Projecting the Economic Damages from Temperature Related Mortality in the United States Using GCAM

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Quantifying climate damages in GCAM

- Incorporating climate damages in GCAM enhances our understanding of the trade-offs of different climate policy options.

- **Benefits:**
  - Quantify the damages consistently with climate policy costs
  - Uniform assumptions about socioeconomic scenarios
  - Capture cumulative nature of damages and feedbacks

- **Challenges:**
  - Spatial and temporal scale of damages compared to GCAM
  - Extrapolation from existing damage relationship
  - The potential and representation of adaptation
  - Availability of relevant variables in socioeconomic scenarios

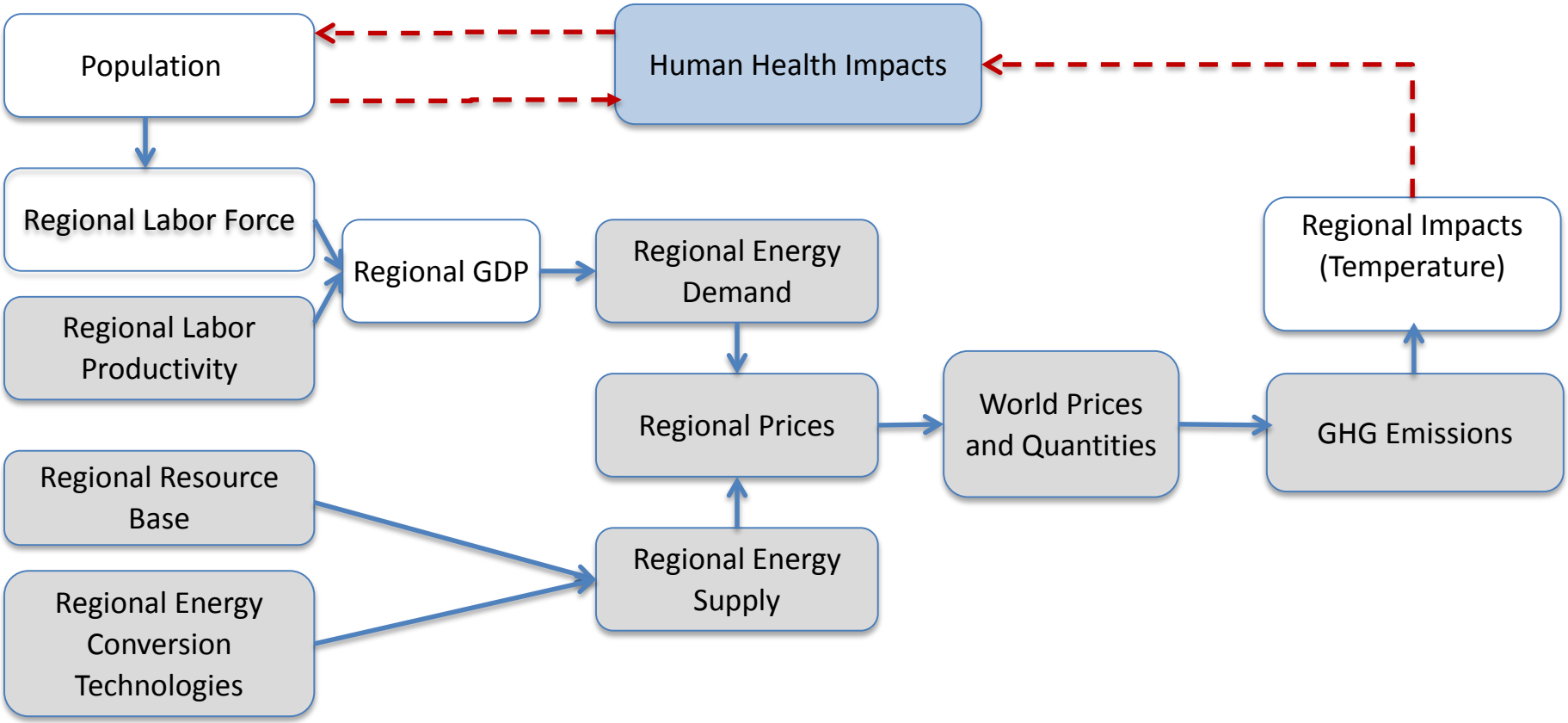
Human health damages in GCAM

OBJECTIVE: Evaluate the economic damages from temperature related mortality in the United States from present to 2050.

1. Empirical models of the relationship between elevated temperatures and premature mortality for the US
2. Demography model to track the adverse health outcomes and adjust population
3. Scenarios for climate change (RCPs) and socioeconomic conditions at a state-level resolution

- GCAM-USA: a version of GCAM with sub-regional detail in the United States

Conceptual model for adding health impacts



Elevated temperatures and human health

- Substantial evidence links elevated daily temperatures to premature mortality over all age groups in summer months.

- Linear functional form:

$$\Delta Mortality = y_0 \cdot pop \cdot \beta \cdot \left(T_{daily} - T_{baseline}\right)$$

- β is a measure of the increase in risk over baseline risk (y_0)
  - 1 – 3% increase in the relative risk of mortality over baseline for an increase per ^{o}C on hot days using the average daily temperature from the meta-analysis conducted by Hajat and Kosatky (2010).

Daily temperatures and climate change

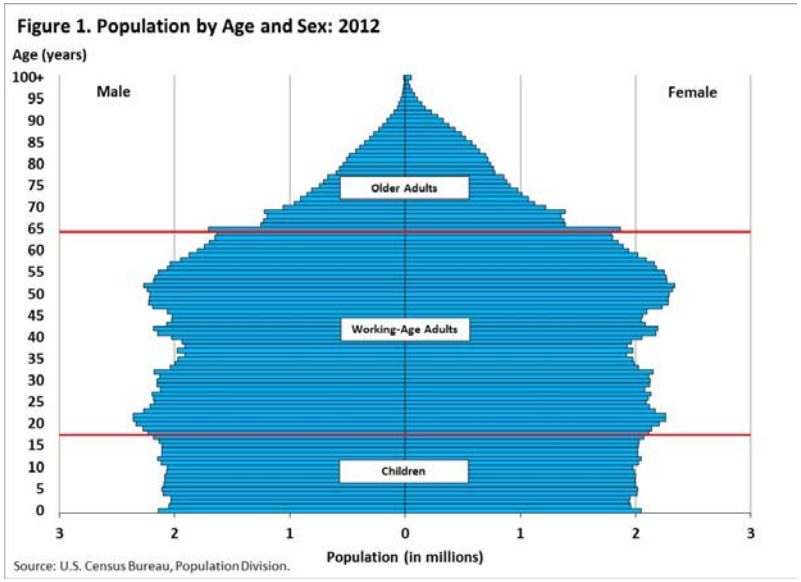
- Daily mean temperatures from CMIP5 archive:
  - Compare RCP4.5 and RCP8.5
  - Look at a range of GCMs to capture “hot” and “cold” projections
- Produce daily population weighted state-level temperatures for each “year”
  - Five year running average for each day of May through September
- Baseline temperature (threshold) is the average daily mean of 2003 – 2007 for each month (May to September).

Population and age structure

- Independent annual projections at the state-level with age structure calibrated to the US Census

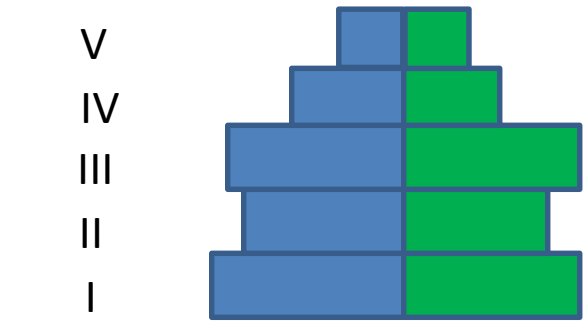
- Average age, gender and state-specific mortality and fertility rates from CDC (http://wonder.cdc.gov/)

- Age, gender and state-specific migration rates and baseline populations from the US census (http://www.census.gov/). Rates are averaged over a ten-year period (2001-2010) and assumed to stay constant in the future



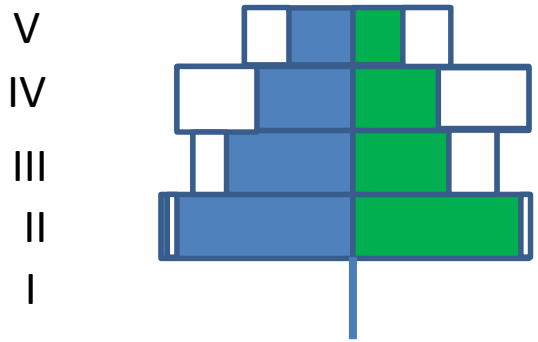
Schematic Visualization of the model process for each year and state (without migration)

1. Initial Population

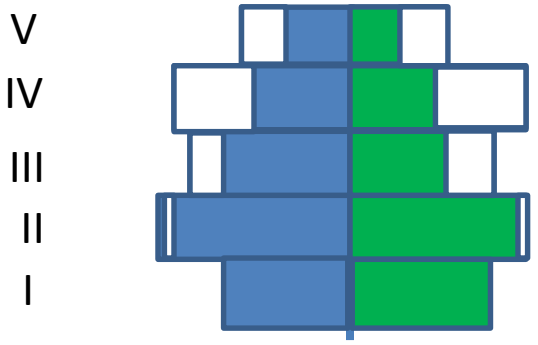


2. Moving age groups forward one time-step

3. Collapsing oldest age group and applying mortality rates



4. Calculating new birth group



Economic damages

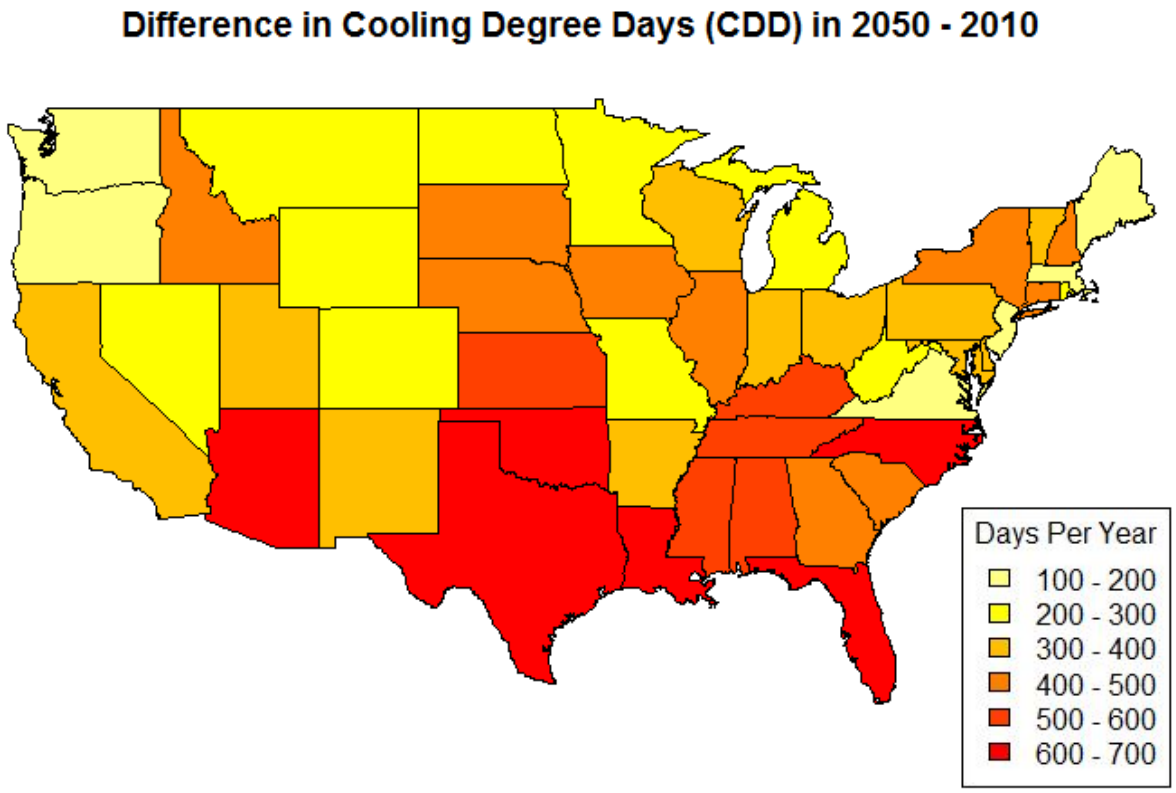
- Annual Energy Outlook (AEO) from the Energy Information Agency as baseline disaggregated to state

1. Willingness to pay (WTP) to avoid these damages
   - Value of a Statistical Life (VSL) adjusted for income growth
2. Costs of adaptation
   - Increased air conditioning usage
3. Decreases in labor productivity as decrease in GDP
   - Structure of the economy

- Not included: increase in health expenditures

Addressing adaptation

- Increased air conditioning usage will offset some of the increase in health effects



Accounting for uncertainty

- Sources of uncertainty:
  - Magnitude of health effects
  - Selection of GCM and temperature increases
  - Spatial and temporal averaging
  - Effectiveness of adaptation
  - Future economic scenarios

- **Next Step:** Run our human health damage model through a series of bounding "experiments" along these dimensions

Thank you! Questions?

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