An Updated Social Cost of Carbon: Calculating the Cost of Climate Change

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MEET THE TEAM

*The views expressed in this paper are those of the authors and do not necessarily reflect the views or policies of the US Environmental Protection Agency

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The Social Cost of Carbon (SCC) Initiative

A collaborative effort led by RFF and UC Berkeley, supported by funding from the Alfred P. Sloan Foundation, the Hewlett Foundation, NSF, NIH, and others

Key objectives:

- Improve the scientific basis for the SCC by fully implementing recommendations of a landmark 2017 NASEM study and transparently updating the SCC
- Develop open-source software tools for SCC estimation to promote transparency and create a common modeling platform for the scientific community
- Facilitate the US government process to update the federal SCC

Background and motivation

- The social cost of carbon (SCC) is an estimate, in dollars, of the economic costs (or "damages") of an incremental ton of CO_2 emissions
- The SCC underpins policy analysis across a wide range of applications in the federal government and elsewhere
- The Biden administration issued an executive order for a comprehensive update to the SCC value used by the federal government

Primary outputs from the SCC Initiative

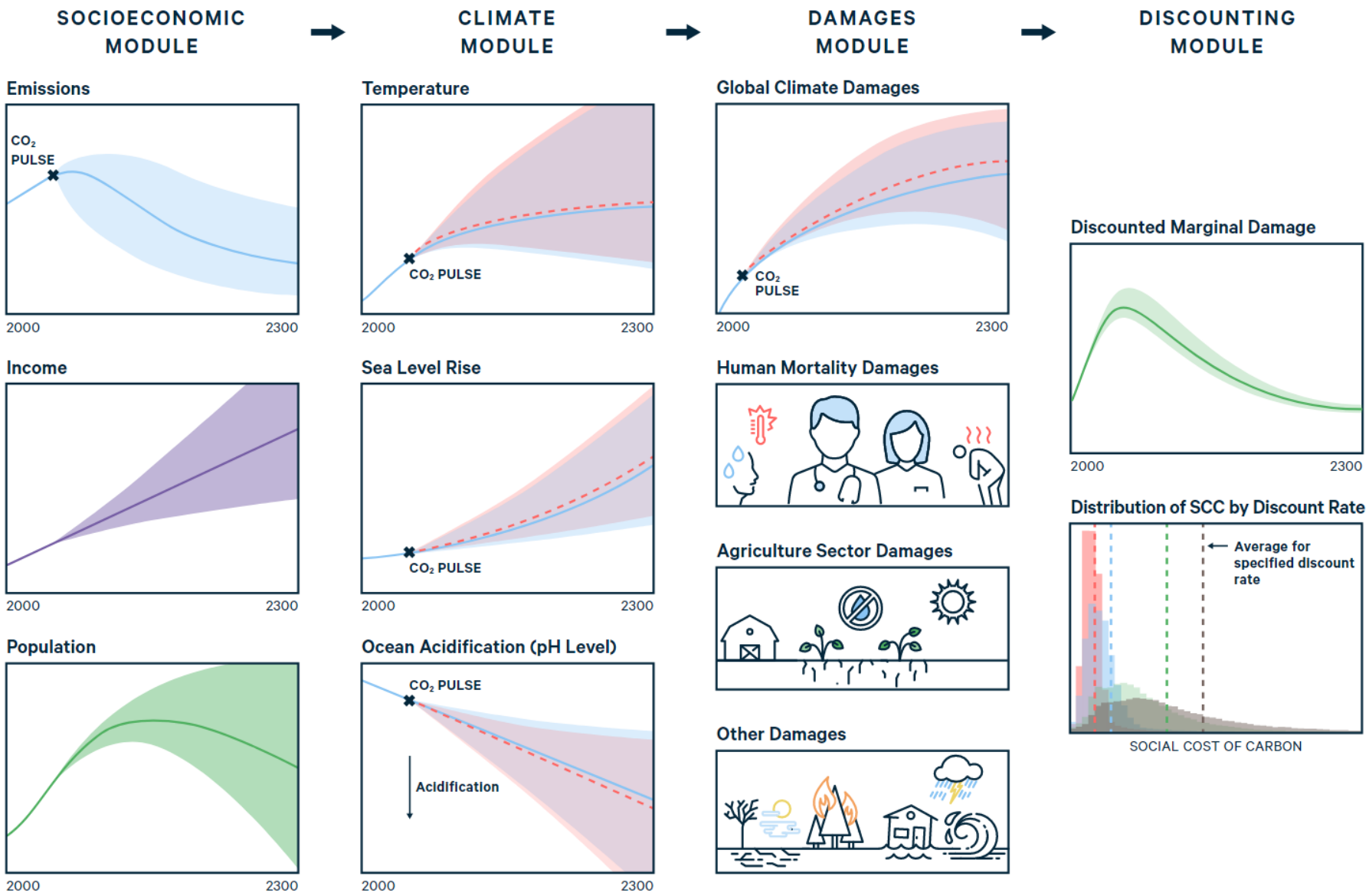
- The Greenhouse Gas Impact Value Estimator (GIVE) model
- The Mimi computational platform (Mimi.jl)
- RFF Socioeconomic Projections (RFF-SPs)*
- Implementation of modern climate models (FaIR climate and BRICK SLR models) and damage functions
- Discounting approach that accounts for uncertainty**

**Raftery and Ševčíková 2021; Müller, Stock, Watson 2020; Rennert et al. 2021*
***Newell, Pizer, Prest 2022*

Preview of conclusions

- Improved scientific basis and transparency of implementation are fully responsive to the NASEM near-term recommendations
- Results are based on full characterization of all major SCC uncertainties and their interactions
- Updated estimate of the SCC of $185 per ton of CO_2 is more than 3 times the current interim federal estimate of $51 per ton
- A higher SCC increases the expected net benefits of more stringent climate change policies

A modular framework for calculating the SCC



An integrated modular framework:

The Mimi computing platform

- Platform to write and run modular integrated assessment models
- Two audiences: academic research & policy applications
- Highlights:
  - Open source and free
  - Fast
  - Easy to use
  - Decentralized (NASEM recommendation to “unbundle”)
  - Transparency in research (readability of code)
- Platform advanced features:
  - Uncertainty analysis
  - Sensitivity analysis
  - Optimization
  - Visualization

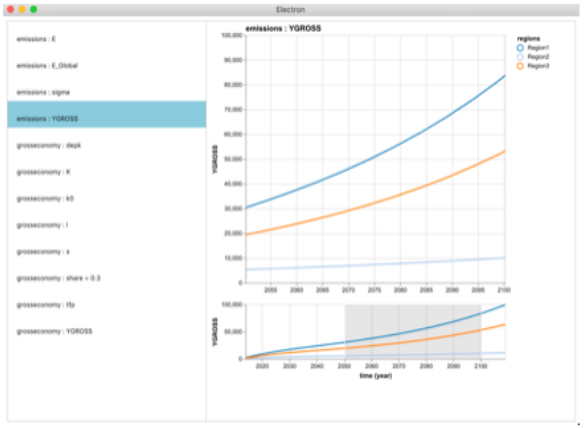
Examples

1. Models
2. Monte Carlo Simulations
3. Sensitivity Analysis

Below are a few snapshots of Mimi's interactive UI, referred to as the Explorer and enabled with the `explore` and `plot` functions. This is mean to be a teaser windown into Mimi's functionality, and we direct interested parties to the github Documentation for further information.

Models

After creating and running a model using the Mimi framework, users are able to interactively explore the parameters and variables associated with their model using the `explore` function:



https://www.mimiframework.org

Mimi is full-featured with many of the past SCC models and updated modules available

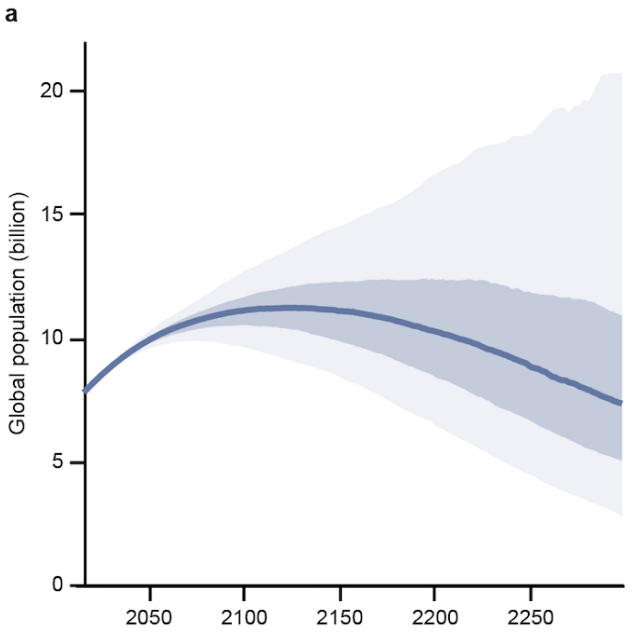
- Complete integrated assessment models
  - FUND
  - DICE (2010, 2013, 2016, 2016R2 versions)
  - RICE, RICE+AIR
  - PAGE2009, PAGE-ICE, PAGE2020
  - Mimi-IWG
    - DICE, FUND, PAGE versions and specific configurations used for calculating SC-GHGs in 2013 and 2016 releases.
  - NICE and NICER
  - AWASH
  - GIVE
- Socioeconomic projections
  - RFF Socioeconomic Projections (RFF-SP)
  - Shared Socioeconomic Pathways (SSP)
  - EMF22 scenarios used by IWG
- Climate modules
  - FaIR (1.3, 1.6 and 2.0 versions, plus exact IPCC AR6 version)
  - SNEASY
  - HECTOR (methane*)*
  - MAGICC (methane)
- Ocean
  - BRICK
  - Simplified ocean pH model
- New damage functions
  - Mortality: Cromar et al. 2022
  - Agriculture: Moore et al. 2017
  - Energy: Clarke et al. 2017
  - Sea level rise: CIAM, Wong et al., Diaz 2017

RFF Socioeconomic Projections (RFF-SPs)

- Multi-century, probabilistic projections of country-level population and GDP per capita, and global GHG emissions
- Account for future policies and dependencies between the variables
- Incorporate both statistical and structured expert judgment methods to account for the extended time horizon

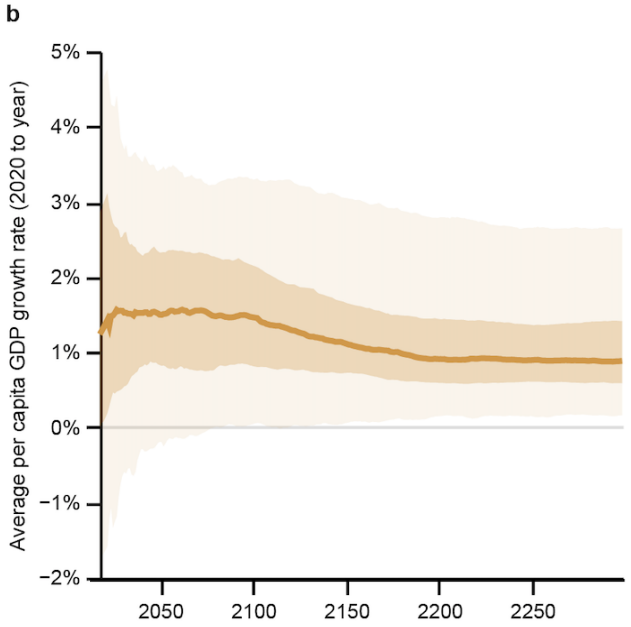
RFF Socioeconomic Projections (RFF-SPs)

Population



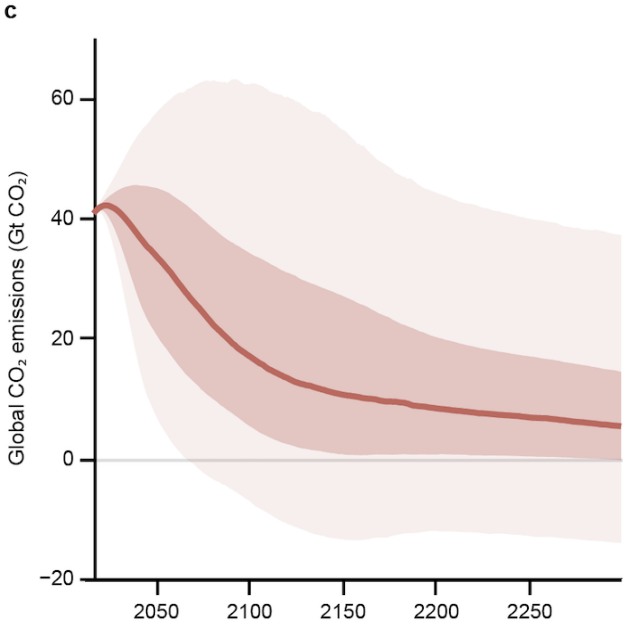
Extends the fully probabilistic statistical approach used by the UN for official population forecasts, incorporating improvements from a panel of nine leading demographers*

Growth in GDP per capita



Country-level econometric growth projections** constrained using expert uncertainty from RFF's *Economic Growth Survey****

Global CO_2 emissions

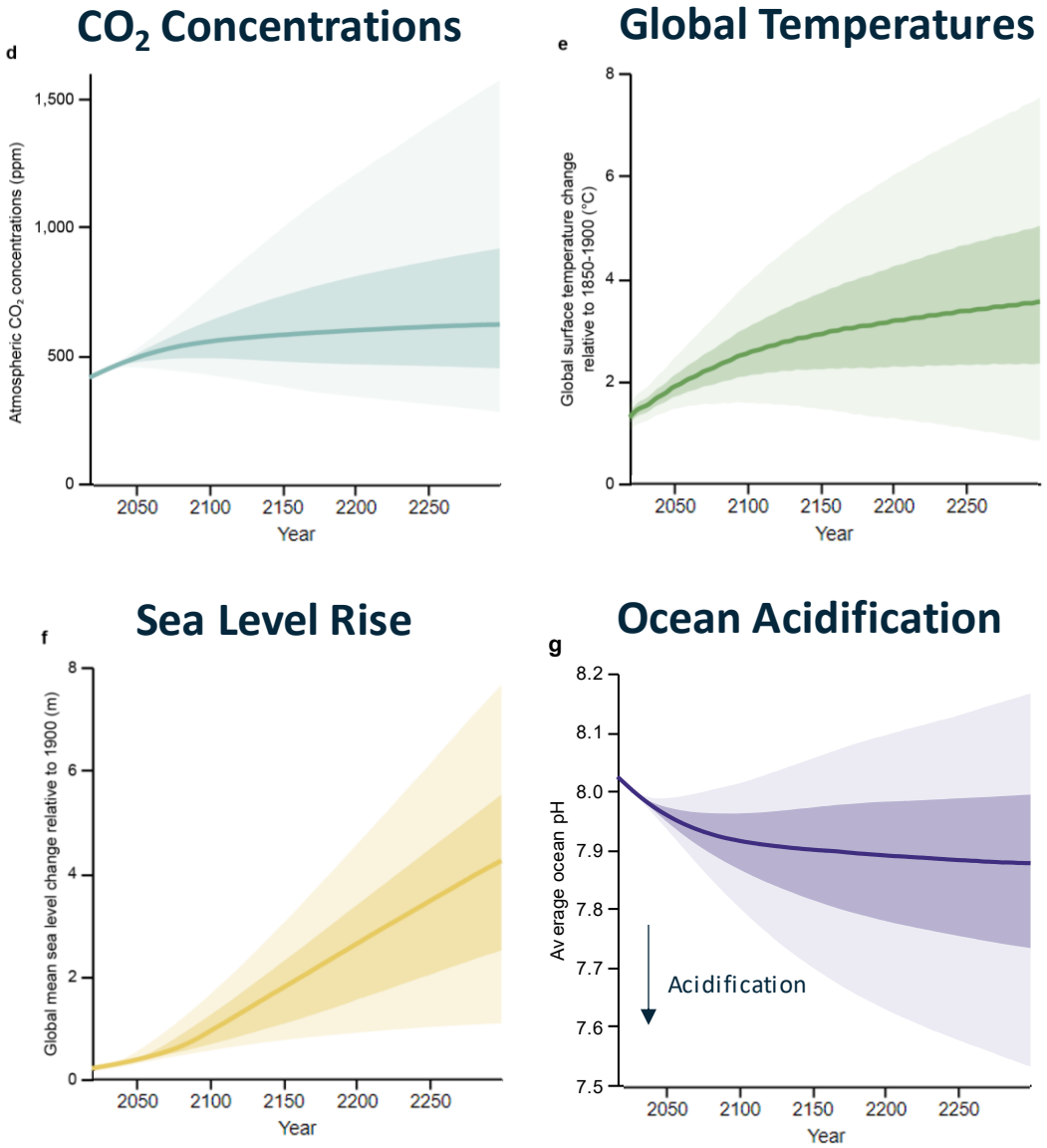


Projections generated through RFF's *Future Emissions Survey**** , which are conditioned on future economic growth and reflect an "Evolving Policies" case

Shaded areas represent 25-75% and 5-95% ranges , *Raftery and Ševčíková (2021), **Müller, Stock, Watson (2020), ***Rennert et al. 2021

Implementation of modern climate models on GIVE

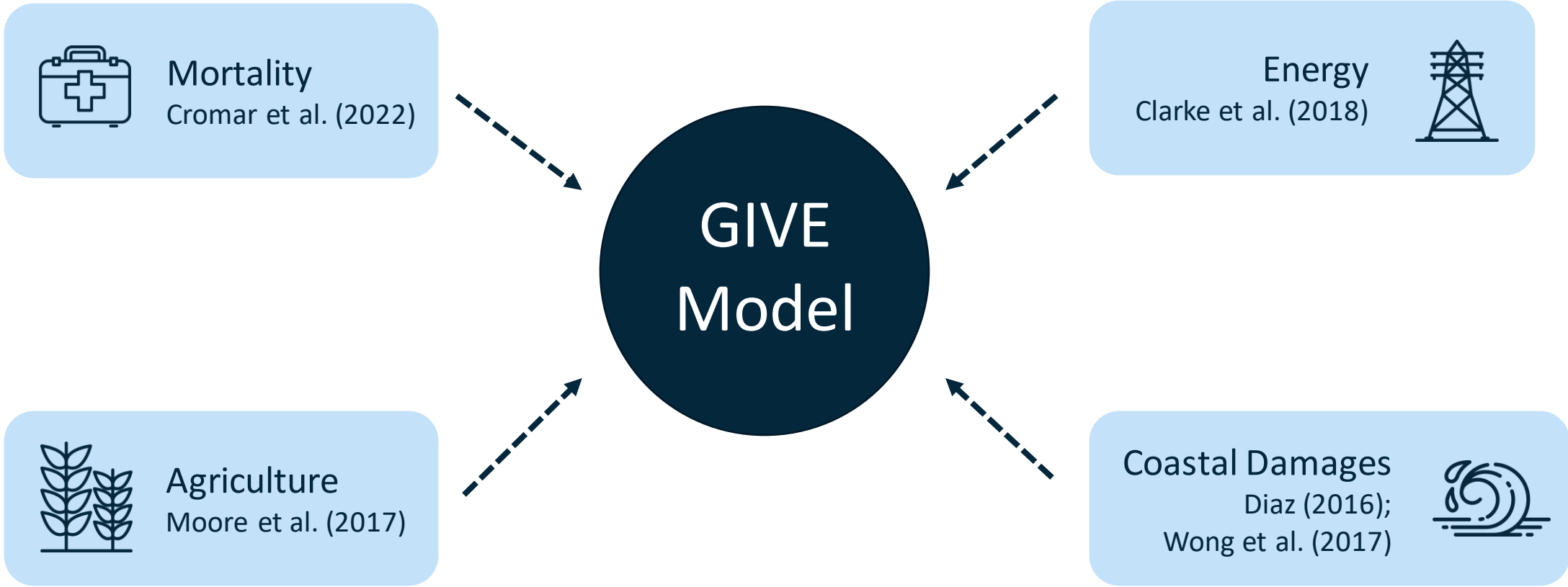
- GIVE calculates the response of the climate system using the FaIR* climate model, the BRICK sea level rise model**, and a modeled response of ocean acidification***
- By sampling emissions trajectories from the RFF-SPs as well as from the climate model parameters, the GIVE model incorporates compounding uncertainties from both elements



Shaded areas represent 25-75% and 5-95% ranges

* Forster et al. (2021), Smith et al. (2021), ** Wong et al. (2017),
*** NASEM (2017)

Implementation of modern sectoral damage functions



Stochastic discounting with growth

- NASEM recommended that the discount rate should
  - Align with the consumption rate of interest
  - Capture the long-term relationship between discount rates and economic growth to reflect risk

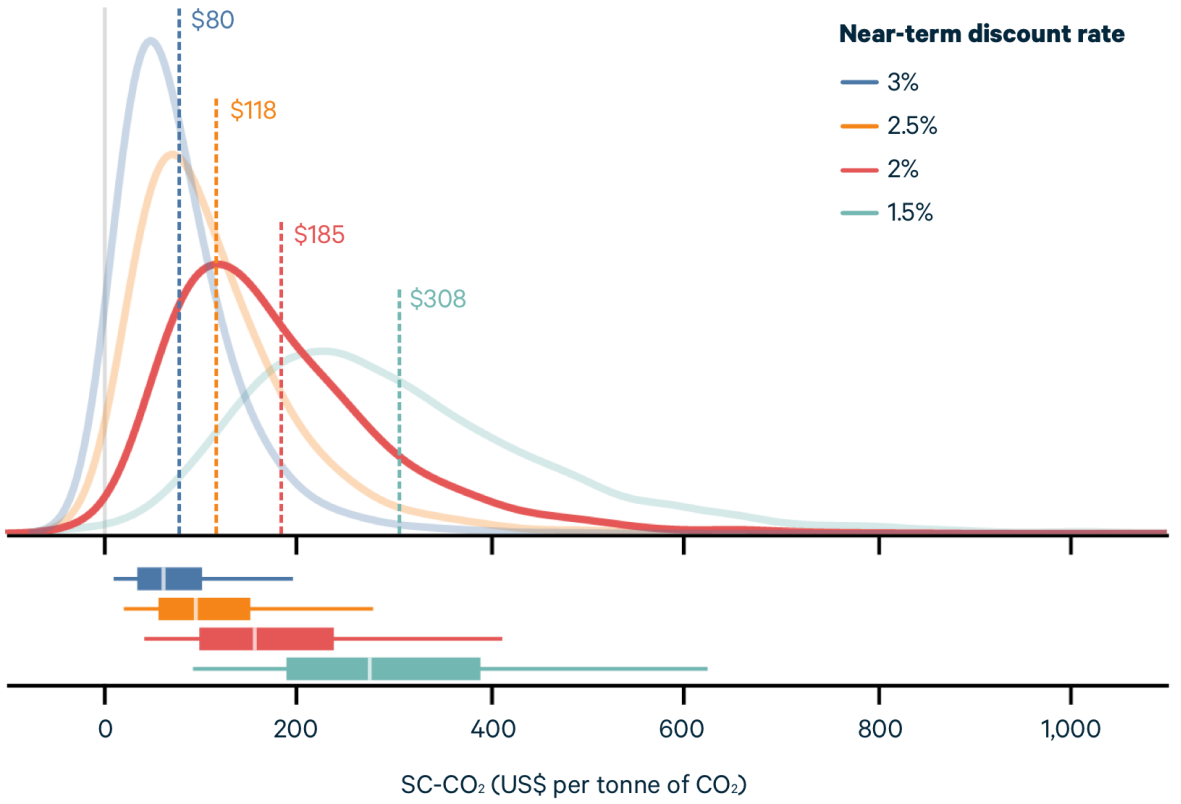
$$r_t = \rho + \eta g_t$$

- Focus on a 2% discount rate, reflecting consensus from recent economic literature*
- Newell, Pizer, Prest (2022) calibrate ρ and η parameters to match near-term rates *and* reconcile long-run interest rate behavior** and economic growth uncertainty***

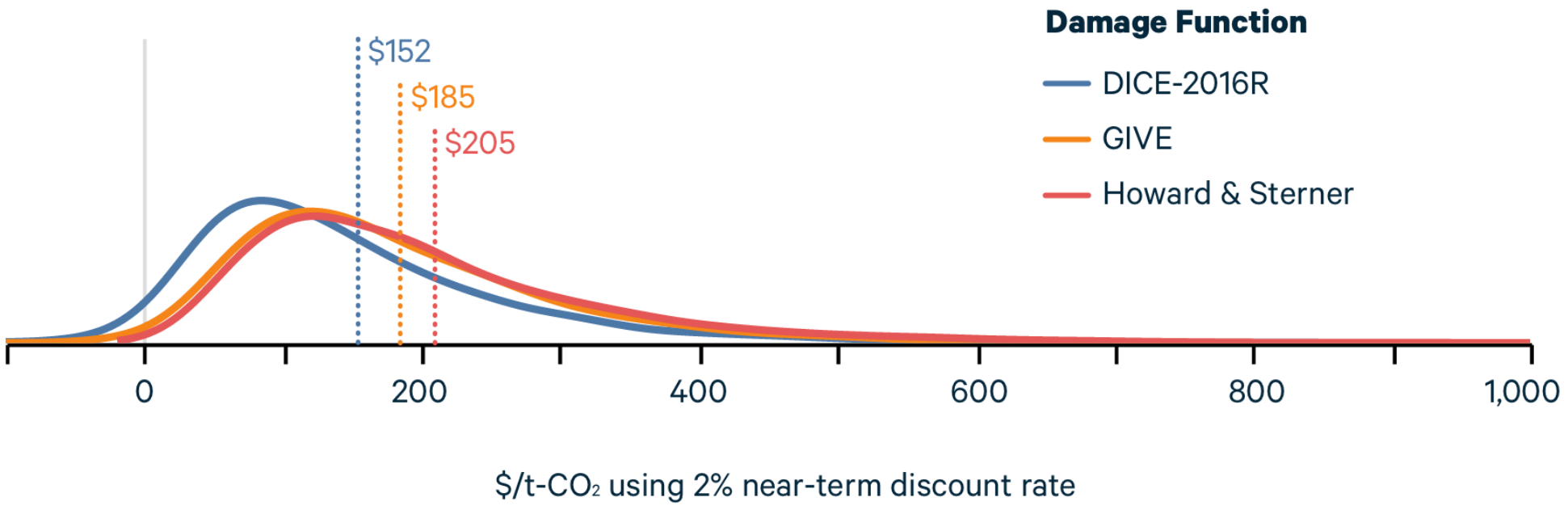
* Giglio et al. (2015); Bauer & Rudebusch (2020, 2021); CEA (2017); Drupp et al. (2018); etc.
** Bauer & Rudebusch (2021)
*** Rennert et al. (2021); Müller, Stock, & Watson, (2020)

SCC estimates from the GIVE Model

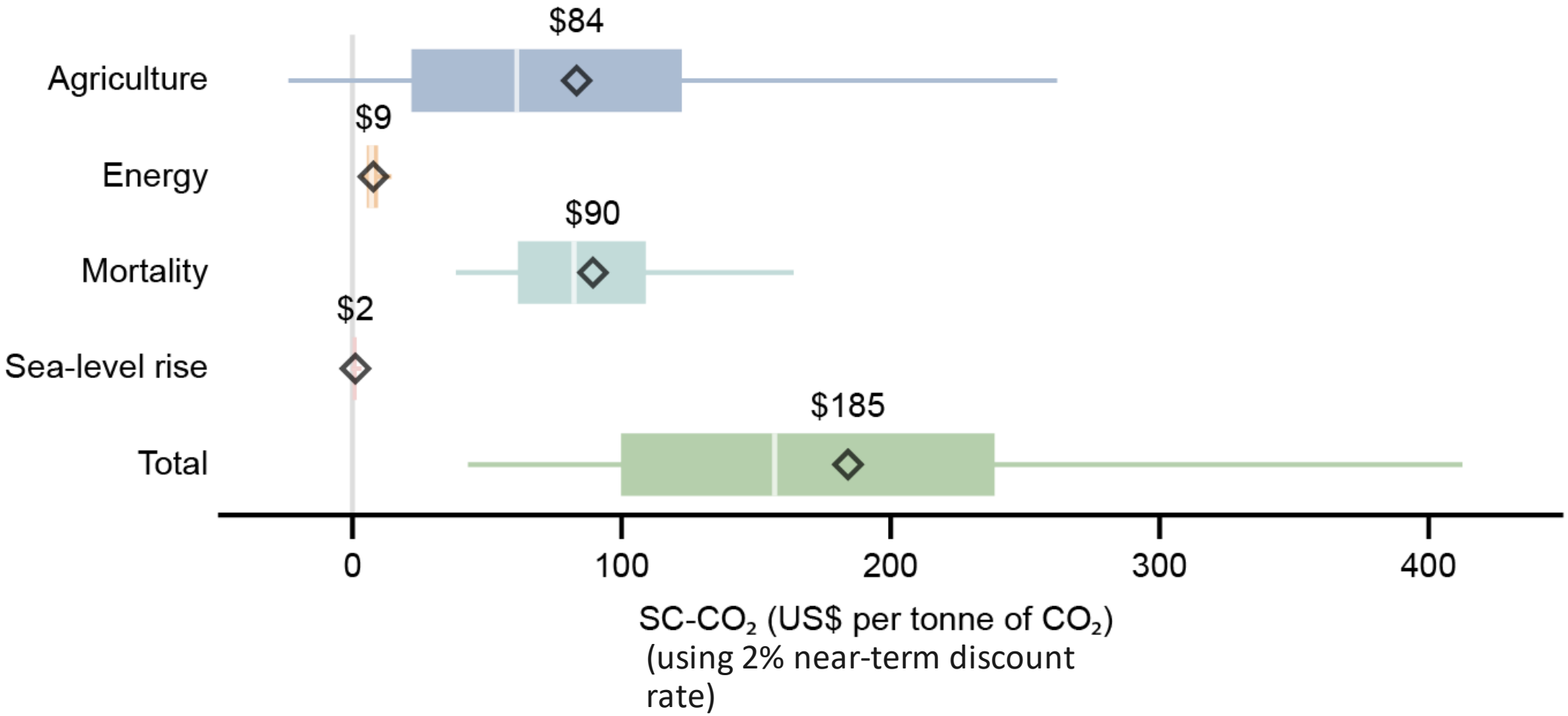
- Means and distributions of the SCC from 10,000 runs of the GIVE model, for discounting approaches calibrated to 4 near-term rates
- Using the preferred 2% near-term discount rate, the mean SCC is $185/ton of CO_2
- Using a 3% discount rate, the mean SCC is $80/ton of CO_2, a ~60% increase over the current federal estimate of $51/ton



Results from GIVE sectoral damages are comparable to global damage functions based on meta-analyses



Partial SCC values, by damage sector



Related and future work

- Other greenhouse gases (SC-CH_4, SC-N_2O, HFCs)
- Incorporating damages from additional sectors
  - E.g., biodiversity loss, labor, etc.
  - Additional damage functions for sectors currently represented
  - Improved treatment of adaptation, and its costs
  - Mimi framework is designed to incorporate new research
- Long-term NAS recommendations
  - Feedbacks, interactions, and tipping elements
- Distributional effects and equity weighting

RFF Social Cost of Carbon Explorer

GREENHOUSE GAS: Carbon Dioxide

rff.org/sccexplorer

Socioeconomic Module

Determines future projections of GDP, population, and emissions.

SOCIOECONOMICS: **RFF-SPs**

OUTPUTS
- CO_2 Emissions
- World GDP per Capita Growth
- World Population

Climate Module

Transates emissions projections into changes in the climate system.

TEMPERATURE: **FAIR**

SEA LEVEL RISE: **BRICK**

OCEAN PH: **Fung**

OUTPUTS
- CO_2 Concentrations
- Temperature
- Sea Level Rise
- Ocean pH

Damages Module

Translates changes in the climate system into economic damages.

METHOD: **Sectoral**

HEALTH: **Cromar**

AGRICULTURE: **Moore**

ENERGY: **Clarke**

COASTAL IMPACTS: **Diaz**

OUTPUTS
- Undiscounted Marginal Damages

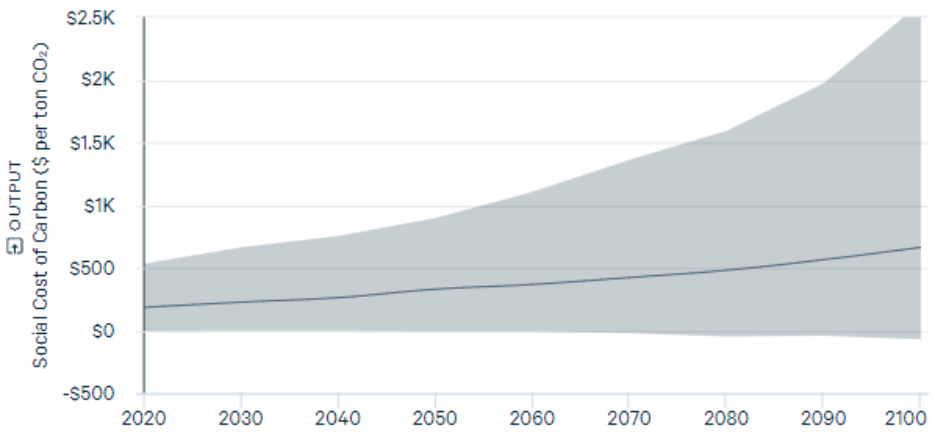
Discounting Module

Translates future economic damages into present-day dollars.

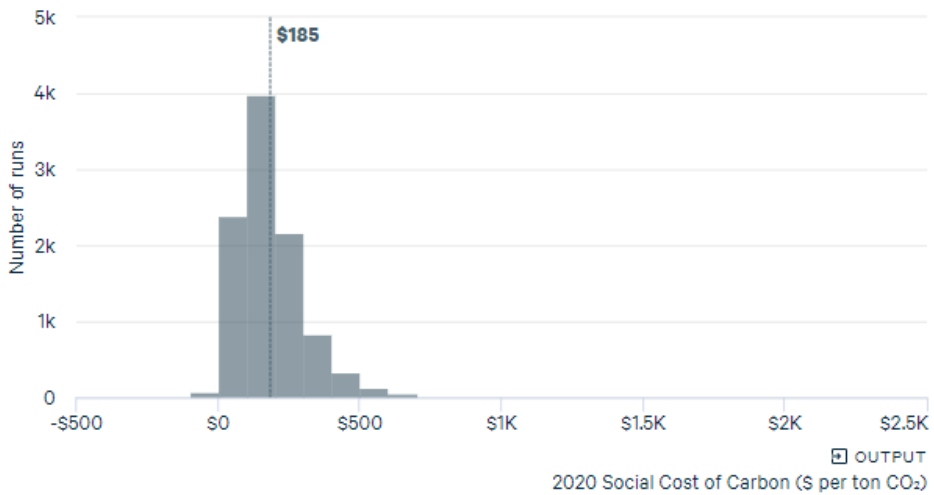
DISCOUNT RATE (METHODOLOGY NOTE): **2.0%**

OUTPUTS
- **Social Cost of Carbon**

Projection 2020–2100



Distribution of 2020 Values



SHOW: Mean + 95% Interval

Thank you.

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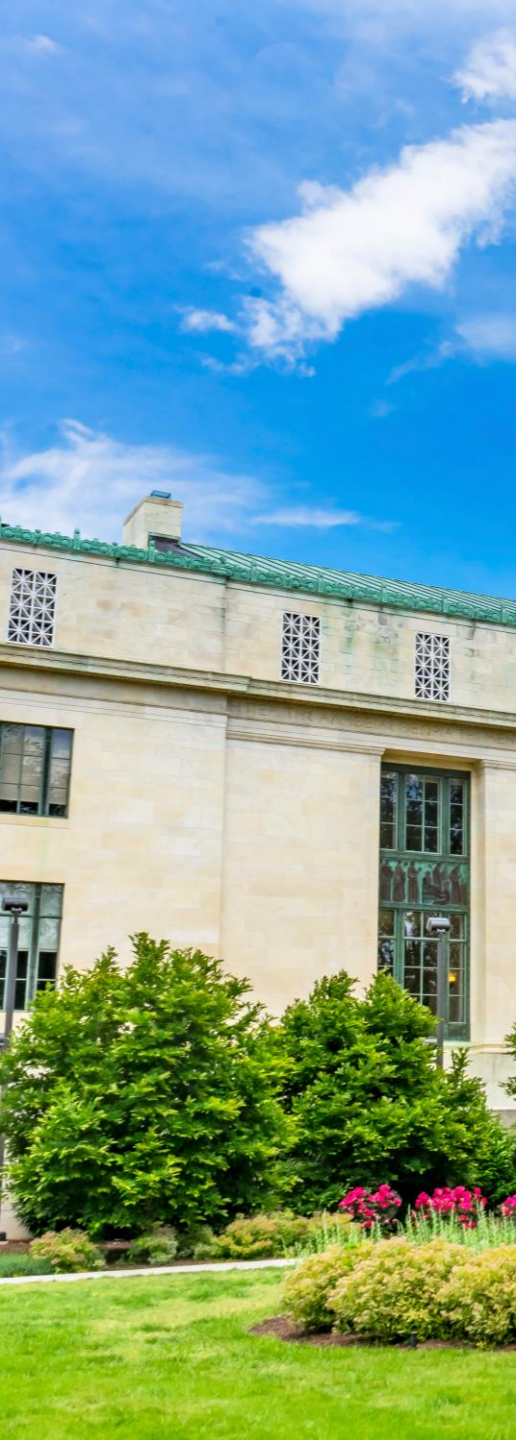
Social Cost of Carbon Initiative: www.rff.org/SCC



Major NASEM recommendations

1. Establish a **regularized process** to update SCC estimates
2. Build an **integrated framework** to “unbundle” the process of SCC estimation into 4 modules
3. Implement **key scientific improvements** across the four modules