ScienceNews
EDUCATOR GUIDE

NASA/SASKIA MADLENER

February 13, 2021

Earth's Oceans Broke Heat Records in 2020

SOCIETY FOR SCIENCE

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About this Guide

In this Guide, based on the online *Science News* article "Earth's oceans are storing record-breaking amounts of heat," students will learn about how the amount of heat energy that Earth's upper oceans have absorbed has increased over time. Then, students will discuss strategies for interpreting, understanding and communicating data.

This Guide includes:

Article-based Comprehension Q&A — Students will answer questions about the online *Science News* article "Earth's oceans are storing record-breaking amounts of heat," which explores how the upper oceans' heat storage capacity has changed over time. A version of the story, "Earth's oceans broke heat records in 2020," appears in the February 13, 2021 issue of *Science News*. Related standards include NGSS-DCI: HS-PS3; HS-ESS3.

> **Student Comprehension Worksheet** — These questions are formatted so it's easy to print them out as a worksheet.

Cross-curricular Discussion Q&A — Students will discuss how graphs and quantitative analogies are useful for interpreting and understanding data. Then, students will analyze and compare how effective each strategy is at communicating a scientific claim. As an extension, students may propose an alternative method of displaying or explaining given data. Related standards include NGSS-DCI: HS-PS3; HS-ESS3.

> **Student Discussion Worksheet** — These questions are formatted so it's easy to print them out as a worksheet.

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Article-based Comprehension, Q&A

Directions for teachers: Ask your students to read the online *Science News* article "Earth's oceans are storing record-breaking amounts of heat," which explores how the upper oceans' heat storage capacity has changed over time, and answer the following questions. A version of the story, "Earth's oceans broke heat records in 2020," appears in the February 13, 2021 issue of *Science News*.

1. What is the main finding described in the *Science News* article?

In 2020, the total amount of heat stored in the oceans' upper 2,000 meters was higher than any other year on record dating back to the 1950s.

2. Why is tracking ocean temperature important?

Warmer waters melt more ice off Greenland and Antarctica, which raises sea levels. Warmer waters can also make tropical storms more intense.

3. Where did the ocean temperature data that the researchers used come from?

Ocean temperature data came from moored sensors, Argo floats, underwater robots and other instruments around the world.

4. How much heat energy did the upper oceans store in 2020 compared with the annual average from 1981 to 2010?

Upper ocean waters contained 234 sextillion joules more heat energy.

5. How does that amount compare with data from 2019? Why did the researchers come up with two estimates?

Upper ocean waters stored at least 1 sextillion joules and may have stored as much as about 20 sextillion joules more heat energy than 2019. Researchers thought their estimate of 20 sextillion joules may have been too high, so they used a different, more conservative mathematical model to come up with a second estimate.

6. About how many kettles of water could be boiled by the jump in heat energy storage from 2019 to 2020, according to the researchers? Why is there a range given in the article?

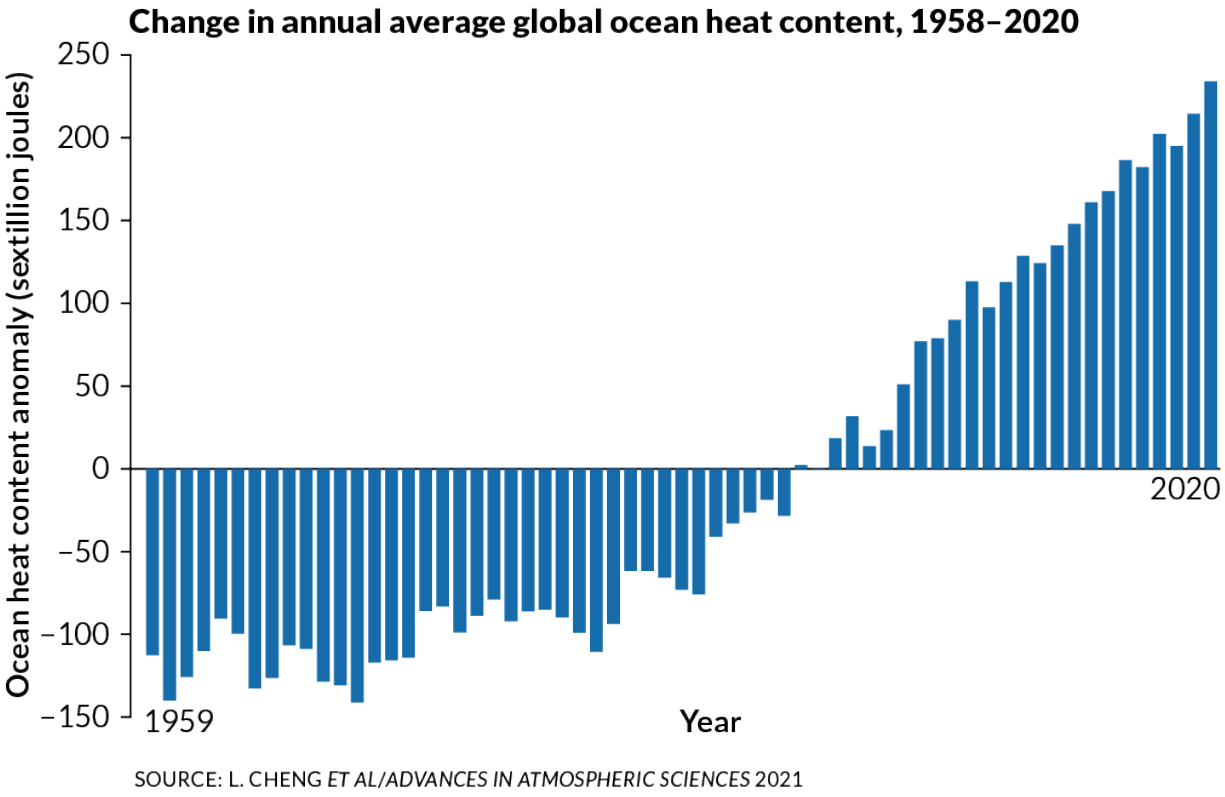
The increase in heat energy storage between 2019 and 2020 could boil and estimated 65 million to 1.3 billion kettles of water. A range is given because researchers came up with two estimates for the jump in heat energy storage.

7. Why do you think climate scientist Michael Mann compares the ocean heat records to the film *Groundhog Day*? You can look up the film if you are not familiar with it.

In the film, the same day repeats over and over again. Scientists are seeing a similar trend in ocean heat records over the last few years — each new year becomes the hottest ever recorded.

Dive into data

Answer the following questions after examining the graph below. The graph appears in a version of the story, "Earth's oceans broke heat records in 2020," in the February 13, 2021 issue of *Science News*.



SOURCE: L. CHENG *ET AL/ADVANCES IN ATMOSPHERIC SCIENCES* 2021

1. What does the graph show? Define the x- and y-axes and their units.

The graph shows the change in the annual average upper ocean heat content from 1958–2020. The x-axis shows time in years, and the y-axis shows the change in ocean heat content from the baseline average in sextillion joules.

2. Around what year did the oceans begin to store more heat than the baseline average? How much more heat did the oceans store that year?

The oceans began to store more heat than the baseline average around 1998. That year, the oceans stored about 25 sextillion joules more heat energy than the baseline average.

3. State the general trend of the data shown in the graph, including the general trend in the rate of change in heat content.

The upper oceans' average annual ocean heat content has generally increased since 1958. The rate appears to increase gradually from 1958 to about 1985. After that, the rate appears to increase more drastically and rapidly.

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Student Comprehension Worksheet

Directions: Read the online *Science News* article "Earth's oceans are storing record-breaking amounts of heat," and answer the following questions. A version of the story, "Earth's oceans broke heat records in 2020," appears in the February 13, 2021 issue of *Science News*.

1. What is the main finding described in the *Science News* article?

2. Why is tracking ocean temperature important?

3. Where did the ocean temperature data that the researchers used come from?

4. How much heat energy did the upper oceans store in 2020 compared with the annual average from 1981 to 2010?

5. How does that amount compare with data from 2019? Why did the researchers come up with two estimates?

6. About how many kettles of water could be boiled by the jump in heat energy storage from 2019 to 2020, according to the researchers? Why is there a range given in the article?

7. Why do you think climate scientist Michael Mann compares the ocean heat records to the film *Groundhog Day*? You can look up the film if you are not familiar with it.

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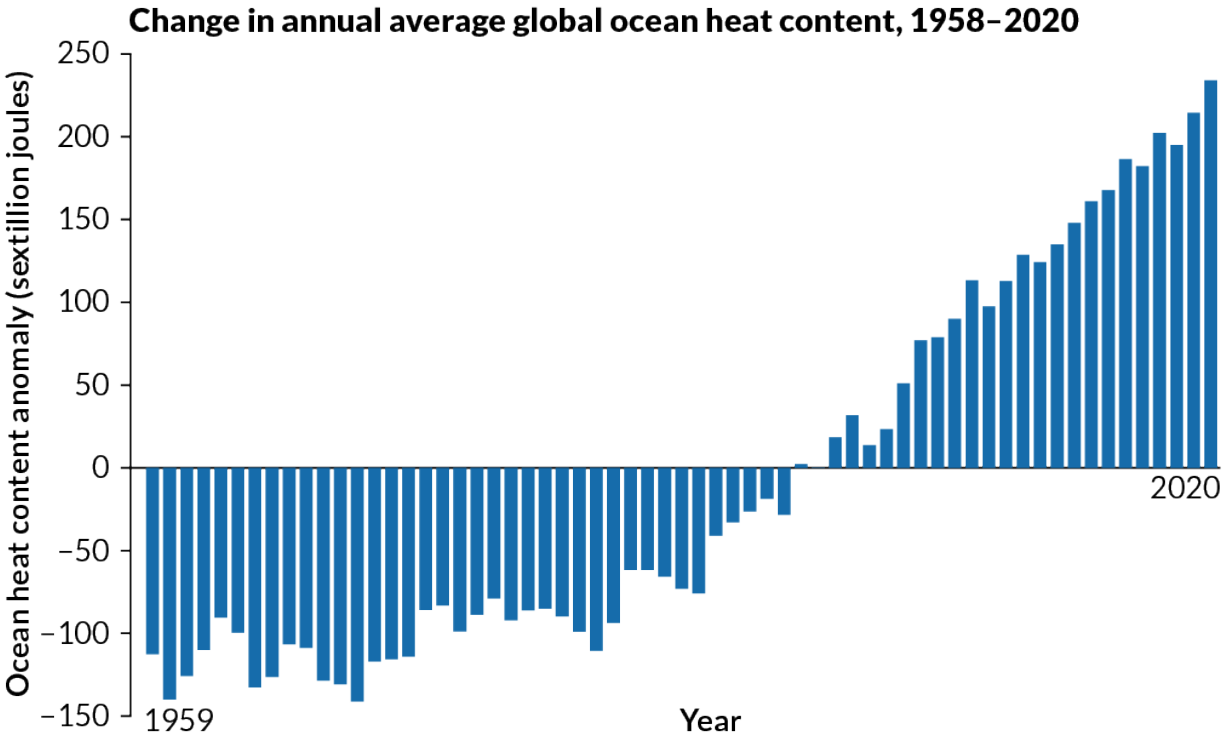
Answer the following questions after examining the graph below. The graph appears in a version of the story, "Earth's oceans broke heat records in 2020," in the February 13, 2021 issue of *Science News*.



SOURCE: L. CHENG *ET AL/ADVANCES IN ATMOSPHERIC SCIENCES* 2021

1. What does the graph show? Define the x- and y-axes and their units.

2. Around what year did the oceans begin to store more heat than the baseline average? How much more heat did the oceans store that year?

3. State the general trend of the data shown in the graph, including the general trend in the rate of change in heat content.

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Cross-curricular Discussion, Q&A

Directions for teachers:
Have students read the online *Science News* article "Earth's oceans are storing record-breaking amounts of heat." A version of the story, "Earth's oceans broke heat records in 2020," appears in the February 13, 2021 issue of *Science News*. Use the first set of prompts to identify data that researchers used as evidence to support a scientific claim. The final two sets of prompts ask students to discuss how effective a graph and an analogy is at helping the reader interpret the claim. As a final exercise, have students propose an alternative method of displaying or explaining the oceanic heat data.

Want to make it a virtual lesson? Post the online *Science News* "Earth's oceans are storing record-breaking amounts of heat," to your learning management system. Pair up students and allow them to connect via virtual breakout rooms in a video conference, over the phone, in a shared document or using another chat system. Have each pair post its answers to the third set of questions, or conduct a class discussion to allow groups to share out.

Define the claim and supporting data
Answer the following questions individually before discussing them with a partner.

1. What claim does the article make about the ocean?

Researchers state that the total amount of heat stored in the upper 2,000 meters of Earth's oceans was higher in 2020 than in any other year on record dating back to the 1950s.

2. What data, or evidence, is given to support the claim?

Ocean temperature data from moored sensors, underwater robots and other instruments were used in mathematical models to estimate the average amount of heat energy stored in the upper oceans in 2020. That data was compared with historical ocean temperature data going back to the 1950s.

Communicate the findings
Discuss the following questions with a classmate. Write down your thoughts and be prepared to share your answers with the class.

1. What analogy did scientists come up with to describe their findings? What information was likely needed to create the analogy?

Scientists used the difference in the amount of heat energy stored in upper the oceans from 2019 to 2020 to calculate the approximate number of kettles of water that could be boiled with that energy. In order to create the analogy, one must know the increase in the amount of energy, the heat of vaporization of water

(typically given in J/mol), the molar mass of water, the density of water, and the volume of a typical water kettle.

2. Based on the information given in the article, can you to figure out the calculation used to come up with the analogy? What assumptions do you have to make? Explain.

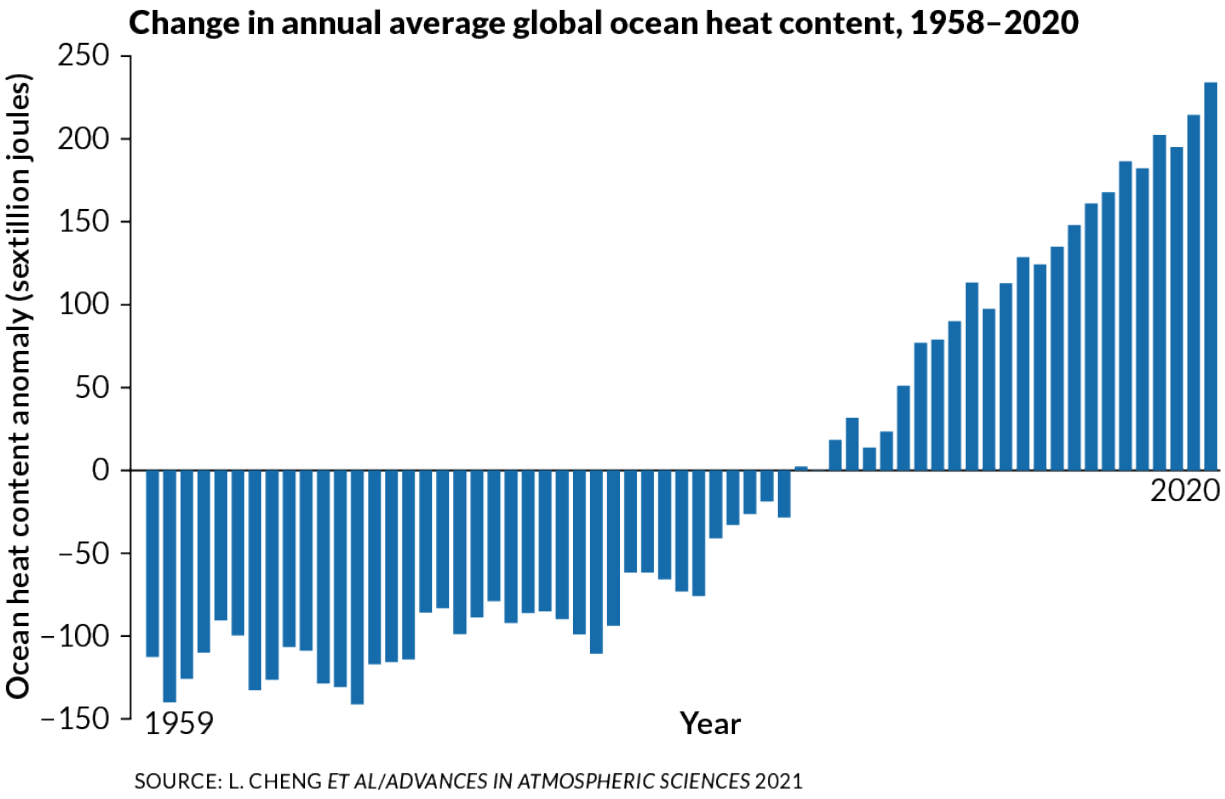
The main assumptions that you would have to make in this calculation are the starting temperature of the water and the volume of a typical water kettle. If we don't know the what assumptions the researchers made, then it might be challenging to get the same answer.

3. Does the analogy present the relevant data in a way that supports the claim? What usefulness do analogies have in communicating concepts? Explain.

The analogy provides a relative value for the amount of heat mentioned in the article and shown on the graph. The analogy doesn't directly support the claim, but it does help readers understand the magnitude of the increase in heat content from 2019 to 2020. When communicating data and information to a general audience, familiar references help give perspective and meaning to quantities that difficult to conceive or are otherwise unusual.

Display the data

The graph below appears with the story in the February 13, 2021 issue of *Science News*. Study the graph and discuss the following questions with a partner. Be prepared to turn in your answers to your teacher.



SOURCE: L. CHENG *ET AL/ADVANCES IN ATMOSPHERIC SCIENCES* 2021

1. What information was needed to create the graph? Describe how that information is displayed on the graph.

Data on annual average ocean heat content (in sextillions of joules) from the 1950s to 2020 was needed to create the graph. The average ocean heat content from 1981 to 2010 is used as a baseline and is represented as zero on the y-axis. Yearly change from that baseline is plotted as upward or downward pointing bars on the graph. Upward pointing bars indicate a positive rate of change of annual heat content compared to the average, and downward pointing bars indicate a negative rate of change of annual heat content compared to the average.

2. What overall trend in data does the graph display? Does the graph's design present the relevant data in a way that supports the claim? Explain.

The graph shows a general increase in average annual ocean heat content since 1958, though there are some years that haven't followed that general trend. The rate of increase is gradual from 1958 until about

1985, at which point the rate of increase appears to be larger until 2020. The graph gives the reader a historical trend in ocean heat content, which is beneficial when supporting the claim that the total amount of heat stored in the upper oceans was higher in 2020 than in any other year on record dating back to the 1950s. The graph provides the evidence to the reader, but does not directly interpret it.

Analyze the strategies

Discuss the following questions with a classmate. Write down your thoughts and be prepared to share your answers with the class.

1. Did you find the analogy or the graph more beneficial to your understanding? Is it effective to pair the strategies? Explain.

Student answers will vary. Answers should mention that the graph provides a comprehensive dataset that the reader must interpret whereas the analogy provides a familiar interpretation of the data for the reader. However, the analogy does not provide any factual data to support the scientific claim.

2. What other strategies could be used to communicate the findings to the public?

Other diagrams, graphs, data visualizations or analogies could be used to communicate the claim to the reader.

Extension: A new alternative

Propose an alternative method of displaying or explaining the oceanic heat data described in the *Science News* article. Or, create your own analogy for another *Science News* article that appears in the February 13, 2021 issue. The analogy should communicate the magnitude of quantitative data used to support a scientific claim.

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Student Discussion Worksheet

Directions: Discuss and answer the following questions about the online *Science News* article "Earth's oceans are storing record-breaking amounts of heat." A version of the story, "Earth's oceans broke heat records in 2020," appears in the February 13, 2021 issue of *Science News*.

Define the claim and supporting data
Answer the following questions individually before discussing them with a partner.

1. What claim does the article make about the ocean?

2. What data, or evidence, is given to support the claim?

Communicate the findings
Discuss the following questions with a classmate. Write down your thoughts and be prepared to share your answers with the class.

1. What analogy did scientists come up with to describe their findings? What information was likely needed to create the analogy?

2. Based on the information given in the article, can you to figure out the calculation used to come up with the analogy? What assumptions do you have to make? Explain.

3. Does the analogy present the relevant data in a way that supports the claim? What usefulness do analogies have in communicating concepts? Explain.

Display the data

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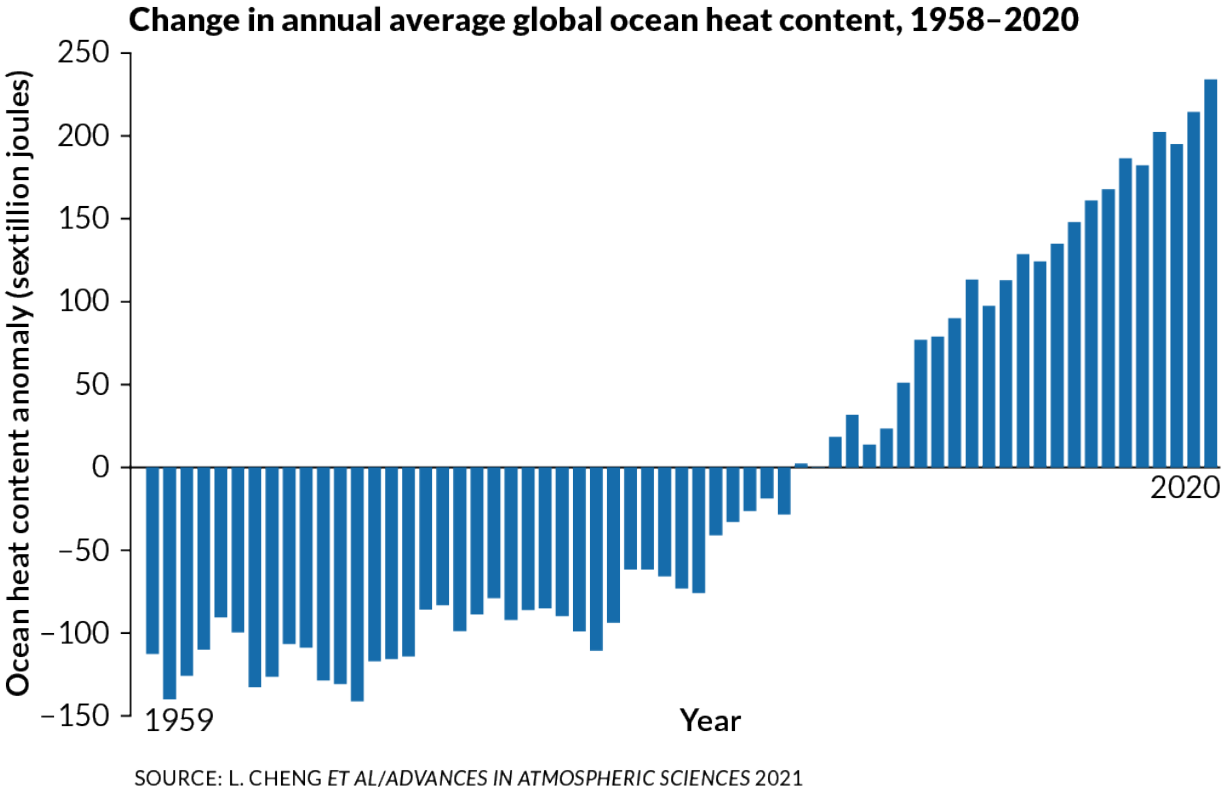

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1. What information was needed to create the graph? Describe how that information is displayed on the graph.

2. What overall trend in data does the graph display? Does the graph's design present the relevant data in a way that supports the claim? Explain.

Analyze the strategies

Discuss the following questions with a classmate. Write down your thoughts and be prepared to share your answers with the class.

1. Did you find the analogy or the graph more beneficial to your understanding? Is it effective to pair the strategies? Explain.

2. What other strategies could be used to communicate the findings to the public?

Extension: A new alternative

Propose an alternative method of displaying or explaining the oceanic heat data described in the *Science News* article. Or, create your own analogy for another *Science News* article that appears in the February 13, 2021 issue. The analogy should communicate the magnitude of quantitative data used to support a scientific claim.