Challenges for climate science after Paris

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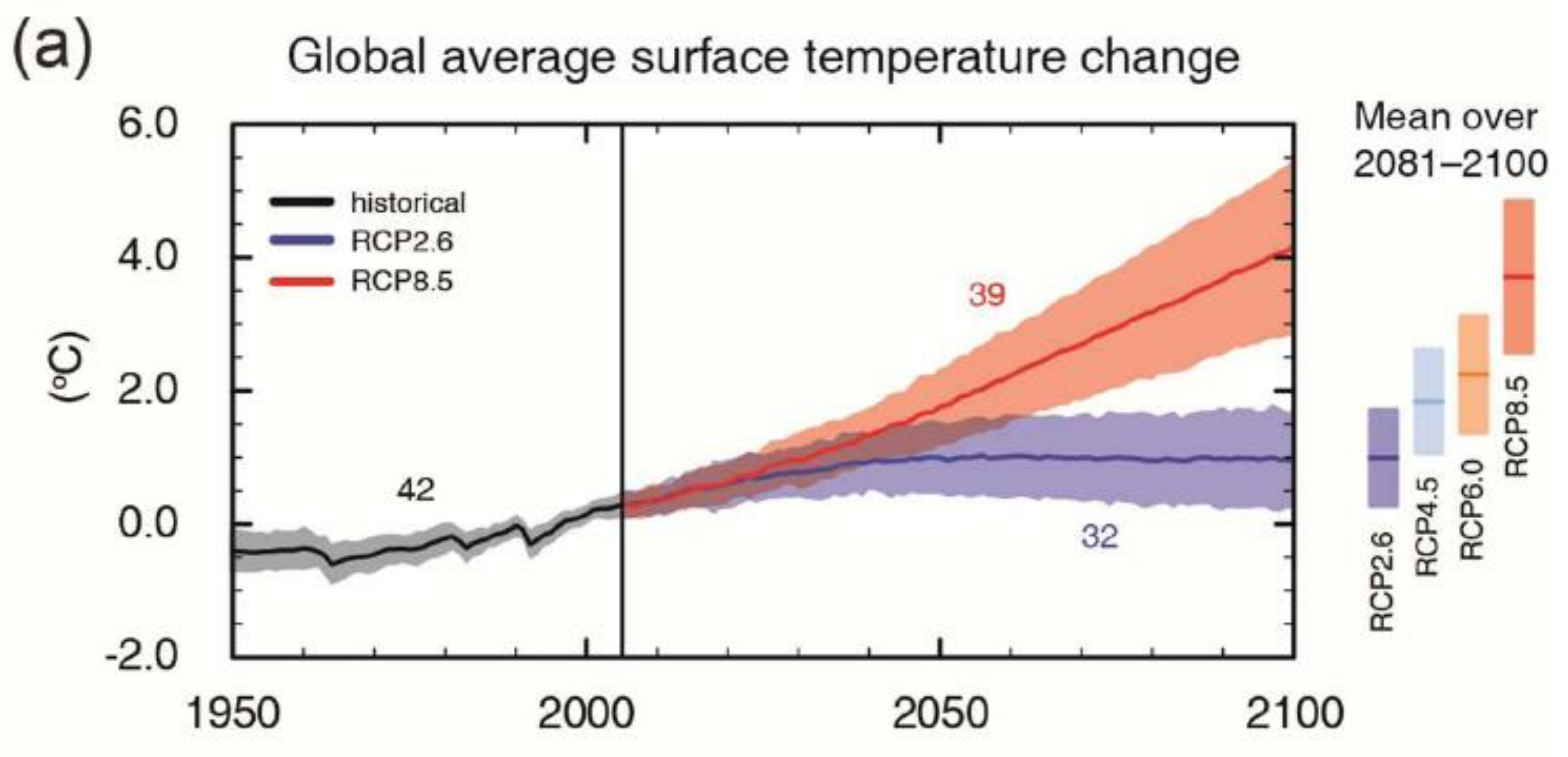
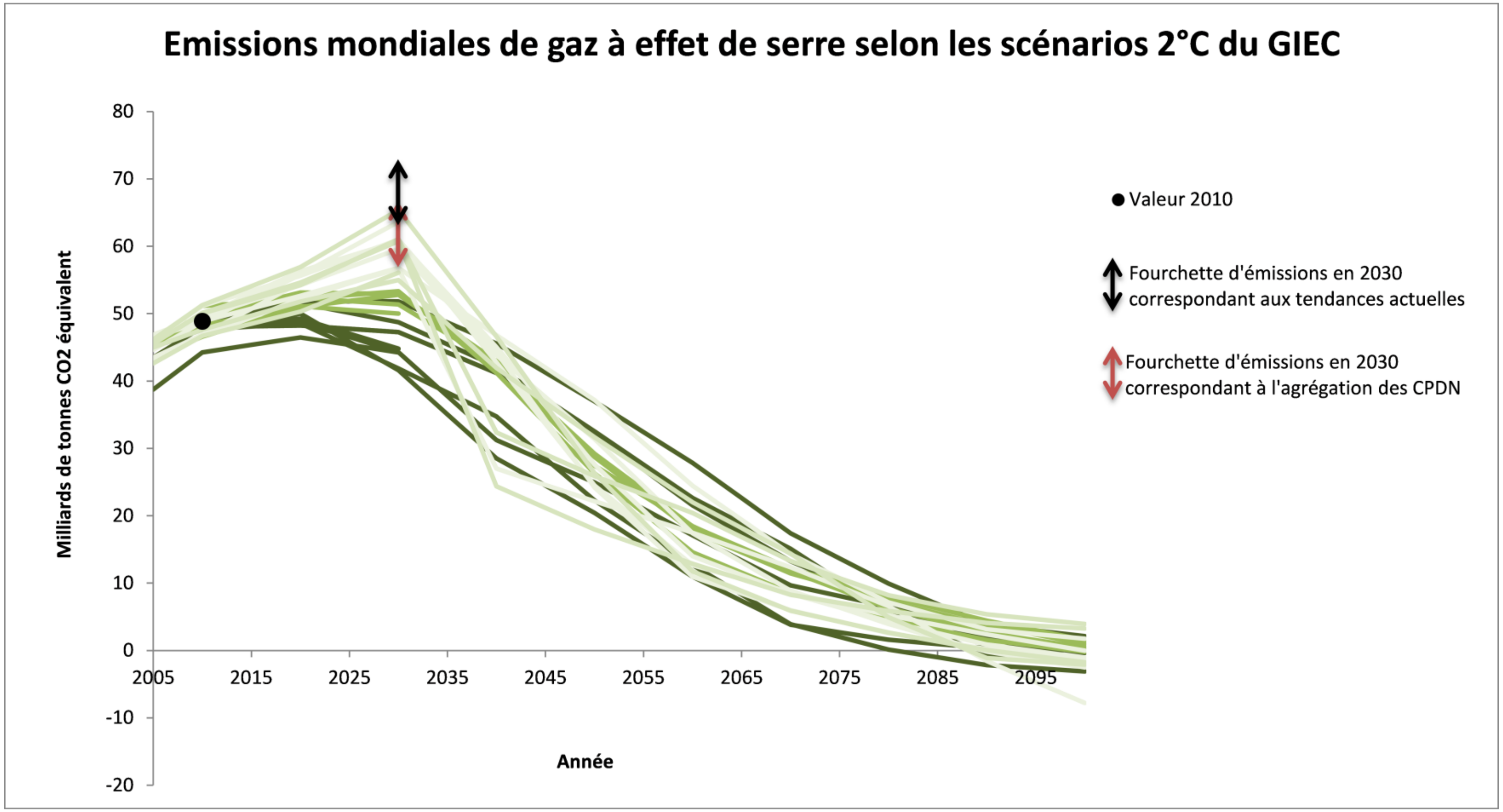
View from the IPCC 2014



IPCC WGI 2014

Just before Paris : ~3°C



Scenarios allowing 2C, + agregation of INDCs et BaU.

Source : IPCC, AR5, SPM, 2014 ; GICN, 2015,
Courtes of O. Boucher and H. Benveniste

Now 1.5°C is the target

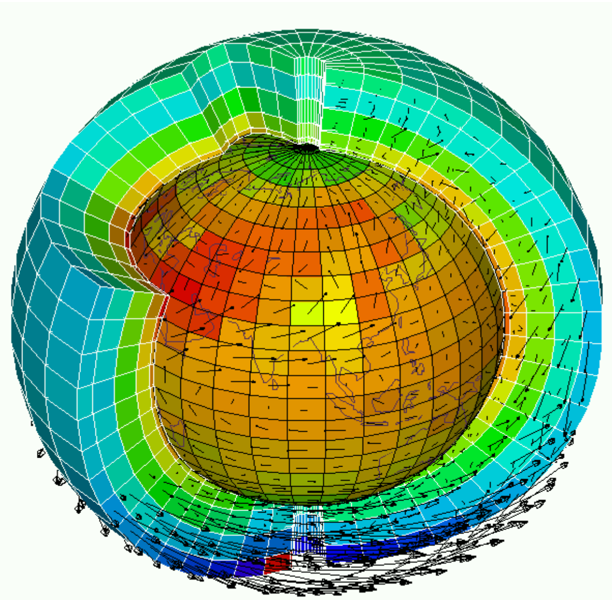
The 1.5°C issue opens new science

See eg Rogelj & Knutti, 2016, NGS

- How 1.5°C is different from today and from 3°C [climate, impacts, at relevant scale]? What damages avoided by an additional ½ degree?
- How does the [regional] climate reacts to mitigation and adaptation from land use/management changes?
- Tipping points: what and where precisely?
- **1.5°C difficult/impossible to reach with CO2 kept as increasing** Overshoot probable: how does the earth (and our models) work with decreasing/negative emissions and atmospheric CO2?
- Other issues: governance of geoengineering & negative emissions, ethics, …

Regional impacts from climate change (atmospheric composition)

Global and regional modeling



Zoom & Downscaling

Global model (eg IPSL-CM)

Regional model

Why?

- To provide higher-resolution climate projections for impact studies
- To better describe extreme events
- **To evaluate the effects of regional policies** (for some issues)

IMPACT2C www.impact2c.eu

IMPACT2C investigates the impacts of +2ºC global warming for Europe and other vulnerable global regions - Bangladesh, Africa (*Nile & Niger river basins),* **the Maldives**
and

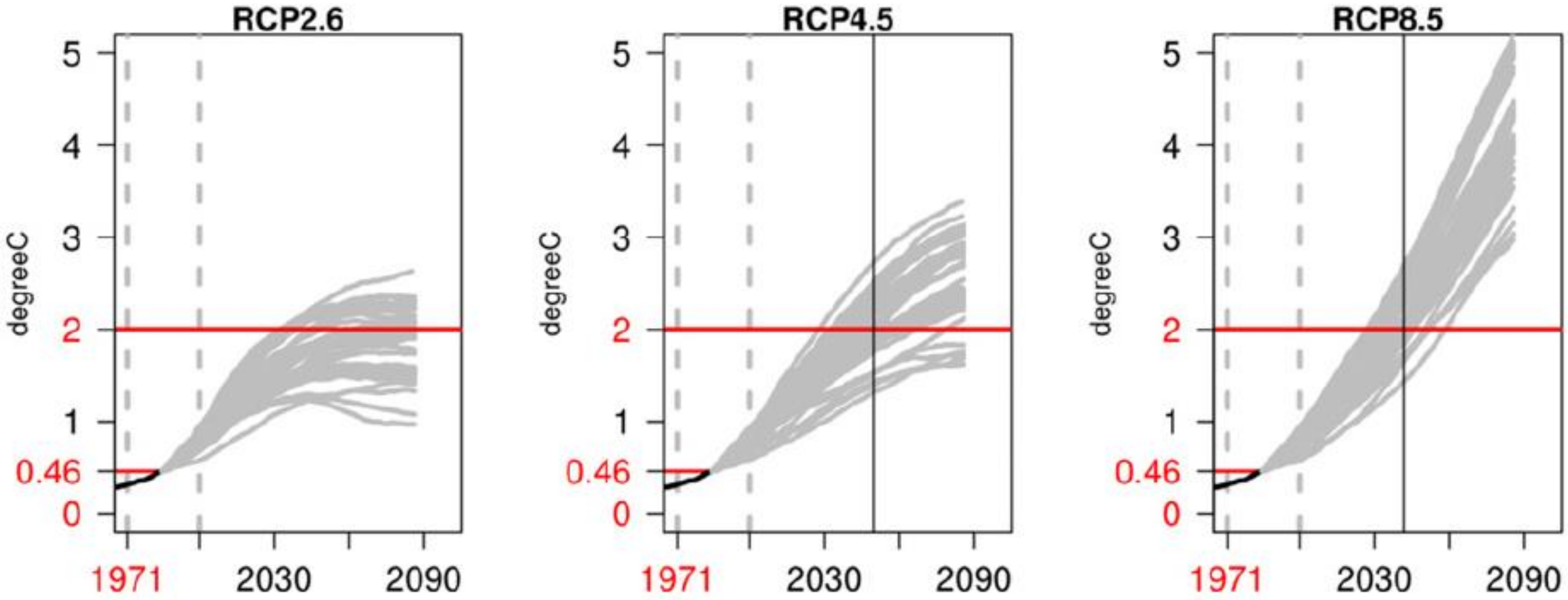
✓ *provides detailed ensemble based climate change scenarios, statistics and derived indices, tailored to the needs of various sectors, for the time slice when the global temperature is simulated to be +2ºC above pre industrial levels*

✓ *provides detailed analysis of risks, vulnerabilities, impacts and costs for range of sectors using consistent RCPs/ and SSPs (Representative Concentration Pathways / Shared Socio-economic Pathways)*

✓ *provides analysis of adaptation response strategies accounting for the regional differences in adaptive capacity*

+3˚ C considered in many cases

Investigate 2C in most populated scenarios (RCP4.5 and RCP8.5)



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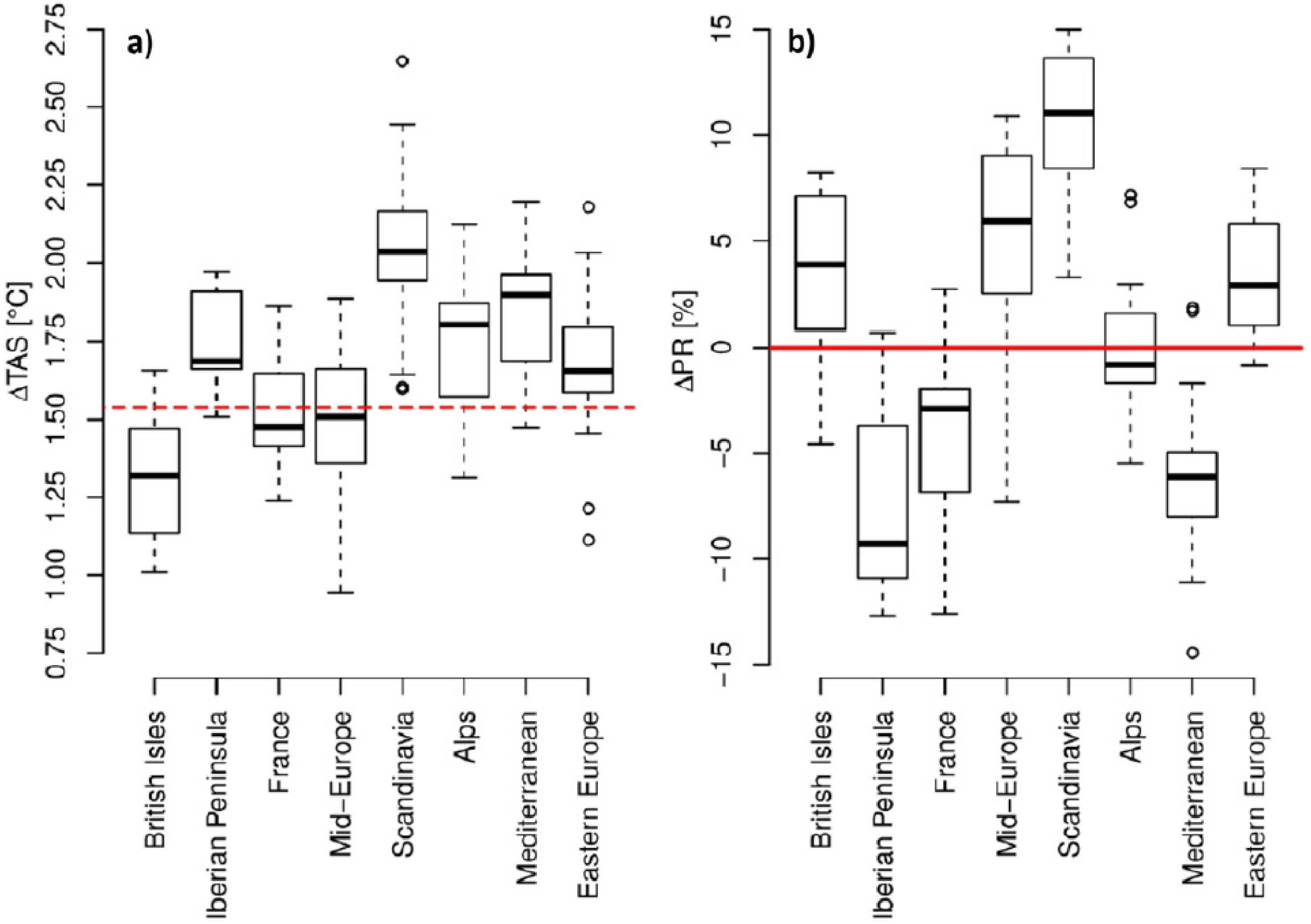
2C in Europe: what warming?



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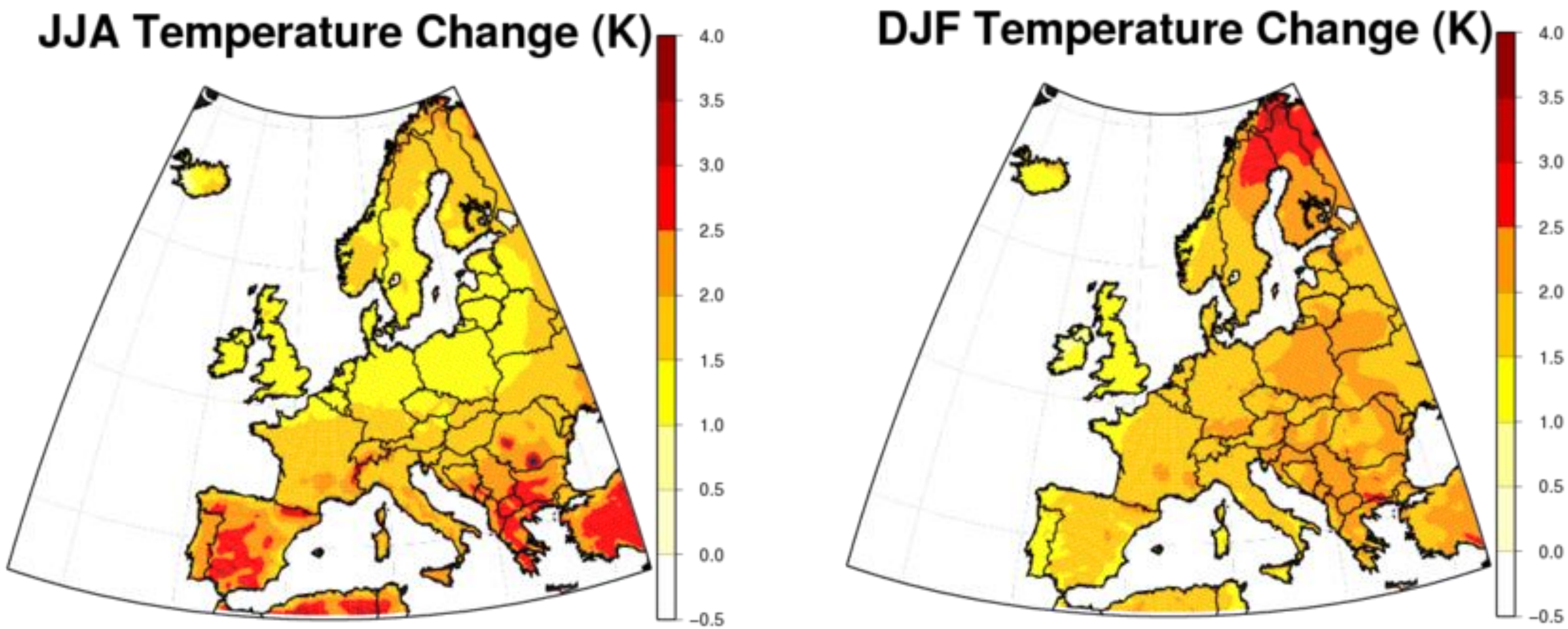
Robust climate changes in a +2° C Scenario (statistics from 15 models)

- Warming (relative to 1971-2000) doubled over Mediterranean areas in Summer
- Warming (relative to 1971-2000) doubled over Northern areas in winter
- All models agree on sign



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Source: IMPACT2C

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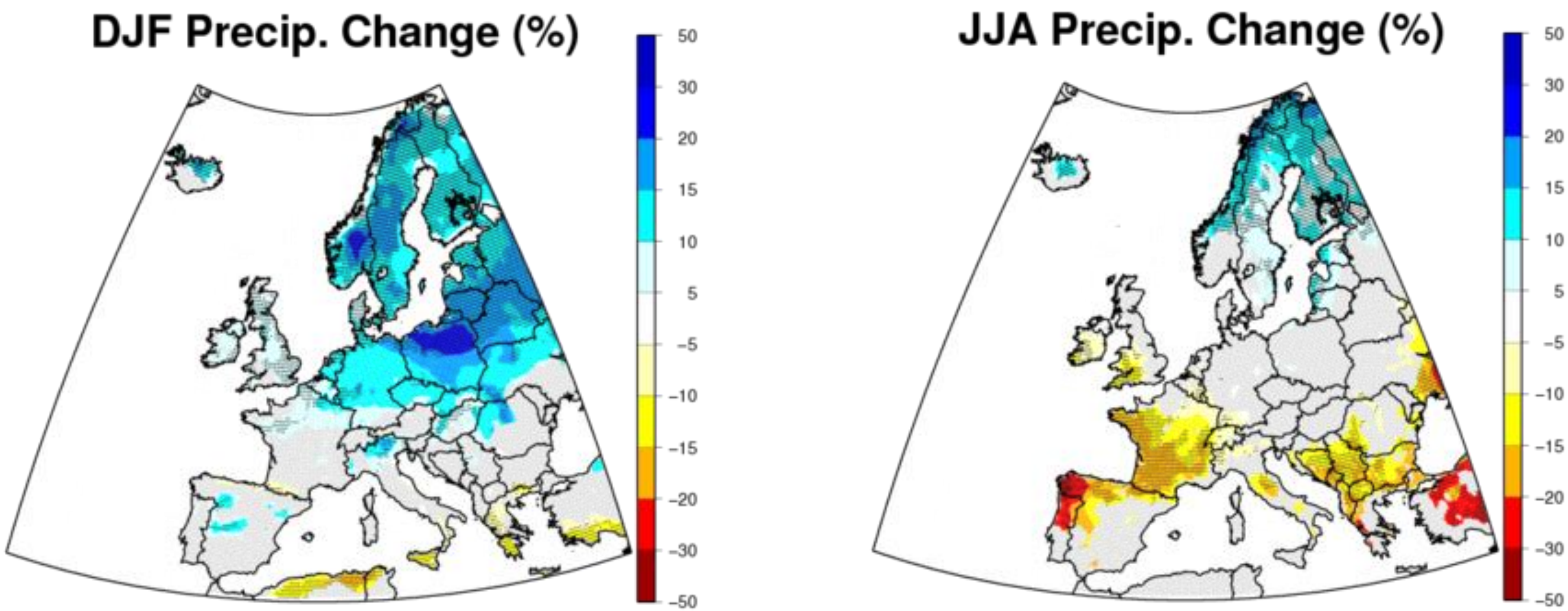
Robust changes in precipitations

• Less précipitation over Southern/Central Europe in summer
• More winterime precipitation almost everywhere, but models agree on sign only over Northern Europe



Colored areas: where 12 models at least agree among 15

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Source: IMPACT2C

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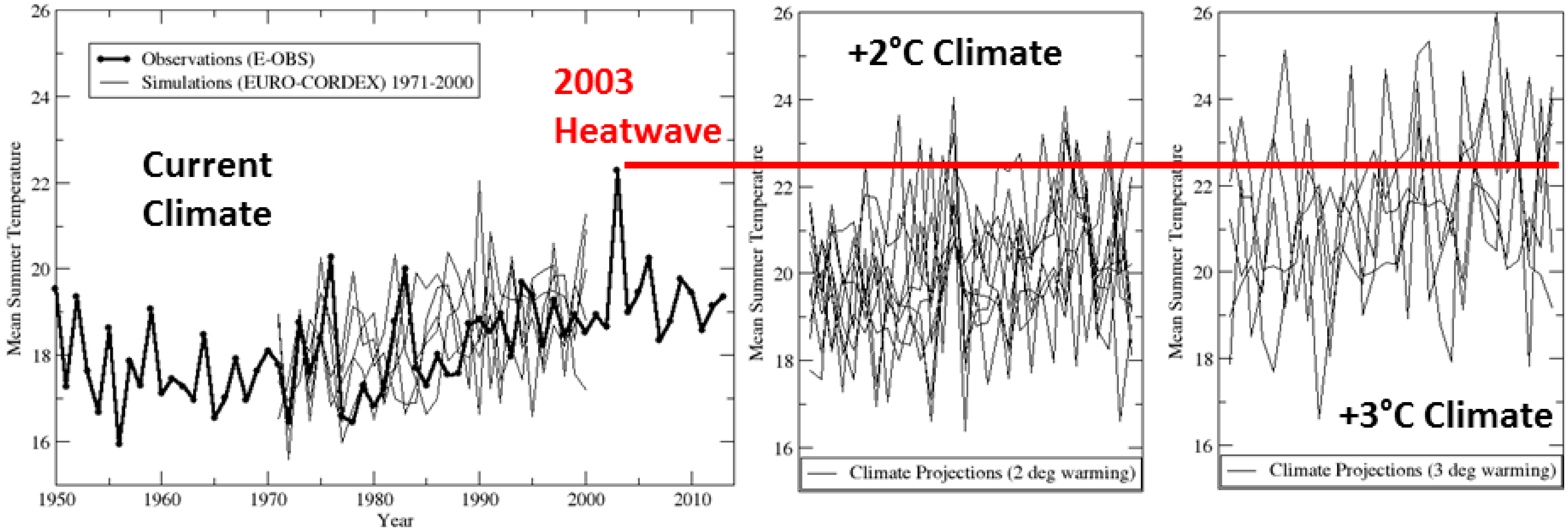
Heatwaves like 2003: many more in 3C than in 2C



Mean Summer temperatures near Paris in +2 and +3 climates

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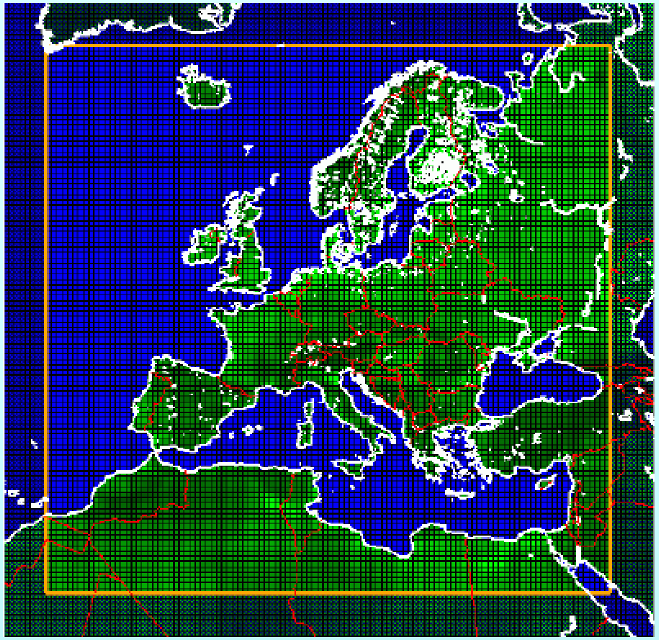
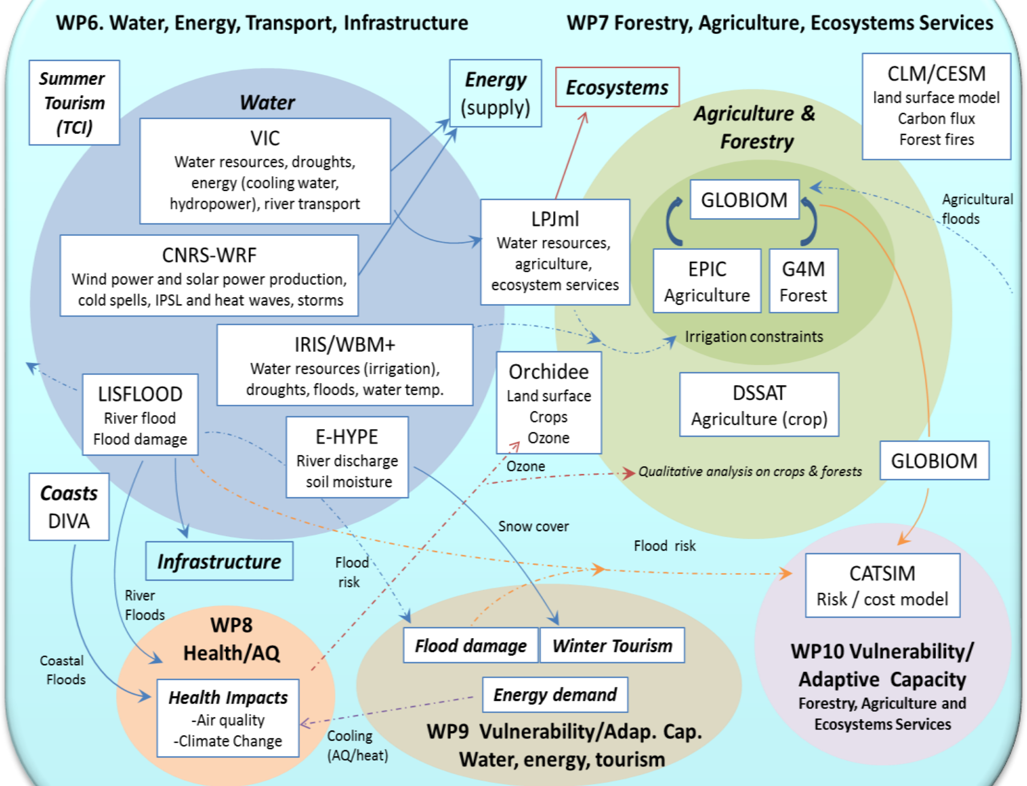
IMPACT2C: *modelling environment and linkages*

Climate projections



WCRP CORDEX

Impact assessment



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multi-model-multi-scenario approach

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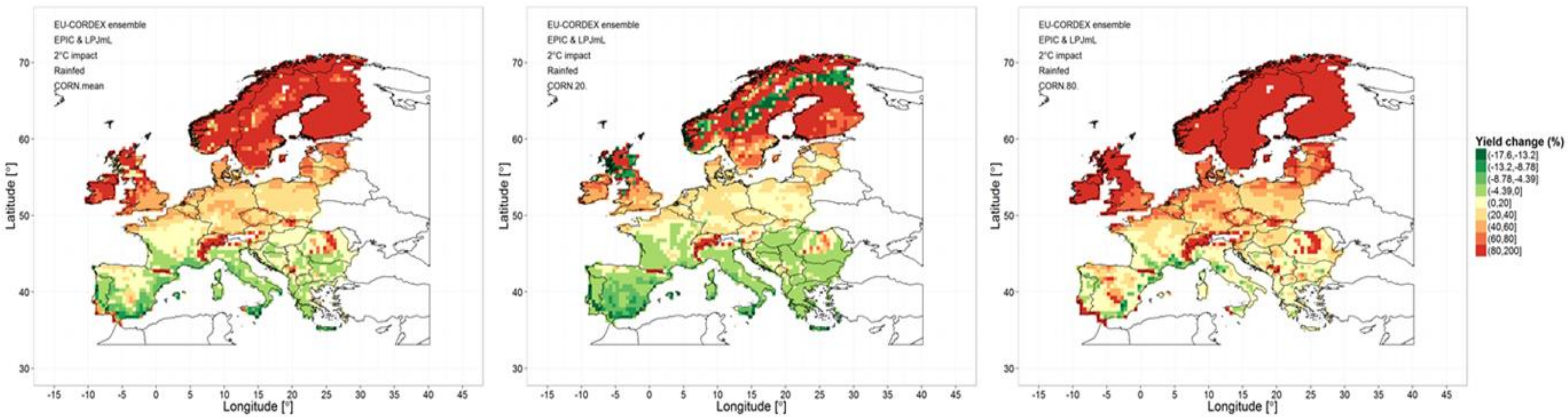
Impact of +2C on crop yield

- yields of summer crops would increase by more than 20% in many regions of Central, Western and Northern Europe
- yields of winter crops would decrease by approximately 20% in Western Europe and Balkan
- all crops would provide lower (and more vulnerable) yields in Southern Europe (high uncertainty though)



mean | **20th pctl** | **80th pctl**

Maize (rainfed), yield change [%]

RCP4.5

IIASA

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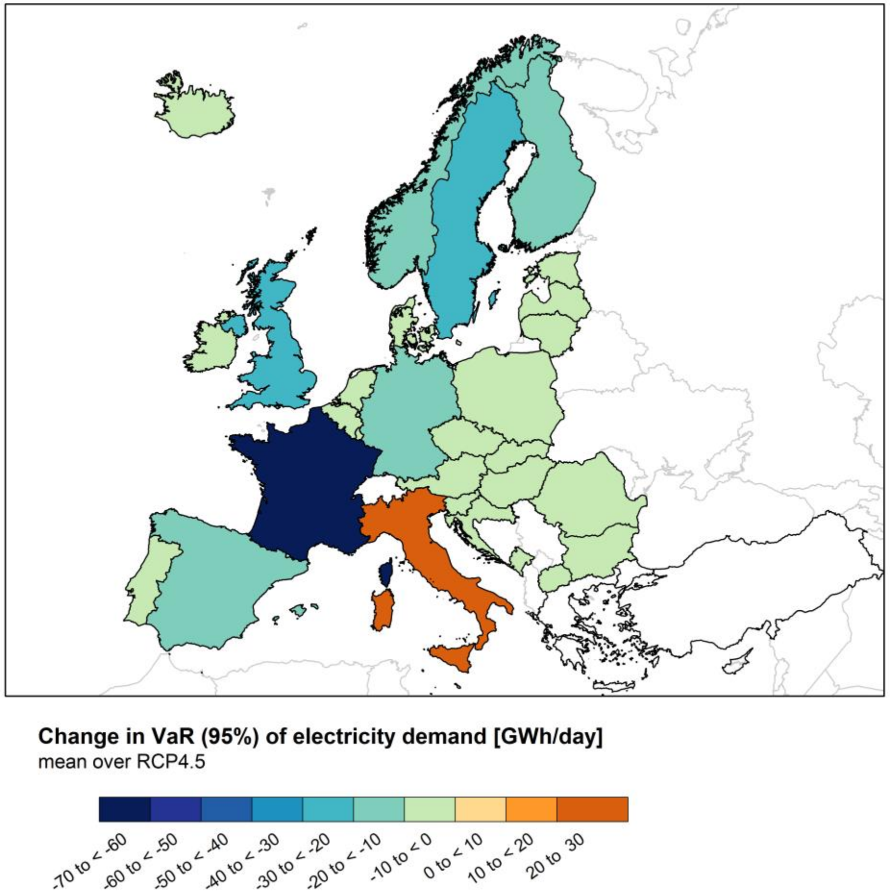
Impact of +2C on electricity demand

- **Heating effect dominates in most countries (except Italy)**
  overall, under +2° C warming a decrease in electricity consumption

- **Decrease of relative VaR the highest in Scandinavia and France**
  Sweden (up to -6.4 %-points), Norway (up to -6.3 %-points), France (up to -5.3 %-points), Finland (up to -4.6 %-points)

- **Decrease of absolute VaR by far the highest in France/ Increase of VaR in Italy (up to 2 %-points) due to increase in cooling demand**



the Value at Risk (VaR) resulting from adverse weather conditions, and represents – for a given level of confidence [α] over a given period of time – the maximum expected loss

RCP4.5

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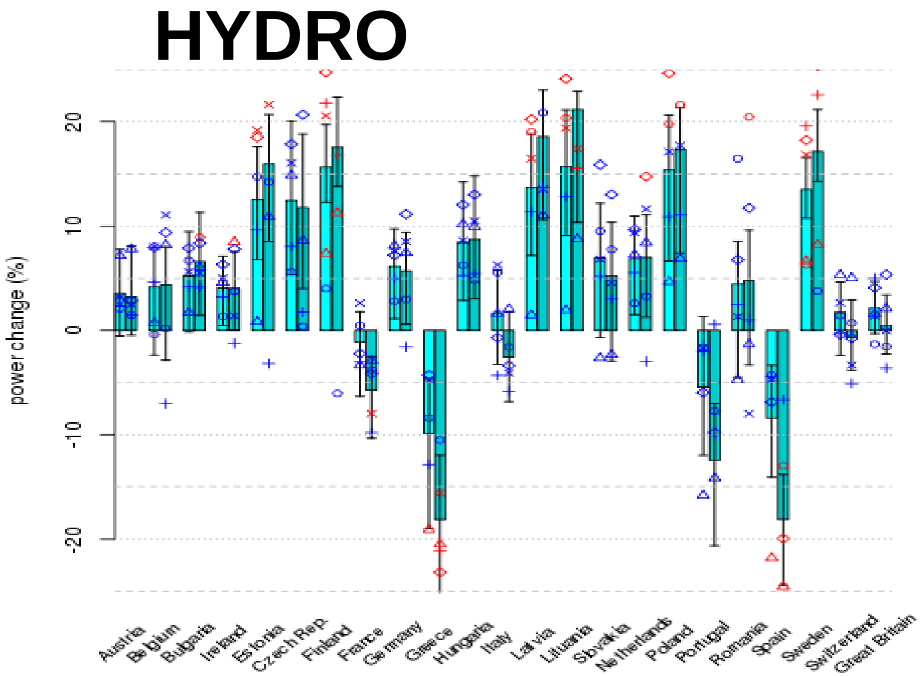
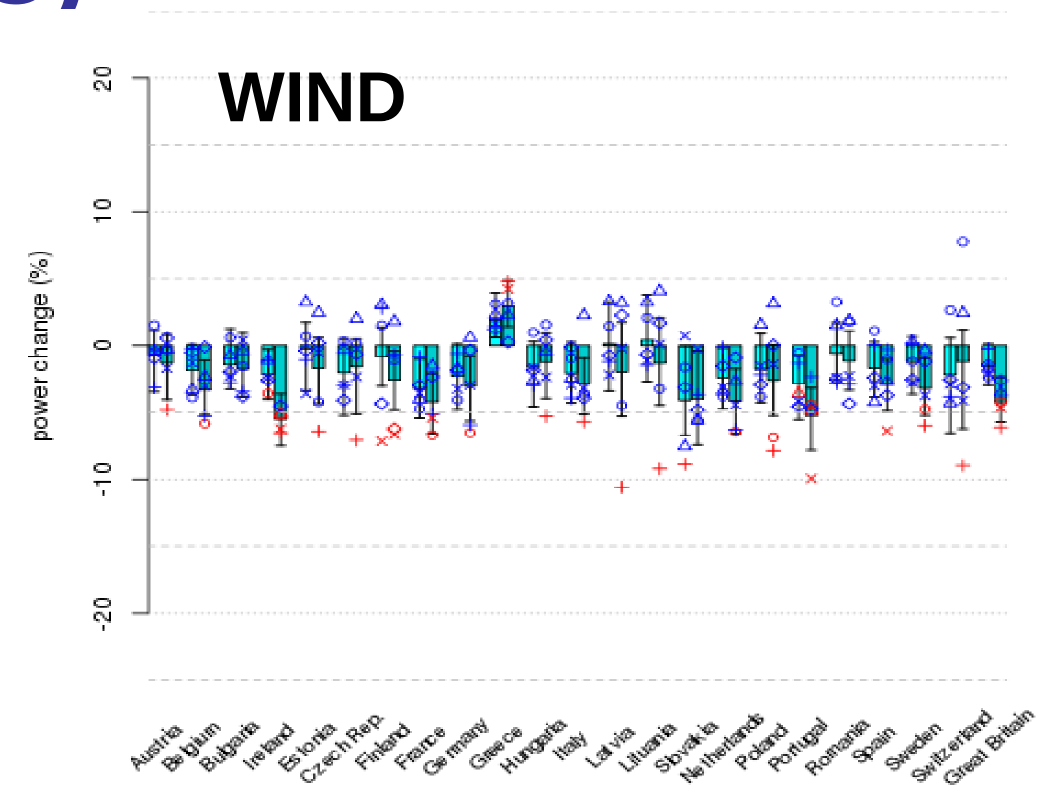
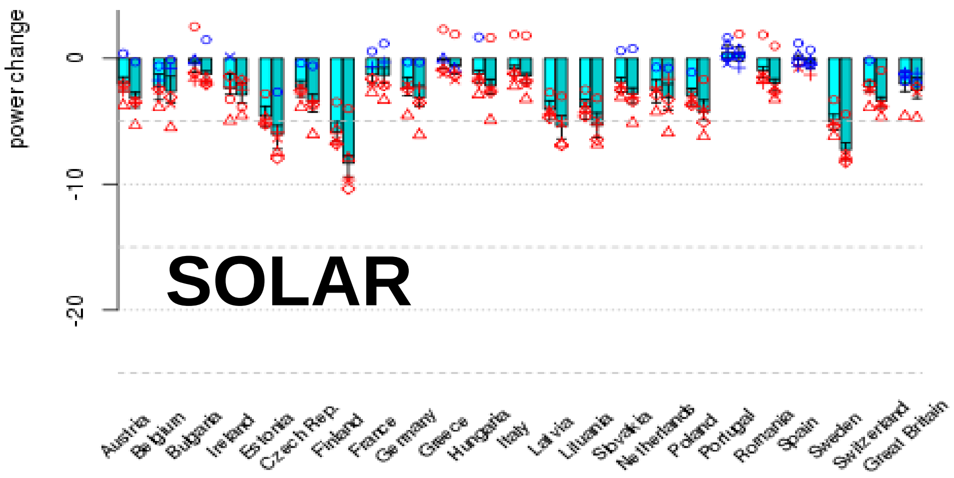
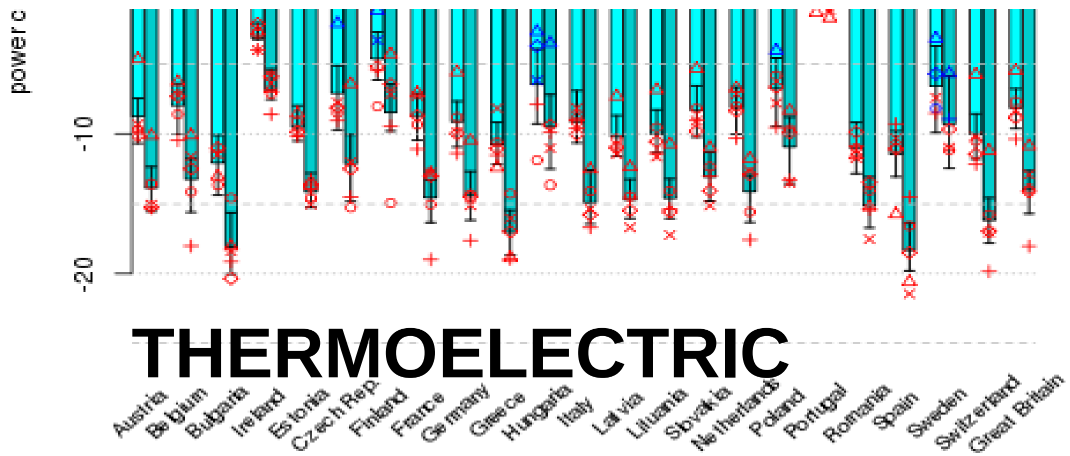
Energy production per technology (+2° C and +3° C)









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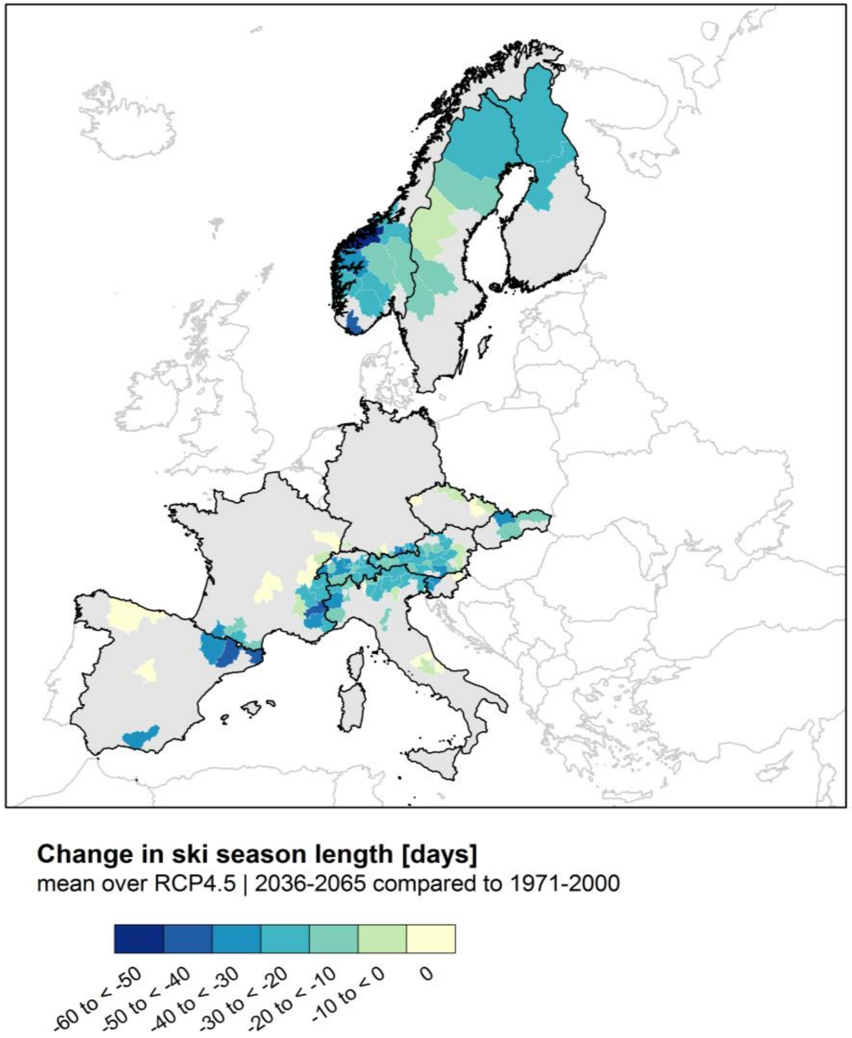
Impact of +2C on winter tourism

Ski season length

- **Up to 5.2 million nights (424 million €) per season additionally at risk in a +2° C world**
  Mainly caused by a shift in the expected value of overnight stays rather than from changes in the variability

- **Among 4 „big players“ of European skiing tourism:**
  Austria and Italy most affected
  Increase in risk of losses in overnight stays the lowest in France

- **Risk of losses in overnight stays in Sweden higher, compared to other Scandinavian countries, even in the reference period**



RCP4.5

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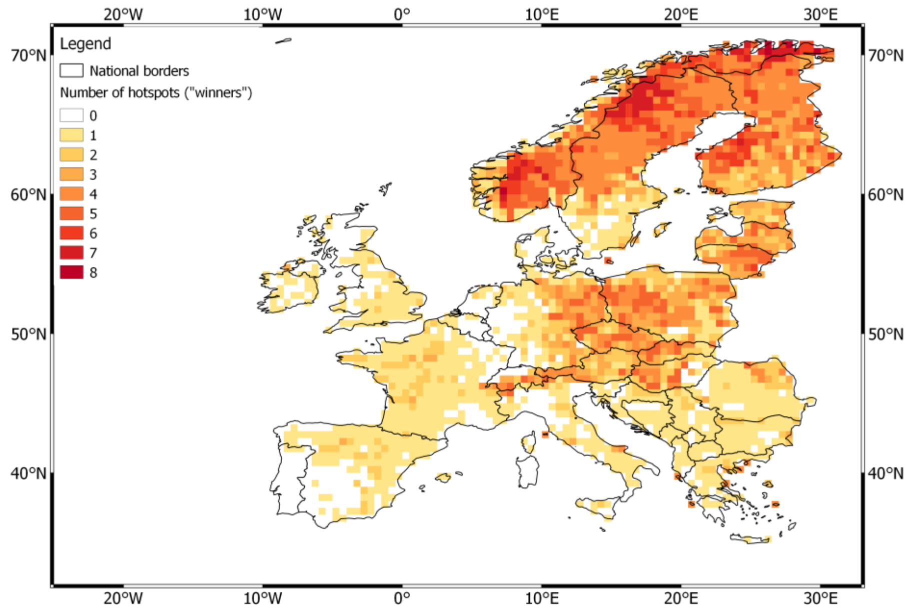
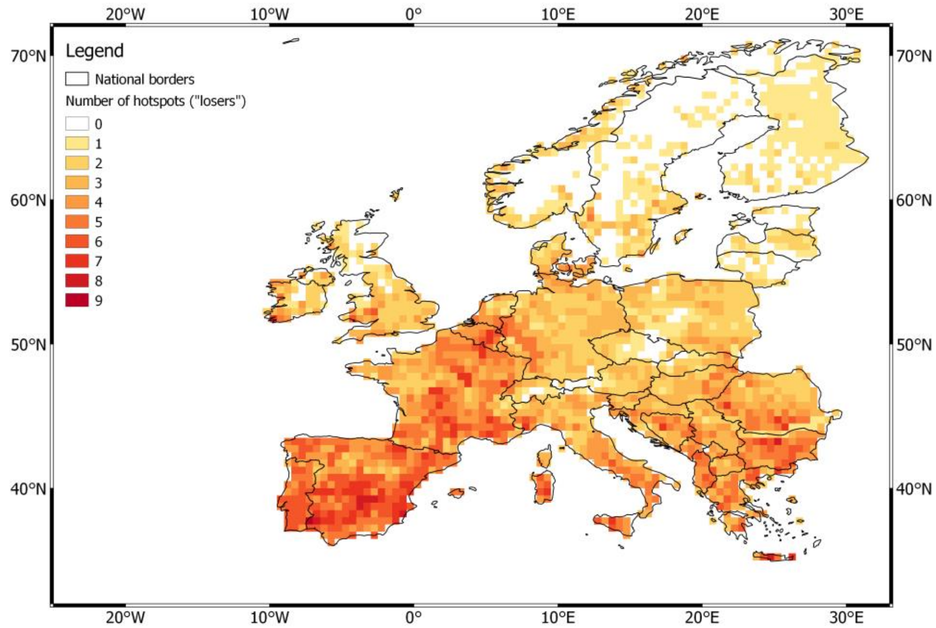
What does +2ºC global warming mean for Europe?

An integration and hot-spot mapping exercise using the IMPACT2C sector results shows a strong distributional pattern across Europe, with hot-spots clearly emerging in the south



Robust multi-sectoral hotspot **'winners'**

northern (Norway and Sweden)
north-eastern Europe (Poland, eastern Germany, the Czech Republic and the Baltic states)



Robust multi-sectoral hotspot **'losers'**

southern Europe (Spain, France, Bulgaria, Romania, and Greece)

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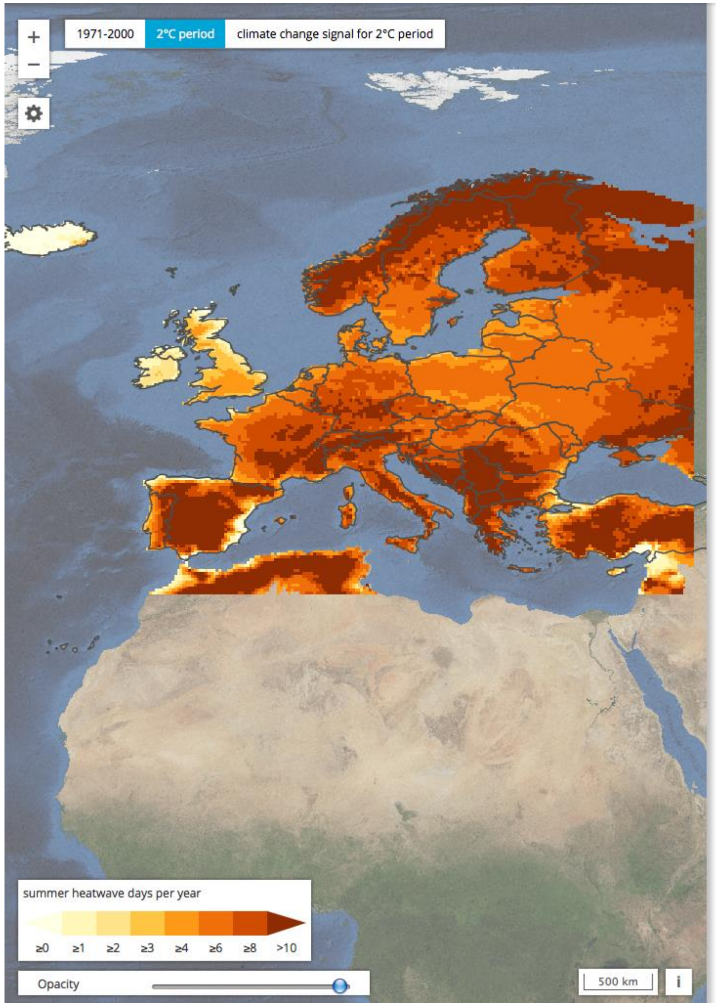
IMPACT2C atlas: www.atlas.impact2c.eu

By presenting a wide variety of potential climate change impacts, the IMPACT2C atlas aims to serve various audiences in gathering information for the development of recommendations on possible adaptation strategies on national and international levels



Summer Heat Waves

Key messages:

- **Heat waves are projected to become more frequent, more intense and to last longer**
- **Under a +2°C global warming scenario, the number of heat wave days is projected to be more than double in Europe, with much larger increases in Mediterranean areas**
- **Under a +3°C global warming scenario, the number of heat wave days is projected to be more than quadruple**

Why is the content of this map important?

Heat waves are periods of temperature exceeding 5°C above normal lasting more than 5 days. On average, a few heat wave days per year are found in the 1971-2000 reference period. This number could rise to more than 10 days in general in a 3°C warmer climate. Limiting the warming to 2°C would half this increase.

Which sectors are affected by this result?

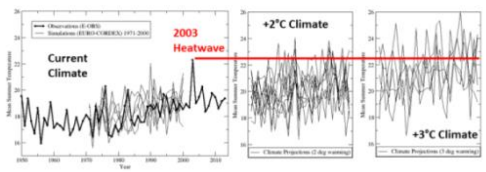
Heat waves affect a number of economic sectors such as health, energy, agriculture, and they also affect ecosystems. They increase mortality and threaten harvests, and induce high river temperatures and low flows, which potentially lead to thermal electricity production management issues.

What is shown on the maps?

Figures show the current and future average number of heat wave days per summer. Heat waves are projected to become much more frequent in the future than they were throughout the 1971-2000 reference period. In most areas, the number of heat wave days are projected to increase by a factor of 2 to 10. A marked increase is simulated across Mediterranean areas.

Details and further information:

The heat wave that Europe underwent in 2003 is often taken as a reference point for future climate. The figure below shows mean summer temperatures in Central-northern France as observed (E-OBS), simulated and projected (EUROCORDEX) by an ensemble of models. Summers similar to the 2003 summer period were exceptional around 2000. Such summer conditions would be expected to remain infrequent under a +2°C global warming but become the norm under a +3°C global warming.



Additional information: ›

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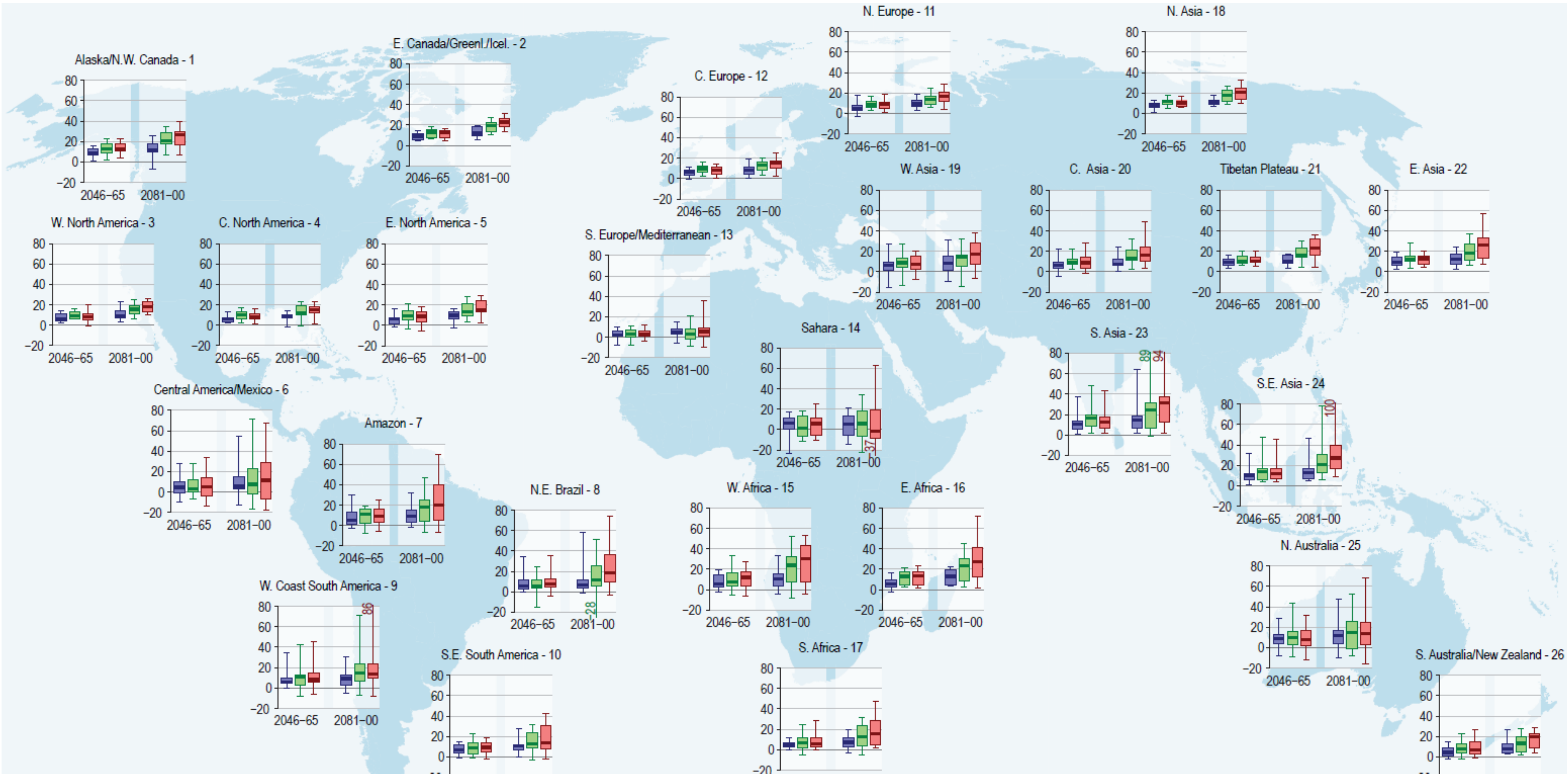
Limitations

- Non stabilized scenarios: commited impacts not taken into account (eg sea level rise impacts)
- No land use changed assumed at regional scale
- Models still do not explicitely resolve local scale, for extreme events and local adaptation [downscaling uses statistical modeling]

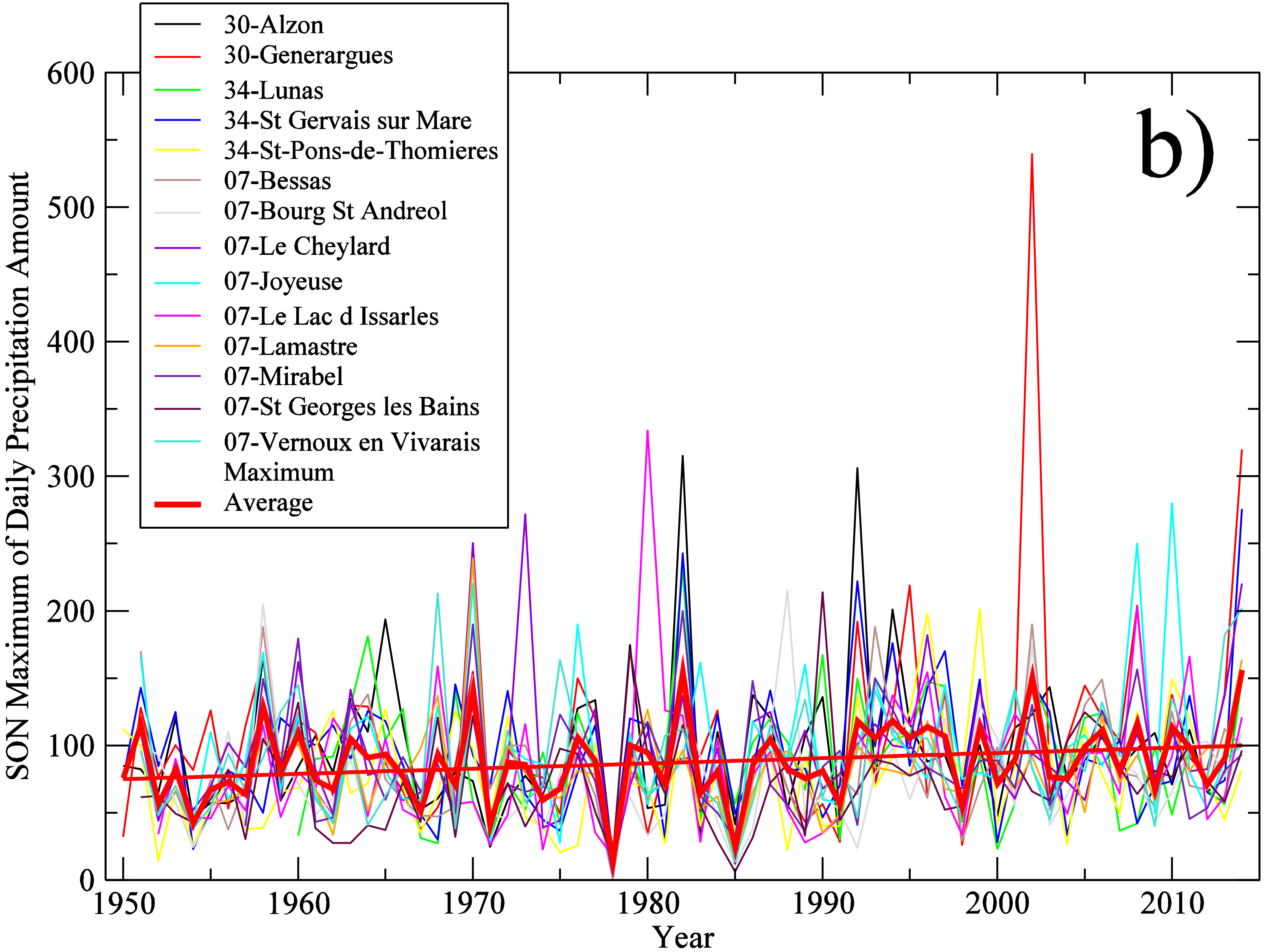
Ex: projected increase of heavy precipitation



SREX, Seneviratne et al., 2012

Models do not simulate explicitely processes leading to most extreme precipitations (convection)

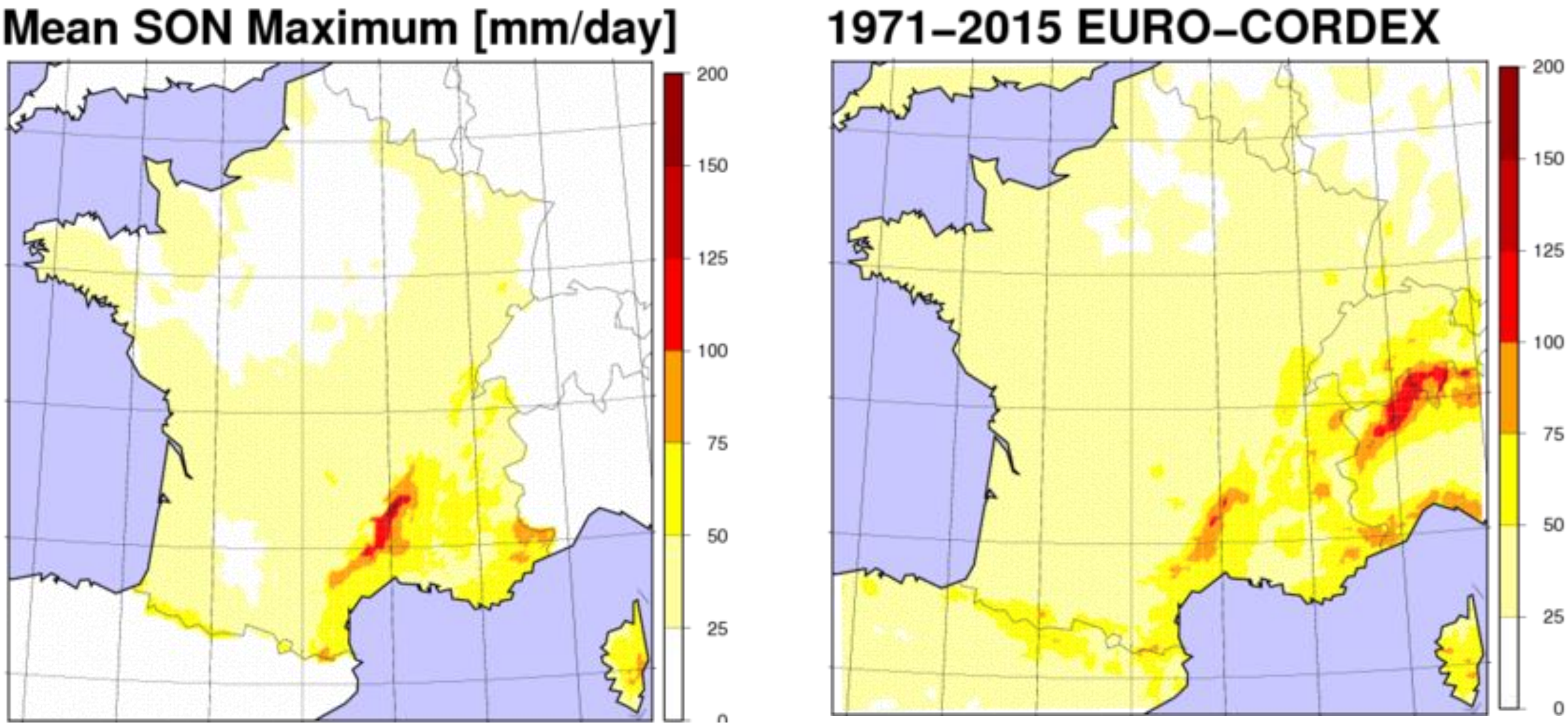
Emerging signals (here 14 rain gauges in the Cévennes area, fall daily maximum) locally have a higher increase rate



+30%

Vautard et al., 2015

State-of-the-art regional climate models – non explicit convection



SAFRAN
Observation

EURO-CORDEX
Model Ensembe Mean

Mitigation and negative emissions have a number of poorly assessed climate consequences

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Constraints on negative emissions (after Smithe et al., 2016)

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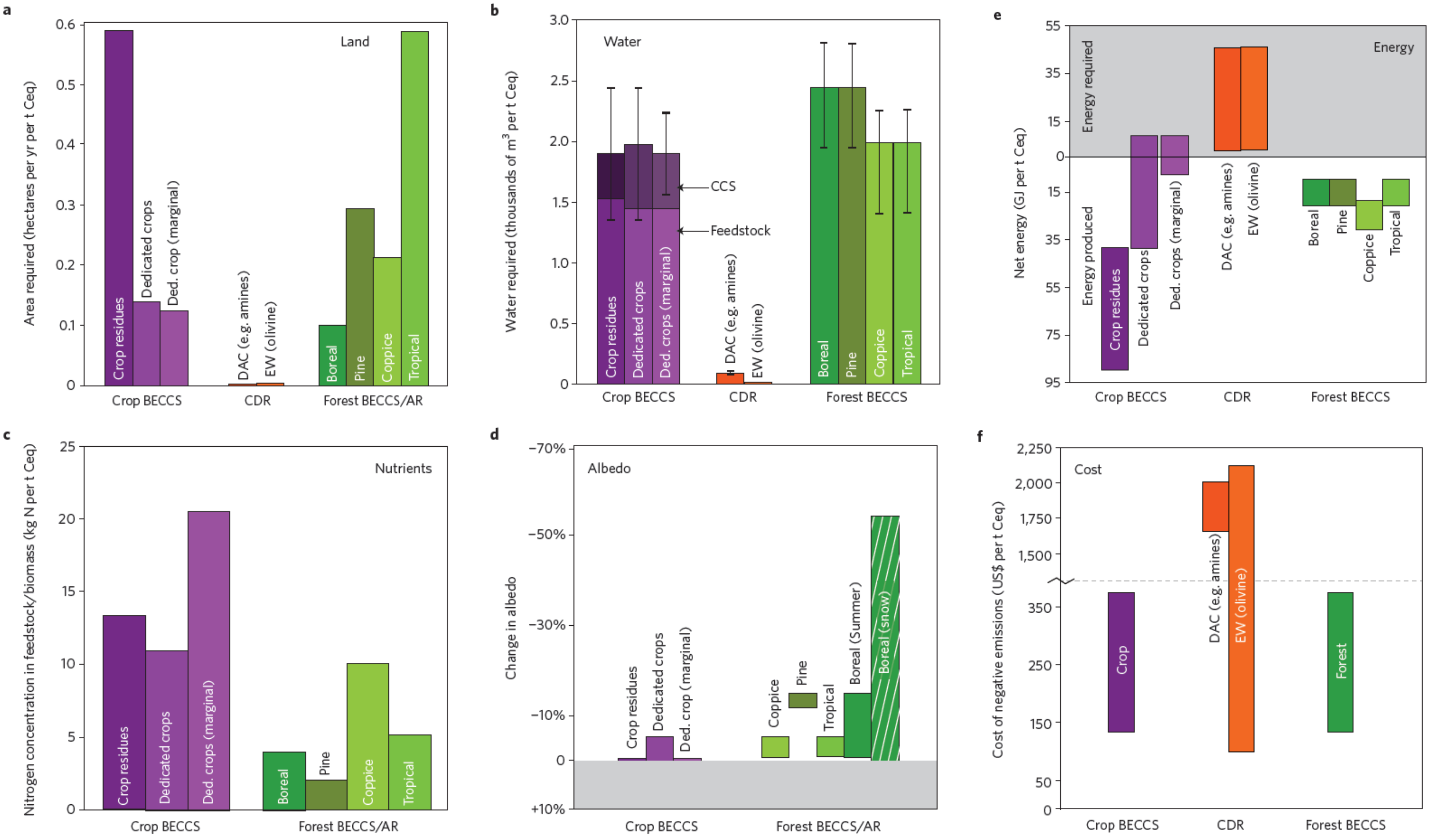
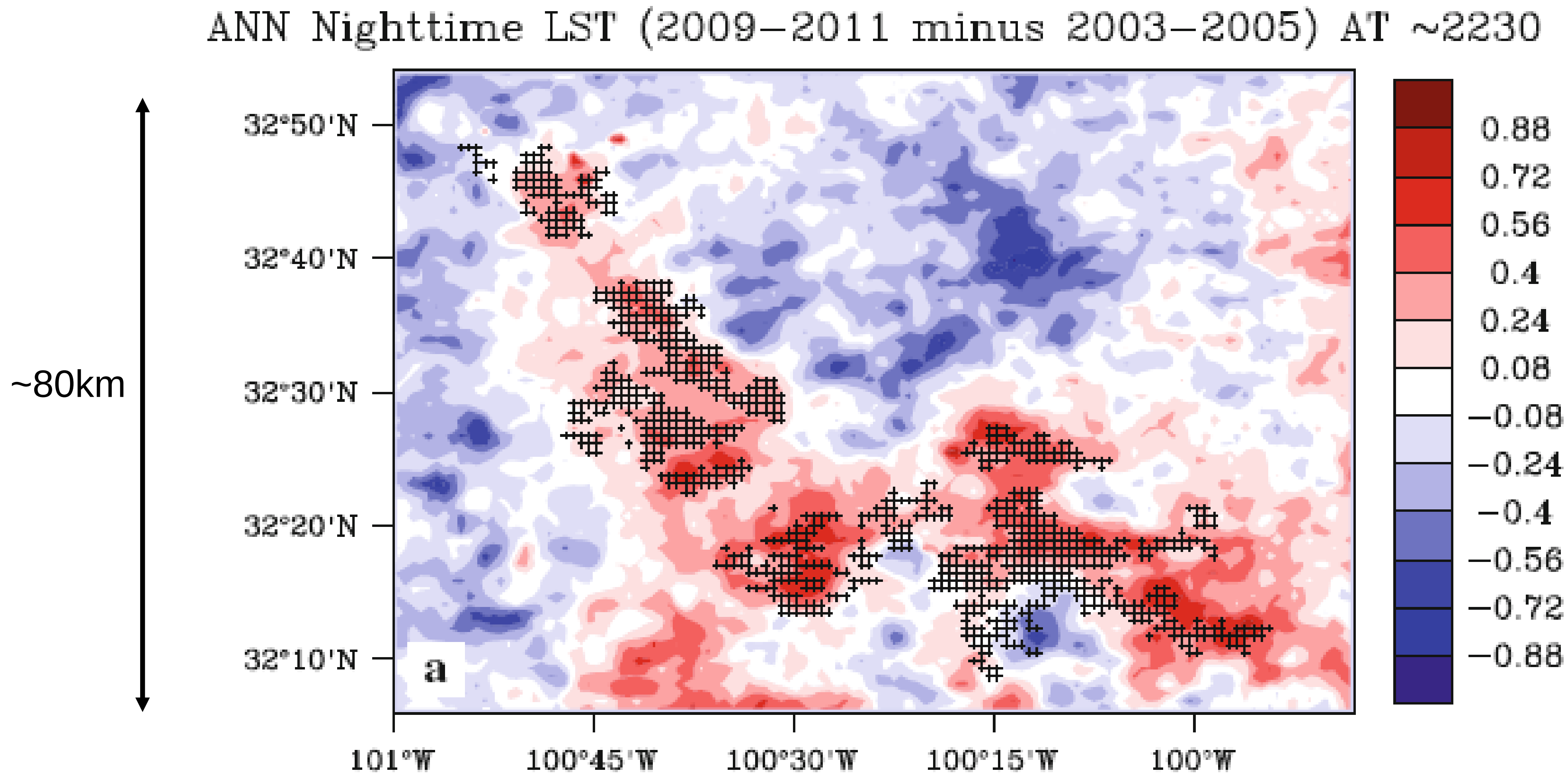
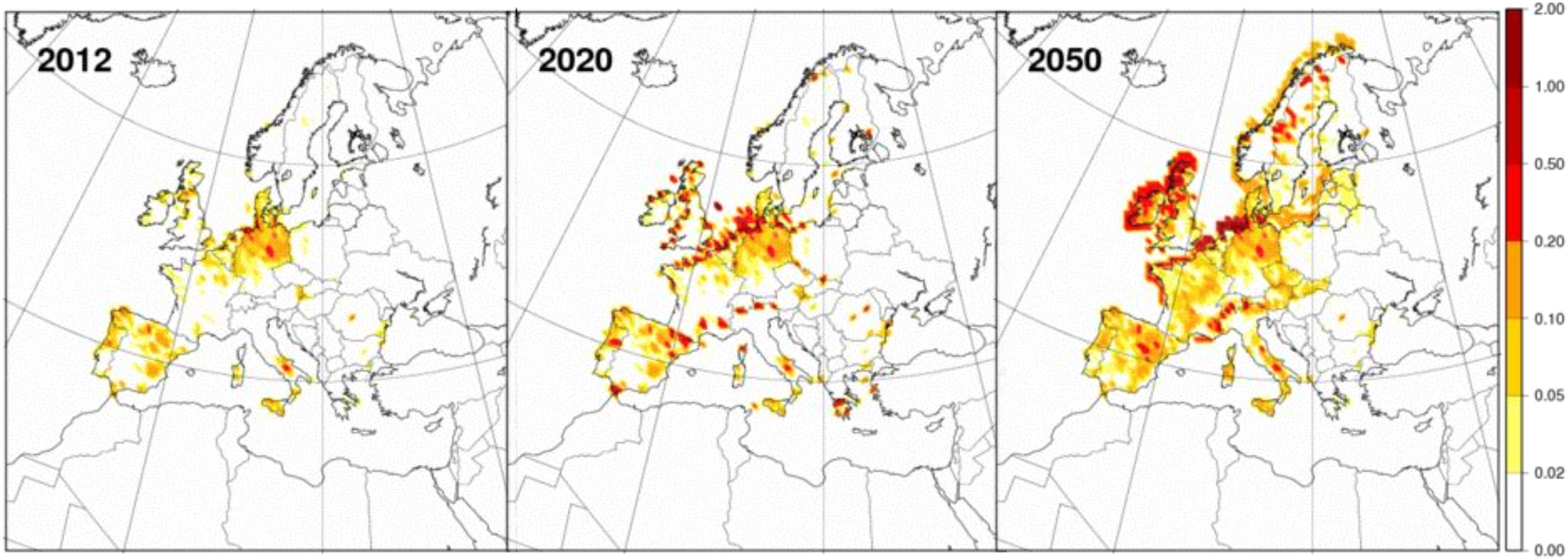


Observed T differences in Texas wind farms areas



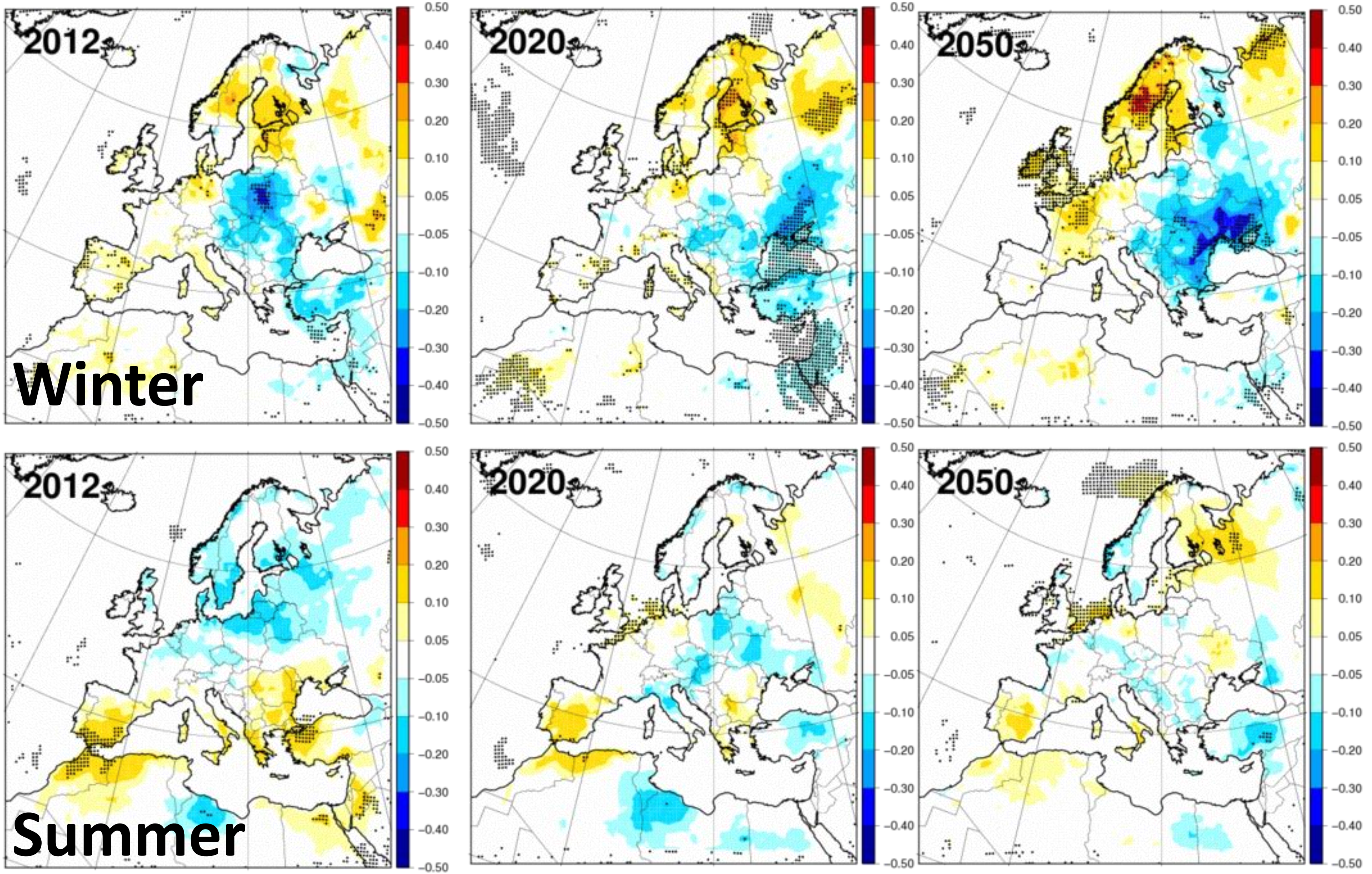
Zhou et al., 2013

Wind Energy at European scale
Scenarios for 2020 and 2050

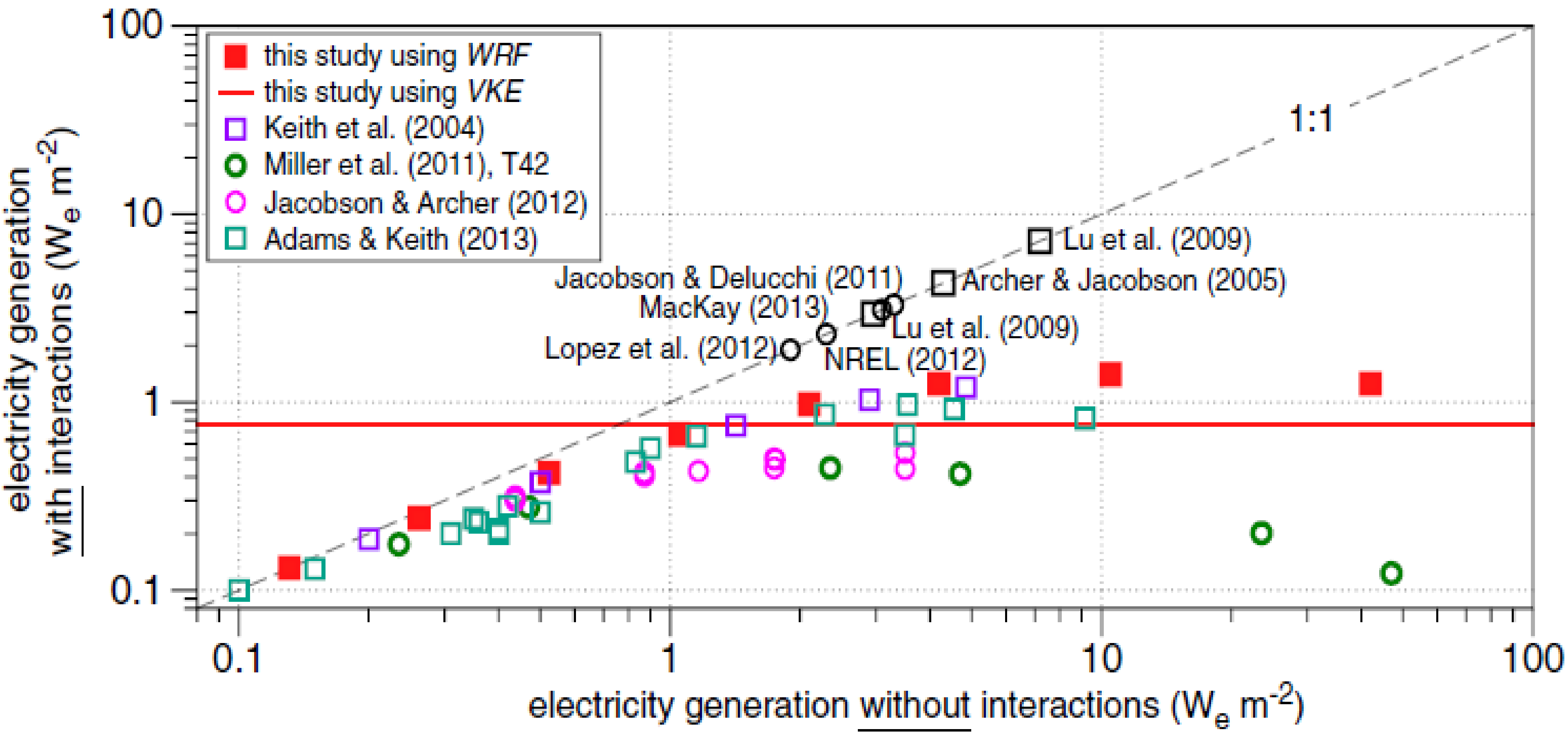


Vautard et al., 2014; Jerez et al., 2014

Impacts on temperature



Large-scale wind power development alters resource itslef, a neglected factor



Miller et al., 2015 PNAS

Conclusions

- The Paris agreement triggers a number of new climate scientific challenges
- Regional and local consequences of altered and strongly mitigated climate must be assessed with new generation of models
- Interdisciplinarity is more than required!

Governance/ethical issues ahead: Climate control

- New technologies for geoengineering or negative emissions may be controls of the large-scale climate, possibly owned or mastered by a few countries or companies

→ Governance issues are crucial, requiring social-science research and strong links to geosciences

Thanks for your attention!

Additional slides

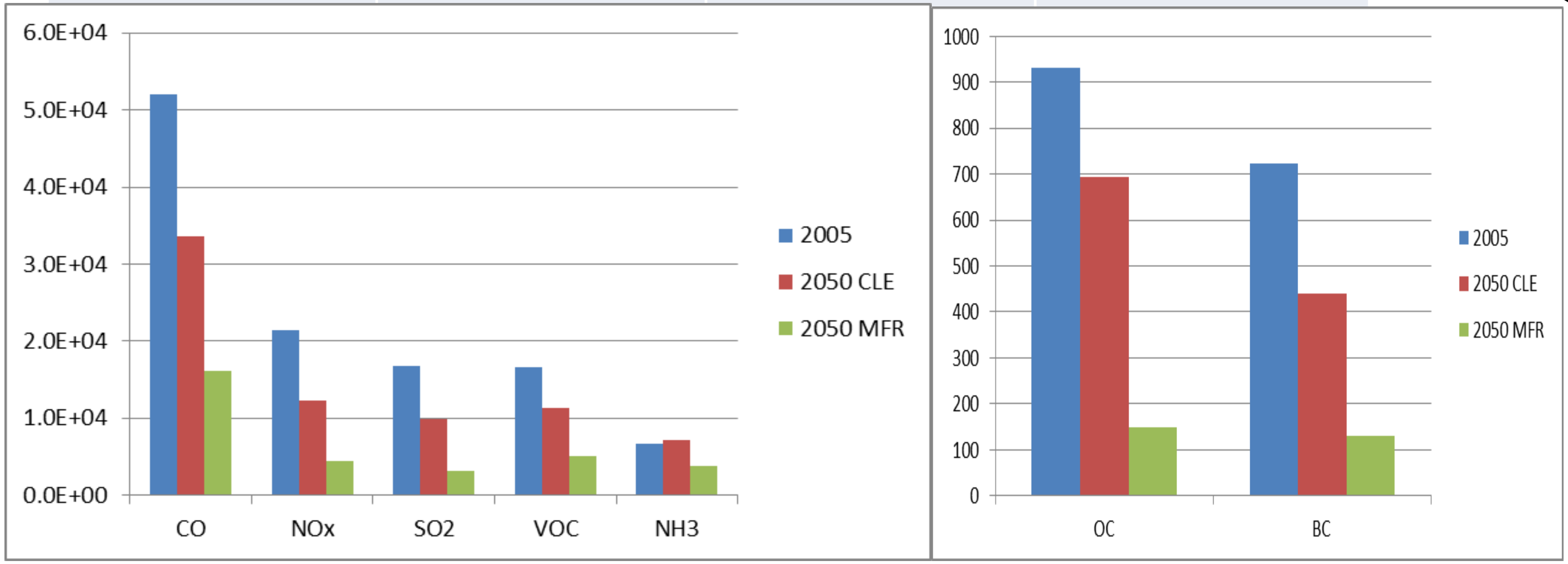
Air quality : Scenario simulations

Name	Climate	Boundary conditions	Emissions
HINDCAST	1989-2008	2005	V4a 2005 CLE*
HISTORICAL	1971-2000	2005	V4a 2005 CLE*
S1	+2°C RCP4.5	2050	V4a 2050 CLE*
S2	1971-2000	2050	V4a 2050 CLE*
S3	+2°C RCP4.5	2050	V4a 2050 MFR**

Baseline

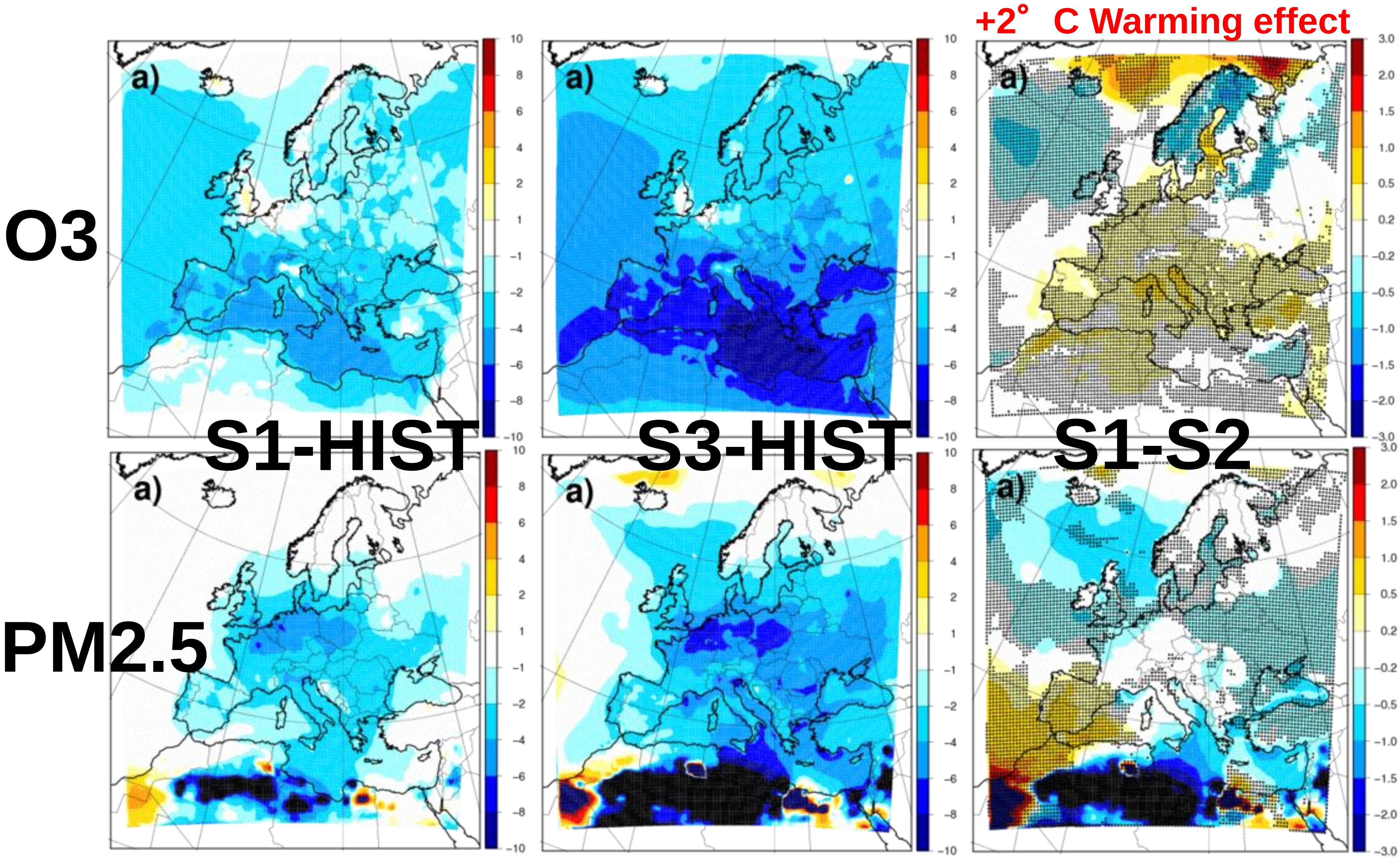
To test the effect of climate change only S1-S2

Advanced All low-emission technologies deployed

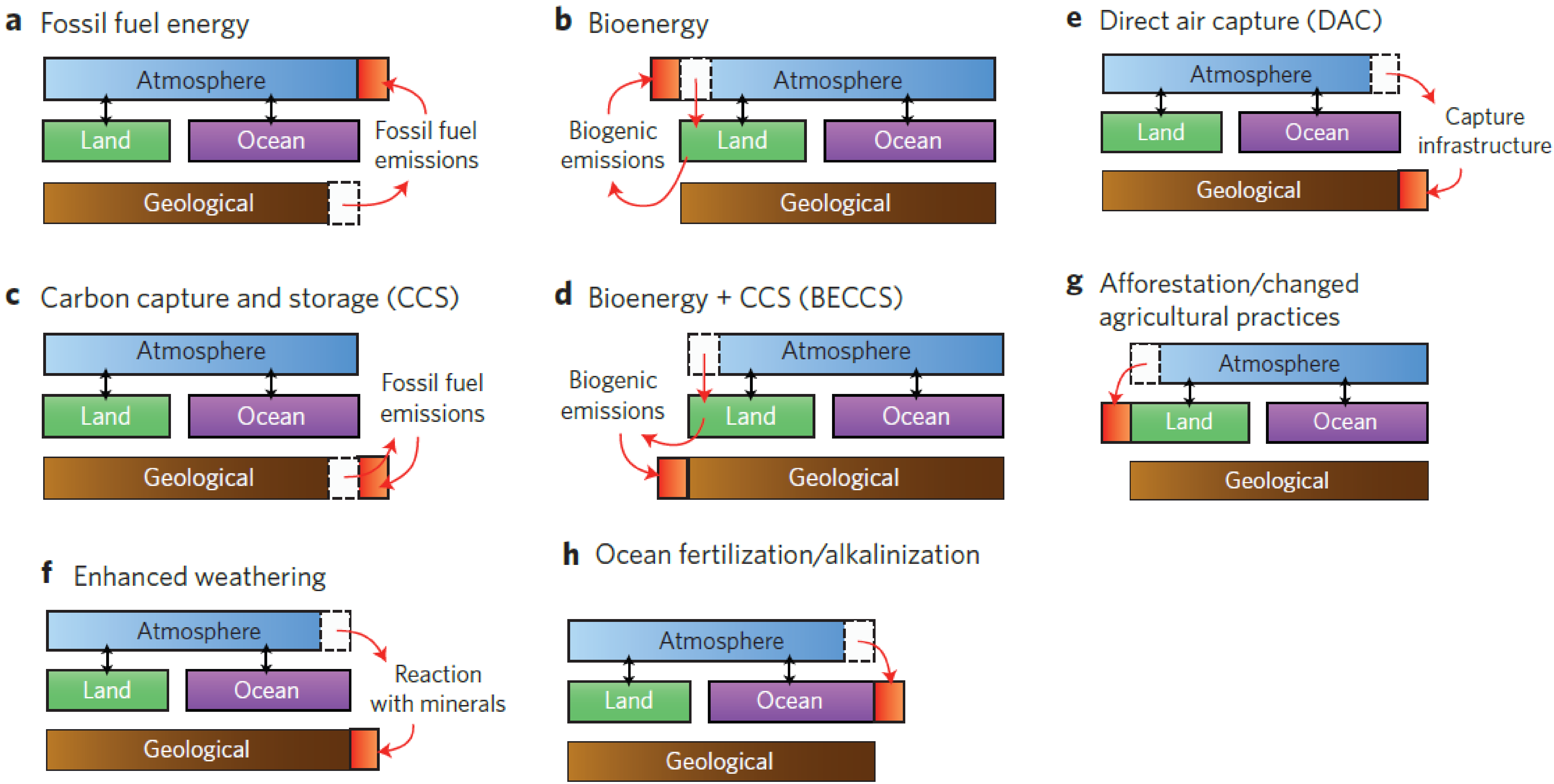


Results

1) Fate of air pollution driven by emission controls
2) Effects of +2° C climate change small, small O3 climate penalty effect

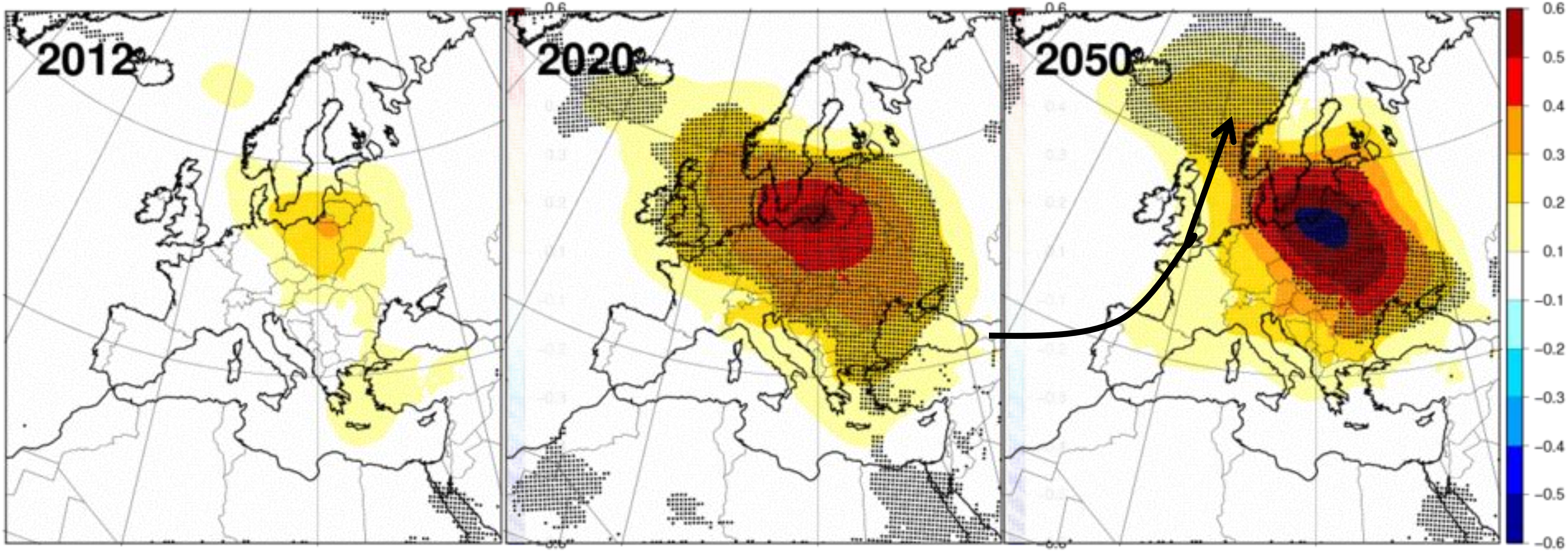


Technologies and carbon fluxes



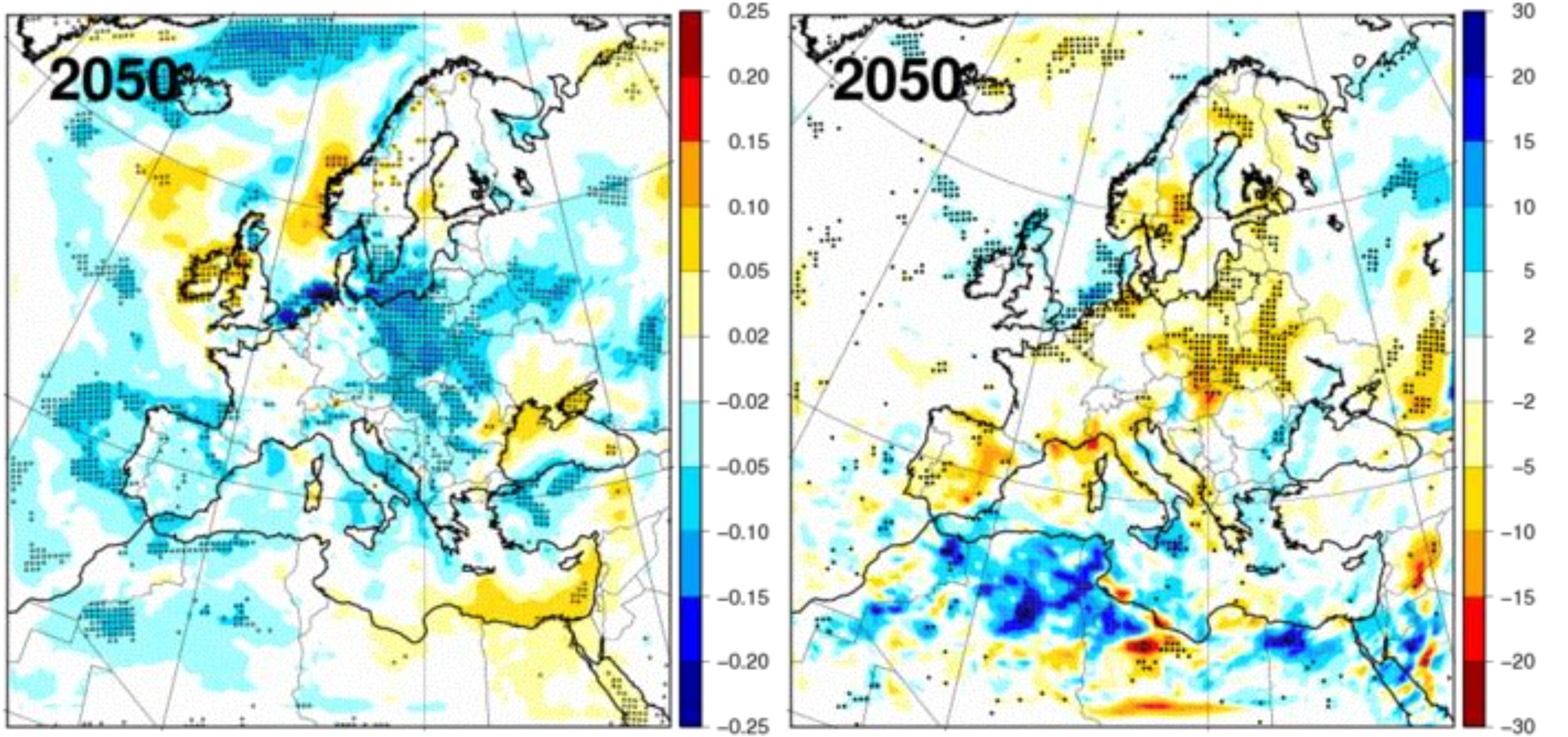
Impact on the synoptic flow (sea level pressure, winter)

Units: hPa



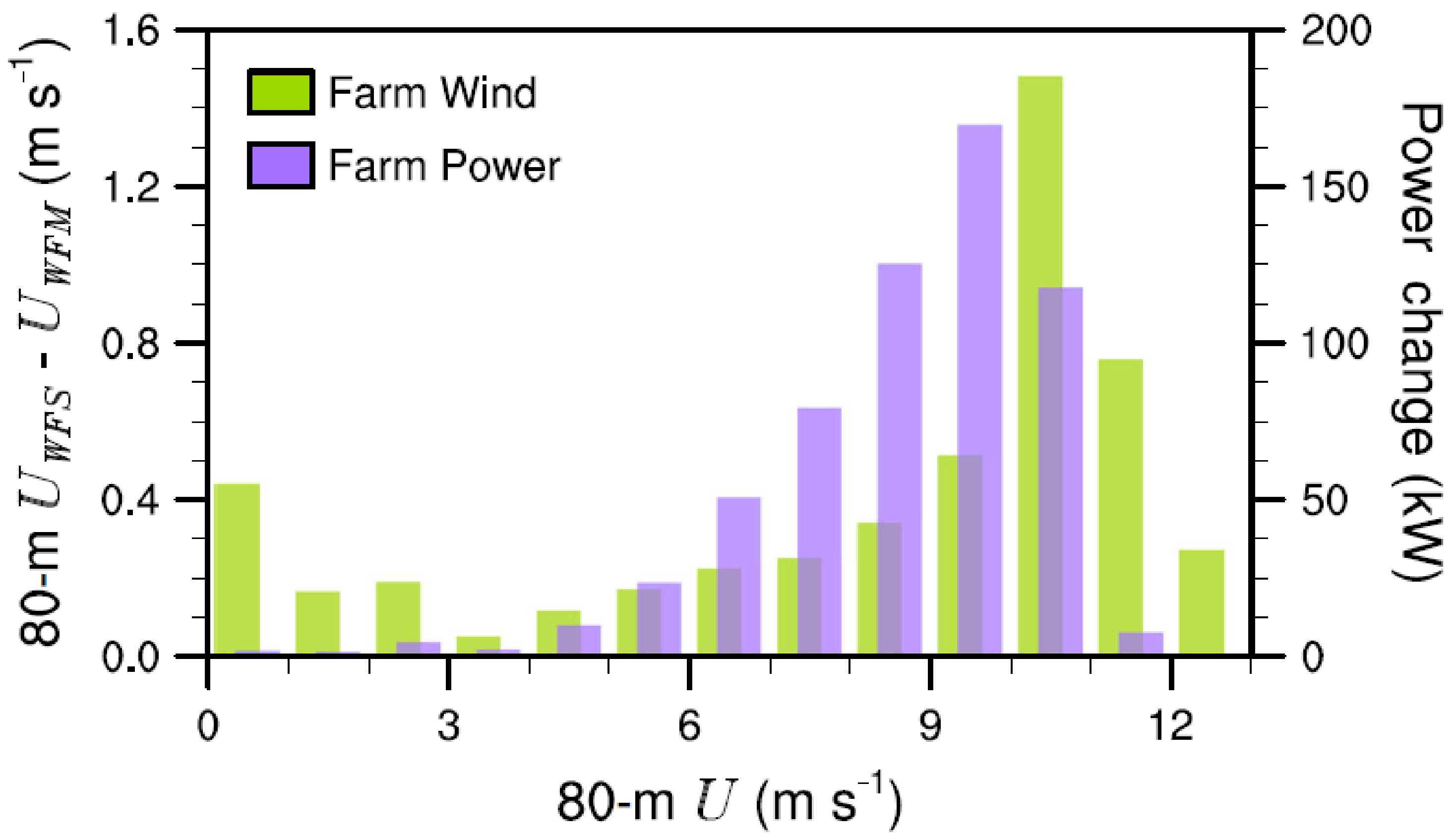
Precipitation, wind in winter

10m Wind (m/s) — Precipitation (%)



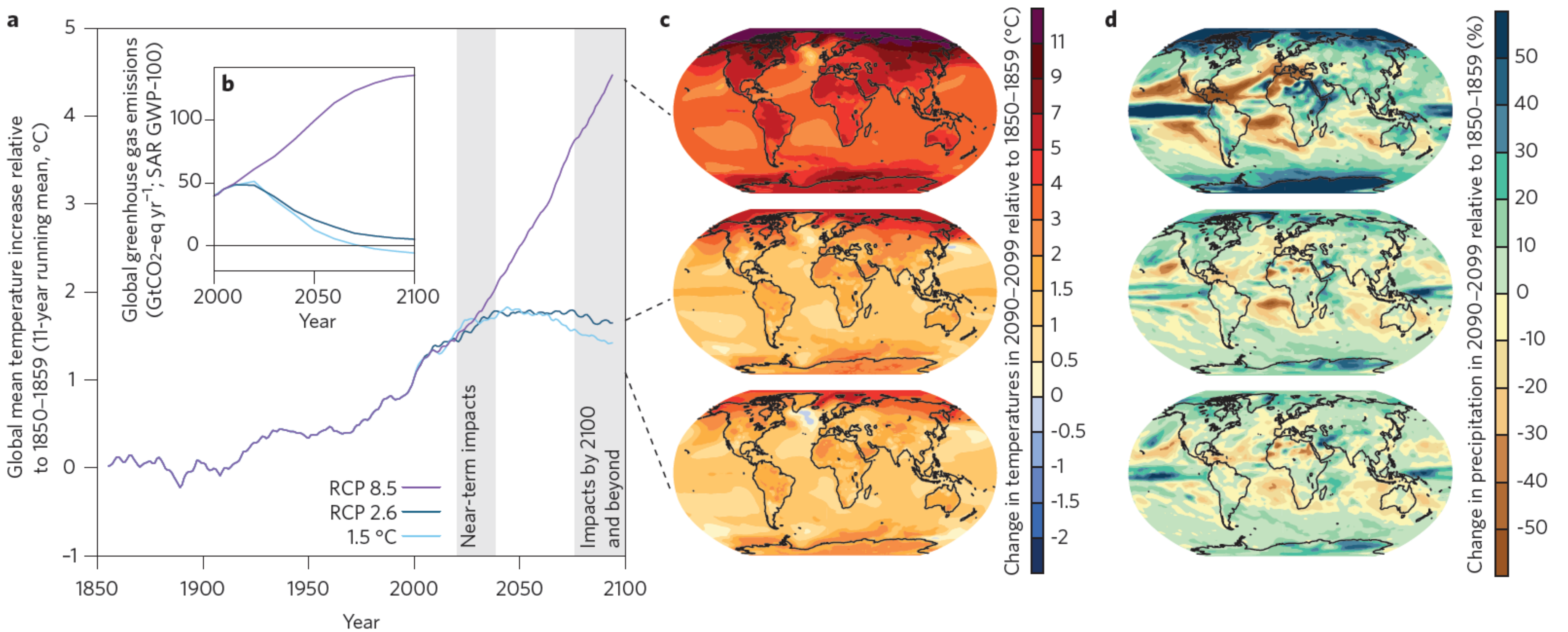
Interactions éolien-agriculture: un sujet à « défricher »

Expériences avec la rugosité en **remplaçant une culture de maïs par une culture de soja** sous une grande ferme éolienne dans le middle west (248 Mwatts, 121 turbines)



Vanderwende and Lundquist, 2015, BLM

What does it mean at local/regional scale?



Rogelj and Knutti, 2016

Statistical methods detect a change but cannot attribute it to human influence