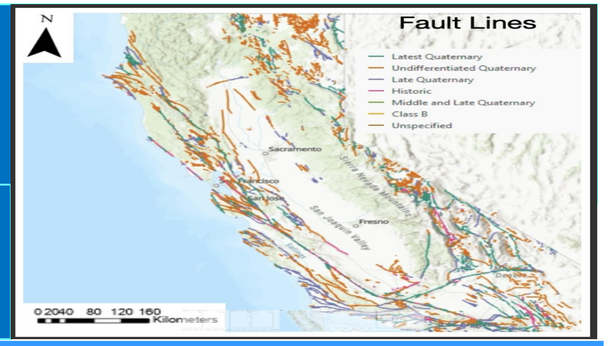
California Earthquakes

Emerging Hot Spot Analysis



Introduction

An earthquake is a natural occurrence caused by the movement of seismic tectonic plates beneath the surface of the Earth. Every year, the USGS (United States Geological Survey) detects around half a million earthquakes around the world. An average of 20,000 people are killed as a result of the earthquake. Predicting possible earthquake locations, particularly in earthquake-active areas or seismic hot spots, is critical for disaster preparedness and mitigation. The west coast of US is one such earthquake-active areas because of presence of fault lines. As per USGS, California(CA) has the most earthquakes that can cause more damage than any other state in the US. There are 15700 known faults in CA, out of which 500+ are active faults. There is a greater than 99% probability of one or more earthquakes of magnitude 6.7 striking in CA [1].

This is going to be case study, of finding earthquake hotspots. In this study, an earthquake hot spot is defined as a location with the significant earthquake activity within an area with low or normal seismic activity. To investigate such predictions, spatial time pattern mining is often utilized. The goal is where are the new emerging hotposts found in CA ? And To analyse the variations in results of hotspot analysis using different data years.

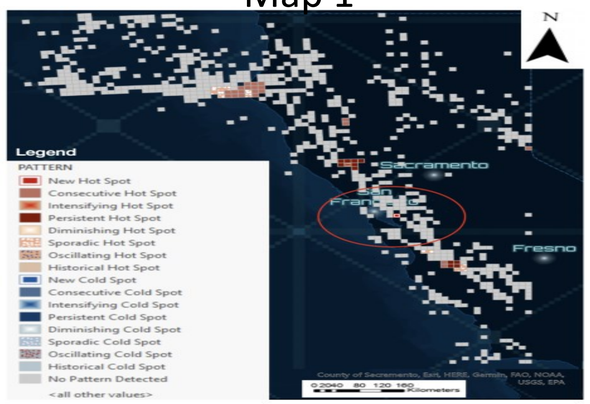
Methods

To find the hotspots, I merged the Earthquake data into 5 years (2017 to 2021) and 10 years (2012 to 2021). Then performed space time cube analysis to determine the temporal features of the earthquake events, as shown in time series charts (by visualizing in 3D)_. The output Space-Time NetCDF cube is analyzed in Emerging Hotspot analysis using a space-time implementation of Getis-Ord Gi* Statistic [2] to create eight different types of clustering for hot and cold spots, respectively, as shown in Map 1 and Map 2. Table 1 and Table 2 are the summary tables of hot and cold spots for 5 and 10 years data respectively.

Results

From the table 1 and 2 we can see that the total number of hot spots determined for 10 years data is more than the 5 years data. This is because of a greater number of events are considered to the 10 years data. All the patterns are increasing in number because of the increase in earthquake events from 5 years to 10 years except the Consecutive Hotspots, which decreased from 21 to 13. Consecutive Hotspots are the geographical locations where events are clustered for more than 90% of the time. This might be because of wide spread distribution i.e unclustering of earthquake events through out the years.We can see that most of the hot spots patterns are found along the west coast clustered in north and south west of the maps. But there is difference in the new hot spot found in 5 years and 10 years data.

Map 1



Map 2

Table 1

Summary of Results	HOT	COLD
New	1	0
Consecutive	21	0
Intensifying	1	0
Persistent	11	0
Diminishing	0	0
Sporadic	13	0
Oscillating	0	0
Historical	0	0

All locations with hot or cold spot trends: 47 of 695

Table 2

Summary of Results	HOT	COLD
New	3	0
Consecutive	13	0
Intensifying	8	0
Persistent	5	0
Diminishing	7	0
Sporadic	15	0
Oscillating	0	0
Historical	0	0

All locations with hot or cold spot trends: 51 of 983

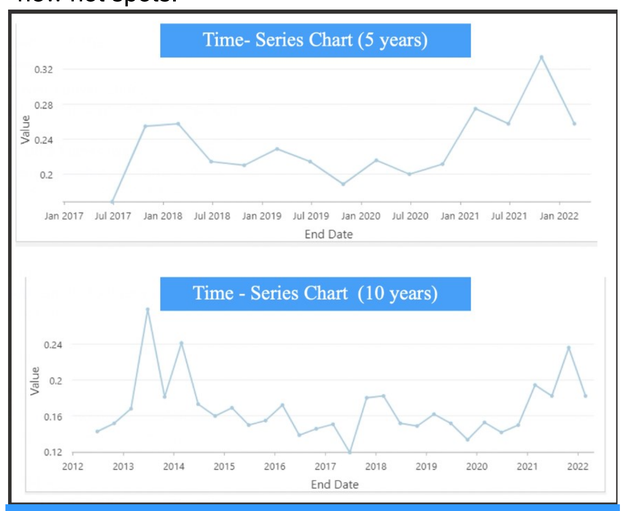
New Hotspots are new geographical locations which are statistical significance for final time step. There is only 1 new hotspot found in 5 years data near San Francisco, which can be seen from circle indicated in map 1. Whereas 3 new hotspots are found in 10 years data, which are located near north-west coast, can be seen from circle indicated in map 2.In map 2, new hot spots are where in north where there are clusters of different cubes present. But in map 1 the new hot spot is found near San Francisco, which can be an anomaly. This can be validated from the time series graph of 5 years. We can see that there is only one significant increase in number of events, which is around end of December, 2021. This sharp increase in events is attributed to M6.2 Petrolia earthquake occurred on December 20, 2021[3]. Because of this change of events there might be error in statistical interpretation of new hot spot values. Hence we found an anomaly in the 5 years data. Which is balanced out in 10 year data because of prior events in 2013 and 2014.

Data Sources

- Earthquake Catalog USGS - https://earthquake.usgs.gov/earthquakes/search/
- Fault Lines ArcGIS Living Atlas - https://services2.arcgis.com/ FiaPA4ga0iQKduv3/arcgis/rest/services/Earthquake_Faults_and_Folds_in_the_USA/FeatureServer

Conclusion

I can conclude that the new emerging hot spots of the earthquakes events are highly depended on the number of events in the spatial location. To solely use the statistical measure of emerging hot spot analysis for the disaster preparedness and mitigation is not the ideal measure. We need to correlate our number of events with the past events to validate our results. In this study, the new hot spots which are located to the north-west of the California are the likely to be actual new hot spots.



Referred links

[1] https://www.earthquakeauthority.com/California-Earthquake-Risk

[2] https://pro.arcgis.com/en/pro-app/2.8/tool-reference/spatial-statistics/h-how-hot-spot-analysis-getis-ord-gi-spatial-stati.htm

[3]https://www.usgs.gov/programs/earthquake-hazards/news/m62-petrolia-earthquake-december-20-2021-was-really-two

Projection System : NAD 1927 California (Teale) Albers (Meters).

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Thank You, Sumeeta!

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