Global-warming reverse-impact: observed summer-daytime coastal-cooling in California air-basins

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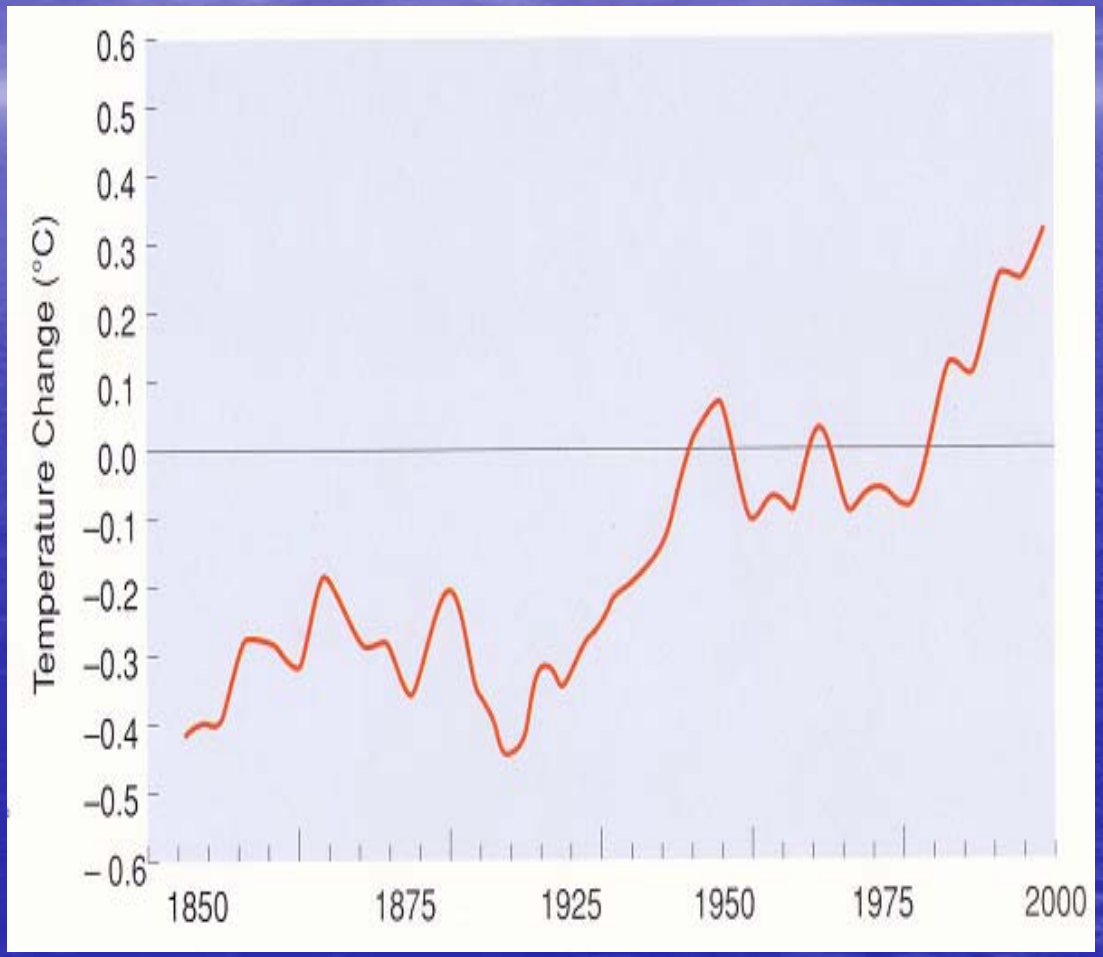
OUTLINE

- Global-warming → reverse impacts
- Coastal-cooling observations
  - Methodology
  - Results
    - South Coast Air Basin
    - SFBA and Central Valley
- Conclusion
  - Summary
  - Implications
- FUNDING: Santa Clara University

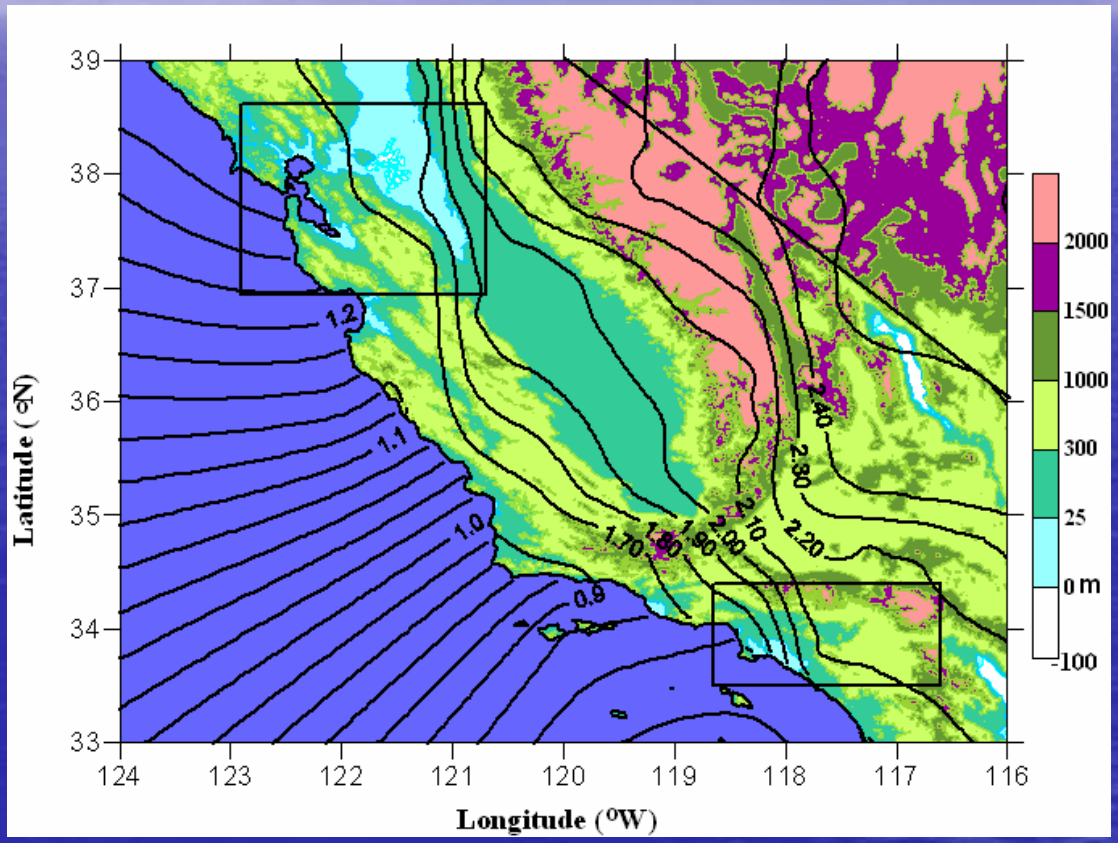
Global Warming

- Models: past & future asymmetric-warming (i.e., $\Delta T_{min} > \Delta T_{max}$) on
  - global scale (1.0-2.5 deg resolution)
  - regional scale (10 km resolution)
- Global scale obs
  - match model results
  - show accelerated-warming since '70s →



California Warming: JJA 1900-2000 Δ-T_{aver}(K)

- USC Stat-downscaled global-model results
  - 2-m AGL
  - 10-km horiz-grid
  - warming-rates decrease towards coast
- Coastal SSTs
  - ICOADS data
  - 2-deg horiz resolution
  - Warming, but
  - At slower rate than at inland sites



Reverse-Impact Hypothesis

INLAND WARMING →

INCREASED (COAST TO INLAND) $\partial(p,T)/\partial n$ →

INCREASED SEA BREEZE

FREQ, INTENSITY, PENETRATION, & DURATION →

COOLING SUMMER COASTAL T_{max}

San Francisco Chronicle

How S.F. Could Get Even Foggier

'Greenhouse Effect' Could Backfire

By Charles Petit
Chronicle Science Writer

Notions that global warming from the "greenhouse effect" might bring balmy summers to San Francisco beaches got a dash of cold water this week.

A government oceanographer says a warmer Earth will make it even colder and foggier along Northern California's coast and that the trend may already have started here and in similar coastal regions in Spain, Morocco and Peru.

Hotter weather in the Central Valley might mean higher winds along the coast. The wind would stimulate upwelling of the cold water and onshore breezes that make the region's famous fogs, reports Andrew Bakun in today's issue of the journal Science.

Bakun is a physical oceanographer and chief of the Pacific Fisheries Environmental Group, a 12-person research laboratory operated by the National Oceanic and Atmospheric Administration in Monterey.

In an interview, Bakun emphasized that his projection cannot calculate just how much foggier it may get. He also said he could easily turn out to be wrong — just as widely accepted predictions that the Earth on average will warm by 3 to 9 degrees Fahrenheit in the next century may also turn out wrong.

But, he said, the main point is that even if the greenhouse scenario is correct for the planet on average, "it is a mistake to think that means it will warm up everywhere. There are very good reasons to think it will be colder here, at least in summer."

He also suspects that the summer fog season would start earlier in the season and end later.

Summer fog streams regularly across California's coast, most intensely between Point Conception northward into Oregon, because of several factors.

The chief ones are upwellings of deep, cold ocean water to the surface along the shore and breezes that draw relatively warm, humid air inland. The combination of chilling from the upwelling water, and land that forces the air upward, causes fog to condense from the air.

Although measurements are not precise, data suggest that winds have already started picking up along California's coast. Studies of wind stress — the amount that winds push surface currents — show a roughly upward trend since about 1945. This is during a time that some climatologists believe they have detected a slight warming of the Earth. Similar trends appear under way off the coasts of Peru, Spain and Morocco where local fog conditions resemble those of Northern California.

Upwelling causes both the frigid swimming conditions along Northern California's beaches, as well as the good fishing. The deep waters carry nutrients that support much of the shallow marine life of California.

A fisheries specialists, Bak not sure that more intense u ing would improve fishing. " would be more nutrients, bu will also have more rapid exp these nutrients offshore, and wind means more turbulence.

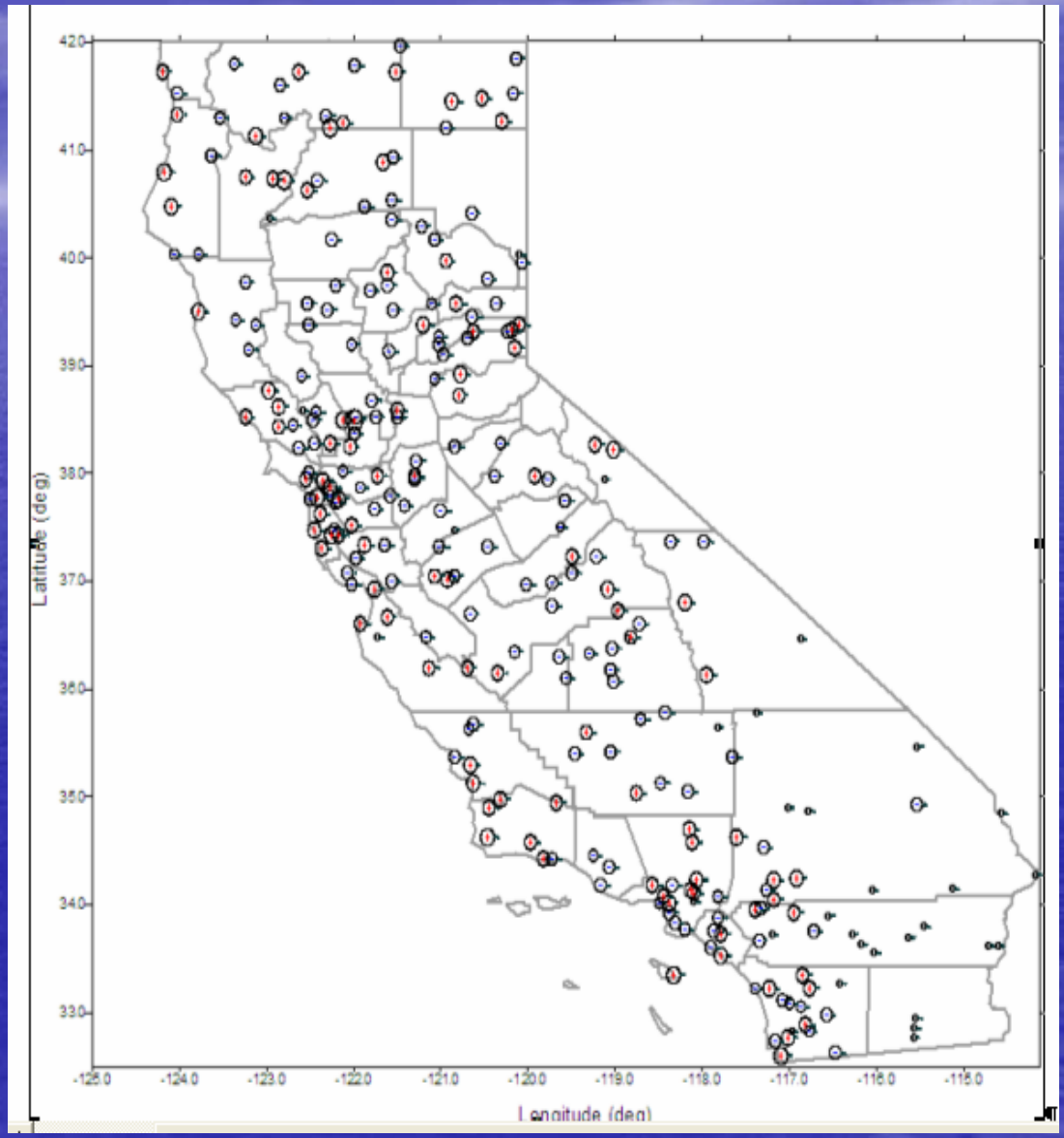
WHY 'GREENHOUSE EFFECT' MAY MEAN MORE COASTAL FOG

Heat in the Central Valley creates a weather cycle that promotes fog along the coast, which drifts inland and cools things down. If the "greenhouse effect" makes the Central Valley hotter, the whole process could produce more fog.

Source: National Oceanic and Atmospheric Administration

CALIF TEMP-DATA

- FROM NCDC
- 2-m VALUES
- DAILY T_{MAX} & T_{MIN}
- 300 NWS CO-OP SITES
- 1948-2005

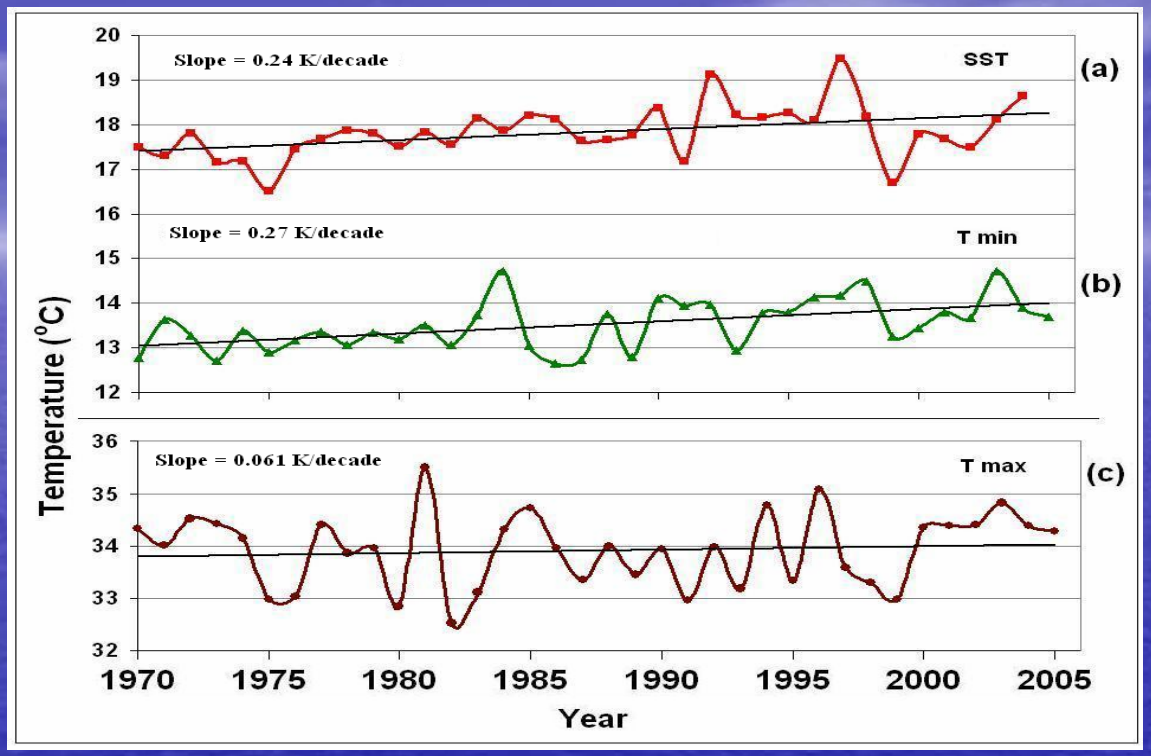


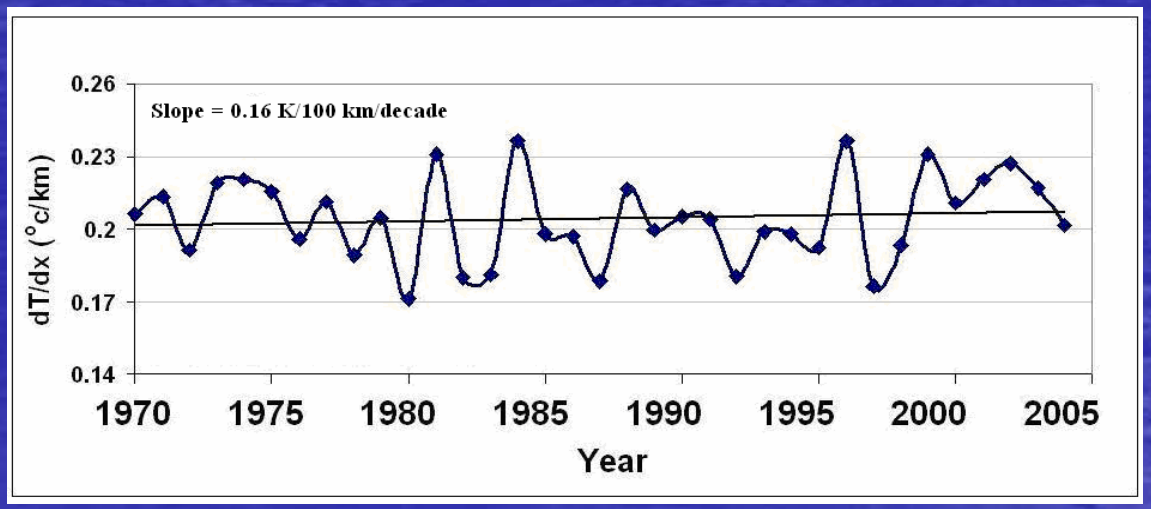
ANALYSES

- 1970-2005 data
- Annual & summer warming/ cooling trends (K/decade) for SST, T_{max}, T_{min}
- Spatial dist of summer T_{max}-trends plotted (in 2 black boxes)
  - South Coast Air Basin
  - SFBA and Central Valley
- Summer land-sea T_{aver}-grad (surrogate for p-grad) trend calculated by use of
  - SST: SFBA black-box ocean
  - 2-m land-values: red-box

Calif Asymmetric-Warming: 1970-2005

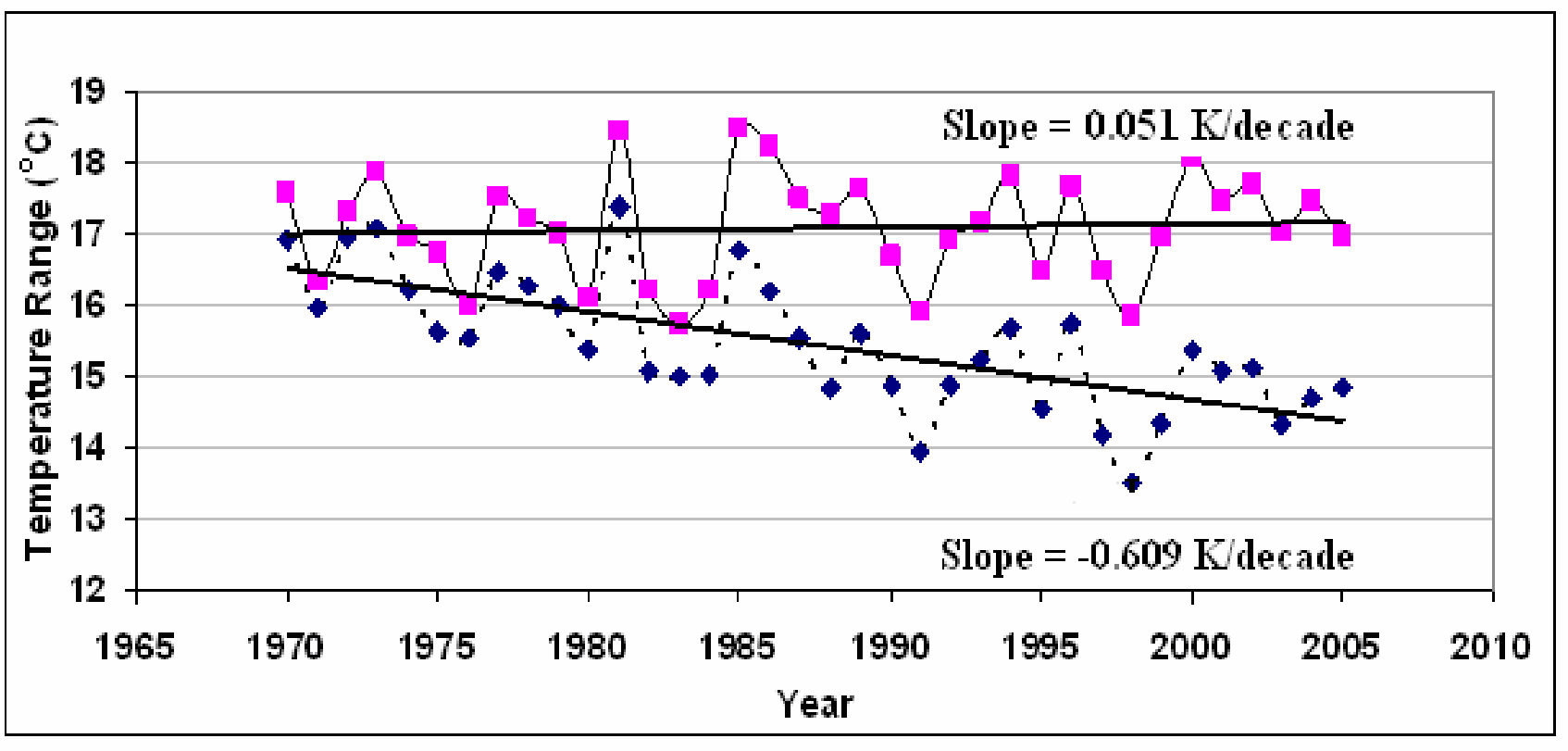
- Middle curve (T_{min})= 0.27 K/decade
- Lower curve (T_{max})= 0.061 K/decade (small-Δ b/t 2 large nos.)
- Top curve (SST)= 0.24 K/decade
  ****
- Thus, from T_{aver} & SST: Right curve (T-grad)= 0.16 K/100-km/decade → stronger sea breeze



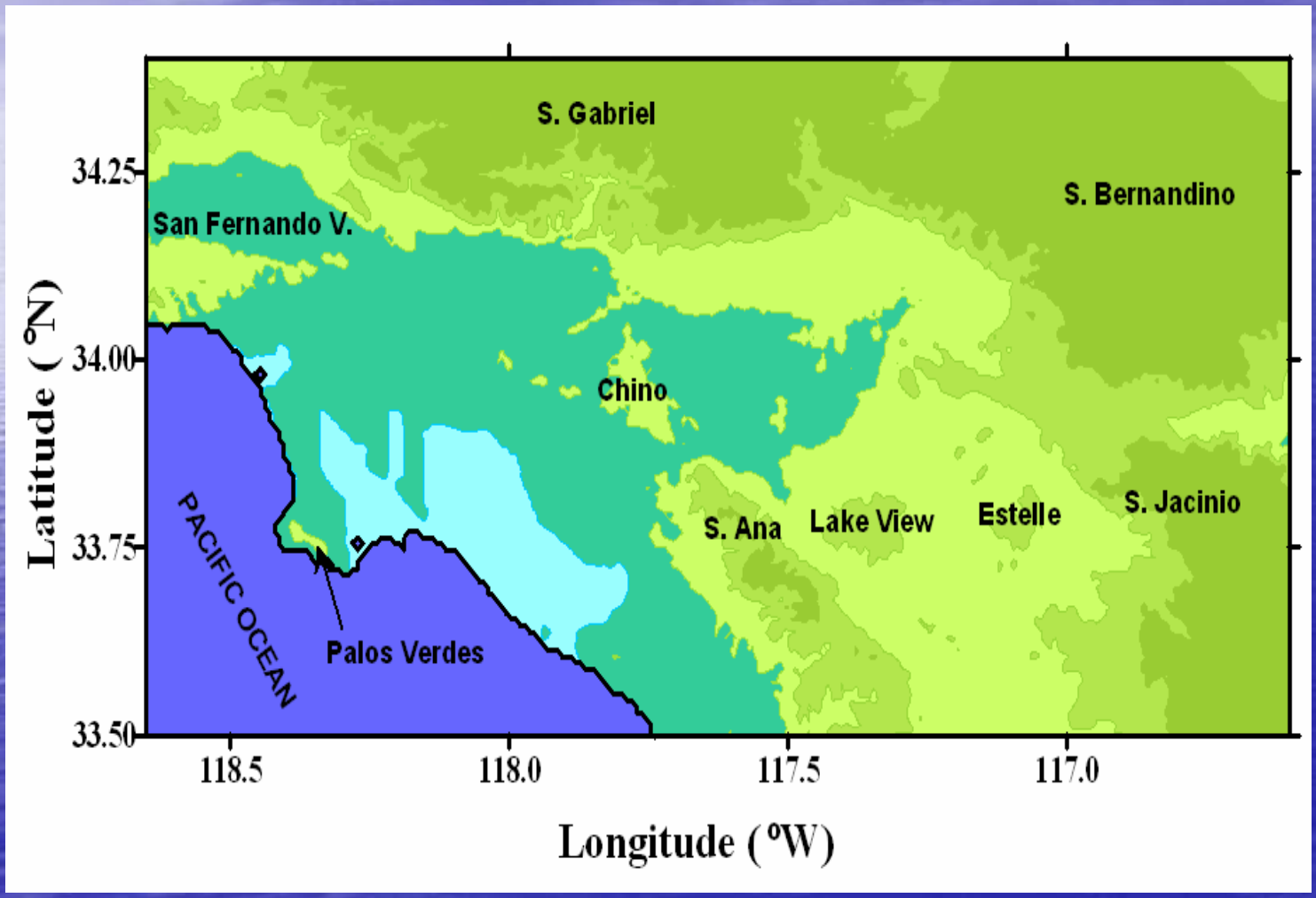


Changes in Diurnal temperature-range (DTR) values: all of Calif

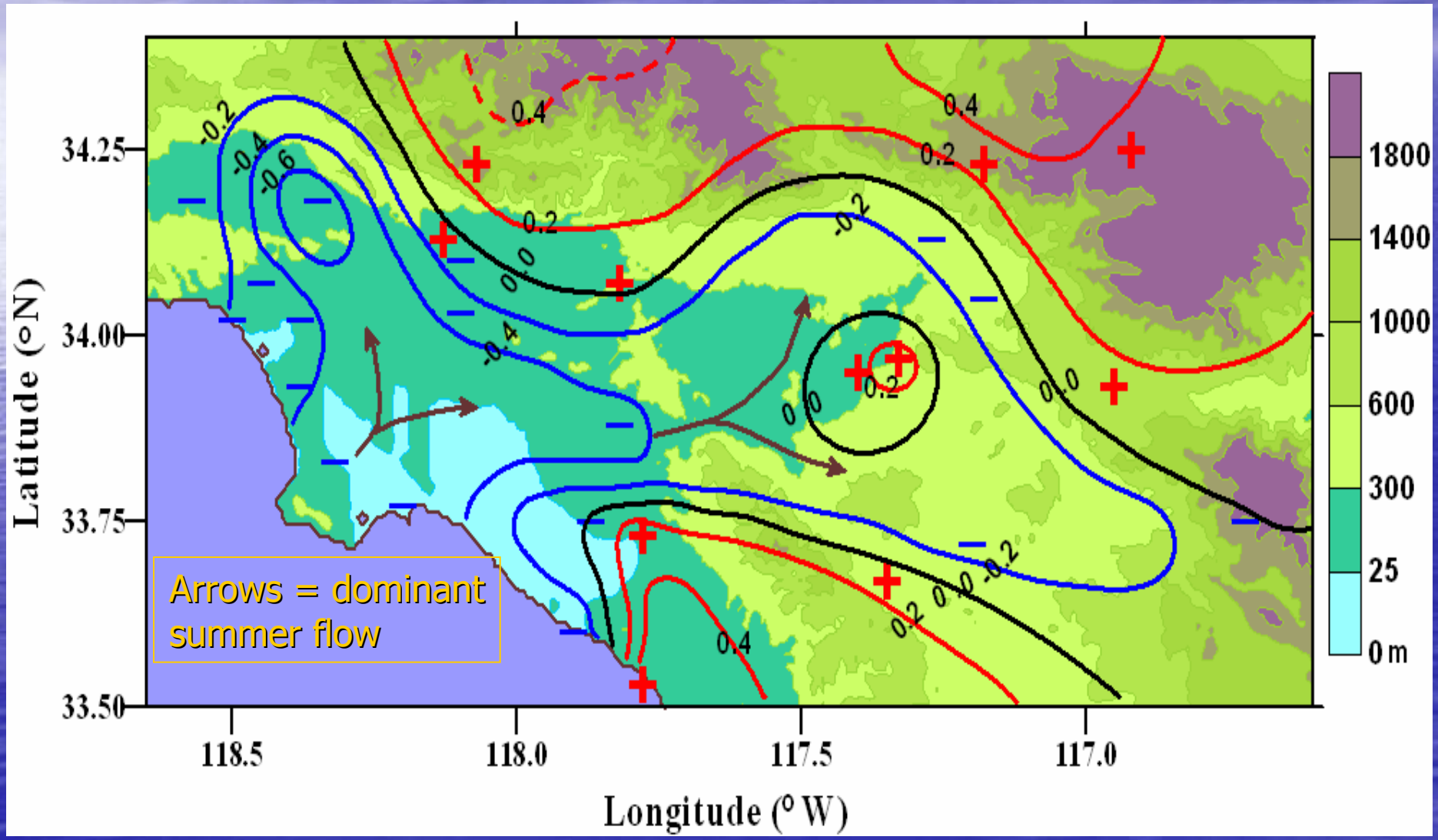
- daytime-warming (mainly inland) sites: 0.05 K/decade
  (as T_{max} increased a bit faster than did T_{min}; why?)
- daytime-cooling (mainly coastal) sites: -0.61 K/decade
  (as T_{max} decreased & T_{min} increased)



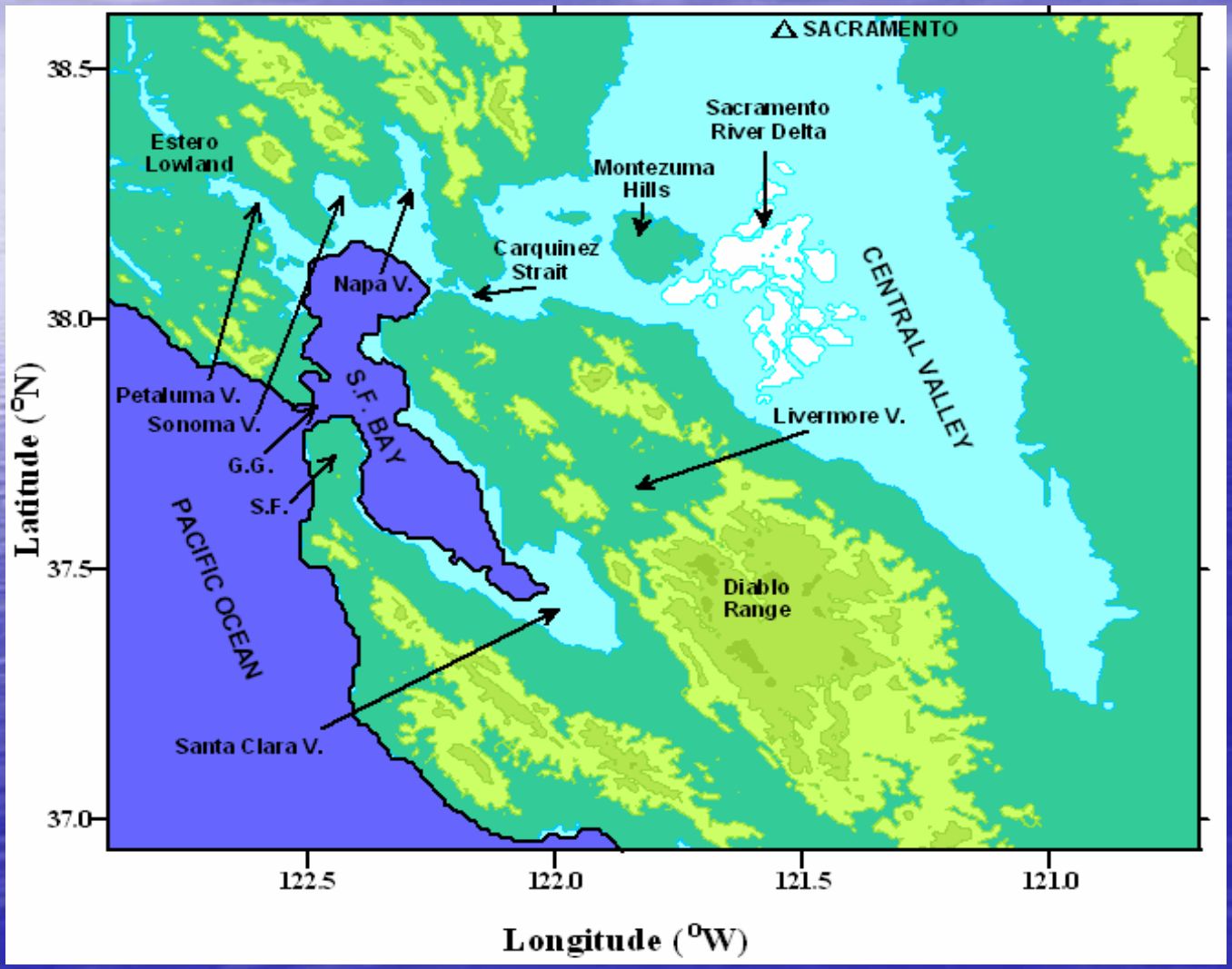
Significant South Coast Air Basin Topography



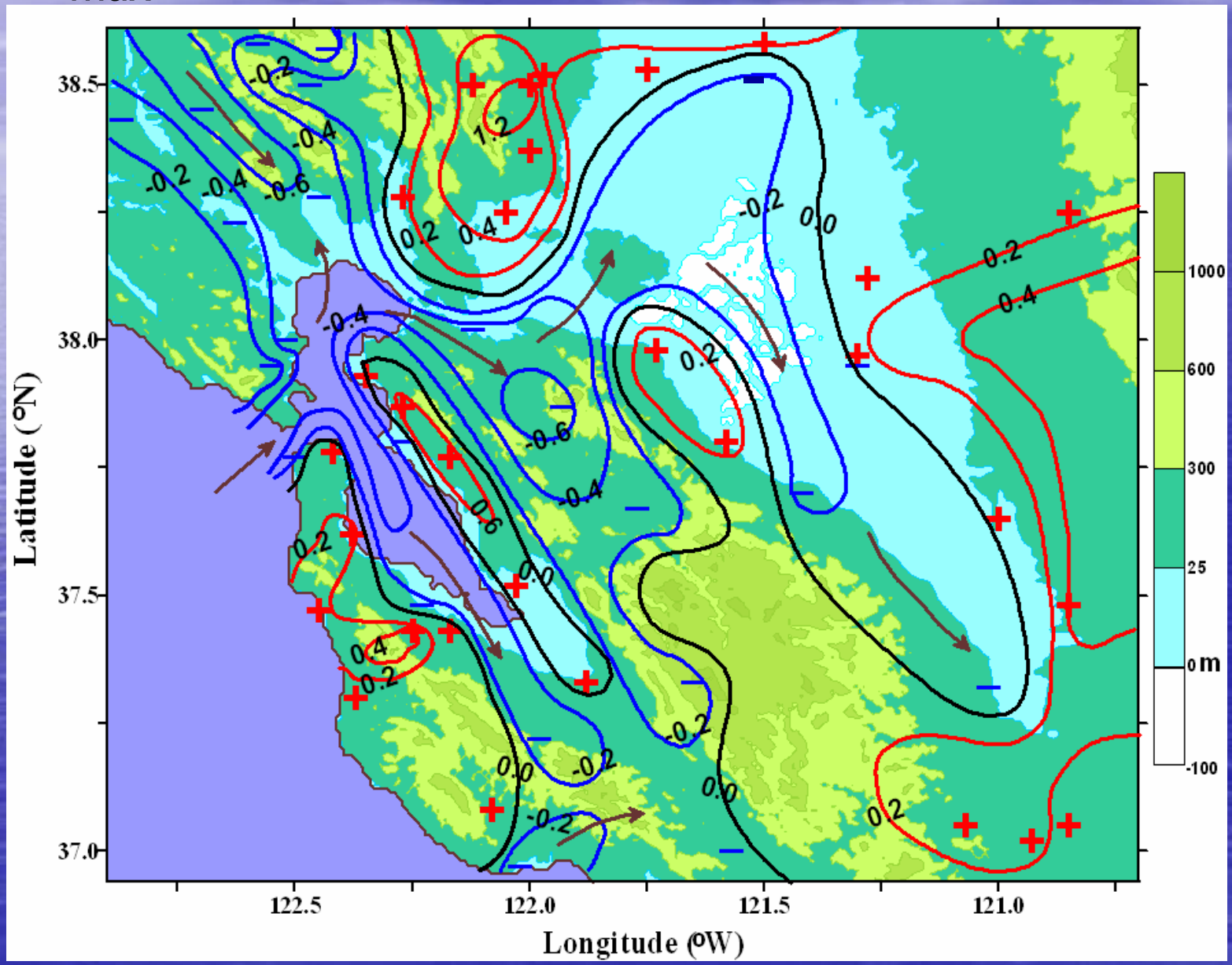
SCAB 1970-2005 summer T_{max} warming/cooling trends (K/decade)



Significant SFBA and CenValley Topography



SFBA & CenV 1970-2005 summer T_{max} warming/cooling trends (K/decade)



Statistical Significance: 1970-2005

Parameter (all Calif)	Rate (K/decade)	r	N_e (years)	Significance (%)
DTR (cooling areas)	-0.61	0.70	6	95
DTR (warming areas)	0.05	0.07	31	32
T_{min}	0.27	0.52	11	93
T_{max}	0.06	0.09	30	68
SST	0.24	0.45	14	92
100-km dT/dx	0.16	0.10	30	40

Region-Area	Rate (K/decade)	r	N_e (years)	Significance (%)
Coastal-SFBA	-0.16	0.23	22	72
Inland-SFBA	0.47	0.58	10	95
Coastal-SoCAB	-0.33	0.37	17	87
Inland-SoCAB	0.21	0.25	22	74
Coastal-Both	-0.22	0.32	19	83
Inland-Both	0.40	0.53	11	93

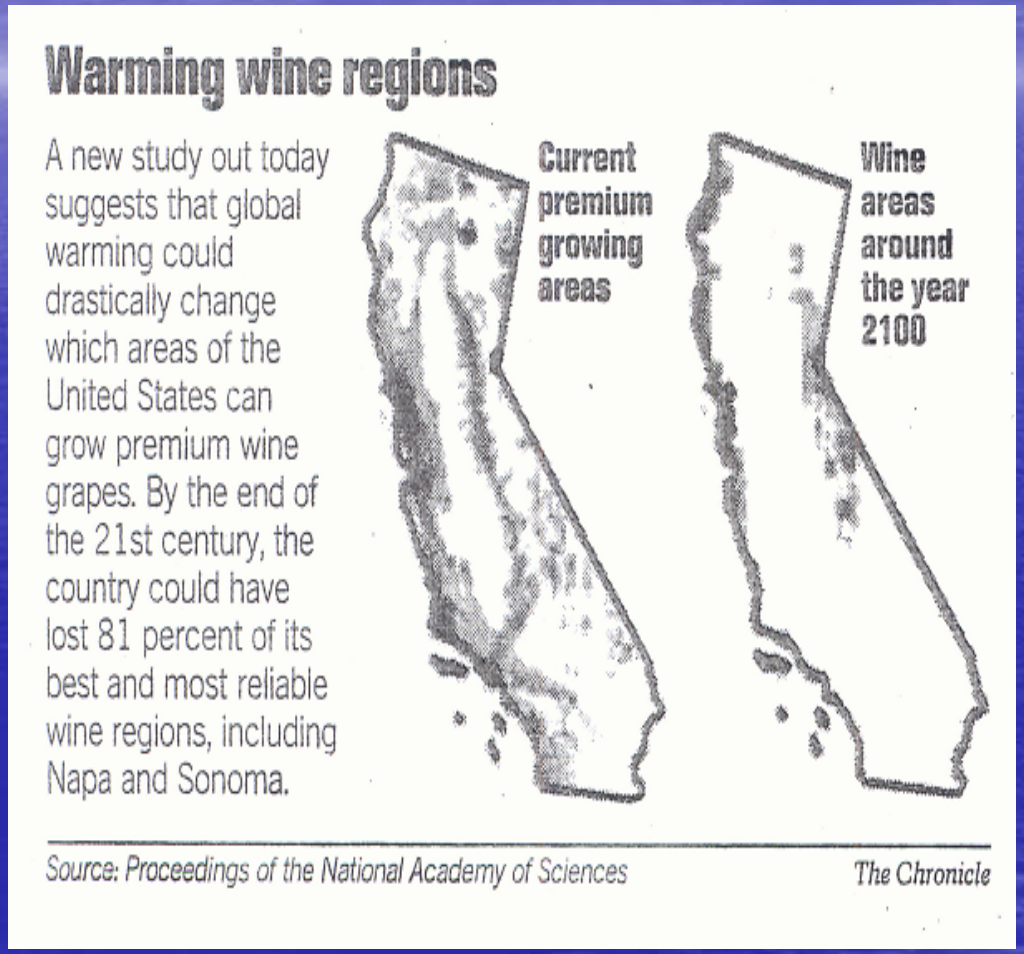
SUMMARY

- MIN-TEMPS IN CALIF WARMED FASTER THAN MAX-TEMPS → ASYMMETRIC WARMING
- SUMMER DAYTIME MAX-TEMPS COOLED IN LOW-ELEVATION COASTAL AIR- BASINS
- FOLLOWING AREAS COOLED IN CENTRAL CALIFORNIA:
  - MARINE LOWLANDS
  - MONTEREY
  - SANTA CLARA VALLEY
  - LIVERMORE VALLEY
  - WESTERN-HALF OF SACRAMENTO VALLEY

GOOD IMPLICATIONS

- AGRICULTURAL AREAS MAY NOT SHRINK

  e.g.: NAPA WINE AREAS MAY NOT GO EXTINCT →
- ENERGY-NEED FOR COOLING MAY NOT INCREASE AS RAPIDLY AS POPULATION
- LOWER HUMAN HEAT-STRESS & MORTALITY RATES
- URBAN-OZONE LEVELS WILL CONTINUE TO FALL



IMPLICATIONS FOR CALIF OZONE

- PAST DECREASES MAY BE IN-PART DUE TO JJA MAX-TEMP COOLING-TREND & NOT ONLY TO EMISSION REDUCTIONS
- WHEN MAX-T DECREASES, THE FOLLOWING ALSO DECREASE:
  - BIOGENIC PRECURSOR EMISSIONS
  - PHOTOCHEM REACTION RATES
  - ENERGY-USE FOR COOLING AND THUS ANTHROPOGENIC PRECURSOR EMISSIONS

REQUIRED FUTURE-EFFORTS:

ANALYSIS OF OBS & MESO MET MODELING
TO SEPARATE-OUT INFLUENCES
(DISCUSSED IN LITERATURE) OF

- WARMING SSTs →
  weaker sea breezes
- INCREASED COASTAL UPWELLING →
  stronger sea breezes
- LAND-USE CHANGES
  - AGRICULTURAL: INCREASED INLAND IRRIGATION →
    inland cooling → decreased sea-breezes
  - URBANIZATION: STRONGER UHIs →
    increased sea-breezes
- OTHER SEA-BREEZE INFLUENCES

  INCREASED WIND VELOCITY, STRATUS CLOUD COVER, & SOIL MOISTURE →
  coastal cooling

WHERE TO LOOK FOR COASTAL-COOLING

- GC winds in same-direction as sea-breeze
- Low-elevation air-basins
- Cool coastal ocean-currents
- Upwelling areas

i.e.: mid-lat (what lat range?) west-coast areas

What other-types of reverse-impacts might exist, *e.g.,* in mt areas?

Thanks: any questions??