Climate Economics for Engineers

ENV-724 (Thalmann/Vielle/Vöhringer), Session 3, 7 Oct. 2020

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Overview

23.09	Economic activity as a source of greenhouse gases, climate scenarios	Frank Vöhringer
30.09	Impacts of climate change: valuation and uncertainty	Philippe Thalmann
07.10	Impacts of climate change: net costs (aggregation, discounting)	Frank Vöhringer
14.10	Adaptation to climate change	Marc Vielle
21.10	Mitigation: abatement measures, cost curves, innovation	Frank Vöhringer
28.10	Cooperation: mitigation as a public good, international climate policy	Frank Vöhringer
04.11	Instruments for climate policy	Philippe Thalmann
11.11	Swiss climate policy	Philippe Thalmann
18.11	Solar radiation management: economics and governance	Frank Vöhringer
02.12	Final exam	all

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Overview for today

- social cost benefit analysis (continued)
  - aggregating the benefits of mitigation
    - around the globe
    - over time
- uncertainty in cost-benefit analysis
  - some additions on climate scenarios
  - tipping points
  - communicating uncertain results
- target setting
  - Botzen/van den Bergh paper
  - optimization or precaution?

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Social cost benefit analysis (reminder)

- method to evaluate public projects or policies
- compute the net present value of a project

$$NPV = \sum_{t=0}^{T} \frac{B_t - C_t}{(1+r)^t}$$

  - execute project when NPV>0
  - financing restriction: choose project with highest NPV, if NPV>0
- social perspective
  - valuation of externalities and non-market goods
  - revenue recycling
  - interpersonal aggregation

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Aggregating utility? Or consumption?

- utility: measure of happiness or satisfaction
  - preference order
  - ordinal scale (unclear how much something is prefered)
- way out: equivalent variation
  - after shock: how much income can we take away from a person so it is still at the previous utility level
  - negative for climate damages
  - but: consumption at market prices ≠ welfare

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Interpersonal aggregation

- interpersonal comparisons of utility unquantifiable
- way out: social welfare function
  - in principle: ordered preferences about social states
    - negotiating the Pareto Principle
  - in practice: weighted aggregation of individual welfare
    - widespread in theoretical papers: social welfare functions reflect inequality aversion
    - problematic applied modeling default: sum of consumption values
    - usually applied in international aggregation: purchasing power parities
    - rarely applied in international aggregation: equity weights

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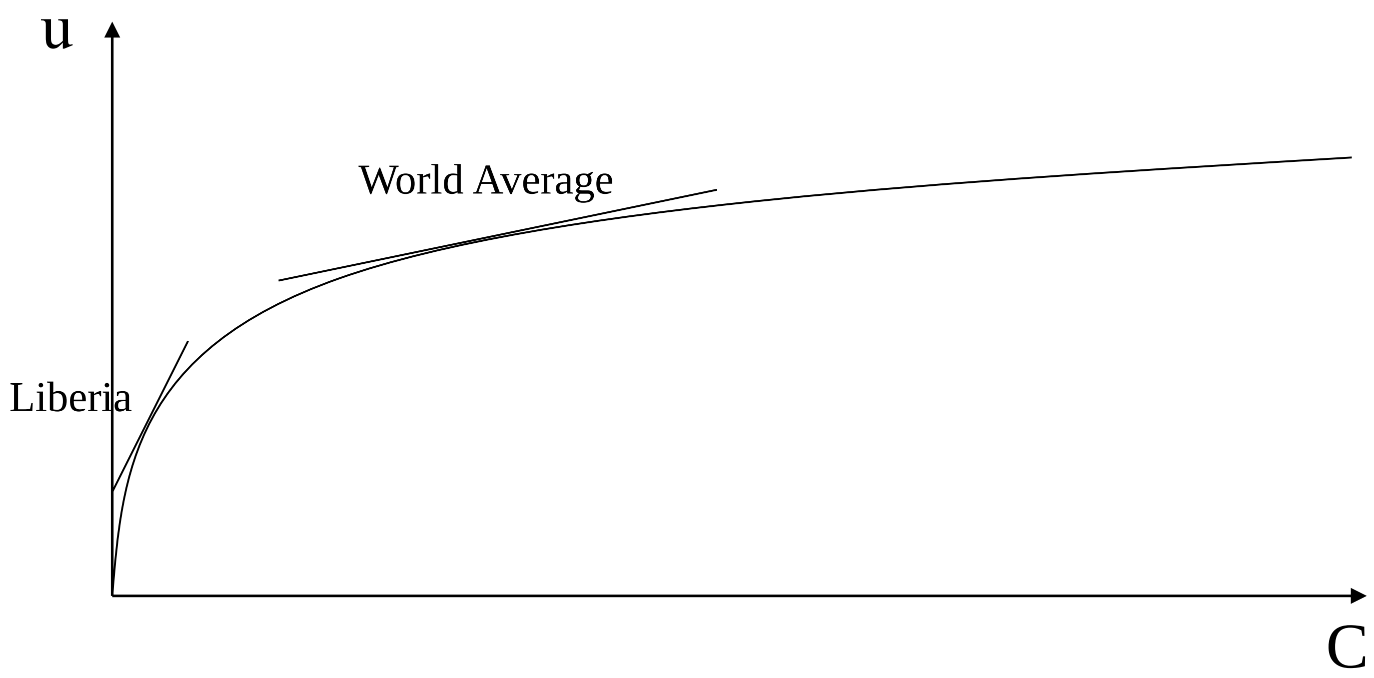
Equity weights

- adjust WTP for differences in marginal utility
  - e.g.: divide by world average



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Which was the more devastating storm?

- Mitch
  - 1998
  - mostly Honduras and Nicaragua
  - damage to infrastructure: 7 bio. US$
  - deaths: 11 000-18 000
- Katrina
  - 2005
  - USA
  - damage to infrastructure: 81 bio. US$
  - deaths:~1 800

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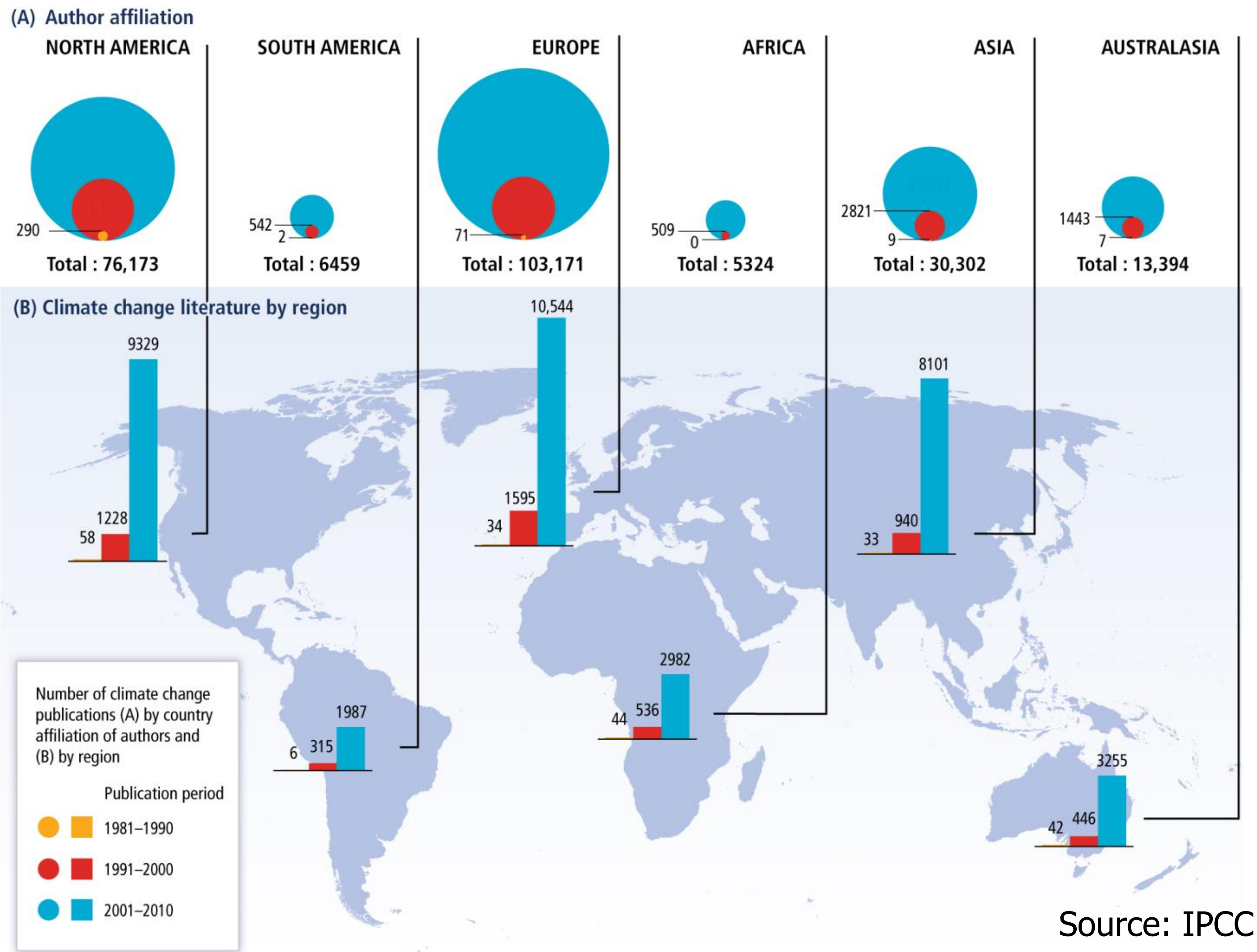
Climate change literature by region



Source: IPCC 5AR TS WGII

Box TS.1 Figure 1 | Number of climate change publications listed in the Scopus bibliographic database. (A) Number of climate change publications in English (as of July 2011) summed by country affiliation of all authors of the publications and sorted by region. Each publication can be counted multiple times (i.e., the number of different countries in the author affiliation list). (B) Number of climate change publications in English with individual countries mentioned in title, abstract, or key words (as of July 2011) sorted by region for the decades 1981–1990, 1991–2000, and 2001–2010. Each publication can be counted multiple times if more than one country is listed. [Figure 1-1]

Aggregating values from different periods

- real versus nominal prices
  - nominal prices: in current currency units
  - real prices: in deflated currency units, e.g. “2015 CHF”
    - inflation may not influence the valuation
      => use real prices & state the base year
    - price indices available e.g. at the OECD website

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Aggregating values from different periods

- discounting
  - future values are multiplied by $(1+r)^{-t}$
  - r>0 => the present value becomes lower the later a certain value accrues
  - why do economists discount?
    - time preference
    - risk
    - growth
    - opportunity costs

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The usual types of discounting

- business discounting
  - expected internal rate of return of alternative investment opportunities
  - risk-free market interest rate + risk premium of the investment

- social discounting
  - pure rate of time preference

    + consumption growth rate · elasticity of marginal utility w.r.t. consumption
  - e.g. Nordhaus (2007): 3.0% + 1.3% * 1 = 4.3%

    Stern Review (2006): 0.1% + 1.3% * 1 = 1.4%

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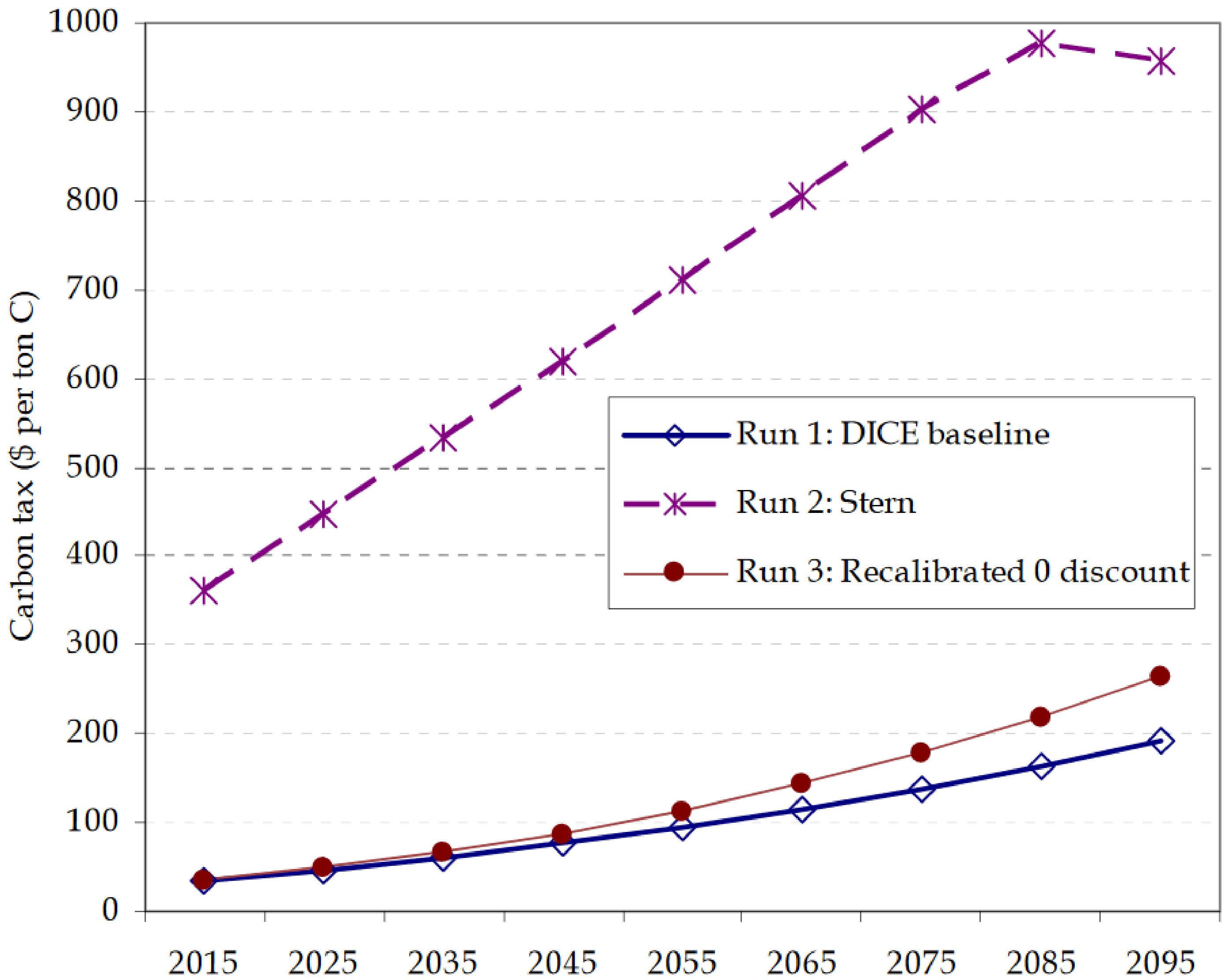
Intergenerational valuation issues

Optimal carbon tax rates



Source: Nordhaus 2007

Discounting: example 1

Damage in 2080	1 Bio. CHF						
Discount rate	0%	1%	3%	5%	7%	10%	14%
Present value in Mio. CHF	1000	550	170	54	17	3	0

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Long-term discounting

- bequest motive
- negative risk premium?
- descriptive or prescriptive?
  - intergenerational welfare function: normative discounting
- exponential consumption growth?
- substitutability of natural and man-made capital?
- hyperbolic discounting?
  - future values are multiplied by $(1 + at)^{-b/a}$, with a,b > 0
  - near-term discount rates > long-term discount rates
  - supported by empirical evidence
  - dynamically inconsistent: agents will not carry out the initially planned consumption path

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Discounting: example 2

Damage function „200“	100 Mio. CHF + (t-1)*20 Mio. CHF, t = 1 (2020) to 200 (2219)						
Damage function „1000“	Same as above for t=1 to 200; 4080 Mio. CHF for t = 201 (2220) to 1000 (3019)						
	Discounting at a constant rate						
Discount rate	0%	1%	3%	5%	7%	10%	15%
PRV in Bio. CHF “200”	418	127	25	10	5	3	1
PRV in Bio. CHF “1000”	3682	181	25	10	5	3	1
	Hyperbolic discounting						
Parameter a	0.04	0.04	0.04	0.12	0.12	0.12	
Parameter b	0.05	0.1	0.2	0.05	0.1	0.2	
Initial rate	4.8%	9.3%	17.8%	4.6%	9.0%	17.2%	
Rate after 10 years	3.6%	7.0%	13.5%	2.3%	4.6%	8.9%	
Rate after 50 years	1.7%	3.3%	6.5%	0.7%	1.4%	2.8%	
Rate after 200 years	0.6%	1.1%	2.2%	0.2%	0.4%	0.8%	
PRV in Bio. CHF “200”	53	10	2	137	47	7	
PRV in Bio. CHF “1000”	127	13	2	712	152	11	

Summary on discounting

- Future values are multiplied by $(1+r)^{-t}$
- Why do economists discount?
  - time preference
  - risk
  - growth
  - opportunity costs
- Different "types" of discounting
  - Business discounting: minimum internal rate of return in the respective risk category
  - Social discounting: Pure rate of time preference + consumption growth rate · elasticity of marginal utility w.r.t. consumption
  - Long-term discounting in prescriptive analysis: involves normative choices, limited substitutability of natural capital matters

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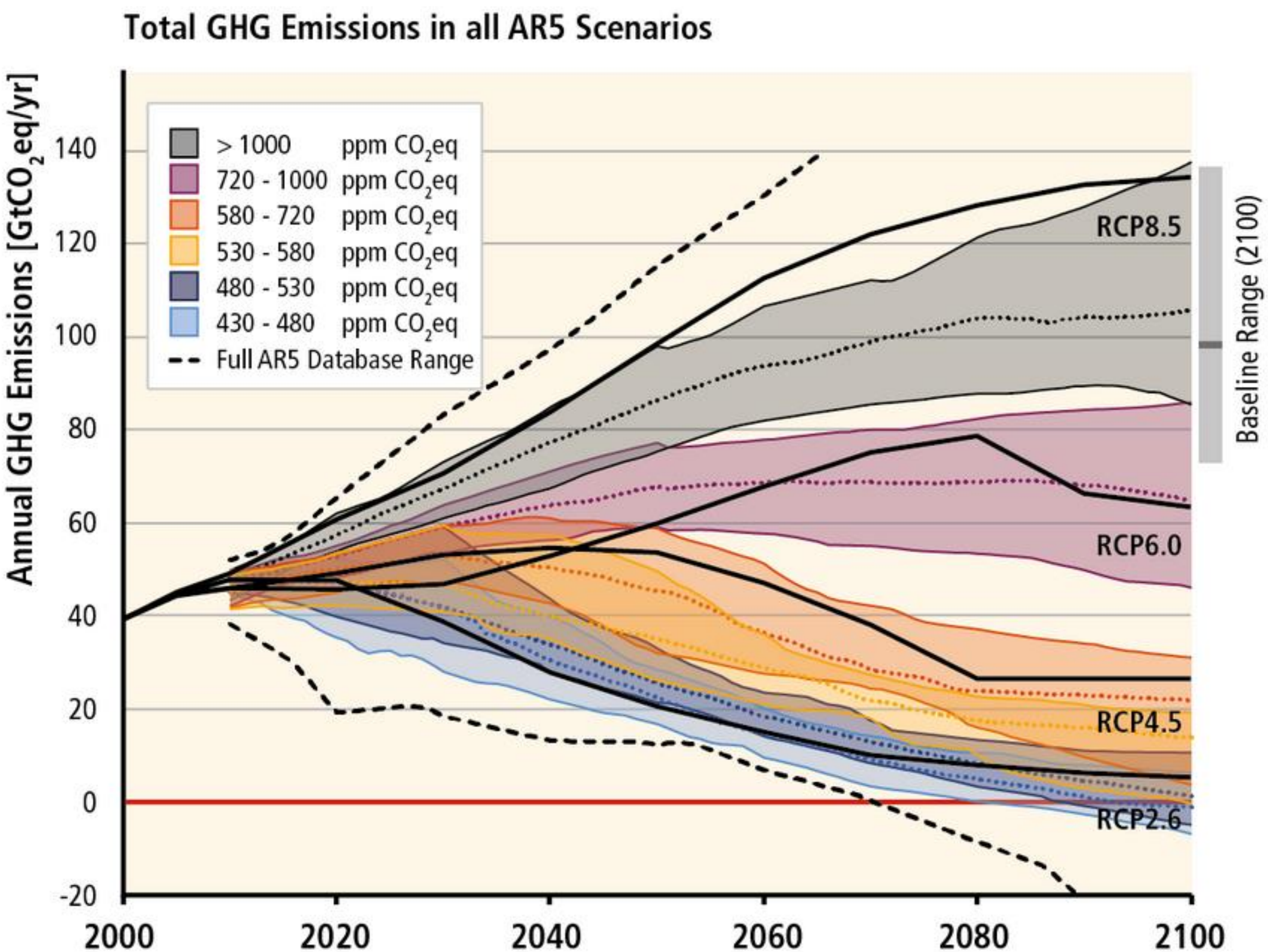
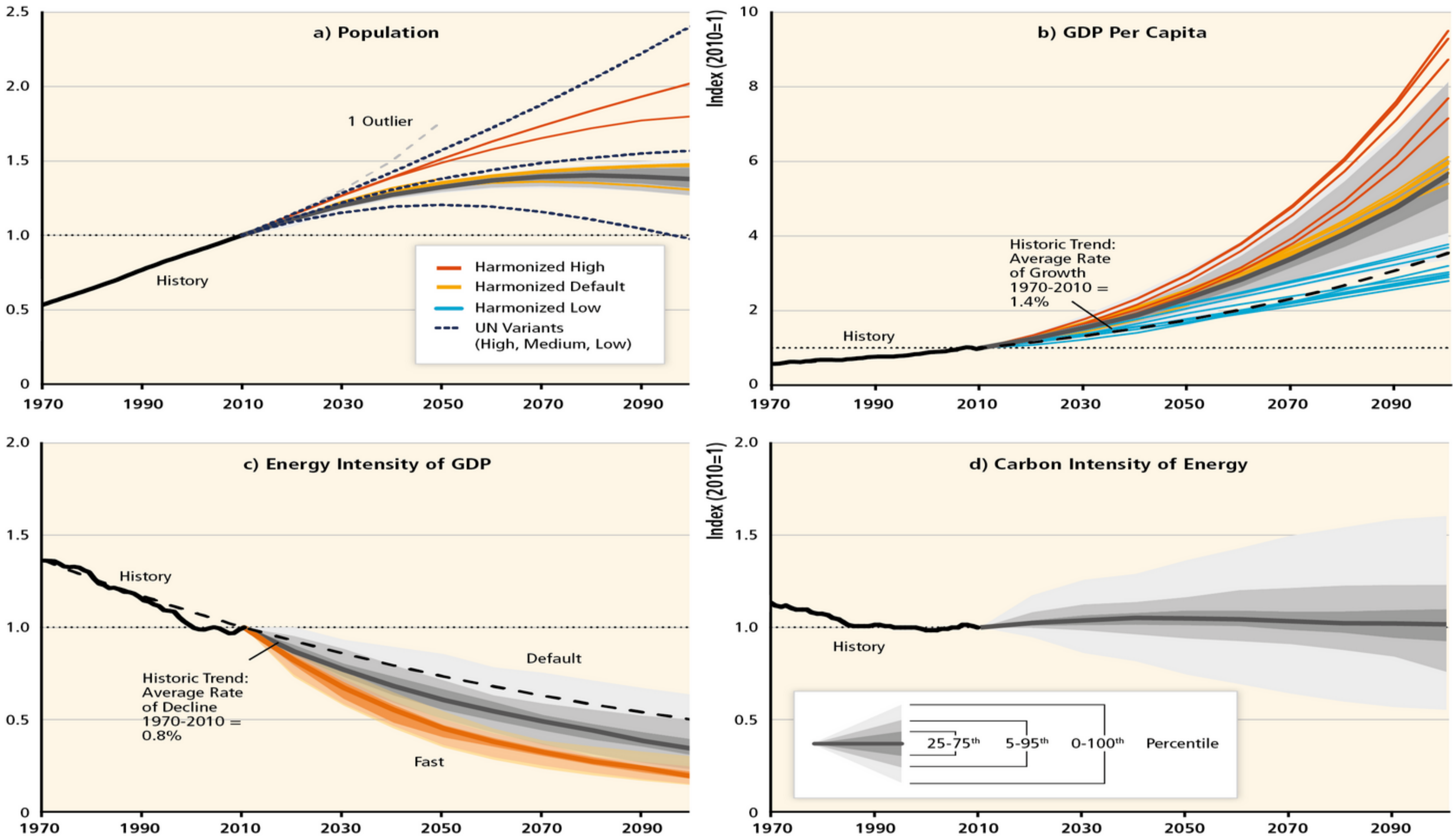
Climate scenarios

Global GHG emissions scenarios



Source: IPCC

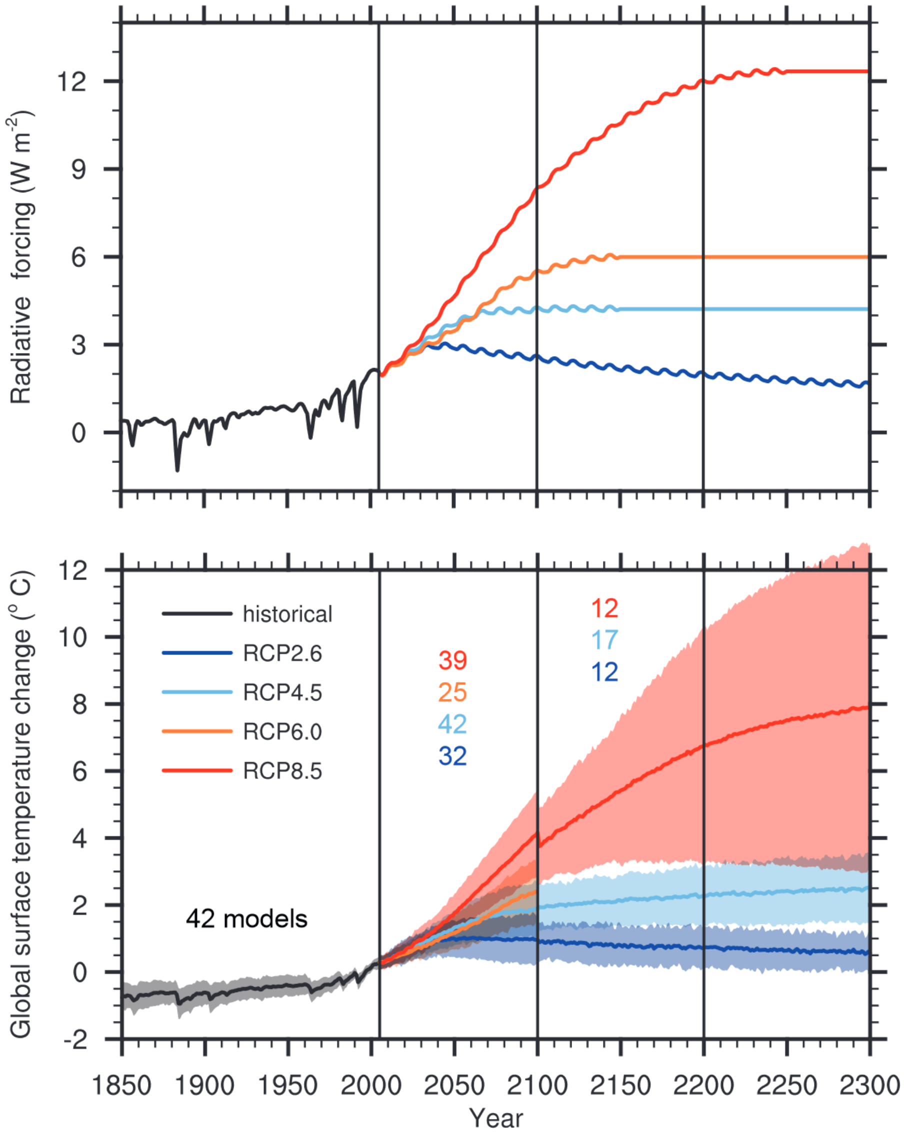
Emissions scenarios: economic drivers

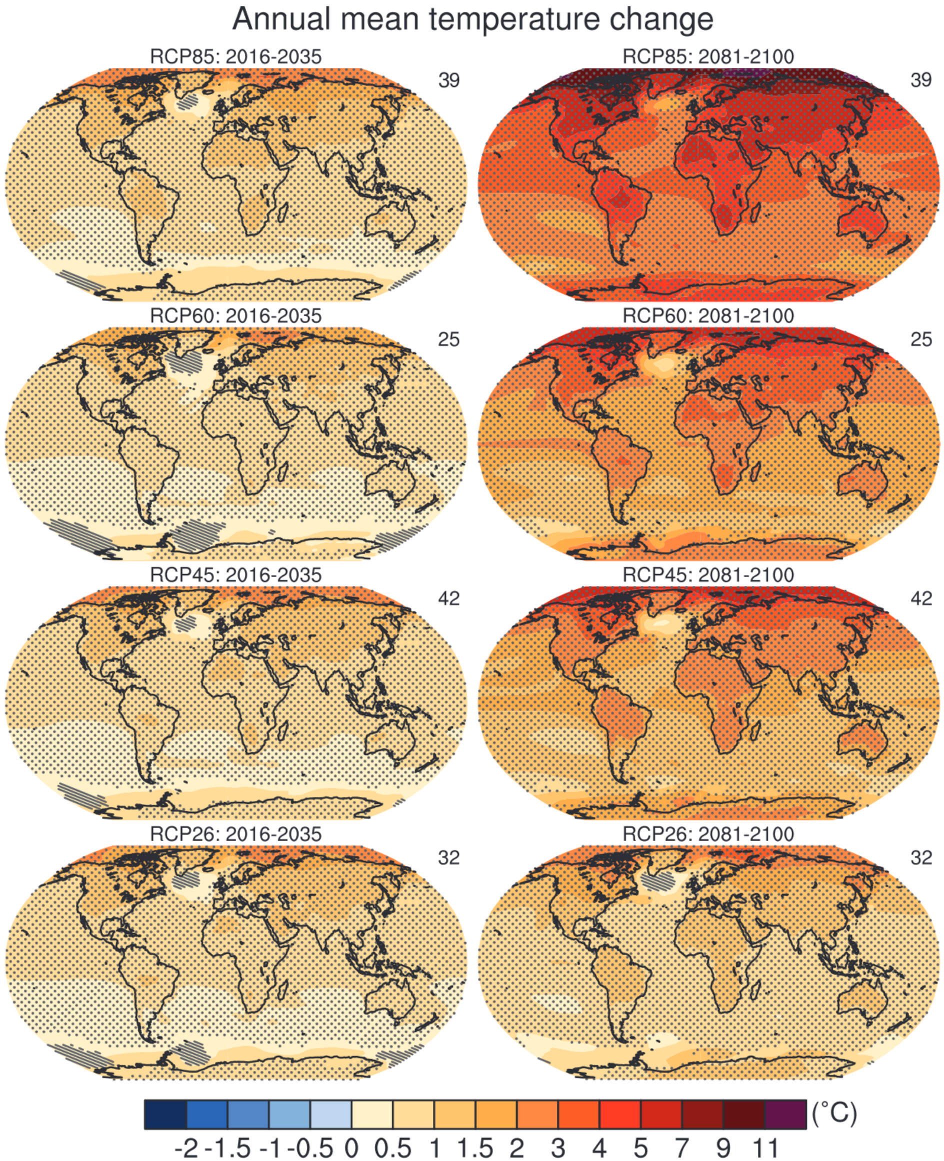


Source: IPCC

Climate scenarios

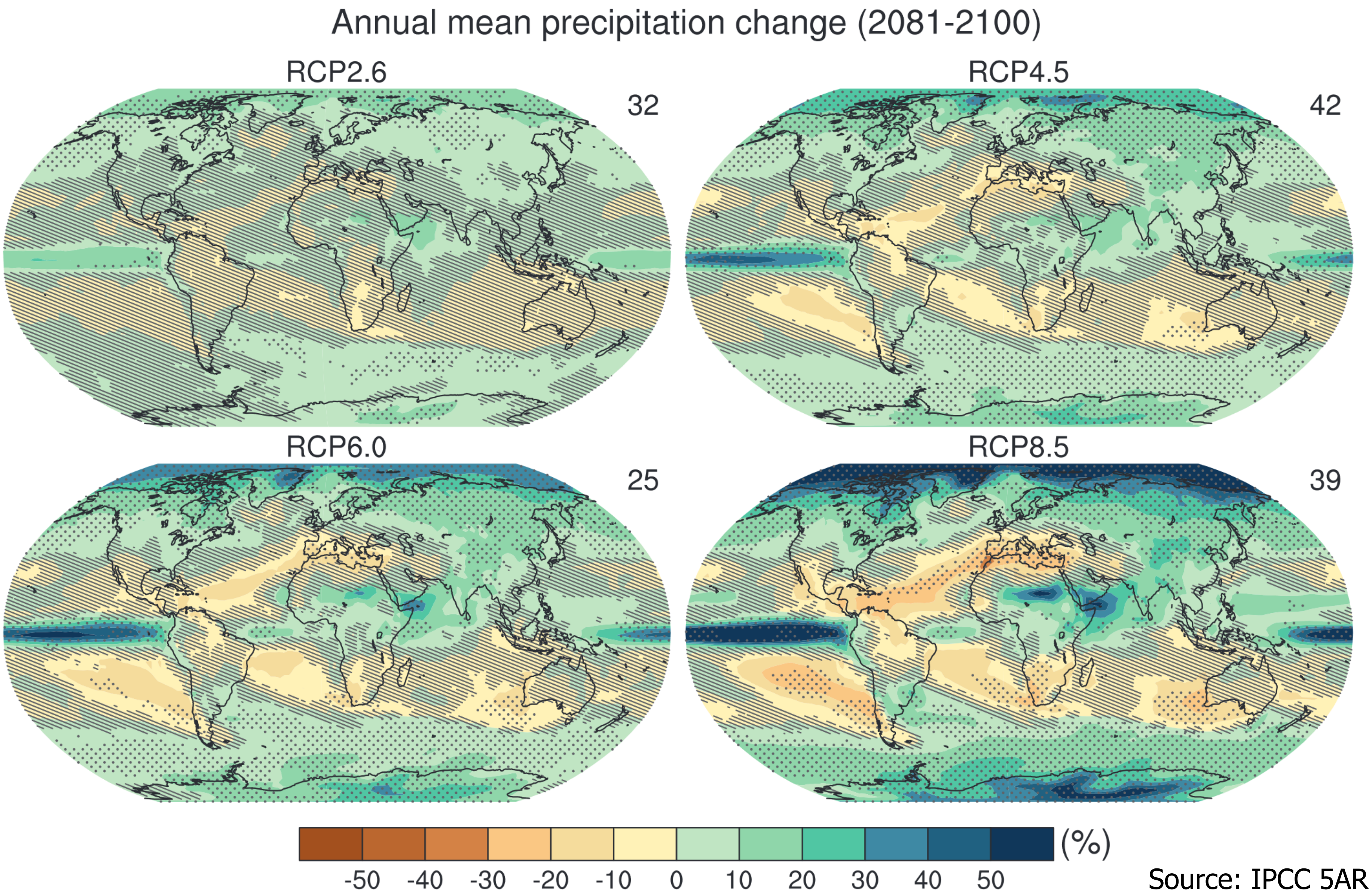
Multi model projections: temperature change





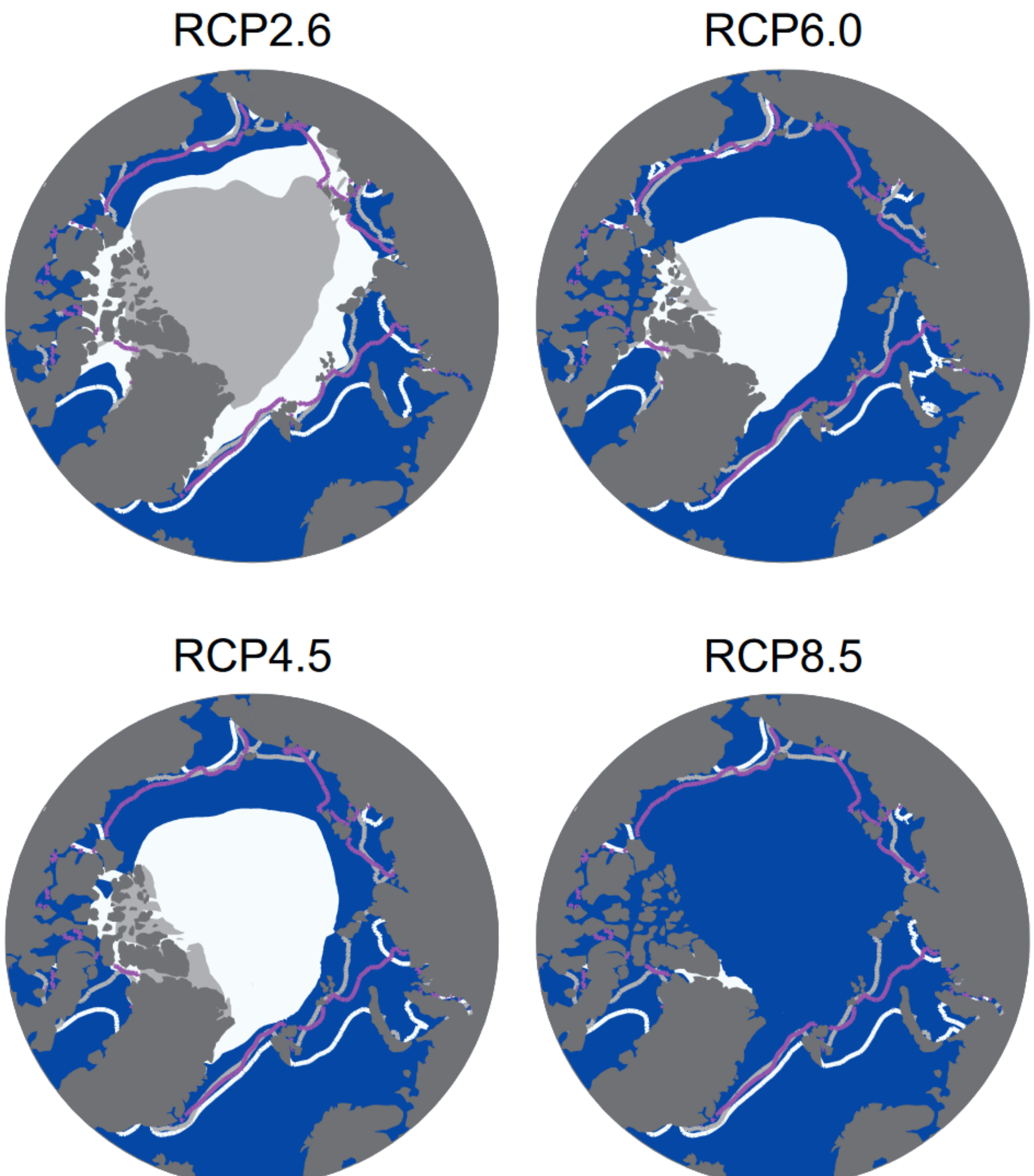
Source: IPCC 5AR

Multi model projections: precipitation change



Source: IPCC 5AR

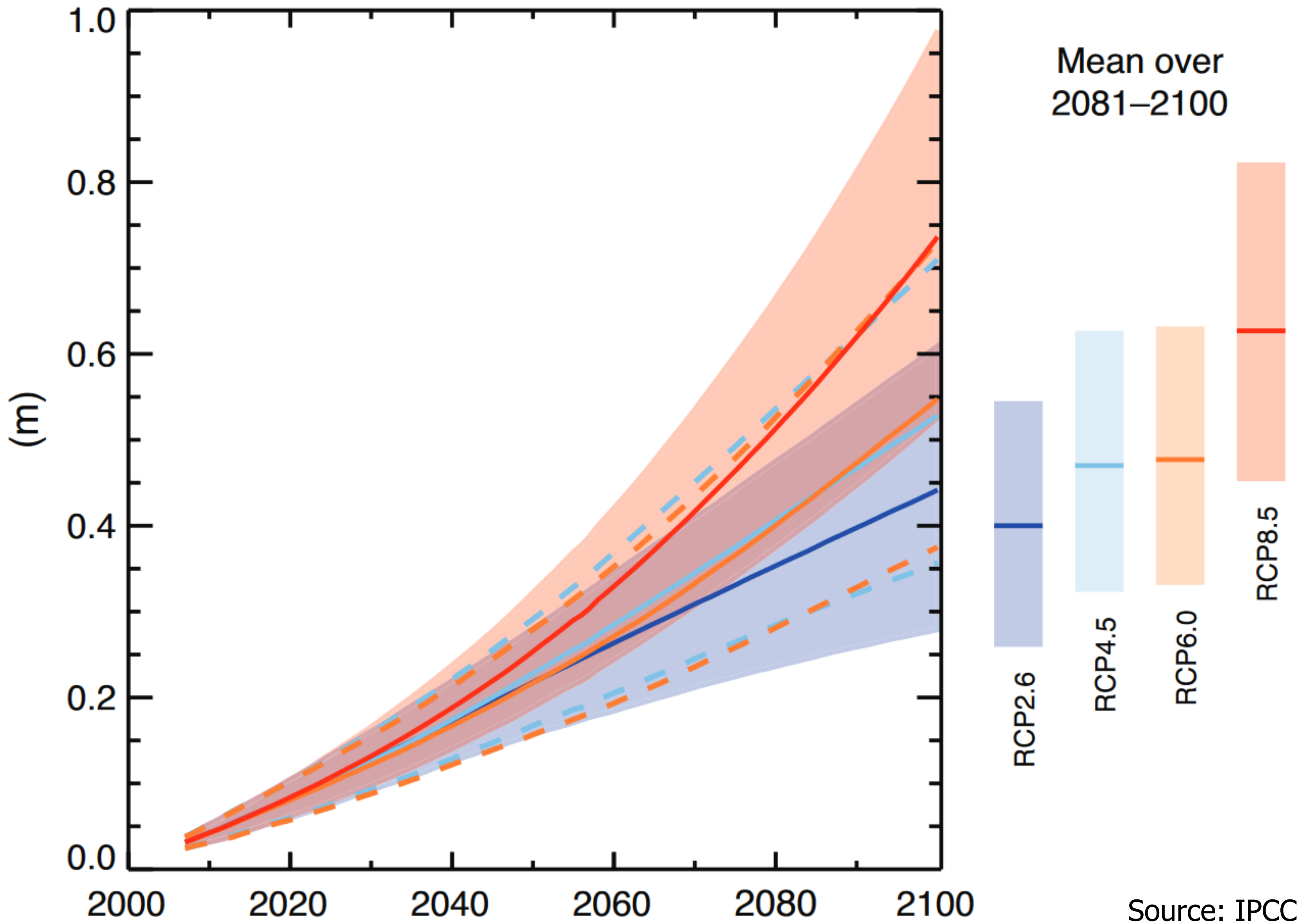
Sea ice extent (2081-2100, September, northern hemisphere)



Source: IPCC 5AR

Climate scenarios

Sea level rise (global average)



Source: IPCC 5AR

Article | Open Access | Published: 29 October 2019

New elevation data triple estimates of global vulnerability to sea-level rise and coastal flooding

Scott A. Kulp & Benjamin H. Strauss

Nature Communications **10**, Article number: 4844 (2019) | Cite this article

- For 2100, typical central estimates range from 50–70 cm sea level rise under RCP 4.5
- Recent projections with Antarctic ice sheet dynamics: 70–100 cm (RCP 4.5), 100–180 cm (RCP 8.5)
- Structured elicitation of experts opinion: 5% chance of > 2m in 2100
- In 2100 and under high emissions scenarios: 380 million additional people below annual flood levels

Definition of a tipping point

A critical point
at which a tipping element
(a component of the Earth system,
at least sub-continental in scale),
can be switched
– under certain circumstances –
into a qualitatively different state

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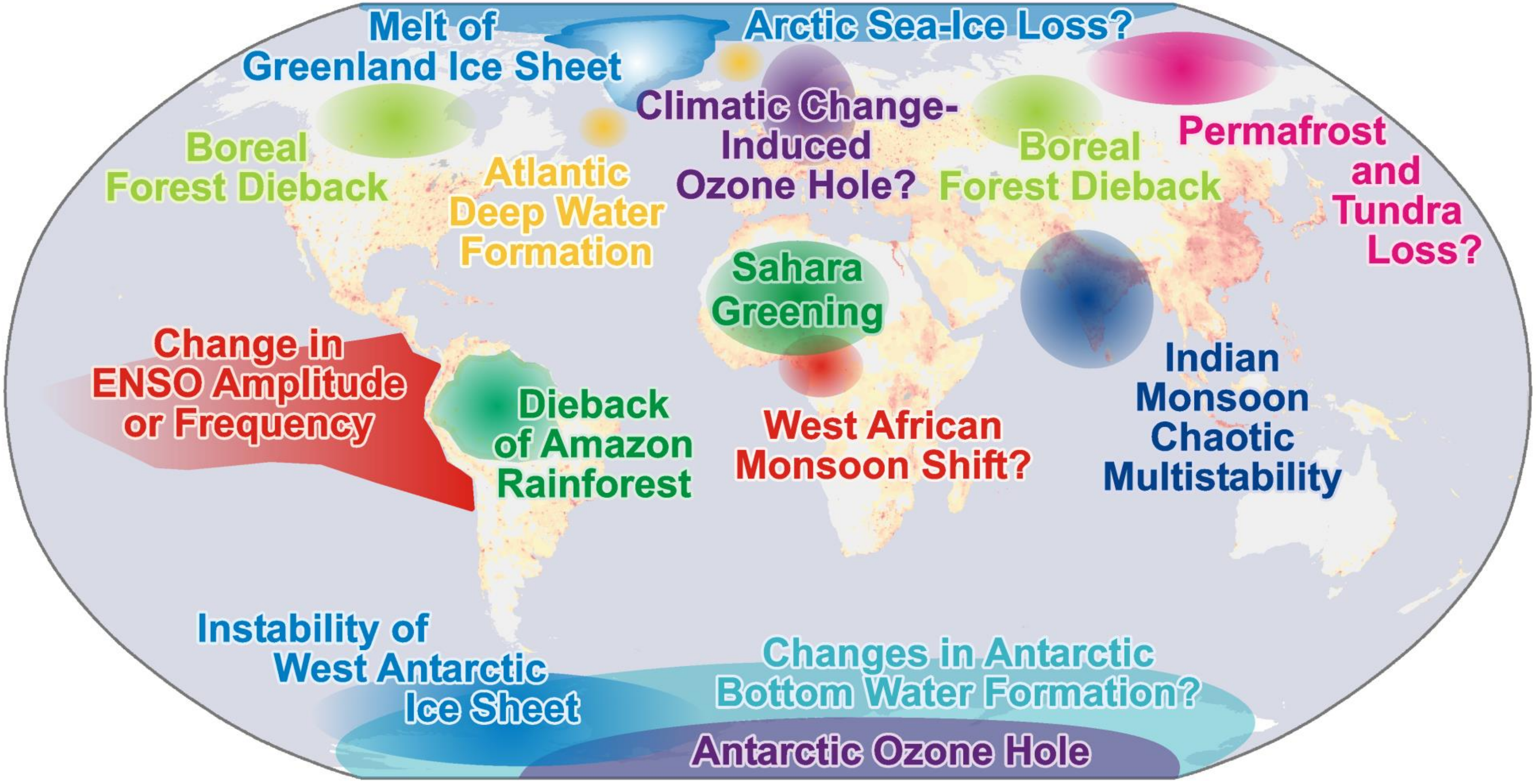
Potential tipping elements



Lenton et al.

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Tipping points

Critical values, timescales, impacts

Tipping element	Feature of system, F	Control parameter(s), ρ	Critical value(s)*, ρ_{crit}	Global warming*†	Transition timescale*, T	Key impacts
Greenland ice sheet (GIS)	Ice volume (–)	Local ΔT_{air}	+~3 °C	+1–2 °C	>300 yr (slow)	Sea level +7 m
West Antarctic ice sheet (WAIS)	Ice volume (–)	Local ΔT_{air}, or less ΔT_{ocean}	+~ 8°C	+3–5 °C	>300 yr (slow)	Sea level +4–6 m
Atlantic thermohaline circulation (THC)	Overturning (–)	Freshwater input to N. Atlantic	+0.1–0.5 Sv	+3–5 °C	~100 yr (gradual)	Regional cooling, sea level, ITCZ shift
El Niño Southern Oscillation (ENSO)	Amplitude (+)	Thermocline depth, sharpness in EEP	–	+3–6 °C	~100 yr (gradual)	Drought in SE Asia and elsewhere
Indian summer monsoon (ISM)	Rainfall (–)	Planetary albedo over India	0.5	–	~1 yr (rapid)	Drought
Sahara/Sahel and WAM	Veg. fraction (+)	Precipitation	100 mm/yr	+3–5 °C	~10 yr (rapid)	Increased carrying capacity
Amazon rainforest	Tree fraction (–)	Precipitation, dry season length	1100 mm/yr	+3–4 °C	~50 yr (gradual)	Biodiversity loss, decreased rainfall
Boreal forest	Tree fraction (–)	Local ΔT_{air}	+~7 °C	+3–5 °C	~50 yr (gradual)	Switch of biome

*Numbers given are preliminary as they are the result of a three-fold subjective but informed procedure: (1) selection of workshop participants, (2) assessment by the experts at the workshop, and (3) aggregation of multiple expert opinions by workshop group leaders and authors of this review article.

†Global mean temperature change above present (1980–1999) that corresponds to critical value of control, where this can be meaningfully related to global temperature.

Lenton et al. 2008
(not IPCC AR5!)

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Results from literature review and workshop

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Consequences

- looking at gradual changes and multimodel multirun averages does not suffice
- precautionary principle

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Uncertainty in cost-benefit estimates

- sources:
  - climate system / climatology
  - social sphere / social sciences
    - politics, social dynamics, economic development
    - technology
    - adaptation (autonomous and planned, ancillary benefits, suboptimal)
    - valuation (international aggregation, human lives, ecosystems, ...)
    - discount rates
  - non-linearities: tipping points and possible surprises in both the climate system and the social sphere
- methodological implications
  - scenario analysis
  - Monte Carlo simulations
  - risk aversion / valuation of low probability catastrophic risks
  - insurance function of climate policy

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Optimization or precaution?

- optimal emissions trajectories from integrated assessment
  - see e.g. Botzen/van den Bergh 2012
  - economists: framework for thought experiments
  - yet influential in the political debate (e.g. USA 1990s, Stern Review)
- precautionary principle
  - prevent dangerous anthropogenic interference with the climate system (UNFCCC, 1992)
    - "2°C above pre-industrial levels" (EU 1996)
    - "well below 2°C above …" (Paris Agreement 2015)
    - "pursue efforts to limit … to 1.5°C" (Paris Agreement 2015)
  - sustainability concept: critical limits
    - threshold values for natural capital components
    - how arbitrary and how costly is the threshold? -> a bit of CBA?
  - cost-effectiveness analysis rather than cost benefit analysis

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