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Dynamic inversion of a Slab-push earthquake in Northern Chile

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We study the dynamic rupture propagation of a M 6.7 intraplate earthquake that occurred 16 December 2007, a month after a large thrust event of Tocopilla, Chile (M 7.7). The occurrence of a slab push event after a large subduction earthquake is well explained by Coulomb stress transfer models and crack dynamics. A dense seismic network, equipped with short period and accelerometers was deployed after the event of 14 November 2007 by the Task Force of GFZ Potsdam and the University of Chile in Santiago. This network was in place on December 16 providing an excellent data set for this earthquake. We used these data to make a detailed study of rupture processes. We localized the main event of December 16 and the aftershocks that occurred within 24 h of the main event. The main event was located at 43 km depth, while the aftershocks distribution covered a circular zone of 5 to 8 km of radius centred on the main shock epicentre. The aftershocks are distributed on an almost vertical plane that agrees with one of the fault planes of the mechanism (86° dip) and all the aftershock have the same mechanism as the main event. We used nearest accelerometric records in order to do dynamic inversion, two of these accelerometers were situated right above the hypocentre. We performed a non-linear dynamic inversion based on the neighbourhood algorithm (NA) and MonteCarlo methods with an L2 norm. The data was initially filtered in the 0.05-1 Hz. The velocity model was derived from previous work by GFZ. The earthquake was modelled using finite differences on a grid of variable size. Friction was modelled by the standard Ida slip weakening friction law. At each step of the inversion more than 32 full numerical simulations are carried in parallel. These simulations have been optimized in order to reduce the computer time to a minimum. The best models that result from dynamic inversion reduced the variance by more than 30 %, these models ruptured a relatively small zone of the fault plane with a diameter of about 6 km. The rupture speed was quite slow and the energy release rate that gives the best results was of the order of 10 MJ/m2. We explored a large area of the parameter space in search for solutions with faster rupture speeds but we have failed to find them. It appears then that this earthquake, located right under the transition zone from steady to stick slip, propagated very slowly. We have confronted the results of dynamic inversion with displacement records filtered at several frequency bands up to 4 Hz. The inverted models depend on the frequency band used for the inversion because the observed and synthetic records are controlled by a large stopping phase that contains most of the radiated energy. We also study the initiation of the event on seismograms, the event started by a clear cascade process involving several initial ruptures.