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Large tsunamigenic slip-deficit threatens the most populated coast of Chile

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The amount and distribution of offshore slip deficit determine how tsunamigenic the next earthquake could potentially be. Unfortunately, as dramatically learned from the 2011 Japan tsunami disaster, shallow locked regions are difficult to identify from instrumental data and from the seismogenic behavior of the recent past. Against all predictions of an aseismic shallow zone, the 2011 earthquake, with a magnitude 9, ruptured to the trench with over 50 m of highly tsunamigenic slip. The six centuries of plate-tectonic motion required to accumulate such amount of offshore slip deficit (50 m / 8 mm·y-1) are much longer than the typical recurrence intervals that have characterized the local seismogenic behavior in the recent past, but are consistent with those of great tsunami inundation events in the region, as inferred from stratigraphic evidence. Learning from this experience could prevent forthcoming tsunamigenic earthquakes from being a surprise along other subduction zones.

Here we assess the slip deficit offshore the central Chilean megathrust, which faces the most populated coastal segment of the country. To this end, we first constrain the rupture zones of the 1730, 1822, 1906 and 1985 earthquakes by combining rupture and tsunami modeling with historical and instrumental records. We show that the three most recent earthquakes ruptured the deeper megathrust in a piecemeal fashion and that the large 1730 tsunamigenic earthquake was characterized by large shallow slip. These results combined with modern loading rates from plate convergence imply up to 20 m of slip deficit potentially accumulated offshore this latitude range. According to stratigraphic evidence of past tsunami inundation, the repeat times of 1730-like events range between 200 and 600 years, and therefore, a near-future earthquake peaking 20 m of shallow slip seems plausible. In an attempt to anticipate the extent of tsunami inundation in populated coastal cities facing the central Chilean megathrust, we combine our slip deficit results with spatial patterns of seismicity and geodetic observations to construct a suite of realistic tsunami source scenarios. For each scenario, we compute tsunami inundation in high-resolution digital terrain elevation models constructed from different sources of topo-bathymetric data. The simulation results indicate extensive inundation in some places and identify specific areas where pedestrian evacuation times may exceed the timing of tsunami inundation. In these areas, vertical evacuation seems to be the only solution to reduce human losses in future events.

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