Climate Change-Related Temperature Impacts on Warm Season Heat-Mortality: A Proof-of-Concept Methodology Using BenMAP

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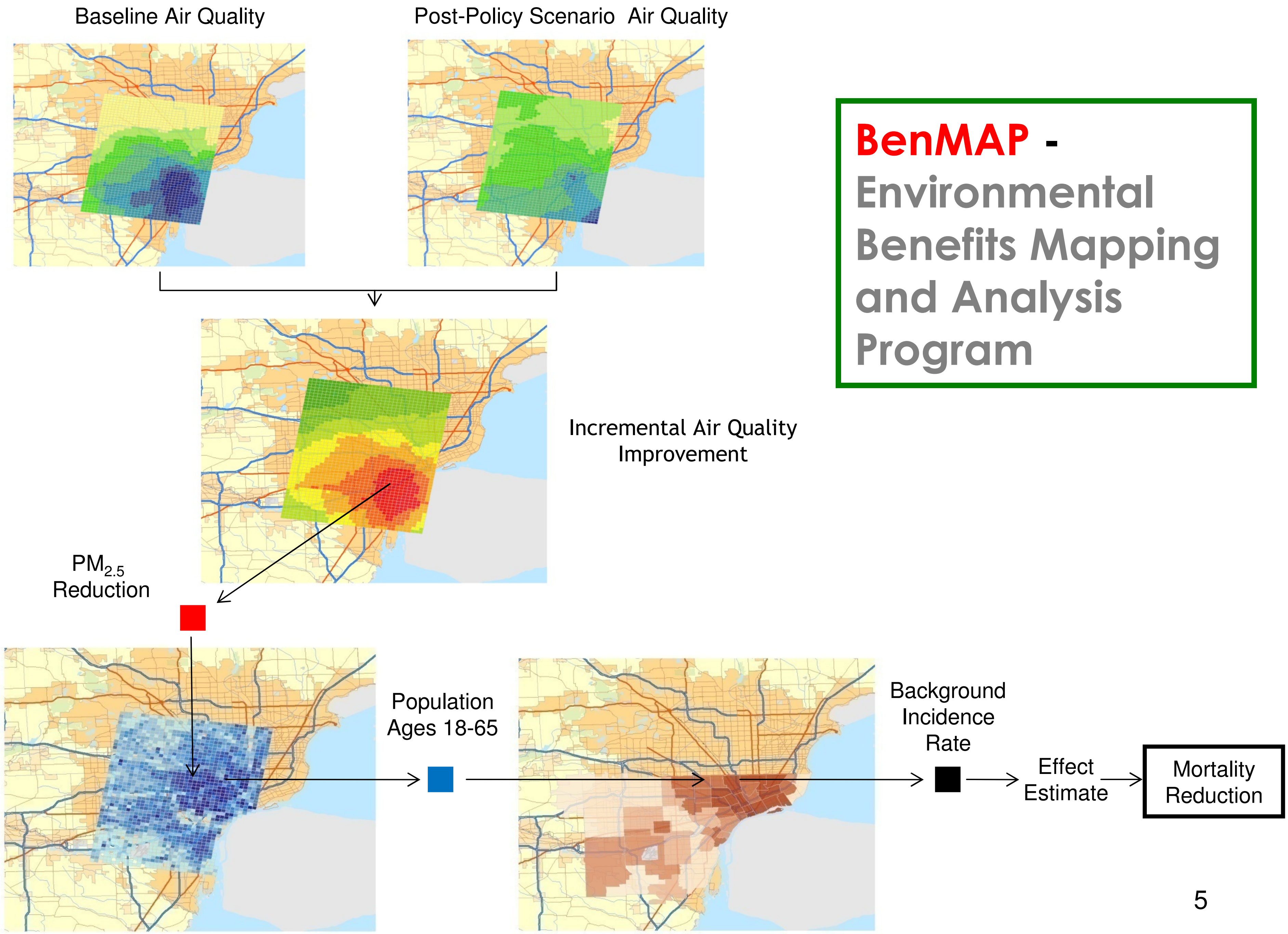
Project goals

- Near-term goals
  - Build technical capacity in BenMAP model
  - Develop a proof-of concept approach to estimating temperature-mortality impacts
- Longer-term goals
  - Quantify temperature-mortality impacts associated with climate change scenarios
  - Estimate joint climate and criteria pollutant impacts

Background

- Six factors define the human thermal environment
  - Air temperature
  - Radiant temperature (e.g., sunlight, other heat sources)
  - Humidity
  - Air movement
  - Metabolic heat of activity
  - Clothing
- Body heat storage triggers thermoregulation system
  - Efforts to increase heat loss stress the body – hyperthermia may result
- Heat is primary weather-related cause of US mortality (more than hurricanes, lightning, tornadoes and floods combined)
- Estimated 2~6°C increase by end of century (Intergovernmental Panel on Climate Change)
  - Heat islands may see 5~11°C
- Both temperature and heat waves expected to increase (US Global Change Research Program)

BenMAP - Environmental Benefits Mapping and Analysis Program



Component 1: Population Exposure

- Using standard Woods & Poole projections of county-level population
  - Allocate population to climate modeling grid
  - W&P population projected to 2030
  - BenMAP performs linear extrapolation for subsequent years to 2050
- BenMAP matches temperature change with population to estimate exposure

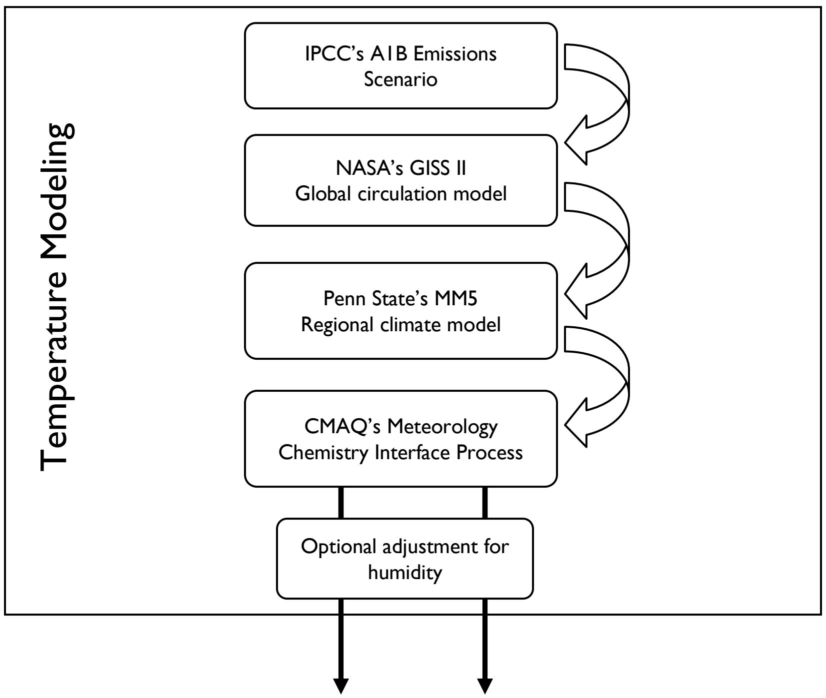
Component 2: Health Impact Functions

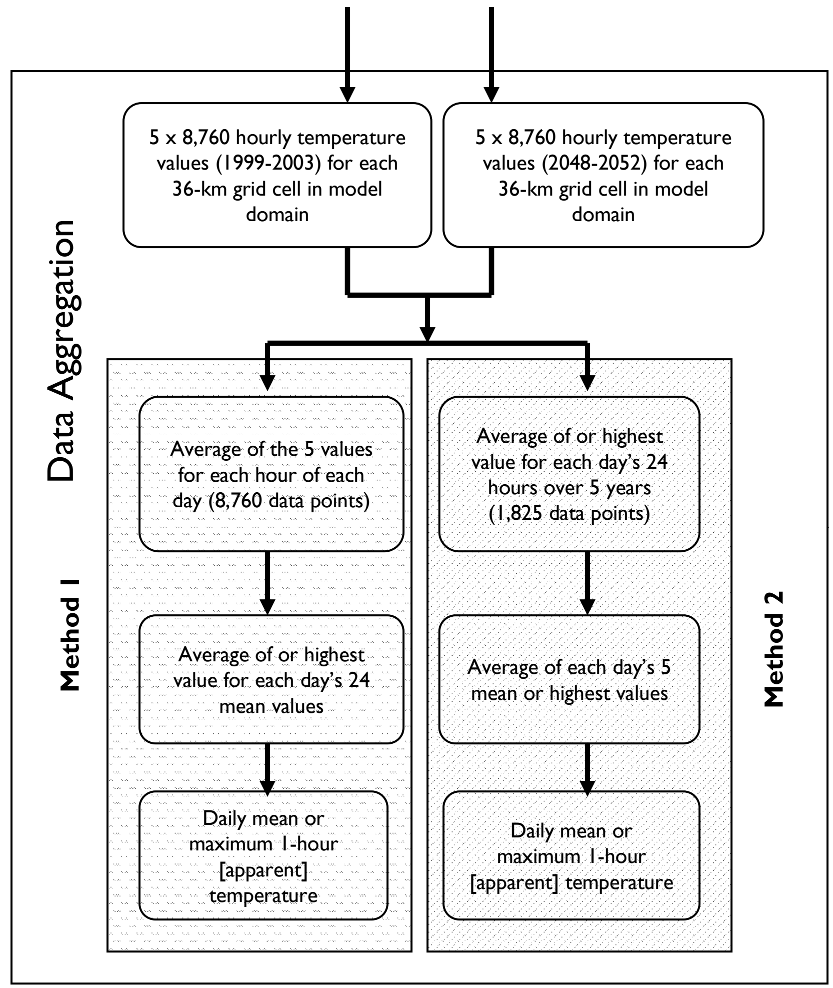
Authors	Location	Impact	Relative Risk or Percent	Conditions	Population
Basu, Feng and Ostro (2008) – CA *Office of Env Haz Assess; UC Davis*	Nine California counties, 1999-2003	All cause mortality, excluding accidents	2.3% per 5.55°C	mean daily apparent T, warm season only	All ages
Basu and Ostro (2008) – *CA OEHA*	Nine California counties, 1999-2003	All cardiovascular deaths	2.6% per 5.55°C	mean daily apparent T, warm season only, unlagged	All ages
Medina-Ramón and Schwartz (2007) - *Harvard*	42 random large US cities, 1989-2000	All cause mortality	0.43% per 1°C	minimum threshold >17°C, 2 day cumulative	All ages
Zanobetti and Schwartz (2008) - *Harvard*	Nine US cities in warm and cold climates, 1999-2002	All cause mortality, excluding accidents	1.8% per 5.55°C 2.7% per 5.55°C	mean daily apparent T, warm season only, adjusted for PM2.5 and ozone	All ages
Basu, Domenici and Samet (2005) – *CA OEHA; Johns Hopkins*	20 largest US cities, 1992	All cardiovascular and all respiratory deaths	1.02~1.10 per 5.55°C (five geographic regions)	mean daily apparent T, summer only	Ages 65-99

Component 3: Temperature modeling

- Air quality modeling group modeled meteorological changes (including temperature) related to a climate scenario
  - IPCC "A1B" emissions scenario
  - EPA's Climate Impact on Regional Air Quality (CIRAQ) program
    - NASA's global circulation model GISS-II to simulate climate for period 1950-2055
  - Results downscaled by DOE's PNNL to 36-km grid using regional climate model MM5 for current (ca. 2000) and future (ca. 2050) conditions
- CIRAQ downscaled meteorology used in the ORD/NCEA report addressing climate change impacts on ozone

Temperature Aggregation Methodology

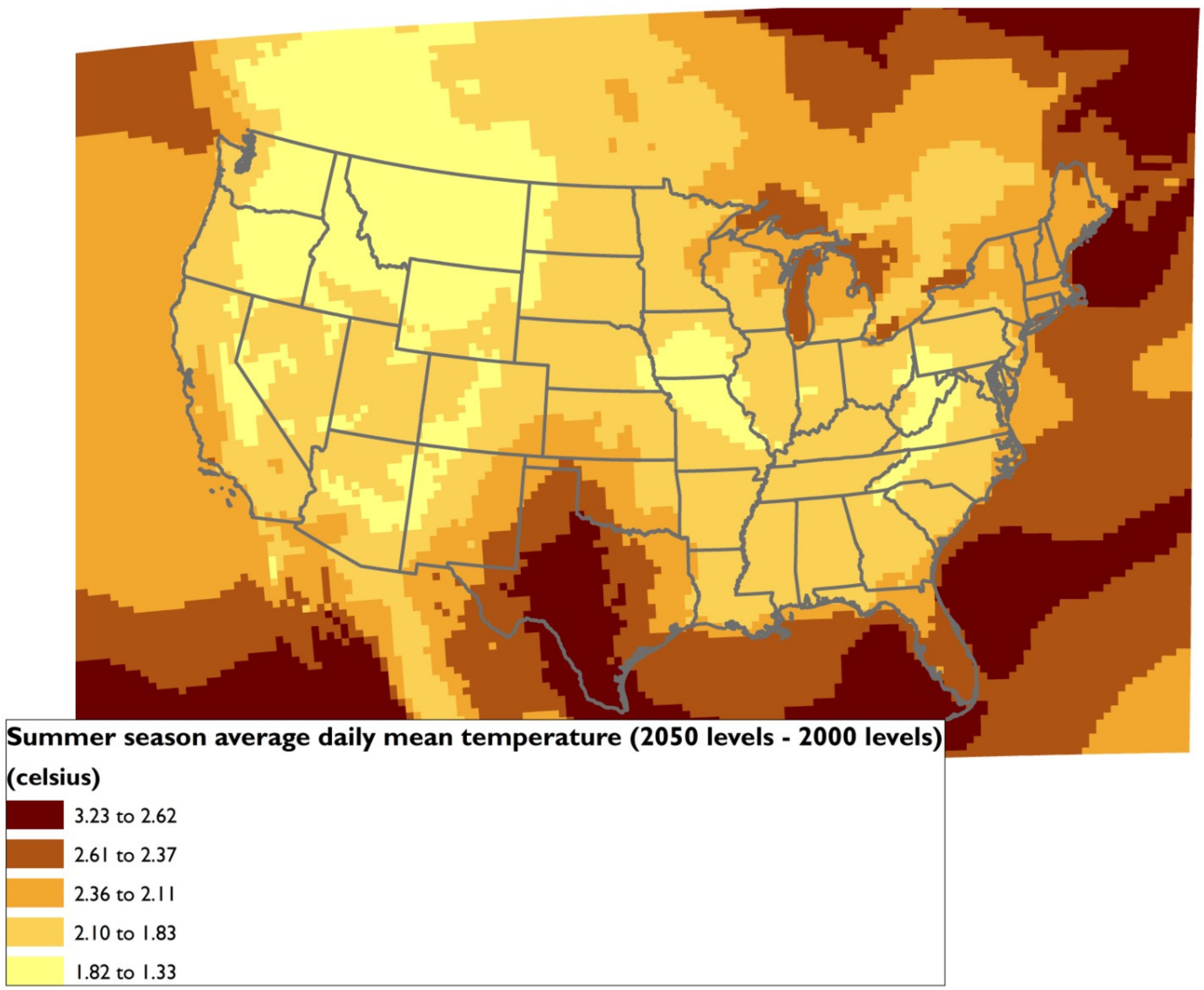




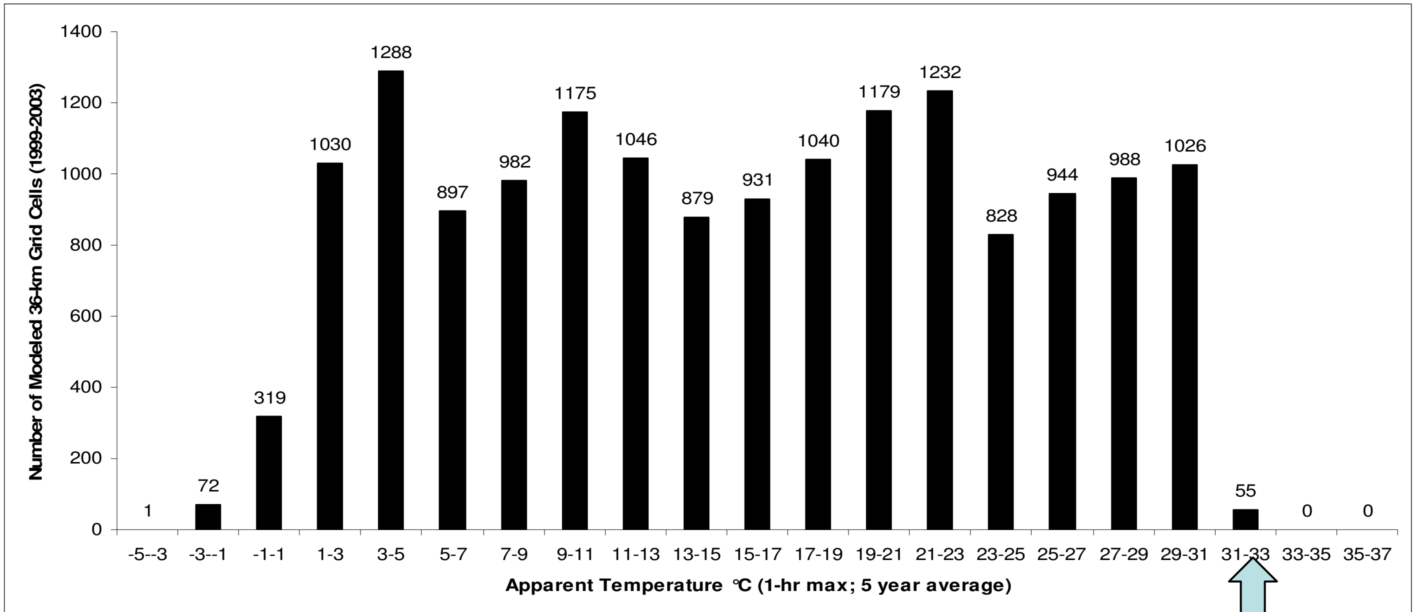
Results

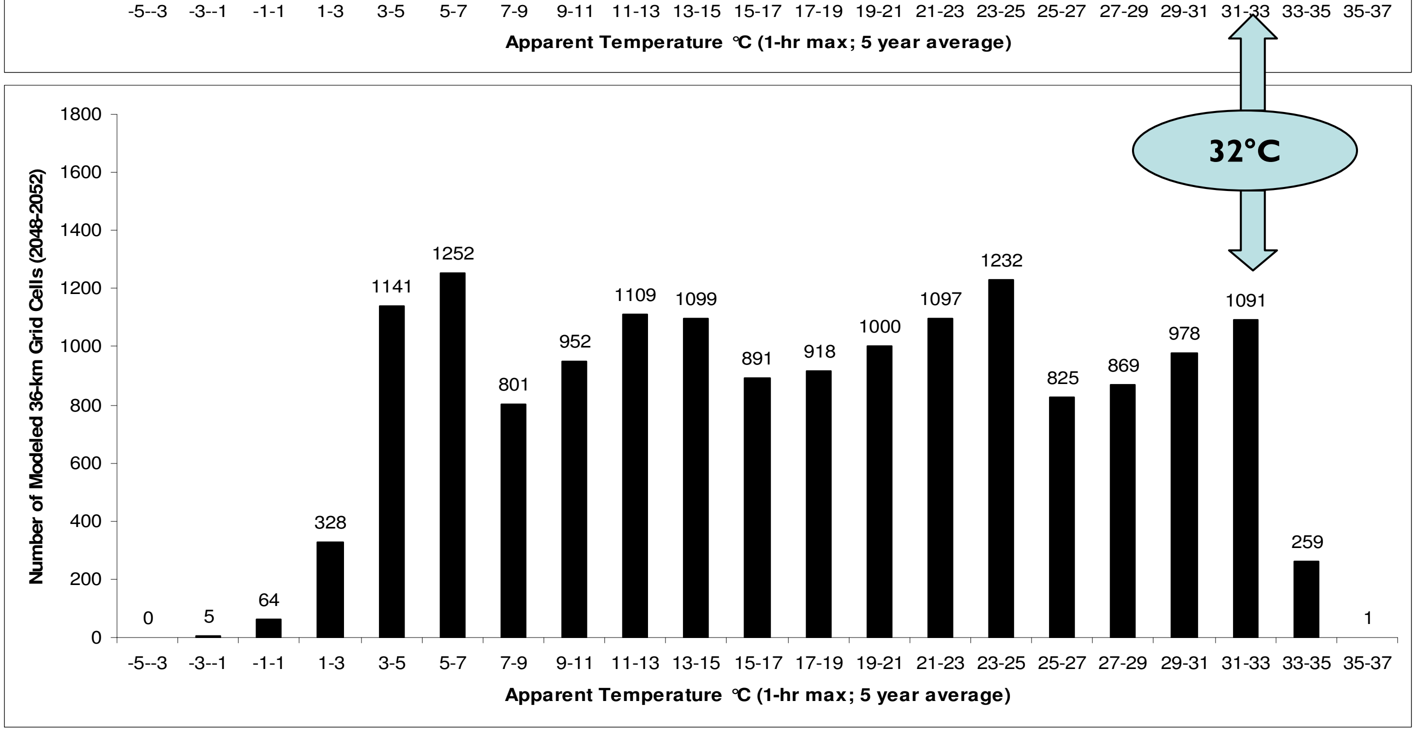
- Summer and winter season temperatures ~2°C higher
- Incidence of heat-related mortality in warm season
  - 0.1% of all cause mortality
  - 0.9% of cardiovascular disease mortality
  - 0.7% of nonaccidental deaths
- Various factors influence results
  - Warm season vs. heat wave; other seasons
  - Displacement ("harvesting") between seasons or not
  - Spatial & temporal heterogeneity
  - Acclimatization (biophysical desensitization) & adaptation (change in behavior patterns)
  - Impact of air pollution (e.g., ozone - higher concentrations, more episodes, enhanced effect with higher temperature)

Change in Summer Season Daily Average Temperature (Higher 2050 Levels - Lower 2000 Levels)



Numbers of Modeled Grid Cells And Associated 1-Hour Temperature Ranges



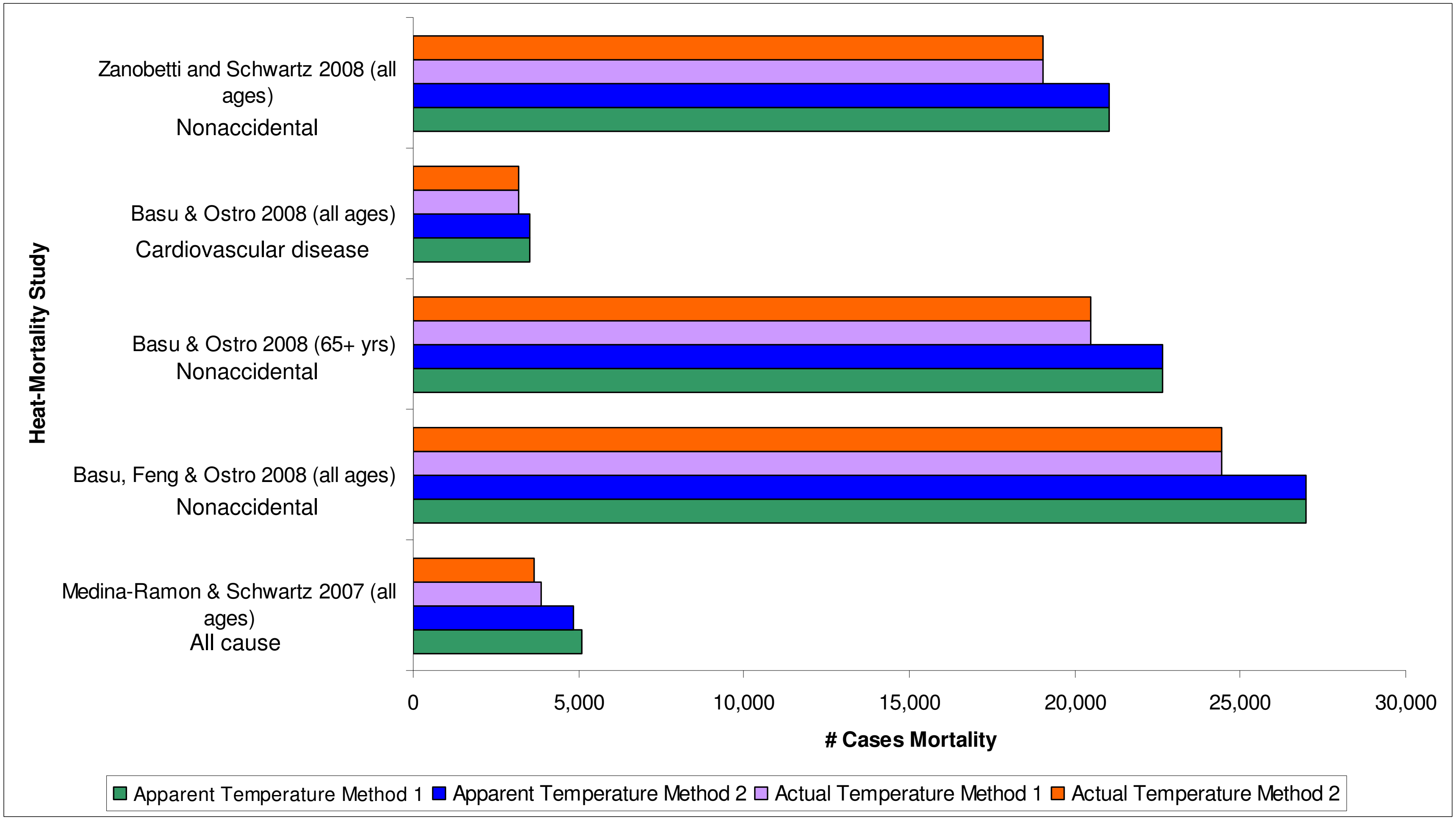


Number of Cells ≥ 32º C

(out of 15,912 modeled cells)

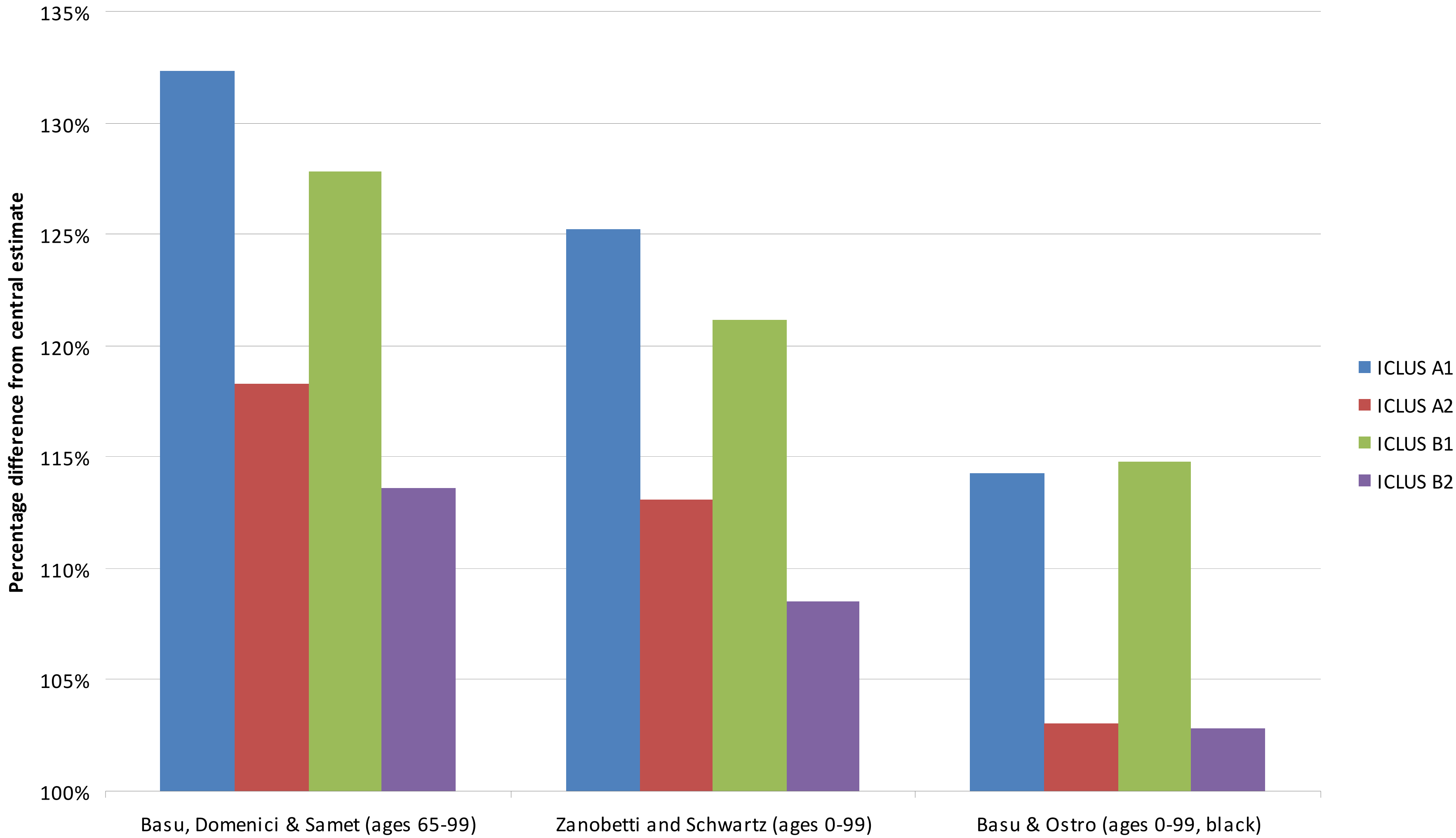
	2000	**2050**
1 hour max	18 cells	865 cells
24 hour mean	0 cells	255 cells

Estimated Warm Season Temperature-Related Mortality



All functions based on apparent temperature except Medina-Ramon & Schwartz

Influence of Population Assumptions on Results



Lessons Learned

- Climate-induced health impacts are highly sensitivity to population projections
  - Absolute change in temperature as important as location of susceptible populations
  - The longer the time horizon, the greater the divergence among projections
  - Future analyses should consider multiple population projections
- Temperature-mortality effects are sensitive to location
  - Location affects susceptibility, acclimatization and adaptation
  - National pooled risk estimates may poorly account for risk at specific cities
- Current approach not capturing joint impacts
  - Interaction of temperature and pollution or multiple pollutants in health impact assessment not addressed
  - Joint impacts may be synergistic

Next steps

- Identify "critical" factors that drive analytical results
  - Mortality & morbidity
  - Warm season vs. heat wave; other seasons
  - Displacement ("harvesting") or not
  - Sensitive populations – elderly, infants, all
  - All cause mortality or cardiovascular & respiratory
  - Spatial & temporal heterogeneity
  - Acclimatization & adaptation
  - Impact of air pollution (e.g., ozone - higher concentrations, more episodes, enhanced effect with higher temperature)
- Refine health impact functions
  - Consider estimating reduction in mortality from increases in wintertime minimum temperatures
- BenMAP enhancements
  - Apply risk estimates by city
  - Quantify joint impacts of temperature and air pollution
  - Incorporate "temperature rollback" feature

Leapfrogging Lessons

- Heat-related health impacts can be quite region- and season-specific
- A holistic approach to estimating impacts is important
- Urban populations may be at particular risk due to heat islands

THANK YOU!
谢谢

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http://www.epa.gov/ttn/ecas/benmodels.html