Costa Rica's digital earthquake catalog quashes a common misconception

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Analysis of 14 years of earthquake records reveals that these events aren't seasonal

By **Esteban J. Chaves, Ph.D.**, Volcanological and Seismological Observatory of Costa Rica OVSICORI, Universidad Nacional

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Una traducción de este artículo está disponible en español.

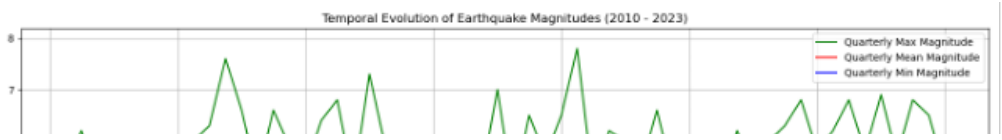
In Latin American countries, one can hear stories that pass from generation to generation. One of them is that, when the weather is too hot or it's raining a lot, an earthquake may occur. For instance, on Easter, the general public may be expecting a large event simply because the temperature is high. Another story says that if the pattern of clouds shows some rock-like shape, an earthquake may occur. These stories have been demystified by local scientists, but still prevail i

(formerly known as Twitter) pages, reporting events has become simple and accessible for people in Costa Rica. Even people living in Nicaragua and Panama near the Costa Rican border contribute to OVSICORI, as these countries do not have quick automatic response from a seismological observatory.

These datasets — both the complete catalog and the list of felt earthquakes — provide invaluable information about when and where earthquakes occur, along with how people experience them. We invite researchers to dive into this data, much of which is open access through OVSICORI's website. More scientists applying different methods can help us not only better understand earthquake and fault physics, but also Earth's structure beneath Costa Rica.

Which quakes do people feel?

Felt events (Figure 1) between 2010 and 2015 show a variable quarterly average magnitude, with values between 3.0 and 4.5 (red line). However, as of 2016, the behavior stabilized, with values between 3.4 and 4.0. In other words, we now know that earthquakes with magnitude of about 3.5 and above are likely to be felt.



Temporal evolution of the magnitude of felt earthquakes from 2010 until Dec. 31, 2023. The green, red and blue lines show the quarterly average of the maximum, average, and minimum magnitudes, respectively. Credit: Chaves, 2024, CC BY-NC-ND 4.0

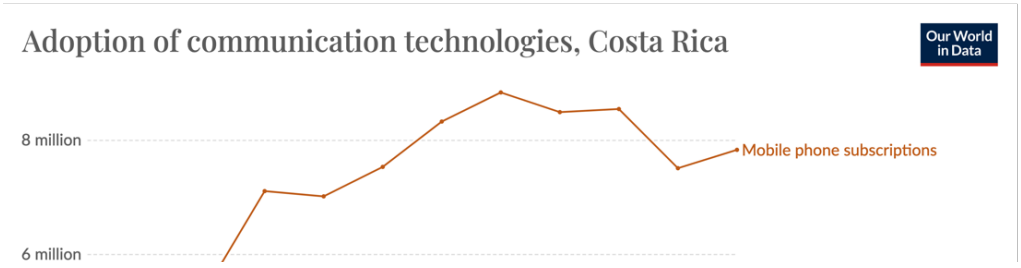
There are two possible reasons for the stabilization that occurred in 2016. First, in 2016 the seismic network in the country was expanded. The deployment of more seismic stations means both more robust measurements of earthquake magnitude, and the capability of detecting smaller magnitude events.

Of the felt earthquakes in the catalog, 75% have magnitudes less than or equal to 4.3, while 25% have magnitudes less than or equal to 2.8. This highlights that people live very near fault traces and can feel a good proportion of small magnitude events. This information can be incredibly useful in several key areas, including:

1. Targeted Education and Preparedness: If people are sensitive to smaller tremors and live near faults, these communities might be more receptive to educational efforts focused on earthquake preparedness.
2. Influence on Building Codes and Land Use: This information contributes to building codes and land-use planning. To reduce damage from frequent, low-magnitude tremors, codes are often stricter in areas near active faults. Knowing where faults are located can help local officials prepare for larger events.
3. Public Communication and Risk Perception: Knowing that people feel small events and their potential impacts helps both people and governmental agencies to take proactive steps to manage risks. This preparedness can reduce panic, foster a sense of control, and encourage preventive actions, ultimately saving lives and reducing injuries.

The second reason for the 2016 change may be the result of a notable increase in the number of felt earthquake reports received through OVSICORI's social networks (Figure 2). The increase in felt reports may be due to a combination of factors, including increase in internet availability at the national level and the use of social media networks as tools for immediate communication. For example, a time series extracted from the World Bank database demonstrates how, as of 2016, around 3.7 million people gained access to internet service in Costa Rica (Figure 3). During the same period, there was a significant increase in the number of mobile telephone accounts (smartphones), which surpassed the number of fixed telephone lines nationwide.

Moreover, a sustained increase in the number of mobile subscriptions on different platforms (e.g., 3G/5G/LTE phone connectivity) began in 2013, reaching a number greater than 8 million in 2016. This increase in connectivity means that people could more easily access social media apps like Twitter and Facebook. Greater connection between OVSICORI and the public means more felt reports.



Recurrence time of large events in Costa Rica between 2010 and 2023

Between 2010 and 2023, a total of 37 earthquakes with magnitudes greater than or equal to 6.0 occurred in Costa Rica (Figure 4 and Figure 5).

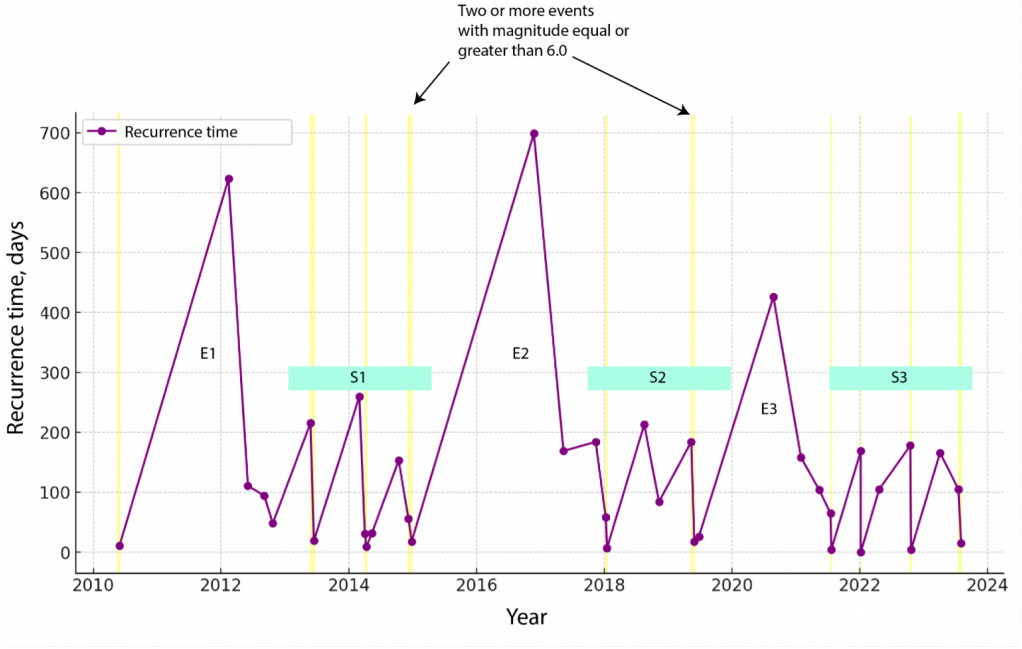
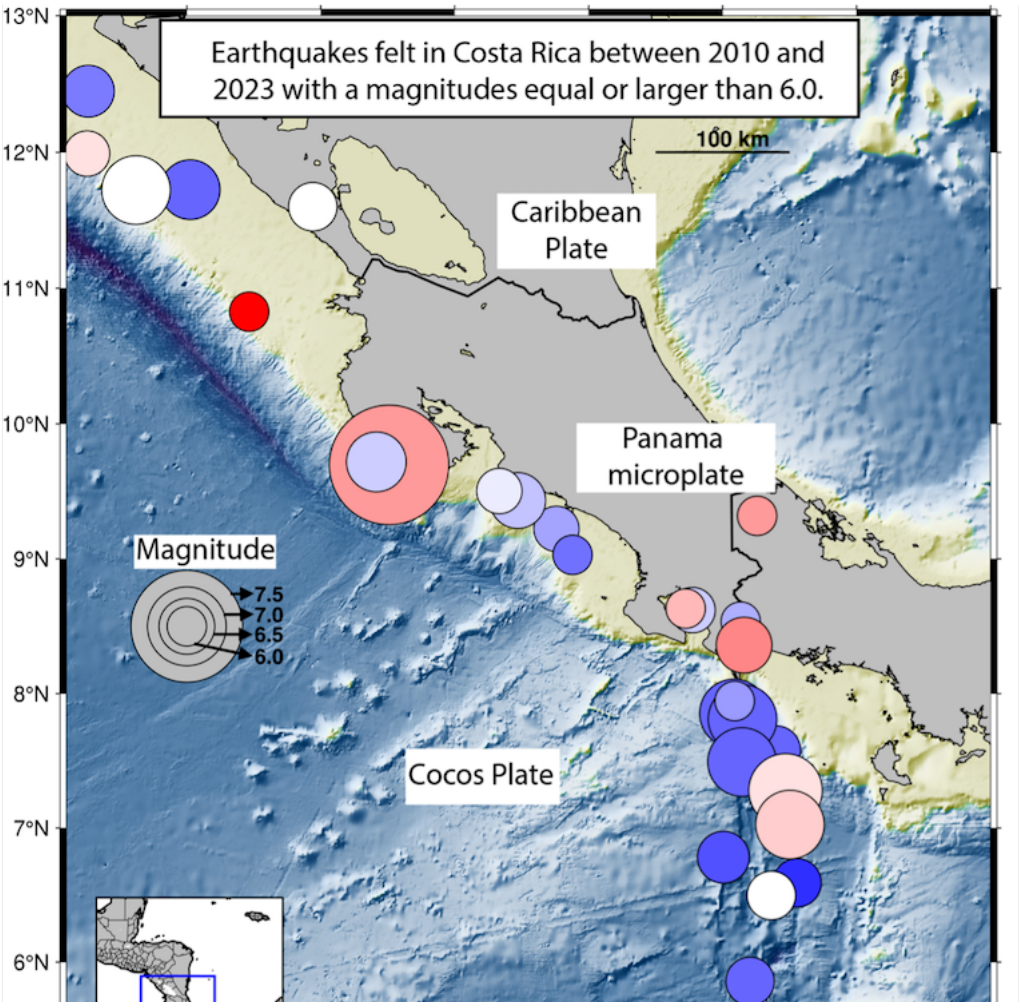


Figure 4. Recurrence time of earthquakes with magnitudes greater than or equal to 6.0 that occurred in Costa Rica between 2010 and 2023. The yellow bars indicate the periods in which two or more moderate to large earthquakes occurred in less than 20 days. Credit: Chaves, 2024, CC BY-NC-ND 4.0

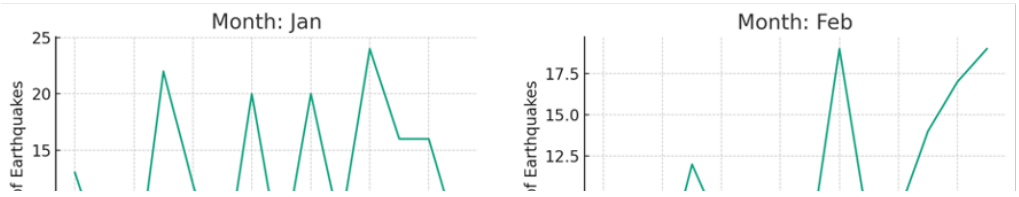
generated a sequence of cascading aftershocks. Locals reported to OVSICORI that they felt the main event and a great number of these aftershocks.



infrastructure, implementing effective building codes and improving emergency response strategies. Additionally, understanding recurrence times aids in deciphering the tectonic processes driving earthquake generation, including stress accumulation and release along fault zones. Ultimately, such knowledge is invaluable for reducing potential human and economic losses, as it informs public policies and risk management practices, enhancing resilience in earthquake-prone areas.

Annual and monthly distribution of felt earthquakes

To explore the question of seasonal variation of earthquakes in Costa Rica, I analyzed the monthly count of events for the 14 years of data collected. If earthquakes vary by season, a consistent and repeatable pattern as a function of time should appear. Indeed, except for the month of January, across all years of data collection, the monthly count of felt earthquakes shows a random (or "stochastic") distribution, suggesting no direct relationship between the number of felt earthquakes and whether Costa Rica was in the dry or rainy season (Figure 6).



annual series) show relatively low correlation values or negative correlation.

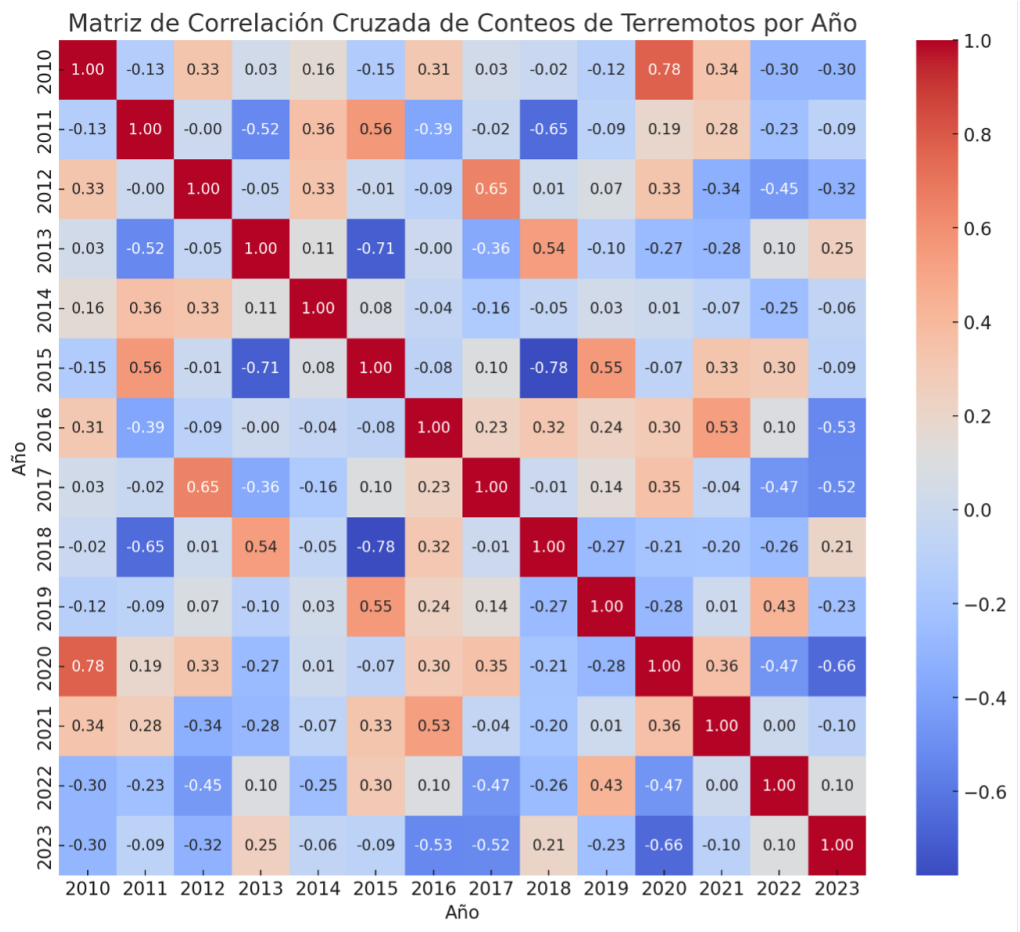


Figure 7. Cross-correlation matrix for the annual time series of felt earthquakes in Costa Rica between 2010 and 2023. There is no correlation between the monthly distribution of

using the following link: http://www.ovsicori.una.ac.cr/index.php/sismos-sentidos.

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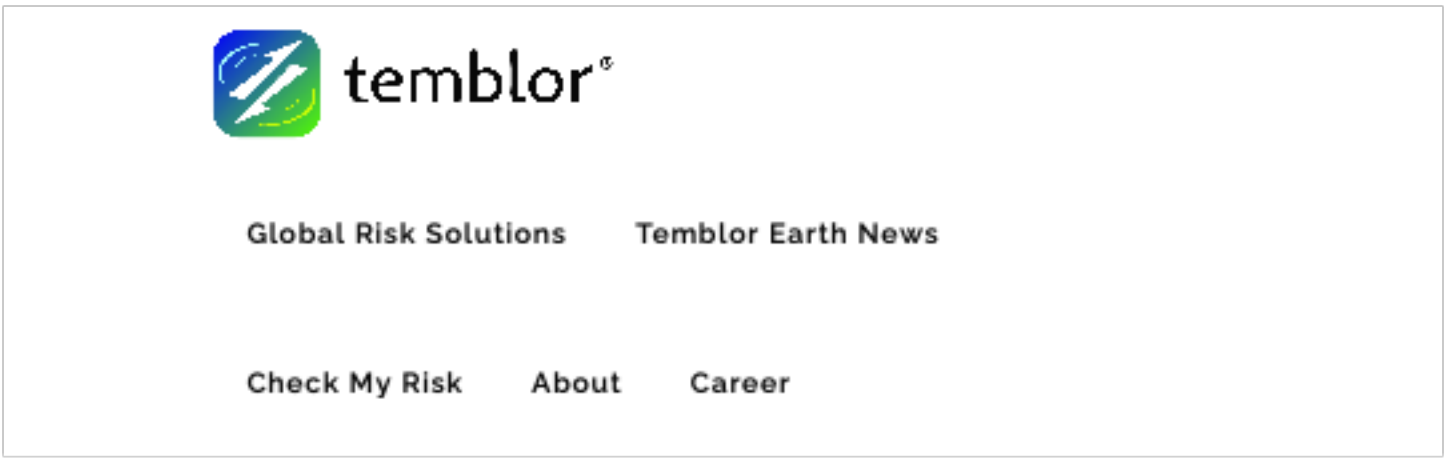

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