

Today I Learned About Sea Level Rise, Part 2

Description:

Following up on the demonstrations in Today I Learned About Sea Level Rise, Part 1, Dive Deeper assignments lead students to explore data related to the impacts of thermal expansion, land ice melt, storm surge, and high-tide flooding. Teams of students each learn about these topics and bring their learning together in a jigsaw.

Skills & Objectives

SWBAT

- Understand that the burning of fossil fuels is causing a buildup of heat-trapping gases, which is warming the atmosphere and ocean.
- Explain that melting land ice adds to rising seas, while melting sea ice does not.
- Explain that warm water molecules expand, taking up more space.
- Discuss the impacts of sea level rise on the effects of storm surge.
- Explain the concept of high-tide or 'sunny day' flooding.
- Investigate solutions for sea level rise.

Skills

- Observation
- Interactive online models
- Graphing
- Communication

Students Should Already Know That

- In coastal areas, the tide rises and falls in daily, weekly, and monthly patterns.

Standards Alignment:

HS-ESS2-2: Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.

HS-ESS2-4: Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes.

CCSS.ELA-LITERACY.RI Informational Texts

CCSS.ELA-LITERACY.RST Science and Technical Subjects

CCSS.ELA-LITERACY.RH History/Social Studies

CCSS.ELA-LITERACY.SL Speaking & Listening

Disciplinary Core Ideas:

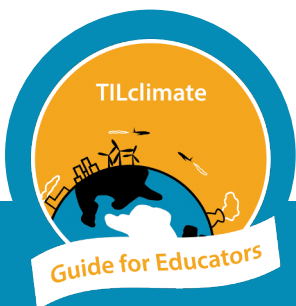
ESS2.A: Earth Materials and Systems

ESS2.D: Weather and Climate

ESS3.B: Natural Hazards

ESS3.C: Human Impacts on Earth Systems

ESS3.D: Global Climate Change



Today I Learned About Sea Level Rise, Part 2

How To Use These Activities

Pages with the circular “TILclimate Guide for Educators” logo are intended for educators. Simpler pages without the dark band across the top are meant for students.

Each of the included activities is designed to be used as a standalone, in sequence, or integrated within other curriculum needs. A detailed table of contents, on the next page, explains what students will do in each activity.

If students will be doing all four activities in sequence, they may skip the “A Warming Planet” paragraph at the top of each. Otherwise, the activities may be used in a jigsaw, with teams of students each doing just one. The “Each One, Teach One” instructions on page # can then be used to structure a conversation, with groups reshuffled so that each team has a representative from each investigation.

All activities in this set require internet access. They could also be assigned as homework or asynchronous remote work.

A Note About Printing

All student pages are designed to be printable in grayscale, except for the Ocean Heat Content map on page #. A few copies of this page could be printed color for students to share, or the image projected in the classroom.

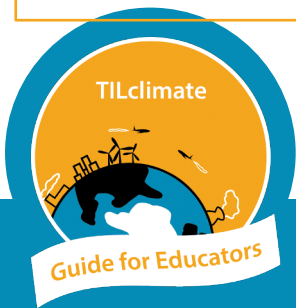
The worksheets do not leave space for students to answer questions. Students may answer these questions in whatever form is the norm for your classroom – a notebook, online form, or something else. This allows you, the teacher, to define what you consider a complete answer.

Engineering Solutions

Two versions of the Engineering Solutions page are provided. One for schools whose nearby city has a climate adaptation plan and one for those who do not. A simple internet search of “{Name of City} Climate Adaptation Plan” should provide a website or PDF document with your nearest city’s plan.

Podcasts in the Classroom: Throughout these Guides for Educators, we invite students to think about how they would share their learning with family and friends. Student-created podcasts are shareable, creative, and have multiple options for embedded assessment. We would love to hear any podcasts or see any other projects you or your students create! Email us at tilclimate@mit.edu, Tweet us @tilclimate, or tag us on Facebook @climateMIT.

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Today I Learned About Sea Level Rise, Part 2

Detailed Table of Contents

Page	Title	Description	Time (min)
	Podcast Episode	Students listen to TILclimate: TIL about sea level rise, part 2, either as pre-class work at home or in the classroom. https://climate.mit.edu/podcasts/til-about-sea-level-rise-part-2	10-15
1-3	Land Ice Melt (internet required)	Students read about the effect of land ice vs sea ice on sea level rise. Then they graph relative melt rates of Antarctic and Greenland ice sheets.	20-25
4-6	Thermal Expansion (internet required)	Students read about the effect of warming water on sea level rise. Using the NOAA Sea Level Rise Viewer, they compare flood predictions for various emissions scenarios.	20-25
7-8	Storm Surge (internet required)	Students read about the impact of sea level rise on storm surge. Using the NOAA Coastal Inundation Dashboard, they investigate the effects of historical flood levels and possible impacts of future storms.	20-25
9-10	High-Tide Flooding (internet required)	Students read about high-tide or nuisance flooding as a result of sea level rise. Using the NOAA Sea Level Rise Viewer, they analyze the frequency of flood days in a chosen coastal area.	20-25
11-12	Jigsaw Share (discussion)	If students did the activities in teams or as homework, reshuffle groups to include 'experts' on each topic. Students share their learning and discuss how to share what they learned with others. Then, they discuss and collect solutions to sea level rise.	20-25
13	Engineering Solutions (internet required)	Students investigate case studies of adaptation and mitigation for climate change from around the US. Two versions of this activity are supplied - see note on previous page.	20-25
14	Solutions (discussion)	Collected solutions are sorted into four categories, and then groups or individuals choose one solution to investigate further.	variable



Today I Learned About Sea Level Rise, Part 2

Land Ice Melt, Thermal Expansion, Storm Surge, High-Tide Flooding, and Solutions

This Educator Guide includes four internet-based investigations and a solutions-oriented wrap-up. Educators may pick and choose among the pieces of the Guide, as suits their class needs.

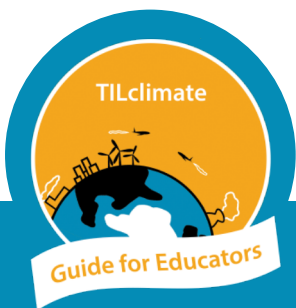
Parts of this Guide may align with the following topics:

- Physical science: Thermal effects on liquids, wave action.
- Life/environmental science: Ocean warming effects on oceanic habitats, sea level rise effects on coastal habitats, human coastal adaptation and change.
- History/social science: History of coastal development and building, governmental and non-governmental solutions to complex problems.
- ELA/literature: Fictional works set in a future with significantly higher sea levels.
- ELA/nonfiction: Understanding and communicating complex scientific topics.

MIT Resources

We recommend the following as resources for your own better understanding of climate change or as depth for student investigations. Specific sections are listed below:

- Climate Science, Risk & Solutions, an interactive introduction to the basics of climate change. <https://climateprimer.mit.edu/>
 - 02 The greenhouse effect and us
 - 06 Predicting climate
 - 08a Sea Level Rise
 - 10 What can we do?
- MIT Climate Portal Explainers are one-page articles describing a variety of climate topics. <https://climate.mit.edu/explainers>
 - Sea Level Rise
 - Coastal Ecosystems and Climate Change
 - Cities and Climate Change
 - Climate Models
 - Hurricanes



Today I Learned About Sea Level Rise, Part 2

Wrap-Up Discussion Questions

While all climate issues can be difficult to talk about, sea level rise is one of the more immediate effects of climate change and may be more traumatic for students. As you discuss sea level rise in the classroom, keep social-emotional learning in mind. For more on this, read “How to Use TILclimate Educator Guides.”

- Why is sea level changing?
- Why are so many major cities in coastal areas?
- Even if we stopped all carbon dioxide emissions tomorrow, cities around the world would still have to deal with some sea level rise. What are some adaptations to higher tides and storms that communities are using?
- We are all connected to the ocean, even if we do not live on the coast. What are some ways that your life is connected to the ocean every day? (oxygen from algae, shipping goods on ships, seafood to eat, etc.)

Climate Solutions

Climate solutions can be thought of as falling into four co-equal categories. Across all categories, a focus on community-level solutions leads to more effective action. Community-level solutions change decision-making so that the default option for individuals is the one that has the best result for the climate. For example, policies that increase the solar and wind mix in the electric grid, instead of asking homeowners to install solar panels. For more on talking about climate change in the classroom, see “How to Use TILclimate Educator Guides.”

•Energy Shift

How do decision-makers make the switch from carbon-producing energy to carbon-neutral and carbon-negative energy?

•Energy Efficiency

What products and technologies exist to increase energy efficiency, especially in heating and cooling buildings?

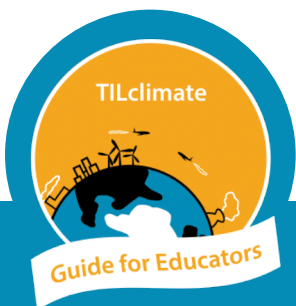
•Adaptation

How can we adapt buildings to keep people safe from heat and cold?

•Talk About It

Talking about climate change with friends and family can feel overwhelming. What is one thing you have learned that you could share to start a conversation?

What solutions are the most exciting in your classes? We would love to hear from you or your students! Images, video, or audio of student projects or questions are always welcome. Email us at tilclimate@mit.edu, Tweet us @tilclimate, or tag us on Facebook @climateMIT.



Today I Learned About Sea Level Rise: Land Ice Melt

“The other thing that's going on—has kind of taken over—and that's the melting of ice off of glaciers all around the world.. and from the big ice sheets in Greenland and the Antarctic.”

James Renwick, Victoria University of Wellington, New Zealand

TILclimate podcast: today I learned about sea level rise, part 1

A Warming Planet

When we burn fossil fuels like coal, oil, and natural gas, we release carbon dioxide (CO₂) into the atmosphere. Carbon dioxide and other gasses act like a blanket, trapping heat on Earth.

Ice Melts in the Heat

Our warming planet means that more ice is melting. We know that melting ice is adding to sea level rise, but which types of ice have the biggest impact?

Sea Ice vs Land Ice



When most of us think about ice and the ocean, we probably think about icebergs, or the sea ice that covers the arctic. That the ice that was already in the water in your model did not raise the overall water level when it melted. The iceberg has already had as much of an effect on the water around it as it was going to. Just like a person in a bathtub, an iceberg *displaces* the water around it, raising the sea level just a bit as it floats. When an iceberg melts, that same volume is added to the water, so the water level stays the same. For the same reason, if you fill a glass with ice cubes and water and let all the ice melt, your glass will not overflow.



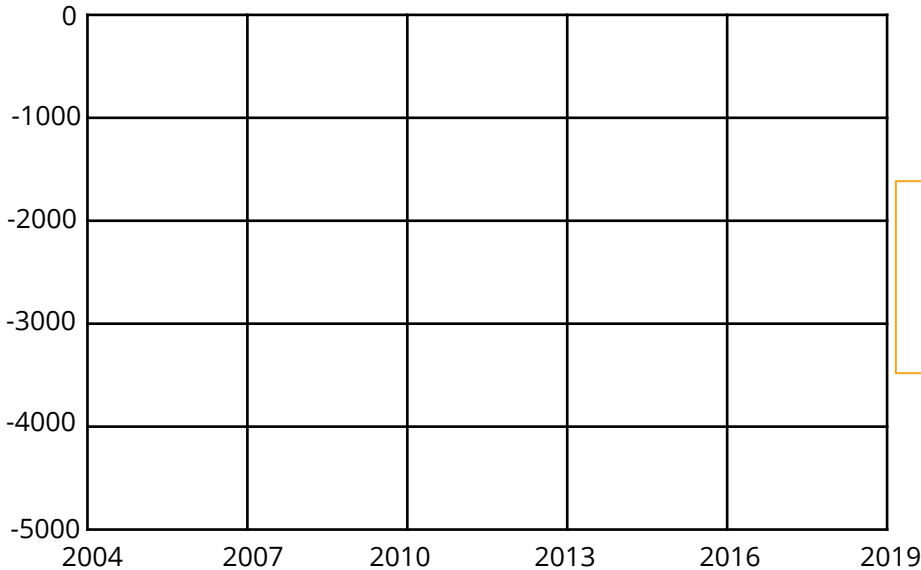
Ice on land comes in many forms, but the majority is either glaciers or the ice sheets in Greenland and Antarctica. Glaciers are extremely large bodies of ice that move down a slope or move outward from a central point. They are found in cold regions all over the world. The Antarctic and Greenland ice sheets are the first and second largest areas of ice on Earth.

When ice that has been on land melts, it flows either directly or through rivers to the ocean. Unlike the sea ice, this ice was not already displacing volume – it is an added volume of water. Therefore, when land ice melts, it raises the global level of the ocean.

Today I Learned About Sea Level Rise: Land Ice Melt

Investigating the Largest Ice Sheets

1. Visit <https://climate.nasa.gov/vital-signs/ice-sheets/>
2. Assign a different color of pencil/marker to Greenland and to Antarctica in the legend below. Label the units on the y axis.
3. Copy down the data points for January of each of the labeled years for each ice sheet. Draw a line through each set of data points to see the ice loss from each sheet over time.



Observe

What do you notice?

Watch

Observed ice mass loss between 2002-2020:

Antarctica <https://svs.gsfc.nasa.gov/31158>

Greenland <https://svs.gsfc.nasa.gov/31156>

Extend

What other questions could you investigate using tools on this site?

Today I Learned About Sea Level Rise: Land Ice Melt

Analyze

Note in the maps how much more land (and coastline) there is in the northern hemisphere than in the southern.



Southern Hemisphere



Northern Hemisphere

Given what you know about melting ice sheets, what do you notice and predict?

Slowing It Down

Communities and leaders all over the world are taking practical, common-sense steps to the switch away from fossil fuels and toward greener, cleaner forms of energy such as wind and solar. These changes will be pivotal in creating the future we want.

Share

Talking about major changes like sea level rise can feel overwhelming. Communities all over the world are taking action to protect people and places from harm. How would you explain what you observed and learned to a family member or friend?

Images: Sean Baker (Marvin01), CC BY 2.0, via Wikimedia Commons

Today I Learned About Sea Level Rise: Thermal Expansion

“About 90% of the total heating from increased greenhouse gases in the atmosphere is going into ocean water. So, the ocean’s warming. And if you heat water it's going to expand.”

James Renwick, Victoria University of Wellington, New Zealand
TILclimate podcast: today I learned about sea level rise, part 1

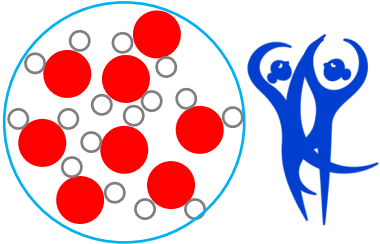
A Warming Planet

When we burn fossil fuels like coal, oil, and natural gas, we release carbon dioxide (CO₂) into the atmosphere. Carbon dioxide and other gasses act like a blanket, trapping heat on Earth.

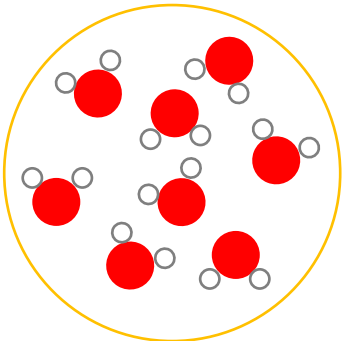
Let’s Add Some Energy

When we warm up any liquid, like water, it makes the molecules in that liquid move around more – the added heat is giving those molecules energy.

Cooler and Warmer Water



Cool water has less energy, so the molecules pack more closely together, like people dancing a slow dance.



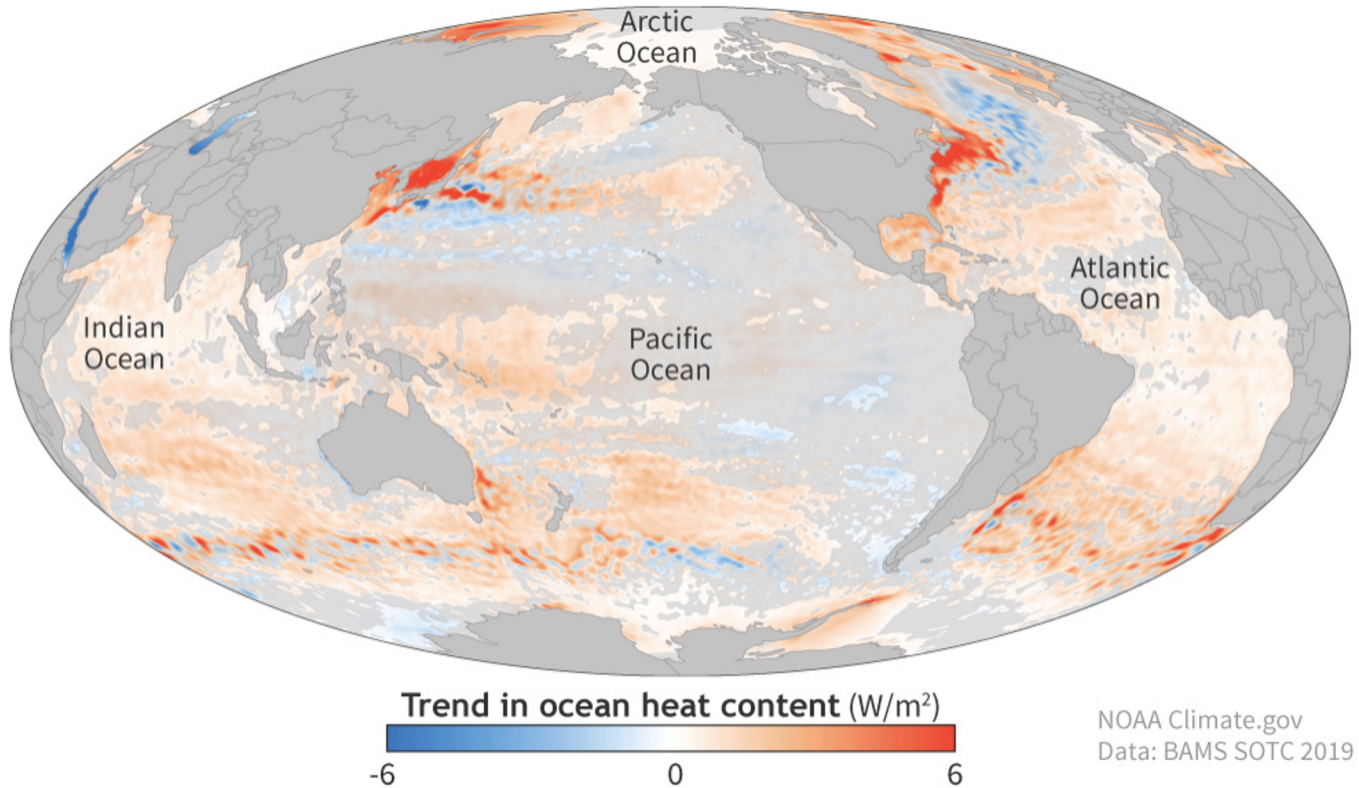
Warm water has more energy, so the molecules move around more and take up more space, like people dancing to faster music.

Images: ballet, Mark S Waterhouse, the Noun Project

Today I Learned About Sea Level Rise: Thermal Expansion

Change in Ocean Heat Content, 1993-2019

The ocean is not warming evenly. Due to a combination of oceanographic factors, some areas are warming much more quickly than others. What patterns do you observe?



Slowing It Down

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Talking about major changes like sea level rise can feel overwhelming. Communities all over the world are taking action to protect people and places from harm. How would you explain what you observed and learned to a family member or friend?

<https://www.climate.gov/news-features/understanding-climate/climate-change-ocean-heat-content>

Today I Learned About Sea Level Rise: Thermal Expansion

Investigating Sea Level Rise Models

1. Visit <https://coast.noaa.gov/slr/>
2. Click **Local Scenarios** on the left-hand side of the screen.
3. Zoom in on any coastal city you choose. Click on the  icon. The Scenario menu shows predicted sea levels for five scenarios from *Intermediate Low* to *Extreme*.
4. Move the right-hand slider between the five scenarios.

Observe

How much difference is there between the scenarios?

The Intermediate Low scenario models a situation in which global carbon dioxide emissions are cut dramatically within the next few decades.

The right-hand slider selects which scenario you are looking at. The left-hand slider models sea level rise by foot.

Blue color shows flooded areas, while green is tidal or storm flooding.

Observe

What do you notice under a low-emissions future vs a high-emissions future?

Analyze

Why does the Intermediate Low scenario still show some sea level rise?

Analyze

Repeat this process for another city in a different part of the country. What do you notice?

Extend

What other questions could you investigate using this tool?

Today I Learned About Sea Level Rise: Storm Surge

"It's really the storm events that cause the damage. Beaches are pretty flat places. And when you get a storm, even with a little bit of sea level rise, that makes it so much easier for the storm waves, to come inland and, and do damage."

James Renwick, Victoria University of Wellington, New Zealand

TILclimate podcast: today I learned about sea level rise, part 2

A Warming Planet

When we burn fossil fuels like coal, oil, and natural gas, we release carbon dioxide (CO₂) into the atmosphere. Carbon dioxide and other gasses act like a blanket, trapping heat on Earth. This warming is causing sea levels to rise around the world, due to a combination of ice melting and warm water expanding.

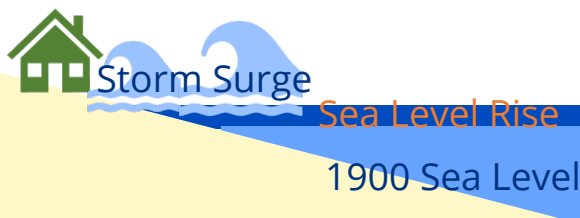
Adding Height

As sea levels rise, the ocean reaches farther up on beaches, rocky shores, salt marshes, and seawalls. This added baseline height makes any ocean movement larger and more powerful. According to coastal engineers, four inches of sea level rise makes any given coastal event three times more likely.

Storm Surge & Sea Level Rise



When a large storm such as a hurricane reaches the coast, the winds often push the ocean up against the land. This extra water is called *storm surge*. Storm surge is often the most damaging part of a storm, as water reaches much farther inland than during normal times.



With additional sea level rise, storm water can spread even farther, damaging roads, buildings, and other infrastructure.

Today I Learned About Sea Level Rise: Storm Surge

Investigating Historical Storms

1. Visit <https://tidesandcurrents.noaa.gov/inundationdb/>
2. Click on the pin for any coastal city you choose. Data for this city will pop up.
3. Click **Inundation History Page**.
4. Click **Top-10 Water Levels**. Note the height of the largest flood.
5. Click back to the map. Zoom in on the city you are studying. At the bottom of the legend on the right-hand side of the screen, turn on **Sea Level Rise**.
6. Drag the slider on the **feet above MHHW** to a number close to the largest flood for that city. (For example, in Boston the highest flood was January 4, 2018 at 4.89 feet above mean high water. Drag the slider to 5 feet.) Note the color bar for Water Depth, showing where the water would be shallow and where it might be deep.

Observe

What do you notice about where flooding may have occurred during this storm event?

Analyze

If you add one more foot of sea level rise to this same storm, what do you notice?

Analyze

Repeat this process for another city in a different part of the country. What do you notice?

Extend

What other questions could you investigate using this tool?

Slowing It Down

Communities and leaders all over the world are taking practical, common-sense steps to switch away from fossil fuels and toward greener, cleaner forms of energy such as wind and solar. These changes will be pivotal in creating the future we want.

Share

Talking about major changes like sea level rise can feel overwhelming. Communities all over the world are taking action to protect people and places from harm. How would you explain what you observed and learned to a family member or friend?

Today I Learned About Sea Level Rise: High-Tide Flooding

"A lot of the low lying areas that have been developed as population centers over the last half century or longer, they're already having trouble with what's called sunny day flooding. That is just a high tide. And when the tide comes in, it's a bit higher, maybe best part of a foot higher than it used to be a hundred years ago. And that's enough when there's a high tide to push the water onto the roads, if you're very close to sea level."

James Renwick, Victoria University of Wellington, New Zealand

TILclimate podcast: today I learned about sea level rise, part 2

A Warming Planet

When we burn fossil fuels like coal, oil, and natural gas, we release carbon dioxide (CO₂) into the atmosphere. Carbon dioxide and other gasses act like a blanket, trapping heat on Earth. This warming is causing sea levels to rise around the world, due to a combination of ice melting and warm water expanding.

Adding Height

As sea levels rise, the ocean reaches farther up on beaches, rocky shores, and salt marshes, as well as human-built defenses such as sea walls. This added baseline height makes any ocean movement larger and more powerful. According to coastal engineers, four inches of sea level rise makes any given coastal event three times more likely.


High-Tide Flooding

In some areas, high tide floods up into streets and parks daily or weekly. As sea levels rise, this will happen more frequently because high tide will be higher. This kind of flooding – called “sunny day” or “nuisance” flooding – is less damaging than storm surge but can cause more frequent disruptions. Salt water can slowly hurt metal building supports, roads, and other infrastructure.



Today I Learned About Sea Level Rise: High-Tide Flooding

Investigating Nuisance Flooding

1. Visit <https://coast.noaa.gov/slr/>
2. Zoom in on any coastal city you choose.
3. On the left-hand side of the screen, click **High Tide Flooding**. Red color now highlights areas that experience floods at extreme high tides. For more information on how this layer was developed, click the  icon at the bottom of the left-hand menu.


Observe

What do you notice about the pattern of flood areas?

The red flooding layer only has a single color, which does not tell how deep the flooding is at that location. Keep in mind that some areas may only get a few inches of high tide water, while other areas may get more.

Analyze

Find an area prone to high-tide flooding that is not right next to the coast. Zoom in to that area and try to trace a path to the nearest tidal water (ocean, harbor, or tidal river.) What are some of the pathways that water follows in this city?

4. Find and click the nearest  icon to bring up a map of local historical flooding events.

Observe

What do you notice about flooding in this city?

Analyze

Repeat this process for another city in a different part of the country. What do you notice?

Extend

What other questions could you investigate using this tool?

Slowing It Down

Communities and leaders all over the world are taking practical, common-sense steps to switch away from fossil fuels and toward greener, cleaner forms of energy such as wind and solar. These changes will be pivotal in creating the future we want.

Share

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Today I Learned About Sea Level Rise: Jigsaw Share

“The more we talk about it, the sooner, and the more planning is done around this, to have it all happen in a sort of compassionate, humane way, the better.”

James Renwick, Victoria University of Wellington, New Zealand

TILclimate podcast: today I learned about sea level rise, part 2

Each One, Teach One

Members of your group each learned about Land Ice Melt, Thermal Expansion, Storm Surge, and High-Tide Flooding. Give each person 2-3 minutes to summarize what they learned for the rest of the group.

Discuss:

- Why is sea level rising?
- What are some impacts of sea level rise that people are already experiencing?
- What are some impacts that people will experience in the future?

Now What?

Talking about climate change at any time can seem scary or overwhelming. Rising sea levels are already threatening people and places, and so this can feel like an unstoppable force. However, there are things we can do – and there are people doing them.

On the next page, you will find four categories of climate solutions. With your group, discuss solutions that you have seen or read about – or that you can imagine – for each of these categories.

Try to find solutions at the community level. For example, think about how roads have traffic lights, lines, and required car safety features instead of hoping that all drivers will choose to be safe drivers. In the same way, climate change solutions that change the way whole communities heat their homes will have more effect than asking homeowners to turn down the thermostat.

Today I Learned About Sea Level Rise: Solutions

"If we get to more than two degrees C of warming, a lot of the coastal cities and all the infrastructure that's there now would have to be abandoned or go under water. We're going to see people looking to be re-homed on a scale that just hasn't been seen before. Personally, I think we all have a moral responsibility to help others, so I'd be up for it, but I don't run the world."

James Renwick, Victoria University of Wellington, New Zealand

TILclimate podcast: today I learned about sea level rise, part 2

What Do We Do Now?

Sea level rise is a direct consequence of the burning of fossil fuels like coal, oil, and natural gas. Leaders around the world are working to dramatically reduce our use of fossil fuels. You may have seen some of these solutions around your community or in media. Solutions tend to fall into these four categories:

Energy Shift

Americans are innovators. What are some innovations you have seen that are shifting our energy systems away from producing carbon dioxide?

Energy Efficiency

Reducing our energy use overall reduces the demand for fossil fuels and makes the transition to renewable energy easier. What are some solutions that you have seen that are helping communities use less electricity, gas, and oil?

Talk About It

72% of American adults agree that climate change is happening, but only 35% talk about it even occasionally*. How can you share what you learned about sea level rise with your friends, family, or larger community?

Adaptation

Cities and towns all over the world are changing coastlines, roads, buildings, and infrastructure to handle a warming world. What are some solutions that you have seen that are helping communities protect people and places from climate impacts?

*<https://climatecommunication.yale.edu/visualizations-data/ycom-us/>

Today I Learned About Sea Level Rise: Solutions

Engineering Solutions

Engineers and designers are problem-solvers. There are many kinds of engineers and many kinds of designers: electrical, mechanical, biomedical, coastal, architectural, industrial, and environmental just to name a few. In the case of sea level rise, there are two big categories of engineering and design challenge: **adaptation** and **mitigation**.

Adaptation is physical changes to infrastructure, systems, or places to resist and recover from the effects of climate change. For example, rain gardens are a common way to adapt streets and parking lots to increased rainfall.

Mitigation is policy and technology that reduces the amount of carbon dioxide being added to the atmosphere. For example, policies that encourage electric utilities to get more of their energy from solar or wind instead of coal or natural gas.

Adaptation

1. Visit <https://toolkit.climate.gov/case-studies>.
2. Under **Filter by climate threat/stressor** select **Sea level rise**.
3. Explore a few of the case studies. What do you notice? Which stories do you find the most exciting?
4. Choose one case study to focus on – how would you change, adapt, or improve on their solution?

Mitigation

1. Look through the local Climate Action Plan your teacher provided.
2. What are some of the major plans this city is using to reduce carbon emissions?
3. Choose one area of emissions reduction (for example, transportation or buildings.) What is one strategy this city is using that you are most excited about?
4. How would you change, adapt, or improve on this solution strategy?

What's My Place?

It's not just engineers and designers. People from all walks of life are involved in protecting people and places from harm. Whether you are a scientist, activist, artist, businessperson, doctor, lawyer, or something else entirely, there is a place for you in creating the world we want. As you explore the case studies, look for the different kinds of jobs that are involved.

Today I Learned About Sea Level Rise: Solutions

Engineering Solutions

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Adaptation

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3. Explore a few of the case studies. What do you notice? Which stories do you find the most exciting?
4. Choose one case study to focus on – how would you change, adapt, or improve on their solution?

Mitigation

1. Visit <https://carbonneutralcities.org/cities/> and choose one city to focus on.
2. Look through the information provided for that city.
3. What are some of the major plans this city is using to reduce carbon emissions?
4. Choose one area of emissions reduction (for example, transportation or buildings.) What is one strategy this city is using that you are most excited about?
5. How would you change, adapt, or improve on this solution strategy?

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Today I Learned About Sea Level Rise: Solutions

“If we turn off the emissions, the sooner we do that, the sooner the rate of sea level rise starts to decrease and plateau out. But we're not so sure about how long it would take to completely stop.”

James Renwick, Victoria University of Wellington, New Zealand

TILclimate podcast: today I learned about sea level rise, part 1

What Do We Do Now?

Sea level rise is a direct consequence of the burning of fossil fuels like coal, oil, and natural gas. Leaders around the world are working to dramatically reduce our use of fossil fuels. At the same time, coastal cities and towns around the world are changing to adapt to a future with more water.

Share What You Learned

Previously, you were asked to think about solutions that you have seen, either in person or in the media. Other members of your class or group discovered solutions you haven't seen or heard about. Share with each other, and then choose one solution in each of the four areas below to investigate further.

Energy Shift

Energy Efficiency

Talk About It

Adaptation