Geophysical Research Abstracts
Vol. 21, EGU2019-15244-1, 2019
EGU General Assembly 2019

Next-generation surface kinematic constraints for geodynamic models

Sabin Zahirovic (1), R Dietmar Müller (1), Simon E Williams (1), John Cannon (1), Maria Seton (1), Dan J Bower (2,3), Michael Tetley (4), Christian Heine (1,5), Eline Le Breton (6), Shaofeng Liu (7), Samuel H J Russell (1), Ting Yang (2,8), Jonathon Leonard (1), and Michael Gurnis (2)

(1) EarthByte Group, School of Geosciences, University of Sydney, Sydney, Australia (sabin.zahirovic@sydney.edu.au), (2) Seismological Laboratory, California Institute of Technology, Pasadena, CA 91125, USA, (3) Center for Space and Habitability, University of Bern, Gesellschaftsstrasse 6, 3012 Bern, Switzerland, (4) AUGURY, Laboratoire de Géologie de Lyon, Université Claude Bernard Lyon 1, Lyon, France, (5) Shell Specialist Geosciences, Global Solutions International B.V., 2288 GS Rijswijk, The Netherlands, (6) Department of Earth Sciences, Freie Universität Berlin, Berlin, Germany, (7) State Key Laboratory of Geological Processes and Mineral Resources and School of Geosciences and Resources, China University of Geosciences (Beijing), Beijing 100083, China, (8) Southern University of Science and Technology, Shenzhen, China

Forward and adjoint plate-mantle models currently represent the primary means of understanding the evolution of the plate-mantle system over time periods significantly longer than 100 Myr. These plate motion- and subduction-driven models depend on kinematic models as surface boundary constraints and are widely used for understanding plume-plate, asthenosphere-plate and slab-plate interactions, including effects on dynamic surface topography. An important facet of plate kinematic models in this context is that subduction zone geometries and locations are as accurately modelled as possible in a mantle reference frame. This is a key for matching tomographically imaged subducted slabs using geodynamic modelling. Conventional rigid plate models are not well-suited for matching this criterion, as they do not take into account the time-dependent extensional or compressional continental lithospheric deformation along active plate margins. In addition, the majority of published absolute plate reference frames do not well reflect key "rules of geodynamics", including that the majority of subduction zones should neither roll back nor advance at speeds more than 2 cm/year, and that net rotation of the plates should not exceed $\sim$0.2-0.3°/Myr. Hotspot reference frames are generally better suited to matching these criteria than paleomagnetically derived reference frames, but are generally lacking or incomplete for times before 70-80 Ma. Paleomagnetically-derived absolute reference frames typically result in "zodiac-like" apparent polar wander paths, whose kinks do not necessarily correspond well to times at which other data indicate plate reorganisations, e.g. data constraining the cessation or initiation of subduction, thus shortening or lengthening the subduction system. This is problematic because the majority of the forces driving absolute plate motion originate from subduction and are thought to change only when the network of plate boundaries changes substantially, particularly through ridge-trench collision and subduction initiation. "Tweaks" applied to paleomagnetic reference frames including empirical true-polar wander corrections and/or the assumption of the long-term stability Large Low Shear Velocity Provinces (LLSVPs) often do not make these models geodynamically reasonable in the sense of displaying acceptable subduction zone migration behaviour or net lithospheric rotation rates. We present a new generation of global plate model that is designed to tackle these issues. The new model, spanning the last 240 Myr, incorporates plate deformation along plate interiors and edges, thus tracking subduction zone locations relative to overriding plates with an extending or compressing edge, and adopts a new type of mantle reference frame optimised for minimising subduction zone migration speeds as well as net lithospheric rotation. For the last 80 Myr major hotspot tracks are included in the inversion. In our optimized model net rotation is consistently below 0.25°/Myr (using a 5 Myr median filter), and trench migration scatter is substantially reduced. Due to its open-access nature and its coupling to the open-source GPlates software as the primary model-building/modification tool, this plate model can be easily improved in the future by the community, assimilating new constraints on plate deformation or linking it to alternative absolute reference frames.