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Modeling the interactions between slab dynamics and continental overriding plate deformation during flat subduction

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Shallowing of slabs during their descend into the upper ~200 km of the mantle, i.e. flat subduction, can be associated with extensive geochemical, structural, and dynamic modification of the continental lithosphere. Anomalously buoyant oceanic lithosphere, overthrusting, and interactions with cratonic keels have been suggested to explain flat slabs, but the dynamics of flat slab subduction remain to be fully understood. Here, we explore self-consistent flat-slab subduction using the finite element code ASPECT with adaptive mesh refinement and a free surface boundary condition. We focus on the role of the structure of the overriding continental plate including the role of keels. Results show that flat slabs arise when the subduction interface is weak and the overriding continental lithosphere is positively buoyant, leading to trench rollback. Substantiating previous work, we also observe that a strong continental keel further enhances flat slab formation. Our results also indicate that as the slab flattens, regions of pronounced subsidence and extension develop within the foreland region, on top of more typical, larges-scale subsidence recorded within the continental interior. Regional uplift and subsidence of the overriding plate are not only linked to flat slab emplacement and removal, but also affected by slab dynamics of the shallow upper mantle. Our work can contribute to a better understanding of continental deformation including sediment transport on continent-wide scales.