Paper 68: Interaction of global-warming & urban-climate in different climate-zones

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Overview of Themes

My interests: Observation & simulation of polluted coastal urban-atmospheres (40 years) in a changing climate (last 5 years)

No. 1: Global climate-change is here
No. 2: Global climate-change is a function of time & location
No. 3: Urban-areas create their own climate
No. 4: Urban & global climate-changes interact, for good or bad

Work supported by: NSF & SCU

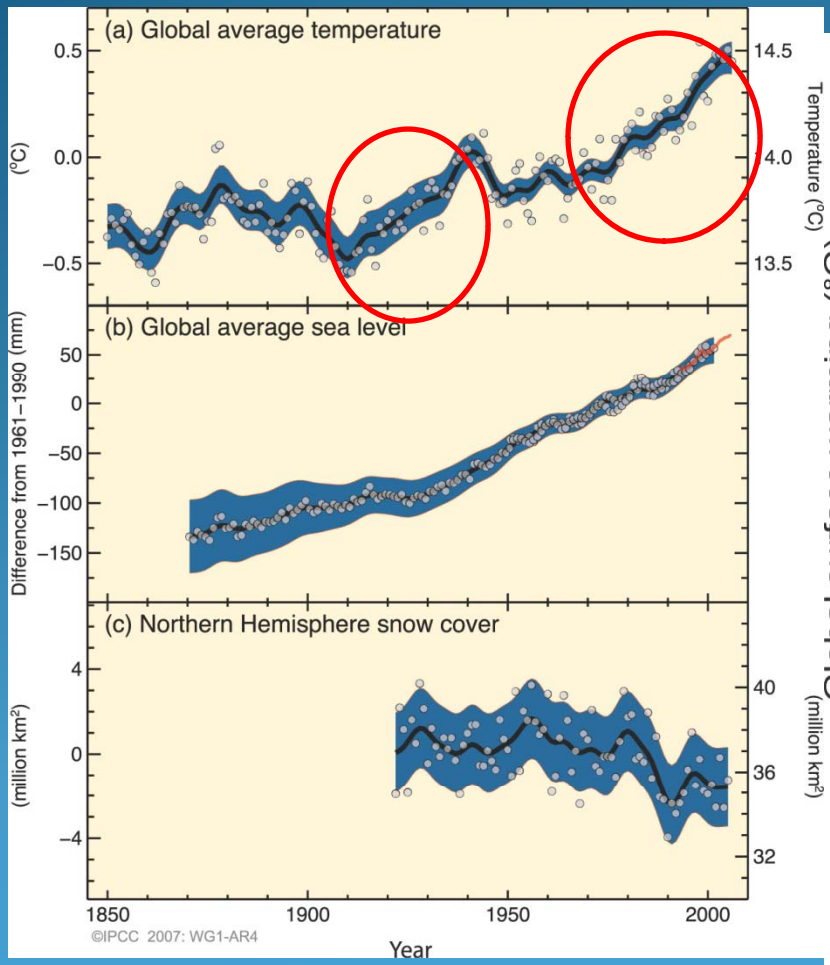
Theme 1: IPCC global-average Temp-trends

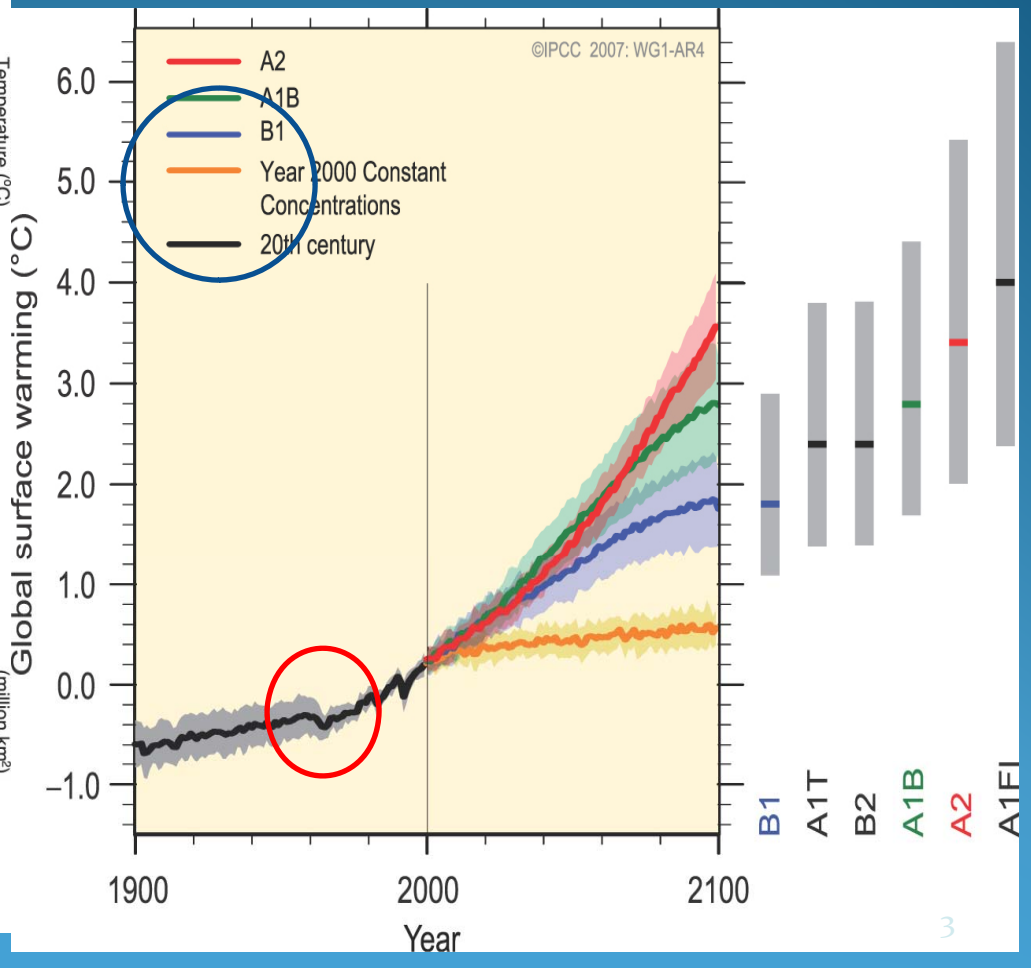
> Past (upper left):

>> warming: (circles) 1900-1945 & 1970-present, >> cooling: 1945-1970

>> single trend -line underestimates recent (1970-present) warming-rate

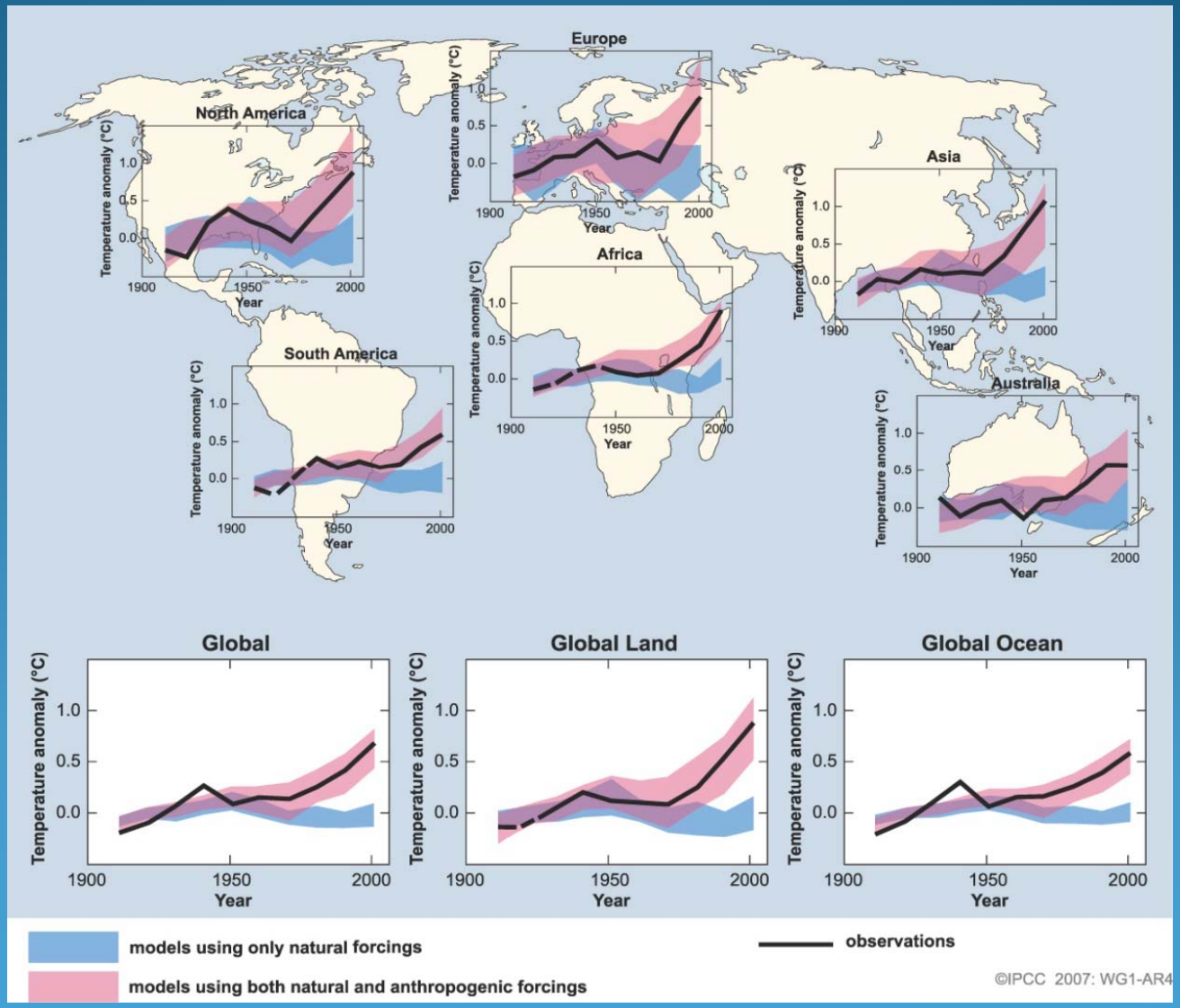
> Future warming (right): depends on assumed CO_2 emission-rate (colors) & on climate-model used (spread in results of one color)





Theme 2: IPCC Temp-Changes (total & anthropogenic): not-uniform over globe)

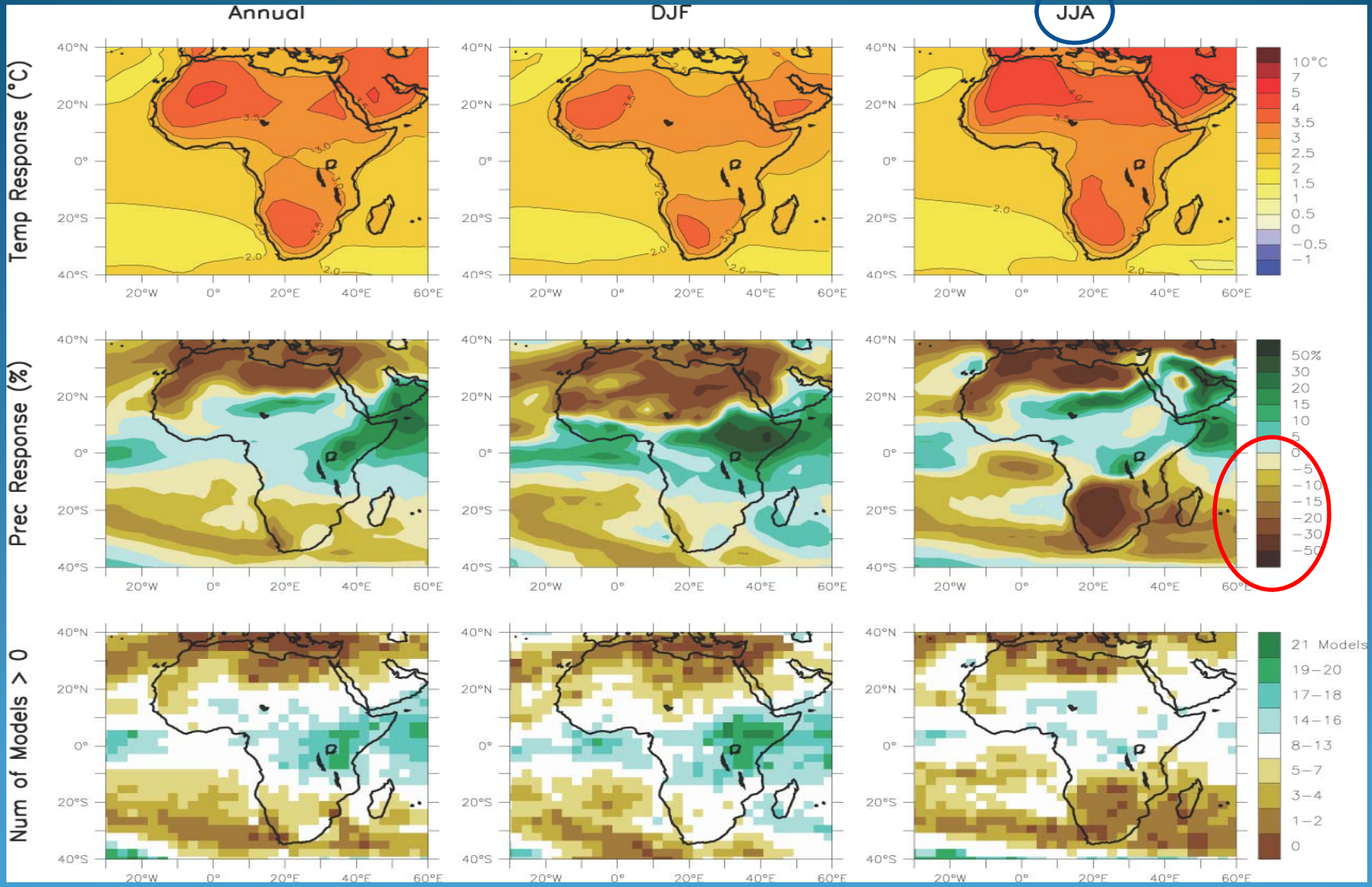
Note: models show max-change due to human-activities



IPCC-Changes are not-uniform: seasonally & regionally

Notes: (a) Δtemp (upper): land > SST , & JJA > annual > DJF

(b) Δprecip (middle): increase (blues) & decrease



Global-Change summary

> "Meteorology view" of climate-change physics:
GHGs → redistribution of energy →
changed large -scale atm/ocean flow-patters →
changed movement of warm/cold air & of storms →
more heat/cold waves & droughts/flooding →
many losers & a few-winners (on some-issues, only)→
migration & conflict

> Lesson: true-magnitudes of local climate-changes, require segmented-trends on correct-scales
>> temporal: period (which years), season, time of day
>> spatial: lat/long area, altitude, distance from sea*,
urban* vs. rural

> ( )* foci of one-part of this talk

Theme 3: URBAN WEATHER/CLIMATE CHANGES: battles b/t conflicting-effects

> VISIBILTITY: decreased
> TURBULENCE: increased (mechanical & thermal)
> FRONTS (synoptic & sea breeze): slowed

> PRECIP: increased or decreased
> WIND SPEED: increased or decreased
> WIND DIRECTION: con- or divergence
> THUNDERSTORMS: triggered or split

> SOIL MOISTURE*: increased or decreased
> TEMP*: increased (UHIs) or decreased (UCIs)
( )* one foci of this talk

URBAN CLIMATE: causes of UHIs

> GRASS & SOIL →

CONCRETE & BUILDINGS →

ALTERED SFC (SENSIBLE & LATENT) HEAT FLUXES

> FOSSIL -FUEL CONSUMPTION (IN HIGH-LAT CITIES)→

ATMOSPHERIC POLLUTANTS & HEAT

> ATM POLLUTION & BUILDINGS→ DECREASED

>> INCOMING SOLAR-ENERGY

>> OUTGOING TERRESTRIAL-ENERGY

> A NET EFFECT: CITIES -LOSE STORED SOLAR-ENERGY SLOWLY AT-NITE (IN LOW-LAT CITIES) →

CITIES "GENERALLY" COOL-LESS THAN RURAL-AREAS →

CITIES REMAIN-WARMER AT-NITE →

URBAN HEAT ISLAND (UHI) FORMATION →

LOCALIZED "GLOBAL-WARMING " ANALOGY

Study 1: Coastal-cooling: hypothesis

INCREASED GHG-INDUCED INLAND TEMPS→

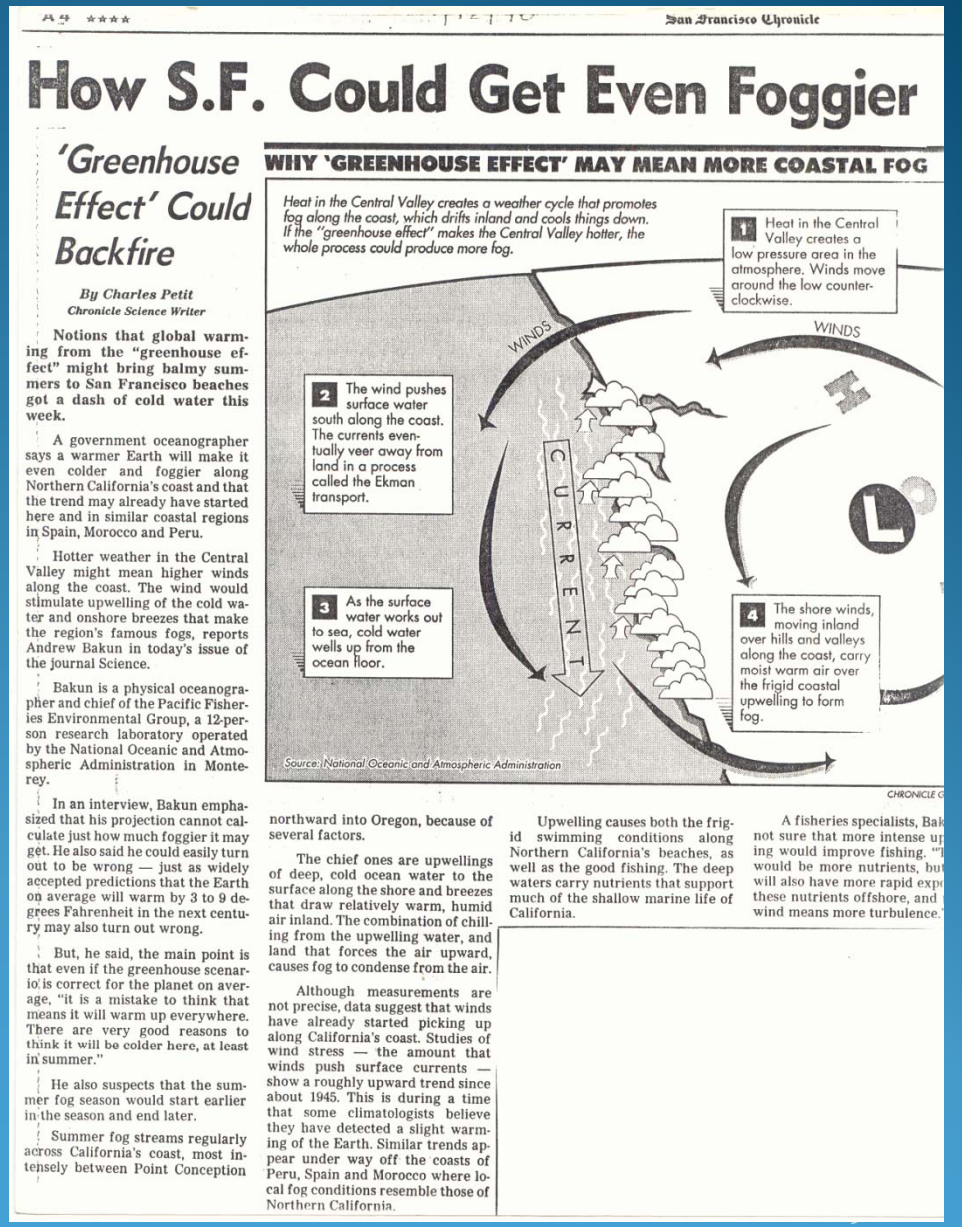
INCREASED (COAST TO INLAND) PRESSURE & TEMP GRADIENTS→

INCREASED SEA-BREEZES (FREQ, INTENSITY, PENETRATION, &/or DURATION) →

COASTAL-AREAS SHOULD SHOW COOLING SUMMER DAYTIME MAX-TEMPS (i.e., A "REVERSE REACTION" TO GHG- WARMING)

NOTE: NOT A "NEW "IDEA →

Lebassi et al. (2009): J. of Climate



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.

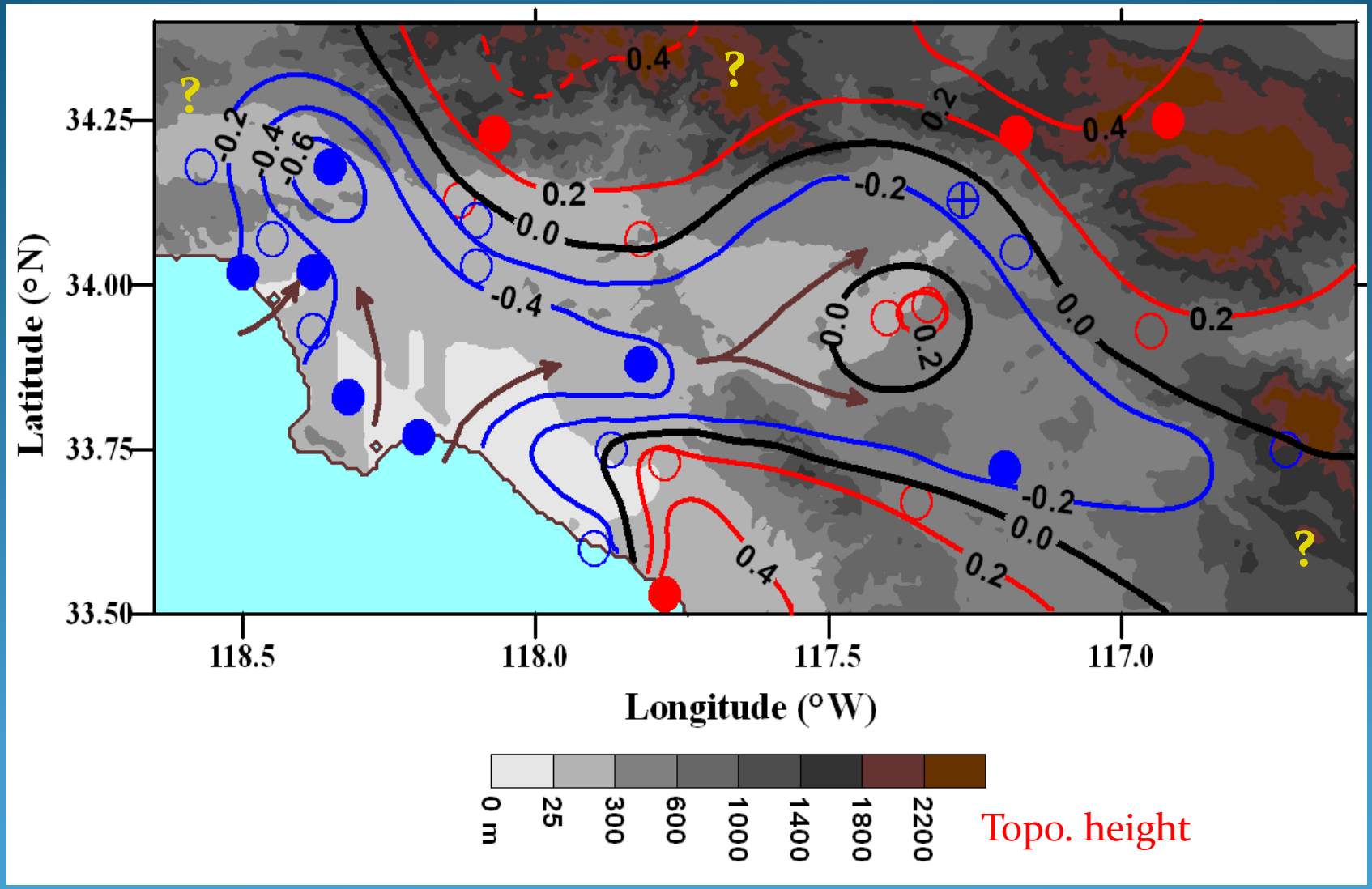
WHY 'GREENHOUSE EFFECT' MAY MEAN MORE COASTAL FOG

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

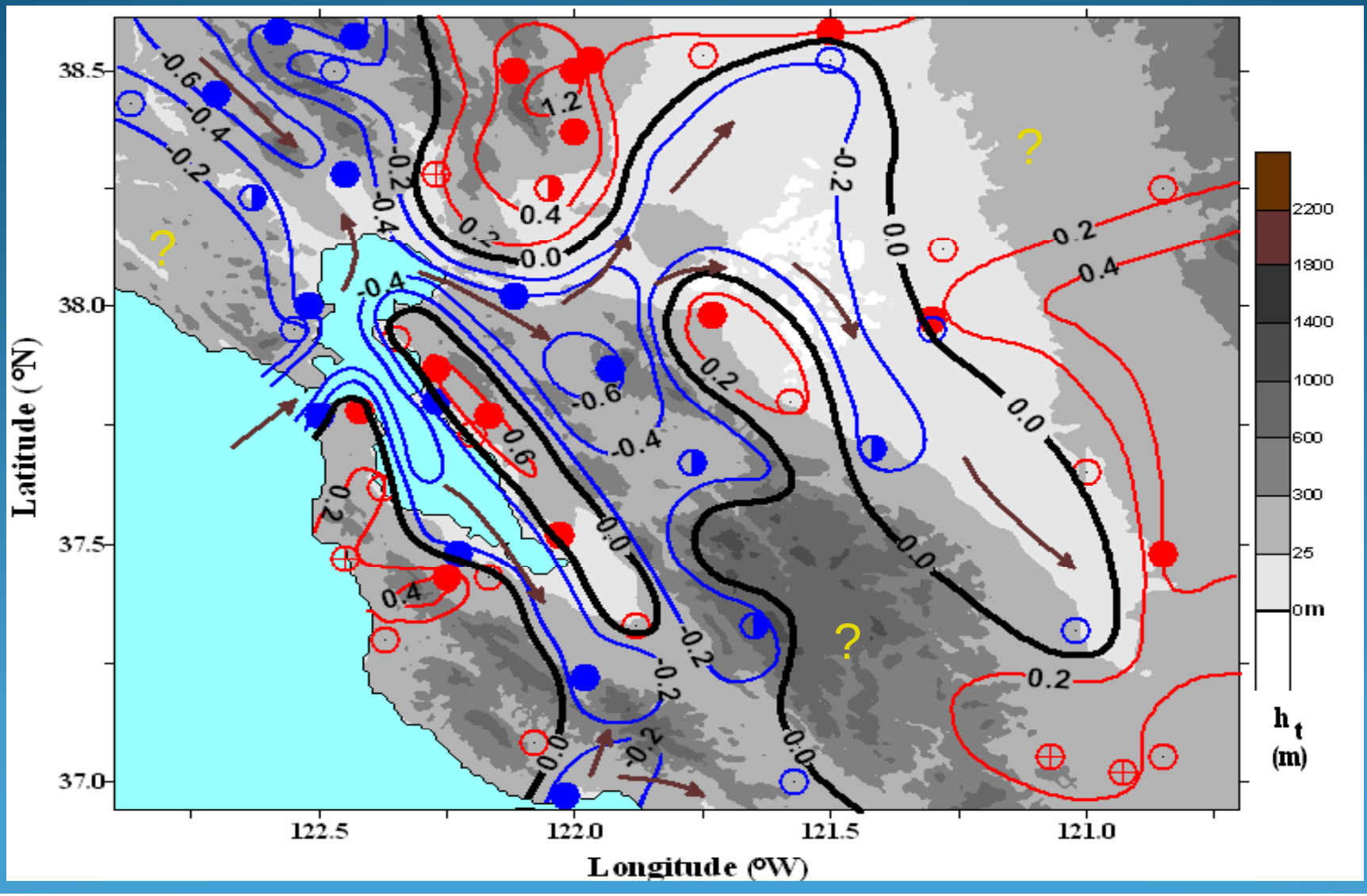
CHRONICLE G

LA 1970-2005 COOP JJA-average T_{max} warming/cooling trends (^{0}C/dec); solid, crossed, & open circles = sig levels of 0.99, 0.95, & not significant, respectively; arrows = average winds

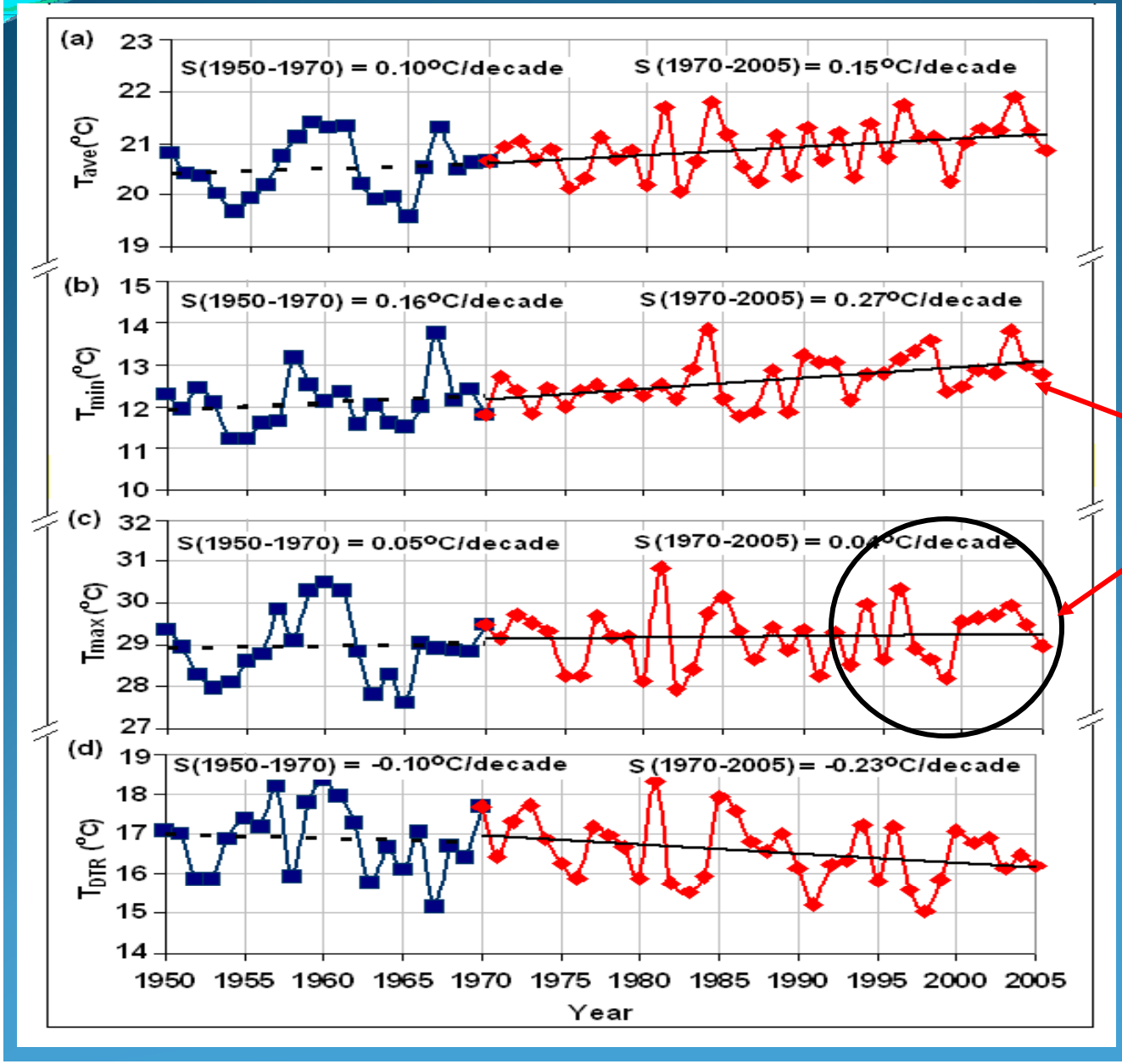


Same for SFBA & Central Valley

COOLING AREAS: MARIN LOWLANDS, MONTEREY, SANTA CLARA V., LIVERMORE V., WESTERN HALF OF SACRAMENTO V.



All-California 1970-2005 JJA temperature trends (°C decade^{-1})

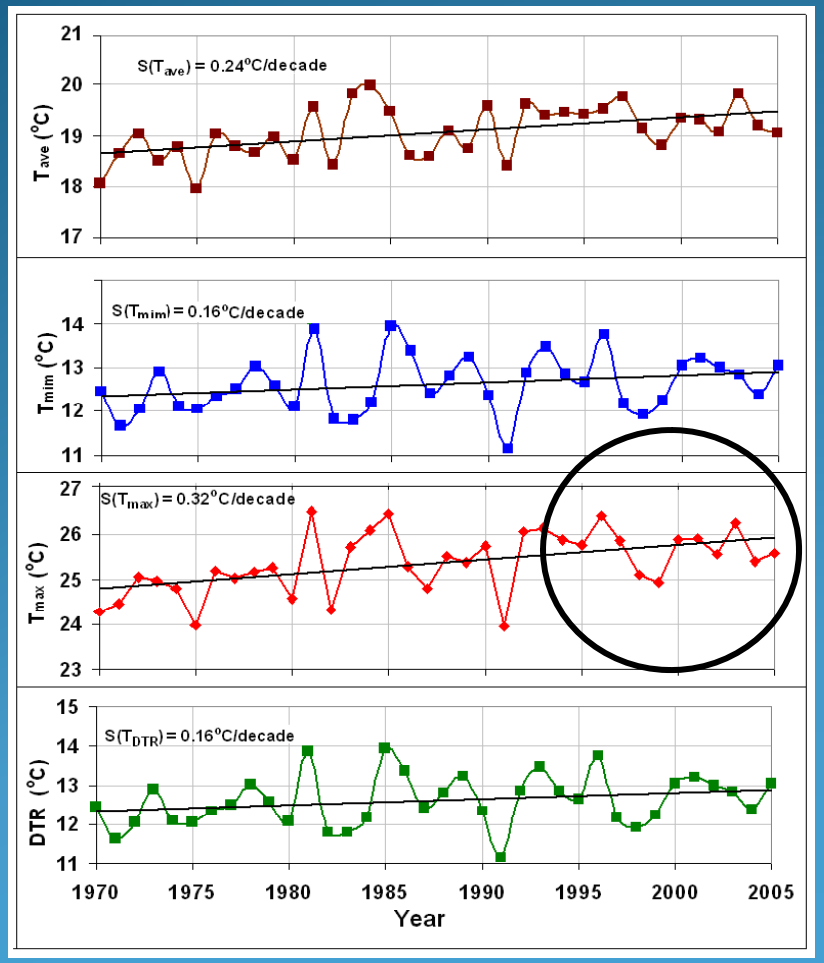


T_{min} (Curve b) increasing faster than T_{max} (Curve c), i.e., asymmetric warming in lit.

Results 2: Combined SFBA & LA 1970-2005 JJA trends (^{o}C/decade) of T_{max} (Curves C)

Results: 35 years equals 1.05^{o}C of cooling

Inland T_{max} warming sites



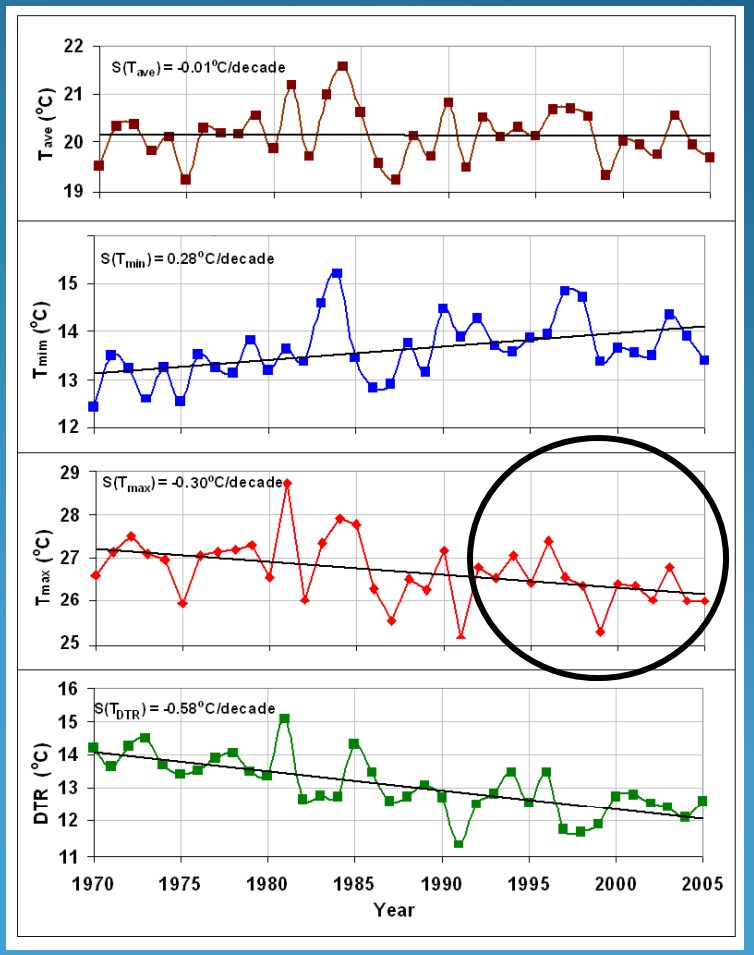
(a)

(b)

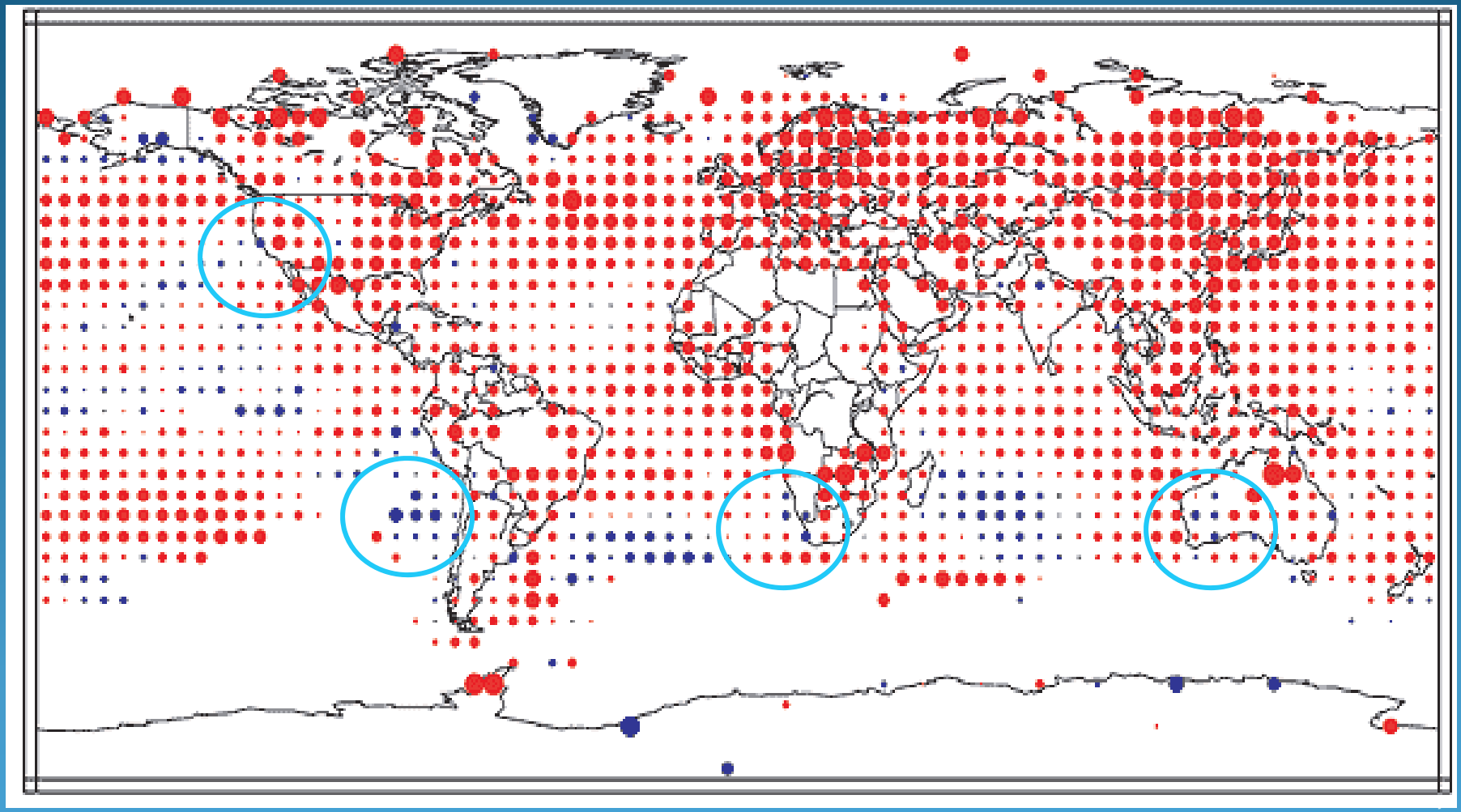
(c)

(d)

Coastal T_{max} cooling sites

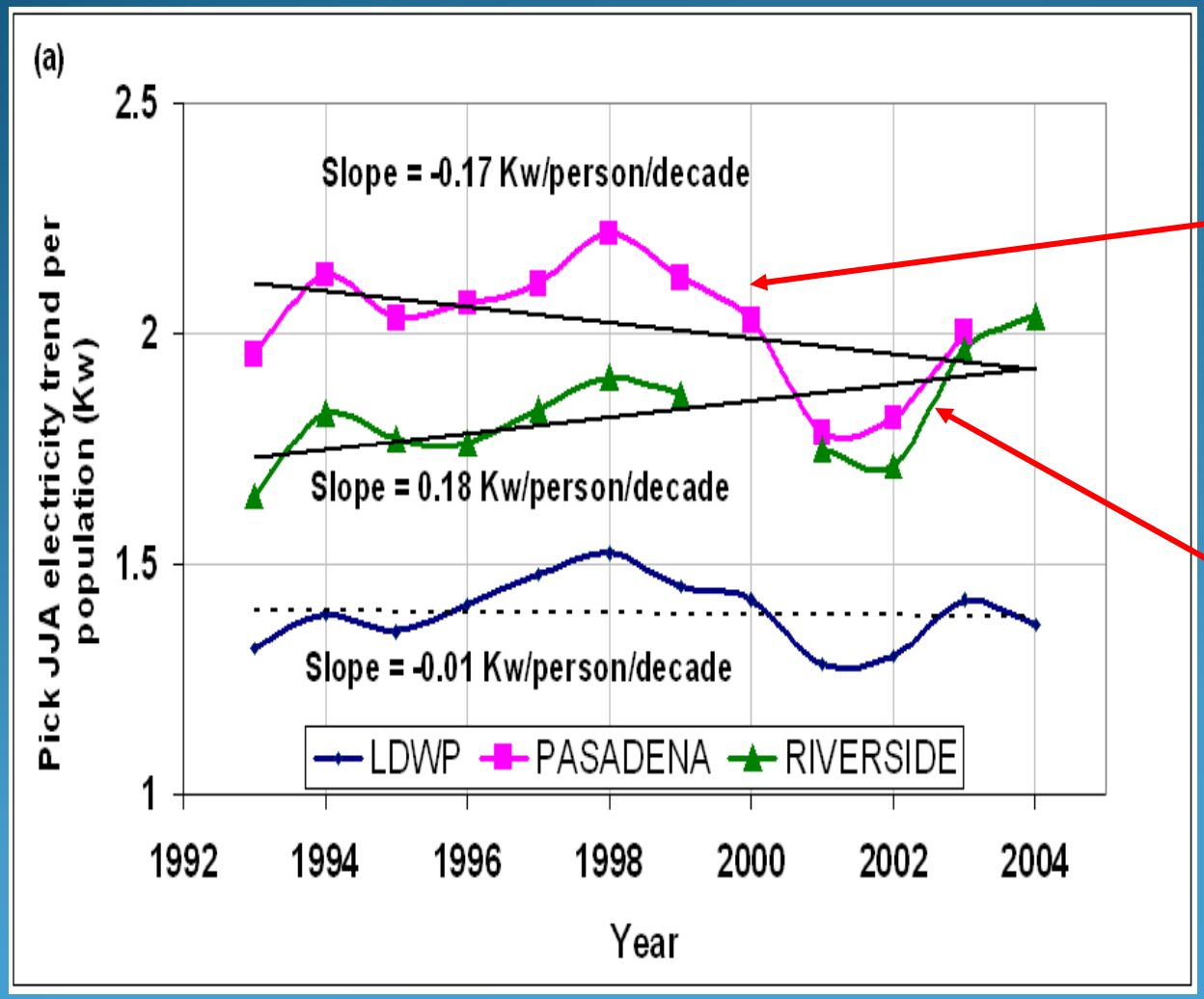


Where costal-cooling might occur:
at all (but Portugal) mid-lat W-coast Marine-Med climates



Peak Summer Electricity-Trends for 1993-2004 (Kw/person/decade)

Data from: LA Dept. of Water & Power (LDWP), Pasadena, & Riverside



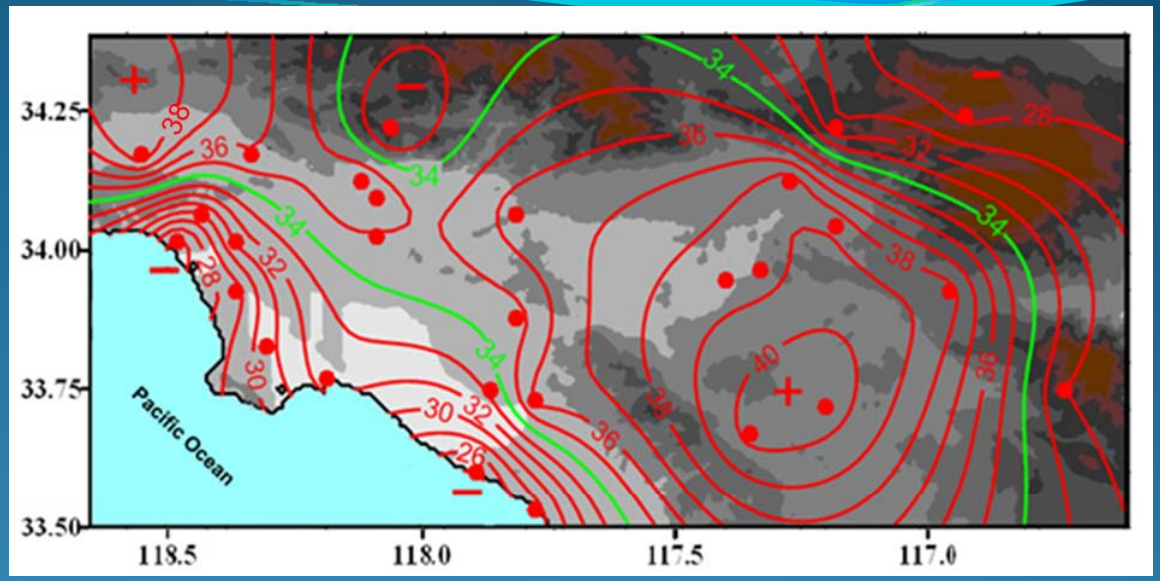
Results show:

- Coastal-cooling LDWP & Pasadena: downward trend (-7%/decade)
- Inland-warming River-side: upward trend (10%/decade)

From: Lebassi et al. (2010) J Solar Engin

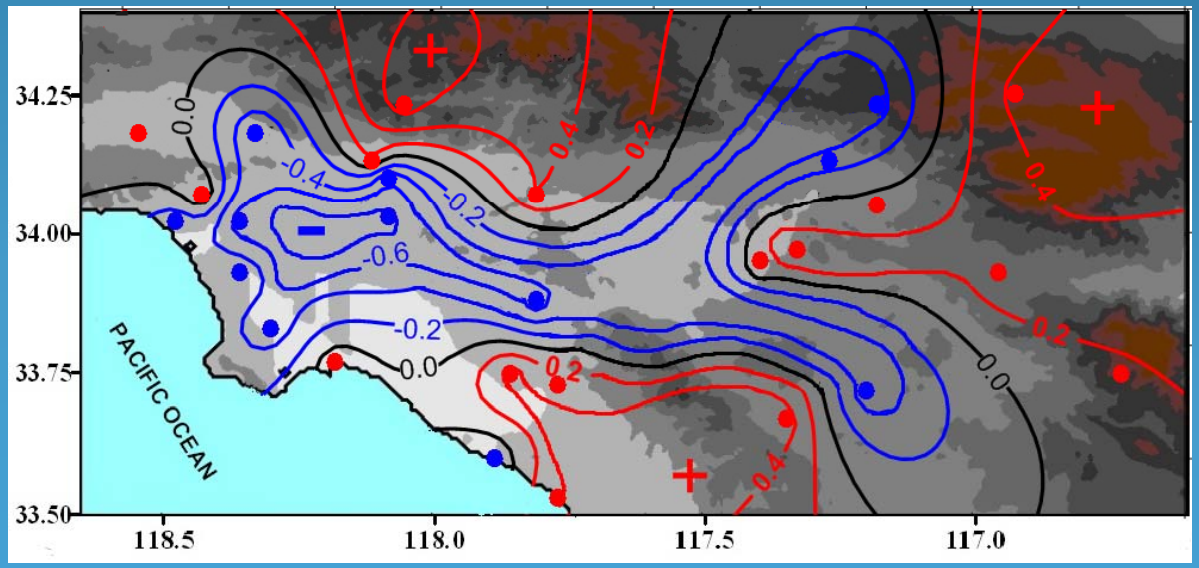
New Results: Extreme-max Temp (°C), anytime from '70 - '10

- Cool coast: 27-34°C
- Cool Mt.-tops (due to elev): 28-34°C
- Inland hot-areas (b/t cool costal & Mt. areas): 34-40°C



- Coastal low-elev. areas: large decreases (up to -0.8°C/dec)
- Mt. areas: large increases, up to 0.6°C/dec
- Elevated coastal areas: small increases (up to 0.4°C/dec)
- Max decrease: again not at coast
- When cool air does not exit Basin → ozone episode

Annual-T_{max} trend (°C/dec) from '70 to '10



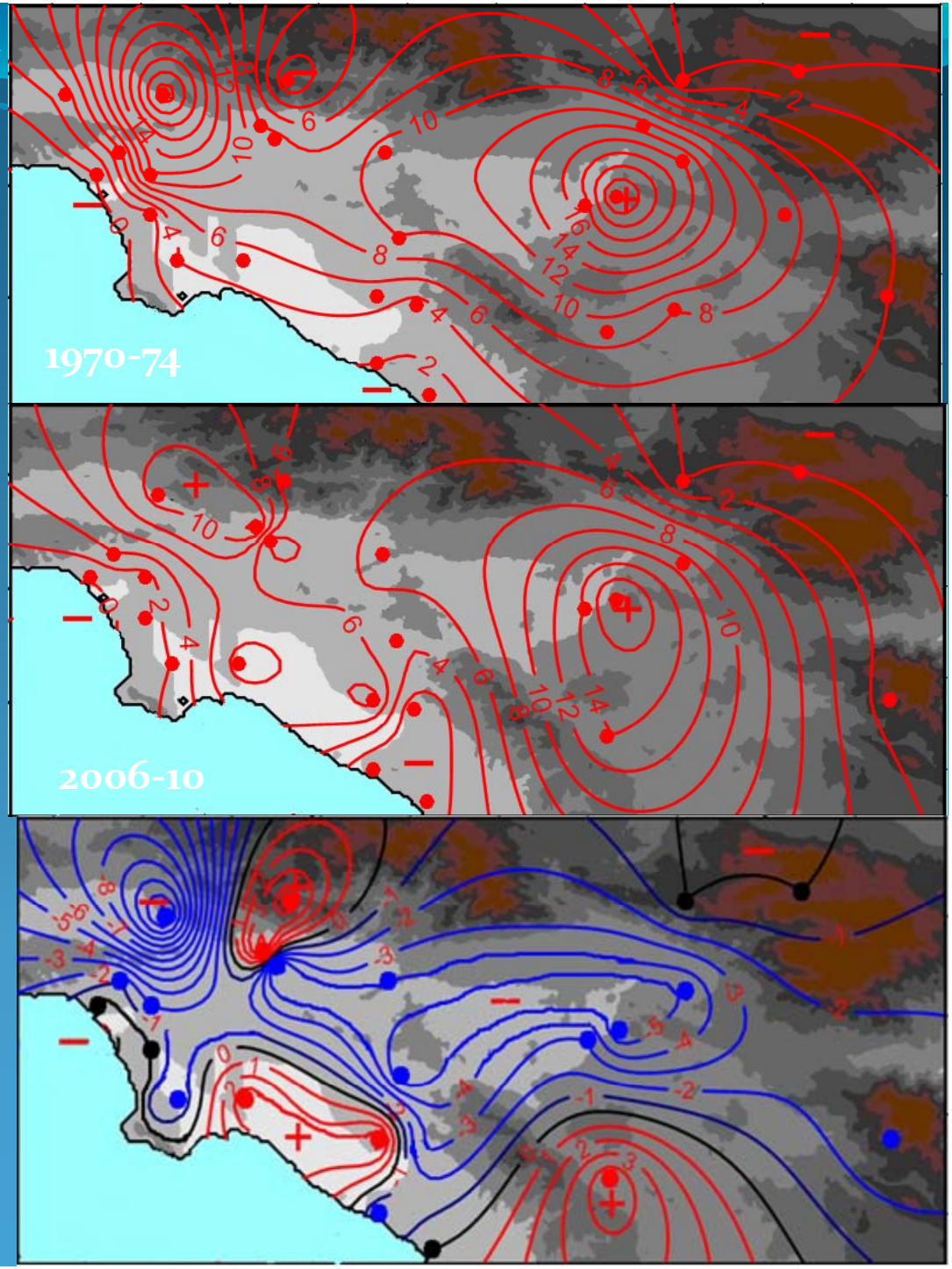
Two-day heat-waves (days/5-years) with $T_{max} \geq 95^{o}F$ in indicated period (upper 2-graphs): changes (lower-graph) are 2006-10 values minus 1970-4 values

Results: No. of heat-waves (top two-graphs)

- inland areas have max
- coastal areas have few
- Mt. areas have none

Results: Changes in No. of heat-waves (bottom graph)

- Coastal low-elev areas: large decreases, of up to -11 days/5-years
- Mt. areas: No change, as there were none
- Inland low-elev areas & elevated coastal areas: smaller increases, of up to 4 days/5-years
- Max decrease: again not at coast, as coastal-effect was always there



Summary of JJA coastal-cooling

- CONCURRENT: COOLING-T_{MAX} IN LOW-LEVEL COASTAL-
- AREAS & WARMING-T_{MAX} IN INLAND-AREAS

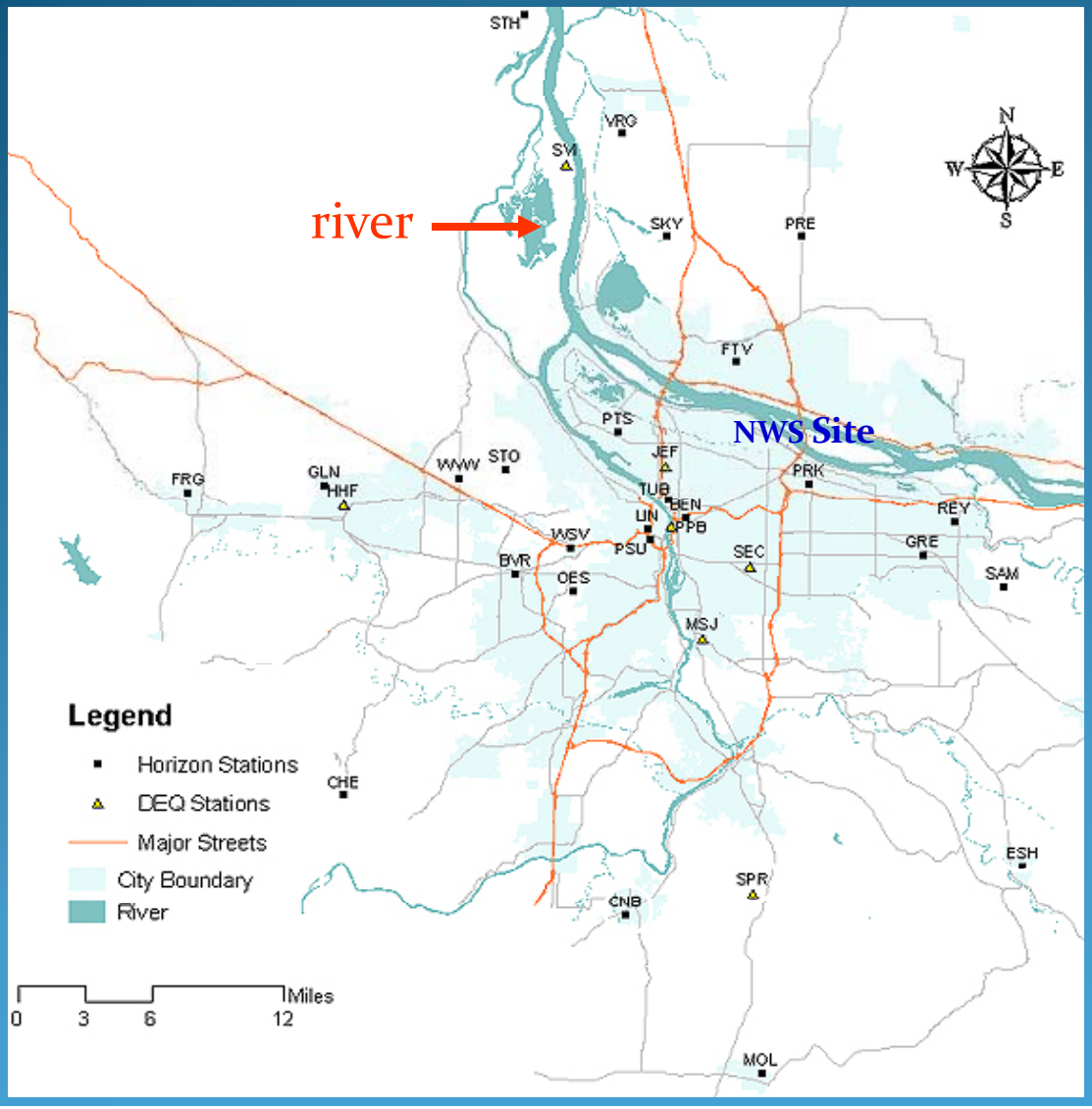
- LA-BASIN URBANIZATION →
  UHI INCREASED (not shown)→
  COASTAL-COOLING HAD TO OVERCOME BOTH
  GHG-WARMING & AN INCREASING-UHI

- PREVIOUS CALIF. STUDIES WERE NOT SPECIFIC ENOUGH
  (i.e., 1970-PRESENT, SUMMER vs. WINTER, DAY vs. NITE,
  COASTAL vs. INLAND, & URBAN vs. RURAL),
  & THUS THEY GOT "IRRELEVANT" TRENDS OF
  T_{MAX} , DTR, & T_{AVE}

> > COASTAL-COOLING IS A "WINNER," BUT AREA WILL STILL HAVE FLOODING & REDUCED WATER-SUPPLY

Study 2: Portland 2006 heat-stress study, interdisciplinary study with social scientists (phone banks)

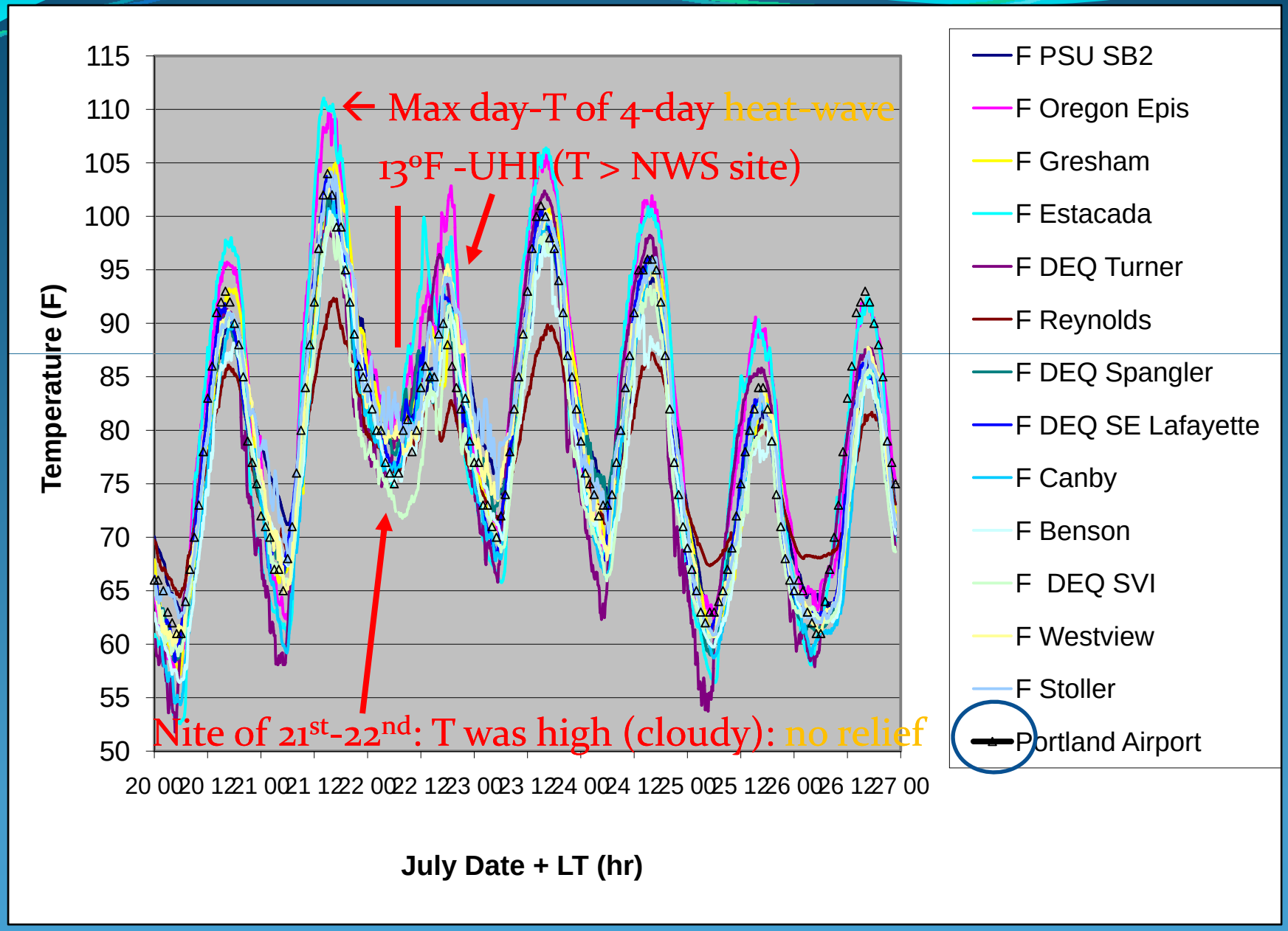
Temp data: 12 meso-net sites + one NWS airport-site



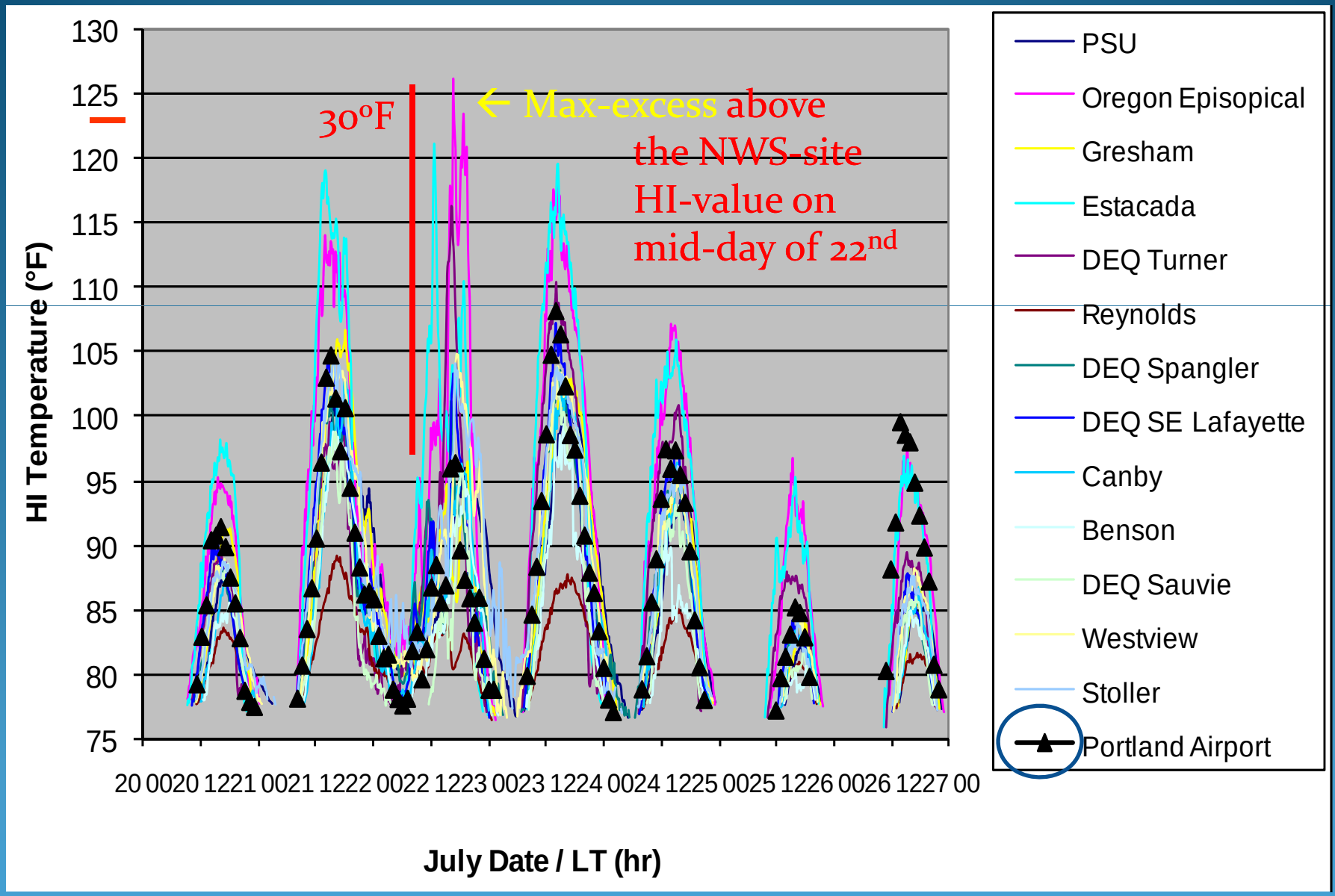
Meso-Met Sites

Canby – CNB
Stoller – STO
Reynolds – REY
Estacada – ESH
Westview – WVW
Spangler Road – SPR
SE Lafayette – SEC
Oregon Episcopal – OES
PSU – Portland State
Benson – BEN
Sauvie Island – SVI

Results 3: T-data from 12 meso-net sites + one NWS-site (shown as Δ)



Results 4: HI (T, RH) values for meso sites + NWS site
(Note: original-T must be ≥75 F to get HI-value)



HI-Project: Summary & Recommendations

>> Daytime 22-July had max

> UHI (13°F) > HI minus Temp value (26°F)

> underestimated HI-value (30°F = 126-96°F)

>> Such heat –waves

> rare now

> will be more-freq, due to combined-effects from

>> UHI-growth

>> GHG-induced global-warming → more-freq

moist warm -flows from south → more heat-waves

>> Recommendation: urbanize

> Wx forecasts (& models): temps must-include UHI-effects

> HI-forecasts: use UHI-values

>> Growing UHIs → an"urban-bias" in global-warming record (corrected for, by reducing the warming)

Le Grande Summary

- Global climate-change is here to stay
- Global climate-change impacts are a function of averaging-time & geographic-location
- Urban areas create their own climate-changes
- Urban & global climate-changes interact in different climate-type areas, for good or bad

Interactions of global climate-change & urban-climate in different climate-regions

Bob Bornstein
pblmodel@hotmail.com

IPCC 2007-report at: IPCC_Report.htm

Thanks for listening!
Questions?