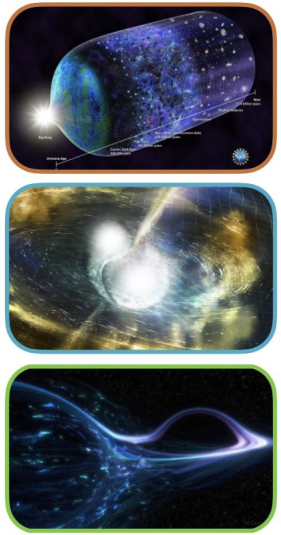
LHO Earthquakes and West Texas Fracking Impacts on CE

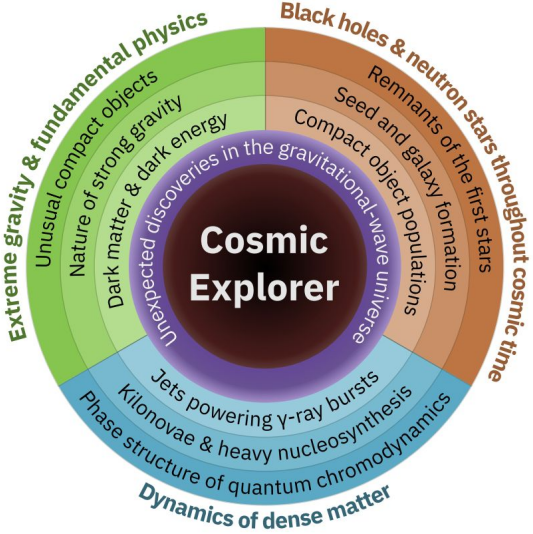
Lance Blagg

Mentor: Dr. Robert Schofield

UNIVERSITY OF OREGON

Cosmic Explorer

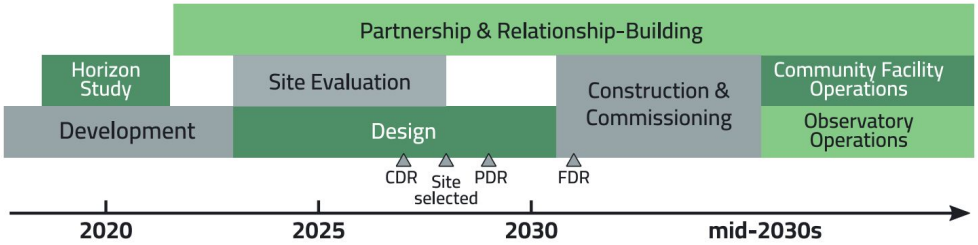




- Next big ground based detector
- 40 km arms
- Will be able to detect GWs from binaries of the first black holes

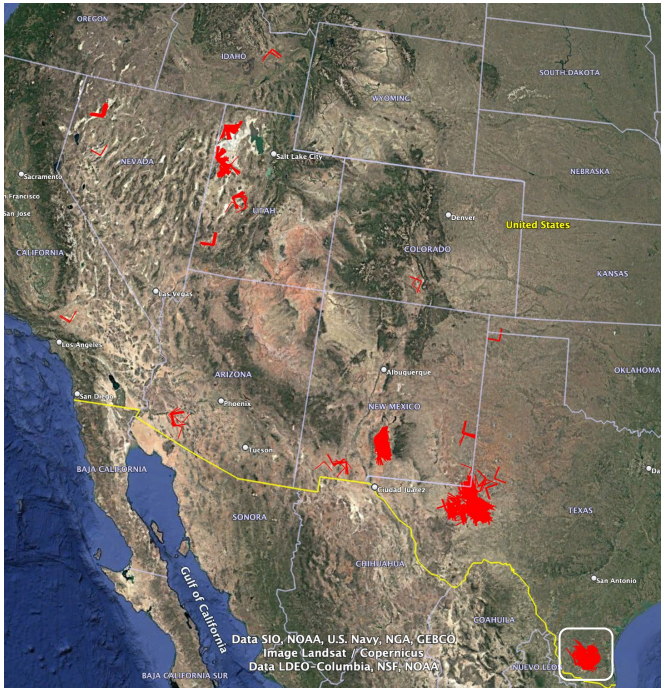
Site Selection

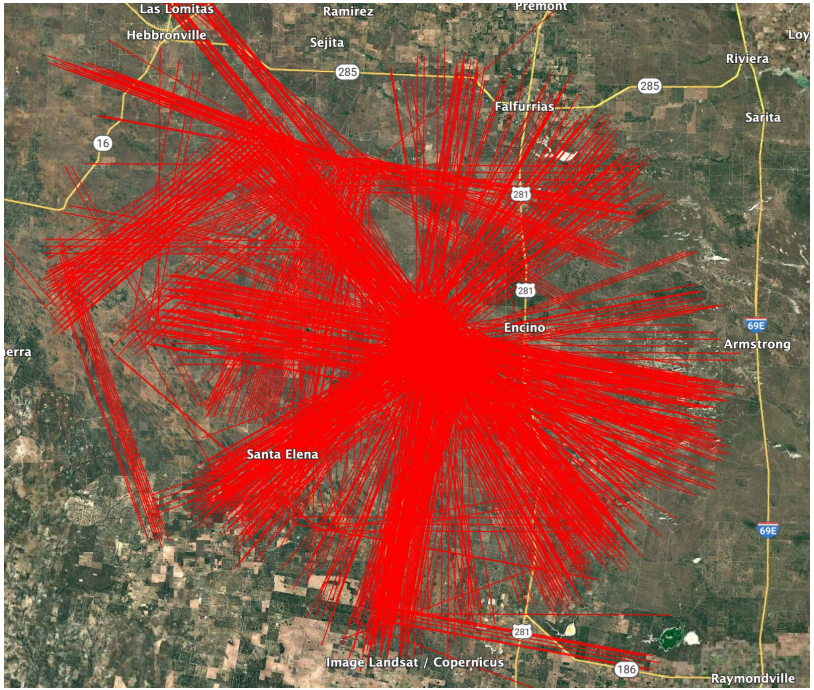
- Meet science goals
- Build within cost boundaries
- Attract, support and retain a diverse workforce
- Community focused model with partnerships centered around local and Indigenous communities



Paraphrased from Kate Daniel

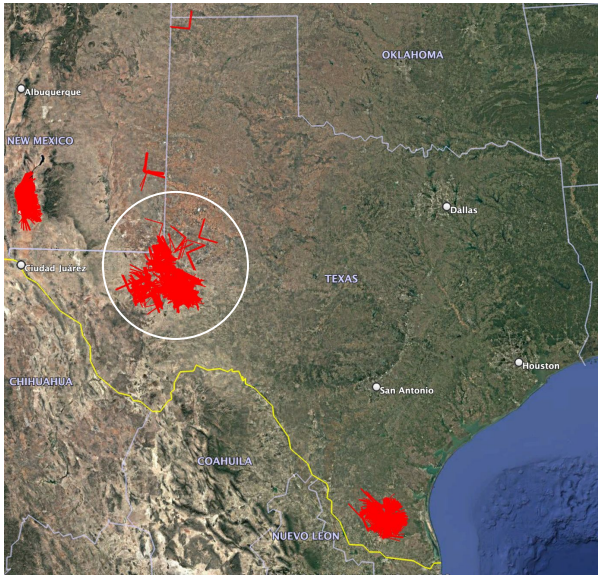
Some Potential Sites

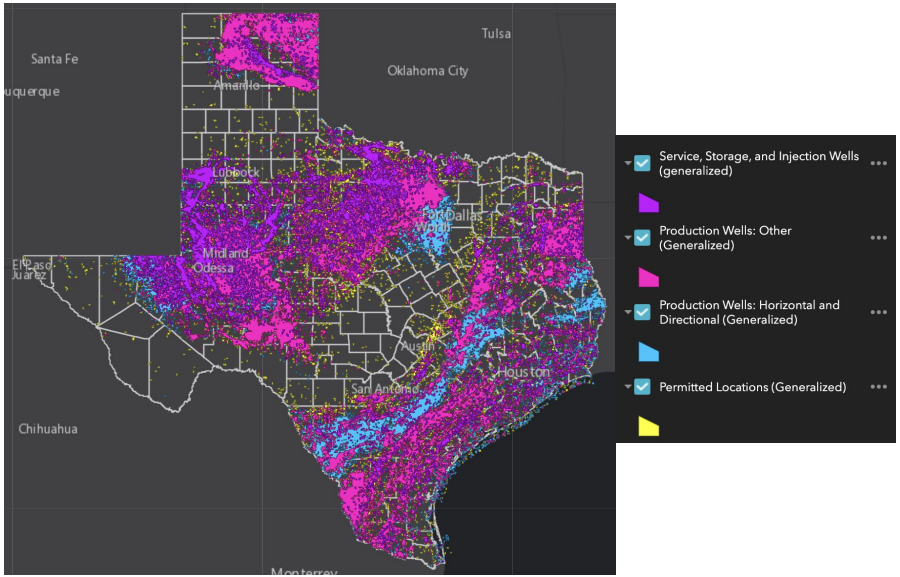




Earthquake Study

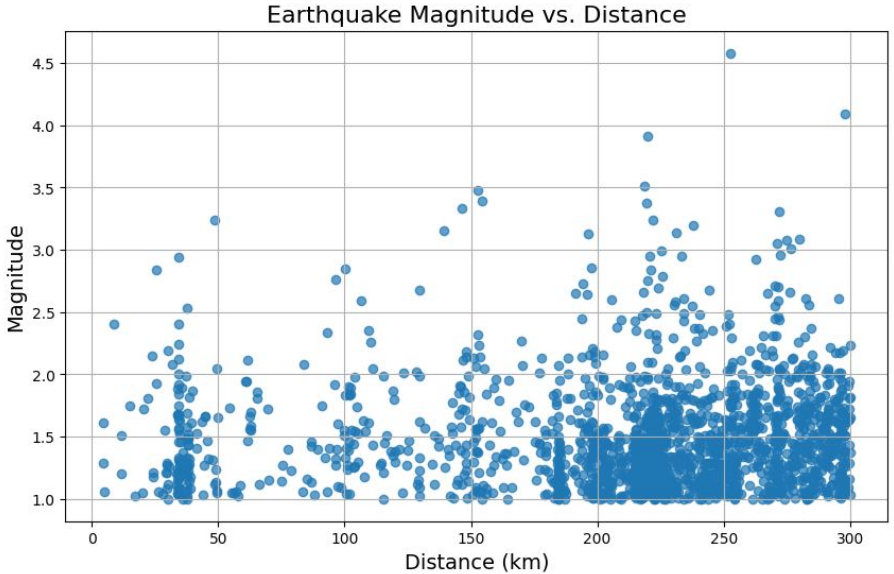
- Goal is to help determine if fracking in Texas will be an issue for CE





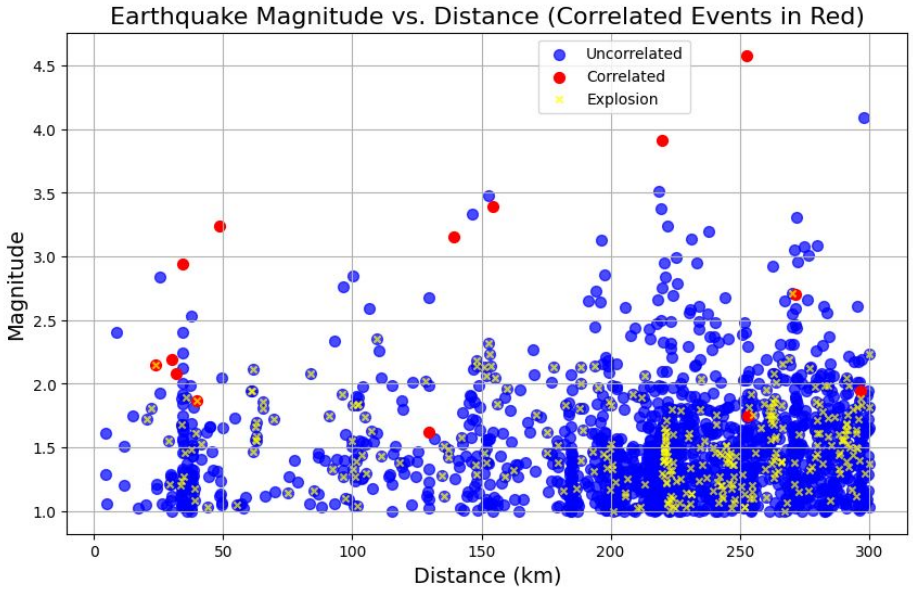
First: Analyze EQs around LHO

- **Gathered**:
  - All earthquakes (EQs) from USGS during O2, O3 and O4 (up to Feb 6) within 300km radius of LHO
  - All locklosses
  - Data for all observing times via DQSEGDB
- Removed all EQs that occurred outside of observing, leaving 1801 EQs



LHO Earthquakes and Locklosses

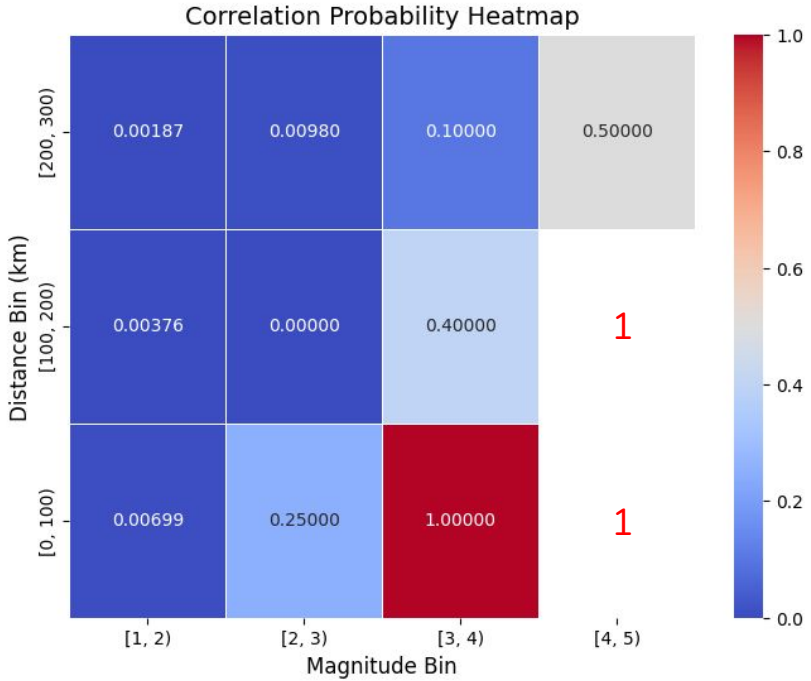
- Correlation criteria
  - If lockloss occurs within 120 seconds of EQ, flag as correlated
  - Slowest surface wave travel speed ~2.5km/s
  - 300km/2.5km/s=120s
- Wanted to analyze depth but least constrained parameter



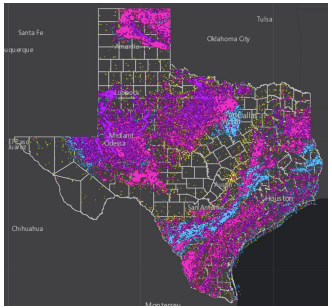
LHO Results

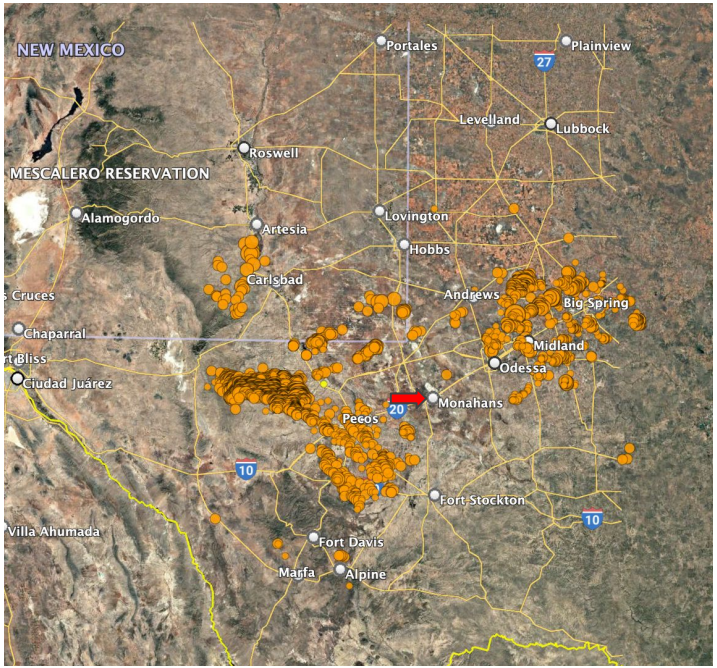
- 14 locklosses caused by EQs during the 3 runs, within this distance

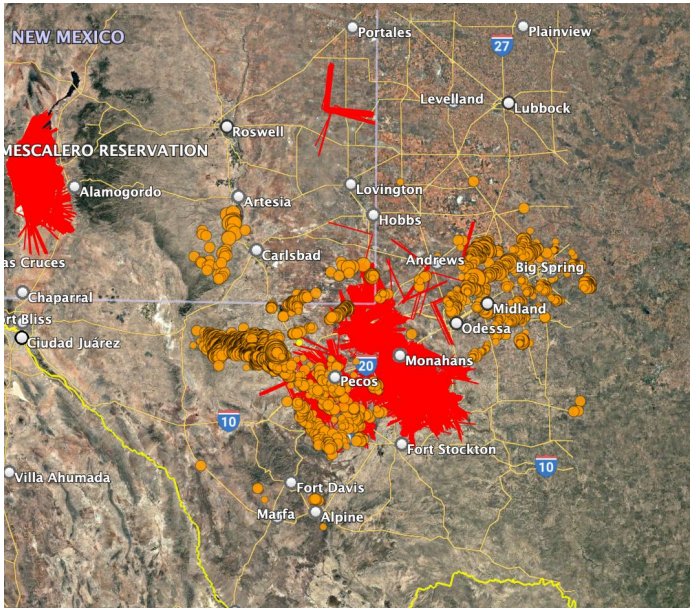
Distance Bin	Magnitude Bin	Total Events	Correlated Events	Correlation Probability
[0, 100)	[1, 2)	143	1	0.00699
[0, 100)	[2, 3)	16	4	0.25
[0, 100)	[3, 4)	1	1	1.0
[0, 100)	[4, 5)	0	0	NaN -> 1.0
[100, 200)	[1, 2)	266	1	0.00376
[100, 200)	[2, 3)	33	0	0.0
[100, 200)	[3, 4)	5	2	0.4
[100, 200)	[4, 5)	0	0	NaN -> 1.0
[200, 300)	[1, 2)	1072	2	0.00187
[200, 300)	[2, 3)	102	1	0.00980
[200, 300)	[3, 4)	10	1	0.1
[200, 300)	[4, 5)	2	1	0.5



West Texas Fracking

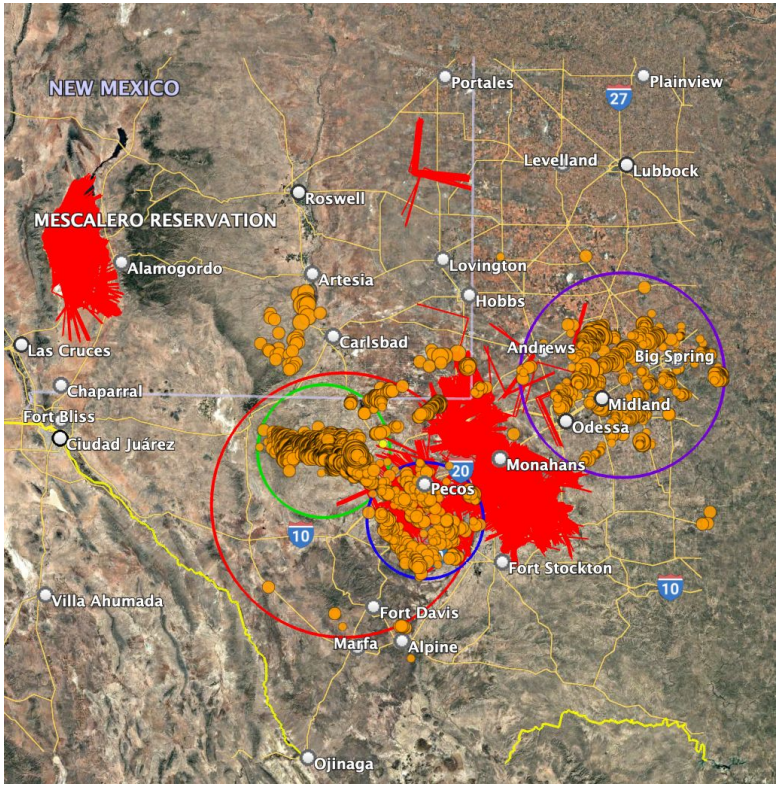




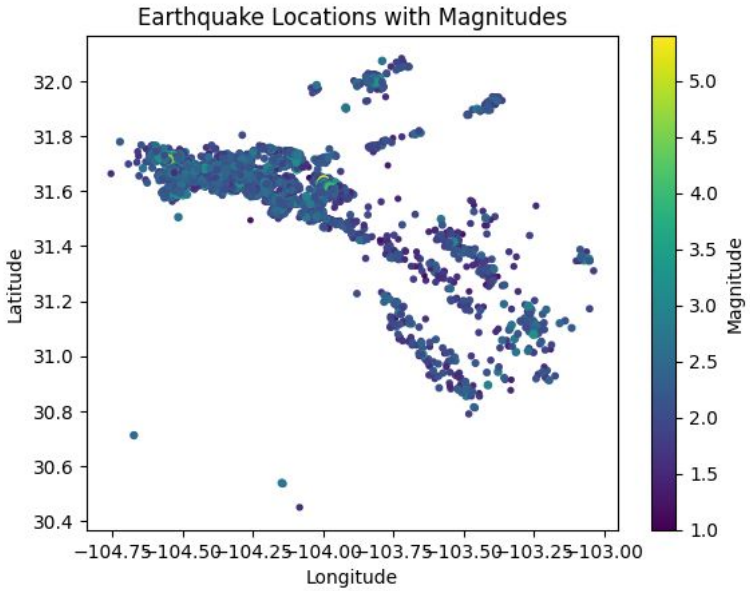


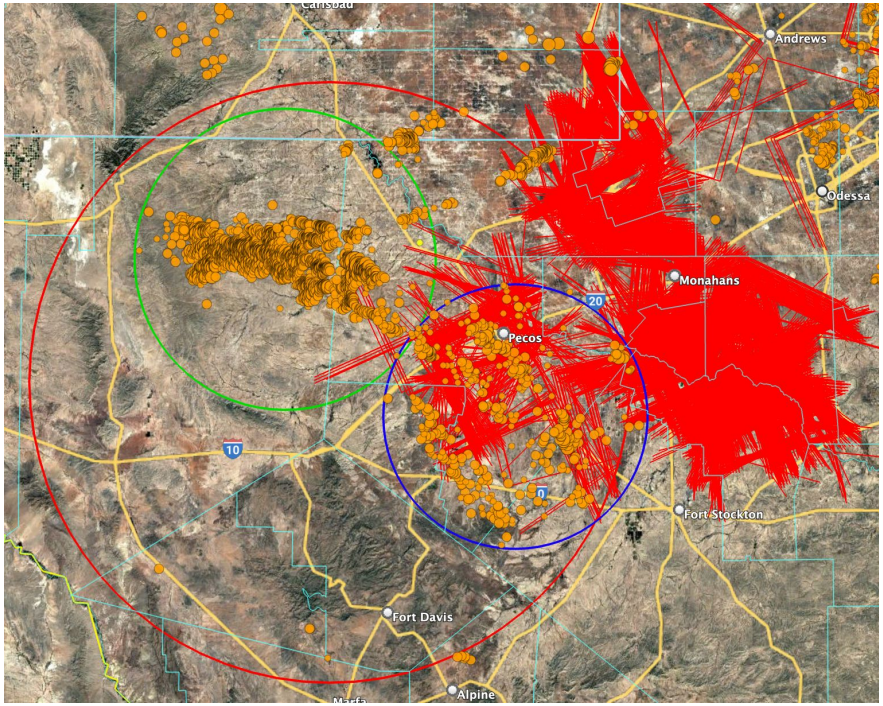
Analysis

- Pulled all EQ data from
  - 200km radius circle around Monahans, TX
  - For 1000 days prior to Jan 1, 2025 (April 7, 2022)
- 12068 EQs Total
- Divide densest pockets of EQs into “exclusion zones”
- Multiply the lockloss probabilities from LHO to get *rough* idea of how a detector would be affected



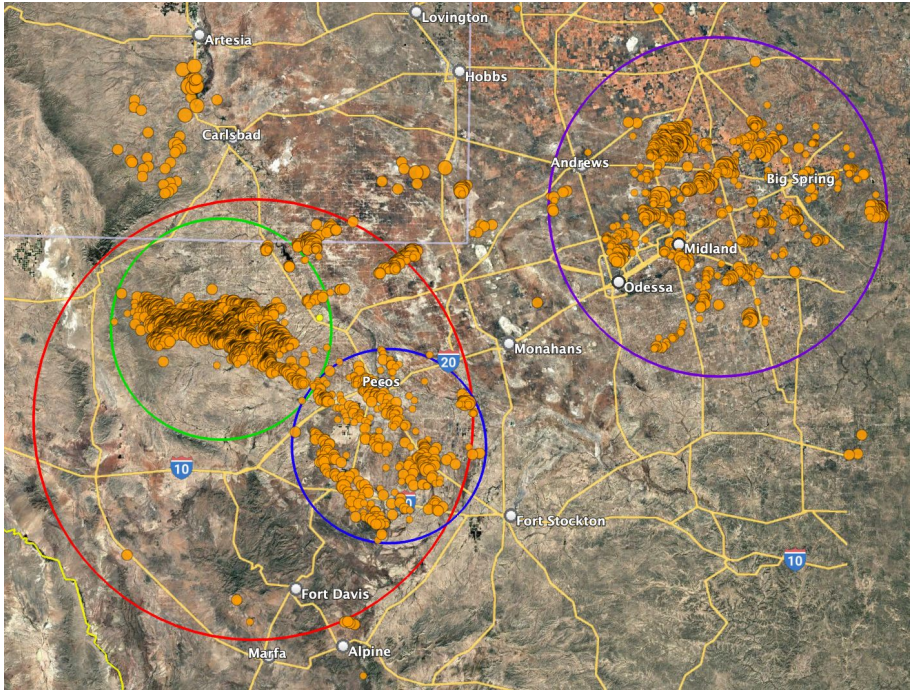
West Circles



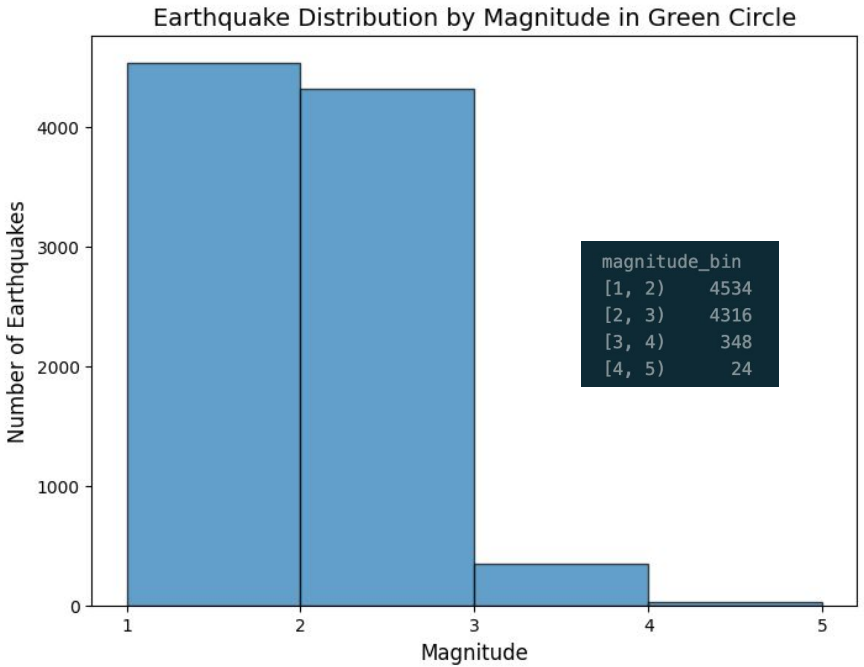


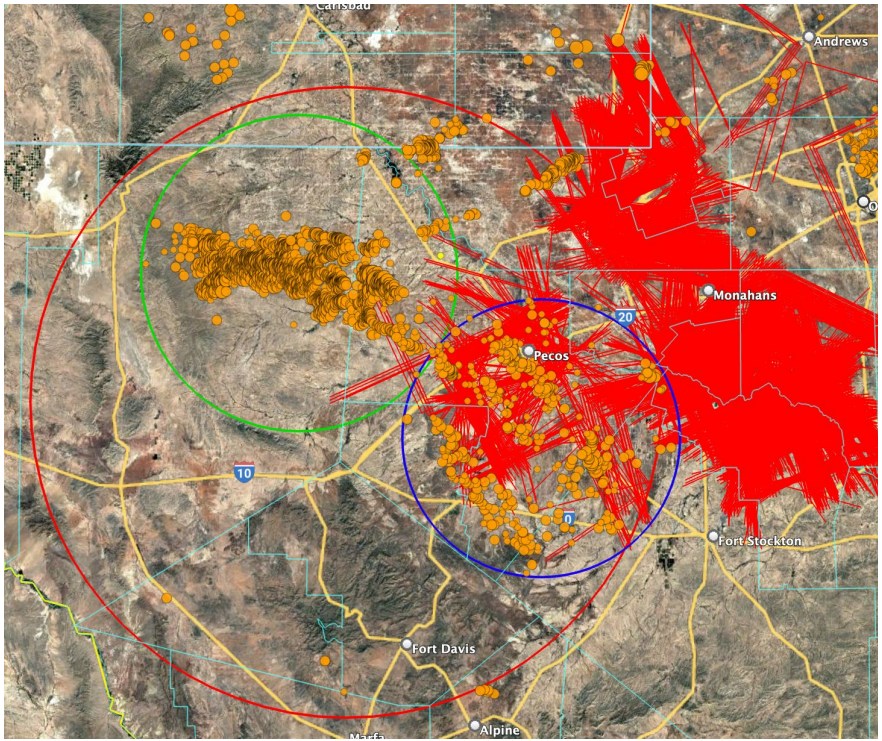
Analysis

- In red circle there were 9889 EQs, comprising ~82% of EQs of sampled region, but further divided after looking at heatmap
  - Green circle: 9225 EQs (~76% of total)
  - Blue Circle: 463 EQs (~3.8%)
- Purple circle comprised 2076 EQs (~17%)
- Between green, blue and purple circles, we get 97.5% of EQs in sampled region



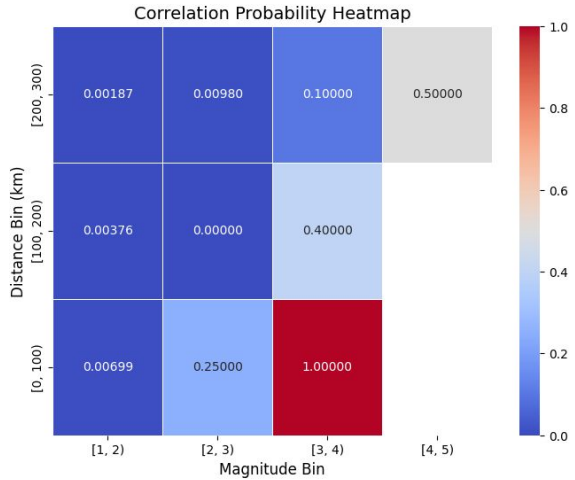
West Circle-Green





West Circle-Green

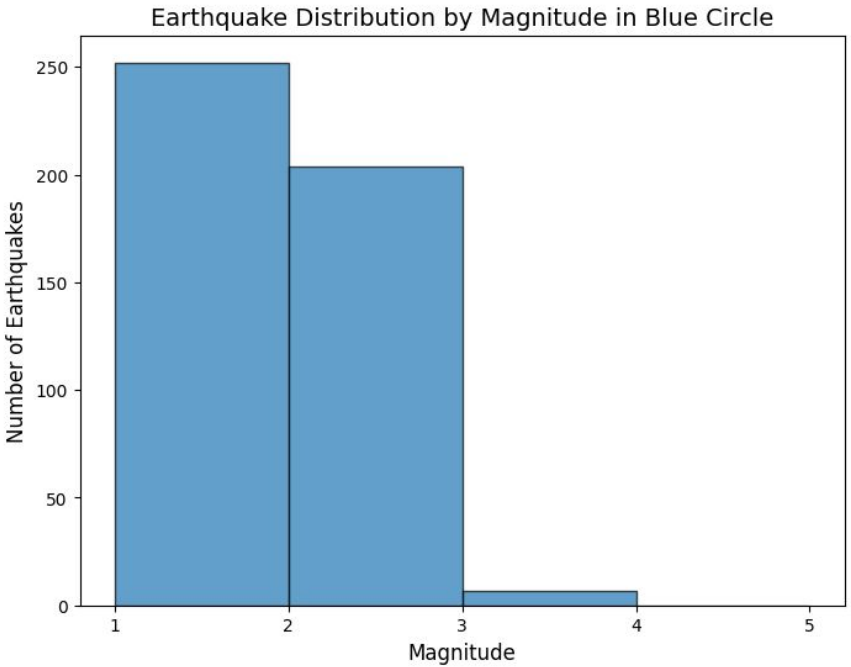
magnitude_bin	
[1, 2)	4534
[2, 3)	4316
[3, 4)	348
[4, 5)	24

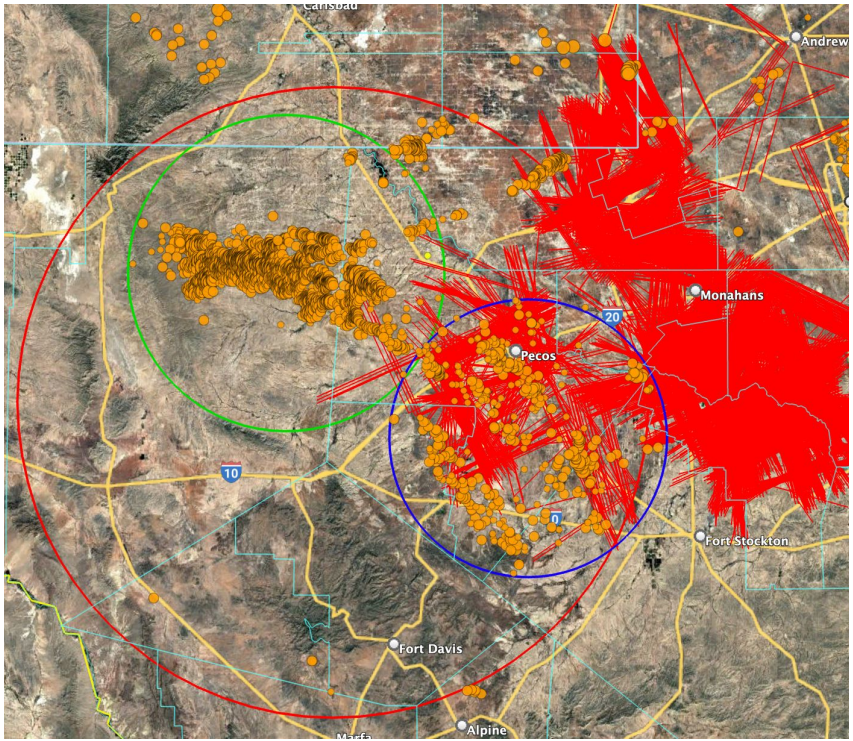



```
Calculations for [0, 100):
[1,2): 4534 * 0.0069930069930069 = 31.706293706293284
[2,3): 4316 * 0.25 = 1079.0
[3,4): 348 * 1.0 = 348.0
[4,5): 24 * 1.0 = 24.0

Calculations for [100, 200):
[1,2): 4534 * 0.0037593984962406 = 17.04511278195488
[2,3): 4316 * 0.0 = 0.0
[3,4): 348 * 0.4 = 139.20000000000002
[4,5): 24 * 1.0 = 24.0

Calculations for [200, 300):
[1,2): 4534 * 0.001865671641791 = 8.458955223880395
[2,3): 4316 * 0.0098039215686274 = 42.313725490195864
[3,4): 348 * 0.1 = 34.800000000000004
[4,5): 24 * 0.5 = 12.0

Final weighted sums:
```

	Distance Bin	Lockloss Per Day	Lockloss Per 2 Days
0	[0, 100)	1.482706	2.965413
1	[100, 200)	0.180245	0.360490
2	[200, 300)	0.097573	0.195145

West Circle - Blue

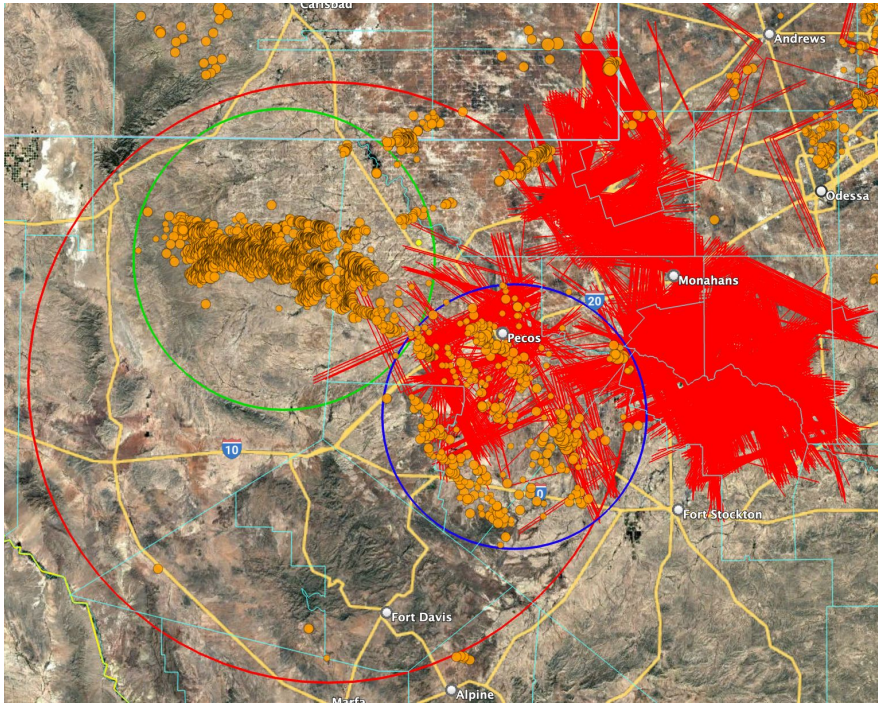




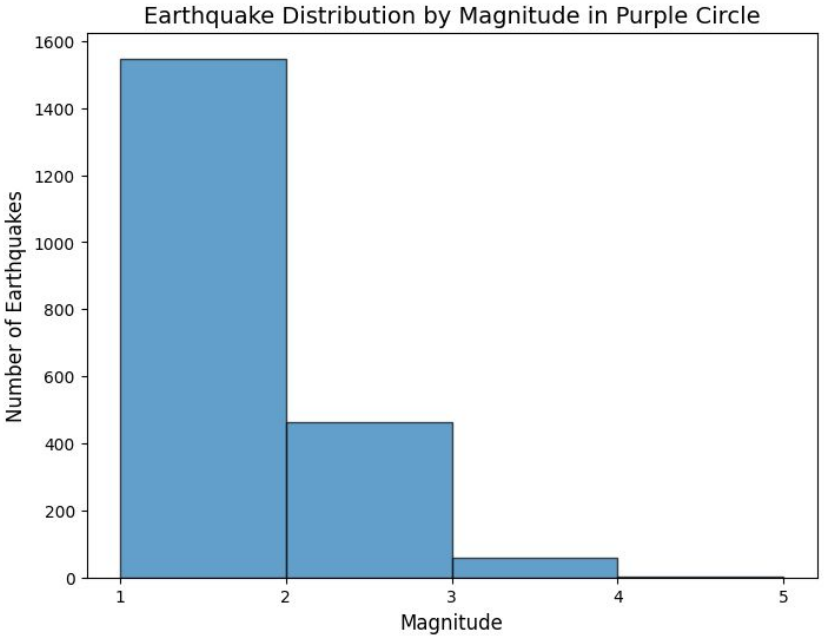
West Circle - Blue

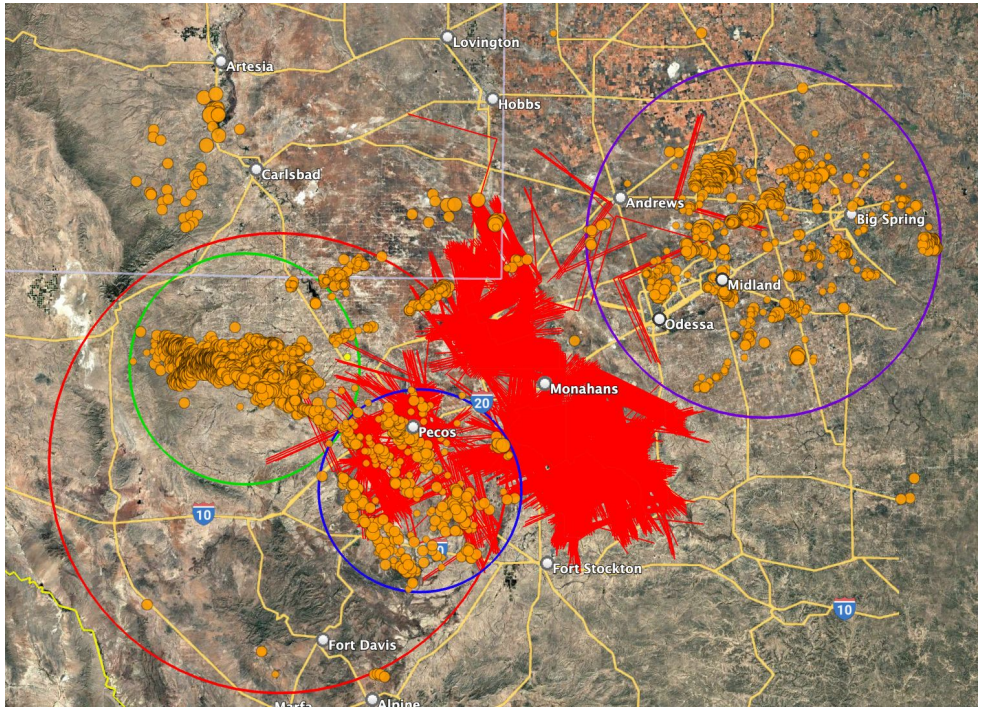
```
Calculations for [0, 100):
[1,2): 252 * 0.0069930069930069 = 1.7622377622377388
[2,3): 204 * 0.25 = 51.0
[3,4): 7 * 1.0 = 7.0
[4,5): 0 * 1.0 = 0.0

Calculations for [100, 200):
[1,2): 252 * 0.0037593984962406 = 0.9473684210526312
[2,3): 204 * 0.0 = 0.0
[3,4): 7 * 0.4 = 2.8000000000000003
[4,5): 0 * 1.0 = 0.0

Calculations for [200, 300):
[1,2): 252 * 0.001865671641791 = 0.47014925373133204
[2,3): 204 * 0.0098039215686274 = 1.9999999999999898
[3,4): 7 * 0.1 = 0.7000000000000001
[4,5): 0 * 0.5 = 0.0

Final weighted sums:
```

	Distance Bin	Lockloss Per Day	Lockloss Per 2 Days
0	[0, 100)	0.059762	0.119524
1	[100, 200)	0.003747	0.007495
2	[200, 300)	0.003170	0.006340



West Texas- Purple Circle

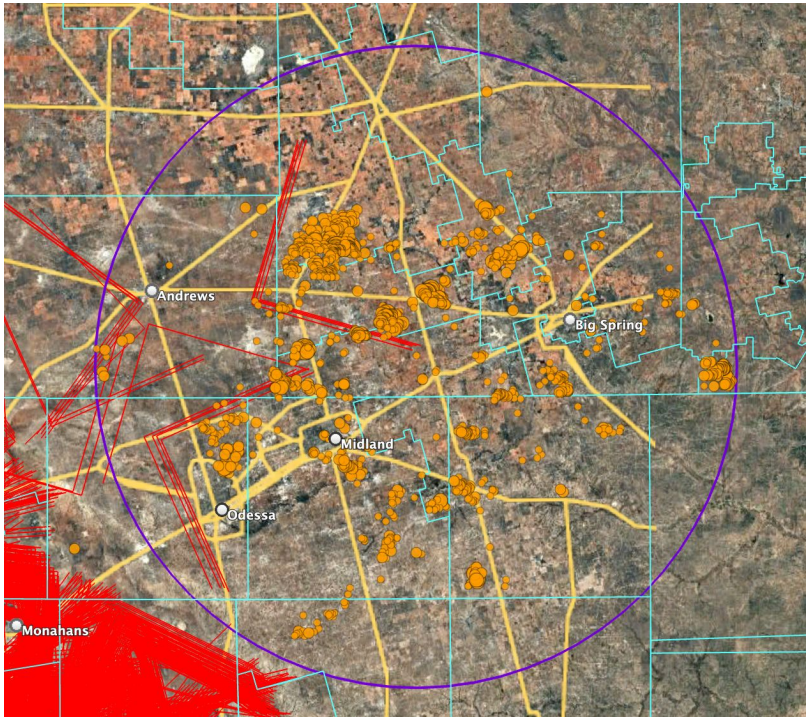




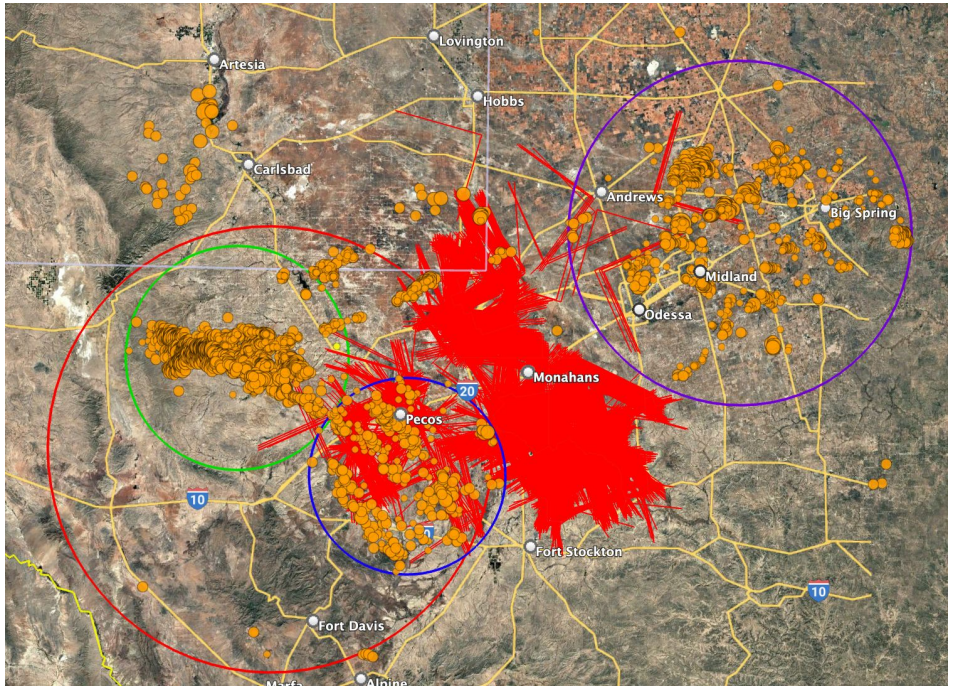
West Texas- Purple Circle

```
Calculations for [0, 100):
[1,2): 1548 * 0.0069930069930069 = 10.825174825174681
[2,3): 463 * 0.25 = 115.75
[3,4): 59 * 1.0 = 59.0
[4,5): 4 * 1.0 = 4.0

Calculations for [100, 200):
[1,2): 1548 * 0.0037593984962406 = 5.819548872180449
[2,3): 463 * 0.0 = 0.0
[3,4): 59 * 0.4 = 23.6
[4,5): 4 * 1.0 = 4.0

Calculations for [200, 300):
[1,2): 1548 * 0.001865671641791 = 2.8880597014924683
[2,3): 463 * 0.0098039215686274 = 4.539215686274487
[3,4): 59 * 0.1 = 5.9
[4,5): 4 * 0.5 = 2.0

Final weighted sums:
```

	Distance Bin	Weighted Sum	Locklosses Per 2 Days
0	[0, 100)	0.189575	0.379150
1	[100, 200)	0.033420	0.066839
2	[200, 300)	0.015327	0.030655



Summary



West Circle Green

Distance Bin	Locklosses Per Day	Locklosses Per 2 Days
[0, 100)	1.483	2.965
[100, 200)	0.180	0.360
[200, 300)	0.098	0.195

West Circle Blue

Distance Bin	Locklosses Per Day	Locklosses Per 2 Days
[0, 100)	0.060	0.120
[100, 200)	0.004	0.007
[200, 300)	0.003	0.006

East Circle Purple

Distance Bin	Locklosses Per Day	Locklosses Per 2 Days
[0, 100)	0.190	0.380
[100, 200)	0.033	0.067
[200, 300)	0.015	0.031

West Circle Green

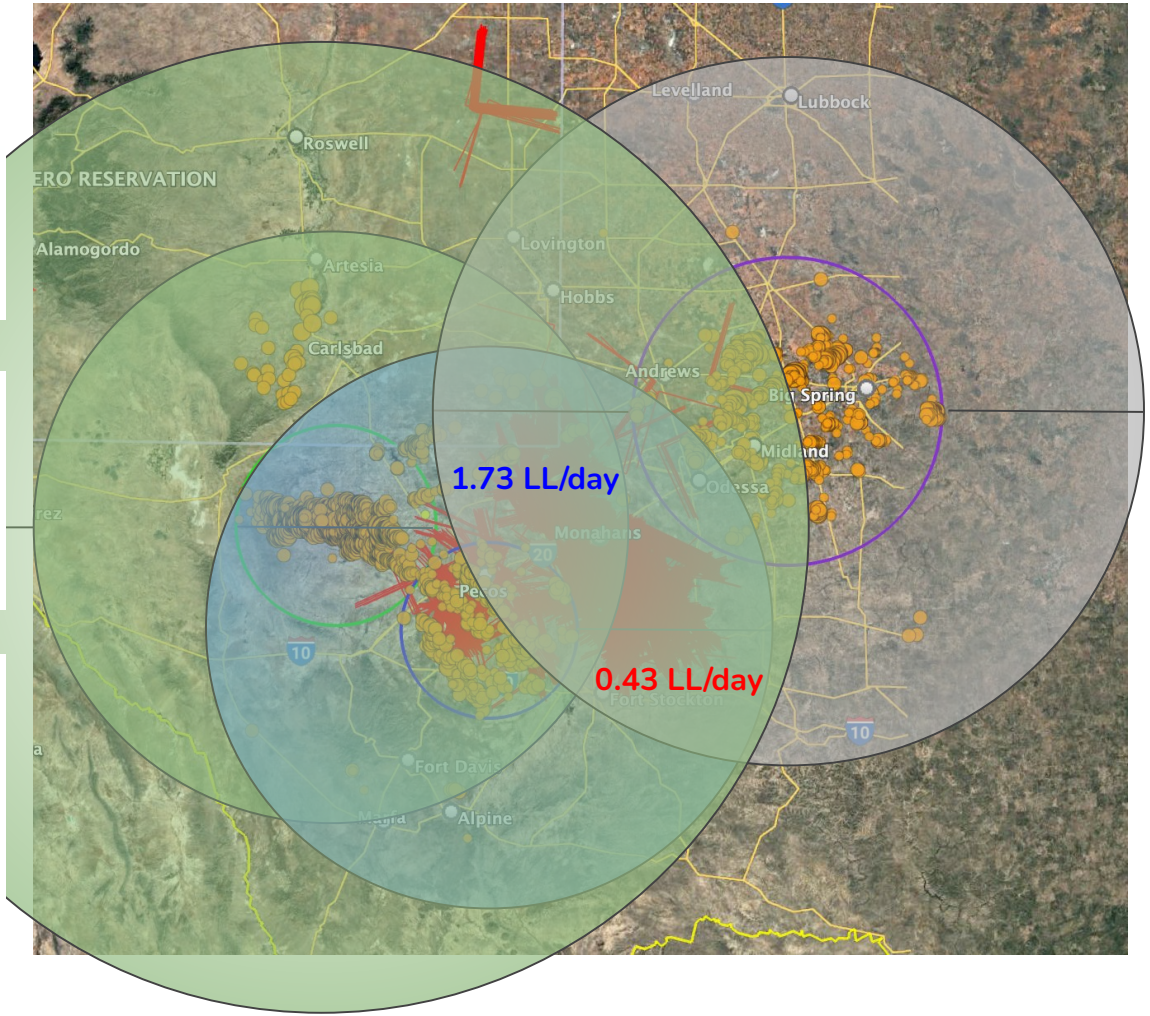
Distance Bin	Locklosses Per Day	Locklosses Per 2 Days
[0, 100)	1.483	2.965
[100, 200)	0.180	0.360
[200, 300)	0.098	0.195

West Circle Blue

Distance Bin	Locklosses Per Day	Locklosses Per 2 Days
[0, 100)	0.060	0.120
[100, 200)	0.004	0.007
[200, 300)	0.003	0.006

East Circle Purple

Distance Bin	Locklosses Per Day	Locklosses Per 2 Days
[0, 100)	0.190	0.380
[100, 200)	0.033	0.067
[200, 300)	0.015	0.031



Other Things to Consider

- Haven't accounted for size of detector
- Sensitivity differences in LIGO/CE
- How much will fracking regions move? Will they increase?
- Probability table entry with 0
- ~3 EQs over magnitude 5
- Soil/land differences

Follow Up Results

- Extensive pipeline and well infrastructure in the Midland/Odessa area that might make it infeasible to build atop of
- Learned we need to focus on less densely welled/pipelined areas
- Detector *likely* placed elsewhere!