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The Evolution of Surface Plate Velocities and its Link to Mantle Dynamics

Tobias Rolf (1,2,3), Paul Tackley (2), and Fabio Capitanio (3)

(1) Centre for Earth Evolution and Dynamics, University of Oslo, Norway, (2) Institute of Geophysics, Department of Earth Sciences, ETH Zurich, Switzerland, (3) School of Geosciences, Monash University, Australia

At the present day, the outermost shell of the Earth is subdivided into several tectonic plates whose velocities are well determined. By knowing these velocities, inferences about the present organization of Earth's deeper interior can be made, and consequently, understanding the evolution of plate velocities can likely constrain the evolution of plate tectonics in general and specifically its link to deeper mantle dynamics.

In many previous studies using structure and velocities of the tectonic plates have been reconstructed within a kinematic framework, with some plates (e.g. India) showing significant temporal variations in their average velocity. However, these reconstructions are limited by the preservation of seafloor (i.e. < 200 Myr) and cannot explain Earth's surface evolution in a dynamically consistent manner.

Here, we use fully dynamic 3D spherical mantle convection simulations with self-consistent plate tectonics and continental drift to study the structure and dynamic evolution of Earth's plate velocities over timescales that significantly exceed the kinematically reconstructed timespans as well as the duration of Earth's supercontinent cycle. In this study, we present long-term evolutions of oceanic and continental plate velocities. We observe significant fluctuations in velocity magnitude for both types of plates that seem to be linked to the assembly and break-up of large (super-)continents as well as large-scale reorganizations of mantle flow.