Module Overview

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https://pxhere.com/en/photo/1074673

Module Components

…Plus all supporting materials

Module Components

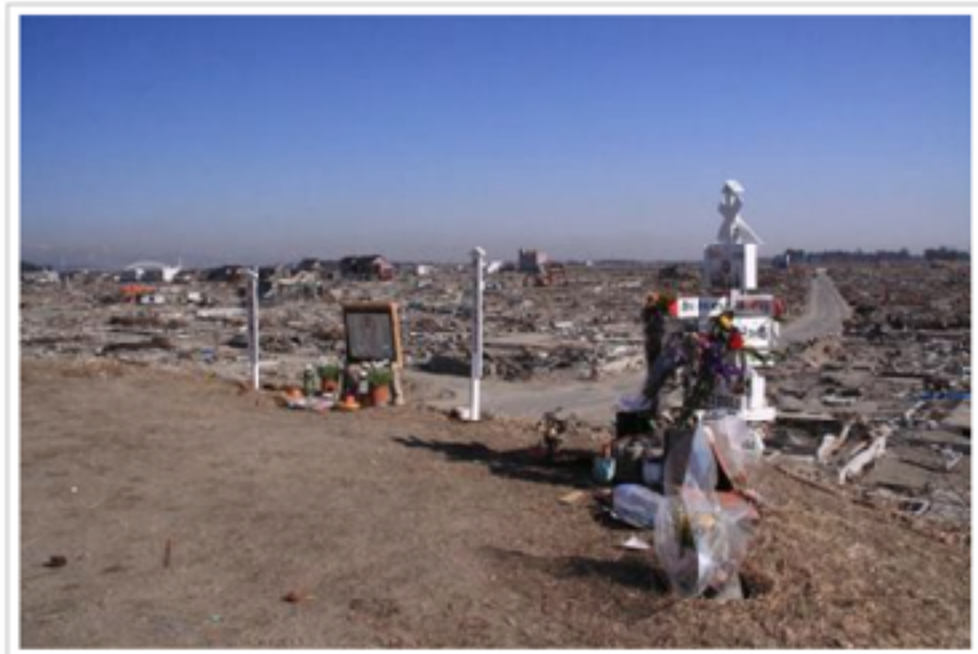
Unit 1: Earthquake!

…Plus all supporting materials

Summary

In this opening unit, students develop the societal context for understanding earthquake hazards using as a case study the 2011 Tohoku, Japan, earthquake. It starts with a short homework "scavenger hunt" in which students find a compelling video and information about the earthquake. In class, they share some of what they have found and then engage in a series of think-pair-share exercises to investigate both the societal and scientific data about the earthquake.

Learning Goals



Unit 1 Learning Outcomes

- Students will be able to **describe** human impacts from the 2011 Tohoku, Japan, earthquake
- Students will be able to **interpret** a variety of images related to the science and human impact of earthquakes

▶ Show more info on how learning outcomes connect to science literacy principles and module goals

Unit 1 Teaching Objectives

- Affective: Provide students with the opportunity to analyze the human impact from an earthquake.
- Cognitive: Facilitate students' ability to interpret a range of data images related to earthquakes.

Two short UNAVCO videos:

Mirror-image subduction settings? What can GPS tell us about future earthquakes?

and

GPS as an essential component of Cascadia earthquake early warning — What have we learned from the Tohoku earthquake & tsunami?

Module Components

Unit 1: Earthquake!

Unit 2: Mashing it up — physical models of deformation and strain

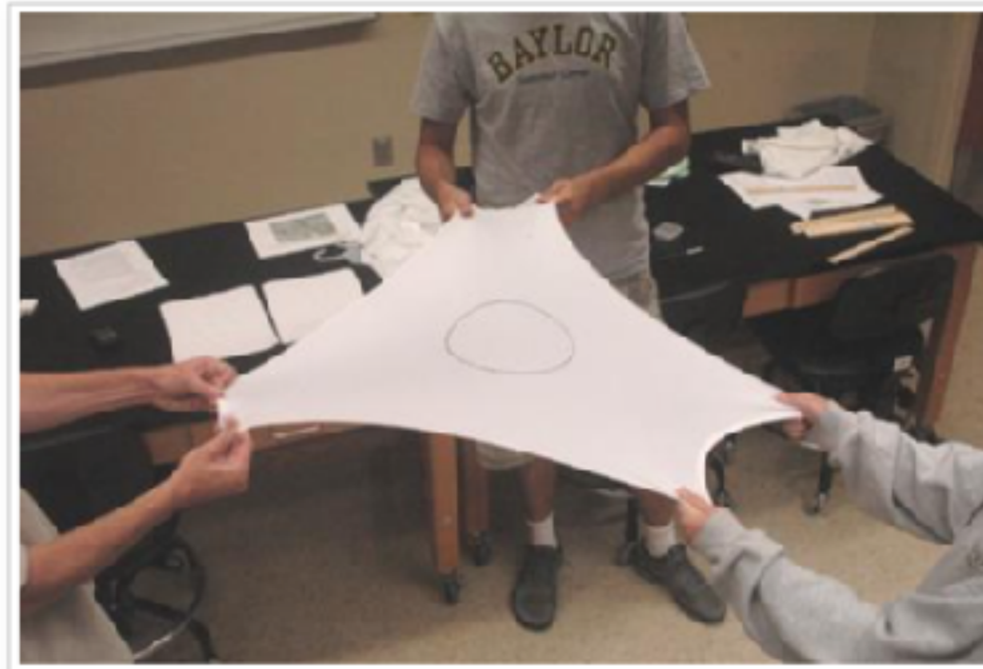
…Plus all supporting materials

Summary

Students gain an intuitive understanding of strain and deformation through a series of physical model activities using everyday materials such as bungee cords, rubber bands, fabric, index cards, silly putty, sand, and more. Can be run to fill an entire lab session exploring multiple materials or as a shorter exercise using just rubber bands and stretchy fabric. An addendum provides mathematical content (vectors, matrices, multidimensional strain) that can be used by instructors interested in building student quantitative skills.

Learning Goals

Unit 2 Learning Outcomes



- Students will be able to **use** physical models to **illustrate** different types of deformation and strain.
- Students will be able to **mathematically calculate** 1-D extension.
- Students will be able to correctly **analyze** and **depict** how a triangle of GPS stations and inscribed circle move or deform during translation, rotation, dilation, contraction, or distortion.

  ▸ Show More info on how learning outcomes connect to science literacy principles and module goals

Unit 2 Teaching Objectives

- Cognitive: Facilitate students' ability to make calculations and depictions related to extension, deformation, and strain.
- Behavioral: Provide an opportunity for students to connect physical models to principles of deformation and strain.

Play Time!

Fun with Silly Putty

Module Components

Unit 1: Earthquake!

Unit 2: Mashing it up — physical models of deformation and strain

Unit 3: Getting started with GPS data

…Plus all supporting materials

Summary

This unit provides essential background information on GPS (global positioning system) and reference frames. Students learn how to access GPS location and velocity data from the Plate Boundary Observatory (PBO). They calculate total horizontal motion graphically and mathematically and tie the observed motions to local strain.

▸ *Show more information on GPS versus GNSS*

Learning Goals

Unit 3 Learning Outcomes

- Students are able to **locate** Plate Boundary Observatory (PBO) GPS stations and **download** precise location and velocity data.
- Students are able to **calculate** the total horizontal GPS velocities both graphically and mathematically.
- Students are able to **predict** the type/s of strain and/or deformation resulting from different velocities at neighboring GPS stations
  ▸ Show more info on how learning outcomes connect to science literacy principles and module goals

Unit 3 Teaching Objectives

- Cognitive: Facilitate student ability to solve infinitesimal strain calculations using multiple quantitative methods and to qualitatively describe the connection between GPS velocities and strain.
- Behavioral: Provide an opportunity for students to access and download GPS data.

Module Components

Unit 1: Earthquake!

Unit 2: Mashing it up — physical models of deformation and strain

Unit 3: Getting started with GPS data

Unit 4: GPS and infinitesimal strain analysis

…Plus all supporting materials

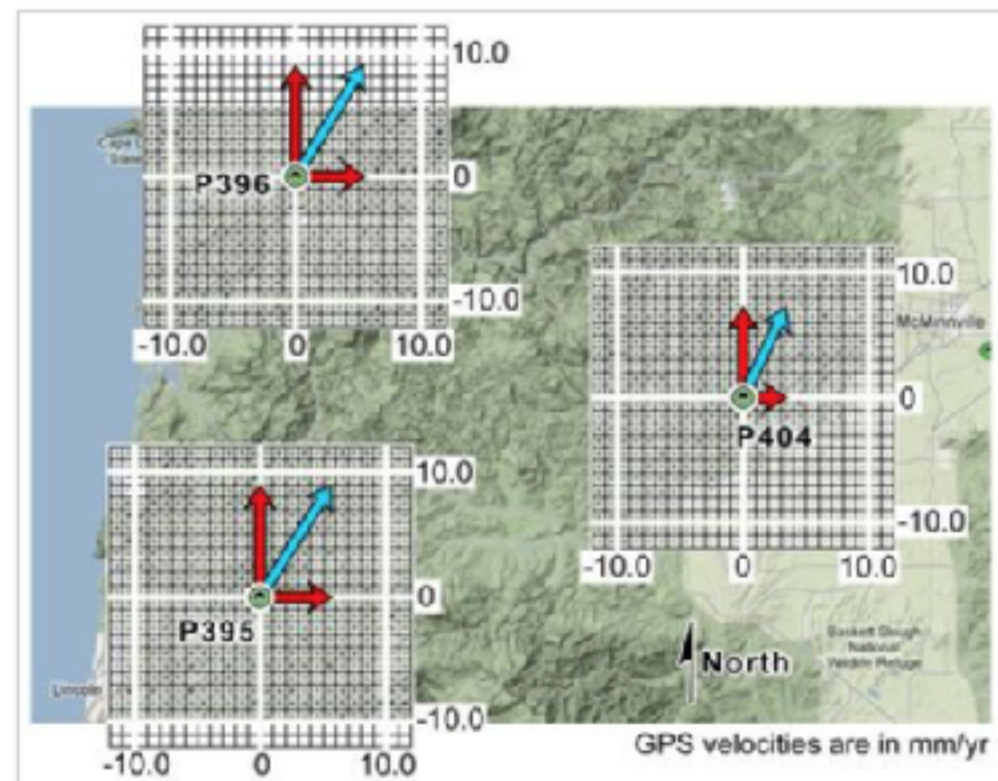
Summary

Students work with GPS velocity data from three stations in the same region that form an acute triangle. By investigating how the ellipse inscribed within this triangle deforms, students learn about strain, strain ellipses, GPS, and how to tie these to regional geology and ongoing hazards. This unit contains the primary infinitesimal strain analysis for the module. After the instructor demonstrates the method using data from Japan, students investigate three different GPS station triangles in three difference tectonic regimes: convergent (U.S. Pacific Northwest), extensional (Wasatch fault, Utah), and strike-slip (San Andreas Fault, California).

▸ *Show more information on GPS versus GNSS*

Learning Goals

Unit 4 Learning Outcomes



- Students will be able to use the GPS Strain Calculator to **compute** how a three-station triangle of GPS stations has rotated, translated, and or strained in relation to a stable reference frame (i.e., in relation to stable North America).
- Students will be able to **analyze** the tectonic and geological implications of the calculated strain, **connect** to regional earthquake risks, and **develop** mitigation strategy proposals.

  ▸ Show more info on how learning outcomes connect to science literacy principles and module goals

Unit 4 Teaching Objectives

- Behavioral: Provide an opportunity for students to learn to use the GPS Strain Calculator and Strain Ellipse Visualization tool.
- Cognitive: Facilitate students' ability to interpret the GPS Strain Calculator output for geologic and tectonic implications.
- Affective: Encourage reflection and analysis of societal impacts of earthquakes.

Module Components

Unit 1: Earthquake!

Unit 2: Mashing it up — physical models of deformation and strain

Unit 3: Getting started with GPS data

Unit 4: GPS and infinitesimal strain analysis

Unit 5: 2014 South Napa Earthquake and GPS strain

…Plus all supporting materials

Summary

The 2014 South Napa earthquake was the first large earthquake (Mag 6) to occur within the Plate Boundary Observatory GPS network since installation. It provides an excellent example for studying crustal strain associated with the earthquake cycle of a strike-slip fault with clear societal relevance. The largest earthquake in the California Bay Area in twenty-five years, the South Napa earthquake caused hundreds of injuries and more than $400 million in damages. This activity uses a single triangle of GPS stations (P198, P200, SVIN), located to the west of the earthquake epicenter, to estimate both the interseismic strain rate and coseismic strain. By the end of the exercise, the students also have direct evidence that considering the recurrence interval on a single fault, which is part of a larger system, is not reasonable. An extension option gives the opportunity to discuss earthquake early warning systems.

▸ Show more information on GPS versus GNSS

Learning Goals

Unit 5 Learning Outcomes

- Students are able to **access** and **analyze** GPS data in order to **calculate** and **interpret** interseismic and coseismic strain in the region between three neighboring GPS stations.
- Students are able to **evaluate** how a calculated recurrence interval relates to the regional strain and fault system.
  ▸ Show more info on how learning outcomes connect to science literacy principles and module goals

Unit 5 Teaching Objectives

- Affective: Encourage reflection and analysis of societal impacts of earthquakes.
- Cognitive: Facilitate students' ability to compare interseismic strain with coseismic displacements.

Module Components

Unit 1: Earthquake!

Unit 2: Mashing it up — physical models of deformation and strain

Unit 3: Getting started with GPS data

Unit 4: GPS and infinitesimal strain analysis

Unit 5: 2014 South Napa Earthquake and GPS strain

Unit 6: Applying GPS strain and earthquake hazard analysis to different regions

…Plus all supporting materials

Summary

Students select their own set of three stations in an area of interest to them, conduct a strain analysis of the area between the stations, and tie the findings to regional tectonics and societal impacts in a 5–7 minute class presentation. For many students this is their first foray into "research" and can be a powerfully eye-opening and exciting (if intimidating) experience. In larger classes, students can work in pairs to shorten total time needed for presentations. Unit 6, along with exam question/s, is the **Summative Assessment** for the module.

Learning Goals

Unit 6 Learning Outcomes

This unit is intended to provide the summative assessment for the entire module. As such the students should demonstrate a mastery of the learning goals for the entire module. These include the following:

1. Students are able to **access** and **analyze** GPS data in order to **calculate** and **interpret** ongoing strain in the region between three neighboring GPS stations.
2. Students are able to **synthesize** how calculated local strain is related to regional tectonics and earthquake hazard and risk and **propose** mitigation strategies.

▸ Show more info on how module goals connect to science literacy principles

Unit 6 Teaching Objectives

Unit 6 is intended to be a synthesis of the different techniques and concepts covered in the module, as applied to a new location of the students' choosing. Support students as they progress through the Unit 6 workflow and, where necessary, help them in recalling and applying previously learned material.

Onward to GPS basics…

Note GPS Basics, from GPS Spotlight site at UNAVCO:
https://spotlight.unavco.org/how-gps-works/gps-basics/gps-basics.html