New constraints on the upper mantle properties beneath Cordillera Talamanca

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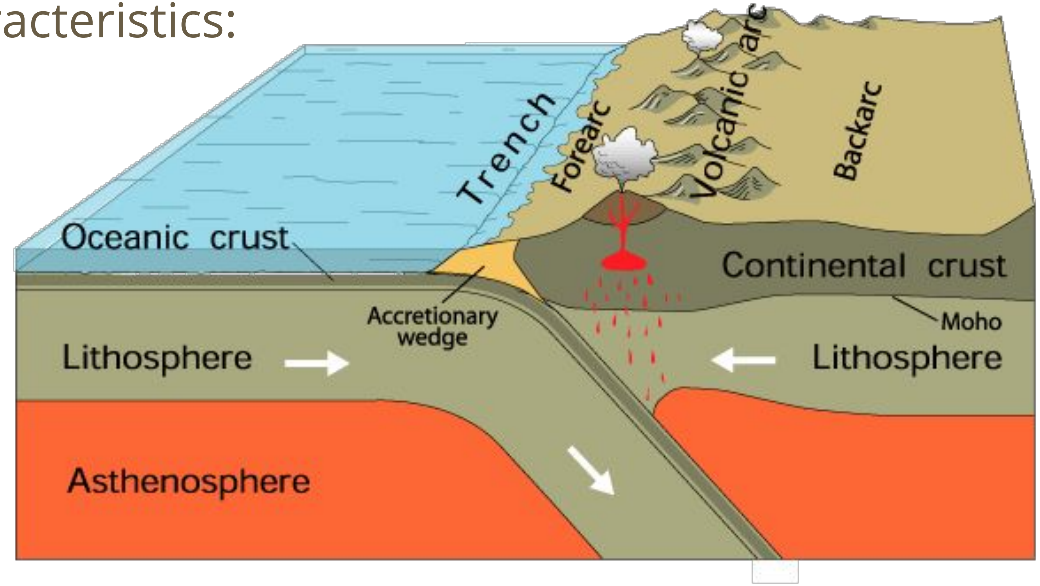
Study Area: Southern Costa Rica

- Costa Rica sits atop a subduction zone
  - Oceanic crust subducts below continental lithosphere

- Subduction zones have 2 characteristics:

  volcanic arc

  earthquakes



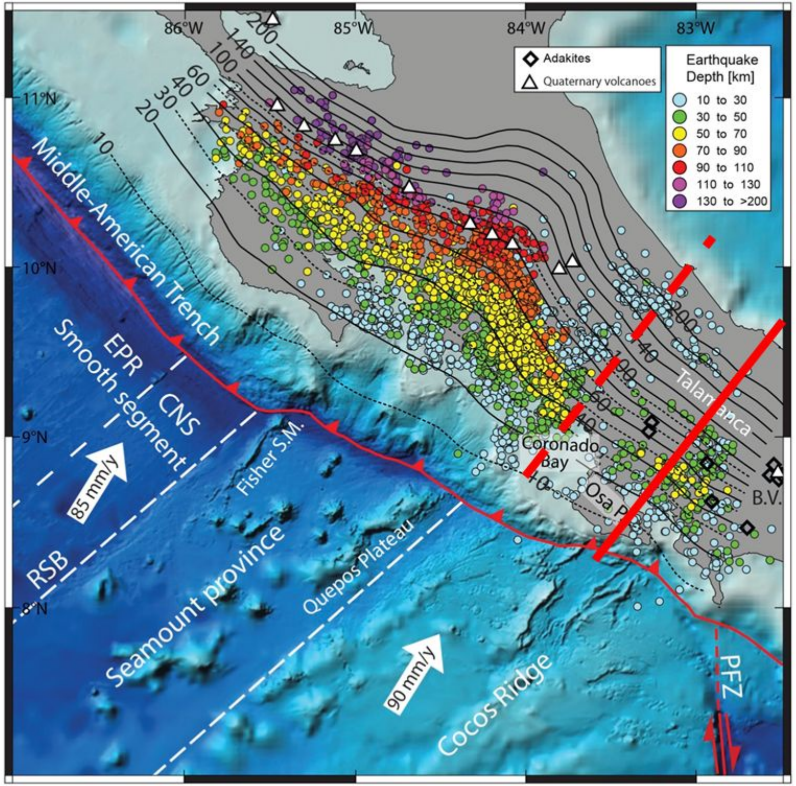
Problem: Southern Costa Rica is complicated

- Lack of volcanoes and deep earthquakes that would be expected in a typical subduction zone configuration
- Seismic properties below the Talamancas are poorly understood

How to study these properties?

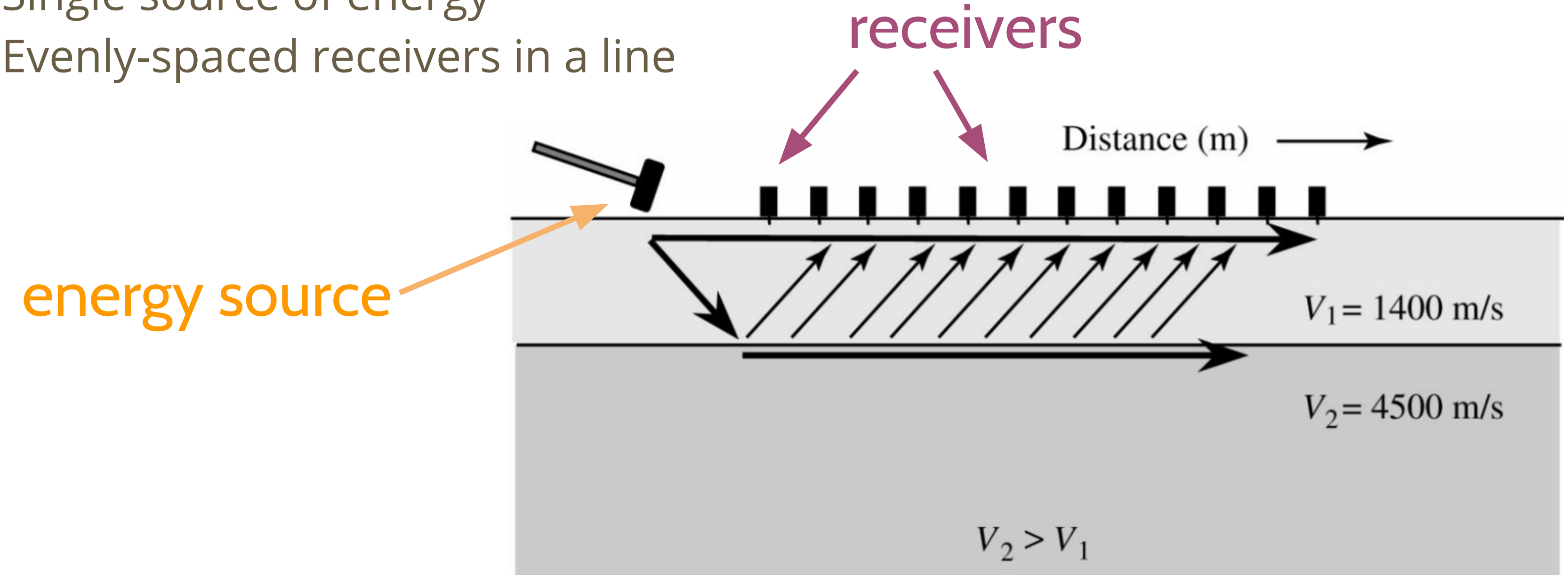
–earthquakes

(specifically, seismic refraction)

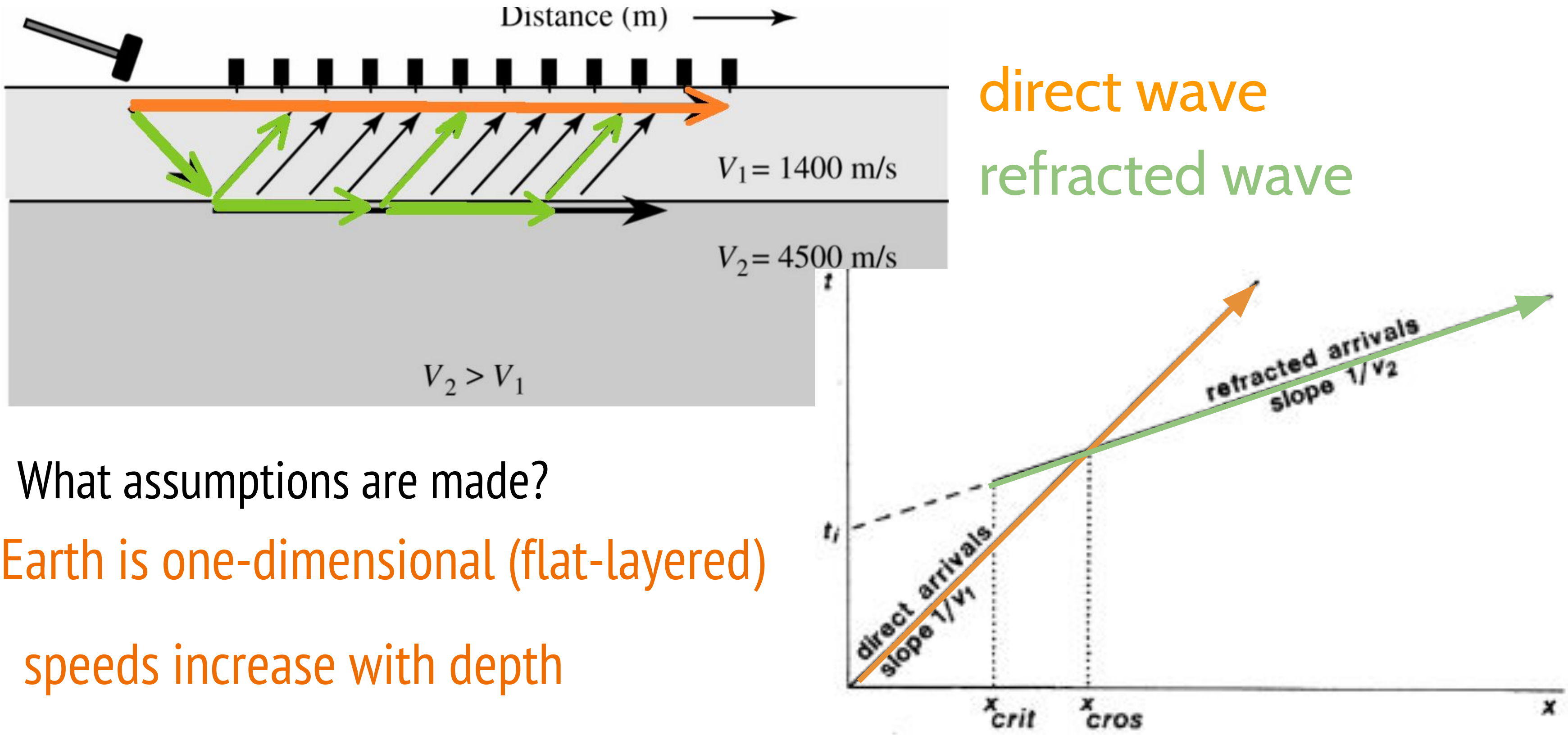


Seismic Refraction – An Overview

- Used to determine large scale crustal layering
  - Thickness
  - Velocity
- Single source of energy
- Evenly-spaced receivers in a line



Seismic Refraction – Principles



direct wave

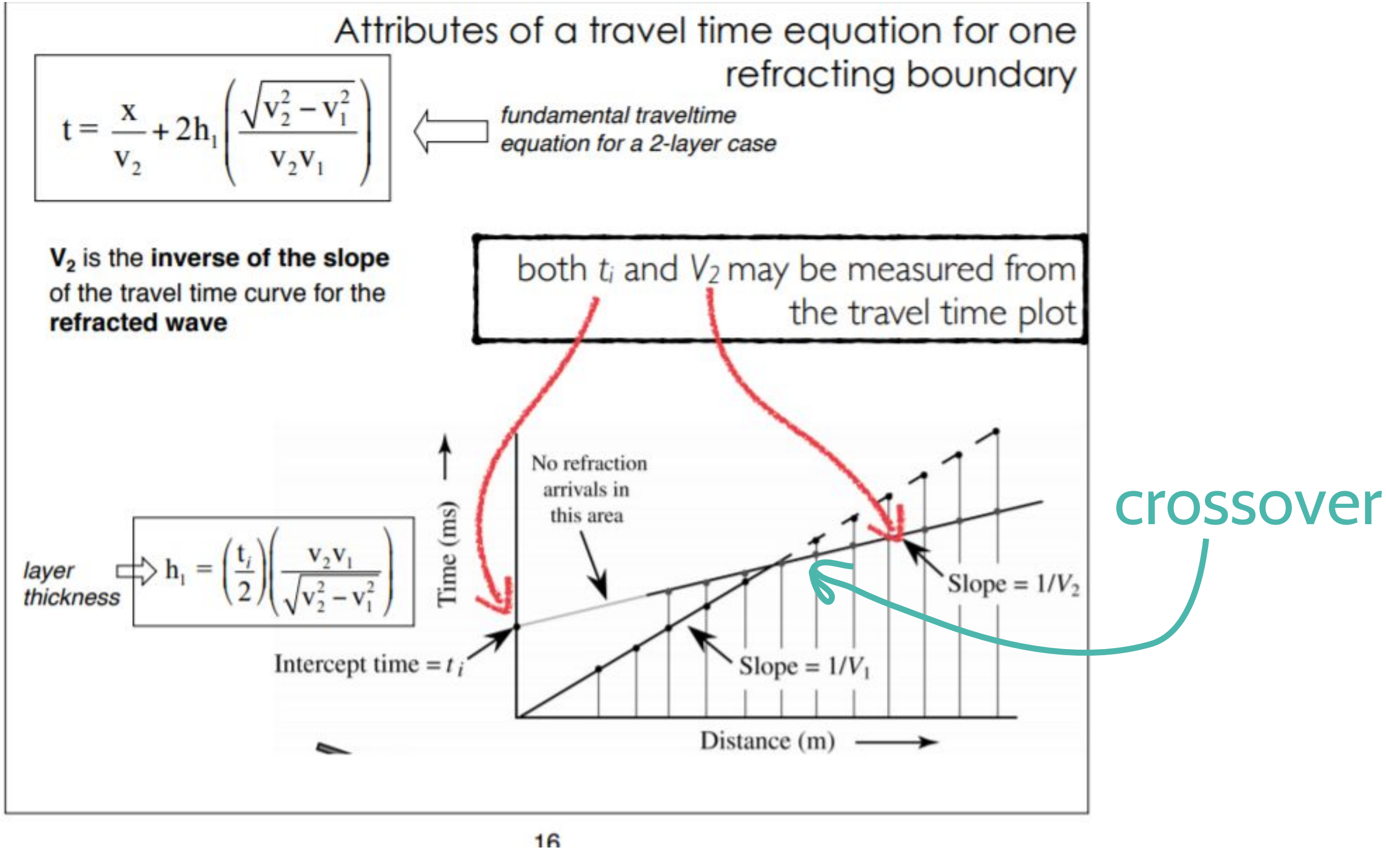
refracted wave

What assumptions are made?

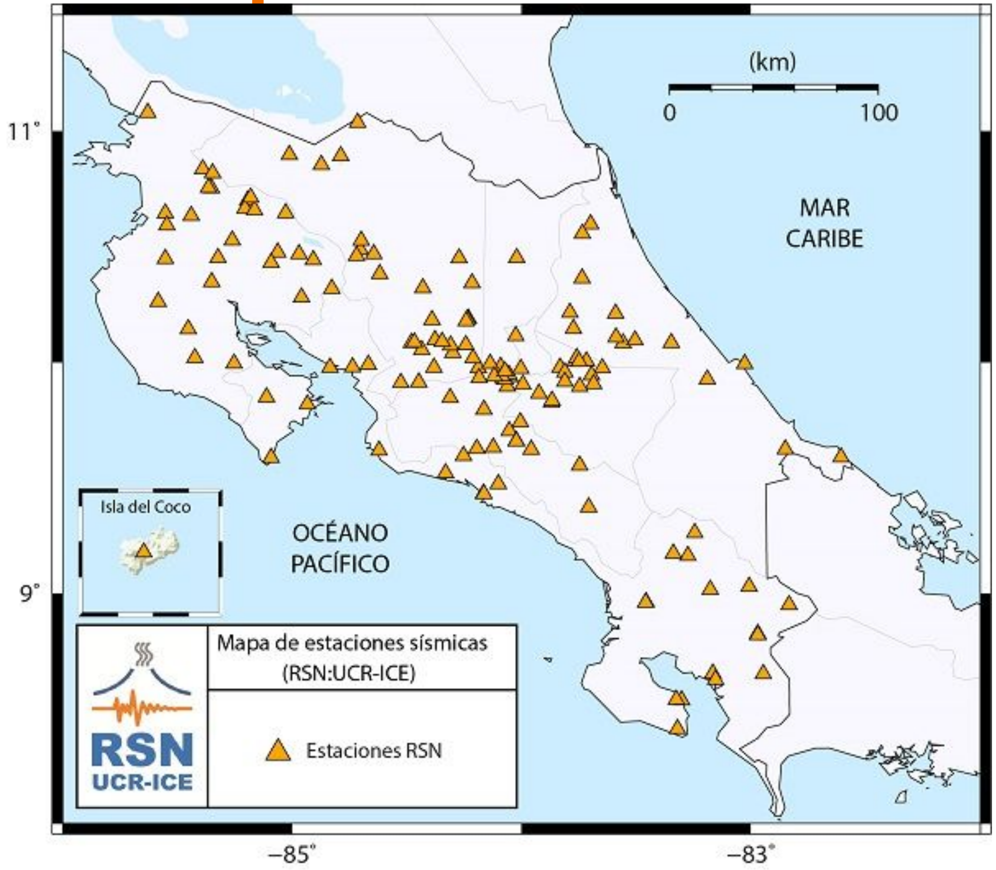
Earth is one-dimensional (flat-layered)

speeds increase with depth

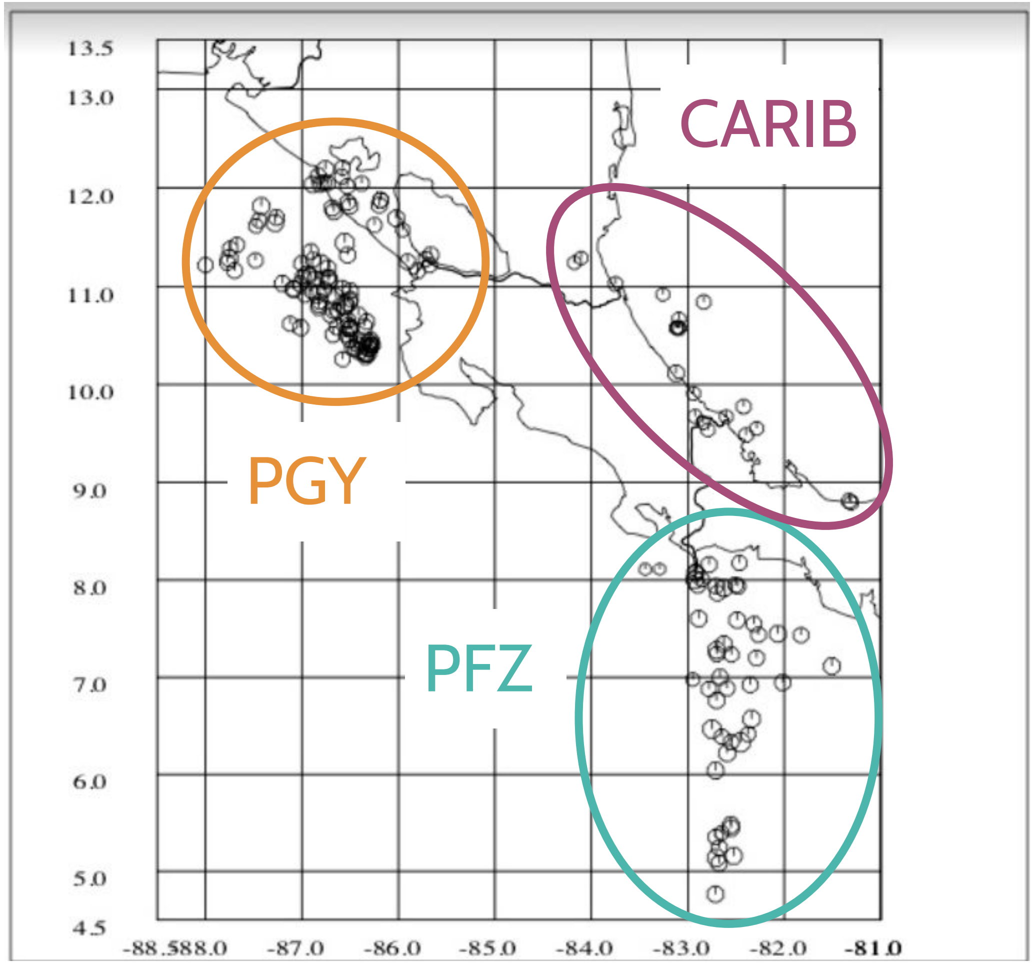
Seismic Refraction – Principles



Seismic Station Map

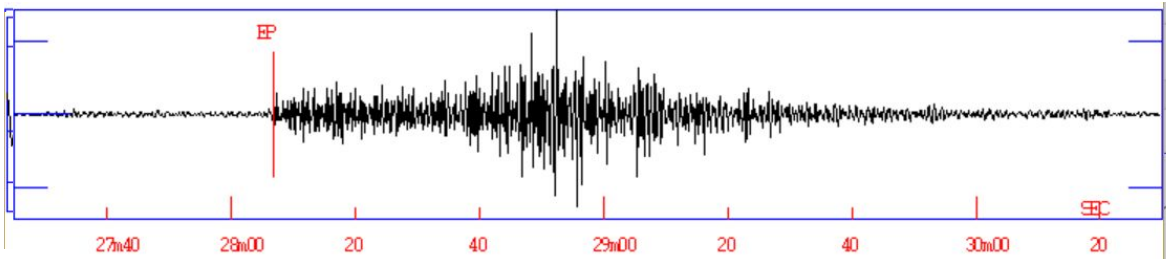


Source Regions



Earthquake Selection Criteria

- Outside of the borders of Costa Rica
- Magnitude of 5 or greater (4.5 or greater in the Caribbean region)
- Large range of source-receiver distances
- Shallow depth of hypocenter (<20 km)
- Good waveforms (first arrivals can be picked with limited filtering)



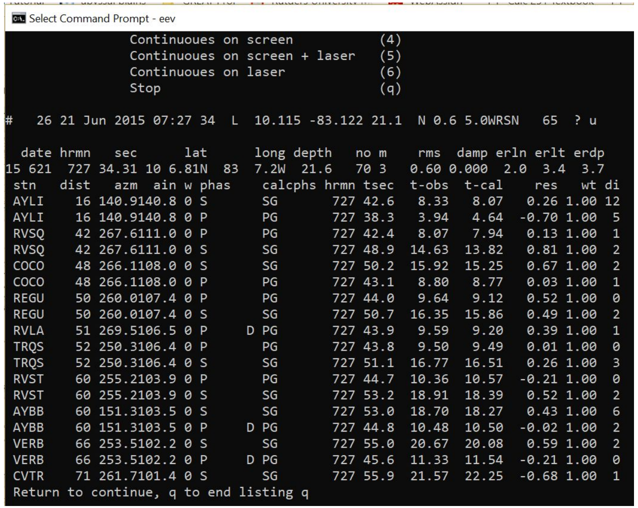
Good waveform – unfiltered

Decent waveform – filtered

What I Did

Step 0:

Worked with Krista Thiele at ICE for 3 weeks and learned how to pick first arrivals of earthquakes in SEISAN



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Select Command Prompt - eev
                Continuoues on screen            (4)
                Continuoues on screen + laser    (5)
                Continuoues on laser             (6)
                Stop                             (q)

#   26 21 Jun 2015 07:27 34  L  10.115 -83.122 21.1  N 0.6 5.0WRSN   65  ? u

  date hrmn   sec      lat      long depth   no m    rms  damp erln erlt erdp
15 621  727 34.31 10 6.81N  83  7.2W  21.6   70 3   0.60 0.000  2.0  3.4  3.7
 stn   dist   azm  ain w phas    calcphs hrmn tsec  t-obs  t-cal    res   wt di
 AYLI    16 140.9140.8 0 S       SG       727 42.6   8.33   8.07   0.26 1.00 12
 AYLI    16 140.9140.8 0 P       PG       727 38.3   3.94   4.64  -0.70 1.00  5
 RVSQ    42 267.6111.0 0 P       PG       727 42.4   8.07   7.94   0.13 1.00  1
 RVSQ    42 267.6111.0 0 S       SG       727 48.9  14.63  13.82   0.81 1.00  2
 COCO    48 266.1108.0 0 S       SG       727 50.2  15.92  15.25   0.67 1.00  2
 COCO    48 266.1108.0 0 P       PG       727 43.1   8.80   8.77   0.03 1.00  1
 REGU    50 260.0107.4 0 P       PG       727 44.0   9.64   9.12   0.52 1.00  0
 REGU    50 260.0107.4 0 S       SG       727 50.7  16.35  15.86   0.49 1.00  2
 RVLA    51 269.5106.5 0 P     D PG       727 43.9   9.59   9.20   0.39 1.00  1
 TRQS    52 250.3106.4 0 P       PG       727 43.8   9.50   9.49   0.01 1.00  0
 TRQS    52 250.3106.4 0 S       SG       727 51.1  16.77  16.51   0.26 1.00  3
 RVST    60 255.2103.9 0 P       PG       727 44.7  10.36  10.57  -0.21 1.00  0
 RVST    60 255.2103.9 0 S       SG       727 53.2  18.91  18.39   0.52 1.00  2
 AYBB    60 151.3103.5 0 S       SG       727 53.0  18.70  18.27   0.43 1.00  6
 AYBB    60 151.3103.5 0 P     D PG       727 44.8  10.48  10.50  -0.02 1.00  2
 VERB    66 253.5102.2 0 S       SG       727 55.0  20.67  20.08   0.59 1.00  2
 VERB    66 253.5102.2 0 P     D PG       727 45.6  11.33  11.54  -0.21 1.00  0
 CVTR    71 261.7101.4 0 S       SG       727 55.9  21.57  22.25  -0.68 1.00  1
 Return to continue, q to end listing q
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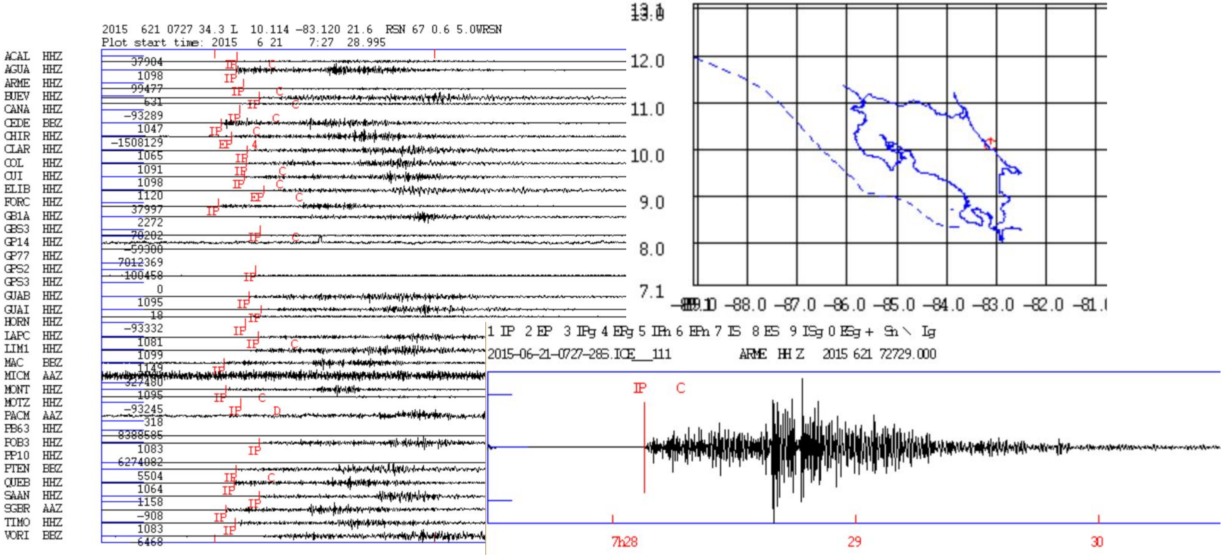
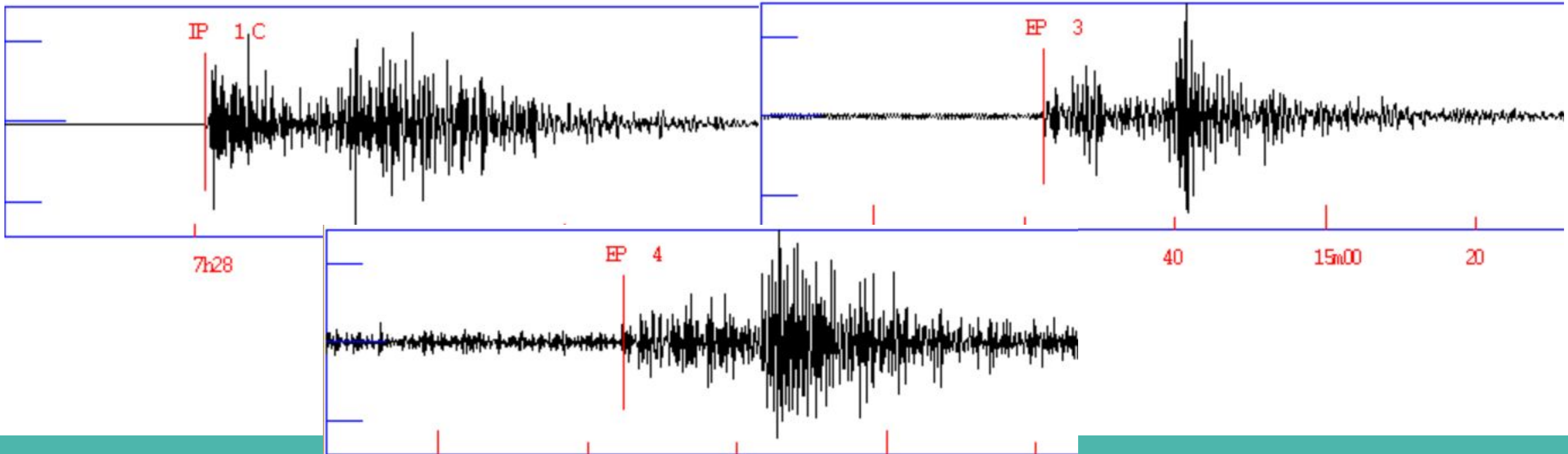


What I Did

Step 1:

First order primary measurements

- Picked over 1300 first arrivals of P-waves from the set of earthquakes
- Added weights to the picks for more accurate location

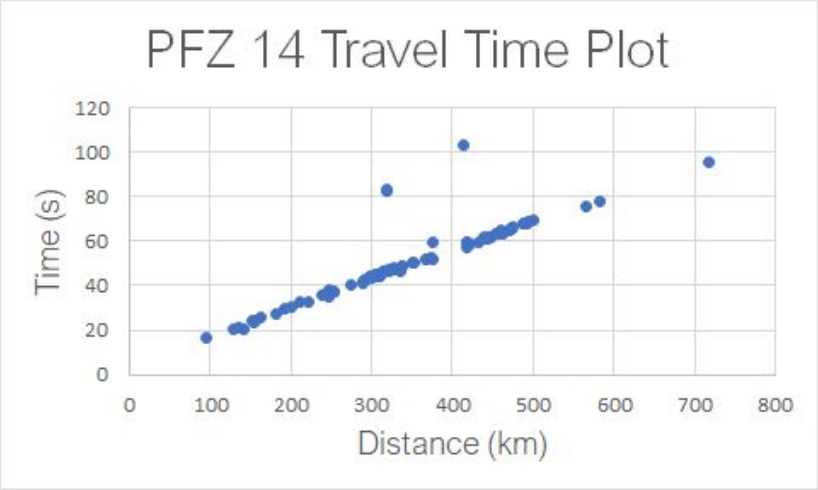


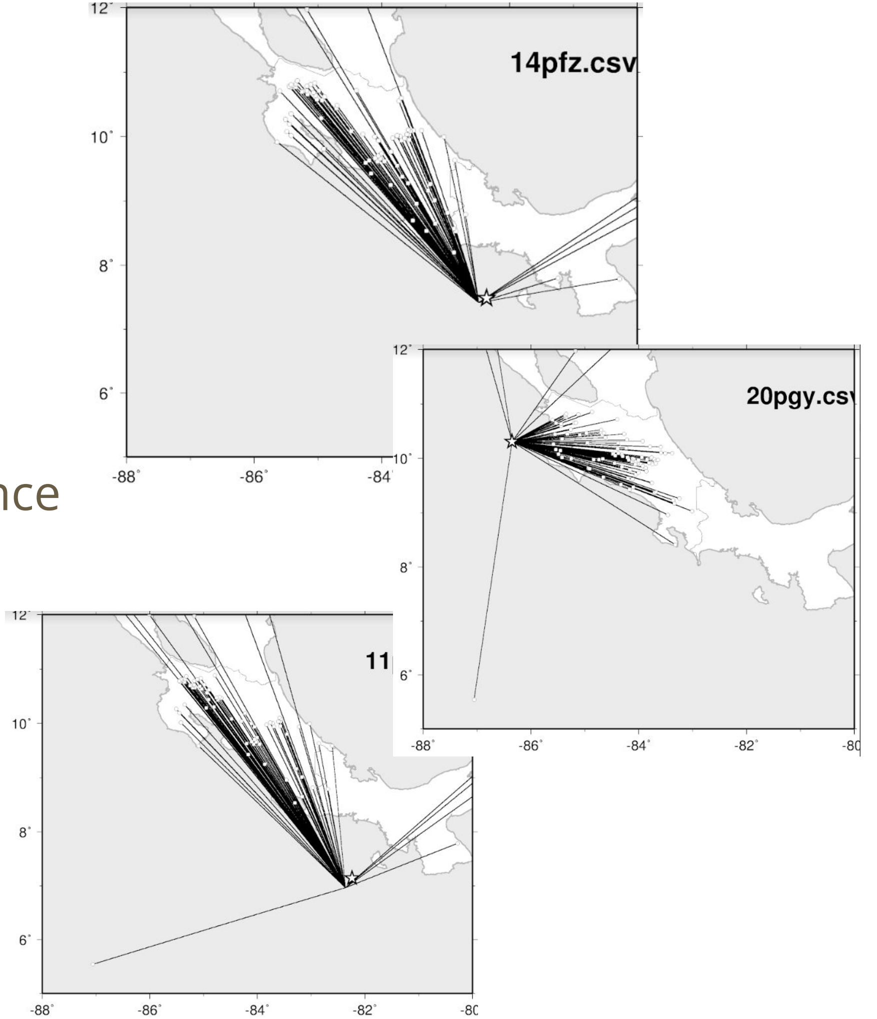
What I Did

Step 2:

Data processing and analysis (early stages)

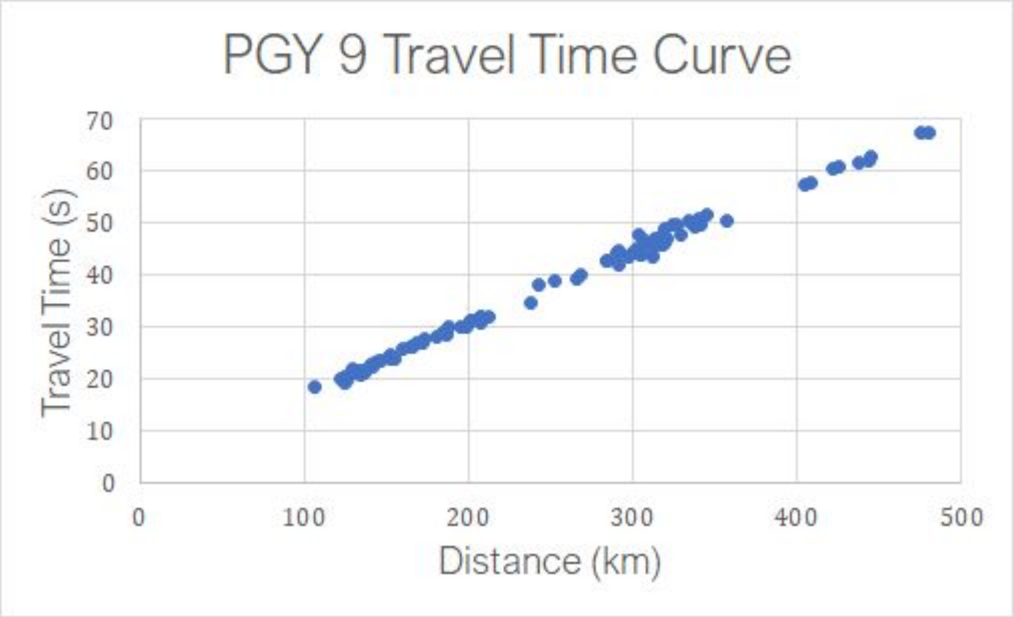
- Created maps of ray paths
- Created graphs of travel time vs. distance





Example Travel Time Curve: PGY Event #9

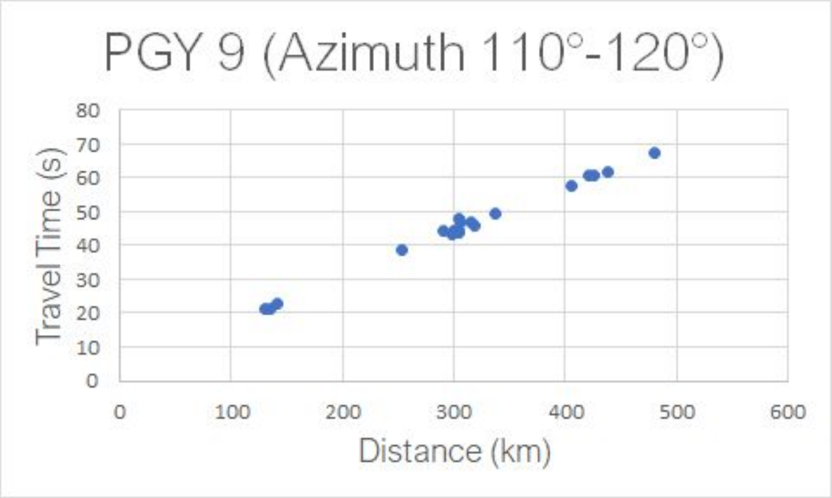
high residuals

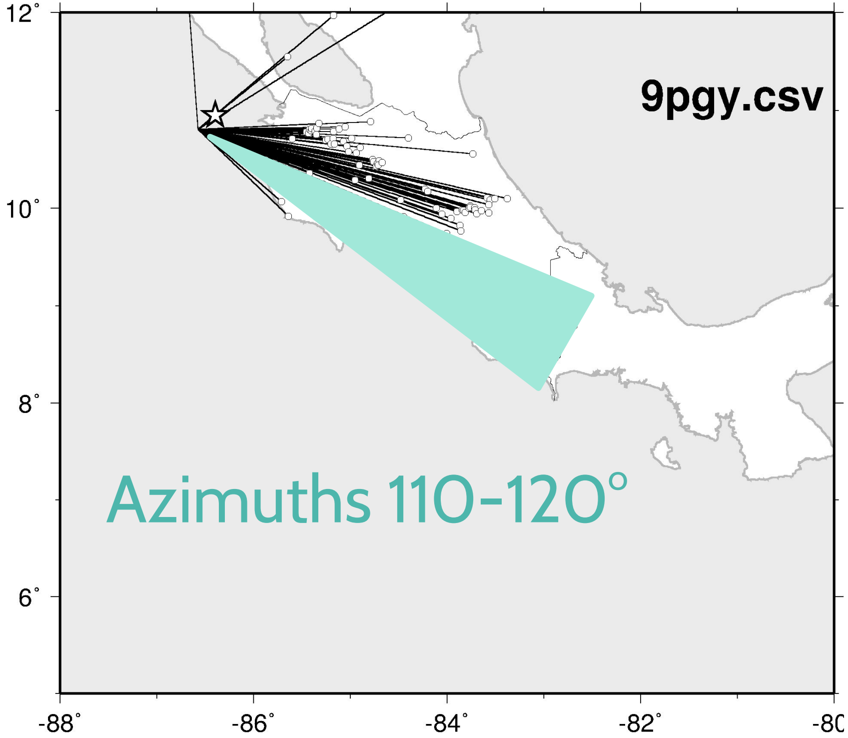


May 14, 2015
14:08:12
Mw 5.4

Ray Path Map + Azimuth Filtering

Filter for azimuth that targets the Talamancas

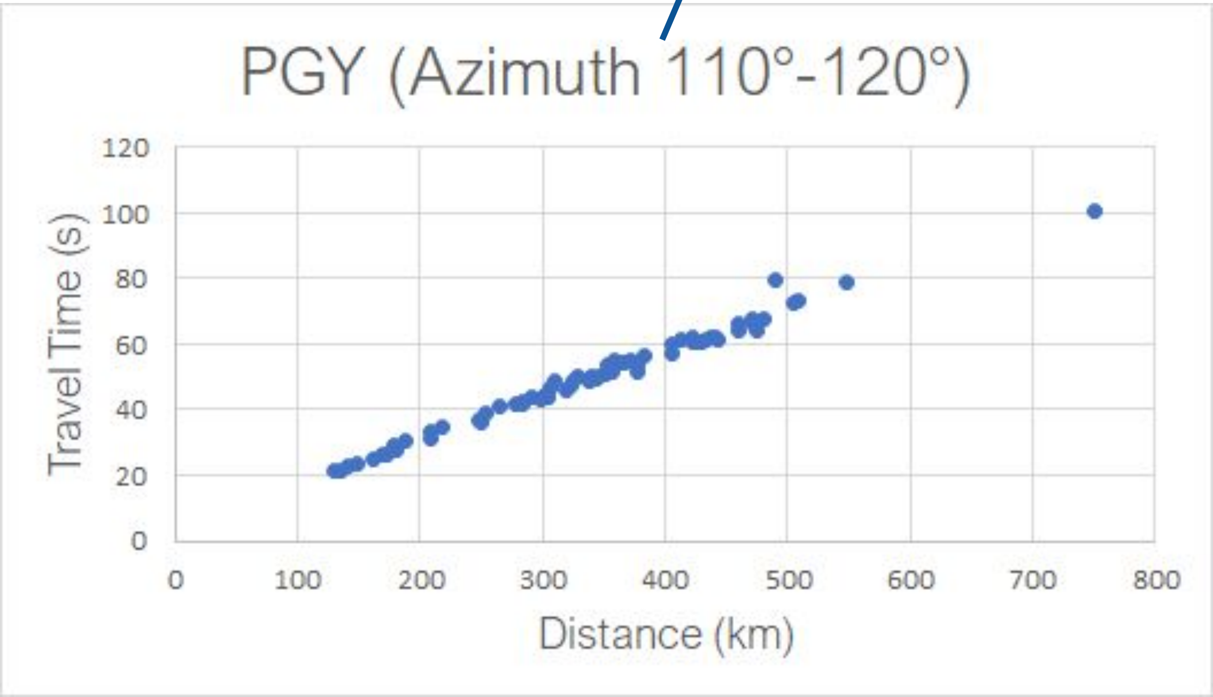




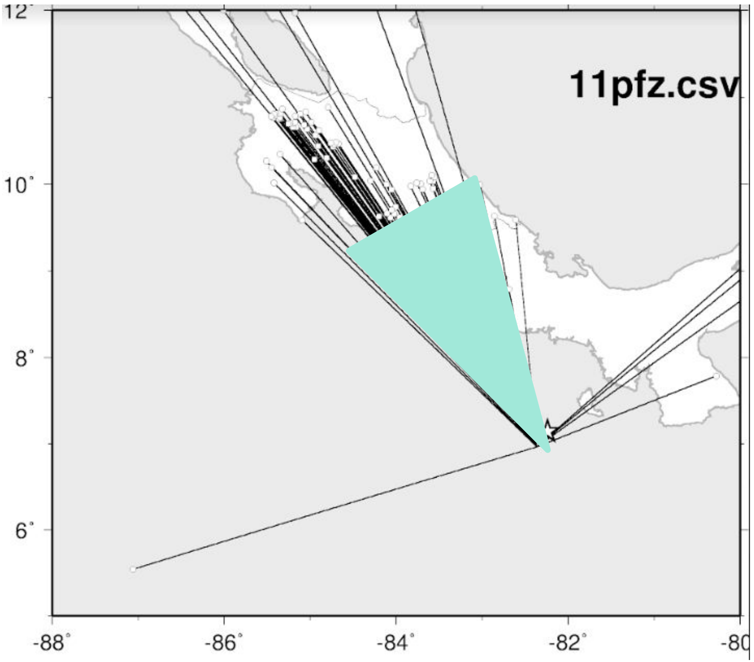
Combining Events from One Region

- Take multiple events that are relatively close to one another
- Select all first arrivals that fall within the range of azimuths
- Construct travel time plot

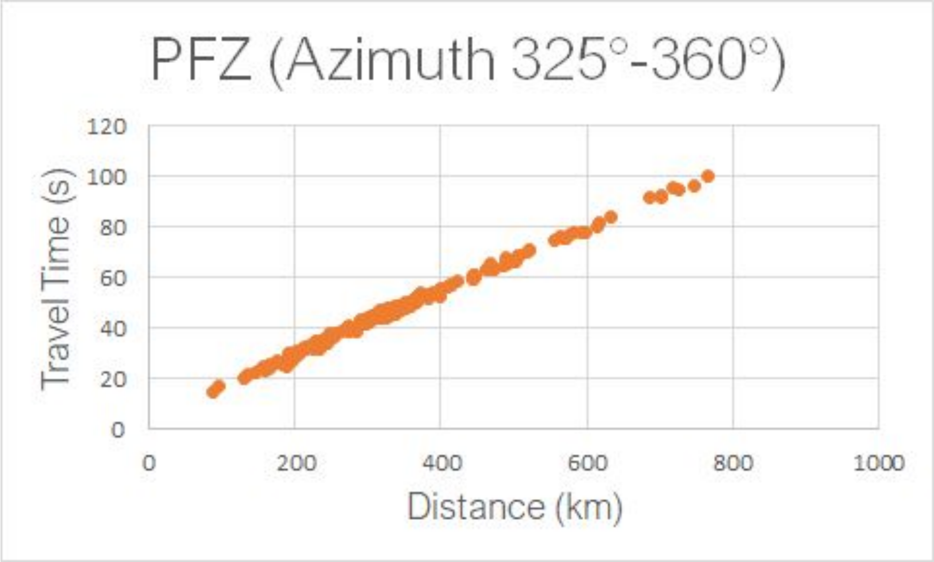
PGY Events
2, 8, 9, and 12



Combining Events from One Region

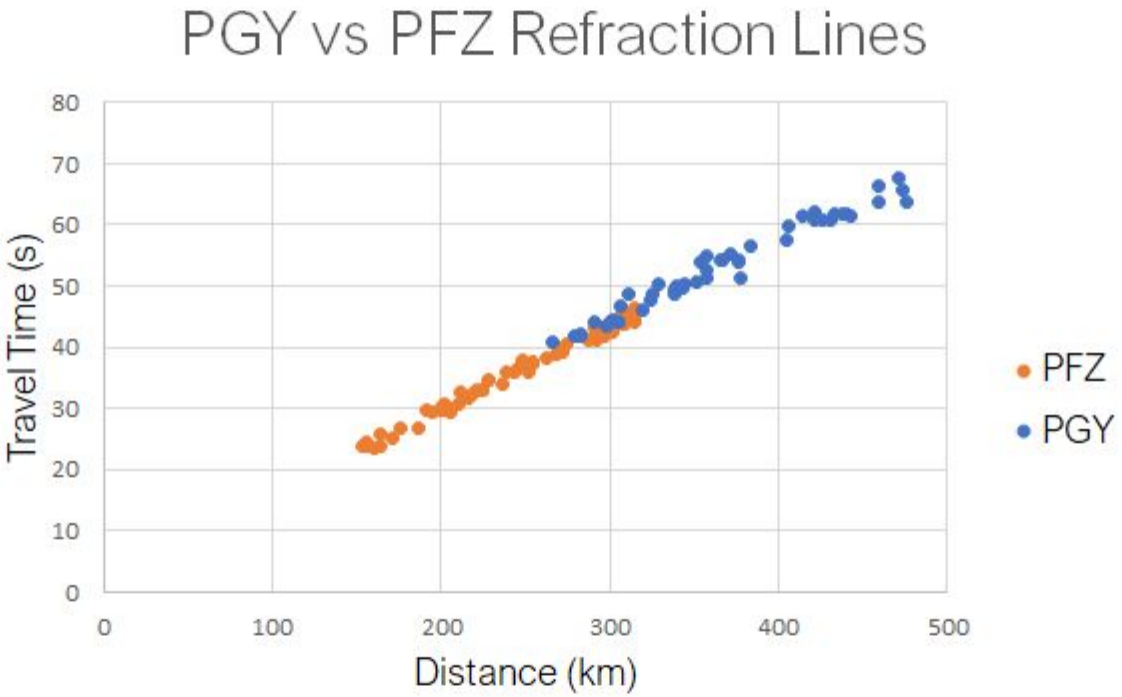


Azimuths 325-360°



PFZ Events 5, 9, 11, 12, and 14

Comparing Refraction Lines from Two Regions



PGY: 250-450 km

slope = $1/v_2$ = 0.1258

$v_2 \approx 7.949$

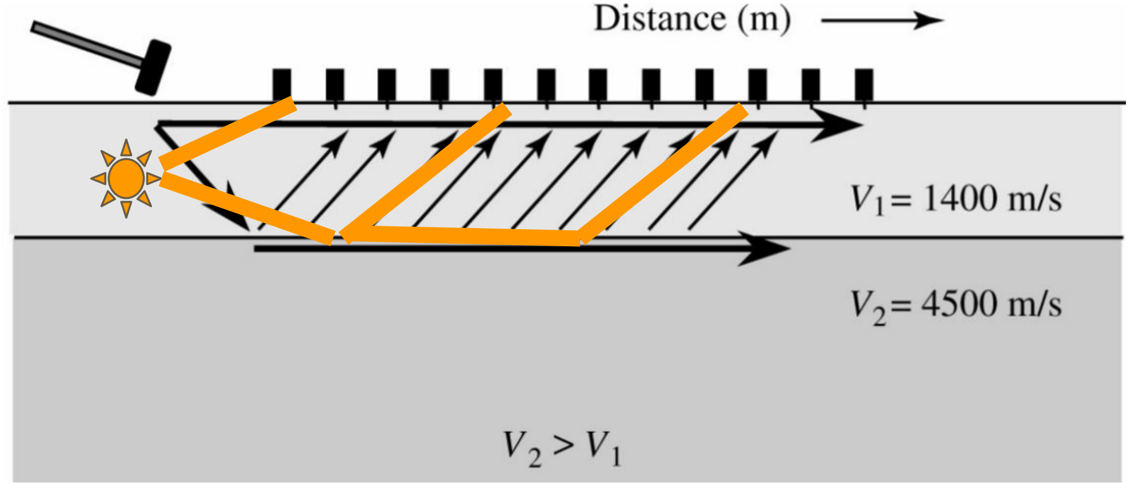
PFZ: 150-315 km

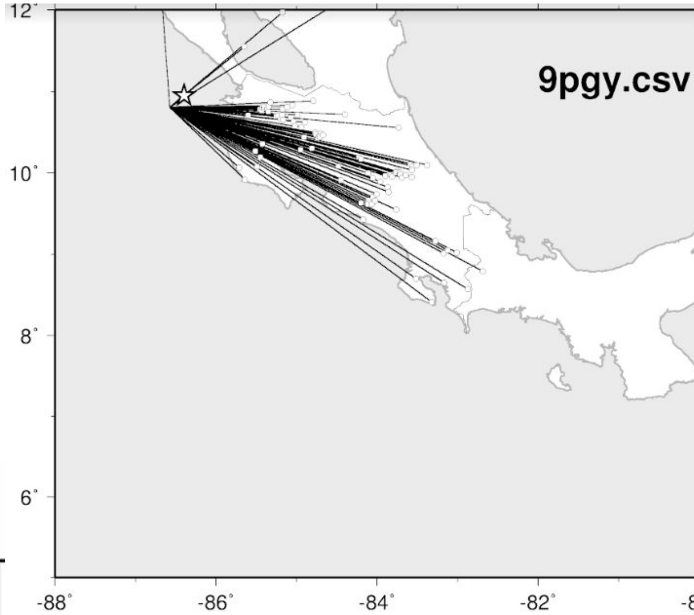
slope = $1/v_2$ = 0.1354

$v_2 \approx 7.385$

Future Work

1. Resolve technical glitches
2. Determine possible mislocation and correct for it
3. Determine influence of depth of source

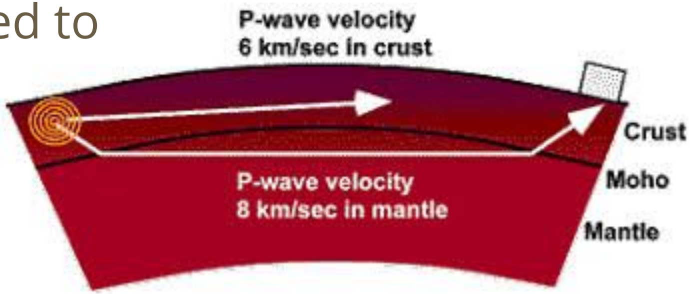




Future Work

These primary first-order measurements will be used to

- Constrain seismic properties of the lithosphere below the Cordillera Talamanca
- Improve RSN's current seismic velocity model
  - Earthquake analysis software requires a generalized 1-dimensional velocity to accurately locate earthquakes
  - The origins of the current model used by the RSN are unknown



3.500	0.000	
5.000	1.000	
6.000	6.000	
6.800	13.000	B
8.000	35.000	N
8.260	200.000	
8.500	300.000	

Thank you!

Thank you!