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Modeling of Global-Warming and Urbanization Impacts on Summer Coastal California Climate Trends

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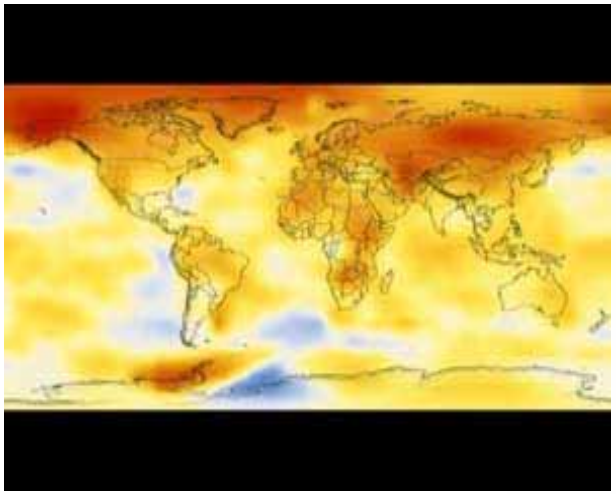
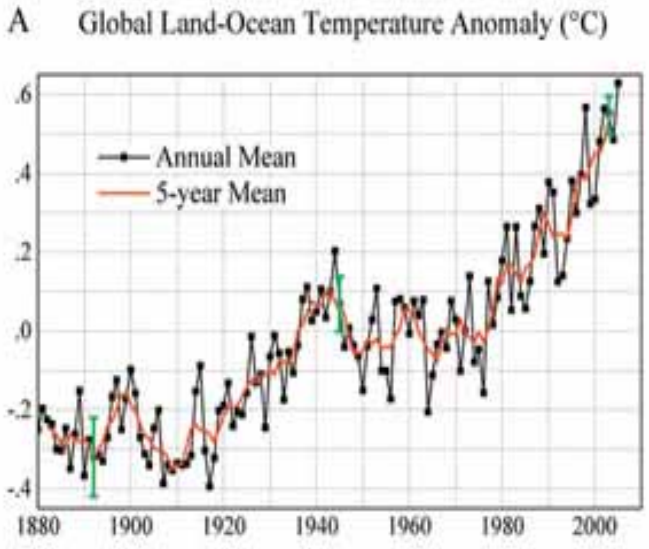
Outline and Motivation

Outline

- Motivation
- Observations
  - Spatial
  - Temporal
- Modeling
- Summary
- Ongoing Work

From NASA RESEARCH NEWS (2006), group led by James Hansen, GISS, NYC





- Earth has warmed approximately 0.2 K/decade for past 30 years, with max warming after 1970.
- Land temps has warmed faster than SSTs

Research Questions Hypothesis

1. **What is the relative climatic impacts of global climate change in urban coastal regions?**
2. **Under these conditions of LCLU and global climate change, what are the combined effects *in sea breezes, surface temperatures*, precipitation, and extreme events?**

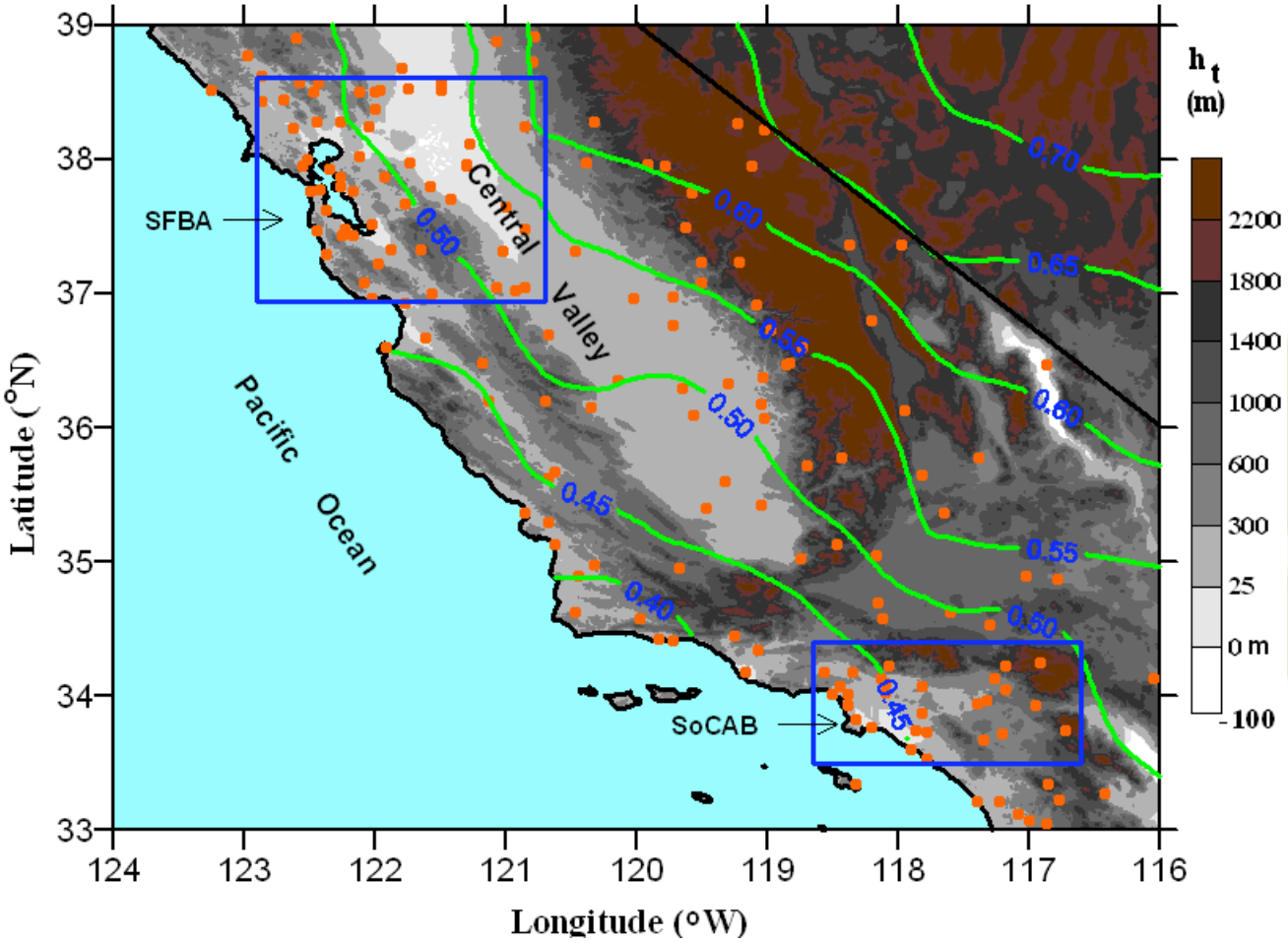
a. GHG WARMING/LULC

and/or

b. INCREASED INLAND WARMING → INCREASED HORIZONTAL T- & p-GRADIENTS (COAST TO INLAND)→ INCREASED SEA BREEZE: FREQ, INTENSITY, PENETRATION, &/OR DURATION → COASTAL REGIONS DOMINATED BY SEA BREEZE SHOULD THUS COOL DURING SUMMER DAYTIME PERIODS

Hypothesis

SCU (Maurer) statistically 10-km downscaled 1950-2000 modeled JJA temps (^{0}C) show total warming rates that decrease to coast (Dots are California NCDC sites & boxes are study sub-areas)



OBS. Result 1: Lebassi et al. (2009) J. of Climate

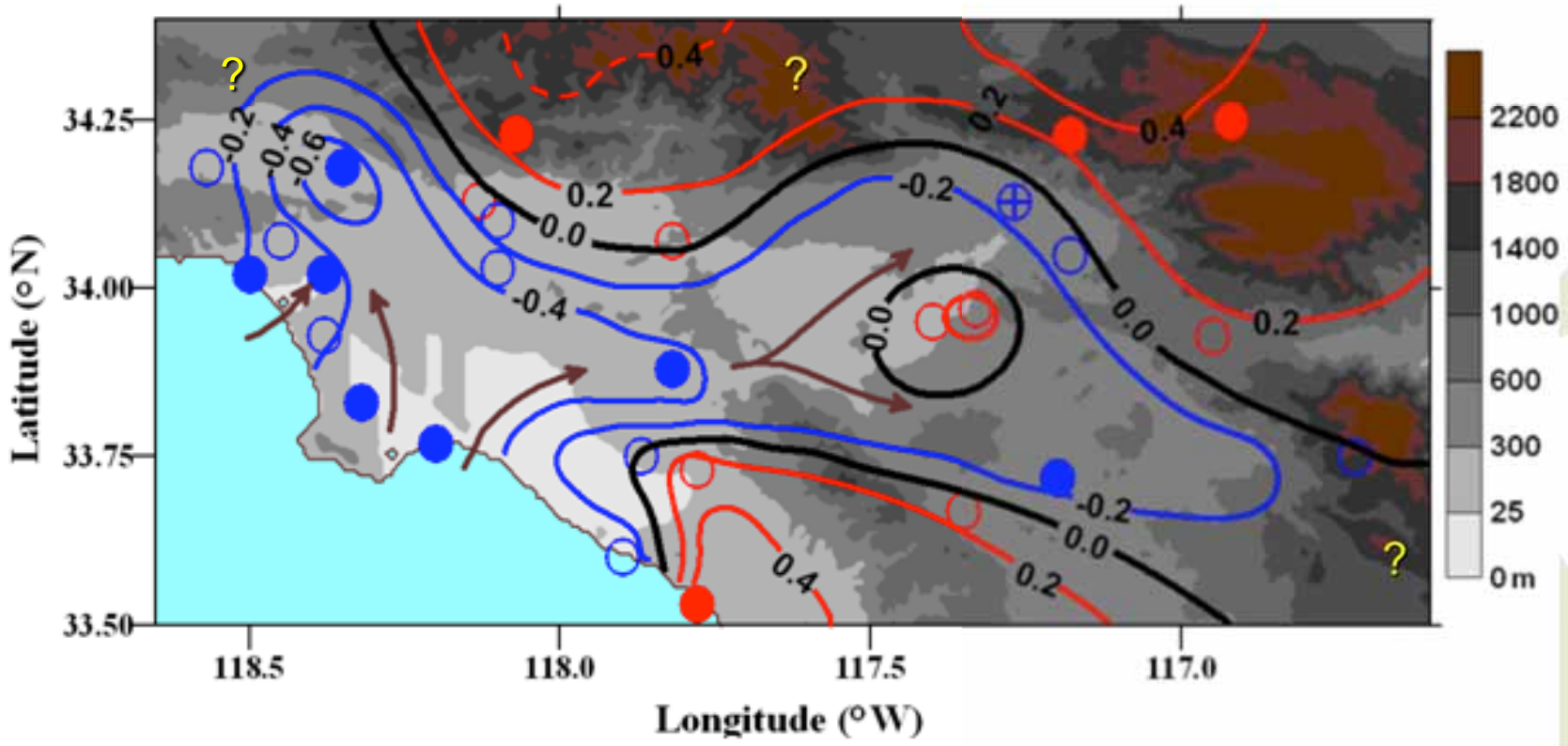
Observed 1970-2005 CA JJA max-Temp (^{0}C/decade) trends in SFBA & SoCAB (arrows = flow dd) show concurrent:

> low-elev. coastal-cooling (max away from coast)

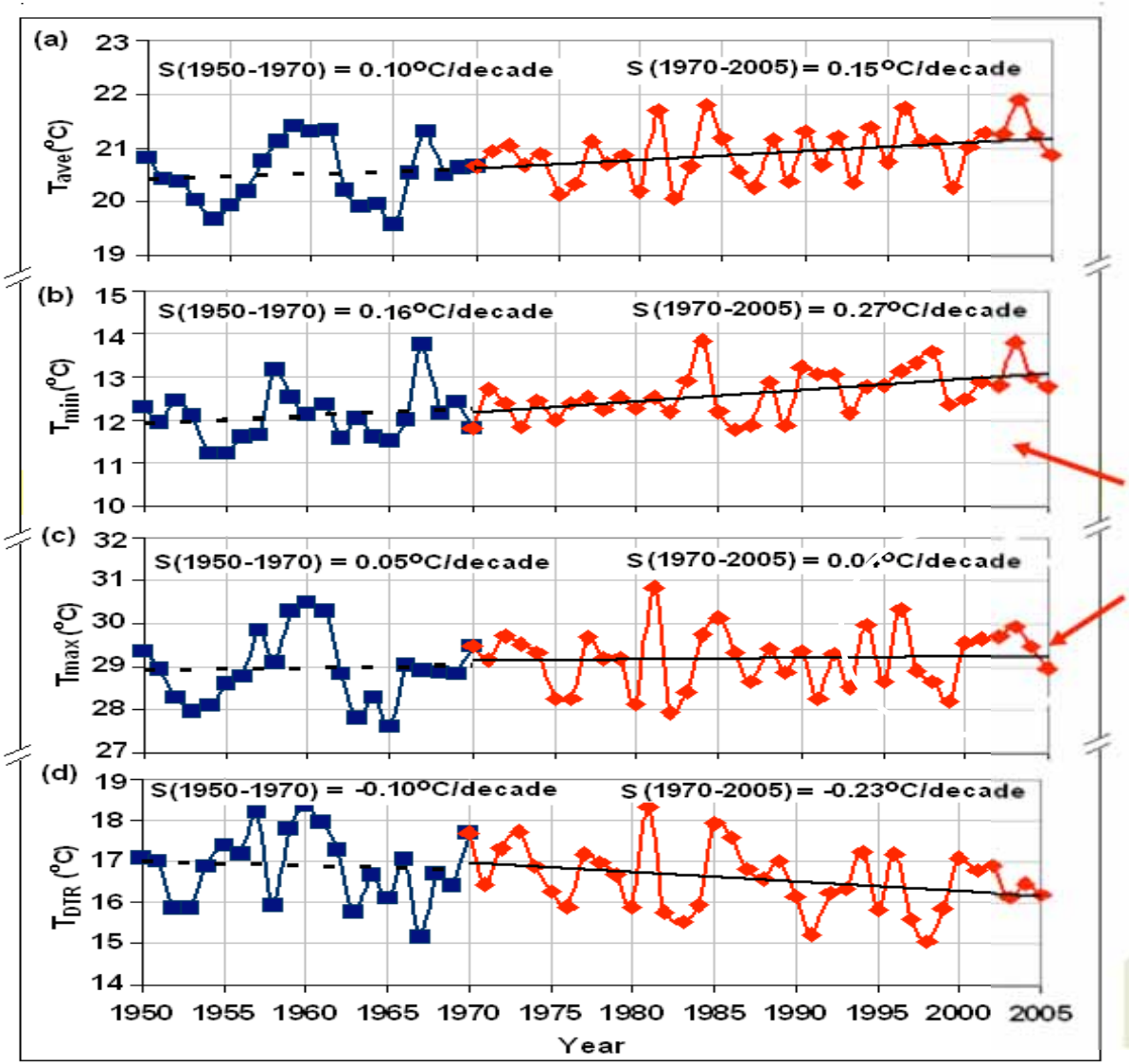
> high elev. & inland-warming

> ? = more data needed

> signif. levels: solid circles >99% & open circles <90%)



Results 2: All-California 1970-2005 JJA temperature trends (^{o}C decade^{-1})

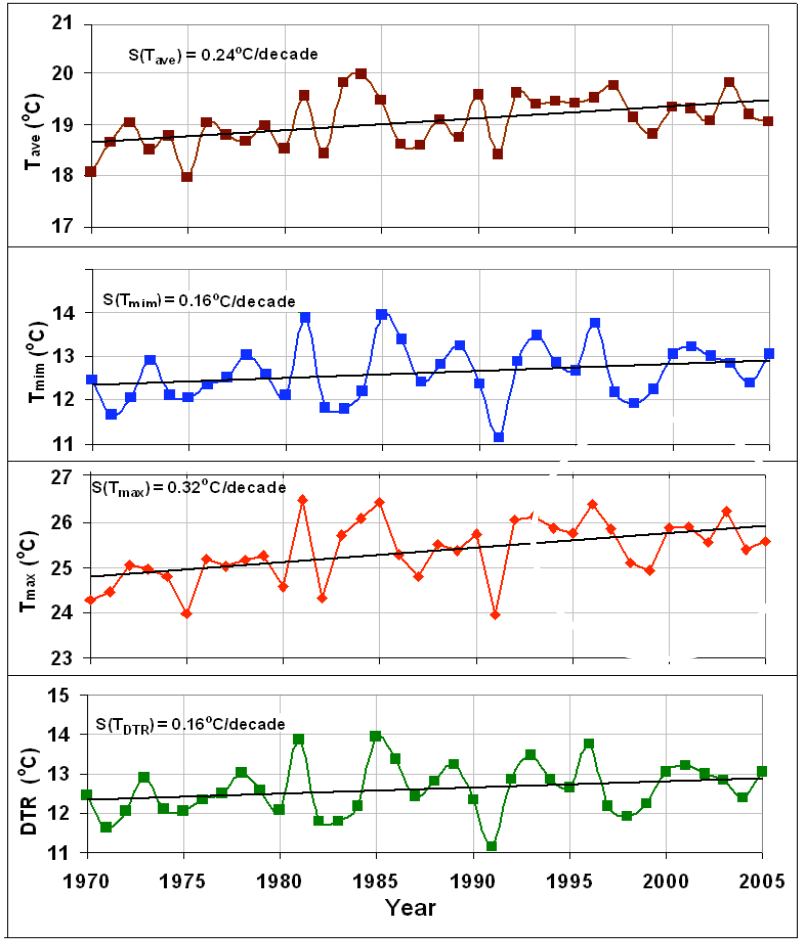


T_{min} (Curve b) increasing faster than T_{max} (Curve c), i.e., asymmetric warming in lit.

Results 3: Combined SFBA & SoCAB 1970-2005 JJA trends

Results: 35 years equals 1.05°C of cooling

Inland T_{max} warming sites



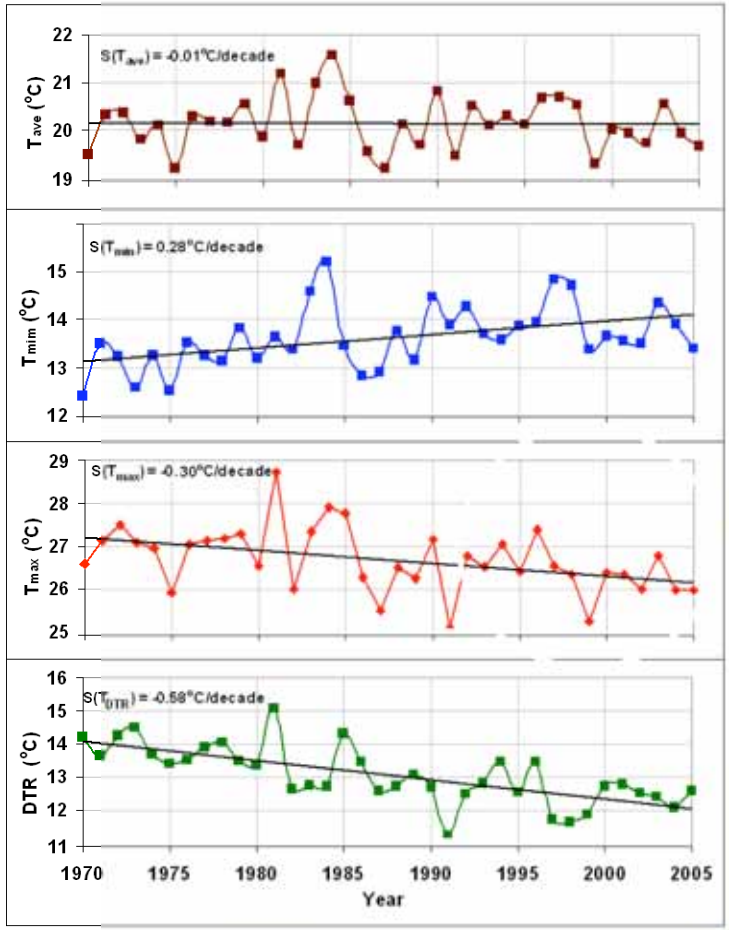
(a)

(b)

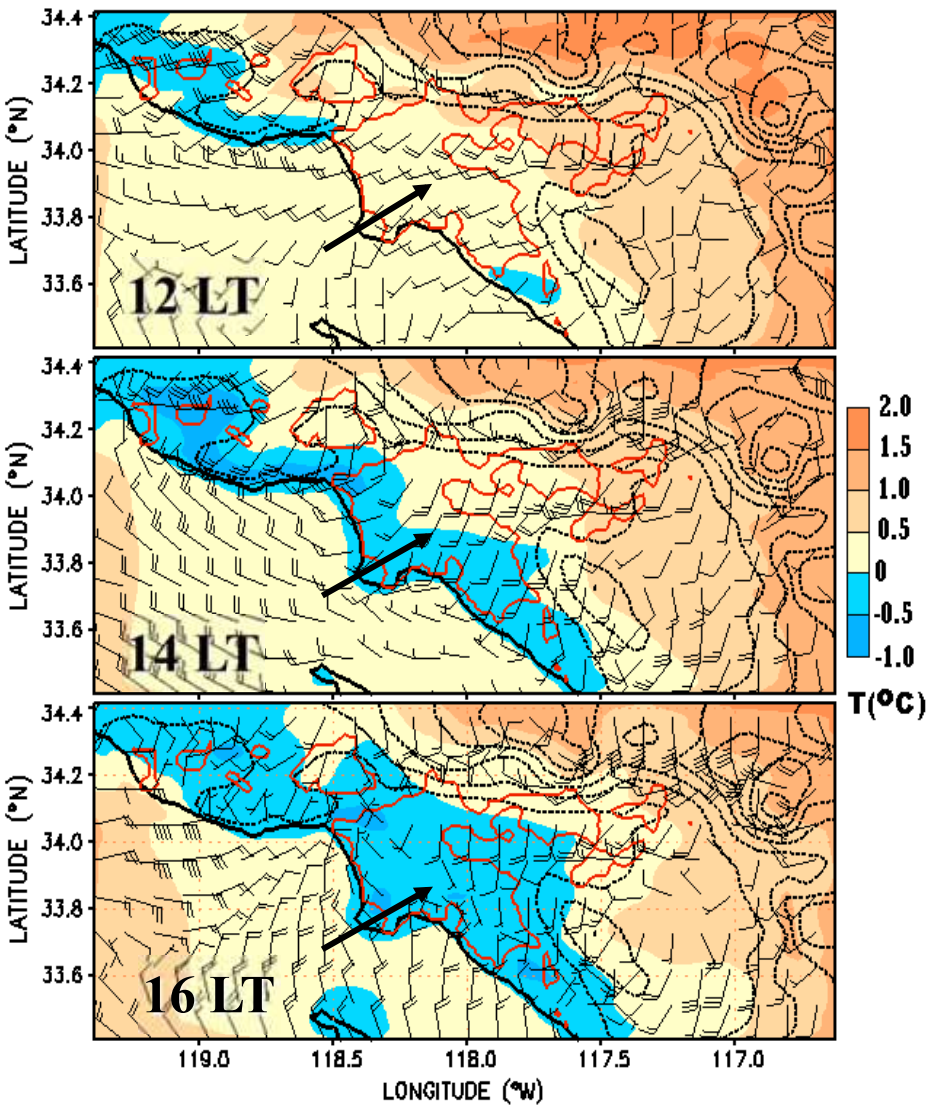
(c)

(d)

Coastal T_{max} cooling sites



Modeling Result



RAMS 5-year simulation-periods (JJA): past (1966-70) & present (2001-2005) have similar PDO- & temp-variations (below) → large-scale-variability effects eliminated

D-2 JJA-Ave Present minus Past
ΔT(°C) & ΔV (barb=0.5 m s^{-1})
Where red line=urban outline; LT local time

- **12 LT: SB better defined & coastal-cooling is in 2-parts**
- **14 LT: SB acceleration now visible & coastal- cooling is seen as stronger N of city**
- **16 LT: SB starts to slow offshore, but is still accelerating over city**

- **Peak coastal-cooling over 35-years of about 1.0°C matches observed trend of 0.3 °C/decade**

Summary and Implications

Observations:

SUMMER DAILY-AVE MAX-TEMPS HAVE
- COOLED IN LOW-ELEVATION COASTAL AREAS
- WARMED IN INLAND AREAS

Careful separation of :
summer vs. winter, day vs. night, inland vs. coastal, low vs. high elev, urban vs. rural, & pre- & post-1970 → to correctly capture trends in specific regions.

Modeling:

Increased global-warming (1970-2005) resulted in

> increased sea-breezes (up to 2 m/s) over ocean & coastal plane, & thus

> sea-breeze induced coastal-cooling (up to $1^{o}C$) over coastal-plane

matched (for both aerial extent & magnitude) matched our observations

Urbanization (results not shown) produced (relative to the global-warming case) a

> small UHI (up to $1^{0}C$) and a

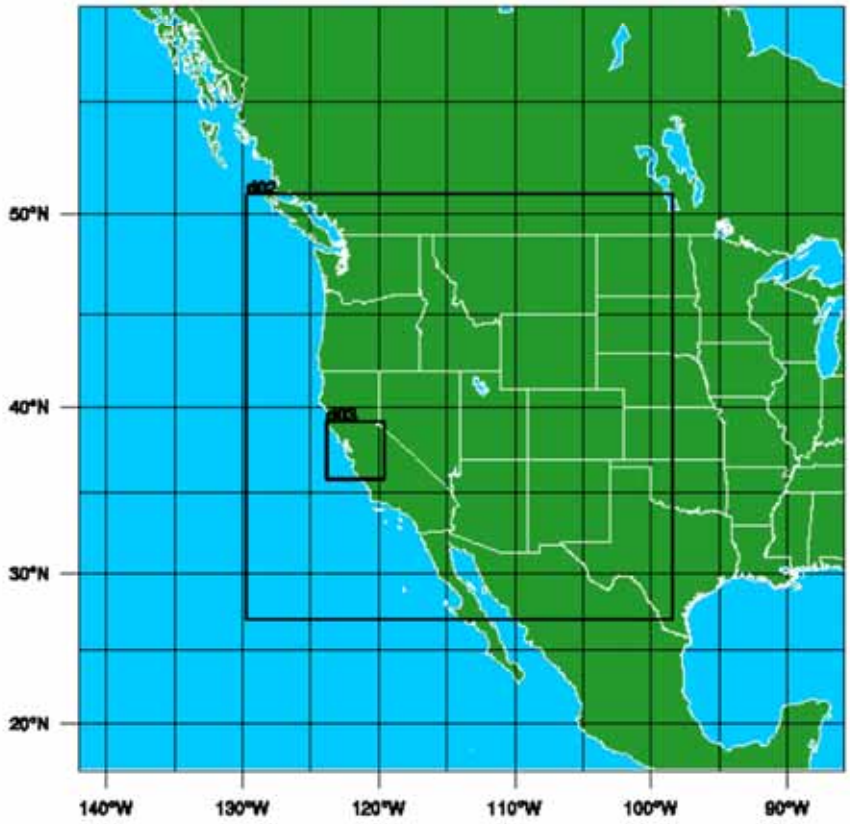
> large reduced sea-breeze penetration & intensity (up to 1.5 m/s) due to the larger urban-z_0

Implications: lower peaks of

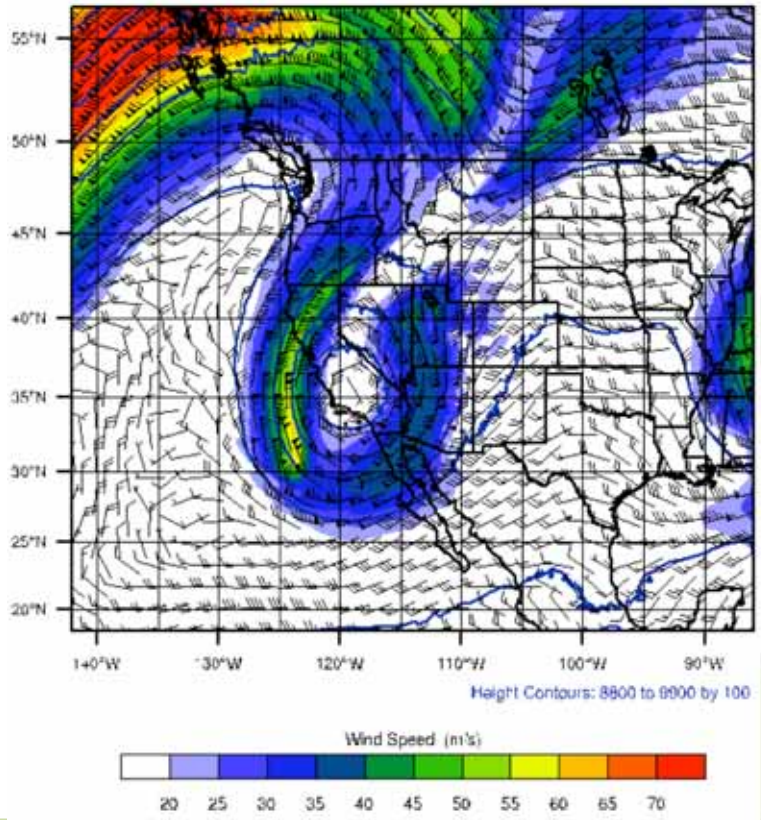
- energy-use for cooling
- heat-stress level
- O3 concentration
- vineyard- & redwood- damage

Ongoing Work

High Resolution Simulations using the Weather Research and Forecast (WRF) Model at resolution 1.3, 4, and 12 km for the area shown in the figure.



WRF simulations the the 300 mb Jet stream over the Western USA goal is to simulate 2 decades, which can potentially answer many outstanding scientific questions



Publications related to this work

Lebassi, B. H, J. E. González, and R. Bornstein, 2011a: Onshore and Offshore California Coastal-Cooling: General Circulation and Mesoscale Effects. (Under review by research group).

Lebassi, B. H, J. E. González, and R. Bornstein, 2011b: RAMS modeled differences between 1970 and 2005 summer daytime temperatures and winds in coastal Southern California. (Submitted to JGR).

Lebassi, B. H, J. E. González, D. Fabris, E. Maurer, N. L. Miller, C. Milesi, and R. Bornstein, 2009, Observed 1970-2005 cooling of summer daytime temperatures in coastal California, J. Clim., **22**, 3558-3573, doi:10.1175/2008JCLI2111.1.

Lebassi, B., J. E. Gonzalez, R. Bornstein, and, D. Fabris, (2010), Impacts of Climate Change in Degree Days and Energy Demand in Coastal California, J. Sol. Energy Eng, **132**, 031005, doi:10.1115/1.4001564

Lebassi, B., Observational and Modeling Study of Global Warming and Urbanization Impacts on Coastal California Climate, (2010), Ph.D. Thesis, 95 pp.

Lebassi B., D. Fabris, J. E. Gonzalez, S. Zarantonello, S. Chiappari, N. L. Miller, and R. Bornstein, 2005, Urban heat islands in California's Central Valley, AMS BAMS, pp. 1542-1543.

Thank You!