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Complex rupture of an apparently simple asperity during the 2014/04/01 Pisagua earthquake (Northern Chile, Mw=8.1)

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We analyze the 2014/04/01 Pisagua earthquake with an extensive dataset, including dense inland observations (strong motion and GPS data, used both for their static and dynamic displacements), teleseismic data (P waves, SH waves, and high-frequency surface waves modeled through an empirical Green function approach) and tsunami data. The obtained kinematic source model is also validated a posteriori with InSAR data, for which the main aftershock (2014/04/03, Mw7.6) is taken into account. Data directly sensitive to the final displacement of the earthquake (static GPS, tsunami data and InSAR) well constrain a simple slip patch mostly located south of the hypocenter, half way between the coast and the trench. However, waveform data require that this patch has been broken in a complex way, involving an initial downdip rupture propagation followed by an updip propagation starting $\sim$30s after rupture initiation. After this episode, during which most of the seismic moment is released, rupture still proceeds north of the hypocenter. This model reconciles the high-frequency imaging of the earthquake with back-propagation techniques, which are mostly sensitive to the initial downdip rupture propagation, with the low-frequency rupture process characterized by a slow propagation toward the South. The Pisagua earthquake illustrates how the rupture velocity of an earthquake can appear slow without being really so. This rupture process further documents the heterogeneous nature (in terms of stress or friction law) of this segment of the Chilean subduction zone, already imaged by the abundance of foreshocks which were unable to grow in a large event.