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Seismic characteristics of outer-rise earthquakes in the different seismic coupling subduction zones

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Characterizing the seismogenic zone of major subduction plate boundaries provides us a possible to reduce large earthquakes hazard. In the past several decades, many scientists have analyzed various geophysical methods and datasets, such as seismic and geodetic ground motion data, historical tsunami deposits, aftershock distributions, and seafloor bathymetry, trying to understand the mechanisms behind great devastating earthquakes, and to estimate the probability of a major earthquake occurrence in the future.

In this study, by using the global earthquake catalog (GCMT) from January 1, 1976 to December 31, 2011. We firstly re-examines the outer-rise earthquake model proposed by the Christensen (1988) at the subduction zones suggested to have different coupling levels. The compressive stress cumulated during the subducting processes are often reflected by the occurrence of compressional outer-rise earthquakes. Thus, in the region where the compressional outer-rise earthquakes take place without any corresponding large underthrusting earthquakes, the seismic potential is usually considered to be high. We re-examined the high seismic potential areas determined by this criteria in Christensen (1988) and confirm that the large underthrusting earthquakes did really occur in the 30 years following the appearance of compressional outer-rise events, such as in Tonga region in the vicinity of 20S, a M_w 8.3 large earthquake occurred in 2006. This result represents that the outer-rise earthquake model could be an indicator for the generation of large earthquakes along subduction zones. In addition, to have a more accurate estimation for the seismic potential, we discuss the relationship between the generation of earthquakes and the change of cumulative gravitational potential energy caused by earthquakes (ΔGPE) over time. Our result shows an acceleration of ΔGPE before large earthquakes.

Our result also shows that the extensional outer-rise events for strong seismic coupling subduction zone only presented after the occurrence of earthquakes with magnitude larger than 8, for instance, after the 2012 March M_w 9.0 Tohoku, the 2010 February M_w 8.8 Chili and the 2006 November M_w8.3 Kamchatka earthquakes, which is consistent with the analysis performed by Christensen (1988). Based on our analysis, the outer rise earthquakes occur immediately after the main event which does not coincide with the result stating in Christensen (1988) that they occur in the 30 years after the earthquake. In addition, the duration of the extensional outer-rise earthquakes occurrence appears to be correlated with its magnitude. Meanwhile, for the earthquakes with magnitude smaller than 8, as well as in the weak coupling areas, this observation is not engaged.