Sea-level rise and science to understand regional impacts in south Florida

Tiffany Troxler,
Director, Sea Level Solutions Center and Research Scientist,
Southeast Environmental Research Center,
Florida International University

FIU GIS DAY,
NOVEMBER 6, 2015
Climate Change Facts, regional implications

- Greenhouse gases are high and rising
- Oceans are warming and acidifying
- Sea levels are rising
Scientific Consensus

97 out of 100 climate experts agree humans are causing global warming

Doran et al 2009, Anderegg et al 2010
http://sks.to/consensus
South Florida projections for SLR

Unified Southeast Florida Sea Level Rise Projection for Regional Planning Purposes

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>
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<tr>
<td>2030</td>
<td>6</td>
<td>10</td>
<td>12</td>
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<td>2050</td>
<td>14</td>
<td>26</td>
<td>34</td>
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<tr>
<td>2100</td>
<td>31</td>
<td>61</td>
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Compact 2015
South Florida is very vulnerable to SLR
Sea level rise will interact with changes in precipitation and temperature

IPCC Climate Change Scenario Descriptions:

**Most Pessimistic**
Assumes a “business as usual” attitude, or little to no response to adverse climate change affects.

**Most Optimistic**
Assumes a concerted, global effort to mitigate human impacts.

Source: SFWMD, 2012
Sea level rise can be experienced through storms

IPCC Projections:
• Storm intensity expected to increase
• More extremes in wet/dry, hot/cold (very likely)
  = Unpredictable water supply

Hurricane Wilma - October 24, 2005
• Swamped Everglades & flooded Miami
“sunny day” flooding in Miami

Alton Rd between 8th and 10th streets has been flooding every year for the past 7 years at least.
Tidal Flooding today, in 2030 and in 2045

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

Legend
- NS_Profile
- EW_Profile
- Everglades National Park
- County
- DTM (m, NAVD88)
  - High: 52
  - Low: -1

Keqi Zhang
Inundation Caused by Sea Level Rise

Keqi Zhang
<table>
<thead>
<tr>
<th>County</th>
<th>Sea Level (m)</th>
<th>Area (km²)</th>
<th>Pop</th>
<th>Prop ($m)</th>
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<td>31</td>
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Land Area Hypsometric Curves for Elevation

Palm Beach  

Broward  

Miami-Dade

Keqi Zhang
Population Hypsometric Curves for Elevation

Palm Beach

Broward

Miami-Dade

Keqi Zhang
Everglades is also very vulnerable to climate change, sea level rise

Pre-Drainage

Post-Drainage

McVoy et al. 2011
SL vulnerability due to:

- Greatly reduced freshwater discharge
- 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)

Courtesy Hal Wanless
Saltwater Intrusion into Everglades wetlands

Groundwater salinity keeps rising

Mangroves are quickly encroaching into freshwater marsh

Dead cypress and encroaching mangroves in southern Shark River Slough

Sawgrass production is declining as they are exposed to salt water
White zone of low productivity is expanding.

White zone is shifting to the interior at a rate of about 10 km per 50 years.

Ross et al. 2000
Gaiser et al. 2006
Peat Collapse
Cape Sable: case study

Whitewater Bay

Lake Ingraham

Middle Cape

East Cape

collapsed marsh

Flamingo
1. **Current**

Sawgrass marsh builds peat soil on top of the limestone only in freshwater areas. Mangroves develop peat soil in saline and brackish conditions.

2. **Saltwater Intrusion**

Intrusion of saltwater causes sawgrass dieback and mangrove expansion. Freshwater peat soil begins to degrade with exposure to saltwater.

3. **Peat Collapse**

Freshwater peat collapses and the water is too deep for plants to become established. Mangroves established elsewhere help to re-stabilize soil.

H2H Graphics & Davis
How will sea level rise and saltwater intrusion affect the C balance of Everglades peat soils?

Temperature & pH
TEA availability
Substrate quality
Soil fertility
Decomposer community
Plant stressors
Disturbance
Hydrology

SOIL C BALANCE
The effects of projected sea-level rise on Everglades coastal peat marsh ecosystems

Objectives:

1) Investigate the potential for and mechanisms of peat collapse in coastal freshwater and brackish marsh ecosystems of the southern coastal Everglades using integrated mesocosm and field manipulations.

2) Develop actionable information and best management practices for water management and conservation of coastal south Florida.

FIELD EXPERIMENTS IN FRESHWATER & BRACKISH SITES

OUTDOOR MESOCOSMS
Everglades & urban water supply
The water flowing into the Everglades recharges the Biscayne Aquifer

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.
This Biscayne Aquifer provides over 90% of the drinking water of south Florida.

Since 1985, there has been a decline in the available freshwater resources of 12–17% in the Biscayne Aquifer.

Multiple utilities are at risk.

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
Urban groundwater salinity rising with SLR
Adaptations to Climate Change and Sea Level Rise

Arrows show dry season seawater INFLUX into the Everglades creeks and groundwater (not to scale)
Sea level rise with freshwater restoration

2 Foot SLR
No Flow Restoration

2 Foot SLR
+ Flow Restoration

CISREP 2014
Coastal wetlands: Unique habitats that can deliver valuable services to urban environment
Mangroves: why are they important?

Ecosystem Services

- Filter runoff
- Trap carbon in peat
- Provide habitat
- Protect land against flooding
- Improve water quality
- Support fisheries and recreational resources
- Reduce CO₂ from atmosphere
Mangroves and soils increase drag on water motion, absorb wave action and hold sediment in place.
Carbon storage in mangrove forests

*Data is per unit area, where tCO2eq/ha is tons of carbon dioxide equivalents per hectare

Great fish habitat makes for great recreational & tourism opportunities
Tourism, Commercial and Recreational Fishing Industries Depend on the Everglades & Our Natural Resources

• 5.5 million people, in 2008, engaged in Everglades recreational activities

• $935 million in Direct Spending

• $912 million in Indirect Spending

• 417,868 Recreational fishing licenses were issued in the Everglades watershed. (Source: US Census Bureau for US Fish and Wildlife Service, FY 2006)

• $5 billion commercial & recreational fishing industry.
### “Blue” Carbon Monitoring System

Linking soil and satellite data to reduce uncertainty in coastal wetland carbon burial: a policy-relevant, cross-disciplinary, national-scale approach

<table>
<thead>
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<th>Lisamarie Windham-Myers</th>
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<td>Kristin Byrd</td>
<td>U. Maryland/NOAA</td>
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<td>Judith Drexler</td>
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<td>Kevin Kroeger</td>
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<td>John Takekawa</td>
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<td>Isa Woo</td>
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<td>Postdoc: Meagan Gonneea</td>
<td>Jim Morris</td>
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<td>NASA-JPL</td>
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<td>Marc Simard</td>
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WETCARB
Wetland-Estuary Transports and CARbon Budgets

Study area

115 estuaries in NOAA's Coastal Assessment Framework. Excludes Mississippi River and Plume. Covers >90% of estuarine surface area.

Alana Menendez (City College of New York)
Audra Hinson (Texas A&M)
Chuanmin Hu (University of South Florida)
Fang Cao (City College of New York)
Hannah Wells (Valparaiso University)
Jack Hutchings (University of Florida)
Jose Fuentes (Penn State)
Kevin Kroeger (USGS)
Lauren Seidensticker (Penn State)
Maria Herrmann (Penn State)
Maria Tzortziou (City College of New York)
Mike Kemp (University of Maryland)
Ray Najjar (Penn State)
Rusty Feagin (Texas A&M)
Simone Alin (NOAA)
Tom Bianchi (University of Florida)
Wei-Jun Cai (University of Delaware)
Wiley Evans (NOAA)
Arts & Sciences

The FIU College of Arts & Sciences' Aquarius Reef Base allows for unprecedented monitoring of the effects of climate change on seagrass and coral reef ecosystems both of which are critical to the future of a planet with ever-rising temperatures.

Architecture + The Arts

Miami 2100: Envisioning a Resilient Second Century, an exhibit by the FIU College of Architecture + The Arts, combined stunning visuals with presentations on sea level rise and climate change.

Geographic Information Systems

The FIU Geographic Information Systems (GIS) Center provides the tools to visualize and understand the complexity of sea level rise impacts beyond just the obvious flood impacts.

Journalism & Mass Communication

Faculty and students in the School of Journalism and Mass Communication provide an "Eve on the Rise" website and application to help inform and engage the public on issues related to sea level rise.

Everglades Research

The Florida Coastal Everglades Long-Term Ecological Program (FCE LTER), which has made ground-breaking discoveries in the dynamics of the complex South Florida ecosystem in response to sea level rise and Everglades restoration.

Engineering & Computing

The FIU College of Engineering and Computing (CEC) faculty is engaged research related to sea level rise impacts. Specifically, hurricane wind damage, prevention strategies and improved building standards are studied using the "Wall of Wind" facility.
MISSION

The SLSC will conduct, facilitate, and synthesize research and education to advance understanding of sea-level rise and its impacts on the well-being of both human and natural systems, and to connect this knowledge into actions for the benefit of society.

• The SLSC will serve as a center for ‘thought leadership’ to communicate the understanding of the challenge of rising sea level to local, regional, national and international stakeholders at all levels by…
MISSION

• synthesizing the most up-to-date and accurate data associated with modeling and predictions of sea level rise risks

• providing information, expertise and a forum to assess impacts on the physical, health, economic, social, and ecological infrastructure, and develop solutions for mitigating these impacts

• actuating ‘knowledge to action’ by facilitating and leading adaptation and mitigation planning and assessment strategies

• developing global public communication and information dissemination outlets for issues related to sea level rise

• using Miami and South Florida as the world’s test case for adaptation to sea level rise
FIVE YEAR PLAN

• Develop a tool chest for cities to address sea level rise
• Create cutting-edge science & education resources
• Become the go-to-hub for SLR media
• Impact policies through briefings
• Expand knowledge of leaders for effective actions
• Develop & share practical methods for preparing for climate change
Downscaling sea level rise scenarios

Predicting urban flooding

Timescales for detecting a significant acceleration in sea level rise

We will know if sea level in 2100 will increase by:
- 1.5 - 2 m (by 2020)
- 0.5 - 1 m (by 2030)

Models improve successful adaptation

Maps produced by Pete Harlem, FIU
Measuring impacts of flood mitigation on water quality

Sea level rise risks to the Everglades
Designing a resilient city

Developing design solutions for the 22nd
Century coastal city

Communicating sea level impacts

Building community awareness and inspiring
action

Eyes on the Rise
Sea Level Rise South Florida

Winner: Florida International University

Florida International University is one of the 2014-15 winners of the Challenge Fund for
Innovation in Journalism Education. See all 12 winners and the Honorable Mentions.

PROJECT TITLE: SEA LEVEL RISE SOUTH FLORIDA: HOW ARE WATERS
AFFECTING YOU?

TEAM
Florida International University:
- Robert Gutsche, Jr., Assistant Professor,
- Susan Jacobson, Assistant Professor,
- Kate McMillin, Assistant Professor,
- Juliet Pinto, Associate Professor,
The rising seas threaten low-lying, flood-prone coastal areas around the world. The ramifications will rapidly ripple through all societies, and the methods and means that allow for a successful adaptation to sea level rise are largely local in nature. It will take cooperation - from the local to international levels - to efficiently develop and implement the policies and strategies necessary to address this threat to resources and security. In response, Florida International University (FIU) has launched the Sea Level Solutions Center (SLSC).
Types of solutions

- **Mitigation**: Mitigate the CAUSES of climate change. Anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases.

- **Adaptation**: Mitigate the EFFECTS of climate change. Adjustment in natural or human systems to a new or changing environment.
WE HAVE ENERGY CHOICES
CRISIS IS OPPORTUNITY

Los Angeles
Green Roof Initiative

Palm Springs
White Roof Initiative
Arrows show dry season seawater INFLUX into the Everglades creeks and groundwater (not to scale) – more freshwater will buy time
Retrofitting Existing Buildings

**Before**

08. Dry Floodproofing

09. Wet Floodproofing

10. Elevate on Piles

11. Protect Building Systems

**After**

- Bulkheads
- Beaches and Dunes

A range of possibilities

Portland Green Streets
MAKING ROOM FOR WATER IN THE CITY

PUBLIC SPACE

Canal Street
Absorbent Street
Floodable Park
Underground Cistern
NEW INNOVATIONS CREATE NEW JOBS

NATIONAL SOLAR JOBS CENSUS 2013

OVER 142,000 AMERICANS WORK IN THE SOLAR INDUSTRY

THE SOLAR FOUNDATION

Research and Education to Advance Solar Energy

Image courtesy of groSolar
System-oriented innovations that support local and national actions

**Problems:** Climate change and nutrient pollution

**Goal:** Reduce GH gases emissions & local nutrient pollution

**System-oriented analysis of costs & benefits:**
1. Fertilizer & waste management costs
2. Fertilizer & waste GHG emissions

**Solutions & unanticipated benefits:**
1. New revenue stream for investments in long-term sustainability

Example – local student projects to address global issues – composting!

Project idea and analysis: Marbelys Garriga & Ivanna Picon
What’s your idea??!

Make your innovation a solution

Thanks to friends and colleagues who have fostered discussion, shared ideas & advanced the science