Level	Measuring Sea Surface Temperatures with Satellites
High School	

Time Required	Lesson Summary
Initial Instruction: 2.5- 50 min class periods (125 min) Data Collection 3weeks: 10 minutes /week Wrap up:	Students will learn how satellites collect data and communicate that with researchers on Earth. Students will use this data to create a thermal map which will help them understand isotherms. Students will also use the satellite data to determine changes in sea surface temperature.

Standards

NGSS

HS-PS4-2 Evaluate questions about the advantages of using a digital transmission and storage of information.

HS-ESS3-1 Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate how influenced human activity.

Vocabulary	Objectives
Isolines Isotherms Satellite Radiometer Infrared Sea Surface Temperature Radiation	• Students will be able to describe how satellites collect data and send it to the surface of the Earth. • Students will be able to create isotherms. • Students will be able to use satellite data to determine changes in sea surface temperature.

Materials

- Websites:
  Sea Surface Temperature SST Contour Charts (last accessed 5/13/23)
  NOAA's IOOS Environmental Sensor Map (last accessed 5/13/23)

- Worksheets:
  Map of SSTs
  Satellites & SST Worksheet

- Colored pencils or markers, Sharpies

Pre-Requisites
Students should have previously learned about the electromagnetic spectrum.

Safety Considerations
None

Pacing Notes
Day 1: introduction, thermal map activity, discussion Day 2: Introduce SST maps, complete the SST student sheet Weeks 2, 3 and 4: 10 minutes on one day to collect data Day 3: Conclusion questions, trend map

Before the Lesson
Teachers should become familiar with the sites that will be used so they are able to troubleshoot if needed. An optional portion of the lesson is to use local data to check the sea surface temperature using NOAA's IOOS Environmental Sensor Map. (last accessed 5/13/23) Teachers should determine which local station has the water temperature data.

Assessments	Classroom Instructions
Pre-Activity Assessments	**Introduction**
Listen to students' reasoning for their answers. Correct as	1. While you are taking care of administrative duties students should be responding to the following prompts:

necessary.	What makes our oceans warm? Where is the Earth's water usually the warmest? How do we know how hot the water is? 2. After you are finished with your tasks lead the class in a brief discussion over the prompts. Allow students to share their ideas and others to politely challenge those ideas if they feel they are incorrect. By the end of the discussion make sure that students are aware that the heating is due to the sun and that the equator has the warmest water.
Activity Embedded Assessments	**Activities**
Walk around while students are drawing the thermoclines. **Ask**: Why did you draw it that way? **Ask**: Is there any other possibility that meets the requirements? Collect and grade the sheet. Pay attention to who in the class is engaged. If you see a student not interested ask them one of the questions if appropriate.	**Day 1** 1. **Thermal Map Activity** Pass out the map of SSTs. Explain to them that the numbers represent the ocean temperature in °C and that they are going to be creating a thermal map. Students need to draw a shape around all of the data points that belong to one of the following groups: 1-10, 11-20, 21-30, 31-40. The first one has been done for them. These shapes should share lines with neighboring shapes so that there is no space between shapes. They should not include land masses in their shapes and they should not include areas of the ocean with no data points. See the key for this activity for a better idea of what the map should look like. After students are finished drawing all the lines with a pencil they should go back and go over their lines with a Sharpie. This will make the isotherms visible after the map has been colored. The last thing students need to do is color their map. They should assign a different color to each of the groups indicated above and should write the color in the Key box. 2. **Whole Class Discussion** After the activity guide the class in a discussion. It is suggested you use the following questions but feel free to use some of your own as well. What did you notice about the isotherms on your page? Why do you think they occurred in those locations? Were you surprised by any of the data? How were these measurements collected?

	Allow students to share their ideas but then at the end make sure you tell them that this data was collected with satellites. 3. **What are satellites and how do they work?** a. Project the Satellite Presentation for your class Students should take notes during the presentation. Be sure to pause periodically for student questions.
Walk around listening to students. If they cannot answer these questions. Stop, go back and reteach.	b. After page 4 and the video stop and have students discuss the following with the person sitting next to them for 3-4 min. Then ask for volunteers to share their answers with the whole class. What is the electromagnetic spectrum? What do we use the spectrum for? What are radio waves? Why are radio waves important? c. After page 8 pause and **Ask:** Who can summarize what the JPSS does? 4. **Conclusion Day One: Satellite communication activity** a. Hand out the student sheets and direct the students to this webpage, https://spaceplace.nasa.gov/dsn-game/en/ (last accessed 5/13/23)
Walk around and observe students. Ask: Why are you doing that? Ask: What do those lines going to or from the satellite represent?	b. You can either allow students to work with a partner or have them work alone.
	Day Two 1. Introduction While you are taking care of administrative tasks students should be completing an entrance ticket. They should write a short response to the following prompt: How do satellites measure sea surface temperature?
Consider collecting and giving a grade.	After you have completed your tasks invite students to share their responses with the class.

	2. SST map introduction a. Project the following web page on the board, https://www.ospo.noaa.gov/Products/ocean/sst/contour/index.html Explain to students that this webpage provides the same type of information that was included in yesterday's activity. Tell them that they are going to start an activity today that will continue for the next month. Stress the importance of keeping track of their data page.
Walk around while students are practicing converting. Answer questions as needed.	b. Students are expected to convert the metric measurement of temperature to the English unit. Have students use the formula °F = 1.8°C + 32 to determine the temperature in °F. Practice using this formula a few times before placing students in groups.
Walk around and check student progress. Do they know where to get the information? Are they able to make the conversions?	3. SST Activity a. Hand out the student page. b. Either have students choose/assign partners or have students work independently. c. Project the blank Pacific coast document. Each student or pair of students is going to collect data on one point for the next month. It is important that the class have as many data points as possible so everyone should be collecting from a different area. The point where a latitude and longitude line cross is a collection point. Go around the room and have each person or group indicate which point they want to collect data on. Students should write the lat and long numbers on their papers. d. Repeat the step above with the blank North Atlantic, blank South Atlantic, and blank Gulf of Mexico documents. e. Have students go to https://www.ospo.noaa.gov/Products/ocean/sst/contour/index.html They need to click on the correct maps and collect the needed data. Then they should convert those measurements into degrees F. 4. Conclusions Conduct a whole class discussion about what they saw on the maps. Consider using the questions below as well as your own. In addition, allow students to ask questions and allow their peers to respond. Be sure your class knows how to interact respectfully before using this technique. What did you notice about the maps? What areas had warmer water?

Collect and grade the paper.	What areas had cooler water? **Week 2 and 3 (10 minutes)** 1. Have students get out their data sheet and go to the webpage to collect their data. Once the information has been collected students should convert the temperatures. **Week 4 (Final Day)** 1. Have students get out their data sheet and collect the needed data. Students also need to indicate the trend for each point, did the temperature increase, decrease or stay the same. 2. Put up the Blank Pacific Coast Diagram. Go around the room and have each individual or group indicate the trend for their point. Students should record this data on their paper by making a red dot for increase, a blue dot for decrease, or a brown dot for stays the same. If one location increased from week one to two and then decreased for the remaining time the dot can be red on top and blue on bottom. Feel free to make the adjustments necessary to reflect the trends your students record at that spot. 3. Continue with the Blank North Atlantic, South Atlantic and Gulf of Mexico maps. 4. Once students have all the data they should answer the questions on the paper.
Post Activity Assessments	**Closure**
	Sea surface temperatures have an impact on ocean living creatures and on humans. Have a discussion with your class about the impacts of changes in ocean temperature. Consider using some of the questions below as well as your own. How do rising sea temperatures impact humans? How do rising sea temperatures impact fish? How do rising sea temperatures impact marine mammals? How do lowering sea temperatures impact humans? How do lowering sea temperatures impact fish? How do lowering sea temperature impact marine mammals?
Educator Resources	

- IOOS Maps Environmental Sensor Map - (Salinity and much more)
- Universal Time Converter (UTC)
- National Environmental Satellite, Data and Information Service (NESDIS)
- The World in Real-Time (NOAA/NESDIS)
- Currently Flying NOAA/NESDIS Satellites
- SWOT - (video, 2:38) Satellite to Survey the World's Water (Launches Nov 2022)
- How to use the interactive satellite maps - https://youtu.be/Aad2NrX60sY (1:32)
- Electromagnetic Spectrum Graph from vecteezy.com

Extension for future weather unit:

- Weather Satellites video:
  - GOES Cartoon Video
  - GOES R-Series Satellite Video
- Smithsonian Article Using Loggerhead Turtles to study/learn about cyclones
- East and West GOES Animation (00:56) https://www.nesdis.noaa.gov/news/geostationary-operational-environmental-satellite-goes-east-and-west-visualization
- Hurricane Ivan - How does the eye change as the storm follows its path?
- https://www.nesdis.noaa.gov/news/hurricane-ivan-0
- GOES Series Mission https://www.nesdis.noaa.gov/current-satellite-missions/currently-flying/geostationary-satellites
- Virtual School Series National Weather Service
- Excellent Weather / Ocean Content - NOAA/NWS JetStream

All web pages last accessed 5/13/23.

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Below is a list of the lesson titles included in the series. All lessons can be accessed from this web page, https://superknova.org/educational-resources/.

Middle School

Introduction to Satellites
Weather Predicting
Introduction to Radio Wave Communication
The Importance of Radio Astronomy

Cubesat Model Building
Understanding FM Radio
Radio Frequency Technology
Who Decides if You Get 5G?

High School

The Uses of Radio Waves and Frequency Allocation
Is Radio Technology Safe?
Diffraction of Radio Waves
Measuring Sea Surface Temperatures with Satellites
Marine Animal Tracking and Bathymetry
How to Design Your Own Crystal Radio
How Radio Waves Changed the World
Simple Wireless Communication
Seeing and Hearing the Invisible
Local Wireless Radio Frequency Communication
Investigating the Internet Connection
The Geometry of Radio Astronomy

Informal

Modeling Radio Astronomy