Managing the Everglades in a Time of Rapidly Rising Sea Level

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State of Florida Legislative Committee

on Everglades Restoration

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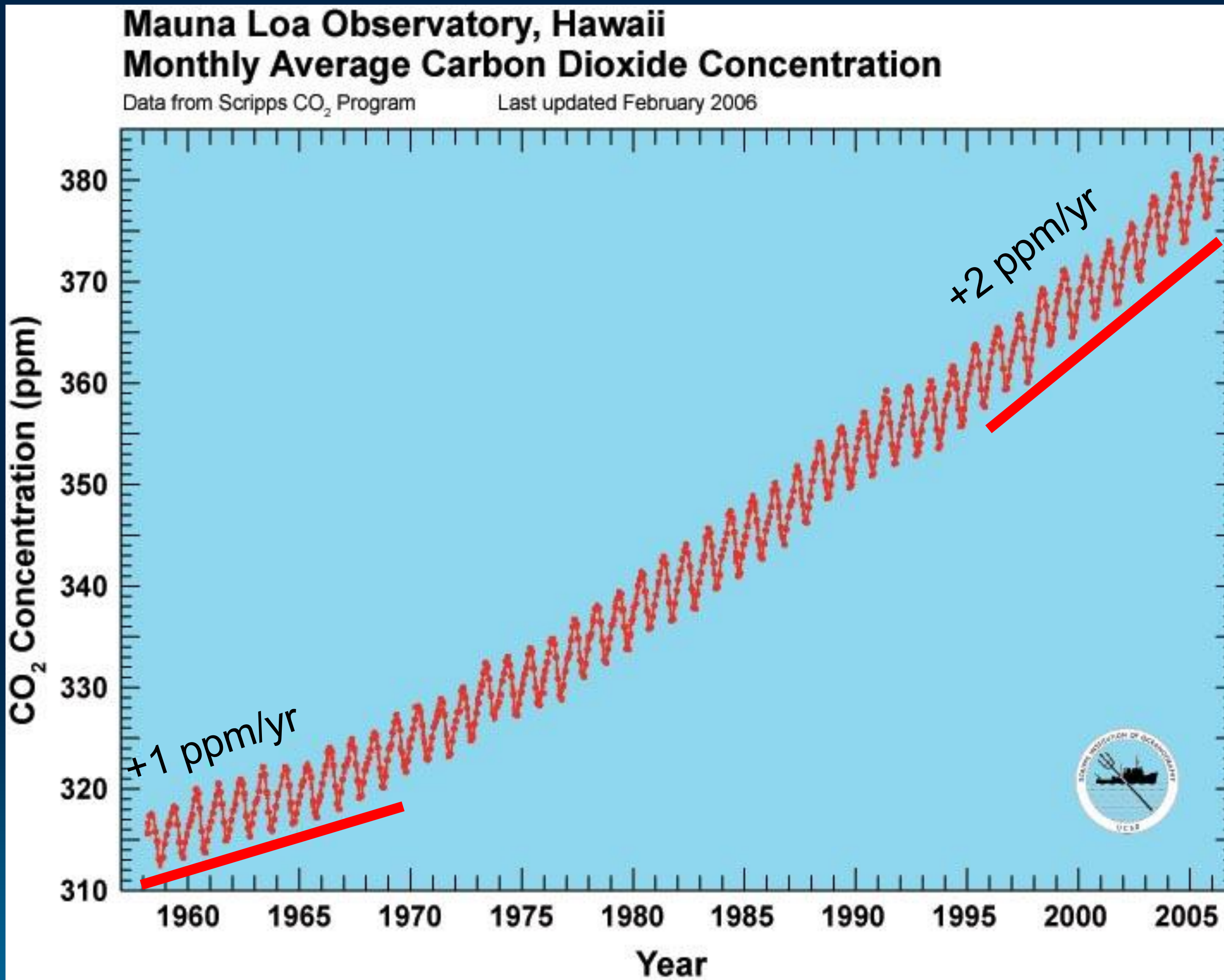
HUMAN-INDUCED GLOBAL WARMING IS REAL.

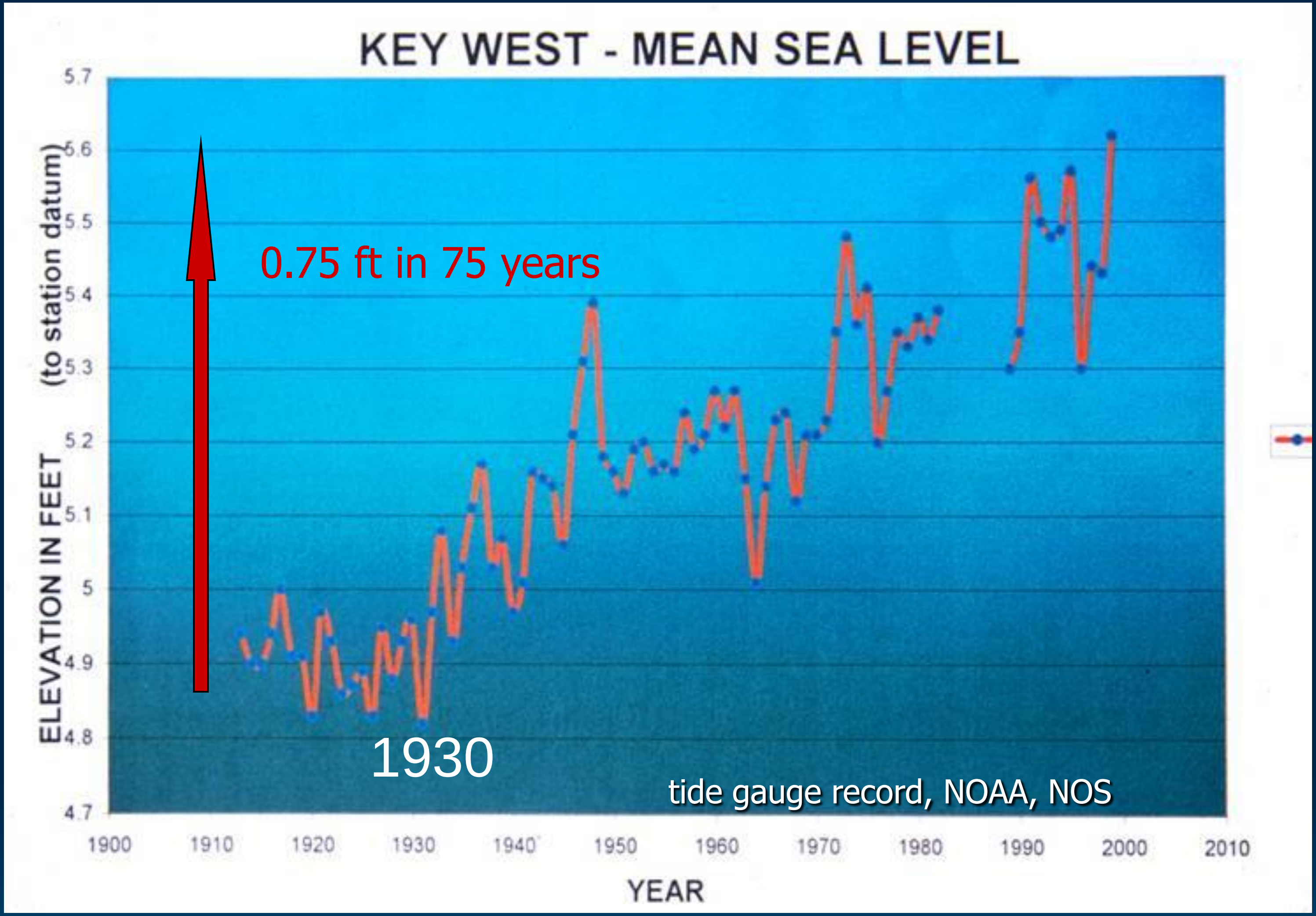
It has already started.

During the coming century, it will change Florida and Earth beyond your wildest imaginations.

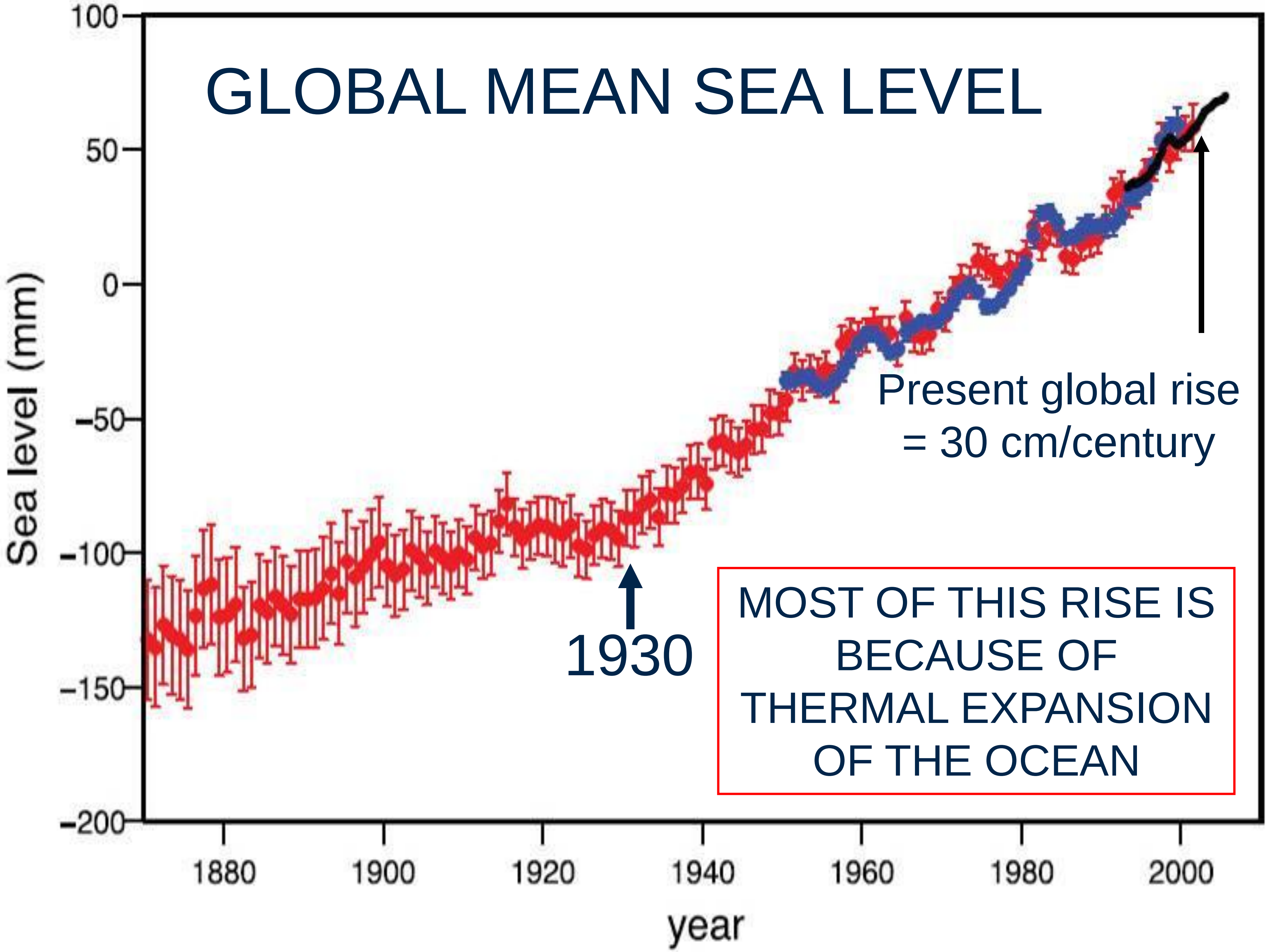
CO2 is increasing at an increasing rate,



and so are methane and the other greenhouse gasses.



Beginning in 1930, the rate of relative sea level rise increased about 8 fold over that of the past 2,000 years. It is presently rising at 30 cm (1′) / 100 years!


GLOBAL MEAN SEA LEVEL
Sea level (mm)
100
50
0
-50
-100
-150
-200
1880
1900
1920
1940
1960
1980
2000
year
1930
Present global rise
= 30 cm/century
MOST OF THIS RISE IS
BECAUSE OF
THERMAL EXPANSION
OF THE OCEAN

Most of this historic rise is the result of warmer, expanded oceans.

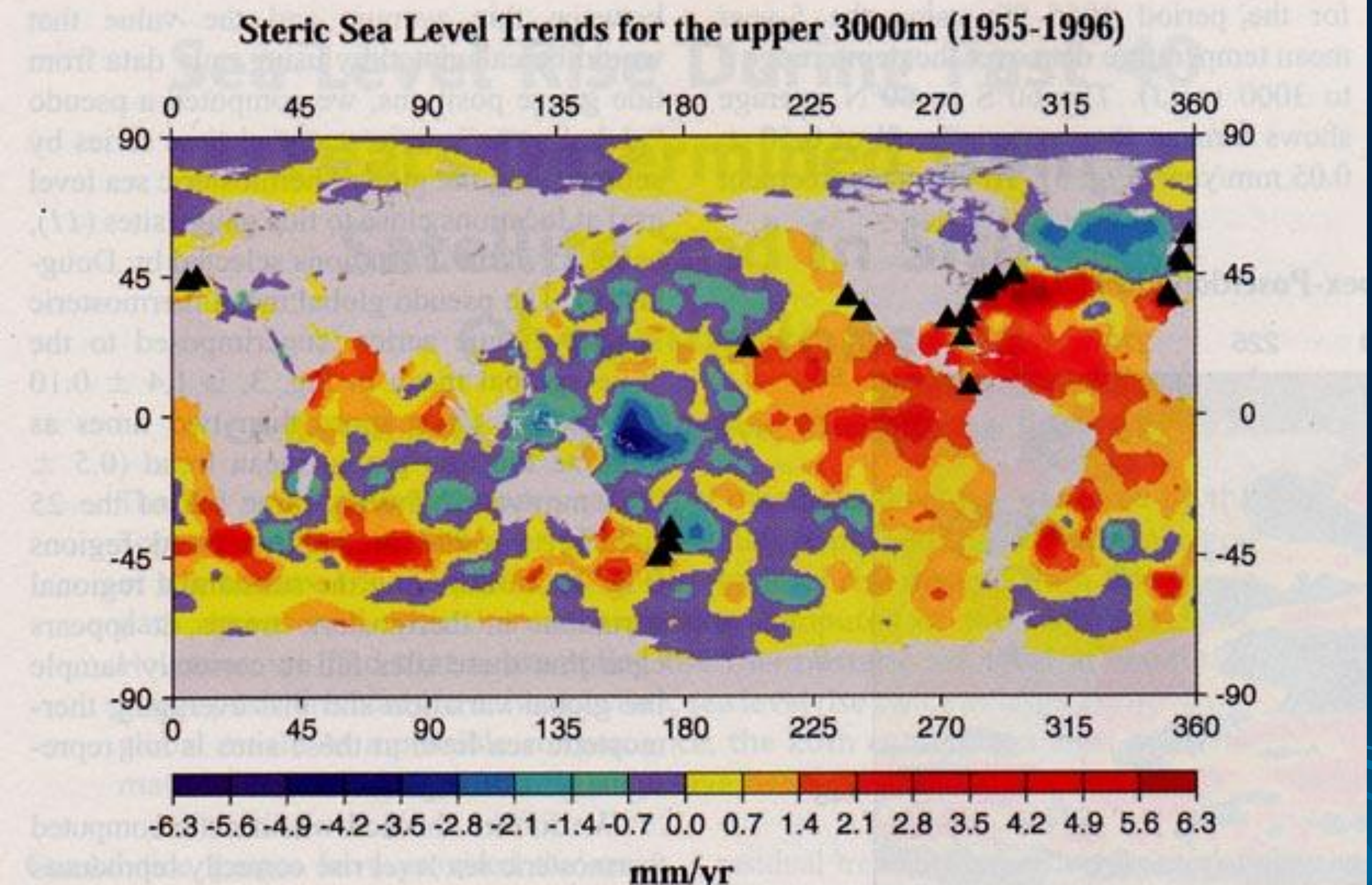


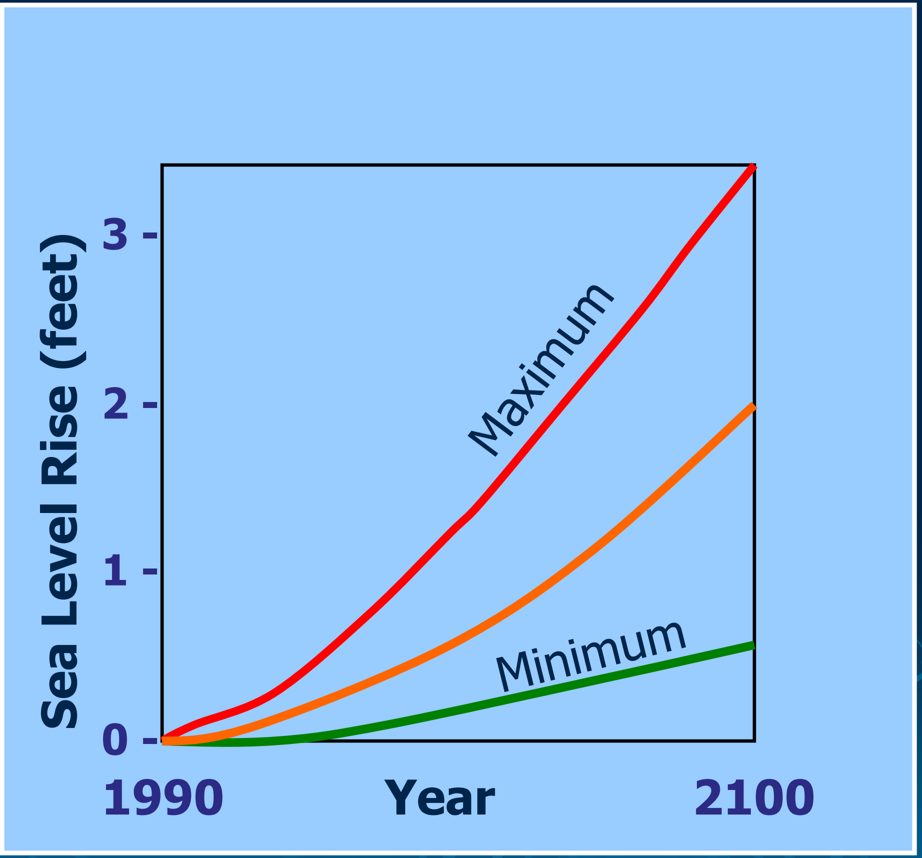
Fig. 4. Map of the geographical distribution of thermosteric sea level trends for 1955–96 computed with temperature data from (3) down to 3000-m depths. Black triangles show the locations of the 25 tide gauges.

Climate and Sea Level Do Not Respond Gradually to stresses

- Like the stress/strain concepts in physics, climate stresses, at some point will result in rapid shifts and changes and new ‘state’.
- IPCC and other climate and sea level forecasts assume gradual linear responses and changes - not sudden tipping points and switches to new states.
- This is what has scientists studying climate, the Arctic and sea level close to panicked about the future.

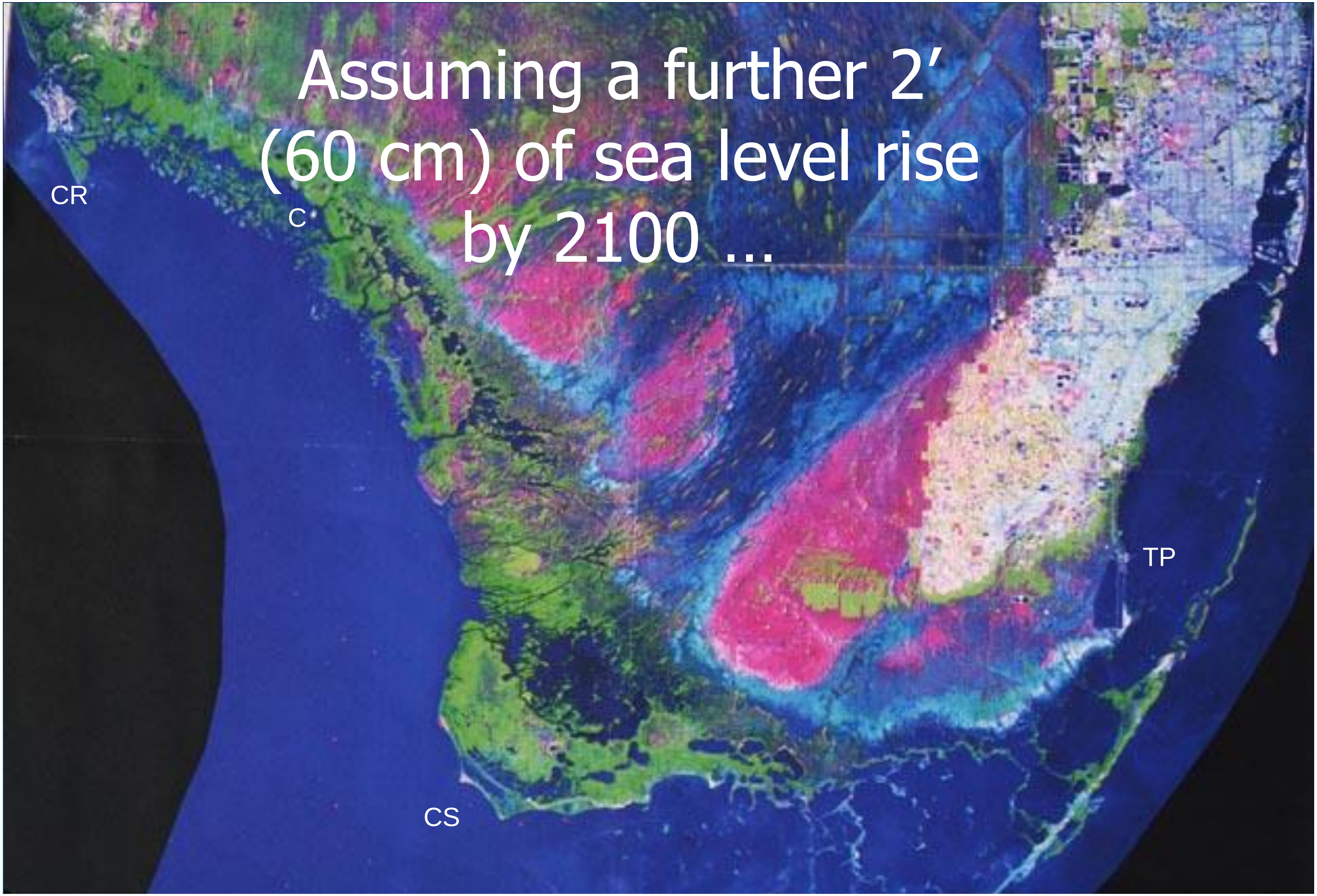
What is forecast for the future?

- 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 and sea level.

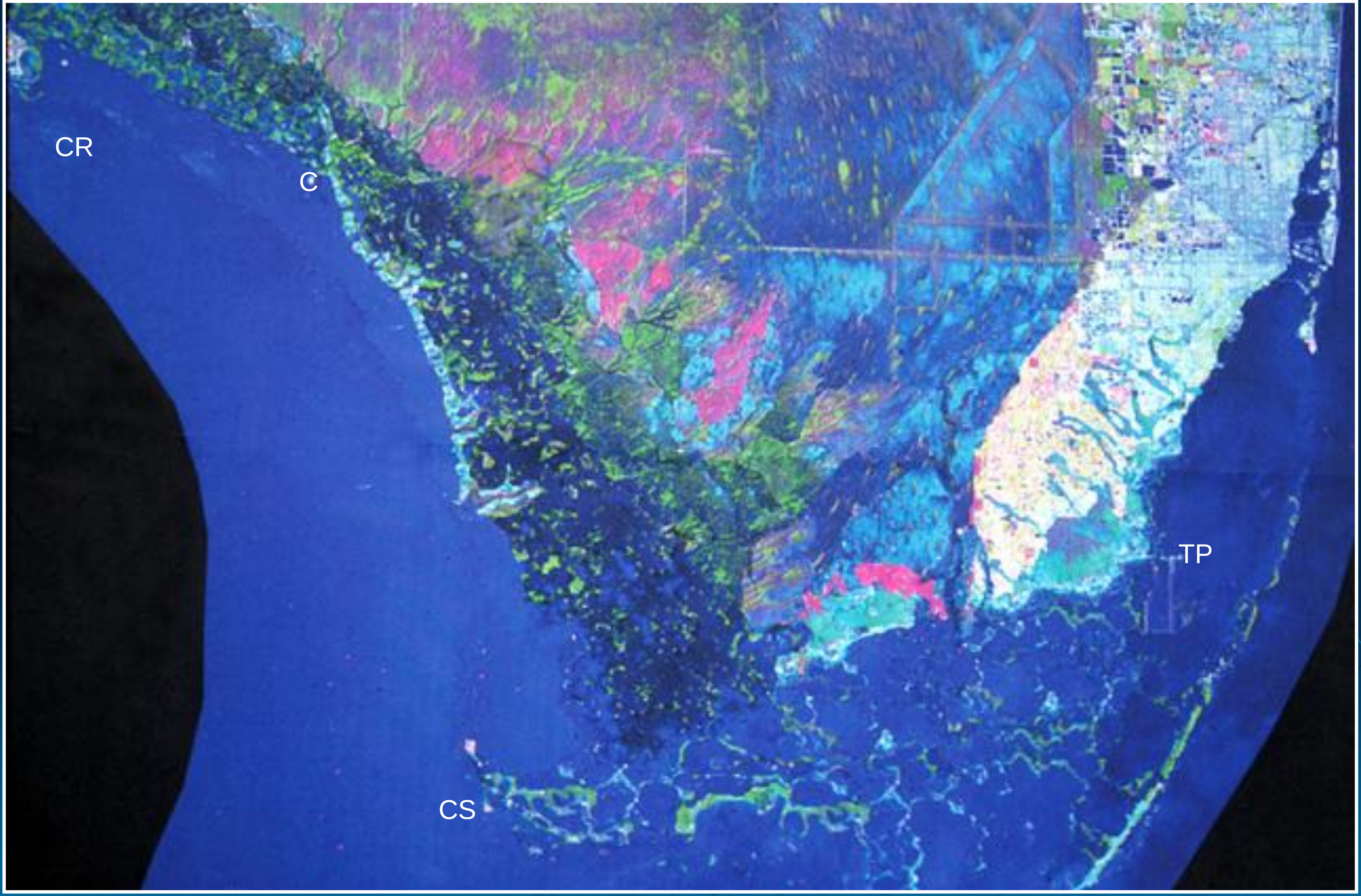


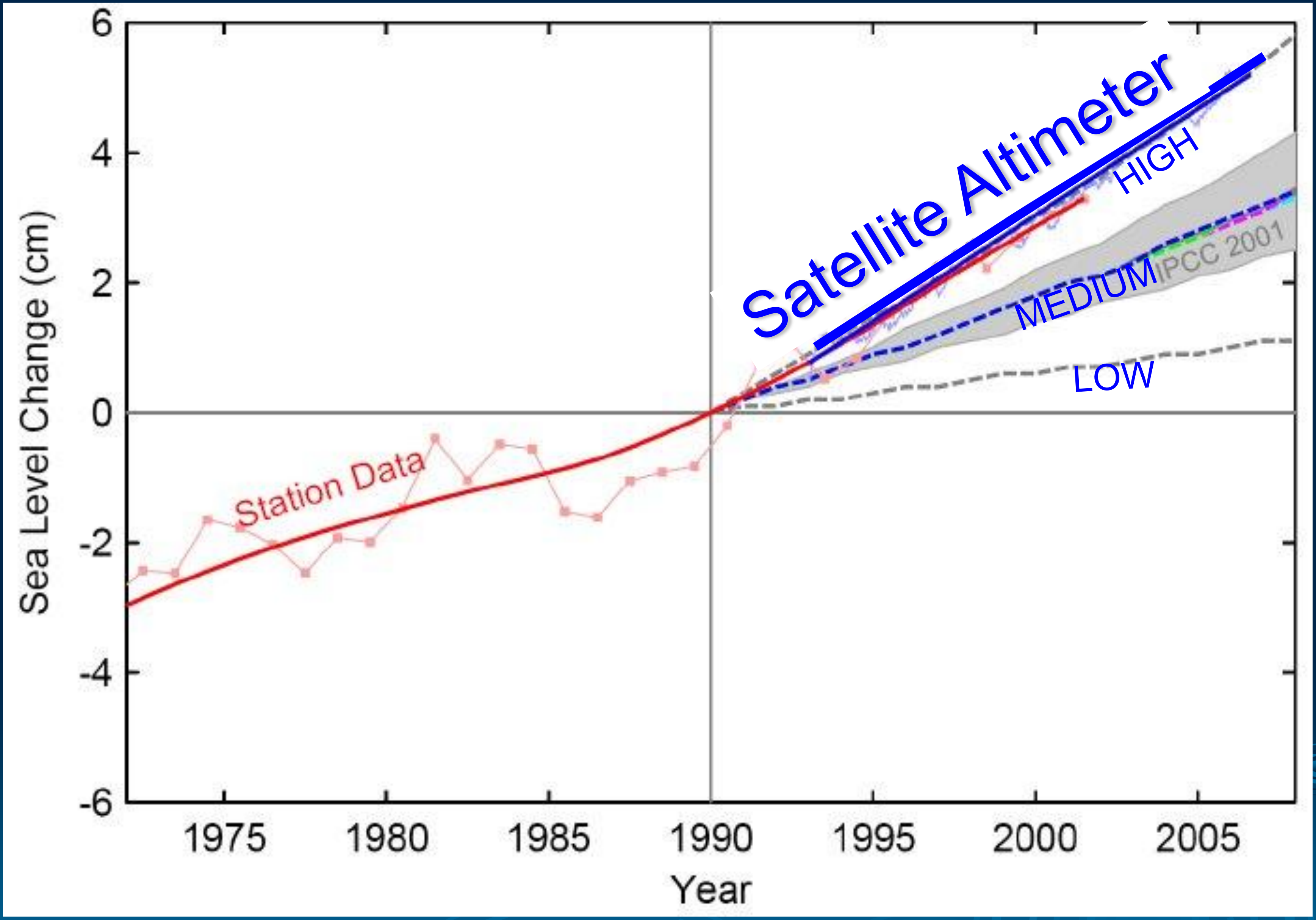
IPCC, 2001

South Florida 1995



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





Global sea level rise (based on tide gauge and satellite data) has been following the highest end of the 2001 IPCC sea level projection.

Intergovernmental Panel on Climate Change Historical Influences on Global Sea Level Rise

Source	Global Sea Level Rise (mm yr–1) 1961–1992	1993–2003
Thermal Expansion	0.03 ± 0.12	**1.6 ± 0.5**
Glaciers and Ice Caps	0.43 ± 0.18	0.77 ± 0.22
Greenland Ice Sheet	0.003 ± 0.12	0.21 ± 0.07
Antarctic Ice Sheet	0.12 ± 0.41	0.21 ± 0.35
Other	0.83 ± 0.7	0.3 ± 1.0
Observed	**1.8 ± 0.5**	**3.1 ± 0.7**

Calculated from IPCC, 2007

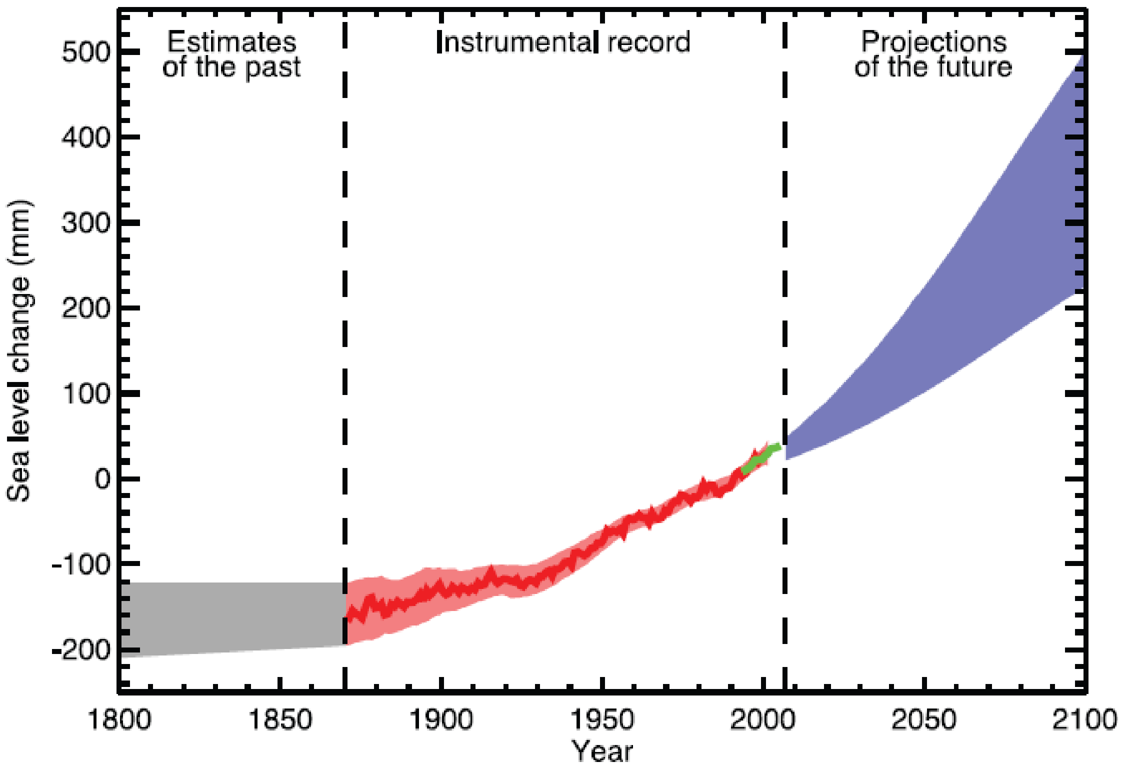
IPCC 2007
Projection For Coming Century

“Thermal expansion is projected to contribute more than half of the average rise, but land ice will lose mass increasingly rapidly as the century progresses.

“An important uncertainty relates to whether discharge of ice from the ice sheets will continue to increase as a consequence of accelerated ice flow, as has been observed in recent years.

“This would add to the amount of sea level rise, but quantitative projections of how much it would add cannot be made with confidence, owing to limited understanding of the relevant processes.”

IPCC 2007 Projection



FAQ 5.1, Figure 1. *Time series of global mean sea level (deviation from the 1980-1999 mean) in the past and as projected for the future. For the period before 1870, global measurements of sea level are not available. The grey shading shows the uncertainty in the estimated long-term rate of sea level change (Section 6.4.3). The red line is a reconstruction of global mean sea level from tide gauges (Section 5.5.2.1), and the red shading denotes the range of variations from a smooth curve. The green line shows global mean sea level observed from satellite altimetry. The blue shading represents the range of model projections for the SRES A1B scenario for the 21st century, relative to the 1980 to 1999 mean, and has been calculated independently from the observations. Beyond 2100, the projections are increasingly dependent on the emissions scenario (see Chapter 10 for a discussion of sea level rise projections for other scenarios considered in this report). Over many centuries or millennia, sea level could rise by several metres (Section 10.7.4).*

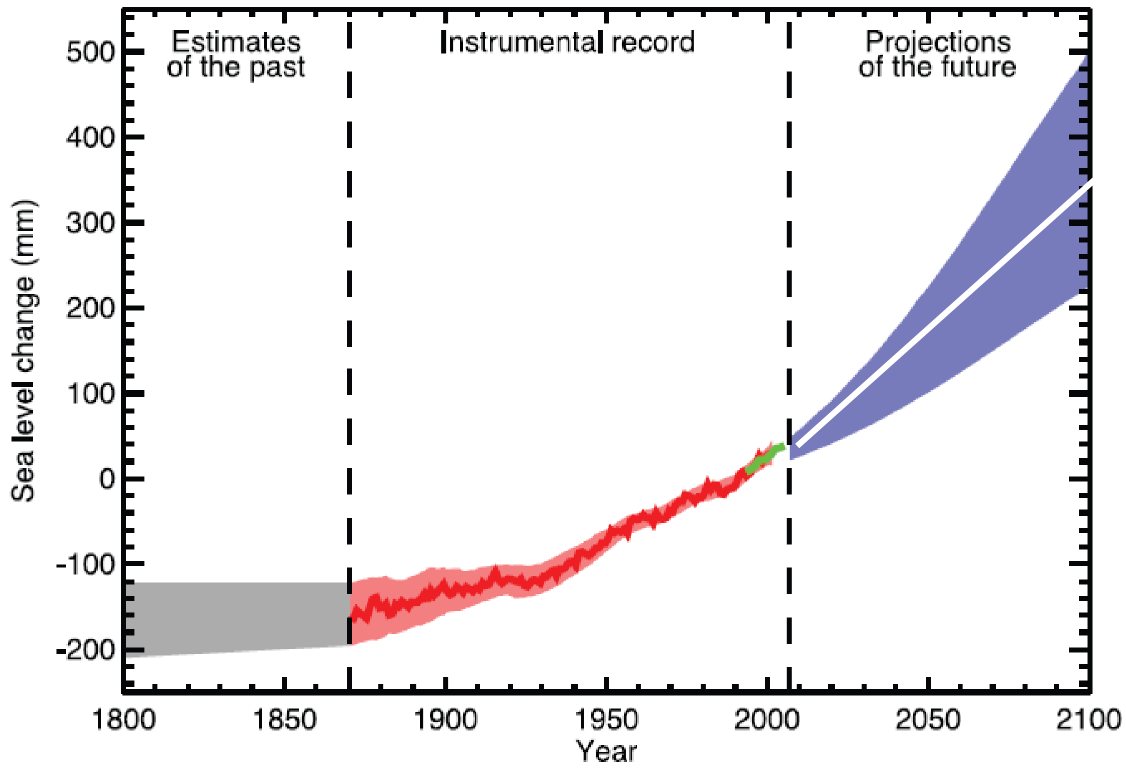
30 cm = 1 foot

This 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, 2007

IPCC 2007 Projection



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30 cm = 1 foot

White line in projection is a continuation of currently observed rate of rise (green line).

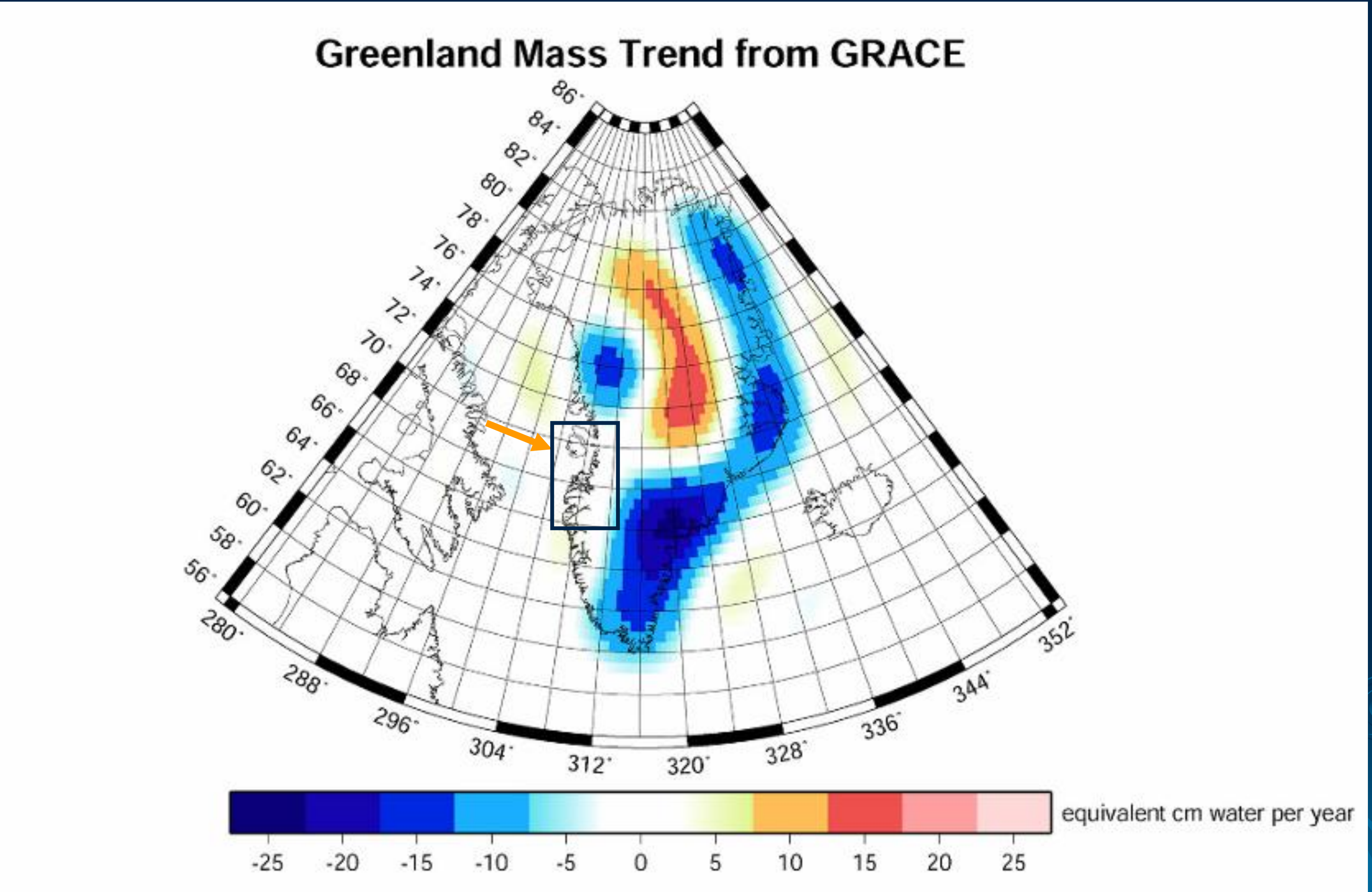
In other words, the 2007 IPCC report projects no increase in rate of global sea level rise through this century!

This projection is incomplete and thus not valid for planning,

The Answers to Florida's future lie in the Arctic

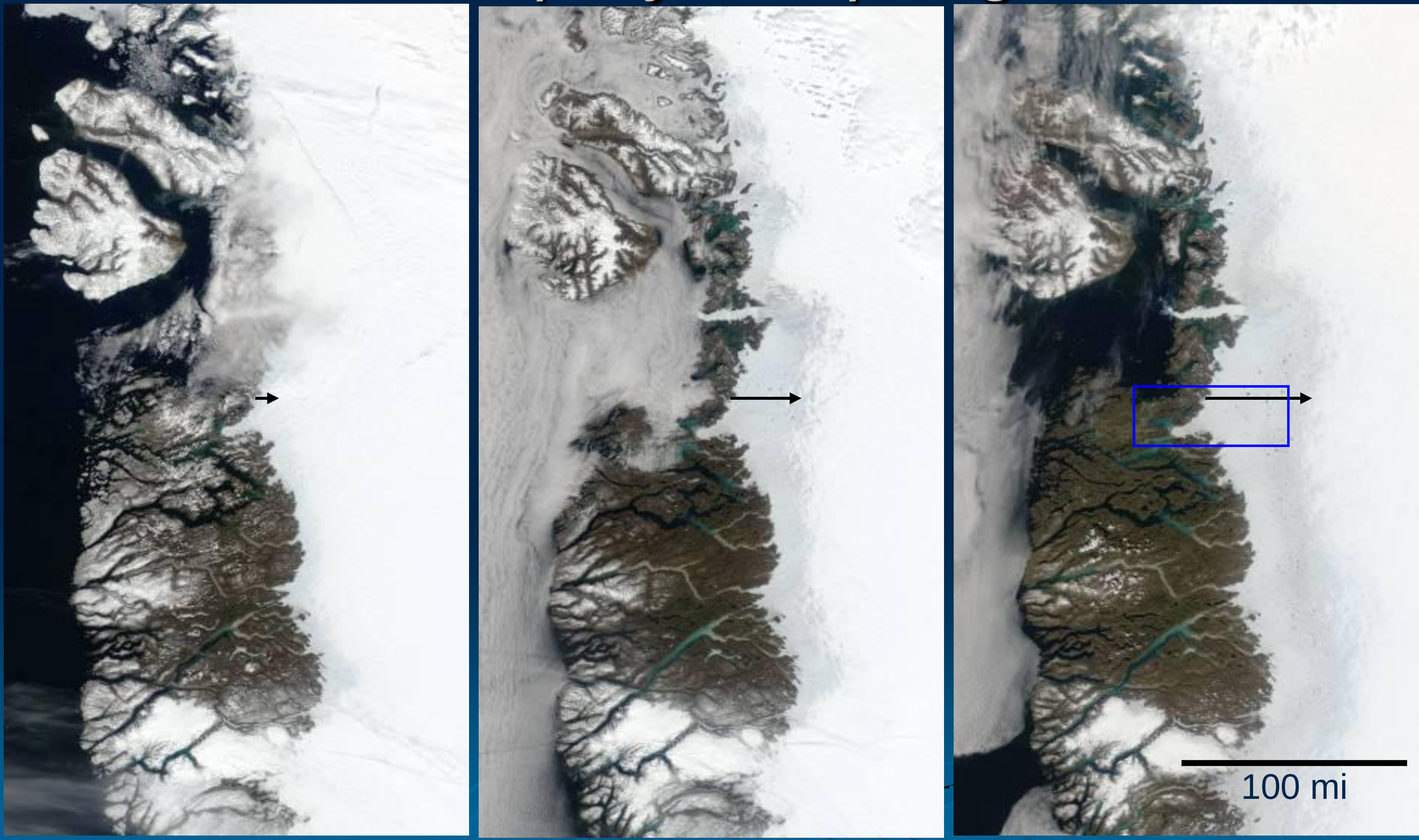
Since 2000,
the Greenland Ice Sheet
and the Arctic Ocean pack ice
have been rapidly falling apart.

Change in mass 2003-2005

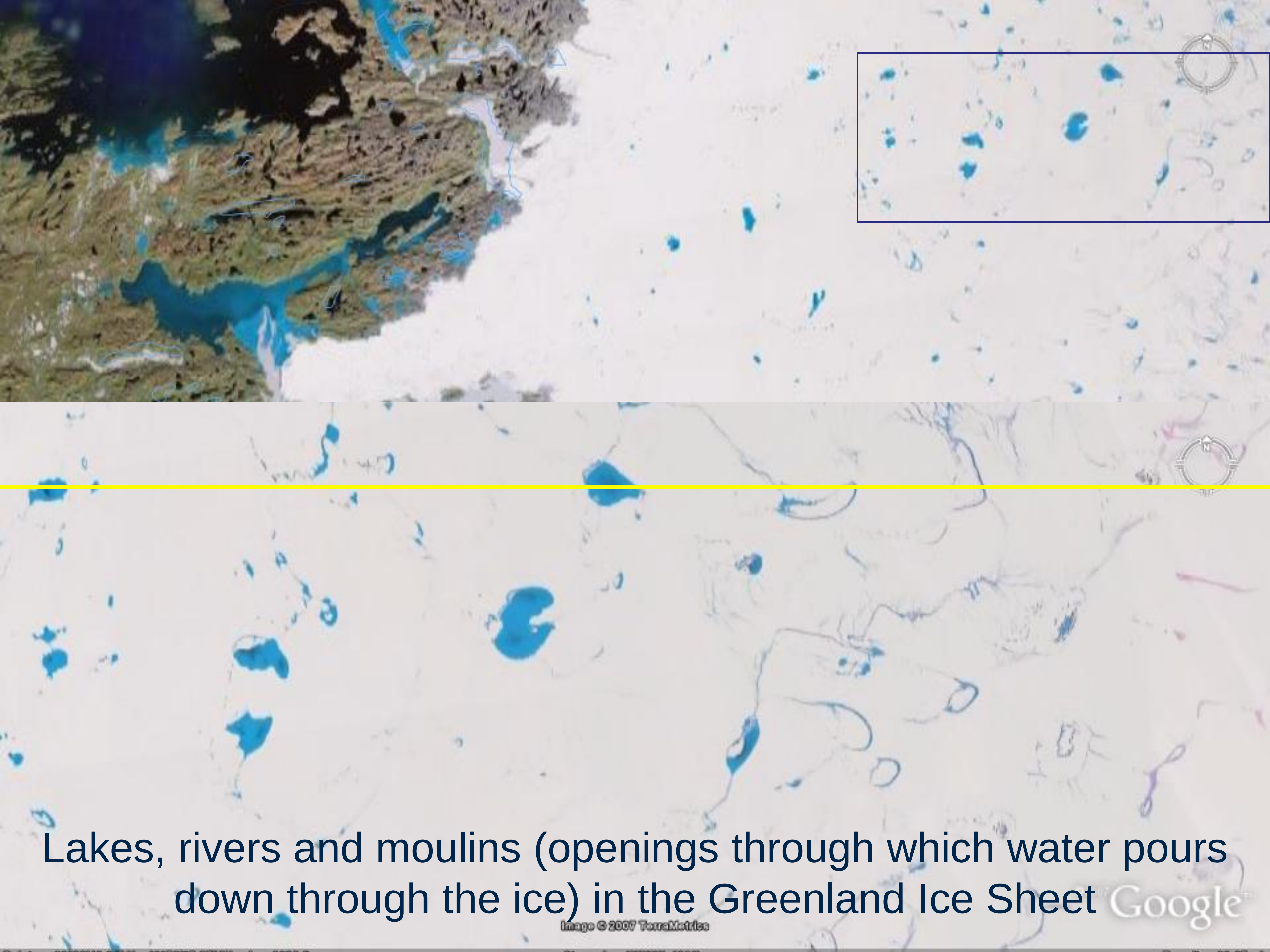


Melt zone is expanding northwards and to higher elevations

The margin of the Greenland ice sheet is rapidly collapsing



2001 2002 2003

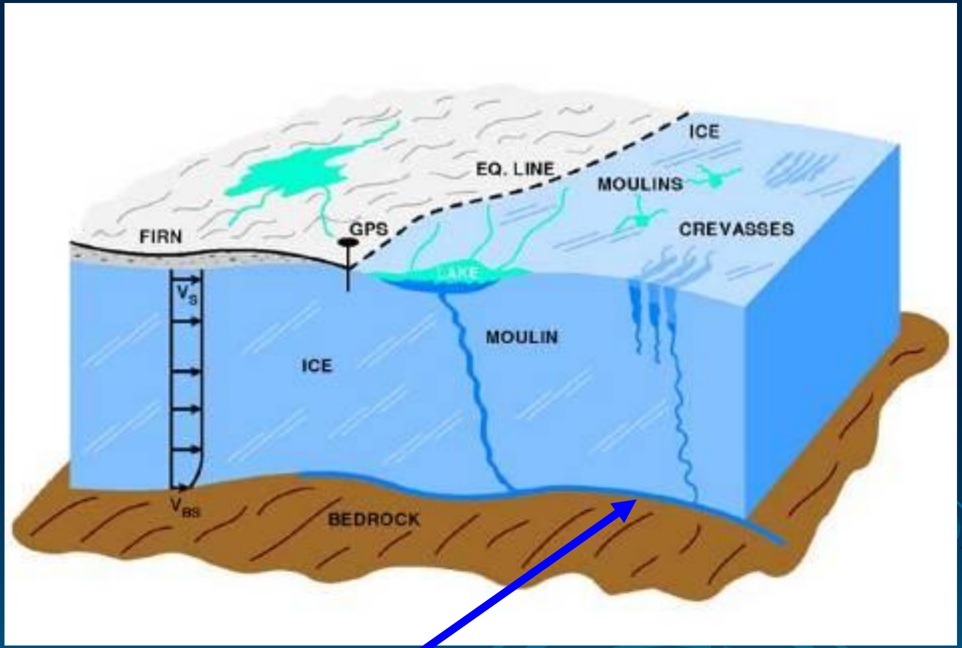


Lakes, rivers and moulins (openings through which water pours down through the ice) in the Greenland Ice Sheet


© 2008 Europa Technologies
Image © 2008 TerraMetrics

MOULINS

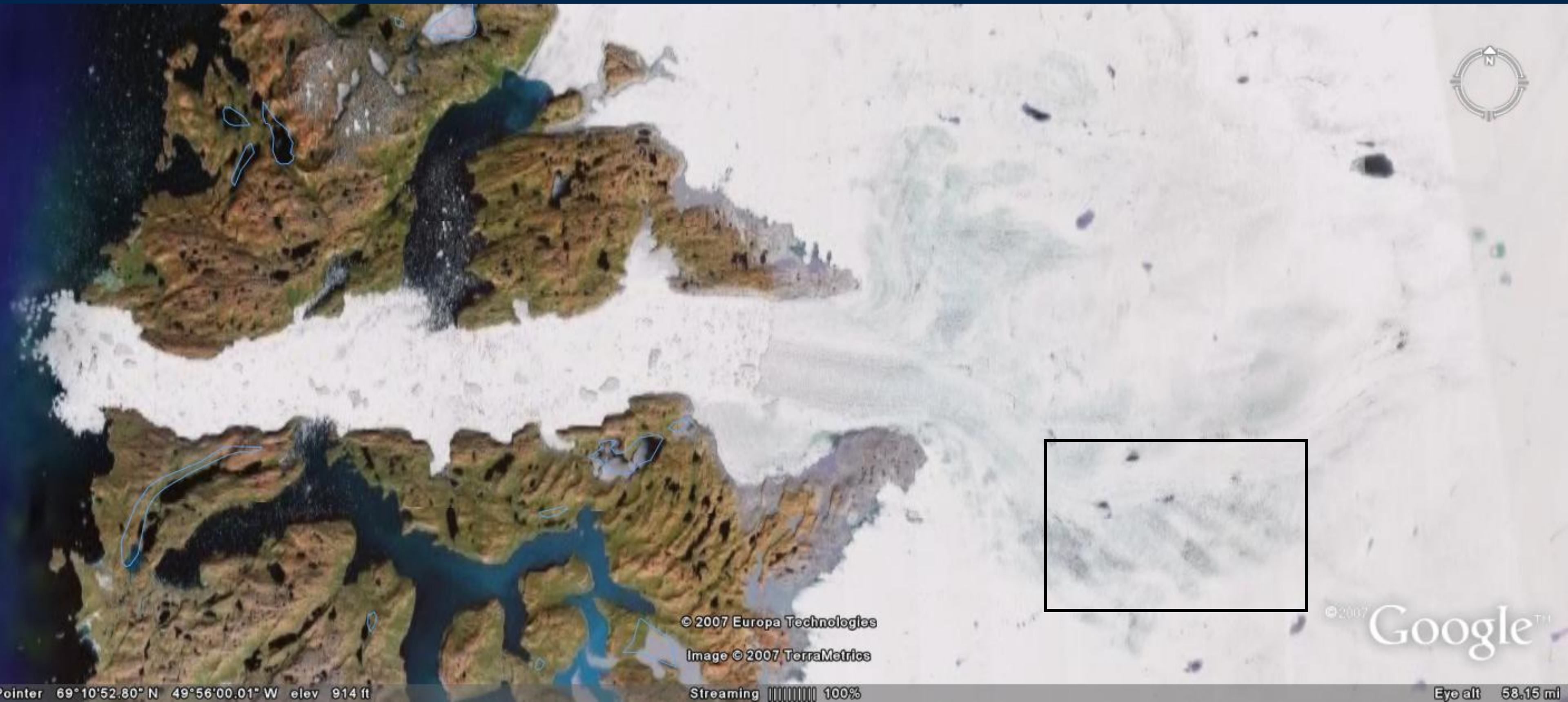
Like karst in limestones



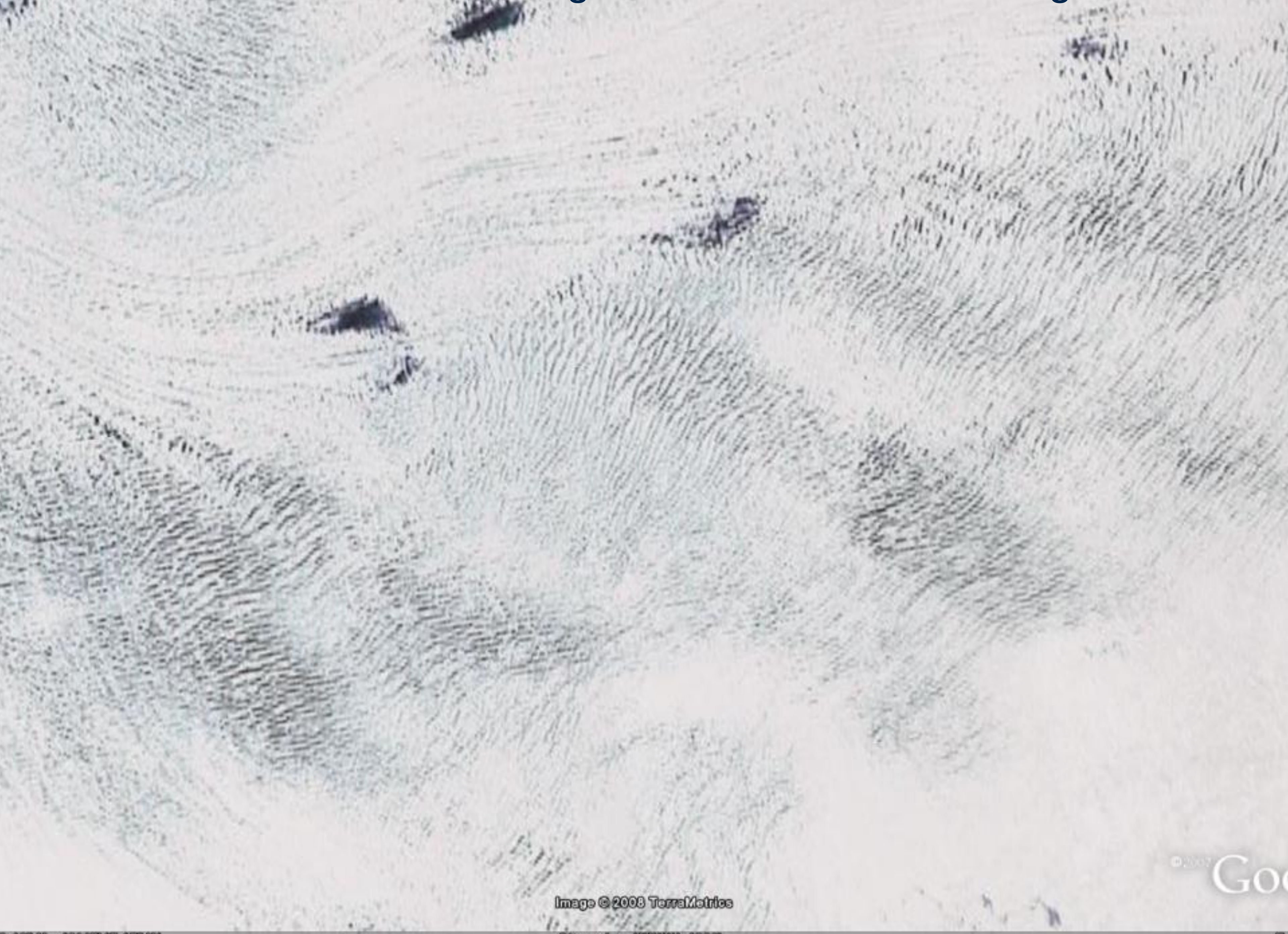
Water lubricates base of ice sheet

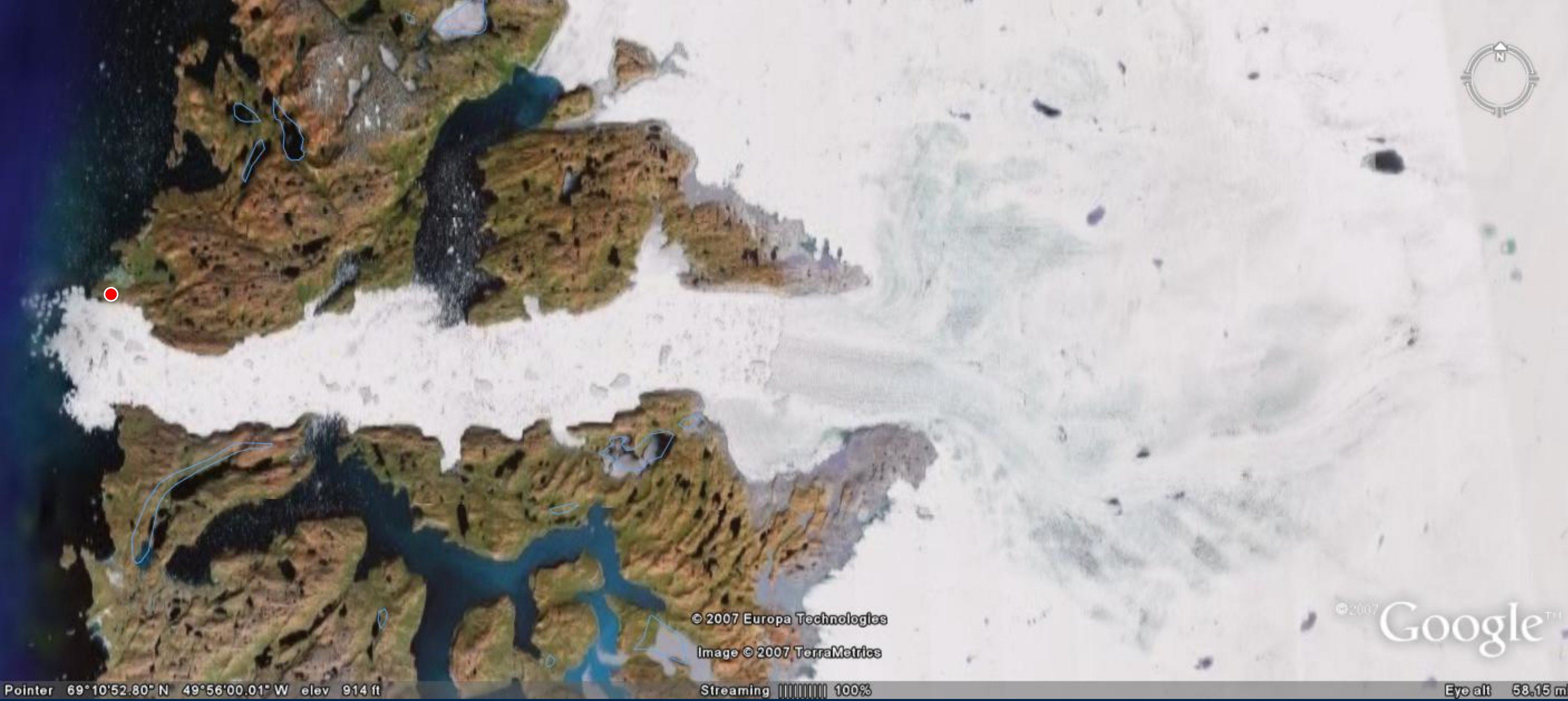
- Thousands of moulins 10-15 meters across have opened up all over.
- melt water is pouring through to the bottom of the glacier, creating a lake 500 meters deep causing the glacier "to float on land."
- These melt-water rivers are lubricating the glacier, like applying oil to a surface and causing it to slide into the sea. It is causing a massive acceleration which could be catastrophic.

(Dr. Robert Corell, Chair Arctic Climate Impact Assessment, Sept 8, 2007)



Intensive fracturing occurs towards the margins.

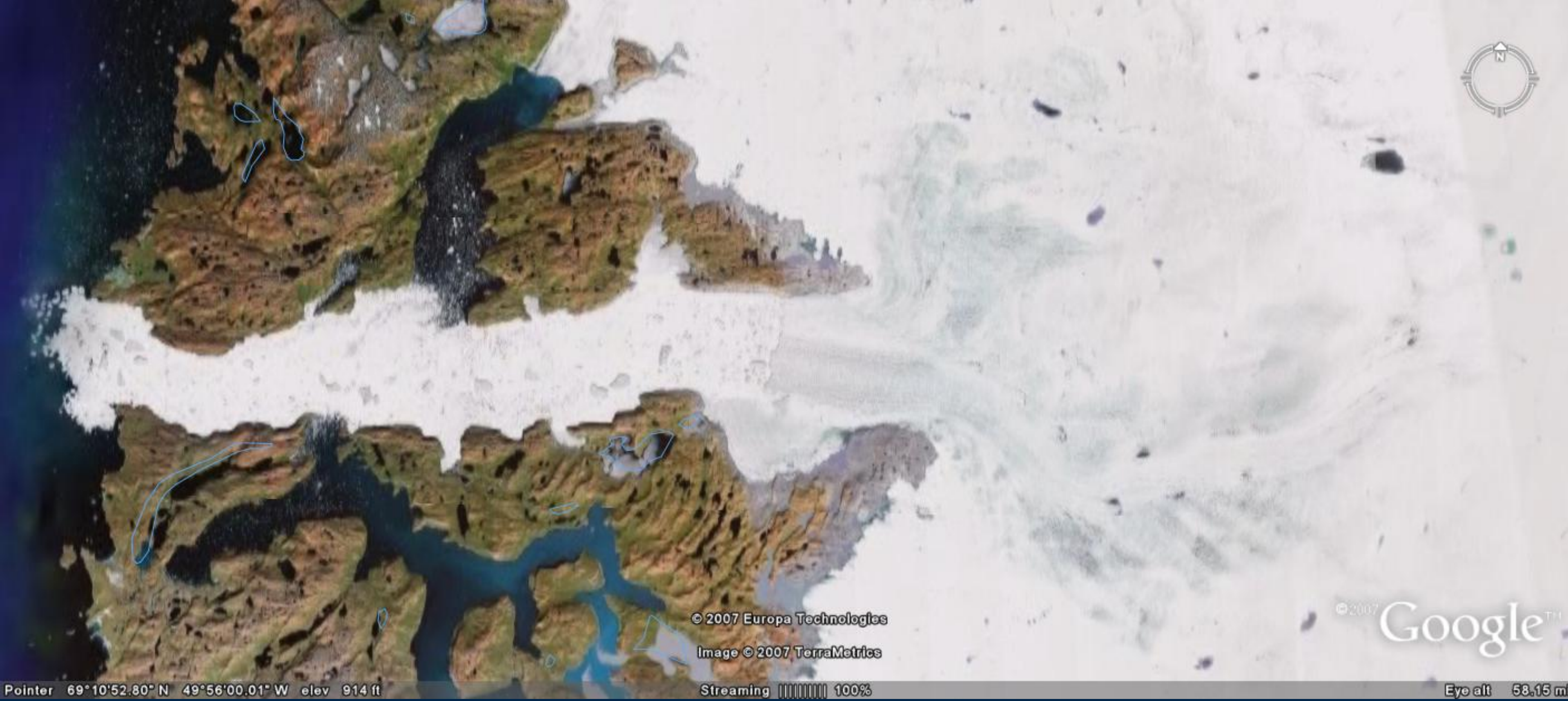




- The Jacobshavn Isbreen (5 km wide and 1.5 km deep), once moving at 2-3 km, is now moving at 15km a year into the sea, although in surges it moves even faster. 'One surge moved 5 km in 90 minutes - an extraordinary event. It's exuding like toothpaste.'

(Dr. Robert Corell, Chair Arctic Climate Impact Assessment, Sept 8, 2007)

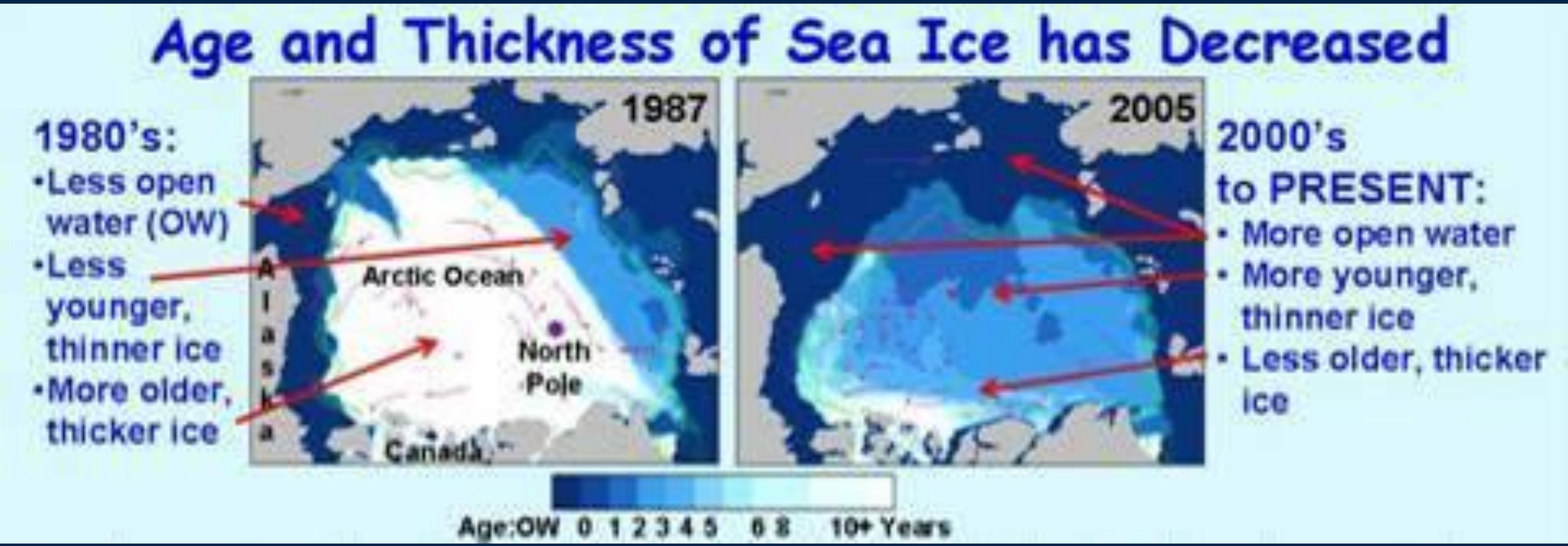
Jacobshavn Isbreen I in Ilulissat, Vestgrønland (Greenland); Photograph by Dirk Jenrich



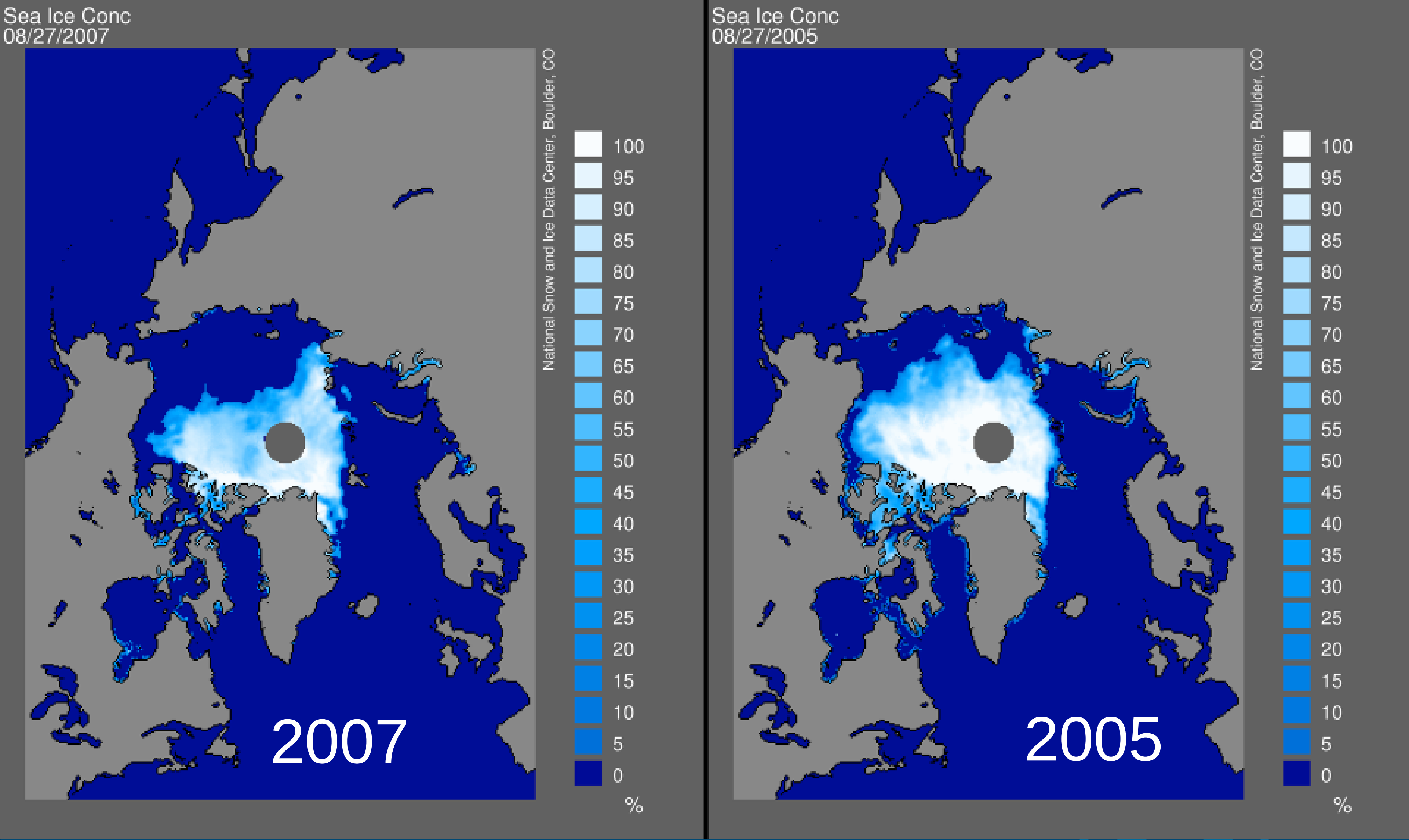
- "Five years ago we made models predicting how much ice would melt and when. "Five years later we are already at the levels predicted for 2040, in a year's time we'll be at 2050."

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

Arctic Pack Ice Cover

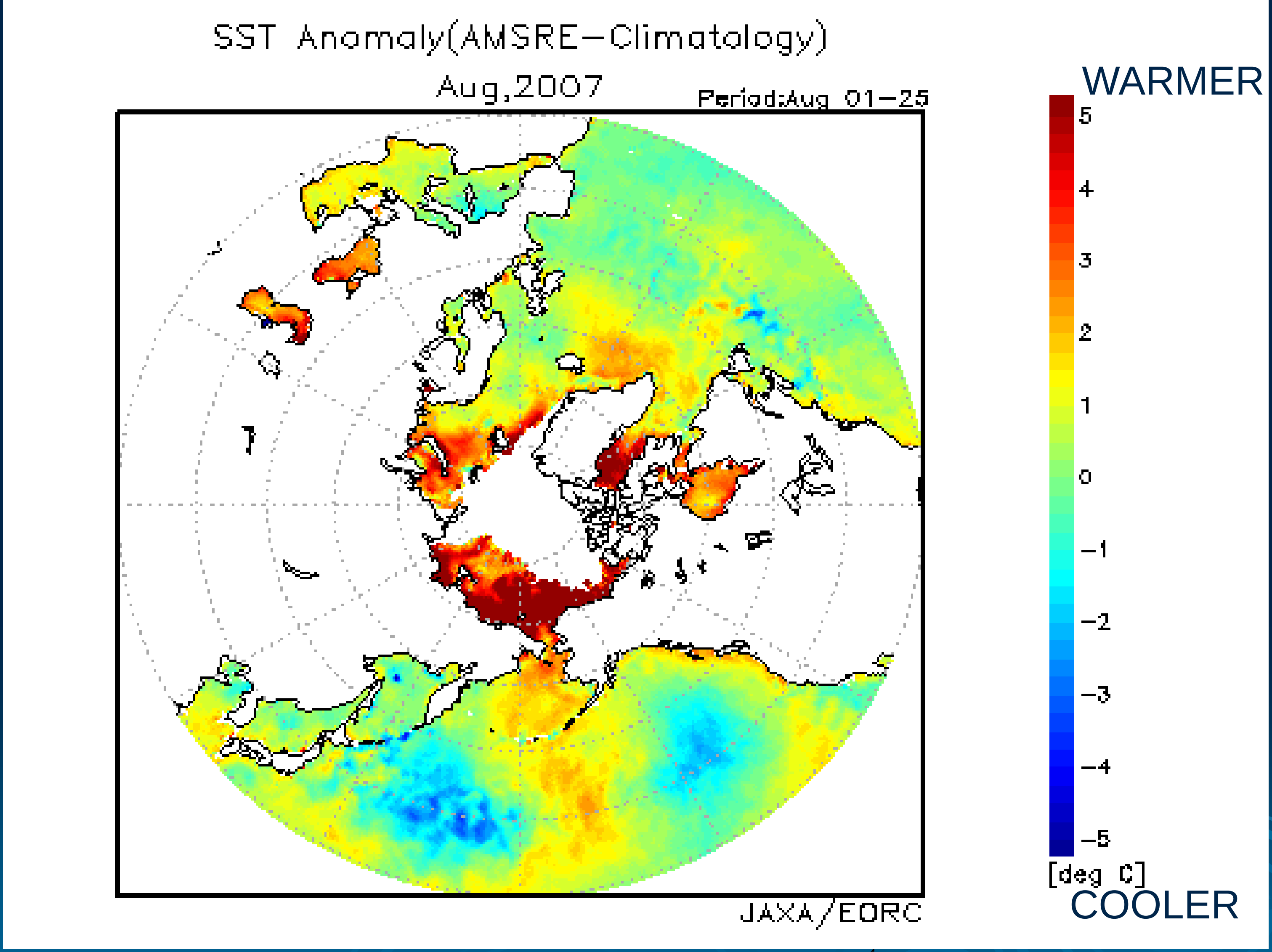


a powerful control on Arctic ocean and land temperatures, permafrost, and methane and carbon dioxide release.



This year the floating Arctic pack ice covered 33% less area than the previous record low in 2005. It is so thin and broken, it could easily just float out into the Atlantic.

Sea Surface Temperature Anomaly

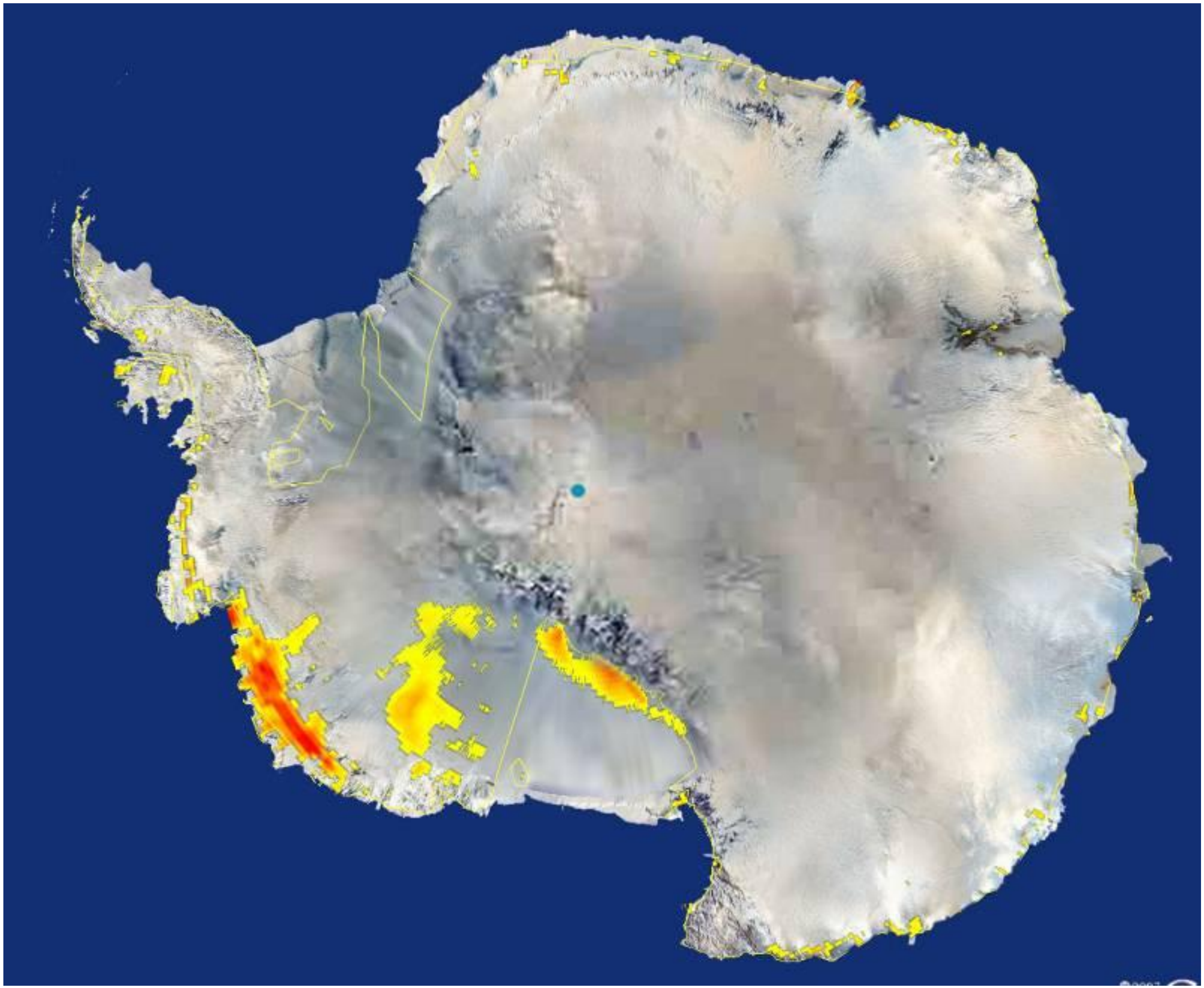


Earth Observation Research Center, Japan Aerospace Exploration Agency
JAXA EORC

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

Scientists are just now recognizing that Antarctica is also rapidly melting.

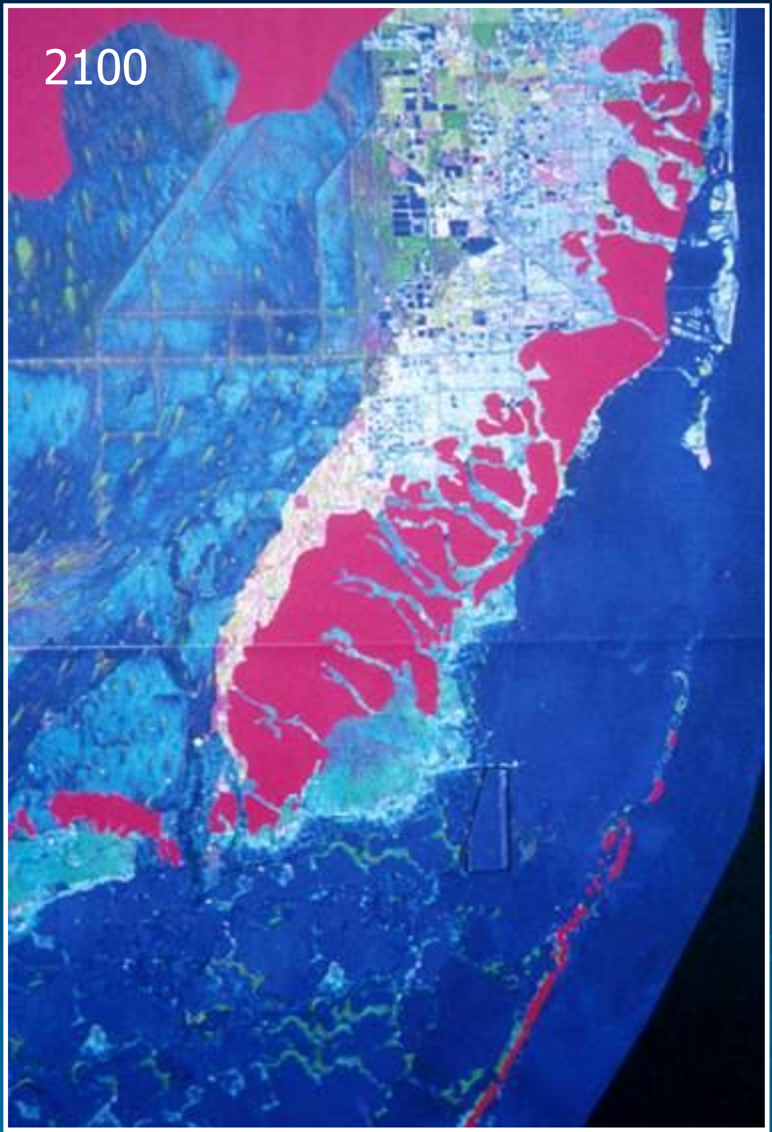


Scientists on the Miami-Dade Climate Change Task Force:

- "With what is happening in the Arctic and Greenland, [there will be] a likely sea level rise of **at least** 1.5 feet in the coming 50 years and a total of **at least** 3-5 feet 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)

Red is areas today with limestone more than 5' above 'sea level' (NGVD 1927-29).

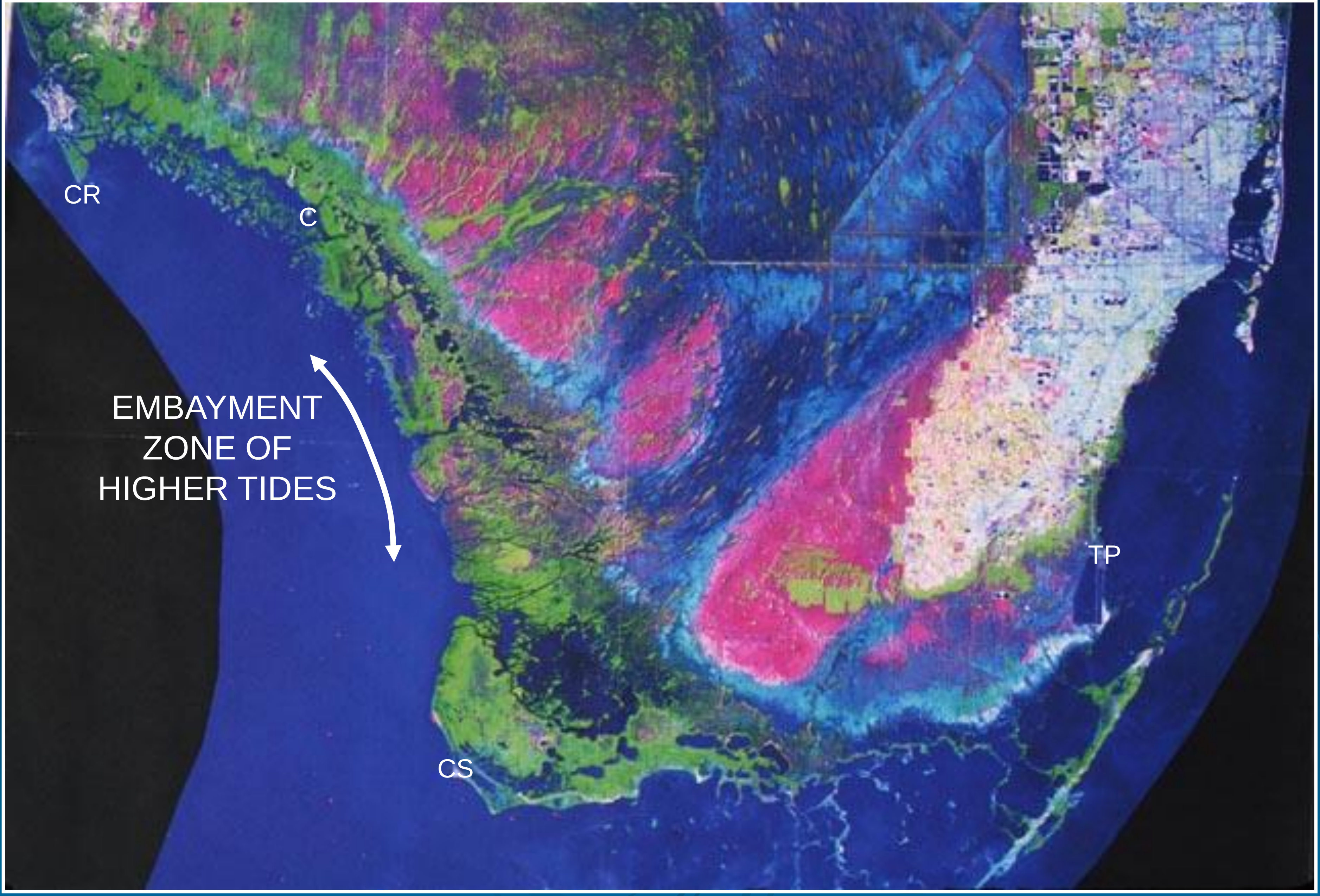


NGVD 1927-29: 0′ is mean lower low water in 1927-29.

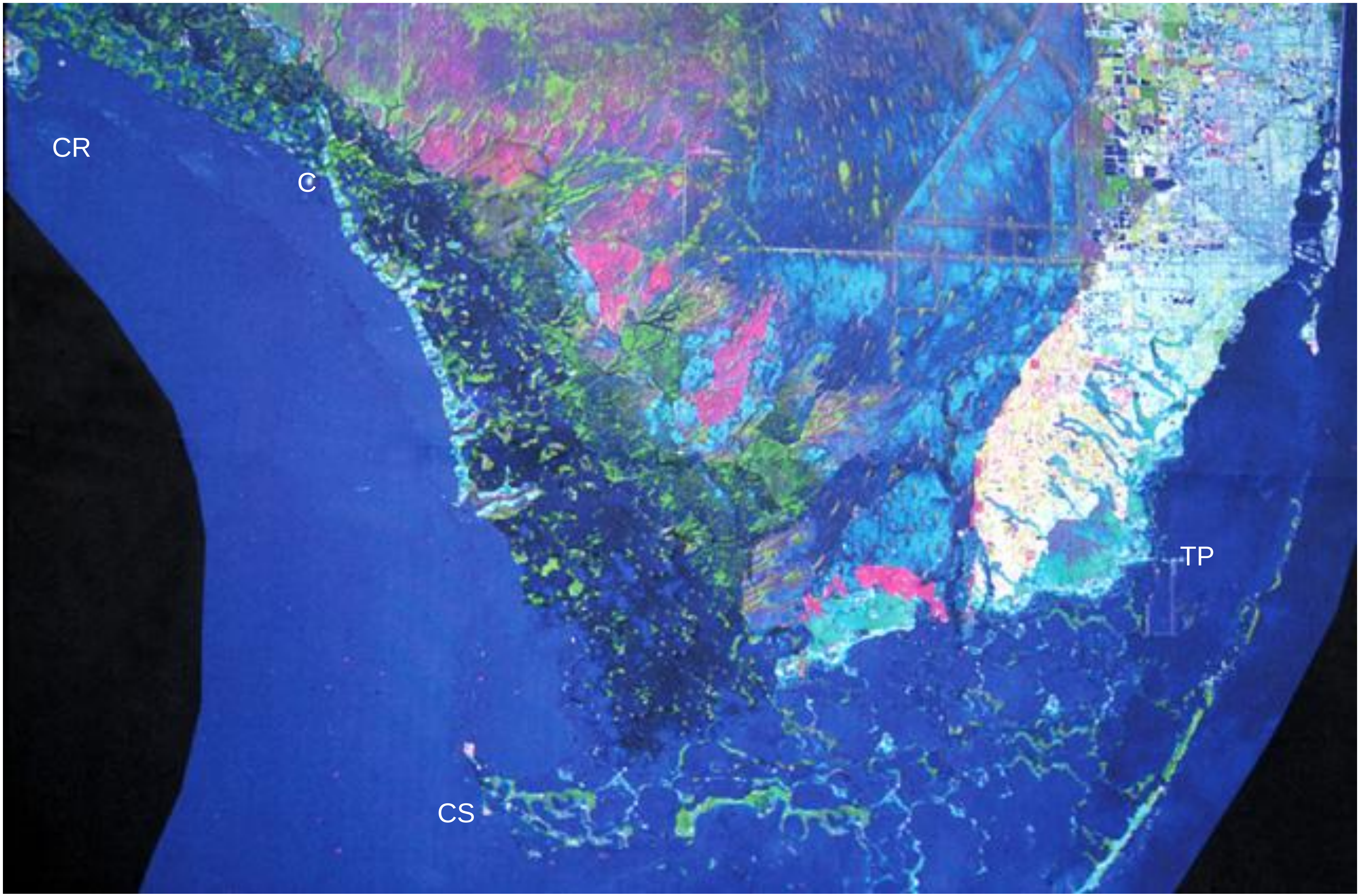
Today, mean higher high water (MHHW) is about 2.5′ above 1929 mean sea level (+3.8' NGVD).

With a 2 ft rise, MHHW will be about 4.5′ above 1929 mean sea level (+5.8' NGVD).

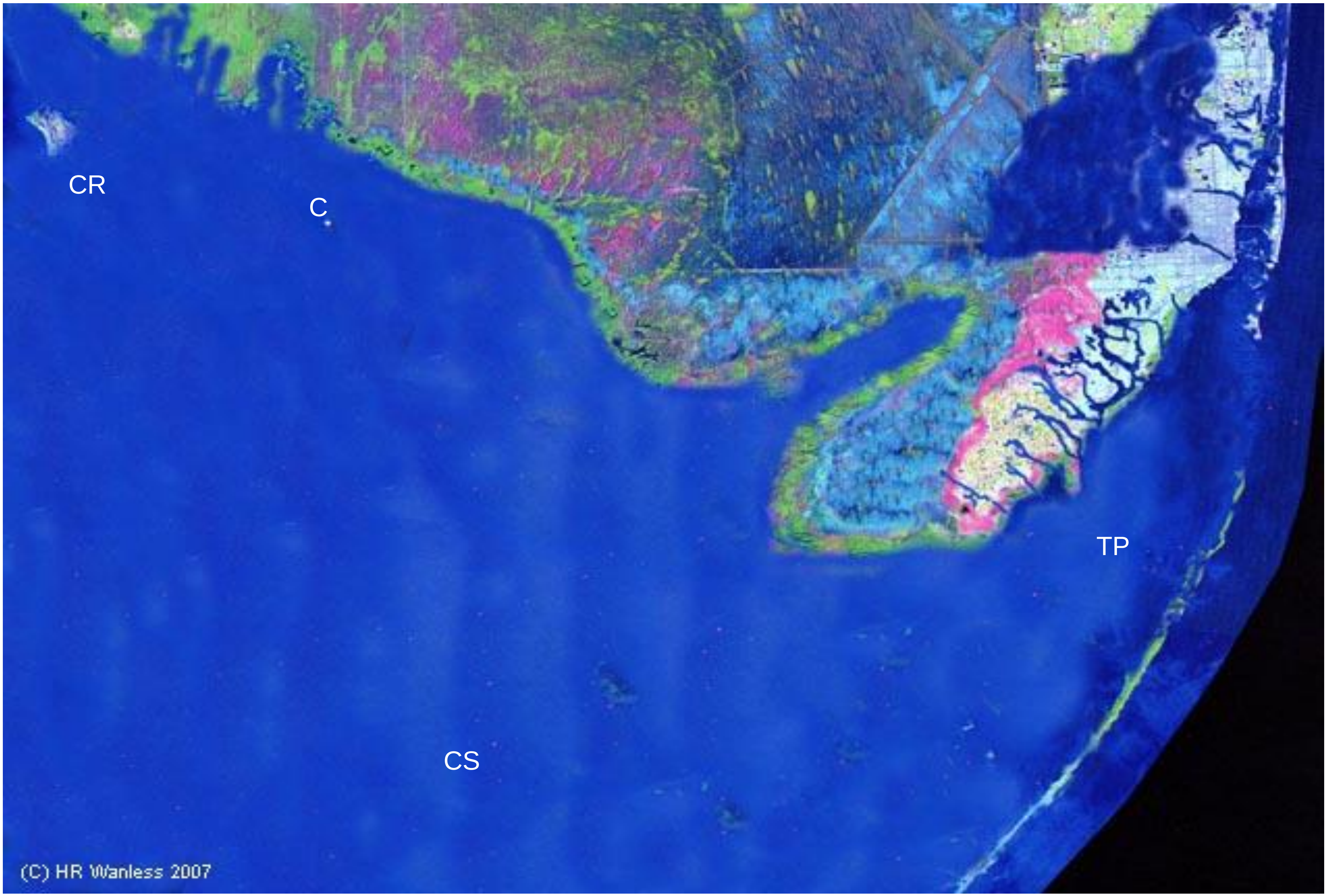
South Florida 1995



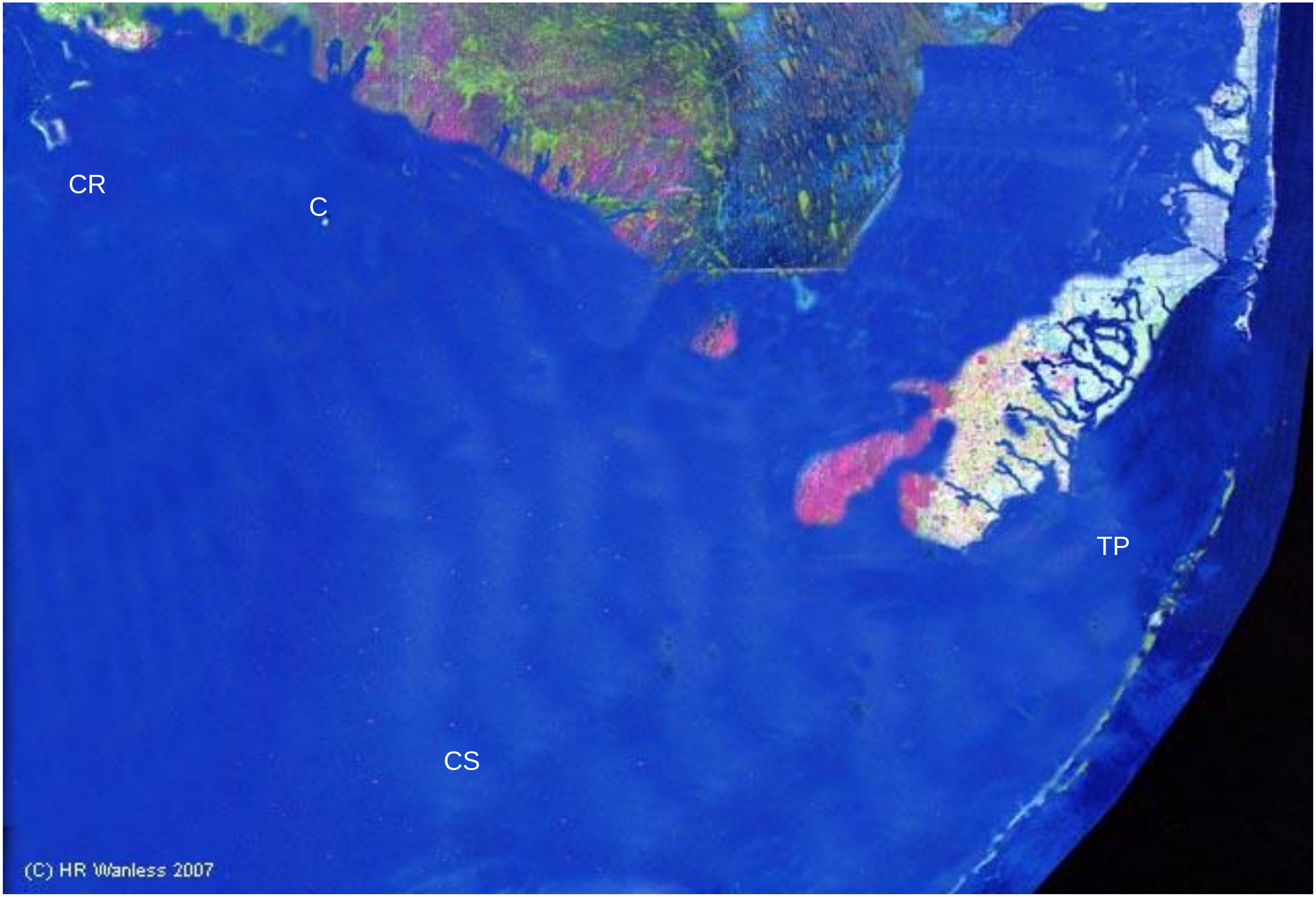
+2 foot rise (mhhw = +4.5' above 1929 MSL) **South Florida 2100**



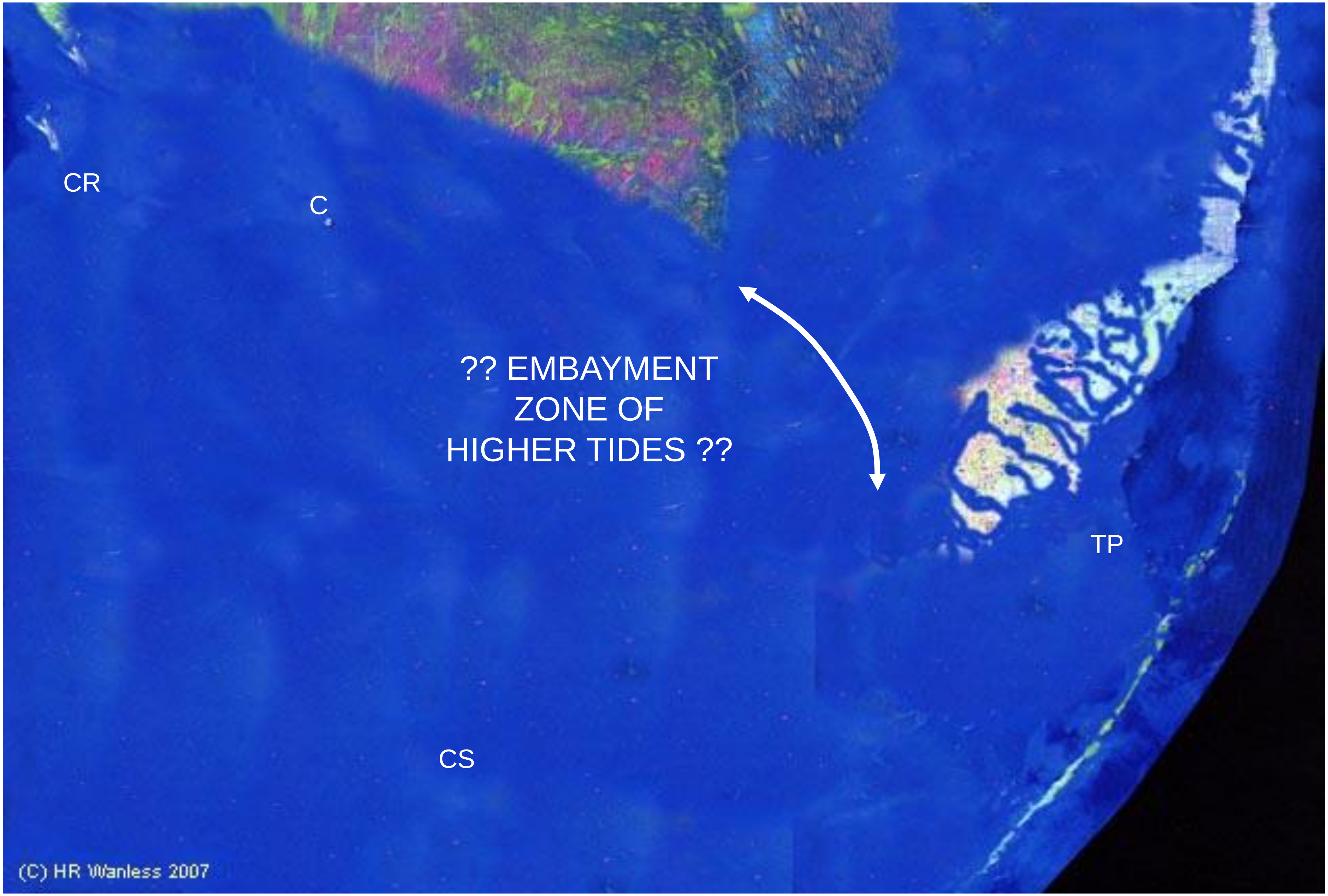
+4 foot rise (mhhw = +6.5' above 1929 MSL) **South Florida 2100**

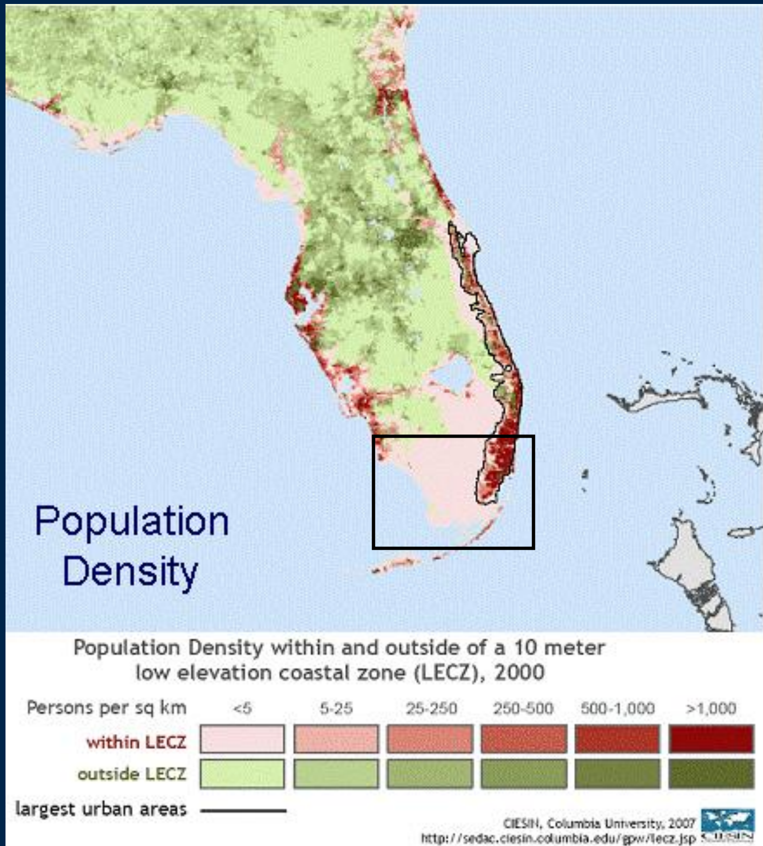


+5 foot rise (mhhw = +7.5' above 1929 MSL) **South Florida 2100**

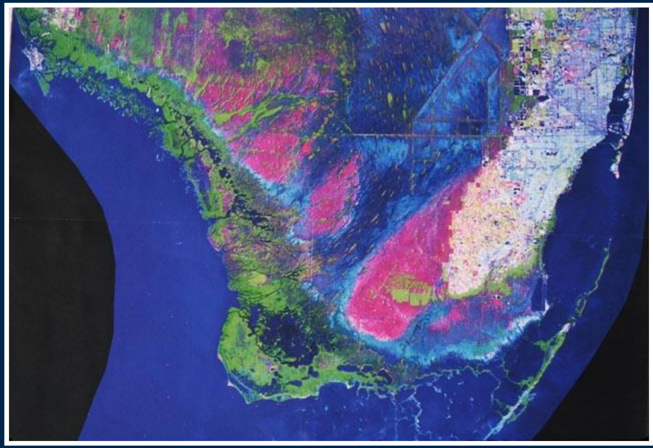


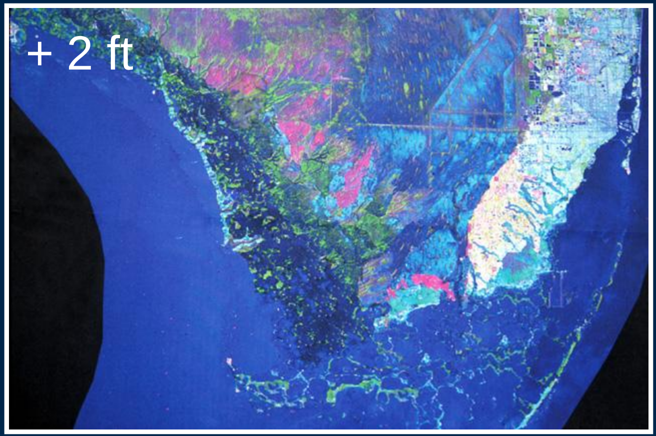
+6 foot rise (mhhw = +8.5' above 1929 MSL) South Florida 2100

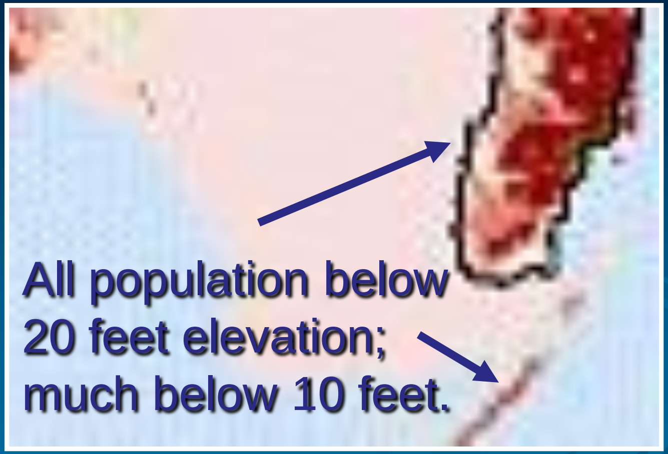


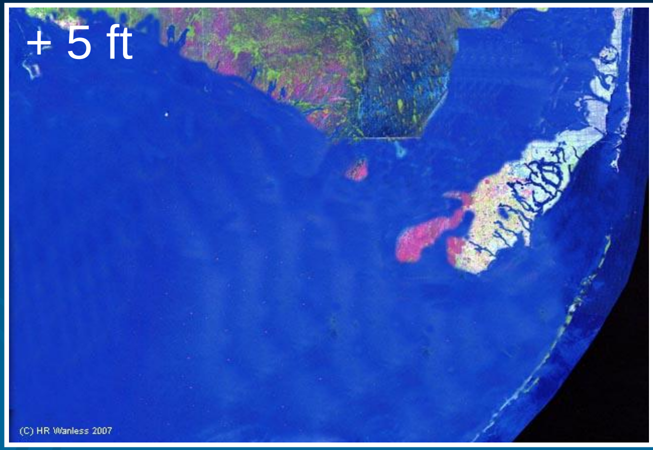


http://sedac.ciesin.columbia.edu/gpw/lecz.jsp





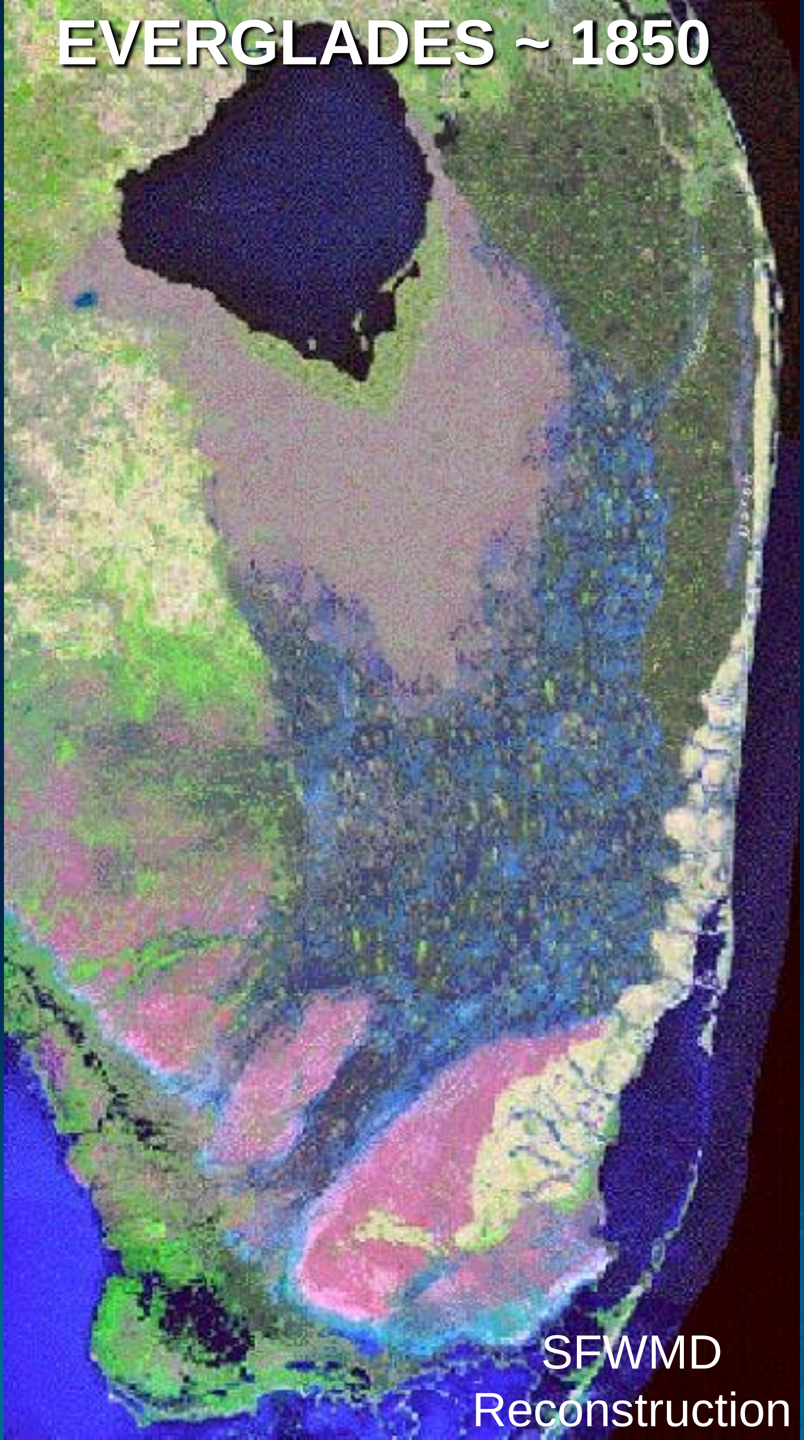




EVERGLADES RESTORATION

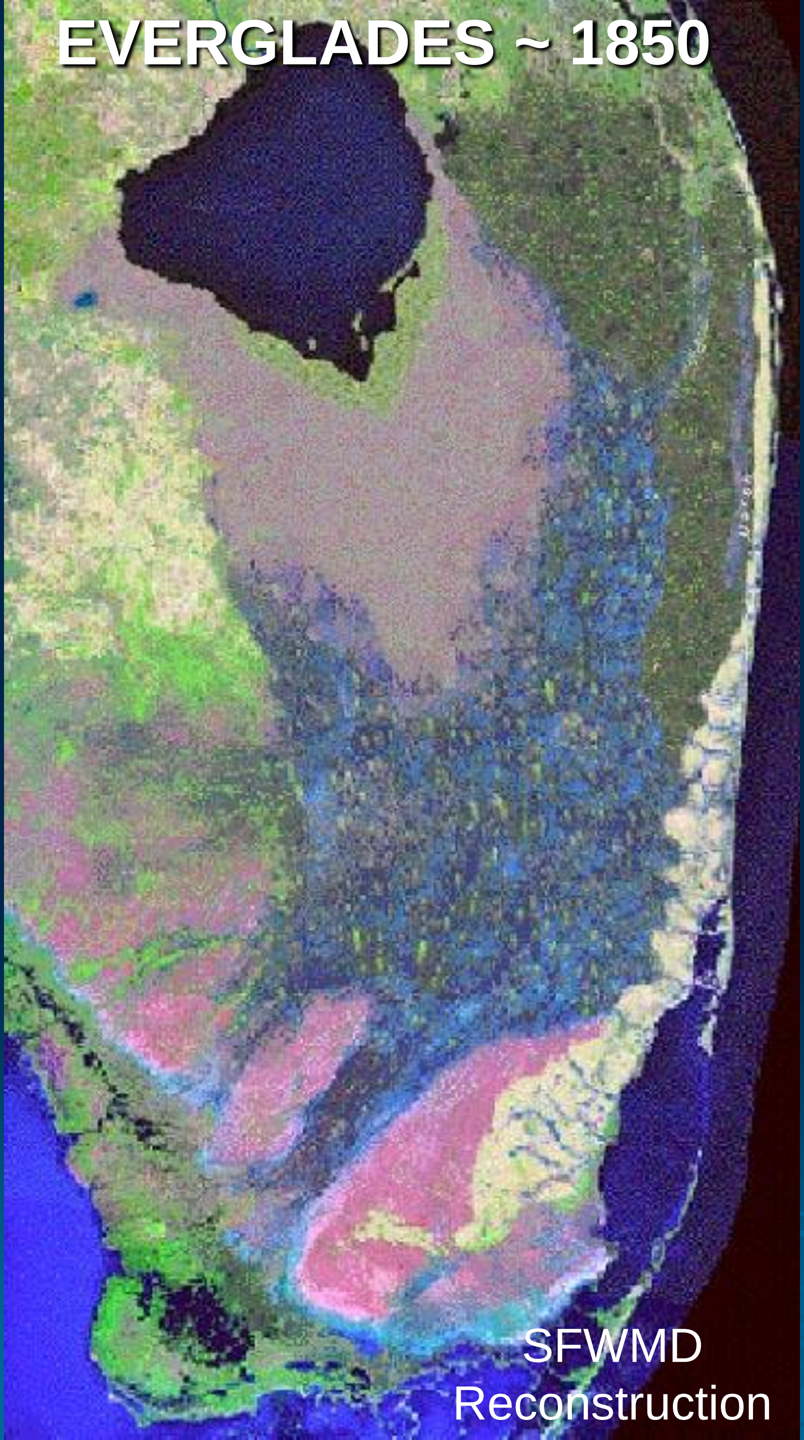
How will sea level rise affect the Everglades?

What are the implications for the Comprehensive Everglades Restoration Plan?

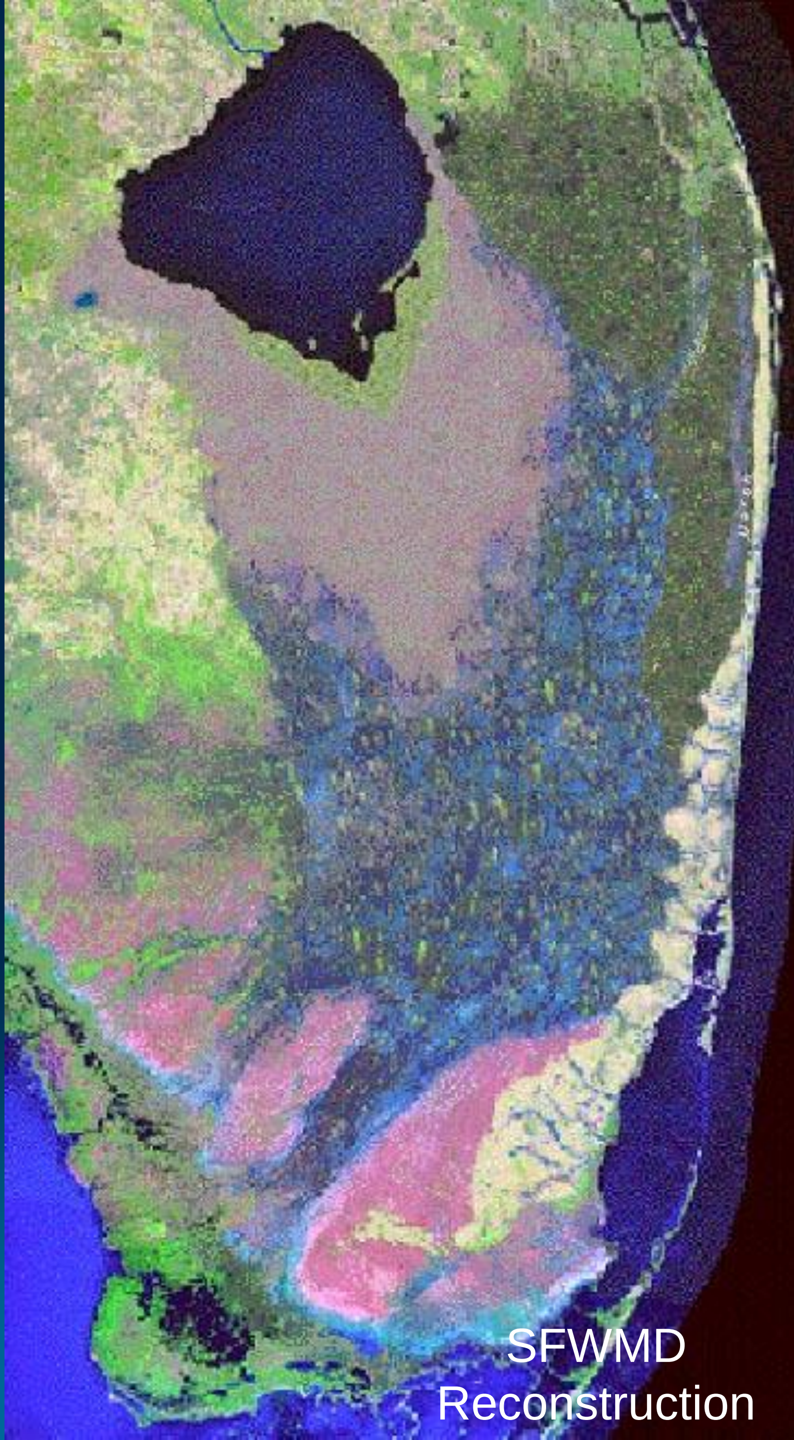


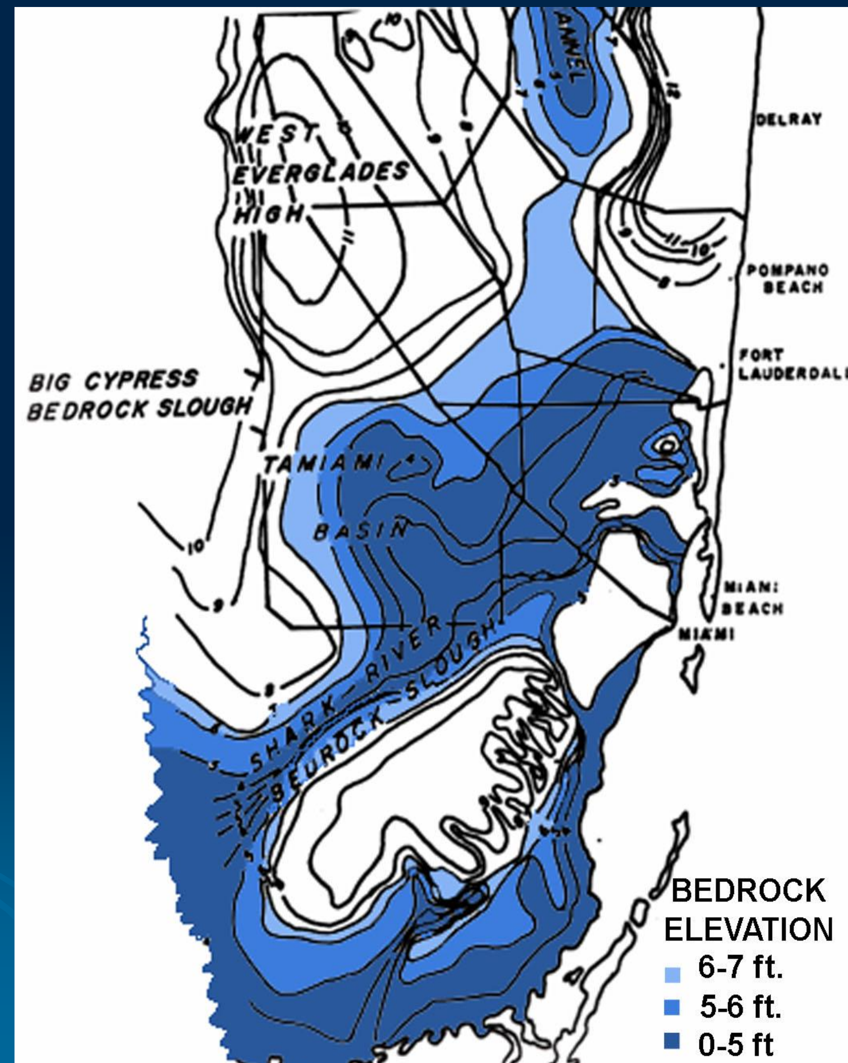
MUST UNDERSTAND:

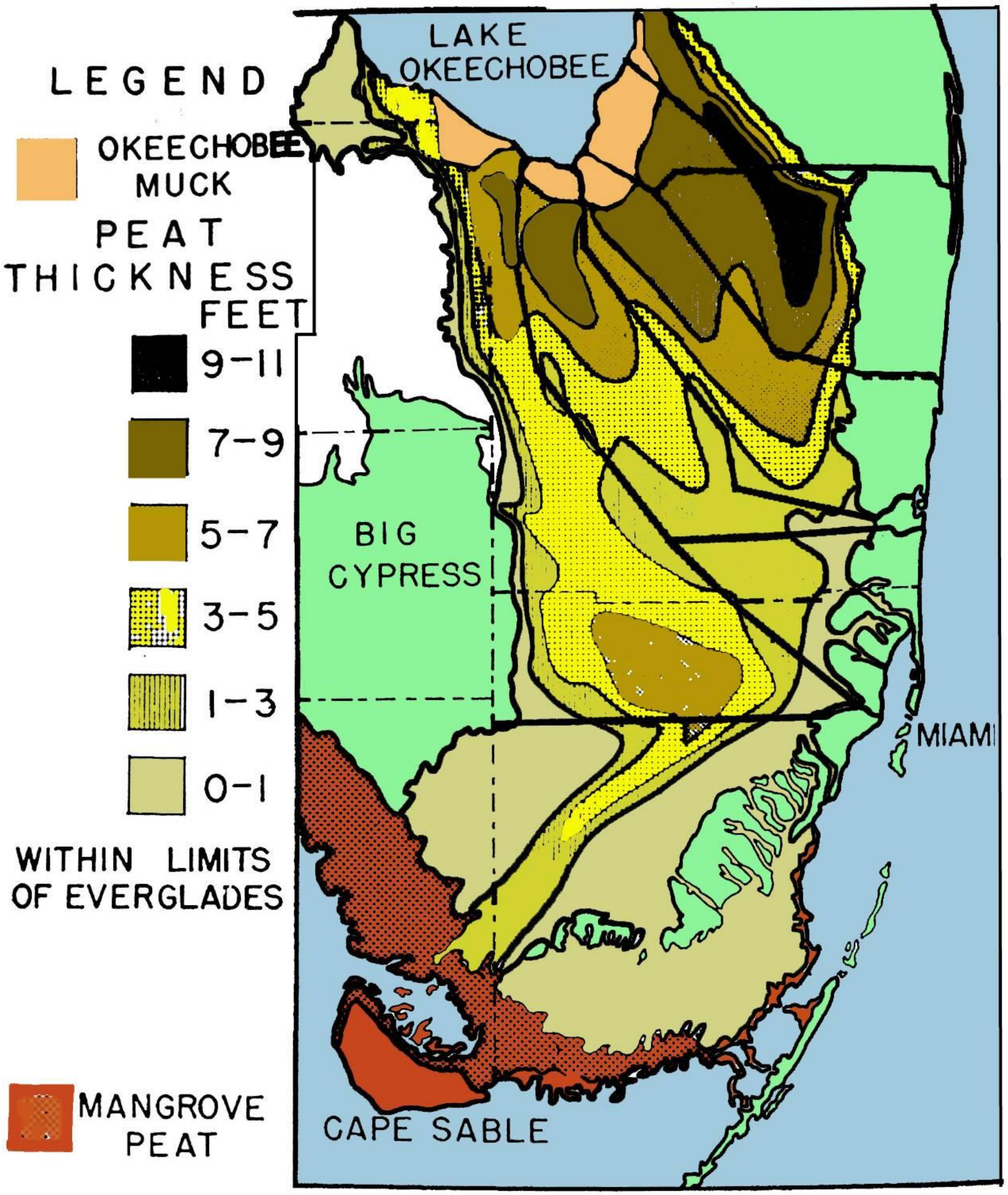
- Underlying bedrock elevation,
- Organic peat thickness, and
- How freshwater wetland and peat will respond to saline intrusion.


EVERGLADES ~ 1850
SFWMD
Reconstruction

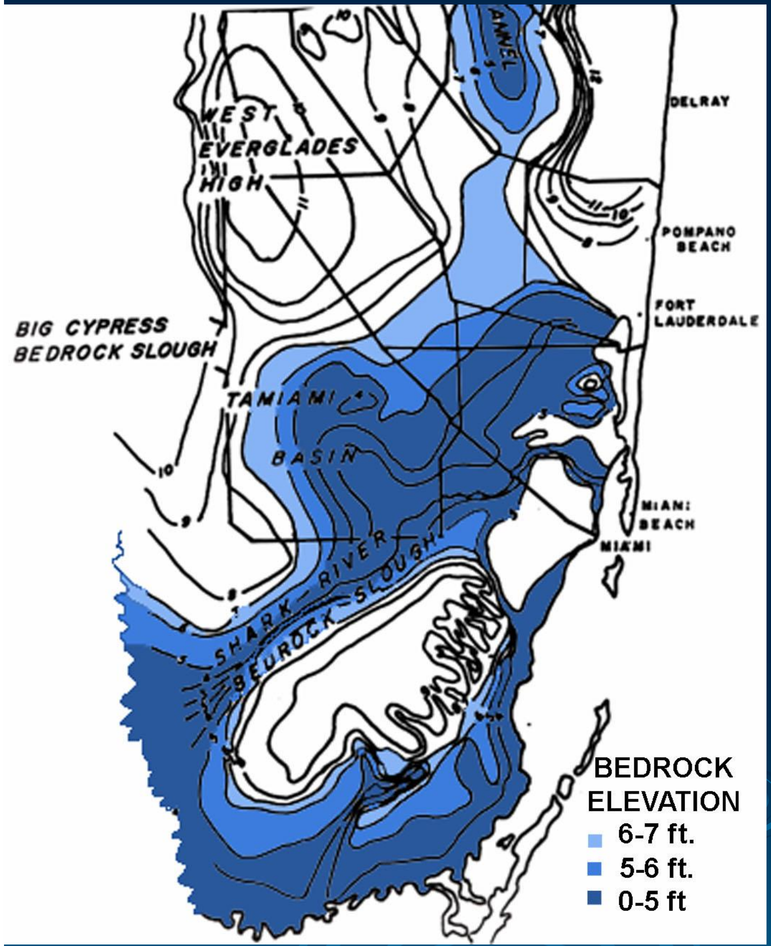

W/ BEDROCK
ELEVATION MAP
WEST
EVERGLADES
HIGH
BIG CYPRESS
BEDROCK SLOUGH
BEDRO
ELEVAT
6-7 ft.
5-6 ft.
0-5 ft


SFWMD
Reconstruction


WEST
EVERGLADES
HIGH
DELRAY
POMPANO
BEACH
FORT
LAUDERDALE
BIG CYPRESS
BEDROCK SLOUGH
TAMIAMI
BASIN
MIAMI
BEACH
MIAMI
SHARK RIVER
BEDROCK SLOUGH
BEDROCK
ELEVATION
6-7 ft.
5-6 ft.
0-5 ft

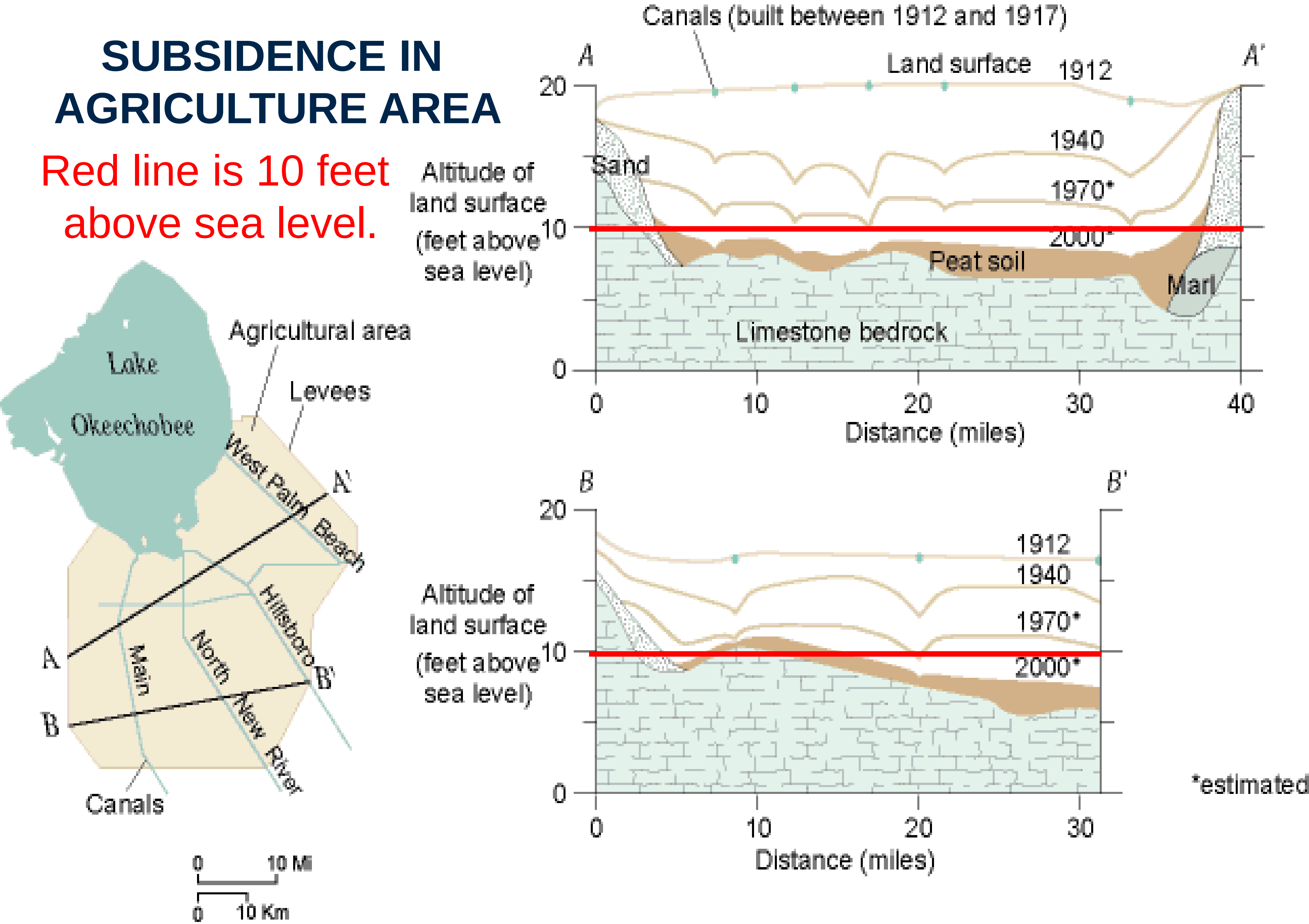


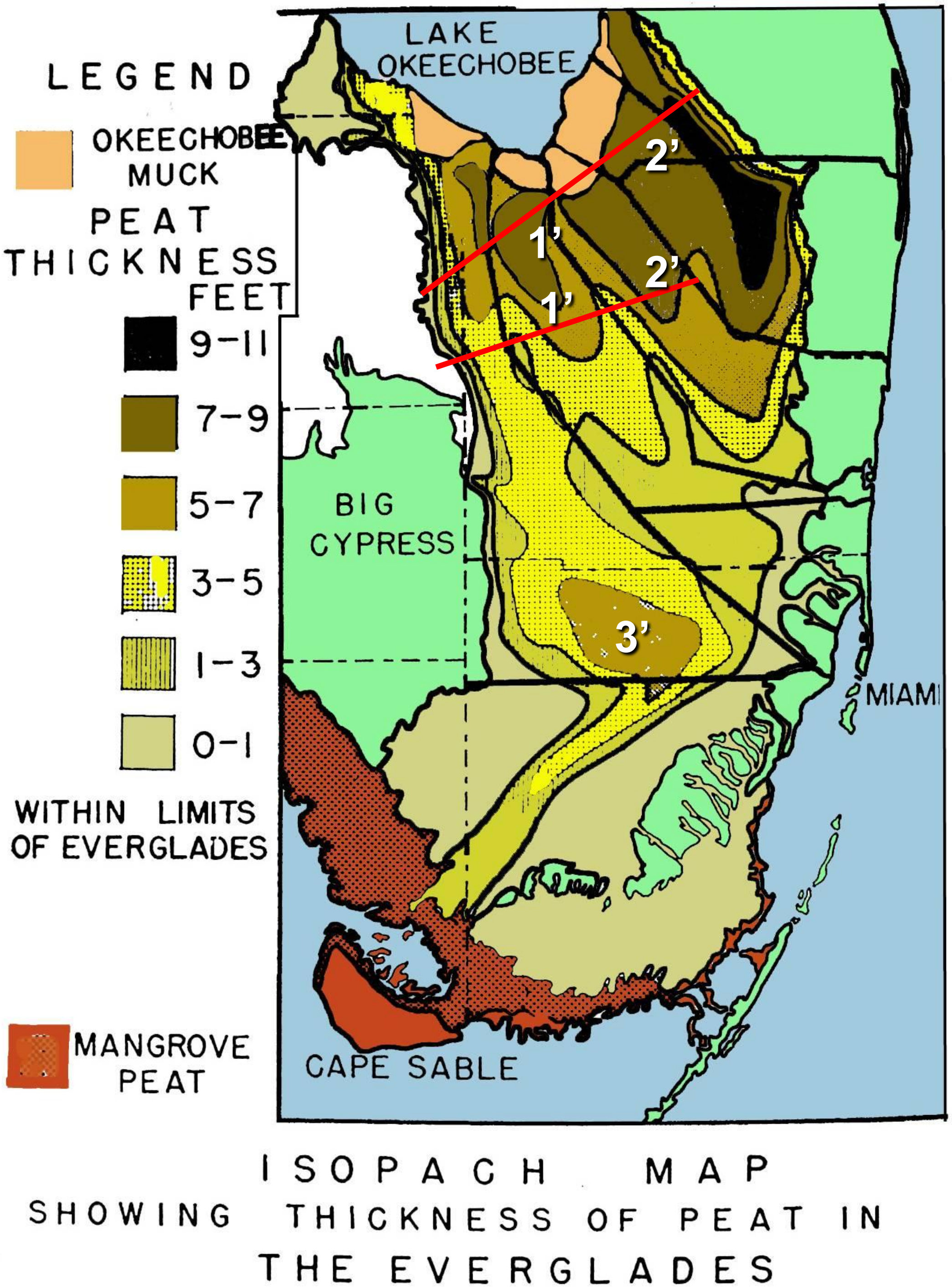
ISOPACH MAP SHOWING THICKNESS OF PEAT IN THE EVERGLADES

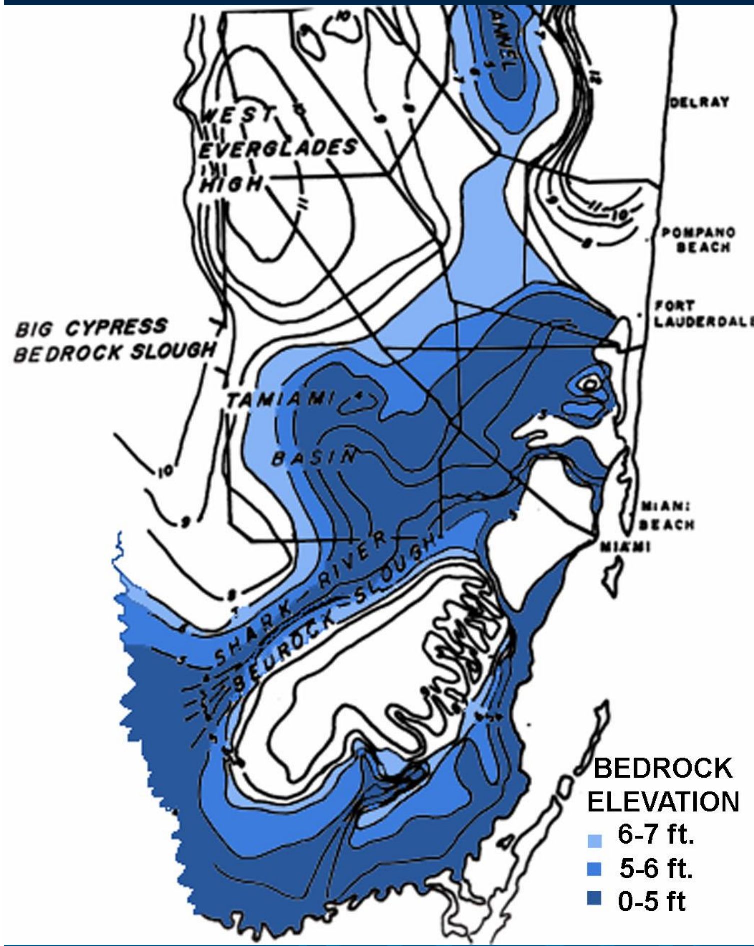


SUBSIDENCE IN AGRICULTURE AREA

Red line is 10 feet above sea level.

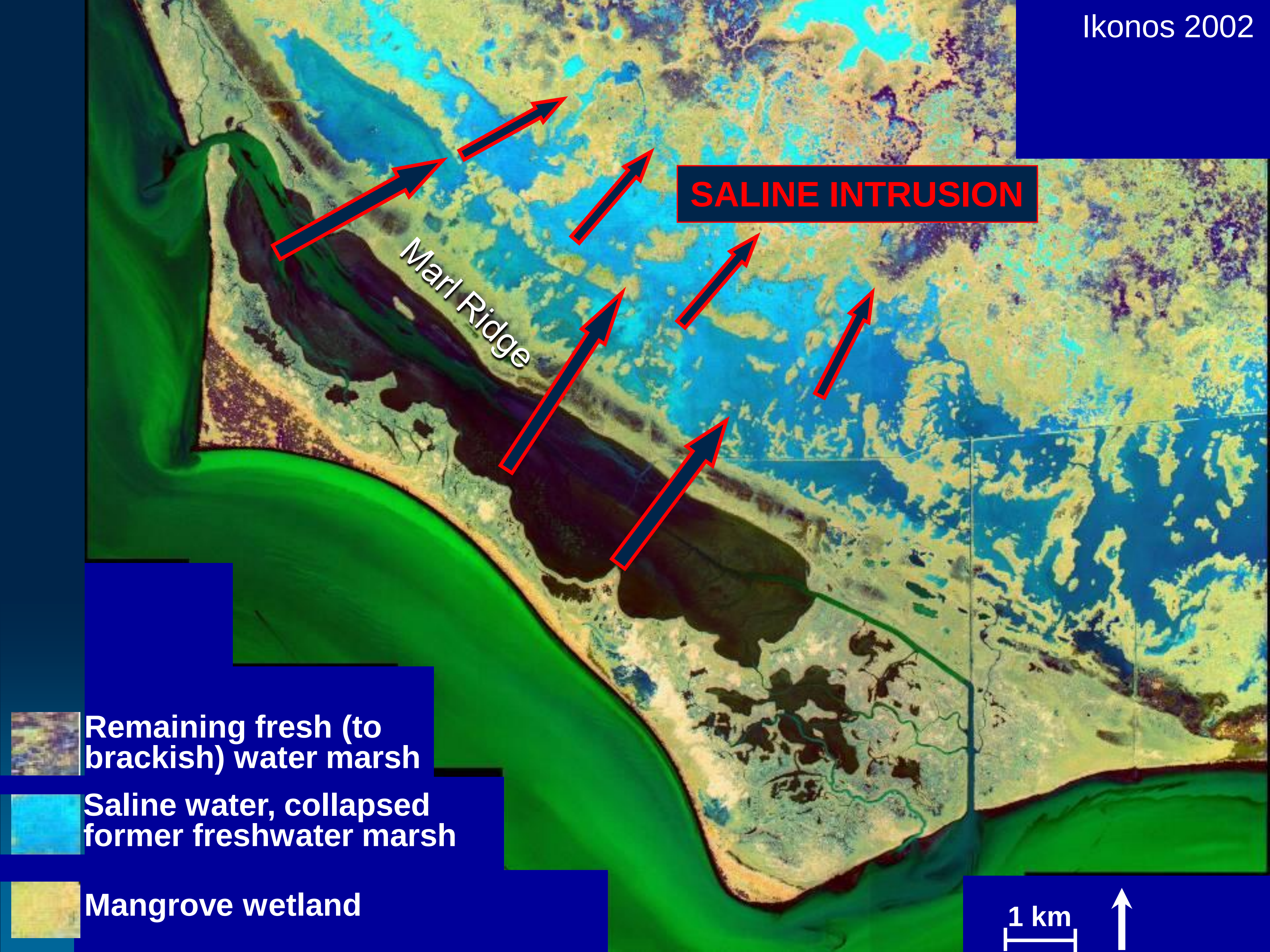




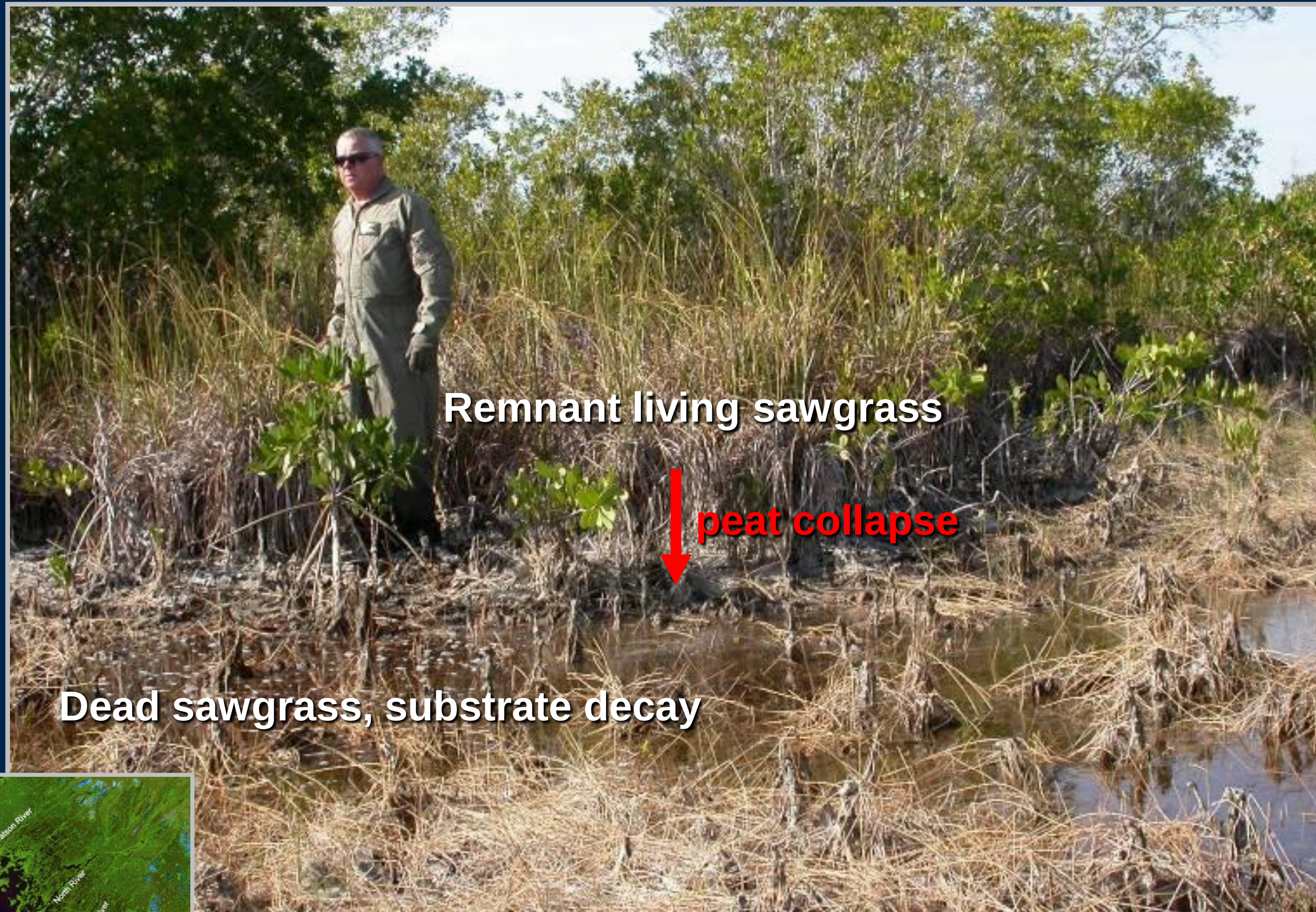


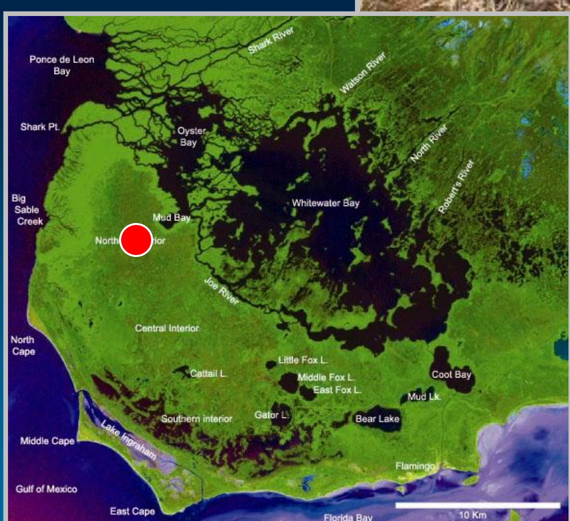
So, there is little elevation provided by peat buildup to help hold back encroachment by rising sea level.

On Cape Sable saline intrusion has inundated former freshwater marshes resulting in collapse of the marsh peat and expanding open water areas.



Ikonos 2002
SALINE INTRUSION
Marl Ridge
Remaining fresh (to brackish) water marsh
Saline water, collapsed former freshwater marsh
Mangrove wetland
1 km





WIDESPREAD INUNDATION & COLLAPSE OF FRESWATER WETLANDS

AND CONVERSION TO OPEN WATER

ON MANGROVE COASTLINES

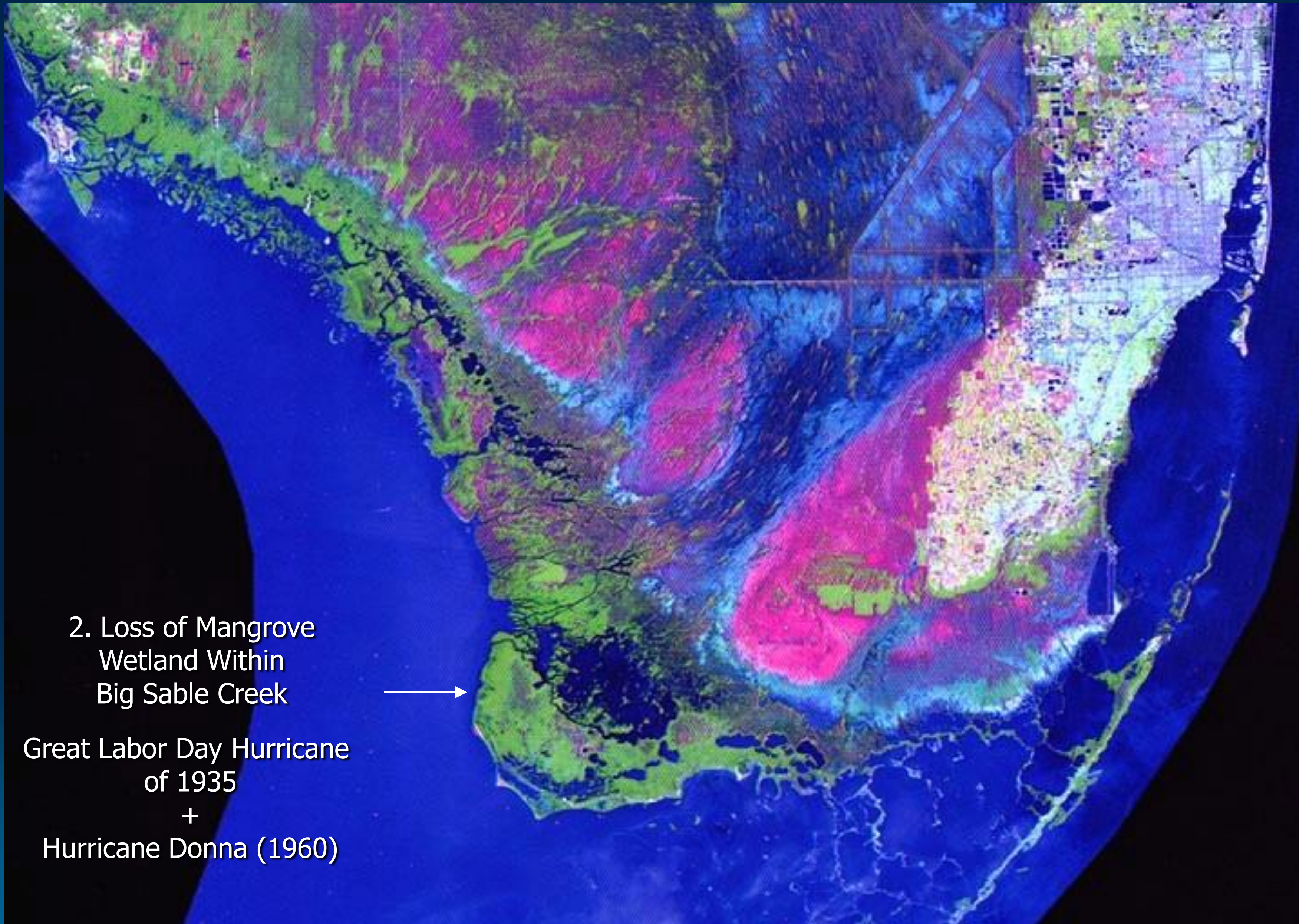
In the big ones, this … Becomes this.

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.

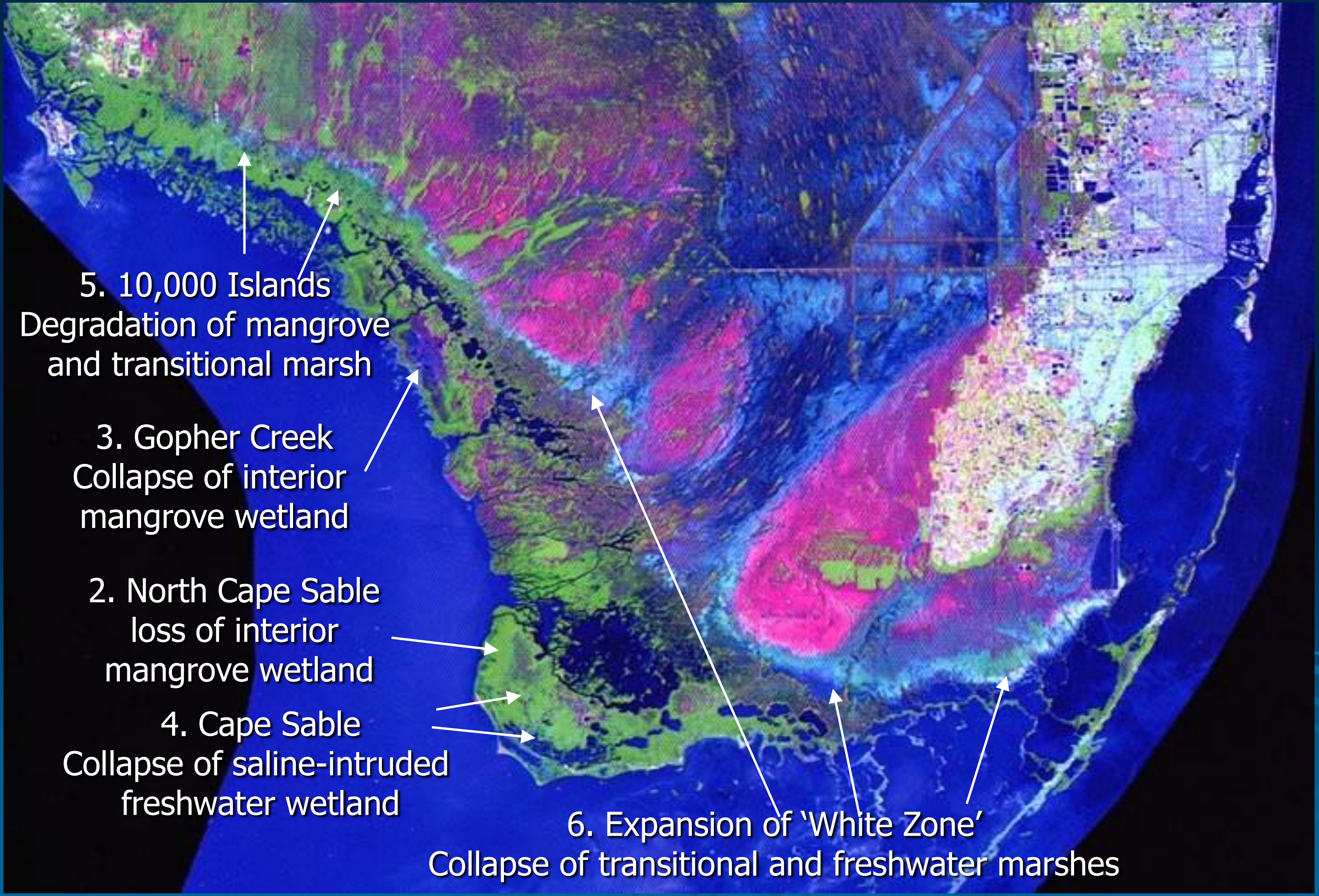
Highland Beach and mangroves, Hurricane Andrew

Tom Smith, USGS, Highland Beach

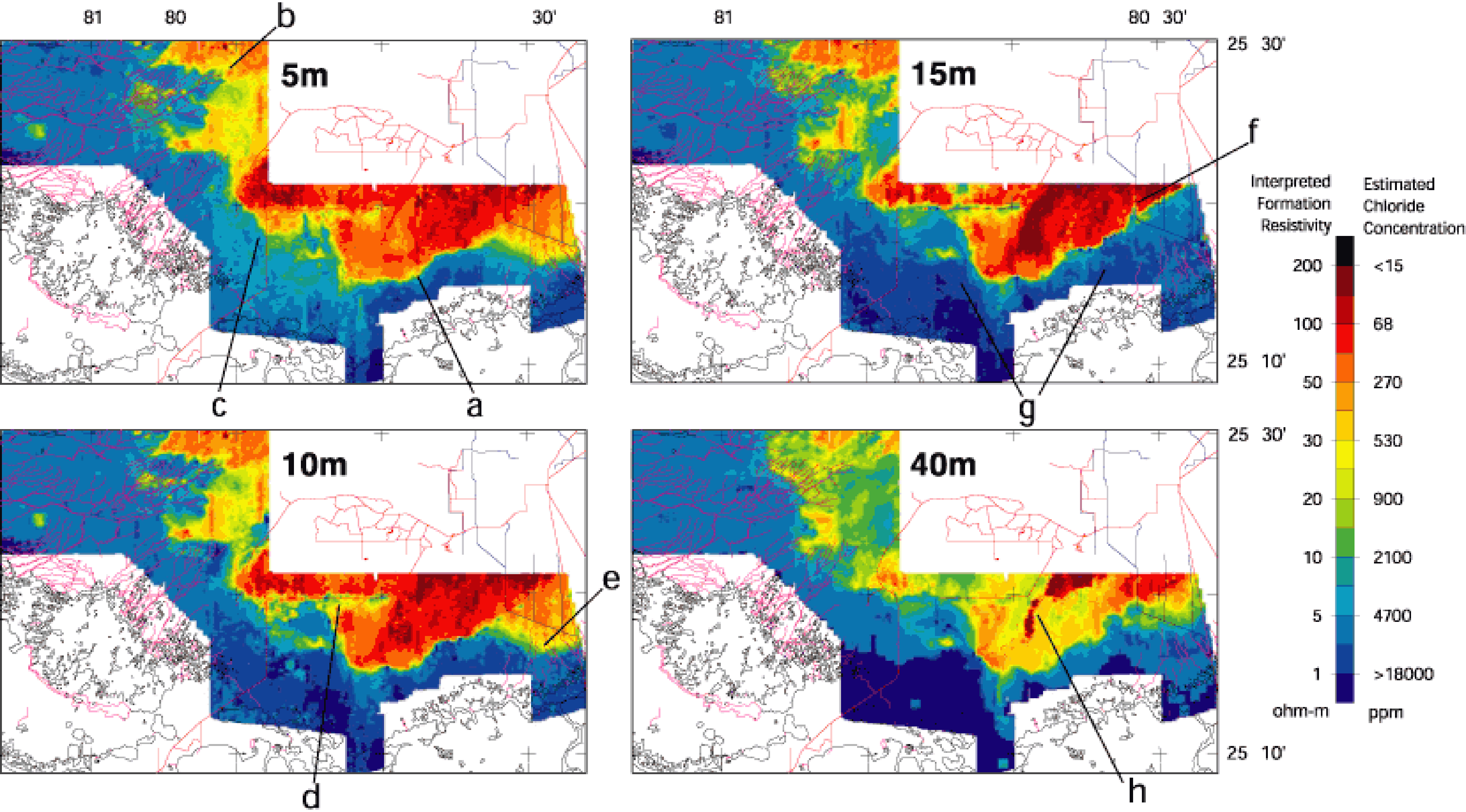

2. Loss of Mangrove
Wetland Within
Big Sable Creek
Great Labor Day Hurricane
of 1935
+
Hurricane Donna (1960)

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

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

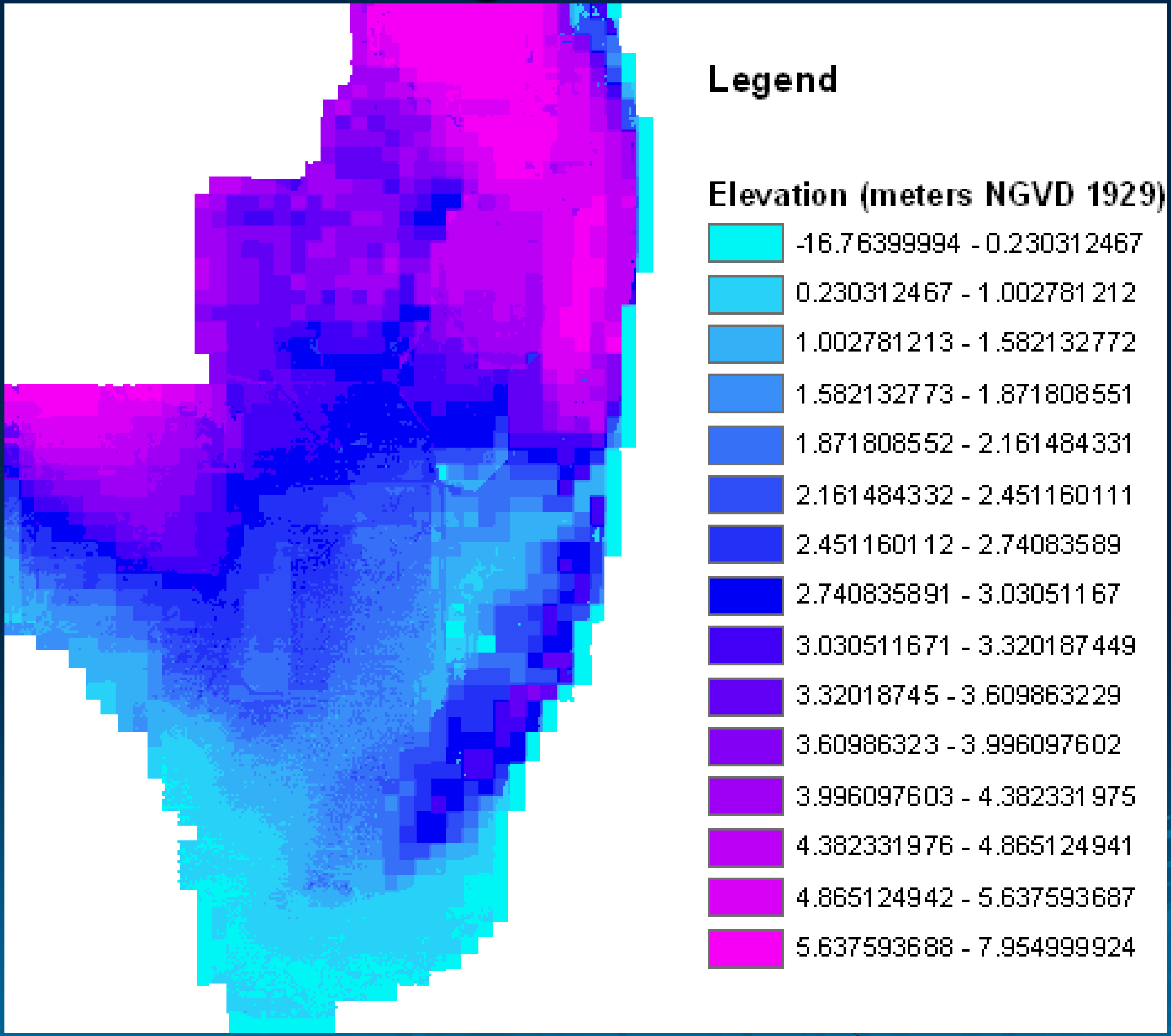


Saline intrusion with depth below surface from aerial electromagnetic surveys by USGS-SOFIA.



Fitterman and Deszcz-Pan, 2001 (USGS-SOFIA)

So, Everglades communities and their peat presently will provide little protections from rising sea level



From: Scott M. Duke-Sylvester

Everglades Restoration –

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

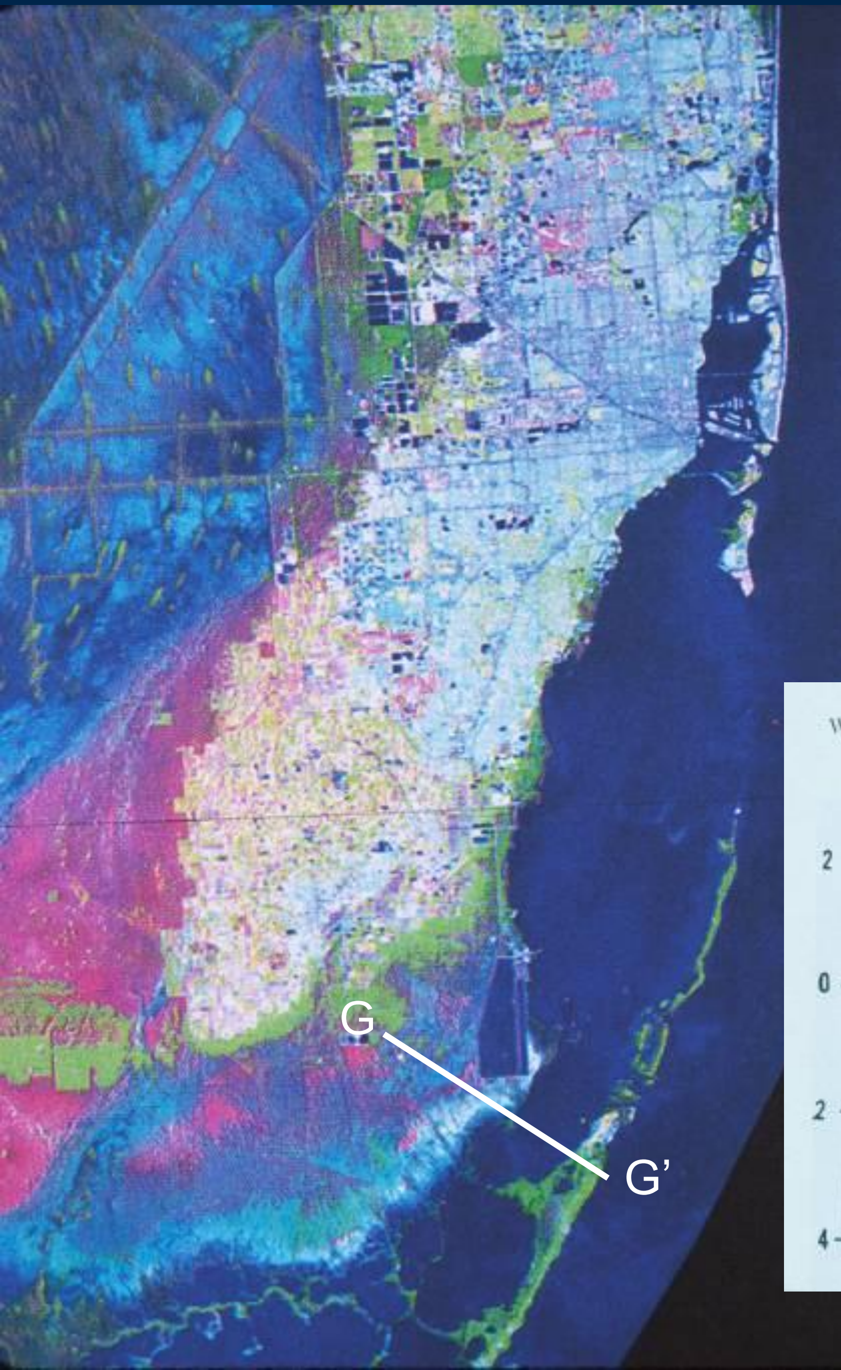
is now more important than ever

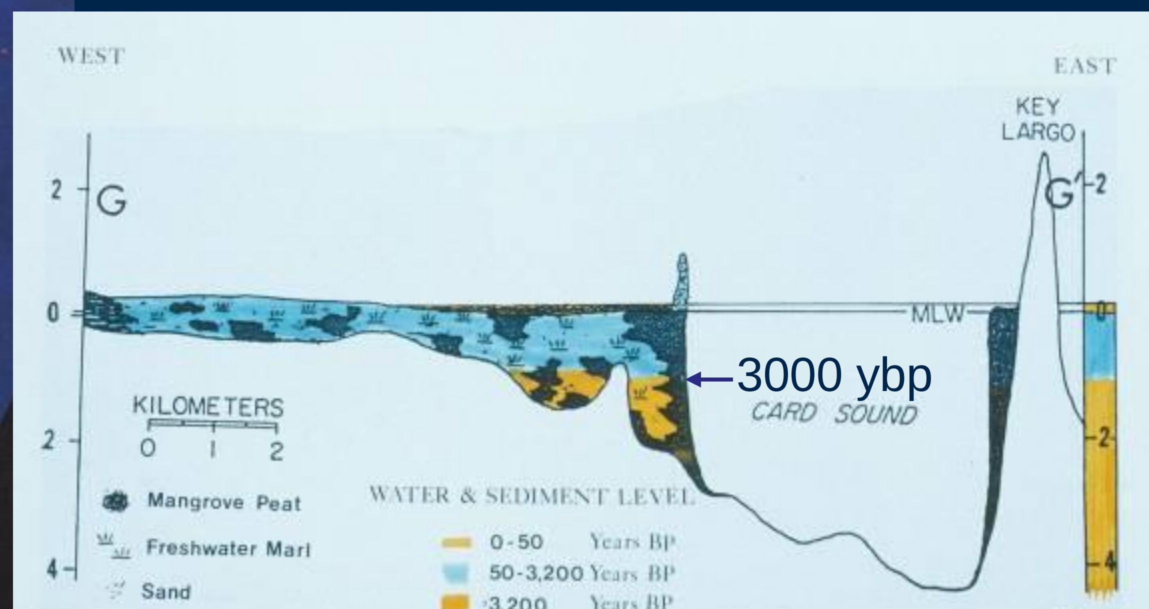
- Gradually and persistently building back the organic peat levels through raising water levels will be critical to retarding saline intrusion.

- Properly done, Everglades Restoration will greatly prolong the viability of the freshwater Everglades and the sources of fresh groundwater.

- This should become the focus of the Everglades Restoration effort.
- There will need to be research to quickly learn how to most rapidly build resilient peat substrates back up.
- There will need to be a commitment to cleaning and reusing water.

The natural Everglades and its flow built up the substrate with gradually rising sea level, keeping the marine waters from transgressing inland.



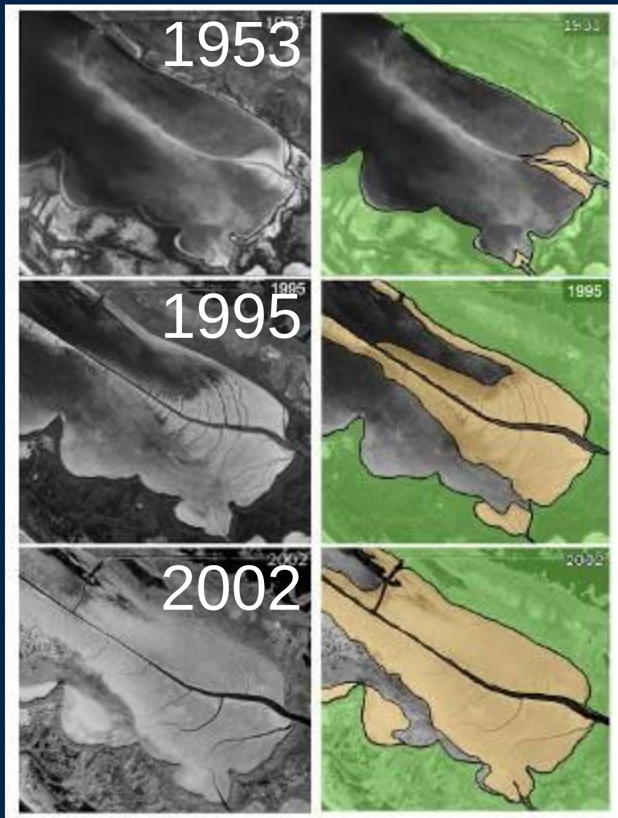


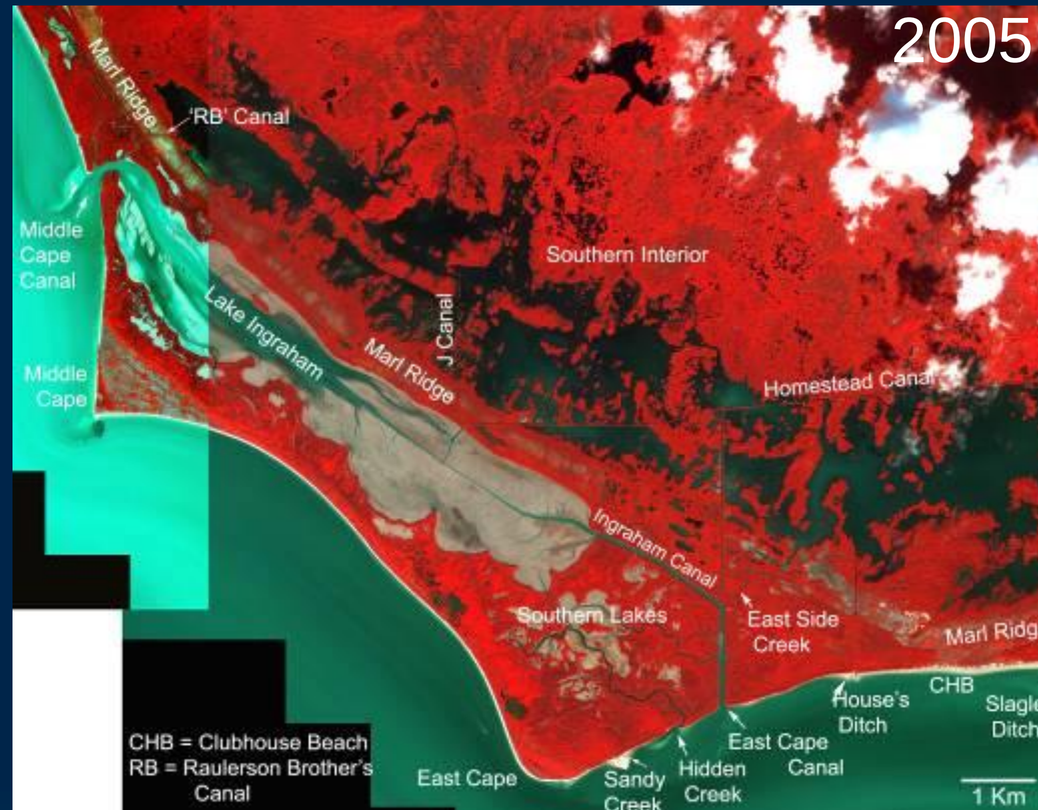
Wanless, 1967

As both freshwater and mangrove wetlands
collapse and evolve,
there is coming a landscape-scale release and recycling
of sediment, organics and nutrients.

The sands and muds are being pumped inward, filling interior bays.

Rapid erosion, redistribution and sedimentation

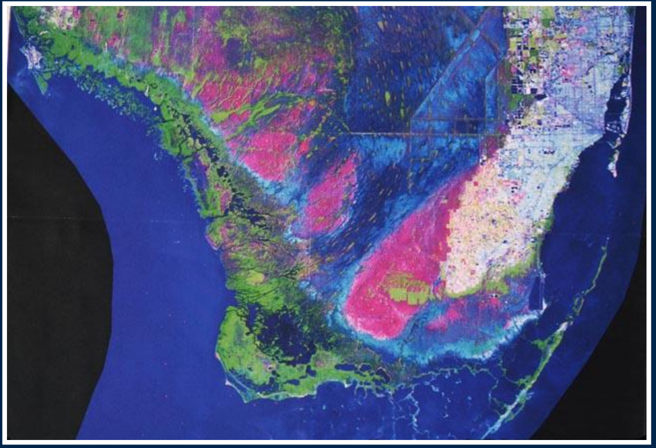


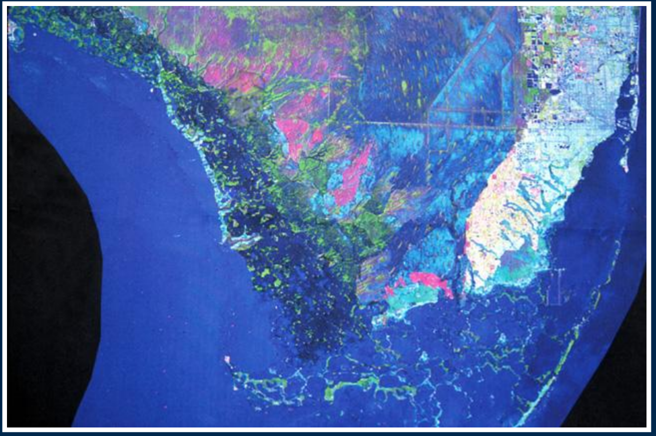


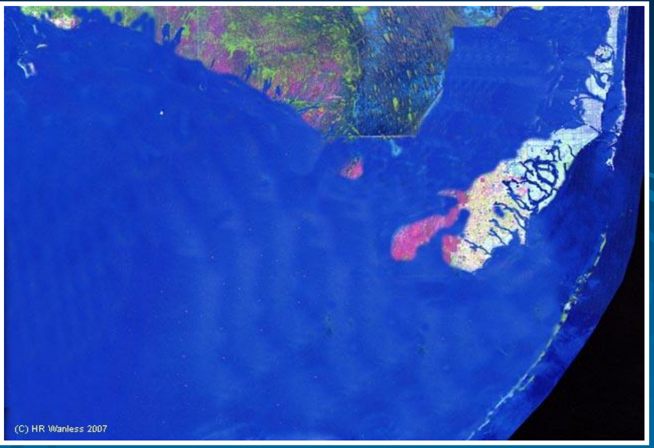
- It may be wise to aid vegetative colonization of these newly created shallows and to do what is necessary to revegetate wetlands destroyed by Hurricanes and freezes.
- This would aid the marginal wetlands in their struggle to keep up with the increased rates of sea level rise.
- They are our front line defense protecting our freshwater Everglades.

New mangrove colonization on Lake Ingraham delta, Cape Sable

Florida has a close to catastrophic evolution of its coastal environments, infrastructure and resources beginning this century.







Cape Romano, November 18, 2003

HUMAN-INDUCED GLOBAL WARMING IS VERY REAL.

It is time to reassess every aspect of how we are managing, protecting and modifying our coastal and low wetland environments.

We must work with the reality of the future.

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