Western Science

Department of Earth Sciences

Ph.D. Geophysics Public Lecture

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Probabilistic Fault Displacement Hazard Assessment Using Stochastic Source Modeling

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Biological & Geological Sciences Building, Room 1065

Abstract

Fault displacement hazard assessment results are strongly influenced by rupture geometry, data constraints, and modeling methods. Large earthquakes often involve multiple segments or branches and step-overs, resulting in complex geometries. Traditional fault displacement hazard assessment methods usually consider isolated faults, and the possibility of multi-segment fault ruptures is overlooked. Therefore, the resulting hazard can be underestimated. Furthermore, the uncertainties associated with available data can further impact the reliability of fault displacement hazard results. This thesis develops a refined stochastic source modeling method that integrates ground truth and remotely sensed data, and explicitly accounts for fault complexity and data uncertainty. It characterizes the uncertainty of fault rupture in terms of its position, geometry, and slip distribution and adopts statistical scaling relationships and analytical equations for calculating the surface displacement due to a fault rupture. Chapter 2 investigates the impact of offset, Global Positioning System (GPS), and Interferometric Synthetic Aperture Radar (InSAR) data in improving stochastic source modeling of the 2002 Denali earthquake, Alaska, United States. This chapter studies the effectiveness of individual datasets in source model selection, considering their limitations due to uncertainties. Moreover, an adequate number of datasets and their types for reliable source estimation are explored. Based on the surface displacement characterization of the 2002 Denali earthquake, the combined use of all available datasets increases the robustness of the stochastic source modeling method. Chapter 3 extends the stochastic source modeling method to complex, multi-segment fault systems by defining multiple asperity zones for the ruptured system based on the released seismic moment. In addition, it introduces a refined model selection framework that incorporates the uncertainty of available datasets. The proposed methodology is applied to the 2019 Ridgecrest earthquake sequence, California, United States. The results of the retrospective analysis of the 2019 Ridgecrest earthquakes indicate significant enhancement in the performance of the method and the match of the corresponding surface displacements to the observed data by considering different released seismic moments and slip syntheses for individual segments. Chapter 4 characterizes the surface fault displacement hazard due to the Leech River Valley–Devil's Mountain Fault system in southwestern British Columbia, Canada. This potential step-over configuration is represented in the fault displacement hazard model for the first time. The results of the prospective fault displacement hazard assessment of Leech River Valley Fault and Devils' Mountain Fault show the significant contribution of a multi-rupture scenario to the total hazard at selected sites around Victoria. Overall, these studies progress from method development and validation in complex tectonic settings using a retrospective framework to prospective fault displacement hazard assessment.

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