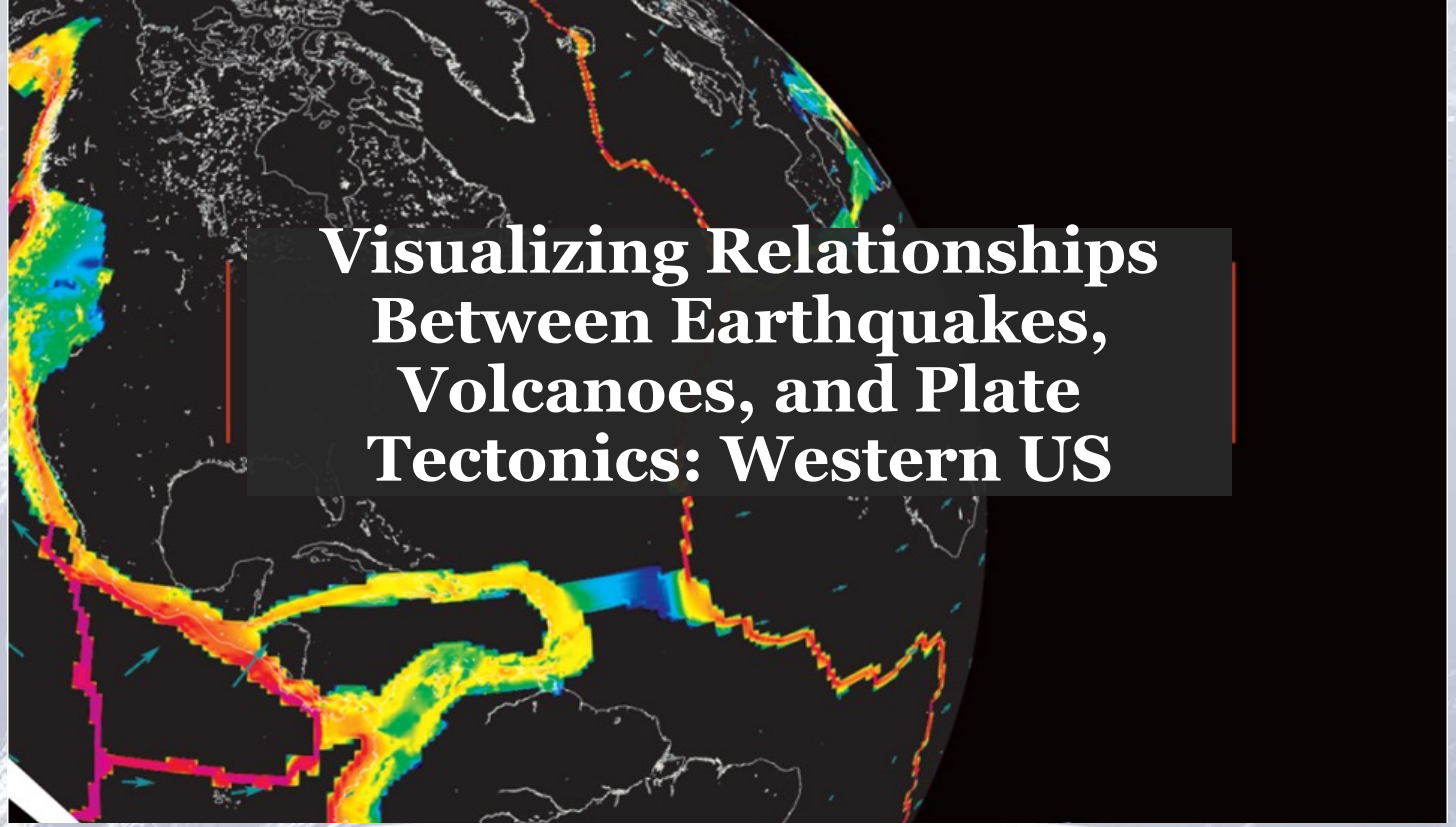

Visualizing Relationships Between Earthquakes, Volcanoes, and Plate Tectonics: Western US

Authors: Ruth Powers (UNAVCO Master Teaching-in-Residence);
Becca Walker and Shelley Olds (UNAVCO)

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National Science Foundation's Geodetic Facility for the Advancement of Geoscience
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Activity Outcomes

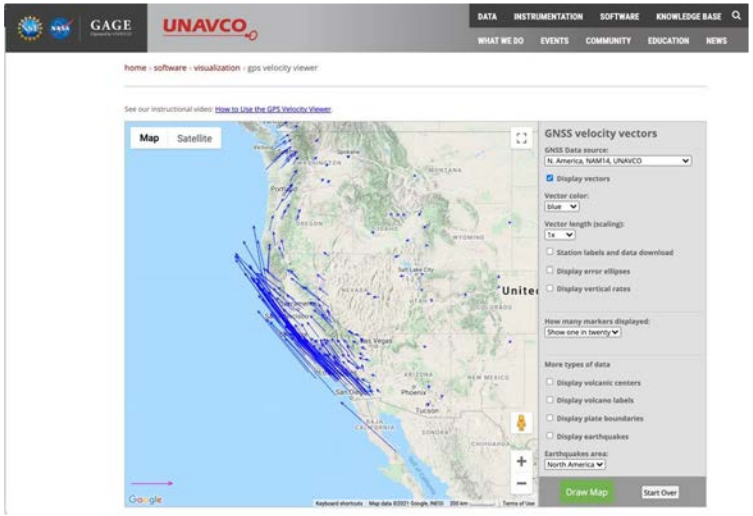
Learners should be able to…

- Describe how the locations of earthquakes, volcanoes, and velocity vectors from GPS stations in the Western United States inform us about plate boundary zones
- Describe and draw a velocity vector
- Analyze regional plate motion and crustal deformation based on velocity vector maps
- Describe the difference between a plate boundary and plate boundary zone
- Describe potential societal impacts of active seismic and volcanic regions

Part 1: Prepare your map for study using the **UNAVCO GPS Velocity Viewer**

Google search for:

UNAVCO GPS Velocity Viewer



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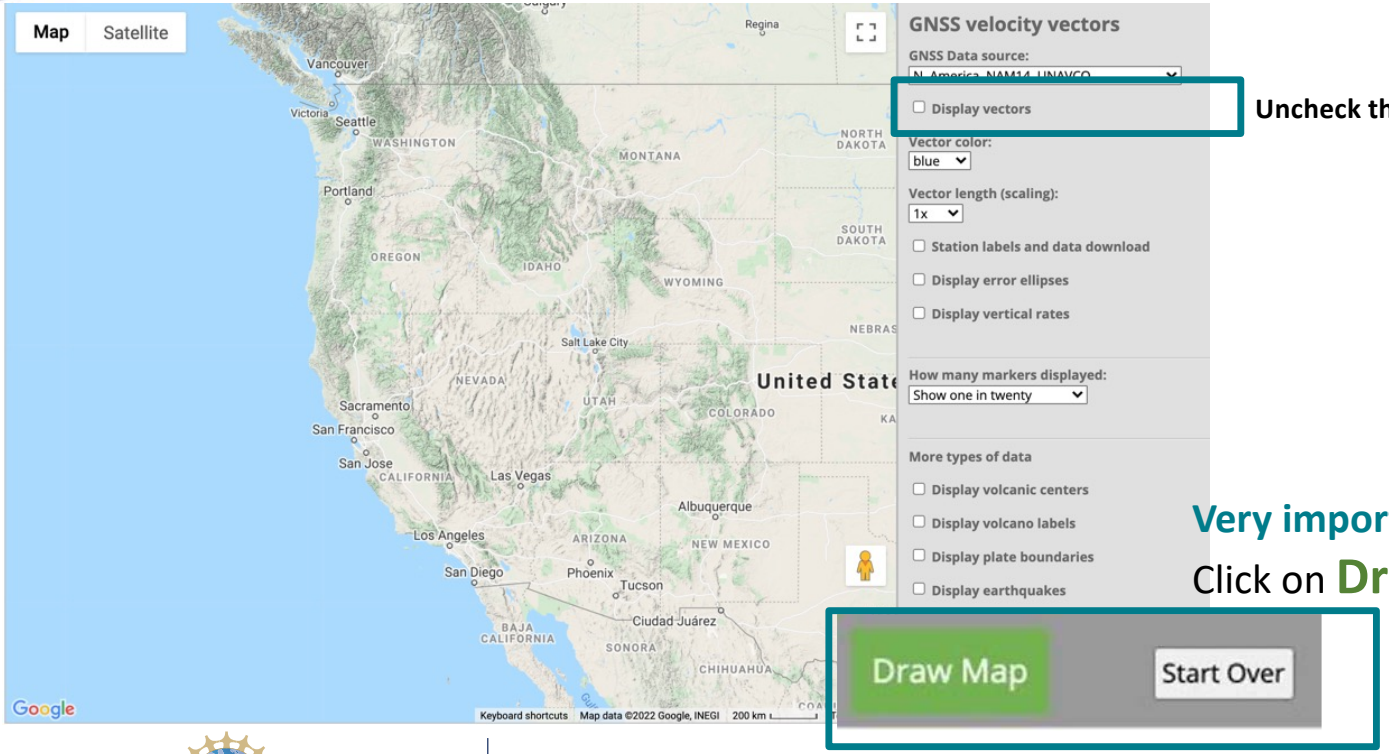
Remove all of the vectors & Reposition the map



Uncheck the box labeled: Display vectors

Very important!!!

Click on **Draw Map** to apply changes

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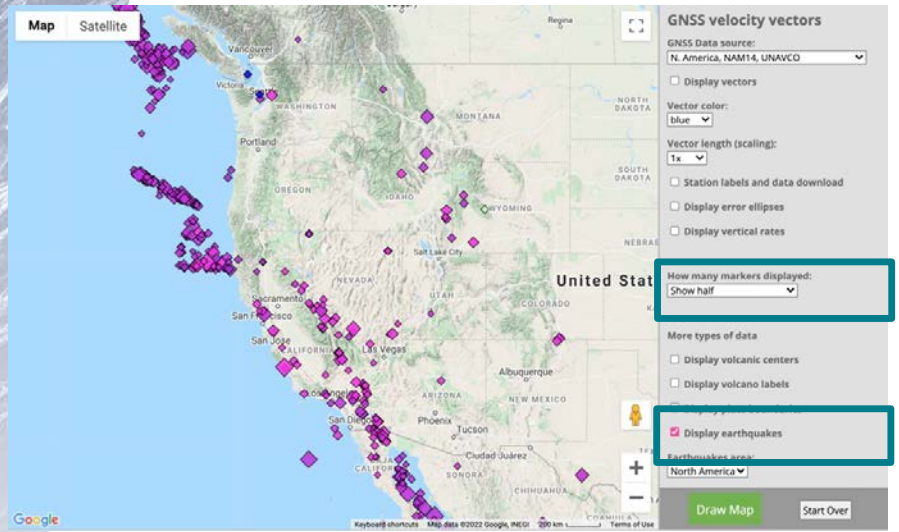
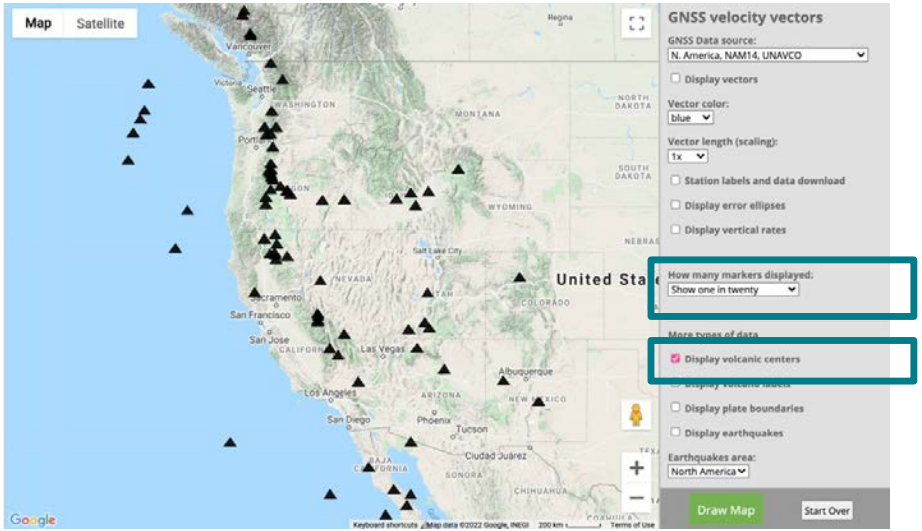
Part 2: Study, Record, & Discuss earthquake and volcano data





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Study, Record, & Discuss

- Work with a partner
- Add your feature (either Earthquakes or Volcanoes)
- Study your map
- Answer the questions
  - How are the data distributed?
  - How would describe the spatial pattern(s) of the data? Are they located near the edges of the continent, mid-continent, in the ocean?
  - At what depth(s) do the earthquakes occur? What other data would be useful?

Compare the Earthquake and Volcano Data

Discussion:

A. What geographic features (mountains, plains, valleys, etc) are found where there are only:
   - Earthquakes?
   - Volcanoes?

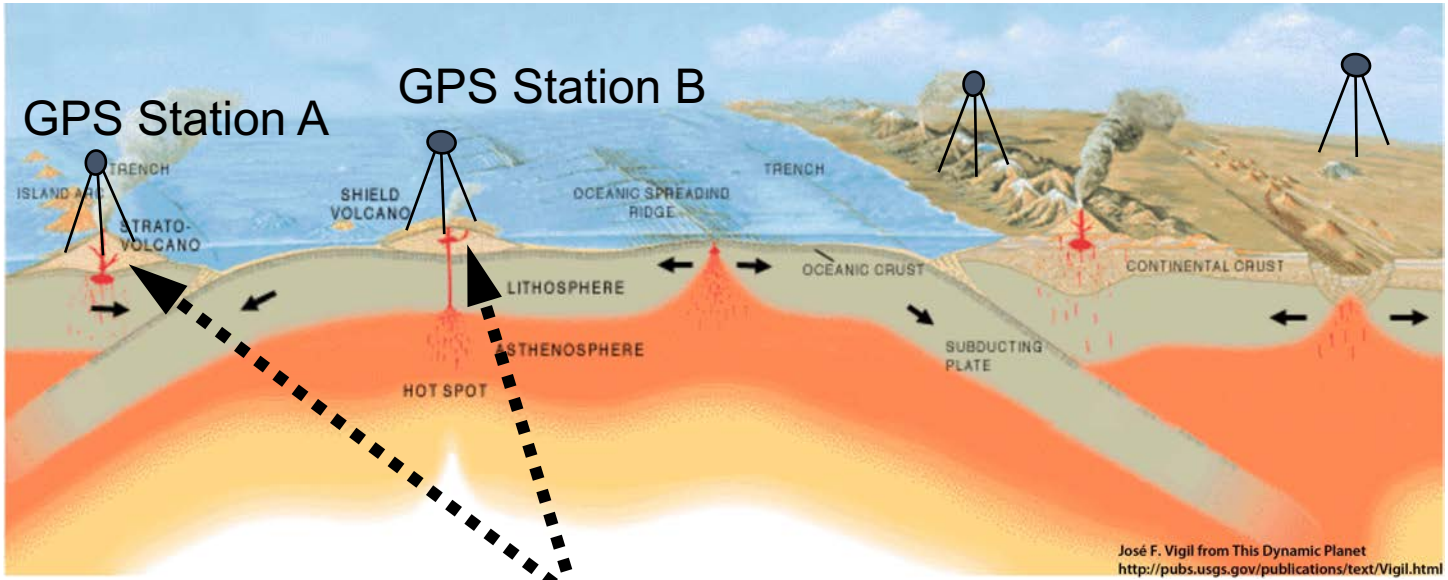
B. In which regions do you find earthquakes and volcanoes near each other? What's there?

C. Summarize the relationships you discovered.

D. What explanation can you provide for the observed relationships?

Part 3: How is Alaska moving over time? Analyzing GPS data

- GPS station positions change as tectonic plates move.



How will the ground under GPS Station A move relative to GPS Station B?

GPS stations are not to scale

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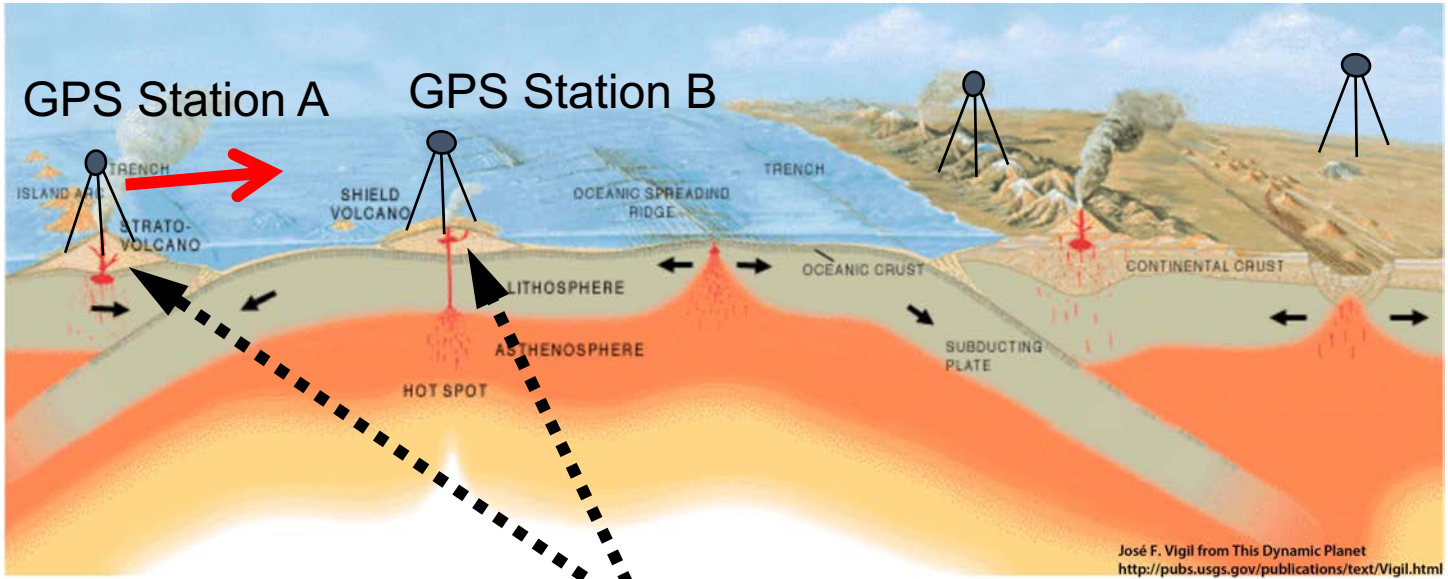
How will the ground under GPS Station A move relative to GPS Station B?



GPS Station A is moving toward GPS Station B.

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GPS stations are not to scale

Anatomy of a High-precision Permanent GPS Station

GPS Monument

- Monument legs attach the GPS antenna to the ground.
- GPS antenna inside of dome

If the ground moves, the GPS station moves.

Additional station equipment

- Solar panel for power
- Equipment enclosure
  - GPS receiver
  - Power/batteries
  - Communications/ radio/ modem
  - Data storage/ memory

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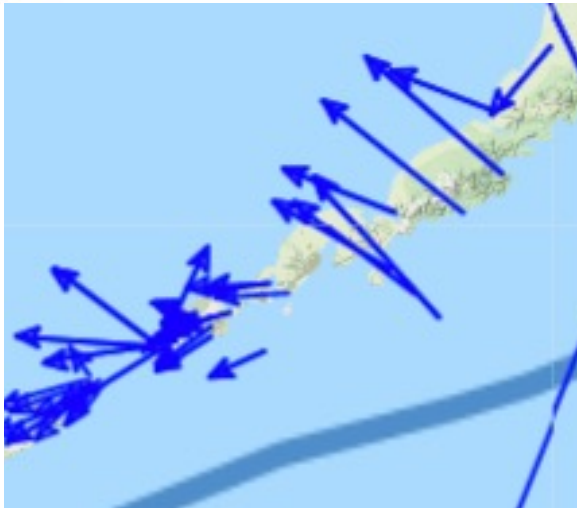
About Velocity Vectors



- Length of the vector arrow = how fast the plate is moving (magnitude).
- Direction of the vector arrow = the direction that the plate is moving *at that GPS station*
- Tail of vector = location of GPS station

Notice the different lengths of the vectors. Where is the ground moving most quickly?

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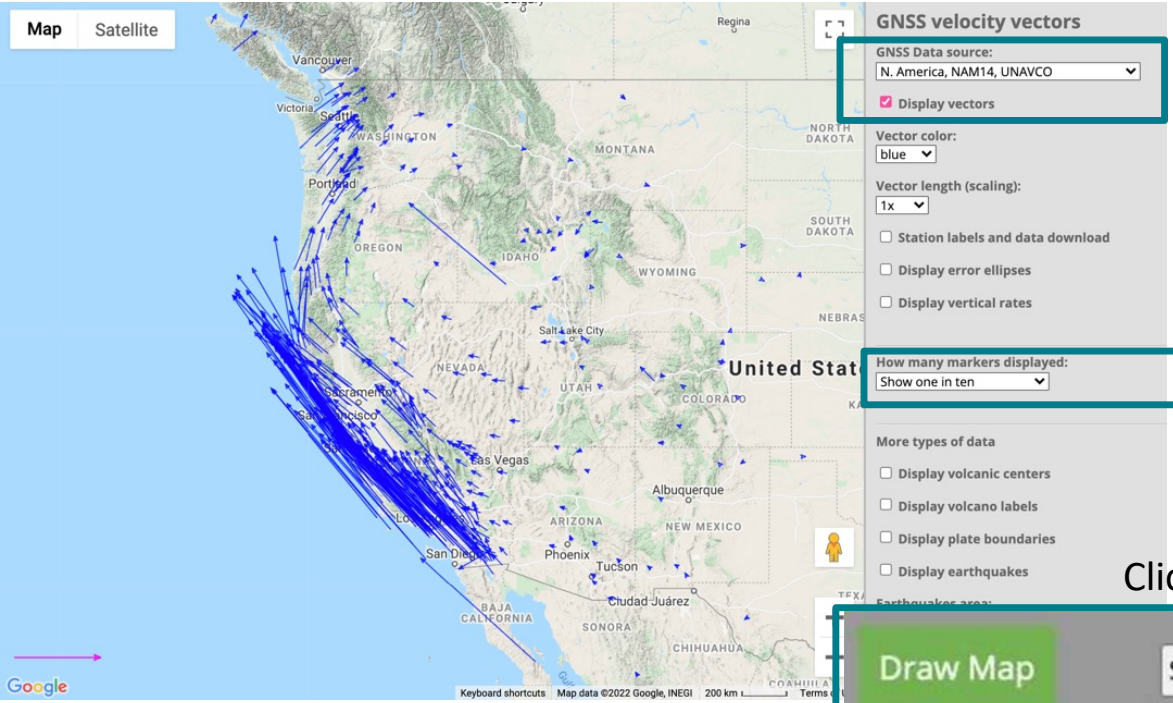
Add Velocity Vectors



Keep the GNSS Data source on N. America.

Check the box next to **Display vectors**

Tip: Select **Show one in ten** for the Western US. Choose one in one hundred before zooming out to continent level.

Click on **Draw Map** to apply changes

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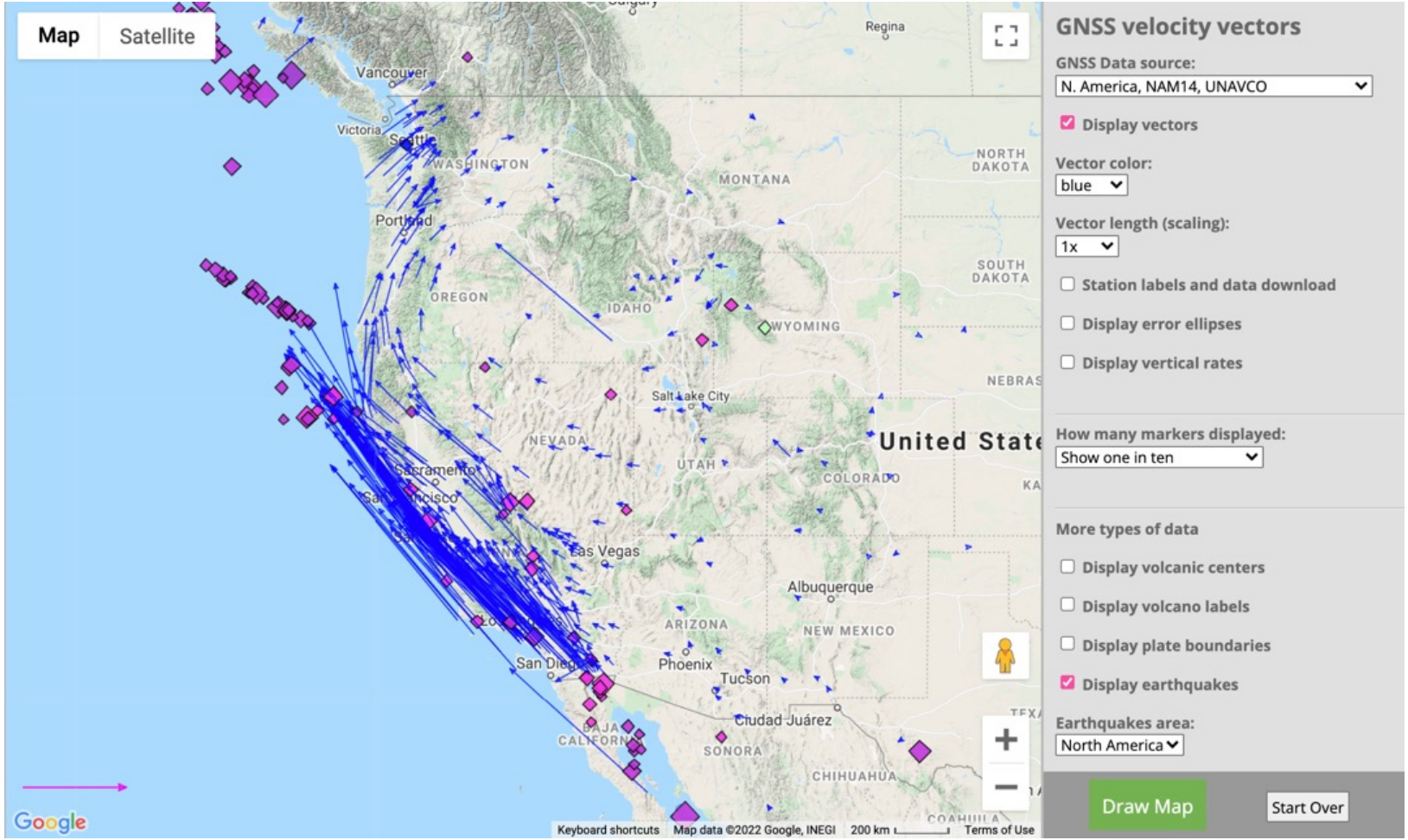
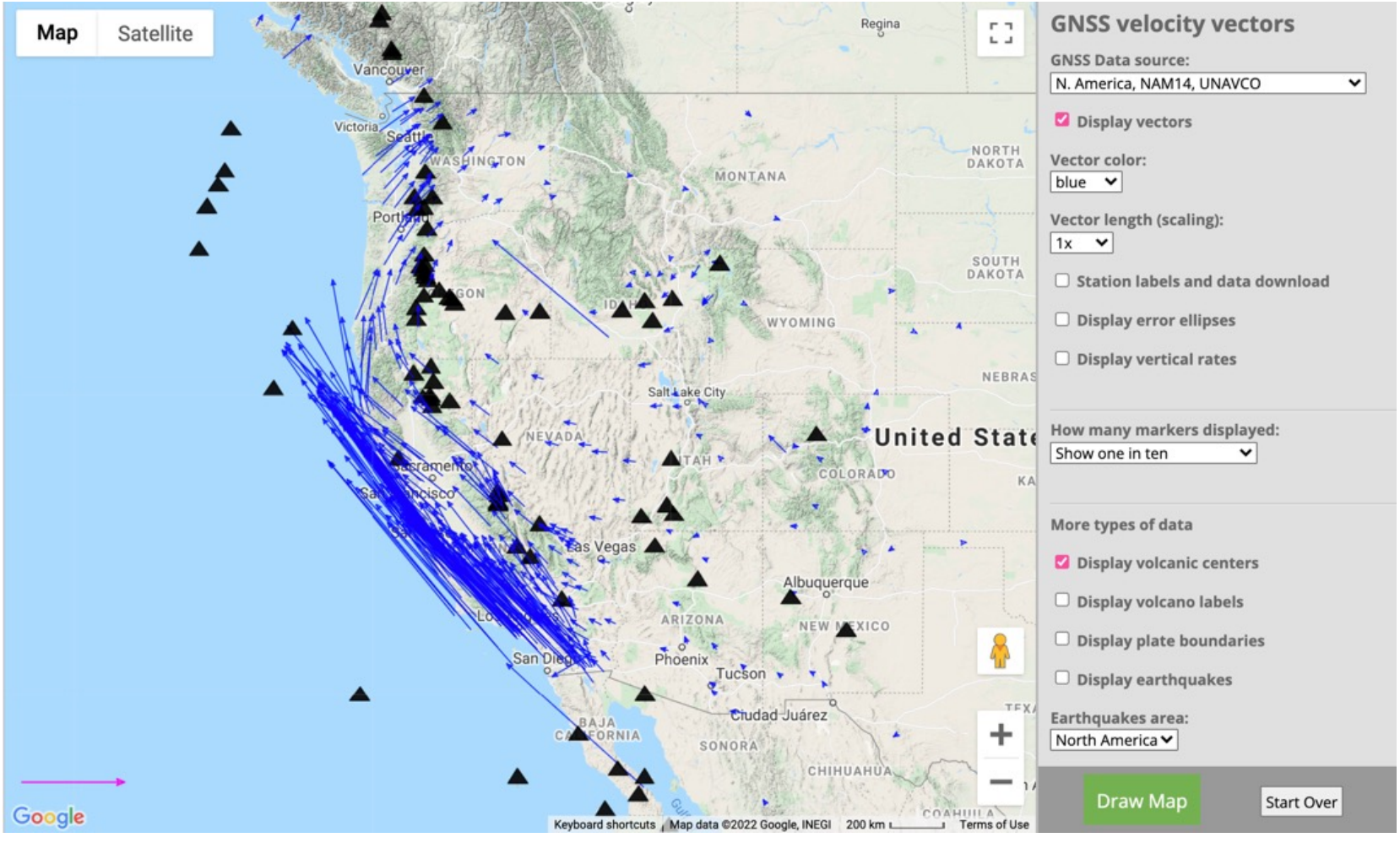
Study & Sketch the Vectors

- Sketch some of the directions & lengths of the vectors.
  - Add different data types (earthquakes, volcanoes, plate boundaries)
  - What do you notice about the length of the vectors (the velocities) from the coast to inland? What patterns do you see?
  - How do the directions of the GPS vectors change?
  - What patterns do you see in different regions?
  - How do the ground motions compare to the locations of earthquakes and volcanoes?

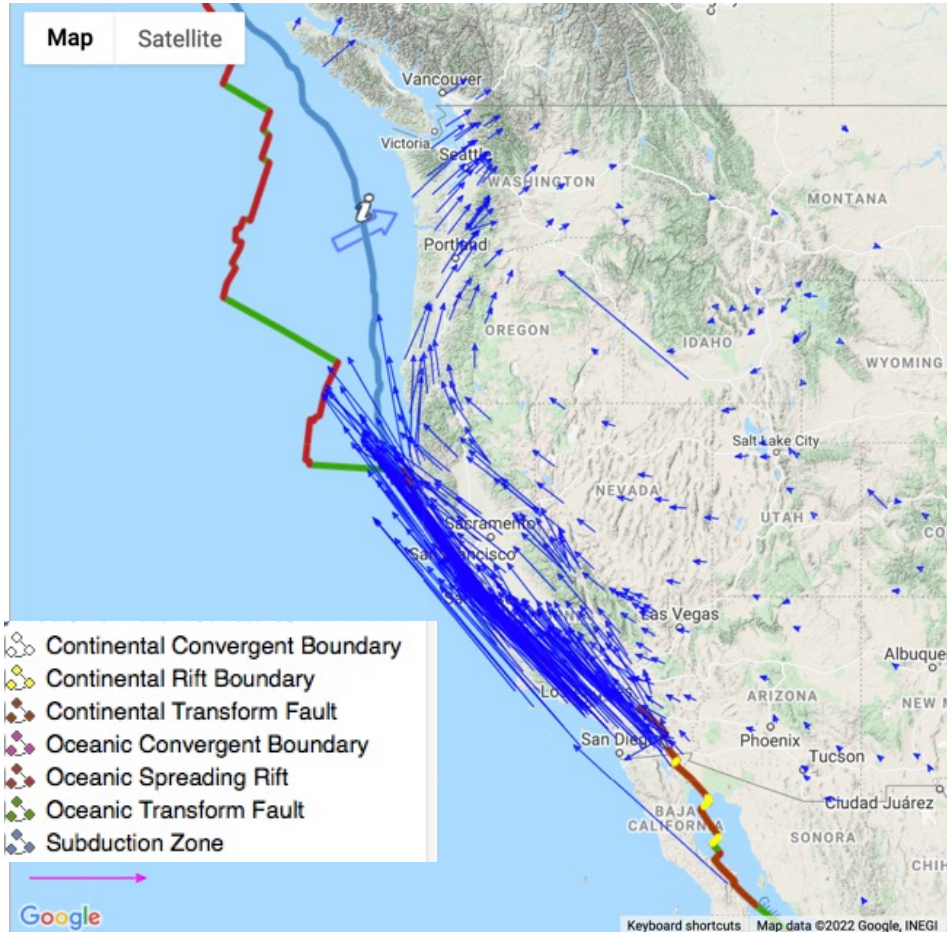
Examples: Earthquakes & Ground Motion



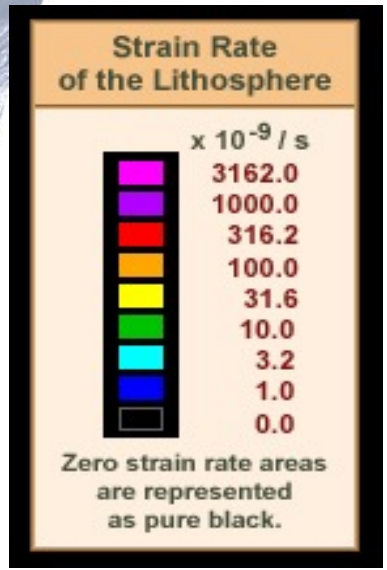
Examples: Volcanoes and Ground Motion

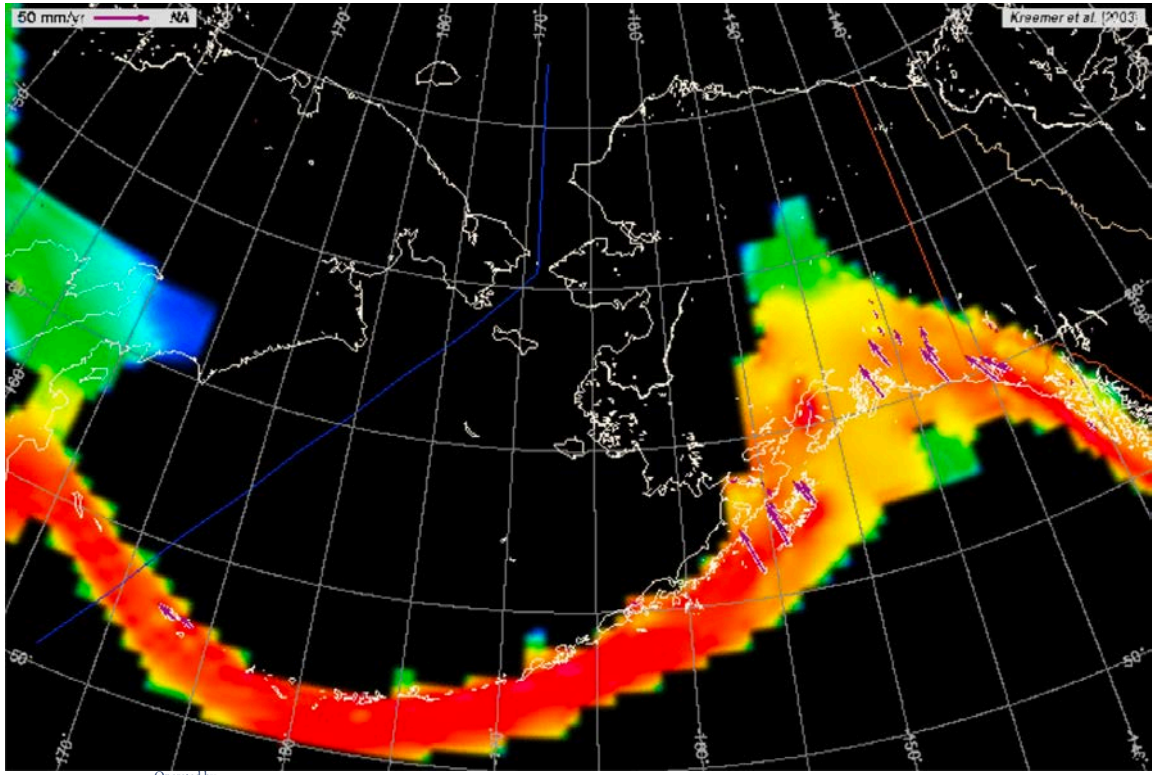


Types of Plate Boundaries



Societal Impacts & Plate Boundary Zones





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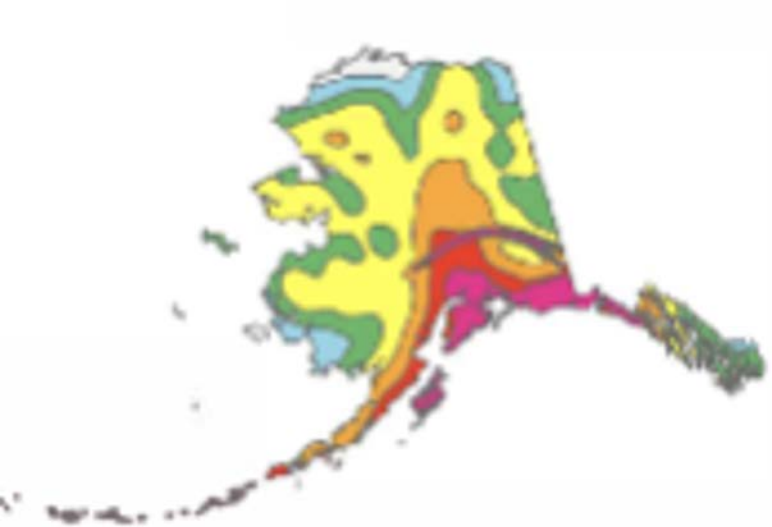
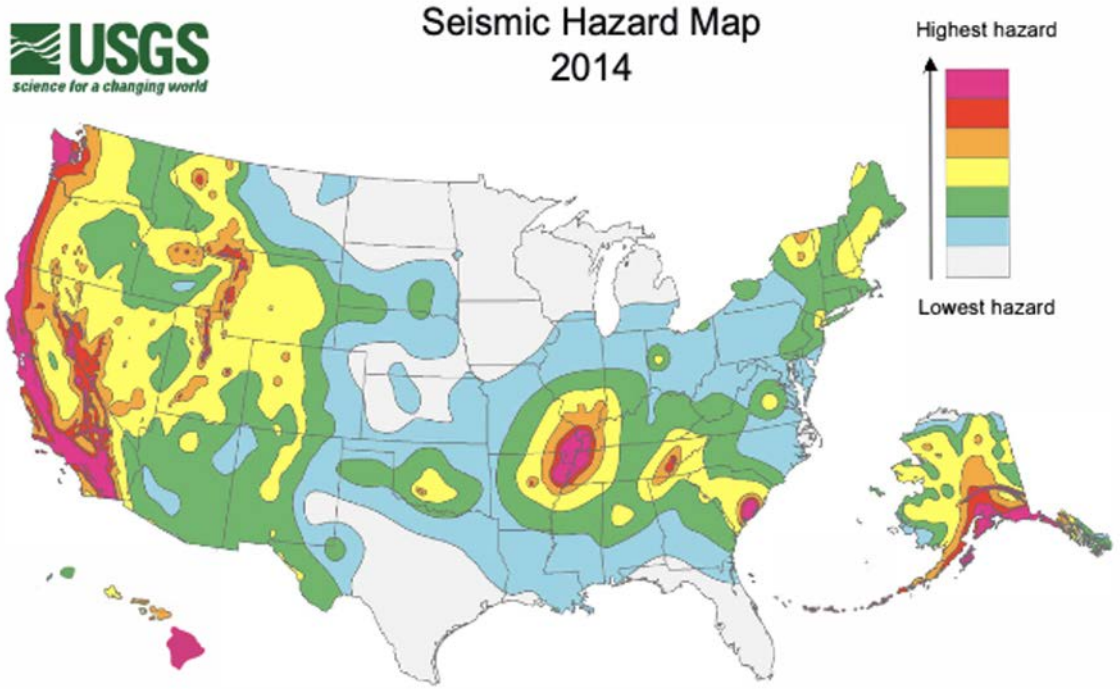
Societal impacts & Seismic Hazards





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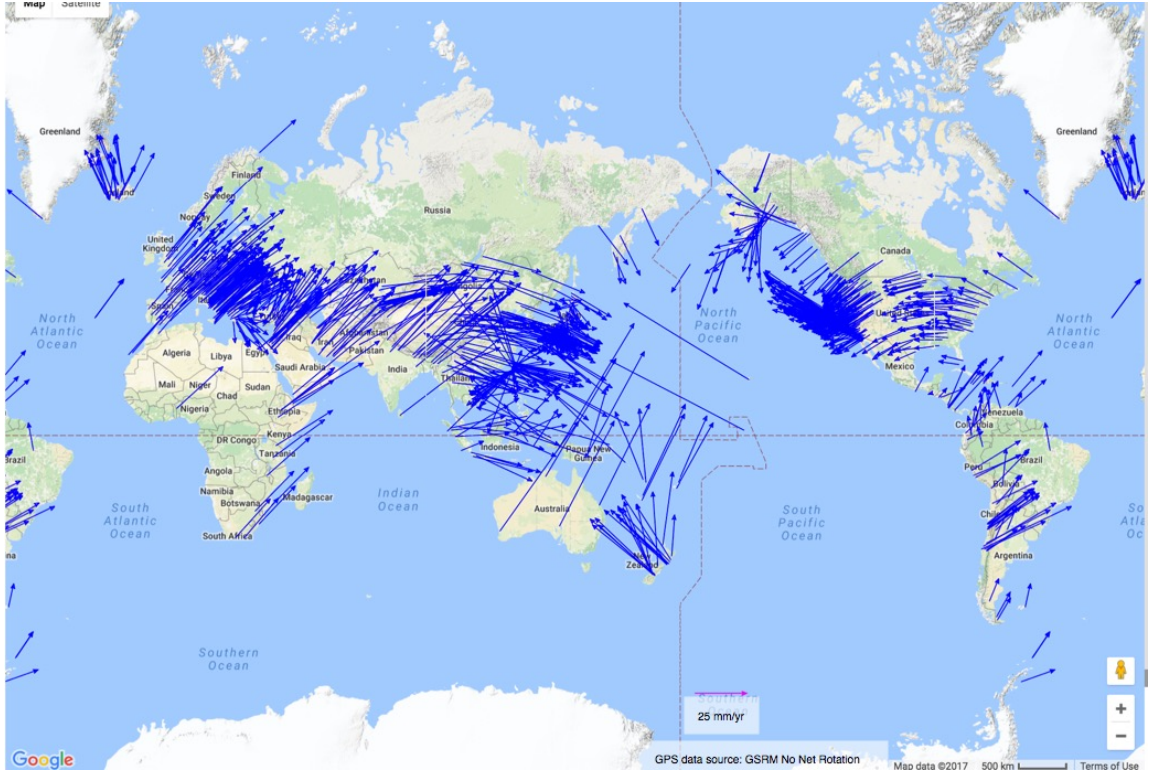
Wrap Up

What we did:

- Studied the patterns of earthquakes and volcanoes and made hypotheses about the relationships
- Compared ground motion in different regions of Alaska
- Determined plate boundary zones using multiple lines of evidence:
  - Ground motions from GPS data
  - Earthquake locations
  - Volcano locations
- Discussed societal impacts

Continue to explore the world!



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Thank you!

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One more thing: Reference Frames & GNSS Data Sources

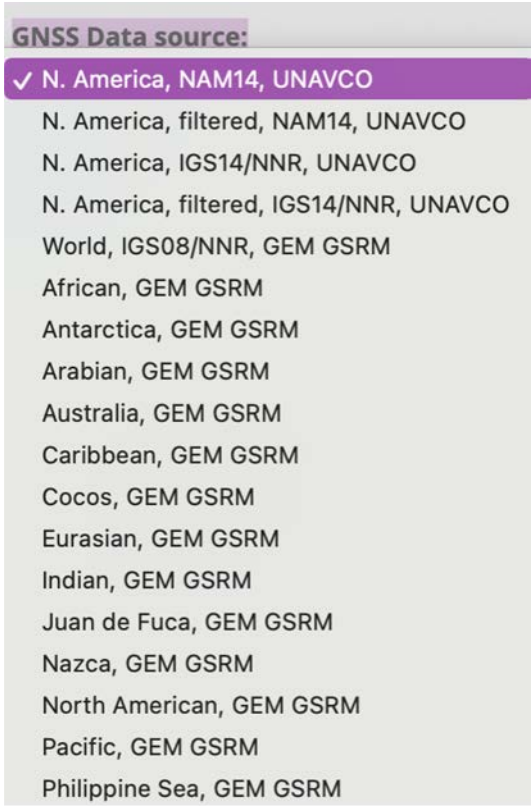
The surface of the Earth is not stationary. It moves.

… Every location on the Earth is moving.

How do we compare the motion of one location to another?

Scientists have chosen reference locations, often the interior region of tectonic plates and state (scientifically), **“This region is not moving!”.** Every point on Earth thus moves relative to that stationary point/region.

For the North American Reference Frame (NAM14), we measure the motion of the adjacent tectonic plates, including the edges of the North American plate, compared to that reference region (eg Kansas/ midwest)



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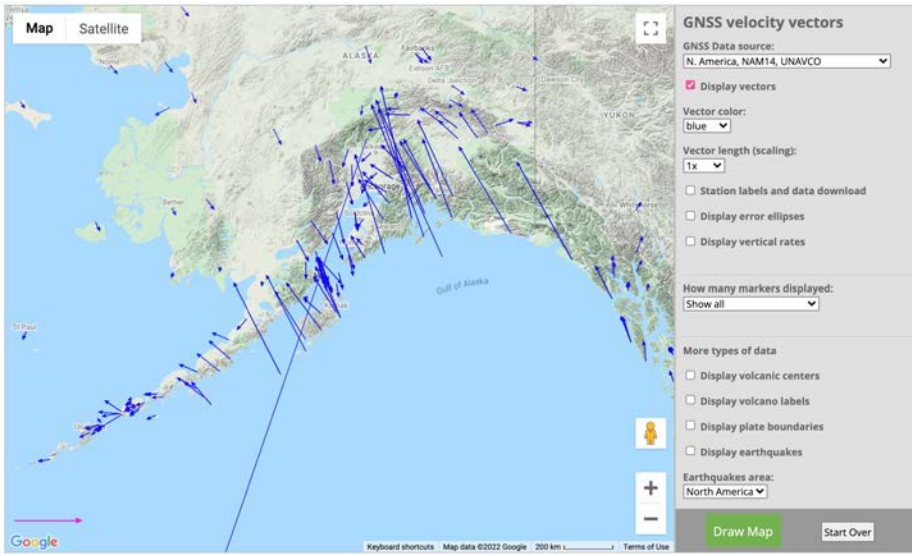
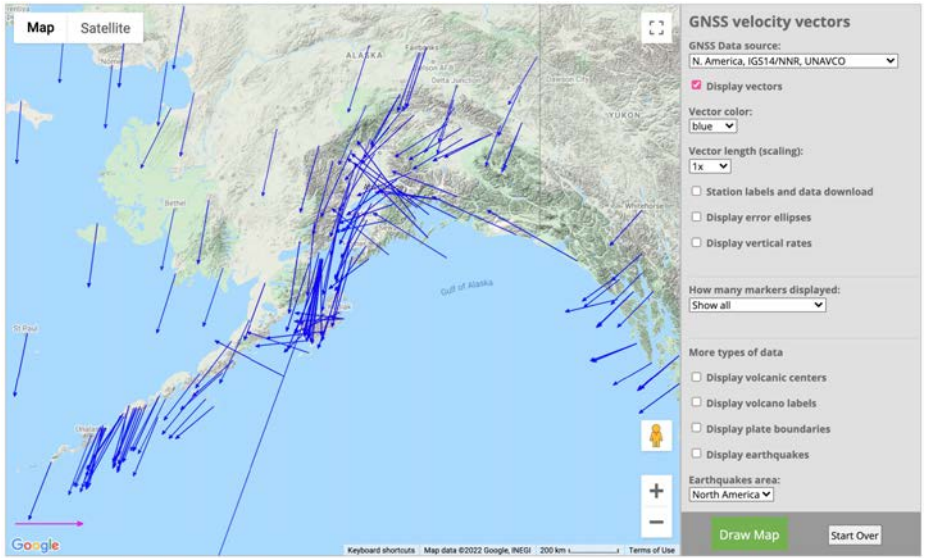
Ex: Two reference frames:

North American vs IGS14/No Net Rotation



N. America, NAM14, UNAVCO



N. America, IGS14/NNR, UNAVCO

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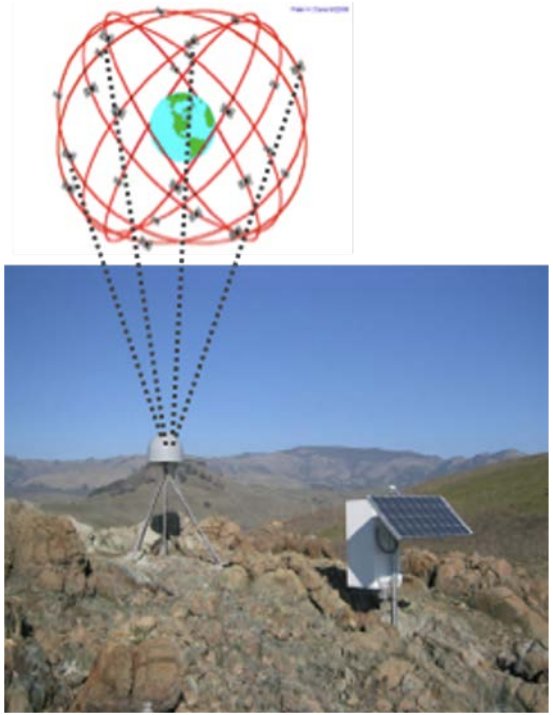
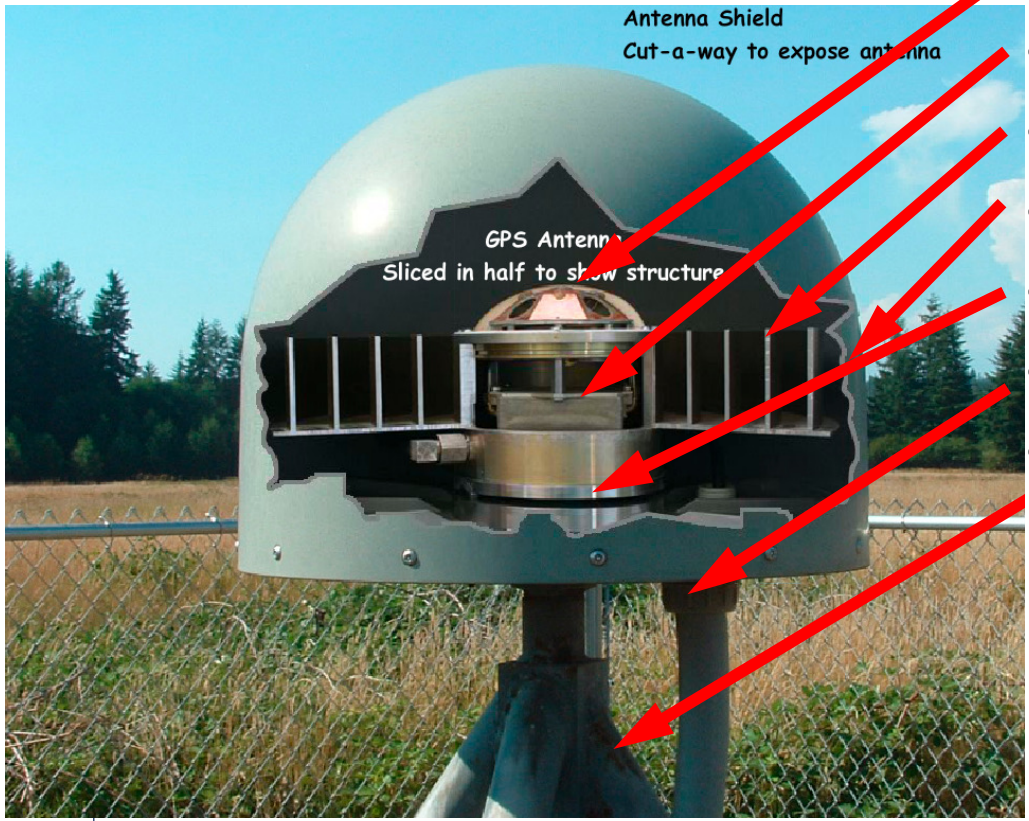
How GPS Works

- Four satellite signals are needed to locate the receiver in 3-dimensional space.
- The fourth satellite is also used for time accuracy.
- Position can be calculated within to a millimeter.
- Ground control stations around the world



Anatomy of a GPS Antenna



- Antenna
- Amplifier
- Choke ring
- Dome
- Antenna Mount
- Cable
- Supports

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