Review of **Earthquake Scaling Equations under Small Strain, Steady Moment Release-Rate Conditions in Southern Andes from 2015 to 2017**
by Patricio A. Toledo et al. (MS No.: egusphere-2026-3399)

The authors review the theoretical and empirical scaling laws for earthquakes in application to the Sothern Andes seismicity in 2015-2017 and discuss implications in terms of Small Strain, Steady Moment Release-Rate. Although the Unified Scaling Law for Earthquakes is mentioned in passing – Refs. Bak et al. (2002) = Christensen et al. (2002) and Kossobokov and Mazhkenov (1994) – a few remarks may help the authors in revising their preprint, so that to clarify the issues of scaling and complexity of seismic processes:

(i) Bak et al. (2002) = Christensen et al. (2002) (see PNAS correction dated March 17, 2003 and Erratum Phys. Rev. Lett. 90, 109901 (2003), https://doi.org/10.1103/PhysRevLett.88.178501) investigated not the entire California as claimed in Notes of Table 3, but Southern California only: **"**Catalogs of Southern California earthquake data from 1984–2000 were used in this analysis (12).**"** (Ref. "12. The Southern California Seismographic Network Catalogs (1984) http://www.scecdc.scec.org/ftp/catalogs/SCSN/.) Compare 293,405 earthquakes considered by Bak et al. (2002) to 6,274 earthquakes the authors have used in the preprint.

Note also that "a region from 20°N to 45°N latitude and 100°W to 125°W longitude" (see "**Fig. 1.** Southern California seismic region covered by a grid of cells of 4° × 4° (*Left*) and cells of 1° × 1° (~ 111 × 111 km$^2$) (*Right*).") appears to be too large for analyzing spatial distribution scaling of the epicenters of "293,405 earthquakes" most of which fall well inside 30°N to 40°N latitude and 110°W to 125°W longitude. Therefore, the estimations of Bak et al. (2002) might be biased due to inaccurate choice of the region.

(ii) Unlike the misleading statement in lines 331-333, Kossobokov and Mazhkenov (1994) investigated a number of seismic regions of the world incl. Northern California and Southern California along with a number of classical fractals incl. Koch's Curve and Sierpinsky's sets of different dimensions (as a control) to assess A, B, and C of the USLE as follows:

$$\log_{10} N(M, L) = A + B \cdot (5 - M) + C \cdot \log_{10} L\ ,\ M_{-} \leq M \leq M^{-}$$

where: (i) the coefficients $A$ and $B$ are similar to the *a-* and *b-values* from Gutenberg-Richter law; (ii) the coefficient $C$ is the *fractal dimension* ($D$ per Mandelbrot) of the set of epicenters (the coefficient $C$ shows how the expected annual number of earthquakes, $N$, is changing with linear dimension, $L$, of an enveloping area); and (iii) $M_{-}$ and $M^{-}$ are the limits of the *magnitude range* where this relationship holds.

NB: The coefficient A is as important as the *a-value* of the classical Gutenberg-Richter relationship; therefore, the authors may wish to revise the values of the coefficients picked from (Kossobokov and Mazhkenov, 1994) and the corresponding values α, β, γ, $\alpha_Q$, $\beta_Q$, and $\gamma_Q$ in Table 3 of their preprint. Note that the number of hierarchy levels h = 6 for both Northern California and Southern California scales the area from 800 × 800 $km^2$ down to 25 × 25 $km^2$, i.e. ~ 4 times finer than in Bak et al. (2002).

(from Table 6, Kossobokov and Mazhkenov, 1994)

| # | Region | Observation Period | Magnitude Range | $L_0$, km | h | A | B | C | S |
|---|---|---|---|---|---|---|---|---|---|
| … | | | | | | | | | |
| 6 | Northern California | 1980-1987 | 1.5-5.0 | 800 | 6 | -3.89 ±0.14 | 0.80 ±0.02 | 1.29 ±0.04 | ±0.10 |
| 7 | Northern California | 1980-1987 | 2.5-5.0 | 800 | 6 | -3.88 ±0.25 | 0.80 ±0.05 | 1.28 ±0.08 | ±0.12 |
| … | | | | | | | | | |
| 9 | Southern California | 1949-1985 | 3.0-5.0 | 800 | 6 | -4.25 ±0.11 | 0.82 ±0.02 | 1.52 ±0.04 | ±0.04 |
| 10 | Southern California | 1980-1987 | 2.0-5.0 | 800 | 6 | -4.31 ±0.06 | 0.90 ±0.01 | 1.50 ±0.02 | ±0.04 |
| 11 | Southern California | 1980-1987 | 3.0-5.0 | 800 | 6 | -4.36 ±0.11 | 0.89 ±0.02 | 1.51 ±0.04 | ±0.04 |
| … | | | | | | | | | |

(iii) Note also the recent articles [Kossobokov V. (2021) Unified Scaling Law for Earthquakes that Generalizes the Fundamental Gutenberg-Richter Relationship. In: Gupta H.K. (eds) Encyclopedia of Solid Earth Geophysics. Encyclopedia of Earth Sciences Series. Springer, Cham, p.1893-1896. https://doi.org/10.1007/978-3-030-58631-7_257; Nekrasova A. K., Kossobokov V. G. (2020) The Unified Scaling Law for Earthquakes. Journal of Volcanology and Seismology 14(6): 353–372. https://doi.org/10.1134/S0742046320060056] and, in particular, the Global maps of A, B, and C on a regular 1°×1° worldwide grid (based on the USGS Global Hypocenters Data Base of shallow M ≥ 4 earthquakes, 1964-2002) [Nekrasova, A., Kossobokov, V.

(2019) Unified Scaling Law for Earthquakes: Global Map of Parameters. ISC Seismological Dataset Repository. https://doi.org/10.31905/XT753V44] are available for a free use and comparisons. For example, the values of A, B, and C in a region from 15°S to 50°S latitude and 65°W to 80°W longitude vary in the following ranges: $-1.26 \leq A \leq 0.11$ (average -0.39), $0.43 \leq B \leq 1.03$ (average 0.80), and $0.66 \leq C \leq 1.31$ (average 1.13). The authors may wish to compare the A, B, and C distributions and their non-trivial correlations over the territory considered (see Figures C1 and C2, below) to the regional tectonics.

Figure C1. The maps of A (top), B (middle), and C (bottom) values in the Chili region color coded by quartiles: 1st green, 2nd yellow, 3rd orange and 4th red.

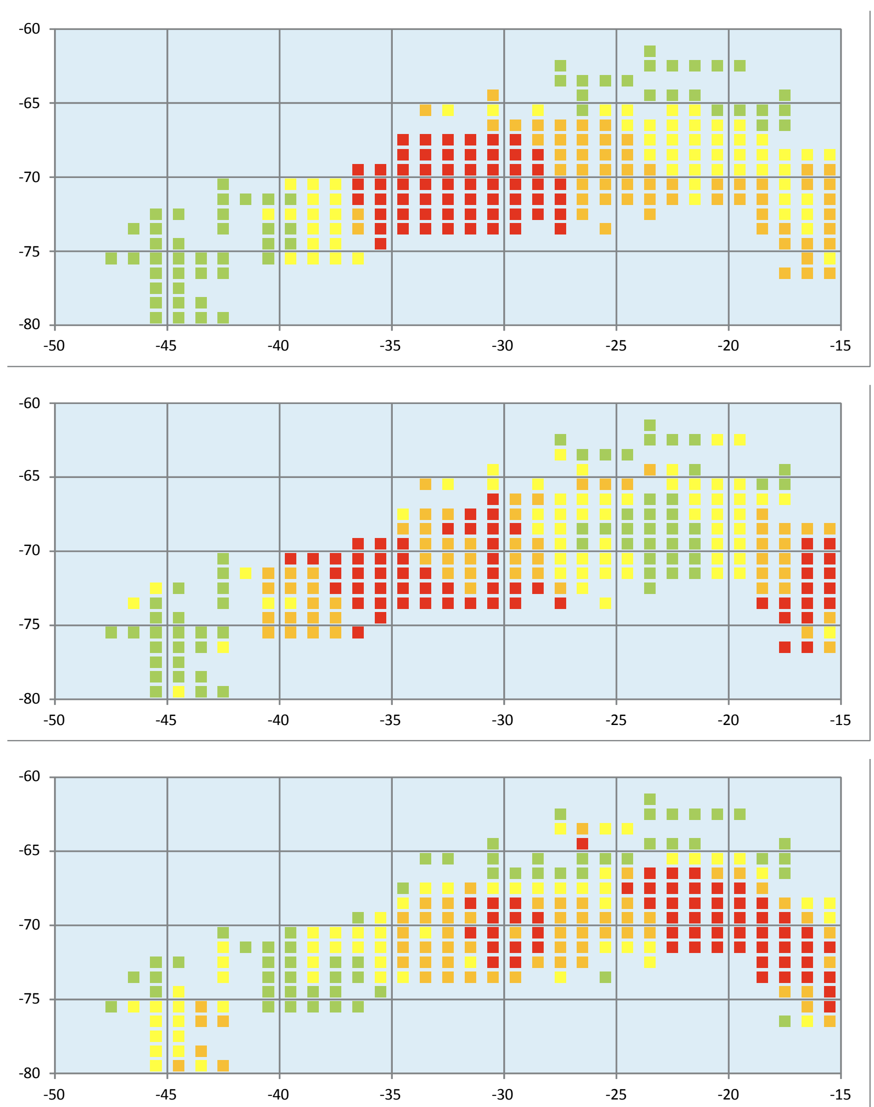
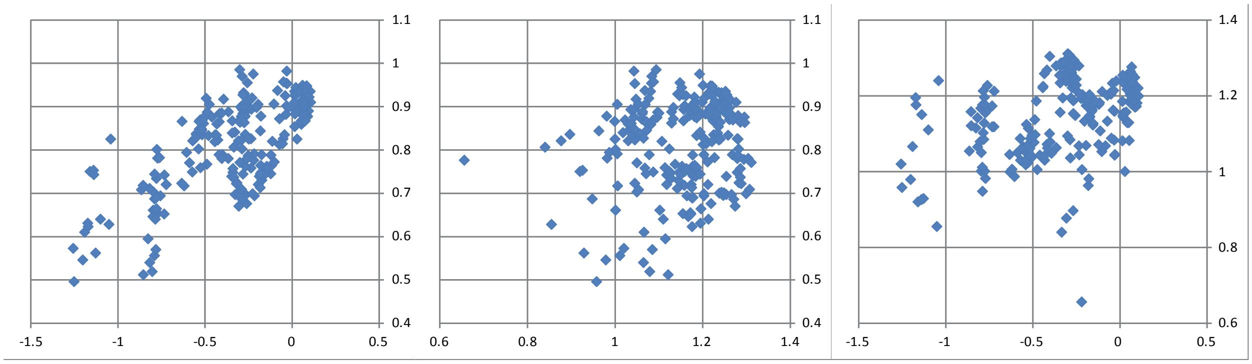


Figure C2. Pairwise distribution of A vs B, B vs C, and A vs C in the Chili region.




(iv) Bak et al. (2002) emphasize the role of the USLE control parameter; in essence, USLE "states that the distribution of waiting times between earthquakes depends only on this value". Evidently, A, B, C, and the control parameter varies in space and time (see [Filippova A, Fomochkina A, Kossobokov V and Nekrasova A (2025) Characterizing the foreshock, main shock, and aftershock sequences of the recent major earthquakes in Southern Alaska, 2020–2024. Front. Earth Sci. 13:1660221. https://doi.org/10.3389/feart.2025.1660221] and references therein): over the years we found that "the uniform analyses of foreshock-main shock-aftershock sequences in Central Italy, New Zealand, Southern Alaska, Japan, Taiwan, and worldwide (5, 9, 7, 1, 1, and 156 cases, respectively) do not support a unique scenario in seismic energy release, but (i) provide fundamental constrains on modelling realistic earthquake sequences, (ii) give a new confident insight into better understanding of regional seismic dynamics, and (iii) can be used to improve seismic hazard assessments, including forecast/prediction claims at different magnitude-space-time scales."

Therefore, in my opinion, the 3 years of data on earthquake epicenters (2015-2017) appear to be too small for straight forward comparisons with rather long-term tectonic characteristics of the region, as well as for justifying the unique theoretical model. I guess, this should soften a bit the authors' claims and conclusions.

Cordially,

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