CURRENT UNDERSTANDING OF ECONOMIC CONSEQUENCES OF CLIMATE CHANGE

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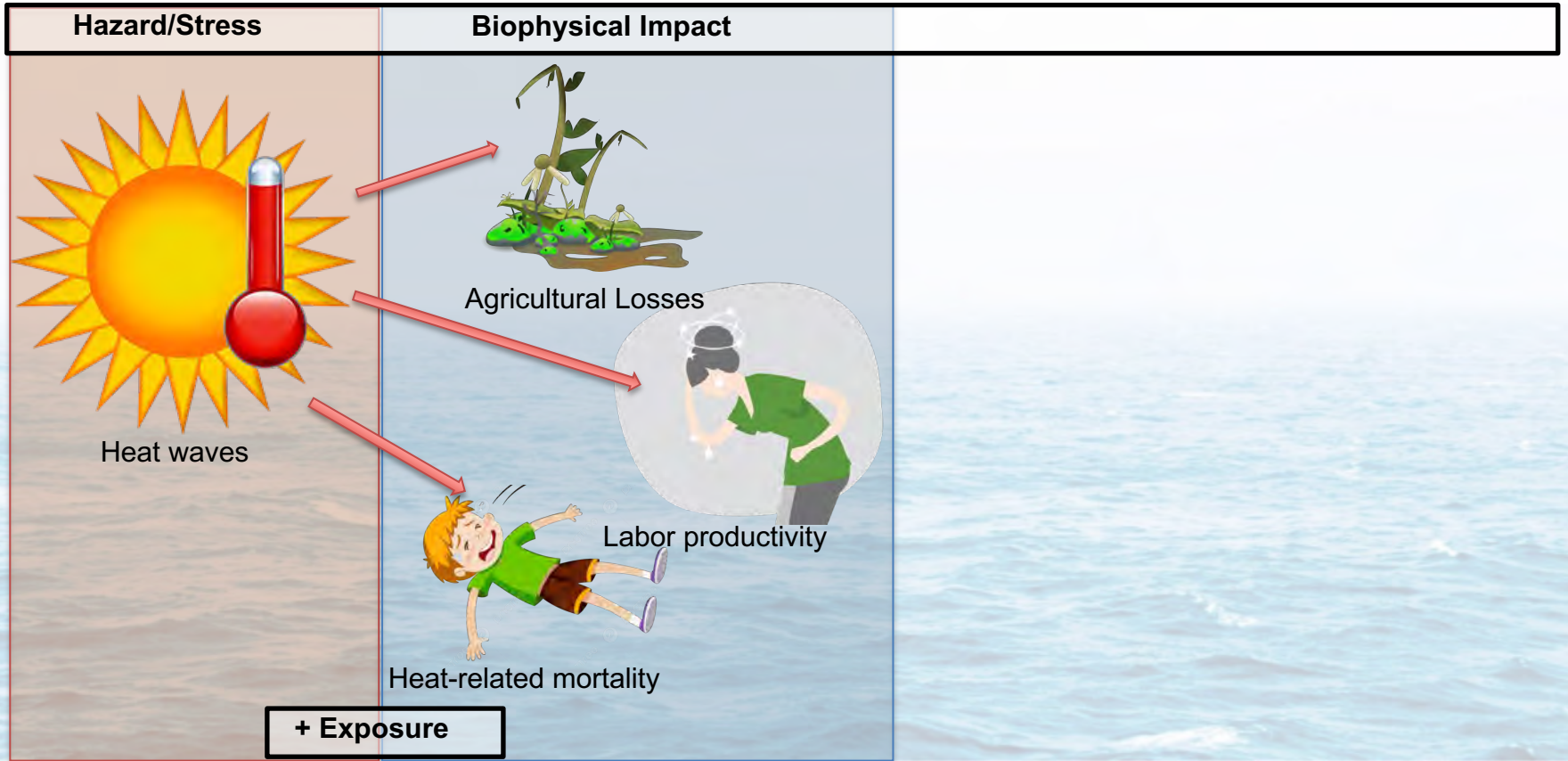
University of Delaware
March 28, 2024

XLVI MIT Global Change Forum

From impacts to economics



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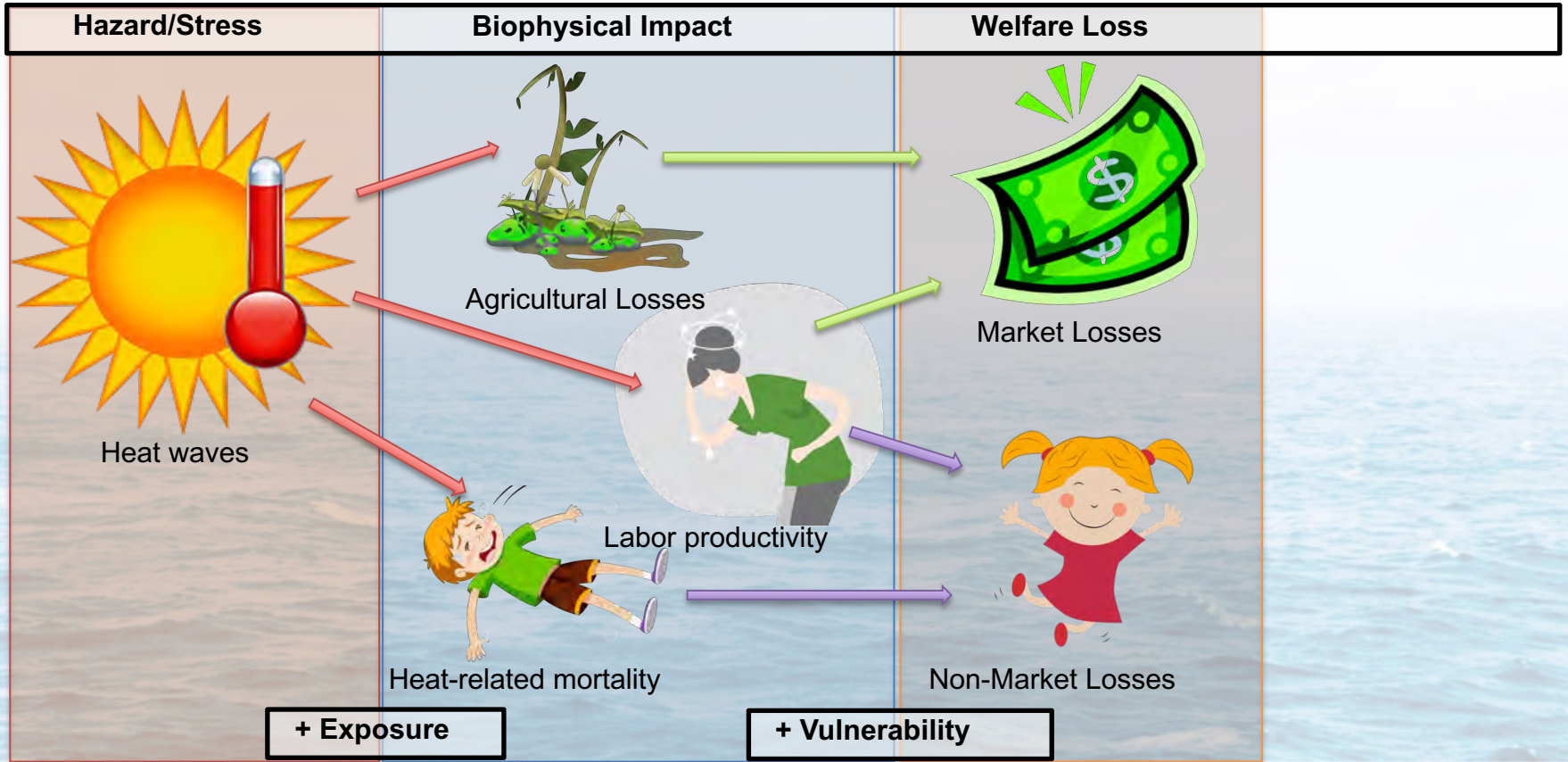

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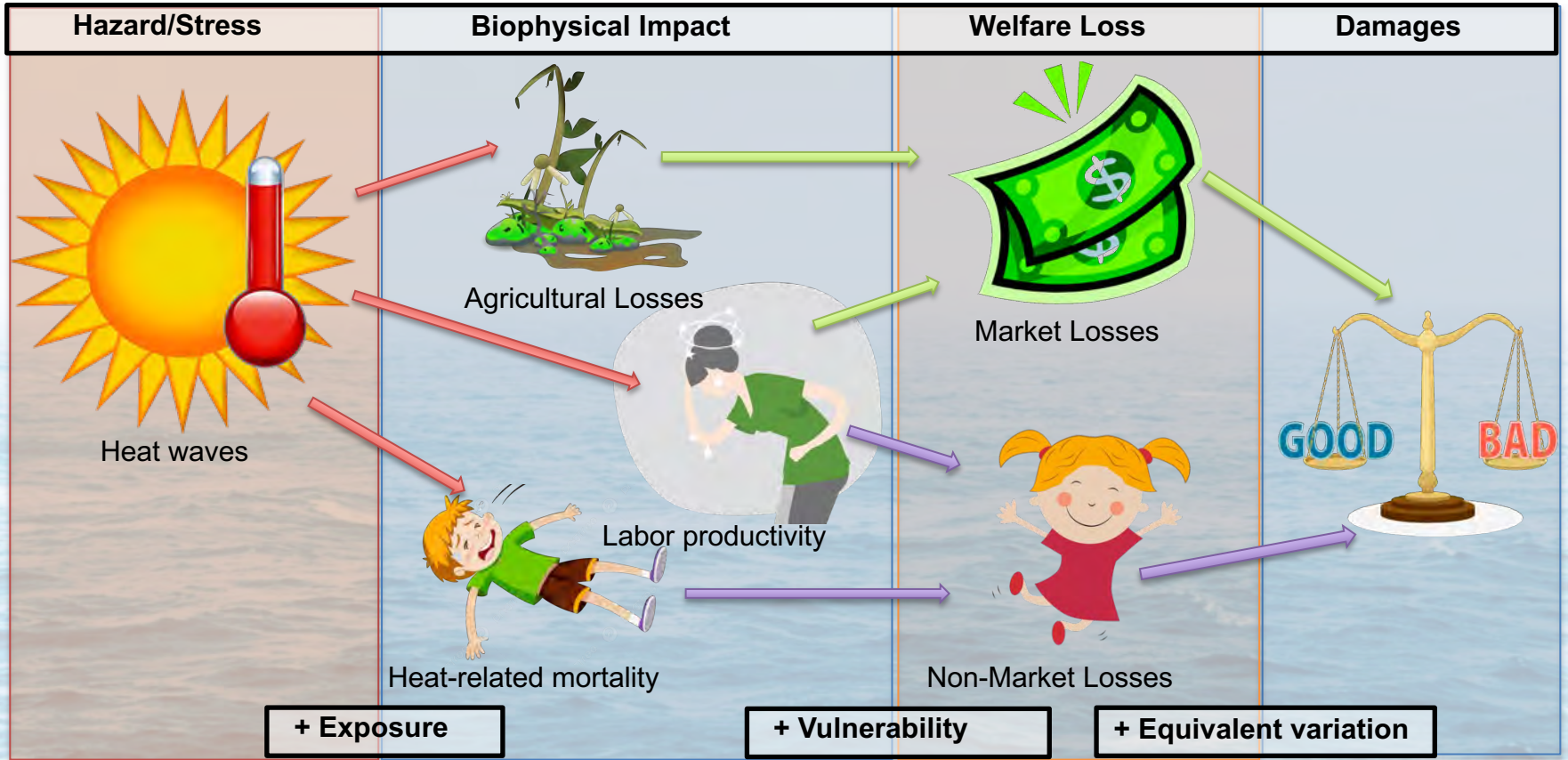


Defining economic consequences of climate change

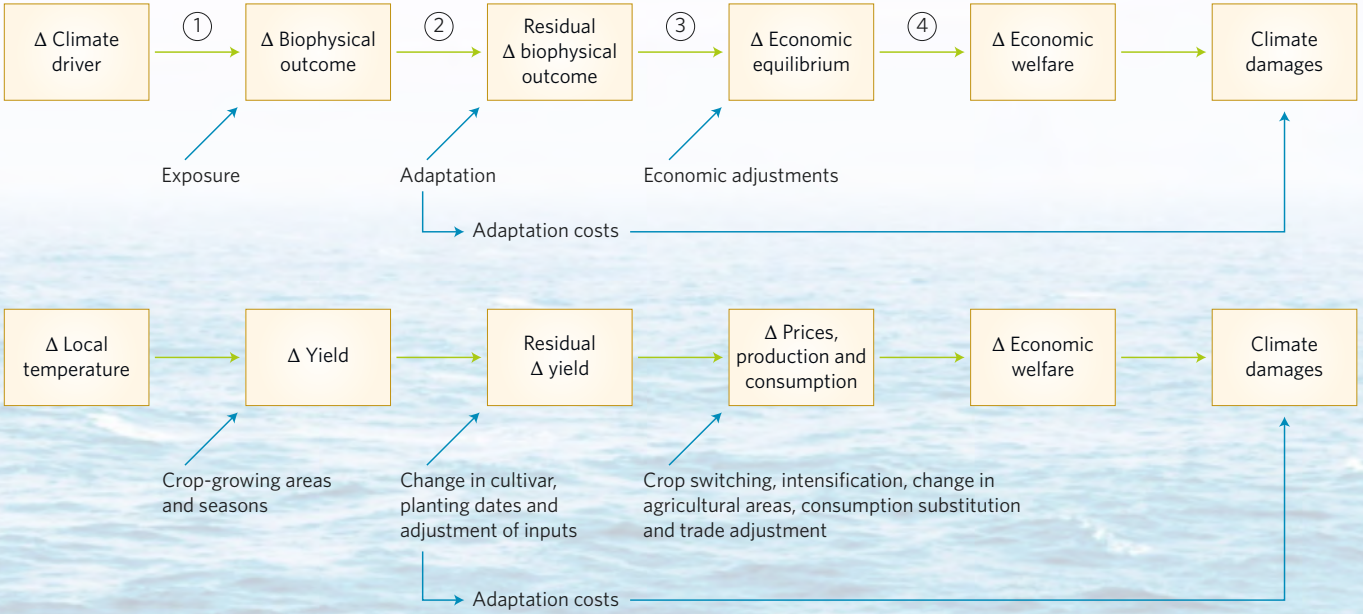
Parts of a definition for **economic risks of climate change**:

1. Concerned with changes in **welfare**, not just financial outcomes.
2. A comprehensive evaluation of economic risk includes:
   - Losses to income or consumption,
   - Welfare loss from **non-market impacts**,
   - **Inequality** in losses, and the role of non-climate-related inequality,
   - **Variability** in impacts and disasters
   - Multiple forms of uncertainty
3. Exposure, vulnerability, and resilience all change over time.

(Hallegatte et al. 2016)

How do we get economic risks?

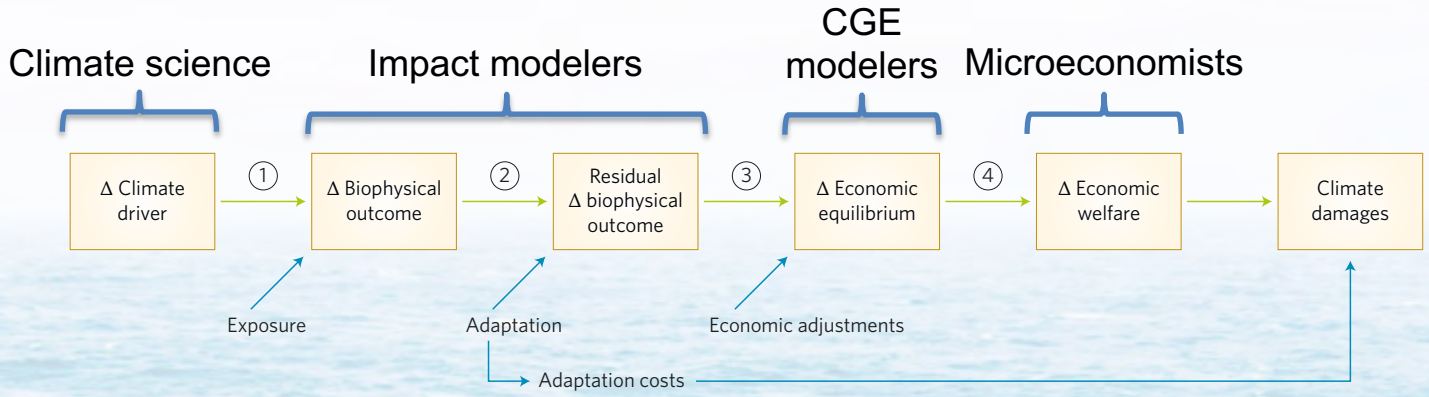
- General process for calculating economic risks is:



Diaz & Moore (2017)

How do we get economic risks?

- Many disciplines involved!



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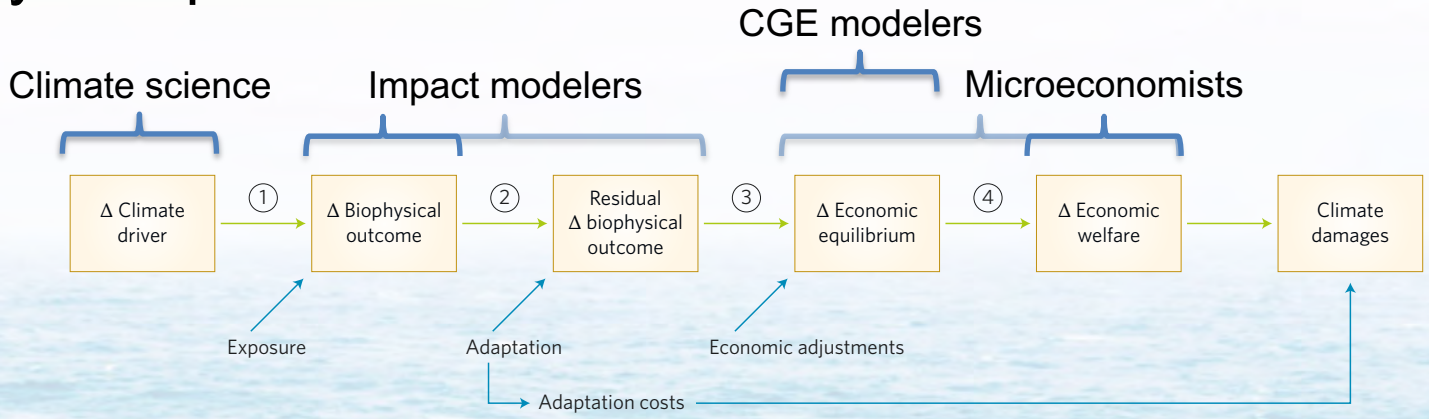

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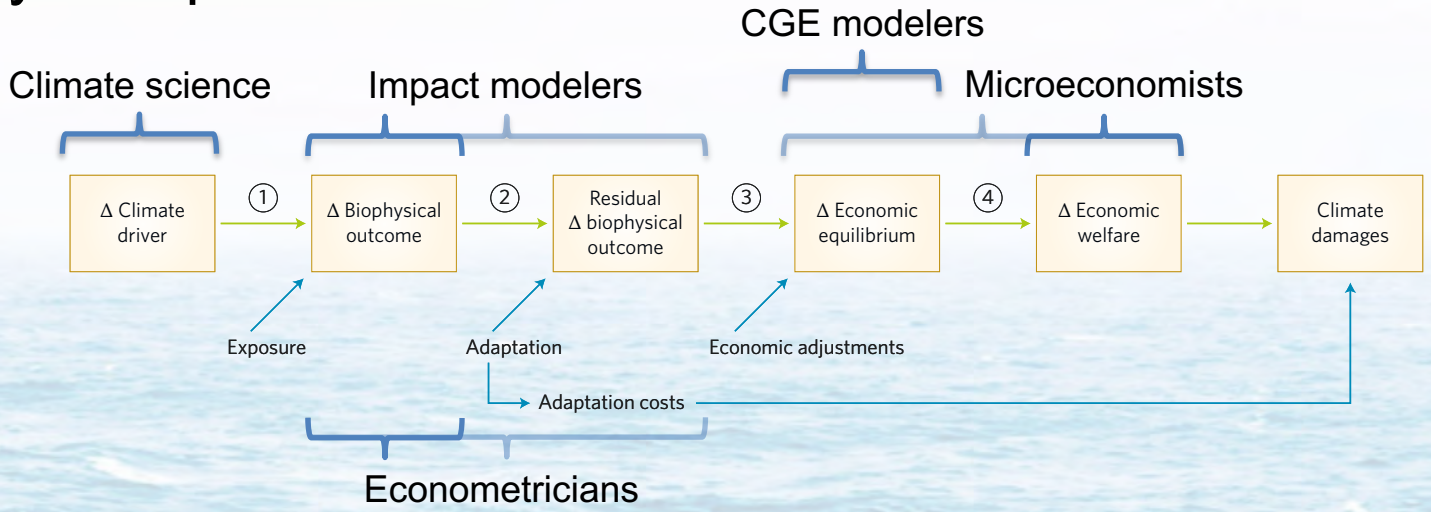

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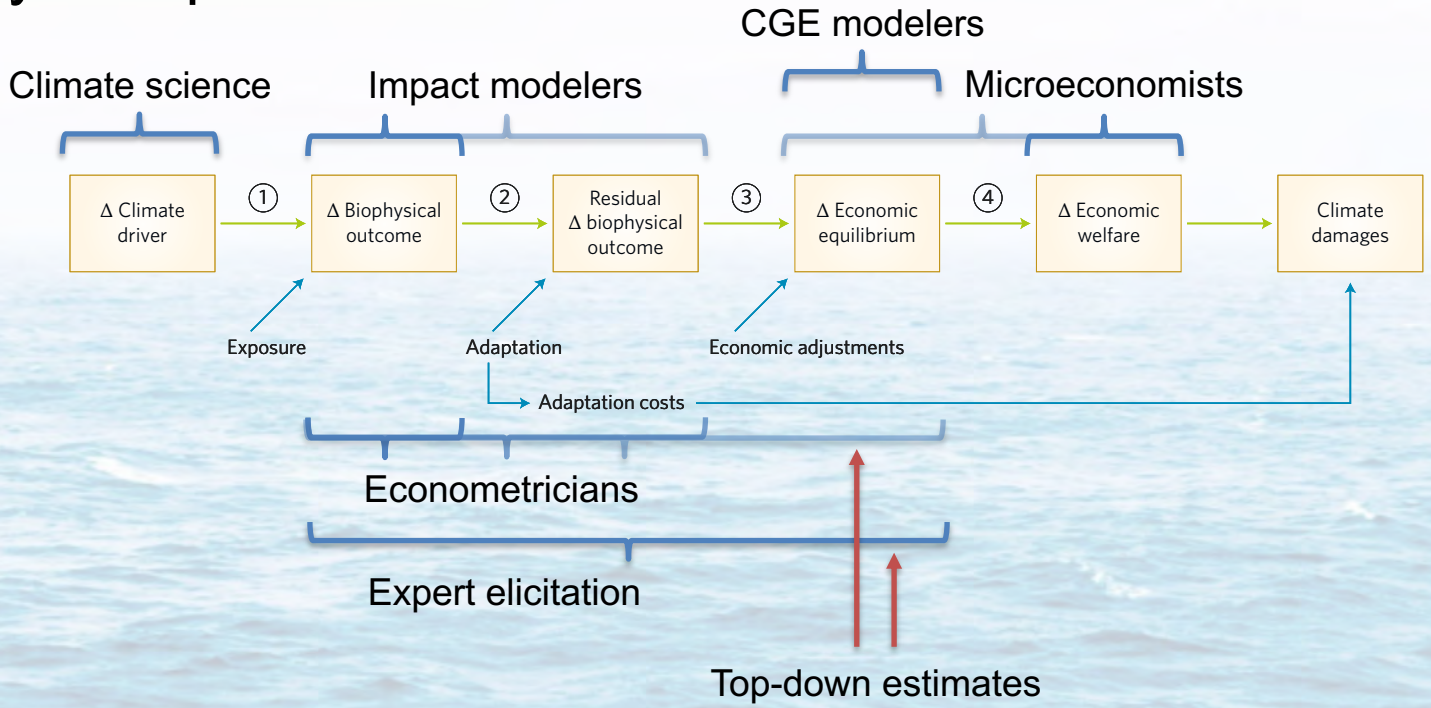
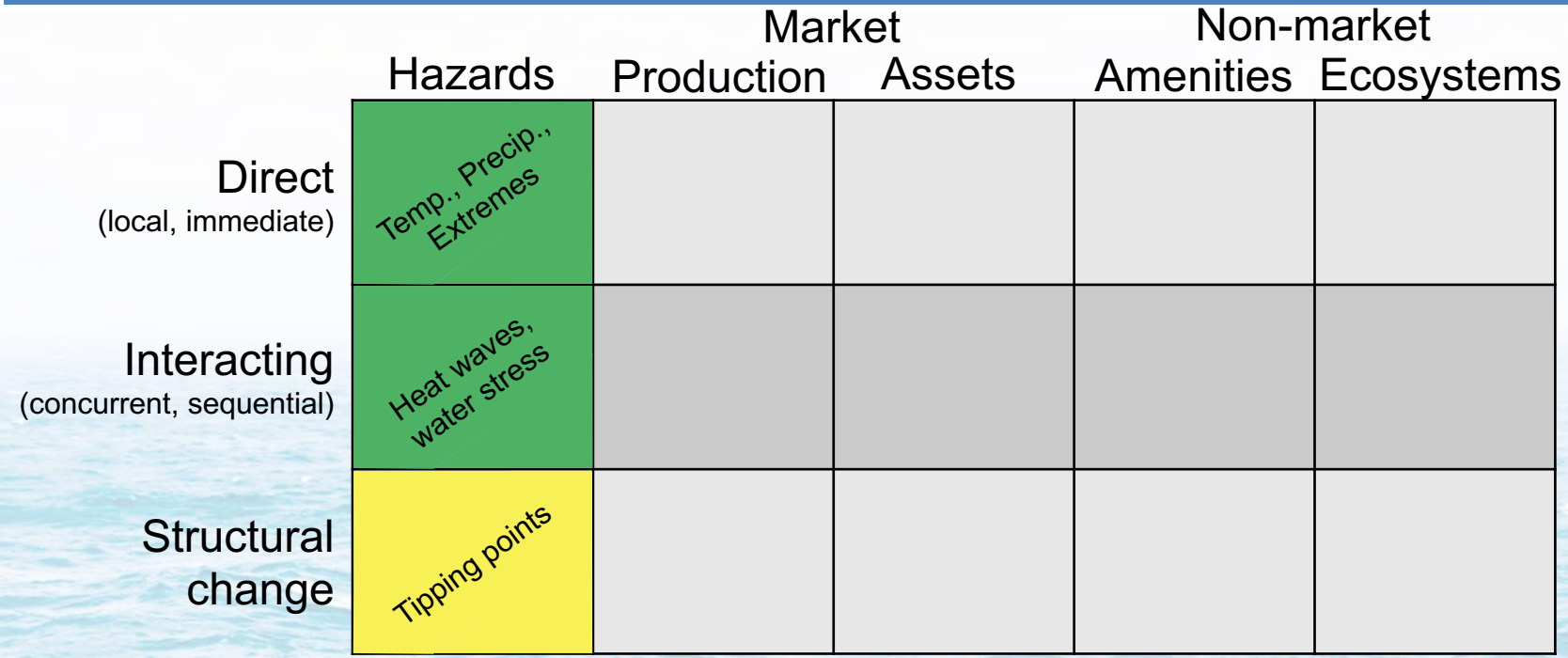


Frontier of knowledge



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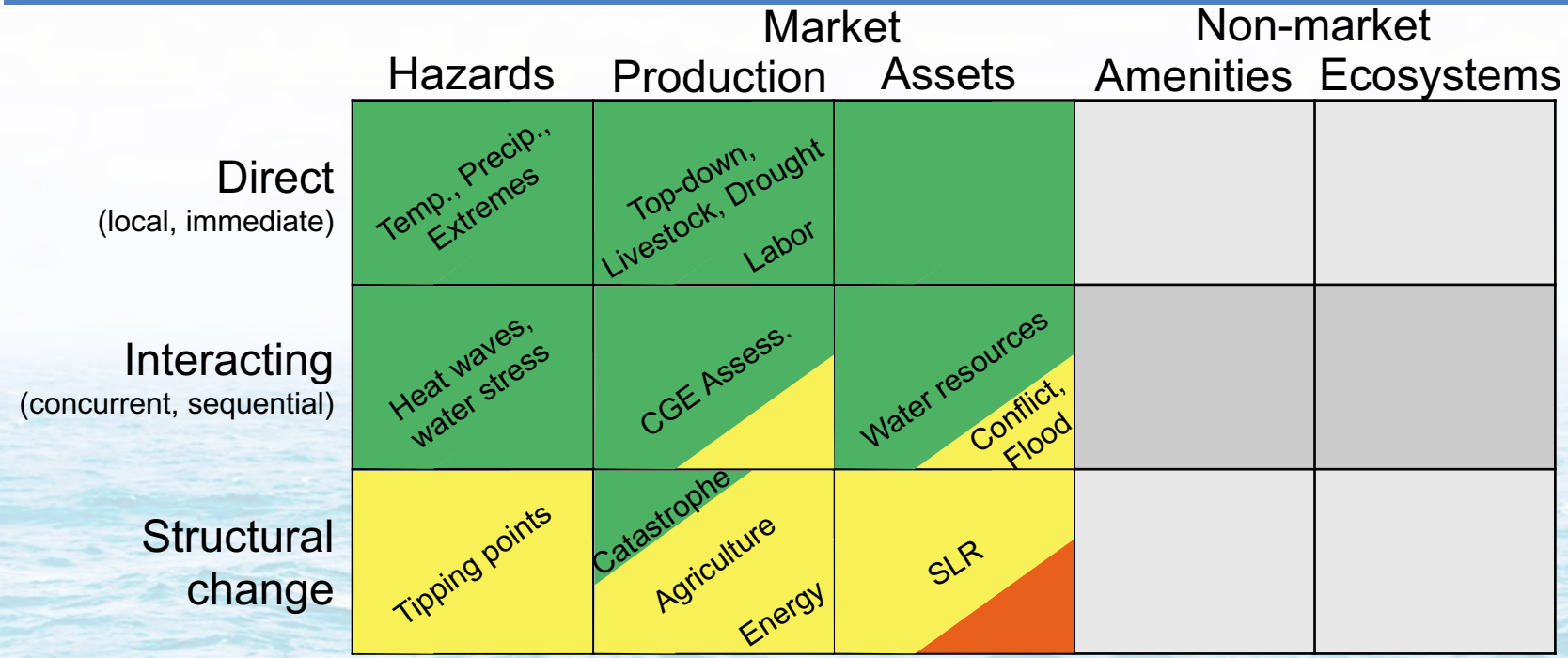

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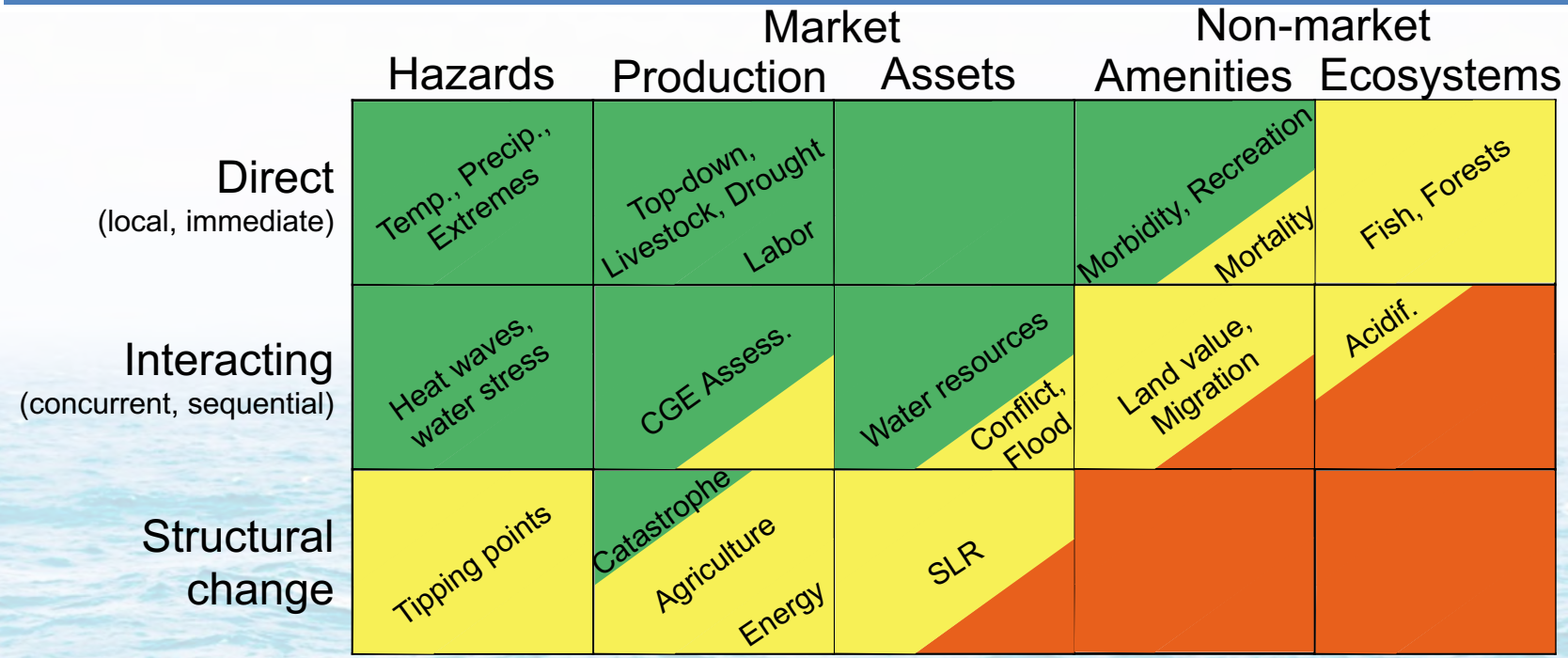

Some general observations

What do we know about the economic risks?

- Losses from climate change exceed costs of mitigation.
- Damage increase more quickly at higher temperatures.
- Considerable heterogeneity which reinforces inequality.
- Nearest-to-consensus estimate of damage from 1 t CO_2 is $190 (EPA SCC).
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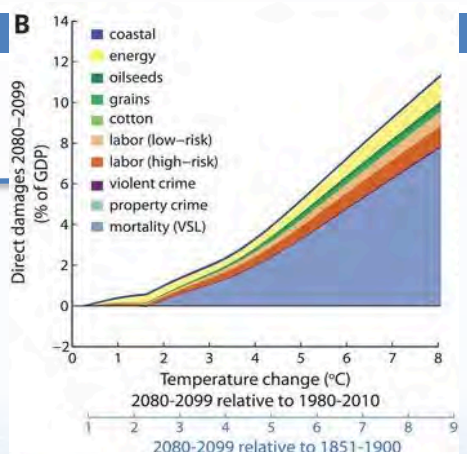

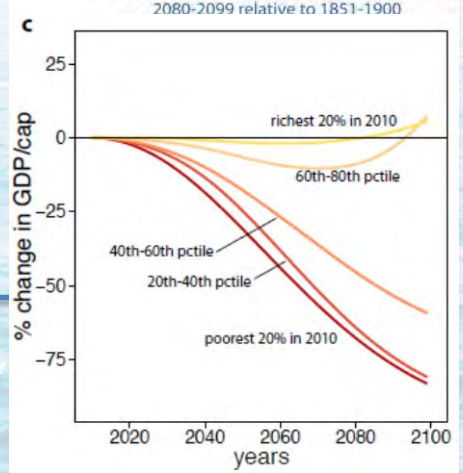

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What do we disagree on?

- Which channels produces the greatest effects.
  - Mortality, labor productivity, agriculture, GDP growth
- Capacity for adaptation and economic adjustment.
- Importance of variability, global trade, tipping points.

Channel	Inclusion	With adaptation	With feedbacks
Economic output	45%	38%	7%
Health	38%	14%	21%
Agriculture	34%	17%	24%
Coastal inundation	31%	17%	17%
Energy	31%	14%	21%
Extreme events	28%	21%	21%
Forestry	14%	10%	3%
Labour productivity	14%	3%	10%
Tourism	14%	3%	10%
Water availability	14%	10%	3%
Biodiversity/Ecosystems	7%	7%	0%
Fluvial floods	7%	3%	3%
Crime	3%	0%	3%
Ecosystems	3%	3%	0%
Fishery	3%	3%	3%
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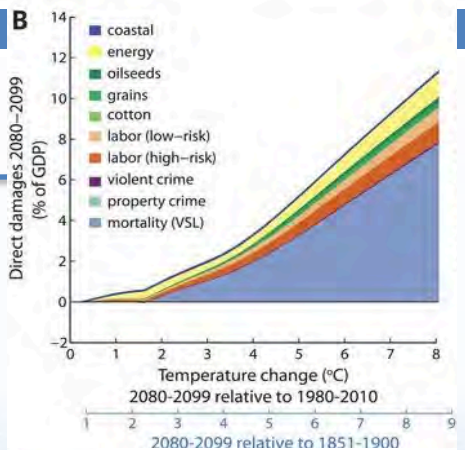

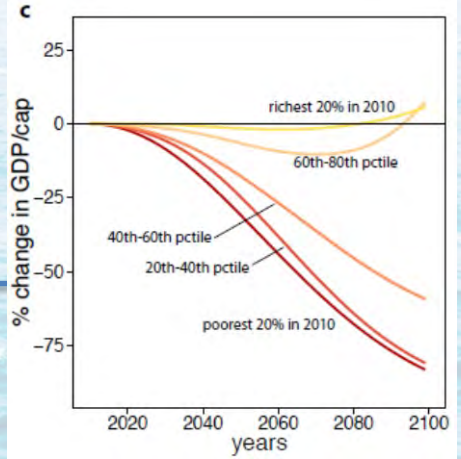

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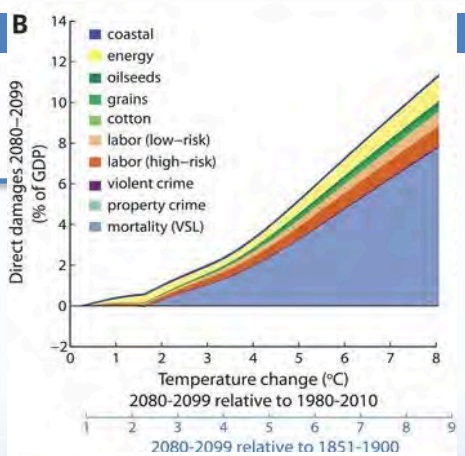
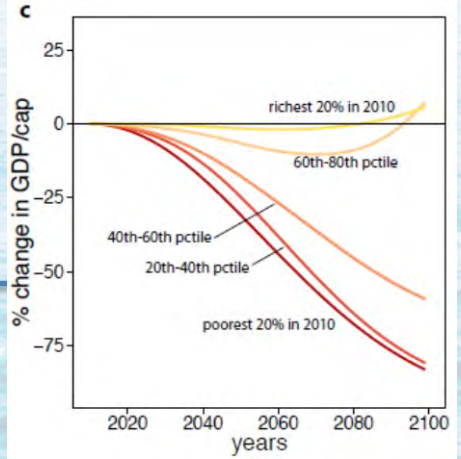
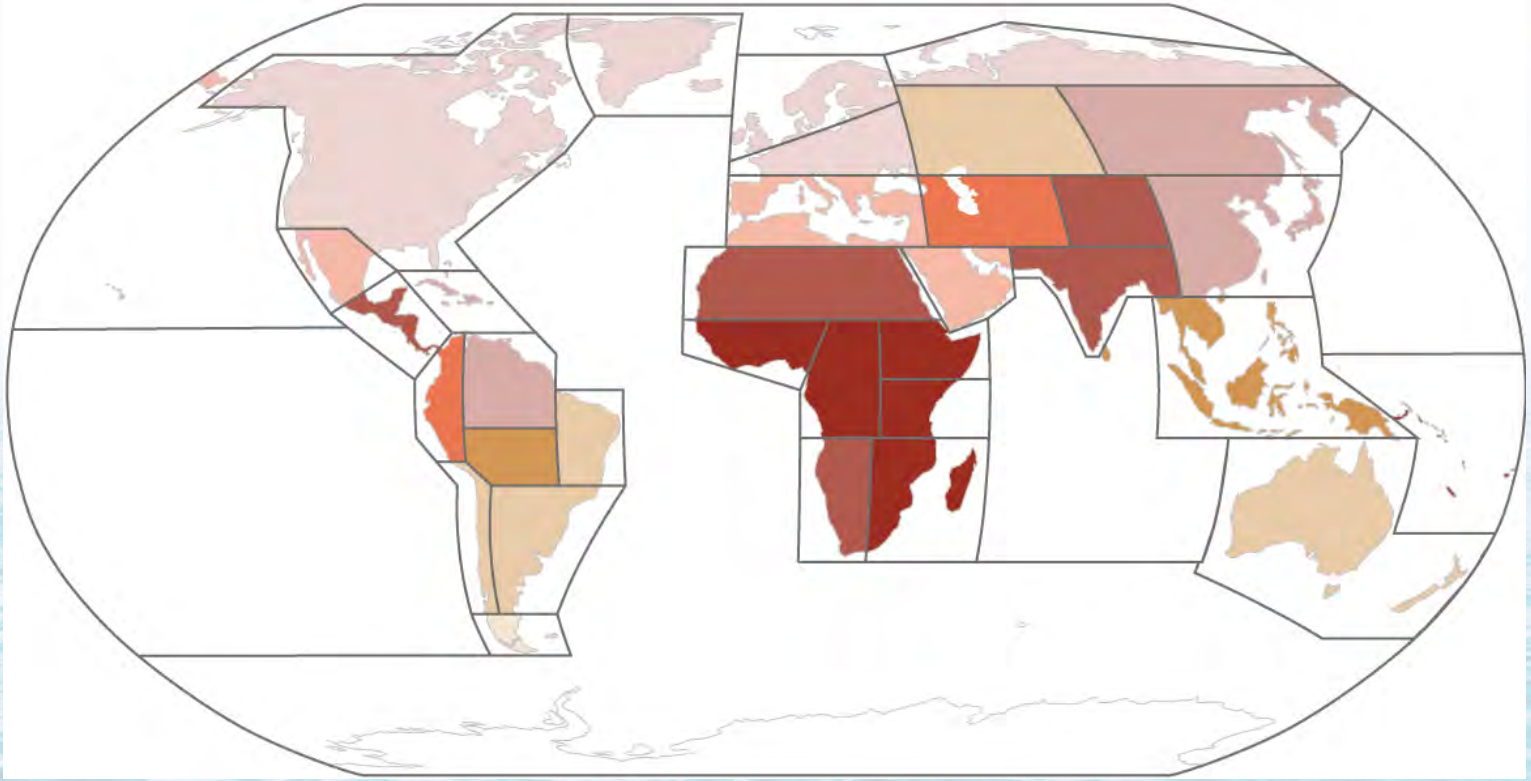


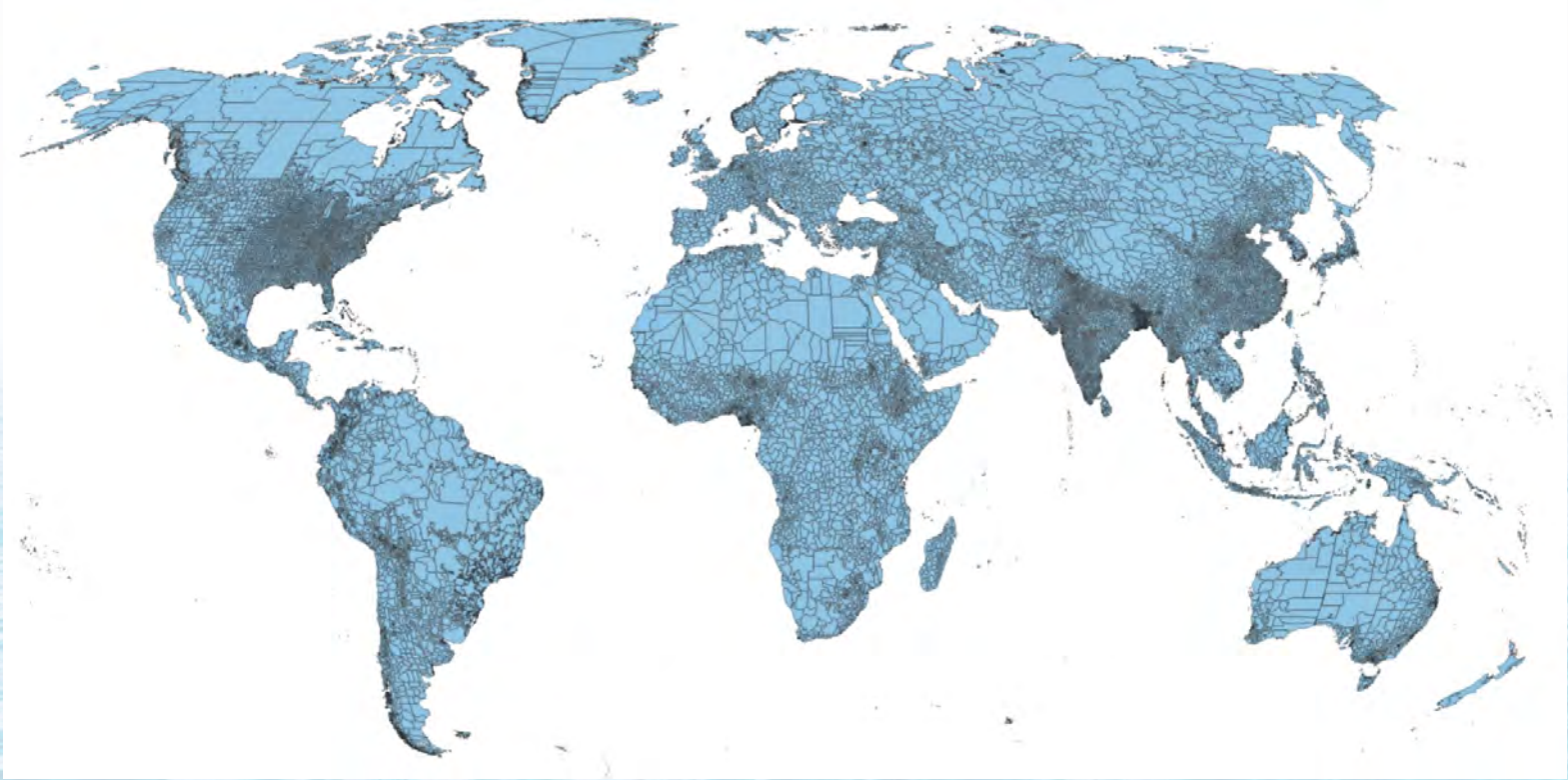


Inequality in vulnerability



(IPCC AR6, Figure 8.5)

Unprecedented spatial granularity



Climate Impact Lab: 24,378 regions capture subnational inequality of damages

Evaluating inequality

- Heterogeneity in damages, but what is inequality? We consider:
  - Damages reinforcing existing economic inequality.
  - Damages on groups that are not responsible for emissions.
  - Excess damages due to lack of adaptation funding.

Our “data”

- Mortality — heat and cold deaths (Carleton et al, QJE, 2022)
  - All cause mortality (<5)
  - All cause mortality (5-64)
  - All cause mortality (>64)
- Energy — energy and electricity demand (Rode et al, Nature, 2021)
  - Electricity consumption
  - Other fuels consumption
- Agriculture — crop yields (Hultgren et al, R&R)
  - Maize
  - Wheat
  - Rice
  - Soybean
  - Sorghum
  - Cassava
- Labor — labor supply & disamenity (Rode et al, 2022)
  - High risk labor
  - Low risk labor
- Coastal — sea level rise and storm damages (Depsky et al, in review)
  - Sea level rise inundation
  - SLR × tropical cyclone surge

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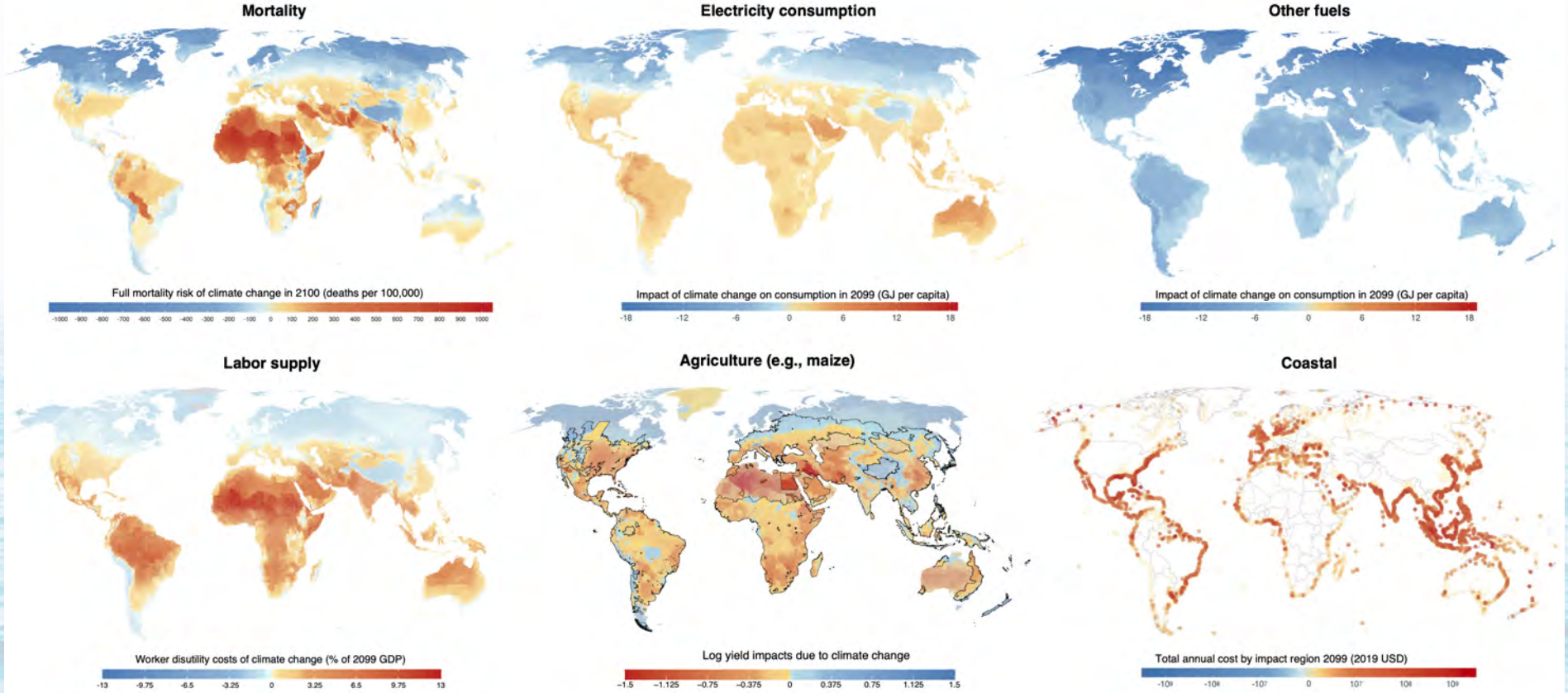
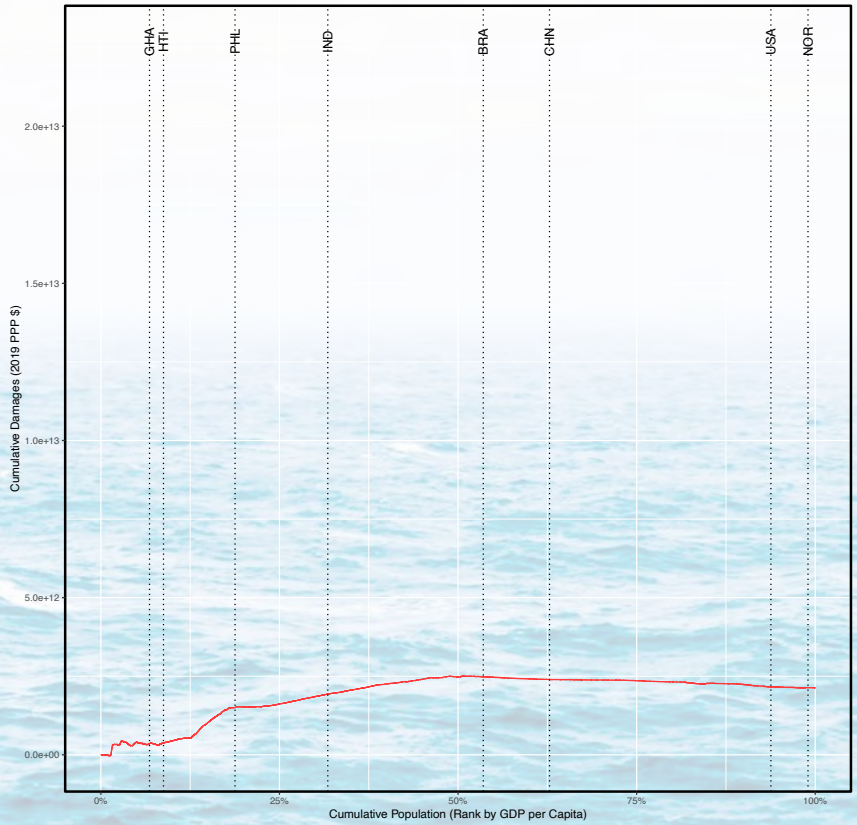
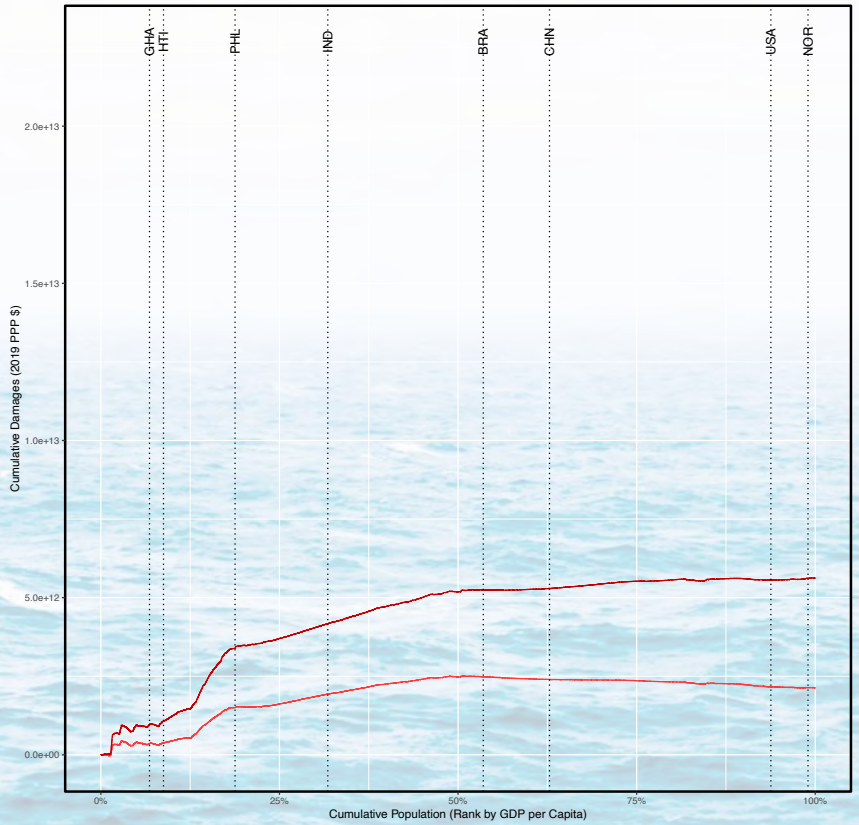

Mortality
Full mortality risk of climate change in 2100 (deaths per 100,000)
-1000 -900 -800 -700 -600 -500 -400 -300 -200 -100 0 100 200 300 400 500 600 700 800 900 1000
Electricity consumption
Impact of climate change on consumption in 2099 (GJ per capita)
-18 -12 -6 0 6 12 18
Other fuels
Impact of climate change on consumption in 2099 (GJ per capita)
-18 -12 -6 0 6 12 18
Labor supply
Worker disutility costs of climate change (% of 2099 GDP)
-13 -9.75 -6.5 -3.25 0 3.25 6.5 9.75 13
Agriculture (e.g., maize)
Log yield impacts due to climate change
−1.5 −1.125 −0.75 −0.375 0 0.375 0.75 1.125 1.5
Coastal
Total annual cost by impact region 2099 (2019 USD)
-10⁹ -10⁸ -10⁷ 0 10⁷ 10⁸ 10⁹

Inequality in damages



Total Damages
2080-2099
Under full adaptation, with costs of adaptation
By global warming level

Inequality in damages



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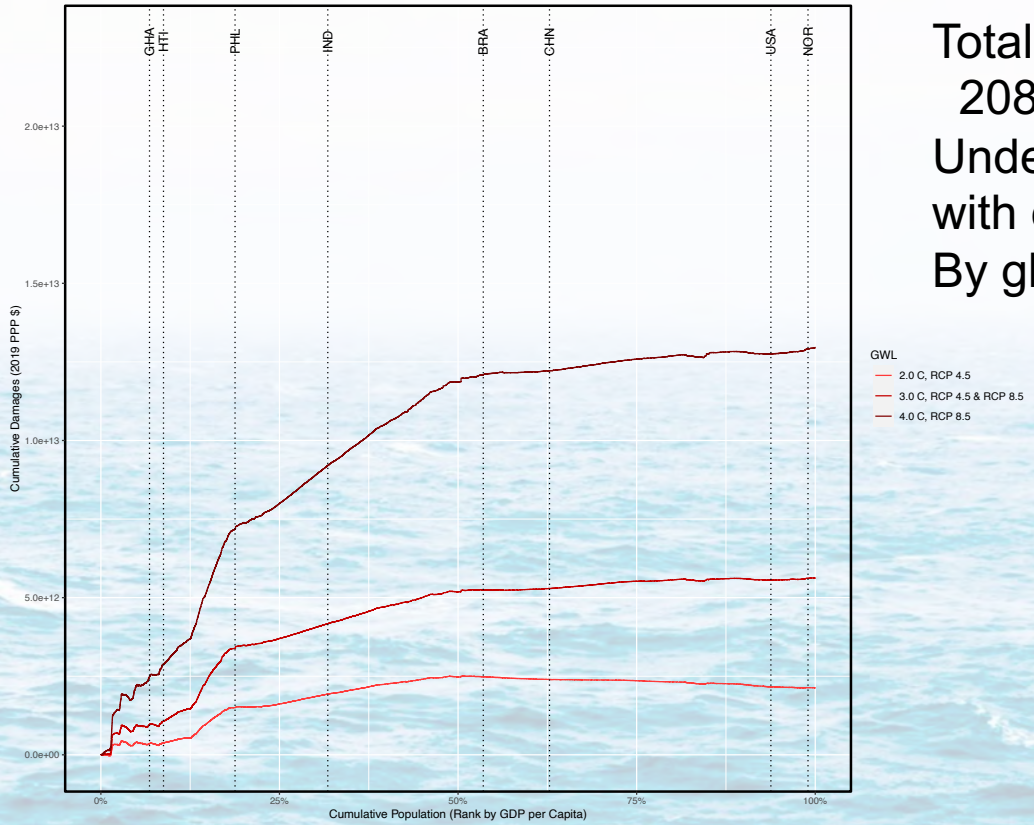

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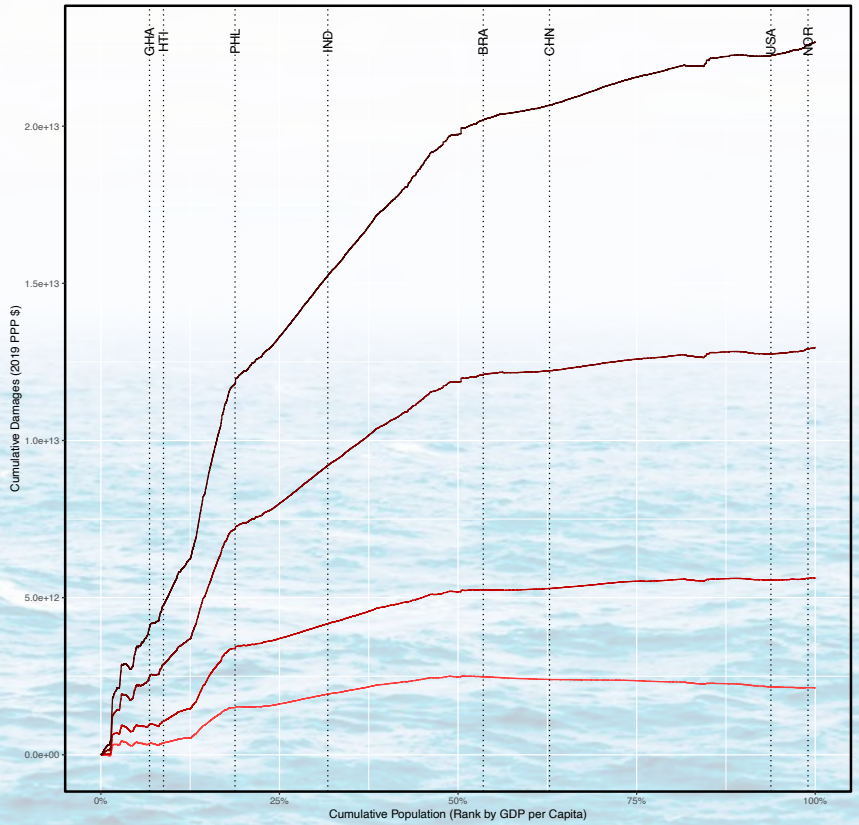

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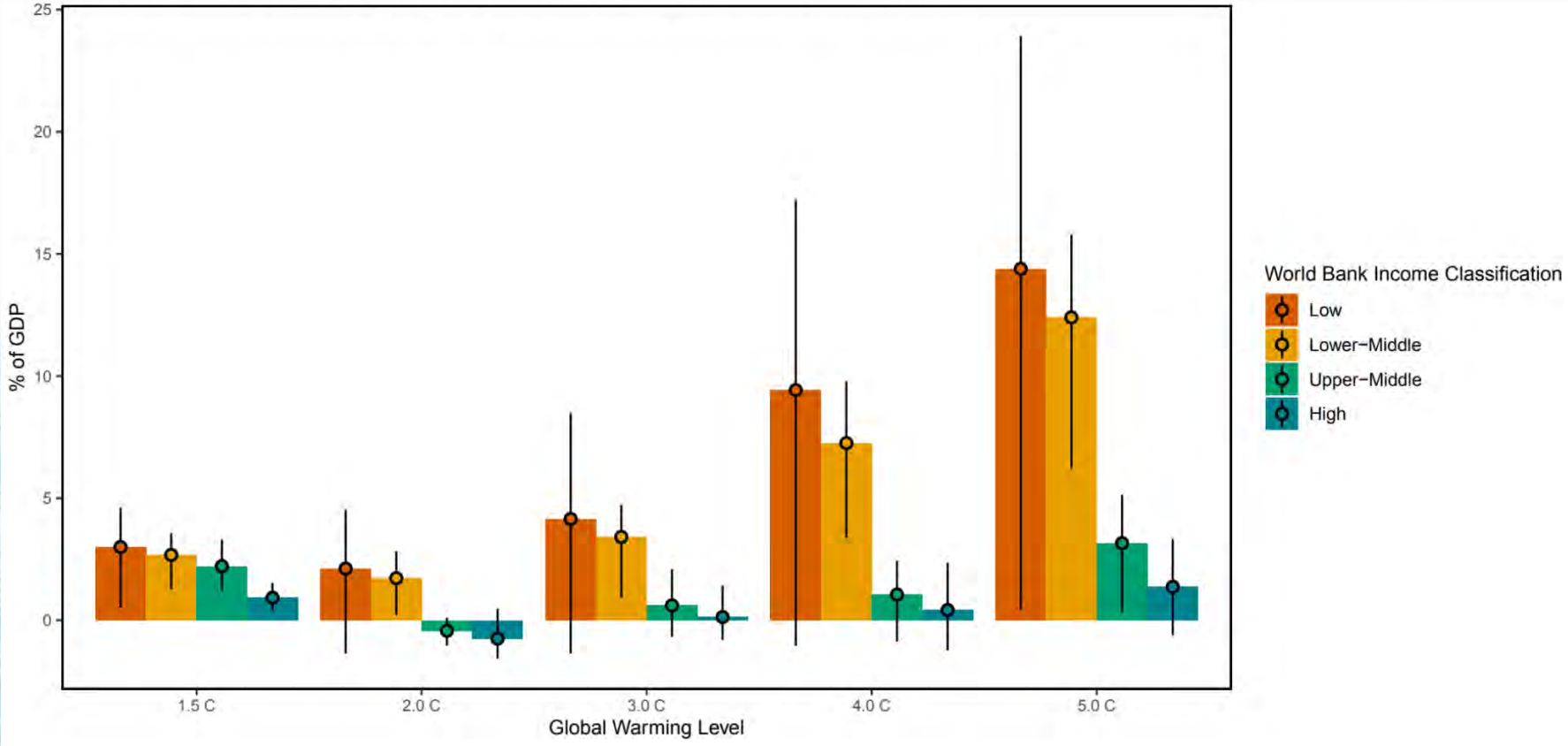
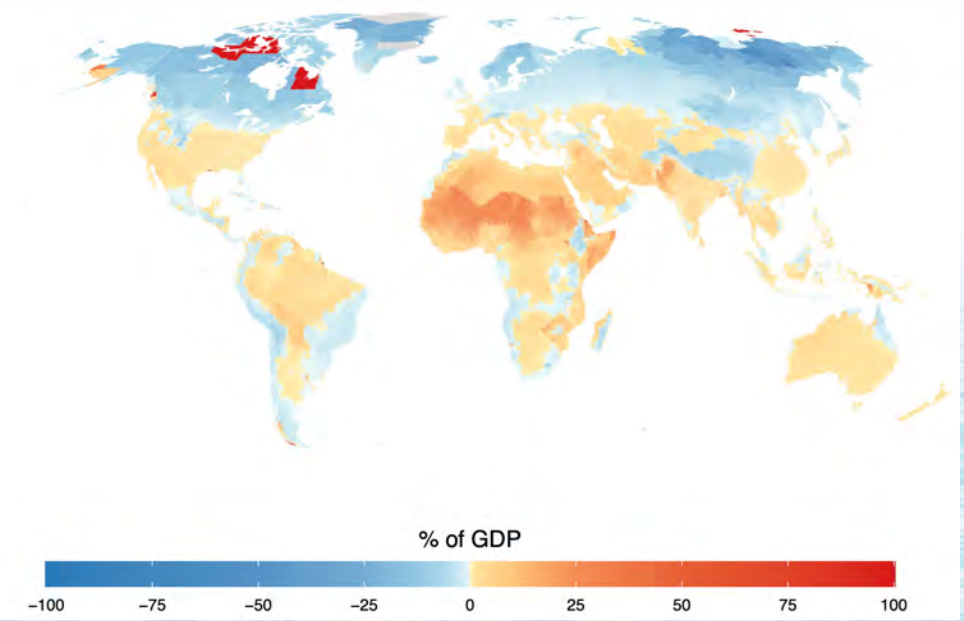
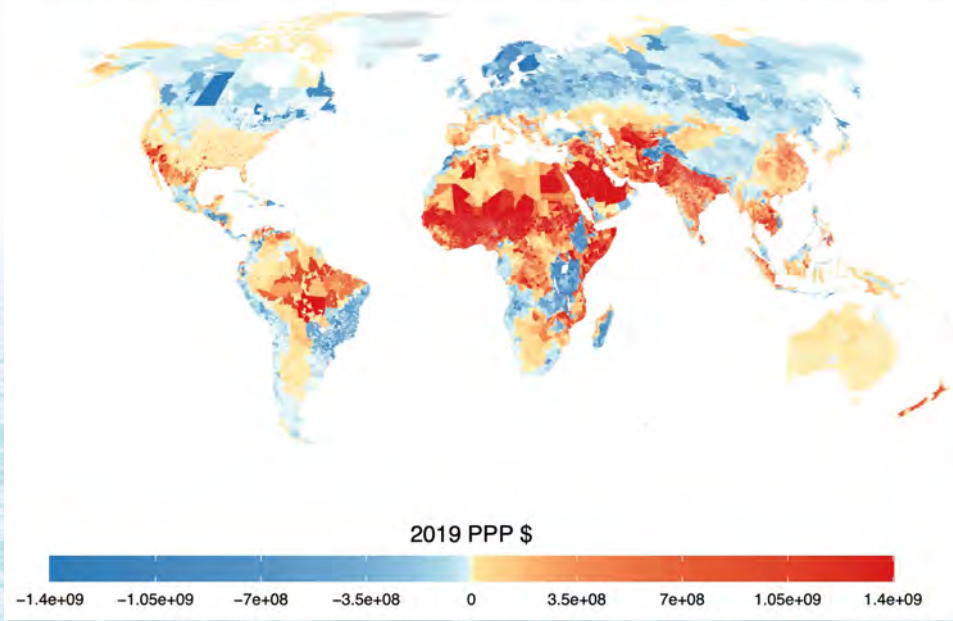


Inequality in damages

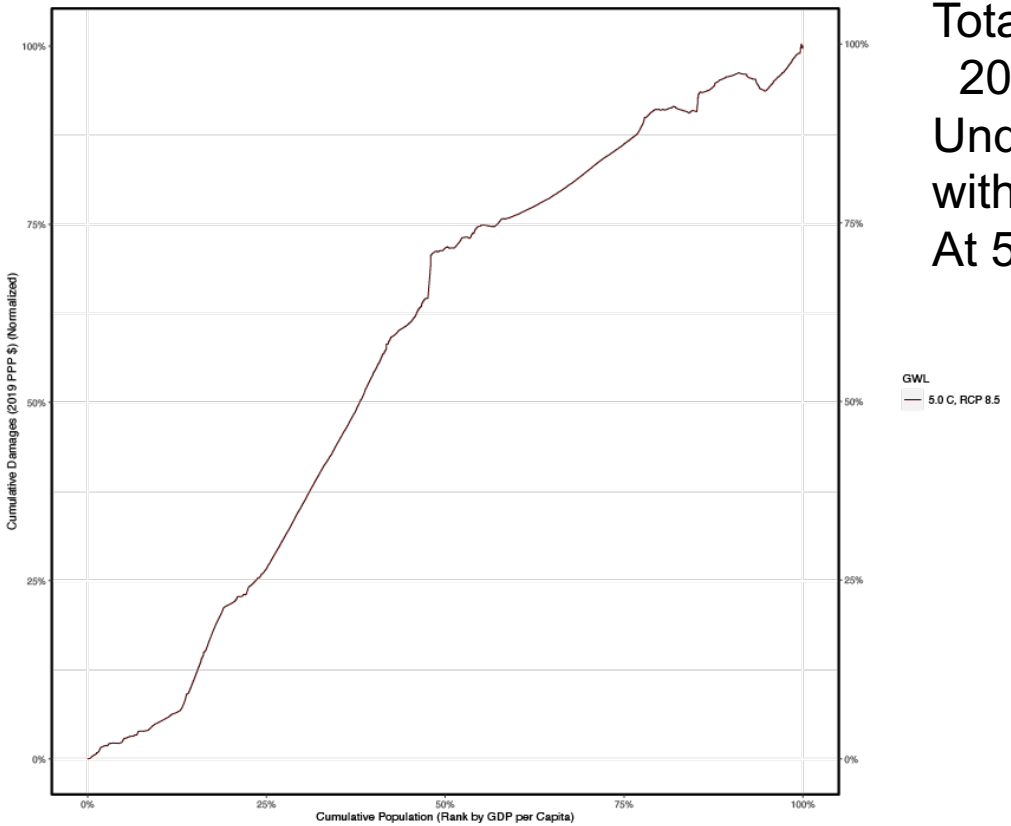
Full Adaptation & Costs across 5 sectors





(3 C under SSP3 at end-of-century)

Comparison to emissions



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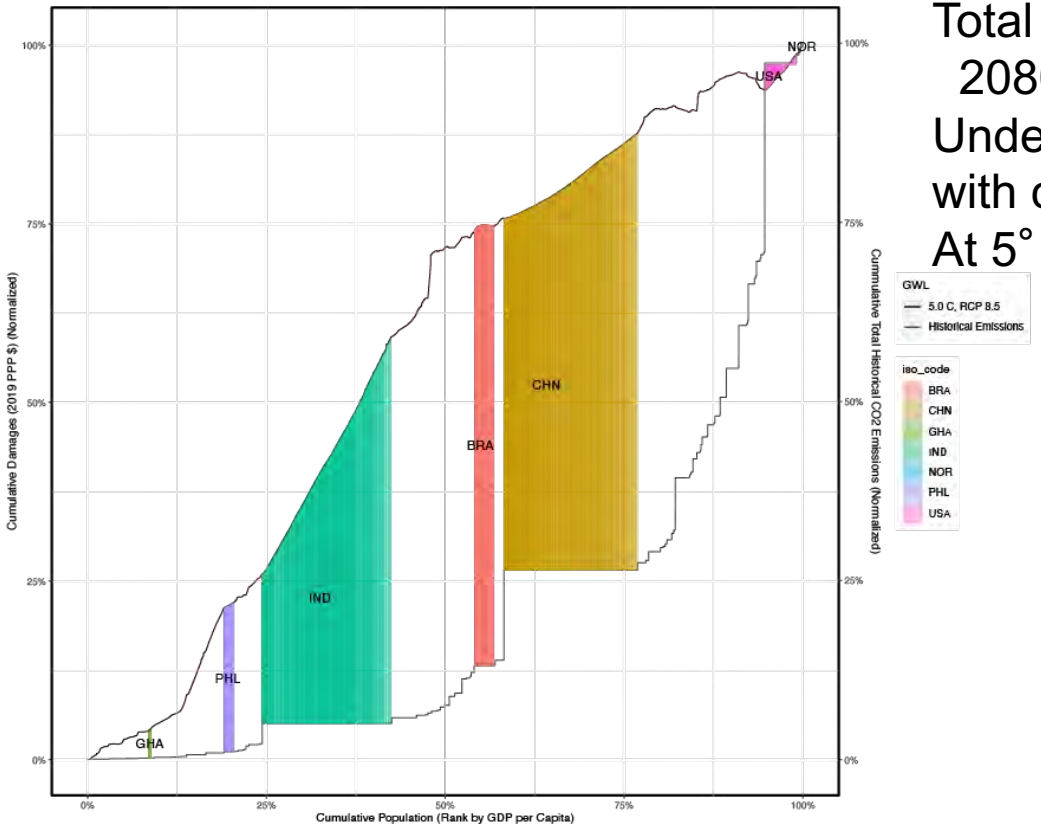

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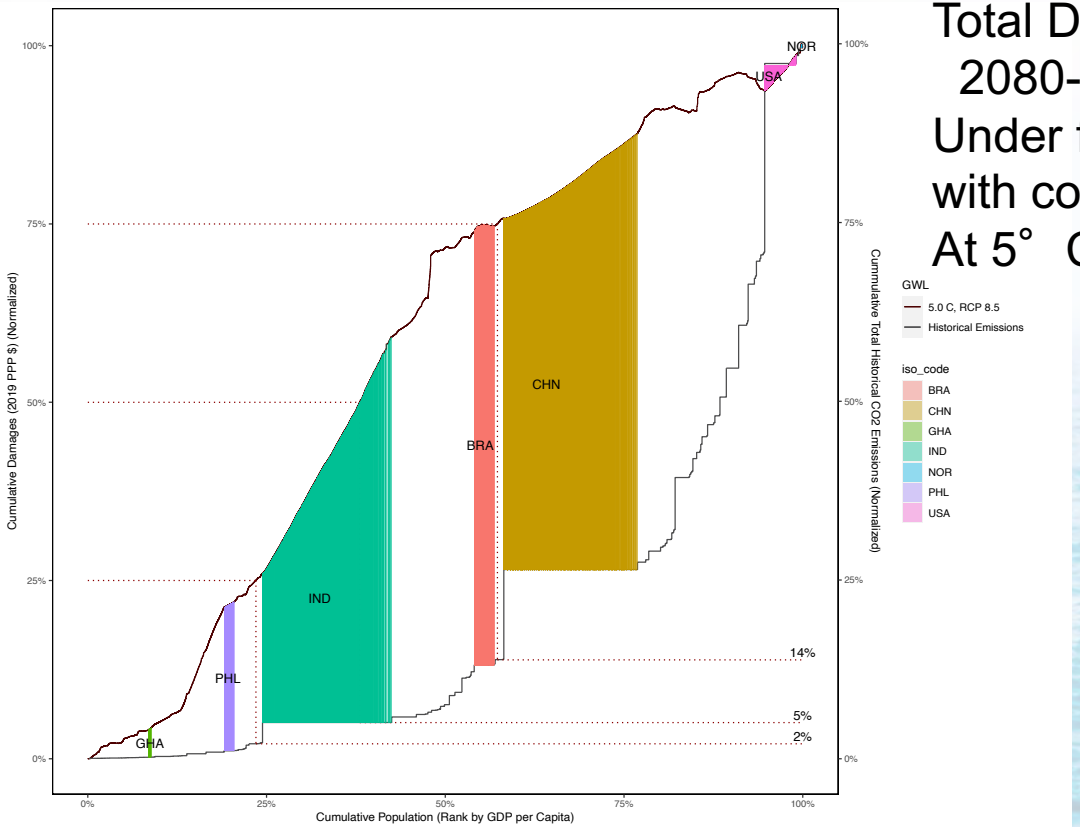

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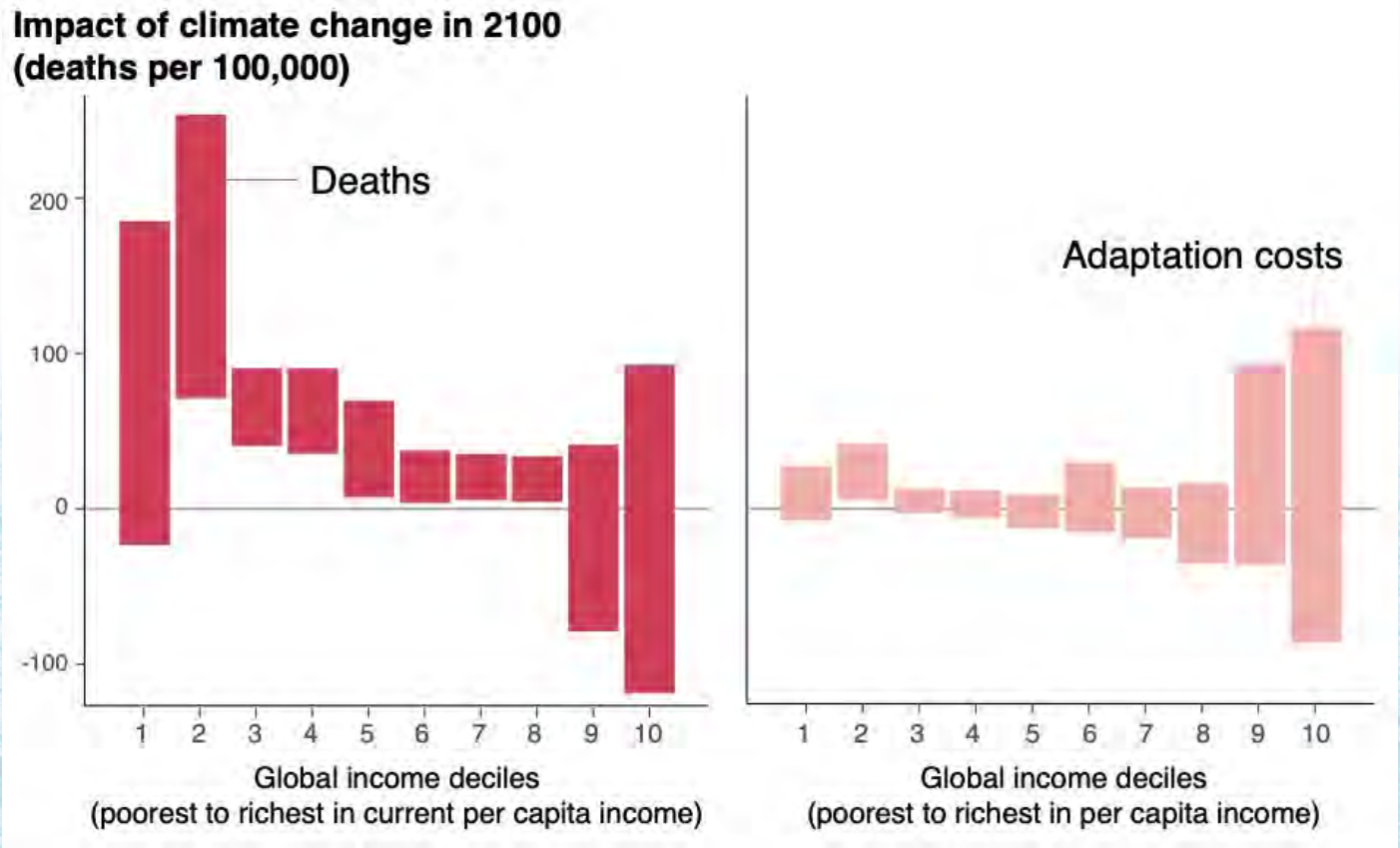
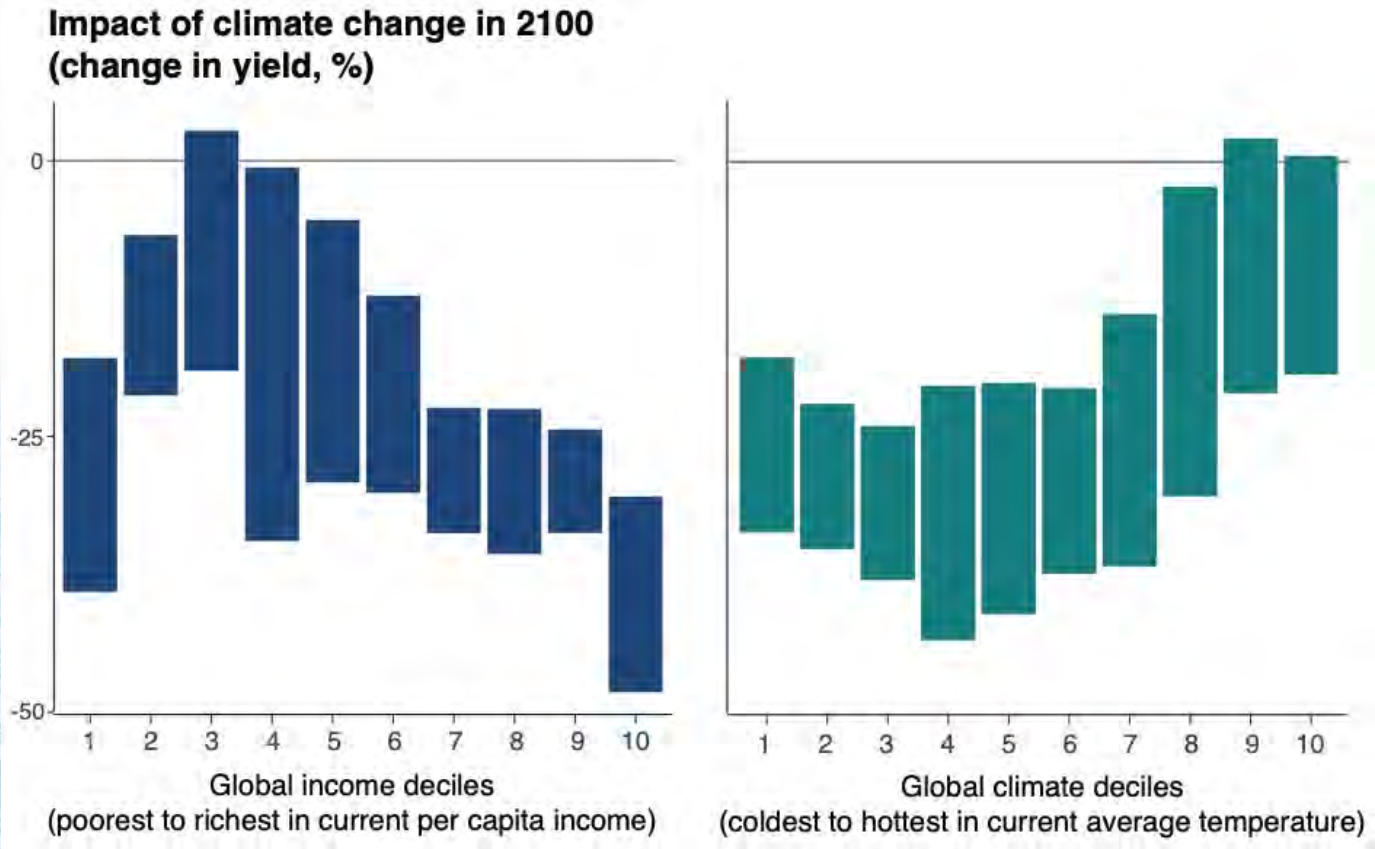
Costs of adaptation: Mortality



Costs of adaptation: Agriculture



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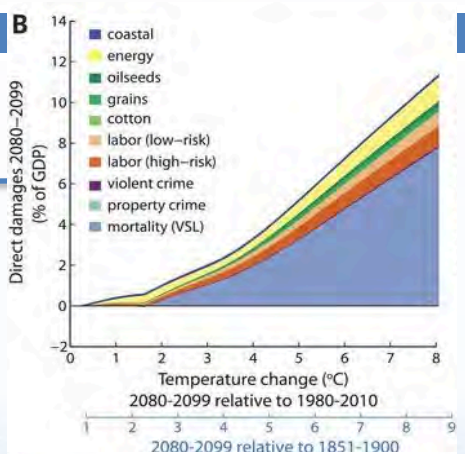
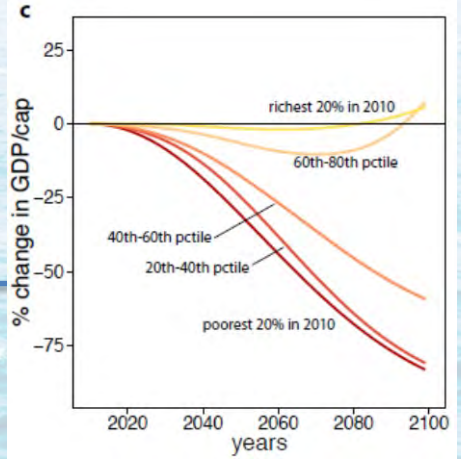
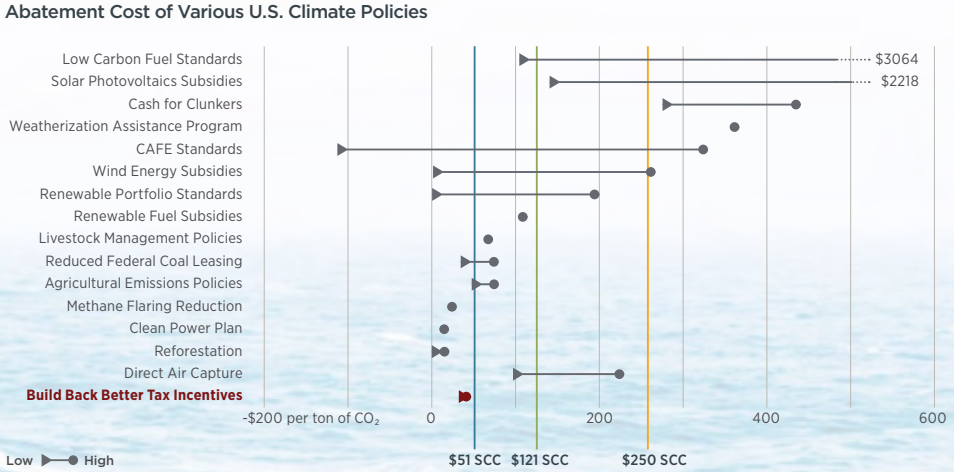




Apply to cost-benefit policy

- EPA mandate to use cost-benefit analysis



Gillingham & Stock (2018)

Enter the social cost of carbon (SCC)

- Includes >80 regulations, $1 trillion in benefits
- Also used by 11 states, Canada, France, Germany, Mexico, Norway, UK

History of the US SCC

- Prior to 2009: Different agencies, diff. SCCs.
- 2009 – 2016: \$52 / tCO_2 (Obama admin.)
- 2016: National Academy of Sciences report
- 2016 – 2020: \$1-\$8 / tCO_2 (Trump admin.)
  - Only count impact on US population
- 2021: \$52 / tCO_2 (Biden admin.)
  - Interim value. Biden convenes process based on NAS to updated the SCC.
- 2023: \$190 / tCO_2: EPA releases new SCC in appendix to the Methane Rule

Some consequences of inequality

1. Some regions devastated,

   Weitzman's Dismal Theorem: infinite SCC?

2. Value of SCC

	With economic uncertainty	+ Spatial inequality
Low Emissions	$78.80	$106.10
High Emissions	$238.70	$453.20
Lower minimum level to 10%	$274.10	$936.50

Synthesis

- Rapid progress from multiple methodologies, and top-down/bottom-up scales.
  - No end in sight for assessing high-priority impact channels.
  - New approaches needed to grapple with interacting structural changes and catastrophic risk.
- Enormous inequality in damages, reinforcing existing inequality
  - Inequality can triple social cost of carbon

Thank you!