Disasters at the nature-society interface:
Their management, simulation and prevention

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Progress in the field of earthquake disaster simulation has been slow. In 1966 an uncorrelated Cox process model for earthquake time series was proposed independently by Vere-Jones and Davies, and by Epstein and Lomnitz. Limited numerical predictions, such as probabilities of exceedance of certain magnitudes, may be obtained from such models which continue to be widely used in so-called *Probabilistic Seismic Hazard Assessment* (PSHA). It is easy to show, however, that large earthquakes are not independent events. A Hurst exponent H=0.72 has been determined for large Mexican earthquakes, whereas the expected value is H=0.5 for a Poisson process (Lomnitz, 1994). Positive clustering is a result of complexity.

It is time to recognize that earthquake disasters occur at the interface between two complex systems—nature and society. But what shall we do next? Available books on the nonlinear dynamics of disasters are hardly more than intelligent toolboxes (e.g., Bunde et al., 2002). Even so, they can be extremely useful as it is clear that the mathematical structure underlying critical phenomena is similar across a wide range of situations in geophysics, geology, biology, economics and other fields. The problem for seismologists is the lack of a common language with biophysicists, econophysicists or climate experts, who are working actively along the same lines. Earthquakes are like congestive heart failures or stock market crashes, in that they are multifractal processes usefully simulated as critical phenomena in nonlinear, nonequilibrium dynamical systems.

What is the interface between nature and society? This interface has a name: *technology*. The 1985 Mexico earthquake was a technological disaster, and so was the 2001 World Trade Center disaster. We briefly develop an analogy between these two disasters and we conclude that both were caused by emergent phenomena involving an unexpected technological failure.

We define *accidents* as technological failures without a salient unexpected feature. They are linear (e.g., the probability of car accidents is proportional to the mileage), and therefore accidents are manageable and insurable. Disasters must be prevented, not managed because they cannot be profitably insured. The challenge of disaster prevention is understanding both complex systems well enough to identify and foresee emergent nonlinear features. Hence the importance of simulation.

Basic ideas are developed by looking at multifractal earthquake modeling.