Today I Learned About Sea Level Rise, Part 1

This Guide for Educators was developed by the MIT Environmental Solutions Initiative as an extension of our TILclimate (Today I Learned: Climate) podcast, to make it easier for you to teach climate change, earth science, and energy topics in the classroom. Whether used as a substitution for a lecture or as a supplemental introduction to a unit, TILclimate’s short, science-driven episodes and associated activities deepen student understanding of the multiple interlocking aspects of climate change.

The first three pages of this Guide will help you decide whether and how to bring these lessons into your classroom. The remainder of this Guide features a set of printable activities you can distribute to your students exactly as written here, or modify for your own use.

Description:

Through a hands-on demonstration, students will gain a clear understanding of the two major factors influencing sea level rise – land ice melt and thermal expansion. Additional solutions-oriented background information expands students real-world connections.

Today I Learned About Sea Level Rise, Part 2 will include Dive Deeper assignments lead students to explore data related to the impacts of thermal expansion, land ice melt, storm surge, and high-tide flooding.

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.
- Observe and explain that warm water molecules expand, taking up more space.
- List and consider some real-world solutions for sea level rise.

Standards Alignment:

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

Disciplinary Core Ideas:

ESS2.C: The Roles of Water in Earth's Surface Processes
ESS2.D: Weather and Climate
ESS3.B: Natural Hazards
ESS3.C: Human Impacts on Earth Systems
ESS3.D: Global Climate Change
Introduction Activity:

*These shorter activities are designed for classes with less time, as an introduction, or as the work of one team in a larger class-wide project.*

**Pre-class work:** Students listen to TILclimate: Sea Level Rise Pt 1 (under 15 minutes long) at home. The podcast episode is available at https://tilclimate.mit.edu or on any podcast app.

**Demonstrations (Pages 1-2):** The active portion of each demonstration takes between 5-10 minutes. With a heat lamp, the demonstration may be finished by the end of a class period. With ambient temperature (or a sunny windowsill) the demonstration will finish by the next day. Demonstrations may either be prepared and performed by a teacher with students watching, or by teams of students – each team performing one demonstration.

**Background Information and Thinking (Pages 3-5):** After the demonstration, students can complete these pages in class, as homework, or use the included questions as a discussion. The discussion of solutions is key to avoiding a sense of ‘doom and gloom’ when learning about climate change.

**Included:**

- Educator overview
- Suggestions for use, supply lists, and preparation instructions
- Student demonstration sheets
- Student background information and solutions discussion

**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 you or your students create! Email us at tilclimate@mit.edu, Tweet us @tilclimate, or tag us on Facebook @climateMIT.
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This can be done as a single demonstration, or in pairs and small groups. Supplies are listed for a single demonstration – multiply as necessary. Some of the preparation can also be done by students. The two demonstrations take similar amounts of time to put together, so teams of students can be working on them at the same time.

**Land Ice vs Sea Ice**

- Two equal-sized clear containers, rectangular in shape
- Modeling clay or similar waterproof material
- Room-temperature water
- Ice cubes (smaller ice cubes will melt more quickly)
- Tape or a marker to mark the side of the clear containers
- Optional, to speed up heating: heat lamp

Use the modeling clay to make two same-size land areas, one in each plastic container (green areas below.)

This is a side view.

![Diagram of Land Ice vs Sea Ice](image)

**Thermal Expansion**

- A clear plastic bottle with a screw-on lid. (Such as a 12-20oz disposable water bottle, with either a screw top or flip-cap lid. Thicker, sturdier bottles work better than thinner, more flexible ones.)
- Food coloring or liquid watercolor
- A clear plastic straw
- Tape or a marker to mark the side of the straw
- Hot glue or waterproof caulk
- Cold water
- Optional, to speed up heating: heat lamp

- Drill or cut a hole through the center of the top of the bottle cap. If you have a flip-top cap, you may not need this step.
- Slide the plastic straw through the hole, leaving enough straw out the bottom to reach more than halfway into the bottle, and with 2-3 inches out the top of the cap.
- Using hot glue or waterproof caulk, seal around the hole where the straw is.
- Make sure that the lid can still be screwed on tightly.

![Diagram of Thermal Expansion](image)
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Land Ice vs Sea Ice

Step 1: Add your ice to your model.
Put equal amounts of ice into your two models – on the “land” in one, and in the bottom of the other.

Step 2: Add your ocean to your model.
Pour room temperature (or a little warmer) water into both models until the water level is about the same. Mark the water level on the side of each container.

Make a prediction.
Will the water level change in each of the models? Why or why not?

Step 3: Warm up your model.
As we burn fossil fuels like coal, oil, and natural gas, we add carbon dioxide (CO$_2$) to the atmosphere. This carbon dioxide acts like a blanket surrounding Earth, trapping heat. Much of this heat is absorbed by the ocean. You can warm up your model quickly with a heat lamp, or more slowly by leaving it at room temperature and coming back to it the next day.

Observe the changes
Did the water level change in either of your models?
Did it do the same thing in both, or something different in each model? Why do you think this is?

Modeling the Real World
Where in the world do we have ice floating in the ocean? Where do we have ice on land? If each of these types of ice were to melt, which one would have a larger effect on the level of the sea around the world?
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Thermal Expansion

Please note that water will spill as part of this demonstration - protect your work surface.

Step 1: Fill your bottle with cold water colored with food coloring or watercolors.
Fill the bottle all the way, to the absolute top. Water will probably spill out.

Step 2: Screw the cap onto your bottle.
Carefully, so that no water spills out. Make sure the straw sits more than halfway into the bottle but does not touch the bottom, and that 2-3 inches of the straw is sticking out above the bottle cap.

Step 3: Mark the water level on the straw.
Using a waterproof marker or lab pencil, mark how far up the straw the water comes. If there is no water in the straw above the cap, unscrew the cap and add more water to your bottle.

Make a prediction.
Will the water level in the straw change? If so, will it go up or down? Why do you think this will happen?

Step 4: Warm up your model.
As we burn fossil fuels like coal, oil, and natural gas, we add carbon dioxide (CO₂) to the atmosphere. This carbon dioxide acts like a blanket surrounding Earth, trapping heat. Much of this heat is absorbed by the ocean.
You can warm up your model quickly with a heat lamp, or more slowly by leaving it in a sunny window and coming back to it the next day.

Observe the changes.
Did the water level change in the straw? How much? Did it go up or down? Why?

Modeling the Real World
As heat is being absorbed by the ocean, what would you expect to happen to sea levels, based on your observations?
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A Warming Planet

When we burn fossil fuels like coal, oil, and natural gas, we release carbon dioxide (CO$_2$) into the atmosphere. Carbon dioxide and other gasses act like a blanket, trapping heat on Earth. A regular amount of carbon dioxide in the atmosphere is good – without it, Earth would lose most of its heat to the cold of space, and life would not be possible. However, what we are experiencing since the beginning of the industrial age in the 1800s is rampant carbon dioxide – it is out of control and causing too much warming. As we learned in the demonstrations, warming has two effects on the level of the ocean worldwide – thermal expansion (warm water taking up more room) and melting land ice (adding more water to the ocean.)

The Seas Are Rising...

Due to a combination of thermal expansion and land ice melting, Earth has already seen eight to nine inches of sea level rise since 1880. The rate of rise is also changing – tide records from 1900-1990 showed four to five inches of rise, and then in the 25 years from 1990-2015, a further three inches.¹

From the 1970s through the early 2000s, thermal expansion and ice melt added about equally to sea level rise. Since 2005, however, melting has been adding almost twice as much volume to the ocean as has thermal expansion. Worldwide glaciers, the Greenland Ice Sheet, and the Antarctic have all been melting at higher rates in the past twenty years than in the centuries before.²

¹National Oceanic and Atmospheric Administration “Tracking sea level rise... and fall” published August 2017
https://www.noaa.gov/explainers/tracking-sea-level-rise-and-fall
² National Oceanic and Atmospheric Administration “Climate Change: Global Sea Level” published January 2021
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... But Not Equally

Due to effects such as plate tectonics, ocean currents and winds, pumping water and oil out of the ground, and even the gravity of ice sheets, the amount and intensity of sea level rise around the world is not even. In some places (especially Alaska and Northern Europe) sea level is falling because of plate tectonic and other geological forces. However, most of the world is experiencing between 3 and 9mm of rise per year. That is a range of under a foot to over three feet in 100 years.

https://tidesandcurrents.noaa.gov/sltrends/

What’s Going to Happen?

Climate impacts are already being seen and felt around the world. Since heat-trapping gases remain in the atmosphere for tens to thousands of years, some climate impacts will continue even if we dramatically reduce fossil fuel use in the coming years.

<table>
<thead>
<tr>
<th>Gas</th>
<th>Lifetime in the Atmosphere</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂ Carbon Dioxide</td>
<td>&gt;1,000 years</td>
</tr>
<tr>
<td>N₂O Nitrous Oxide</td>
<td>&gt;100 years</td>
</tr>
<tr>
<td>CH₄ Methane</td>
<td>&gt;10 years</td>
</tr>
</tbody>
</table>

https://www.epa.gov/ghgemissions/understanding-global-warming-potentials

“If we get to more than two degrees C of warming, it’s pretty likely we'll lock in four or five meters of sea level rise, at least... Personally, I think we all have a moral responsibility to help others... I hope that the humanitarian tendency of people to help others in distress wins out.”

James Renwick, Victoria University of Wellington, New Zealand

**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.

**Energy Shift**

Americans are innovators. What are some innovations you have seen, either in person or in the media, 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, either in media or in person, 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 occasionally⁴. 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, either in media or in person, that are helping communities protect people and places from climate impacts?

⁴https://climatecommunication.yale.edu/visualizations-data/ycom-us/