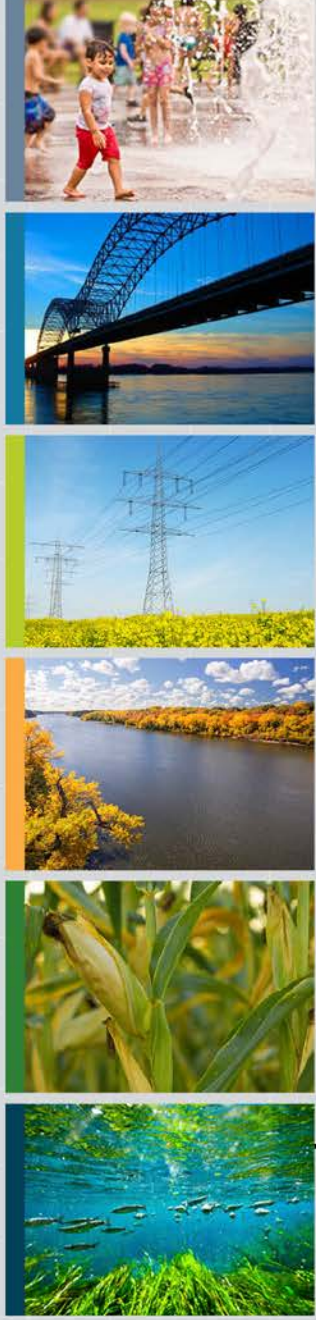
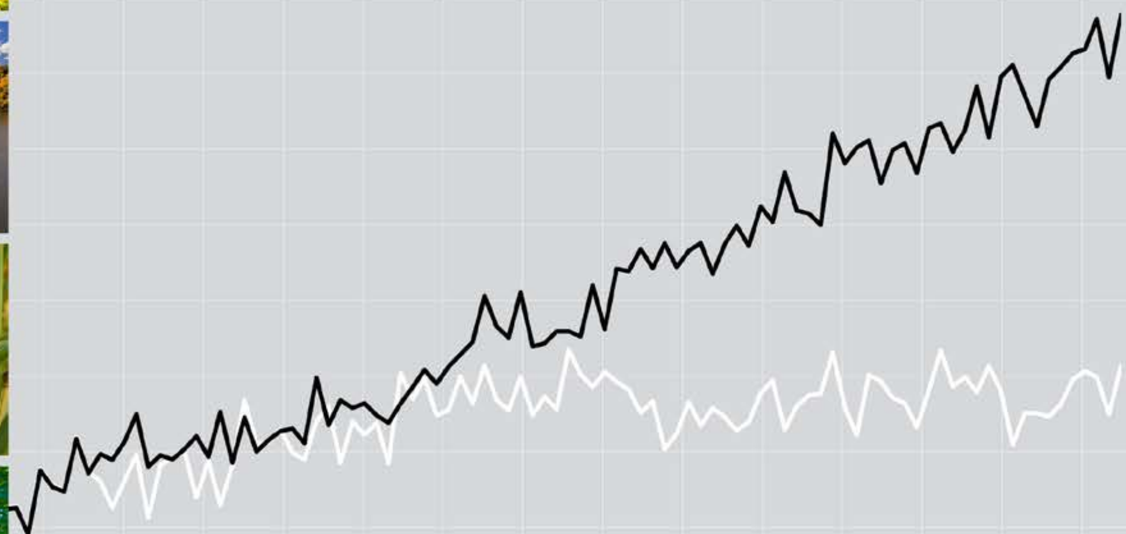


Climate Change in the United States

Benefits of Global Action



EPA's Climate Change Impacts and Risk Analysis (CIRA) Project

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NAS Characterizing Risks Workshop
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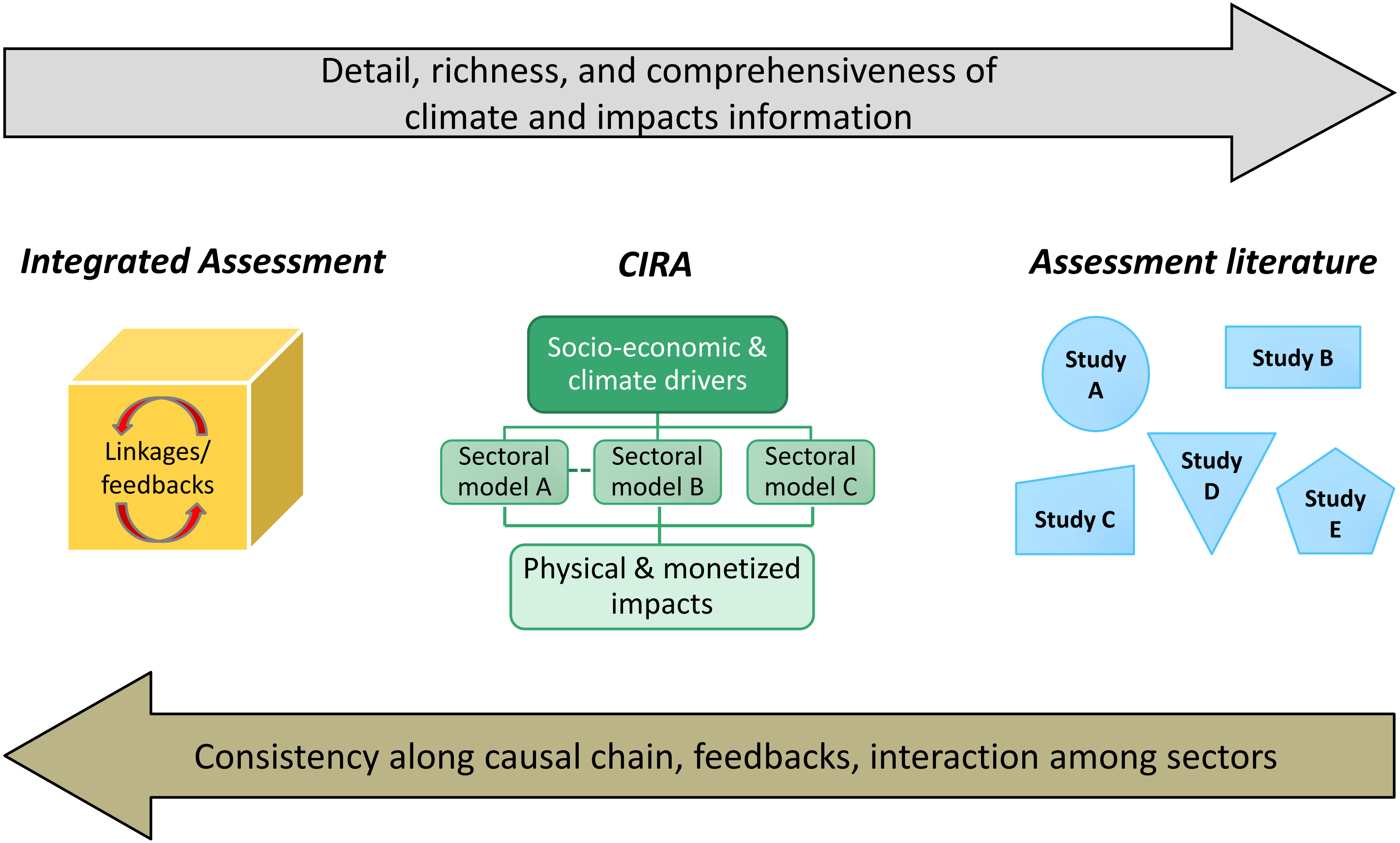
United States Environmental Protection Agency

About CIRA and the 2015 Report

- EPA has a long history of analyzing the economic impacts of environmental damage, and the implications of mitigation (costs and benefits) .
  - For climate, historical focus has been on GHG mitigation costs (e.g. IPCC WGIII, CCSP 2.1a, EMF, etc).
- In June 2015, EPA released a report describing risks of inaction on climate change and the benefits (avoided damages) to the U.S. of global action to reduce GHGs.
- The report summarizes results from EPA's Climate Change Impacts and Risk Analysis (CIRA) project, a collaborative effort with multiple impacts modeling teams.
  - Consistent socioeconomic, emissions, and climate data are used to quantify physical and economic impacts across multiple U.S. sectors (e.g., human health, infrastructure, water resources).
  - More than 20 detailed, process-based sector impact models were applied, each of which was separately grounded in the peer-reviewed literature (~35 papers underlying CIRA).

Where CIRA Sits Relative to Other Approaches



Sectoral Impacts Covered in the 2015 Report

There are many important impacts (physical effects and economic damages) of climate change that were not included in the 2015 report. Therefore, the report estimates just a portion of the total benefits of reducing GHGs.

Key Findings of the Report

Global action on climate change avoids costly damages in the U.S. Across sectors, global GHG mitigation is projected to prevent or substantially reduce adverse impacts in the U.S. this century compared to a future without emission reductions.

Global action on climate change reduces the frequency of extreme weather events and associated impacts. Global GHG reductions are projected to substantially reduce how often extreme temperature and precipitation events occur by the end of the century.

Global action now leads to greater benefits over time. For a majority of sectors, the benefits to the U.S. of GHG mitigation are projected to be even greater by the end of the century compared to the next few decades.

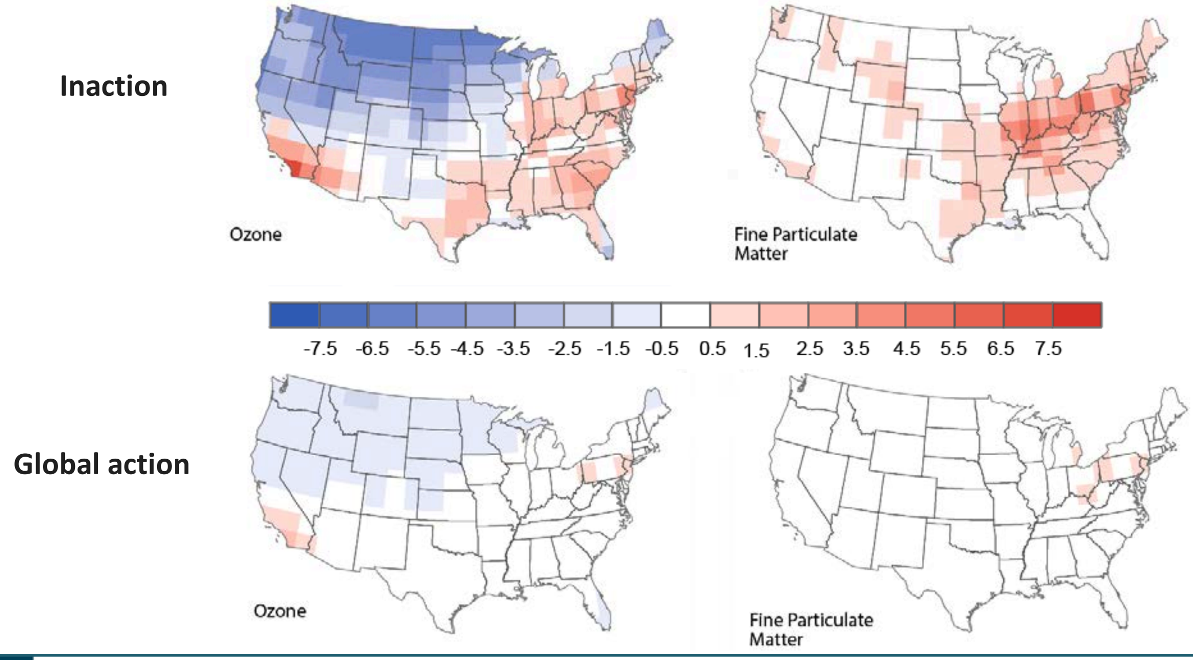
Adaptation can reduce damages and overall costs in certain sectors. Though actions to prepare for climate change incur costs, they can be very effective in reducing certain impacts, and will be necessary in addition to GHG mitigation.

Impacts are not equally distributed. Some regions are more vulnerable than others and therefore will experience greater impacts.

CIRA: Focus on Avoided Risks and Economic Impacts
Example sector: Air Quality

- Holding emissions of traditional air pollutants constant, unmitigated climate change is projected to worsen air quality across the large regions of the U.S., especially in the East, Midwest, and South.
  - Impacts on ozone are projected to be substantial for densely populated areas.
  - Although there is less certainty in PM2.5 response, results indicate large changes in densely populated areas (results do not include wildfire emissions → follow-up analysis).
- Global GHG Mitigation provides significant health benefits in the U.S., such as avoiding 13,000 premature deaths/yr by 2050 and 57,000 by 2100. Annual economic benefits of these avoided deaths are estimated at $160B in 2050, and $930B in 2100.

Projected Impacts on Air Pollution in 2100



Estimated change in annual-average, ground-level hourly concentrations (ppb for O_3 and μgm^{-3} for PM2.5) from 2000-2100

CIRA 2.0

CIRA2.0 is Underway

- We are "piloting" an approach for using coordinated impacts analysis to inform NCA4.
  - Leveraging CIRA1.0 sectoral models (and some new ones) to conduct new simulations driven by USGCRP/NCA4-recommended scenarios (RCPs, socioeconomics) and climate projections.
  - Focus: estimating avoided risks and economic damages due to global GHG reductions (and for some sectors, adaptation too).

- Developing a technical report that will document and describe:
  - The methods of the analyses conducted, with references to model documentation and underlying/supporting literature.
  - Detailed descriptions of results for each sector, with comparisons of results to findings from the literature.
  - Results summarized for each of the NCA4 regions.
  - Report will be peer reviewed.

Mapping of CIRA2.0 Sectors onto NCA Sectors

Human Health
- Air quality
- Temp mortality
- Labor
- Coastal property

Water
- Supply/demand
- Water quality
- Flooding damages
- Urban drainage

Energy
- Electricity demand/supply
- *Hydropower*
- *Thermo-cooling*
- *Electric reliability*

Transportation
- Roads
- Bridges
- *Rail*
- *AK infrastructure*

Agriculture
- Ag yield and market effects

Forests
- Wildfire
- Timber yield & market effects

Ecosystems
- Coral
- Shellfish
- Freshwater fish
- Carbon storage

Possibly Include
- *Temp morbidity*
- *Winter recreation*
- *Harmful aquatic blooms*

Select Missing Sectors
- Conflict
- Residual damages post extreme events
- Biodiversity loss
- Ecosystem-scale acidification effects
- Vector-borne disease
- Groundwater
- Livestock
- Wetland ecosystems

Summary

- Several coordinated impact analyses driven by consistent scenarios/inputs (e.g., CIRA, ACP, BRACE) are demonstrating capability to provide a type of information that has generally been absent from the NCA.

- CIRA1.0 provides a source of recent, peer reviewed estimates for NCA authors on avoided risks and economic damages.

- CIRA2.0 provides an opportunity to pilot how the results of a coordinated impacts exercise using NCA4 scenarios/projections could inform the development of the assessment.

- In the longer-term, a USGCRP-led coordinated impacts modeling effort could serve as a credible and feasible way to incorporate avoided risk and impacts valuation information more broadly in future NCAs.

Thank you.

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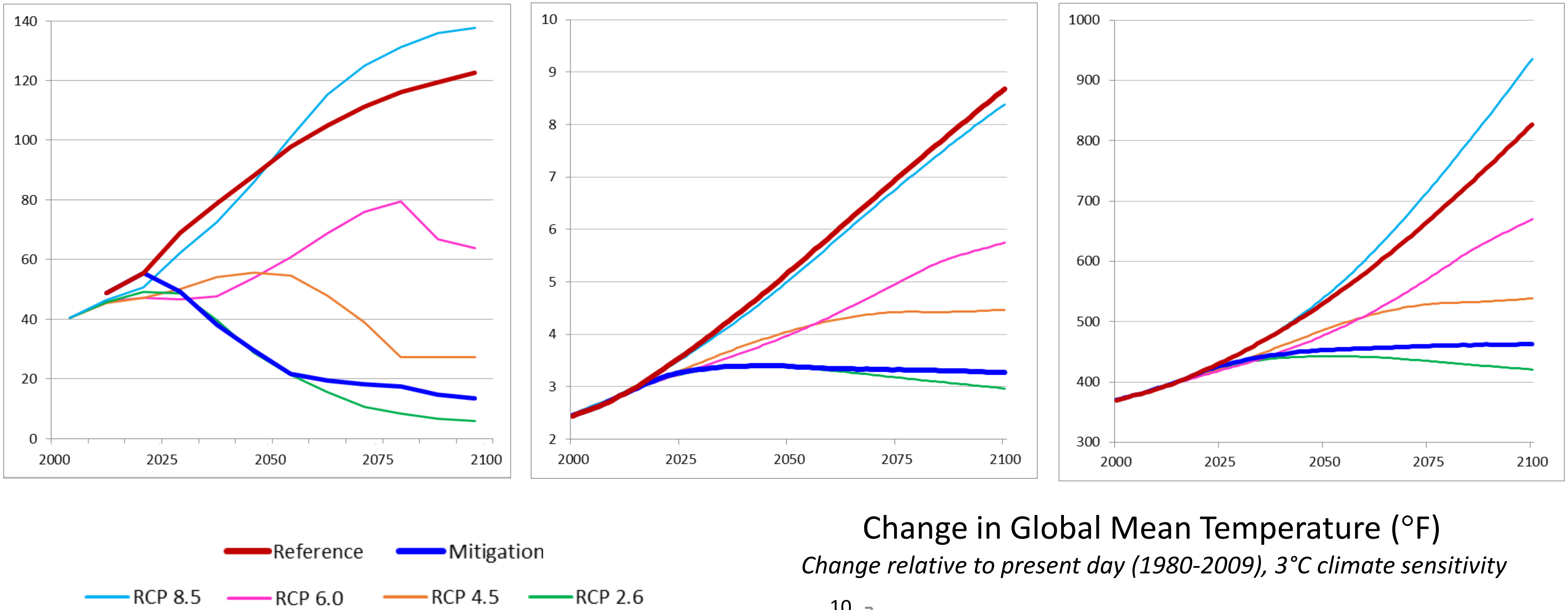
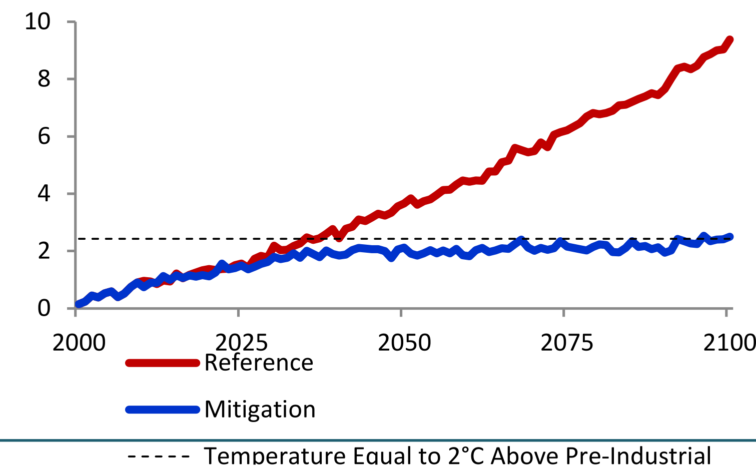
CIRA Global GHG Emissions Scenarios

Global GHG Emissions (GT CO_2-eq.) | GHG Radiative Forcing (W/m^2) | CO_2 Concentration (ppm)



Change in Global Mean Temperature (°F)

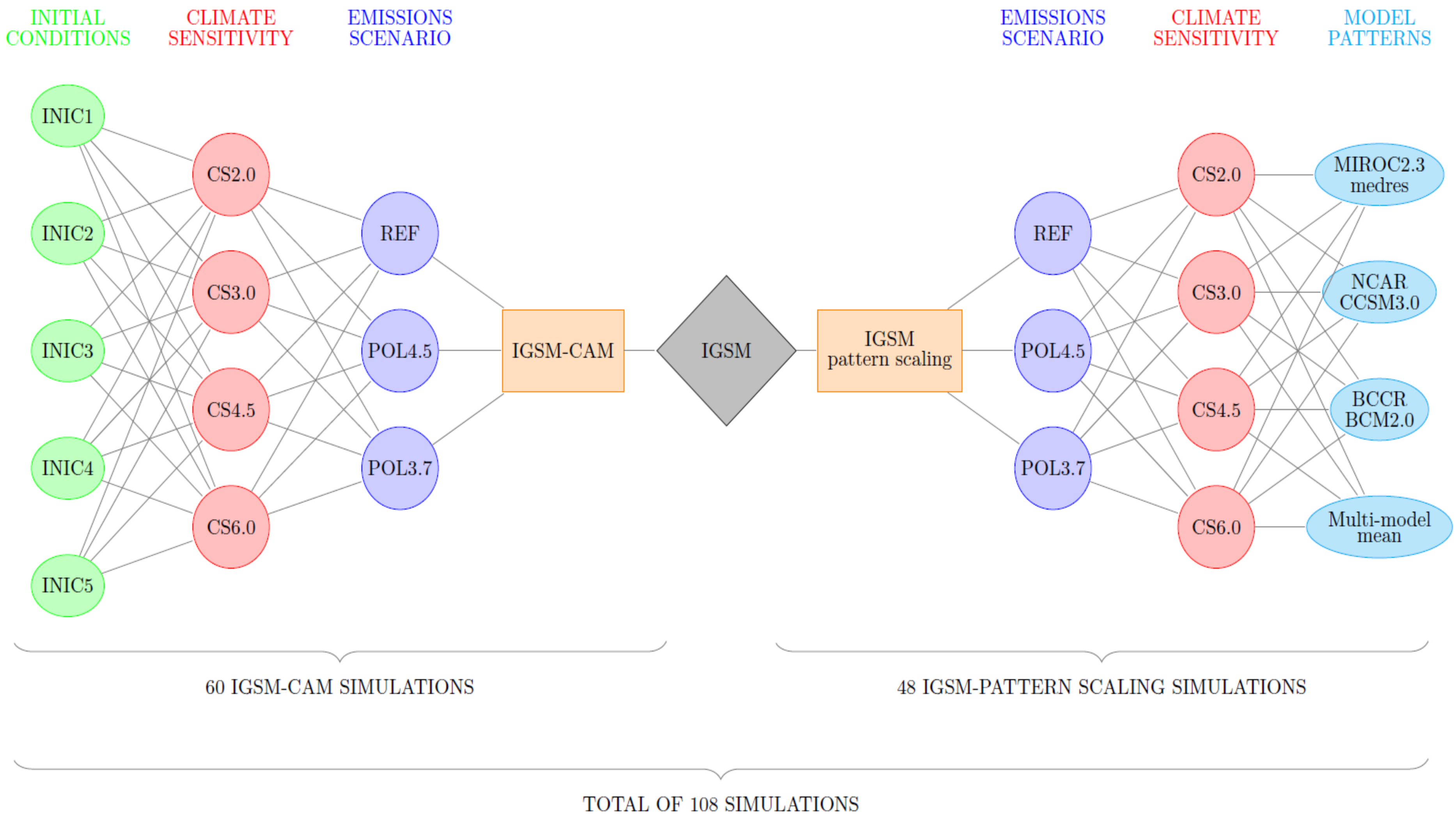
Change relative to present day (1980-2009), 3°C climate sensitivity



- Emission scenarios developed using MIT's Emissions Prediction and Policy Analysis (EPPA) model, and the Integrated Global System Modeling (IGSM) Framework.

See Paltsev et al. (2013)

CIRA Uncertainty Framework For Climate Projection



See Monier et al. (2014)

CIRA Impact Sector Coverage

Human health

- ● Thermal stress (mortality)
- ● Air quality
- ○ Vector-borne disease
- ○ Other extreme event morbidity, mortality
- ● Environmental justice / vulnerable populations
- ● Labor supply/productivity

Agriculture

- ● Crop yield (U.S.)
- ○ Crop yield (global)
- ○ Specialty crops (U.S. and global)
- ○ Livestock production
- ○ Dairy production
- ● Carbon storage

Forests

- ● Change in timber production (U.S.)
- ● Change in CO_2 storage
- ● Wildfire

Freshwater Resources

- ● Drought
- ● Flooding damages
- ● Water supply and demand
- ● Water quality
- ○ Groundwater

Ecosystems

- ● Species-level (coral, freshwater fish, shellfish)
- ○ Biodiversity
- ○ Coastal wetlands
- ○ Other acidification effects

Energy

- ● Temperature effects on energy (electricity) supply and demand
- ◐ Precipitation and system effects on hydro power
- ◐ Change in thermo-cooling capacity
- ○ Climate & system effects on wind/solar generation
- ○ Extreme event effects on reliability

Infrastructure

- ● Non-coastal roads and bridges
- ● Coastal property
- ● Urban drainage
- ● Inland property damages from floods
- ◐ Coastal energy infrastructure
- ◐ Alaska infrastructure
- ○ Coastal infrastructure (e.g., roads, POTWs)
- ○ Transportation waterways
- ○ Telecommunication infrastructure

Tourism

- ● Coral reef recreation
- ● Recreational fishing
- ○ Other recreation (e.g., winter, boating, birding)

Other

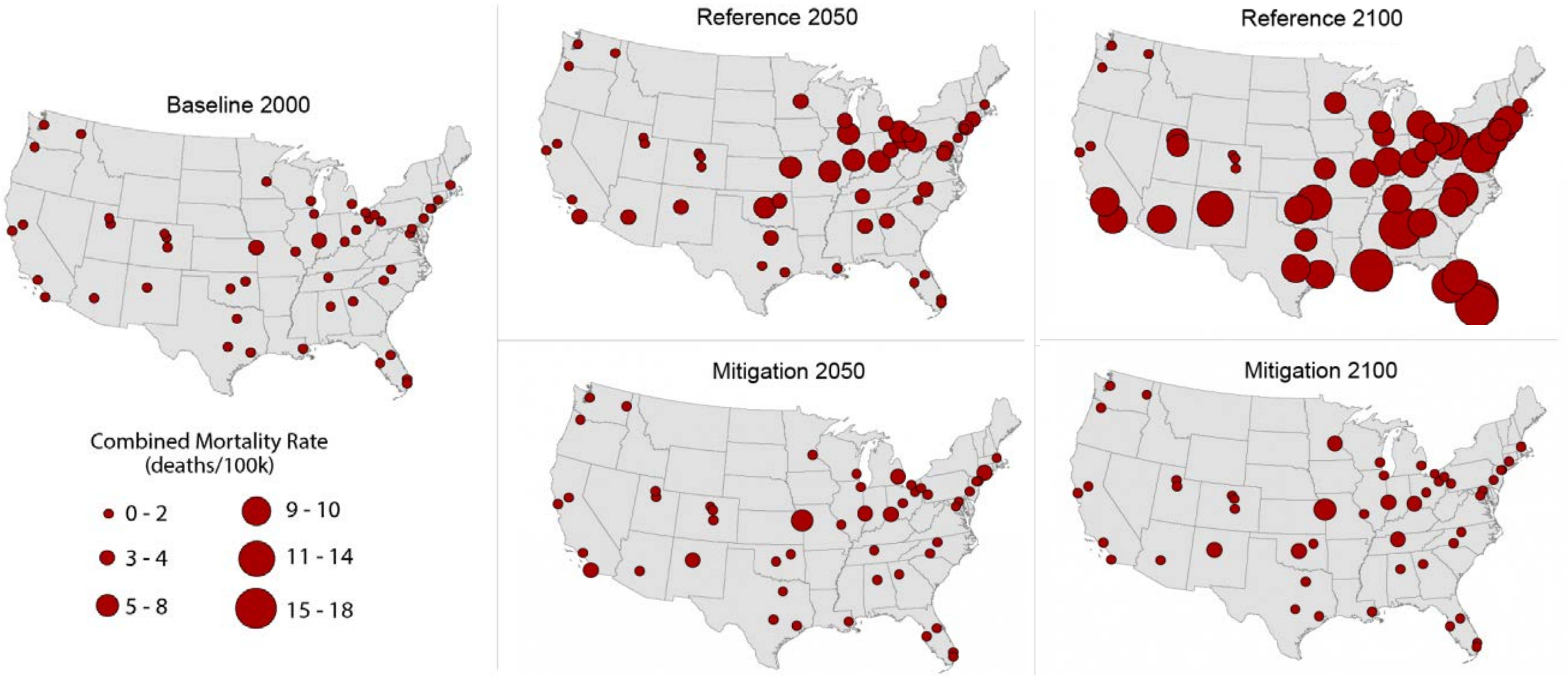
- ○ Impacts beyond the contiguous U.S.
- ○ Residual damages post extreme events (e.g., hurricanes)
- ○ Catastrophic climate change (e.g., ice sheet collapse)
- ○ National security risks (e.g., conflict, mass migration)

KEY

- ● Existing CIRA capacity
- ◐ In progress
- ○ Not currently in CIRA

Extreme Temperature Mortality

- Without global GHG mitigation, a dramatic increase in extreme heat mortality is projected for the 49 cities modeled; mortality from extreme cold continues to diminish.
- Results suggest a considerable annual reduction in mortality in the 49 cities that grows over time with global GHG reductions.
  - Global GHG mitigation is projected to save ~1,700 lives each year in 2050, and ~12,000 in 2100.
  - Inclusion of other cities would increase these benefits substantially.
- Acclimatization sensitivity: even with an optimistic assumption regarding human response to extreme temperature, a large increase in net mortality is projected without mitigation.



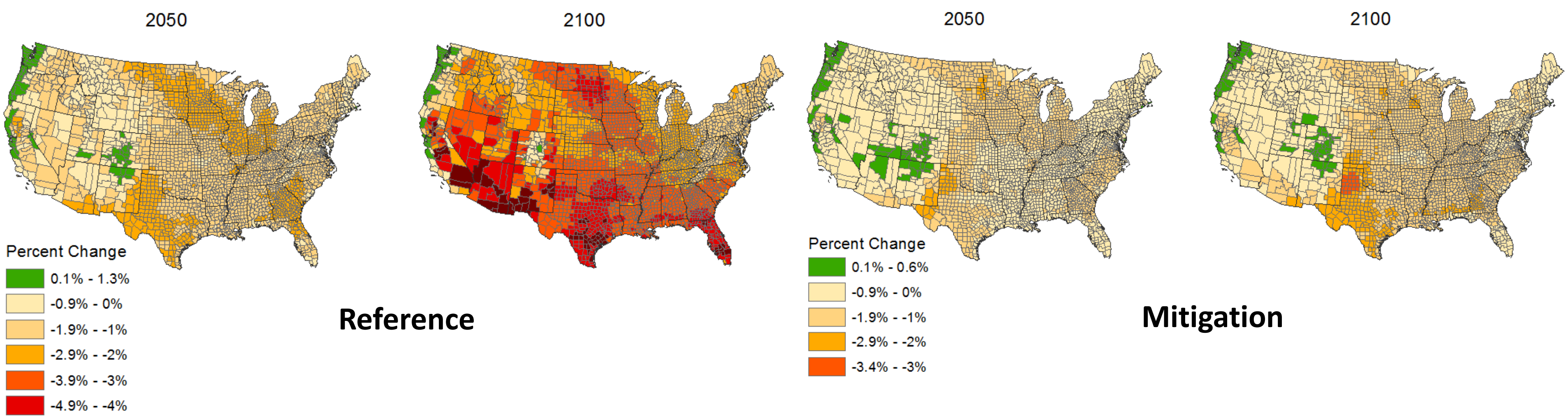
* Only 49 cities analyzed, cities without a dot would experience changes that are not estimated here.

See Mills et al. (2014a)

Examples of Results – Labor Sector

- Without global GHG mitigation, labor hours in the U.S. are projected to decrease due to increases in extreme temperatures. By 2100, over 1.8 billion labor hours are estimated to be lost each year, costing an estimated $170 billion annually in lost wages.
- By the end of the century, global GHG mitigation is estimated to benefit the contiguous U.S. by saving an annual 1.2 billion labor hours and $110 billion in wages that would otherwise be lost due to unmitigated climate change.
- Counties in the Southwest, Texas, and Florida that are estimated to lose more than 5% of high-risk labor hours under the Reference do not experience such losses under the Mitigation scenario.

Estimated Percent Change in High-Risk Labor Hours in 2050 and 2100



Estimates normalized by the high-risk working population in each county.

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