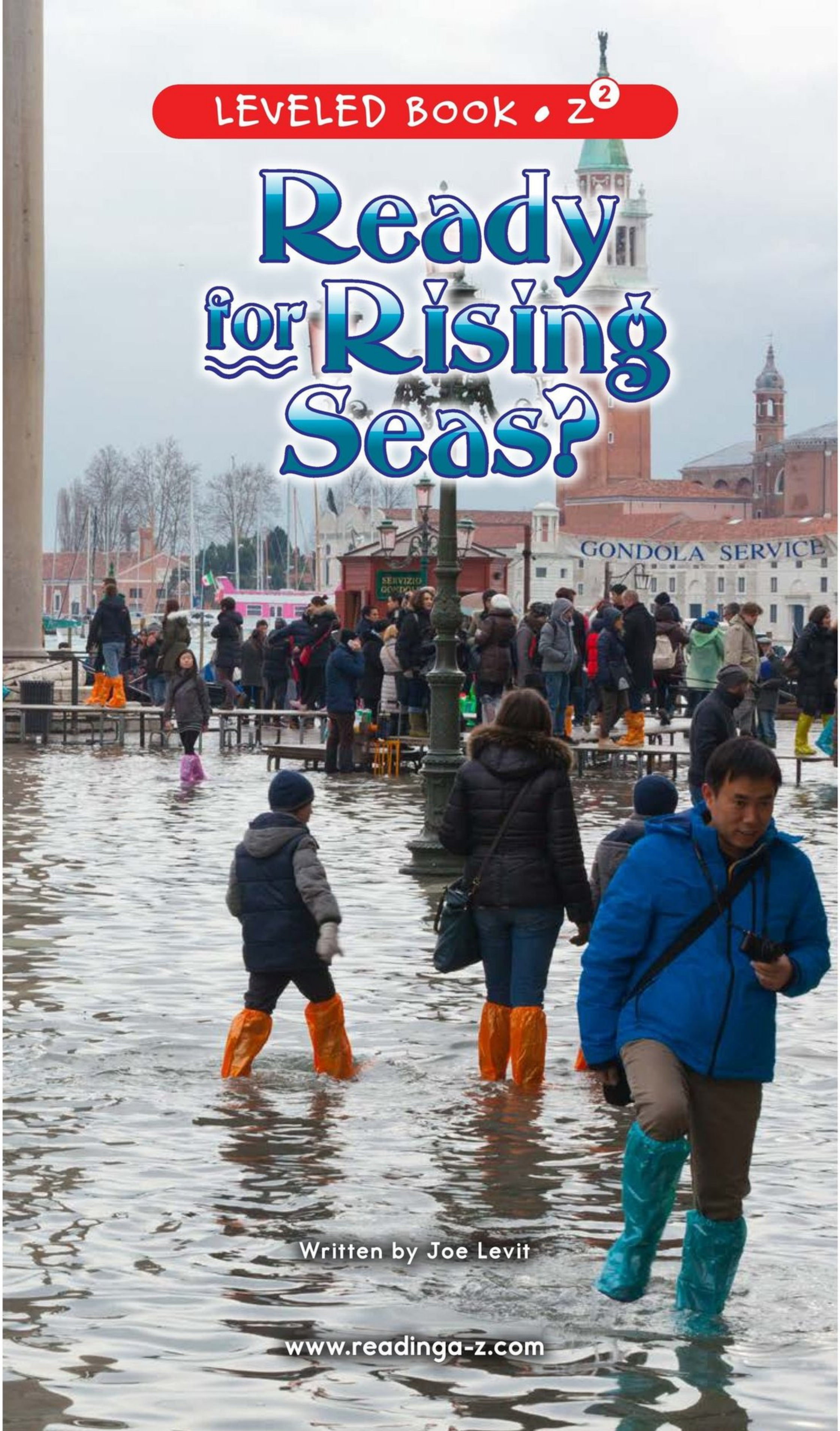
LEVELED BOOK • Z[2]

Ready for Rising Seas?



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Focus Question

What is the potential impact of rising sea levels on coastal towns?

Words to Know

atmosphere
carbon dioxide
catchments
curtailing
deforestation
displace
emissions
encroaching
evacuation
fluctuated
glaciers
Industrial Revolution
lagoon
last resort
legislation
levees
molecules
reefs
sea level
storm surge
strategies
susceptible
thermal expansion
wetlands

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Correlation

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Fountas & Pinnell	Y–Z
Reading Recovery	N/A
DRA	70+

Giant chunks of ice calve off the Perito Moreno Glacier in Argentina and fall into the Pacific Ocean.

Table of Contents

With 105 km (65 mi.) of canals, Amsterdam is used to water. Scientists predict that sea levels there will rise about one meter (3.3 ft.) in the next century.

The Encroaching Sea

Many people are drawn to the sea. It's one reason some of the world's biggest and best-loved cities are built on coasts—nice locations, until those seas begin to rise.

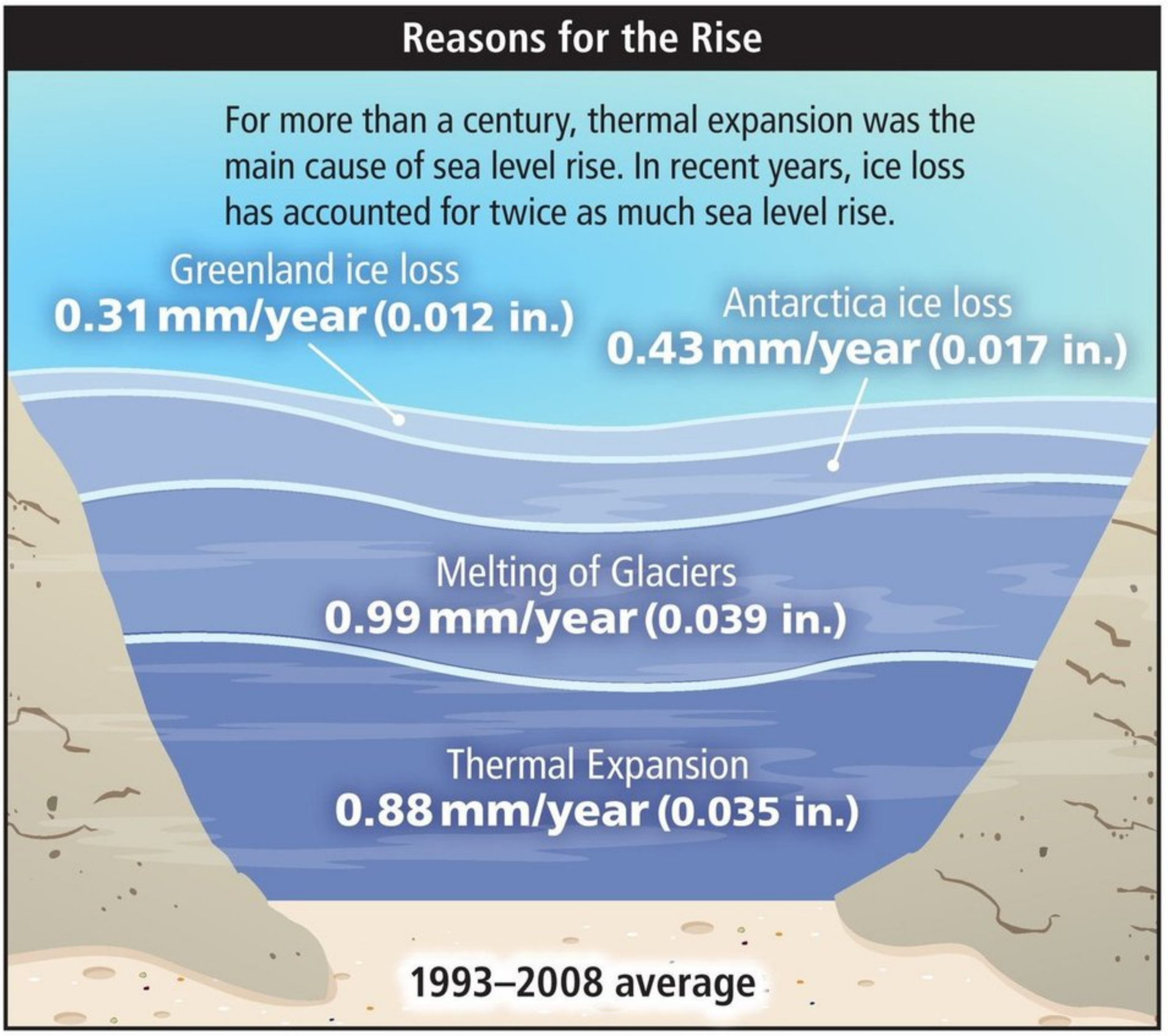
In the next hundred years, many coasts can expect a 0.6-meter (2 ft.) rise in **sea level**. For some places, that rise spells disaster; for places better prepared, it may not. So what can be done about the **encroaching** sea—and what should be done?

Why Sea Levels Are Rising

Sea level rise is not a new event. Ocean water around the world has been rising for more than one hundred years. But in the last several decades, the rate of the rise has increased. Scientists measure sea level rise by tracking tides and sifting through satellite data. Tide stations let us know what is happening at specific locations. Satellites measure the average height of the entire ocean. All these things allow us to gauge how sea levels are changing over time.

Two main factors have caused sea levels to rise. First, as the temperature of the oceans warms, the water itself expands—its water **molecules** increase in volume, and the water actually fills up more space. For many years, **thermal expansion** was the main cause of sea level rise. More recently, however, a new cause has taken the lead.

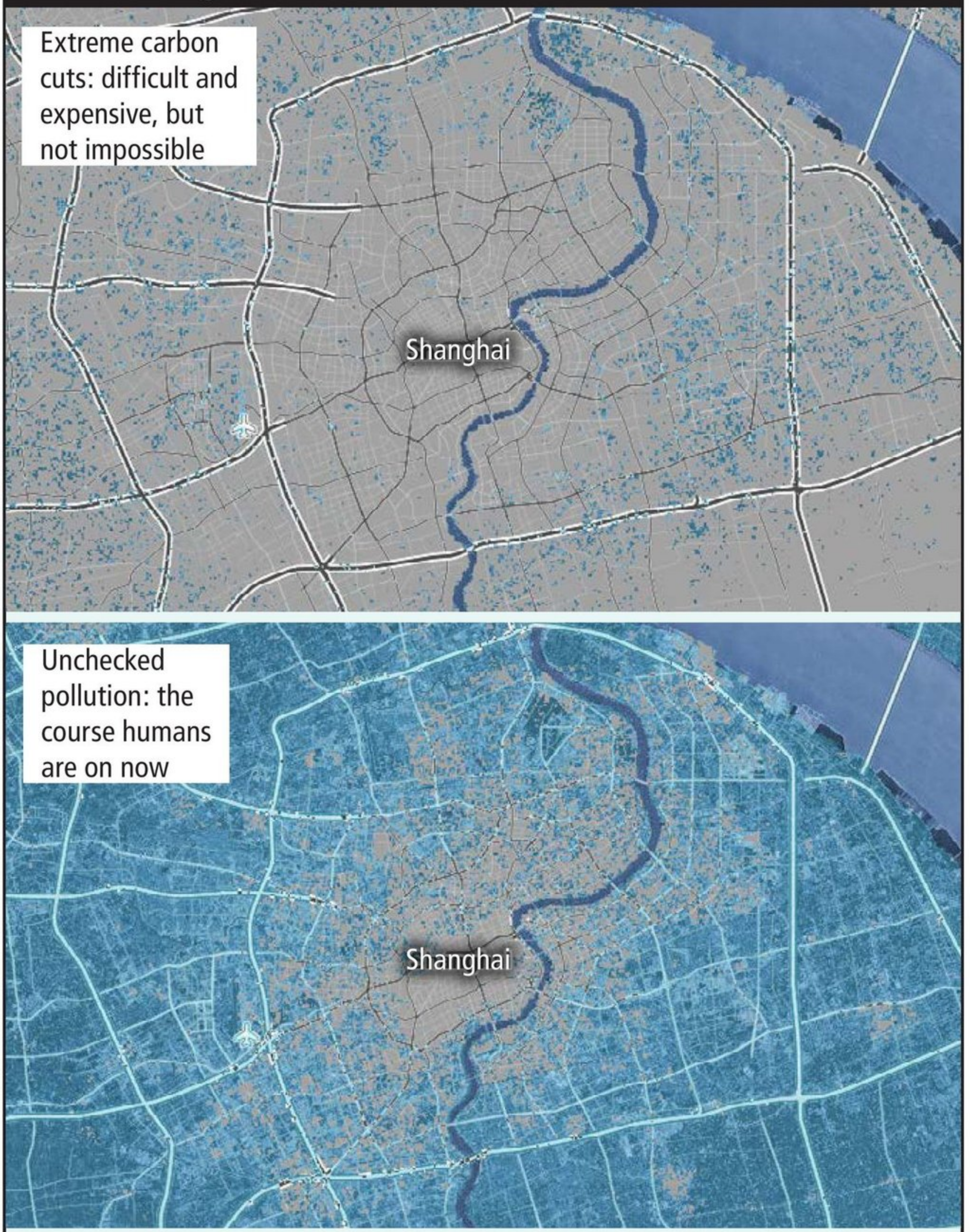
Melting of land-based ice is the second—now main—reason for the rapid rise in sea levels. This melting includes **glaciers** and the ice sheets that cover much of Greenland and nearly all of the land in Antarctica. Those two enormous ice sheets hold more than 99 percent of the freshwater ice on Earth. Since 2003, their melting has accounted for nearly 80 percent of sea level rise. Let's consider for a moment what would happen if they melted entirely.



If the entire Greenland ice sheet melted, scientists estimate that sea levels would rise about 6.7 meters (22 ft.). That alone would swamp many major cities around the world and **displace** huge populations of people. But if the same thing happened instead to all the ice in Antarctica, sea levels would rise by 61 meters (200 ft.)!

Neither of these events is going to happen overnight. The ice sheet on Greenland is nearly the size of Mexico, and the one on Antarctica is larger than the United States and Mexico combined. Still, even the current sea level rise is causing immediate problems worldwide.

Shanghai, China: Which Sea Level Will We Choose?

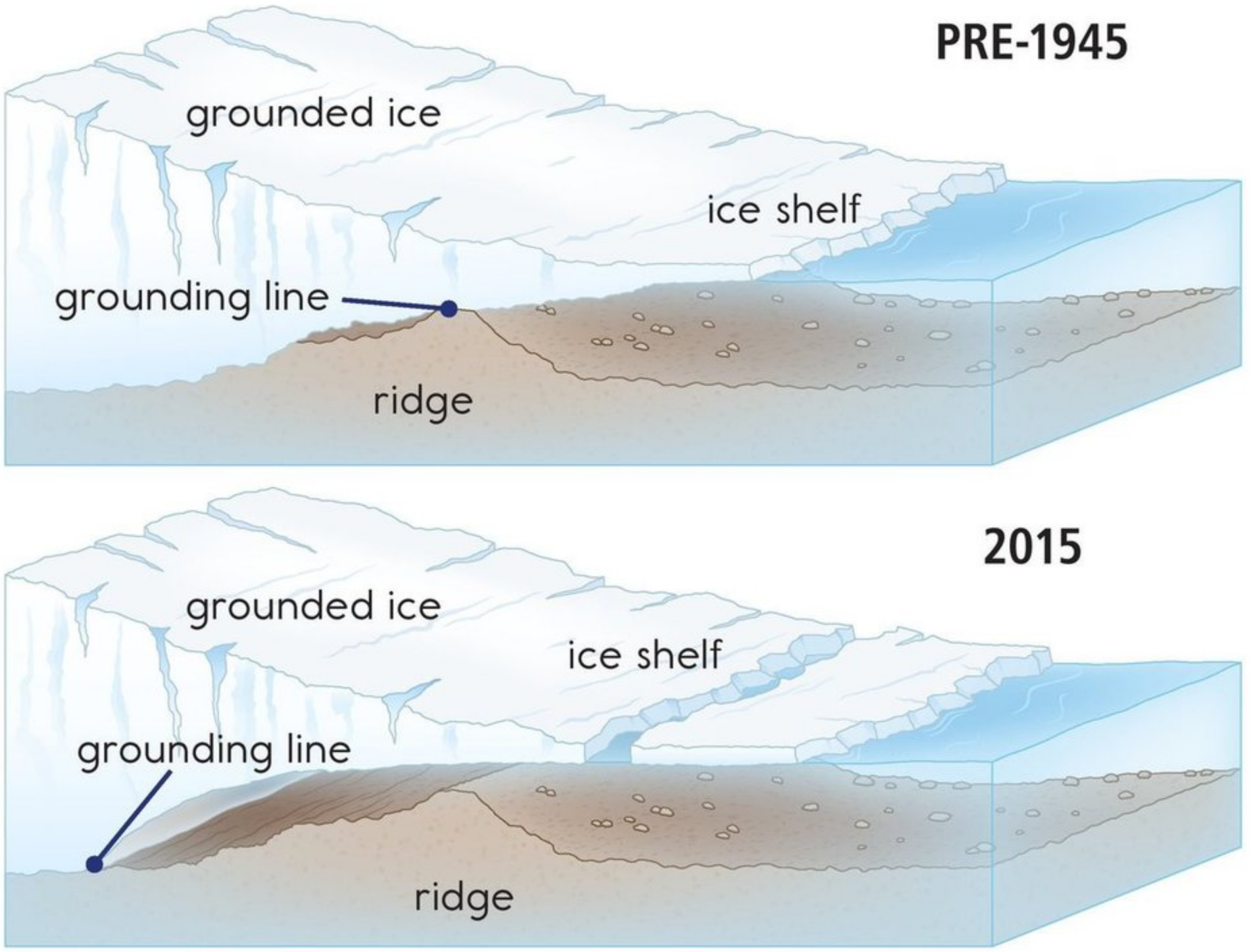


China is the world's leading carbon polluter. It also faces the greatest risks from coastal flooding, with 145 million people living in places threatened by rising seas—*if* emission levels stay the same.

These maps project two different futures. Which one we choose depends on how we choose to burn fossil fuels in the years to come.

Source: Climate Central

Pine Island Glacier Ice Shelf, West Antarctica



A sudden pulse of warm water in 1945 created a cavity behind the glacier's grounding line—the point at which it starts to float rather than be attached to land. Over the next 70 years, the grounding line of the glacier retreated roughly 48 kilometers (30 mi.). As a result, a huge 583-square-kilometer (225 sq. mi.) iceberg broke off the thinning glacier in 2015. Another ice sheet ten times that size snapped off West Antarctica in July 2017.

Our Part in the Problem

Sea levels have **fluctuated** naturally over the course of Earth's history—sometimes dramatically. However, the actions of humans now and over the last century are contributing to a faster rise in sea levels in a short period of time.

Beginning with the **Industrial Revolution** (1760–1840), thermal expansion was the main cause of sea level rise. Humans caused most of

this expansion by burning large amounts of coal and oil, and by cutting down huge swaths of tropical forests around the world. These activities increased the amount of **carbon dioxide** in our **atmosphere**. Carbon **emissions** and those from other gases became a kind of blanket around our planet, trapping heat inside.

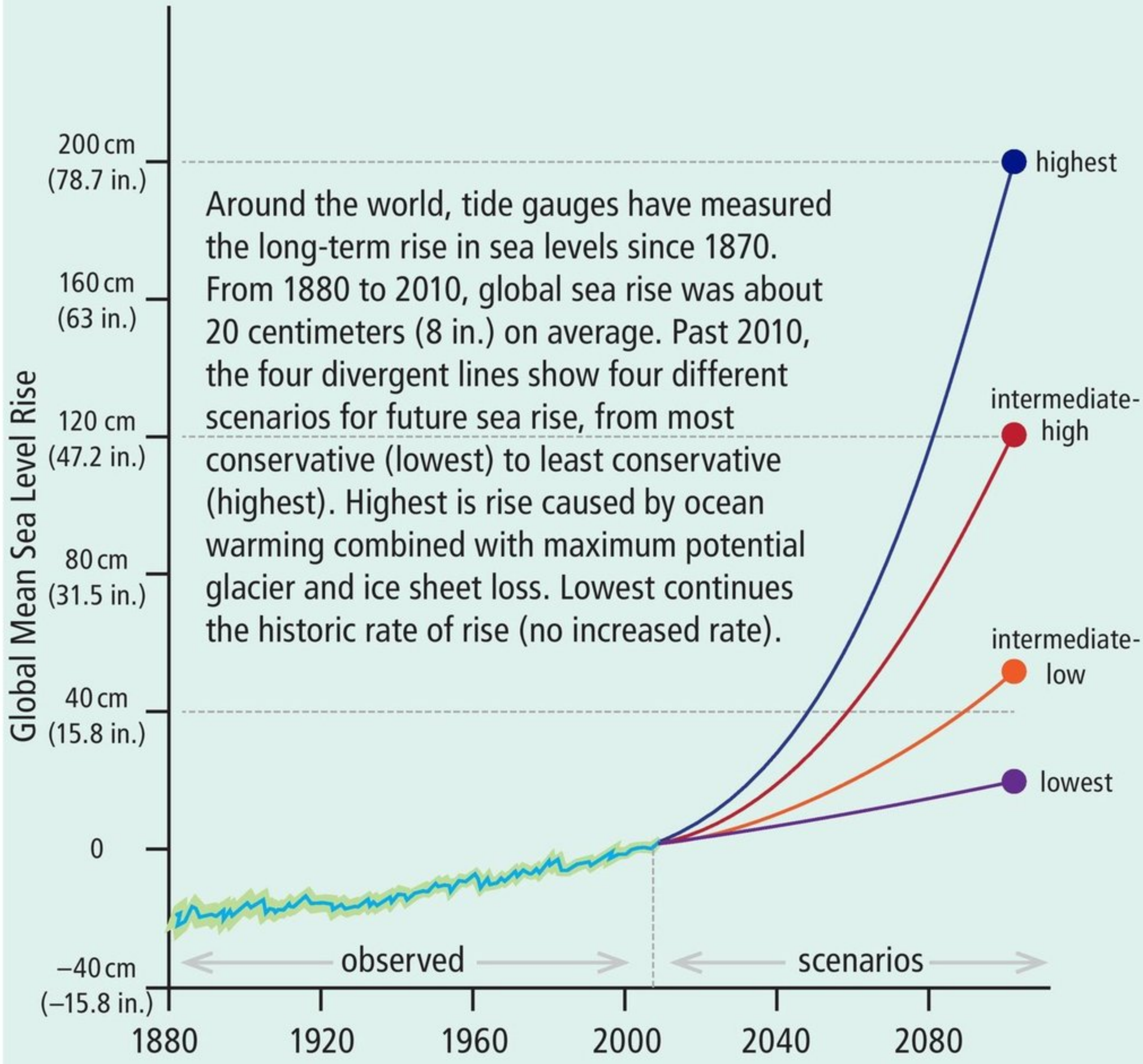
Once temperatures grew warm enough, subsurface waters washing against the West Antarctic Ice Sheet caused it to thin. This in turn has caused most of the glaciers in that part of Antarctica to melt and retreat. At this point in time, we wouldn't be able to halt some amount of future sea level rise even if we wanted to. If we stop all global gas emissions tomorrow, researchers project that sea levels will still rise 0.36–0.79 meters (1.2–2.6 ft.) by the year 2100. This will occur because the oceans and land ice will continue to adjust to the gases already in the atmosphere.

The Rising Horizon

Not every place on Earth is experiencing a rise in sea level. In Juneau, Alaska, for instance, the *land* has risen by as much as 3 meters (10 ft.) within the last two hundred years, and it may rise another 0.9 meters (3 ft.) by 2100.

The same gases that are melting ice worldwide are shrinking glaciers in Alaska. The land is *uplifting* as the weight of billions of tons of glacial ice melts away.

Sea Rise: Fact and Future



"Observed" portion reproduced by permission of CSIRO Australia, ©CSIRO* (See disclaimer on page 2); "scenarios" source: NOAA, 2016

Sea level rise will erode shorelines and put some places underwater permanently. Eight of the world's ten largest cities are situated near a coast, so there is no doubt that sea level rise will impact urban areas. Roads, bridges, subways, landfills, and sewage treatment plants will be at risk, along with schools, businesses, and homes.

Lifting a Lighthouse

On the Outer Banks of North Carolina stands the tallest lighthouse in the United States and the tallest brick building in the world when it was completed in 1870. At the time, it was placed 457 meters (1,500 ft.) from the ocean—a safe distance. Yet storm-driven tides and the rising sea eroded the sand on the ocean side of the cape over time. In fact, sea levels in the Outer Banks have been rising two to three times faster than the global average. By 1970, the lighthouse was only 37 meters (120 ft.) from the waterline.

Usually, a structure this large is considered an immovable object. But in 1999, the National Park Service shifted the lighthouse to a location 488 meters (1,600 ft.) away from the waves. Mounted on a heavy foundation of hydraulic jacks and steel beams, the lighthouse was moved down a metal runway at only 1.5 meters (5 ft.) per minute. The whole operation took twenty-three days, but it ensured that the lighthouse would be warning ships about the dangerous offshore Diamond Shoals for another hundred years.

Cape Hatteras Lighthouse survived a major earthquake, more than forty hurricanes, and a half-mile relocation, all without a crack.

When we think of sea level rise, it's easy to picture some people on coastlines being worried about water covering parts of their cities. However, even some places far from an ocean aren't safe from sea level rise, and even places that are currently safe from flooding may have to deal with drinking-water issues. After all, salt water can leak into groundwater sources.

Luckily, there are multiple **strategies** to help us tackle the issue of rising water itself. We can take measures to protect people and property now, and affect the pace that sea levels rise in the future.

Case Study #1: New Orleans, United States

New Orleans has always been **susceptible** to storms. The city, which is located near the Gulf of Mexico and between the Mississippi River and

In the aftermath of Hurricane Katrina, many New Orleans neighborhoods were underwater.

Lake Pontchartrain, has an average elevation of 0.6 meters (2 ft.) below sea level. A **storm surge** from Hurricane Katrina in 2005 caused multiple failures along **levees** built to keep out the sea, and 80 percent of the city flooded.

Since that catastrophe, the levees have been rebuilt and raised. Now they have gravel reinforcement and gates to control the flow of water, but city experts warn that these barriers can only do so much. As the sea level rises, each storm will be coming in on levels of water that are higher than they were when Hurricane Katrina hit. That's why city officials are looking for additional solutions.

Where it is possible, cities and countries try to use **wetlands** to absorb floods and slow down erosion. Wherever wetlands can be used or remade, they help populations deal with sea level rise. New Orleans is considering artificial wetlands to help retain floodwater. However, wetlands require a lot of space, and creating new ones takes a long time.

Many houses in New Orleans are built on stilts, but for the long term, floatable homes may be the answer. These homes would normally rest

IJburg, a suburb of Amsterdam, features at least seventy-five floating houses. They address not only the problem of rising sea levels but also housing shortages in dense urban areas.

on foundations, but in an enormous flood they could float up to 3.7 meters (12 ft.) while anchored to poles. The city is also creating better **evacuation** plans. During a disaster, the most important thing is to get people to safety in a hurry.

Case Study #2: Kushiro, Japan

When your entire nation is made up of islands, sea level rise takes on a different kind of importance. From 1970 to 2003, Kushiro, Japan, experienced the highest rate of sea level rise in the world. The water there rose more than 0.8 centimeters (0.33 in.) per year. That may not seem like much, yet the impact becomes enormous with time— more than 0.9 meters (3 ft.) in a hundred years. If what happened in Kushiro were to happen in other parts of Japan, more than 90 percent of Japan's sandy beaches would disappear, and thirty million people living within 9.7 kilometers (6 mi.) of the sea would be at risk.

Global vs. Local?

Strange as it may seem, the surface of the ocean is not flat—and sea levels around the world aren't changing at the same rate. Many factors influence sea level rise at any given location, from erosion to ocean currents to subsidence (the opposite of uplift, as described in The Rising Horizon on page 9). Satellite data give us the average height of the entire ocean. Tide stations give us local measurements.

The Arakawa River passes right through the heart of Tokyo. With a population of more than thirty-seven million, Tokyo is the world's largest city.

Yet that is not the only problem. A higher sea makes all major threats to coastal communities more likely. Typhoons, tsunamis, and normal storm surges would all come in atop higher water, causing significant property damage and loss of life. That's why cities like Tokyo are investing in immense levees to help protect their population.

When rivers flood in combination with sea level rise, disaster can occur. Along Tokyo's Arakawa River, officials are paying people to relocate for up to four years as they build a longer, taller levee. The angle of the levee is important, too. The new levees slope gently downward so that floodwaters will gradually flow onto and away from them rather than breaking them.

Case Study #3: Suva, Fiji

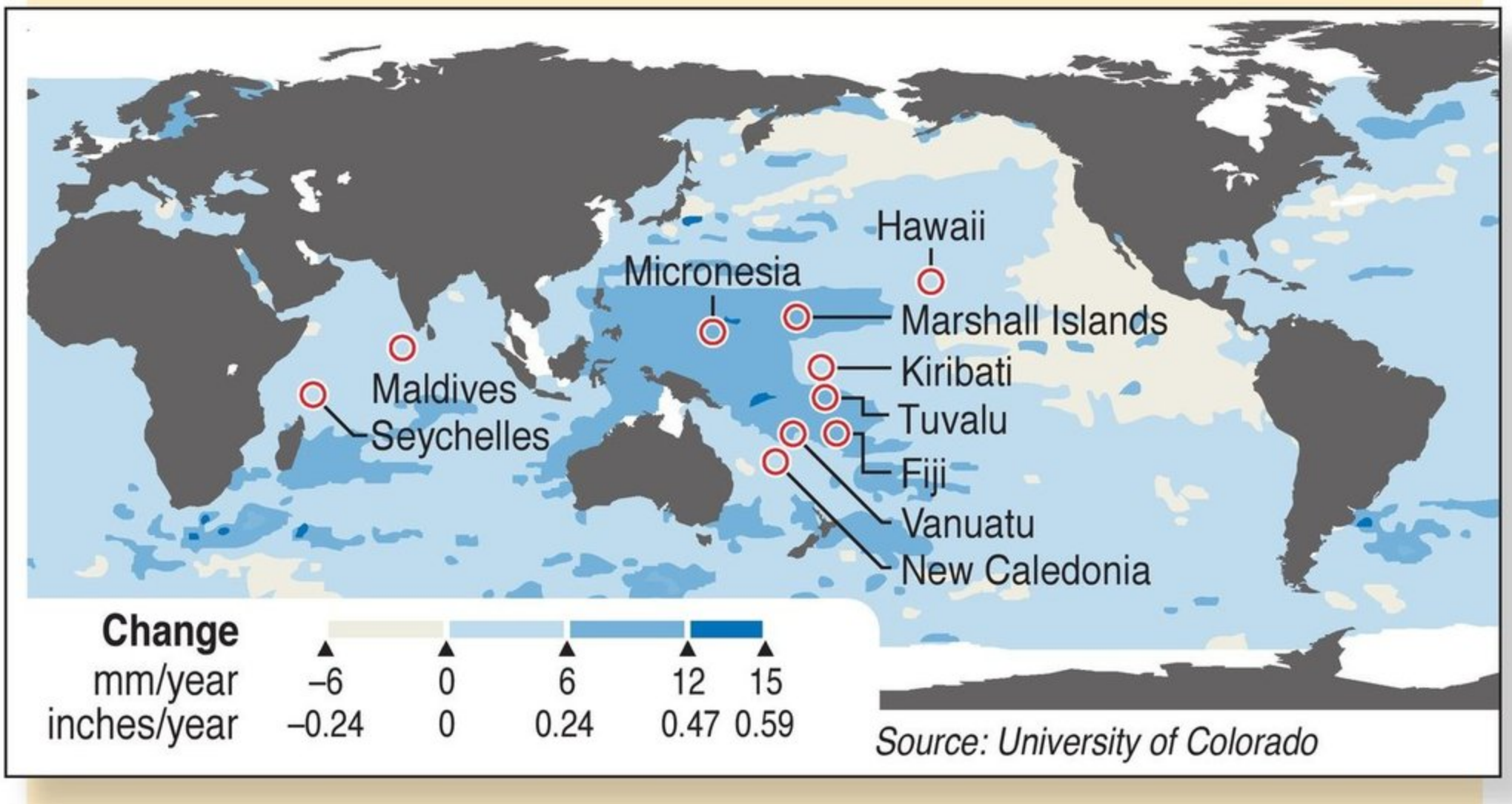
Fiji is a small island nation east of Australia in the South Pacific Ocean. Like many of the places most at risk worldwide, its coastal cities could see more than 0.6 meters (2 ft.) of sea level rise in the next century. That will be tough on tourism, upon which the country's economy depends.

Fiji deals with periodic higher levels of water when El Niño events occur, but people are also part of the problem. Too many people living near the ocean has exposed much of the coast to erosion. It has also caused the **deforestation** of **catchments**, which are habitats such as mangrove forests that naturally collect water within tidal zones and help drain it back out to sea.

A father and his children cross a flooded bridge in Fiji after a cyclone in 2009. Future projections show a decrease in the frequency of tropical cyclones but an increase in their intensity (stronger wind, more rainfall).

Island Alliance

Forty-three island states (some shown below) have urged big polluting countries to cut greenhouse emissions. Otherwise, rising sea levels threaten to wash them off the world map.



The capital city of Suva is looking at natural remedies to help it survive future storms. Officials there are beefing up laws and public awareness to protect mangrove forests and coral **reefs**. They are also looking to plant new mangrove forests and use artificial reefs to help strengthen coastlines.

Even with these changes, the sea will advance where people don't want it to, so the government is encouraging people to settle away from coastal areas and is planning for the possibility that some small, rural coastal areas may simply have to be evacuated. This strategy, called *managed retreat*, is usually a **last resort**. Yet in time, moving people may be the only option for many areas, not just Fiji.

In these instances, abandoning, moving, or demolishing buildings before a severe storm hits or the sea level reaches a dangerous height can keep people safe. However, managed retreat can be very expensive in areas that are heavily developed, and there are often difficult legal battles for property rights.

Case Study #4: Venice, Italy

Venice was built on a group of 117 islands in the middle of a **lagoon** on the edge of the Adriatic Sea. The engineers who constructed the city knew they had to create structures that could handle high tides. They accomplished this by setting buildings atop platforms of submerged wood, with a type of rock on top that does not let water through. Though this has worked for centuries, there are still times when especially high tides flood the city, and with sea levels on the rise, these events are becoming more common.

These extreme tides, called *acqua alta,* happen when a few natural forces combine: a very high tide during a full or new moon, low atmospheric pressure (which causes water to flow to the area), and a north-blowing wind, called a *scirocco*. This wind pushes water up the Adriatic Sea into the lagoon. When a strong acqua alta occurs, city squares and businesses end up soaked.

During a 2010 Venice *acqua alta*, tourists used planks to get around. Locals went swimming in the city's famous St. Mark's Square!

To combat this, the city has been working to install seventy-eight mobile floodgates into the lagoon. These gates rest on heavy concrete foundations. When a high tide is looming, authorities will be able to raise the floodgates and seal off the lagoon from the sea. The gates will then protect the city against tides almost 3 meters (10 ft.) high. They are expected to handle sea level concerns over the next century.

These mobile gates will help protect Venice from floods and rising sea levels . . . at least for a time.

Conclusion

Most research looks at the impacts of global warming by 2100. Yet one of the biggest impacts for humans will be long-term sea level rise. It will last twice as long as human history—but today's humans can help change the course of history.

Scientists have determined that the most effective way we can combat sea level rise is by **curtailing** our emission of gases that warm the atmosphere, in particular the main culprit: carbon dioxide. This is easier said than done. The growing world population consumes energy at an ever-increasing rate. And when governments fail to pass **legislation** that would reduce emissions, it makes this goal even harder to accomplish.

Antarctica's Future = Our Future

No further emissions

Leave 95% underground

Leave half in ground

Burn it all

To burn or not to burn? That is the question. Depending on how much carbon humans bring out of the ground (and burn) in the years to come, less Antarctic ice will melt—or more. While "no further emissions" is impossible at this point, if we only burn another 5 percent, we could keep the rise in global temperature under 2 degrees Celsius (3.6°F). Anything beyond that, experts say, is dangerous for humans and most other living things.

Meanwhile, to keep people and property safe in the future, both planners and ordinary citizens must prepare now. Some places have begun; others don't appear to have clear plans in place. As the seas rise on coastal people, those of us on higher, drier ground have to wonder: What can we do to help avert this crisis?

It's a compelling question. After all, there is a lot at stake.

Glossary

atmosphere *(n.)* a layer of gases surrounding a planet, star, or moon (p. 9)

carbon dioxide *(n.)* an invisible gas that is formed by the chemical breakdown or burning of organic substances, such as fossil fuels (p. 9)

catchments *(n.)* areas or objects that collect water (p. 17)

curtailing *(v.)* limiting, restricting, or reducing something (p. 21)

deforestation *(n.)* the clearing away of trees and other vegetation in an area (p. 17)

displace *(v.)* to take the place of someone or something; to force someone or something out (p. 6)

emissions *(n.)* things that are produced and given off as part of a process (p. 9)

encroaching *(adj.)* gradually intruding or going beyond normal or acceptable limits (p. 4)

evacuation *(n.)* the act or process of moving people out of danger (p. 15)

fluctuated *(v.)* changed; shifted back and forth or up and down (p. 8)

glaciers *(n.)* large bodies of accumulated ice and compacted snow that are found year-round and that slowly move downhill (p. 5)

Industrial Revolution *(n.)* a shift in manufacturing and transportation from human and animal power to machine power that started in the late eighteenth century (p. 8)

lagoon *(n.)* a shallow, calm body of water between a reef and the shoreline or in the center of an atoll (p. 19)

last resort *(n.)* a course of action available when all other options have failed (p. 18)

legislation *(n.)* a law or set of laws made by a government (p. 21)

levees *(n.)* ridges or raised areas that prevent a river from overflowing (p. 13)

molecules *(n.)* the smallest parts of a substance that can exist by themselves, made of one or more atoms (p. 5)

reefs *(n.)* ridges of coral, rock, or sand that lie very near the surface of the ocean (p. 18)

sea level *(n.)* the height of the ocean's surface, used as a standard in measuring the depth of other things (p. 4)

storm surge *(n.)* a quick rise in sea level, caused by the strong winds of a storm pushing water toward the shore (p. 13)

strategies *(n.)* careful plans for solving problems or achieving goals (p. 12)

susceptible *(adj.)* easily affected or influenced; vulnerable (p. 12)

thermal expansion *(n.)* the enlarging of a liquid's volume or a solid's dimensions due to an increase in temperature (p. 5)

wetlands *(n.)* areas of land that are marshy or swampy (p. 14)

Ready for Rising Seas?

A Reading A–Z Level Z2 Leveled Book
Word Count: 1,899

Connections

Writing and Art

Write and illustrate a cause-and-effect chain for rising sea levels.

Science

Research to learn about an animal that will be affected by rising sea levels. Write an essay explaining where the animal lives and how its population will be affected as sea levels rise.