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**OESCHGER CENTRE
CLIMATE CHANGE RESEARCH**

Coloquios Paco Ynduráin 2014

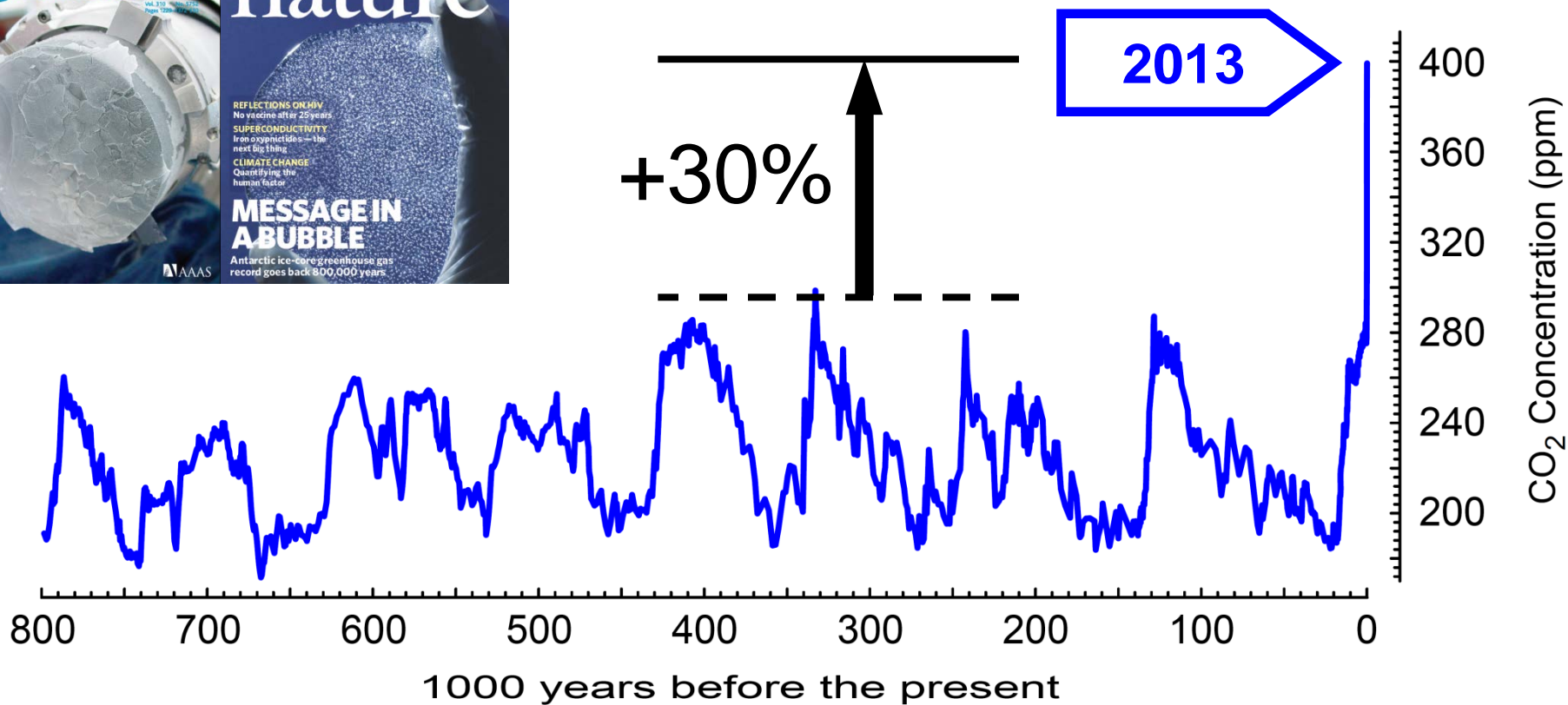
Climate Change: Too late for 2°C?

Thomas Stocker

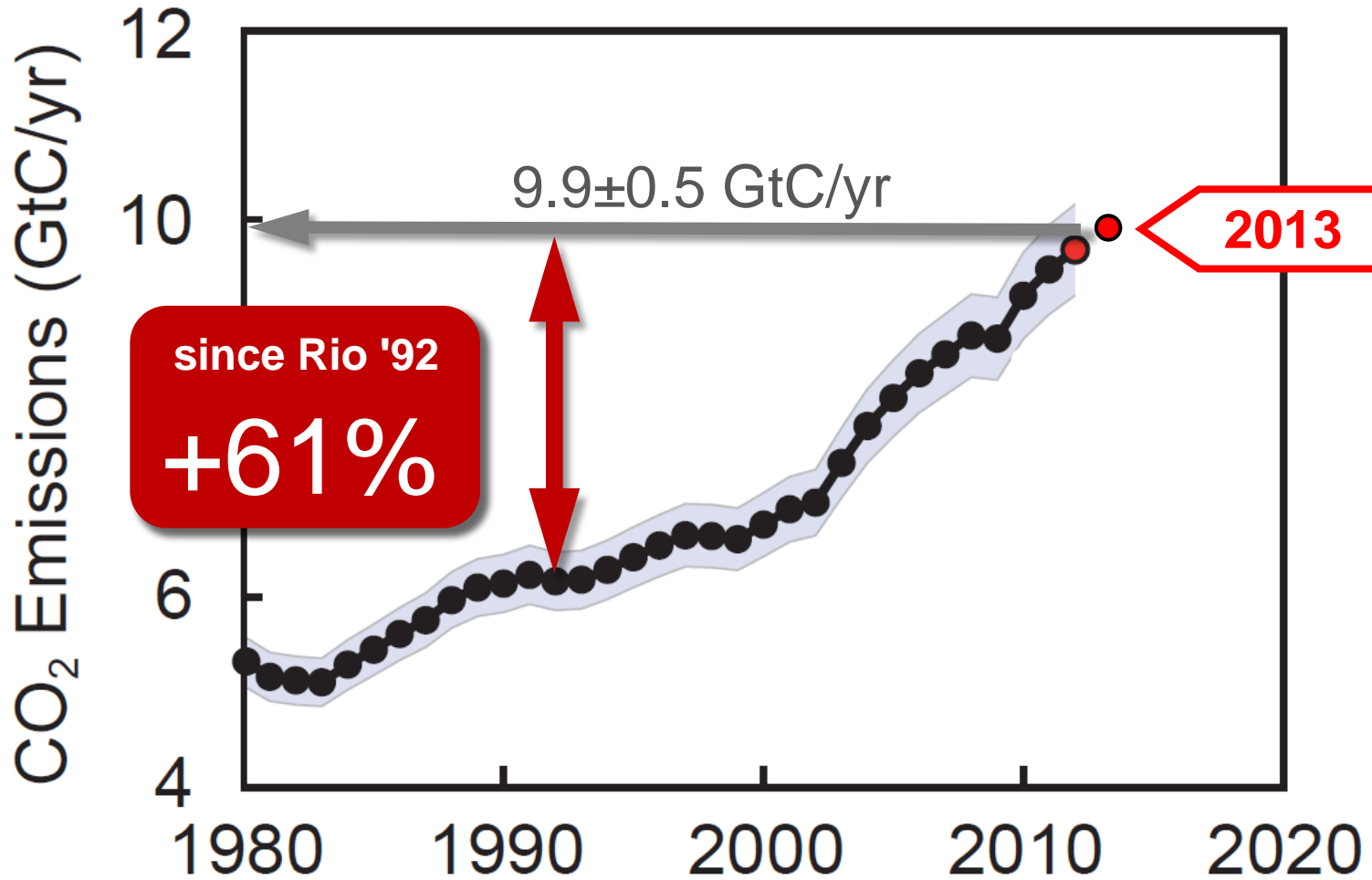
Climate and Environmental Physics, University of Bern

1. Climate Change: The IPCC 5th Assessment
2. Climate Instabilities: What are the risks?
3. Climate Targets: Too late for 2°C ?

Unprecedented: CO₂ of the past 800,000 years



Unprecedented: CO₂ Emissions by human activity

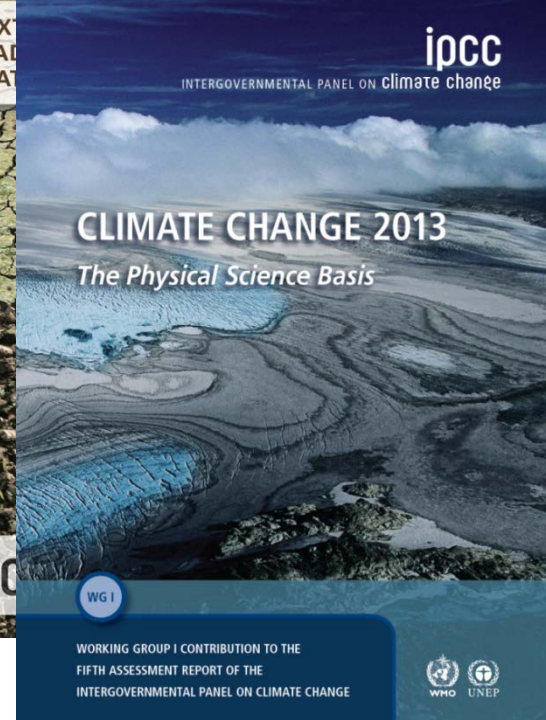
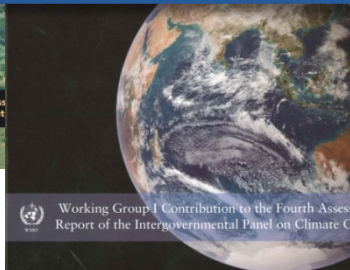
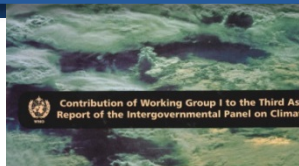
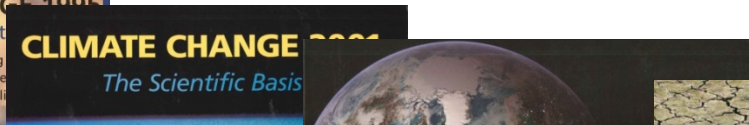
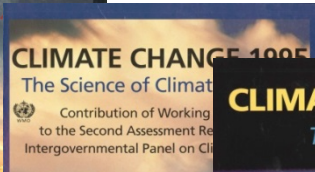
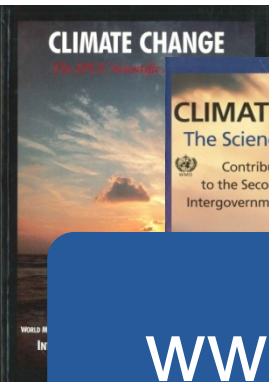


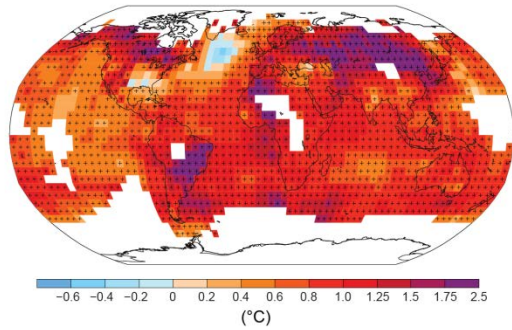
Charge of the Intergovernmental Panel on Climate Change (IPCC):

to assess on a comprehensive, objective, open and transparent basis the scientific, [...] information relevant to understanding the scientific basis of risk of human-induced climate change,

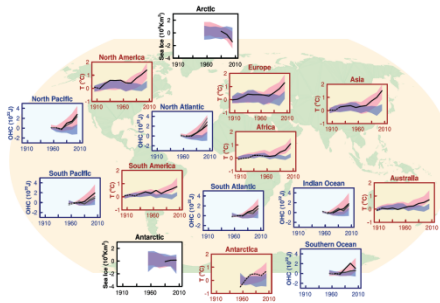
...

www.climatechange2013.org

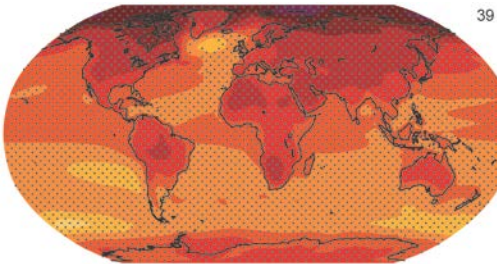




Warming of the climate system is unequivocal, [...]



Human influence on the climate system is clear.



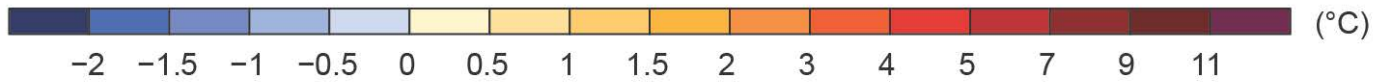
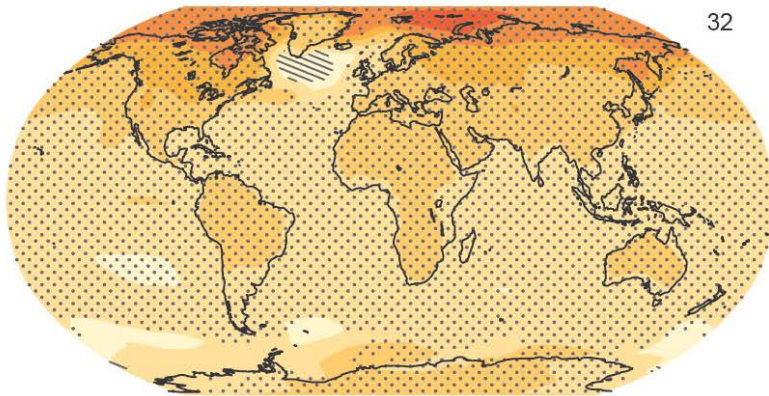
Continued emissions of greenhouse gases will cause further warming.

39

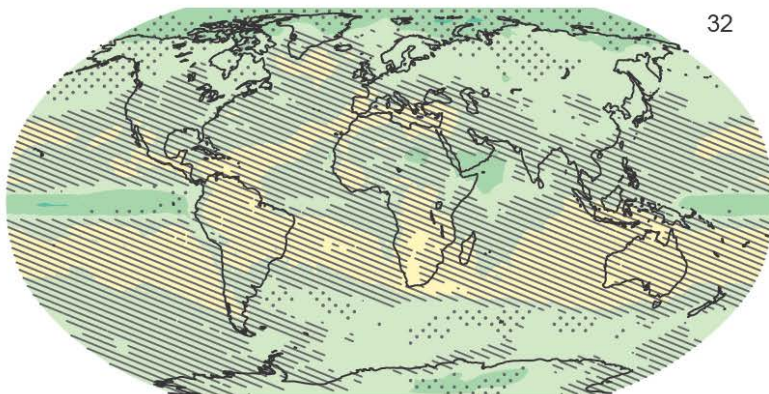
RCP2.6

CO_{2eq} = 475 ppm

Change in average surface temperature (1986–2005 to 2081–2100)



Change in average precipitation (1986–2005 to 2081–2100)





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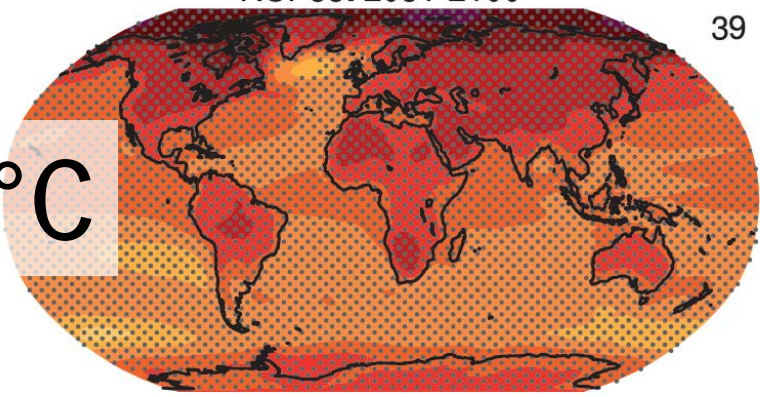
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RCP85: 2081-2100

39

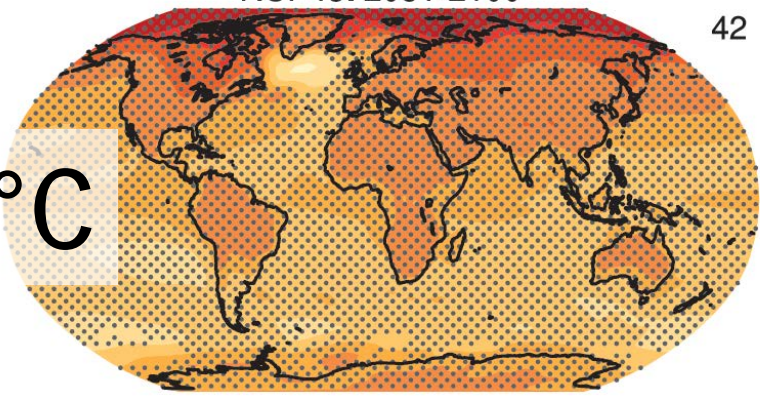
4.3°C



RCP45: 2081-2100

42

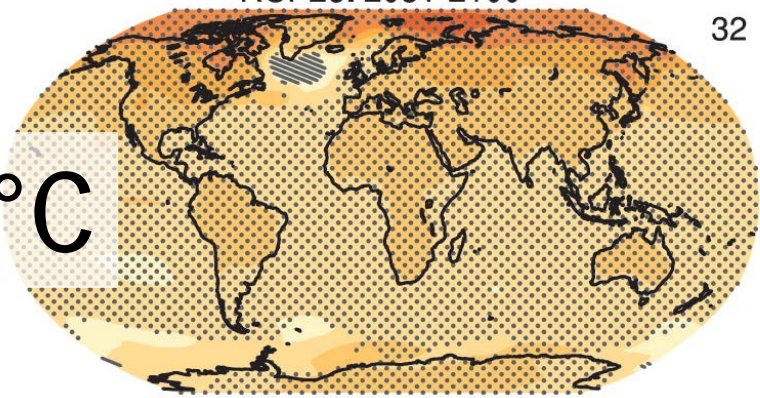
2.4°C



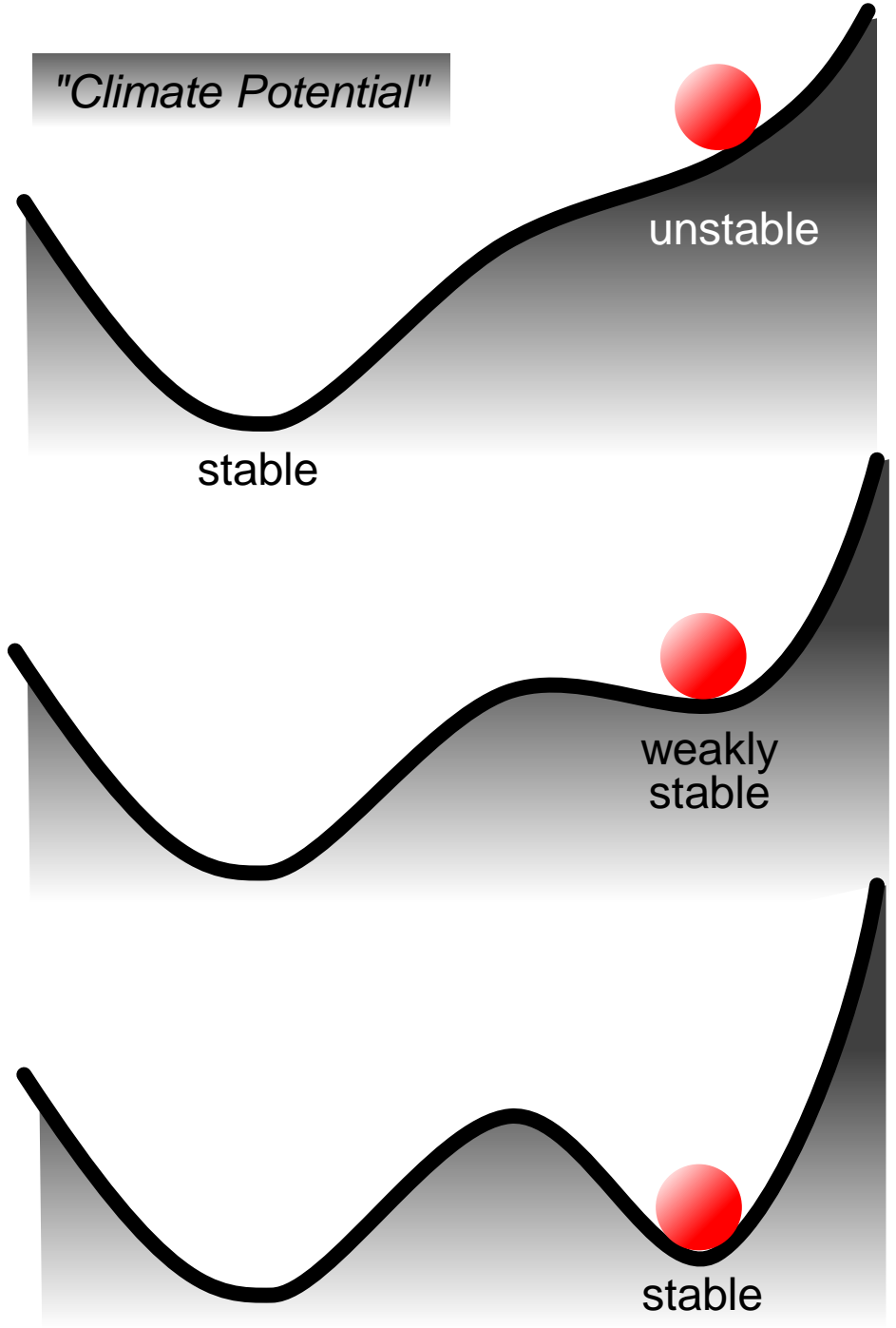
RCP26: 2081-2100

32

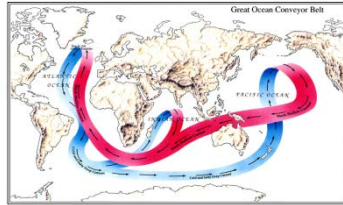
1.6°C



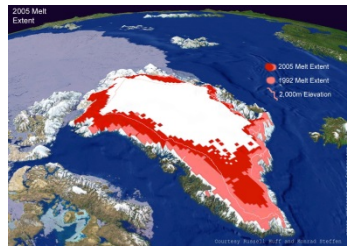
"Climate Potential"



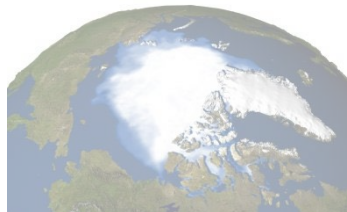
Possible tipping points in the climate system



North Atlantic ocean circulation



Greenland ice sheet

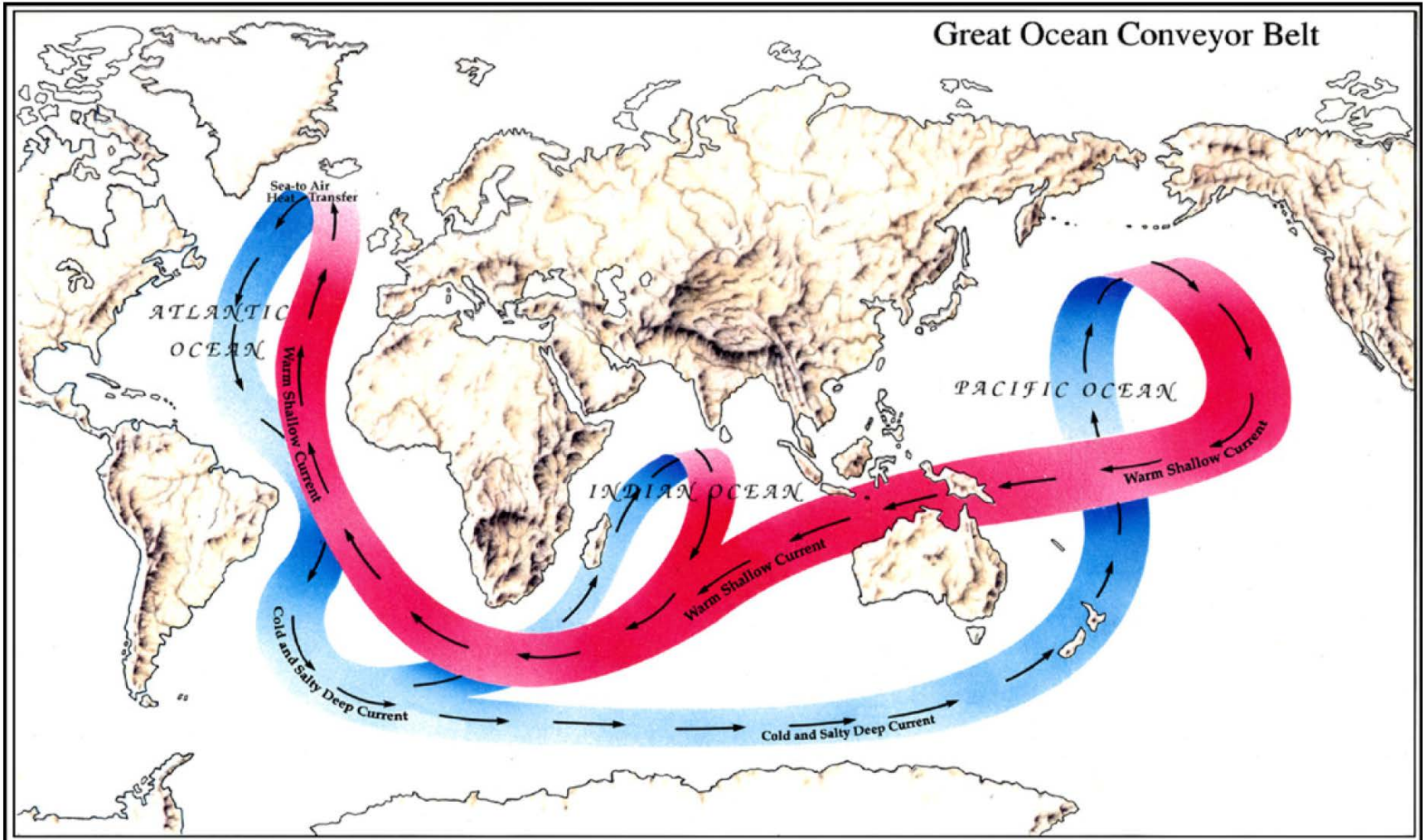


Arctic sea ice



Ocean acidification

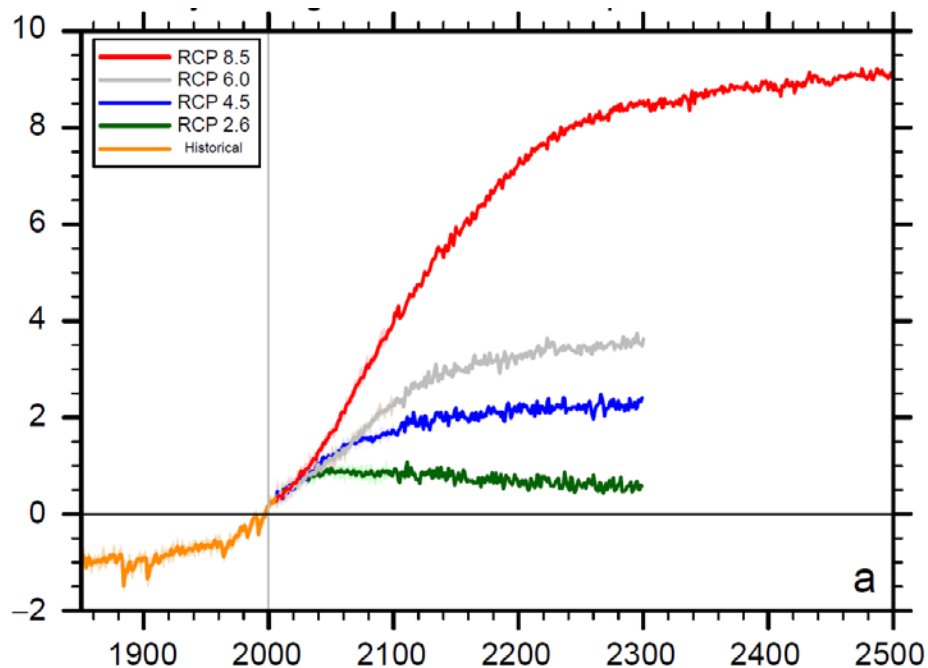
North Atlantic ocean circulation: Tipping point possible



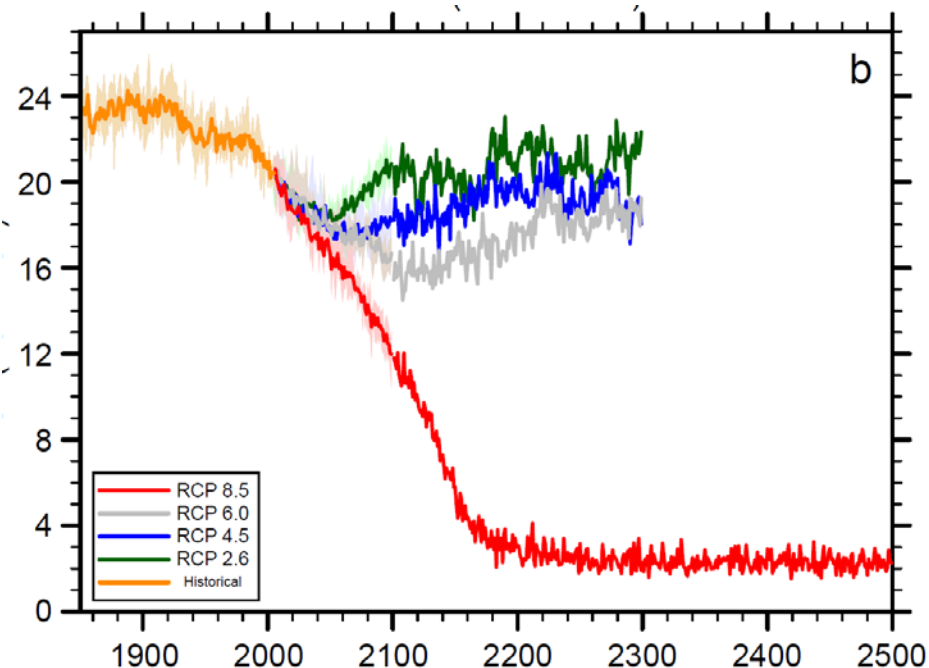
(Broecker, 1987)

North Atlantic ocean circulation: Tipping point possible

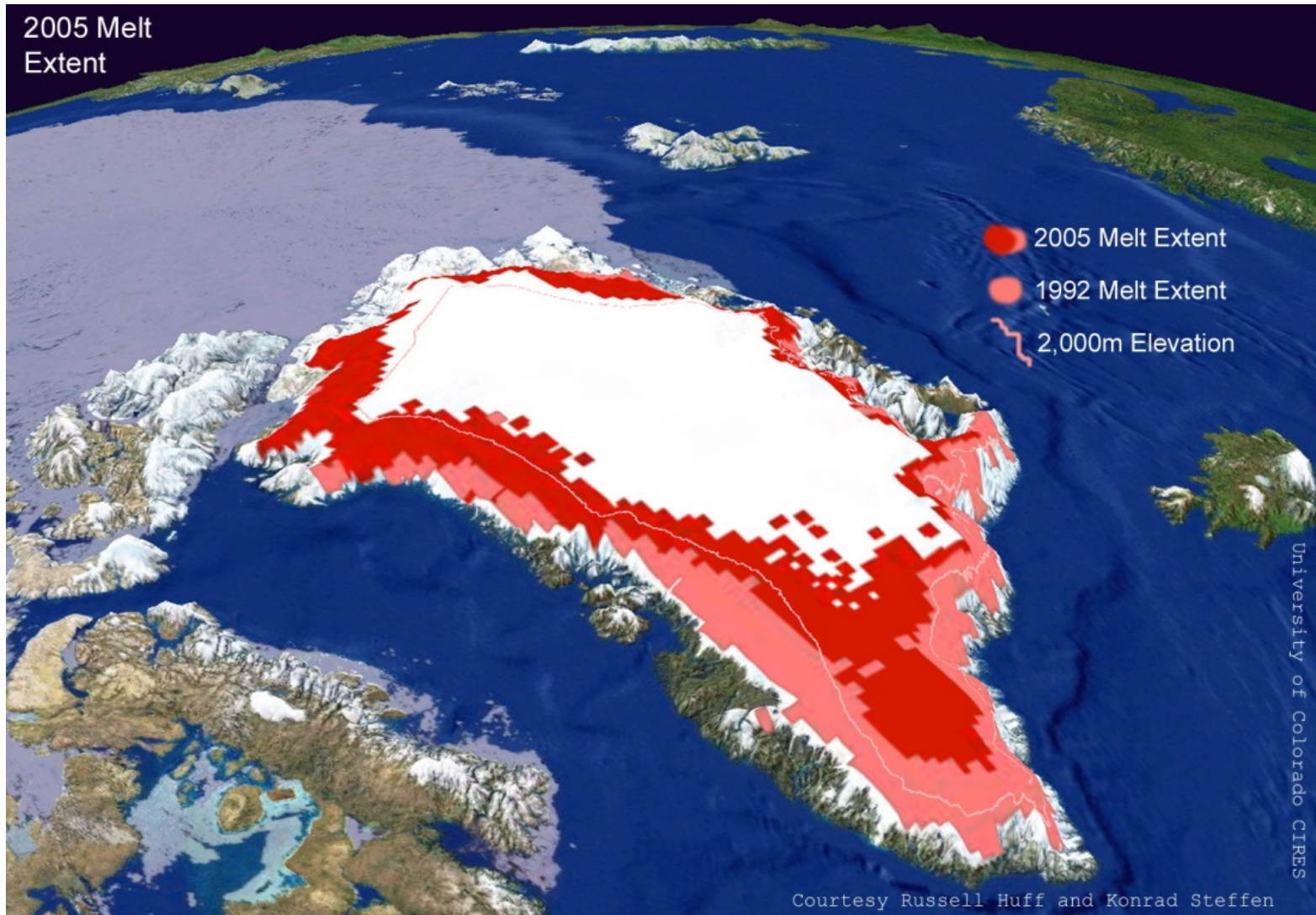
Temperature anomaly (rel. 1985-2005)



Change in circulation ($10^6 \text{ m}^3/\text{s}$)



Greenland ice sheet: Tipping point exists (*high confidence*)

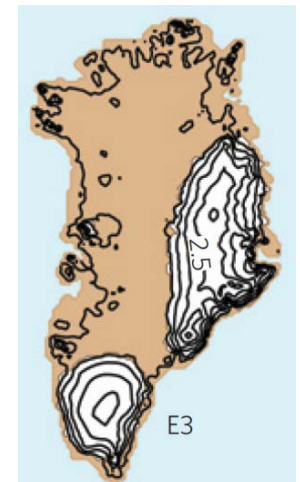
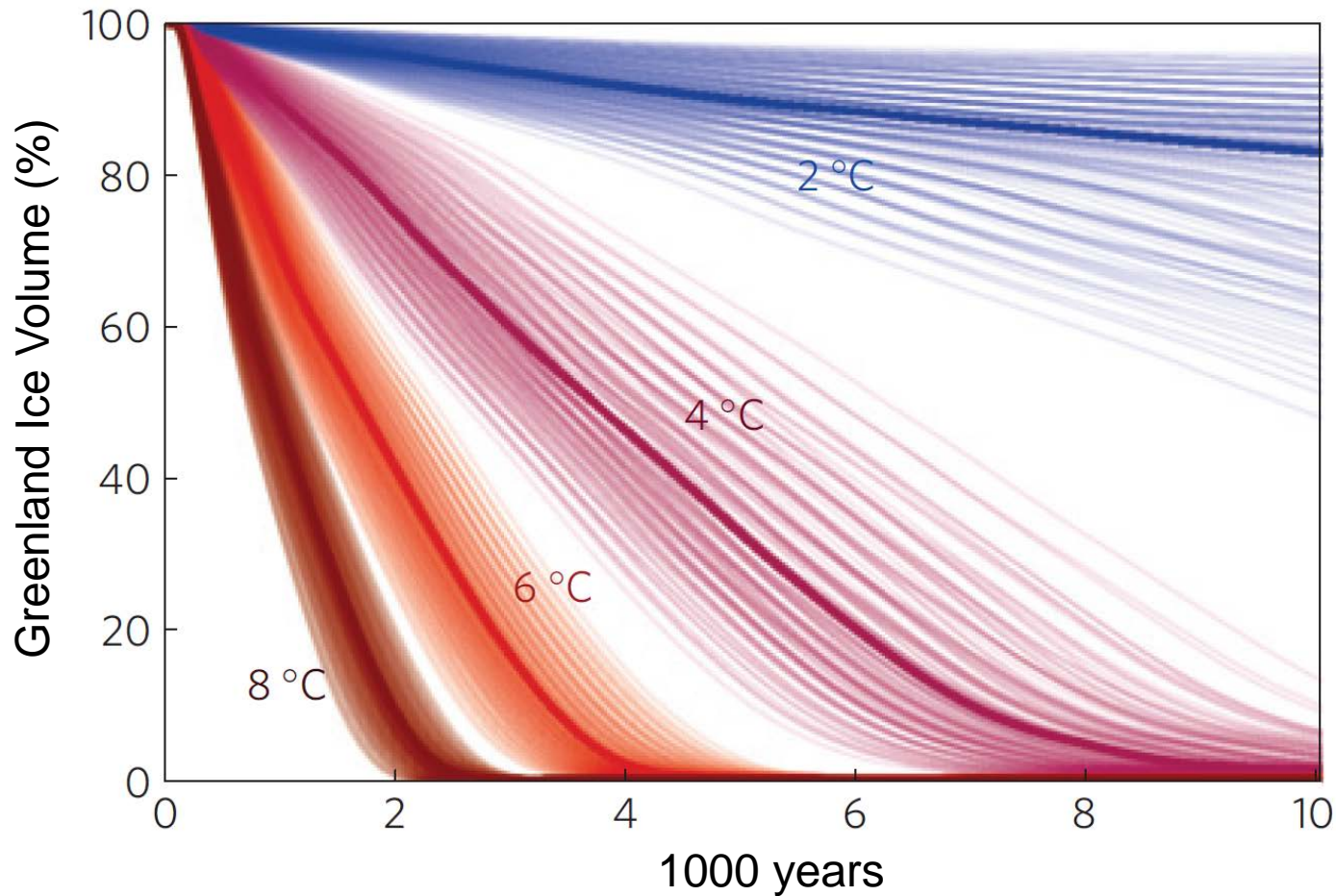


Greenland ice sheet: Tipping point exists (*high confidence*)

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(Robinson et al., 2012)



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Global Mean Temperature Change



TCRE

**Transient Climate
Response to
Cumulative Carbon
Emissions**

All CO₂ Emissions since 1750



Warming since 1880: **0.85 °C**



TCRE
Transient Climate
Response to
Cumulative Carbon
Emissions

Cumulative Emissions
from 1870 to 2011: **515 GtC**

Warming since 1880: **0.85 °C**

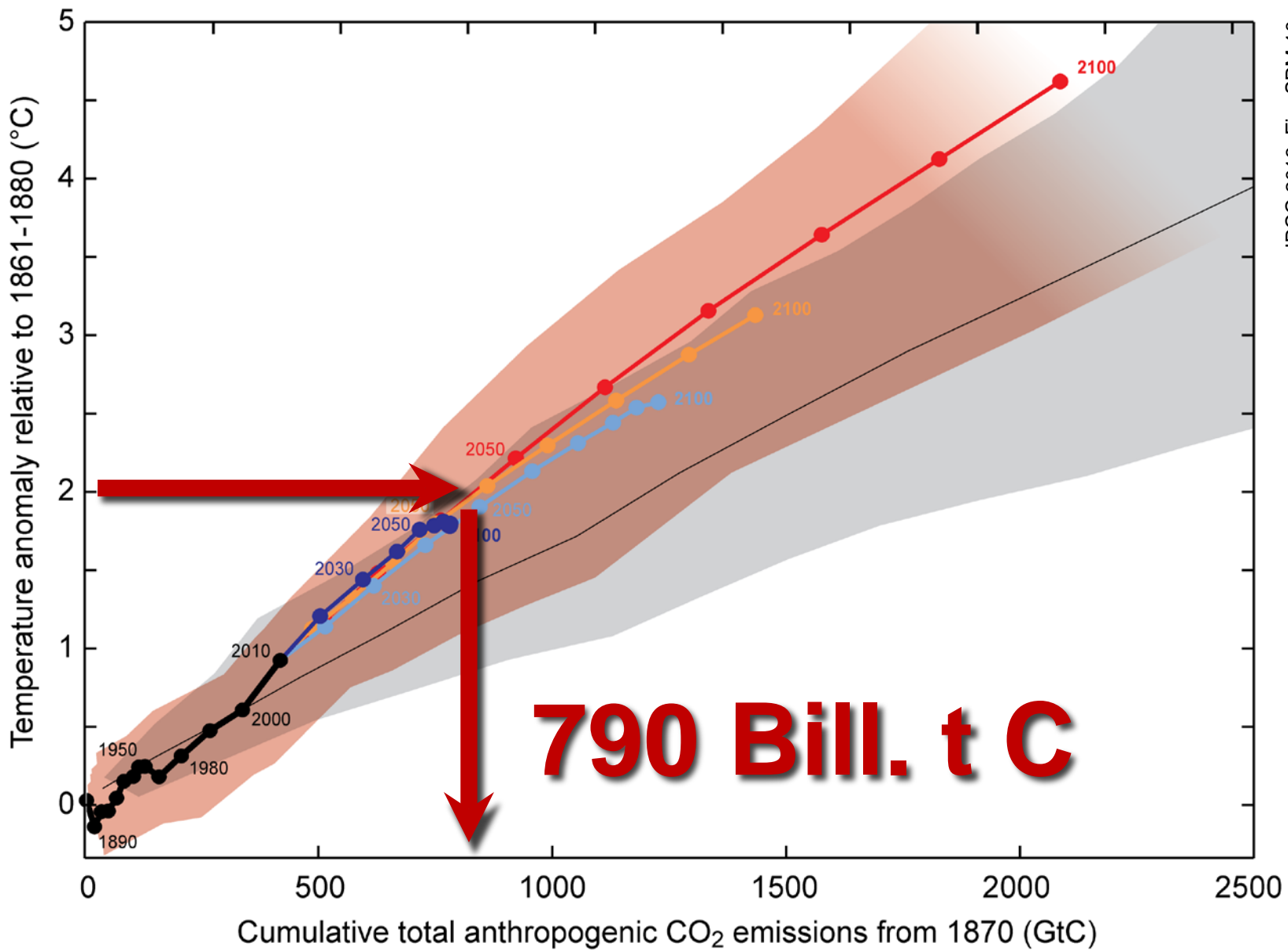


TCRE

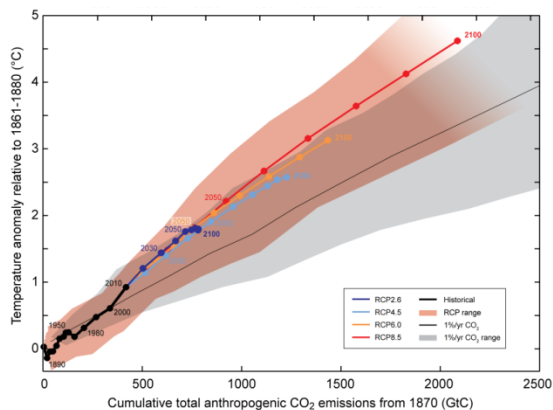
**0.8 to 2.5 °C
per 1000 GtC**

Cumulative Emissions
from 1870 to 2011:

515 GtC



IPCC 2013, Fig. SPM.10



Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions.

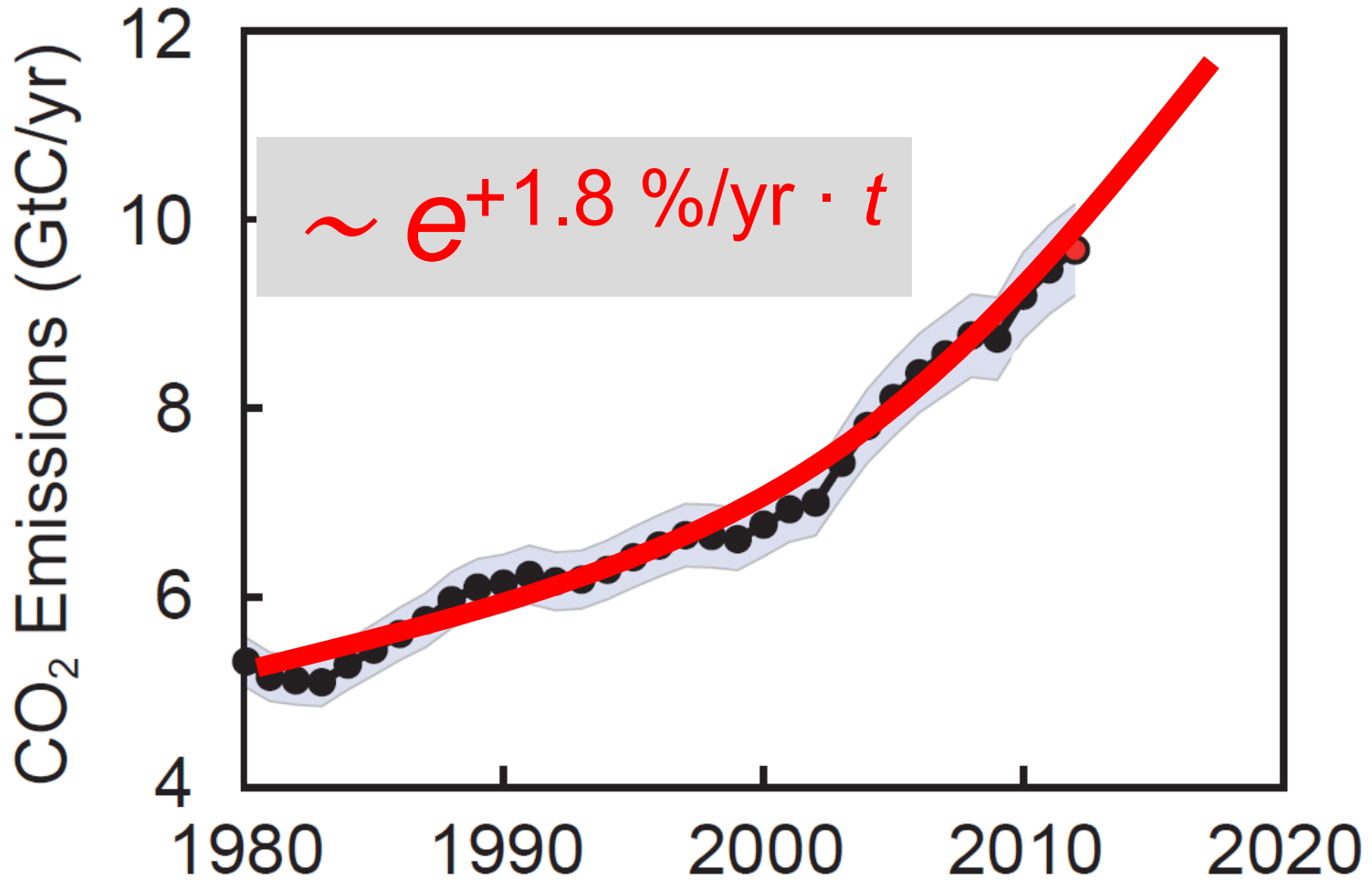
Budget for the 2°C target: 790 Bill. t C

CO₂ emitted until 2011: -515 Bill. t C

Remaining emissions: 275 Bill. t C

CO₂ emissions 2013: 9.9 Bill. t C/yr

CO₂ Emissions: Nearly exponential increase



**Cumulative
CO₂ Emissions:**

$$C_{\infty} = \int E(t) dt$$

**Peak
Warming:**

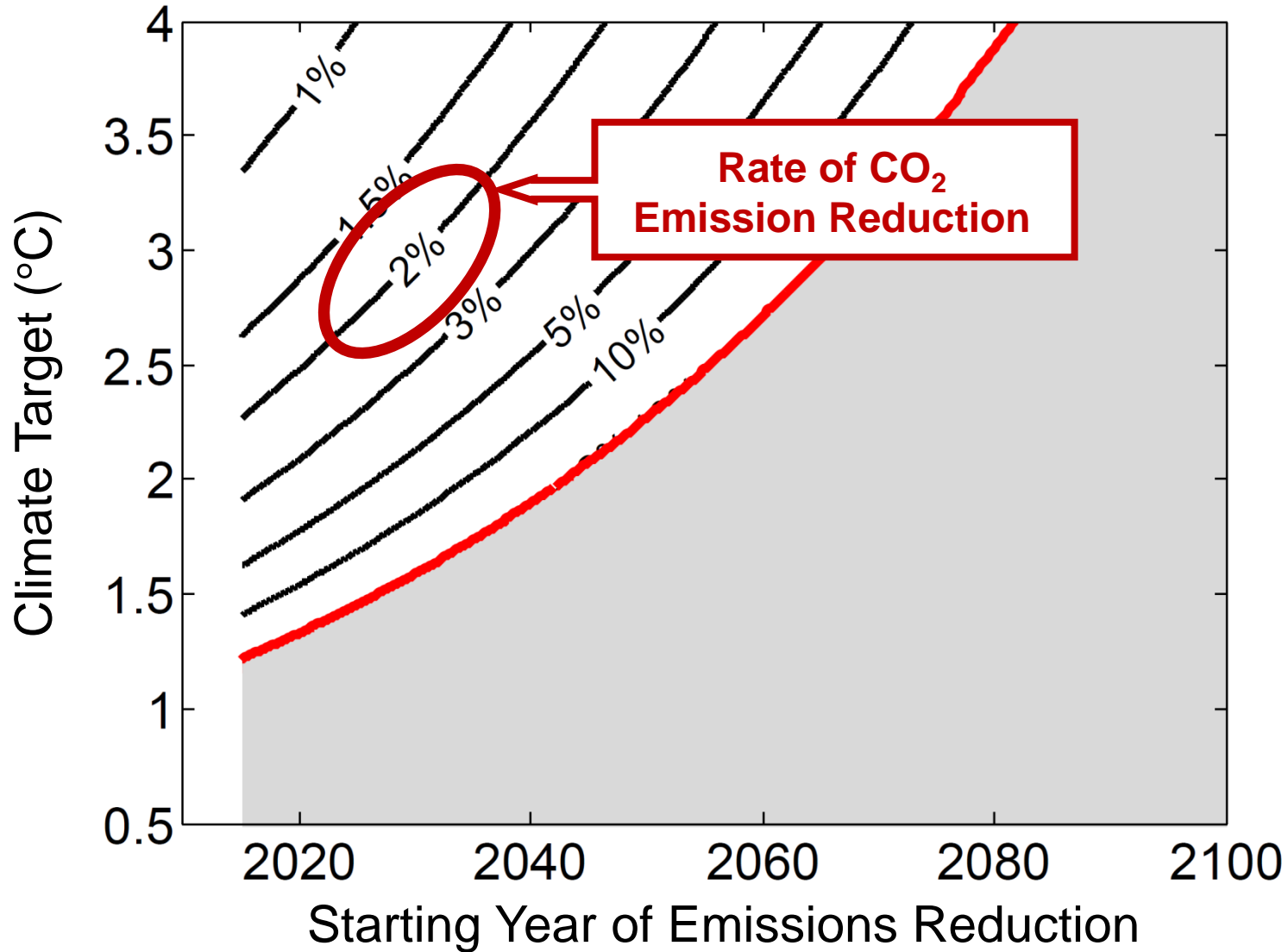
$$\Delta T = \text{TCRE} \cdot C_{\infty}$$

Start Time of CO₂
Emission Reduction

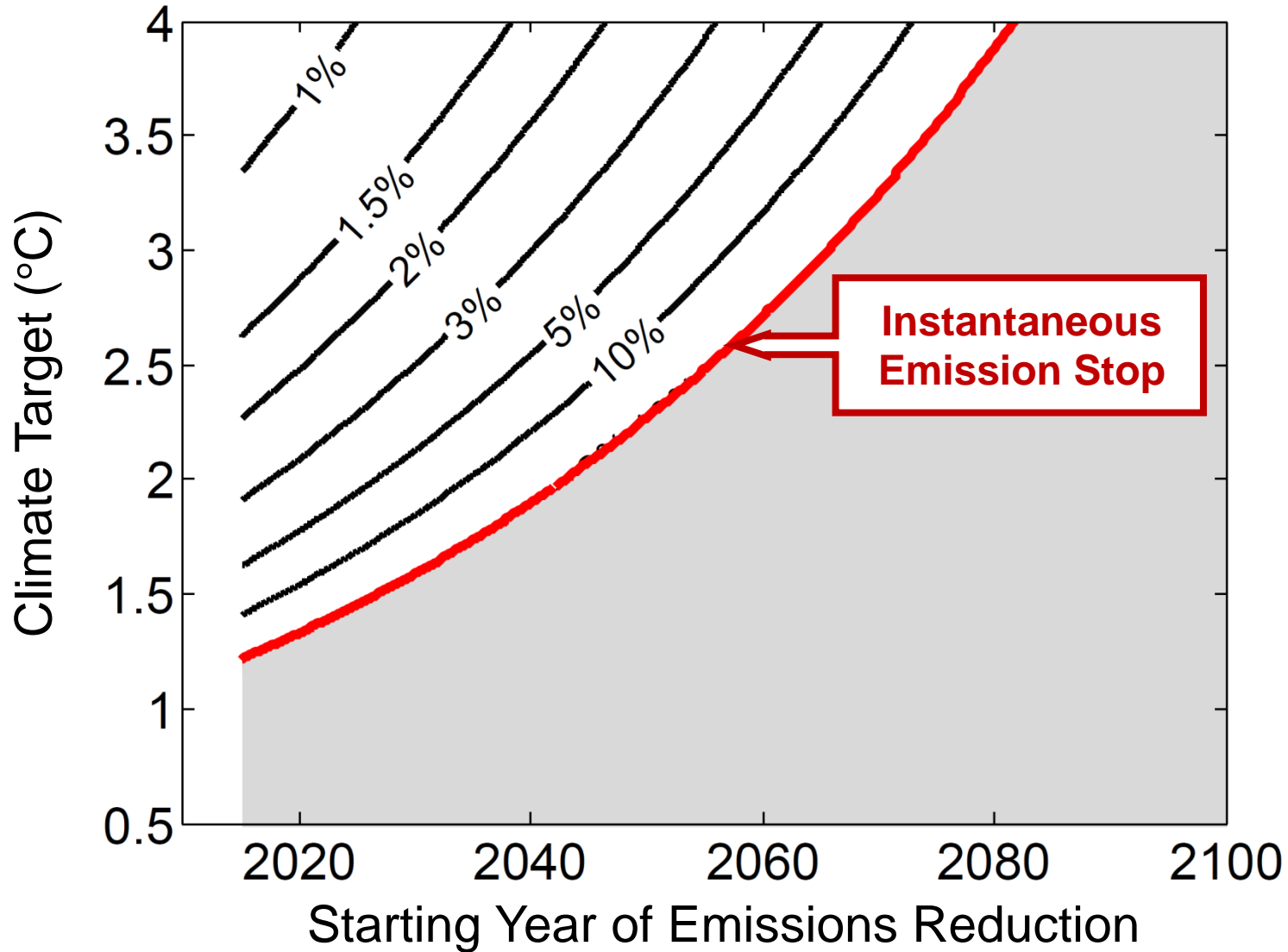
$$\Delta T = \text{TCRE} \cdot f(t_1, s)$$

Rate of CO₂
Emission Reduction

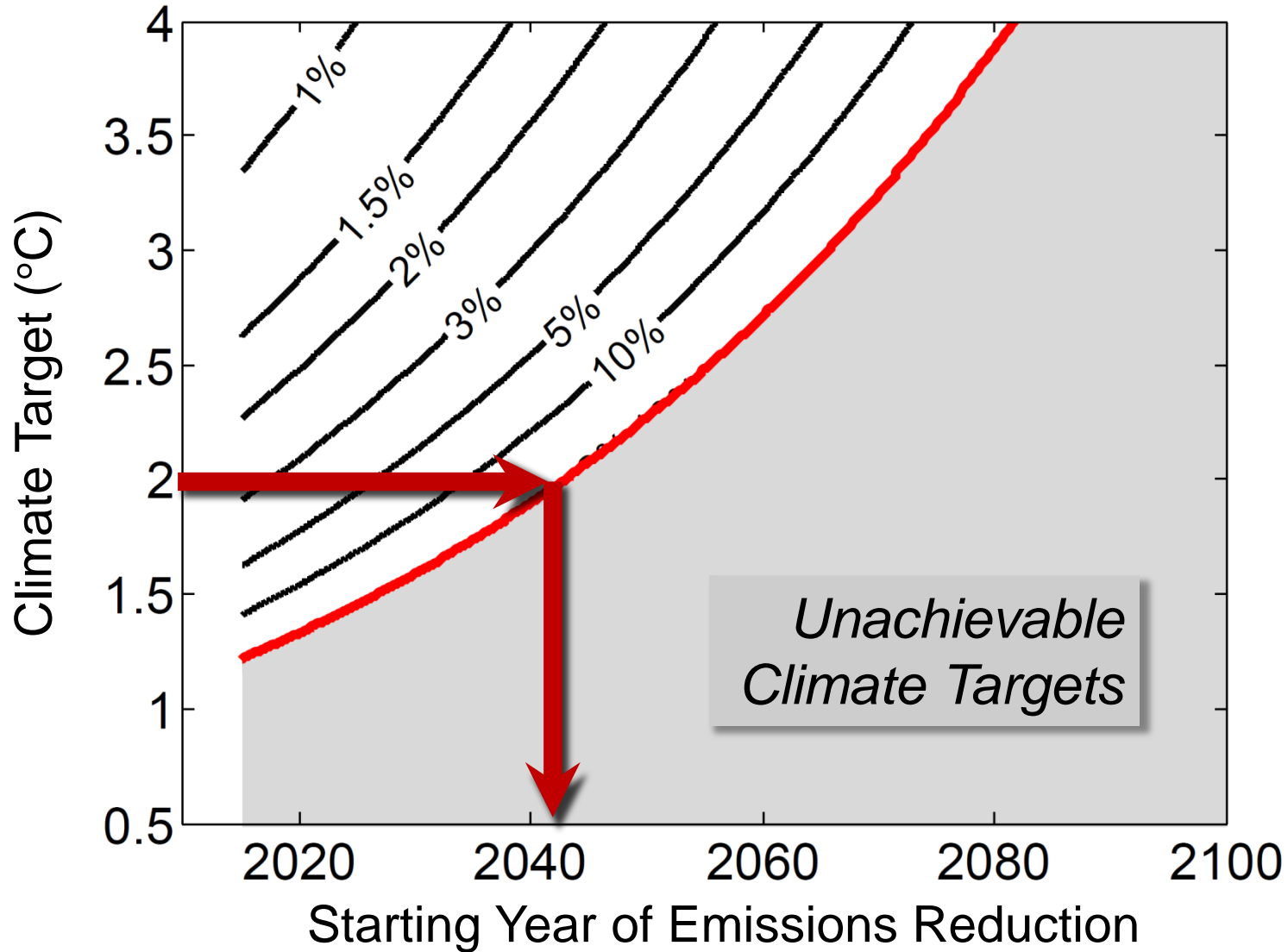
The closing door of climate targets



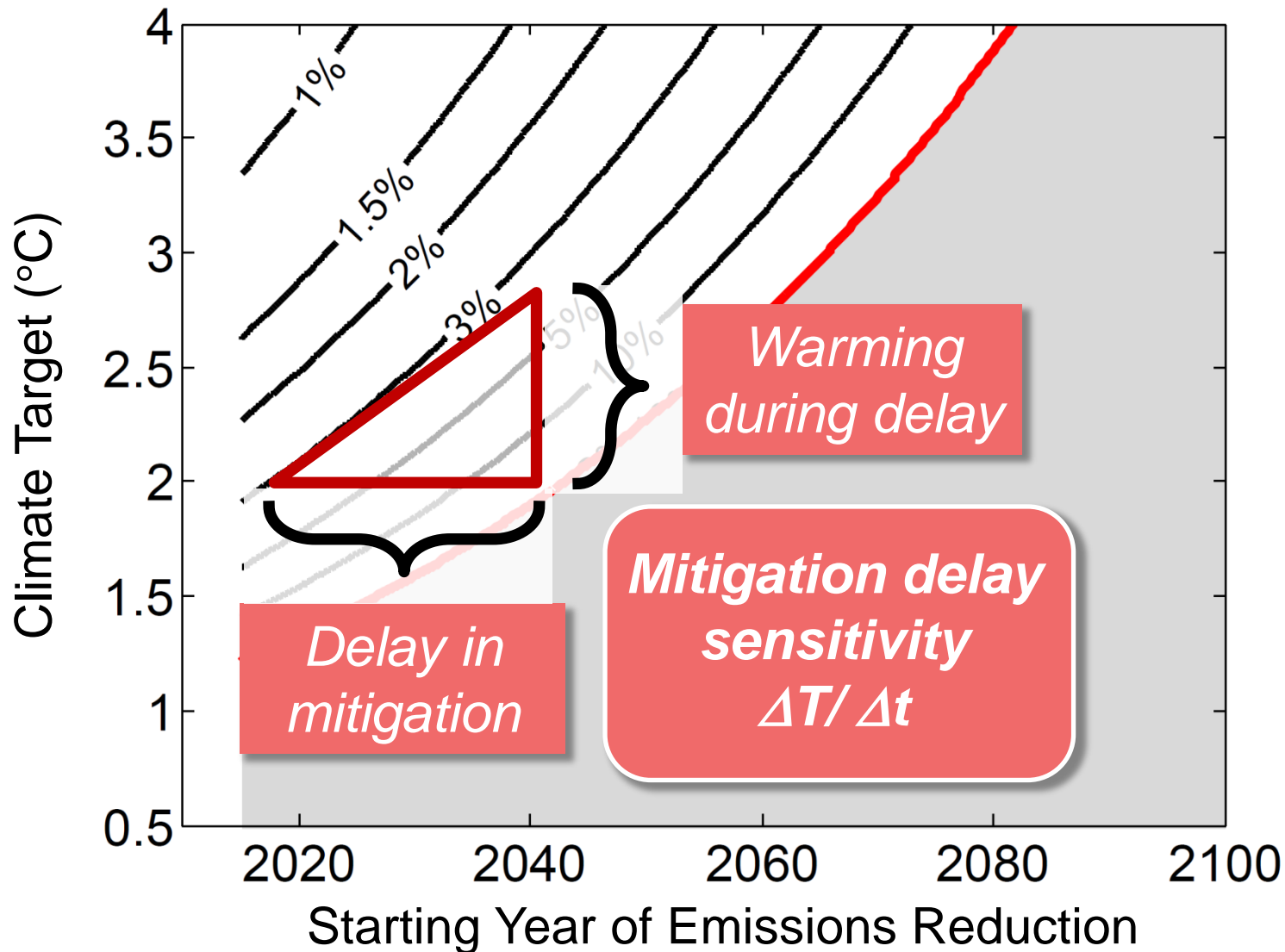
The closing door of climate targets



The closing door of climate targets



Mitigation delay: Peak temperature rises fast



Mitigation delay: Peak temperature rises fast

20th century warming: ≈ 0.08 °C per decade

1951 to 2012 warming: ≈ 0.12 °C per decade

1998 to 2012 warming: ≈ 0.05 °C per decade

Mitigation Delay Sensitivity

≈ 0.4 °C per decade

**Committed peak warming rises 3 to 8
times faster than observed warming**

- ❖ Climate change is observed
- ❖ The cause is identified and clear
- ❖ Unprecedented climate state ahead
- ❖ Risk for tipping points increases
- ❖ Options to limit climate change vanish

Climate Change 2013: The Physical Science Basis

Working Group I contribution to the IPCC Fifth Assessment Report

Further Information

www.climatechange2013.org

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