RAPID STEPS OF SEA LEVEL RISE:
An Ominous View Into the Future

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Mostly < 10 feet
GLOBAL MEAN SEA LEVEL

Present global rise = 30 cm/century = S. Florida rate

MOST OF THIS RISE WAS BECAUSE OF THERMAL EXPANSION OF THE OCEAN

from IPCC 4th Report, 2007
Key West Sea Level

South Florida sea level rise
= 30 cm/century
= global rate

1930
SAME AS GLOBAL BUT WITH MORE VARIABILITY

Key west Sea Level from NOAA-NOS

1997 El Nino
Global sea level rise (based on tide gauge and satellite data) has been following the highest end of the 2001 IPCC sea level projection. Sea level rise is running at the high end of predictions – and is accelerating!
Scientists on the Miami-Dade County Climate Change Advisory 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)*
The U.S. Army Corps of Engineers (*) is now required to incorporate likely sea level rise into all civil works planning. This projection is also used by the Southeast Florida Regional Planning Council.

* Department of the Army, U.S. Army Corps of Engineers, Circular No. 1165-2-211. 1 July 2009
With continued melt from the Ice Sheets at the current acceleration, a conservative but realistic projection for sea level rise will be at least 4.5 feet (★) by the end of the century – likely much more.
If at + 5 feet at 2100, sea level will be rising at 1 foot per decade – and accelerating!
South Florida is very vulnerable to even a small amount of sea level rise.
+2 foot rise (shhw = +4.5’ above 1929 MSL)

- Increased risk from storm surges;
- Persistent flooding of lowest lying communities.

Seasonal higher high water

H. Wanless, 2007
+4 foot rise (shhw = +6.5’ above 1929 MSL)

South Florida 2100

- All barrier islands abandoned;
- Complete loss of freshwater resources;

Seasonal higher high water

(C) HR Wanless 2007

H. Wanless, 2007
South Florida 2100

+5 foot rise (shhw = +7.5’ above 1929 MSL)

- Infrastructure collapse;
- Increased pollution risk from inundation of eroding dumps and industrial sites;
- Sea level rising at 1 foot per decade.

Seasonal higher high water

(C) HR Wanless 2007

H. Wanless, 2007
• Miami-Dade, Broward, and Monroe counties diminished and risky place to live - including all of the Florida Keys
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
– AND STORM SURGES

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

from PPT by William B Potter
Now the bad news -

“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)

“It may happen much faster than we are anticipating.”

(Wanless, SEJ, 2011)

+ 6 meter shoreline of 120,000 years ago
FLORIDA THROUGH TIME

120,000 years ago
+ 6 meters (+20’)
~ ½ from Greenland
~ ½ from Antarctica

18,000 years ago
- 120 meters (-420’)

Today

How did this sea level rise occur?
Sea Level rise since last glacial maximum 18,000 years ago.

Smoothed sea-level rise curve based on C-14 dating of corals

Based on Fairbanks, 1989
BUT SEA LEVEL RISE RATES DID NOT GRADUALLY INCREASE AND DECREASE LIKE THIS.

RATHER, THERE WERE REPEATED STILL STANDS AND THEN RAPID PULSES OF SEA LEVEL RISE.
SEA LEVEL STILL STANDS AND RAPID RISES.

Recorded by preserved drowned barrier islands, tidal inlet sand deltas, and reefs on the shelf.

Rapid rises from 1-10 meters.

*D & W = DOMINGUEZ AND WANLESS, 1991
- Florida and Brazil

MILLIKEN ET AL, 2008 – Texas Shelf

ANDERSON ET AL, 2004 - Texas Shelf

RODRIGUEZ ET AL, 2000 - Texas Shelf

JARRETT ET AL, 2005 - SW Florida Shelf
COASTAL STABILIZATION & SED RECYCLING

COASTAL EROSION and INUNDATION
WILL THERE BE SIGNIFICANT RAPID SEA LEVEL PULSES IN THE FUTURE?

YES.

AND WE MAY BE SEEING THE BEGINNING NOW --
We have seriously increased the warming stressors.

We must expect a serious ice melt and sea level response – as it has in the past.

From Hansen, 2009, p. 153
Rate of mass loss more than doubled on both Greenland and Antarctica between 2002 and 2009.

Is now an annual 17% acceleration in melt rate and a 5% acceleration in the contribution to rise in sea level.
Map of Greenland showing locations of 184 glacial earthquakes for the period 1993–2005. Note the tight clustering of earthquake epicenters near major outlet glaciers.
Antarctic teleseismic detections that are likely to correspond to glacial earthquakes.

Collapsing front of glacial outlets produce seismic events.

Helheim Glacier, Greenland

ICE DISCHARGE THROUGH OUTLET GLACIERS HAS DRAMATICALLY INCREASED – BECAUSE OF WARM OCEAN WATERS MOVING IN BELOW

The Jacobshavn Isbreen in western Greenland (5 km wide and 1.5 km deep) is now moving at more 15km a year into the sea, although in surges it moves even faster.
We now know that warm waters moving under the outlets are driving the accelerated melt.
2009 - Pine Island Glacier, a major outlet for the West Antarctic Ice Sheet (WAIS), 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.
Estuarine circulation now promoting rapid melting beneath ice.

Warm denser ocean water flows in

Cooled less dense melt water flows out

Melting and mixing

60 kilometers
Can melt much of the West Antarctic Ice Sheet from below – and have in the past.

= Pine Island glacier outlet of West Antarctic Ice Sheet

= was open seaway during last interglacial (when sea level was 20’ higher than today)
It is time to recognize the likelihood of having pulses of rapid sea level rise in the 1-10 meter range in the near future.

- Leading to a 10-30 m (33-100 ft) sea level rise from multiple rise pulses.

Elevations greater than 150’
Recommend quick planning and implementation for putting things too important to lose (seed banks; National archives and libraries, unique coherent cultural hubs) and too valuable to be disrupted (nuclear power and waste disposal sites, critical military and transportation centers, agricultural centers) -

- At greater than 165 feet (>50 meters) elevation and
- In areas that will not be in the chaos of rapid relocation.
MIAMI-DADE COUNTY LiDAR MAPS

Elevations from Mean High Water Level

PRESENT TOPOGRAPHY

D = recent development
T = Tunnel to Port
MIA = Airport
= Emergency Operations

Sea Level Rise

+0.6 m (+2 ft)

100% land area

72% land remains

Datum = NAVD88

MHW

Elevations from Mean High Water Level

from Peter Harlem, SERC, FIU, 2010
MIAMI-DADE COUNTY LiDAR MAPS

Elevations from Mean High Water Level
from Peter Harlem, SERC, FIU, 2010

+1.2 m (+4 ft) Sea Level Rise

62% land remains

+1.8 m (+6 ft) Sea Level Rise

44% land remains
73% of that is less than 2 feet above sea level
MIAMI-DADE COUNTY LiDAR MAPS
Elevations from Mean High Water Level

+2.4 m (+8 ft) Sea Level Rise
12% land remains

Datum = NAVD88
MHW

+3.0 m (+10 ft) Sea Level Rise
9% land remains

Datum = NAVD88
MHW

from Peter Harlem, SERC, FIU, 2010

MHW
Earth has a close to catastrophic evolution of its coastal and low-lying environments, habitats, infrastructure and resources underway.

H. Wanless, 2007
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.
- Consensus that there will be accelerating SLR well beyond end of century.
- Not certain when there will be rapid pulses of ice release and melt and sea level rise –BUT IT WILL HAPPEN.
It is curiously inconvenient and a bit comic now – but not when you visualize the remainder of the century and beyond.
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