Methodology and Technical Overview of 2019 Projection: Part I

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Acknowledgement

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Experts Consulted

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Southeast Florida (rate of rise)

Lake Worth (14”)

Miami Beach (9”/100 yrs)

Key West (9”/100 yrs)

Vaca Key (14”/100 yrs)
Recent Trends in Regional Tide Gages ("shift in ~2012")

Key West
Vaca Key
Virginia Key
Lake Worth
Mean Sea Level Data at Key West

- Monthly MSL
- 5-Year Mean
- Tidal Epoch

- 2000-2017: 3.9"
- 1992-2000: 0.2"
- 1915-2017: 10.7"
Factors Affecting Global Mean Sea Level Rise

Global Sea-Level Rise
What causes sea level to change?

- **Land/Water Storage**
  - Changes in runoff and storage of surface and ground water affect sea levels

- **Thermal Expansion**
  - As water warms, it expands

- **Land-Based Ice Melting**
  - As glaciers, Greenland and Antarctica Ice Sheets melt, they add mass

After IPCC (2001)
Mass Changes in Ice Sheets

Greenland

Grace Satellite

NASA

Antarctica

2005-2015

Cazenave et al. 2018
Sea Level Budget

Dieng, H. B., A. Cazenave, B. Meyssignac and M. Ablain (2017)

NCA, Climate Science Report, Chapter 12
Additional Factors Affecting Regional Sea Level

After IPCC (2001)
Δ Relative Sea Level (RSL) of Sweet et al. (2017):
following probabilistic framework of Kopp et al. (2014)

\[ \Delta \text{RSL} = \Delta \text{GMSL} + \Delta \text{RSL}_{\text{climatic}} + \Delta \text{RSL}_{\text{non-climatic}} \]

Global Mean Sea Level (GMSL) Scenarios for 2100:

1) Δ Oceanographic Processes (thermal expansion, dynamics from CMIP5 models)
2) Δ Ice Mass w/ gravity ‘fingerprints’

Glacial Isostatic Adjustment (GIA), tectonics, sediment compaction,

Illustrative Fingerprints (Hay et. al. 2015)
(a) Greenland
(b) Antarctica
Projections Considered

- NOAA 2012
- DoD/SERDP 2016
- NOAA 2017
- IPCC/SROCC 2019

- Tampa Bay 2019
- Maryland 2019
- California 2019
- Washington 2018
- New York 2019
Sea Level Projections: Deep Uncertainty

- Greenhouse gas emission pathways
- Inadequate understanding and modeling of Marine Ice Sheet Dynamics (particularly Antarctica)

*Watch for Dynamic Adaptive Policy Pathway talk – Webinar 3
NOAA 2017 Regional Projections Methodology

Methods: Historical Trends, Climate Models, and Mixed

<table>
<thead>
<tr>
<th>Process</th>
<th>Sources</th>
</tr>
</thead>
</table>
| Ice sheet mass changes               | • IPCC AR5  
• Expert Elicitation  
• Fingerprints                                                  |
| Glacier Mass Changes                 | • Glacier Models                                               |
| Oceanographic processes              | • IPCC (CMIP5 Models)                                          |
| Land-water Storage                   | • Empirical Relationships                                     |
| GIA/Tectonics/Sediment Compaction    | • Long-term background rate modeled using tide gages           |
Global Scenarios Selected for 2019 Projections

**NOAA Global Mean Sea Level (GMSL) Scenarios for 2100**

<table>
<thead>
<tr>
<th>GMSL rise Scenario</th>
<th>RCP2.6</th>
<th>RCP4.5</th>
<th>RCP8.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low (0.3 m)</td>
<td>94%</td>
<td>98%</td>
<td>100%</td>
</tr>
<tr>
<td>Intermediate-Low (0.5 m)</td>
<td>49%</td>
<td>73%</td>
<td>96%</td>
</tr>
<tr>
<td>Intermediate (1.0 m)</td>
<td>2%</td>
<td>3%</td>
<td>17%</td>
</tr>
<tr>
<td>Intermediate-High (1.5 m)</td>
<td>0.4%</td>
<td>0.5%</td>
<td>1.3%</td>
</tr>
<tr>
<td>High (2.0 m)</td>
<td>0.1%</td>
<td>0.1%</td>
<td>0.3%</td>
</tr>
<tr>
<td>Extreme (2.5 m)</td>
<td>0.05%</td>
<td>0.05%</td>
<td>0.1%</td>
</tr>
</tbody>
</table>
Why bias towards RCP8.5?

• “In the absence of an ambitious increase in adaptation efforts compared to those currently underway, high to very high risks are expected in many coastal geographies at the upper end of the RCP8.5 likely range” (SROCC, 2019)

• “..advises that local governments and regional agencies assess the likelihood of the three SLR scenarios using RCP 8.5, which models climate change without additional efforts to constrain emissions” (Tampa Bay CSAP)
Interpretations of the GMSL rise scenarios (NCA, Climate Science Reprot, Chapter 12)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intermediate-High</td>
<td>Slightly above high end of very likely range under RCP8.5</td>
</tr>
<tr>
<td></td>
<td>Middle of likely range under RCP8.5 when accounting for possible ice cliff instabilities</td>
</tr>
<tr>
<td>High</td>
<td>High end of very likely range under RCP8.5 when accounting for possible ice cliff instabilities</td>
</tr>
<tr>
<td>Extreme</td>
<td>Consistent with estimates of physically possible “worst case”</td>
</tr>
</tbody>
</table>
Regional Projections – South Florida

NOAA Intermediate High Scenario

Sea Level Rise (cm)

Global

Regional

Years

2000 2020 2040 2060 2080 2100

GMSL
KEY WEST
MIAMI BEACH
VACA KEY
 VIRGINIA KEY
grid_26.5_280.5
grid_25.5_278.5
grid_26.5_260.5
grid_24.5_276.5
grid_24.5_279.5
grid_24.5_260.5

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Most Recent SE Climate Compact Projections

Unified Sea Level Rise Projection
(Southeast Florida Regional Climate Change Compact, 2019)

<table>
<thead>
<tr>
<th>Year</th>
<th>IPCC Median (inches)</th>
<th>NOAA Intermediate High (inches)</th>
<th>NOAA High (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2040</td>
<td>10</td>
<td>17</td>
<td>21</td>
</tr>
<tr>
<td>2070</td>
<td>21</td>
<td>40</td>
<td>54</td>
</tr>
<tr>
<td>2120</td>
<td>40</td>
<td>92</td>
<td>136</td>
</tr>
</tbody>
</table>

50 Year Planning Horizon

Observed 5-Year Average Mean Sea Level

Relative Sea Level Rise near Key West, FL (Inches Relative to Mean Sea Level in Year 2000)


175 NOAA Extreme
136 NOAA High
92 NOAA Intermediate High
40 IPCC Median

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Moving Mean Sea Level with USACE SLC Scenarios for Key West, FL

In order to capture tooltips, press the print screen ('prt sc') button.

Compare Acceleration in 5-year MSL Moving Average

Accelerating sea level change in Florida 30-Years JUN 1988 to JUN 2018, Key West, FL

Source: Landers (2018) USACE/ Broward Flood Risk Management Study for Tidally Influenced Coastal Areas; USACE Sea Level Tracker
NOAA et al. 2017 Relative Sea Level Change Scenarios for: KEY WEST

RSLC in feet

Year

2000  2010  2020  2030  2040  2050  2060  2070  2080  2090  2100

NOAA High

NOAA Int-High

IPCC Median

Legend:
- Red: NOAA High
- Orange: NOAA Int-High
- Black: IPCC Median
Unified Sea Level Rise Projection

(Florida Regional Climate Change Compact, 2019)

<table>
<thead>
<tr>
<th>Year</th>
<th>IPCC Median (Feet NAVD)</th>
<th>NOAA Intermediate High (Feet NAVD)</th>
<th>NOAA High (Feet NAVD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2040</td>
<td>0</td>
<td>0.6</td>
<td>1</td>
</tr>
<tr>
<td>2070</td>
<td>0.9</td>
<td>2.5</td>
<td>3.7</td>
</tr>
<tr>
<td>2120</td>
<td>2.5</td>
<td>6.9</td>
<td>10.5</td>
</tr>
</tbody>
</table>

5-Year Average of Mean Sea Level

- 1990: -0.2
- 2000: 0.0
- 2010: 0.6
- 2020: 1.8
- 2030: 4.6
- 2040: 6.9
- 2050: 10.5
- 2060: 13.8

Year
Datums

- Mean sea level
- North American Vertical Datum 1988

**Numbers rounded for simplicity**
High Tides
Nuisance Flooding
Future Nuissance Flooding