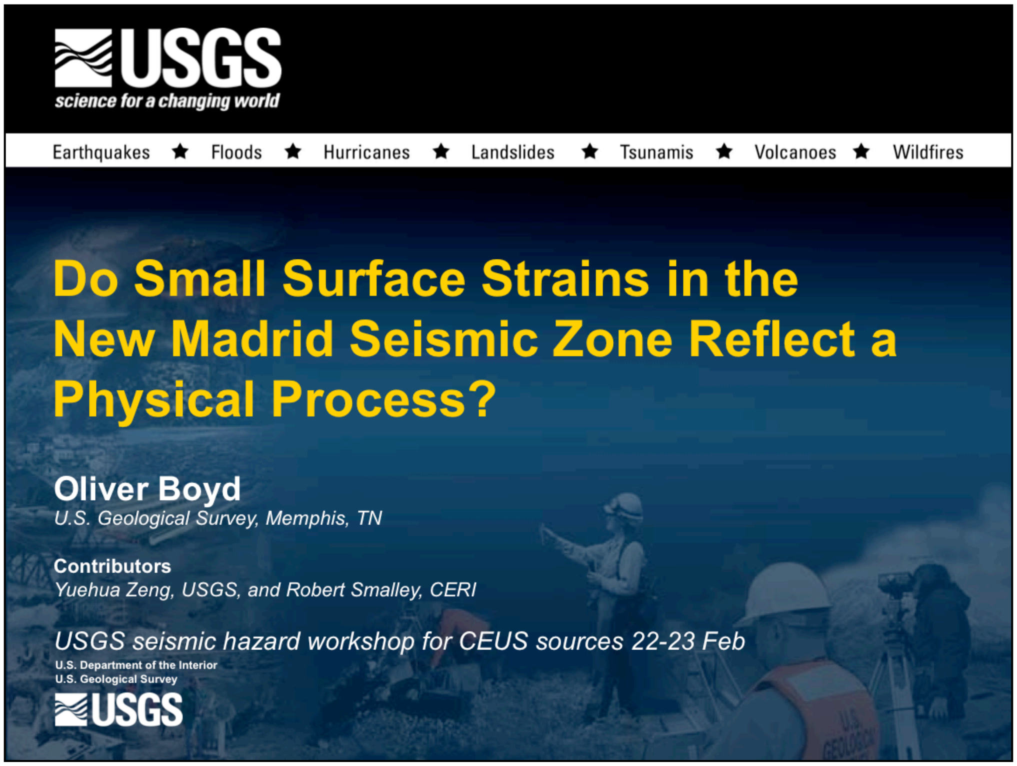
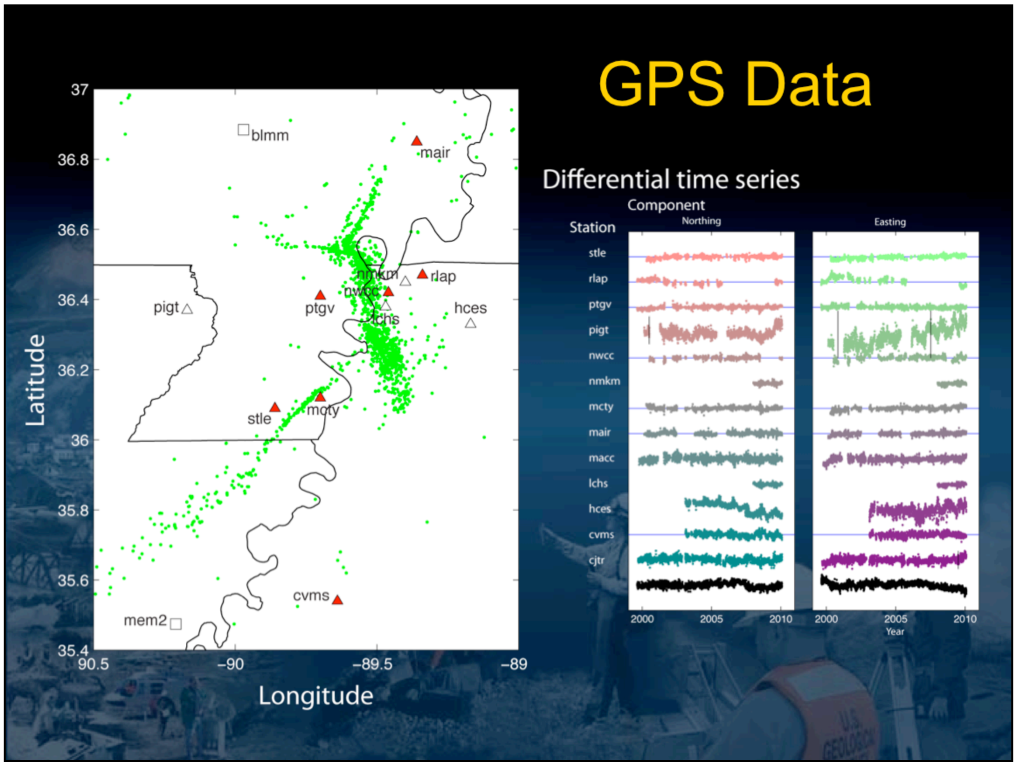
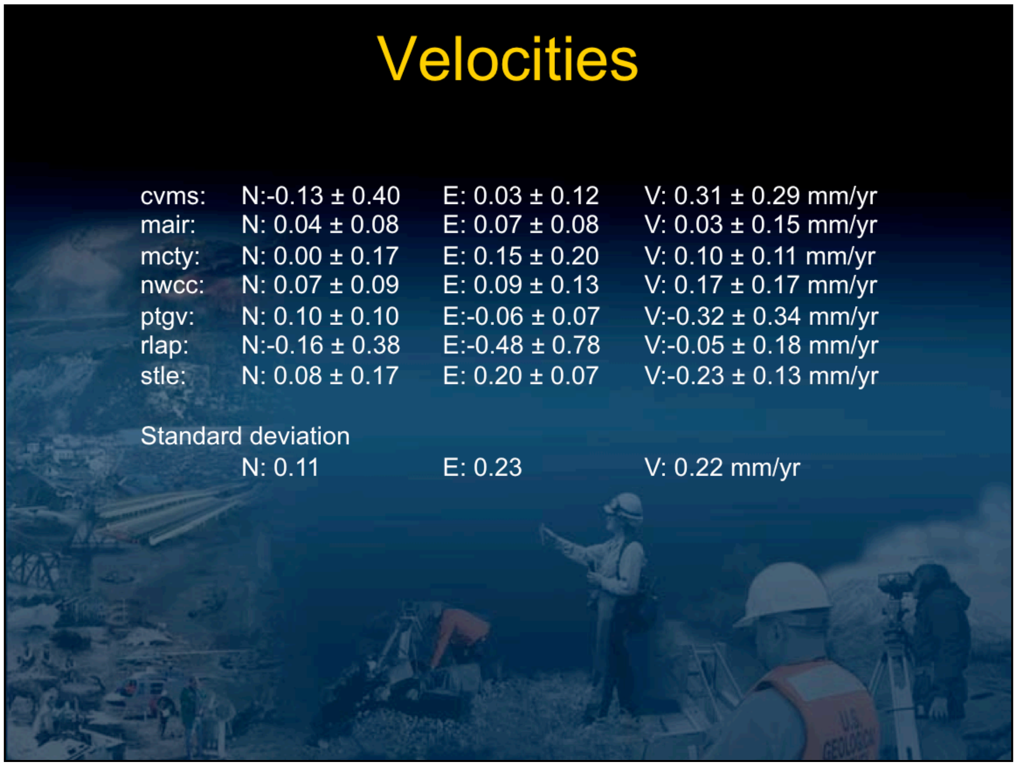


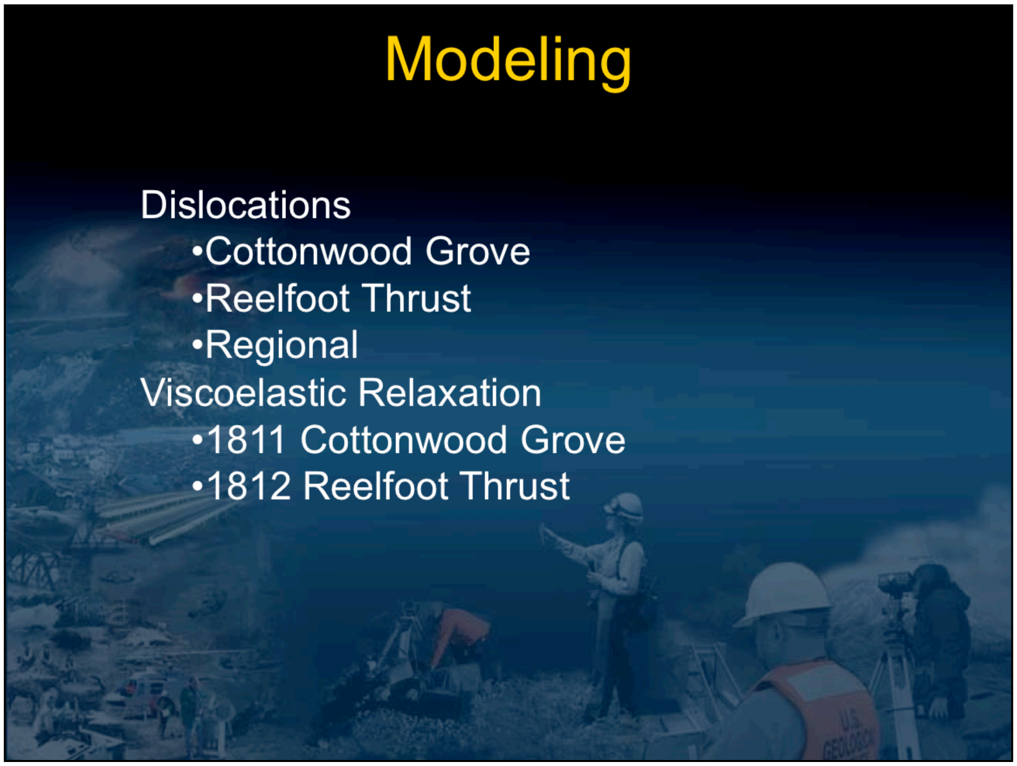
After more than a decade of geodetic data in the New Madrid seismic zone, researchers have found very low rates of surface deformation. Some have argued that stress is not being built up on the New Madrid fault system. I have worked with several researchers including Yuehua Zeng and Bob Smalley and conclude that there is signal and that it can be modeled.



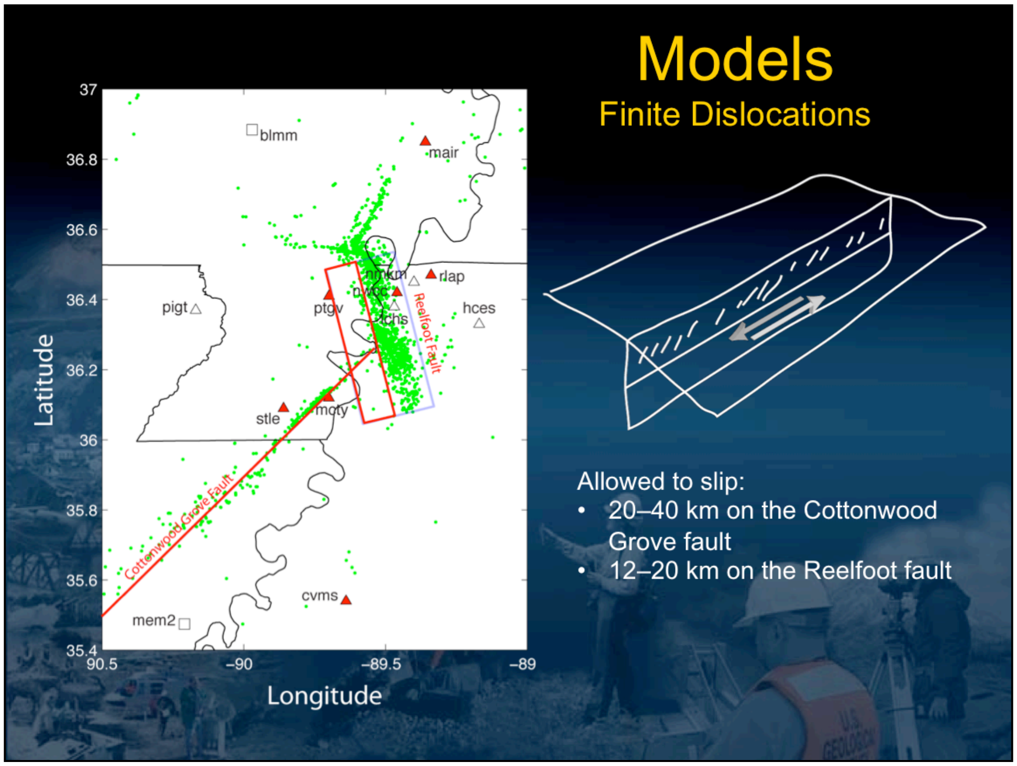
The triangles and squares are the available GPS sites in the region. Triangles are stations in the GAMA network and squares are part of the CORS network. Monumentation for the GAMA network was designed for tectonic studies, while monumentation for CORS was not, so I consider only the GAMA stations. I also don't consider the GAMA stations NMKM and LCHS because they are short time series nor do I consider PIGT and HCES, which are particularly noisy stations. The data I model are velocities derived from differential time series.



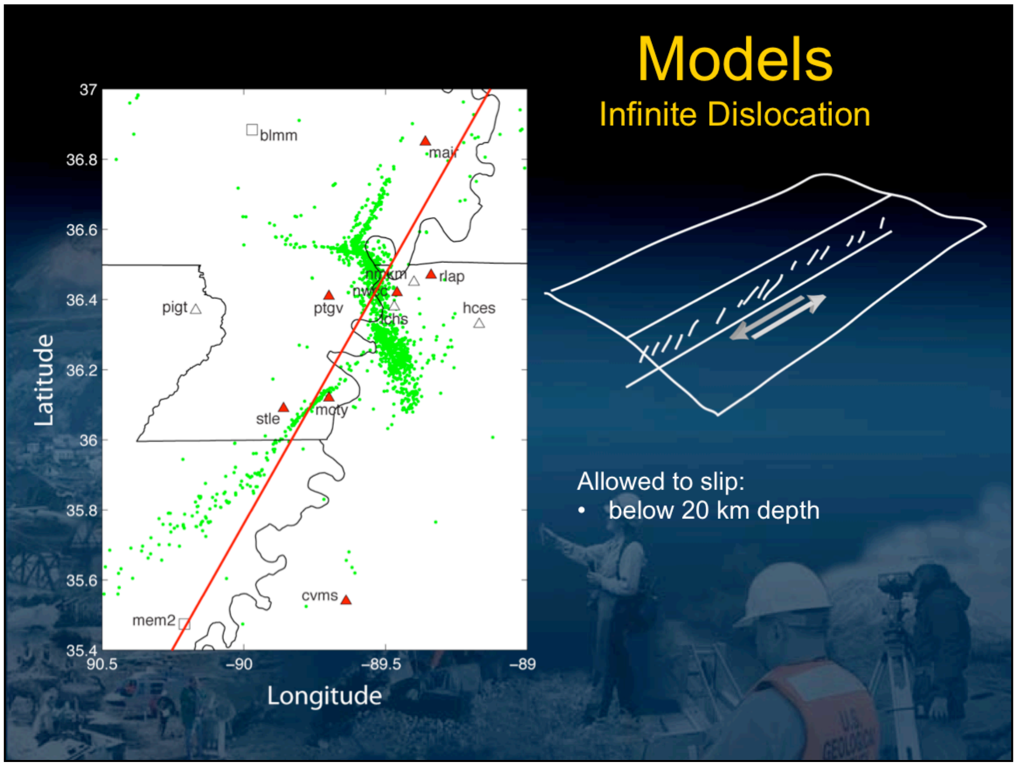
The velocities are generally small, on the order of 0.1 to 0.2 mm/yr with uncertainties, derived from white, flicker, and random walk noise models, of the same order.



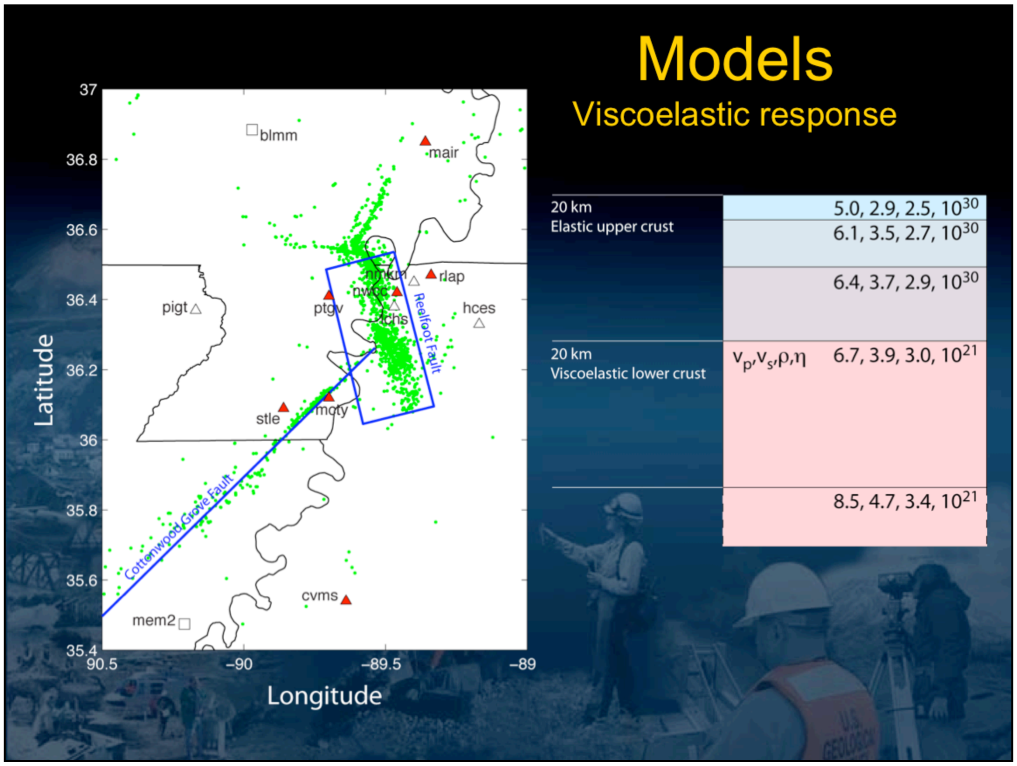
We model the velocity vectors with several dislocation models and a viscoelastic response model.



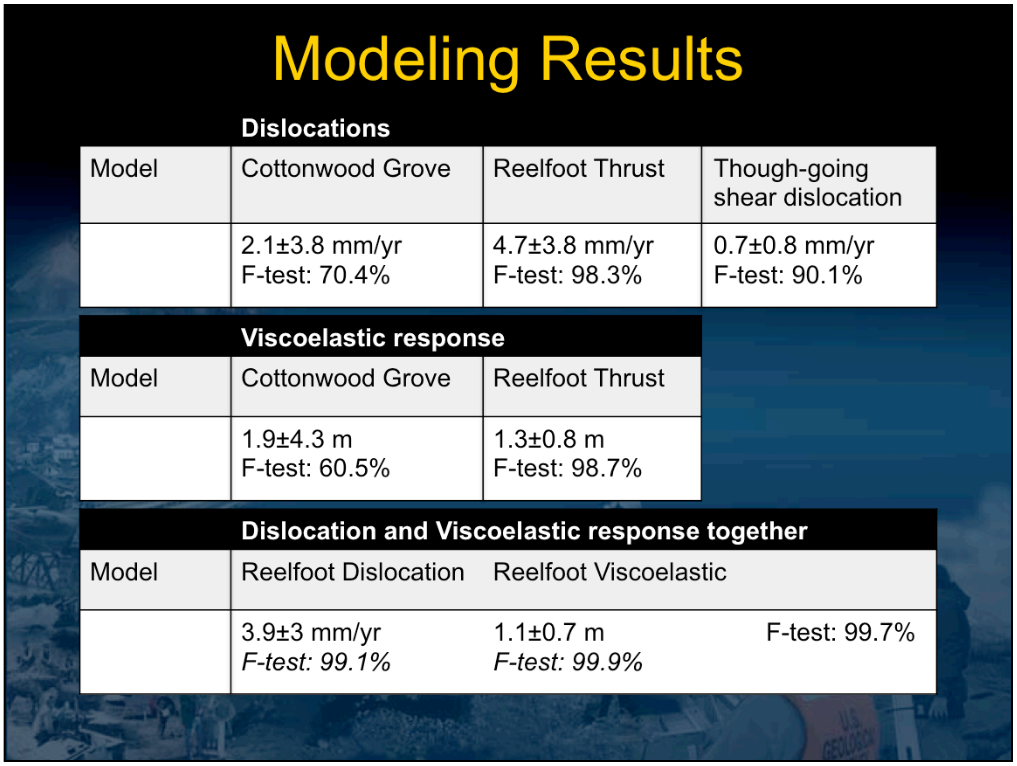
The first set of models I test is a set of finite dislocations. The first is strike-slip creep between 20 and 40 km depth beneath the Cottonwood Grove fault. The second is based on Art Frankel's work, dip-slip creep between 12 and 20 km depth beneath the Reelfoot thrust.



I also model is an essentially infinite strike-slip dislocation below 20 km depth, which is based on the work of Tom Pratt.



For the viscoelastic model, I assume that slip during the 1811–1812 earthquakes occurred on a fault patch between 5 and 20 km depth. I assume an essentially elastic upper crust and viscoelastic lower crust and upper mantle with a viscosity of 10^{21} Pa s.



Modeling Results

Dislocations

Model	Cottonwood Grove	Reelfoot Thrust	Though-going shear dislocation
	2.1±3.8 mm/yr F-test: 70.4%	4.7±3.8 mm/yr F-test: 98.3%	0.7±0.8 mm/yr F-test: 90.1%

Viscoelastic response

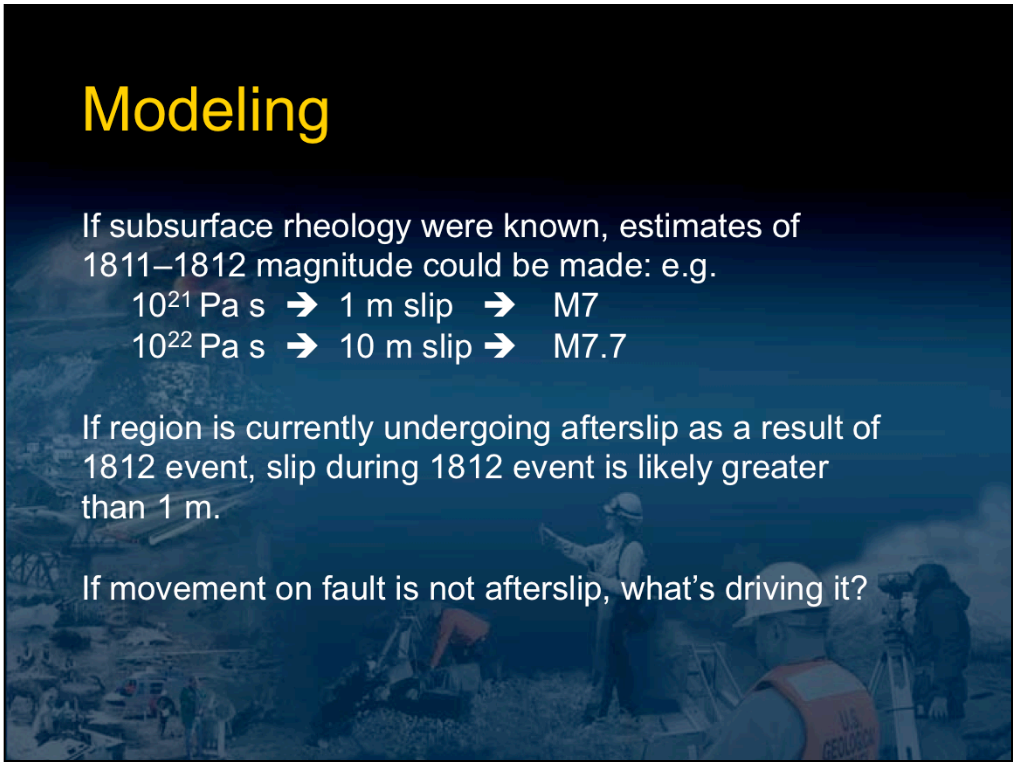
Model	Cottonwood Grove	Reelfoot Thrust
	1.9±4.3 m F-test: 60.5%	1.3±0.8 m F-test: 98.7%

Dislocation and Viscoelastic response together

Model	Reelfoot Dislocation	Reelfoot Viscoelastic	
	3.9±3 mm/yr *F-test: 99.1%*	1.1±0.7 m *F-test: 99.9%*	F-test: 99.7%

I find that modeling the Cottonwood Grove fault alone yields a right-lateral slip rate of about 2±4 mm/yr. An F-test suggests that this model has a 70% chance of being more significant than a null hypothesis, which is not very good. I think part of the reason the fit is so poor is because there is not enough data along the Cottonwood Grove fault to constrain the modeling. Art's model, thrust slip on a relatively shallow finite dislocation creeping at nearly 5 mm/yr beneath the Reelfoot thrust does quite well. A through-going shear dislocation at just less than 1 mm/yr of right-lateral deformation also does a fair job.

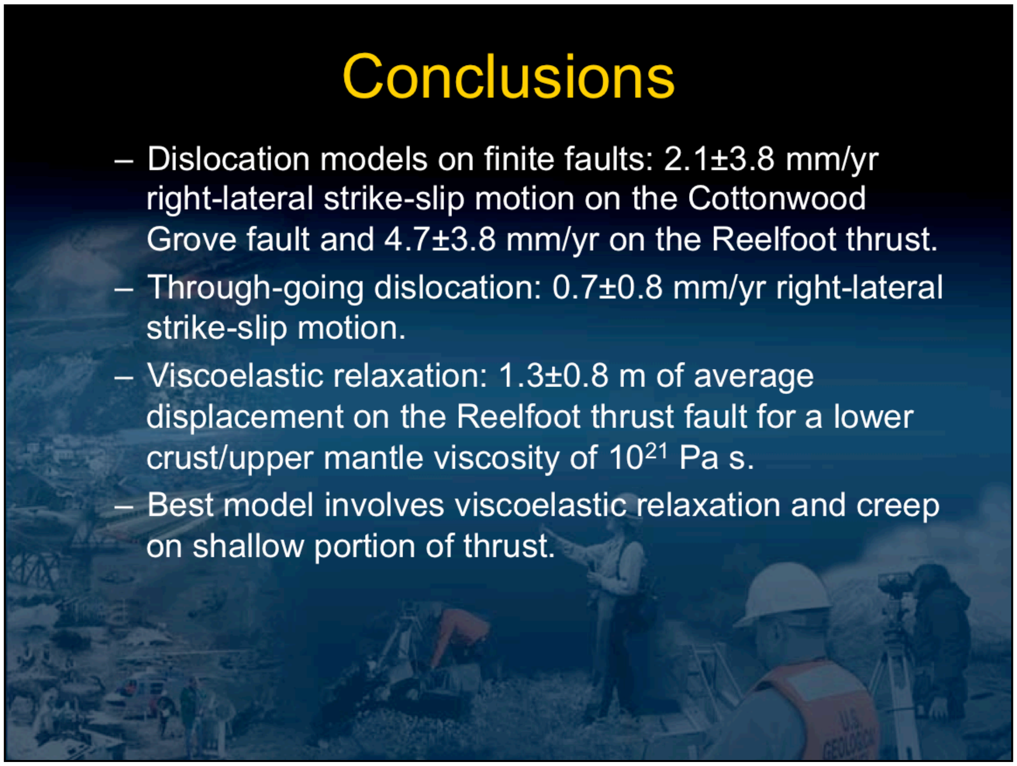
Like a finite dislocation, viscoelastic relaxation on the Cottonwood Grove fault is also not able to model the data well. On the other hand, viscoelastic relaxation on the Reelfoot thrust does very well with an F-test suggesting this model has a 99% chance of being better than a null hypothesis. This model has 1.3 m of slip during the 1812 event. If creep on the Reelfoot Thrust is modeled together with viscoelastic relaxation from the 1812 event, an F-test suggests that this combination is 99.9% better than a null hypothesis. There is a high probability that adding one model to the other is significant. When modeled together, I find that the shallow portion of the Reelfoot fault is slipping at 4 mm/yr and that there was 1 m of thrust offset during the 1812 event.



For the viscoelastic model, the resulting displacement on the Reelfoot fault yields a magnitude of about 7. If I choose a viscosity of 10^{22} Pa s, the inverted model fits the data just as well but results in 10 times the slip, a magnitude around 7.7. Assuming then that some of the surface deformation is a result of viscoelastic relaxation, knowing the rheology would give us another independent way to estimate the magnitude of the 1812 event.

If the shallow slip on the Reelfoot fault is afterslip from the 1812 event, it would have been higher in the past and likely suggests that the slip in 1812 was greater than 1 m.

If it's steady-state creep, what's driving it?



In conclusion…