# Trying to make sense out of chaos

By JASON BROWN
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On March 11, I anxiously opened an email sent to me by Richard, a former PhD student of mine.

Richard had given a research talk at the Tokyo University of Science that day, and at 2:45 in the afternoon he could feel the whole building sway back and forth. The email said he and his wife Karen were safe but unable to travel because of the destruction that ensued, and they expressed how lucky they felt to be alive and how sad they were for others farther north who lost everything.

While Japan experiences earthquakes regularly, we are not immune to them in Atlantic Canada. Since the 1950s, there have been more than 20 earthquakes within 50 kilometres of Nova Scotia, and in 1929, a 7.2-magnitude quake caused a tsunami that killed 28 people in Newfoundland.

I know that predicting such disasters is fraught with difficulties. You would think that mathematics would be able to forecast earthquakes, but the sad truth is it can't.

It's not for lack of trying. There has been some luck in making broad predictions, saying that with a high probability a certain area of a country is likely to have a big quake, but often the window for the event is many months or even years, and no planning or preparation can be based on such a weak prediction.

There are also researchers out there looking for patterns among the main shocks and aftershocks, both in terms of their intensity and timing. But people are always looking for patterns to explain the unknown, and sometimes they see patterns even when none exist.

The relationship between earthquakes and their aftershocks is actually quite interesting in that not only do major earthquakes have aftershocks but the aftershocks each have their own smaller aftershocks and so on.

This kind of organization of an event or object into parts that are each very much like the original, only smaller, is a type of mathematical structure called a fractal. Fractals are all around us in nature, from trees to clouds to seashores. The fractal structure of our brains, lungs and circulatory systems allows for a huge amount of surface area within a small space. Fractals are both simple and complex, and we couldn't live without them.

But what often accompanies fractals is something called chaos. Chaos in mathematics has a very particular meaning — it is an outcome based on a long sequence of small and seemingly insignificant events that are completely determined but can seem to be utterly random. It is not that the mathematics is weak, it is that the mathematics says a long-term forecast is like a shot in the dark. Or as the famous physicist Niels Bohr said, "Prediction is very difficult, especially if it's about the future."

Earthquakes may be truly chaotic. They are the result of many, many small stresses in the Earth's crust as the tectonic plates brush up against one another. One of the key features of chaos is that it is often extremely sensitive to measurements. A tiny change in a number can make the difference between nothing happening and all hell breaking loose.

None of this is solace for those in Japan trying to get their lives back together, but it is worthwhile to invest in earthquake research. Some new work suggests there may indeed be patterns of precursors that might be used to predict the main quakes. Though, as often happens with chaos, a big effort achieves only very tiny gains.

But I think we can all agree that in this case, even a small peek into the future is worth the effort.

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