Sea Level Rise in South Florida: Causes, Consequences and Opportunities

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Develop new interdisciplinary solutions through partnerships and collaboration

The SLSC is a university-wide center for:
1) conducting, facilitating, and synthesizing research and education to advance understanding of sea-level rise and its impacts on the well-being of both human and natural systems, and
2) converting this knowledge into actions for the benefit of society
Create interdisciplinary, solution-oriented science and training opportunities that are policy-relevant

Sea Level Solutions Center Interdisciplinary Studio

Taking a holistic, system-oriented approach - that integrates evaluation of future scenarios - to realize a new and resilient Miami while training the next generation of innovators.
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Sustainable South Florida

Global Change
SLR, Storms

Everglades Vulnerability and Adaptation

Urban Vulnerability and Adaptation

Restoration Ecosystem Services

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Alton Rd between 8th and 10th streets has been flooding every year for the past 7 years at least.
Southern Florida Topography

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

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

Map by Peter W. Harlem
GIS-RS Center and SLSC, FIU, 2015
Southern Florida with 3 feet of Sea Level Rise

Map by Peter W. Harlem
GIS-RS Center and SLSC, FIU, 2015
Southern Florida with 4 feet of Sea Level Rise
Southern Florida with 5 feet of Sea Level Rise!

Map by Peter W. Harlem
GIS-RS Center and SLSC, FIU, 2015
Southern Florida with 6 feet of Sea Level Rise

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

Map by Peter W. Harlem
GIS-RS Center and SLSC, FIU, 2015
Southern Florida with 8 feet of Sea Level Rise

Map by Peter W. Harlem
GIS-RS Center and SLSC, FIU, 2015
Southern Florida with 9 feet of Sea Level Rise

Map by Peter W. Harlem
GIS-RS Center and SLSC, FIU, 2015
Southern Florida with 10 feet of Sea Level Rise

Map by Peter W. Harlem
GIS-RS Center and SLSC, FIU, 2015
Southern Florida with 11 feet of Sea Level Rise

Map by Peter W. Harlem
GIS-RS Center and SLSC, FIU, 2015
Understanding the Science and Data Behind the Maps:

1) Historic patterns
2) Observations
   Tide Gauges (1807-)
   Satellites (1950-)
3) Models
It’s not a natural cycle

Present day: 402 ppm CO₂

Human perturbation
Tide Gauges

Tide gauge record – long record (1800s-), but poor spatial coverage.
Satellite Altimetry

Satellite altimetry record – near-global coverage, but short record length (1993-)

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Climate Change drives sea level rise

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Understanding the Science and Data Behind the Maps:

Models

1. Carbon dioxide increases temperature
2. Increased temperature increases ice melting but also, thermal expansion and land subsidence due to agriculture, thawing, flooding
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° C = 2.3 meters (7.5 feet) of committed SLR

- 1° C (1.8° F) = 2.3m (7 ft.)
- 2° C (3.6° F) = 4.6m (14 ft.)
- 3° C (5.4° F) = 6.9m (21 ft.)
- 4° C (7.2° F) = 9.2m (28 ft.)
### Unified Sea Level Rise Projection
(Southeast Florida Regional Climate Change Compact, 2015)

<table>
<thead>
<tr>
<th>Year</th>
<th>IPCC AR5 Median (inches)</th>
<th>USACE High (inches)</th>
<th>NOAA High (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2030</td>
<td>6</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>2060</td>
<td>14</td>
<td>26</td>
<td>34</td>
</tr>
<tr>
<td>2100</td>
<td>31</td>
<td>61</td>
<td>81</td>
</tr>
</tbody>
</table>

![Graph showing sea level rise projection](Compact 2015)
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.
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Implications for drinking water in south Florida

Water from Lake Okeechobee, the Water Conservation Areas (WCAs) and the C&SF Canals recharge the Biscayne Aquifer.

The Biscayne Aquifer supplies 90% of the south Florida’s drinking water -- more than 8 billion gallons of water each day.
Saltwater intrusion from freshwater extraction
Two Levels of Response:

1. Mitigation - direct intervention such as reducing carbon emissions; Long-time frame

2. Adaptation - modifying infrastructure or behavior to adjust to rising temperatures and sea level, increased coastal flooding and perturbation of weather patterns; Immediate and short-time frame
Two Levels of Response:

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**Coral Gables Proposed Sustainability Plan**

**GOALS:**

<table>
<thead>
<tr>
<th>Focus Area</th>
<th>Action</th>
<th>Metric</th>
<th>Baseline</th>
<th>Completion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy</td>
<td>Reduce electricity use</td>
<td>20%</td>
<td>below 2013 levels</td>
<td>by 2025</td>
</tr>
<tr>
<td>Water</td>
<td>Reduce water consumption</td>
<td>20%</td>
<td>below 2013 levels</td>
<td>by 2025</td>
</tr>
<tr>
<td>Materials</td>
<td>Divert solid waste*</td>
<td>75%</td>
<td></td>
<td>by 2020</td>
</tr>
<tr>
<td>Fleet</td>
<td>Reduce fossil fuel use</td>
<td>20%</td>
<td>below 2013 levels</td>
<td>by 2025</td>
</tr>
<tr>
<td>Climate</td>
<td>Reduce greenhouse gas emissions</td>
<td>20%</td>
<td>below 2013 levels</td>
<td>by 2025</td>
</tr>
<tr>
<td>Others</td>
<td>Of total projects**, implement</td>
<td>100%</td>
<td></td>
<td>by 2025</td>
</tr>
</tbody>
</table>

*City operations and single family residential waste*

**as identified in the Coral Gables Sustainability Management Plan**

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RESULTS: GREENHOUSE GAS EMISSIONS REDUCTIONS

Local Government Operations GHG Inventory and Forecast w/ Projected Reductions from Plan Projects

2008 Backcast value

19% reduction from
Two Levels of Response:

1. Mitigation - direct intervention such as reducing carbon emissions; Long-time frame

2. Adaptation - modifying infrastructure or behavior to adjust to rising temperatures and sea level, increased coastal flooding and perturbation of weather patterns; Immediate and short-time frame
Tidal Flooding today, in 2030 and in 2045

Southeast Florida will advance from <10 events today to 240 events in 2045

Source: UCS, Encroaching Tides

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### Table 6.1 Sample of Climate Hazards and Adaptive Responses Across Sectors

<table>
<thead>
<tr>
<th>Projected Change in Climate Phenomena (Likelihood)</th>
<th>Drivers of Urban Exposure and Vulnerability</th>
<th>Consequences for Cities, if Unaddressed</th>
<th>Sectors Involved</th>
<th>Sample Adaptive Responses (not an exhaustive list)</th>
<th>Relative Investment Level / Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warmer with fewer cold days and nights, more hot days and nights (virtually certain)</td>
<td>Urban heat island effect. Lack of electricity and cooling systems, especially in many informal settlements.</td>
<td>Exacerbated air pollution, Heat-induced illness and death</td>
<td>Transportation, housing, private sector building industry, public health</td>
<td>Green infrastructure, including improved vegetation and green building investments for natural cooling.</td>
<td>Medium to high with significant economic and sustainable development co-benefits</td>
</tr>
<tr>
<td>Hot spells/heat waves—increased frequency (very likely)</td>
<td>Lack of diversified energy supply and substandard energy infrastructure.</td>
<td>Energy shocks and disruptions because of increased demand</td>
<td>Energy</td>
<td>Investment in clean energy and energy efficiency.</td>
<td>Low to medium</td>
</tr>
<tr>
<td>Heavy precipitation events—increased frequency (very likely)</td>
<td>Rapid urban growth leading to informal settlements on marginal land with no roads or drainage systems, or drains that are clogged with debris and silt.</td>
<td>Exacerbated flooding and landslides</td>
<td>Land use, housing, solid waste, public health, emergency management</td>
<td>Development and enforcement of a sound land use plan that a) is based on understanding of climate change vulnerabilities, b) effectively encourages dense, mixed-use development in resilient areas, and c) engages ecological planning approaches outside of city limits (for example, village-level watershed management on the outskirts of a city, protection of mangroves and wetlands on nearby coastline).</td>
<td>High, involving significant political and staff investment</td>
</tr>
<tr>
<td>Intensity of tropical cyclone activity increases (likely)</td>
<td>Contaminated waters and spread of disease in stagnant waters</td>
<td>Blockage of emergency routes because of road flooding, resulting in delayed emergency evacuations</td>
<td>Transportation, emergency management, private sector</td>
<td>Improved solid waste handling practices (for example, proximity to drinking water supply, corrosive-resistant containers) to prevent leakage and contamination.</td>
<td>Medium to high.</td>
</tr>
<tr>
<td>Rising sea level (virtually certain)</td>
<td>Nonexistent or substandard transportation infrastructure.</td>
<td>Losses in commercial activity</td>
<td></td>
<td>Short-term clearance/disposal of solid waste from drains to prevent clogging.</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Public health engagement and risk prevention around likely flood-related diseases.</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Investment in roads and other transportation choices for informal settlements.</td>
<td>Medium to high</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Green infrastructure.</td>
<td>Medium to high with significant economic and sustainable development co-benefits</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Relocation of storage yards for buses and train cars out of flood-prone areas to reduce the risk of damage or loss of this equipment.</td>
<td>High</td>
</tr>
</tbody>
</table>
Current FIU Projects and Proposals:

1) Florida Coastal Everglades Program and SERC – Understanding Everglades ecology and hydrology for restoration

2) SERC research on water quality – coastal, canals, rivers and wetlands

3) Sustainable Built Environment and Informatics Program (SLSC/SBEI) - Development of ‘big data’ capabilities for ‘Smart Cities’

4) SLSC-CAKE (Center for Advanced Knowledge Enablement)-US.DOT proposal – ‘Smart Cities’; proposal to build next generation road and traffic system to minimize energy, carbon emissions and adapt to sea level rise