Co-location of the downdip end of seismic locking and the continental shelf break

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Along subduction margins, the morphology of the near shore domain records the combined action of erosion from ocean waves and permanent tectonic deformation from the convergence of plates. We observe that at subduction margins around the globe, the edge of continental shelves tends to be located above the downdip end of seismic coupling on the megathrust (locking depth). Coastlines lie farther landward at variable distances. This observation stems from a compilation of well-resolved coseismic and interseismic coupling datasets. The permanent interseismic uplift component of the total tectonic deformation can explain the localization of the shelf break. It contributes a short wave-length gradient in vertical deformation on top of the structural and isostatic deformation of the margin. This places a hinge line between seaward subsidence and landward uplift above the locking depth. Landward of the hinge line, rocks are uplifted in the domain of wave-base erosion and a shelf is maintained by the competition of rock uplift and wave erosion. Wave erosion then sets the coastline back from the tectonically meaningful shelf break. We combine a wave erosion model with an elastic deformation model to show how the locking depth pins the location of the shelf break. In areas where the shelf is wide, onshore geodetic constraints on seismic coupling is limited and could be advantageously complemented by considering the location of the shelf break. Subduction margin morphology integrates hundreds of seismic cycles and could inform seismic coupling stability through time.