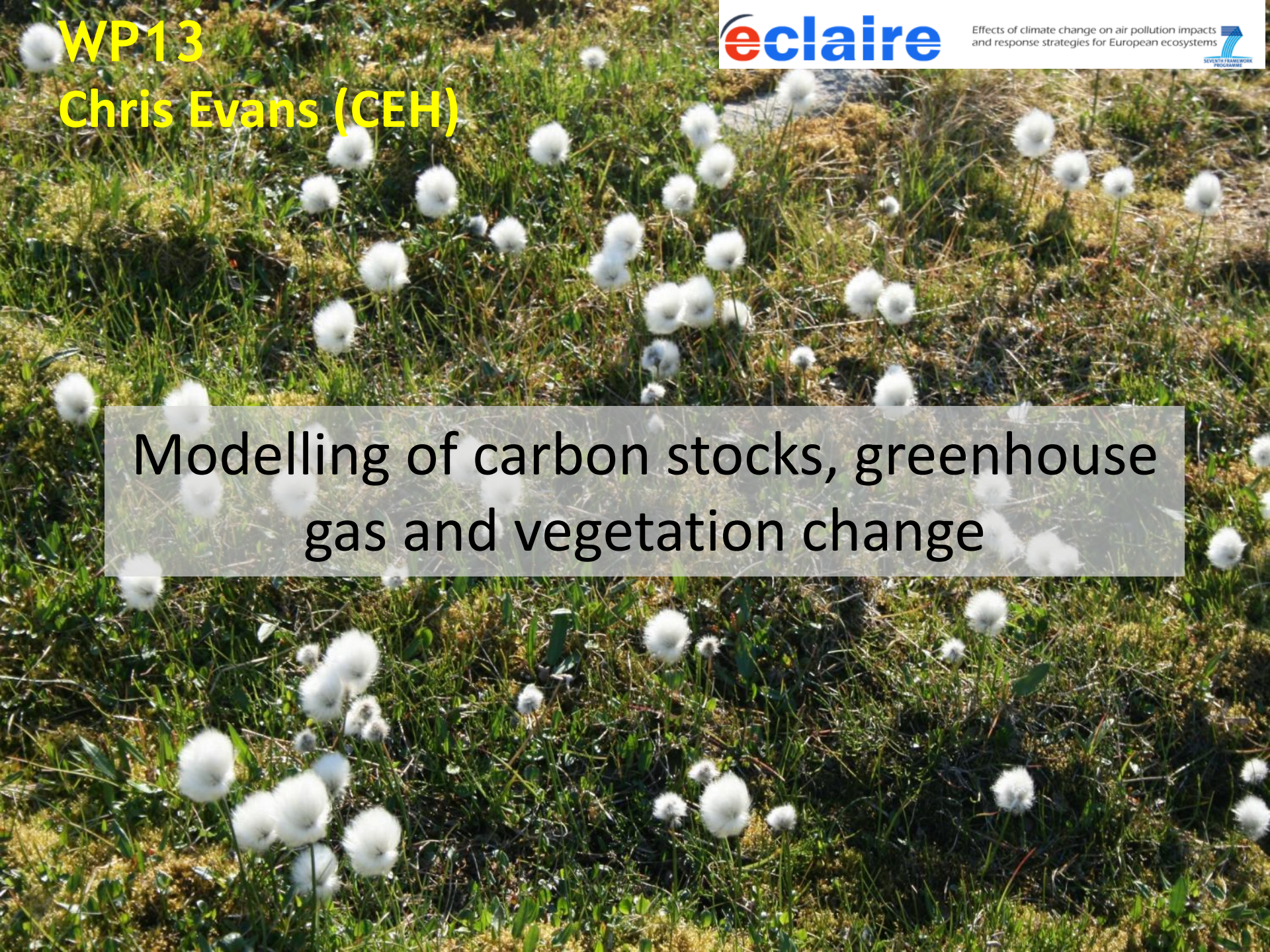
WP13 Modelling of C stocks, GHG and vegetation change

From experimental simulations develop **dose-response relationships** and **novel thresholds** for key ecosystem responses

Define ecosystem services affected by pollution impacts

WP18 Valuation of ecosystem services

Pollutant combinations, variable environments, policy relevant responses



WP13

Chris Evans (CEH)

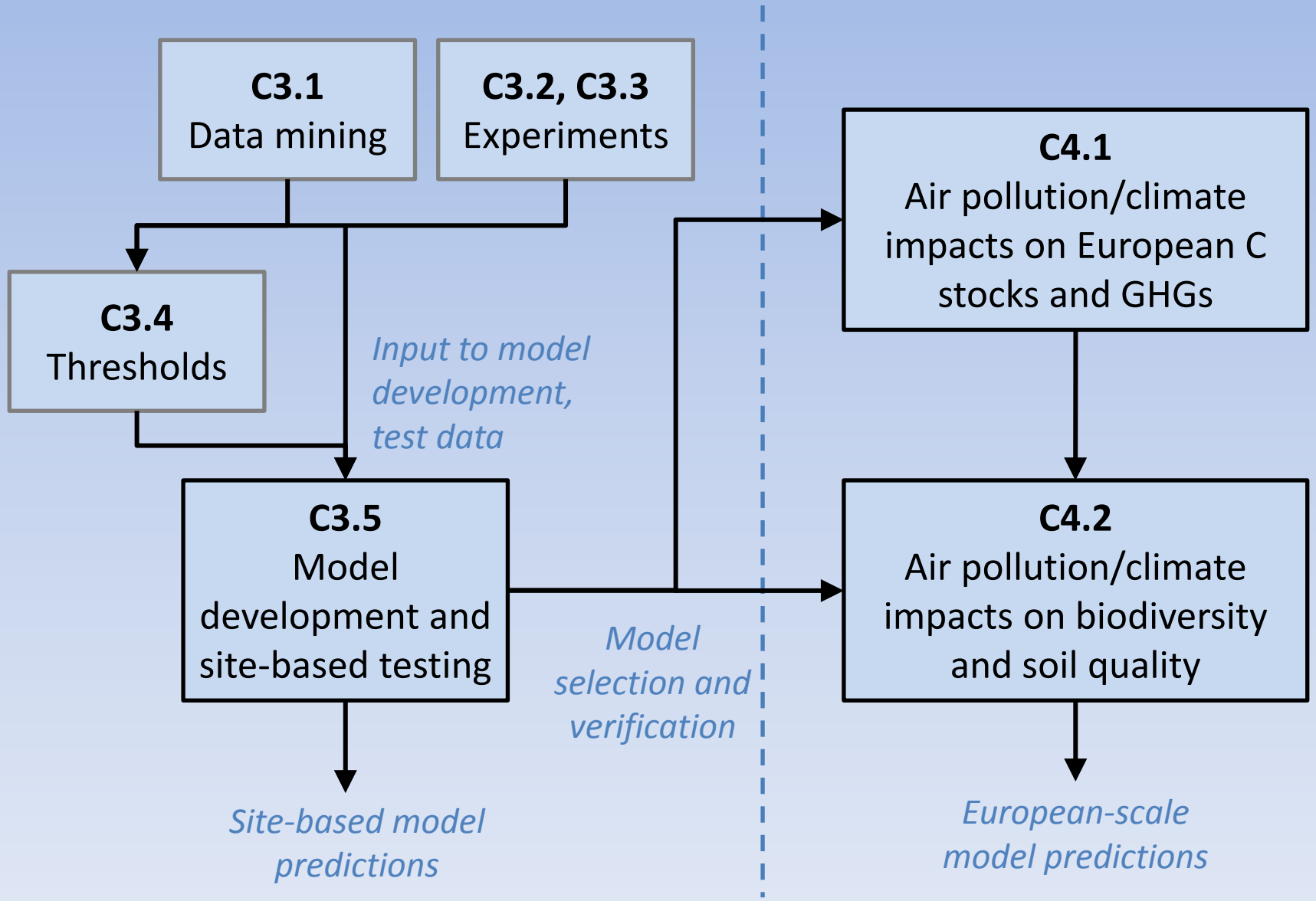
eclaire

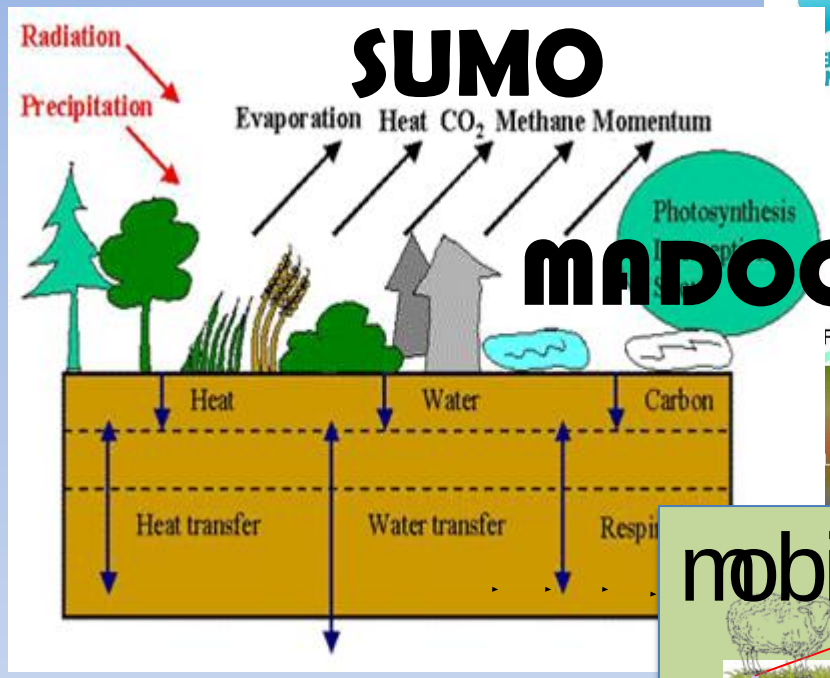
Effects of climate change on air pollution impacts and response strategies for European ecosystems

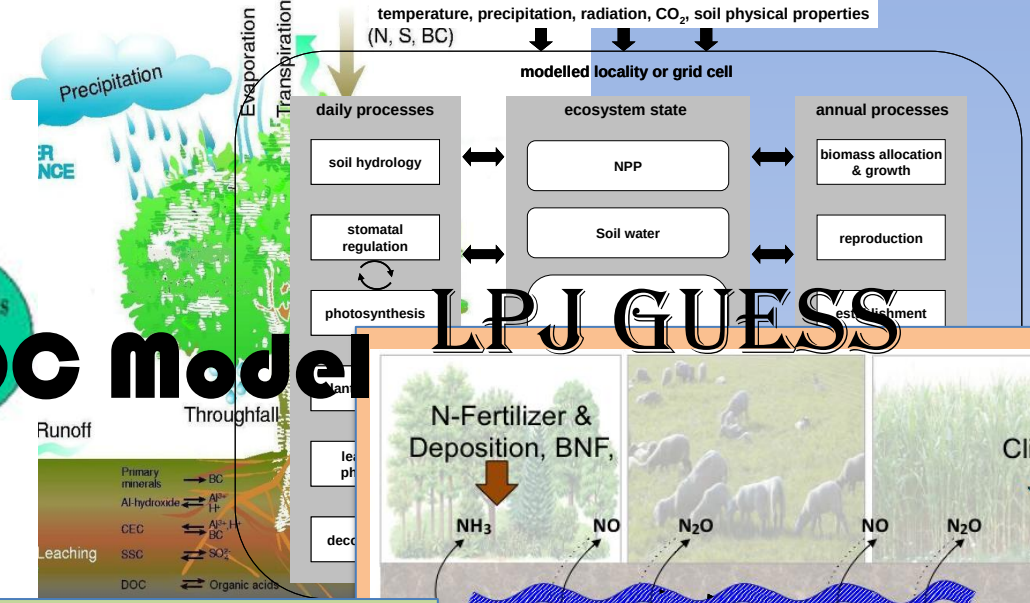
SEVENTH FRAMEWORK PROGRAMME

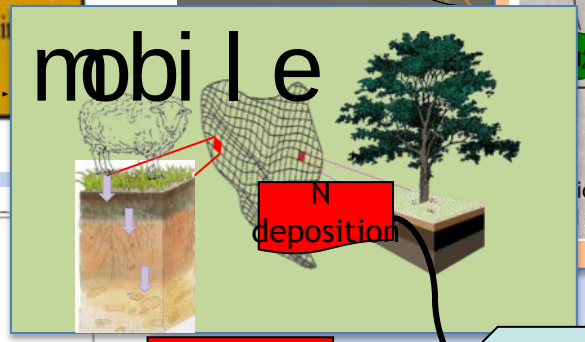
Modelling of carbon stocks, greenhouse gas and vegetation change

Modelling in C3, and links to C4

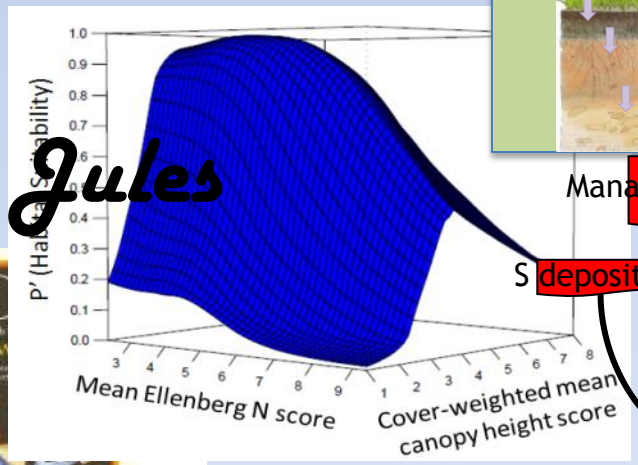


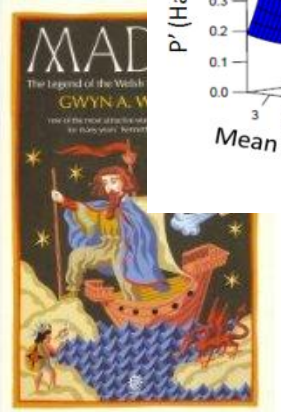

SUMO
Radiation
Precipitation
Evaporation Heat CO_2 Methane Momentum
Photosynthesis
Heat
Water
Carbon
Heat transfer
Water transfer

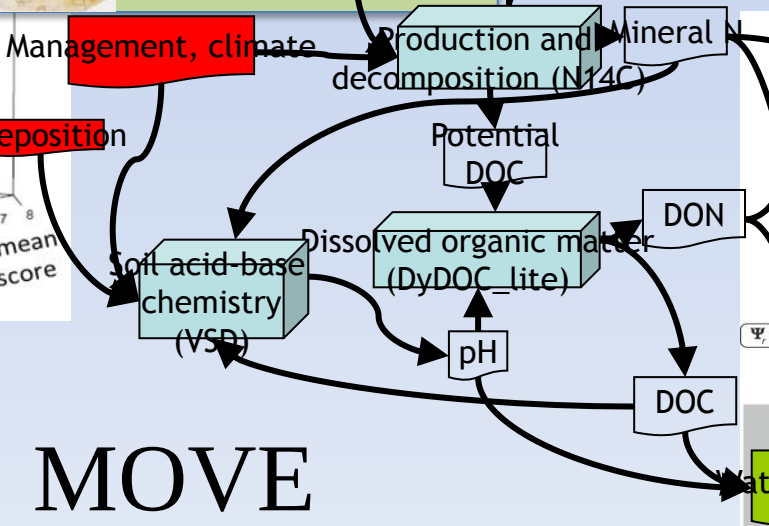

MADOC Model
Precipitation
Evaporation
Transpiration
Throughfall
Runoff
Primary minerals
Al-hydroxide
CEC
SSC
DOC
Leaching
Organic acids
temperature, precipitation, radiation, CO_2, soil physical properties
(N, S, BC)
modelled locality or grid cell
daily processes
ecosystem state
annual processes
soil hydrology
stomatal regulation
photosynthesis
NPP
Soil water
biomass allocation & growth
reproduction
LPJ GUESS

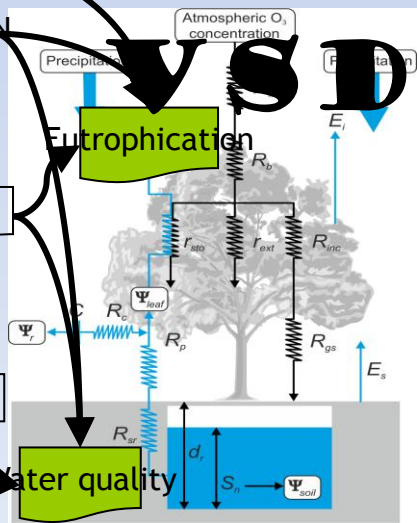

mobile
N deposition

N-Fertilizer & Deposition, BNF,
Climate
NH_3
NO
N_2O
NO
N_2O
$NH_4^+ \rightarrow NH_2OH \rightarrow NO_2^- \rightarrow NO_3^-$
$NO_3^- \rightarrow NO_2^- \rightarrow N_2O \rightarrow N_2$
Nitrification
Denitrification
Environmental conditions
- Temperature, moisture & pH
Modified from Davidson, 19


Jules
P' (Habitat Suitability)
Mean Ellenberg N score
Cover-weighted mean canopy height score

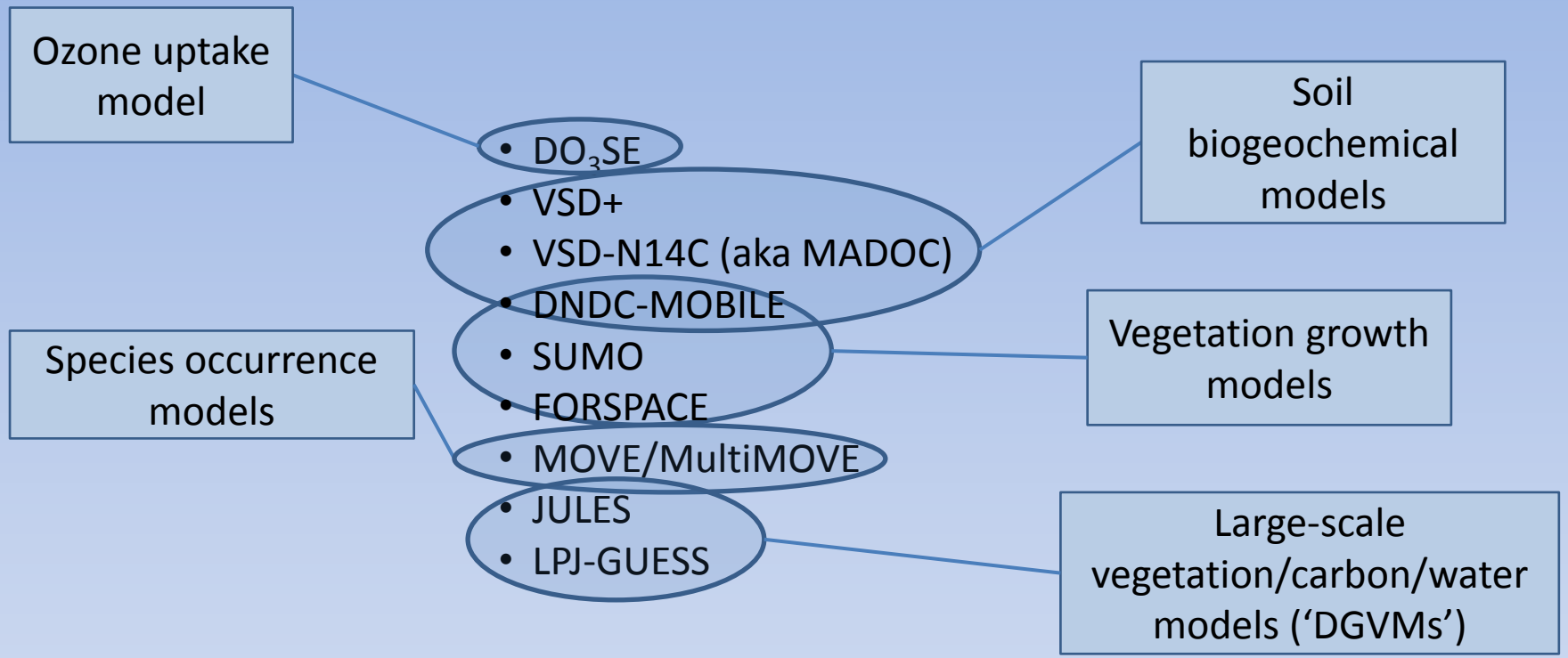

MAD
GWYN A. W


Soil C
Carbon stocks
Biomass C
Management, climate
Production and decomposition (N14C)
Mineral N
S deposition
Potential DOC
DON
Dissolved organic matter (DyDOC_lite)
Soil acid-base chemistry (VSD)
pH
DOC
Water quality


VSD
Atmospheric O_3 concentration
Eutrophication

MOVE

Which models, and why so many?



- Models have different (but overlapping) strengths
- Linked models may be required to evaluate multiple drivers (e.g. O_3, N, climate) and multiple impacts (productivity, carbon, water quality, biodiversity)
- Use of multiple models targeted at different spatial scales should allow effective testing and selection, underpinning for regional application, and ensemble predictions using different models

All models do something, no models do everything…

Processes/habitats modelled		Model/model chain					
		VSD+-SUMO-MOVE	VSD-N14C-GBMOVE	DNDC-MOBILE	DOSE	JULES	LPJ-GUESS
Drivers	Ozone				●		
	Nitrogen	●	●	●		●	?
	Sulphur	●	●	●			
	PM (diffuse radiation)					●	
	CO_2					?	?
	Climate change	●	●	●	●	●	●
Vegetation processes	Primary production (inc yield)			●	●	●	●
	Plant competition/succession	●				●	●
	Species diversity	●	●				?
Soil processes	Acid-base chemistry	●	●	●			
	Carbon cycling	●	●	●		●	
	Nitrogen cycling	●	●	●		●	
C and GHG fluxes	Net land-atmosphere C balance	●	●	●		●	●
	Dissolved C and N loss		●				
	BVOC emissions					●	●
	CH_4 uptake/emission			●		●	●
	N_2O uptake/emission			●		●	●
	BVOCs						●
Habitat types	Forests	●	●	●	●	●	●
	Grassland	●	●	●	●	●	
	Agriculture			●	●	●	
	Wetland and heathland	●	●	●	?	●	

C3
Ecological response processes & thresholds