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Can varying mechanical behaviors along the megathrust explain the observed short- and long-term deformation of the overriding plate? Insights from the Chilean subduction zone

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Recent studies have pointed out to a discrepancy between the short- and long-term deformation of overriding plates of subduction zones. This led to debates on when and how major events could contribute to permanent deformation. This discrepancy has notably been observed along the Chilean subduction zone where the coast is observed to subside during and shortly after major earthquakes while a coastal uplift has been inferred for the last 400 ky. This discrepancy might be related to a complex mechanical behavior of the megathrust at the down-dip end of the locked zone. For instance, the megathrust could vary along-dip from segments with well-localized faults to segments made of large fracture networks or shear zones. These zones of distributed deformation would impede large nucleation and rupture propagation and favor aseismic creep. In this study, we propose to seek possible location of segments of distributed deformation along the megathrust along the whole Chilean subduction zone. To do so, we apply the critical taper theory. According to this theory, a fracture network could be obtained for wedges with equivalent basal and internal frictions. We thus seek for regions with such specific frictional properties.
These conditions are found at three different depths: at shallow depth, where it could be related to seamount features deforming the overriding plate; along the coast, which could explain the inferred long-term deformation; and at greater depth where it could reveal the brittle-ductile transition.
We then compare these segments with the short-term deformation (co-seismic slip of the recent large earthquakes and interseismic coupling). We show that distributed deformation along the megathrust could explain why the Tocopilla and Iquique earthquakes only ruptured part of the megathrust. Finally, we discuss how the different mechanical behaviors could reconcile the short- and long-term deformation of the coast.