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Characteristics of the earthquake rupture expansion derived from a large catalog of Source Time Functions

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The mechanisms governing the seismic rupture expansion and leading to earthquakes of very different magnitudes are still under debate. In the cascade model, the rupture starts from a very small patch, which size is undetectable by seismological investigation. Then rupture grows in a self-similar way, implying that no clues about the earthquake magnitude can be found before rupture starts declining. However, dependencies between early phases of the rupture process and final magnitude have also been proposed, which can be for example explained if an energetic start is more likely to result in a large earthquake.

Here, the analysis of the early phases of the seismic rupture is achieved from an observational point of view using the SCARDEC database, a global catalog containing more than 3000 Source Time Functions (STFs) of earthquakes with magnitude larger than 5.7. This dataset is theoretically very suitable to investigate the initial phase, because STFs directly describe the seismic moment rate released over time, giving access to the rupture growth behavior. Our method consists in computing the STFs slope, i.e. the seismic moment acceleration, at several prescribed moment rates. In order to ensure that the chosen moment rates intersect the growth phase of the STF, its value must be high enough to avoid the very beginning of the signal -not well constrained in the deconvolution process-, and low enough to avoid the proximity of the peak moment rate. This approach does not use any rupture time information, which is interesting as (1) the exact hypocentral time can be uncertain and (2) the real rupture expansion can be delayed compared to origin time. If any magnitude-dependent signal exists, the average or median value of the slope should vary with the magnitude of the events, despite the intrinsic variability of the STFs.

The preliminary results from the SCARDEC dataset exhibit only a weak dependence of the slope with magnitude, within a large measurements variability, in the magnitude domain where the chosen moment rate value crosses most of the STFs onsets. Our results additionally point out that slope values quickly increase with the moment rate, which results in a moment rate function growing faster than quadratically with time (the quadratic evolution being the classical self-similar behaviour). These findings will be discussed in the frame of existing models of seismic rupture expansion.