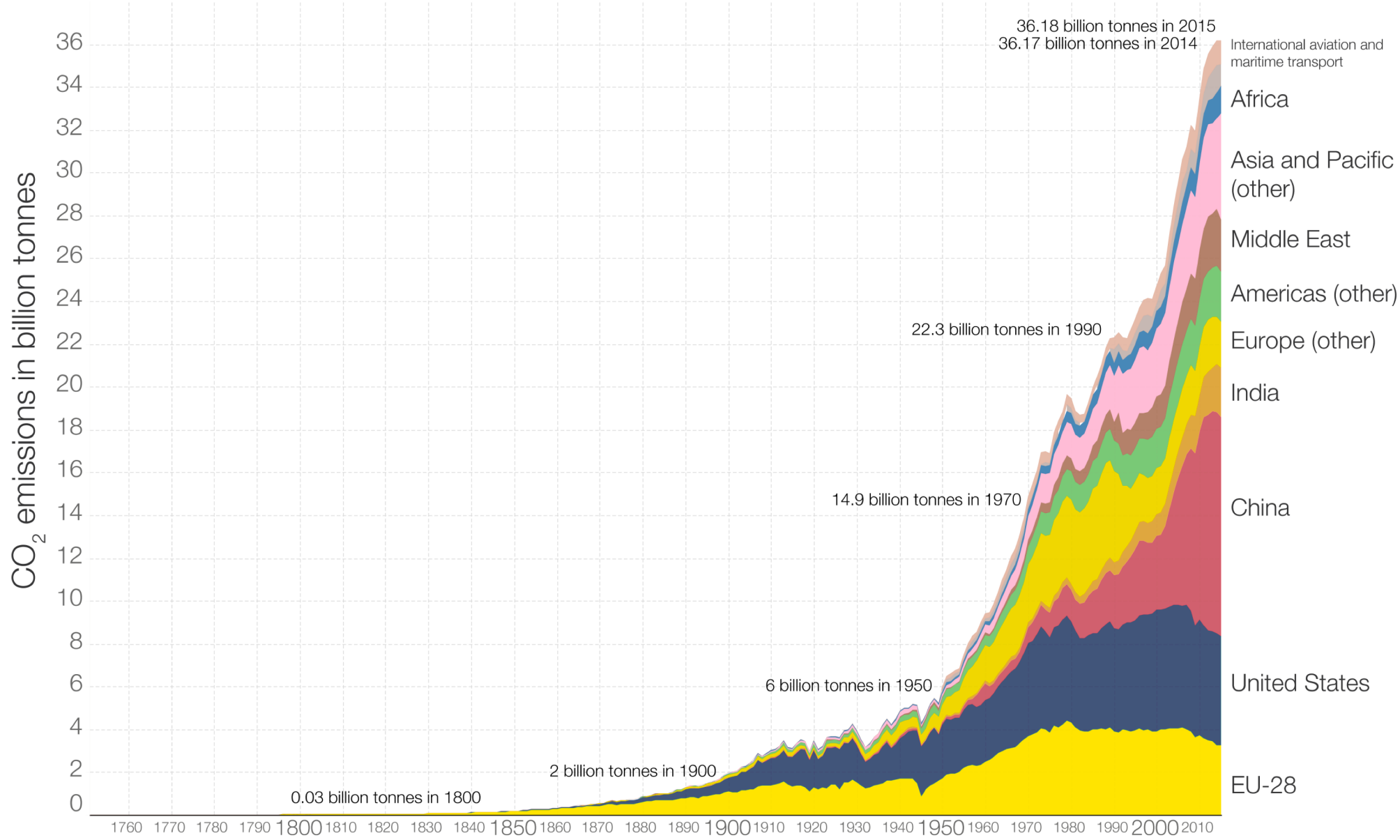
What is the social cost of carbon?

Ivan Rudik – Cornell Dyson

Global CO_2 emissions by world region, 1751 to 2015

Annual carbon dioxide emissions in billion tonnes (Gt).

Our World in Data



Data source: Carbon Dioxide Information Analysis Center (CDIAC); aggregation by world region by Our World In Data.
The interactive data visualization is available at OurWorldinData.org. There you find the raw data and more visualizations on this topic.

What is the level of annual CO_2 emissions that maximizes societal well-being?

How much lower or higher than today (36 billion tons)?

The correct answer depends on the social cost of carbon

We will go over why the social cost of carbon matters and how it is calculated

What is the social cost of carbon (SCC)?

Why is it important?

SCC – the global **external** cost (in today's dollars) from emitting another metric ton of CO_2

Why do we want an SCC estimate?

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SCC – the global **external** cost (in today's dollars) from emitting another metric ton of CO_2

Why do we want an SCC estimate?

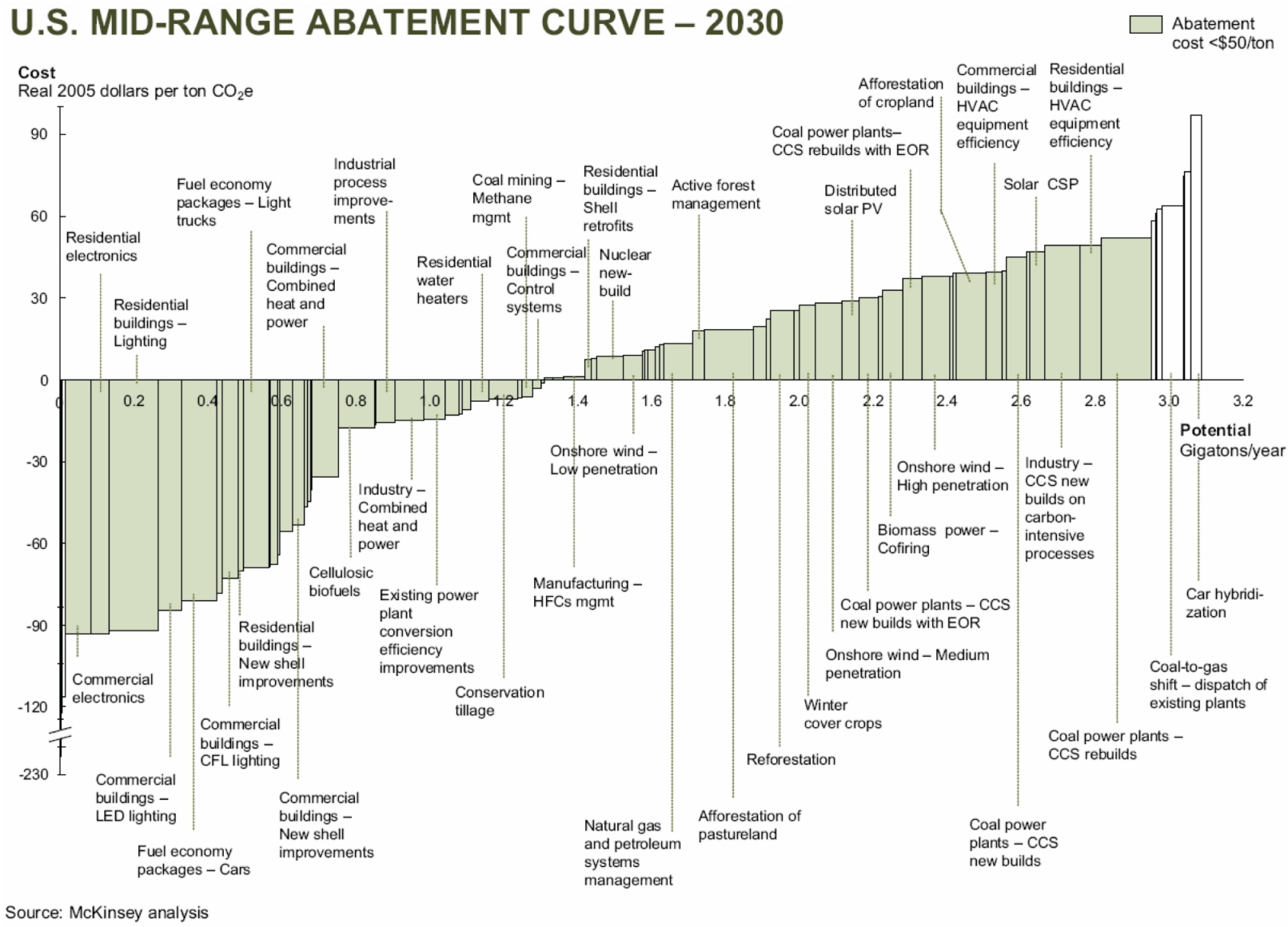
It tells us the costs CO_2 emissions and informs

- How much climate action should we take
- Which regulations make sense

The SCC tells us which technologies make sense to deploy

Some technologies have negative cost!

Some costs are higher than standard SCC estimates



Source: McKinsey analysis

What is the social cost of carbon (SCC)?

Why is it important?

The SCC depends on 4 main things:

1. Effect of emissions on the climate
2. The effect of the climate on the physical environment
3. The future economic damage of these impacts
4. How we value future costs and benefits from climate change

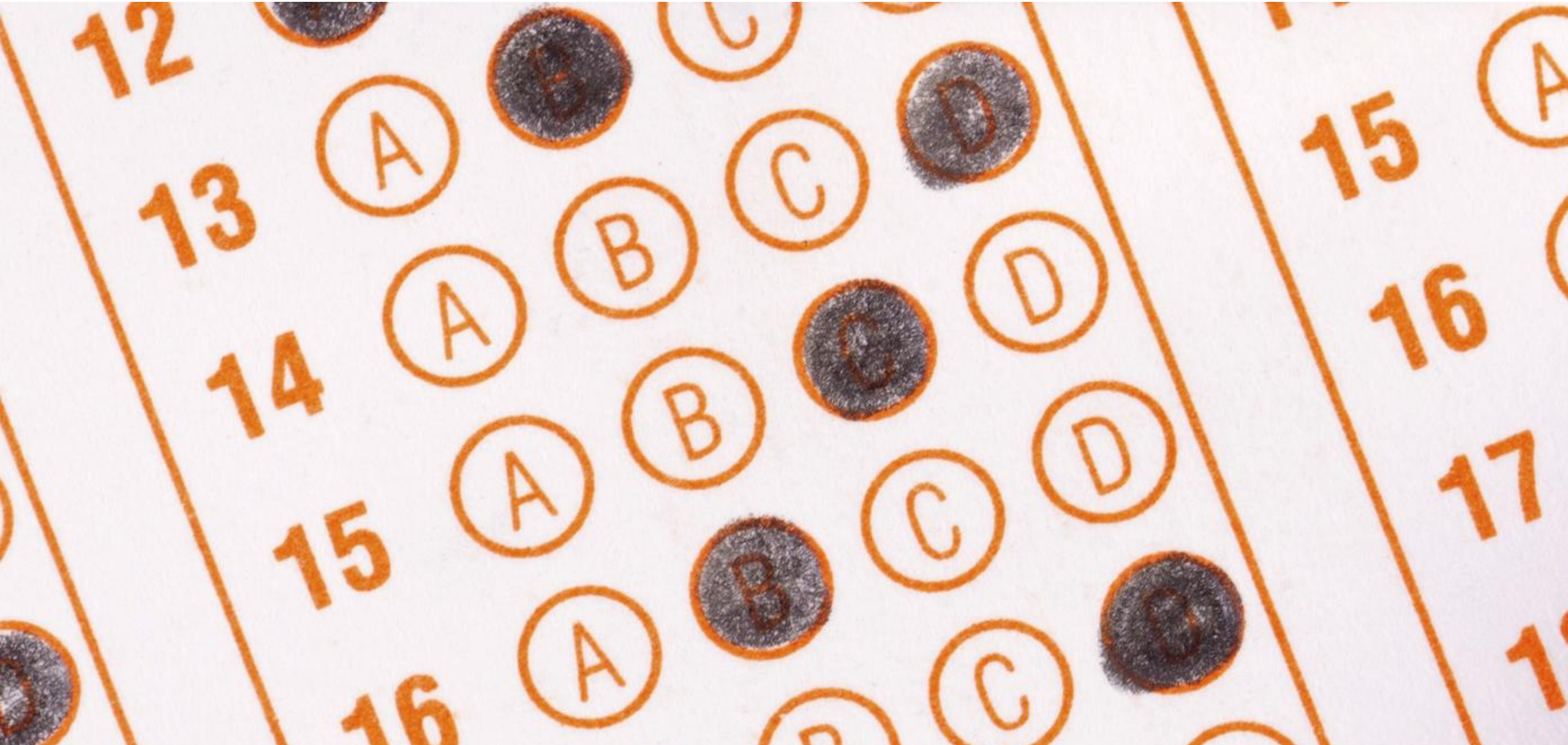
What is (or should be) in current SCC estimates?

Reduced agricultural productivity

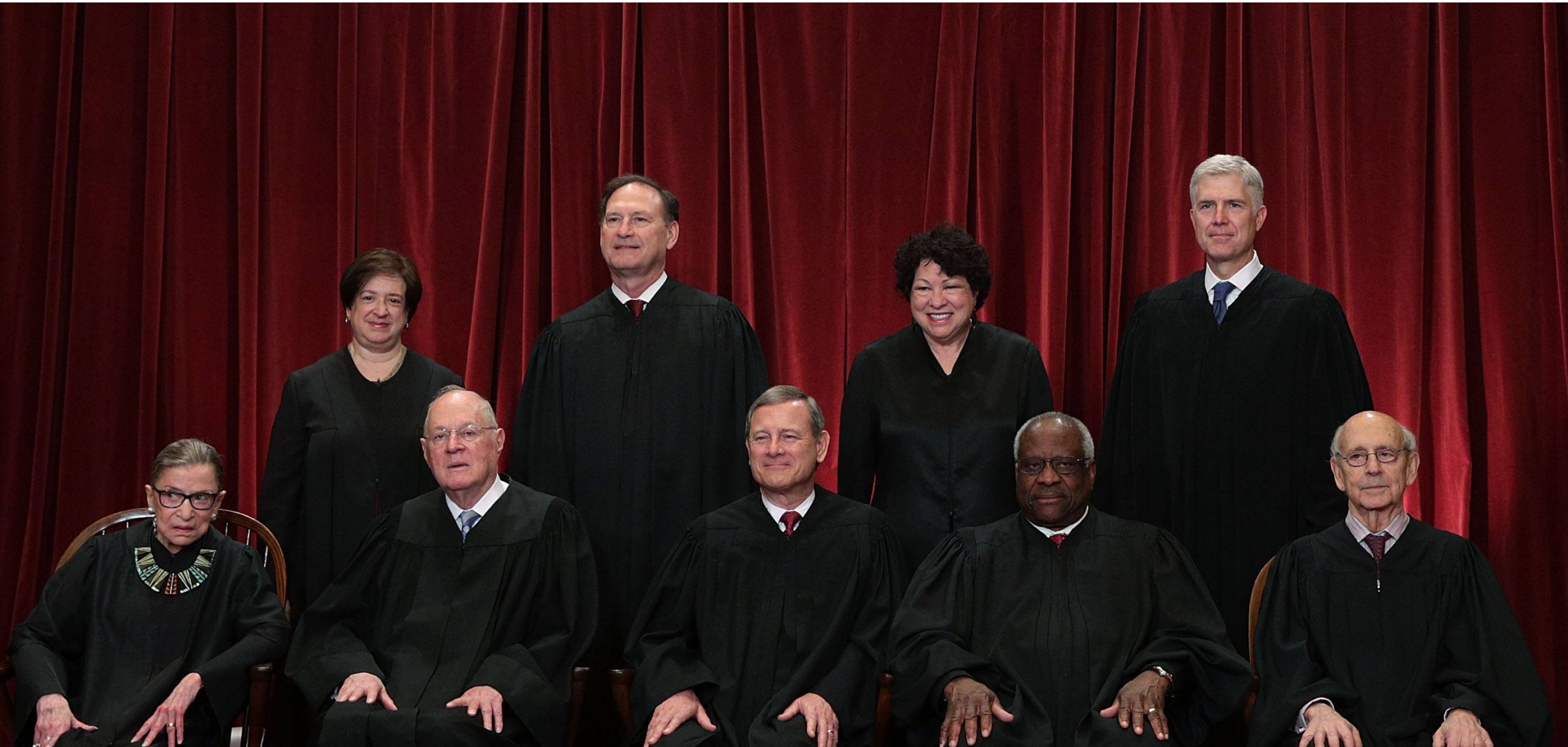
Health effects

Reduced labor productivity

Reduced cognitive function



Affected decisionmaking



Ecosystems damages

and lots of other stuff

This is a huge
area of research

go get a PhD and be an
environmental economist!

How do economists compute the SCC?

The three big pieces for computing the SCC

1. **Climate-economy model / integrated assessment model (IAM):** models the economy and its interaction with the climate system

2. **Damage function:** the impact of changes in climate on the economy

3. **Discount factor:** what's the present value of future costs and benefits?

1. Dynamic integrated climate-economy model

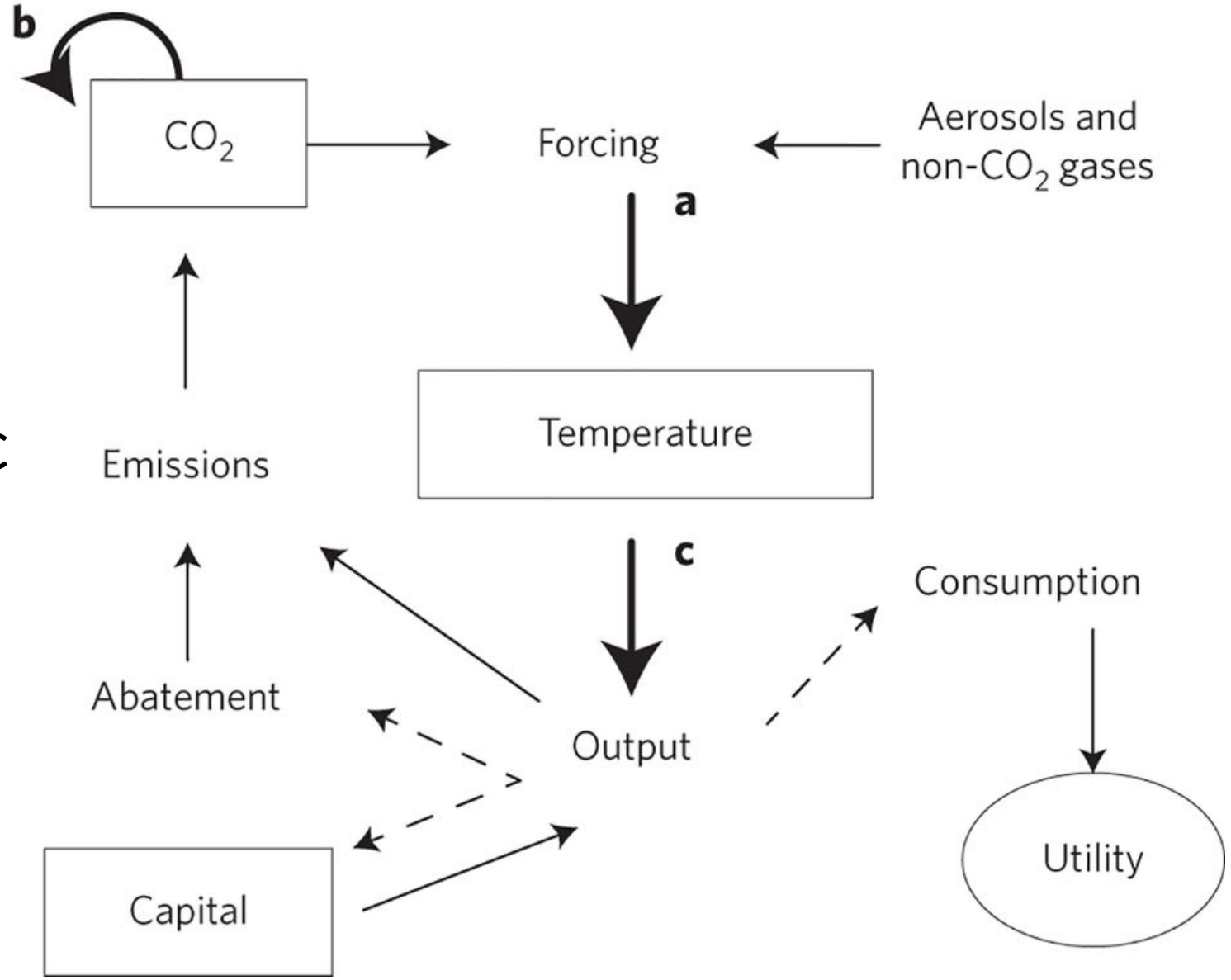
Bill Nordhaus developed the DICE model for estimating the SCC and understanding how to design optimal policy

DICE model structure and website

We can use the DICE IAM to simulate the future under different policies, beliefs about inequality, etc

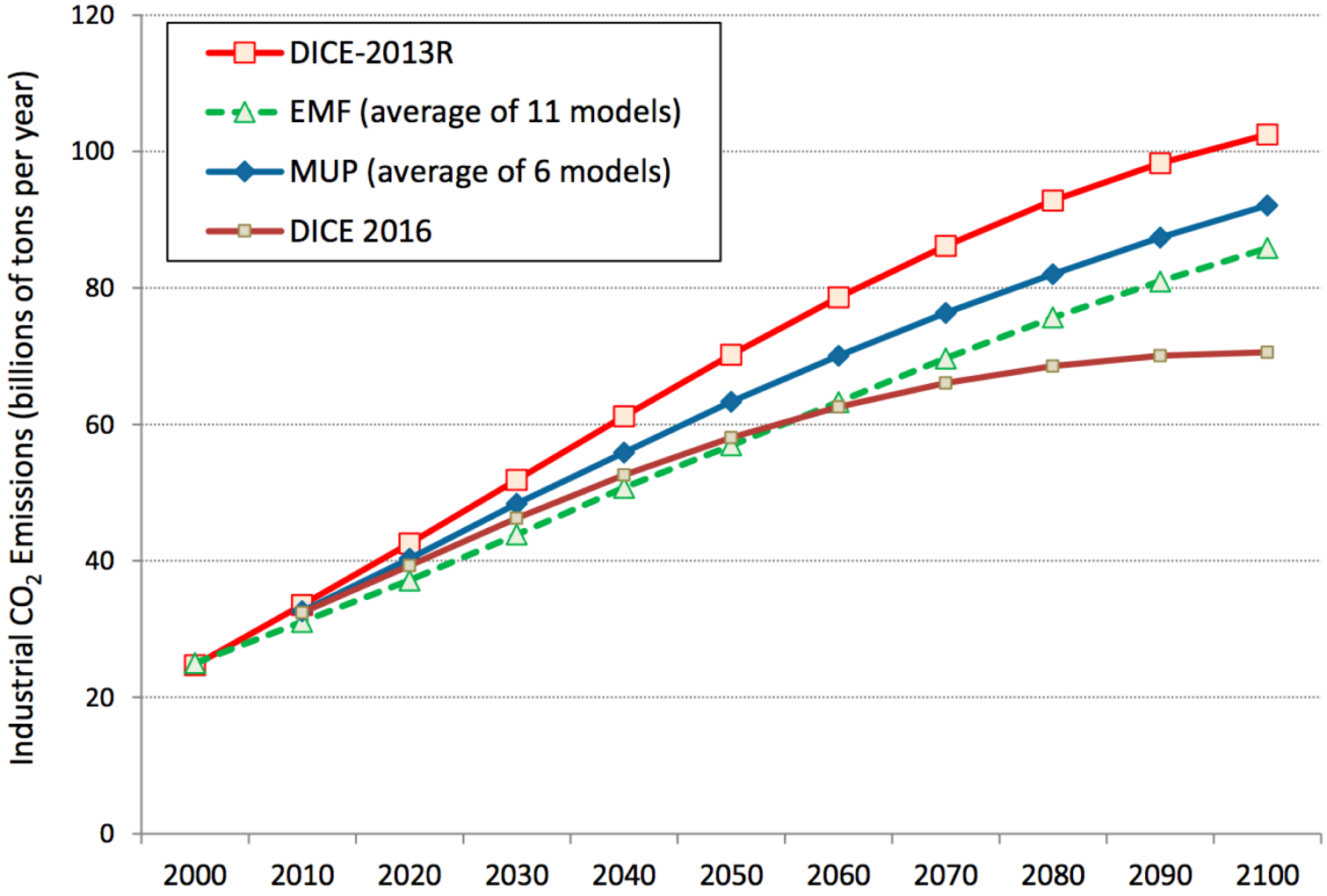
We can also **optimize** climate policy

http://webdice.rdcep.org



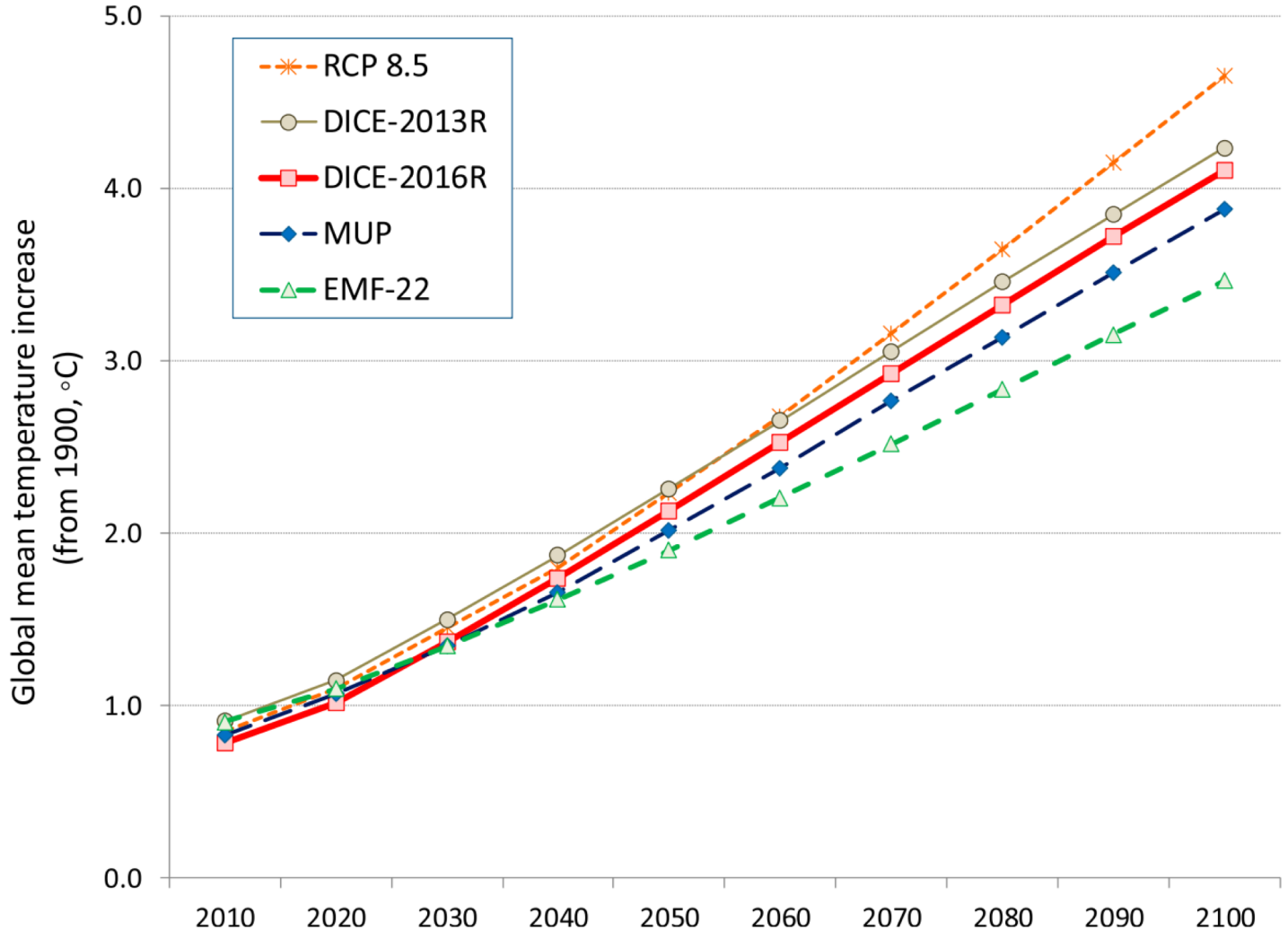
DICE model structure and website

DICE has a baseline level of emissions that follows other big modeling efforts



DICE model structure and website

These emissions eventually lead to warming similar to the benchmark scenarios



The DICE SCC under difference scenarios

Table 1. Global SCC by different assumptions

Scenario	Assumption	2015	2020	2025	2030	2050
Base parameters						
	Baseline*	31.2	37.3	44.0	51.6	102.5
	Optimal controls†	30.7	36.7	43.5	51.2	103.6
2.5 degree maximum						
	Maximum†	184.4	229.1	284.1	351.0	1,006.2
	Max for 100 y†	106.7	133.1	165.1	203.7	543.3
The Stern Review discounting						
	Uncalibrated†	197.4	266.5	324.6	376.2	629.2
Alternative discount rates*						
	2.5%	128.5	140.0	152.0	164.6	235.7
	3%	79.1	87.3	95.9	104.9	156.6
	4%	36.3	40.9	45.8	51.1	81.7
	5%	19.7	22.6	25.7	29.1	49.2

2. Damage functions

We need a way to link the economy and climate together to form a closed system

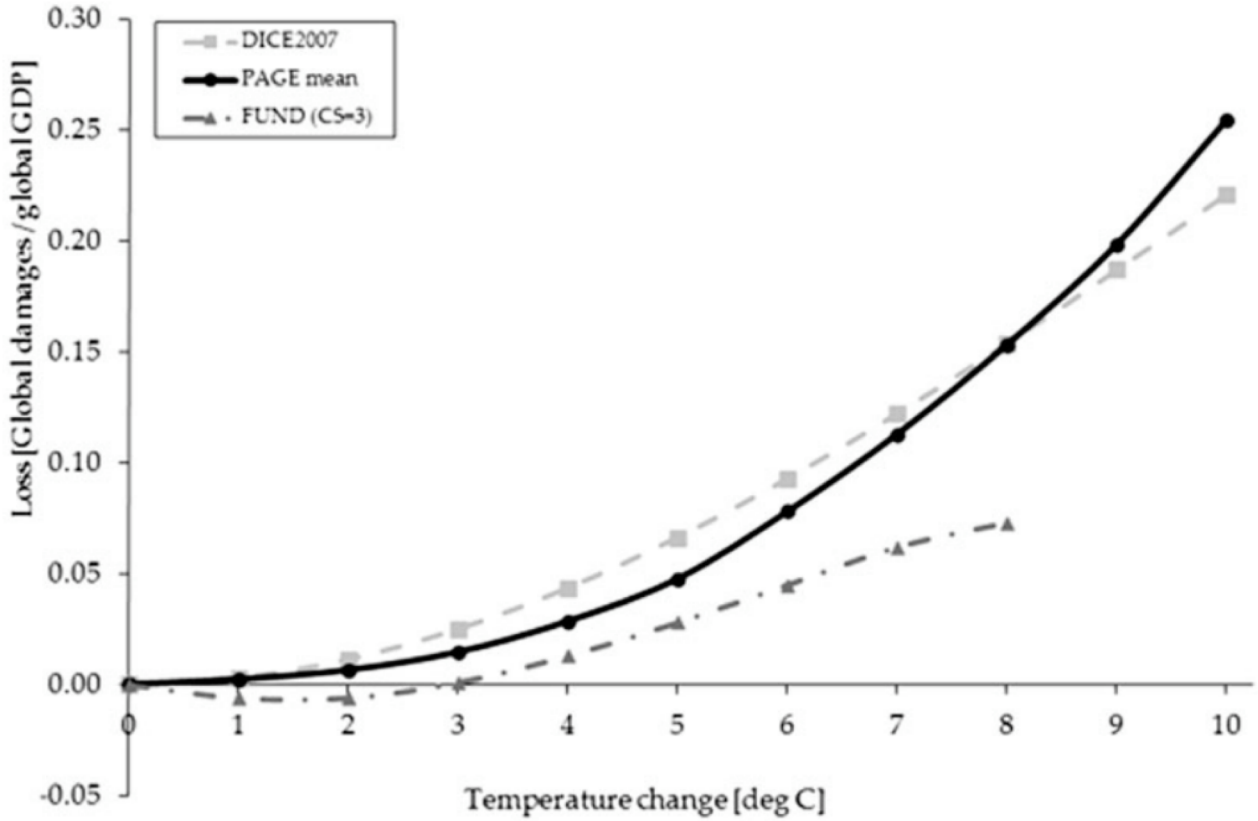
Economy → climate:
industrial production generates CO_2 emissions

Climate → economy, the damage function:
warming reduces income/productivity/GDP

2. Damage functions

Estimating damages / impacts is the probably one of the most important pieces of IAMs because damages are hard to pin down

The damage functions for the 3 IAMs used to generate the SCC for US regulatory analysis →



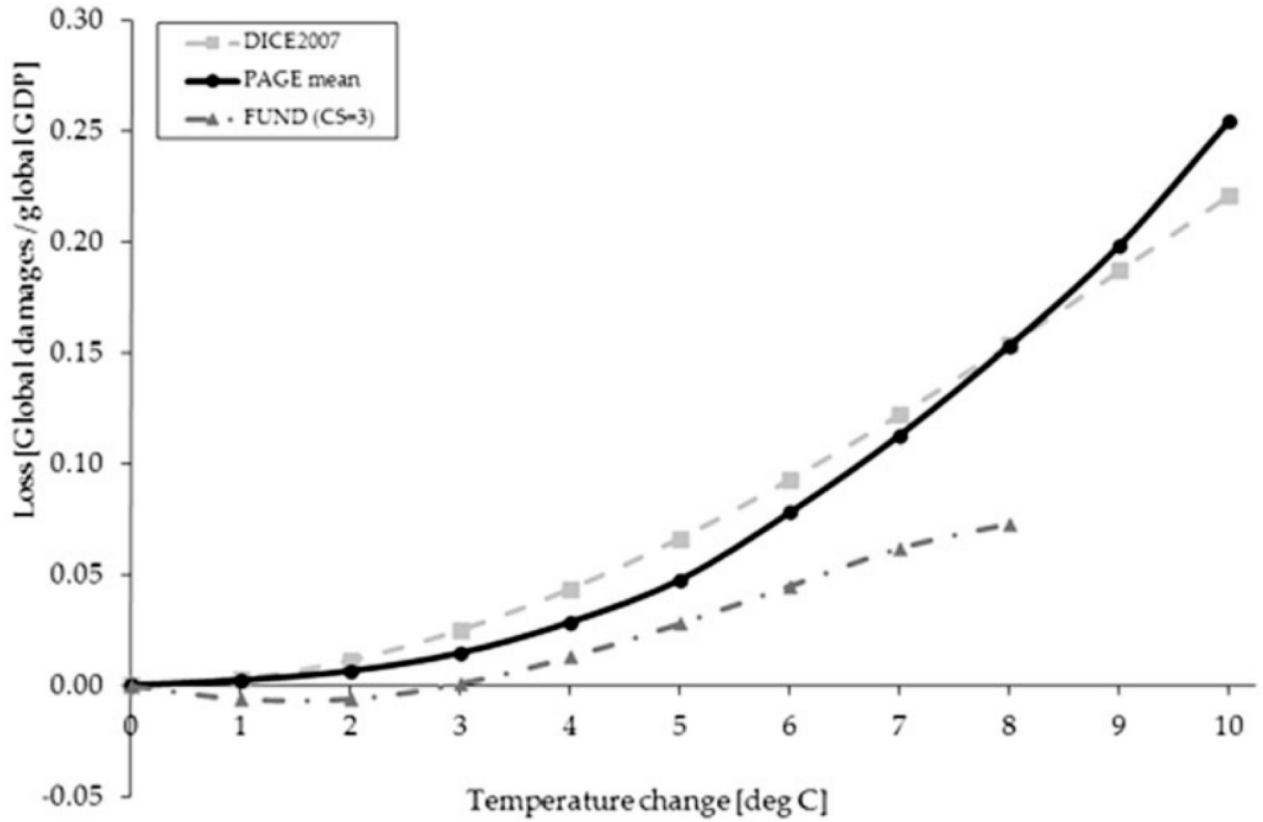
The old-school damage functions

These are based on studies from the early 1990s

Lots of advances since then in methods and data

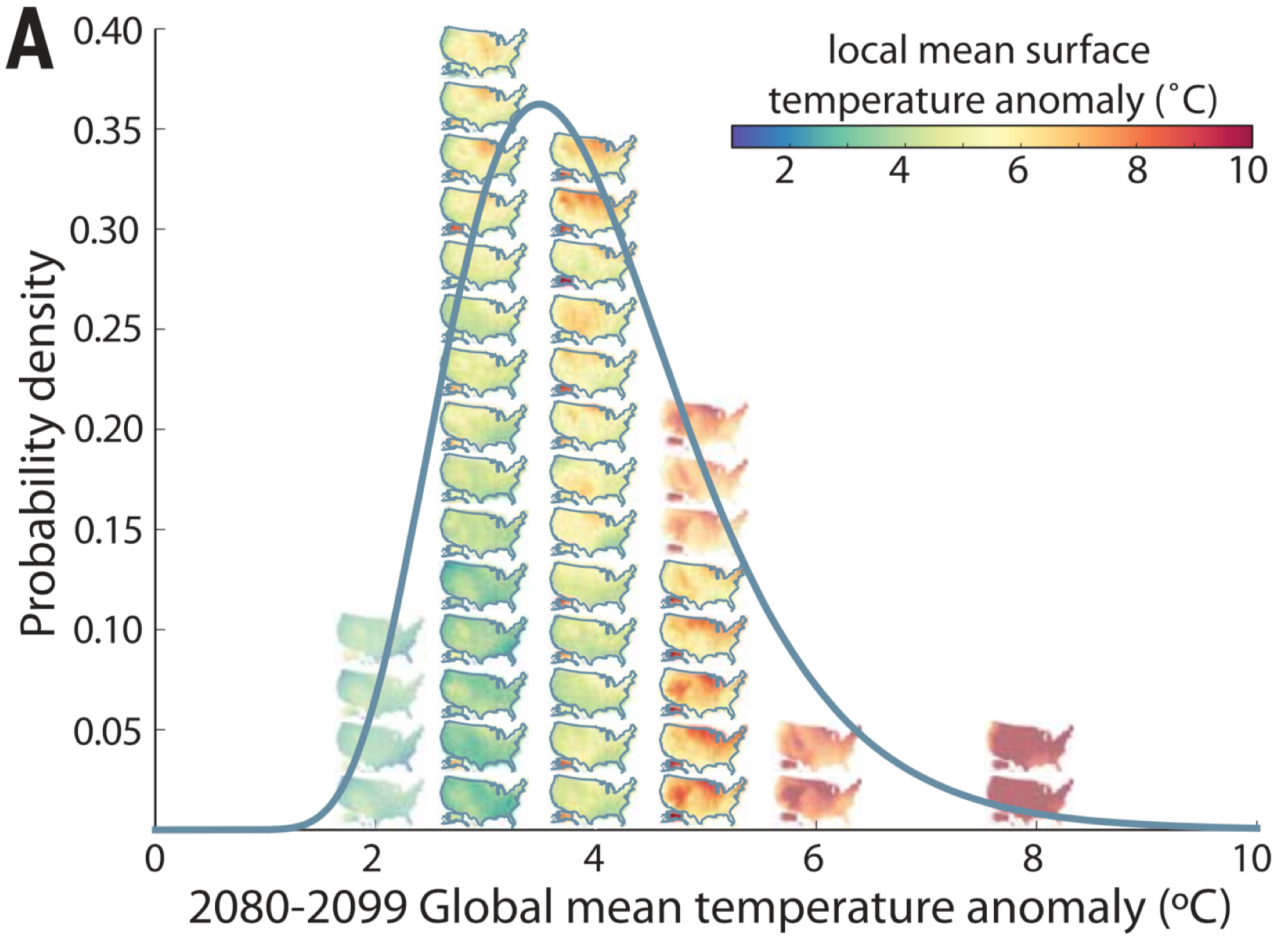
What have economists been doing recently?

Trying to build these from the ground up using modern studies

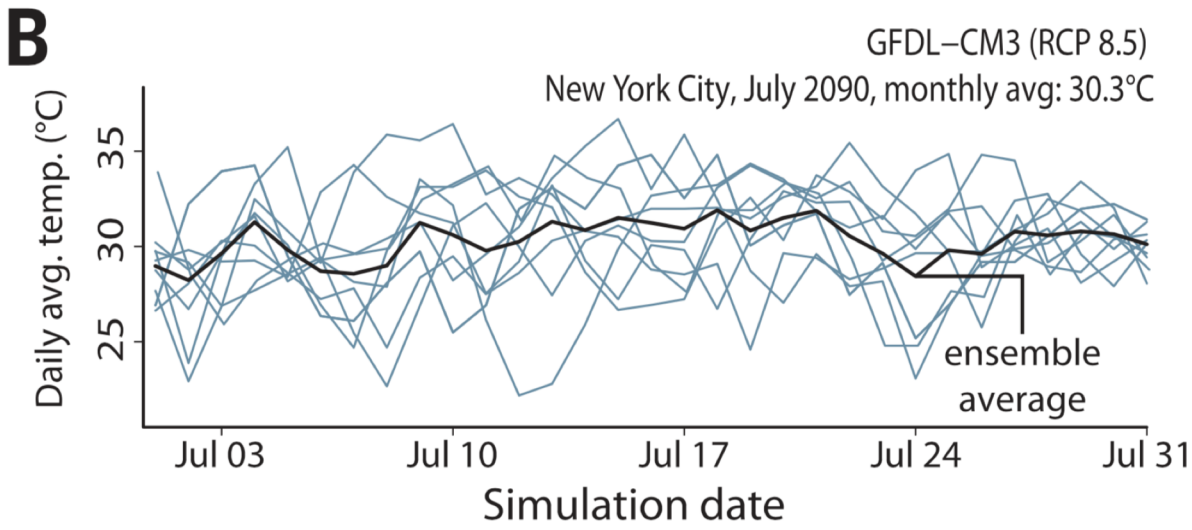


Damages in the United States

44 models of the future of the US



Example NYC July in 2090

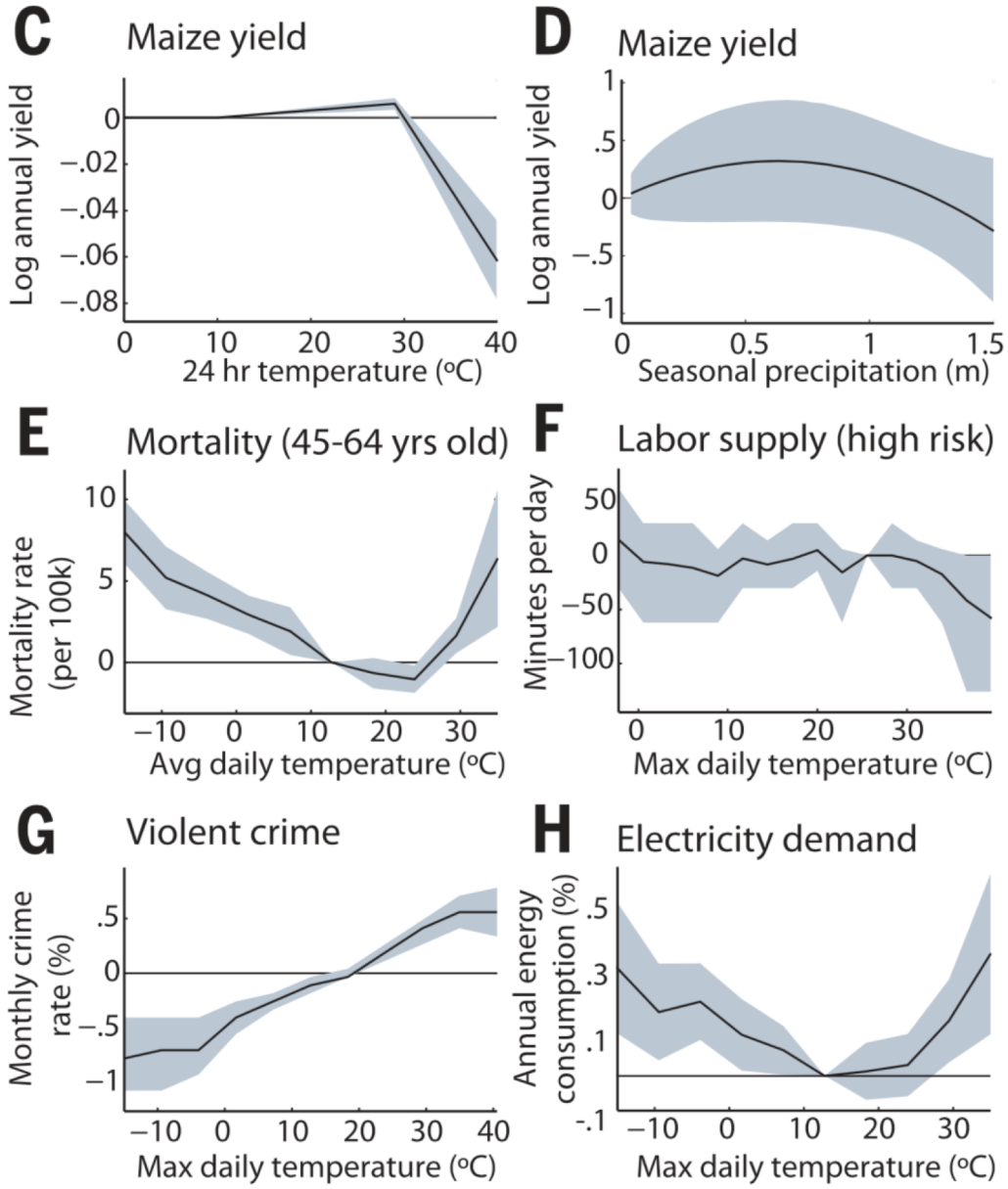


Hsiang et al. (2017)

Damages in the United States

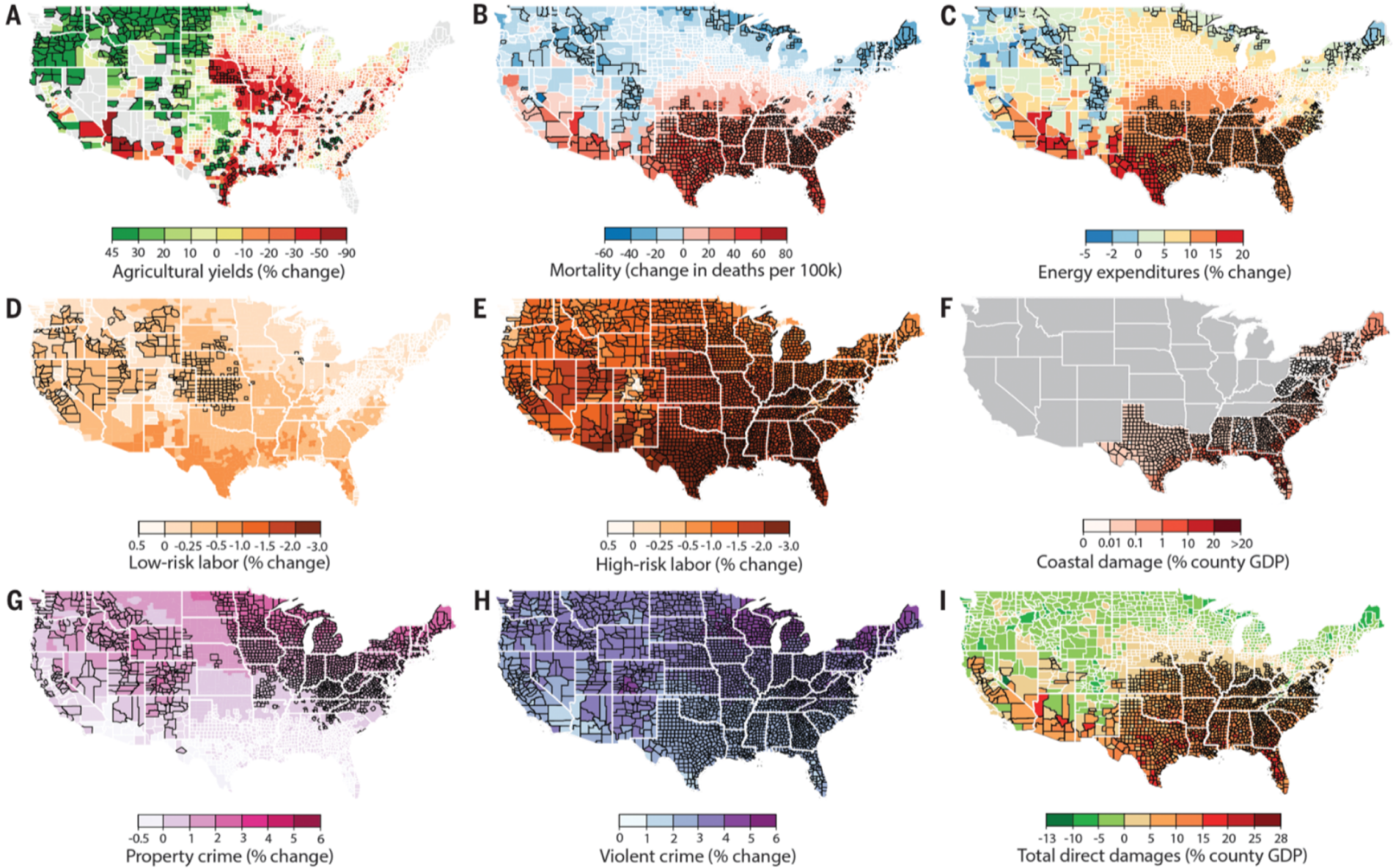
Impacts of weather on economic outcomes of interest

All comes from recent work studying the effect of temperature / precipitation on outcomes



Damages in the United States

Damages under RCP 8.5

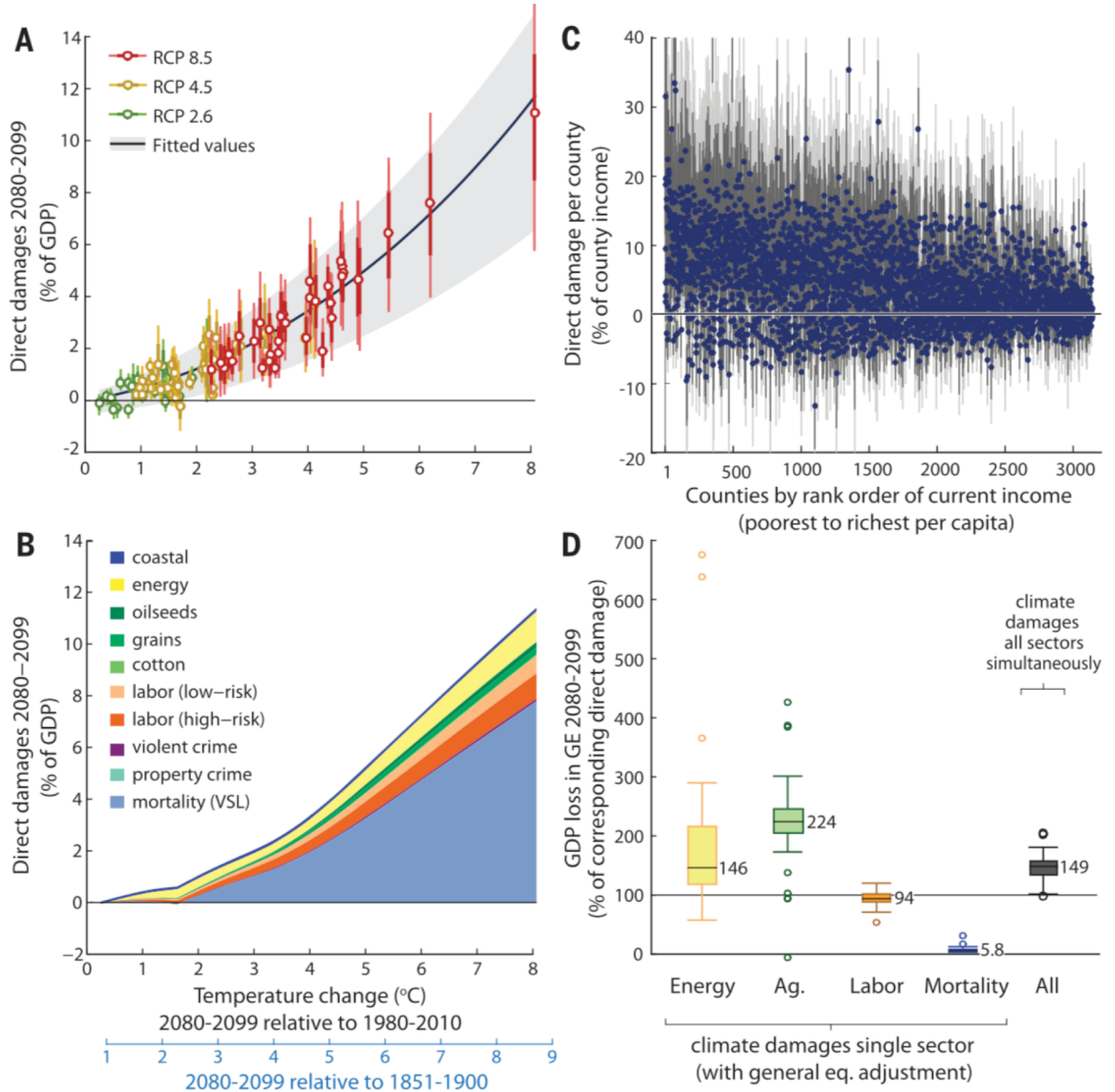


Damages in the United States: aggregated

Mortality is the key driver

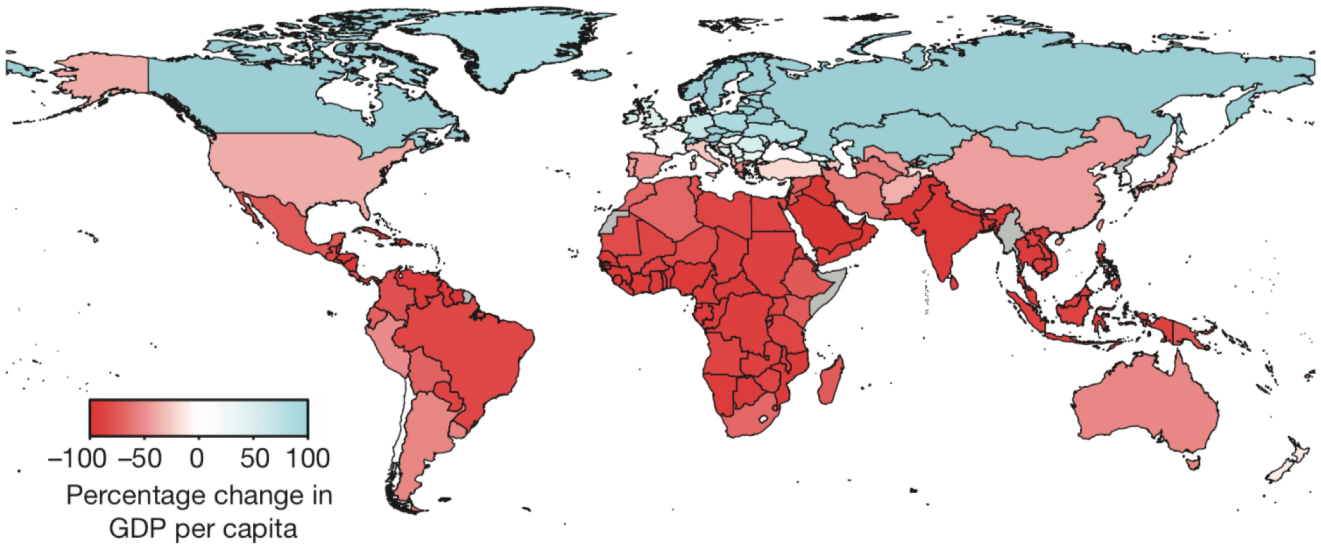
Poorer counties are hit harder

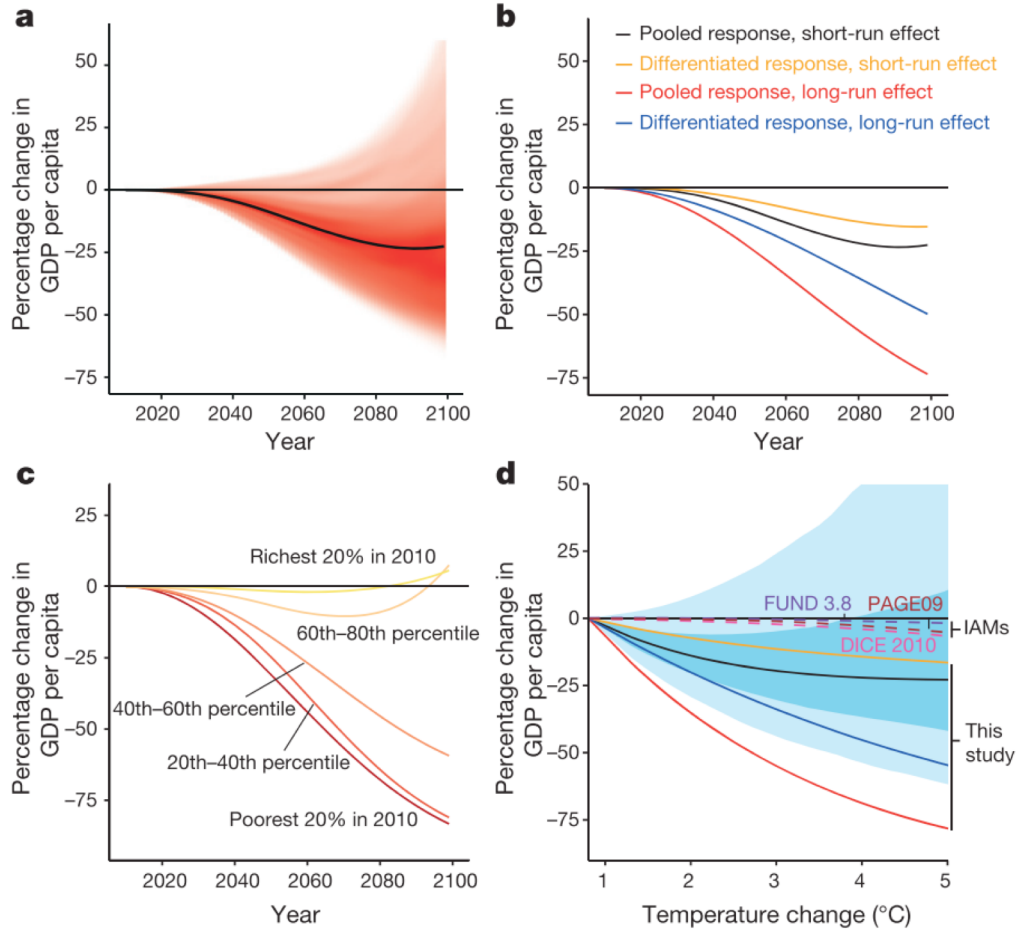
Allowing for a full economic response makes things worse



Damages and growth rates

What if climate change doesn't just affect income/productivity, but how income/productivity **grows**





3. Discount rates

If I took $1000 from you today, how much would I need to pay you back in 1 year for you to feel better off?

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If we give up $1000 today, how much should future generations get in return in 100 years? How about 200 years?

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If we give up $1000 today, how much should future generations get in return in 100 years? How about 200 years?

Alternatively: If we spend $1000 today abating emissions, how big do the benefits need to be in 100 years for it to make society better off?

3. Discount rates

How much money would society demand for future generations if we were to reduce our consumption by $1,000 today?

The answer to this question depends on the **discount rate** δ

Society demands $\$1+\delta$ dollars next year

in exchange for a reduction of $1 today

3. Discount rates

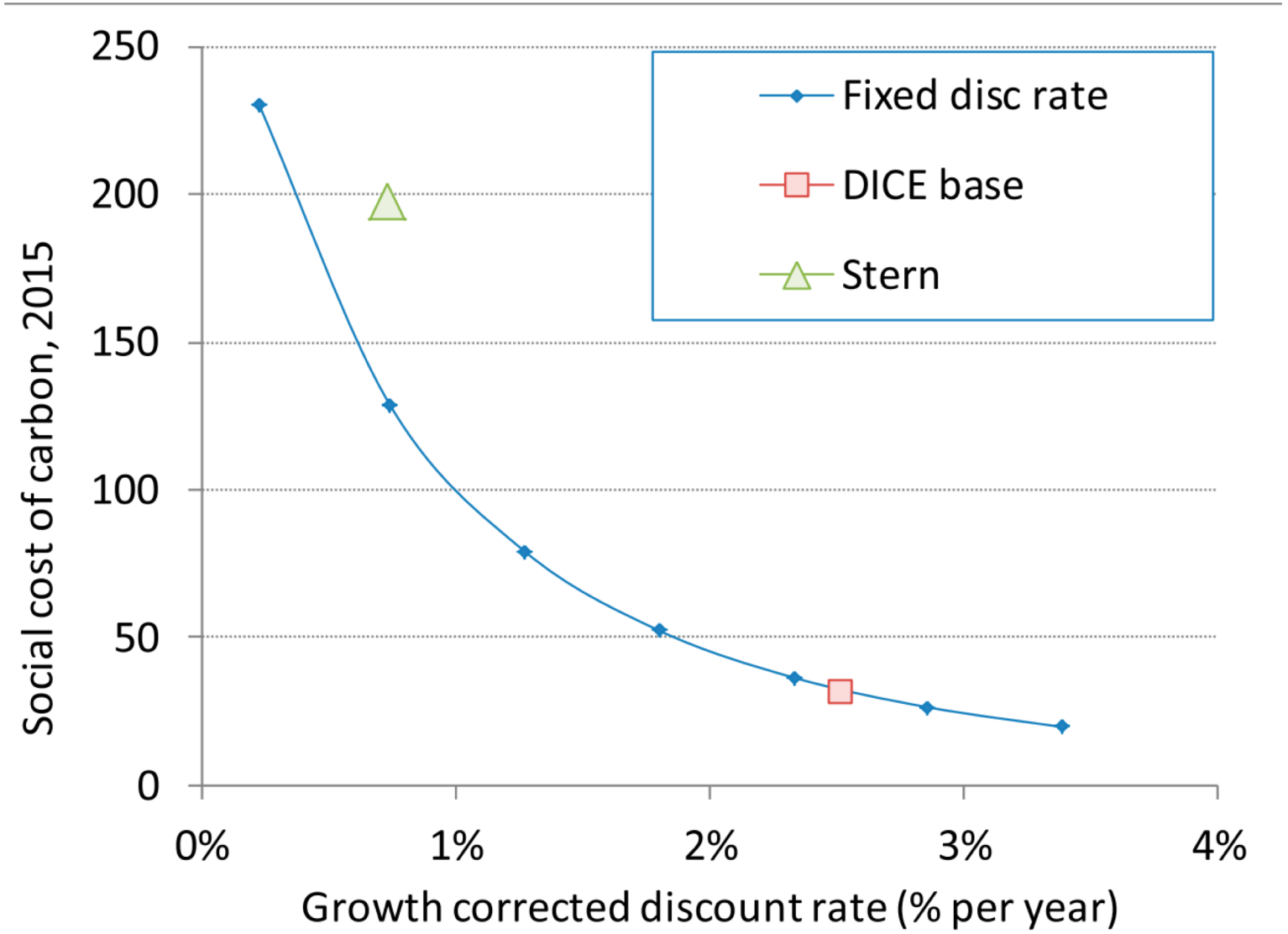
The discount rate **dramatically** affects the SCC and how aggressively we should be dealing with climate change

Why? A big disconnect in when the costs and benefits of emissions reductions happen

The costs we bear today,

the benefits almost entirely accrue in the future

3. Discount rates



3. Discount rates

With a bunch of math and economics you can show that the discount rate depends only on **three** things:

1. Pure rate of time preference (impatience)
2. Growth in consumption (who's rich?)
3. Aversion to inequality between individuals/generations (do we dislike inequality?)

Pure rate of time preference (PRTP)

How much less we value future dollars (or future generations) because of purely the passage of time: now is better than later

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There is no right answer for the PRTP,
we need to ask ourselves what is an ethically defensible value?

Many argue it should be 0: why should we value future generations less solely because they came after us?

Growth x inequality aversion

Suppose we found $1000 and we have to split it up
between a rich person and a poor person

How should we split it up to maximize their combined well-being?

Think about the relative value of $1
depending on how wealthy you are

Growth x inequality aversion

As a society we are generally averse to inequality across people

- Both in the same time and across different generations
- E.g. progressive income taxation, unemployment insurance, etc

What does this mean about who should bear the cost of combating climate change?

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What does this mean about who should bear the cost of combating climate change?

Richer people and richer generations

Growth x inequality aversion

Richer nations today should bear more of the cost

If we believe future generations will be richer,
future generations should bear more of the cost

How averse to intergenerational inequality should we be?

No right answer: we need to stake out an ethical position

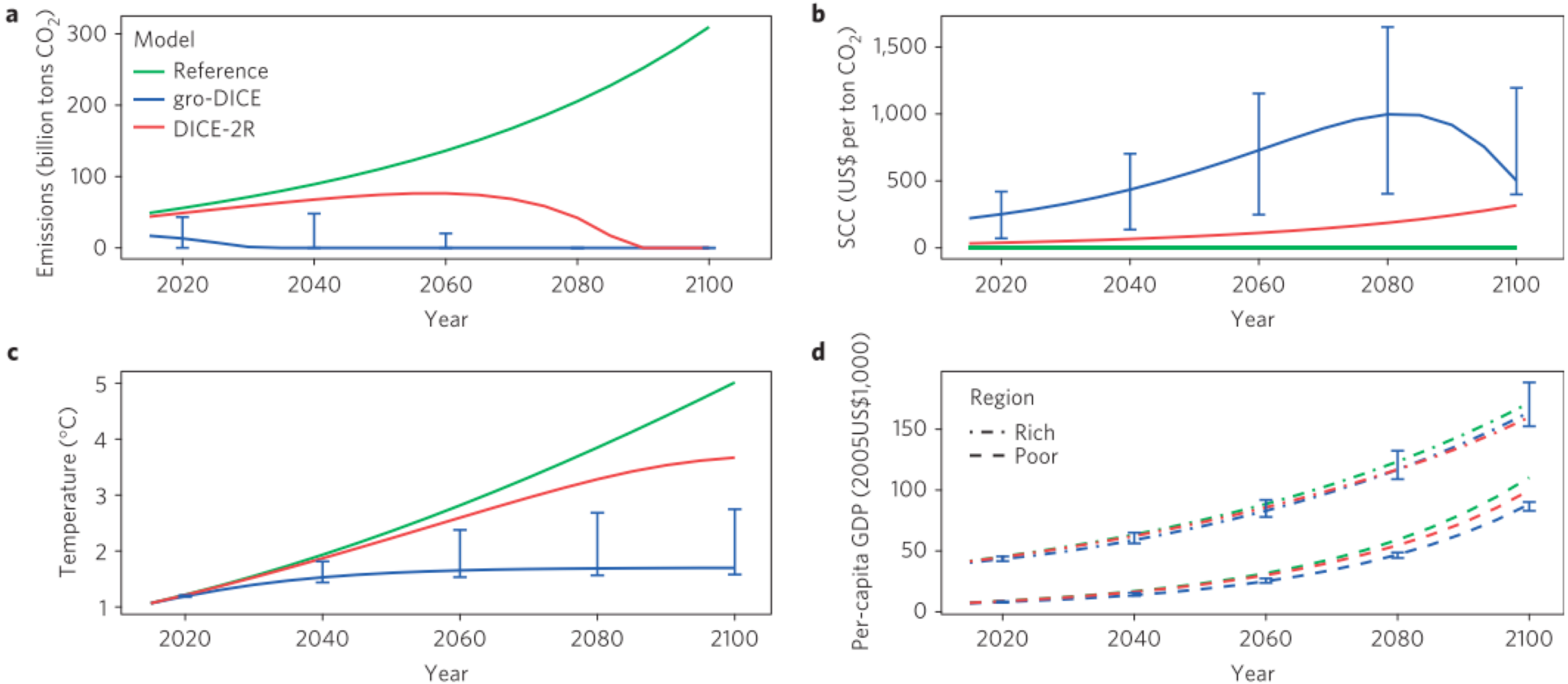
Putting it all together

1. IAMs are our comprehensive model of the world
2. Damage functions connect the climate to the economy
3. The discount rate tells us the benefits from taking climate action today

What are some recent SCC estimates?

For reference: \$50/tCO_2 SCC = \$0.50/gallon increase in gasoline

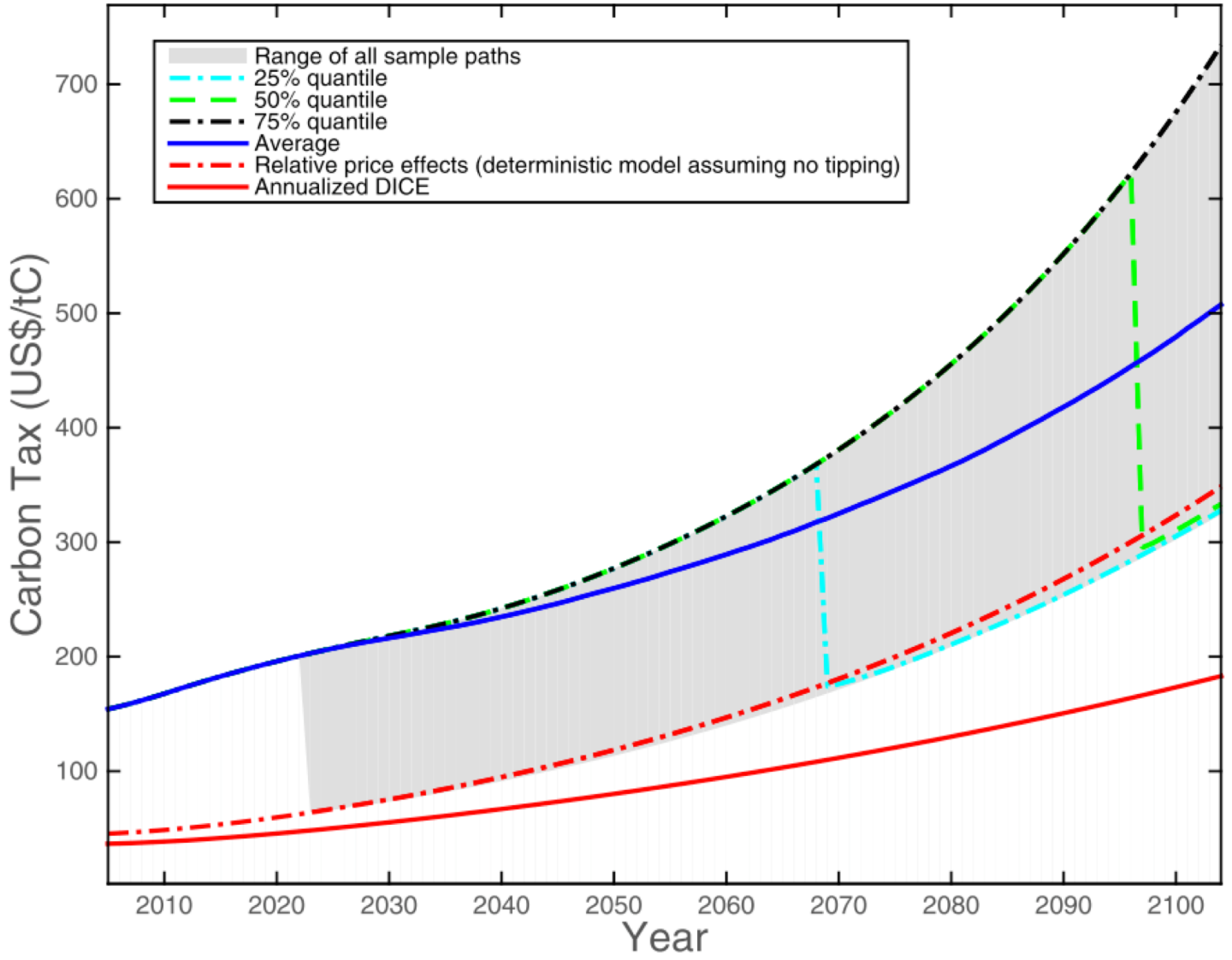
Growth rate effects, inequality, adaptation



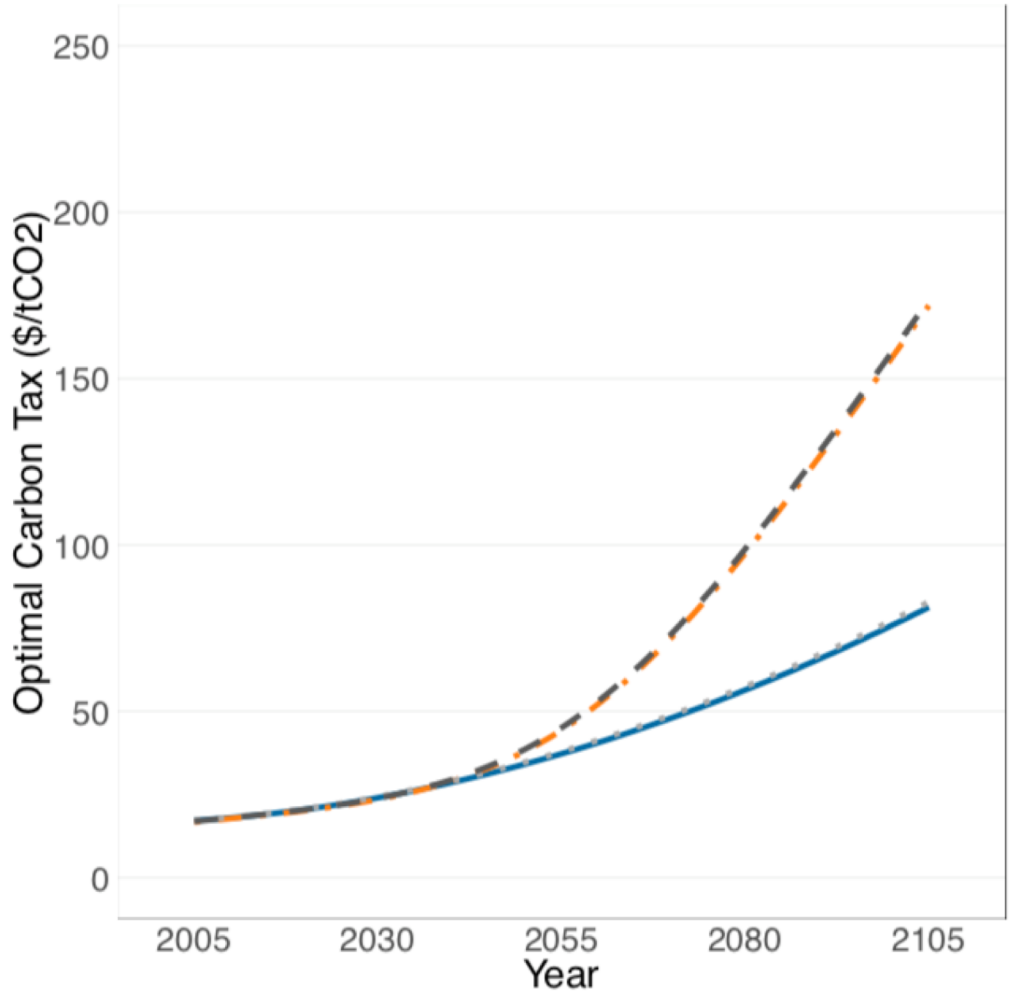
Tipping points, non-substitutability, less inequality aversion

What if we account for irreversible tipping points in the climate system (e.g. ice sheet collapse)?

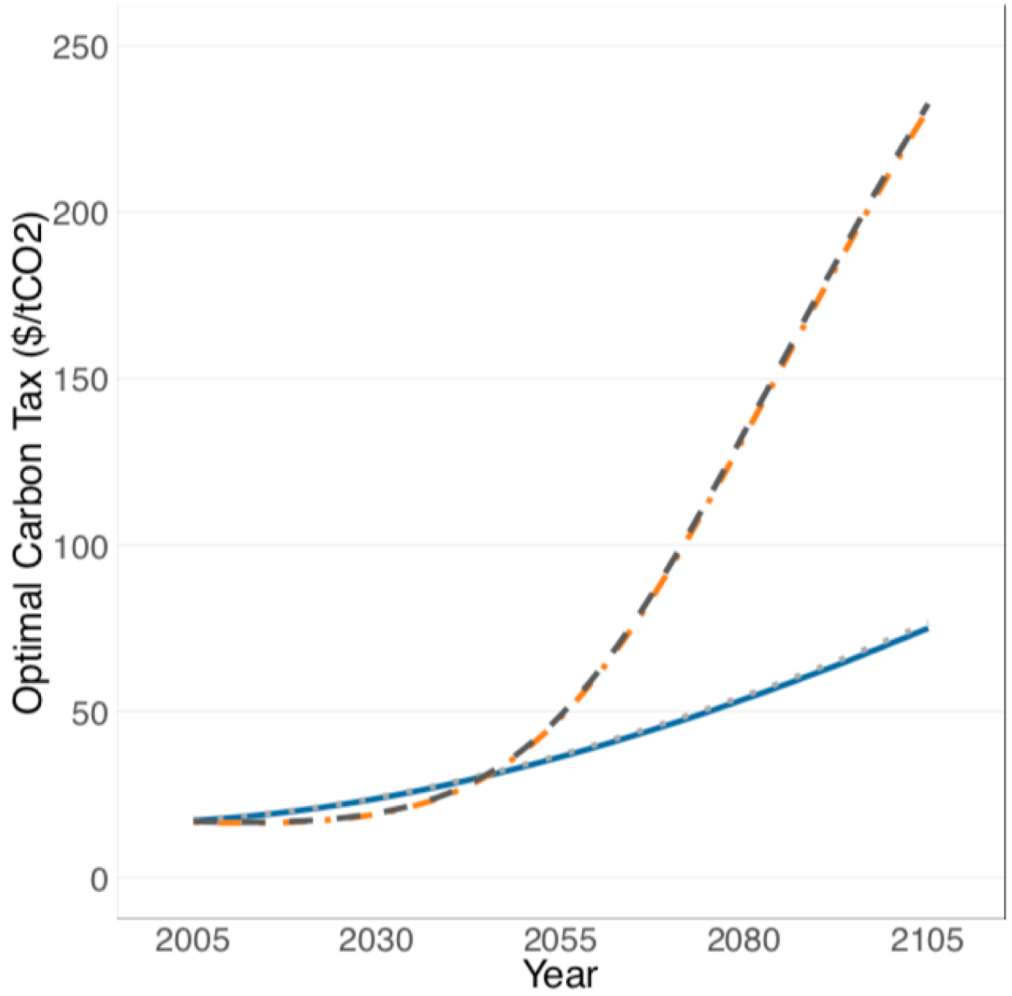
What if we account for people caring about the non-market components of the environment?



What if we allow our models to update damage function estimates?



(c) $d_1 = 0.0056, d_2 = 3.0$



(d) $d_1 = 0.01, d_2 = 3.0$

What is the social cost of carbon?

A number that tells us the damage caused by our CO_2 emissions

A benchmark for the efficiency of regulations and technologies