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Scaling Laws for Free Subduction From 3D Boundary-Element Numerical Simulations

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We are conducting a study of free buoyancy-driven subduction using a three-dimensional boundary-element method (BEM) in combination with thin viscous sheet theory, with the goal of determining quantitative scaling laws for key subduction parameters that can be compared with geophysical observations and analog laboratory experiments. The BEM method is first used to determine the velocity field on the sheet's mid-surface, from which the local bending moment is inferred. We thereby find that the fundamental length scale of the deforming sheet is the 'bending length', defined at each instant as the length of the portion of the sheet's mid-surface where the bending moment is significant. We further identify a dimensionless 'stiffness' parameter that quantifies whether subduction is resisted primarily by the viscosity of the sheet itself or by that of the ambient fluid. Using these results, we will present scaling laws for the instantaneous sinking speed and internal deformation rate of a subducting slab, with particular attention to the effect of the slab's width. Finally, we will present time-dependent BEM solutions for the evolution of the slab's shape and compare them to laboratory observations.