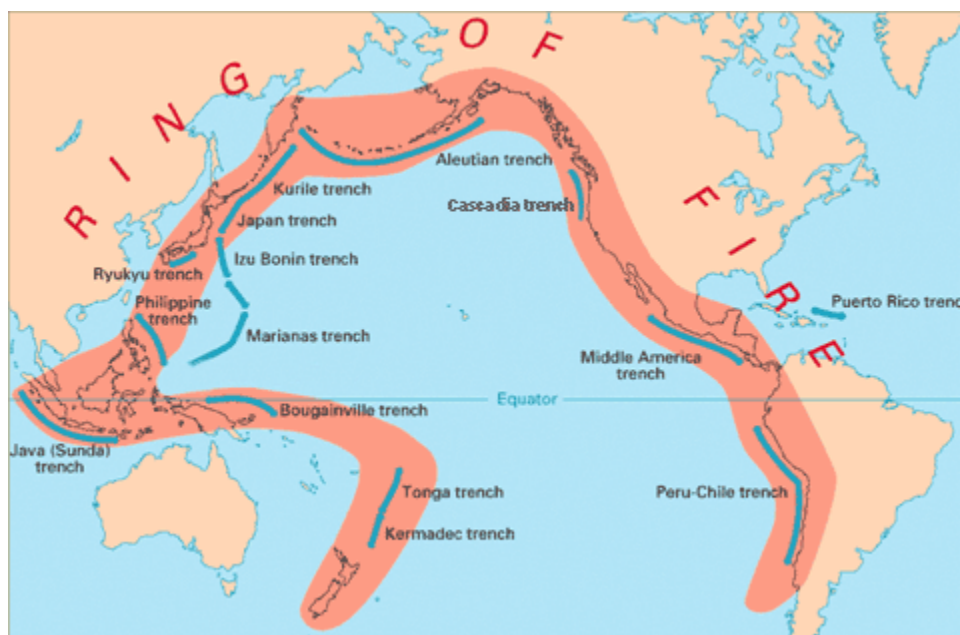


Global Clustering of Giant Earthquakes: A Revolution in Earthquake Risk Management?

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Megathrust Fault Systems Around the "Ring of Fire" (USGS)

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Extreme events govern tail risk. The forefront of earthquake science now shows that “giant” earthquakes, once assumed to strike randomly with time, actually occur in clusters. This key understanding, that probabilities of the world’s largest earthquakes are cyclical rather than uniform over time, will have far-reaching implications for the insurance industry’s management of earthquake risk. In particular, strategies and decisions for underwriting and pricing that are driven by tail risk need to be reconsidered.

EQECAT’s recent white paper, “Spatial and Temporal Earthquake Clustering: Part 1: Global Earthquake Clustering” makes a compelling case that we are currently experiencing a global cluster of earthquakes exceeding magnitude (M) 8.5. Four earthquakes exceeding M8.5 have occurred since 2004 (Indonesia M9.1, 2004 and M8.6, 2005; Chile M8.8, 2010; Japan M9.0, 2011). The previous cluster, from 1950 to 1965, witnessed six events between M8.6 and M9.5. Between the two clusters, no earthquake exceeding M8.5 occurred anywhere on the globe. The random chance of such clustering is less than 1%.

As stated by Thenhaus et. al. in the paper, “If the current cycle follows the one that occurred in the 1950 - 1965 timeframe, we may be only about half way through the cycle, and the largest earthquake in the current cluster may not have yet occurred.” **Logical next questions: What other locations across the globe are most susceptible to that future giant earthquake? And, what consequences might be reasonable to expect?**

Giant earthquakes have historically occurred on megathrust fault systems, where subducting tectonic plates converge with overriding plates. Megathrust zones encircle the Pacific Ocean and underlie the Himalaya. Populations exposed to giant quakes include Japan, Indonesia, northern India, the Philippines, the west coast of Central and South America, and the Pacific Northwest of North America. A global cluster of giant earthquakes is unlikely to affect probabilities on non-megathrust faults, such as those in California, Turkey, and Taiwan, because the rupture areas are too small to generate a quake larger than M8.5.

The Factor of Surprise

To establish rational expectations for giant earthquakes, risk owners must account for consequences typically excluded from catastrophe models. For example, in the 2011 Tohoku-oki earthquake, sea walls in coastal Japan built for an estimated 10-meter maximum tsunami suffered a surprise inundation nearly four times as high. The most significant losses from a modeled M9 Cascadia scenario, as another example (see sidebar), will include disrupted utility and transportation networks, causing delayed recovery; widespread destruction of coastal communities caused by unprecedented tsunami heights; extensive ground failures including landslides and liquefaction; hazardous materials contamination; as well as severe shaking amplification in tall buildings and long-span bridges due to long duration of shaking. Loss consequences of these effects are only “surprises” insofar as catastrophe models characterize them only minimally, if at all (which is reasonable, given that such perils emerge only in the most extreme events). However, they should no longer be true surprises since they reflect the same non-modeled damage seen after Tohoku.

The current cluster calls for innovative and explicit assessment of these extraordinary perils—the *known* unknowns—associated with giant earthquakes. The next hurdle of innovation facing insurers is to quantify that peril contributing perhaps the biggest surprise losses in giant quakes: tsunami.

Tsunami models, a largely-unexplored frontier of catastrophe modeling, are well-suited to collaboration between modelers and stakeholders.

Quantifying the Unknown

How to quantify, then, the effect of “surprises” from giant earthquakes? As scientists and engineers, we are the first to admit a model’s limitations: we can only calculate what we can measure. That’s why it’s so critical to conduct a full accounting of uncertainty. EQECAT’s unique approach reflects our science-driven perspective: we focus scientific rigor on the most variable parameters of the model, and we retain uncertainty explicitly through each step of the modeling calculation. In contrast, a more simplified treatment of uncertainty, using mean values in intermediate steps, and applying synthetic uncertainty at the end, underestimates loss, sometimes severely, especially when **assessing the “tail” losses most affected by giant quakes.**

Business Implications

The reality of earthquake clustering could dramatically alter how re/insurers allocate capital to support earthquake exposure. The multi-decadal time span of clusters makes it possible to optimize capital accordingly. Presuming that capital adequacy reserves are maintained to a specific recurrence probability, the chosen strategy would depend on our current position within the cluster. An instructive gauge of this position may be global seismic moment, a measure of energy release: the cumulative seismic moment released since 2004 now stands at one third that of the previous 15-year cluster.

- At the beginning of a cluster of giant earthquakes, re/insurers may decide to maintain significantly more capital than that implied by long-term average earthquake rates, particularly if averages are **dominated by the “quiet period” from 1965 to 2004.**
- Over the course of a cluster, capital requirements could be reduced from their peak early in the cluster.
- At the end of a cluster, and between clusters, re/insurers could return to a baseline level of capital.

Ultimately, if we accept the evidence of a current global cluster, and our likely position mid-way through, then another giant earthquake in the foreseeable future can no longer be dismissed as an **“unknown unknown.” As industry leaders put into practice new** insights on clustering, so, too, will leading-edge models. Not only will we incorporate global clustering of giant quakes, but also the phenomena of regional clustering—aftershocks and stress-triggering—subjects of the next two papers in **EQECAT’s series.**

Cascadia Scenario

The Cascadia subduction zone, off the west coast of North America, converges half as fast as tectonic plates in Chile or Japan, but it does have a history of generating M9 earthquakes. The time interval between large Cascadia events has varied between 200 and 1,000 years. The most recent M9 earthquake, dating from 1700, was deduced from tsunami records in Japan and carbon-dating of trees that drowned from inundation.

A M9 earthquake on the Cascadia subduction zone would affect the cities of Vancouver, BC, Seattle, WA, and Portland, OR, and a population exceeding 10 million. Insured losses could approach \$100 billion, with about 20% of losses occurring in each of the cities of Seattle and Vancouver. Total economic damage could exceed \$400 billion, the same magnitude of losses from a hypothetical M8 on the southern San Andreas Fault in California.