# éclaire

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

SEVENTH FRAMEWORK PROGRAMME

**Mark Sutton**

**Centre for Ecology & Hydrology, Edinburgh**

ÉCLAIRE Final Meeting, Edinburgh, 1 September 2013

LRTAP

Long-range Transboundary Air Pollution

# ÉCLAIRE objectives

- To provide robust understanding of air pollution impacts on European land ecosystems including soils under changing climate conditions.
- To provide reliable and innovative risk assessment methodologies for these ecosystem impacts of air pollution, including the economic implications, to support EU policy.
- Focus on $O_3$ and N, and where relevant their interactions with VOCs, aerosols and S.

# Key questions for ÉCLAIRE

- How will climate change alter the threat of air pollution on ecosystems?
  - Changing emissions, transport and deposition of air pollutants?
  - Changing vulnerability of ecosystems for a given pollution dose?

# Two kinds of delivery in ÉCLAIRE

- The European Commission is watching – every promised deliverable checked!
  - Fine View: Complete the promised deliverables
  - Big View: Keep the big messages in mind
  - Plus the EU want's lots else too…

# ÉCLAIRE Key Issues

**bVOCs**

**Ozone**

**Nitrogen**
$NH_3$ $NO_x$ $N_2O$

**Particulate Matter**

**Temperature**

**Drought**

**$CO_2$ increase**

**Ecosystem functioning**

**Ecosystem vulnerability**

**Ecosystem quality**

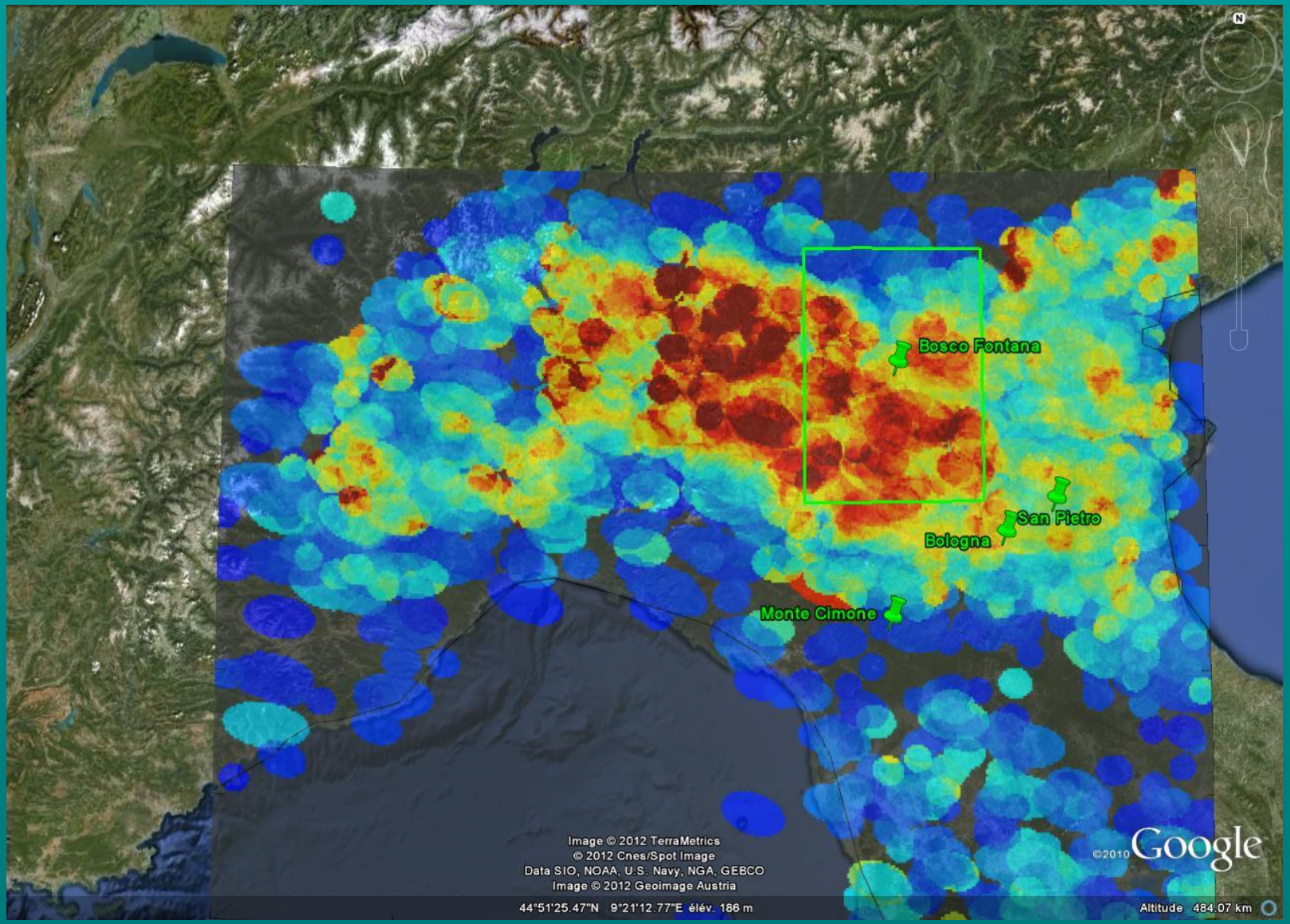
**Ecosystem Services**

**Mitign/adapn options**

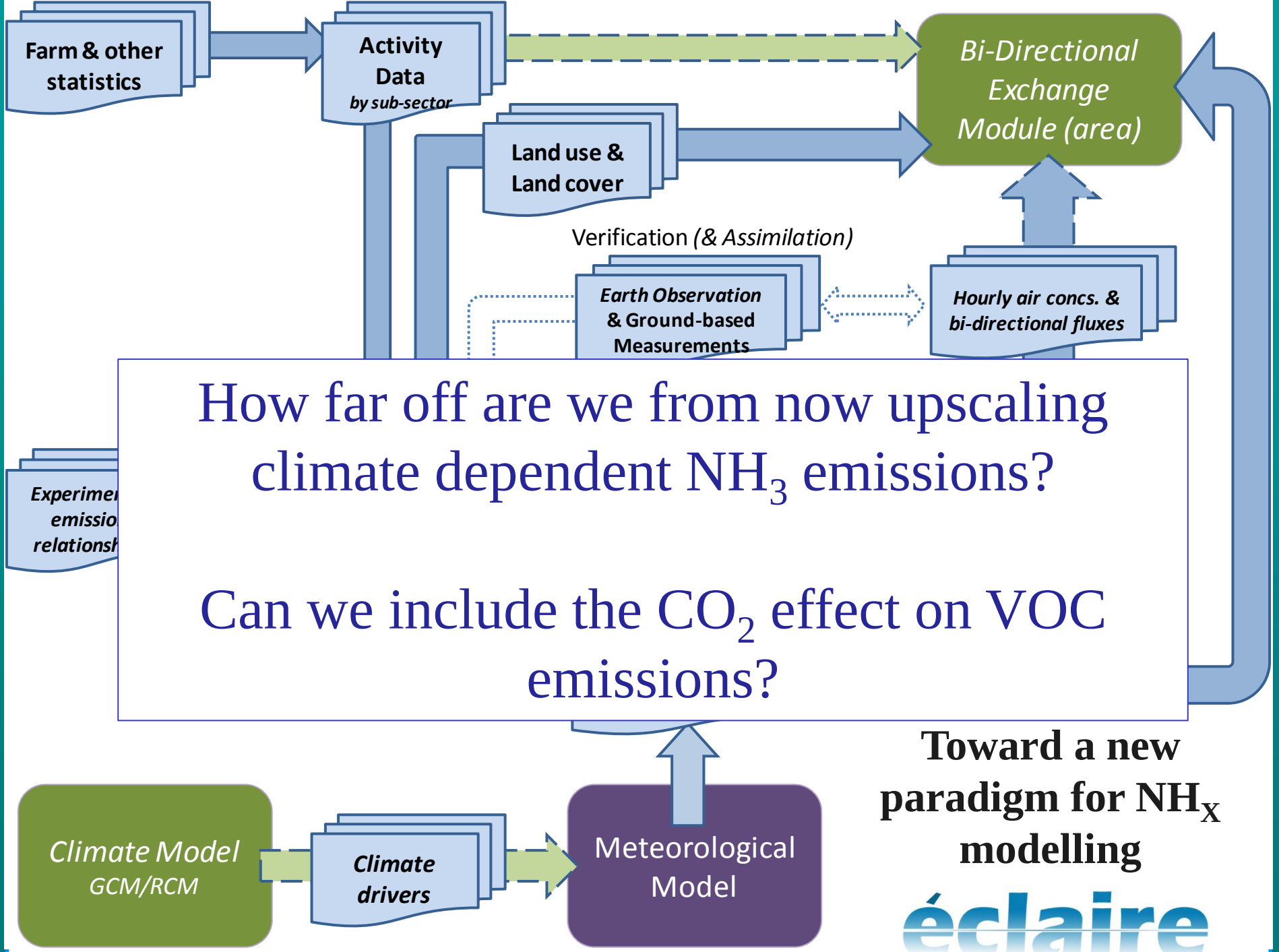
**Values & Priorities**

# Processes : Example of Bosco Fontana


# $NH_3$ column (June-August 2012)




Yasmine Ngadi and colleagues


Farm & other statistics
Activity Data
by sub-sector
Bi-Directional Exchange Module (area)
Land use & Land cover
Verification (& Assimilation)
Earth Observation & Ground-based Measurements
Hourly air concs. & bi-directional fluxes
Experimen
emissio
relationsh
How far off are we from now upscaling climate dependent $NH_3$ emissions?
Can we include the $CO_2$ effect on VOC emissions?
Climate Model
GCM/RCM
Climate drivers
Meteorological Model
Toward a new paradigm for $NH_X$ modelling
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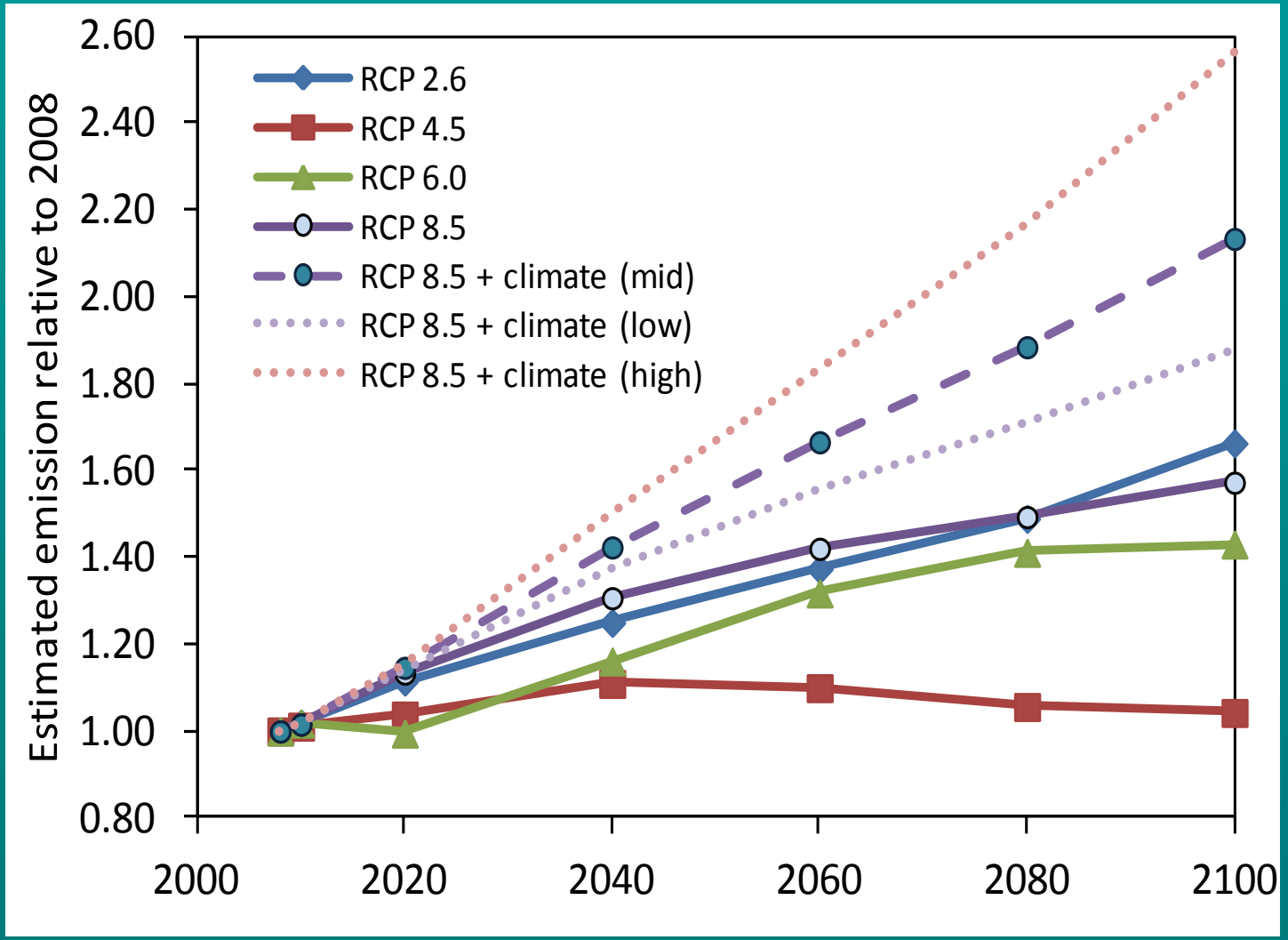
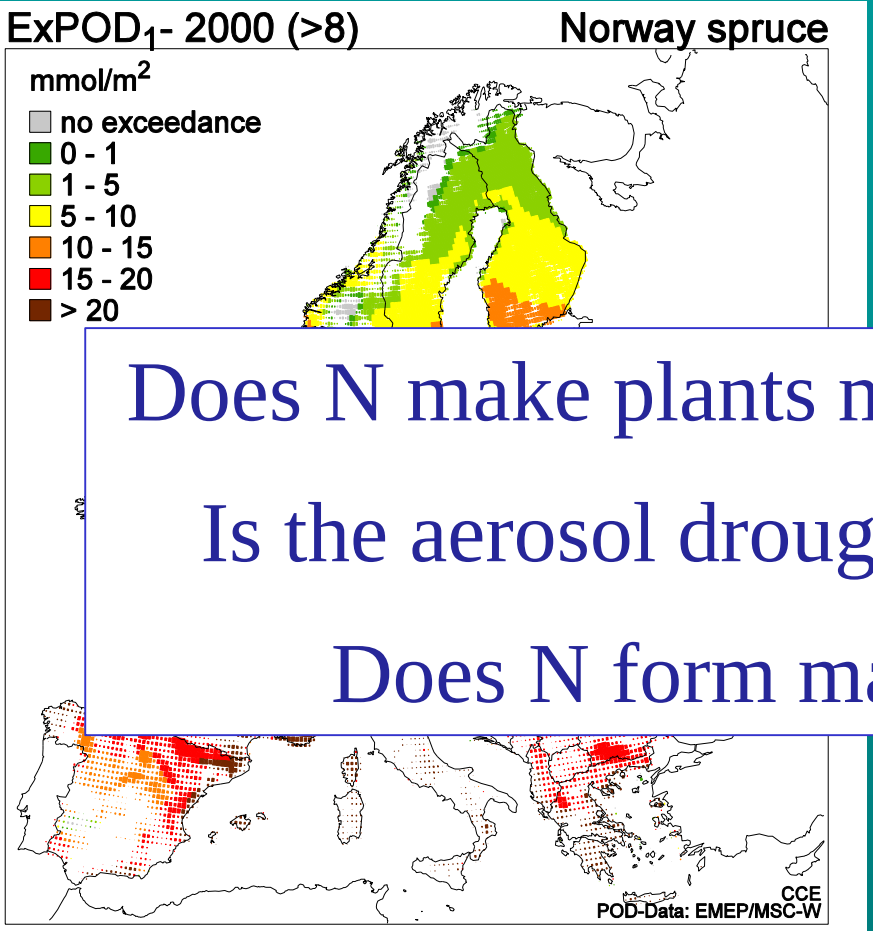
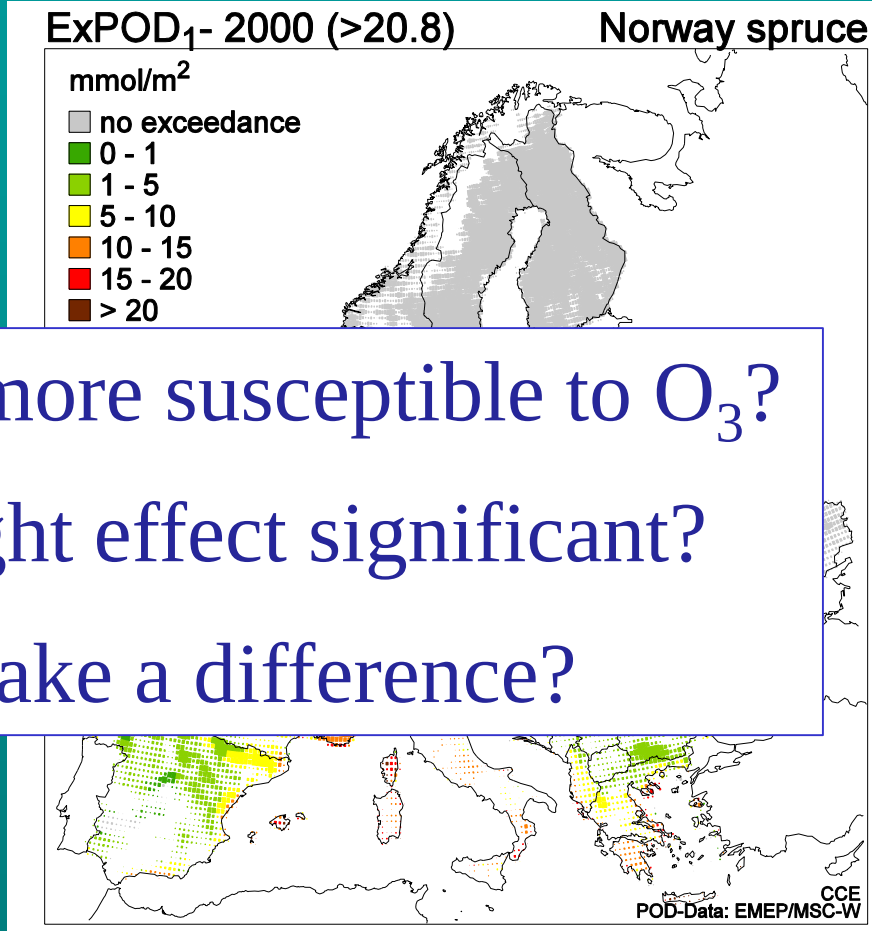
# How will climate change alter ammonia emissions?




Sutton et al. *Phil Trans. Royal Soc. B.*, 2013

# Phytotoxic ozone dose



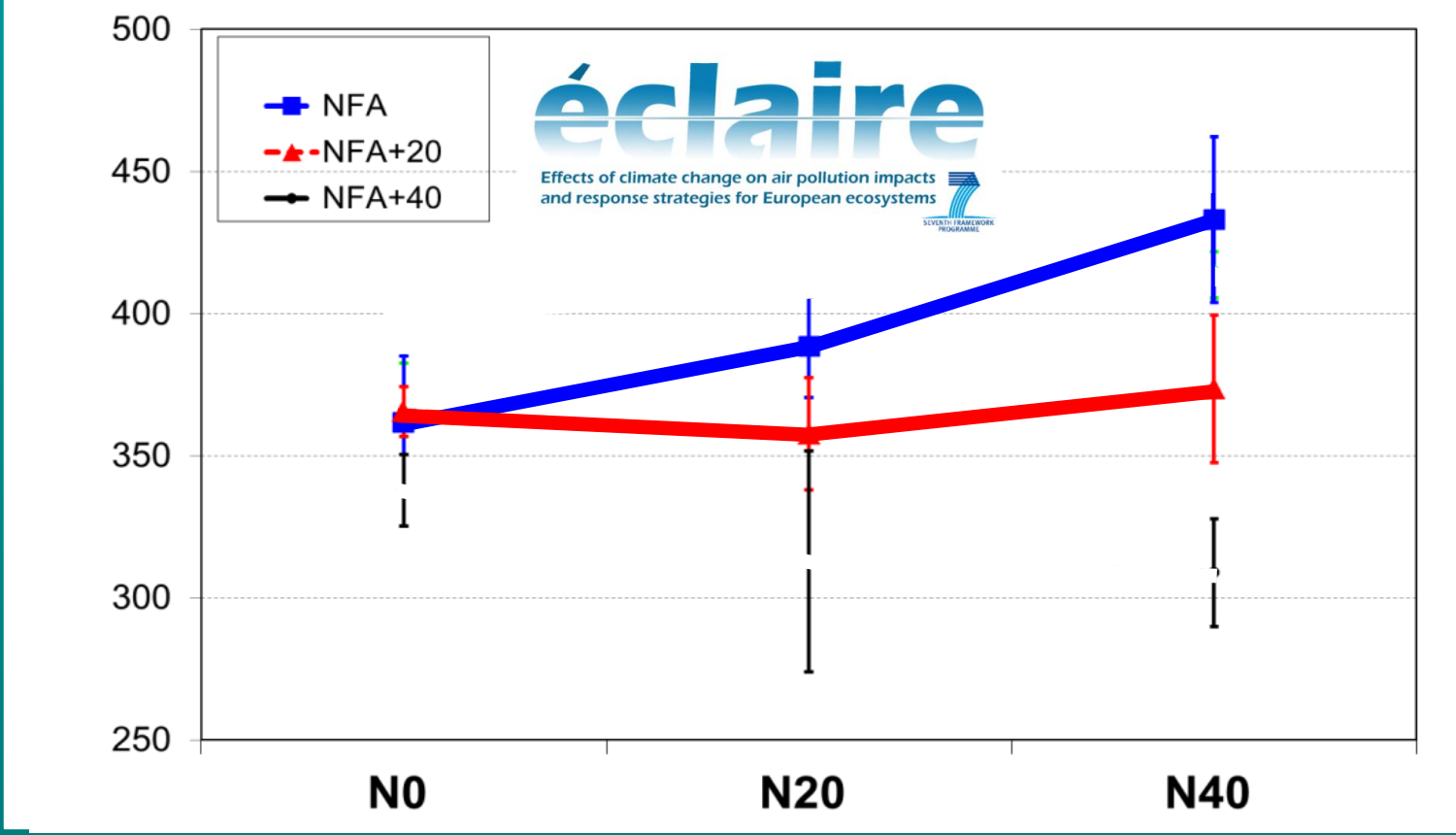

Does N make plants more susceptible to $O_3$?

Is the aerosol drought effect significant?

Does N form make a difference?

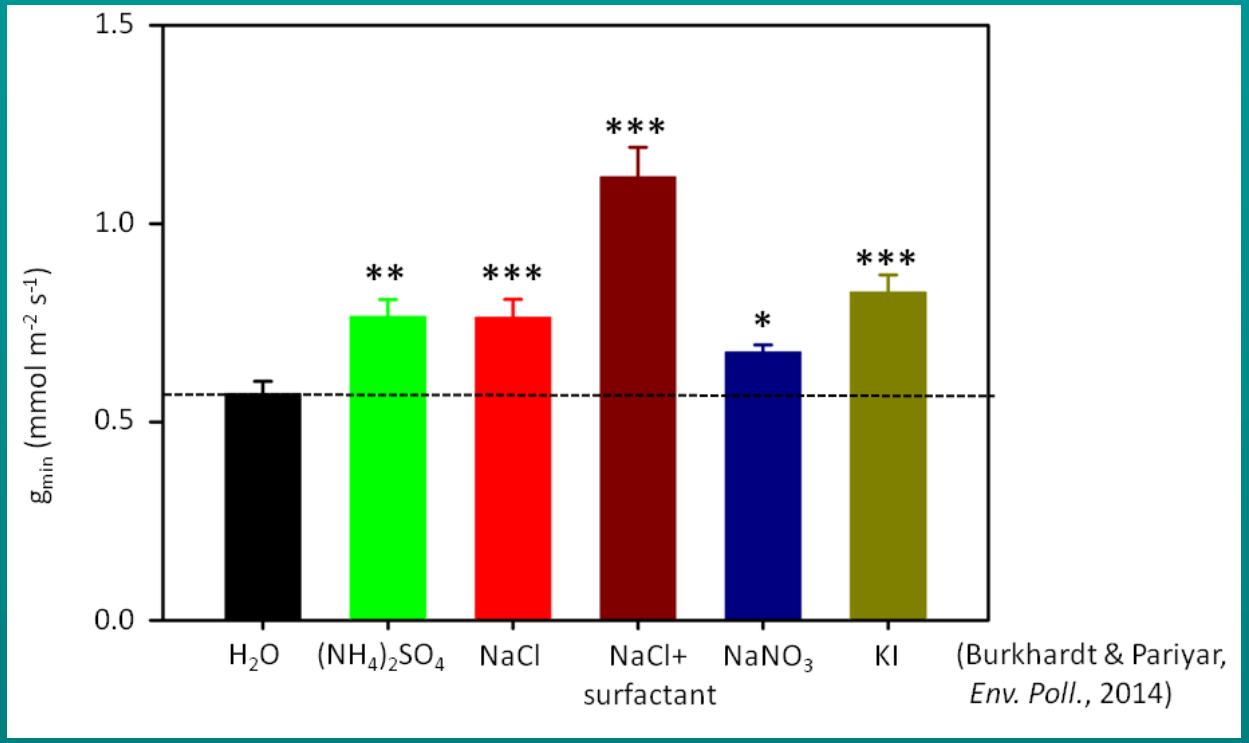
Exceedances of POD1 for Norway spruce in 2000 (left: critical limit = 8; right: 20.8 mmol/m2 = 5% yield reduction) with cover-scaled grid cells

# New Finding: Ozone reduces agricultural Nitrogen Use Efficiency




Alonso, Bermejo et al. Ozone and nitrogen interactive response of an annual pasture yield (g dw $m^{-2}$) from the 2013 experiment. NFA =non filtered air, NFA+20 =non filtered air supplemented with 20 nl $l^{-1}$ of $O_3$, NFA+40 = non-filtered air supplemented with 40 nl $l^{-1}$ of $O_3$. N0=soil N background, N20=20 kg N $ha^{-1}$;N40=40 kg N $ha^{-1}$ addition.

# New Finding: Hygroscopic Particulate Matter (PM) increases plants' vulnerability to drought




- minimum conductance ($g_{min}$) of pine needles in response to aerosol treatment

- increased $g_{min}$ means less drought tolerance

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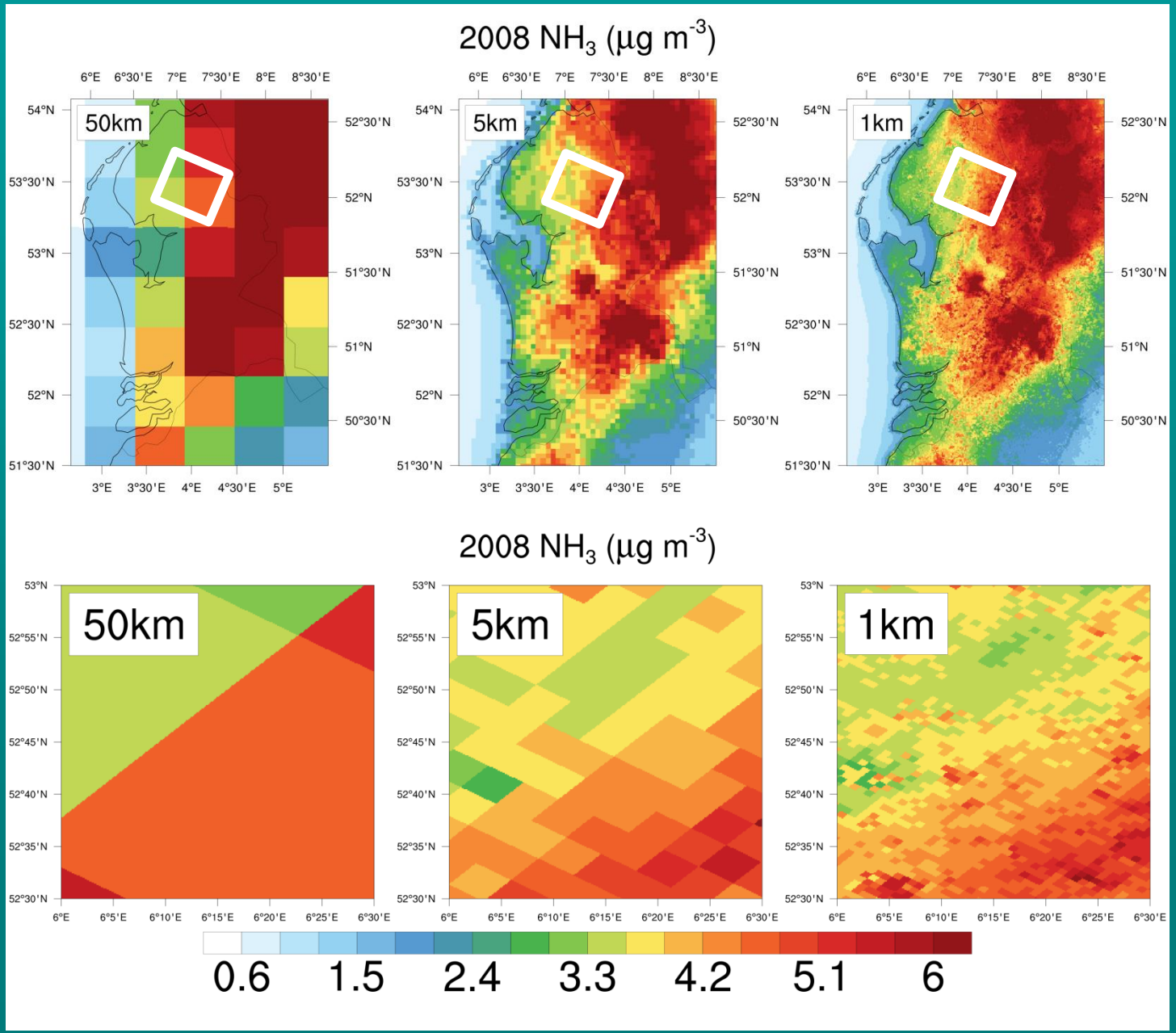
*Shyam Pariyar, Jürgen Burkhardt*

# Addressing spatial variability: how to generalise




Concentration

50km$^2$
4.5 µg m$^{-3}$

5km$^2$
~2.5 - 5

1km$^2$
~2.5- >6

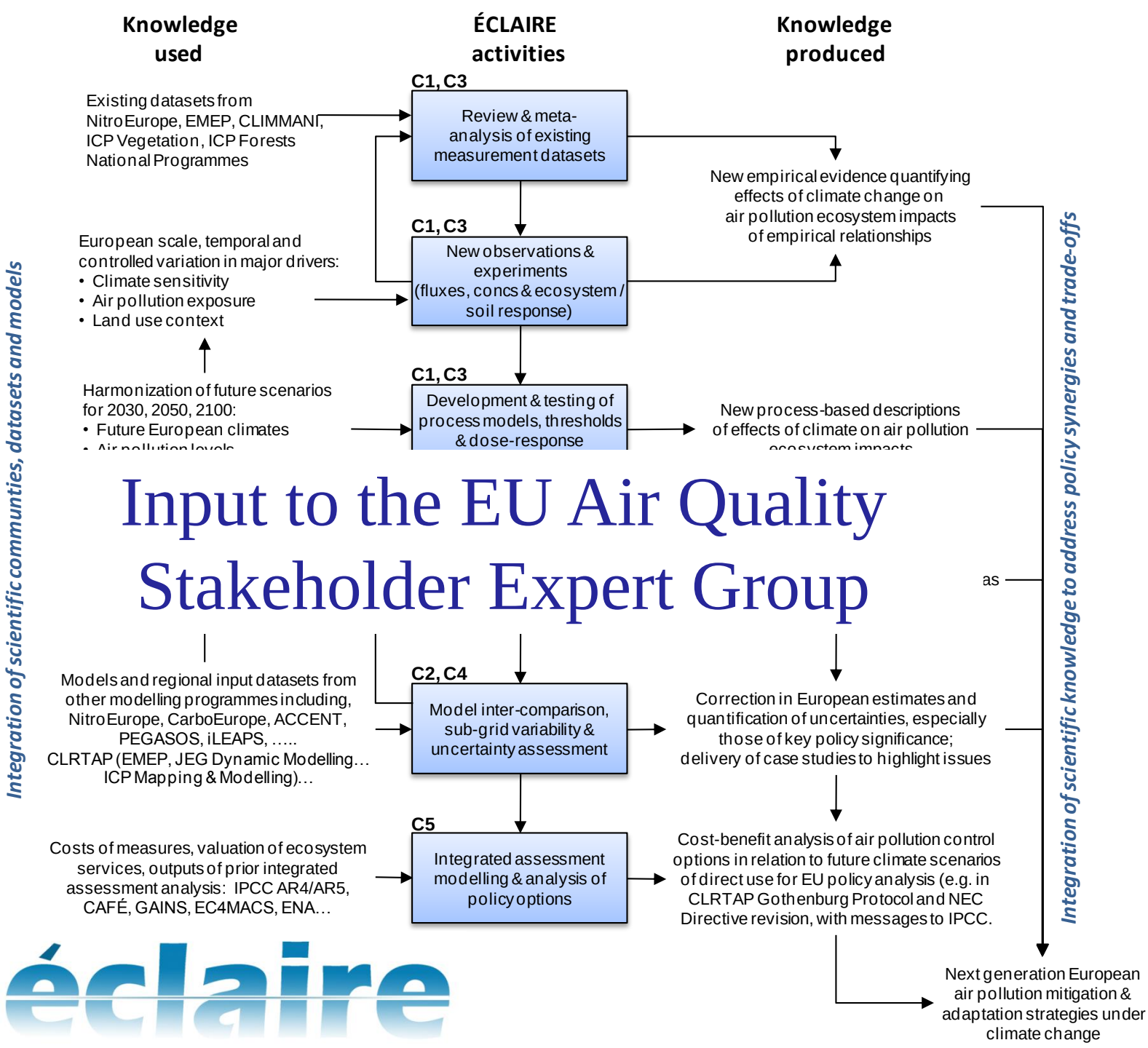
Vieno et al.

# ECLAIRE Key message

**"The emerging message is that climate change will worsen the threat of air pollutants on Europe's ecosystems:**

- Climate warming is estimated to increase the emissions of many trace gases, such as ammonia ($NH_3$), soil emissions of nitrogen oxides ($NO_x$) and important biogenic volatile organic compounds (BVOCs). These effects would increase ground-level concentrations of $NH_3$, $NO_x$ and ozone ($O_3$), particles ($PM_{2.5}$) as well as atmospheric nitrogen deposition.
- Climate warming may increase the vulnerability of ecosystems towards air pollutant exposure or atmospheric deposition. Such effects may occur as a consequence of combined perturbation, as well as through specific interactions, such as between drought, $O_3$, N and aerosol exposure."

# ÉCLAIRE Delivery Path



# ÉCLAIRE Outreach: EU

- EU Report Research Findings in Support of the EU Air Quality Policy Review
- Green Week: ECLAIRE stand: talks & panels
- Four Presentations to the European Parliament (e.g. NECD; Circular Economy)
- Foresight Expert Panel: JHEB *Junction of Health Environment & Bioeconomy* (Future H2020).

# MENU FOR A BETTER ENVIRONMENT

**Our menu choices from field to plate have the potential to improve both air quality and climate – Dr Clare Howard explains how we can get our 'just desserts' and the role of research.**

50% of the global population is estimated to be alive due to the use of man-made nitrogen fertilisers in farming. Over the last century yields have improved, but at the same time losses of nitrogen to the environment have led to impacts on air and water quality, biodiversity and climate. The use of man-made fertilisers and manures in farming can be highly inefficient, with 80% of inputs eventually being lost. This shortens lives through impacts on air and water pollution, threatens biodiversity and drives climate damage.


More efficient use of nitrogen in farming is possible during the application of fertilisers and manures, in animal feeding, housing and manure storage. Injection of manures into the soil, can reduce ammonia emissions by 70%. There are many factors affecting the uptake of such measures, but it is important to recognise that there are potential co-benefits for business and industry: Keeping nitrogen in the farming system saves significantly on fertiliser costs. Innovative agricultural methods and 'nitrogen accounting' are central to developing the 'Green Economy' in European farming.

Our own choices as citizens are also important. Losses of nitrogen from farming systems are magnified as you move through the food chain – livestock require feed and excrete nitrogen– which increases losses. Nitrogen losses when you eat steak are higher than if you ate the cereals the cow ate. Decreasing our consumption of meat would have dramatic benefits on air and water quality.


Enter the role of research. We need to u
the environment due to farming practi
including processes of nitrogen losses
to air pollution. As air pollution is intric
policymakers also need to understand
change is likely to have on air pollution
ECLAIRE project, Effects of climate cha
response strategies for European ecosy
range of measurement and modelling
projections of air pollution and climate
implications for mitigation strategies. S
the final part of the chain, linking the l
European policies.

**As with any dilemma, the outcome
we make. Food security requires nit
minimise its environmental effects.
improved farm management practi
with a lower meat content, then a 'ju
with improved climate is certainly w**

Dr Clare Howard works at the NERC C
as Project M
and the UNECE Ta

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fertilizers europe

# Forum on Fertilizers and Nutrients for Growth

28 May 10:00 - 13:00

Building: Altiero Spinelli (ASP), Room: A5G1

Register: conference@fertilizerseurope.com

Opening address

Chair
Britta Reimers MEP

Political Perspectives

Vice-Chair
Julie Girling MEP

Join the debate

Keynote speaker - Our Nutrient World

Prof. Mark Sutton, Center for Ecology and Hydrology, Edinburgh
Author of the UNEP report "One Nutrient World"
Professor Sutton is the author of the recent UNEP report Our Nutrient World: The challenge to produce more food and energy with less pollution. This Global Overview on Nutrient Management addresses the scientific complexity of how humanity can rise to these challenges and maximize the opportunities of improved nutrient management.

The EU Year of "Air Quality"

EU Air Pollution Policy Review 2011-2013
Alan Seatter,
Deputy Director General of DG Environment

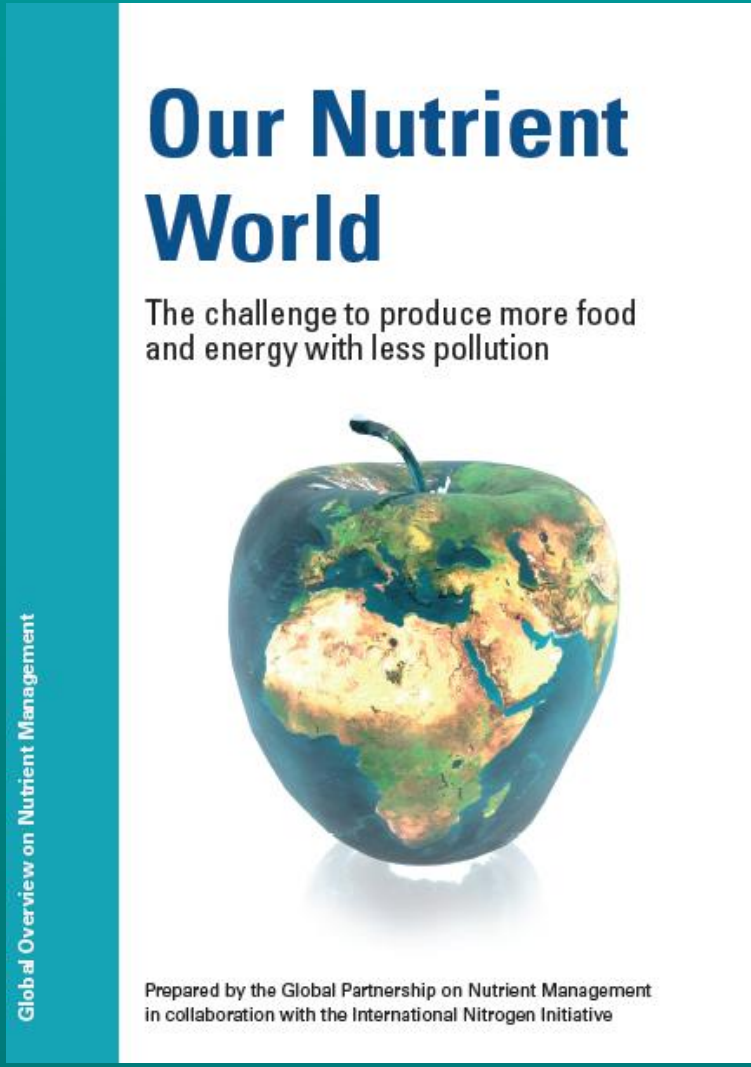
How Fertilizers can provide a solution
Jacob Hansen,
Fertilizers Europe

## From Parliament Magazine

- Green Week &
- EU Parliament Forum

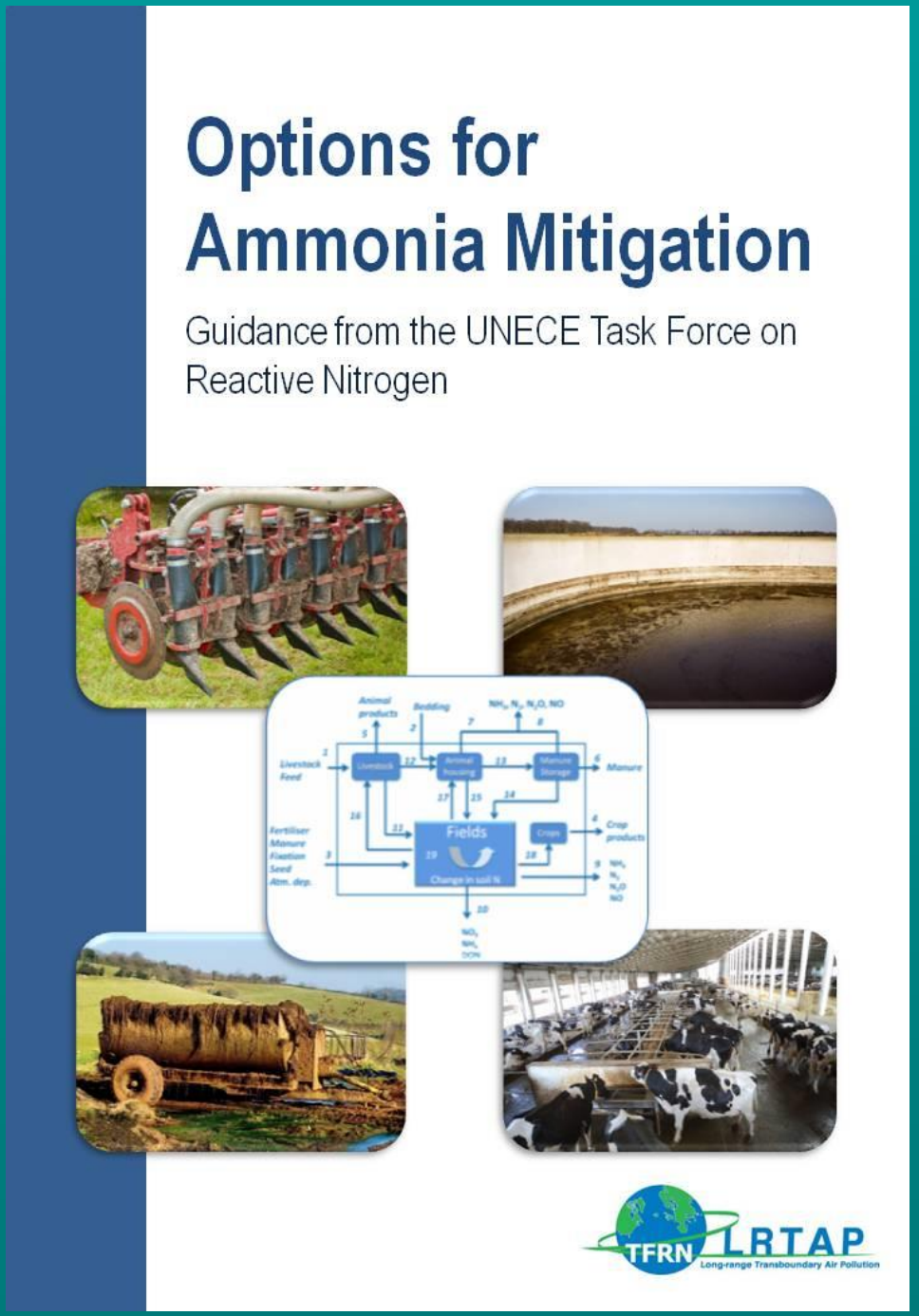
# ÉCLAIRE Outreach: International

- UNECE: ECLAIRE providing underpinning across the LRTAP convention:
  - EMEP, Working Group Effects;
  - WG Strategies & Review;
  - Executive Body (+ EfE 2016)
- Report for UNEP "Our Nutrient World" in coop INI & GPNM
- Developing INMS with UNEP
- Toward higher level engagement:
  - OECD Environment Policy Committee (EPOC+ Minist Conf);



# ECLAIRE Team provided UNECE Ammonia Guidance

**Plus revised Framework Code to support NECD revision**

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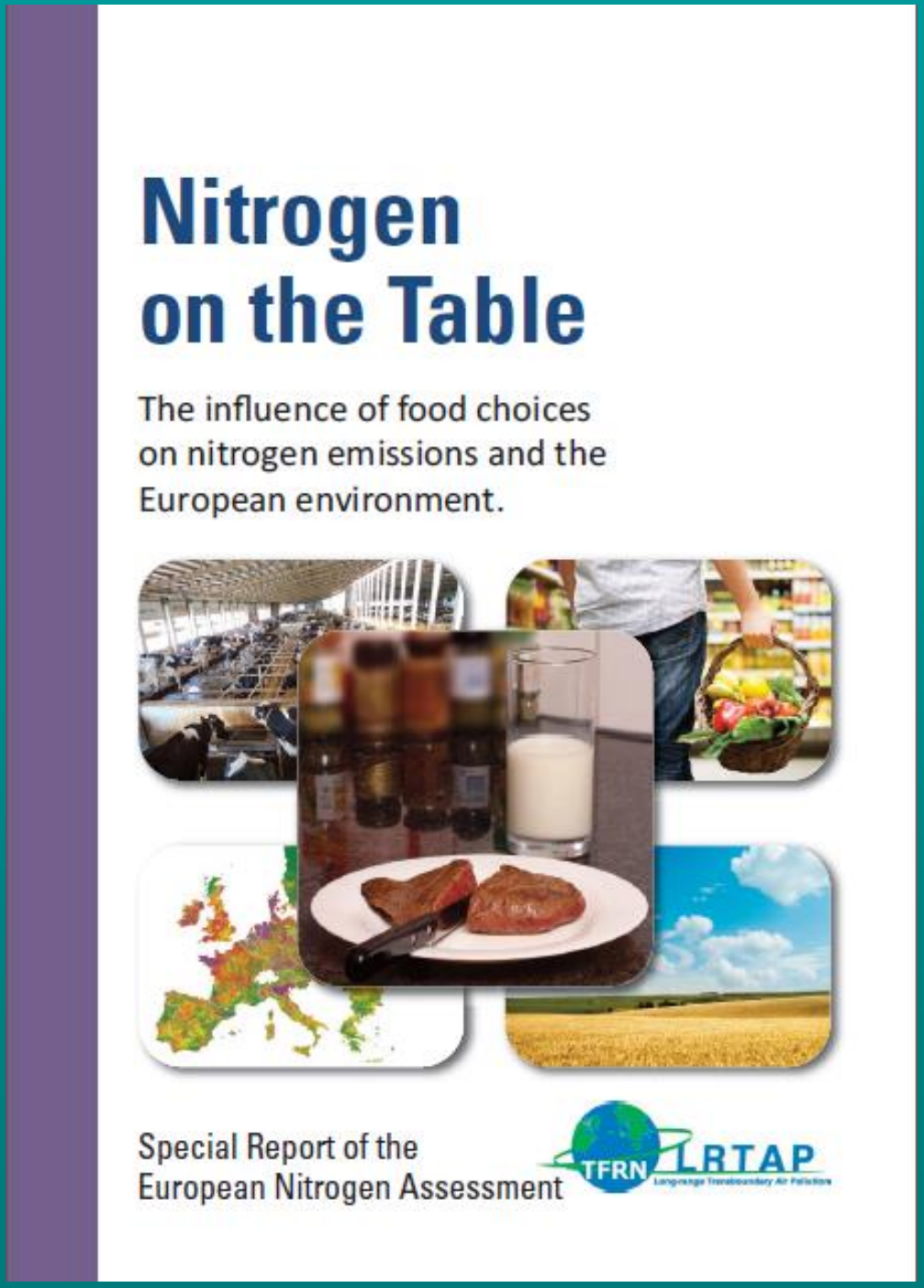
# Full report to be launched in the summer

## Executive Summary out already



THE TIMES

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consumption of meat
ucts to reduce pollutic

Britain's livestock
suffer a "severe" loss
such a change in diet b
environmental benefi
pollution of the air, wa
lower greenhouse gas

A team of scientis
United Nations Econo
for Europe (Unece)
reducing nitrogen
chemical fertiliser and

The task force on r
concluded that if eve
became "demitarian" — halving the
amount of meat and other animal prod-



TIMES FAST — THE TIMES — FUTURE

# Eat Less Meat

## A vital message is buried in a new report on climate change

It is not alarmist to predict food shortages and price inflation within the next half century if we fail to change what we eat. The world's population, now roughly seven billion, is expected to rise to ten billion by 2050. More than 200 million hectares of forest have been cleared for farming in the past ten years and forest clearance in the Amazon alone continues at a rate equivalent to 93 football pitches an hour. In the meantime, by far the most costly use of farmland is for grazing cows and sheep.

Rising crop yields and better science will undoubtedly help with food supply, but rising prosperity will also give more humans a taste for beef and lamb. One option is to herd the bulk of the world's livestock indoors. The animals producing most of our red meat would never see the light of day or breathe fresh air. That might be economical but it would be neither compassionate nor healthy — for humans or the animals themselves. The right course is to raise livestock with due regard for animal welfare and retain meat as part of a balanced diet. That means eating less of it.

How much less? For Britons, 40 per cent less, according to the Department of Energy and Climate Change. The figure comes from a report on changes that the department says will have to be made to our lives to do our "fair share" towards limiting global carbon emissions.

Meat production is a carbon-intensive business, and the political urgency behind the report is the need to appear serious about carbon emissions in the build-up to a UN climate conference in Paris in November. The environmental urgency is another matter. It will be hotly debated long after the conference, whether or not the heads of state attending reach any sort of accord and whether or not world temperatures actually rise in line with scientists' projections.

What is not in doubt is the compelling case for cutting back on meat, regardless of its impact on global warming. A 30 per cent reduction in meat consumption would, a former chief medical officer has said, prevent 18,000 premature deaths a year in Britain. Globally, meat farming is a big cause of acid rain because of the high ammonia content in animal waste. It is a principal cause of deforestation but also of desertification as a result of over-grazing. The former drives down biodiversity. The latter hurts farm yields, and both trends will only worsen as demand for a more western diet grows among China's rapidly expanding middle class.

That demand will be used as an argument for more intensive factory farming of cattle and sheep. The technology exists and is being used to house huge new Chinese herds that live almost entirely indoors. This is neither an ethical nor a sustainable food future. The lesson of battery-farmed poultry and pork is that it depends on the over-use of antibiotics and produces meat that is too high in fat and low in protein to be worth the cost in animal welfare.

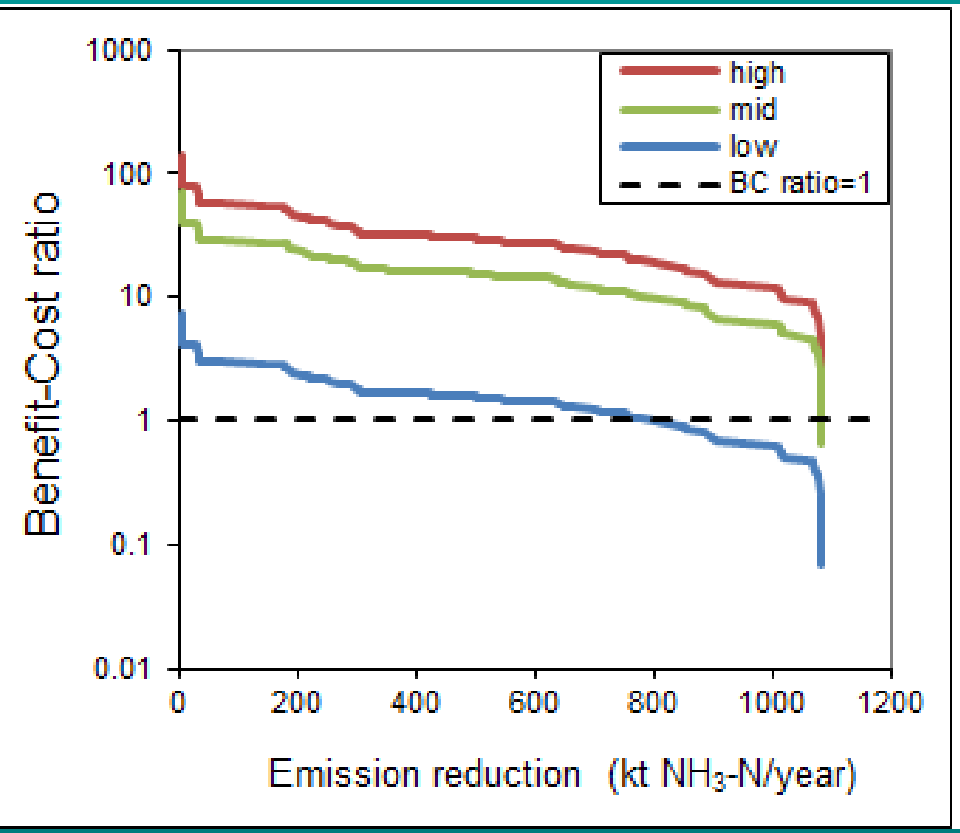
There is no doubt that freely grazing cattle are inefficient converters of farmland to food. A field the size of a football pitch produces, by weight, 60 times more fruit and vegetables than beef. This is not an argument for more industrialised farming, but for changing our habits. The US Department of Agriculture will shortly urge Americans to eat less meat. It is good advice. If we all did, we would be healthier and might even enjoy it more.

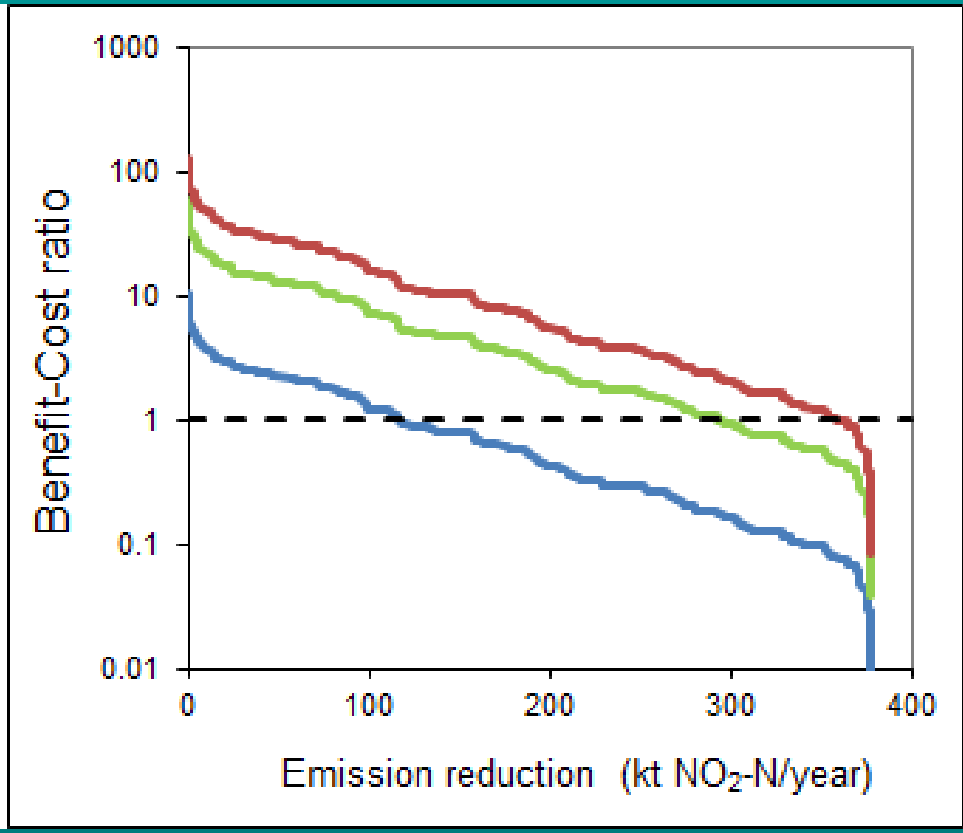
The team questioned whether people would be likely to cut consump- biofuels to replace fossil fuels. Professor for pasture and goes some way to protecting our wonderful countryside."

*ne Table*

Westhoek et al., 2014

# EU benefit-cost ratios for $NH_3$ and $NO_x$ mitigation




Van Grinsven et al.
(*Environmental Science and Technology*, 2013)

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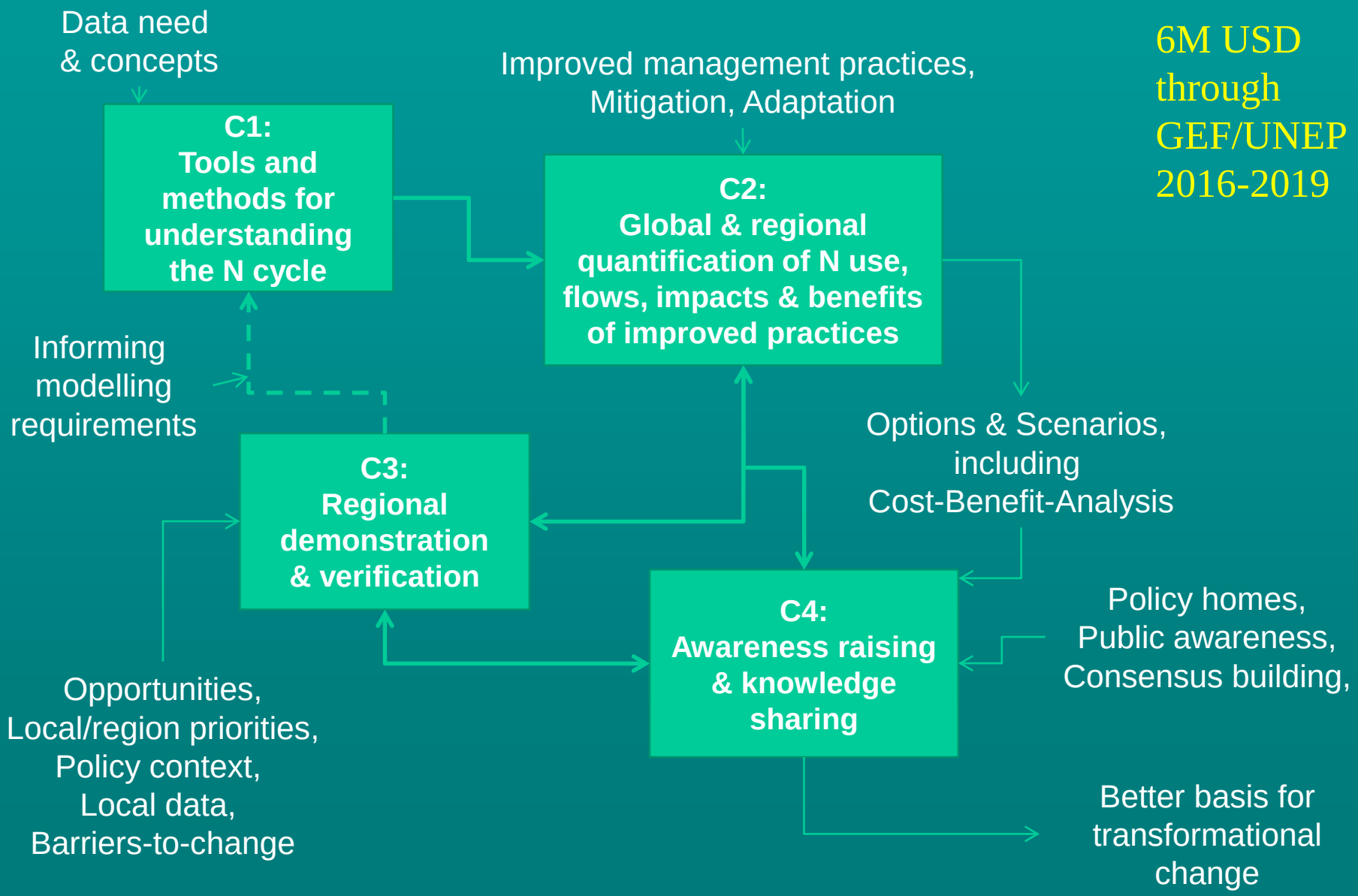
# Toward the International Nitrogen Management System (INMS)

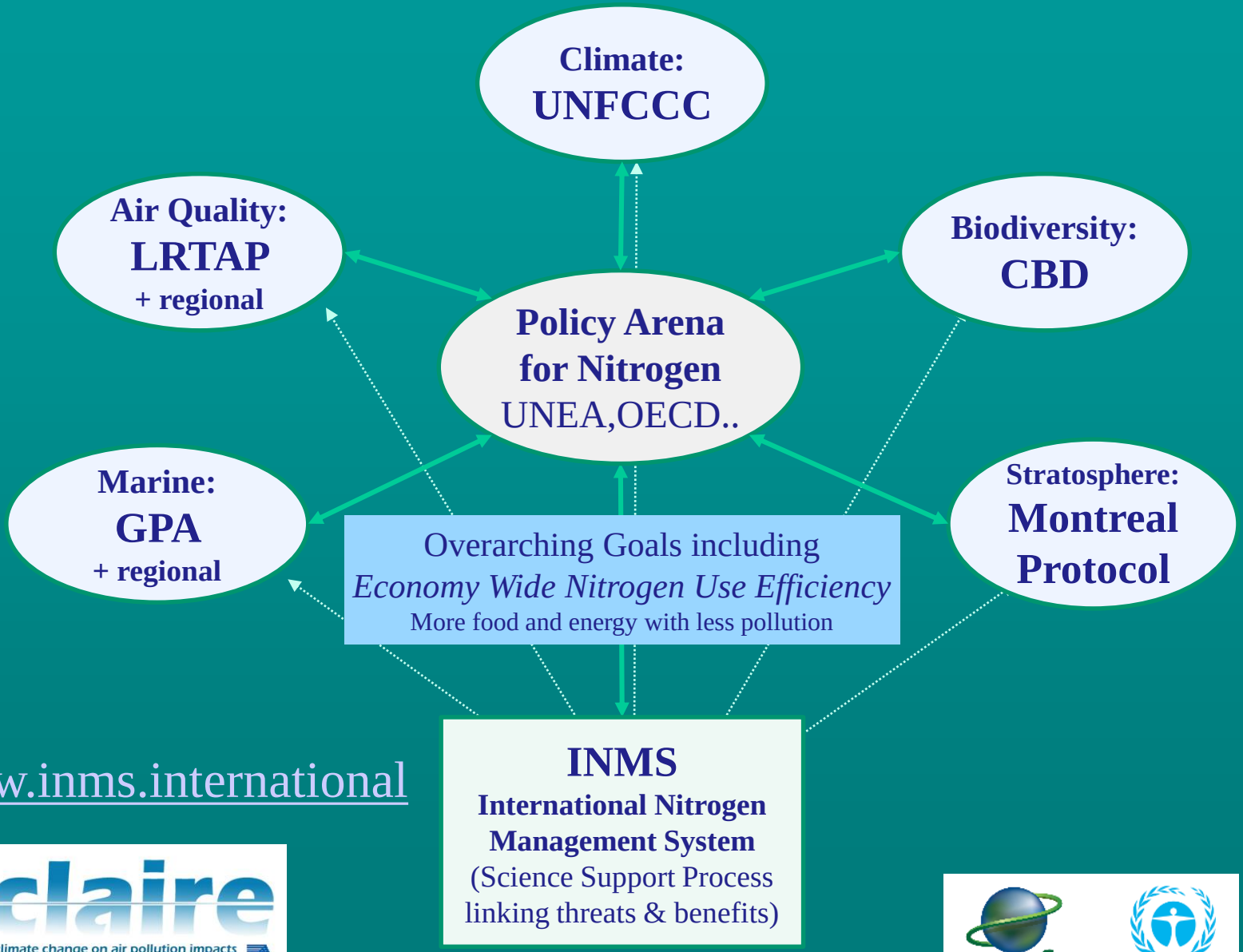
- Initiative with United Nations Environment Program (UNEP)
- Toward a global science-policy support framework for nitrogen, addressing multiple co-benefits
- Engage with countries, industry, civil society in cooperation with UNEP, LRTAP, Marine Conventions FAO etc
- Linking the economic, environmental, food and energy benefits of better *Nitrogen Use Efficiency*

- **ECLAIRE scientists taking the lead**
- **What should the EU contribution look like?**

# Towards the International Nitrogen Management System (INMS)



# Linking International Nitrogen Policy Frameworks




www.inms.international

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gef UNEP

Towards INMS