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Mechanisms controlling the modes of the sinking slab into the transition zone

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It is generally accepted that subducting slabs can either sink into the lower mantle, lie down in the mantle transition zone, or even stagnate beneath it. Several studies have looked at correlations between subduction zone parameters and the ability of the slabs to penetrate into the lower mantle. These studies have suggested that the key parameters to control whether slabs stagnate or penetrate are trench motions, slab strength, buoyant features and/or the overriding plate. For example, there is evidence that older lithospheres show significant trench retreat, and tend to lie down flat above the transition zone (northwest Pacific), whereas younger lithospheres, less able to drive trench retreat, tend to sink into the lower mantle (central America). Moreover, numerical modelling studies have shown further correlations with parameters that cannot be directly observed. For example, slab penetration is inhibited by density and viscosity increases associated with post-spinel phase transition.

Numerical modelling has been one of the key tools to investigate slab penetration, and a lot of insight has been gained from these studies. But most of these studies assume (statistical) steady state scenarios, in which slab stagnation or slab penetration is more or less a permanent feature. However, on Earth different modes of slab - transition zone interaction probably need to be able to change in time from penetrating to stagnant and also vice versa. In this study, using 2D self-consistent numerical subduction models, we test plausible mechanisms which may trigger different modes of slab deformation in the transition zone and may explain both spatial and temporal variability.