[AV]Modern Observations: Temperature Data and Their Interpretation*

By
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Abstract

The global surface temperature time series reveals that our planet has been warming over the last century and especially over the last few decades. The observing systems that produce the raw instrumental data that go into the time series have undergone a variety of changes that can introduce non-climatic biases into the data. For example, sea surface temperature observations used to be made by sticking a thermometer into a bucket of surface water hauled up on deck. Now ships make their measurements using thermometers in engine cooling water intake pipes which bring in water from several meters below the surface. Such changes have caused a great deal of effort to be expended developing approaches to remove the various non-climatic biases.

This presentation will describe the ongoing efforts to insure robust calculation of global mean surface temperature including improving international data exchange, quality control and homogeneity adjustment methodology. Analyses that evaluate how well these methods remove biases from a variety of sources, such as urban heat islands, will also be described. Lastly, no discussion of global surface temperature data would be complete without interpreting or attributing the climate change signal imbedded in the surface temperature time series. Therefore, the talk will very briefly outline some of the science that supports the statement by the Nobel Prize winning Intergovernmental Panel on Climate Change's Fourth Assessment Report that "most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations."

Modern Observations: Temperature Data and their Interpretation

Thomas C. Peterson
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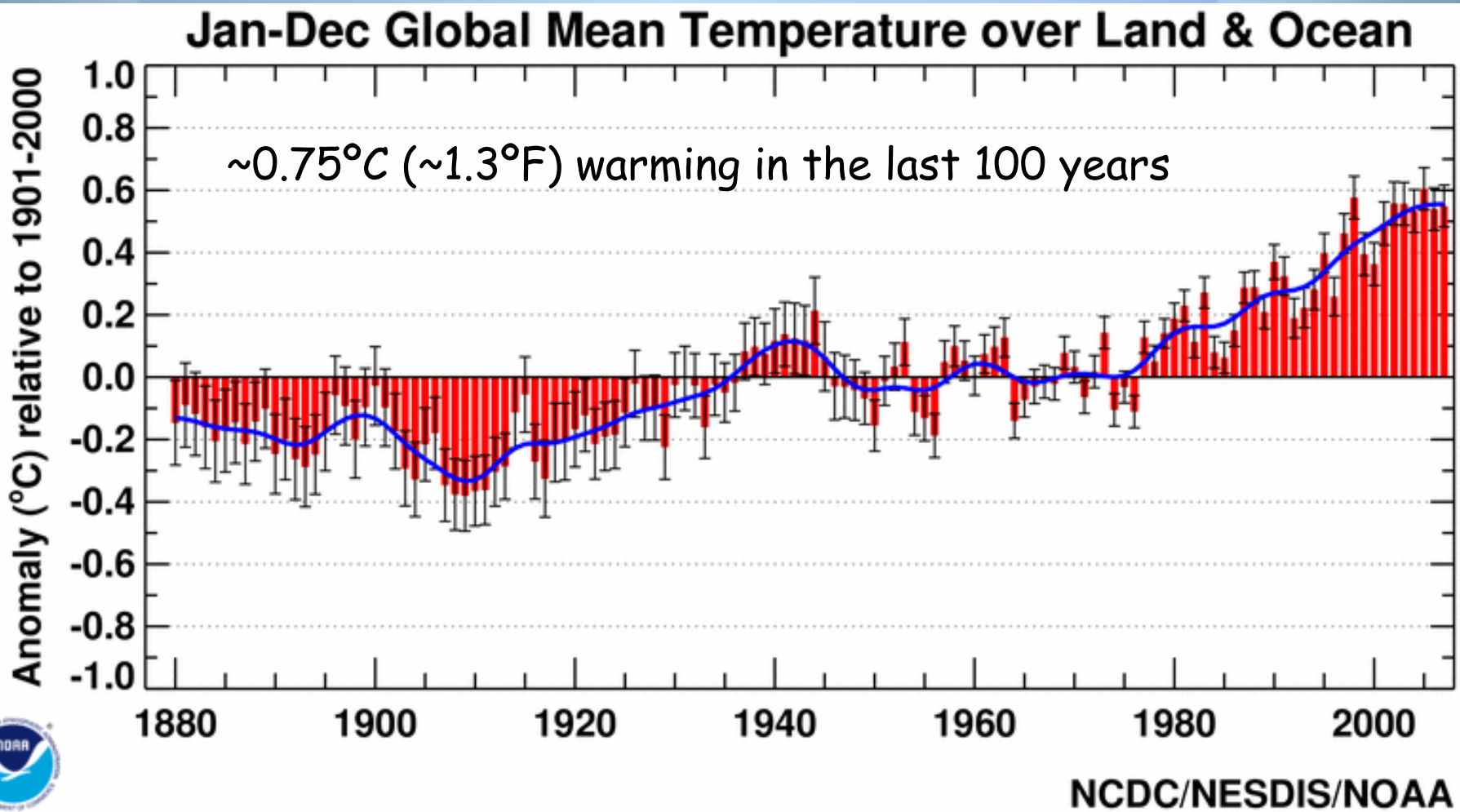
Outline

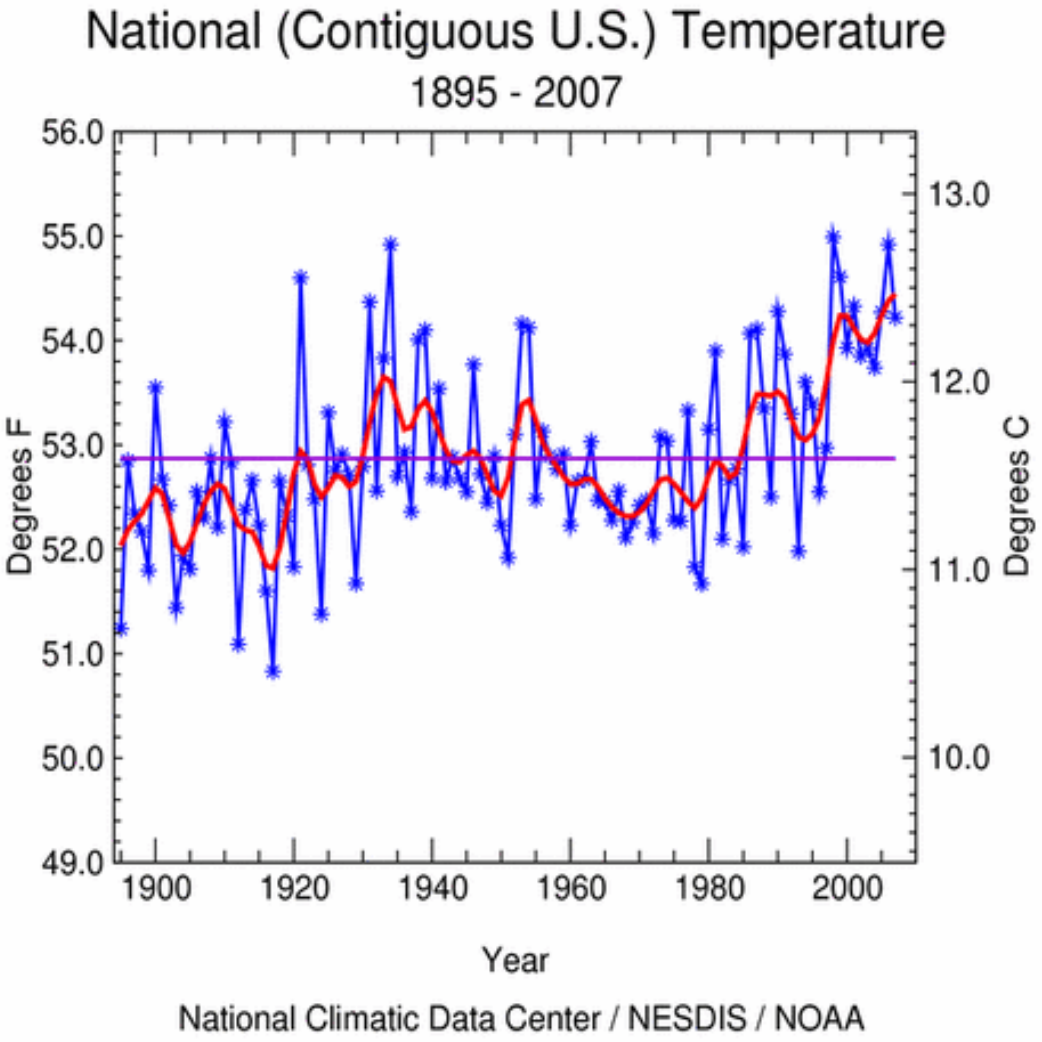
- How the climate is changing according to the data
- Efforts to ensure the data base is robust
- Post production quality assurance
- Climate change attribution
- Final comment
  - Each of the above topics could be a full presentation on their own

How the climate is changing according to the data

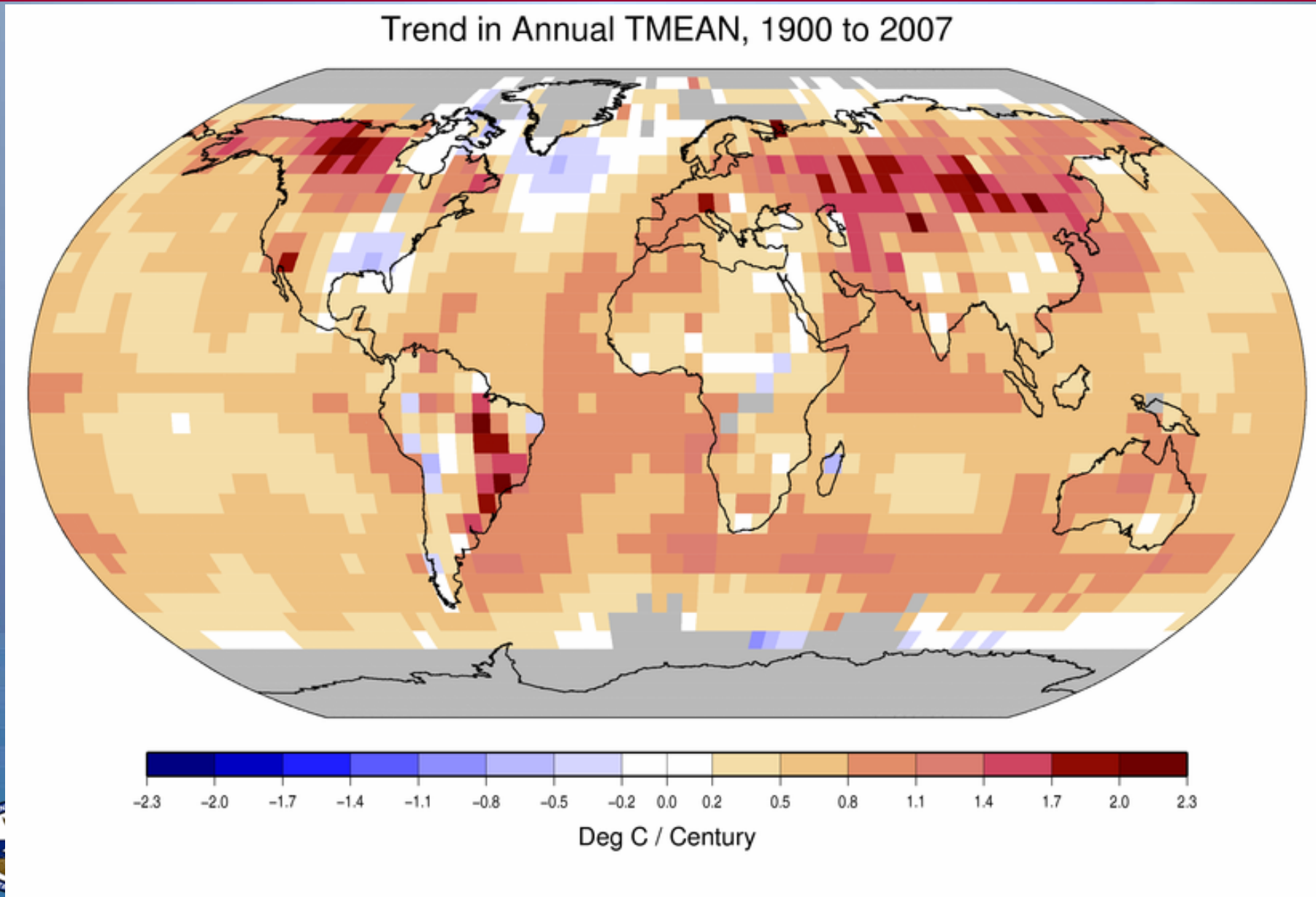
Global temperatures are rising



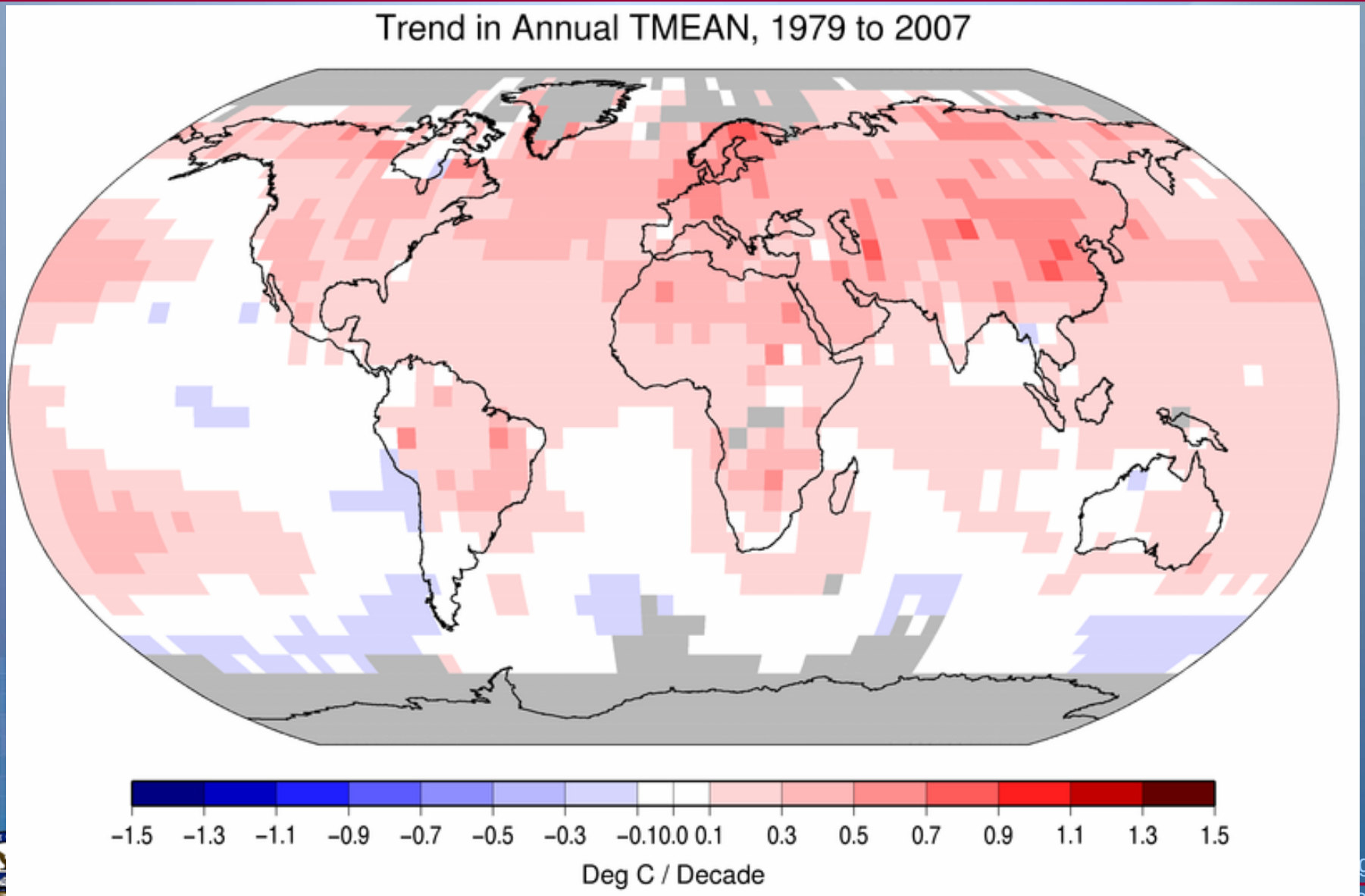
US temperatures are generally similar



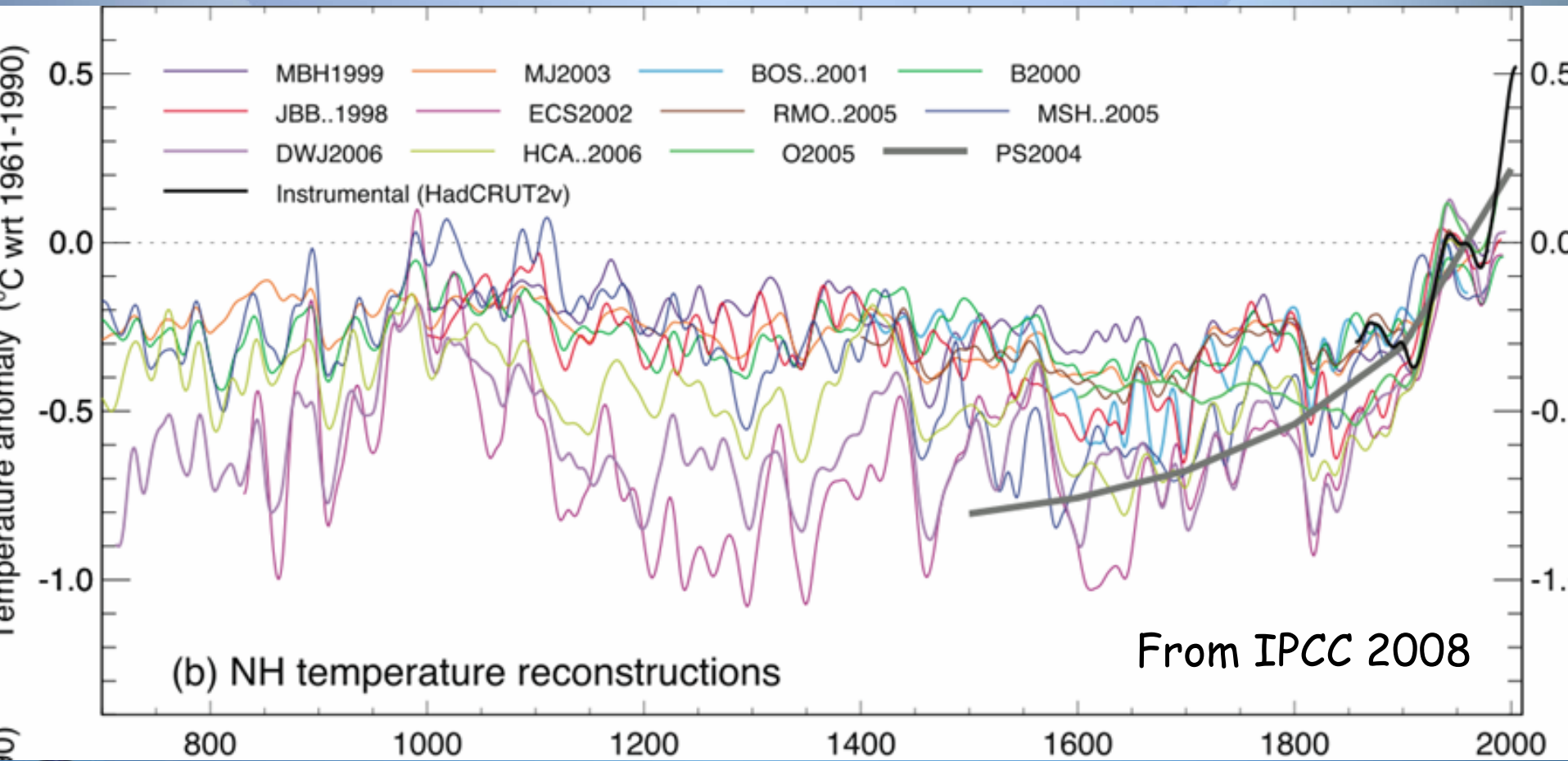
Global warming is not uniform around the globe, e.g., the SE US cooled



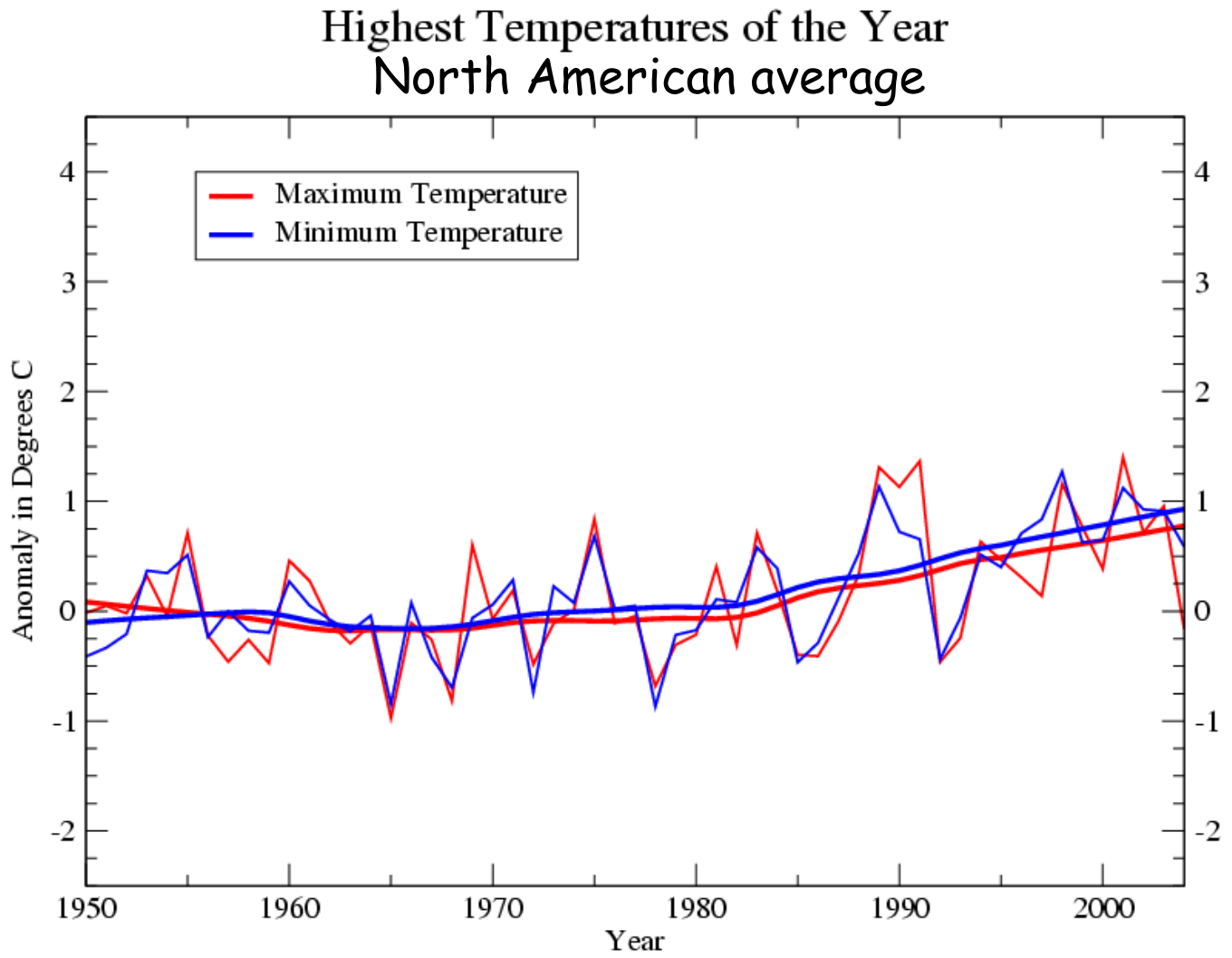
More warming in the last few decades



The recent observed climate change is beyond the bounds of natural variability

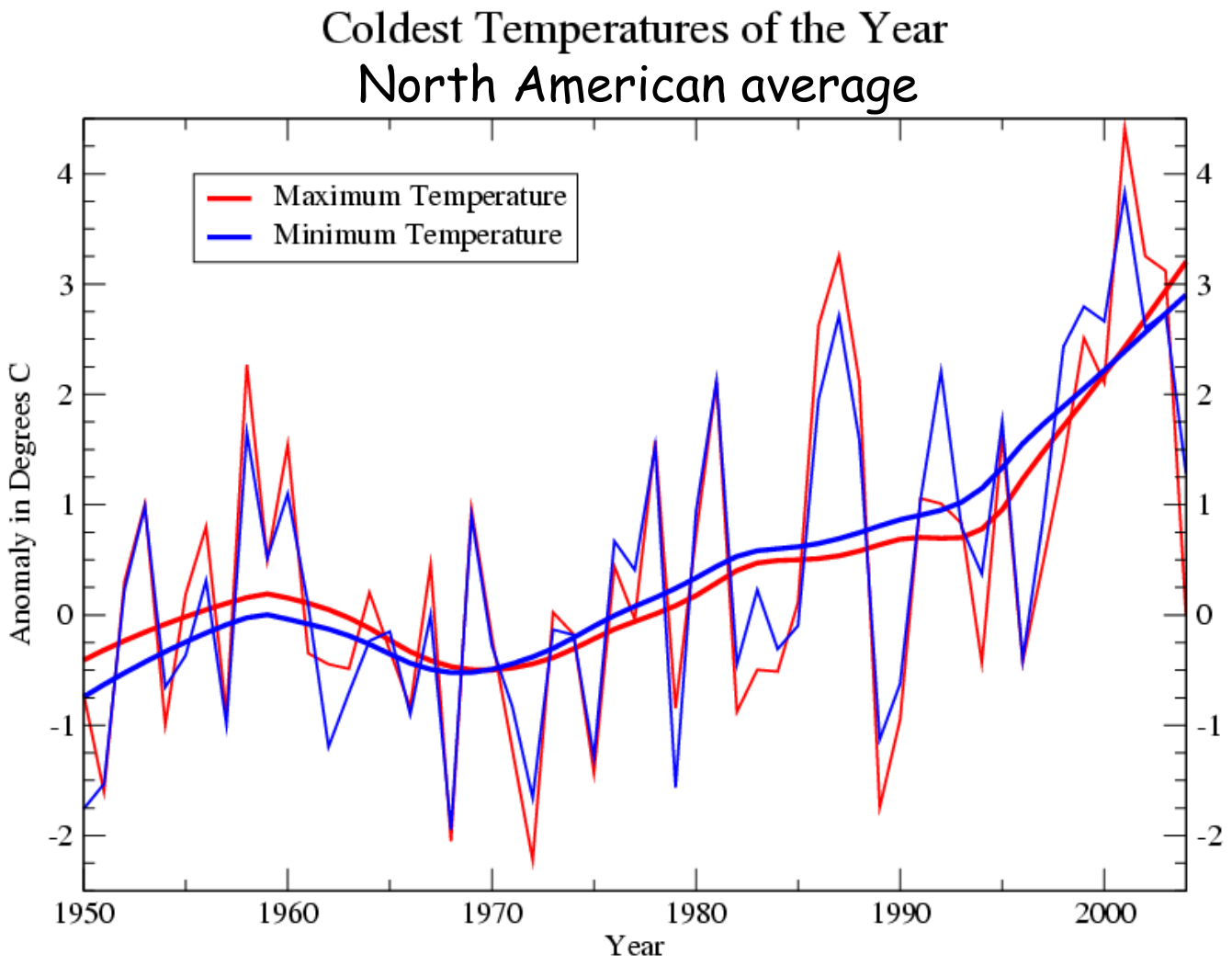


The hottest summertime temperatures are increasing



Peterson et al., 2008 permission of NRC/AMS © Amer. Meteorological Soc.

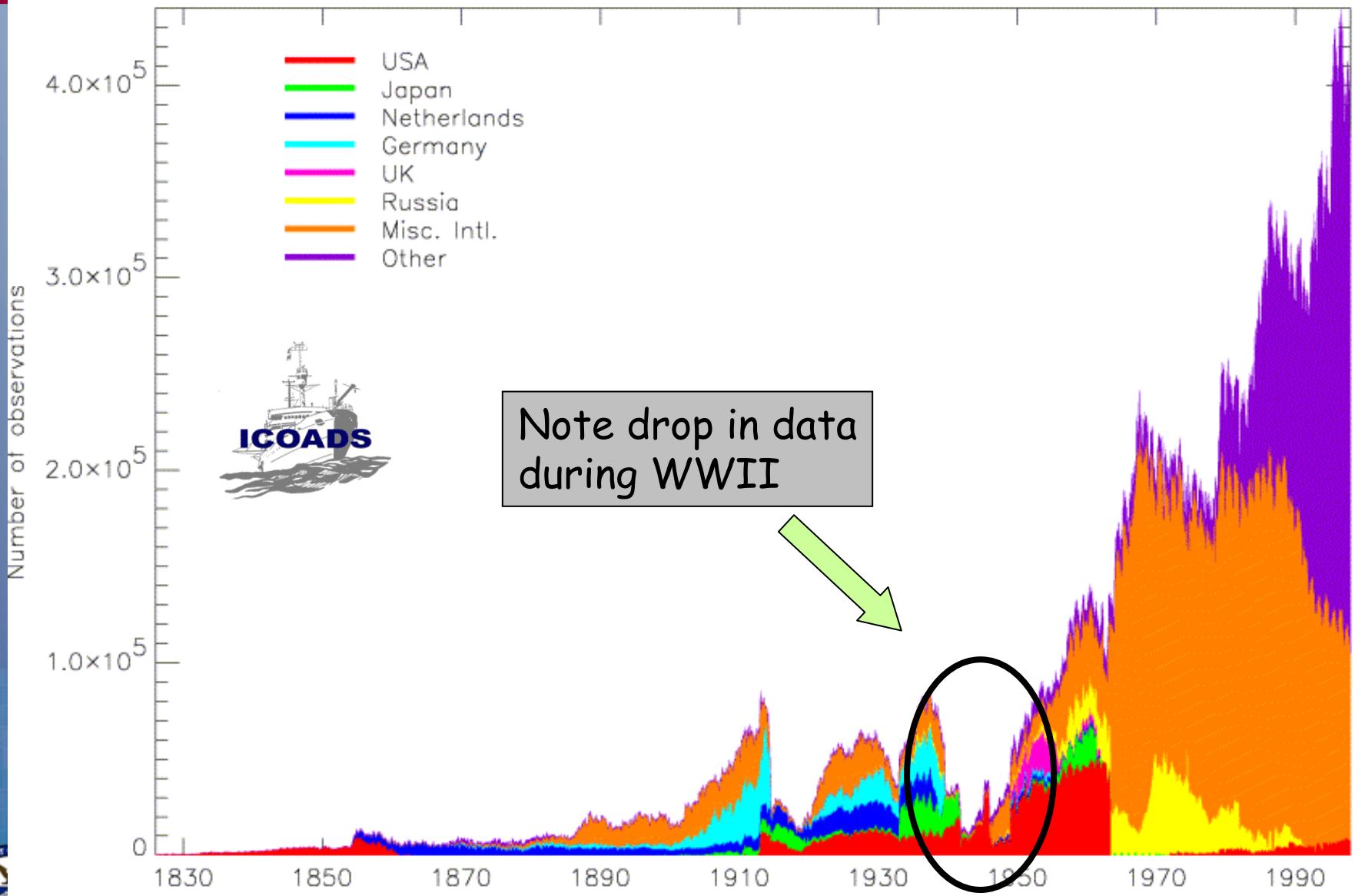
Coldest winter temperatures are warming faster



Peterson et al., 2008 permission NRC/AMS © Amer. Meteorological Soc.

Efforts to insure the data base is robust

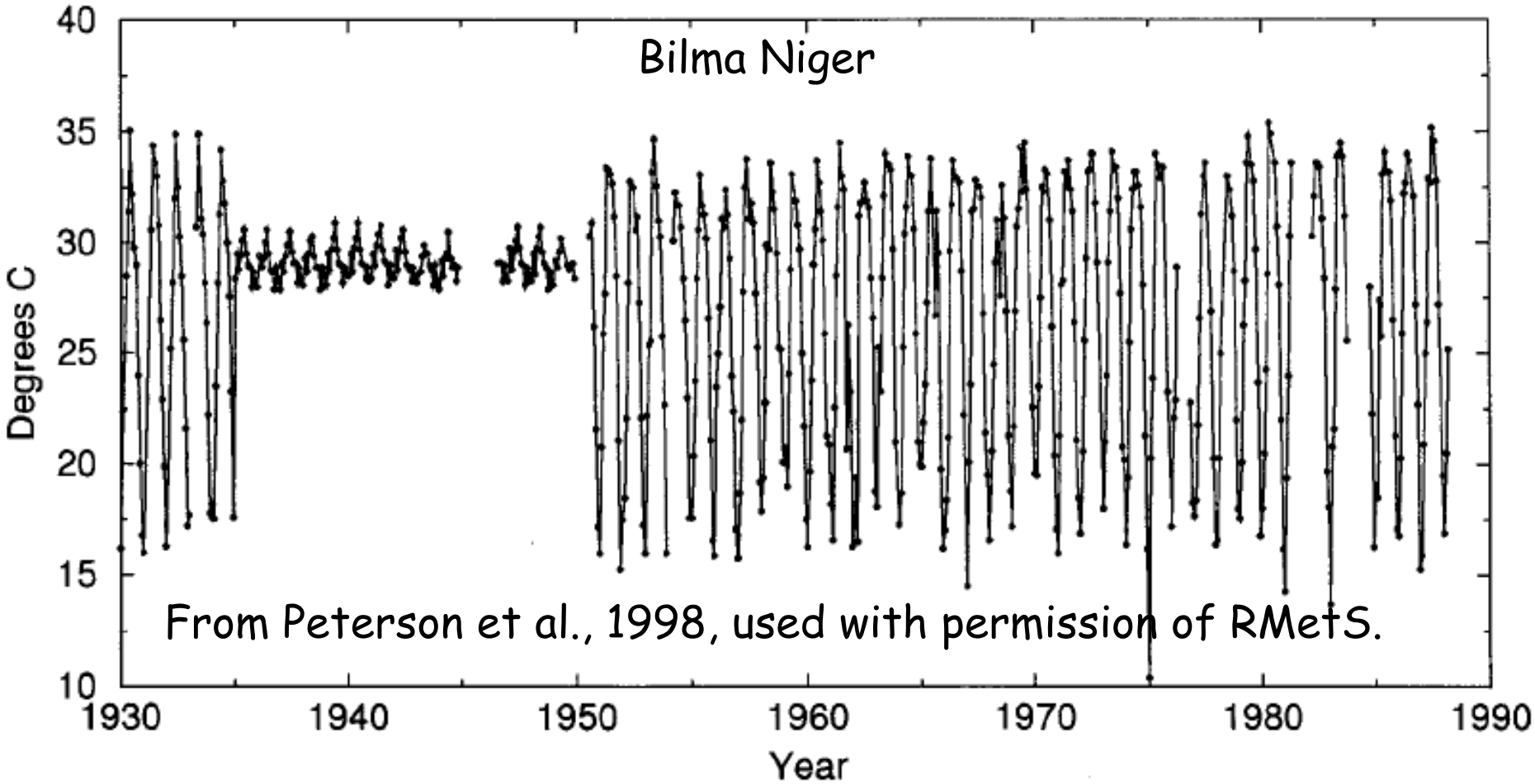
International data exchange



Source: Scott Woodruff, 1992 International COADS Workshop

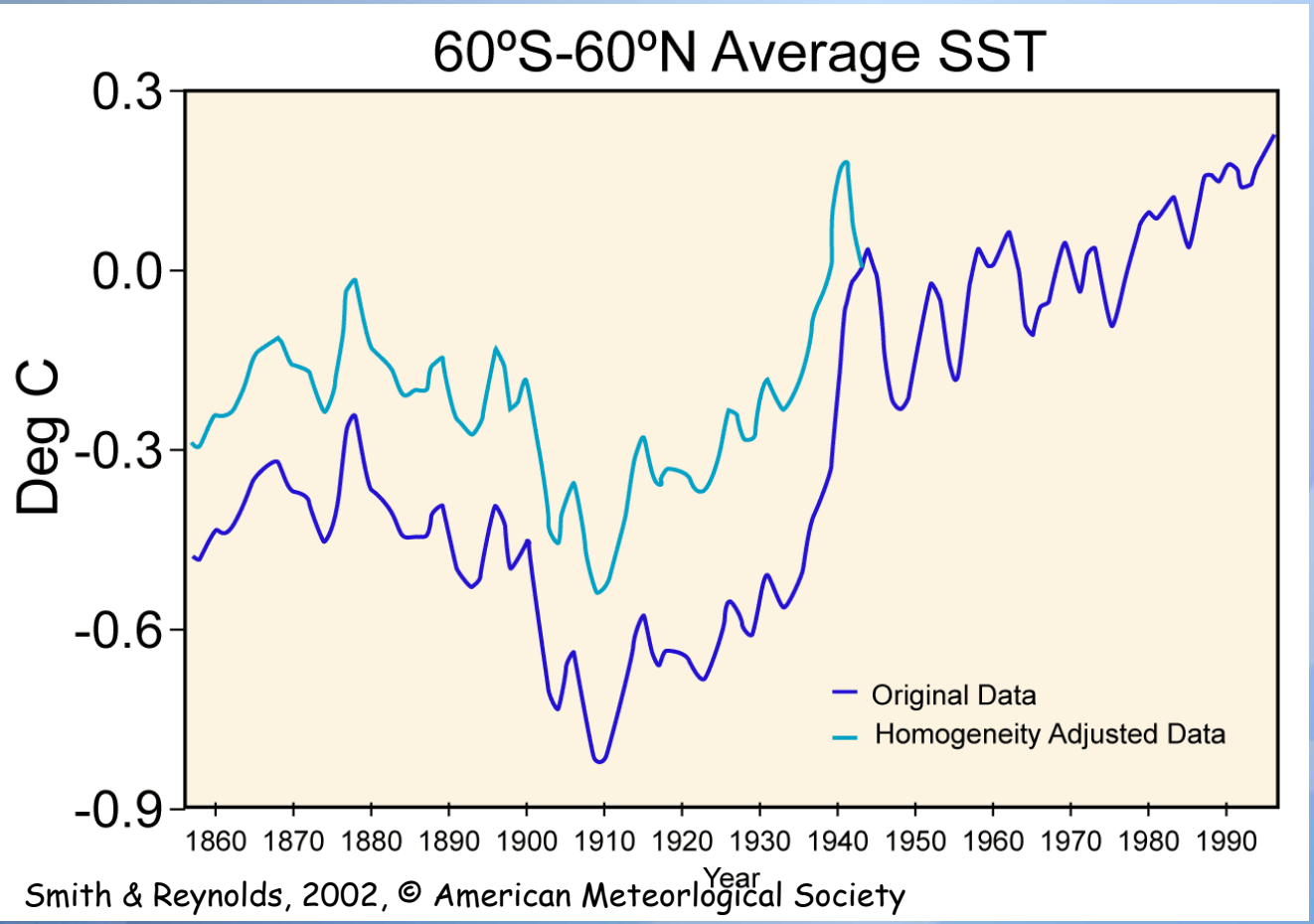
Quality control

- A wide variety of checks have been developed to identify erroneous data points.



From Peterson et al., 1998, used with permission of RMetS.

Homogeneity adjustments – Sea Surface Temperature example



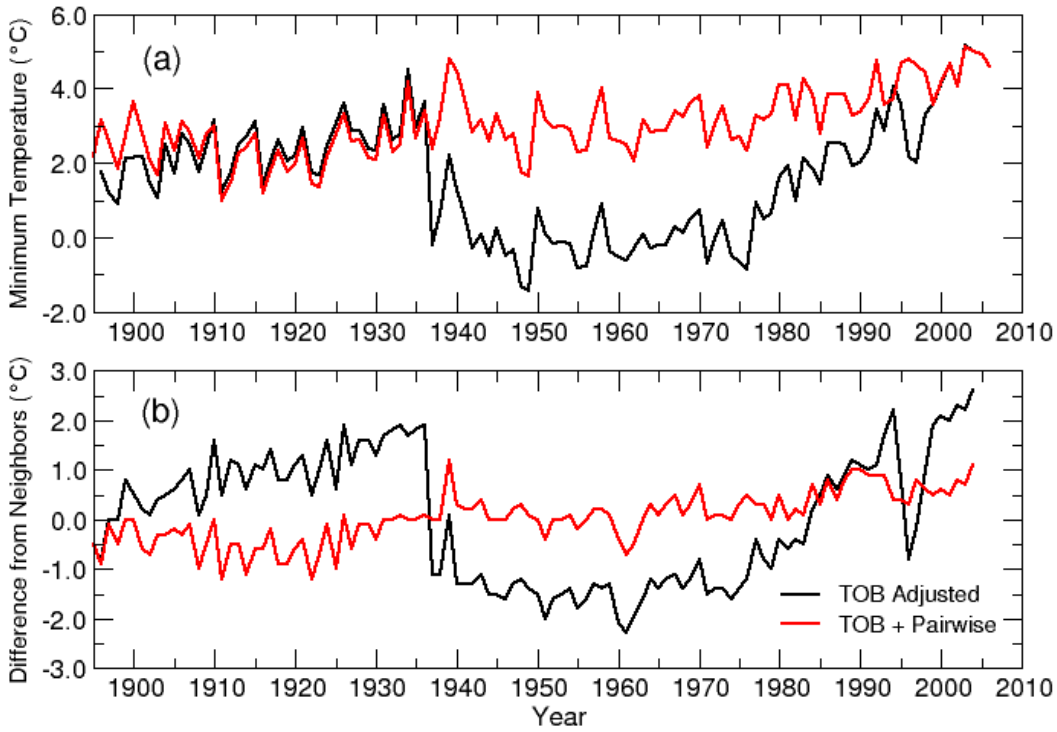
Smith & Reynolds, 2002, © American Meteorological Society

- Adjust historical data to make them equivalent to being observed by modern instruments at current station locations

SST measured before ~ 1941 are significantly cooler than later SST, owing to change from using uninsulated buckets to a mixture of insulated buckets and engine coolant water intakes.

Homogeneity adjustments – Land air temperature station example

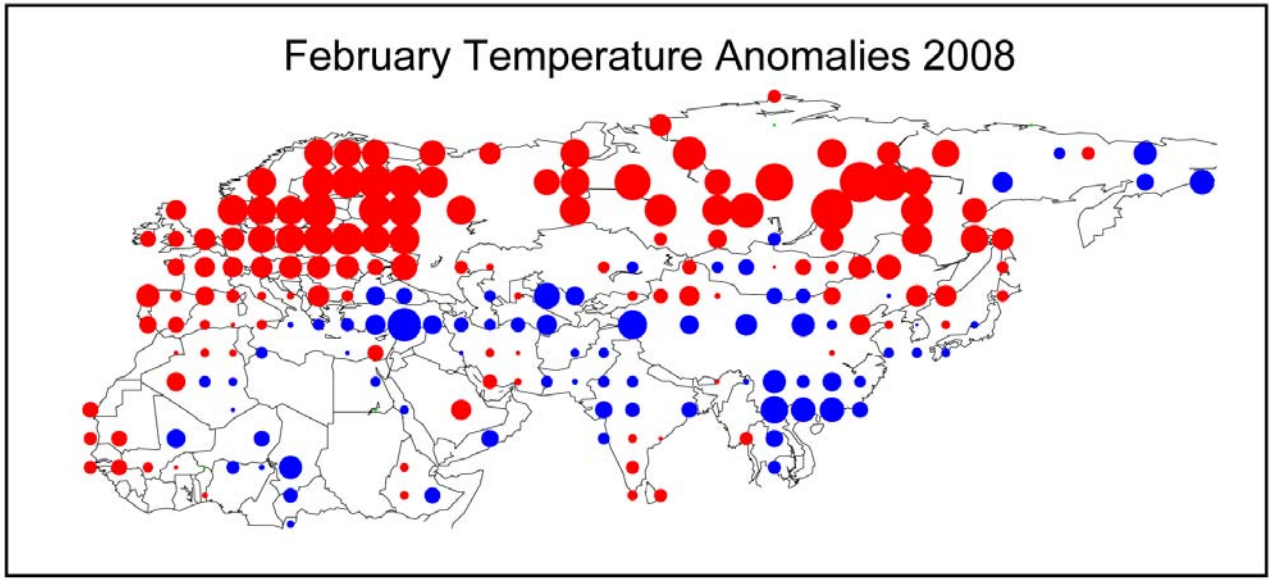
Reno Nevada annual minimum temperature

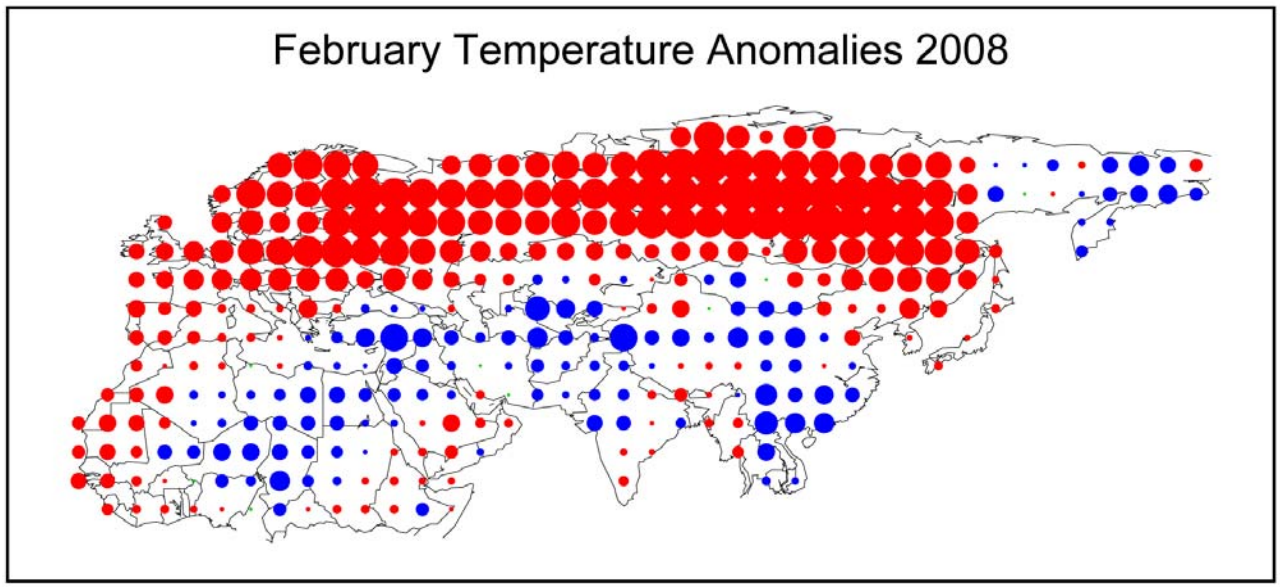


Menne et al., 2008 © Amer. Meteorological Soc.

- Red is fully adjusted
- Black is only time of observation adjusted
- Top: temperatures
- Bottom: difference between Reno and mean of 10 nearest neighbors

Spatial interpolation to fill in data sparse areas

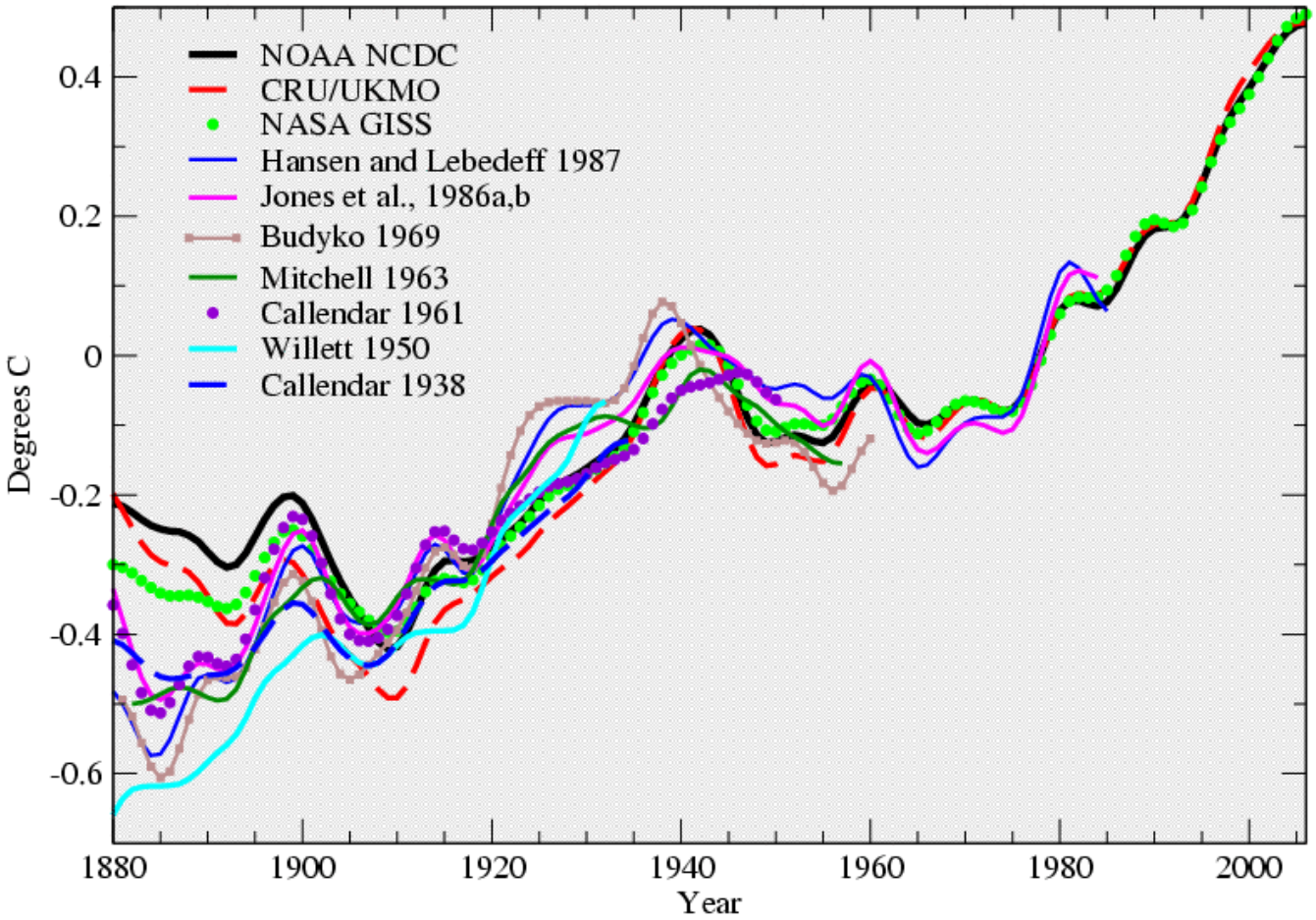




- Prevents bias towards areas with good international data exchange
- NCDC's approach uses Empirical Orthogonal Teleconnection Functions

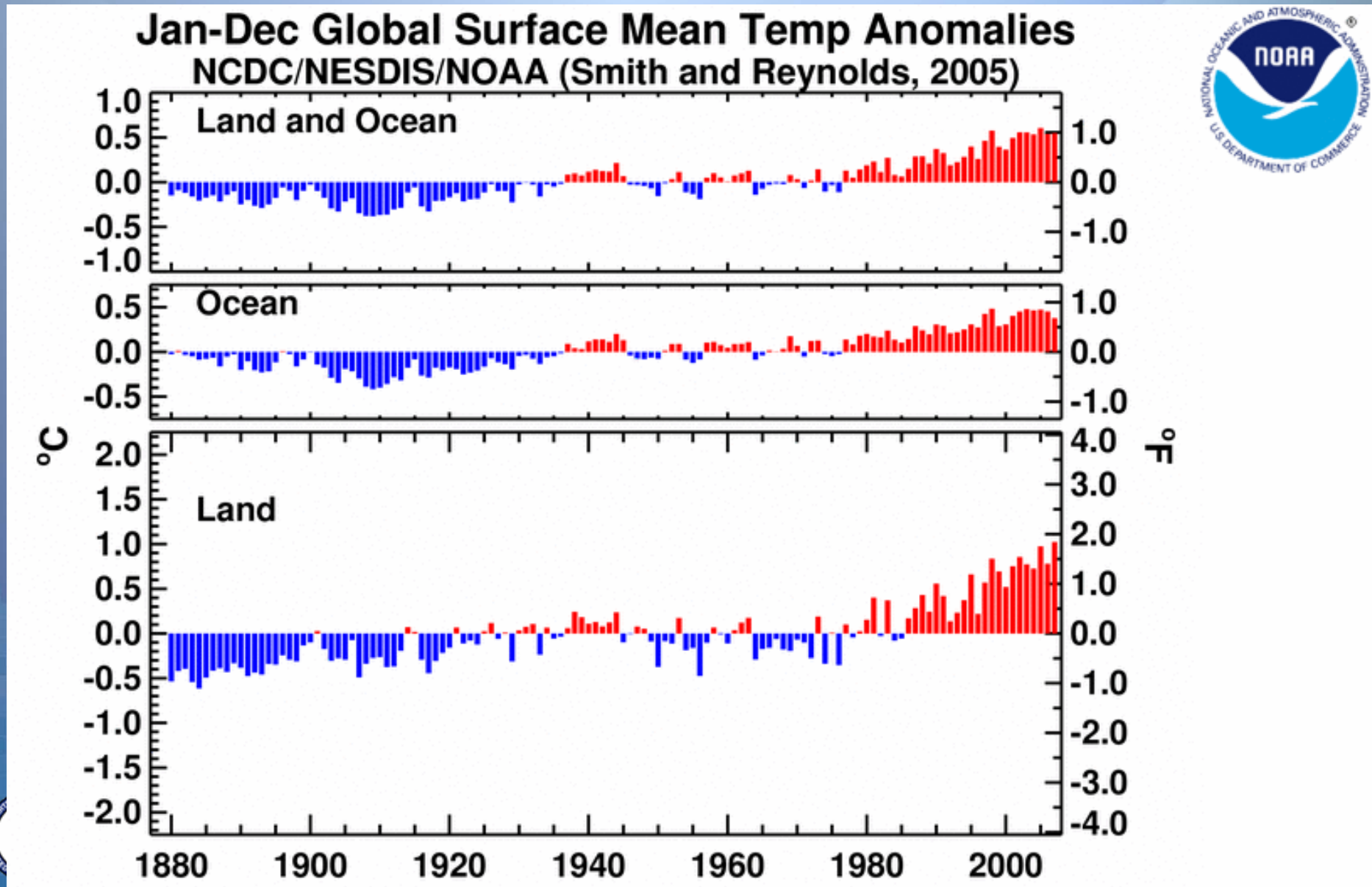
Post production quality assurance

Comparison with other data sets: They show the same thing

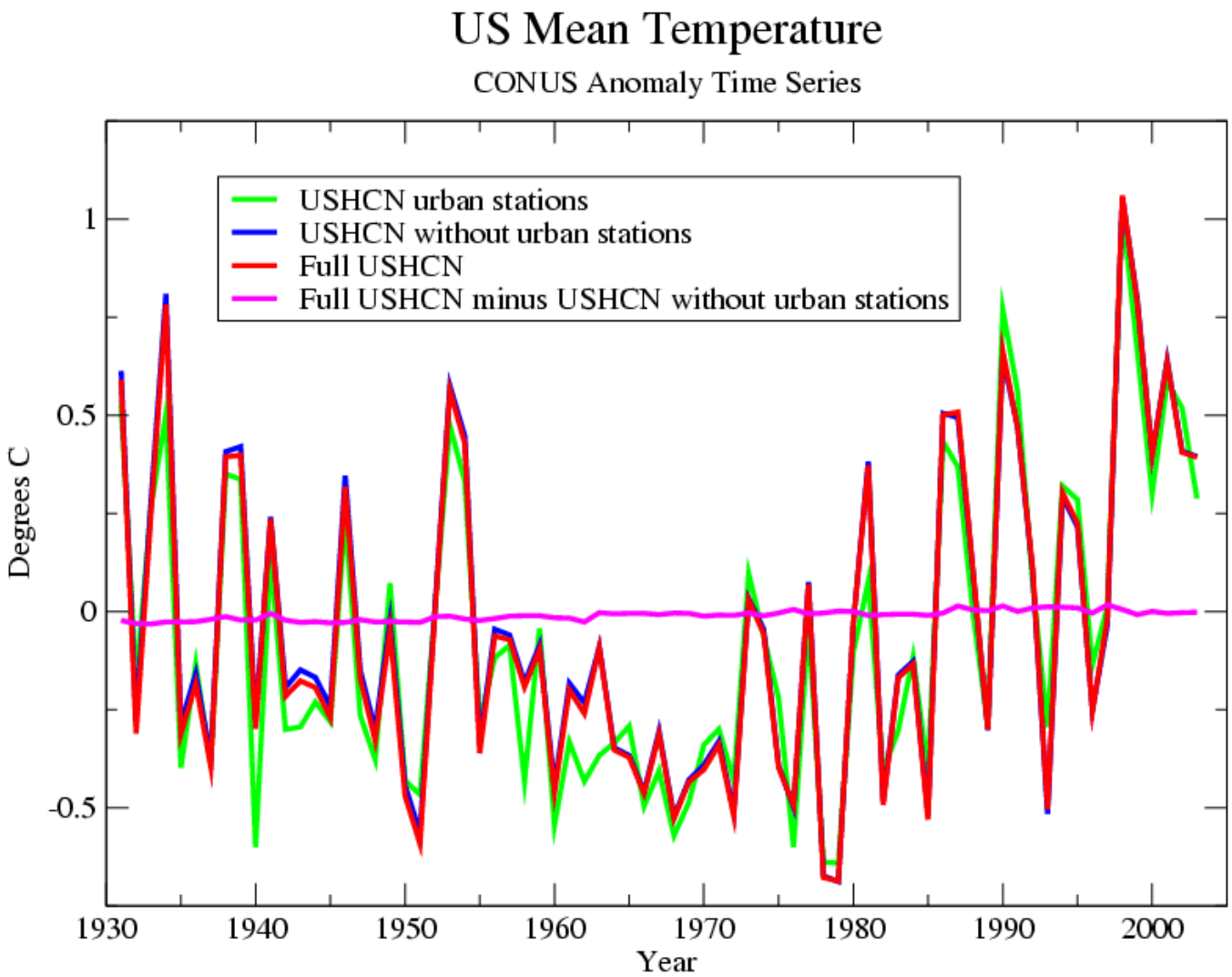


From Menne and Peterson, 2007, updated from IPCC 2007

Comparison of land and oceans: They show the same thing



Comparison of urban and rural stations: They show the same thing



Peterson & Owen, 2005 © BAMS and from IPCC 2007

Some stations have poor siting

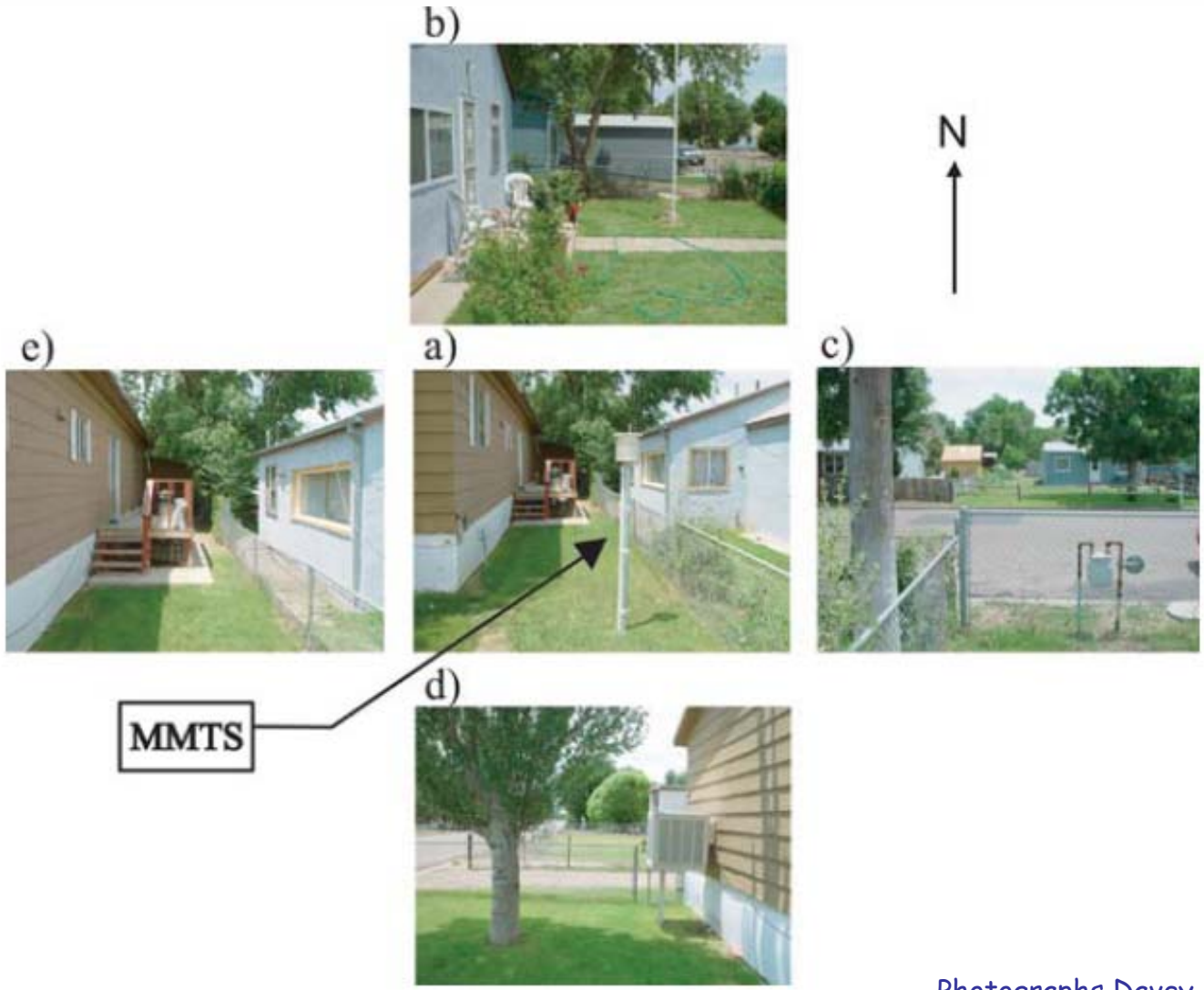
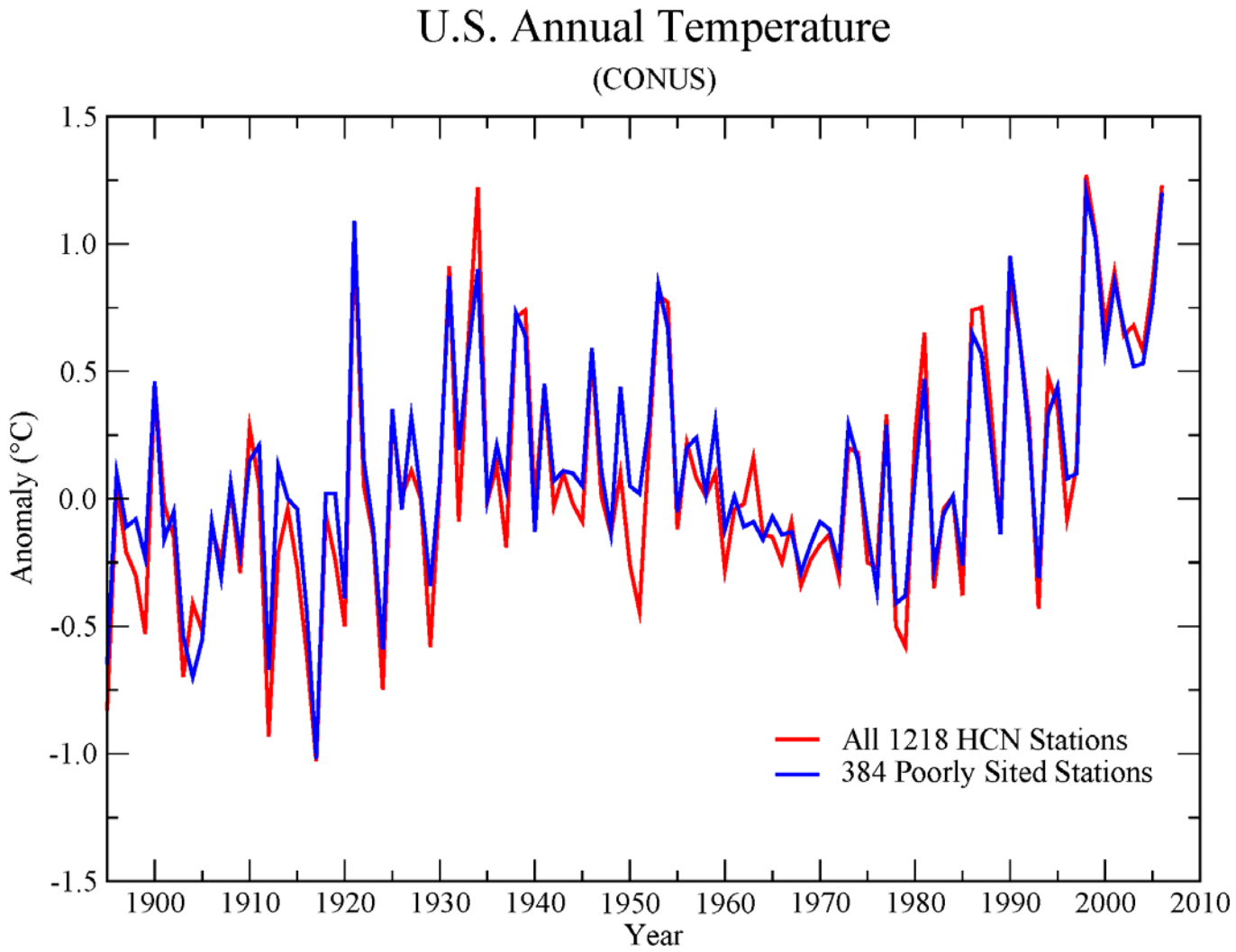


Fig. 10. Same as Fig. 3, except for Lamar, CO.

Photographs Davey & Pielke, Sr. 2005

Comparison of stations with poor and good siting: They show the same thing



Poorly cited stations in this example show less warming

Doesn't a station over concrete have a warm bias compared to a station over grass?

- For climate change purposes the relevant questions are:
  - Does the bias change over time?
  - Can the changing bias be accounted for?

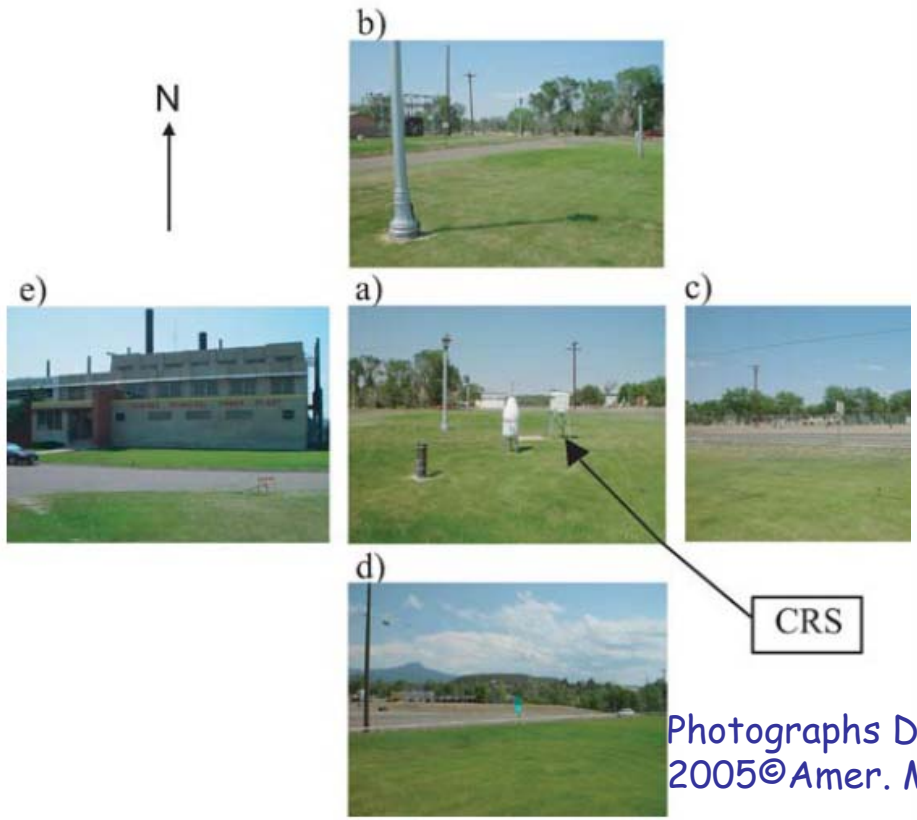


Fig. 13. Same as Fig. 3, except for Trinidad, CO.

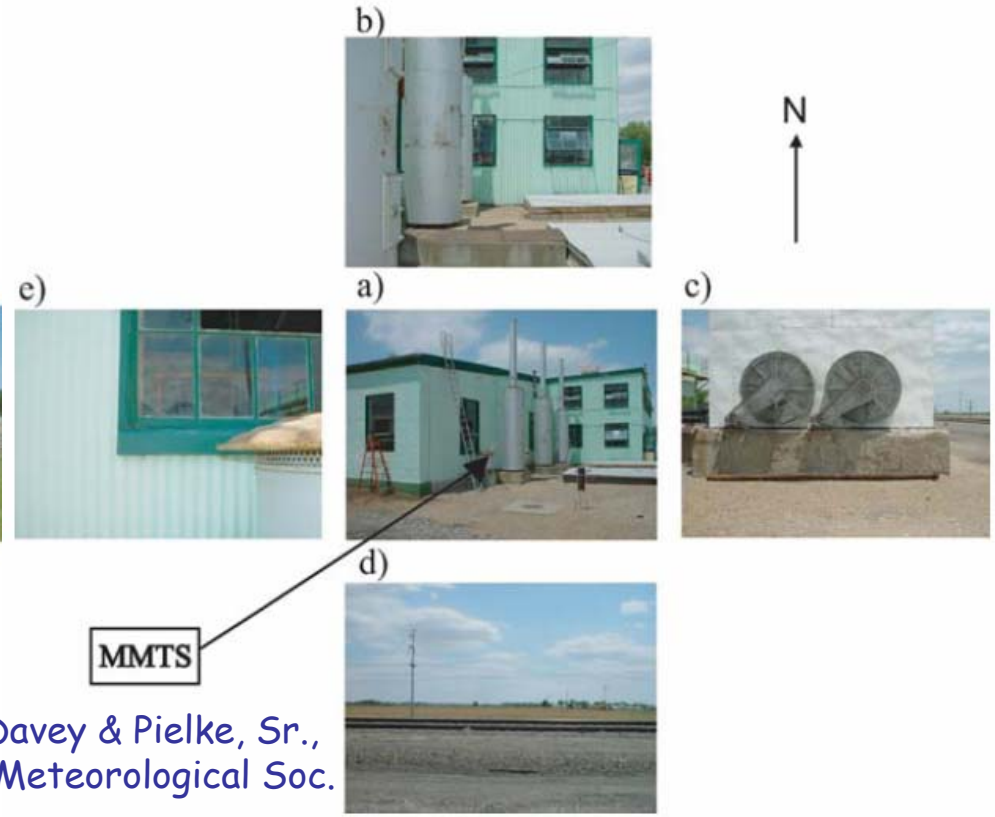
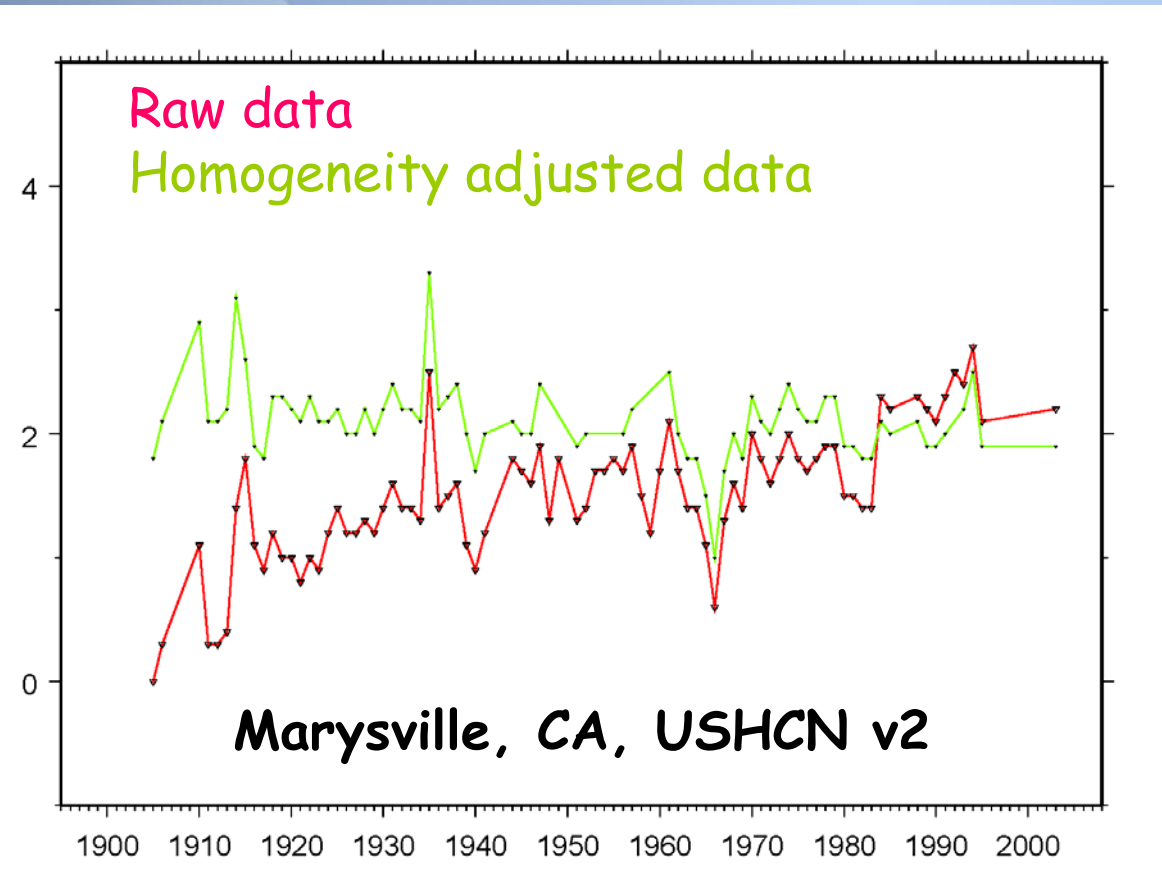


Fig. 12. Same as Fig. 3, except for Las Animas, CO.

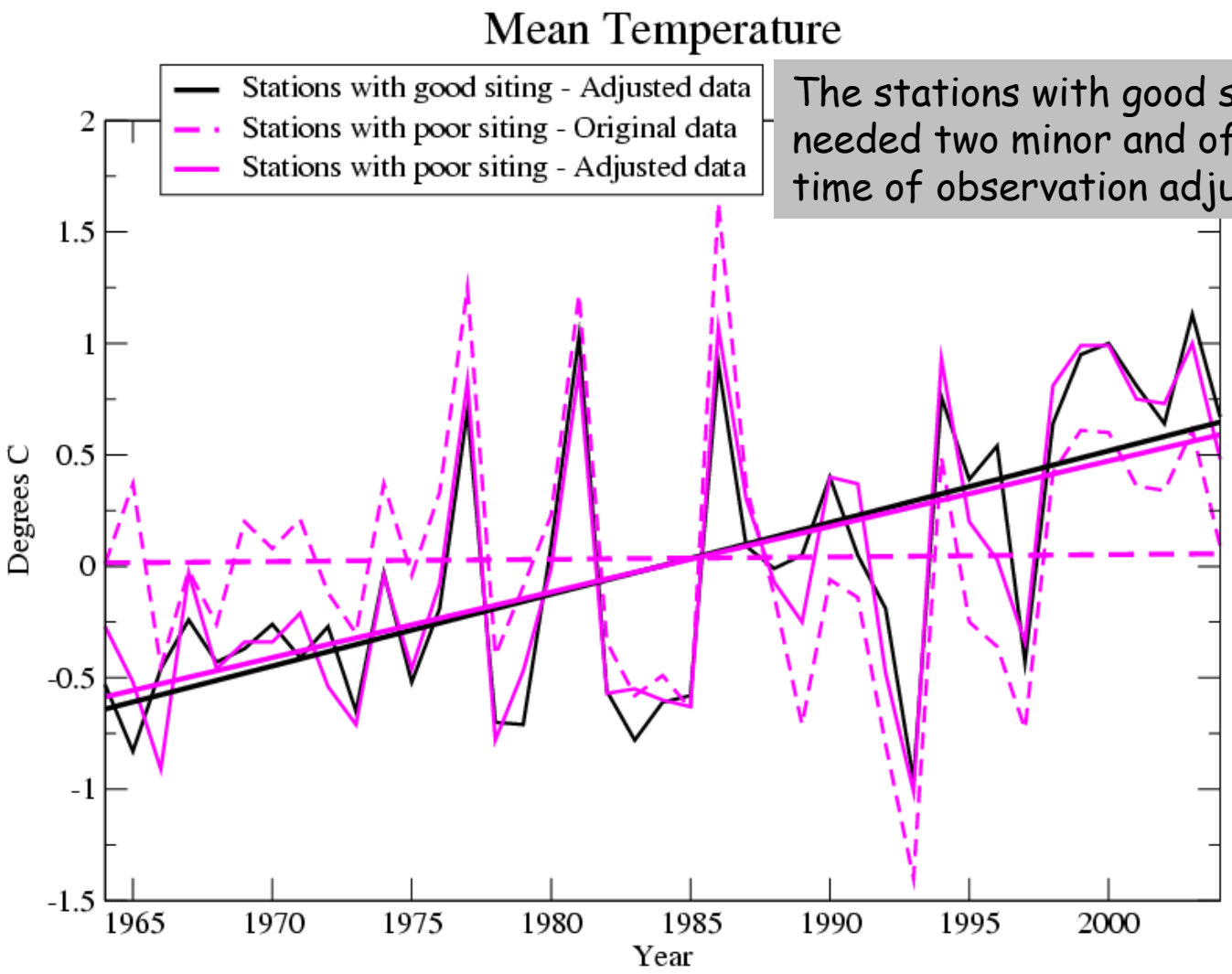
Photographs Davey & Pielke, Sr., 2005©Amer. Meteorological Soc.

A poorly sited station compared to its neighbors



- The station is 2° C warmer than neighbors
- But adjusted data's trend agrees with its neighbors

Comparison of homogeneous and homogeneity adjusted stations: They show the same thing



The stations with good siting only needed two minor and offsetting time of observation adjustments

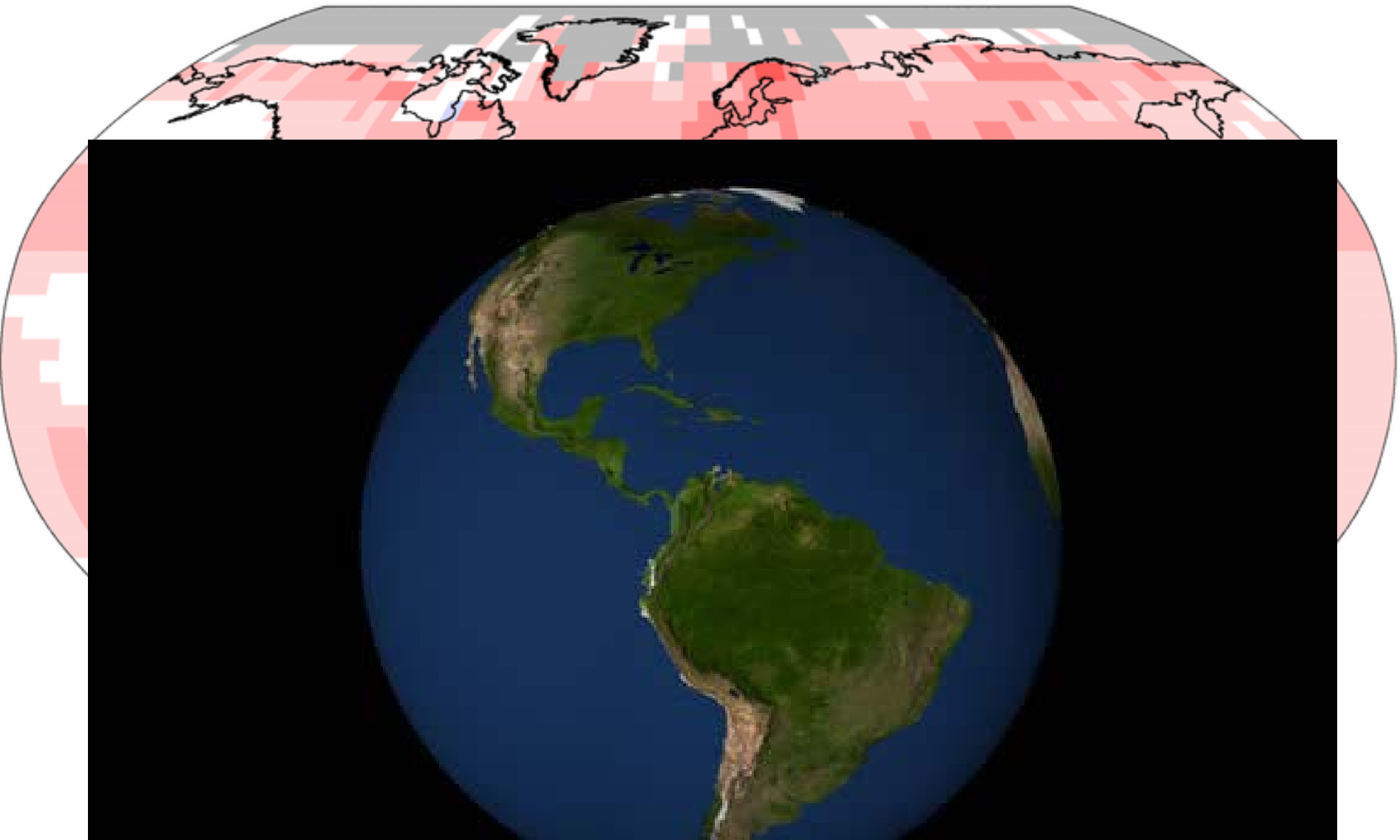
Peterson 2006©Amer. Meteorological Soc.

Comparison of surface and upper air: Satellites and balloon data also show warming.

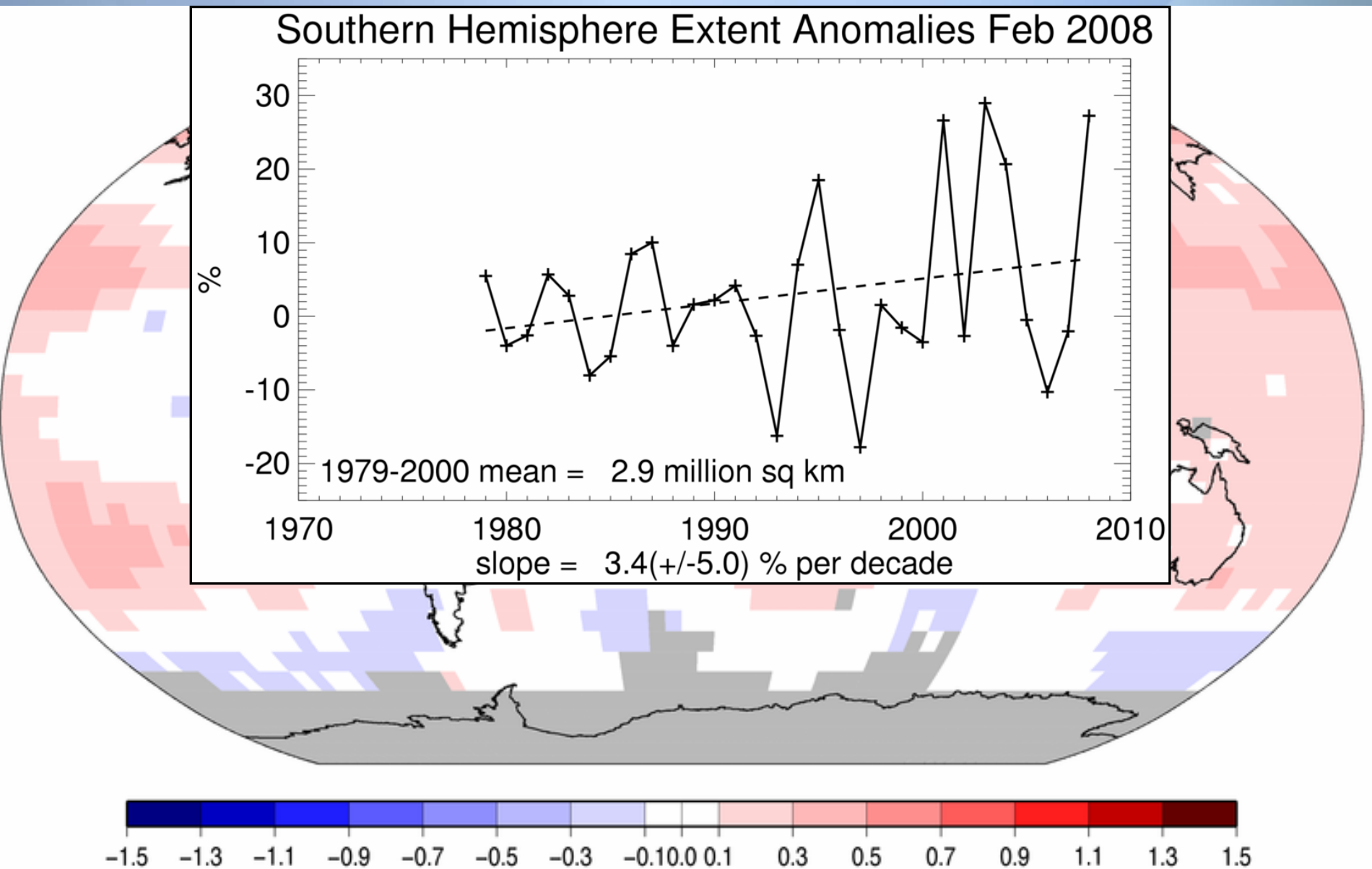
Comparison with non-thermometer data

- Data from sources other than surface thermometers support the climate change that the instrumental observations are indicating

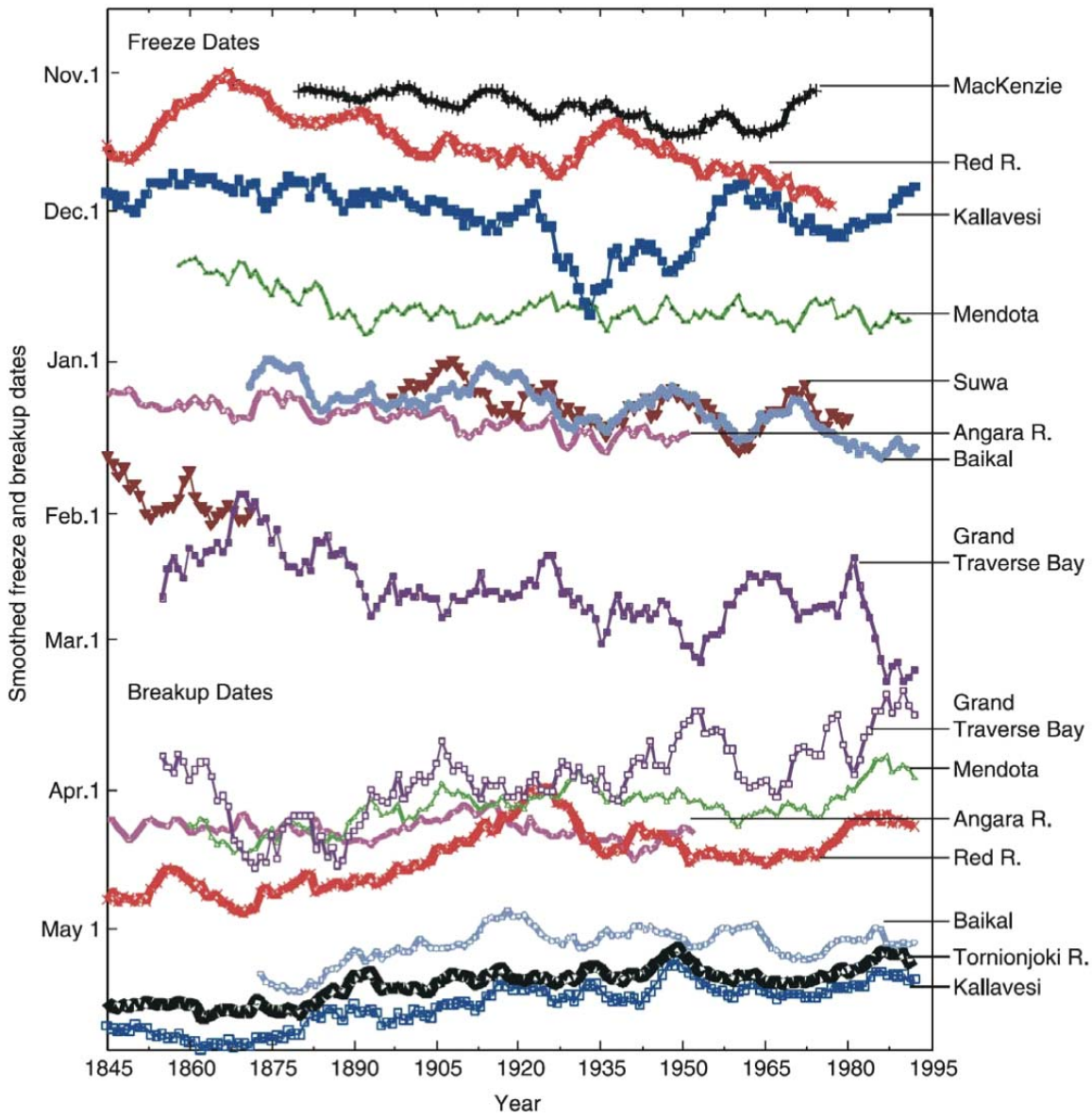
Arctic sea-ice is shrinking



Antarctic sea ice is increasing



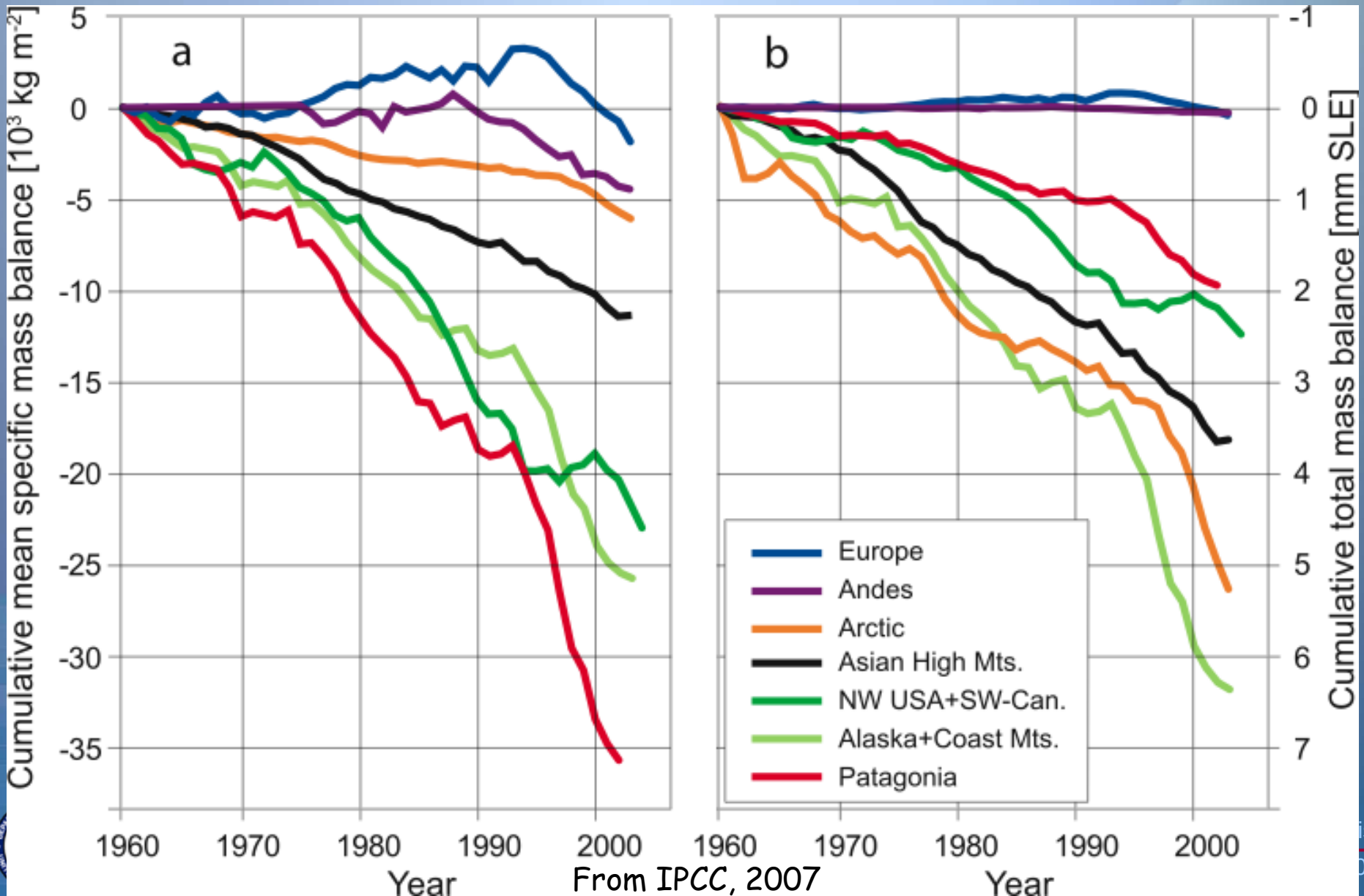
Lakes and rivers are freezing later and thawing earlier



From IPCC, 2007

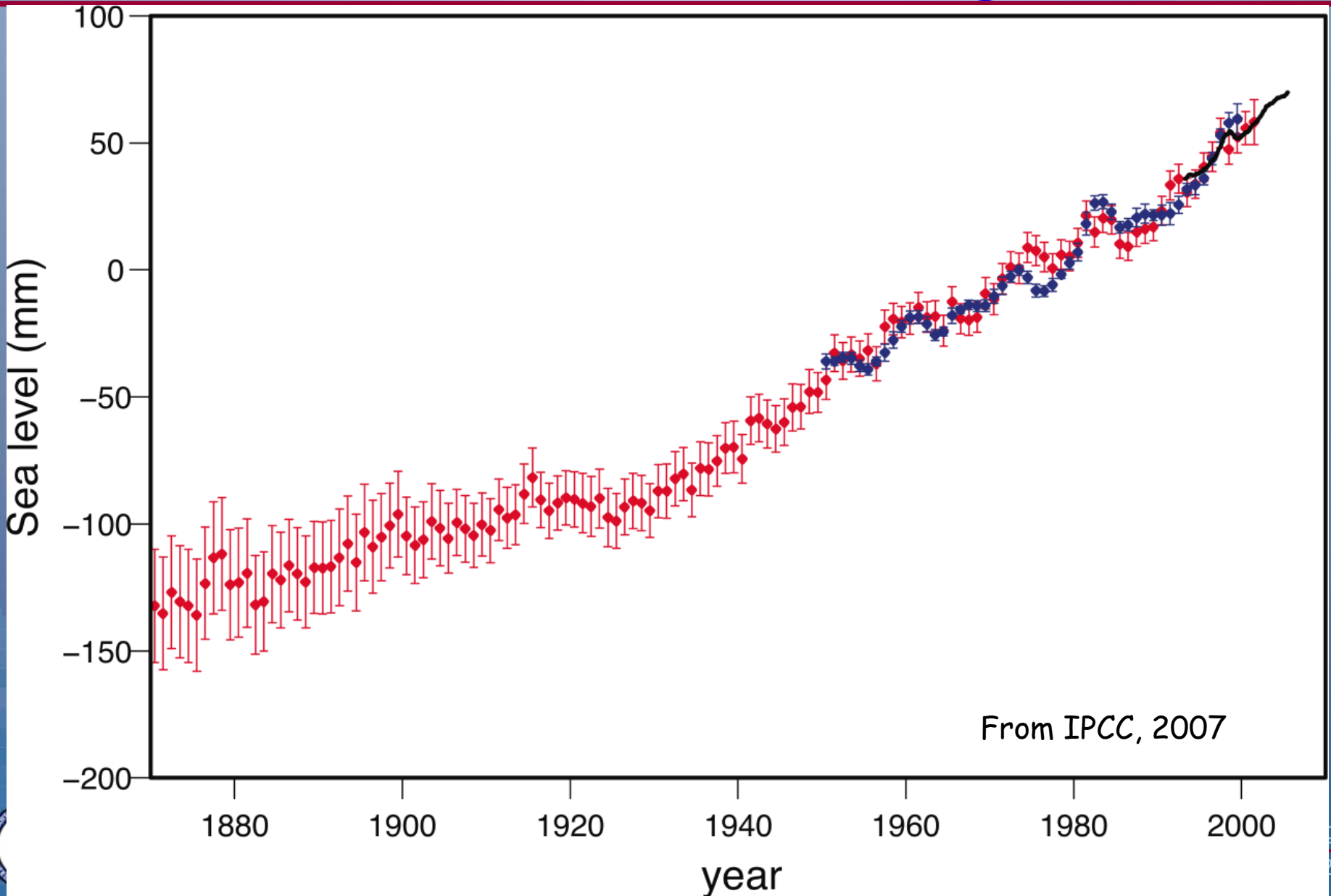
Figure 4.5

Glaciers are melting



From IPCC, 2007

Sea level is rising



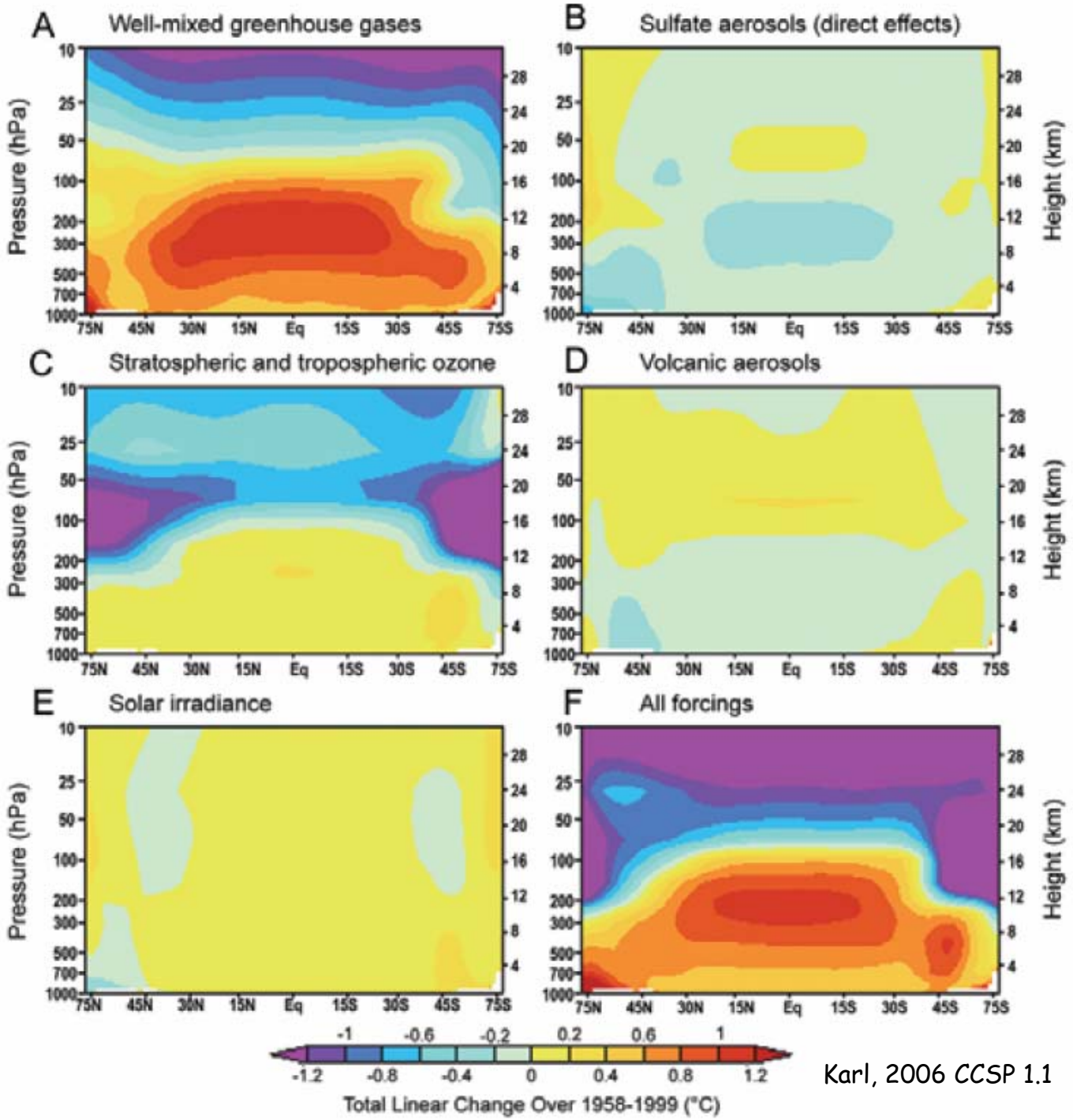
Plants and animals are acting as if it is warming

- Plants are blooming 1-3 days/decade earlier
  - "Altered timing of spring events has been reported for a broad multitude of species and locations" (IPCC 2007).
- Animals species are moving poleward
  - "Many studies of species abundances and distributions corroborate predicted systematic shifts related to changes in climatic regimes" (IPCC 2007)

What is causing the climate change?

Climate change detection and attribution

- The climate has warmed
  - Statistically significant change
  - Climate change has been detected
- But what has caused the detected change?
  - Climate change attribution

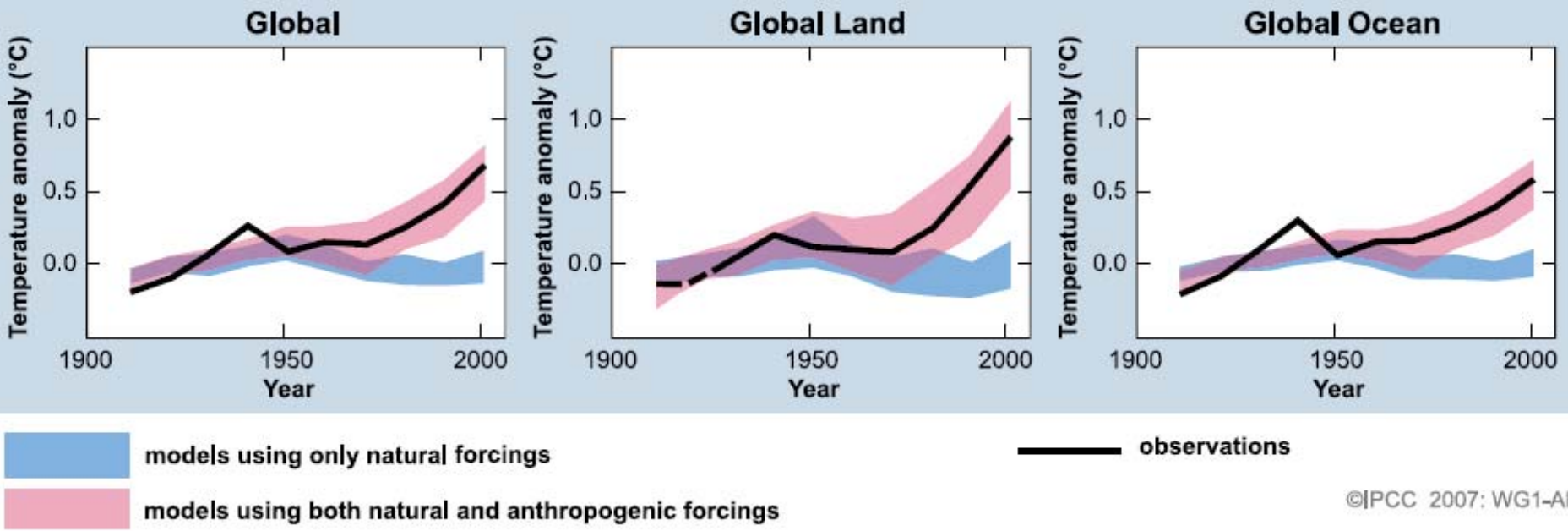


Karl, 2006 *CCSP* 1.1

- Each climate forcing has its own fingerprint of change in the climate.

Models with and without human produced climate forcings reveal:

- "Most of the observed increase in global average temperatures since the mid-20th century is *very likely* due to the observed increase in anthropogenic greenhouse gas concentrations" (IPCC 2007).



Final comment

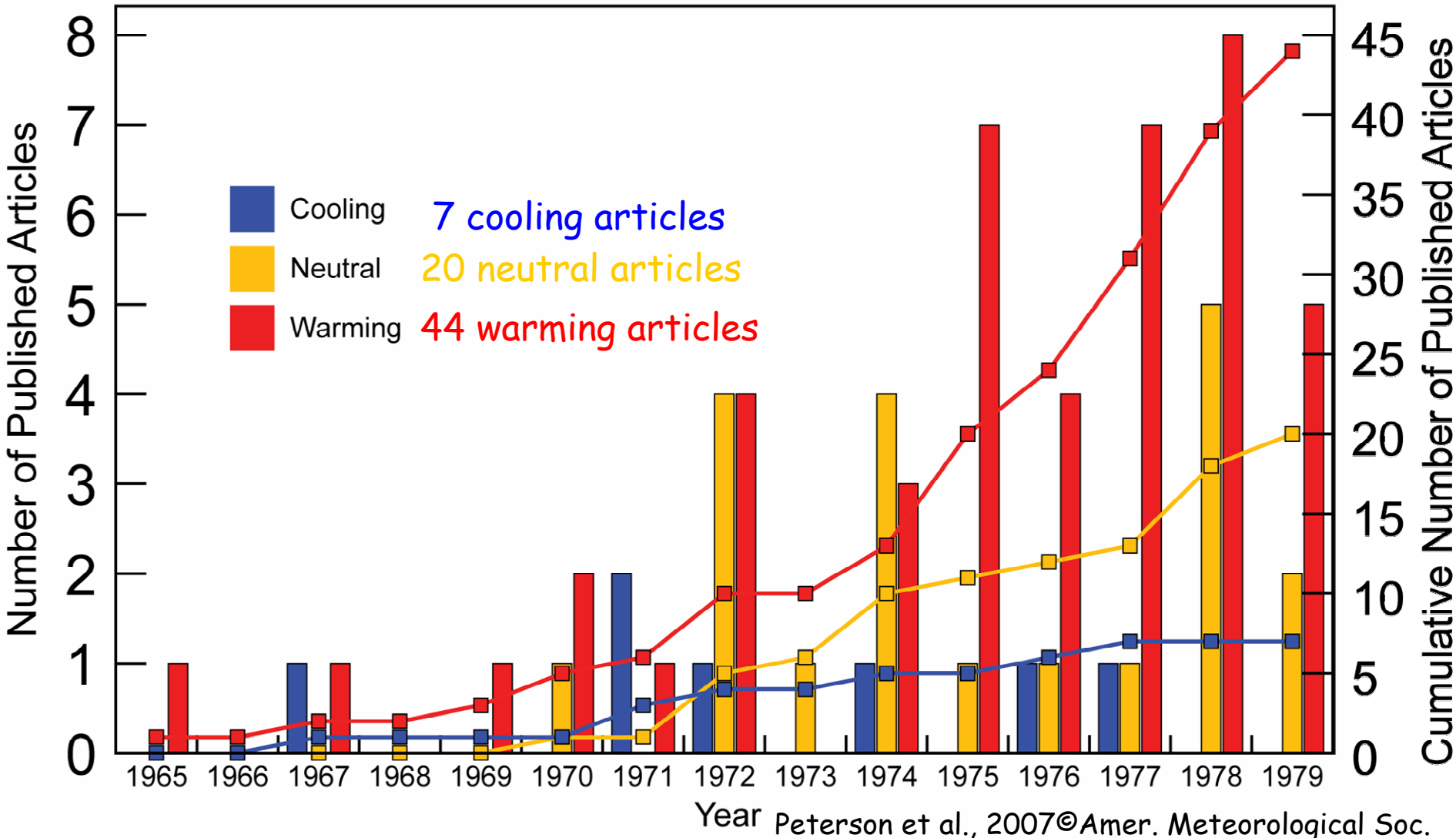
- Stepping out into record hot weather, a friend who is an expert on climate change detection and attribution was asked if the high temperatures they were experiencing were due to global warming
- He responded:
  - You can't attribute any one day's temperature to global warming
  - But unusually warm weather like that does give us the privilege of experiencing the weather we are bequeathing our children and grandchildren


The End

Question and Answer Session

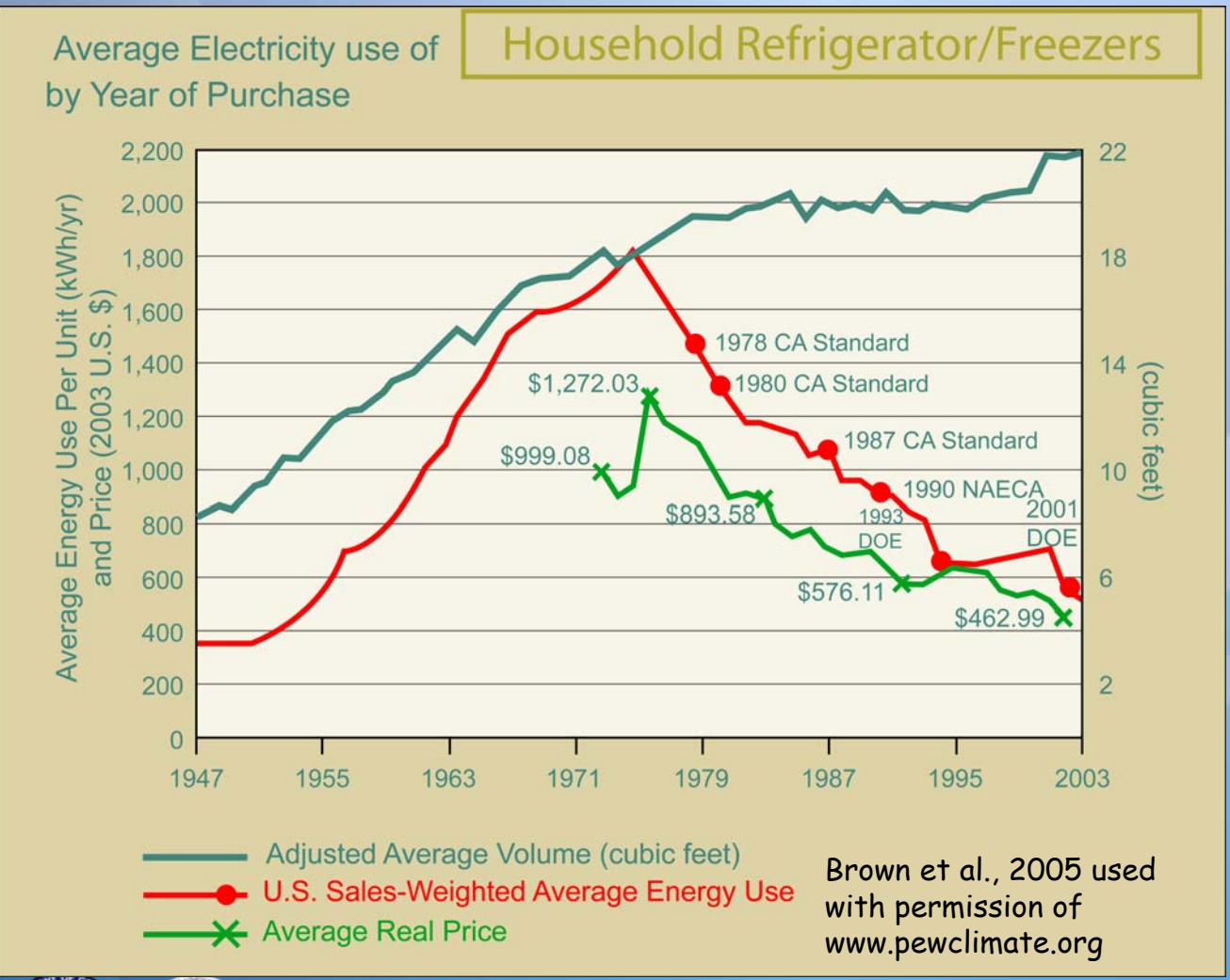
But didn't all the scientists predict global cooling back in the 1970s?

Global cooling articles only 10% total climate change articles



Peterson et al., 2007©Amer. Meteorological Soc.

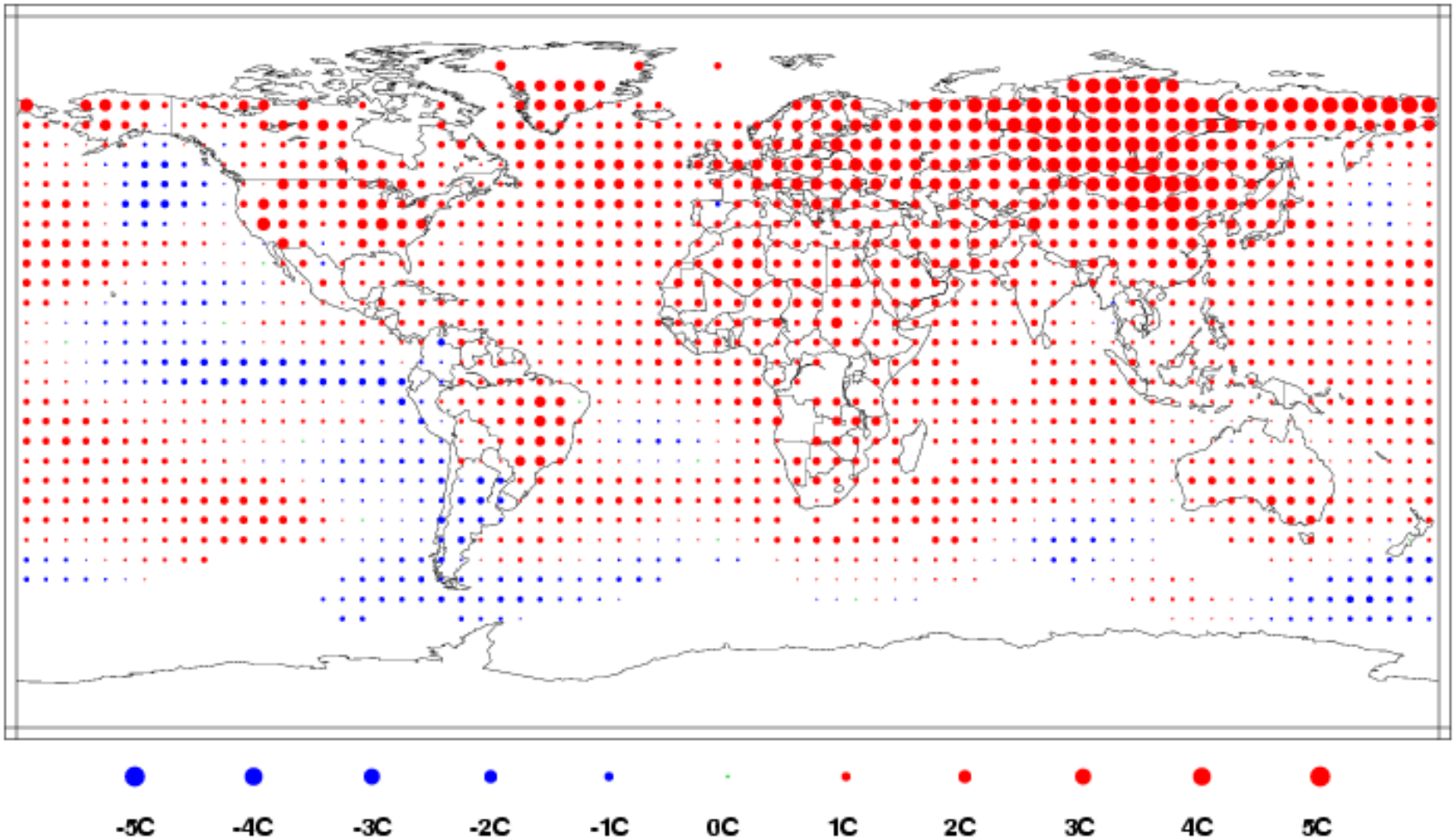
Aren't all the solutions painful?



Brown et al., 2005 used with permission of www.pewclimate.org

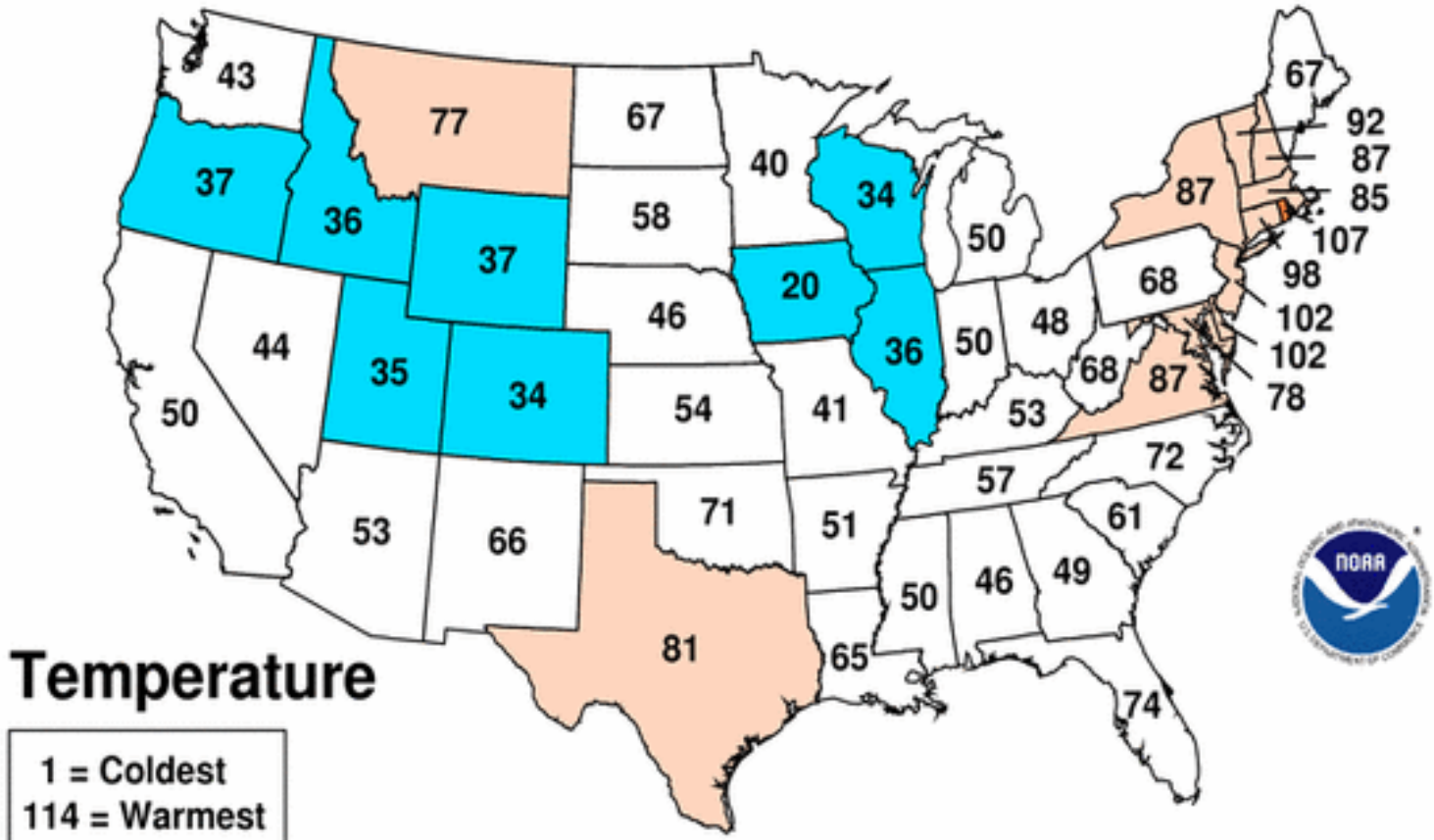
- Efficiency can work wonders
  - Electricity use per refrigerator has decreased to <30% of 1972 value
  - Meanwhile, refrigerator size has increased
  - And refrigerator price has decreased (in constant dollars).

Annual Mean Temperature Anomalies 2007



January-March 2008 Statewide Ranks

National Climatic Data Center/NESDIS/NOAA



January-March 2008 Statewide Ranks

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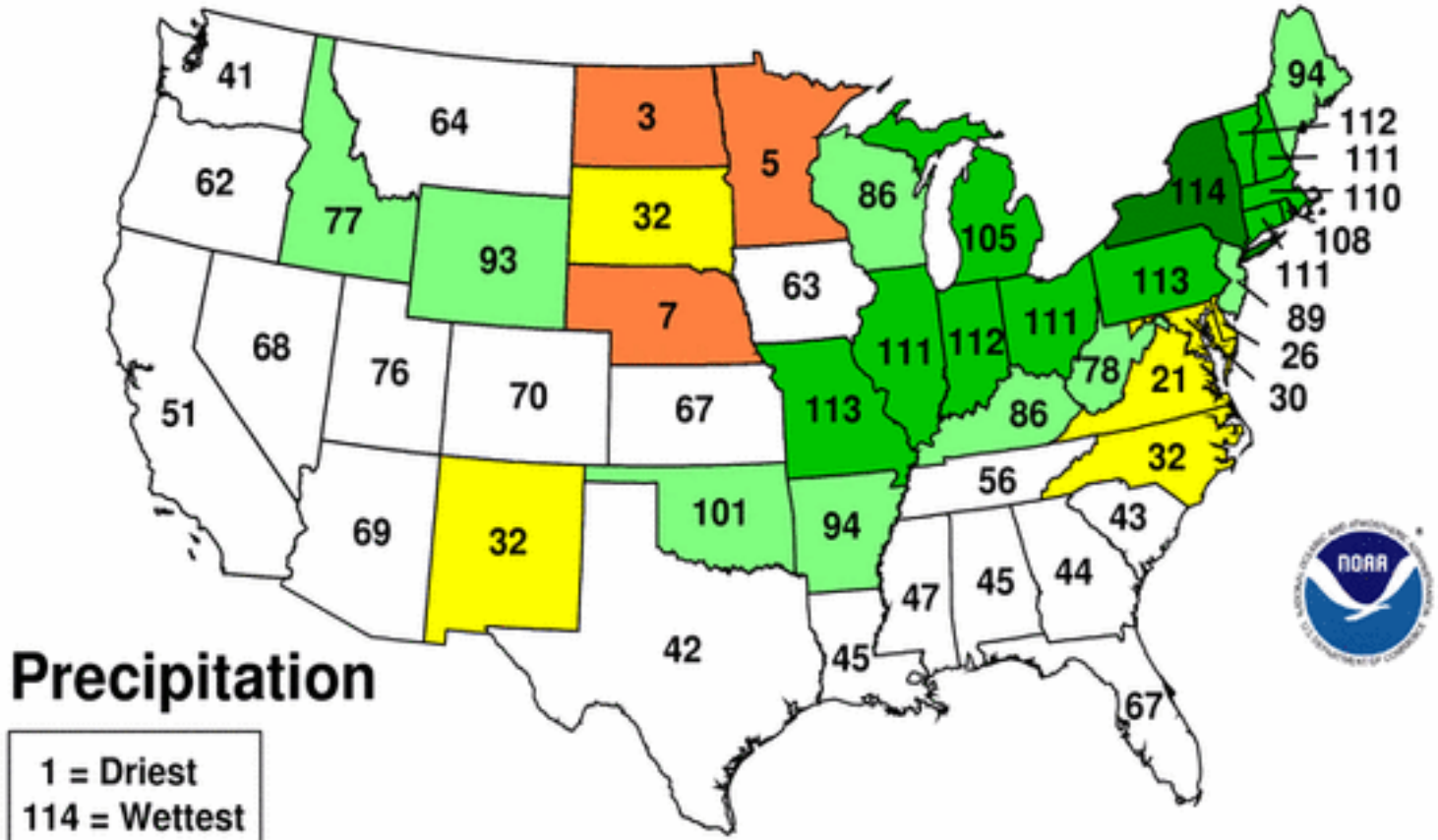


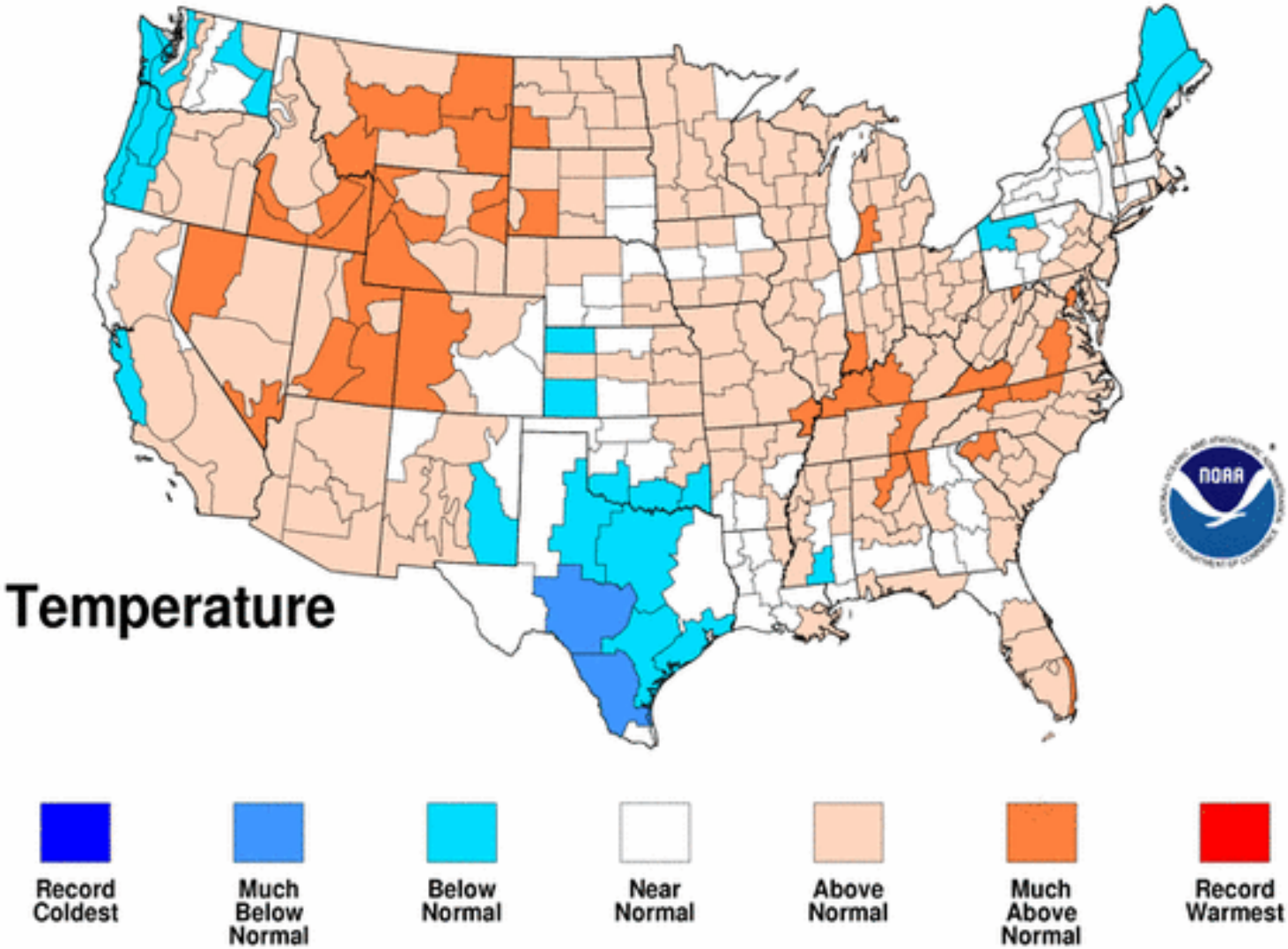
Precipitation

1 = Driest
114 = Wettest

Record Driest	Much Below Normal	Below Normal	Near Normal	Above Normal	Much Above Normal	Record Wettest

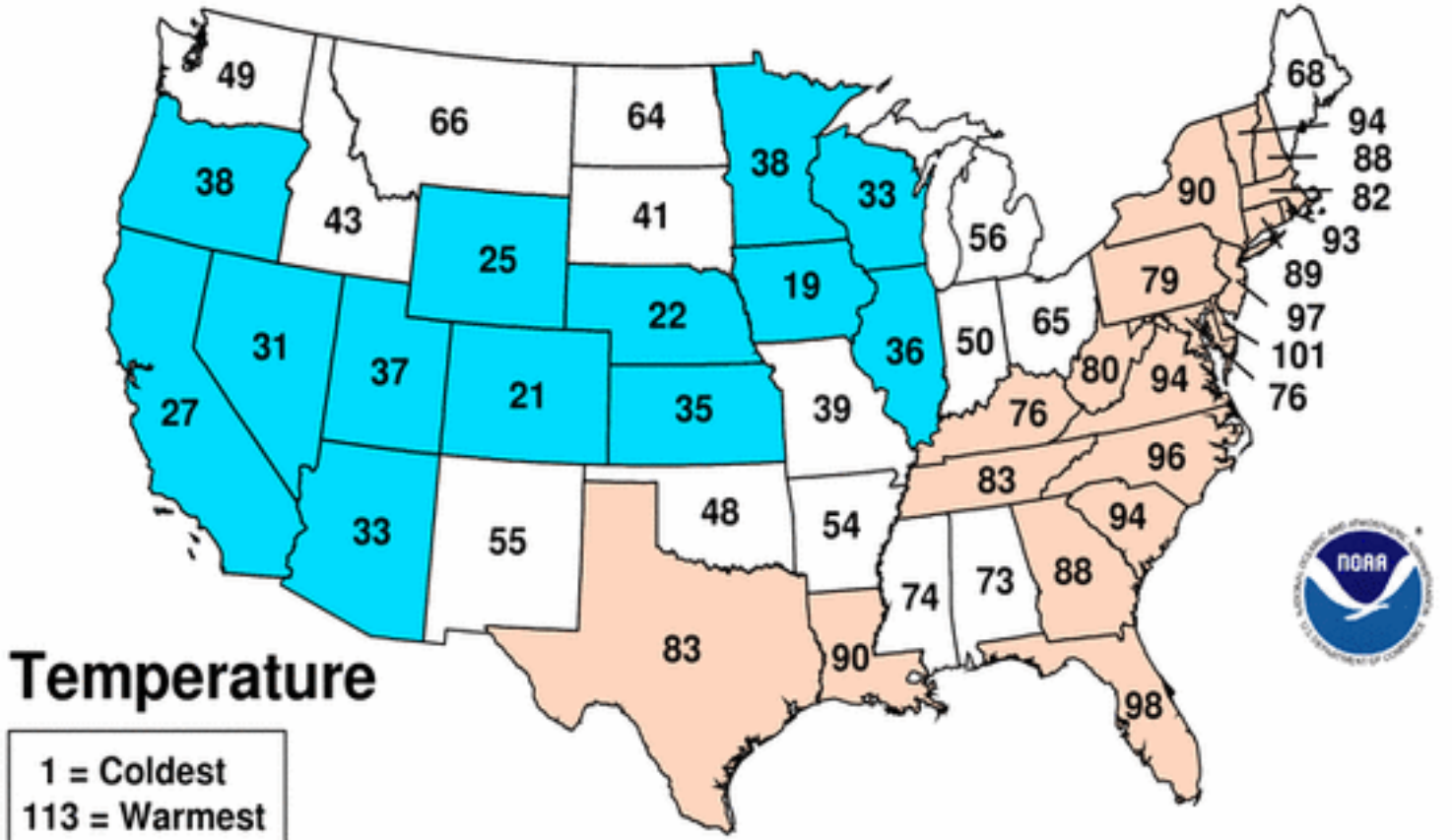
Jan - Dec 2007

National Climatic Data Center/NESDIS/NOAA



Dec 2007-Feb 2008 Statewide Ranks

National Climatic Data Center/NESDIS/NOAA



Temperature

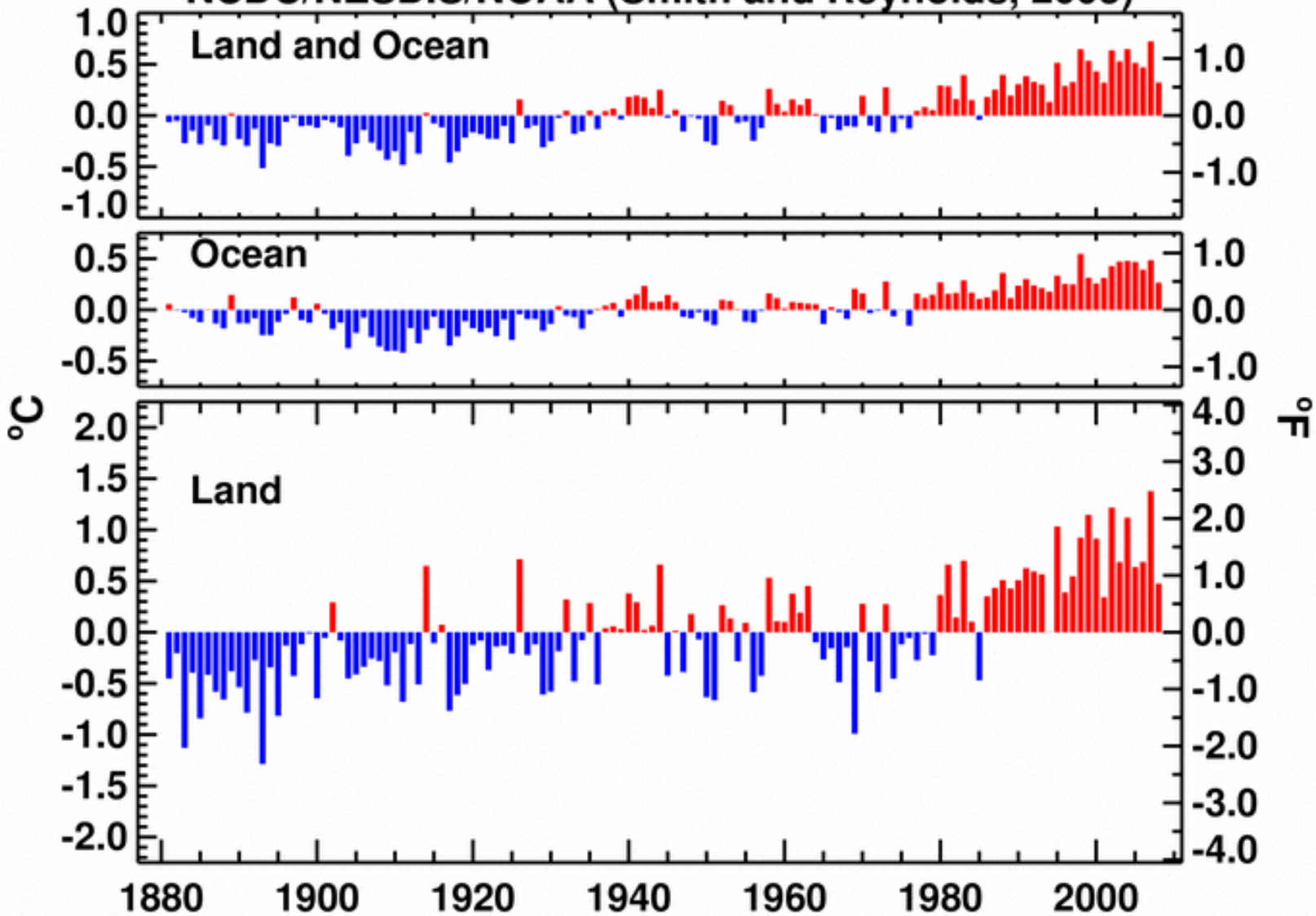
1 = Coldest
113 = Warmest

Record Coldest	Much Below Normal	Below Normal	Near Normal	Above Normal	Much Above Normal	Record Warmest

logists
, 2008

Dec-Feb Global Surface Mean Temp Anomalies

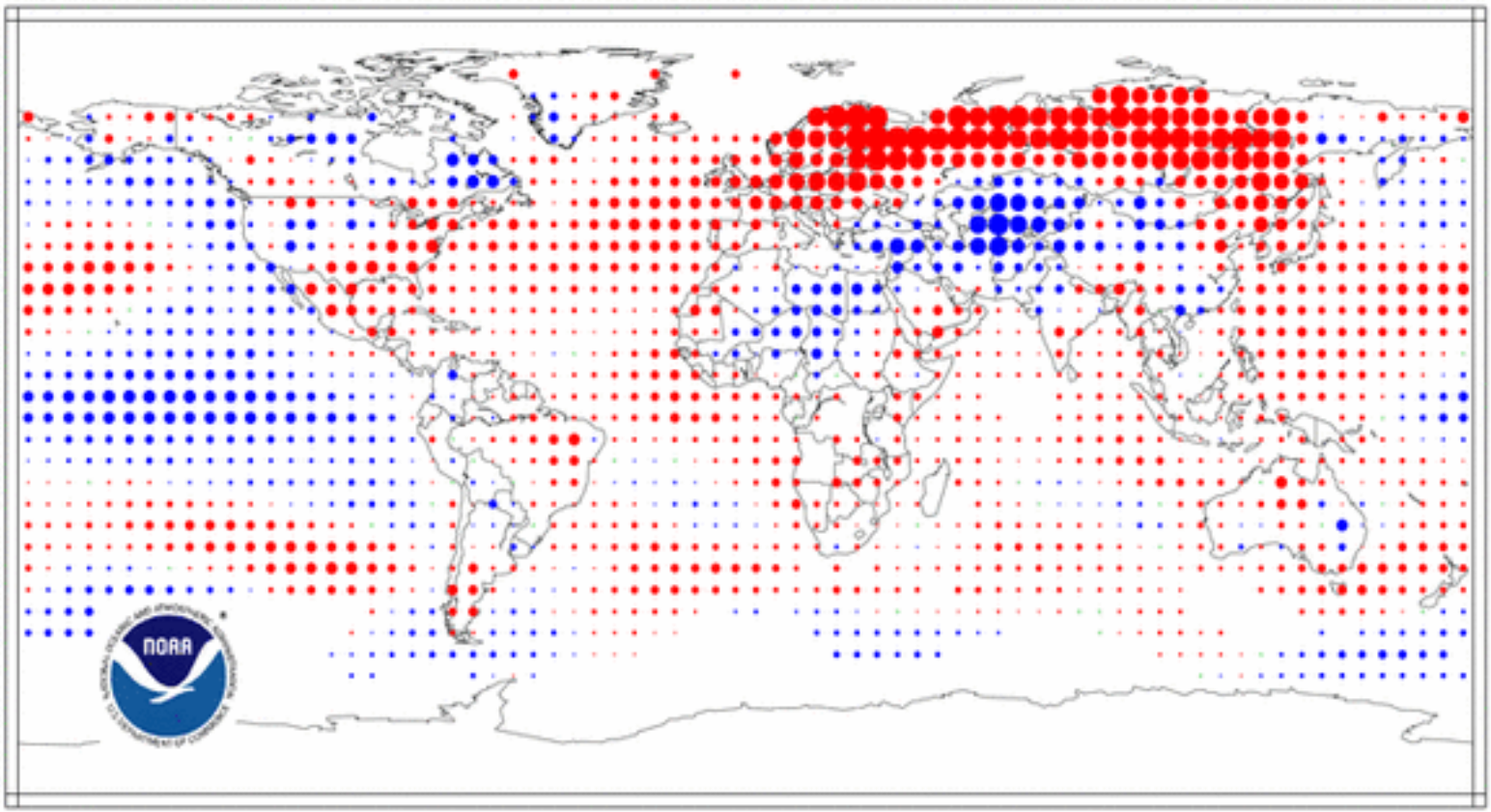
NCDC/NESDIS/NOAA (Smith and Reynolds, 2005)



Temperature Anomalies Dec-Feb 2008

(with respect to a 1961-1990 base period)

National Climatic Data Center/NESDIS/NOAA

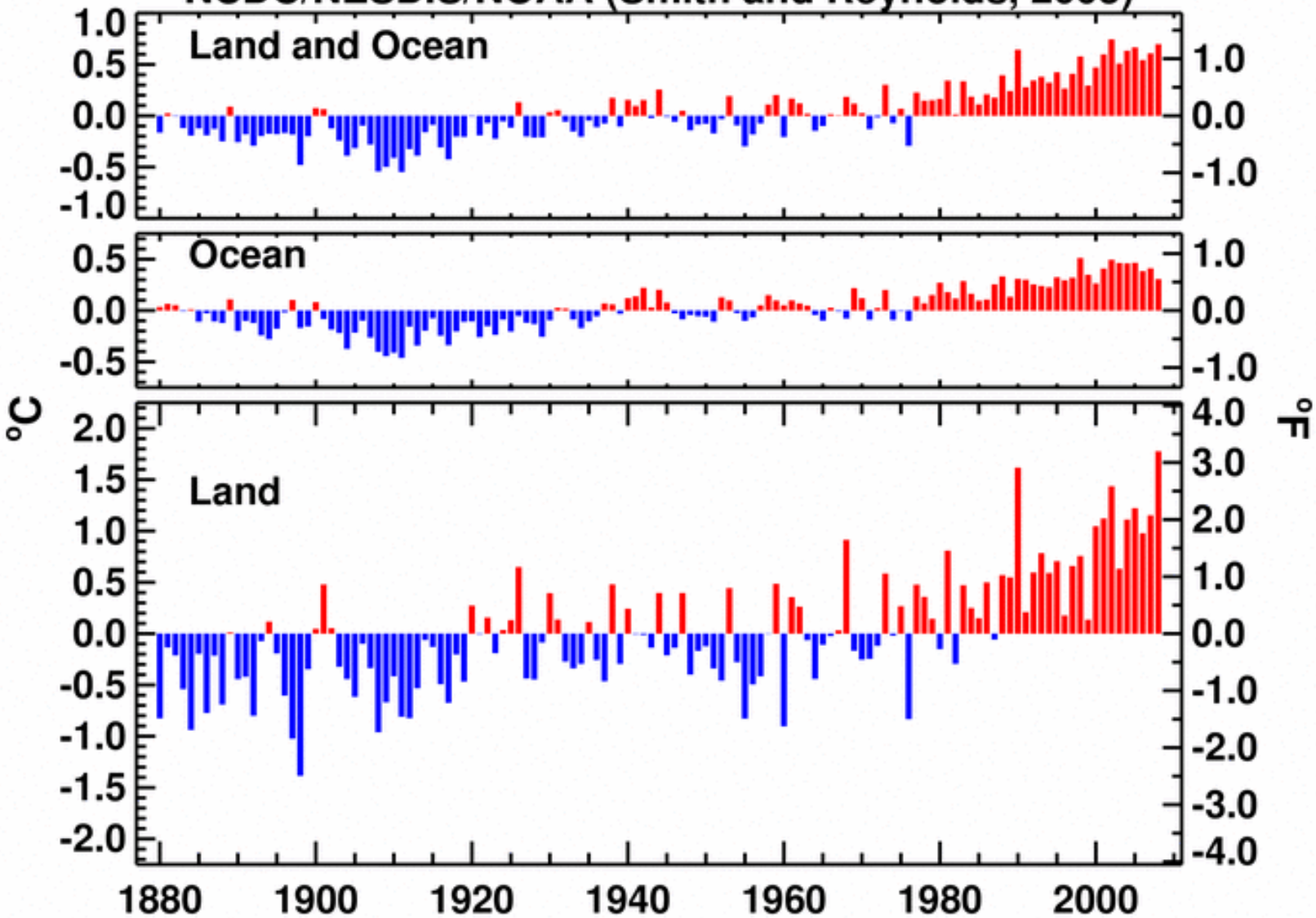


-5C -4C -3C -2C -1C 0C 1C 2C 3C 4C 5C

Degrees Celsius

March Global Surface Mean Temp Anomalies

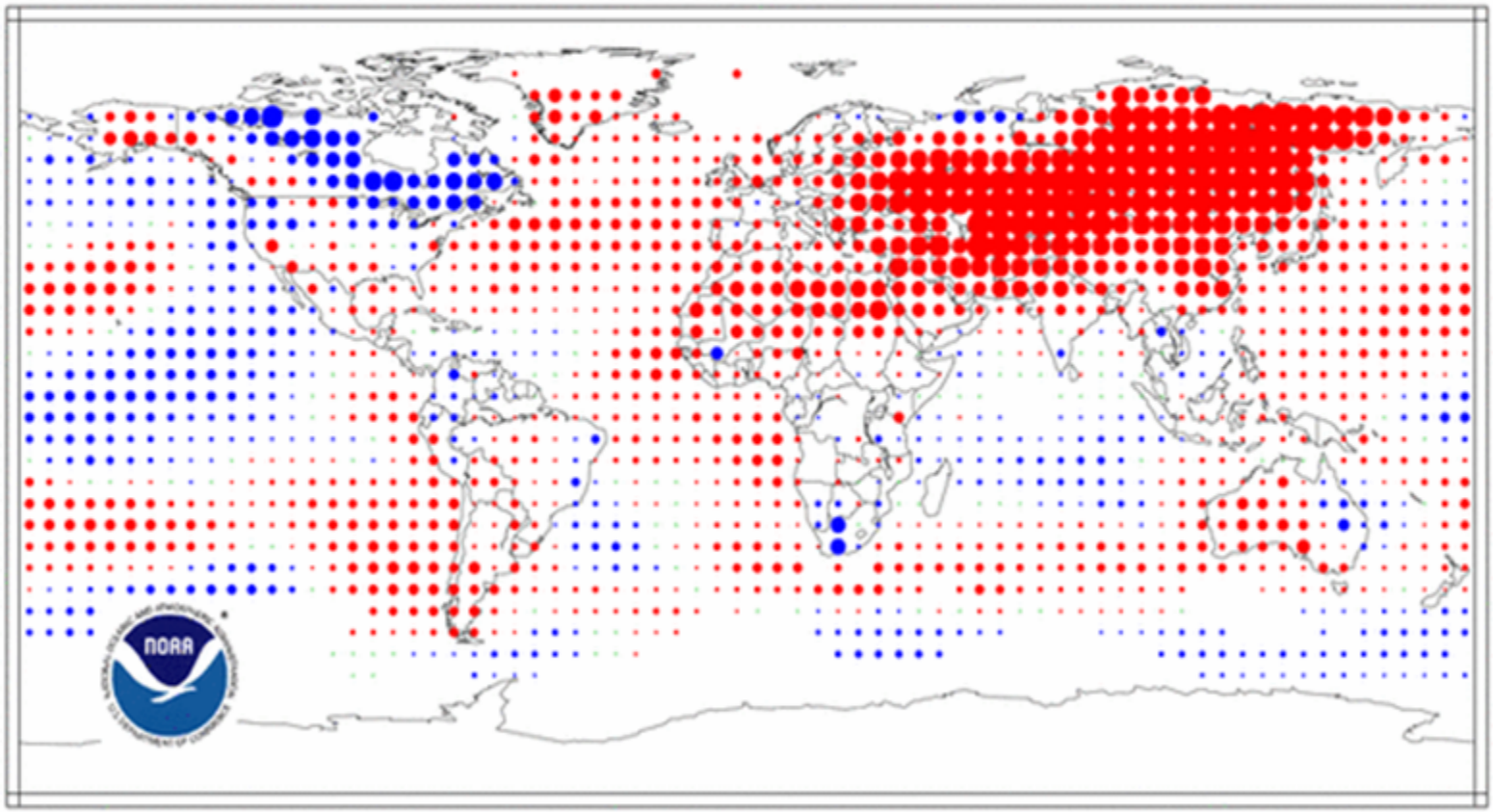
NCDC/NESDIS/NOAA (Smith and Reynolds, 2005)



Temperature Anomalies March 2008

(with respect to a 1961-1990 base period)

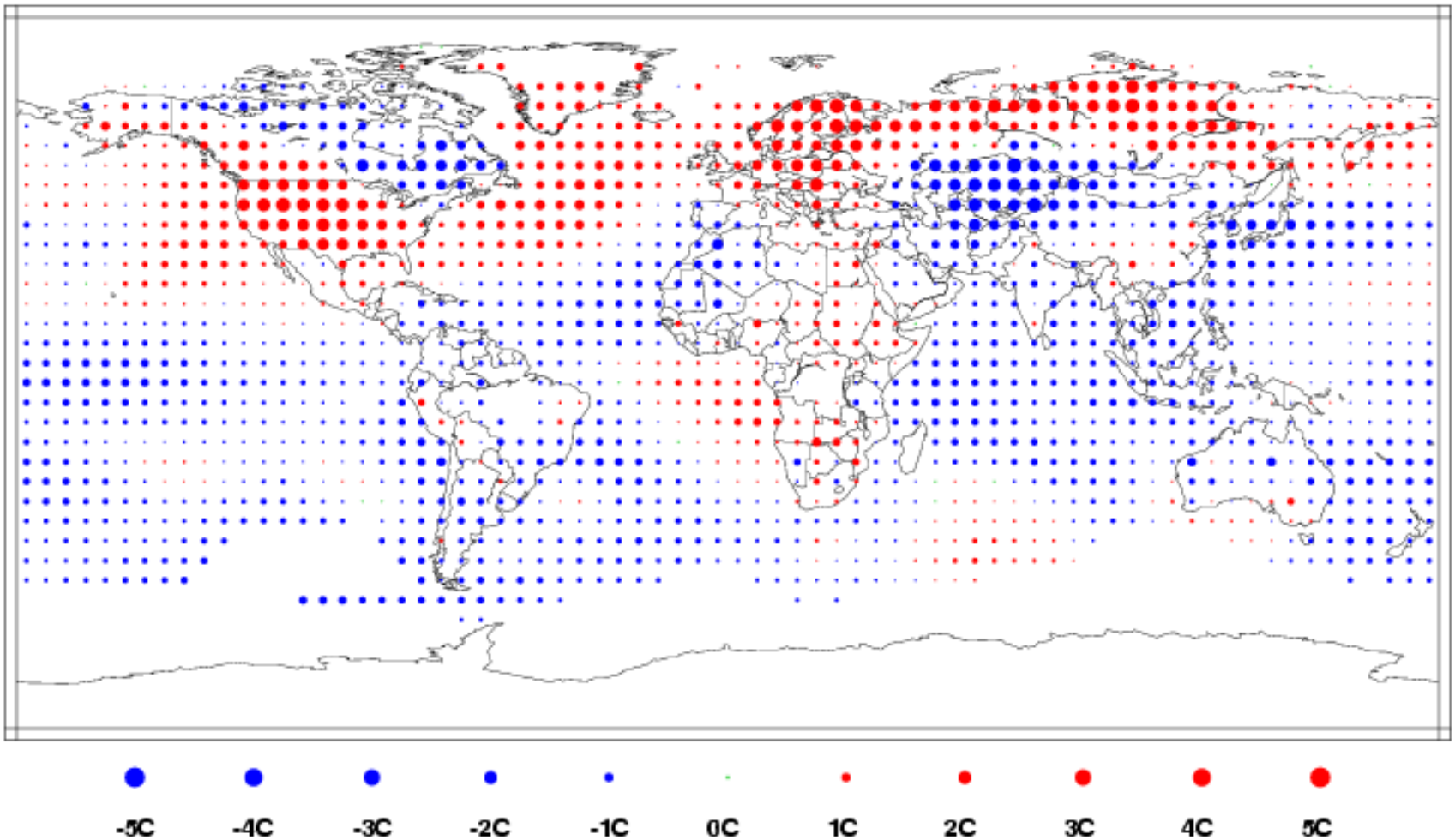
National Climatic Data Center/NESDIS/NOAA

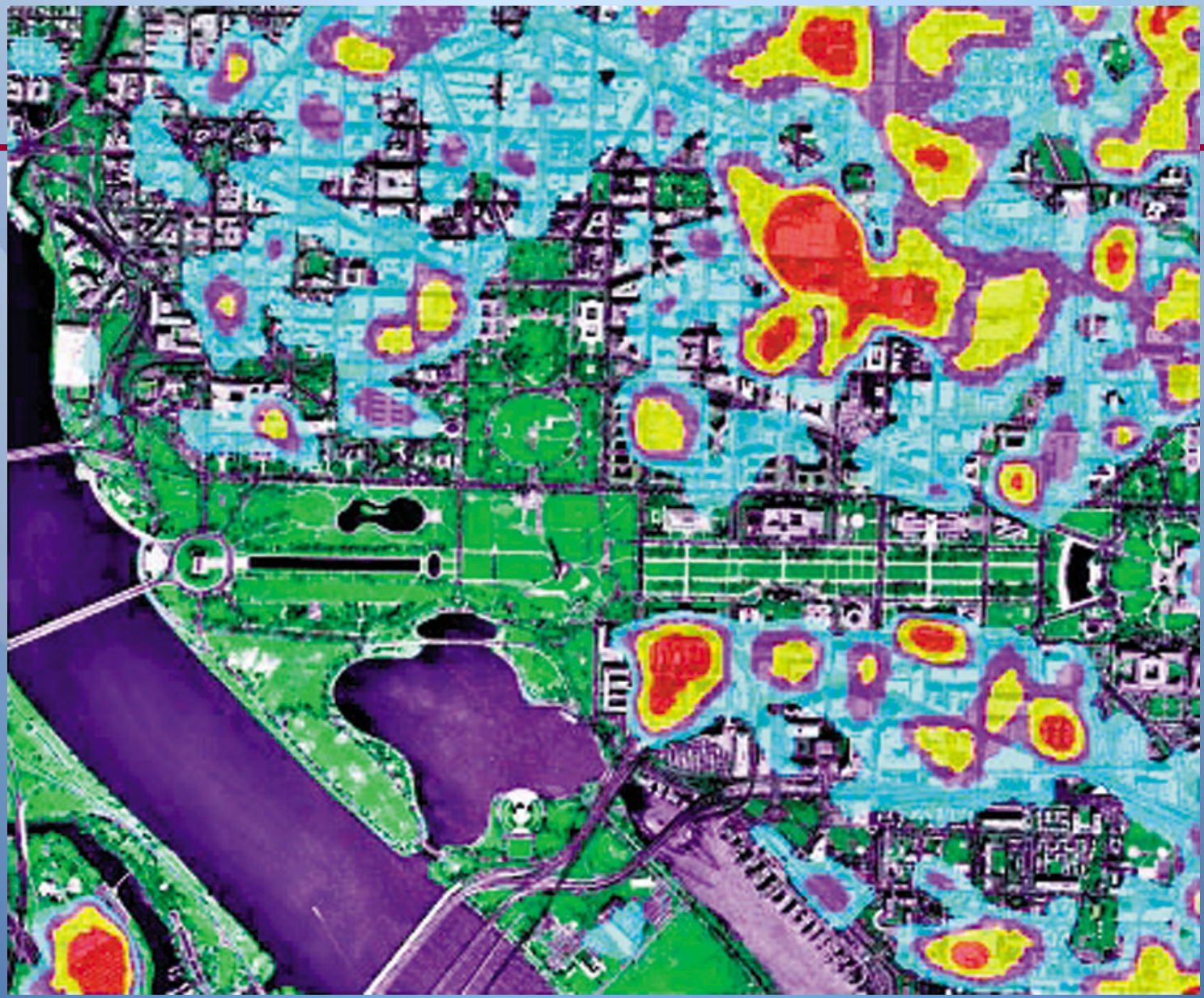


-5C -4C -3C -2C -1C 0C 1C 2C 3C 4C 5C

Degrees Celsius

Annual Mean Temperature Anomalies 1934

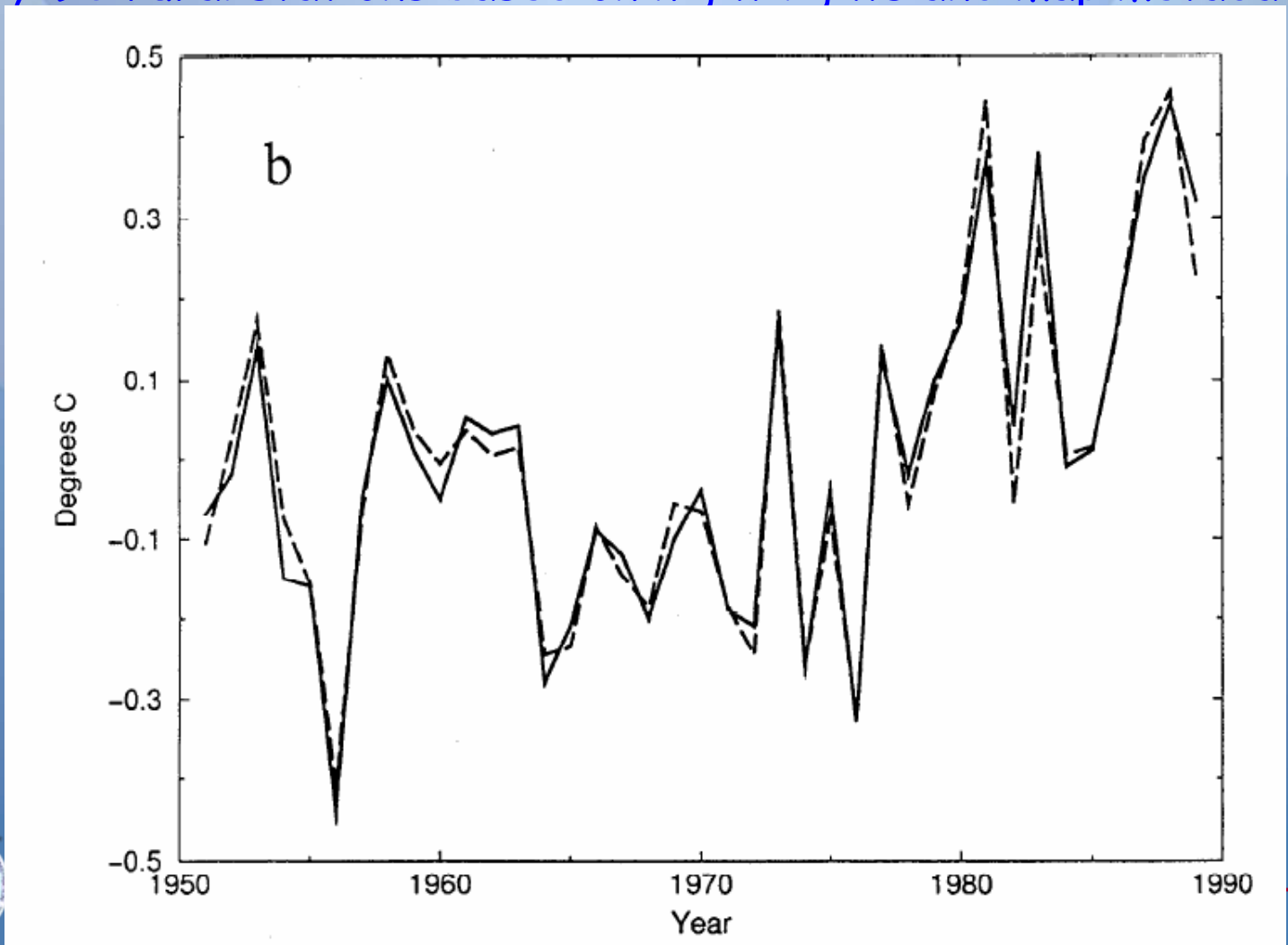




Washington D.C. Landsat image, 11 AM in August.
Courtesy of Stephen Stetson, Global Environmental Management, Inc.

Rural stations and full data set show the same thing

- From Peterson et al., 1999's global analysis
- 7,280 stations in full data set
- 2,290 rural stations based on night lights and map metadata



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