Earthquake complexity, Simulators, and SEAS

Bruce E. Shaw

Lamont Doherty Earth Observatory, Columbia University

Sequences of Earthquakes and Aseismic Slip (SEAS)
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Earthquake Complexity

- Earthquakes are complex
- Why are they complex?
- How do we quantify the complexity?
- SEAS: How do we do code comparisons in this context?
Origin of Complexity

▶ Dynamic (Frictional weakening → Complexity)
▶ Material Heterogeneity
▶ Geometrical Heterogeneity
Material heterogeneities

Multiplicative strength heterogeneities

- Pinning of behaviors in space
- Invariance to additive strength heterogeneities
Geometrical heterogeneities

Venus

Clay

Model
Earthquake Simulators

- Aim to reproduce complexity
- Approximations → reproduce statistically
- Gauntlet of measures
- Tool for examining robustness and sensitivity
- Operates at scales relevant to hazard
Hazard comparison simulator and UCERF

Triangulation replication

UCERF2/UCERF3  Model/UCERF3
Other spectral periods and timescale

Agreement over broad range of engineering interest

Mean absolute ln ratio useful measure of spatial correlation

Hazard smears things out a lot, especially combined with GMPEs
Ground Motion
Comparing Simulator with GMPEs

- Simulator matching GMPEs over range where good data
- Running gauntlet of ground motion measures
- Can do fully deterministic non-ergodic seismic hazard
Chaos

- Exponential divergence of nearby solutions
- Large fluctuations
- Large exponents $\rightarrow$ can’t predict past next big one
- Need statistical description
Phase Diagrams
Comparing behavior bifurcation across models

Weakening Rate

Stress Drop Ratio

Shaw Model

Ward Model
SEAS Opportunities
Potential complexity studies

- Statistics on systems that give complex behaviors
- Changes of statistics to parameters $\rightarrow$ phase diagrams
- Changes in complexity as add material heterogeneities
- Robustness and sensitivity of behaviors and measures
- Subsets of UCERF fault systems; sensitivity to add/subtract faults
- Test simulator results in overlapping regimes
- Ensemble models