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Slip distribution of the 2015 September 16, Illapel (Chile) Mw 8.3 earthquake from joint inversion of tsunami and InSAR data

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On September 16, 2015 an Mw 8.3 interplate earthquake occurred offshore the Illapel region, Chile, approximately in the area of the 1943 Mw 8.1 earthquake. The epicenter is located at 71.7 °W, 31.6 °S at a depth of ∼25 km. In this region the Nazca Plate is subducting under the South America Plate with a convergence rate of ∼74mm/yr.
This earthquake generated a tsunami that struck the Chilean coast from ∼24 °S to ∼38 °S, with particularly severe damages around the area of Coquimbo city where a tide gauge recorded a maximum tsunami wave amplitude of ∼4.7 m. The tsunami has been distinctly recorded by several tide gauges distributed along the Chilean coast and also by some DART buoys located in the South Pacific ocean. The inland coseismic deformation has been detected through InSAR processing of Sentinel-1 images, acquired from ascending and descending orbits.
In this work we present the slip distribution of the earthquake obtained by jointly inverting the tsunami waveforms recorded by 3 DART buoys and 15 tide gauges, and the ground displacement retrieved by InSAR data. In order to honour the geometry of the subducting plate, we use a fault model that accounts for the variability of the strike and dip angles along the slipping surface composed by 20x20 km subfaults. We use the Green's function approach and a simulated annealing technique to solve the inverse problem. Synthetic checkerboard tests indicate that tsunami and InSAR data well constrain the offshore and onshore part of the slip distribution respectively, whereas the overall target slip distribution is well recovered by jointly using the two datasets.
The slip distribution of the Illapel event features a main patch of slip updip of the hypocenter, extending for ∼200 km along strike, ∼120 km along dip and reaching the trench with a maximum slip of ∼9 m; the slip direction is ∼110°, pretty consistent with the relative convergence axis between the Nazca and the South America Plates. We also observe a strong spatial correlation between the slip model and the distribution of the aftershocks occurred during two weeks after the mainshock, that are mainly located near the edges of the rupture area.