

**Climate Change and the Potential Impacts on Mortality from Heat:
Preliminary Findings for California and Selected Urban Areas**

California's increasingly urbanized population faces a significant and growing risk of adverse health effects from extreme heat events associated with climate change. This presentation will examine the impacts of climate change as projected by two global climate models, forced by two difference emissions scenarios. Results suggest that Californians may face far greater heat mortality risks than previously thought.

Many studies have established the connection between extreme heat and summer excess mortality. Humans respond to a combination of climatic stressors (daily temperature range and magnitude, humidity, solar load, air pollution, duration of extreme heat, etc.). Also important are the seasonal timing and frequency of extreme heat events. Of greatest concern are not just single hot days, but extended heat events that occur early in the season (when acclimatization is incomplete, and the number of susceptible individuals is greatest) with little temperature relief at night.

We assessed the potential impacts of increasing extreme heat on the urban populations of five cities (Los Angeles, Sacramento, Fresno, San Francisco, and Riverside) using climate projections developed using two climate models (NCAR's low-sensitivity Parallel Climate Model (PCM) and the UK Met Office's medium-sensitive HadCM3 model) and two emissions scenarios (the higher (A1fi) and lower (B1) SRES emissions scenarios). For city-specific analyses, global model results were statistically downscaled to individual stations. Statewide analyses used global model outputs.

Future risk of heat-related mortality was assessed in a general sense by examining changes in the frequency and intensity of heat waves, duration of heat waves, the length of the heat wave season, and the time of the first heat wave per year. All indicators point to a growing risk of heat-related mortality, with climate change under the highest emissions scenario posing a significantly greater risk than less severe future climate.

City-specific mortality estimates were then developed for the periods 1989-1998 (the reference period), 2045-2054, and 2090-2099, using procedures that calculate apparent temperature thresholds beyond which mortality tends to markedly increase. Apparent temperature is a heat index that combines temperature, relative humidity, and wind speed. More complex approaches – such as air mass-based synoptic approaches – were attempted but encountered methodological and data challenges that could not be solved at this time.

We calculated mortality results with and without acclimatization. Human physiology, behavior, and environment are adaptable to a certain degree. To reflect this acclimatization in mortality estimates, various approaches have been adopted, including comparisons with analogue cities or regions (i.e., places where temperature or climatic conditions at present are similar to those expected in the future for the target city). The

¹ This presentation draws on an extended health impacts analysis that involved the following collaborators: Katharine Hayhoe (ATMOS Research and Consulting), Laurence S. Kalkstein (University of Delaware), Scott C. Sheridan (Kent State University), Norman Miller (Lawrence Berkeley National Laboratory), Michael Dettinger (USGS, La Jolla, CA), Julia Verville (UCS), and the presenter.

analogue-city approach suffers from the fact that the target and analogue city most likely differ in demographic make-up and physical structure. To remedy this shortfall, a new approach was developed for this study, in which analogue summers in the same city were used to obtain insights in the acclimatization potential.

Demographic changes, and societal decisions affecting adaptation, such as urban design, and changes in the health care sector will determine the actual mortality rates. Significant efforts will have to be undertaken to provide effective early warning systems, public education, air conditioning and "cooling centers" (especially to the elderly, children, the poor, and already-ill)^v, and other adaptation options to avoid major increases in the number of heat-related deaths in California. The urgency for such measures only grows in light of expected population increases and demographic shifts.

The study offers valuable insights for heat-mortality studies more generally:

1. More recent GCM runs project far greater temperature increases than previously suggested. This raises the specter of more severe human health impacts from heat than previously thought.
2. Regional GCM projections (downscaled or not) give insights into numerous variables that are of great significance to human health. Temperature extremes are but one of several telling indicators of future health risk.
3. Downscaled results suggest interesting regional differences, only some of which we're fully able to explain at this time. Societal factors contribute significantly to some of the less-than-obvious differences.
4. There is ample room for future resolution of various data and methodological challenges that currently limit a more comprehensive approach to human health risk assessments under climate change.

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A geographer by training (Ph.D. 1997, Clark University), Susi's research foci for the last ten years have been the human dimensions of global change. She has researched the uncertainties in the human dimensions (causes, impacts, and responses) of global change, especially in the coastal context. During a post-doc at Harvard's Kennedy School of Government (Global Environmental Assessment project), she examined the role and influence of science and assessments in policy- and decision-making. She also worked for the Heinz Center in Washington, DC on a congressionally mandated project on coastal erosion and management. From 1999-2003, Susi was the staff scientist for climate change for the Union of Concerned Scientists, managing various climate change impacts projects and working in the trenches of effective climate change communication and social mobilization for change. Since September 2003 she is back in the world of research, focusing on the communication—social change interface, societal transition toward greater sustainability, the impacts of climate change on coasts and human health, as well as on adaptation to climate change.

Selected Recommended Reading:

- Chestnut, L.G., Breffle, W.S., Smith, J.B., and Kalkstein, L.S. (1998). Analysis of differences in hot-weather related mortality across 44 U.S. metropolitan areas. *Env.ironmental Science & Policy* **1**: 59-70.
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- Kalkstein, L.S. and Greene, J.S. (1997). An evaluation of climate/mortality relationships in large U.S. cities and the possible impacts of a change in climate. *Env. Health Perspectives* **105**(1): 84-93.
- Kalkstein, L.S. (1991). A new approach to evaluate the impact of climate upon human mortality. *Env. Health Perspectives* **96**: 145-50.
- Kalkstein, L.S. and Davis, R.E. (1989). Weather and human mortality: An evaluation of demographic and interregional responses in the US. *Annals of the AAG* **79**(1): 44-64.
- Kalkstein, L.S. and Valimont, K.M. (1986). An evaluation of summer discomfort in the United States using a relative climatological index. *Bulletin of the American Meteorological Society* **7**: 842-848.
- Martens, W.J.M. (1998). Climate change, thermal stress and mortality changes. *Soc. Sci. Med.* **46**(3): 331-344.
- McGeehin, M.A. and Mirabelli, M. (2001). The potential impacts of climate variability and change on temperature-related morbidity and mortality in the United States. *Environ. Health Perspectives* **109**, 185-189.
- Smoyer, K.E. (1998). Putting risk in its place: methodological considerations for investigating extreme event health risk. *Soc. Sci. Med.* **47**(11): 1809-1824.