EARTH SCIENCES
RESEARCH JOURNAL

Earth Sci. Res. J. Vol 18 Special Issue (July, 2014)

UNIVERSIDAD NACIONAL DE COLOMBIA
SEDE BOGOTÁ
FACULTAD DE CIENCIAS
DEPARTAMENTO DE GEOCIENCIAS
RESEARCH GROUP IN GEOPHYSICS

A Stochastic Rupture Probability Model for Earthquakes on Subduction Zones: A Case study from the Nazca subduction zone

Mehrdad Mahdyiar, Gerald Galgana, Bingming Shen-Tu, Elliot Klein, Claire Pontbriand, Feng Wang, Khosrow Shabestari, and Wenzheng Yang
AIR Worldwide, 131 Dartmouth St., Boston, MA 02116, USA.
ggalgana@air-worldwide.com

ABSTRACT

Most subduction zones rupture in complex patterns that create earthquakes of different magnitudes with overlapping rupture areas. This makes it difficult to identify a single characteristic earthquake for time dependent rupture probability analysis (TDRPA). For many subduction zones, limited historic earthquake data on large magnitude earthquakes do not provide sufficient information to estimate reliable mean recurrence intervals and rupture probabilities for such earthquakes. To improve the situation there is a need to complement the TDRPA with auxiliary data. Physical models based on geodetic data have been successfully used to obtain information on the state of coupling and slip deficit rates for subduction zones. Coupling information provides valuable insight into the complexity of subduction zone rupture processes, as demonstrated by the excellent correlation between the coseismic slip distribution from the 2010 M 8.8 Maule, Chile earthquake and the corresponding results from a GPS-based physical model published before the earthquake (Moreno et al., 2010).

In this study we present a TDRPA model that is formulated based on slip deficit rate distribution over subduction zones. In this model, a subduction zone is represented by an integrated network of cells. Each cell ruptures multiple times from numerous earthquakes that have overlapping rupture areas. The rate of rupture for each cell is calculated using a moment balancing concept that uses information from historic data and slip deficit rates. The model enables us to estimate the expected mean recurrence intervals for all cells forming the subduction zone. This information in conjunction with past earthquake rupture data is used to estimate time dependent rupture probabilities for cells. Rupture probabilities for earthquakes are formulated by integrating different combinations of cells that form rupture areas of different magnitude earthquakes at different locations on the subduction zone. The resulting rupture probability estimates are fully consistent with the state of coupling of the subduction zone and the regional and local earthquake history as the model takes into account the impact of all large (M>7.5) earthquakes on the subduction zone on TDRPA. The granular rupture model as formulated in this study allows estimating rupture probabilities for large earthquakes other than just a single characteristic magnitude earthquake. This provides a general framework for formulating physically-based rupture probability models for large earthquakes on subduction zones that is consistent with their true locking state and earthquake history. We will present the formulation of the proposed TDRPA model, its application to the entire Nazca plate subduction zone and the model sensitivity to some common initial assumptions critical to TDRPA.

KeyWords: Seismic Hazards, Earthquake Rupture, Stochastic Models, Subduction Zones, Interplate Coupling, Kinematic Models.