Observations and modeling of the rupture development based on the analysis of Source Time Functions

Julien Renou¹, Martin Vallée¹, and Hideo Aochi²,³
¹Université de Paris, Institut de Physique du Globe de Paris, CNRS, Paris, France (renou@ipgp.fr)
²Laboratoire de Géologie, Ecole Normale Supérieure, CNRS, PSL Reasearch University, Paris, France (h.aochi@brgm.fr)
³Bureau de Recherches Géologiques et Minières, BRGM, Orléans, France (h.aochi@brgm.fr)

Our knowledge of earthquake source physics, giving rise to events of very different magnitudes, requires observations of a large population of earthquakes. The development of systematic analysis tools for the global seismicity meets these expectations, and allows us to extract the generic properties of earthquakes, which can then be integrated into models of the rupture process. Following this approach, the SCARDEC method is able to retrieve source time functions of events over a large range of magnitude (Mw > 5.7). The source time function (which describes the temporal evolution of the moment rate) is suitable for the analysis of transient rupture properties which provide insights into the generation of earthquakes of various sizes. Our study aims at observing the rupture development of such earthquakes in order to add better constraints on dynamic source models. We first focus on the development of earthquakes through the analysis of the SCARDEC catalog. The phase leading to the peak of the source time function (“development phase”) is extracted to characterize its evolution. From the computation of moment accelerations at prescribed moment rates, we observe that the evolution of the moment rate during the development phase is independent of the final magnitude. A quantitative analysis of the moment rate increase as a function of time further indicates that this phase does not respect the steady t² self-similar growth. These observations are then compared with dynamic source models. We develop heterogeneous dynamic models which take into consideration rupture physics. Heterogeneous distributions of the friction parameter and the initial stress contribute to generate highly realistic rupture scenarios. Rupture propagation is strongly influenced by these two dynamic parameters which induce a clear preferential direction of propagation together with a local variability of the rupture velocity. Variability of the kinematic parameters also tends to correlate rupture velocity and slip velocity, which is a key feature for the transient behavior of the development phase previously observed. These findings are expected to put further constraints on future realistic dynamic rupture scenarios.
