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Formation and stability of a double subduction system: a numerical study

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Examples of double subduction systems can be found in both modern (Izu-Bonin-Marianas and Ryukyu arcs, e.g. Hall [1997]) and ancient (Kohistan arc in Western Himalayas, e.g. Burg [2006], Burg et al. [2006]) tectonic record. A double subduction system has also been proposed to explain the high convergence rate observed for the India-Eurasia convergence [Jagoutz et al., 2015; Holt et al., 2016, 2017]. Rates of convergence across coupled double subduction systems can be significantly faster than across single subduction systems because of slab pull by two slabs. However, despite significant geological and geophysical observations, our understanding about this process is limited, and questions regarding double subduction remain largely unexplored in terms of physical factors controlling its initiation, duration and dynamics.

Subduction initiation (of a single system) in itself has been a popular and challenging topic in the research community for the last few years, and various mechanisms (i.e. collapse at a passive margin or transform fault [Gerya et al., 2008; Stern, 2004], driven by compression [Hall et al., 2003; Toth and Gurnis, 1998], due to shear heating under compression [Thielmann and Kaus, 2012] or plume induced initiation [Gerya et al., 2015]) have been proposed. However, initiation of a secondary subduction, and formation of a stable double subduction system has not been studied before. Previous studies of double subduction either introduced weak zones to initiate subduction [Mishin et al., 2008] or both the subduction systems were already initiated [Jagoutz et al., 2015], thus assuming a priori information regarding the initial position of the two subduction zones.

In this study, we perform 2D and 3D numerical simulations to investigate i) subduction initiation of a secondary system in an already initiated single subduction system, and ii) the dynamics and stability of the newly formed double subduction system. For this, we employ the code LaMEM [Kaus et al., 2016] capable of simulating lithospheric deformation while simultaneously taking mantle flow and an internal free surface into account. We start from a single subduction setup, where subduction is already initiated (mature) and we stress the system by controlling the convergence rate of the system (i.e. imposing influx/outflux boundary conditions). Under certain conditions, a second subduction may develop and transform into a stable double subduction system. Preliminary results suggest that the fate of the incipient secondary subduction depends on internal factors (i.e. buoyancy and rheology), but also on the dynamics of the primary subduction zone and the boundary conditions (i.e. convergence rate).