U.S. Climate Change Impacts and Risk Analysis Research

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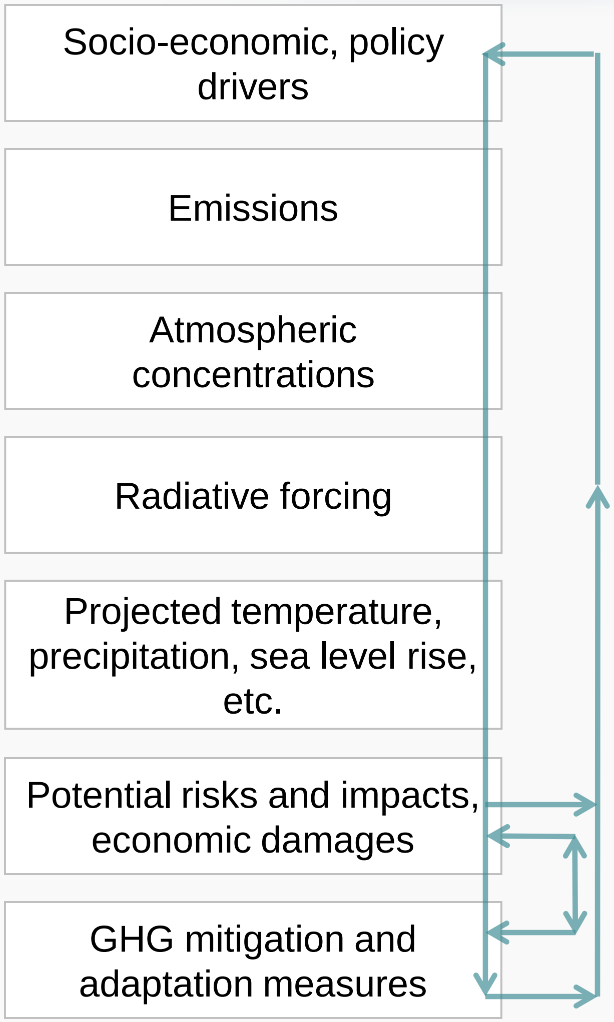
Overview

- Goal and Scope
- Methodology
- Illustrative results
- Next steps

Goal and Scope of Impacts Research

- Our goal is to quantify (where possible) and communicate the benefits (i.e., avoided or reduced impacts) of mitigation & adaptation actions.

- The research explores how impacts and damages may change under a consistent set of scenarios, data, and assumptions.
  - Existing impacts literature is largely based on inconsistent assumptions along the causal chain from socio-economics to emissions to climatic effects and impacts.
- Initial focus is on:
  - Risks and impacts within the U.S., without ignoring key global linkages or key regional components.
    - Impacts and benefits across a range of sectors, e.g., water resources, human health, ecosystems, energy.
  - Potential benefits of mitigation scenarios (adaptation later).
  - Analyzing key sources of uncertainty, including emissions pathway, climate sensitivity, climate models, etc.



Our ideal tools and results

- Integrated model(s) with internally consistent emissions drivers, impact sectors, and economic valuation
  - Climate impacts feed back into the economy and climate
- Identify, quantify, and be transparent about key uncertainties along the causal chain
- Multiple future scenarios, BAU and policies
- Outputs that communicate effectively to multiple audiences about how impacts and risks change from one scenario to another.

Methodology

Analytical Approach

- Develop estimates of climate change impacts and damages in multiple sectors that can be synthesized
  - *Begin with integrated assessment (IA) models to develop three internally consistent socio-economic, emissions, and climate scenarios (BAU, RF 4.5, RF 3.7)*
  - *All sectoral models use consistent population, GDP, and emissions data*
  - *Climate inputs consistent with all socio-economic and emissions scenarios*

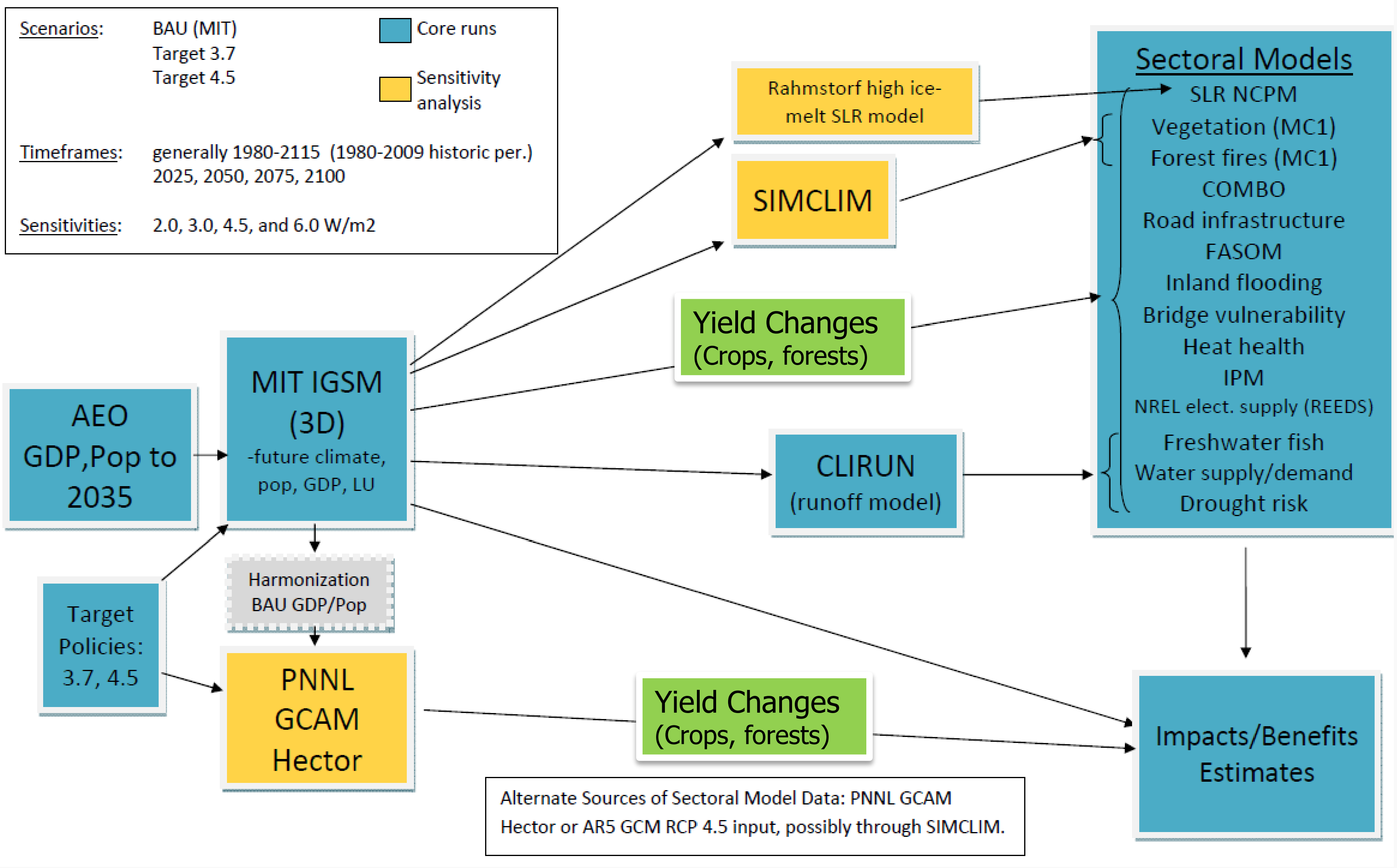
- Explore uncertainties around impacts estimates
  - *Scientific: Multiple climate sensitivities (2.0, 3.0, 4.5, and 6.0)*
  - *Model: Use of multiple IA and sectoral models where possible*
  - *Variability: Analysis of changing temperature and precipitation patterns*

- Understand what drives differences in model results
  - *Comparison of data inputs and outputs*
  - *Discussions about model structures, methods, etc.,.*

Methodology

- Begin with IA models (MIT IGSM and GCAM) to develop three internally consistent socio-economic, emissions, and climate scenarios
  - Reference: Business as usual
    - GDP and population harmonized with US (EIA) data through 2035, EPPA projections through 2100
  - Policy scenarios:
    - 4.5 W/m^2 and 3.7 W/m^2, stabilization in 2100
- Multiple climate sensitivities (2.0, 3.0, 4.5, and 6.0)
- Climate data from MIT's 3D CAM component of IGSM
- Sectoral models develop estimates with these consistent socio-economic and climate data

Impacts Research Operational Schematic



Data Flow

- **Inputs**
  - Reference GDP and population (EIA through 2035)
  - Policy scenario, RF targets
- **IA Model Outputs**
  - Global GHG concentrations
  - Global and domestic emissions
    - CO_2, non-CO_2 GHG, criteria pollutants
  - Sea Level Rise
  - Temperature change
    - Global annual average
    - Gridded monthly, daily, hourly
  - Precipitation
    - Gridded monthly, daily, hourly
- **Changes in impact sectors** (use IA outputs as inputs)
  - Temperature-related mortality
  - SLR property damages and adaptation response costs
  - Road and bridge infrastructure adaptation
  - Inland flooding damages
  - Water supply and demand
  - Drought risk (not monetized)
  - Electricity supply
  - Energy demand
  - Population
  - Crop yields projections
  - Vegetative carbon sequestration and provisioning of grazing lands
  - Forest fire frequency/magnitude and suppression costs
  - Coral reef cover and recreational/existence values
  - Freshwater fish habitat and recreational fishing impacts
  - Air quality

Examples of Data Needs for Sectoral Modeling

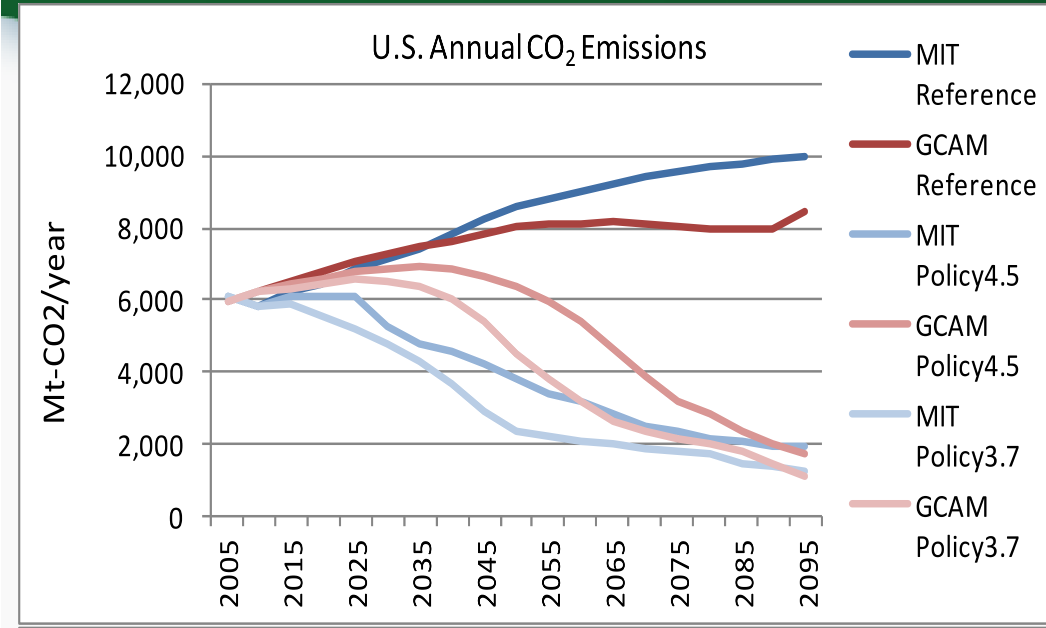
	Inputs		
Sector/Model	Socio-economic	Climate	Other
COMBO		Global avg ΔT	
SLR/Coastal Property Model	GDP growth	Global avg SLR	
Ecoservices/forest fires	ΔLU (Developed Land)	Monthly avg T, daily max T, monthly mean precip	CO2 Concentrations, elevation
Inland flooding	Population growth	Monthly ΔPrecip	
Heat health	Pop growth, demographic changes, VSL = f(GDP/cap)	Max and min daily T	
Bridge vulnerability		Daily precip to calculate 2 y and 100 y 24 hour max precip	Land cover type
Drought risk		Monthly avg temp and precip	
Freshwater fisheries	Value of fishing day, Population growth	Monthly avg max T and avg precip	
Water supply-demand	Population growth	Monthly avg, max, and min T, total monthly precip, cloud cover, wind, relative humidity	
FASOM	Demand (population, GDP)		Yield changes due to climate changes (EPIC)
IPM	Population, GDP	ΔT (daily/hourly)	

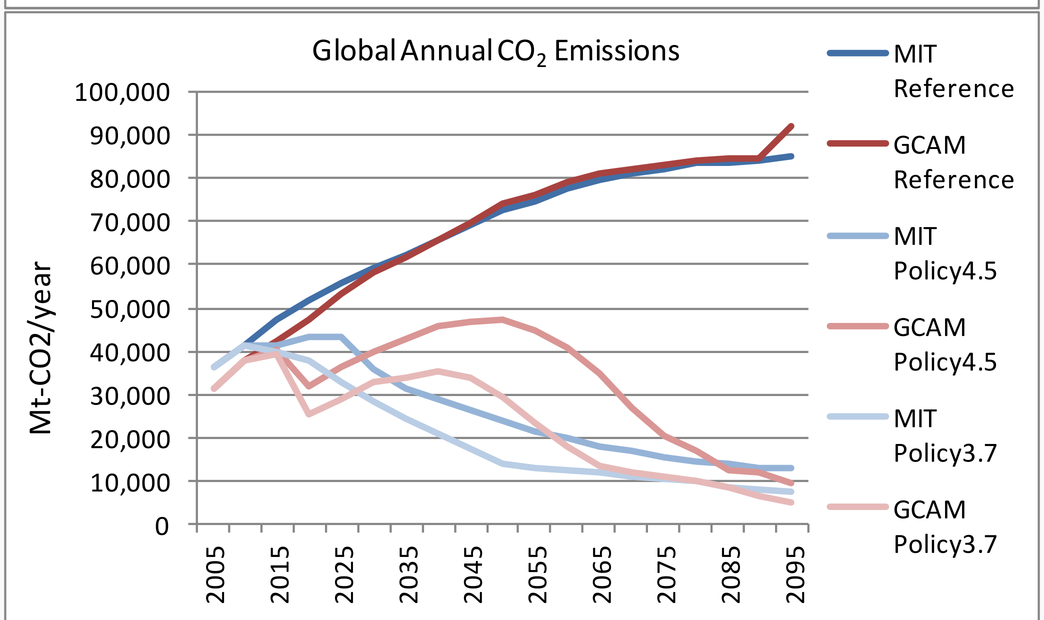
Coverage of Impacts in CIRA vs. North American Impacts Listed in AR4

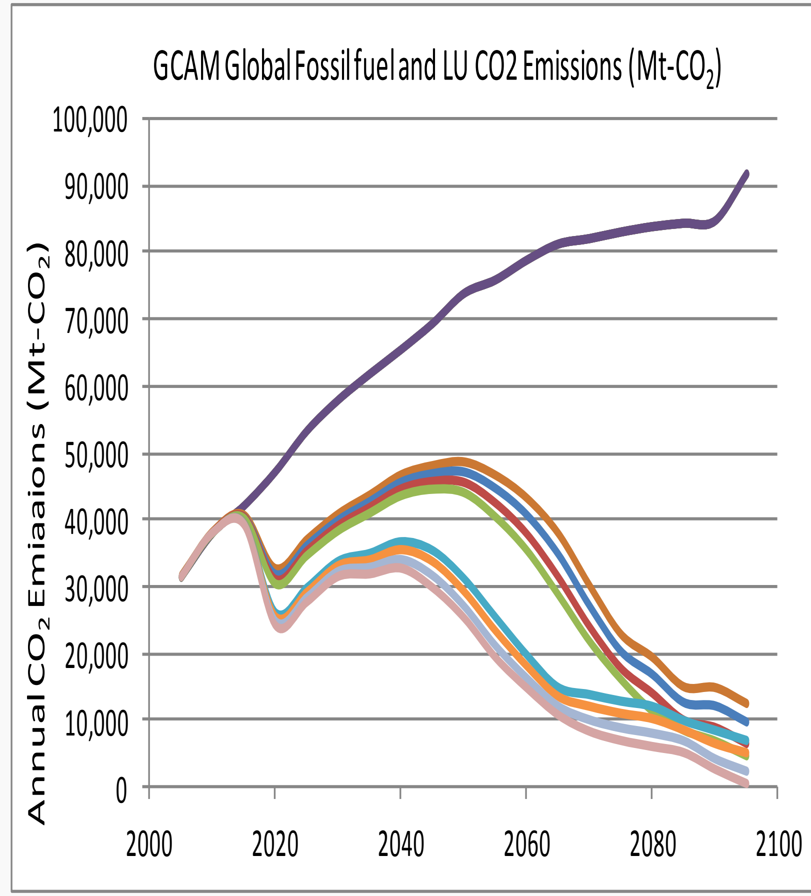
- Human health
  - Thermal stress (mortality)
  - Waterborne illness
  - Vector- and rodent-borne disease
  - Extreme event morbidity, mortality
- Agriculture
  - Crop yield
  - Livestock production
  - Carbon storage
- Fishery productivity
- Forests
  - Change in production
  - Change in CO_2 storage
- Freshwater Resources
  - Water quality
  - Water supply
  - Water demand
- Energy
  - Temperature effects on energy (electricity) supply and demand
  - Precipitation and system effects on hydro power
  - Climate and system effects on wind and solar generation
- Infrastructure
  - Roads and bridges
  - Waterways
  - Coastal property
  - Inland property
- Tourism
  - Coral reefs
  - Other recreation
- Ecosystems
  - Biodiversity
  - Services (coral reef existence)

Change in US Climate

CO_2 Emissions

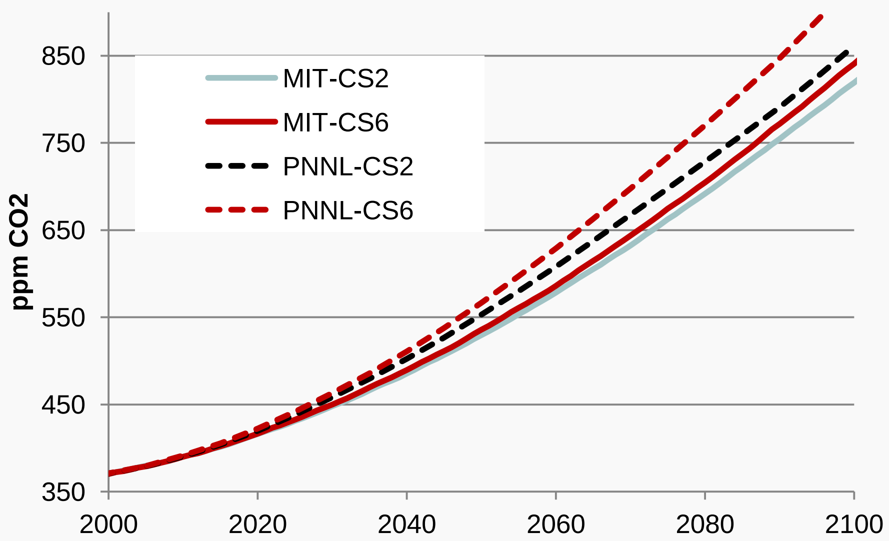




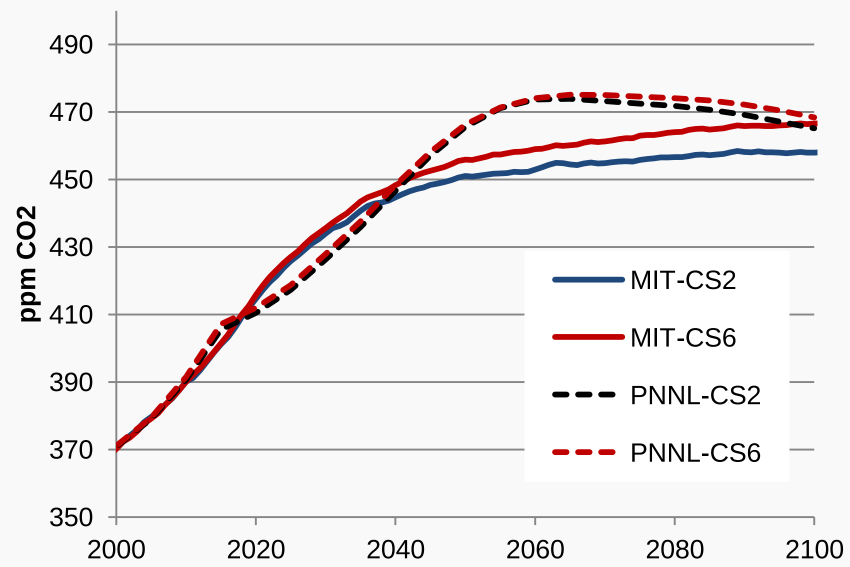


CO_2 Concentrations

Reference

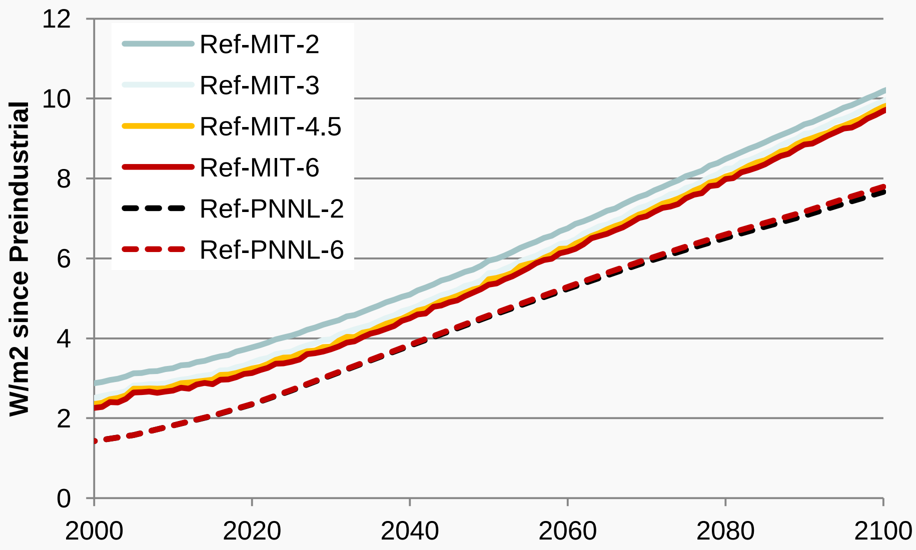


3.7 Policy



Forcing

Reference



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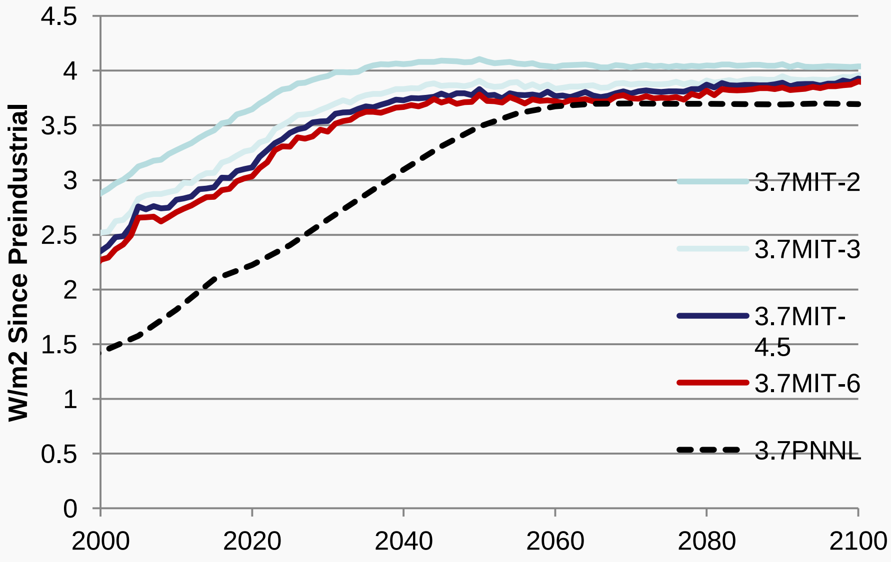
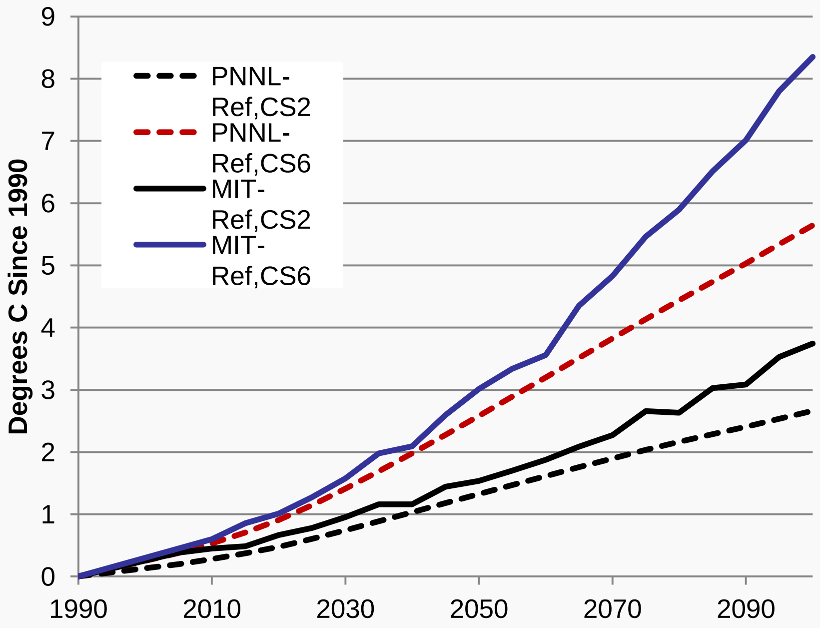


Temperature

Reference



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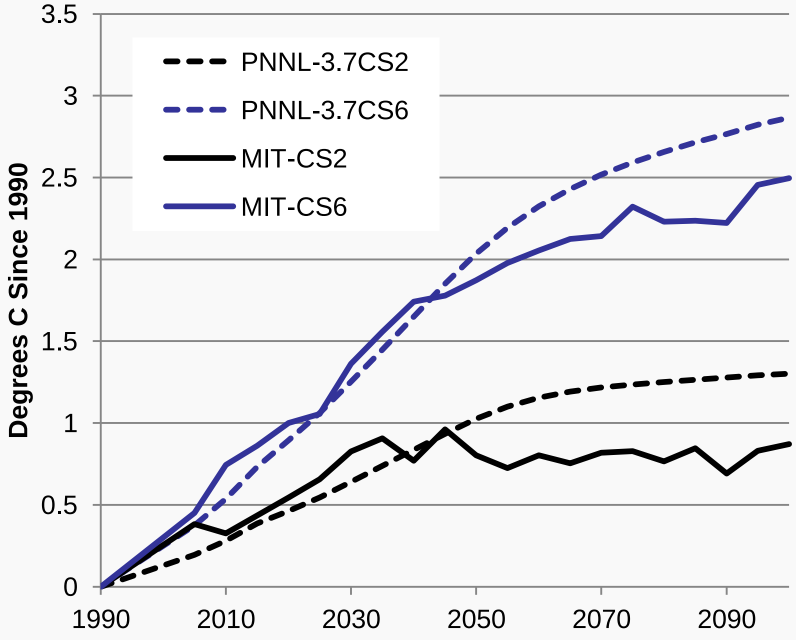
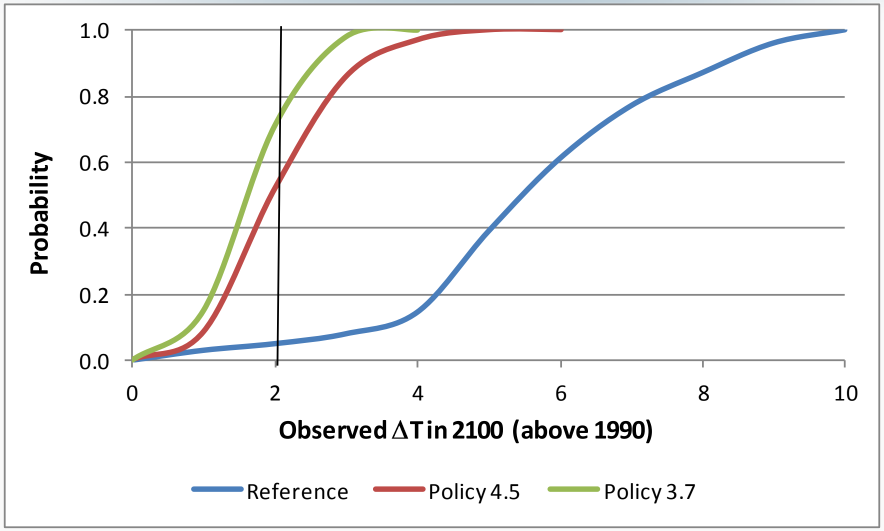
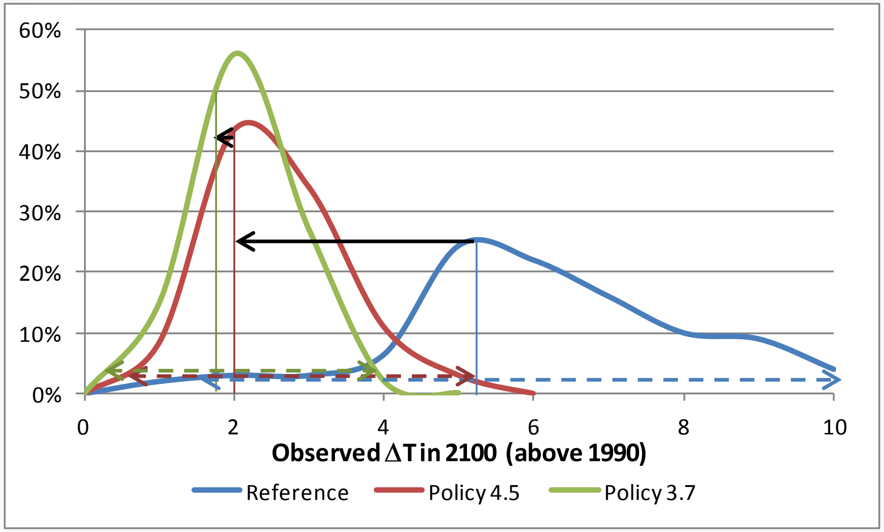
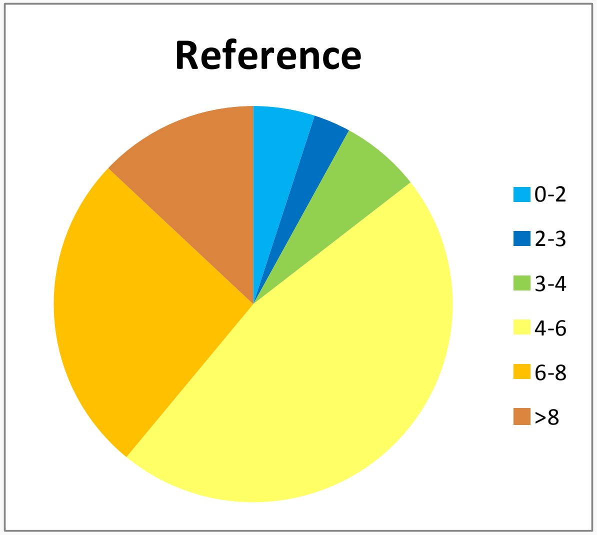
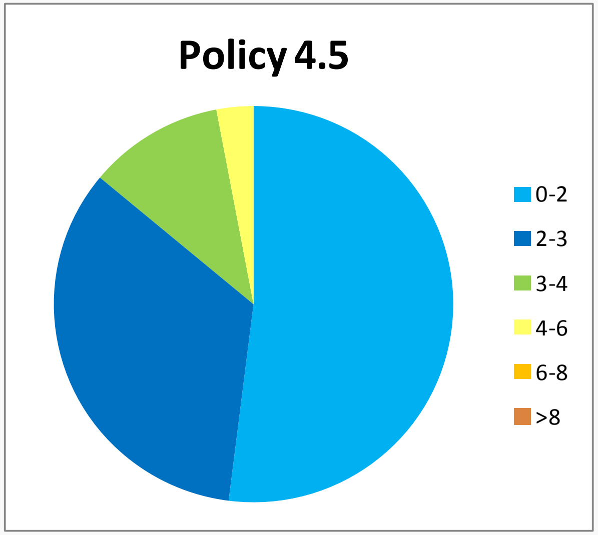


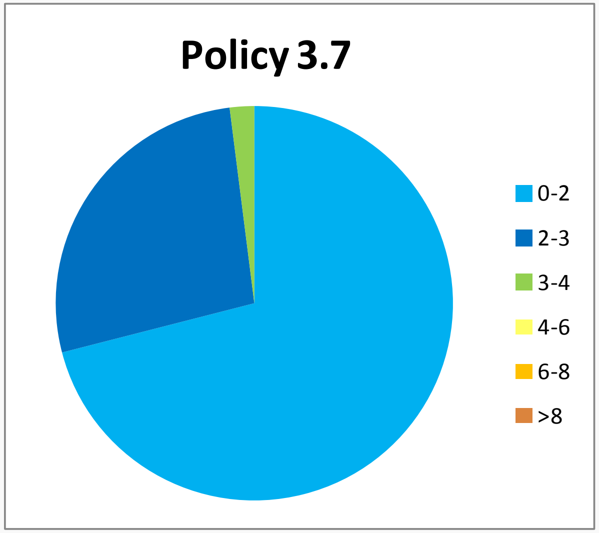
Presentation of Results
(Global Average ΔT from 1990, IGSM)





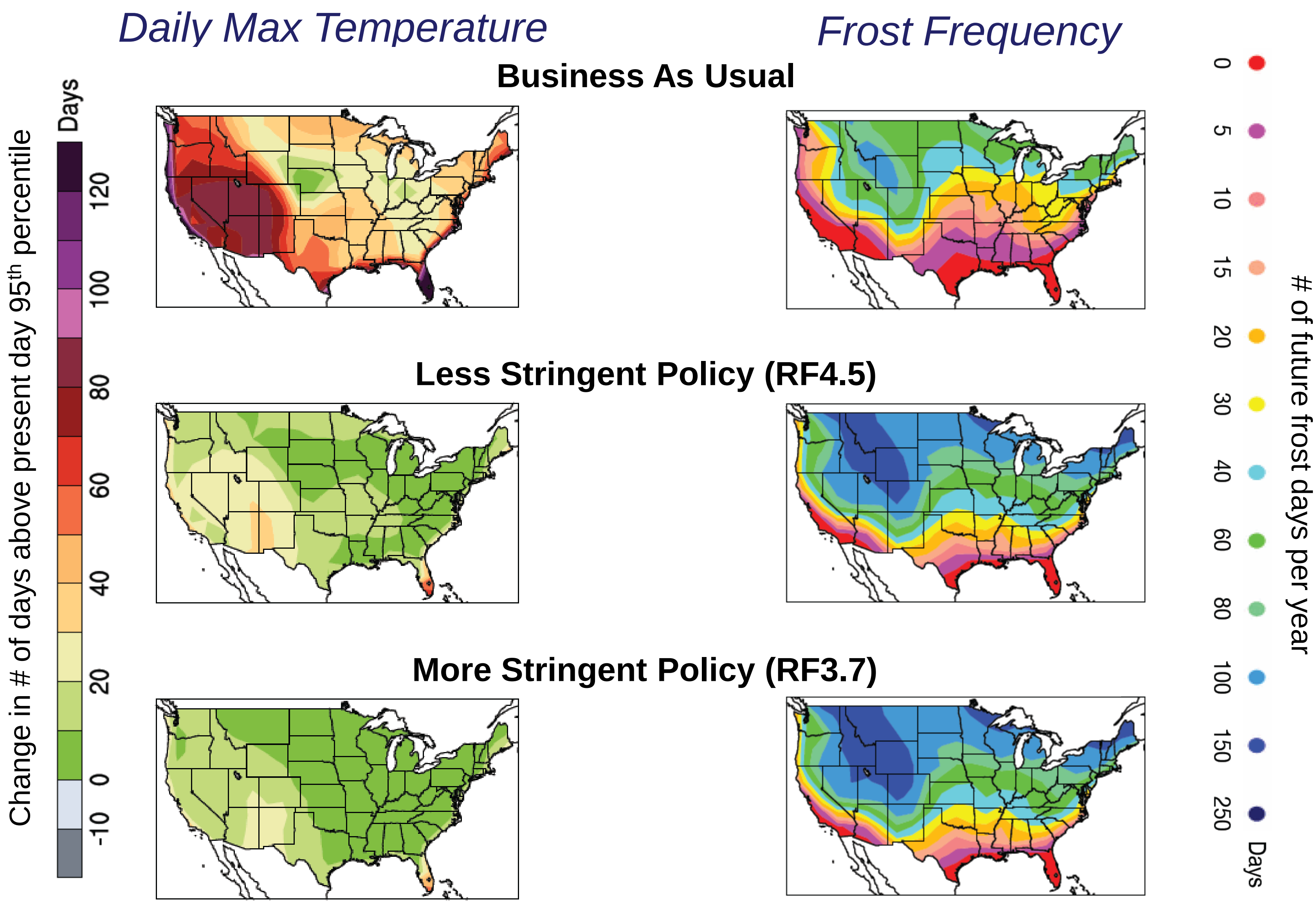






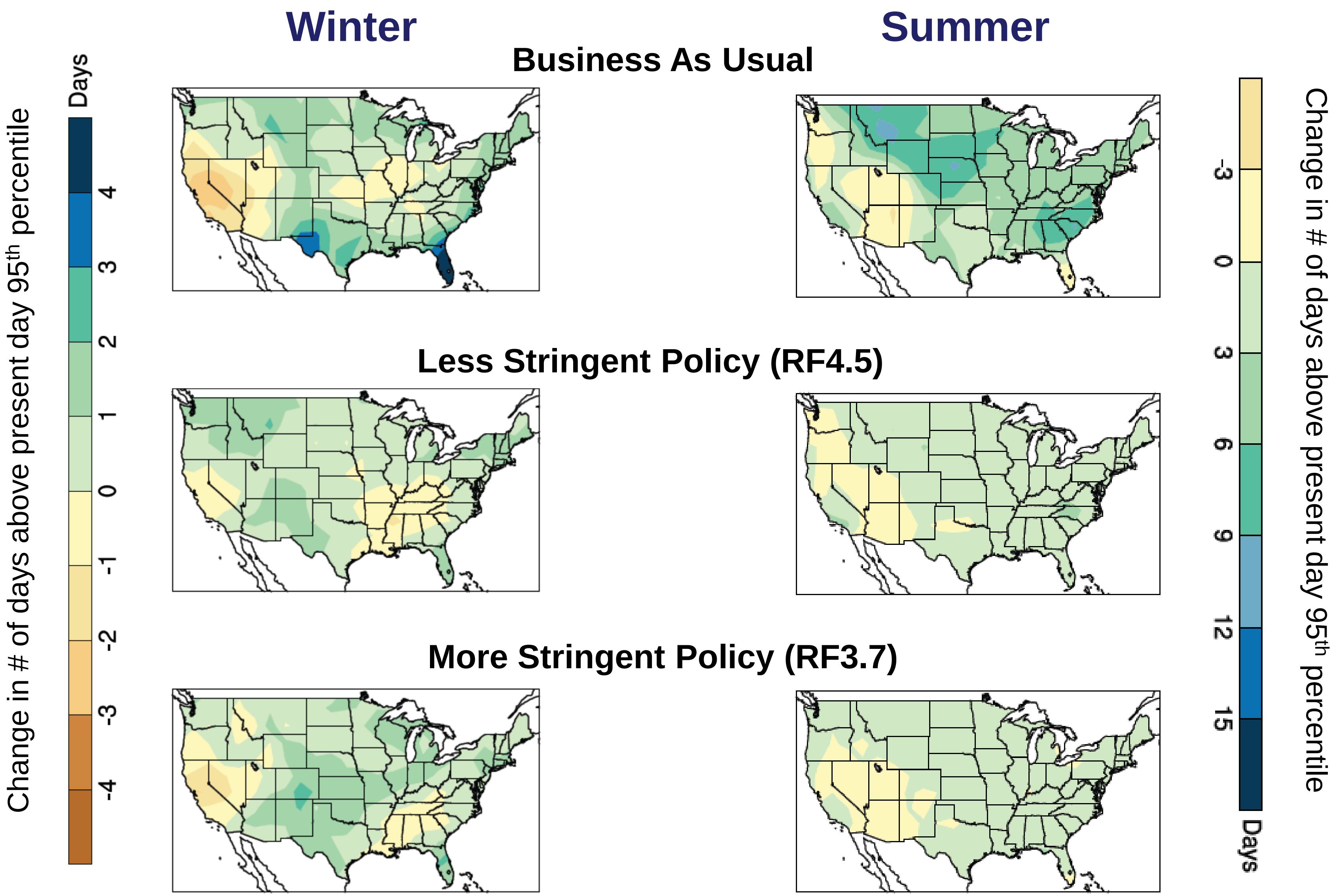
Changes in Temperature Extremes

Without mitigating GHGs, today's hottest days become more frequent, and the number of frosts will decrease.



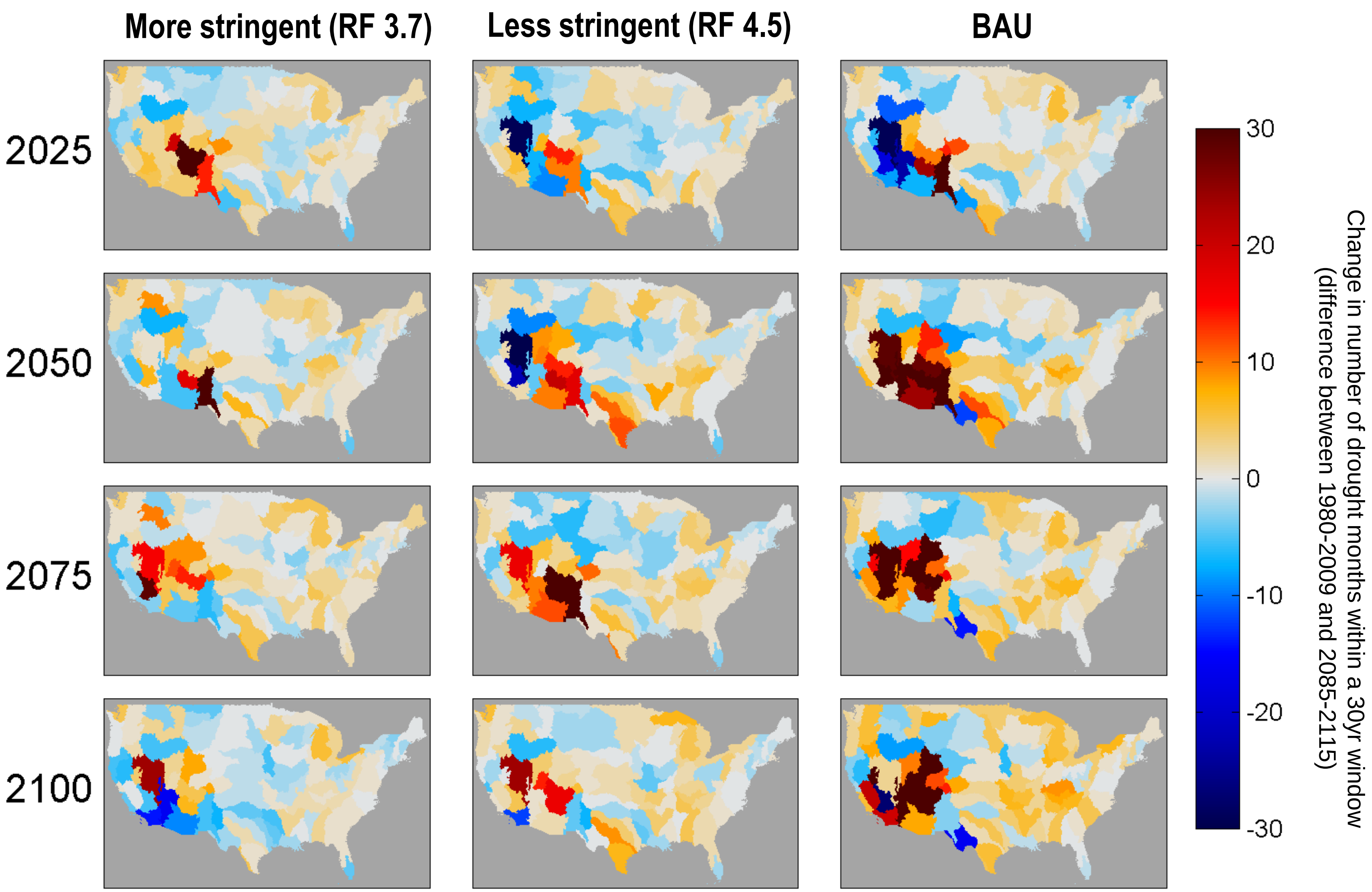
Changes in Extreme Precipitation

Without mitigating GHGs, extreme precipitation will become more common.

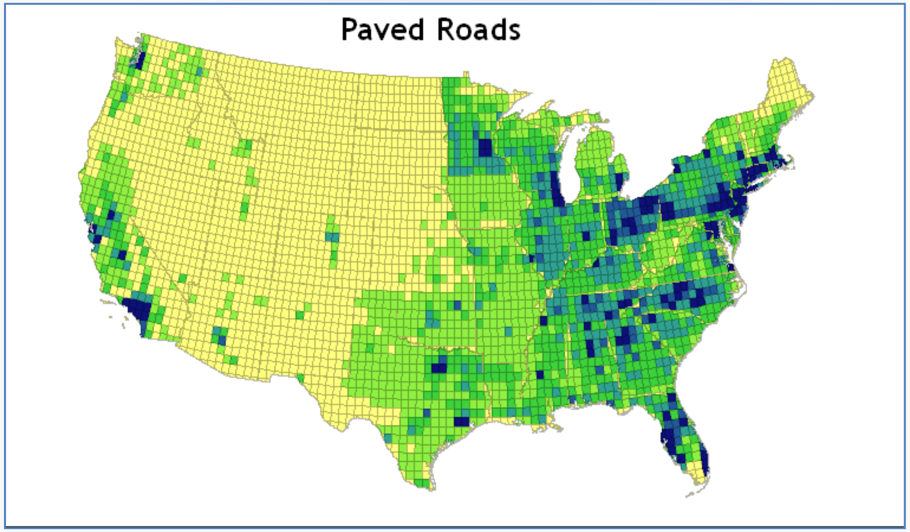


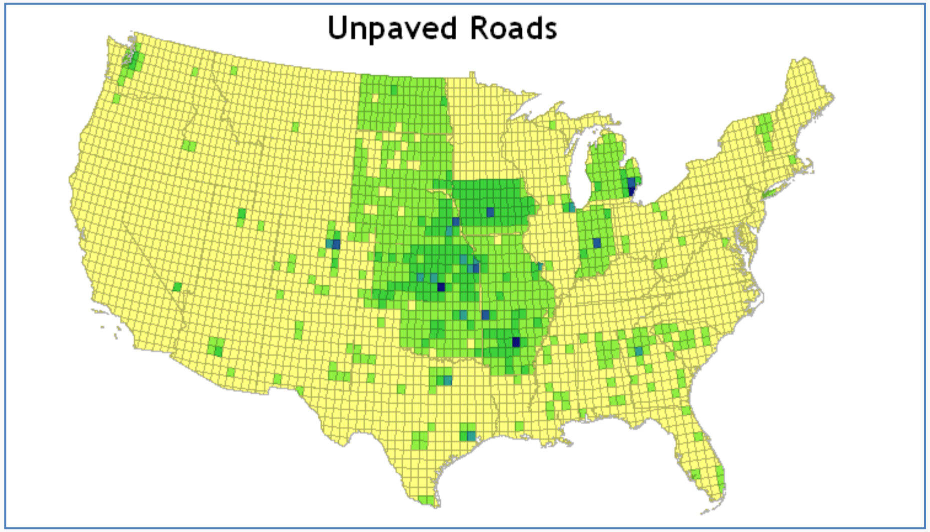
Impacts

Changes in Drought Risk Through 2100



U.S. Road Network

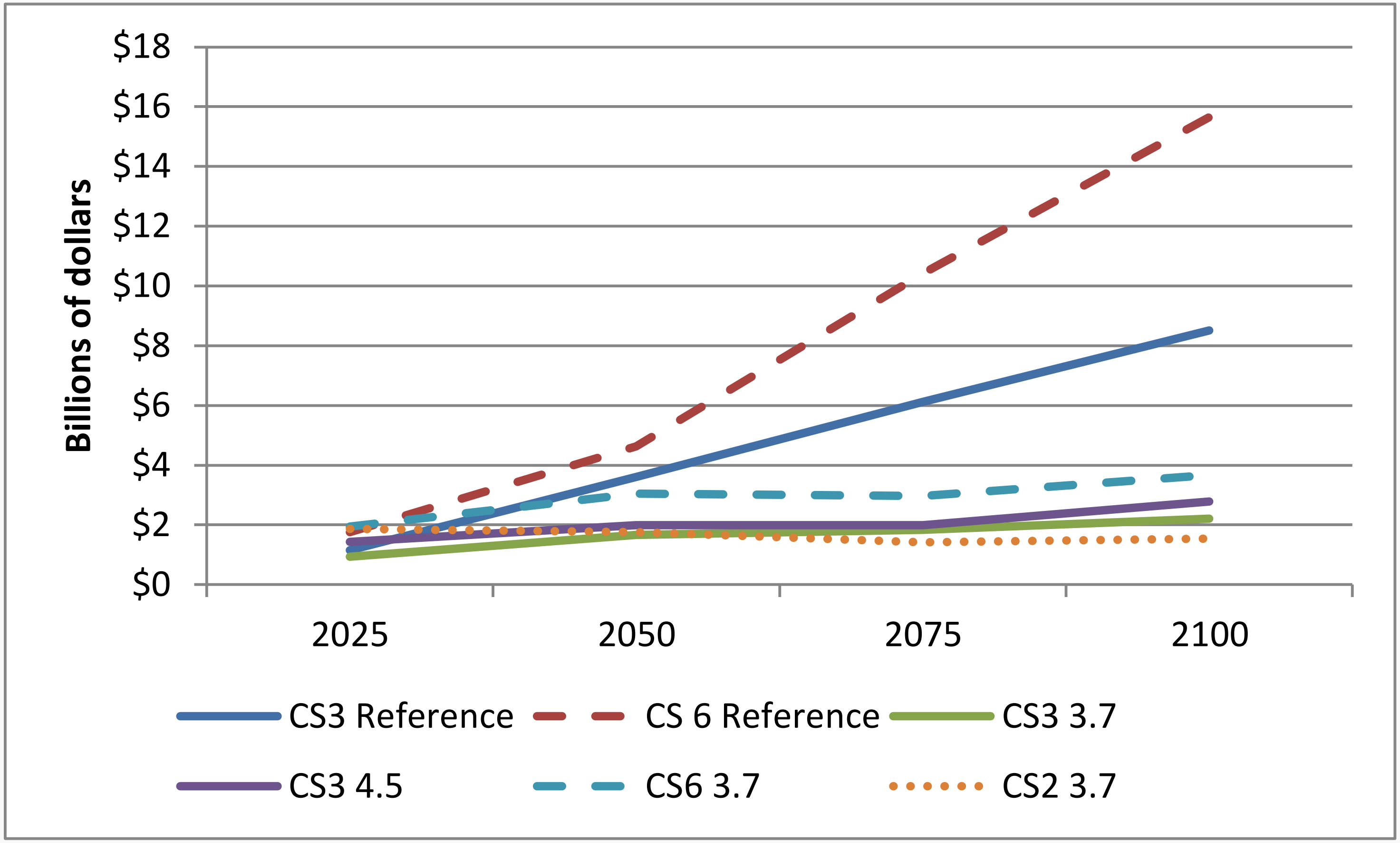




Lane Miles

- 0 - 1,000
- 1,000.1 - 2,000
- 2,000.1 - 3,000
- 3,000.1 - 4,000
- 4,000.1 - 5,000
- Greater than 5,000

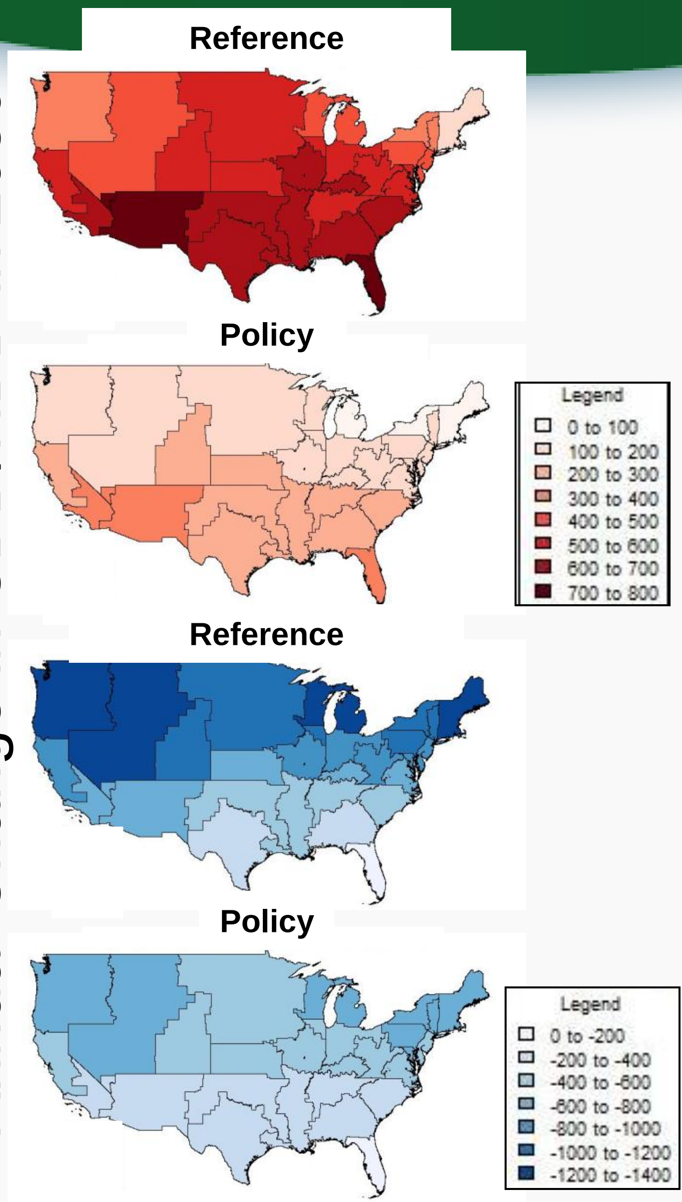
Road Incremental Maintenance Costs by Scenario 2025-2100

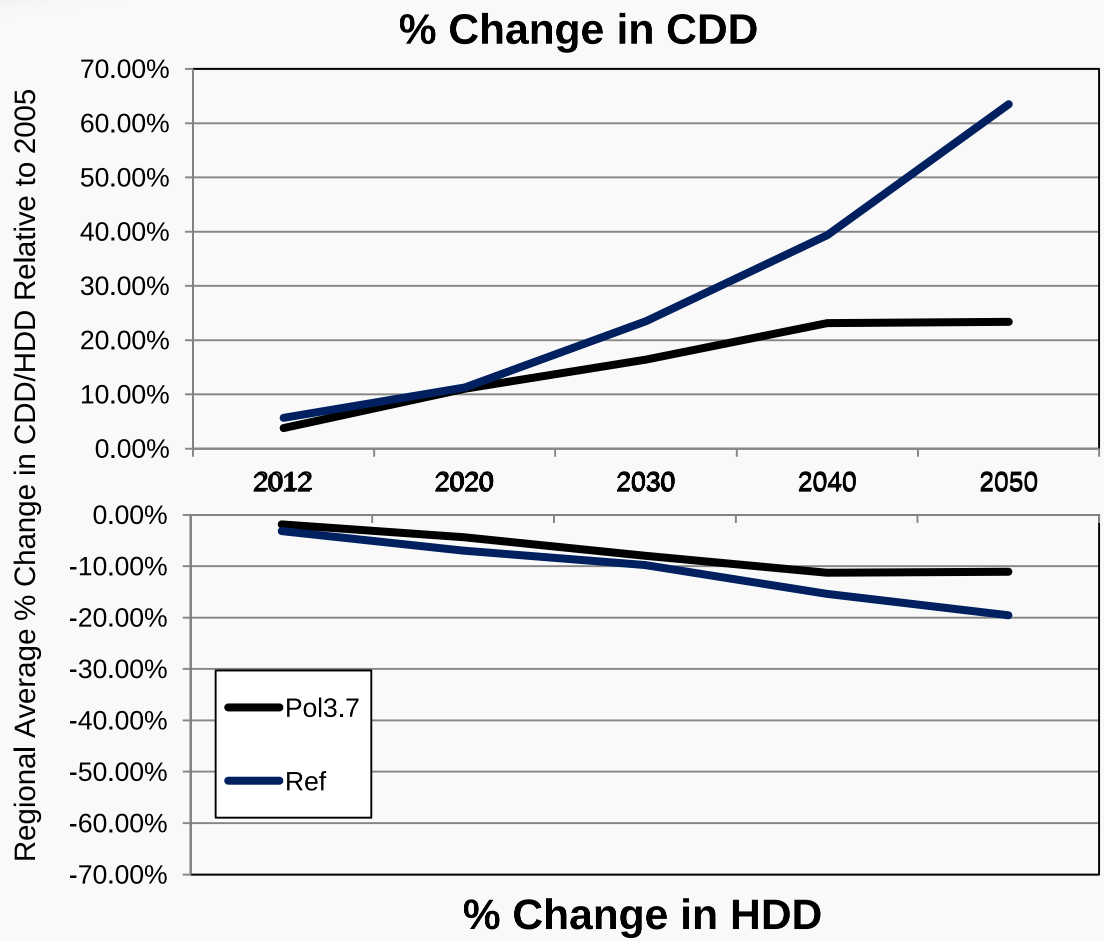


Note: Values are expressed in undiscounted year 2005$.

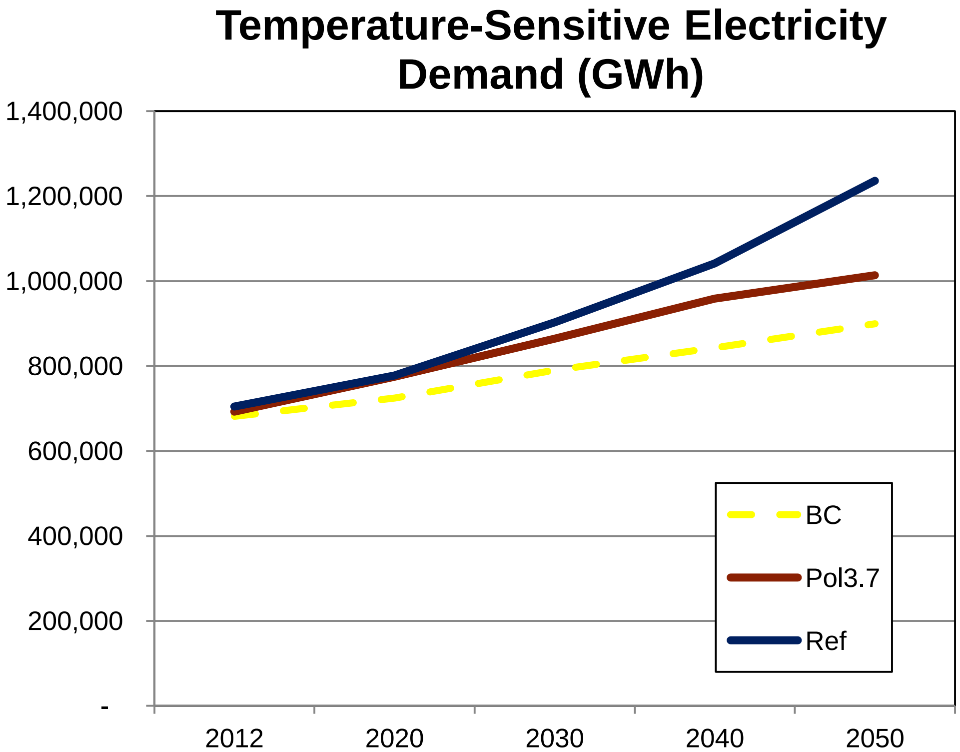
Electricity: National HDD & CDD

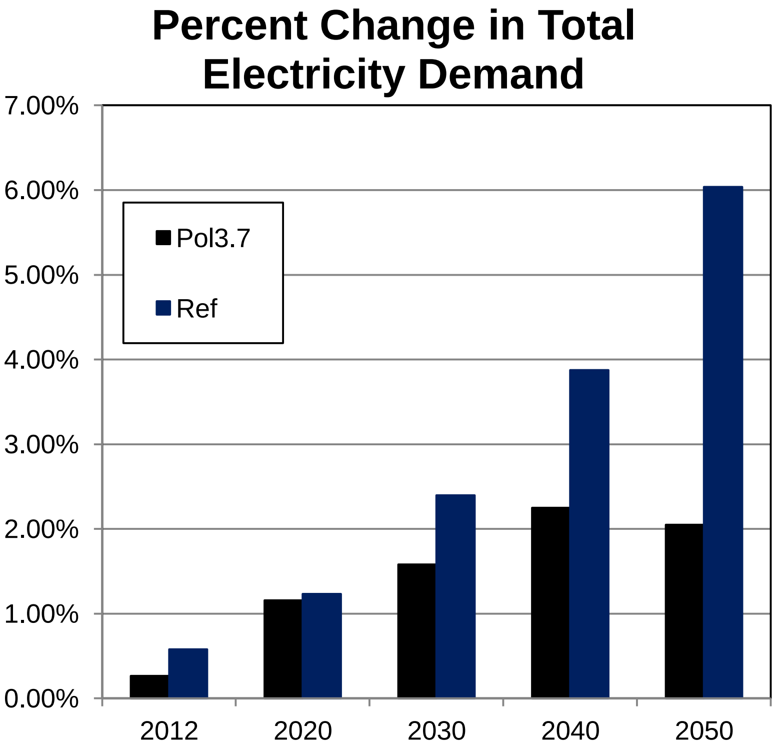
Annual Change in CDD/HDD in 2050





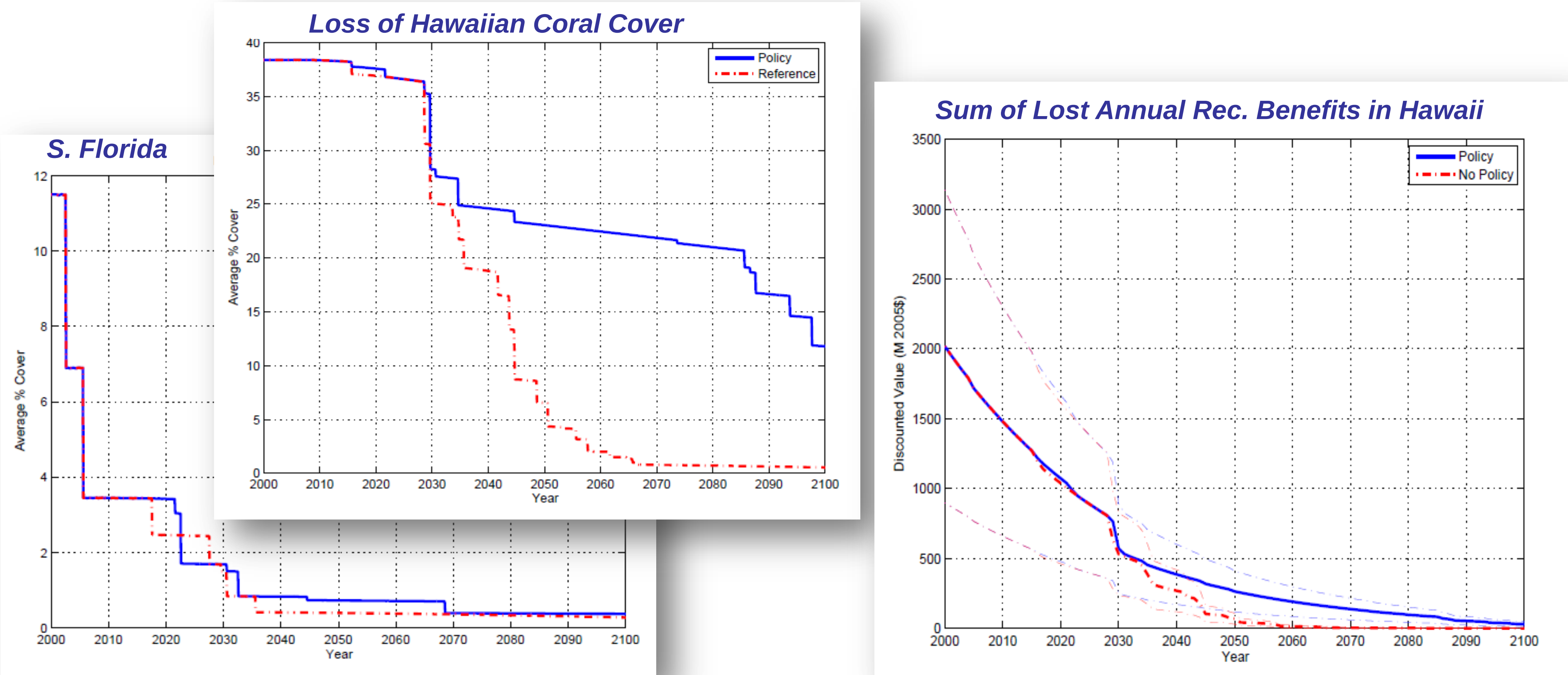
Temperature-Sensitive & Total Electricity Demand (GWh)





- Temperature sensitive demand is 37% greater in the Ref scenario and 13% higher in the Pol3.7 scenario than the BC by 2050.
- The change in temperature sensitive demand increases total electricity demand by over 6%.

Estimated Decline in U.S. Coral Reefs



- GHG mitigation delays Hawaiian coral reef loss compared to BAU.
  - The more stringent policy scenario (RF3.7) avoids ~$9B in lost recreational value for Hawaiian reefs, compared to the BAU.
- GHG mitigation provides only minor benefit to coral cover in South Florida and Puerto Rico *(not shown)*, as these reefs are already being affected by climate change, acidification, and other stressors.

Next Steps

Peer Review of Impacts Research

- Peer review of methods and results
  - Special issue
    - Overview of methodology and goals
    - Individual papers on each component of the project
  - Individual papers for each topic/impacts sector
    - Overall approach and scenario development
    - Extreme events and assessing uncertainty of regional climate change
    - Coastal development, infrastructure, and heat health
    - Energy supply/demand and water resources (drought, flooding damages, water supply/demand)
    - Ag/forestry and ecosystems (coral reefs, freshwater fish, vegetation/wildfire)
  - Key methods and results assembled in a single paper
    - Will require a significant amount of supplementary material.

Communication of Results

- Estimating impacts and economic damages in an analytically rigorous and consistent way will enable clear communication of climate change impacts and risks to a variety of audiences
  - Researchers
    - Distribute findings through peer reviewed publication and conference presentations
  - Policy makers
    - Schedule briefings with interested committees
    - Incorporate results into legislative analyses
  - Public
    - Share results through EPA's updated climate change website
    - Summary report

Other Potential/Future Impact Analyses

- Incorporate impacts into CGE framework
- Population
  - Leverage EPA-ORD's ICLUS model to examine climate change impacts on regional population growth
  - Disaggregated data may be used in future iterations as inputs to other sectoral models (e.g. land use, energy)
- Energy Supply
  - NREL's ReEDS model to look at climate change impacts on energy transmission, including extreme events
- State-level impacts
  - Penn State, Boston University developing a state-level impacts model using sectoral damage functions to examine impacts with interstate trade

Thank you.

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