USGS Earthquake Data Analysis

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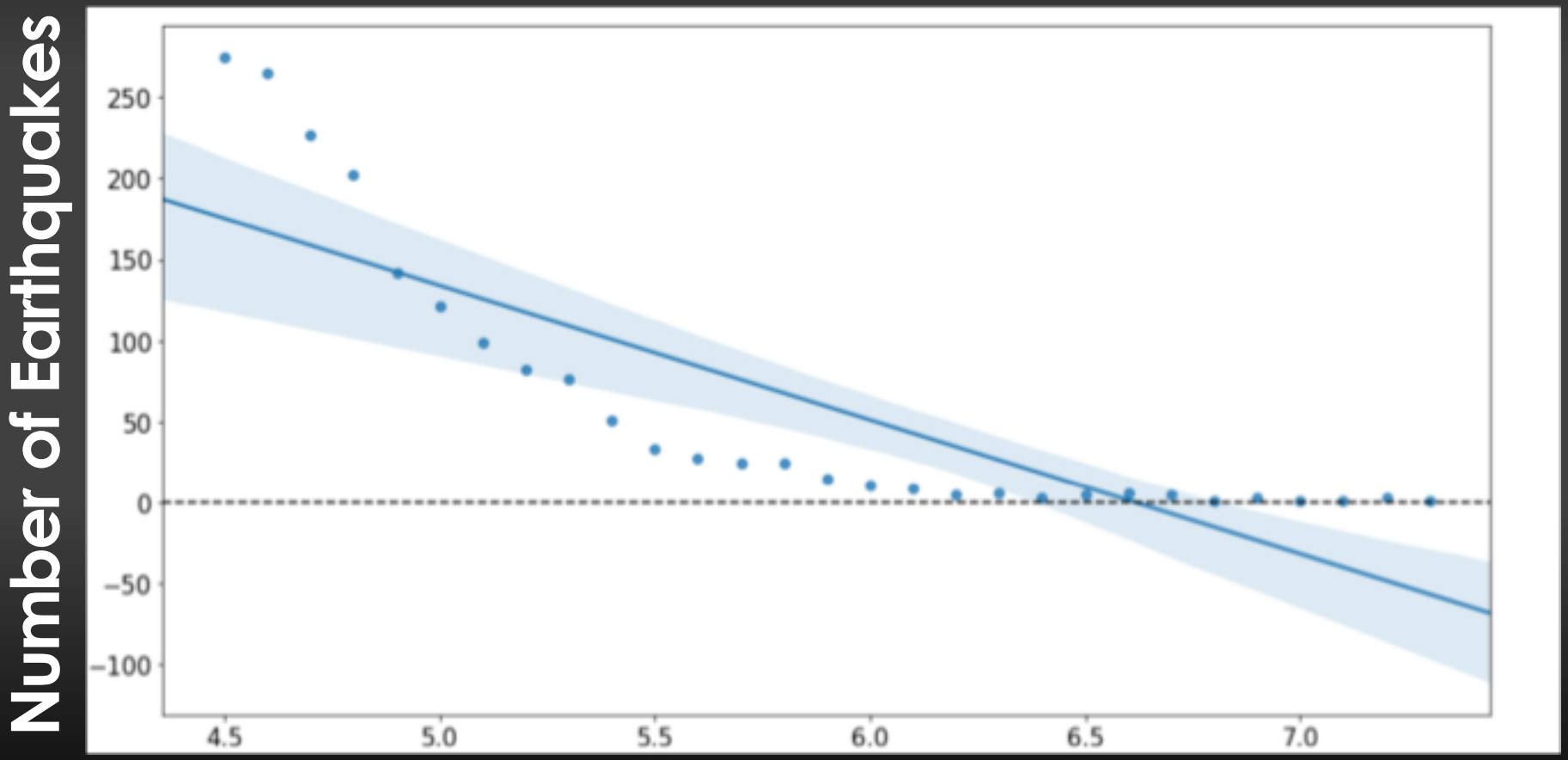
Questions I Wanted to Answer

- What are some relationships and trends in historical earthquake data?
- Has the increased prevalence of oil industry fracking caused earthquakes? And what damages can we expect from this human induced seismic activity?
- How can we use this data to can analyze freshly issued catastrophe bond Acorn Re 2018?

Earthquake Frequency vs. Magnitude

*US Earthquakes over magnitude 4.5 from 1970-2017



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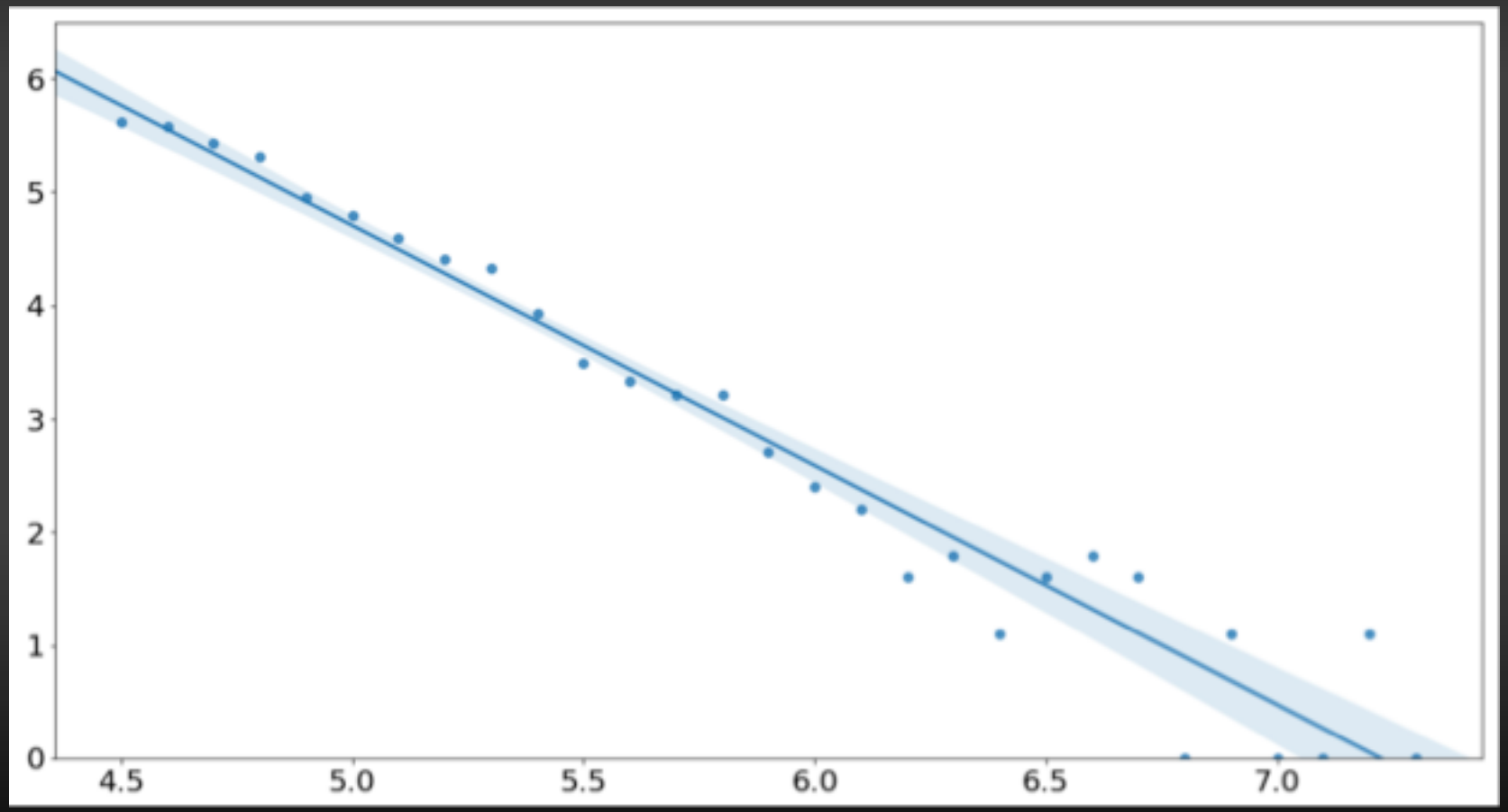
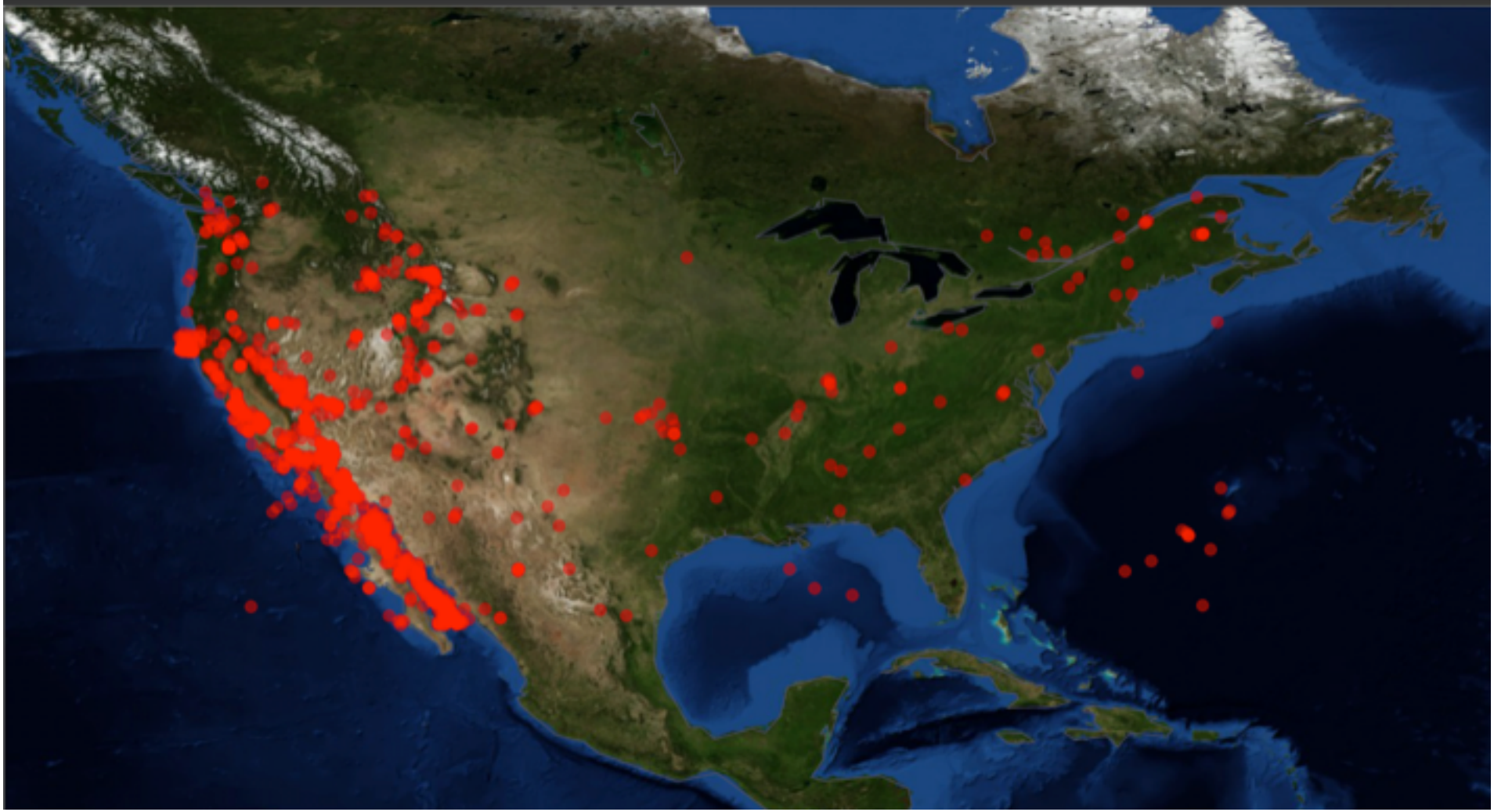
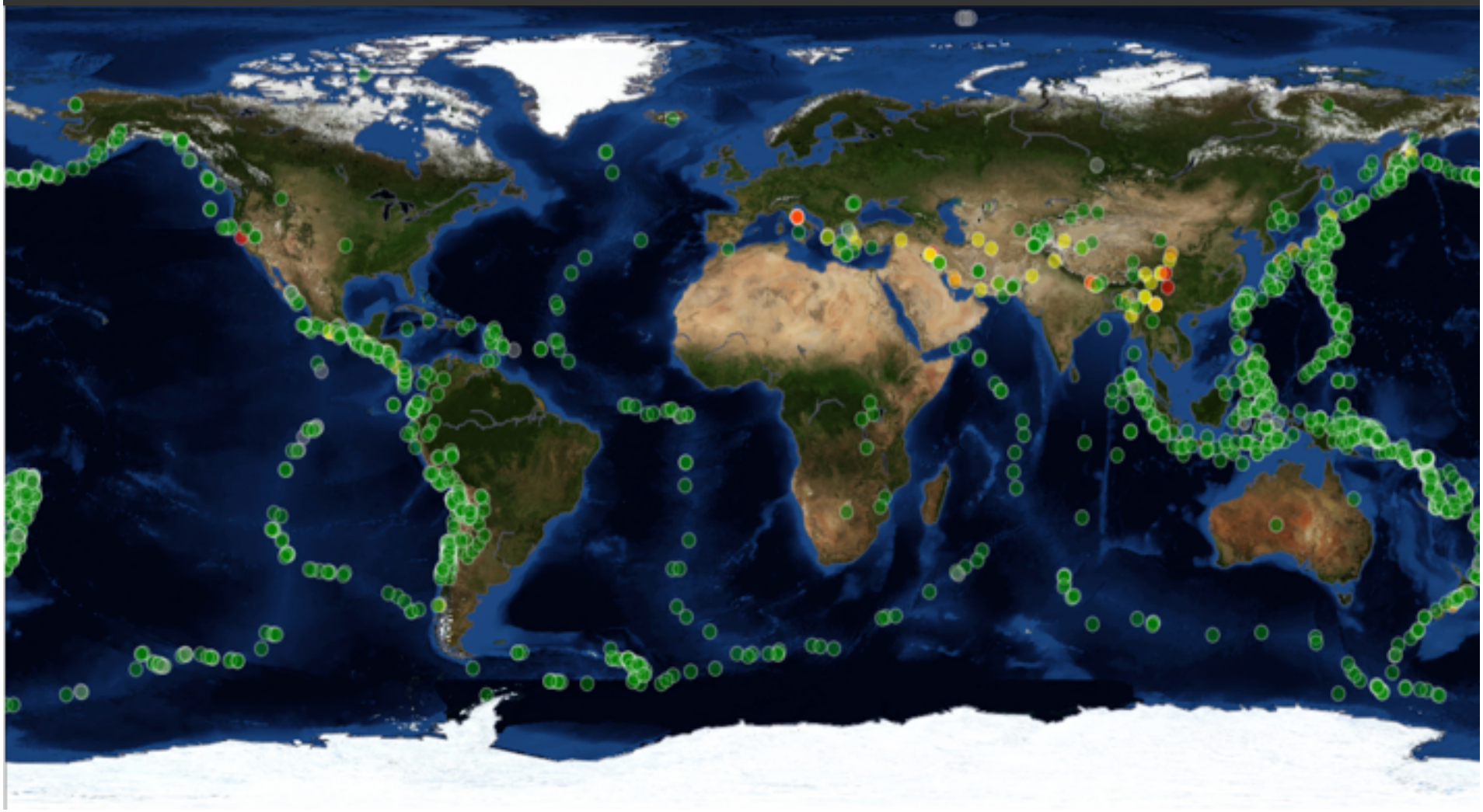


US Earthquakes Over Magnitude 4.5
1970 - 2017



Earthquakes Over Magnitude 5.6 Since 2013

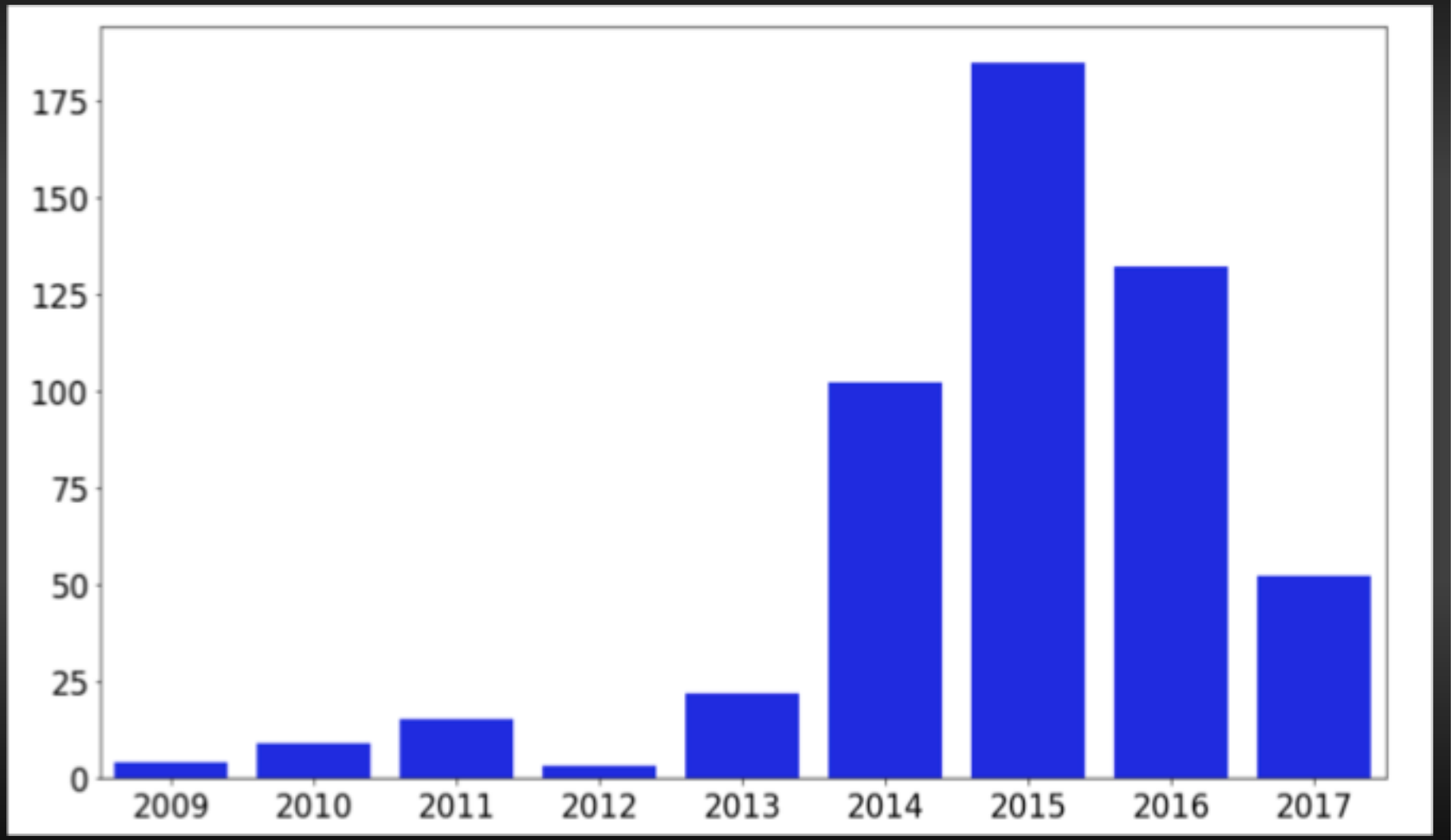


EDA - Takeaways

- There exists a very nice linear relationship between earthquake intensity and frequency.
- California dominates the historical US seismic activity.
- Location is a key driver of predicting earthquake damage.
- On a global scale – California's seismic activity has been relatively calm for the last 5 years.
- Now let's look at Oklahoma earthquake frequencies over time.

Earthquake Frequency by Year in Oklahoma

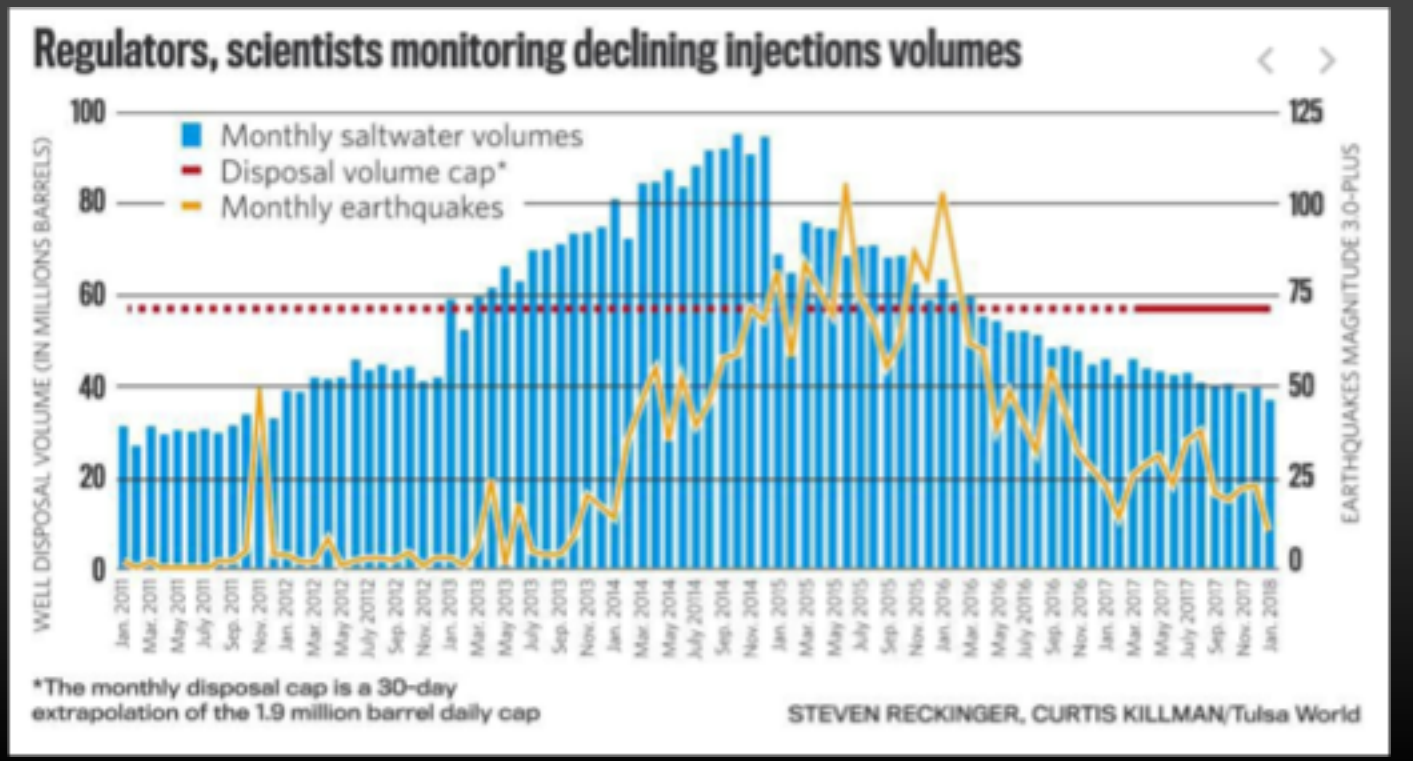
*Includes years with 3+ Earthquakes over magnitude 3.5 for 1975-2017



*included if there were more than 2 earthquakes in the year

Human Induced Seismicity - USGS

- Waste water injections (Not the act of Hydraulic Fracking) are thought to be responsible for the increase and decrease in earthquake activity.
- In 2017 regulators in Oklahoma put restrictions on wastewater disposal volumes.
- While earthquake frequency increased in Oklahoma, most of the seismicity has been benign. Aside from the 5.8 earthquake in 2016 in Pawnee and the 5.7 earthquake in 2011, earthquakes have not been strong enough to be destructive.



Acorn Re Proxy Catastrophe Bond Experience Rating: Link

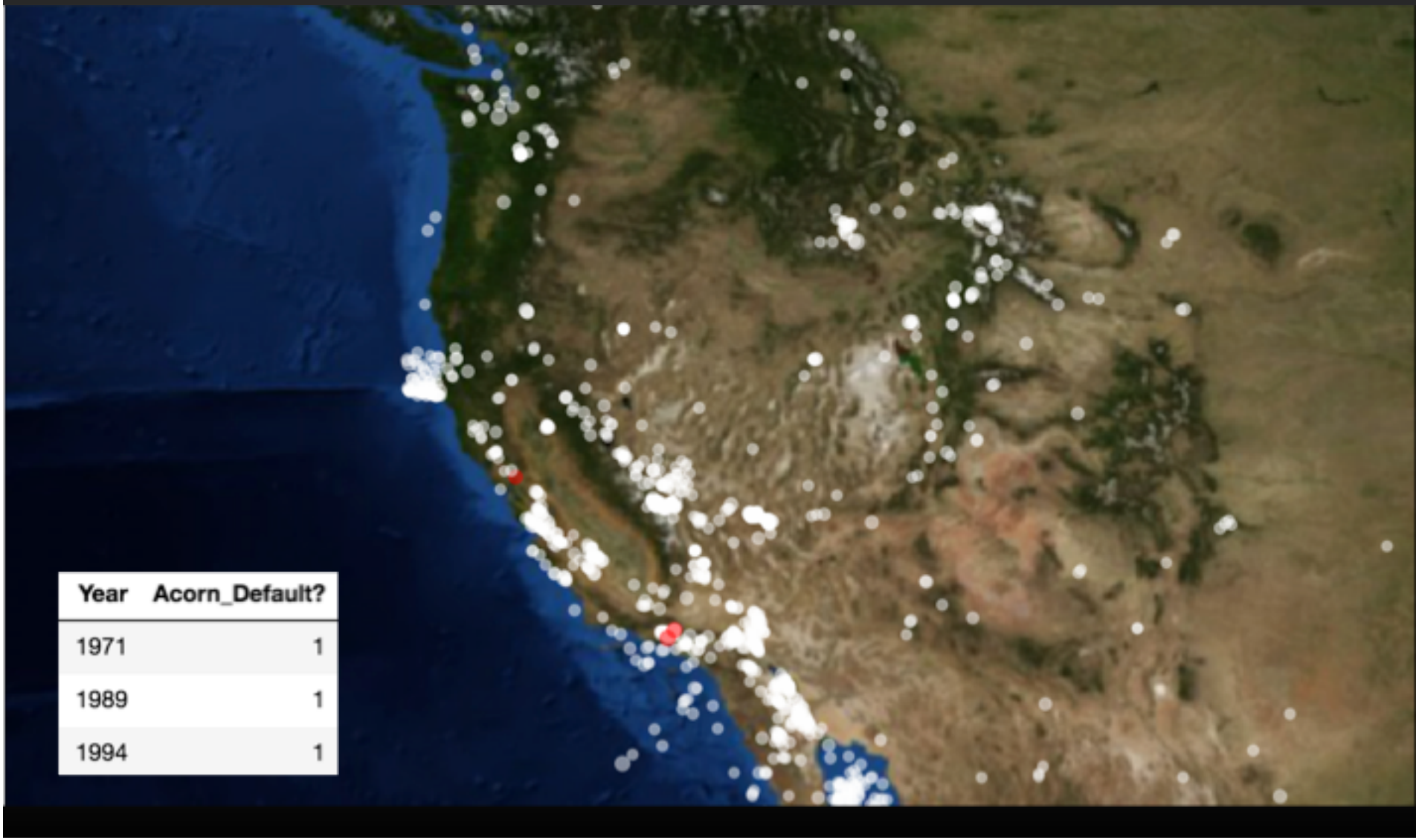
- Assume the bond is a zero coupon with a one year maturity that pays a 10% return.
- Suppose the bond defaults if there is an earthquake within 100 km of downtown LA or San Francisco of magnitude 6.5 or greater and depth of 60 km or less.
- The Cat Bond market risk capital outstanding exceeds 36 billion dollars and has increased by 100+% since 2012.

Bond Analysis Process

- Use Long/Lat of each quake to obtain distance from major cities.
- Define each earthquake as a defaulting earthquake if it meets the default conditions
- Group by year and count the years with one default
- There are 3 years with at least one quake that defaulted the bond in our 48-year sample which suggests a 6.25% default probability.

Magnitude	Earthquake_Name	Time	Depth_KM	LongLat_String	Latitude	Longitude	DistanceFromLA_KM	DistanceFromSF_KM	Acorn_Default
7.3	Landers, California Earthquake	1992-06-28 11:57:34 (UTC)	0.1	34.200°N 116.437°W	34.200	-116.437	167.110404	668.878403	0
7.2	offshore Northern California	1980-11-08 10:27:34 (UTC)	19.0	41.117°N 124.253°W	41.117	-124.253	946.799198	403.574105	0
7.2	12km SW of Delta, B.C., MX	2010-04-04 22:40:42 (UTC)	10.0	32.286°N 115.295°W	32.286	-115.295	337.456994	890.131016	0
7.2	20km SSW of Rio Dell, California	1992-04-25 18:06:05 (UTC)	9.9	40.335°N 124.229°W	40.335	-124.229	876.512767	324.714738	0
7.1	16km SW of Ludlow, CA	1999-10-16 09:46:44 (UTC)	13.7	34.603°N 116.265°W	34.603	-116.265	191.739845	655.087348	0
7.0	Baja California, Mexico	2012-04-12 07:15:48 (UTC)	13.0	28.696°N 113.104°W	28.696	-113.104	769.674835	1328.789357	0
6.9	1km W of Day Valley, California	1989-10-18 00:04:15 (UTC)	17.2	37.036°N 121.880°W	37.036	-121.880	467.167125	94.976185	1
6.9	Sonora, Mexico	2009-08-03 17:59:56 (UTC)	10.0	29.039°N 112.903°W	29.039	-112.903	752.649205	1311.433395	0

Acorn Proxy Default Map



Year	Acorn_Default?
1971	1
1989	1
1994	1