Abstract

Since 1906, California’s San Andreas Fault System has not produced a M7.5+ earthquake in over 100 years. After over a century of dormancy, the San Andreas Fault is approaching its recurrence rupture interval of 140 years (Wald et al., 2019). In light of this absence of large earthquakes, we investigated different types of earthquake droughts, the likelihood of our current seismic drought ending in the next 30 years, and a forecast of the seismic rate after the drought has ended. In order to measure and compare the statistical likelihood of major earthquake ruptures in California, we defined an earthquake drought four different ways. We used RSQSim (Rate State earthquake Simulator), a physics-based earthquake simulator, on the Blue Waters supercomputer to generate 2 million year catalog of simulated earthquakes. We calculated probabilities regarding earthquake behavior based on the time-independent Poisson distribution model in order to find the overall probability of a M7.5+ earthquake occurring over any 30-year period. We then compared this time-independent model to a time-dependent model to see the differences in probability between the earthquake occurrences. Using a catalog of 2 million years, the probability of being in a drought of 100 years or more on the San Andreas Fault system (Definition 2) is 2%. Furthermore, the probability of a M7.0+ drought ending event occurring for the same definition such that a 100 year drought has passed is 91%. Therefore, California, regardless of which definition used, is in an extremely unlikely drought and is very likely to see the drought end soon.

Drought Definitions

1. **Statewide drought**: using all faults in California, there has not been any M7.5+ earthquakes in a 100 year period.
2. **San Andreas Sub-System**: looking at the San Andreas Fault, the San Jacinto Fault, the Hayward Fault, and the Elsinore Fault, specifically, if there is an absence of M7.0+ earthquakes in a 100 year period.
3. **Five site drought**: using the 5 paleoseismic sites stated by Biasi and Sharer (2019) as the most seismically active sites in California which have not had a ground-rupturing earthquake (M6.5+) in over 100 years.
4. **Thirty site drought**: We extended the drought to include 30 paleoseismic sites extracted from UCERF3.

Methodology

- Calculated the time-independent and time-dependent probabilities of a 100-year drought, and likelihood of large earthquakes 30 years after 100 year drought.
- Generated catalogs using RSQSim which ran on Blue Waters.
- Wrote code in Java that finds the frequency of earthquakes and droughts.
- Specified the friction parameters and time frame, for which the output file details the date, magnitude and location of the earthquakes that ruptured within that time frame.

RESULTS

Probability = # of times specified outcome occurs
# of total possible outcomes

where the specified outcome is the number of drought years and the total number of outcomes is the total length of the catalog (2 million years)

**Time-Dependent Probability**: counted the number of droughts with at least one such earthquake divided by the total number of droughts.

**Time-Independent Probability**: the total earthquakes divided by the length of the catalog

Similarly, for the other probabilities, we counted the total number of occurrences, and divided by the total possible outcomes.

Figure 1: Visual drought definitions: (A) Mapped faults throughout all of California, (B) San Andreas, Hayward, San Jacinto, and Elsinore Faults, (C) Locations of 5 paleoseismic sites, (D) Locations of 30 paleoseismic sites.

Figure 2: Locations of 30 paleoseismic sites. (A) Locations of UCERF3, (B) Locations of 5 paleoseismic sites, (C) Locations of 2000 years catalog, (D) Locations of 2 million years catalog.

Figure 3: Flow chart of the approach and methodology

Figure 4: Probabilities of earthquakes and earthquake droughts with respect to each of the four definitions using the preliminary 2 million year catalog.

**Summary**

- California is in an extremely unlikely drought
- The likelihood of the drought ending is likely to extremely likely for some of the definitions and probabilities
- Time dependent probability of drought ending in 30 year period is 91% for a M7.0+ on SAF sub system
- Time dependent statewide M7.5+ is ~78%

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References
