

VISUALIZATION 1: VISUALIZING GLOBAL EARTHQUAKES - WHERE AND WHY DO EARTHQUAKES OCCUR?

as part of the series:

'Global Earthquakes: Teaching about Earthquakes with Data and 3D Visualizations'

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Activity Description

Summary of the activity:

The purpose of this activity is to introduce students to the distribution of earthquakes on the surface of earth and how their distribution is related to the geometry and type of plate boundaries. Because the depth of earthquakes can be difficult for students to visualize in 2D representations, this activity allows students to visualize the 3D distribution of earthquakes within Earth's surface, which is essential for understanding how different types of earthquakes occur in different tectonic settings. Talking points and questions are included to use this visualization as part of an interactive lecture. In addition to playing back the visualization, instructors can also download the visualization software and data set and explore it themselves.

Intended audience:

Introductory level undergraduate students, although this visualization could be adapted for younger students with more background given.

Teaching materials:

Computer and projector to run and project visualization movie.

Conceptual Learning Goals:

- The lithosphere is broken into plates of different and uneven sizes and shapes, and these plates fit together like a puzzle that covers the entire surface of Earth.
- Earthquakes are not distributed randomly, and most earthquakes occur in distinct narrow belts.
- These belts of earthquakes define the boundaries of tectonic plates because earthquakes happen in places where rocks break and move, so earthquakes occur where movement of the crust is taking place, which happens the most at plate boundaries.
- Most earthquakes are concentrated along boundaries between major tectonic plates, especially in subduction zones and along transform faults, with fewer occurring along spreading ridges.
- Earthquakes only occur on the thin veneer on the surface of the earth.

Higher Order Thinking Skills Goals:

- Synthesize large data sets to recognize naturally occurring patterns
- Use patterns in data sets to make and test predictions about the distribution and characteristics of earthquakes
- Visualize data in 3D that is traditionally represented in 2D

Instructor's Notes

How to run the activity:

This visualization is to be used as the first visualization in this series, or alone.

This visualization can be used in any class format, and is presented here in a way that is especially conducive for use in a lecture-based course, including very large lecture courses.

Begin the movie and use the 'talking points' given below to highlight key aspects of the visualization to your students. When you reach a "*Quakes Question*", pause the visualization and ask your students the question. Instruct them to write down their ideas as you begin playing the visualization again. Once they have written down some ideas, pause the movie again, and either have them discuss their observations with a partner, or choose a few students to share with the entire class. Continue playing the visualization and pausing for questions and discussion.

Background for students:

Introduce these concepts prior to showing the visualization. Key terms are in **bold**.

- What is an earthquake?
- Causes of earthquakes: Earthquakes are places where rocks break and move; strain accumulates as there is movement of rock, and then the strain releases all at once as the rock breaks during an earthquake.
- Plate tectonics: The lithosphere is made up of **tectonic plates** that fit together covering the outer surface of earth like a jigsaw puzzle. Tectonic plates fit together in a couple of different ways – some separate, others collide, and others slide past one another.
 - Plates move away from each other at **divergent boundaries**.
 - Plates move toward each other at **convergent boundaries**.
 - Plates slide past each other at **transform boundaries**.
- Hypocenter vs. epicenter: They **hypocenter** is the place where the rock ruptures and slips, and energy radiates away from this point. The hypocenter can be beneath Earth's surface, and often is. The **epicenter** is the point on Earth's surface directly above the hypocenter. This is what is typically shown on maps of earthquakes.
- Magnitude: The **magnitude** of an earthquake is a measure of the amount of ground movement that happens during an earthquake event.

Talking points:

- [0:00] Imagine that we are out in space and we are looking towards the earth. What do we see? We notice regions of land, sea, and ice. We also notice features with tall mountains and deep trenches. From here, we are looking at the outermost layer of earth, the lithosphere, which is made up of **tectonic plates**.

- These tectonic plates move as the uppermost layer of Earth. They move apart, they collide, and they slide side by side. Motion along these plates causes earthquakes.
- [0:27] This is a data set of all earthquakes since 1900 with a magnitude greater than 5.
 - Approximately 70,000 earthquakes are plotted. Each point is the **hypocenter** of the earthquake.
 - The color of the dot indicates its magnitude. Green points are the smallest magnitude and red points are the largest magnitude.
- Typically we only view data sets like this in two dimensions with points plotted on a rectangular map. By viewing the earth in this virtual 3D model we can observe a lot more things about what is going on, and we can change our perspective of what we want to look at. For example, we can look at earth from the outside, and we can see the location of earthquakes as we are used to seeing them on maps. Because the surface of the earth is transparent, we can also see where the earthquakes are in 3D, relative to the surface of earth.

‘Quakes Question #1: Make some observations about how earthquakes are distributed on Earth.

Key Observations:

- Earthquakes are only at the surface of Earth and just below the surface, and the hypocenters are not very deep.
- Earthquakes are not distributed uniformly or randomly across the whole surface of earth, but rather they are in distinct narrow belts.
- Earthquakes occur in the oceans, on edges of continents, and within continents.

- [1:07] Now let’s look specifically at this zone of earthquakes at the western edge of South America. Trace that belt of earthquakes to make an enclosed shape. That belt of earthquakes outlines a **tectonic plate** – this plate is called the Nazca Plate [teacher trace outline on screen or with a pointer].
- [1:24] This visualization allows us to see the location of earthquakes in this belt in 3 dimensions.

‘Quakes Question #2: What happens to the belt of earthquakes under the western margin of South America?

- Some earthquakes occur at depth, below the uppermost surface of Earth.

- As you observed, belts of earthquakes occur all over the Earth – in ocean, on the edges of continents, and sometimes within continents. These belts of earthquakes define boundaries of **tectonic plates**.
- [1:42] One of the ways that these plate boundaries were first recognized was from where earthquakes are located. We can overlay a map of tectonic plates, and you can see that the boundaries where the plates meet occur in the zones of earthquake belts. Each of these lines represents a **plate boundary zone**. Where two plates meet is not just one plane, but rather it is a broad area over which earthquakes occur where the plates come together.

- [2:15] Earthquakes with different characteristics occur at different types of tectonic boundaries. This is because different processes happen whether the plates are moving towards each other, moving apart, or sliding past each other.

'Quakes Question #3: Add to your list of observations about earthquake distribution. Pay attention to the patterns of earthquakes in oceans, on edges of continents, and in the middle of continents. Also note the depth of earthquakes in these different settings.

[No class discussion after this – leave the ideas open for later discussion with modules 2-3. Either leave it hanging so students can keep thinking about it OR have students compare their observations with a partner after watching the video and add any additional shared observations to make their own more complete.]

(NOTE: The talking points and 'Quakes Questions' could easily be adapted to an inquiry activity that students complete on their own as they watch the video.)

Evaluation:

'Quakes Questions' throughout the activity are short-answer questions that students answer while the visualization is playing to ensure that they are taking away key concepts.

In addition, 'ConcepTest' questions can also be used to assess whether students have met the goals of the activity. Because this activity provides a highly visual/spatial way of learning about earthquakes and plate boundaries the assessments should also be visual/spatial. ConcepTests are questions that focus on key concepts. Poll your students in class with these questions to ensure understanding before moving on.

ConcepTest questions can be found at <http://serc.carleton.edu/introgeo/conceptests/index.html>.

Suggested questions:

<http://serc.carleton.edu/introgeo/conceptests/examples/eqplateboundaries.html>

**Note that some of these questions require students to interpret 2D representations of earthquake distribution, and some students may have difficulty mentally translating from the 3D visualization to the 2D questions causing them to answer incorrectly even if they conceptually understand.

Software download:

The visualization software used to create this visualization is freely available and can be downloaded from <http://keckcaves.org/education/>. In addition to playing back the visualizations available here, instructors can also download the visualization software and data sets and explore it themselves. Download the software and quick-start guide to begin exploring your own data sets in your classroom.