130,000
-120,000 ybp
(& 2170?)
+ 6 meters

18,000 ybp
-120 meters

Present

SUMMARY OF CHALLENGES AND OPPORTUNITIES

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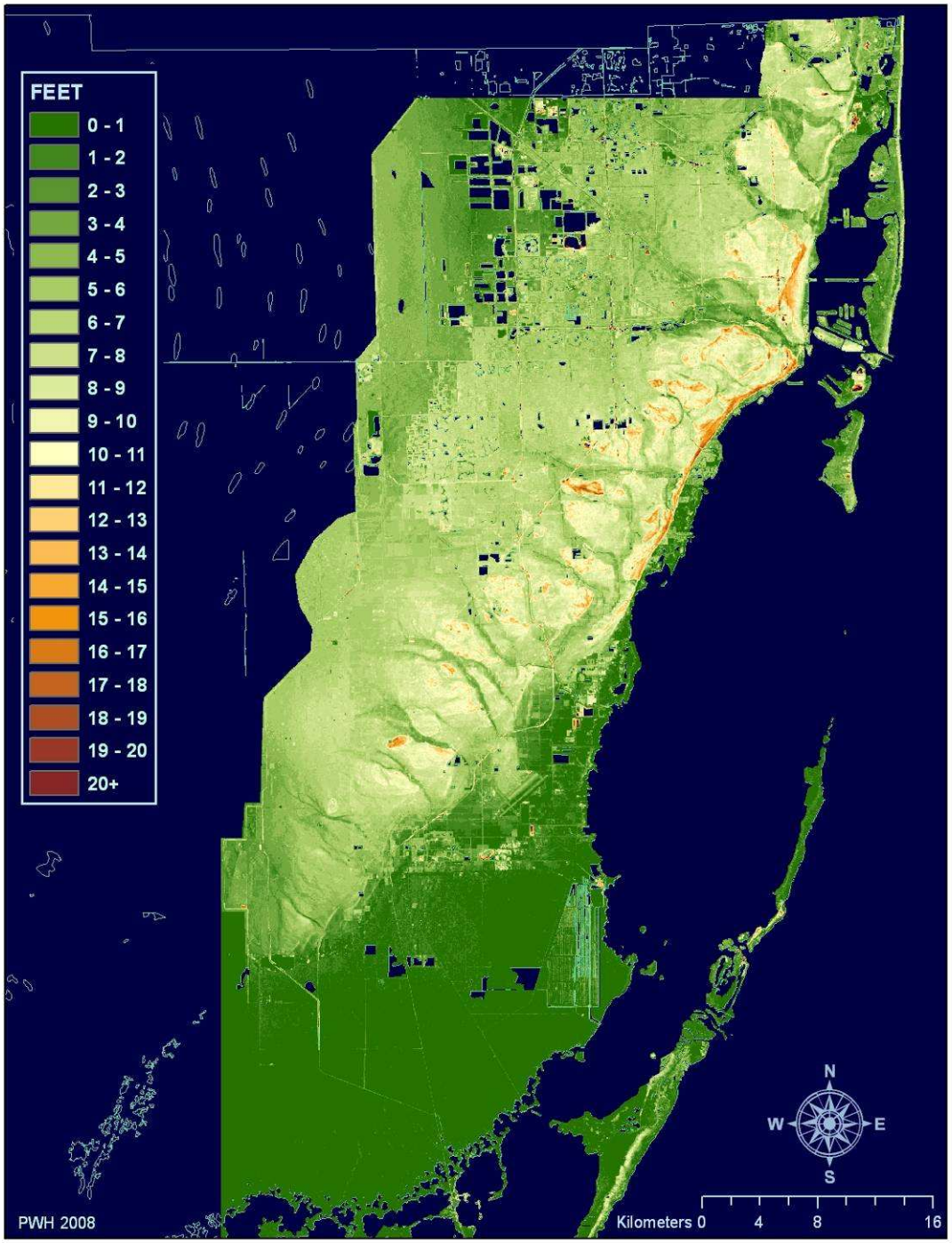
Keeping Our Heads Above Water: Surviving the Challenges of Sea-Level Rise in Florida

Archbold Biological Station, Lake Placid, Florida

January 13, 2010


Welcome to
Wade County



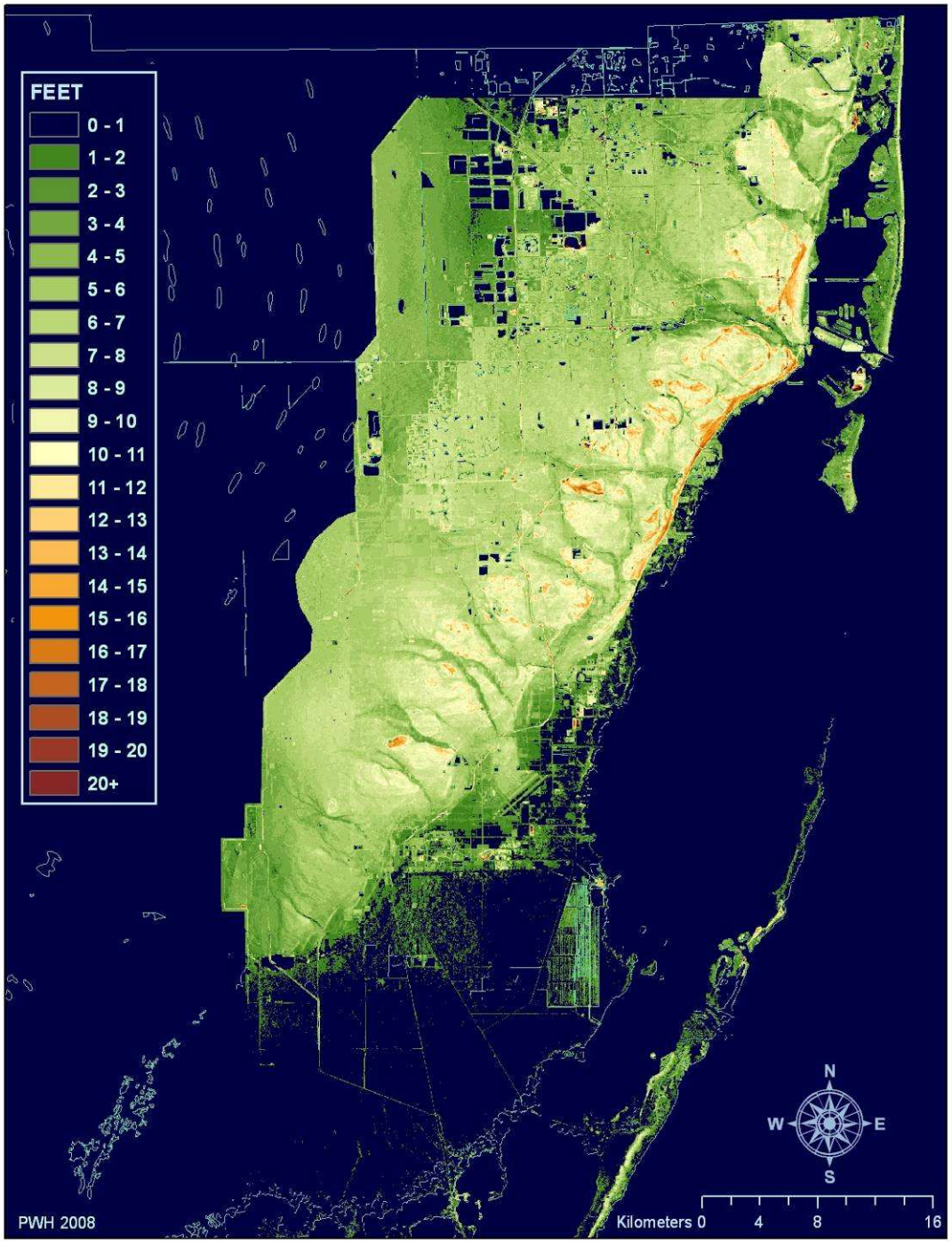
SLR = 0 Ft.

DATE = 2004

Current Conditions

- Raster elevation map of area covered by combined LiDAR data sets.
- Brown areas are high ground, dark green are near sea level.
- Main limestone ridge, barrier islands are IHRC data.
- Area from Turkey Point south and NW lake region from USACE-CSOP data.

Prepared by:
Peter Harlem, 2008

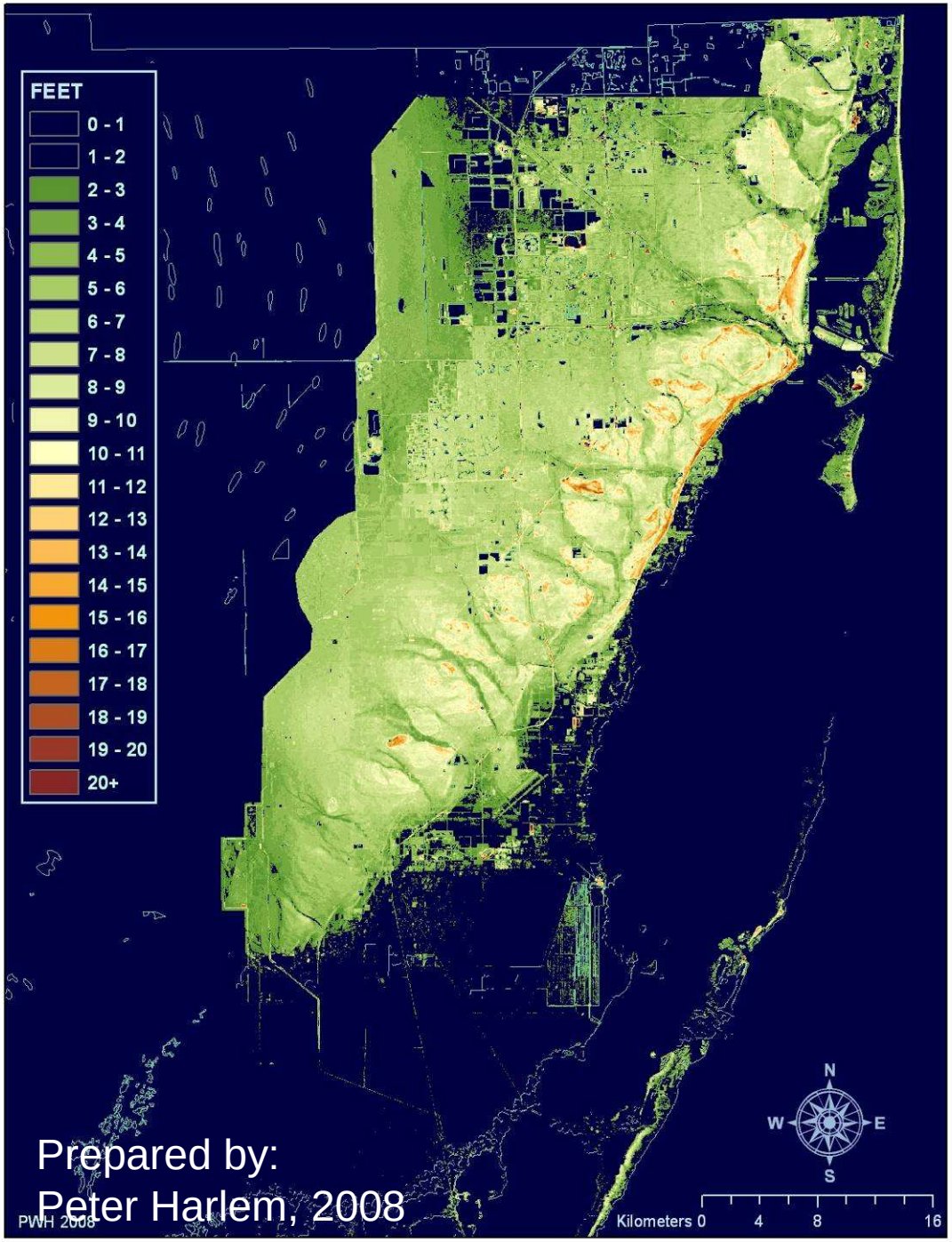


+ 1 Ft.

DATE = 2042

- 83% of land surface remains above mean high tide.
- Coastal plain and marshes inundated at high tides.
- Mangrove swamps deepen, coastal vegetation migrates upslope.
- Beach erosion increases.
- Levees like the L-31E expected to restrict encroachment - delaying salt water intrusion in south Miami-Dade.
- Southern Everglades not protected by equivalent structure.

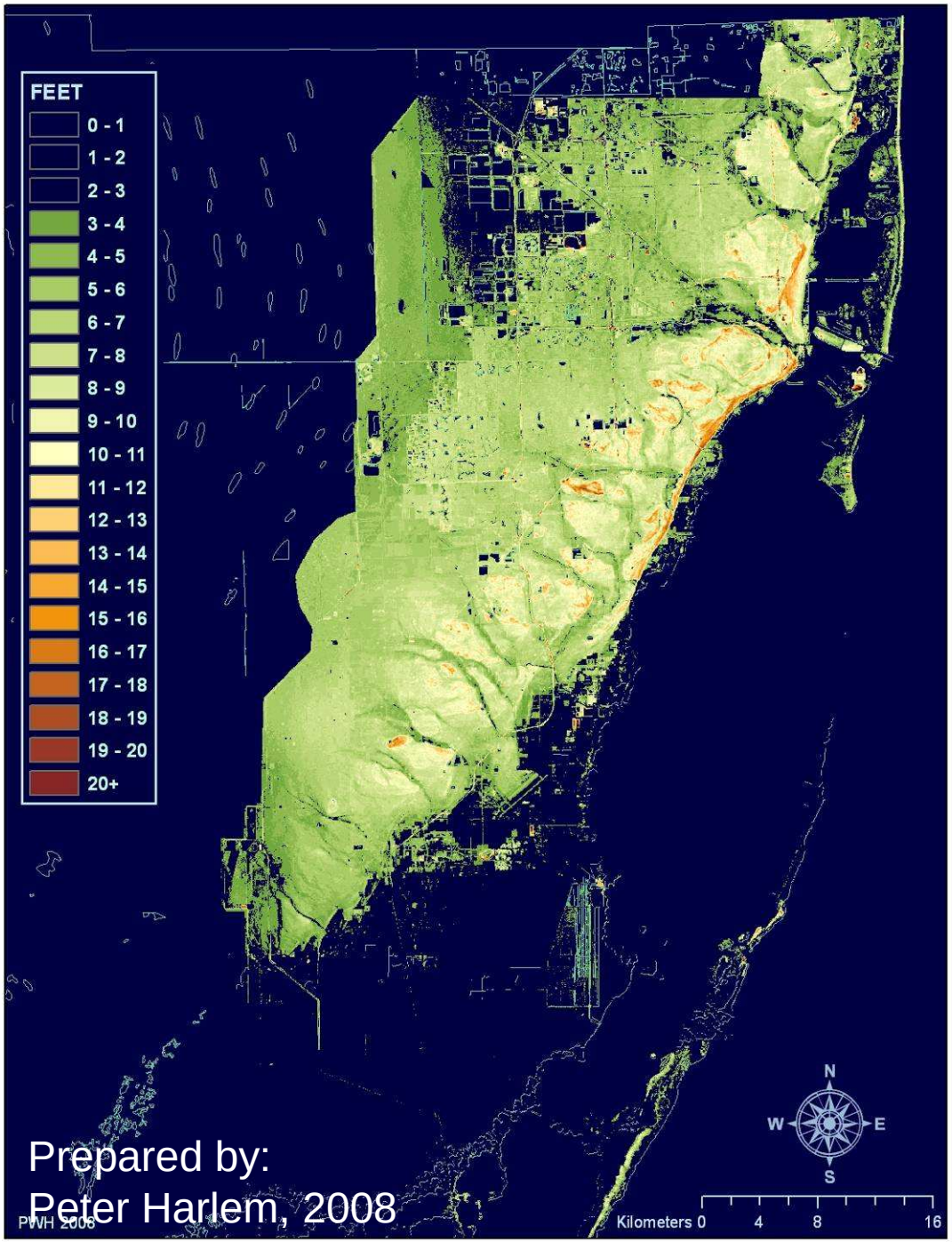
Prepared by:
Peter Harlem, 2008



+ 2 Ft.

DATE = 2066

- 72% of land surface remains.
- Sandy barrier islands challenging to live on: fill areas eroding; beach front rapidly eroding; storm channeling.
- Existing mangrove swamps collapse; inundation and collapse of lower freshwater marshes.
- Much of upper and lower Keys inundated.
- Coastal levees under wave attack.
- Access to barrier islands and publics works becomes difficult – Turkey Point, South Dade landfill.

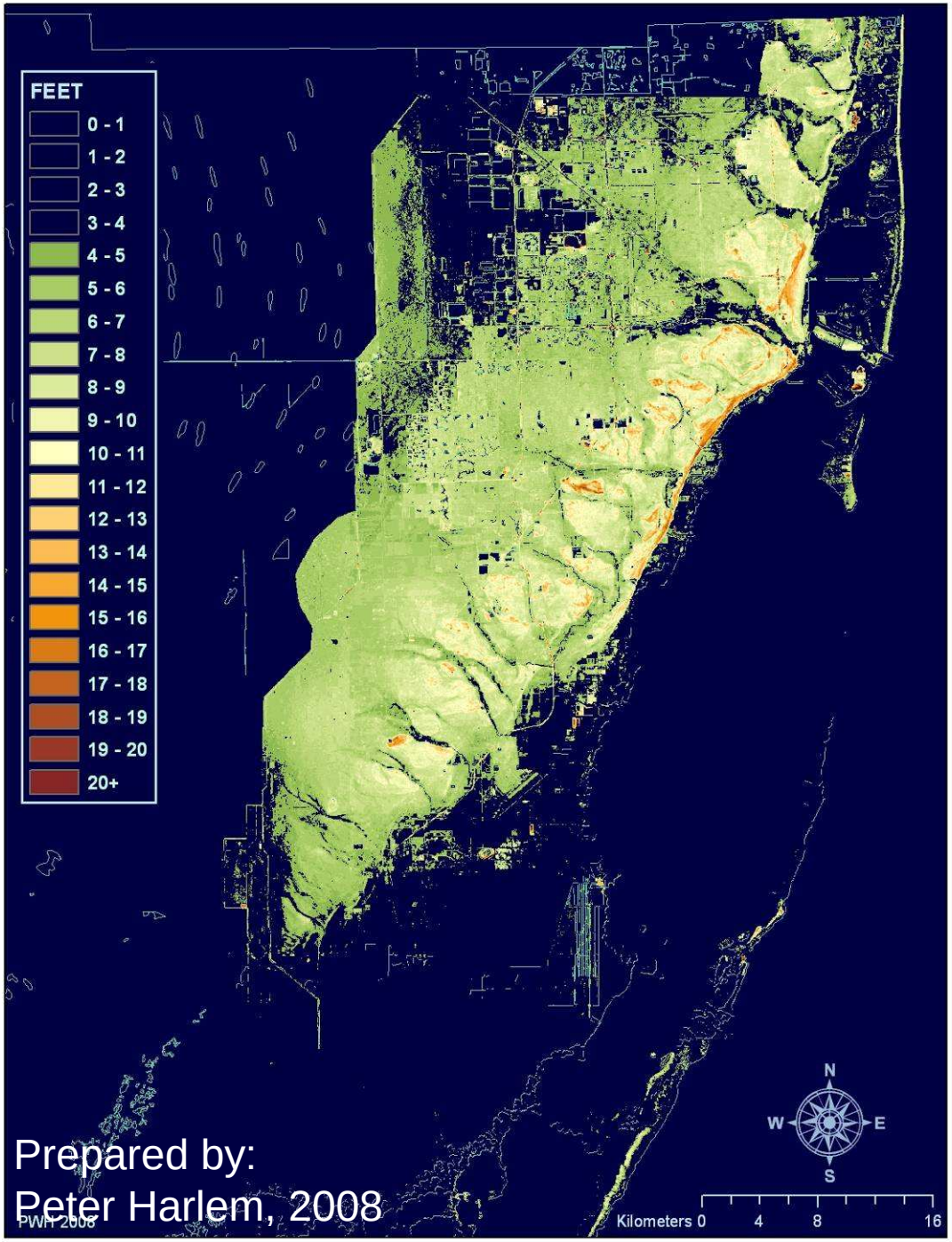


Prepared by:
Peter Harlem, 2008

+ 3 Ft.

DATE = 2084

- 67% of land surface remains.
- Sandy barrier islands essentially gone.
- Massive amounts of mud and organics clogging coastal bays and inner coasts.
- Potable water supply threatened by salt water encroachment.
- Flooding and saline intrusion through paleo channels through coastal ridge (transverse glades) – threat to major economic engine and county water quality.
- Causeways inundated.

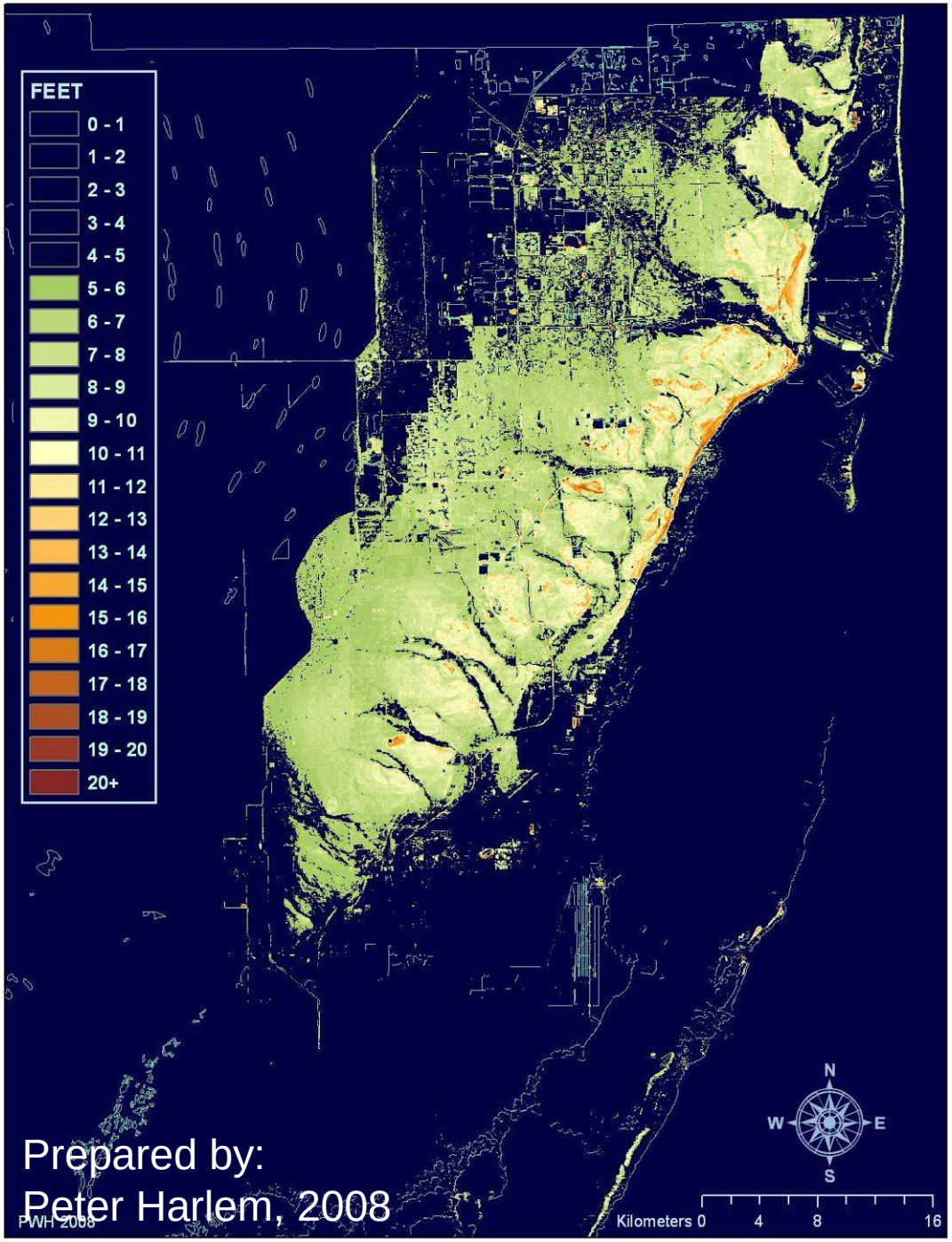


Prepared by:
Peter Harlem, 2008

+ 4 Ft.

DATE = 2098

- 62% of land surface remains.
- Northern rivers tidal dominated producing interior flooding.
- Only highest portions of barrier and man made islands remain above tide.
- Increased coastal wave energy.
- Everglades inundated west of Miami-Dade County. Groundwater flow to bays ends causing total collapse of estuaries.
- Much of remaining low upland in west Miami-Dade County becoming wetland habitat.

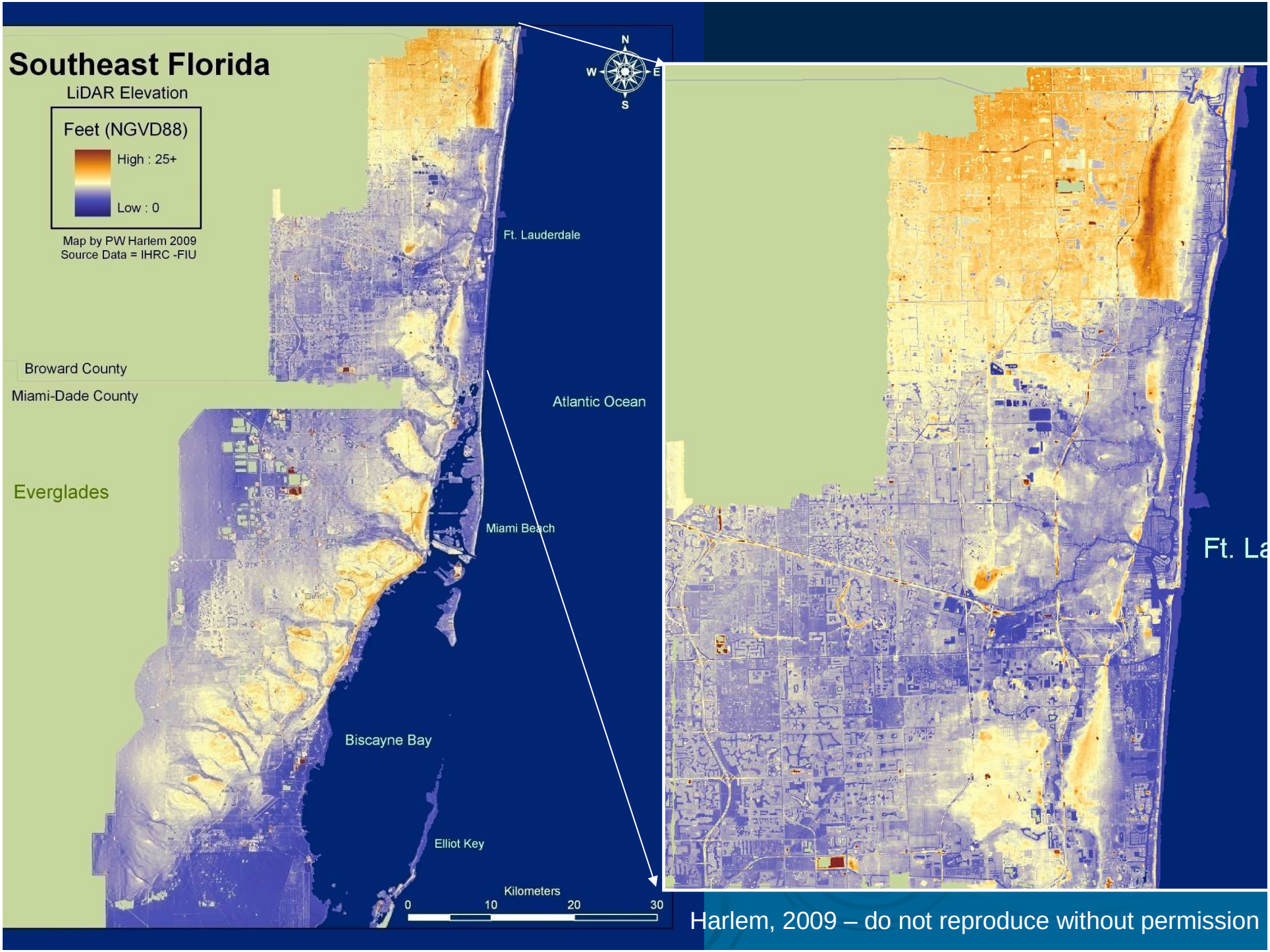


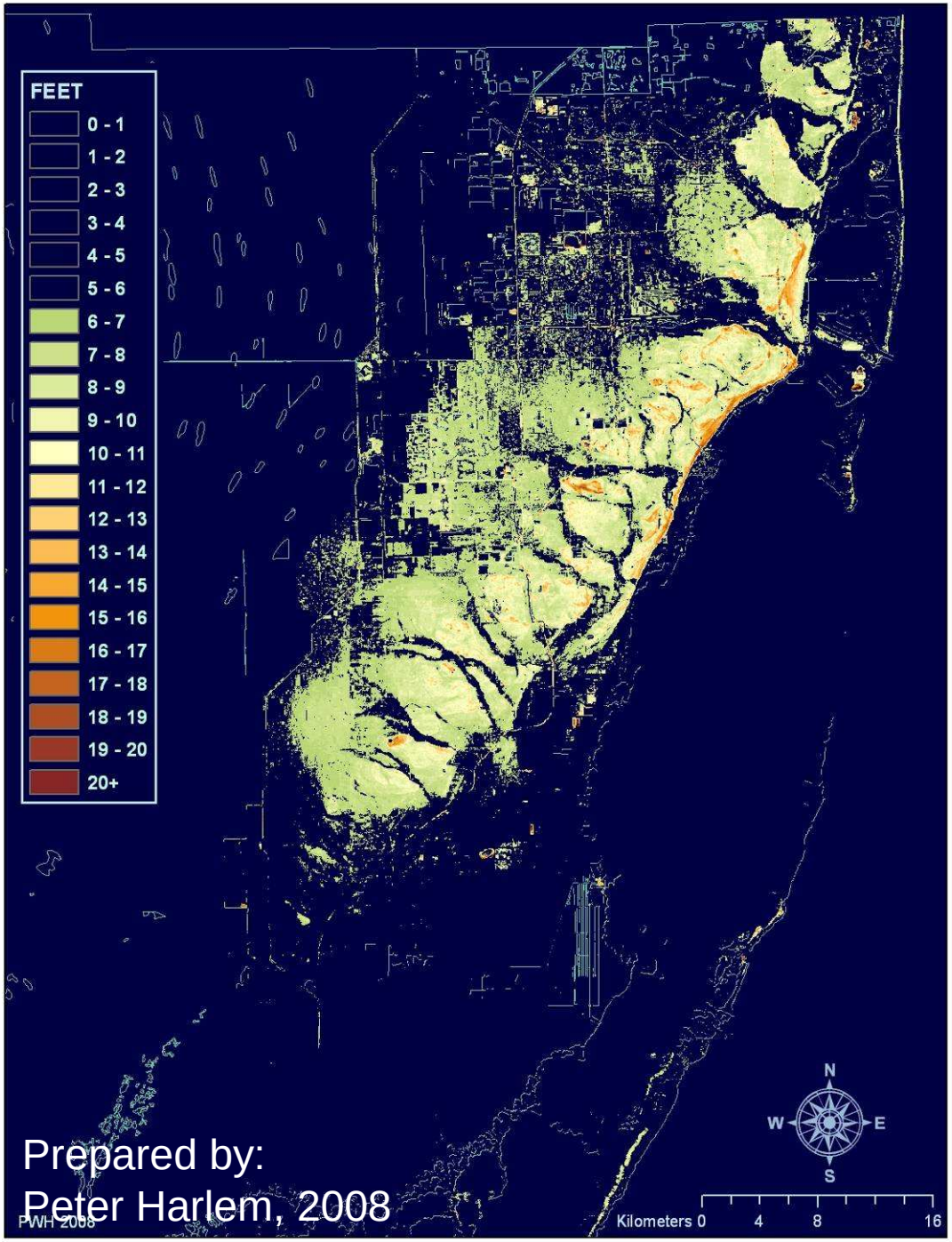
Prepared by:
Peter Harlem, 2008

+ 5 Ft.

DATE = 2110

- 54% of land surface remains.
- Most transverse glades flooded at high tide.
- Coastal ridge now divided by tidal channels into a series of independent islands.
- Everglades inundated to north of Broward County with major tidal channels through ridge in north Miami-Dade and Broward.
- Rainfall greatly reduced.



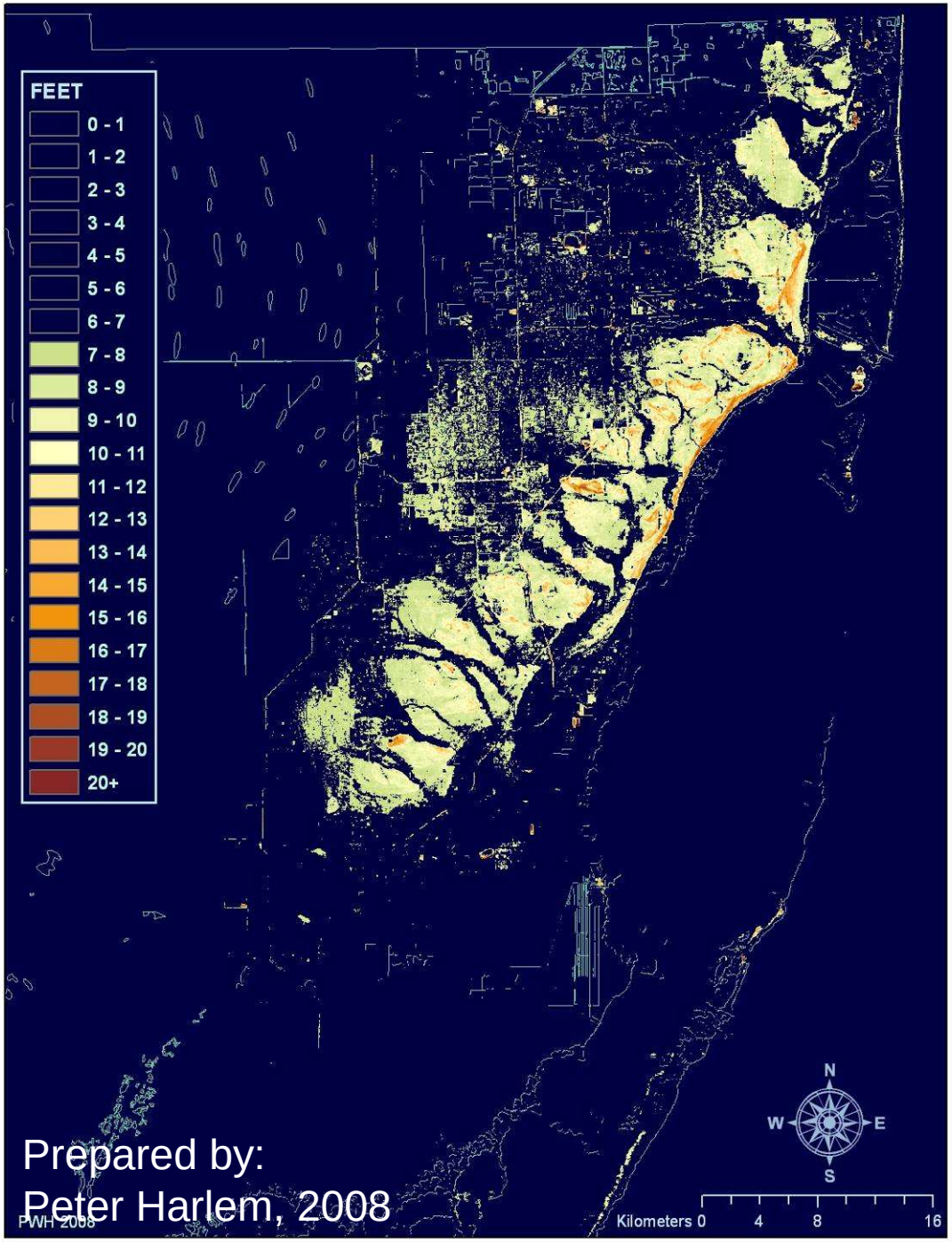


Prepared by:
Peter Harlem, 2008

+ 6 Ft.

DATE = 2120

- 44% of land surface remains.
- Dry climate prevails as land for convection diminishes - onset of Florida Keys-like environment.
- SW portion of ridge inundated.
- Waste disposal sites inundated and releasing to the sea.
- Storm surges moving up Everglades estuary compound risk.

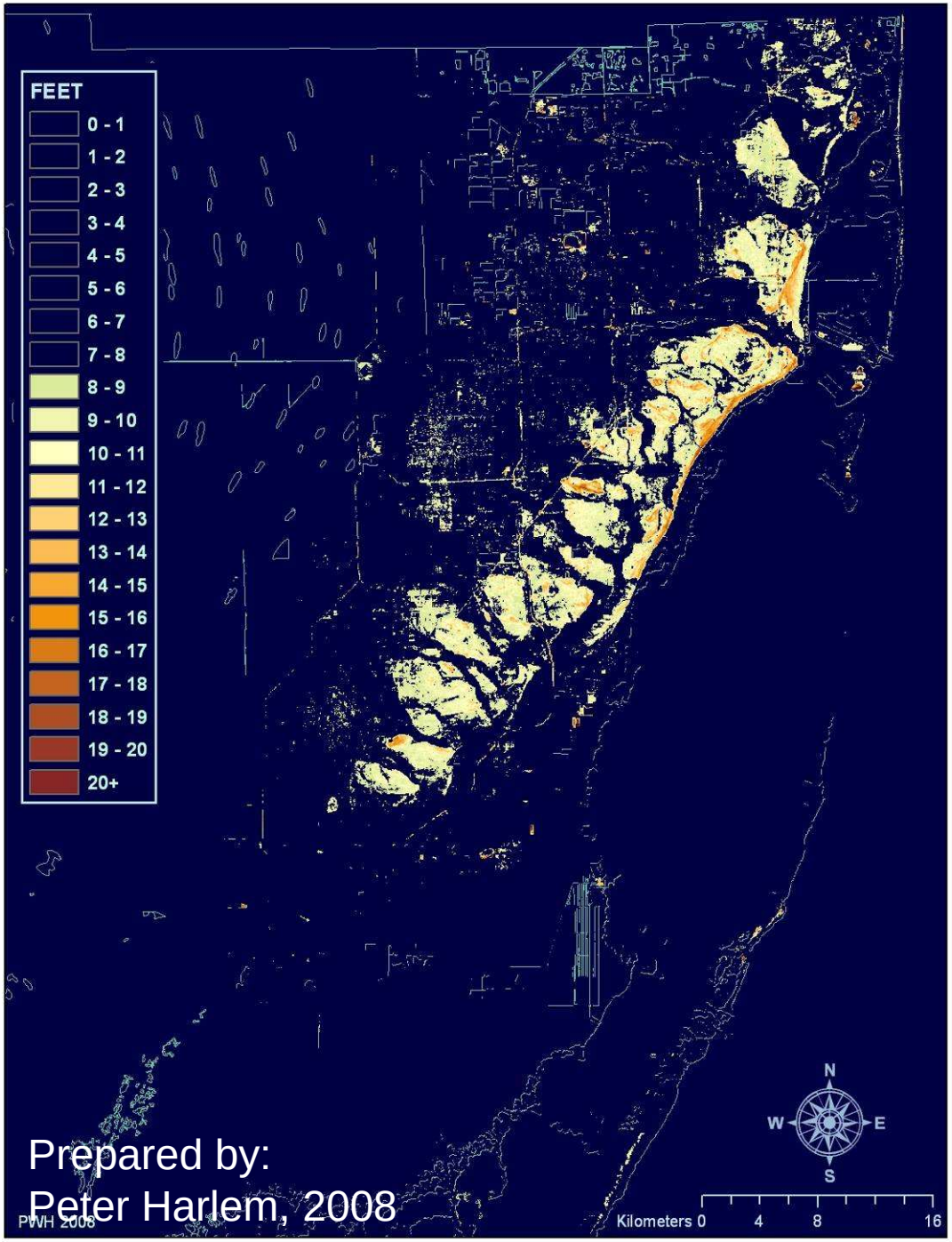


Prepared by:
Peter Harlem, 2008

+ 7 Ft.

DATE = 2128

- 33% land surface remaining.
- Total loss of mainland climate.
- Storm surges have reduced much of historical development below 10 feet to rubble.
- Vast mud flat attempting to form on west side of coastal ridge

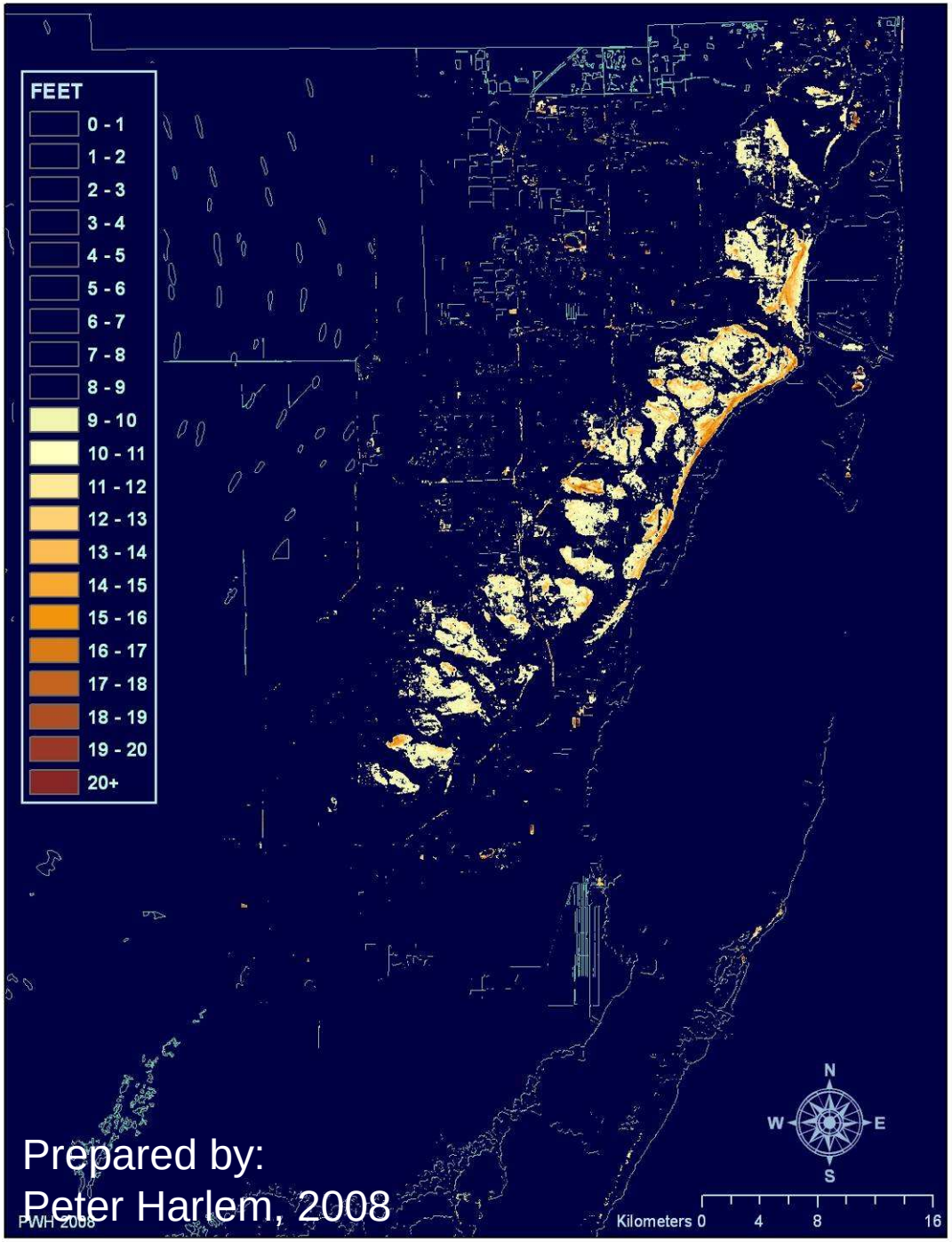


Prepared by:
Peter Harlem, 2008

+ 8 Ft.

DATE = 2135

- 12% land surface remaining.
- Rate of rise accelerating - ~1 ft. every 6-7 years.
- Everglades now extension of Florida Bay.
- Shoreline energy increased considerably – large surf common.

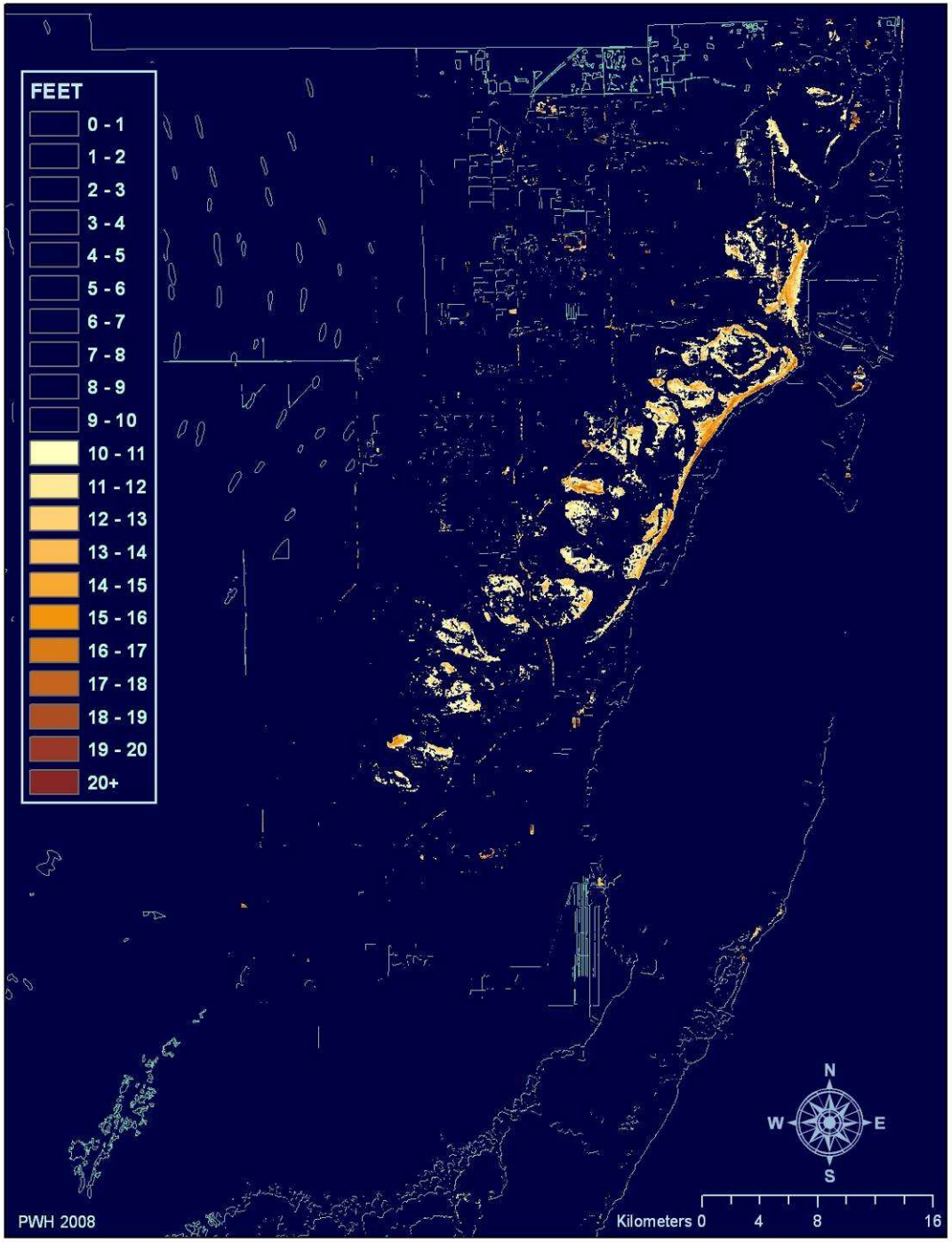


Prepared by:
Peter Harlem, 2008

+ 9 Ft.

DATE = 2144

- 14% land surface remaining.
- Transverse glades now passes between many small islands.
- Creation of extensive nearshore shelf ecosystems.
- Transportation restricted to boat or helicopter.

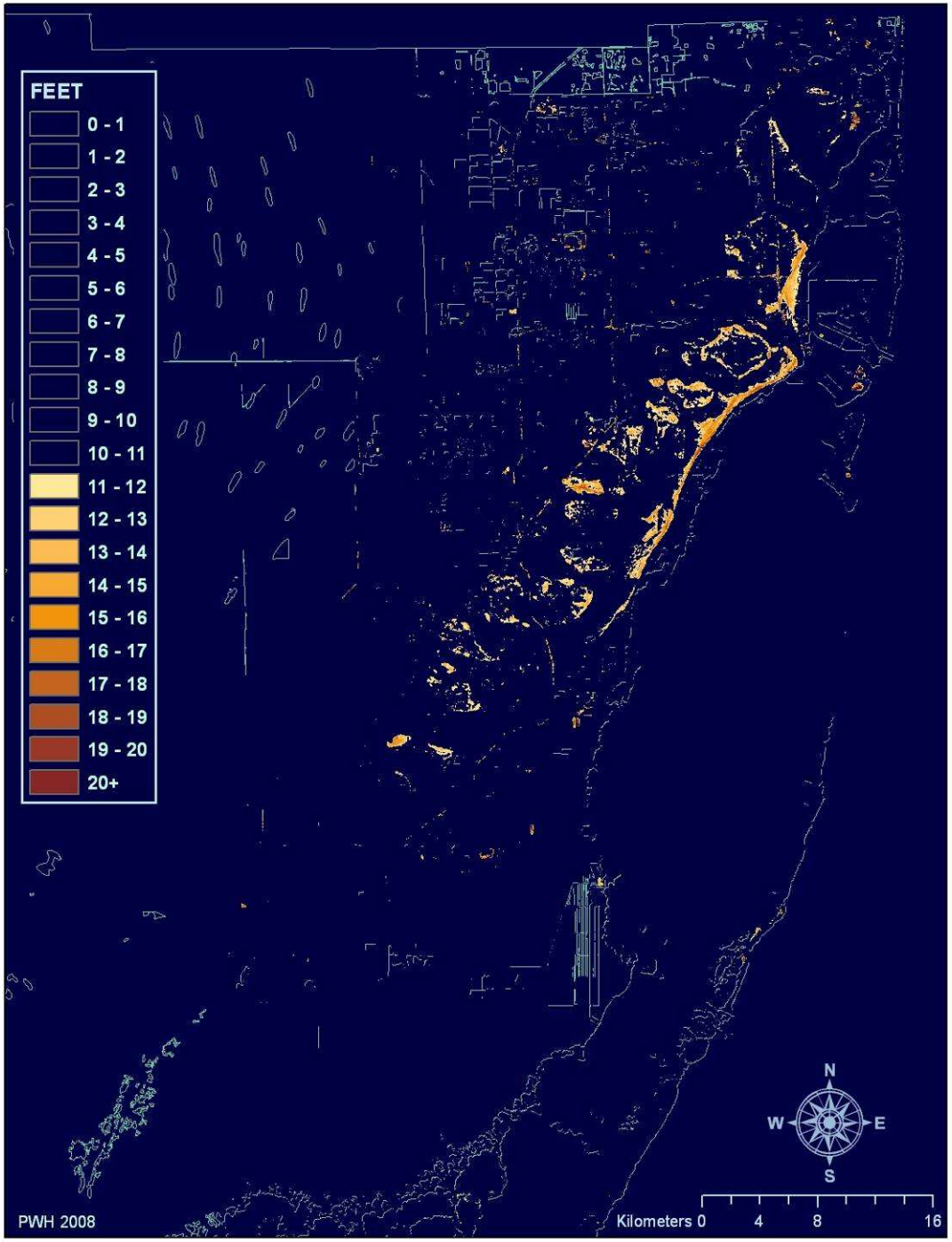


+ 10 Ft.

DATE = 2150

- 9% of land surface remaining.

Prepared by:
Peter Harlem, 2008

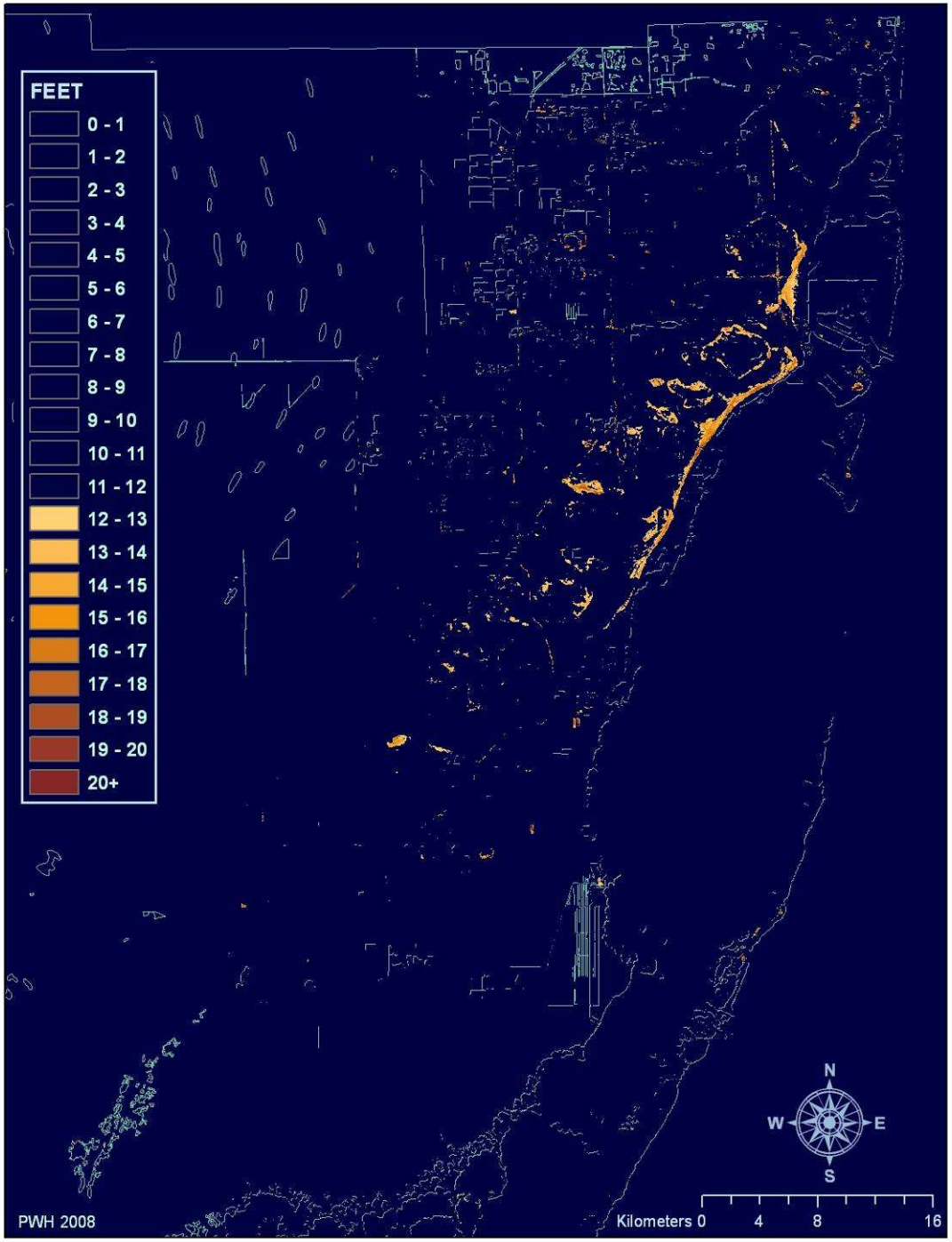


+ 11 Ft.

DATE = 2155

- 5% of land surface remaining.

Prepared by:
Peter Harlem, 2008

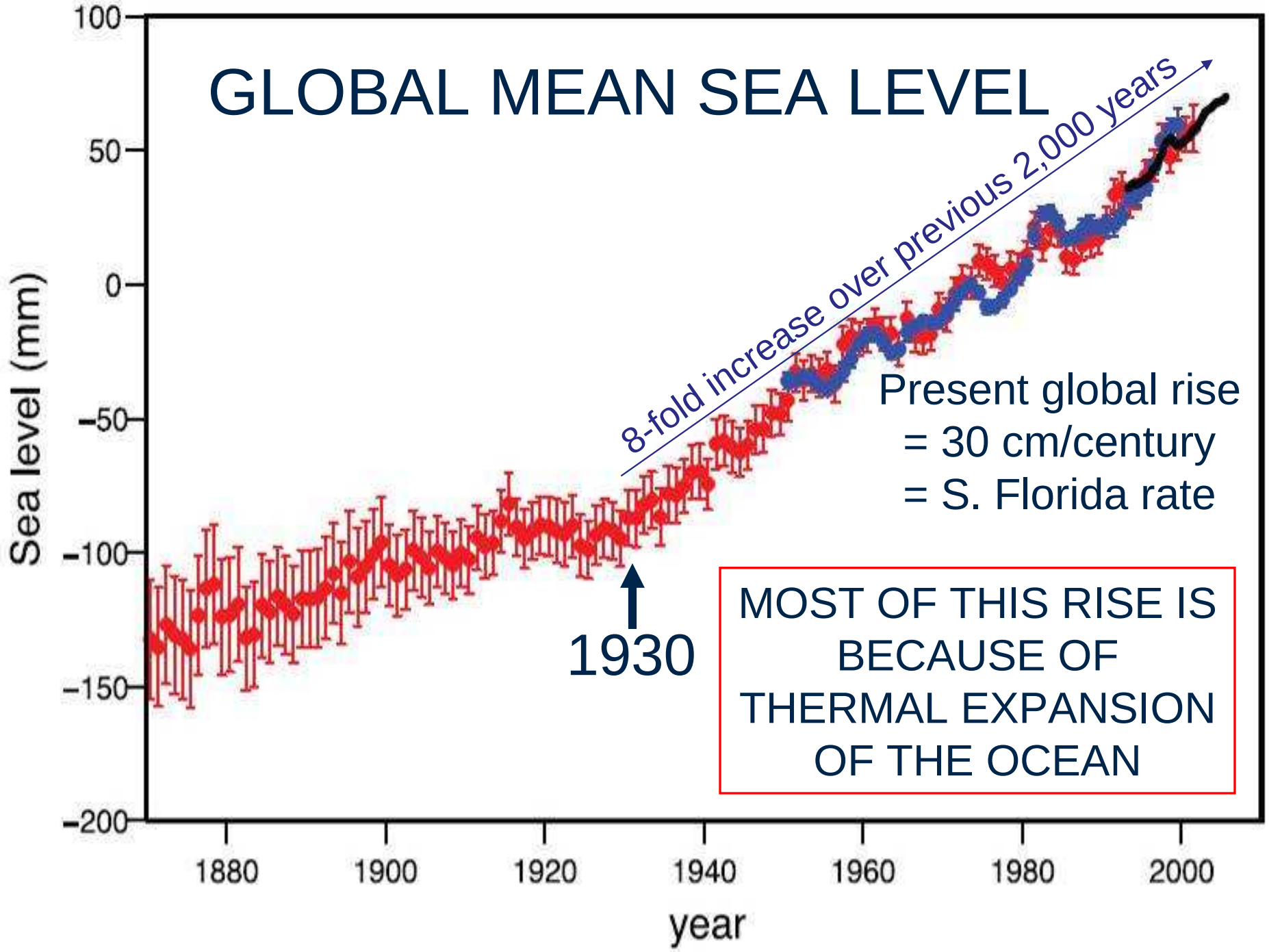


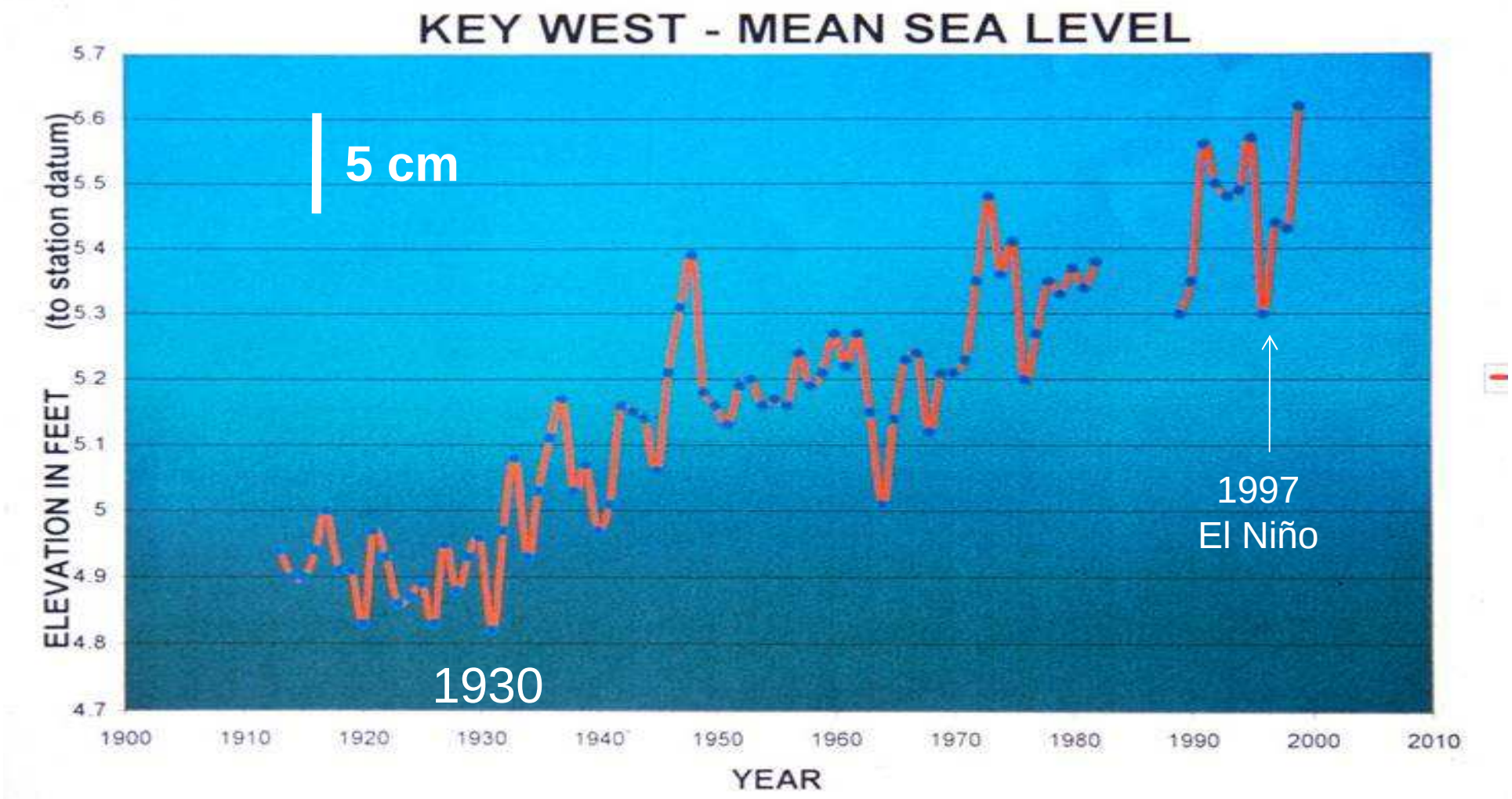
+ 12 Ft.

DATE = 2159

- 3% of land surface remaining.

Prepared by:
Peter Harlem, 2008

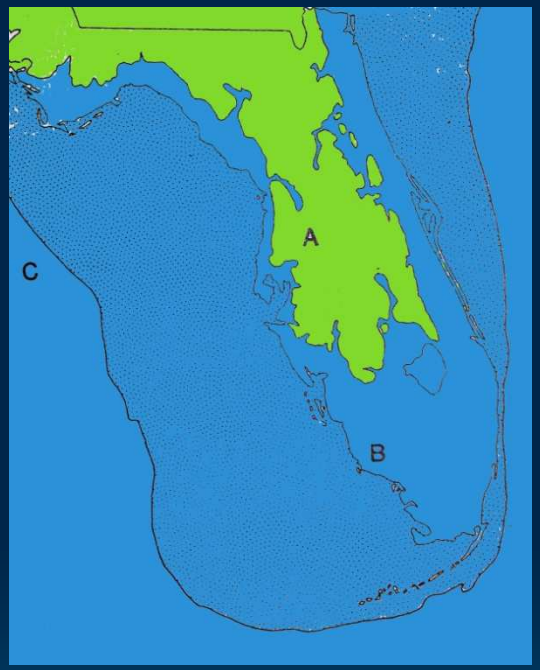

GLOBAL MEAN SEA LEVEL
8-fold increase over previous 2,000 years
Present global rise
= 30 cm/century
= S. Florida rate
1930
MOST OF THIS RISE IS BECAUSE OF THERMAL EXPANSION OF THE OCEAN
Sea level (mm)
100
50
0
−50
−100
−150
−200
1880
1900
1920
1940
1960
1980
2000
year



tide gauge record, NOAA, NOS

South Florida's sea level curve is similar to the global average but with regional anomalies.

FLORIDA THROUGH TIME



120,000 years ago

+ 6 meters

~ ½ from Greenland

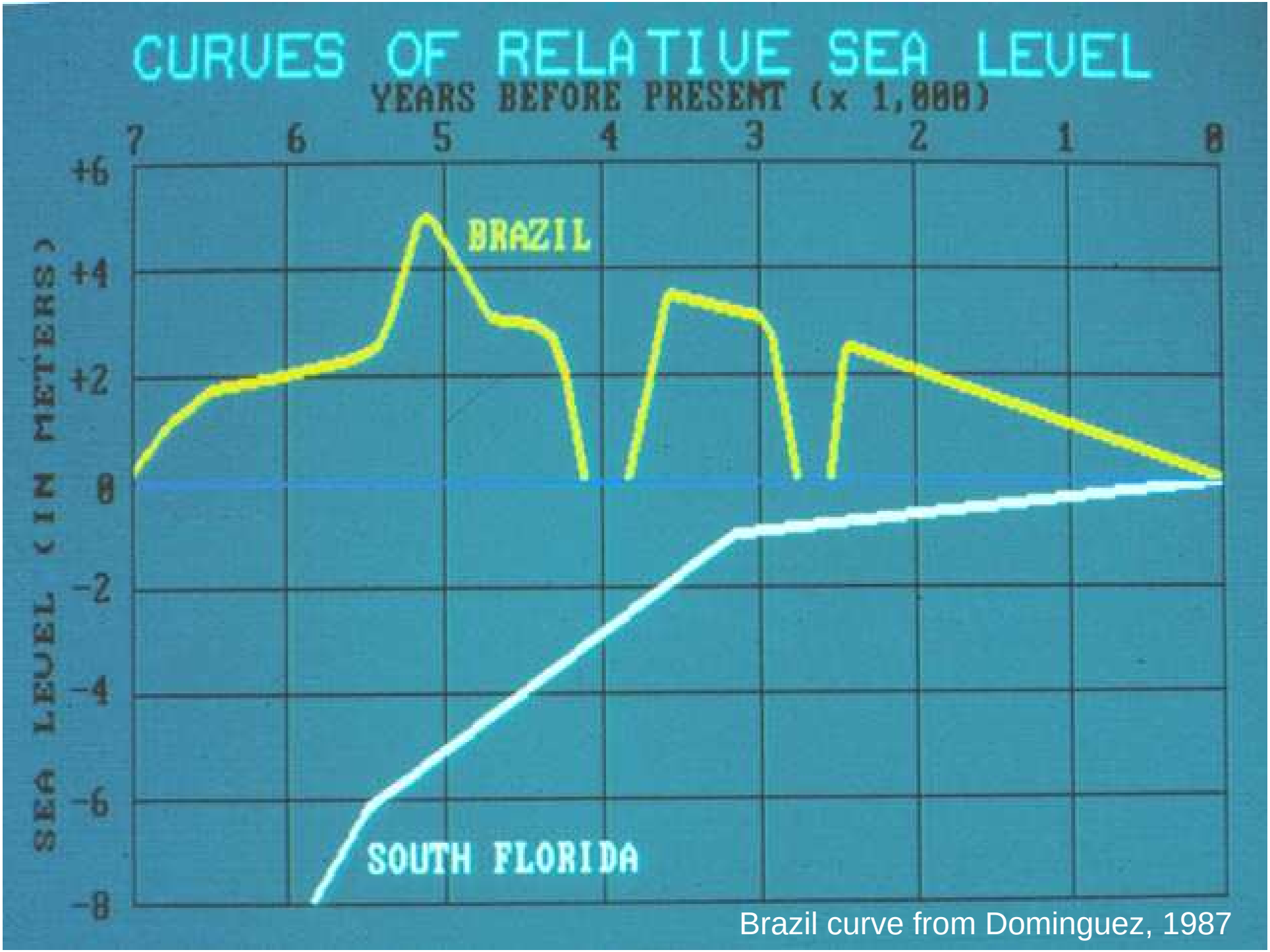
~ ½ from Antarctica

18,000 years ago

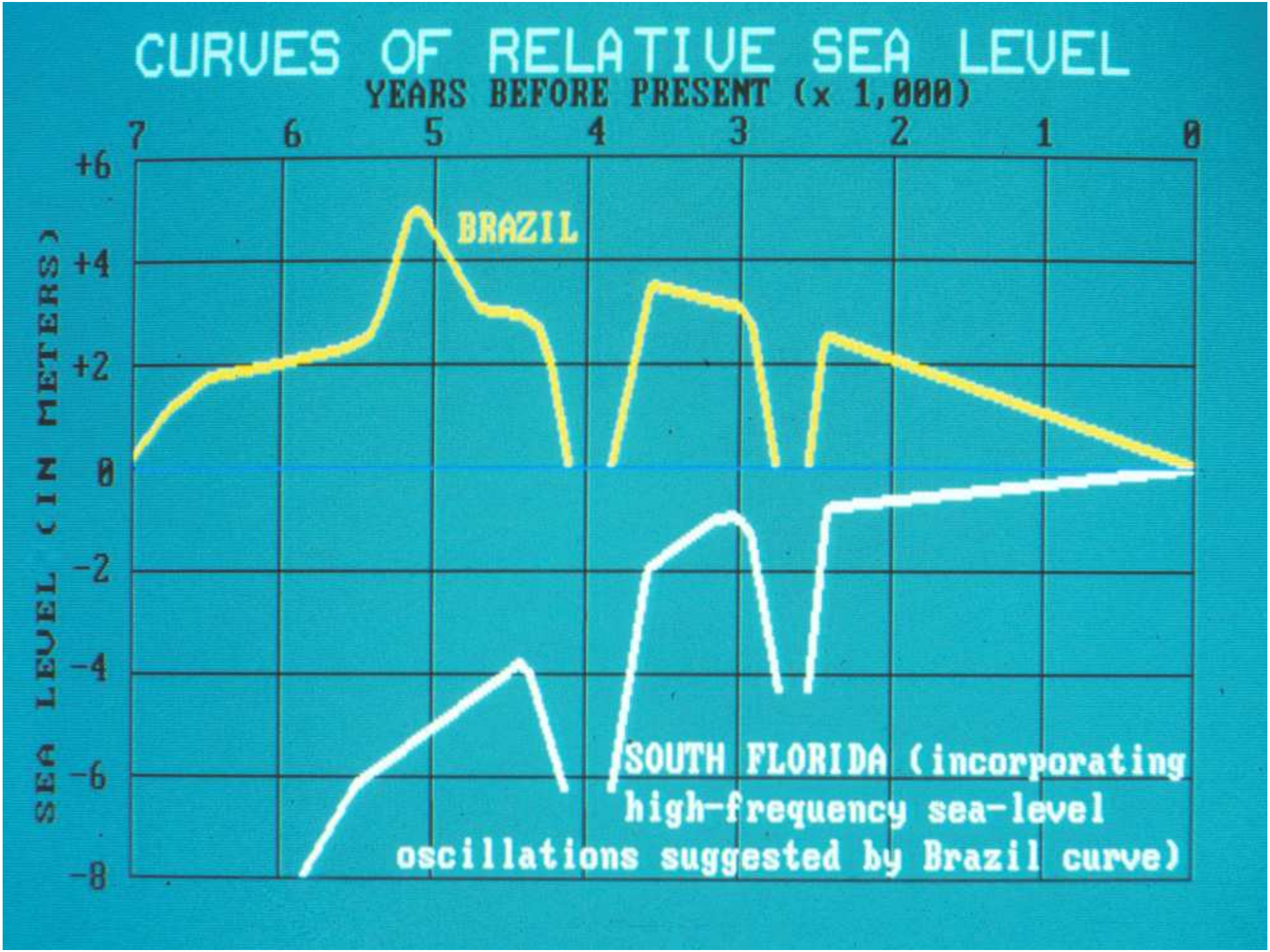
- 120 meters

Today

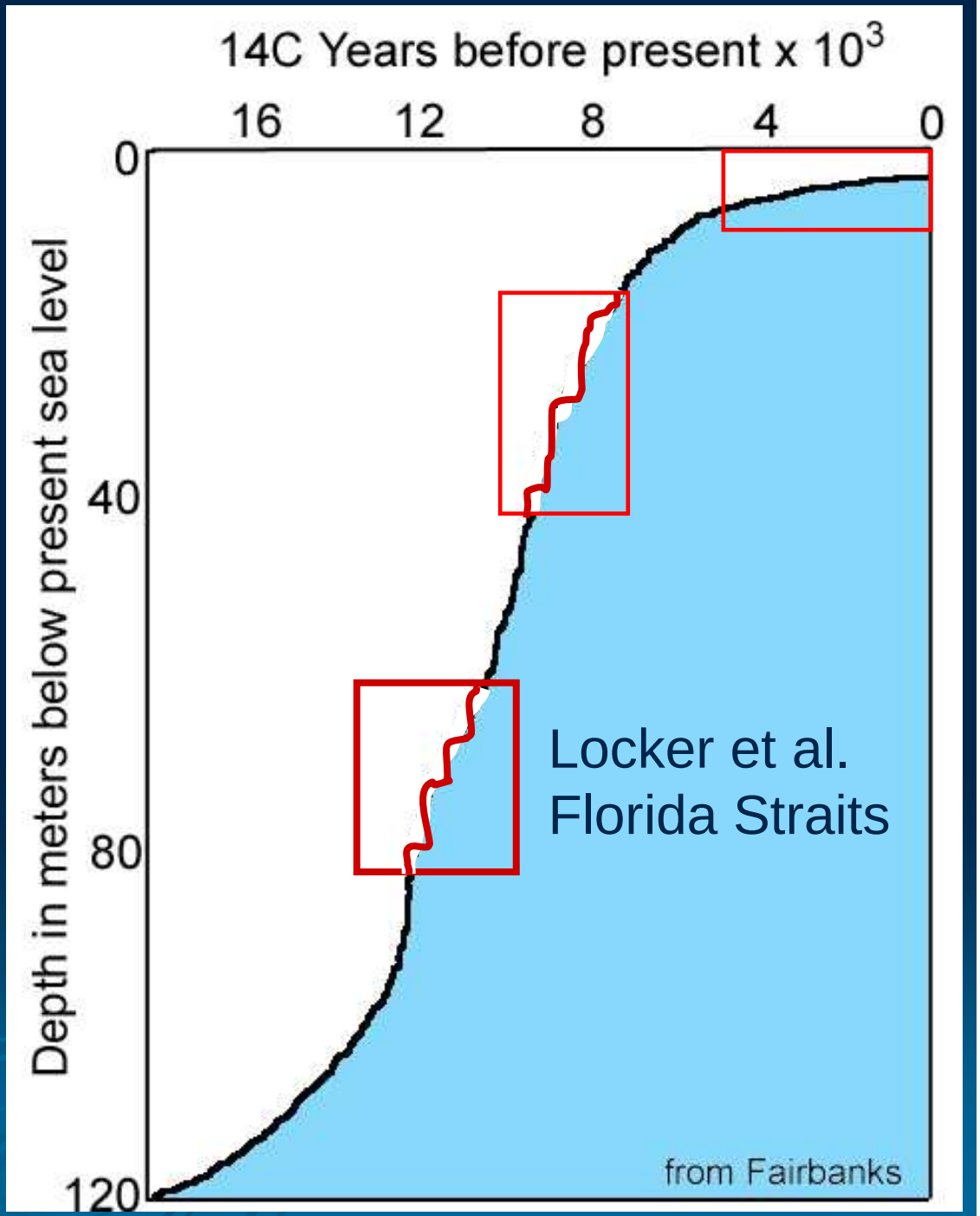
How did this sea level rise occur?



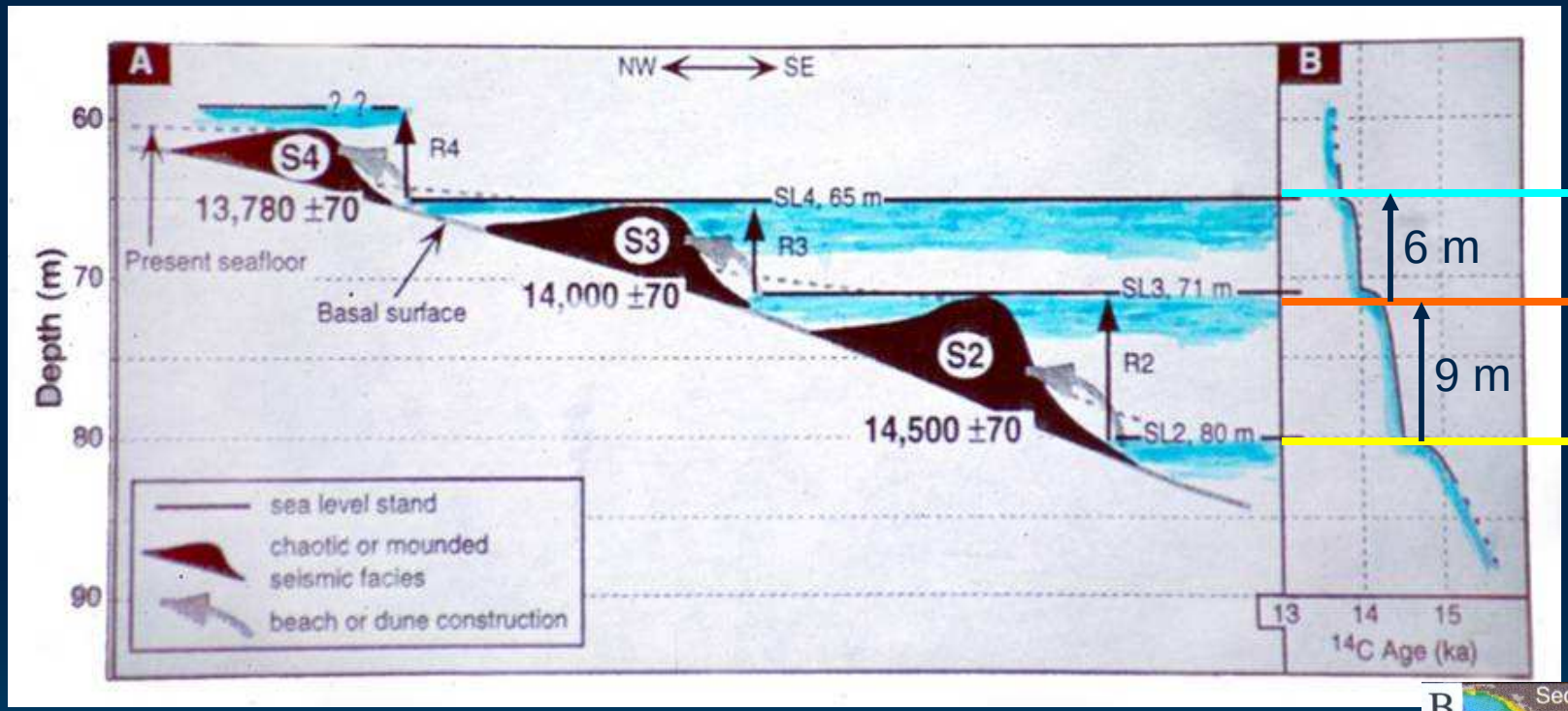
Brazil curve from Dominguez, 1987

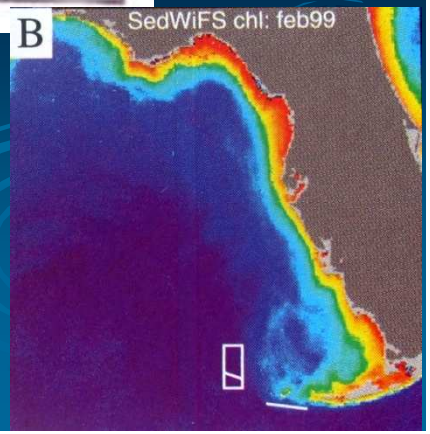

CURVES OF RELATIVE SEA LEVEL
YEARS BEFORE PRESENT (x 1,000)
7
6
5
4
3
2
1
0
+6
+4
+2
0
-2
-4
-6
-8
SEA LEVEL (IN METERS)
BRAZIL
SOUTH FLORIDA (incorporating high-frequency sea-level oscillations suggested by Brazil curve)

The post-glacial sea-level curve is not smooth, but has numerous pauses and steps or high frequency oscillations.



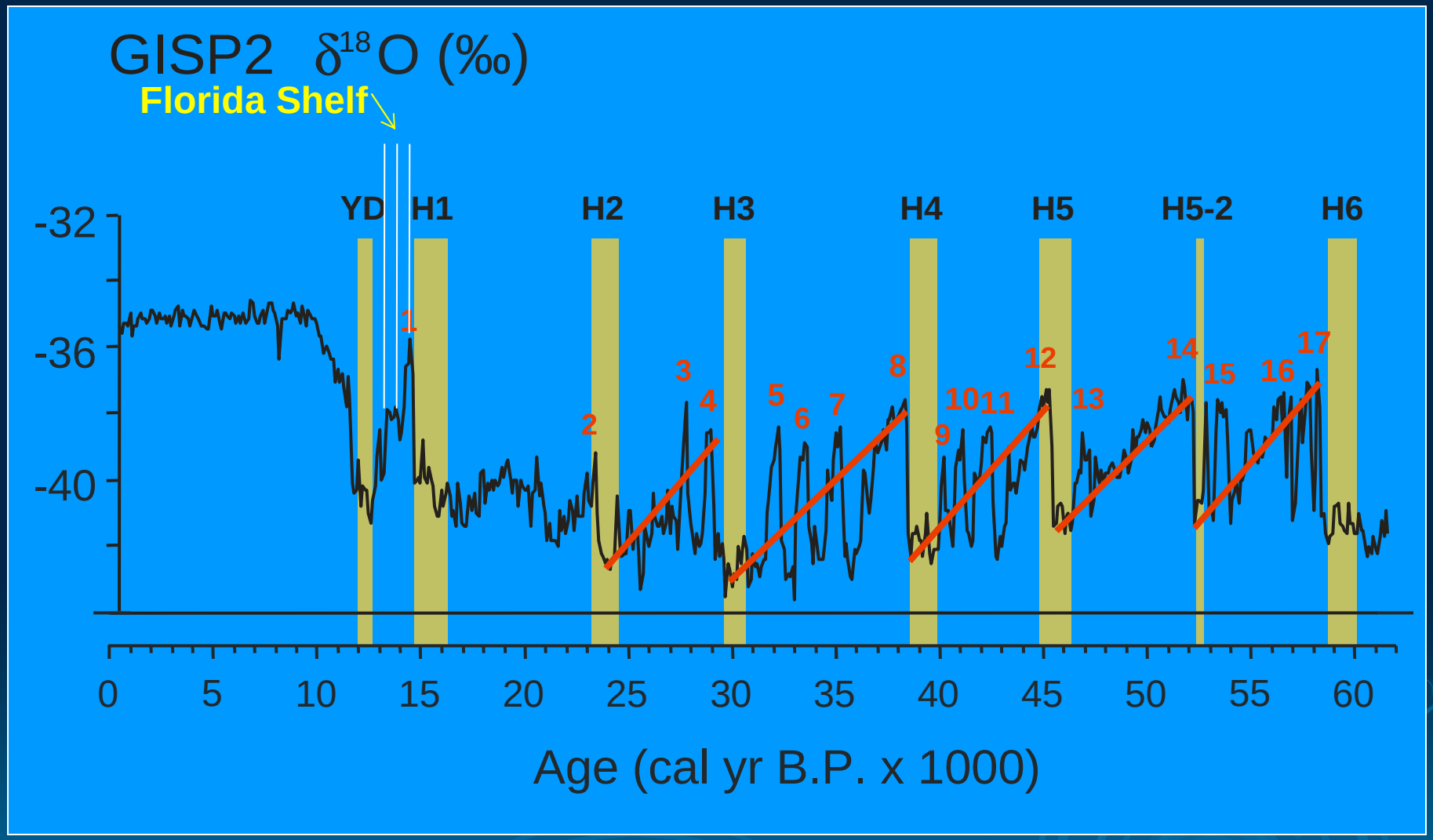
Recent research shows that relative sea level rise is not a simple curve but one with significant stops, drops and rapid rises.



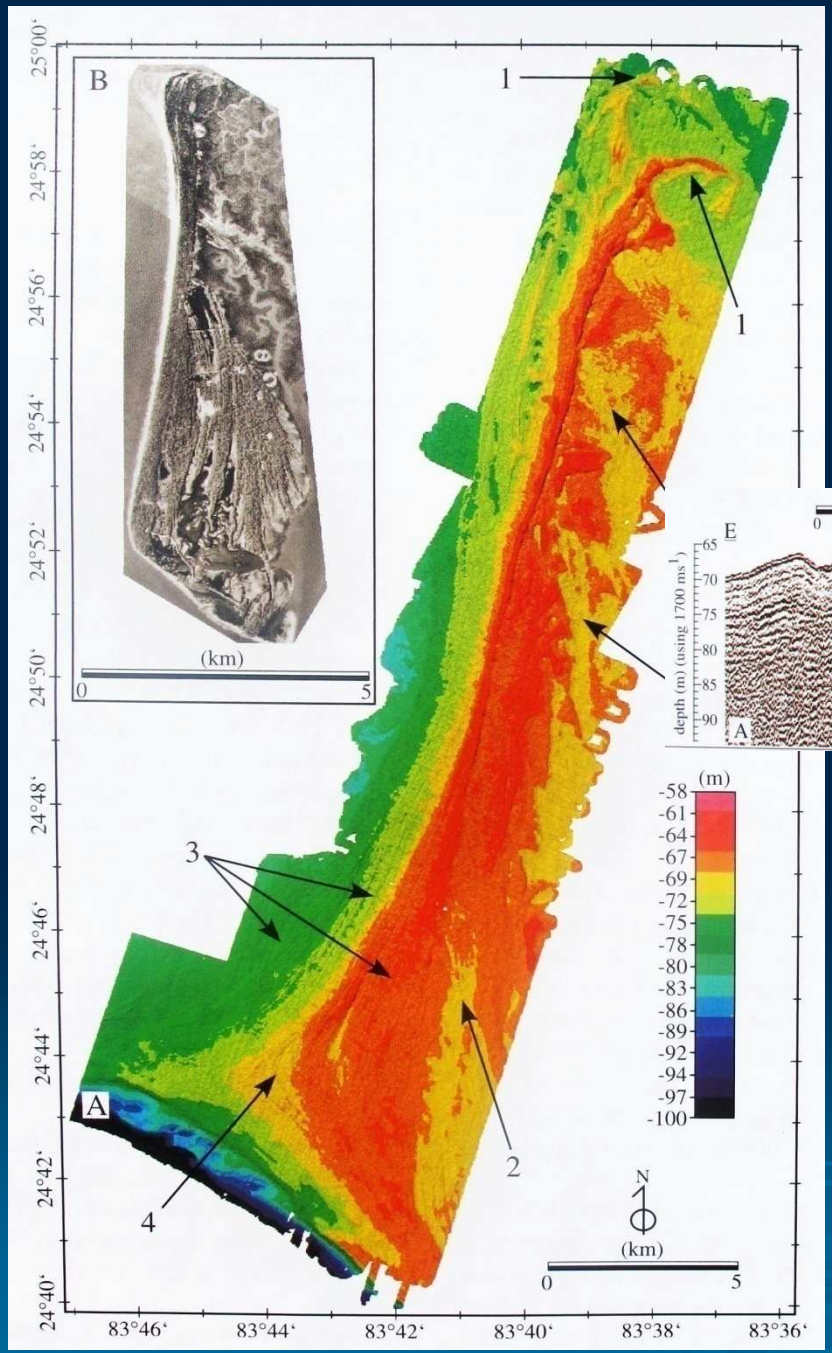


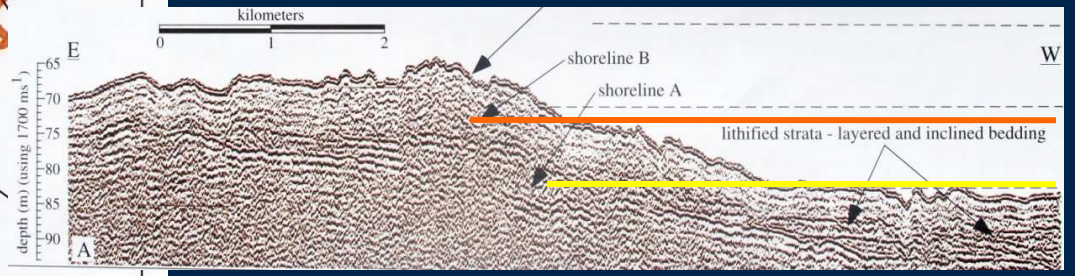
As sea level was first advancing out of the last ice age, it rose in 6-10 meter steps 200-500 years apart, each still stand leaving a distinct beach ridge.

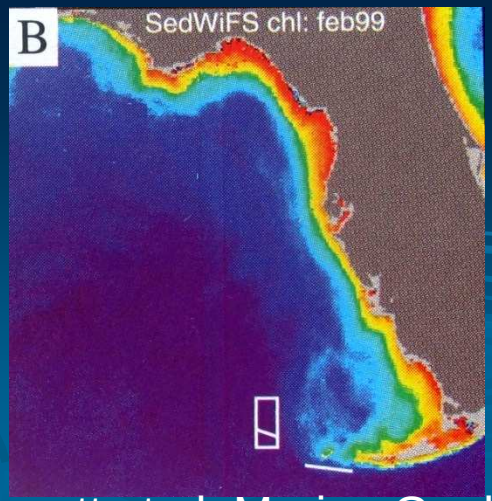
(SW of Key West: S. Locker, et al.)


GISP2 δ18O (‰)
Florida Shelf
YD
H1
H2
H3
H4
H5
H5-2
H6
-32
-36
-40
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
0
5
10
15
20
25
30
35
40
45
50
55
60
Age (cal yr B.P. x 1000)

Pulley Ridge, a deep coral reef capping a drowned barrier island

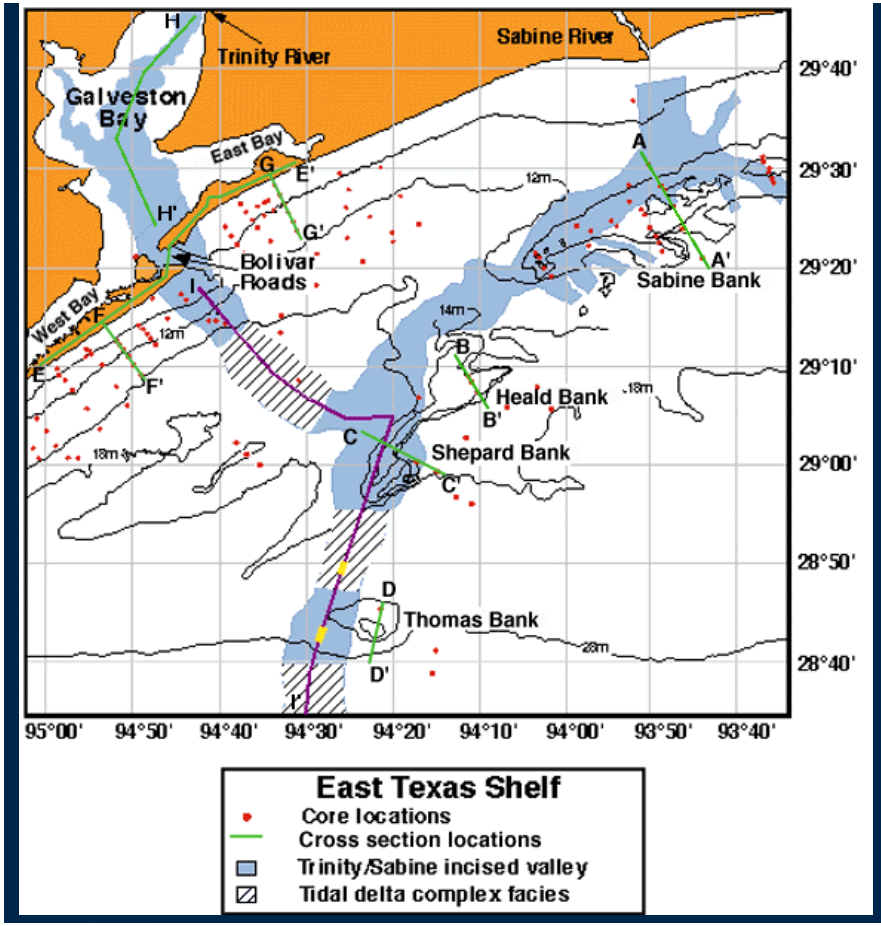


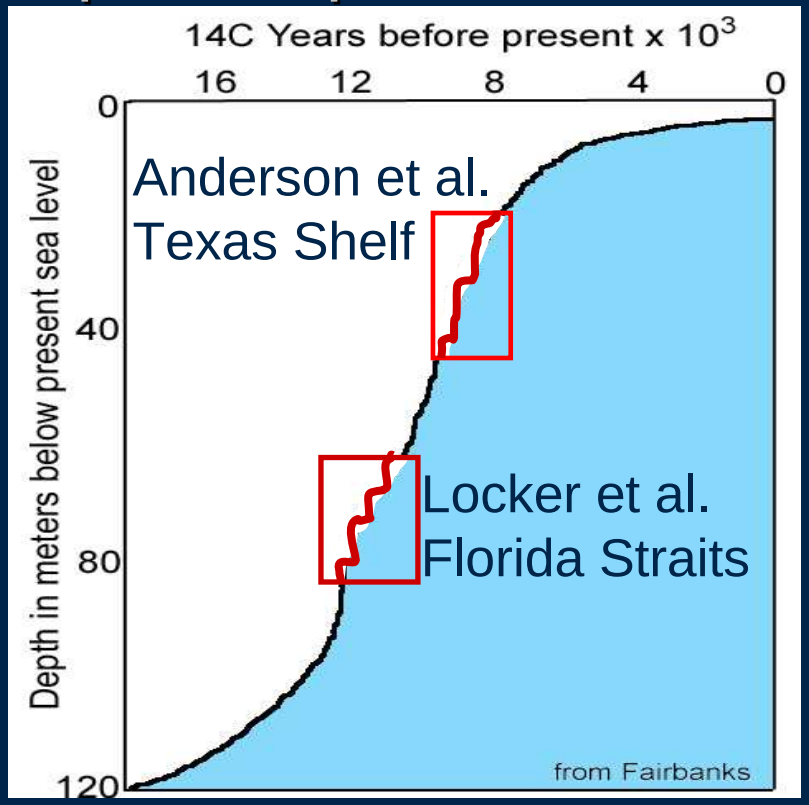


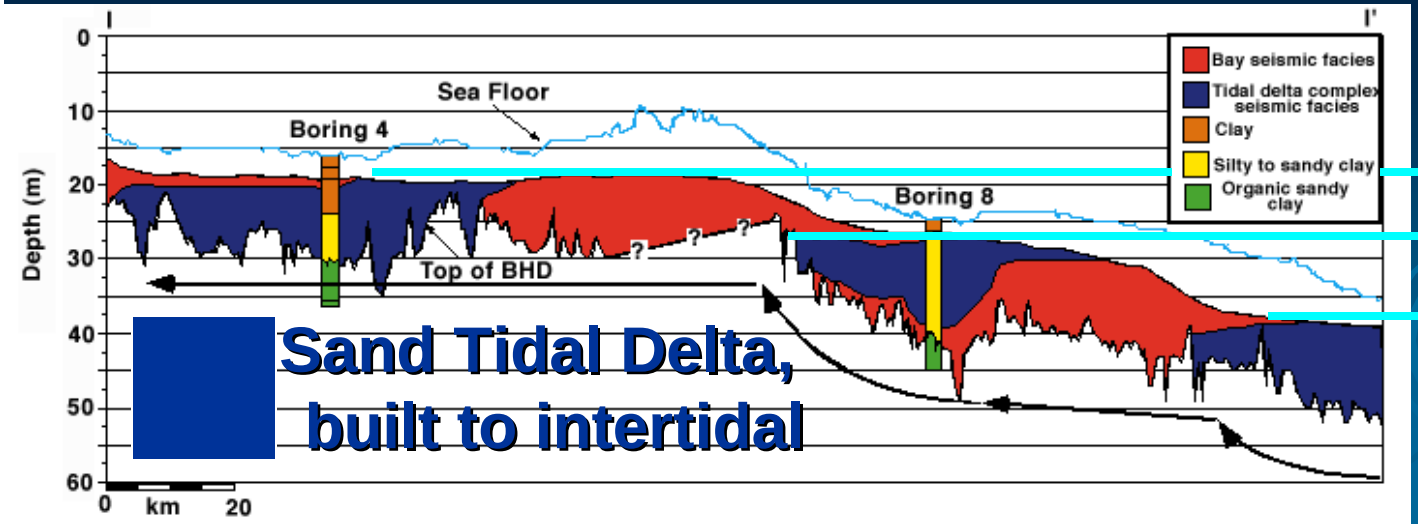


From: Jarrett et al, Marine Geology, 2005

Steps of rapid sea level rise



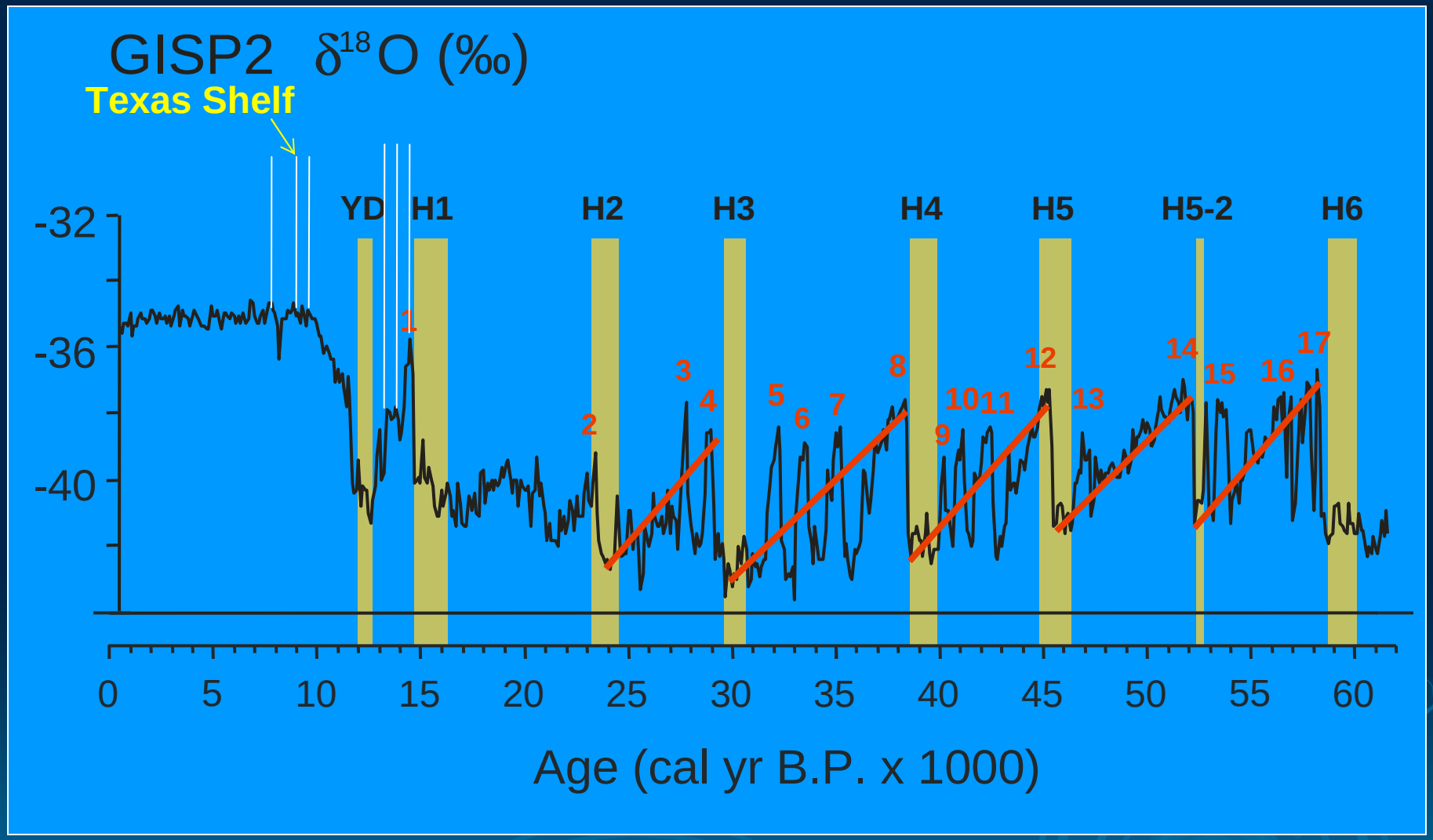




Sand Tidal Delta, built to intertidal

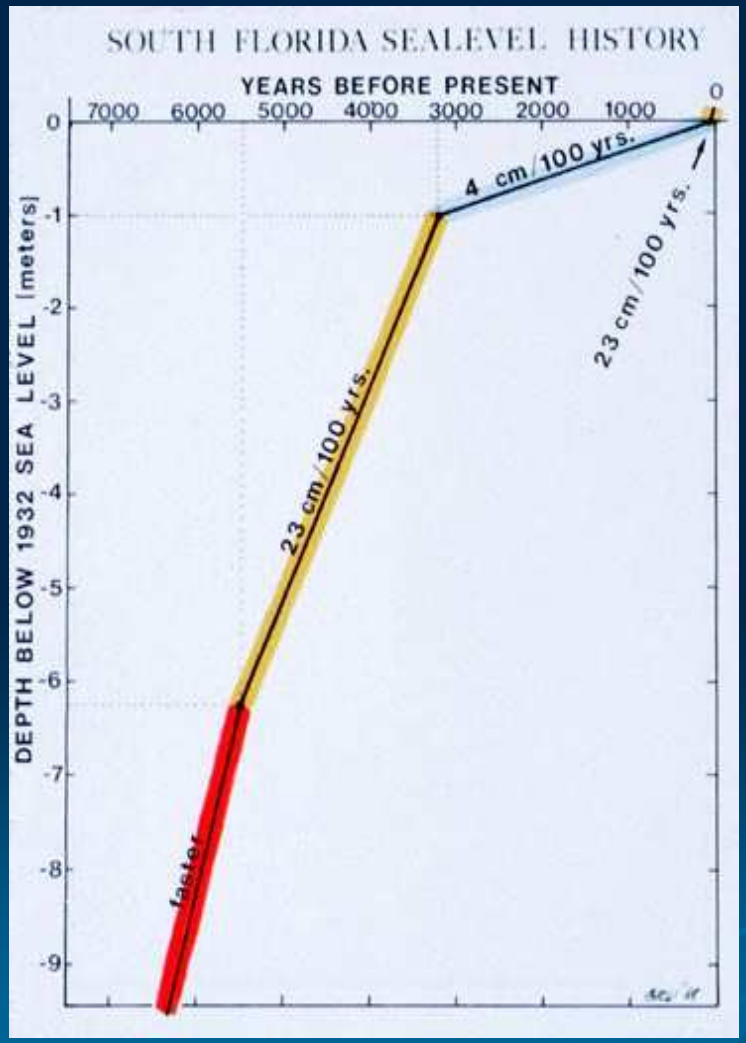
-19m
+8m
-27m
+11m
-38m

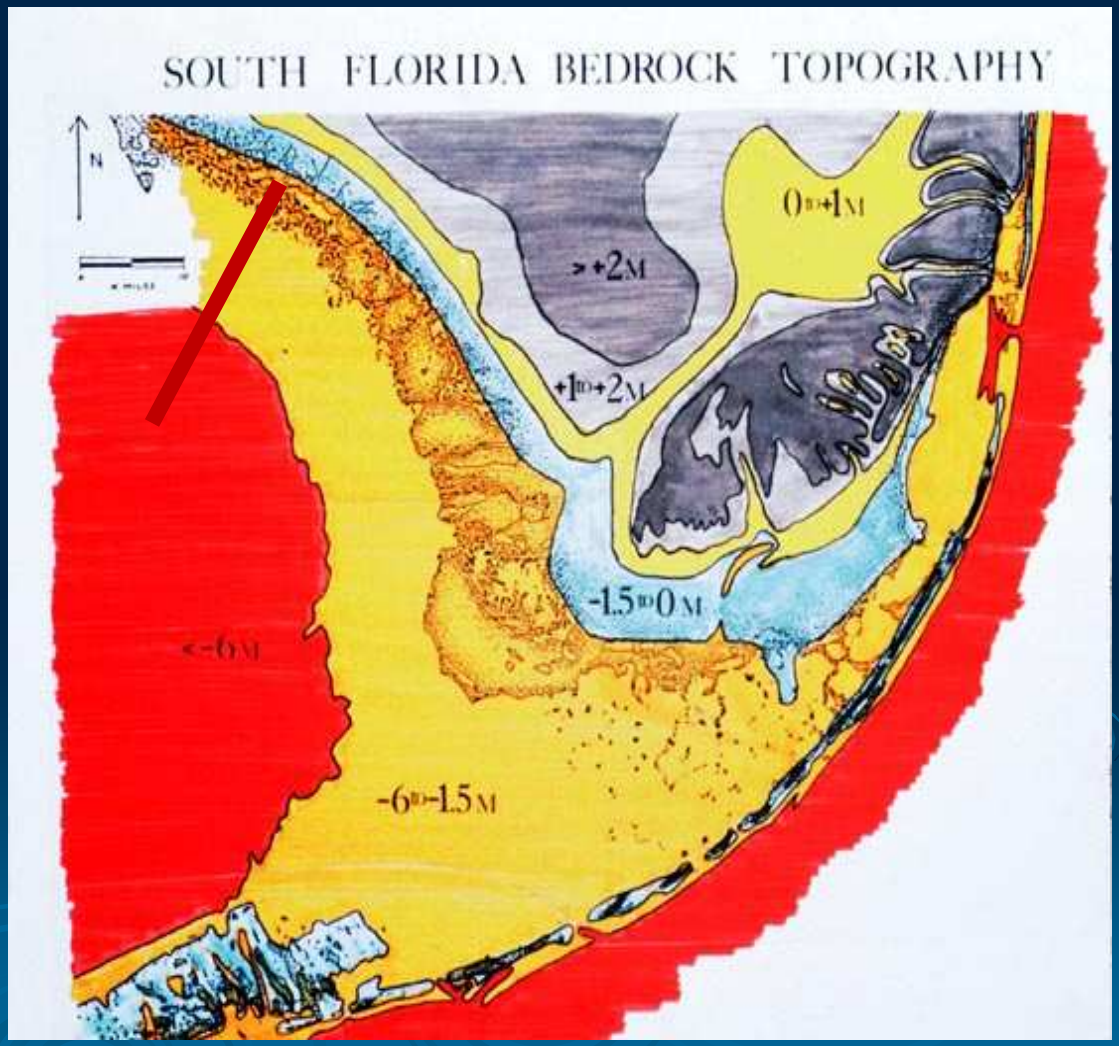
John Anderson,
Rice University



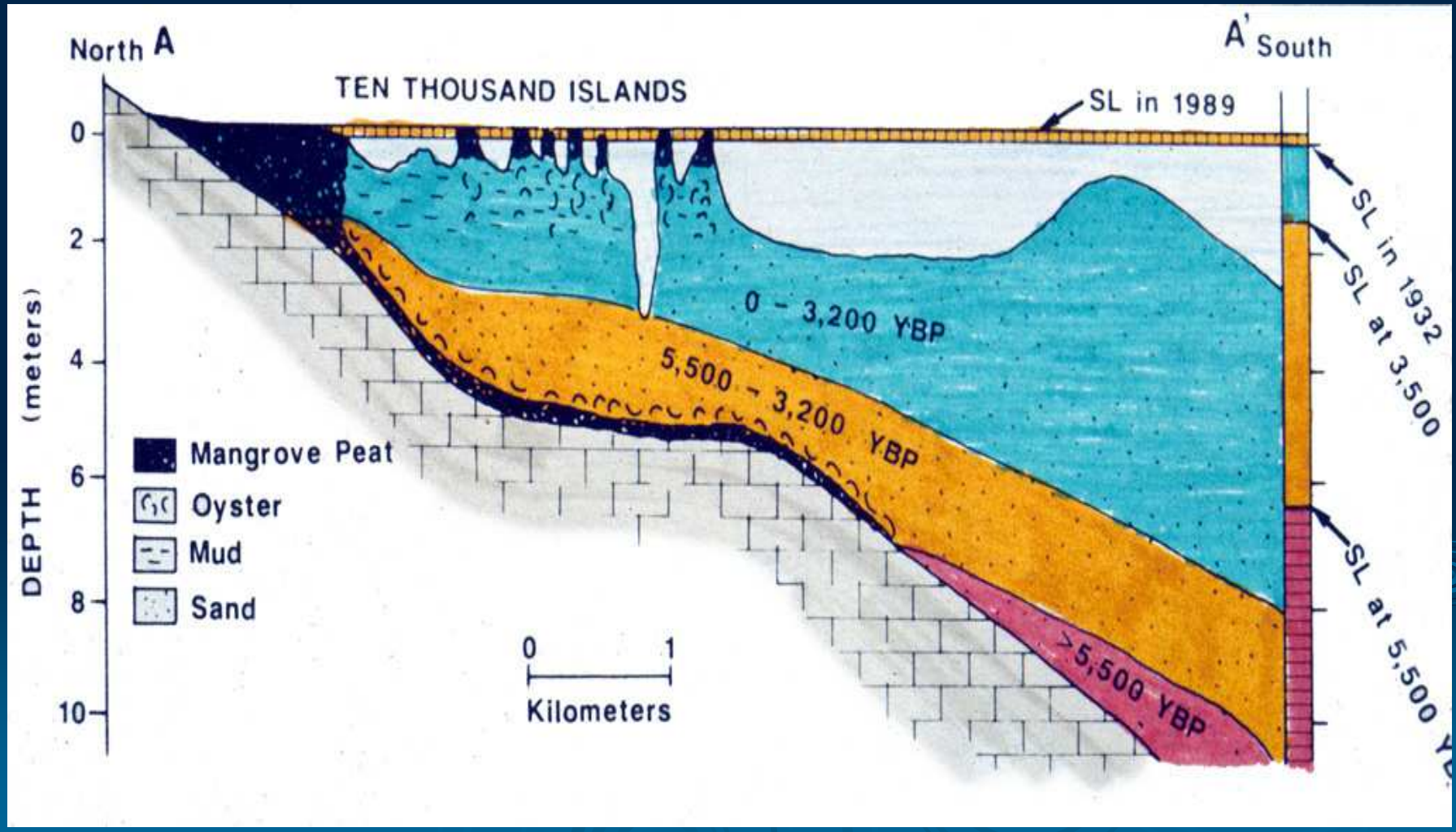
(added to diagram of E.C. Grimm and W.A. Watts, this meeting)

RATE OF SLR IS CRITICAL

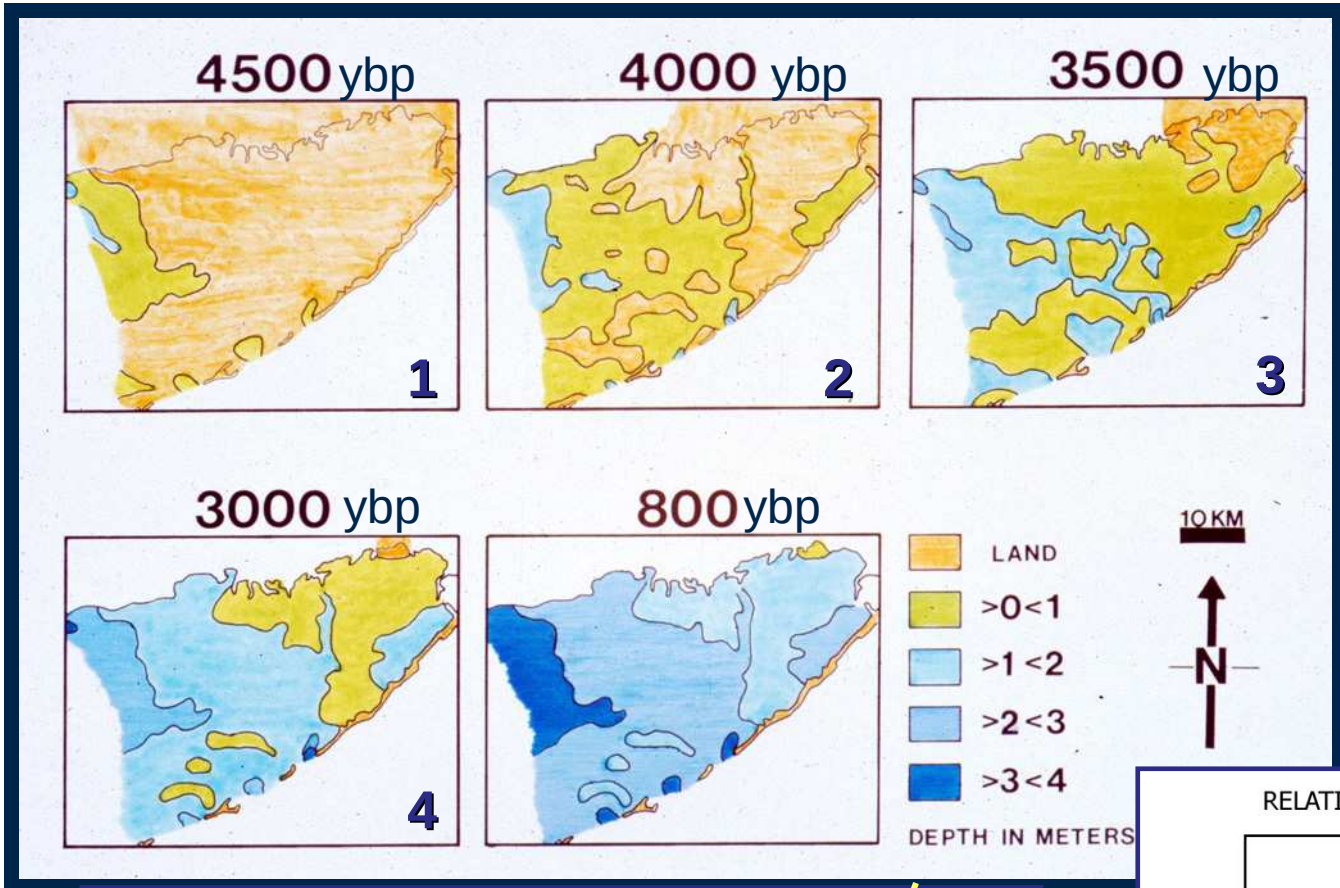




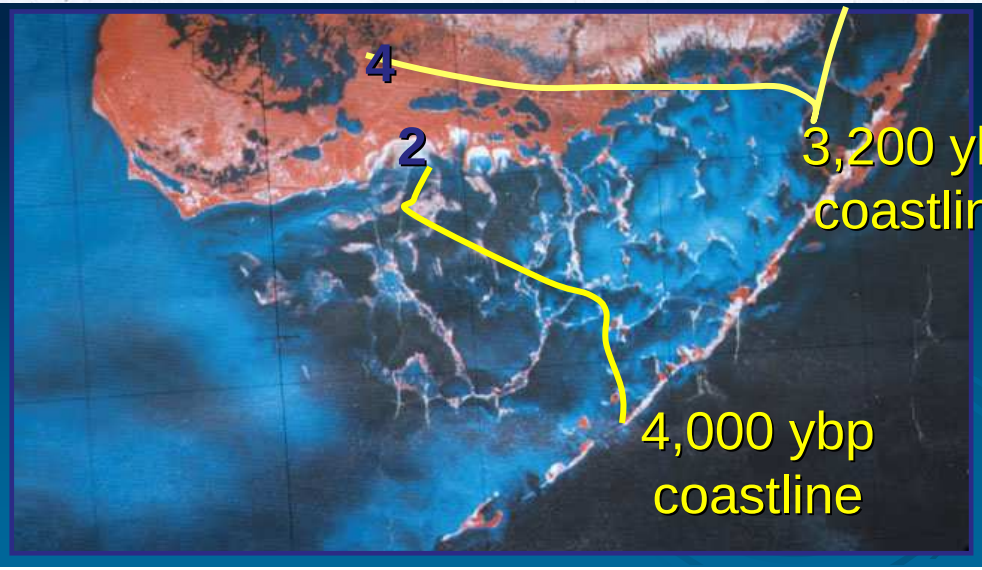
Present environments were present in the past - sometimes

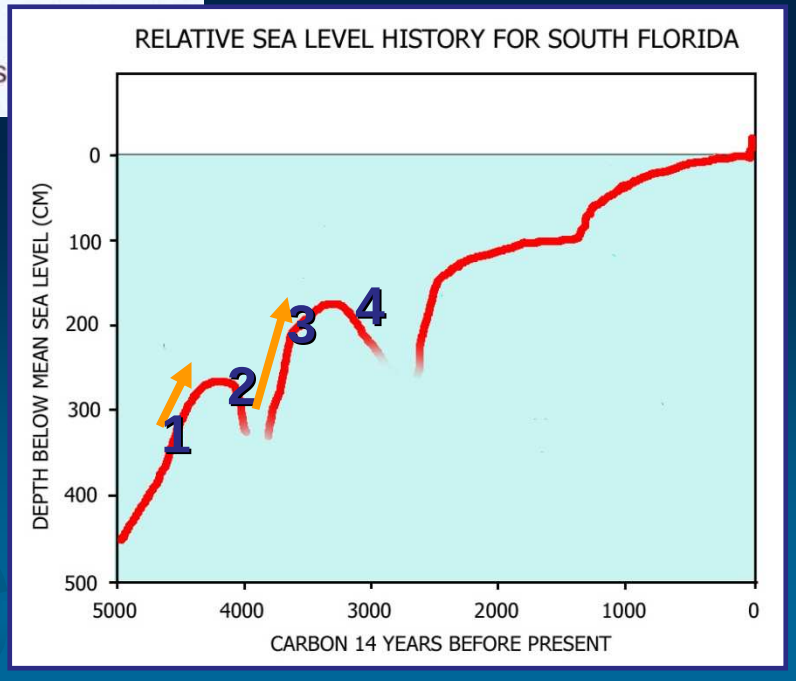


from R.W. Parkinson, 1987

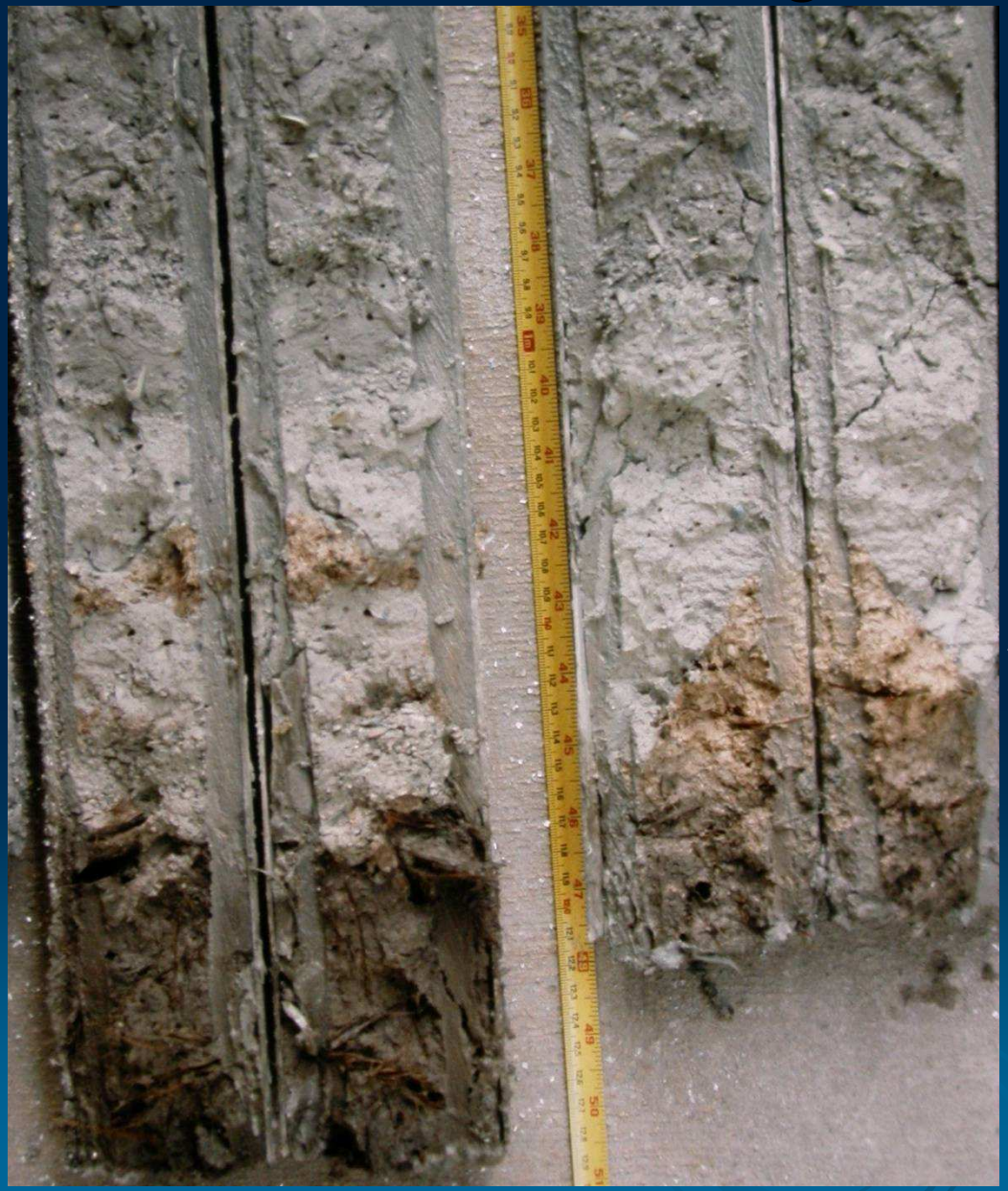


Florida Bay was inundated during two pulses of sea level rise between 4,500 and 3,200 ybp.

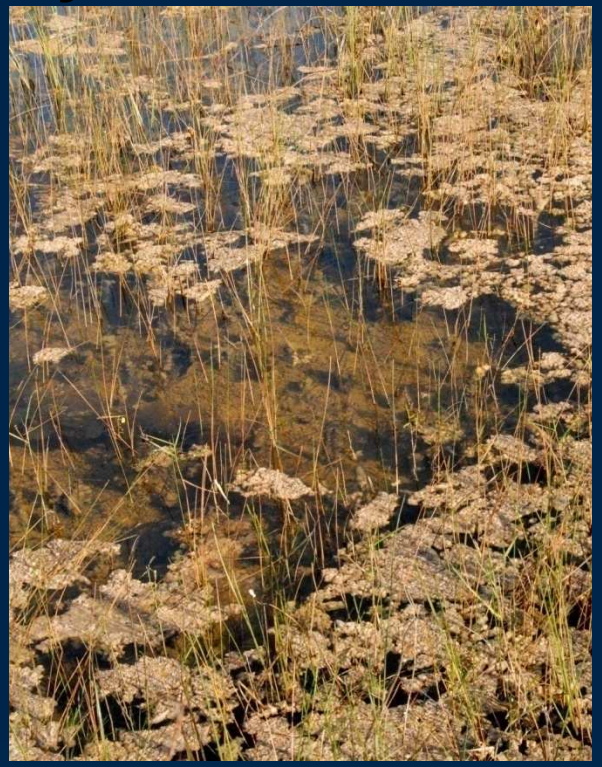




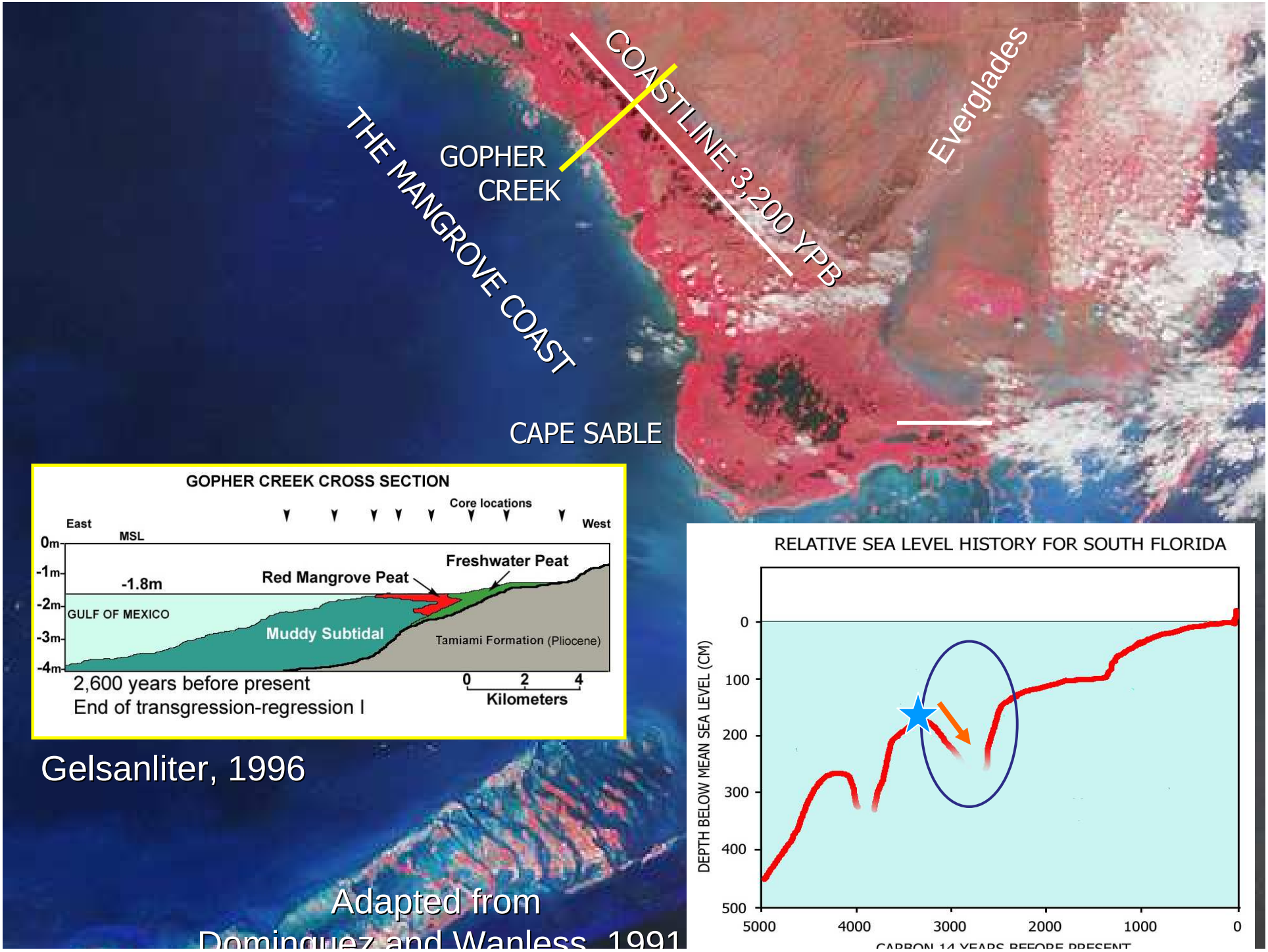
Base of cores through Florida Bay mud banks



Marine carbonate mud bank



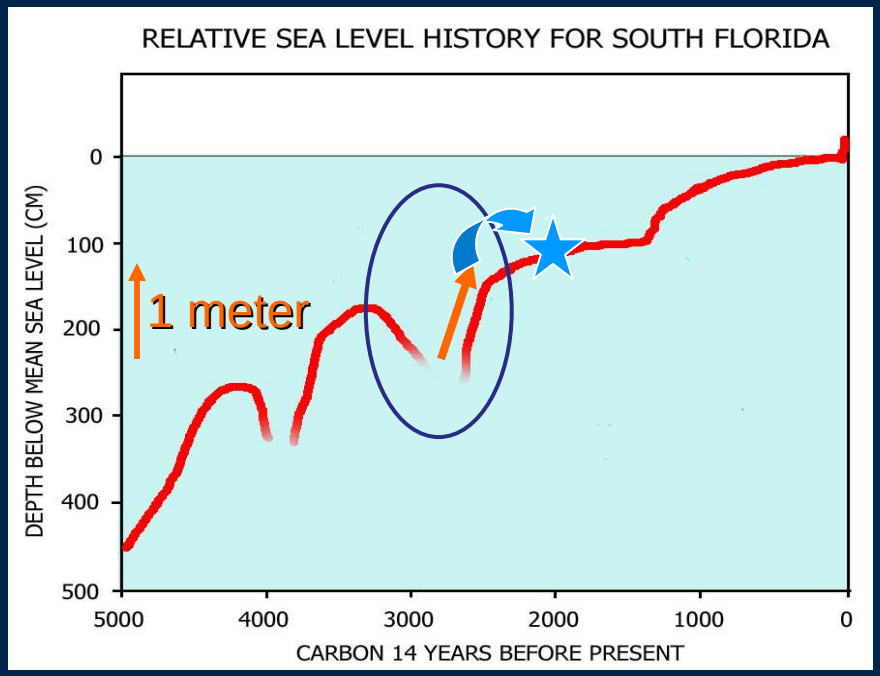
← Freshwater calcite mud = drier Everglades marsh

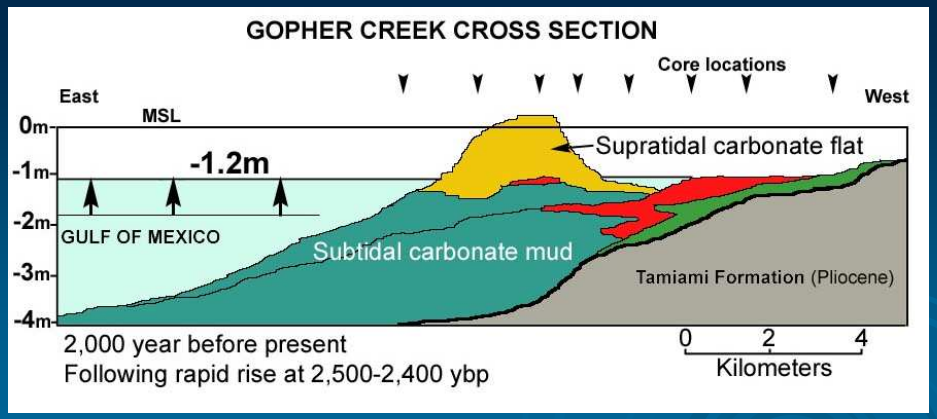


Gelsanliter, 1996

Adapted from
Dominguez and Wanless, 1991

A small, rapid rise 2,500-2,400 ybp; then a 400 year period of intensive sediment erosion and recycling.



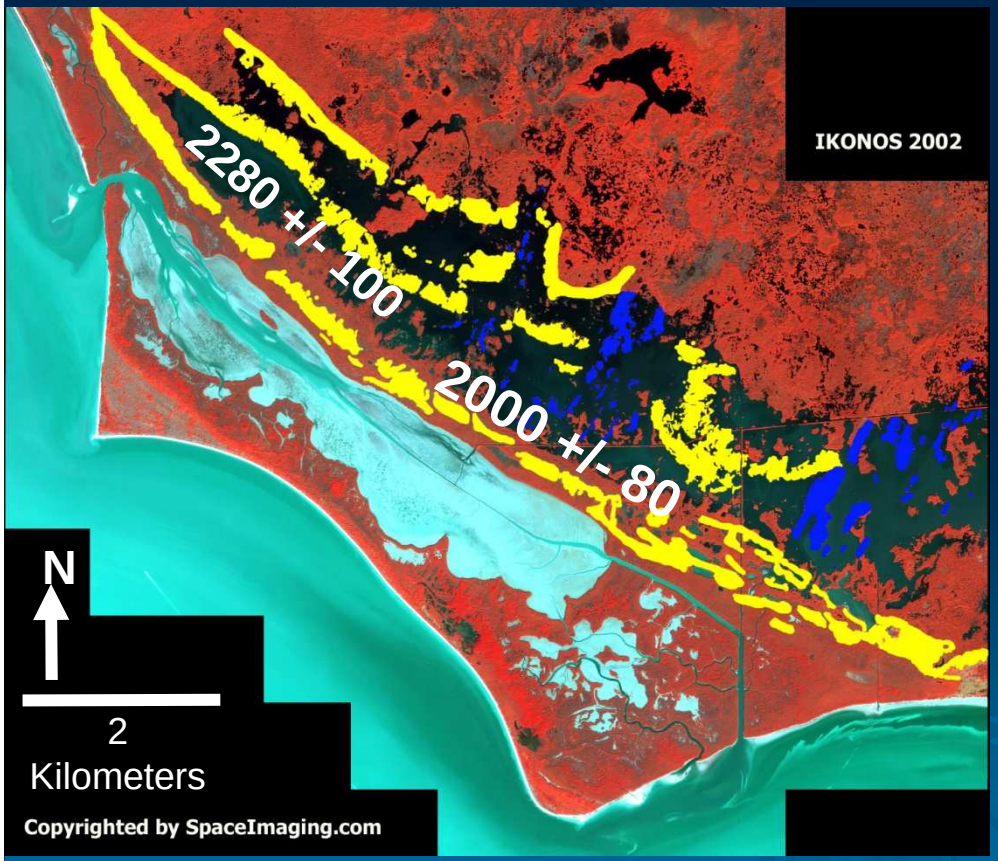


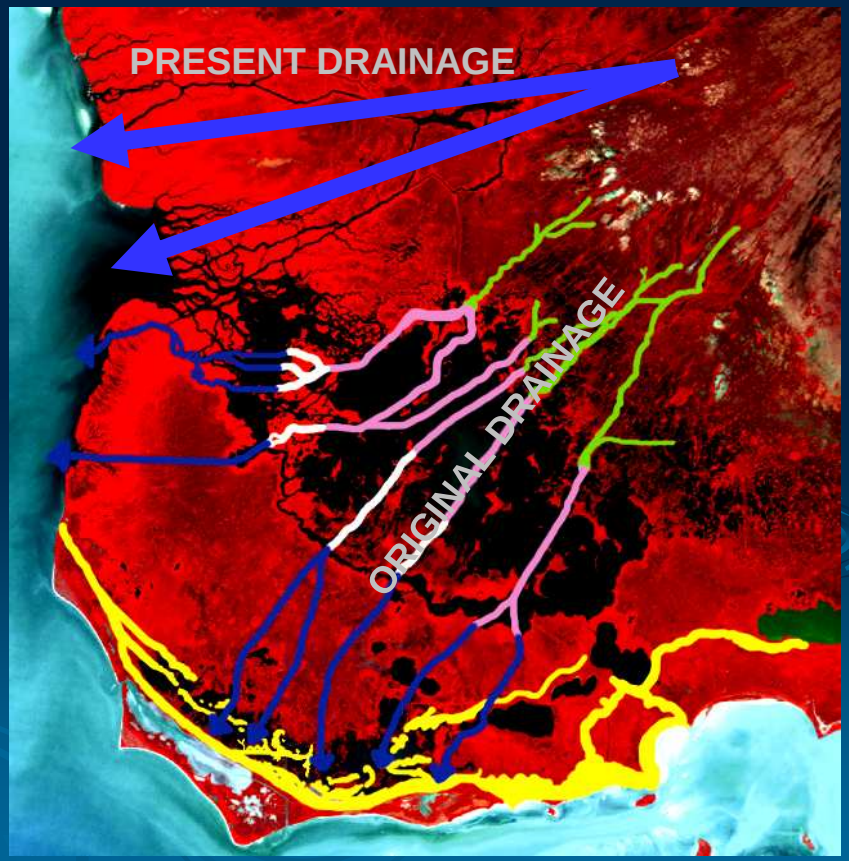
From S. Gelsanliter, 1996

POST-RISE SEDIMENT RECYCLING

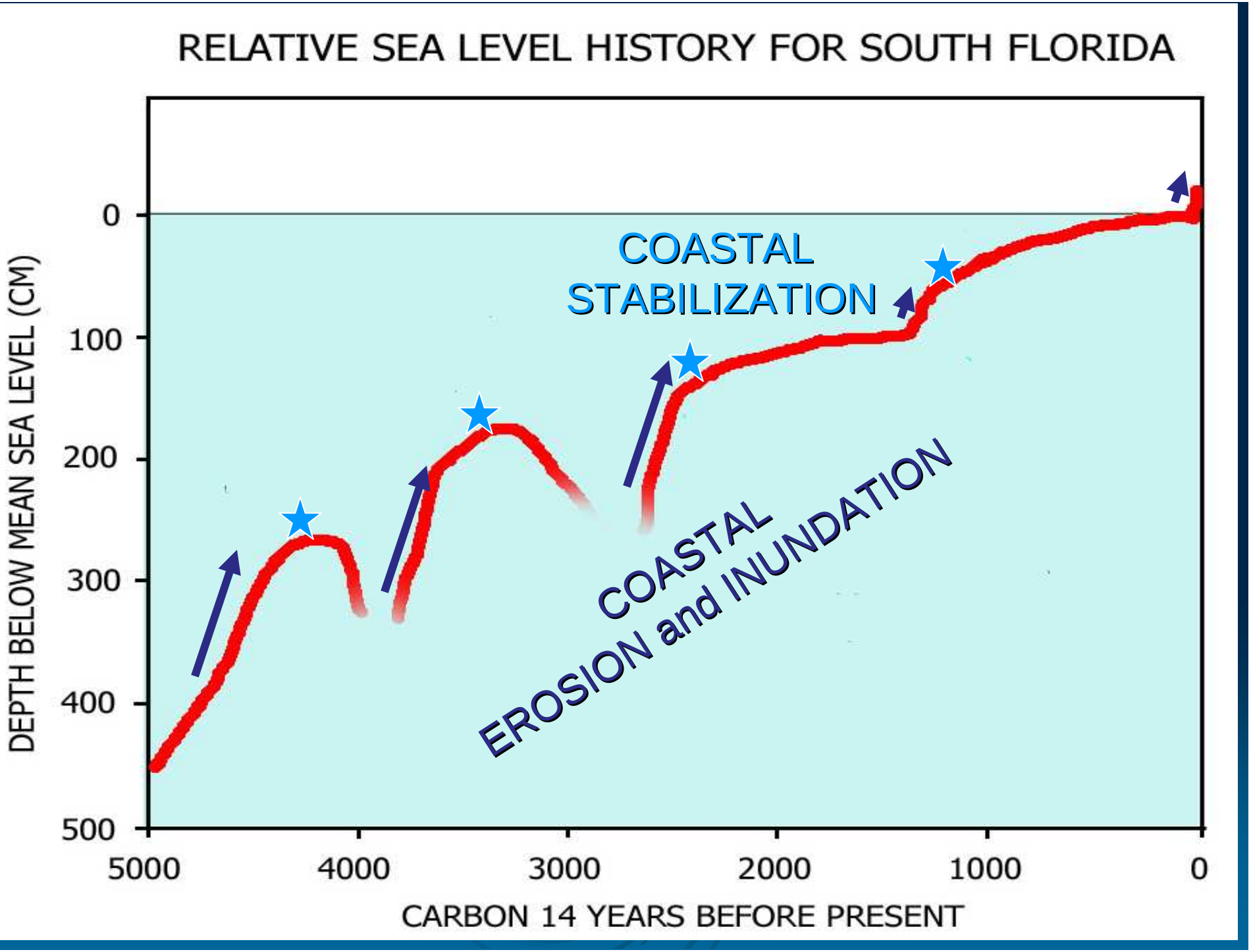
Recycled mud built a series of coastal mud ridges (yellow) during 400 years following this rapid sea level rise step.

These mud ridges gradually blocked the original discharge of the Everglades, forcing new outlets.





From K. Jackson, 2004; Dates Based on Roberts et al. (1977)

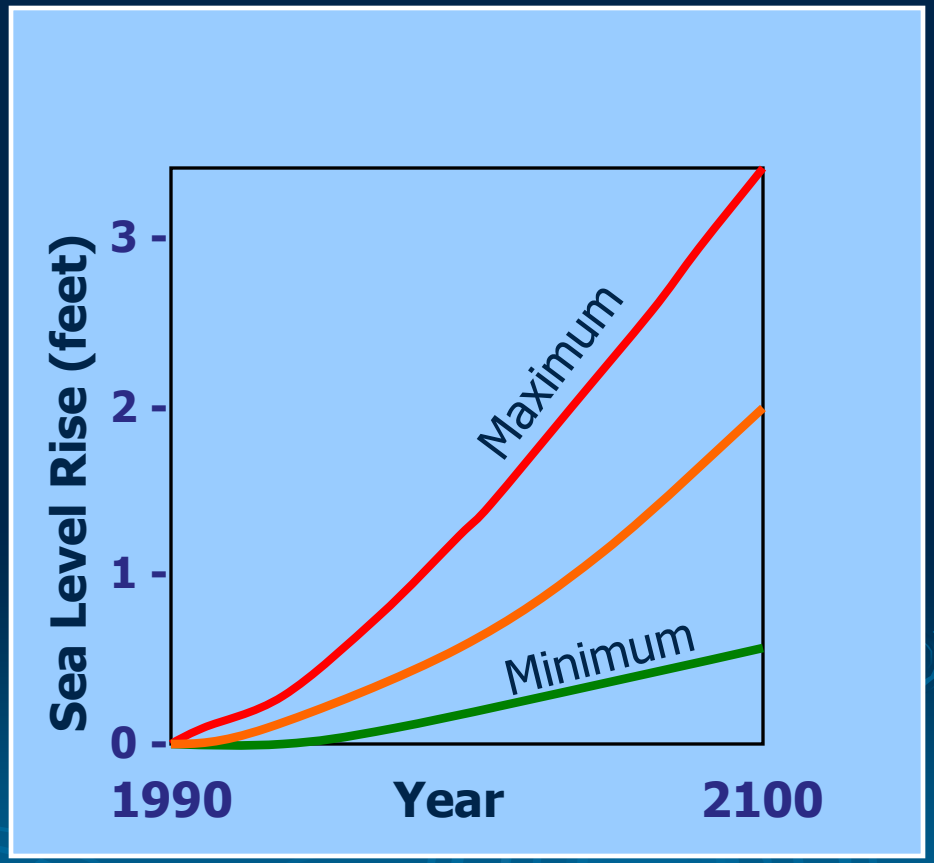

RELATIVE SEA LEVEL HISTORY FOR SOUTH FLORIDA
DEPTH BELOW MEAN SEA LEVEL (CM)
0
100
200
300
400
500
5000
4000
3000
2000
1000
0
CARBON 14 YEARS BEFORE PRESENT
COASTAL STABILIZATION
COASTAL EROSION and INUNDATION

Climate, Ice and Sea Level Do Not Respond Gradually to stresses

- When stressed and destabilized, climate, polar ice and sea level will, at some point, reach a tipping point and undergo rapid change towards a new state.
- IPCC and other climate and sea level forecasts assume gradual linear responses and changes - not sudden tipping points, switches to new states, rapidly reinforcing feedbacks, and rapid rises.

Forecasts have used linear responses.

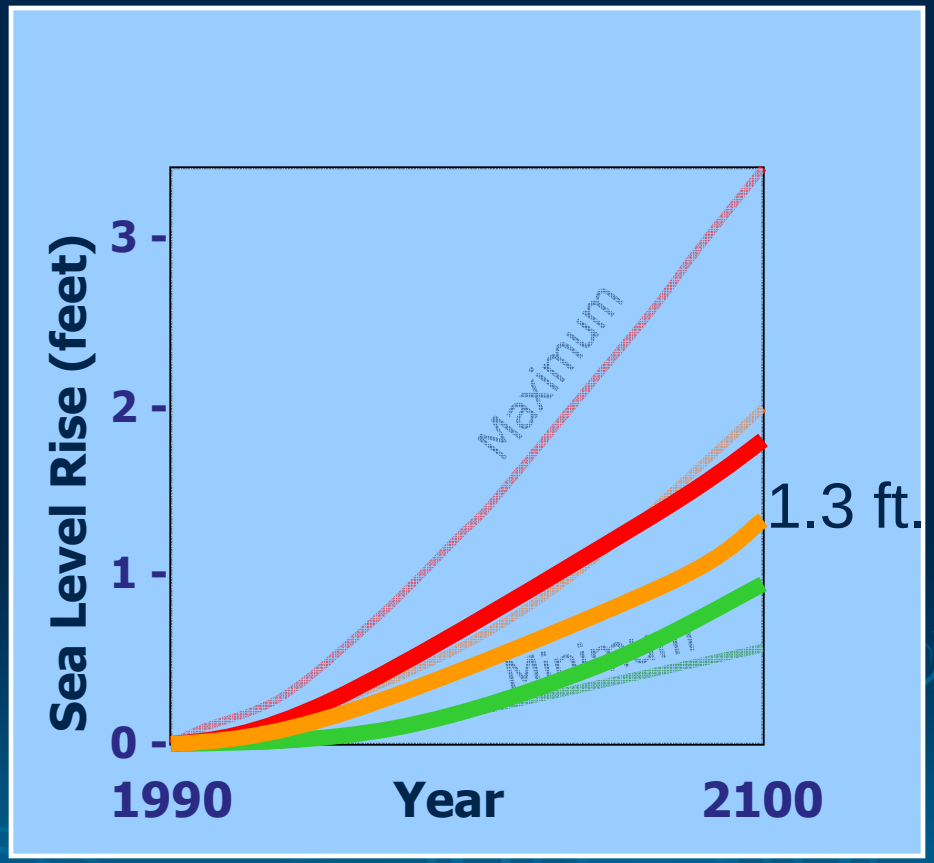
- Because of global warming, the 2001 UN Intergovernmental Panel on Climate Change forecasted a 2-foot further rise of sea level by 2100.
- These projections assumed a gradual linear response of climate ice melt, and sea level.



IPCC, 2001

The 2007 IPCC Report reduced the median projection to ~1.3 feet

- This reduced projection has over half the sea level rise as because of warming (expansion) of the ocean water
- i.e. only 10-25 cm would be from melting ice input by glacial and ice cap ice.

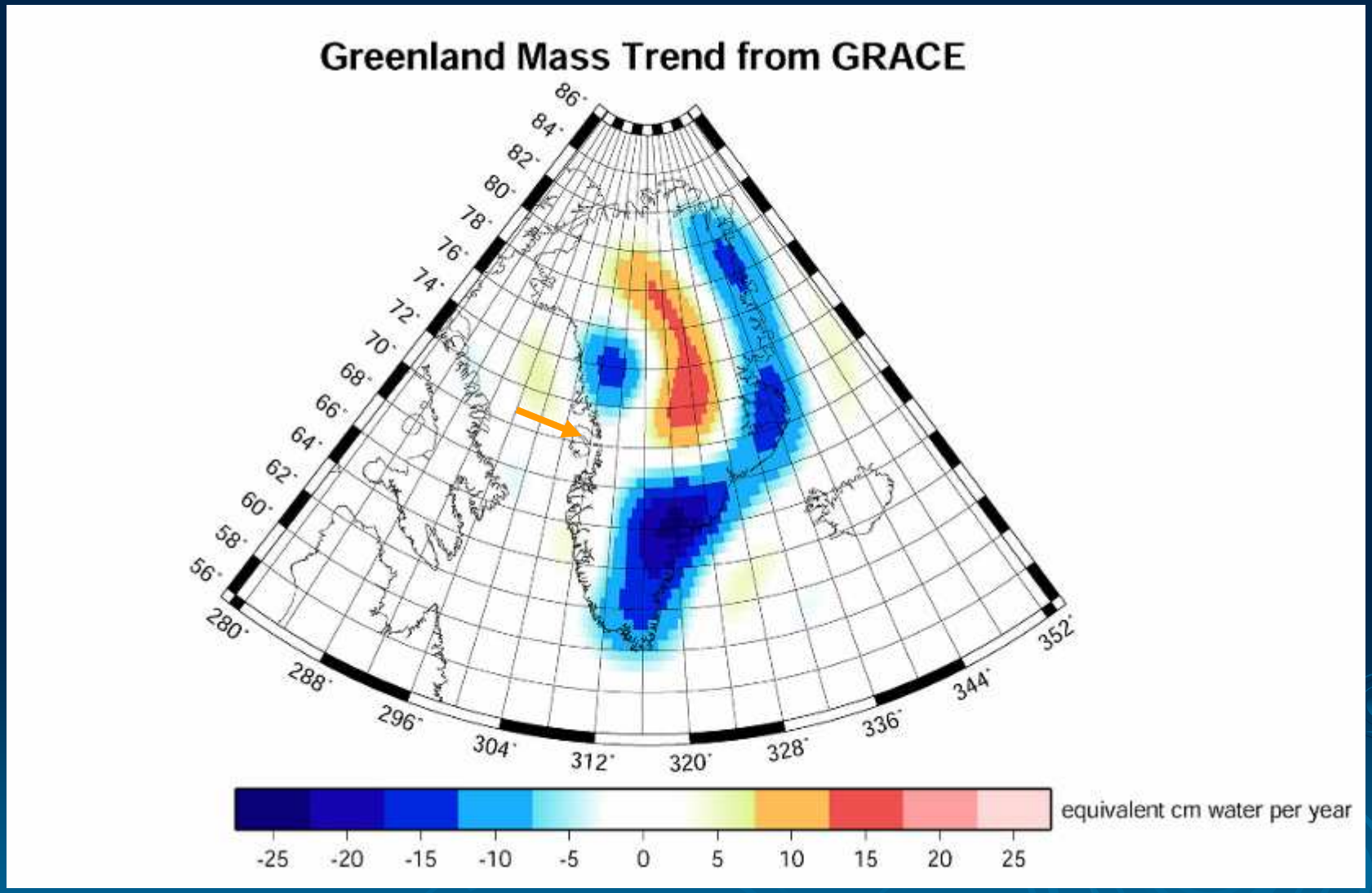


IPCC, 2001

The Answers to Florida's future lie in the Arctic

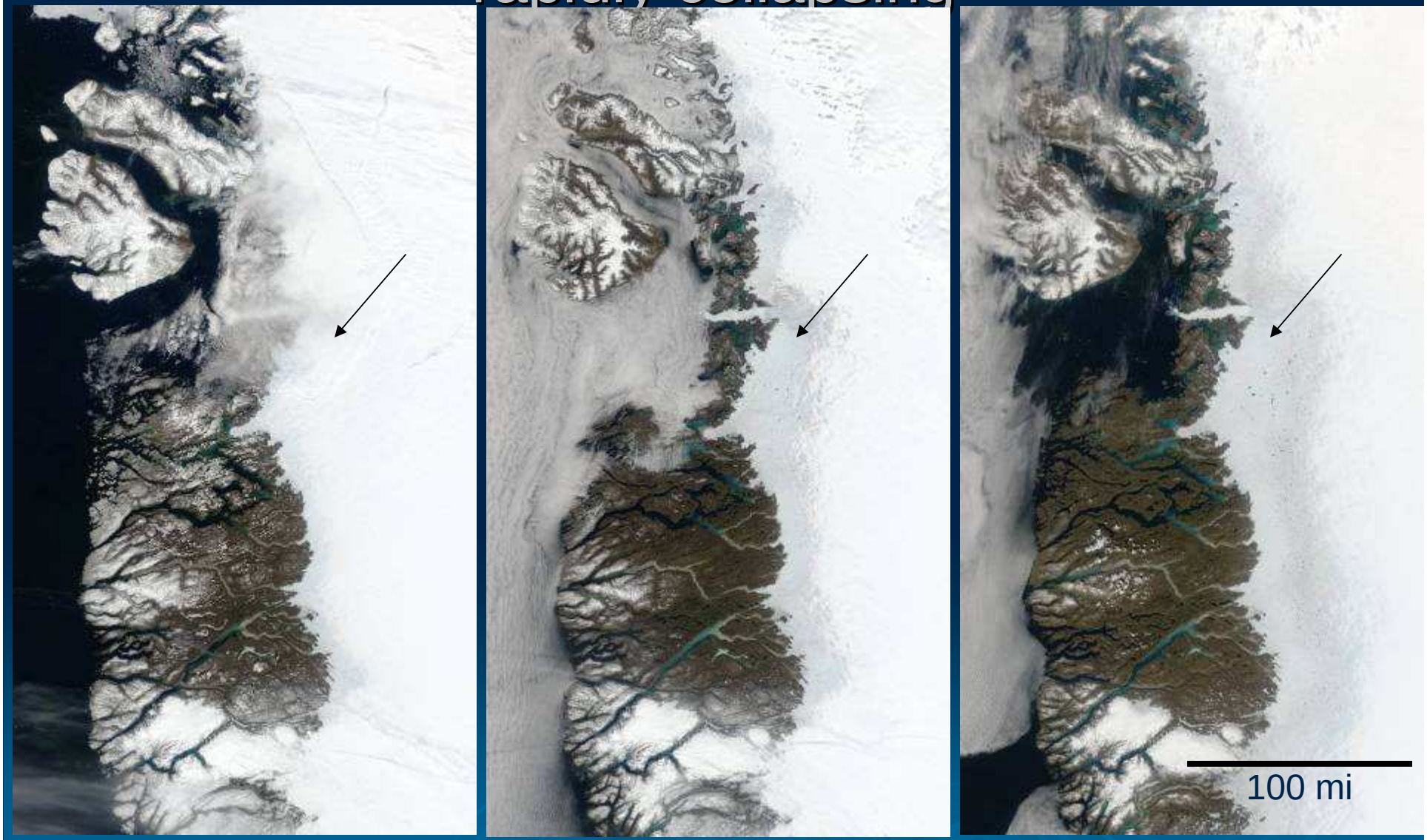
Since 2000,
the Greenland Ice Sheet
and the Arctic Ocean pack ice
have been rapidly falling apart.

Change in mass 2003-2005

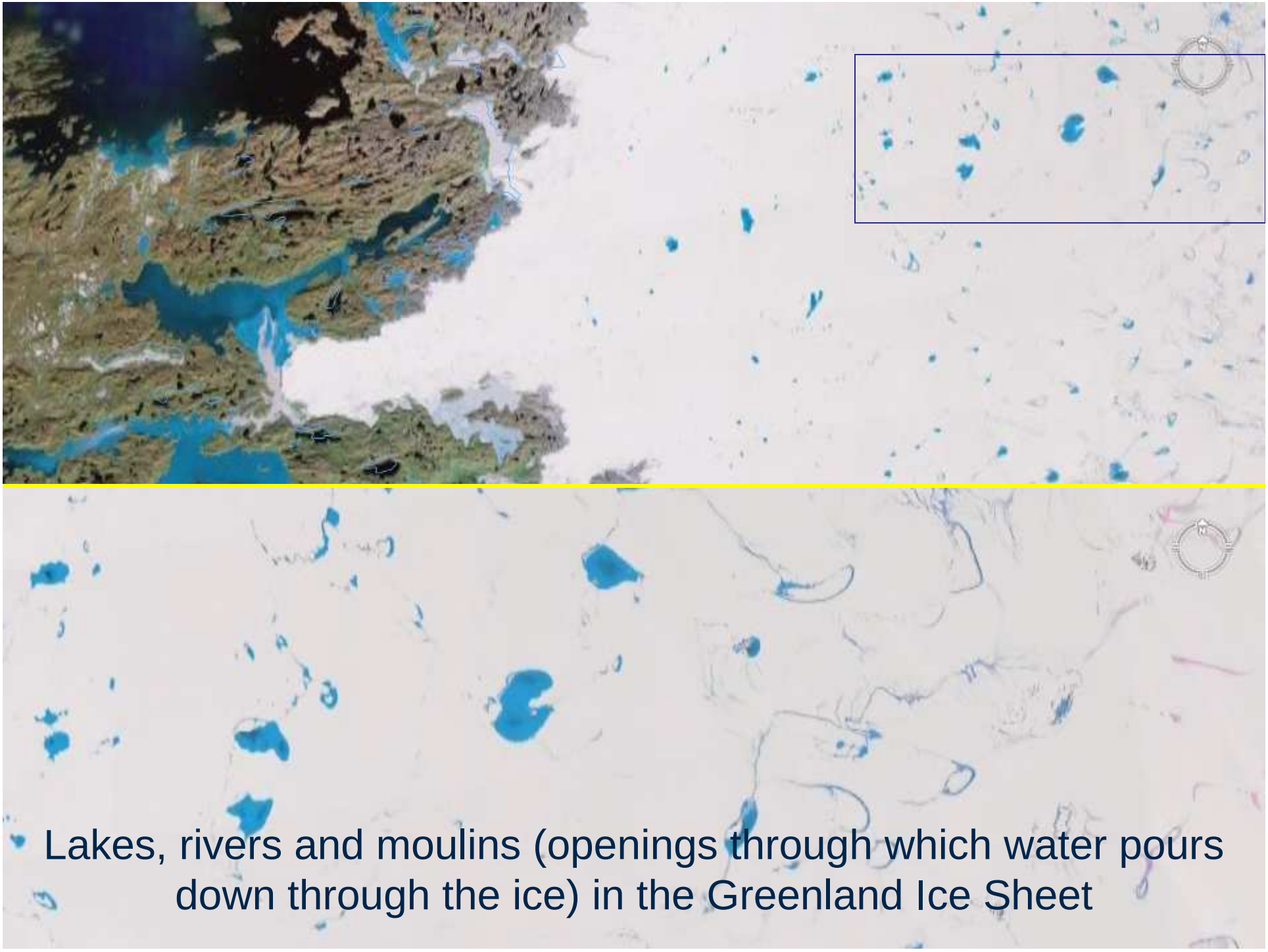


Melt zone is expanding northwards and to higher elevations

The margins of the Greenland ice sheet is rapidly collapsing



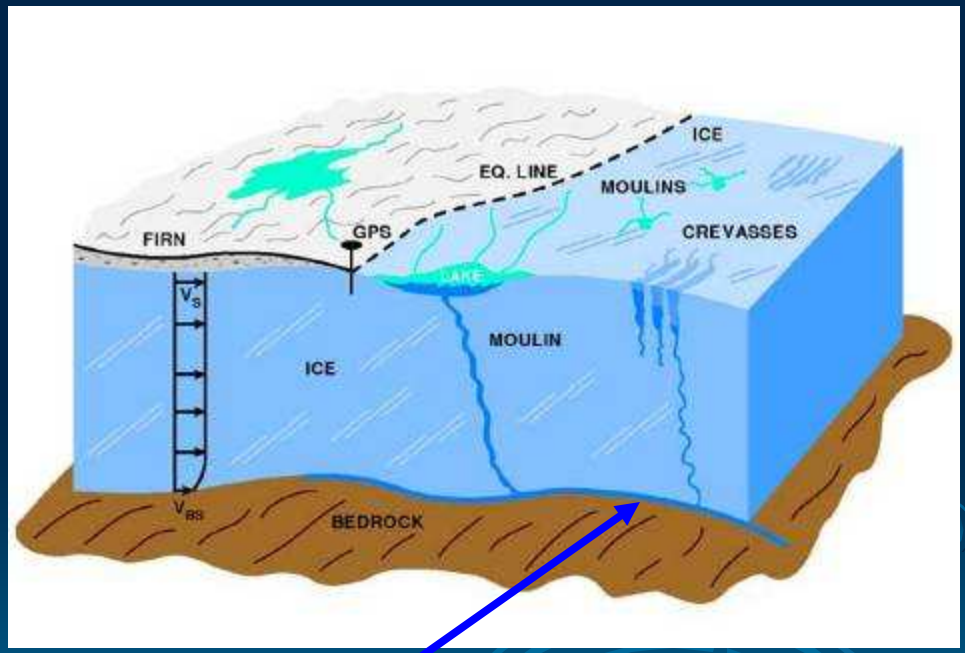
2001 2002 2003



Lakes, rivers and moulins (openings through which water pours down through the ice) in the Greenland Ice Sheet

MOULINS

Like karst in limestones



Water lubricates base of ice sheet and results in fracturing and weakening of the ice sheet.

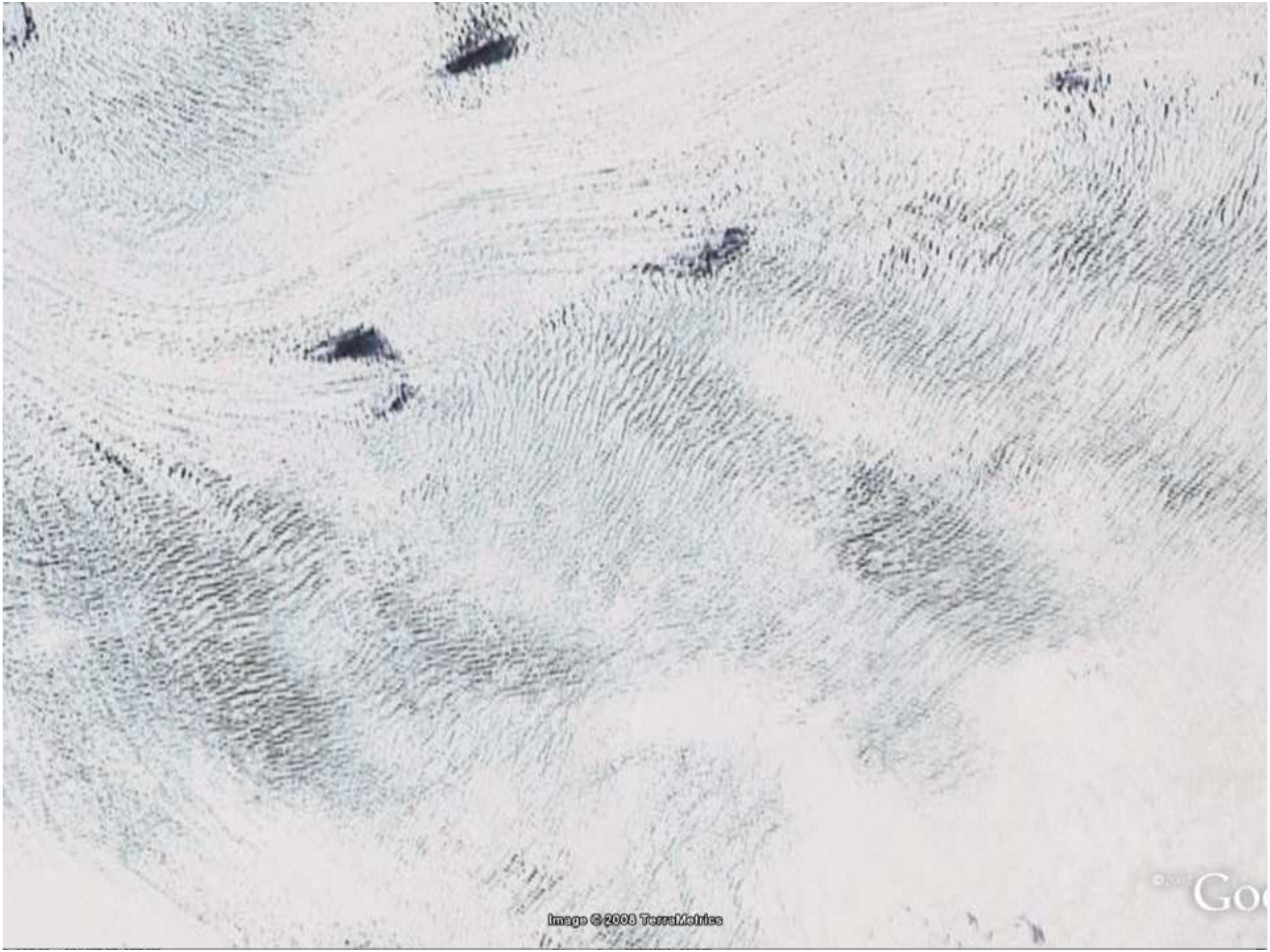


Image © 2008 TerraMetrics

- "Five years ago we made models predicting how much ice would melt and when. "Five years later we are already at the levels predicted for 2040, in a year's time we'll be at 2050."

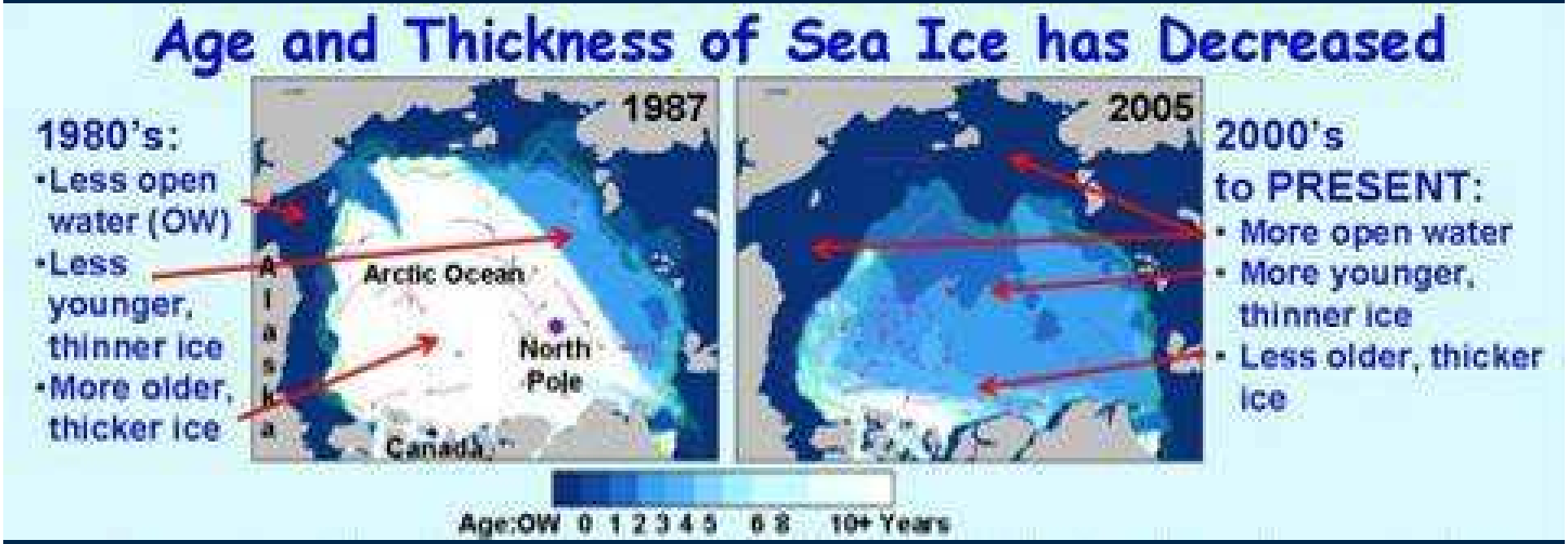
(Veli Albert Kallio, Finnish polar/ice scientist, September 8, 2007)

And it keeps getting worse

- A recent study documents that the Greenland Ice Sheet responds (melts) to atmospheric warming much more rapidly and vigorously than is presently being considered in current ice sheet projection models.

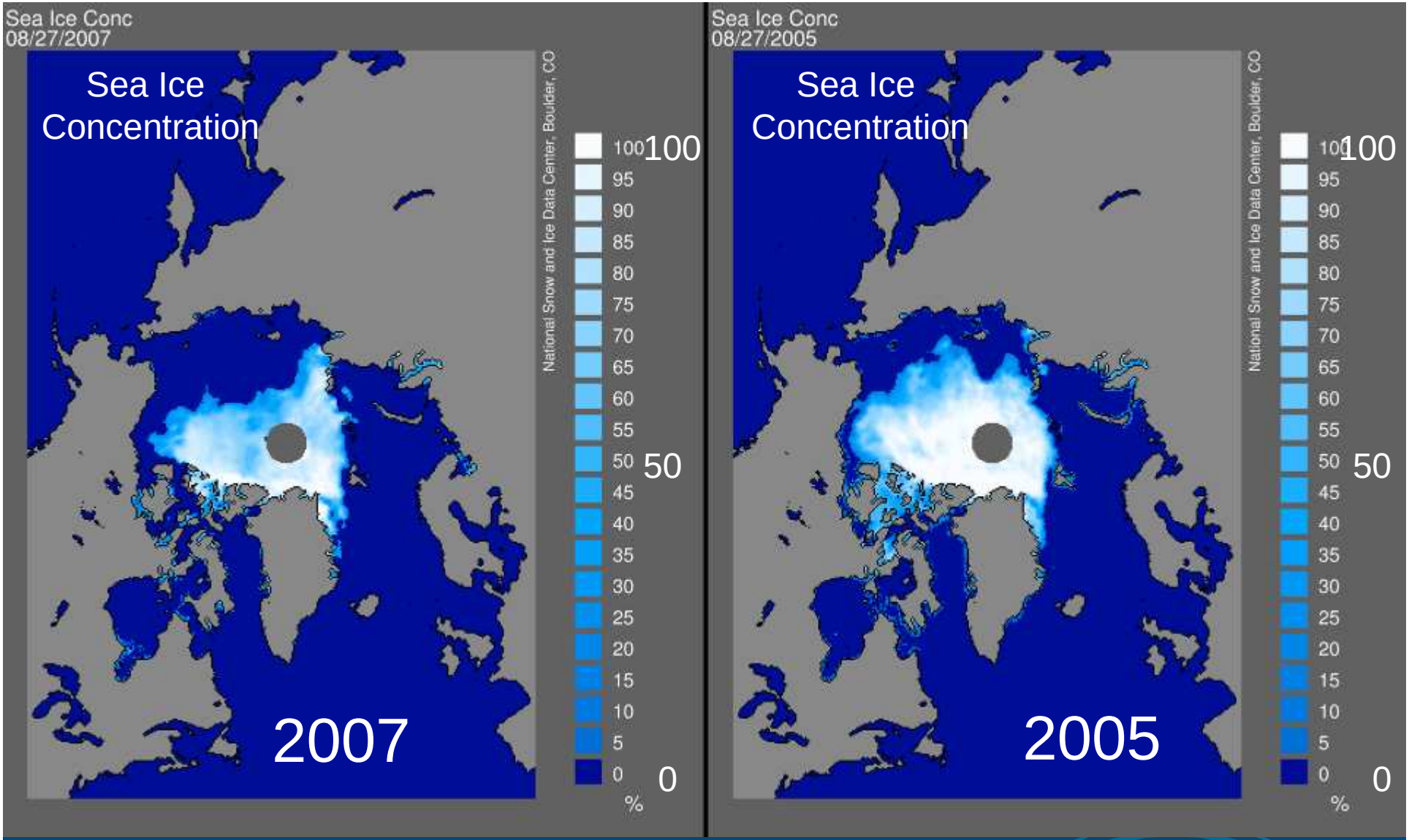
Vinther and others, 2009. Holocene thinning of Greenland ice sheet. *Nature, v. 461, p 385-388.*

Arctic Pack Ice Cover



Historically the refrigerant for the Arctic -

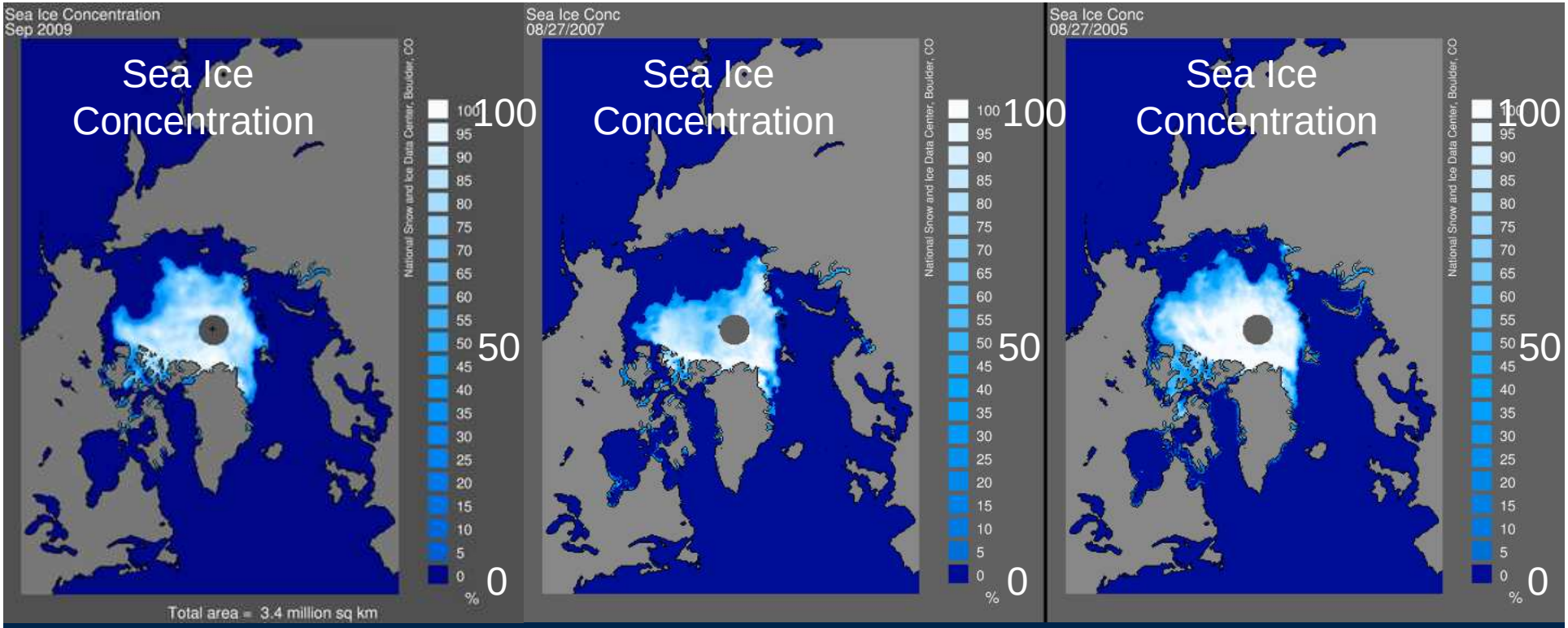
a powerful control on Arctic ocean and land temperatures, permafrost, and methane and carbon dioxide release.



In 2007, the floating Arctic pack ice covered 33% less area than the previous record low in 2005.

North Pole web cam – August 25, 2007

Ice reflects nearly all incoming solar radiation back into the air and space. Open water absorbs over 90% of incoming solar radiation

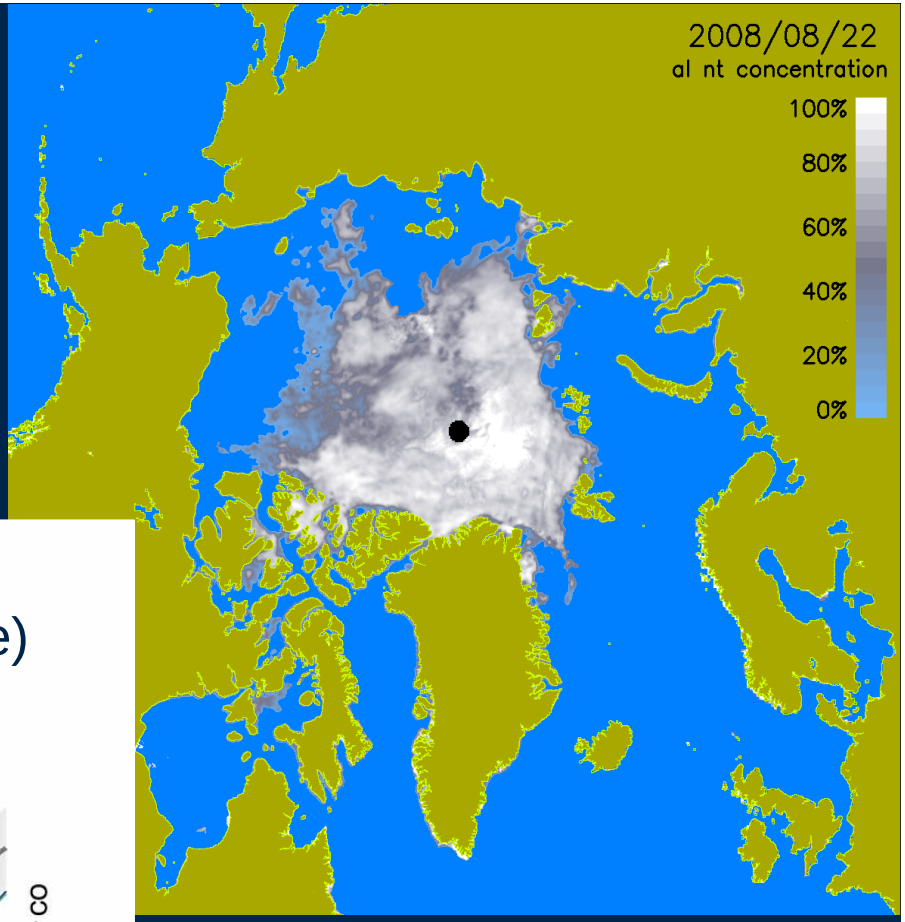


2009 2007 2005

Through 2008 and 2009 the warming Arctic Ocean thinned the pack ice so it is now 90% first year ice, mostly <1 meter thick, broken up, and with large open water areas.

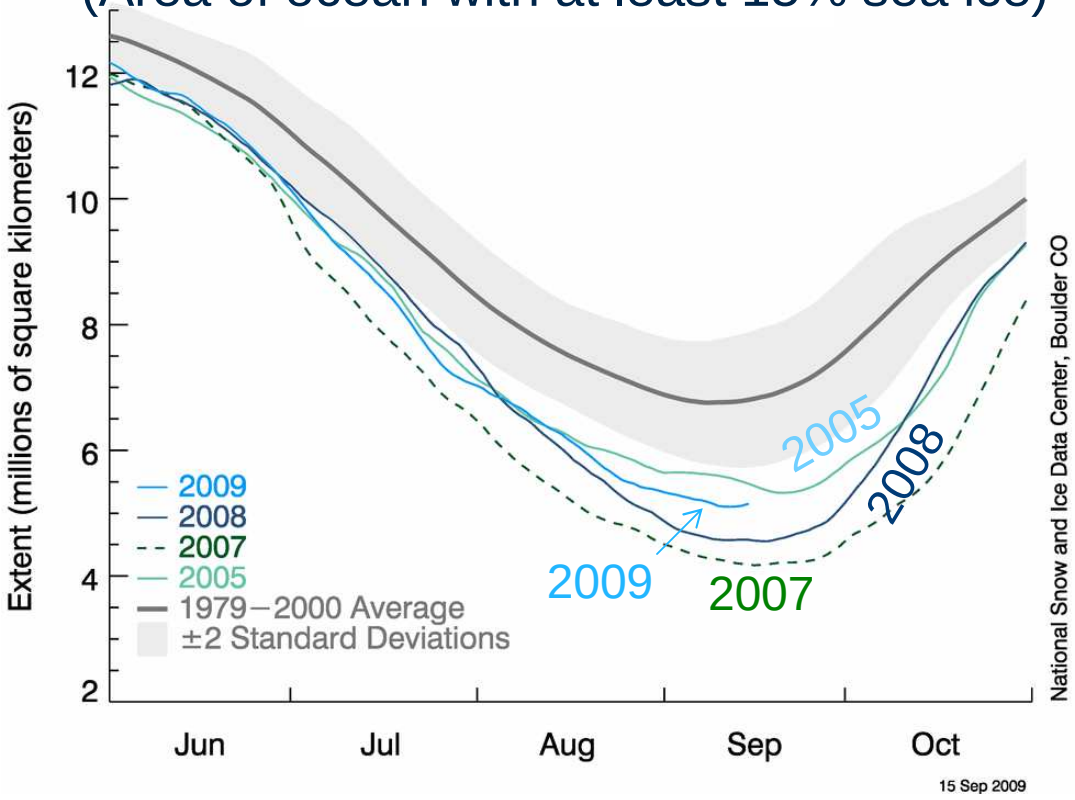
It could easily just float out into the Atlantic.

September 2008 and 2009 - record low volume of ice



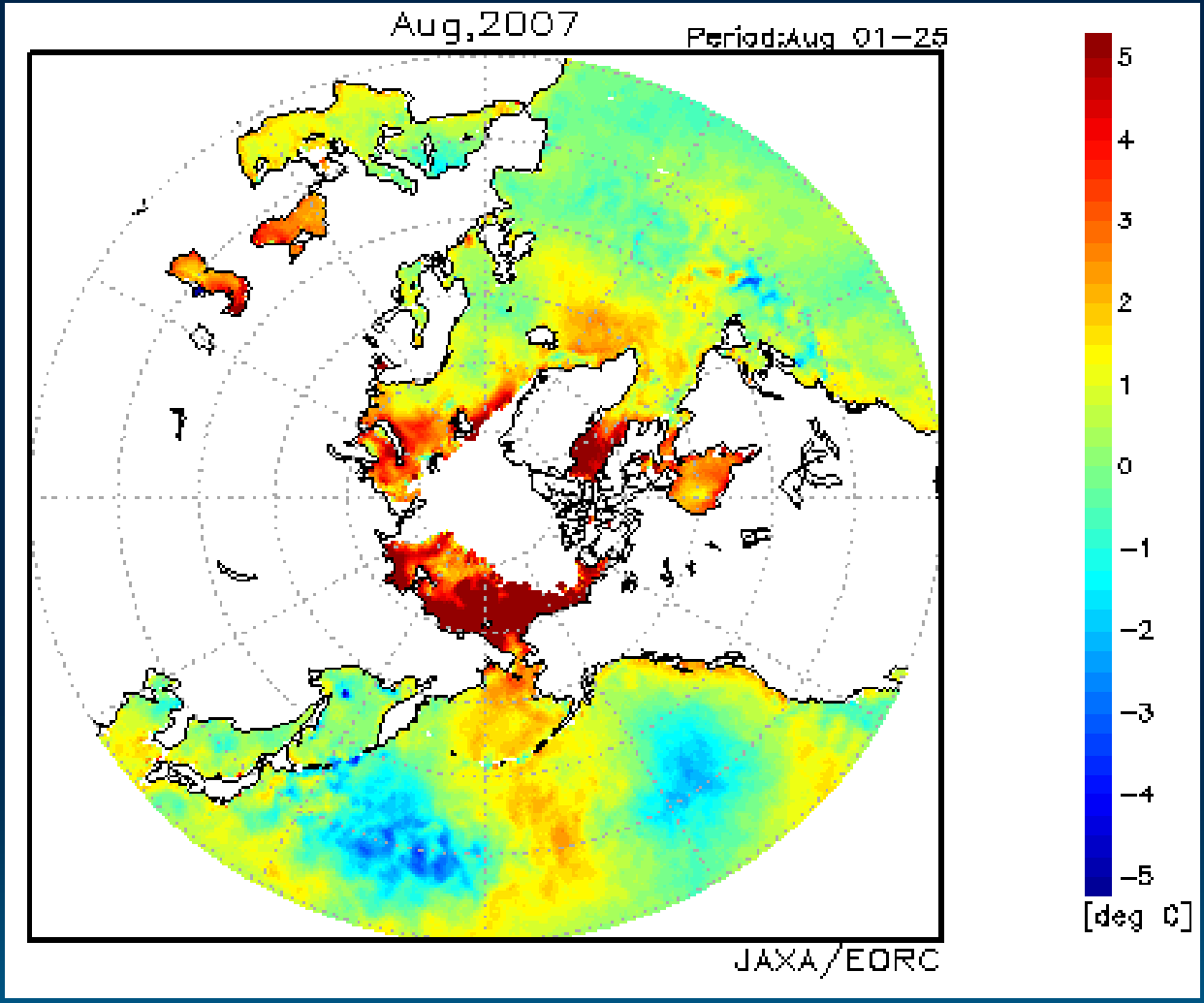
Arctic Sea Ice Extent

(Area of ocean with at least 15% sea ice)



- much of the ice left was thin, first-year ice and was broken up by August storms in 2008.

Arctic Sea Surface Temperature Anomaly

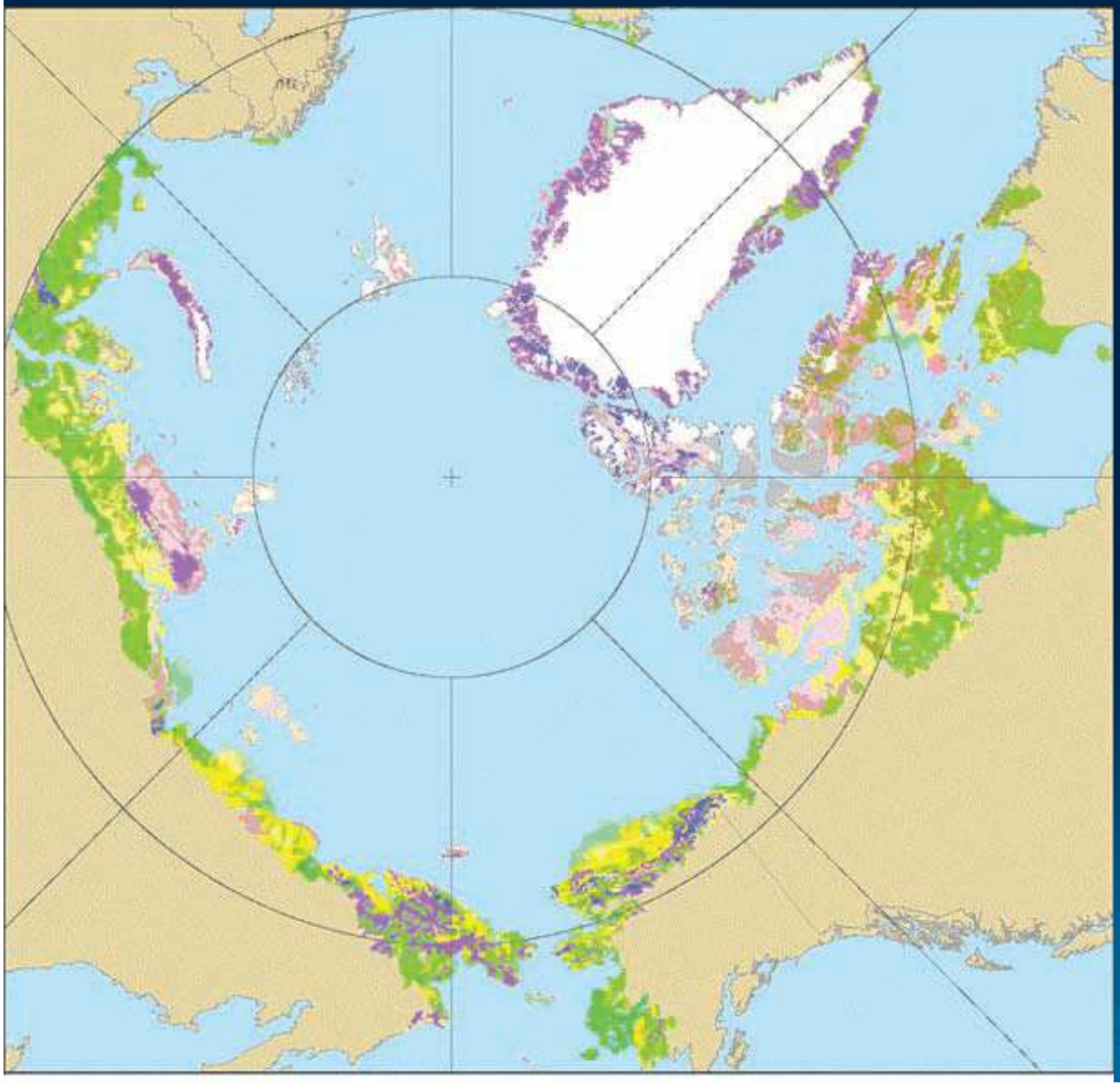


REINFORCING FEEDBACKS ARE ACCELERATING ARCTIC AND GREENLAND TRENDS

Five years ago the Arctic was projected to lose summer pack ice by 2070. Today scientists project the summer Arctic may be ice free within a decade!

Earth Observation Research Center, Japan Aerospace Exploration Agency

Tundra and permafrost rim the Arctic Ocean



- Tundra and permafrost beneath is frozen ground 150-2,000 feet thick.
- Huge amounts of organics are frozen in the permafrost.
- 80% of tundra is within 100 km of Arctic Sea Ice.
- 20% of tundra has been lost since the 1980s.
- 3-5 meters of permafrost are expected to melt in the coming 100 years (Ted Schuur, University of Florida).
- Organic decay from melting the upper 3 meters of permafrost will release as much CO2 as is presently in the atmosphere.

Reinforcing feedbacks in the Arctic and Greenland make future rapid warming inevitable and unstoppable.

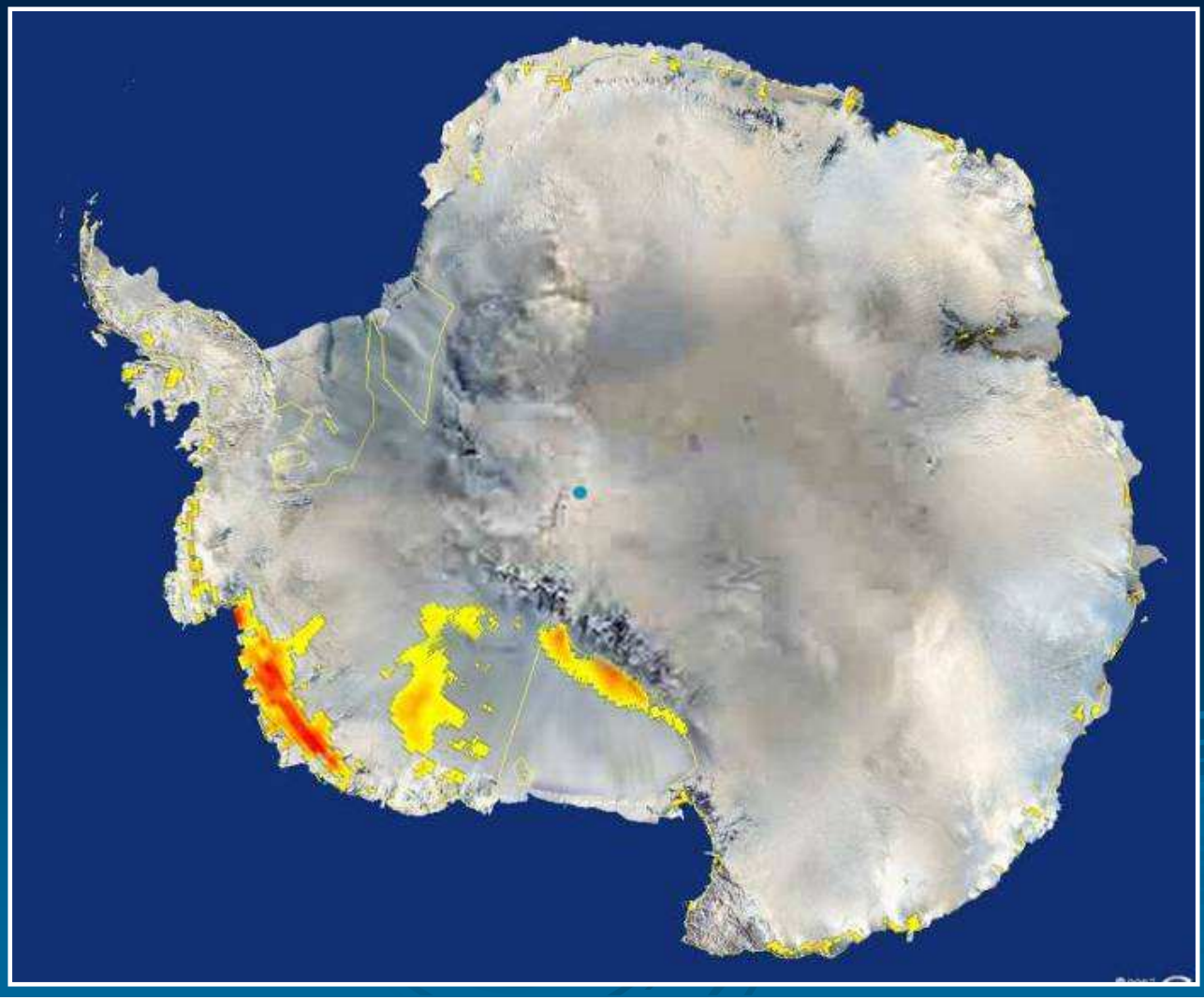
Greenland

1. Surface melt areas adsorb more heat.
2. Melt water lubricates base of ice sheet
3. Rapid loss to ocean
4. Lowering of ice sheet elevation
5. Further warming and destabilization.

Arctic Ocean

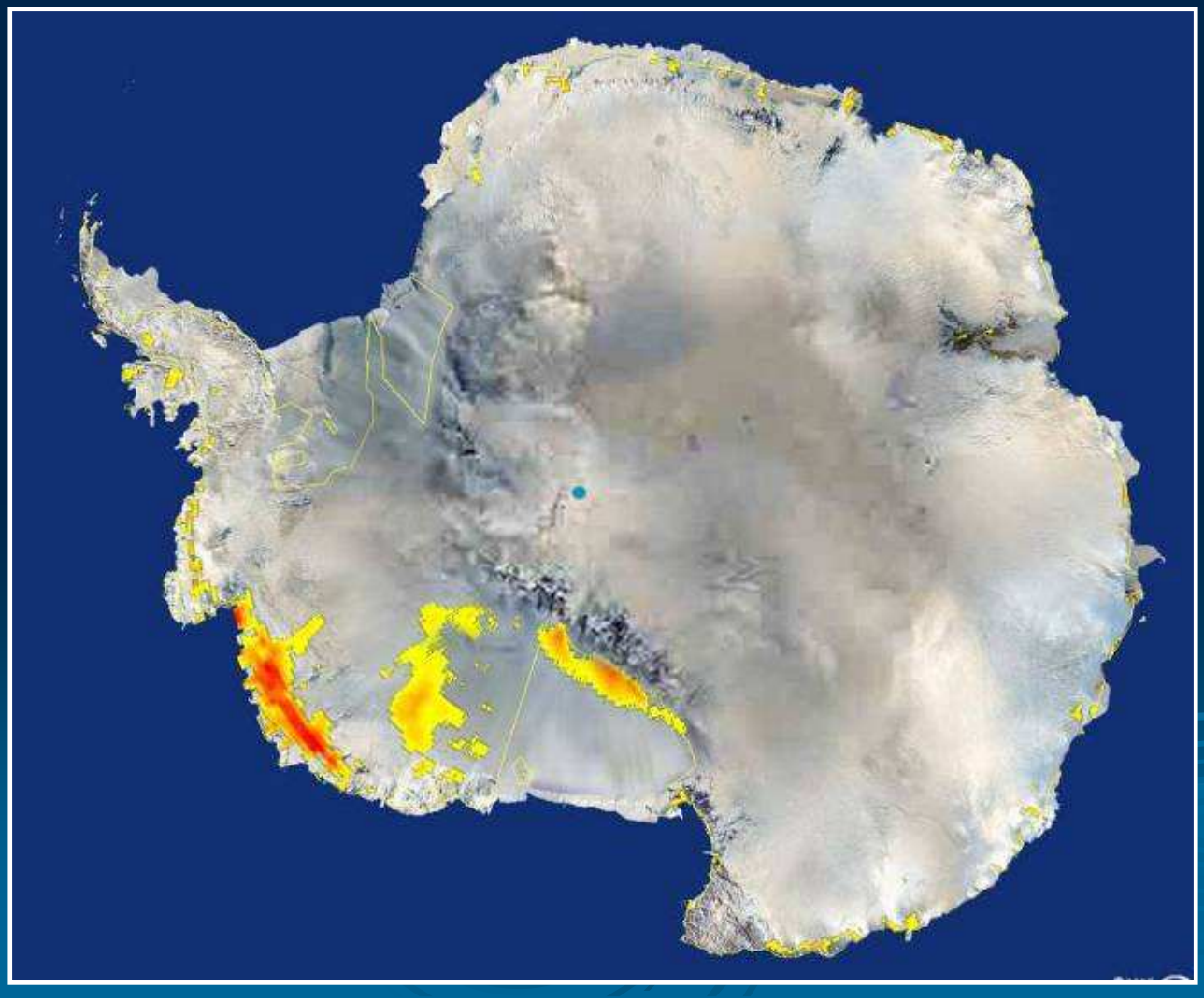
1. Persistent warming from atmosphere.
2. More open water
3. More heat adsorption
4. More melting
5. Warming of adjacent tundra and northern Greenland
6. Accelerated release of CO2 and ice melt

Scientists are just now recognizing that Antarctica is also rapidly melting, and has been for some time. This is because of increased wind shear, which has increased circulation of warmer water and melting under the ice shelves – and --



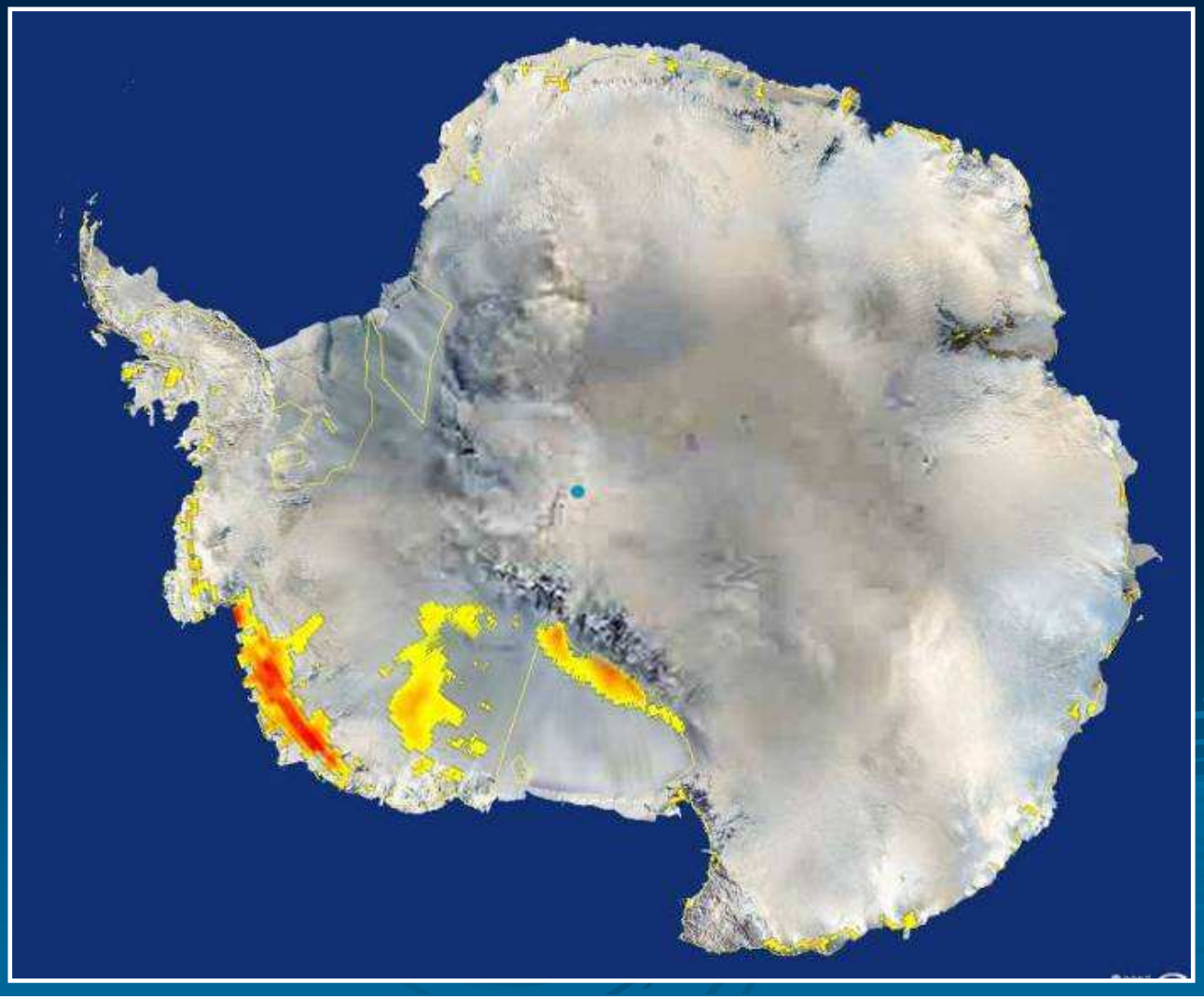
2009 - “From 1957 to 2006 temperatures across Antarctica rose 0.2 degrees Fahrenheit per decade, comparable to the warming that has been measured globally.”

Eric Steig (Univ. Washington) & Drew Shindell (NASA Goddard Inst. for Space Studies) as quoted in New York Times, January 22, 2009, p. A6



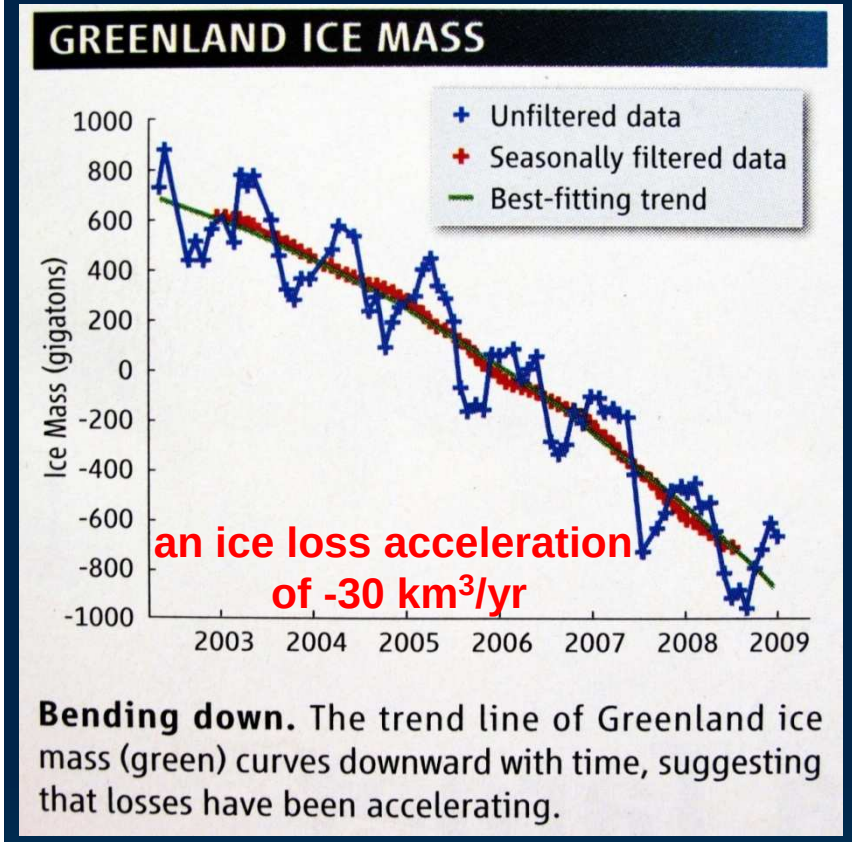
2009- Pine Island Glacier, the largest in West Antarctica, is melting at a rate 4 times faster than just a decade ago – because of warming waters.

It is thinning at 16 m per year – 90 m in the past decade.



A. Shepard, University of Leeds, August 2009.

RECENT DATA FROM THE GRACE SATELLITES



Bending down. The trend line of Greenland ice mass (green) curves downward with time, suggesting that losses have been accelerating.

Science, October 6, 2009, p.217.

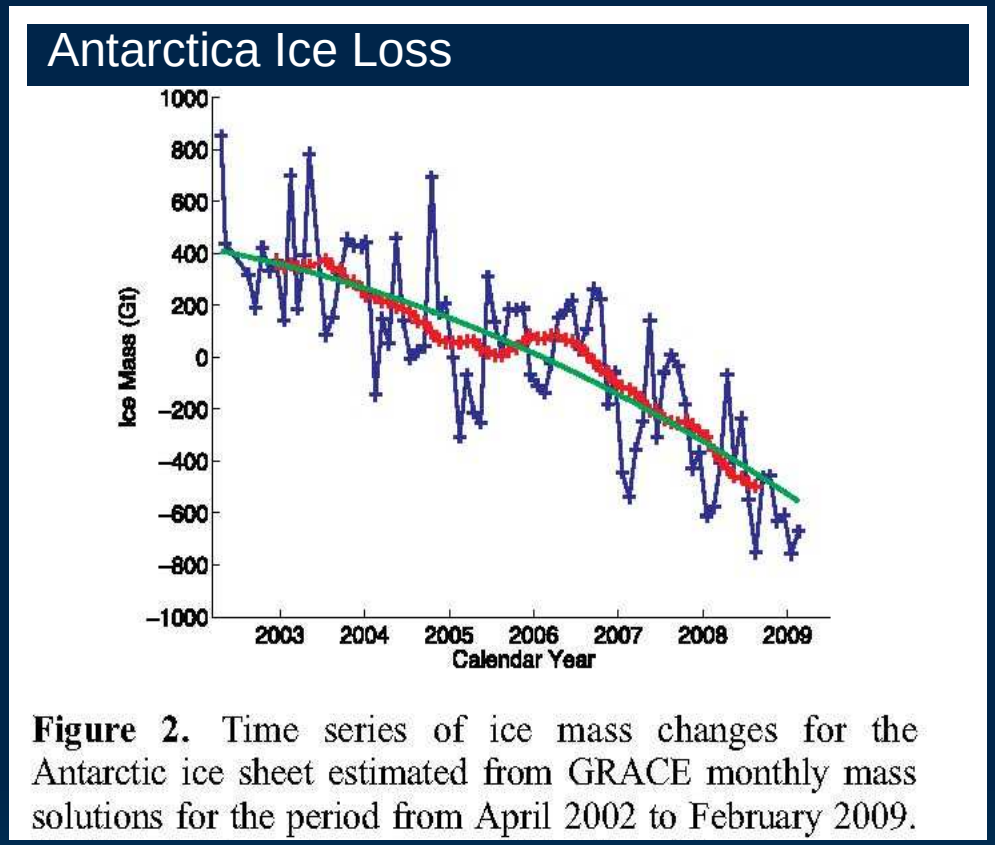


Figure 2. Time series of ice mass changes for the Antarctic ice sheet estimated from GRACE monthly mass solutions for the period from April 2002 to February 2009.

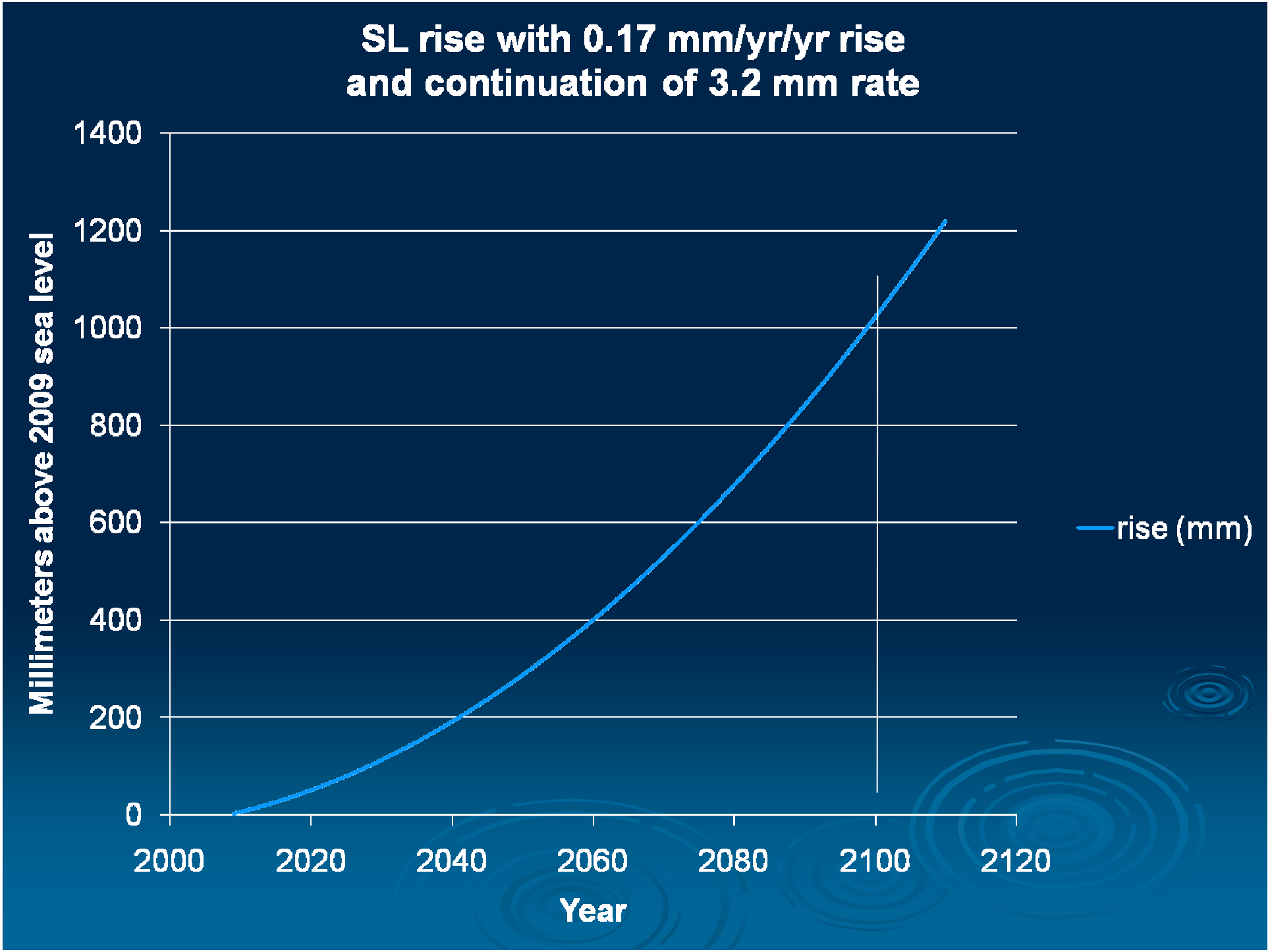
Velicogna, 2009. *Geophysical Research Letters*

- Rate of mass loss has more than doubled over past 7 years on both Greenland and Antarctica.
- Is now an annual 17% acceleration in melt rate and a 5% acceleration in the contribution to rise in sea level.

What are credible current estimates and projections for sea level rise in Florida?

Scientists on the Miami-Dade Climate Change Task Force:

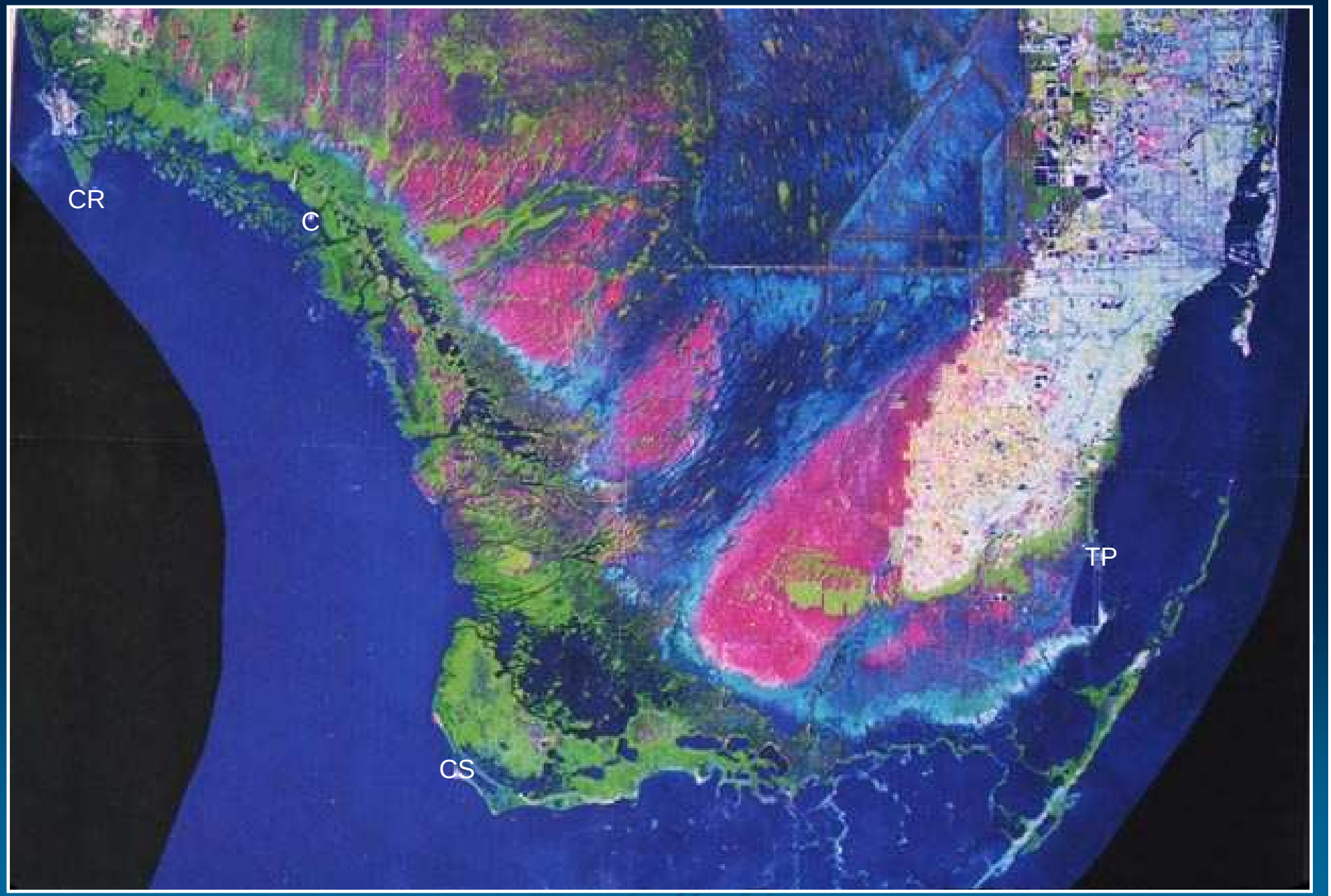
- "With what is happening in the Arctic and Greenland, [there will be] a likely sea level rise of **at least** 1.5 (45 cm) feet in the coming 50 years and a total of **at least** 3-5 feet (90-150 cm) by the end of the century, possibly significantly more. Spring high tides would be at +7 to +9 feet.
- "This does not take into account the possibility of a catastrophically rapid melt of land-bound ice from Greenland, and it makes no assumptions about Antarctica."
- "The projected rises will just be the beginning because of further significant releases from Greenland and possibly Antarctica." *(September 20, 2007)*


SL rise with 0.17 mm/yr/yr rise
and continuation of 3.2 mm rate
Millimeters above 2009 sea level
1400
1200
1000
800
600
400
200
0
2000
2020
2040
2060
2080
2100
2120
Year
rise (mm)

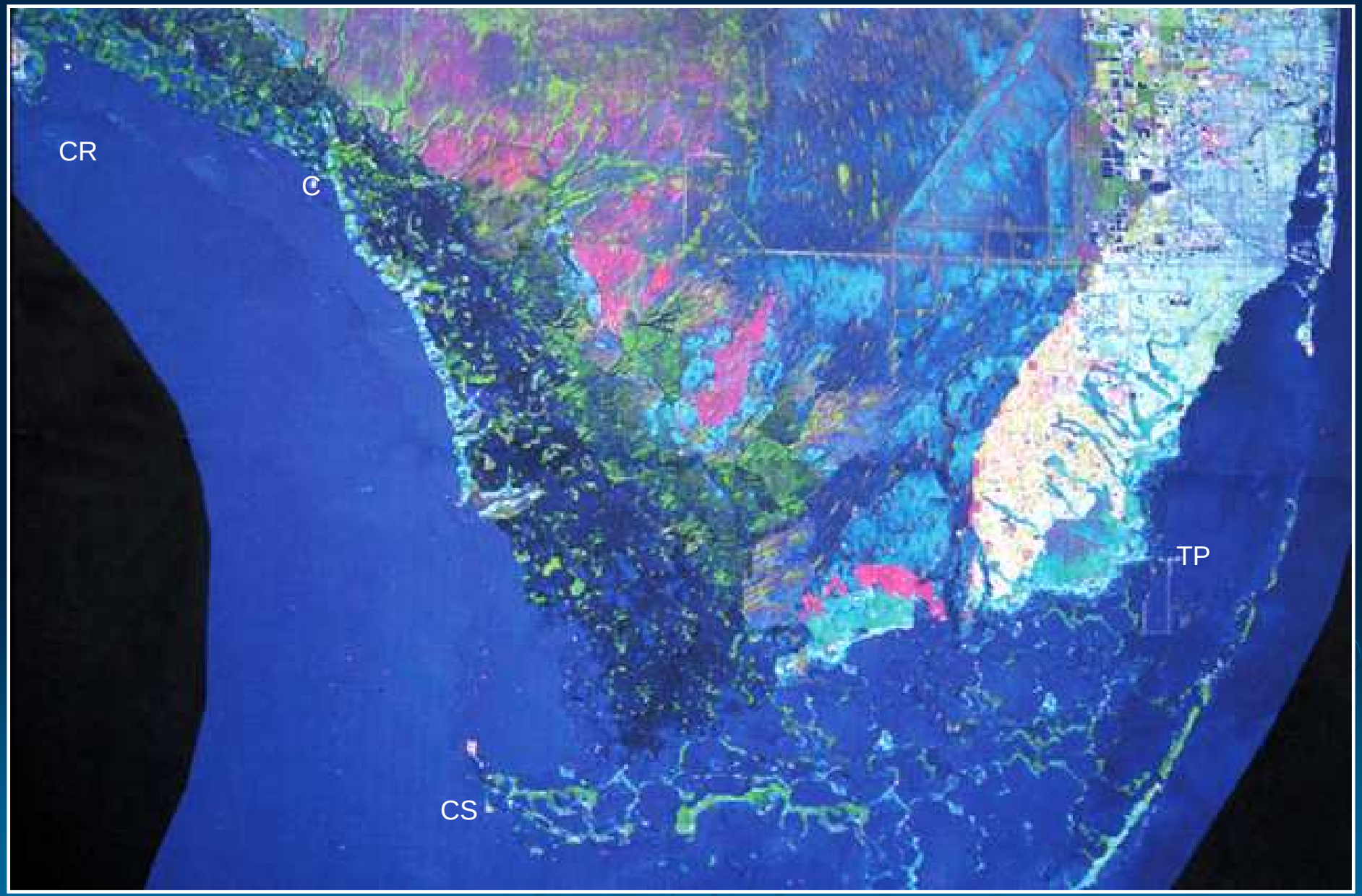
RECOMMENDED MINIMUM PLANNING SLR

- **Thermal expansion = 32 cm**
- **Non-ice sheet glacial melt =10-25 cm**
- **Ice Sheet melt Greenland and Antarctica = 75 cm**
- **Total = 117-132cm**
- **But**
  - **Since Arctic is rapidly melting and warming, will add to Greenland**
  - **Since Antarctic is coming more active**
- **Make planning total = at least 150 cm**

South Florida 1995



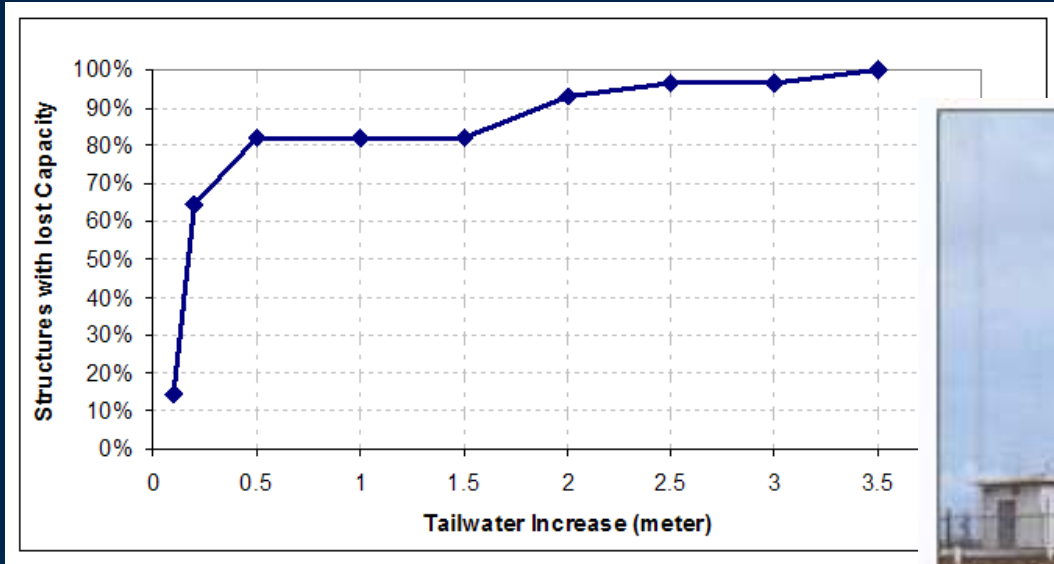
+2 foot rise (mhhw = +4.5’ above 1929 MSL) **South Florida 2100**



1-2’ versus 3-5’ – All the difference

- A 1-2 foot rise this century –
  - Miami and barrier islands are still sort of inhabitable;
  - probably worth throwing up extensive defenses;
  - and just maybe will get hold of global warming problem before all is lost.

Every county and city urgently needs accurate and detailed elevation maps from which to assess future drainage and infrastructure risk.

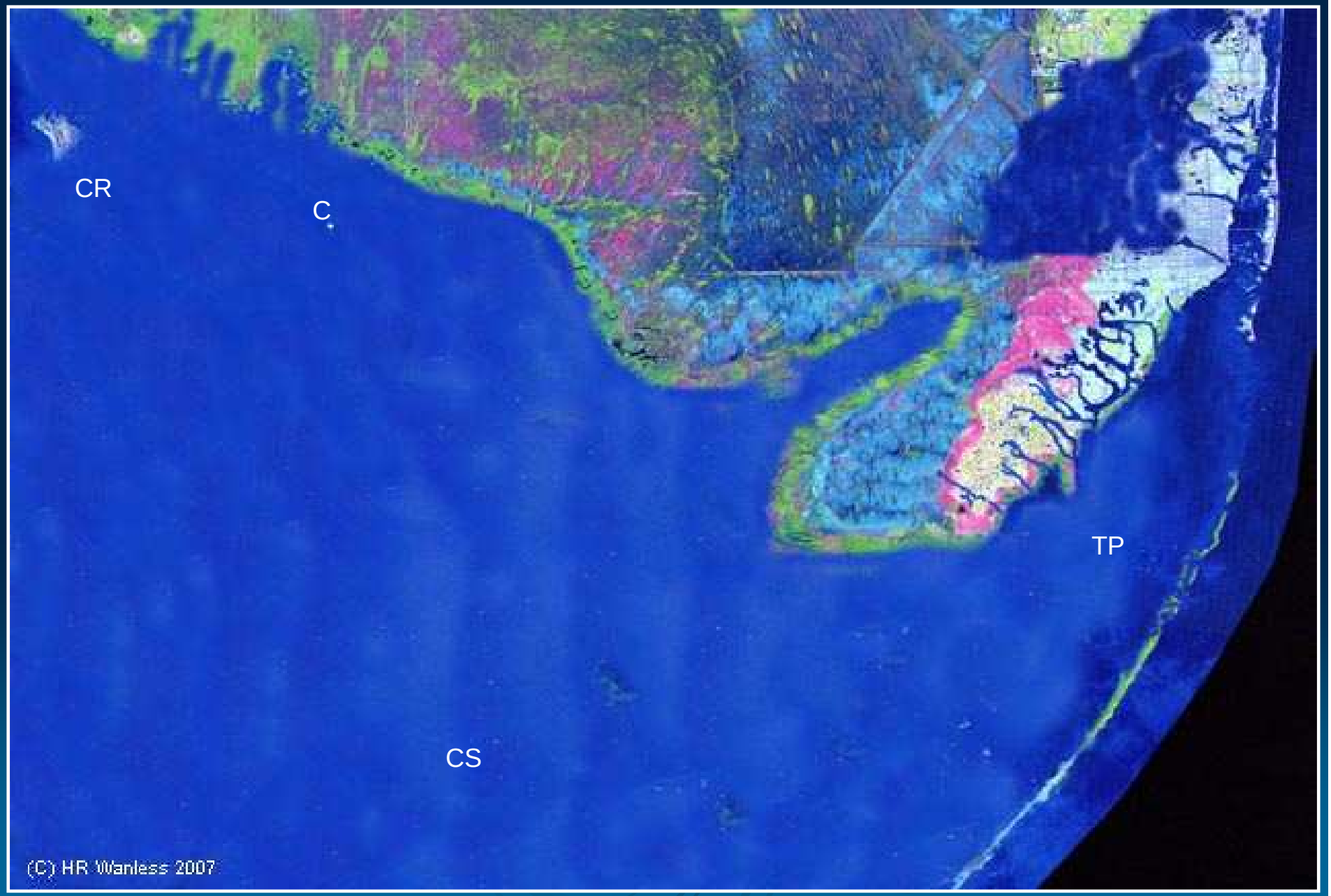


In SE Florida, a 50 cm (20 inch) sea level rise will make 80% of our coastal water control structures useless.

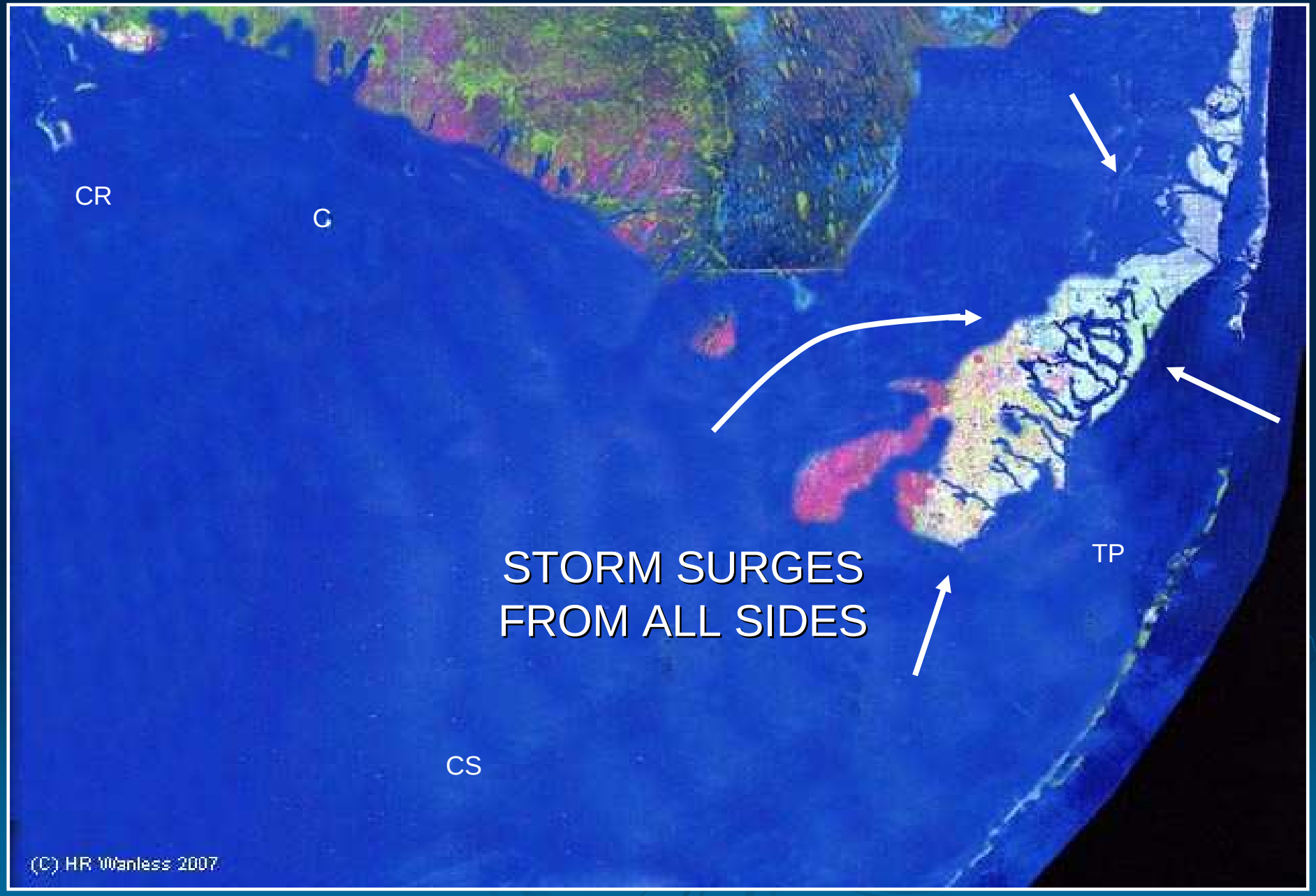
1-2’ versus 3-5’ – All the difference

- 3-5 foot rise this century –
  - All barrier islands abandoned;
  - Miami-Dade & Broward diminished and risky place to live;
  - increased pollution risk from eroding dumps;
  - sea level rising at 0.6 to1 foot per decade.

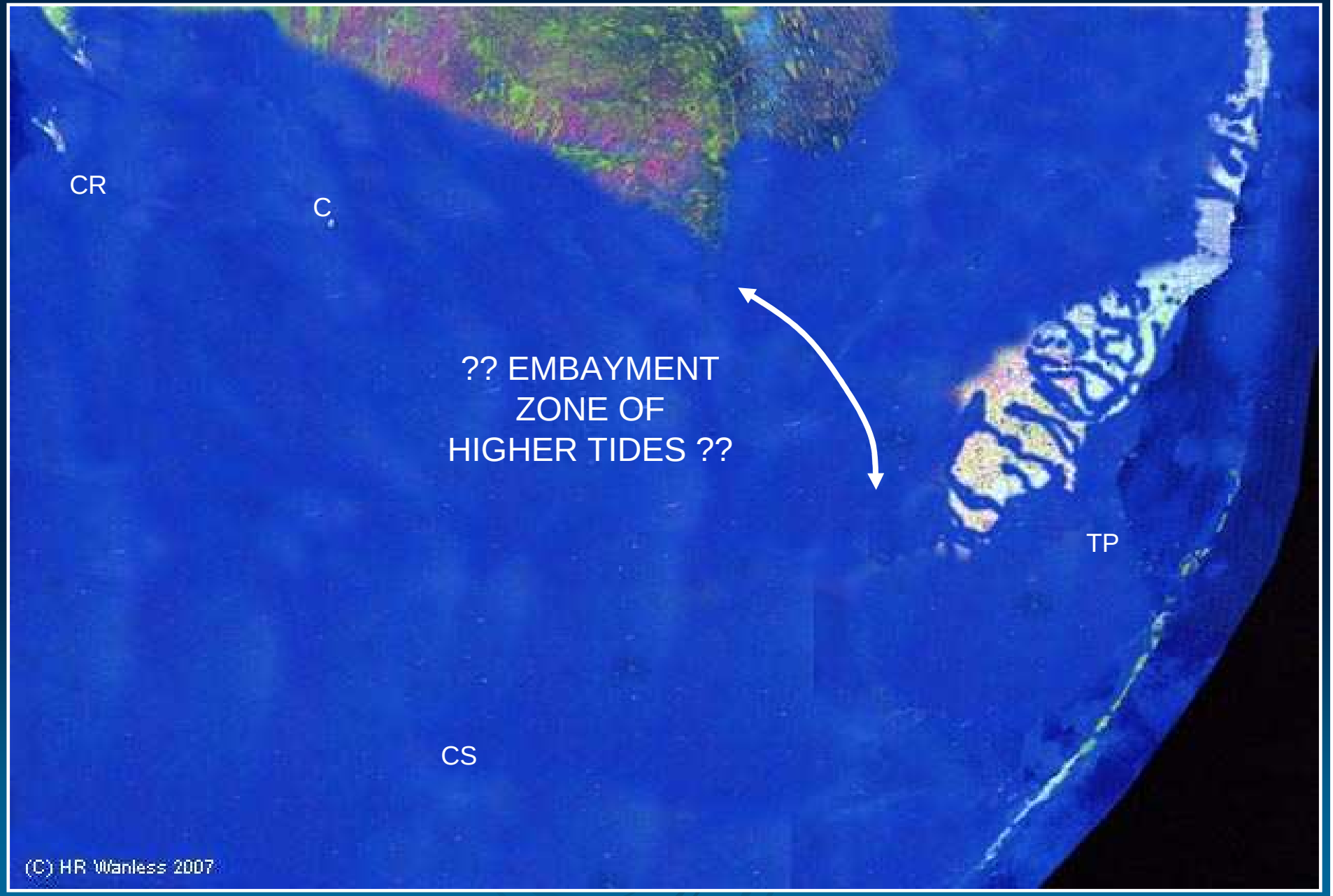
+4 foot rise (mhhw = +6.5’ above 1929 MSL) **South Florida 2100**



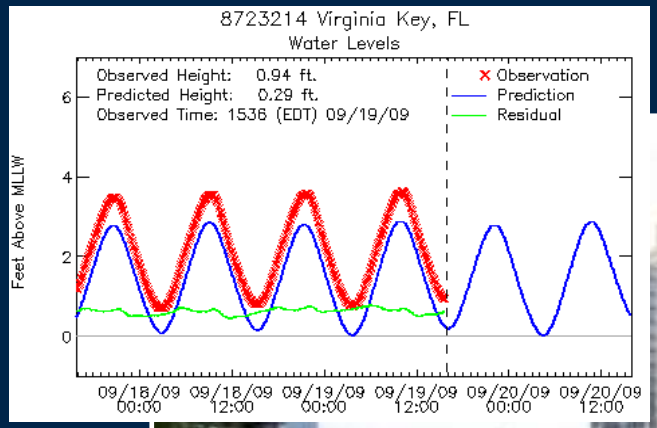
+5 foot rise (mhhw = +7.5’ above 1929 MSL) South Florida 2100



+6 foot rise (mhhw = +8.5' above 1929 MSL) **South Florida 2100**



+ Higher than predicted tides



This is high tide in the 1700 block of North Bayshore Dr., Miami FL. Unfortunately, this flooding is not associated with storm surge or any other exceptional tidal or weather event. It has become the regular twice a day occurrence of the tide.

from Tim O. Walker

ON TOP OF THIS SEA LEVEL RISE WILL BE HIGHER TIDES AND STORM SURGES

Bolivar Peninsula, Texas
Hurricane Ike, Category 2, September 2008

from PPT by William B Potter

Maps must show conditions at

- OCEAN LEVEL
  - High tide (HHW)
  - Any regional deviation from global prediction
  - Expected annual storm surge level
  - Expected hurricane surge levels
  - Consider changing tide ranges
- INTERIOR WATER LEVELS
  - Expected or necessary elevated freshwater elevation
  - Areas that will not drain effectively with various rain intensities.

Regional influences in SLR

- Regional subsidence or uplift of land.
  - Post glacial rebound, collapse of peripheral bulge, tectonic, from withdrawal of fluids.
- Changing speed or pattern of currents.
- Redistribution of balance of mass between water and land on the planet, affecting Earth's rotation (causing water to build up along the North American coasts and in the Indian Ocean).

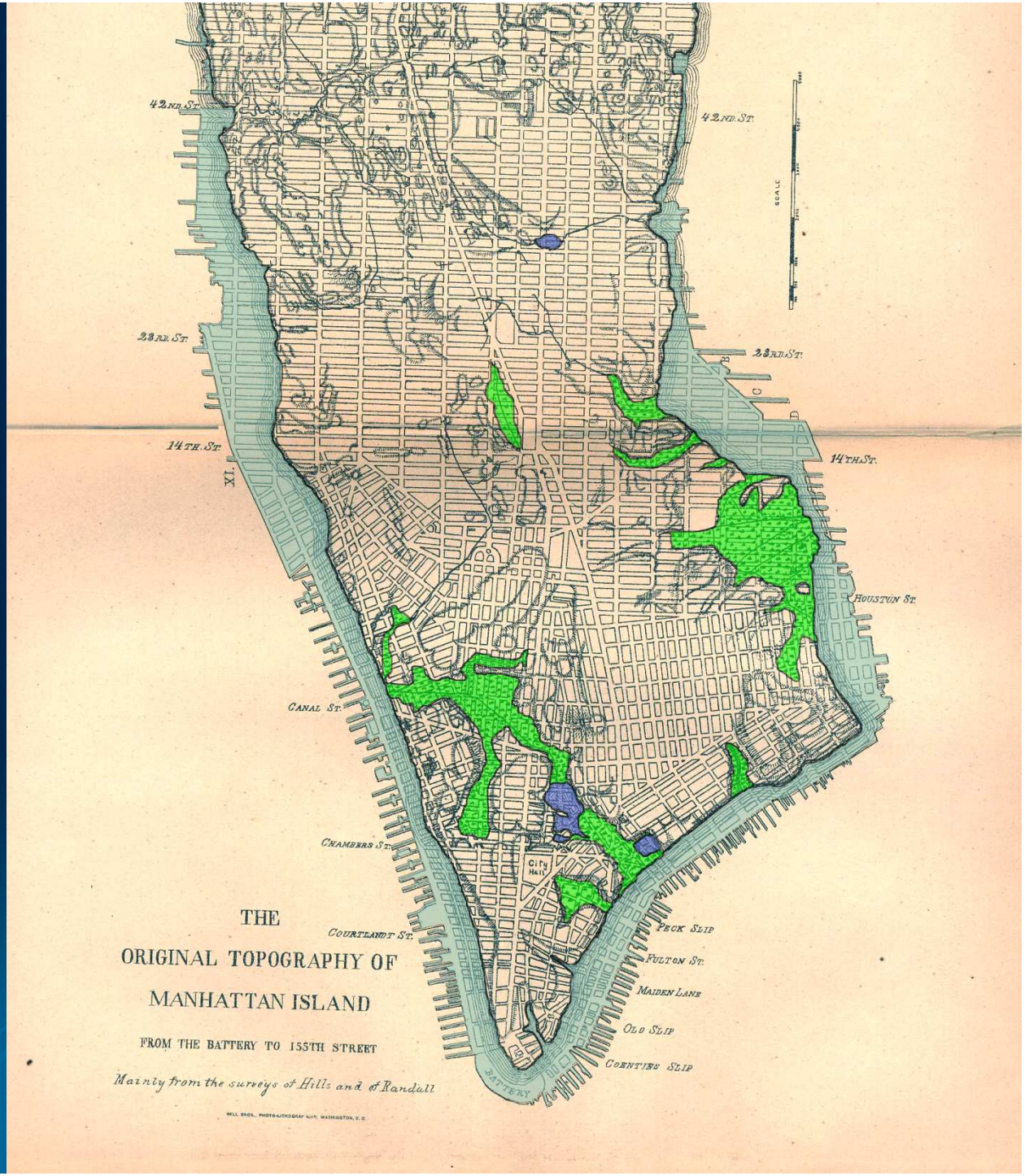
NEW YORK
South Manhattan

Presently has relative Sea-level rise of ~55 cm /century

MOST VULNERABLE LOW-LYING LAND

- Filled Land
- Filled Marsh
- Filled Lakes

Most coastal fill is less than 2 meters above sea level.

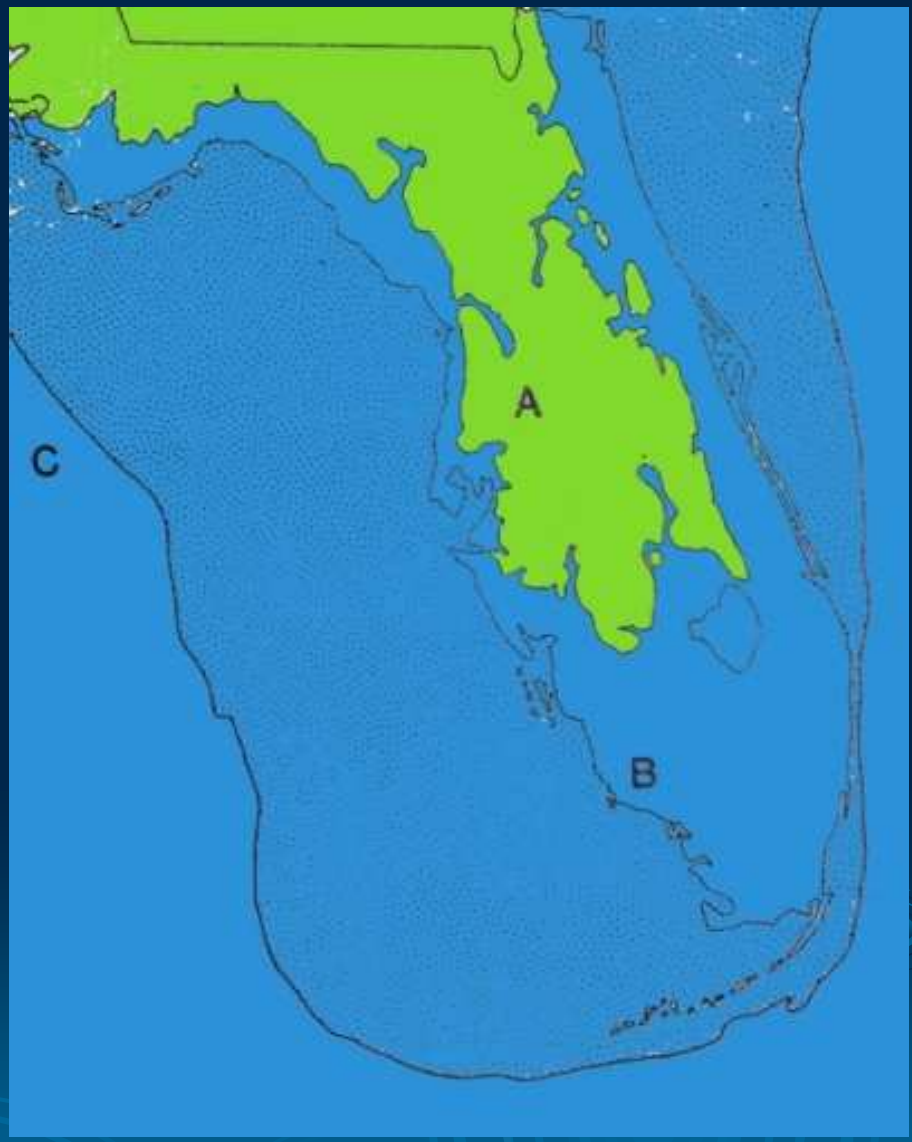


What level of uncertainty accompanies the models, predictions and empirical measurements upon which these estimates are based?

- Minimum is quite certain and should be accelerating.
- Not certain where there will be rapid pulses of ice release and melt and SLR.
- Consensus that there will be accelerating SLR well beyond end of century unless we rapidly reduce GHG levels in atmosphere.

- “The warming we're on track to do now is more than enough to commit us to last-interglacial levels of sea-level rise.”

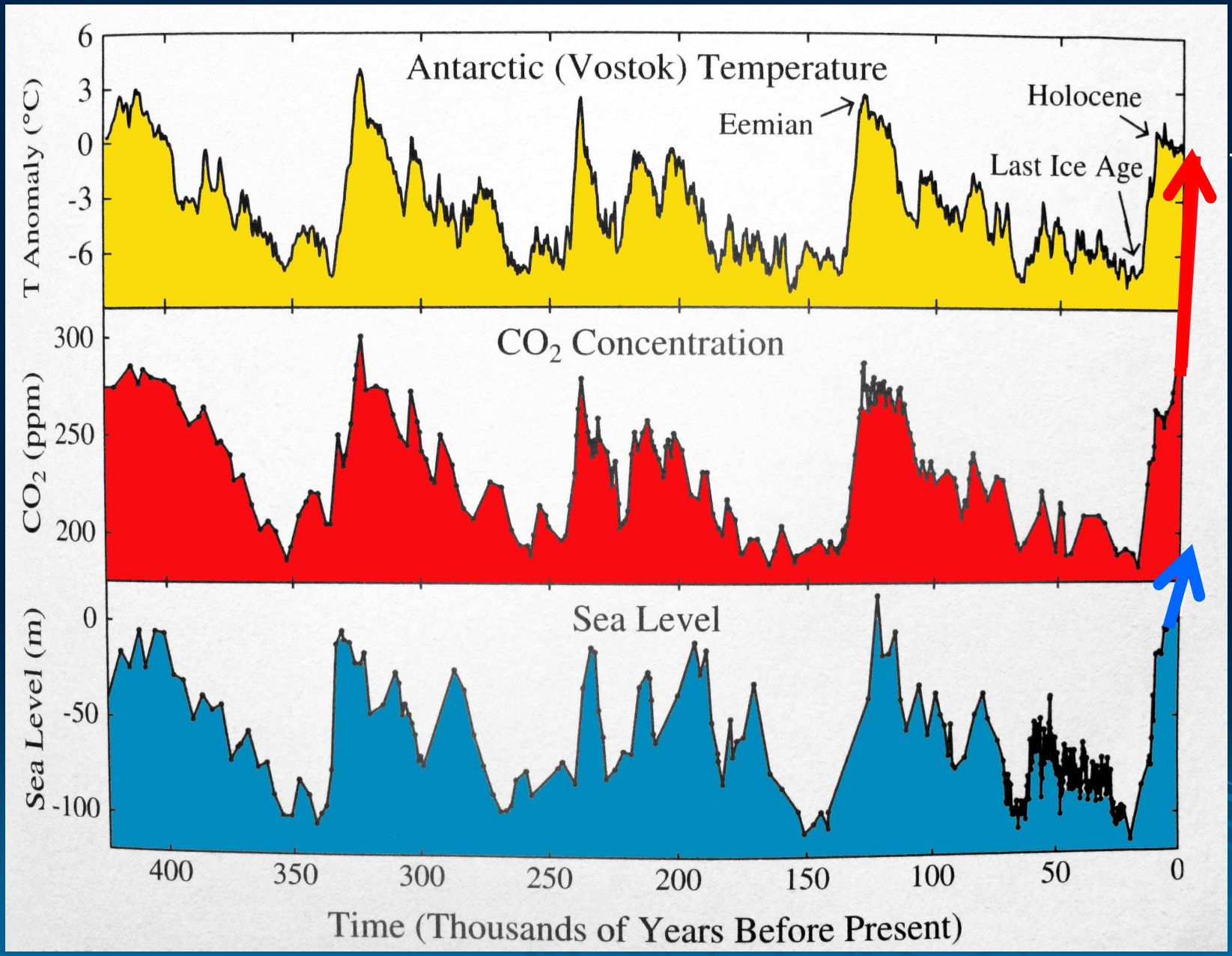
  (Kopp, Nature, 2009).



Through the Pleistocene, sea level has formed beaches across the entire Florida peninsula.

Beach sand

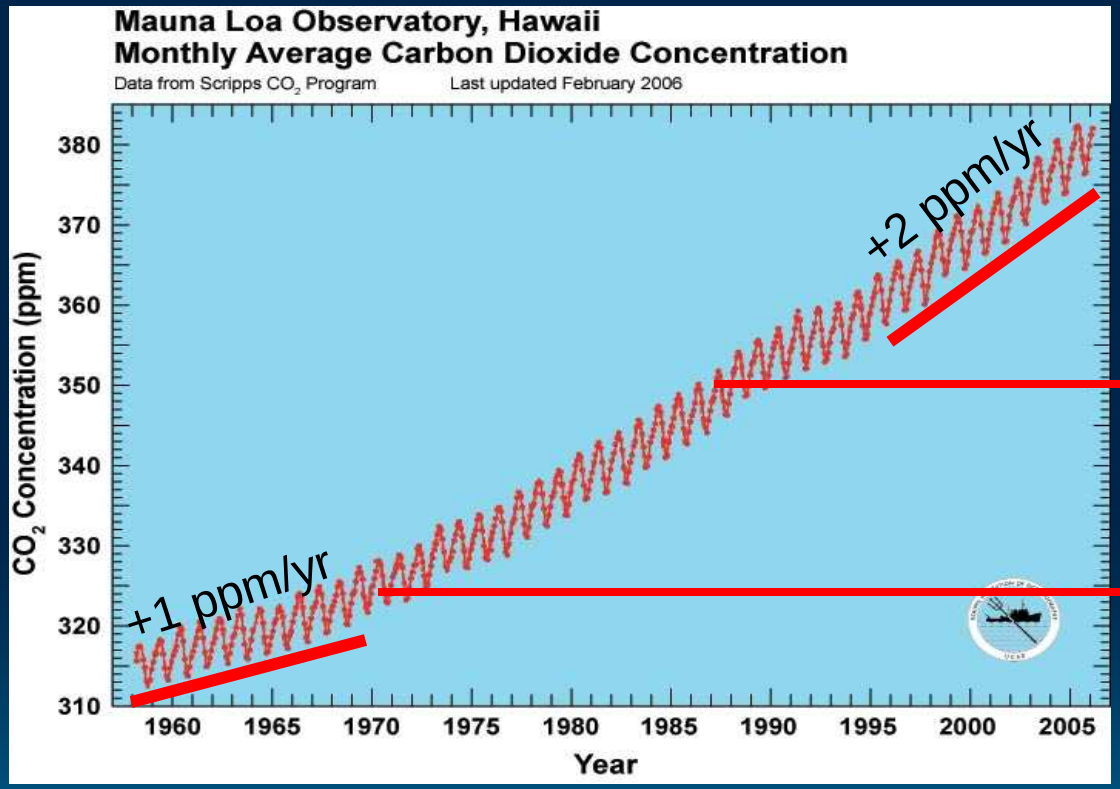
Archbold Biological Station



From Hansen, 2009, p. 153

What can we do?

- Most critically, we need to get off the CO2-producing addiction.



Presently 387 ppm and rising about 2.5 ppm / year

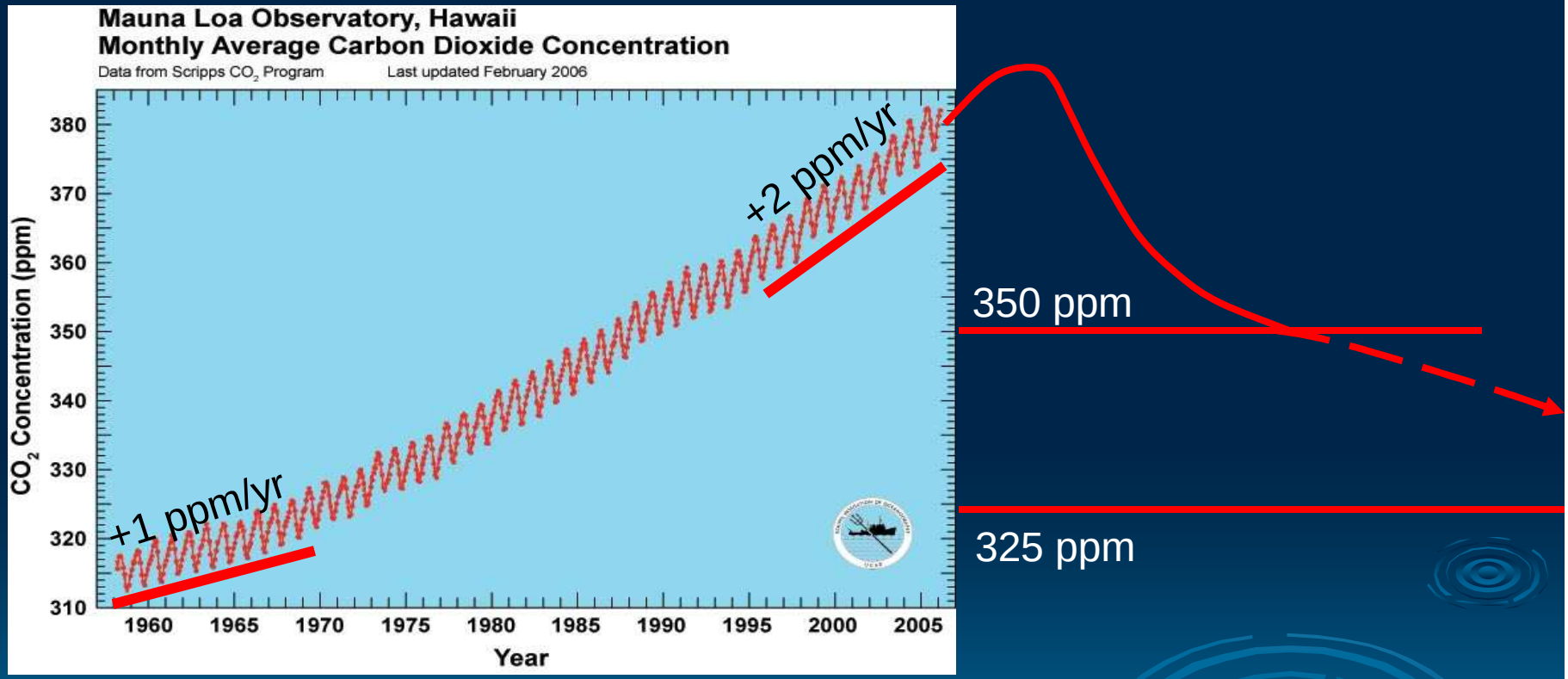
350 ppm

325 ppm

- Leading climatologist, Dr. James Hansen, says we quickly need to reduce atmospheric CO2 to 325-350 ppm.

We must stop warming.

- Lowering atmospheric CO2 will slow the heat imbalance between the atmosphere and the ocean.



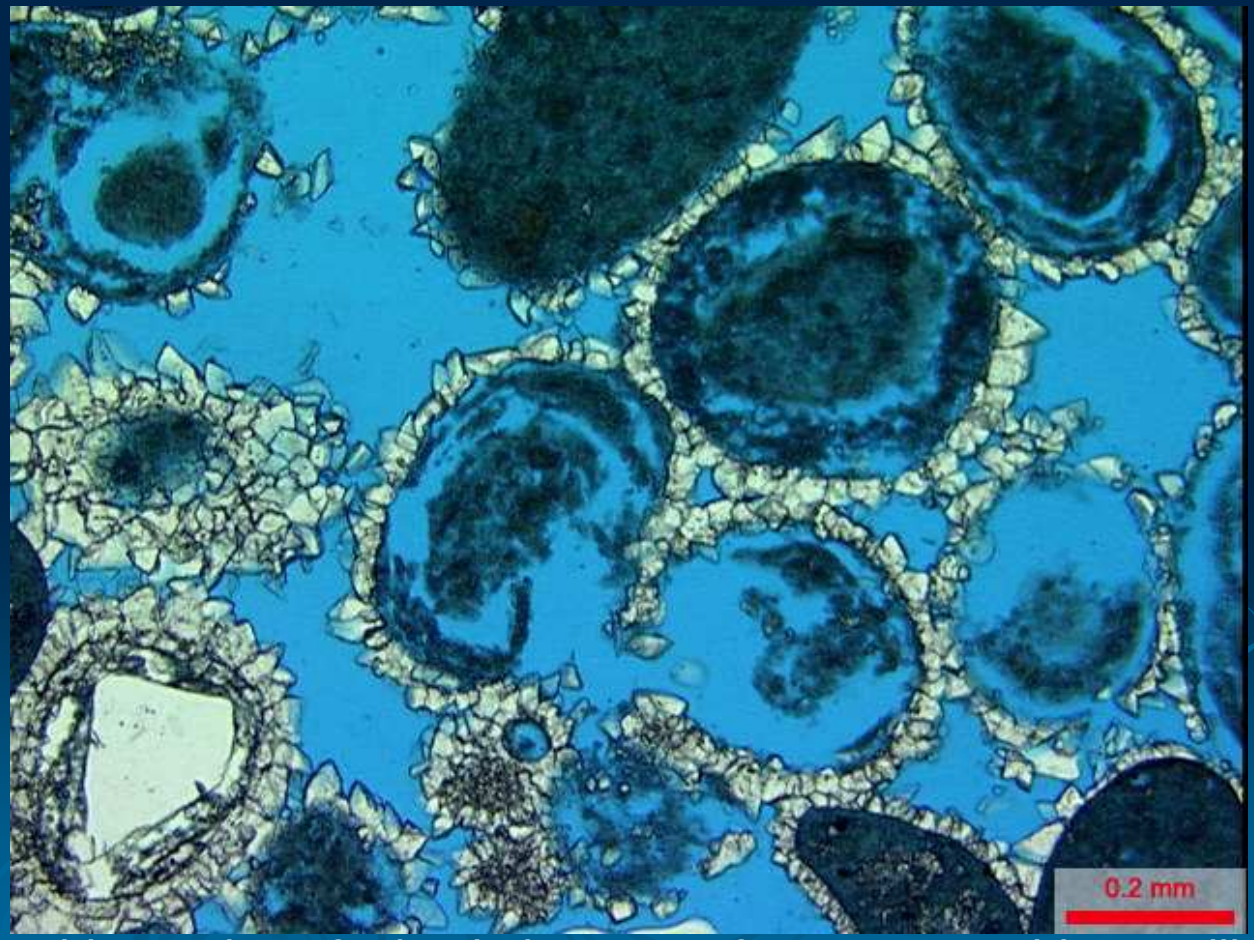
- This probably will not slow the first 3-5 feet of sea level rise, but will be a step for limiting a catastrophic greater rise.

The problem of a philosophy of permanence of place & environment

- We just can’t imaging losing where we are.
- Makes us want to defend!!

IMPORTANTLY, FLORIDA IS UNDERLAIN BY POROUS LIMESTONE AND SAND

We cannot build dikes to keep out rising water.

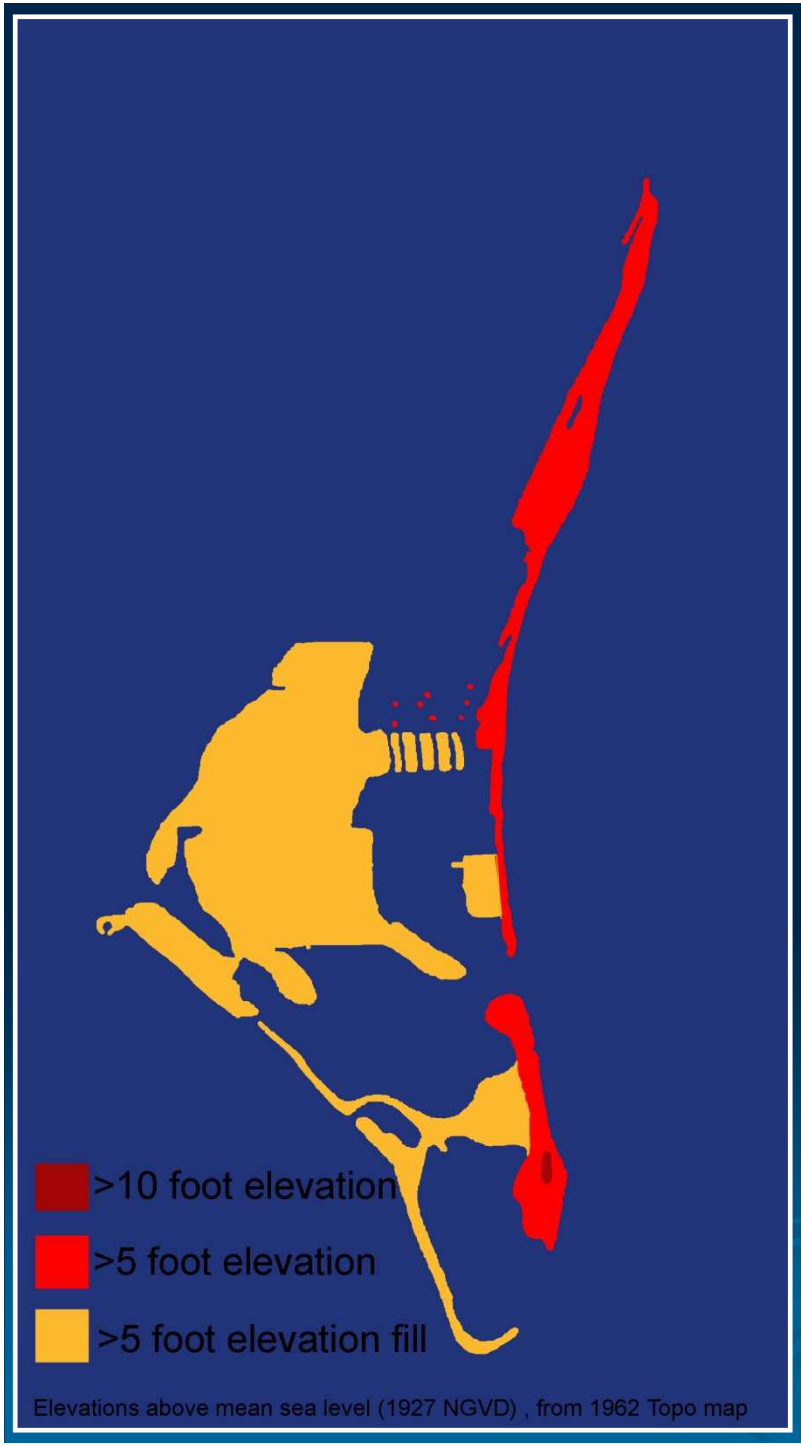


Thin section of Miami Limestone from Dr. Donald McNeill

BLUE IS POROSITY
(void space in limestone)

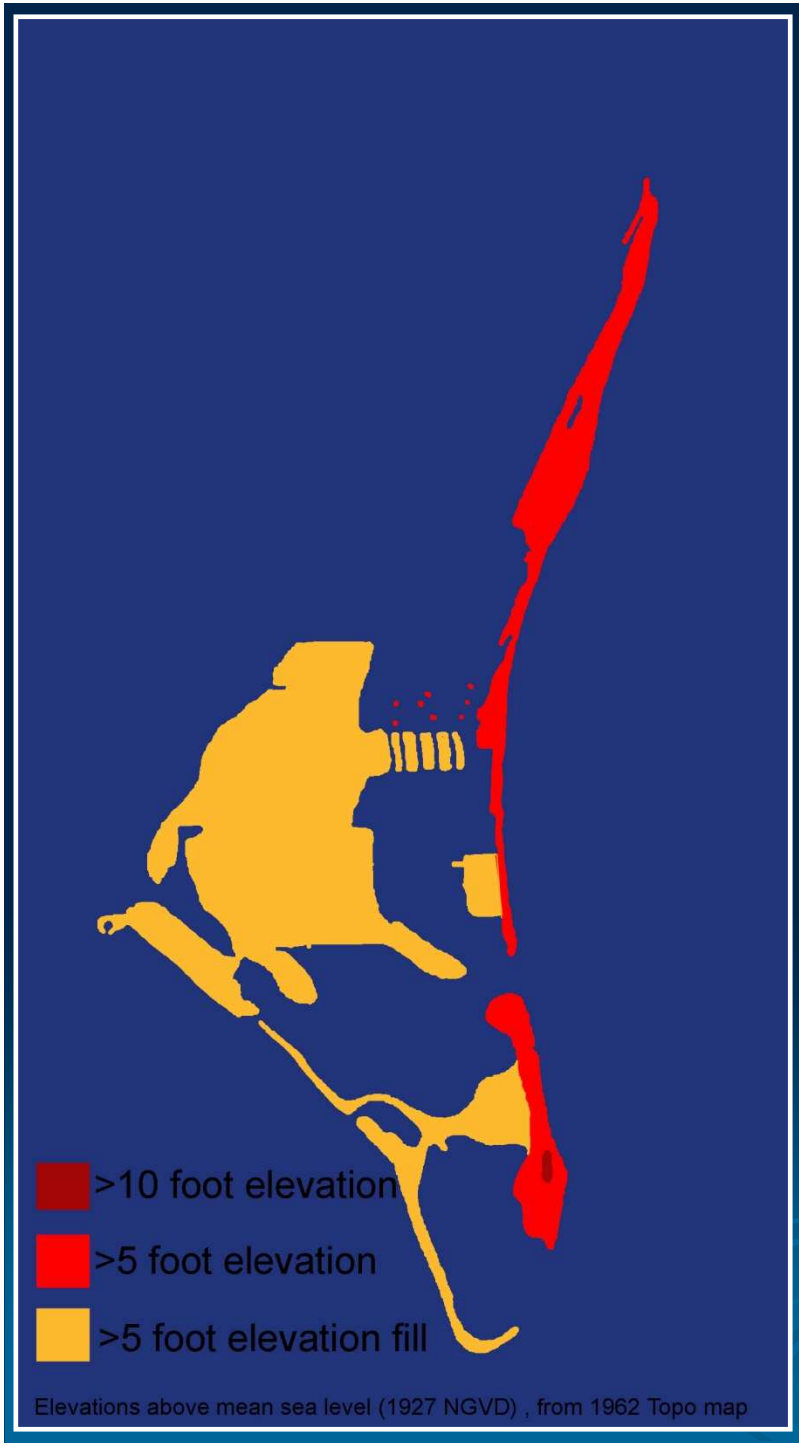
- We must also realize that the expansive coastal wetlands, which have grown over the last 2,400 years of relative SL stability, will be diminished with rapidly rising sea level– even though there may be broader areas temporarily available as coastal wetland habitats.
- In many areas it is not just sea level inundating across the land. It is also migration or collapse of substrates – sand or organics

Areas > 5 feet above mean sea level



Key Biscayne – Potentially emergent areas at MHHW with a +2.5 foot sea level rise

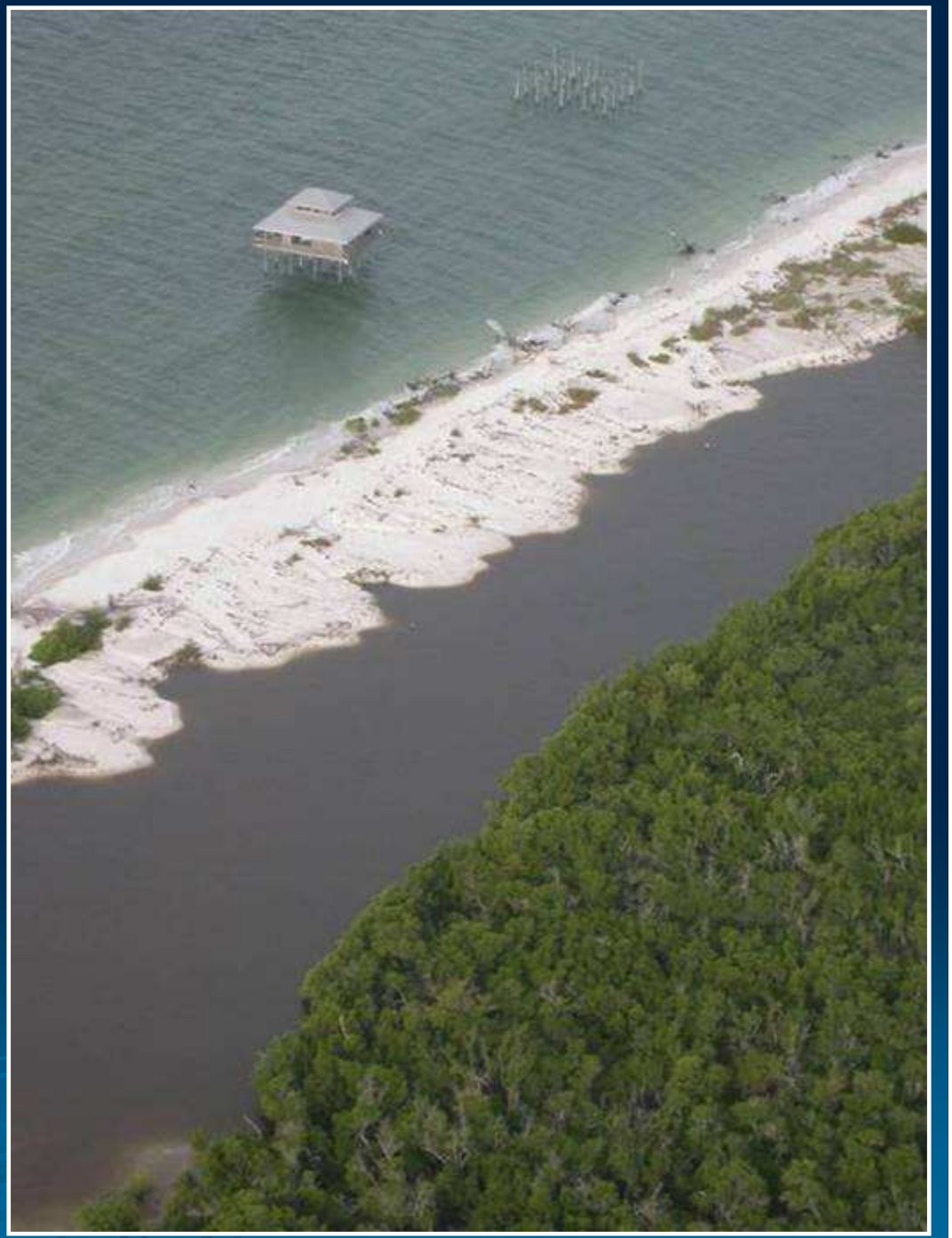
Elevations based on 1962 USGS topographic map



Will actually look more like this

The problem is that sandy barrier islands will try to move landward –

or if the rise is too fast, it will just be over ridden and abandoned.



Cape Romano, November 18, 2003

For every foot of sea level rise,

the shore will shift landward 500-2,000’.

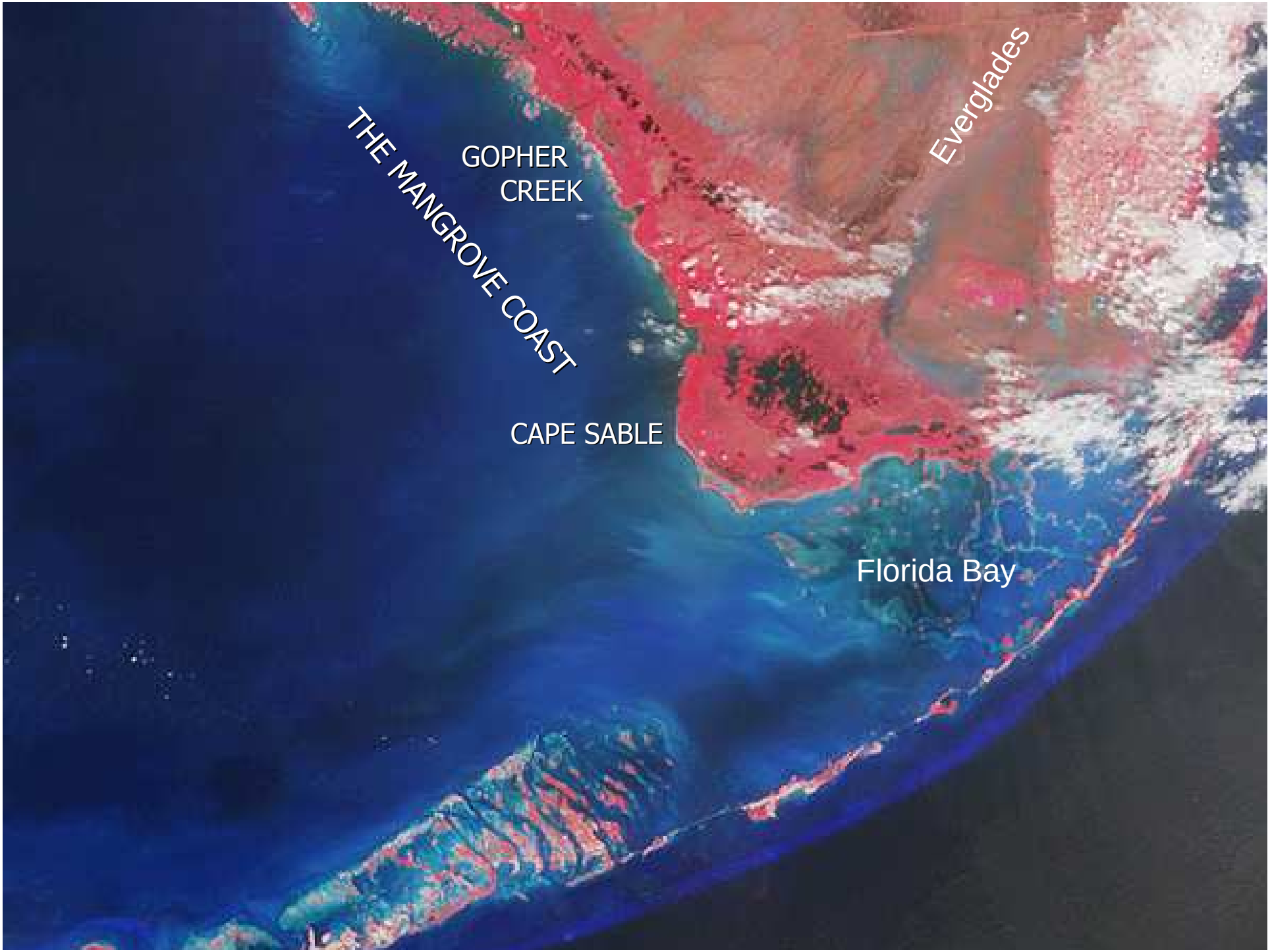
Orrin Pilkey, Duke University

With a 4-5 foot rise in sea level, essentially all sandy barrier islands will be abandoned - rapidly migrating landward or being overridden.

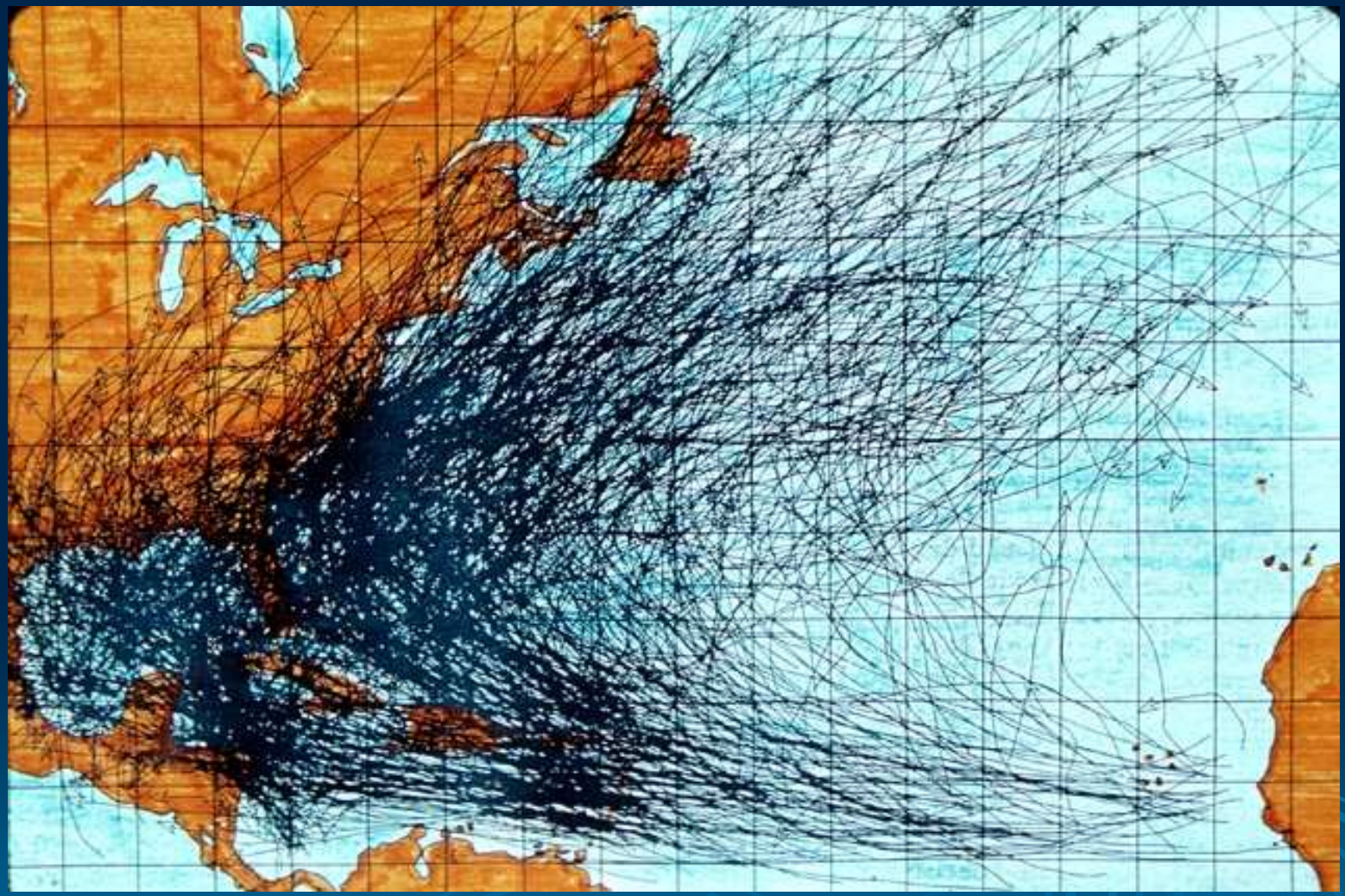
Tidal inlets will become more numerous, and many lagoons will become basically open to the sea

The 10 inch sea level rise we have had to date is rapidly eroding our low energy coastal system and giving a preview of how coastal environments will respond.

We are already seeing increased turbidity and nutrient loading in our coastal waters

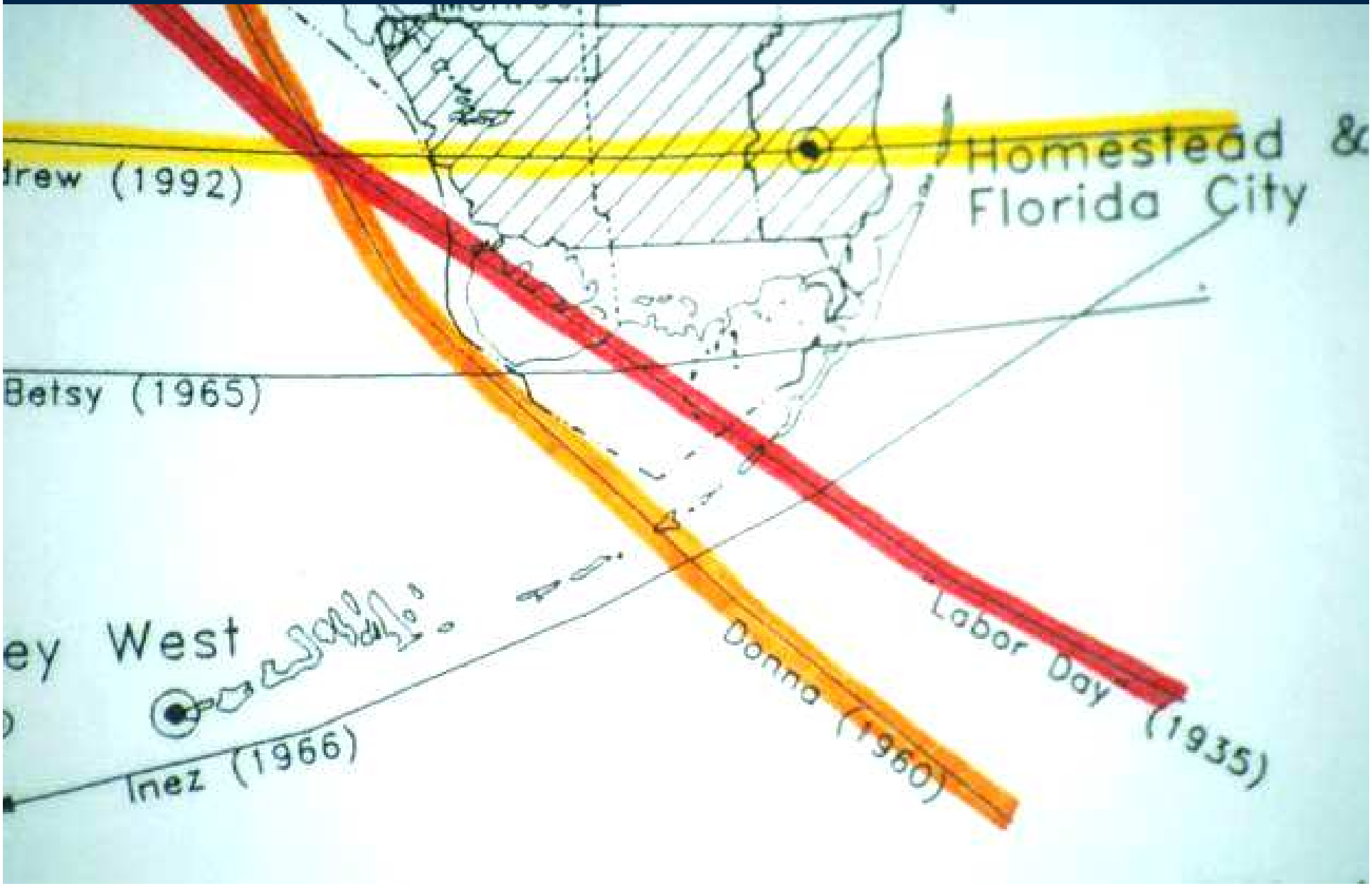

THE MANGROVE COAST
GOPHER
CREEK
Everglades
CAPE SABLE
Florida Bay

Most coastal changes will be caused or initiated by hurricanes

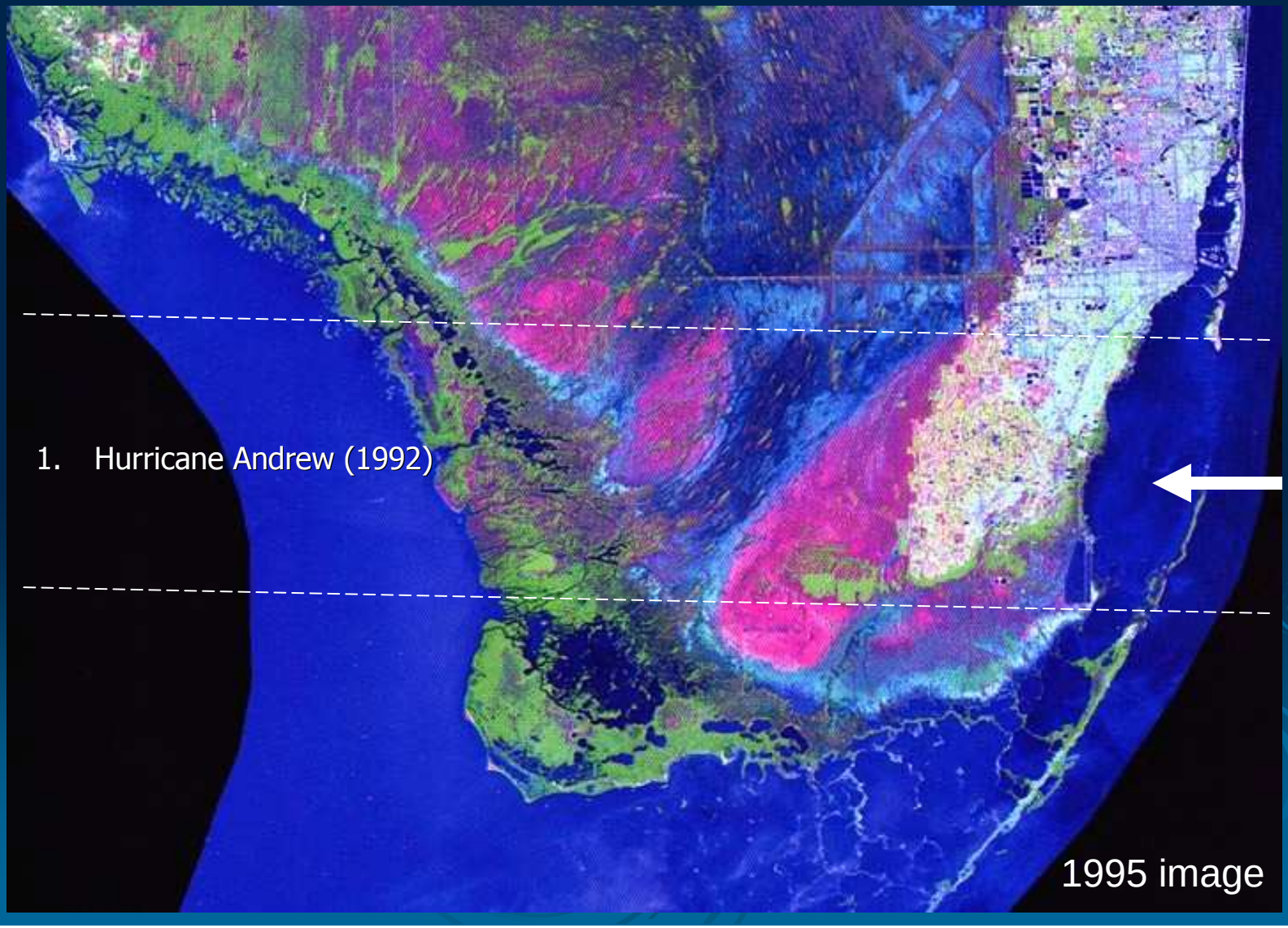


... of which we get plenty.

Three big ones of the past century



Hurricane Andrew is the most recent of a series of Catgory 4 and 5 hurricanes that have initiated evolution of the coastal complex.



Hurricanes are effectors of change in our natural environments

Hurricane Andrew, 1992

ON MANGROVE COASTLINES

In the big ones, this … **Becomes this.**

Vast areas of mangrove swamp destroyed by the major hurricanes of 1935, 1960 and 1992 have evolved into shallow bays because –

the rapid subsidence of the root peat prevents recovery as a mangrove community.

Highland Beach and mangroves, Hurricane Andrew

Tom Smith, USGS, Highland Beach

Figure 3-5. Sequential aerial photographs showing the impact of the Great Labor Day Hurricane of 1935 on Big Sable Creek and minimal recovery in the subsequent 18 years. The area was mature black mangrove forest with narrow tidal creeks prior to the storm. See Figures 3-6 to 3-10 for sequential maps.

The Great Labor Day Hurricane of 1935 decimated the mature mangrove forest of Big Sable Creek.

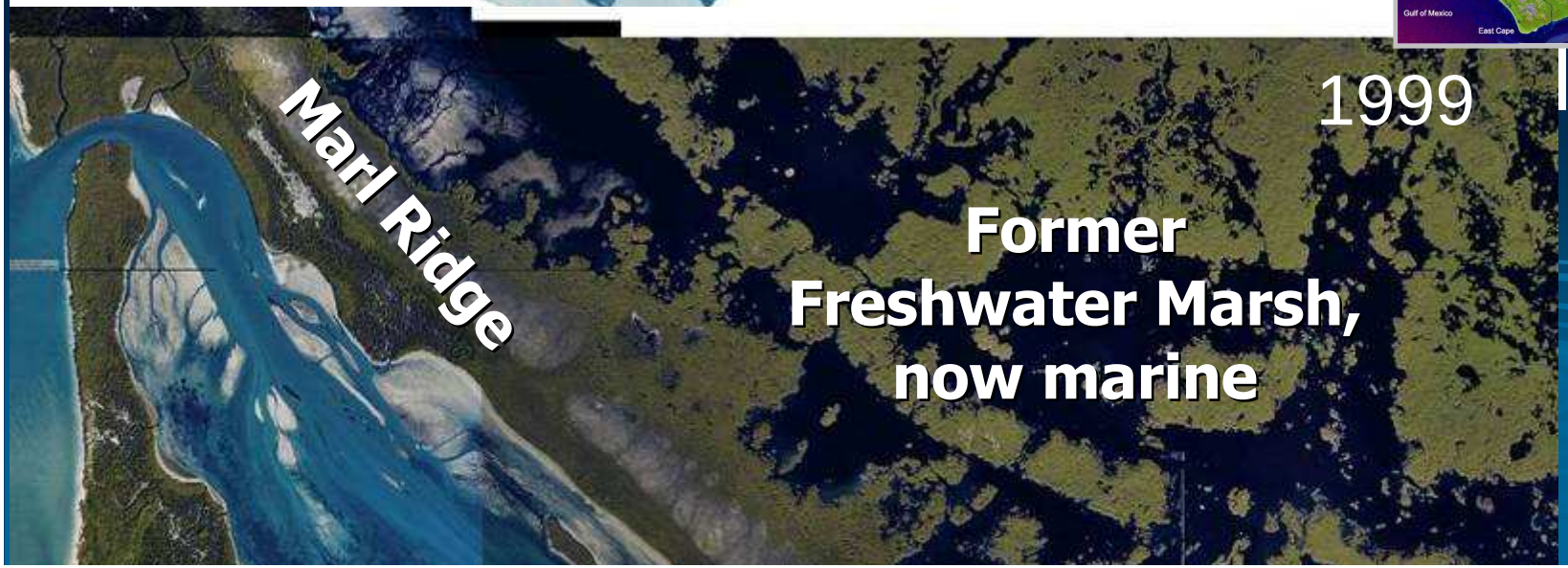

1935
1960

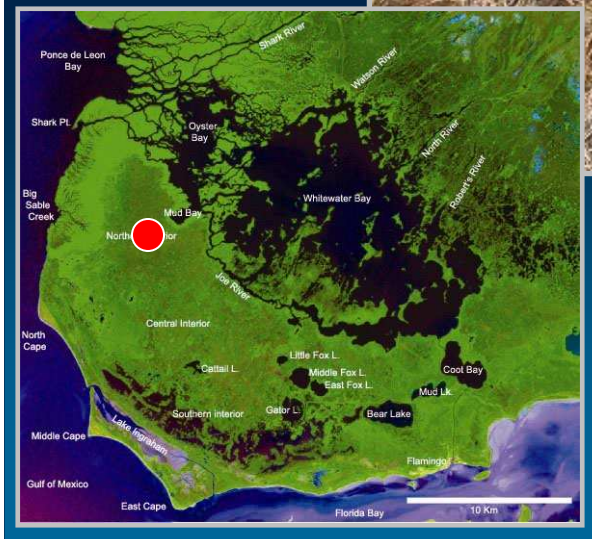
1962

1981

Dead peat surface is now about 3’ (1 m) lower than living mangrove surface – through decay.

On Cape Sable, historical saline intrusion has resulted in collapse of freshwater peat.



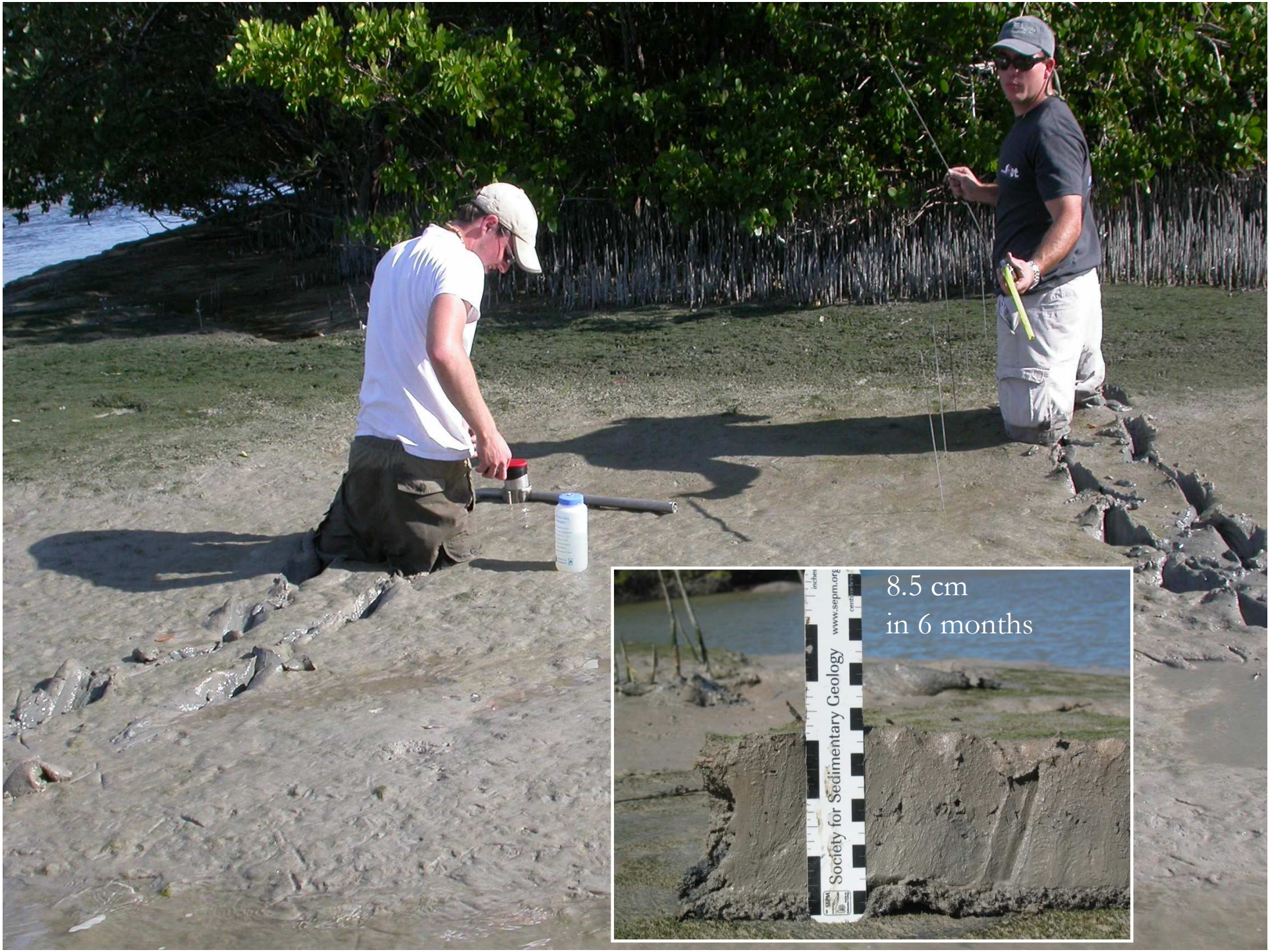


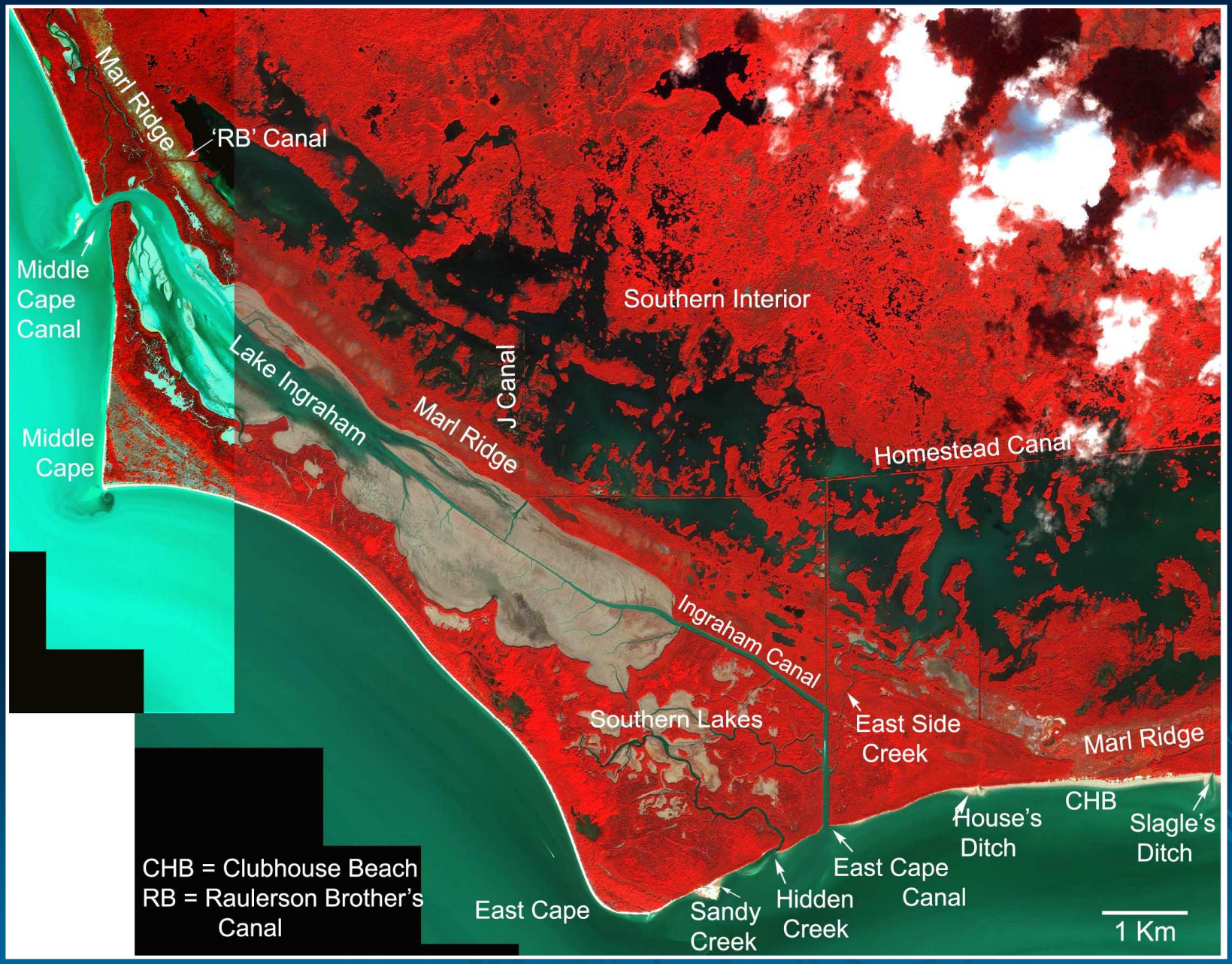
WIDESPREAD INUNDATION & COLLAPSE OF FRESWATER WETLANDS – in areas not modified by humans.

AND CONVERSION TO OPEN WATER

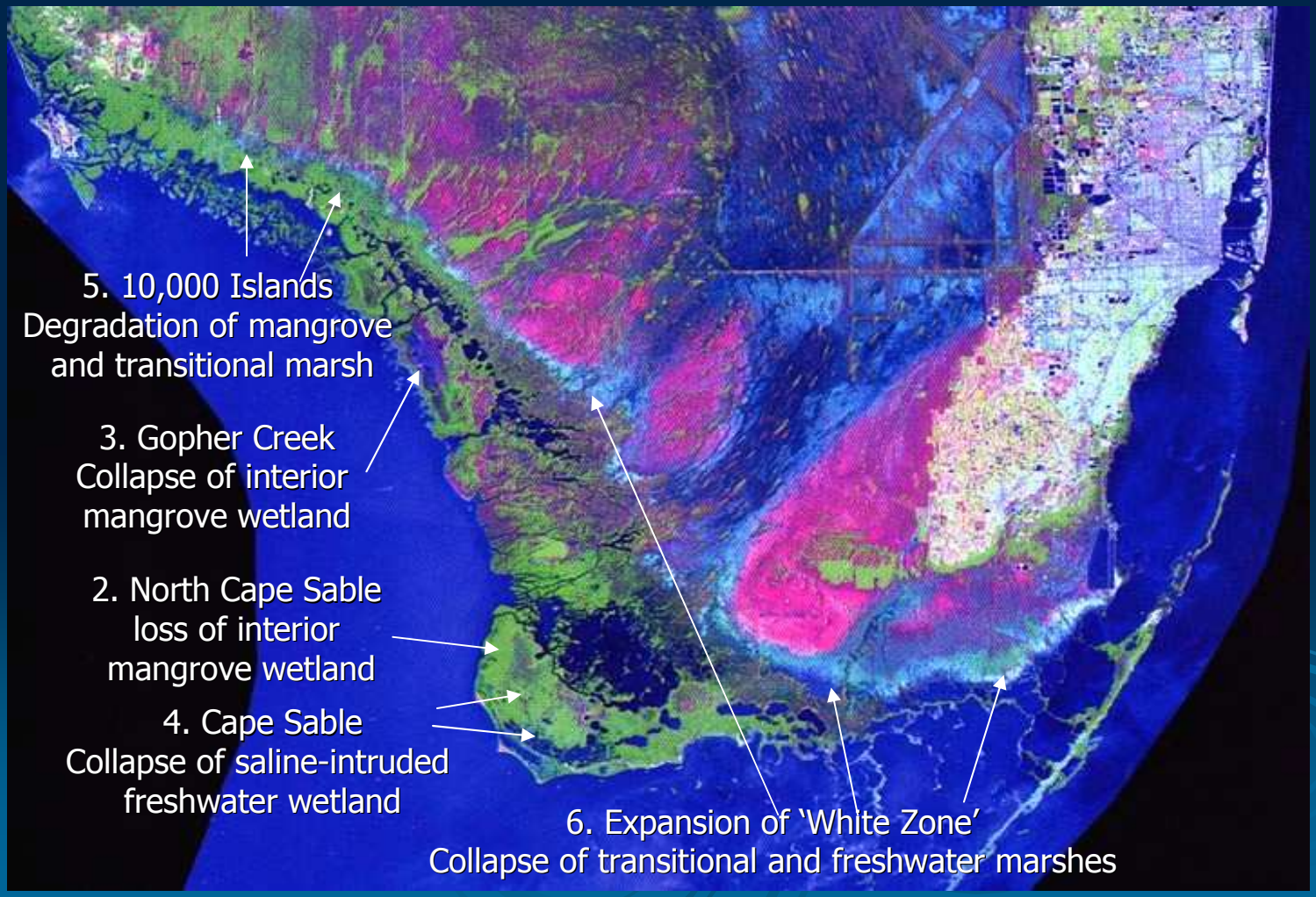
Rising sea level is a time of high nutrients and turbidity


This mud can be encouraged to re-deposit in the inner coastal zone to slow rapid coastal backstepping

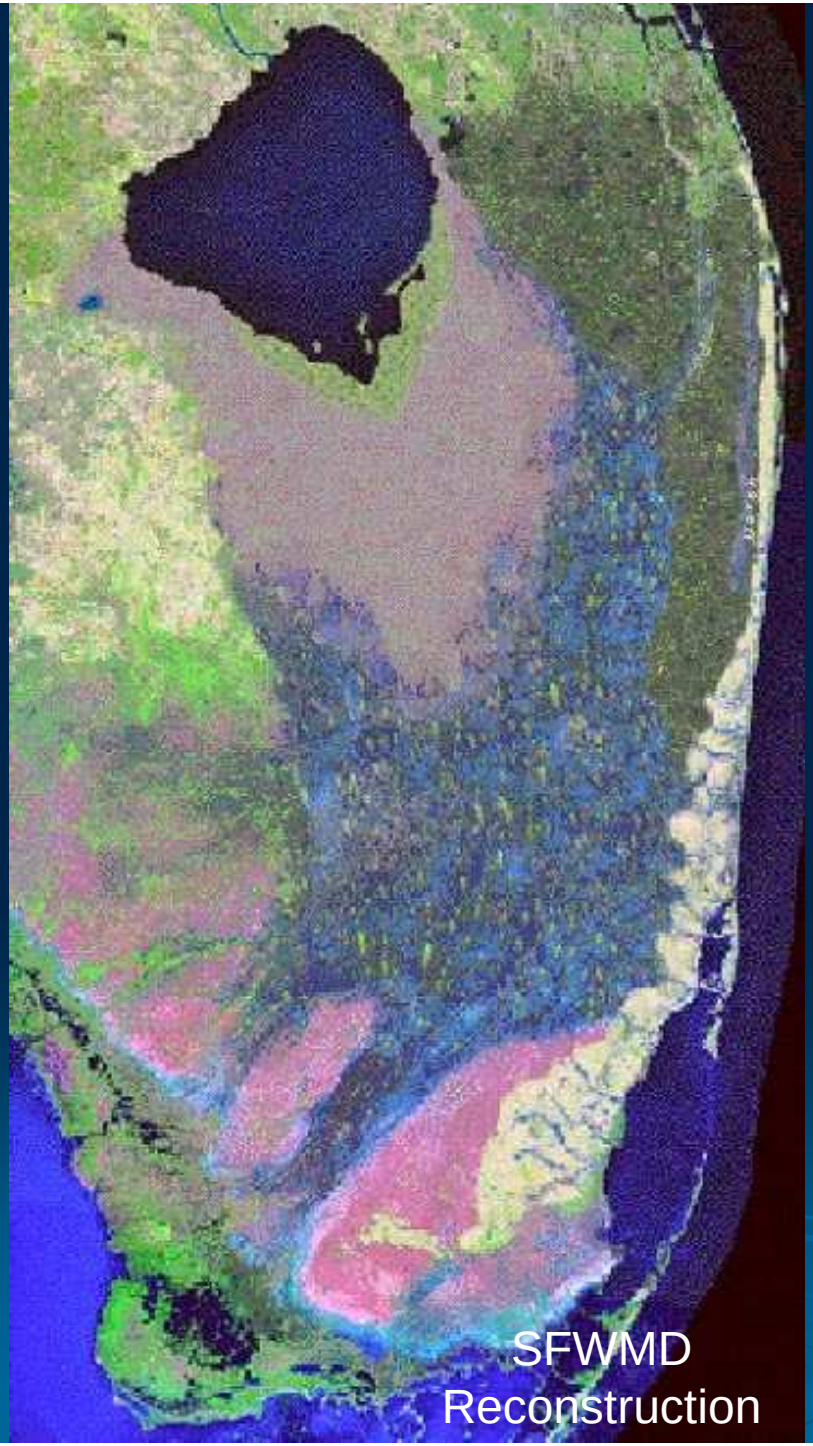

8.5 cm
in 6 months
Society for Sedimentary Geology
www.sepm.org


Marl Ridge
'RB' Canal
Middle Cape Canal
Middle Cape
Lake Ingraham
Marl Ridge
J Canal
Southern Interior
Homestead Canal
Ingraham Canal
Southern Lakes
East Side Creek
Marl Ridge
CHB
House's Ditch
Slagle's Ditch
East Cape Canal
Hidden Creek
Sandy Creek
East Cape
CHB = Clubhouse Beach
RB = Raulerson Brother's Canal
1 Km

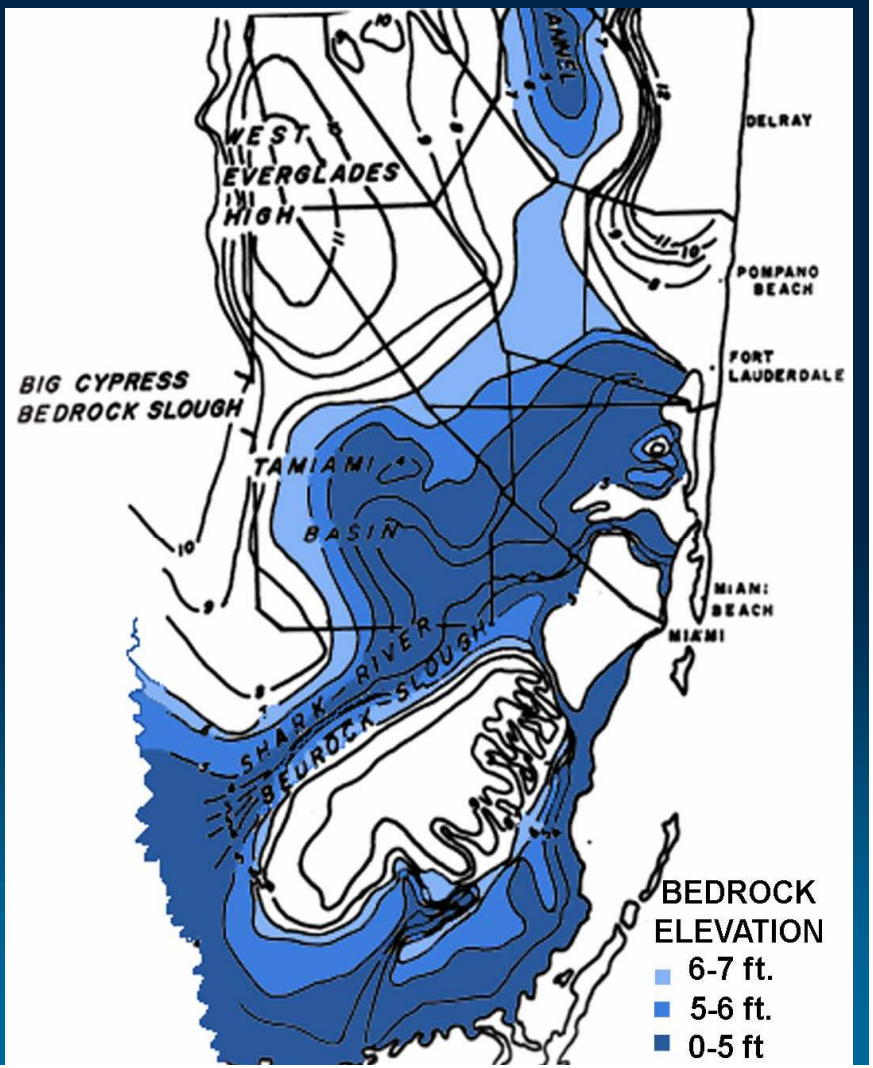
Rapid loss of saline and freshwater wetlands is occurring throughout south Florida's coastal complex in response to sea level rise and saline intrusion.



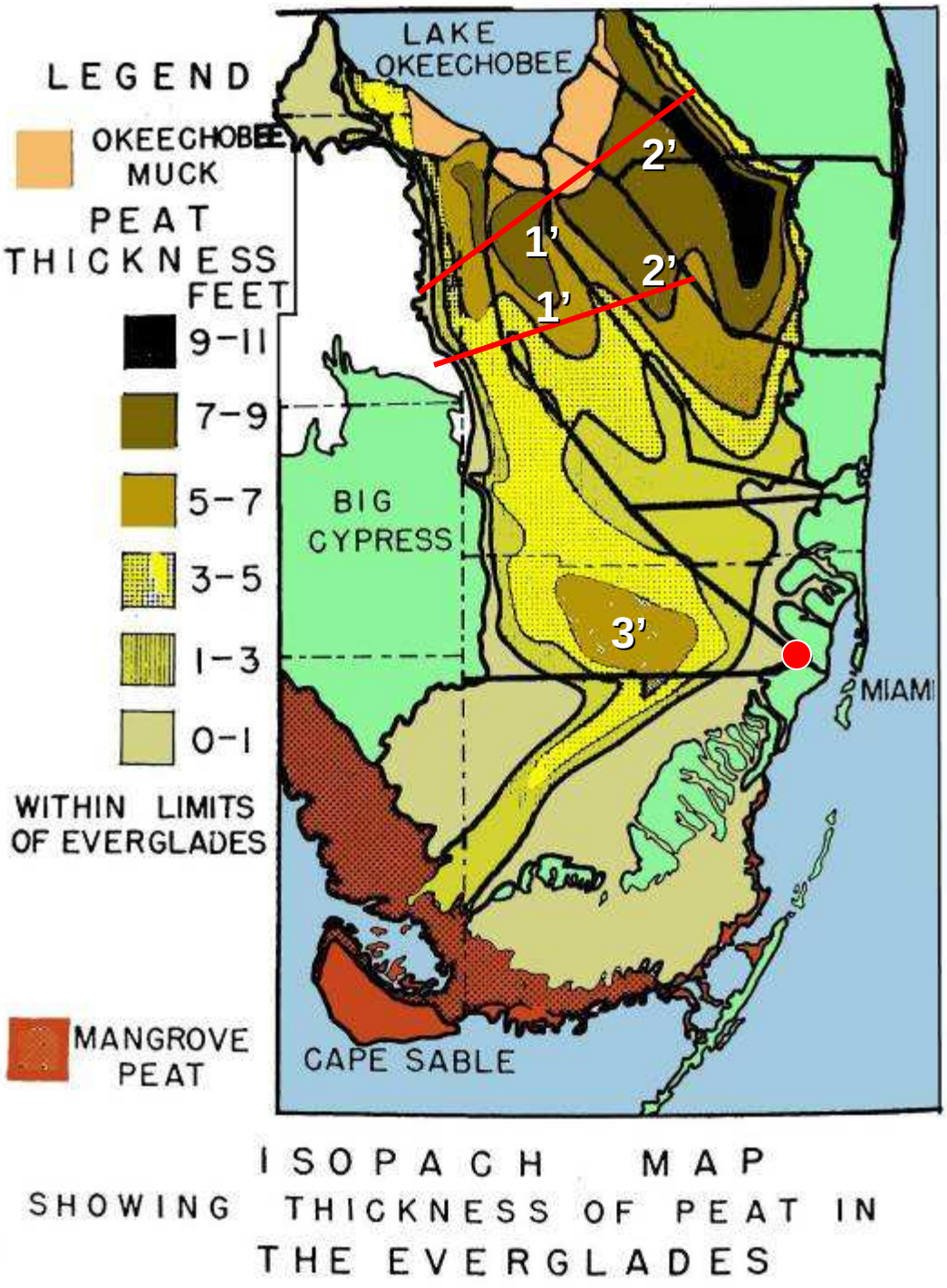
Low-lying coastal wetlands, such as the Everglades will be largely overwhelmed by a 4-5 foot rise of sea level.



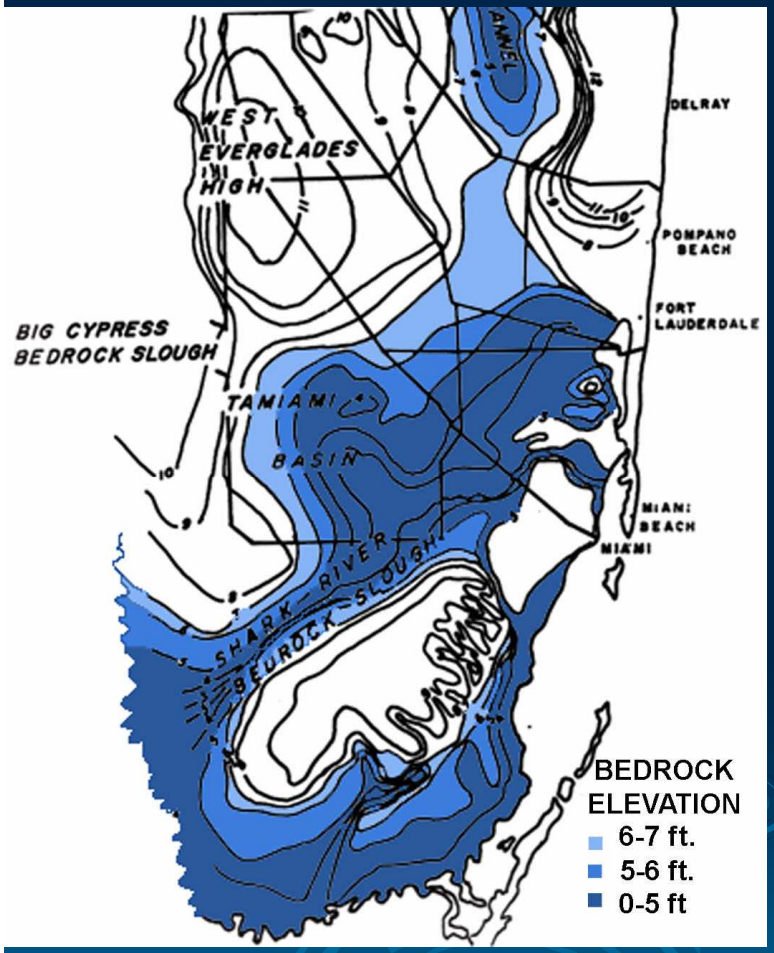
The underlying bedrock is low and -



most of the peat has been lost.



ISOPACH MAP SHOWING THICKNESS OF PEAT IN THE EVERGLADES



So, there is little elevation provided by peat buildup to help hold back encroachment by rising sea level.

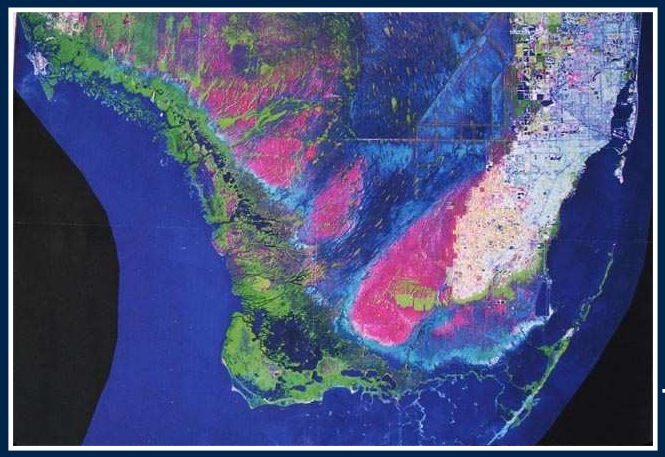
Everglades Restoration –

the re-establishment of a reliable flow and increasing level of southward flowing fresh water –

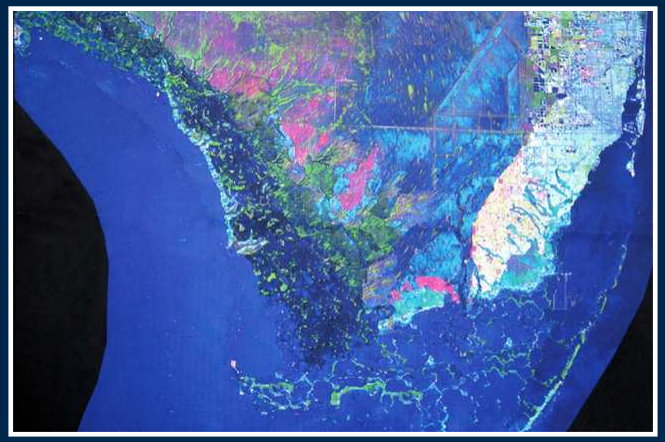
leading to the regrowth of thick organic peat (an adsorbent sponge to maintain the freshwater head through the dry season)

is now more important than ever.

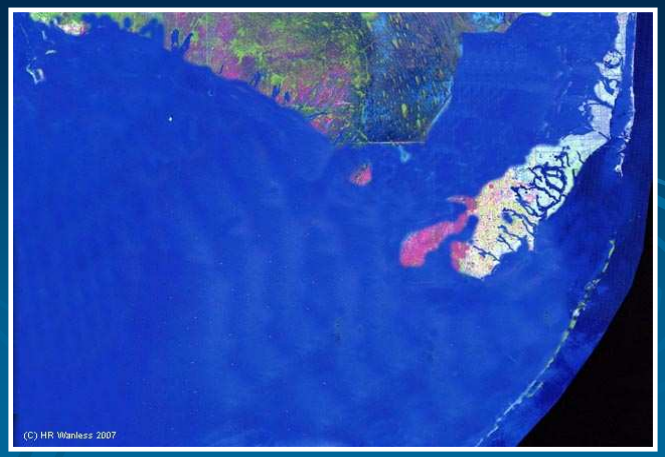
Earth has a close to catastrophic evolution of its coastal and low-lying environments, habitats, infrastructure and resources underway this century, and we tend to be ignoring the track record for very rapid sea level responses to climatic destabilization.



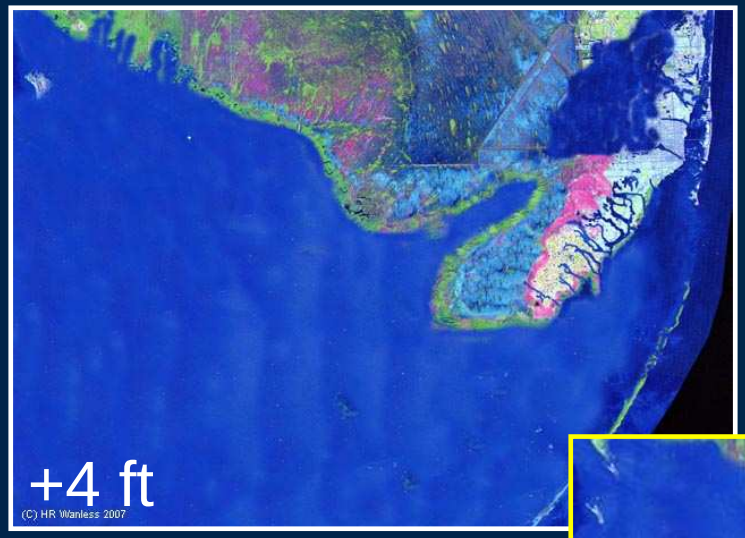
TODAY



+ 2 ft



+ 5 ft



• This is the minimum we must plan for by the end of the century.

• Any further melt acceleration, and it will be more

• Green house gasses are sufficiently high that this is a likely scenario in the next ___, but this too is possible sooner it portions of Greenland or Antarctica destabilize.

The United States is still the leading cause of global warming.

- We must take the lead in -
  - Drastically reducing our greenhouse gas and fine particulate soot production and release.
  - Rapid development and implementation of truly clean energy sources.
  - Removing CO_2 from the atmosphere.
- Then, we can take the leadership that the world will follow.

In a time of rapid sea level rise, we must work responsibly to reduce -

- economic risk in coastal development,
- risk to human life and property,
- environmental degradation associated with challenging an advancing ocean,
- the level of greenhouse gasses in the atmosphere.

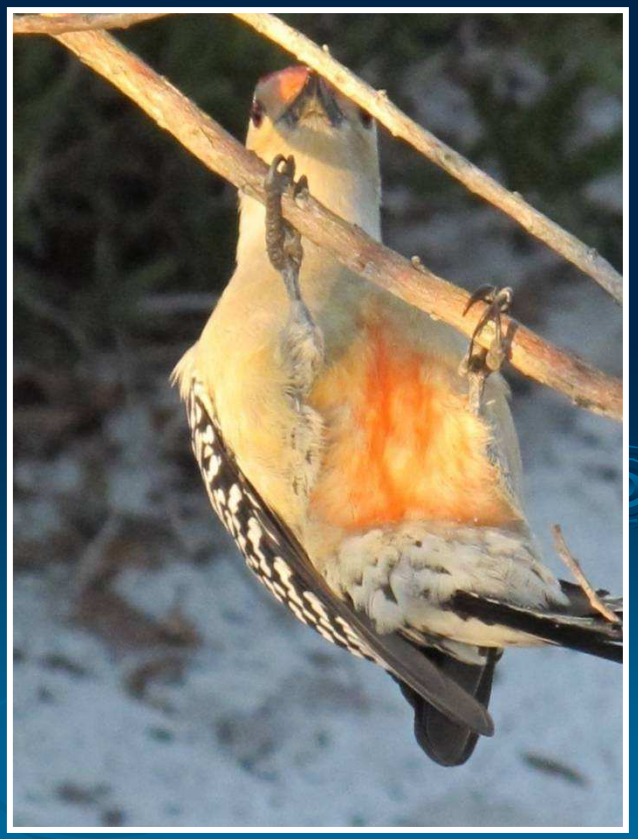
ENJOY THE FUTURE OF THE HISTORY OF EARTH!

ENJOY THE FUTURE OF THE HISTORY OF EARTH!

High tide in the 1700 block of North Bayshore Dr., Miami FL. Unfortunately, this flooding is not associated with storm surge or any other exceptional tidal or weather event.

FROM ALL OF US – THANKS REED

- AND HILARY AND EVERYONE AT ARCHBOLD



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