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EXCERPT FROM...

Climate Change: Global Sea Level

Author: Rebecca Lindsey, *November 19, 2019*

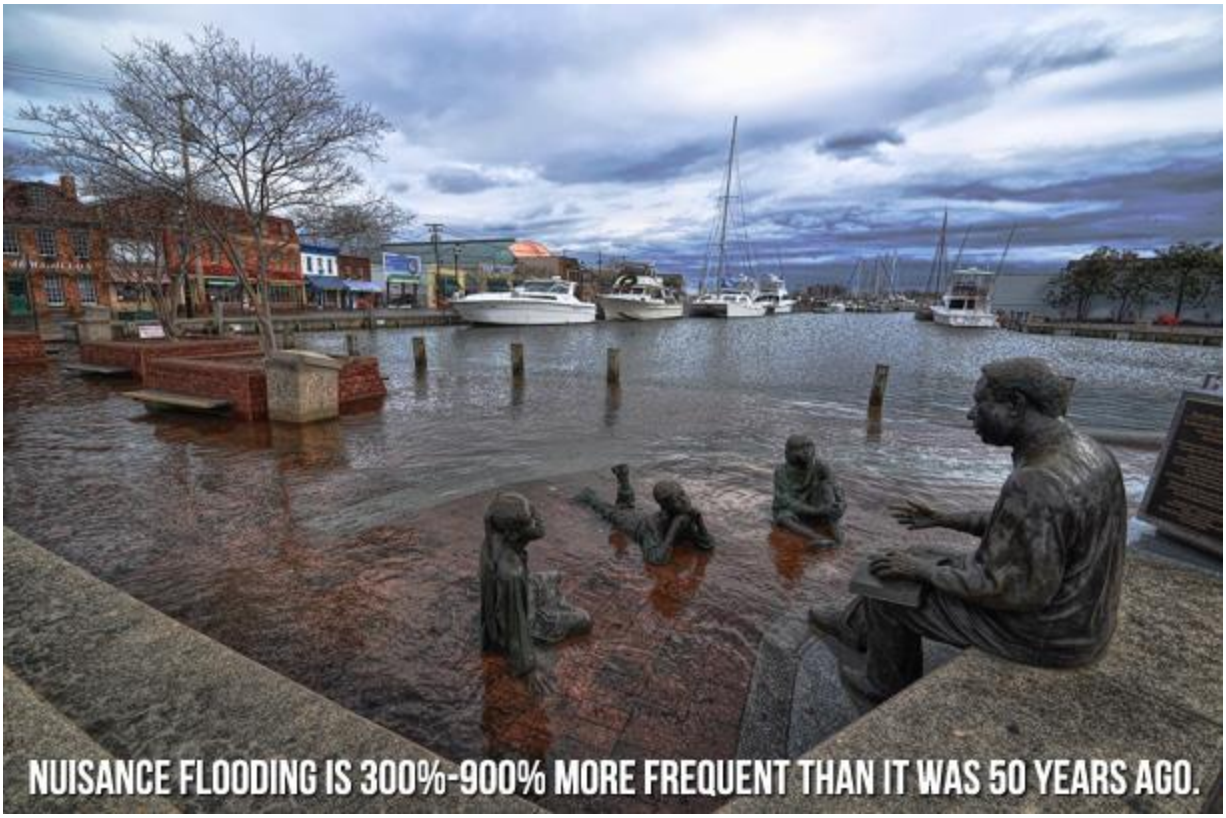
WHY SEA LEVEL MATTERS

In the United States, almost 40 percent of the population lives in relatively high population-density coastal areas, where sea level plays a role in flooding, shoreline erosion, and hazards from storms. Globally, 8 of the world's 10 largest cities are near a coast, according to the U.N. Atlas of the Oceans.

South Beach, Miami on May 3, 2007. Photo by Flickr user James WIlliamor, via a Creative Commons license.

In urban settings along coastlines around the world, rising seas threaten infrastructure necessary for local jobs and regional industries. Roads, bridges, subways, water supplies, oil and gas wells, power plants, sewage treatment plants, landfills—the list is practically endless—are all at risk from sea level rise.

Higher background water levels mean that deadly and destructive storm surges, such as those associated with Hurricane Katrina, "Superstorm" Sandy, and Hurricane Michael—push farther inland than they once did. Higher sea level also means more frequent high-tide flooding, sometimes called "nuisance flooding" because it isn't generally deadly or dangerous, but it can be disruptive and expensive. (Explore past and future frequency of high-tide flooding at U.S. locations with the Climate Explorer, part of the U.S. Climate Resilience Toolkit.)



Nuisance flooding in Annapolis in 2012. Around the U.S., nuisance flooding has increased dramatically in the past 50 years. Photo by Amy McGovern.

In the natural world, rising sea level creates stress on coastal ecosystems that provide recreation, protection from storms, and habitat for fish and wildlife, including commercially valuable fisheries. As seas rise, saltwater is also contaminating freshwater aquifers, many of which sustain municipal and agricultural water supplies and natural ecosystems.

Read the entire article at:
https://www.climate.gov/news-features/understanding-climate/climate-change-global-sea-level

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WHAT'S CAUSING SEA LEVEL TO RISE?

Global warming is causing global mean sea level to rise in two ways. First, glaciers and ice sheets worldwide are melting and adding water to the ocean. Second, the volume of the ocean is expanding as the water warms. A third, much smaller contributor to sea level rise is a decline in the amount of liquid water on land—aquifers, lakes and reservoirs, rivers, soil moisture. This shift of liquid water from land to ocean is largely due to groundwater pumping.

Pedersen Glacier, at Aialik Bay in Alaska's Kenai Mountains, in 1917 (left) and 2005 (right).

In the early 20th century, the glacier met the water and calved icebergs into a marginal lake near the bay. By 2005, the glacier had retreated, and the lake had become a small grassland. Photos courtesy of Louis H. Pedersen (1917) and Bruce F. Molina (2005), obtained from the Glacier Photograph Collection, Boulder, Colorado USA: National Snow and Ice Data Center/World Data Center for Glaciology. **Large images:** 1917 | 2005

From the 1970s up through the last decade or so, melting and heat expansion were contributing roughly equally to observed sea level rise. But the melting of mountain glaciers and ice sheets has accelerated:

The decadal average loss from glaciers in the World Glacier Monitoring Service's reference network quintupled over the past few decades, from the equivalent of 6.7 inches (171 millimeters) of liquid water in the 1980s, to 18 inches (460 millimeters) in the 1990s, to 20 inches (-500 millimeters) in the 2000s, to 33 inches (850 millimeters) for 2010-2018.

Ice loss from the Greenland Ice Sheet increased seven-fold from 34 billion tons per year between 1992-2001 to 247 billion tons per year between 2012 and 2016.

Antarctic ice loss nearly quadrupled from 51 billion tons per year between 1992 and 2001 to 199 billion tons per year from 2012-2016.

As a result, the amount of sea level rise due to melting (with a small addition from groundwater transfer and other water storage shifts) from 2005–2013 was nearly twice the amount of sea level rise due to thermal expansion.

Melt streams on the Greenland Ice Sheet on July 19, 2015. Ice loss from the Greenland and Antarctic Ice Sheets as well as alpine glaciers has accelerated in recent decades. NASA photo by Maria-José Viñas.

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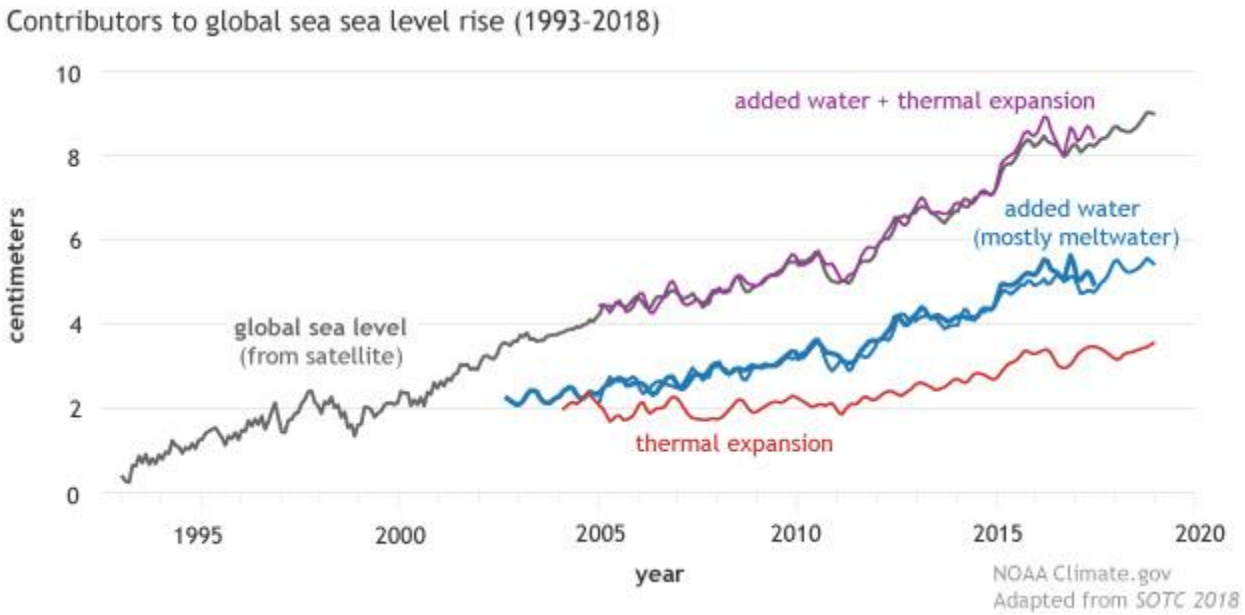
MEASURING SEA LEVEL

Sea level is measured by two main methods: tide gauges and satellite altimeters. Tide gauge stations from around the world have measured the daily high and low tides for more than a century, using a variety of manual and automatic sensors. Using data from scores of stations around the world, scientists can calculate a global average and adjust it for seasonal differences.

Since the early 1990s, sea level has been measured from space using radar altimeters, which determine the height of the sea surface by measuring the return speed and intensity of a radar pulse directed at the ocean. The higher the sea level, the faster and stronger the return signal is.

To estimate how much of the observed sea level rise is due to thermal expansion, scientists measure sea surface temperature using moored and drifting buoys, satellites, and water samples collected by ships. Temperatures in the upper half of the ocean are measured by a global fleet of aquatic robots. Deeper temperatures are measured by instruments lowered from oceanographic research ships.

Observed sea level since the start of the satellite altimeter record in 1993 (black line), plus independent estimates of the different contributions to sea level rise: thermal expansion (red) and added water, mostly due to glacier melt (blue). Added together (purple line), these separate estimates match the observed sea level very well. NOAA Climate.gov graphic, adapted from Figure 3.15a in *State of the Climate in 2018*.



To estimate how much of the increase in sea level is due to actual mass transfer—the movement of water from land to ocean—scientists rely on a combination of direct measurements of melt rate and glacier elevation made during field surveys, and satellite-based measurements of tiny shifts in Earth's gravity field. When water shifts from land to ocean, the increase in mass increases the strength of gravity over oceans by a small amount. From these gravity shifts, scientists estimate the amount of added water.

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