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Seismic slip on an upper-plate normal fault during a large subduction megathrust rupture

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Quantification of stress accumulation and release during subduction zone seismic cycles requires an understanding of the distribution of fault slip during earthquakes. Reconstructions of slip are typically constrained to a single, known fault plane. Yet, slip has been shown to occur on multiple faults within the subducting plate owing to stress triggering, resulting in phenomena such as earthquake doublets. However, rapid stress triggering from the plate interface to faults in the overriding plate has not been documented before.

We have analysed seismic data from the magnitude 7.1 Araucania earthquake that occurred in the Chilean subduction zone in January 2011. We find that the earthquake, which was reported as a single event in global moment tensor solutions, was instead composed of two ruptures on two separate faults. We use 3-D full waveform simulations to better constrain the centroid of the second rupture.

Within 12 s, a thrust earthquake (Mw 6.8) on the plate interface triggered a second large rupture on a normal fault 30 km away in the overriding plate (Mw 6.7). We define this set of events as a 'closely spaced doublet' (CSD). This configuration of partitioned rupture is consistent with normal-faulting mechanisms in the ensuing aftershock sequence. We conclude that plate interface rupture can trigger almost instantaneous slip in the overriding plate of a subduction zone. This shallow upper-plate rupture may be masked from teleseismic data, posing a challenge for real-time tsunami warning systems.