Advances in Monetizing Climate Impacts

FrEDI & Methane-Ozone

Marcus C Sarofim, OAR/OAP/CCD/CSIB

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CAAAC Meeting

A Flexible Climate Impacts Framework: The Framework for Evaluating Damages and Impacts (FrEDI)

FrEDI is a **reduced form framework** that draws upon detailed temperature-impact relationships from over 30 peer-reviewed studies to **rapidly estimate** climate change impacts and damages **under any temperature pathway**.

Inputs:

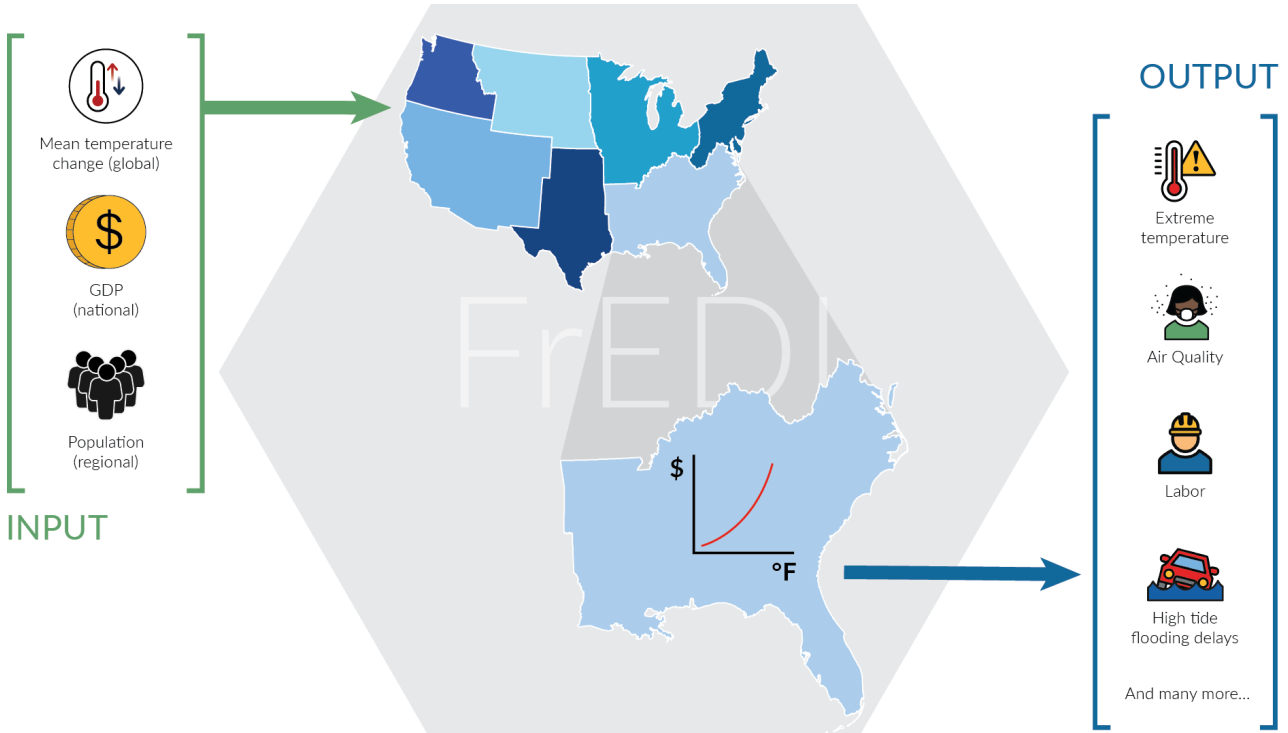
- Projections of U.S. population and GDP, and a global temperature scenario

Outputs:

- Rapid estimates of physical and monetized climate change impacts
  - Across 20+ sectors
  - At the national or NCA region scale

Framework characteristics:

- Open-source and transparent (available on github: www.github.com/usepa/FrEDI)
- Robust and flexible modeling framework



Example Sectoral Impact Analysis (pre-FrEDI): Climate Effects on Air Quality

GCM output
RCP scenario

↓

Dynamic downscaling to simulate detailed meteorology (WRF)

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Atmospheric chemistry modeling (CMAQ)

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Health impact modeling (BenMAP)

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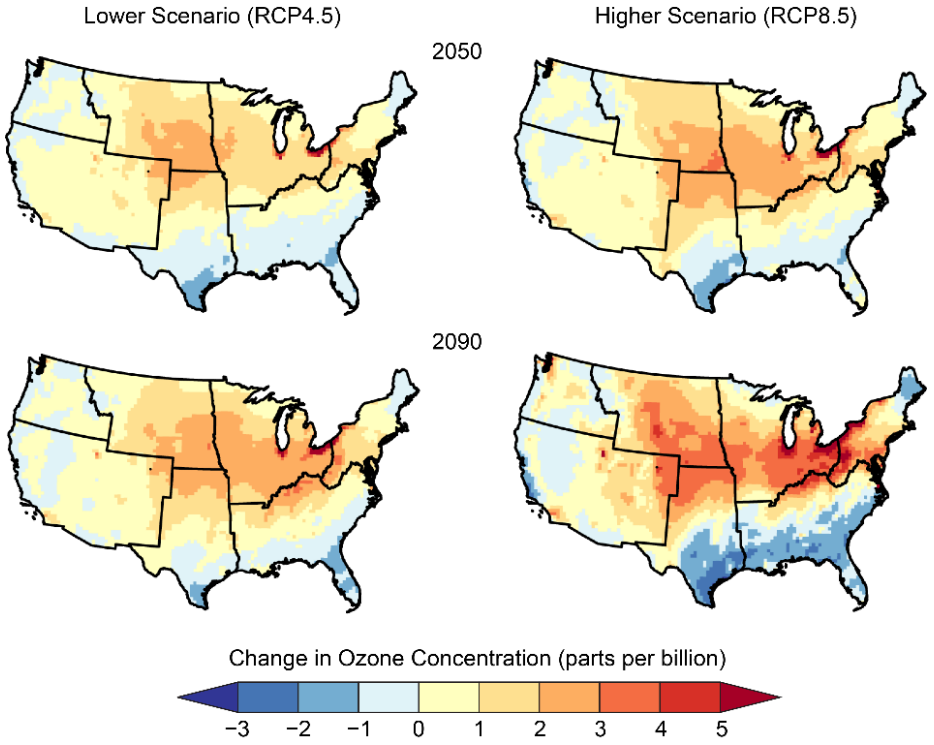
Valuation of mortality and morbidity



Change in Summer-Average Maximum Daily Ozone

Maps show the change in summer-average maximum daily 8-hour ozone concentrations (ppb) in 2050 (2045-2055) and 2090 (2085-2095) compared to 2000 (1995-2005).

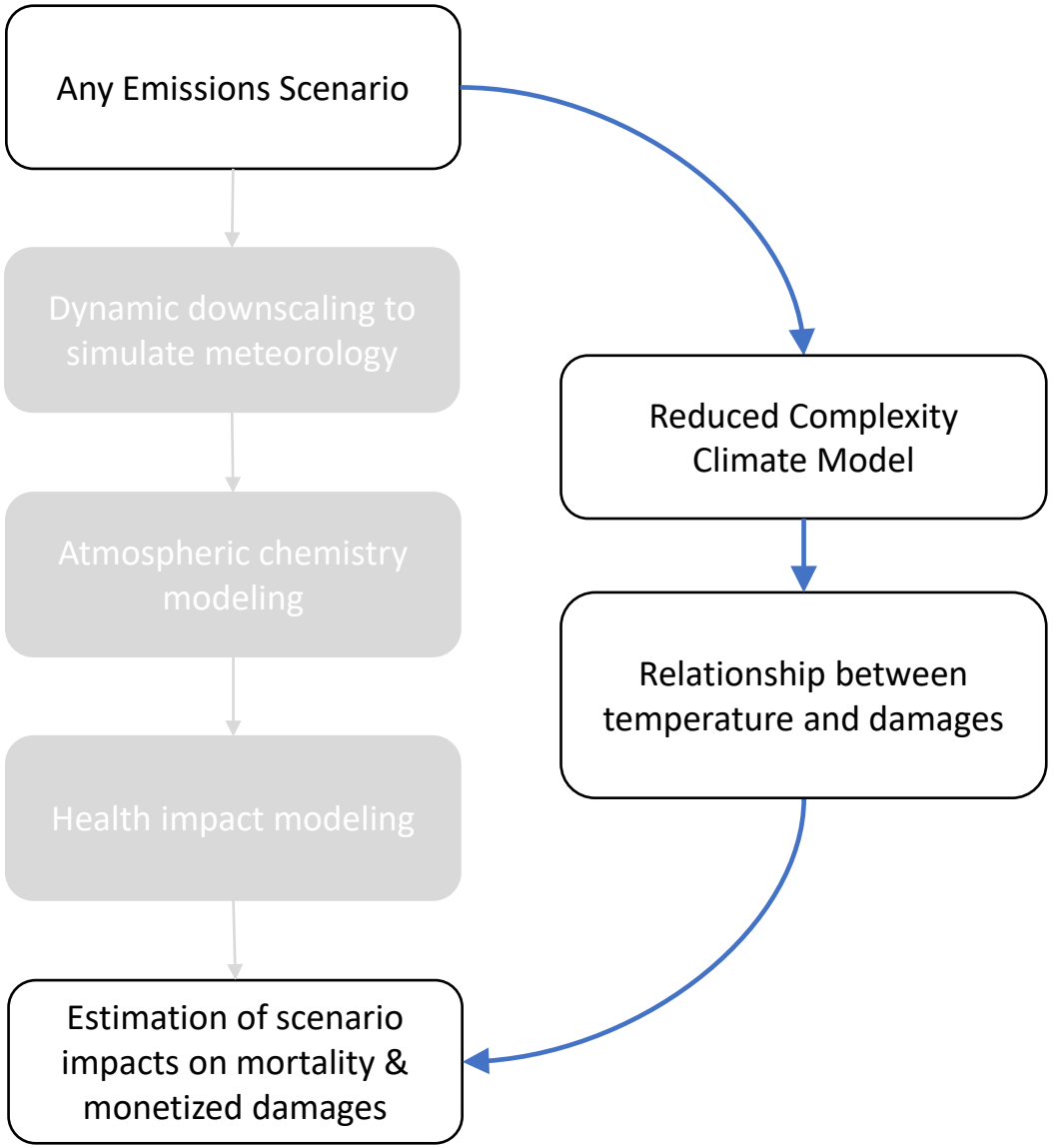
Figure 13.2 from NCA4 Volume II; Table from EPA, 2017

Table 3.2. Cost of Excess (or Avoided) Ozone-Related Premature Deaths

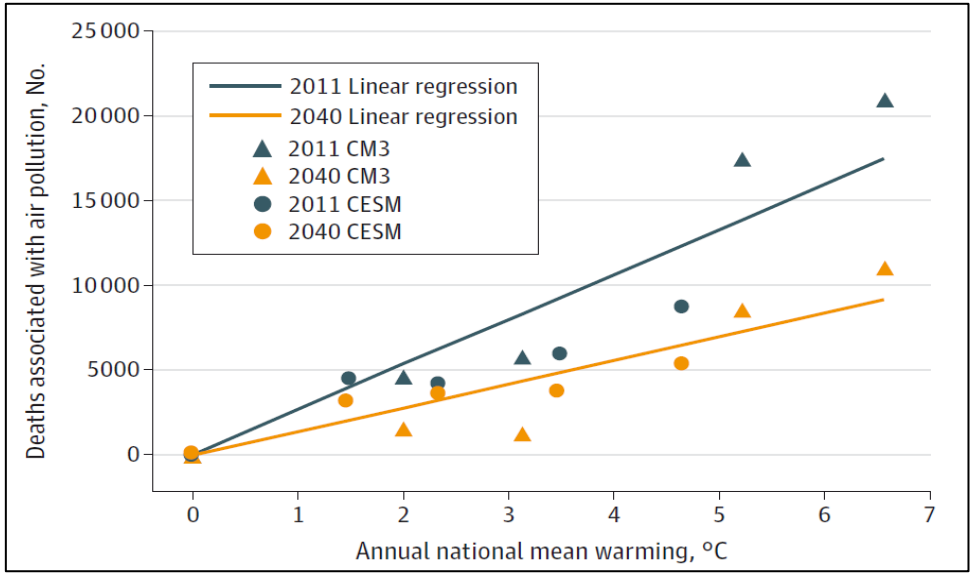
Deaths compared to 2000 (1995-2005). Units are millions of $2015

	2050		2090	
	RCP8.5	RCP4.5	RCP8.5	RCP4.5
Deaths	790 (420 to 1,200)	550 (300 to 810)	1,700 (920 to 2,500)	1,200 (630 to 1,700)
Estimated Value	$9,800 ($880 to $28,000)	$6,900 (-$900 to $21,000)	$26,000 (-$2,200 to $78,000)	$18,000 ($1,600 to $51,000)

FrEDI Sectoral Analysis Approach: Climate Effects on Air Quality



Deaths Associated with O_3 and $PM_{2.5}$ by Temperature



Fann et al. 2021, doi:10.1001/jamanetworkopen.2020.32064

We developed reduced form relationships between changes in temperature and the economic (or physical) damage from the detailed bottom-up sectoral studies using an impacts by degree approach.

Current FrEDI Sectoral Coverage v3.0

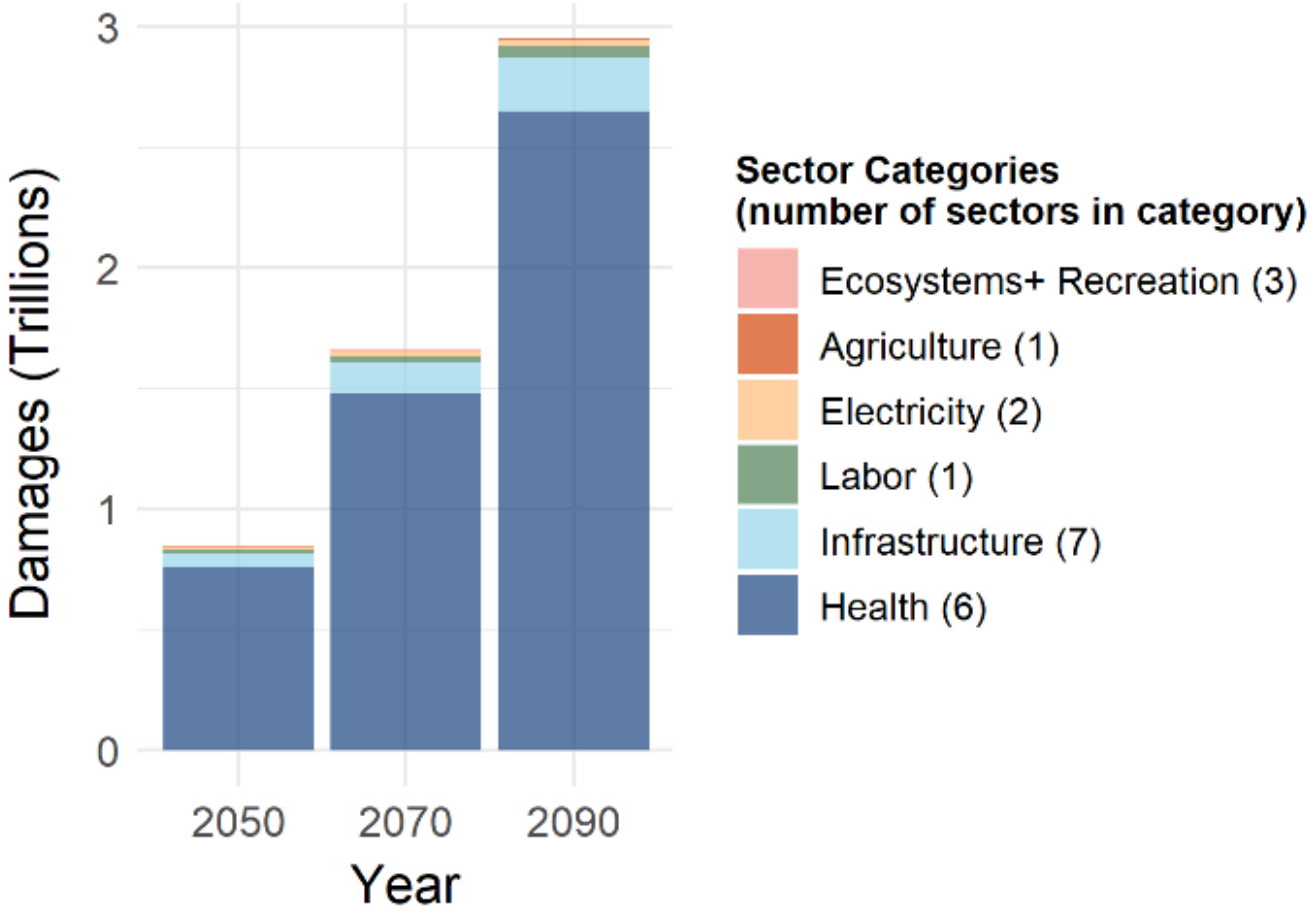
FrEDI is **not a comprehensive accounting** of all expected climate-driven impacts within the U.S., nor does it address impacts to U.S. interests due to climate change globally, but is the **most detailed and comprehensive tool** to date of the magnitude of long-term climate-driven damages and the distribution of where, when and to whom these damages will occur within U.S. borders

Current FrEDI Impact Sectors:

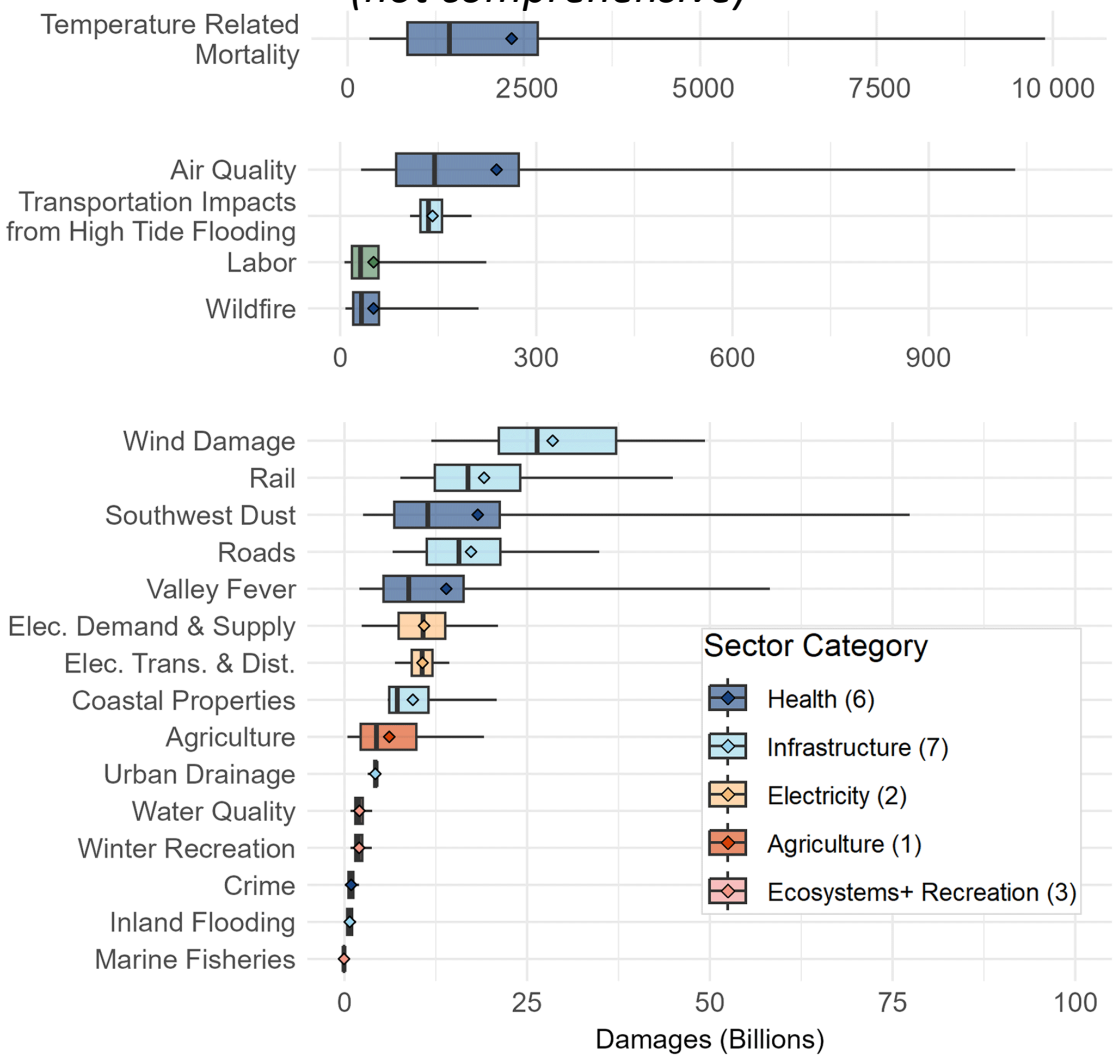
- Agriculture (CIL)
- Coastal property
- Electricity demand/supply
- Electricity trans/distribution infrastructure
- Extreme temperature mortality
- Extreme temperature mortality (CIL)
- Extreme temperature mortality (ATS)
- Hightide flooding and traffic
- Inland Flooding (residential)
- Labor allocation
- Marine fisheries
- Ozone/$PM_{2.5}$ health effects
- Property & violent crime (CIL)
- Rail infrastructure
- Road infrastructure
- Southwest dust
- Tropical Storm Wind
- Urban drainage
- Water quality
- Wildfire/AQ health effects and suppression costs
- Winter recreation
- Valley Fever

Impacts from Climate Change Over Time and Across Sectors

FrEDI U.S. Total Climate-Driven Damages (Trillion$)
(not comprehensive)



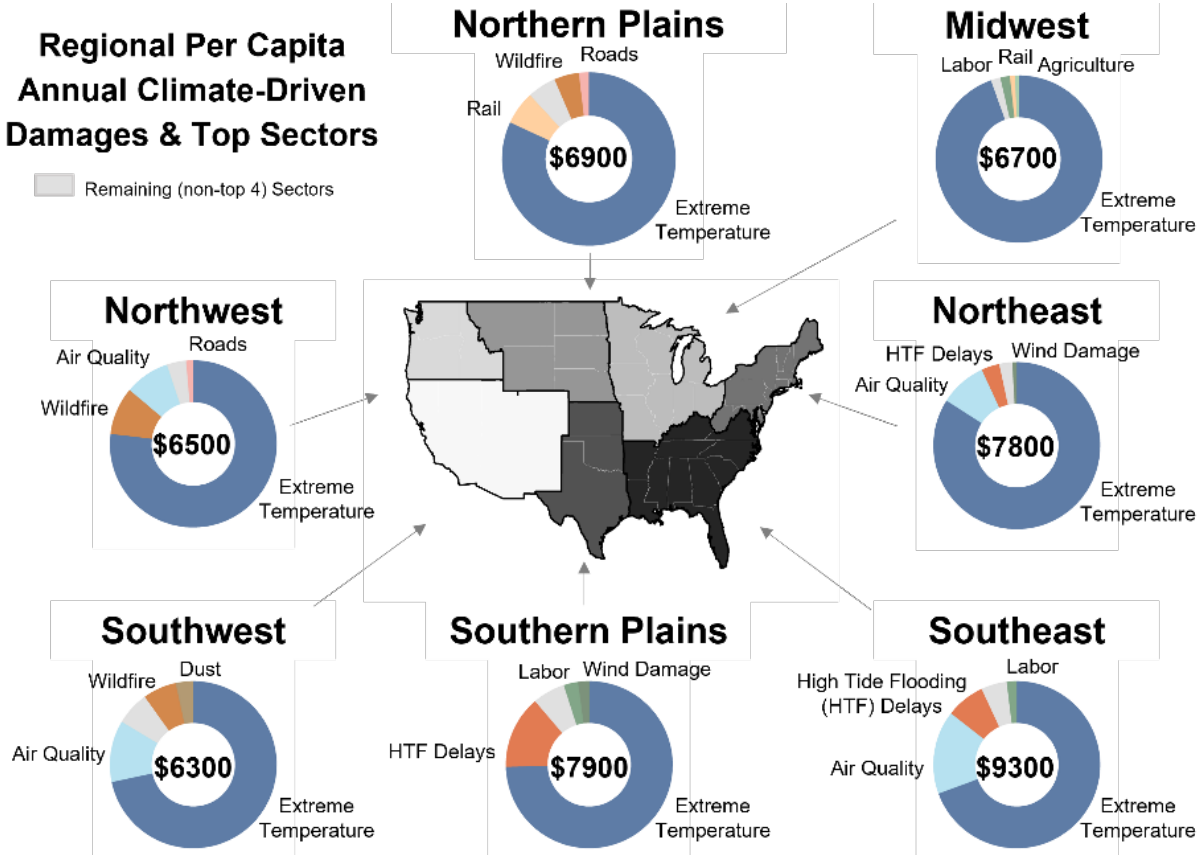
FrEDI U.S. Climate Driven Damages in 2090, by sector
(not comprehensive)



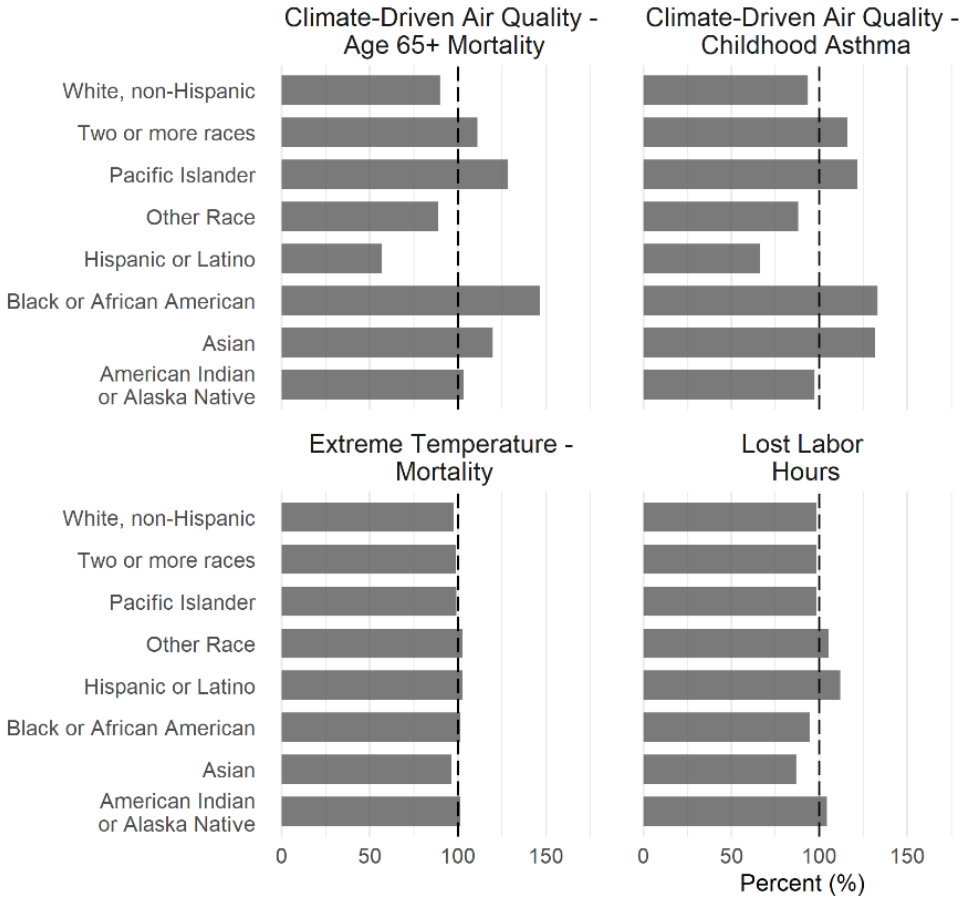
Figures from Hartin et al., 2023, ESD, https://doi.org/10.5194/esd-14-1015-202

Regional and race/ethnicity specific impacts

FrEDI Regional 2090 Climate-Driven Impacts ($/person), and largest 4 impact sectors



Relative Annual 2090 Climate-Driven Damages ($), by race/ethnicity



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Valuing Methane-Ozone Mortality

INPUT

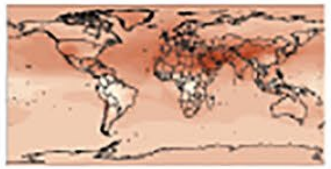
TROPOSPHERIC OZONE CHANGE BY COUNTRY & YEAR

CLIMATE & CLEAN AIR COALITION TO REDUCE SHORT-LIVED CLIMATE POLLUTANTS

1 Atmospheric lifetime of a methane pulse

ipcc INTERGOVERNMENTAL PANEL ON climate change

2 Ozone change per parts per billion of methane change



POPULATION CHARACTERISTICS BY COUNTRY, YEAR, & AGE

RESOURCES *for the* FUTURE

3 Population projections

4 All-cause mortality rate projections

INTERNATIONAL FUTURES AT THE PARDEE CENTER

5 Projected fraction of all-cause mortality attributable to respiratory mortality

OZONE MORTALITY FUNCTION

15 IHME

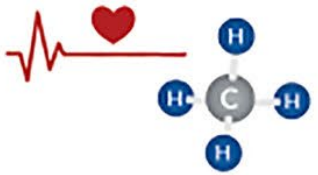
6 Ozone concentration response function from the Global Burden of Disease

BenMAP

OUTPUT

MORTALITY BY COUNTRY OVER TIME

Respiratory mortality attributable to a change in long-term ozone exposure per ton of methane emitted



MONETIZATION & NET PRESENT DAMAGES

Monetization and net present damages

Figures from McDuffie et al., 2023, Earth's Future, https://doi.org/10.1029/2023EF003853

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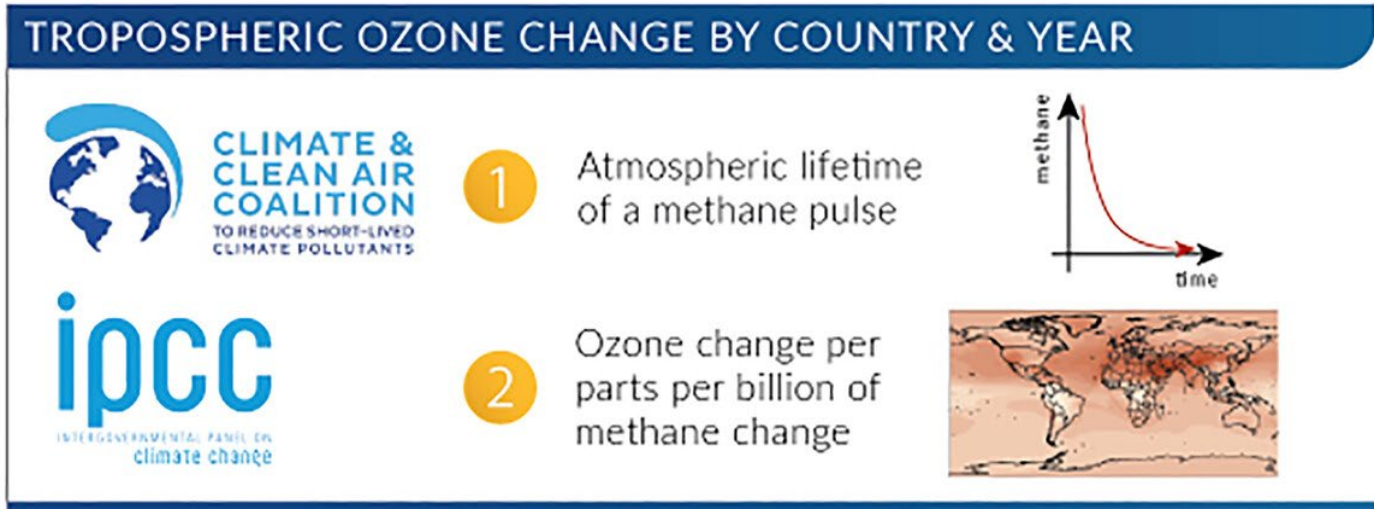

Atmospheric Chemistry

- Global methane emissions -> global methane concentrations
  - IPCC perturbation lifetime
- Methane concentration -> spatially resolved ozone changes
  - CCAC response maps, 5 GCMs
- Secondary effects (e.g., NOx influence)
  - CCAC analysis by country

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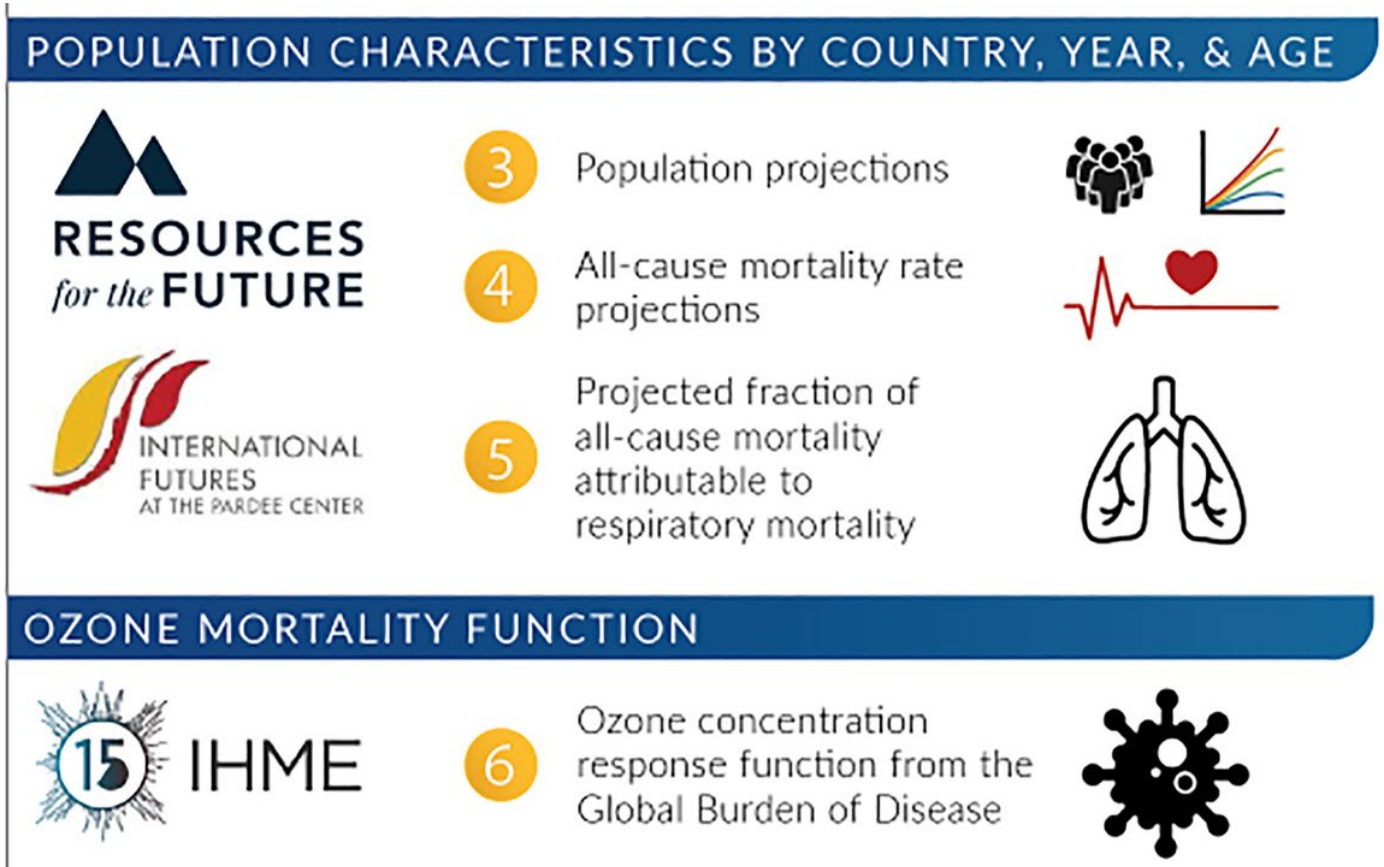
Health modeling



- Mortality exposure response function
  - Global burden of disease (COPD)
- Future population size & age by country
  - RFF-SP scenarios
- Future respiratory mortality by country
  - All-cause mortality: RFF-SP
  - All-cause/respiratory ratio: International Futures

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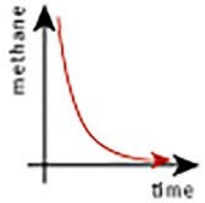

ipcc
INTERGOVERNMENTAL PANEL ON climate change

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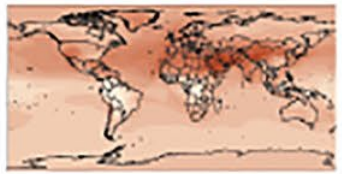

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Economics

- Future GDP (by country)
  - RFF-SP scenarios
- VSL
  - EPA estimate of $10 million for the U.S. in 2020
- Income elasticity
  - 1
- Discount rates
  - Ramsey, 2%

Figures from McDuffie et al., 2023, Earth's Future, https://doi.org/10.1029/2023EF003853

Comparison to EPA's New Social Cost of Methane (SC-CH_4)

From EPA's Final Rule – Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review: Regulatory Impacts Analysis

Source	$/tonne CH_4	Global Benefits ($)	Notes
SC-GHG	$1600 (SC-$CH_4$)	$110B	2% Ramsey discounting, RFF-SP socioeconomics, average of DSCIM, GIVE, and meta-analysis
McDuffie et al.	$1800	$110B	2% Ramsey discounting, RFF-SP socioeconomics, methane chemistry effects only. Global mortality aggregated over time from a pulse of methane is ~760 deaths/million metric tons

Total CH_4/O_3 benefits from the methane emission reductions under this rule are approximately equal to the climate benefits as estimated by the SC-GHG

General caveats:

- SC-GHG is not a comprehensive measure of climate impact categories
- SC-GHG climate modeling may not include some tipping points and/or feedbacks
- See https://www.epa.gov/system/files/documents/2023-12/epa_scghg_2023_report_final.pdf for more complete description of these issues

Questions?