

Patterns in Earthquake Magnitudes

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Dataset

- from kaggle.com, dataset on all earthquakes from 1965-2016 with magnitudes greater than 4.5
 - Magnitude
 - Longitude
 - Latitude
 - Time
 - Depth
 - Type
 - different error measurements: a lot of missing data
- Found the source of this dataset: earthquake.usgs.gov
 - Pulled more data
 - Earthquakes > 2.5 in different specific regions and times
 - 2012 — 2017 Chile and California/Mexico
 - 2007 — 2017 San Francisco Bay Area

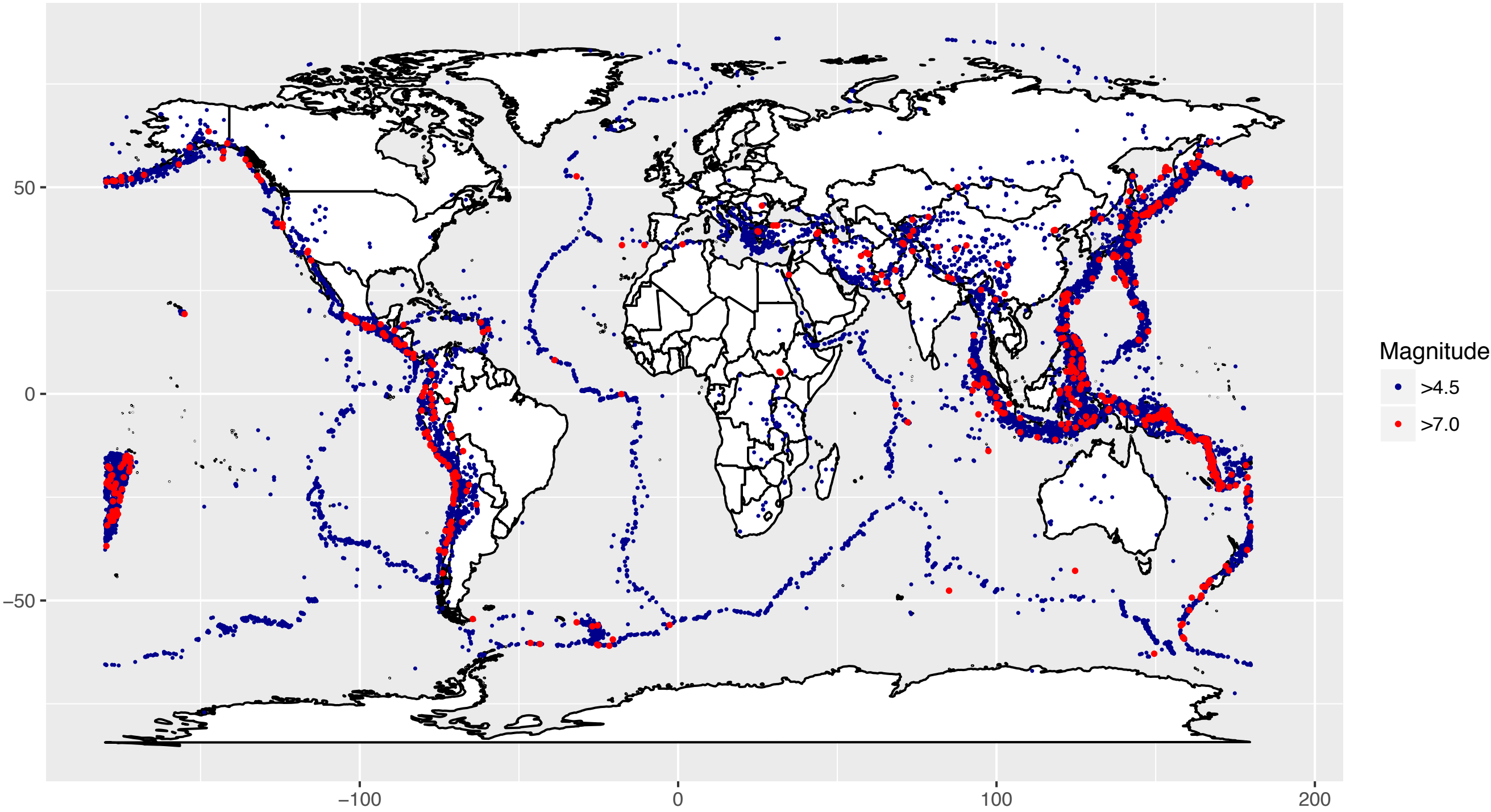
Background: Magnitude

- Log base 10 scale: An earthquake with a magnitude of 4.0 has 10 times the shaking amplitude as an earthquake with a magnitude of 3.0
- Richter scale
 - logarithm of the ratio of amplitudes (wikipedia.org/Richter_magnitude_scale)
- Moment magnitude scale
 - used by the US since the 1970s but takes on similar values of magnitude as old one (wikipedia.org/Moment_magnitude_scale)
- Different algorithms are used to obtain magnitudes of earthquakes based on size and location
 - for this project, we treated all magnitudes the same

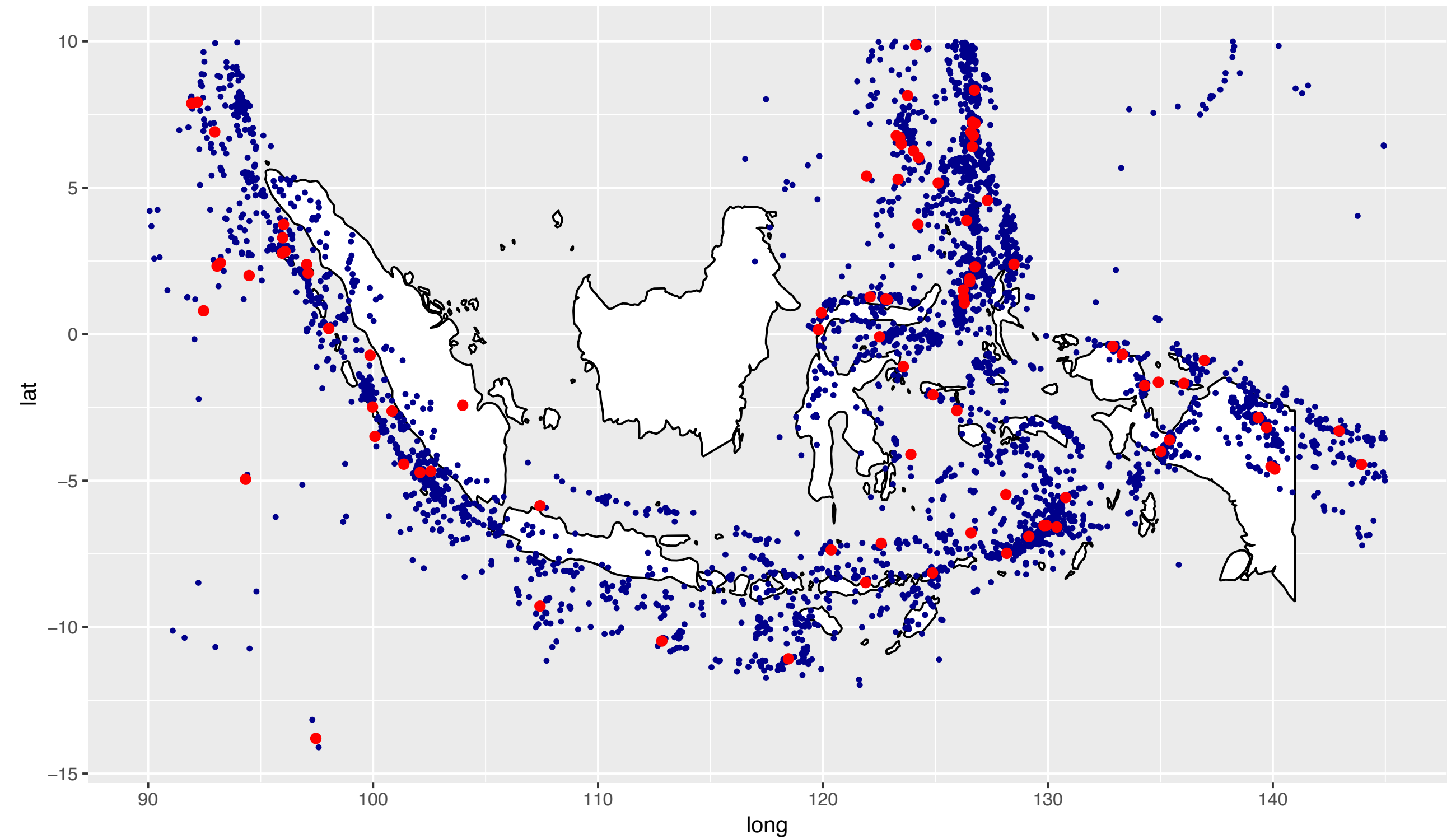
Challenges

- A lot of data for spatial and time modeling
 - Especially with lots of smaller earthquakes
- Not many covariates or other variables
- Very hard to predict based on location/time
- More complicated project, needs more time
- Also need an expert on earthquakes
- Focusing on mapping spatial points and objects, EDA
- Also trying to apply certain spatial and temporal models while looking for patterns

Earthquakes 1965–2017, Magnitudes > 4.5

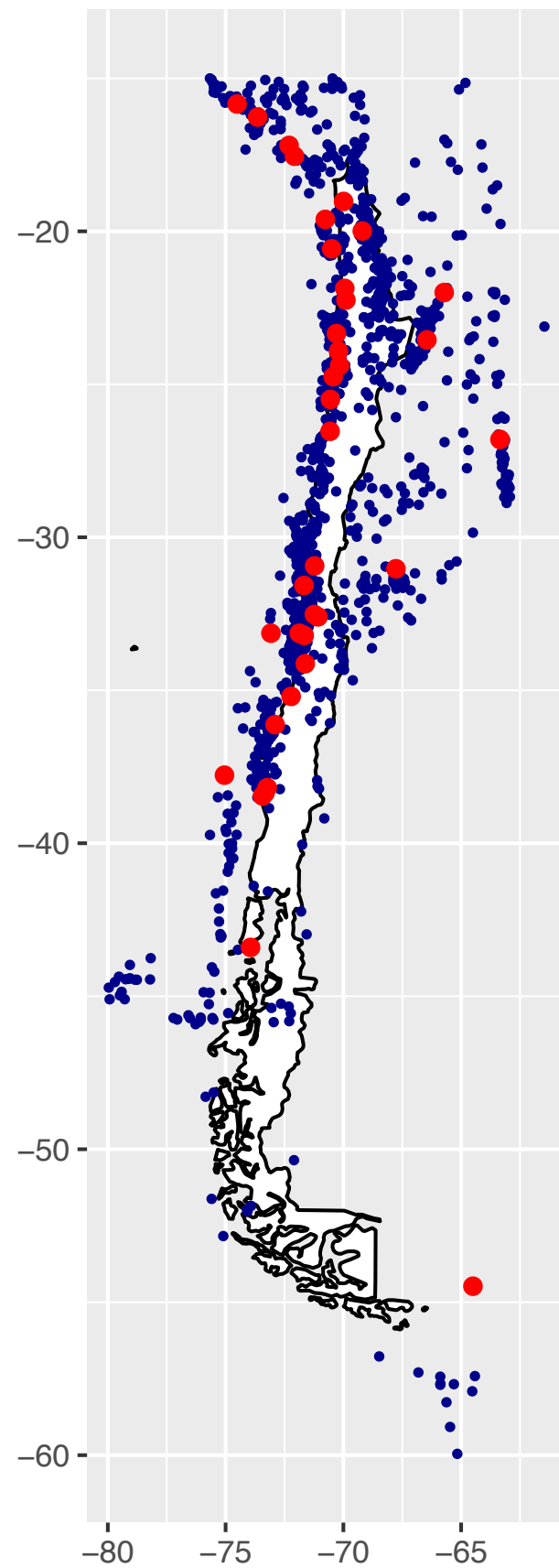


Earthquakes in Indonesia, 1965–2016, Magnitudes > 4.5

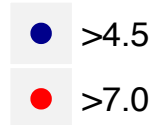


Earthquakes 1965–2016, Magnitudes > 4.5

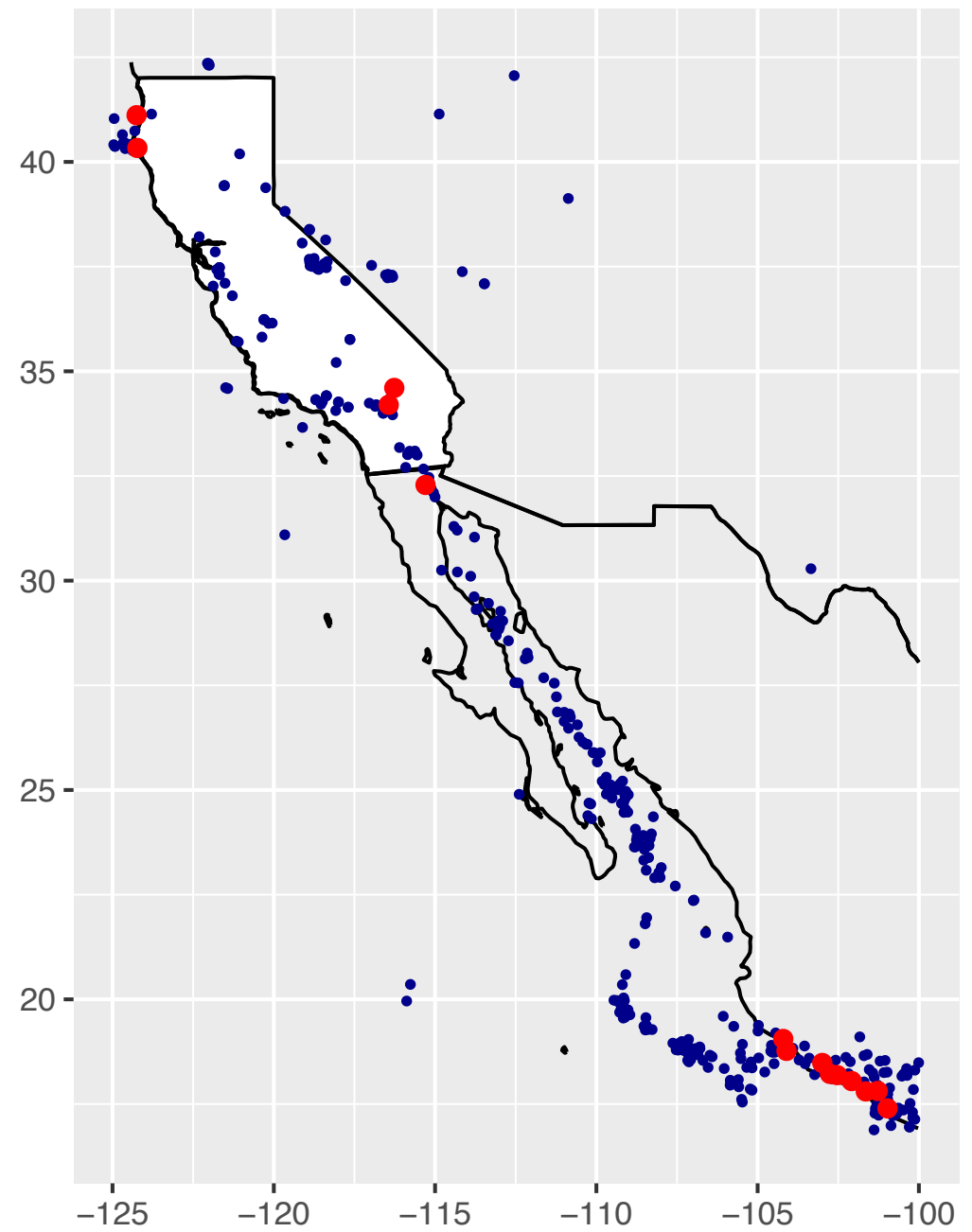
Chile



Magnitude



California/Mexico

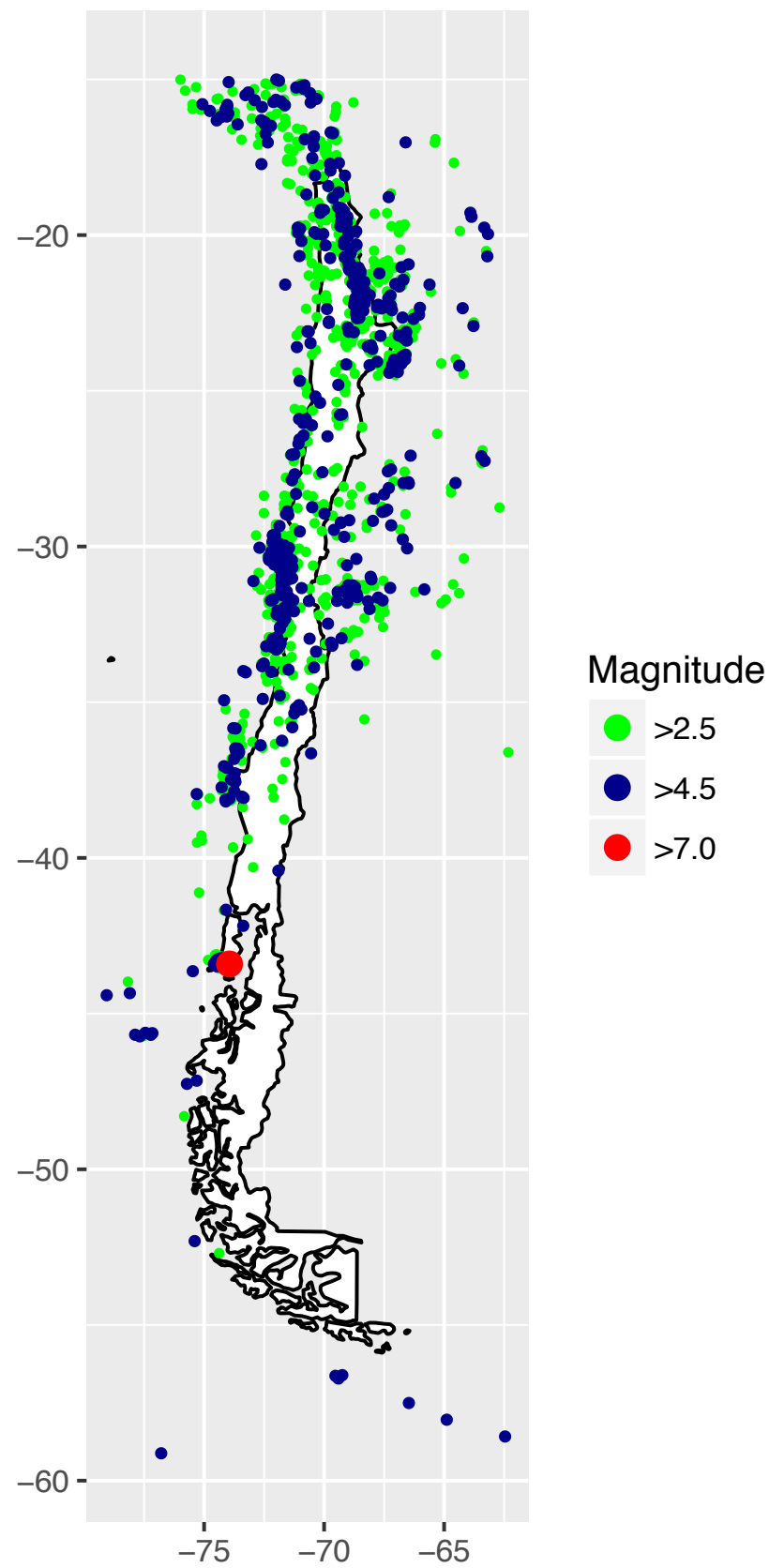


Magnitude

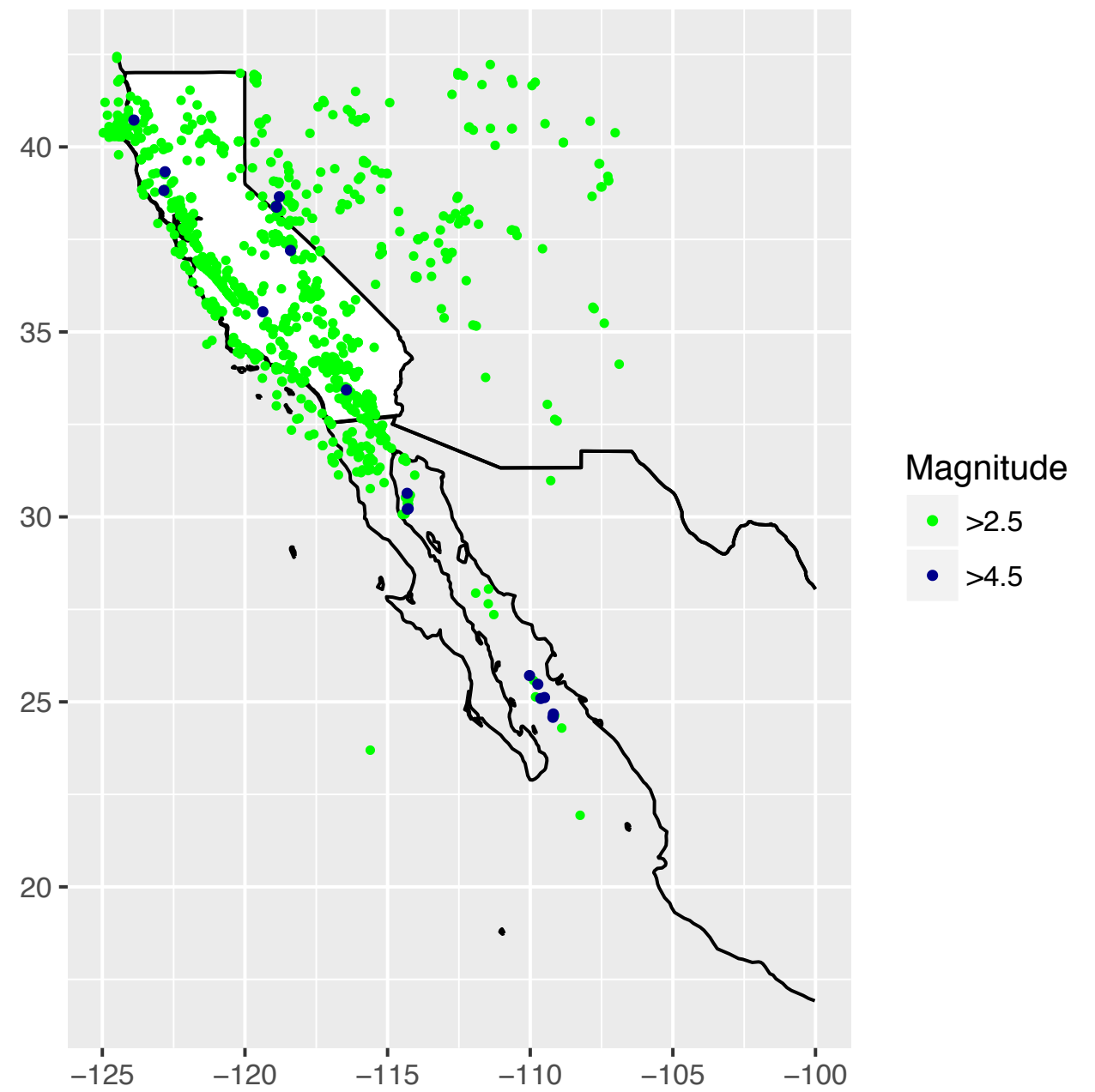


Earthquakes Jan 2016 – Apr 2017, Magnitudes > 2.5

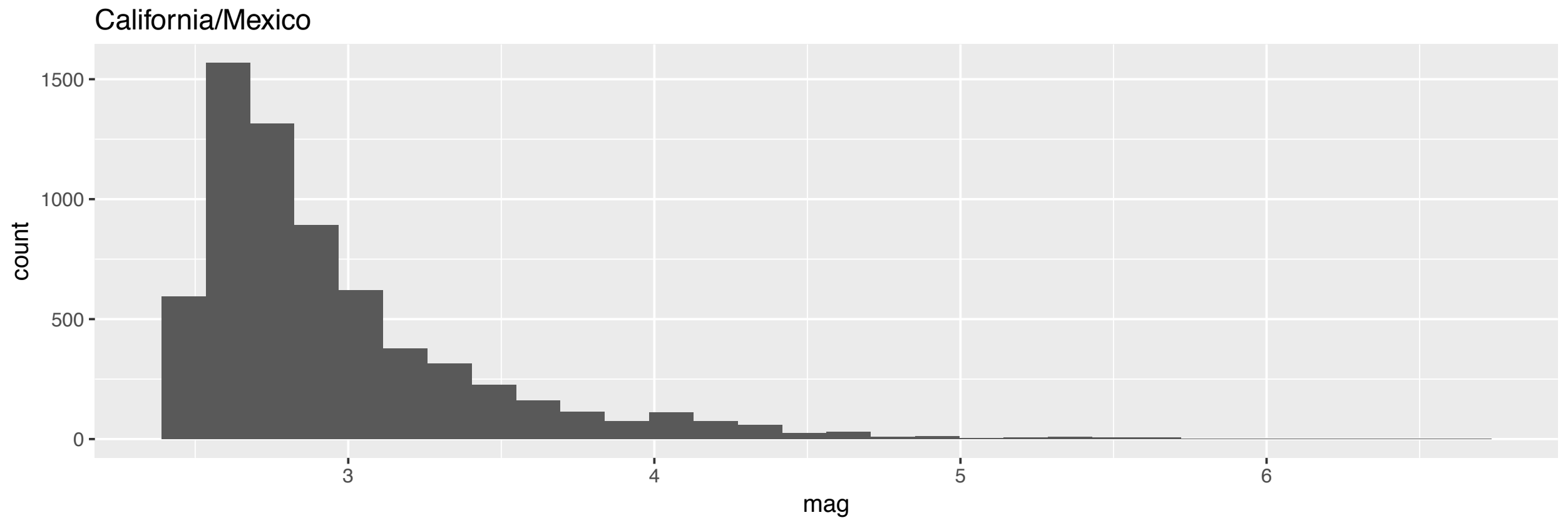
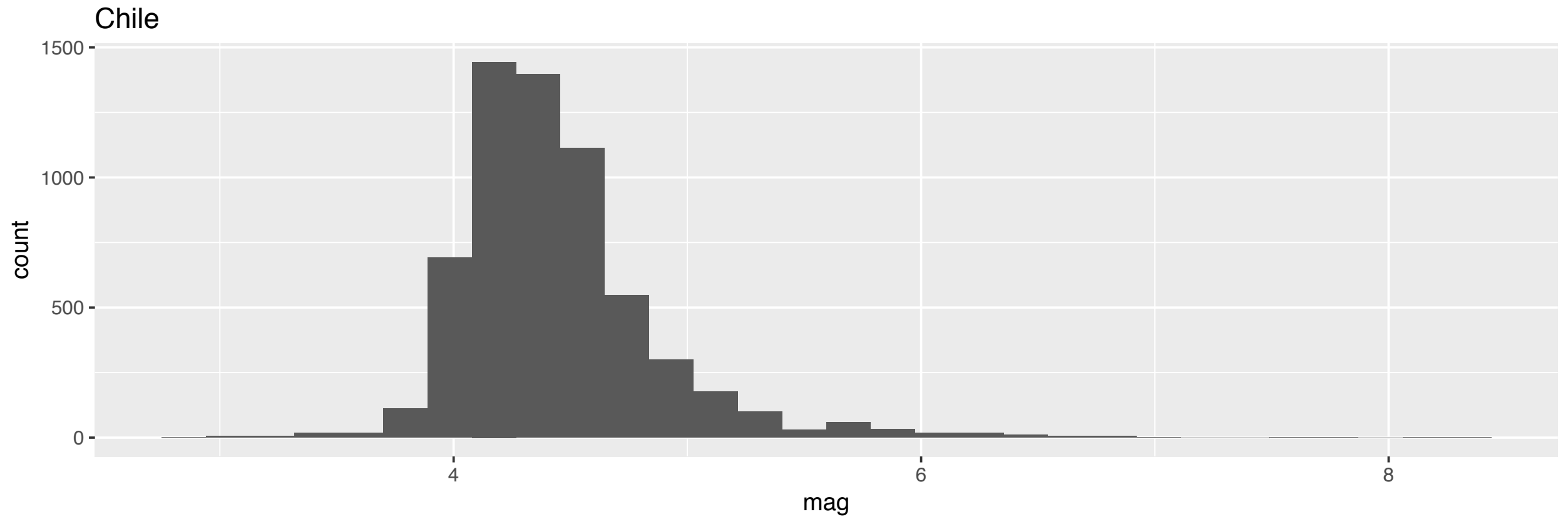
Chile



California/Mexico

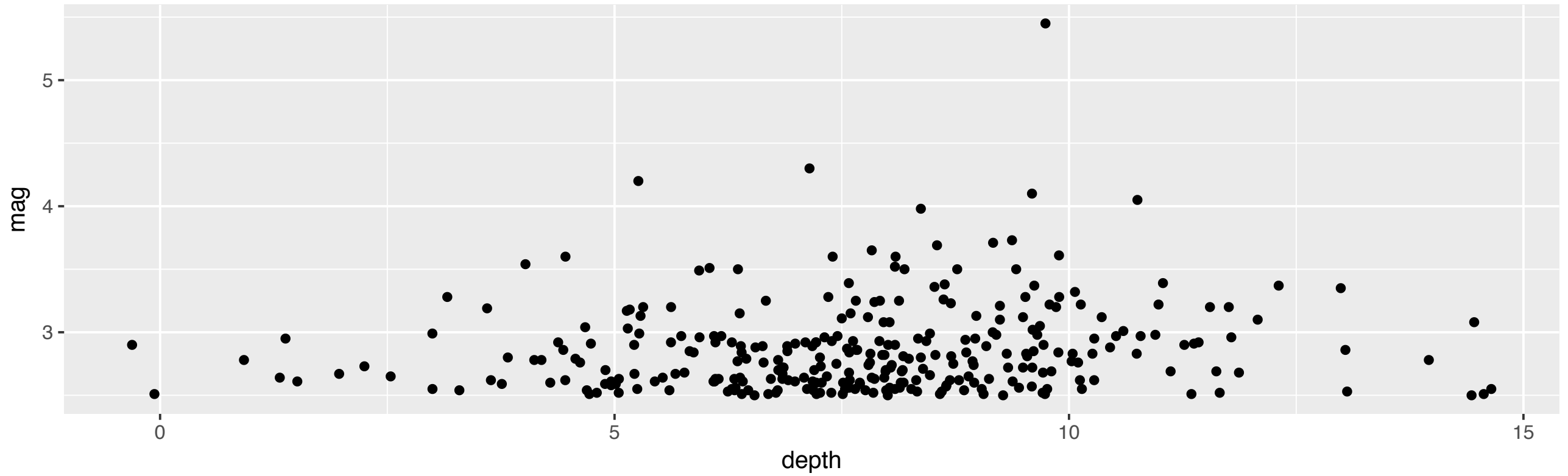


Earthquakes Jan 2012 – Apr 2017, Magnitudes > 2.5

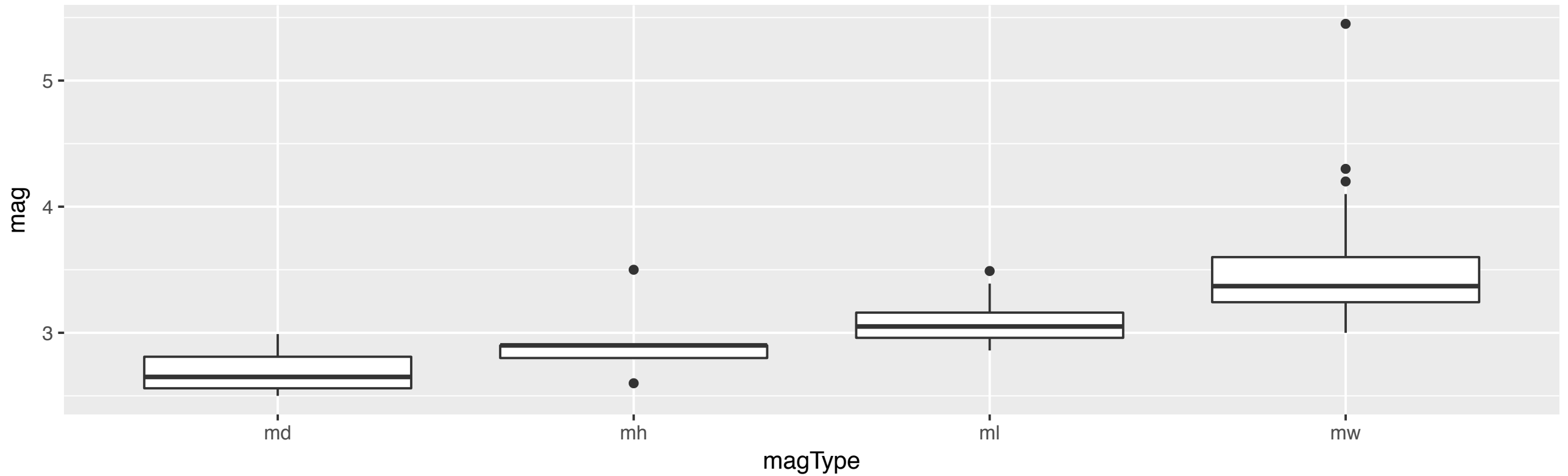


10 years of Earthquakes, Magnitudes > 2.5

Depth vs. Magnitude in Bay Area

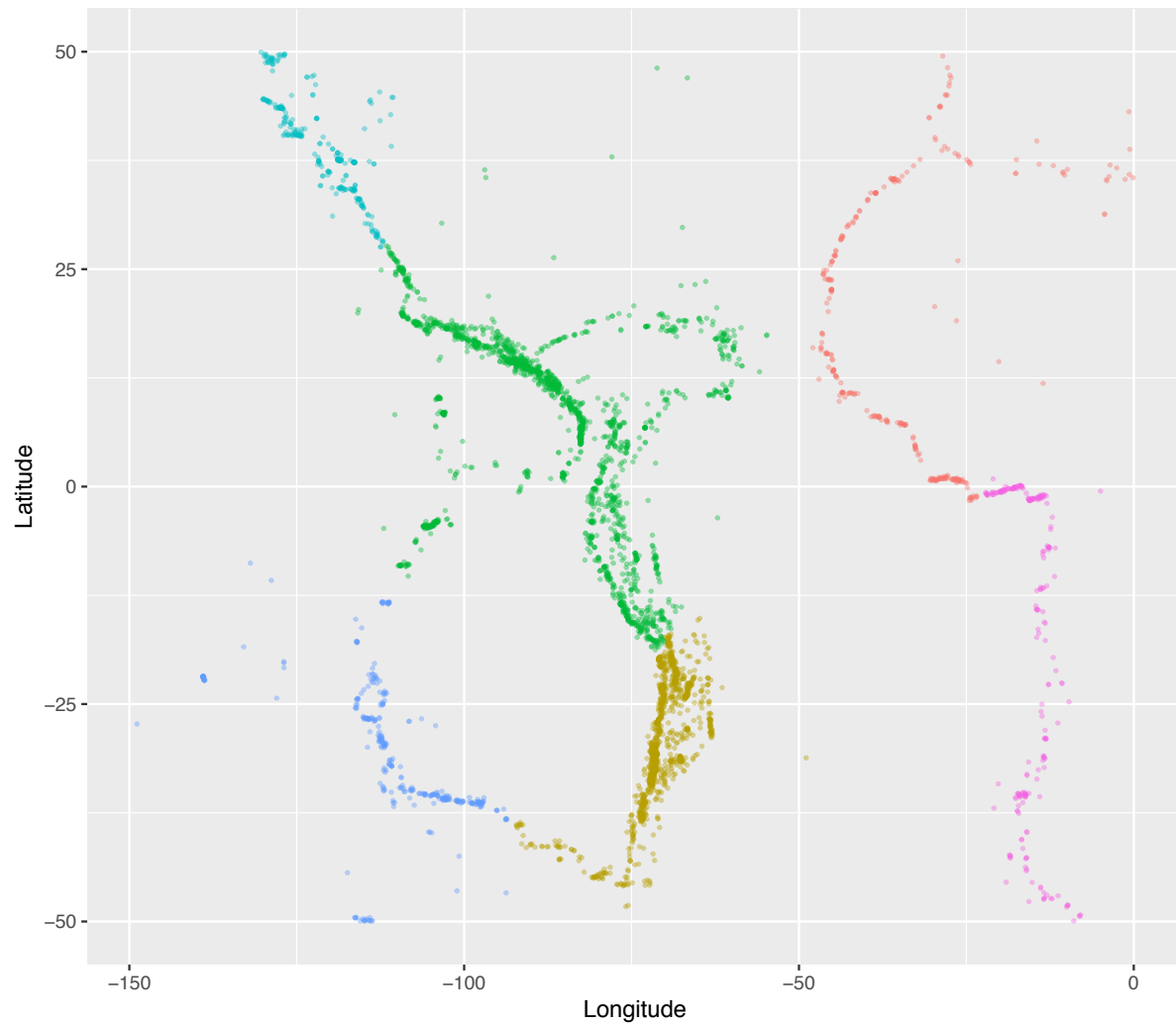


Mag Type vs. Magnitude in Bay Area

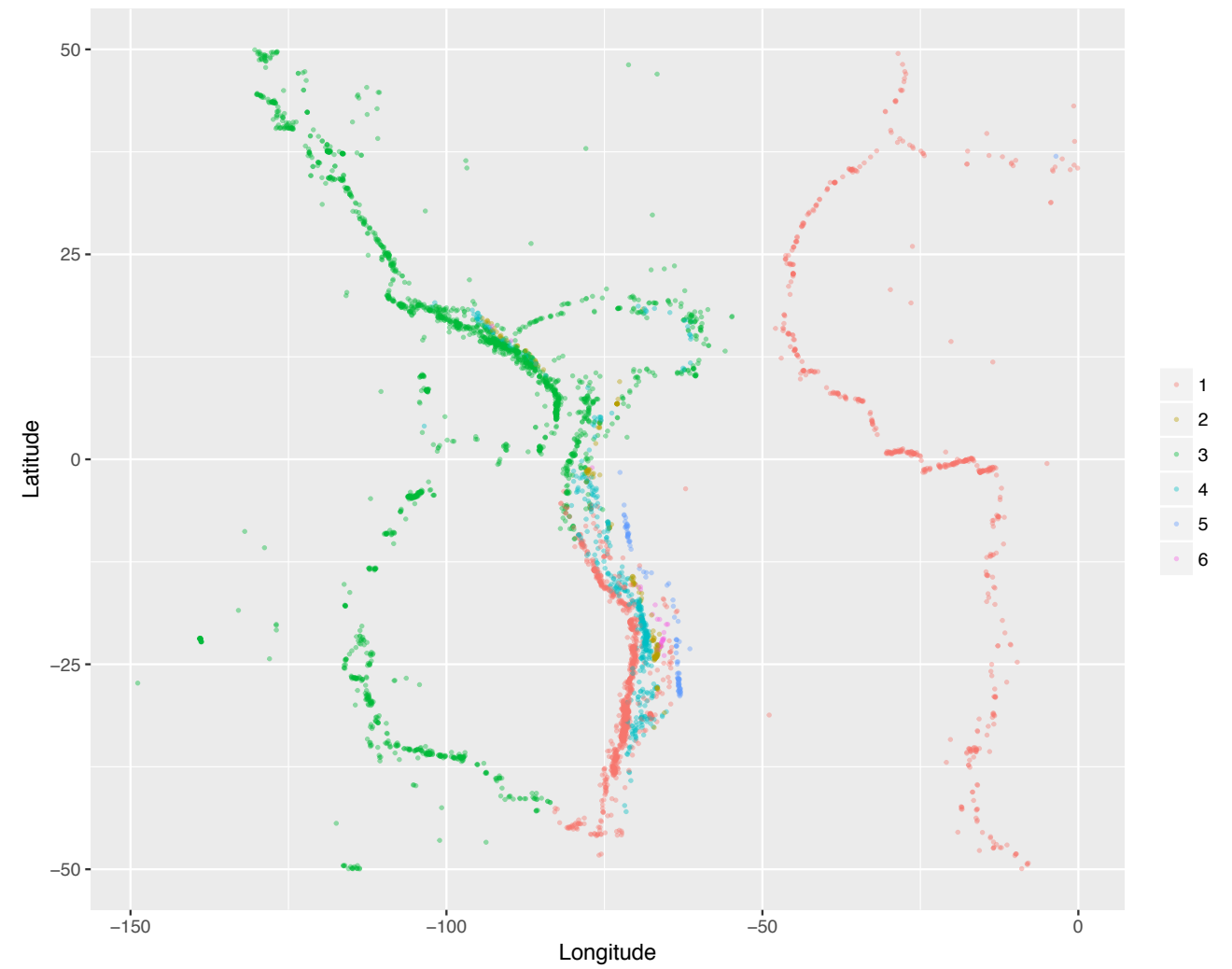


Hierarchical Clustering

Just Latitude/Longitude



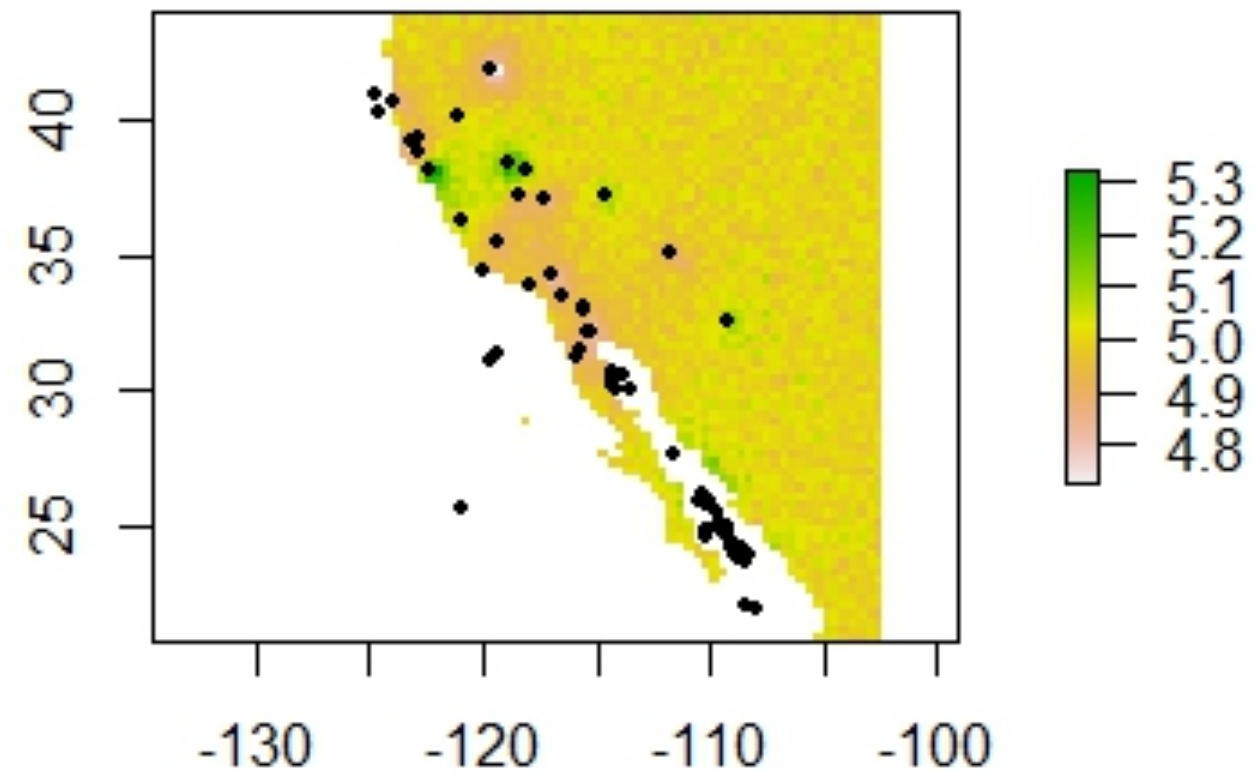
Using Latitude/Longitude, Depth, and Magnitude



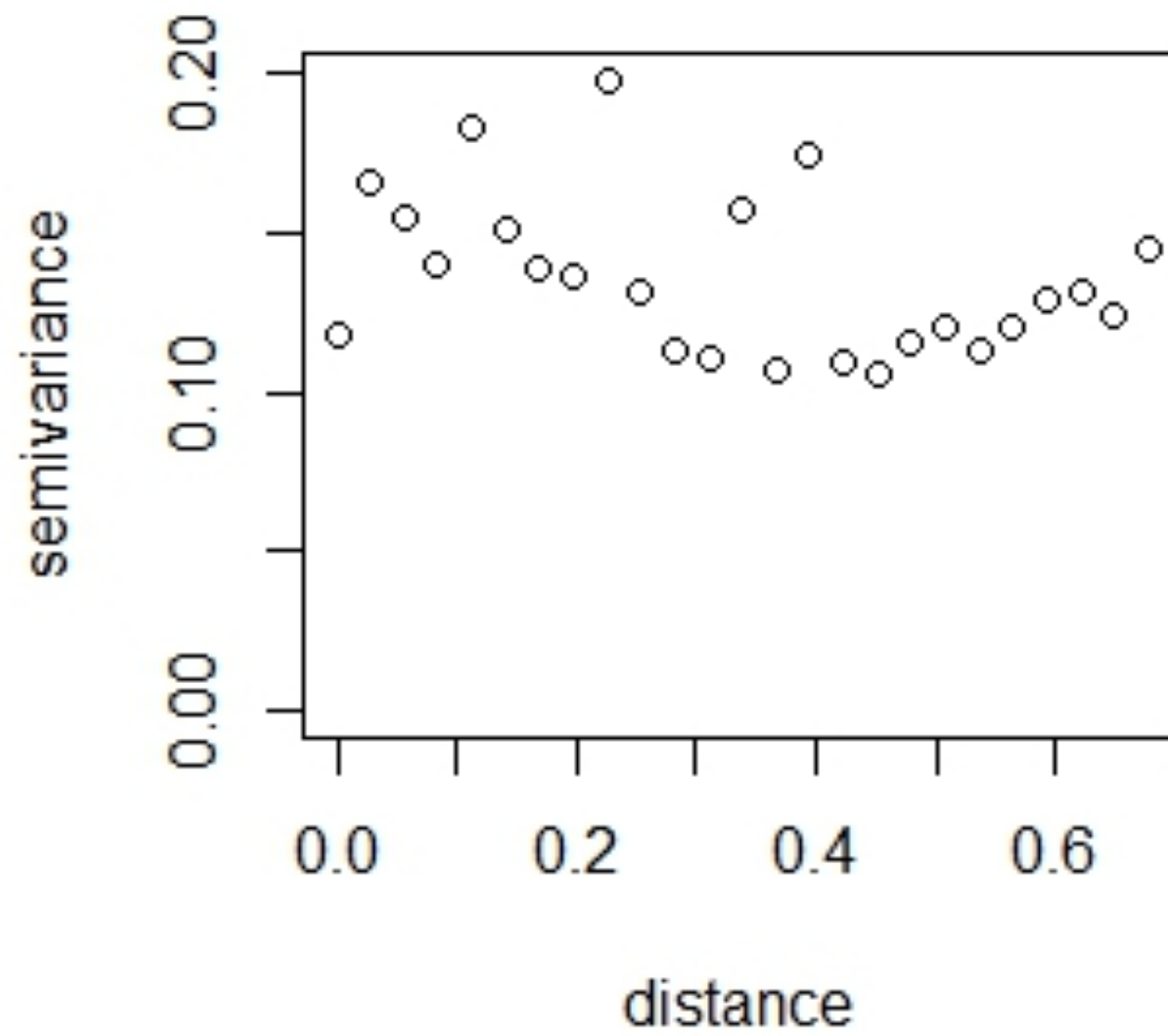
Spatial Modeling

- Difficult with so many points
- Focusing on magnitude also difficult because earthquakes inherently only happen in certain areas
- Magnitudes don't seem to be locally as related, more globally related, but we can't build a global model with time constraints
- We fit a Spatial Gaussian Process Model to earthquake magnitude using depth as our only covariate.

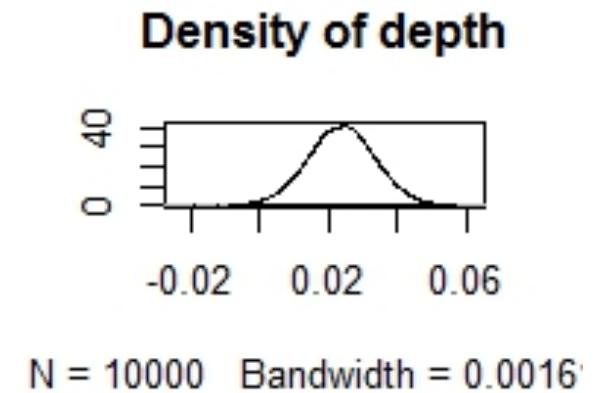
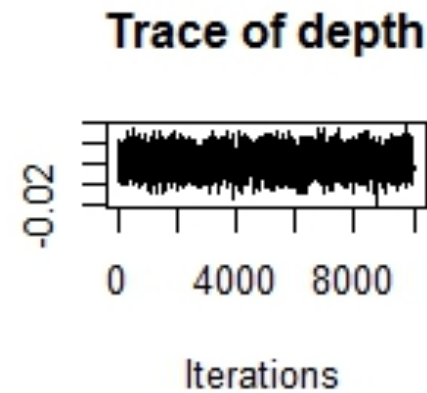
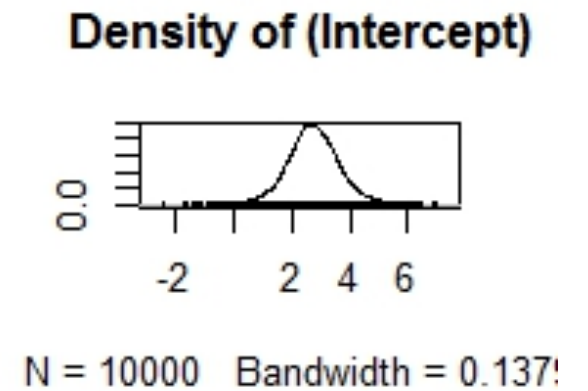
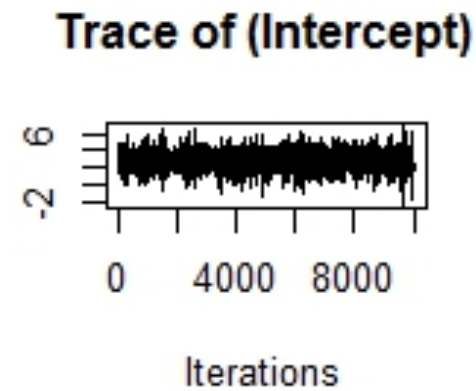
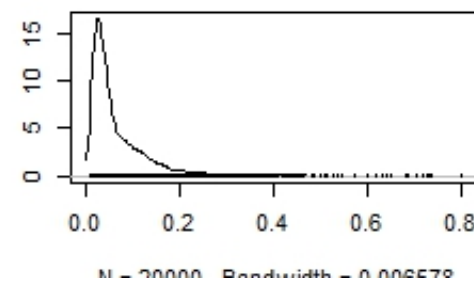
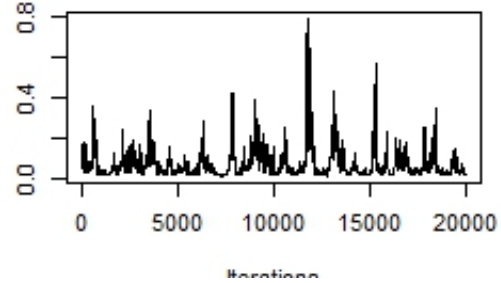
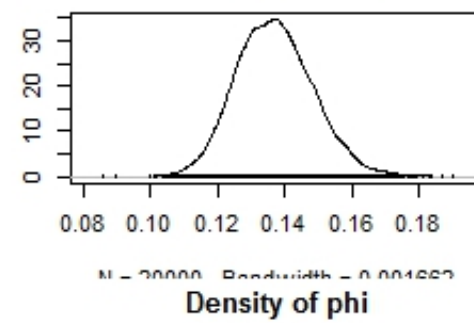
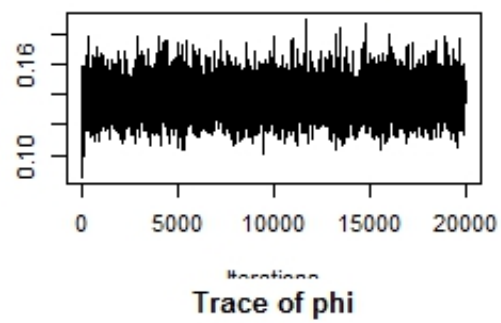
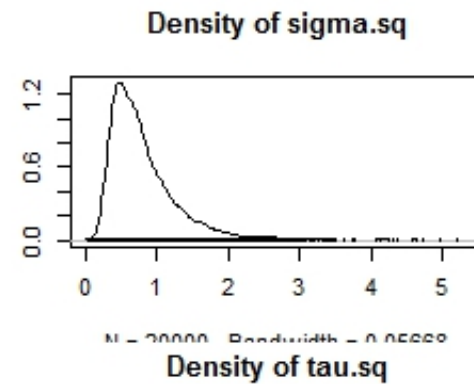
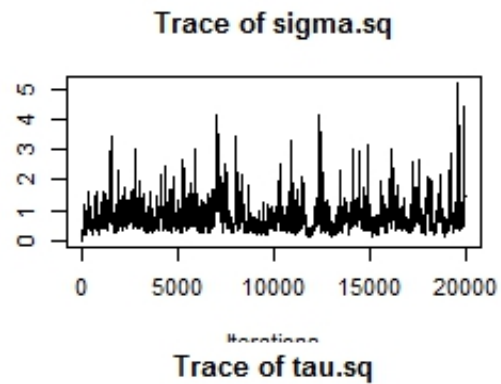
Spatial Model Attempt #1



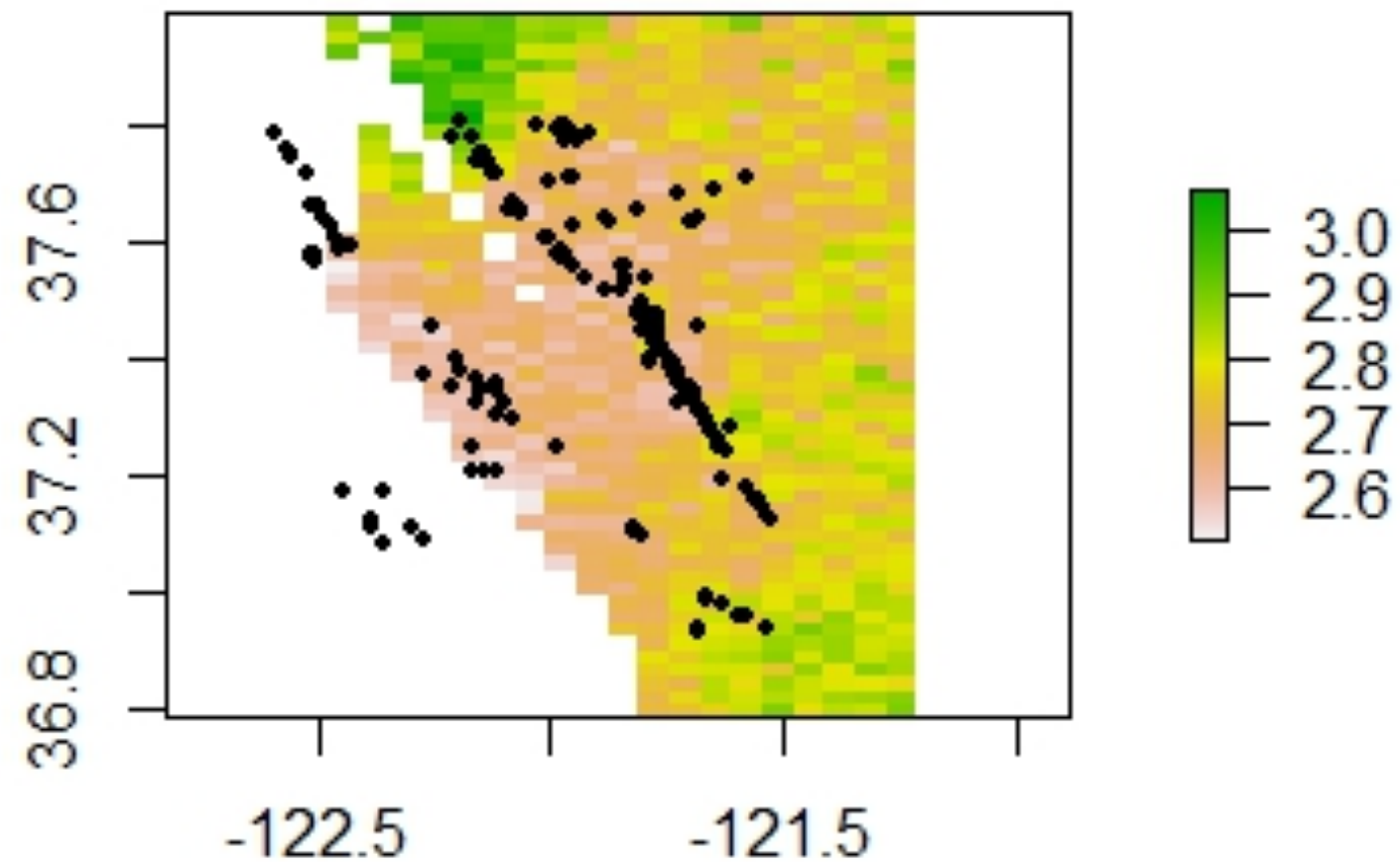
Variogram



Trace plots

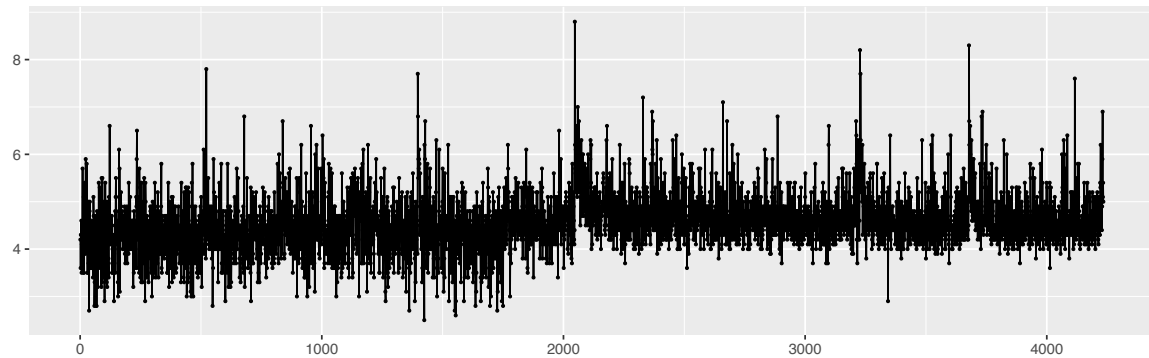


Spatial Model Attempt #2

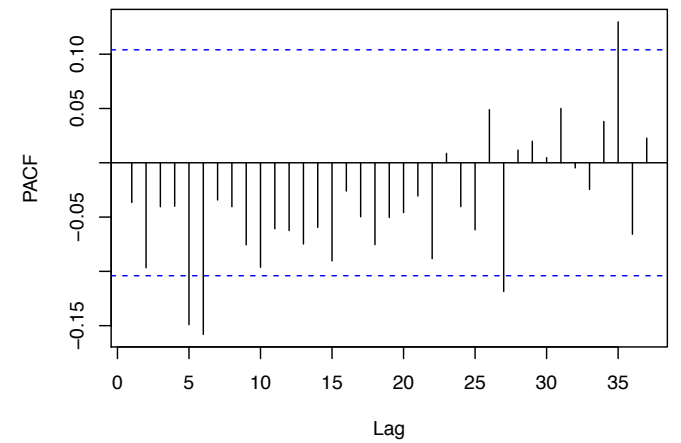
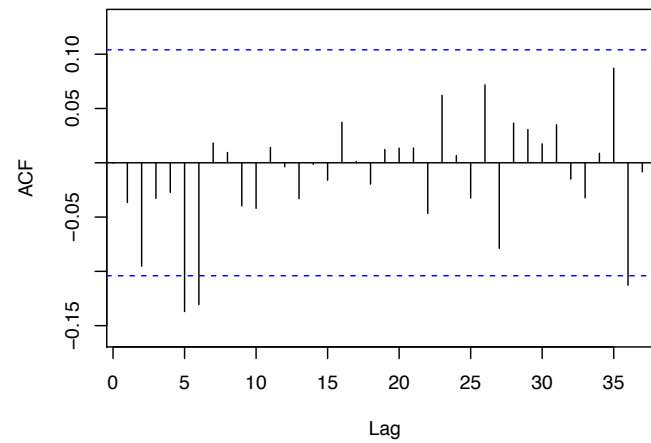
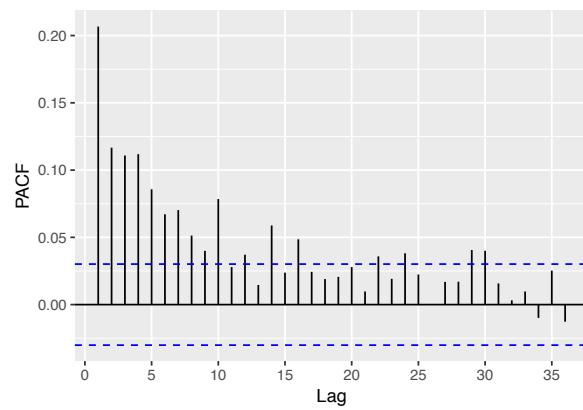
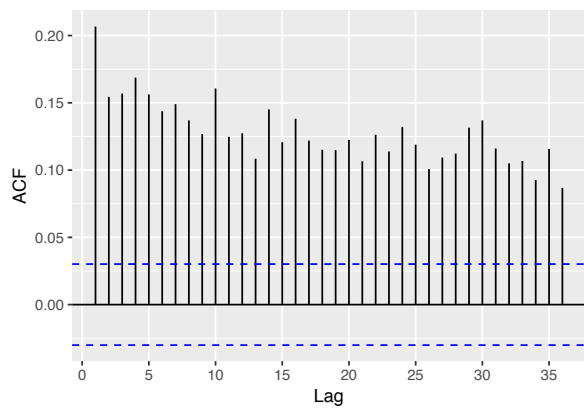
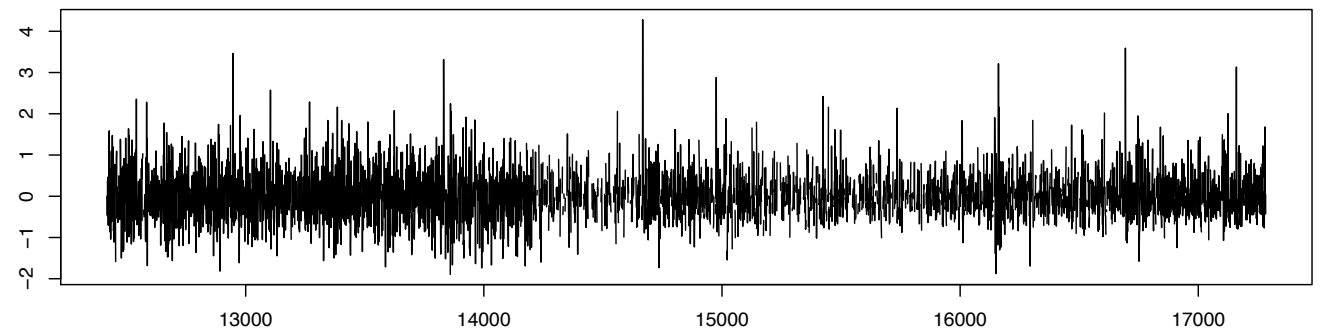


Time Model #1

Chile 2004–2017

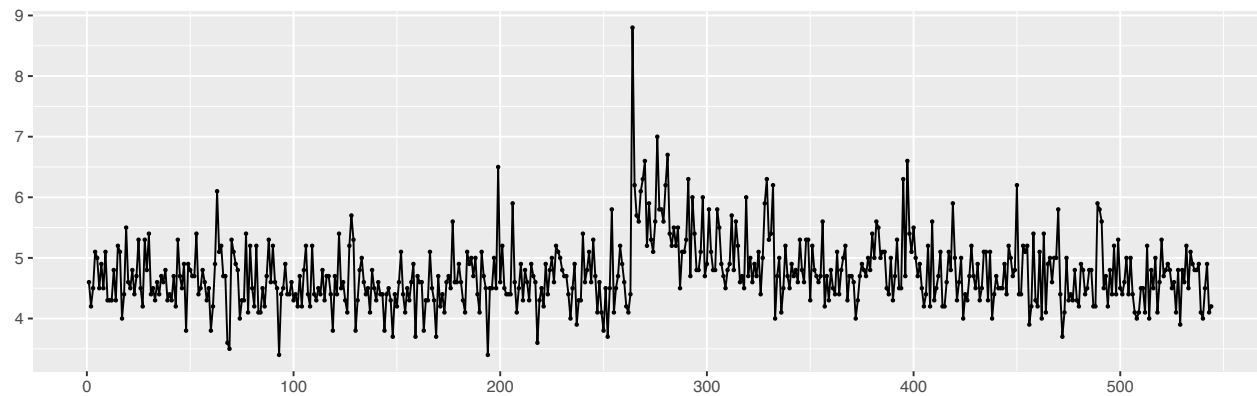


AIC: 7596

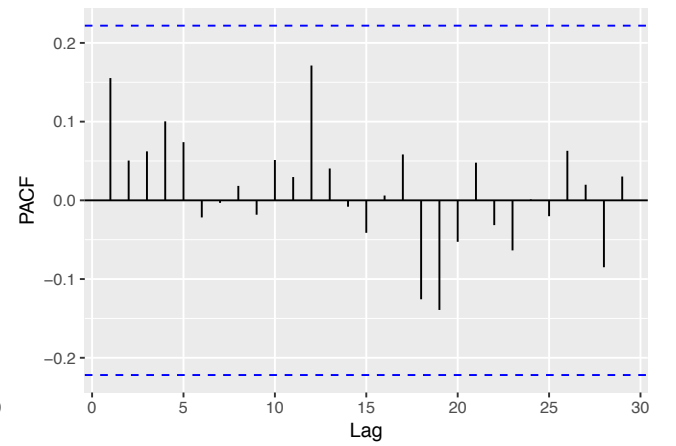
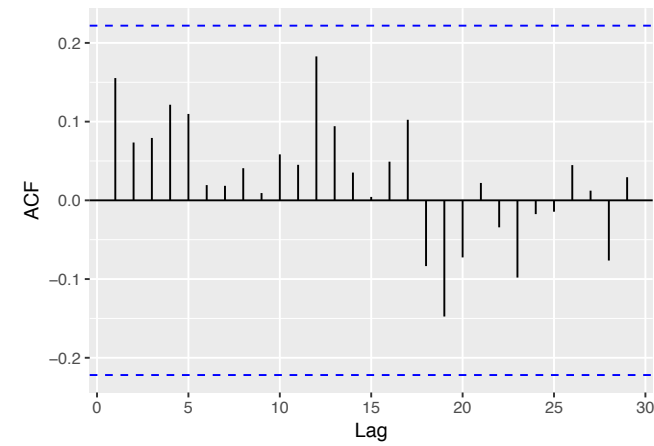
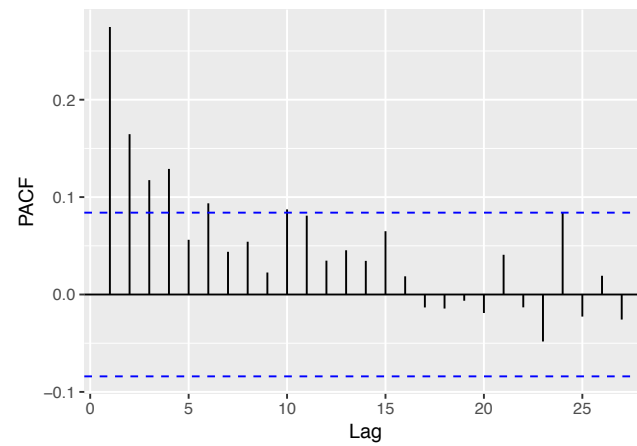
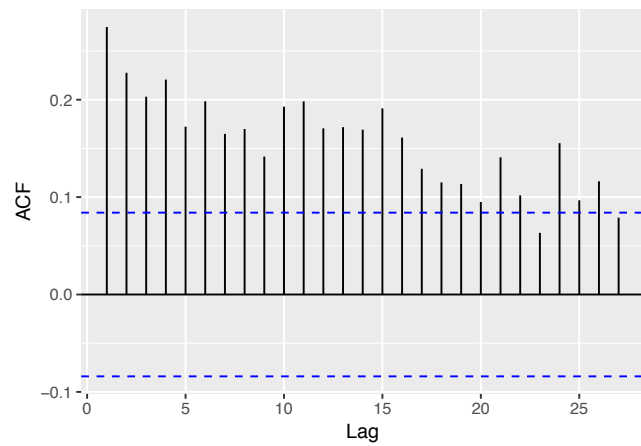
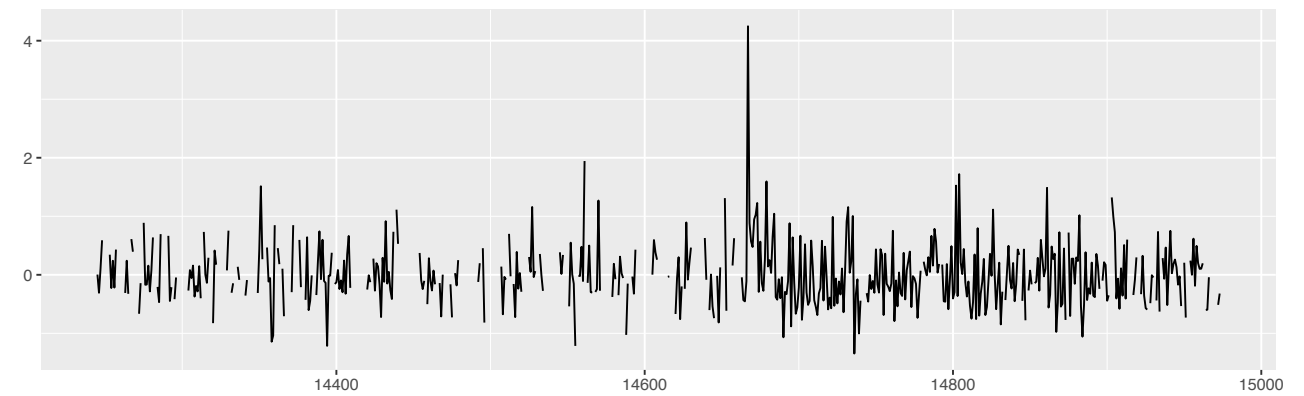


Time Model #2

Chile 2009 and 2010



AIC: 847



The End.

References:

<https://kaggle.com/usgs/earthquake-database>

<https://earthquake.usgs.gov/earthquakes/search/>