# Accelerating Sea Level Rise

*By John Benson*

*December 2020*

## 1. Introduction

I write frequently about climate change, as it is one of the most important issues of our time. Fossil-fueled electric generators are major greenhouse gas (GHG) producers and GHG is the primary cause of climate change. Thus it didn't surprise me, when I read my latest copy of Science a few weeks ago, I found that we have been seriously underestimating one of the major effects of climate change: sea-level rise. This effect has major impacts, especially for low-lying coastal areas.

I have written on the possible effects of sea-level rise and possible solutions for this in the following described and linked post from a bit over a year ago.

**Economics and Climate Change Refugees:** How will our economy will deal with repeated disasters that destroy infrastructure, where these disasters are mainly forced by climate change and are steadily getting worse? I believe these will eventually require one of two types of response. One is to increase the resilience of these areas (if such is economically viable) to withstand these forces for a reasonable amount of time, and the other is to retreat from the areas ravaged by these forces.

The primary "forces" I focused on in this paper are coastal storms (hurricanes and other strong and persistent storms), inland flooding, and wildfires. In the paper linked below we looked at the title economics, and a government program designed to be the ultimate solution (should all else fail), but instead has turned into the worst disaster of all.

https://energycentral.com/c/ec/economics-and-climate-change-refugees

This post is about improved techniques for measuring the average sea-level, the accelerating rise these are showing, and the probable main driver of the speed-up.

## 2. New Science

The following text is from the source referenced here. [1]

*Ask climate scientists how fast the world's oceans are creeping upward, and many will say 3.2 millimeters per year—a figure enshrined in the last Intergovernmental Panel on Climate Change report, from 2014. But the number, based on satellite measurements taken since the early 1990s, is a long-term average. In fact, the global rate varied so much over that period that it was hard to say whether it was holding steady or accelerating.*

*It was accelerating, big time. Faster melting of Greenland's ice has pushed the rate to 4.8 millimeters per year, according to a 10-year average compiled for Science by Benjamin Hamlington, an ocean scientist at NASA's Jet Propulsion Laboratory (JPL) and head of the agency's sea level change team. "The [Greenland] mass loss has clearly kicked into higher gear," agrees Felix Landerer, a JPL sea level scientist. With the help of new data, new models of vertical land motion, and—this month—a new radar satellite,*

[1] Paul Voosen, Science, "Seas are rising faster than ever", Nov 20, 2020, https://www.sciencemag.org/news/2020/11/seas-are-rising-faster-ever

*oceanographers are sharpening their picture of how fast, and where, the seas are gobbling up the land.*

*Hamlington and colleagues first reported signs of the speedup in 2018 in the Proceedings of the National Academy of Sciences. Since then, they and others have become more confident about the trends. In a 2019 study in Nature Climate Change, a group led by Sönke Dangendorf, a physical oceanographer at Old Dominion University, used tide gauge readings that predate satellite records to show seas have risen 20 centimeters since 1900. The team's data show that, after a period of global dam building in the 1950s that held back surface water and slowed sea level rise, it began to accelerate in the late 1960s—not the late 1980s, as many climate scientists assumed, Dangendorf says. "That was surprising," because the main drivers of sea level rise—the thermal expansion of ocean water from global warming, together with melting glaciers and ice sheets—were thought to have kicked in later.*

**Note from author:** 4.3 mm per year is a bit less than 2 inches per decade

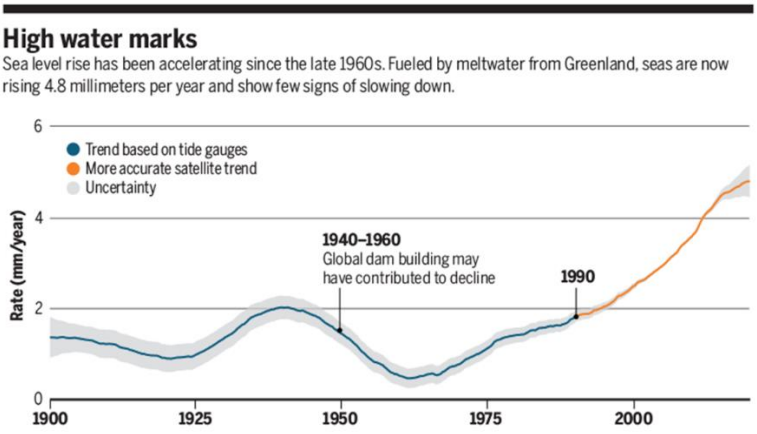
From this site,[2] *when Sentinel-6 Michael Freilich was encapsulated in the payload fairing of a SpaceX Falcon 9 rocket, it was the last time human eyes would have a close-up look at the satellite. But now that the spacecraft is in orbit after launching from Vandenberg Air Force Base in central California on Nov. 21, NASA's Eyes on the Earth is keeping track.*

*The Sentinel-6 Michael Freilich satellite—developed jointly by NASA, the European Space Agency (ESA) in the context of the European Copernicus program led by the European Commission, EUMETSAT, and NOAA, (with funding support from the European Commission and contributions from CNES)...*

*The satellite will use electromagnetic signals bouncing off the ocean's surface to make some of the most accurate measurements of sea levels to date. It will be followed by a second satellite in 2025, and together they will constitute a nearly 30-year record of changing sea levels, informing scientists, decision-makers, and NASA's facilities managers alike.*

# 3. Long-Term Trends

The chart below, from reference 1 shows the long-term trend of the ocean-level rise.




Credits: (graphic) Sönke Dangendorf adapted by n. Desai/science; (data) Dangendorf et al., Nature Climate Change, 9, 705 (2019); Iegeais et al., earth system science data, 10, 281 (2018)

[2] NASA, "Sentinel-6 Michael Freilich", https://www.nasa.gov/sentinel-6

The following is also from reference 1.

*The coasts are where sea level rise hits home—and where large local variations can mask the global average. In work published last month in Scientific Data, Anny Cazenave, an ocean geophysicist at the International Space Science Institute, and colleagues reanalyzed the satellite record and showed sea level rise at 20% of the coastal sites they surveyed across Europe, Asia, and Africa was significantly different from that of the open ocean. "We have to explain that," she says.*

*Some of the variation reflects the vertical motion of the land itself, due to the slow bobbing of continental plates that "float" on a viscous mantle. Coastal ocean currents, freshwater from nearby rivers, and weather patterns can also inject variability by causing water to pile up or retreat from the continents, Cazenave says.*

*But Dangendorf believes currents in the open ocean drive much of this variable sloshing, routing rising water from the open ocean—where there is more water to warm and expand—to the coastlines. One reconstruction of Norwegian sea levels from 1960 to 2015, for example, showed shifting currents were the best explanation for mysterious, and frequent, 20-millimeter swings in height. Dangendorf is now tracing sea level rise in nine coastal regions to their ocean sources, and has found them to be typically 500 to 1000 kilometers away; much of the sea level rise in the northern half of the U.S. east coast, for example, comes from waters swept out of the Labrador Sea.*

*The trends are worrisome. Aimée Slangen, a climate scientist at the Royal Netherlands Institute for Sea Research, and colleagues are integrating recent projections from climate models to predict when sea levels will rise 25 centimeters* (10 inches) *above 2000 levels, a point when 100-year floods on some coastlines could be a near annual occurrence. In unpublished work, Slangen finds that the threshold will be reached sometime between 2040 and 2060. Efforts to slow climate change won't do much to postpone it given the inertia of ocean warming and ice melt, though they could forestall much greater increases later in the century. And that near-term certainty, though dire, is "quite good for decision-making," Slangen says.*

# 4. Greenland's ice sheet

The source referenced here[3] is an excellent summary of a recent paper that is referenced and linked therein.

*We've known for some time now that Greenland's ice sheet is melting at an alarming rate. Greenland lost more ice last year than in any year on record, and the melting has accelerated rapidly since the 1990s.*

*But in the context of Earth's 4.5 billion-plus year history, melting in any one year or even a few decades amounts to the blink of an eye. Whether the rapid disintegration we're seeing on Greenland today compares to anything that has happened in the past is a question on which the science is not completely clear.*

[3] Drew Kann, CNN, Greenland's ice sheet is melting as fast as at any time in the last 12,000 years, study shows, September 30, 2020, https://www.cnn.com/2020/09/30/weather/greenland-ice-sheet-melt-carbon-emissions-climate-change/index.html

*Now, a new study published in the journal Nature provides some answers, and it is not good news: The rate of melting we're seeing today already threatens to exceed anything Greenland has experienced in the last 12,000 years.*

*Over the last two decades, Greenland's ice sheet has melted at a rate of roughly 6,100 billion tons per century, a rate approached only during a warm period that occurred between 7,000 and 10,000 years ago.*

*"We know there's a lot of year-to-year variability, so what we were interested in doing is capturing the more meaningful trends over decades and maybe up to a century," said Jason Briner, a professor of geology at the University at Buffalo and the lead author of the study. "And when you do that, and think about the direction that Greenland is heading this century, it's pretty clear we're in quite anomalous times."*

*The big difference between now and then? The influence of human activity.*

*The melting seen today is driven primarily by greenhouse gas emissions, whereas the warming that occurred thousands of years ago was a result of natural climate variability, Briner said.*

*How much Greenland melts going forward is up to us.*

*Under a scenario where humans continue to raise concentrations of heat-trapping gases in the atmosphere, Greenland's ice loss could reach unprecedented levels, with more than 35,900 billion tons of ice potentially lost by the end of this century.*

*Right now, Briner says current melt rates track closely with this worst-case scenario.*

*However, if the world resolves to slash emissions enough so that global warming peaks around 2050, ice losses this century could be held to 8,800 billion tons -- still a massive amount, but only enough to raise sea levels by about an inch, compared to the roughly 4 additional inches we can expect under a high-emissions scenario…*

Note that Greenland is only one source of climate change driven sea level rise. About half the rise comes from thermal expansion as the oceans heat up. Over 90% of the heat caused by climate change ends up in the oceans. Other major sources include the Antarctic Ice Sheet, and the melting of glaciers on land that are not associated with either of the two major ice sheets.

Per the article referenced here,[4] *the most recent special report from the Intergovernmental Panel on Climate Change says we can expect the oceans to rise between 10 and 30 inches by 2100 with temperatures warming 1.5 °C. That's enough to seriously affect many of the cities along the U.S. East Coast. Another analysis based on NASA and European data skewed toward the higher end of that range, predicting a rise of 26 inches by the end of this century if the current trajectory continues.*

# 5. Realistic Monitoring

The new administration that was elected by the U.S. people as verified by the Electoral College today (as I'm writing this) has promised to put a high priority on responding to climate change. As any good general (or engineer) will tell you, the first step in any battle is to scout the battleground, which in this case is the earth, and its climate. From the

[4] Christina Nunez, National Geographic, "Sea level rise, explained", Feb 19, 2019, https://www.nationalgeographic.com/environment/global-warming/sea-level-rise/#close

above, you can see we have started to do this and started to understand the challenges, but much more work to be done.

The new administration understands this and will start to rebuild our scientific bodies, and give them direction as soon as it takes office. At least one house of U.S. Congress is on-board.

From the source referenced here,[5] *Rep. Nydia M. Velázquez (D-NY) has introduced a bill, entitled The National Sea Level Risk Analysis Act (H.R. 8750) to help coastal communities address present and future flooding risks and develop innovative and science-based solutions to combat the climate crisis.*

*The bill would direct the National Oceanic and Atmospheric Administration (NOAA) to collect and centralize data on flood risks across the nation. By identifying flood risks, the database, entitled the National Coastal Data Information System, would help coastal communities prepare for future natural disasters. Through a collection of maps, data on rising sea levels, and more, the system would help coastal cities and towns address the unique problems climate change poses to their area…*

From the bill: *(1) combine existing observations, modeling, predictions, products and services into an integrated framework for producing and maintaining authoritative and timely data, maps, and information services which quantify and communicate coastal flood risk to the States…*

[5] Congresswoman Nydia M. Velázquez, U.S. House of Representatives, NY Seventh District, Media Center, Press Release, "Velazquez Introduces Bill Establishing National Database to Combat Rising Sea Levels", Nov 19, 2020, https://velazquez.house.gov/media-center/press-releases/vel-zquez-introduces-bill-establishing-national-database-combat-rising?et_rid=17039174&et_cid=3580485