

Process Book Of Earthquake Analytics

- **Basic Info**

Project name: Earthquake Analytics -- Visualizing the Earthquake data by D3.js

Team members: Jinfa Zhao (jzhao30) Jiaqi Duan (jduan4)

Email: Jinfa: jzhao30@dons.usfca.edu ; Jiaqi: jduan4@dons.usfca.edu

Github repository: <https://github.com/comeFar/Earthquake-Analytics>

Project website:

<https://comefar.github.io/Earthquake-Analytics/EarthquakeOverview.html>

- **Background and Motivation**

There are million of earthquakes occur in the world each year. Some of them are very serious. They can do a great damage to buildings and cause fires by damaging electrical power or gas lines. What's more, earthquakes can cause buildings sinking, tsunami and floods. An earthquake may cause injury and loss of life and property damage.

As we know, earthquakes are natural phenomenon. However, some USGS geophysicists claim that human activities may also cause the earthquake happen, such as fracking. Drilling may trigger seismic activity.

Earthquake is very difficult to predict by the recently technologies. So we plan to build a Data Visualization on earthquakes to improve earthquake monitoring and help people understand earthquake easier and more efficient. In the same time, our visualization will show the relationship between earthquake and fracking. It will help scientists to find out the relationship between human activities and earthquake happening.

- **Project Objectives**

We try to build a Data Visualization on earthquakes by D3.js. It will work on the web and provide interactive function to users. We will learn how to use D3.js to build a web-based interactive visualization and explore earthquake data set using visualization techniques. We will build a geometric graph to show the earthquakes happened in the world. We will also build a geometric graph to show the location of fracking and earthquake happened in the world. So we can check if the fracking may cause earthquake. For details, we will also build bar chart,

search query, crossfilter and scatter plot to analyze the specific data. This project can make a great impact. First, it improve earthquake monitoring. Second, the interactive visualization help common people get more understanding on earthquake. Third, it may help scientist study the pattern of earthquakes and predict earthquakes happening. Fourth, it may help scientist find out if the human activities would trigger seismic activity.

- **Data**

We got the earthquake data from United States Geological Survey's (USGS) Earthquake Hazards Program website. The website link is <http://earthquake.usgs.gov/earthquakes/feed/v1.0/csv.php>

For the fracking data, we got from fracking data org. The fracking data is collected in February 2016. The website link is <http://frackingdata.org/fracfocus-data/>

- **Data Processing**

We plan to use the more significant earthquakes happened in the a month whose magnitudes are larger than 2.5. After clean up, there will be 1324 records. Some data are missing in some attributes, such as nst, gap, magError. We may mark them to zero. The data processing will be done in excel by filtering or manual operation.

- **Visualization Design**

General Design 1:

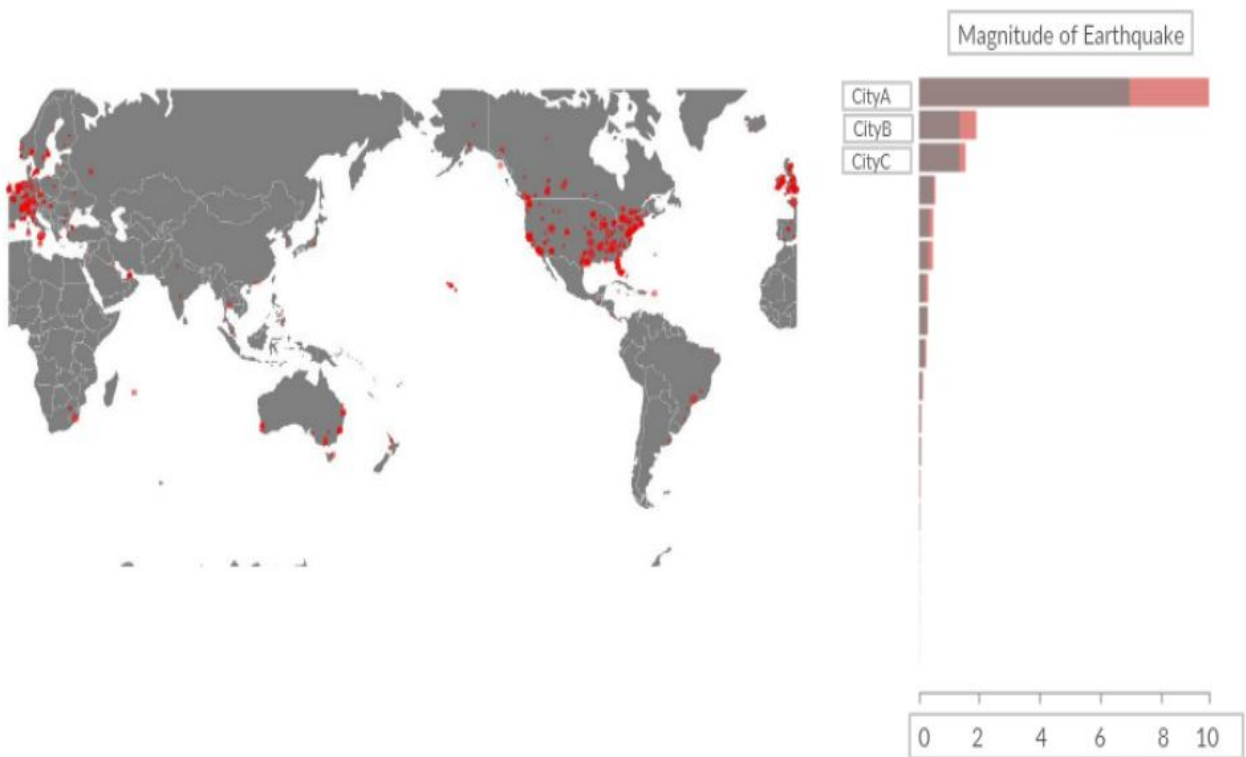


Figure 1: General design sketch 1

In this design, we trying to use geo-visualization to provide the location of the earthquake and combining with bar chart we can compare the magnitude of earthquake among different cities. Also, there are tooltips on the map so that we can easily find the information about this location.

General Design 2:



Figure 2: General design sketch 2

In this design, we try to combine geo-visualization with pie chart to show which places take place earthquake more frequently. The left side will show the geometric graph, the right sight will the earthquakes happen percentage in different countries.

General Design 3:

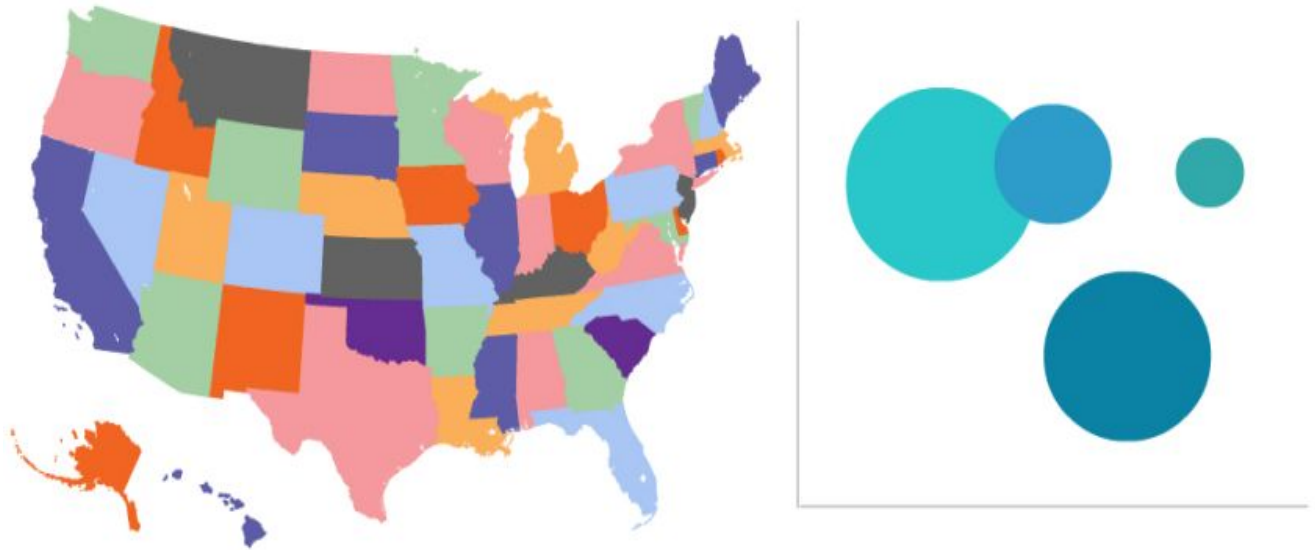


Figure 3: General design sketch 3

In this design, we try to combine geo-visualization with bubble chart. Each bubble represent each earthquake, and we can see the information about the earthquake from the tooltips on the bubble.

Our final choice:

After discussion, we prefer the design one as our final design. First, we can use the geometric graph to show the general idea to the user. User can click the circles in the location to get more information about it. The right size bar chart also provide more details to user. User also can use slider to filter the bar chart.

- **Must-Have Features**

(1)A Geometric graph to show the earthquakes happen around the world. We may use size or color of circle to represent the magnitude of an earthquake.

- (2) Interactive of Geometric graph: when a user click on one circle, it will show up the location and the information of the earthquake, such as magnitude, depth, time and so on, tooltip.
- (3) Some words description to indicate what we found from the visualization.
- (4) Back and forward button for user to continue exploring the next visualization.
- (5) A Geometric graph to show the location of fracking and the earthquakes happen around the world. We can check if the location of fracking near the earthquake center.
- (6) Earthquakes show up by the time happening.

Here is workflow of our data visualization:

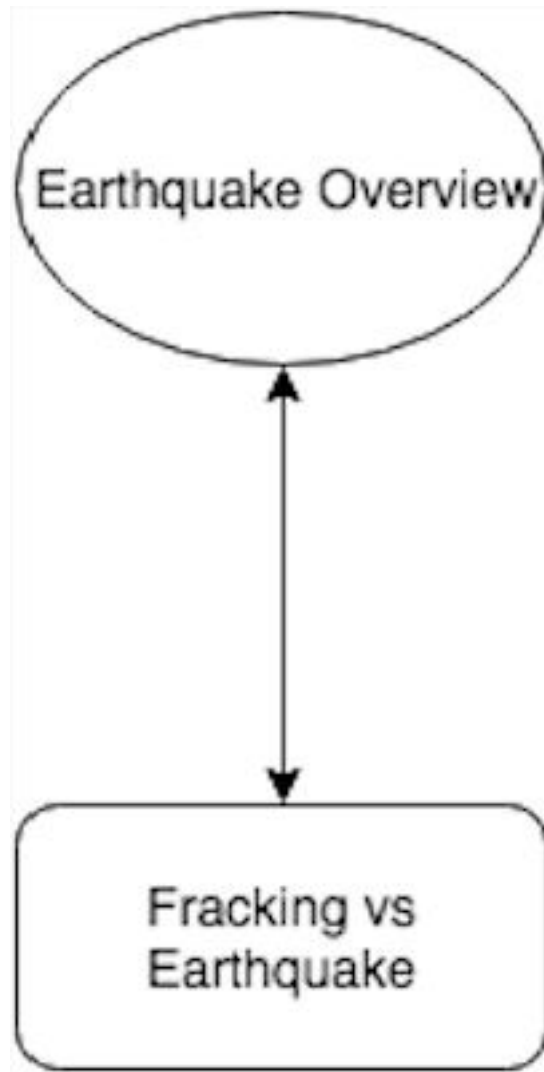


Figure 4: Workflow diagram

Here is a sketch shows the relationship between earthquake and fracking in USA:

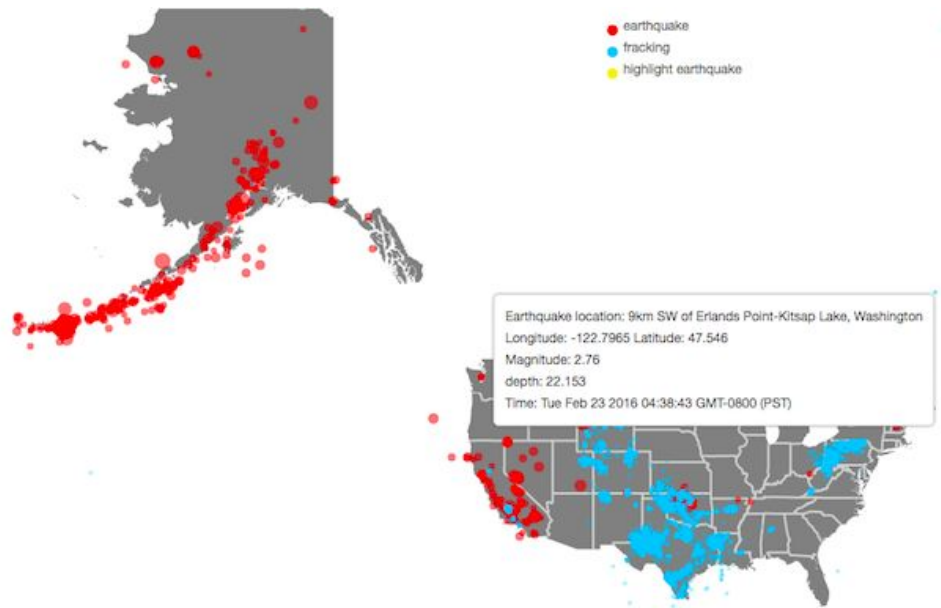


Figure 5: Sketch of relationship between earthquake and fracking

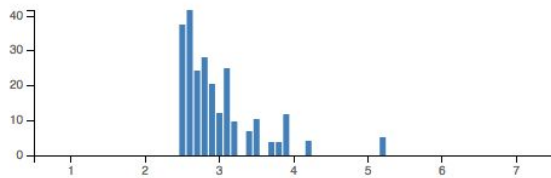
- **Optional Features**

- (1) Build some bar charts based on different attributes.
- (2) Filter using crossfilter in bar charts and line chart. User can use crossfilter to show the most significant earthquakes.
- (3) Query for place and time to highlight earthquakes.
- (4) Animation during graph transition.
- (5) Build Scatter plot graph.
- (6) Provide high light and tooltip function in scatter plot graph.
- (7) Build a 3D global map
- (8) Zooming and tooltip for interactive Geometric graph
- (9) Rotation animation
- (10) 3D global map to 2D

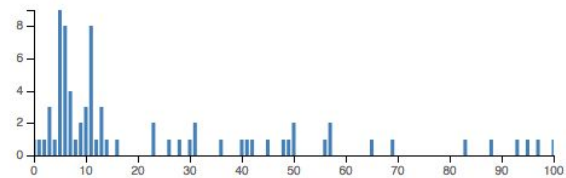
Below is the sketch of CrossFilter:

United States Earthquakes

Events by Magnitude



Events by Depth (km)



Events per hour

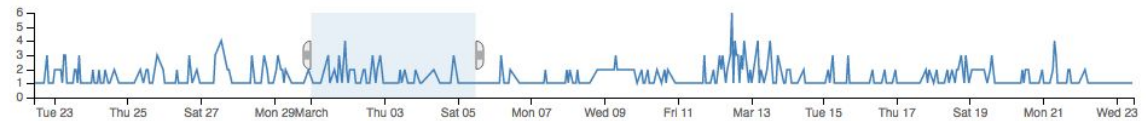


Figure 6: Sketch of CrossFilter

Below is searching and highlight in a Geometric graph,

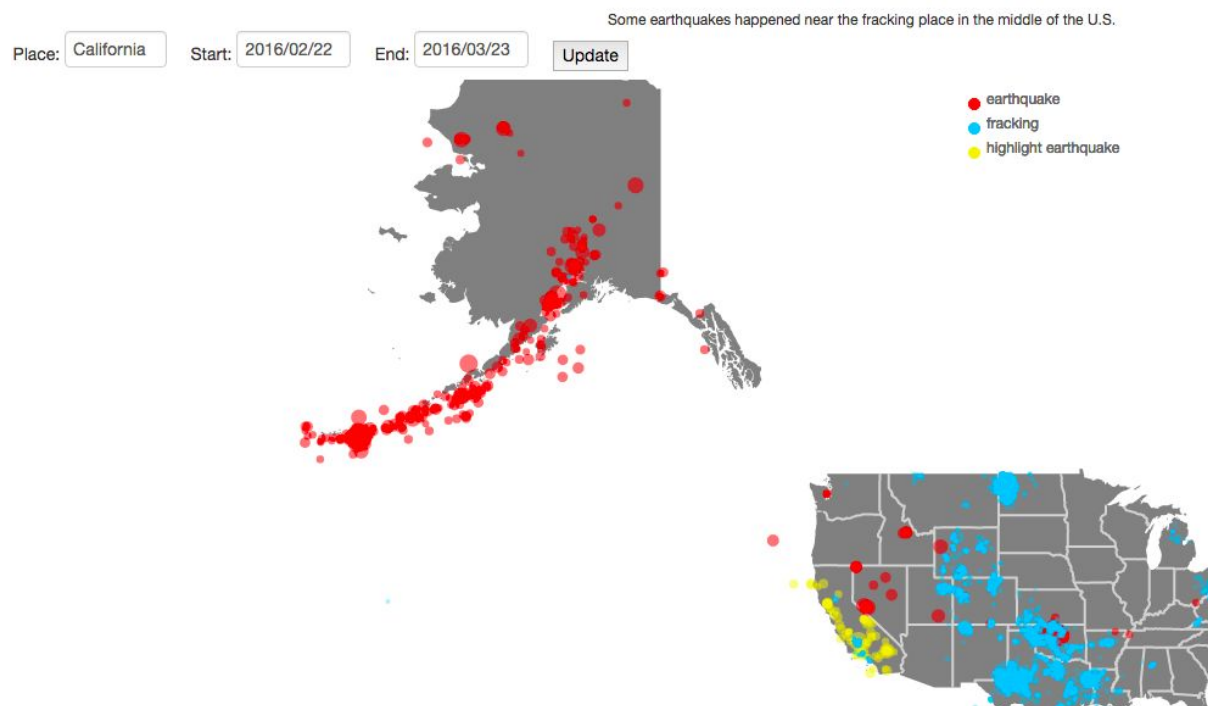


Figure 7: Query and highlight earthquake

Below is the scatter plot design sketch:

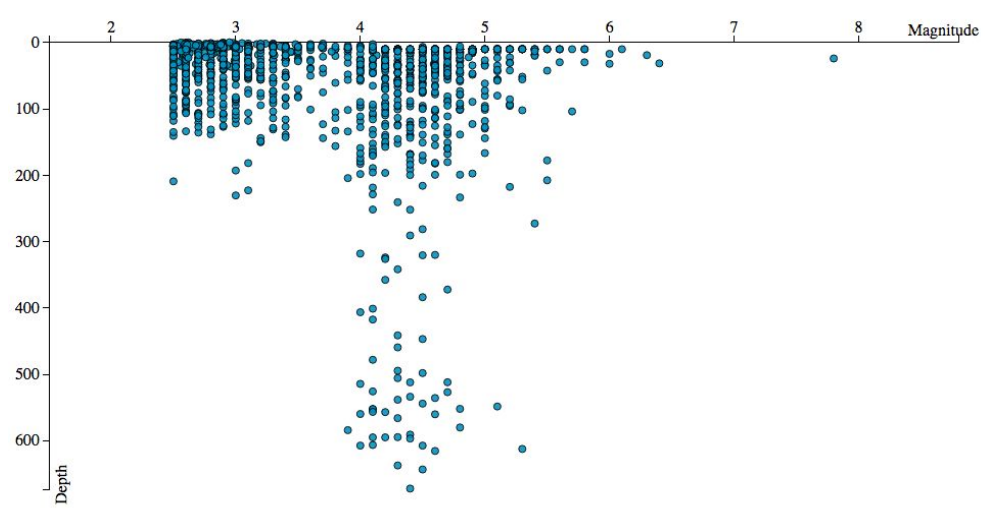


Figure 8: Scatter plot design sketch

- **Other Design Sketches**

User Interface:

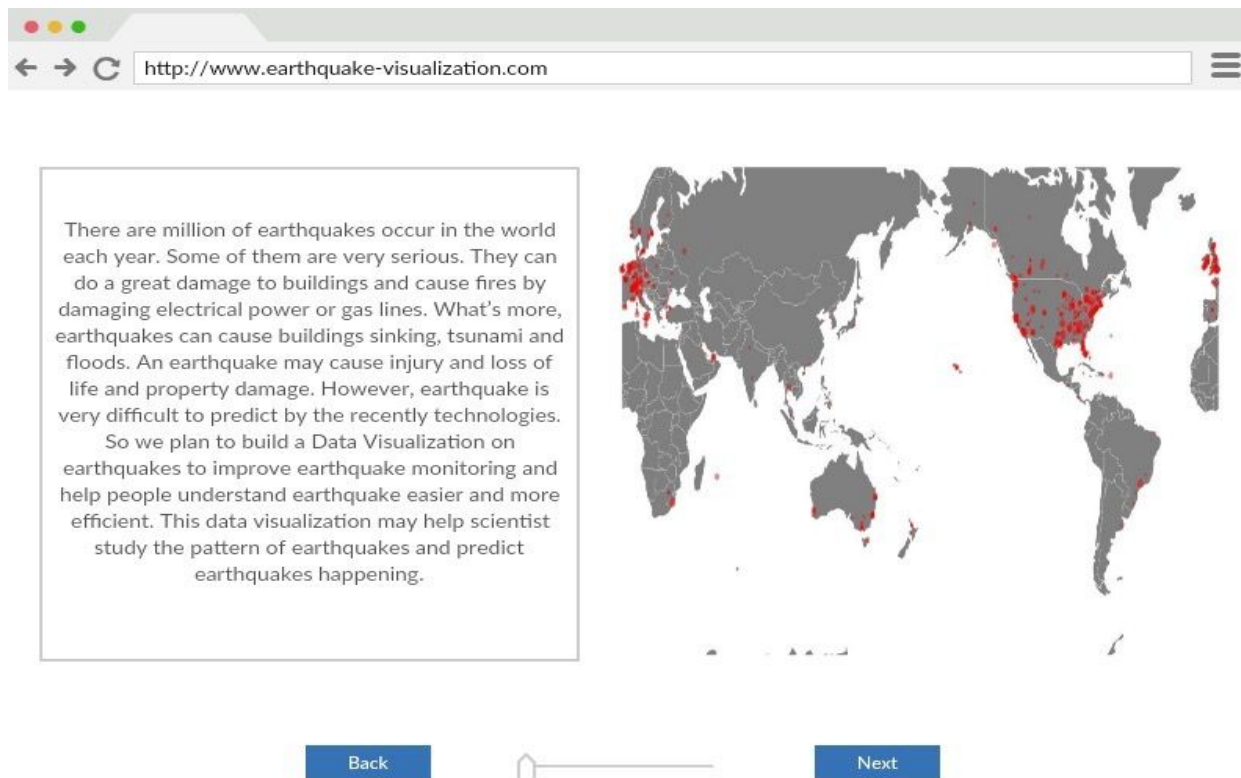


Figure 9: User Interface 1

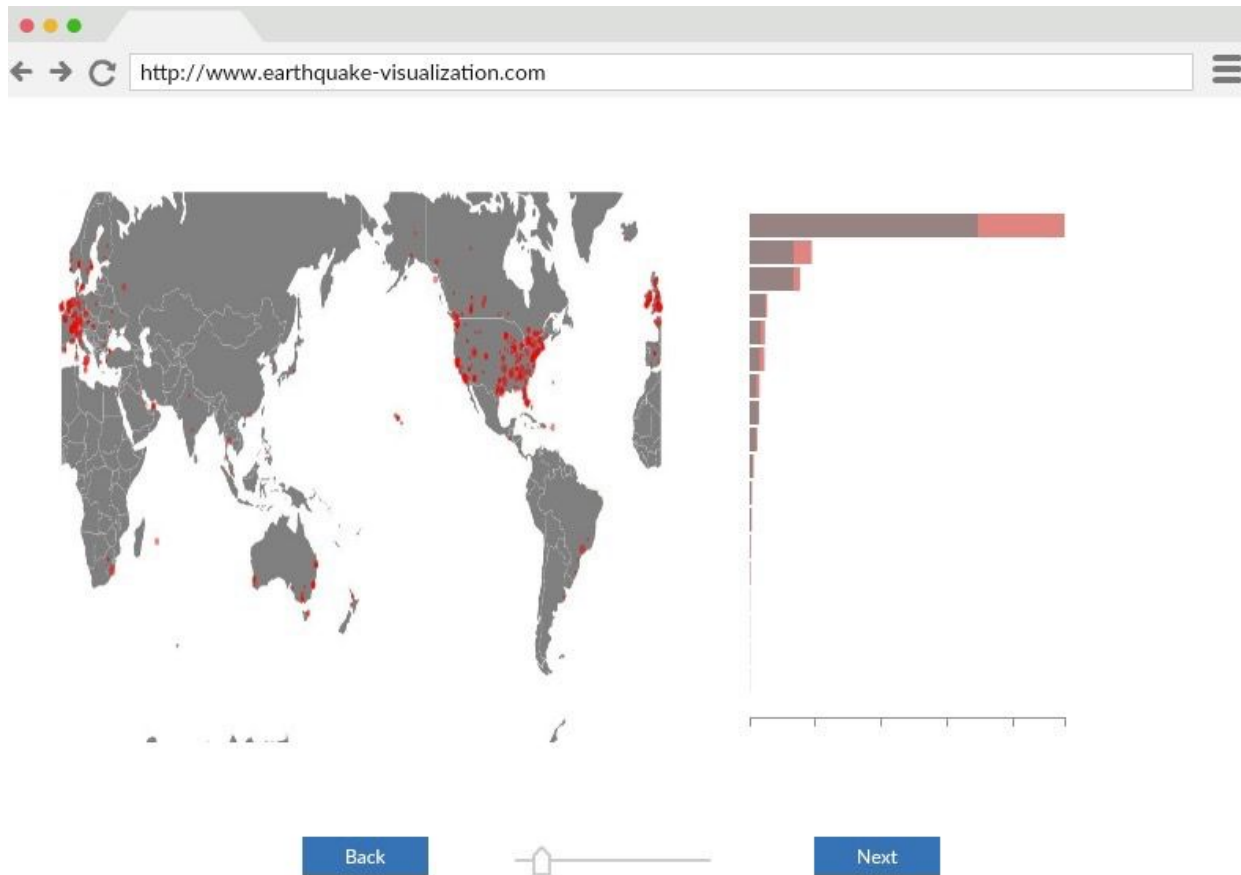


Figure 10: User Interface 2

This is a storytelling user interface, users can click back or next to move to different visualization. Users also can move the slider to directly find what they want.

- **Project Schedule**

Week	Goal, Milestones	Description
3/28-4/3	Revised Proposal and Annotated Bibliography	Study the earthquake dataset and do research on geometric graph on d3.js
4/4-4/10	Data Processing and Working on Geometric graph	Data Processing and Working on Geometric graph
4/11-4-17	Alpha Release;	Finish Alpha Release and build the demo interface, such as word description, Back and forward button
4/18-4/24	Develop Interaction on Geometric graph	Implement Interaction on Geometric graph
4/25-5/1	Beta Release	Implement bar chart and slider for bar chart
5/2-5/8	Implement crossfilter and search	Implementing crossfilter and search
5/9-5/15	Final Project Presentation	Implementing scatter plot
5/16-5/19	Report, Source Code, Presentations slides, and User Manual	Documenting and testing. Submit assignment.

- **Related Work:**

[1] Stephen Ornes, July 26, 2013, Fracking waste and quakes, <http://mrges.com/news/ESNews/scinews/files/fracking-waste-and-quakes.pdf>

This article introduces what is fracking. It also points out that small central U.S. quakes have been occurring near sites of hydraulic fracturing, or fracking. It also mentions that fracking added pressure to a crack in Earth's crust. It explain the relationship between fracking and earthquakes. I like one of its visualization showing the risk of earthquake happening and the place actually have earthquake in the past three year. This may be a good example for our visualization.

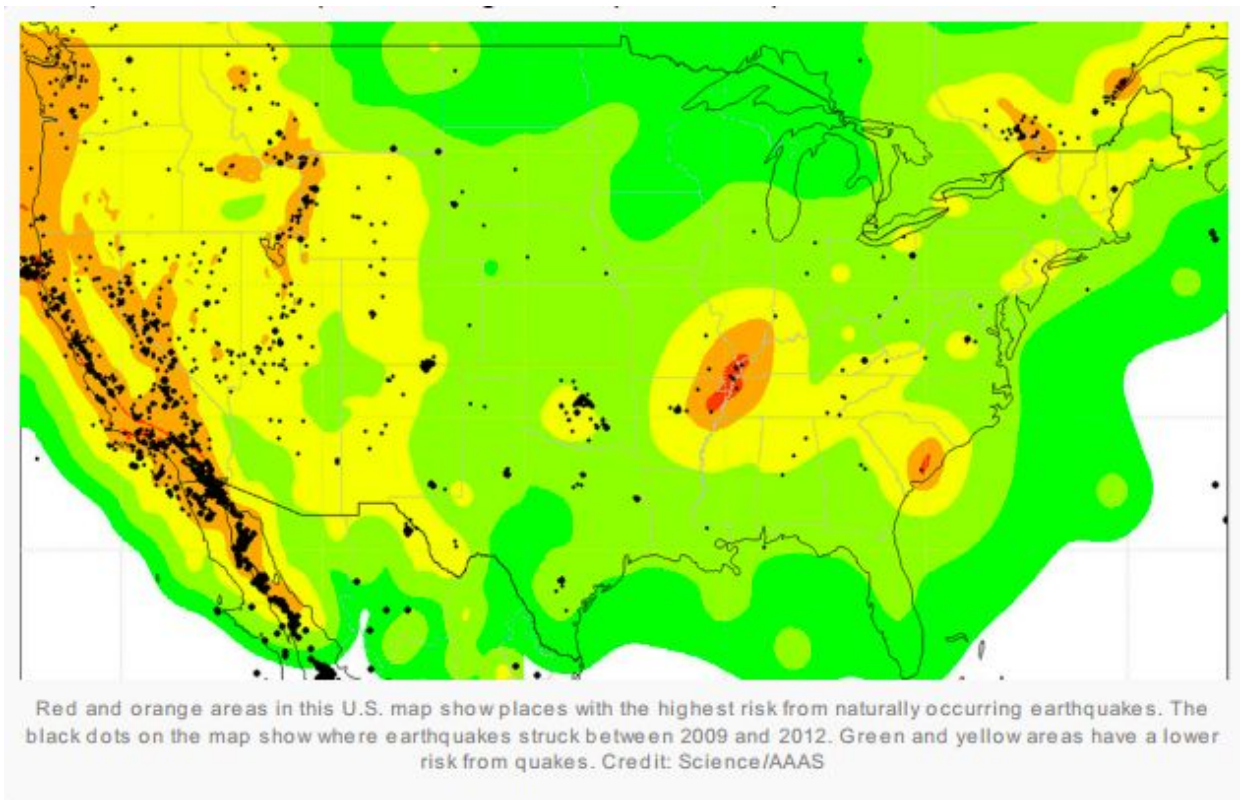


Figure 1: U.S. map showings risk of earthquake and places have earthquakes between 2009 and 2012

[2]Falk Amelung and Geoffrey King, March 1, 1997, Earthquake scaling laws for creeping and non-creeping faults, <http://onlinelibrary.wiley.com/store/10.1029/97GL00287/asset/grl9988.pdf;j>

[sessionid=97D877EAB6AADDAA6005B251394E297C.f02t04?v=1&t=imeafz8r&s=9609667b73ad67f58d791e5e990004c24dda2ae1](https://www.researchgate.net/publication/312111111/figure/fig/1/figure-fig1/1513111111/AMELUNG-AND-KING-CREEPING-AND-NON-CREEPING-FAULTS)

This paper talks about the dependence of the summed moment release on the fault dimension differs between non-creeping faults and creeping faults or volcanic regions. The frequency size scaling for creeping faults changes to that of a non-creeping fault for increased loading rate. I like one of the visualization they use in the paper, drawing the bar chart in a geometric graph. It make people know the location of seismicity and the moment-fault length distribution. This would be an great example for our visualization.

AMELUNG AND KING: CREEPING AND NON-CREEPING FAULTS

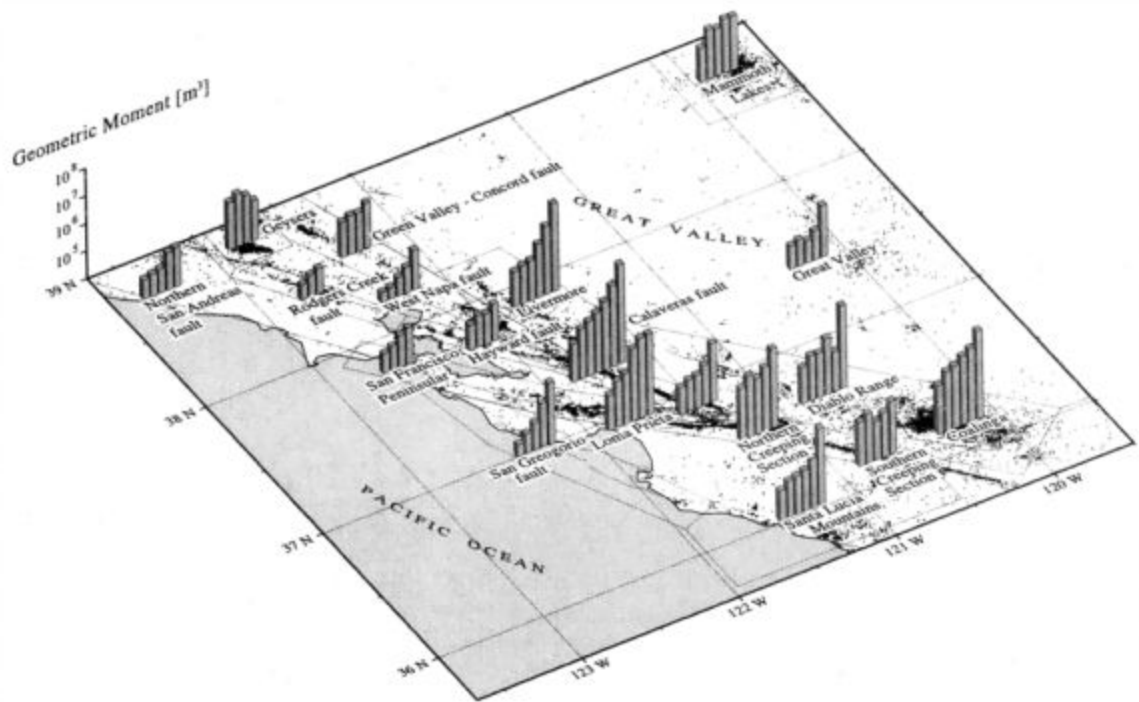


Figure 2: Creeping and non-creeping faults

[3]CETT, N. "Learning how to not make your own earthquakes." Science 25 (2010): 1624,

<https://scits.stanford.edu/sites/default/files/science-2012-kerr-1436-7.pdf>

This short article also presents that fracking can induce earthquakes, and it gives an idea that As fluid injections into Earth's crust trigger quakes across the United States, researchers are scrambling to learn how to avoid

making more, which indicate that Wastewater injection could be another factor inducing the earthquake.

[4]Ellsworth, William L. "Injection-induced earthquakes." *Science* 341.6142 (2013): 1225942,

<http://users.clas.ufl.edu/prwaylen/GEO2200%20Readings/Readings/Fracking/Earthquakes%20and%20fracking.pdf>

This article introduces that human-induced earthquakes become an important topic of political and scientific discussion, because it can result for widespread damage and an overall increase in seismicity. The article also introduces some injection-induced earthquakes, like earthquakes induced by hydraulic fracturing will also responsible for the increasing numbers of earthquakes. Here the article shows more and more frequent earthquakes occurred recent years.

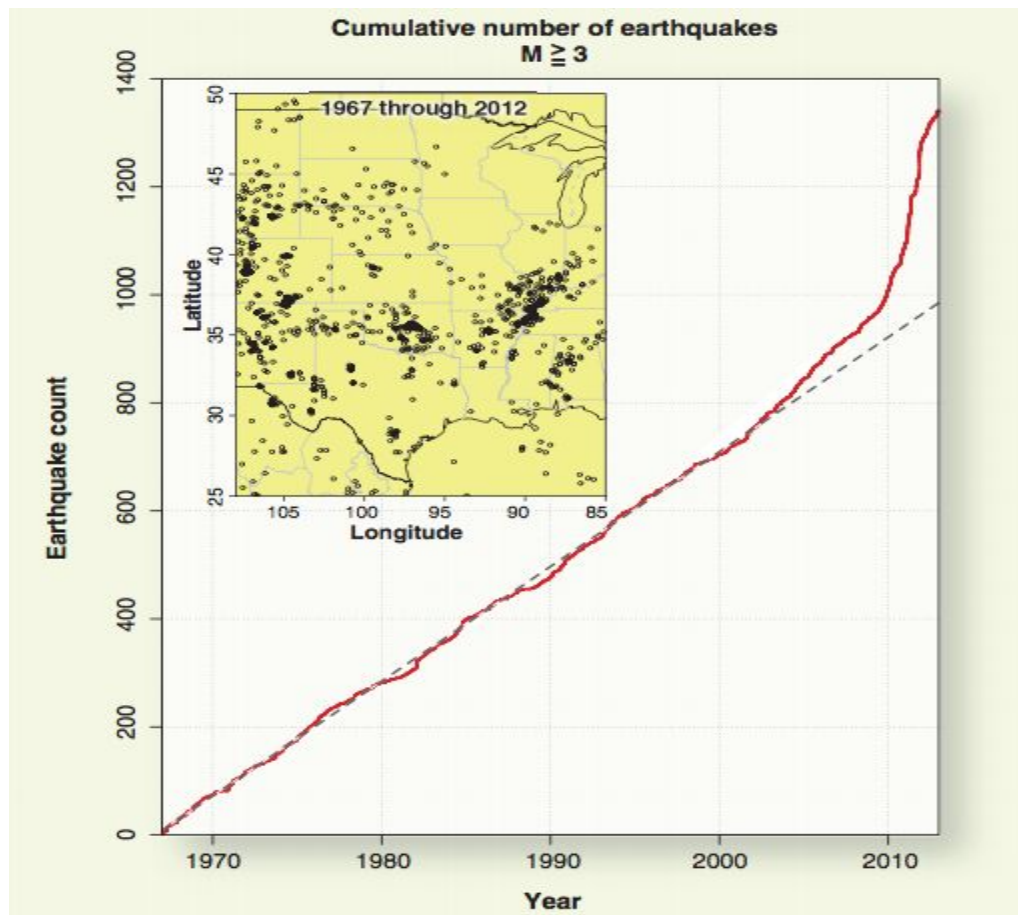


Figure 3: Cumulative count of earthquakes with $M \geq 3$ in the central and eastern United States, 1967–2012.

- **Questions:**

(Alpha release) How to show the relationship between earthquakes magnitude and depth?

How to show the location of earthquake in a geometric graph?

How to show the size of magnitude in the graph?

How to show the fracking data and earthquake data in a same geometric map

(Beta release) How to make a time slider to play the data by time?

How to show earthquake on the 3D map?

How to differentiate different earthquakes on the 3D map?

Can we make the map more interactive?

What visualization can be added to make the geo-visualization more Interactive?

How to transfer 3D map to 2D map

(Final release)

How to choose the correct colors to show the magnitude of earthquake?

Which way to do the query is the best?

- **Exploratory Data Analysis:**

When we first got the data, we wrote some python script to clean the data. After we studied the data, we consider to design one overview visualization for all the earthquakes and one visualization to show the relationship between earthquake and fracking. We also found that the magnitude and depth are the major factor of earthquake. So we want to build a scatter plot to show their relationship. Then we also wanted to improve the user interactive, such as tooltip, zoom, query and so on.

- **Design Evolution:**

(1) Alpha Release:

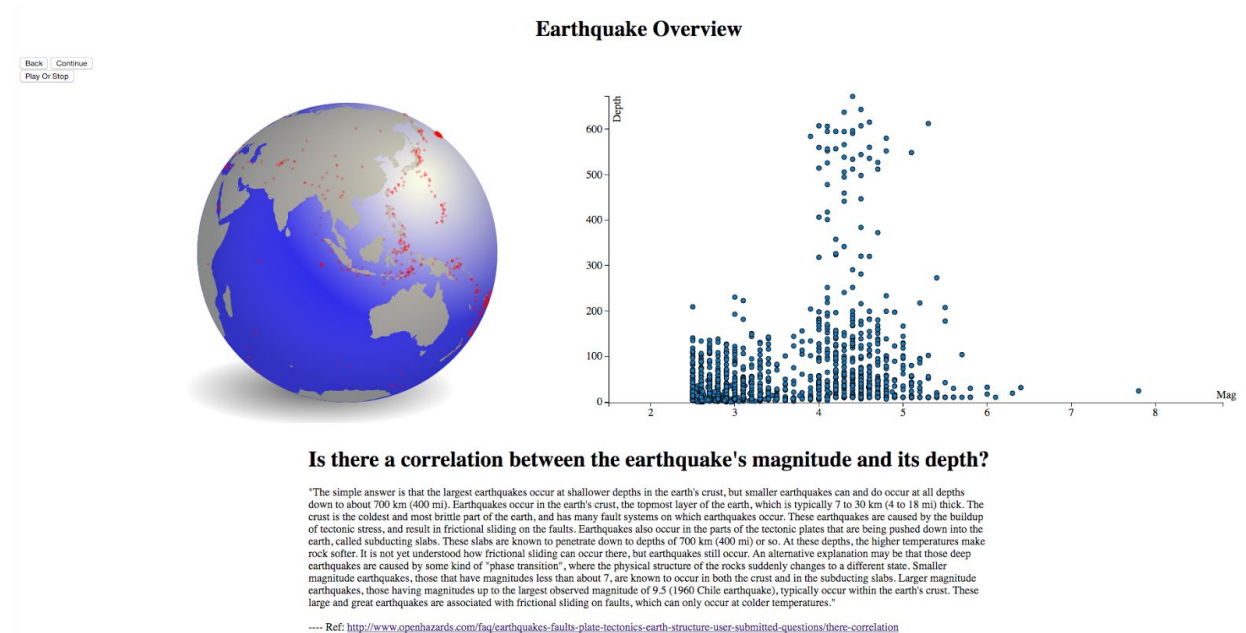


For our alpha release, we implement a geometric graph. The red circles represent the earthquakes happen in the world. The size of circle represent magnitude of the earthquake. The earthquakes show up in the order of time.

(2)Beta Release

We implement the interactive tooltip for showing more information of an earthquake. User can click a dot to see more information of an earthquake. We also implements the continue and back button for two graphs.

Overview



We implemented two new visualizations on the overview page. The first visualization we used svg to build a 3D global map to show the overview of the earthquake on the world. We also add animation of rotation for the 3D global map and when user move cursor to one point it will show the information about the earthquake as tooltip. Here are some links we referred to:

<https://www.jasondavies.com/maps/rotate/>

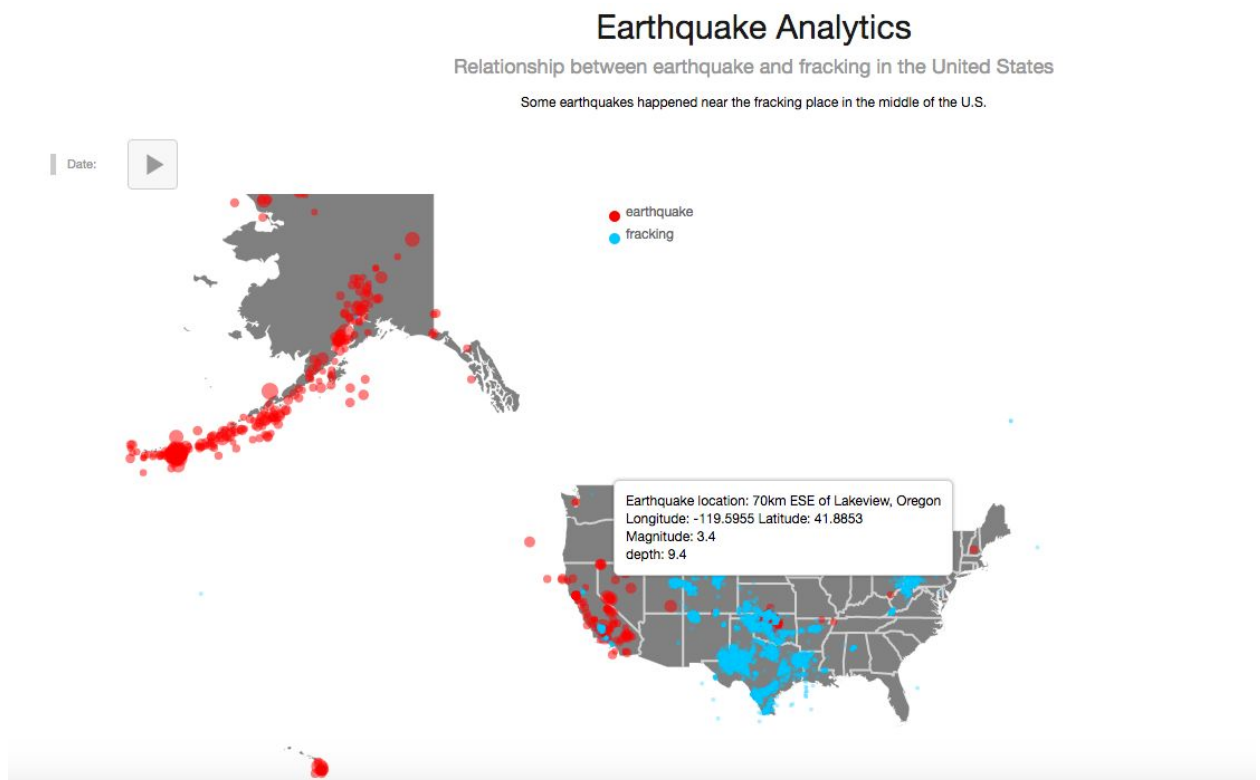
<http://bl.ocks.org/dwtkns/4973620>

<http://codepen.io/gartempe/pen/onckm>

Our second visualization is scatter plot. We use this visualization to show the relationship between magnitude and depth of the earthquake. The plot shows that magnitude between 4-5 earthquake usually happens at deep places and magnitude between 2-3 usually happens at shallow places. We also gives a background reading about the visualization and here is the link:

<http://www.openhazards.com/faq/earthquakes-faults-plate-tectonics-earth-structure-user-submitted-questions/there-correlation>

Fracking vs Earthquakes in the U.S.

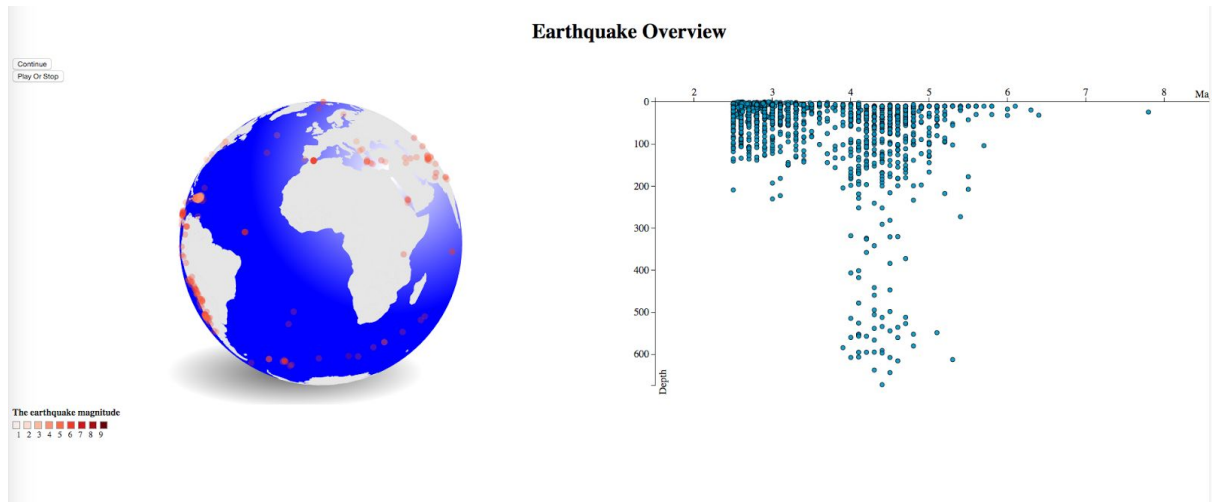


We implement a legend for identify the circle of earthquake and the circle of fracking. We implement tooltip for both earthquake and fracking. We also add some texts for introduction. The red circles can show up in order of earthquakes

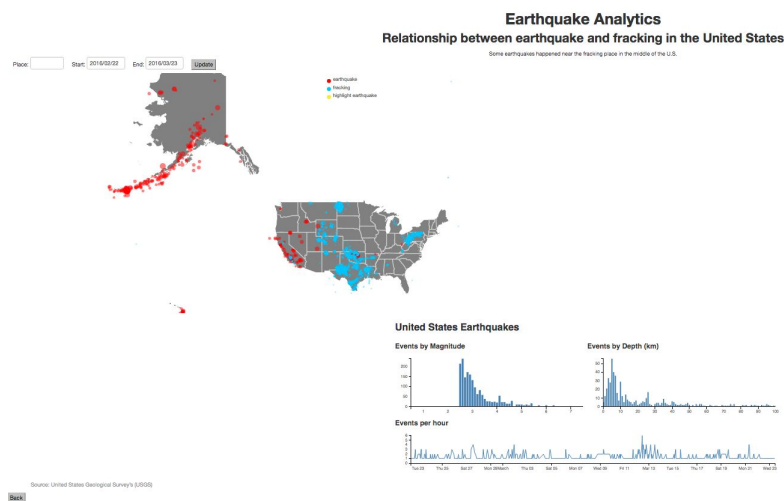
happening by time. We make a play button. But it is still thinking about how to implement the time slider.

(3)Final Release

In the final release, we add legend to show different magnitude of the earthquakes.



For the relationship of earthquake and fracking graph. The overview look as below



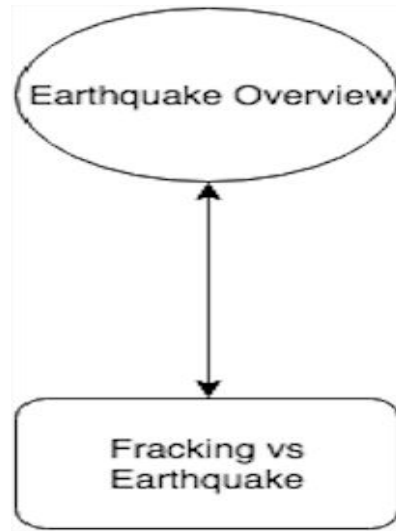
We implemented a query function to highlight the earthquake. User can search the earthquake by place and time.

We also implemented a zoom in zoom out function for geometric graph.

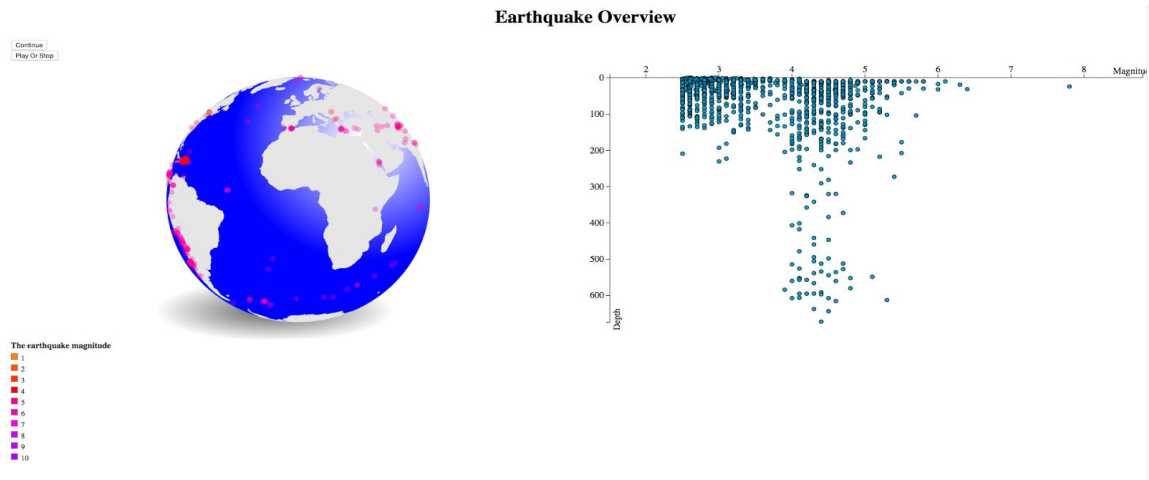
We also implement crossfilter for bar chart and line chart to analyze the relationship between depth and magnitude and time.

- **Implementation:**

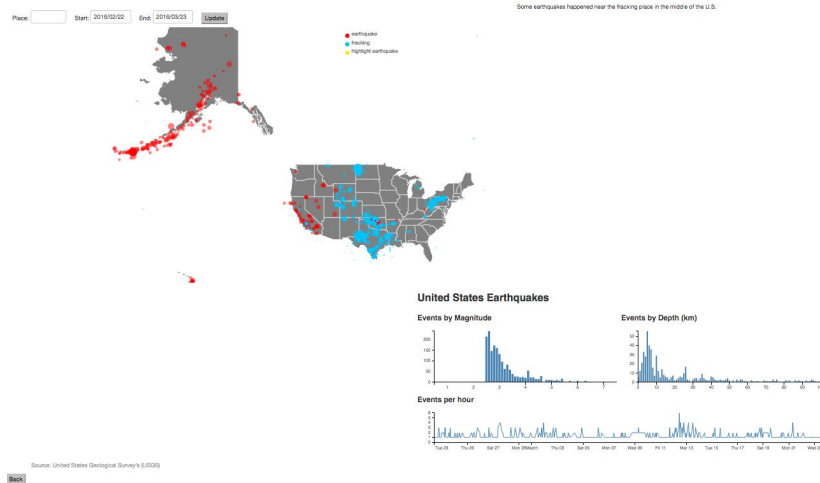
We implement our visualization by D3. We use the html, css, json for our project too. Below is the overview of our project:



Earthquake Overview



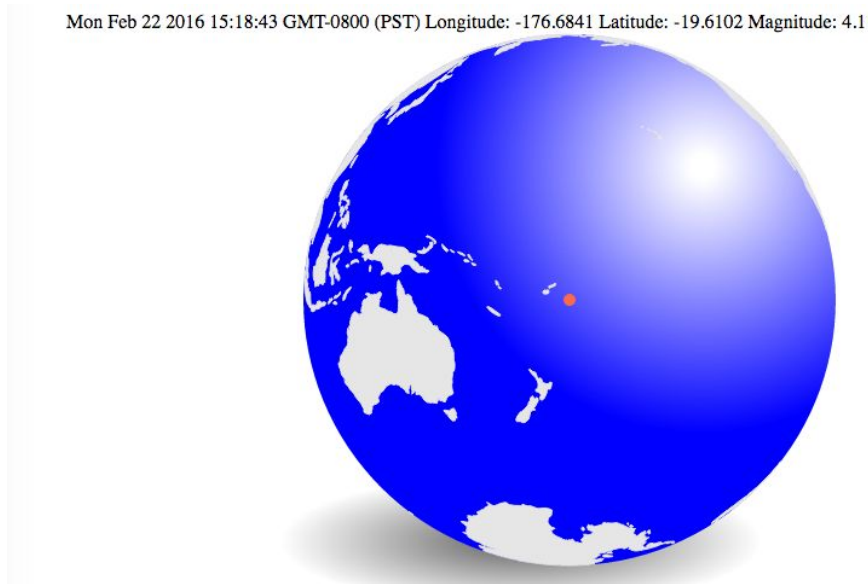
Earthquake Analytics
Relationship between earthquake and fracking in the United States



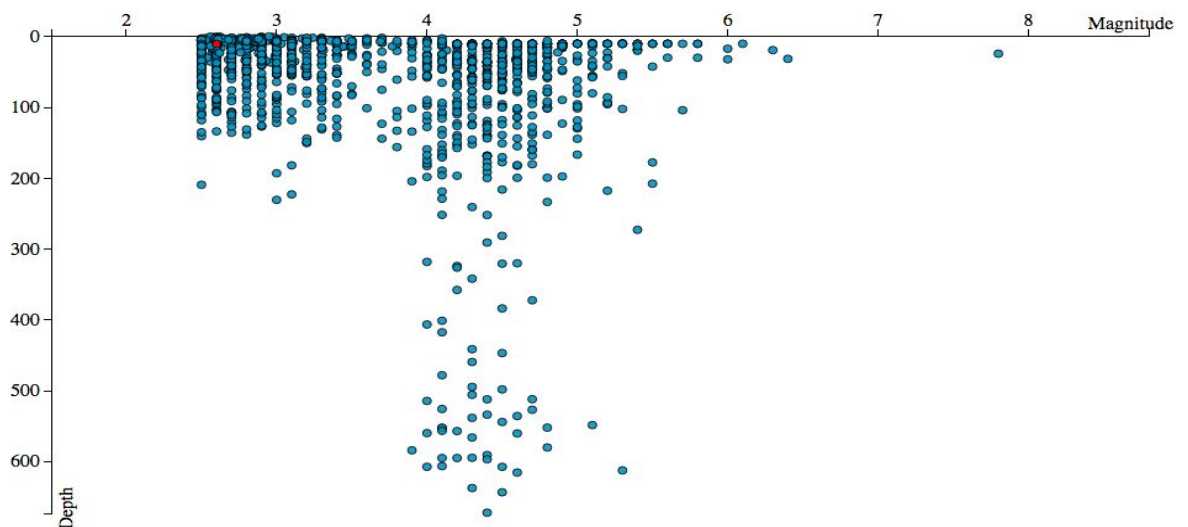
Here are features we implemented in our project:

1. Build a 3D global map and plot earthquakes on the map with tooltip.
2. Draw a scatter plot to show the relationship between earthquake depth and magnitude.
3. Add rotation animation to the global map to display earthquake occurrence
4. Add animation to expand 3D map to 2D

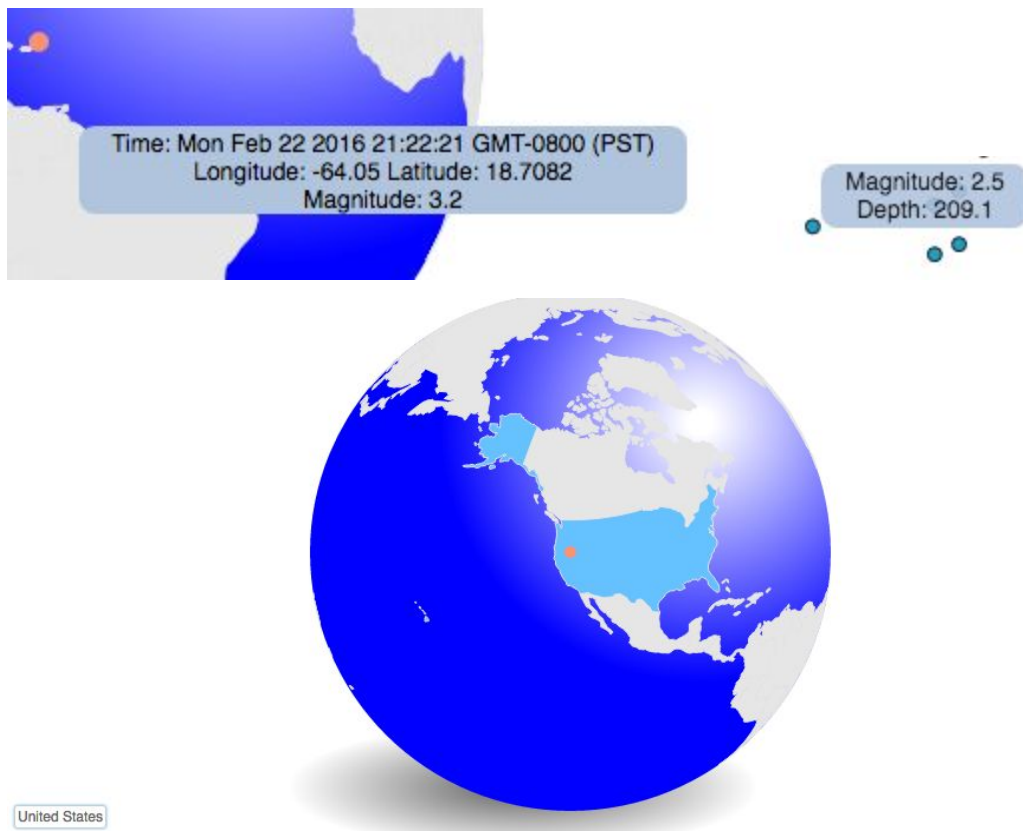
User can click “Play Or Stop” to play and pause the rotation animation. And also add a title to show the information about the earthquake during the animation:



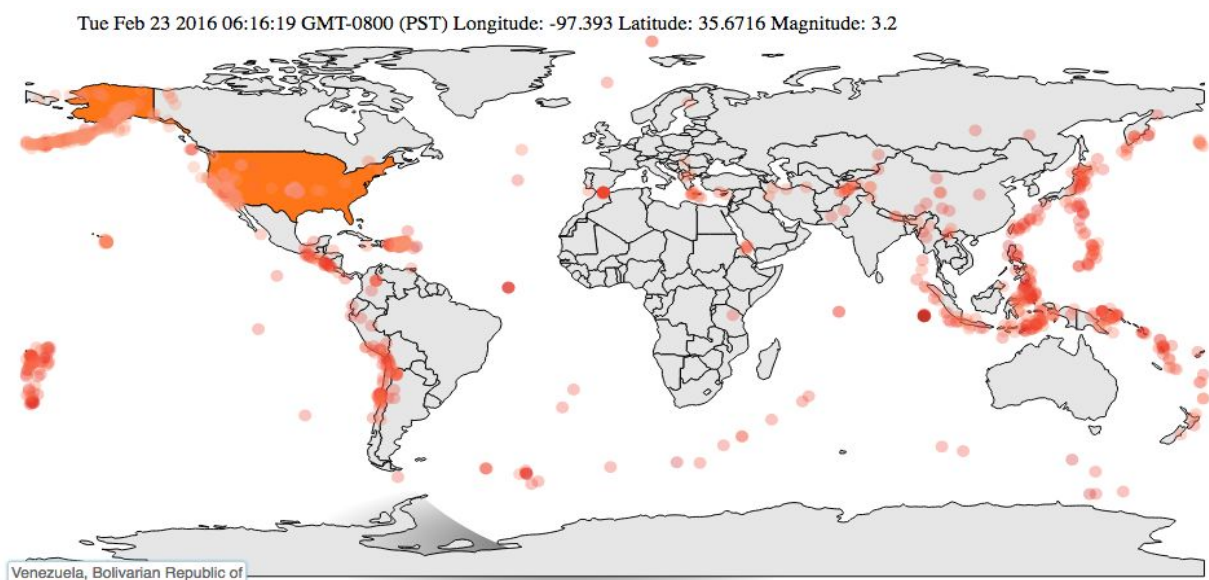
Highlight the scatter plot during the animation:



3 kinds of Tooltips: First one shows the earthquake information. Second one shows the magnitude and depth on the scatterplot. Third one shows countries on the global map.



We also implemented projection the 3D earth to 2D. User just need to click one of the countries on the map then the projection will change.



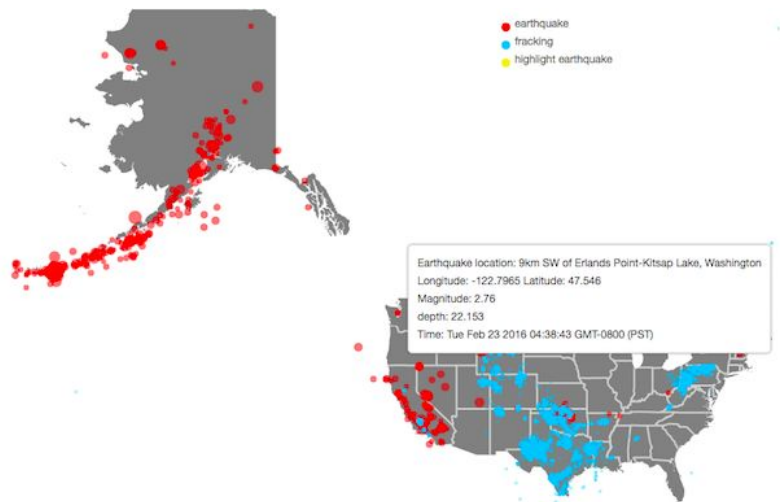
Here are some references about the projection and rotation animations:

<https://bl.ocks.org/mbostock/4183330>

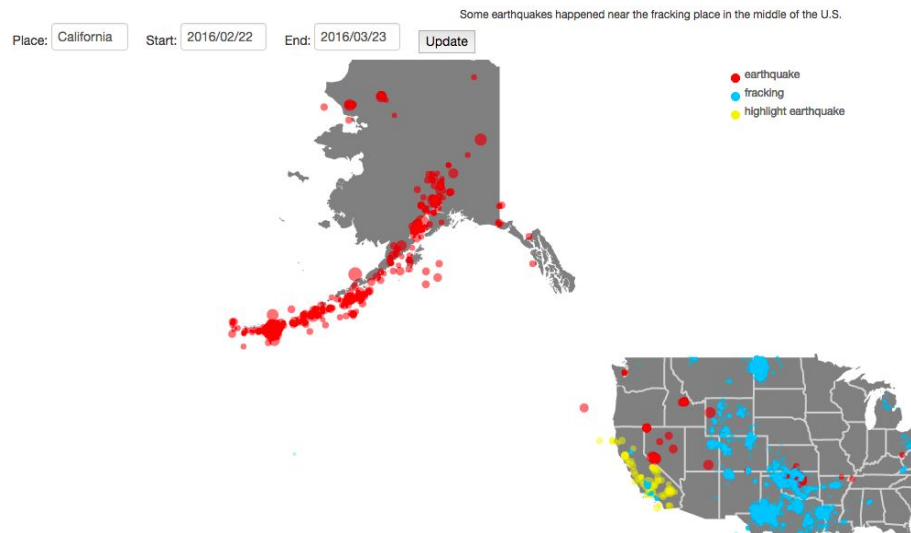
<http://bl.ocks.org/KoGor/7024546>

For second visualization:

1. Geometric graph to show earthquakes happen around the United States. The earthquakes show up by the time happening.
2. We use red color represent earthquakes, and we use size of circle to represent the magnitude of an earthquake. We use blue color represent fracking. We use
3. yellow color represent highlighting earthquake
4. Interactive Geometric graph: Zooming and tooltip.

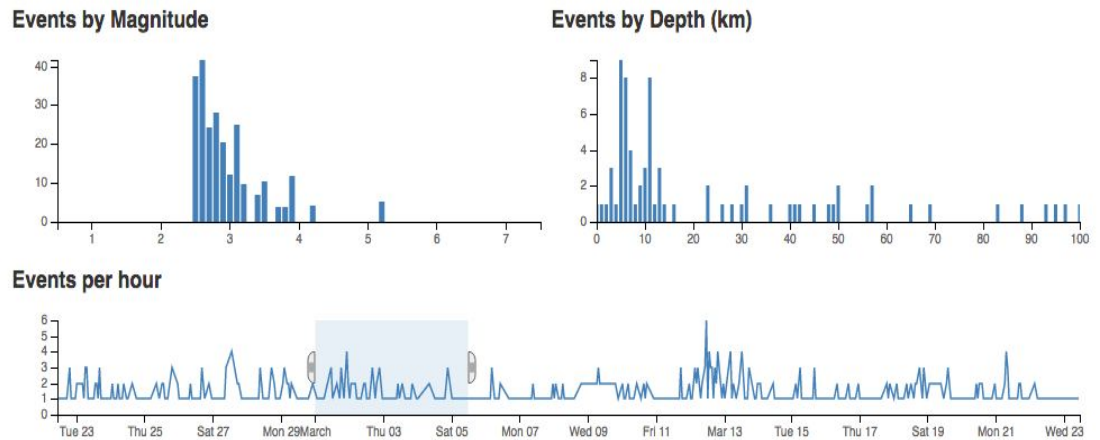


5. Searching in a Geometric graph.



6. Use CrossFilter to show how many earthquakes happening in Bar chart and line chart. Events by Magnitude, by depth, by time

United States Earthquakes



- **Evaluation:**

According to Plate tectonics theory, most earthquakes are caused by the plates movement.

From the earthquake overview we can know that earthquake happens everyday. From the fracking location we can notice that there are some earthquakes happened in the middle of United States. However, these places are not the “movement area”.

Our visualization make a very detail view to show the overview of earthquake happening in the world and the relationship between earthquake and fracking. We also provide a lot of user interactive for the user. They help the user to easy to understand the earthquake.

We also meet some challenges during our development. (1)D3 documents are hard to use. (2)Rotation animation.(3)Showing the relationship between fracking and earthquake.(4)Improve the User Interactive: provide tooltip, filtering,highlight,zoom, crossfilter, earthquake play and map transition between 2D to 3D.(5)Improve the User Friendly.

For our future work, making the user interface looks more pretty and professional. Provide more user interaction, such as tooltip. Provide more datasets to let user to

select.