Sea Level Rise in South Florida

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Sustainable South Florida

Global Change
SLR, Storms

Everglades Vulnerability and Adaptation

Urban Vulnerability and Adaptation

Restoration Ecosystem Services

FIU Institute of Water and Environment
Southeast Environmental Research Center
Alton Rd between 8th and 10th streets has been flooding every year for the past 7 years at least.
‘It’s tough to make predictions, especially about the future.’

Yogi Berra, NY Yankees
Temperature is Increasing due to human activities which introduce greenhouse gases into our atmosphere.
Predictions by the IPCC suggest that we will reach a temperature anomaly of $+2^\circ$ to $4^\circ$ Centigrade by the end of the 21st Century.

Predictions for 2100 range from 0.5 to 2 meters of sea level rise.

But SLR does not stop at the year 2100. Because warming (expanding) the ocean and melting of polar ice to equilibration are much slower processes.
Temperature Anomaly vs. Sea Level Rise Commitment

Commitment levels are achieved when the ocean equilibrates to the combined effects of an expanding warming ocean, melting of land ice primarily at the poles, and other smaller drivers.

Levermann et al. in 2013 calculated that the commitment level relationship is:

- $1^\circ C (1.8^\circ F) = 2.3 m (7 ft.)$
- $2^\circ C (3.6^\circ F) = 4.6 m (14 ft.)$
- $3^\circ C (5.4^\circ F) = 6.9 m (21 ft.)$
- $4^\circ C (7.2^\circ F) = 9.2 m (28 ft.)$
Southern Florida Future Sea Level Rise Maps

The maps on the following slides show 1 foot level inundation layers.

Remember the rate of temperature rise is much faster than the rate at which the ocean rises.

Variability in timing between layers is likely and the higher levels will take much more than a century to be realized.

Therefore: Do not panic about the sea level rise rate, but **DO PANIC** about the temperature rise.
Southern Florida Topography

Topography with all lands above 0 feet (NAVD88 datum) shown.

Map by Peter W. Harlem
GIS-RS Center and SLSC, Florida International University
2015
Southern Florida with 1 foot of Sea Level Rise

This is the approximate commitment level for a temperature rise of 0.1 degrees C which occurred in the late 1970s.

This level will be realized between 2018 and 2024: the exact timing is uncertain because warming (expanding) the ocean and melting of polar ice to equilibration are slow non-linear processes.

Map by Peter W. Harlem
GIS-RS Center and SLSC, Florida International University 2015
Southern Florida with 2 feet of Sea Level Rise

This is the approximate commitment level for a temperature rise of 0.3 degrees C which occurred at the end of the 1980s

This level will be realized between 2031 and 2042: the exact timing is uncertain because warming (expanding) the ocean and melting of polar ice to equilibration are slow non-linear processes.
Southern Florida with 3 feet of Sea Level Rise

This is the approximate commitment level for a temperature rise of 0.4 degrees C which occurred in the mid-1990s.

This level will be realized between 2048 and 2066: the exact timing is uncertain because warming (expanding) the ocean and melting of polar ice to equilibration are slow non-linear processes.
Southern Florida with 4 feet of Sea Level Rise

This is the approximate commitment level for a temperature rise of 0.5 degrees C which occurred around 2000.

This level will be realized between 2074 and 2100: the exact timing is uncertain because warming (expanding) the ocean and melting of polar ice to equilibration are slow non-linear processes.
Southern Florida with 5 feet of Sea Level Rise

This is the approximate commitment level for a temperature rise of 0.7 degrees C which occurred in the early 2010s.

This level will be realized between 2084 and 2112: the exact timing is uncertain because warming (expanding) the ocean and melting of polar ice to equilibration are slow non-linear processes.
Southern Florida with 6 feet of Sea Level Rise

THIS IS WHERE WE KNOW WE ARE!

This is the approximate commitment level for a temperature rise of 0.8 degrees C which occurred in the mid-2010s.

This level will be realized sometime between 2094 and 2122: the exact timing is uncertain because warming (expanding) the ocean and melting of polar ice to equilibration are slow non-linear processes.

Map by Peter W. Harlem
GIS-RS Center and SLSC, Florida International University 2015
Southern Florida with 7 feet of Sea Level Rise

This is the approximate commitment level for a temperature rise of 0.9 degrees.

This level will be realized in the late 21st or early 22nd Century: the exact timing is uncertain because warming (expanding) the ocean and melting of polar ice to equilibration are slow non-linear processes.
Southern Florida with 8 feet of Sea Level Rise

This is the approximate commitment level for a temperature rise of 1.1 degrees.

This level will take a long time to realize because warming (expanding) the ocean and melting of polar ice to equilibration are much slower processes.
Southern Florida with 9 feet of Sea Level Rise

This is the approximate commitment level for a temperature rise of 1.2 degrees C.

This level will take a long time to realize because warming (expanding) the ocean and melting of polar ice to equilibration are much slower processes.
Southern Florida with 10 feet of Sea Level Rise

This is the approximate commitment level for a temperature rise of 1.3 degrees.

This level will take a long time to realize because warming (expanding) the ocean and melting of polar ice to equilibration are much slower processes.
Southern Florida with 11 feet of Sea Level Rise

This is the approximate commitment level for a temperature rise of 1.5 degrees.

This level will take a long time to realize because warming (expanding) the ocean and melting of polar ice to equilibration are much slower processes.

Map by Peter W. Harlem
GIS-RS Center and SLSC, Florida International University
2015
Southern Florida with 12 feet of Sea Level Rise

This is the approximate commitment level for a temperature rise of 1.6 degrees.

This level will take a long time to realize because warming (expanding) the ocean and melting of polar ice to equilibration are much slower processes.
Southern Florida with 13 feet of Sea Level Rise

This is the approximate commitment level for a temperature rise of 1.7 degrees.

This level will take a long time to realize because warming (expanding) the ocean and melting of polar ice to equilibration are much slower processes.

Map by Peter W. Harlem
GIS-RS Center and SLSC, Florida International University
2015
Southern Florida with 14 feet of Sea Level Rise

This is the approximate commitment level for a temperature rise of 1.9 degrees.

This level will take a long time to realize because warming (expanding) the ocean and melting of polar ice to equilibration are much slower processes.
Southern Florida with 15 feet of Sea Level Rise

This is the estimated commitment level for a temperature rise of 2.0 degrees C.

This level will take a long time to realize because warming (expanding) the ocean and melting of polar ice to equilibration are much slower processes.
Southern Florida with 30 feet of Sea Level Rise

This is the estimated commitment level for a temperature rise of 4.0 degrees.

This level will take a long time to realize because warming (expanding) the ocean and melting of polar ice to equilibration are much slower processes.

Map by Peter W. Harlem
GIS-RS Center and SLSC, Florida International University 2015
Sea Level Rise Projections

USA: Florida

+ 1 meter (3.3 feet)

+ 3 meters (~9.8 ft)
The Everglades is now half its original extent.
Everglades is also very vulnerable to climate change, sea level rise.
Vulnerability due to:

• Porous, shallow limestone aquifer susceptible to intrusion

• Thin peat soils caused by evaporation and drainage

• Long exposed coastline, low & flat topography

• Lost natural water storage (small changes in rain triggers floods or droughts)
SEA LEVEL RISE AND SALTWATER INTRUSION

Limestone
SLR + population growth = a threatened urban water supply

In 2010
Population = 5.6 million
Water demand = 1.8 billion gal./day

By 2030
Population = 6.6 million
Water demand = 2.1 billion gal./day
Since 1985, there has been a decline in the available freshwater resources of 12–17% in the Biscayne Aquifer.
COASTAL RIVERS

- Agriculture
- Industrialization
- Urbanization

- 1000 people/km
  (Overeem & Syvitski 2009)
EFFECTS OF URBANIZATION: IMPACT ON STREAMS

- Physiochemical elements
  - nutrient enrichment
  - contaminant pollution
  - water quality and toxicity

- Biological components
  - biotic interactions
  - habitat structure
  - energy source
  - alterations in trophic structure
EFFECTS OF URBANIZATION: IMPACT ON STREAMS

- **Physical integrity**
  - loss of large woody debris
  - canopy opening
  - stream hydrology
  - geomorphology
  - Sedimentation

- **Ecological Integrity**
  - Replacement of native species by exotics
  - Variation of ecosystem processes and trophic structure
The mouth of the Miami River at Brickell Key (February 2010).

<table>
<thead>
<tr>
<th>Origin</th>
<th>The Everglades</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mouth</td>
<td>Brickell Point</td>
</tr>
<tr>
<td>Basin countries</td>
<td>United States</td>
</tr>
<tr>
<td>Length</td>
<td>5.5 mi (8.9 km)</td>
</tr>
<tr>
<td>Source elevation</td>
<td>Sea level</td>
</tr>
<tr>
<td>Avg. discharge</td>
<td>50 ft³/s (15 m³/s)</td>
</tr>
</tbody>
</table>

Map of Miami, Florida with the river in blue.
EMERGING POLLUTANTS

HUMAN IMPACTS

![Graph showing mass loads of various antibiotics in wet and dry seasons.](image1)

![Bar chart comparing caffeine concentration in Biscayne Bay and Miami River.](image2)
Sustainable South Florida

- Global Change
  - SLR, Storms

- Everglades Vulnerability and Adaptation
- Urban Vulnerability and Adaptation
- Restoration Ecosystem Services
### TOTAL ECOSYSTEM VALUE (TEV) DECREASES WITH SLR

<table>
<thead>
<tr>
<th>SLR (feet)</th>
<th>Total Ecosystem Value* (TEV)</th>
<th>Mangrove C Sequestration Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (current)</td>
<td>$74,095,938,139</td>
<td>$32,140,703</td>
</tr>
<tr>
<td>0 (degraded)</td>
<td>$8,007,406,688</td>
<td>$937,770</td>
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<tr>
<td>1</td>
<td>$6,135,730,745</td>
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<tr>
<td>5</td>
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</tbody>
</table>

*2013 Dollars

**Assumption:** Time-independent Succession/Degradation

- TEV dec from $74B to $5B with 5 ft SLR
- C sequestration value dec from $32M to $490K
Research and Education Focus Areas

Detection and Identification  Fate and Transport  Impacts and Visualization

Mangrove Ecology  Coral Epigenetics

Discovery-based Education
THANK YOU!
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