Meeting: “Ozono e vegetazione: il contributo della ricerca italiana”
Università di Pisa, 24 novembre 2016

Ozono, vegetazione e adattamento al cambiamento climatico

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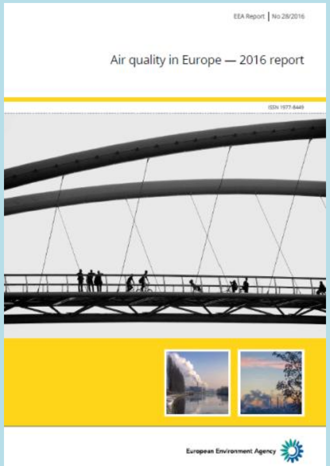
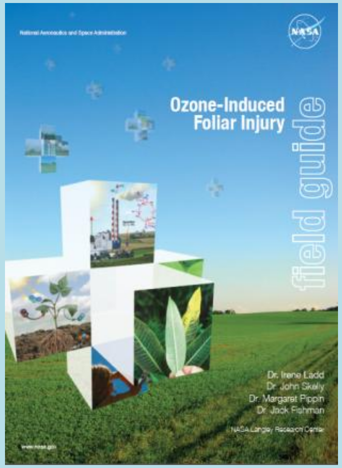
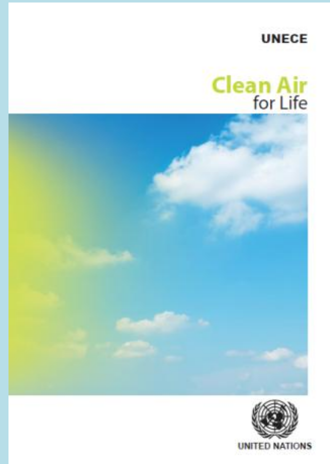
Presentation's structure

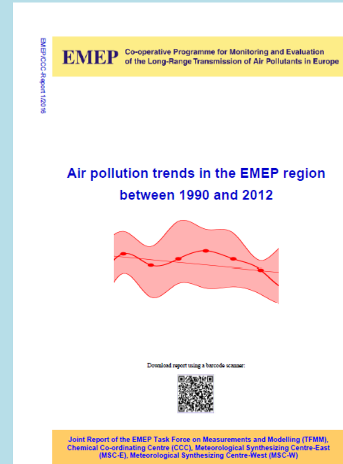
- Ozone: the present status
- Ozone present impacts on crops, forests and biodiversity
- Interactions between ozone and climate change
- Ozone levels: future projections
- Ozone exposure and risk: future projections
- International policies
- Climate change adaptation strategies
- Examples of sectoral adaptation measures and tools
- Conclusions

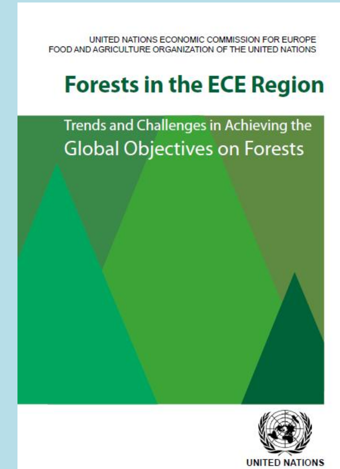
2016 - a bloom of reports

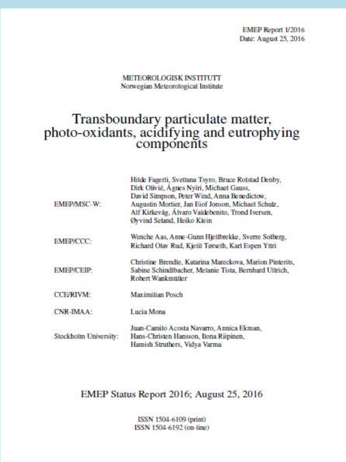


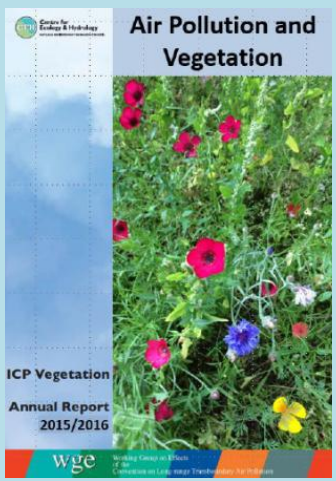


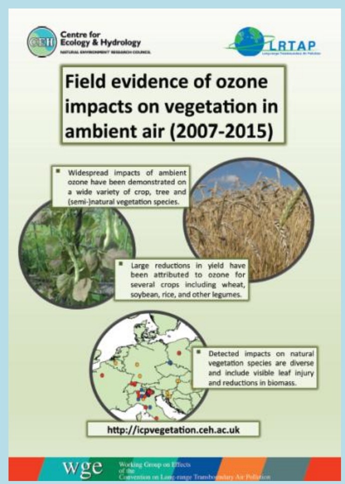






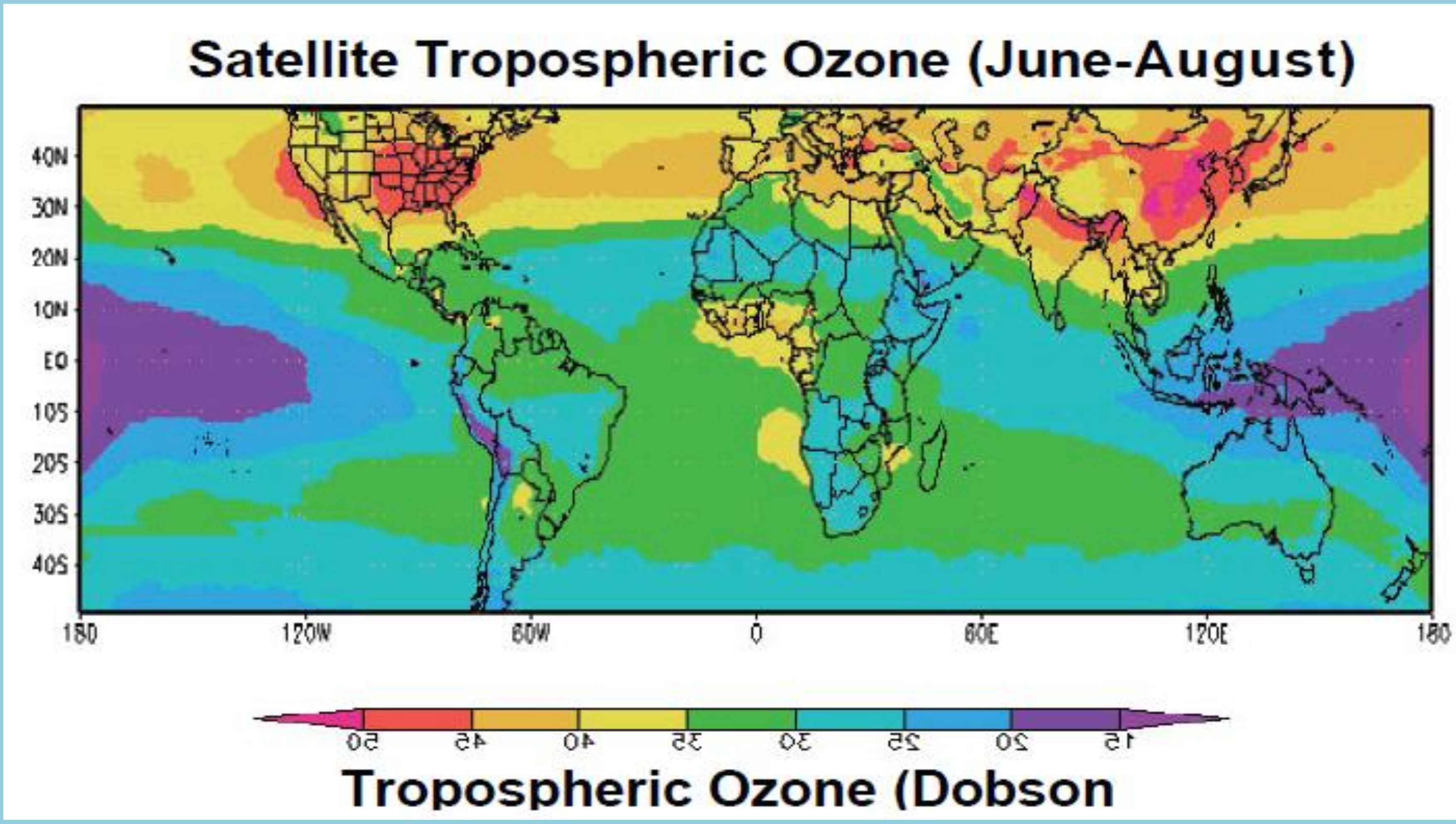






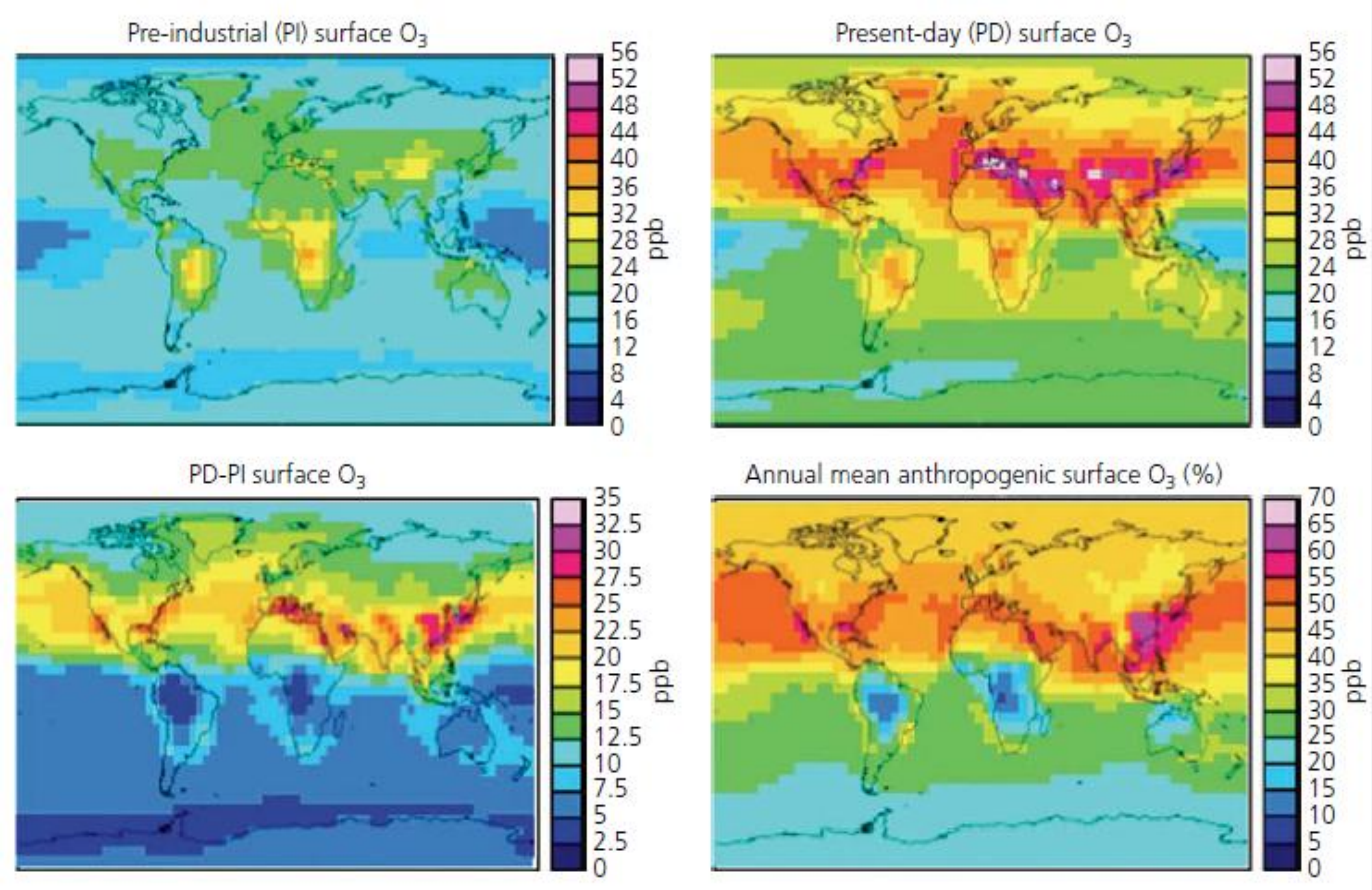
Ozone: the present status

Troposheric ozone worldwide



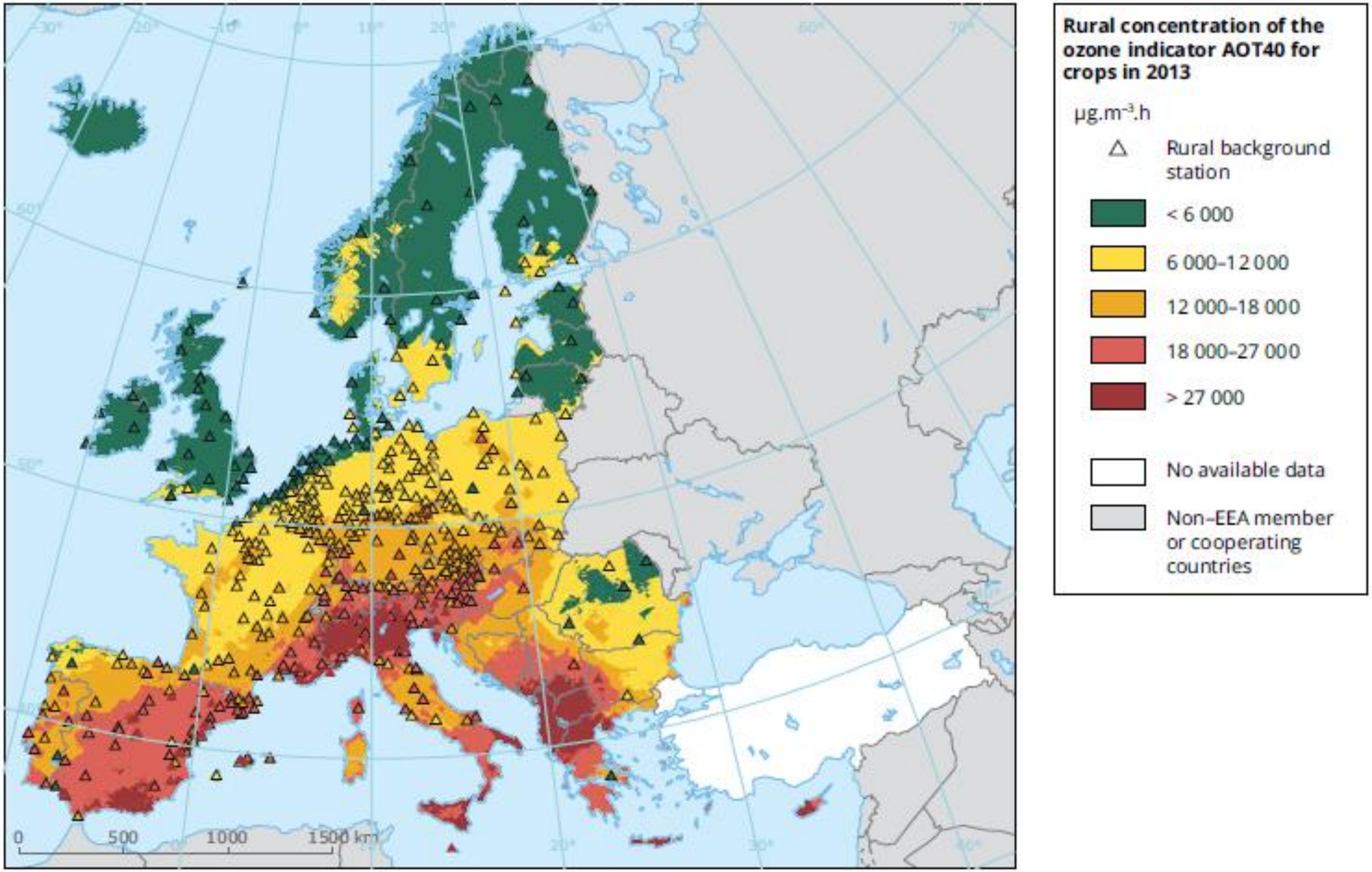
Source: NASA 2015

Worldwide ozone distribution and trend



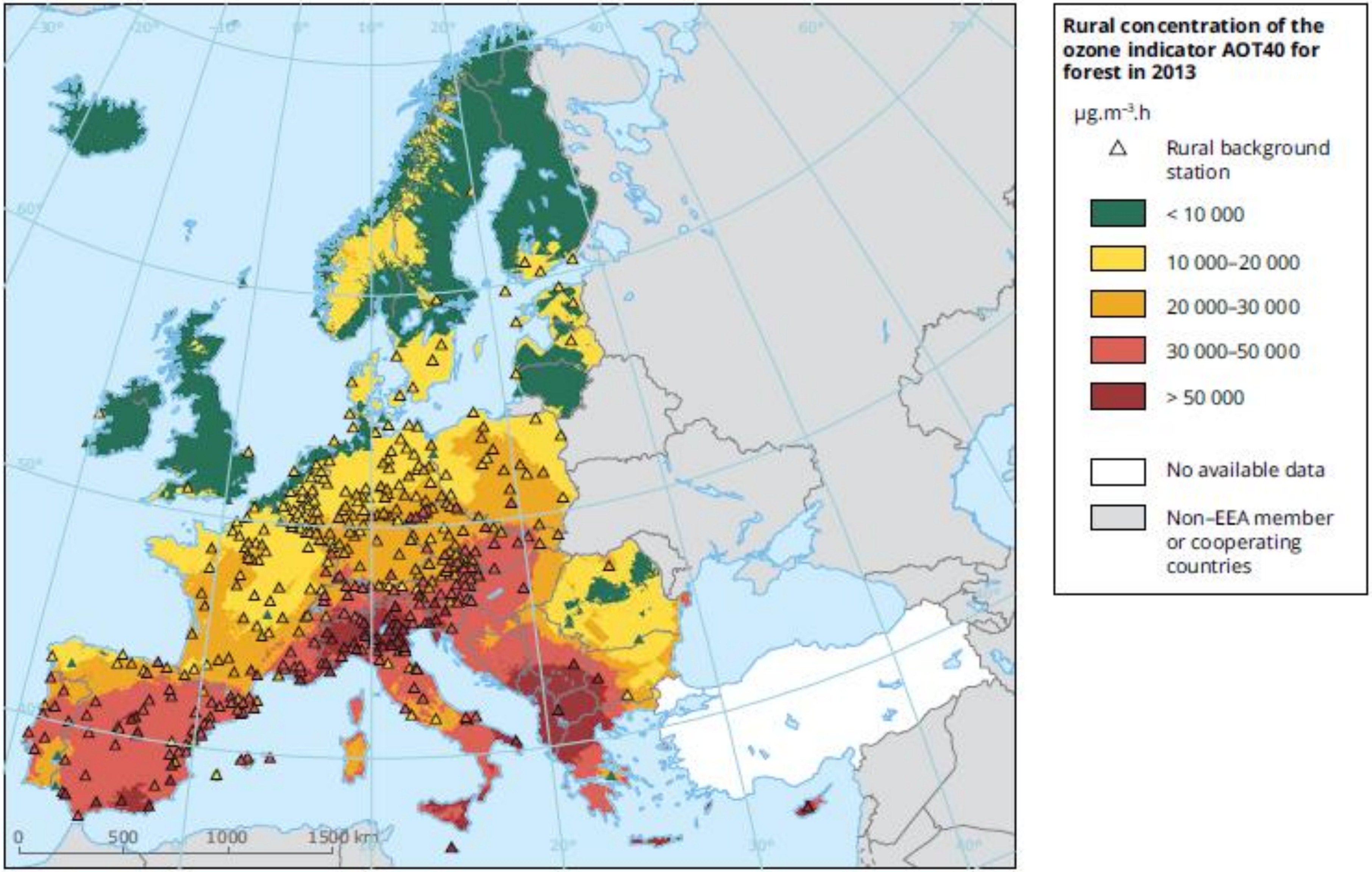
Source: UK Royal Society 2008, Science Policy Report

Europe: ozone rural AOT40 for crops in 2013



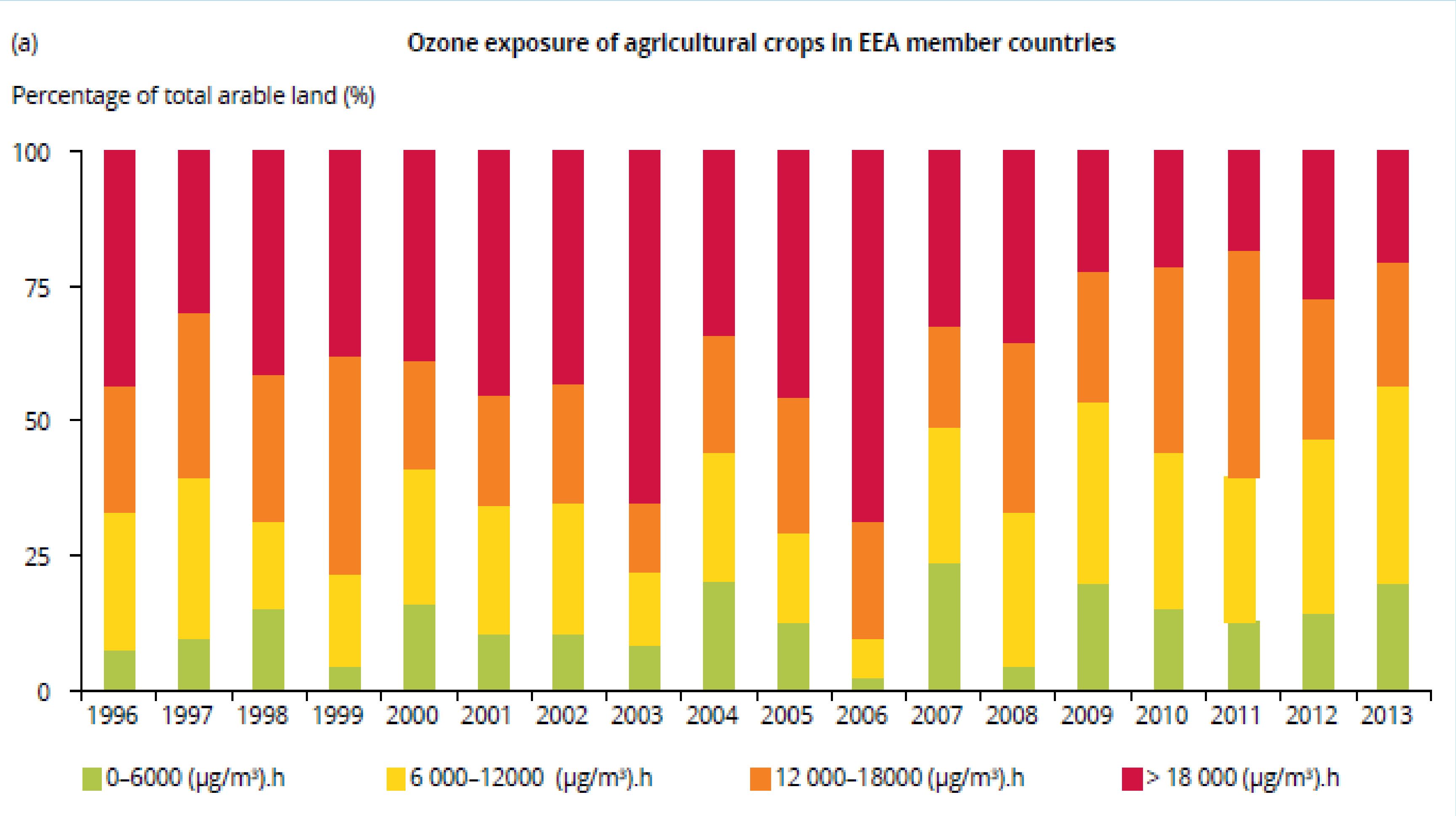
Source: ETC/ACM, 2016b.

Europe: ozone rural AOT40 for forests in 2013



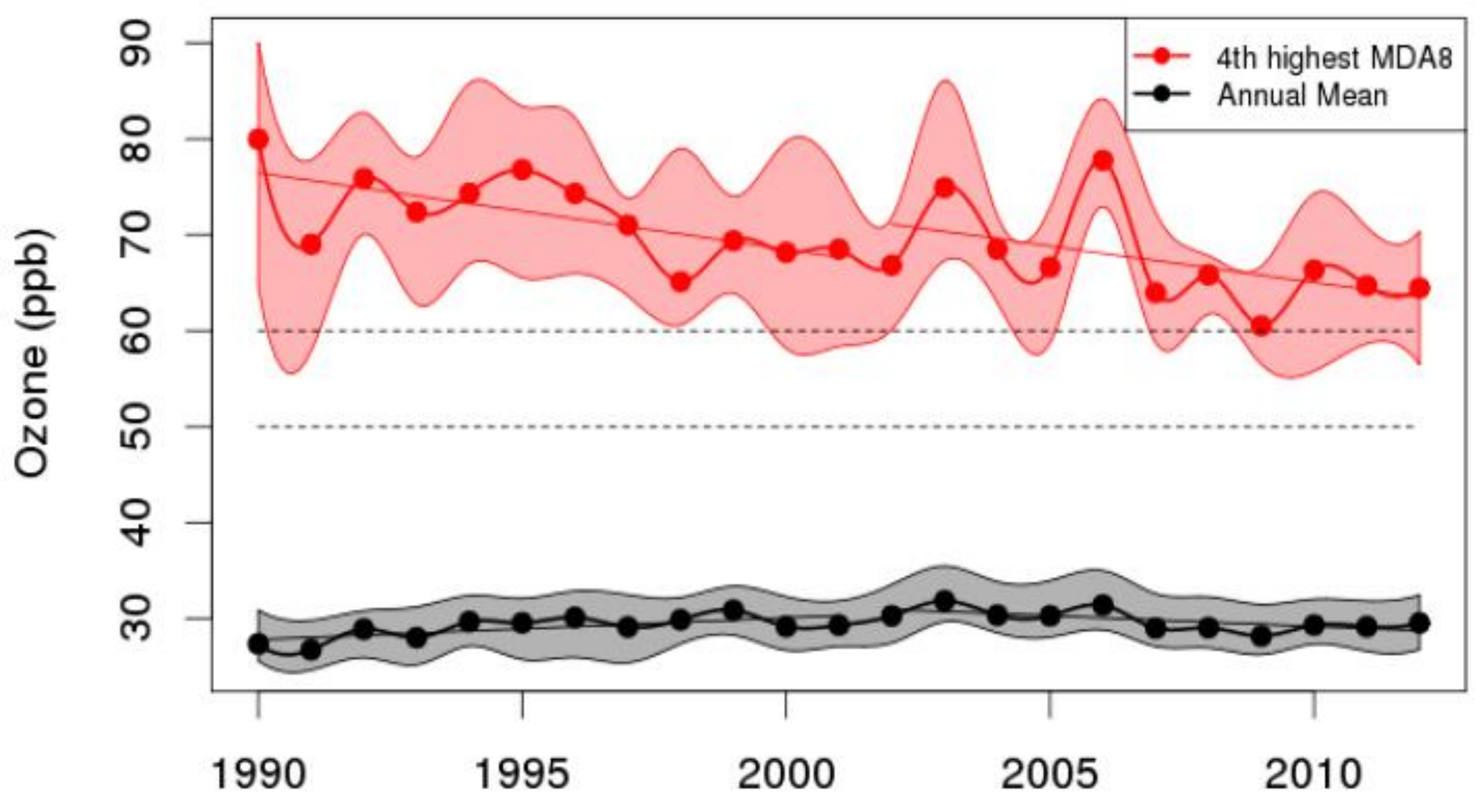
Source: ETC/ACM, 2016b.

Europe: ozone exposure trend for crops 1996-2013



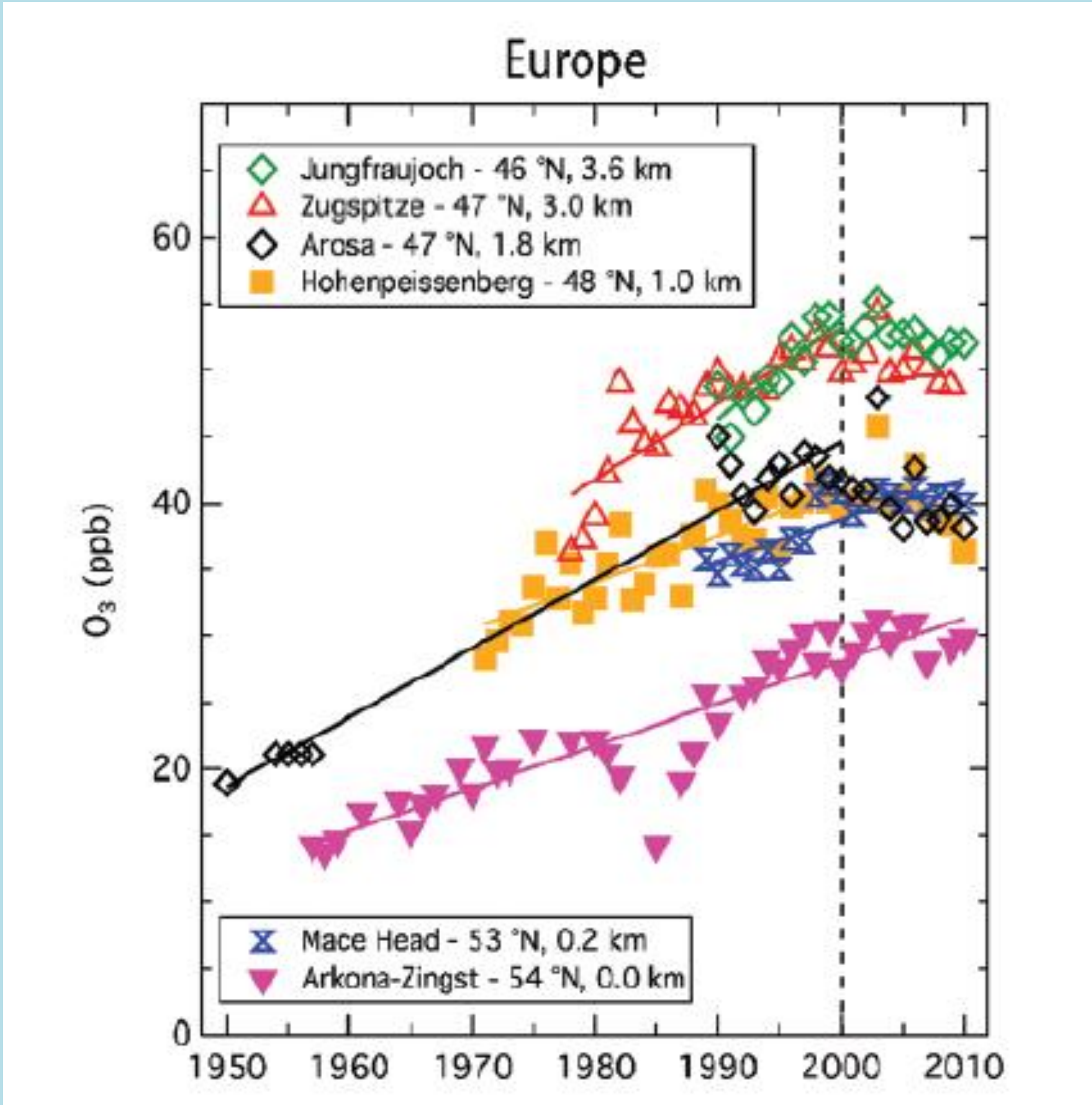
Source: EEA 2016, Air Quality Report

Ozone trends: background and peak levels



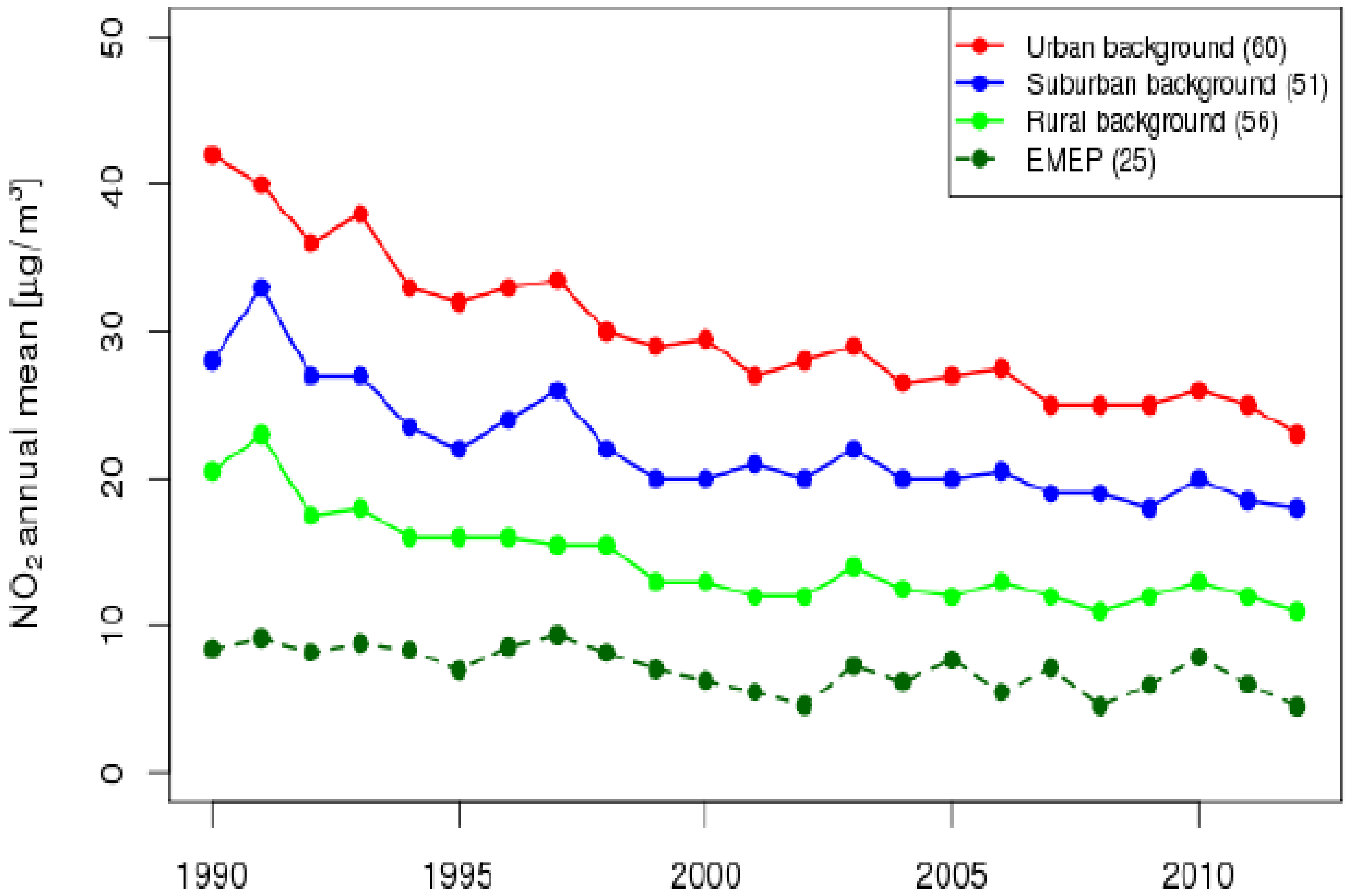
Source: EMEP-TFMM 2016_Air pollution trends in the EMEP region

Ozone trend in remote rural sites



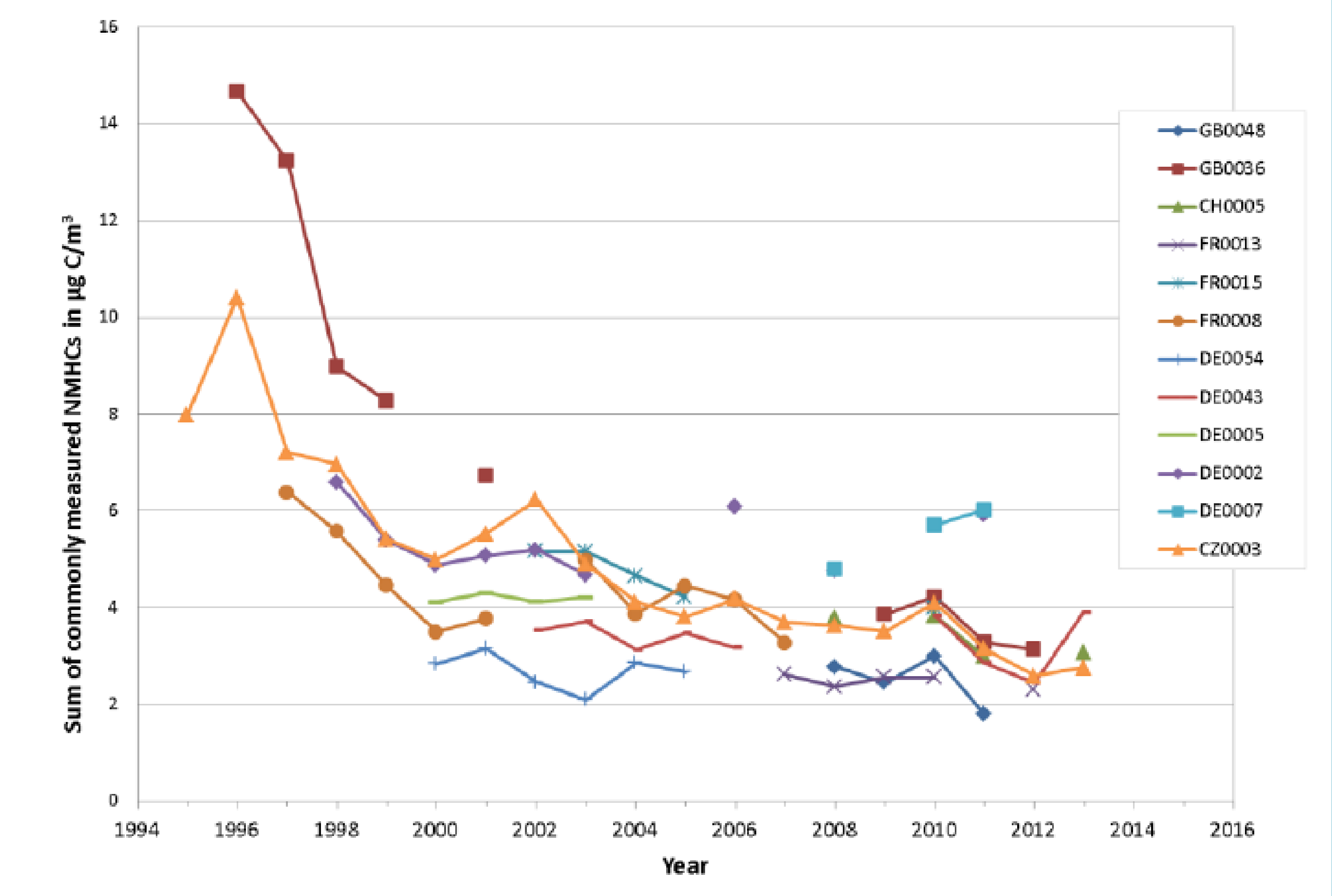
Source: EMEP-TFMM 2016_Air pollution trends in the EMEP region

NO_2 trend in the EMEP region



Source: EMEP-TFMM 2016_Air pollution trends in the EMEP region

VOCs trend in the EMEP region



Source: EMEP-TFMM 2016_Air pollution trends in the EMEP region

Ozone present impacts on crops, forests and biodiversity

Metric for ozone impact on vegetation

$$\text{M12 (ppbv)} = \frac{1}{n}\sum_{i=1}^{n}[C_{O_3}]_i$$

$$\text{AOT40 (ppmh)} = \sum_{i=1}^{n}([C_{O_3}]_i - 0.04) \text{ for } C_{O_3} \geq 0.04 \text{ ppmv}$$

$$\text{POD}_Y = \int \max(F_{st} - Y, 0)\, dt$$

Crops exposure to ozone worldwide in 2000

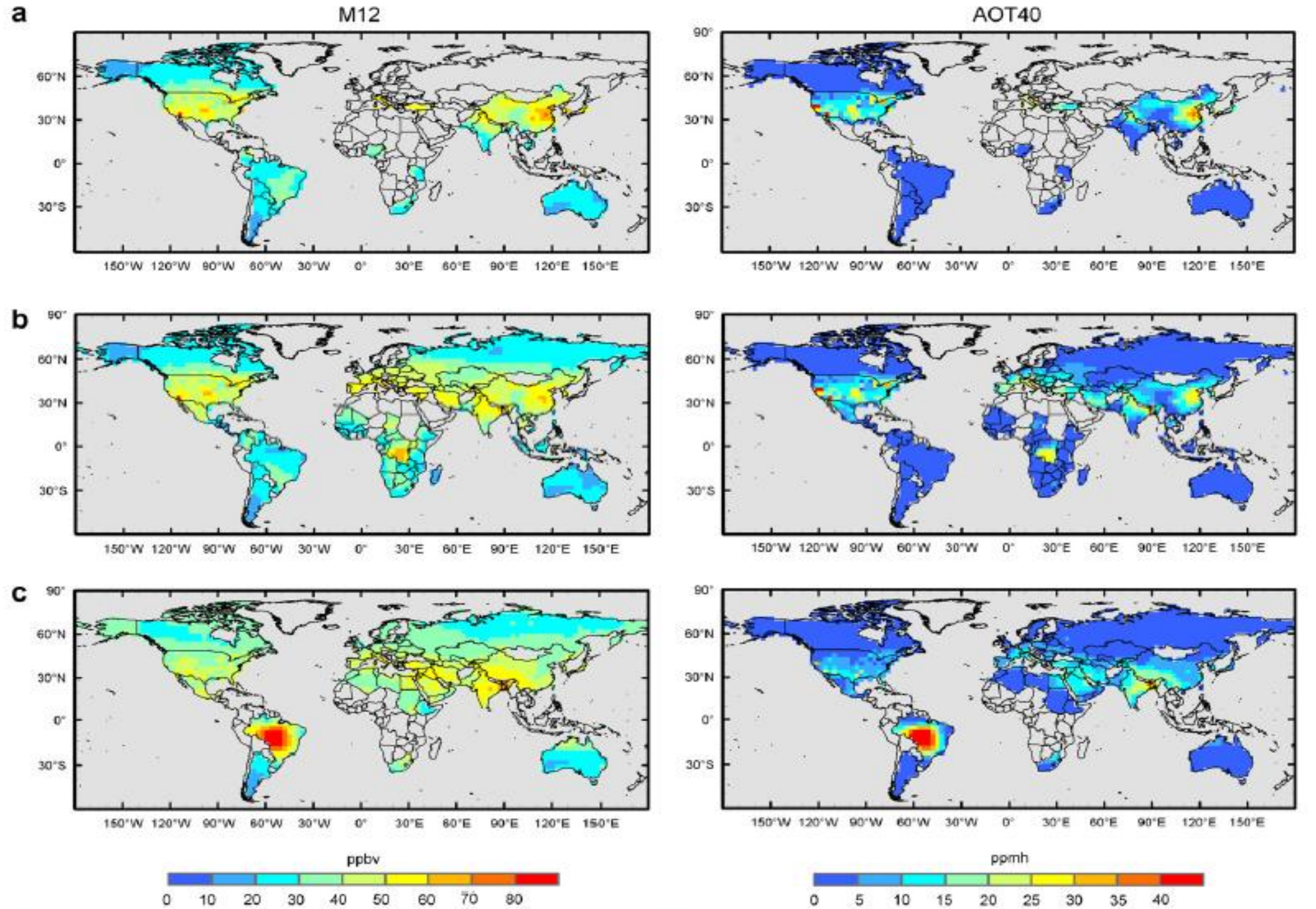


Fig. 3. Global distribution of O_3 exposure according to the M12 (left panels) and AOT40 (right panels) metrics during the respective growing seasons in each country (where crop calendar data are available) of (a) soybean, (b) maize, and (c) wheat. Values in the U.S. have been corrected using observation data as described in Section 3.

Source: Avnery et. al.,2011, Atm. Env. 45, 2284-2296

Yield loss (soybean, maize, wheat) in 2000

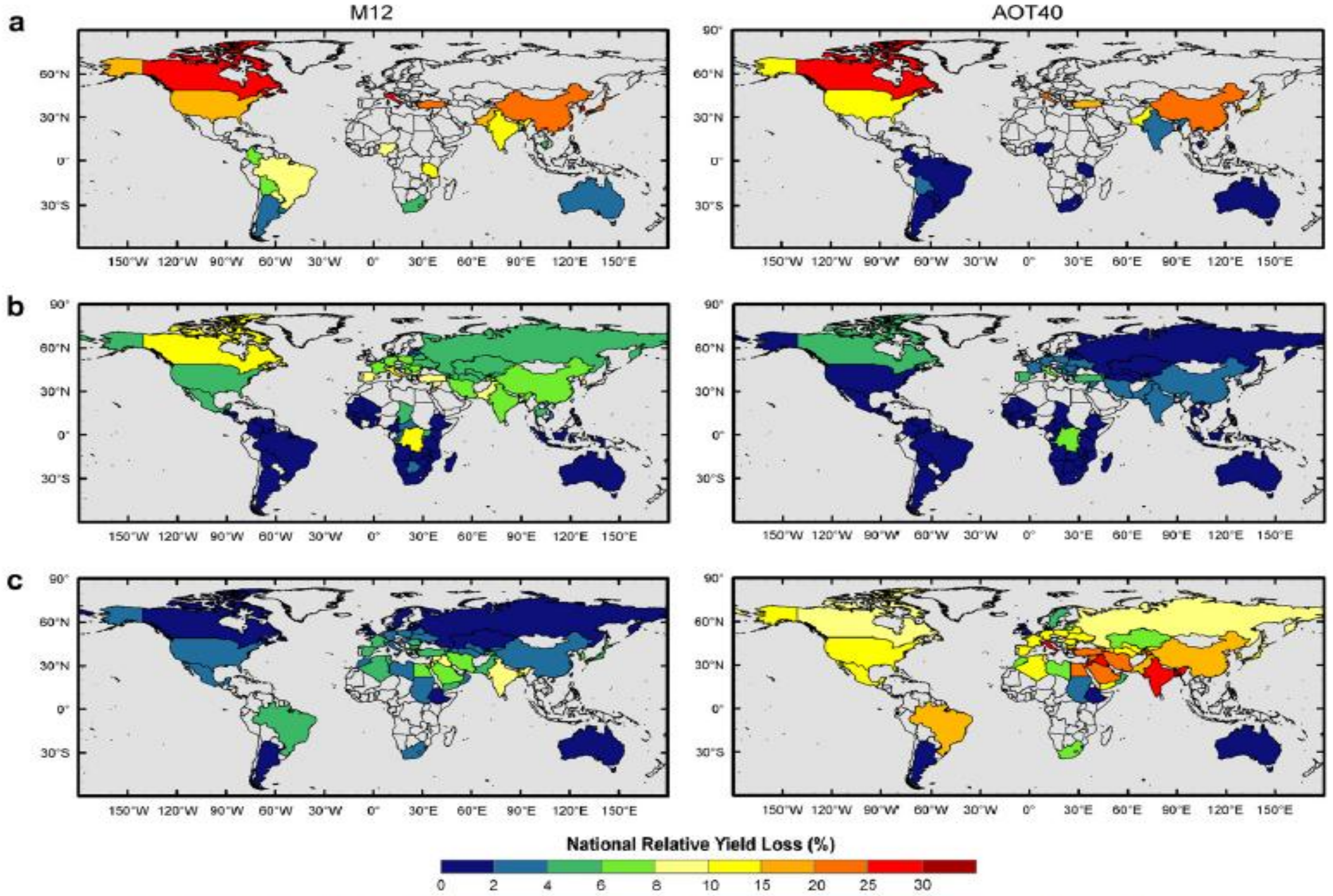


Fig. 4. National relative yield loss according to the M12 (left panels) and AOT40 (right panels) metrics for (a) soybean, (b) maize, and (c) wheat.

Source: Avnery et. al.,2011, Atm. Env. 45, 2284-2296

Crop yield reduction worldwide (2007-2015)

Crop	No. of datapoints	% yield reduction
Soybean[1,2]	3	22.5
Rice[1,2,4]	11	13.7
Wheat[1,2]	10	7.4
Durum wheat[2]	2	14.2
Peas / beans[3]	2	3.2

Crop yield reductions, using data from [1]China, [2]India, [3]Japan and [4]Pakistan

Source: WGE 2016, Field evidence of ozone impacts on vegetation

OTC validation experiments

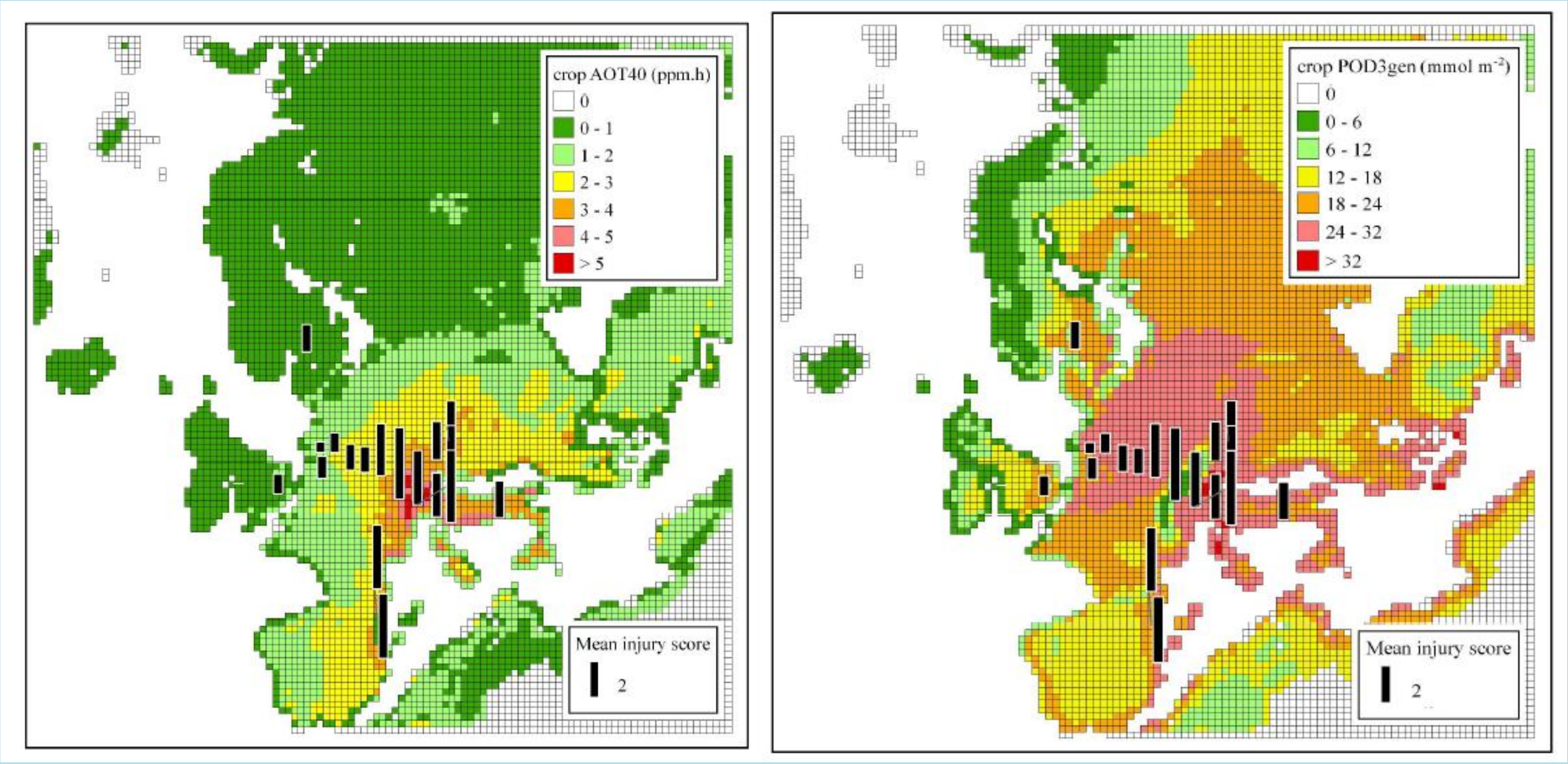
Ozone exposure experiments using open-top chambers in Spain and Italy

Country	Ozone (24h mean, ppb)	Species	Biomass reduction	Reference
Spain	28	Mediterranean pasture	8%	Calvete-Sogo et al., 2014, Atmospheric Environment 95:197-206.
Italy	37	*Quercus ilex*	17%	Gerosa et al., 2015, Atmospheric Environment 113: 41-49.
Spain	35	*Quercus ilex*	1%	Alonso et al., 2014, Plant Biology 16: 375-384.
Spain	32	*Briza maxima*	3%	Sanz et al., 2011, Environmental Pollution 159: 423-430.
Japan	19	*Betula ermanii*	4%	Hoshika et al., 2013, Environmental and Experimental Botany 90: 12-16.

Examples of responses to ozone shown in non-filtered compared to filtered air experiments

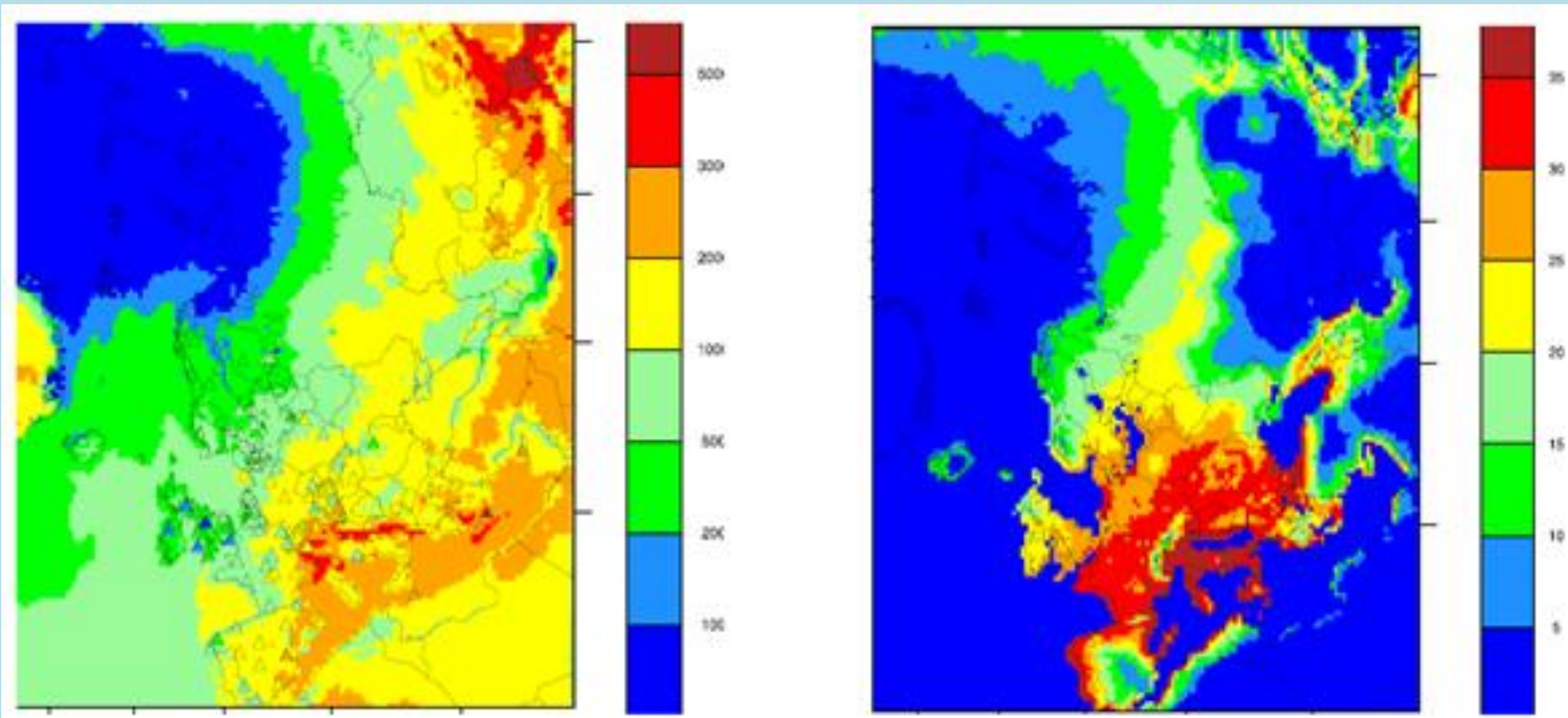
Source: WGE 2016, Field evidence of ozone impacts on vegetation

Risk maps for ozone exposure of crops in Europe 1990-2006



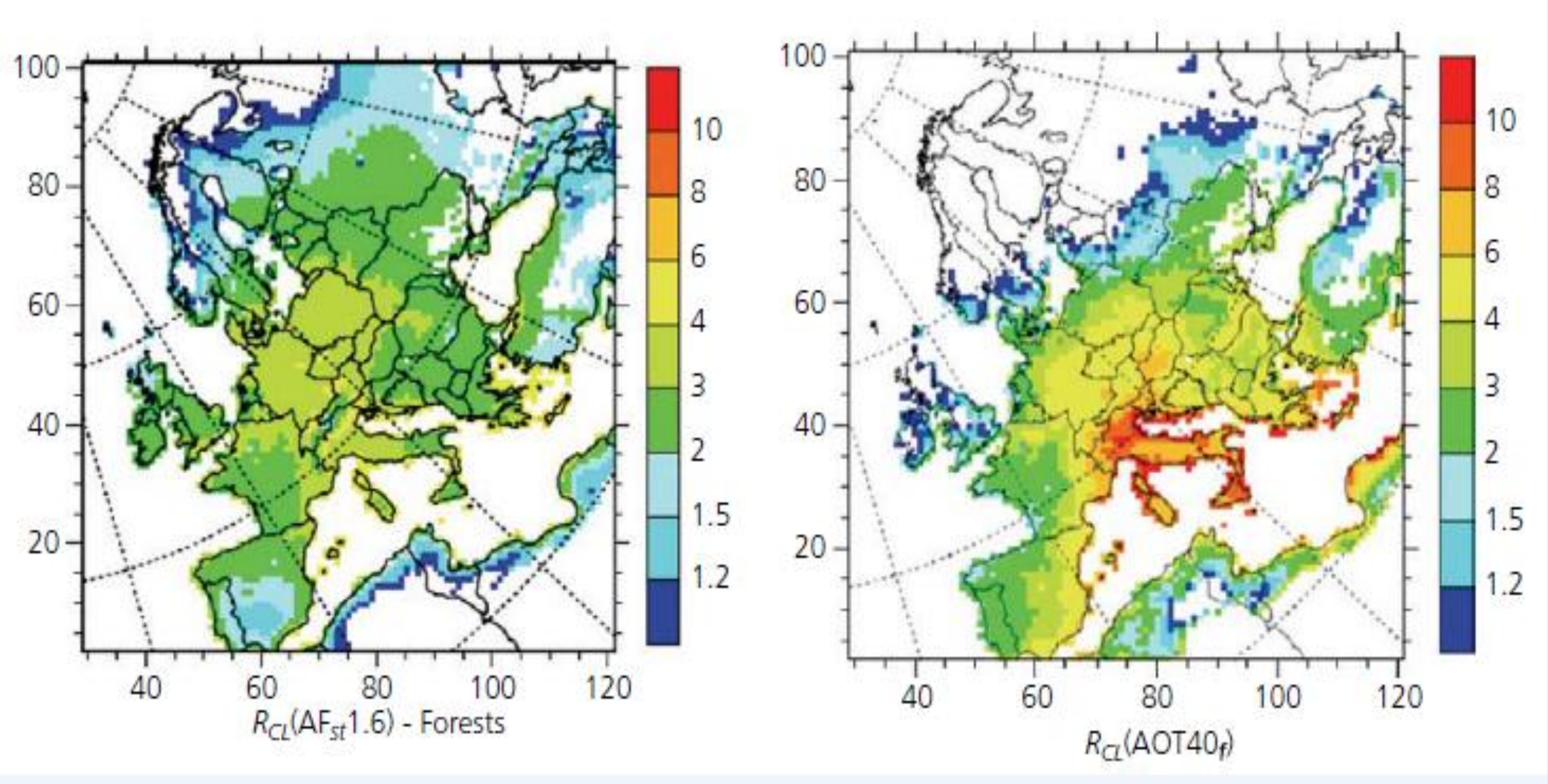
Source: Mills et. al. 2011, Global Change Biology 17, 592-613

Ozone exposure for forests (AOT40 vs POD1)



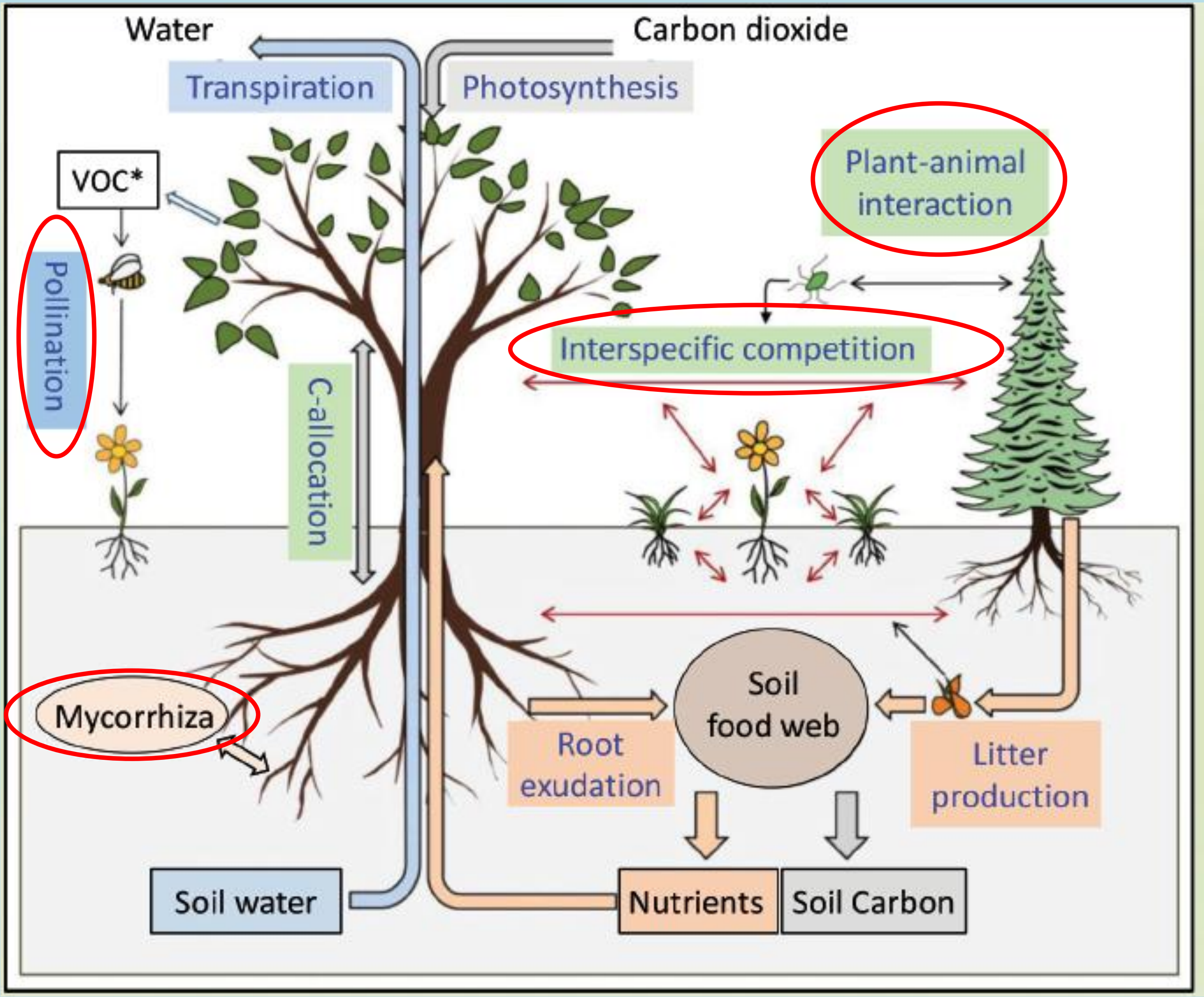
Source: EMEP 2016, Status Report

Ozone exposure for forests
POD1.6 vs AOT40



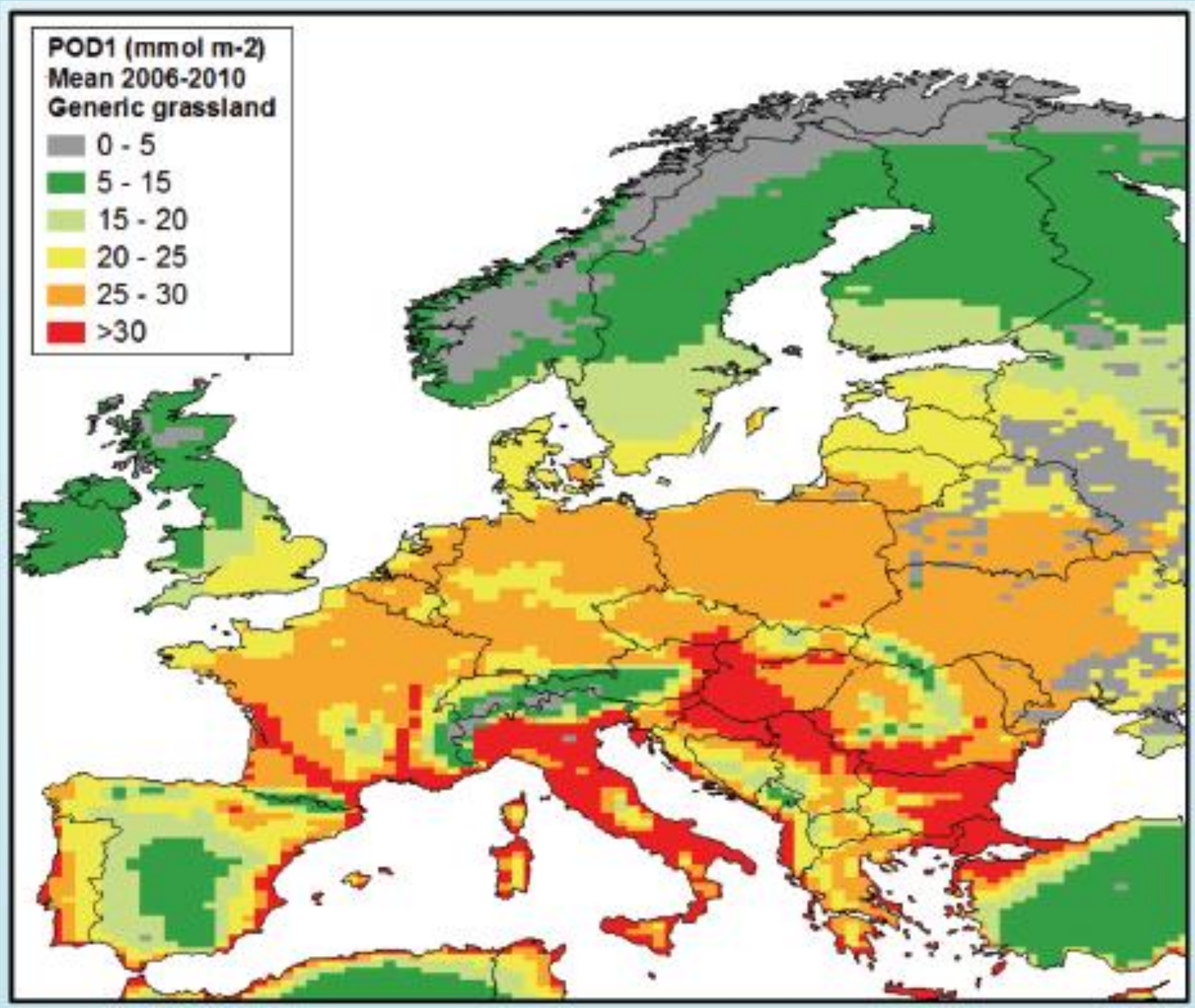
Source: UK Royal Society 2008, Science Policy Report

Ozone impacts on biodiversity



Source: WGE 2016, Report on biodiversity

Grassland exposure to ozone



Source: WGE 2016, Report on biodiversity

Risk assessment for grassland

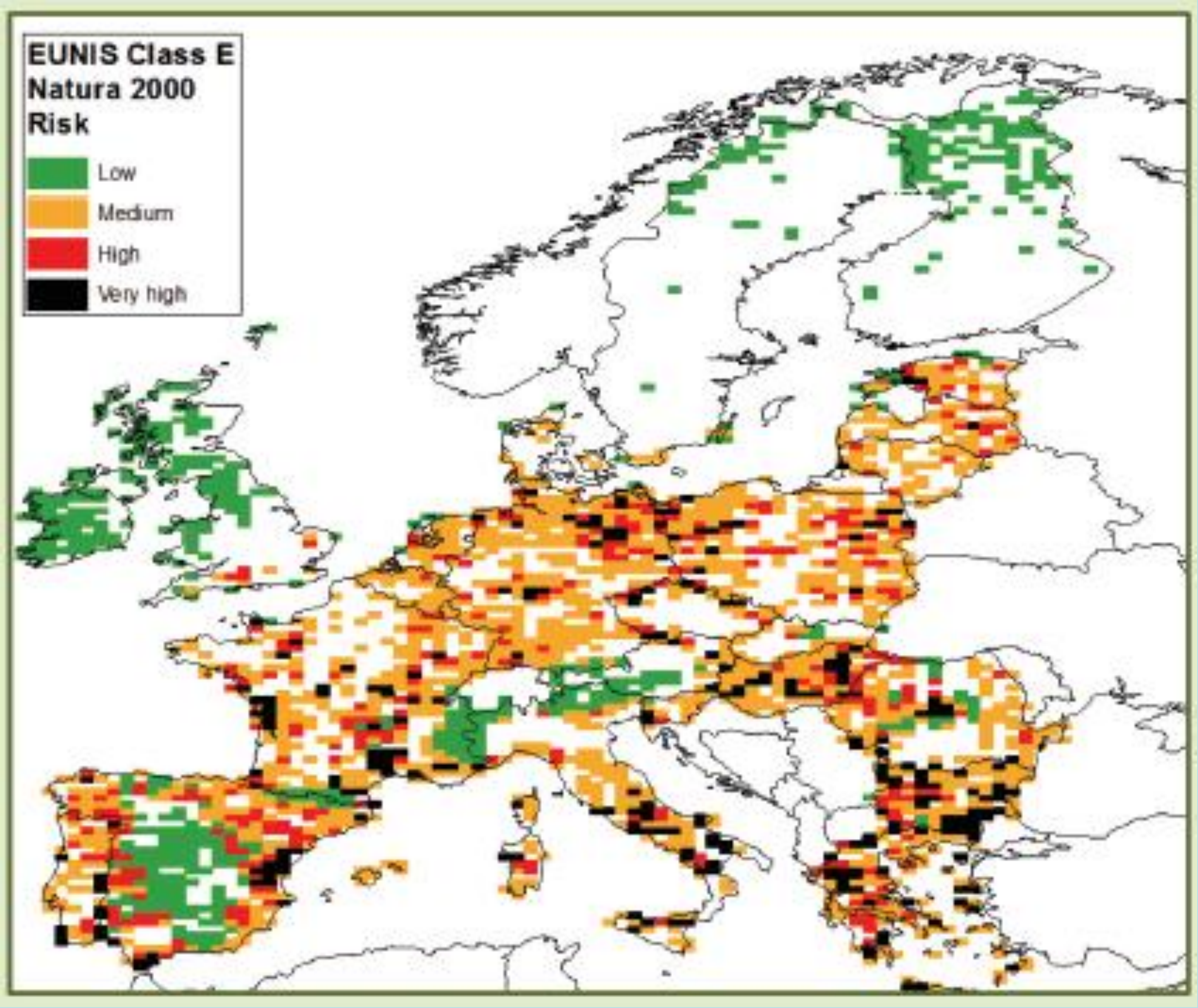
Matrix for calculating the risk of ozone impact on grasslands, based on the phytotoxic ozone dose (POD_1) for grass and the grassland area (%) per grid cell (0. 5° (longitude) by 0.25° (latitude)). POD_1 was calculated over a six months period (April – September).*

Grassland area in grid cell (%)	POD_1 grass (mmol m^{-2})*	<5	5 - 15	15 - 20	20 - 25	25 - 30	>30
	RISK	**1**	**2**	**3**	**4**	**5**	**6**
0.5 – 5	**1**	**1**	**2**	**3**	**4**	**5**	**6**
5 - 10	**2**	**2**	**4**	**6**	**8**	**10**	**12**
>10	**3**	**3**	**6**	**9**	**12**	**15**	**18**

** Simpson et al., 2012. Atmospheric Chemistry and Physics 12: 7825-7865.*

Source: WGE 2016, Report on biodiversity

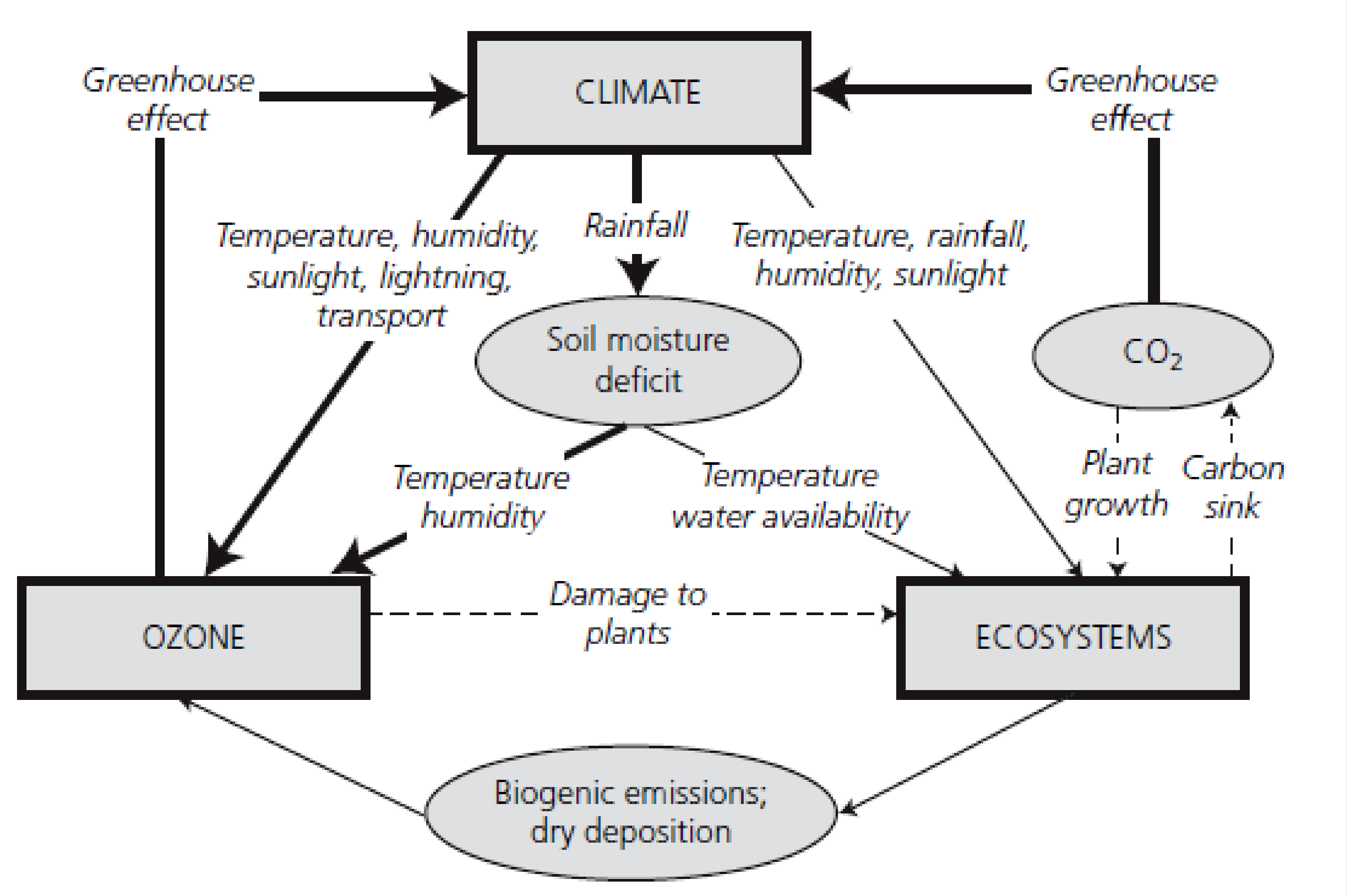
Risk map for grassland



Source: WGE 2016, Report on biodiversity

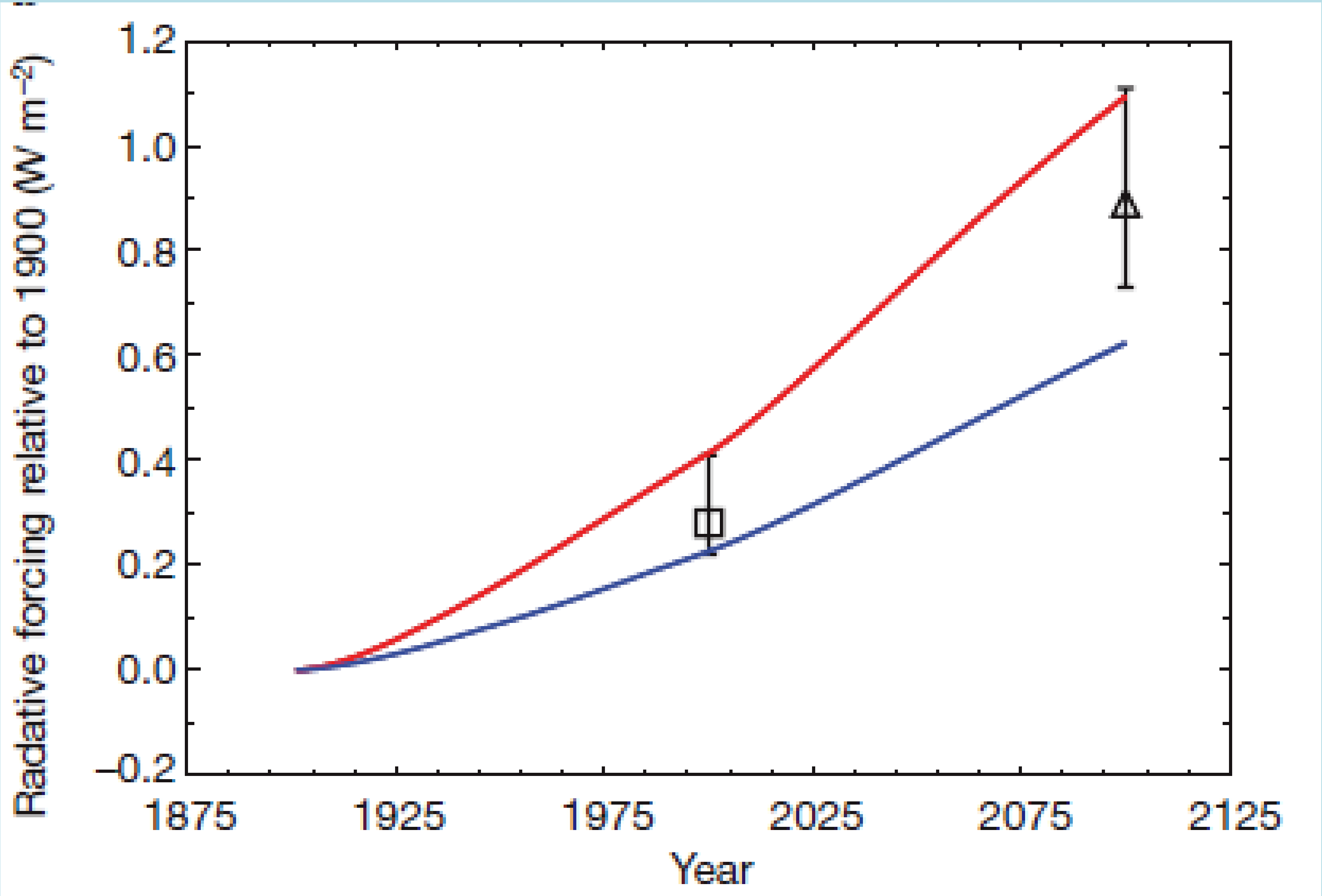
Crossed interactions between ozone and climate change

Ozone, climate and ecosystem interaction



Source: UK Royal Society 2008, Science Policy Report

Ozone as a driver of climate change



Source: Sitch et al. 2007, Nature 448, 791-795

Impacts of climate change on ground ozone levels

- **Emission fluxes of ozone precursors**
  (e.g. VOC from vegetation, NO_X from soil and lightning, CH_4 from wetlands and NO_X, CO and VOC from wild fires);

- **Atmospheric chemistry**
  (e.g. via changes in temperature and atmospheric water vapour content);

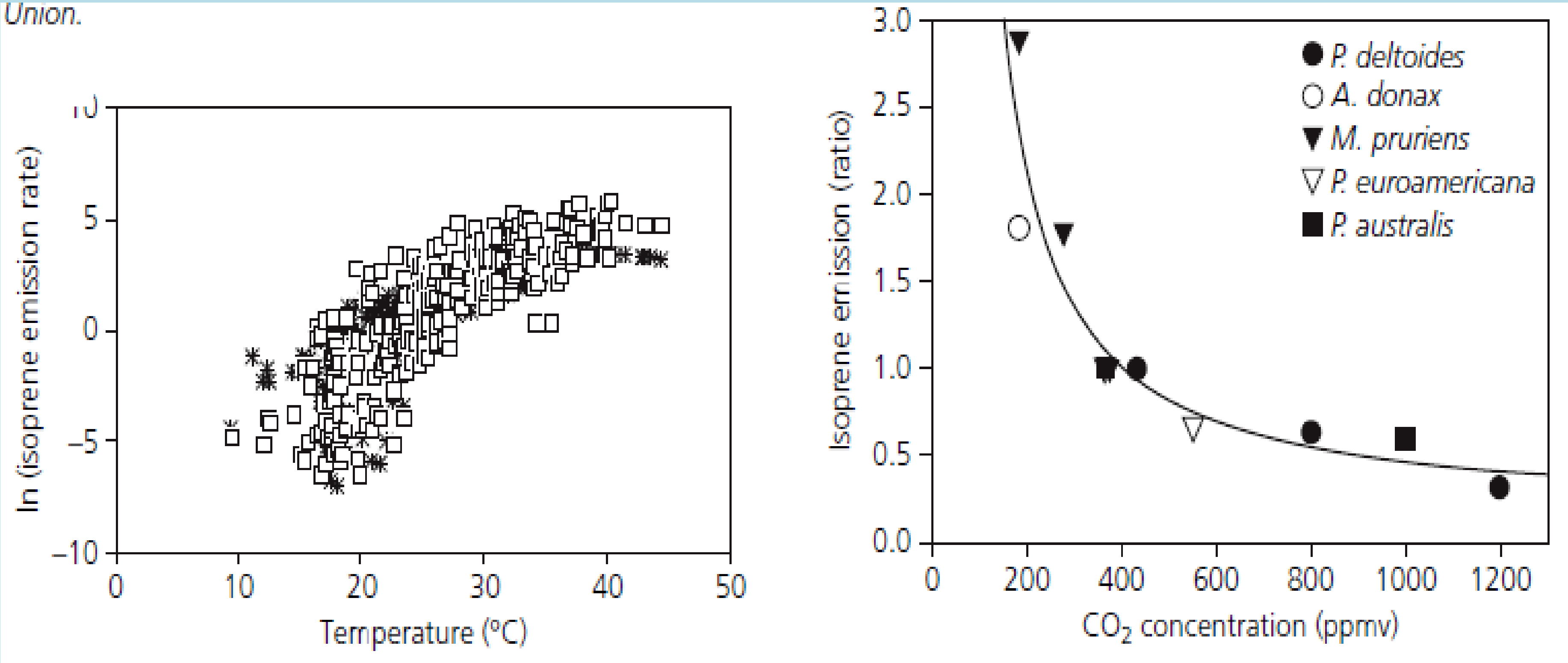
- **Atmospheric dynamics**
  (e.g. boundary layer ventilation, convective mixing, prevalence of anticyclonic blocking highs, precipitation, and stratosphere-troposphere exchange);

- **Loss of ozone by dry deposition to vegetation**
  depending on soil moisture content and CO_2 concentrations.

Factors influencing biogenic VOCs emission

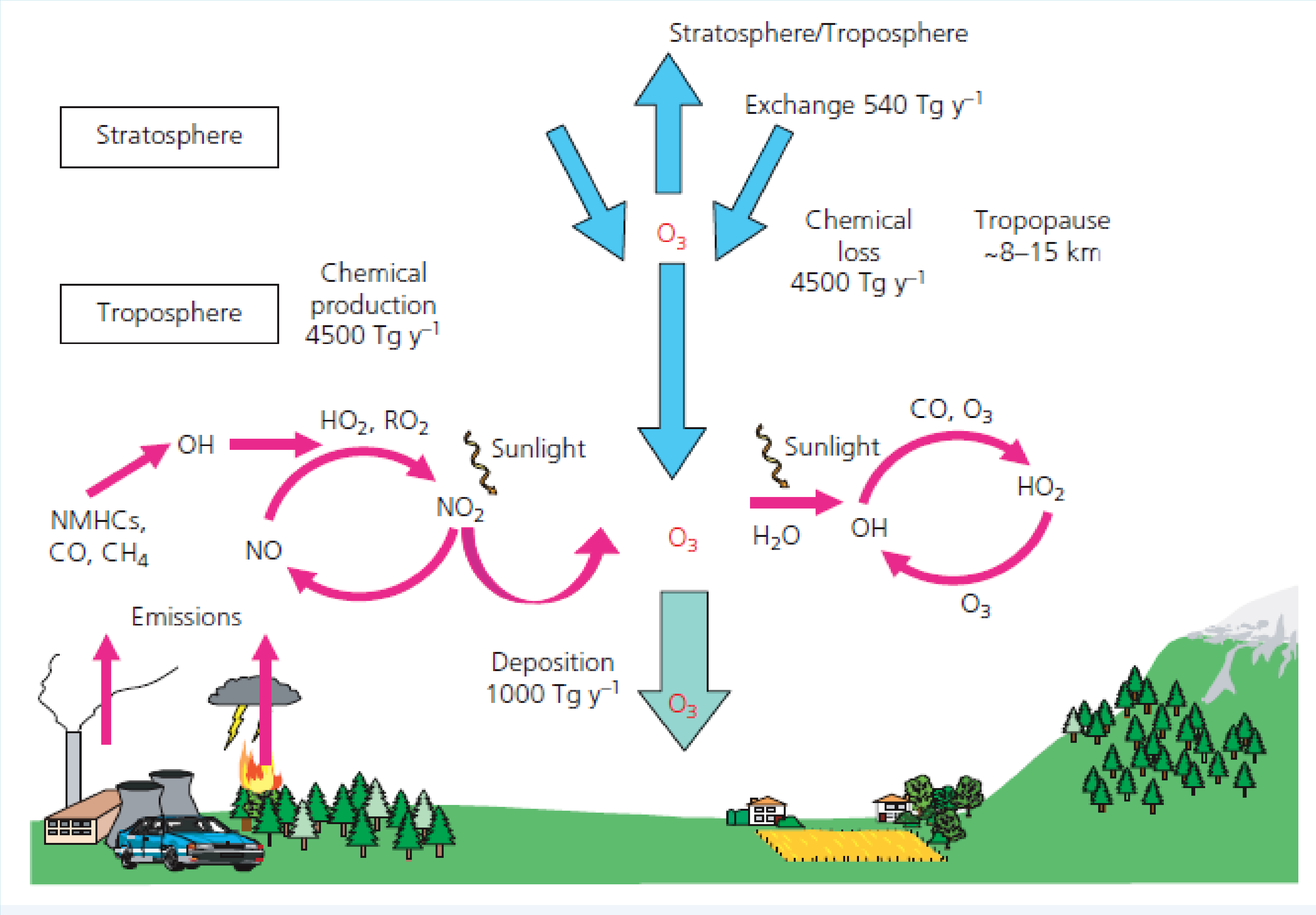
Factor	Effects included in latest emissions estimates for natural nmVOC for this study (Lathiere *et al.* (unpublished data)
Light	Yes
Temperature (current and previous)	Yes
Ambient CO_2 concentration	Yes
Losses within the canopy by reaction and/or deposition	Yes
Leaf age	Yes
Biomass	Yes
Plant species (usually by functional type)	Yes
Drought	Yes
O_3	No
Herbivory	No
Wind damage	No
Fire	No
Logging	No
Nutrient status	No
Circadian control	No

The puzzle of isoprene emissions



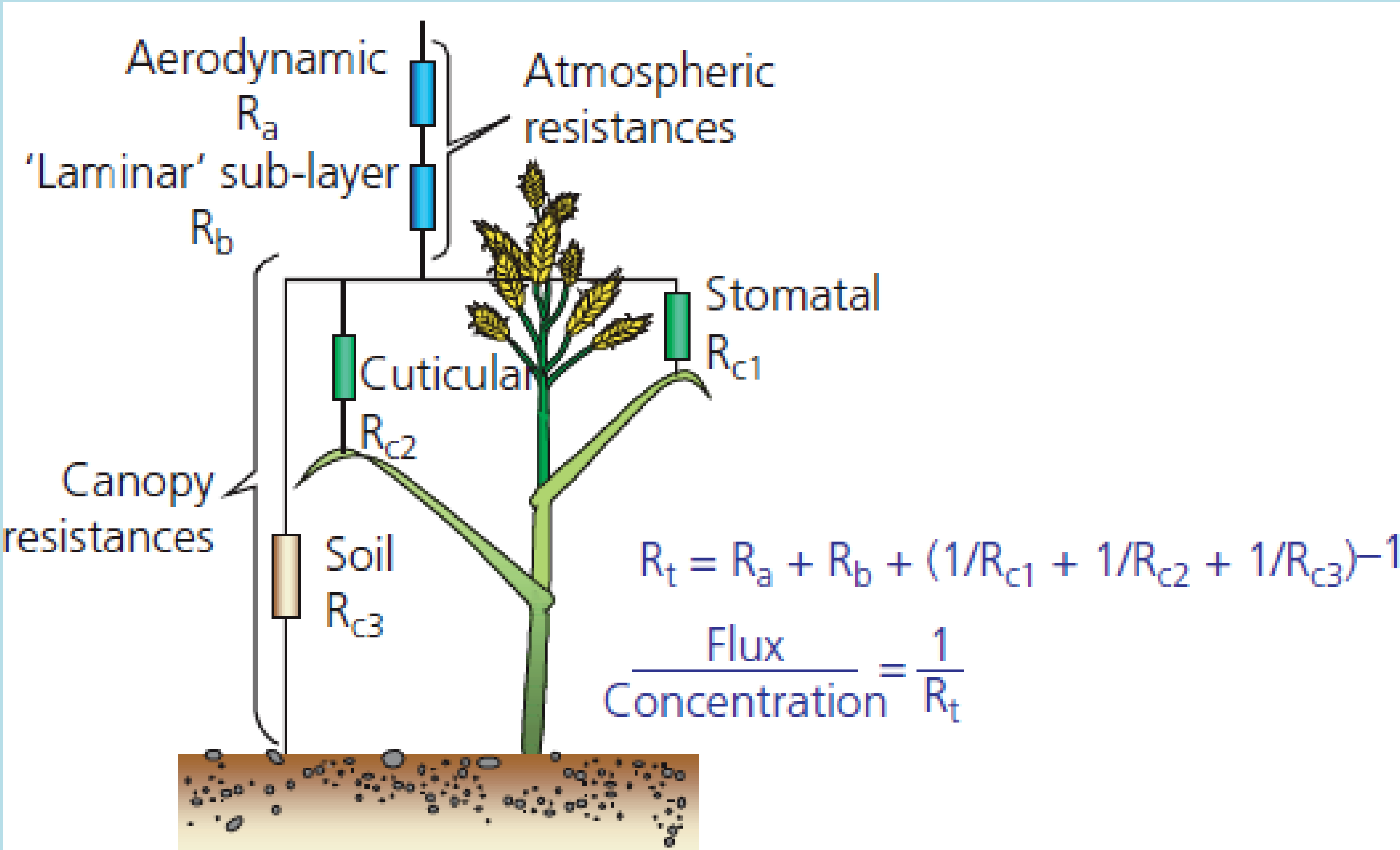
Source: UK Royal Society 2008, Science Policy Report

Ozone sources and sinks affected by climate change



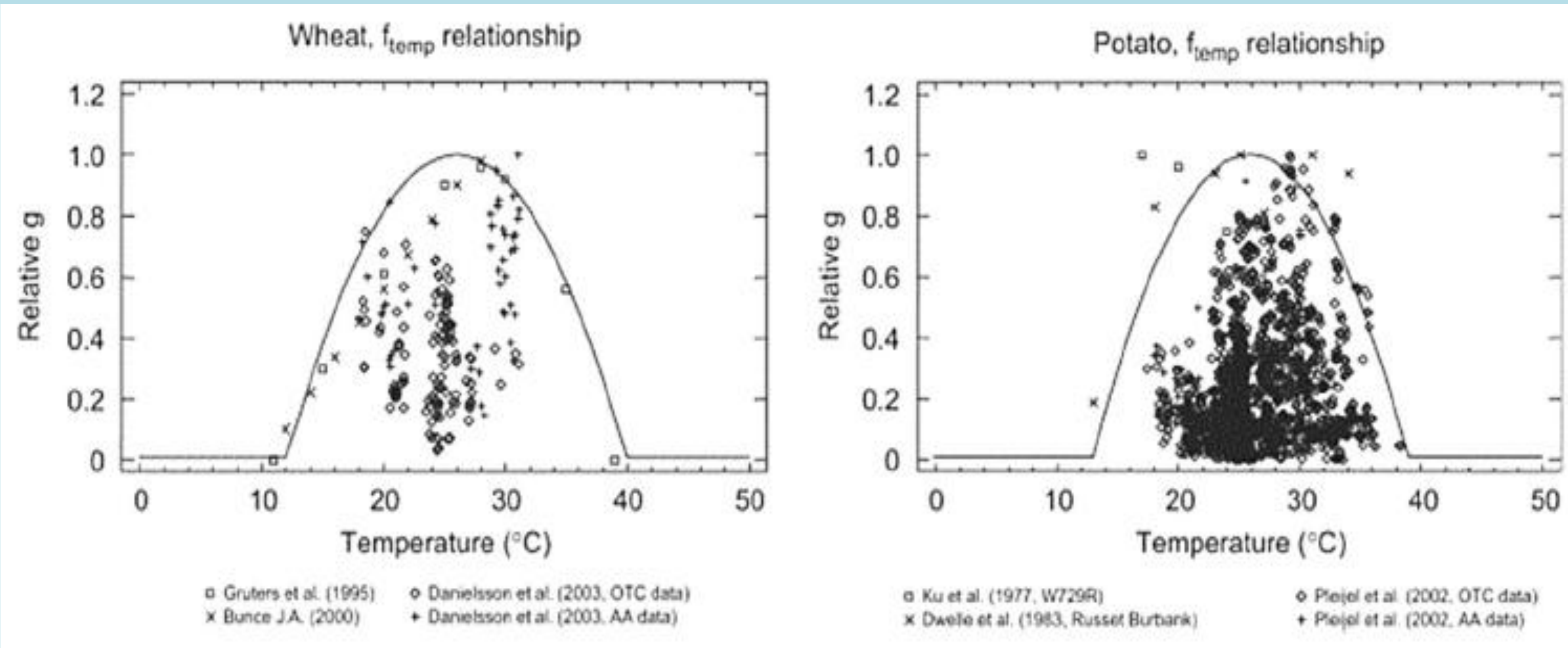
Source: UK Royal Society 2008, Science Policy Report

Deposition parameters are in turn affected by CC



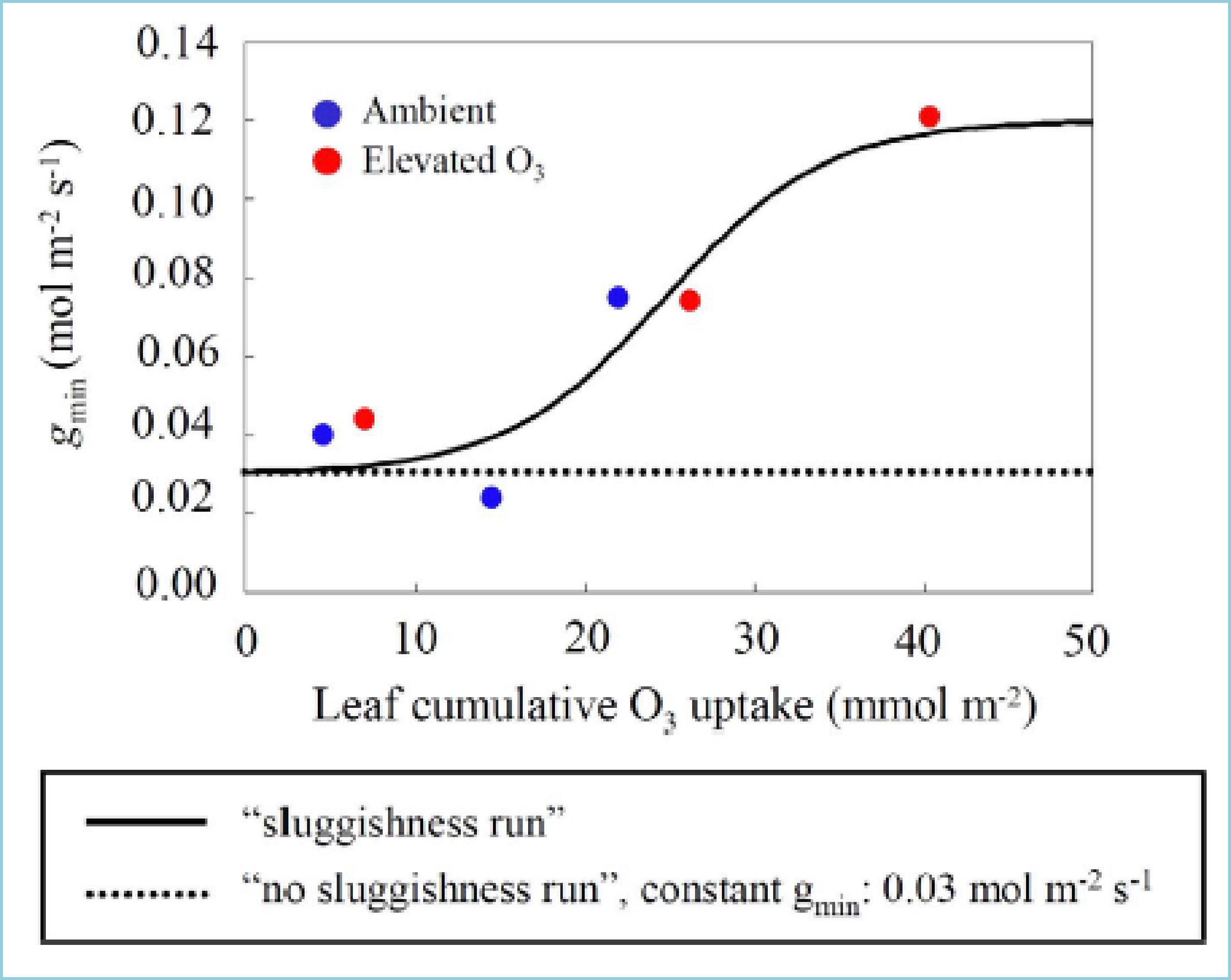
Source: UK Royal Society 2008, Science Policy Report

Stomatal opening vs temperature



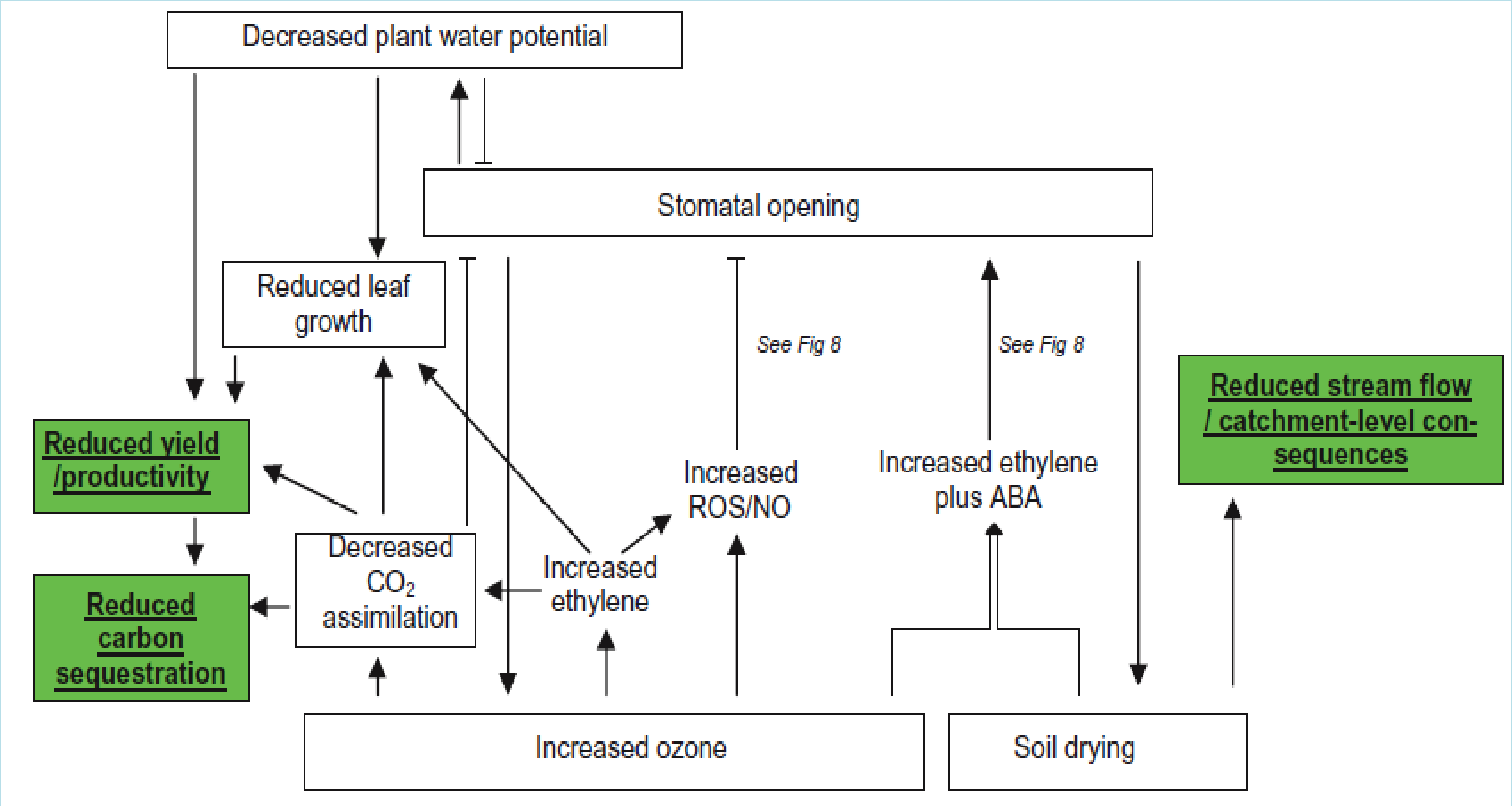
Source: Mills et al. 2016, Env. Poll. 208, 898-908

Role of stomatal sluggishness



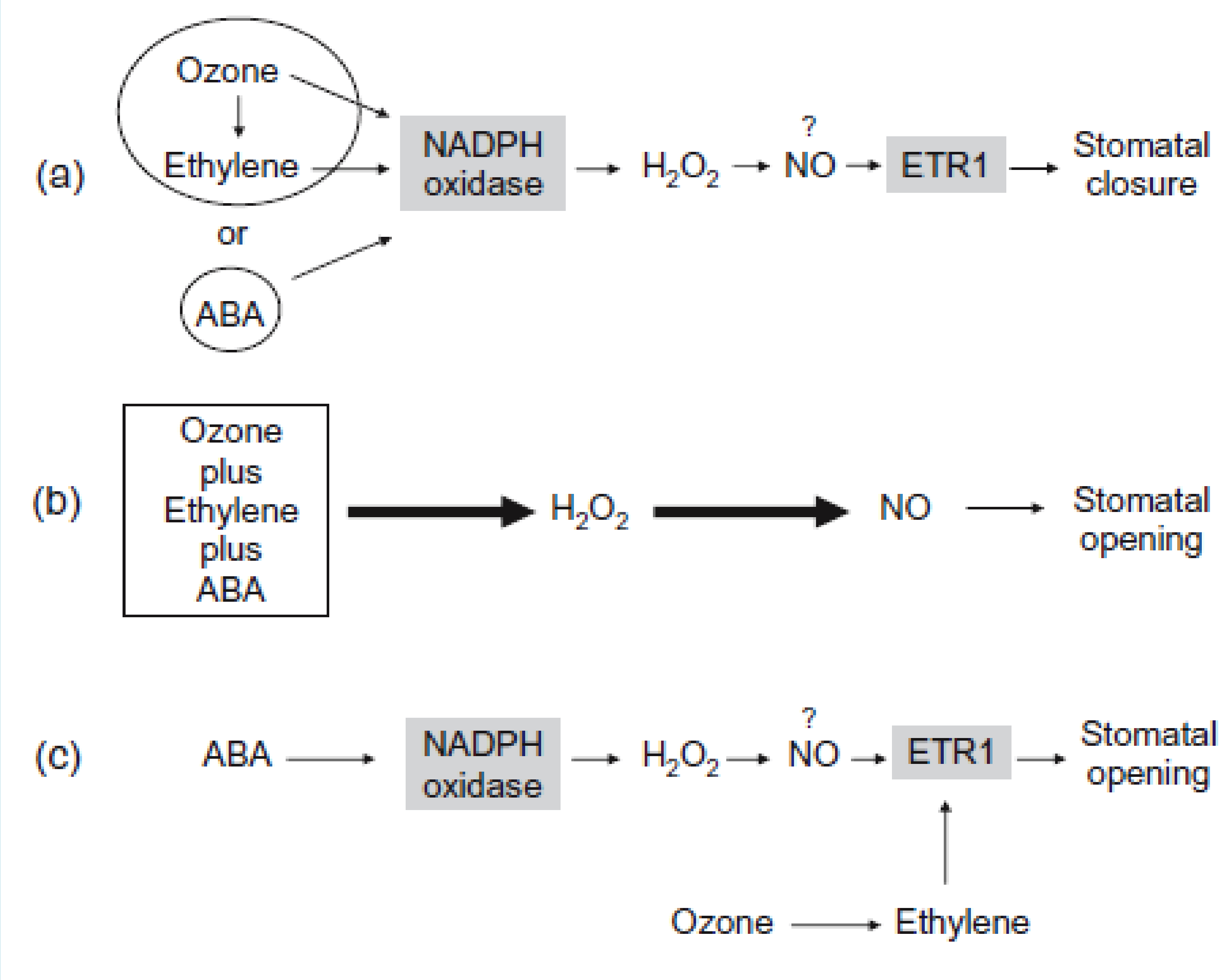
Source: Hoshika and Paoletti 2015, Nature Scientific Reports 5:09871

Drought and ozone in the stomatal opening regulation



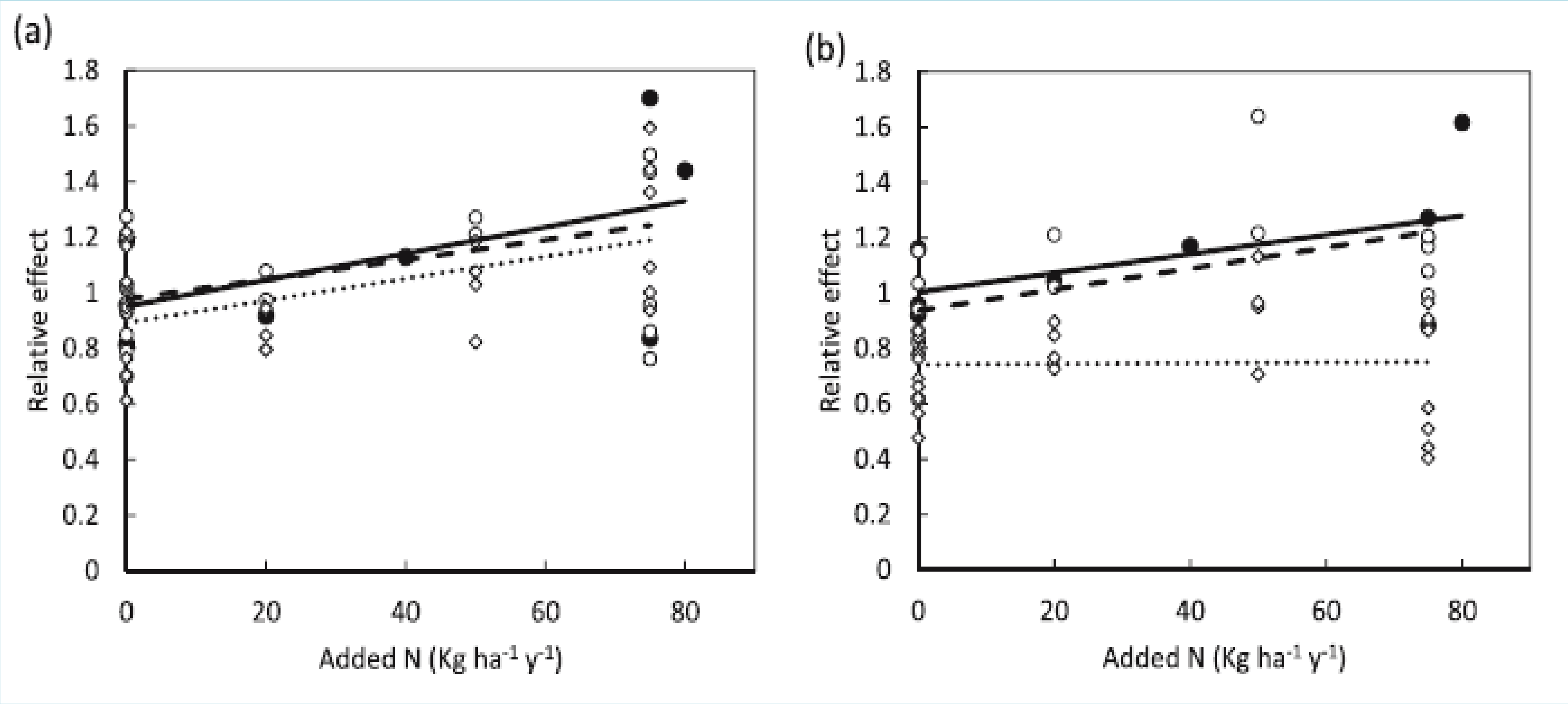
Source: Wilkinson and Davies, 2010, Plant Cell Env. 33, 510-525

Interference of ozone + ethylene in the ABA-induced stomatal opening regulation



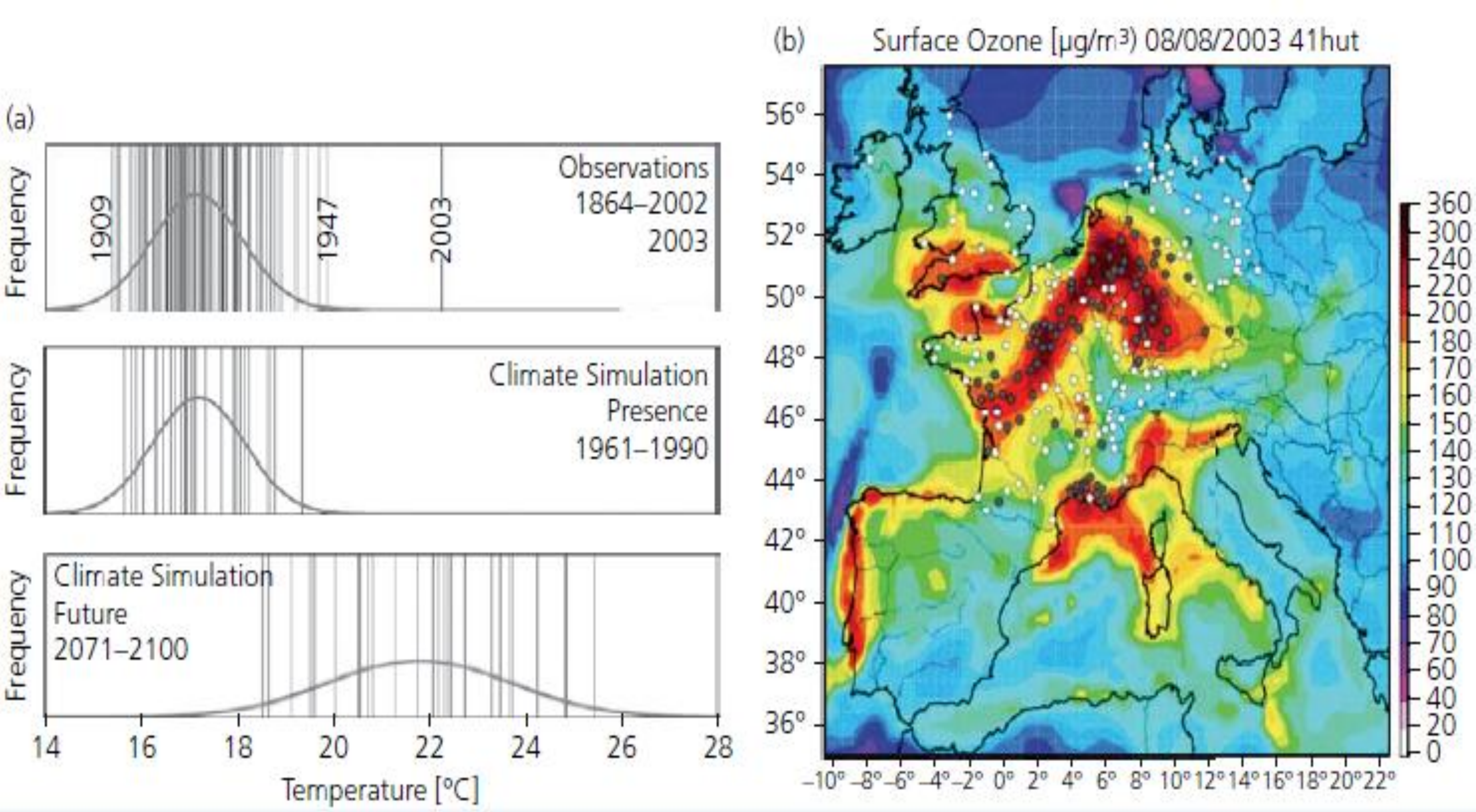
Source: Wilkinson and Davies, 2010, Plant Cell Env. 33, 510-525

Nitrogen effect on the response of shoot and root biomass to ozone



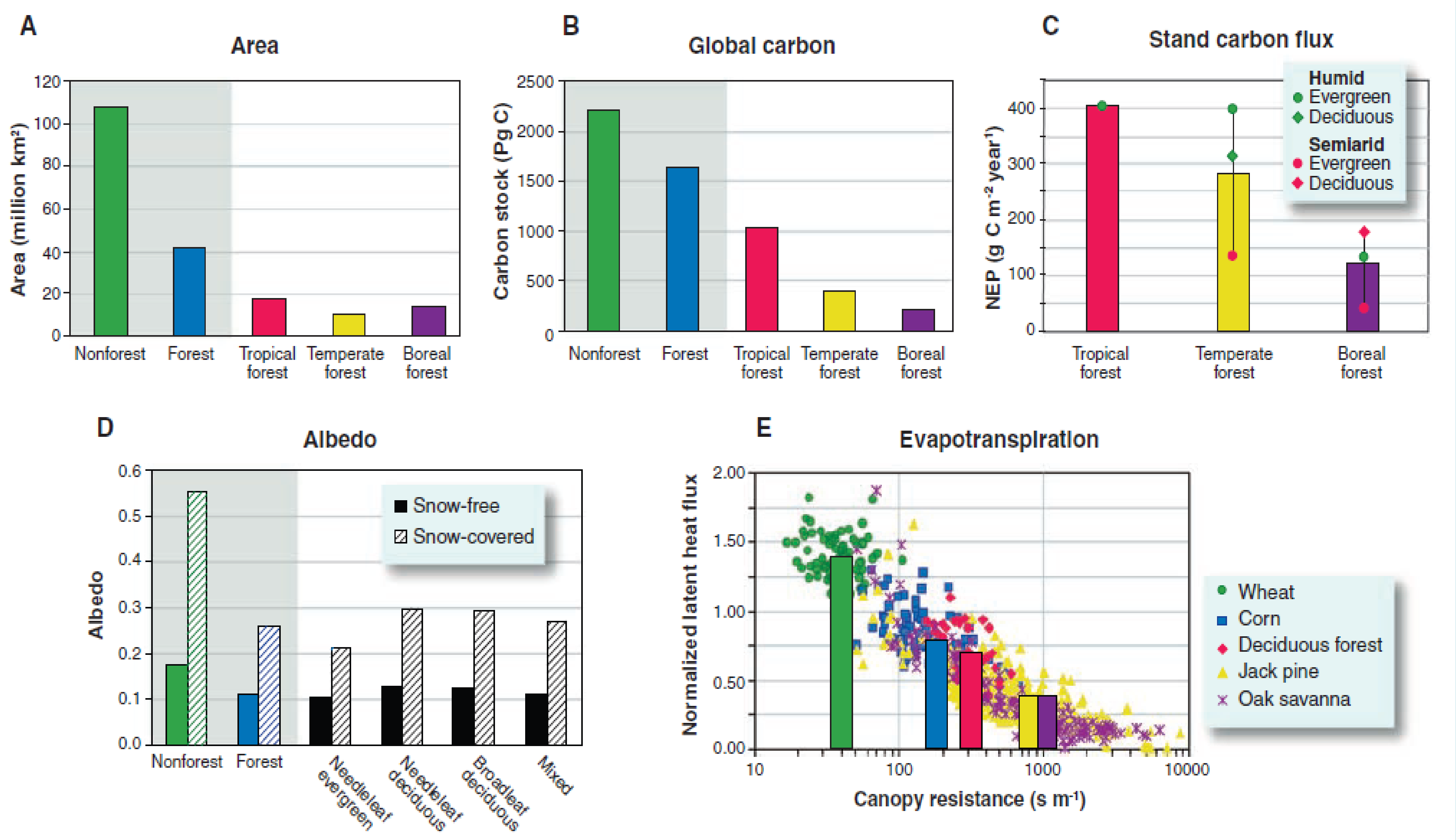
Source: Mills et al. 2016, Env. Poll. 208, 898-908

Ozone and CC extreme events: heat waves



Source: UK Royal Society 2008, Science Policy Report

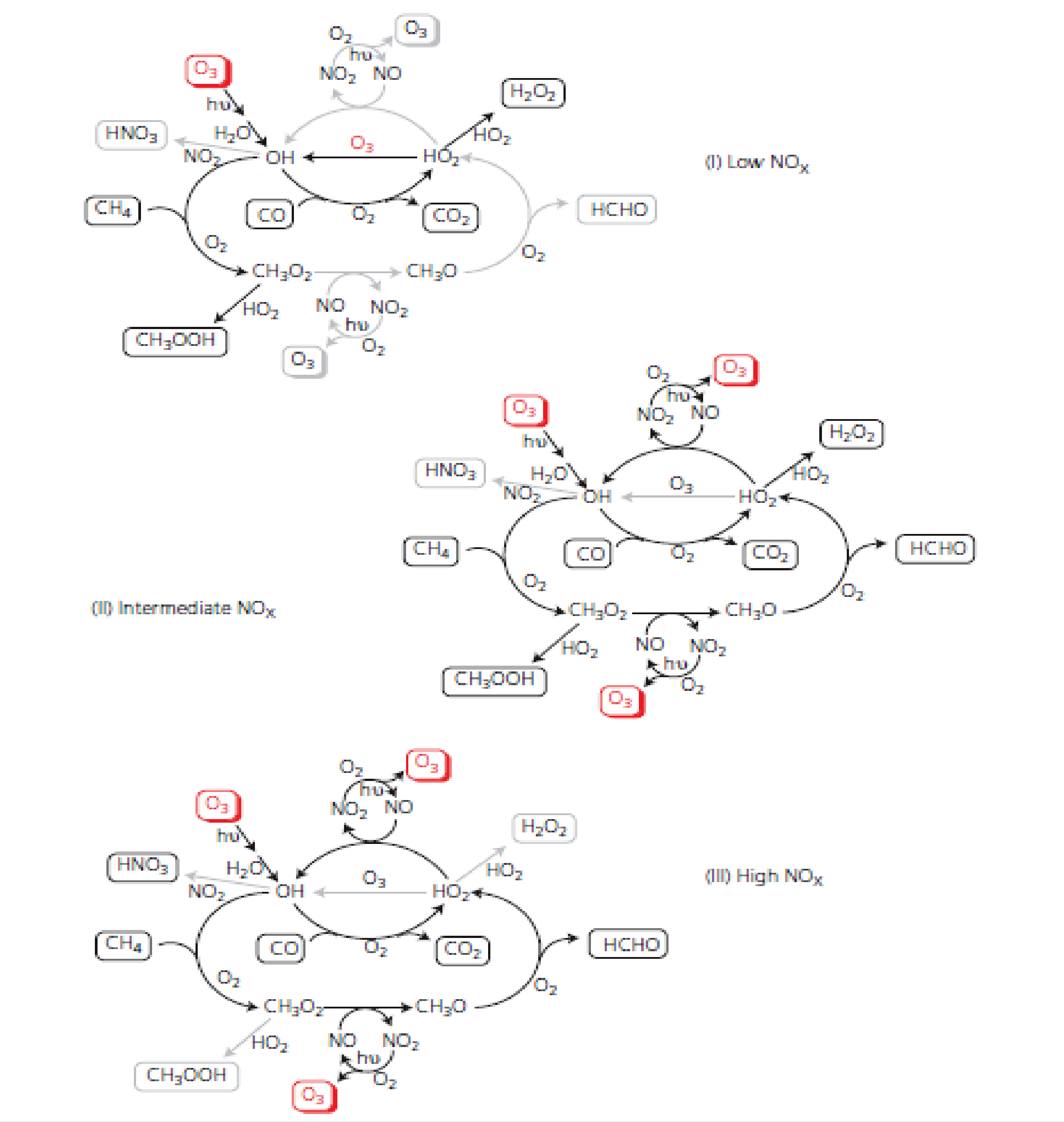
Forests effects on climate change



Source: Bonan 2008, Science 320, 1444-1449

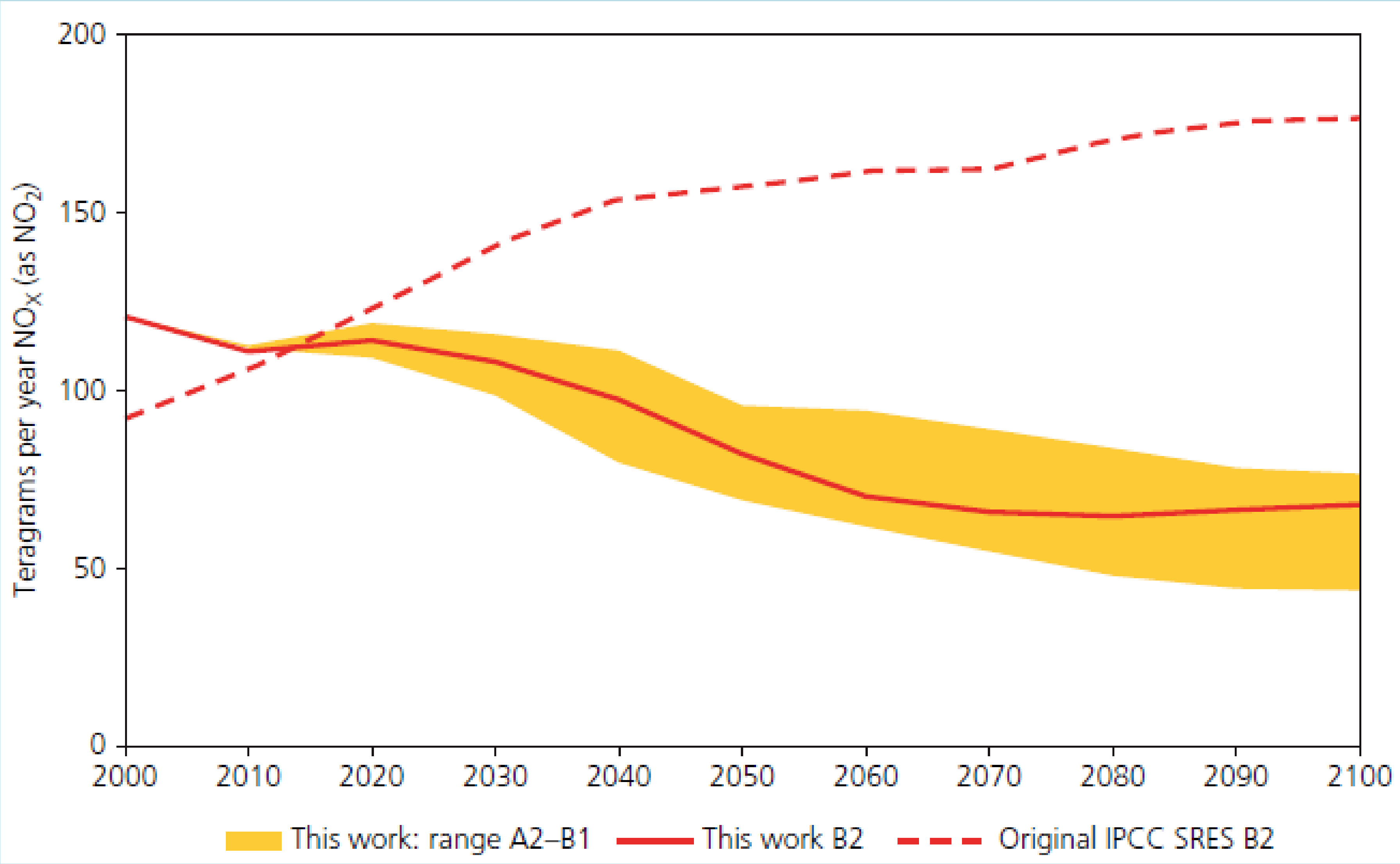
Ozone future projections

Ozone, methane and NOx



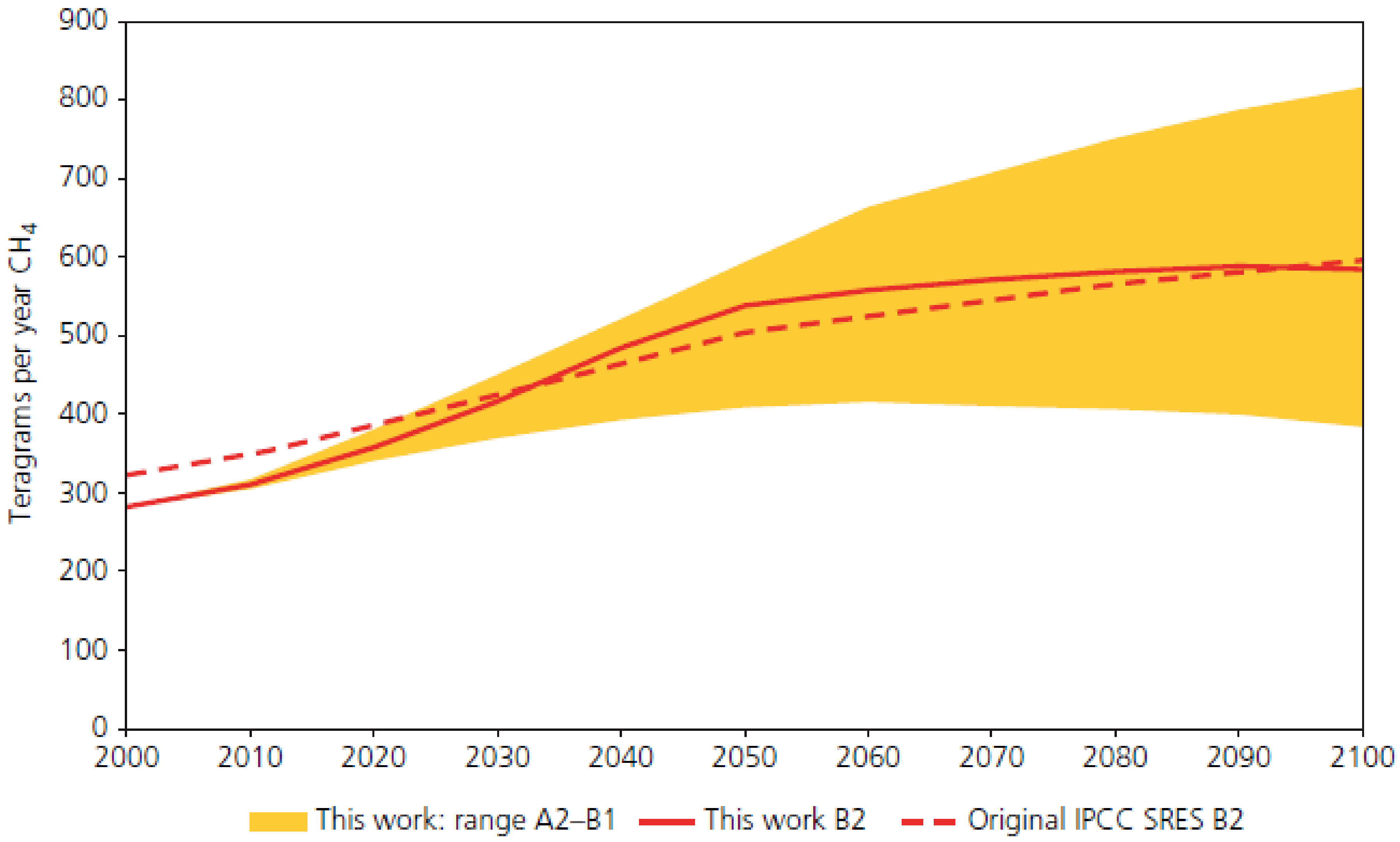
Source: UK Royal Society 2008, Science Policy Report

NO_2 anthropogenic predicted emissions



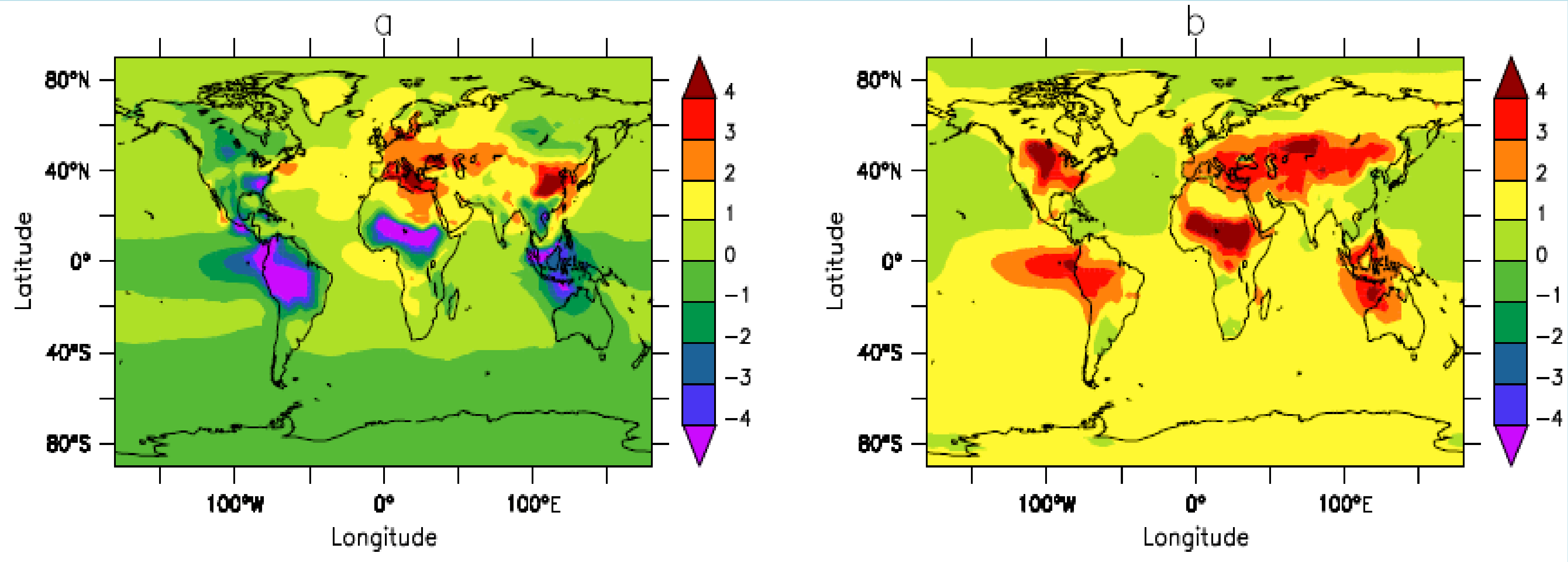
Source: UK Royal Society 2008, Science Policy Report

CH_4 predicted emissions



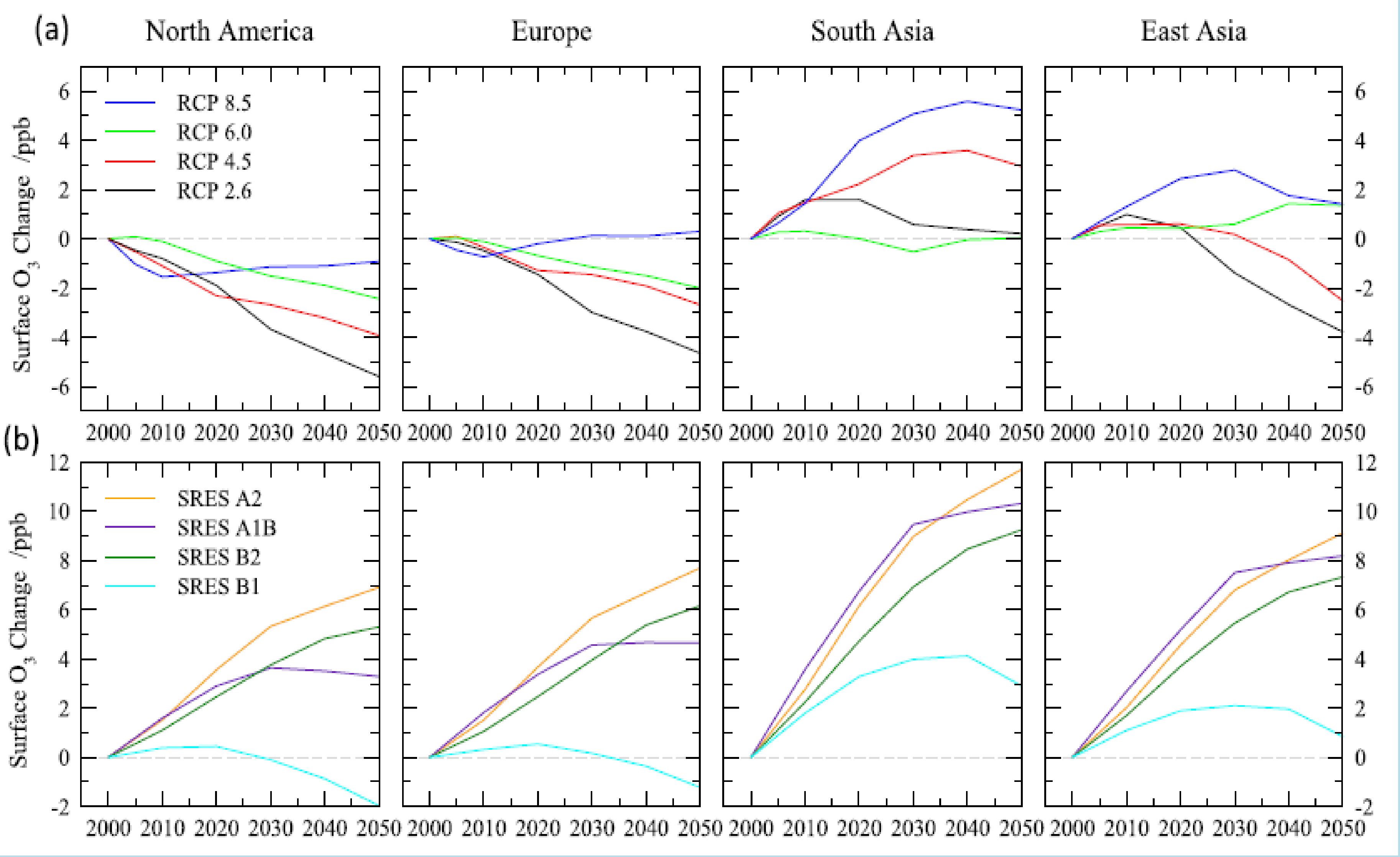
Source: UK Royal Society 2008, Science Policy Report

Expected changes in surface ozone due to increase of isoprene and soil-NOx emissions



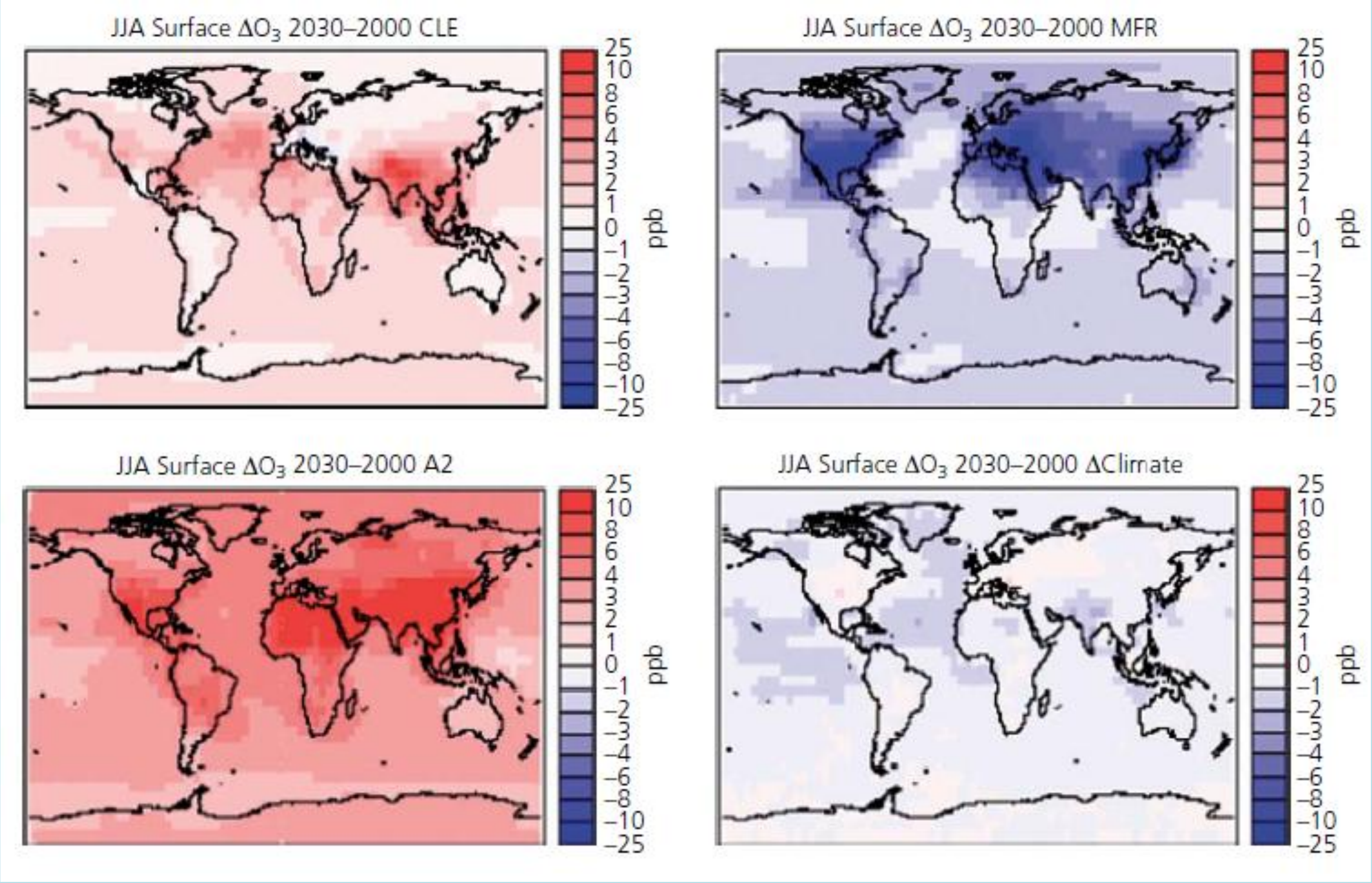
Source: Zeng, Pyle, Young 2008, Atmos. Chem. Phys. 8, 369-387

Ground ozone concentration projections under RCP and SRES scenarios



Source: Mills et. al. 2016, Env. Poll. 208, 898-908.

Ozone projections by 2030



Source: UK Royal Society 2008, Science Policy Report

Changes in surface ozone due to CC only

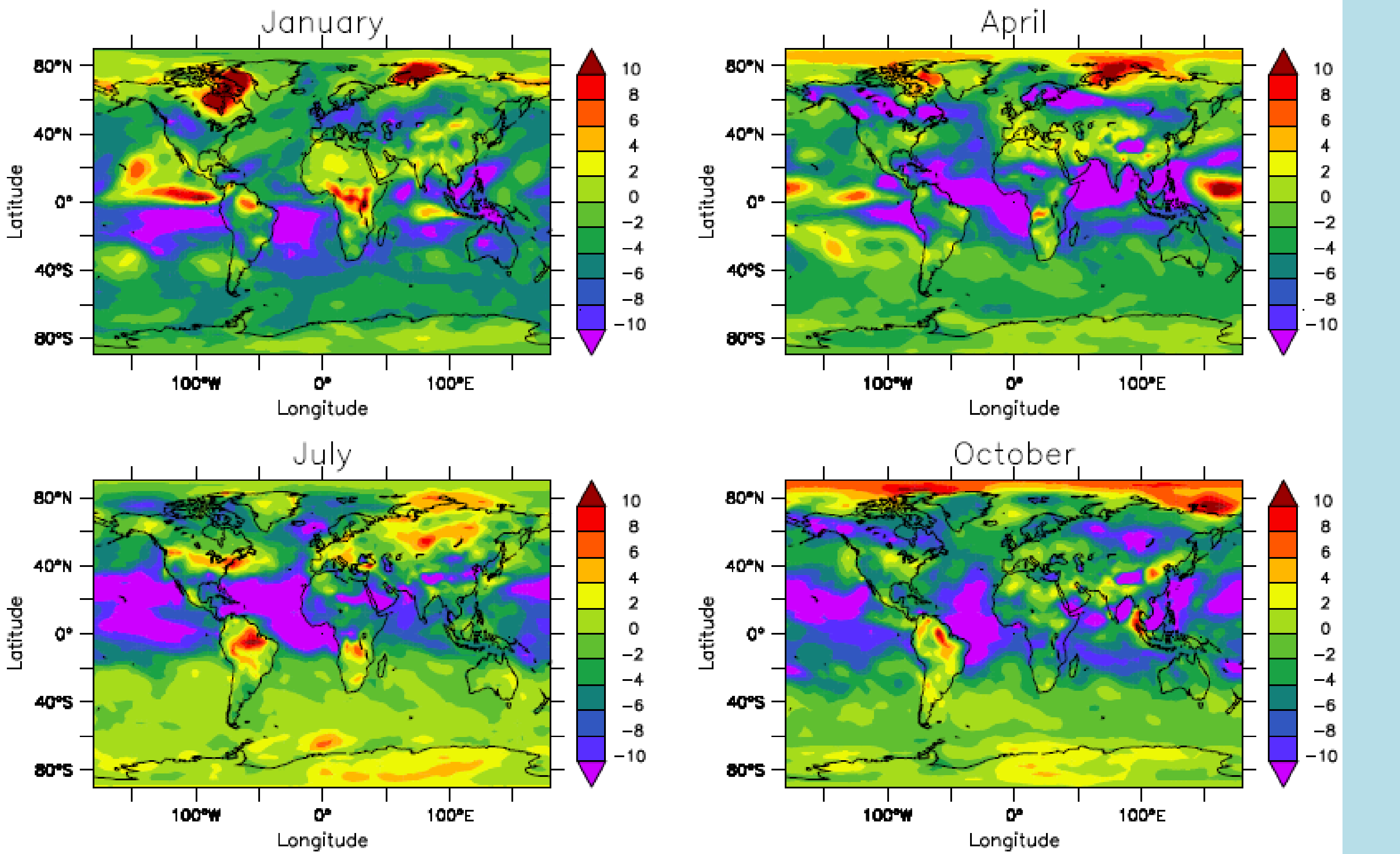
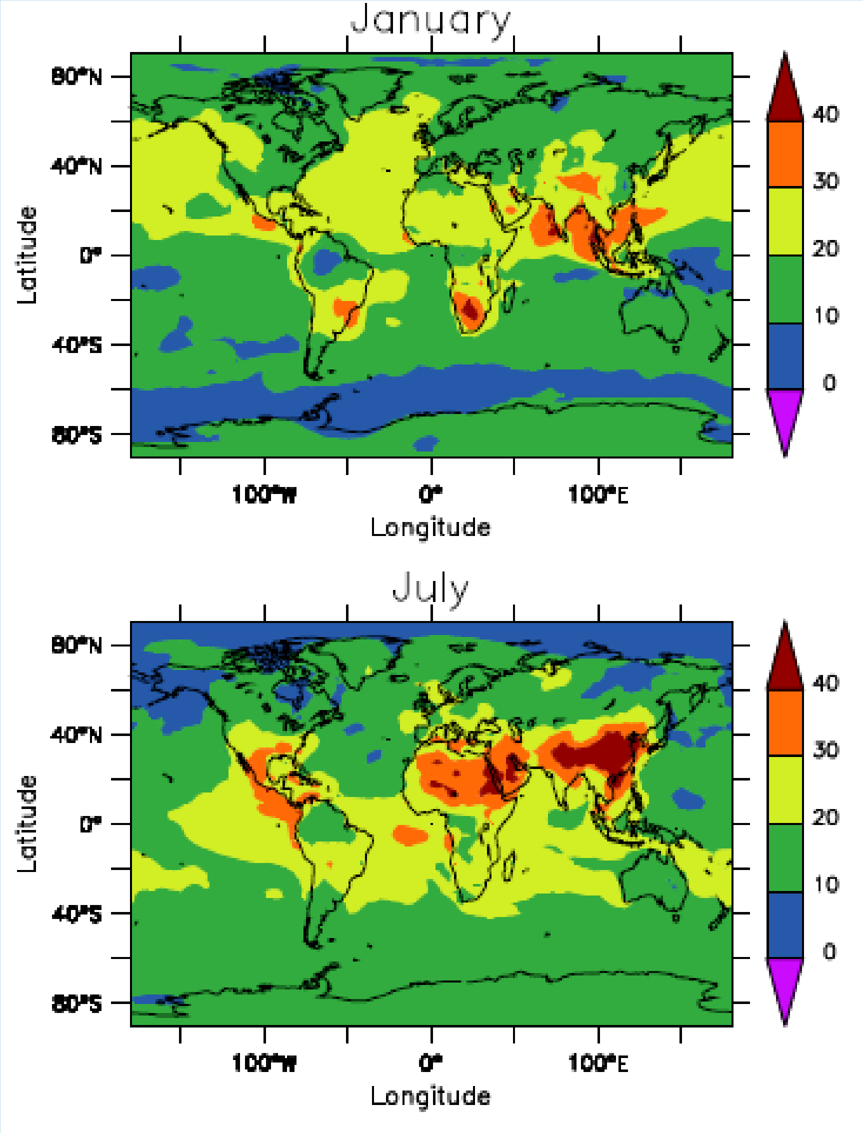


Fig. 10. Changes in surface O_3 (ppbv) between 2000 and 2100 due to climate change, for January, April, July and October.

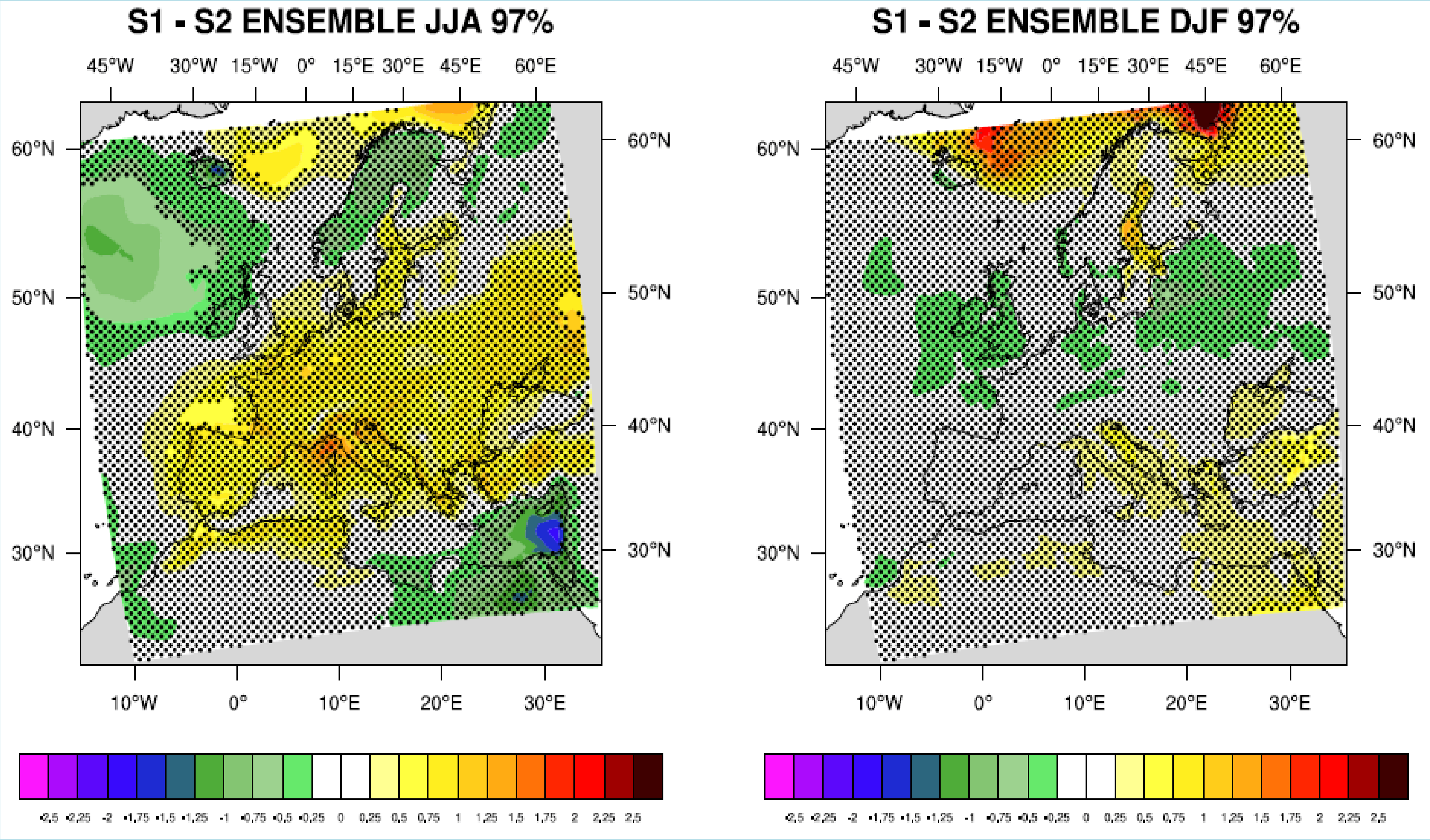
Source: Zeng, Pyle, Young 2008, Atmos. Chem. Phys. 8, 369-387

Changes in surface ozone due to emission changes only



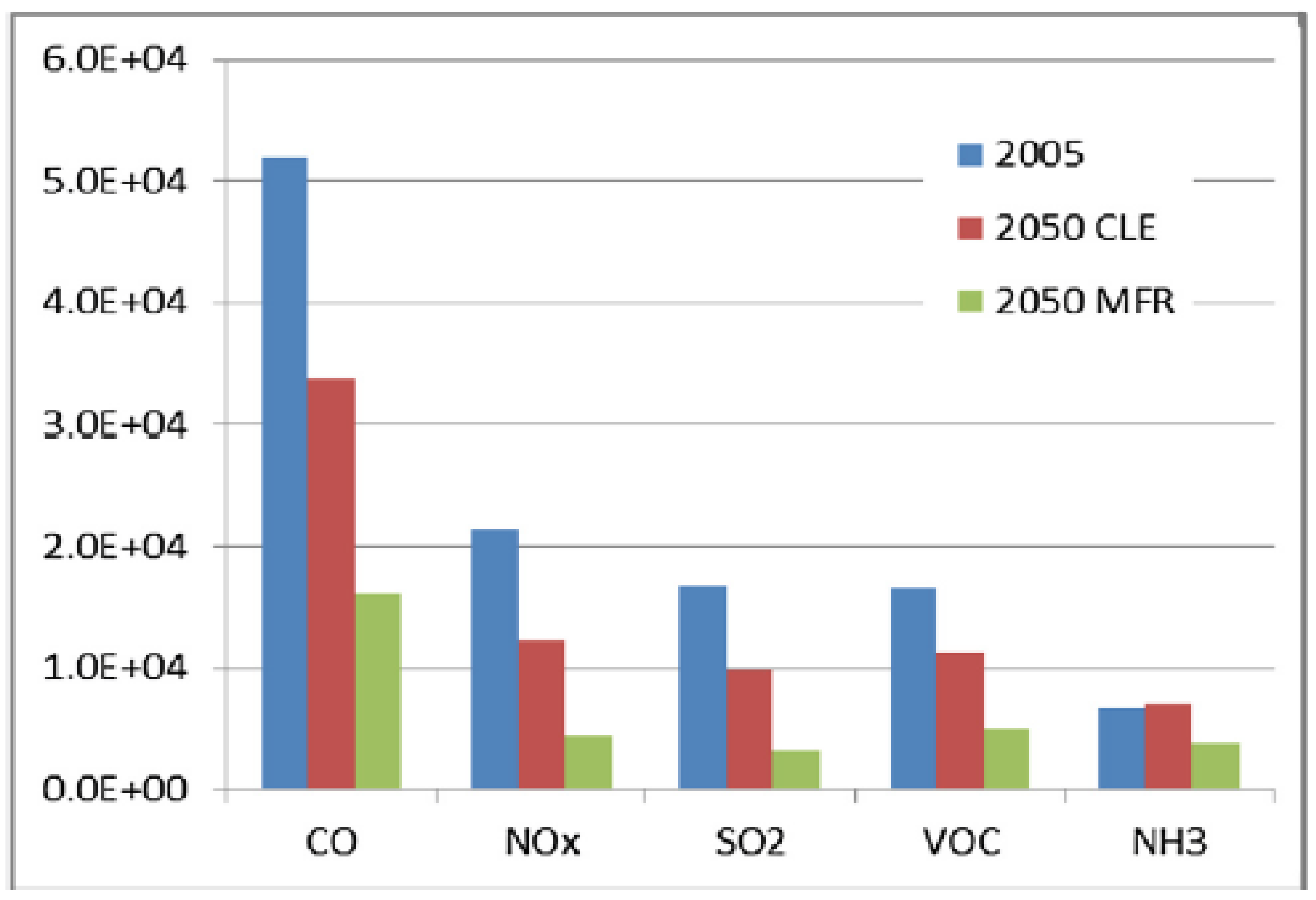
Source: Zeng, Pyle, Young 2008, Atmos. Chem. Phys. 8, 369-387

Changes in surface ozone due to CC only



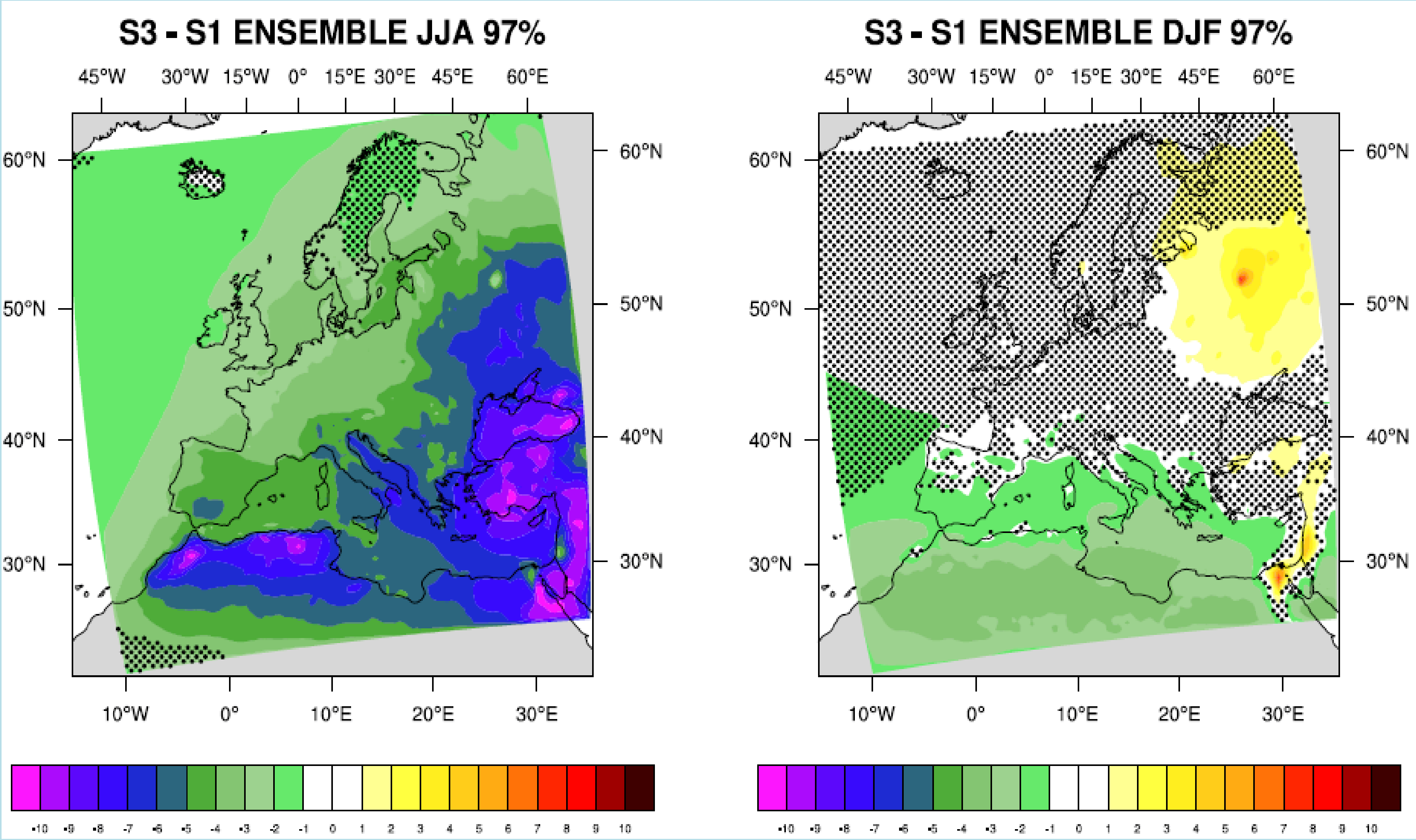
Source: Watson et al. 2016, Atm. Env. 142, 271-285

Changes in emissions under CLE and MFR scenarios



Source: Watson et al. 2016, Atm. Env. 142, 271-285

Changes in surface ozone due to emission changes only



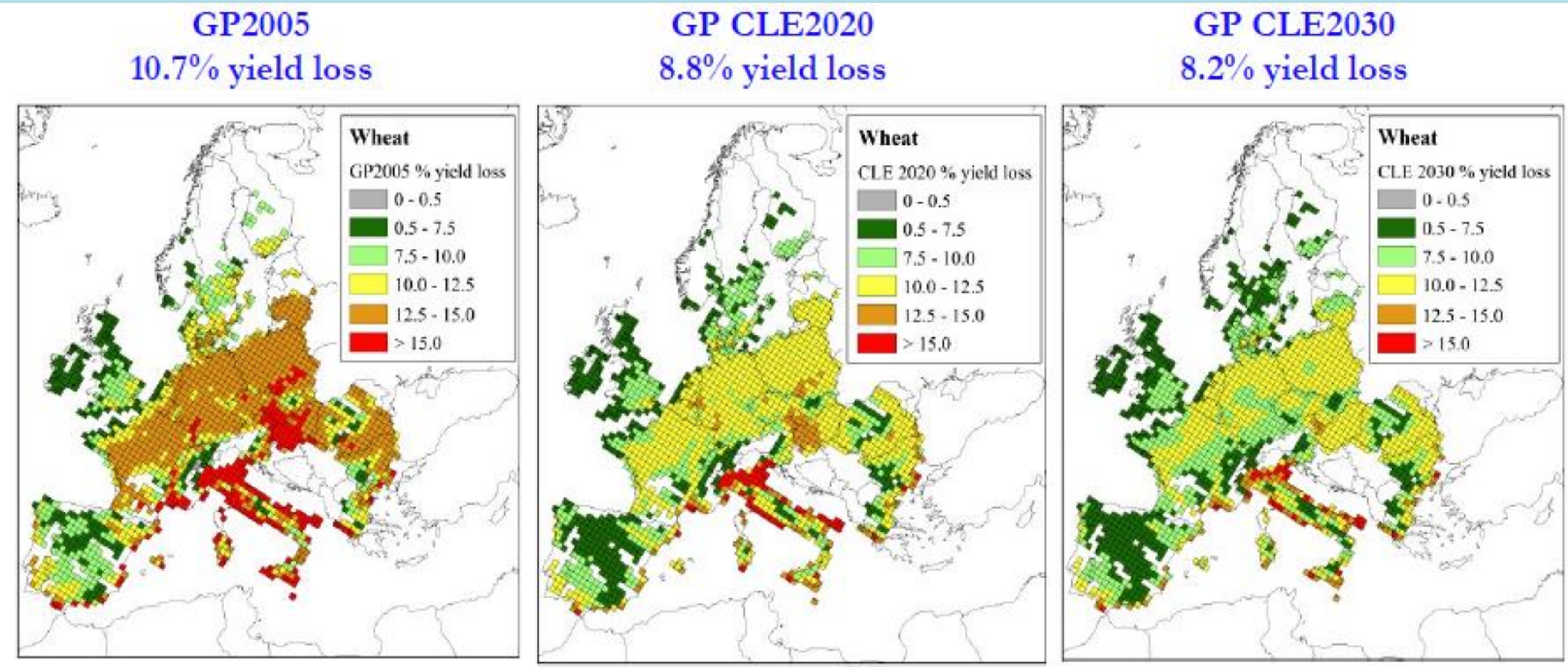
Source: Watson et al. 2016, Atm. Env. 142, 271-285

Lurking uncertainties

- Changes in temperature
- Changes in atmospheric humidity and SWC
- Anthropogenic GHGs emissions (N_2O and CH_4)
- Anthropogenic high-ox NOx emissions
- Natural soil & vegetation emissions
- Hemispheric transport patterns
- Feedback (-) by increased water vapour
- Feedback (+) by increased stratosphere-troposphere exchange

Ozone exposure and risk: projections

Predicted wheat yield reduction in Europe



Source: WGE 2016, Trends in ecosystem response to ozone

Global ozone exposure by 2030 under the B1 scenario

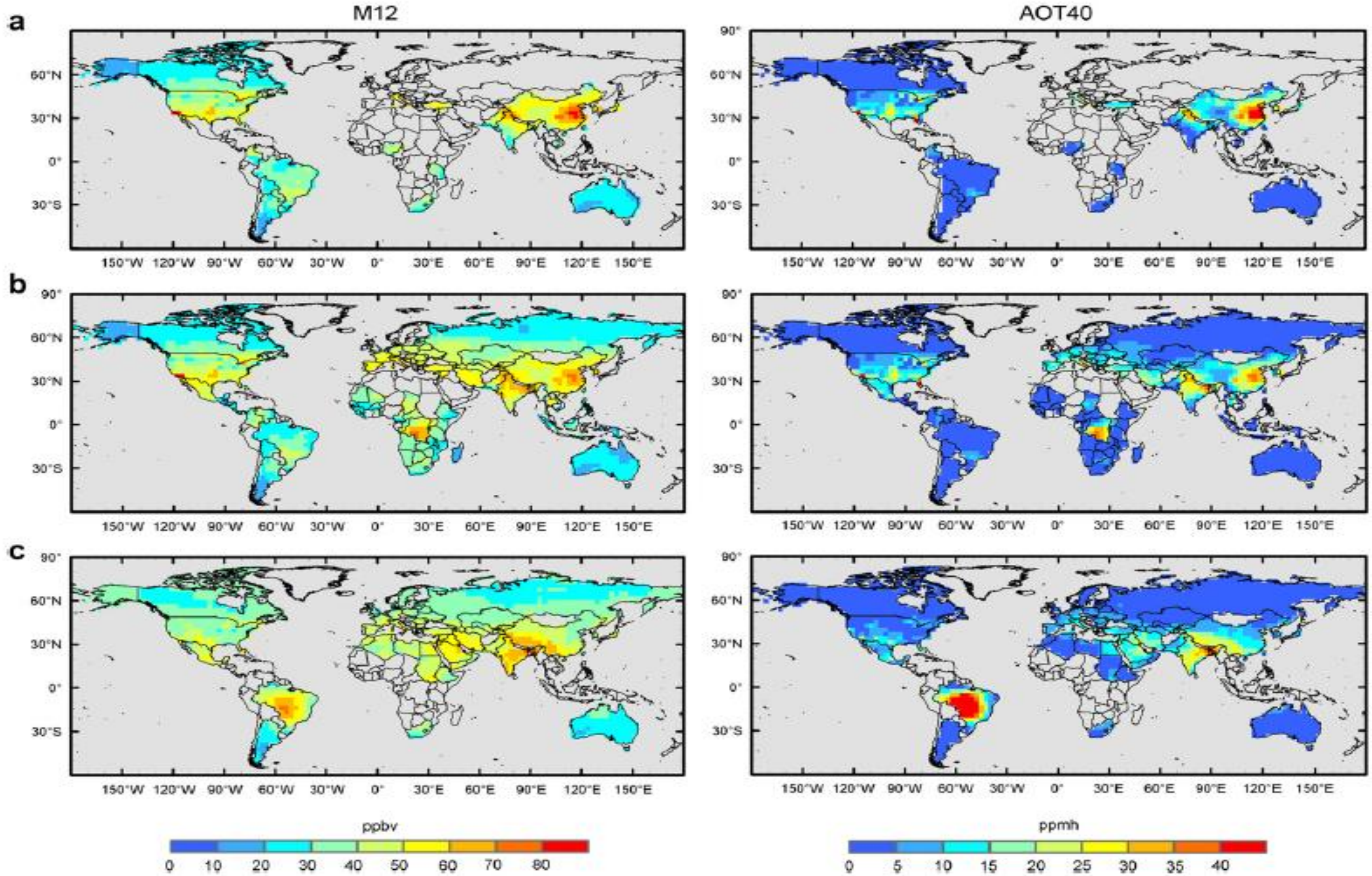


Fig. 2. Global distribution of O_3 exposure according to the M12 (left panels) and AOT40 (right panels) metrics under the 2030 B1 scenario during the respective growing seasons in each country (where crop calendar data are available) of (a) soybean, (b) maize, and (c) wheat. Minor producing nations not included in this analysis (where growing season data were unavailable) together account for <5% of global production of each crop. Values in the U.S. have been corrected using observation data as described in Section 2.1.

Source: Avnery et. al.,2011, Atm. Env. 45, 2297-2309

Yield loss (soybean, maize, wheat) under the 2030 B1 scenario

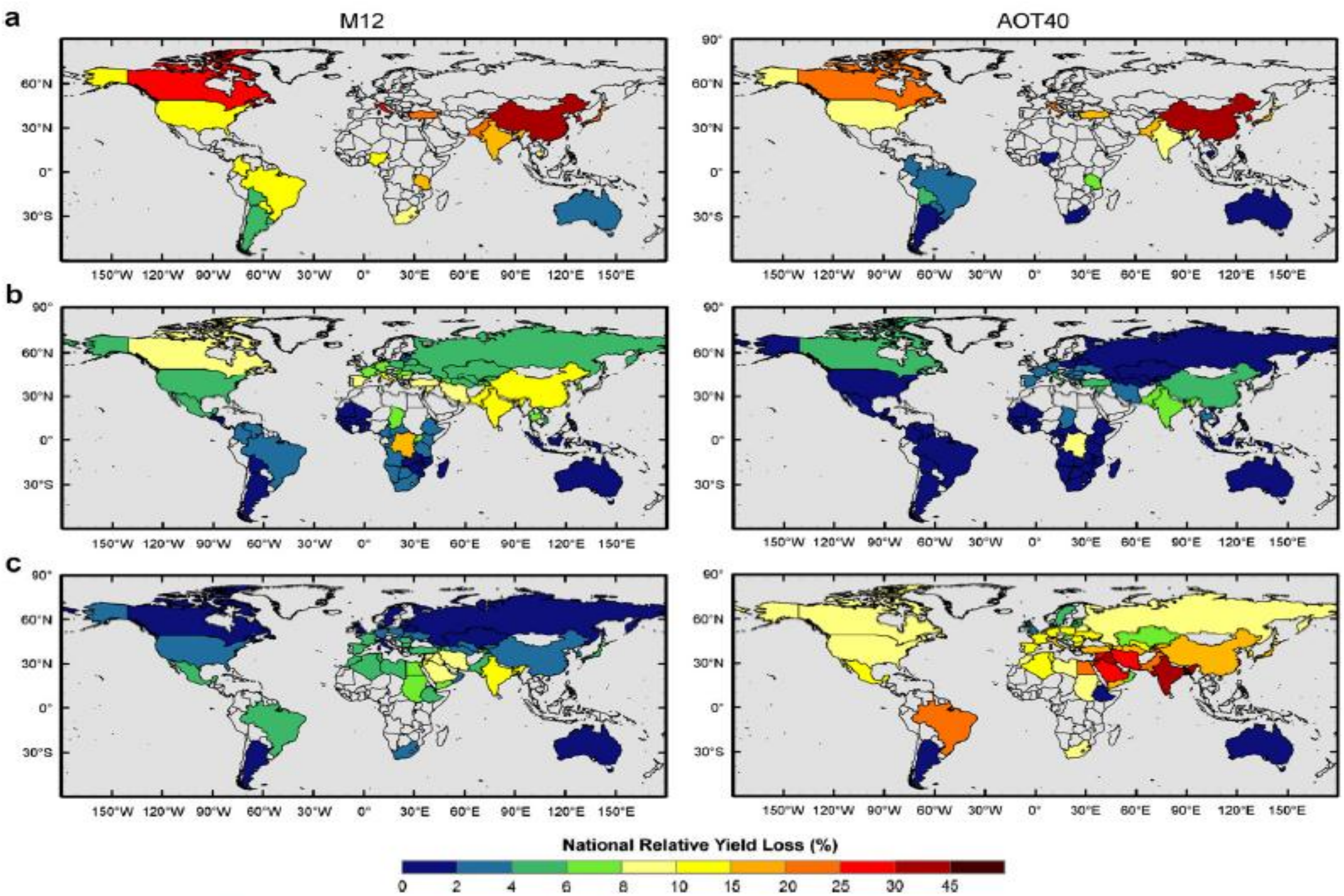
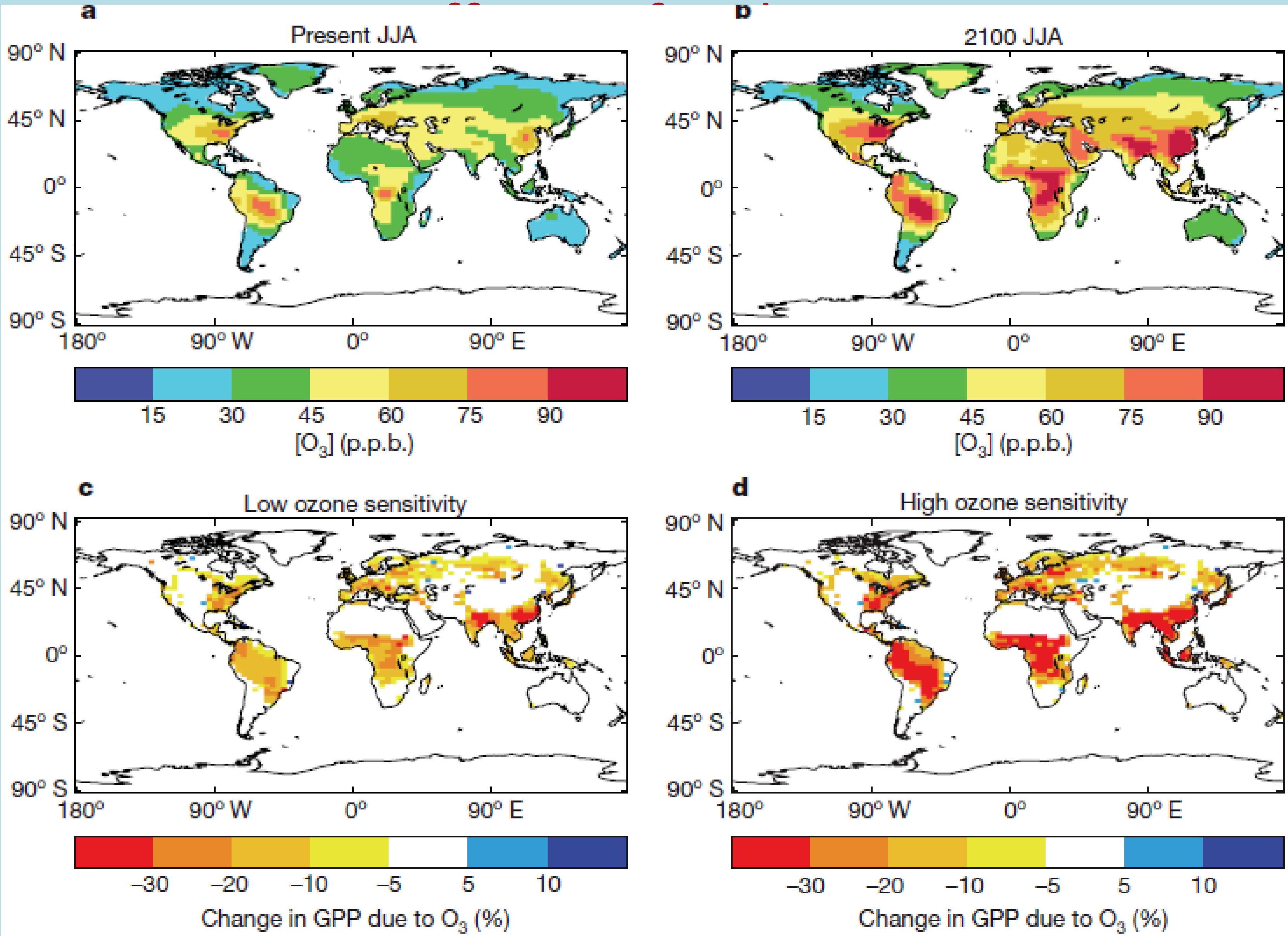


Fig. 4. National relative yield loss under the 2030 B1 scenario according to the M12 (left panels) and AOT40 (right panels) metrics for (a) soybean, (b) maize, and (c) wheat.

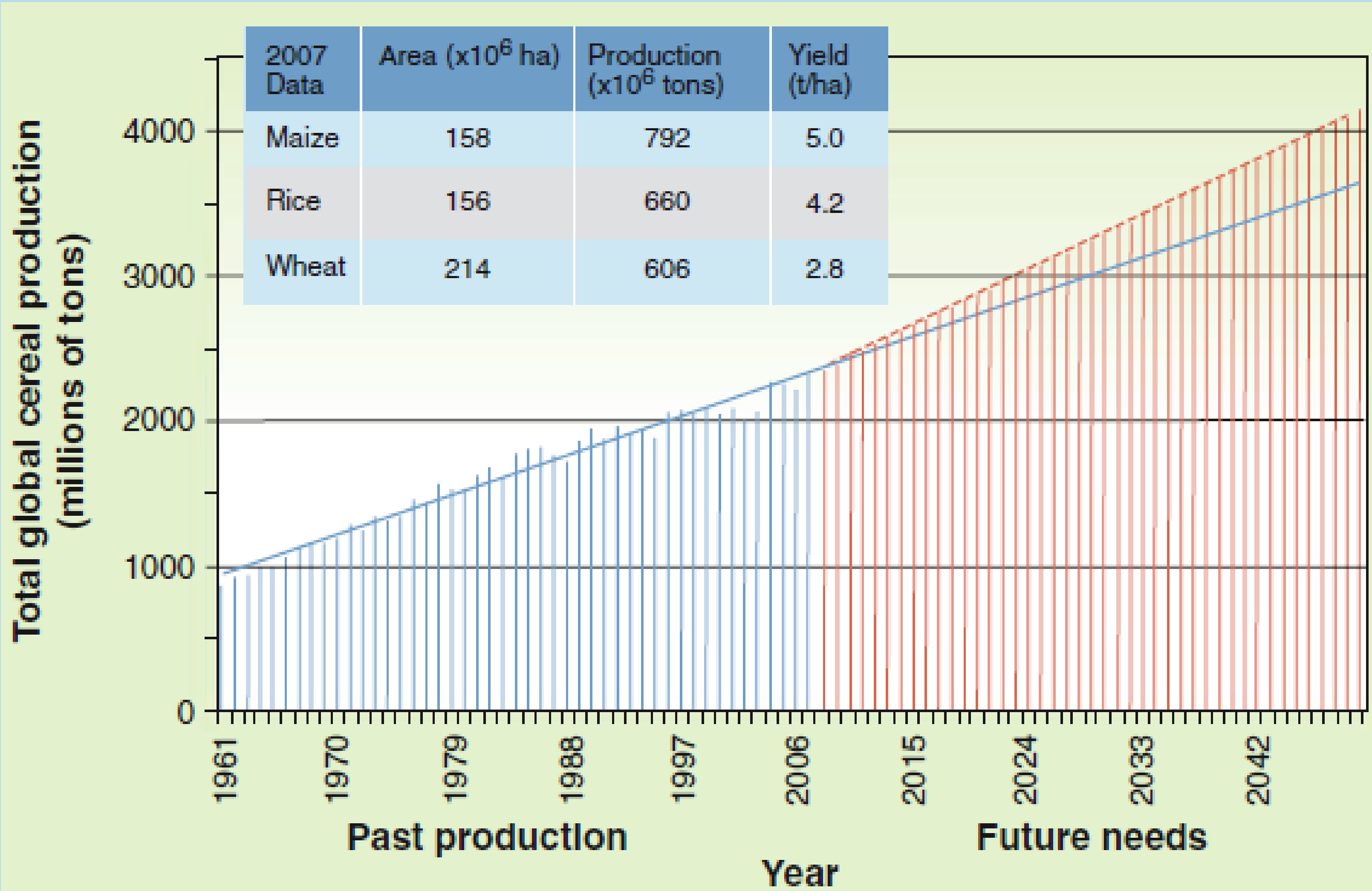
Source: Avnery et. al.,2011, Atm. Env. 45, 2297-2309

Present and predicted (2100) GPP due to ozone



Source: Sitch et al. 2007, Nature 448, 791-795

Critical yield losses:
world cereal demand by 2050



2007 Data	Area ($x10^6$ ha)	Production ($x10^6$ tons)	Yield (t/ha)
Maize	158	792	5.0
Rice	156	660	4.2
Wheat	214	606	2.8

Source: Tester and Langridge 2010, Science 327, 818-822

International policy

Il protocollo di Gothenburg (1999, rev 2012): obiettivi

Article 2: OBJECTIVE

1. The objective of the present Protocol is to control and reduce emissions of sulphur, nitrogen oxides, ammonia, volatile organic compounds and particulate matter that are caused by anthropogenic activities and are likely to cause adverse effects on human health and the environment, natural ecosystems, materials, crops and the climate in the short and long term, due to acidification, eutrophication , particulate matter or ground-level ozone as a result of long-range transboundary atmospheric transport, and to ensure, as far as possible, that in the long term and in a stepwise approach, taking into account advances in scientific knowledge, atmospheric depositions or concentrations do not exceed:

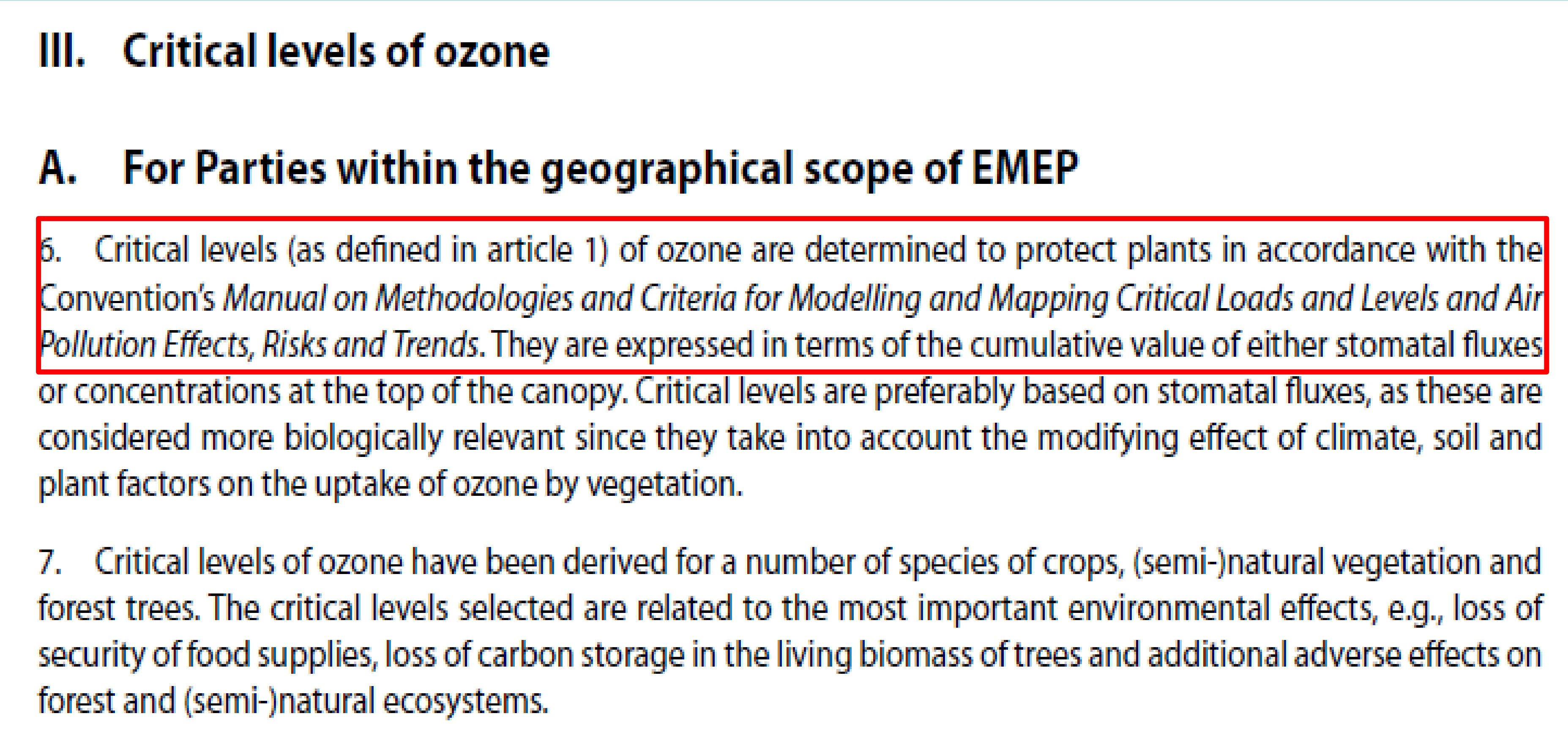
(a) For Parties within the geographical scope of EMEP and Canada, the critical loads of acidity, as described in annex I, that allow ecosystem recovery;

(b) For Parties within the geographical scope of EMEP, the critical loads of nutrient nitrogen, as described in annex I, that allow ecosystem recovery;

(c) For ozone:

(i) For Parties within the geographical scope of EMEP, the critical levels of ozone, as given in annex I;

Il protocollo di Gothenburg: Annex I, part III



III. Critical levels of ozone

A. For Parties within the geographical scope of EMEP

6. Critical levels (as defined in article 1) of ozone are determined to protect plants in accordance with the Convention's *Manual on Methodologies and Criteria for Modelling and Mapping Critical Loads and Levels and Air Pollution Effects, Risks and Trends*. They are expressed in terms of the cumulative value of either stomatal fluxes or concentrations at the top of the canopy. Critical levels are preferably based on stomatal fluxes, as these are considered more biologically relevant since they take into account the modifying effect of climate, soil and plant factors on the uptake of ozone by vegetation.

7. Critical levels of ozone have been derived for a number of species of crops, (semi-)natural vegetation and forest trees. The critical levels selected are related to the most important environmental effects, e.g., loss of security of food supplies, loss of carbon storage in the living biomass of trees and additional adverse effects on forest and (semi-)natural ecosystems.

Il protocollo di Gothenburg: determinazione dei livelli critici

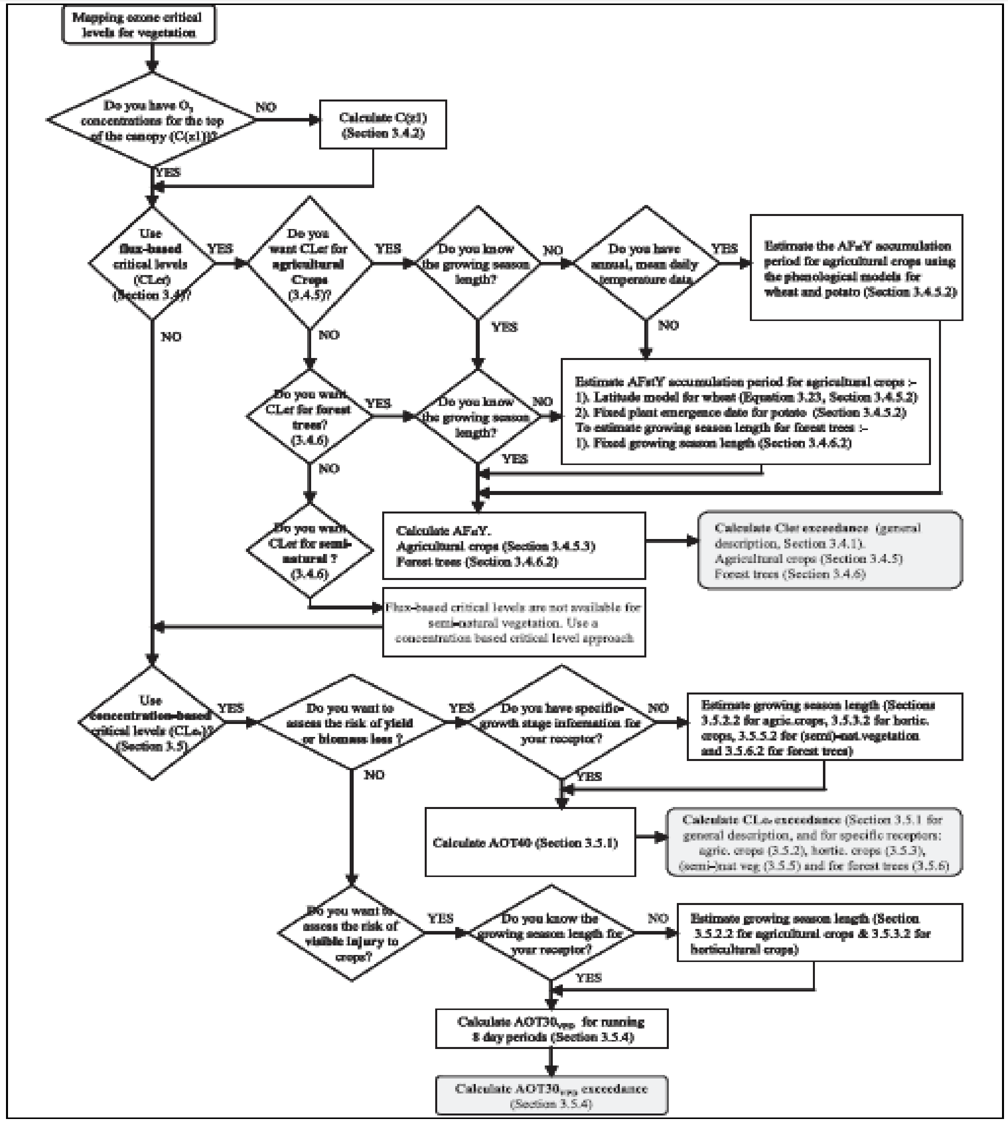


Figure 3.1: A schematic diagram illustrating the steps involved in calculating exceedance of the flux-based and concentration-based critical levels of ozone for agricultural and horticultural crops, (semi-) natural vegetation and forest trees.

Il protocollo di Gothenburg: livelli critici per l'ozono

Table 3.5: Critical levels for ozone. The methods for calculating each critical level are described in Section 3.4 and 3.5.

Approach		Crops	(Semi-) natural vegetation	Forest trees
Stomatal flux-based critical level	CLe_f	*Wheat*: An $AF_{st}6$ of 1 mmol m^{-2} PLA *Potato*: An $AF_{st}6$ of 5 mmol m^{-2} PLA	Not available	*Birch and beech*: Provisionally $AF_{st}1.6$ of 4 mmol m^{-2} PLA
	Time period	*Wheat*: Either 970°C days, starting 270°C days before mid-anthesis (flowering) or 55 days starting 15 days before mid-anthesis *Potato*: Either 1130°C days starting at plant emergence or 70 days starting at plant emergence		One growing season
	Effect	Yield reduction		Growth reduction
Concentration-based critical level	CLe_c	*Agricultural crops*: An AOT40 of 3 ppm h *Horticultural crops*: An AOT40 of 6 ppm h	An AOT40 of 3 ppm h	An AOT40 of 5 ppm h
	Time period	*Agricultural crops*: 3 months *Horticultural crops*: 3.5 months	3 months (or growing season, if shorter)	Growing season
	Effect	Yield reduction for both agricultural and horticultural crops	Growth reduction in perennial species and growth reduction and/or seed production in annual species	Growth reduction
VPD-modified concentration-based critical level	CLe_c	An $AOT30_{VPD}$ of 0.16 ppm h	Not available	Not available
	Time period	Preceding 8 days		
	Effect	Visible injury to leaves		

Il protocollo di Gothenburg: ruolo della ricerca scientifica

Article 8: ***RESEARCH, DEVELOPMENT AND MONITORING***

1. The Parties shall encourage research, development, monitoring and cooperation related to:

(a) The international harmonization of methods for the calculation and assessment of the adverse effects associated with the substances addressed by the present Protocol for use in establishing critical loads and critical levels and, as appropriate, the elaboration of procedures for such harmonization;

(b) The improvement of emission databases, in particular those on particulate matter, including black carbon, ammonia and volatile organic compounds;

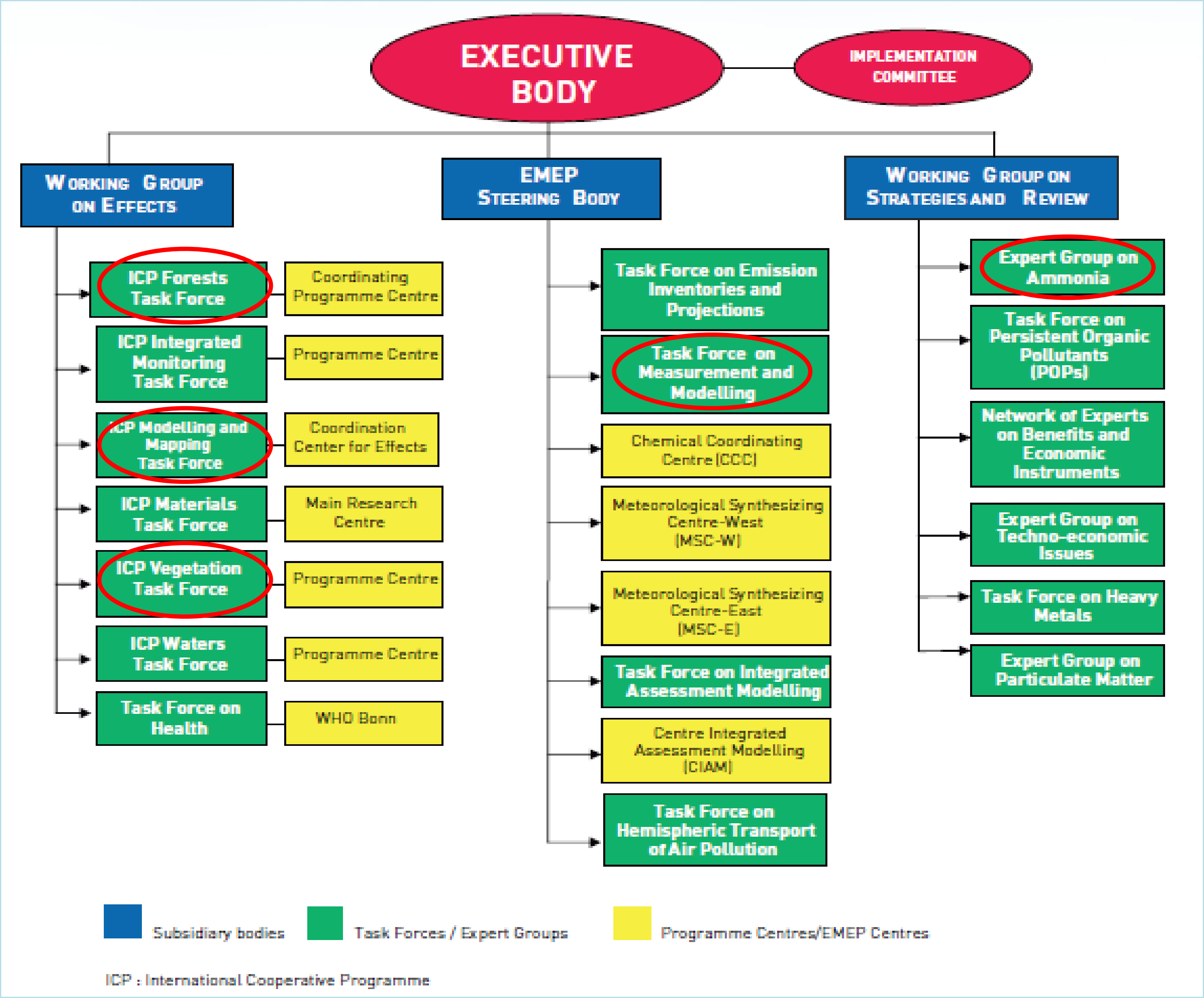
(c) The improvement of monitoring techniques and systems and of the modelling of transport, concentrations and depositions of sulphur, nitrogen compounds, volatile organic compounds and particulate matter, including black carbon, as well as of the formation of ozone and secondary particulate matter;

(d) The improvement of the scientific understanding of the long-term fate of emissions and their impact on the hemispheric background concentrations of sulphur, nitrogen, volatile organic compounds, ozone and particulate matter, focusing, in particular, on the chemistry of the free troposphere and the potential for intercontinental flow of pollutants;

(d bis) The improvement of the scientific understanding of the potential co-benefits for climate change mitigation associated with potential reduction scenarios for air pollutants (such as methane, carbon monoxide and black carbon) which have near-term radiative forcing and other climate effects;

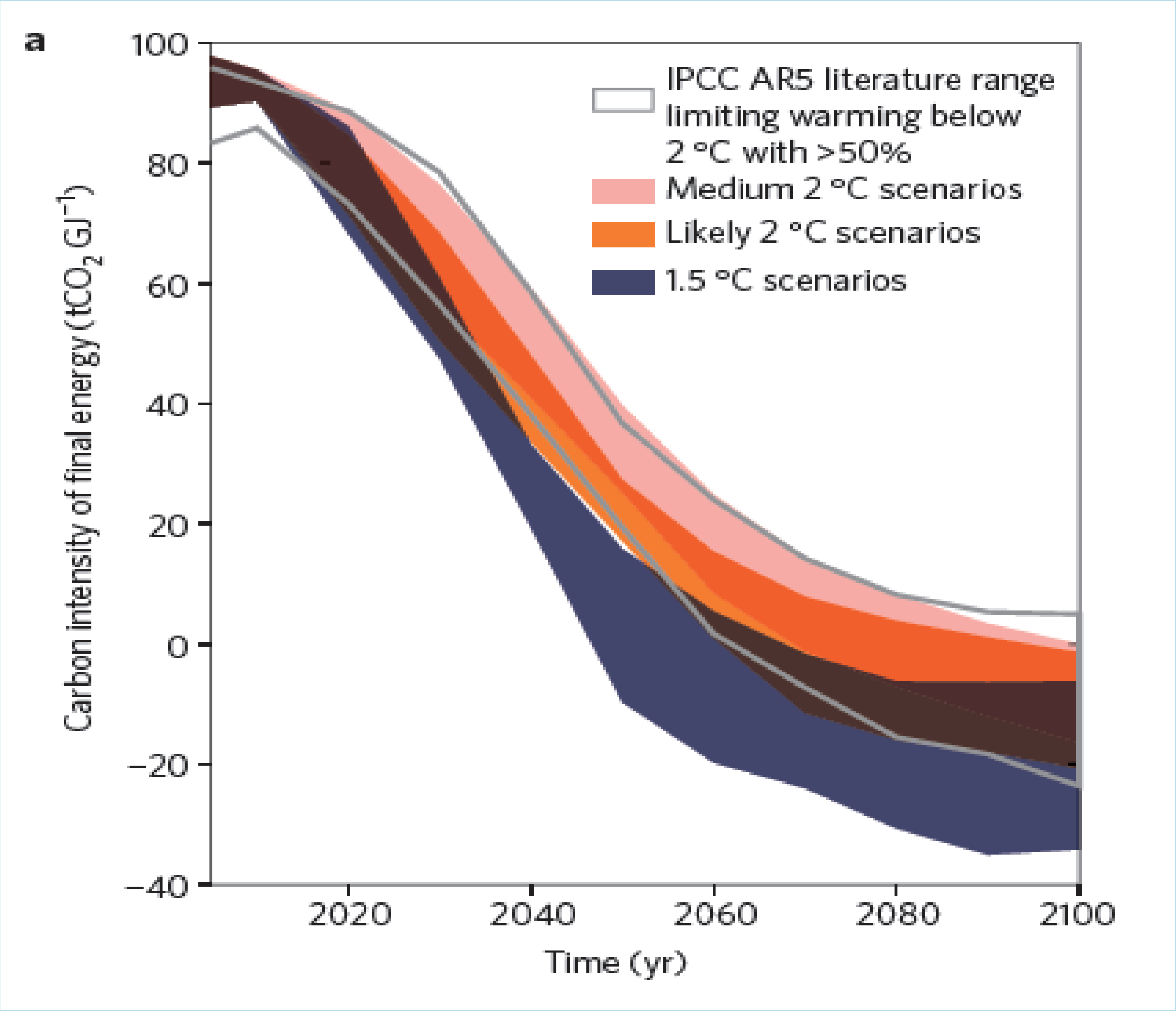
(e) The further elaboration of an overall strategy to reduce the adverse effects of acidification, eutrophication, photochemical pollution and particulate matter, including synergisms and combined effects;

The UN-ECE Convention on Long-Range Transboundary Air Pollution



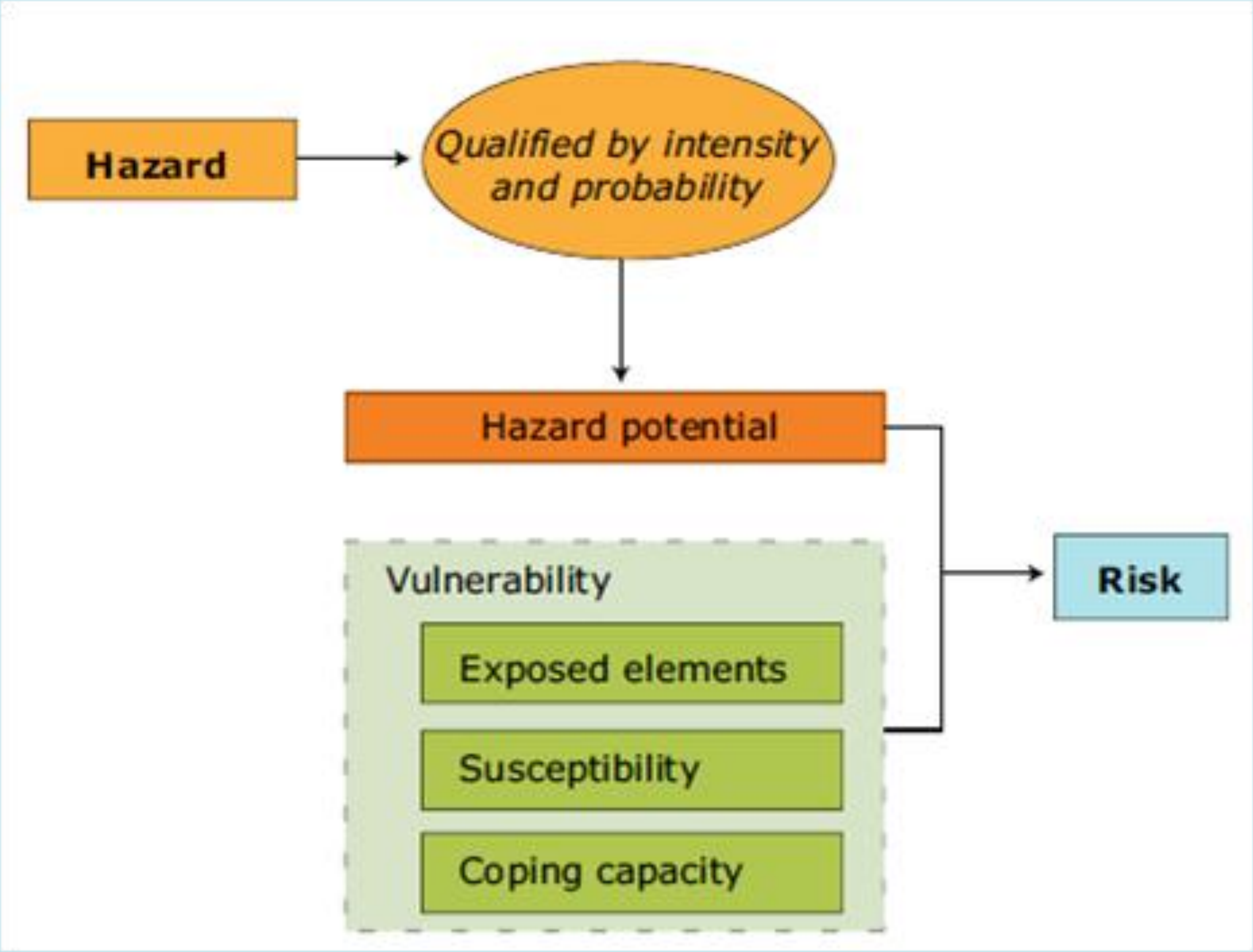
Climate change adaptation strategies

Requested emission reduction under RCP ≤ 4.5 scenarios



Source: Rogelj et a. 2015, Nature Climate Change, 5, 519-528

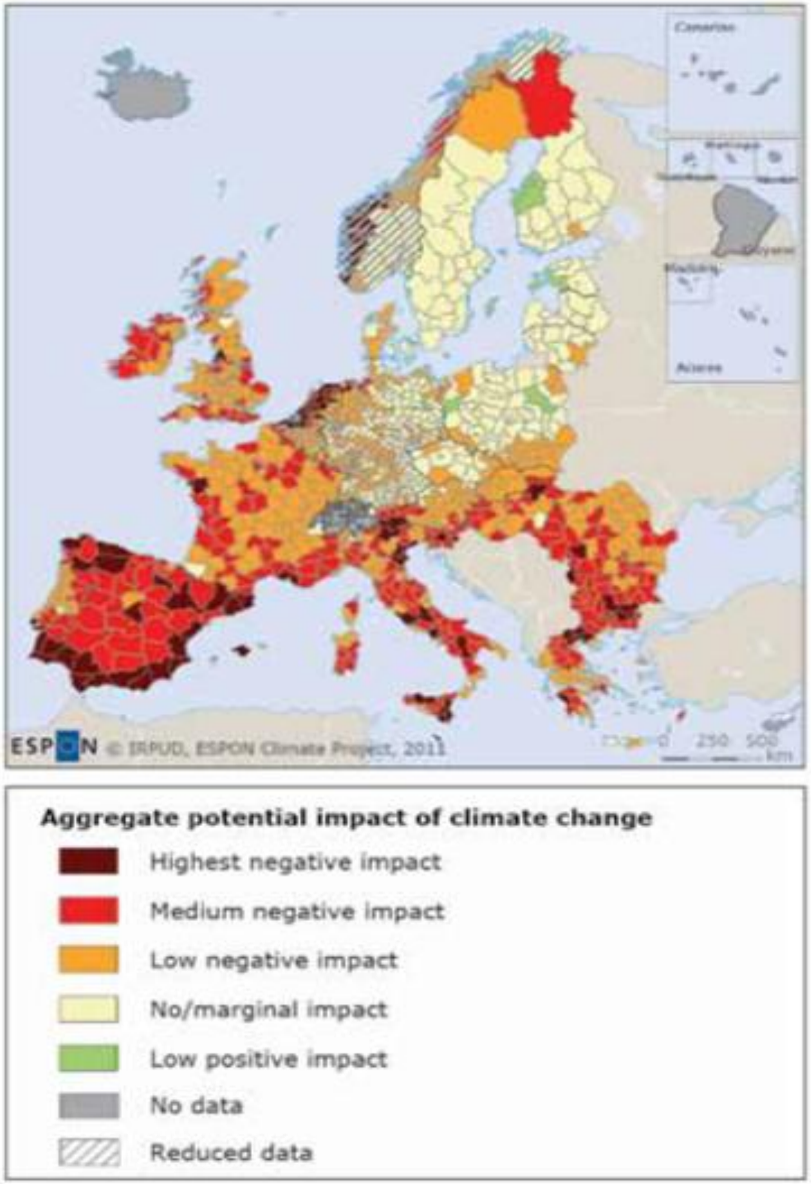
Adaptation is based on risk assessment

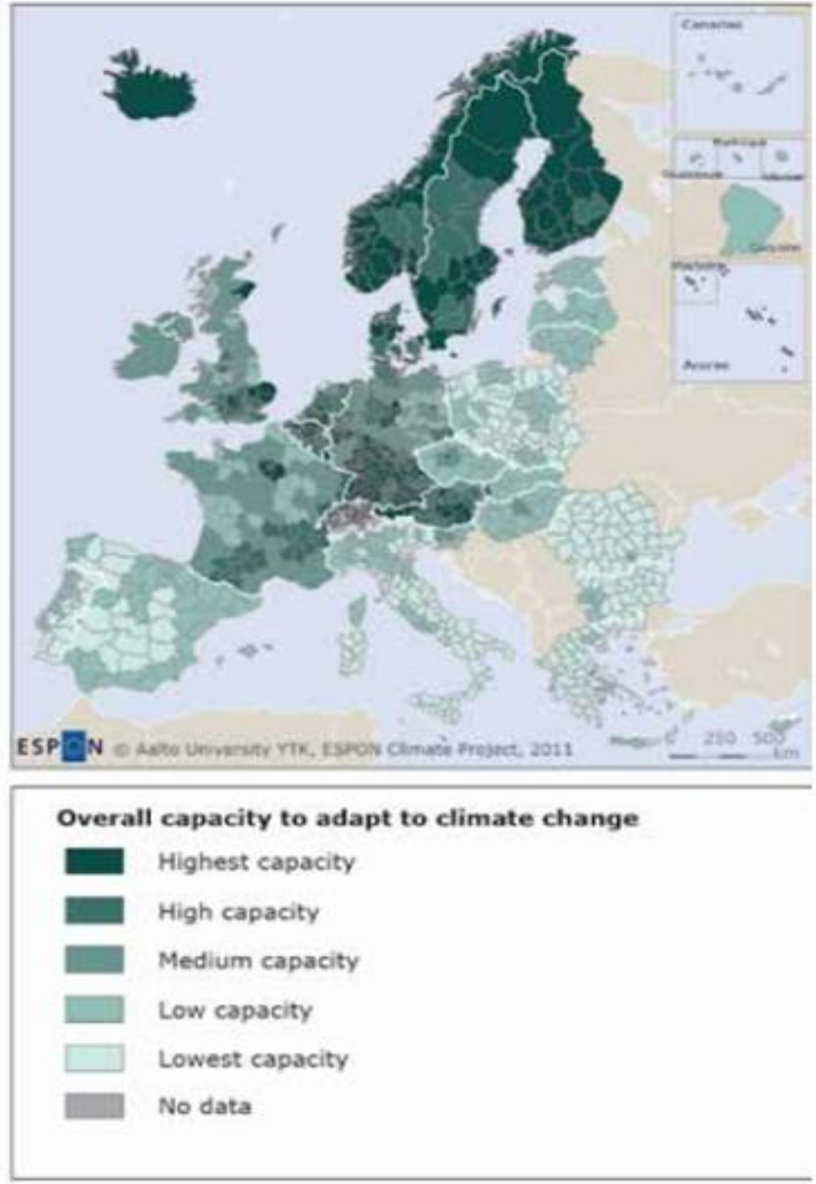


Local climatic pressure

Source: Espon 2013, Climate Project

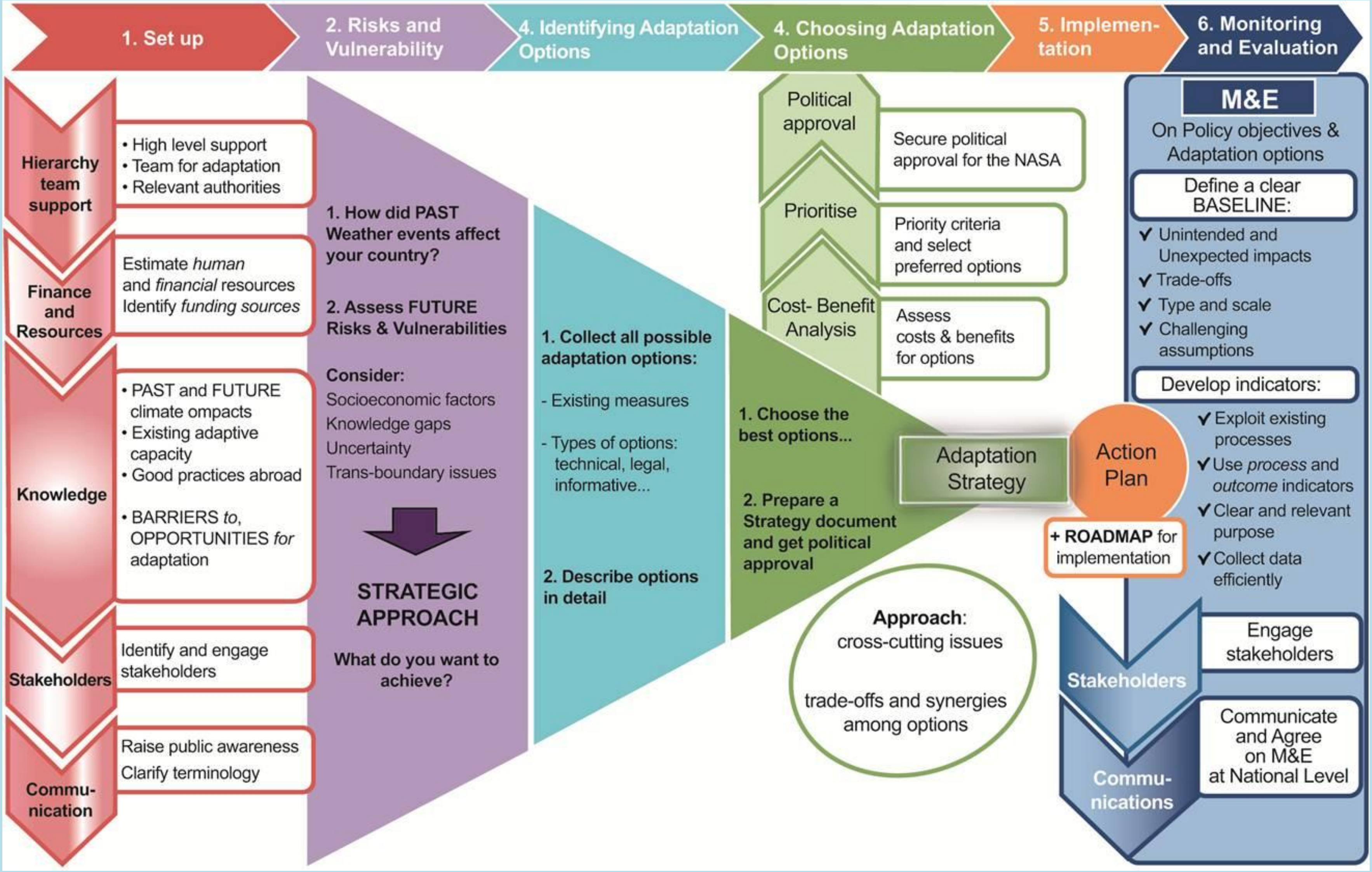
Impacts, vulnerability and resilience factors





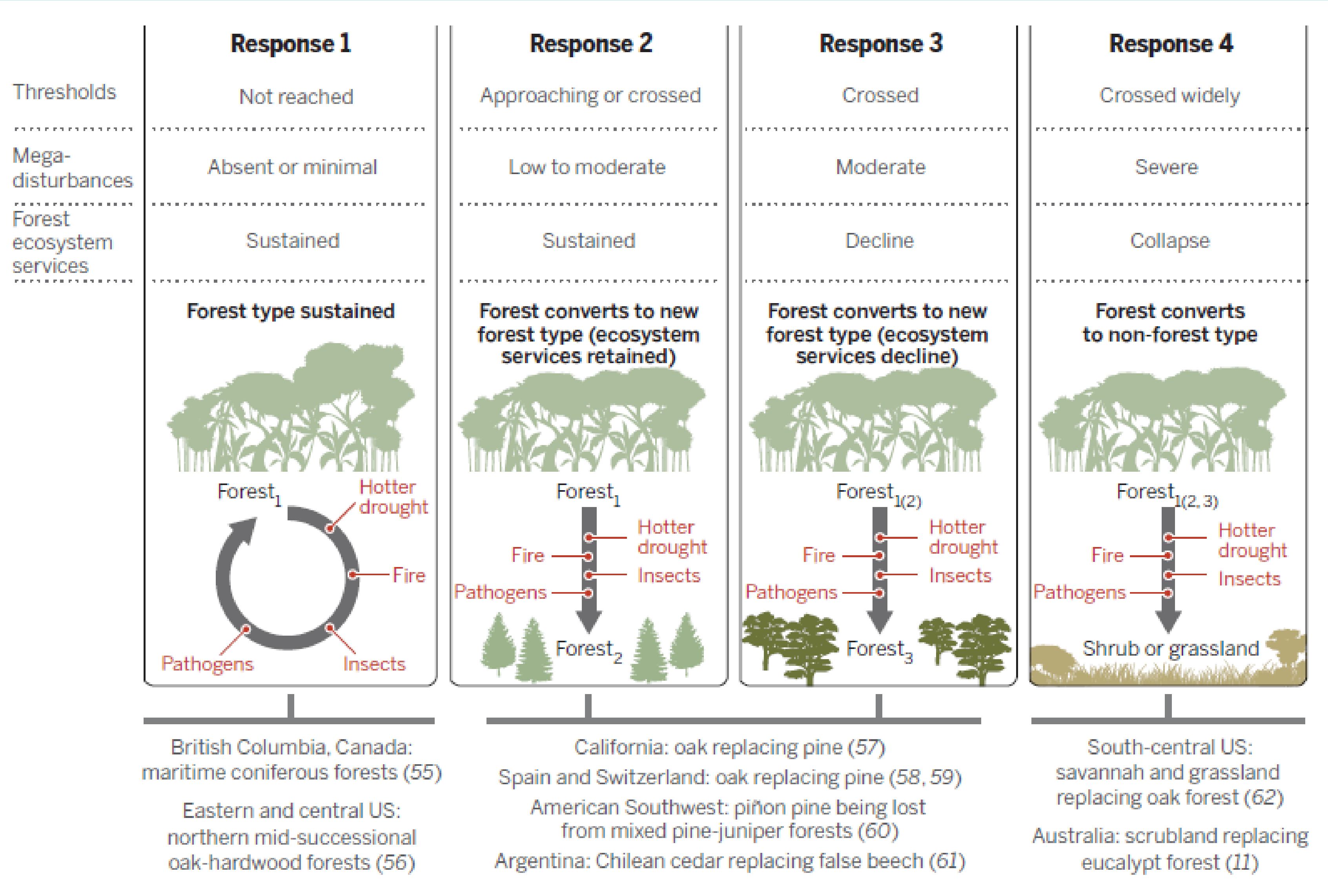
Source: Espon 2013, Climate Project

The adaptation process



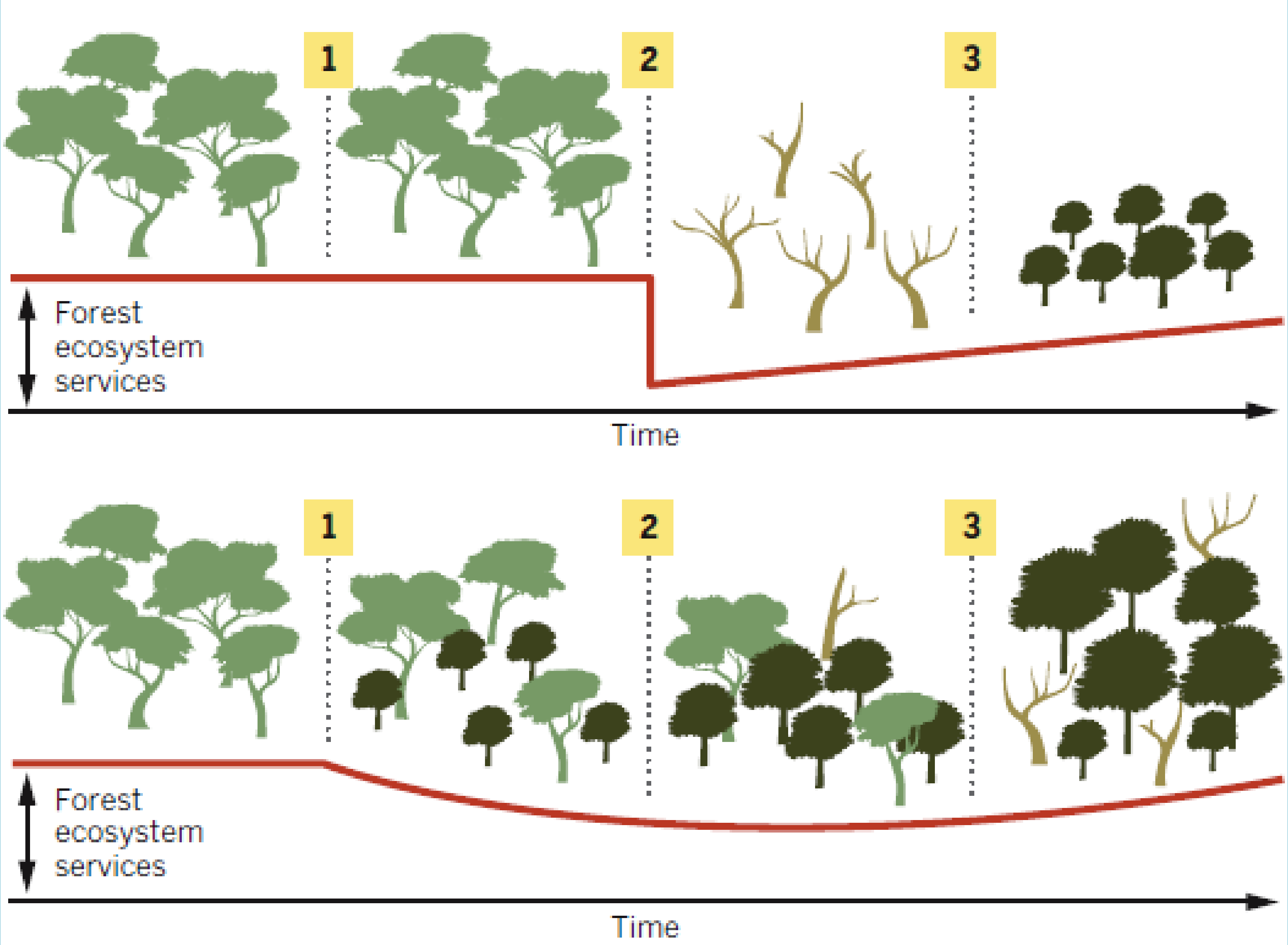
Two examples of sectoral adaptation at global level

Adaptation and forests



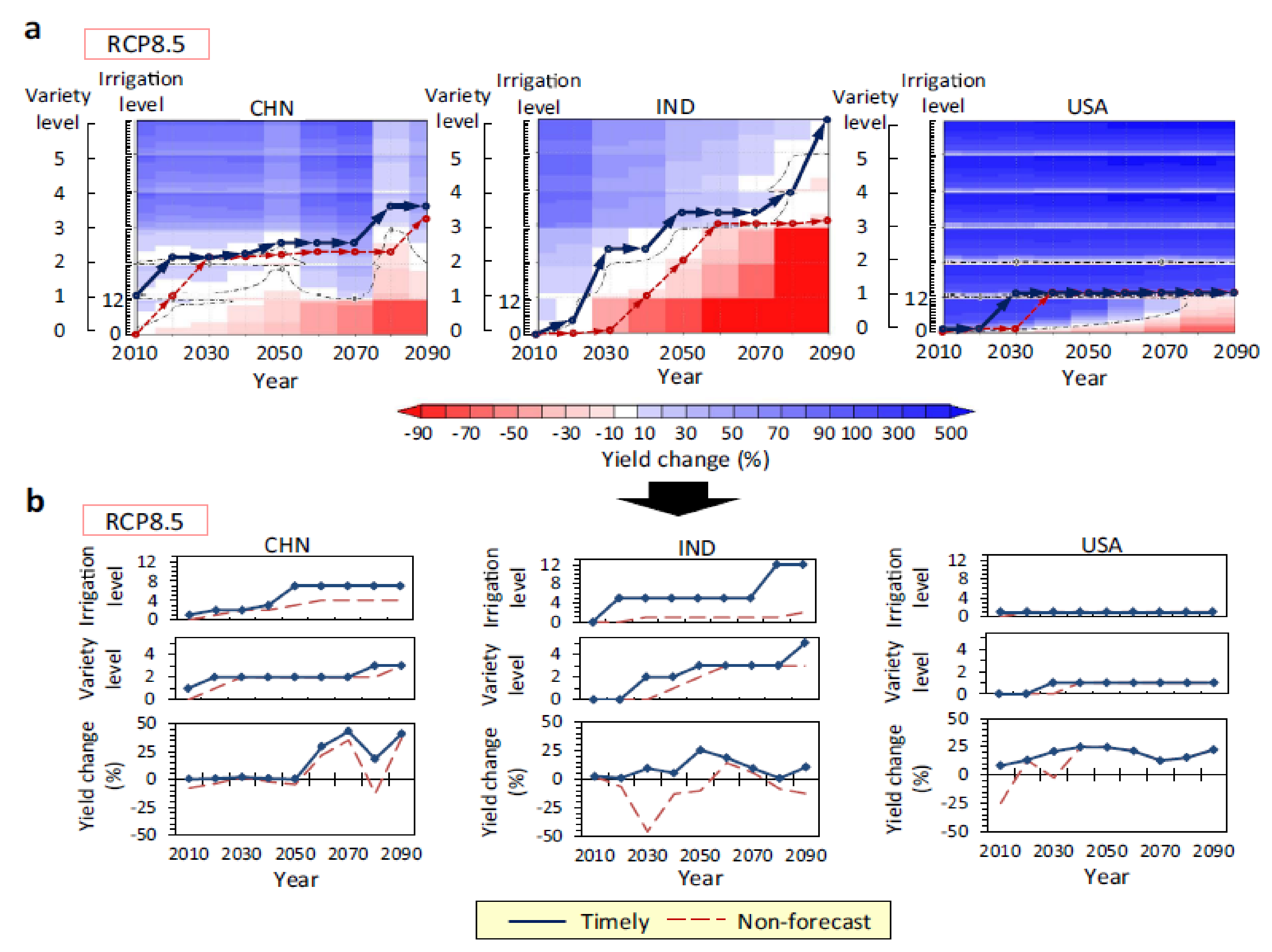
Source: Millar and Stephenson 2015, Science 349, 823-826

Adaptation and forest management



Source: Millar and Stephenson 2015, Science 349, 823-826

Adaptation practices in agriculture



Source: Tanaka et al. 2015, Nature Scientific Report 5:14312

Two examples of adaptation strategies

- The UK National Adaptation Plan (UK-NAP)
- The Regional Adaptation Strategy of the Lombardy Region (RL-SRACC)

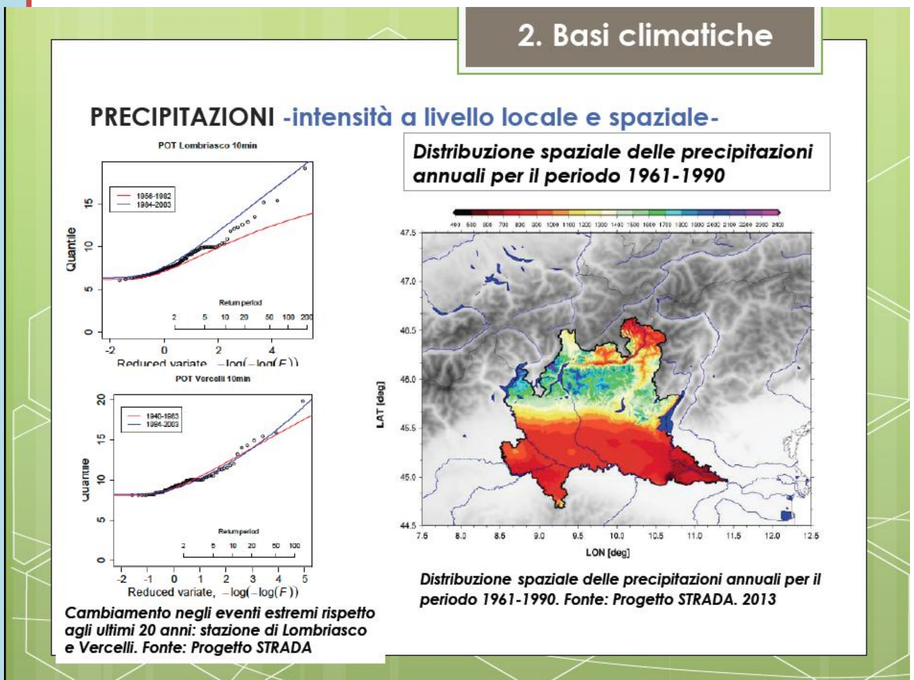
The UK National Adaptation Plan

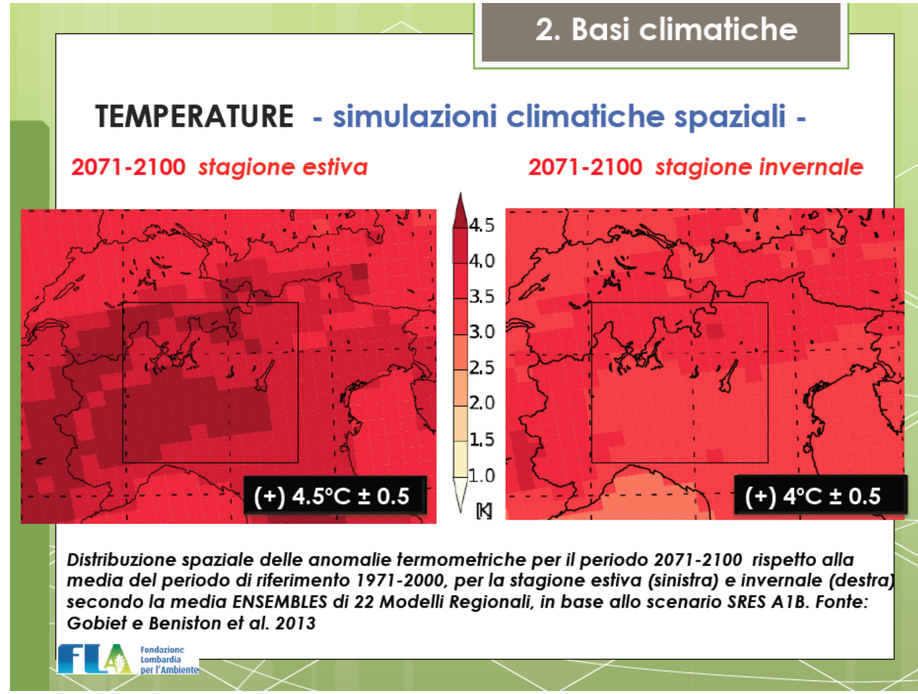
CCRA Risk	Description
FO1a	Forest extent affected by red band needle blight[54]
WA7	Insufficient summer river flows to meet environmental targets
FL4a/b	Agricultural land at risk of flooding/regular flooding
FO4a	Decline in potential yield of beech trees in England
AG5	Increases in water demand for irrigation of crops
FO1b	Forest extent affected by green spruce aphid
FO2	Loss of forest productivity due to drought

Objective 18: To embed climate change adaptation into agriculture, horticulture and forestry research programmes, in order to improve knowledge of likely climate impacts and contribute to the development and uptake of climate resilient crops, tree and livestock species as well as relevant technologies.

The Lombardy Region adaptation strategy

Climate change evidences and projections



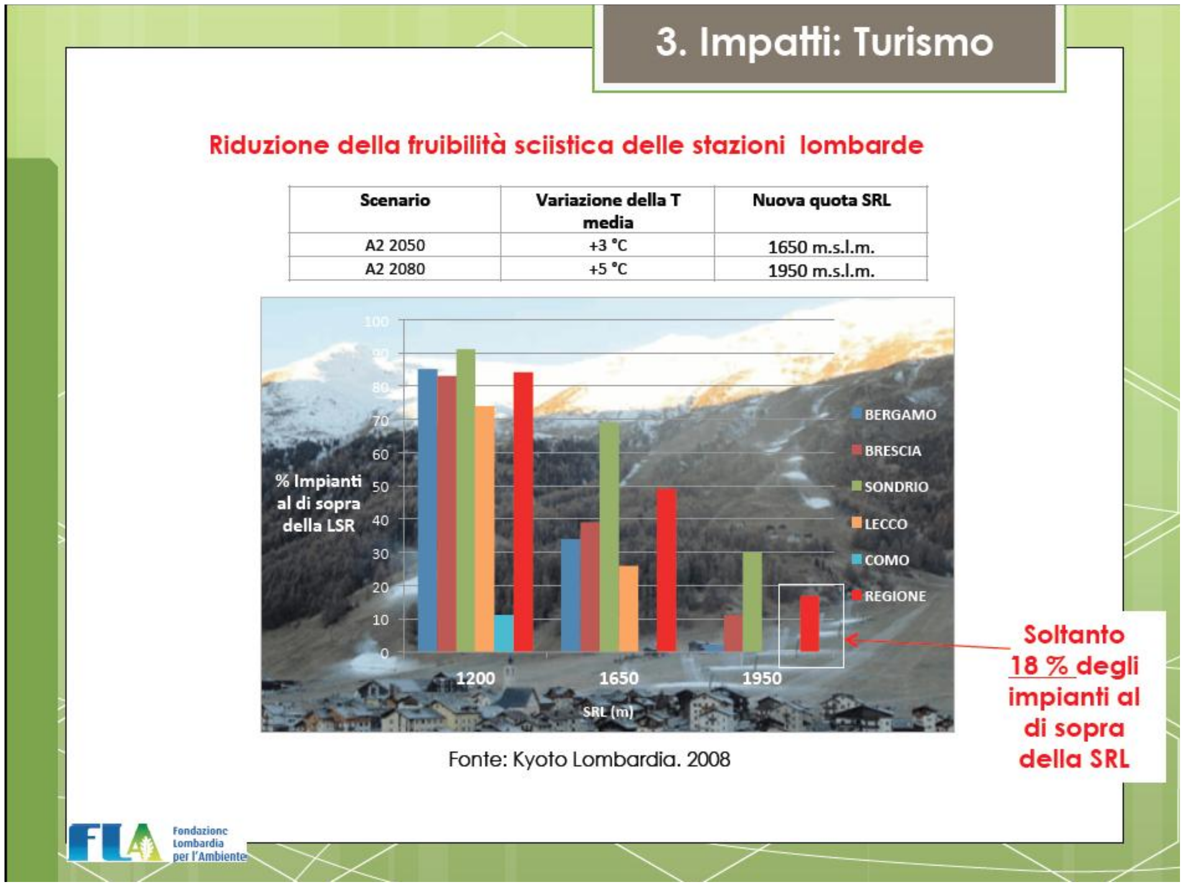


Example of climatic information presented during the workshops. Left: evolution of intense precipitation events during the period 1984-2003 compared with 1958-1982 in two weather stations of the Lombardy territory. Right: map of the rainfalls intensity in the Lombardy territory during the 1961-1990 time period. Source: with data from STRADA Project. 2013

Spatial distribution of the projected thermometric anomalies for the period 2071-2100 compared to mean temperature of the reference period 1971-2000. Source: with data from Gobiet et al. 2013

Fondazione Lombardia per l'Ambiente

climate change impacts and vulnerabilities



Projected impact of climate change on the winter tourism sector in Lombardy: projected percentage of skiing areas below the snow line (Snow Reliability Line) by provinces under two different future scenarios of global warming. Source: with data form Kyoto Lombardia Project. 2008

Adaptation objectives priority and specific adaptation options

Relevant impacts per sector

Adaptation objectives

Proposed adaptation measures

Nome/cognome:
Email:

Risorse idriche: Obiettivi settoriali per l'adattamento e proposta di misure di adattamento

Ciclo idrologico e qualità delle acque		*Obiettivi strategici per l'adattamento*		*Proposta di misure di adattamento*[1]
Impatti	***Importanza relativa dell'impatto***	***Obiettivi***	***Necessità d'intervento***	***Proposta***
	Importanza (1-5)		***Necessità (1-5)***	
1-Alterazione delle caratteristiche fisico-chimiche e biologiche delle acque superficiali e sotterranee (Qualità)		**1.1** Ampliare e rinforzare le reti di misurazione, monitoraggio e sorveglianza delle risorse idriche superficiali e sotterranee **1.2** Incrementare la resilienza dei corpi idrici alle implicazioni del mutame… assicurar… servizi e… forniti **1.3** Gara… stato ec… delle ris… regionali… consider… mutame… **1.4.** App… conosce… implicazi… cambiam… nella qua…		**Soft o non strutturali:** 1. Potenziare ed estendere gli attuali strumenti e reti di monitoraggio e il controllo della qualità delle risorse idriche lombarde (identificare i gap esistenti nell'attuale rete di monitoraggio costituita da 260 punti di prelievo e misura, relativi a 175 corpi idrici superficiali)(1.1; 2.1; 2.2; 3.3) 2. Intensificare il controllo dell'evoluzione del grado di diluizione degli inquinanti nelle acque sotterranee durante i periodi a maggiore rischio (es: periodi siccitosi prolungati) (1.1; 1.2; 1.3; 2.3; 3.1) 3. Rinforzare la prevenzione dei casi di penuria, fioriture algali e peggioramento eccessivo della qualità dei corpi idrici in considerazione all'incremento di eventi climatici estremi (es: intensificare il monitoraggio dell'influenza degli scarichi termici nelle acque superficiali) (1.1; 1.3) 4. Minimizzare i disturbi associati alla captazione e al rilascio di acque dalle centrali idroelettriche e termoelettriche (1.3; 2.1; 2.2; 2.3) 5. Ampliare la caratterizzazione dettagliata delle acque del territorio regionale e concretamente completare la … uo minore (1.1; 2.1; 2.2; 3.3; 4.4) … ma e dei feedback del suolo (1.1; 2.1; 2.3; 4.4) … ura nei sistema di monitoraggio attuali: Introdurre i … dice Sintetico di Invaso per i corsi d'acqua Montani … la portata e lo sfruttamento da parte dell'uomo (1.1; … … à delle acque rispetto alle attività antropiche in … matici connessi (es: misura 121 del Programma di … di coperture delle vasche di stoccaggio degli effluenti … ati) (1.3; 3.1) … o-fisiche delle acque superficiali e sotterranee (1.2, … … tegrità ecologica delle aree riparie e delle zone di … modulazione e regolazione dei processi e delle

1 I superindici localizzat… uali la misura in questione si prevede abbia delle **sinergie positive per il raggiungimento di tali obiettivi.**

<u>Weighting process (2 parameters)</u>

i. **Relevance of each impact from a sectoral point of view (1=very low importance; 5=very high importance)**

ii. **Need for actions to fulfill each adaptation objective (1=very low priority; 5=very high priority)**

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Objective and measures prioritarization

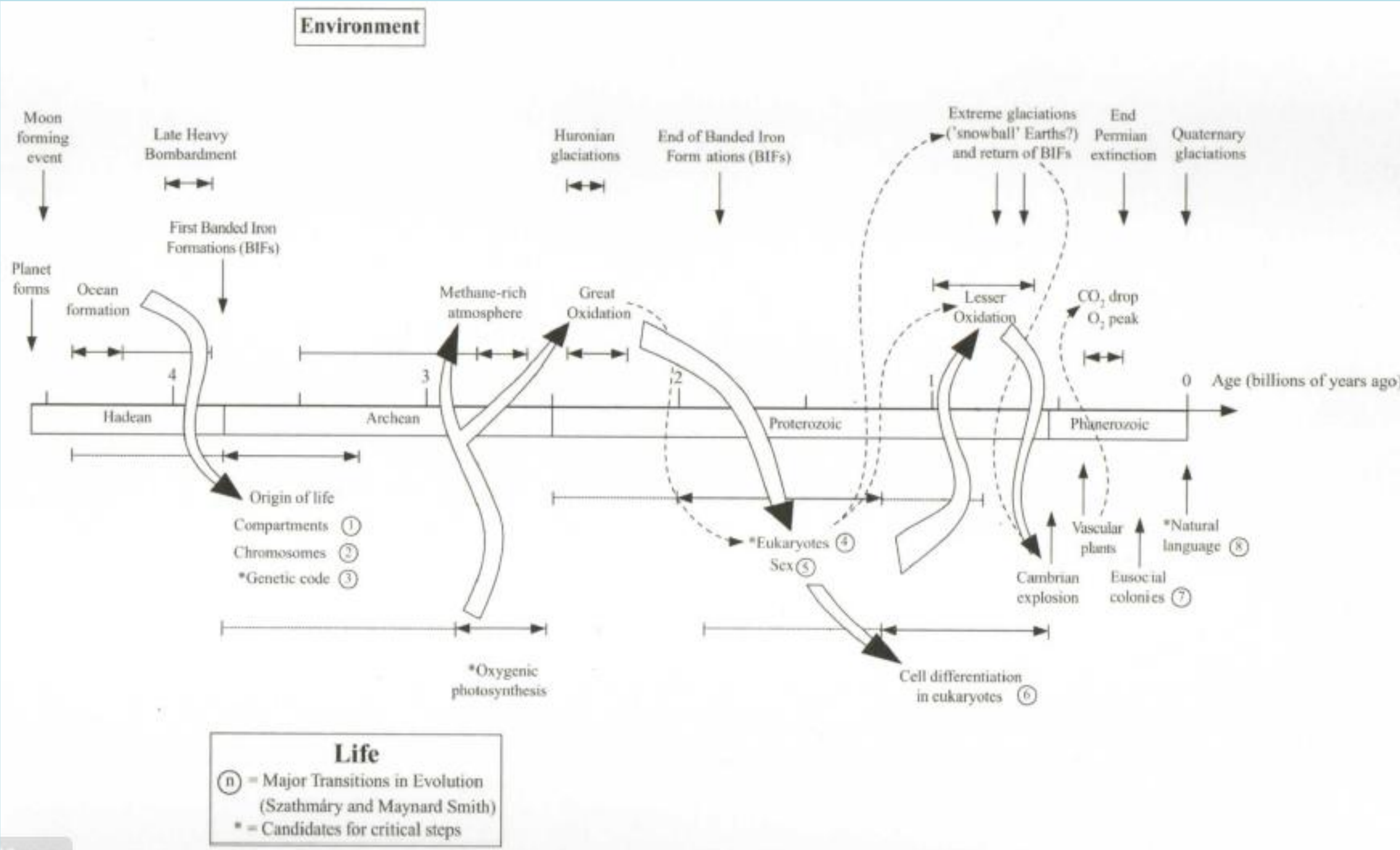
Simple additive weighting algorithm to determine objective priorities...

Relevance of each impact (from 1 to 5) + **Need of adaptation actions in each adaptation objective (from 1 to 5)** = **Priority of Adaptation objectives (from 1 to 5)**

$$(W_1+W_2+W_3+W_{n,,,})\ /n \quad + \quad (W_1+W_2+W_3+W_{n,,,})\ /n \ \ /\ 2 \quad = \quad P$$

Conclusion and wishes

The life on earth and its fight against the oxygen revolution(s)



Source: T. Lenton and A. Watson, 2013, Revolutions that made the Earth, Oxford

The United Nations’ Sustainable Development Goals (2016-2030)

The fight against ozone impacts for a sustainable development

Sustainable Development Goals (SDGs) and links to air pollution

In September 2015, countries adopted a set of goals to end poverty, protect the planet, and ensure prosperity for all as part of a new sustainable development agenda. Each goal has specific targets to be achieved over the next 15 years.

2 ZERO HUNGER

Abating nitrogen emissions and managing nitrogen more sustainably has direct impacts on soil quality.

3 GOOD HEALTH AND WELL-BEING

Reducing air pollution helps to mitigate the risk factors for non-communicable diseases such as respiratory and cardiovascular diseases, including cancers.

6 CLEAN WATER AND SANITATION

Water pollution is notably linked to depositions from air pollution. Consequently, one way of reducing water pollutants is to reduce air pollution.

7 AFFORDABLE AND CLEAN ENERGY

Given that a major source of air pollution is energy production, consumption and transport, increasing the share of renewable energies and improving energy efficiency under this SDG will serve to reduce air pollution. Investing in clean technologies in this sector, as called for under this SDG, will also achieve reductions in air pollution.

8 DECENT WORK AND ECONOMIC GROWTH

A focus of the green economy is to improve and increase jobs while focusing on cleaner sectors and technologies that are sustainable which includes sectors that have a reduced impact on air pollution such as renewable energies or improved transport, as promoted under this SDG.

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

Old industries and technologies are a major source of air pollution, and upgrading and retrofitting many facilities, as called for under this SDG, will serve to significantly reduce air pollution. Investment in research and innovation will also provide options for achieving improvements in industrial production while reducing waste and air pollution.

11 SUSTAINABLE CITIES AND COMMUNITIES

Under SDG 11, there is an explicit target linked to improving air quality: *"by 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality, municipal and other waste management"*. Reducing air pollution at the national level also helps to improve air quality at the city level.

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

Improvements in life cycle management of chemicals and all wastes will contribute to reducing air and water pollution. Improving companies' practices with a focus on complying with international and national norms will also serve to reduce emissions of air pollutants.

13 CLIMATE ACTION

As greenhouse gases and some key air pollution have the same sources, combating climate change will bring improvements to air quality. In turn, reducing air pollution will help in bringing about climate co-benefits.

14 LIFE BELOW WATER

Reducing air pollution, particularly nutrient (nitrogen) pollution will help reduce marine pollution from land-based activities.

15 LIFE ON LAND

Reducing air pollution helps mitigate effects on ecosystems and biodiversity.


Grazie per la vostra attenzione