Future Sea Level

A break with the past

In the late 1990s, a dramatic event surprised and disturbed glaciologists around the world, increasing concern that global warming could cause Earth's great ice sheets at the north and south poles to disintegrate rapidly and catastrophically. A frozen stream of ice in the Jakobshavn Glacier on Greenland's west coast suddenly accelerated seaward. Already one of the world's fastest moving glaciers, Jakobshavn doubled its speed.

Mountainous blocks of ice broke off Greenland's perimeter at a furious rate, clogging a 35-mile long fjord with icebergs bigger than aircraft carriers. Fortunately, Jakobshavn settled down several years later. But before it did, the glacier had expelled tens of billions of tons of ice into the Atlantic.

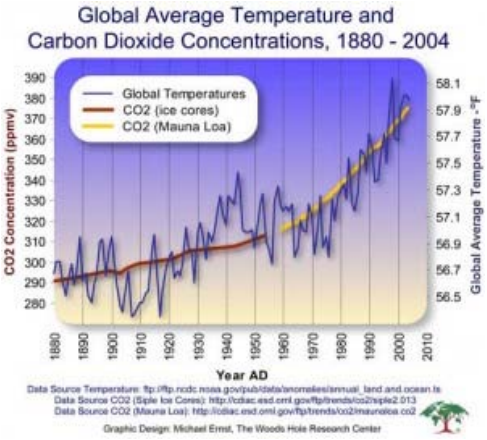
Jakobshavn glacier in 2013
Photo: Gretel Ehrlich

Scientists aren't sure why Jakobshavn sped up, or tapered off later. They haven't been able to calculate the top speed that an ice stream like Jakobshavn could achieve. Nor can they specify the limit of how much mass such streams of ice in Greenland or Antarctica could cast into the sea. They'd dearly like to know, as many researchers believe the accelerated flow of solid ice in ice streams could dramatically increase the rate of sea level rise. Until these questions are resolved, some researchers consider it possible that sea level rise later this century could be many feet.

Global warming basics

Earth is getting hotter. The planet has heated up by around 1.5 degrees Fahrenheit (0.8 degree Celsius) since the 1880s. When the oceans heat up, their water expands and creeps up shorelines. Higher temperatures also threaten mountain glaciers and the huge ice sheets at Earth's north and south poles. Since extra heat also cranks up evaporation and precipitation, sometimes in the form of snow that compensates for melting, higher temperatures don't necessarily always make glaciers shrink.

In practice, though, scientists have discovered that all the world's major glaciated mountain ranges including the Andes, the Himalayas, the Swiss Alps and the mountains of Alaska are losing ice. The continental-size ice sheets of the poles are shedding massive amounts of mass into the sea. As a result, sea level has gone up by about 4.5 inches (11 centimeters) since 1950. The rate at which sea level is increasing appears to be going up, though researchers can't be sure until more time has passed.



About 40 percent of the world's inhabitants work and farm and sleep within about 50 miles of a coastline. The sea laps the land of eight of the world's top ten cities. As the sea rises, many of these people are threatened with increased flooding, storm damage and salt intrusion into groundwater. Billions of dollars of property and millions of lives are at risk.

How fast and how high might sea level grow in the future? Government planners and residents of coastal regions are among the many people who could plan better if they knew the answer. Scientists have made estimates of future sea level. But their results are uncertain because the task is complicated by the numerous factors that influence sea level rise.

Earth's ice

Ice occurs naturally in various forms in many parts of the world. Each kind has its own particular relationship to global warming and sea level. When viewed from space, Earth's most obvious feature, after the oceans, is, a vast white wintertime band of snow covering northern Asia, Europe and North America. Global warming will reduce the amount of land covered in snow. But that melted snow will have virtually no impact on sea level. That's because the layer of snow is thin, and the volume of water in snow is dwarfed by the vastness of oceans.

The second most noticeable form of frozen water on Earth is sea ice. Sea ice, as the name suggests, is water frozen on the ocean's surface, generally near the poles. The amount of sea ice varies with the

100 YEARS RISING

Check out 100 Years Rising on Tumblr
Watch, hear and read stories of sea level rise from around the country. Post your own reactions.

RADIO FOR YOUR EYES

GRETEL'S NOTEBOOK

Read notebook selections.
Join science writer Gretel Ehrlich on her most recent trip to Greenland. She writes: "Twenty years after my first visit to Greenland, I returned...to contemplate the demise of ice."

Glacier Slideshow
Take a narrated tour of Gretel Ehrlich's aerial photos of glaciers.

Icebergs near Greenland
Photo: Gretel Ehrlich

seasons. At its maximum extent, such ice covers about 10 million square miles of water, an area about the size of ten Australias. The amount of sea ice in the Arctic has been declining steadily for at least as long as systematic satellite monitoring began in the late 1970s. Many researchers predict that the Arctic will be virtually free of sea ice in summers before the middle of this century; perhaps much sooner.

The disappearance of sea ice will not alter sea level. That's because sea ice floats, just like ice cubes in a drink. When a soda on the rocks warms up, the level of the surface remains fixed. (However, the loss of sea ice will have numerous other detrimental effects. Sea ice reflects sunlight back into space, whereas ocean water absorbs most sunlight that hits it. Less sea ice means a warmer Arctic. The temperature differential between the Arctic and equatorial regions, a major force behind Earth's weather patterns, will be muted.

Iceberg Slideshow
Gretel Ehrlich narrates photos of her boat trip among the icebergs near Ilulissat, Greenland.

Moreover, sea ice performs important roles in polar ecosystems. Marine mammals such as some seals and polar bears depend on it as a platform for hunting and resting. Many of the marine plants that form the foundation for the polar food chain, known as phytoplankton, also depend on sea ice for part of their life cycle.)

Unlike sea ice, the huge ice sheets of Antarctica and Greenland rest on land (or, in some cases, the seafloor). Sea level does rise when they melt. The ice sheets occupy less area than sea ice or snow, but they're radically thicker (more than a mile, or about 1.6 kilometers, from top to bottom in places). All together, the polar ice sheets hold enough water to lift sea level by about 250 feet (76 meters). Mountain glaciers also raise sea level as they recede, which they're doing, at a spectacular rate. But mountain glaciers hold only a small fraction of the water stored in polar ice sheets: only enough to raise sea level by about 2 feet (0.6 meters).

Unlike ice cubes

Because polar ice sheets are so massive, the rate at which they might melt has received concerted scientific attention. Still, many questions remain. If ice sheets behaved like an ice cube dropped out of a freezer tray on a summer day, predicting how fast they'd waste away—and how fast sea level would rise—would be relatively easy.

Ice cubes melt from the outside inward. As the exterior dribbles off, inner ice appears in an orderly fashion, like layers peeled off an onion. To predict the fate of ice melting this way requires taking into account factors like air temperature and the movement of air currents. Scientists know how to perform such calculations for ice cubes as well as for ice sheets. Researchers have estimated, roughly, that if all the world's glaciers melted this way, sea level rise by about 15 inches (0.4 meters) by the end of the century. Sea level rise of this magnitude can't be ignored, but it's relatively small, and it would occur over many decades.

40 percent of the world's inhabitants work and farm and sleep within about 50 miles of a coast.

But, while behaving in part like ice cubes, ice sheets also waste away in a manner unlike any ice cube: from the inside out. Frozen ice streams convey an ice sheet's bulk from the interior to the perimeter at the sea, sometimes hundreds of miles away. At the edge of the ice sheet, great blocks shear off and fall into the water. An ice sheet flowing this way could lose volume much faster than one that suffers surface melting alone.

Alternate Approaches

There are two primary means of forecasting future sea level. In one, scientists create a mathematical model of sea level that takes into account how much water will expand and how much glaciers will grow or shrink. This method requires a detailed understanding of factors like how heat penetrates into the ocean's depths, how changes in air temperature influences precipitation and, of course, the behavior of warming glaciers. Researchers have created such models. But they suffer from uncertainty about how Earth's complex parts work and relate to each other.

Blowing Rocks Preserve,
Florida

The other major way that scientists try to predict future ocean inundation is by studying sea level in Earth's past, when the planet was as warm or warmer than today. For the last two million years or so, Earth has cycled more than a dozen times between ice ages and warm periods. The last ice age ended about 12,000 years ago. Scientists think these temperature swings are controlled in part by changes in Earth's orbit around the sun. During an ice age, billions of tons of water freezes on mountaintops and at the poles. Sea level falls hundreds of feet. During a warm period, in contrast, this ice melts, ocean basins swell with the extra liquid, and the seas rise.

Climate researchers are especially interested in how high the sea rose during previous warm periods, prior to the most recent ice ages. Several such epochs have been hotter than today, making them possible analogs to our warmer future. The most recent warm period, about 100,000 years ago, was 2 to 4 degrees Fahrenheit (1 to 2 degrees Celsius) warmer than today. Many scientists believe that sea level was 15 to 20 feet higher then.

Choosing whether to act

Earth's temperature will rise sharply unless steps are taken to reduce significantly the amount of fossil fuel burned to make electricity, power vehicles and to heat homes. We'll have to make heroic efforts to prevent global temperature from reaching or surpassing that of the last warm period.

If Earth does get that hot, many scientists believe that sea level will rise to the level it reached during that earlier spell. They readily admit, however, that they can't predict how quickly the sea would go up.

They've uncovered evidence that within the past 20,000 years sea level has gone up at a rate as fast as 12 feet (4 meters) per century. However they can't say if global warming could cause sea level to rise that quickly in the future.

Dan Grossman is print journalist and radio and web producer. You can see more of his work on the extensive Sea Change website.

Sources

Tags

climate change ,rising-seas ,sea levels