The dynamics of double slab subduction from numerical and semi-analytic models

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Regional interactions between multiple subducting slabs have been proposed to explain enigmatic slab kinematics at a number of subduction zones, a pertinent example being the advancing motion (i.e. toward the upper plate) of the Izu-Bonin trench (Cizkova & Bina, 2014). An additional, important example is the rapid pre-collisional plate convergence of India and Eurasia during the Late Cretaceous, which is hypothesized to be due to the existence of two north-dipping subduction zones (e.g. Jagoutz et al., 2015). However, dynamically consistent 3-D numerical models of double subduction have yet to be explored, and so the physics of such double slab systems remain poorly understood. Here we augment fully numerical finite element models (CitcomCU) with semi-analytic subduction models (FAST: updated from Royden & Husson, 2006) to explore how subducting slab kinematics, particularly trench and plate motions, can be affected by the presence of an additional slab, with all of the possible slab dip direction permutations. A second subducting slab gives rise to more complex dynamic pressure and mantle flow fields and, for double slab systems within which the two slabs dip in the same direction (e.g. Izu-Bonin and Ryuku trenches, Late Cretaceous India-Eurasia), an additional slab pull force that is transmitted across the subduction zone interface. While the general relationships among plate velocity, trench velocity, asthenospheric pressure drop, and plate coupling modes are similar to those observed for the single slab case, we find that multiple subducting slabs can interact with each other and indeed induce slab kinematics that deviate significantly from those observed for the equivalent single slab models. Double subduction therefore provides a geodynamic mechanism to induce slab kinematics which differ drastically from those predicted from single slab experimental/modeling studies.

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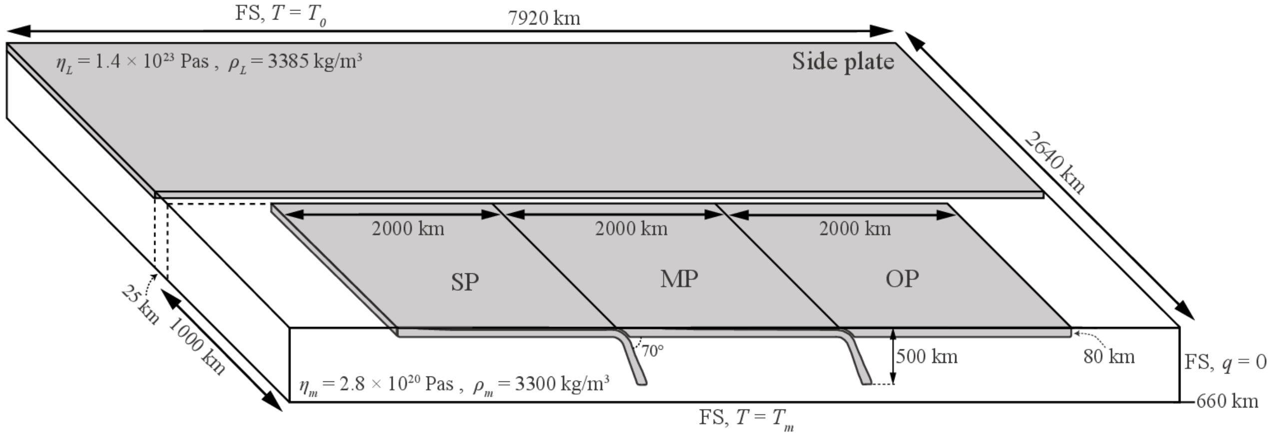
a) Schematic illustration of reference (numerical) model setup



b) Snapshot of modeled dynamic pressure, and mantle velocity (arrows), field