Geophysical Research Abstracts
Vol. 15, EGU2013-269-1, 2013
EGU General Assembly 2013

Pulse-like rupture induced by three-dimensional fault zone flower structures

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Mature faults are often embedded in low-velocity fault zones (LVFZs). Numerical simulations of dynamic rupture including a LVFZ by Huang and Ampuero (2011) showed that if the wave velocity contrast between the LVFZ and the country rock is strong enough, ruptures can behave as pulse-like ruptures. The healing front that stops the rupture is generated by reflected waves from the LVFZ-country rock interface. However, the numerical study by Huang and Ampuero (2011) was limited to two-dimensional problems with fault-parallel fault zone structures. Natural fault zones include complexities such as flower structures with depth-dependent velocity and thickness, and limited depth extent. We will show here that the mechanism of pulse generation induced by the LVFZ also operates efficiently in such three-dimensional fault zone structures. This investigation requires high resolution and flexible mesh generation, which are enabled here by the high-order accurate ADER-DG method with an unstructured tetrahedral element discretization (Pelties et al., 2012). Our simulations show that the pulse generation mechanism is robust to the depth extent of the LVFZ and to the position of the hypocenter (whether it is inside or below the LVFZ). In particular, for events with hypocenter deeper than a shallow LVFZ, we find that a healing front emerges soon after the rupture enters the LVFZ, with rise time controlled by the LVFZ properties. Moreover, this healing front reflects from the free surface and propagates downdip beyond the bottom of the LVFZ, inducing there pulse-like rupture with longer rise time. Thus, we find that the depth-dependence of rise time might reflect the depth extent of the LVFZ.

References:

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