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Benchmarking subduction: the decoupling problem

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Modelling lithospheric subduction in a dynamically self-consistent way is a challenging task due to the problem of decoupling of the downgoing slab from the free surface and the overriding plate. Various weakening approaches have been used in viscous model formulations. In an attempt to understand the differences of such models we have defined a very simple, purely viscous, isothermal model set-up to serve as a first subduction benchmark case. The model set-up is defined by a 3000km x 700km box with a highly viscous, dense slab overlying a viscous mantle, a free surface being mimicked by an overlying low viscosity, zero density layer ("sticky air"). Subduction is initiated by thickening of the slab at one side. This set up has been run by a variety of different numerical codes as well as a laboratory experiment. Rather than converging to one time dependent solution, the modelling results show a surprising diversity of model behaviours. Some of them entrain a thin layer of the weak surface layer, leading to effective decoupling. While this self-consistent decoupling process seems to be physically reasonable given the fluid dynamical model set up, its occurrences and details are still strongly dependent on the numerical resolution and the code implementation. In nature the entrained weak material may correspond to the subduction of sediments releasing water. For the sake of a reasonable benchmark comparison, we modify the model parameters to obtain comparable solutions with the different codes.