Climate-Driven Increases in Extreme Heat and Energy Demand in California

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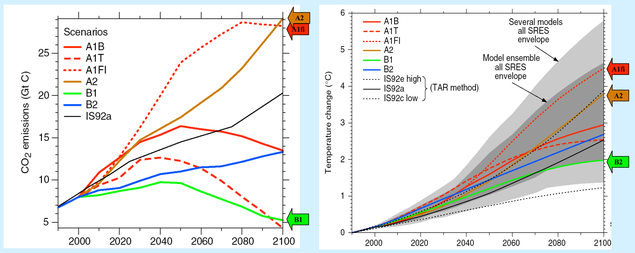
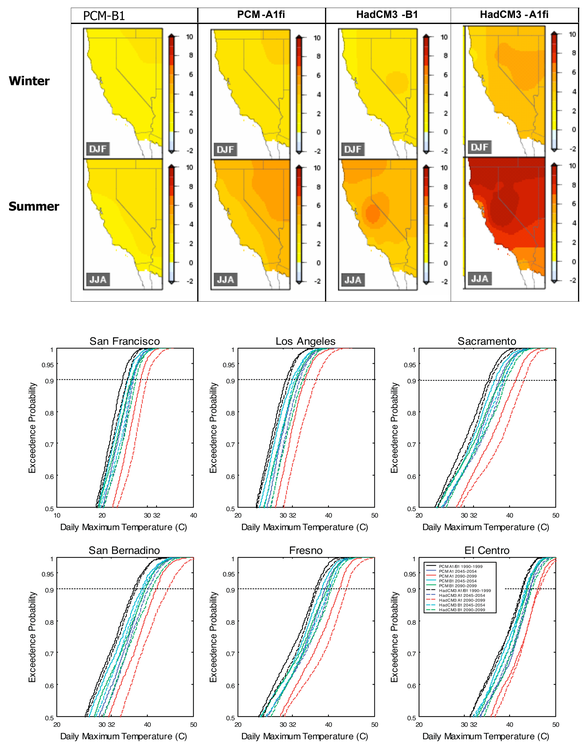
INTRODUCTION

Summer temperatures under scenarios of future climate change are projected to increase considerably, accompanied by longer, more frequent, and more severe extreme heat conditions. These projections have important implications for energy demand in California, a region where suppliers are already challenged by growing population and increasing summer demand. Here, we analyze the potential impacts of rising temperature on California heat and energy demand based on projections from three atmosphere-ocean general circulation models (AOGCMs) – HadCM3, GFDL, and PCM – forced with the IPCC SRES with higher (A1fi), mid-high (A2), and lower (B1) emission scenarios.

IPCC Emission Scenarios and Climate Projections



CALIFORNIA TEMPERATURE SENSITIVITY

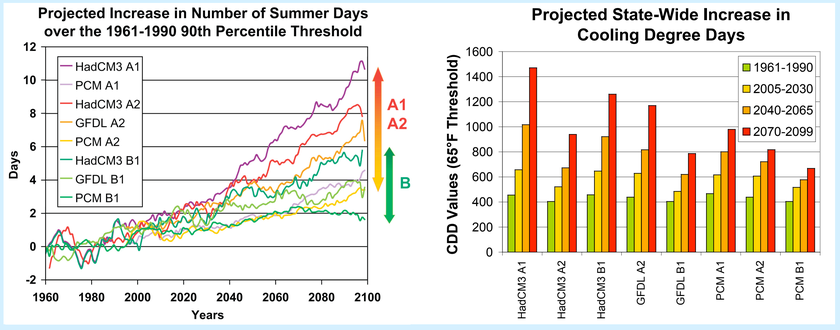


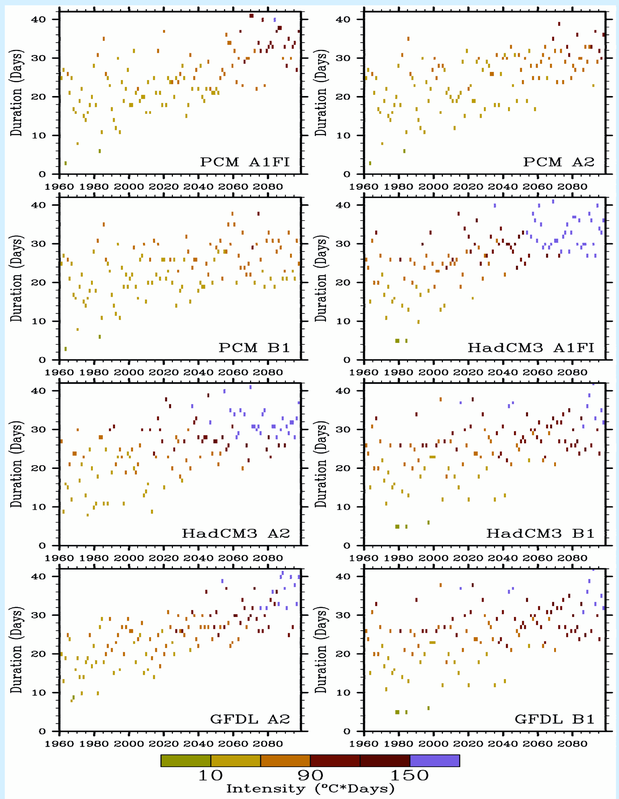
Temperature exceedance probabilities for PCM (dashed) and HadCM3 (solid) projections under emission scenarios A1fi (Red) and B1 (Green) for 2090-2099 for San Francisco, Los Angeles, Sacramento, San Bernadino, Fresno, and El Centro. The blue dash-dot-dot-dash line indicates the 90% exceedance.

CALIFORNIA SUMMER TEMERPATURE

By 2100, state-wide summer temperature increases range from 2-5°C under the lower B1 scenario up to 4-8 ° C under the higher A1fi scenario, with shifts towards more frequent extreme heat conditions occurring through changes in both the mean and variance of summer temperatures. In particular, heat extremes, defined here as the 90th percentile of mean-daily summer temperatures, will be exceeded A-A'% of summer days under the A1fi scenario, B-B'% of summer days under the A2 scenario, and C-C'% of summer days under the B1 scenario. Through statistical downscaling of daily temperatures, we also generated Cooling Degree Day (CDD) projections to reflect a base human comfort level related to air conditioning for five California cities (Los Angeles, Sacramento, Fresno, San Francisco, and San Bernardino). CDD values show the largest increases for coastal areas, and increase northward from Los Angeles to San Francisco.

EXTREME HEAT AND HEATWAVES





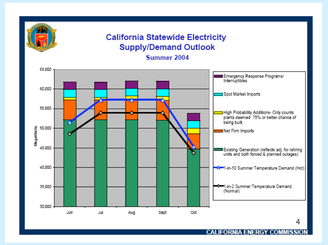
Each climate projection of the California-mean temperature indicates that the 10% warmest summer days (90% exceedance) will increase in number, the duration of heat events will be longer, warmer, and more intense, where intensity is a measure of energy demand in degree-days.

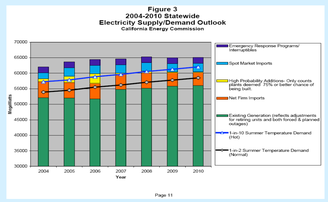
PROJECTED ENERGY DEMAND

Present world demand for energy is approximately equivalent to a continuous power consumption of 13 trillion watts (i.e. 13 TW). With aggressive conservation and energy efficiency, an *expected global population of 9 billion* accompanied by rapid technology growth is projected to more than double energy demand to *30 TW by 2050* and to more than triple this demand to *46 TW by 2099*.California energy demand is on an upward trend with future summer demand due to high temperature approaching *65 GW by 2010*.

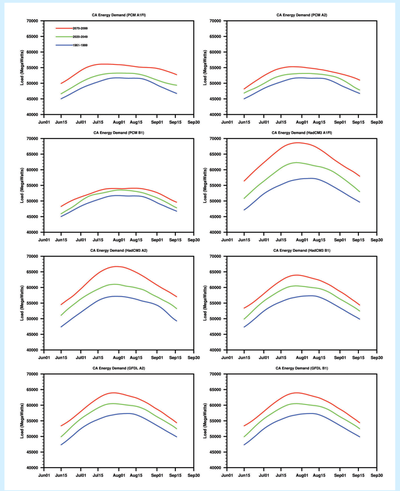
EXTREME TEMPERATURE AND ENERGY DEMAND

Using observed correlations between energy demand and temperature, we estimate the additional energy supply that would be required to meet the Cooling Degree Day (CDD) demands based on a sliding scale from 65ºF (the current-day definition) up to 75ºF, to simulate the potential role of adaptation. Without taking into account the competing effects of population increases, technological advances, or adaptation strategies, we estimate that by 2100 California could require more than 10,000 MW of additional power during peak summer days for residential cooling purposes alone, an amount that exceeds current-day California energy capacity by 17%. Based on these projections, future brownouts and blackouts may be more frequent, unless active prevention measures are taken, such as increased energy efficiency practices, conservation, or reliance on alternative energy sources.





California's summertime peak energy demand 1-in-10 likelihood currently results in energy shortages. Projected energy demand for the next 10 years indicates California will need to rely on external energy sources during peak energy demand periods due to heat extremes.



California-wide residential JJAS energy demand for l960-2000 (blue), 2050 (yellow), and 2100 (red), with A) PCM/A1fi, B) PCM/B1, C) GFDL/A2, D) GFDL/B1, E) HadCM3/A2, and F) HadCM/B1.

Conclusions

- Analyses of AOGCM-projections indicates that heat extremes will likely be more frequent, more intense, and persist longer.
- Energy demand correlations indicate that California will likely exceed current capacity projections.
- Energy efficiency technologies can reduce energy demand.
  - Advances in materials research can decrease the impact on the power grid during heat extremes.
  - Albedo changes will decrease the urban heat island effect.
- Adaptation can reduce demand. Get people to replace air conditioning by fans and good circulation in residences.

References

Hayhoe, K, D. Cayan, C.B. Field, N.L. Miller, S.H. Schneider and others, *Emissions Pathways, Climate Change, and Impacts on California, Proc. Nat'l Acad. Sci.,101, 12422-12427, 2004.*

Miller, N.L. 2005: New Emissions Scenarios and California Climate Change: An Analysis of Extreme Heat. California Climate Change Governor's Initiative.

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