Analysis of the Gutenberg-Richter Law Using CTBTO SEB Data for the Americas Region

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INTRODUCTION AND MAIN RESULTS

This study evaluates seismic activity in the Americas region using data from the Screened Seismic Event Bulletin (SSEB) of the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO). By applying the Gutenberg-Richter law, we calculated a and b to estimate recurrence intervals and maximum expected magnitudes for localized subregions. Using magnitude intervals of 0.5, the analysis refines the characterization of seismic activity.

This study demonstrates the effectiveness and hard work of the CTBTO teams get dataset for high-resolution seismic analysis and underscores its potential for enhancing regional seismic hazard assessments. We used more than a thousand evens inside America and calculated a 5.0 almost 47 days.

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USE

The Gutenberg–Richter (G–R) law describes the relationship between earthquake frequency and magnitude:

$$\log 10N(M \geq m) = a - b\,m$$

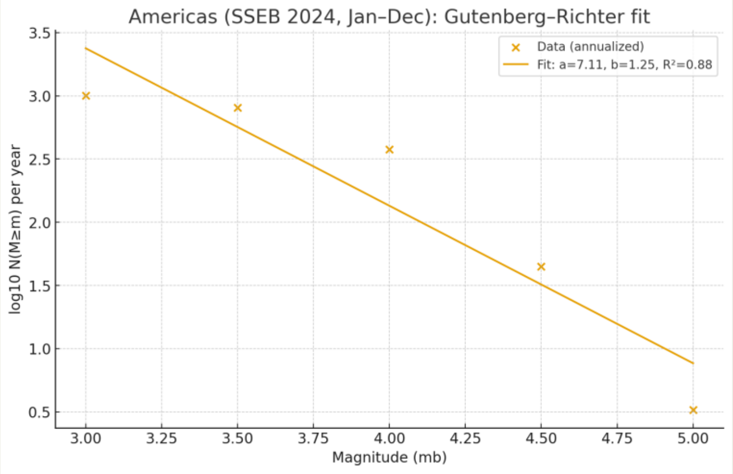
Parameter a measures seismic productivity (events per unit time), and b captures the proportion of small to large events; typically, $b \approx 1$. To apply it rigorously, one sets a completeness magnitude Mc, estimates a and b (ideally via maximum likelihood), and assumes an approximately stationary, for visualization process 0.5 magnitude bins are used.

The importance of Gutenberg – Richter Law enables derivation of exceedance rates, return periods, and the probability that an event larger than a threshold will occur within a given time window; comparison of tectonic subregions; evaluation of network performance and catalog consistency; study of b-value changes linked to stress states; and inputs to seismic-hazard models and building codes. It is a statistical screening tool: it does not predict individual events, but it quantifies recurrence.

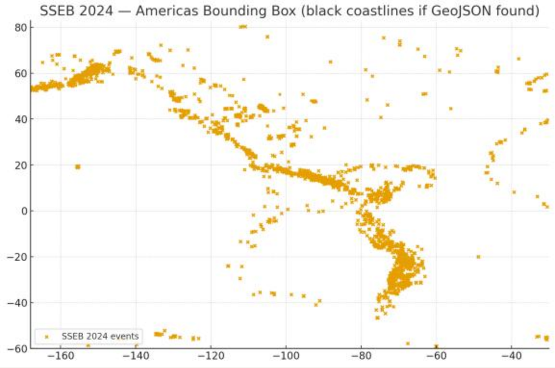
Methodology

We used CTBTO SSEB bulletins from 2024 as the data source. Each event, we extracted date–time, latitude, longitude, and magnitudes, prioritizing the definitive mb (if absent, the event was excluded from the fit).

To represent only the continent, we applied a spatial cut with the bounding box lon −168 to −30, lat −60 to 83. The effective time window T was computed between the first and last events in the subset. On this subset we built the cumulative magnitude–frequency distribution. Histograms with 0.5-magnitude steps were used for visualization only; the fit used cumulative counts independent of binning, annualized as N/T. For the completeness magnitude Mc we explored thresholds from 2.5 to 6.0. by least squares using points with m≥Mc (requiring ≥4≥4 points).



Result



Annual exceedance rates & return periods:

$$M \geq 4.5\colon \sim 32.19/yr \rightarrow return\ period \sim 11.3\ days$$
$$M \geq 5.0\colon \sim 7.67/yr \rightarrow \sim 47.6\ days$$
$$M \geq 5.5\colon \sim 1.83/yr \rightarrow \sim 6.6\ months$$
$$M \geq 6.0\colon \sim \frac{0.44}{yr} \rightarrow \sim 2.29\ years\ (extrapolated)$$

Completeness & fit:

Completeness magnitude (Mc): ~3.0 (mb), chosen by maximizing R^2 (0.5-mag bins).Gutenberg–Richter (annualized):

$$a = 7.11, b = 1.25, R^2 = 0.88.$$

Maximum observed mb in this subset: 5.1 (note: projections for ≥6.0 are extrapolations).