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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 et al. [2006]) tectonic record. A double subduction system has been proposed to explain the high convergence rate observed for the India-Eurasia convergence [Aitchison et al., 2000, Jagoutz et al., 2015; Holt et al., 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, questions regarding double subduction remain largely unexplored. For example, it is unclear how a double subduction system forms and remains stable over millions of years. Previous numerical 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, Holt et al., 2017], thus assuming a priori information regarding the initial position of the two subduction zones. Moreover, the driving forces initiating a stable double subduction system remain unclear. In the context of India-Eurasia, Cande and Stegman [2011] found evidence the Reunion mantle plume head provided an ephemeral driving force on both the Indian and African plates for as long as 25 Million years, and had significant influence on plate boundaries in the region. How this influenced the fast plate motion of India during the Cenozoic remains a central question for understanding plate tectonics.

In this study, we perform 2D and 3D numerical simulations using the code LaMEM [Kaus et al., 2016] 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. 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. 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).