Where we are and Where we are going

The four stages of climate change denial

- It’s not happening

- It’s not happening
- **YES IT IS !**

- It’s not happening
- **YES IT IS !**
- **It’s not us**

- It’s not happening
- **YES IT IS !**
- **It’s not us**
- **YES IT IS !**

- It’s not happening
- **YES IT IS !**
- **It’s not us**
- **YES IT IS !**
- **It’ll be good for us**

- It’s not happening
- **YES IT IS !**
- **It’s not us**
- **YES IT IS !**
- **It’ll be good for us**
- **NO IT WON’T !**

- It’s not happening
- **YES IT IS !**
- **It’s not us**
- **YES IT IS !**
- **It’ll be good for us**
- **NO IT WON’T !**
- **There isn’t anything we can do about it**

- It’s not happening
- **YES IT IS !**
- **It’s not us**
- **YES IT IS !**
- **It’ll be good for us**
- **NO IT WON’T !**
- **There isn’t anything we can do about it**
- **YES THERE IS ! (Feb 23rd)**

- It’s not happening
- **YES IT IS !**
- **It’s not us**
- **YES IT IS !**
- **It’ll be good for us**
- **NO IT WON’T !**
- **There isn’t anything we can do about it**
- **YES THERE IS ! (Feb 23rd)**
- **… BUT IT WON’T BE EASY…**

Climate Science
February 16

- Review of Last Week's Material
- Physical Signs of a Warming World
- Ocean Acidification: The other evil twin to global warming
- Human and Ecological Impacts
- Societal, Economic Impacts; interactions with other global issues (or Feb. 23rd)
- Charlee Smith graph discussion
- "Quiz" Answers and Review
- Responses to "top 8 myths" (or Feb. 23rd)
- Balog "trailer" (or Feb. 23rd)

Summary of Feb. 9 Material

- Weather: short term, semi-chaotic;
- El Nino-La Nina longer term “weather”
- Climate: Averages over time and regions
- Computer simulations do well at global temperature projections; so-so at precipitation and regional climate
- The earth is out of energy balance & most of the accumulated heat is going to the oceans

Feb. 9th summary: continued

- The carbon-cycle is also out of balance; fossil fuel burning dumps twice as much CO_2 into the atmosphere as oceans and biosphere absorb.
- Hemisphere & globally averaged temperatures are higher than any over at least the last 1000 years.
- Ice ages are triggered by wobbles in the Earth's motion and amplified by feedbacks

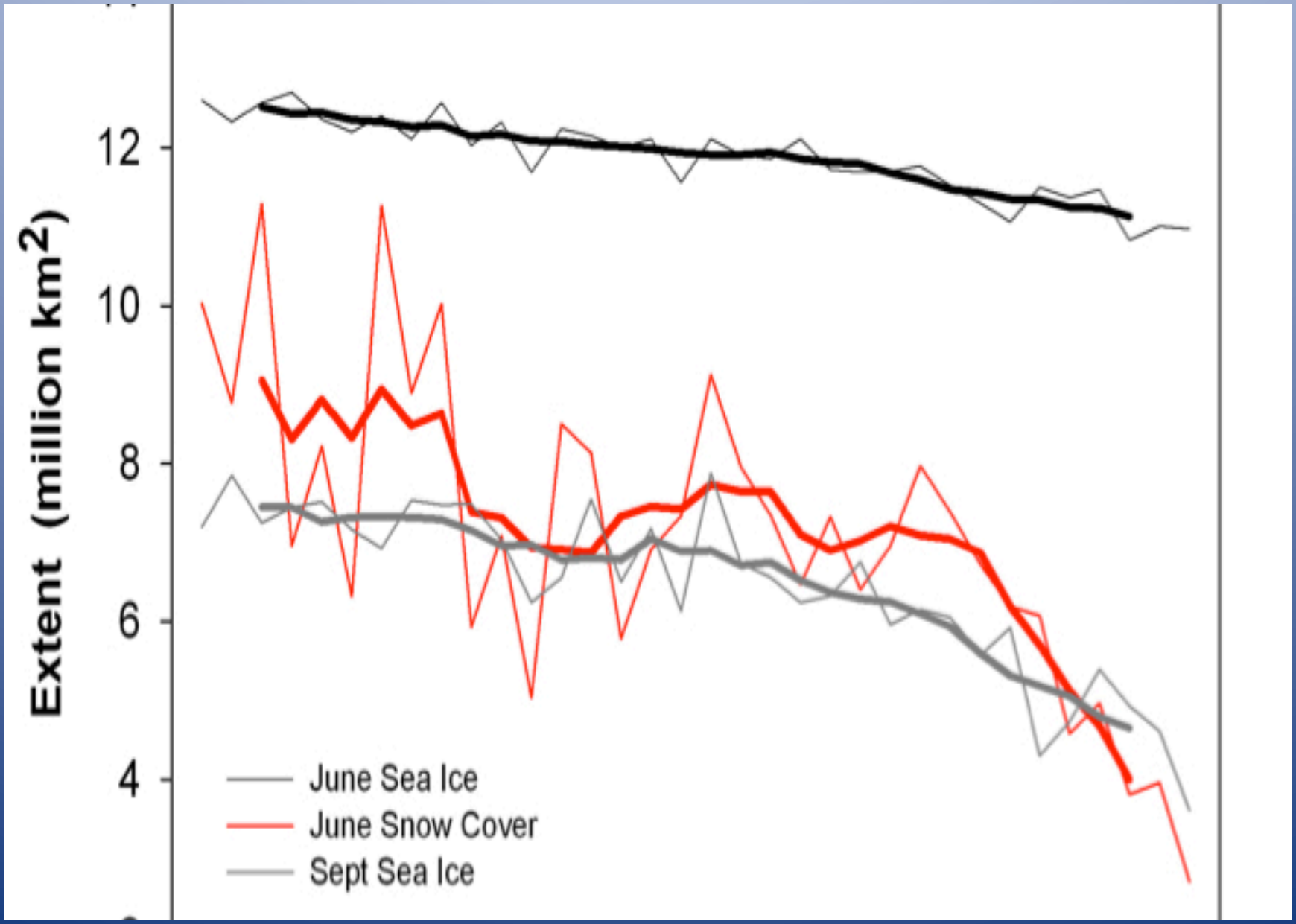
Feb. 9 summary: continued

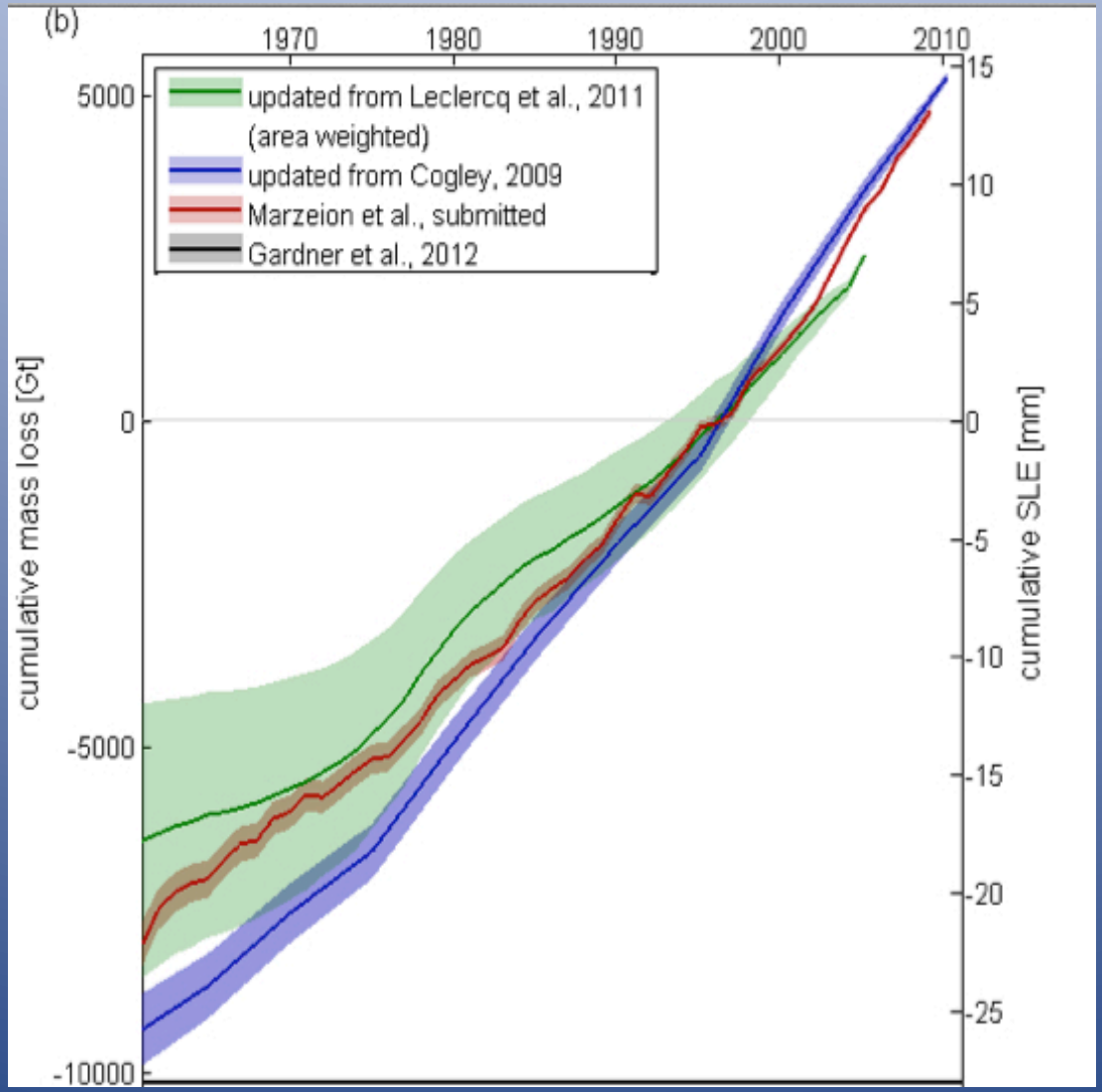
- On all time scales, CO_2 and global temperatures are tightly coupled
- The CO_2 level caused by the last decades of fossil fuel use is already higher than at any time in 800,000 years.
- By the end of this century, on any "business as usual" trajectory, CO_2 will be higher than at any time in at least 20 million years
- The CO_2 imbalance persists for centuries; we are locked into some further warming.

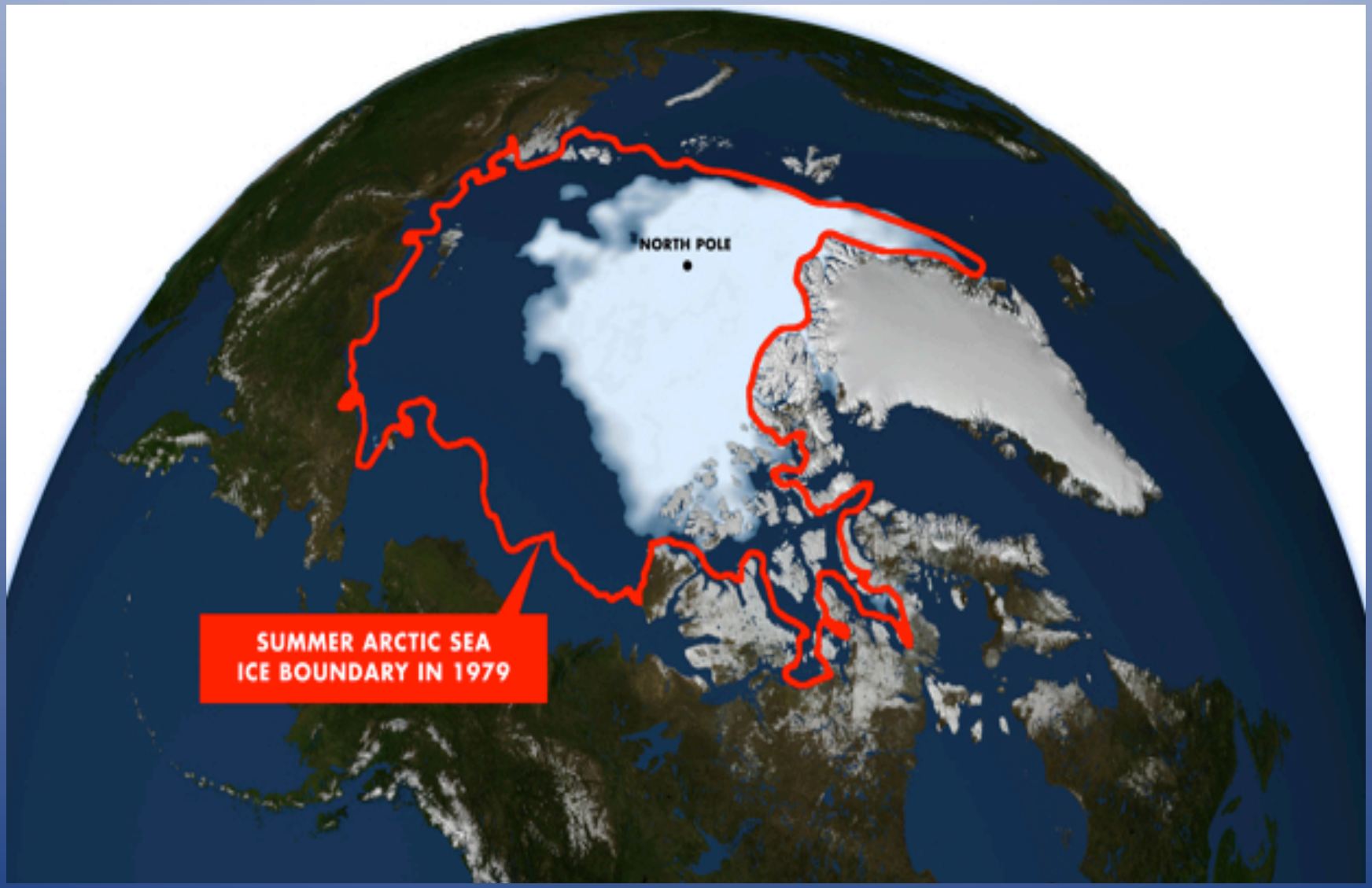
Segment 8:
Signs of A Warming World

Plants & little critters know it

42


Extent (million km2)
12
10
8
6
4
June Sea Ice
June Snow Cover
Sept Sea Ice

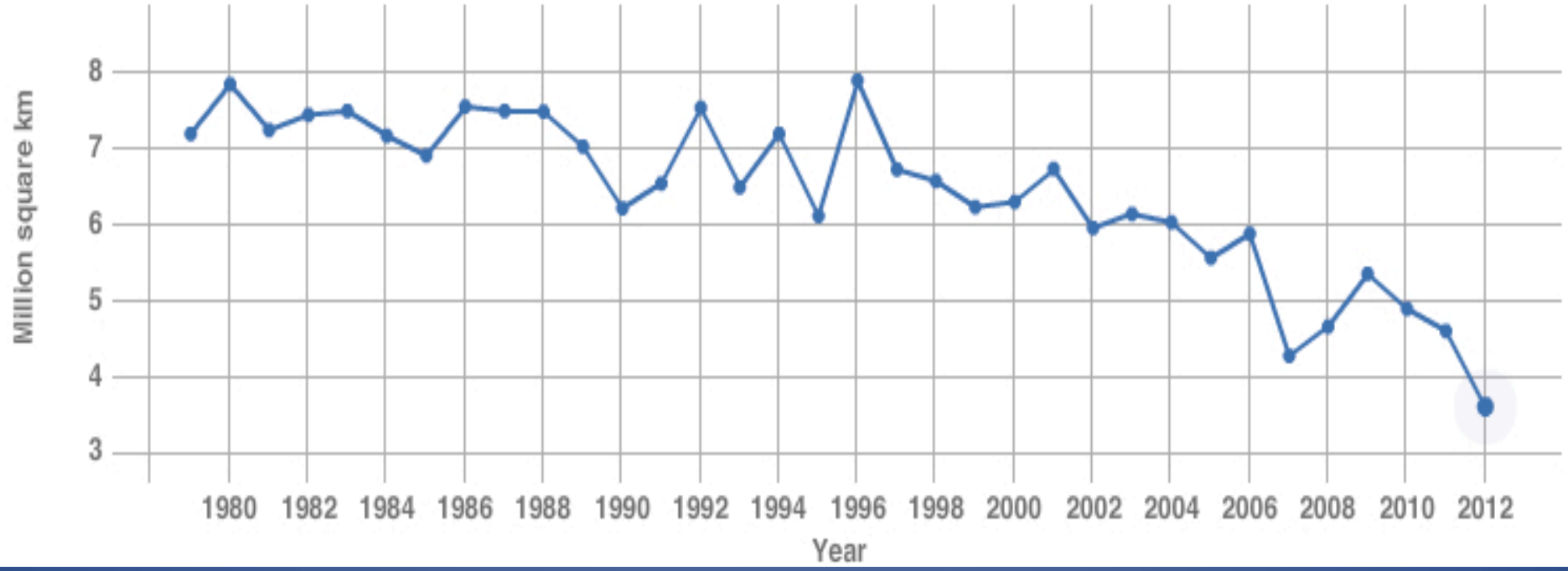

(b)
1970
1980
1990
2000
2010
5000
0
-5000
-10000
15
10
5
0
-5
-10
-15
-20
-25
updated from Leclercq et al., 2011
(area weighted)
updated from Cogley, 2009
Marzeion et al., submitted
Gardner et al., 2012
cumulative mass loss [Gt]
cumulative SLE [mm]

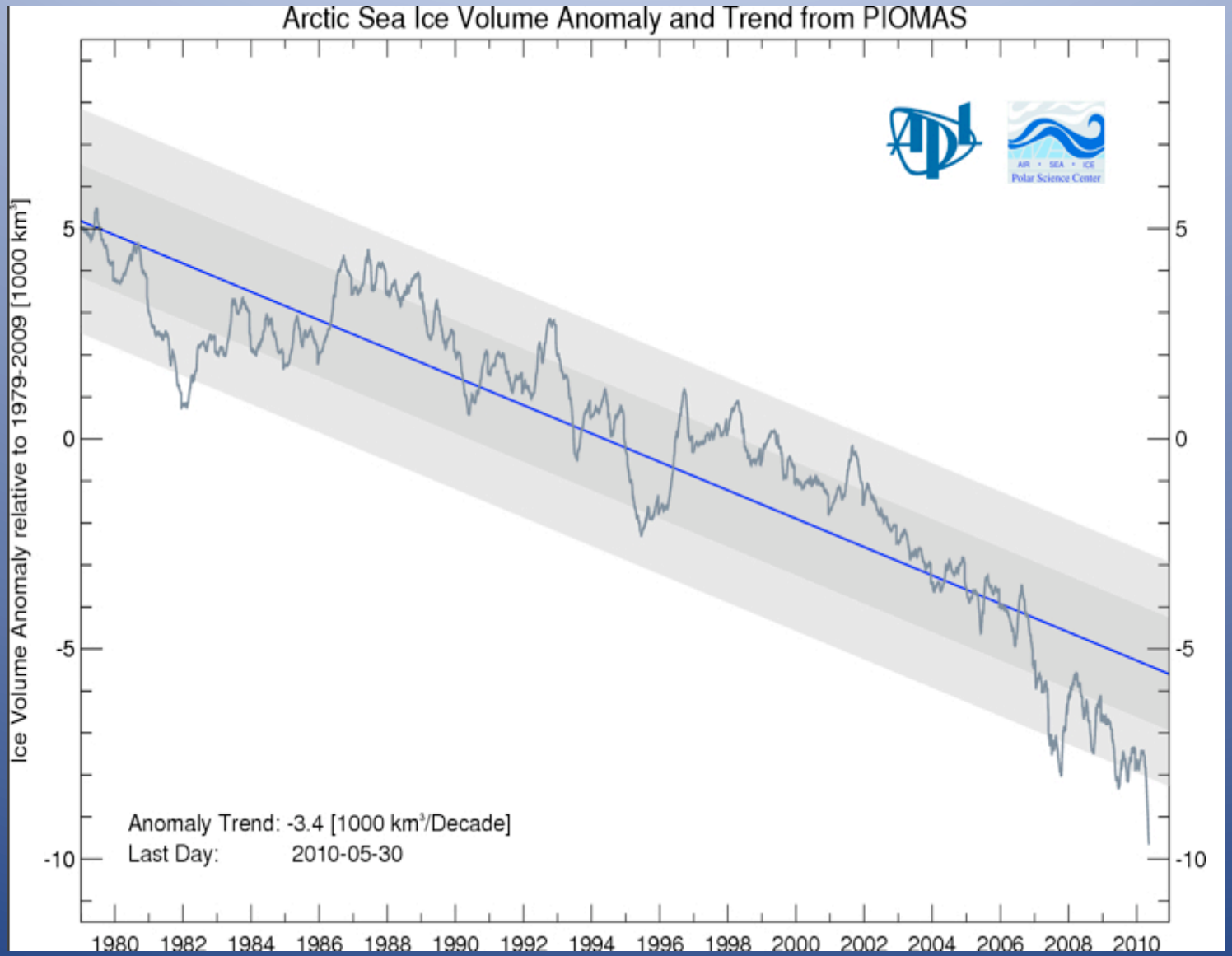

NORTH POLE
SUMMER ARCTIC SEA
ICE BOUNDARY IN 1979

AVERAGE SEPTEMBER EXTENT

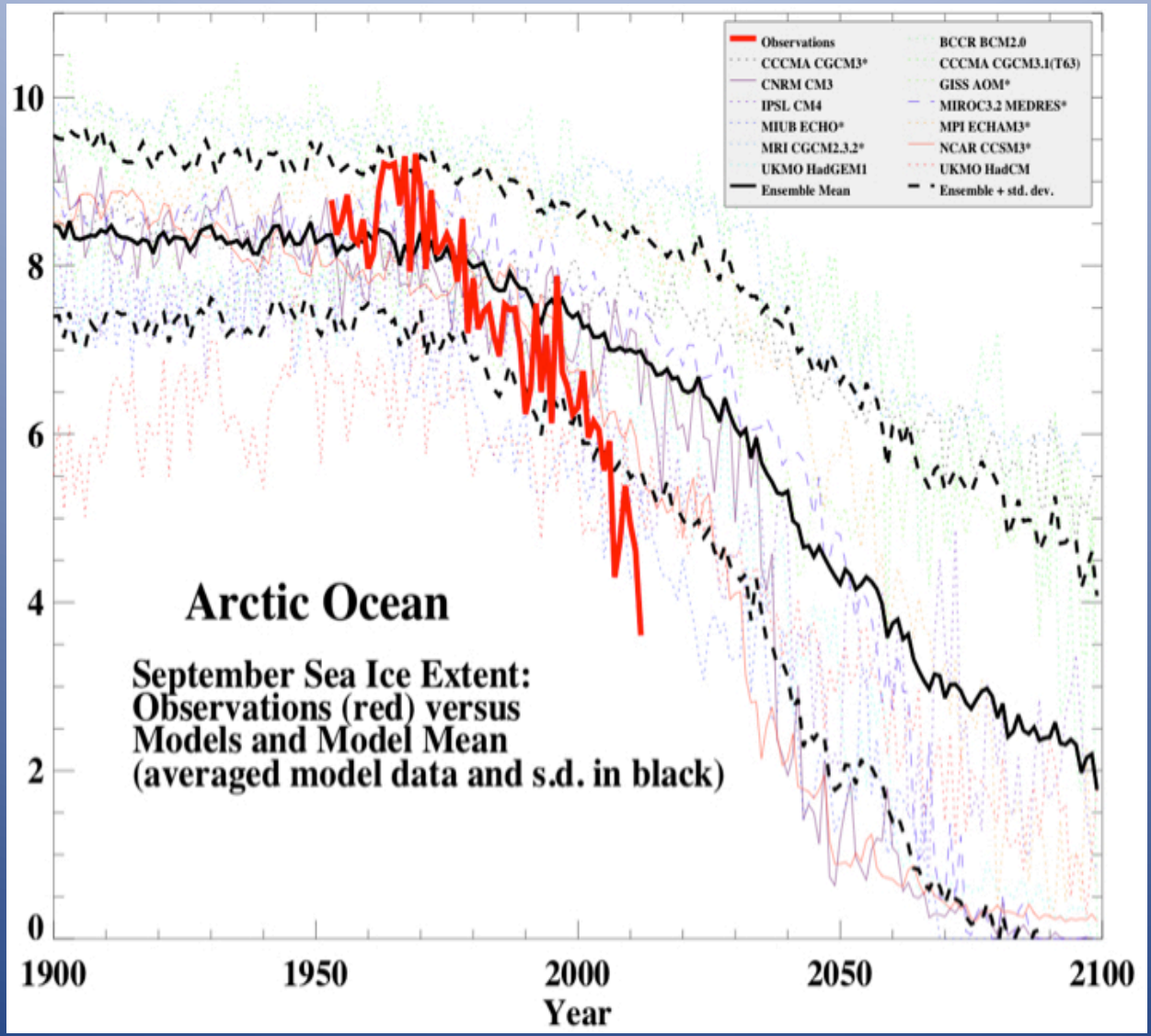
Data source: Satellite observations.

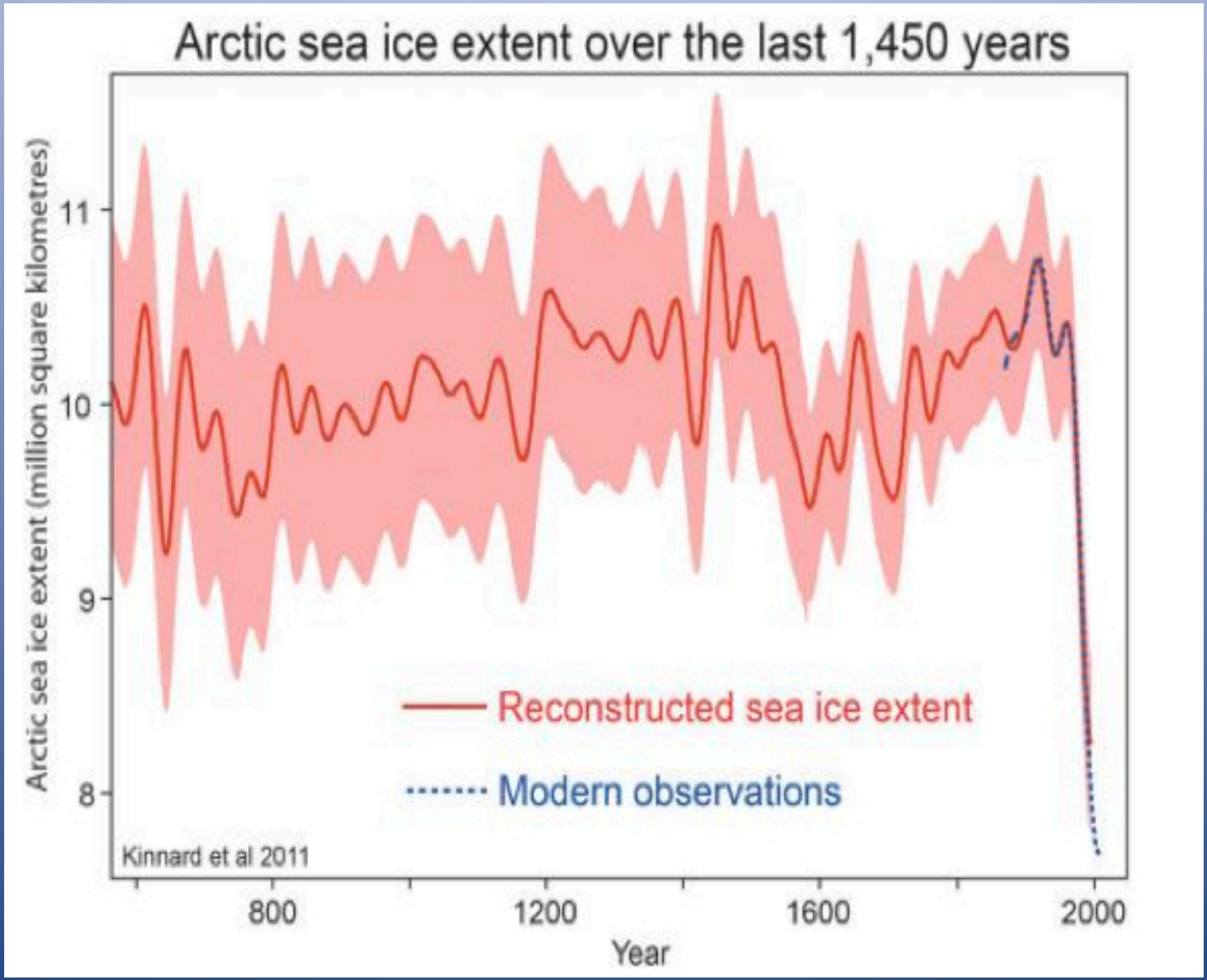
Credit: NSIDC




Arctic Sea Ice Volume Anomaly and Trend from PIOMAS
Ice Volume Anomaly relative to 1979-2009 [1000 km³]
5
0
-5
-10
Anomaly Trend: -3.4 [1000 km³/Decade]
Last Day: 2010-05-30
1980 1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010
Polar Science Center

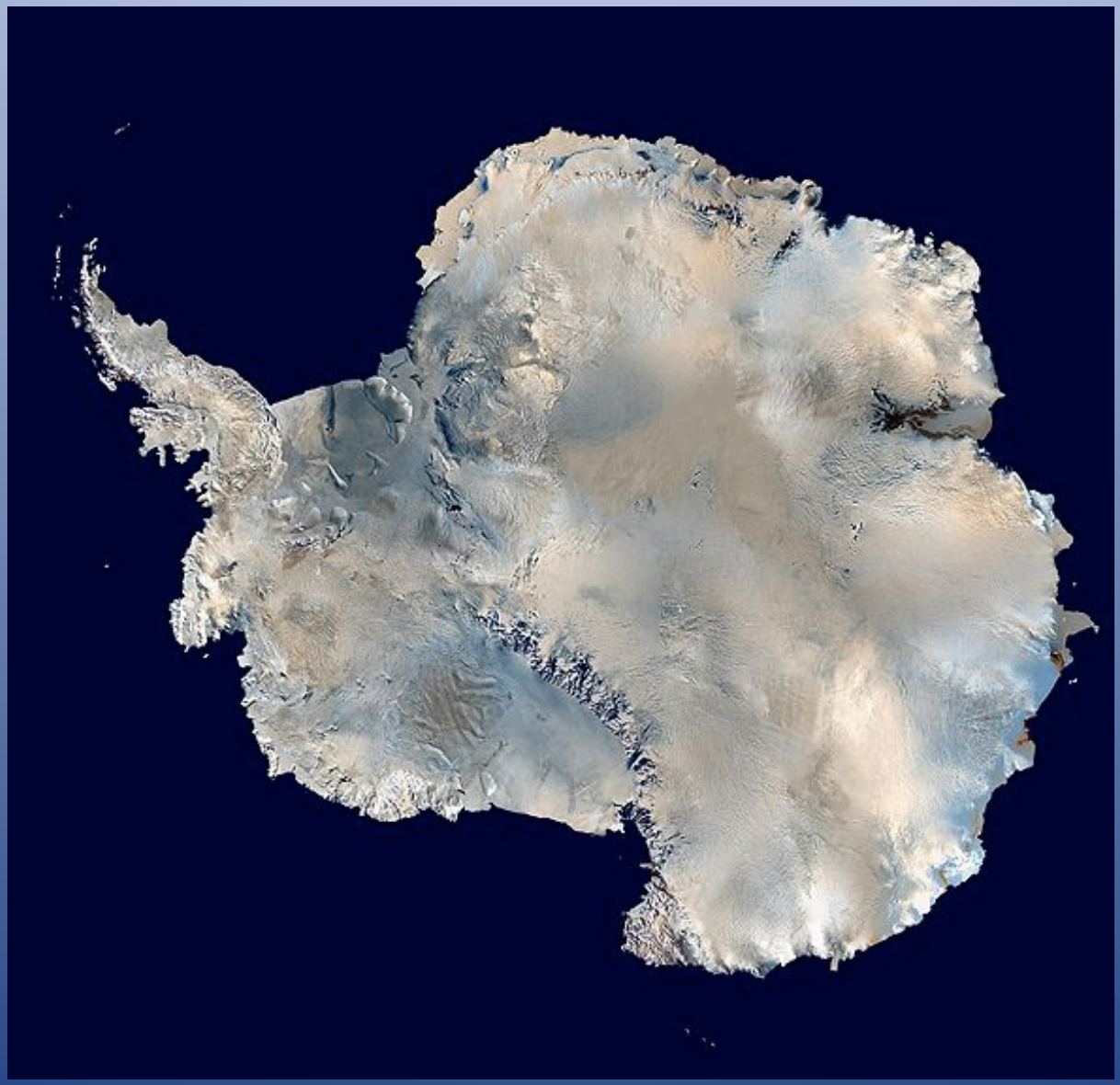
Feb 16


Observations
CCCMA CGCM3*
CNRM CM3
IPSL CM4
MIUB ECHO*
MRI CGCM2.3.2*
UKMO HadGEM1
Ensemble Mean
BCCR BCM2.0
CCCMA CGCM3.1(T63)
GISS AOM*
MIROC3.2 MEDRES*
MPI ECHAM3*
NCAR CCSM3*
UKMO HadCM
Ensemble + std. dev.
Arctic Ocean
September Sea Ice Extent:
Observations (red) versus
Models and Model Mean
(averaged model data and s.d. in black)
10
8
6
4
2
0
1900
1950
2000
2050
2100
Year

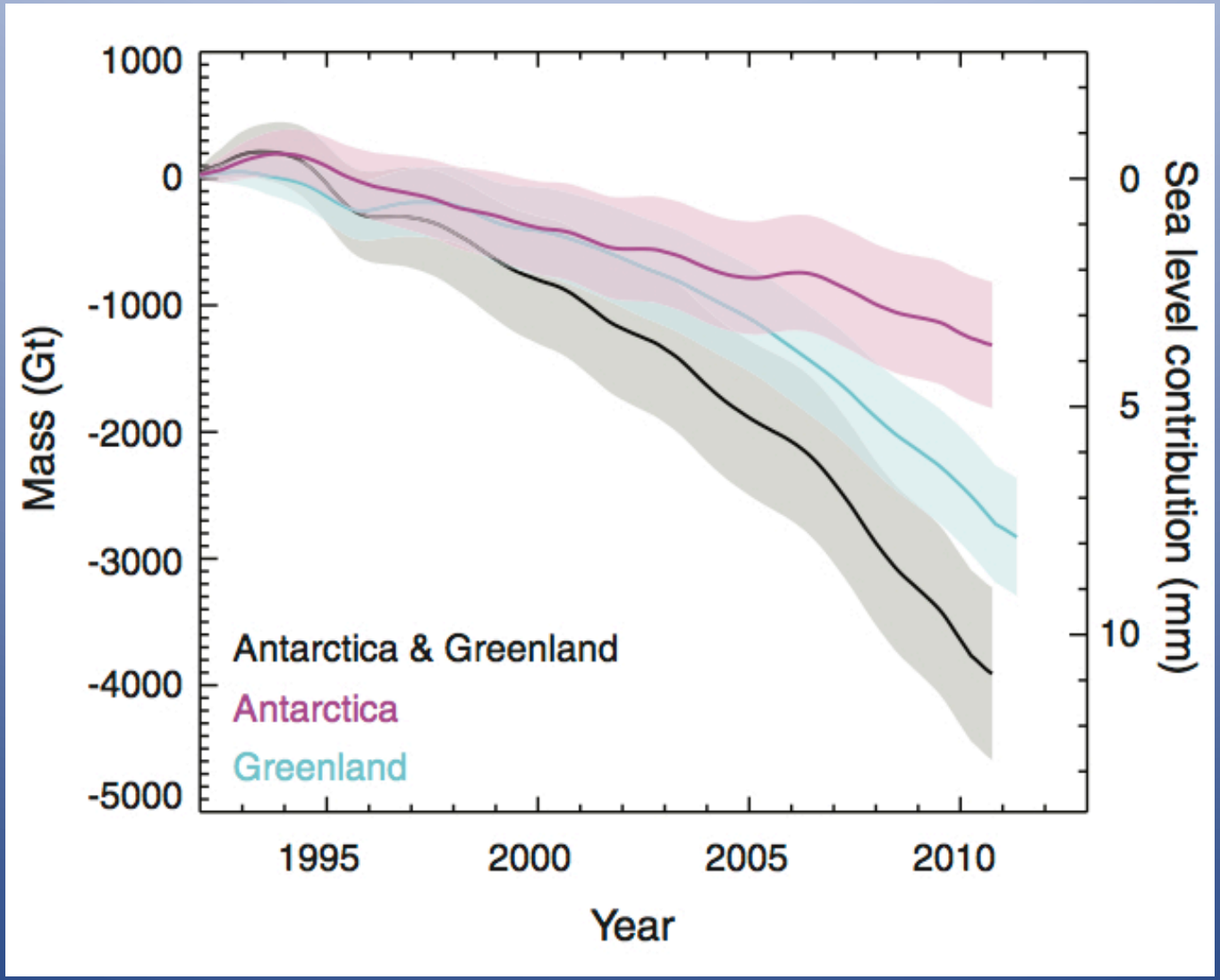

Arctic sea ice extent over the last 1,450 years
Arctic sea ice extent (million square kilometres)
11
10
9
8
Reconstructed sea ice extent
Modern observations
Kinnard et al 2011
800
1200
1600
2000
Year

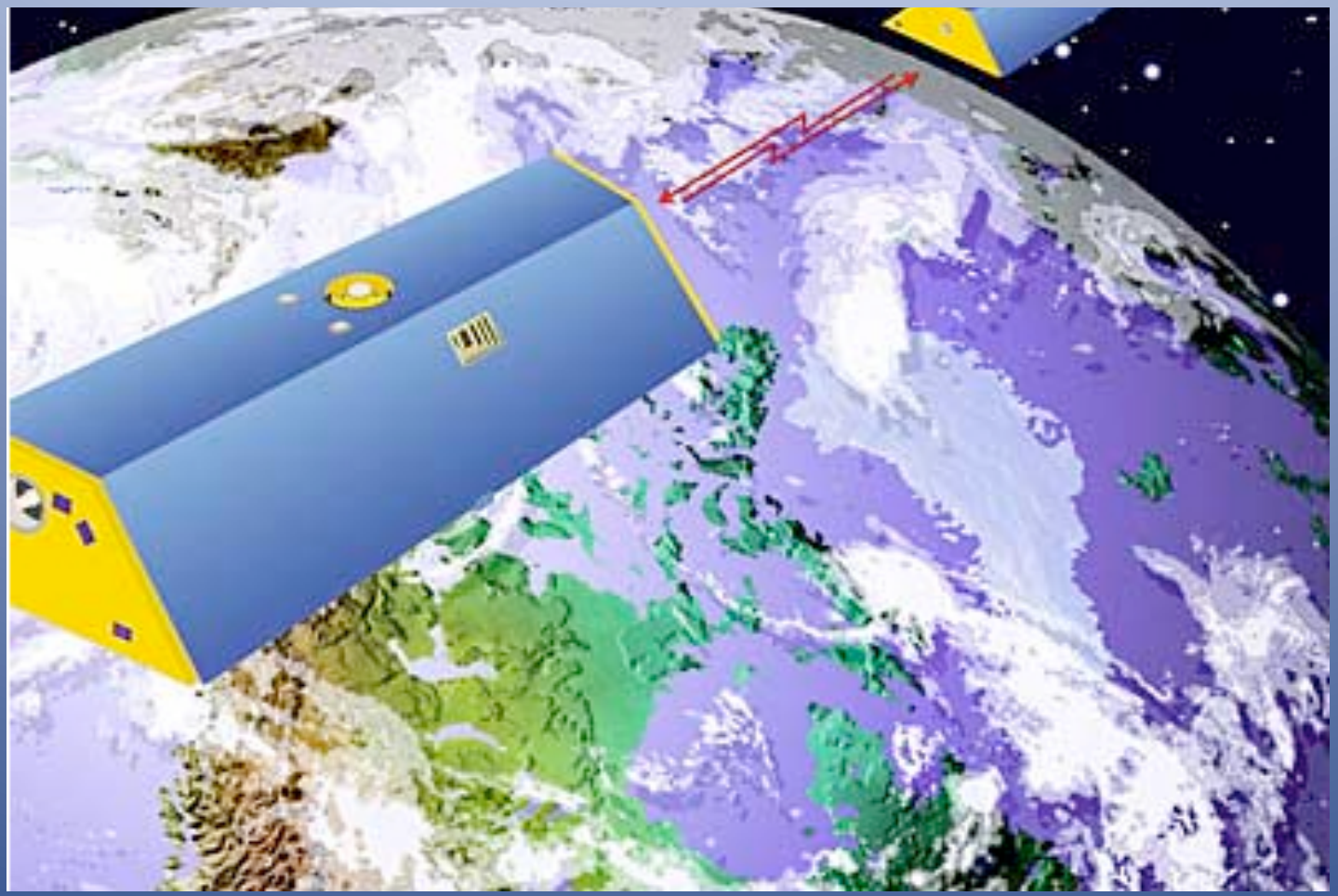
The Greenland Ice Sheet

20

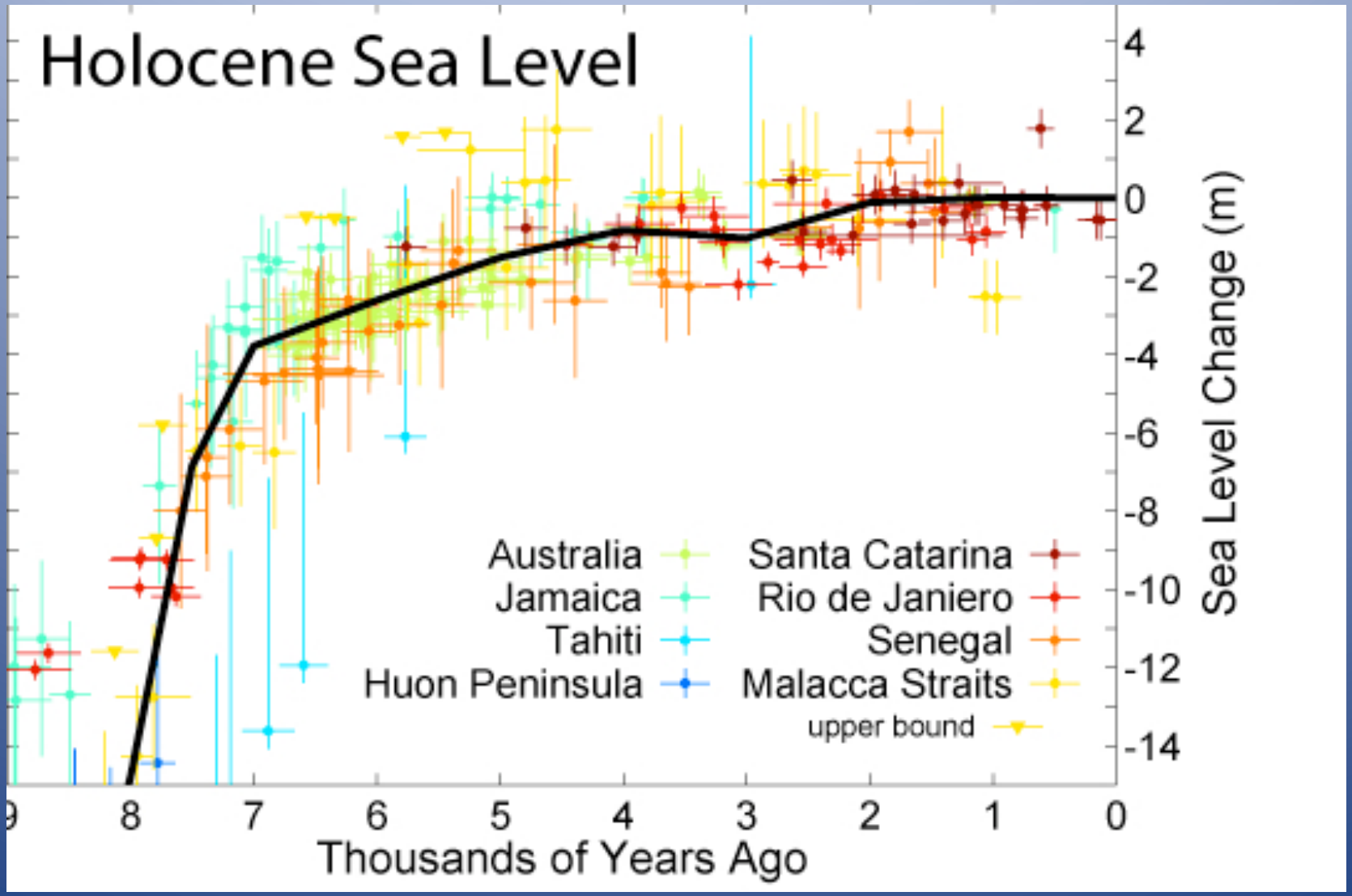


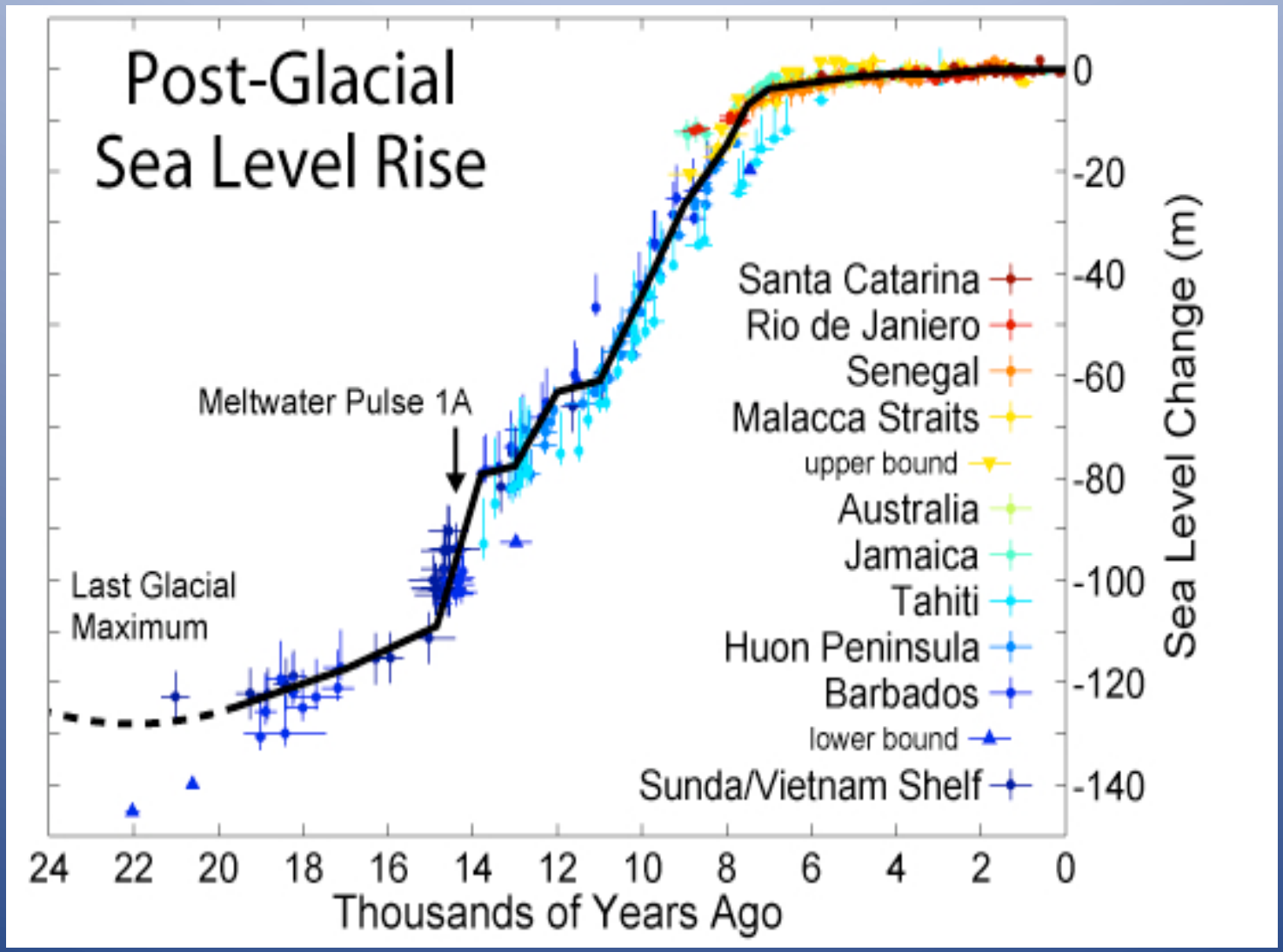
Feb 16

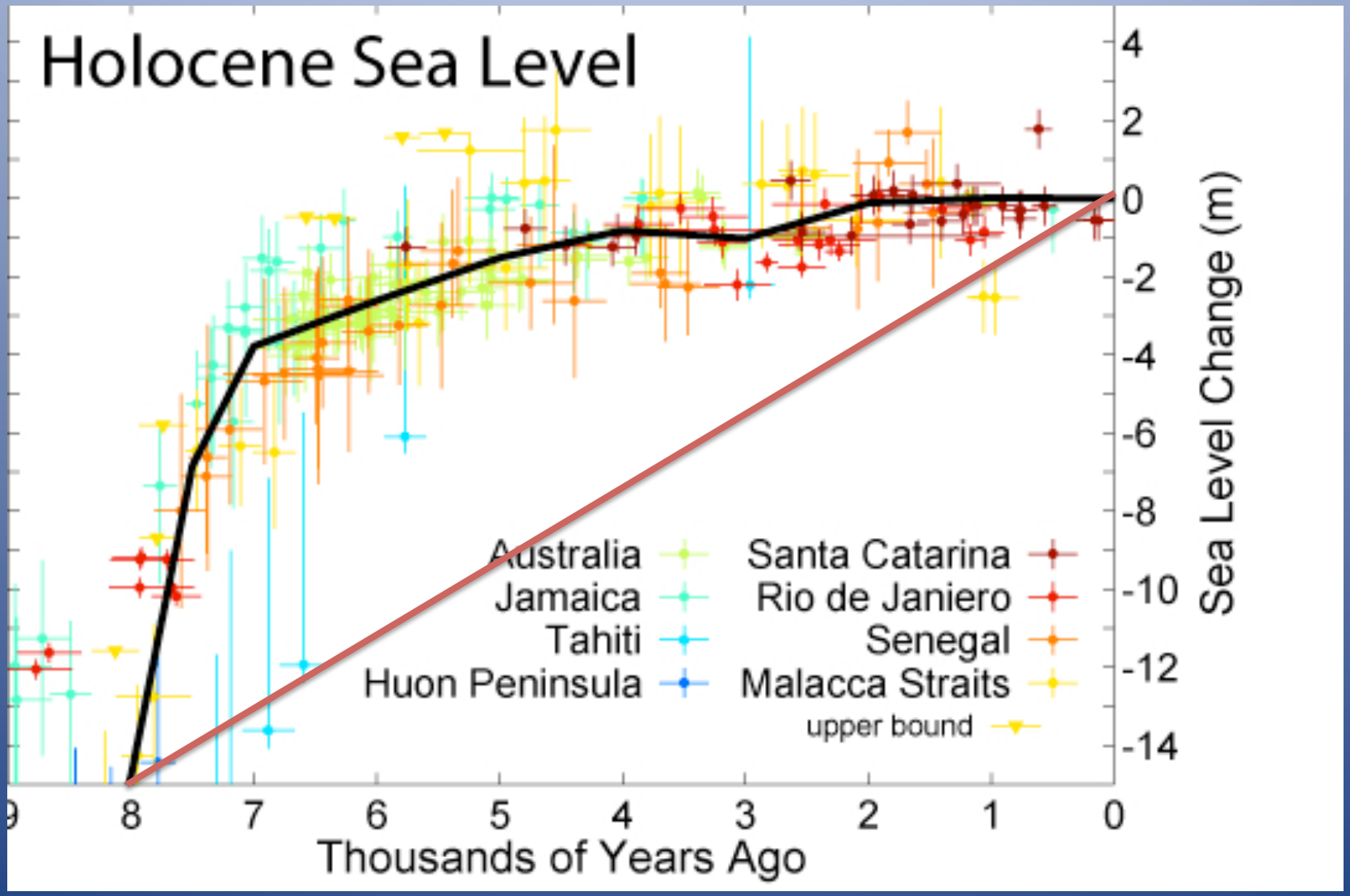

1000
0
-1000
-2000
-3000
-4000
-5000
Mass (Gt)
0
5
10
Sea level contribution (mm)
1995
2000
2005
2010
Year
Antarctica & Greenland
Antarctica
Greenland

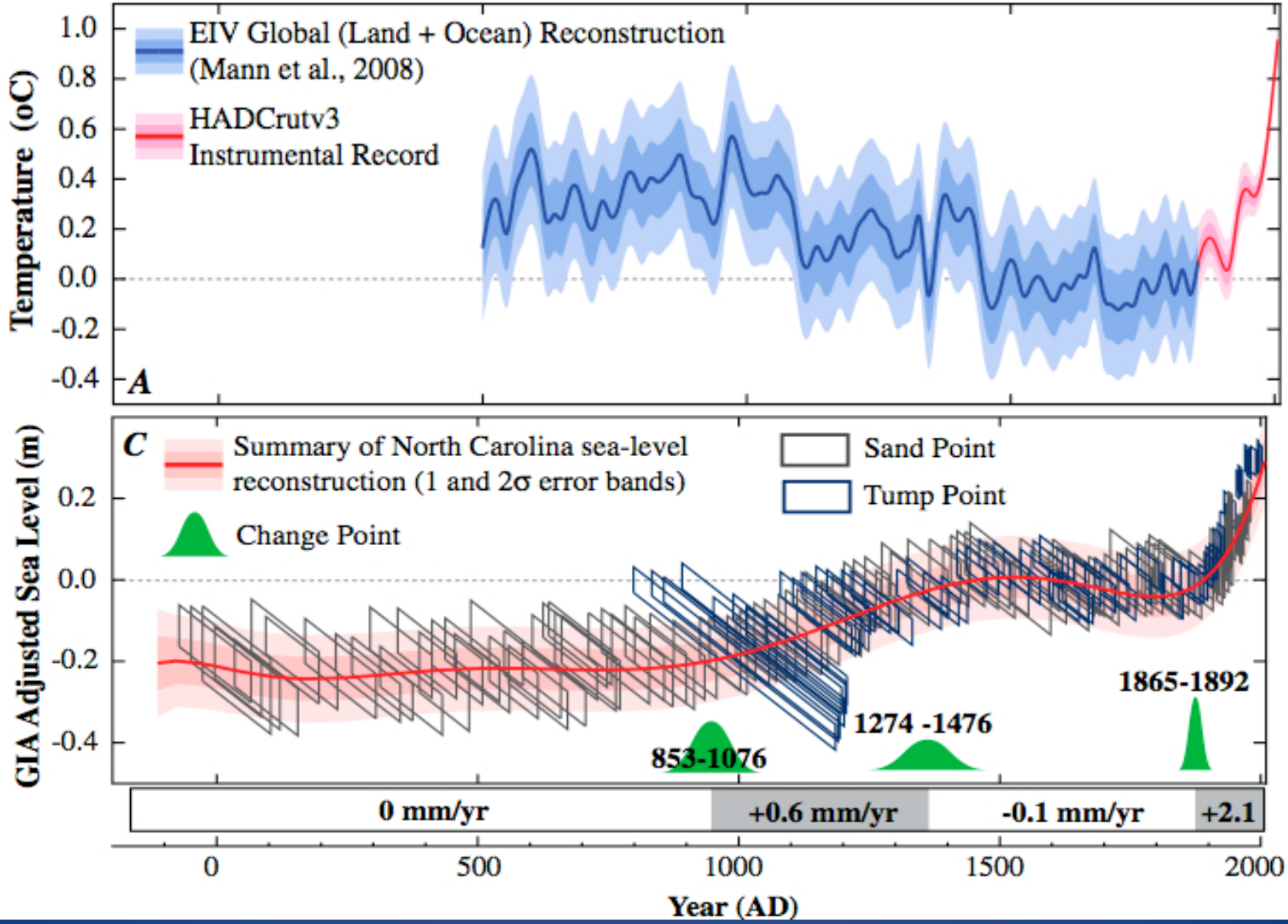


GRACE satellites


Holocene Sea Level
Australia
Jamaica
Tahiti
Huon Peninsula
Santa Catarina
Rio de Janiero
Senegal
Malacca Straits
upper bound
4
2
0
-2
-4
-6
-8
-10
-12
-14
Sea Level Change (m)
9
8
7
6
5
4
3
2
1
0
Thousands of Years Ago


Post-Glacial
Sea Level Rise
Meltwater Pulse 1A
Last Glacial
Maximum
Santa Catarina
Rio de Janiero
Senegal
Malacca Straits
upper bound
Australia
Jamaica
Tahiti
Huon Peninsula
Barbados
lower bound
Sunda/Vietnam Shelf
0
-20
-40
-60
-80
-100
-120
-140
Sea Level Change (m)
24
22
20
18
16
14
12
10
8
6
4
2
0
Thousands of Years Ago


Holocene Sea Level
Australia
Jamaica
Tahiti
Huon Peninsula
Santa Catarina
Rio de Janiero
Senegal
Malacca Straits
upper bound
Sea Level Change (m)
4
2
0
-2
-4
-6
-8
-10
-12
-14
8
7
6
5
4
3
2
1
0
Thousands of Years Ago

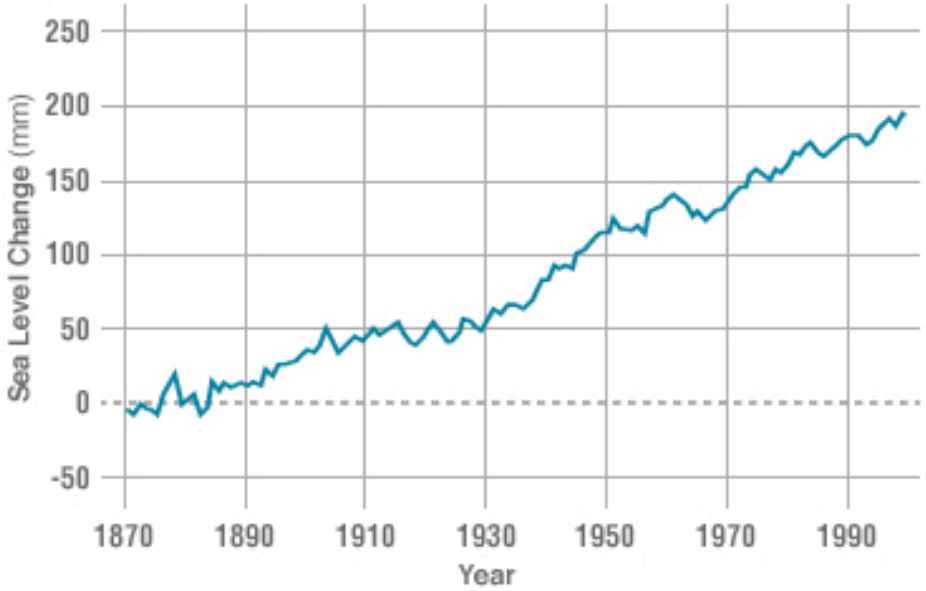

EIV Global (Land + Ocean) Reconstruction
(Mann et al., 2008)
HADCrutv3
Instrumental Record
Temperature (oC)
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
A
C
Summary of North Carolina sea-level
reconstruction (1 and 2σ error bands)
Change Point
Sand Point
Tump Point
GIA Adjusted Sea Level (m)
0.2
0.0
-0.2
-0.4
853-1076
1274 -1476
1865-1892
0 mm/yr
+0.6 mm/yr
-0.1 mm/yr
+2.1
0
500
1000
1500
2000
Year (AD)

Data updated 2.5.13

GROUND DATA: 1870-2000

RATE OF CHANGE ↑1.70 mm*

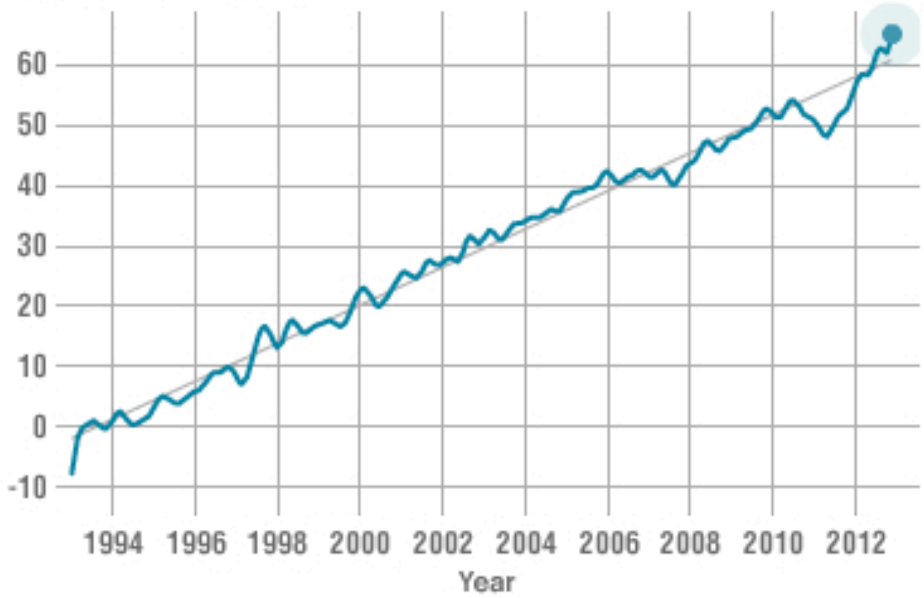
Data source: Coastal tide gauge records.
Credit: CSIRO



SATELLITE DATA: 1993-PRESENT

RATE OF CHANGE ↑3.16 mm

Data source: Satellite sea level observations.
Credit: CLS/Cnes/Legos



SEGMENT 9
Ocean Acidification:
Global Warming's Other Evil Twin
see this website:

http://www.skepticalscience.com/Mackie_OA_not_OK_post_0.html

Placeholder for shell animation

- *The current rate of decrease in pH is thought to be **ten to a hundred times faster** than anytime in the past **50 million years**, and many important species like **corals, oysters, mussels, clams, crabs and plankton** may be adversely impacted and **may not have sufficient time to evolve** mechanisms to cope with this changing chemistry….it is clear that the **rise in CO2 is decreasing the corals' ability to build their skeletons***

- *"It is sobering to think we have used the lower range of IPCC scenarios yet still envisage serious if **not devastating ramifications** for coral reefs. …pathways [lead to **600 to 1000 ppm] and global temperatures of 3° to 6°C defy consideration as credible alternatives…** policies that result in [CO2]atm above 500 ppm appears extremely risky for coral reefs and the tens of millions of people who depend on them directly*

Healthy Coral

Dead Coral

Segment 10:
Impacts on US and the rest of the Ecosystem

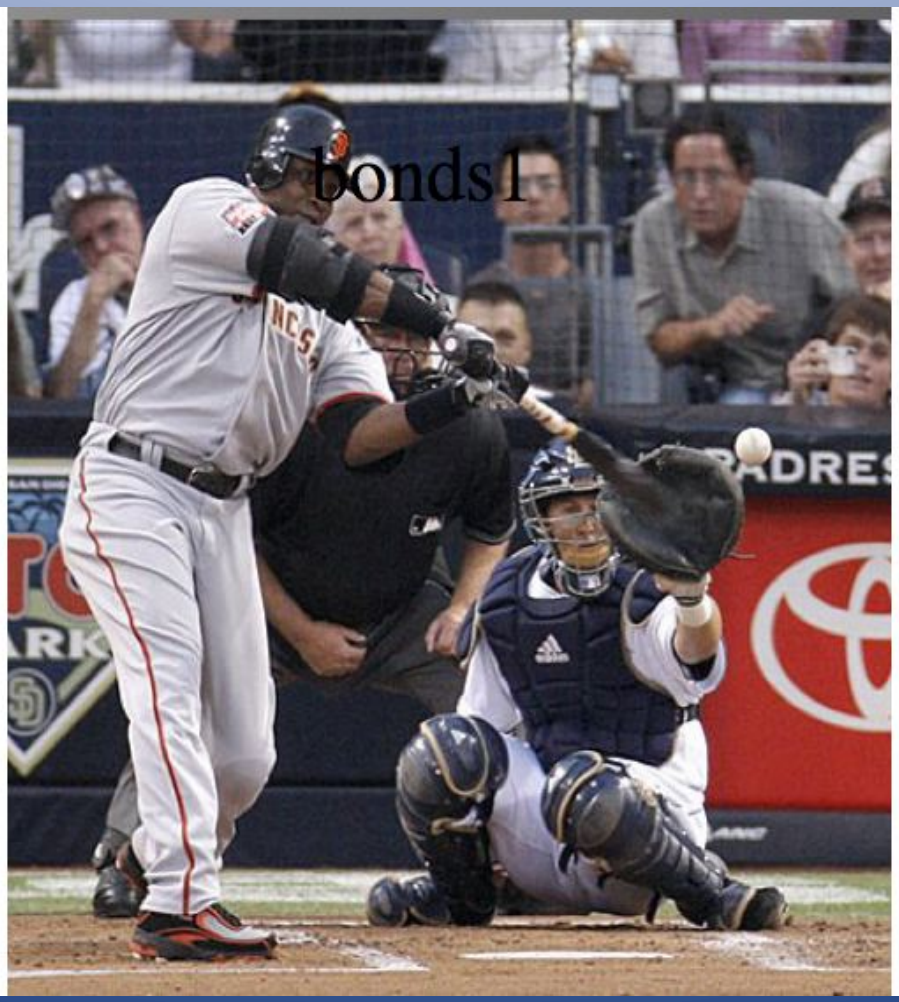
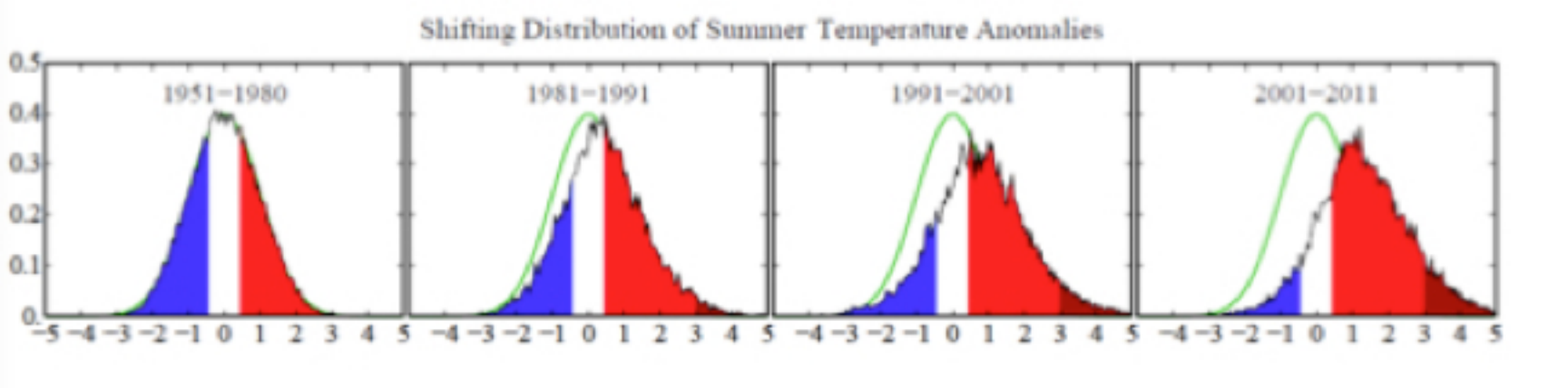
These impacts must be viewed in the context of others, including:

- World population headed toward 10 billion
- Environmental Degradation, Pollution
- Destruction of wildlife habitats
- Competition for increasingly scarce resources (especially water)
- Poverty and Social & Ethnic tensions
- Nuclear Proliferation threat

Extreme Weather Events: Posing the issue correctly

- Heat waves
- Droughts
- Floods & Intense storms
- Wildfires
- Hurricanes
- Tornedos

Metaphor Time!



Increasing Probability of Heat Waves