New Emission Scenarios and California Climate Impacts: An Analysis of Extreme Heat

Norman L. Miller
Contact: Norman L. Miller, 510/495-2374, nlmiller@lbl.gov

RESEARCH OBJECTIVES

Two global climate models, the low-sensitivity NCAR/DOE Parallel Climate Model and the medium-sensitivity UK Met Office HadCM3 model, were used to calculate climate change resulting from the B1 (lower) and A1fi (higher) emissions scenarios. These scenarios bracket a large part of the range of Intergovernmental Panel on Climate Control (IPCC) nonintervention emissions futures, with atmospheric concentrations of CO_2 reaching ~550 ppm (B1) and ~970 ppm (A1fi) by 2100. The objectives of this Extreme Heat Analysis component of the larger study (Hayhoe et al., 2004) is to quantify the change in likelihoods of extreme heat days for urban population centers, for the higher and lower emission scenarios of 2045–2054 and 2090–2099, compared to the reference period 1989–1998.

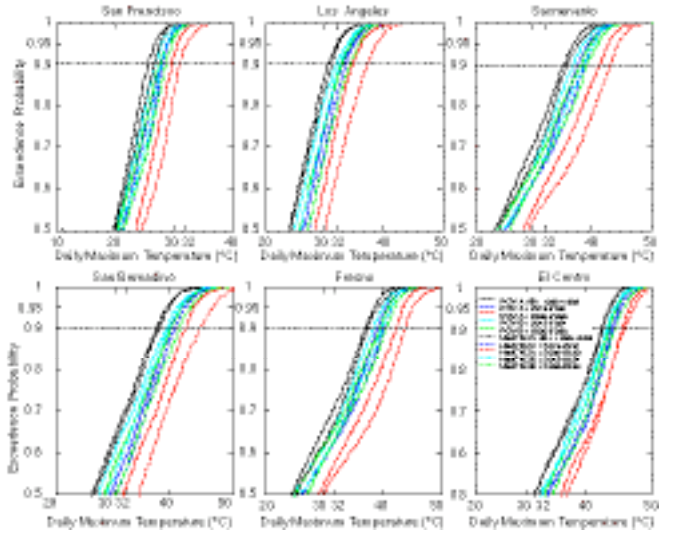

Figure 1. Temperature exceedance probabilities for PCM (dashed) and HadCM3 (solid) projections under emission scenarios A1fi (Red) and B1 (Green) for 2090–2099 for San Francisco, Los Angeles, Sacramento, San Bernadino, Fresno, and El Centro

APPROACH

Changes in local temperature extremes were evaluated based on calculated exceedance probability (EP) analyses, using the distribution of daily maximum temperatures downscaled to representative locations and ranked. Exceedance probabilities define a given temperature for which the probability exists that X% of days throughout the year will fall below that temperature. Conversely, there is a probability that (100-X)% days will lie above that threshold. For example, if the 35°C EP averages 95% for 2070–2099, an average of 95% or ~347 days per year lie below 35°C. Exceedance probabilities of daily time series have been used to indicate the likelihood of occurrence of temperature, precipitation, and runoff (Miller et al., 2003).

ACCOMPLISHMENTS

The maximum daily temperature (Tx) EP at San Francisco, Los Angeles, Sacramento, San Bernadino, Fresno, and El Centro for emission scenarios A1fi and B1, using PCM and HadCM3, are shown in Figure 1. The 2090–2099 50% and 95% Tx EPs for San Francisco increase by more than 7°C for the HadCM3 A1FI scenario, and 6°C for the PCM A1FI scenario. The 1990–1999 baseline 95% EP becomes 58% and 70% for HadCM3 and PCM A1FI, and 86% and 78% for B1, respectively. Such shifts indicate that San Francisco's historic 5% warmest days may occur as frequently as 30–42% of the year for A1FI and 14-22% for B1, by the end of this century.

Los Angeles has a more dramatic shift. In the 2090–2099 HadCM3 and PCM B1 projections under the A1fi emission scenario, the heat threshold is exceeded by 35% and 22%, respectively. (See Figure 1). The lengthening of future heat-wave seasons results primarily from earlier onset, with the season beginning 25–40 days earlier under B1, and twice that (50–80 days earlier) under the A1fi scenario. Under A1fi, 49–83 more heat-wave days are seen, which represents an increase of ~20–30 more days than under the B1 scenario.

SIGNIFICANCE OF FINDINGS

The significance of this extreme heat analysis is the well-established link between extreme heat and excess summer mortality. A simple temperature threshold approach without acclimatization suggests that heat mortality in Los Angeles may increase by 2–4 times under B1 and 6–10 times under A1fi by the 2090s. With acclimatization, these estimates are 15–20% lower. Individuals likely to be most affected include the elderly, children, economically disadvantaged, and already ill.

RELATED PUBLICATIONS

Hayhoe, K, D. Cayan, C.B. Field, P.C. Frumhoff, E.P. Maurer, N.L. Miller, S.C. Moser, S.H. Schneider and others, Emissions Pathways, Climate Change, and Impacts on California. Proc. Nat'l Acad. Sci., 101, 12422–12427, 2004. Berkeley Lab Report LBNL-56119.

Miller, N.L., K.E. Bashford, and E. Strem: Potential impacts of climate change on California hydrology. J. Amer. Water Resourc. Assoc, 39, 771–784. 2003. Berkeley Lab Report LBNL-51313.

ACKNOWLEDGMENTS

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