



SEA-LEVEL RISE AND ITS IMPACT ON FLORIDA

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GLOBAL SEA-LEVEL RISE AND THE INFLUENCE OF CLIMATE CHANGE

- *It is well-established that global warming has resulted in global sea-level rise.¹*
- *Since 1870, average global sea level has risen by about 8 inches.²*
- *As the climate has become increasingly warmer, the annual rate of sea-level rise has accelerated.³*
- *Average annual sea-level rise between 1993 and 2011 was 78 percent higher than between 1961 and 1993.^{4,5}*
- *The two most significant factors contributing to sea-level rise are warming ocean water and freshwater input from melting ice sheets, ice caps, and glaciers:⁶*
 1. *Thermal expansion – or the warming of ocean water that causes it to increase in volume.⁷*
 - a. *From 1961 to 2003, 23 percent of the average annual rise in global sea level was attributed to warming of the oceans.⁸*
 - b. *From 1993 to 2003, 52 percent of the average rise in global sea level was attributed to warming of the oceans – meaning warming oceans became the leading contributor to sea-level rise.⁹*

2. *The melting of Greenland and Antarctic ice sheets, as well as global ice caps and glaciers.*¹⁰

a. *Combined, the melting of these ice sheets, ice caps, and glaciers attributed to 38 percent of annual global sea-level rise from 1993 to 2003.*¹¹

b. *Recent research using satellite observations find Greenland and Antarctic glacial ice melting at accelerating rates, as follows:*¹²

Average annual ice loss from the Greenland Ice Sheet:^{13,14}

i. *From the year 1992 to 2000: 51 Gigatonnes – or the weight of almost 2,537 Great Pyramids.*

ii. *From the year 2000 to 2011: 211 Gigatonnes – a 314 percent increase in ice loss above the 1992-2000 annual average.*

Average annual ice loss from the Antarctic Ice Sheet:

i. *From the year 1992 to 2000: 71 Gigatonnes – or the weight of almost 3,532 Great Pyramids.*

ii. *From the year 2000 to 2011: 87 Gigatonnes – an 18 percent increase in ice loss above the 1992-2000 average.*

■ *The Regional Climate Action Plan established by the Compact provides impact estimates on the region using unified sea-level rise projections of one to three feet.*¹⁶ *Key findings from this assessment include:*

□ *By the year 2060, it is estimated that sea levels along Florida’s coastline could rise an additional 9 inches to 2 feet.*

□ *In the Florida counties of Monroe, Palm Beach, and Broward, the aggregate taxable property values vulnerable to a one-foot rise in sea level are estimated to be as high as \$4 billion, increasing to more than \$31 billion if sea levels were to rise three feet.*

□ *If sea level along the coastline of Monroe County were to rise by one foot, three of four hospitals, 65 percent of schools, and 71 percent of emergency shelters would be located on properties below sea level.*

□ *Almost 900 miles of roadway from Miami-Dade through Palm Beach would be impacted by a sea-level rise of three feet.*

■ *Florida’s Miami-Dade and Broward counties, individually, have more population living less than 4 feet above sea level than any state in the nation except for Florida and Louisiana.*¹⁷

■ *It is estimated that 40 percent of the population and housing units in the United States at risk from sea-level rise are in Florida.*¹⁸

■ *In Miami Beach, sea-level rise has made prolonged flooding a frequent event after strong storms, particularly in low-elevation neighborhoods. This has led city officials to consider a \$206 million renovation of their drainage system.*¹⁹

■ *Keith London, former Hallandale Beach City Commissioner, noted that the County “just spent \$10 million on new wells because salt water seeped into six of our wells that were close to the coast.”*²⁰

FLORIDA’S VULNERABILITY AND COST ESTIMATES

*Four county governments in Southeast Florida, in response to impacts of sea-level rise, established the Southeast Florida Regional Climate Change Compact in January 2010. The purpose of this agreement between the county governments of Broward, Miami-Dade, Monroe, and Palm Beach Counties – which have a combined population of 5.6 million – is to develop mitigation and adaptation strategies through joint efforts and to actively inform critical policymaking and government funding decisions at the state and federal levels.*¹⁵

- *Barry Heimlich, research affiliate with Florida Atlantic University's Florida Center for Environmental Studies who led a study of the impacts of climate change on Southeast Florida's water infrastructure,²¹ has stated:*

Significant challenges to the water systems in Southeast Florida due to climate change are expected to begin within the next two decades. Water managers will have to contend with increasing saltwater intrusion and more intense drought. Furthermore, risk of flooding will increase as a result of more intense rain storms coupled with sea level rise that will cause reduced capacity of flood control systems.²²

LOCAL GOVERNMENTS RESPONDING TO THE IMPACTS OF SEA-LEVEL RISE

The Southeast Florida Regional Climate Change Compact led a successful effort to provide for the designation of "Adaptation Action Areas" under Florida state law. These areas are designated as part of local comprehensive plans in order to prioritize infrastructure improvements and funding in areas subject to sea-level rise and coastal flooding.

The Compact also provides a model for addressing the risks of climate change. The Compact has established 110 action items to mitigate greenhouse gas emissions and build resilience to local climate change impacts. The action items are meant to help empower communities to actively address seven broad goals: Sustainable Communities; Transportation Planning; Water Supply, Management and Infrastructure; Natural Systems; Agriculture; Energy and Fuel; and Risk Reduction and Emergency Management.

Here is what local officials are saying about sea-level rise:

- *Kristin Jacobs, Broward County Commissioner:*

Rising sea levels are a tangible problem that we face every day here in South Florida. As sea levels continue to rise and threaten our coastline, we could lose one of America's most beautiful natural treasures and one of Florida's greatest economic engines.²³

- *Fred Beckmann, Miami's Public Works Director:*

It's the first time, as far as I know, that any community in South Florida and actually in the entire state of Florida is taking into account sea level rise as they plan their storm water infrastructure.

- *Dr. Jennifer Jurado, Director of Natural Resources, Planning and Management Division, Broward County:*

The overall issues are so much greater, I think we're easily looking at hundreds of millions of dollars...That's just for the next 20 to 30 years, to handle a moderate three to seven inch rise.²⁴

ENDNOTES

1. United States Global Change Research Program. (<http://www.global-change.gov/what-we-do/assessment/previous-assessments/global-climate-change-impacts-in-the-us-2009>).
2. Church, J. A. and N. J. White (2006), A 20th century acceleration in global sea-level rise, *Geophys. Res. Lett.*, 33, L01602, doi:10.1029/2005GL024826. Available at: <http://www.agu.org/journals/abs/2006/2005GL024826.shtml>.
3. See: Church, J. A. and N. J. White (2006), A 20th century acceleration in global sea-level rise, *Geophys. Res. Lett.*, 33, L01602, doi:10.1029/2005GL024826. (Available at: <http://www.agu.org/journals/abs/2006/2005GL024826.shtml>) and, Rahmstorf, S. and M. Vermeer, 2011. Discussion of: Houston, J.R. and Dean, R.G., 2011. Sea-Level Acceleration Based on U.S. Tide Gauges and Extensions of Previous Global-Gauge Analyses. *Journal of Coastal Research*, 27(3), 409-417. *Journal of Coastal Research*, 27(4), 784-787. West Palm Beach (Florida), ISSN 0749-0208. (Available at: http://www.pik-potsdam.de/~stefan/Publications/Journals/rahmstorf_vermeer_2011.pdf).
4. <http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-spm.pdf>.
5. <http://iopscience.iop.org/1748-9326/7/4/044035/article>.
6. The time periods chosen for discussion of sea-level rise throughout this fact sheet are consistent with those used by the Intergovernmental Panel on Climate Change's Fourth Assessment Report (AR4) and more recent research led by Stefan Rahmstorf. Note that the AR4 highlights the years of record between 1961 and 2003, dividing this time period into two segments: before and after the year 1993. That year is significant because it is the first in which improved satellite data became available for measuring sea-level rise; prior to 1993 only in-situ observations are available. When referring to the time period of 1993 to 2011, we use results from updated records presented in a recent research article led by Stefan Rahmstorf (<http://iopscience.iop.org/1748-9326/7/4/044035/article>), who is a known expert on global sea-level rise and a contributing author to the AR4.
7. <http://www.climate-science.gov/Library/sap/sap4-1/final-report/sap4-1-final-report-all.pdf>.
8. <http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-spm.pdf>.
9. <http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-spm.pdf>.
10. <http://www.climate-science.gov/Library/sap/sap4-1/final-report/sap4-1-final-report-all.pdf>.
11. <http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-spm.pdf>.
12. <http://www.sciencemag.org/content/338/6111/1183.full.pdf?sid=4b1533c9-952a-42a4-bdc7-fb15831c3905>.
13. According to National Geographic, the Great Pyramid consists of 2.3 million stones, each weighing an average of 2.5 to 15 tons. Assuming an average weight of 8.5 tons per stone, the estimated weight of the Great Pyramid is 20.1 million tons. National Geographic's assessment of the Great Pyramid can be found online at: <http://science.national-geographic.com/science/archaeology/giza-pyramids/>.
14. All time periods of annual ice loss from the Greenland and Antarctic ice sheets were taken directly from Shepard et al., 2012. (<http://www.sciencemag.org/content/338/6111/1183.full.pdf?sid=4b1533c9-952a-42a4-bdc7-fb15831c3905>). This is the most recent scientific assessment of the Greenland and Antarctic ice sheets, conducted by an international group of 47 scientists. The assessment combined an ensemble of satellite altimetry, interferometry, and gravimetry data sets using common geographical regions, time intervals, and models of surface mass balance and glacial isostatic adjustment to estimate the mass balance of the Earth's polar ice sheets.
15. <http://southeastfloridaclimatecompact.org/>.
16. <http://southeastfloridaclimatecompact.org/pdf/Regional%20Climate%20Action%20Plan%20FINAL%20ADA%20Compliant.pdf>.
17. <http://slr.s3.amazonaws.com/factsheets/Florida.pdf>.
18. Strauss, Benjamin H., et al. 2012. Tidally adjusted estimates of topographic vulnerability to sea level rise and flooding for the contiguous United States. *Environmental Research Letters*, 7, 014033. Online at: <http://stacks.iop.org/1748-9326/7/i=1/a=014033>.
19. <http://miamibeachfl.gov/publicworks/scroll.aspx?id=27280>.
20. http://www.ucusa.org/news/press_release/florida-sea-level-rise-letter-0342.html.
21. See the Southeast Florida's Resilient Water Resources portion in the projects section of the FAU climate change web site (http://www.ces.fau.edu/climate_change).
22. <http://www.fau.edu/mediarelations/releases1011/101117.php>.
23. <http://www.votekristinjacobs.com/news,kristin-jacobs-calls-attention-to-rising-sea-levels-on-earth-day>.
24. <http://www.palmbeachpost.com/news/weather/rising-sea-comes-cost-south-florida-cities/nR2Qw/>.

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