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The heterogeneous distribution of elastic properties in the tsunamigenic region of subduction zones

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In the shallow region of subduction zones, topographic variations of the interplate interface condition the structural integrity of the upper plate, and thus the distribution of elastic properties in this region, which determines its tsunamigenic potential. Yet, we know little about the distribution of elastic properties in these shallow regions, which yields large uncertainty during tsunami hazard assessment.

Here we assess topographic variations of the interplate boundary as well as the distribution of elastic properties of the upper plate in two tsunamigenic regions of the Middle American Trench. We focus on the rupture area of three tsunami earthquakes, the 1992 Nicaragua event, and the 1932 and 1995 Jalisco-Colima earthquakes (Pacific Mexican coast).

We use 2D coincident wide-angle (WAS) and multichannel seismic (MCS) lines acquired across the rupture area of each event to jointly invert refracted and reflected travel-times (TT) and obtain the P-wave velocity (Vp) structure of the tsunamigenic region of the upper plate, and the geometry of the interplate boundary. Mixing both types of seismic data allowed for the first time to retrieve small-scale local topographic variations of the interplate that would have been omitted with the classical inversion of WAS TT. From Vp, we derive other elastic parameters namely, density, S-wave velocity, and rigidity using well-established empirical relationships.

The results show that the heterogeneous distribution of the elastic properties of the upper plate in the shallow tsunamigenic region correlates with topographic variations of the interplate in both margins. These results not only sustain the direct relationship between the interplate relief and the tectonic structure of the overriding plate as it has been already stated by previous authors, but they also allow to quantify the relationship between topographic highs of the subducted plate with low rigidity regions in the upper plate. This quantification is of paramount importance in these shallow regions of the subduction, because low rigidity implies high slip during coseismic deformation, and therefore, high tsunamigenic potential. The heterogeneous distribution of elastic properties inferred for the upper plate in this study should be considered during tsunami modeling, tsunami hazard assessment and tsunami early warning systems.