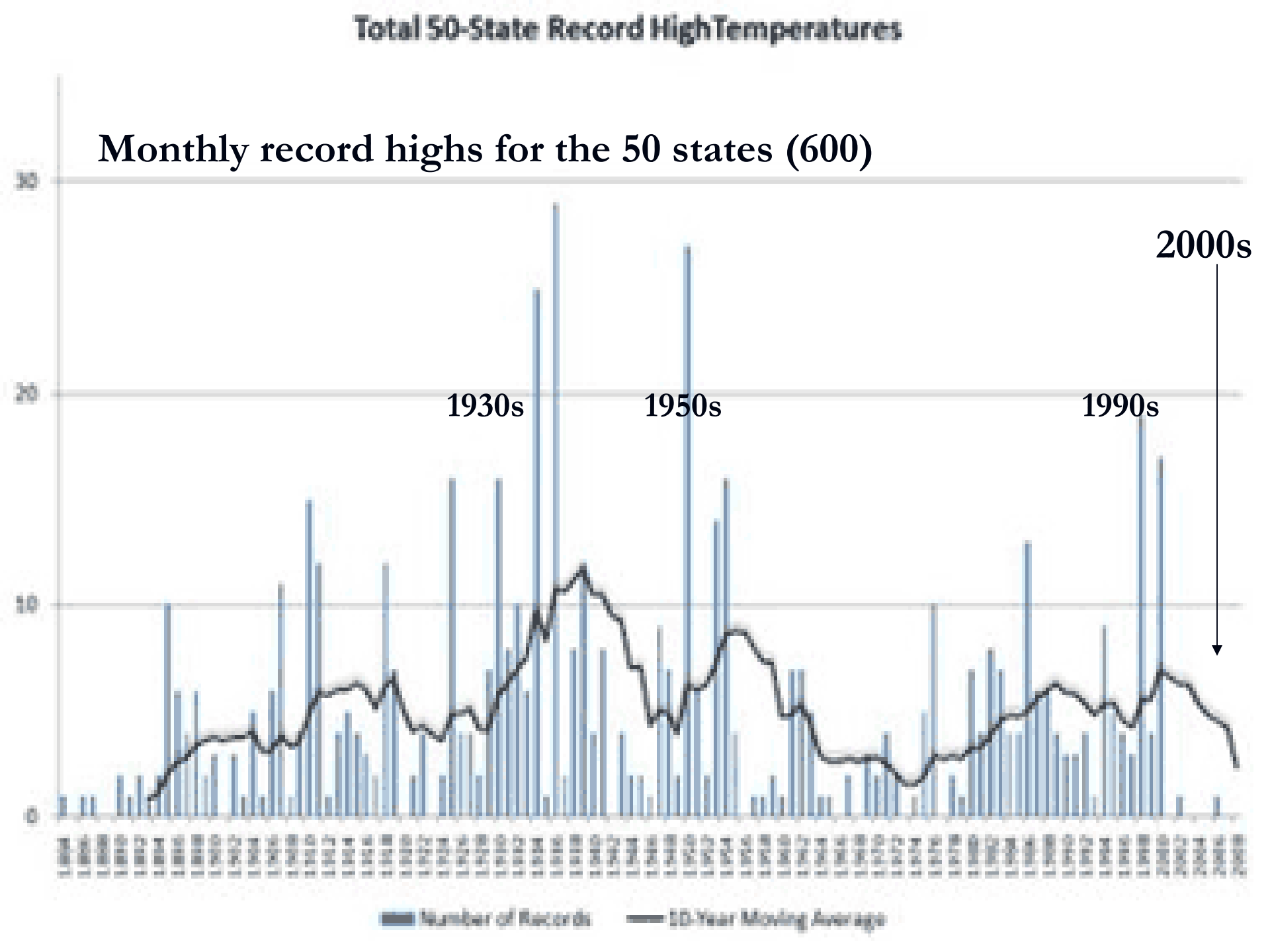

Total 50-State Record HighTemperatures
Monthly record highs for the 50 states (600)
30
20
10
0
1930s
1950s
1990s
2000s
Number of Records
10-Year Moving Average

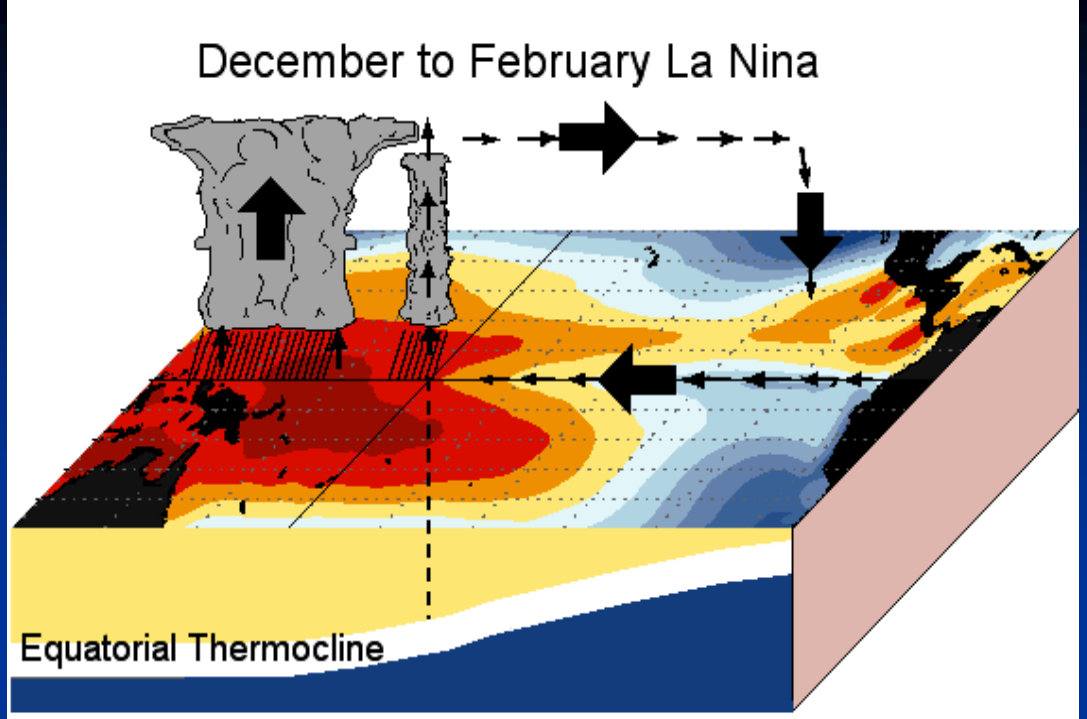
Continent	*All-time High*	*Place*	*Date*
Africa	136	El Azizia, Libya	September 13, 1922
North America	134	Death Valley, CA	July 10, 1913
Asia	129	Tirat Tsvi, Israel	June 22, 1942
Australia	128	Cloncurry, Queensland	January 16, 1889
Europe	122	Seville, Spain	August 4, 1881
South America	120	Rivadavia, Argentina	December 11, 1905
Oceania	108	Tuguegarao, Philippines	April 29, 1912
Antarctica	59	Vanda Station, Scott Coast	January 5, 1974

NCDC World Wide Record High Temperatures

Natural Climate Drivers

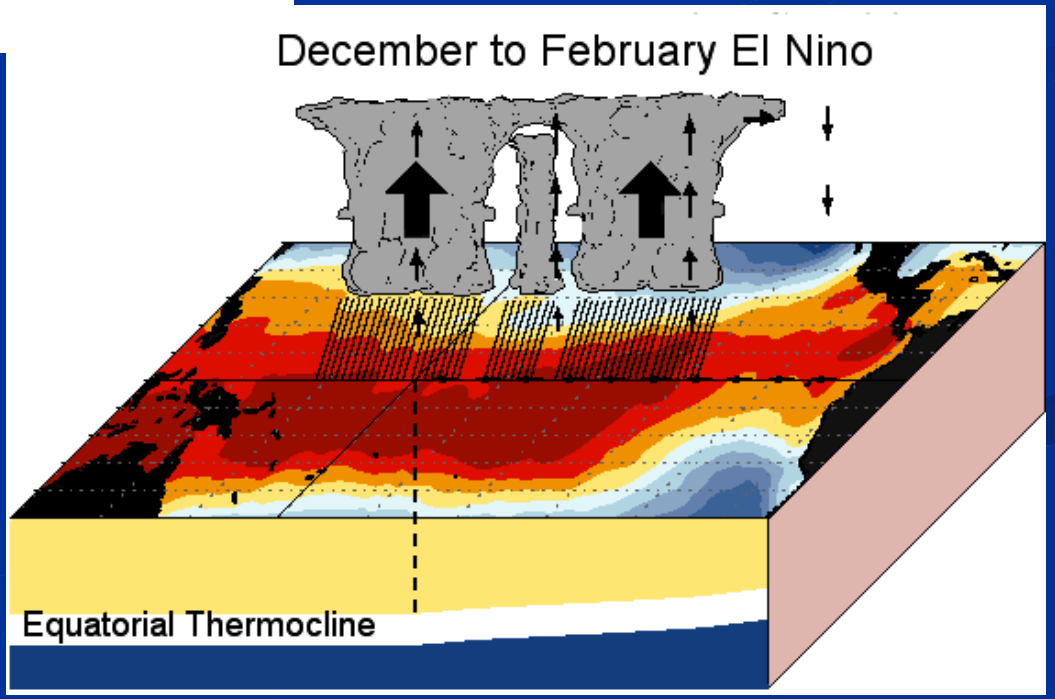
- Ocean cycles - annual and decadal
- Solar cycles – longer term
- Volcanism

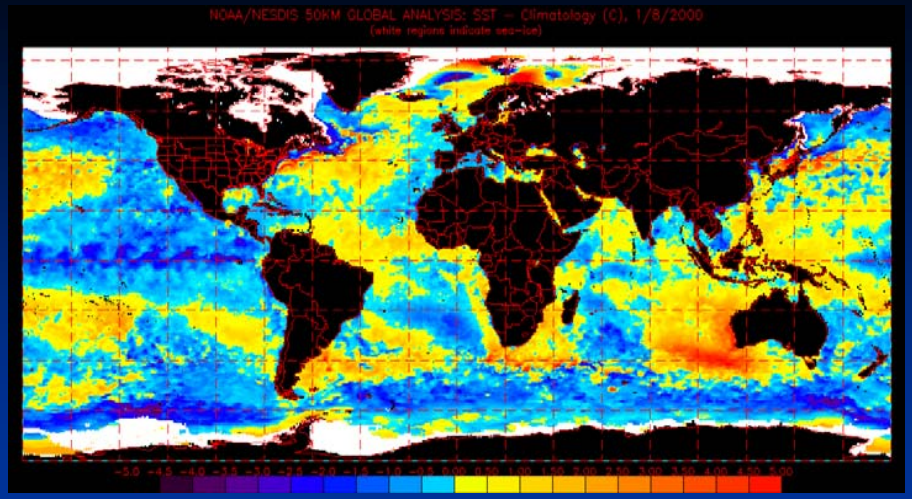
Covered in IPCC science chapters, but downplayed in models and ignored in summaries

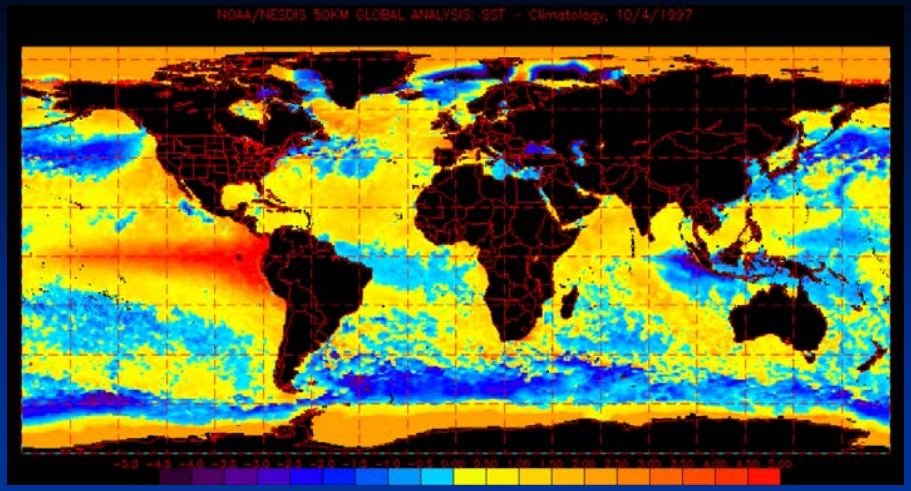


El Nino Southern Oscillation ENSO

The "Walker Circulation"

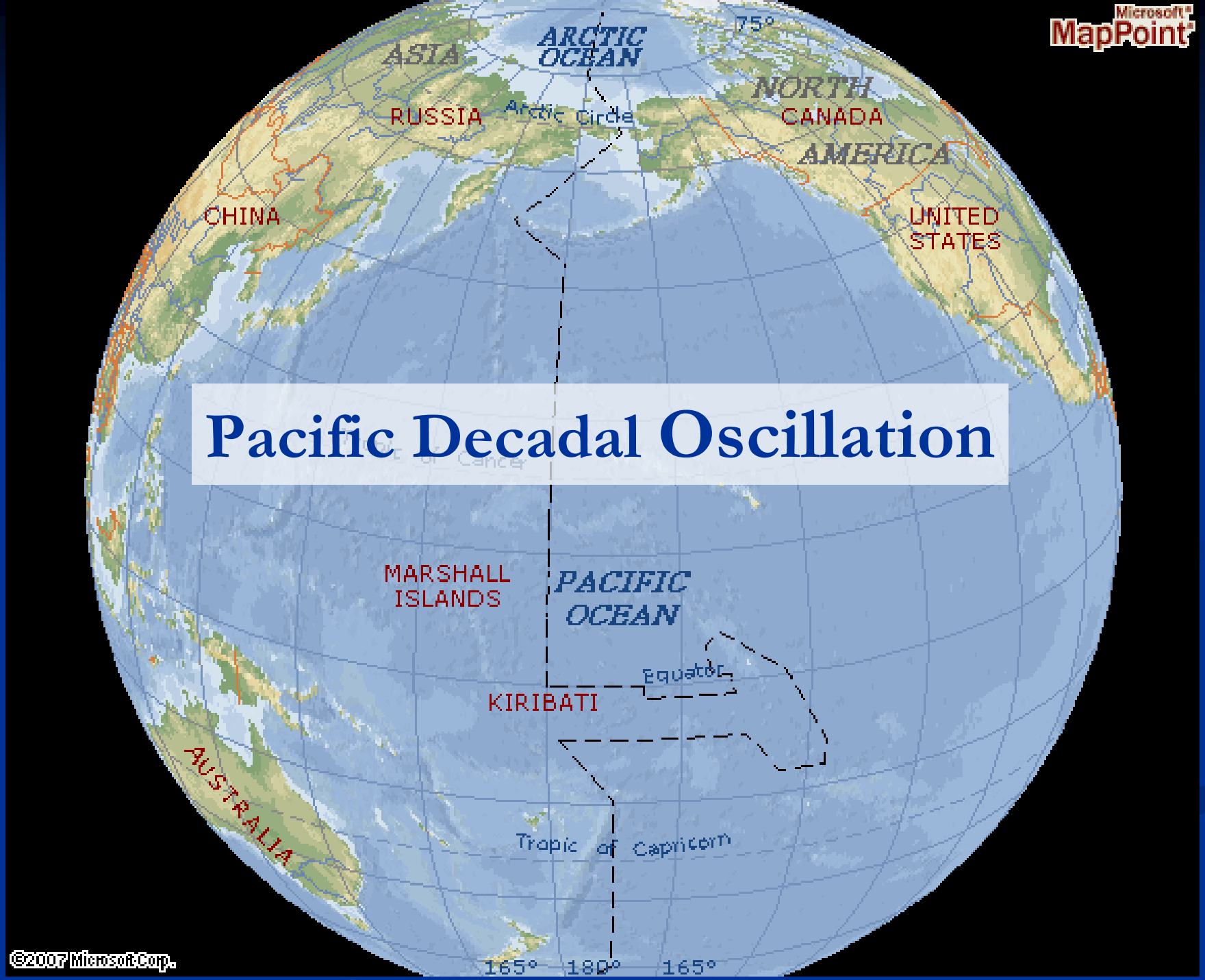






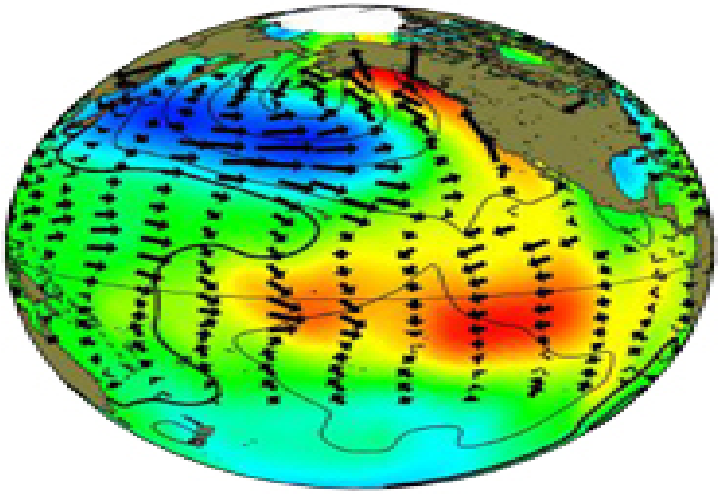
LA NINA

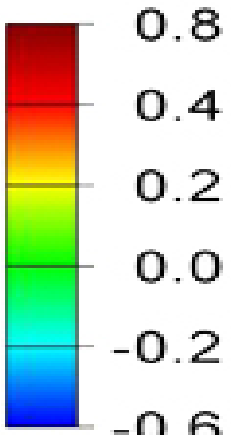
EL NINO


Microsoft MapPoint
ARCTIC OCEAN
75°
ASIA
NORTH AMERICA
RUSSIA
Arctic Circle
CANADA
CHINA
UNITED STATES
Pacific Decadal Oscillation
MARSHALL ISLANDS
PACIFIC OCEAN
Equator
KIRIBATI
AUSTRALIA
Tropic of Capricorn
165°
180°
165°
©2007 Microsoft Corp.

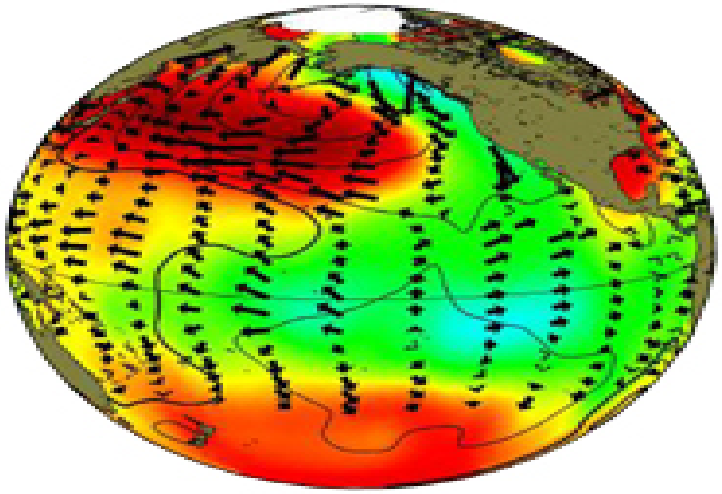
Pacific Decadal Oscillation

positive phase



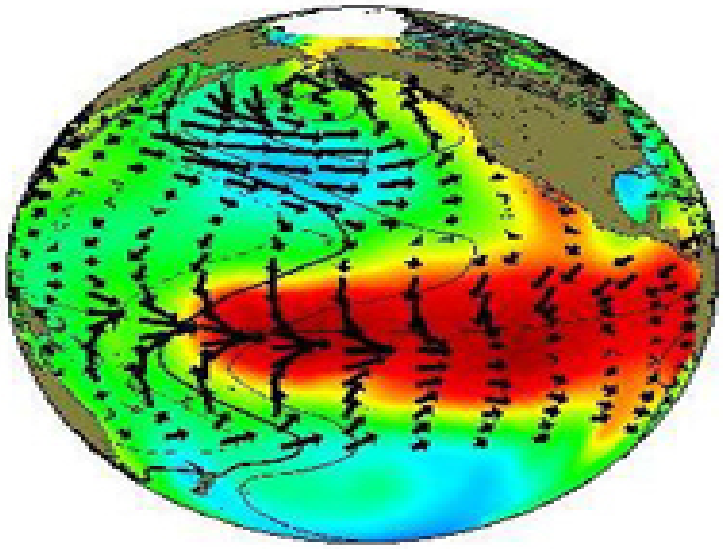


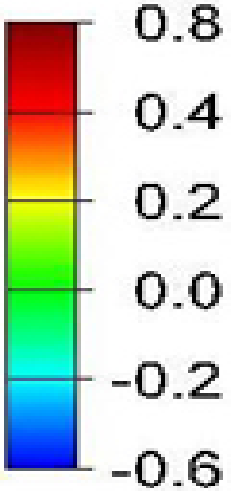
negative phase



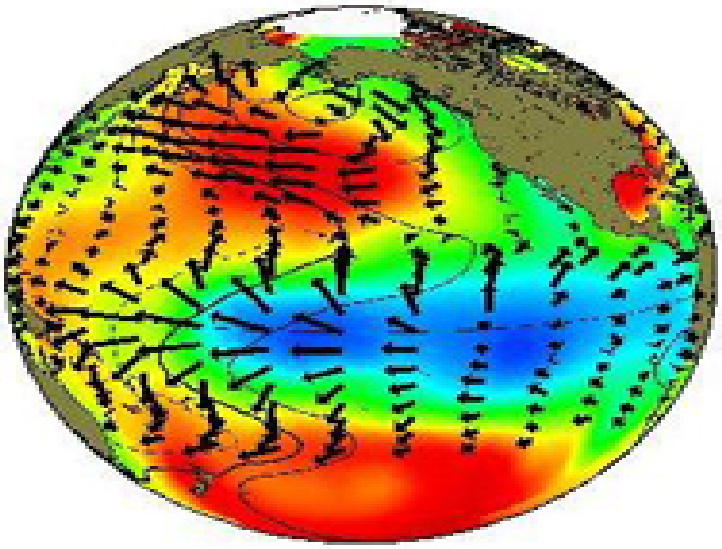
El Nino Southern Oscillation

El Nino

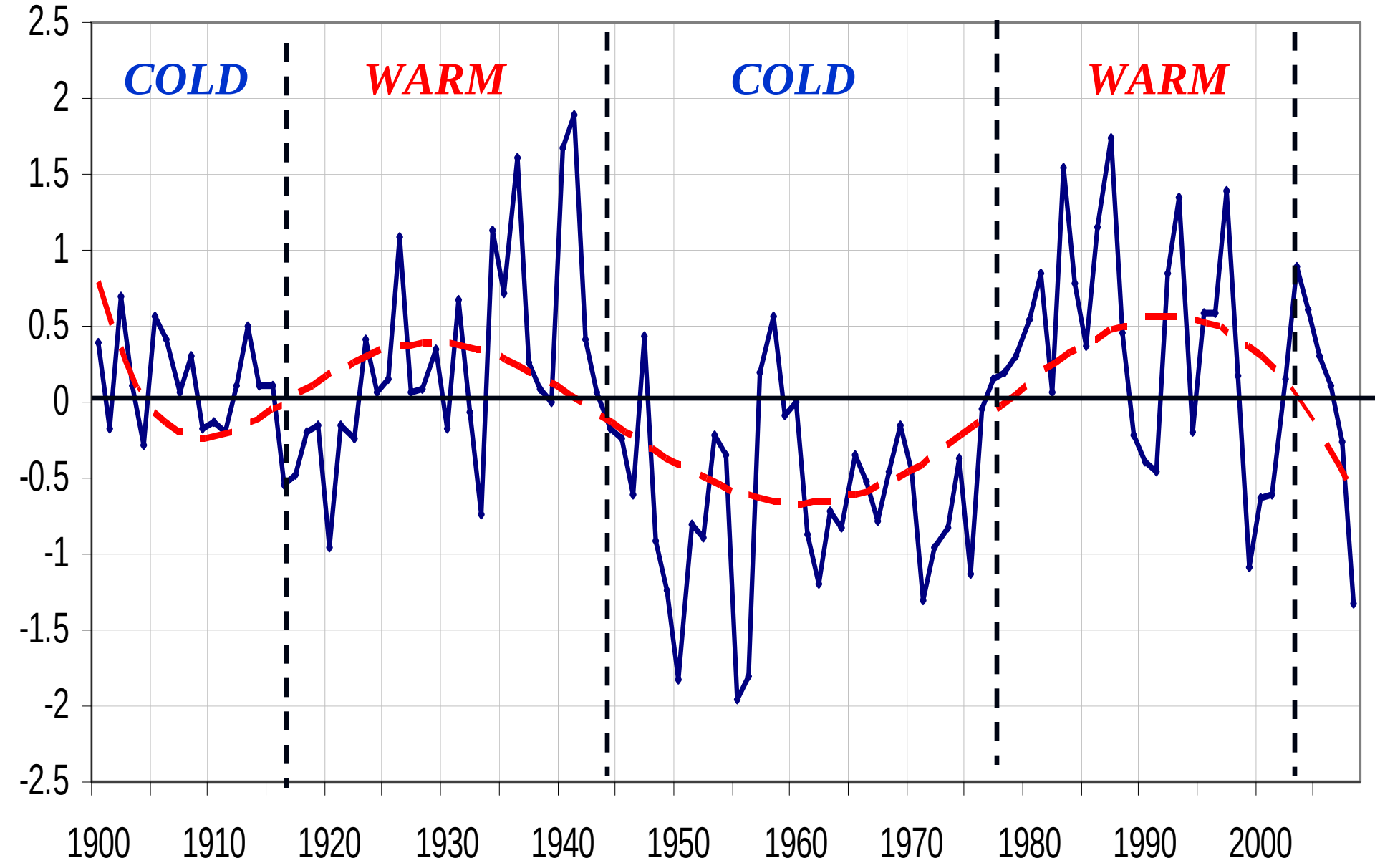


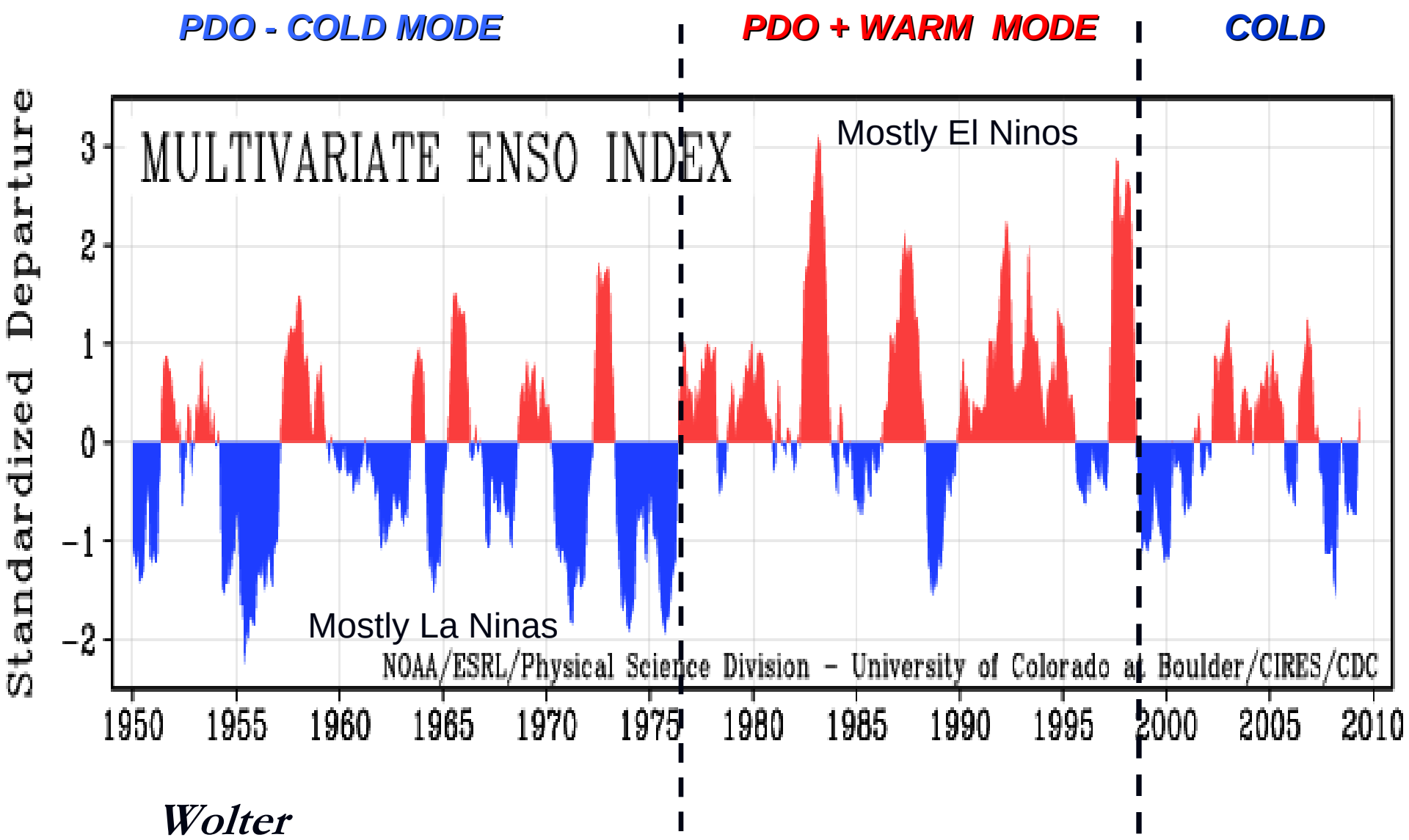


La Nina

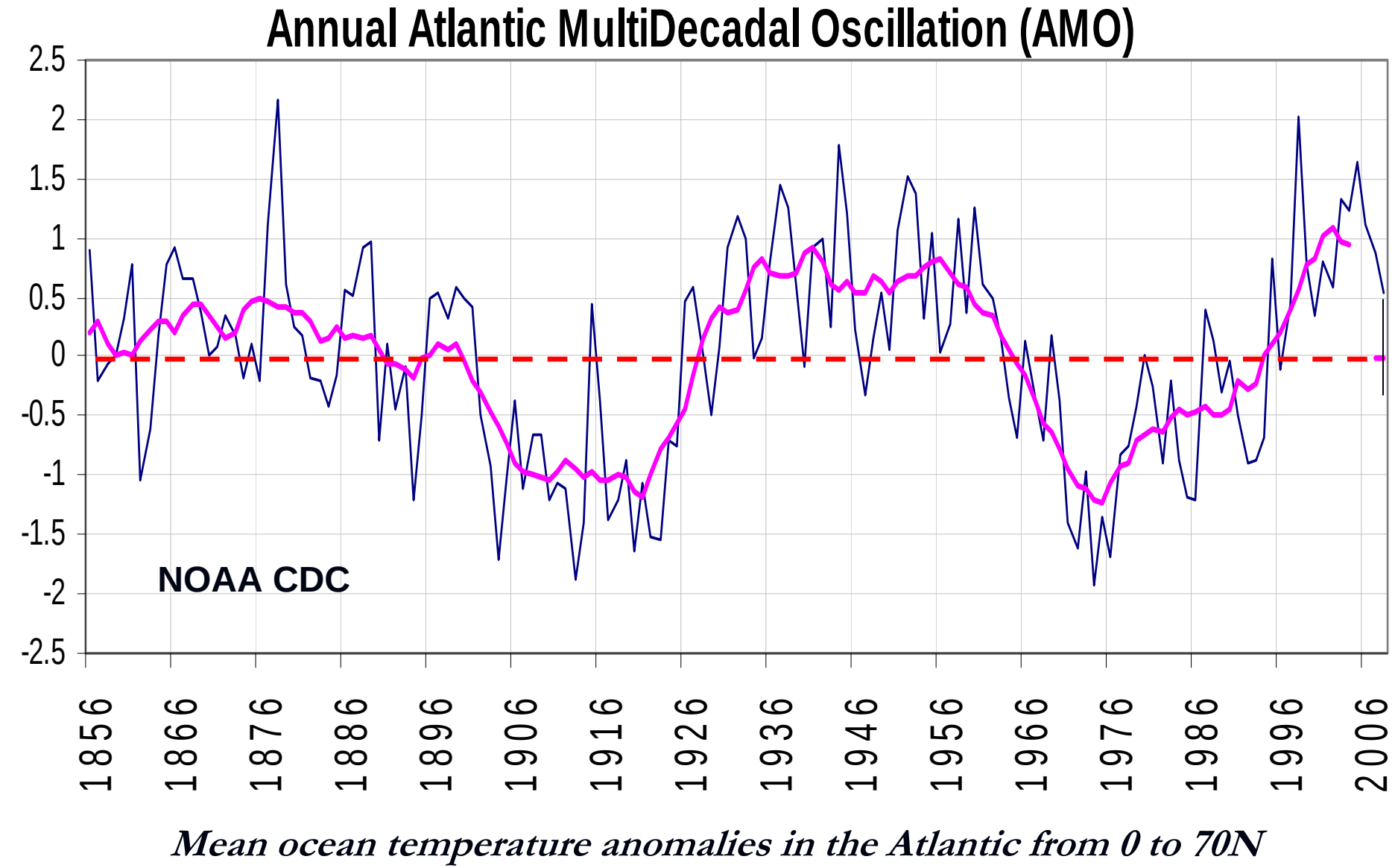


PDO Annual


COLD
WARM
COLD
WARM
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000


PDO - COLD MODE
PDO + WARM MODE
COLD
MULTIVARIATE ENSO INDEX
Mostly El Ninos
Mostly La Ninas
NOAA/ESRL/Physical Science Division - University of Colorado at Boulder/CIRES/CDC
Standardized Departure
3
2
1
0
-1
-2
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Wolter

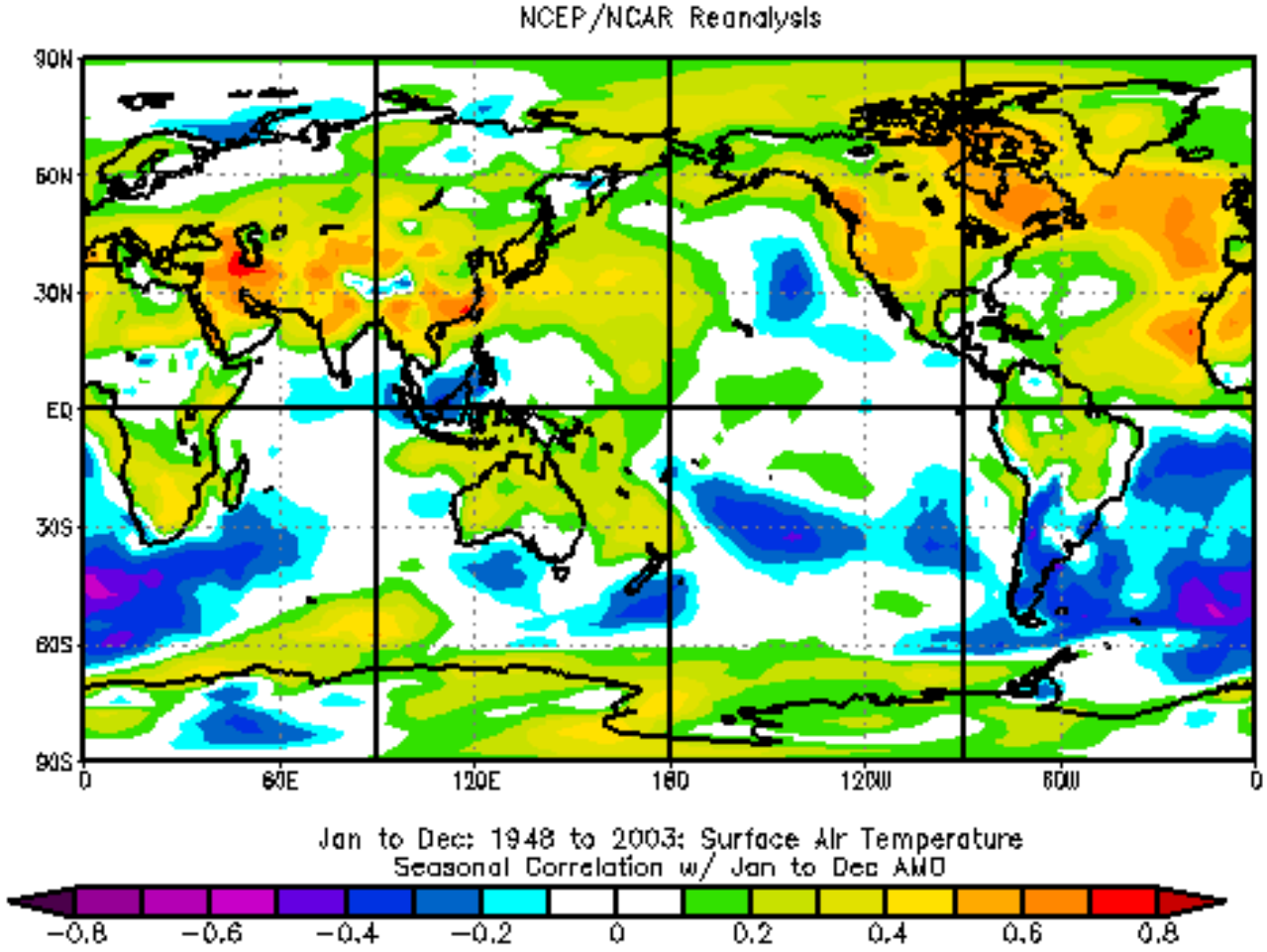
Atlantic MultiDecadal Oscillation



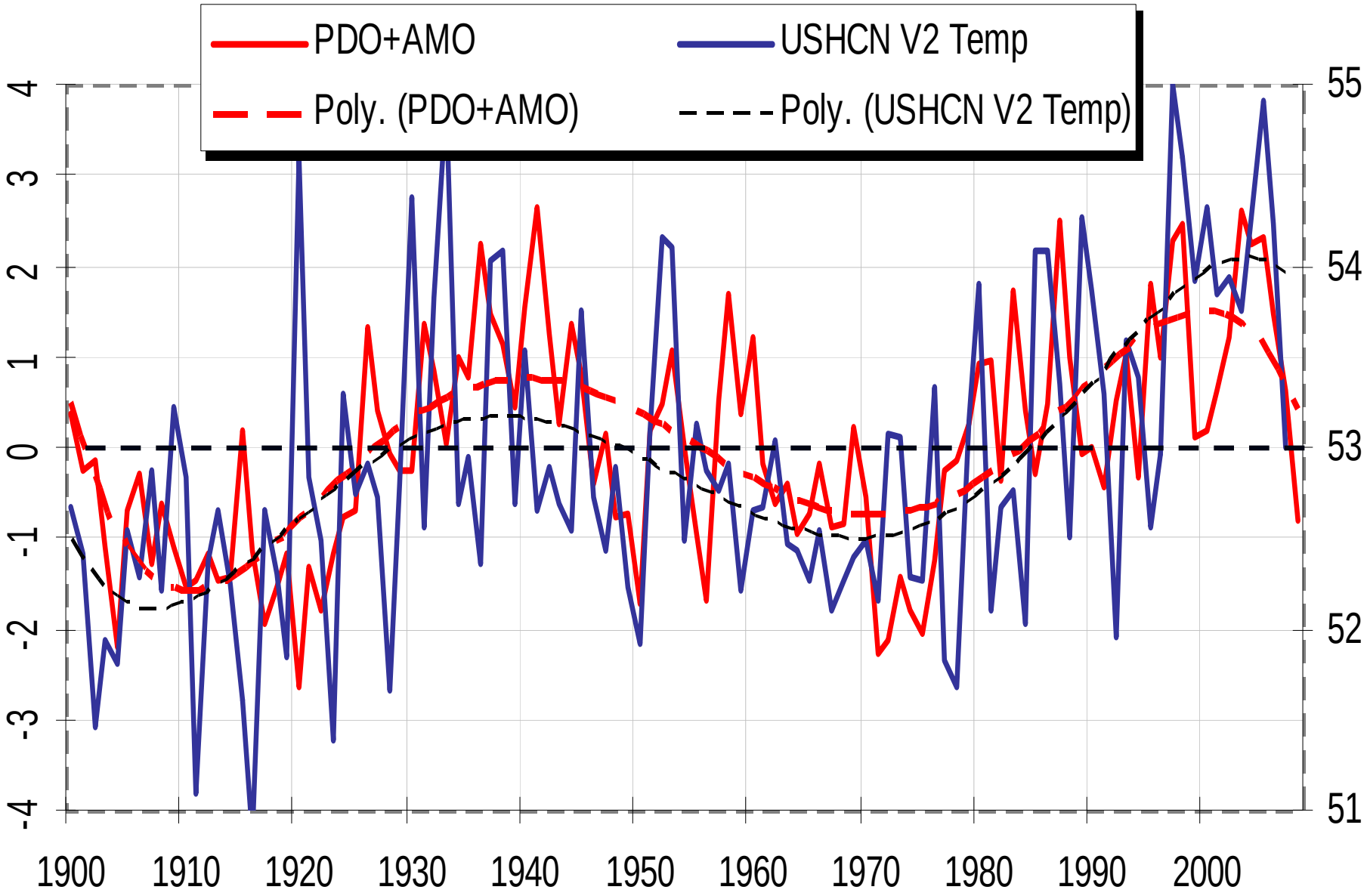
Mean ocean temperature anomalies in the Atlantic from 0 to 70N

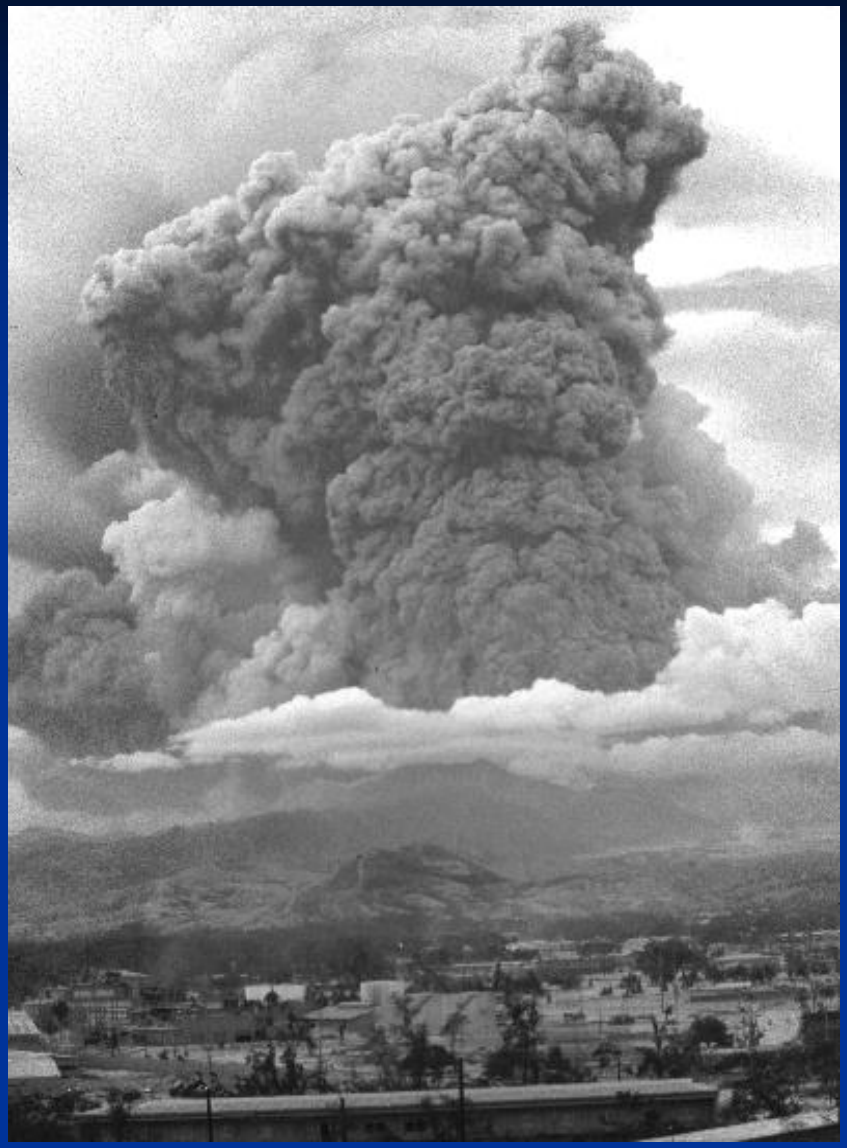
Atlantic Multidecadal Oscillation

Correlates with northern hemisphere warmth, statistically significant in places

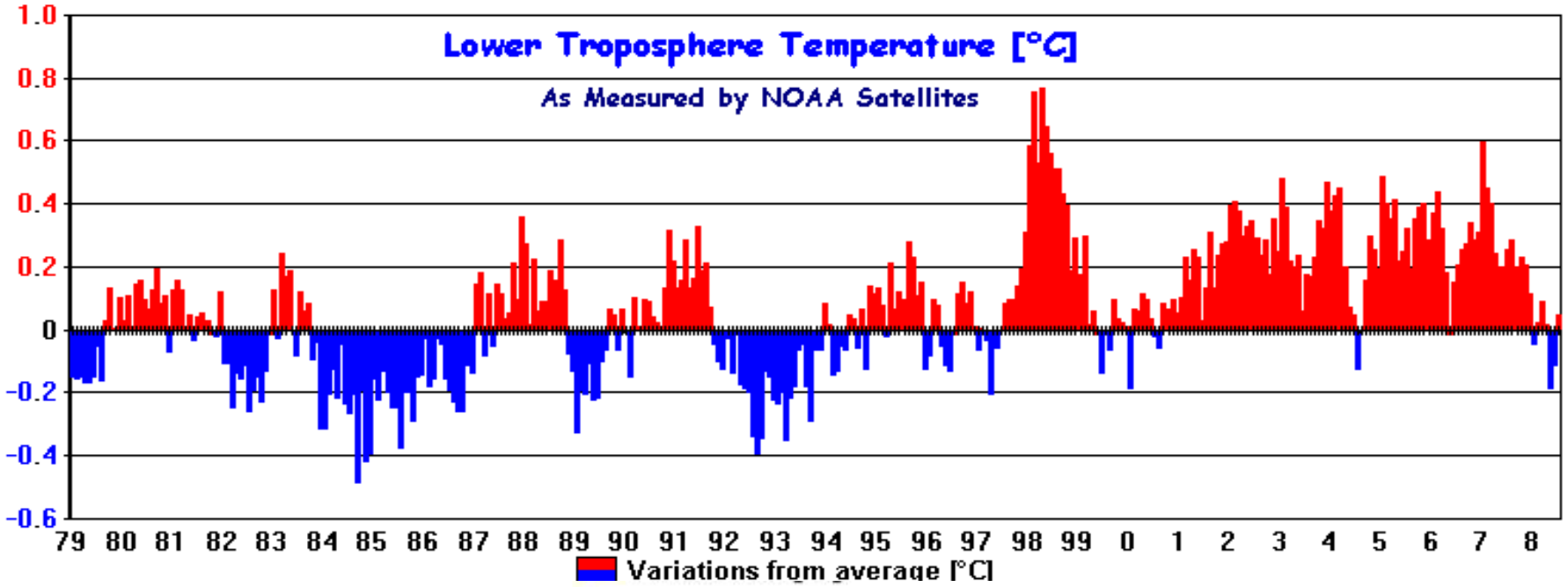


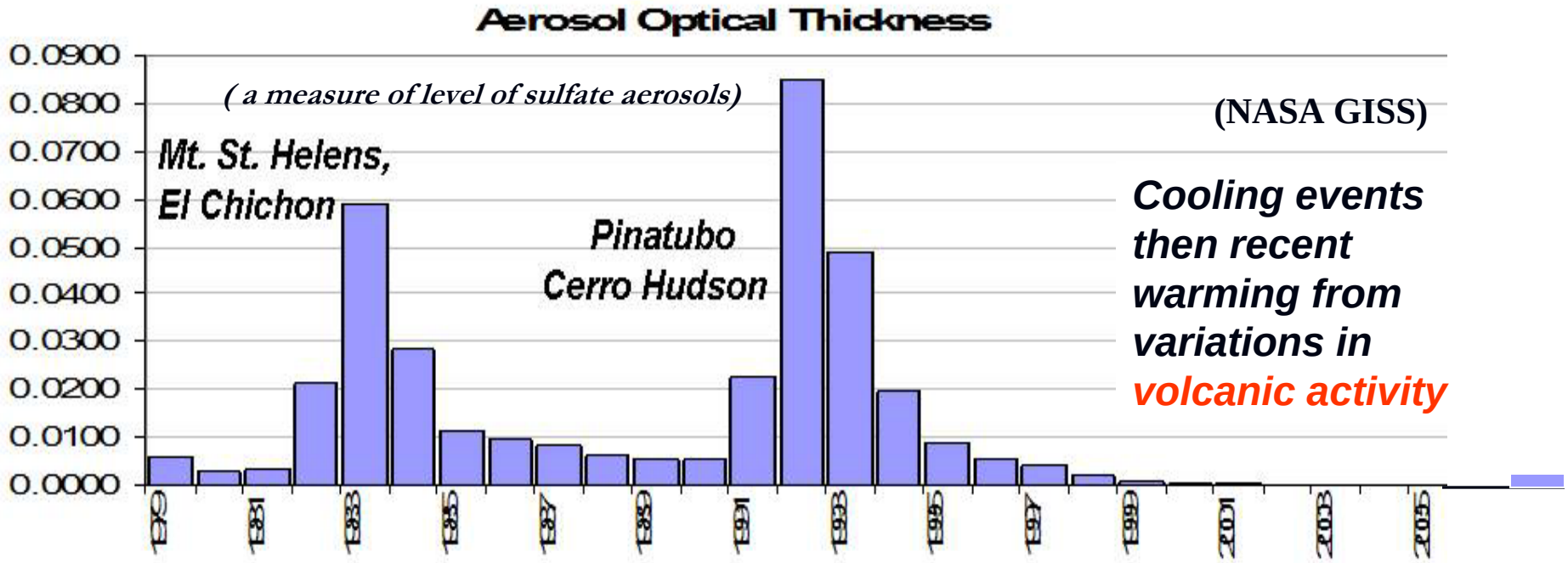
PDO+AMO vs USHCN V2 Annual Temp





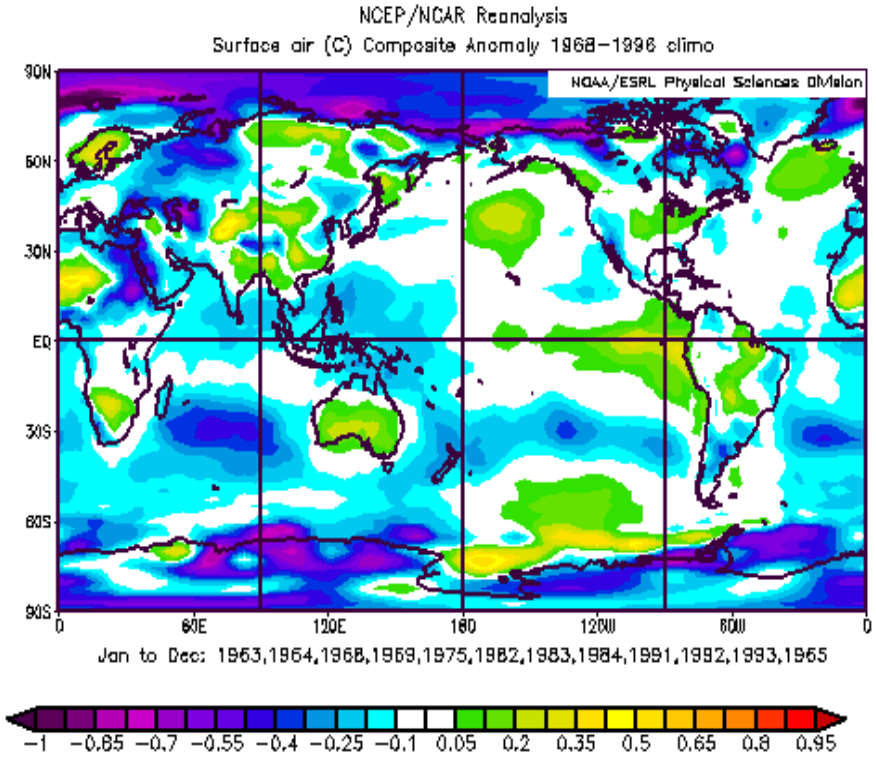
Major Volcanic Eruptions


Lower Troposphere Temperature [°C]
As Measured by NOAA Satellites
1.0
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 0 1 2 3 4 5 6 7 8
Variations from average [°C]

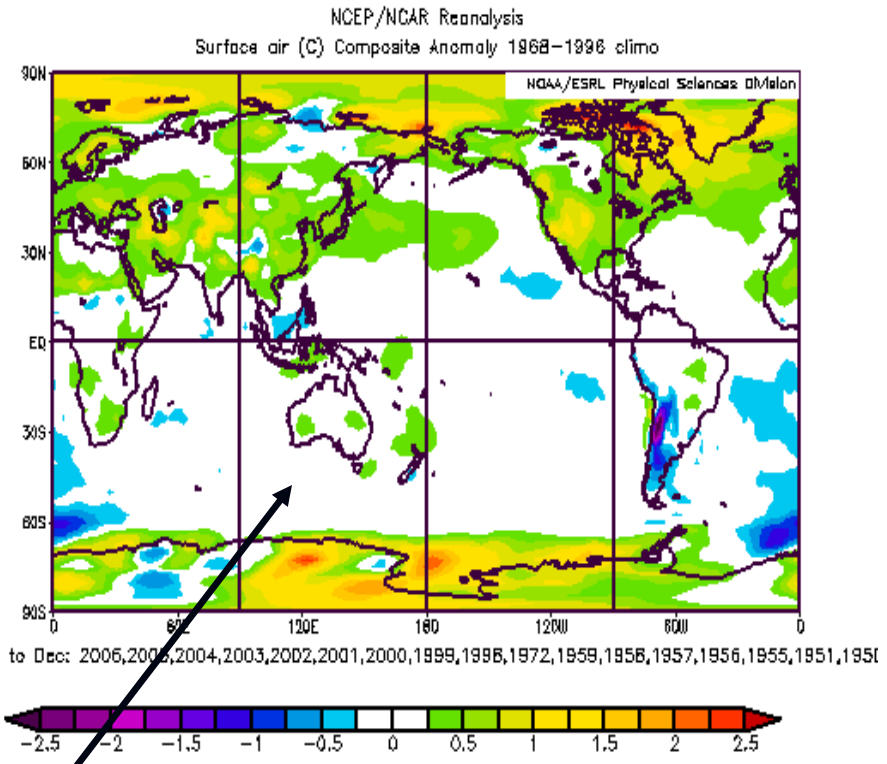

Aerosol Optical Thickness
(a measure of level of sulfate aerosols)
(NASA GISS)
Mt. St. Helens,
El Chichon
Pinatubo
Cerro Hudson
Cooling events then recent warming from variations in volcanic activity
0.0900
0.0800
0.0700
0.0600
0.0500
0.0400
0.0300
0.0200
0.0100
0.0000
79
81
83
85
87
89
91
93
95
97
99
01
03
05

Years with more than ½ STD departures stratospheric aerosols

More than 1/2 STD Above



More than ½ STD Below



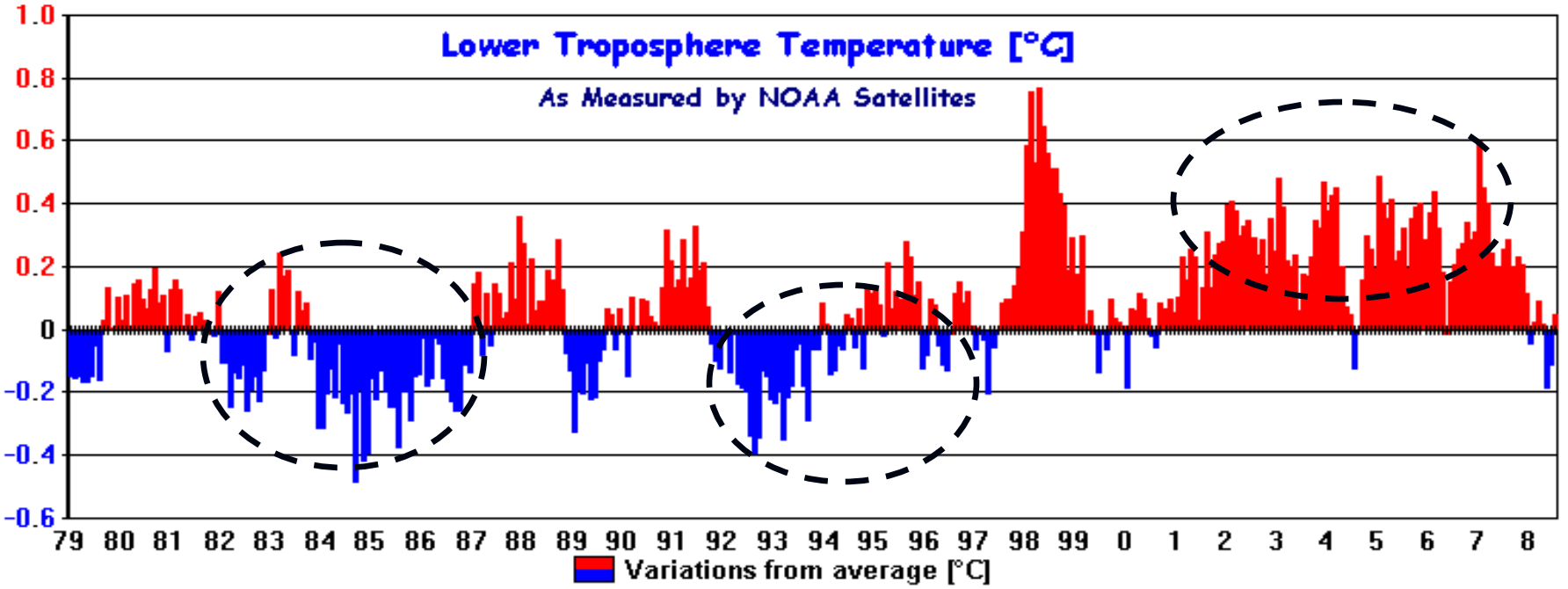
Annual Temperature Anomalies

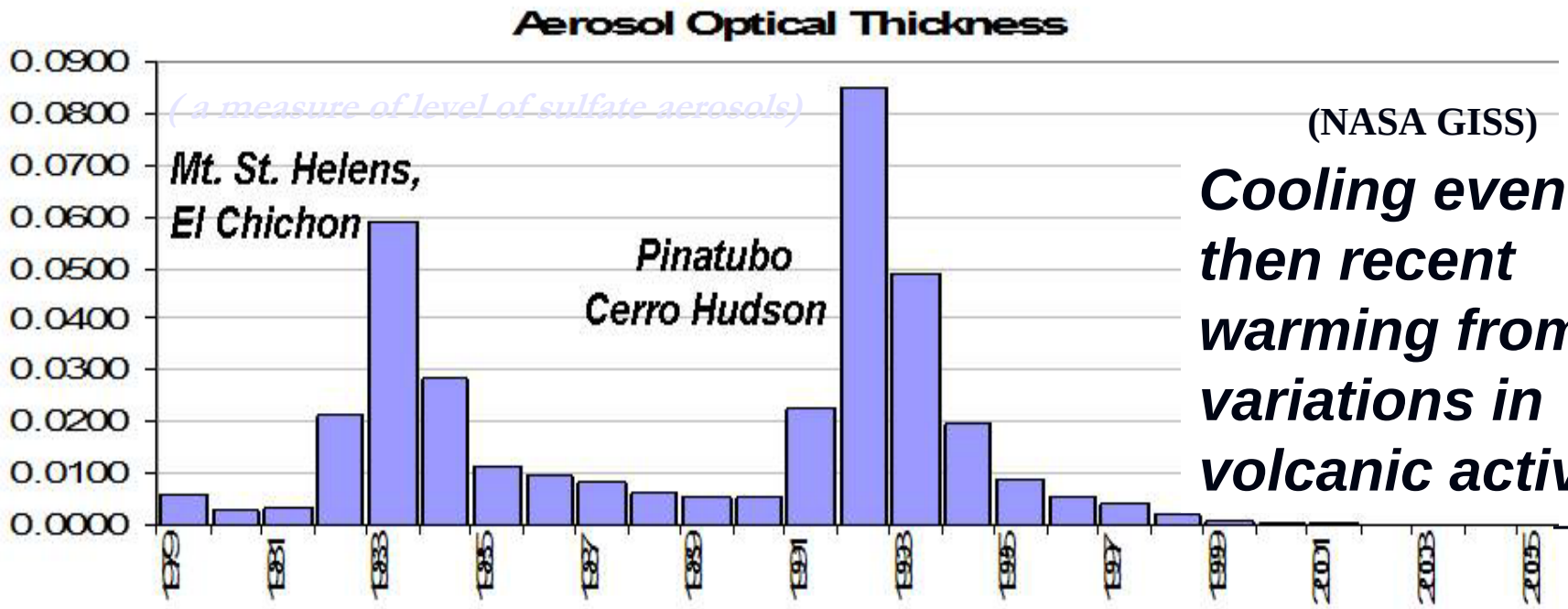
Data NASA GISS, CDC

Early to Mid 2000s

After major eruptions

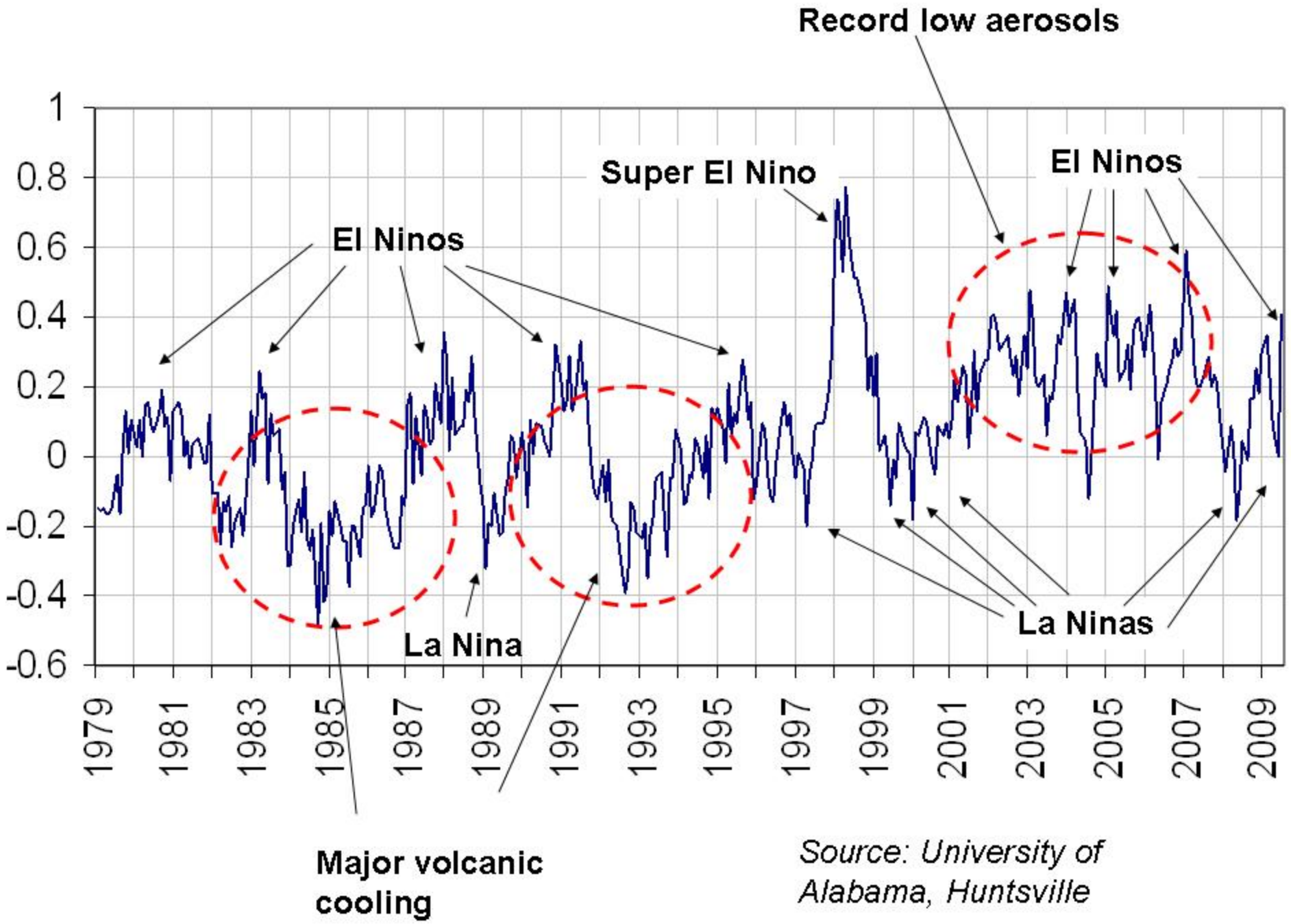
During quiet periods





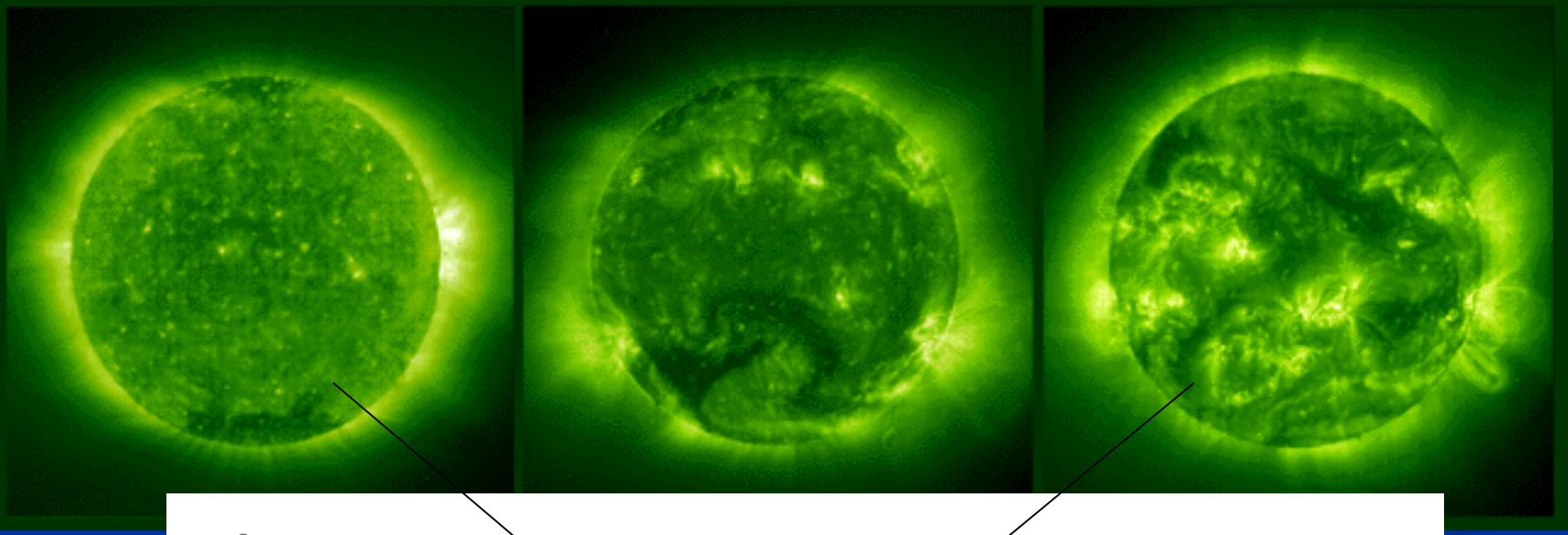
(NASA GISS)

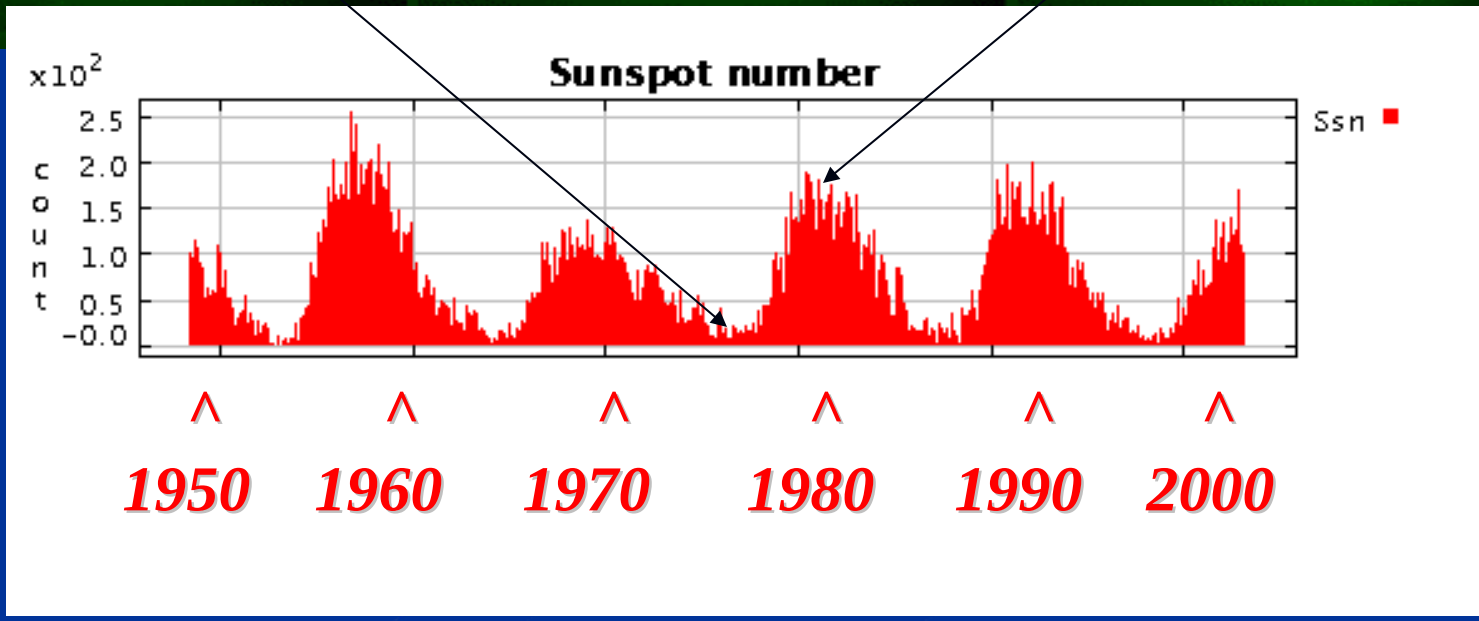
Cooling events then recent warming from variations in volcanic activity



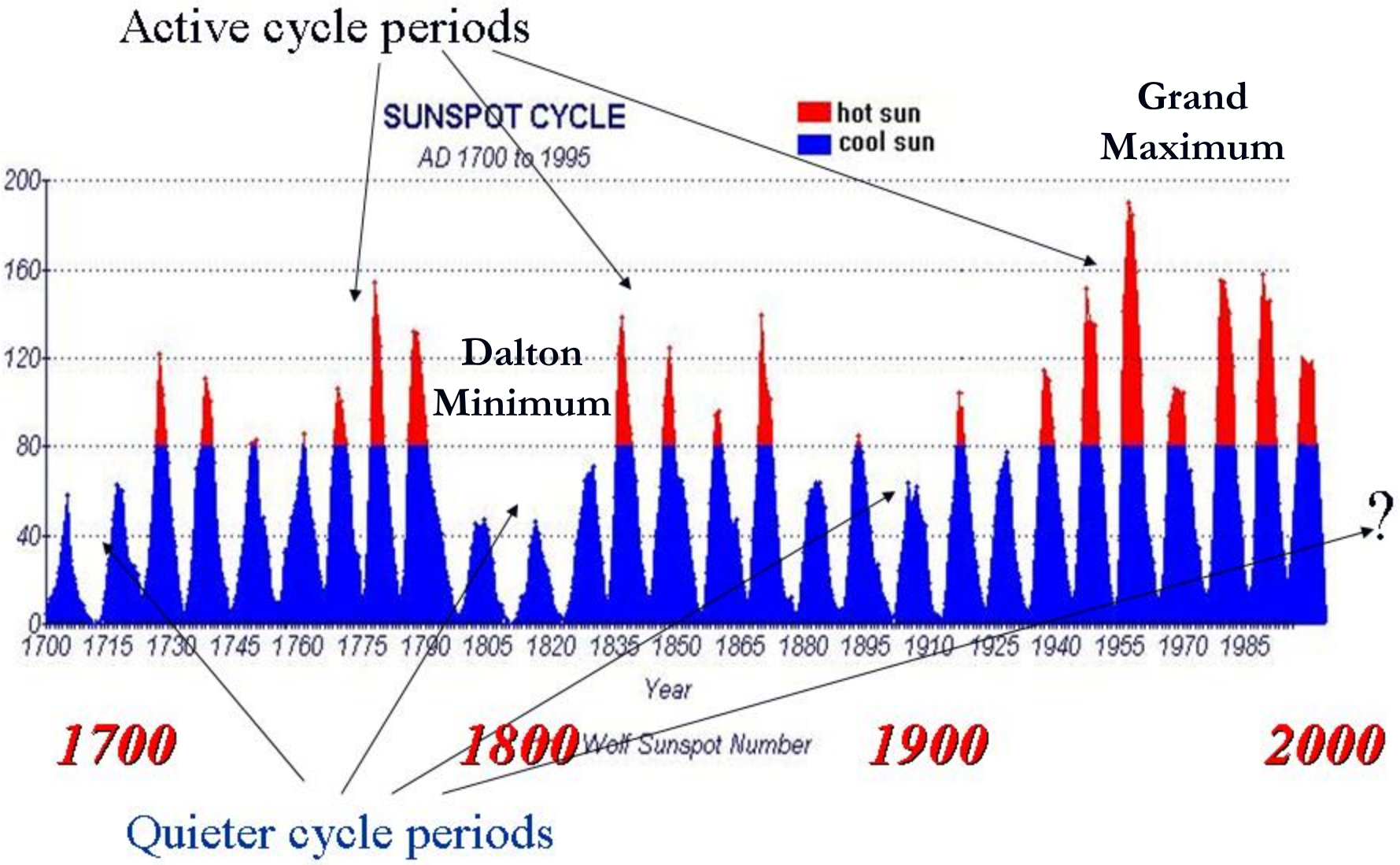
Source: University of Alabama, Huntsville

11 YEAR SOLAR SUNSPOT CYCLE





11 year solar cycles vary in their strength on a longer term on cycles of 22, 53, 88, 106, 213, 429, etc. years



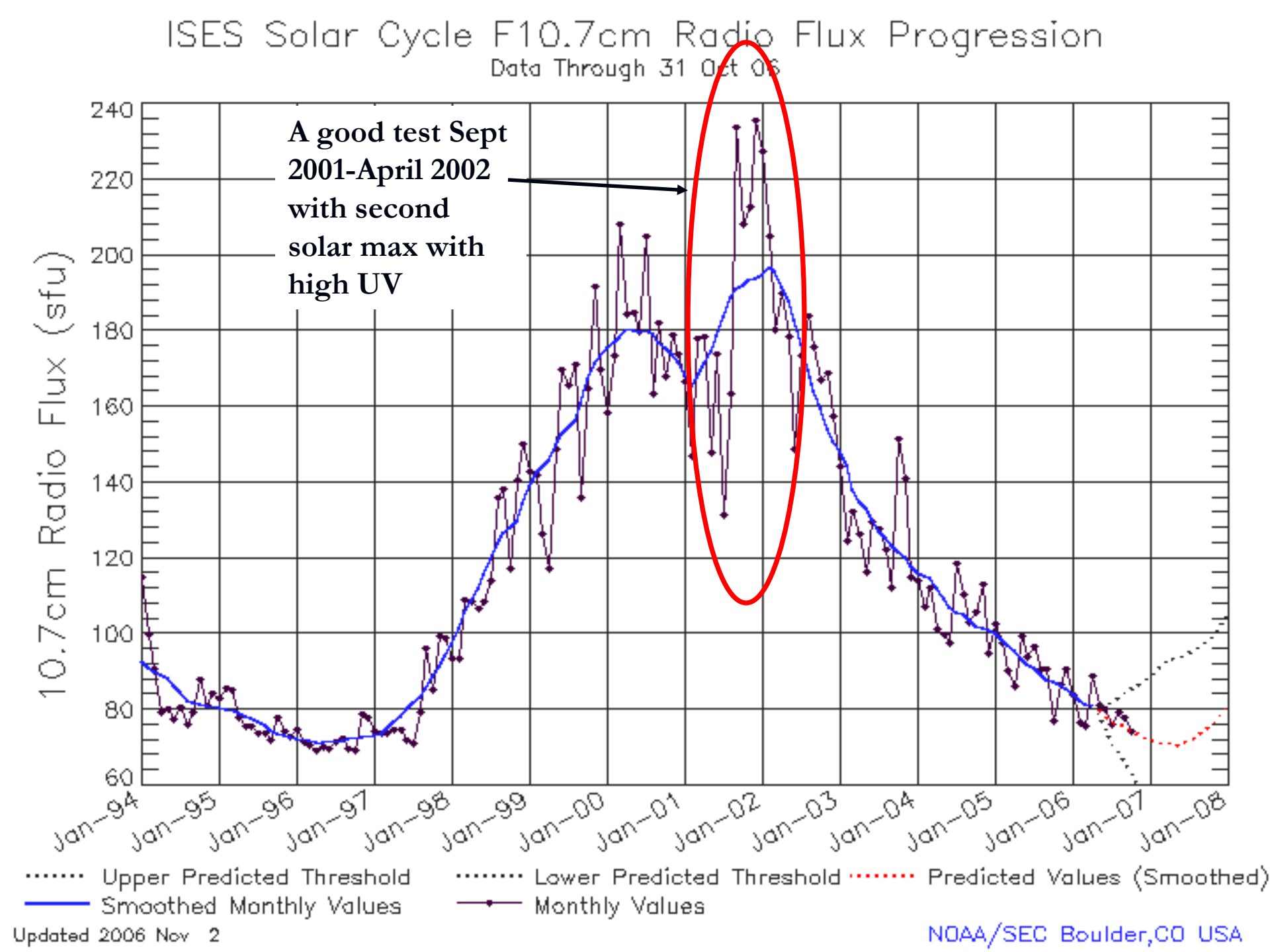
Cyclical Factors - Solar

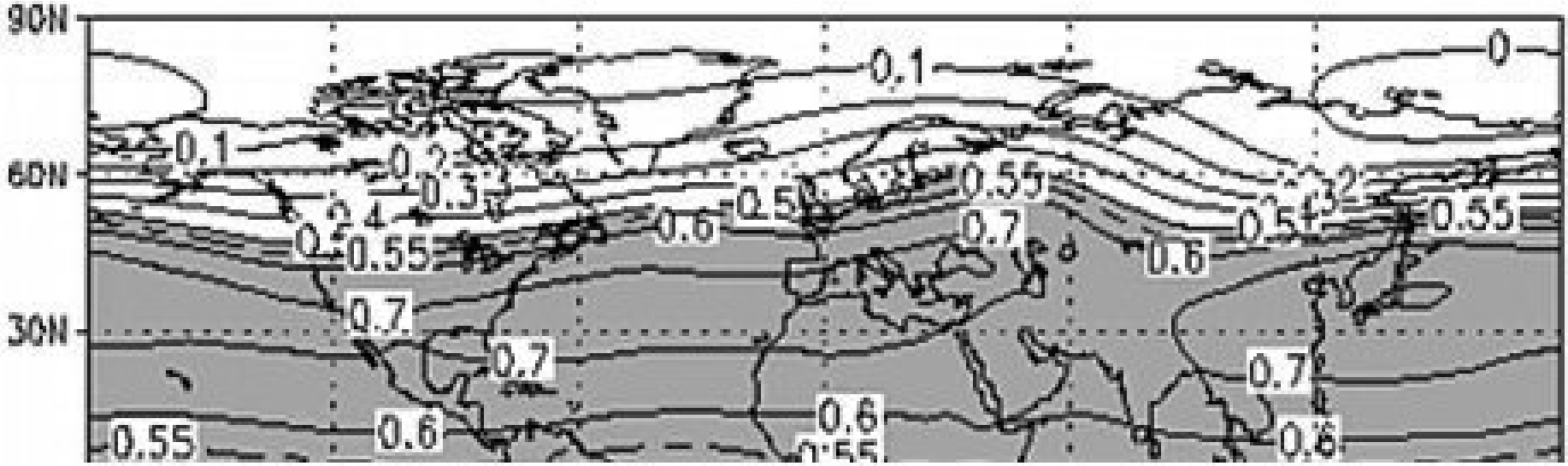
- Direct Effects
  - Changes in solar brightness (irradiance) (Baliunas, Soon, Hoyt, Schatten, Scafetta/West)
- Indirect Effects
  - UV warming through ozone chemistry high up in low and mid latitudes (Shindell at NASA GISS, Labitzke)
  - Geomagnetic storms that warm high latitudes (Labitzke, Pyche et al)
  - Active sun reduces low cloudiness by diffusing galactic cosmic rays - ion mediated nucleation (Svensmark)

Scaffetta and West (2007) using Total Solar irradiance as a proxy for the total solar effect suggested the sun may account for 69% of the changes since 1900

Ultraviolet Radiation and Ozone

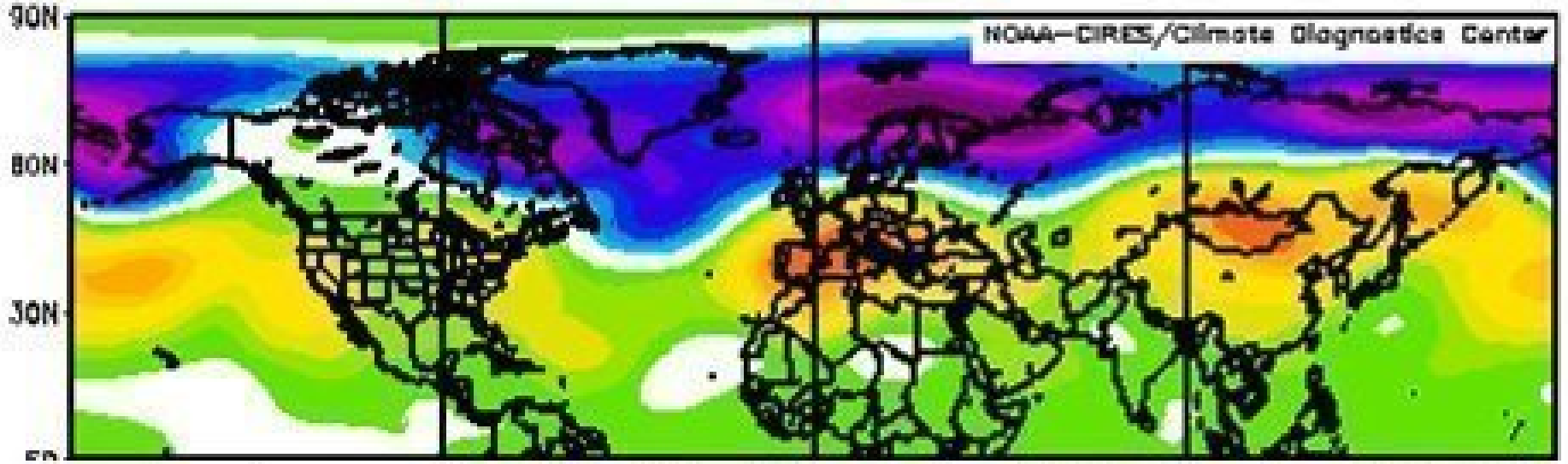
- Though solar irradiance varies only 0.1% over the 11 year cycle, radiation at longer UV wavelengths are known to increase by 6 to 8 percent with still larger changes (factor of two or more) at extremely short UV and X-ray wavelengths (Baldwin and Dunkerton, JAS 2004).
- Labitzke has shown statistically significant differences of temperatures in the lower stratosphere into the middle troposphere with the 11 year solar cycle (warmest at max)
- Shindell et al NASS GISS (1999) showed results from a global climate model including ozone and UV found UV induced stratospheric ozone changes and generated heat that penetrates into the troposphere, in effect confirming Labitzke's findings


ISES Solar Cycle F10.7cm Radio Flux Progression
Data Through 31 Oct 06
A good test Sept 2001-April 2002 with second solar max with high UV
10.7cm Radio Flux (sfu)
240
220
200
180
160
140
120
100
80
60
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Upper Predicted Threshold
Lower Predicted Threshold
Predicted Values (Smoothed)
Smoothed Monthly Values
Monthly Values
Updated 2006 Nov 2
NOAA/SEC Boulder,CO USA

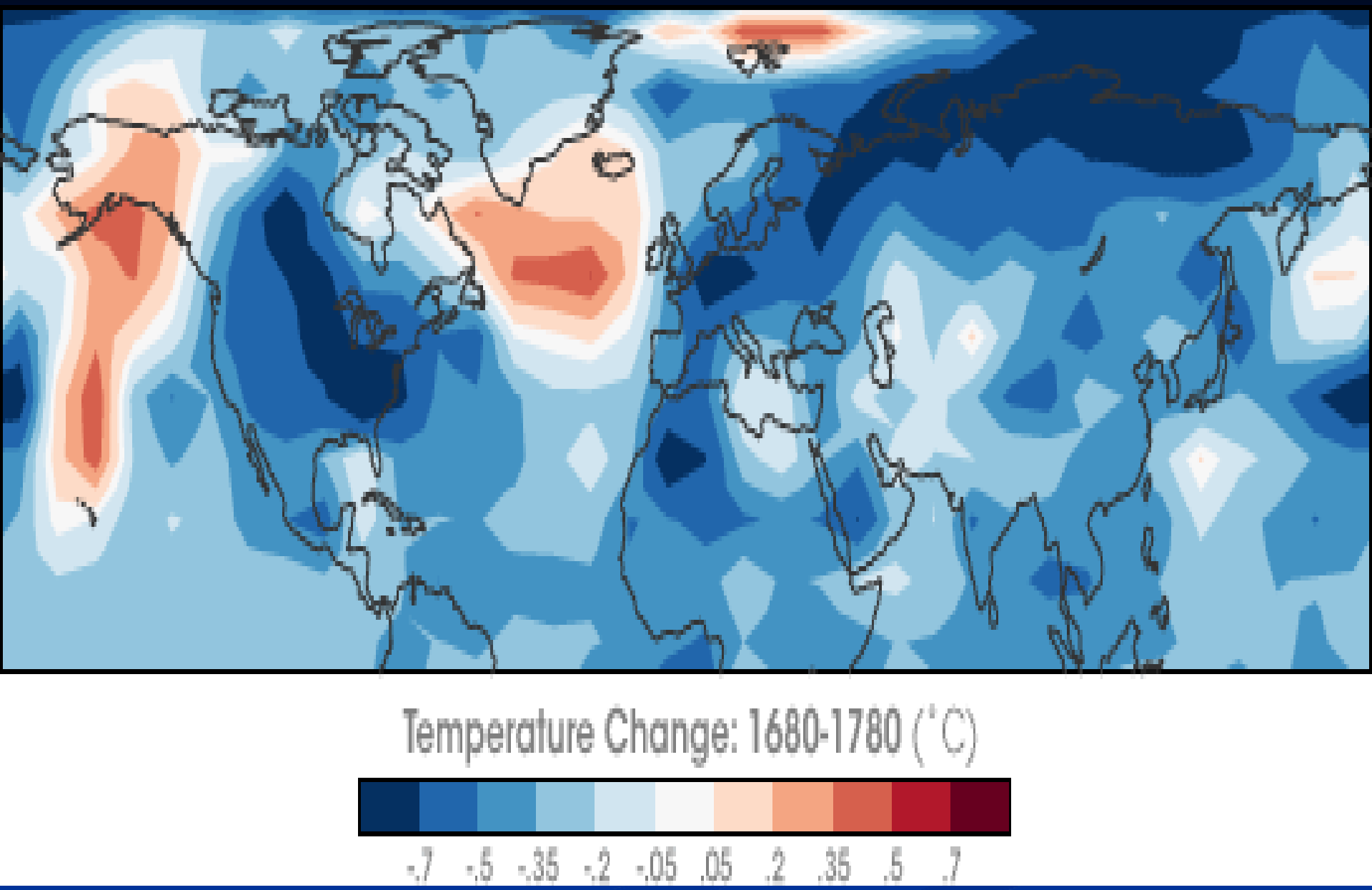


Correlation high atmosphere heights with solar flux (Labitzke)

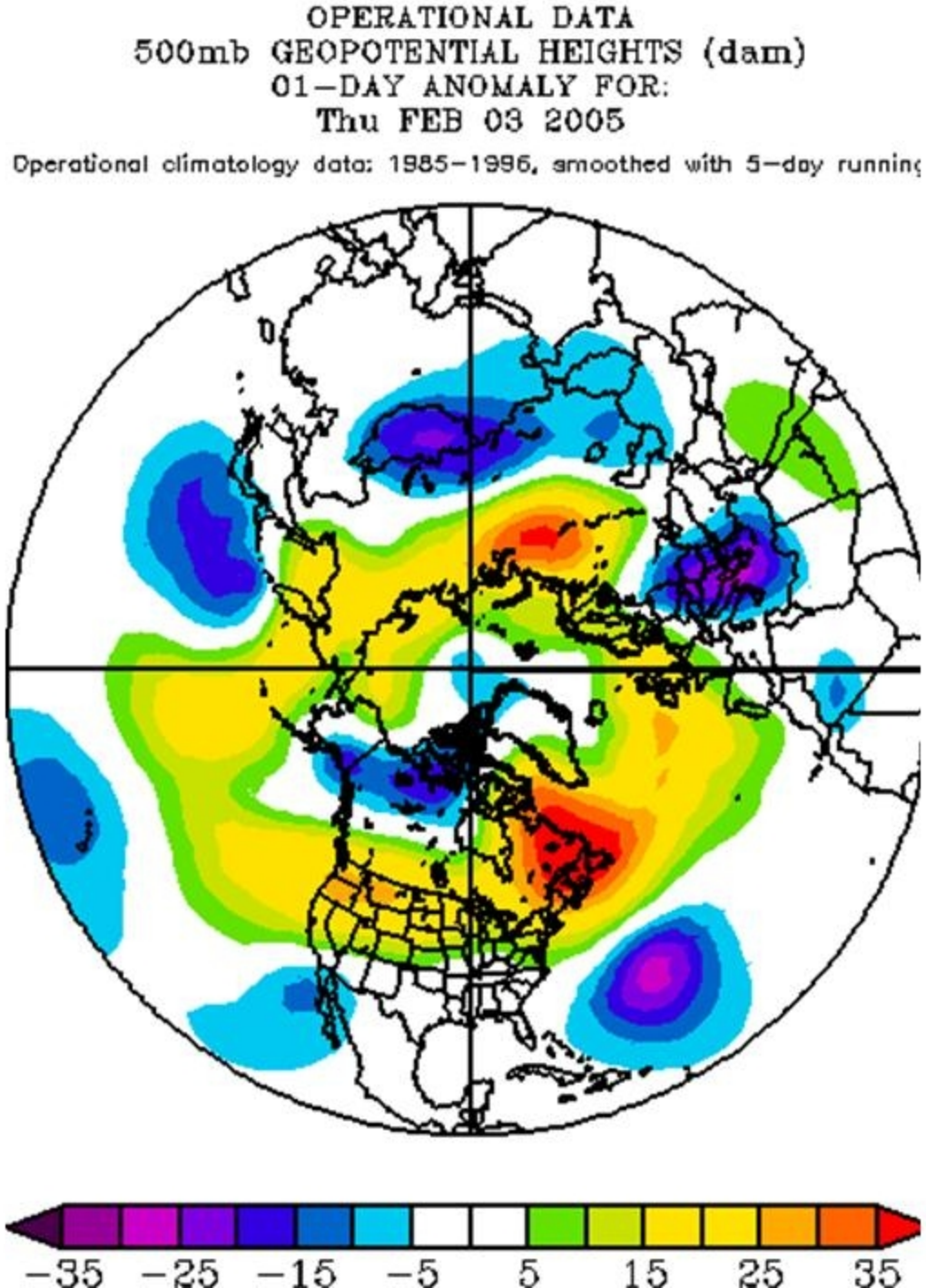
Pattern fit the findings of Labitzke and Shindell's models

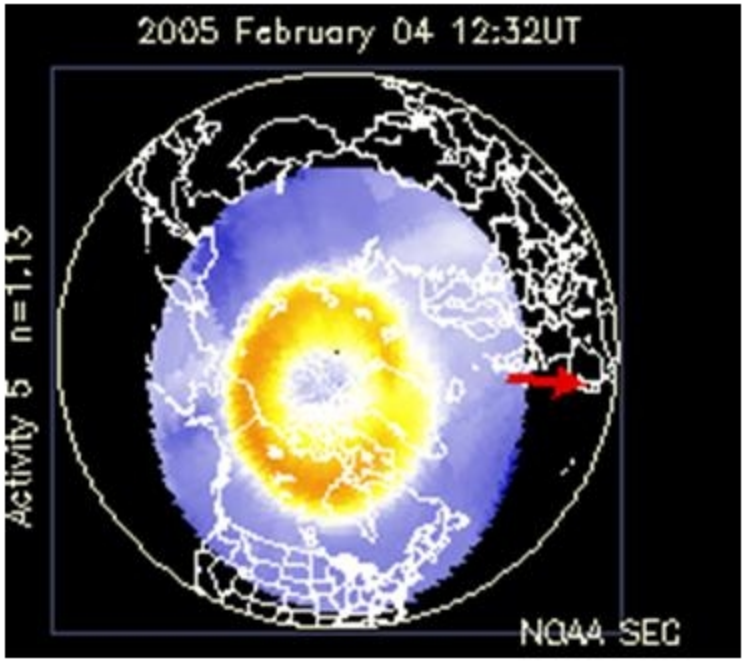


Actual anomalies 500mb heights during high flux Jan/Feb 2002



Maunder Minimum – Little Ice Age (Shindell NASA)



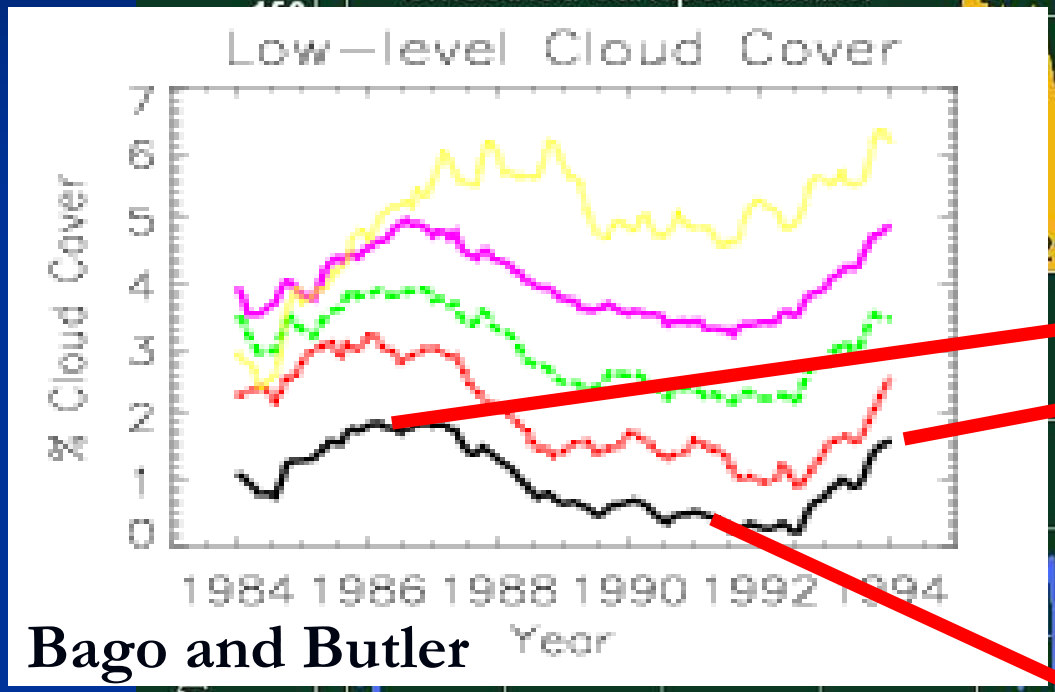


Auroral ring when sun is quiet, It expands when active

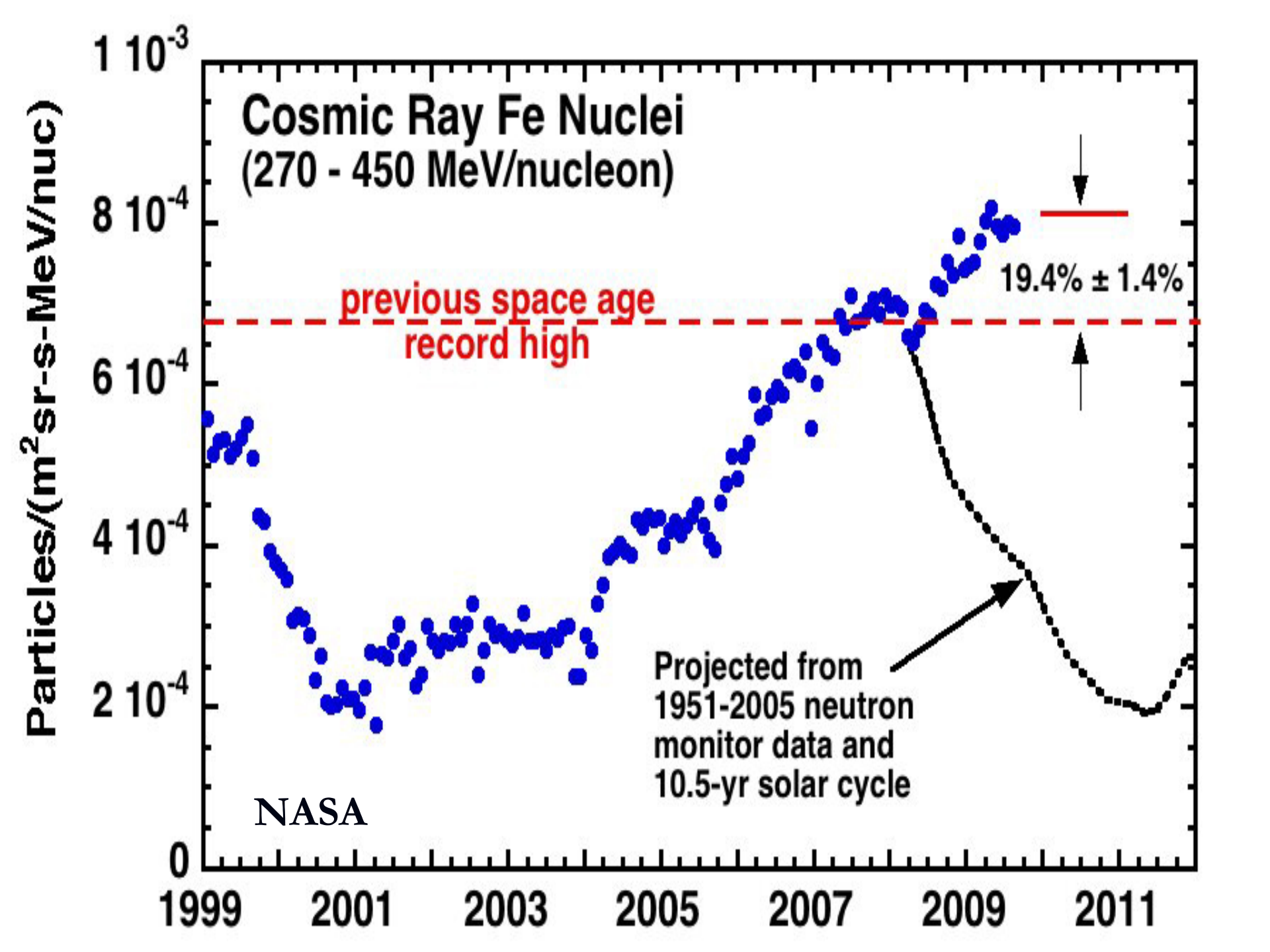
Warming in upper levels in mid-latitudes is outside the "auroral ring" suggesting geomagnetic storms of 1/17-21 may have contributed

An inverse relationship

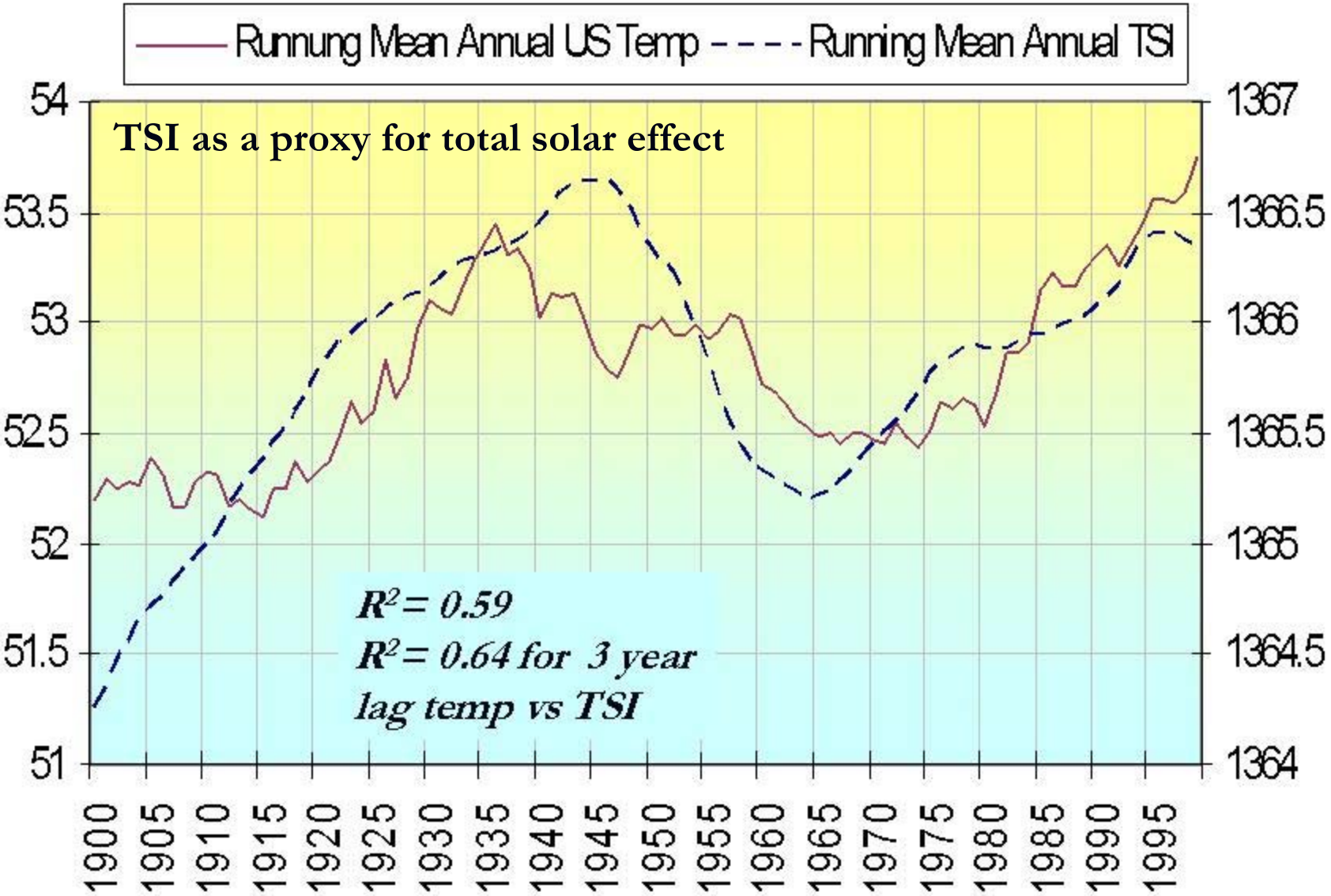
Cosmic Rays and the Solar Cycle

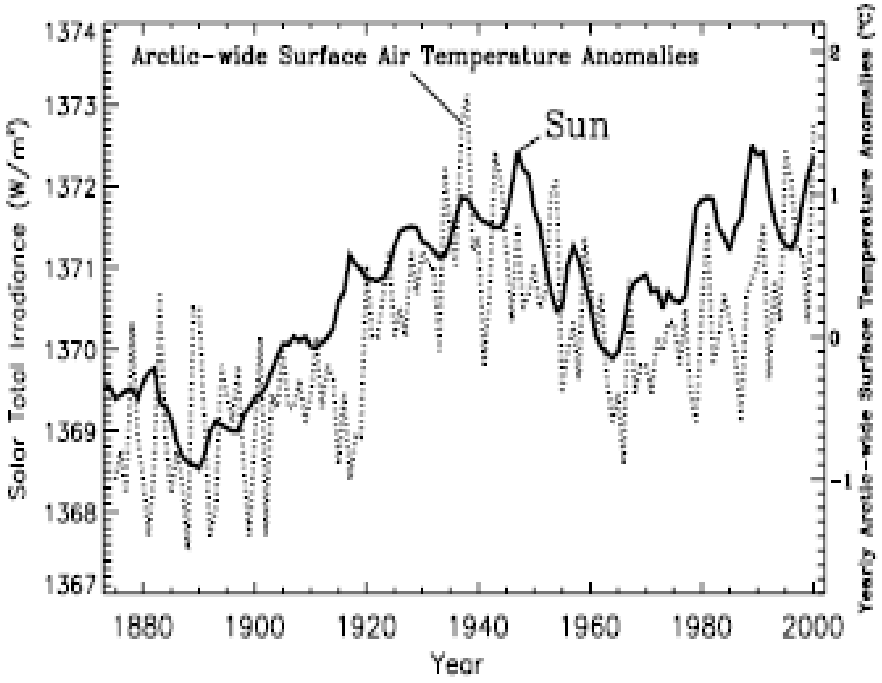


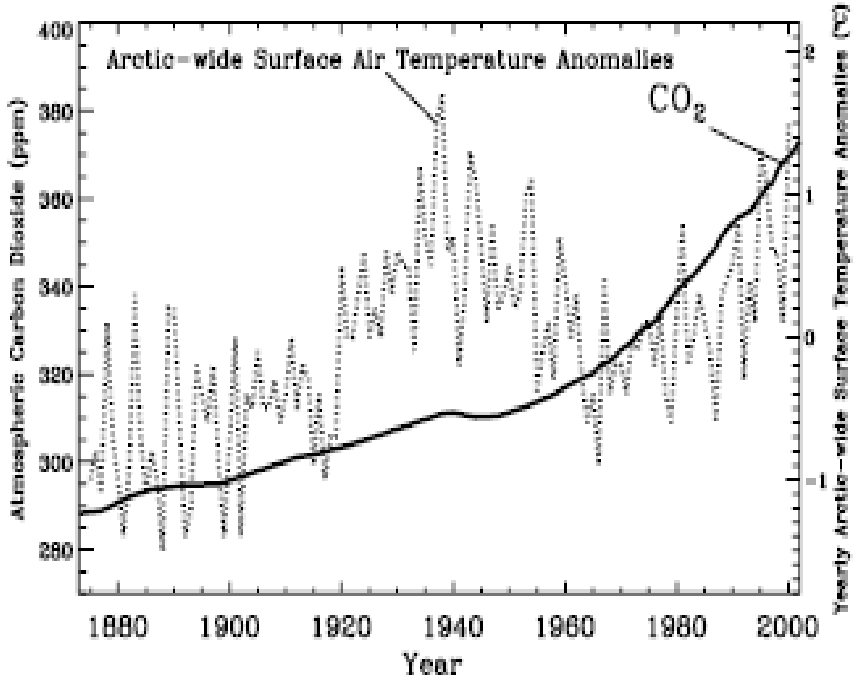
Bago and Butler


Cosmic Ray Fe Nuclei
(270 - 450 MeV/nucleon)
Particles/(m²sr-s-MeV/nuc)
1 10⁻³
8 10⁻⁴
6 10⁻⁴
4 10⁻⁴
2 10⁻⁴
0
1999
2001
2003
2005
2007
2009
2011
previous space age
record high
19.4% ± 1.4%
Projected from
1951-2005 neutron
monitor data and
10.5-yr solar cycle
NASA

NCDC Annual Mean US Temperature vs Hoyt Schatten TSI



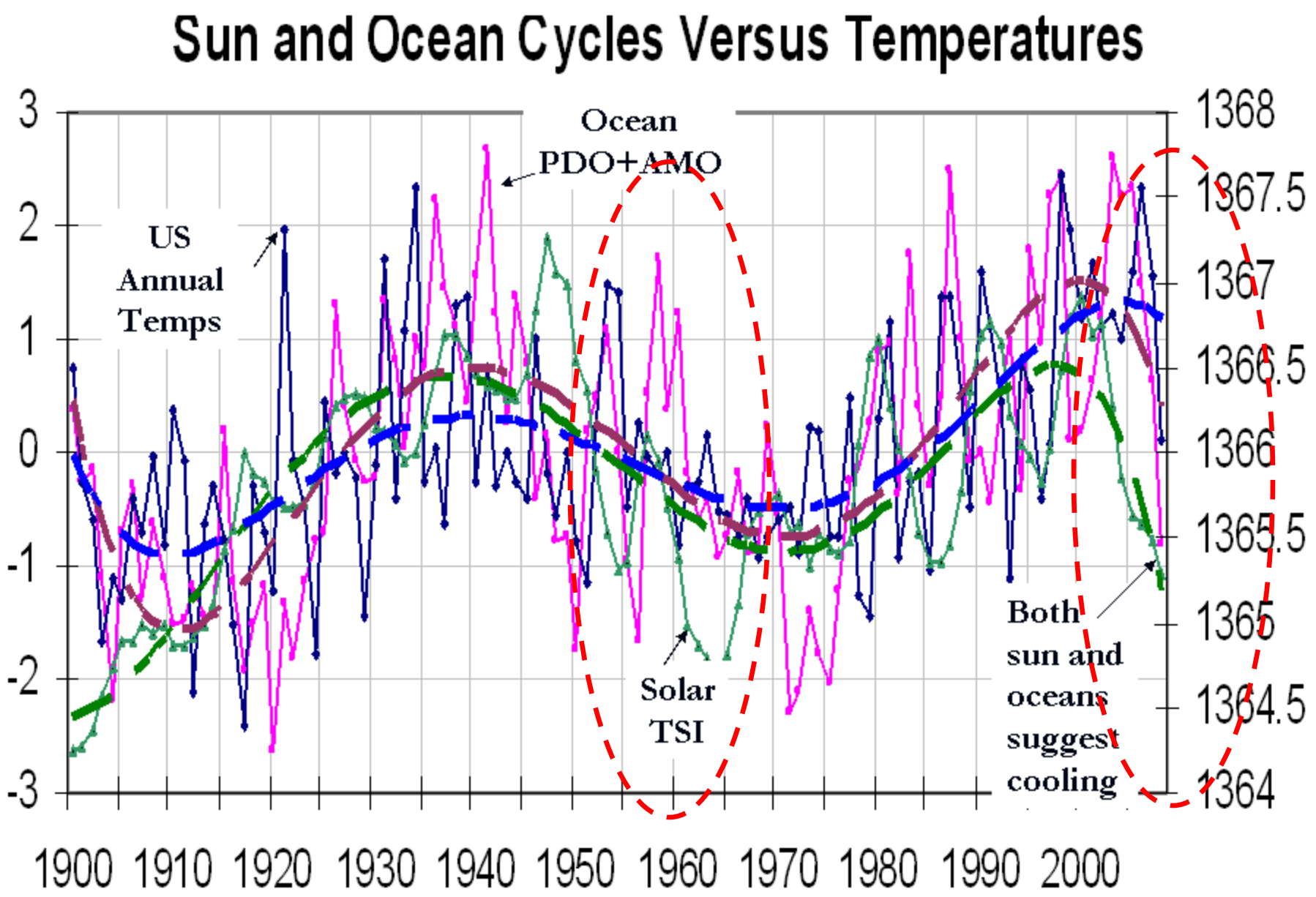




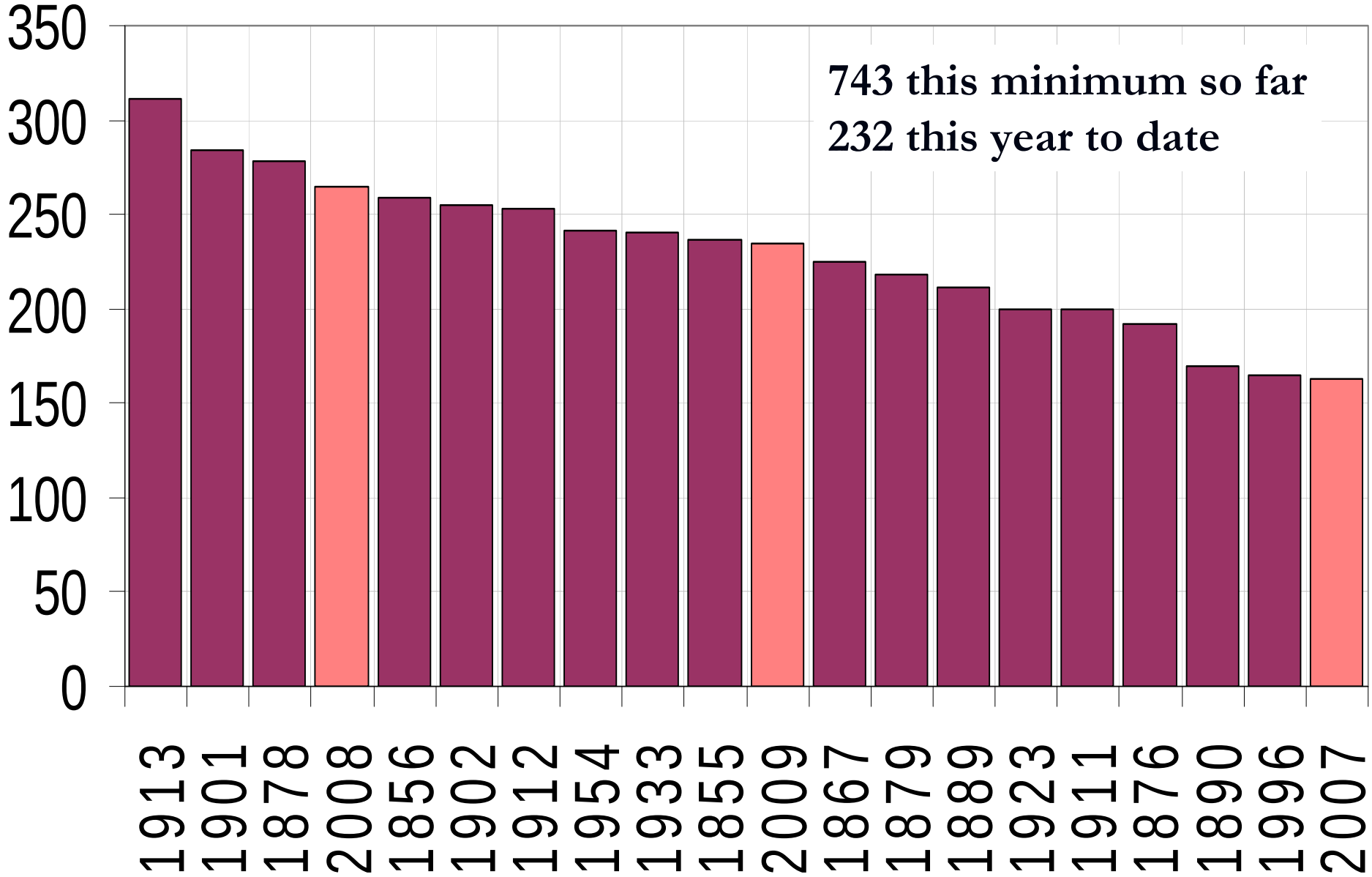
Arctic Annual Mean Temperatures vs Solar Irradiance

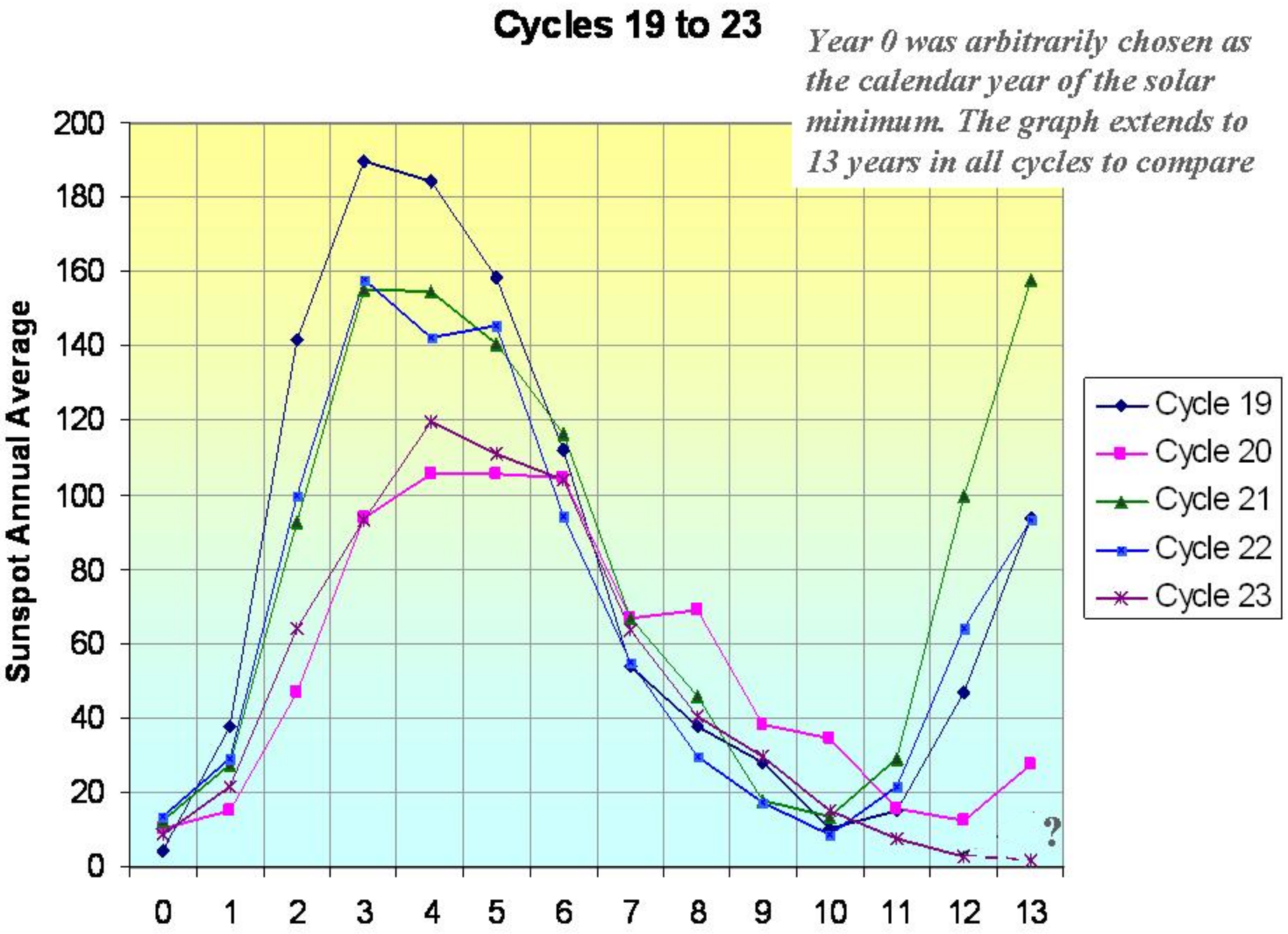
(Soon GRL 2005)

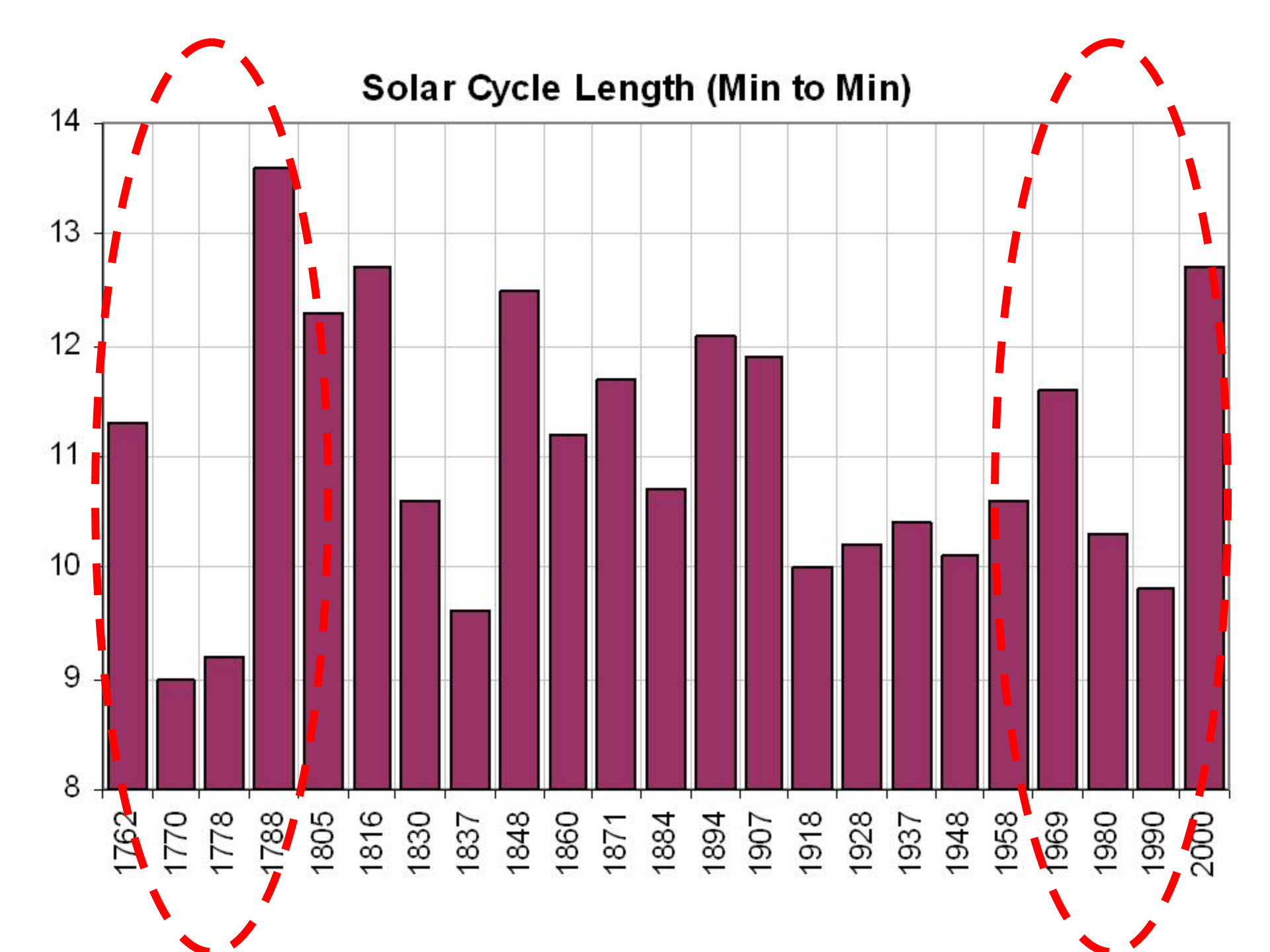
Fit is much better of solar irradiance with arctic temperatures (Polyakov) (79%) than with Greenhouse gases (22%)

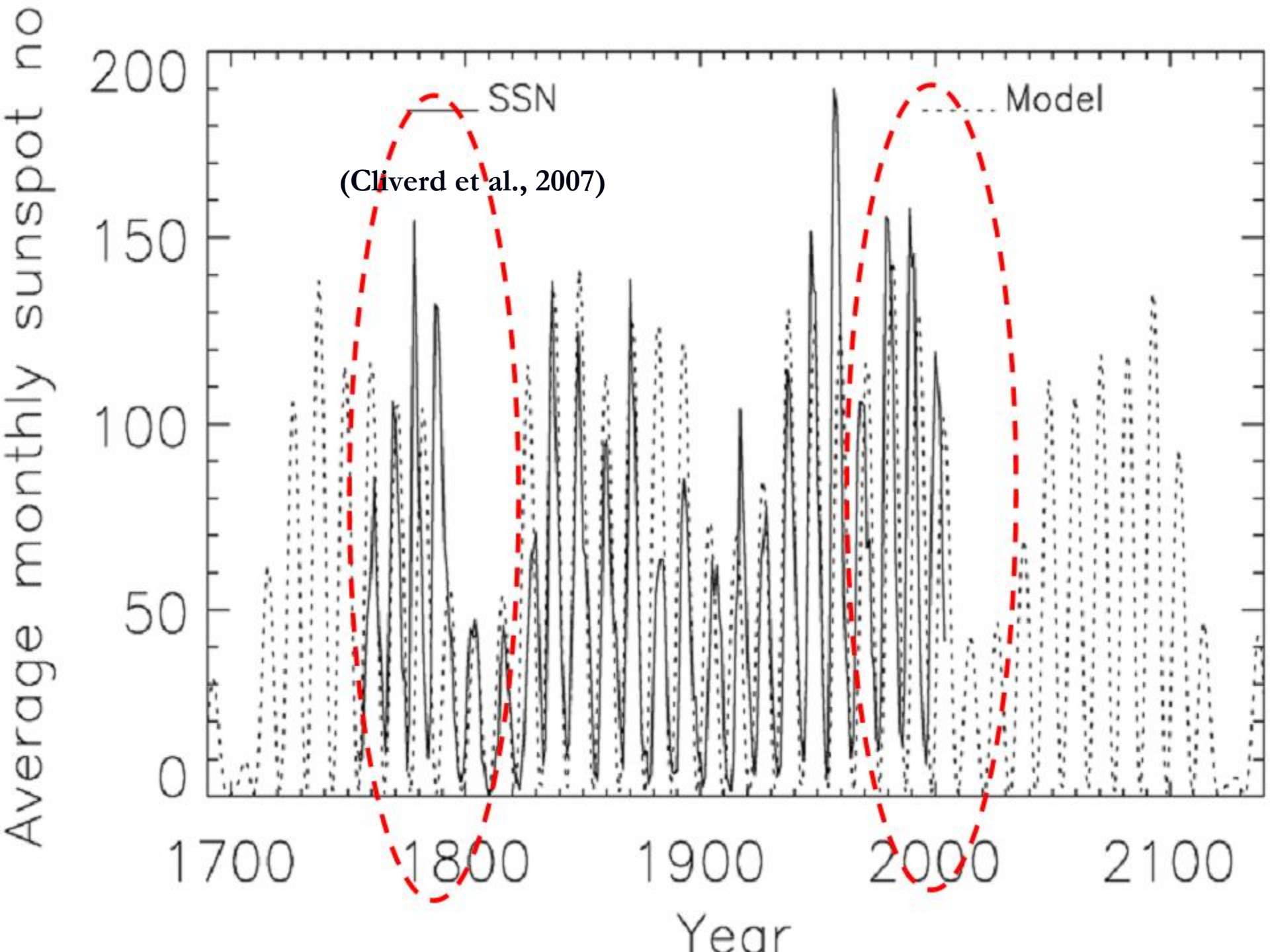

Sun and Ocean Cycles Versus Temperatures
Ocean
PDO+AMO
US
Annual
Temps
Solar
TSI
Both
sun and
oceans
suggest
cooling
3
2
1
0
-1
-2
-3
1368
1367.5
1367
1366.5
1366
1365.5
1365
1364.5
1364
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000

Top Sunspotless Day Years 1849-2009

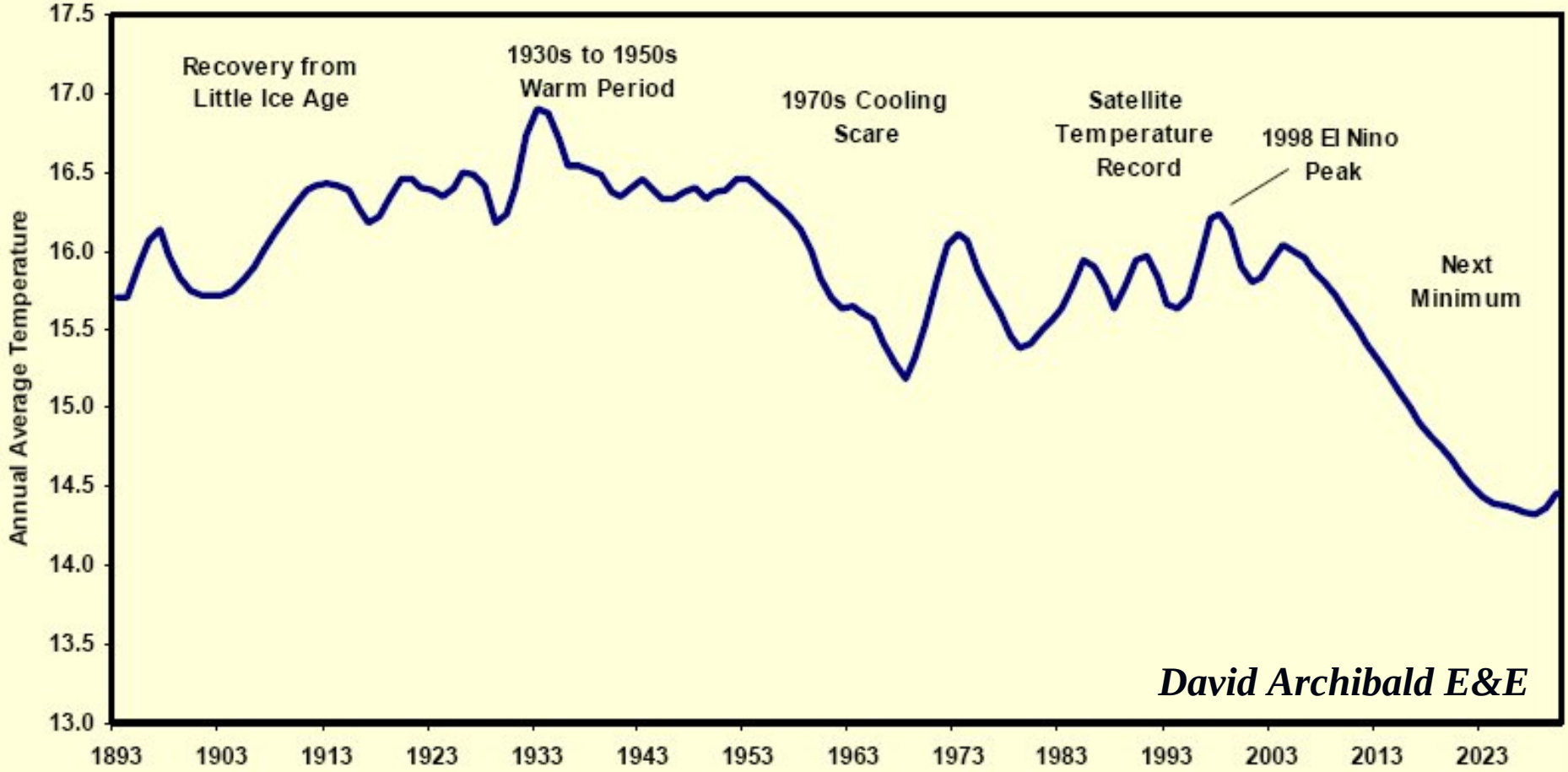



Cycles 19 to 23
Year 0 was arbitrarily chosen as the calendar year of the solar minimum. The graph extends to 13 years in all cycles to compare
Sunspot Annual Average
200
180
160
140
120
100
80
60
40
20
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13
?
Cycle 19
Cycle 20
Cycle 21
Cycle 22
Cycle 23


Solar Cycle Length (Min to Min)
14
13
12
11
10
9
8
1762
1770
1778
1788
1805
1816
1830
1837
1848
1860
1871
1884
1894
1907
1918
1928
1937
1948
1958
1969
1980
1990
2000


SSN
Model
(Cliverd et al., 2007)
Average monthly sunspot no
200
150
100
50
0
1700
1800
1900
2000
2100
Year

Projected Temperature Profile to 2030



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