AN OVERVIEW OF EARTHQUAKE FORECASTING IN CALIFORNIA

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Earthquakes are a grave natural threat to many megacities, including Tehran and Los Angeles. Principal strategies for reducing earthquake risks in urbanized regions include stringent seismic safety provisions enforced through building codes and disaster preparations informed by realistic scenarios of earthquake cascades. The effectiveness of these strategies depends on the ability to forecast earthquakes and their effects in space and time. Earthquake scientists cannot yet accurately predict the occurrence of large earthquakes in the short term, but they are learning more about the temporal changes in earthquake probabilities, as well as the strong ground motions generated during earthquakes.

This presentation will describe recent advances in earthquake forecasting methodology for California, a region that contains about three-quarters of the U.S. national earthquake risk. A major achievement has been the development of the Uniform California Earthquake Rupture Forecast (UCERF) by the Working Group on California Earthquake Probabilities, which is now in its third release. UCERF3 is a fault-based model comprising a time-independent (Poisson) component (WGCEP, *BSSA*, 2014) and two time-dependent components: a long-term model based on Reid renewal statistics (WGCEP, *BSSA*, 2015) and a short-term model based on Omori-Utsu clustering statistics (WGCEP, in preparation). The time-independent component has been incorporated into the 2014 update of the U.S. Geological Survey's National Seismic Hazard Maps. The short-term component, UCERF3-ETAS, augments the long-term, fault-based forecast with epidemic-type aftershock sequence statistics. This prototype model, which is under active development, conforms with the spatiotemporal consistency requirements for operational earthquake forecasting (OEF) articulated by the International Commission on Earthquake Forecasting (ICEF, 2011). As recommended by the ICEF, the pre-deployment validation gauntlet for UCERF3-ETAS will include short-term prospective testing within the international Collaboratory for the Study of Earthquake Predictability (CSEP).

A second area of major progress has been in the use of physics-based earthquake simulations to improve the predictions of ground motions. Large-scale numerical simulations based on the anelastic wave equation and its nonlinear generalizations are a powerful tool for predicting propagation effects caused by three-dimensional crustal heterogeneities that cannot be easily represented by empirical ground motion prediction equations (GMPEs), such as directivity, basin amplification, and directivity-basin coupling. The CyberShake Project of the Southern California Earthquake Center (SCEC) has demonstrated that more accurate simulations of wave propagation using high-resolution crustal models could reduce the residual variance of the strong-motion predictions by up to a factor of two relative to the GMPEs in current use. Such a reduction could improve the estimation of exceedance probabilities at high hazard levels by an order of magnitude, which would have a broad impact on the prioritization and economic costs of risk-reduction strategies for critical facilities, lifelines, and other large-scale infrastructure. Further improvements in earthquake predictability may come from combining rupture simulators that account for the physics of rupture nucleation and stress transfer with ground-motion simulators that account for wave excitation and propagation.