Earthquake Data Visualization (2001-2022)

By Xiangan Zhu

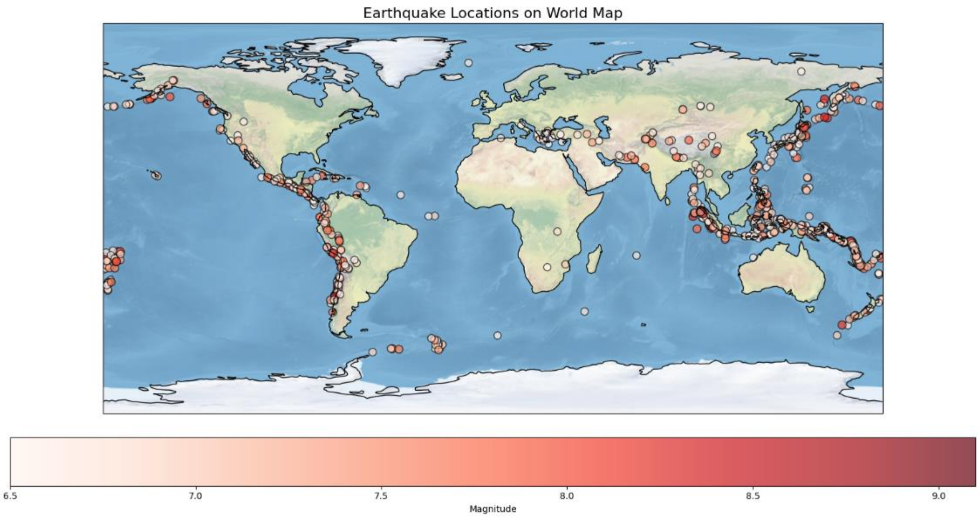

Figure1: Earthquake Locations on World Map

Figure 1: The background is a world map is used as the base for spatial visualization of earthquake occurrences. The points represent earthquake events, with their locations plotted based on latitude and longitude. Magnitude intensity is indicated using a gradient color scale from light red (lower magnitude) to dark red (higher magnitude). It clearly shows the concentration of earthquakes along tectonic plate boundaries, especially in the Pacific Ring of Fire. Magnitude-based color gradient allows quick visual identification of high-magnitude earthquake clusters.

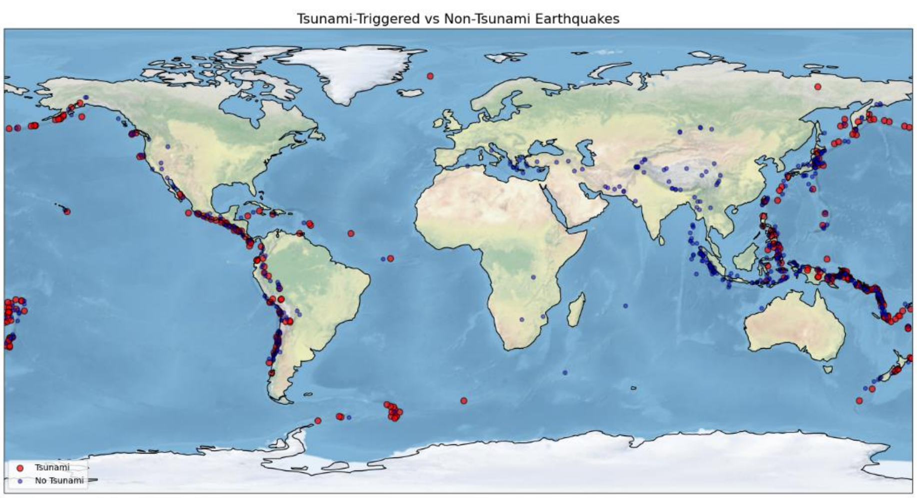

Figure 2: Tsunami-Triggered vs Non-Tsunami Earthquakes

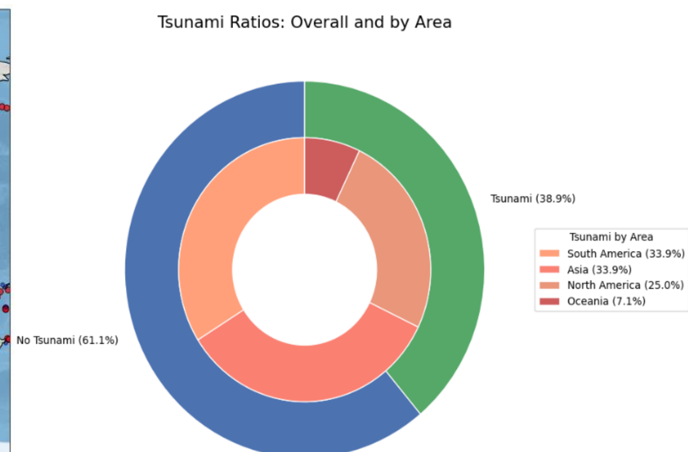

Figure 3: Tsunami Ratios - Overall and by Area

Figure 2: Background is a global map to compare tsunami-triggering earthquakes geographically. Red points represent earthquakes that triggered tsunamis, and blue points indicate non-tsunami-triggering earthquakes.
It demonstrates that tsunami-triggering earthquakes are clustered in oceanic regions, particularly subduction zones. And shows that tsunami-triggering events are predominantly concentrated in the Pacific and Indian Oceans.
Figure 3: Outer ring displays the percentage distribution of tsunami-triggering and non-triggering earthquakes overall. Inner ring breaks down tsunami-triggering events by geographical areas.
The donut chart clearly illustrates the proportion of tsunami vs. non-tsunami earthquakes globally. Asia and South America as the primary contributors to tsunami-triggering earthquakes. It demonstrates that most earthquakes globally do not trigger tsunamis, which is critical for disaster risk assessment.

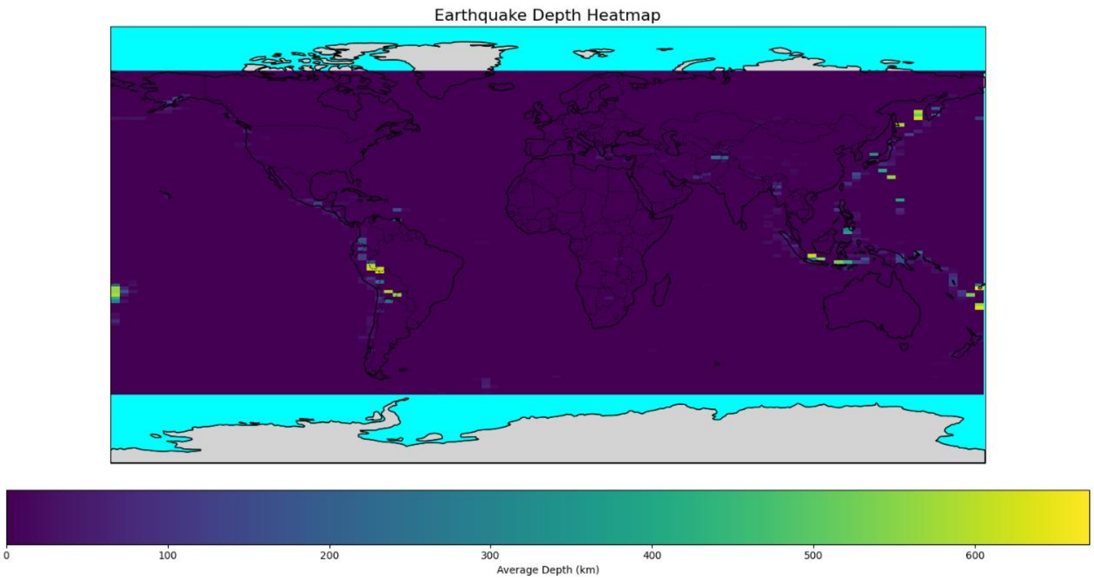

Figure 4: Earthquake Depth Heatmap

Figure 4: The Heatmap aggregates earthquake depths at specific locations for a global overview. Depth values represented on a color scale from purple (shallow) to yellow (deep).
It shows regions of shallow-focus earthquakes like along mid-ocean ridges and deep-focus earthquakes such as subduction zones. It highlights areas like the Tonga Trench and Andes where deeper earthquakes are prevalent.

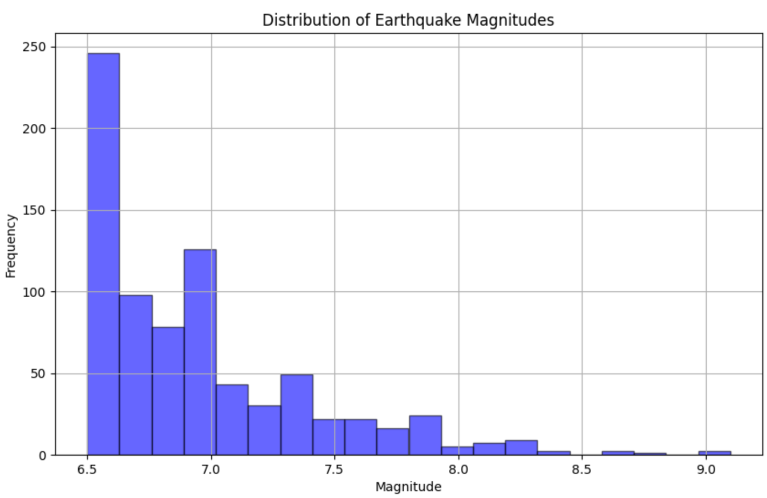

Figure 5: Distribution of Earthquake Magnitudes

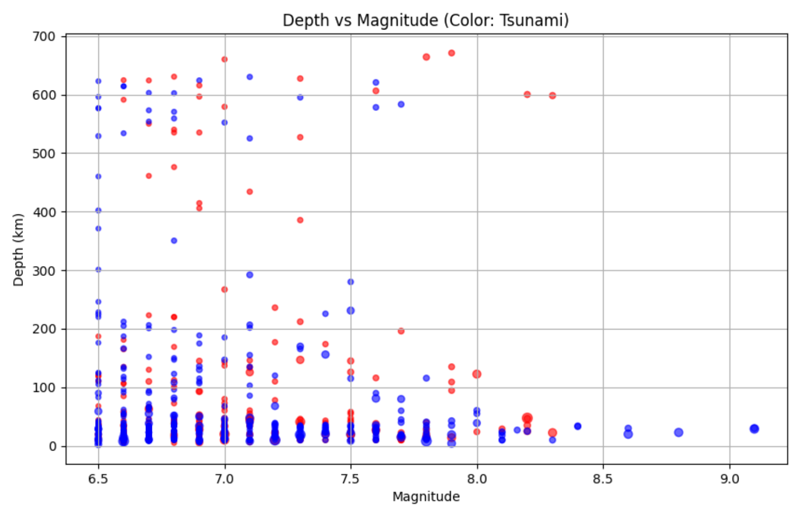

Figure 6: Depth vs Magnitude

Figure 5: X-axis is earthquake magnitudes and Y-axis is frequency of occurrences. The histogram displays frequency distribution of earthquake magnitudes, binned by intervals.
The figure indicates that the majority of earthquakes occur between magnitudes 6.5 and 7.0, with a sharp drop-off for higher magnitudes. It provides evidence of the rarity of extreme-magnitude earthquakes (above 8.0). It also shows how the frequency of earthquakes diminishes as magnitude increases, aligning with the Gutenberg-Richter law.

Figure 6: Each point represents an earthquake, with the x-axis indicating magnitude and the y-axis representing depth. Red points correspond to tsunami-triggering earthquakes, and blue points represent non-tsunami events.
It reveals that tsunami-triggering earthquakes often occur at shallow depths, which amplifies their tsunami-generating potential. And shows no significant trend between depth and magnitude, indicating that large earthquakes can occur at varying depths.

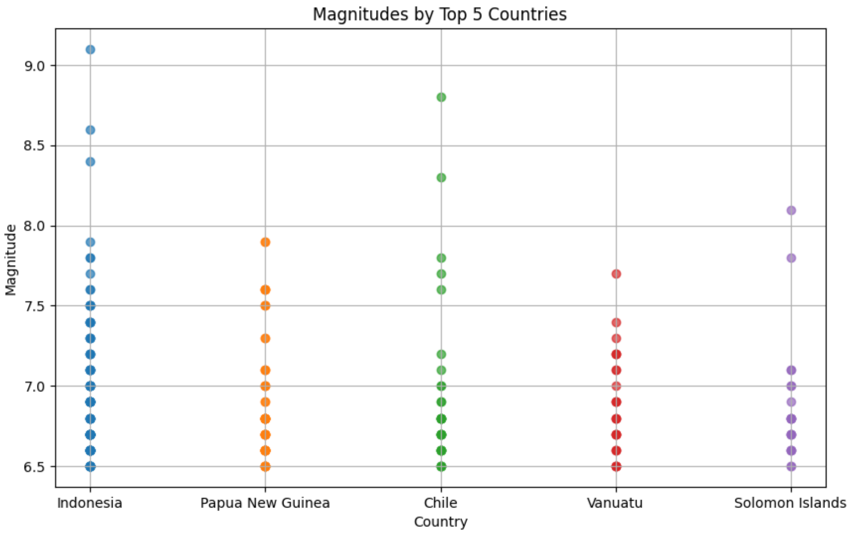

Figure 7: Magnitudes by Top 5 Countries

Figure 7: Each point corresponds to an earthquake event, with magnitude on the y-axis and country categories on the x-axis. Different colors represent earthquakes in the top 5 countries based on seismic activity.
Indonesia has the most frequent high-magnitude earthquakes compared to other countries. Chile's consistent seismic activity, likely due to its location along the South American subduction zone. Vanuatu and Papua New Guinea showcase significant seismic activity despite their smaller landmass.

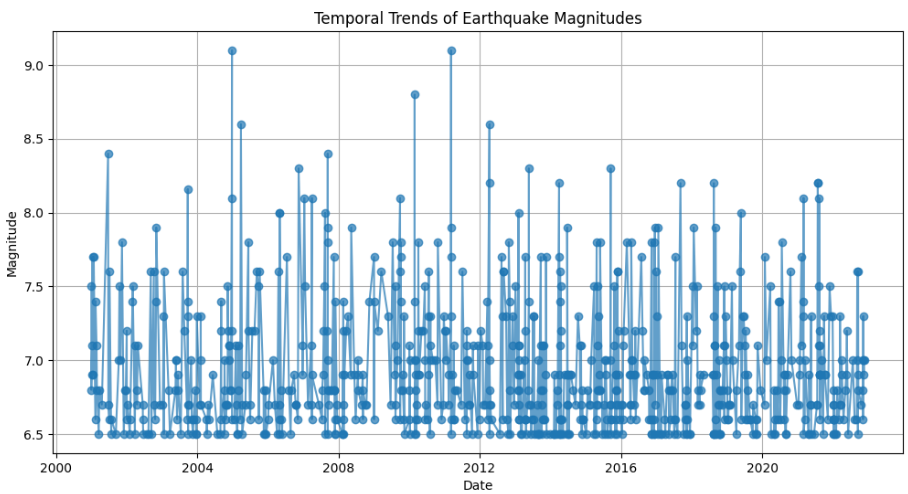

Figure 8: Temporal Trends of Earthquake Magnitudes

Figure 8: Points represent individual earthquakes, plotted by date on the x-axis and magnitude on the y-axis. Vertical lines show trends or variability in magnitudes over time. The figure shows a consistent frequency of earthquakes over the years, suggesting no increase in seismic activity due to external factors. It highlights spikes in earthquake magnitudes at specific times, potentially correlating to significant seismic events. Extreme magnitude events (above 8.0) are rare and occur sporadically over the years.

Data and method: The data I used for this project was downloaded from Kaggle.com. You can also find the .csv file on my GitHub page. The dataset used for this analysis includes global earthquake records with attributes such as date, time, location, magnitude, depth, tsunami trigger status, and regional information. It focuses on earthquakes with magnitudes ≥6.5 to highlight significant events, ensuring the analysis is impactful and relevant. Using Python libraries like Matplotlib, Pandas, and Basemap, the analysis incorporated spatial mapping to identify earthquake-prone regions and tectonic patterns, histograms for magnitude distributions, scatter plots to explore relationships between depth and tsunami occurrence, and temporal plots to study trends over time. Heatmaps and donut charts provided additional insights into earthquake depth and tsunami ratios by region. The visualizations were enhanced with color encoding and geographical layering to clearly represent magnitude, depth, and tsunami-triggering patterns.

Importance: The presented figures are significant because they provide a comprehensive visual representation of global earthquake patterns, which are critical for understanding and mitigating seismic risks. By highlighting regions prone to high-magnitude earthquakes and tsunami-triggering events, these visualizations help identify areas most vulnerable to natural disasters, guiding disaster preparedness and risk reduction efforts. The spatial analysis underscores the role of tectonic boundaries in seismic activity, offering insights valuable for scientific research and policymaking. The temporal trends and magnitude distributions shed light on the frequency and severity of earthquakes, which are essential for designing resilient infrastructure and emergency response systems.

GitHub Link: https://github.com/XianganZhu/INFSCI2415_Final-Project.git