

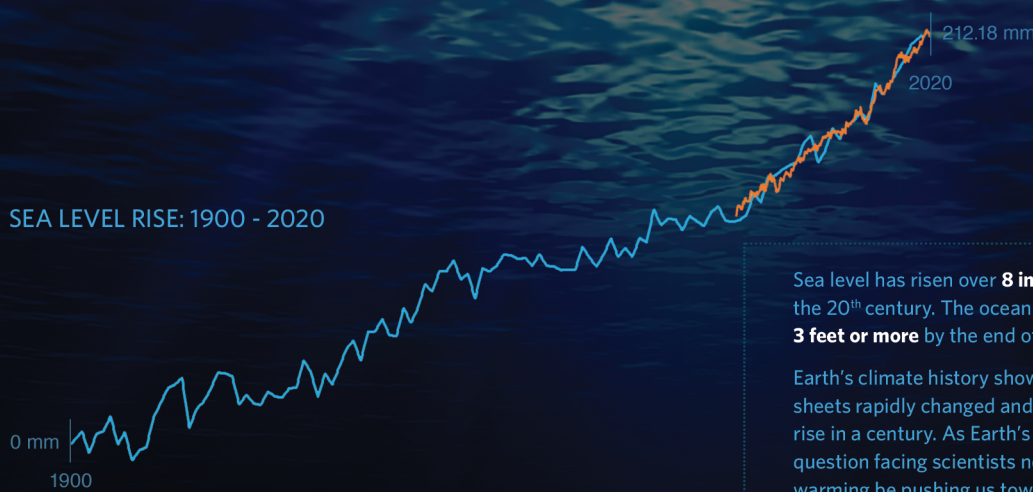
OUR RISING SEAS

Sea surface height change between 1992 and 2019, based on data collected from the TOPEX/Poseidon, Jason-1, -2 and -3 satellites. Orange/red regions are where sea level has risen up to 15 cm, and blue regions are where sea level has fallen up to 15 cm. Image Credit: NASA's Scientific Visualization Studio

AS OUR OCEAN WARMS, SEA LEVEL RISES

We know seas are rising and we know why. The urgent questions are by how much? and how quickly?

SEA LEVEL RISE: 1900 - 2020



Credits: Frederikse et al. (2020); GSFC/PO.DAAC

Sea level has risen over **8 inches** since the beginning of the 20th century. The ocean is projected to rise by as much as **3 feet or more** by the end of this century.

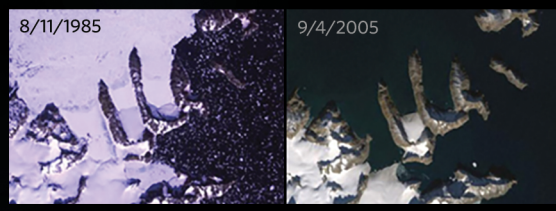
Earth's climate history shows there have been times when ice sheets rapidly changed and created multiple meters of sea level rise in a century. As Earth's ice sheets continue to change, a key question facing scientists now is: Could human-caused global warming be pushing us toward one of those times?

OUR OCEAN ABSORBS MORE THAN 90% OF THE HEAT TRAPPED BY HUMAN-PRODUCED GREENHOUSE GASES

This extra heat causes the sea level to rise. But why?



As water warms, its molecules move and interact more, causing the water to take up more space. If you've used a mercury thermometer, you've seen the same effect: **thermal expansion**, in action.



The extra heat causes the **melting of ice sheets and glaciers** on land. Greenland, in the Arctic, is warming about two times faster than the rest of the planet.

SEA LEVEL RISE AFFECTS US ALL

More than **160 million people** live along coasts in the U.S., about half the nation's population. **Eleven of the world's 15 largest cities** lie along shores, including New York City. Sea level rise means the ocean will gradually inundate low-lying areas, and storms like hurricanes, bolstered by even higher seas, will extend their reach inland. All of society bears the burden for storm damage and those costs are expected to rise: Annual losses from flooding in the world's biggest coastal cities could rise from about **\$6 billion a year** today to **\$1 trillion a year** by 2050.



HOW MUCH ICE ARE WE LOSING NOW?



559 GIGATONS OF ICE LOST FROM THE GREENLAND ICE SHEET IN 2019

How much water did that add to our ocean? An Olympic-sized swimming pool is 25 meters wide, 2 meters deep and 50 meters long. To hold 559 gigatons, that pool would have to be almost **11.2 billion meters** long and would stretch **29 times the distance from Earth to the Moon**. If Michael Phelps could maintain his 400-meter world-record pace, it would take him over 216 years to swim one length of this fictional pool. The Greenland Ice Sheet holds enough ice to raise seas by **20 feet**.

242 GIGATONS OF ICE LOST FROM ANTARCTICA IN 2019

The Antarctic Ice Sheet covers about **5.4 million square miles**, an area larger than the United States and India combined. The Antarctic Ice Sheet holds enough ice to raise seas by **190 feet**. The West Antarctic Ice Sheet is the single largest threat to rapid sea level rise. In 2014, two studies found that the loss of the region's glaciers is underway, but are uncertain of how long it will take.



MEANWHILE, IN ALASKA ...

In 2019, Alaskan glaciers lost an impressive **113 gigatons** of ice. The average ice loss from 2004 to 2020 is **79 billion metric tons per year** — enough to cover the state of Alaska with a foot of water every seven years.

THE LATEST

Scientists estimate that Greenland lost **280 gigatons** of ice per year, on average, between April 2002 and March 2020. Antarctica lost **147 gigatons** of ice per year, on average, during the same time period.

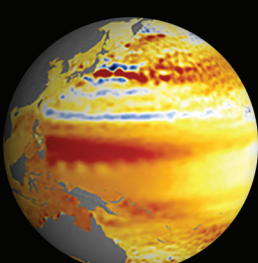
AS SEAS RISE, NASA DEEPENS OUR UNDERSTANDING

From space to the ocean floor, NASA missions provide data for scientists around the world

800 MILES ABOVE EARTH

A PRECISE GLOBAL VIEW

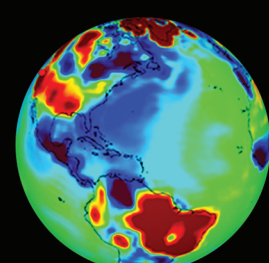
Since 1992, NASA, NOAA and European partners have been tracking ocean surface height from more than 800 miles (1,336 kilometers) above. The **Sentinel-6 Michael Freilich** satellite launching in 2020 will follow **TOPEX/Poseidon, Jason-1, -2 and -3**, and extend their body of research. Its radar altimeters measure the precise distance between the satellite and the ocean by bouncing a microwave signal to the sea and timing the round-trip travel.



300 MILES ABOVE EARTH

IDENTIFYING CHANGES AND CAUSES

Since 2002, the twin satellites of the **GRACE** missions have mapped **Earth's gravitational field** every 30 days. Gravity is determined by mass. While most of Earth's mass — its land areas and interior — doesn't move much in 30 days, its water and ice do, causing Earth's gravity to shift. By tracking these changes in gravity, the original **GRACE** and the current **GRACE Follow-On** satellites effectively weigh how much ice sheets and glaciers are shrinking, and how much ocean mass and sea level are



INCREASING OUR FOCUS

ICESat-2, and future satellites such as **NISAR**, will increase our understanding of Earth's ice and how it's changing. NASA also sends researchers into the field via research aircraft, snow machines, helicopters and boats, such as during the recent **Oceans Melting Greenland** and **Operation IceBridge** missions. Follow along at nasa.gov/earth.

NASA uses the vantage point of space to increase our understanding of Earth, improve lives and safeguard our future. The agency freely shares data and works with institutions around the world to gain new insights into how our planet is changing.