Exploring a new take on quakes

Scripps seismologist learns state regions' aftershocks dissimilar

Gary Robbins, San Diego Union-Tribune, 10-11-10

It's lunchtime, and old friends are gathered at a restaurant, chatting away. Suddenly, their table starts shaking. Glasses clink. Silverware shifts. Everything has been set in motion by an earthquake that most of the diners ignore.

Eventually, one friends asks another: "How big is it?" The blithe reply: "4.0."

Actor Steve Martin delivers the verdict in the 1991 movie "L.A. Story," a social satire that suggests that Californians are so savvy about earthquakes that they overlook anything but a catastrophic event.

It's an insightful moment; many of us have stood around guessing the size of a quake rather than taking cover. Such behavior is odd, because seismologists like Debi Kilb will tell you that scientists only have a rudimentary understanding of quakes.

Kilb works at the Scripps Institution of Oceanography, where she studies the basic nature of earthquakes, particularly aftershocks. She also studies how a quake can trigger another shaker at a distant location. Kilb told us what scientists have been learning during a recent series of interviews.

Question: You've been studying the aftershocks of moderate-sized quakes in Southern California. Any surprises in the data?

Answer: Yes, which is exciting because so often an unexpected finding or observation can be a clue to help answer unanswered scientific questions. In my postdoctoral work at Princeton, I studied aftershock sequences in Northern California along the Hayward, San Andreas and Calaveras faults. I expected the signature of aftershocks in Southern California to be similar, but that's not the case. We are seeing more evidence that seismicity patterns in the south are much more complicated than patterns in the north.

We're also finding deeper earthquakes in the south. They run from the surface to a depth of about 12 miles. Quakes in Northern California typically extend to only about six miles in depth.

The "footprint" of aftershock sequences also is different in Southern California. Generally speaking, aftershocks here tend to occur within a volume, whereas in Northern California the aftershocks tend to be more constrained to a single fault plane. So, it's a 3-D distribution versus a 2-D distribution.

And there's a notable difference in the size of aftershocks. Typically for magnitude 5.0 mainshocks in Northern California, the largest aftershocks will be about magnitude 4.0. In Southern California, the largest aftershocks to 5.0 mainshocks measure about 3.0.

Question: Do scientists know why the characteristics of aftershocks are so different in the northern and southern parts of the state?

Answer: The short answer is no. But to my mind, there is one clear difference that might be primarily responsible: In the south, there are multiple faults of various sizes that accommodate plate tectonics motion. But in the north, there are usually just a few primary fault strands accommodating the plate motion.

We can basically think of Northern California as having just a few very defined seismic freeways. These well-known freeways (or faults like the San Andreas or Hayward) are the destination for almost all earthquakes. In Southern California, however, there are many seismic freeways, big ones and small ones all going in different directions. Put another way, the fault structure of the Southern California region is very complicated in comparison with Northern California, and this, I hypothesize, is one of the reasons that the aftershock sequence characteristics differ in the two regions.

Question: Does the complexity of fault systems in Southern California indicate that we're at more risk of large earthquakes?

Answer: It might appear that way because one might think the more faults the more earthquakes. But San Diego is in the unique position to be located relatively far from the major active faults. The San Jacinto fault is about 50 miles east of us, and the San Andreas fault is even farther away at 100 miles. If you look at seismic hazard maps colored as "red" for extreme shaking likely and "green" for extreme shaking unlikely, San Diego consistently sits in the "green."

Question: Why is it so important to measure small earthquakes when it is the big earthquakes that are destructive?

Answer: Well, first if we restrict ourselves to say magnitude 5 and above earthquakes in Southern California, we would only have a handful of data because they occur here, on average, maybe every five years or so. But more importantly, the small quakes are telling us how small-scale stress/strain changes in the crust of the Earth are being accommodated.

The spatial distribution of aftershocks is particularly useful for helping us understand how the mainshock earthquake changes the local stress field. For example, in both the Landers 1992 and Easter 2010 earthquakes, most of the aftershocks are located north of the mainshock, not south. This asymmetry in the aftershock distributions was clear even within the first 24 hours of each sequence. From these simple observations, we can infer that the rupture likely started in the south and rocketed up the mainshock fault plane to the north.

Question: San Diego State University recently helped organize a large earthquake drill for emergency responders and relief agencies that had this scenario: A 9.2 quake hits off the Aleutian Islands and triggers a series of large earthquakes on Southern California faults later that day. Is that plausible?

Answer: I suppose it is possible, but it is extremely unlikely. We have good examples of 9-plus earthquakes in Alaska (1964), Chile (1960), Indonesia (2004) and Kamchatka (1952), none of which triggered a series of large earthquakes over 3,000 miles away, or for that matter any significant distance from the original earthquake rupture. The earthquake drill scenario is much better suited for a Hollywood movie.

The thread that does hold true is that large earthquakes can trigger smaller earthquakes at greater distances than we thought just a few decades ago — but by small I'm talking magnitude 1s and 2s, quakes that are so small that they are rarely felt by people. For example, we have evidence that the 2002 magnitude 7.9 Denali quake triggered small quakes, in the magnitude 1.0 to 2.0 range, here in Southern California.