ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Integrating changes in extreme events in scenario development

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Scenario Forum, Denver, DU, Colorado, USA; March 12, 2019

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- **What are limits to adaptability to extremes?**

2018 extremes

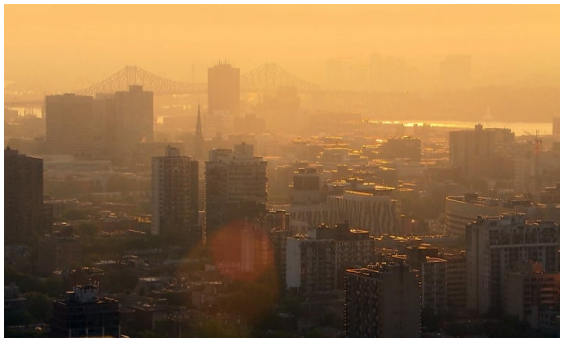
Sweden

UK

Japan

Germany

California



Canada

Relevance of extremes for scenarios

- Extremes affect ecosystems:
  - A single fire and/or drought event can destroy a large part of a forest and annihilate several years of CO_2 storage
  - Affects production of biofuels, food
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- Extremes affect people
  - Single events can kill people (e.g. 2018 heatwaves in Japan/Canada, heavy rain associated with tropical cyclones), spread diseases (e.g. cholera), and destroy livelihoods (flooding, fire)
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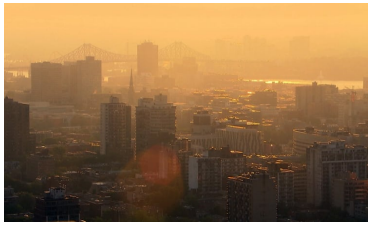

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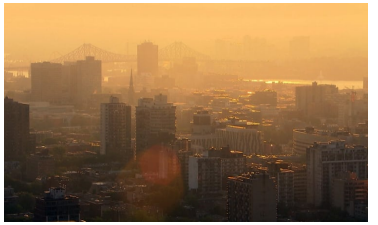
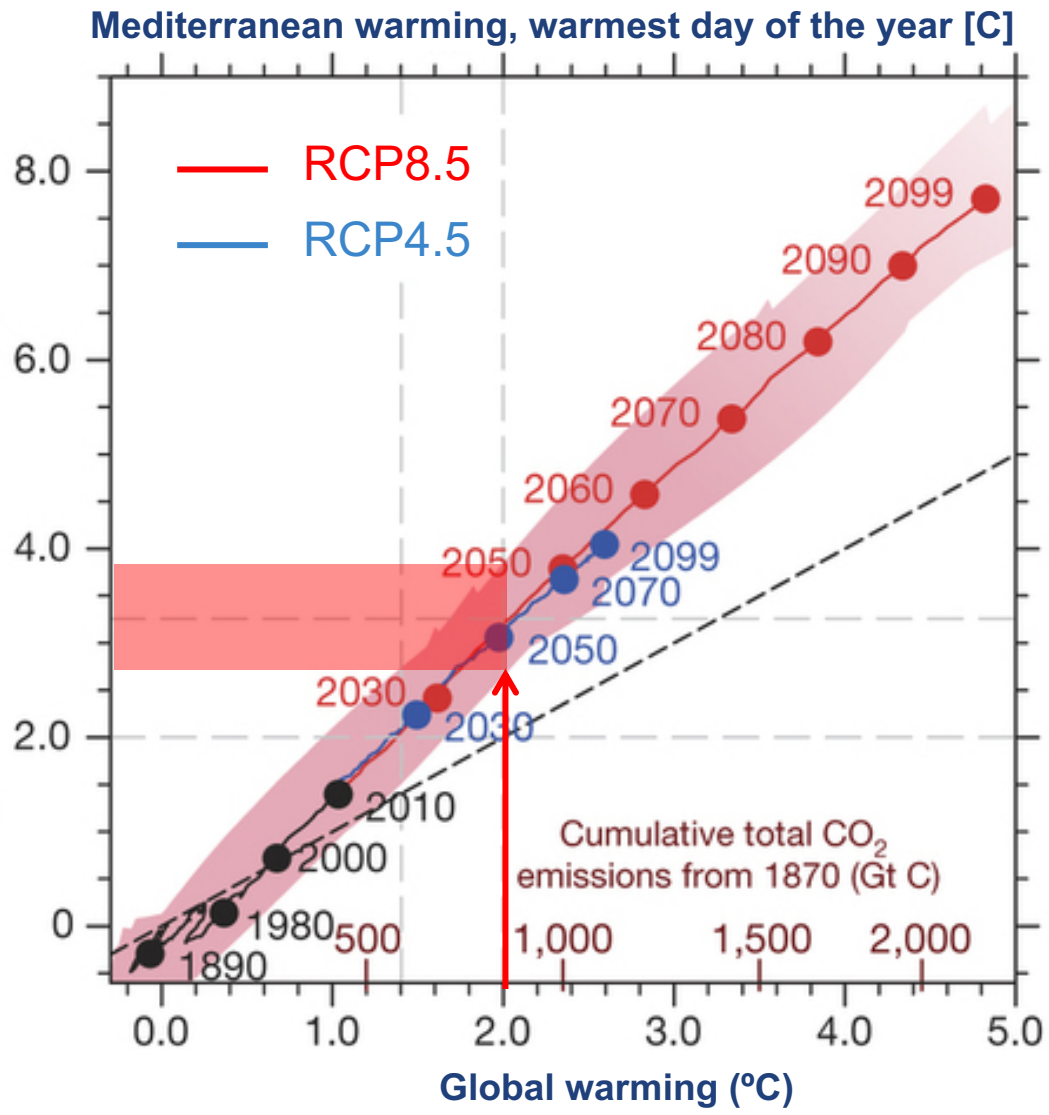


- Extremes can affect energy production and use
  - Lack of cooling for nuclear power plants during heatwaves
  - Enhanced energy demand for cooling during heatwaves

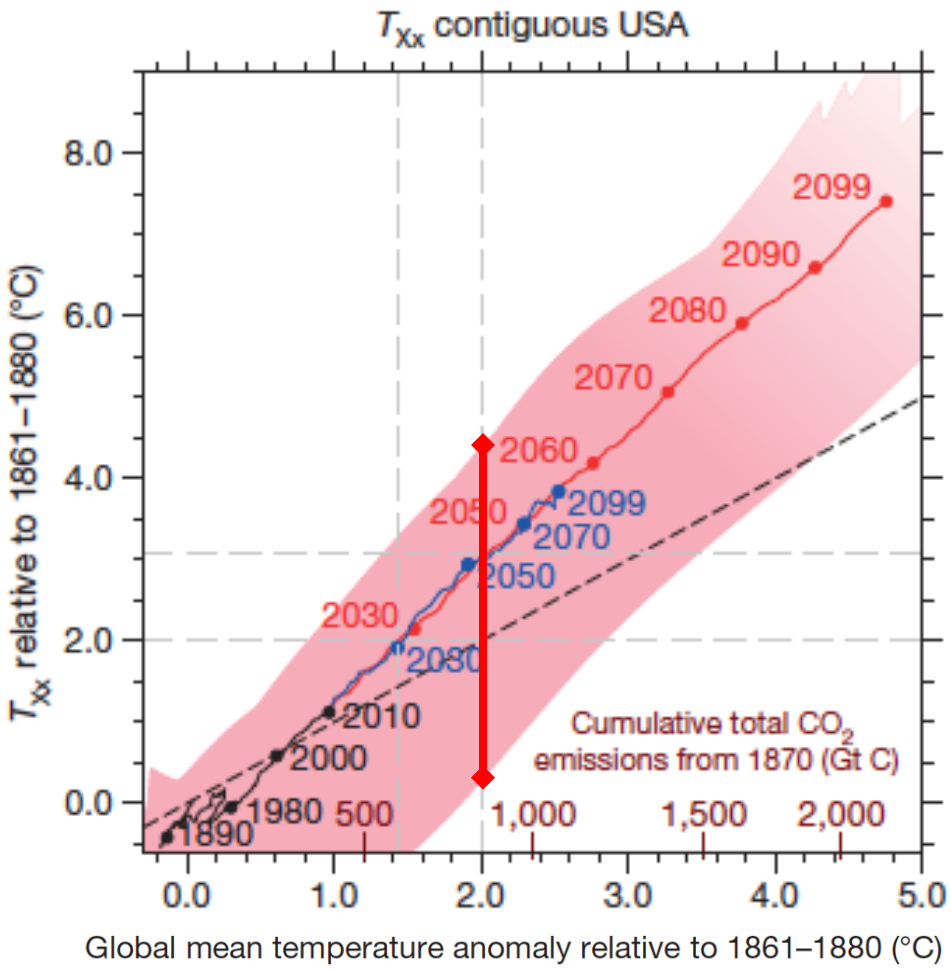
Regional extremes vs global warming

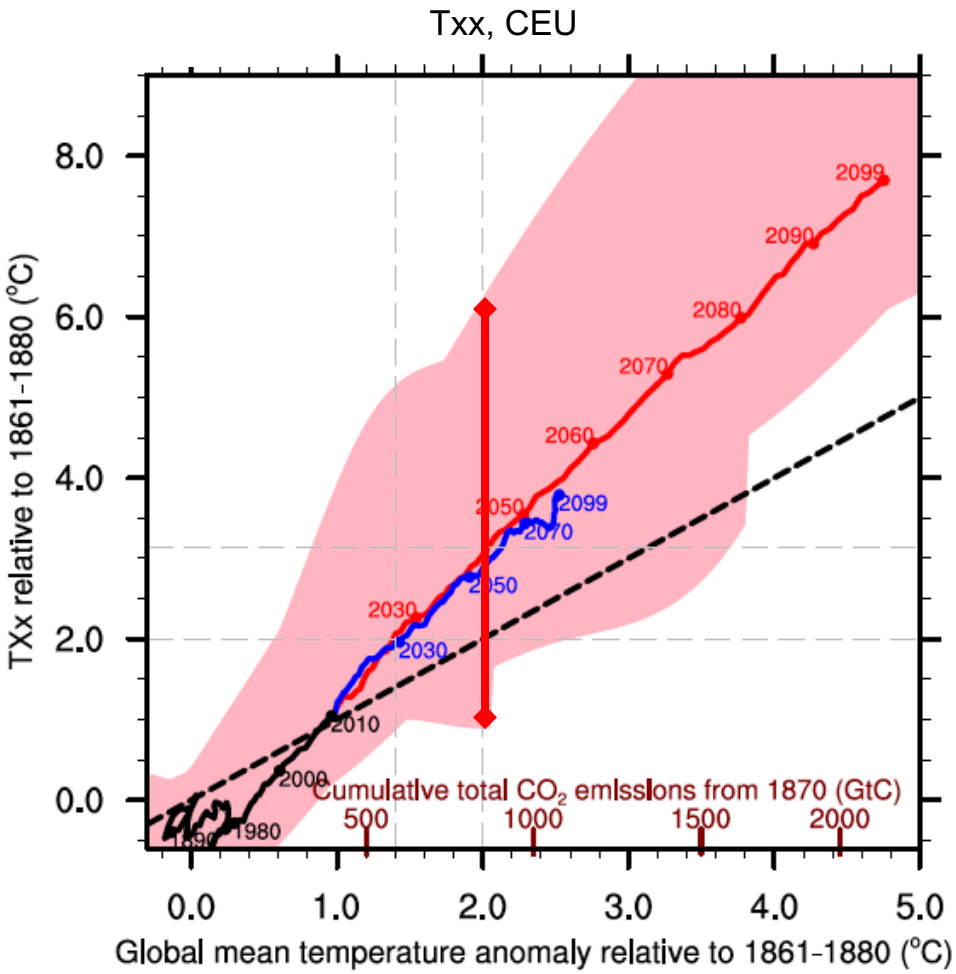


Stronger warming of extremes in land hot spots vs global temperature

(Seneviratne et al. 2016, Nature)

Complex regional scaling: Example from 2 regions





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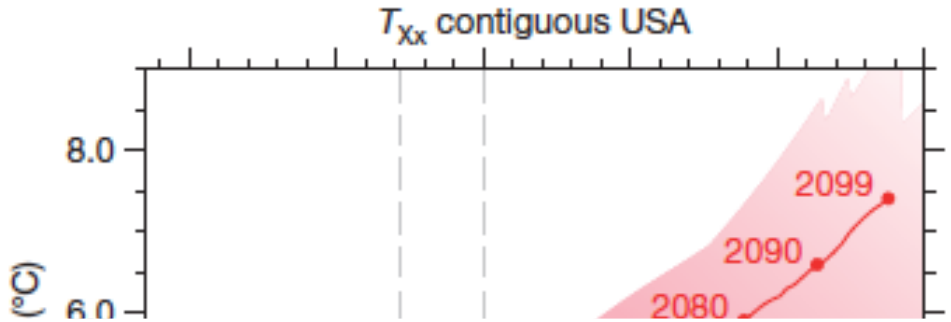
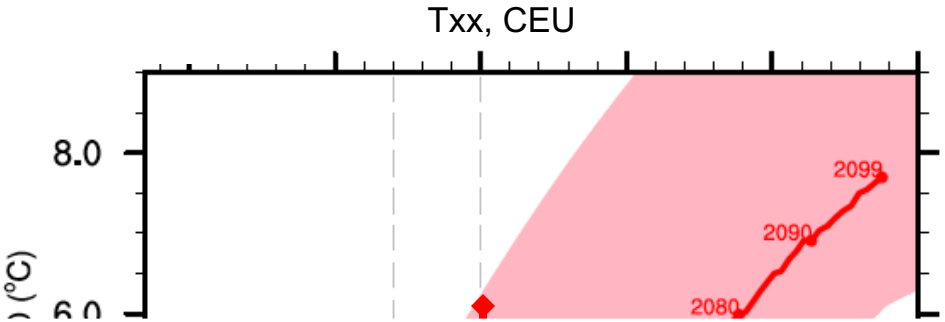




PERSPECTIVE

https://doi.org/10.1038/s41586-018-0181-4

The many possible climates from the Paris Agreement's aim of 1.5 °C warming

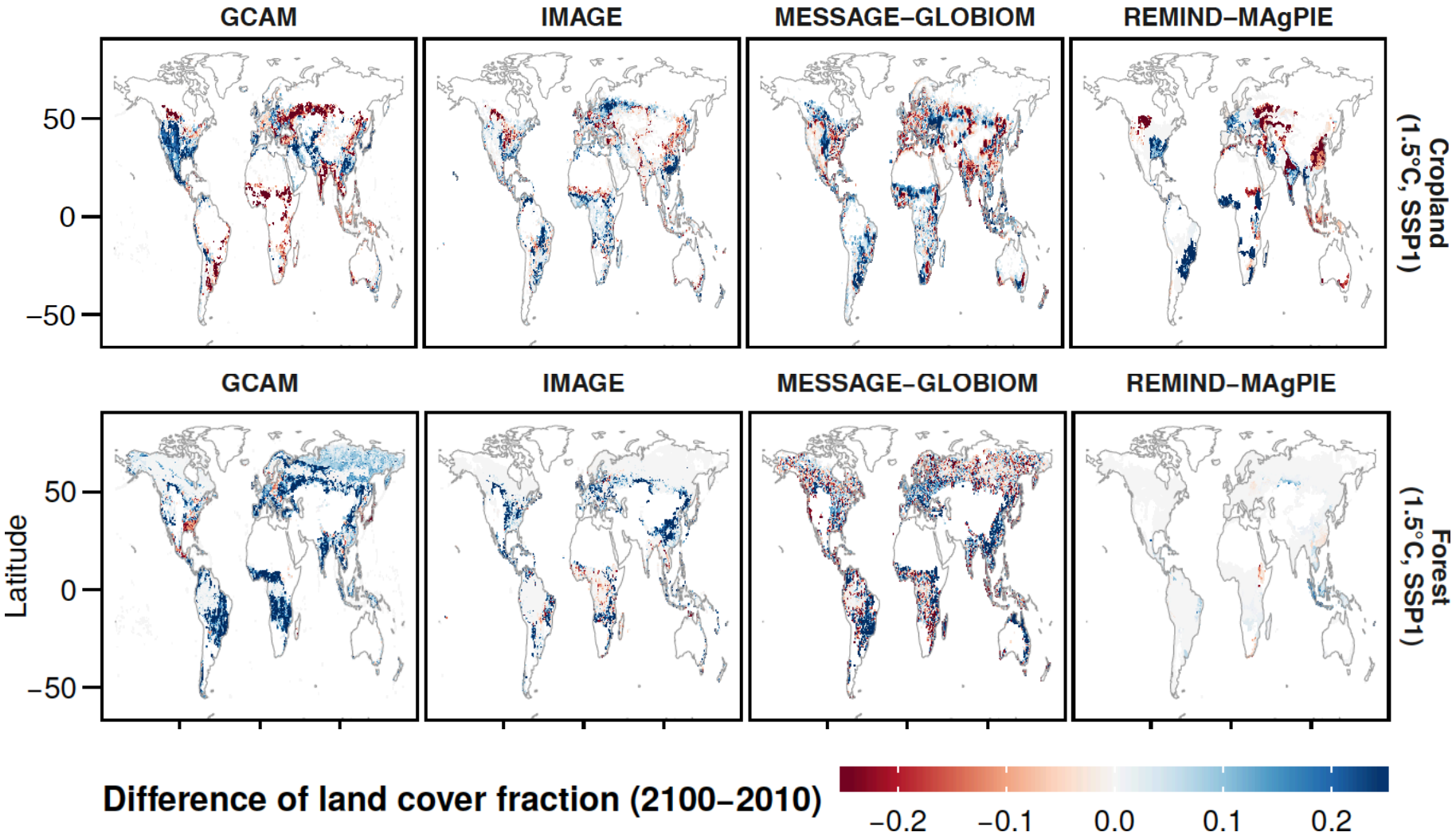
Sonia I. Seneviratne[1]*, Joeri Rogelj[1,2,3,4], Roland Séférian[5], Richard Wartenburger[1], Myles R. Allen[3], Michelle Cain[3], Richard J. Millar[3], Kristie L. Ebi[6], Neville Ellis[7], Ove Hoegh-Guldberg[8], Antony J. Payne[9], Carl-Friedrich Schleussner[10,11,12], Petra Tschakert[7] & Rachel F. Warren[13]

Also large spread at 1.5ºC global warming

(Seneviratne et al. 2018, Nature)

Land use changes in Integrated Assessment Models (1.5C)

Are these changes in land use realistic given changes in extremes?



(Seneviratne et al. 2018, Phil. Trans. Roy. Soc. A)

Do impact models correctly capture extremes? No…

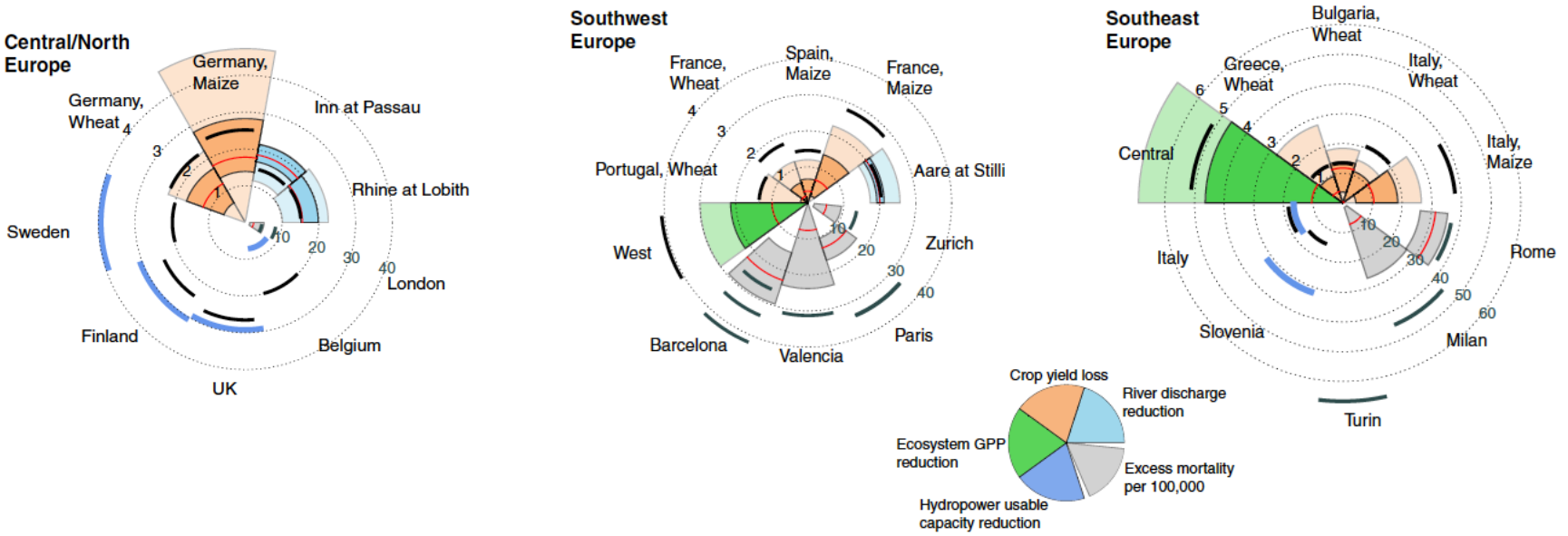
nature COMMUNICATIONS

ARTICLE

https://doi.org/10.1038/s41467-019-08745-6 OPEN

State-of-the-art global models underestimate impacts from climate extremes

Jacob Schewe et al.#



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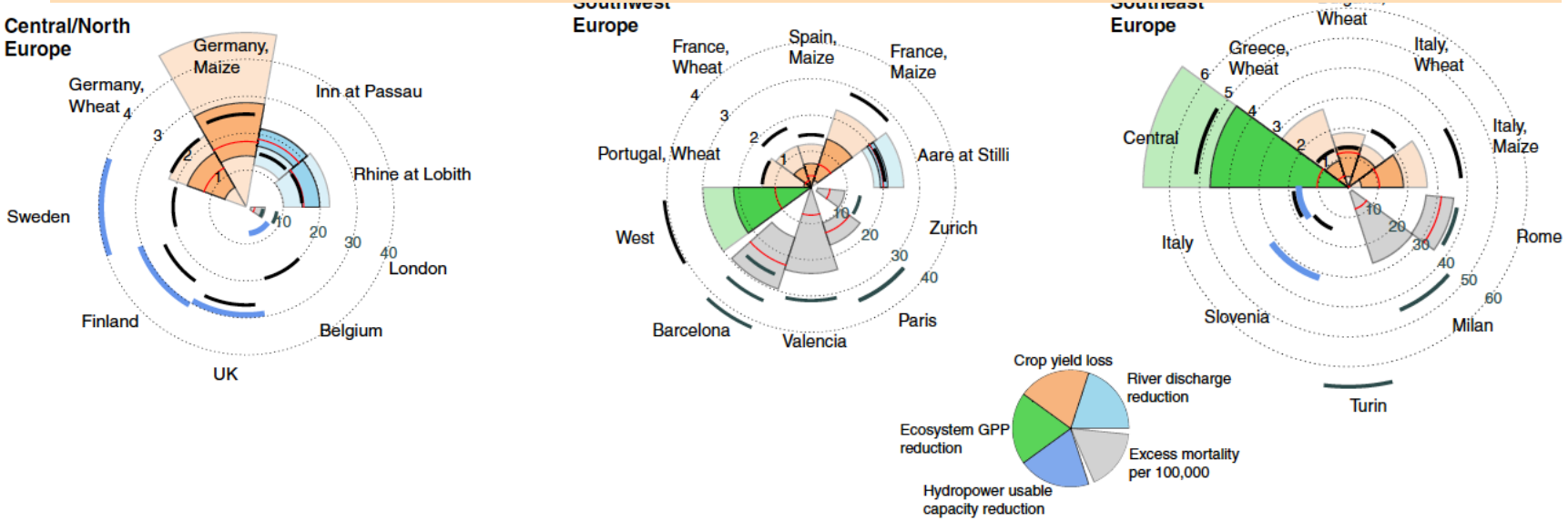
What are implications of integrated assessment models?



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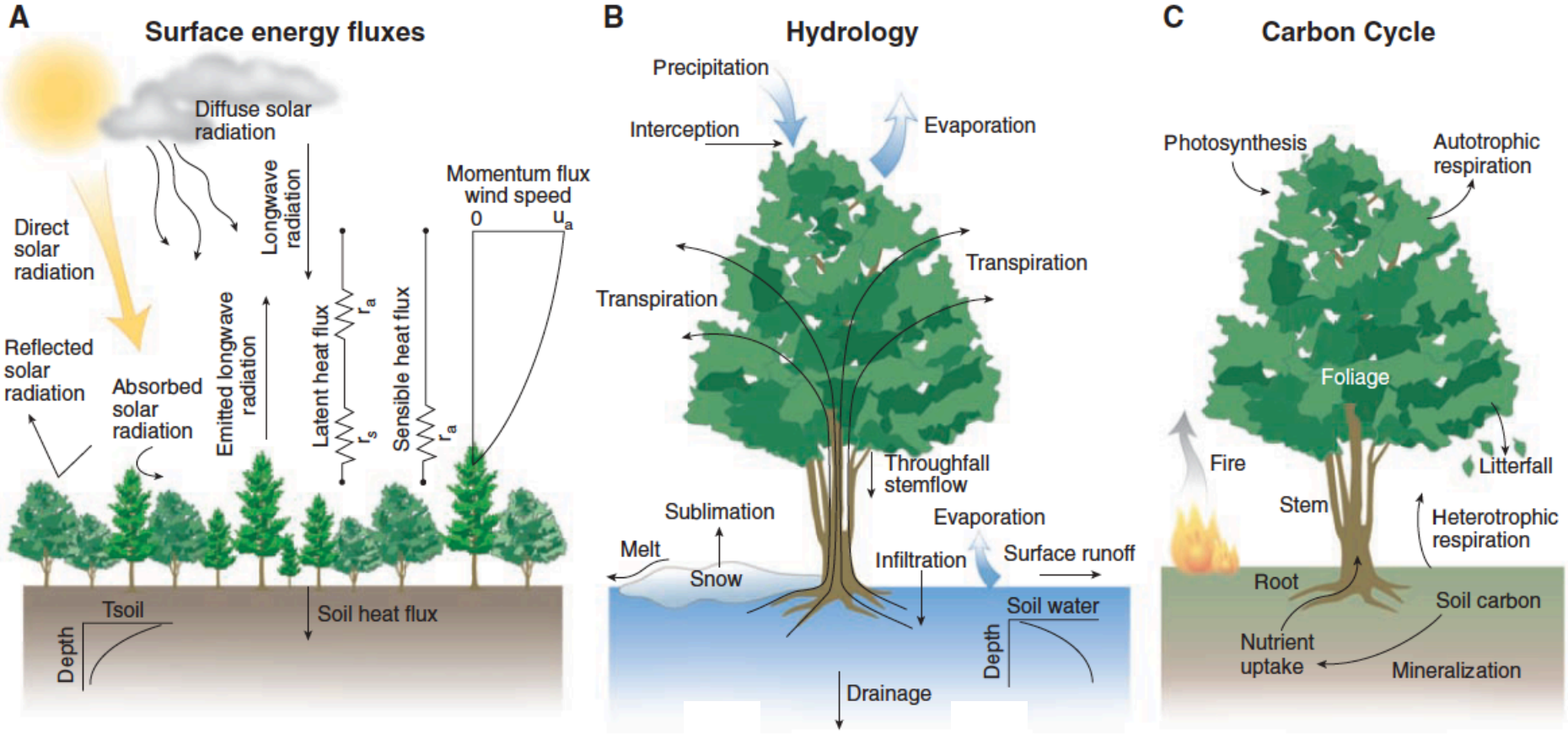
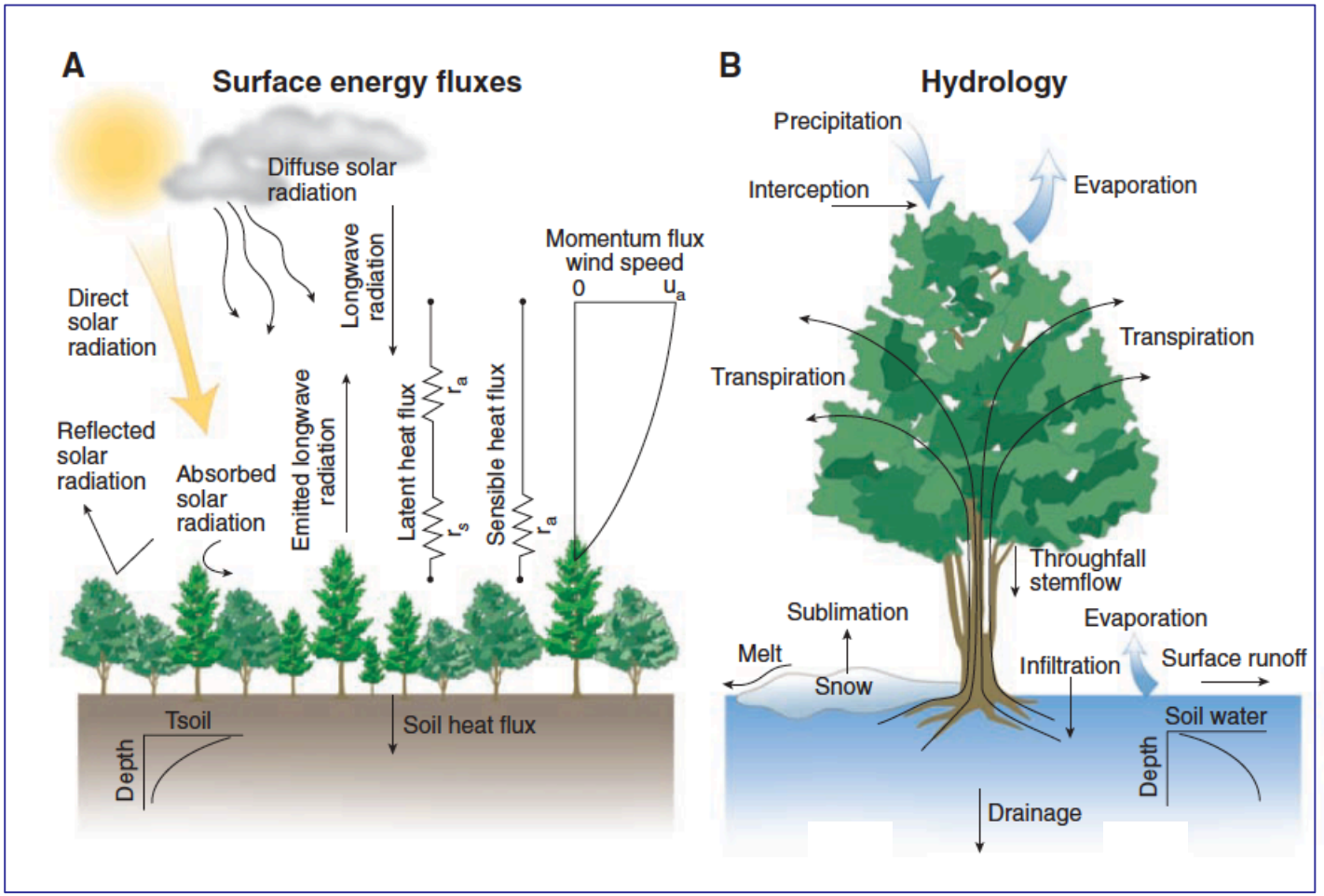
Land use/cover effects on climate



(Bonan 2008, Science)

Biophysical effects (albedo, evapotranspiration)



(Bonan 2008, Science)

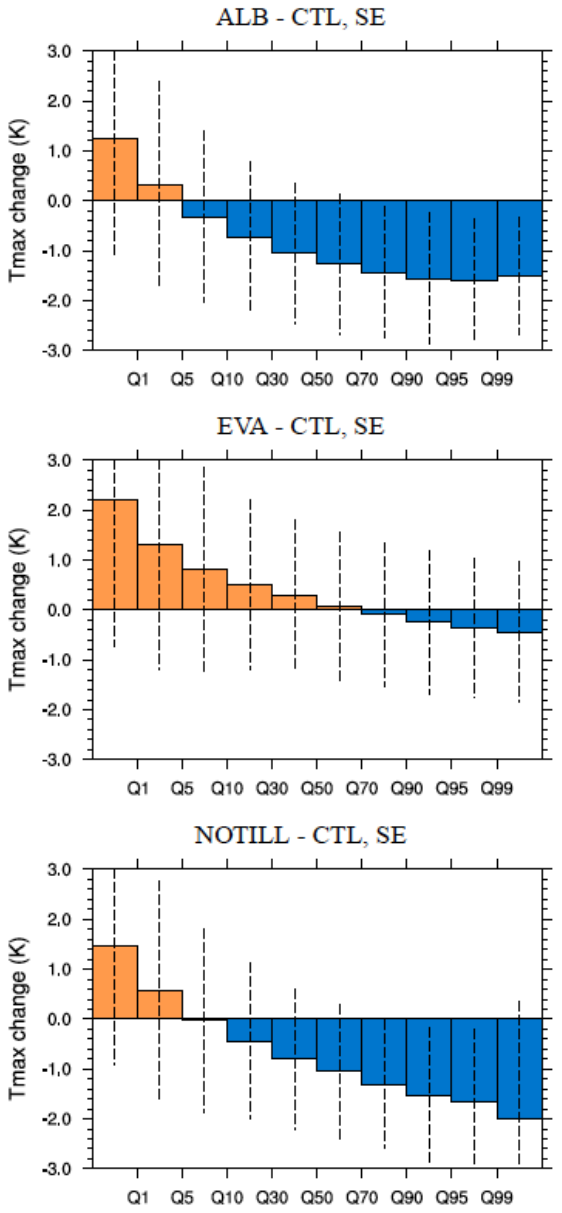
Biophysical effects of LU changes: Links to CO_2 exchanges

Substantial co-benefits (no-till farming)
Substantial trade-offs (e.g. afforestation)

Agricultural management and temperature extremes

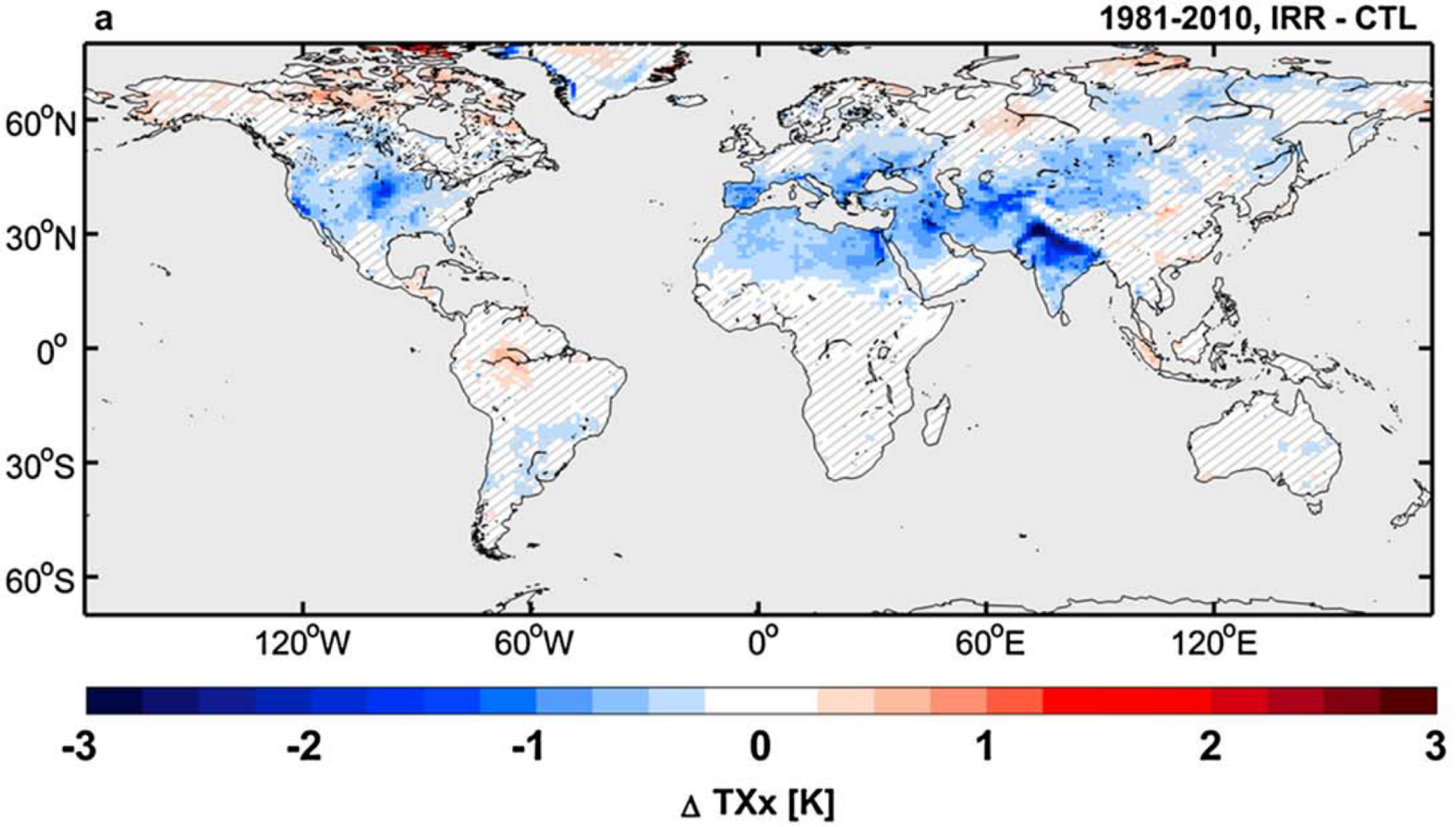
Impacts of no-till farming (albedo, evaporation) on regional temperature extremes:

Preferential cooling of hot extremes both from albedo and evaporation effects (up to 1-2C)!



(Davin et al. 2014, PNAS)

Present-day impacts of irrigation

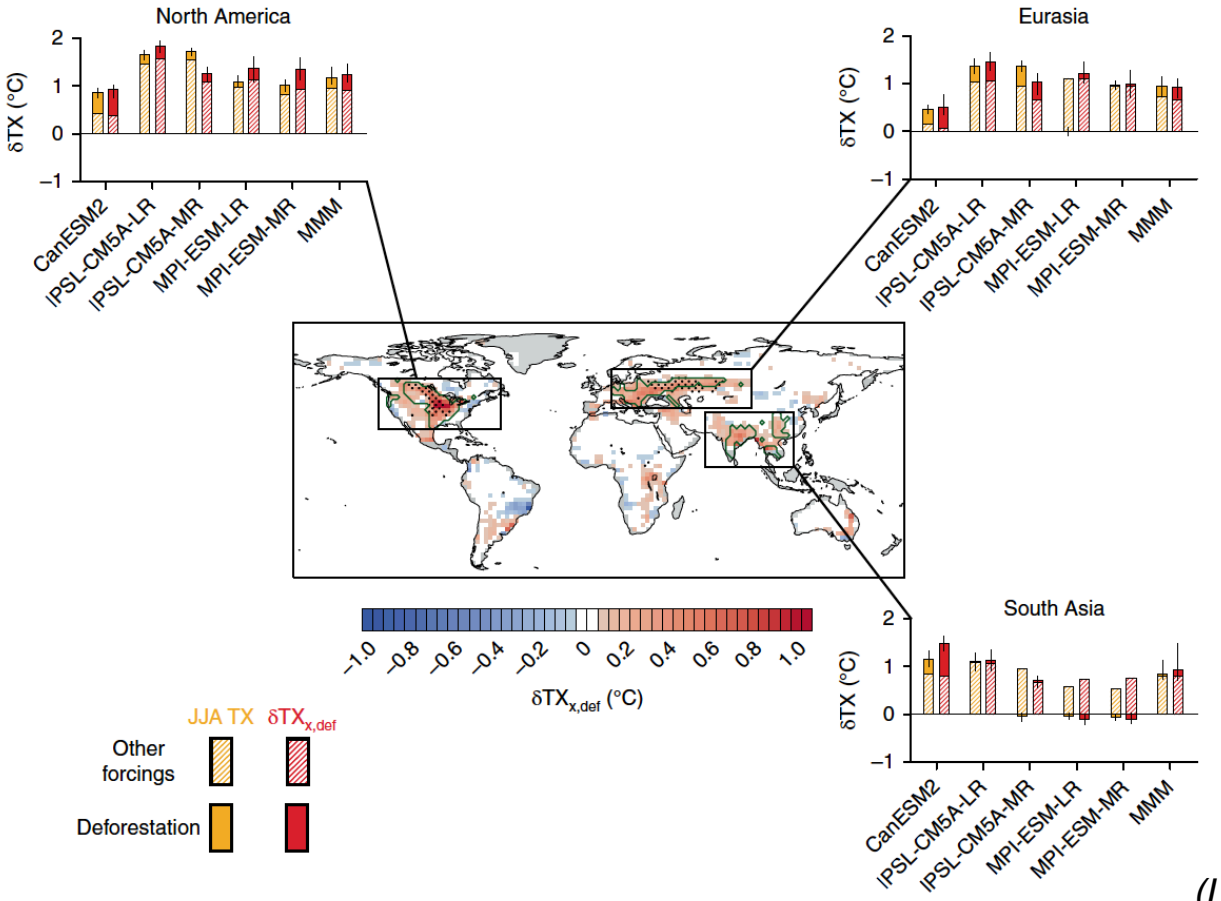


(Thiery et al. 2017, JGR)

Deforestation and temperature extremes

Historical deforestation locally increased the intensity of hot days in northern mid-latitudes

Quentin Lejeune[1,3*], Edouard L. Davin[1], Lukas Gudmundsson[1], Johannes Winckler[2] and Sonia I. Seneviratne[1]



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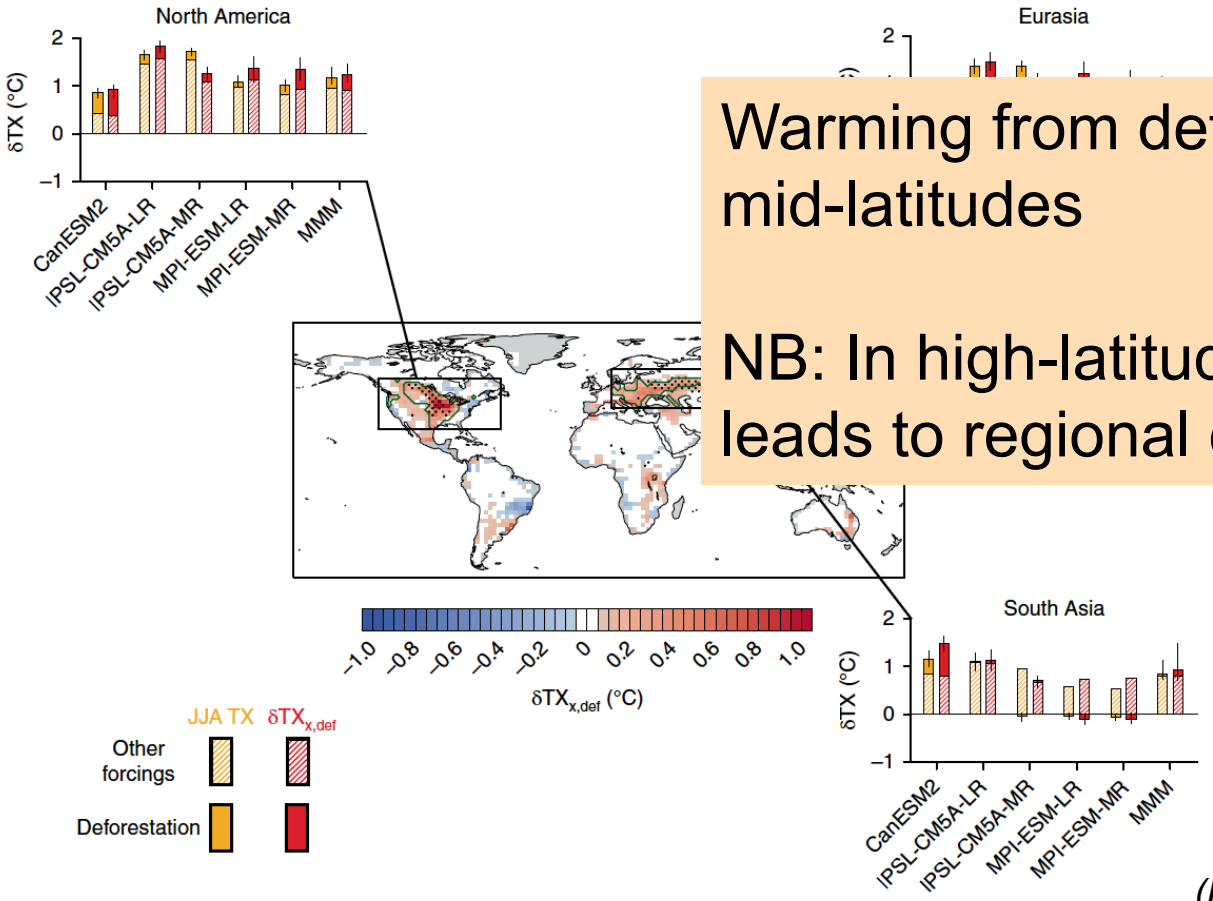


Warming from deforestation in northern mid-latitudes

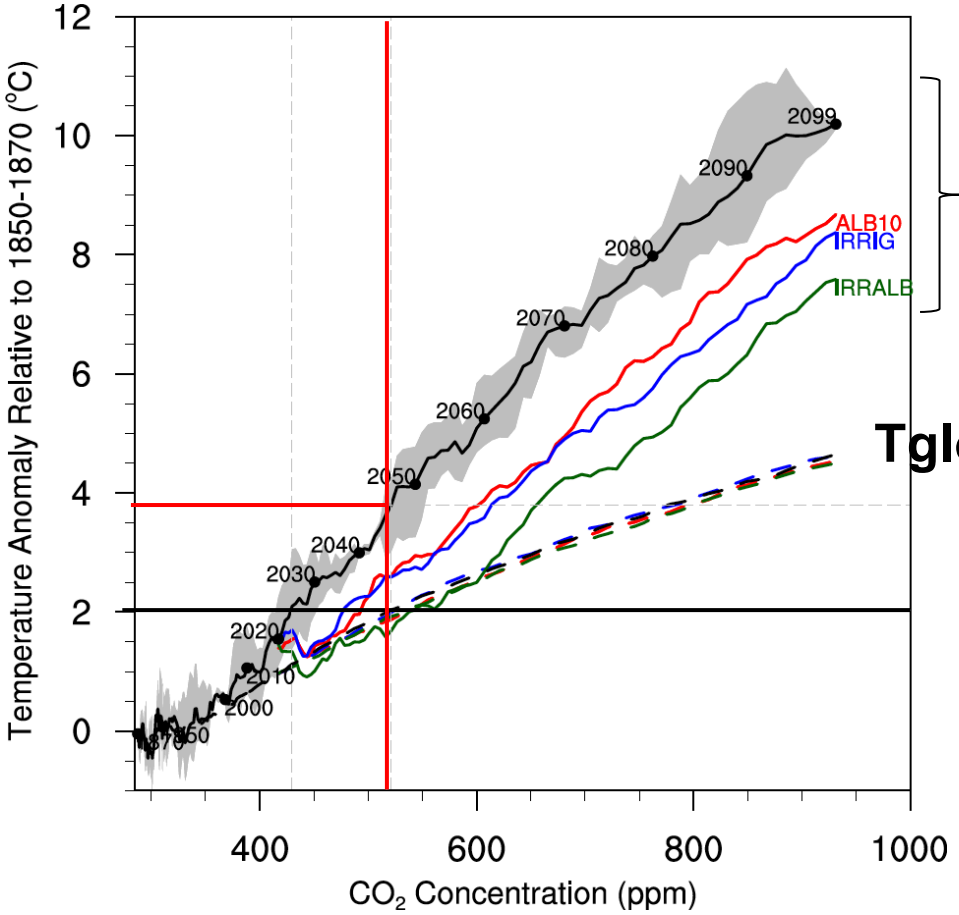
NB: In high-latitude winter, deforestation leads to regional cooling!

(Lejeune et al. 2018, Nature Climate Change)

Biophysical effects of land use changes: Projections


Effects of albedo changes (+0.1) and irrigation on regional temperature extremes (CESM simulations)

Central North American warming, hottest day of the year [C]



TXx (hottest day of year): Reference run and Land use scenarios (albedo increases, irrigation, and combination)

Tglob

(Hirsch et al. 2017, JGR)

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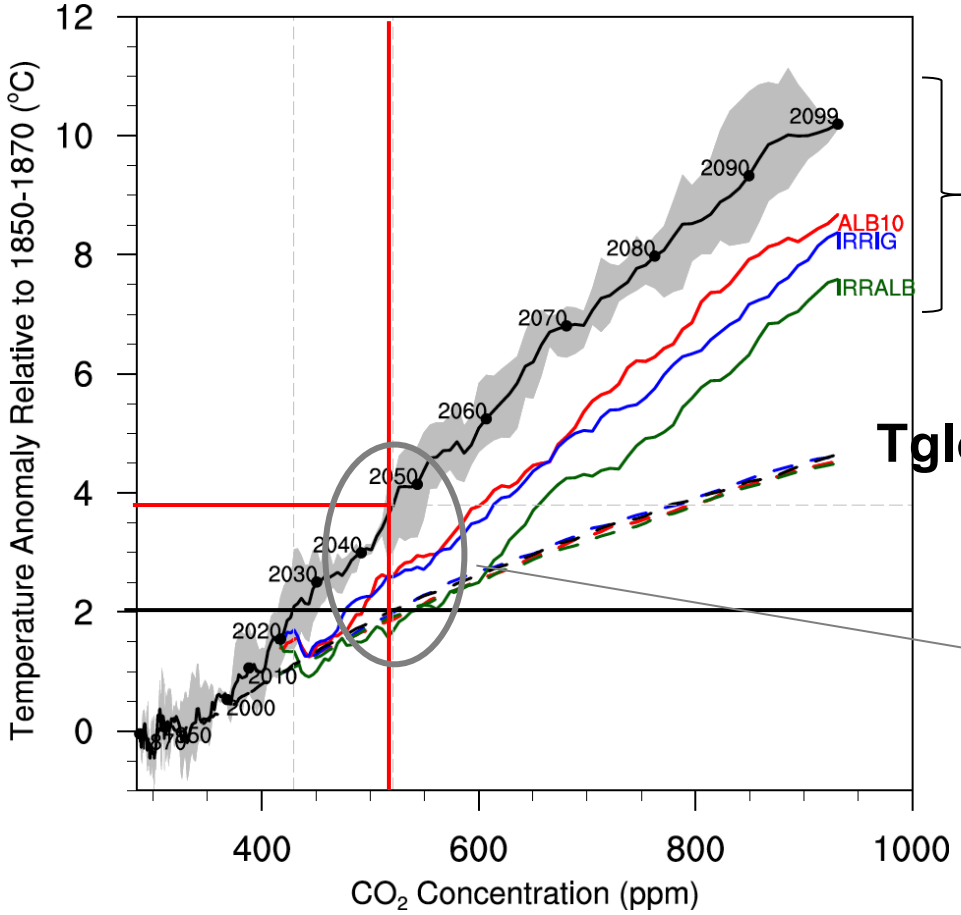

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Tglob

Land use effects are particularly relevant for low-emissions scenarios!

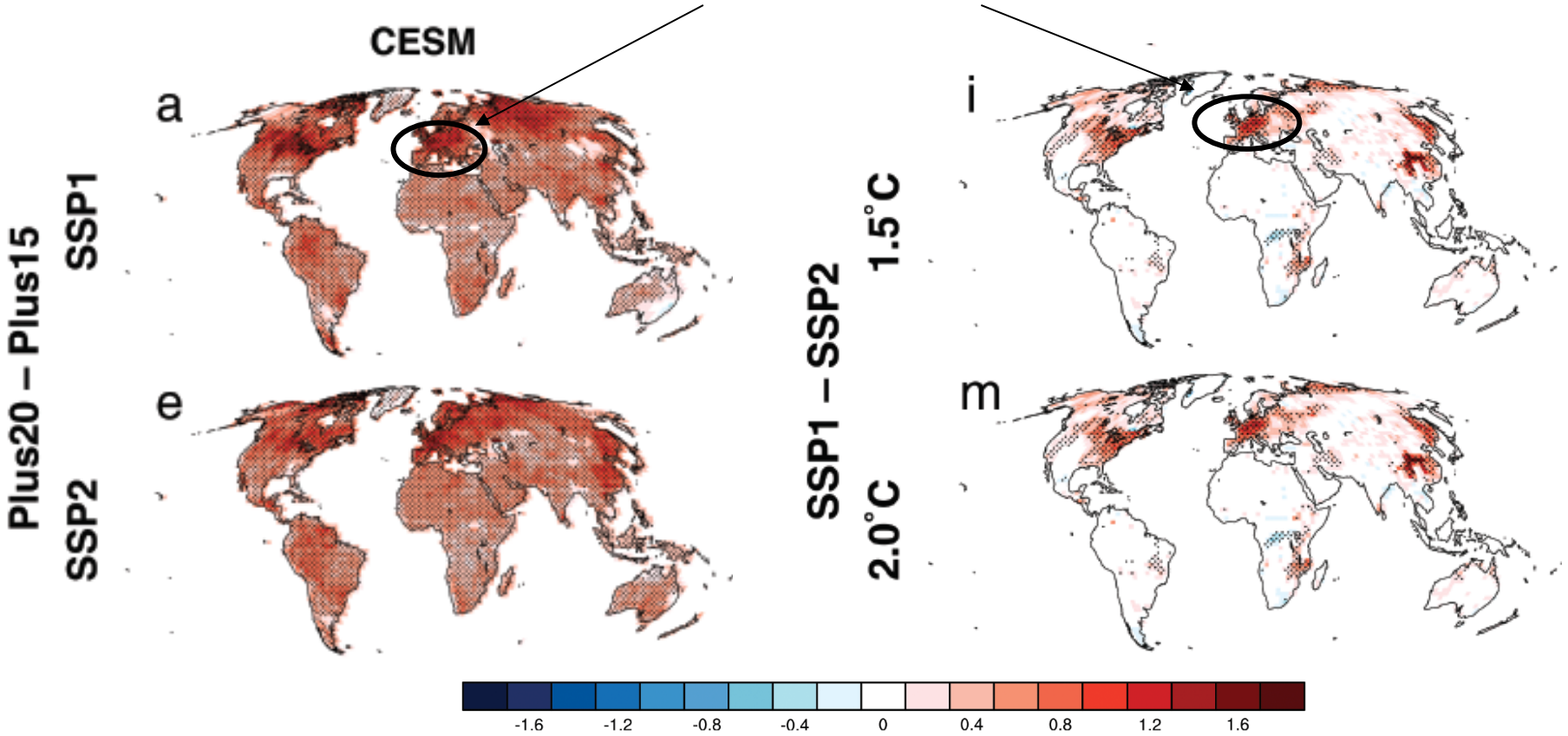
But not included in Integrated Assessment Models…

(Hirsch et al. 2017, JGR)

Land use changes in Integrated Assessment Models (1.5C)

Differences in temperature of yearly hottest day (TXx) based on IMAGE land use scenarios:

Regionally, differences in land use (SSP1,SSP2) can have as much impact as difference in global warming of 0.5ºC (2ºC,1.5ºC)



(Hirsch, Guillod, et al. 2018, Earth Future)

How can we accelerate progress?

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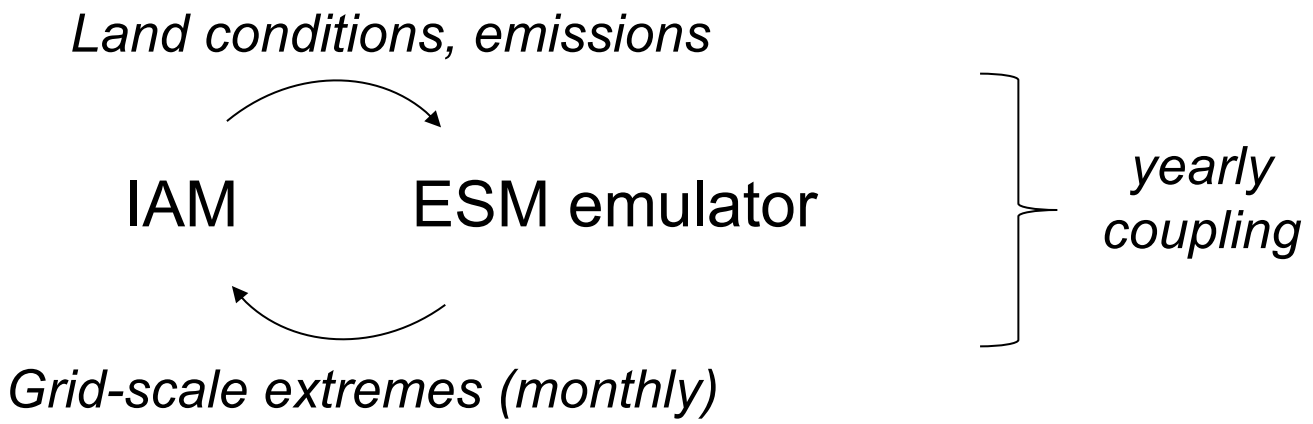

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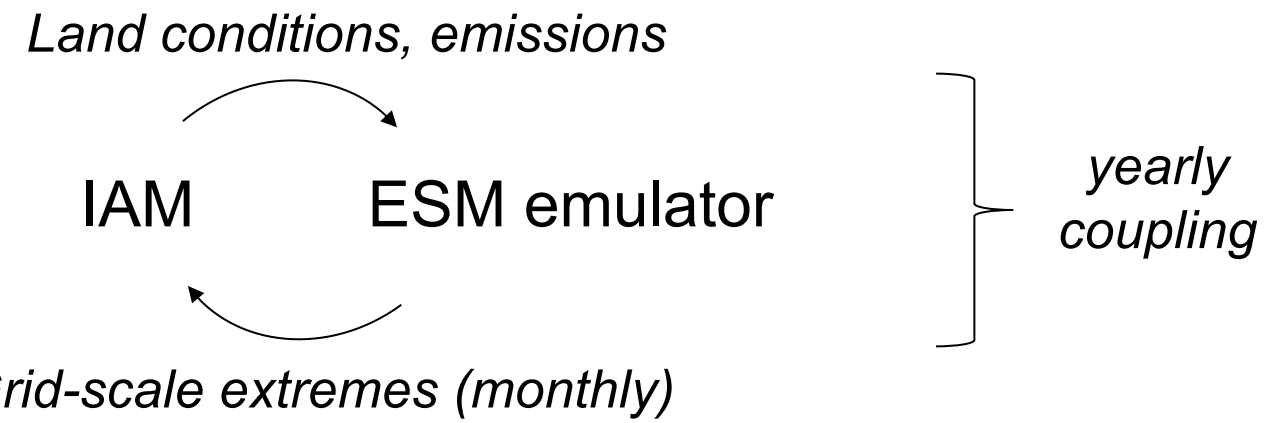
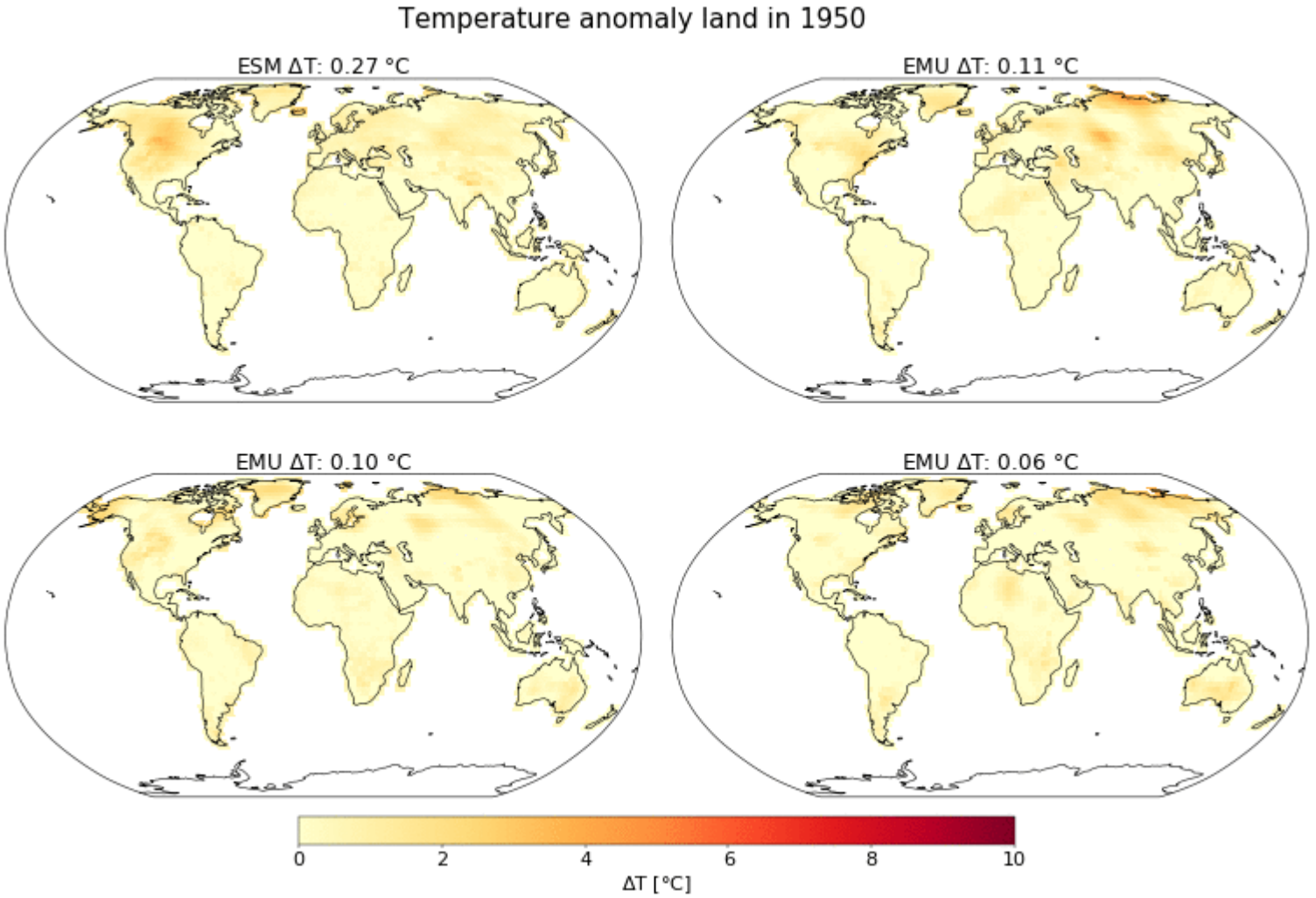
Expands searchable/ optimizable space



An ESM emulator including spatial variability



Including precipitation, extremes, ….?

(Lea Beusch, ETH Zurich)

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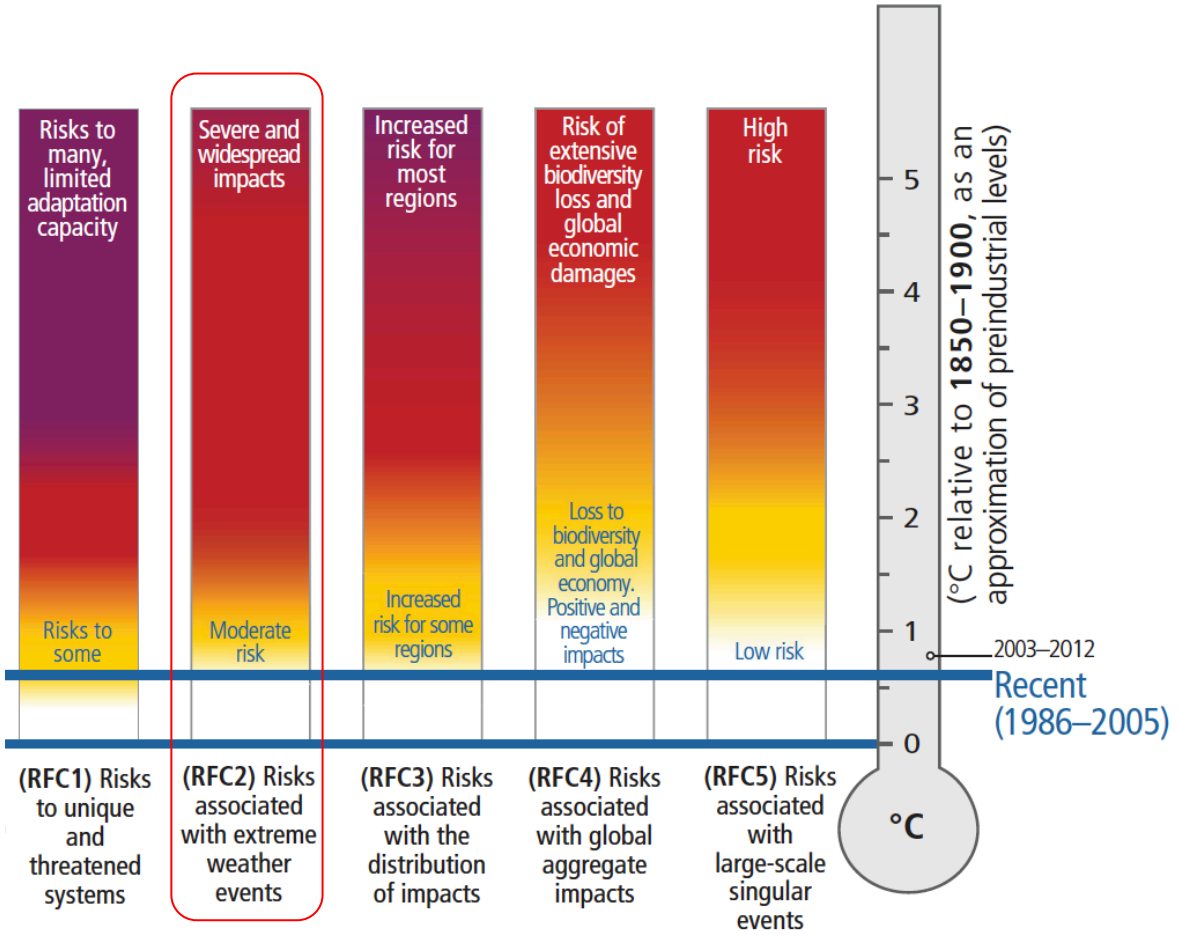
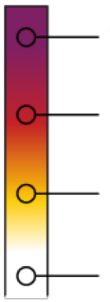
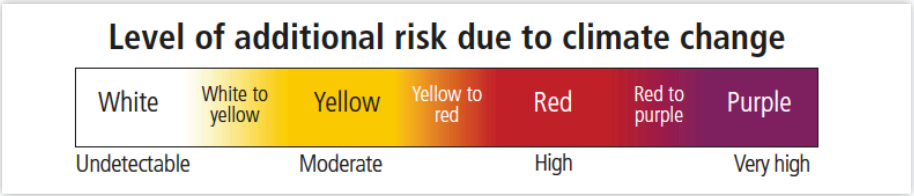
Reason for concern #2





Purple indicates very high risks of severe impacts/risks and the presence of significant irreversibility or the persistence of climate-related hazards, combined with limited ability to adapt due to the nature of the hazard or impacts/risks.
Red indicates severe and widespread impacts/risks.
Yellow indicates that impacts/risks are detectable and attributable to climate change with at least medium confidence.
White indicates that no impacts are detectable and attributable to climate change.



(AR5, WG2, Chapter 19)

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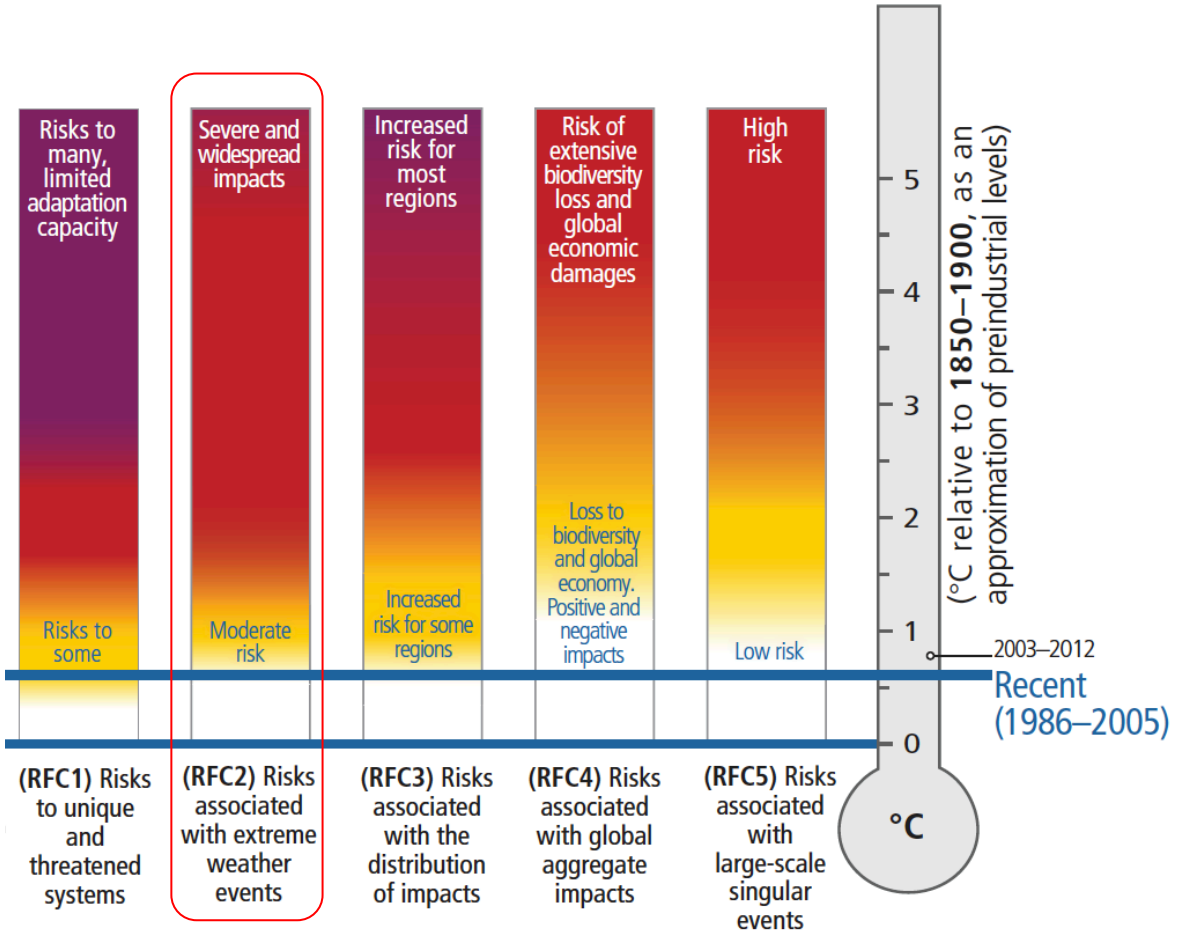

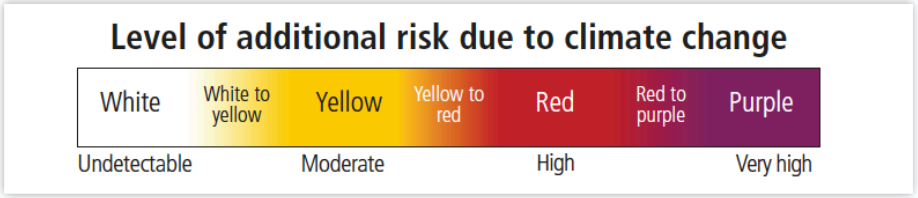

Are there no limits to adaptability below +6ºC?

How about compound events, food security, large-scale conflicts…

Should be part of scenario development

(AR5, WG2, Chapter 19)

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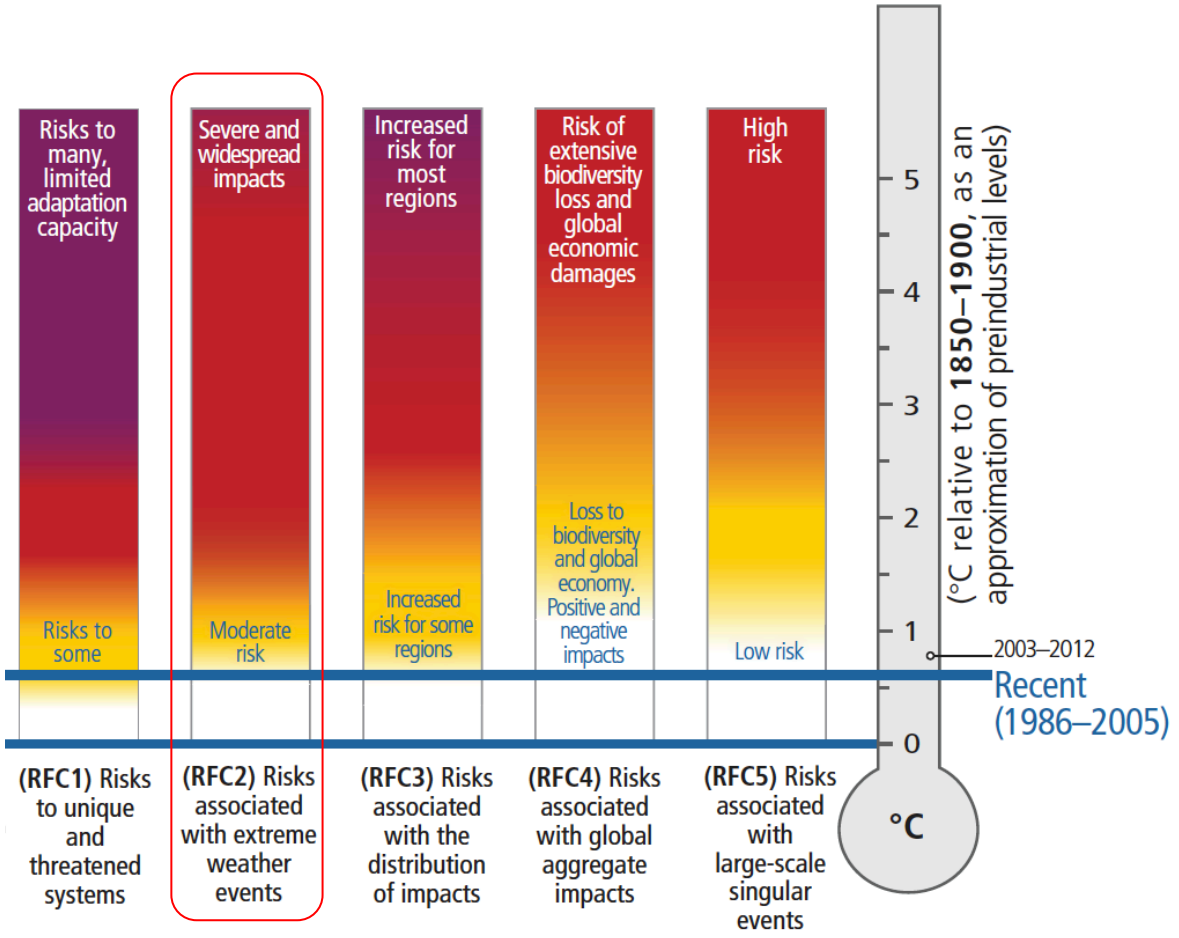

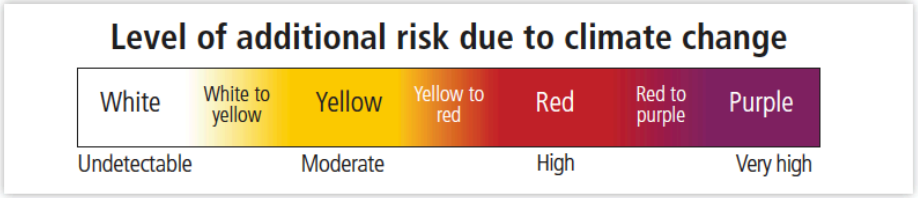

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Is a +4ºC scenario "realistic"?

(AR5, WG2, Chapter 19)

Conclusions and outlook

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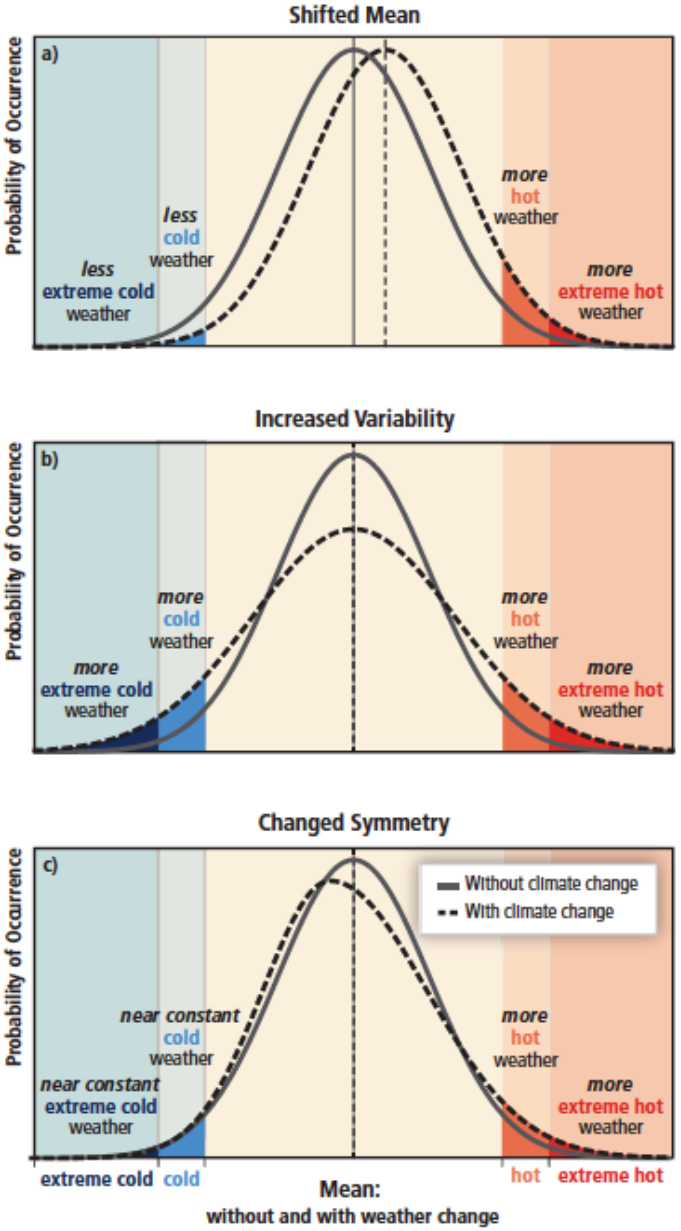
- **New frontier for research on scenario development and IPCC WG1-WG2-WG3 integration!**

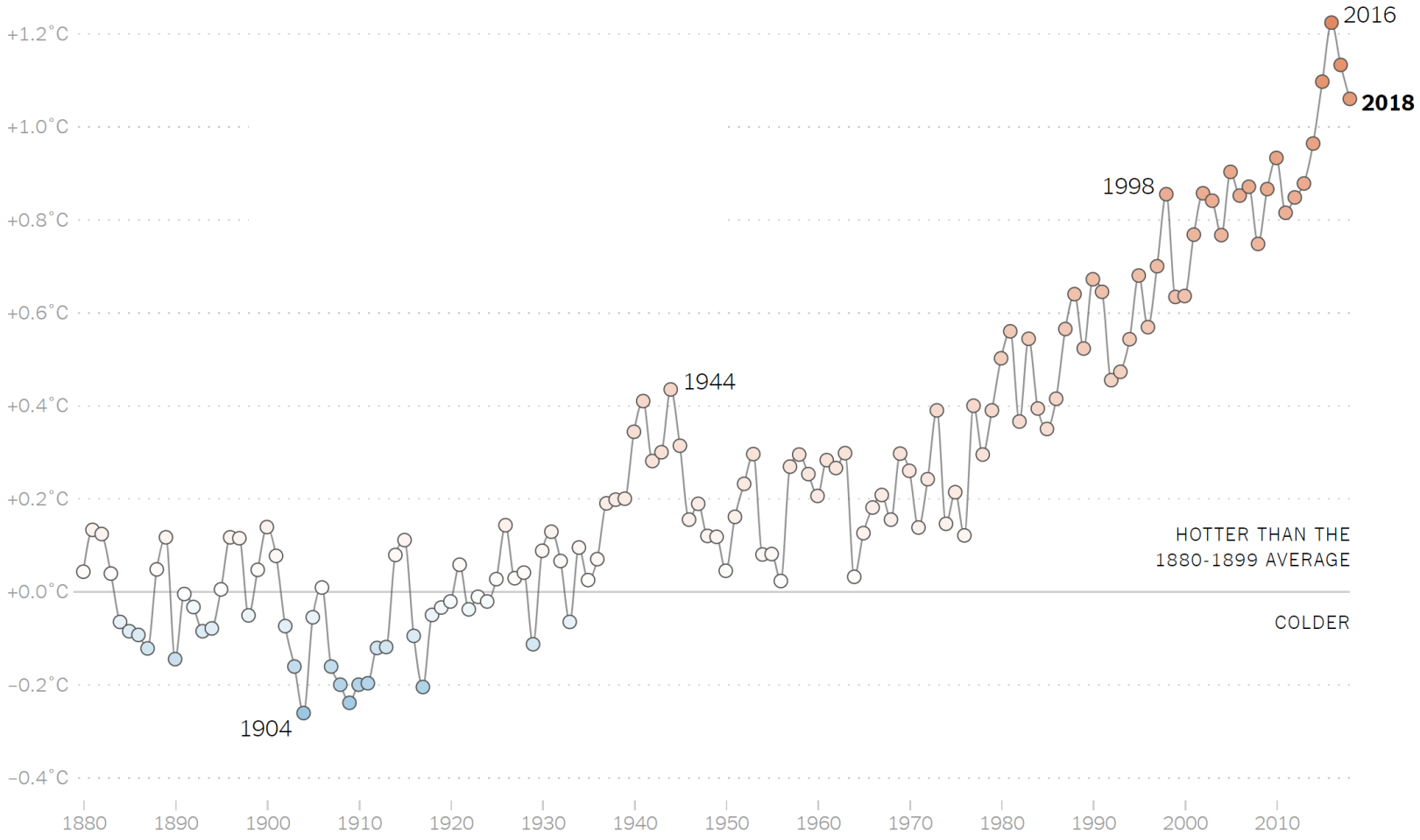
Extremes vs mean



How different are changes in extremes from changes in mean?

(IPCC SREX, 2012)

Was 2018 extreme? In terms of global mean temperature it followed the overall trend



Source: NASA | By The New York Times

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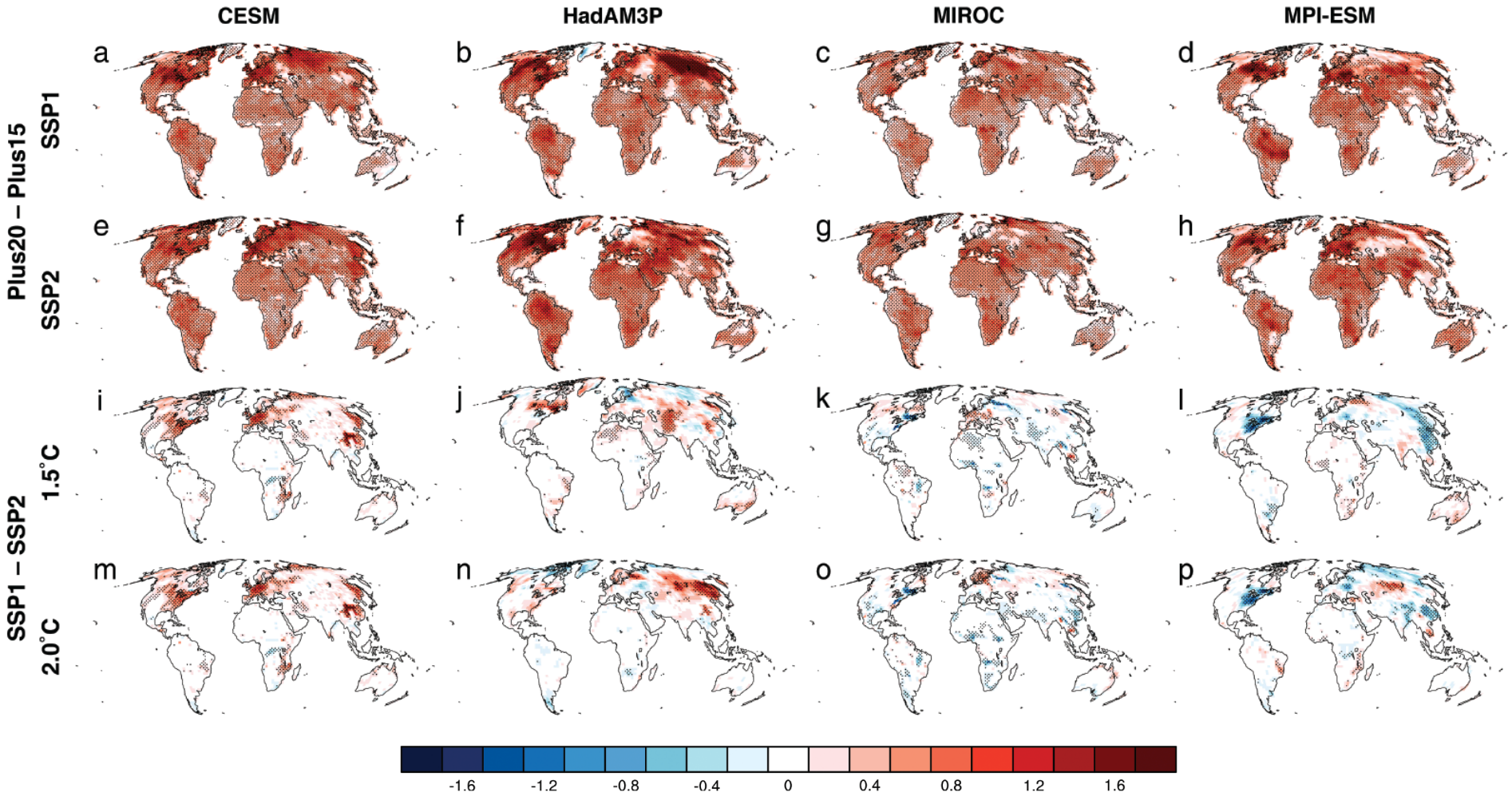

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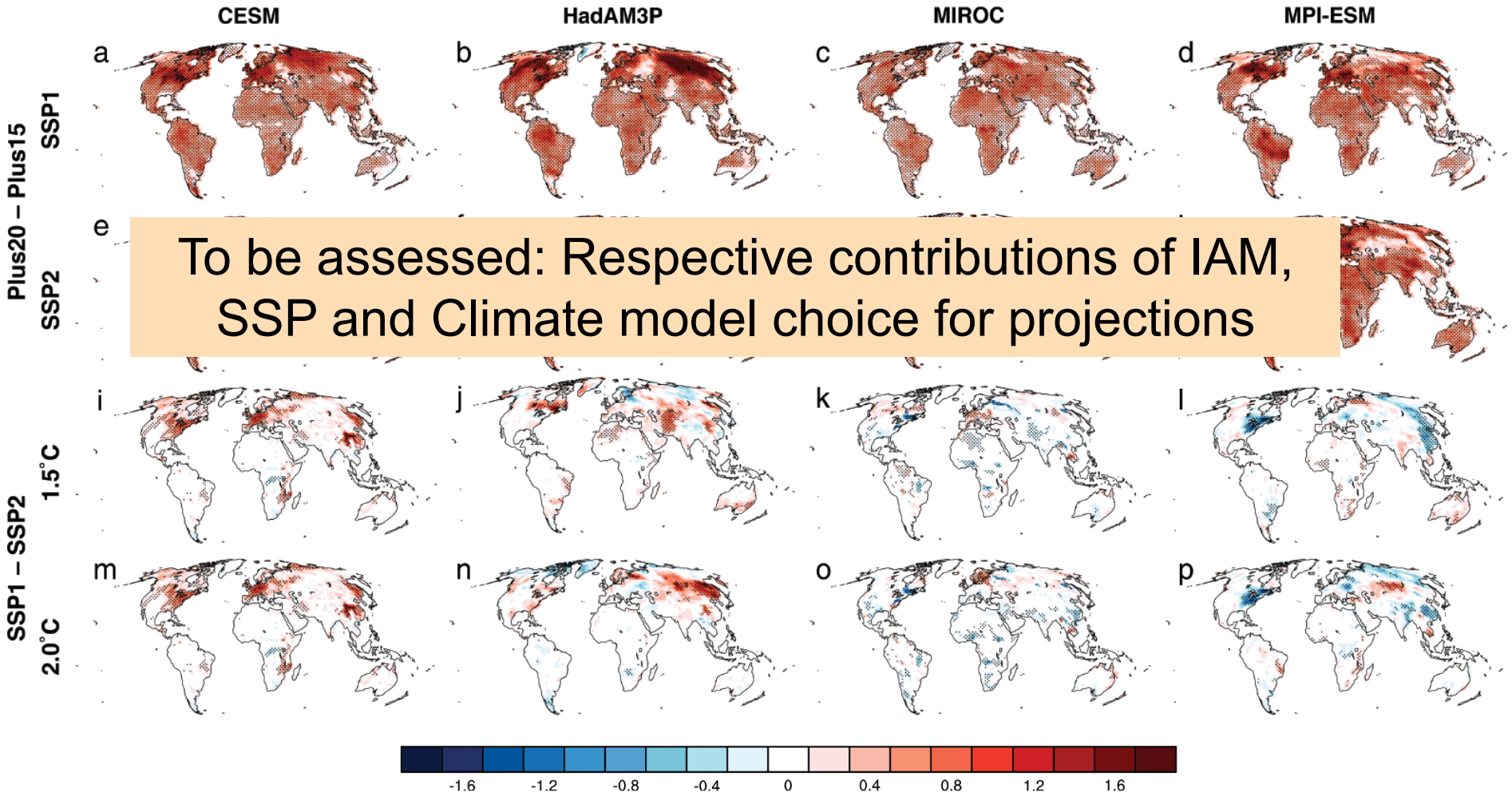

To be assessed: Respective contributions of IAM, SSP and Climate model choice for projections

(Hirsch, Guillod, et al. 2018, Earth Future)

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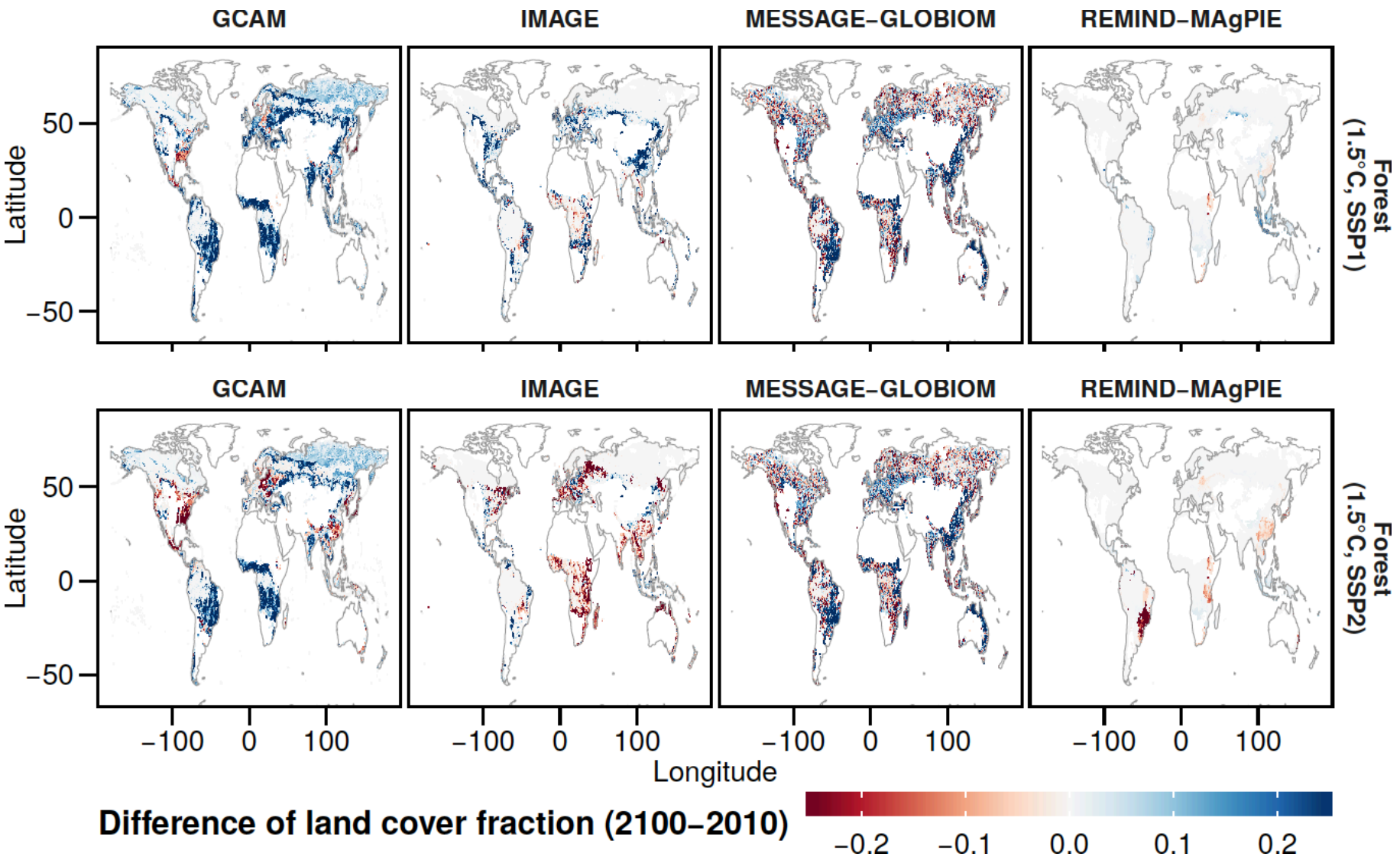

(Seneviratne et al. 2018, Phil. Trans. Roy. Soc. A)