Urban and Rural Temperature Trends in Proximity to Large U.S. Cities: 1951 – 2000

EPA Heat Island Reduction Initiative Webcast
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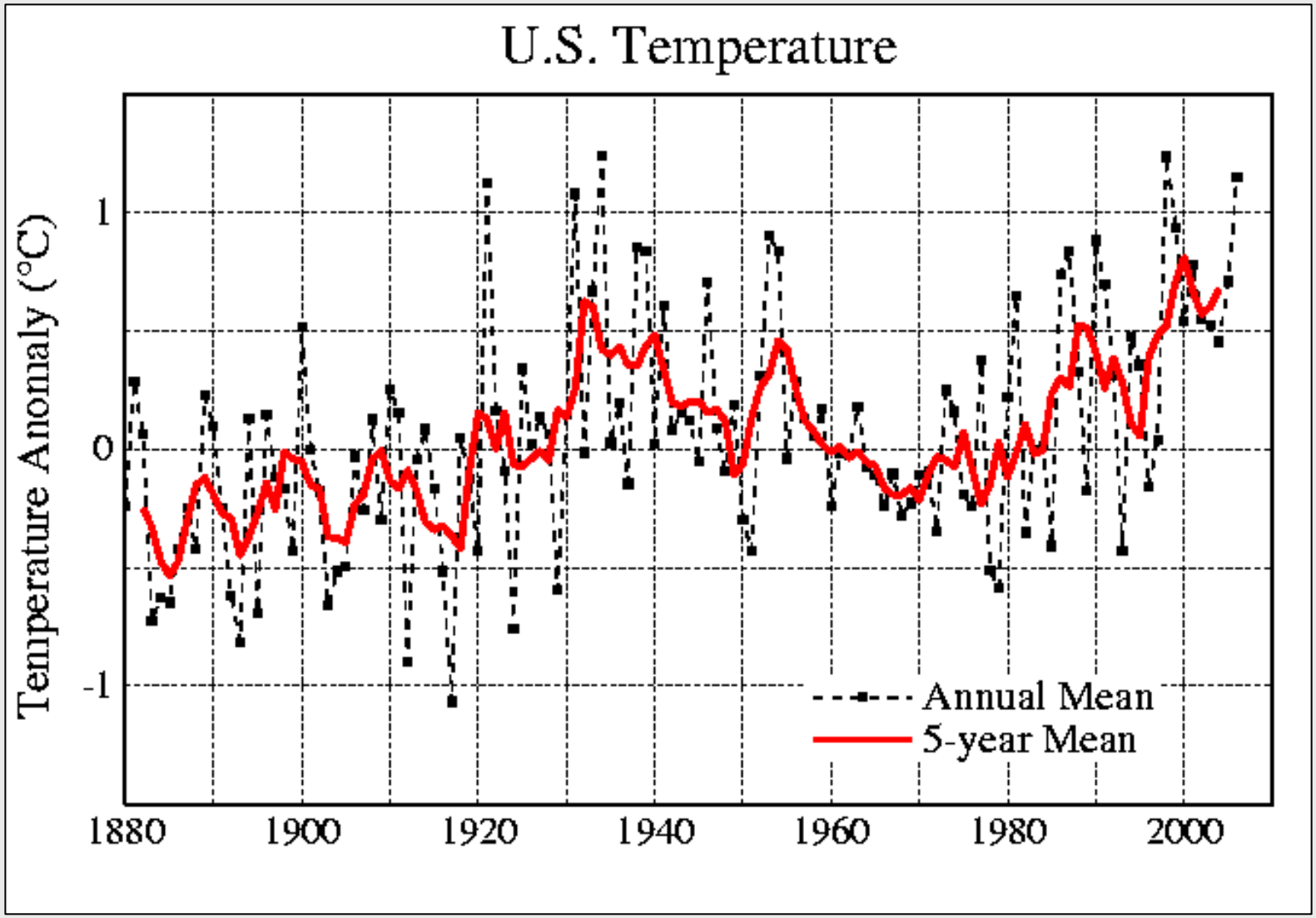
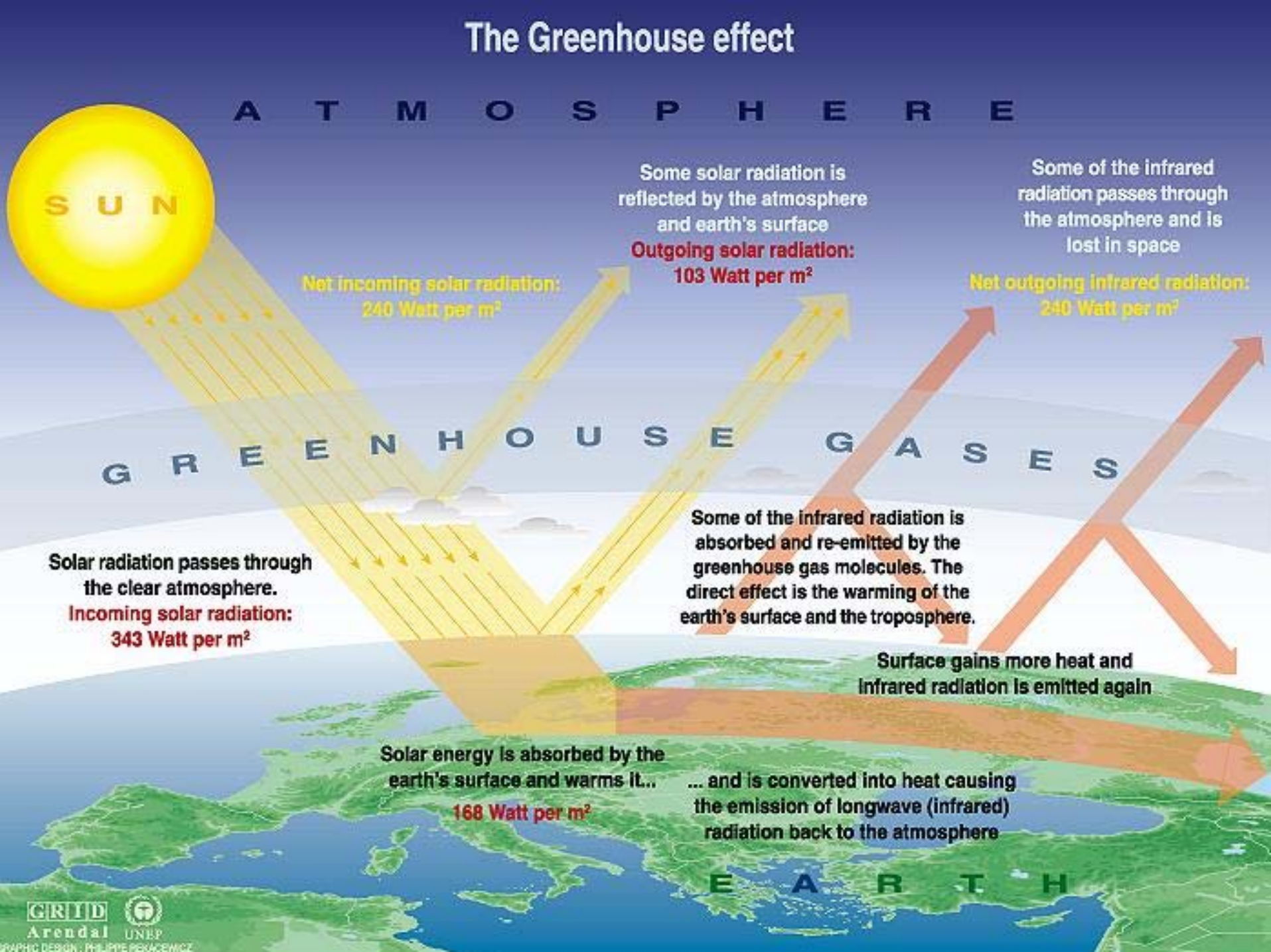
Overview.

- Mechanisms of climate change.
- Measuring urban warming trends.
- Results of study.
- Planning responses to climate change.



Source: NASA Goddard Institute for Space Studies


The Greenhouse effect
ATMOSPHERE
SUN
Some solar radiation is reflected by the atmosphere and earth's surface
Outgoing solar radiation:
103 Watt per m²
Some of the infrared radiation passes through the atmosphere and is lost in space
Net outgoing infrared radiation:
240 Watt per m²
Net incoming solar radiation:
240 Watt per m²
GREENHOUSE GASES
Some of the infrared radiation is absorbed and re-emitted by the greenhouse gas molecules. The direct effect is the warming of the earth's surface and the troposphere.
Solar radiation passes through the clear atmosphere.
Incoming solar radiation:
343 Watt per m²
Surface gains more heat and infrared radiation is emitted again
Solar energy is absorbed by the earth's surface and warms it..
168 Watt per m²
... and is converted into heat causing the emission of longwave (infrared) radiation back to the atmosphere
EARTH
GRID Arendal
UNEP

Land Surface Change.

Approximately 50% of the rise in near surface air temperatures since the 1960s is attributable to land use change.

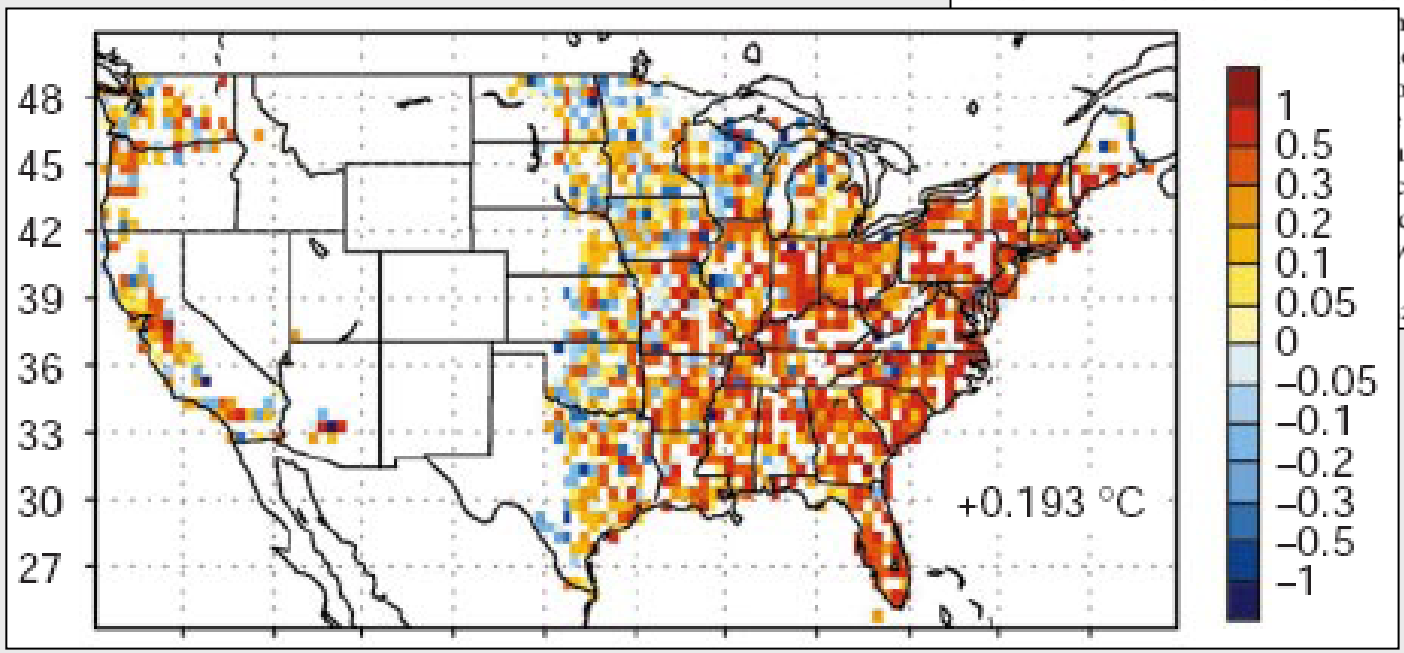
Impact of urbanization and land-use change on climate

Eugenia Kalnay & Ming Cai

University of Maryland, College Park, Maryland 20770-2425, USA

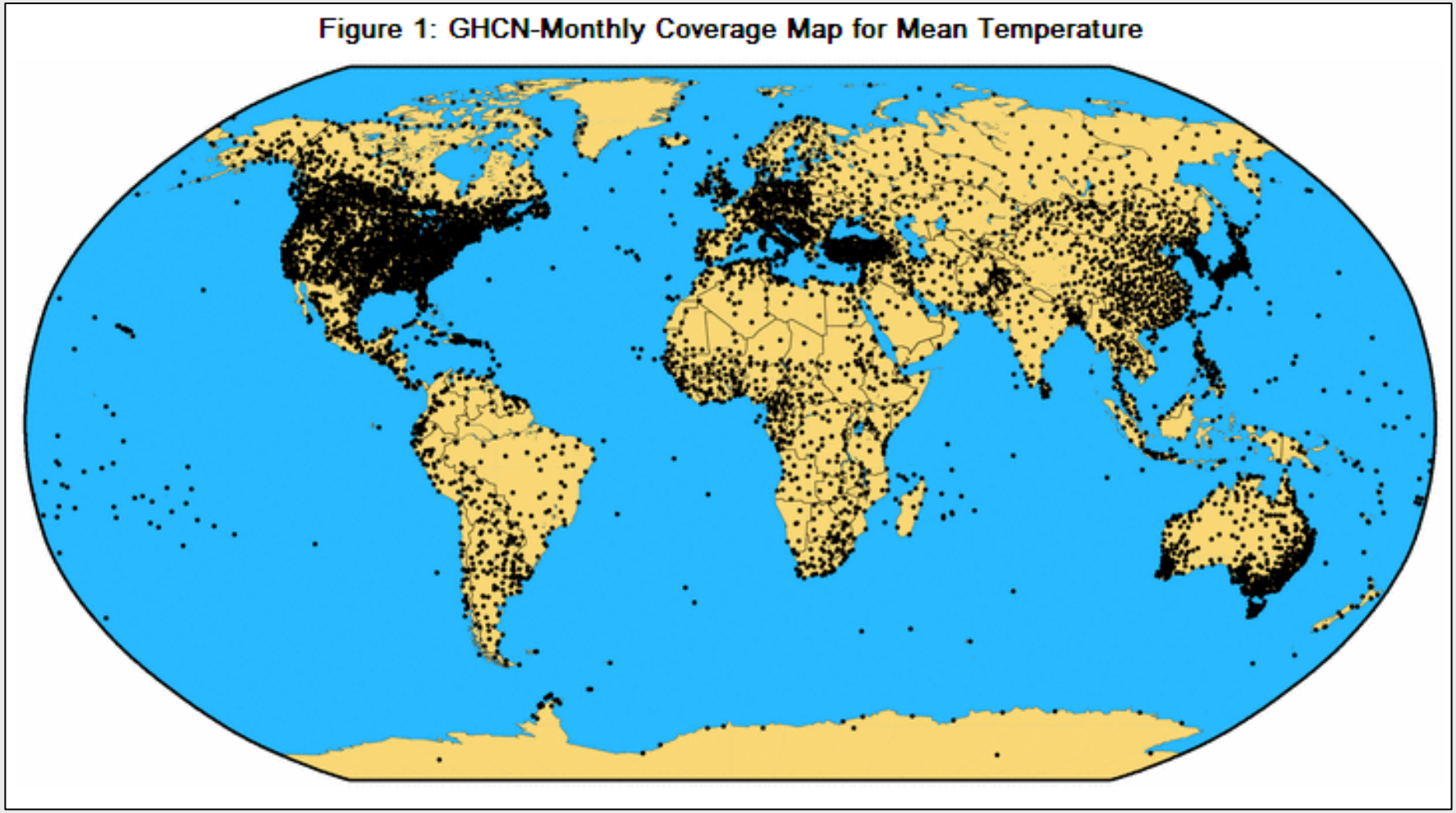
The most important anthropogenic influences on climate are the emission of greenhouse gases[1] and changes in land use, such as urbanization and agriculture[2]. But it has been difficult to separate these two influences because both tend to increase the daily mean surface temperature[3,4]. The impact of urbanization has been estimated by comparing observations in cities with those in surrounding rural areas, but the results differ significantly depending on whether population data[5] or satellite measurements of night light[6–8] are used to classify urban and rural areas[7,8]. Here we use the difference between trends in observed

...ental United States and the ...ction of surface temperatures ...obal weather over the past 50 ... observations, to estimate the ...rface warming. Our results ...crease in diurnal temperature ...d-use changes. Moreover, our ...warming per century due to



Source: Kalnay & Kai, 2003

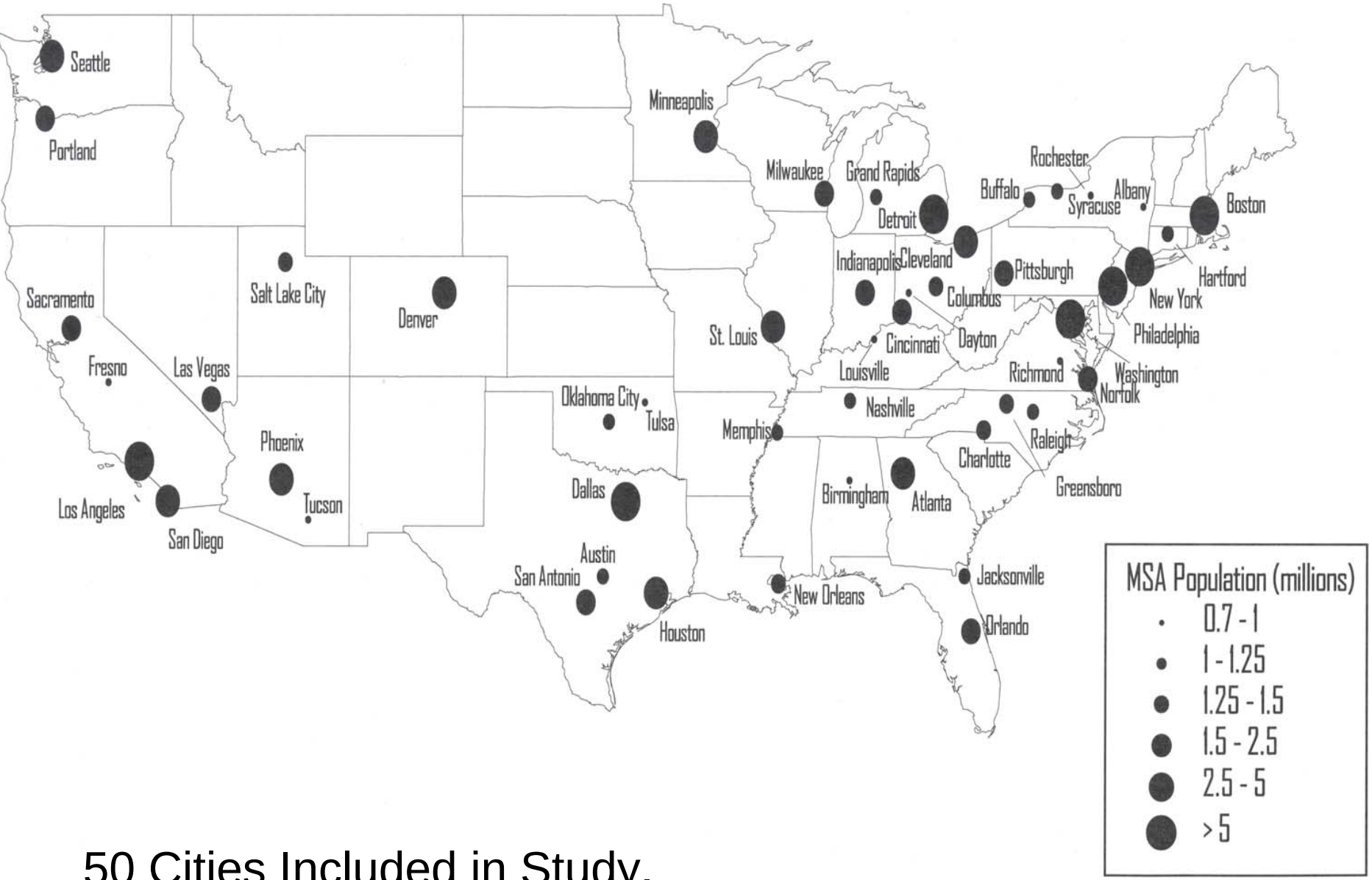
Global Historical Climatology Network.



Source: GISS, 2007.

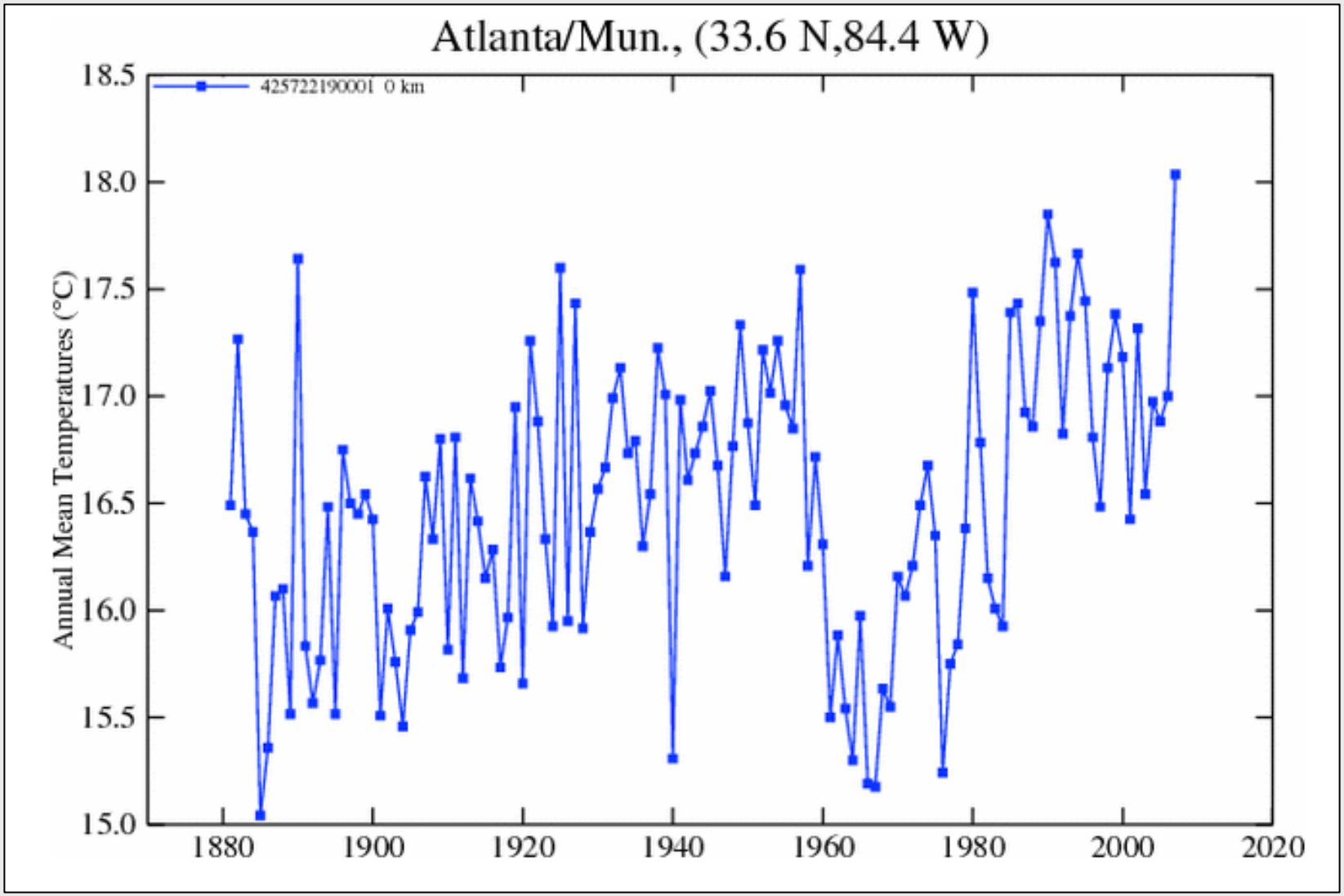
Sources of “Inhomogeneity” in Temperature Record.

1. Change in location of instrument.
2. Change in instrumentation.
3. Change in time of observation.
4. Contamination by urbanization.



50 Cities Included in Study.

Hartsfield-Jackson Observations.



Station Selection.

URBAN.

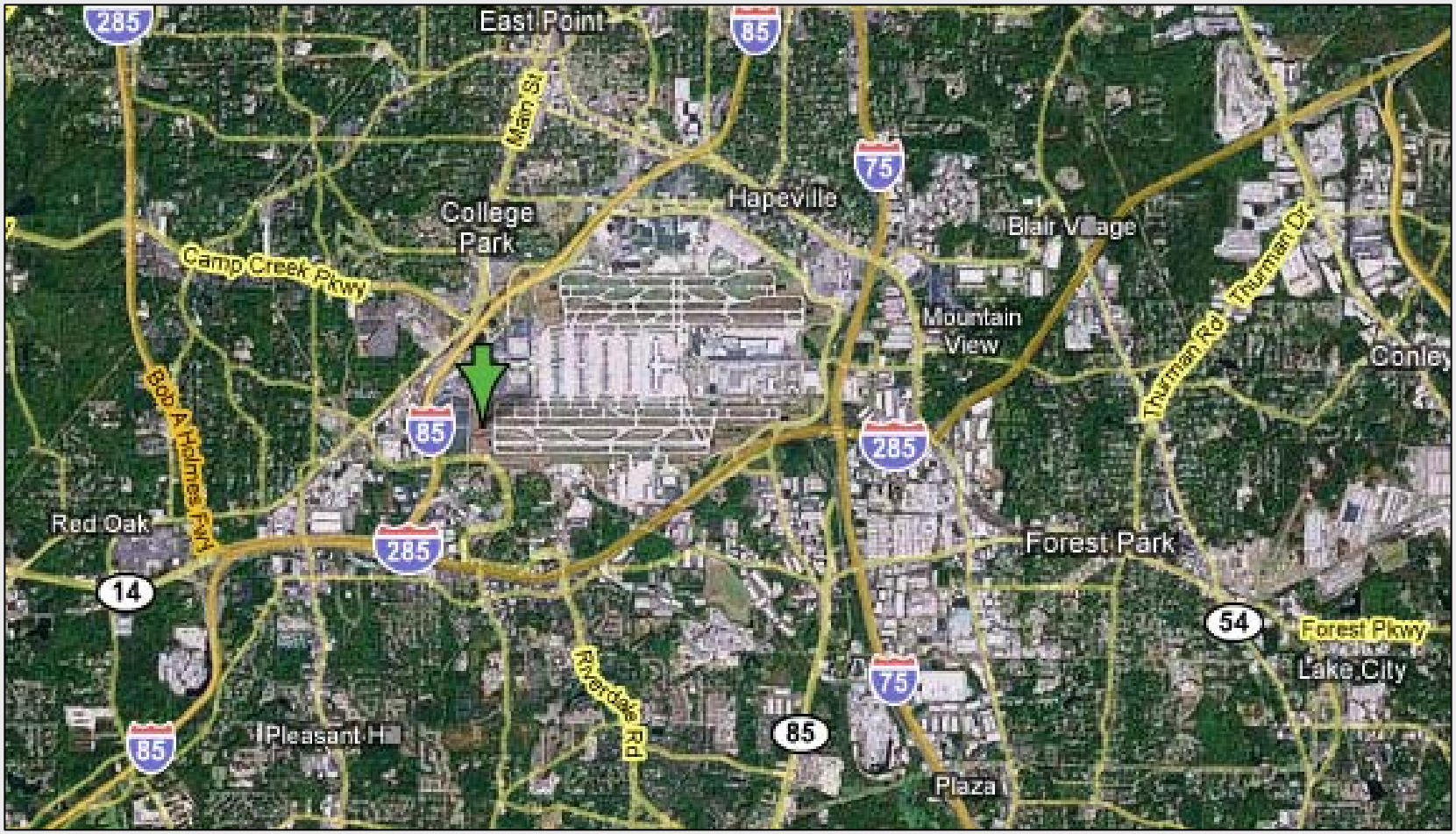
- Airport as single “first-order” meteorological station for each urban center.
- Night light ranking of C (bright).

RURAL

Three stations selected for each city based on:

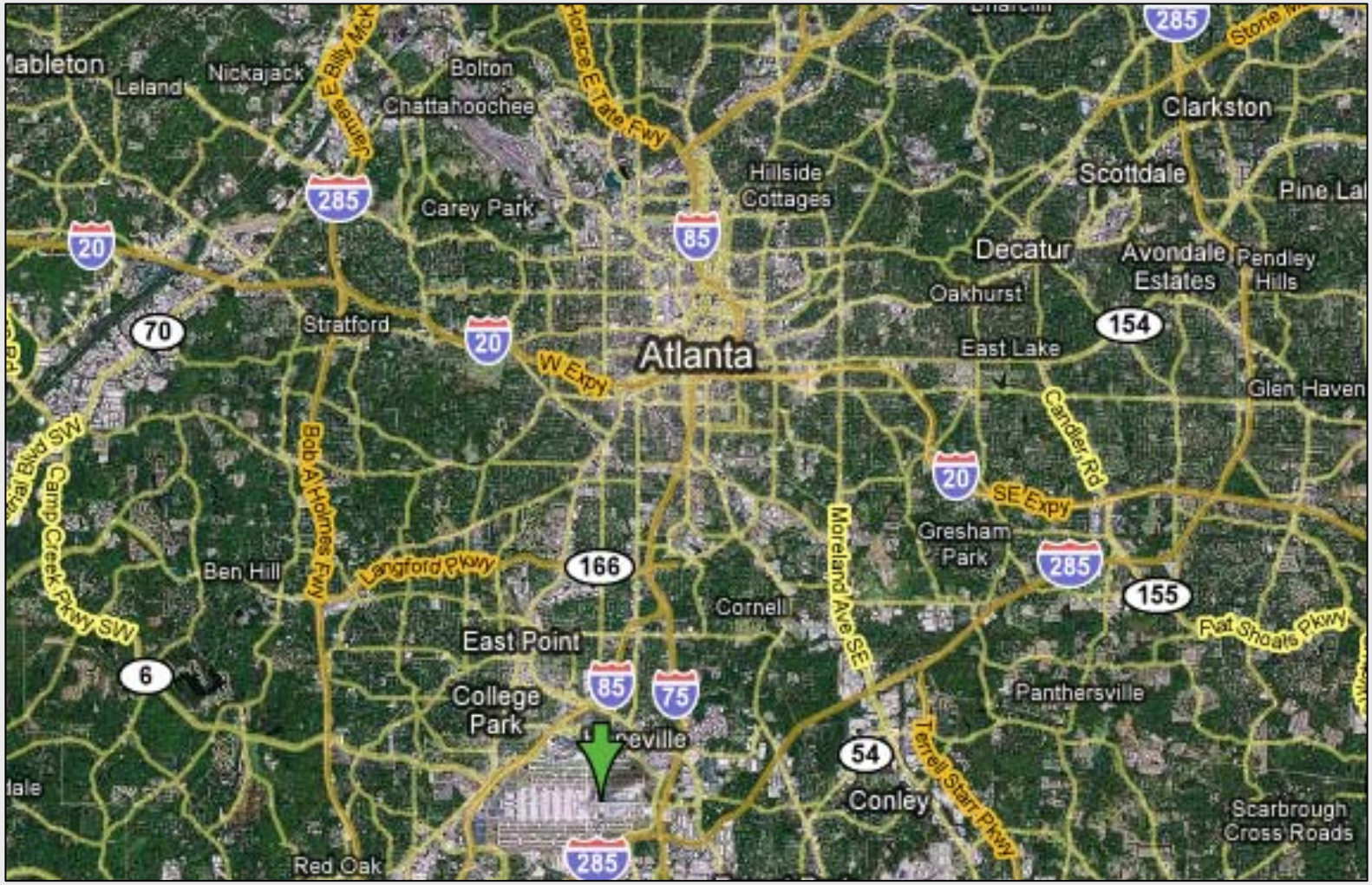
1. Night light ranking of A (dark) or B (dim).
2. Population < 4,000 per square kilometer.
3. Located within 50 to 250 km of urban station.

Hartsfield Meteorological Station.

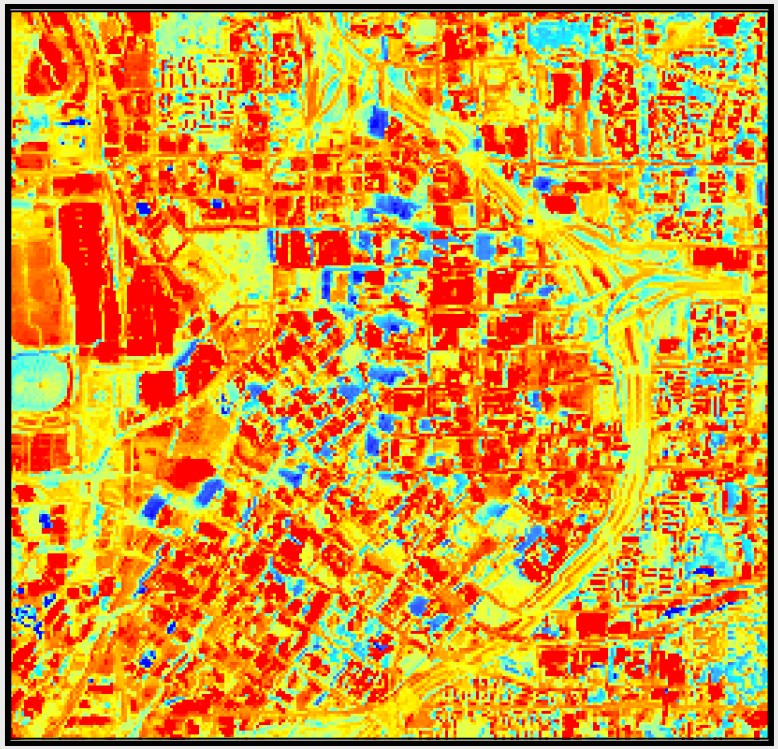


Hartsfield Meteorological Station.

Hartsfield Meteorological Station.

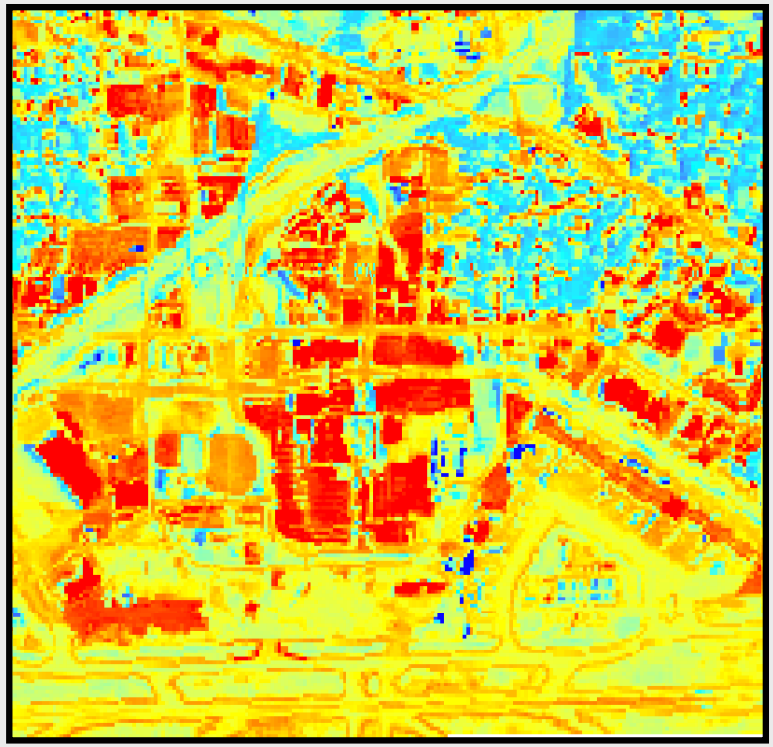


Surface Temperatures.



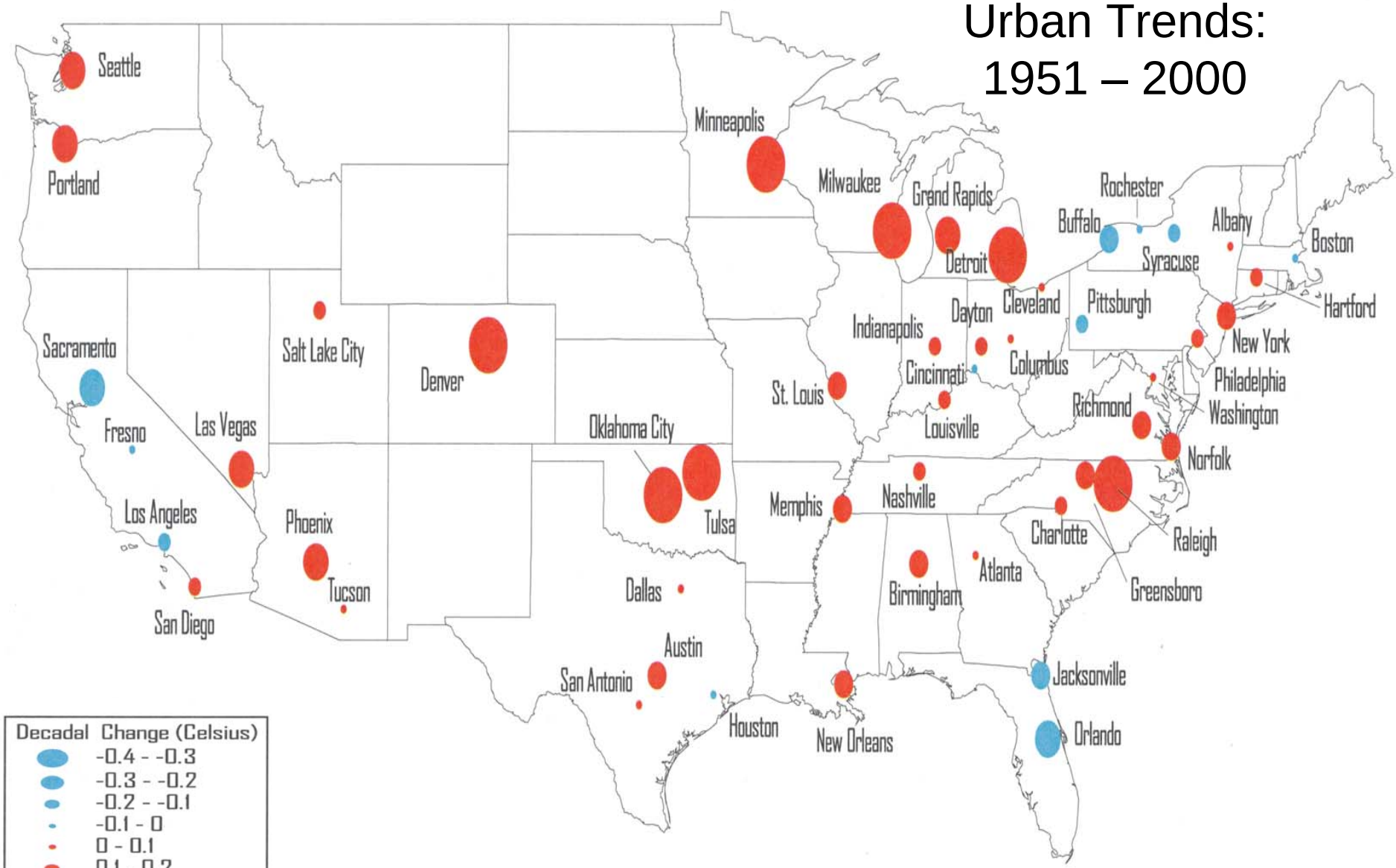
Source: NASA 1997

CBD.

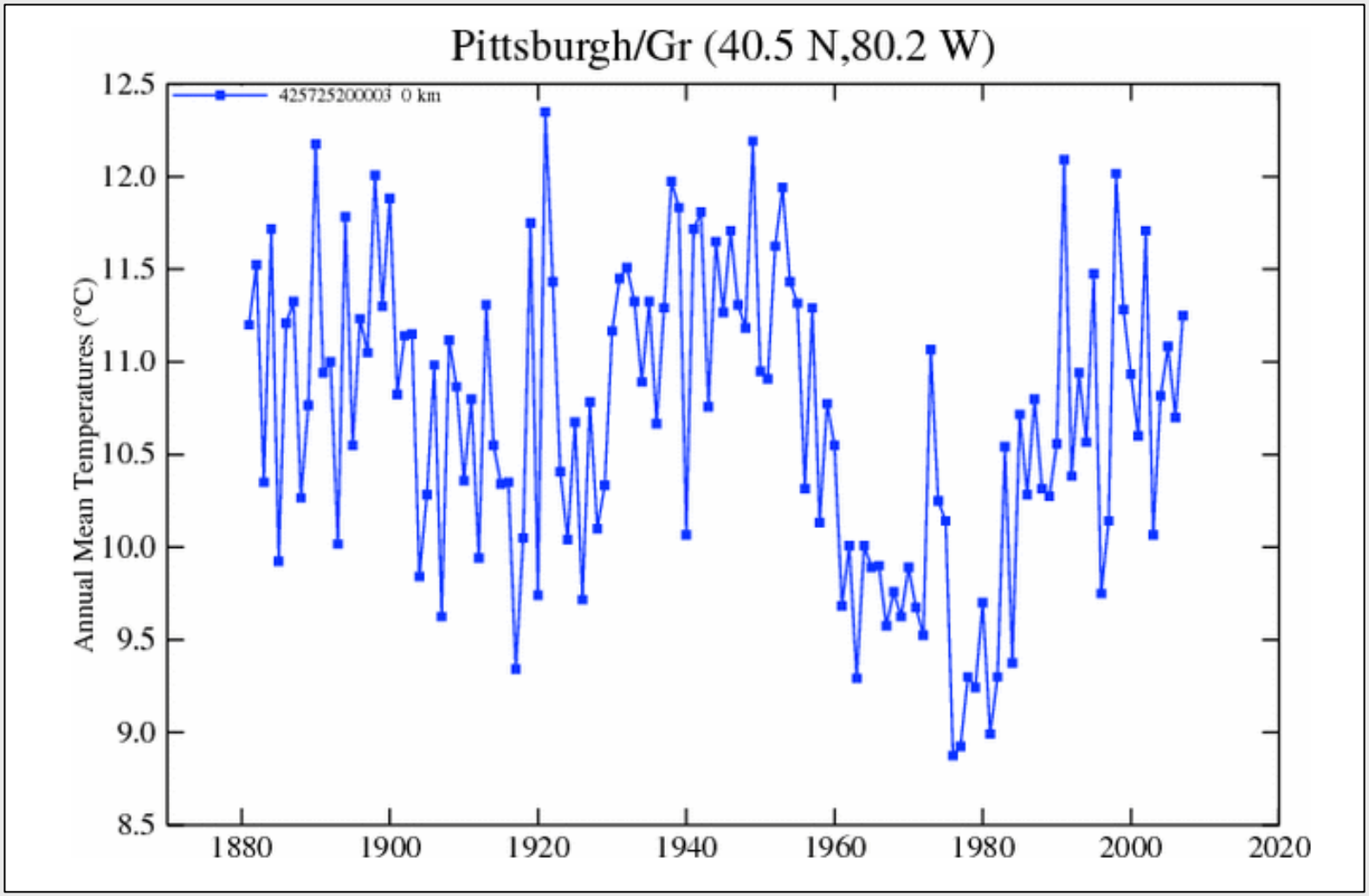


Hartsfield-Jackson.

Urban Trends: 1951 – 2000

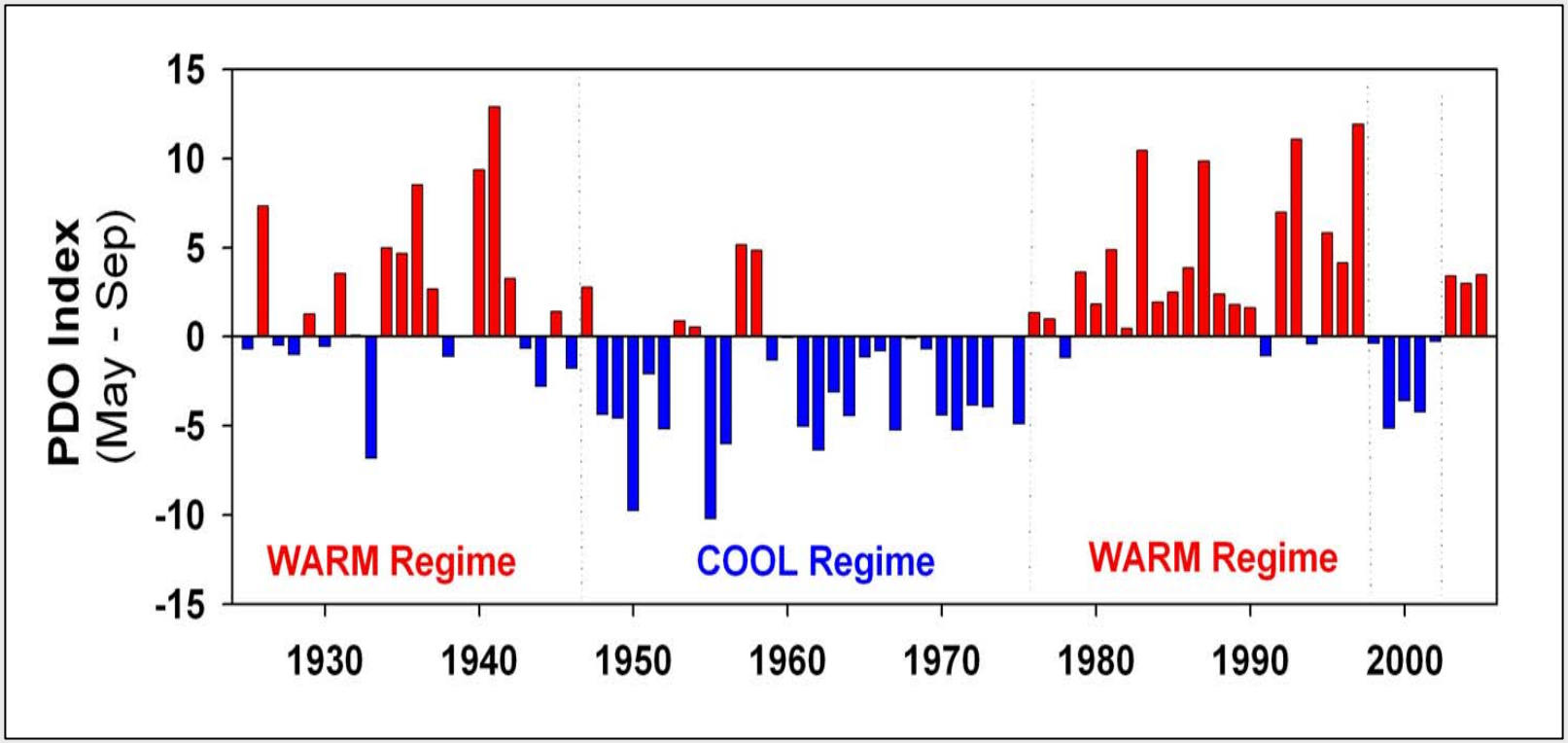


Mean Decadal Change in Urban Temperatures: 0.20 ^{O}C.



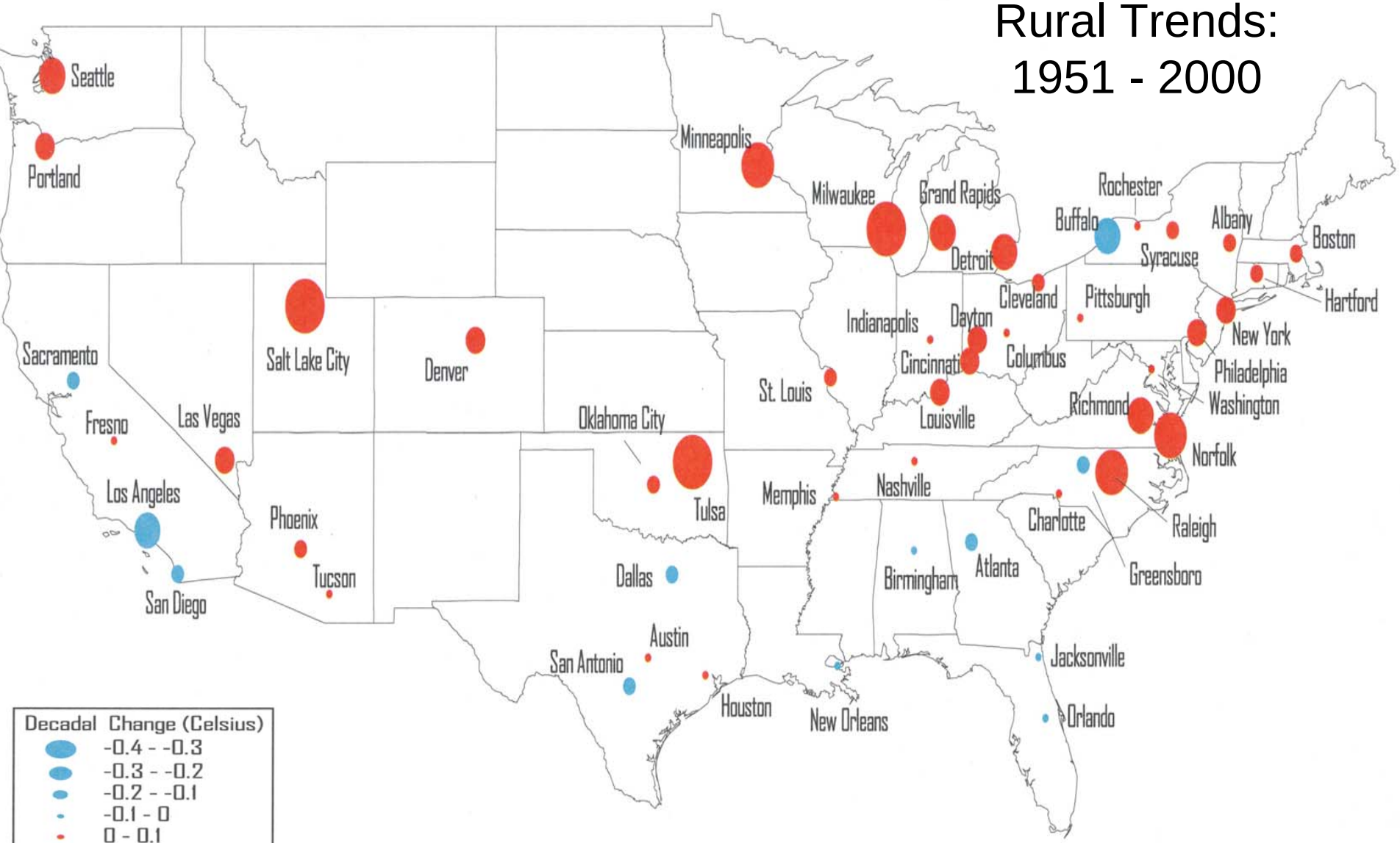
Source: NASA Goddard Institute for Space Studies, GHCN.

Pacific Decadal Oscillation (PDO)



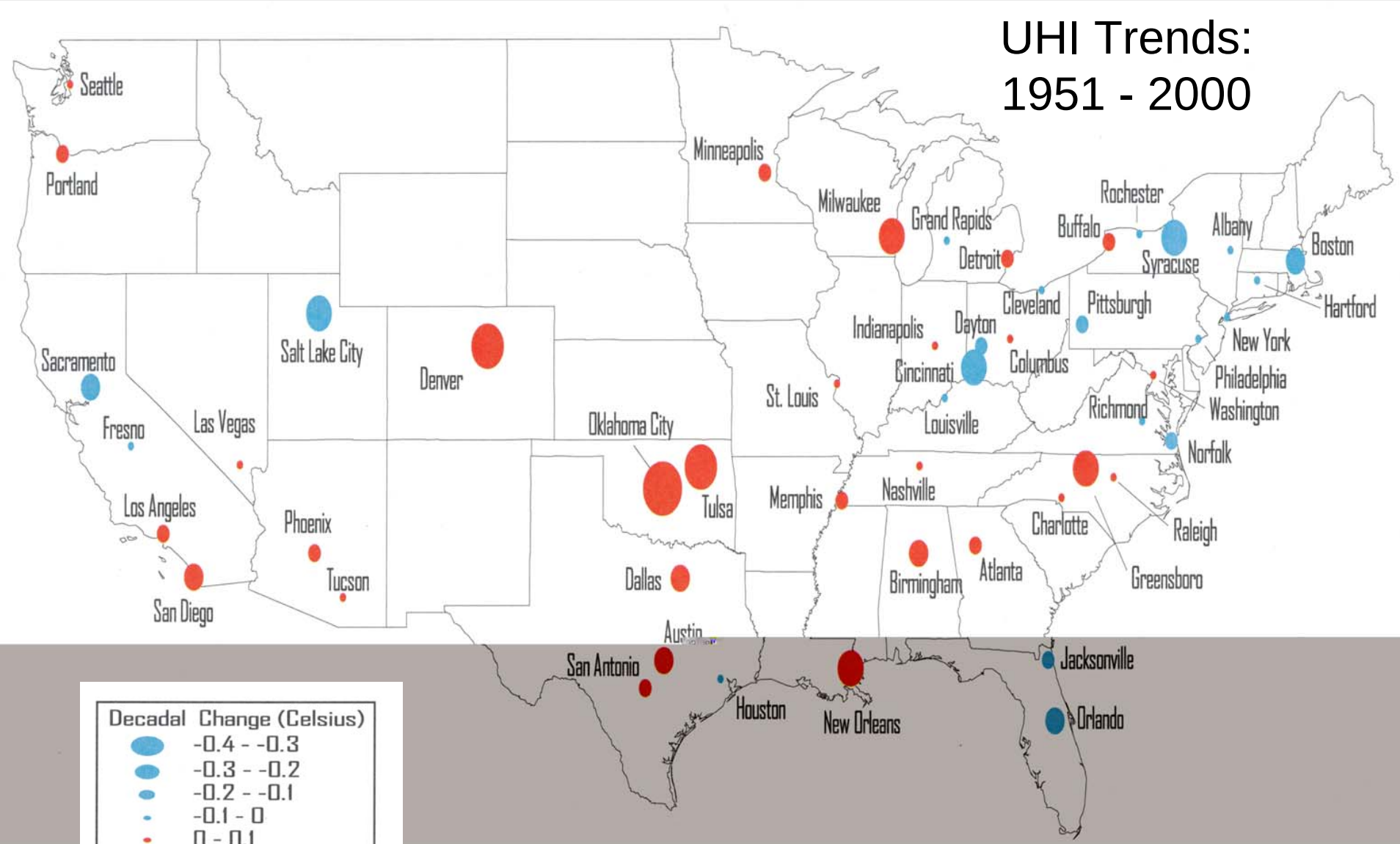
The Pacific Decadal Oscillation is a climate index based upon patterns of variation in sea surface temperature of the North Pacific from 1900 to the present (Mantua et al. 1997). While derived from sea surface temperature data, the PDO index is well correlated with many records of North Pacific and Pacific Northwest climate and ecology, including sea level pressure, winter land–surface temperature and precipitation, and stream flow. (NOAA Fisheries Service)

Rural Trends: 1951 - 2000



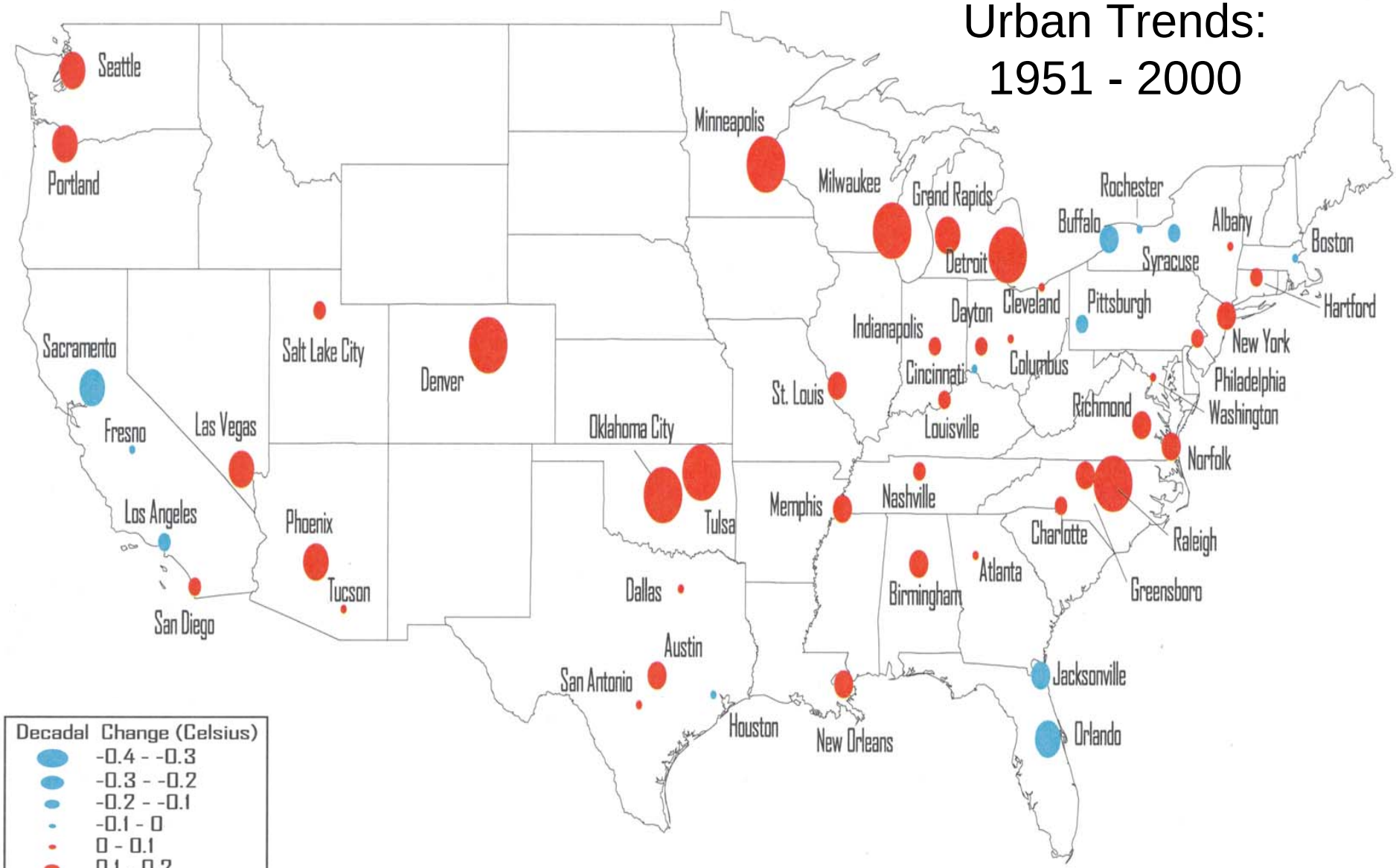
Mean Decadal Change in Rural Temperatures: 0.15 ^{O}C.

UHI Trends: 1951 - 2000



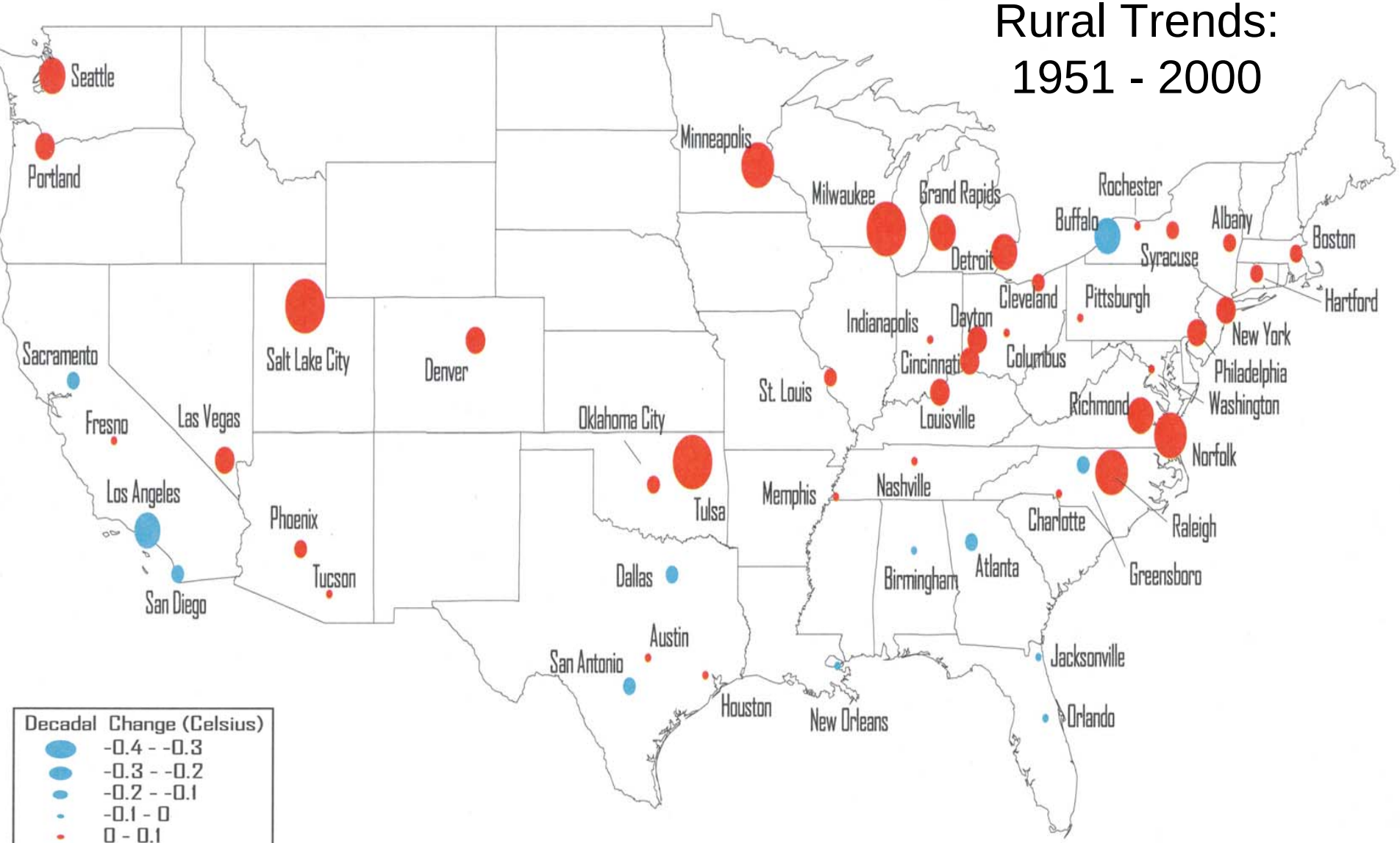
Mean Decadal Change in UHI: 0.05 ^{O}C.

Urban Trends: 1951 - 2000



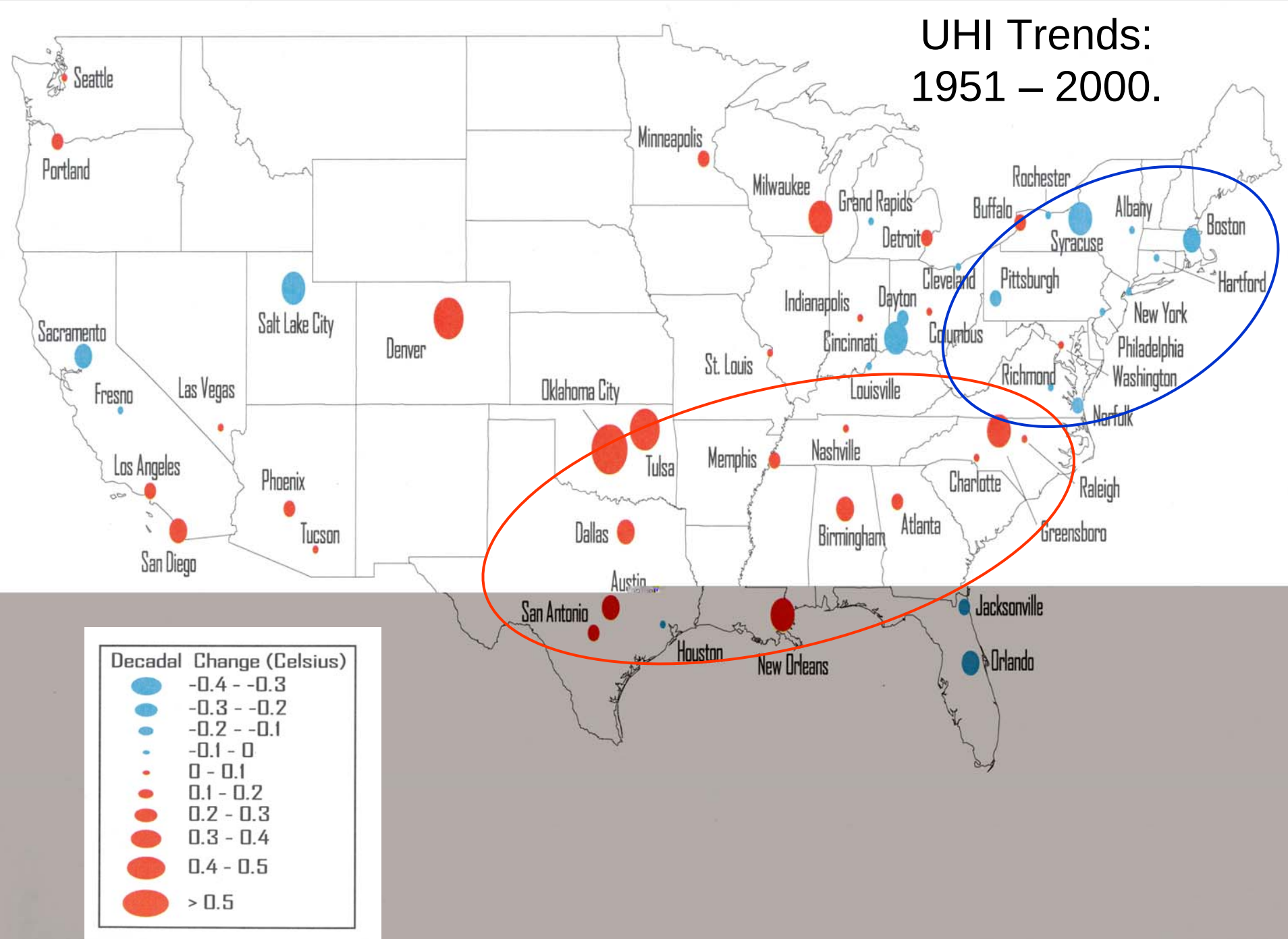
Mean Decadal Change in Urban Temperatures: 0.20 ^{O}C.

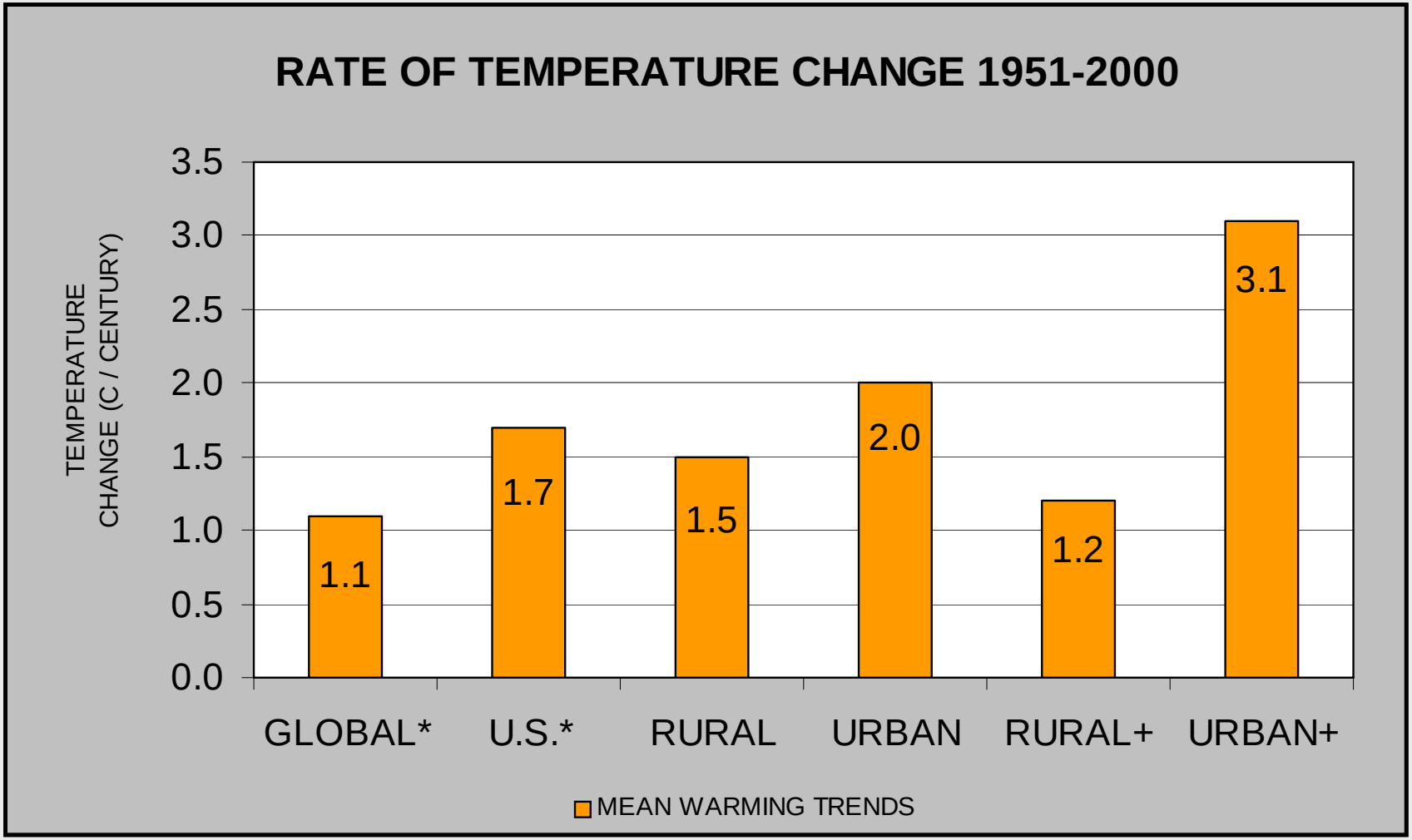
Rural Trends: 1951 - 2000



Mean Decadal Change in Rural Temperatures: 0.15 ^{O}C.

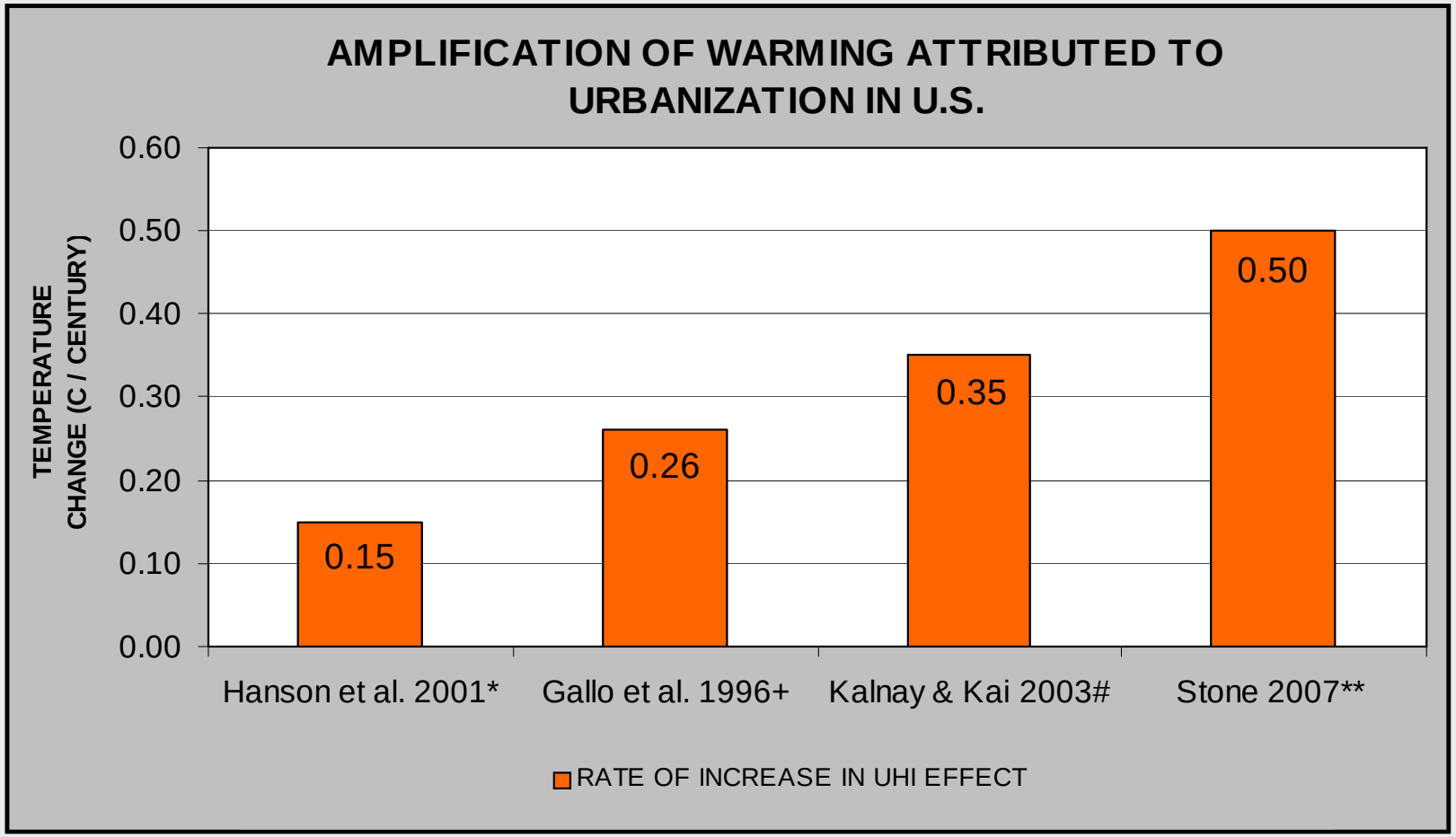
UHI Trends: 1951 – 2000.





* NASA Goddard Institute of Space Studies.

+ Cities in which UHI increased between 1951 and 2000.



* Mean rate over 1900-1999.

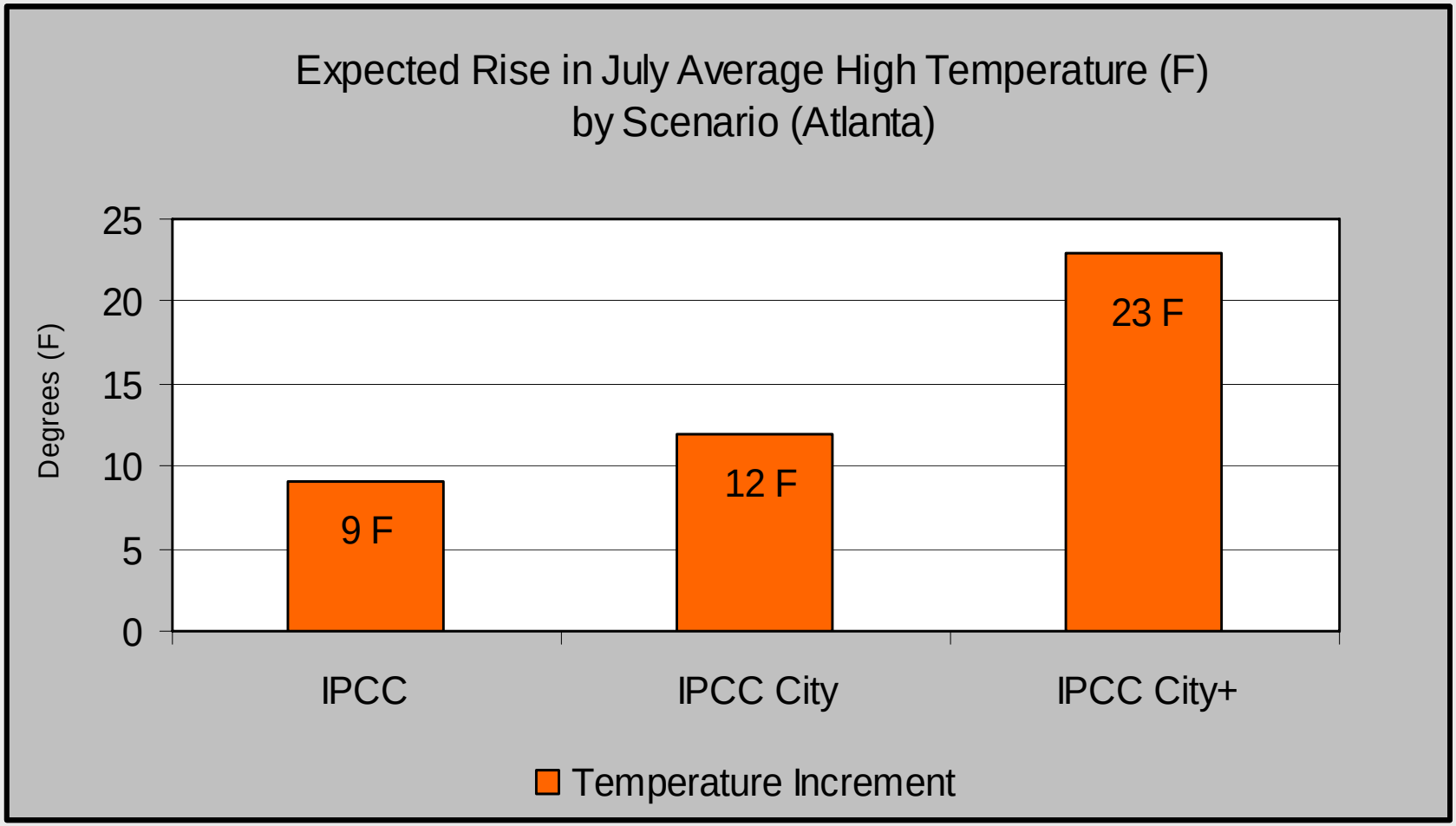
\+ Mean rate over 1950-1996 (results not significant).

\# Mean rate over 1951-2000; reflects impacts of urbanization and agriculture.

** Mean rate over 1951-2000.

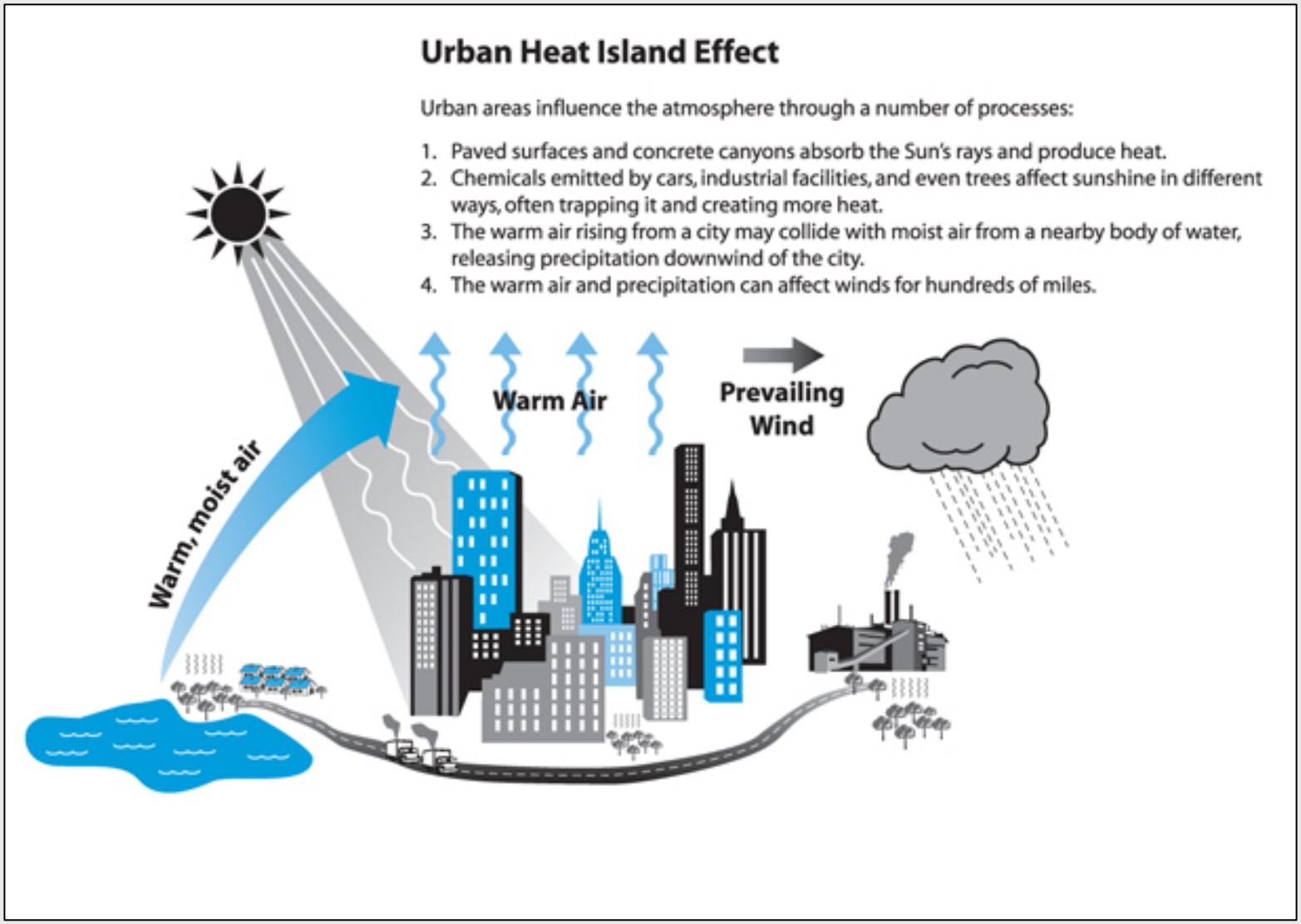
Study Findings.

- On average, the decadal rate of warming in large U.S. cities was 30% greater than that of proximate rural areas taken to represent “background” warming trends.
- For cities in which the urban heat island effect was enhanced during this period (60%), the decadal rate of warming was 150% greater than that of proximate rural areas.
- As warming scenarios developed by the Intergovernmental Panel on Climate Change (IPCC) are based on background global rates of warming, these scenarios (1.4 to 5.8 ^{O}C by 2100) are likely to significantly underestimate the rate of warming in large cities over time.



*Assumes 5 ^{O}C (9 ^{O}F) rise in temperature by 2100. Historical average high temperature for Atlanta in July: 89 ^{O}F.

Negative Feedbacks on UHI.



Source: NCAR, 2006

"More than half of the built environment of the United States we will see in 2025 did not exist in 2000, giving planners an unprecedented opportunity to reshape the landscape." (Nelson, 2006)

Source: www.greeninggothan.org