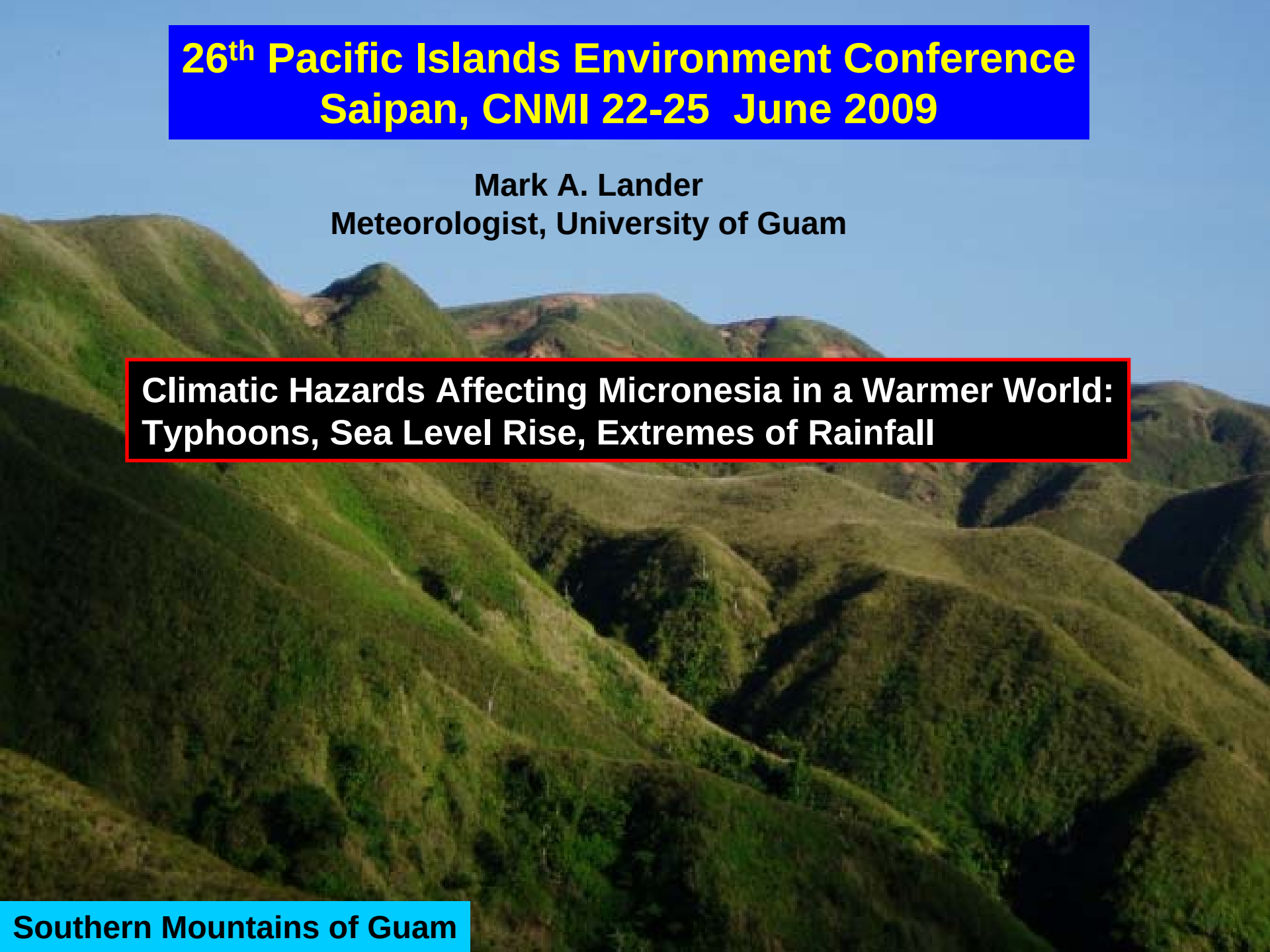
26th Pacific Islands Environment Conference
Saipan, CNMI 22-25 June 2009

Mark A. Lander
Meteorologist, University of Guam

Climatic Hazards Affecting Micronesia in a Warmer World: Typhoons, Sea Level Rise, Extremes of Rainfall



Southern Mountains of Guam

Pacific Climatic and Geologic History

UOG Environmental Science
Class EV547

Taught by Dr. Mark Lander (Meteorologist)
Dr. John Jenson (Hydrogeologist)

Pacific Climatic and Geologic History

What is current state of earth's climate?

Interglacial period in a long sequence of major ice advances (ice ages) and retreats (interglacial)

26th Pacific Islands Environment Conference
Saipan, CNMI (22-25 June 2009)

The Climate of the tropical Pacific Islands in a Warmer World:

(1) Sea Level Rise

(2) Droughts?

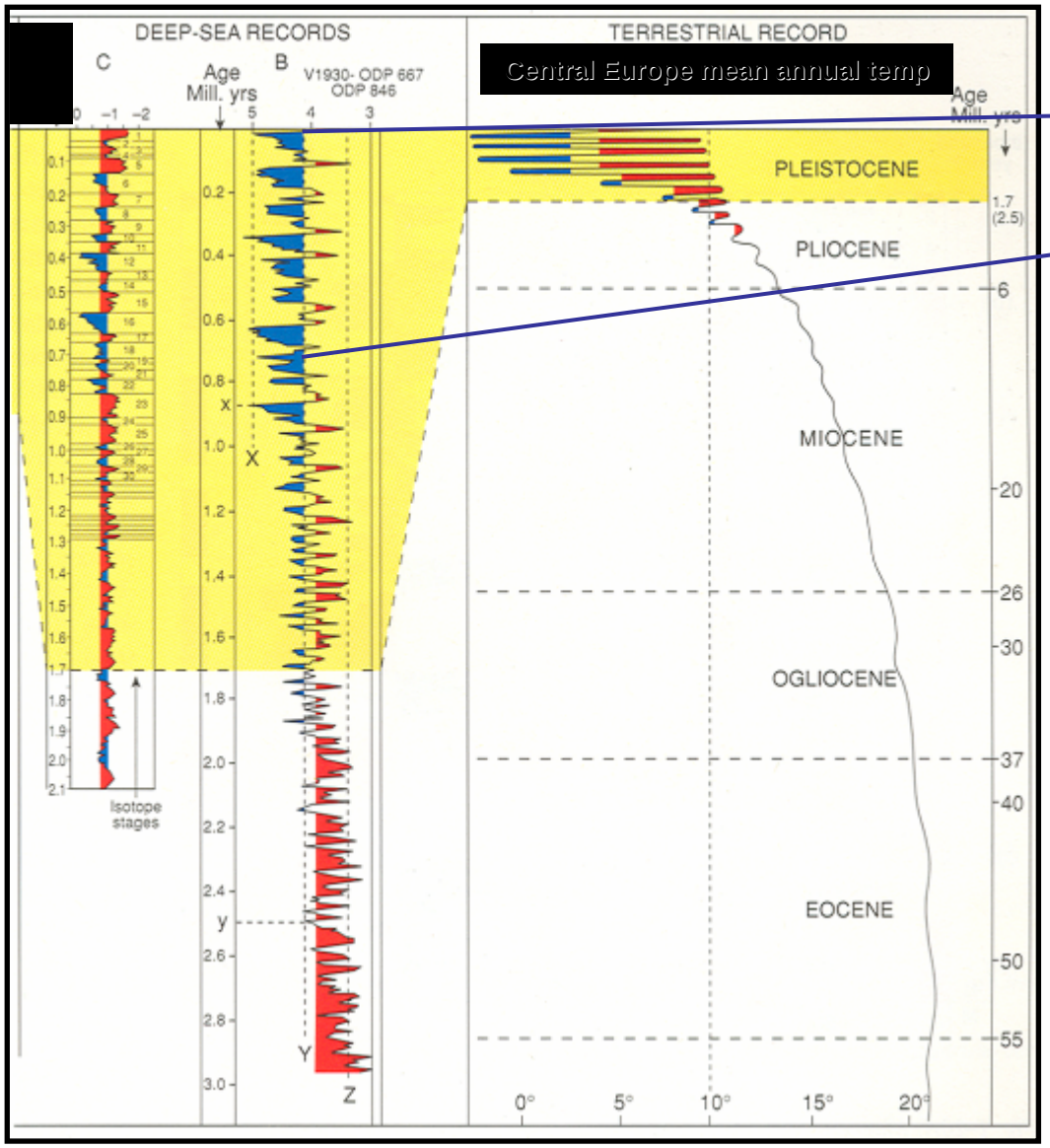
(3) Enhanced short-term rainfall?

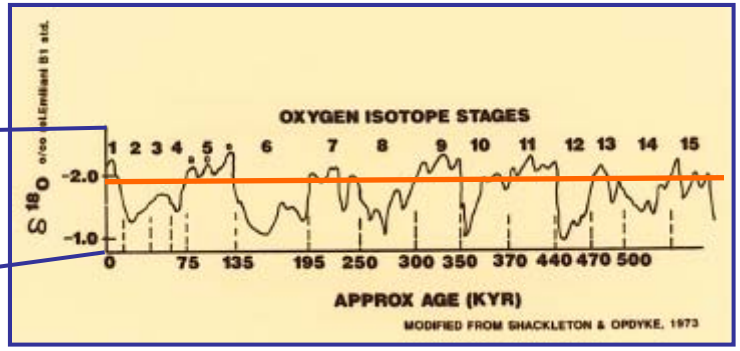
(4) More Typhoons?

(5) Top-end Typhoons more intense?

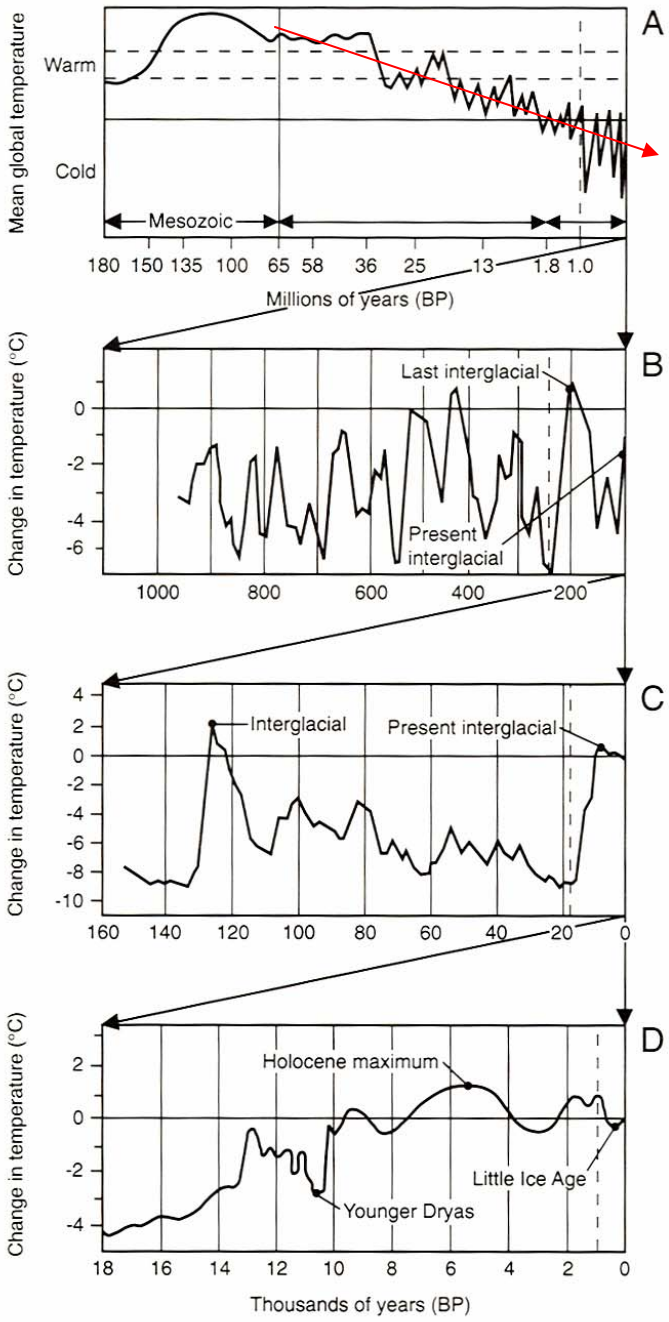
Global Sea-Level History

Past 2 Ma





- For 60% of past 750 ka, sea level has been 50-100 m below present sea level
  - > 25 m for 93% time
  - > 40 m for 83% time
  - > 85 m for 68% time
- For past 125 ka
  - > 25 m, 115 to 11-12 ka
  - > 40 m, 75-80 to 12-13 ka



Global Temperature

Last 180 Million Years

Note Global trend for past 100 million years is down !

Last 1 Million Years

Note mostly ice ages with brief interglacials

Last 160 Thousand Years

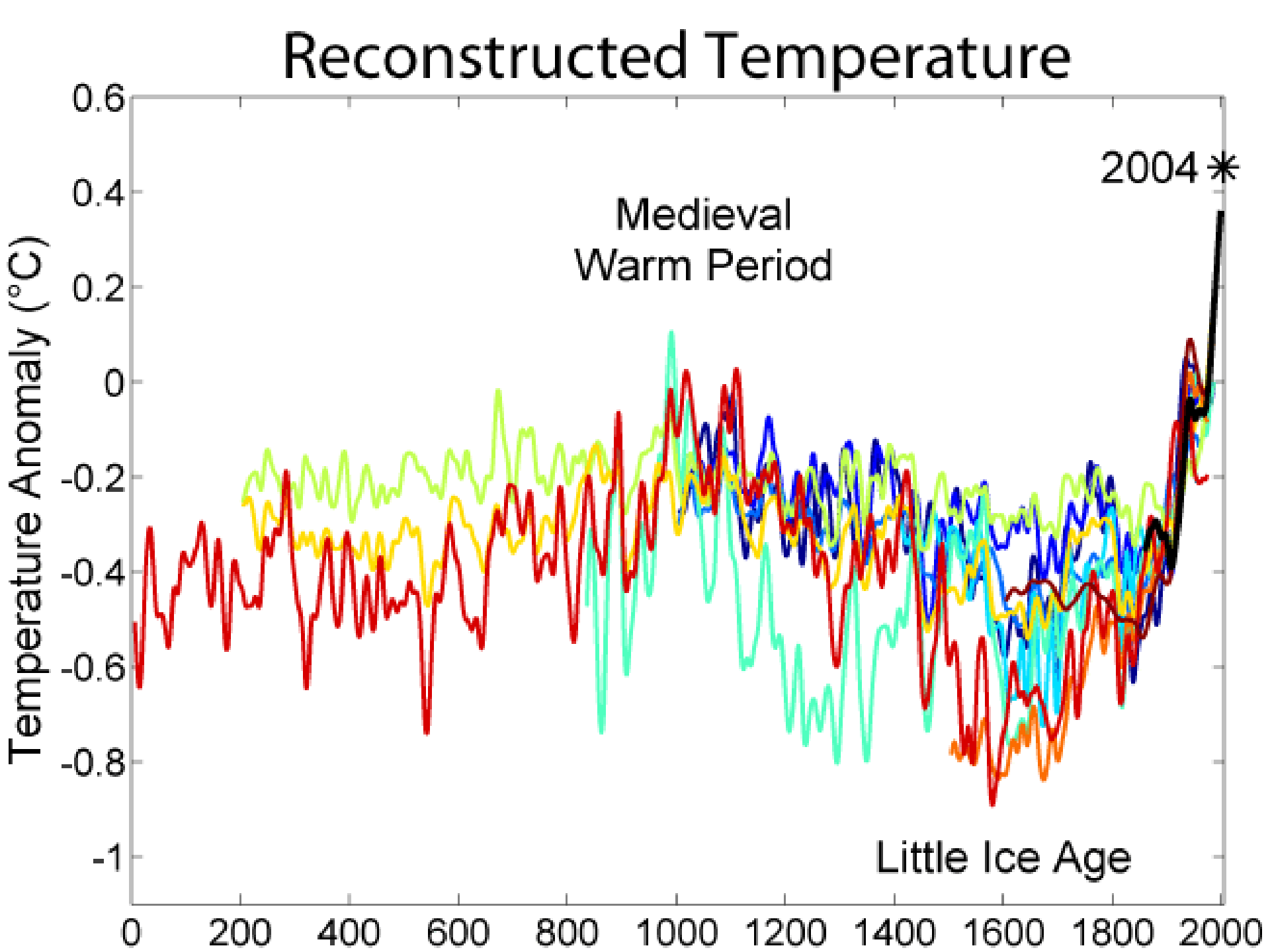
Note last interglacial 130 thousand years ago

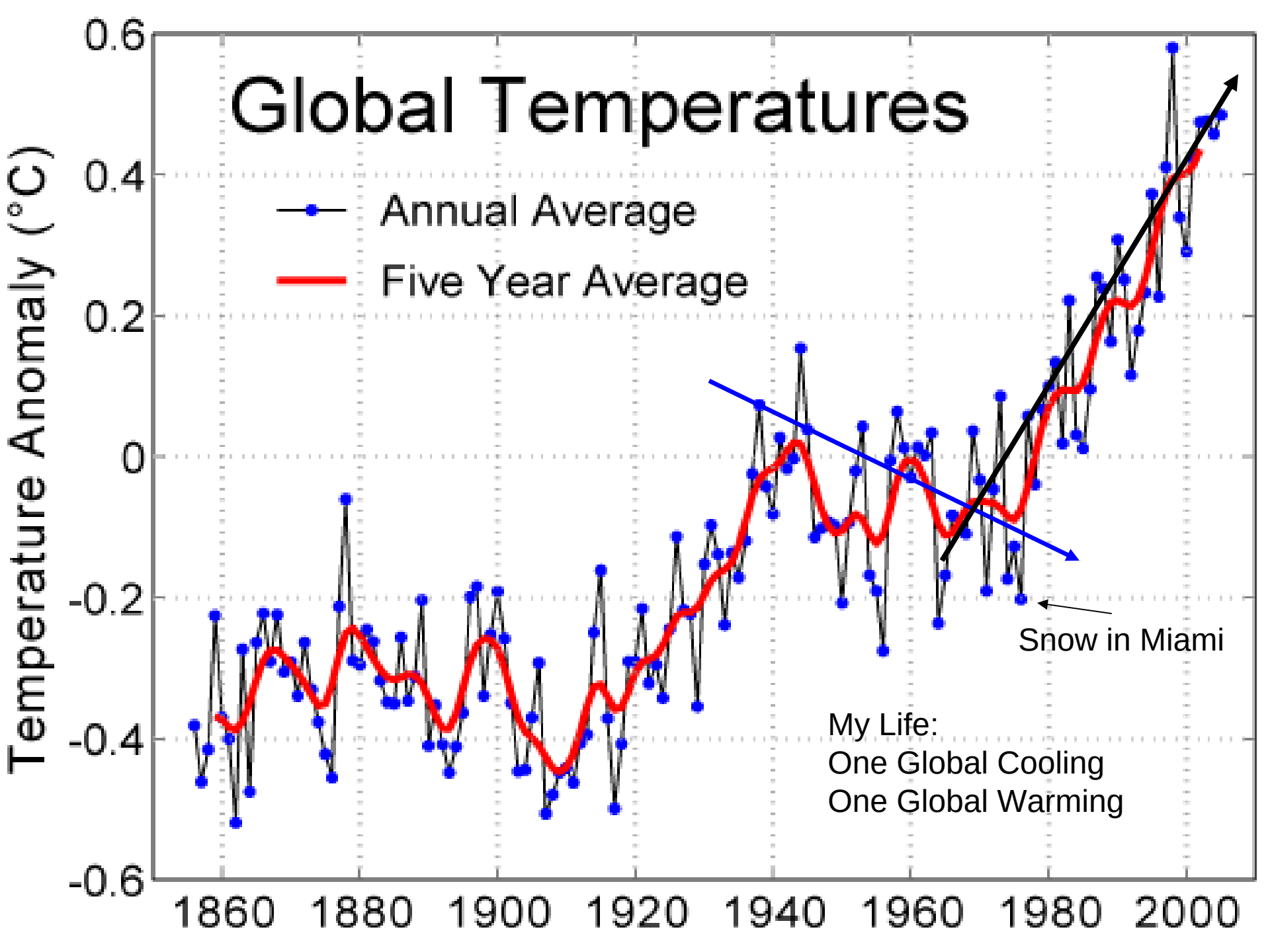
Last ice age peak 20 thousand years ago !

Last 18 Thousand Years

Medieval Warm Period

Little Ice Age


Reconstructed Temperature
Temperature Anomaly (°C)
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2004
Medieval
Warm Period
Little Ice Age


Global Temperatures
Annual Average
Five Year Average
Temperature Anomaly (°C)
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
1860
1880
1900
1920
1940
1960
1980
2000
Snow in Miami
My Life:
One Global Cooling
One Global Warming

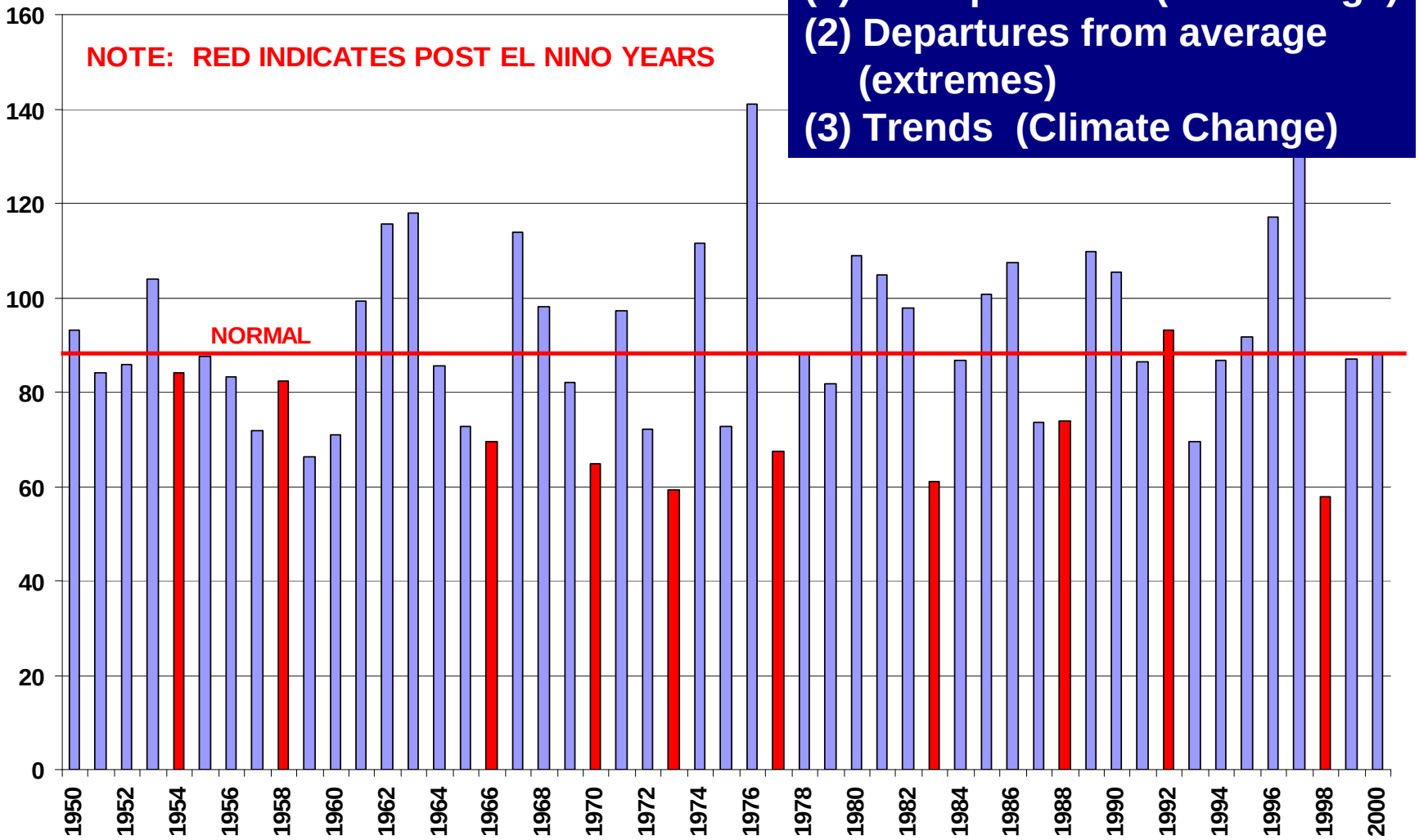
Climate and Weather

Climate is what you expect,
weather is what you get.

Banana Guy, 1998.

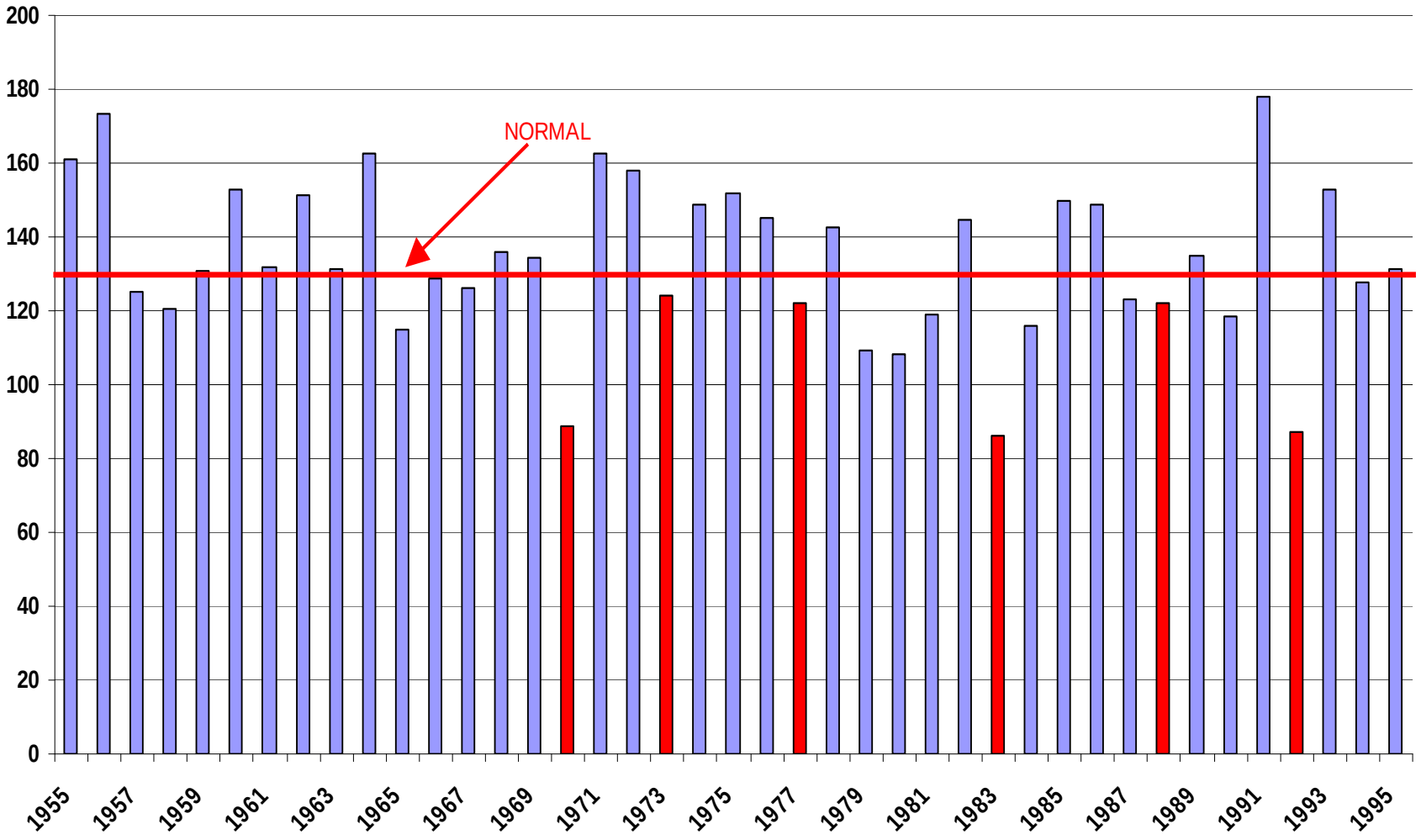
GUAM ANNUA

Tabulation of weather data yields:
(1) An expectation (the average)
(2) Departures from average (extremes)
(3) Trends (Climate Change)



NOTE: POST-EL NINO YEARS IN RED

MAJURO ANNUAL RAIN



NOTE: POST-EL NINO YEARS IN RED

Sea Level Rise

Most Certain of all Climatic Hazards

More Typhoons?
- **Climate Models say No!**

More Intense Typhoons?
- **Kerry Emanuel says Yes! (Small Increase in MPI)**

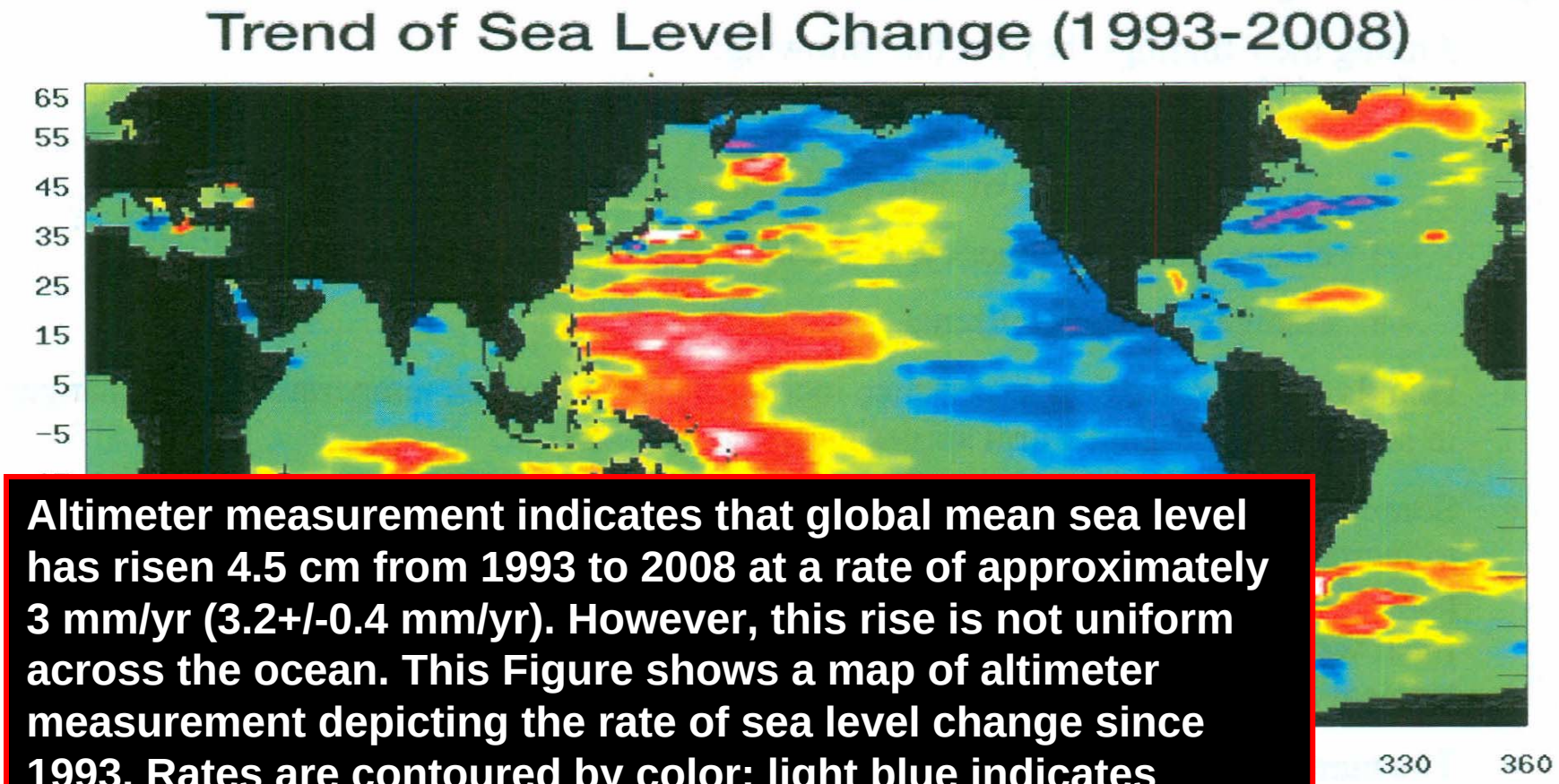
More Floods?
- **Jury is out**

More Drought?
- **Micronesia drier during the medieval warm period?**
- **The Big Nothing (past three years)**

Sea level components

global and local

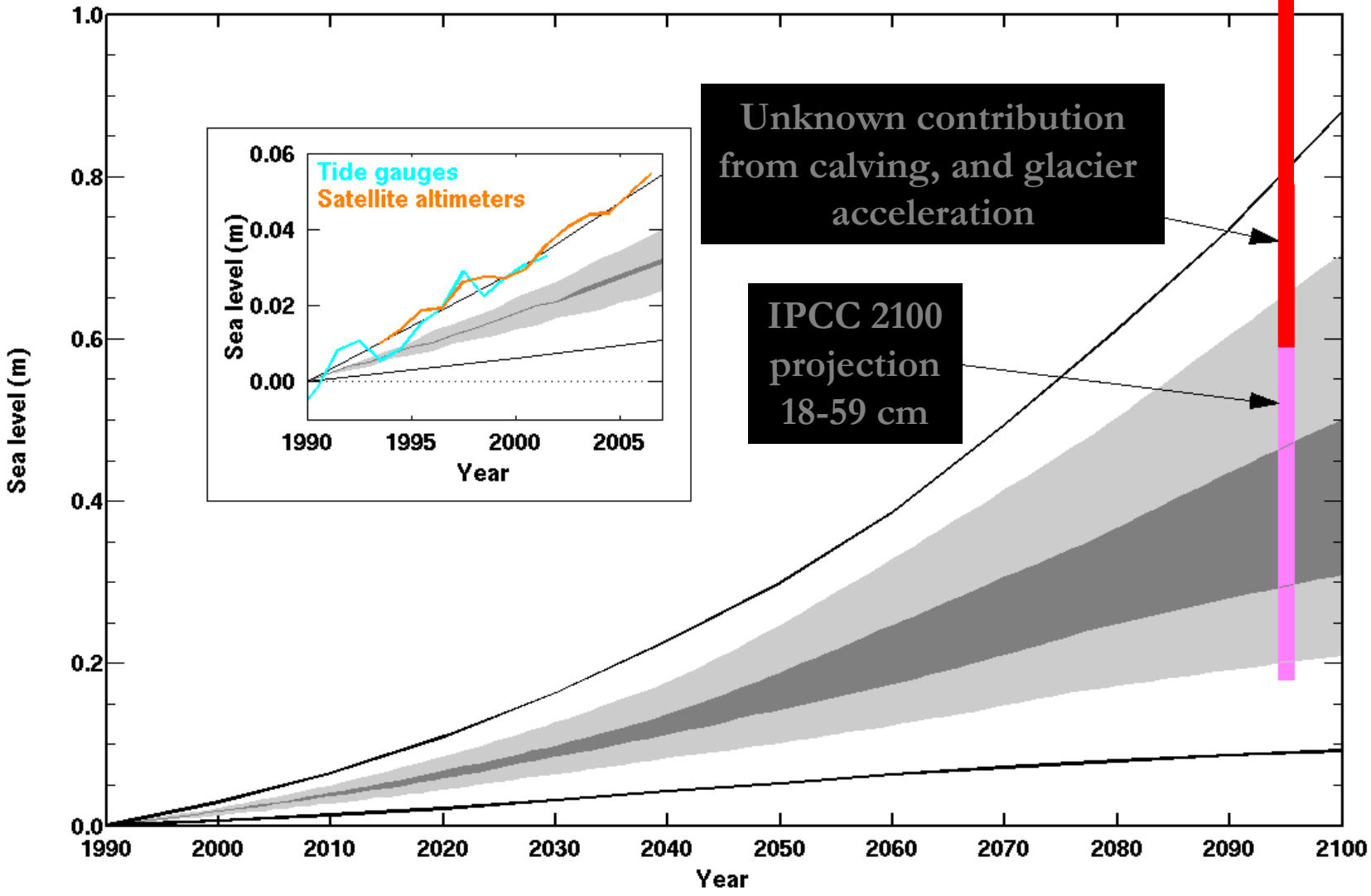
- **Glacio-eustatic component**
  - **Global water volume change due to glacial growth & decay**
  - **Regional gravitational effects: mantle anomalies, continental mass and ice sheet mass**
    - **Time scale: 100 ka to 1 ka**
- **Hydro-isostatic component**
  - **Global ocean basin volume change due to isostatic adjustment of ocean floor and/or continental subsidence or rebound in response to change in load**
    - **Time scale: 100 ka to 1 ka**
- **Tectonic components**
  - **Global: Change in ocean basin volume due to tectonic process, e.g., sea-floor spreading, crustal flexture, continental rifting, collision, uplift and subsidence, etc.**
    - **Time scale: 10 ma to 100 ka**
  - **Local: uplift and subsidence**
    - **Millions of years to instantaneous**
- **Climatic components**
  - **Regional in effect: ENSO, regional wind patterns, storms**
    - **Years and months to days and hours**

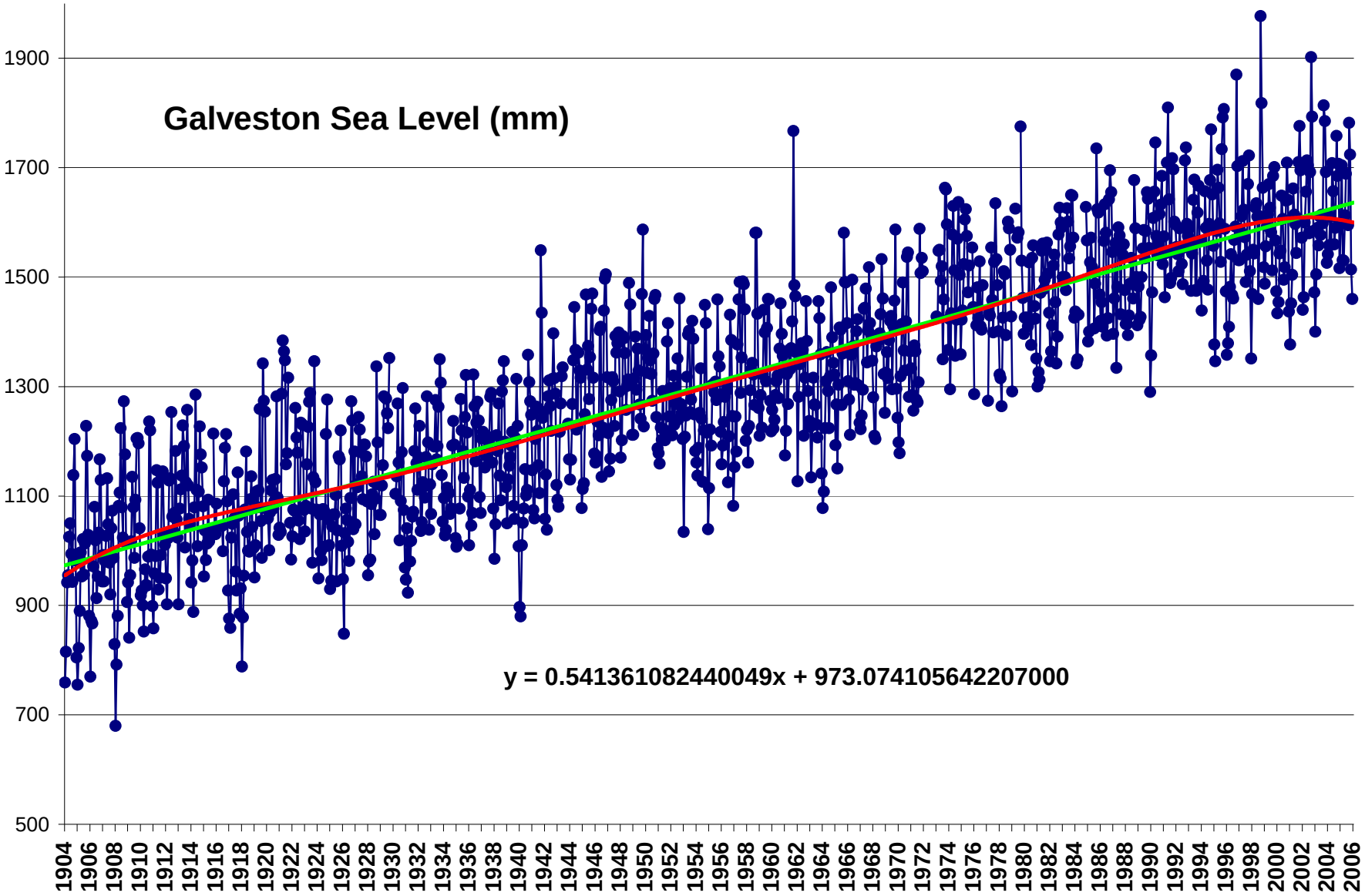


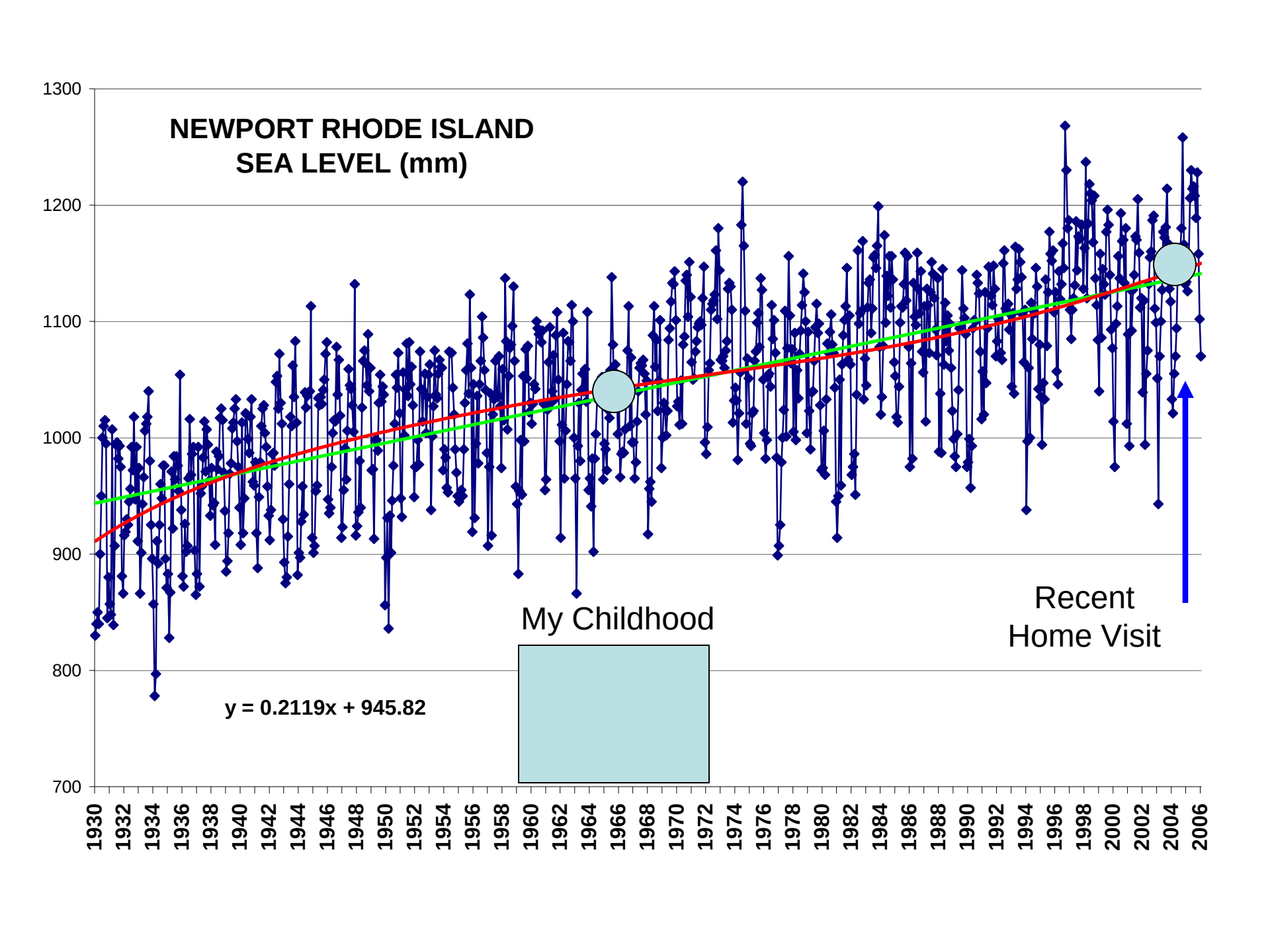
Altimeter measurement indicates that global mean sea level has risen 4.5 cm from 1993 to 2008 at a rate of approximately 3 mm/yr (3.2+/-0.4 mm/yr). However, this rise is not uniform across the ocean. This Figure shows a map of altimeter measurement depicting the rate of sea level change since 1993. Rates are contoured by color: light blue indicates regions where sea level has been relatively stable; green, yellow and red show areas of sea-level rise; blue and purple indicates areas of sea-level fall.

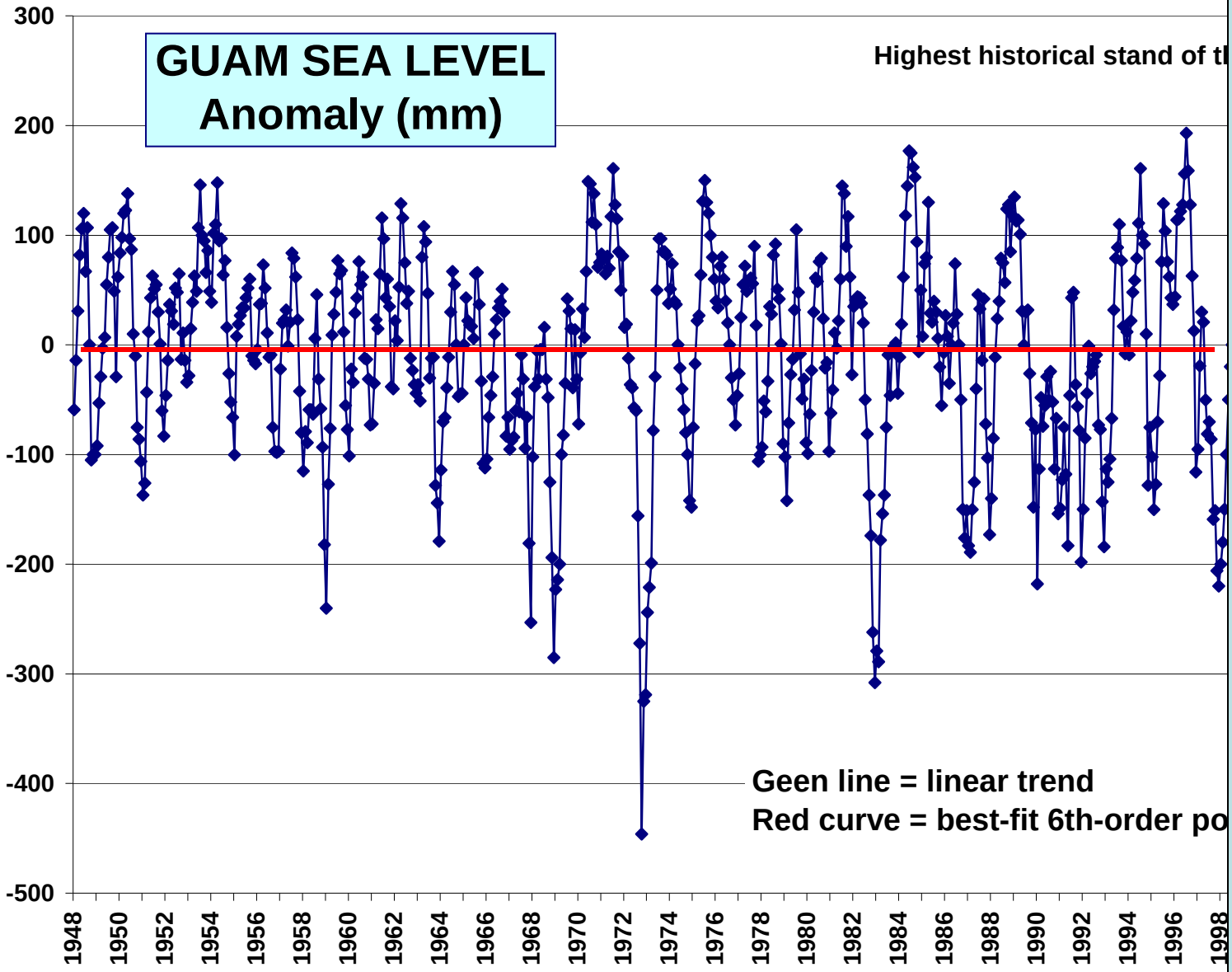
Figure 8. This image, created with sea surface height data from the Topex/Poseidon and Jason-1 satellites, shows exactly where sea level has changed 1993-2008 and how quickly these changes have occurred. The complex surface reflects the influence of warm and cool bodies of water, currents, and winds. (*Source: NASA*[65])

IPCC Sea-level Projection



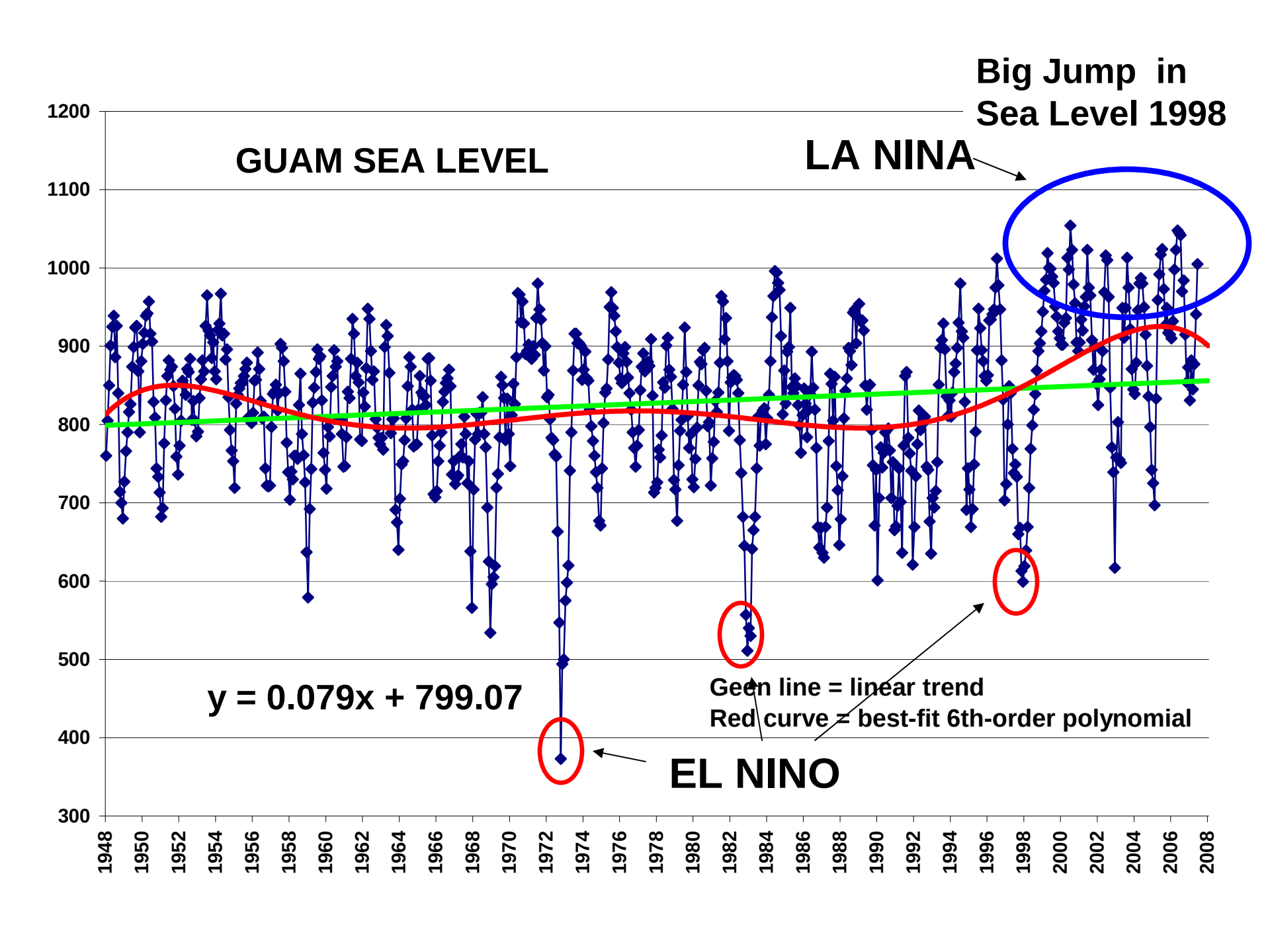

Galveston Sea Level (mm)
y = 0.541361082440049x + 973.074105642207000
1900
1700
1500
1300
1100
900
700
500
1904
1906
1908
1910
1912
1914
1916
1918
1920
1922
1924
1926
1928
1930
1932
1934
1936
1938
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006


NEWPORT RHODE ISLAND
SEA LEVEL (mm)
1300
1200
1100
1000
900
800
700
1930
1932
1934
1936
1938
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
My Childhood
Recent
Home Visit
y = 0.2119x + 945.82

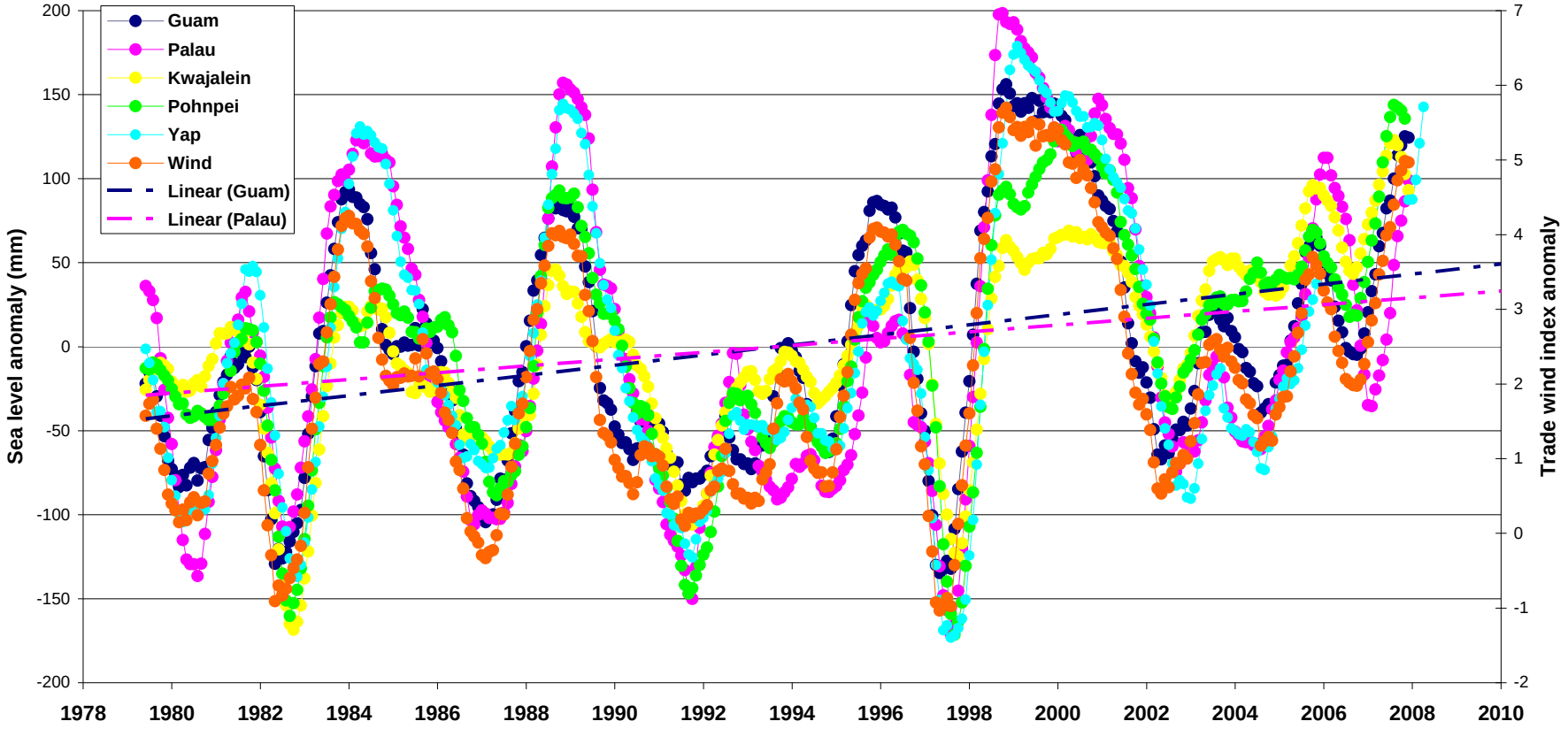


IPCC Report No Trend Throughout Micronesia from 1948 to 1997.

Then …….


Big Jump in
Sea Level 1998
GUAM SEA LEVEL
LA NINA
y = 0.079x + 799.07
Geen line = linear trend
Red curve = best-fit 6th-order polynomial
EL NINO
1200
1100
1000
900
800
700
600
500
400
300
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008

Pacific Island Sea Level 1978-2008



Recent Alarming Sea Level Rise in Micronesia:

1990s dominated by El Niño

Lowers Micronesia Sea Level

2000s dominated by La Niña

Raises Micronesia Sea Level

Change between El Niño and La Niña largest coherent climate signal in the Pacific.

Note: ENSO = El Niño/Southern Oscillation

Hard to pick out effects of long-term Climate change with ENSO going on !!

And ENSO itself may be affected by Climate c

Good News
Sea Level is now Falling
3 inches lower since January 2009 !!!

June 2009: El Niño Watch (CPC)

Relevant climate statistics (Dickinson, 2009):

20th Century sea level rise:
Persistent 1.7 – 1.9 mm/yr

Rise of the sea from 1908 to 1999 = 180 mm

Sea level rise 2.5 mm/yr during 1990s

Sea level rise 4 mm/yr present decade !?

Future Sea Level Rise
Rapid rise (10 mm/yr) 1 meter in next 100 years
Slower rise, but still faster than today (5 mm/yr)

Micronesia in a warmer world

Good News!!

Only big worry is sea level.

Recent Very Rapid rise in Micronesia an artifact of ENSO.

Typhoons and rainfall may not change much. (Confidence Low)

Bad News:

Sea Level Rise on Fast Pace.