Effects of projected climate change on energy supply and demand in the Pacific Northwest and Washington State

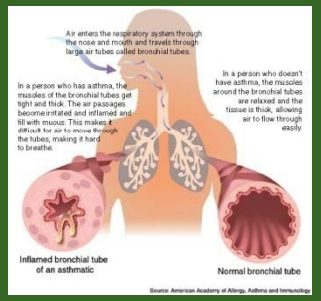
Alan F. Hamlet
Se-Yeun Lee
Kristian Mickelson
Marketa McGuire Elsner

•JISAO/CSES Climate Impacts Group
•Dept. of Civil and Environmental Engineering
University of Washington

Department of Civil and Environmental Engineering

A comprehensive climate change impacts assessment for Washington State

Human Health



Infrastructure

Agriculture/Economics

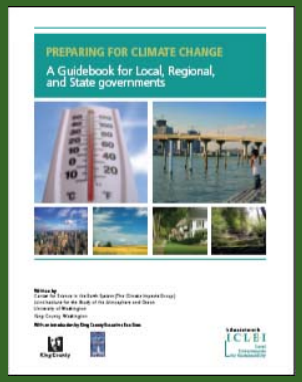
Water Resources

Coasts

Energy

Forest Resources

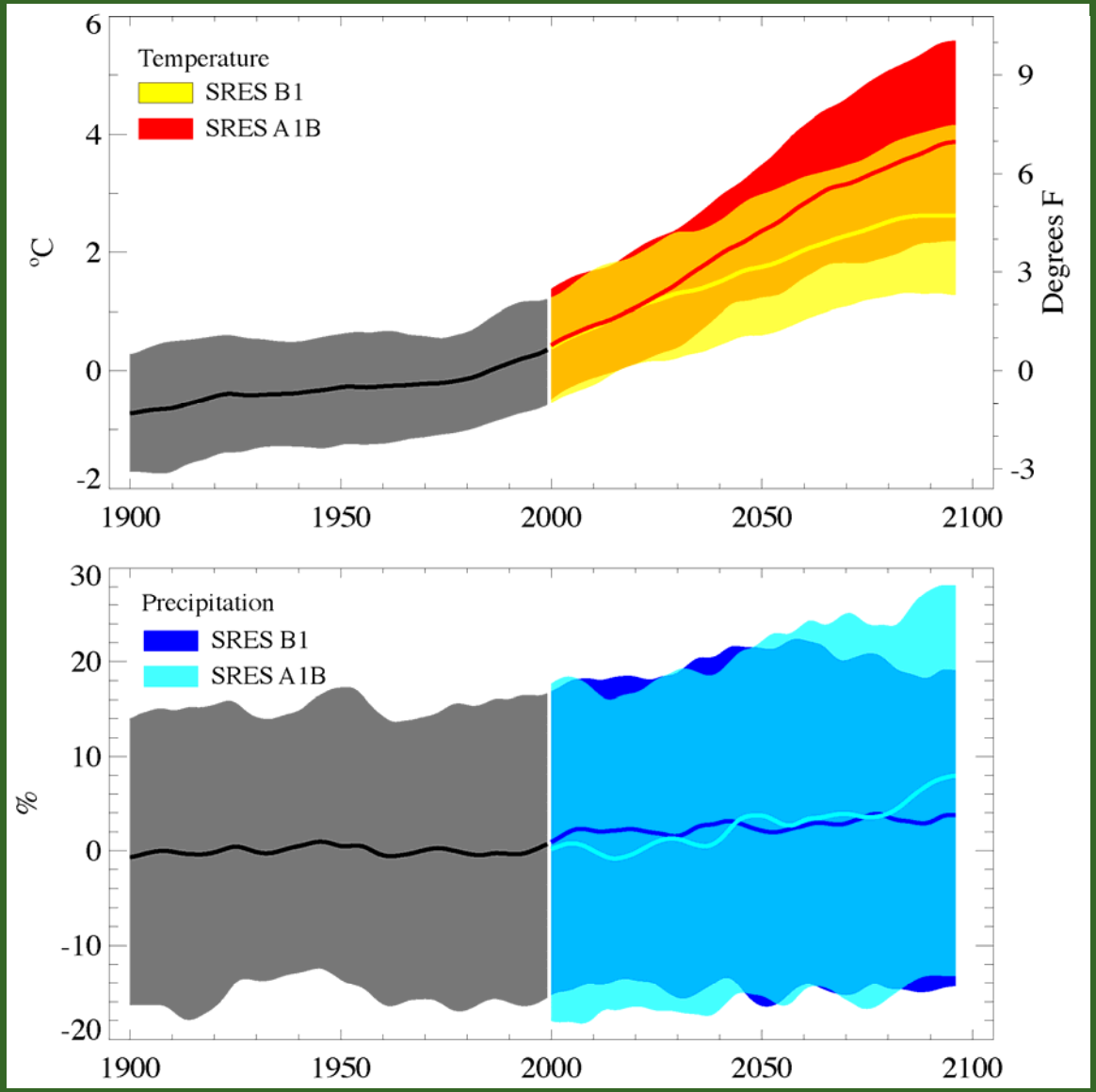
Adaptation



Salmon

Global Climate Change Scenarios for the PNW

21st Century Climate Impacts for the Pacific Northwest Region



Mote, P.W. and E. P. Salathe Jr., 2009: Future climate in the Pacific Northwest

Part I: The Columbia River Hydro System

- Supplies 70% of the Region's Electricity
- Is primarily responsible for the relatively low cost of energy in the PNW
- Strongly affects local energy supplies in WA
- Strongly influenced by climate

Snapshot of Snohomish Co. PUD

Customers (a/o 12-31-07)

- Residential: 283,927
- Commercial: 28,446
- Industrial: 78
- Other (street lighting, temporary lighting, etc.): 316
- Total Customers: 312,767

Generating capacity (Jackson Hydroelectric Project, Everett Cogeneration Facility): 164 megawatts (MW)

Average number of employees (a/o 12-31-07): 881

Energy sales (a/o 12-31-07): 8,255,135 megawatt-hours (MWh)

Operating revenues (a/o 12-31-07): $596,174,000

2007 Power purchases:

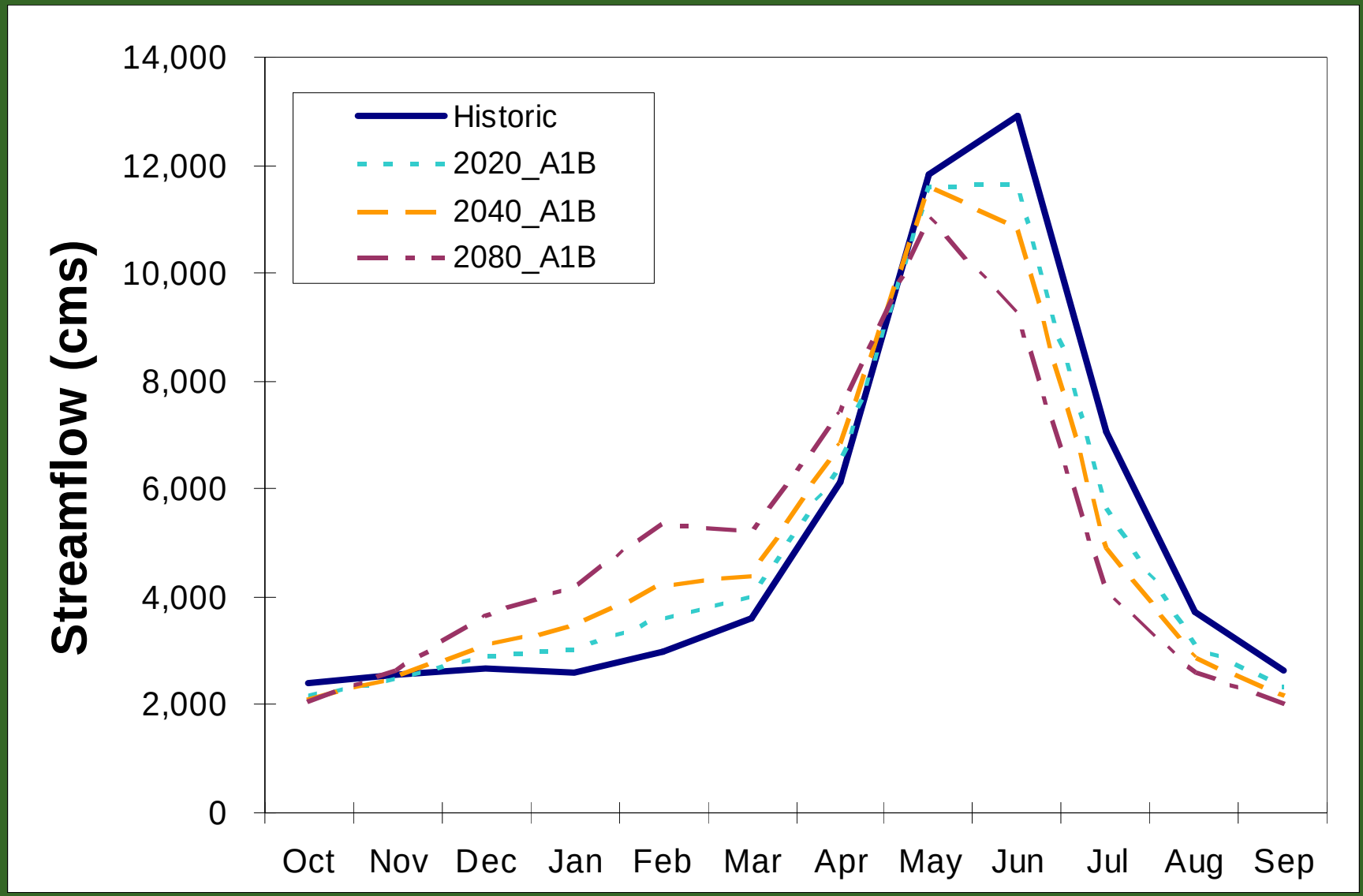
Bonneville Power Administration	88%
Jackson Project	5%
Long-term Contract Purchases	3%
Market Purchases (Net)	2%
Everett Cogeneration & Hampton	1%
Klickitat Landfill Gas	1%

2007 Fuel mix:

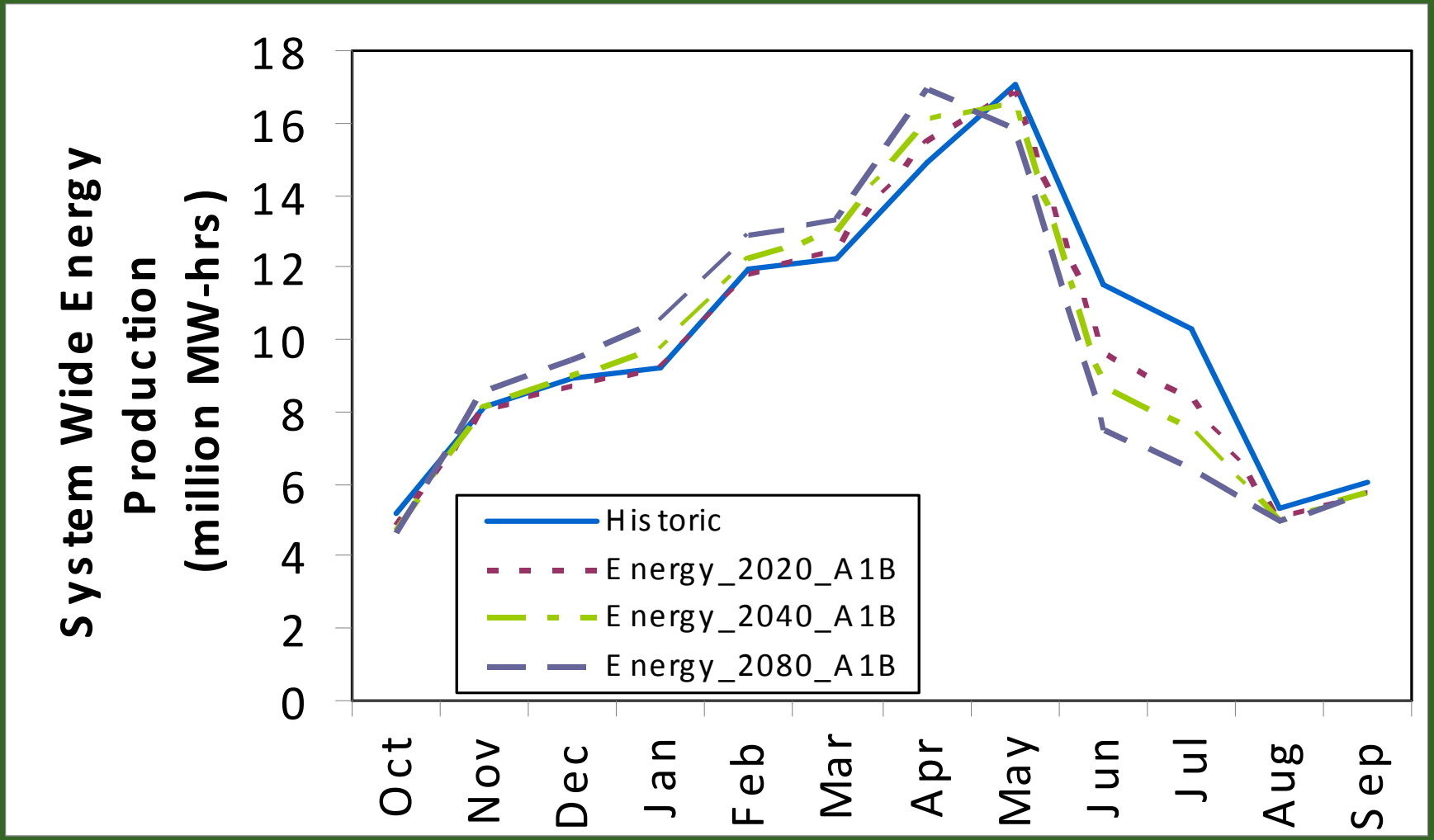
Washington state law requires utilities to publish their fuel mix for customers. The chart below indicates the types of fuel sources the PUD used during 2007:

Biomass	1%
Coal	6%
Hydroelectric Generation	81%
Natural Gas Generation	2%
Nuclear Generation (BPA-supplied)	9%
Other Generation	1%

Changes in Modified Flow in the Columbia River at The Dalles, OR



Streamflow Timing Shifts in the Columbia River Will Impact Regional Electrical Energy Production



Hamlet et al., 2009: Effects of Projected Climate Change on Energy Supply and Demand in the Pacific Northwest and Washington State

Conclusions:

•2020s: regional hydropower production is projected to increase by 0.5-4% in winter, decrease by 9-11% in summer, with annual reductions of 1-4%.

•2040s: hydropower production is projected to increase by 4.0-4.2% in winter, decrease by about 13-16% in summer, with annual reductions of about 2.5-4.0%.

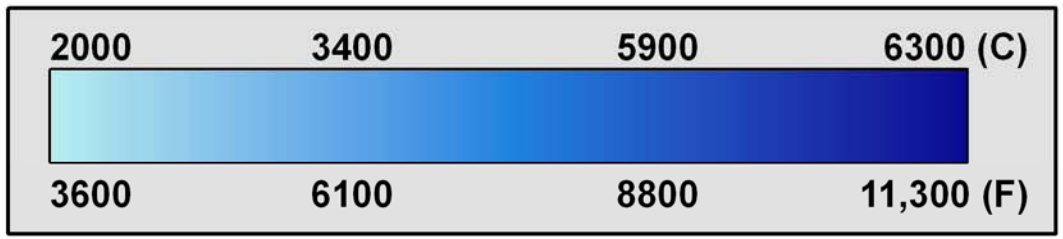
•2080s: hydropower production is projected to increase by 7-10% in winter, decrease by about 18-21% in summer, with annual reductions of 3.0-3.5%.

•The largest and most robust changes in hydropower production are projected to occur from June-Sept, during the peak air conditioning season.

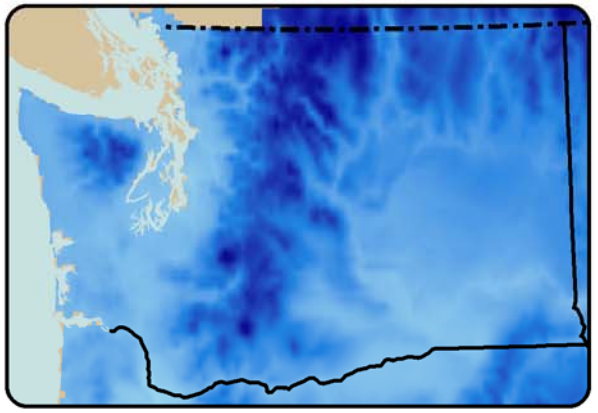
Part II: Changes in Primary Energy Demand for Space Heating and Cooling Needs

- Is a fundamental driver of residential and light commercial energy demand
- Strongly influenced by climate via temperature (heating and cooling degree days)
- Has important implications for individuals, utilities, and high-level planning at the regional and state level

Heating Degree Days



Historical

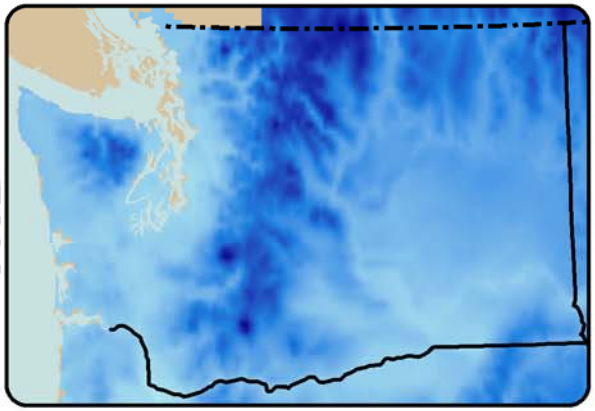


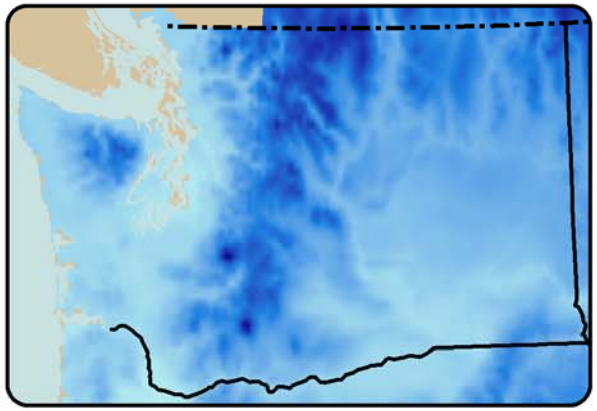
2020s

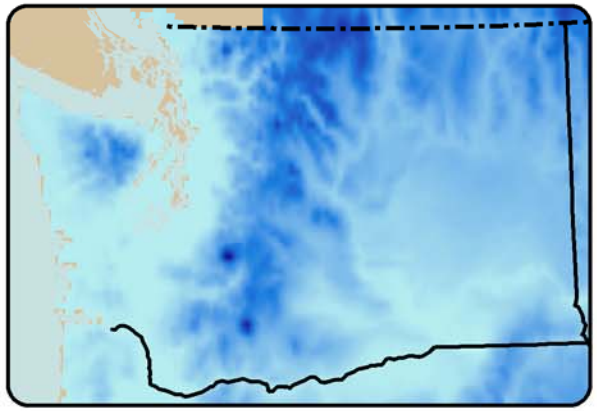
2040s

2080s

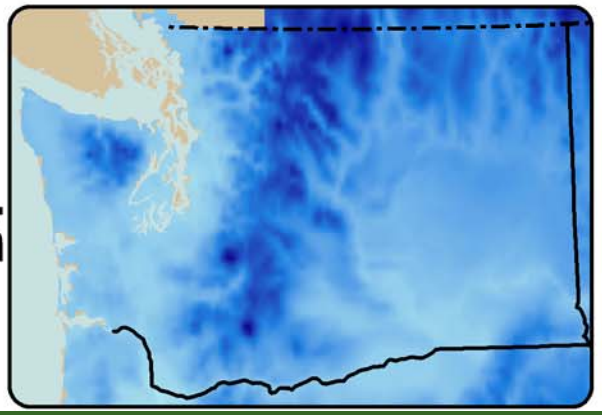
A1B

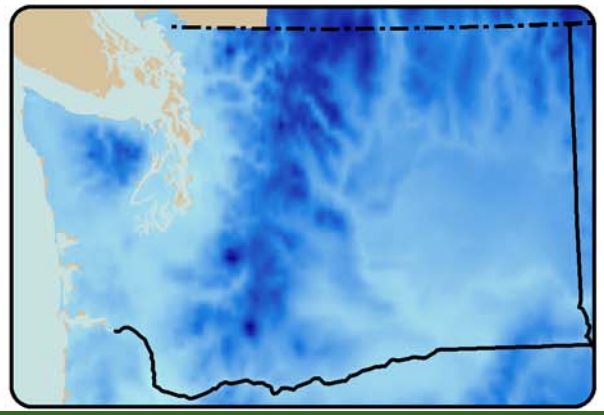


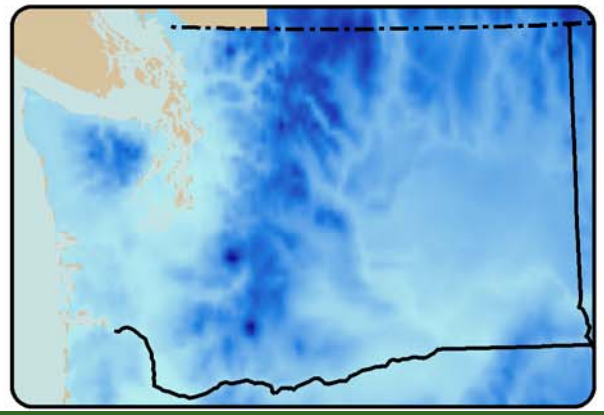


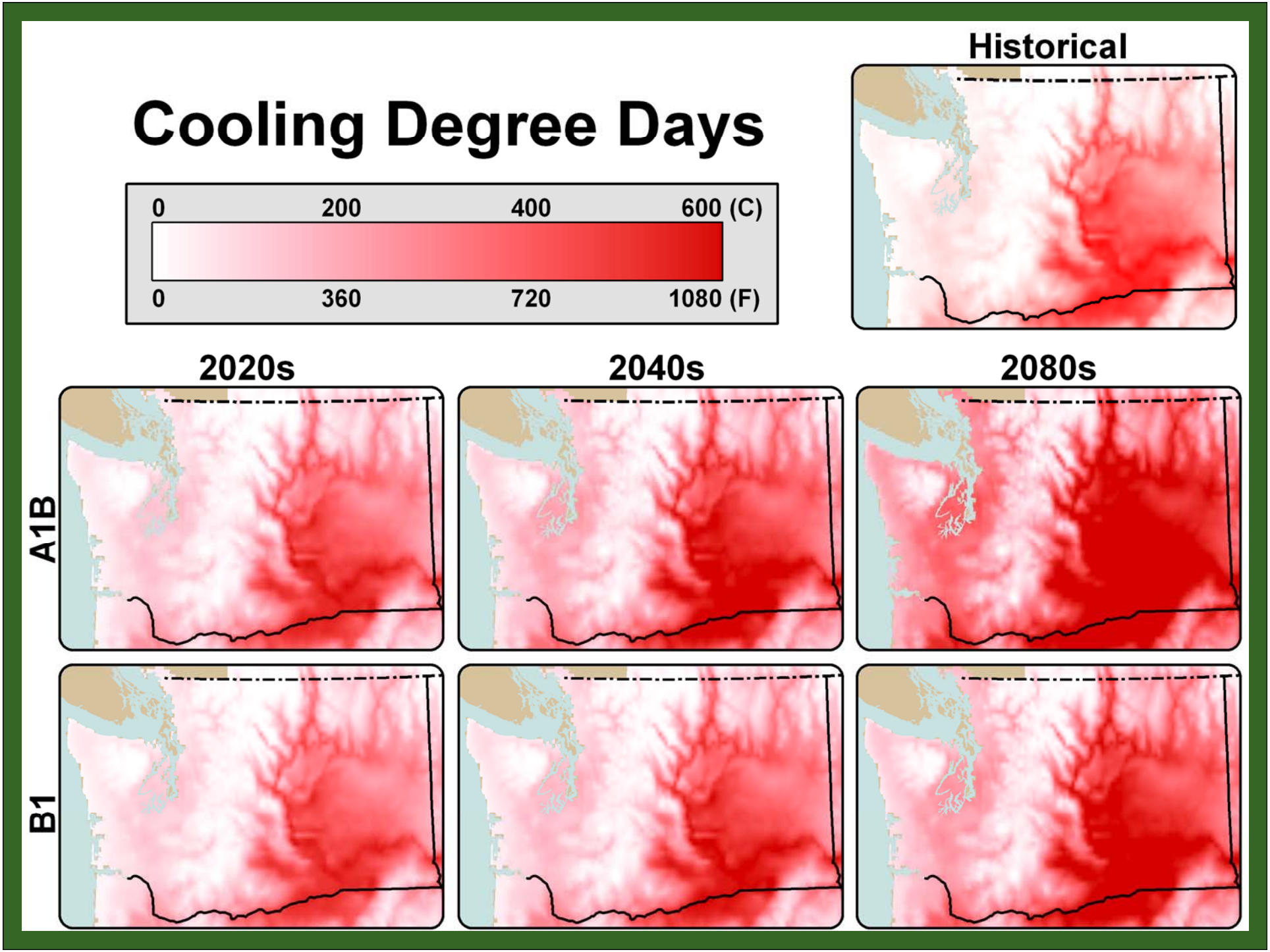


B1








Cooling Degree Days
0
200
400
600 (C)
0
360
720
1080 (F)
Historical
2020s
2040s
2080s
A1B
B1

Relationship Between CDD and A/C_Pen

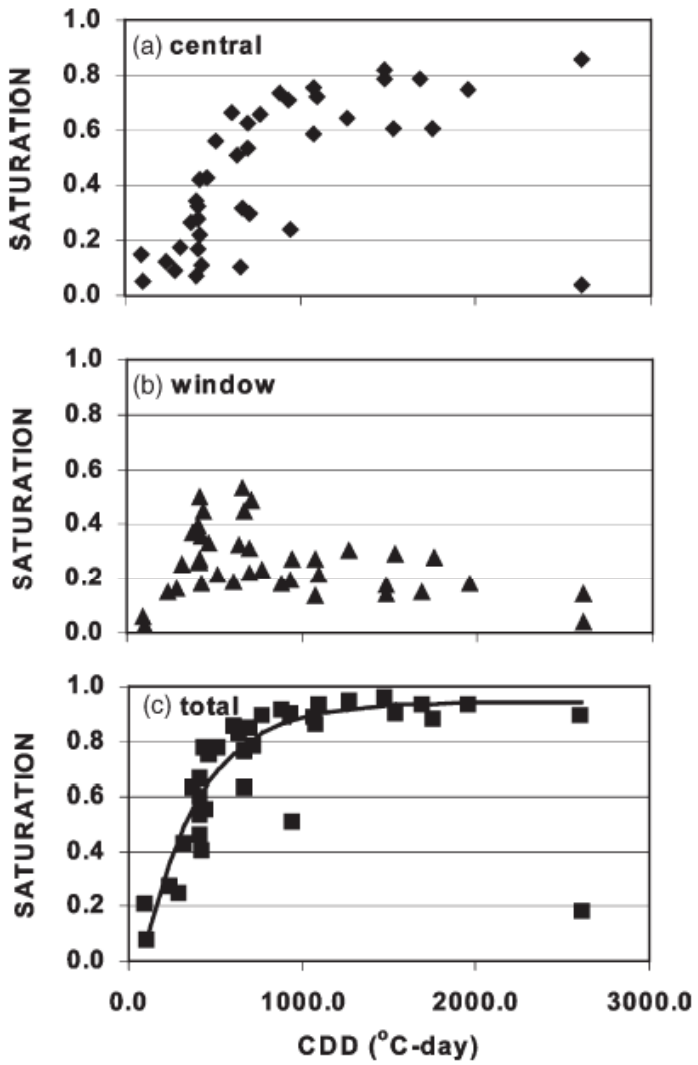
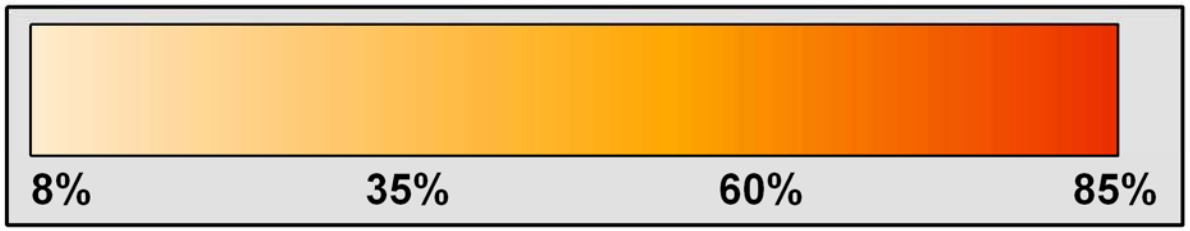
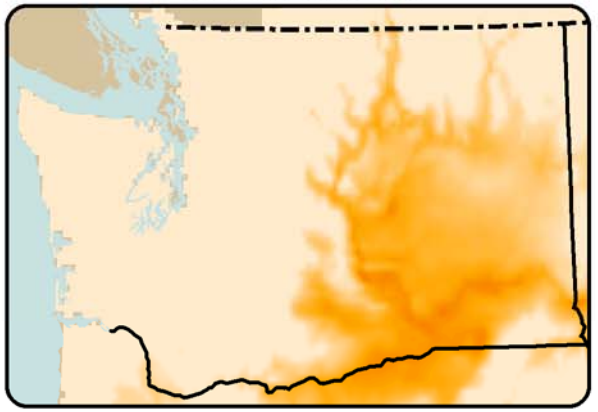


Fig. 1. Residential market saturation for (a) window, (b) central, and (c) combined implementations of air conditioning for 40 US cities. The curve fit in (c) is defined by Eq. (4) and excludes the outlier city of Honolulu.

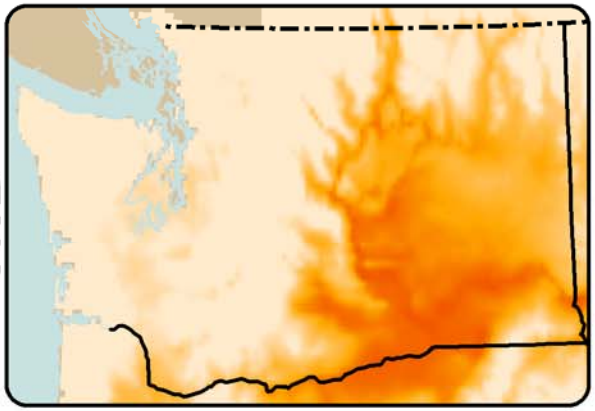
Air Conditioning Market Penetration



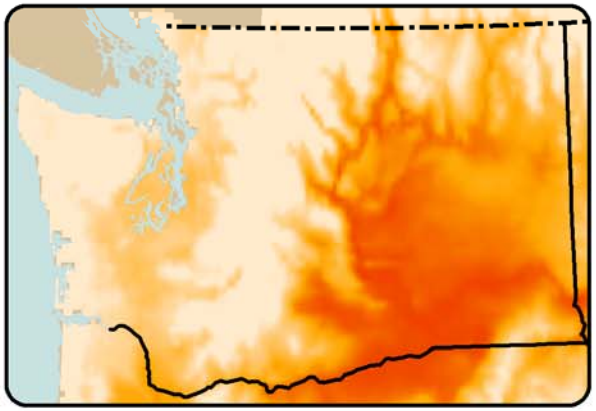
Historical



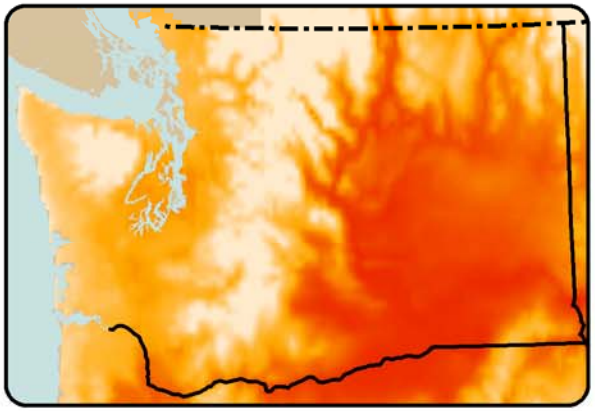
2020s



2040s

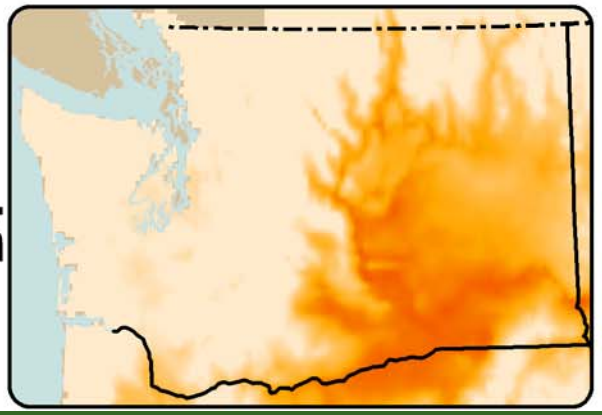


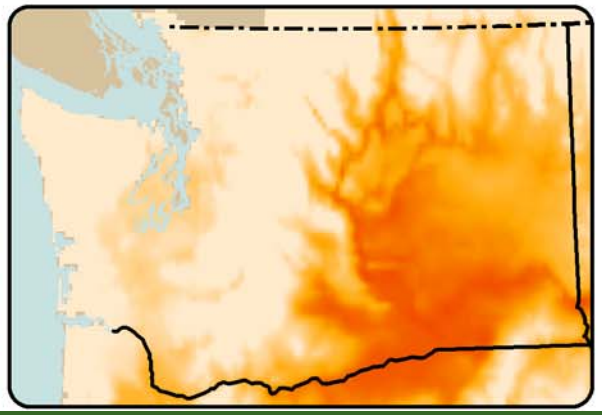
2080s

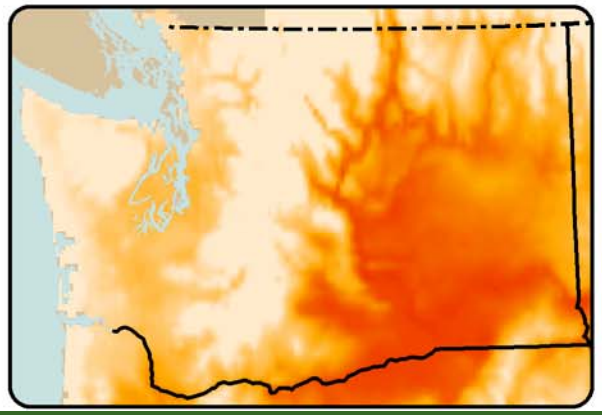


A1B

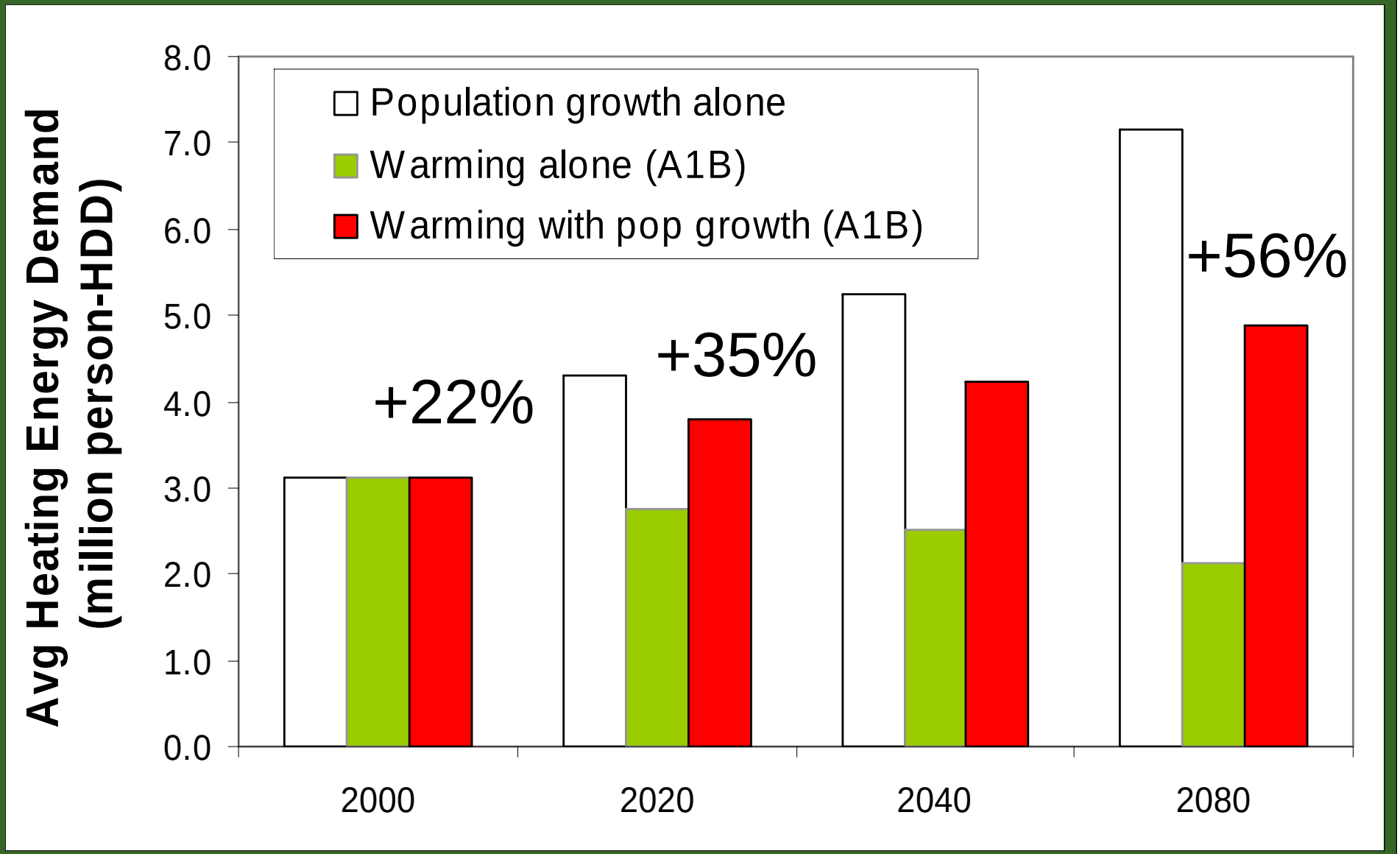
B1



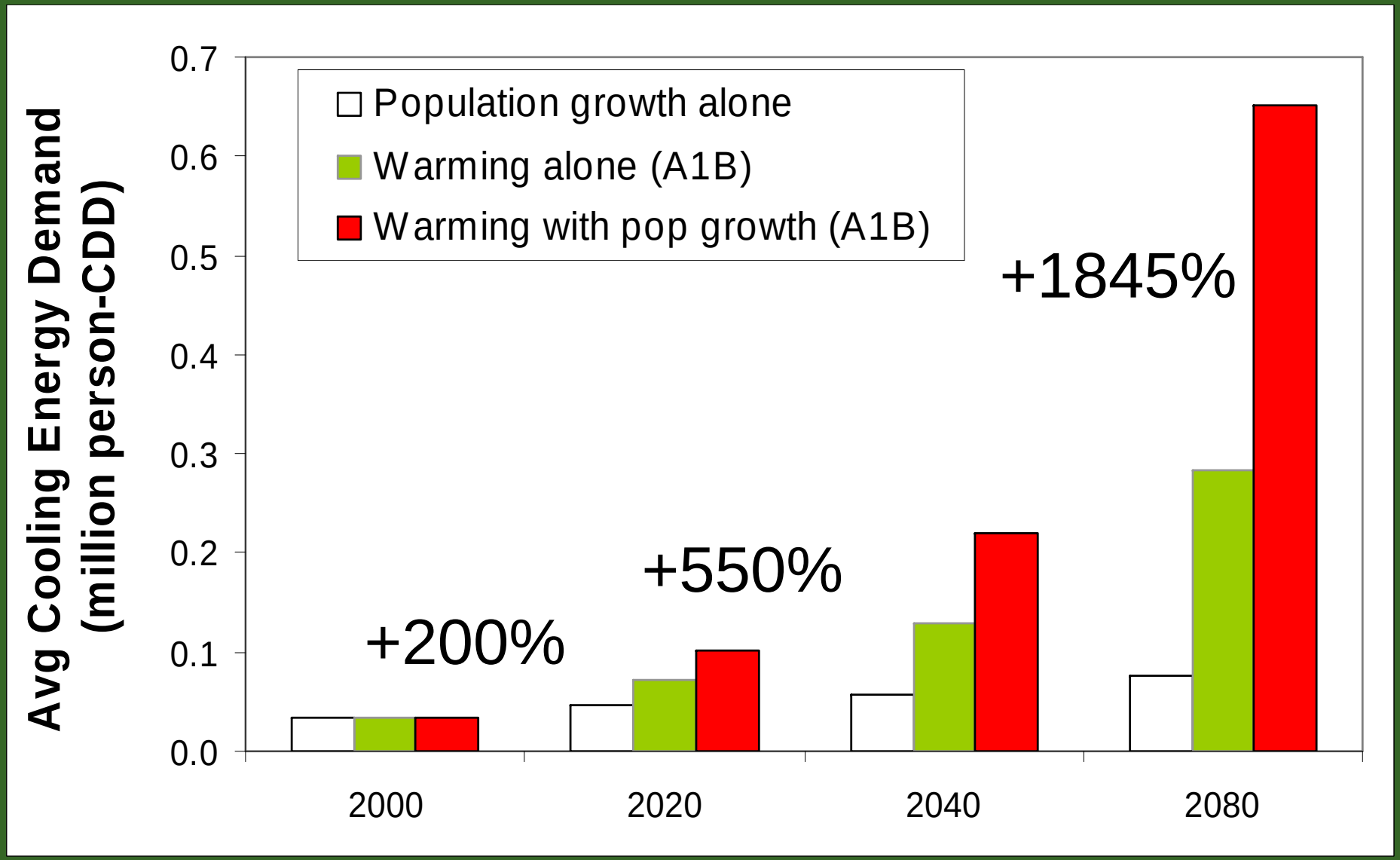




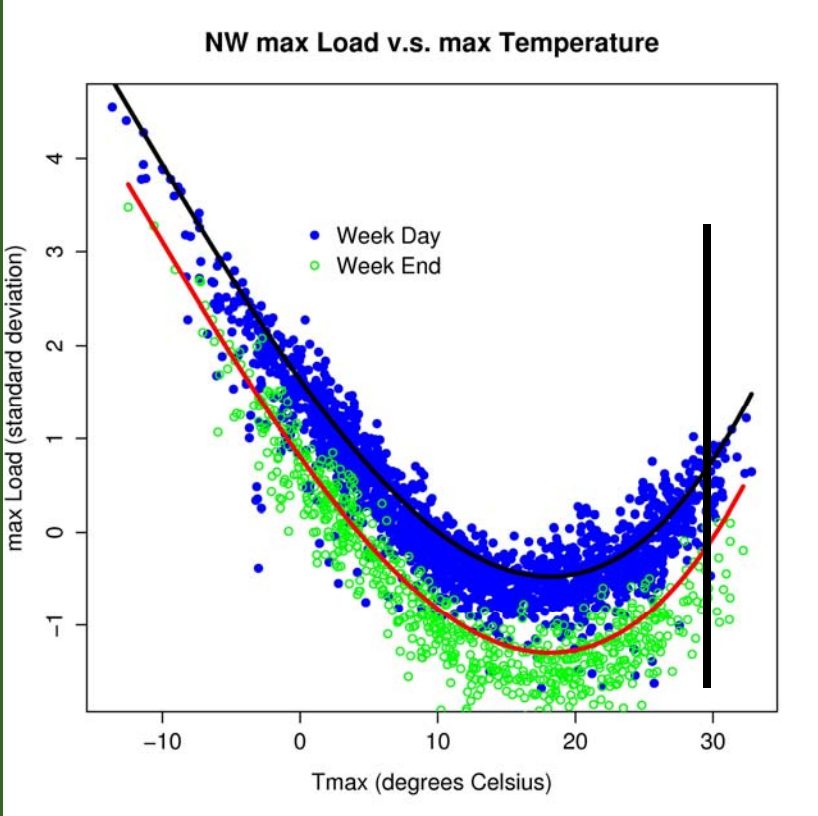
Changes in Heating Energy Demand in WA

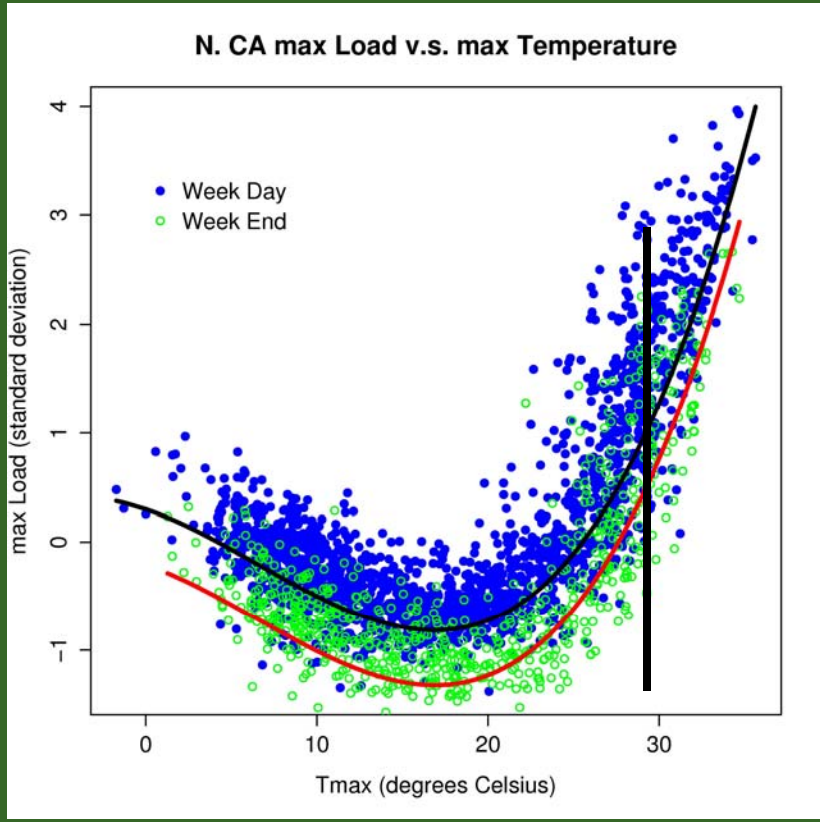


Changes in Residential Cooling Energy Demand in WA



Comparison of Peak Demand in the PNW and N. CA





Westerling A, Barnett T, Gershunov A, Hamlet AF, Lettenmaier DP, Lu N, Rosenberg E, Steinemann AC (2008) Climate forecasts for improving management of energy and hydropower resources in the western U.S., California Energy Commission, PIER Energy-Related Environmental Research Program. CEC-500-2008-XXX

Conclusions

- Despite decreasing heating degree days with projected warming, annual heating energy demand is projected to increase due to population growth.

- Residential and commercial cooling energy demand is projected to increase rapidly due to increasing population, increasing cooling degree days, and increasing use of air conditioning.

- Peak electrical demands in summer will likely increase due to increased population, CDD, and A/C penetration in the PNW.

Inter-Regional Coordination Issues:

The combination of losses of summer energy production from hydropower sources and increasing summer demand in the PNW are likely to reduce the ability to provide energy transfers to CA and the SW in spring and summer. Development of other energy source technology could potentially mitigate these impacts.

Depending on future energy development choices, changing climate could also increase excess capacity in CA in cool season in the future, which might facilitate increased transfers from CA to the PNW at that time of year.