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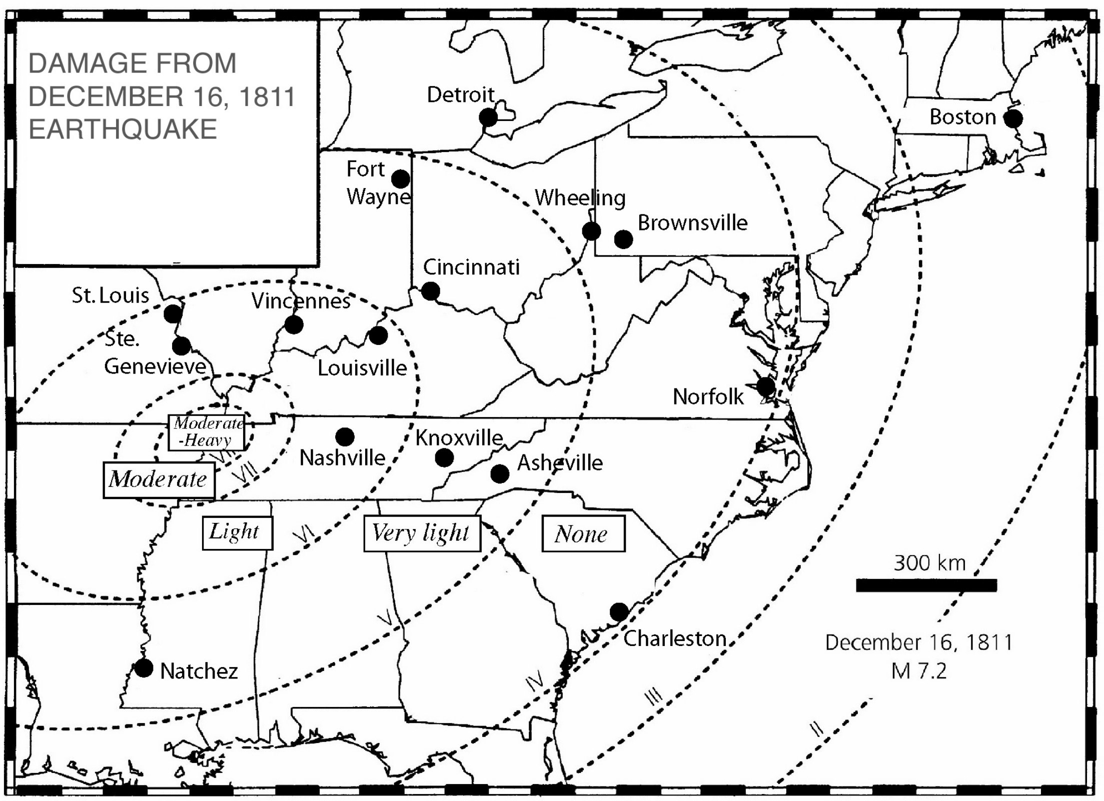
Background for Calais & Stein paper

The GPS data reported here are important for understanding earthquakes in the central U.S. Large (magnitude 7) earthquakes on the New Madrid Fault system shook the Midwest 200 years ago, in 1811 and 1812, and small earthquakes – that may be aftershocks of the big ones – still continue today. There are major questions about how large the earthquake hazard is in the region, which includes parts of Illinois, Indiana, Tennessee, Arkansas and Kentucky.

Thus scientists are trying to find whether big earthquakes are likely to happen there again in the next few hundred years.



Map showing damaged areas for the December 16, 1811 (magnitude 7.2) earthquake, the first of the three major New Madrid shocks in 1811 and 1812. Boxes label different damage zones. Some of the sites from which we have reports are shown. (Hough et al., 2000)

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For almost 200 years, until GPS data came along, we couldn’t say much about whether a large earthquake like those of 1811-1812 will happen on a time scale that concerns us, perhaps in the next hundred years. About all we could say was that there’d been earthquakes in the past, so maybe they would happen again.

Since then, an incredible, almost magical, new technology has changed everything. The magic wand is GPS - the Global Positioning System. GPS sounds too good to be true. Simple GPS receivers the size of a cell phone – or even inside a cell phone – can tell us where we on earth are to an accuracy of a few feet. The fancier ones used in geology locate a point on earth to 1/25 of an inch.

A GPS receiver listens to radio signals sent from satellites orbiting 12,600 miles above the earth. The signals say when they left each satellite and where that satellite was in space. The receiver has a clock and a computer inside, so it computes how long the signal took to arrive. Using the fact that radio waves travel at the speed of light, the receiver figures how far away each satellite is, and where the receiver has to be for each satellite to be that distance away. This is a lot like locating earthquakes using signals from one source received at many seismometers, whereas GPS uses many sources of signal received at one place.

The study uses eight years of data recorded at nine GPS antennas mounted in the ground in the earthquake zone. Looking at how the sites move over time shows how the ground is – or isn’t - moving.

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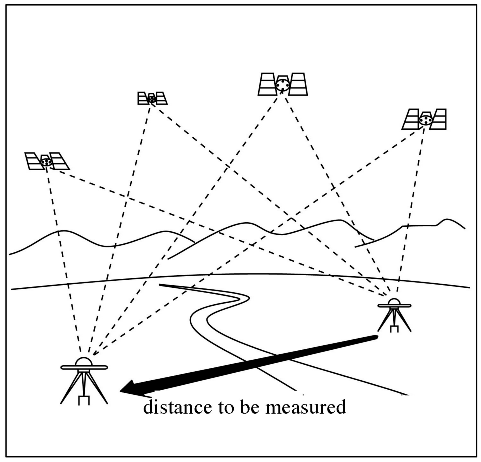

Using precise positions based on signals from GPS satellites, measurements over time show how sites are – or aren't - moving relative to each other.

GPS measurements started in the area about 1990 and started a high-profile argument among geologists. Some studies found that the ground was moving, storing up energy for a future big earthquake. Other studies found that it wasn't. Now the data are good enough to show that nothing's moving.

To the accuracy of the new study's measurements, the motion is zero. The most likely value is zero, and there is a 95% chance that the motion was less than 0.2 millimeters – 100th of an inch – per year.

This result shows that our traditional thinking about what is going on needed changing. Geologic studies had found evidence that New Madrid earthquakes comparable to those of 1811-1812 occurred in about 1450 and 900 AD, or about every 500 years. Thus a common idea was that earthquakes like the 1811 and 1812 ones should happen again in a few hundred years.

Thus it was thought that although small earthquakes happen on other faults, New Madrid was the big player in Midwest earthquakes that would keep happening there.

The GPS data show that the ground is storing up deformation much too slowly for this to be true. Unless things change, there's no way to get a big earthquake for ten thousand years.

This tells us that over long times, the fault can't work the way it has been for the past 2,000 years. Something has to change.

It looks like that the big earthquakes move around between lots of faults that turn on and off. That's what geologists are also finding by looking at fault histories. It looks like New Madrid is just the one that's been active most recently. In this idea, the big earthquakes occur in clusters that occur for a while, and then move somewhere else. We call this idea "episodic, clustered, and migrating."

In it, instead of focusing on one major long-lived fault – like the San Andreas – we need to think of how different faults interact. Geologists are just starting to develop computer models of how it would work.

An interesting question is whether the recent cluster of big earthquakes – the 1811-12, 1450, and 900 AD ones, is coming to an end. We can't tell, but the longer the GPS data keep showing no motion, the more likely it seems.

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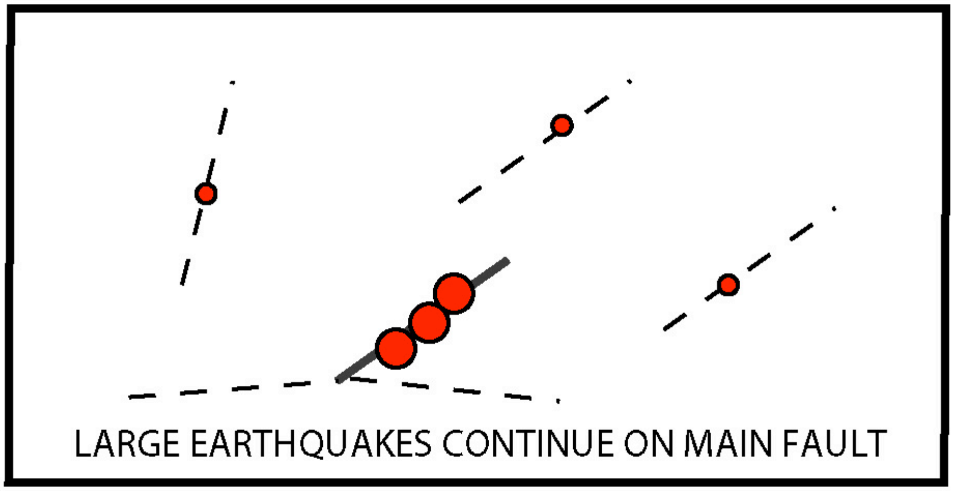
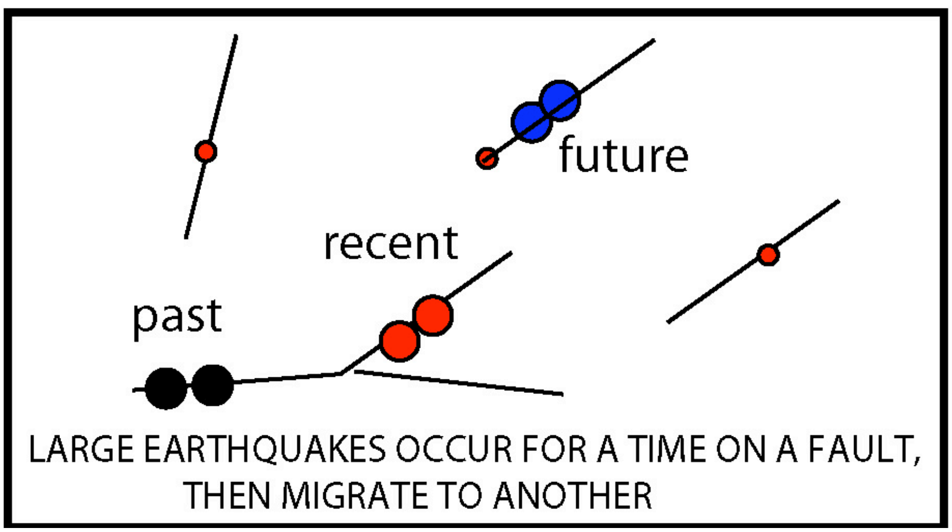


EPISODIC, CLUSTERED, AND MIGRATING



The idea that earthquakes in the mid-continent are episodic, clustered, and migrating implies that we should think differently about earthquake hazards. Conventional thinking has been that the big danger is from earthquakes on the main New Madrid fault, although there was also some hazard from smaller earthquakes on other faults. The Federal Emergency Management Agency (FEMA) is pressuring communities in the region, which includes parts of Illinois, Indiana, Tennessee, Arkansas and Kentucky, to adopt building codes as strong – and as expensive – as California's. Communities are grappling with how to react because it’s not clear if such stricter codes make economic sense. However, as the scientific case for this high hazard appears weaker, FEMA is now slowly starting to back down.

We have a long way to go to fully understand Midwest earthquakes, but the new GPS data are a major step in the right direction.