Tsunami Mapping Taskforce

Grades
9-12

Overview:

In this lesson, students simulate participation in a state taskforce to address the problem of mapping tsunami inundation for coastal communities. Students also learn the strengths and weaknesses of several digital mapping methods. This lesson will take more than one class period.

Targeted Alaska Grade Level Expectations:

Science

[9] SA1.1 The student demonstrates an understanding of the processes of science by asking questions, predicting, observing, describing, measuring, classifying, making generalizations, inferring, and communicating.

[10-11] SA1.1 The student demonstrates an understanding of the processes of science by asking questions, predicting, observing, describing, measuring, classifying, making generalizations, analyzing data, developing models, inferring, and communicating.

[11] SE1.1 The student demonstrates an understanding of how to integrate scientific knowledge and technology to address problems by researching how social, economics, and political forces strongly influence which technology will be developed and used.

[10-11] SE3.1 The student demonstrates an understanding of how scientific discoveries and technological innovations affect our lives and society by researching a current problem, identifying possible solutions, and evaluating the impact of each solution.

Writing

[9-10] 4.5.1 The student documents sources by giving credit for others' ideas, images, and multimedia information, including others' ideas directly quoted or paraphrased by student, by citing sources using a standard method of documentation (e.g., MLA or APA style) (L).

Objectives:

The student will:
- identify strengths and limitations of different digital mapping technologies;
- research and present factors used to prioritize tsunami inundation mapping of various coastal communities; and
- develop and defend an order in which the presented communities receive tsunami inundation mapping.

Materials:

- Computers with Internet access
- STUDENT WORKSHEET: "Digital Mapping Technology Scavenger Hunt"
- STUDENT WORKSHEET: "Tsunami Inundation Mapping Taskforce"
- VISUAL AID: "Homer Tsunami Inundation Map"
- VISUAL AID: "Synthetic Aperture Radar (SAR)"
- VISUAL AID: "Light Detection and Ranging (LIDAR)"
- VISUAL AID: "Multibeam Swath Bathymetry"

Whole Picture:

NOAA's National Tsunami Hazard Mitigation Program

As part of NOAA's National Tsunami Hazard Mitigation Program, the Geophysical Institute at the University of Alaska Fairbanks and the Alaska Division of Geological and Geophysical Surveys are committed to developing tsunami inundation maps for coastal communities along the Gulf of Alaska. Tsunami inundation maps are a valuable resource in planning for the safety of a community. However, the production of these maps is a significant investment. The Alaska Division of Emergency Services evaluates coastal communities based on several factors to determine the sequence in which maps will be completed.

These factors include:

- Is the community designated a TsunamiReady community?
- What is the potential for the community to be affected by a distant tsunami?
- What is the potential for the community to be affected by a local tsunami or seiche?
- What is the degree of community involvement in addressing safety from natural hazards?
- What is the quality of bathymetric data for the community?
- Are there other maps available for this community, specifically Large Scale USGS Base Maps, LIDAR maps, SAR Space Base Maps or SAR Air Maps?
- What is the population of the community?
- How developed is the infrastructure of the community? Are the locations of infrastructure mapped?
- To what degree does the community support industry (tourism, logging, fishing, etc.)?

Making the Maps

To make tsunami inundation maps for a community, tsunami modelers work with bathymetric and topographic data, sources of potential tsunamis, and historical run-up data. Then, they use supercomputers at the Arctic Region Supercomputing Center to numerically simulate a tsunami wave. The technology used to gain the appropriate mapping data has strengths and limitations. Tsunami modelers must consider the following for making maps of Alaskan communities (Suleimani et al., 2007):

- Lack of adequate digital bathymetric and topographic data for many Alaskan coastal communities;
- Large changes in water depths and land elevations that are caused by the 1964 earthquake, most of the existing data do not reflect present conditions;
- Very irregular shoreline;
- Large tidal ranges;
- Lack of information used in merging bathymetric and topographic data for inundation modeling in Alaska.

Tsunami inundation mapping for Homer, Seldovia, and Kodiak (including Women's Bay and the US Coast Guard Station) are complete.

Some Digital Data Collection Methods

These data are used as input for numerical models.

Synthetic Aperture Radar (SAR)

SAR satellites or airplanes gather images of Earth's surface. A microwave signal is sent toward Earth's surface then bounces back to the source. This determines elevation. Scientists look at the backscatter, or quality of the received signal, to determine the type of material the signal hit (vegetation, buildings, mountains, etc.) After gathering many signals, an image is created. This method can create high-resolution images.

Light Detection and Ranging (LIDAR)

To create digital mapping data with LIDAR, a plane flies over the land and sends pulses of narrow, high frequency laser beams toward Earth's surface. To create a swath, a mirror directs the laser in an oval-shaped pattern. This elevation data is linked with a global positioning system (GPS) sensor that gathers latitude and longitude data. This method can produce high-resolution imagery. LIDAR is also used to map bathymetry up to depths of 50 meters in clear water. Mapping through water requires more time because the time for the signal to travel through the medium (water rather than air) is slower. The quality of data decreases as water clarity decreases and turbidity increases.

Multibeam Swath Bathymetry

Multibeam swath bathymetry works by sending out sound pulses in a fan shape from a transducer on the bottom of a ship or submersible vehicle. The sound pulses travel to the seafloor then bounce back. The depth of the ocean is calculated by the time it takes for the sound pulse to return to the source. This technology creates high-resolution maps of the sea floor. The backscatter, or amount of energy that returns to the source, can help determine the material (sand, rock, etc.) that lies on the seafloor.

Activity Preparation:

It may be helpful to write key vocabulary words on the board: topography, bathymetry, tsunami inundation, and backscatter.

Activity Procedure:

1. Explain students will explore what is necessary to make tsunami inundation maps for Alaska's coastal communities. Tsunami inundation mapping is very useful for communities to reduce risk of damage from future inundation. However, it is also very costly in time and resources. Only one community may be addressed at a time. Therefore it is very important to evaluate and prioritize the communities to be mapped. Display VISUAL AID: "Homer Tsunami Inundation Map" as an example. Explain what goes into making the maps using the section *Making the Maps* in the *Whole Picture* section.
2. Explain that it would be useful to understand some of the methods used to get digital mapping data. Distribute STUDENT WORKSHEET: "Digital Mapping Technology Scavenger Hunt" and display each VISUAL AID. As each visual aid is displayed, share the corresponding information from the *Whole Picture* section. Students should complete each section of the worksheet as each mapping method is addressed.

Critical Thinking: Think-Pair-Share method. Pose a question, then allow think time of at least 5 seconds. Ask students to share their response with a partner. Call on pairs to share responses with the class. Use this method to encourage students to consider some possible limitations for each type of mapping method.

- SAR: Examine the sample image of the archipelago on the VISUAL AID: "Synthetic Aperture Radar (SAR)." What is a possible limitation for using this type of data? *(cloud cover obstructing view, water surface is visible but not depth)*
- LIDAR: What is a possible limitation for this mapping method? *(flights depend on weather, maps up to 50 meters in clear water, turbidity decreases quality.)*
- Multibeam swath bathymetry: What is a possible limitation for this mapping method? *(near shore bathymetry depends on how close to shore the vessel may reach)*

3. Explain that once tsunami modelers have this type of information, they have to tackle the problem of lining up bathymetric and topographic data from different sources to create elevations and depths that include the areas above and below the coastline and account for different tidal levels. Then, they perform mathematical and numerical modeling of tsunami waves using these data sets.
4. Distribute STUDENT WORKSHEET: "Tsunami Inundation Mapping Taskforce." Review the task and requirements. Explain the type of format you prefer students to use in citing sources of information (APA or MLA). See *Extension Idea* for other possible requirements. This project may be completed individually or in groups.
5. After students have gathered information, they will present information to the class using PowerPoint. Students should take notes so information, can be aggregated on the board in the form of a chart to help prioritize. For example:

Community	Population	Infrastructure	Industry	TsunamiReady	Tsunami History	Community Involvement
Community a						
Community b						
Community c						

6. Guide class discussion to determine the order of community tsunami inundation mapping. Guide the class in discussing which factors may be manipulated most easily to change a community's standing in the prioritization.

Extension Ideas:

Ask students to rationalize their own order of tsunami mapping in writing. This will address Alaska Writing GLEs [9-10] 4.2.2.

Answers:

STUDENT WORKSHEET: "Digital Mapping Technology Scavenger Hunt"

<table>
<tr><td colspan="2">SAR:
Sketch and describe the operation used to gather mapping data using SAR.
Student sketch and description should show understanding of operation and key components using the information on VISUAL AID: Synthetic Aperture Radar (SAR).</td></tr>
<tr><td colspan="2">What does it map? (Check all that apply)
⊙ land ⊙ land coastal areas ○ near-shore bathymetry ○bathymetry</td></tr>
<tr><td>Strengths:
Produces high-resolution imagery.</td><td>Limitations:
Cloud cover obstructs view.
Views surface of water and not depth.</td></tr>
<tr><td colspan="2">LIDAR:
Sketch and describe the operation used to gather mapping data using LIDAR.
Student sketch and description should show understanding of operation and key components using the information on VISUAL AID: Light and Detection Ranging (LIDAR).</td></tr>
<tr><td colspan="2">What does it map? (Check all that apply)
⊙ land ⊙ land coastal areas ⊙ near-shore bathymetry ○bathymetry</td></tr>
<tr><td>Strengths:
Produces high-resolution imagery.
Topography and some bathymetry.</td><td>Limitations:
Flights depend on weather.
Maps up to 50 meters in clear water.
Turbidity decreases quality.</td></tr>
<tr><td colspan="2">Multibeam Swath Bathymetry:
Sketch and describe the operation used to gather mapping data using multibeam swath bathymetry.
Student sketch and description should show understanding of operation and key components using the information on VISUAL AID: Multibeam Swath Bathymetry.</td></tr>
<tr><td colspan="2">What does it map? (Check all that apply)
○ land ○ land coastal areas ○ near-shore bathymetry ⊙bathymetry</td></tr>
<tr><td>Strengths:
Produces high-resolution imagery.</td><td>Limitations:
near shore bathymetry depends on how close to shore the vessel may reach</td></tr>
</table>

Lesson Information Sources:

Alaska Earthquake Information Center. (n.d.) *Tsunami Inundation Mapping for Alaska Communities*.

Labay, K.A., and Haeussler, P.J. (2008.) *Combined high-resolution LIDAR topography and multibeam bathymetry for Northern Resurrection Bay, Seward, Alaska*: U.S. Geological Survey Data Series 374, 6 pages.

Suleimani, E., West, D., Hansen, R., & Combellick, R. (2007). *Tsunami Inundation Mapping for Coastal Communities*. Presentation to Alaska Seismic Hazards Safety Commission.

Name:___________________________

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Digital Mapping Technology Scavenger Hunt

Student Worksheet (1 of 2)

Tsunami inundation maps are very useful for evacuation planning and public education to reduce risk from future tsunamis. Tsunami maps made by the Alaska Earthquake Information Center and the Arctic Region Supercomputer Center use digital mapping, historical runups, and hypothetical tsunami scenarios to determine the inundation line for the worst-case scenario through numerical modeling. To understand the types of data used and their strengths and limitations, complete the table below.

SAR:
Sketch and describe the operation used to gather mapping data using SAR.

What does it map? (Check all that apply)
O land O land coastal areas O near-shore bathymetry O bathymetry

Strengths:	Limitations:

LIDAR:
Sketch and describe the operation used to gather mapping data using LIDAR.

What does it map? (Check all that apply)
O land O land coastal areas O near-shore bathymetry O bathymetry

Strengths:	Limitations:

Name:____________________________

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Digital Mapping Technology Scavenger Hunt

Student Worksheet (2 of 2)

Multibeam Swath Bathymetry:
Sketch and describe the operation used to gather mapping data using multibeam swath bathymetry.

What does it map? (Check all that apply)

O land O land coastal areas O near-shore bathymetry O bathymetry

Strengths:	Limitations:

Name:___________________________

Grades

9-12

Tsunami Inundation Mapping Taskforce

Student Worksheet

You are a member of the Alaska Division of Emergency Services. You and other members of your class are tasked with determining the order in which tsunami inundation mapping will take place. Tsunami inundation maps are a valuable tool, but are costly in time and resources. Research a community along the Gulf of Alaska or Aleutian Islands then answer the following questions. Present the information to the class via PowerPoint. As a class determine which communities should take priority.

Community: ____

To answer questions #1-3, view the Alaska Community Database Community Information Summaries (http://www.commerce.state.ak.us/dca/commdb/CF_CIS.htm).

1. What is the population of the community?
2. How developed is the infrastructure of the community? Is the infrastructure mapped? Infrastructure is the basic facilities, services, and installations needed for the functioning of a community, such as transportation (roads) and communications systems, water and power lines, and public institutions including schools, post offices, schools, and prisons.
3. To what degree does the community support industry (tourism, logging, fishing, etc.)?
4. Is the community designated a TsunamiReady community? If not, see the TsunamiReady guidelines (http://www.tsunamiready.noaa.gov/guidelines.htm) to consider some necessary steps for the community to be TsunamiReady.
5. What is the potential for the community to be affected by tsunami? See the NOAA/WDC Historical Tsunami Database at NGDC (http://www.ngdc.noaa.gov/hazard/tsu_db.shtml) and select Tsunami Runup Search. Enter your community in “Runup Location Name” then Search. To find specific details about the tsunami events like the source, click on hyperlinks in the tsunami search (Tsu Src) and earthquake magnitude (EQ Mag) columns.

Bonus: What is the degree of community involvement in addressing safety from natural hazards? Can you find anything to answer this question? Does the community have a plan or a brochure to address hazards in the community?

Sources of information must be credited.