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A comparison of mantle convection models featuring plates

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Oceanic plates are an integral part of the Earth's mantle and thus play an important role in its dynamics and evolution. To allow plate behaviour to arise naturally in numerical mantle convection models, self-consistent plate generation methods apply a fully rheological approach (featuring a temperature-, pressure- and stress-dependent viscosity) to achieve plate-like surface motion. However, due to the extreme local viscosity changes that the self-generation of model plates entails, their computational requirements are demanding. Alternative plate modeling methods specify the existence of plates explicitly but can also obtain dynamically determined velocities (e.g., by employing a force-balance method). Here, we present modifications to a force-balance model by utilizing a geotherm- and pressure-dependent viscosity. Accordingly, plate viscosity and plate thickness are no longer prescribed by the modeler but now follow as a dynamic consequence of the temperature dependence of the viscosity and the model's evolution. We describe the new method and present benchmark results for a rheologically self-consistent mantle convection model capable of yielding plate-like surface velocities, and the modified force-balance plate model.