CAUSES OF RISING SEA LEVELS

There are four main causes, two are global and two are local: Melting ice from land into the oceans, expansion of warm waters, slowing of the Gulf Stream, and sinking land all contribute to sea level rise.

Sea level is rising everywhere, but the amount and speed varies by location, even between the East and West Coasts. While the slowing of the Gulf Stream and sinking land affect only some areas, at varying rates, melting ice and thermal expansion (the warming of expanding waters) are considered global causes of sea level rise.

- MELTING ICE

How does melting ice affect coastal communities?

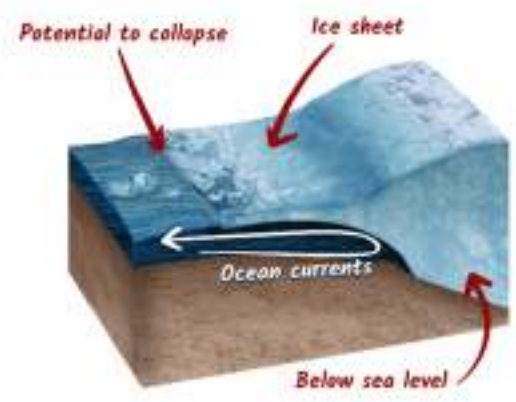
Every year, more than 1.7 trillion pounds of ice are melting from Antarctica, Greenland, and glaciated mountains.2 There are two types of glaciers: continental (ice sheets and ice caps) and alpine (glaciers found in mountains and valleys). When a glacier melts, sea levels rise everywhere, and ice from as far away as Antarctica can impact the coastlines of the United States.

Research shows that ice sheets in Antarctica and Greenland are now melting much more rapidly, and are the largest source of melted ice.

Although it can be difficult to measure ice melting, a new NASA satellite called ICESat-2 was launched in September 2018, and it is expected to help scientists gather enough information to assess future changes in the ice sheets in Greenland and Antarctica and to estimate their height annually

Antarctica contains 90% of the Earth's ice. A portion of this ice rests on land that is below sea level, which means it could be affected by ocean currents that may accelerate the melting of the ice. The ocean has already begun to break off pieces of ice, eroding them from below.

Show image of melting_ice_oceancurrents.png which is an schematic representation of how the melting ice affects ocean currents.



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- THERMAL EXPANSION

Thermal expansion is a scientific term used for expanding water and is responsible for approximately one-third of the global sea level rise. As the oceans become warmer each year, they expand further, and thus, sea level rises.

Think of it like a thermometer: the more it heats up, the more it expands and rises. A warming ocean behaves the same way, raising its level the more it heats up.

The oceans are now 1.2°F warmer than they were in 1950.
1.2 degrees may not sound like much, but for something as massive as the surface of the world's oceans, which warms very slowly, 1.2 degrees is significantly warmer and has caused more than 6 inches of sea level rise.

As the temperature of ocean waters rises, they expand, increasing sea level everywhere. Thermal expansion has intensified, causing sea level to rise 75% faster over the last 10 years compared to previous years.

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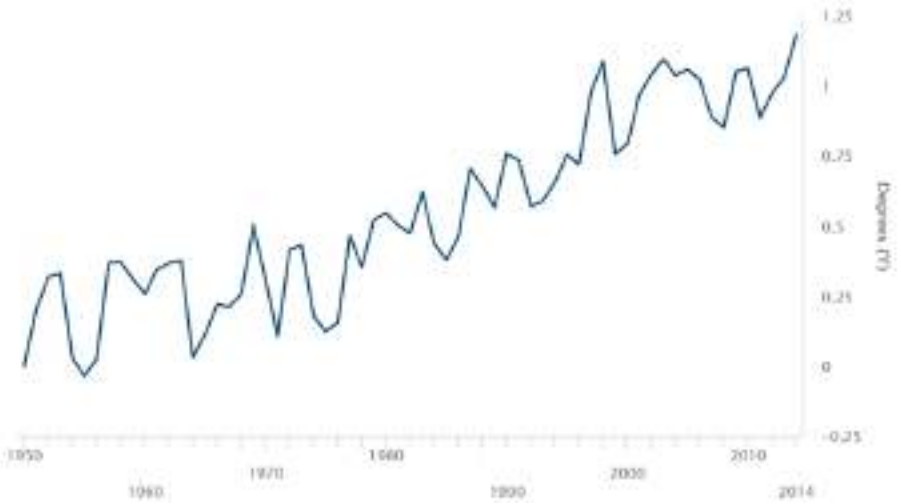

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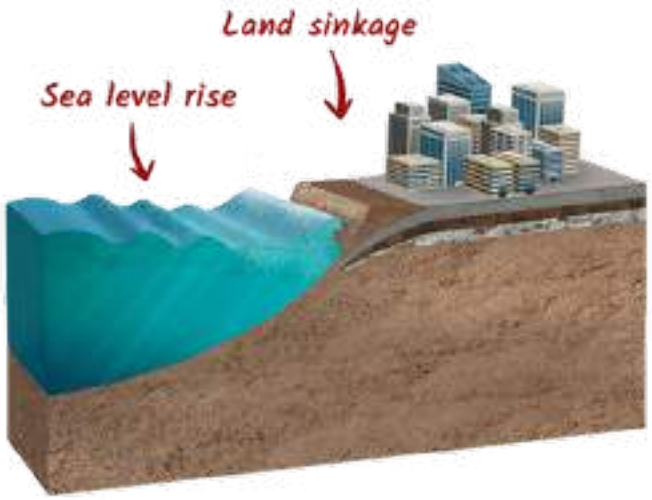
When they warm, deeper waters expand more than shallow waters because deeper waters are under greater pressure due to the water above them. This pressure compresses the water, allowing for a greater capacity to expand, which can further contribute to sea level

rise. Therefore, it is not only important how much the oceans warm, but also which areas of the oceans warm and expand.

Thermal expansion has caused sea level rise, equivalent to adding 142 million Olympic-sized swimming pools of water to the oceans each year.

- LAND SUBSIDENCE

Show image of land_subsidence.png which shows a schematic representation of the land shrinkage due to sea level rise



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Land subsidence is a small contributor to sea level rise, but in some areas, it is responsible for more than half of the sea level rise. Sea levels are measured in relation to the land, which means that when the land sinks to lower levels, sea levels appear higher.

Sea level rise is faster in some communities, such as Norfolk, Virginia, because the land on which these towns are located is sinking.

In California, the land is rising due to changes in the tectonic plates, so sea level is not rising as quickly as in other areas.

There are two main causes behind land subsidence.

Withdrawal of groundwater.

When people pump water out of the ground, voids are created where the water used to be, causing the land to sink to fill the empty space.

Tectonic plates

The tectonic plates under the earth can sink slightly as they slide under each other, causing the land to sink

- THE GULF STREAM

The Gulf Stream is part of a vast conveyor belt-like ocean system that moves water around the world's oceans. The amount of water circulating in the Gulf Stream is 150 times greater than that of the Amazon River and moves at an average speed of four miles per hour.

Due to the melting of glaciers, they add cold, freshwater to the water already circulating in the Gulf Stream, causing disruptions that cause certain water to 'pool' along the coast, which in turn leads to sea level rise in those areas.

Show image of gulf_stream.png which is an schematic representation of the gulf stream currents and its consequences on sea currents.

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CONSEQUENCES

Coastal Flooding: Coastal areas and cities are particularly affected. With rising sea levels, storm surges and storms can cause more severe and frequent flooding.

Coastal Erosion: Erosion of coastlines can result in the loss of land and coastal ecosystems, impacting both human infrastructure and natural habitats.

Salinization of Aquifers: Rising sea levels can lead to the intrusion of saltwater into freshwater aquifers, compromising drinking water supplies and affecting agriculture.

Loss of Habitats: Ecosystems such as mangroves, wetlands, and coral reefs are vulnerable to rising sea levels, which can lead to a decrease in biodiversity and affect species that depend on these habitats.

Displacement of Populations: Coastal communities, especially in developing countries, may be forced to relocate due to the loss of land and resources. This can generate humanitarian crises and land conflicts.

Economic Impact: Flooding and erosion can cause significant damage to infrastructure, resulting in economic losses. The tourism industry, particularly in coastal regions, may also be affected.

FUTURE PROJECTIONS

It is estimated that sea level could rise between 0.3 and 2 meters by the year 2100, depending on greenhouse gas emissions and the success of climate change mitigation policies. Coastal cities like Miami, New Orleans, New York, and many in Asia and Africa are at high risk and will need to adapt to this new landscape

MITIGATION AND ADAPTATION MEASURES

Construction of Resilient Infrastructure: Build levees, seawalls, and other infrastructure to protect coastal areas.

Adaptation Plans: Develop strategies that include the relocation of communities and the restoration of coastal ecosystems, such as mangroves and wetlands.

Emission Reduction: Implement policies to reduce greenhouse gas emissions, which can help mitigate global warming and its associated effects.

Education and Awareness: Inform communities about the risks of rising sea levels and how they can prepare for and adapt to these changes.

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MOST AFFECTED ÁREAS

1. Pacific Islands

- **Maldives**: This island nation faces a direct threat due to its low elevation, which could lead to the disappearance of many of its islands.
- **Tuvalu**: Similar to the Maldives, Tuvalu is at risk of massive flooding and could eventually become submerged.
- **Kiribati**: Many of its islands are only a few meters above sea level.

2. East Coast of the United States

- **Florida**: Cities like Miami and Tampa are experiencing frequent flooding and rising sea levels, affecting infrastructure and water quality.
- **New Orleans**: Known for its low elevation and vulnerability to hurricanes, it is particularly susceptible to flooding from sea level rise.

3. Africa

- **Nairobi, Kenya**: Coastal areas, like Mombasa, are vulnerable to coastal erosion and rising sea levels.
- **Egypt**: The Nile Delta is susceptible to flooding and salinization due to rising sea levels.

4. Asia

- **Bangladesh**: One of the nations most vulnerable to rising sea levels, where many people live in low-lying flood-prone areas.
- **India**: Coastal cities like Mumbai and Chennai face significant risks from rising sea levels and coastal erosion.
- **Vietnam**: The Mekong Delta is highly vulnerable, with many communities at risk of flooding.

5. Europe

- **Netherlands**: Although they have an advanced dike system, the country is very vulnerable due to its low elevation and the possibility of flooding.

- **United Kingdom**: Coastal cities like London and some regions on the east coast face risks from rising sea levels.

6. Arctic

- **Coastal regions of Alaska**: Indigenous communities that rely on sea ice are losing their homes due to erosion and rising sea levels.

MEASURES THAT CAN BE TAKEN

There are two types of measures that can be taken, mitigation measures that seek to address the causes of climate change that contribute to sea level rise and adaptation measures that seek to prepare and protect communities and ecosystems from the effects of sea level rise.

- MITIGATION MEASURES

Reduction of Greenhouse Gas Emissions:

- **Transition to Renewable Energies:** Promote the use of solar, wind, geothermal, and biomass energy to decrease dependence on fossil fuels.
- **Energy Efficiency:** Improve energy efficiency in buildings, industries, and transportation to reduce energy consumption.

Reforestation and Forest Conservation:

- **Protection of Natural Ecosystems:** Protect forests and other ecosystems that act as carbon sinks.
- **Reforestation Projects:** Initiate reforestation projects to absorb CO2 from the atmosphere.

Sustainable Agricultural Practices:

- **Regenerative Agriculture:** Implement practices that improve soil health and capture carbon, such as crop rotation and the use of cover crops.
- **Reduction of Fertilizer Use:** Decrease the application of nitrogen fertilizers that release nitrous oxide, a potent greenhouse gas.

Promotion of Sustainable Transportation:

- **Investments in Public Transport:** Improve and promote the use of public transport to reduce the use of private cars.
- **Active Mobility:** Encourage the use of bicycles and walking by creating appropriate infrastructure.

Development of Carbon Capture Technologies:

- **Carbon Capture and Storage (CCS):** Implement technologies that capture CO2 from industrial sources and store it to prevent it from reaching the atmosphere.

- ADAPTATION MEASURES

Resilient Infrastructure:

- **Construction of Levees and Barriers:** Build levees, walls, and other structures to protect coastlines from flooding and wave action.
- **Improved Drainage Systems:** Develop drainage systems to manage flooding and stormwater.

Restoration of Coastal Ecosystems:

- **Rehabilitation of Wetlands and Mangroves:** Protect and restore wetlands and mangroves, which act as natural barriers against flooding and are important for biodiversity.
- **Coral Reef Conservation:** Implement measures to protect and restore coral reefs, which also help protect coastlines.

Sustainable Urban Planning:

- **Zoning:** Limit development in high-risk areas and promote the relocation of infrastructure to safer zones.
- **Construction of Elevated Housing:** Encourage the construction of buildings in flood-prone areas at higher elevations.

Education and Public Awareness:

- **Education Programs:** Launch campaigns to educate the public about rising sea levels and how they can prepare.
- **Community Involvement:** Engage communities in the planning and implementation of adaptation measures.

Research and Monitoring:

- **Monitoring Sea Level Changes:** Utilize satellite technology and other tools to monitor sea level rise and its impacts.
- **Scientific Research:** Promote research on climate change and its effects, which can help inform effective policies and strategies.

Development of Early Warning Systems:

- **Flood Warning Systems:** Implement systems that can alert communities about imminent floods or storms.

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Short-Term Projections (2020-2040):

- Sea levels are expected to rise between 0.3 to 0.6 meters (30 to 60 cm) by 2040, depending on the region and emissions scenario.

Medium-Term Projections (2040-2060):

- By 2060, projections indicate a sea level rise of between 0.5 to 1.2 meters (50 to 120 cm).

Long-Term Projections (2100):

- According to IPCC (Intergovernmental Panel on Climate Change) reports, by 2100, sea levels could rise between 0.7 to 1.1 meters (70 to 110 cm) in the lowest emissions scenario and up to 2.0 meters (200 cm) in the highest emissions scenario, in the case of accelerated ice sheet melting in Greenland and Antarctica.

United States: Coastal cities like New York and Miami have started significant investments in resilience projects. New York has initiated the "East Side Coastal Resiliency" project, which includes building levees and sea walls. Miami has also invested heavily in raising roads and installing pumps to manage flooding caused by sea level rise.

Netherlands: The Netherlands, long known for its expertise in water management, has expanded its system of dikes and sea walls. It is also implementing "Room for the River," which allows certain areas to flood in a controlled way to relieve pressure from other regions. This approach is integrated with urban planning to ensure long-term resilience.

Tuvalu and Pacific Islands: Island nations like Tuvalu are at the frontline of rising sea levels and have engaged in coastal adaptation projects. Tuvalu has invested in raising land levels and developing flood-resistant infrastructure, supported by international funds like the Green Climate Fund. They are also considering long-term plans that include potential relocation if parts of the islands become uninhabitable by mid-century (Robert Bosch Stiftung)(UNDP).

Germany: Germany is a key player in global climate action and has taken a leadership role in addressing the needs of small island developing states. It has invested in adaptation efforts, including flood management systems, and advocates for international climate justice. Germany has also focused on legal frameworks to protect the sovereignty of nations that may lose land to rising seas(Robert Bosch Stiftung).

Bangladesh: With one of the most vulnerable coastlines in the world, Bangladesh has invested in mangrove restoration and flood management systems. It has also implemented large-scale community-based adaptation projects to protect its agricultural land from saltwater intrusion.

Curiosities

Global Sea Level Rise: Since 1880, global sea levels have risen by about 21–24 cm (8–9 inches), with about one-third of that rise happening in the last 25 years. The average annual rate of sea-level rise from 2006 to 2015 was about 3.6 mm per year, more than double the average annual rate for most of the 20th century.

Acceleration: Sea level rise is accelerating. According to NASA, the rate of increase is now 3.3 mm per year, compared to 1.4 mm per year from 1900 to 1990. This acceleration is driven primarily by melting ice sheets and glaciers, as well as the expansion of seawater as it warms (thermal expansion).

Projected Sea Level Rise by 2100: By the end of the century, sea levels could rise between 0.3 to 2 meters (1–6.5 feet), depending on future greenhouse gas emissions and ice sheet stability. The IPCC (Intergovernmental Panel on Climate Change) estimates a rise of around 0.6 to 1.1 meters (2–3.6 feet) by 2100 if high emissions continue.

Regional Variations: Sea-level rise is not uniform globally. Areas like the U.S. East Coast, Gulf Coast, and Southeast Asia are experiencing faster increases due to land subsidence and changes in ocean currents. In some places, sea levels are rising up to three times faster than the global average.

Impact on Populations: Approximately **680 million** people live in low-lying coastal zones, and many are vulnerable to rising seas. Cities like Miami, New York, Tokyo, and Mumbai are at significant risk. By 2100, coastal flooding could affect **hundreds of millions of people** globally.

Thermal Expansion: The warming of the oceans contributes significantly to sea-level rise. As ocean water warms, it expands, accounting for about **one-third** of the observed sea level rise in recent decades.

Glacial Melting: Greenland and Antarctic ice sheets are losing ice mass at an increasing rate. The Greenland Ice Sheet is currently losing around **279 gigatons** of ice per year, and the Antarctic Ice Sheet loses about **148 gigatons** annually.