CGE Model and Dataset Development in EPA's Climate Change Division

Estimating Economy-Wide Impacts from the *Climate Change Impacts and Risk Analysis (CIRA) Project (and other endeavors)*

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Outline

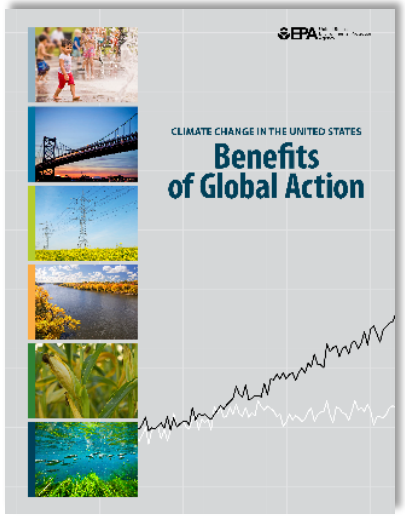
- Overview of CIRA
- Climate impacts in CGE models
- Extensions & other efforts

Disclaimer: Views expressed in presentation do not necessarily represent those of the U.S. EPA.

CIRA Project and the Technical Summary Report

- The Climate Impacts and Risk Analysis project is designed to quantify the multi-sector impacts of climate change in the U.S., and evaluate changes in physical and economic damages under different scenarios.
- Consistent socioeconomic and emission/climate projections(5 GCMs) are used to quantify impacts across 24 sectors covering human health, infrastructure, electricity, water resources, agriculture, & ecosystems.
- Over 74 collaborators across EPA, other federal agencies, national labs, academia, and consultants.
- Underlying methodologies and results published in over 35 peer-reviewed publications including special issues in *Climatic Change* and *Environmental Research Letters.*

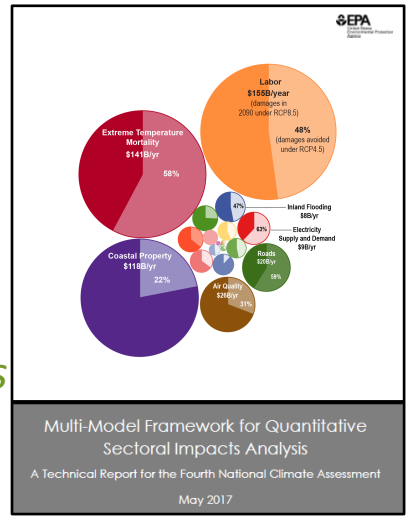
CIRA 1.0



2015

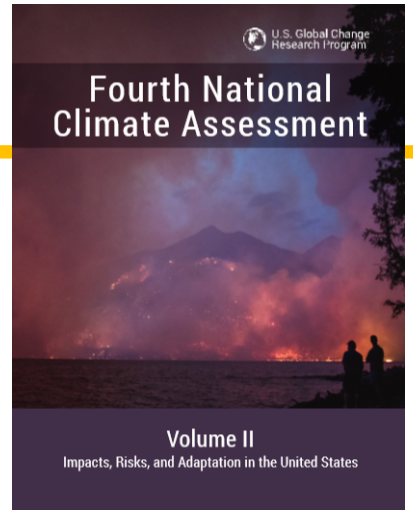
Applied Methodologies to NCA scenarios

CIRA 2.0



2017

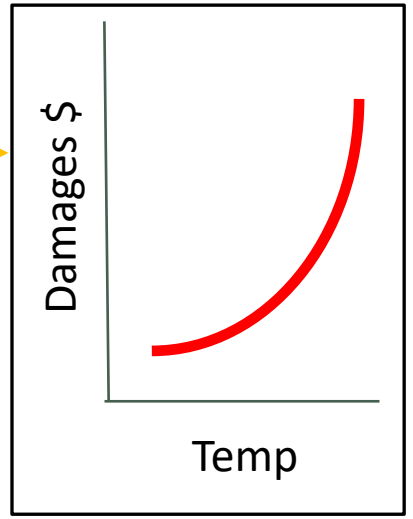
Technical Input to NCA4



2018

Reduced Form

CIRA 3.0



Current work

Sectoral Impacts Covered in CIRA

Health

- Air Quality
- Aeroallergens
- Extreme Temperature Mortality
- Labor
- West Nile Disease
- Harmful Algal Blooms
- Domestic Migration

Infrastructure

- Roads
- Bridges
- Rail
- Alaska Infrastructure
- Urban Drainage
- Coastal Property

Electricity

- Electricity Demand and Supply

Water Resources

- Inland Flooding
- Water Quality
- Winter Recreation

Agriculture

- Domestic Yields and Welfare Effects
- U.S. and Global Agriculture Interactions

Ecosystems

- Coral Reefs
- Shellfish
- Freshwater Fish
- Wildfire
- Carbon storage

Many important impacts are not included in the modeling framework. Future work will expand and deepen the sectors covered.

Results: Outdoor Labor Impacts

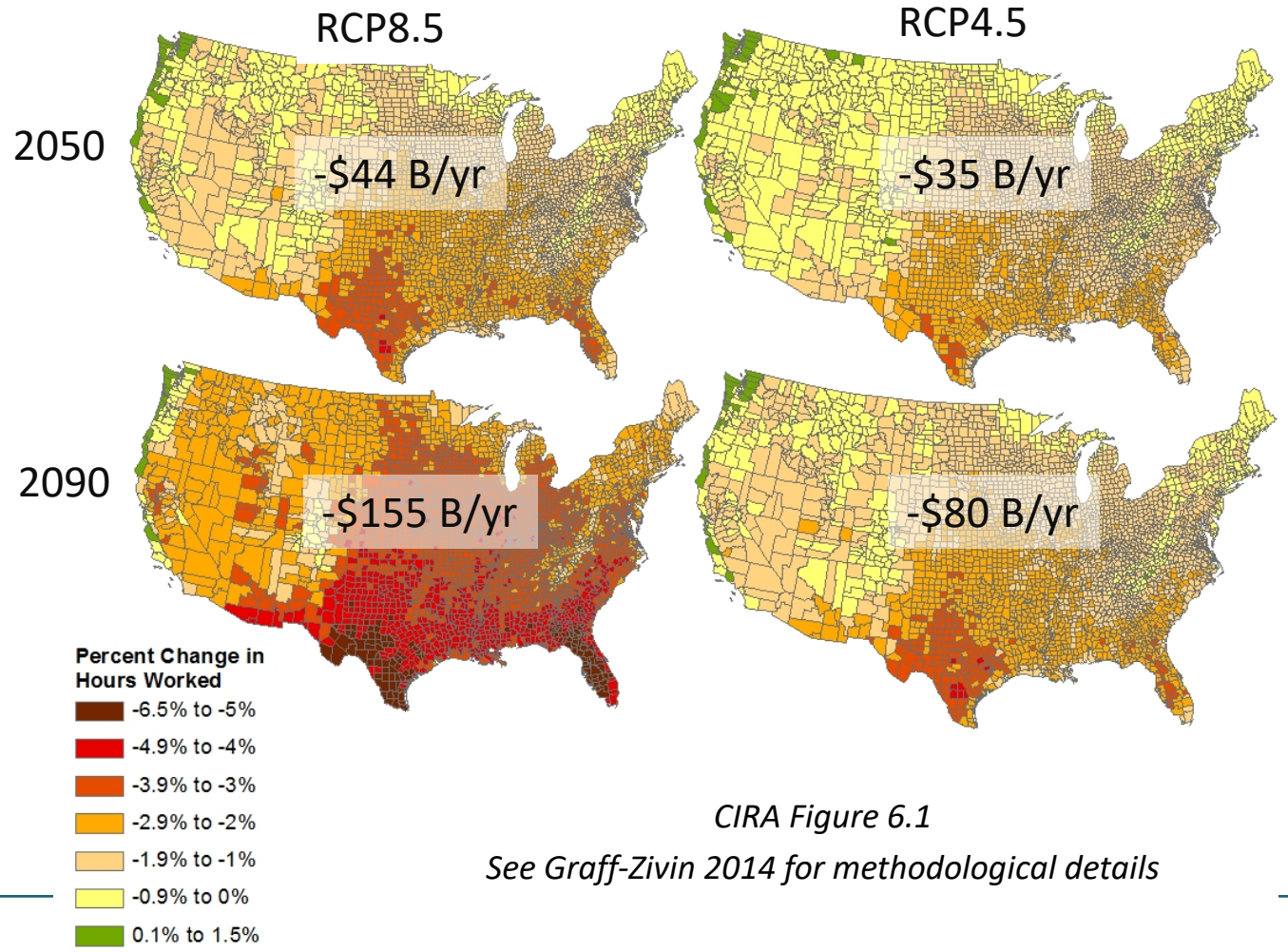
- This analysis focuses on the net impact of changes in extreme temperatures (both hot and cold) on outdoor ('high-risk') labor.

- Approximately 880 million labor hours ($44B) are projected to be lost annually by 2050 under RCP8.5, rising to 1,900 million hours ($155B) by 2090.
- Under RCP4.5, labor losses are projected at 700 million lost hours ($35B) by 2050 and 970 million lost hours ($80B) by 2090.

- This analysis assumes population growth with the same composition of outdoor labor, and does not include effects of new adaptive technology (only existing adaptations). Additional climate impacts on laborers (e.g., AQ) are not included.

Estimated Percent Change in High-Risk Labor Hours in 2050 and 2090

Change in hours worked from the 2003-2007 reference period, normalized by the high-risk working population in each county. Values represent average across five GCMs.



CIRA Figure 6.1

See Graff-Zivin 2014 for methodological details

Results: Extreme Heat Mortality

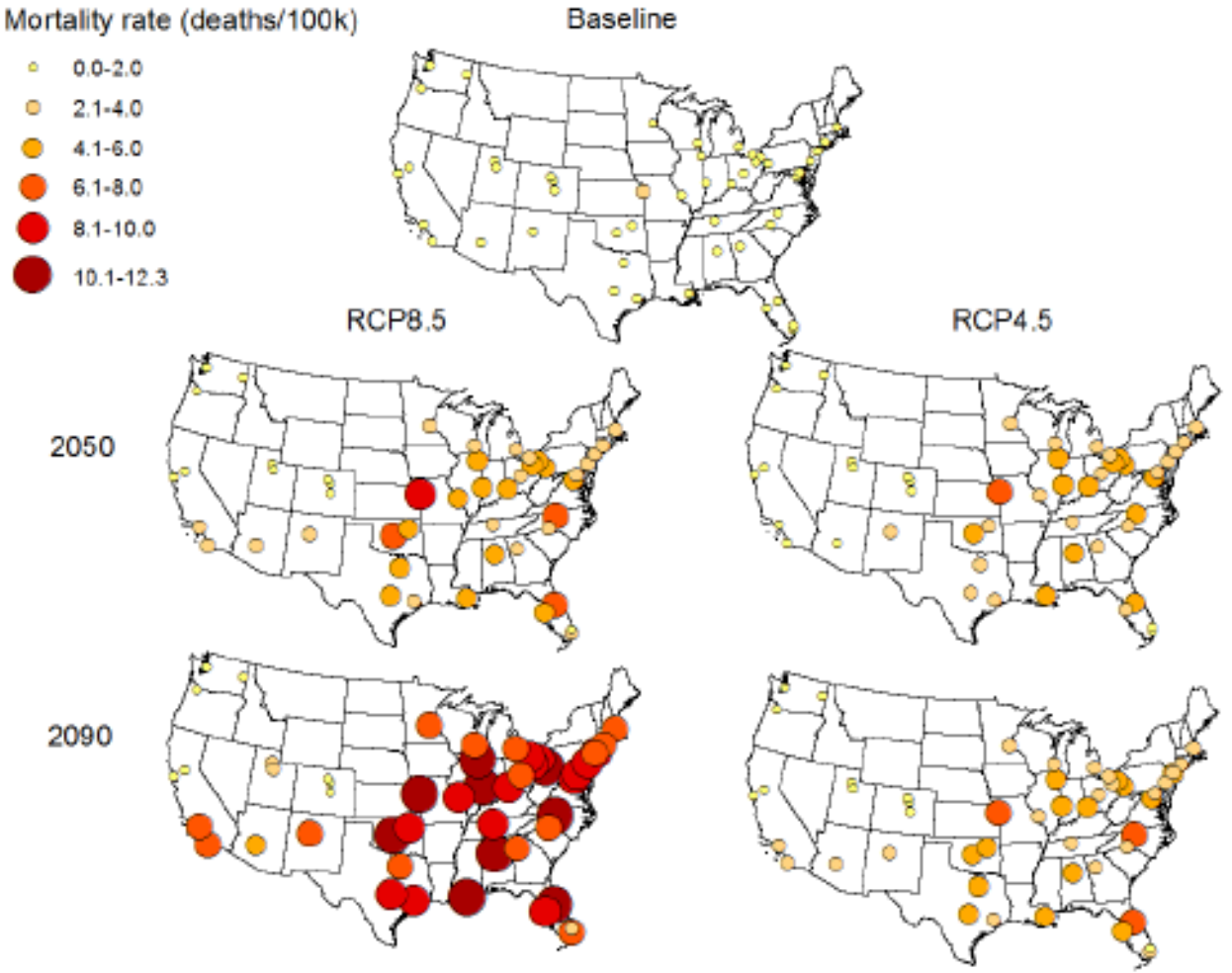
- Changes in extreme temperatures are projected to result in a net average increase of approximately 9,300 premature deaths per year under RCP8.5 by 2090 in the 49 modeled cities. Under RCP4.5, more than 5,000 deaths are avoided each year by 2090.

- The projected reduction in deaths from extremely cold days is far less than the projected increase in deaths from extremely hot days in all climate models, scenarios, and time frames.

- Annual damages associated with additional extreme temperature related deaths are estimated at $140 billion under RCP8.5 and $60 billion under RCP4.5 by the end of the century.

- Mortality from extremely hot days decreased more than 50% under both RCP8.5 and RCP4.5 in 2050 and 2090 when the human health response to extreme temperatures was evaluated using Dallas' threshold for extreme heat (in all cities with thresholds initially cooler than Dallas), as a sensitivity analysis to consider the effect of adaptation.

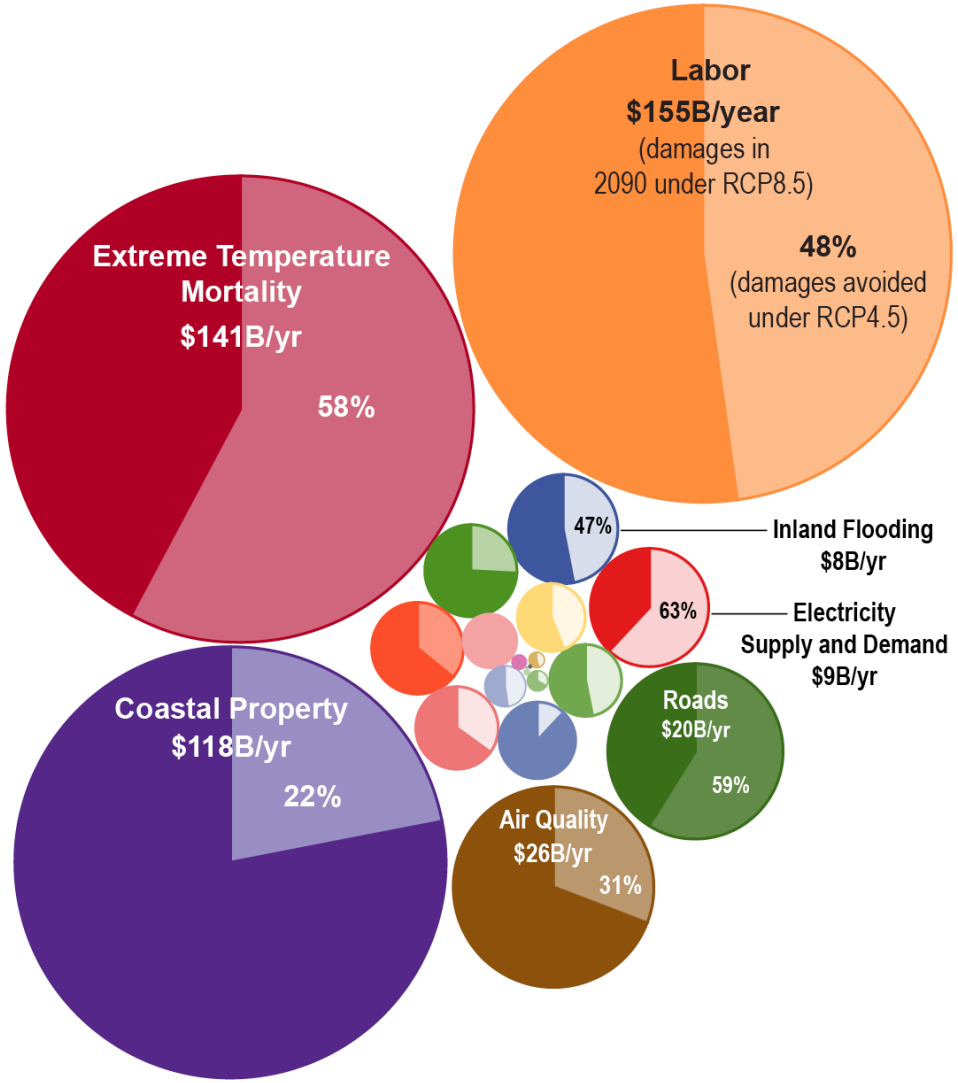
CIRA 2 Figure 5.1 Projected Extreme Temperature Mortality in Select Cities
Estimated net mortality rate from extremely hot and cold days (number of deaths per 100,000 residents). Cities without circles should not be interpreted as having no extreme temperature impact.



Results: Projected Damages Across Sectors and Reduction Potential

- Climate change is projected to result in adverse impacts across most US sectors.
- The projected magnitude of economic damages varies widely ($millions to $100 billion per year).
- Scenarios with lower global emission (i.e., RCP4.5 vs. RCP8.5) show reduced economic damages.
- Direct damages in 2090 across top 7 sectors are roughly 0.7% of GDP for RCP8.5 vs. 0.4% for RCP4.5. Lower emissions scenario avoid 45% of direct damages.

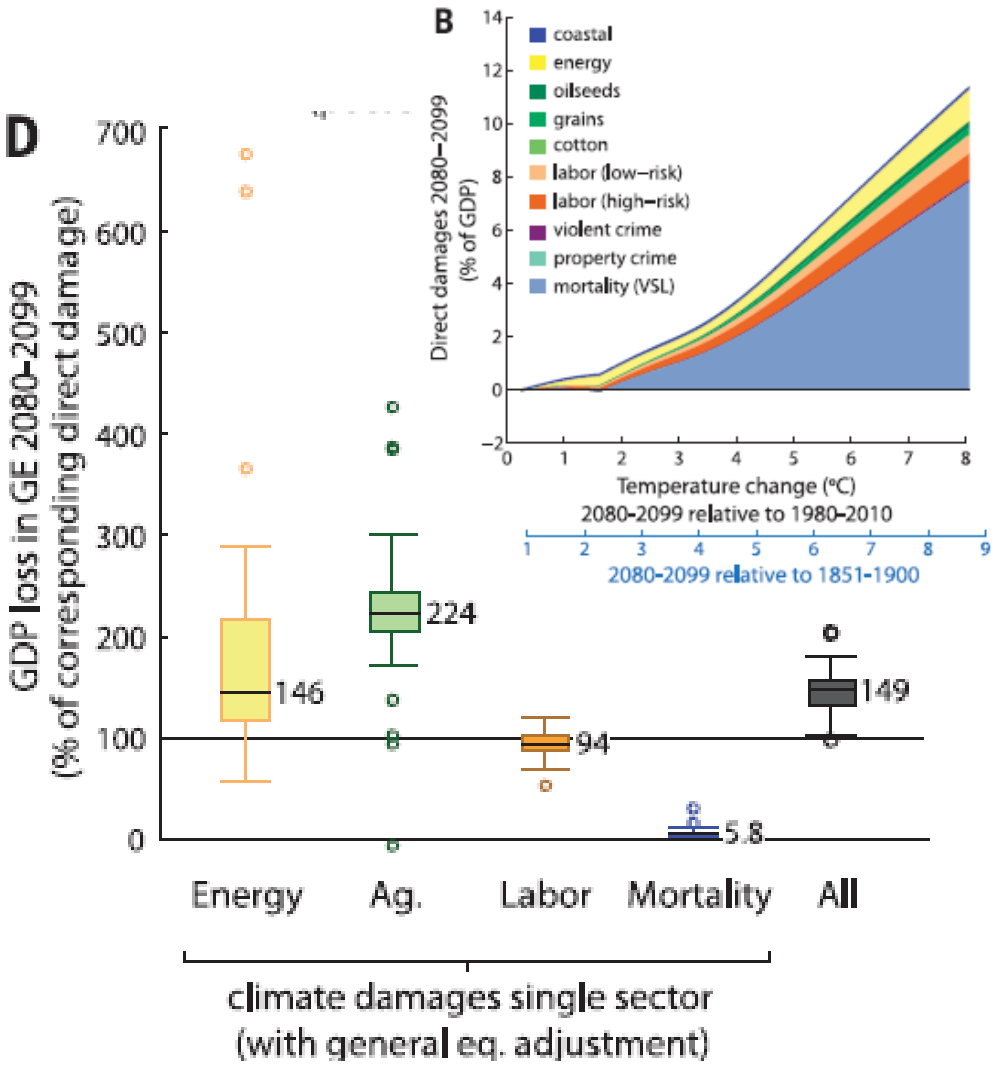
The total area of each circle represents the projected annual economic damages (in 2015 dollars) under a higher scenario (RCP8.5) in 2090 relative to a no-change scenario. The decrease in damages under a lower scenario (RCP4.5) compared to RCP8.5 is shown in the lighter-shaded area of each circle.



NCA4 Figure 29.2

Other Economy-Wide Climate Impact Analyses

- Climate Impacts Lab / American Climate Prospectus
  - RHG-MUSE model
  - 7 sectors: labor, heat mortality, coastal, energy, ag, crime
  - Economy-wide impacts are 50% greater than direct damages
  - Heat mortality only considers lost labor
- EU JRC PESETA I, II, III
  - Static implementation in GEM-E3
  - 6 sectors: labor, heat mortality, coastal, inland flooding, ag
  - Focus on 2 degrees (2030-2040)
  - EU GDP loss ~2%, half coming from heat mortality VSL
- OECD Circle
  - Global analysis to 2060
  - Crop yields and labor supply impacts lower GDP by 0.9% and 0.8%



Source: Hsiang et al. Science 2017

Incorporating CIRA impacts into USREP

- USREP developments
  - Disaggregate to US 30 regions
  - Extended to 2100
- Methodological Challenges: Temperature Mortality
  - Including in more sophisticated way than ignoring or VSL
  - Accounting for entire US vs. subset of cities
  - Estimating adaption
- Methodological Challenges: Coastal Impacts
  - Translation between bottom-up and top-down
  - Abandon vs. protect (nourish, seawall)

Potential Extensions and Other Modeling Activities

- Implementation with CIRA Reduced-form Damage Functions
  - Damages as a function of Temp, Precip, Pop, GDP, etc.
- Climate impacts in OLG framework
  - Yonezawa & Rausch
  - Singe US region with multiple households
  - Challenge: projections to year 2165
- USREP-ReEDS linkage
- MEEDE dataset development
- US Energy Jobs dataset (usenergyjobs.org)
  - Annual jobs survey by state, sector and occupation published in 2017, 2018, 2019.
    - Fuels; Electric Power Generation; Transmission, Distribution, and Storage; Energy Efficiency; Motor Vehicles
  - First survey by DOE. Subsequent by Energy Futures Initiative, National Association of State Energy Officials.
  - Separate 2019 publication will include wage data.
- Socio-economic projections

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